OceanICU
Understanding Ocean Carbon

OceanICU project

November 2022 – October 2027

Version 1.1

Co-funded by the European Union

UK Research and Innovation

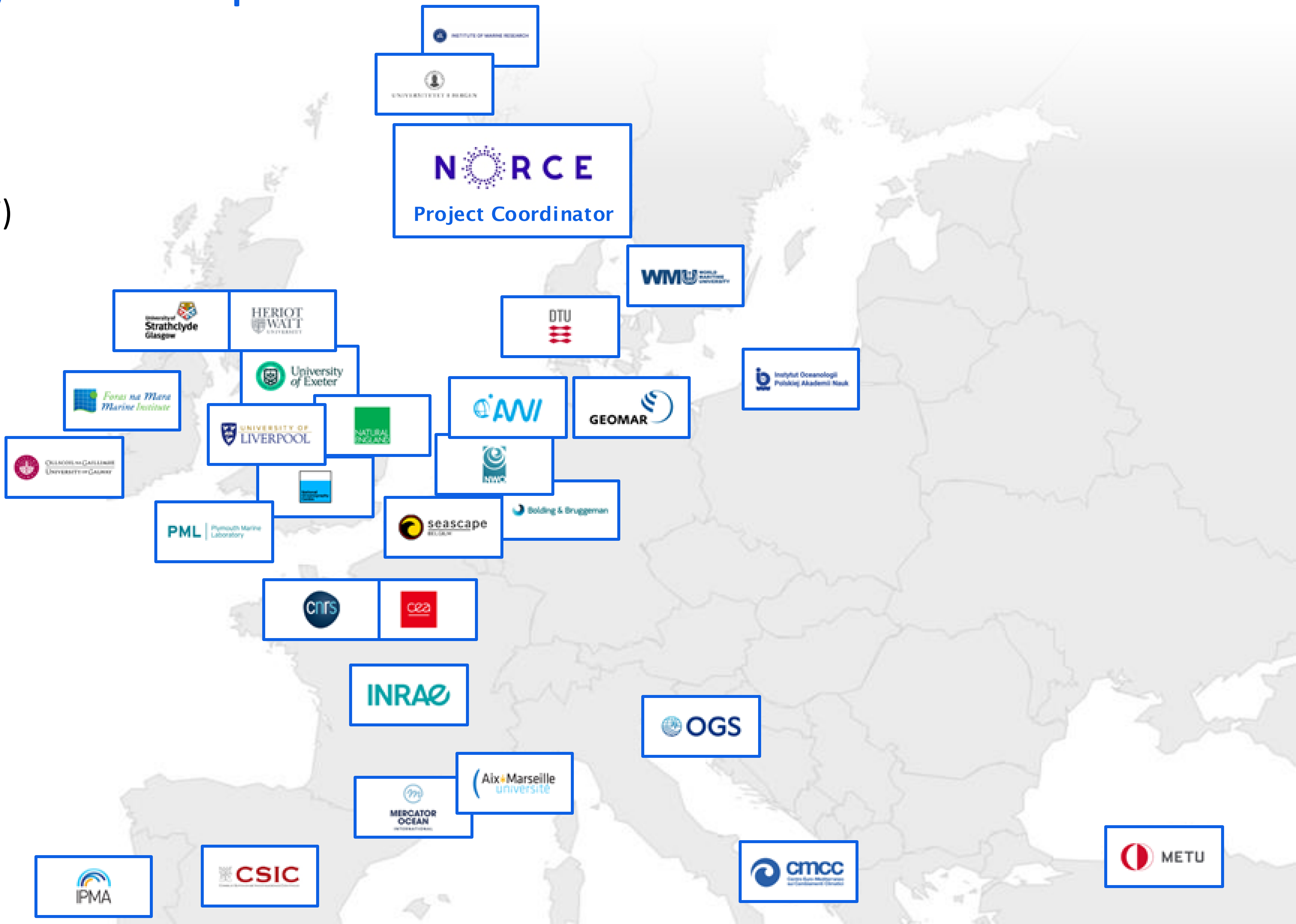
This work was funded by the European Union under grant agreement no. 101083922 (OceanICU) and UK Research and Innovation (UKRI) under the UK government's Horizon Europe funding guarantee [grant number 10054454, 10063673, 10064020, 10059241, 10079684, 10059012, 10048179]. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

OceanICU

A Pan-European project funded by Horizon Europe and UKRI

Consortium & resources

- 31 Partners, 15 nations
- 60 months (Nov 2022 – Oct 2027)
- Funding: €13 102 052,75
- EU and UKRI Funding



The Challenge

The EU Green Deal requires us to move to operating in a carbon neutral way

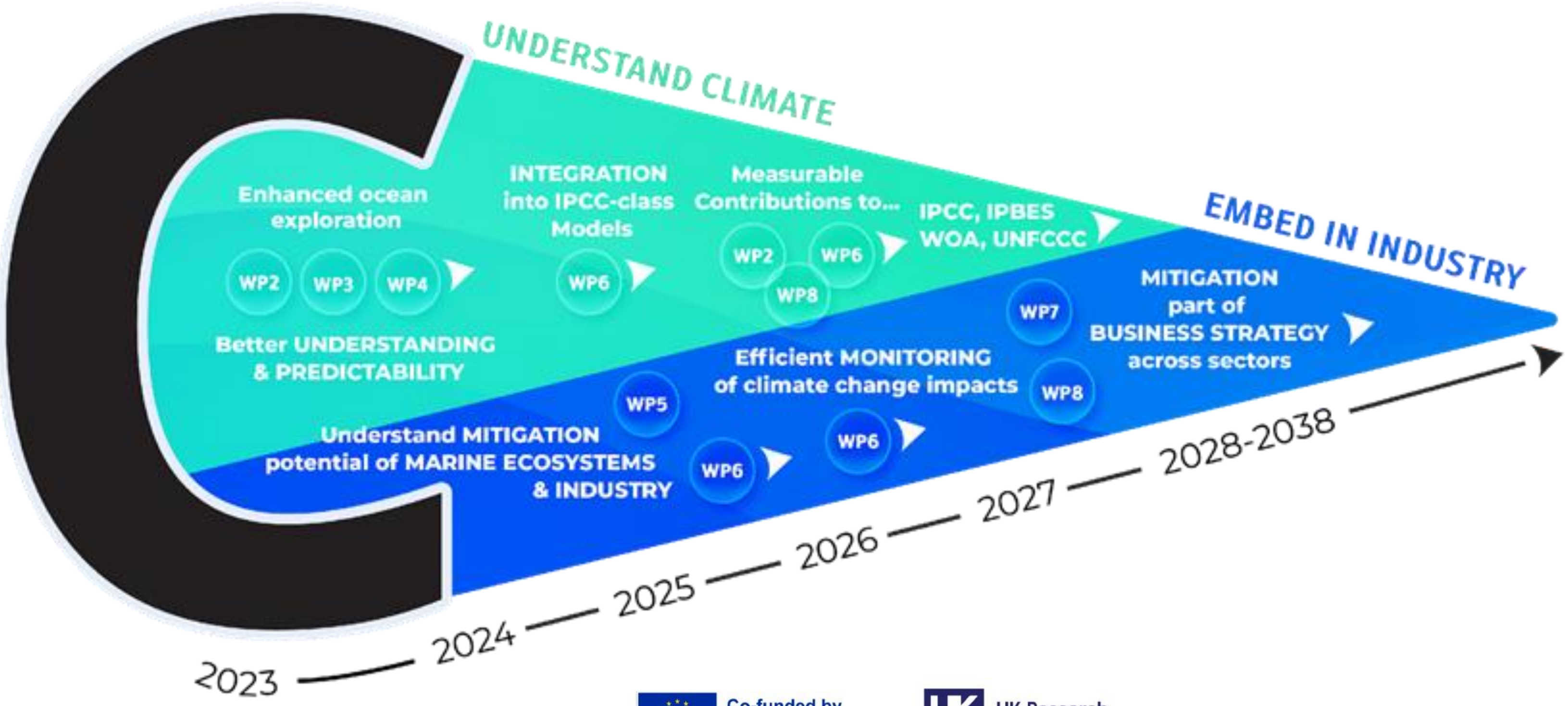
- How does this affect Ocean users?
- Need to compensate for:
  - Direct effects (e.g. GHG production by shipping)
  - Indirect effects (e.g. disturbances to seabed C storage by mining, disturbances to food webs by fishing or mining)
- How large are these indirect effects?
- How do they operate?
- What can we do to reduce or minimise them?

European Green Deal

Our ambition

OceanICU as a fundamental research-based pathway to impact

1. Define **current state of C cycle** (provide a baseline) and assess future climate driven change to Ocean C cycle
2. Quantify **key processes** relevant to these indirect effects
3. Incorporate key processes into **models** to enable indirect effects to be quantified
4. Translate the improved model skills into **new tools** that allow Ocean users and licencers to estimate C cycle impacts on industrial processes
5. Couple these to **estimates of future industrial processes**, fishing and climate change to estimate industrial impacts on Ocean C cycle



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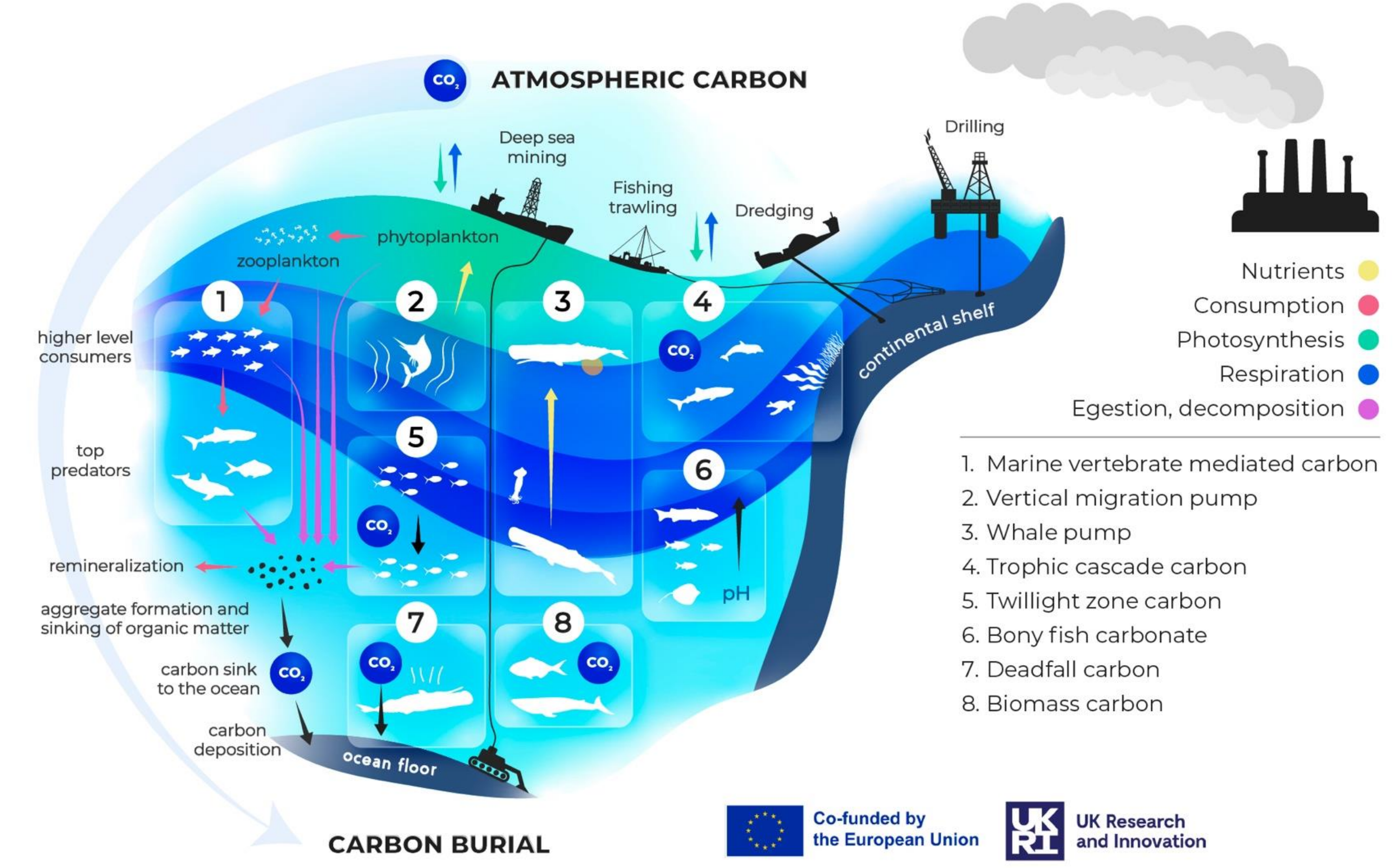
Key issues

Biological C pump processes considered in OceanICU

- Most models include processes relevant to climate but do not include parameters relevant to industry
- There is a need to understand key processes and then model them to deliver overall vision
- Now models containing key processes need forcing with societally relevant scenarios



Created by Seascape Belgium for the OceanICU Horizon Europe project, adapted from Lutz and Martin 2014, Figure 2. A conceptual diagram of marine vertebrate carbon services | Version 1.5 - CC BY-NC-ND 4.0 DEED

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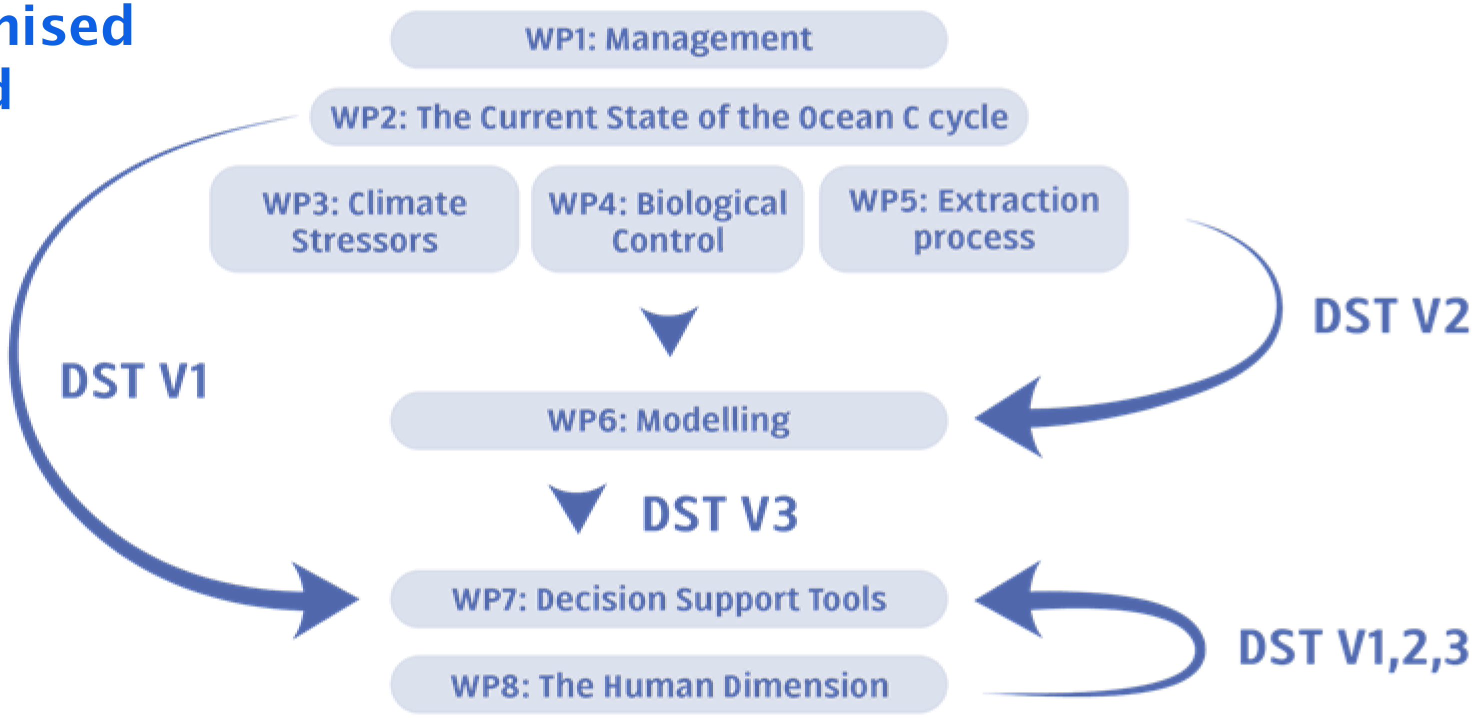
OceanICU Workplan

OceanICU is organised into eight focused work packages



WP1

Programme Management & Communication

WP1 Leader: Richard Sanders (NORCE)
All partners will contribute to achieving various tasks associated in WP1.

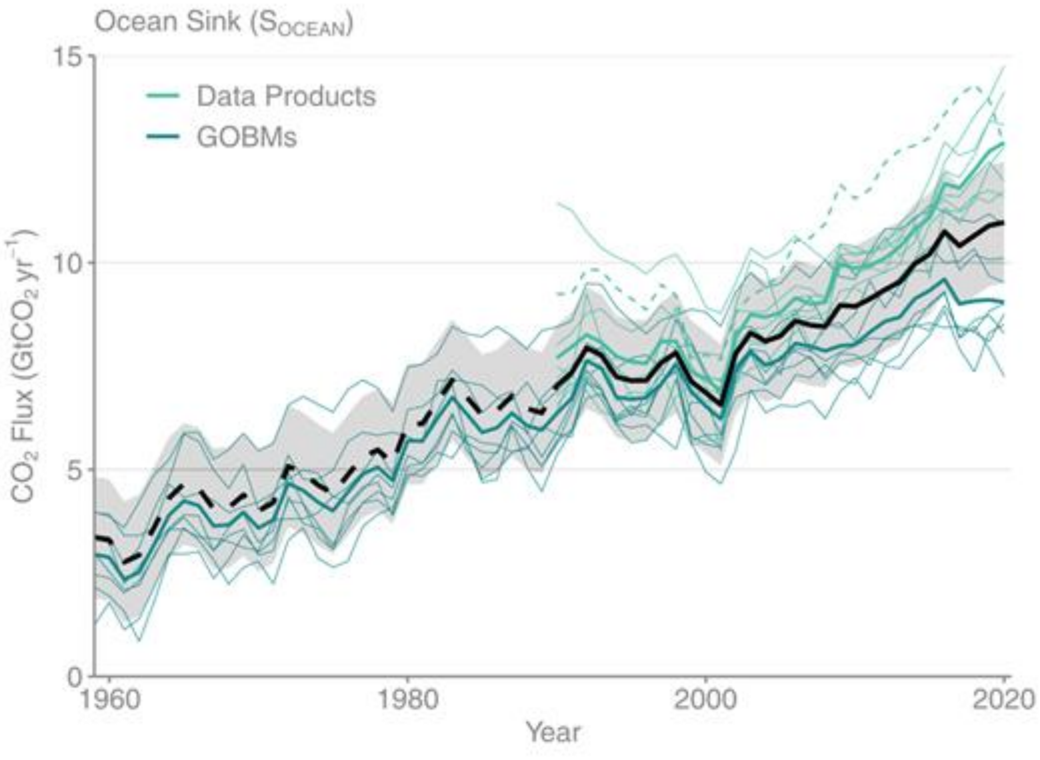
- Data
- Website and Communication, Dissemination & Exploitation Activities
- Meeting BioDiversity and Biogeochemistry

WP2

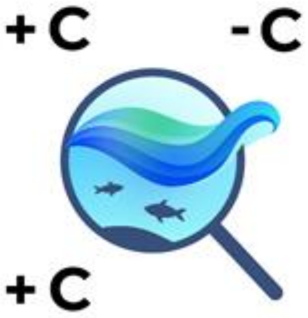
Understanding the Current State of the Ocean Carbon Cycle

WP2 leaders: Siv K Lauvset (NORCE), Andrew Watson (University of Exeter), Marion Gehlen (CEA)
Contributors: UiB, AWI, NOC, LSCE, Heriot-Watt, MI, GEOMAR; in addition all partners will contribute to tasks associated with this work package.

- Model data mismatch
- Role of biology in C_{anth} Uptake
- Role of Ocean physics in regulating Ocean C uptake
- What controls the glacial interglacial cycle in atmospheric CO_2 ?



Global Carbon project



WP3

Impacts of Abiotic Climate Stressors (pH, O_2 & T) on the Biological Carbon Pump (BCP)

WP3 Leader: Jan Taucher (GEOMAR), Heriot Watt (Poulton)
Contributors: GEOMAR, Heriot Watt, Liverpool, NUI Galway, ULPGC, Exeter, LSCE

- Evaluate importance of process
- Define way to include process via simple modification to model
- Implement changes in model to explore impact of changed forcing (climate or human)

Table 1.2.2 Concept Classical BCP	**Methodology** (EX: Experiment; OBS: Observational; DS: Data Synthesis MOD: Modeling)	**Assumption/Hypothesis for Model Inclusion**	**Potential implementation** C:N:P: stoichiometry OM: organic matter PP: primary production EP: export production R: remineralization r: respiration F: particle flux $V_z(x)$: vertical flux of x
Nutrient control over plankton production	(EX, MOD) experiments on dust addition	Biolimitation due to macro- and micronutrients (e.g. Fe)	Fe cycle PP = f(nutrients, Fe)
T and pH control over plankton stoichiometry	(DS) Meta analysis of mesocosm data	T and pH affects organic matter production (stoichiometry) and carbon export efficiency	PP = f(pH, T) EP/PP = f(pH,T)
Biomixing flux of nutrients to surface waters	(MOD) Theoretical model	Enhanced mixing rate	V_z(nutrients) = f(zoo, fish)

WP4

Ecosystem controls on carbon sequestration

WP4 Leaders: Stephanie Henson (NOC) and Javier Arístegui (ULPGC)
Contributors: DTU-Aqua, AMU, AWI, University of Azores,
PML, IIM-CSIC, IMR

- Evaluate importance of process
- Define way to include process via simple modification to model
- Implement changes in model to explore impact of changes forcing (climate or human)

Table 1.2.3: Ecosystem Processes SHUNT	**Methodology** EX: Experiment OBS: Observational DS: Data Synthesis MOD: Modeling	**Assumption/ Hypothesis for Model Inclusion**	**Potential implementation** PP: primary production EP: export production R: remineralization r: respiration F: partile flux $V_z(x)$: vertical flux of x
Twilight Zone Carbon (Diel Vertical Migration)	(DS) Synthesis of existing acoustic data	DVM increases downward flux transport	Enhanced vertical flux in model F = f(zoo, t, I)
Lipid Pump	(DS) Analysis of high latitude copepod lipid content vs water depth	Altered depth and mortality of animals during year	F = f(zoo, z,t)
Dark Carbon Fixation	(DS) Data synthesis and Experimental work	photosynthesis coupled to interior conditions	PP = f(z, T, …)
Whale Pump (nutrient recycling via whale faeces and urine)	(OBS) Nutrient concentration in whale excretions	Adding of nutrients increases PP	Vz(nutrients) = f(whale, …) _impact of adding nutrients
	(MOD) Dissolution rates in seawater	Whales increase Production	Vz(nutrients) = f(whale, …) _impact of adding nutrients

WP5

Impacts of Fishing and Industrial Extraction processes on the Ocean C cycle

WP5 Leaders: Dave Reid (Marine Institute), Matthias Hauckel (GEOMAR)
Contributors: NIOZ, PML, DTU-Aqua, English Nature, Agrocampus Rennes, Strathclyde University, SPC

- Evaluate importance of process
- Define way to include process via simple modification to model
- Implement changes in model to explore impact of changed forcing (climate or human)

Table 1.2.4 Ecosystem Processes LEVER: Fishing	Methodology EX: Experiment OBS: Observational DS: Data Synthesis MOD: Modeling	Assumption/Hypothesis for Model Inclusion	Potential implementation
Overfishing: restructuring	MOD: (STRATH E2E, ECOPATH, ECOTROPH, ECOSIM)	Alters grazing pressure on Zooplankton	Increase Fishing Pressure to High level
Restoration of biomass	(MOD): Trophic Cascade model (NUM FEISTY)	Alteration of grazing pressure on lower trophic levels.	Reduced fishing mortality Remove fishing Pressure
Removal of fixed C from ocean in fishing	(DS): Fisheries removal/harvesting	Biomass removal from system	High level of grazing on Fish
Discard	(DS) Discard-natural mortality data synthesis	Biomass transport to depth	Increase Downward Flux

Table 1.2.5 MTDD LEVER Mining (M) Trawling (T) Dredging (D) Drilling (Dr)	Methodology EX: Experiment OBS: Observational DS: Data Synthesis MOD: Modeling	Assumption/Hypothesis for Model Inclusion	Potential implementation
Sediment additions	(MOD) GETM ERSEM shelf (T+D)	Modification of ballast	Enhanced vertical flux in model
	(MOD) OMEDIA Open Ocean (M+Dr)	Reduced Feeding success	Parameterisation and analysis of trawling impacts on benthic-pelagic POC exchange
	(MOD) MIT GCM Open Ocean (M+DR)	Reduction in PAR	Adjust attenuation length scale for light
CO2 additions	(OBS) Loss of CO2 from sediments (M)	Enhanced CO_2 flux to water column	$Vz(CO_2) = f(trawl,...)$ Parameterisation and analysis of trawling impacts on benthic-pelagic DIC exchange.

WP6

Determine significance of key processes in the evolving Ocean C Cycle

The WP6 Leaders: Iris Kriest (GEOMAR) and Jerry Blackford (PML)

Contributors: DTU, IMR, BB, CEA/LSCE, UiB, NORCE and all partners.

Domain	Model	Features
Physics	(1) GOTM	1D water column
	(2) TMM	3D global steady state
	(3) BLOM	3D global, part of NorESM2
	(4) NEMO	3D global and regional
	(5) GETM	3D regional
	(6) ROMS	3D regional
	(7) UVic	3D ESM
Biogeochemistry	(8) MOPS	7? pelagic variables
	(9) UVic	9 pelagic variables
	(10) iHAMMOC	11? pelagic variables
	(11) PISCES	24 pelagic variables
	(12) ERSEM	55 pelagic variables 34 benthic variables
	(13) BFM (CMCC-ESM2 configuration)	32 pelagic variables 14 benthic variables
	(14) OMEXDIA	variables, sediment only
Higher Trophic Levels	(15) FEISTY	Trait based fish model to predict foodweb biogeography
End to End Models	(16) StrathE2E	26 variables across nutrient to top predators
	(17) Ecopath, Ecosim and Ecospace	50 functional groups for Celtic Sea, 1985-2016

Model type	1D Test beds			3D Test beds				3D Climate				Fish	
Physical Model	1			2		7	5	4	4	3	4	4	4
Biogeochemical Model Process	8	15	12	8	9	15	12	8	12	10	12	17	16
Nutrient control over plankton production													
Nutrient control over plankton stoichiometry													
Biomixing flux of nutrients to surface waters													
O_2, T, and pH control of sinking particles													
Trophic Cascade Carbon													
Controls on remineralisation depths													
CaCO3 production and sensitivity													
Twilight Zone Carbon (Diel Vertical migration)													
Lipid Pump													
Dark Carbon Fixation													
Whale Pump (bouyant faeces)													
Marine Vertebrate mediated carbon													
Deadfall carbon													
Fishing													

WP7

Decision Support Tools
for Ocean Carbon Management

The WP7 Leaders are: Michael St John (DTU) & Jorn Bruggemann (Bolding & Bruggemann Aps) - Contributors: METU, SSBE

- Help policy makers, licencers, practitioners make better decisions
- Where to sample the ocean
- What will the effect of extraction pathway x be on the Ocean C cycle
- What will the combined effects of climate change and resource extraction be on the Ocean C cycle
- Combine models and data via machine learning
- Link to Digital twin
- Multiple scales
- Precise Details unclear

FluxEngine: A Flexible Processing System for Calculating Atmosphere–Ocean Carbon Dioxide Gas Fluxes and Climatologies

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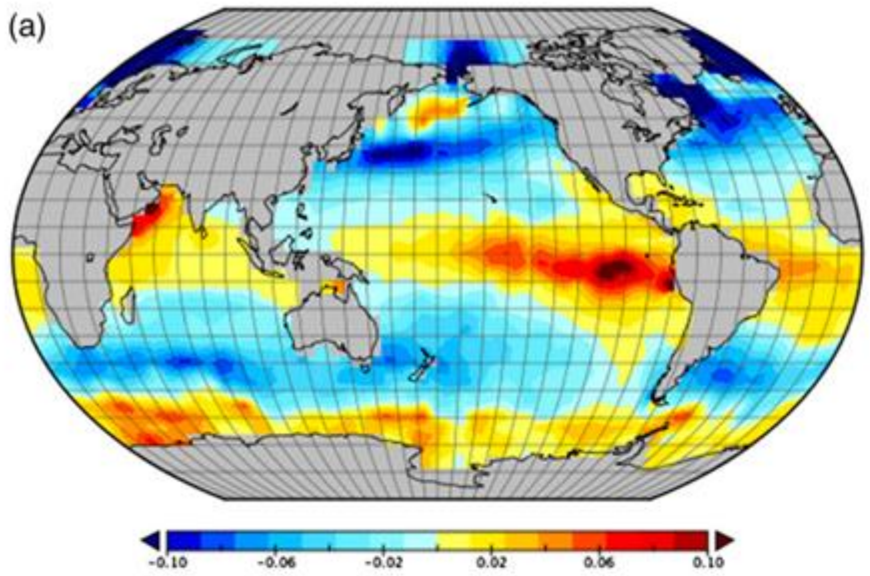

WP8

Connecting OceanICU to Society

The WP8 Leaders are: Debbi Pedreschi (MI), Mary Wisz (WMU), Nathalie Van Isacker (SSBE) - Contributors: GEOMAR, DTU, NORCE

- Climate End users, Fisheries End users, Industrial end users

- What do they need to know?

- What extraction pathways do they foresee?

- What format do they need information in?

Do you work in a blue economy industry such as fishing, mining, offshore renewable energy, tourism or oil and gas? Are you a manager, decision-maker, scientist or policy-maker? Or are you a citizen interested in climate change and its relationship with a sustainable blue future? If any of these apply to you, why not join us on our mission to improve carbon understanding for a healthy and resilient Ocean and sustainable blue economy? Get in touch via the sign-up form to join our stakeholder panels where you can get the opportunity to take part in workshops, consultations or receive notifications about forums, webinars and other events. If you are already involved, please help us spread the word.

SIGN UP

Understanding Ocean Carbon

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