National Oceanography Centre

Controls on oxygen response to climate change on the Northwest European Continental Shelf

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Background

- Climate change affects dissolved oxygen in the ocean through:
  - changing water temperature and salinity (affecting oxygen solubility)
  - increasing biological cycling rates (affecting photosynthesis/respiration)
  - altering nutrient supplies that feed phytoplankton production
  - changing water column stratification (affecting vertical mixing).

- Driven by solubility and nutrient supply changes, there has been a global decline in dissolved oxygen concentrations since at least the middle of the 20th century*.

- In shelf seas
  - under seasonal density stratification, oxygen can become depleted below the pycnocline;
  - low oxygen concentrations are replenished when seasonal stratification breaks down.

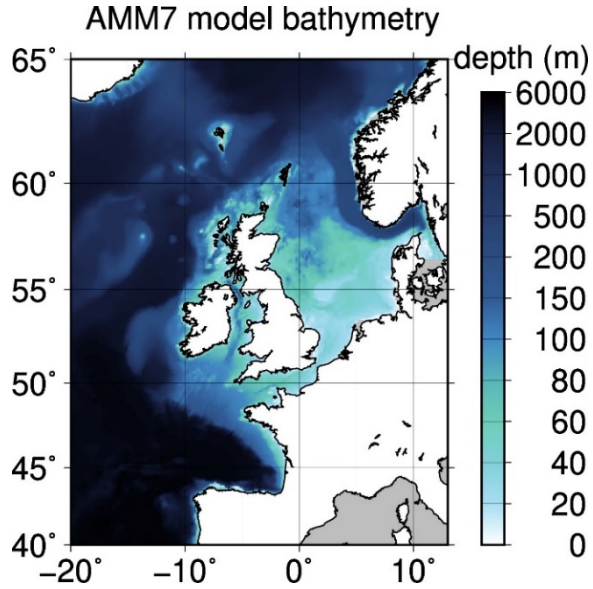
- We investigate *solubility* and *ecosystem* controls on near-bed oxygen concentrations for the northwest European Continental Shelf under the RCP8.5 “business as usual” climate scenario.

*Breitburg et al (2018) doi: 10.1126/science.aam7240

Methods

Model projection using a coupled hydrodynamics-ecosystem model:

- AMM7 (7km horizontal resolution, 33 vertical s-sigma levels)
- Hydrodynamics model: NEMOv3.2[1]
- Ecosystem model: European Regional Seas Ecosystem Model (ERSEM[2])
- RCP8.5 “business as usual” emissions scenario for the period 1980-2099.



Oxygen controls

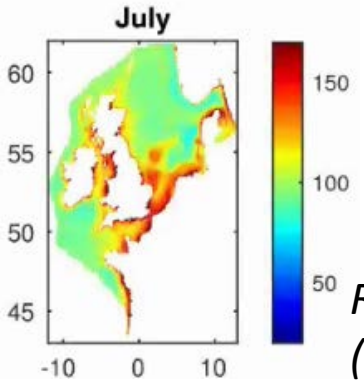
- partition dissolved oxygen (DO) into

solubility DO = (reference DO) × (oxygen solubility)

ecosystem DO change = DO – solubility DO,

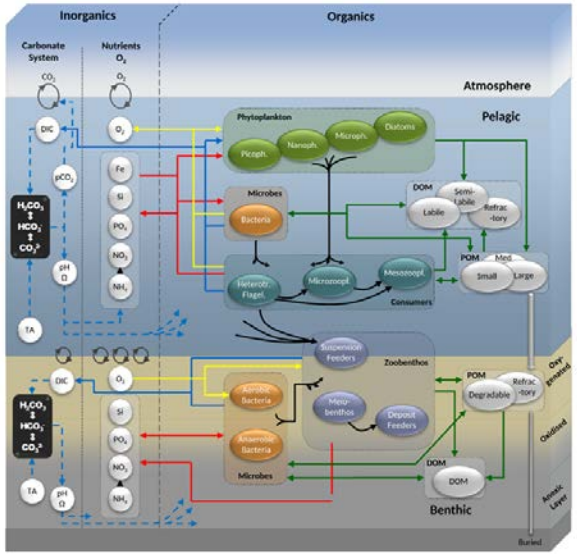
where

- *oxygen solubility* is a function of temperature and salinity[3], and
- *ecosystem DO change* is due to changes in ecosystem processes since the period 1980 – 2009.



Reference DO (%) for July (1980 to 2009 climatology)

ERSEM model[2]



[1]https://www.nemo-ocean.eu/ [2]https://www.pml.ac.uk/Modelling_at_PML/Models/ERSEM

[3]Weiss, R. F. (1970), https://doi.org/10.1016/0011-7471(70)90037-9

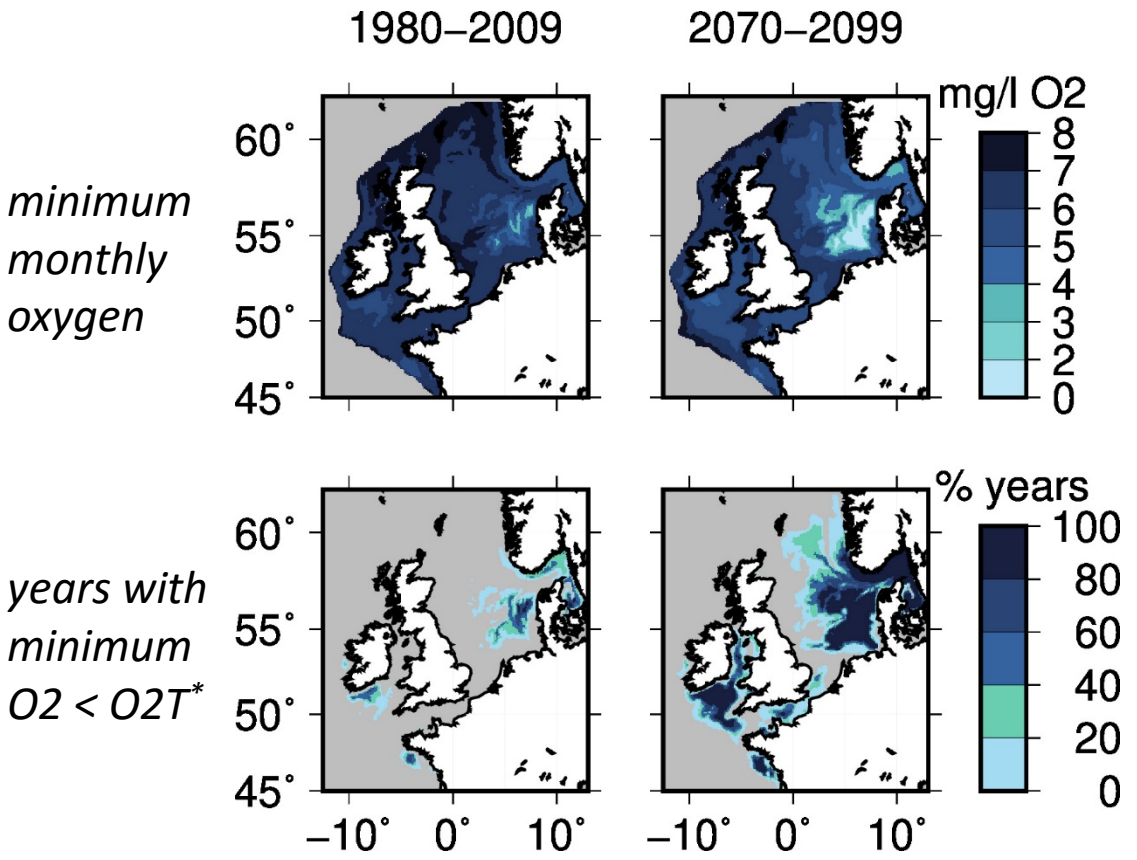
Results: near-bed oxygen change

- Oxygen concentrations on the NW European shelf reduce in the model future.
- By 2099 they are projected to fall below the depletion threshold* more frequently and for longer.

- Projection for the NW European shelf by 2070 – 2099:
  1. the area of oxygen depletion increases by ~240 %
  2. mean near-bed oxygen concentration decreases by ~6.3 %
  3. monthly minimum near-bed oxygen concentration decreases by ~7.7 %

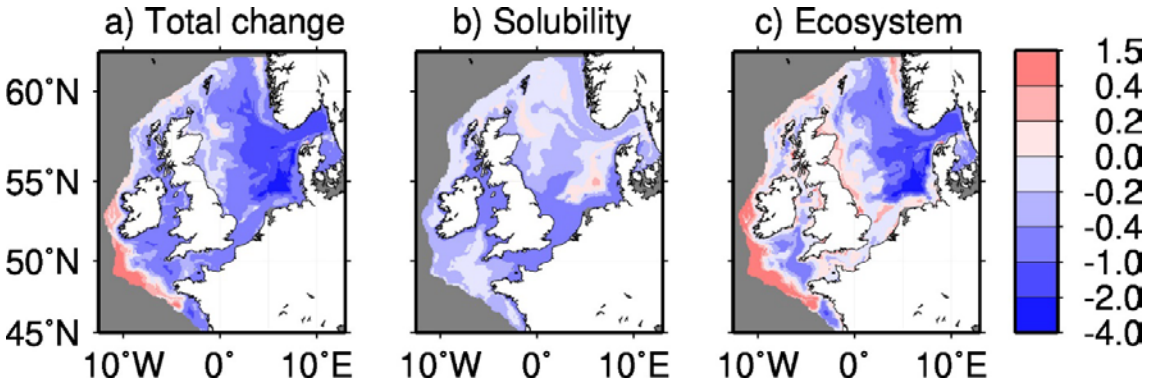
  compared to the 1980 – 2009 mean.

- The model simulation estimates *potential* future oxygen concentrations consistent with the RCP8.5 climate scenario. Results are affected by uncertainties both in model setup and the atmospheric data driving the model.



*O2T = 6 mg l^{-1} is the oxygen depletion concentration for the North Sea (OSPAR, 2003)

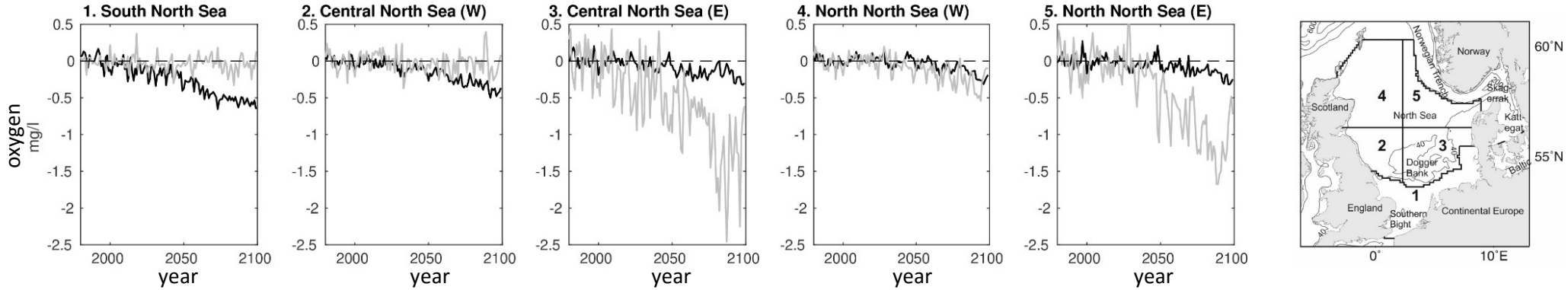
Results: controls on near-bed oxygen



a) Change in minimum near bed oxygen (mg/l) from (1980-2009) to (2070-2099); partitioned into b) solubility and c) ecosystem changes

- Solubility changes account for
  - 73 % of the mean oxygen decline and
  - 50 % of the monthly minimum oxygen decline.
- Ecosystem changes account for
  - 27 % of the mean oxygen decline and
  - 50 % of the monthly minimum oxygen decline.

- By 2050, the ecosystem impact exceeds that of solubility in regions of the eastern North Sea:



Change in minimum near-bed oxygen from present day (solubility; ecosystem). Regions of the North Sea

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Thank you