natESM Working-group proposal

#5: Advancing Ocean Biogeochemistry and Ecology in natESM

1. Summary

Core components of the natESM initiative currently focus on atmosphere and ocean circulation. However, key societal challenges that the HPC modelling community must address— greenhouse gas (GHG) emissions, storage, and their fate in the Earth System, and food provision—require explicit representation of ocean biogeochemistry. These questions cannot be resolved with ocean–atmosphere coupling alone; the ocean component needs biogeochemical processes to be included. This need is further emphasized by the CMIP7 recommendation that greenhouse gas emission-driven simulations with interactive greenhouse-gas cycles are the default mode of Earth System simulations.

Several approaches exist to represent ocean biogeochemistry (BGC), including (1) stand-alone BGC models; (2) process modules embedded within ocean circulation models; and (3) BGC models coupled via common, but not unanimously agreed-upon, community standards. There is also wide diversity in process complexity across existing BGC models within the natESM community, ranging from simple NPZD (nutrient–phytoplankton–zooplankton–detritus) formulations to species-resolving food webs, multiple functional-group frameworks, and optimization or adaptive-dynamics approaches. For historical reasons, development has been focussed on lower trophic levels. It has since then been recognized that science-based mechanistic understanding of how biological and biogeochemical processes respond to environmental change needs to be represented in modern ocean biogeochemical models. As a result, a variety of ocean biogeochemical models exist in Germany. There is also a demand to extend these models to more ecological resolution, for example higher trophic levels and trophic cascades, or bacterial and viral processes, to better represent the marine carbon cycle, associated GHG fluxes, biodiversity, and sustainable fisheries.

It remains an open question whether a single OBGC model can meet the community's diverse needs, or whether a modular framework – combining key elements from existing models – would provide a more sustainable path forward. What is clear, is that natESM will not maintain multiple, parallel OBGC models. The focus will instead be on identifying and integrating the most robust components into a coherent, community-driven system.

2. General information

Estimated duration: 6 months

Responsible contact: **Judith Hauck** (AWI) & **Carsten Lemmen** (Hereon)

WG-members:

Nicolas Gruber (ETHZ)	Olaf Morgenstern (DWD)
Tatiana Ilyina (Uni Hamburg)	Tim Rixen (ZMT)
Andreas Oschlies (GEOMAR)	Malin Ödalen (PIK)

→ ***Open to additional members!***
Interested colleagues are invited to contact the WG leads or join the KickOff meeting.

KickOff: **When?** 21 November 2025, 10:00 – 12:00
Where? https://meet.gwdg.de/b/iri-www-xnq-req

Expected dissolution: April 2026

3. Working-group objectives (tentative)

Survey	ocean biogeochemistry and ecology model options within the natESM community; survey existing coupling methods of hydrodynamics and OGBC within the natESM community.
Compare	the models with respect to biogeochemical/ecological complexity and unique features that could form modules; interoperability and coupling interfaces; community accessibility and support; potential to address carbon cycle, GHG emissions and food provisioning; HPC deployment
Discuss	the option to develop an OGBC framework consisting of multiple modules from currently developed and used BGC modules in the natESM community, and (if supported by the working group)
Identify	next steps to develop a modular natESM OGBC model framework