2010 annual report

Baltic-C

Building predictive capability regarding the Baltic Sea organic/inorganic carbon and oxygen system

Contract Number: Swedish Environmental Protection Agency 08/368
January 2011
Period covering 1 January 2010 to 31 December 2010

Co-ordinator:
Prof. Anders Omstedt
University of Gothenburg
Department of Earth Sciences
Sweden
Tel. +46317862881
Email: Anders.Omstedt@gvc.gu.se

General information

1.1 Objectives:
The overall objective of Baltic-C is to develop and apply a new integrated ecosystem model framework based on the cycling of organic carbon (C_{org}) and carbon dioxide (CO_2) in the Baltic Sea water and drainage basin, taking into account fluxes across the atmosphere and sediment interfaces; the aim is to provide a tool with which to support the management of the Baltic Sea. The program will run three years starting from January 2009. The program is now ready with its second year and some major results and challenges from the second program year will be presented in this report, which refers to the 13 to 24 months period of the Baltic-C project.

1.2 Scientific achievements:
Baltic-C has finished a successful second year (http://www.baltex-research.eu/baltic-c/). Two scientific meetings have been organized during 2010 with the first as a short administrative meeting during the BALTEX conference and a second oriented towards marine observations, modeling and scenarios.

Several research cruises for the determination of the total CO_2, C_T, and total alkalinity, A_T, have been performed in 2008, 2009 and 2010. The investigations covered all major sub-basins of the Baltic Sea between the Kattegat and the Bothnian Bay. The data together with surface water pCO_2 and O_2 measurements from VOS "FINNMAID" forms a unique base for research and model validation data. River input data of river flow, alkalinity, total inorganic carbon, total organic carbon, pH, temperature, Na^+, K^+, Ca^{2+}, Mg^{2+}, Cl^-, SO_4^{2-} have been collected into a database and form the base for model development/validation. However, the data are in many instances incomplete, especially for river monitoring data from Russia in spite of several approaches to Russian authorities at different organizational levels. Several sediment cores have been taken and analyzed. Large efforts have also been taken to collect and analyze meteorological forcing data for present and possible future developments. The develop and preparing models for the Baltic Sea drainage basin and the Baltic Sea itself that includes the CO_2 dynamics are now in progress.

The Baltic-C model system involves two land surface models (LPJ-GUESS, CSIM) and one Baltic Sea model (PROBE-Baltic). Meteorological forcing data and scenarios have been extracted from available sources. The terrestrial vegetation/biogeochemistry model LPJ-GUESS has been enhanced by incorporation of a sub model for C_{org} production in organic wetland soils. The model has been set up for application across the 50 x 50 km simulation grid on which climate atmospheric data are used. The Baltic Sea catchment model CSIM is expanded by including base cat ions, anions, C_{org} and C_T (taking into account the outputs from LPJ-GUESS) and calculates now parameters such as: river runoff, nutrient load, total alkalinity, pH and pCO_2 to the Baltic Sea sub-basins. The Baltic Sea model PROBE-Baltic has been expanded by including the CO_2 dynamics and the present and past conditions have been studied extensively.

Climate scenario data have been extracted for the Baltic Sea drainage basin as well as for the Baltic Sea basins for a period representing the climate change between 1960 and 2100. Data from several emission scenarios (A1B, A2 and B1) as well as three global climate models (ECHAM 5, HadCM3 and CCSM3) are derived to be used to force the different model components within the Baltic-C.

Several contacts between the different participants have been taken to develop the program. Outside the program members of the Baltic-C plays a major role in the Baltic Sea research by contributing in several activities such as: organizing the BALTEX 2010 conference (Janusz Pemkowiak, Anders Omstedt, Bernd Schneider), and working in the planning of the Baltic Sea Science Congress 2011 (Janusz Pemkowiak, Anna Rutgersson, Anders Omstedt, Bernd Schneider). Assessment work is developed within the BACC II initiative (BALTEX Assessment of Climate Change, Anders Omstedt, Anna Rutgersson, Christoph Humborg, Bernd Schneider, Benjamin Smith). The program has also during 2010 developed a close cooperation with Swedish Institute for the Marine Environment by addressing how models and monitoring programs could interact.

1.3 Conclusions:
Comparison with the original research and financial plan:
We are following the original research and financial plan.

Statement if the research plan and schedule of deliverables had to be adapted:
No adaptation necessary.

Do results of third parties will have influence on the working program?
Not expected.

Are there any changes in the future working plan expected?
No changes are expected.

Are there any changes expected for the deliverables?
No changes are expected.

Detailed descriptions by Working Package

2.1 Work Package 1 – Management and Dissemination
Lead Partner: Anders Omstedt, University of Gothenburg
Researchers involved in the current work:
Anders Omstedt and David Rayner

2.1.1 Objective
To implement the effective programme management, synthesis, assessment, and dissemination of the results of Baltic-C.

2.1.2 Methodology and scientific achievements
Task 1.1; Programme management.
Baltic-C has finished a successful second year and the programme managements have been run by Prof. Anders Omstedt and Dr. David Rayner. The program started up in January 2009 and a webpage was created through the BALTEX secretariat (http://www.baltex-research.eu/baltic-c/) were the development of the program can be followed, see also Omstedt (2010) below. Baltic-C data will be described in metadata forms and available on the homepage. Three pH D students dedicated to Baltic-C are in line with the program. Erik Gustafsson defended his PhD 1 October 2010. The design of scenarios has now been given and several different runs are planned for the coming months.

Task 1.2: Workshop and estimated environmental economic aspect.

Initiatives have been taken to have a joint BONUS meeting together with HELCOM and other end users. The coordinator has offered the possibility to host this conference within the university of Gothenburg facilities.

Task 1.3: Synthesis and assessment of Baltic Sea CO_2 system.
The program coordinator has within the BACC II program made it possible to include the assessment of the Baltic Sea CO_2 system. Prof. Bern Schneider, associate prof. Anna Rutgersson, prof. Christoph Humborg are now lead authors covering different part of the BACC II assessment. The lead author kick off meeting was organized by the coordinator together with prof. Hans von Storch and the BALTEX secr. in November, 2010.

Task 1.4: Dissemination.
Several Baltic-C results were presented during the BALTEX 2010 conference. The program has been described in BONUS in Brief November issue. Baltic-C members (Anders Omstedt and Bernd Schneider) have supported HELCOM (Backer (ed), 2010) in summarizing knowledge about acidification and flux of CO_2.

Publications:

Backer, Hermanni (ed). 2010. Outlook Report on the State of the Marine Biodiversity in the Baltic Sea region. UNEP. 35 pages.

Gustafsson, E., (2010). The Baltic Sea Marine System: Human impact and natural variations. Doctoral Thesis A133. Dep. of Earth Sciences, University of Gothenburg.

Omstedt, A., (2010). Baltic-C: Building predictive capability regarding the Baltic Sea organic/inorganic carbon and oxygen system. BONUS in Brief November 2010, page 7.

2.2 Work Package 2 – Measuring the Baltic Sea CO_2 system and carbon inventories (Bernd Schneider, Baltic Sea Research Institute, Germany; participant code 2).
Lead Partner: Bernd Schneider, Baltic Sea Research Institute (IOW), Germany
Researchers involved in the current work:
Dr. Anne Loeffler

2.2.1 Objective
To provide validation data for the biogeochemical modeling of the Baltic Sea carbon cycle and to derive process parameterizations for biomass production and organic matter mineralization.

2.2.2 Methodology and scientific achievements
The contributions to Baltic-C are based on a comprehensive measurement program. Records of the surface water pCO_2 and O_2 are performed with a fully automated measurement system on a cargo ship. Additionally, research cruises are performed in order to characterize the regional and vertical distribution of the variables of the marine CO_2 system. The data are used to characterize the present state of the CO_2 system, to estimate biogeochemical transformation rates and to validate biogeochemical model simulations.

Task 2.1: Recording surface water pCO_2 and O_2 using a fully automated measurement system deployed on VOS "FINNMAID".

The surface water pCO_2 and O_2 measurements on VOS "FINNMAID" (Helsinki – Gdynia – Rostock – Lübeck) were continued during 2010 yielding 3 - 4 pCO_2 and O_2 data sets each week. The data were used to estimate the annual CO_2 air/sea balances for the central Baltic, the western Gulf of Finland and the Arkona Sea. On an average (2004, 2005, 2008, 2009) these three regions acted as a distinct sink for atmospheric CO_2 (Deliverables D6 and D8).

Task 2.2: Determining the organic/inorganic carbon and oxygen pools in different Baltic Sea sub-regions.
A two-week Baltic-C research cruise was performed during June/July 2010. Water samples were taken at about 60 stations in the major basins of the Baltic Sea except the Kattegat and the Gulf of Finland. Chemical analysis was performed for total CO_2, alkalinity, O_2/H_2S and nutrients. The surface water CO_2 partial pressure was recorded continuously during the entire cruise. Additionally, sediment samples were taken by our partners from the IOPAN (Work Package 4) for the characterization of the carbon exchange between the sediments and the water column.

Task 2.3: Compiling and evaluating CO_2/carbon data collected by previous research and monitoring programmes.
A comprehensive data set for total CO_2, CO_2 partial pressure and pH measured in the northern Baltic Sea during 1927 – 1938 (Dissertation by Kurt Buch) was evaluated. Although the analysis of these historic data is not yet finalized, it is obvious that the data will give important information about changes in the trophic state and the external forcing of the marine CO_2 system in the Baltic Sea since the beginning of the last century.

Publication:
Schneider, B., Nausch, G. and Pohl, C., 2010. Mineralization of organic matter and nitrogen transformations in the Gotland Sea deep water. Mar. Chem., 119, 153 – 161.

2.3 Work Package 3 – Inventory of river runoff data

Lead Partner: Matti Perttilä, Finnish Meteorological Institute , Finland.
Researchers involved in the current work:
Laura Joensuu

2.3.1 Objective

Combining existing and new data to provide a reliable dataset of parameters for the river input evaluations of the carbon components and for validating the river runoff models.

2.3.2 Methodology and scientific achievements

Task 3.1: Evaluating the river input concentrations from existing monitoring and research data.
Input concentrations were collected for the following parameters: river flow, alkalinity, total inorganic carbon, total organic carbon, pH, temperature, Na^+, K^+, Ca^{2+}, Mg^{2+}, Cl^-, SO_4^{2-}. Data was collected at one month resolution for the years 1990 – 2008. Appropriate data for Finnish and Swedish rivers was obtained from the HELCOM data system (www.ymparisto.fi). The HELCOM monitoring system for river input is designed for eutrophication and pollution monitoring, not for studying the effects of the climate change. Of the above parameters, only TOC (total organic carbon) is included (as a voluntary parameter). Thus there was very little other data in the HELCOM data files, except from Finland and Sweden. Data for other rivers was obtained either through personal contacts or with the help of national information

centers. The sources are listed in the readme file with the data compilation. For most river inputs, the available data is incomplete with respect to the aim (years 1990 – 2008 at monthly resolution), but can nevertheless be used for modelling the changes (see WP 7). The only major river for which data was not obtained is the Neva, in spite of several approaches to Russian authorities at different organizational levels. Because of the importance of Neva, the lack of data cannot probably be ignored, and thus for this river, other means of evaluation will be attempted. The data compilation is available at ftp://ftp.fmi.fi (deliverable 12) as an Access file.

Task 3.2: Evaluating river concentrations from marine data.
The work to complete the monitoring data is proceeding. Two approaches will be used. Both of them, the extrapolation of marine data to zero salinity, and a box-model approach, will, however, yield input approximations as annual averages.

Task 3.3: Measuring input concentrations.
Input concentrations of the major Finnish and Swedish rivers running into the Gulf of Bothnia have been measured once, in order to obtain a comparison check of the sampling/analysis methodology. Possibility of creating a temporary monitoring system for the Neva River is under consideration.

2.4 Work Package 4 – Mineralization of organic material, deep water–sediment interaction

Lead Partner: Janusz Pempkowiak, Institute of Oceanology, Polish Academy of Sciences, Poland
Researchers involved in the current work:
Ph D student Anna Maciejewska, Ph D student Aleksandra Szczepańska, Dr Karol Kuliński.

2.4.1 Objective

The work package aims to: 1. Quantify organic matter remineralization rates based on organic matter concentration profiles and labile vs. resistant fractions of organic matter in bottom sediments; 2. Quantify the organic matter remineralization rates at the sediment–water interface based on CO_2 concentration time series in the above-bottom water layers; 3. quantify the carbon species (both organic and inorganic) fluxes across the sediment–water interface; and 4. Quantify the carbon burial in bottom sediments as the proportion of carbon originally deposited in sediments.

2.4.2 Methodology and scientific achievements

Task 4.1: Establishing remineralization rate constants for organic matter based on existing data (Regarding D16).

Mineralization rates at the sediment water interface and in the deep water

Surface sediment samples were collected at various locations of the Baltic (28 sediment samples). The following properties of the sediment samples were measured: Corg, DOC, DIC, 210Pb, 137Cs, moisture, loss on ignition, porosity, pCO2, pH, Alktot. Basing on the DOC dynamics on storage mineralization rates we calculated. These ranged from 1.7 $gm^{-2}y^{-1}$ to 2.2 $gm^{-2}y^{-1}$. Larger rates were found in sediments collected from more shallow oxic areas of the Baltic bottom.

Task 4.2: Collecting new experimental data to improve and extend the rates provided in task 4.1 (Regarding D18).

Collected sediment cores analysed
Sediment cores collected in 2009 at the following locations**:** Arkona Deep, Gotland Deep, Bornholm Deep, Gdansk Deep, Gulf of Bothnia, southern coast of the Baltic Sea, were cut into slices 10mm thick. The so obtained samples (243 sediment samples) were analyzed for the following properties: Corg, DOC, DIC, ^{210}Pb, ^{137}Cs, moisture, loss on ignition, porosity, pCO2, pH, Alktot. The Meta data base information's are available on Baltic-C homepage.

*Task 4.3: Establishing loads of carbon species passing across the sediment–water interface over the entire Baltic (*Regarding D19)
Mineralization rates established for a range of environmental condition
Basing on the DIC and DOC profiles in the interstitial water samples obtained from moist sediment samples (see D18),and the ageof the samples derived from ^{210}Pb profiles mineralization rates of organic matter in the sediments column were calculated. These ranged from 2.4 to 5.7 $gm^{-2}y^{-1}$. Larger rated were found in the dipper, anoxic, bottom sediments. The feature is tentatively attributed to faster sedimentation rates, and higher organic matter content in such sediments.

Task 4.4: Determining remineralization rate constants at the sediment surface and in the water column, based on CO_2 concentrations in Gotland Sea deep water (Regarding D20)
Loads of carbon deposited to sediments and return flux of carbon from sediments for the entire Baltic Sea established
Basing on sediment properties derived from the analyzed sediment samples (see D18, D16), and sediment deposition rates derived from210Pband 137Cs profiles it is established that the load of organic matter deposited to sediments in the entire Baltic is $0.37x10^8$mol (+/- 0.05 $x10^8$mol). Of the deposited carbon load 31% is mineralized and returned in the overlaying water as DIC. At the same time 2.9% of the deposited carbon is returned to water as DOC.

2.5 Work Package 5 – Atmospheric forcing (air–sea interaction, scenarios)
Lead Partner: Anna Rutgersson, Uppsala University, Sweden
Researchers involved in the current work:
Dr. Björn Carlsson, PhD Student Maria Norman, Master Student Ida Sjöström

2.5.1 Objective
To provide acid deposition data and scenario data for the biogeochemical modeling of the Baltic Sea carbon cycle and to improve the parameterizations of the air–sea exchange of CO_2.

2.5.2 Methodology and scientific achievements
The first milestone of the project (M1) is reached and integrated data for past, present and future model runs is available. Scientific achievements includes that the lead Partner (Anna Rutgersson) is one of the lead authors of the BACCII book focusing the climate of the Baltic Sea region. BACC II is the new version of the BACC book, the work was started during 2010.

Task 5.1: Air–sea interaction.
Using direct flux measurements from the Östergarnsholm field station a new process was identified altering traditional descriptions of air-sea exchange of CO2 (and other gases). For a deep mixed layer and convection in the water (generated by cooling at the water surface) the transfer velocity was shown to be significantly enhanced (Rutgersson and Smedman, 2010). This enhancement can be introduced in algorithms used to calculate air-sea exchange using the concept of resistors (parallel reasoning to an electric circuit). The water-side convection is

then expresses relating the characteristic velocity of the buoyancy of the direct flux measurements as well as additional measurements have been taken at the Östergarnsholm site during the project. Method development of the eddy-covariance method gave an alternative method to directly estimate fluxes also using ship data (Norman et al. 2010surface water to the friction velocity (representing the mechanically generated turbulence in the water) as is suggested in Rutgersson et al (2010). This will change total calculated air-sea gas transfer as well as the distribution in time and space.

Task 5.2: Acid deposition.
A data base for the acid deposition to the different Baltic Sea basins as well as to the Baltic Sea drainage basin was during 2009 generated for the period 1960 to 2006. Some corrections/updates were done during 2010 together with a more detailed description of the data base. The acid deposition is taken from the EMEP chemical transport model (for 1990 to 2006) (http://www.emep.int/OpenSource/index.html). For the years 1960–1989, the trends in emissions were scaled by the yearly mean in 1990 and multiplied by the mean seasonal variation of the depositions. The emissions were taken from the gridded (1°x1°) EDGAR-HYDE data set (http://www.mnp.nl/edgar/model/). It contains global anthropogenic emissions of NO_x, SO_2, NH_3 among others species which are spatially modeled. Also a data base for deposition of minerals (base cat ions and chloride ions) is generated over the drainage basin. Data base of acid deposition, mineral deposition as well as CO2 concentration (derived according to Rutgersson et al., 2009) is reported as Deliverable 26 (D26) to the BONUS system and in Carlsson et al (2010).

Task 5.3: Climate scenarios and land-use data.
Global Climate scenarios regionally downscaled by the regional climate model RCA is available from the Swedish meteorological and Hydrological Institute through the EU projects PRUDENCE and ENSEMBLES. Climate scenario data is here extracted for the Baltic Sea drainage basin as well as for the Baltic Sea basins for a period representing the climate change between 1960 and 2100. Data from several emission scenarios (A1B, A2 and B1) as well as several global climate models (ECHAM 5, HadCM3 and CCSM3) is derived to be used to force the different model components within the Baltic-C. The data base of atmospheric forcing during past present and future climate in the Baltic Sea region is reported as Deliverable 27 (D27) in the project. The data from the GCM:s was by Carlsson et al (2010) and Sjöström et al (2010) shown to well represent some features of present day climate, some major biases of the parameters from the GCM:s were, however, identified. The scenarios of the Baltic-C project will be derived using both the output from the GCM:s directly as well as using the “delta-change methodology”.

References:
Carlsson, B, T. Wällstedt, A. Rutgersson, and A. Omstedt, 2010. Depositions of acidifying and neutralising compounds over the Baltic Sea drainage basin between 1960 and 2006. In manuscript.

Carlsson B., Rutgersson, A. and Omstedt A. 2010. Analysis of dynamically downscaled climate simulations over the Baltic Sea drainage basin. Presented at the ECOSUPPORT workshop on Uncertainties of scenario simulations, Norrköping, October 2010.

Norman, M., Rutgersson, A., Sørensen, L.L and Sahlée, E., 2010. Estimating fluxes of CO_2 from high frequency measurements using different techniques. Submitted.

Rutgersson, A., M. Norman and G. Åström: Atmospheric CO_2 variation over the Baltic Sea and the impact on air-sea exchange. *Bor. Env Res.*,14, 238–249. 2009

Rutgersson A. and Smedman, A. Enhancement of CO2 transfer velocity due to water-side convection, *J. Marine Syst*., 80, 125-134, 2010.

Rutgersson A., A. Smedman and E. Sahlee, 2010: Oceanic convective mixing and the impact on air-sea gas transfer velocity, *In press Geophys. Res Lett*.

Sjöström, I. 2010. Future wind climate in the Baltic Sea region. Master thesis at the Department of Earth Sciences, Uppsala University, Sweden.

2.6 Work Package 6 – Modelling the organic matter input from terrestrial vegetation and soils

Lead Partner: Benjamin Smith, Lund University, Sweden
Researchers involved in the current work:
LU: Ben Smith, Peter Frodin, Guy Schurgers
External collaborator (not funded by Baltic-C): Alla Yurova, Institution for Numerical Mathematics, University of Moscow.

2.6.1 Objective

The work package will develop and validate the modelling of the organic matter input from terrestrial vegetation and soils and explore the coupling to the river runoff carbon model.

2.6.2 Methodology and scientific achievements

Task 6.1: Terrestrial carbon model setup, validation, and coupling to the river runoff carbon model (WP7).

In work beginning during 2009, the terrestrial vegetation/biogeochemistry model LPJ-GUESS has been enhanced by incorporation of a sub-model for DOC production and sorption dynamics in organic wetland soils based on the model of Yurova et al. 2008. The model has been set up for application across the 50 x 50 km simulation grid on which climate driver data from WP5 are provided. Wetland area fractions provided by WP7 are used to scale the model-generated DOC concentrations to the grid cell scale. For coupling to the river runoff model of CSIM, monthly grid cell averages of DOC production are provided as forcing fields for the CSIM model (WP7).

Model evaluation of DOC fluxes still needs to be performed. This will be based on observations of river DOC discharge, and is dependent on completion of the coupling between LPJ-GUESS (providing grid-level DOC fluxes) and CSIM that accounts for transport to the river mouths.

Work is still underway implementing a modified parameterization of the DOC sub-model applicable to forest soils. DOC fluxes from forest soils are presumably very minor compared to wetlands, but because of the extensive forest coverage over the northern part of the Baltic Sea drainage basin, to total contribution of forest areas to DOC loads to the Baltic may be significant.

Modelling of DOC fluxes from agricultural soils is a much more complex issue because of the complex influence of management on biogeochemistry and hydrology. We therefore intend to use an empirical approach to estimate total DOC loads from agricultural areas of the south.

Task 6.2: Modelling present and past changes in vegetation structure and functioning and in dissolved organic carbon export.

The wetland DOC model, including dynamic vegetation, has been applied under the recent historical climate (ERA40 climate forcing), simulating increasing trends in DOC production over central and southern Finland, Sweden and the Baltic States and decreases in the north, over the last 30 years. These patterns are generally consistent with the trends a north-to-south transect of river discharges and may be attributed to an increase in rainfall over areas showing a positive DOC trend, increased precipitation being associated with increased flushing of organic soils. However, DOC concentrations in runoff simulated by the model, do not show the same trends, the enhanced precipitation causing enhanced runoff and thereby a dilution of the produced DOC. Results were presented by Guy Schurgers at the 6th Study Conference on BALTEX in Miedzyzdroje, Poland, in June 2010. Results have been provided to WP7 for use in forcing the CSIM model.

Task 6.3: Modelling possible future changes in vegetation structure and functioning and in dissolved organic carbon export

Scenarios of possible future changes in greenhouse forcing, climate and human land use are needed to provide a basis for the analysis of interactions and feedbacks in the Baltic Sea CO_2/O_2 system accounting for land-sea biogeochemical coupling. It was previously decided to adopt a selection of the IPCC-SRES narratives, and climate model simulations based on these, as the basic scenario framework of Baltic-C. A refined suite of 15 scenarios (Table) encompassing uncertainty in the true nature of the global climate system (represented by three different GCMs), natural climate variability (represented by three ensemble members for the ECHAM5 GCM) and the future coarse of socio-economic development (represented by three GHG emissions scenarios) was decided upon at the Baltic-C Annual Workshop near Lund in November 2010. Scenarios of land use change consistent with the underlying socio-economic assumptions of the SRES-based GCM scenarios were chosen from the EU project ALARM. The main criteria for the choice of scenarios to explore are that they cover the scope of possible future changes in a comprehensive way, maintaining realistic relationships between different driving variables, and accommodating major aspects of uncertainty. It is not realistic or intended to provide predictions or projections of any "accuracy".

	GCM	*SRES narrative*	*Ensemble member*	*Land cover*	*Nutrient loads*	*GCM bias correction*	**Factor addressed**
1	ECHAM	A1B	#1	present-day	present-day	none	(baseline scenario)
2	ECHAM	A1B	#2	present-day	present-day	none	natural variability
3	ECHAM	A1B	#3	present-day	present-day	none	natural variability
4	HadCM	A1B		present-day	present-day	none	climate system
5	CCSM	A1B		present-day	present-day	none	climate system
6	ECHAM	A2		present-day	present-day	none	emissions (higher)
7	ECHAM	B1		present-day	present-day	none	emissions (lower)
8	ECHAM	A1B	#1	GRAS	present-day	none	land cover change

9	ECHAM	A1B	#1	present-day	"medium"	none	nutrient loads change
10	ECHAM	A2		BAMBU	"business as usual"	none	multi-factor, "business as usual"
11	ECHAM	A1B	#1	GRAS	"medium"	none	multi-factor, "balanced policy"
12	ECHAM	B1		SEDG	Baltic Sea action plan	none	multi-factor, "environmental"
13	ECHAM	A2		BAMBU	"business as usual"	yes	bias-corrected version of Scenario 10
14	ECHAM	A1B	#1	GRAS	"medium"	yes	bias-corrected version of Scenario 11
15	ECHAM	B1		SEDG	Baltic Sea action plan	yes	bias-corrected version of Scenario 12

Future climate simulations for wetlands have been performed for scenarios 1-7 and 9 and delivered to WP7. For the land use change scenarios, overlaying the relevant ALARM land cover scenario is still underway, but runs are expected to be completed before the end of 2010.

Reference:

Yurova, A., Sirin, A., Buffam, I., Bishop, K. & Laudon, H. 2008. Modelling the dissolved organic carbon output from a boreal mire using the convection-dispersion equation: Importance of representing sorption. Water Resources Research 44, W08411.

2.7 Work Package 7 – Modelling the input AT, CT, Ca, and Corg from all rivers to the Baltic Sea

Lead Partner: Christoph Humborg, Stockholm University, Sweden
Researchers involved in the current work:
Magnus Mörth, Christoph Humborg, Teresia Wällstedt and Erik Smedberg

2.7.1 Objective

The work package will model the river inflow of dissolved inorganic and organic carbon species, Ca, N and P from 83 major watersheds forming the Baltic Sea catchments. Further scenario analyses on impacts of climate change and changes in land usage patterns on AT, CT, Ca, and Corg , N and P land-sea fluxes from the Baltic Sea catchments are performed.

2.7.2 Methodology and scientific achievements

Task 7.3: Scenario analyses of AT, CT, Ca and Corg inputs as a function of land cover change and changes in river discharge as an effect of regional climate change.
Much work has been dedicated to filling the gaps in the dataset for calibration and validation. The datasets for Odra, Vistula and Neva have been complemented with data from the Gems database (http://www.gemstat.org/). Much data for calibration and validation data is still

missing, especially for Estonian and Latvian rivers. These gaps have been filled by applying different multivariate correlation functions.
The scenario runs need input data from WP 6, especially data on DOC from forests and agricultural areas as well as data on land-cover change. We have not received these data yet. However, the model has been calibrated and validated for hydrology, SBC, SAA, DOC and DIC for present day conditions and as soon as the scenario input data are delivered, work can be initiated to find retention factors for DOC. Thereafter we can do the scenario runs that we foresee will take about one month work.

Task 7.4: Scenario analyses on effects of regional climate change on N and P fluxes from 83 major watersheds forming the Baltic Sea catchment.
We have received the climate change scenarios for the 8 original scenarios from WP5. During the workshop in Lund in November, it was decided to also run scenarios with delta-change on three different scenarios; we have yet not received data for these additional scenarios. However, we have calculated the effect of changes in temperature and precipitation on N and P fluxes for all 83 watersheds using the strong correlation functions between load and runoff for the catchments of the various Baltic Sea basins (n=7).

Task 7.5: Scenario analyses on changes in land cover types (agricultural vs. forest vs. wetlands) and land use patterns (changes in fertilizer use and livestock density) on N and P fluxes from 83 major watersheds forming the Baltic Sea catchments.
We have not calculated the land cover scenarios because we realized during the project that agricultural practices that we calculated with the NANI tool (Net anthropogenic nutrient inputs) are much more significant for N and P fluxes than relatively moderate changes in agricultural areas. We calculated therefore 4 lifestyle scenarios: i) the effects of 20% increase in fertilizer use, human consumption, animal consumption, animal production, crop production to humans and animals; ii) effect of adjustment of agricultural practices to EU-15 level on nutrient fluxes from transitional countries (Poland, Baltic States and Russia); ii) effect of 20% decrease in atmospheric deposition following the NEC directive and iV) business as usual, increase in human consumption of animal proteins by 3% annually with using the relationships of the various NANI components (animal and crop production and finally fertilizer use).

2.8 Work Package 8 – Modelling the Baltic Sea physical–biogeochemical system based on the CO_2/O_2 dynamics and climate change

Lead Partner: Anders Omstedt, University of Gothenburg, Sweden
Researchers involved in the current work:
Dr. Erik Gustafsson, PhD Student Karin Wesslander, PhD Student Moa Edman

2.8.1 Objective

The work package will develop, validate, and explore a new Baltic Sea physical–biogeochemical model system based on CO_2/O_2 dynamics and applied to past, present, and possible future climate change studies.

2.8.2 Methodology and scientific achievements

Task 8.1: Modelling present and past changes of the Baltic Sea CO_2 system.
The Baltic Sea CO_2 has now been introduced into a well established process-oriented Baltic Sea model and the present and past changes have been studied (Omstedt et al., 2009). The model has been further developed and designed for the scenarios runs and predictive

capability has been improved by includes CO_2 dynamics for oxic and anoxic conditions as well as improved biochemical modeling.

The observational data have also been analyzed in detail with regard to the carbon system (Wesslander et al., 2010). Also a reconstruction of past 500 years river runoff to the Baltic Sea has been published (Hansson et al., 2010). This data forms a base for further studies about past marine conditions in the Baltic Sea and the data has been delivered to other BONUS programs. A new book (Omstedt, 2011) that gives a guide to Baltic Sea modeling including the CO_2 system is in press.

Publications:

Wesslander, K., Omstedt, A., and B., Schneider(2010). On the carbon dioxide air-sea flux balance in the Baltic Sea. Continental Shelf Research 30, 1511-1521. DOI: 10.1016/j.csr.2010.05.014

Hansson, D., Eriksson, C., Omstedt, A., and D., Chen (2010). Reconstruction of river runoff to the Baltic Sea. Int. J. Climatol., DOI: 10.1002/joc.2097

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T*ask 8.2: Modelling possible future changes in the Baltic Sea CO_2 system.*

Before running scenarios we have analyzed factors influencing the acid-base (pH) balance of the Baltic Sea. Using calculations based on the marine carbon system and on Baltic Sea modeling, the sensitivity of surface pH has been examined (Omstedt, Edman, Anderson and Laudon, 2010). The results from this sensitivity study indicate for example that acidification due to river transport of dissolved organic carbon (C_{org}) into the marine system seems marginal although mineralization of terrestrial C_{org} may cause extra marine acidification, but this effect has yet to be quantified. Fossil fuel burning is likely to have both a direct and indirect effect through increased CO_2 levels, altering seawater pH as well as changing the river chemistry. This may severely threaten some species in the Baltic Sea, particularly in the Northern Baltic.

Preparation of scenario runs is ready and the forcing fields are under preparation. The forcing fields for scenarios have been organised and are available at all three model centres in the Baltic-C program.

Publications:

Omstedt, A., Edman, M., Anderson, L., G., and H., Laudon (2010). Factors influencing the acid-base (pH) balance in the Baltic Sea: A sensitivity analysis. Tellus, 62B, 280-295. DOI: 10.1111/j.1600-0889.2010.00463.x