



Climate and marine ecosystem modelling

Climate and Marine primary Production

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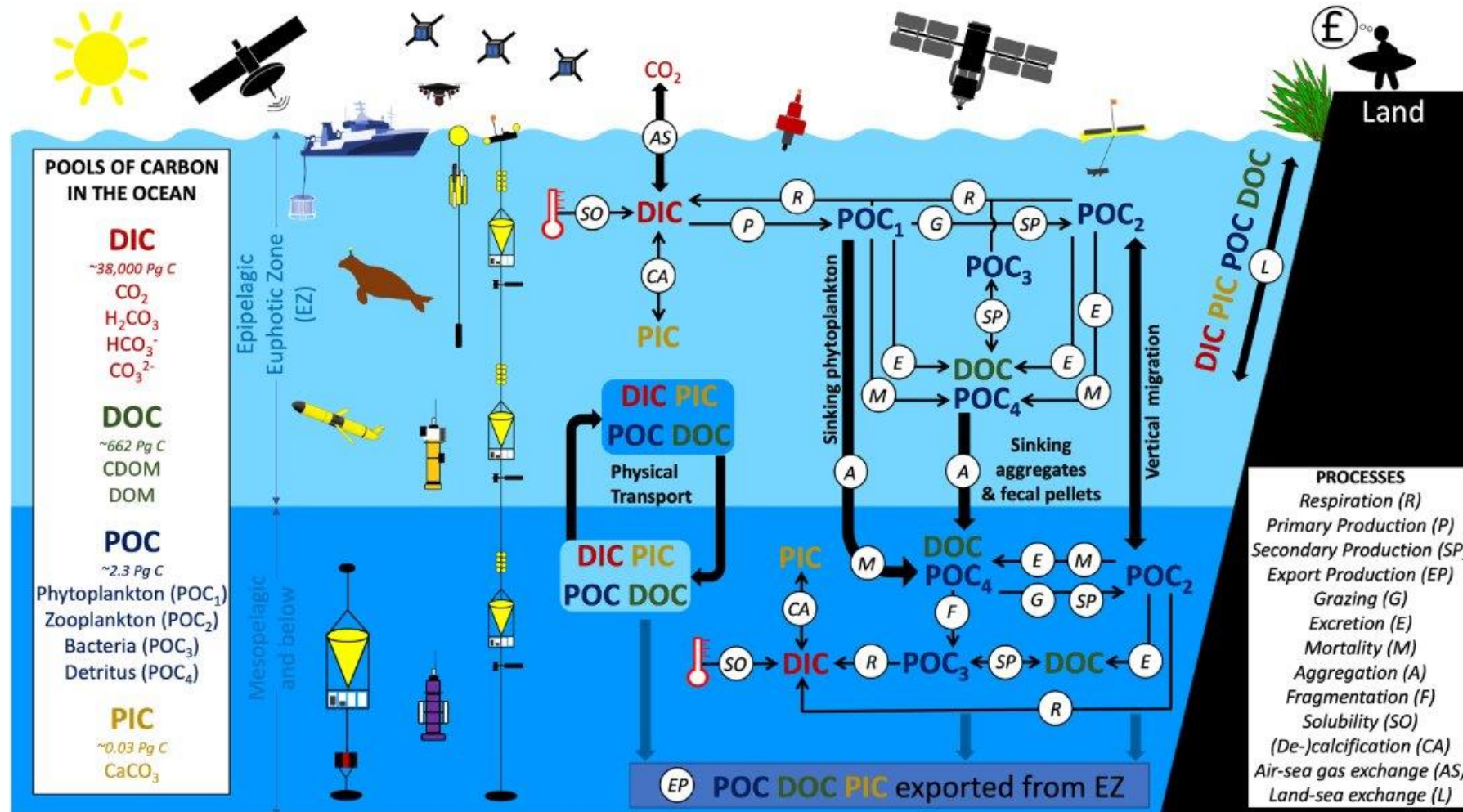
PML | Plymouth Marine Laboratory

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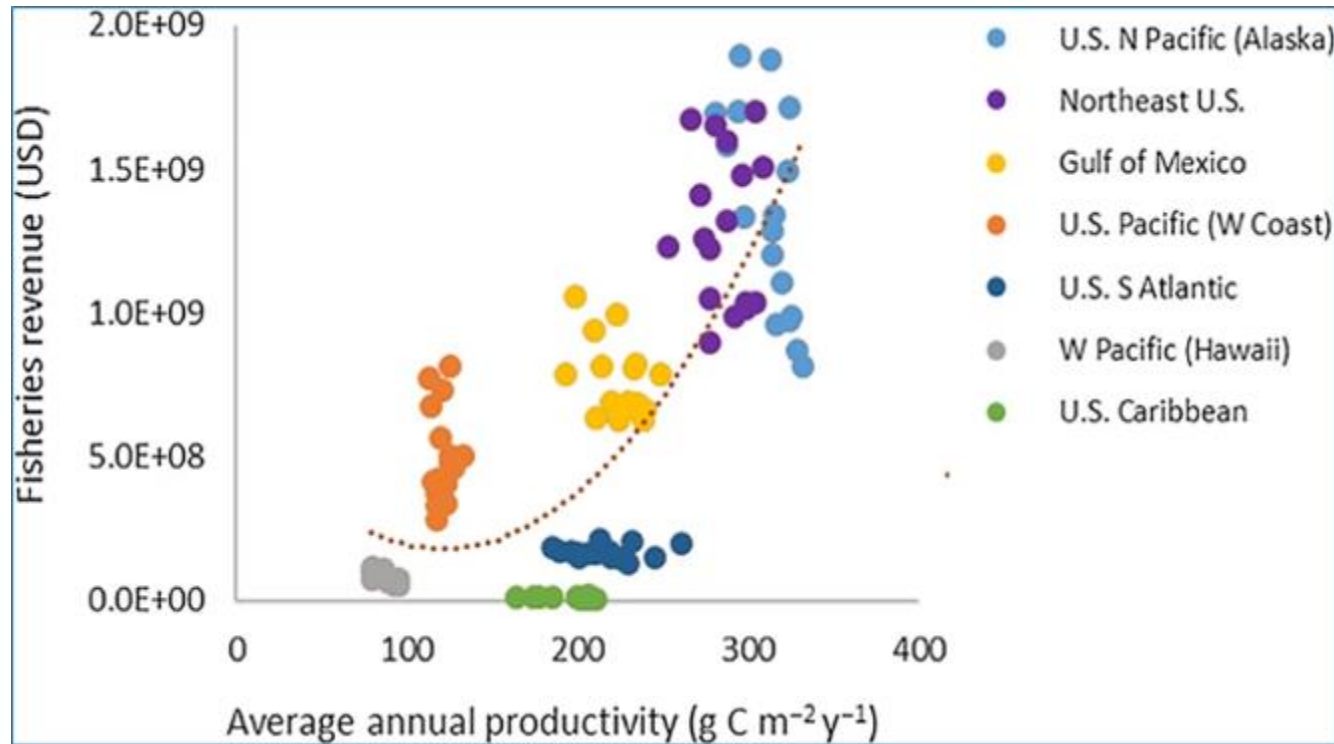
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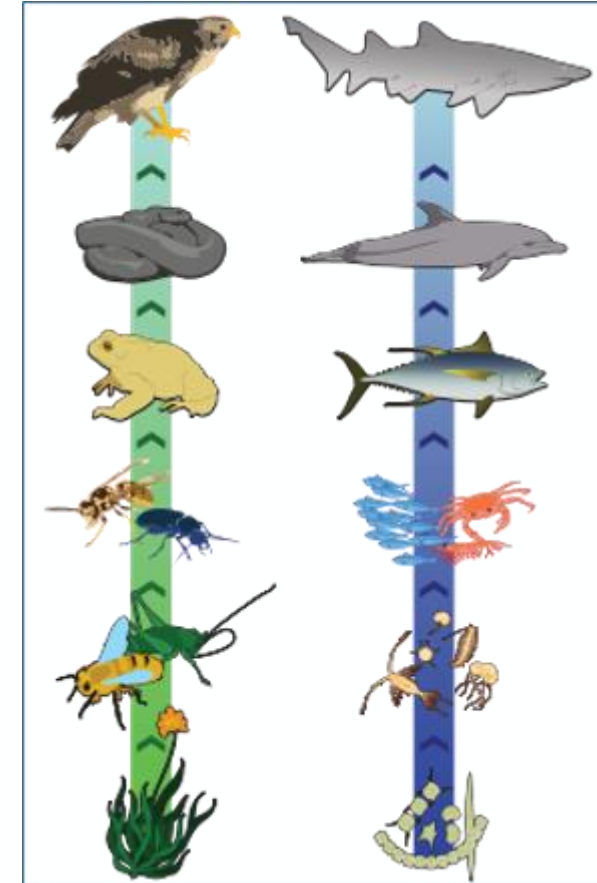
Project Objectives



Primary production sustains pelagic ecosystems and living marine resources

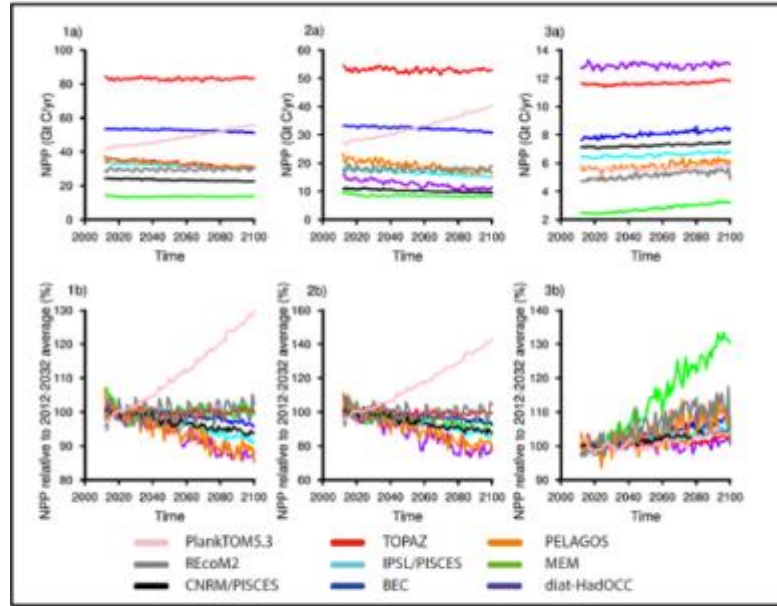


from Marshak and Link (2021)

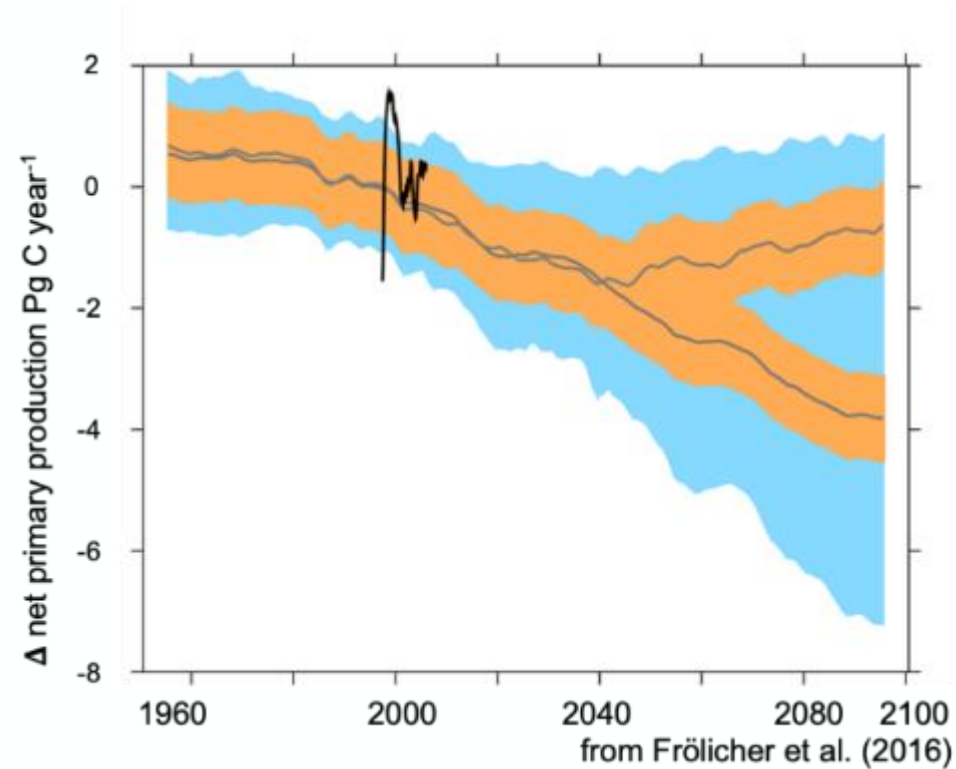


From Study.com

High uncertainty in projections of modelled primary production

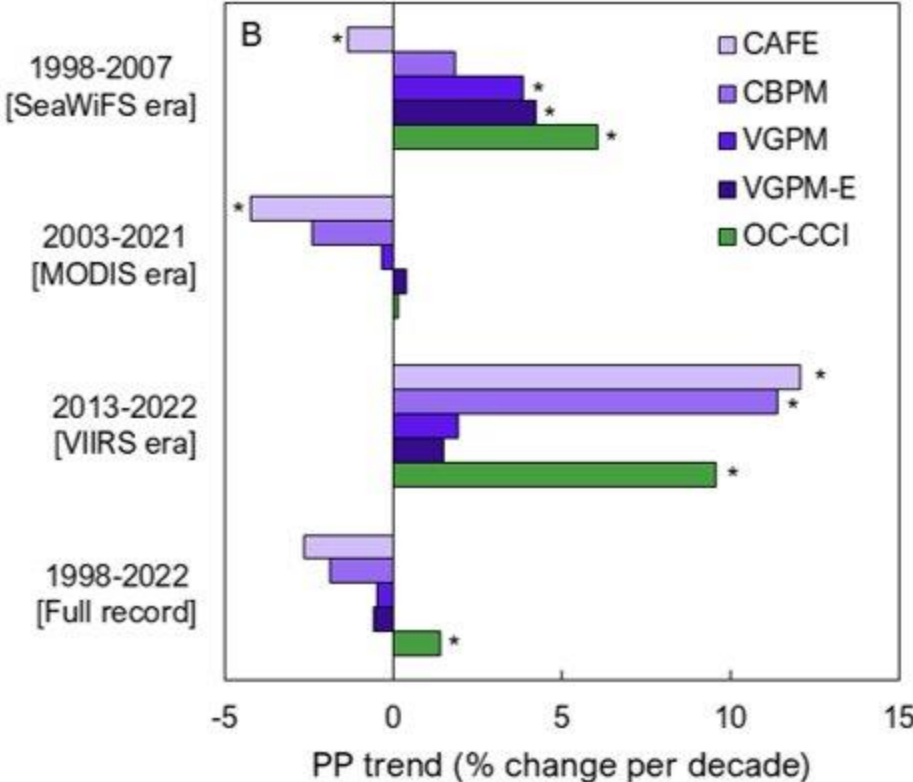
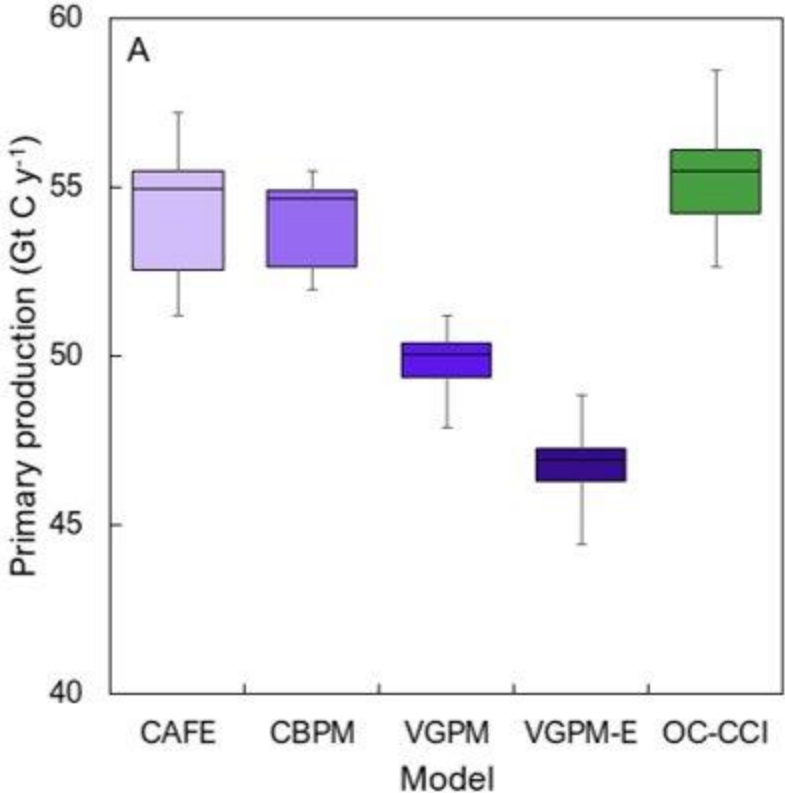


From Laufkötter *et al.* 2015



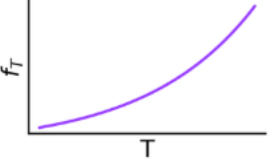
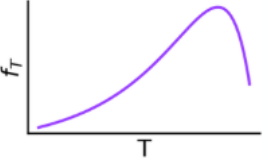
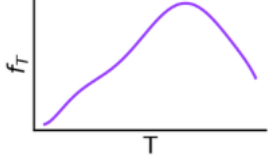
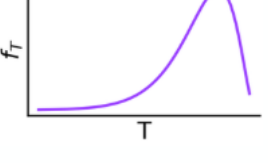
from Frölicher *et al.* (2016)

High uncertainty in current trends estimated from satellite data



From Skakala et al. (2026) under revision

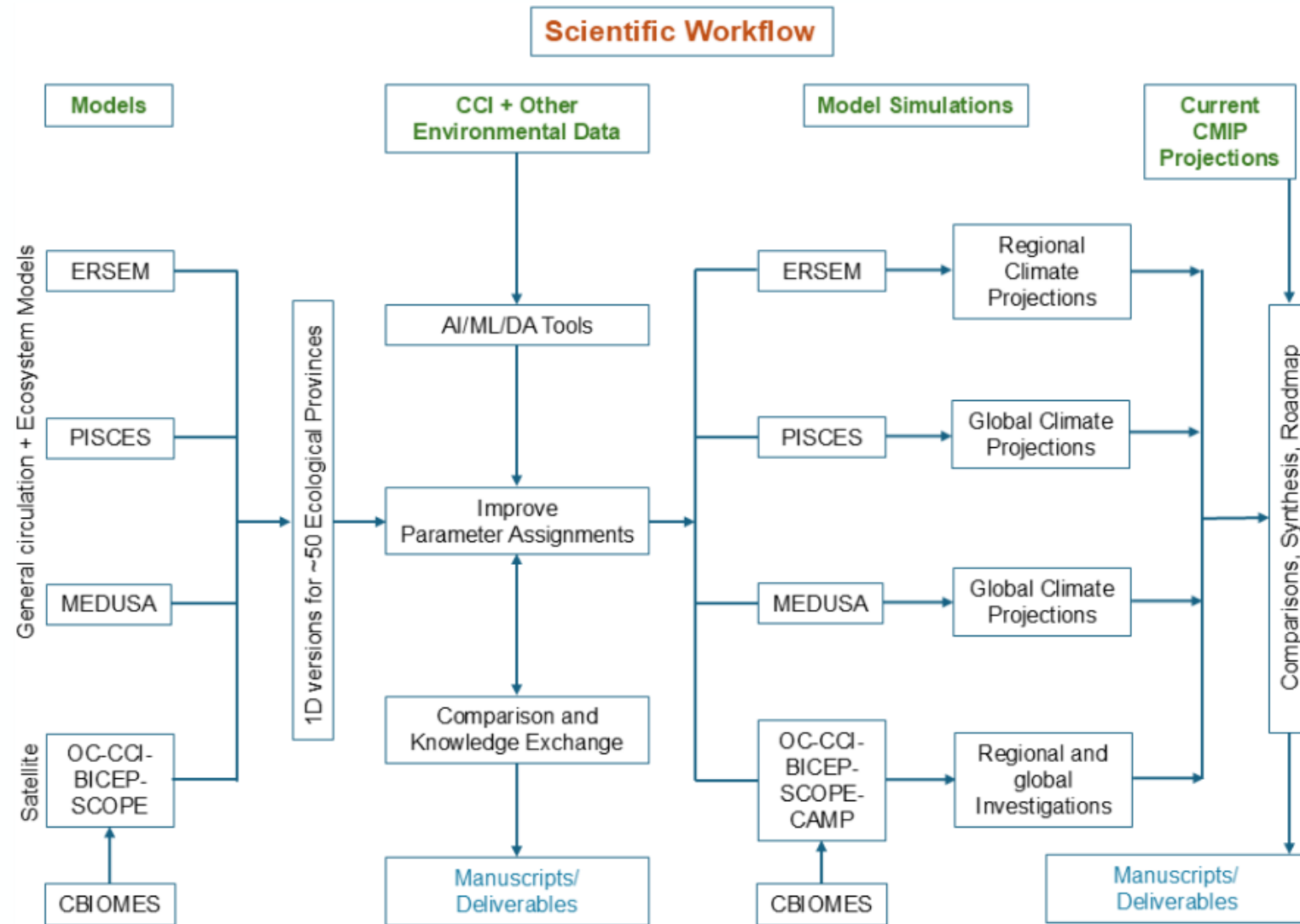
Example of Temperature Limitation on Photosynthesis

Process / Structure	Equation	Description & remarks	Graphical Representation	Examples	Key References
Temperature limitation on photosynthesis	$f_T = e^{A_1 T}$	Exponential temperature dependence on growth rate.		BAHMBI, MEDUSA, NEMURO, BFM, PISCES, PELAGOS, COBALT, DARWIN	Eppley (1972)
	$f_T = Q_{10} \frac{T-A_2}{A_2} - Q_{10} \frac{T-A_3}{A_4}$	Phytoplankton growth rate increases initially exponentially, with enzyme inhibition above optimal temperature		ERSEM	Blackford <i>et al.</i> (2004)
	$f_T = \sum_{i=0}^7 D_i T^i$	Phytoplankton growth rate is represented as an empirical seventh-order polynomial function, fit to observed data.		Vertically Generalised Production Model (VGPM)	Behrenfeld & Falkowski (1997)
	$f_T = A_5 \times e^{A_6 \times T} \times \left(1 - \frac{T - A_7}{A_8}\right)^2$	Function designed to model individual phytoplankton species or types according to their temperature traits, in multi-species models. It has yet to be used routinely in global-scale simulation models, except in a special case of DARWIN.		A version of DARWIN	Norberg (2004), Thomas <i>et al.</i> (2016); Sauterey <i>et al.</i> (2024); Krinos <i>et al.</i> (2025)

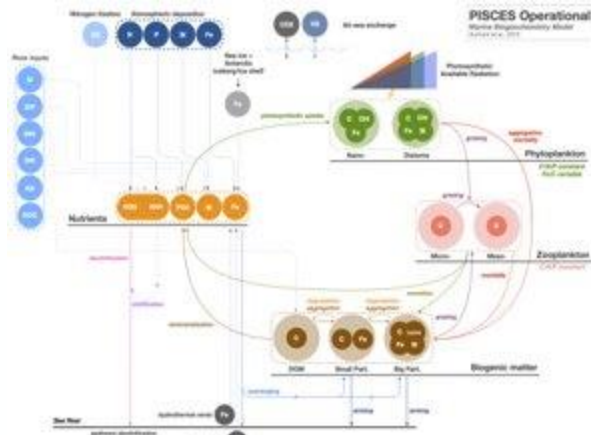
From Skakala *et al.* (2026) under revision

Skeleton overview of the approach

- Global-scale, regional-scale and local-scale (1D) analyses of parameter variability.
- Three ecosystem models (PISCES, MEDUSA and ERSEM) are being used.
- One satellite-based model of marine primary production
- Extensive use of CCI and other satellite data, along with in situ data (BGC-Argodata, and ship-borne observations)
- Tools: Data Assimilation, theoretical sensitivity analyses
- Comparison with CMIP Projections

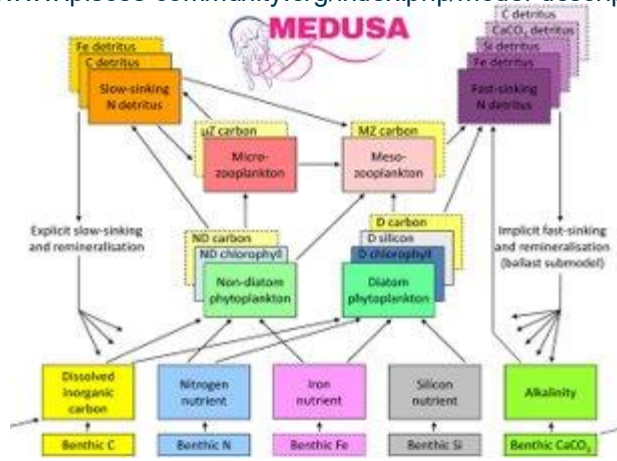


PISCES
Aumont *et al.* (2015)



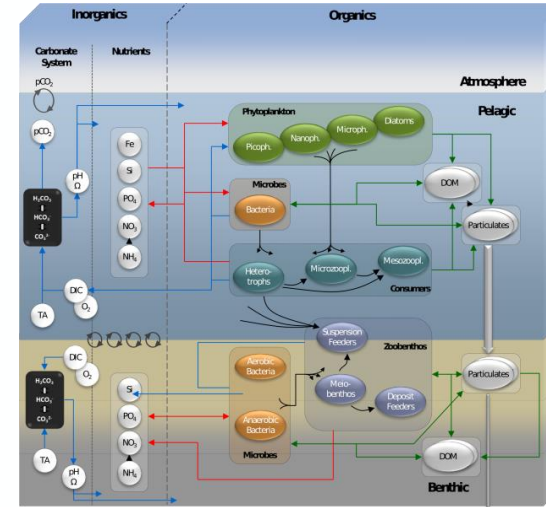
<https://www.pisces-community.org/index.php/model-description/>

MEDUSA
Yool *et al.* (2013)



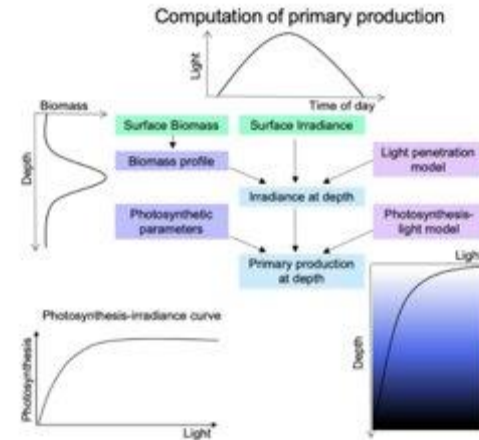
<https://projects.noc.ac.uk/medusa/>

ERSEM
Butenschön *et al.* (2016)



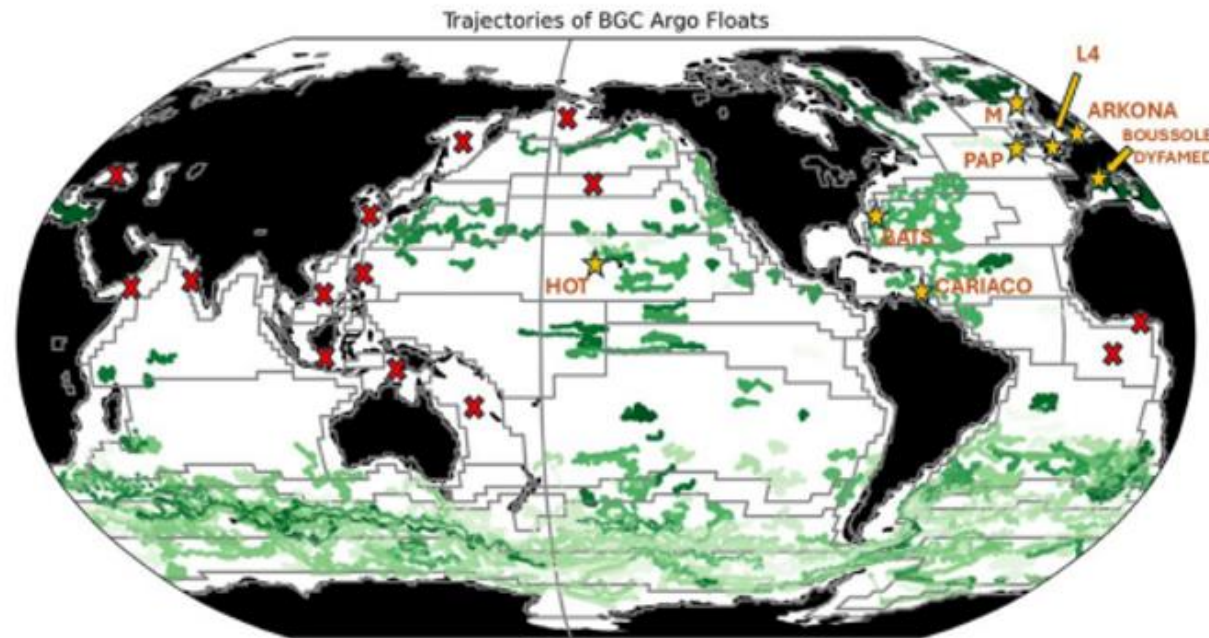
<https://github.com/pmlmodelling/ersem>

EO-PP
Platt and Sathyendranath (1988), updated by Sathyendranath *et al.* (2020) and Kulk *et al.* (2020, 2021)

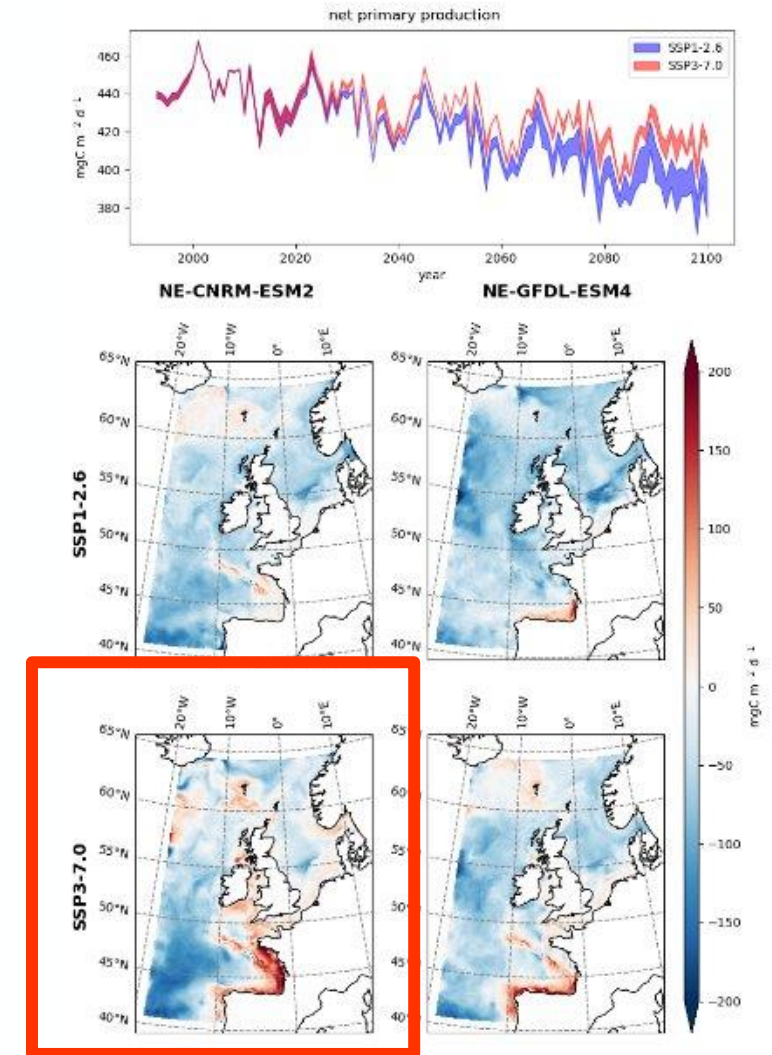


T1: Implementation of 1D model configurations on global domain

- 1D water-column models along the tracks of ~40 BGC-Argo trajectories, representing ~57 Longhurst (biogeochemical) provinces
- Satellite ECV data along the trajectory, and monitoring data where no BGC-Argo available
- Augmented with WOA, SOCAT/GLODAP datasets



- A set of four regional projections for the North-Western European shelf has been analysed.
- All four projections simulate a decrease in netPP.
- NE-CNRM-ESM2 under SSP3-7.0 scenario exhibits the more contrasting pattern of change.
- This will constitute our reference simulation



Thank you



ESA Climate and Marine primary Production- 3 year project

