



# Deltares

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## *Potential ecosystem effects of large-scale implementation of offshore wind farms*

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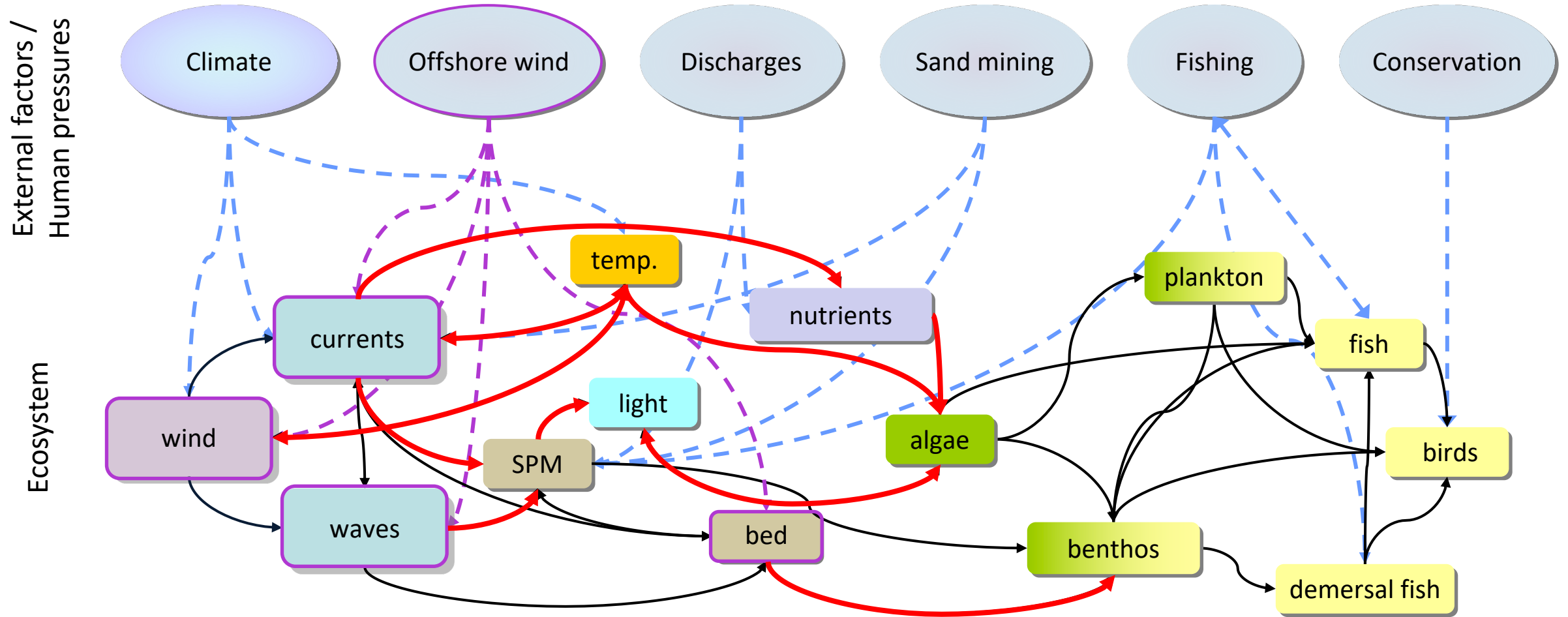
Potential ecosystem effects large-scale offshore wind

# Scope

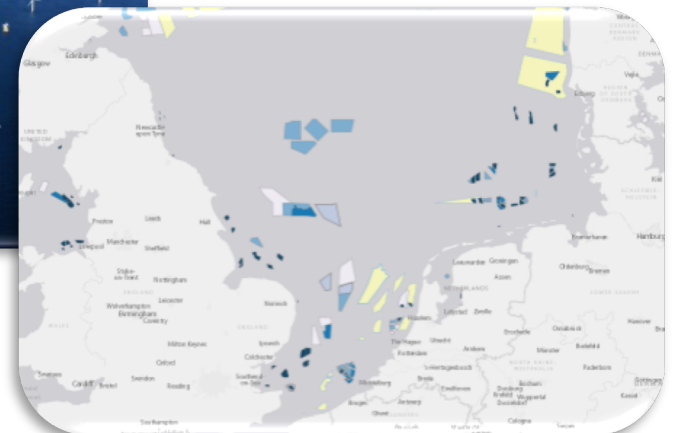
- North Sea: unique source of nature, food, energy
- Projected upscaling offshore wind very large; important to understand effects and minimise negative consequences
- Current (Dutch and other) environmental programmes are geared towards:
  - Birds, bats (collision, habitat loss, migration routes)
  - Marine mammals, fish (noise during construction)
  - Recently: sharks, rays (effects electromagnetic disturbance)
- **Ecosystem effects through changes in the physics of the North Sea system**
  - Under Dutch National programme ecological effects offshore wind (WOZEP)
  - Not directly fisheries related, but relevant



# Effect chain



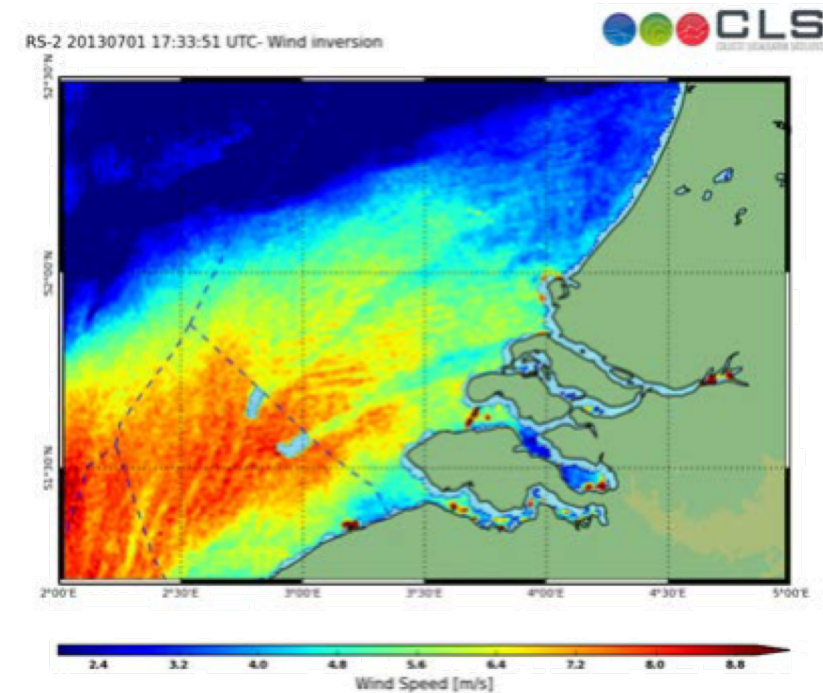
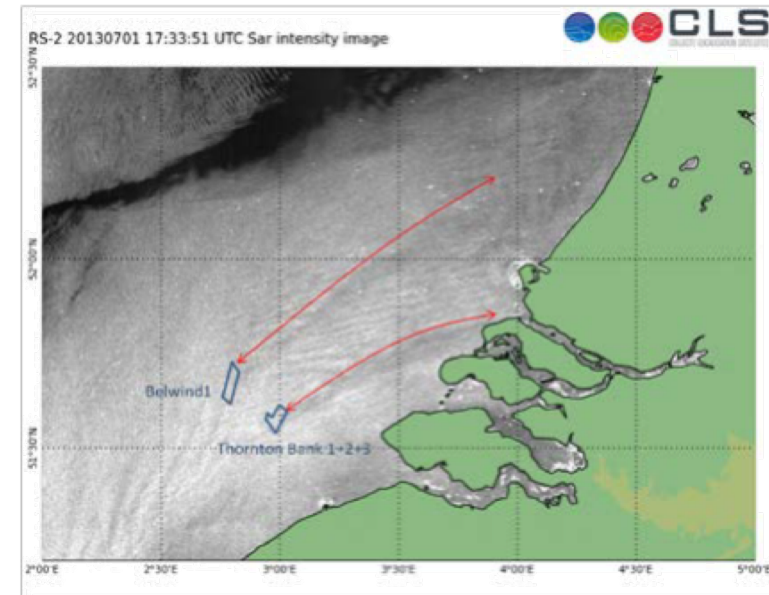
# Effects of OWFs on wind are scale dependent





# Extraction of wind energy

- Processes around individual turbines and within wind farms reasonably well understood
- Large-scale processes (i.e. scale of southern North Sea) poorly understood – also by specialists.
- Wakes can be visible up to 70 km

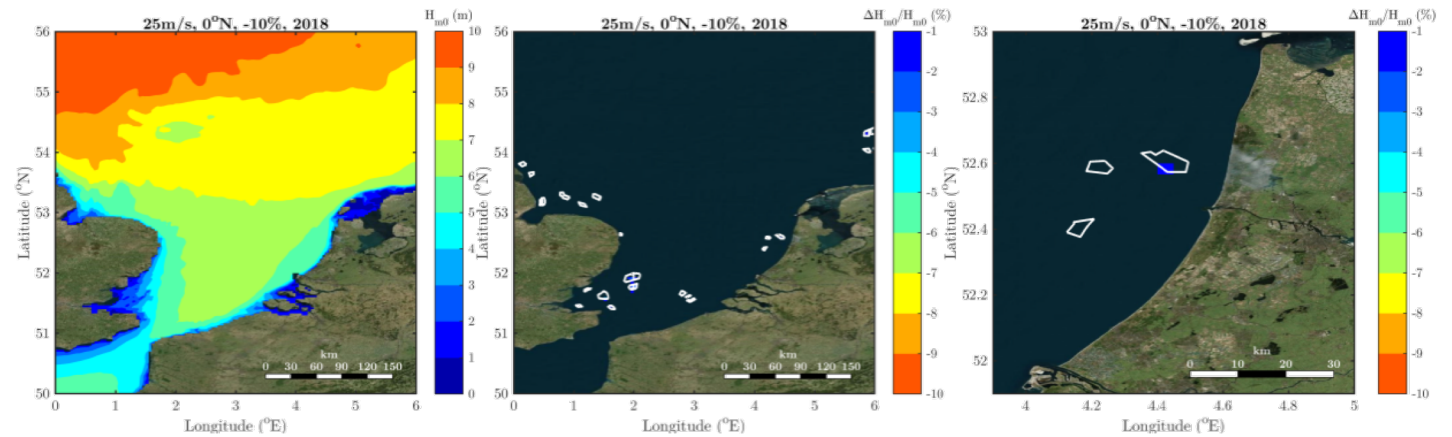


*From: Hasager et al 2015*

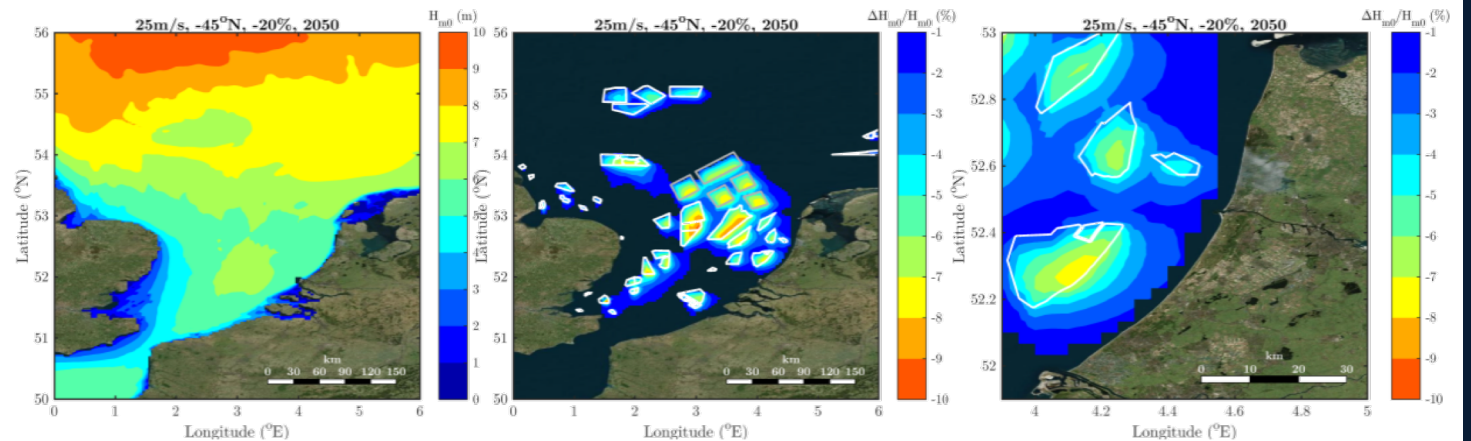
# Waves

- Changes in wind cause changes in waves
  - Speed
  - Direction

Model situation 2018 (wind is forced, -10%)



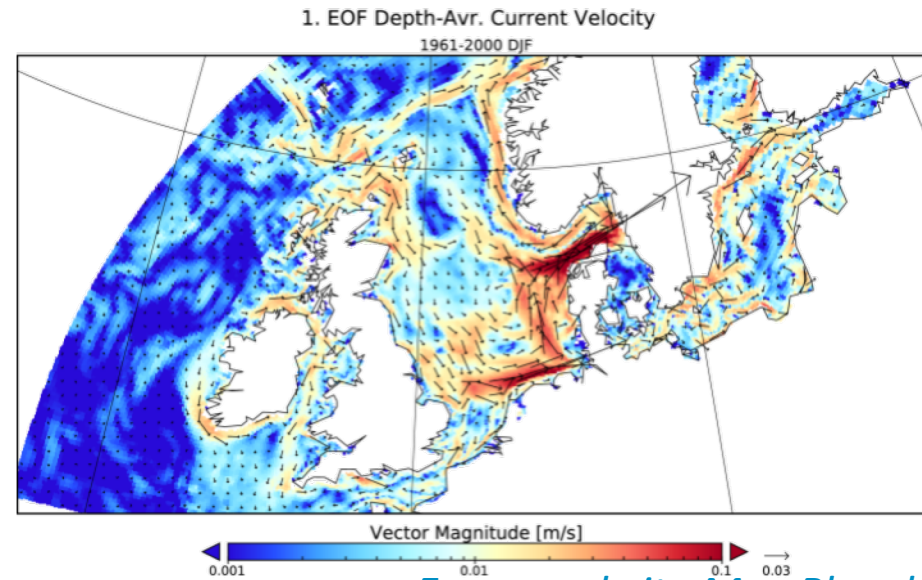
Model scenario 2050 (wind is forced, -20%)



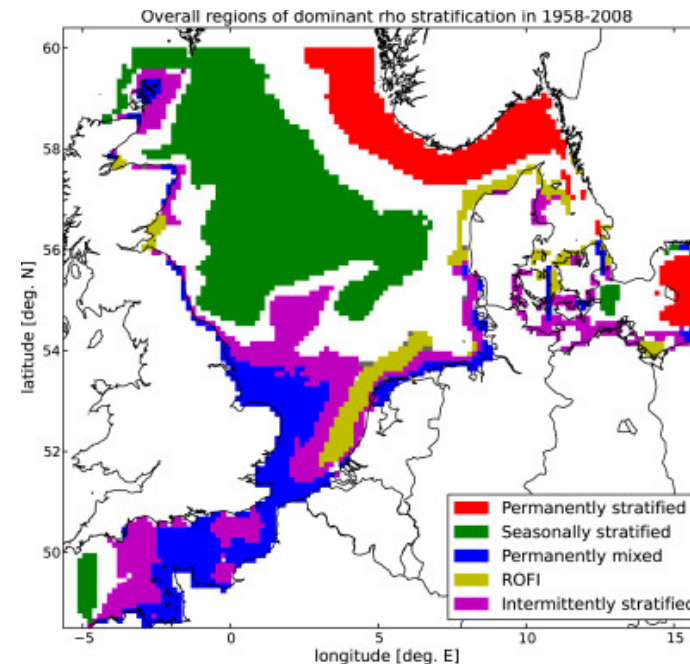
*Note: in model results  
no wake effects assumed*

# Water movement

- Currents are driven by
  - Tides (mainly)
  - Wind
- North Sea characteristics
  - Relatively shallow
  - Partially stratified



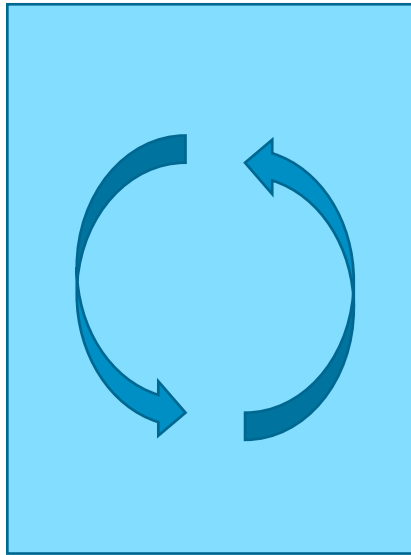
*From: website Max Planck Institute*



*From: van Leeuwen et al 2015*

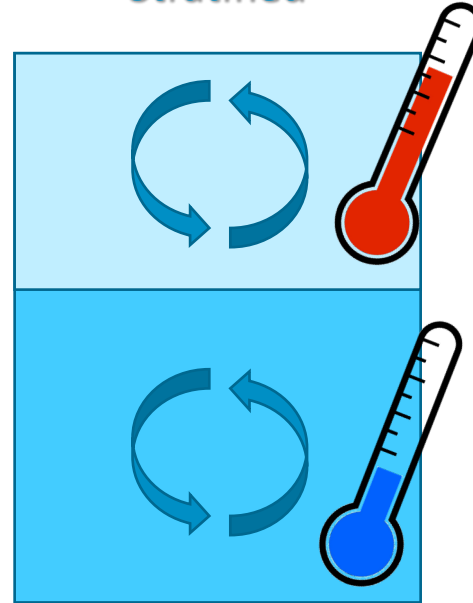
# Stratification

Not stratified

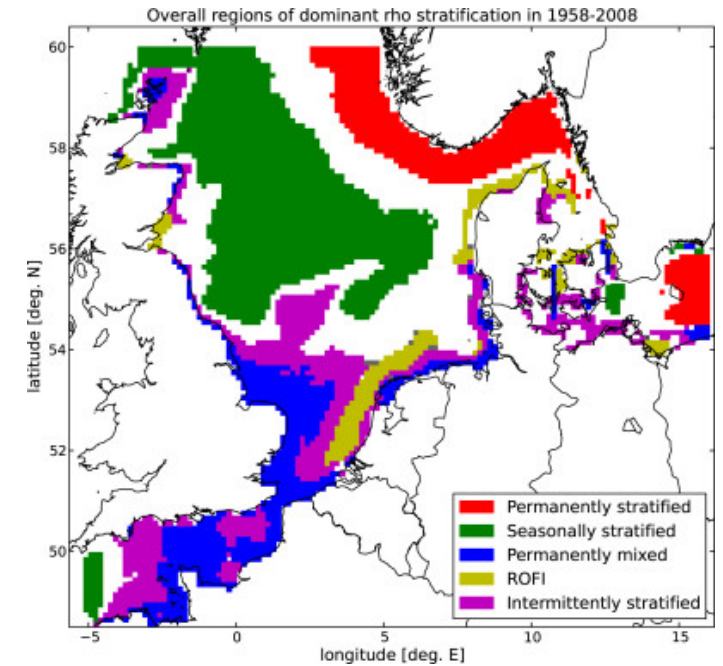


- Water column mixed
- Food, oxygen produced at surface reach the bed
- Nutrients from deep layers reach the surface

Stratified



- Layer of 'light' water (warmer, less saline) on top of 'denser' water
- Food, oxygen produced at surface do not reach the bed
- Nutrients from deep layers are retained

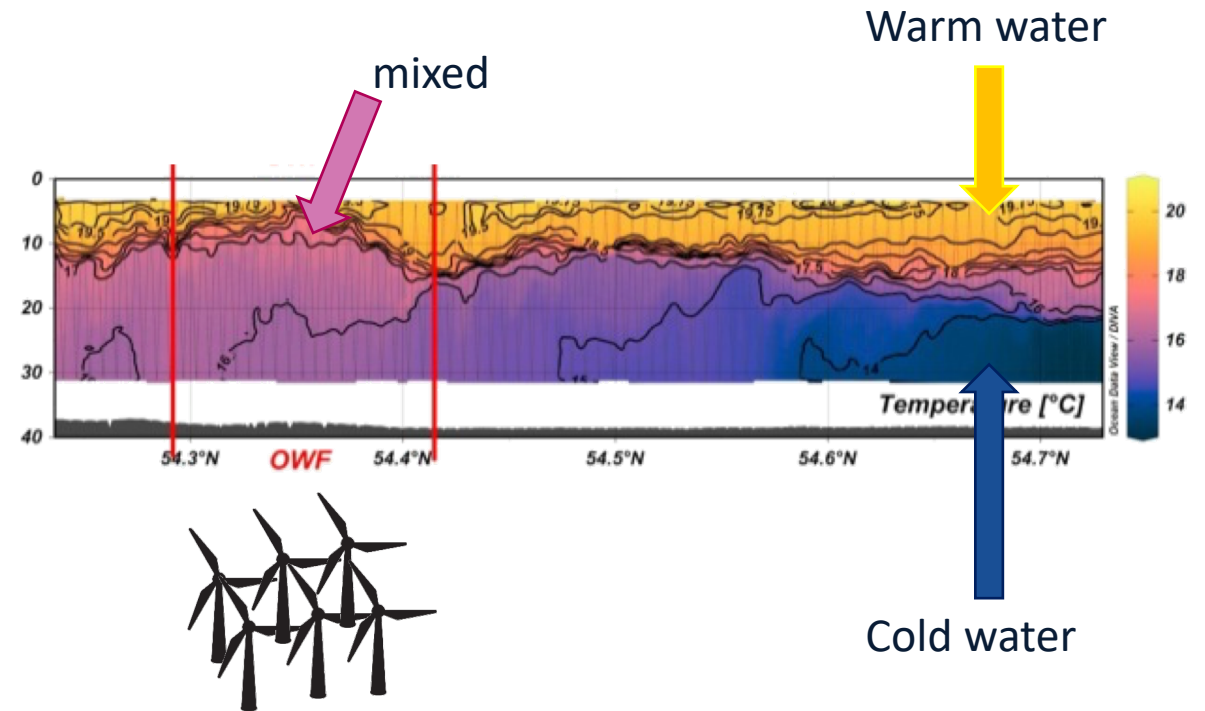


- Large areas stratified in summer (temperature)
- Near rivers permanent stratification (salinity)
- Important factor for sediment transport and ecological functioning



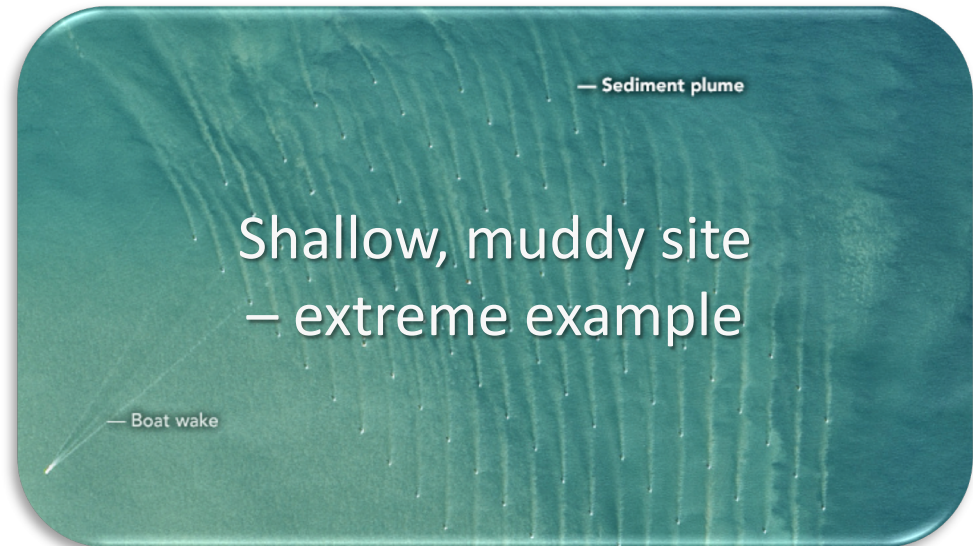
# Interaction currents and wind farms

- Turbines cause increased mixing
  - Decrease in stratification measured in existing German wind farms
  - Not relevant in permanently mixed areas



# Fine sediment dynamics

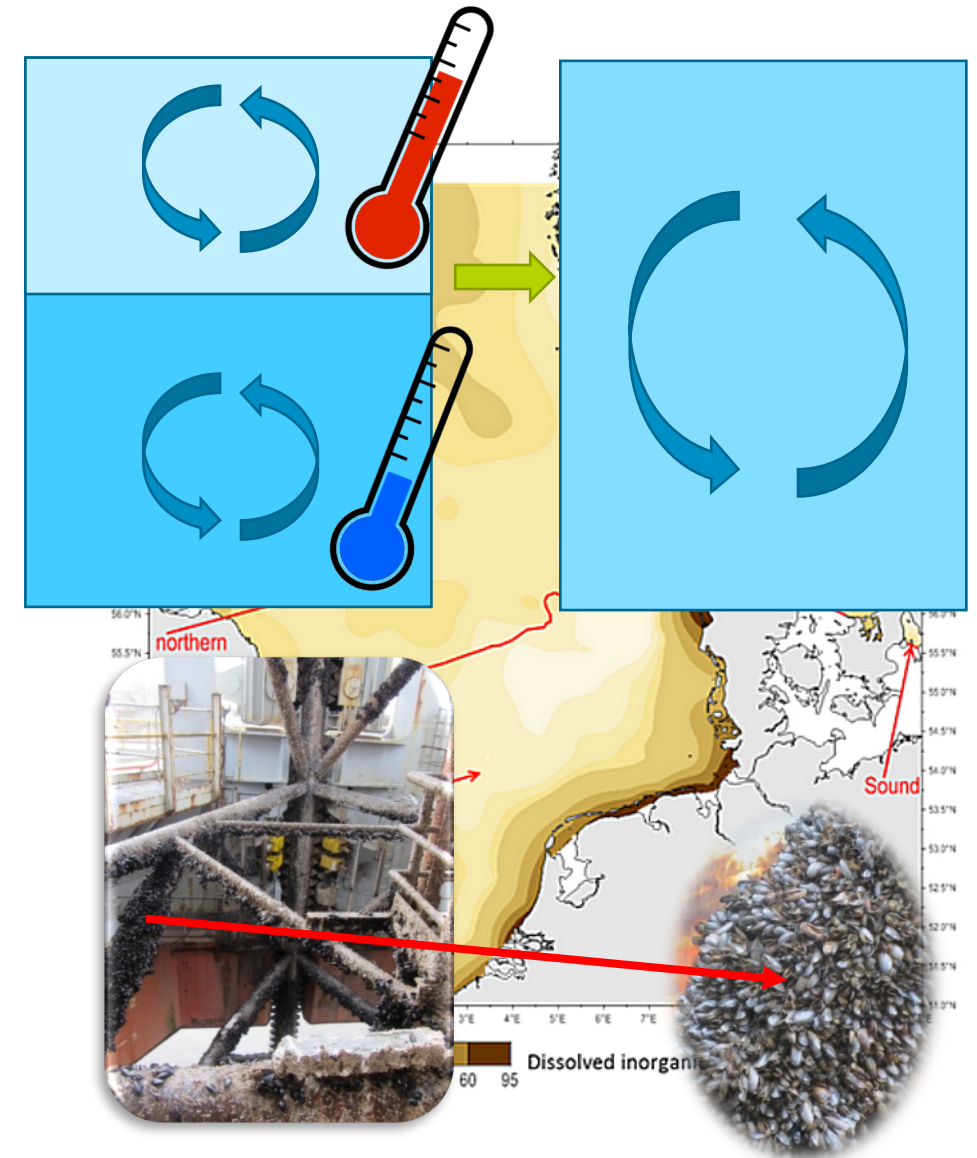
- Turbidity = less light = less algal production
- Influenced by
  - Currents, waves + depth
  - Amount of mud in the seabed
  - Stratification
- Location dependent
- Time scale
  - Short term effects: increase turbidity
  - Long term effects: towards equilibrium more shear stress = less mud in the bed



Source: NASA earth observatory

# Effects on food web

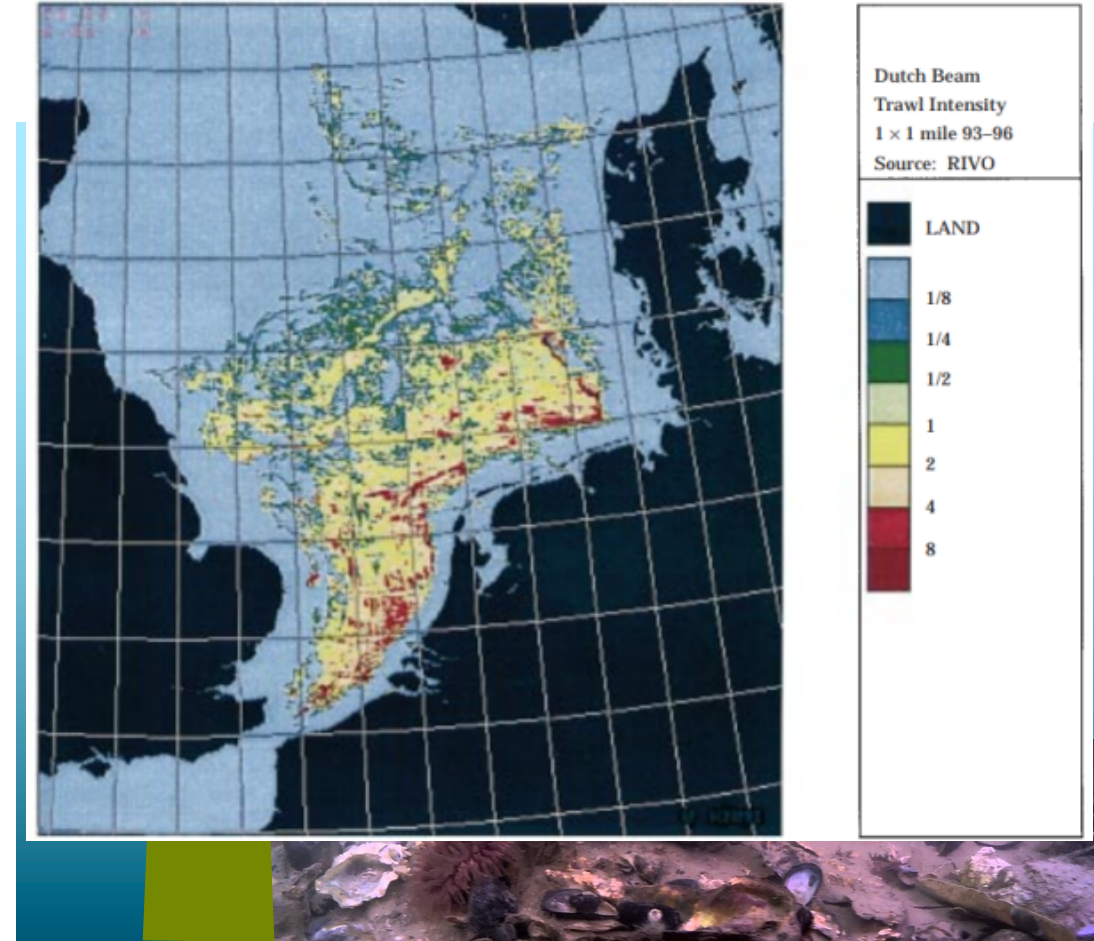
- OWFs can influence nutrient cycling
  - Reduction of stratification *may* lead to enhanced production
  - Enhanced transfer of food towards the seabed
  - Changes in timing spring bloom
- Potential changes in temperature
- New habitat in top layers of water column; high grazing levels of e.g. mussels. Potentially large effect on competition





# Potential ecosystem effects

1. Competition between zooplankton, zoobenthos and 'new' benthos
2. Fish ??????

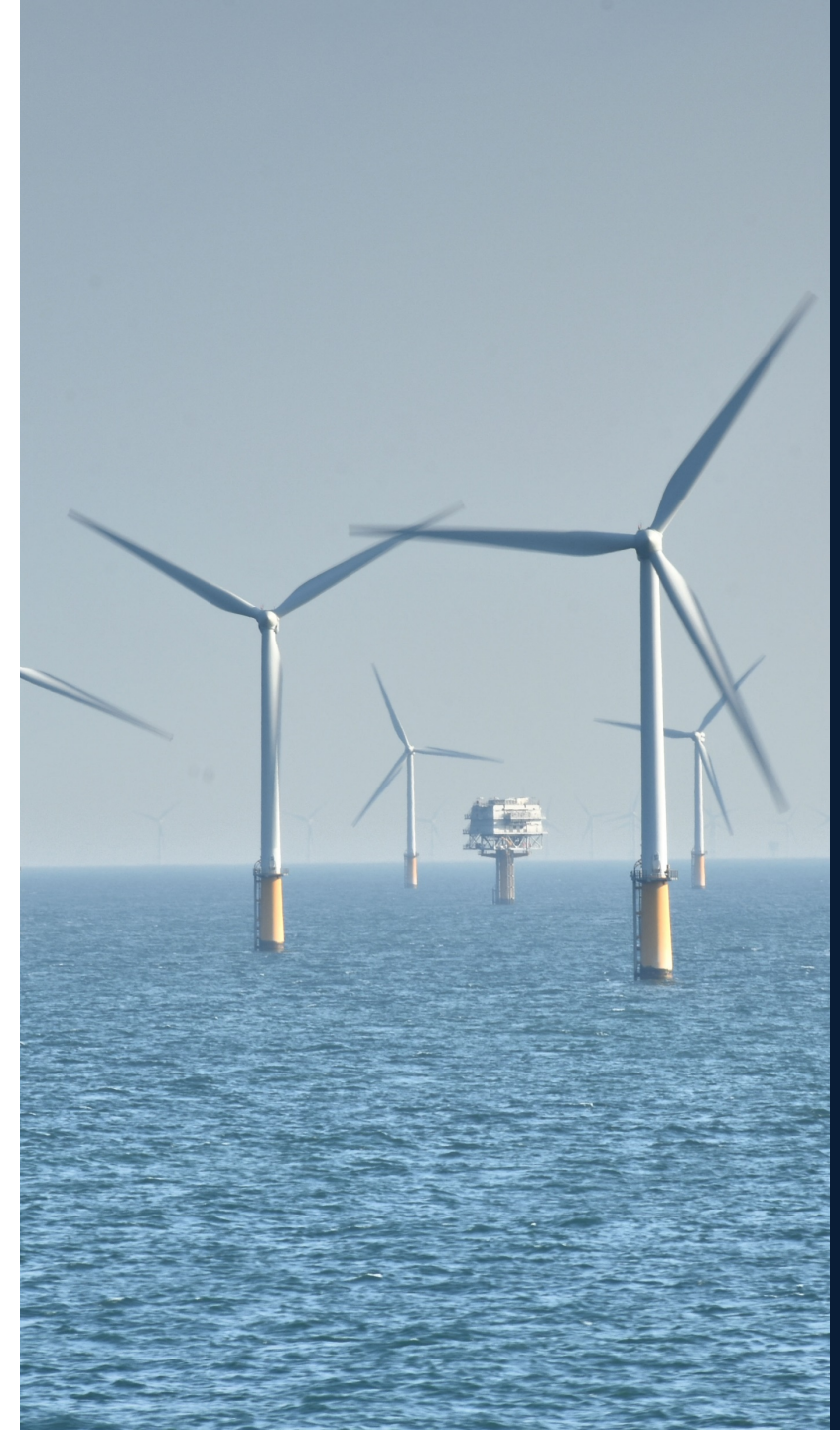




# What does this mean?

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- Large upscaling of offshore wind may have significant ecosystem effects in (parts of) the North Sea; some species benefit, some not.
- Currently much uncertainty in knowledge and tools. First model developments starting now (focus on **stratification**, **fine sediment** and **primary production**)
- However: **decisions needs to be taken sooner than required knowledge is available.**
- Alternatives (e.g. continuing with fossil fuels) have serious known consequences and risks
- Required: **adaptive ecosystem management and international programmes to reduce uncertainties.**



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## Contact

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