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From physics to fish:

impact of two-way coupling between a higher and lower trophic level model on carbon cycling on the North West European Shelf

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MEAP-TT meeting
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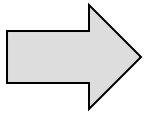
Background

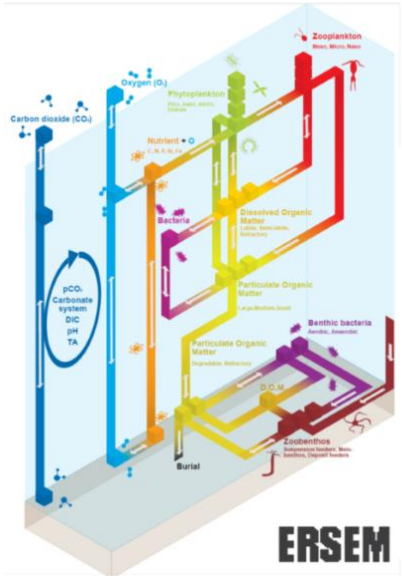
- The marine system is complex with both bottom up and top down processes influencing marine ecosystems
- In order to accurately model these systems and make realistic predictions both top down and bottom up processes need to be taken into account
- Commonly higher trophic level models use inputs from lower trophic levels models that has already been run

From physics to fish

NEMO: Hydrodynamics



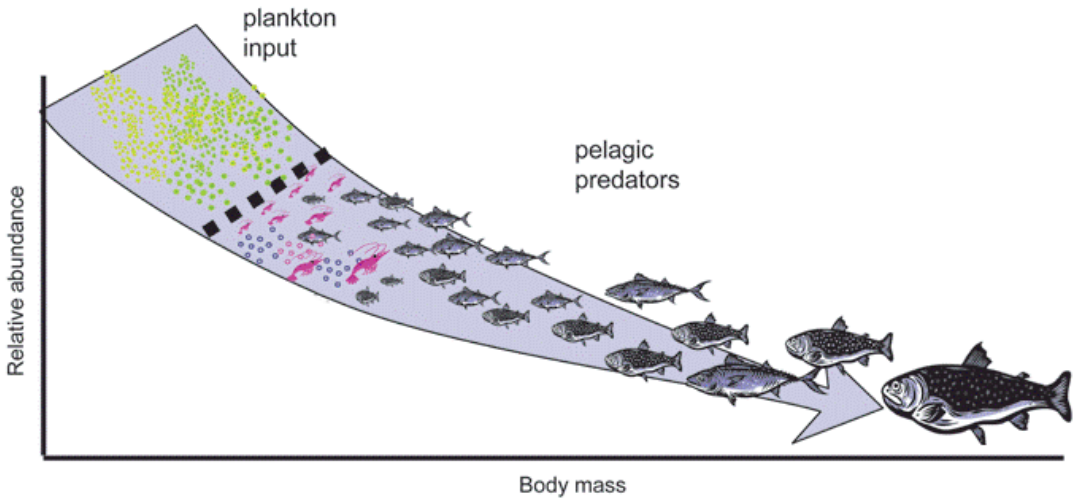
ERSEM: nutrients and plankton



Features:

- Complete model chain from photons to fisheries
- Online coupling, two-way feedbacks
- Spatially explicit

A size-based perspective



Community Size Spectrum Model (based on work by Julia Blanchard)

- 100 size classes: 1 mg – 1000 kg (no explicit species)
- depth-integrated (unit: g/m^2)
- one key rule: large eats small (optimal predator : prey mass ratio = 100)

Other Caveats:

- pelagic stocks only (no demersals)
- No advection/swimming
- Constant spatial and temporal fishing pressure

Simulations

3 Simulations – AMM7 NW European Shelf domain: 1981-2017

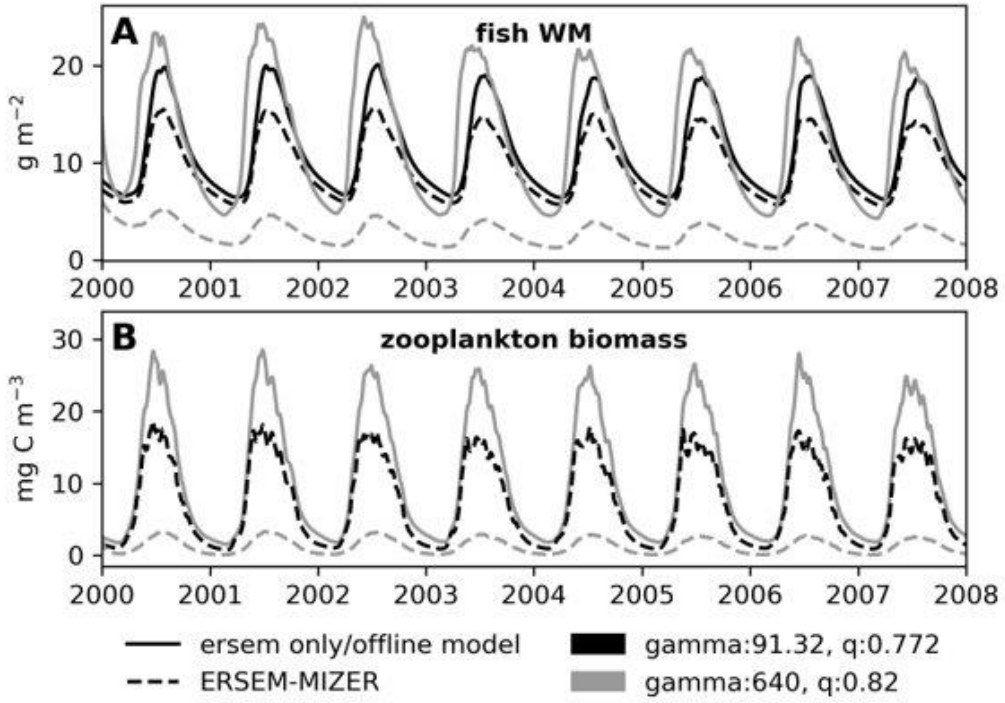
1. Baseline NEMO-FABM-ERSEM simulation

2. Offline FABM-MIZER simulation

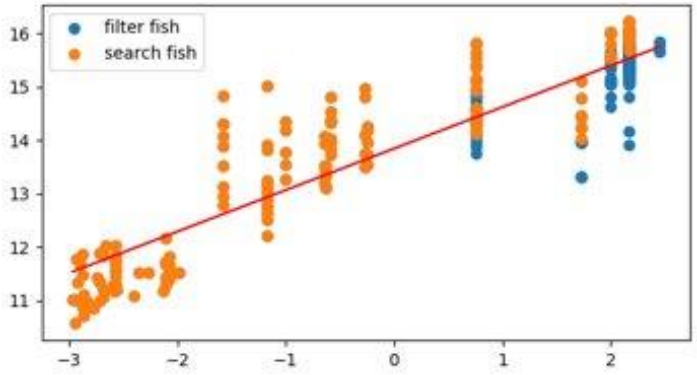
3. Two-way coupled NEMO-FABM-ERSEM-MIZER

Compare:
Two way coupled vs offline: **fish**
Two-way coupled vs baseline ERSEM: **LTL**

Parameterisation



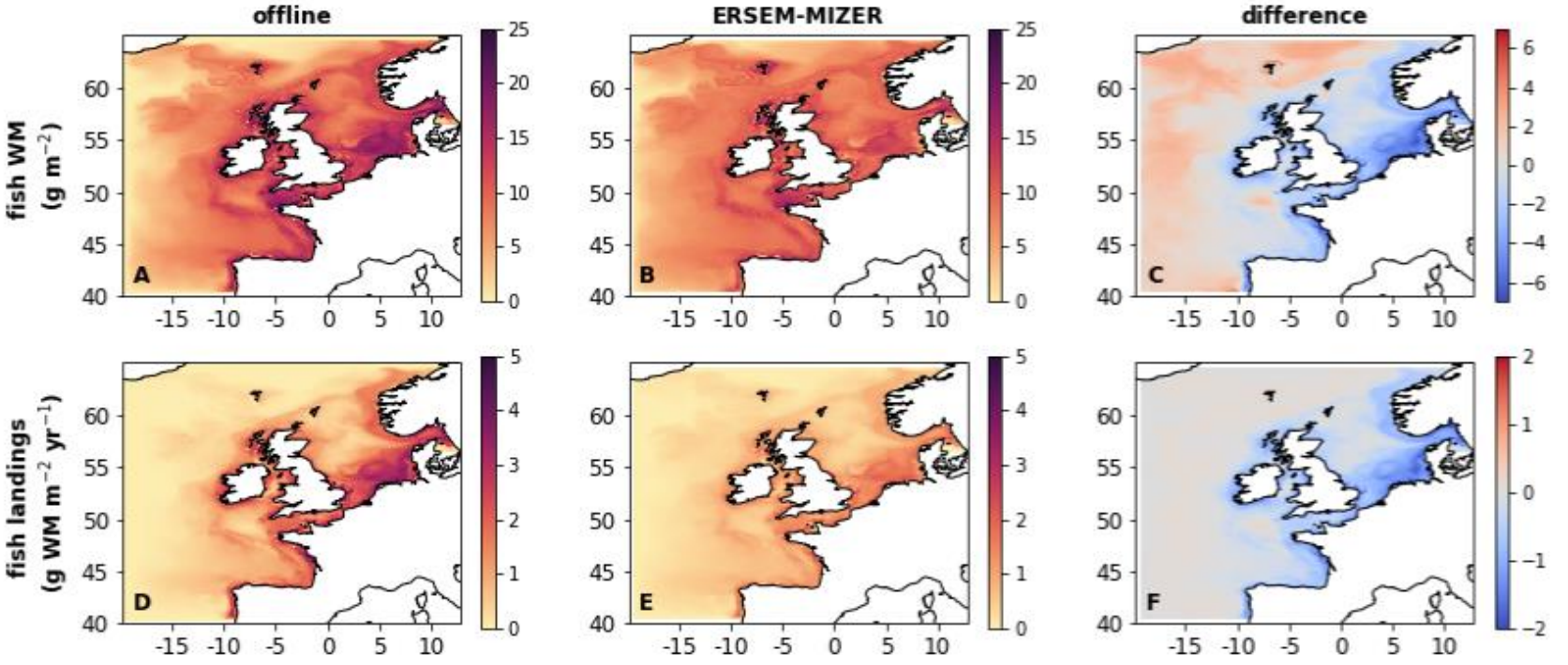
Data from Acuna et al., 2011



Slope (q)= 0.776
Intercept(gamma)= 13.843=91.32

- Changed clearance rate parameters for fish
- Removed mesozooplankton cannibalism
- Set mesozooplankton background mortality to 0

Results - Fish wet mass, and fish landings



- Contrasting differences between shelf and open ocean in response to two way coupling

Results - Fish landings validation

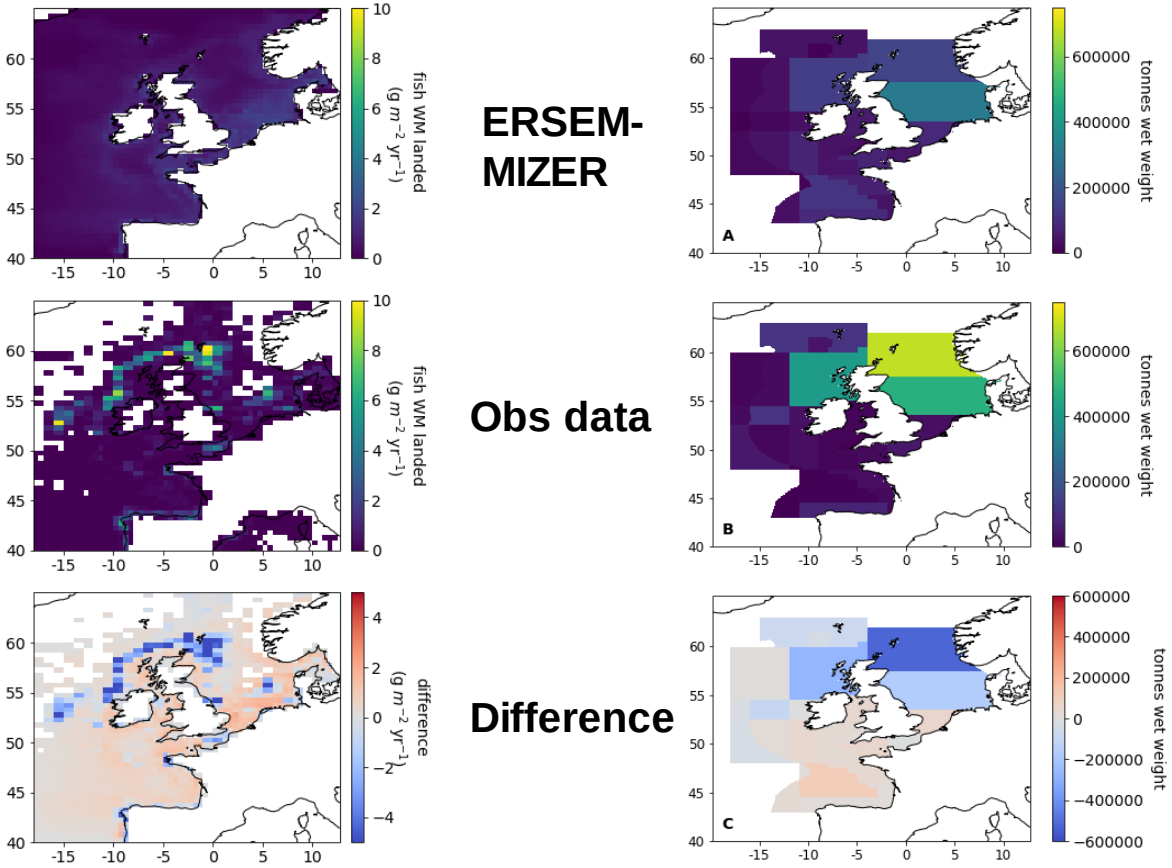
STECF data 2015-2020

ICES data: 2006-2021

ERSEM-MIZER

Obs data

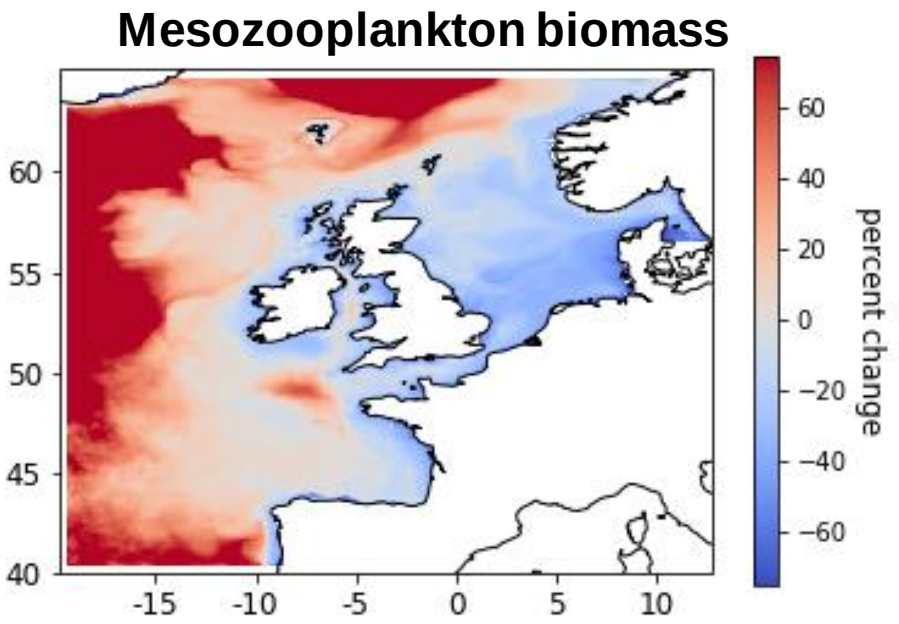
Difference



- Extracted pelagic fish from observational data

Results - Meszooplankton

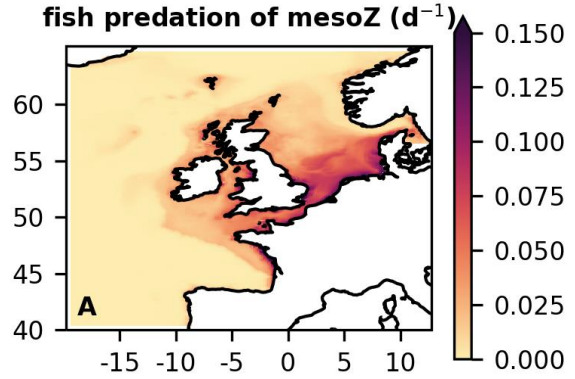
Mean Impacts on biogeochemistry/lower trophic levels



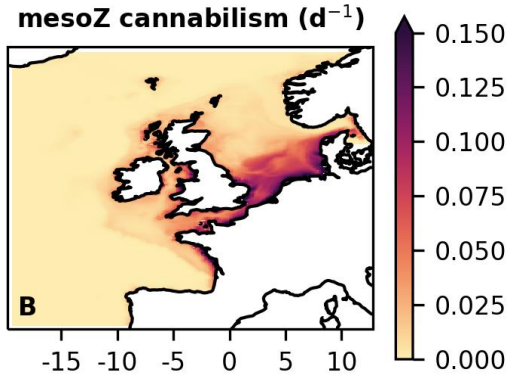
- Decline in biomass on shelf, increase offshelf
- **Onshelf**:
  - declined due to predation pressure from fish
- **Offshelf**:
  - Due to lower mortality/lack of cannabilism with fish exerting a lower pressure

Results - Meszooplankton

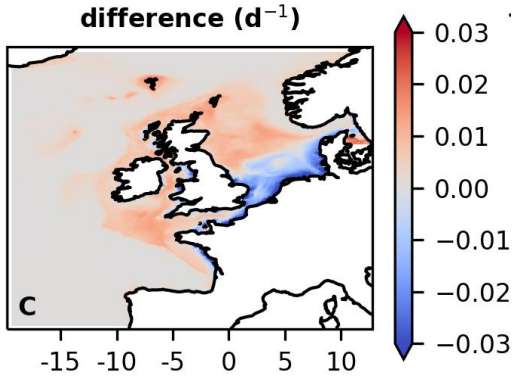
ERSEM-MIZER

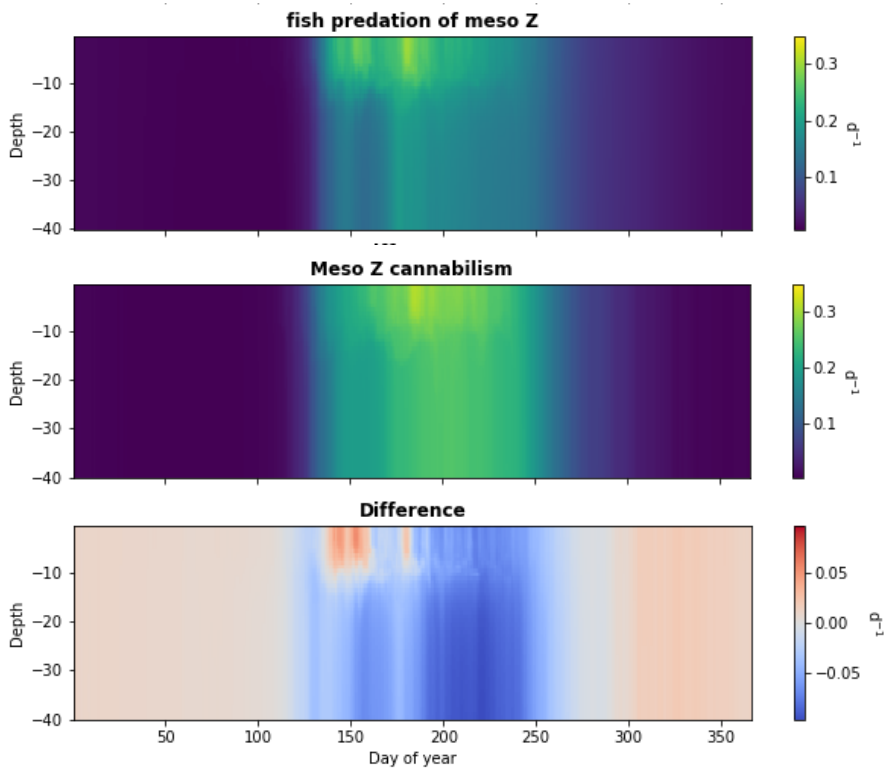


ERSEM



ERSEM_MIZER - ERSEM

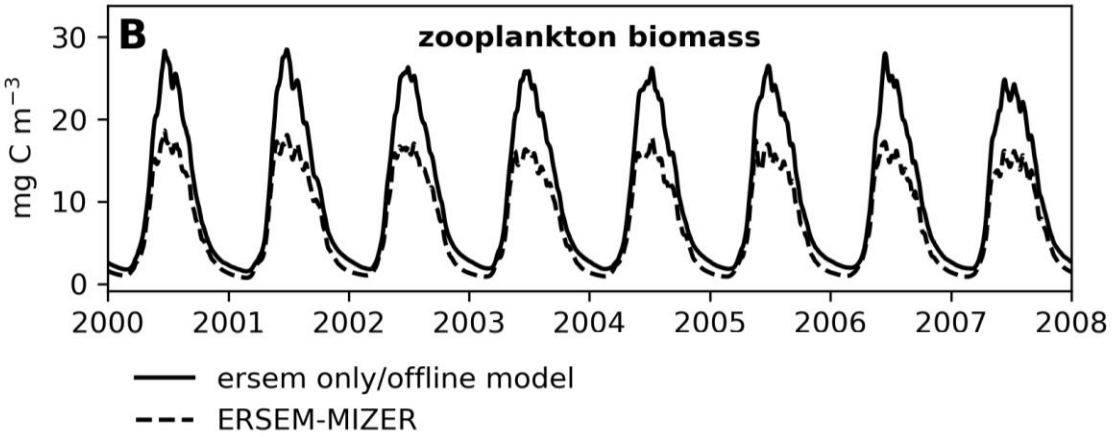


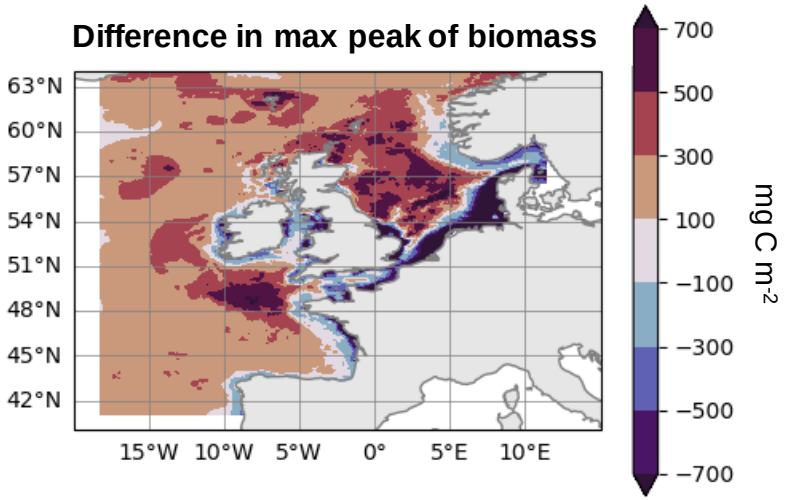


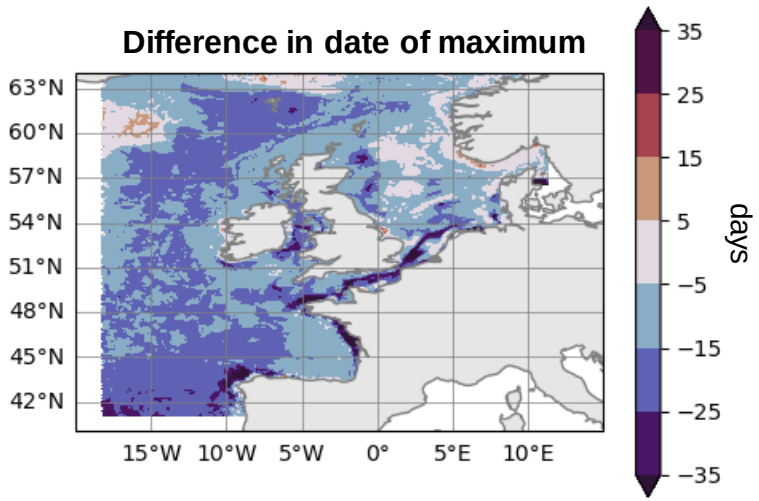
- Spatial (x,y,z) differences occur between mesozooplankton cannabilism and fish predation
- Impacts carbon cycling on the shelf.

Results - Meszooplankton

Mesozooplankton phenology

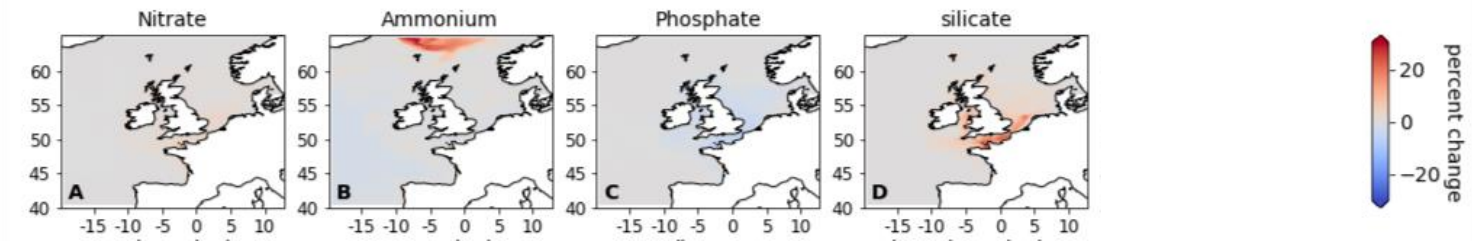






Mesozooplankton maximum is up to a month earlier in ERSEM-MIZER

Mean Impacts on biogeochemistry/lower trophic levels



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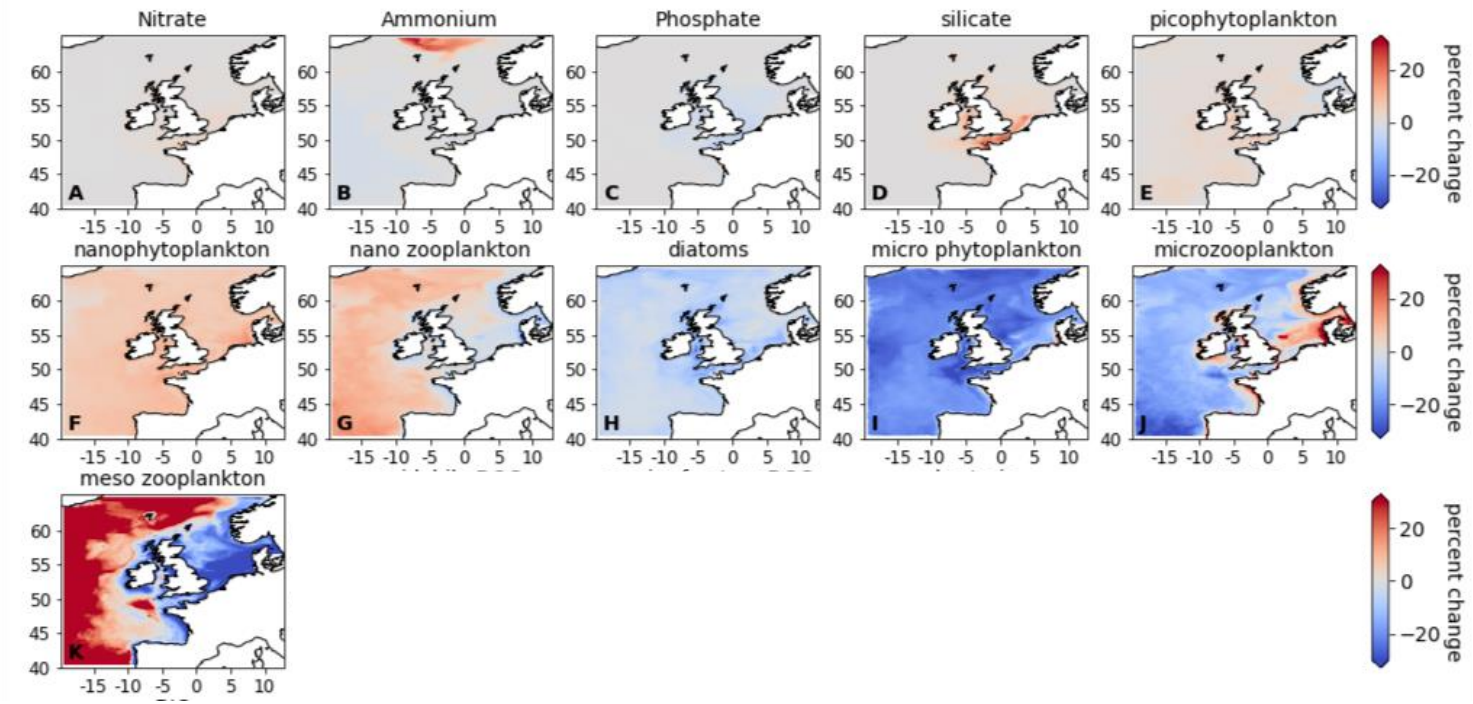

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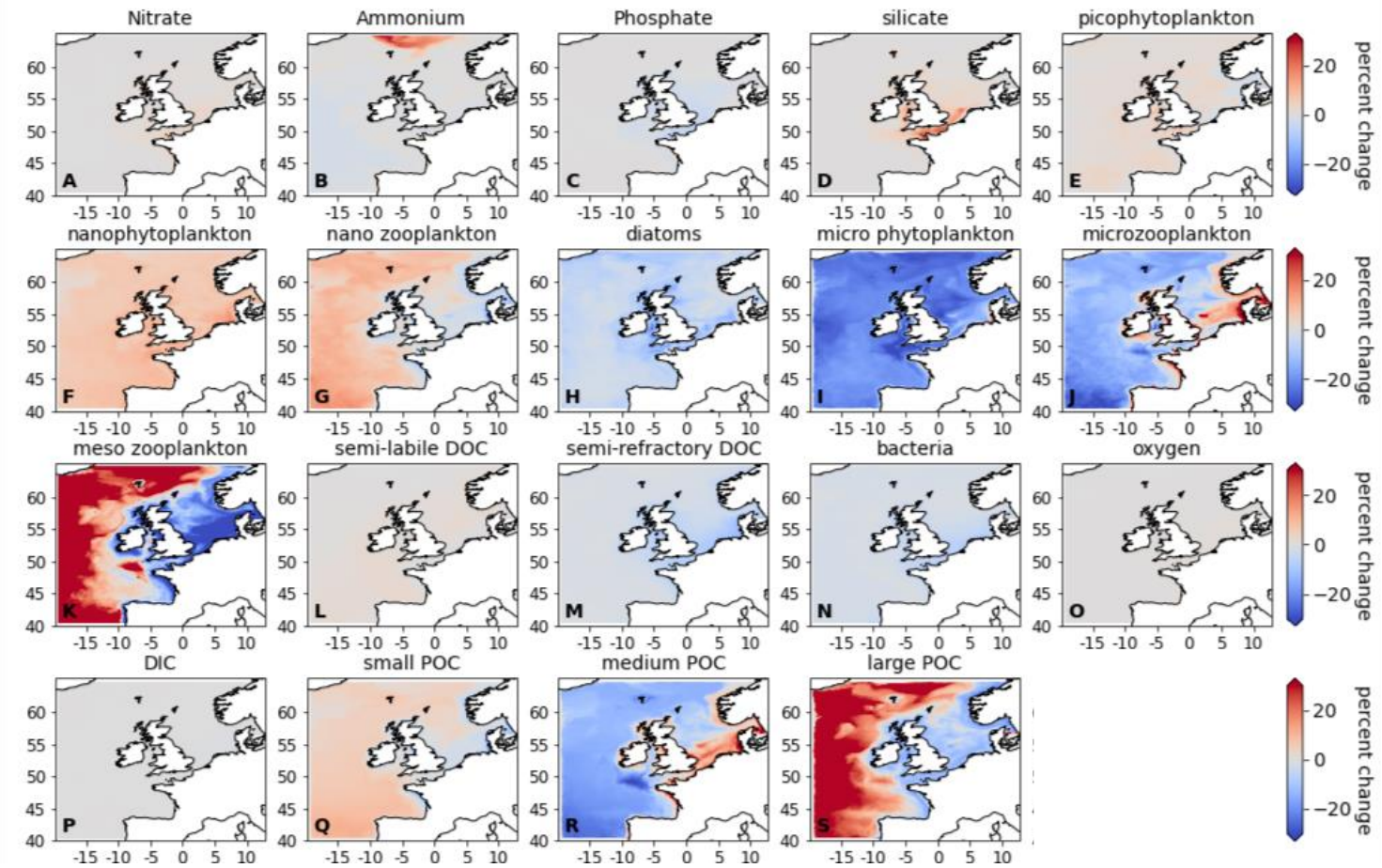

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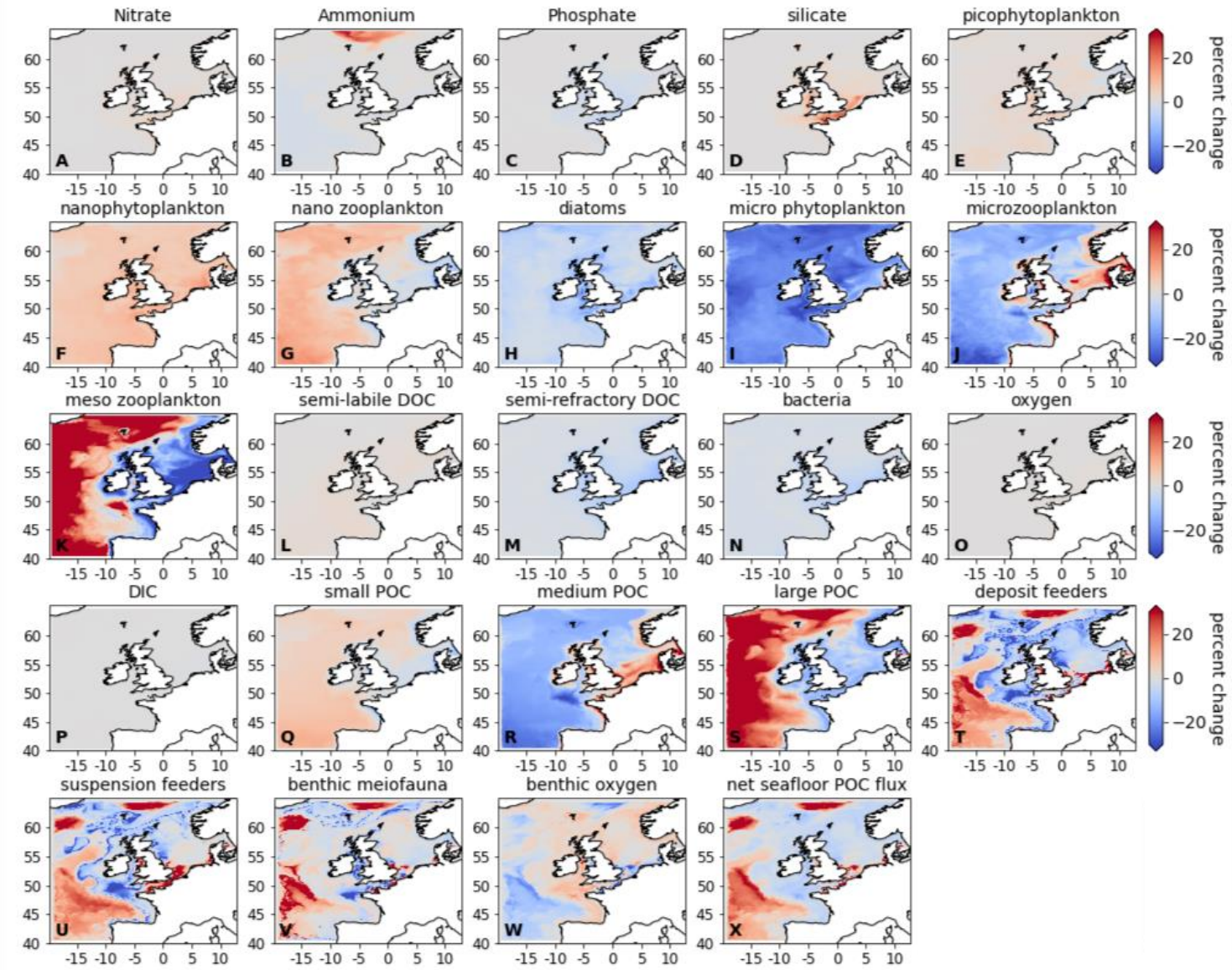
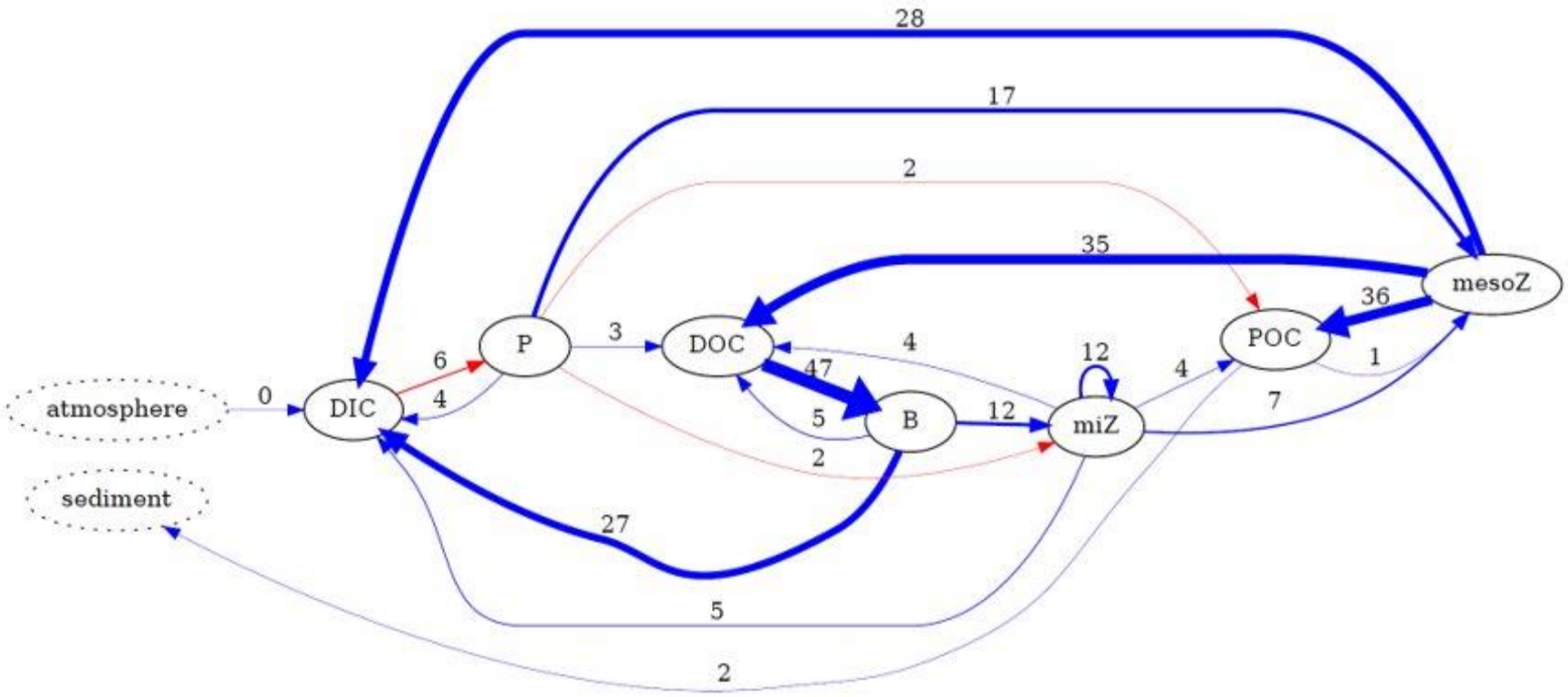
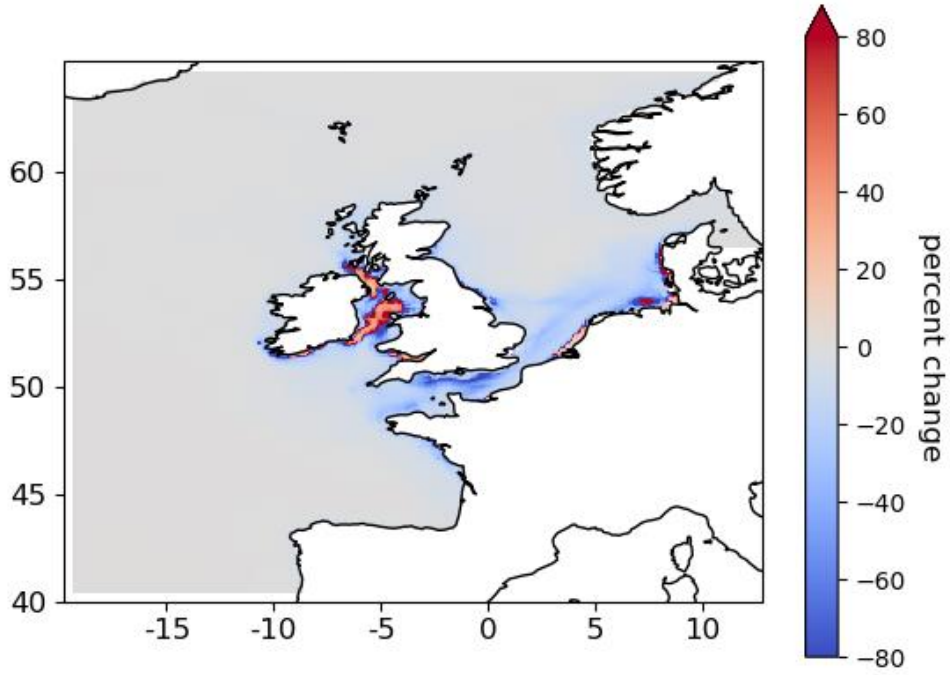


Impact on carbon cycling of whole ecosystem: ERSEM_MIZER – ERSEM only



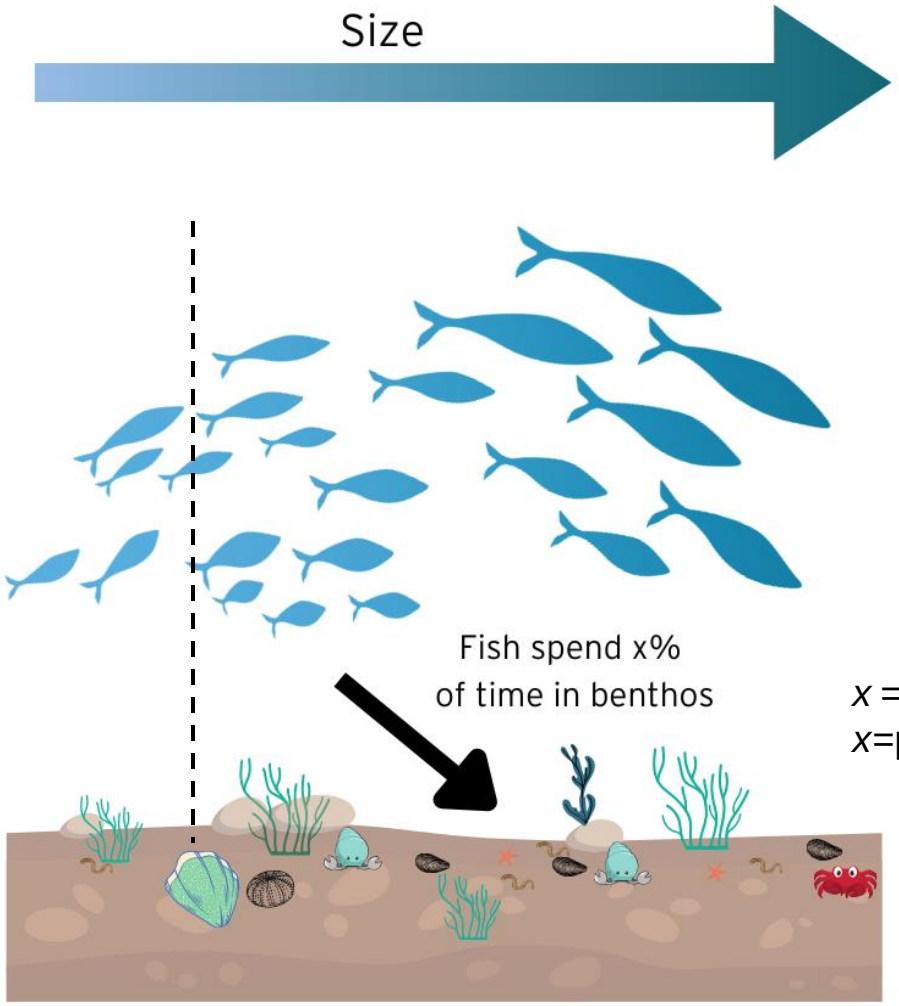
Carbon cycling in the whole ecosystem is reduced with the exception of phytoplankton fluxes

Change in air-sea exchange of CO_2



Next Steps

- Add in benthic feeding by fish



x =constant
x=pelagic plankton: total food

Conclusions

- New **fully coupled** framework allowing the study of both **bottom up** and **top down** impacts of the marine ecosystem
  - 3D – depth resolved feedbacks to the marine system + high spatial resolution

- Mesozooplankton were most strongly impacted
  - Parameters in MIZER and ERSEM needed to be changed to ensure survival
  - Suggests current parameterisation in both ERSEM and MIZER is **not adequate** to capture dynamics of two-way coupled system

- Impacts are seen across the **whole ecosystem** with a **reduction** in **carbon cycling** occurring

- Improvements are still being made to the model – work in progress!

Thank you

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