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Shellfish aquaculture in the North Sea

Production potential and impacts on carbon cycle

1 Multi-use in the North Sea: wind parks and aquaculture

- To meet the Paris Agreement, there are ongoing and planned developments of offshore wind parks in the (Dutch) North Sea.
- The space within these parks is suitable for Multi-Use, including shellfish aquaculture

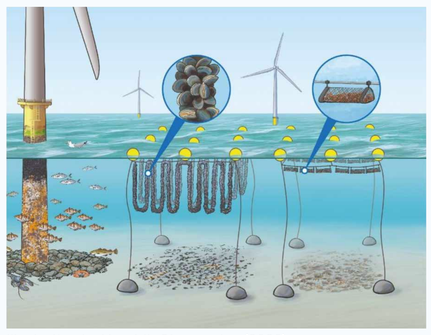
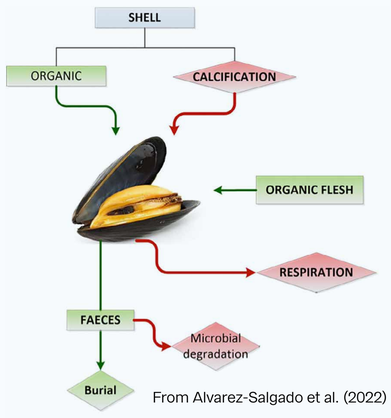


Illustration by Hendrik Gheerardyn (2022)

2 Shellfish aquaculture and carbon cycling

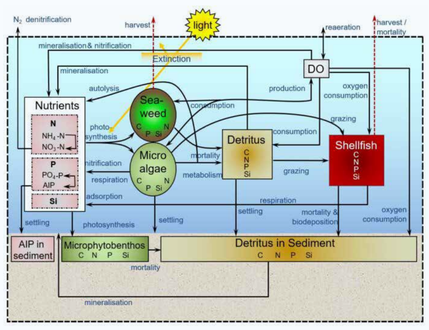
- There is potential for shellfish farming to act as carbon sinks
- Carbon removal (in green) occurs through:
  - Mussels (including their shells) being harvested
  - Shells being buried to deeper sediments
- However, shell formation (in red) also releases CO_2 in the water column



From Alvarez-Salgado et al. (2022)

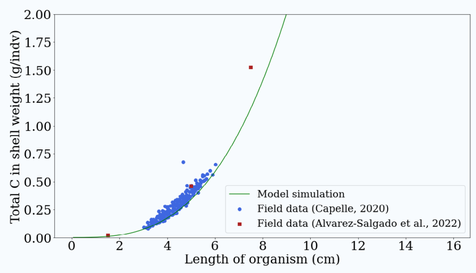
3 Shell formation in a Dynamic Energy Budget (DEB) model

- A biocalcification model was developed to account for shell formation processes (Stechele & Lavaud, in prep.)
- Implementation in the DEB module integrated in Delft3D-FM's water quality process library (Troost et al., 2010; Deltares, 2023)



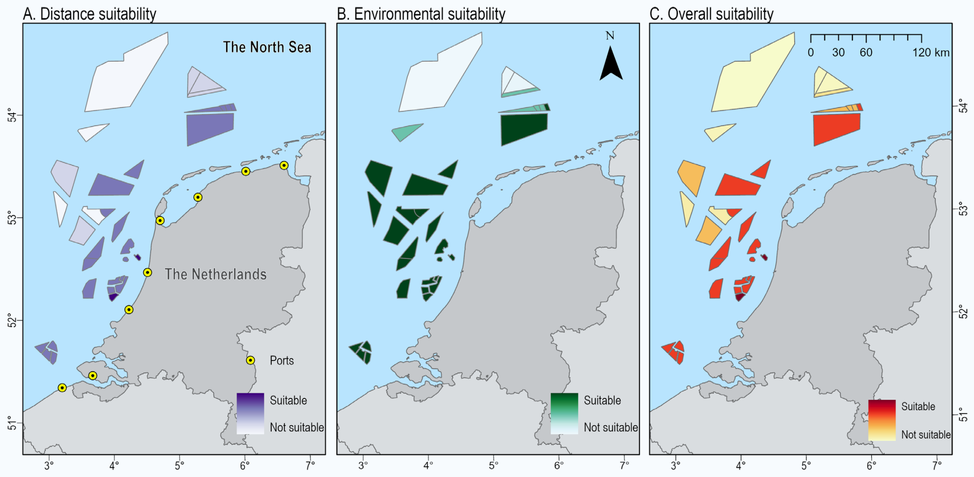
Parametrization

The shell formation module was calibrated based on field data, showing a good match between mussel length and shell C content



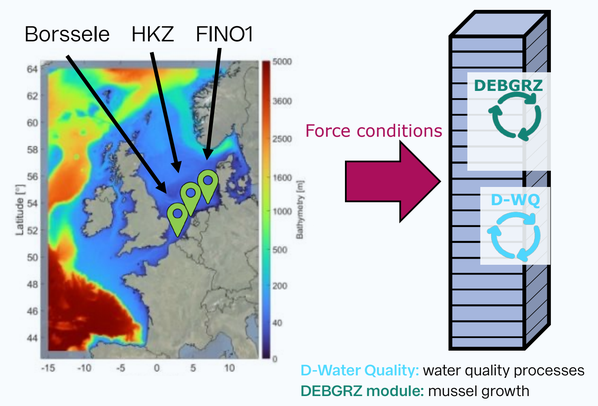
4 Scenarios of suitability for multi-use

- Suitable sites for mussel aquaculture within wind parks (existing and planned) were identified with a fuzzy logic approach using the following variables:
  - Distance to the nearest port
  - Environmental conditions from Delft3D models (chlorophyll-a, flow velocity, chl-a flux and suspended particulate matter), following Steenbergen et al. (2023)



5 Model application in wind parks across the North Sea

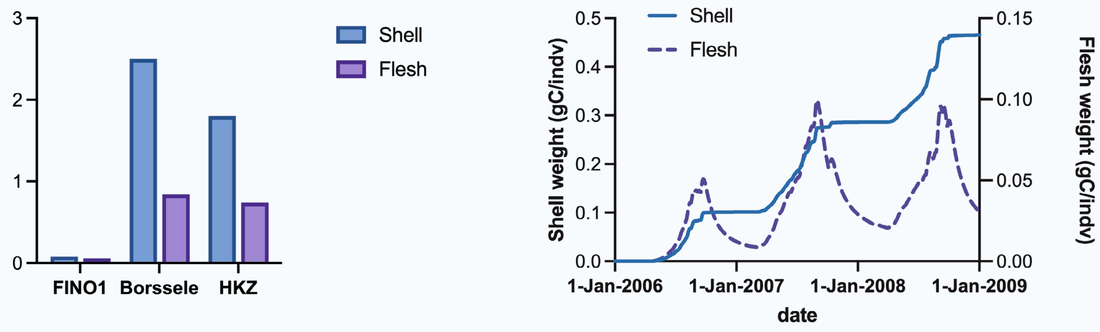
- The mussel growth model was applied to three wind park locations: FINO1, HKZ and Borssele
- A 1DV column model based on the forcing conditions from the 3D – Dutch Continental Shelf Model (DCSM) was used



D-Water Quality: water quality processes
DEBGRZ module: mussel growth

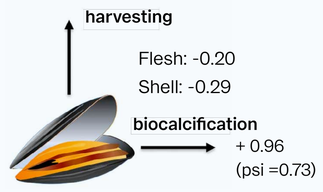
6 Potential mussel growth and carbon fluxes

- HKZ and Borssele locations: higher potential for mussel growth
- The model captures the seasonal growth patterns of mussel flesh (can shrink in winter) and shells (growth in spring-summer, no change in winter)



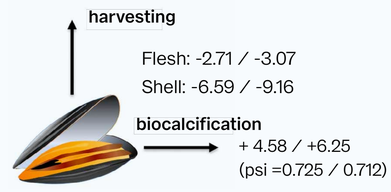
Preliminary carbon fluxes (year 1)

FINO1: carbon source



Mass balance of shells, corrected for biocalcification:
-0.67 g CO_2/indv

HKZ and Borssele: carbon sinks



Mass balance of shells, corrected for biocalcification:
2.01 and 2.91 g CO_2/indv

Conclusions and future work

- Model can be used to identify promising sites for multi-use, estimating mussel production potential and optimal cultivation densities
- Shell formation can be source or sink of carbon depending on locations, but further research is ongoing
- Using a 1DV column model to quantify impacts on environment and carbon cycle has limitations, effects may be local
- Future plans: integrate shell formation module into 3D North Sea model, explore aquaculture upscaling and climate change scenarios

Disclaimer: The figures on potential mussel growth and quantified carbon fluxes presented on this poster are based on preliminary models and calculations. These results are the subject of further research and validation.

References

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