How much carbon can the coastal ocean store?

Carbon Storage in German Coastal Seas - Stability, Vulnerability & Perspectives for Manageability

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In Short

- Biogeochemical modelling of carbon pools in the coastal ocean
- Quantifying changes in carbon pools
- Identifying potential changes in carbon pools due to climate change

Our project investigates the stability and vulnerability of various carbon storage pools in the Baltic Sea, North Sea and Wadden Sea. Germany and its European neighbours have a long history of exploiting, over-exploiting and rehabilitating their coastal waters. This is a consequence of human pressures on these coastal systems, paralleled by climate change driven pressures. Both have the potential to alter the biogeochemistry of the marine ecosystems. Using a coupled physical - biogeochemical model for the Baltic-North-Wadden Sea continuum (Fig. 1), our goal is to establish a budget of carbon pools and fluxes, investigate the sensitivity of these pools and fluxes to climate change and anthropogenic activities and determine whether and to what extent relevant pathways for carbon storage have or will be impacted.

The Modelling Although the North Sea and the Baltic Sea are a coupled system, this has been only poorly reflected in modelling efforts until relatively recently. The differences in the two systems are also reflected in the approaches taken to model these.

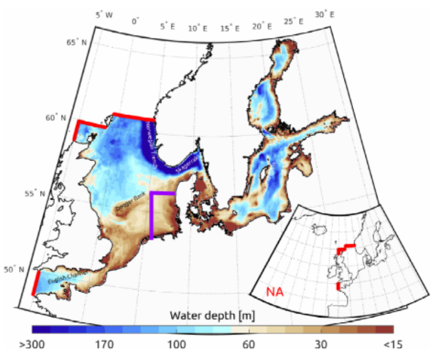

***Figure 1:** Water depth of the North Sea / Baltic Sea. (Red lines delineate the boundary of the 2nm North Sea-Baltic Sea setup with the North Atlantic, purple lines delineate the boundary of the Southern North Sea 600m setup.)*

During the last 10 years, some efforts were undertaken to bridge both systems using higher spatial resolution or vertical adaptive coordinates (e.g. Gräwe et al.,2015a; Hordoir et al., 2019). The need for a further developed coupled model system including a sophisticated biogeochemical module is also motivated by the results of Pätsch et al. (2017); Placke et al. (2018) and Daewel et al. (2019), who clearly reveal shortcomings in our present capabilities to simulate these systems as one entity appropriately.

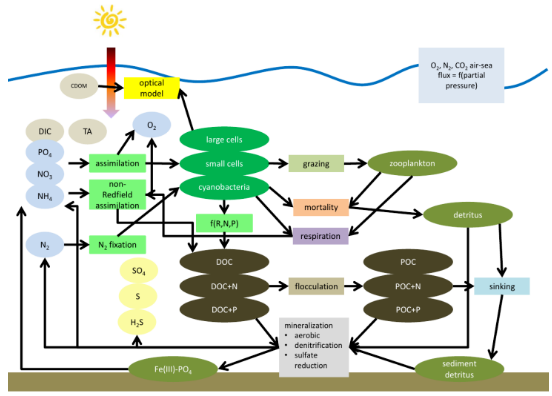

***Figure 2:** Extended Carbon Ecological Regional Ocean Model (ERGOM, Neumann et al., 2022)).*

Here, we have developed a coupled hydrodynamic-biogeochemical model for the North-Baltic-Wadden Sea continuum using the General Estuarine Transport Model (GETM, https://getm.eu) coupled to the Ecological Regional Ocean Model (ERGOM, https://ergom.net). We are working with two model domains shown in Figure 1 : a 2 nautical mile (nm) Baltic Sea - North Sea setup (NSBS2nm), where the boundary with the North Atlantic is shown in red and a 600m Southern North Sea setup (SNS600m), the boundary of which is shown in purple. ERGOM is used and developed since several years at IOW (Radtke et al., 2012; Neumann et al., 2017). Some attempts have been made to extend it to the North Sea (Maar et a., 2011; Wan et al., 2012). In this work, we have built on ERGOM version 1.2 (which allows for non-Redfieldian carbon fixation, Neumann et al., 2022; Fig. 2) by adding dissolved silicate and the Wanninkhof, 2014 parameterization of the piston velocity for air-sea exchange of CO_2. We use this updated model system to reconstruct the seasonal and inter-annual variability in carbon pools and fluxes in the Baltic – North Sea continuum from 1993 to 2022 (Fig. 3).

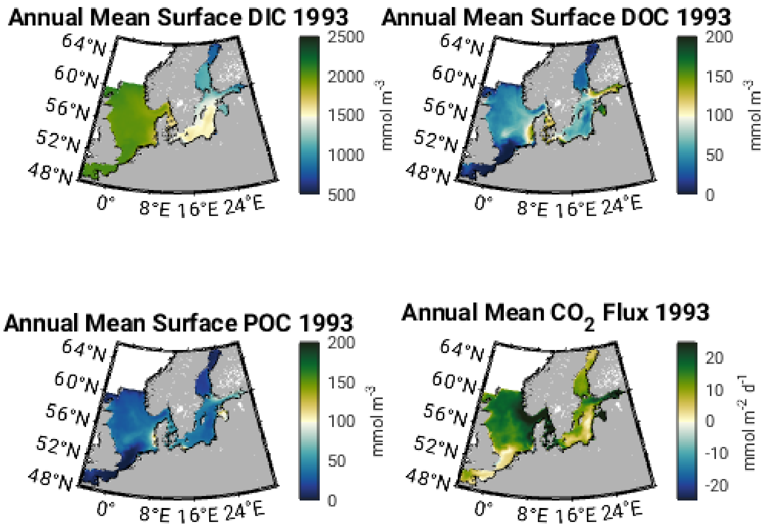

***Figure 3:** Annual mean surface dissolved inorganic carbon (DIC), dissolved organic carbon (DOC), particulate organic carbon (POC) and air-sea CO_2 flux in 1993.*

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https://www.carbostore.de/

More Information

[1] U. Daewel, C. Schrum, J.I. Macdonald, *GMD* **12**, 1765-1789 (2019). doi:10.5194/gmd-12-1765-2019

[2] U. Graewe, P. Holtermann, K. Klingbeil, H. Burchard, *Ocean Modelling* **92**, 56-68 (2015). doi:10.1016/j.ocemod.2015.05.008

[3] R. Hordoir et al., *GMD* **12**, 363-386 (2019). doi:10.5194/gmd-12-363-2019

[4] M. Maar et al., *Ecological Modelling* **222**, 1696-1711 (2011). doi:10.1016/j.ecolmodel.2011.03.006

[5] T. Neumann, H. Radtke, T. Seifert, *Journal of Geophysical Research* **122**, 1090-1101 (2017). doi:10.1002/2016JC012525

[6] T. Neumann, H. Radtke, B. Cahill, M. Schmidt, G. Rehder, *GMD* **15**, 8473-8540 (2022). doi:10.5194/gmd-15-8473-2022

[7] J. Paetsch et al., *Ocean Modelling* **116**, 70-95 (2017). doi:10.1016/j.ocemod.2017.06.005

[8] M. Placke et al., *Frontiers in Marine Science* **5**, 1-20 (2018). doi:10.3389/fmars.2018.00287

[9] H. Radtke, T. Neumann, M. Voss, W. Fennel, *Journal of Geophysical Research* **117**, C9 (2012). doi:10.1029/2012JC008119

[10] H. Radtke, S.E. Brunnabend, U. Graewe, H.E.M. Meier, *Clim. Past* **16**, 1617-1642 (2020). doi:10.5194/cp-16-1617-2020

[11] T. Van Kessel, H. Winterwerp, B. Van Prooijen, M. Van Ledden, W. Borst, *Continental Shelf Research* **31**, S124-S134 (2011). doi:10.1016/J.CSR.2010.04.008

[12] Z. Wan, J. She, M. Maar, L. Jonasson, J. Baasch-Larsen, *Ocean Science* **8**, 683-701 (2012). doi:10.5194/os-8-683-2012

[13] R. Wanninkhof, *Limnology and Oceanography: Methods* **12**, 351-362 (2014). doi:10.4319/lom.2014.12.351

Project Partners

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