ECOSUPPORT

Advanced modeling tool for scenarios of the Baltic Sea ECOsystem to SUPPORT decision making

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1 Concept, objectives and expected outcome of the project

This project addresses the urgent need for policy-relevant information on the combined future impacts of climate change and industrial & agricultural practices in the Baltic Sea (BS) catchment on the BS ecosystem.

The main aim is to provide a multi-model system tool to support decision makers. The tool is based upon scenarios from an existing state-of-the-art coupled atmosphere-ice-ocean-land surface model for the BS catchment area, marine physical-biogeochemical models of differing complexity, a food web model, statistical fish population models, economic calculations, and new data detailing climate effects on marine biota.

Our concept to achieve the above aim is built on the confidence of the models' capacity to simulate changing climate and includes several steps: (i) assessing the predictive skills of the models by comparing observed and simulated past climate variability (i.e. quantification of model uncertainties) and analyzing causes of observed variations; (ii) performing multi-model ensemble simulations of the marine ecosystem for 1850-2100 forced by reconstructions of past climate and by various future greenhouse gas emission and air- and riverborne nutrient load scenarios (ranging from a pessimistic *business-as-usual* to the *most optimistic case*); (iii) analyzing projections of the future BS ecosystem using a probabilistic approach accounting for uncertainties caused by biases of regional and global climate models (RCMs and GCMs), lack of process description in state-of-the-art ecosystem models, unknown greenhouse gas emissions and nutrient loadings, and natural variability; (iv) assessing impacts of climate change on the marine biota (e.g. effects of ocean acidification), biodiversity and fish populations (with focus on cod, sprat and herring); (v) calculating the costs of climate change; (vi) generating a free-access data base of scenario model results and tools to access the database; and (vii) disseminating the project results to stakeholders, decision makers (e.g. via the Helsinki Commission - HELCOM) and the public (webpage, newsletters, seminars, conferences, etc.).

The objectives are to:

1. calculate the combined effects of changing climate and changing human activity (nutrient load reductions [runoff and airborne], coastal management, fisheries) on the BS ecosystem,
2. assess the resulting socioeconomic impacts,
3. perform time-dependent scenario simulations from present climate until 2100, and quantify the uncertainties around these future projections,
4. support decision makers and stakeholders with a tool providing them with relevant and readily accessible information that will help to raise wider public awareness,
5. conduct focused assessments of local-scale impacts of changing climate on coastal areas (with focus on the Gulf of Finland, Vistula Lagoon, and the Polish coastal waters).

The expected outcome is an advanced modeling tool for scenario simulations of the whole marine ecosystem that can underpin and inform management strategies to ensure water quality standards, biodiversity and fish stocks.

2 State-of-the-art, theory and methods

State-of-the-art

Within the recently performed Baltic Sea Experiment (BALTEX) Assessment of Climate Change for the Baltic Sea Basin (BACC, www.baltex-research.eu/BACC) it was concluded that "identified trends in temperature and related variables (during the past 100 years) are consistent with regional climate change scenarios prepared with climate models." BACC enjoyed active contributions by more than 80 scientists and the BACC material was used by HELCOM for its own climate assessment report of the BS. RCM results suggest that global warming may cause increased water temperatures of the BS, reduced sea ice cover, increased winter mean wind speeds causing increased vertical mixing, and increased river runoff causing reduced salinity. The projected hydrographic changes could therefore have significant impacts on the BS ecosystem and its biodiversity. Unfortunately, details have not been investigated thoroughly and the complex response of the ecosystem is unknown according to BACC.

First results from physical-biogeochemical modeling applying the so-called delta approach indicate that by the end of this century the impact of optimistic nutrient load reduction scenarios and the impact of climate change could be of the same order of magnitude in some regions of the BS, emphasizing the urgent need to include climate change into available decision support systems (DSSs) [1]. The DSS **Nest** (http://nest.su.se/nest) developed in the MARE program (www.mare.su.se) is today the only scientifically-based tool available to support the development of cost-effective measures against eutrophication for the entire BS [2]. Nest has been used to set the targets of the Baltic Sea Action Plan (**BSAP**, www.helcom.fi/stc/files/BSAP/ BSAP_Final.pdf); however, Nest does not take the effect of climate change (e.g. changing hydrography or changing carbon cycle) into account. Temperature and salinity changes will have large impacts on species distributions, growth and reproduction of organisms including zooplankton, benthos and fish [3]. These could include the complete loss of entire species, and major restructuring of the food web and trophic flows (e.g., if falling salinity prevents cod reproduction or if the multiple anthropogenic impacts make the system more vulnerable to invasions by ecosystem engineers). For example, given that the three fish species in the BS which have dominated commercial landings for the past several decades are of marine origin (i.e., cod, herring and sprat), is it realistic to expect that all will continue to support comparable fisheries in future? In addition, acidification of the coastal oceans is an emerging and potentially critical threat to BS ecosystems. In the last 150 years, fossil fuel burning has caused the pH of the global oceans to fall by 0.1 units, and by the year 2100 oceanic pH is predicted to be $\leq$ 0.4 units lower than at present. Decadal records of pH in the BS and Skagerrak show acidification proceeding at rates 2 – 5 times faster than in the open ocean. The effects of these changes and their interaction with other climate variables, in mediating both gradual and state-shifts in BS ecosystems are currently unknown but likely to be considerable. Perhaps the greatest impact of acidification will manifest in the reduced capacity of many marine species to build the calcareous skeletons and shells that are essential for their survival [4]. This will be a particular problem for microscopic plankton and larval stages, causing direct impacts on reproductive success and survival in key ecosystem structuring species within the BS such as blue mussels.

Theory and methods

Within ECOSUPPORT we will apply a hierarchy of existing state-of-the-art sub-models of the Earth system (Fig.1). The main emphasis is the coupling of these sub-models. This is the key, novel, contribution that ECOSUPPORT will make toward obtaining an integrated predictive understanding of marine ecosystems. No resources are dedicated to the development of models, however, we will profit from other ongoing projects and in kind contributions (section 8).

Regional climate modeling

For dynamical downscaling a high-resolution coupled atmosphere-ice-ocean-land surface model (the Rossby Centre Atmosphere Ocean model, **RCAO**) with lateral boundary data from GCMs will be applied to calculate future climate of the BS region [5]. The regional scenario simulations will differ depending on the applied GCM at the lateral boundaries and depending on the utilized greenhouse gas and aerosol emission scenario.

To calculate future river flow and riverborne nutrient loadings a new hydrological model developed at SMHI (**HYPE**, HYdrological Predictions for the Environment) is used. It simulates a range of hydrological variables including phosphorus and nitrogen in soils, rivers and lakes. The model is a further development of the earlier HBV model [6] using the vast experience of hydrological and water quality modelling during the past 35 years at SMHI. In addition, the results of the watershed model from Nest are available for ECOSUPPORT.

The transient changes in atmospheric near-surface concentrations of trace species, that were simulated with an advanced photochemical transport model (**MATCH**, Multiple-scale Atmospheric Chemistry and Transport modelling system [7,8]), will be analyzed to estimate changing airborne nutrient deposition over the BS.

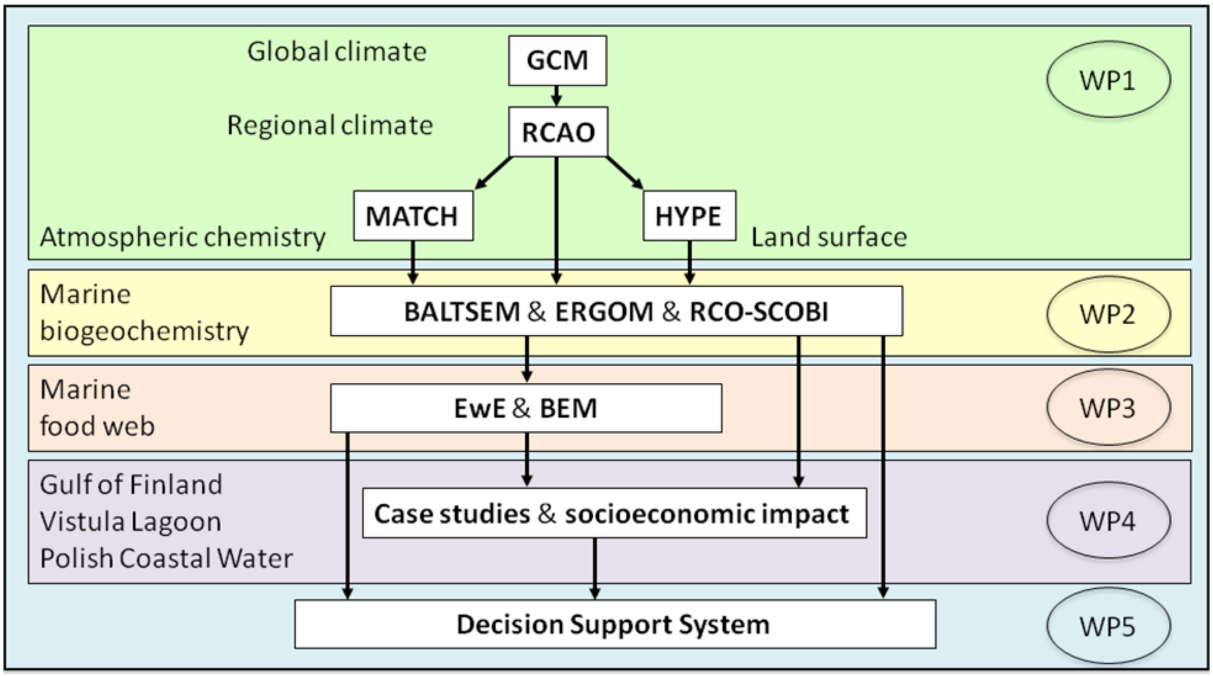


Fig.1: Model hierarchy in ECOSUPPORT and work package structure (see section 11). The schematic is highly simplified neglecting complex interactions (e.g. fish predation pressure on zooplankton, changing society/policy will affect climate and nutrient load scenarios).

Marine biogeochemical modeling

Three state-of-the-art coupled physical-biogeochemical models will be used to calculate changing concentrations of nitrate, ammonium, phosphate, diatoms, flagellates, cyanobacteria, zooplankton, detritus, and oxygen: **BALTSEM** [9,10], **ERGOM** [11], and **RCO-SCOBI** [12,13]. The models are structurally different in that ERGOM and RCO-SCOBI are 3D circulation models comprising sub-basin scale processes while BALTSEM resolves the BS spatially in 13 sub-basins. As the horizontal grid resolution in ERGOM is rather high (3 nautical miles), computational limitations allow us to use ERGOM only for selected time slices. The biogeochemical sub-models are of similar type but the process descriptions differ. With the aid of these three models the response of the BS ecosystem to different external forcing has been evaluated earlier [11,14,15,16]. RCO-SCOBI has been used to assess climate variability of the past 100 years [17] and to study the impact of future climate at the end of the 21^{st} century (e.g. [18], see the BACC book for a summary). BALTSEM was the main mechanistic model of the MARE program and is now an integral part of the work at BNI. For the case studies in the Gulf of Finland and Vistula Lagoon two regional models (based on SCOBI) forced with lateral boundary data from the basin-wide models are used during selected time slices.

Food web modeling
The food web of the BS will be simulated by applying the ecological software **EwE** (www.ecopath.org). An existing food web model for the BS has already been used in NEST, and contains 15 functional groups from primary producers to seals and fishery [19]. The model was parameterized with a focus on fish (sprat, herring and cod). EwE is an excellent tool to: a) address ecological questions; b) evaluate ecosystem effects of fishing; c) explore management policy options; d) evaluate impact and placement of marine protected areas; and e) evaluate effects of environmental changes.
At present, **statistical models for BS fish species** can link climatic forcing and lower trophic level processes to fish dynamics. These models will be integrated within ECOSUPPORT by linking them to outputs from physical-biogeochemical models. Dynamics of cod, herring and sprat have been shown to be driven partly by fluctuations in climate, eutrophication and lower trophic level processes, including those which directly affect reproductive success [20], feeding and survival of larvae, and feeding and growth of adults [21].
We will generate **Bioclimatic Envelope Models** (**BEMs**) for key species in the BS system (and in the models used here) to assess the susceptibility of these taxa to range-extension and possible local extinction arising from climate change. BEMs will be constructed using statistical modelling (CART, [22]) trained with historical distribution data for key taxa, and corresponding oceanographic environmental data [23].

Socioeconomic impact assessment
For the **focus study sites**, Gulf of Finland, Vistula Lagoon and the Polish coastal waters, we will conduct assessments of the impact of climate change on the regional and local development. The **economic assessment of the ecosystem goods and services** delivered from key ecosystems/habitats within the BS (*Fucus* beds, mussel beds, seagrass, shallow soft bottom habitats) and processes (benthic-pelagic coupling, filtration) follows the methods of [24,25]. In order to develop management strategies for sustainable use and conservation in the marine environment, reliable and meaningful, but integrated ecological information is needed. Biological valuation maps that compile and summarize all available biological and ecological information can be used as baseline maps for future spatial planning at sea. Rather than a general strategy for protecting areas that have some ecological significance, biological valuation is a tool for calling attention to areas which have particularly high ecological or biological significance and to facilitate provision of a greater-than-usual degree of risk aversion in management of activities in such areas.
The regional results from the focus study sites will be scaled up to the BS scale. This will support the **charting of socioeconomic implications** from different climate scenarios (e.g. [26,27]). Especially, the costs of nutrient load reductions of defined ecological targets of BS water quality in present and future climates will be calculated with the **Nest economic model** [28]. The metric difference between the results will provide us with a first estimate of costs related to changing climate.

3 Innovation and new approaches

The BS is considered to be an integrated system with its own internal non-linear dynamics that is driven by external factors. The novelty of our approach lays in that we bring together existing model components to design a realistic integrated, process-oriented framework for consistent simulation of the responses of the BS system including its upper trophic levels to possible future external driving scenarios. This unified tool will be validated by simulating the past evolution of the BS, thereby providing realistic quantitative estimates of its limitations and uncertainties. For the first time, this will permit calculation of high-resolution scenarios of the marine ecosystem (including nutrients, autotrophs, zooplankton and fish population dynamics). To estimate the robustness of the projections a multi-model approach comprising 3 state-of-the-art ecosystem models will be applied to quantify uncertainties. Since response times of the BS ecosystem and the time scales of the external forcing are of the same order (decades) it is unlikely that the ecosystem will ever reach steady-state, but rather that ecosystem status will be dominated by transients. Fully coupled atmosphere-ice-ocean-land surface simulations of these transients are not yet available but will be provided (for the period 1960-2100) by ECOSUPPORT and made freely available to the wider research community. Existing time slice scenario simulations are limited to 2071-2100 and focus either on surface variables or assume that future variability will not change, thereby preventing the study of changing extremes. Also there is currently no consistent model-based reconstruction of the marine ecosystem for the past 150 years (since 1850) that includes eutrophication, warming trends due to anthropogenic influences, and decadal variations (such as stagnation periods). Moreover the linkage of lower trophic levels directly and in mechanistic ways to higher levels in such models is virtually non-existent in the global marine community. This project will however pioneer for example how to link eutrophication-related anoxia periods (which have been modeled already by some of our project partners) to fish reproductive success, and detailed models of zooplankton life history to fish growth and survival, and will evaluate how such links will respond to climate change. Such linkages between models and trophic levels are now possible because existing, yet fragmented, process knowledge and expertise in different institutes will be combined in this project. Quantification of the predictability of perturbations in climate and nutrient loads on long timescales is a necessary prerequisite for future projections. Further, ECOSUPPORT will (1) investigate links between the BS and the BS catchment area, (2) enhance collaboration between fish research and research on eutrophication and climate change, and (3) foster collaboration between management of different sectors. (1) - (3) are the most highly ranked gaps in present research identified by the BONUS report on Task 2.1.

4 Themes and key research issues of BONUS-169 Science Plan addressed

ECOSUPPORT contributes mainly to BONUS themes 1, 2, 3, 4, 7. Indirectly, the project contributes also to the themes 5 and 6. An ecosystem approach to the management of human activities (EAM) requires a comprehensive Earth system modeling tool for future scenarios of the BS ecosystem with implications for policy actions and socioeconomic consequences, which will be provided by ECOSUPPORT (**theme 1**).

The BS response to climate change is the result of complex interactions between changes in the entire catchment and the BS itself. Understanding of the long-term variations of the BS as an integrated system is still limited. Consolidating model-based projections for the future and estimating the level of uncertainty inherent in those projections are essential steps in advancing that understanding. Due to the lack of long time series (> 100 years) of important climatic and environmental variables, modeling of the recent past evolution of the BS will provide a precious tool to understand its long-term variability and its long-term response to some of the increasing anthropogenic forcings (**theme 2**).

Within ECOSUPPORT physical-biogeochemical models of differing complexity will be used to analyze the impacts of varying atmospheric forcing and varying volume and nutrient fluxes from land surfaces modeling on basin and local scales. Cause-and-effect studies will improve our understanding of the effects of excessive human-induced inputs of nitrogen and phosphorus since the mid-19th century. Scenario simulations will facilitate the development of scientific strategies to combat eutrophication for the purpose of reaching the environmental targets that have been set, e.g. in the BSAP (**theme 3**).

To achieve sustainable fisheries during the 21st century, new knowledge is needed regarding the ability of the BS to support fish populations on a sustainable basis even under eutrophication and climate change. ECOSUPPORT will estimate how fish populations will react to these drivers and provide the scientific basis that managers can use to develop and implement EAM for fisheries. ECOSUPPORT will use outputs from physical-biogeochemical models (e.g. oxygen, salinity and temperature) to force models of species interactions involving plankton and fish, and physiologically-based models of fish population dynamics under various scenarios of climate change, nutrient loading and fisheries exploitation (**theme 4**).

Outputs from physical-biogeochemical models will also provide estimates of the hydrographic context to which the biota of the BS will be exposed in the future, facilitating prediction of changes to the spatial distributions of marine and freshwater species in the BS (i.e., its biodiversity) (**theme 5**).

As high-resolution 3D circulation models for the atmosphere and the oceans are applied within ECOSUPPORT, spreading of pollutants from point sources and their distributions, fluxes, and mass balances may be calculated for past and future climates (**theme 6**).

Extensive dissemination and outreach activities will inform society about the project results. We will create a public webpage, distribute results to stakeholders via newsletters, and organize end-user conferences with speakers from the project and external guests (**theme 7**).

5 Contribution in producing deliverables described in the BONUS-169 Science Plan

The response of the marine ecosystem during the 21st century depends on several, partly competing drivers, such as (expected) reduced phosphorus and nitrogen loads (due to changing land use or changing emissions to the atmosphere), increased water temperatures and vertical mixing, and reduced salinities and sea ice cover. Consequently, any targets for nutrient load reductions that may be sufficient to improve ecological status in the present climate may well fail under future climate conditions (i.e. on 100-year timescales). Equally, adaptation and mitigation measures that address only regional climate change may prove to be inadequate if they ignore the effects of changes in other drivers such as nutrient loading due to human activities. Therefore, the proposed project combines assessments of multiple drivers from changing climate, industrial, and agricultural practices, using a combination of state-of-the-art natural and socioeconomic models to promote EAM. ECOSUPPORT will focus on substantially enhancing scientific knowledge using a completely novel approach, on transferring the results to various stakeholders, and on raising wider public awareness. ECOSUPPORT contributes mainly to the deliverables **D1** (*better capacity to predict and mitigate environmental risks in a coherent and holistic manner*), **D2** (*better bridging science and policy*), **D3** (*promotion of EAM*), **D4** (*support of coastal zone management* in the focus study sites), **D5** (*scenarios and models for exploring future developments in the BS ecosystem*), **D8** (*scientific information*) and **D10** (*improved cooperation with third parties beyond the EC* – a Russian partner is involved in ECOSUPPORT) of **theme 1** of the BONUS-169 Science Plan. Within **theme 2** mainly **D1** (*tools for quantifying and predicting how climate change and variability, eutrophication and fisheries interact*), **D3** (*methods for risk/environmental assessment*), **D5** (*ecological and socioeconomic cost-benefit analysis and models examining cause and effects of different environmental developments*) and **D6** (*new scientific support for effective and adaptive management*) are addressed.

6 Dissemination plan

During the first 3 months of the project we will establish the **ECOSUPPORT webpage** with a public site and a restricted area for internal information exchange and management

purposes. The public webpage will host the DSS and provide continuously updated information about project results, news, ongoing activities and dissemination events.
We will work to actively involve stakeholders (e.g. representatives from national environmental protection agencies, fishery and agriculture boards, maritime administrations, ministries of the environment, the HELCOM secretary) and scientific networks (e.g. BALTEX) from the beginning of the project by organizing **annual end-user seminars** that will build on previous, very successful initiatives at SMHI such as the Rossby Centre Days or the Marine Environment Day in 2008 "Can we save the Baltic Sea? – Eutrophication in future climate". These one-day seminars will include presentations from invited external guests relevant to the project as well as presentation and discussion of ECOSUPPORT results. Toward the end of the project a larger **international conference** is planned with the aim of bringing scientists and stakeholders together.
On a more local level, each partner institute will contribute to information dissemination with **articles** in local newspapers, **posters** about ECOSUPPORT displayed for local authorities, multi-media presentations, flyers, etc. For example, IOPAS plans practical demonstrations/presentations on the sea shore of Sopot as well as presenting ECOSUPPORT at the Festival of Science in Gdynia and Warsaw. Powerful tools for conveying complex ideas to the public, scientists and students (teaching purposes) are **video animations** from model results of the dynamics of changes in the system. This could be animations of inflows, degradation of reproductive volume following a single inflow event or over scale of entire century, gradual warming/freshening of the BS, contraction/expansion of a species range due to changing salinity, temperature, anoxia, pH, etc.
ECOSUPPORT results will be presented in **talks** and posters at the 6th international study conference on BALTEX, the Baltic Sea Science Congress (BSSC), ICES Annual Science Conferences, HELCOM stakeholder conferences, and Global Change Conferences.
We will work to obtain the widest possible recognition and up-take of our results by publishing our results in highly-ranked **international peer-reviewed scientific journals** as well as through institute reports.
The integrated approach will also be of interest to research groups *outside* the BS and Europe which are studying how multiple driving factors affect estuarine and marine ecosystems. For instance, collaborations with the EU projects MEECE (Marine Ecosystem Evolution in a Changing Environment, www.meece.eu) and ECOOP (European Coastal Sea Operational Observing and Forecasting System, www.ecoop.eu) are envisaged.

7 Participants and management of the project

The complexity of this problem can only be tackled by combining and integrating international forces to form sufficient critical mass to achieve these ambitious goals. We have collected together an outstanding inter-disciplinary cooperation between 11 partner institutes from 7 BS countries to create ECOSUPPORT. ECOSUPPORT will be a fully-integrated component of the large international networks that originated in the previous SWECLIM (Swedish Regional Climate Modeling) and MARE programs. This proposal has also been developed in cooperation with research groups active in BALTEX. The scope of the proposal has been discussed within the BALTEX *Science Steering Group* (SSG) and has been designed to also contribute to the objectives of the science and implementation plan of BALTEX phase two. This adds to existing transnational knowledge transfer between BS countries and provides the free exchange of data from scenario simulations appropriate for a multitude of climate change impact studies.
The 11 participating institutes form an excellent consortium to address the aims of ECOSUPPORT. The consortium comprises university institutes, national governmental agencies and research institutes (including EU-recognized Centers of Excellence), and has expertise in regional climate modeling and climate analysis (GKSS, SMHI), land surface

modeling (BNI, SMHI), atmospheric transport and nutrient deposition modeling (FMI, SMHI), physical-biogeochemical modeling (IOW, BNI, MSI, SMHI), food web and fish population modeling (DTU, BNI, IOW), environmental, ecological, and climate change impact assessments (IOPAS, ABIORAS, BNI, SMHI, CSPR, TMBL), field and laboratory experiments (ABIORAS, IOW, SMHI, TMBL, IOPAS, MSI), regional scale and coastal zone studies (MSI, ABIORAS, IOPAS, SMHI, IOW), socioeconomic impact studies and DSS expertise (BNI, IOPAS, CSPR), and data base management (SMHI, BNI, IOW).

Management structure and procedures

A simple but appropriate and effective management structure for ECOSUPPORT has been chosen following well-proven examples from comparable FP6 projects, in which the coordinator and most partners have considerable and successful experience. The overall decision-making body will be the *General Assembly* (GA) comprising representatives of all partners. ECOSUPPORT is divided into 5 work packages (WPs) with a work package leader (WPL) assigned to each WP. A SSG composed of the WPLs will continuously guide and monitor the project evolution. The *Management Team* will provide support to all day-to-day management duties and tasks of the coordinator.

The General Assembly

The GA is the decision-making body of the project chaired by the coordinator. It will discuss and decide on all project-related issues including science and technical content, finances, intellectual property rights, changes to the work program etc. The GA will conduct annual meetings starting with the kick-off meeting immediately after commencement of the project. In urgent cases where major decisions with potentially significant impact on the future direction of the project may have to be taken, the coordinator may call for additional GA meetings.

Work Package Leader and Science Steering Committee

The WPLs are responsible for coordinating and managing the work within the respective WP with the overall objective to provide all planned deliverables and reach milestones of the respective WP as scheduled. The WPLs are responsible for a continuous monitoring of the WP progress. The WPLs form the SSG of ECOSUPPORT:

Work Package	Partner No and short name	Person in Charge
WP 1	10, GKSS	Eduardo Zorita (Germany)
WP 2	2, BNI	Bo Gustafsson (Sweden)
WP 3	5, DTU	Brian MacKenzie (Denmark)
WP 4	8, MSI	Urmas Raudsepp (Estonia)
WP 5	1, SMHI	Markus Meier (Sweden)

Management of the project

Important elements of project management include decision-making, monitoring of project progress, assessment of project results against project schedule, and reporting at WP and project levels and to the BONUS funding agencies. Main management tools will be meetings, telephone or internet-based conference calls, a dedicated ECOSUPPORT webpage, and continuous e-mail communication between partners and bodies.

The **first GA meeting (kick-off)** will ensure that the detailed work plans for each participant are in alignment with the objectives of the project. The consortium will agree on all details such as data transfer, communication means and schedules and synchronizing of work among participants within as well as among WPs.

Annual **GA meetings** will be conducted. Prior to such meetings, each WPL will provide a written internal WP report to the coordinator. The SSG – in a separate meeting prior to the GA - will i) review the project's progress of the preceding 12 months as stated in all WP reports, ii) assess the progress, in particular project deliverables and milestones, against the work plan as laid down in the project's work plan and, iii) discuss and suggest - based on this

assessment – either the approval of or adjustments to the work plan for the next 12 months and the remainder of the project. The latter suggestions will be input to the GA meeting to be finally discussed, altered, if appropriate, and approved by the GA.
In between the GA meetings, the SSG will have the key role in guiding and monitoring the project's evolution and progress. As the key communication means, **3-monthly SSG telephone conference calls** will be held organized by the coordinator.
Access to the restricted area of the **ECOSUPPORT webpage** will be limited to partners only and it will be used for exchange of confidential material. It will also contain an ECOSUPPORT-internal news board, where in particular sensible material and information too voluminous for e-mail exchange will be stored.
The BALTEX SSG will act as an **external advisory board**.

9 Description of the significant facilities and large equipment available for the project

Super computer resources (including cpu time, disk and tape storage) to perform the vast amount of simulations are provided by GKSS, IOW, MSI, and SMHI. **GKSS** is a member of the German Climate Computing Center in Hamburg, where climate simulations with high-performance computers are performed. Currently the mainframe is a NEC SX-8, which will superseded soon by a IBM Power6 System with a capacity of 140 TeraFlops. **IOW** has access to the compute facilities of the North German Alliance for Advancement of High-Performance Computing (HLRN). In 2008 and 2009 the system will be updated to increase the peak performance up to 312 TeraFlops with 90 Terabytes of main memory. Currently **MSI** owns a Linux cluster with 16 nodes. An extension with 40 additional nodes is requested from BONUS. **SMHI** has access to computational resources of the Swedish Infrastructure for Computing (SNIC), a dedicated Swedish computer for climate science, and an own compute cluster, mainly used for application development. SMHI is also shareholder in a currently built super computer based on a Linux cluster with about 800 computing nodes with 2*4 processor cores each, connected via high performance Infiniband network. The cluster will enable high-resolution simulations of centennial scale length and is well suited for multi-tracer runs with biogeochemical models.

10 Researcher exchange and training, including possibility of organizing a course

Four partners (ABIORAS, GKSS, IOPAS, TMBL) request salaries for PhD students from BONUS. Thus, the upcoming joint summer school between BALTEX and former EUR-Oceans partners (European Network of Excellence for Ocean Ecosystems Analysis, www.eur-oceans.eu) in 2009 will be a good opportunity for training of young scientists and PhD students from ECOSUPPORT: the impact of climate change on ecosystems is the planned topic for this summer school, fitting perfectly with ECOSUPPORT objectives. SMHI, DTU and other partners of this consortium will be heavily involved in the planning and teaching of the summer school. In addition, IOPAS is planning courses for ECOSUPPORT students in Sopot.
Within ECOSUPPORT an exchange of researchers is planned to transfer knowledge regarding integration of models and outputs. As ECOSUPPORT is based upon an interdisciplinary approach with close interactions of disciplines the exchange of researchers is important for the success of the project. ECOSUPPORT partners offer to host guest scientists from other partners.

11 Detailed work plan/research plan divided into Work packages and Tasks

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

In WP1 atmospheric and hydrological forcing functions to drive the coupled physical-biogeochemical BS models will be calculated or just compiled from existing data sources (Fig.1). We will work with both reconstructed historical data using statistical modeling for hindcast simulations during 1850-2007 (task **T1.1**) and with model results from a RCM driven with GCM data at the lateral boundaries for transient scenario simulations during 1960-2100 (**T1.2** and **1.3**). In the overlap period 1961-2004 the quality of the data sets will be assessed using high-quality observational data and available reanalysis products (a high-resolution regionalization of ERA40) (**T1.4**). Due to the chaotic behavior of the Earth system RCM simulations of present climate forced by GCMs (called control simulations) can only reproduce the statistics of weather (climate) but not the weather (single events) itself. On the other hand, the forcing data sets generated in T1.1-3 are suitable to drive hindcast simulations that would reproduce (neglecting model biases) the temporal evolution of the past. Thus, only statistical moments of hindcast and control climate data can be compared. The assessment of the various, structurally differing data sets is of uttermost importance for quality assurance of the modeling studies performed within WP2-4.

T1.1: Forcing data 1850-2007 (1-12)[1](SMHI, BNI, DTU, IOW, FMI, GKSS)

Objective: To reconstruct atmospheric surface forcing fields, river flow, river- and airborne nutrient loads, and greenhouse gas emissions to the BS basin for 1850-2007
Description of work: Using a statistical model [30], available SLP, air temperature, precipitation and cloudiness surface maps with 20’x20’ grid resolution (Climate Research Unit, UK) and 89 stations with daily SLP measurements [31] will be used to reconstruct the atmospheric surface fields that are needed to force a regional ocean model for the BS and North Sea region. A homogeneous data set of monthly riverine loads will be compiled based on available data and estimates for preindustrial conditions a century ago [15,16]. It comprises bioavailable nitrogen, phosphorus and labile organic compounds as concentrations together with respective runoff. The airborne load of nutrients and acid deposition to the BS will be estimated from existing monitoring data and from model calculations (EMEP).
Deliverables: Atmospheric forcing fields (12)[2], riverborne nutrient loads including diffusive and point sources (12), airborne nutrient loads (12)
Milestones and expected results: Consistent reconstructed data to force biogeochemical models 1850-2007

T1.2: Atmospheric forcing data 1960-2100 (1-12) (SMHI)

Objective: To scale GCM simulations down using a RCM 1960-2100
Description of work: The regional coupled atmosphere-ice-ocean-land-surface model RCAO will be used to downscale at least four transient simulations driven at the boundaries by global simulations with two GCMs and two greenhouse gas emission scenarios form the latest IPCC runs (1960-2100), following similar simulations previously performed at SMHI for shorter periods (these are also available for this project). We are aware of the latest discussions about stabilization scenarios within IPCC and will include new developments into the working plan if necessary.
Deliverables: Model data of the first transient simulation to force hydrological models of the catchment area (T1.3) and BS models (T2.3) (6), model data sets of the whole ensemble (12)
Milestones and expected results: Consistent transient scenario simulations with a fully coupled RCM 1960-2100

[1] Start and end month of the task (cf. section12)
[2] Number of the month when the deliverable is due

T1.3: Nutrient load forcing data 1960-2100 (1-12) (SMHI, FMI)

Objective: To calculate transient scenario simulations of river- and airborne nutrient loads 1960-2100
Description of work: Using the hydrological HYPE model forced with RCM results transient simulations of river flow will be performed. The climate scenario simulations will be combined with a number of differing nutrient load reduction scenarios already performed at BNI, e.g. 1) the most optimistic case combining improved sewage treatment, P-free detergents and best possible agricultural practices (BC), 2) the BSAP, and 3) the most pessimistic case assuming business-as-usual in agriculture (BAU). Using available results from IPCC and regional scenarios of atmospheric chemistry from the MATCH model changing atmospheric deposition including estimates for NOx and SOx loads and CO_2 emissions will be compiled. The latter estimates are important for the assessment of acidification.
Deliverables: River flow data (12), river- and airborne nutrient loads and CO_2 emissions (12)
Milestones and expected results: Consistent nutrient load projections to force biogeochemical models 1960-2100

T1.4: Quantification of uncertainties of the forcing data (13-24) (SMHI, FMI, GKSS)

Objective: To quantify uncertainties of forcing data stemming from statistical reconstructions (T1.1) and from the RCM simulations (T1.2 and 1.3)
Description of work: The forcing data will cover different periods, but all of them overlap in 1961-2004. For this period 6-hourly atmospheric data from a high-resolution RCM driven with ERA40 data at the lateral boundaries are available at SMHI. In this simulation a gustiness parameterisation was embedded into the RCM to improve commonly underestimated wind induced mixing in the ocean [32]. The forcing data from the statistical reconstruction (T1.1) and from the RCM simulations (T1.2 and 1.3) will be assessed against this benchmark and/or against observations. If large differences are observed, possible reasons will be investigated.
Deliverables: Quantification of forcing biases (24), analysis of causes of biases in reconstructed and simulated forcing fields (24)
Milestones and expected results: Improved understanding of climate variability in the BS region

WP2: Impact on BS nutrient cycles, autotrophs and zooplankton

Long-term hindcast simulations with the coupled biogeochemical-physical models are needed to validate simulated processes and the sensitivity to changing forcing. For the overlap period (1961-2004) biogeochemical variables and ecological indicators of water quality simulated with reanalyzed (**T2.1**) and reconstructed (**T2.2**) forcing will be compared. Transient simulations forced with various climate change and nutrient load scenarios will be performed with 3 models for 1960-2100 (**T2.3**). A probabilistic analysis of the multi-model ensemble simulations will be performed to quantify uncertainties (**T2.4**).

T2.1: Model validation of biogeochemical processes (1-9) (SMHI, BNI, IOW)

Objective: To run existing biogeochemical and carbon cycle models, validate and quantify model biases using high-quality data for the period 1961-2004
Description of work: A simplified carbon cycle sub-model developed within the PASTgo project (and already coupled to ERGOM) will be used in T2.3 and 3.2 to make a rough assessment of the future development of acidity and to study the impact on the food web, respectively. For the period 1961-2004 high-quality atmospheric and hydrological forcing

data and many observations are available to validate the models and to quantify model biases. Available initial conditions of nutrient concentrations in the water column and in the sediments will be assembled and shared. The latter task is crucial since the memory of the benthic system is quite long. Model simulations will be made with BALTSEM, ERGOM, RCO-SCOBI and joint comparisons with observations and inter comparison will be performed.
Deliverables: Unified high quality initial, forcing and validation data sets (6), model data sets (6), detailed assessment of model skills (9)
Milestones and expected results: Development of a simplified method to calculate BS acidification, quantification of model skills that provide error bars for the climate sensitivity assessment

T2.2: Validation of the long-term biogeochemical variability (7-24) (SMHI, BNI)

Objective: To investigate the predictive skills of the models and the quality of forcing data to reproduce long-term trends and decadal variability during 1850-2007
Description of work: This task is to test that the models manage to simulate the long-time scales associated with both the circulation of the BS and the biogeochemical cycles. This is the only way to test if the models accurately simulate the response to changes in nutrient loads. The models will be forced using data sets of reconstructed atmospheric and hydrological time-series established in T1.1. Validation data are relatively sparse, but there are a few long time series of hydrographical and hydrochemical data including Secchi depth measurements and a few sets of complementing data such as cod recruitment data. The amount and quality of both forcing and validation data is expected to be much lower than in T2.1. Thus quantitative skill assessment will be less precise. Cause-and-effect studies will delineate the impact of climate and nutrient load trends.
Deliverables: Model data sets (24), understanding and quantification of the models capability to simulate perturbations in climate and nutrient loads (24)
Milestones and expected results: Validated models for climate change and nutrient load scenarios

T2.3: Scenario simulations of biogeochemical cycles (7-30) (SMHI, BNI, IOW)

Objective: To perform a multi-model ensemble of transient simulations for 1960-2100 using 3 coupled physical-biogeochemical BS models
Description of work: Scenario simulations will be performed using BALTSEM, ERGOM and RCO-SCOBI driven with atmospheric (T1.2) and hydrological (T1.3) forcing. In this WP the 3 BS models have complementing roles. With the computationally cost effective BALTSEM many simulations assessing uncertainties will be carried out. With the more compute time consuming circulation models only selected long-term simulations (RCO-SCOBI) and time slices of 1960-2100 (ERGOM) will be carried out. For the analysis of the model results advanced statistical methods will be utilized. Horizontal transports between coastal areas and the open sea and integrated ecological quality indicators suggested by HELCOM will be calculated for selected boxes characterizing the BS ecosystem functioning.
Deliverables: Model data of first transient simulation with BALTSEM and RCO-SCOBI (18), model data of all transient simulations (24), analysis of simulated changes (maps, transports, integrated budgets) of biogeochemical variables and ecological quality indicators in future climate and with altered nutrient loads (30)
Milestones and expected results: Projections of BS biogeochemical parameters, quantification of the impact of nutrient load scenarios in future climate

T2.4: Quantification of uncertainties of projected biogeochemistry (13-36) (SMHI, BNI, TMBL, IOW)

Objective: To develop and perform a probabilistic analysis of the multi-model ensemble simulations 1960-2100
Description of work: Using the 3 biogeochemical models, BALTSEM, ERGOM and RCO-SCOBI, about 50 projections of future climate will be performed (per model 4 climate scenarios and 3 nutrient load reduction scenarios approximately). For the analysis of this huge amount of data we will apply a probabilistic approach to quantify uncertainties of biogeochemical variables including acidification. The analysis methods will be developed in close cooperation with end-users. Cause-and-effect studies will be performed to understand the role of various drivers of simulated changes. In addition, sensitivity studies of not well known model parameters will be carried out with BALTSEM and RCO-SCOBI. Within the uncertainty assessment we will also investigate the role of fish predation pressure on zooplankton and the acidification pressure on autotrophs and zooplankton in collaboration with T3.2. Using BALTSEM the required nutrient load reductions to the BS will be calculated in order to keep the BSAP targets in future climate (input to T4.4).
Deliverables: Uncertainty assessment of future projections (33)**,** cause-and-effect studies (36)**,** calculation of nutrient load reductions necessary to meet the BSAP targets (24), analysis of various time horizons, e.g. 2010-2030, 2050-2070 (33)
Milestones and expected results: Understanding of the predictability of biogeochemical parameters in future climate

WP3: Impact on the food web

WP3 will use different statistical models to investigate how key species and entire food webs have been influenced by past climatic variability and human impacts (eutrophication, exploitation) (**T3.1**), and how such biological responses will likely change in future (**T3.2**). In addition, the work will extend and incorporate existing knowledge of dynamics of some species (e. g., sprat, cod [20]) and processes (sprat and herring predation on zooplankton [29,21]) into the coupled physical-biogeochemical models (WP2). Due to the lack of data the assessment of the long-term variability 1850-2007 is limited and integrated into T3.1. Uncertainties of food web projections including lacking process descriptions like invasive species will be quantified in **T3.3**.

T3.1: Process validation of food web models (1-30) (BNI, TMBL, DTU, IOPAS)

Objective: To analyse the predictive skills of the EwE food web model, statistical and process-oriented fish models, and BEMs for key species in the BS during the high data quality period 1961-2004
Description of work: This task will explore different modelling approaches to assess how key species and entire food webs have been influenced by past climatic variability and human impacts (eutrophication, exploitation). We will use advanced process-driven models of key individual species where the knowledge base is more extensive (e. g., some zooplankton and fish species such as *Pseudocalanus* [33,34] and cod [35]) to assess the sensitivity of their life-histories and interactions to past and future climate change, eutrophication and fishing scenarios. We will use EwE mass balance models to assess trophic flows and species interactions in entire BS food webs in situations where detailed process knowledge of species biologies and life-histories is lacking [19].
Models will be used to investigate processes affecting populations, distributions and species interactions (e. g., frequencies of major inflows and extreme climatic events, changes in phenologies affecting predation and competition among species). Model outputs will be

evaluated against observed data to quantify model performance and uncertainty. Experimentally derived data delineating the effects of ≤ 0.4 pH decreases on plankton productivity and survivorship will be assessed in key species in the BS food web models. BEMs for key selected species will be calibrated based on historical spatial distributions of species and oceanographic conditions in this period.

Deliverables: Unified validation data sets (9), food web model and BEM simulation results 1961-2004 (24), detailed assessment of model skills (30), analysis of regime-shifts in the food web (30)

Milestones and expected results: Validated models for climate and nutrient load change scenarios; delineation of the impact of historically changing drivers on dynamics (life-histories, distributions and phenologies) of key species (e. g., cod)

T3.2: Scenario simulations of the food web (19-33) (BNI, TMBL, DTU, IOW, IOPAS)

Objective: Estimate development of key species and food web structure and functioning under various scenarios of future eutrophication, climate change and fisheries exploitation
Description of work: This task will use models to project how populations and food webs will respond to future scenarios of eutrophication, climate change and fisheries exploitation (both individually and in various combinations). Transient scenarios will be used to identify the dynamics of populations and to estimate probabilities when major population and ecosystem thresholds are reached (e. g., when might cod biomass fall below or rise above some specified level?; when and where can we expect significant increases in water column transparency?; when will temperatures rise high enough to allow particular warm-adapted species to reproduce successfully in the BS?; when and where will pH-induced changes in phenology occur?). The transient simulations will also reveal insight into dynamics of regime shifts and their food web and societal (see WP4) consequences, as well as the potential contribution/interference of fishing to solving eutrophication-related problems (e. g. top-down effects on water column transparency).
Deliverables: Food web and fish population model simulations for 1960-2100 (33), calculated envelopes for resilience of species in future climate (33), cause-and-effect studies of simulated changes and analysis of scenarios (33)
Milestones and expected results: To discover changes in the food web due to future climatic changes and address questions such as whether cod or blue mussels can survive in the future BS

T3.3: Quantification of uncertainty of future food web projections (25-36) (BNI, TMBL, DTU, IOW, IOPAS)

Objective: To assess uncertainty of future development of food webs and fish populations using ensemble simulations 1960-2100
Description of work: Climate, population and food web models all have their own uncertainties, yet few research groups have combined these models to estimate overall uncertainty of biological responses or how this uncertainty changes over time and with uncertainties in input forcings (e. g., choice of CO_2 or nutrient loading scenario). Consequently management decisions are based only on a limited fraction of total uncertainty and could lead to unexpected results and mitigation costs. We will overcome this difficulty by using a wide range of outputs from the various climate models (as derived from different model structures and different CO_2 loading scenarios; see WP1-2) as inputs to population and ecosystem models. Ensemble simulations of the ecological models will be conducted from which the probability of various biological responses can be estimated. This approach will quantify uncertainty in biological responses in probabilistic terms as functions of uncertainties in various model components and forcings.

Deliverable: Probabilistic uncertainty assessments of biological responses (e. g., populations, food web structure) to model structure and forcing scenarios (33)
Milestones and expected results: Estimates of future development of populations and food webs in response to future scenarios of eutrophication, climate change and exploitation

WP4: Impact on socioeconomic and regional development, case studies

Special focus will be given on three selected shallow areas to consider regional-specific variety emphasizing the role of costal ecosystems: 1) the Gulf of Finland where strong reduction of nutrient load is foreseen according to BSAP and where climate change scenarios may have strong impact on eutrophication (**T4.1**); 2) the Vistula Lagoon with a large catchments area and emphasis on transboundary issues (**T4.2**); 3) the Polish Economical Zone, which is a primary receiving area of nutrient loads from extensive agricultural regions and which has a perhaps major socioeconomic impact from climate change as Poland should meet the largest country-wise nutrient reduction requirements (**T4.3**). A time slice modeling approach will be used to obtain detailed spatio-temporal distributions of physical and biogeochemical parameters. The time slices are selected according to the results of WPs 1-3 when shifts in marine regimes are indicated in the transient climate change scenario simulations.
Climate change impact on selected issues of socioeconomy is assessed for the BS sub-basins as well as for the whole BS. Results from WPs 1-3 that cover driving forces, physical- and ecosystem indicators will be used together with projections of future developments of agricultural activities, urban areas, harbors, marine traffic, wind-farms, etc for an expert-knowledge-based estimate of socioeconomic scenarios (**T4.4**). Anthropogenic forcing and eutrophication of the BS interact in achieving sustainable economic development and good status of the BS water quality. For the latter, nutrient load reduction is the major concern. Therefore, costs of nutrient load reductions in changing climate will be calculated using the NEST model.

T4.1: Impacts on the Gulf of Finland (1-33) (MSI)

Objective: To provide a detailed assessment of the Gulf of Finland water quality for the coastal zone and open sea during the time periods of marine regime shifts in changing climate conditions
Description of work: A high spatial resolution coupled physical-biogeochemical model for the Gulf of Finland is forced with lateral boundary data from the basin-wide models (WP2). Selected time slices of present and future climates will be calculated. The model results will be analysed for spatial distribution of temperature, salinity, nutrient and phytoplankton in the Gulf of Finland. The transient character of the fields will be separately analysed for the coastal zone and offshore area. The retention of the nutrients in the coastal zone is estimated and nutrient fluxes between coastal and offshore areas will be calculated. Based on the direct output fields from physical-biogeochemical model water quality indicators like Secchi depth, spatial coverage of benthic macroalgae and benthic fauna along with spawning areas for BS herring are estimated.

Deliverables: Model simulations of present and future climates (30), uncertainty estimates of the Gulf of Finland model output fields (33), distribution maps of water quality indicators in the coastal zone and open Gulf of Finland (33), recommendations for future country-wise actions on achieving and preserving good water quality of the Gulf of Finland and management its marine resources (33)

Milestones and expected results: Expert estimation of the changes of the eutrophication, biodiversity and the potential management of marine resources according to changes in antropogenic forcing and climate; suggestions for actions in the Gulf of Finland targeted at preserving good water quality and socioeconomic development in long term perspective

T4.2: Impacts on Vistula Lagoon (1-33) (ABIORAS)

Objective: To assess the impact of climate change on the ecosystem in a coastal lagoon and on the socioeconomic local development

Description of work: The coastal ecosystem of the Vistula Lagoon is marine dominated with a large catchment area shared by Poland and Kaliningrad Oblast of Russia. Hydrological and biogeochemical cycles in present and future climates will be investigated. Especially, the transformation of land originated nutrient loads and the impact of offshore lateral boundary conditions on the biogeochemical cycles in the lagoon will be studied. An indicator analysis of sustainable development of coastal municipalities and a socioeconomic impact assessment will be performed, with Vistula Lagoon as an example on the sub-regional level and with selected coastal municipalities in the Kaliningrad Oblast as local examples.

Deliverables: Model data sets of hydrography and water quality indicators in Vistula Lagoon (30), uncertainty estimates (33), socioeconomic impact assessment (33)

Milestones and expected results: Short- and long-term integrated coastal zone and watershed management strategies for sustainable use and conservation in the lagoon environment

T4.3: Impacts on the Polish Economical Zone (1-33) (IOPAS)

Objective: To assess the impact of climate change on the marine ecology and to valuate changes of the ecosystem goods and services in the Polish Economical Zone

Description of work: Historical data from the Polish Economical Zone (with focus on Puck Bay) will be collated and analyzed. The assessment comprises habitat changes of seagrasses (e.g. Fucus beds) and sandy beaches, changes of the macro- and microflora, changes of meteorological parameters (temperature, salinity, storminess, sea level), and estimates of losses and degradation. From this assessment the degree of historical changes will be defined. Taking the physical-biogeochemical model results (WP2) into account possible future scenarios will be estimated. Biological valuation maps will be compiled that summarize all available biological and ecological information for the study area. The economic assessment of ecosystem goods and services of key ecosystem/habitats on the Polish Economical Zone can be used as baseline maps for future spatial planning at sea [24,25]. Within T4.4 the results of the Polish Economic Zone valuation will be scaled up for the BS region.

Deliverables: 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 (33)

Milestones and expected results: Management strategies for sustainable use and conservation in the marine environment of the Polish Economical Zone

T4.4: BS-scale socioeconomic impacts (1-36) (BNI, ABIORAS, IOPAS, CSPR)

Objectives: To assess the impact of climate change on the BS-scale

Description of work: This task analyses what impacts large-scale socioeconomic drivers of change may have for both the BS region and the economic sectors and activities that currently uses the BS. We will chart the implications of different global and regional socioeconomic and climate scenarios (e.g. [26,27]). In close cooperation with T4.1-4.3 we will discuss how these impacts inflict on the results obtained and we will explore what the scenario storylines – such as varying preferences for environmental sustainability and economic growth and different assumptions on technologic innovation – might imply for sustainable use of the BS. We will also do a policy analysis of problem description, goals, recommendations for action,

existing and proposed national and EU policies and relevant multilateral agreements, e.g. HELCOM. The result of the policy analysis and socioeconomic charting will be compared with implications of the scenarios and conditions for reaching the political objectives.
T4.4 will also quantitatively analyze results on the present costs of necessary nutrient load reductions for different climatic and socioeconomic futures. The country allocation schemes applied in the BSAP, developed by BNI, will be used to calculate the potential extra cost to achieve the targets set in the BSAP. If the simulated future scenarios show a decrease in the water quality, the required extra cost to reduce the nutrient load to the BS will be assigned as the impact of climate change. Since climate scenarios build upon the development of society, the results of T4.4 will also feed back to the modeling tasks of ECOSUPPORT (T2.4).

Deliverables: Stakeholder report about cost estimates of potentially required nutrient reductions to compensate for climate-induced changes in the water quality and socioeconomic impact assessment (36)

Milestones and expected results: Better understanding of the interaction between changing climate and society in the BS region

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

WP5 comprises co-ordination and data management (**T5.1**), the design of the DSS (**T5.2**), and dissemination (**T5.3**).

T5.1: Co-ordination and data management (1-36)

Objective: To coordinate the project scientifically and economically and to manage the flow of observed and simulated data between the project partners

Description of work: Details of the management structure of the project are given in section 7. For research purposes an international meta database including the scenario simulations performed within ECOSUPPRT will be set up at the ECOSUPPORT webpage with links to the Baltic Environmental Database (BED) at BNI, the Live Access Server of the IOW, and data bases at GKSS and SMHI (Rossby Centre).

Deliverables: Technical reports (mid-term and final) and meeting minutes, organisation of annual GA meetings and 3-monthly SSG telephone and internet-based conference calls, set up of the ECOSUPPORT webpage for internal and external information and data exchange (3), maintenance of the webpage (36)

Milestones and expected results: International and inter-disciplinary collaboration between 11 partners from 7 BS countries**,** basis for future networks

T5.2: Decision Support System (DSS) (1-36)

Objective: To provide stakeholders and policy makers with a tool providing them with relevant and easy accessible information to promote EAM

Description of work: On the public site of the project webpage the DSS will be published compiling all information with relevance to stakeholders. The DSS comprises analysis results of the multi-model ensemble simulations combining climate change and nutrient load reduction scenarios. To identify and quantify the impact of nutrient load reductions on the eutrophication status in future climate we will use the ecological quality indicators suggested by HELCOM: winter surface nutrient concentrations, summer average Secchi depths, chlorophyll-*a* concentrations, and extension and duration of hypoxic areas. In addition we will also quantify changes of extension and duration of anoxic areas, extension of areas covered with cyanobacteria, cyanobacteria concentrations, plankton biomass, primary production, nitrogen fixation, denitrification, and permanent burial of phosphorus and sediment concentrations. During the whole project duration stakeholders will be involved in the design of the DSS.

Deliverables: Public available web based DSS (36)

Milestones and expected results: Information of stakeholders about the impact of climate change, mitigation strategies

T5.3: Dissemination and outreach activities (1-36)

Objective: To provide the scientific community and the interested public with state-of-the-art information on the impact of climate change on the BS ecosystem in general and on measures against eutrophication in changing climate in special

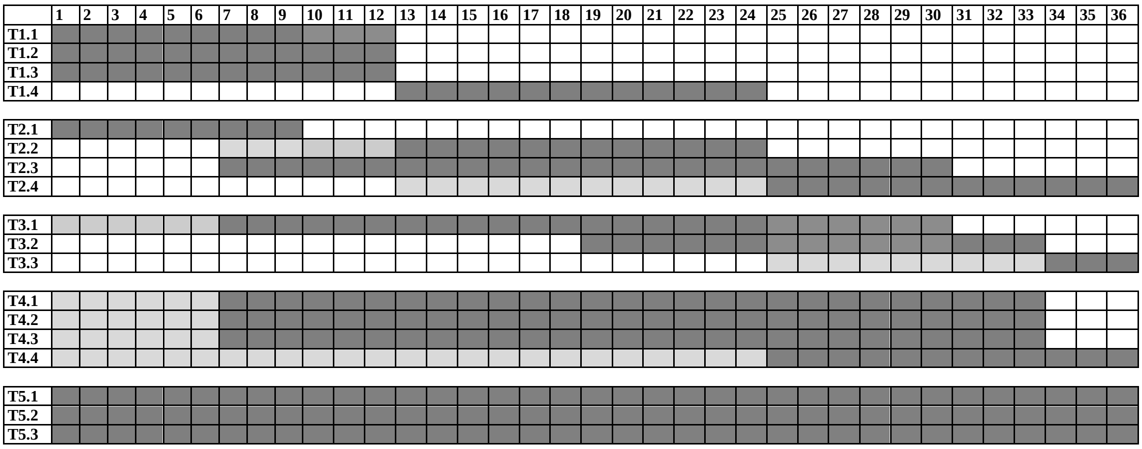
Description of work: Details are given in section 6.

Deliverables: International stakeholder seminars (annually), one international stakeholder conference at the end of the project duration addressing end-users and scientists (36), participation at scientific and stakeholder conferences (e.g. BALTEX, BSSC, ICES, Global Change, HELCOM), publication of project results in scientific journals, news papers, reports, posters, flyers and on the internet, video animations of model simulations

Milestones and expected results: wider public awareness of the impact of climate change

12 Gantt chart or similar to show the timing of different Work packages and Tasks

The timing of deliverables is outlined in section 11. In the Gantt chart light grey periods indicate preparatory phases to collect data or to calibrate models (e.g. when some forcing data are still missing).



13 Plan of submitting project data to some common database

ECOSUPPORT will produce a range of output that will be of interest to other researchers and non-academic users, even after the end of the project. An updated list of checked and documented data will be prepared by the project. The availability of data from ECOSUPPORT will be listed on relevant directories of data bases on the Internet including the **BALTEX data management web page** (www.baltex-research.eu/data) as well as in meta databases that are built up in connection with BALTEX and other programs including possible initiatives on data management emerging from future calls in BONUS. The responsibility for providing data will remain with the individual research groups producing data in ECOSUPPORT, but the possibility of enhancing the availability of large sets of model output using existing infrastructures for holding climate and environmental modeling data in the BS region will be investigated during the project period. The aim in the near future is to use the scenario data also in the **NEST DSS**.

14 Ethical issues

We have not identified any ethical issues in ECOSUPPORT.

15 Reference list

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