OceanICU
Understanding Ocean Carbon

# Deliverable 6.1

## WP6 Implementation Plan

09 June 2023/version 01


OceanICU is co-funded by the European Union, Horizon Europe Funding Programme for research and innovation under grant agreement No.101083922 and by UK Research and Innovation

# About this document

| | |
|---|---|
| Title | D6.1 WP6 Implementation Plan |
| Work Package | 6 **Determine significance of key processes in the evolving Ocean C Cycle** |
| Lead Partner | GEOMAR, PML |
| Lead Author (Org) | Iris Kriest (GEOMAR), Jerry Blackford (PML) |
| Contributing Author(s) | Jorn Bruggemann (BB), Jerry Tjiputra (NORCE) |
| Reviewers | NORCE Norwegian Research Center |
| Due Date | 30.06.2023, M6 |
| Submission Date | 03.07.2023 |
| Version | 1.1 |

Dissemination Level

| | |
|---|---|
| X | PU: Public |
| | PP: Restricted to other programme participants (including the Commission) |
| | RE: Restricted to a group specified by the consortium (including the Commission) |
| | CO: Confidential, only for members of the consortium (including the Commission) |

**OceanICU: Improving Carbon Understanding** is a Research and Innovation action (RIA) funded by the Horizon Europe Work programme topics addressed: HORIZON-CL6-2022-CLIMATE-01-02. Start date: 01 November 2022. End date: 31 October 2027.



OceanICU is co-funded by the European Union, Horizon Europe Funding Programme for research and innovation under grant agreement No.101083922 and by UK Research and Innovation

# Table of contents

# 1. Abstract

This implementation plan describes the details and timeline describing how WP6 will integrate new knowledge about biogeochemical processes that may affect the biological carbon pumps obtained in WP3 to WP5 into OCEANICU modelling tools, with the aim to resolve and to quantify the importance of key biological processes on regional and global C cycles under a range of climate pathways. The implementation and quantification of processes in models will usually proceed in a stepwise fashion: (1) implementation in light-weight, efficient model tools to obtain initial (first order) estimates of process importance in these tools as well as from other sources (for example, "back-of-the-envelope" calculations) (2) the assessment of a subset of processes in large-scale, global and/or regional models to (3) selected process parameterization being implemented in computationally expensive regional and global models simulated for historical, present-day and future scenarios.

# 2. Introduction

## 3. General description

WP6 will incorporate the new knowledge from WP3 to WP5 into OCEANICU modelling tools (regional, basin scale and global earth system models) to resolve and to quantify the importance of key biological processes on regional and global C cycles under a range of climate pathways. Specific objectives are to:

1. Provide an efficient and versatile model framework to test new process parameterizations.
2. Assess and rank process parameterizations for impact on carbon storage.
3. Improve predictive skills of global and regional ocean carbon sinks via refined process representations.
4. Quantify, assess and reduce the model uncertainty of shelf to open ocean carbon exchanges.
5. Reduce the uncertainty and determine the efficiency of natural carbon sink processes relating to climatic and human activities in regional shelf systems.

Given the stepwise approach WP6 consists of diverse modelling groups that employ a variety of models and methods, from local to regional scales and simple (in the biological and physical sense) to complex models: GEOMAR (lead; models MOPS/TMM/FOCI/UVic), PML (lead; model ERSEM/NEMO-regional); BB (FABM/GOTM/GETM); NORCE (iHAMOCC/BLOM); IPSL (PISCES/NEMO); CMCC (BFM/NEMO); IMR (NORWECOM/NEMO); DTU (Feisty/UVIC); OGS (MOPS/TMM).

## 3.1 Deliverables and milestones

- D6.1 (report due date month 8; lead GEOMAR): This report.
- D6.2 (report; due date month 21; lead PML): will report on the development of the model platform (milestone M21) that links together various biogeochemical and physical models used in the proposal, and that will serve as a tool to transfer data and knowledge from earlier WPs (in particular: WP3-WP5) to larger scale models.
- D6.3 (report; due date month 32; lead GEOMAR) will report on ranking of biogeochemical processes and the choice around which parameterisations to take forward into large scale models. It will also report on data delivered to WP7 and received from earlier in the project from WP3 and WP4.
- D6.4 (report; due date month 44; lead PML) will report on the integration of new parameterisations from T6.3 into shelf sea and climate models.
- D6.5 (report; due date month 56; lead GEOMAR) final report; will report on data transfer into WP7 and the results of climate simulations and manuscripts submitted.

The following milestones have been defined: M21-Model platform built (due month 15); M23-Data transferred to WP7 #1 (due month 25); M26-Data transferred to WP7 #2 (due month 46)

# 4. WP6 implementation

To incorporate the new knowledge from WP3 to WP4 into OCEANICU modelling tools and help to resolve and to quantify the importance of key biological processes on regional and global C cycles under a range of climate pathways the following specific activities have been defined:

## 4.1 Task 6.1: Model platform

(Lead: BB; Contributors: GEOMAR, PML, DTU). This task builds the shared model platform, to be used to develop and test newly developed process parameterisations. The core of this platform will be formed by the existing FABM framework (https://fabm.net) that allows to mix-and-match environments (physical models) and biogeochemical/ecosystem modules. The effort in this task is dedicated to bringing a number of additional physical and biogeochemical modules into this framework, in order to provide a continuum of model configurations – from simple, computationally efficient to complex and more realistic – in which the impact of new processes will be investigated. To achieve this task, biogeochemical modules MOPS, iHAMMOC and UVic will be coupled to the FABM framework, in addition to the already existing modules ERSEM, PISCES and BFM. The implementation of the three former models is expected to be finished by the end of 2023. On the physical side, the circulation of the Uvic model as well as the offline circulation embedded in the TMM (Transport-Matrix-Method; Khatiwala, 2007, 2018) will be implemented,

in addition to the already existing 1D and 3D environments. The implementation of Uvic and TMM circulation is expected to be finished in 2024 and will be made available to all partners (milestone M21, month 15) and reported in D6.2 (month 21).

## 4.2 Task 6.2: Process Model implementation

(Lead: PML; Contributors: All WP6 partners). WP6 will provide support to WP3-5 in the development of sub-grid scale parameterizations that can be integrated into light-weight regional or global models and evaluated for their potential impacts on C storage on various spatial and temporal scales. To achieve a constructive and fruitful collaboration the coupled biogeochemical models to be applied in OceanICU have been introduced to other partners of the consortium via handouts containing concise model descriptions, and a virtual workshop presenting the models (held on 2 May 2023; organized by GEOMAR, with participation of all WP6 partners). The recordings of this workshop are available to the OceanICU partners. A virtual introduction workshop for the 1D FABM platform and components is planned for September/October 2023 (organized by BB and PML), and a second introductory workshop that focuses on an extended model platform will be held in 2024. Further support in the development of process parameterisations will be carried out on an individual basis, depending on the matching of process requirements (e.g., spatial or ecological) and characteristics of the different model types. To facilitate the matching between partners from the observing and modelling side, an online survey regarding process specifications (spatial, temporal, ecological scales) has been carried out. Results of the implementation will be reported per D6.3 (month 32).

## 4.3 Task 6.3: Metrics and process ranking

(Lead: GEOMAR; Contributors: all WP6 Partners). This task will define metrics to provide a first estimate of the impact of each process on carbon sequestration, and comparison estimates against available data sets and existing reference simulations. Process sensitivity analysis will be performed mostly in light-weight models to assess potential for inclusion in fully coupled regional systems and ESMs. Depending on the availability of new process parameterisations (milestones 22, 24 and 24) and their implementation in the (light-weight) tools, the process ranking will be carried out in an iterative, step-wise manner, and may also include first-order estimates based on already published data (discussion during Kick-off meeting 21-23 February 2023), in collaboration with partners from WP3 and WP4. The results will be made available to all partners and be presented in D6.3 (month 32). Until then, online biannual meetings with all relevant partners will be held to discuss the available process rankings.

## 4.4 Task 6.4: Shelf and coastal carbon cycling

(Lead: PML; Contributors: IMR, BB, CEA/LSCE). This task will establish the rates and efficacy of biological-mediated carbon sinks in European regional seas (I.e. Nordic Seas; Barents Sea and NW European shelf). Activities will assess the controls on and fate of carbon uptake arising from climate mediated processes (T, O2 and pH) and direct anthropogenic drivers e.g. fishing pressure. Further we will assess the contribution of anthropogenic nutrients delivered down rivers to ocean C storage via stimulating the continental shelf pump. Scheduled for the second half of the project, a meeting between contributors will be scheduled for autumn 2023 to set an agenda.

## 4.5 Task 6.5: Climatic and ecosystem impacts on global carbon sequestrations

(Lead: NORCE; Contributors: CMCC) Process parametrizations from T6.2 will be implemented in NorESM2 and CMCC-ESM2, according to their rank of importance. Changes in cumulative natural vs anthropogenic carbon uptake will be compared with reference simulations without the new processes. The contrast between SSP1-2.6 and SSP5-8.5 scenarios (with and without climate mitigation) will be used to assess the range of potential for natural carbon sequestration.

## 4.6 Task 6.6: Enhancement of ocean carbon uptake predictability

(Lead: UiB; Contributors: NORCE CEA/LSCE) This task will improve predictability of CO2 sinks beyond a few years through improvements in the biological carbon pump mechanisms. We will start with improving the predictability horizon of primary production in key C sink regions, such as the Southern Ocean and the North Atlantic. Historical and new observations (from WP3-4) will be used to refine the estimates of biological-mediated CO2 sinks to enhance predictability and provide guidance on essential future monitoring networks. An OSSE will be undertaken to evaluate optimal sampling strategies for C fluxes in the coastal zone in support of the IOCCP surface ocean pCO2 task team activity (link to WP8).

## 4.7 Task 6.7: Transfer of simulation and scenario data to DST

(Lead: B&B; Contributors: All WP partners) This task will deliver spatial and temporal maps of key habitats for carbon sequestration as well as time series of abiotic and biotic stressors and carbon sequestration to WP7 for the OCEANICU DST development. This contribution will consist of two components: (a) the results of global and regional (North-West Atlantic/North Sea) simulations with light-weight 3D models (UVic for global, GETM for regional), run under scenarios in which human pressures are systematically varied, and (b) the results of high-resolution global and regional experiments

run in T6.4-6.6. In WP7, these results will feed into version 3 of the DST. In addition, WP6 will provide the model components (T6.1) and new process parameterizations (T6.2), which will be used in WP7 in the process-based (1D water column model) component of version 2 of the DST.

## 4.8 Critical risks for implementation

A small number of risks are identified:

- Late availability of novel parameterisations emerging from WPs3-5. Likelihood: Medium, Impact: Medium, Mitigation: parameterisations can be implemented in efficient light-weight global or regional model tools and assessed separately even at a late stage of the project.
- Lack of novel parameterisations and data emerging from WPs3-5. Likelihood: Low, Impact: Medium, Mitigation: Several emerging parameterisations and process descriptions are available in the literature, providing adequate developmental options should WP3-5 not deliver.
- Loss of skilled staff. Likelihood: Medium, Impact: Medium, Mitigation: Mentoring and development of ECRs.
- Restriction in computational capacity: Likelihood: Low, Impact: Medium, Mitigation: Each group has access to national and institutional computing facilities, such that an individual equipment failure can be transferred to another system. Increases in energy costs and net zero considerations may reduce the number of scenarios possible.

## 4.9 Expected results

These results proposed in this section will feed a master document summarizing Key Exploitable Results and KPIs, which will serve to measure the progress, but also the outcomes and potential impact of OceanICU's research within the project's life and after its end'. Two classes of exploitable results are expected:

- A published, test and evaluated suite of updated parameter and process descriptions concerning carbon cycling that will be available to academia worldwide.
- New and improved predictions of the response of carbon cycling to climate and other anthropogenic perturbations.

## 4.10 Gantt Chart

| Year | | 2023 | | | | 2024 | | | | 2025 | | | | 2026 | | | | 2027 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Quarter | | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 |
| End month | | 6 | 9 | 12 | 15 | 18 | 21 | 24 | 27 | 30 | 33 | 36 | 39 | 42 | 45 | 48 | 51 | 54 | 57 | 60 |
| Deliverable | | | 1 | | | | 2 | | | | 3 | | | | 4 | | | | 5 | |
| Milestone | | | | | | 21 | | | 23 | | | | | | | 26 | | | | |
| 6.1 | BB | | Model platform | | | | | | | | | | | | | | | | | |
| 6.2 | PML | | | | | | Process implementation | | | | | | | | | | | | | |
| 6.3 | GEOMAR | | | | | | | | Metrics and process ranking | | | | | | | | | | | |
| 6.4 | PML | | | | | | | | | | | Shelf and coastal cycling | | | | | | | | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6.5 | NORCE | | | | | | | | | | | Global carbon sequestration | | | |
| 6.6 | UiB | | Predictability enhancement | | | | | | | | | | | | |
| 6.7 | BB | | Data to DST | | | | | | | | | | | | |

# 5 WP6 management

## 5.1 WP6 management structure and routines

Since the beginning of the project, regular (monthly) online WP6 meetings are held and will continue throughout the project. Individual meetings are held on a per need basis among the different task leaders and contributors, as well as with other project partners. WP6 participants engage with all project wide meetings.

## 5.2 Key performance indicators (KPIs)

- Number of numerical code modules available for new model parameterisations
- Number of model output available (preindustrial, hindcast, projections)
- Number of non-specialist scientists engaging with model parameterisation and development.
- Number / impact / citations of peer reviewed papers produced based on WP6 modelling.

# 6 Interactions with other WPs

To facilitate a seamless integration of the modelling component into OceanICU we plan and envisage a number of coordinated interactions with other work packages. We also have started an online survey about the potential processes to be implemented, their spatial and regional scales and further requirements and provide a brief online model description for each model.

| WP | Aim | Method | Envisaged date |
|---|---|---|---|
| WP3-WP5 | Introduce partners to BGC model types | Virtual workshop and recordings | 2 May 2023 |
| WP3-WP5 | Introduce FABM framework to partners | Virtual workshop and recordings | Sep/Oct 2023 |
| WP3-WP5 | Introduce extended FABM framework to partners | Virtual workshop and recordings | 2024 |

*Table 1: Planned interactions with WP3 to WP5.*