



# Renewable energy technologies and environmental challenges

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International VISTA seminar 2022

# IMR: A national research institute (for support of ocean management)



Ecosystem and impact



Sustainable harvest



Sustainable aquaculture



Safe and healthy sea food

Observations → research → advice



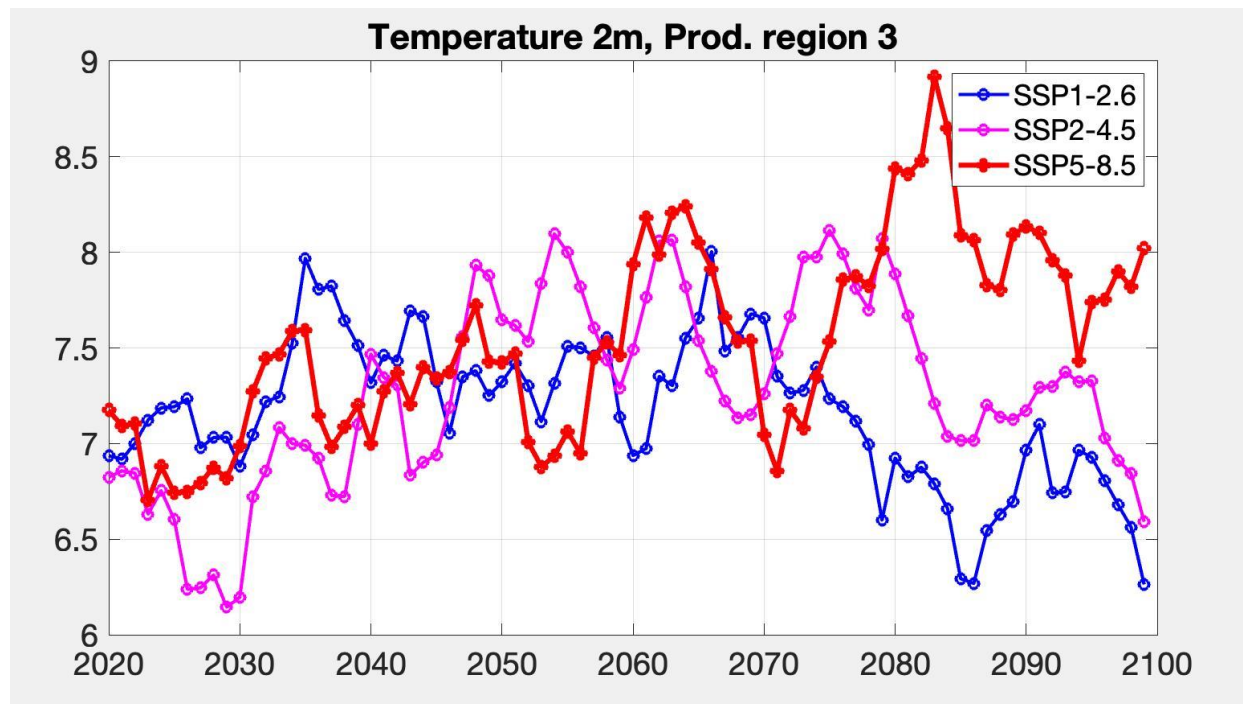
# Outline

1. Wind farm effects in a global warming perspective
2. What do we know about effects of offshore wind farms, and which research topics are important to explore further?
3. How to communicate knowledge to policy makers?
4. Expand offshore wind industry as a mitigation measure?





# 1. Expected climate change



- Expected changes in T2M PO3. Downscaled with NEMO from CMIP6
- Effects of future changes from now until 2041
- Signal is not separated from natural variability



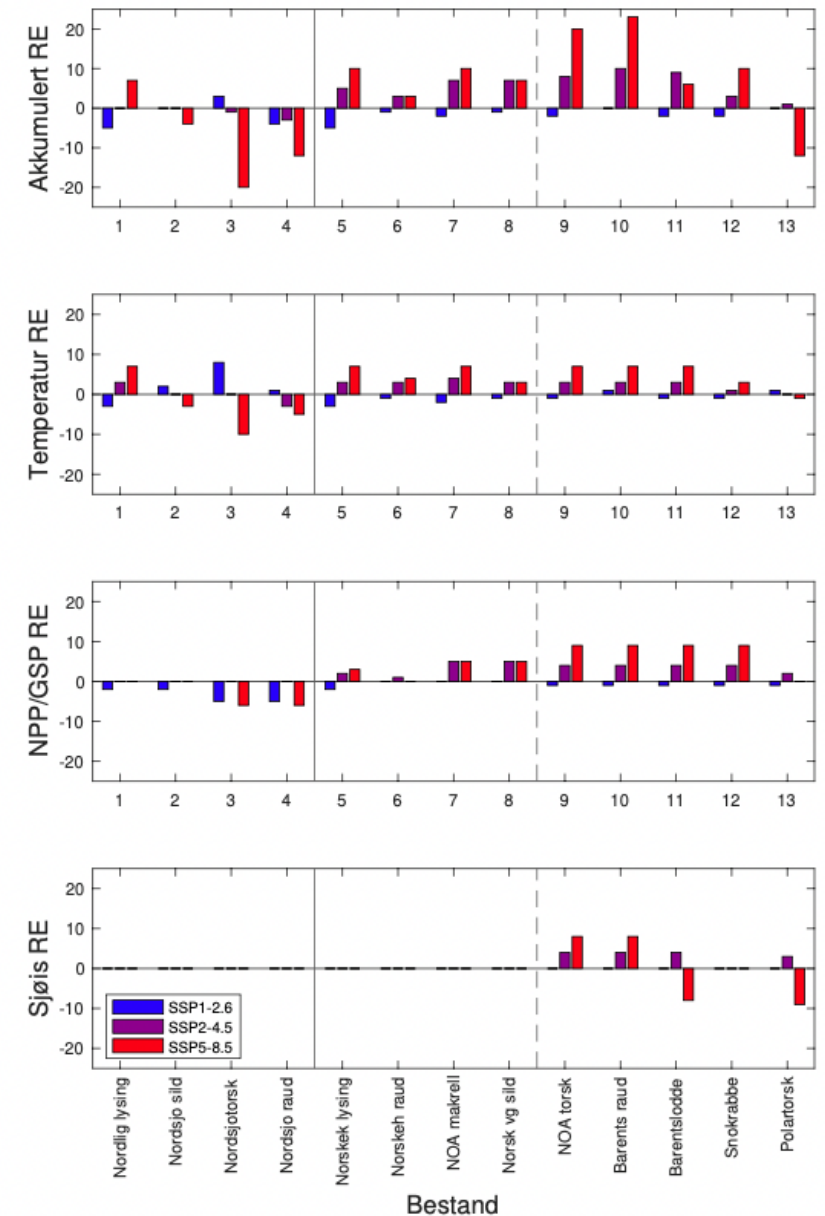
# Ocean warming

## Some findings:

- Climate change is the most influencing factor on the various ecosystem components
- High vulnerability for many different parts of food webs
- Changes in food webs have already been observed in the North Sea, Norwegian Sea and Barents Sea as a result of climate change



Hjøllo, S. S (2022) Pers. comm.  
 Sandø et al (in press): Risikoanalyse for de norske havområdene om direkte og indirekte virkninger av klimaendringer på marine økosystemer under ulike utslippsscenarioer.  
 Rapport til MDIR 3/22

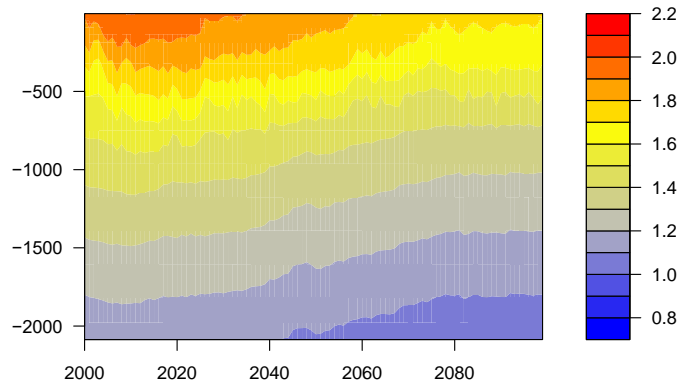


Figur 18: Retningseffekter for de ulike bestandene i scenariene SSP1-2.6, SSP2-4.5 og SSP5-8.5. Øverst er de akkumulerte retningseffektene, deretter kommer komponentene for henholdsvis temperatur, NPP (raudåte) og GSP (fiskebestander), og sjøis. De vertikale linjene viser skillet mellom bestander som er typisk for Nordsjøen, Norskehavet og Barentshavet.

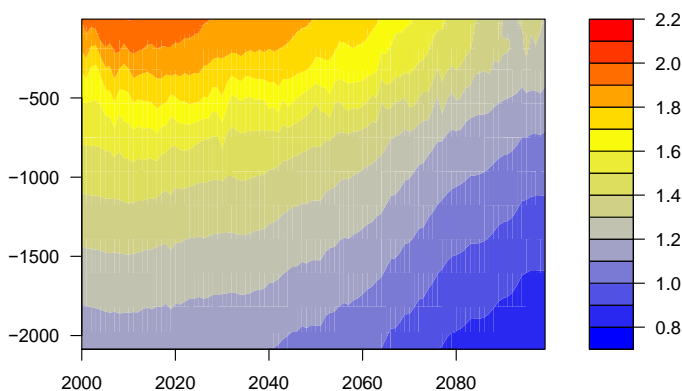
# Effects of ocean acidification (OA)

From the "Vulnerability Report" and the "Climate Risk Report" (IMR 3/22)

Omega(Ar) at station M (66N,2E), RCP4.5



Omega(Ar) at station M (66N,2E), RCP8.5

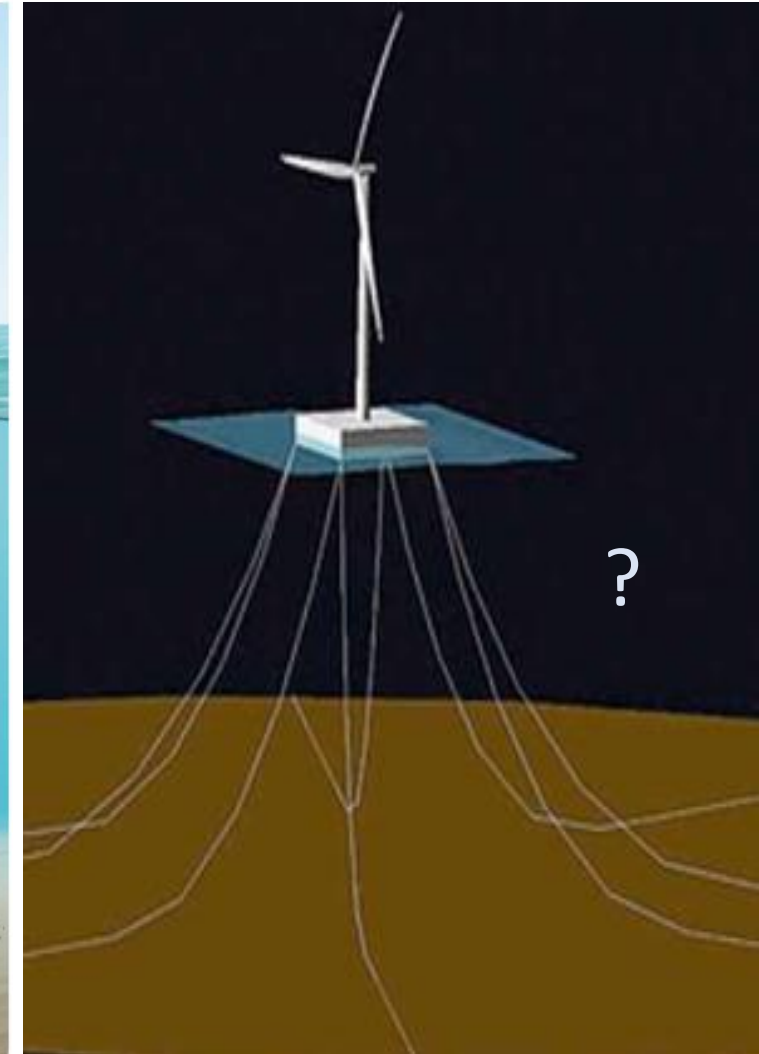
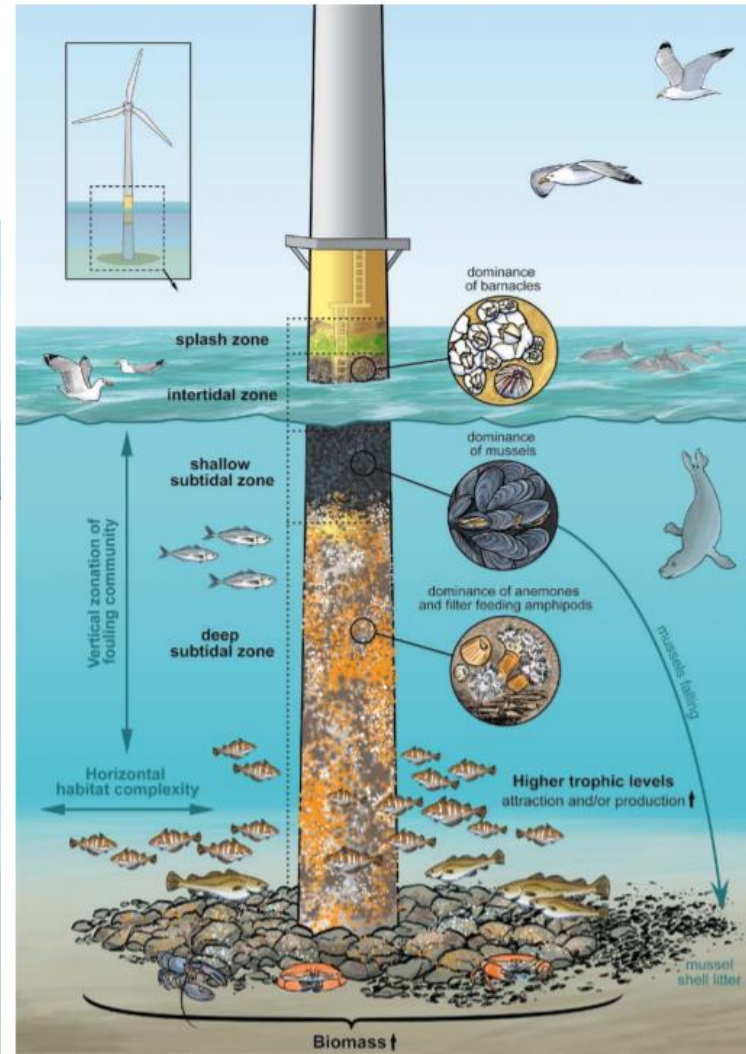
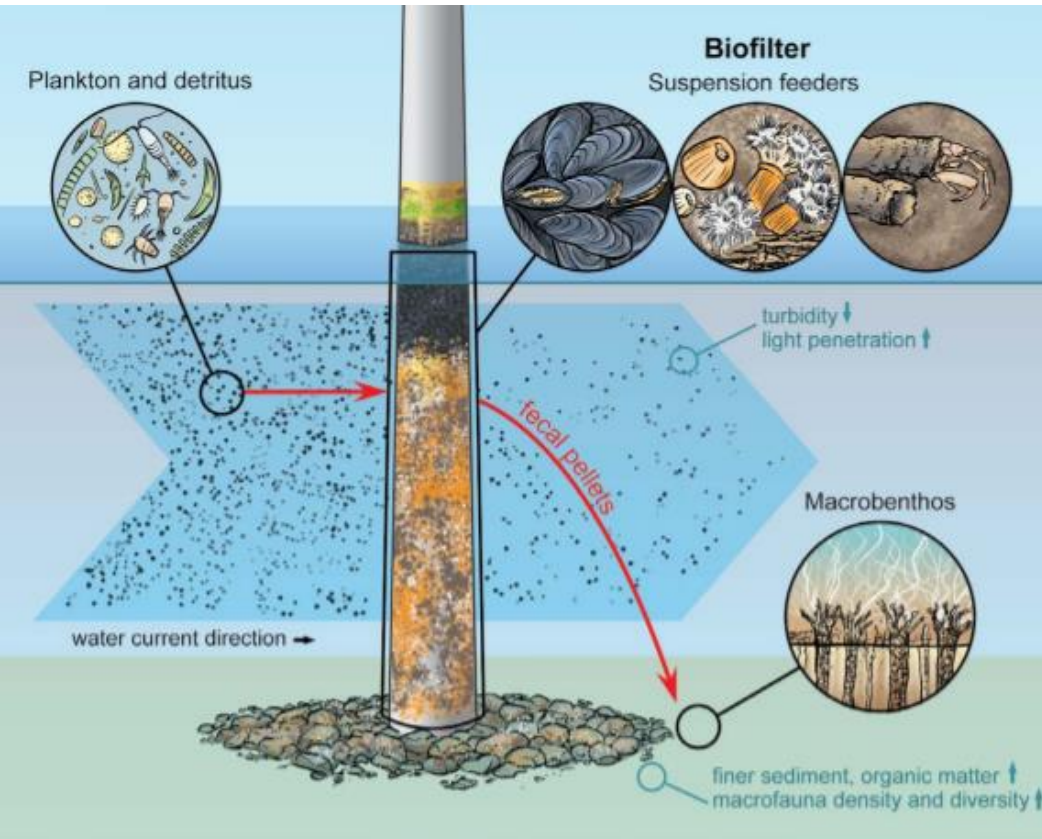


- Phytoplankton communities are generally robust.
- The effect on zooplankton is uncertain, but assumed to be negligible.
- **Seaweed, kelp and eel grass** live in the euphotic zone where the pH naturally varies a lot throughout the day.
- **Benthic communities:** OA can affect calcifying shells, but vulnerability is uncertain.
- Cold-water coral reefs will be affected early, due to their distribution in deep and cold water masses.
- **Seabirds:** OA reduces access to sea snails in wintering areas of black-legged kittiwake (krykkje). Reduced adult survival.



# Bottom-fixed offshore wind farms can affect the ecosystem

- We know that the structures of fixed-bottom turbines can affect the ambient ecosystem



# Knowledge status and advice: What we know

- **Construction work** can harm benthic and demersal communities (blasting noise, physical disturbance)
- HI advises against construction in areas that are important for fish species which lay eggs in the sandy ground (capelin, sandeels)
- and against blasting work which can disturb spawning
- **Background noise** from turbines and increased ship traffic can disturb mammals and fish species that communicate with sound
- **Electromagnetic signals** from power cables can affect species which use magnetism for orientation (skates, sharks, haddock, eels)
- (The reach and impact of these effects is uncertain)





# Other, even more uncertain effects

## Possible negatives

- Impact on primary production
- Changes in small-scale ocean circulation (flow, upwelling) → Zooplankton
- Long-term effects on population level
- Continuous noise/electromagnetism/light → Possible negative ripple effects

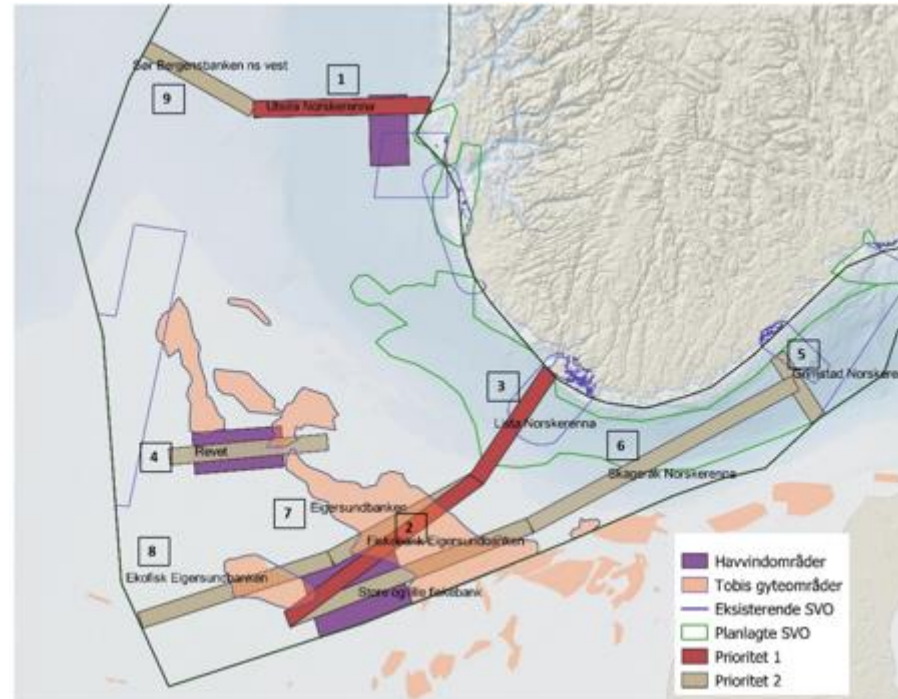
## Possible positives

- Artificial reef effect → more heterogeneous areas (diversity)
- Areas without fisheries → possible positive ripple effects on fish stocks
- Reduced climate effects

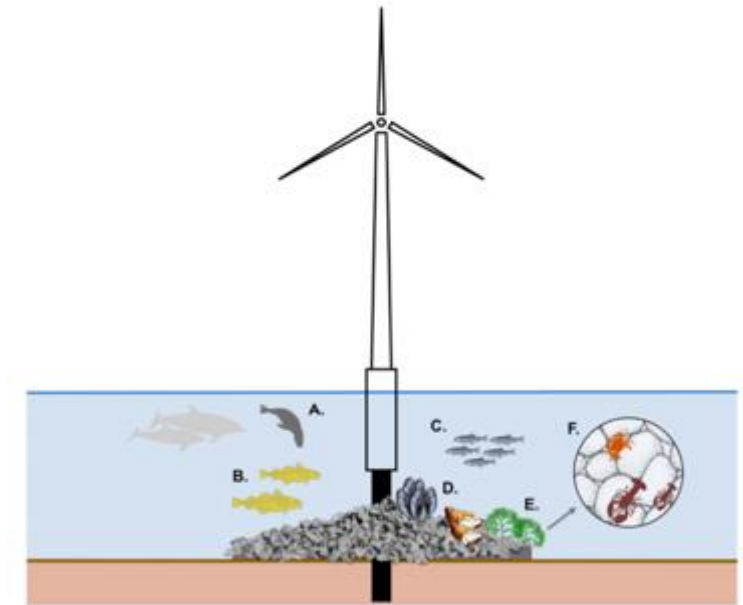


# Early plans

- Hywind Tampen
- New areas opened; Southern North Sea II and Utsira Nord
- There is a lack of mapping in these areas



Mulige kartleggingsområder for Mareano



Glarou et al. 2020 J Mar Sci Eng







# Activities at the Coast

- Aquaculture locations and Production Zones
- Fisheries
- Petroleum installations
- Cold water coral reefs
- Transportation routes
- Military exercise sites
- Marine protected areas (MPAs)
- Ocean wind farms
- Offshore aquaculture to be identified
- Impacts typically assessed per sector
- What is the cumulative impact?



# It is the overall impact that counts!

## 3 focus areas at IMR in establishing a risk assessment tool



Establish indicators for human impact on ecosystems



Map how "Keystone species" are affected by human activity



Carry out a **risk assessment** from overall human impact on the ecosystems along the Norwegian coast





# Approach: ODEMM

## Options for Delivering Ecosystem based Marine Management

Vulnerability report (IMR, March 2022)

$$\text{RISK} = \text{overlap} \times \text{sensitivity}$$

Space



No overlap

In places (<5 % overlap)

Locally (5-50 % overlap)

widespread (>50 %  
overlap)

Time



No overlap

Rarely (<1 months per year)

Some (1–4 months per year)

Often (4-8 months per year)

Extensively (>8 months per year)



# Combination with other activities

- Offshore wind farms can run in co-production with Integrated multi-trophic aquaculture (IMTA)
- Culturing of algae integrated with fish farms: Nutrient from fish can increase algal growth
- Climate smart MPAs: algal farming to increase climate outputs are not in conflict with other MPA goals



Photo: IMR



# The climate role – Blue carbon

- Kelp forests, seagrass beds, mangroves – blue forests
- The most intensive C sinks in the biosphere
  - *terrestrial forests 1.02 t C/ha yr (Grace et al. 1993)*
  - *blue forests up to 17 t C/ha yr (Duarte et al. 2005)*
- Blue forests are the “champions of carbon sequestration” (Carlos Duarte, Norw Science Academy 2022)
- Kelp forest carbon sequestration role «the elephant in the blue carbon room» (Krausse-Jensen et al. 2018)
- Climate mitigation: Macroalgae farming for carbon storage
  - e.g. to counteract emissions from aquaculture → carbon neutral fish farming



Photos: NBFN.no

# Closing remarks

## 1. Wind farm effects in a global warming perspective

- Anthropogenic climate change will be (is) the largest impact factor on marine ecosystems.
- Offshore wind farms and their effects might be necessary to avoid a major crisis (given contribution to GHG reduction)??

## 2. What do we know about effects of offshore wind farms, and which research topics are important to explore further?

- We have some experience and knowledge. But uncertainty (wrt severity of effects) – more mapping and research is needed – IMR estimates 3 years
- The collective impact of all factors is what matters

## 3. How to communicate knowledge to policy makers?

- Through a transparent risk assessment approach
- Develop a closer interaction between science and policy? (Honest Broker (Roger Pielke Jr))

## 4. Combine offshore wind with other industries to strengthen mitigation?

- IMTA can provide sustainable food, novel materials, clean energy as well as play a role in climate change mitigation
- Justified optimism, BUT substantial challenges. R&D needed.

