Baltic-C: Building predictive capability regarding the Baltic Sea organic/inorganic carbon and oxygen systems

Baltic-C kick off
November 2008

Leibniz Institute for Baltic Sea Research Warnemünde

Finnish Meteorological Institute

Uppsala Universitet

Lund University

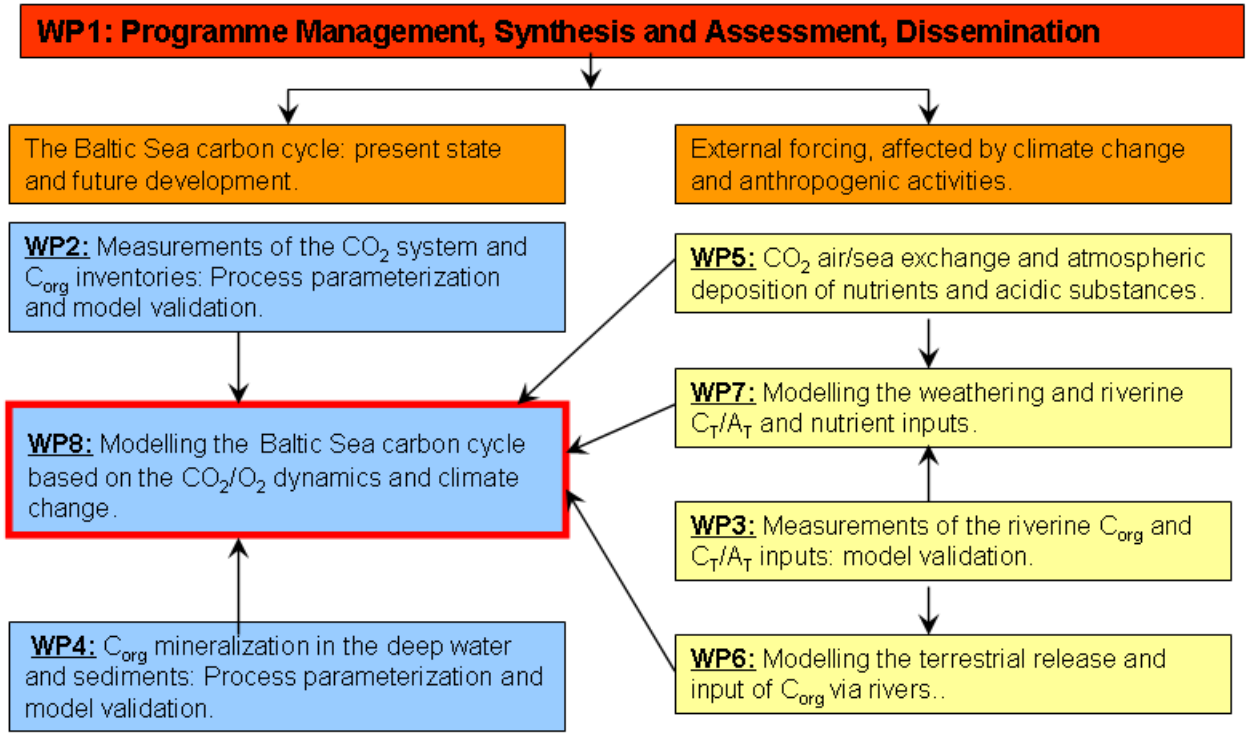
Universitet Stockholms

University of Gothenburg

WP1. Programme management, synthesis and assessment, dissemination (Anders Omstedt, University of Gothenburg, Sweden, and participant code 1).

Anders Omstedt

David Rayner

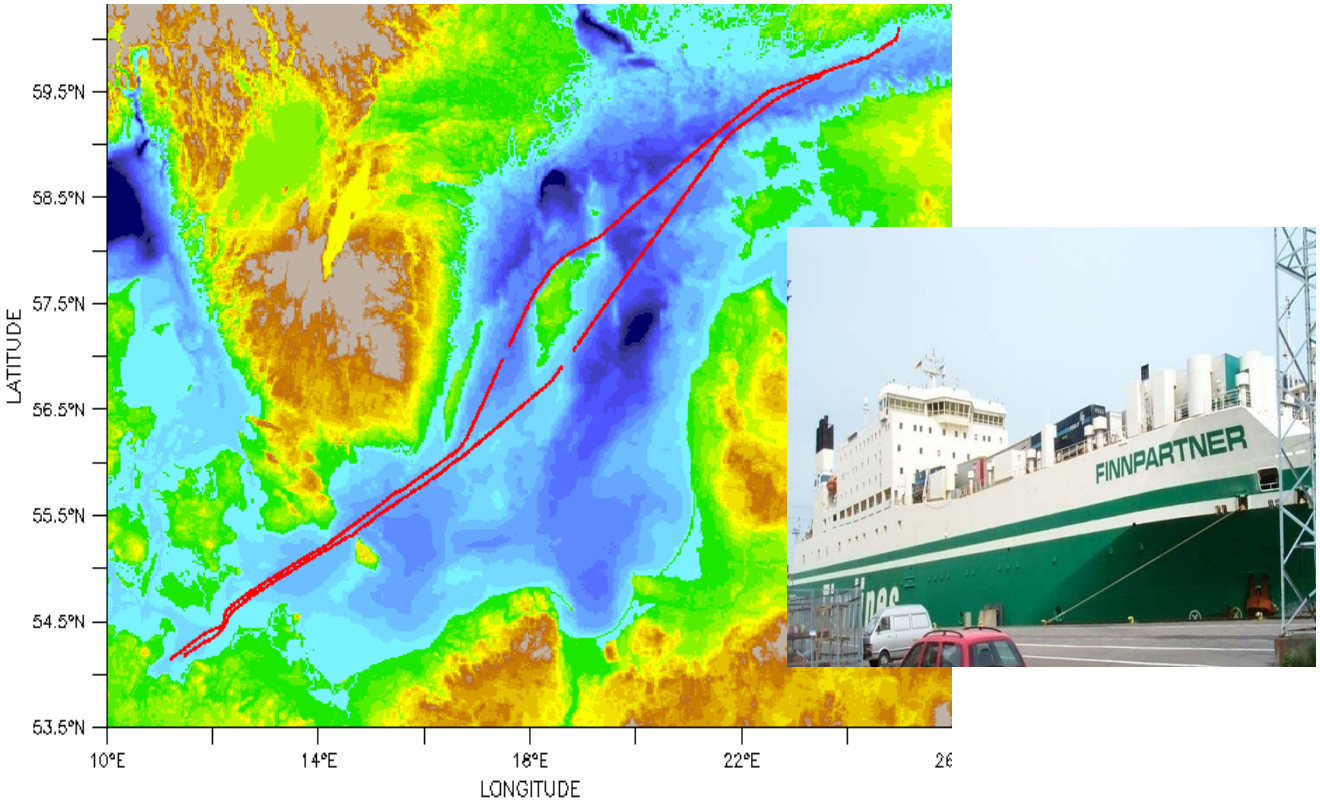


WP2. Measurements of the Baltic Sea CO_2 system and carbon inventories (Bernd Schneider, Baltic Sea Research Institute, Germany; participant code 2).

Bernd Schneider

Anne Loeffler

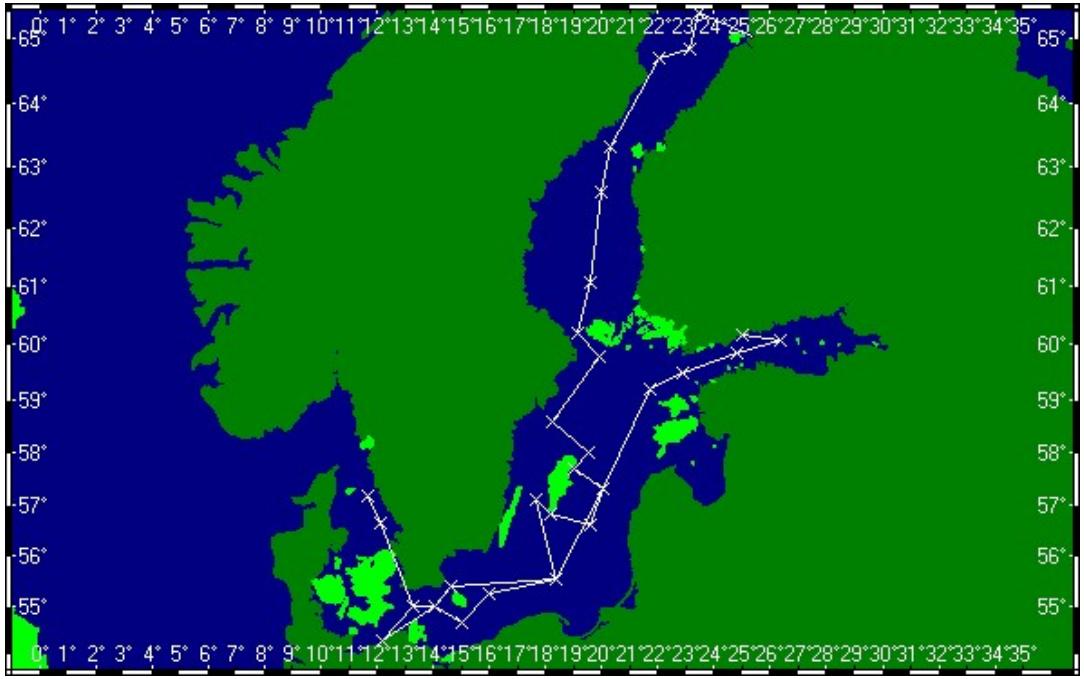
Bernd Sadkowiak



WP3. Inventory of river runoff data (Matti Pertillä, Finnish Institute of Marine Research, Finland; participant code 3).

Matti Pertillä

Laura Joensuu



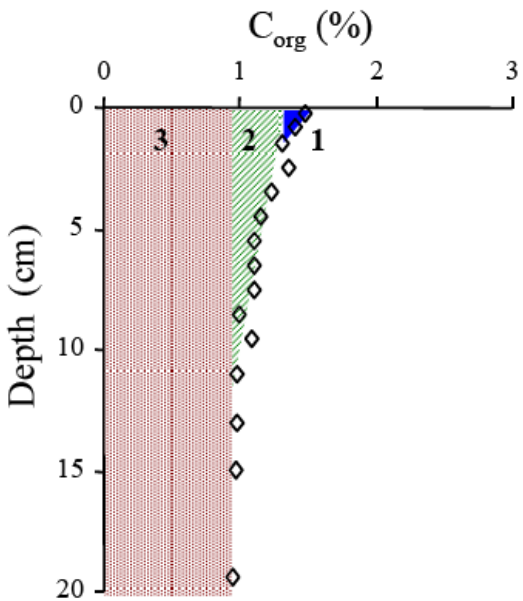
Baltic-C cruise 12.1 – 7.2.2009

WP4. Mineralization of organic material, deepwater–sediment interaction (Janusz Pempkowiak, Institute of Oceanology, Polish Academy of Sciences, Poland; participant code 4).

Janusz Pempkowiak

Anna Maciejewska

Aleksandra Szczepańska



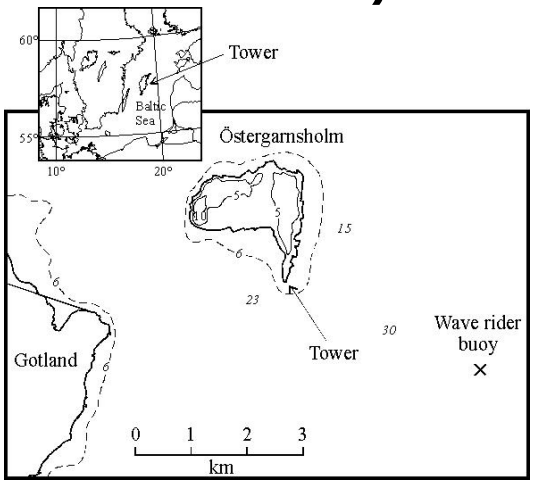
Karol Kuliński

WP5. Atmospheric forcing (air–sea interaction, scenarios) (Anna Rutgersson, Uppsala University, Sweden; participant code 5).

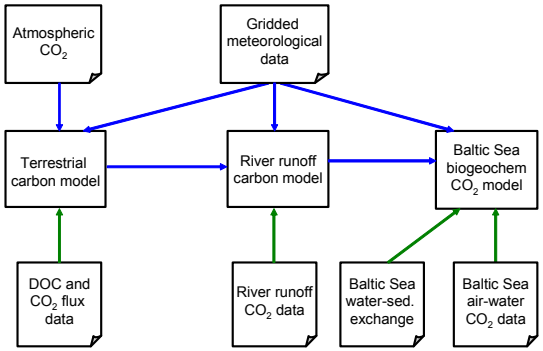
Annna Rutgersson

Björn Carlsson

Maria Norman



a)



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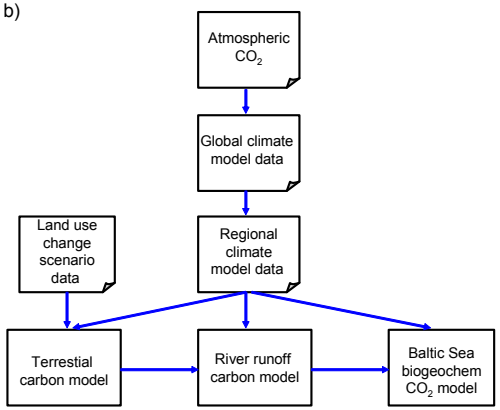
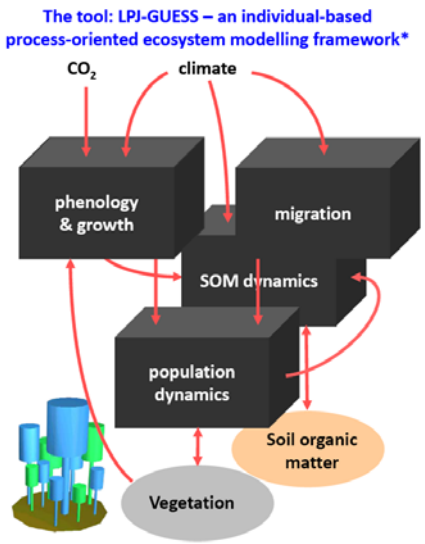
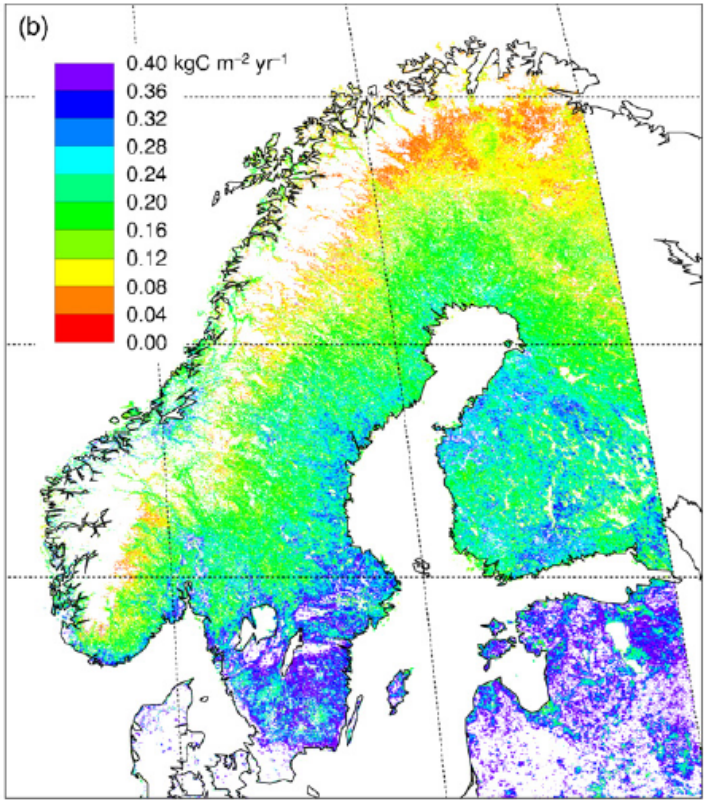


Leibniz Institute for Baltic Sea Research Warnemünde · Finnish Meteorological Institute · Uppsala Universitet · Lund University · Universitet Stockholms · University of Gothenburg

WP6. Modelling the organic matter input from terrestrial vegetation and soils (Benjamin Smith, Lund University, Sweden; participant code 6).

Benjamin Smith

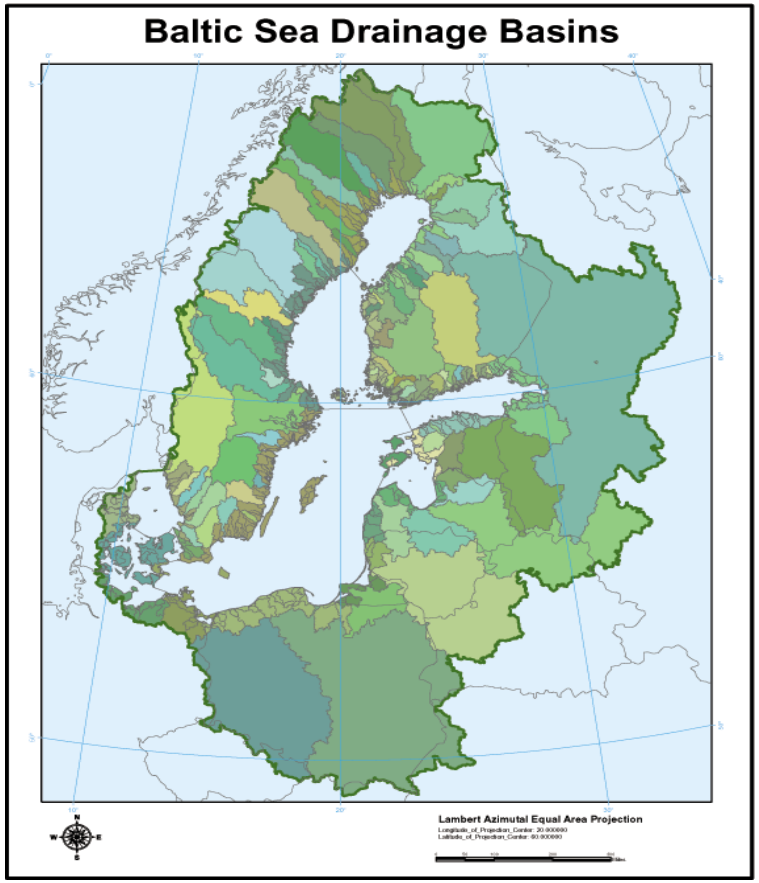




WP. 7. Modelling the input A_T, C_T, Ca, and C_{org} from all rivers to the Baltic Sea (Christoph Humborg, Stockholm University, Sweden; participant code 7).

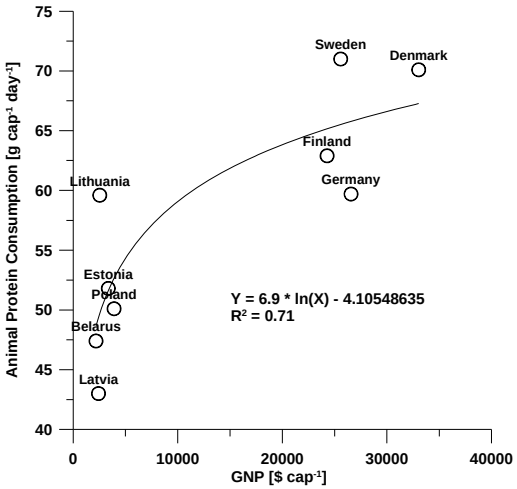
Christoph Humborg

Magnus Mörth



CSIM model

87 major catchments and 21 costal strips



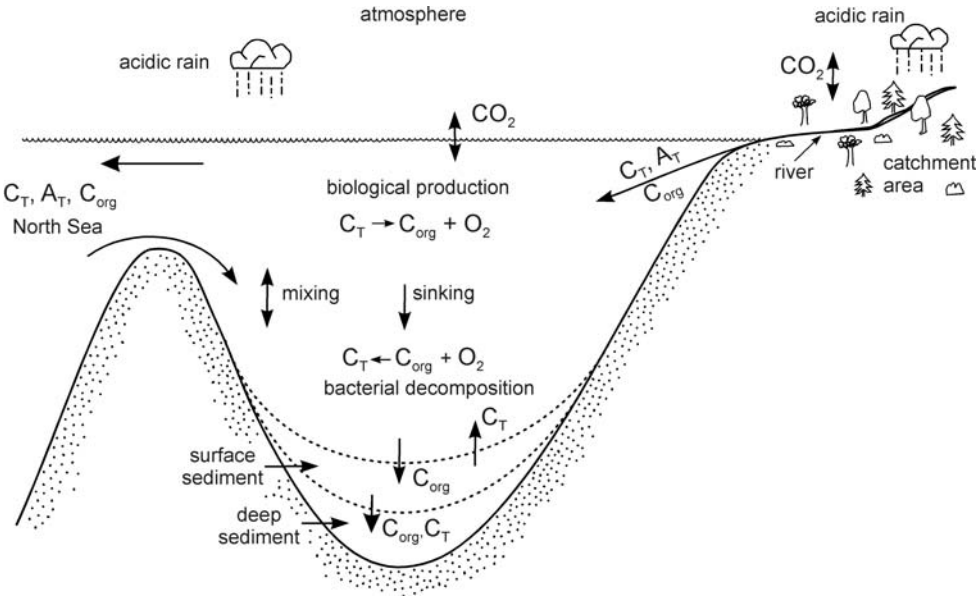
WP8. Modelling the Baltic Sea physical-biogeochemical system based on the CO_2/O_2 dynamics and climate change (Anders Omstedt, University of Gothenburg, Sweden, and participant code 1).

Anders omstedt

Erik Gustafsson

Moa Edman

Karin Wesslander



Some Baltic-C results

http://www.baltex-research.eu/baltic-c/

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

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: http://dx.doi.org/10.1016/j.csr.2010.05.014,10.1016/j.csr.2010.05.014

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

Baltic-C contributions at the **6th Study Conference on BALTEX**, Miedzyzdroje, Wolin, Poland, 14-18June 2010. Click here for references. Click here for conference proceedings (abstract volume)

Omstedt, A. (2009). **Baltic Sea Marine system: An introduction.** Lecture notes for the International Advanced PhD Course on: Climate impact on the Baltic Sea from science to policy. 27 July-5 August, 2009, Nexö, Bornholm, Denmark. Available from the author or here for download.

Reckermann, M., MacKenzie, B., Brander, K., A. Omstedt (2009). **Summer climate on Bornholm** - BALTEX co-organizes interdisciplinary Summer School. BALTEX Newsletter 13, pp. 1-2. International BALTEX Secretariat, GKSS, Geestacht, Germany BALTEX (2009).

BALTEX Phase II 2003-2013. Revised Objectives. International BALTEX Secretariat Publication No. 44, pp.92, GKSS Geestacht, Germany

Bernd Schneider, Seppo Kaitala, Mika Raateoja, Bernd Sadkowiak (2009) **A nitrogen fixation estimate for the Baltic Sea based on continuous pCO_2 measurements on a cargo ship and total nitrogen data.** Continental Shelf Research 29, 1535–1540.

Omstedt, A. , Gustafsson, E. and K., Wesslander, (2009) **Modelling the uptake and release of carbon dioxide in the Baltic Sea surface water.** Continental Shelf Research 29, 870-885. doi:10.1016/j.csr.2009.01.006. View abstract here...

Gustafsson E.O. and A. Omstedt (2009) **Sensitivity of Baltic Sea deep water salinity and oxygen concentrations to variations in physical forcing.** Boreal Environmental Research 14: 18-30.

Hjalmarsson, S., Wesslander, K., Anderson, L.G., Omstedt, A., Perttilä, M., Mintrop, L. (2008) **Distribution, long-term development and mass balance calculations of total alkalinity in the Baltic Sea.** Cont. Shelf Res. 28(4–5), 593–601.

Omstedt A. (2008) Baltic-C: **Building predictive capability regarding the Baltic Sea organic/inorganic carbon and oxygen system.** BALTEX Newsletter 11, pp. 5-7. International BALTEX Secretariat, GKSS, Geestacht, Germany.

Omstedt A. (2008) **Modelling the Baltic Sea acid-base (pH) balance.** BALTEX Newsletter 11, pp. 14-16. International BALTEX Secretariat, GKSS, Geestacht, Germany

On the carbon dioxide air-sea flux balance in the Baltic Sea

Wesslander, K., Omstedt, A., and B., Schneider(2010)

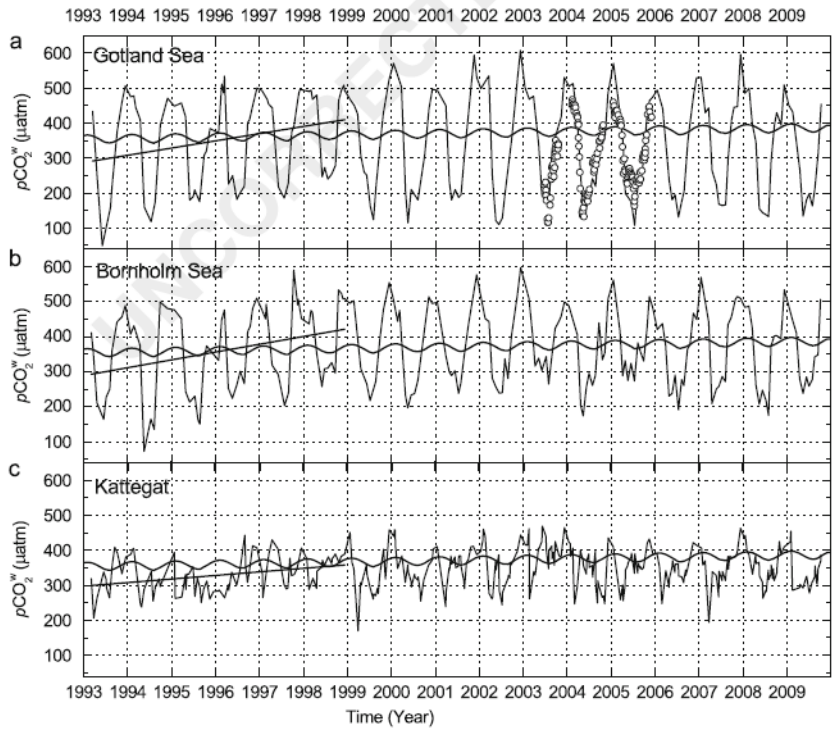


Fig. 6. Time series of calculated pCO_2^w from (a) the East Gotland Sea, (b) Bornholm Sea, and (c) Kattegat. Panel (a) also includes pCO_2^w data from Finnpartner (open circles). The grey thin line represents pCO_2 in the atmosphere. In each panel, a trend line is drawn for the 1993–1998 period.

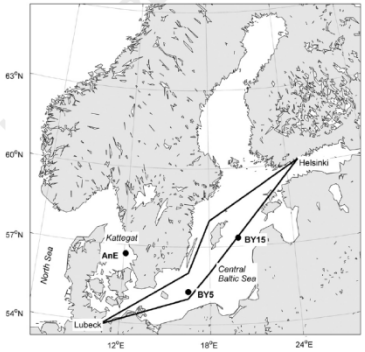


Fig. 1. The Baltic Sea and the Kattegat. The black line is the route of the cargo ship Finnpartner between Lübeck in Germany and Helsinki in Finland. AnE, BY5, and BY15 are the monitoring stations in the Kattegat, Bornholm Sea, and East Gotland Sea, respectively.

Measured data

Wesslander, K., Omstedt, A., and B., Schneider(2010)

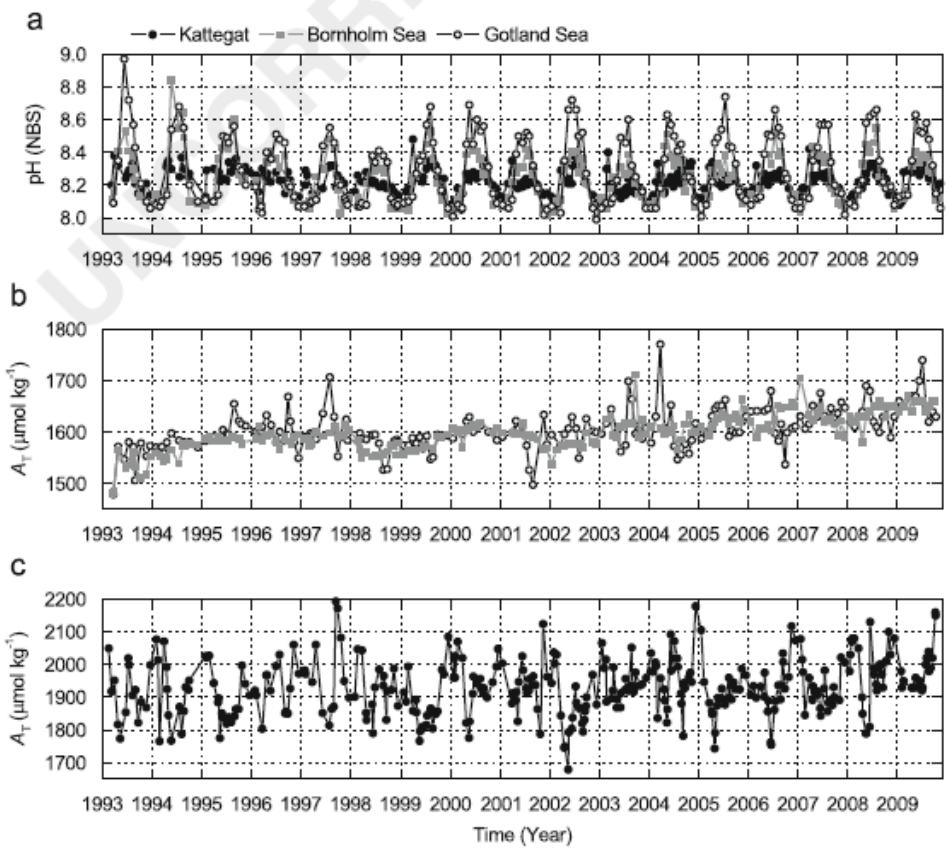


Fig. 4. (a) pH according to the NBS scale and (b,c) total alkalinity, A_T, in µmol kg^{-1}, at a depth of 5 m. Data are from the monitoring stations in the Kattegat (Anholt East—black circles) and the central Baltic Sea (BY5 in the Bornholm Sea—grey squares, BY15 in the East Gotland Sea—open circles).

Air–sea exchange of CO_2 using monitoring data

East Gotland Sea was a source of CO_2 (1.64molm^{-2} yr^{-1}), the Bornholm Sea was a source (2.34 molm^{-2} yr^{-1}), and the Kattegat was a sink (-1.16 molm^{-2} yr^{-1})

Wesslander, K., Omstedt, A., and B., Schneider(2010)

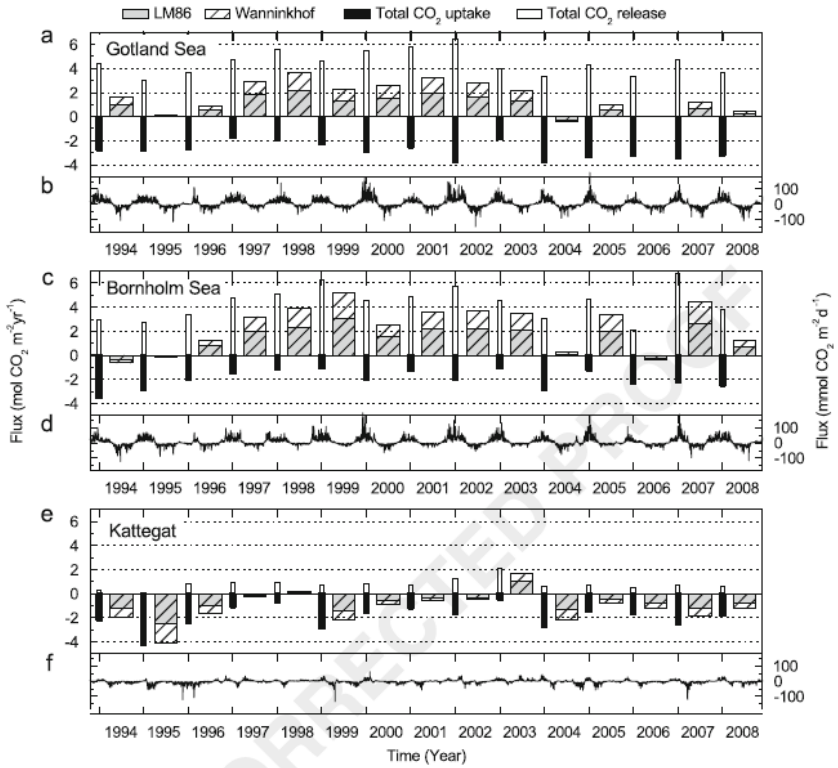


Fig. 8. Air–sea exchange of CO_2 in (a,b) the East Gotland Sea (c,d) the Bornholm Sea, and (e,f) the Kattegat. Panels (a), (c), and (e) show the annual net CO_2 flux in mol CO_2 m^{-2} yr^{-1}, grey bars show the flux with k according to Liss and Merlivat (1986), and the hatched bars show the flux with k according to Wanninkhof (1992). Black bars are the total CO_2 uptake and the white bars are the total release of CO_2 each year. Panels (b), (d), and (f) show the daily flux of CO_2 in mmol CO_2 m^{-2} d^{-1}. Flux is positive from sea to air.

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Distribution and biogeochemical control of total CO2 and total alkalinity in the Baltic Sea

J. Beldowski , A. Löffler a, B. Schneider, L. Joensuu (2010)

J. Beldowski et al. / Journal of Marine Systems 81 (2010) 252–259

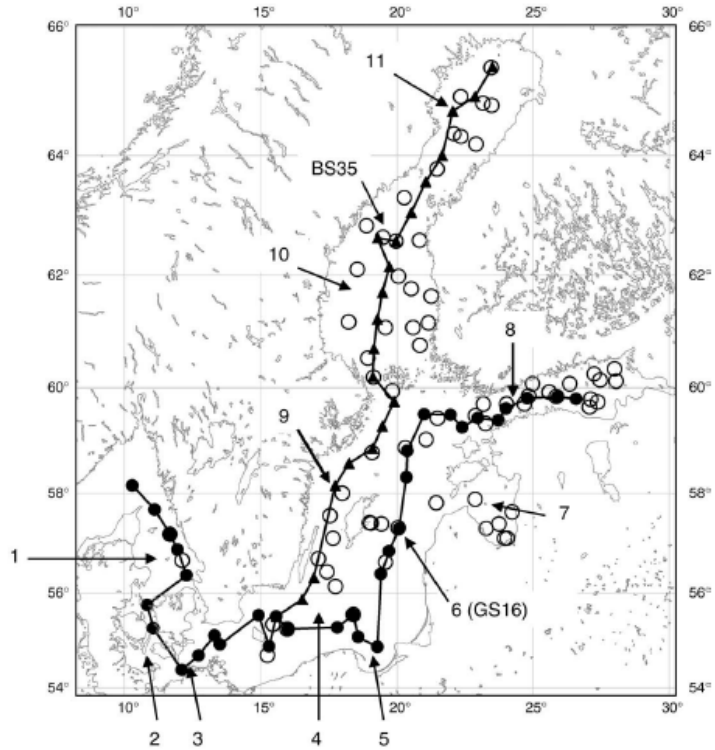


Fig. 1. Sampling stations for the determination of total CO_2 (eastern transect: full circles, western transect: triangles) and total alkalinity (open circles). The subareas are indicated by numbers: 1 – Kattegat, 2 – Belt Sea, 3 – Darss Sill, 4 – Bornholm Basin, 5 – Gdansk Basin, 6 – Gotland Basin, 7 – Gulf of Riga, 8 – Gulf of Finland, 9 – Landsort Deep, 10 – Bothnian Sea, 11 – Bothnian Bay.

For the first time, a synoptic view of the Baltic Sea C_T system is now available (R/V Merian cruise in June/July 2008)

J. Beldowski , A. Löffler a, B. Schneider, L. Joensuu (2010)

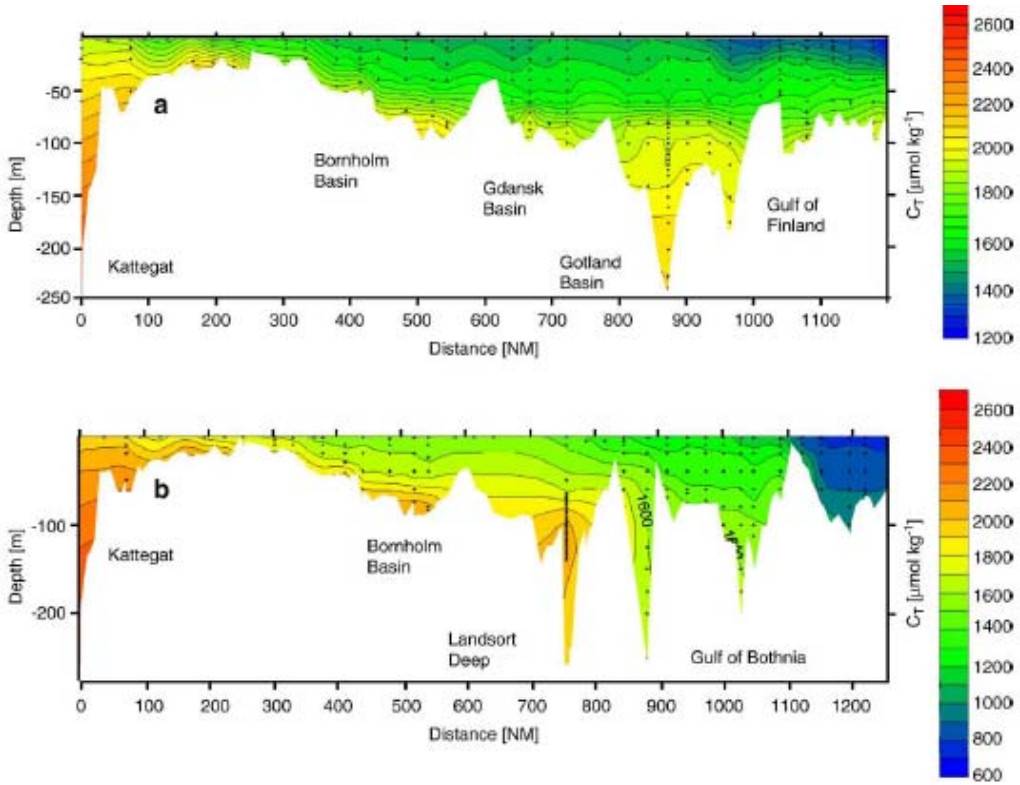


Fig. 2. Depth distribution of total CO_2, C_T, along the eastern transect (a.) and along the western transect (b.). The black dots indicate the sampling depths. The region between the Kattegat and the Bornholm Basin refers to both transects.

Modelling the uptake and release of carbon dioxide in the Baltic Sea surface water

Anders Omstedt, Erik Gustafsson, Karin Wesslander(2009)

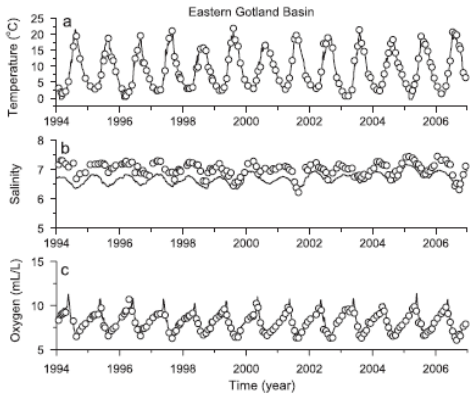


Fig. 3. Observed (circles) and calculated (line) (a) temperature, (b) salinity, and (c) oxygen of the surface layer.

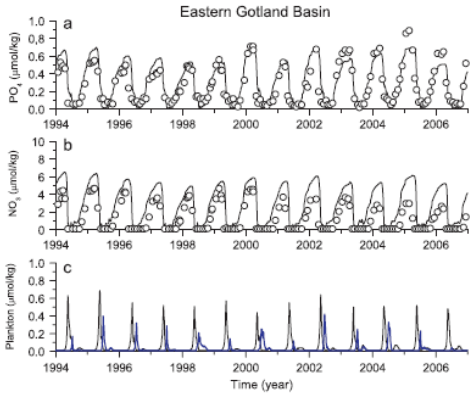


Fig. 4. Observed (circles) and calculated (line) (a) PO_4 concentration, (b) NO_3 concentration, and (c) calculated plankton concentration of the surface layer. Two plankton concentrations are presented in (c), representing one group of *P*- and *N*-limited algae (black) and one group of blue-green algae (blue) which is only limited by *P*. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

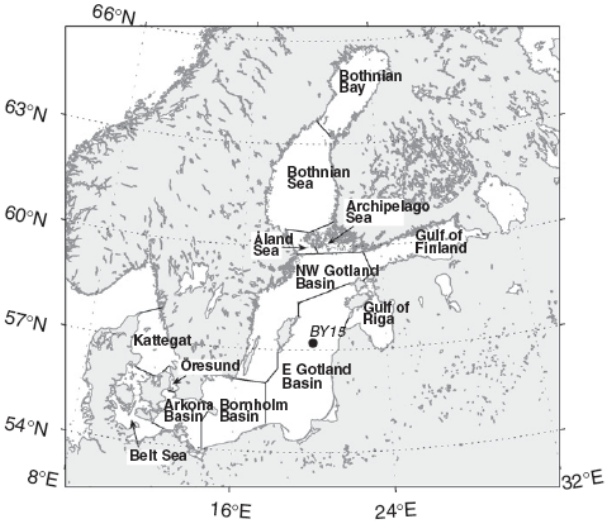


Fig. 1. Map of the Baltic Sea region, showing its division into natural sub-basins used in the PROBE-Baltic model and the position of the BY15 monitoring station in the Eastern Gotland Basin.

Model validation

Omstedt,Gustafsson and Wesslander, (2009)

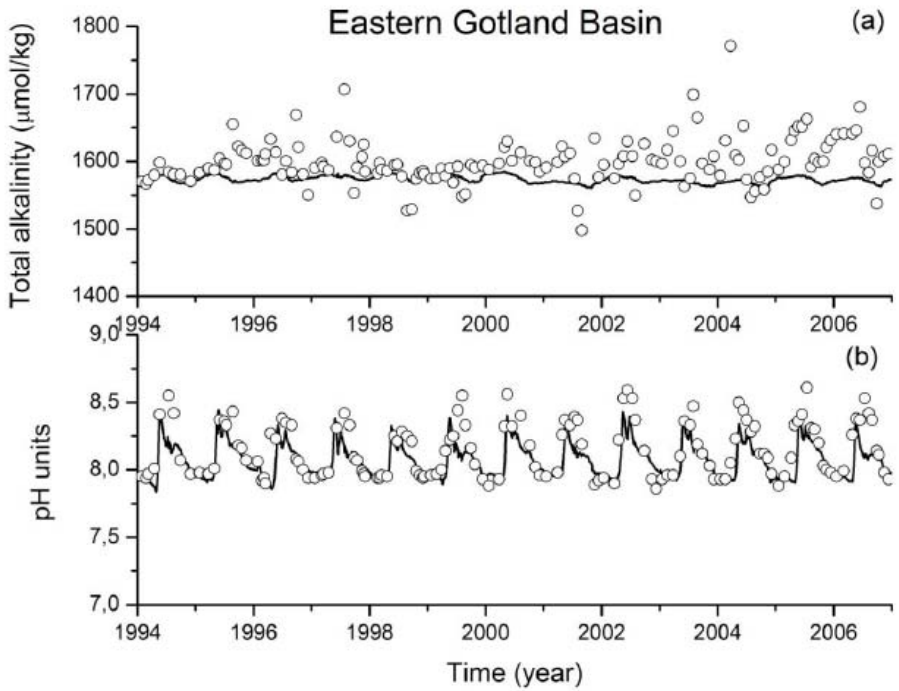


Fig. 5. Observed (circles) and calculated (line) a) total alkalinity and b) pH of the surface layer.

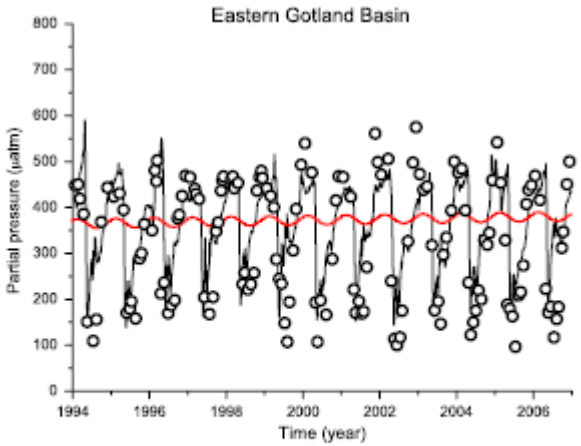


Fig. 6. Surface water partial CO_2 pressure calculated from observations (circles) and from the model (line). The red curve illustrate the partial pressure in the atmosphere. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Model implications

Omstedt,Gustafsson and Wesslander, (2009)

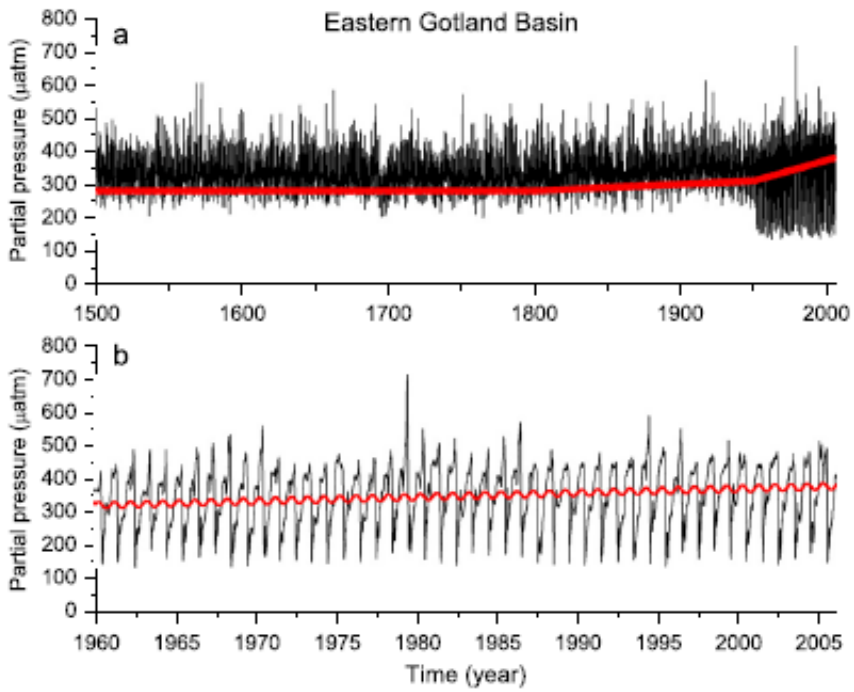


Fig. 8. Calculated CO_2 partial pressure in the atmosphere (red) and in the surface layer (black). Model assumptions are that the anthropogenic CO_2 emissions start in 1750 and eutrophication starts in 1950. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Model implications

Omstedt,Gustafsson and Wesslander, (2009)

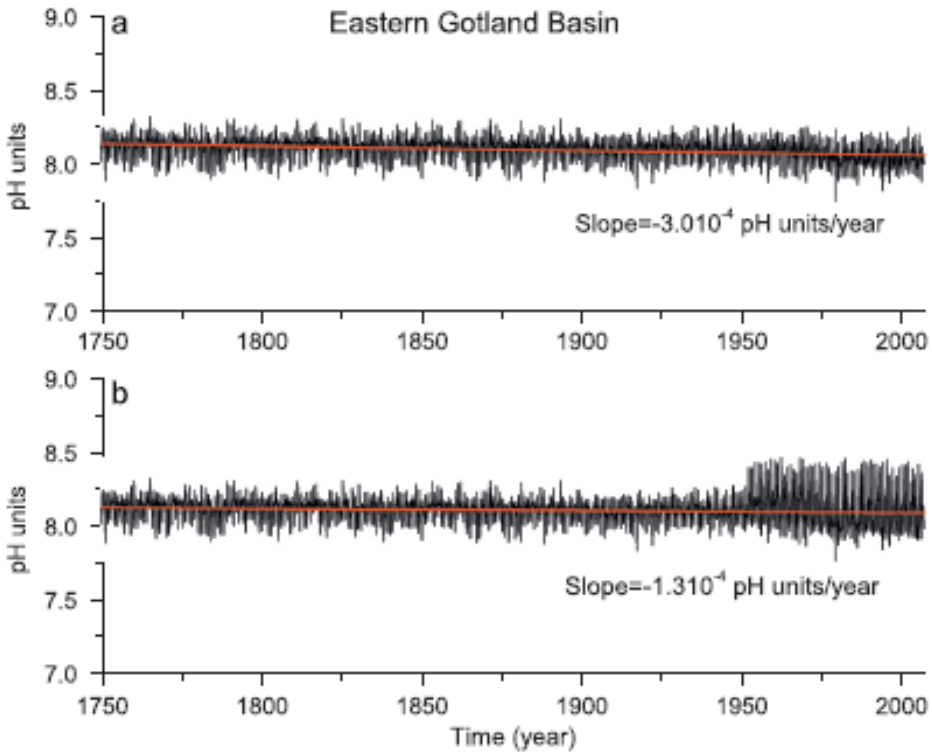
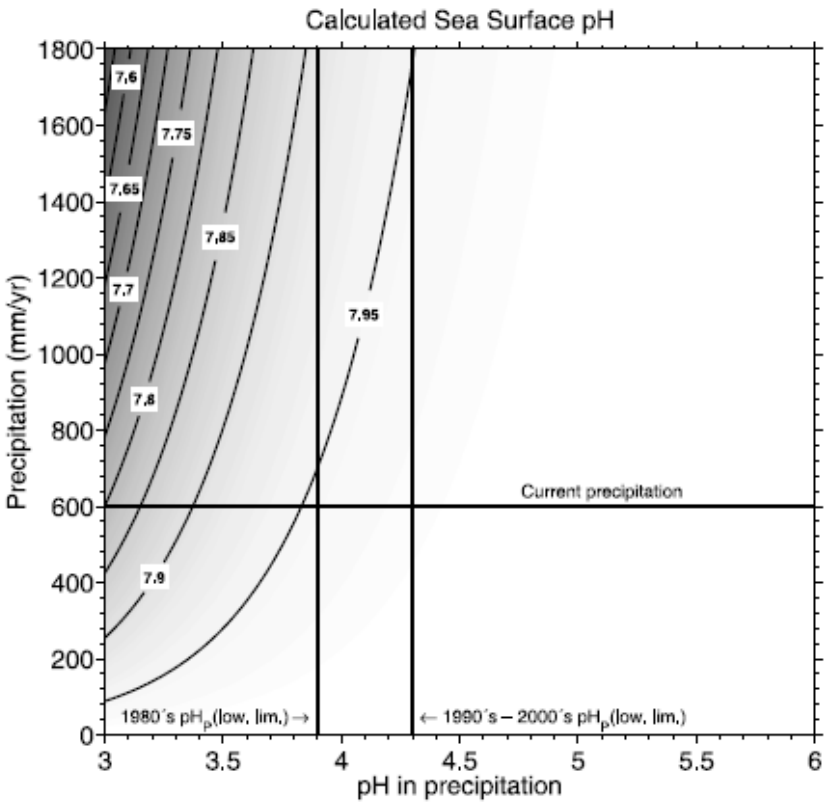


Fig. 10. Calculated pH in the surface layer (black lines) and linear trends (red lines). Model assumptions are that the anthropogenic CO_2 emissions start in 1750 and without (a) and with eutrophication (b). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

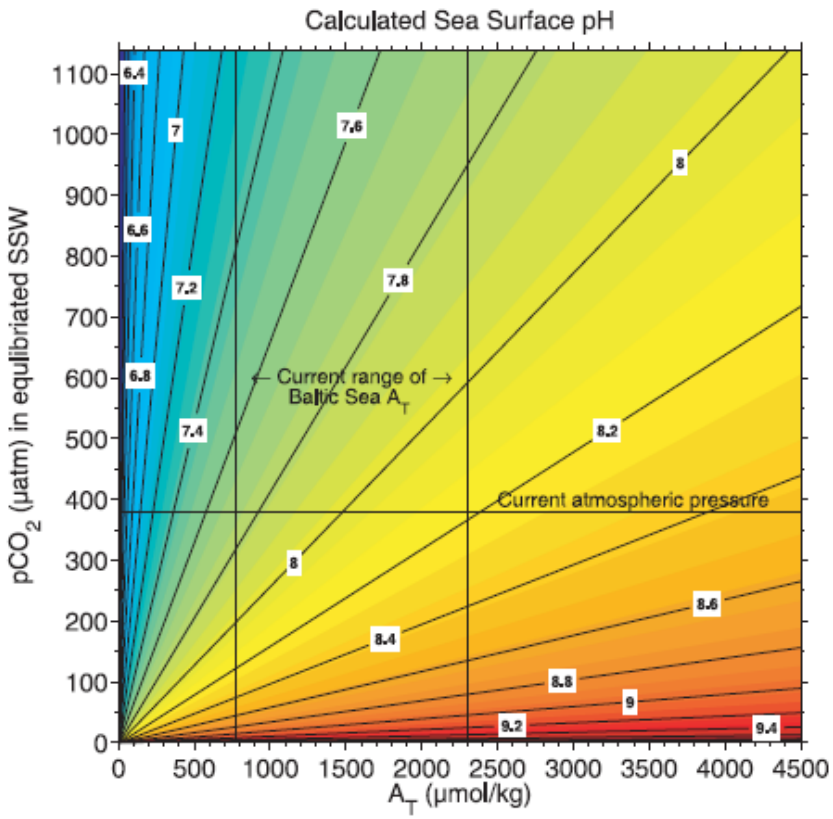
Factors influencing the acid–base (pH) balance in the Baltic Sea: a sensitivity analysis

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

Omstedt, A., Edman, M., Anderson, L., G., and H., Laudon (2010).



Climate change scenarious (SRES)

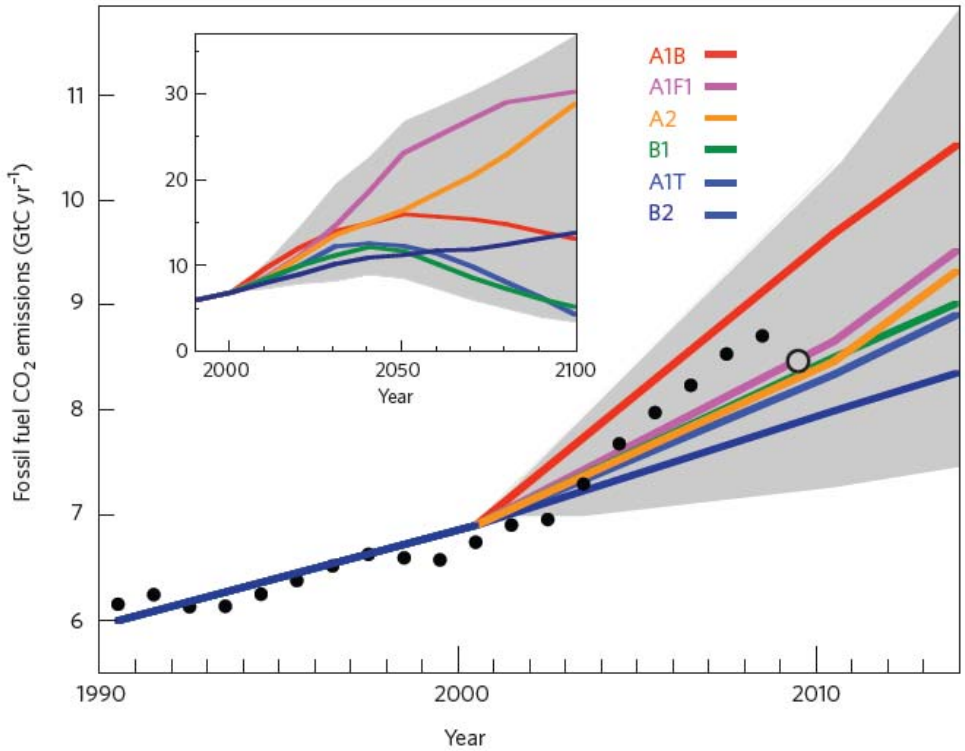


Figure 1 | Fossil fuel CO_2 emissions. The graph shows that estimates of annual industrial CO_2 emissions in gigatons of carbon per year (GtC yr^{-1}) for 1990–2008[13] (black circles) and for 2009[9] (open circle) fall within the range of all 40 SRES scenarios (grey shaded area) and of the six SRES illustrative marker scenarios (coloured lines). The inset in the upper left corner shows these scenarios to the year 2100.

Next generations of scenarios for climate change research and assessment

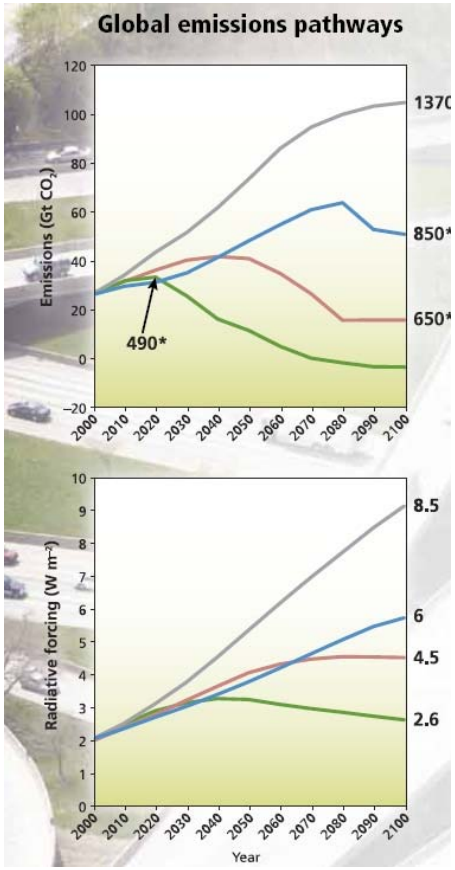
RH Moss *et al. Nature* **463**, 747-756 (2010) doi:10.1038/nature08823

The four pathways

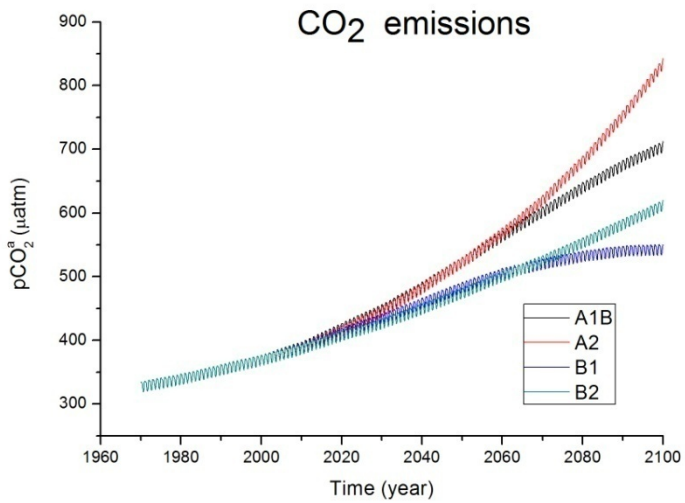
Radiative forcing	*Atmospheric CO_2 equivalent (parts per million)	When
8.5	>1370	By 2100, but rising
6	850	Stabilisation after 2100
4.5	650	Stabilisation after 2100
2.6	490	Peak before 2100 then decline

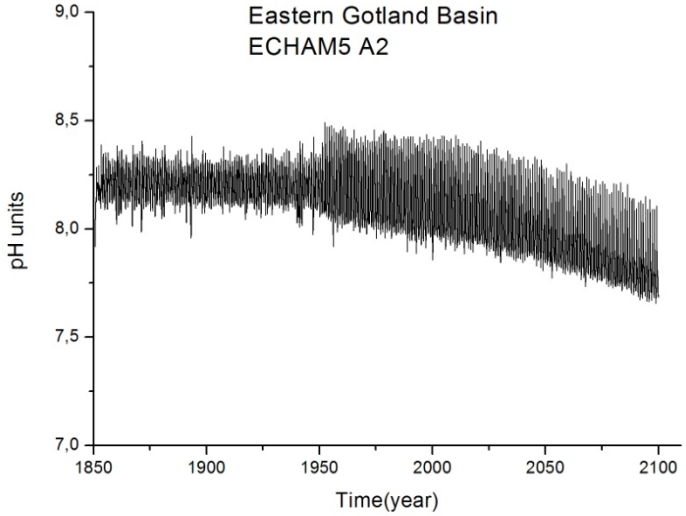
Four plausible global radiative forcing pathways from greenhouse-gas emissions from human activities. The new pathways, known as Representative Concentration Pathways, have been developed for the Intergovernmental Panel on Climate Change Fifth Assessment Report. The numbers associated with each scenario relate to the final radiative forcing (W/m²) by 2100. The 8.5 scenario equates to little effort to reduce emissions, while 2.6 sees emissions peak early then fall.

Figure adapted by permission from Macmillan Publishers Ltd: *Nature*. Moss R H *et al.* (2010). v.463: 747-756. Copyright 2010.

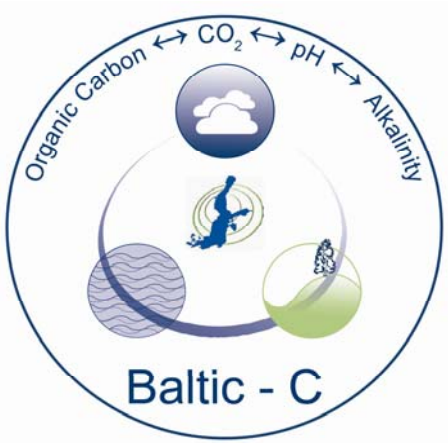


Prel. calculations assuming no change in nutrient loads





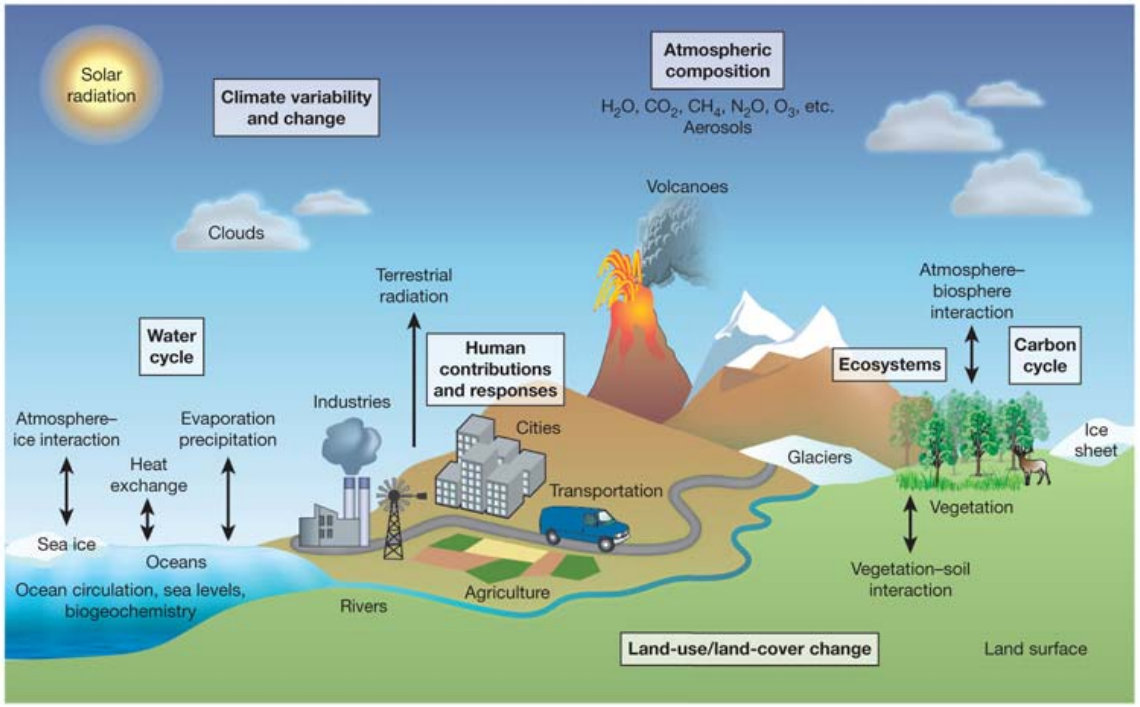
Future?



BONUS/Baltic-C day with presentations about the pH and effects on our coastal seas
4 November, 2010
Department of Earth Sciences, University of Gothenburg

10:00 – 10:10: Welcome
10:15-10:45 BONUS/Baltic-C. Anders Omstedt
10:45-11:15: Modeling the Baltic Sea biogeochemical system. Moa Edman
11:15-11: 45: Can observational pH data confirm the predicted acidification of Baltic Sea surface water? Anders Grimvall
11:45-12:45 Joint lunch
13: 00-13:30: Some marine chemistry research questions related predicting pH changes in coastal seas. Leif Anderson
13:30-14:00: Biological consequences for Baltic Sea-Skagerrak acidification. John Havenhand.
14:00-14:45: Can we predict the impact of OA on marine ecosystems? And do we need to? Sam Dupont
14:45-15:30: Discussions

Thanks

Major natural and anthropogenic processes and influences on the climate system addressed in scenarios

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