



Rijkswaterstaat  
Ministry of Infrastructure  
and Water Management



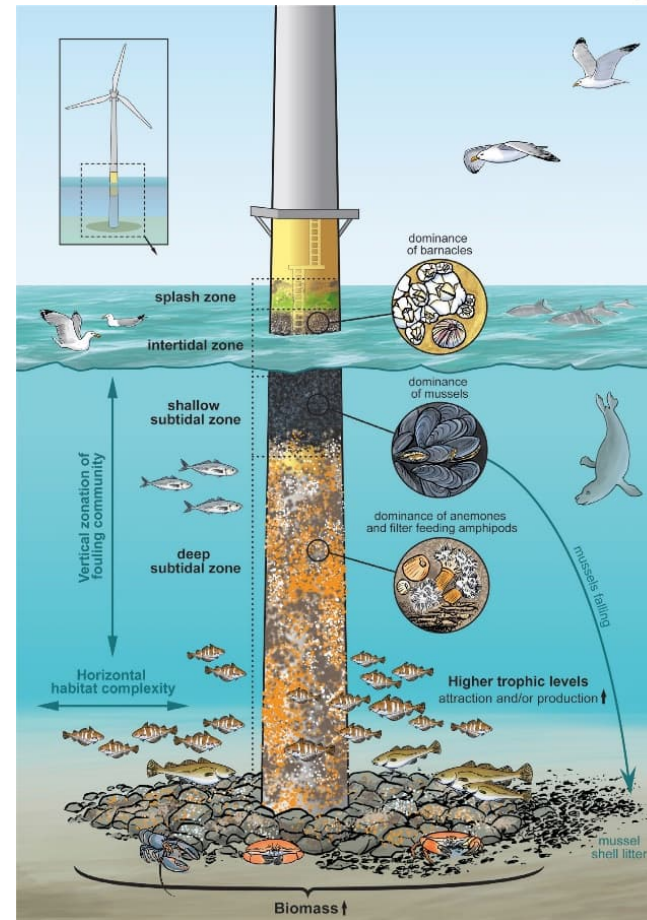
# Monitoring and modelling marine growth on wind turbine foundations.

Maart 2024



## Mogelijke effecten

- De rol van (hard substraat) benthos en de draagkracht van het systeem
- Biomassa kan toenemen
- Verandering in begrazing



Degraer et al. 2020. Oceanogr.



## Doel van het project/veldwerk



- Alternatieve methode voor duikend onderzoek
- Meetprogramma voor hardsubstraat monitoring



# Samenwerking en kansen

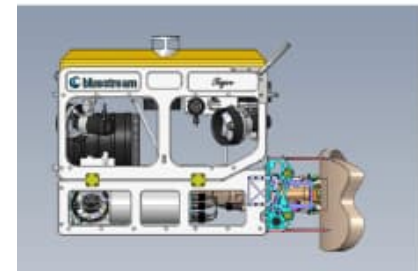
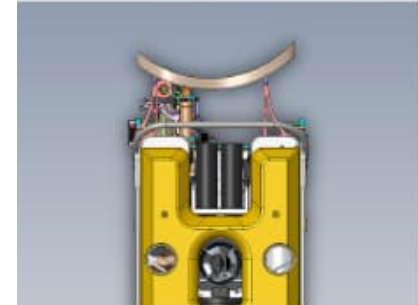
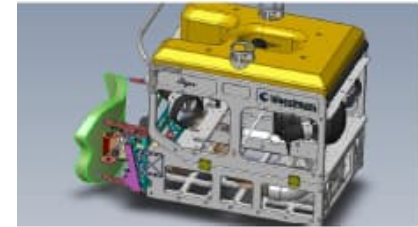
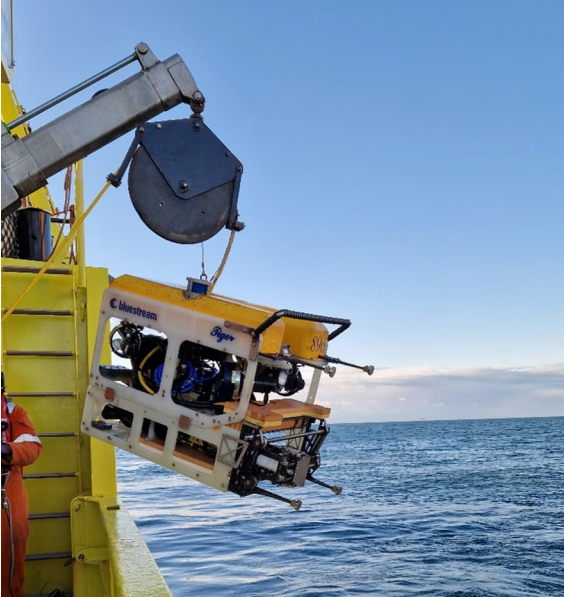
- Remotly Operated Vehicle (ROV)
- Nieuw: Marine Growth Sampling Tool (MGST)





# De MGST testen

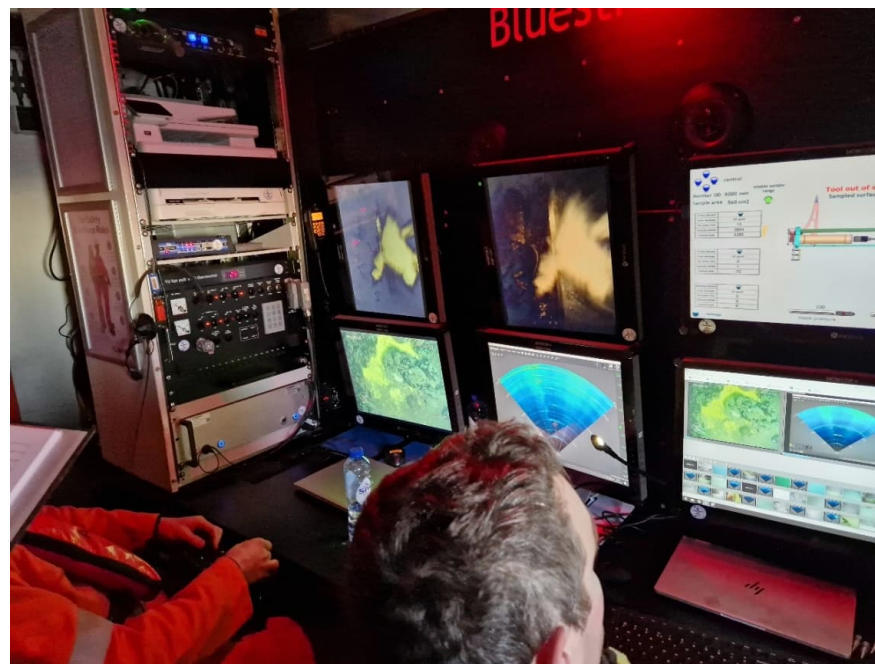
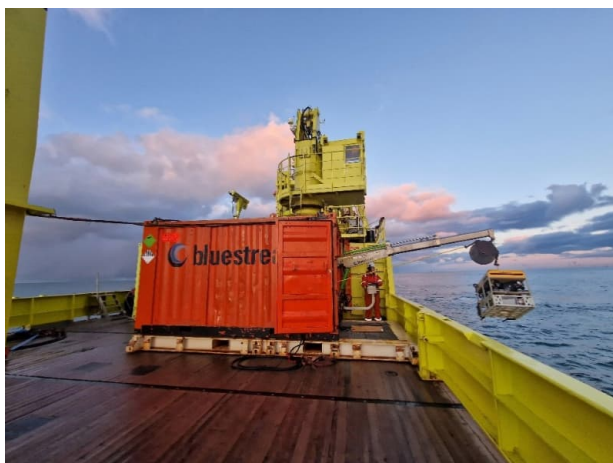
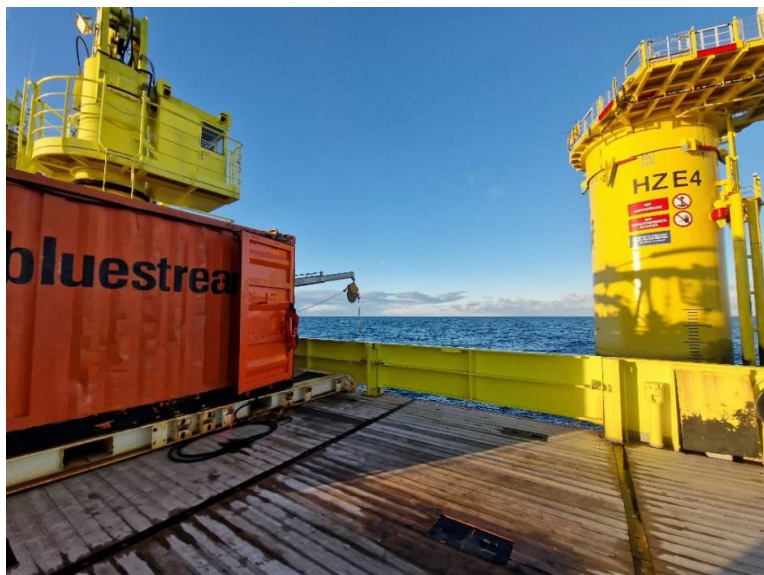
- ROV heeft magneten om grip op asset te krijgen
- MGST om een monster te schrappen
- Losgemaakt materiaal wordt opgezogen in monsterzak



 bluestream



# De MGST testen





# De expeditie



- 2 operationele dagen in het windpark
- 25 schraapmonsters in totaal
- Op verschillende dieptes





## Een succes tot nu toe. Hoe verder?

- › Technische haalbaarheid
- › Analyseren van de monsters
- › Uitrol naar monitoring





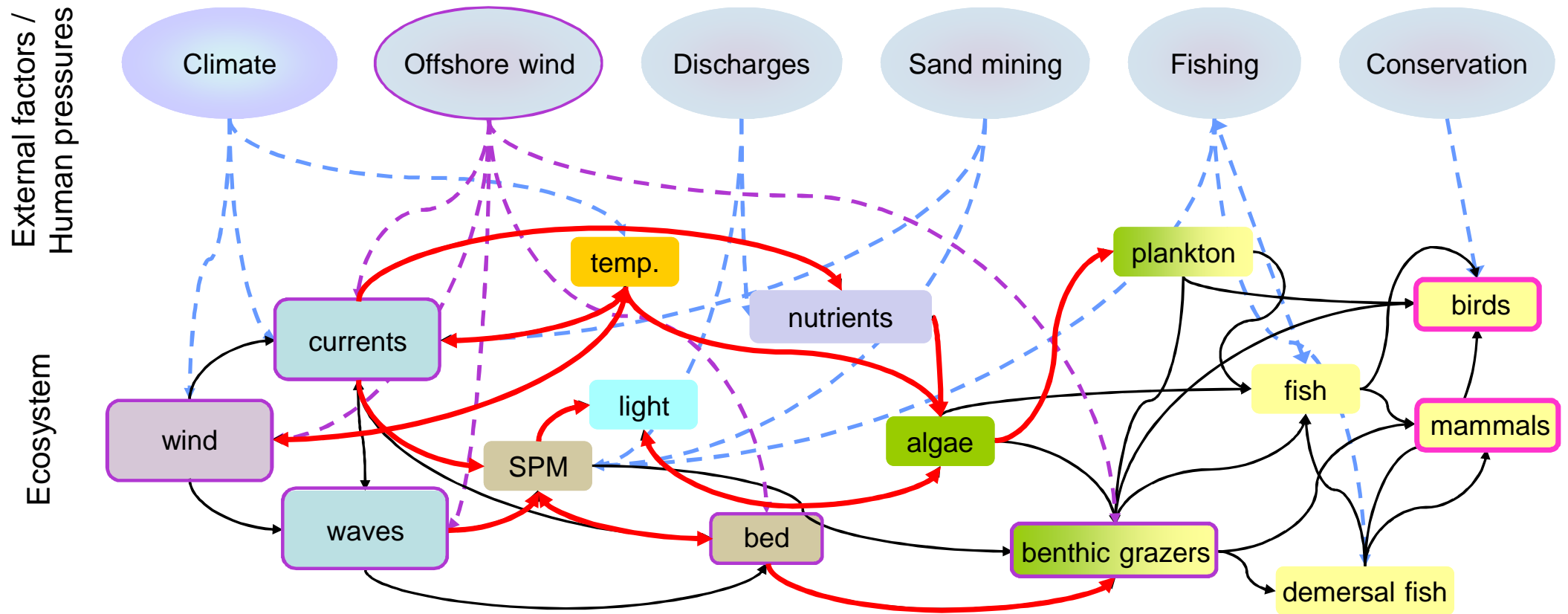


## Kennisontwikkeling

Zo goed mogelijk modelleren  
en waar mogelijk aannames  
in het veld valideren.



# Chain of effects



# Extraction of energy from wind



Photo: Vattenfall

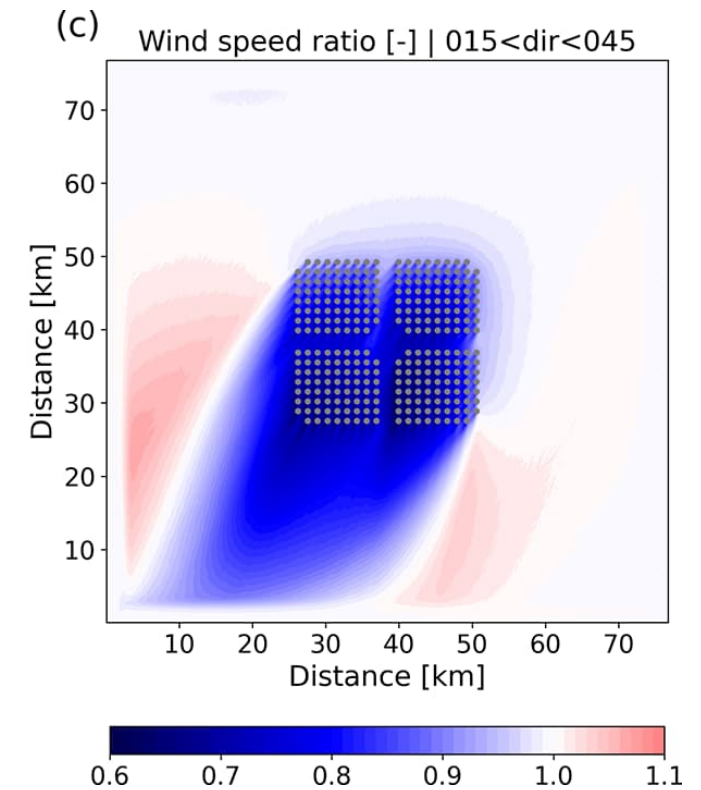
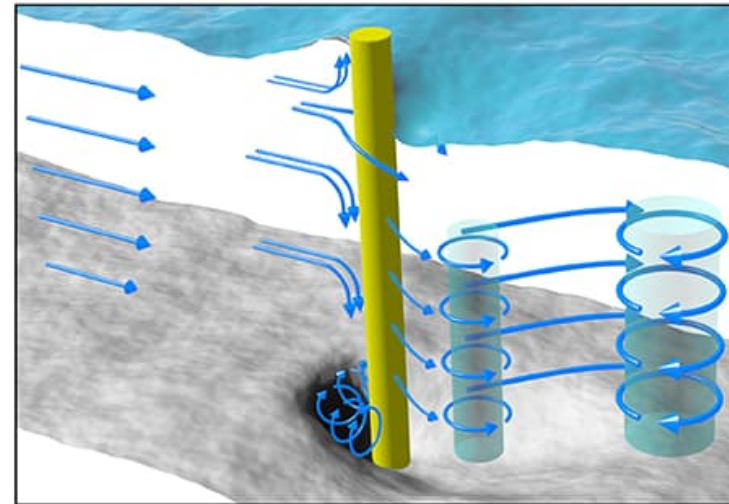
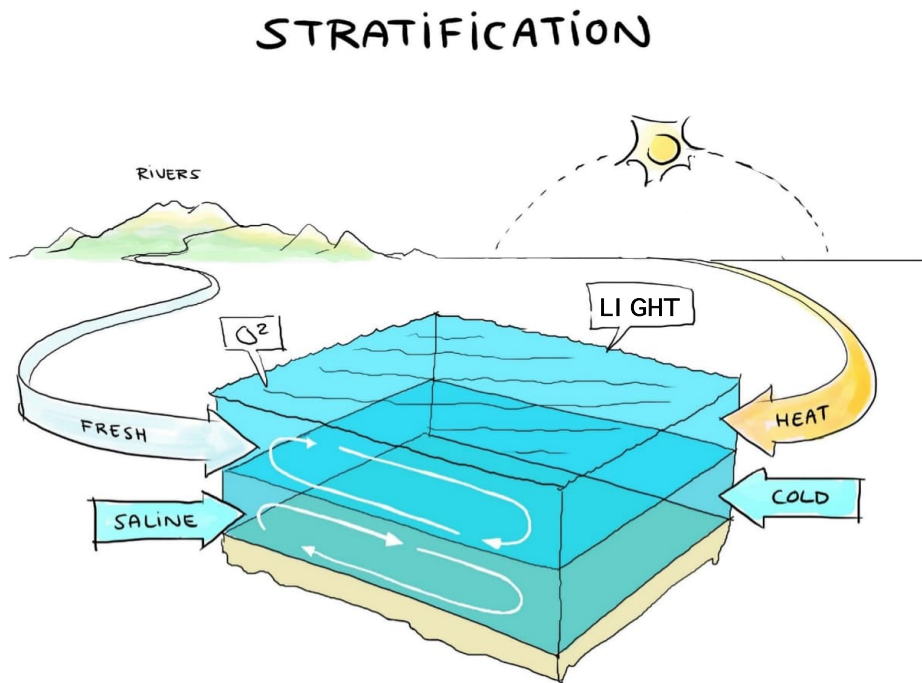


Figure from  
Baas et al. 2023. Wind Energy Systems

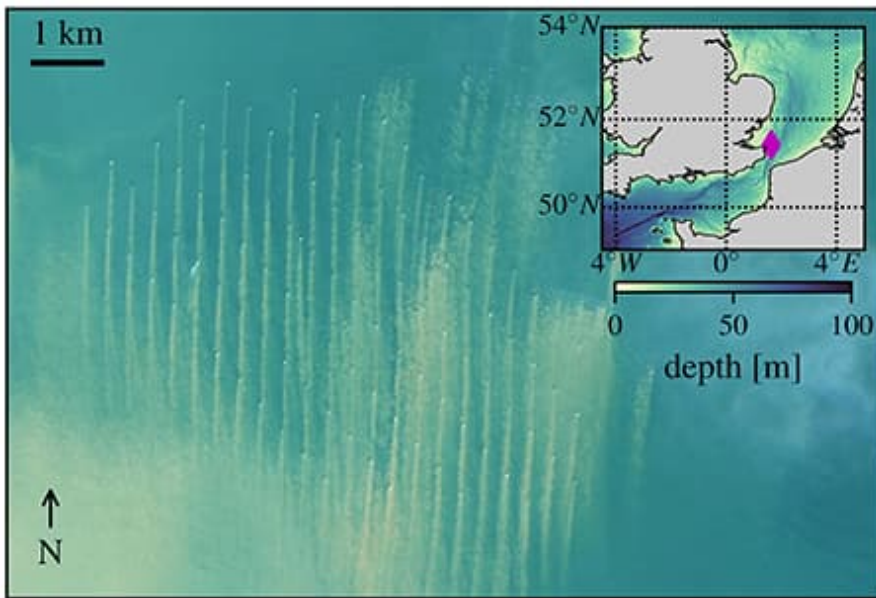
# Disturbance of flow



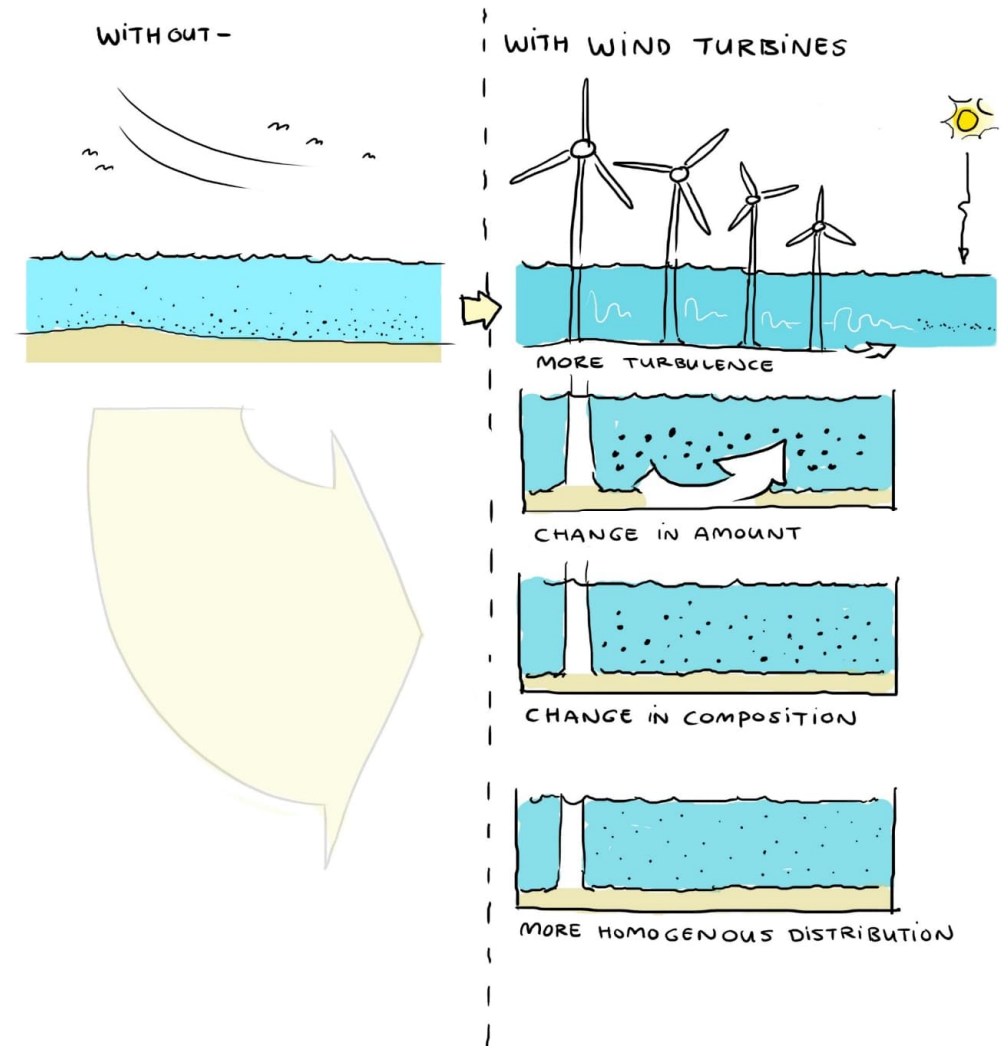
Dorell et al. 2022. Front. Mar. Sci.

- Enhanced mixing of water column
- Locally increased bed shear stress in wake

# Effects on sediments and suspended matter



Foster, 2018. IECS report

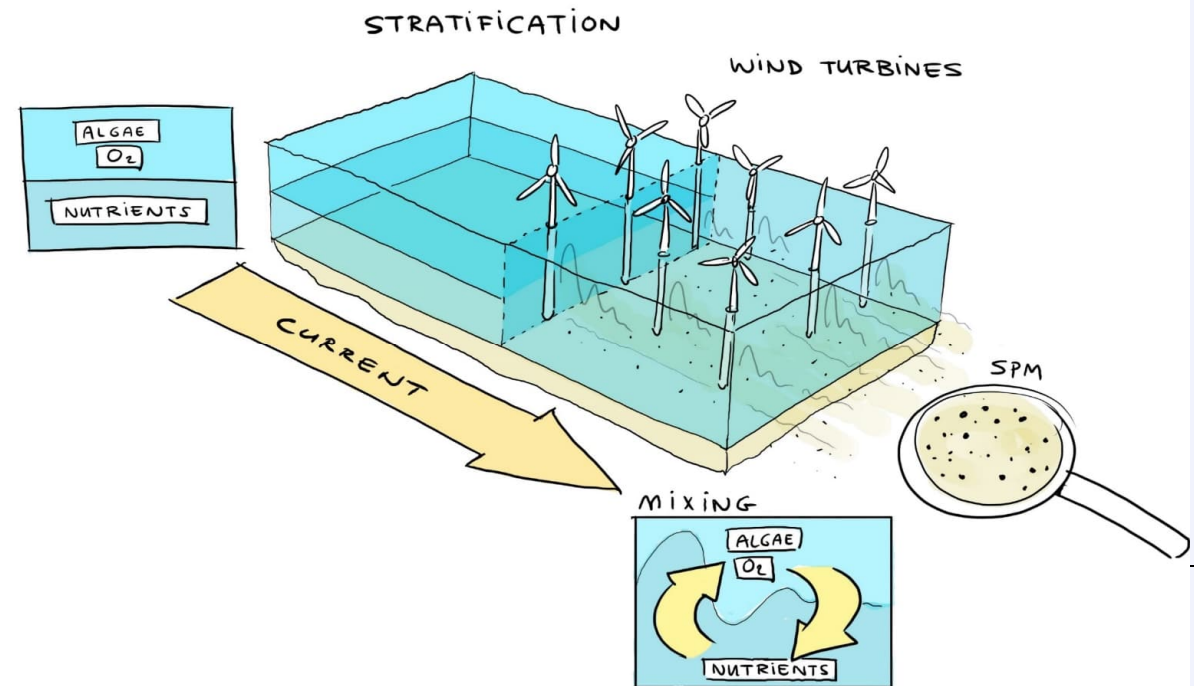


# Effects on stratification and primary production

## Marine primary production

Process by which marine plants, primarily phytoplankton (micro-algae), use sunlight, carbon dioxide, and nutrients to produce organic matter through photosynthesis. This organic matter forms the base of the marine food chain.

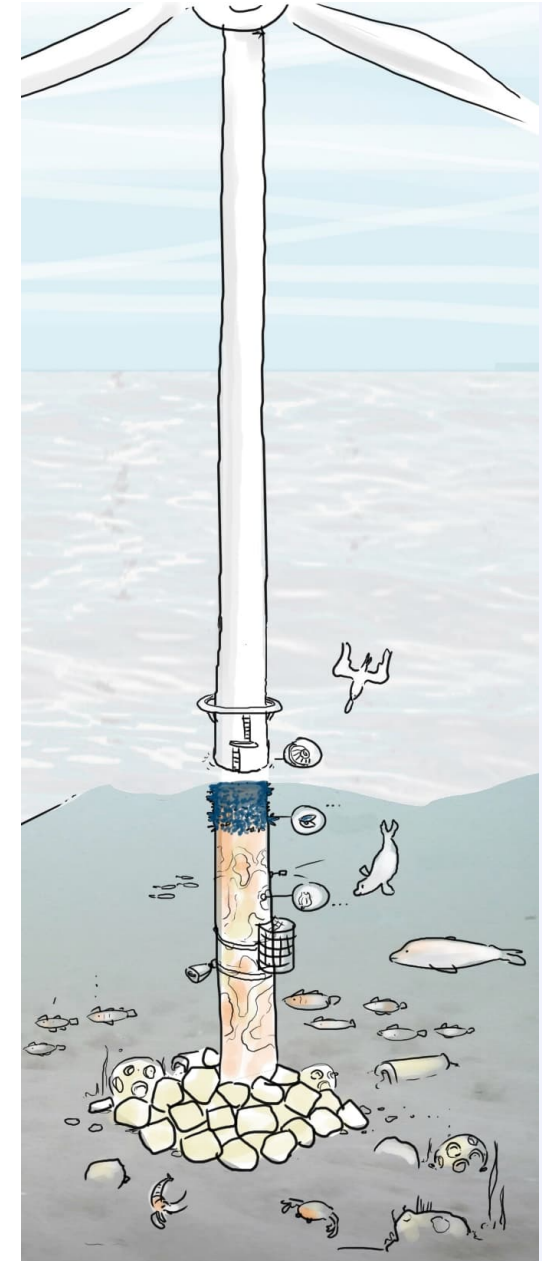
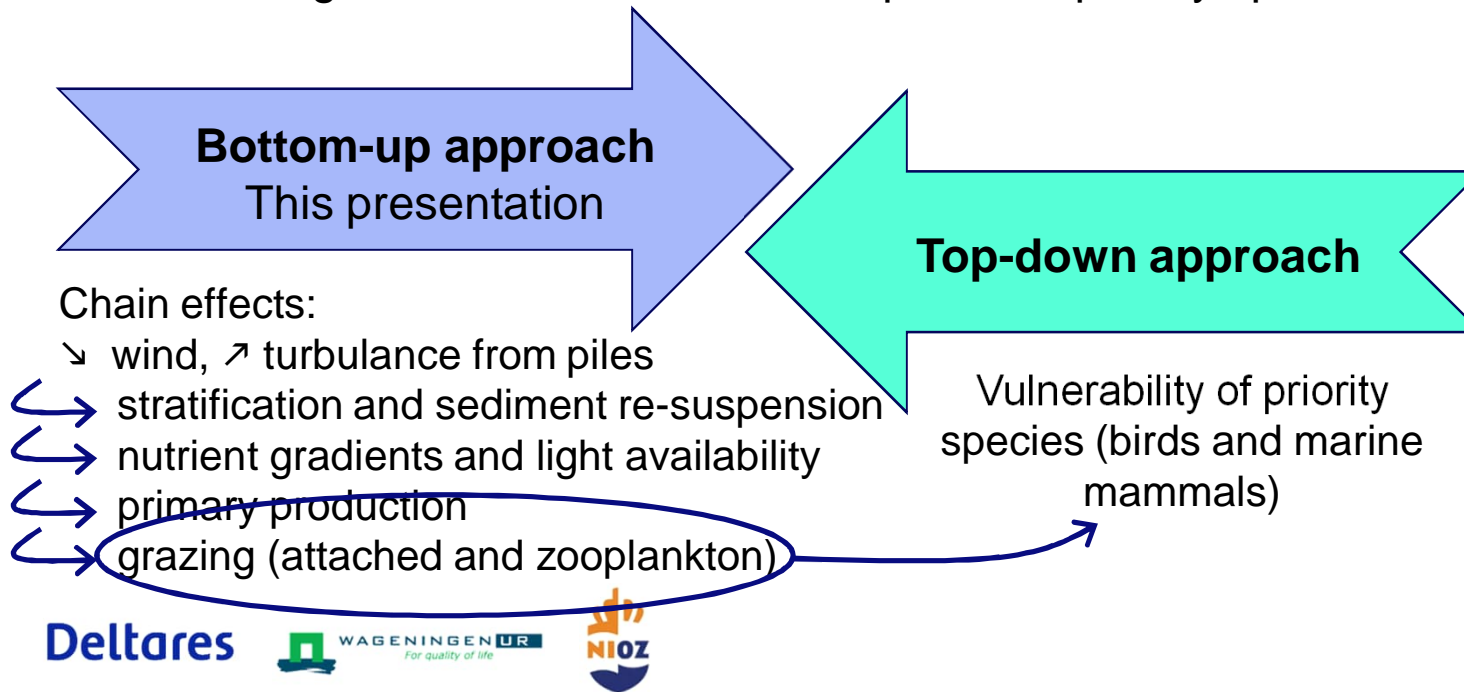
- Increased available nutrients near the surface
- Decreased light availability
- Net effects??



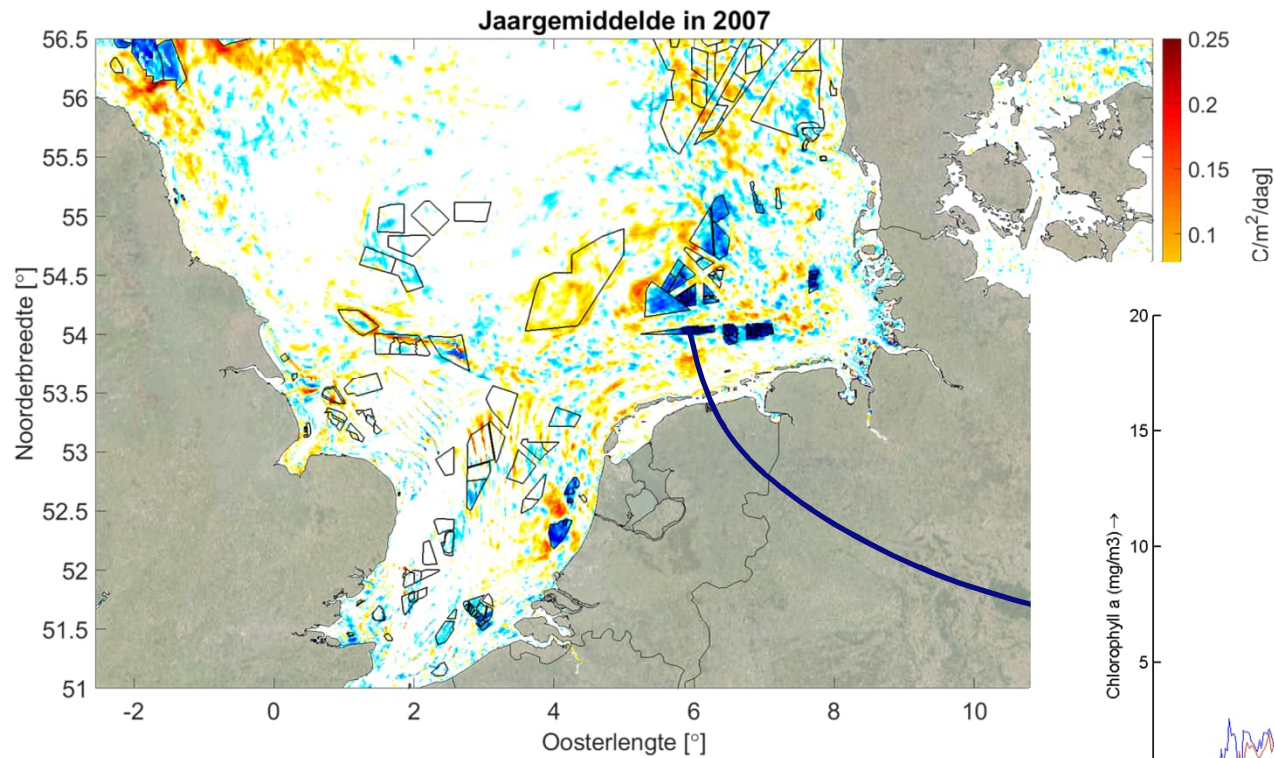
# WOZEP programme



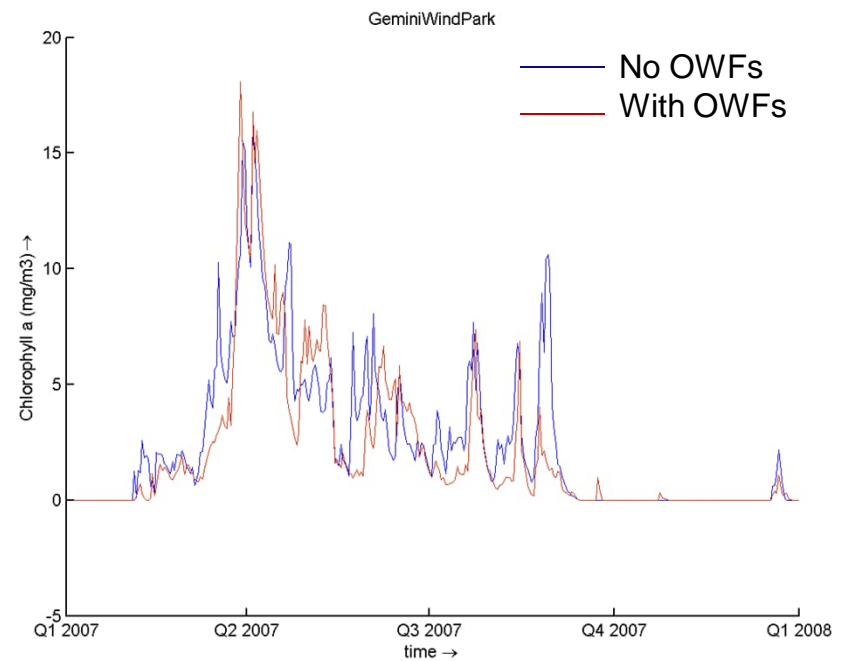
- Reduce knowledge gaps on environmental effects of offshore wind farms (OWFs) in the North Sea
- Quantify potential changes in the ecosystem with coupled physical and ecological models and assess impacts for priority species



# Impacts of OWFs on primary production

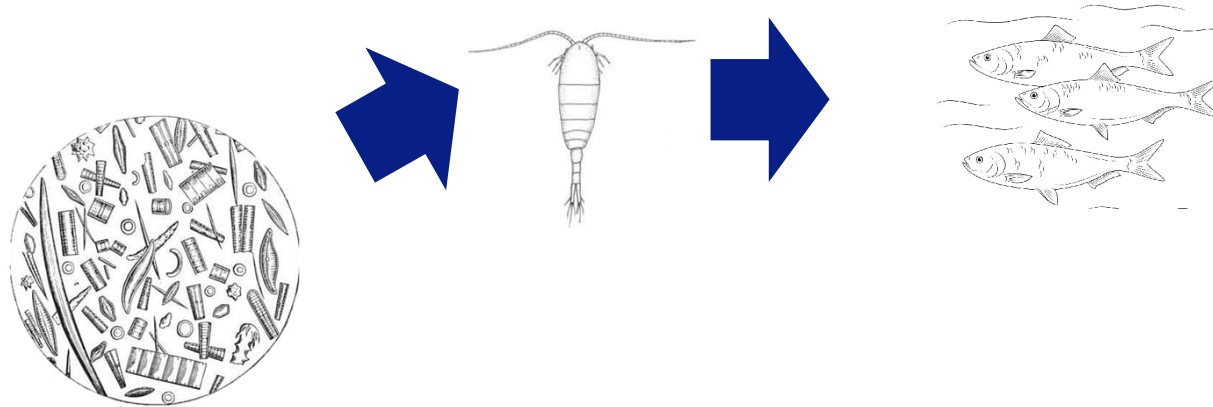


▼ Chlorophyll-a concentrations in the Gemini OWF ( $\mu g/L$ ) (proxy for primary producer biomass)

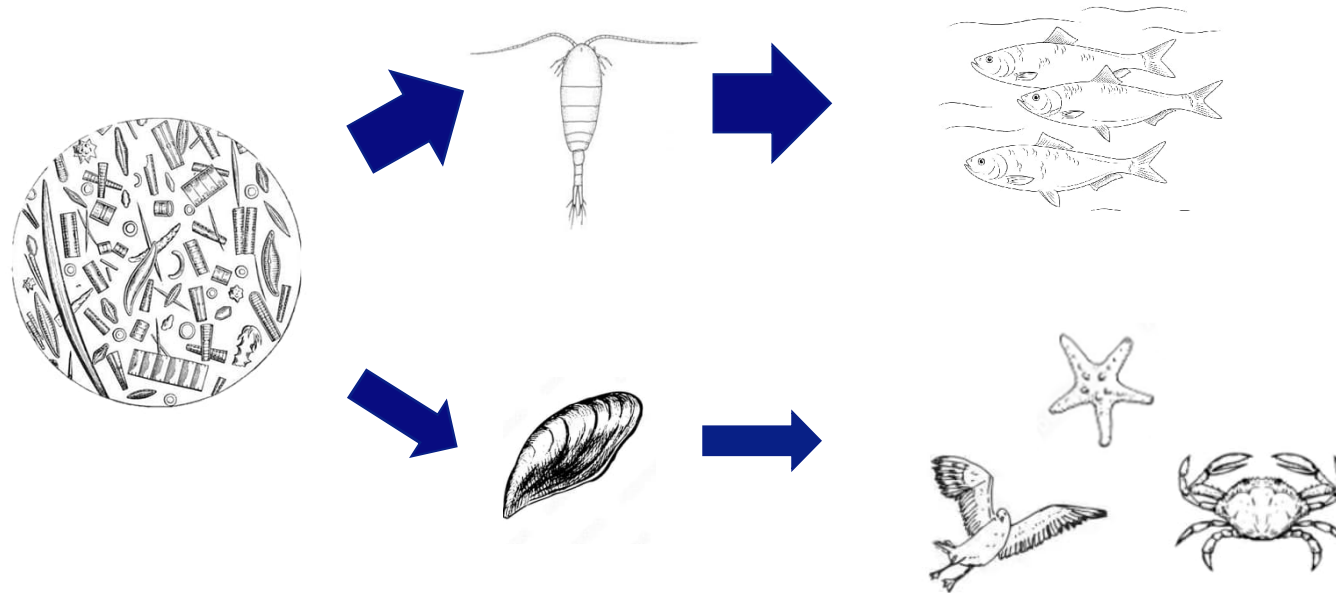




# Competition benthic – pelagic grazers



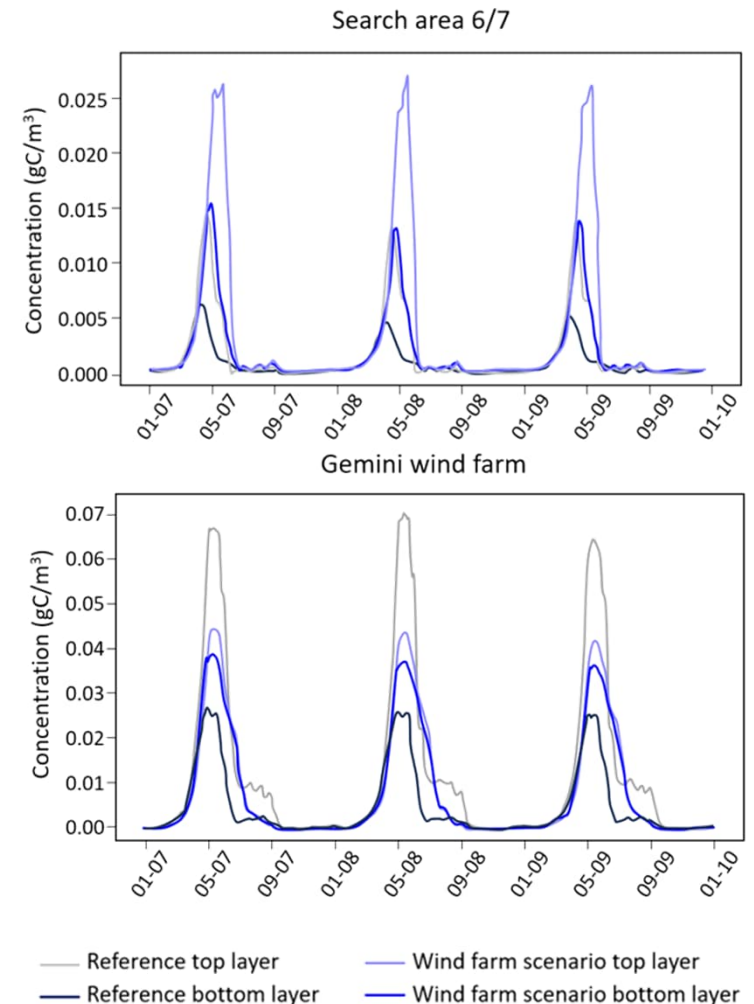
# Competition benthic – pelagic grazers



# Modelling of benthic & pelagic grazers

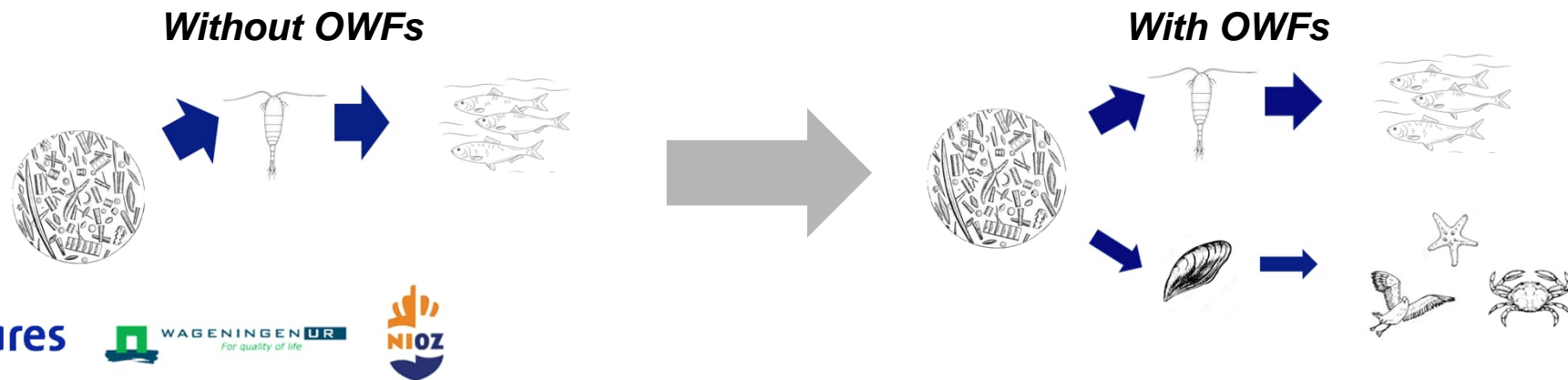
- Modelling of mussels and zooplankton
  - Dynamic Energy Budget theory: life cycles of species
  - 1st 3D tests on effects of mussels (2022 report)
    - Decrease in chlorophyll a in Rhine ROFI and Danish OWFs
    - Effects on chlorophyll a are smaller than those from changes in hydrodynamics and sediments
  - 1st 1D vertical tests on zooplankton parameterization and effects
    - Increase in zooplankton due to OWFs in Search Area 6/7 over entire water column
    - Decrease in surface and increase in bottom zooplankton in Gemini
  - Technology is ready to model competition

**Simulated zooplankton biomass in 1D vertical models ►**



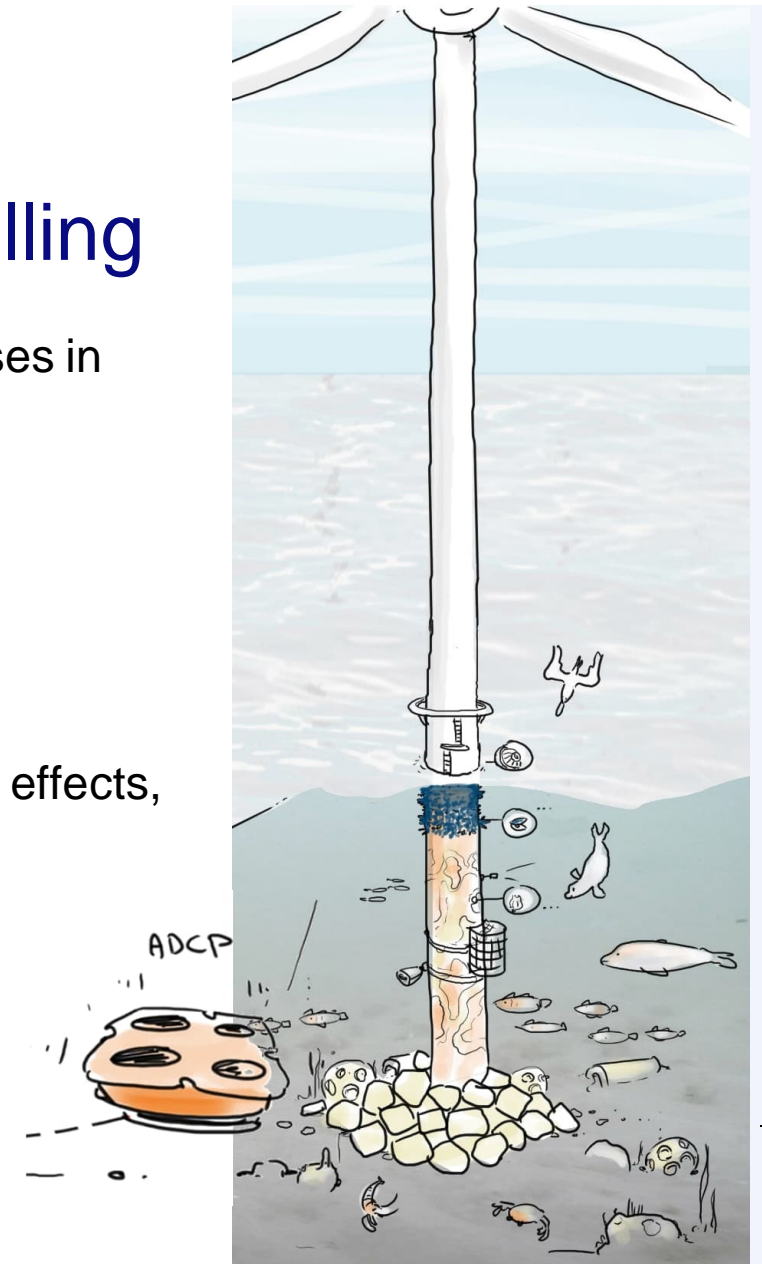
# Modelling of benthic & pelagic grazers

- Strong hypothesis
  - Limited number of species simulated
  - Need for aggregation of species in model
  - Parameterization of life cycles
  - Location of grazers on pillars, access to food
- Once these are validated we will be able to predict shifts in carbon transfers at the bottom of the food chain at relevant scales



# Conclusion: Links between monitoring and modelling

- Need for system understanding to include relevant processes in models
- Monitoring will help validate:
  - Species present on turbines
  - Modelling Hypothesis
  - Biomass
- Need for validation of other elements in bottom-up chain of effects, e.g. hydrodynamics, sediment plumes
- Need for campaigns looking at seabed



# Thank you for your attention

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Deltares

