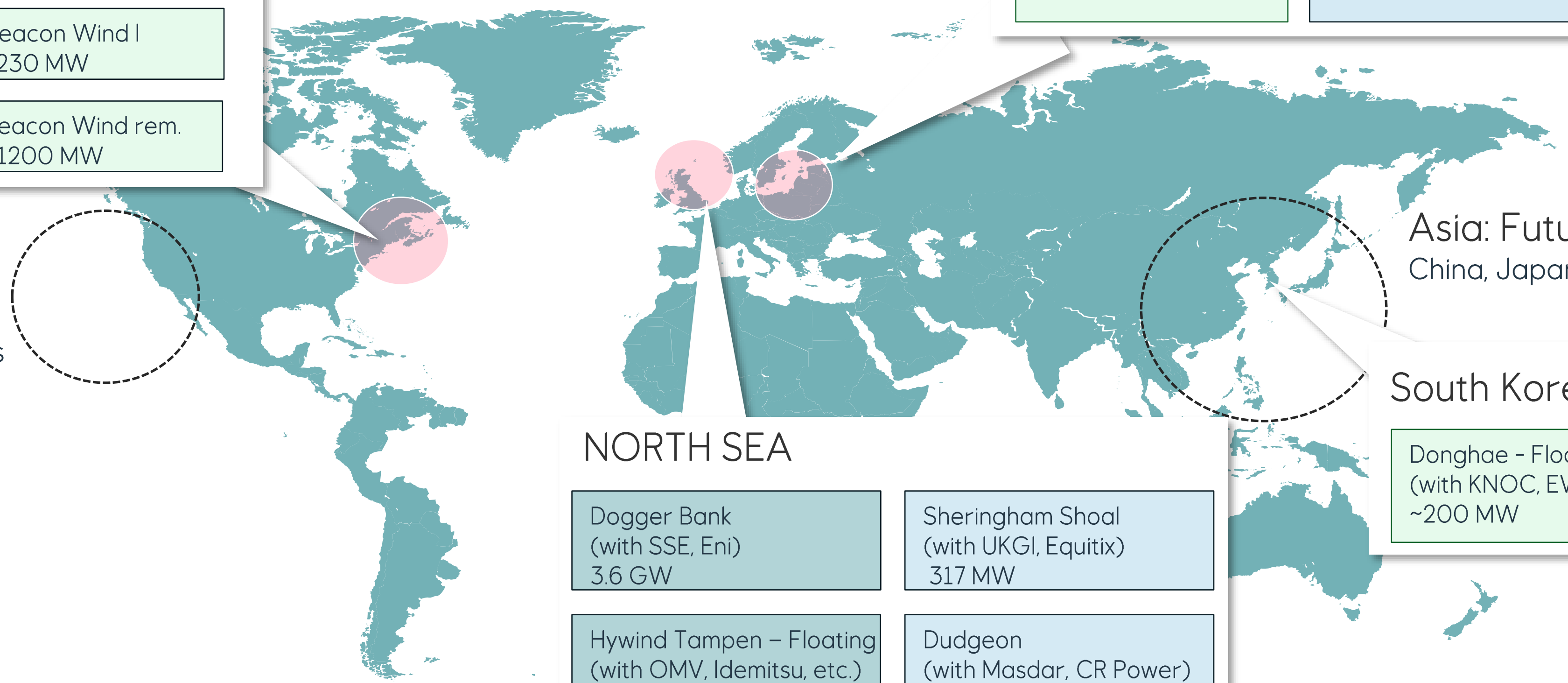
Testing of New Mapping and Monitoring Technologies for Pelagic Fish in Marine Waters

Floating offshore wind – needs for learning and research activities

Kari Mette Murvoll, PhD Ecotoxicology/Pr.researcher TDI

Becoming an energy major in offshore wind



US EAST COAST (JV with BP)

Empire Wind I
816 MW

Beacon Wind I
1230 MW

Empire Wind II
1260 MW

Beacon Wind rem.
~1200 MW

BALTIC SEA

Baltyk I,II,III, Poland
(with Polenergia)
~2.5 GW

Arkona, Germany
(with RWE)
385 MW

US West coast: Future growth

Floating wind opportunities

Asia: Future growth

China, Japan, South Korea, Vietnam

NORTH SEA

Dogger Bank
(with SSE, Eni)
3.6 GW

Sheringham Shoal
(with UKGI, Equitix)
317 MW

Hywind Tampen – Floating
(with OMV, Idemitsu, etc.)
88 MW

Dudgeon
(with Masdar, CR Power)
402 MW

UK Extensions
720 MW

Hywind Scotland - Floating
(with Masdar)
30 MW

South Korea

Donghae - Floating
(with KNOC, EWP)
~200 MW

Firefly
~800 MW

Pipeline
In construction
Producing

A strong growth platform

equinor

In production

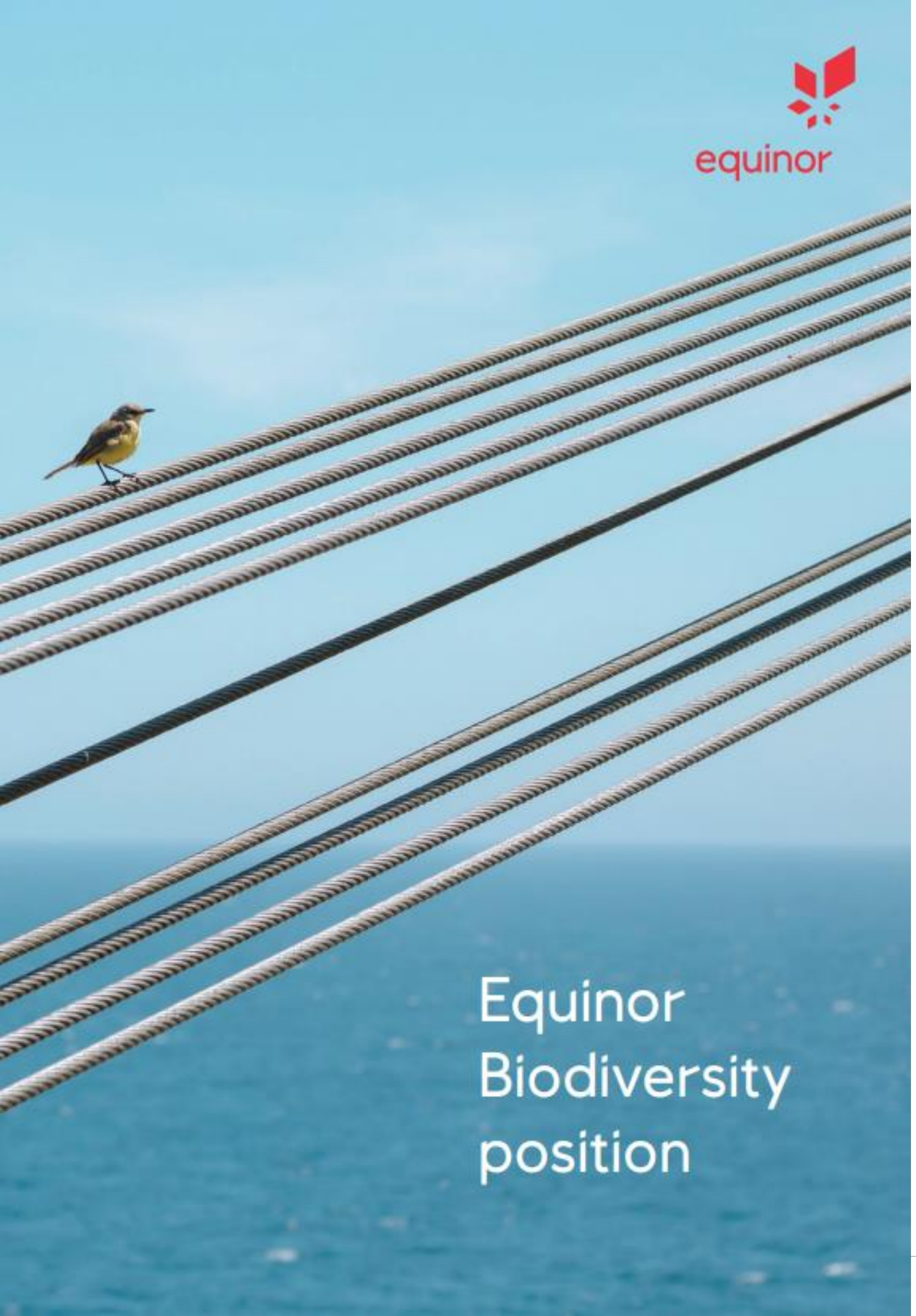
Bottom fixed			Floating
Sheringham Shoal 317MW	Dudgeon 402MW	Arkona 385MW	Hywind Scotland 30MW

Project pipeline

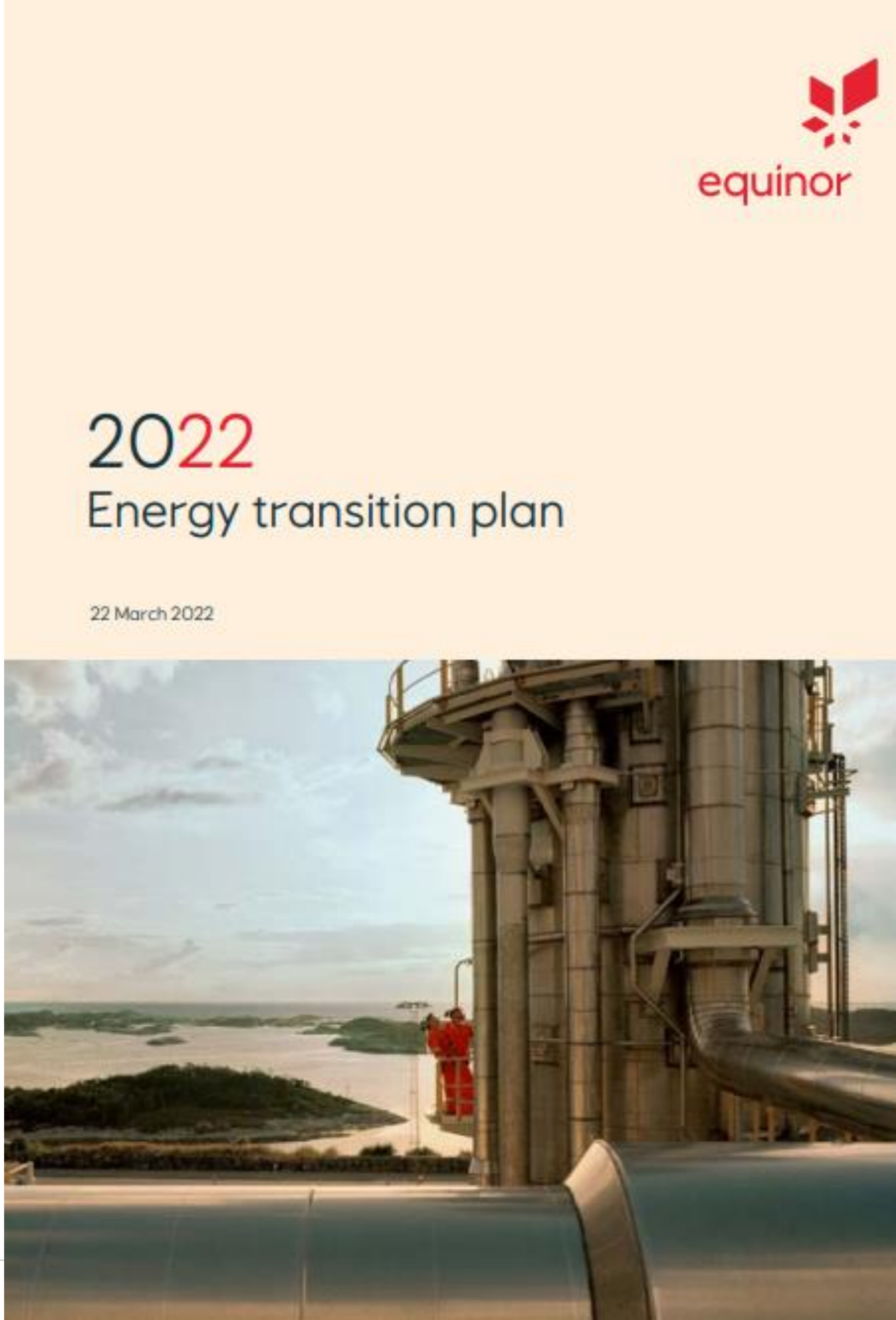
Bottom fixed		Floating
Dogger Bank, UK 3.6GW	Baltyk I, II & III, Poland ~2.5GW	Hywind Tampen, Norway 88MW
US East Coast > 4GW	UK Extensions 720MW	

Oil & Gas and Renewables have clear synergies

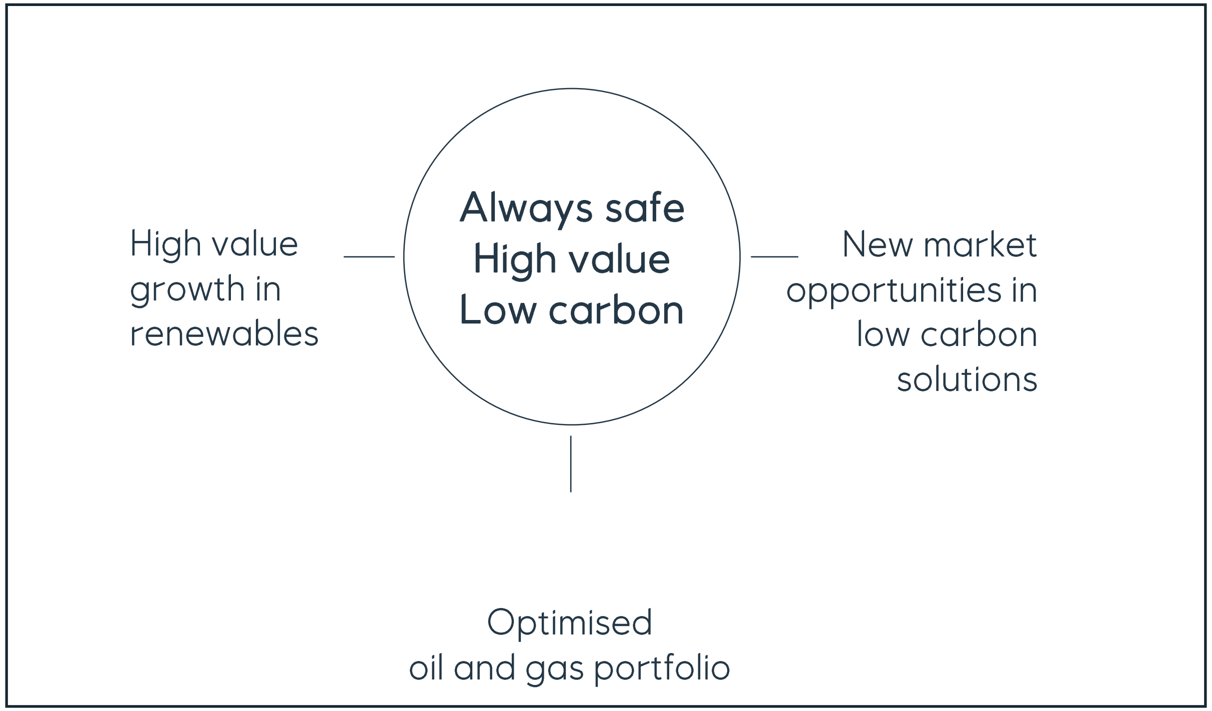
Aasta Hansteen & Hywind Scotland – one common technology: Spar

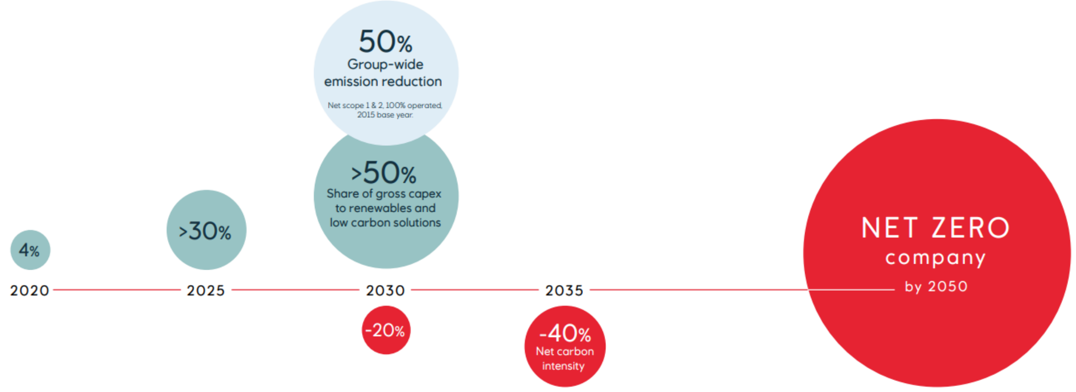


To us, sustainability is at the core of everything we do. Our journey to develop as a broad energy company is founded on a strong commitment to sustainability (Equinor.com)



Equinor's strategies (published equinor.com)





equinor

A leading company in the energy transition

2022
Energy transition plan

22 March 2022

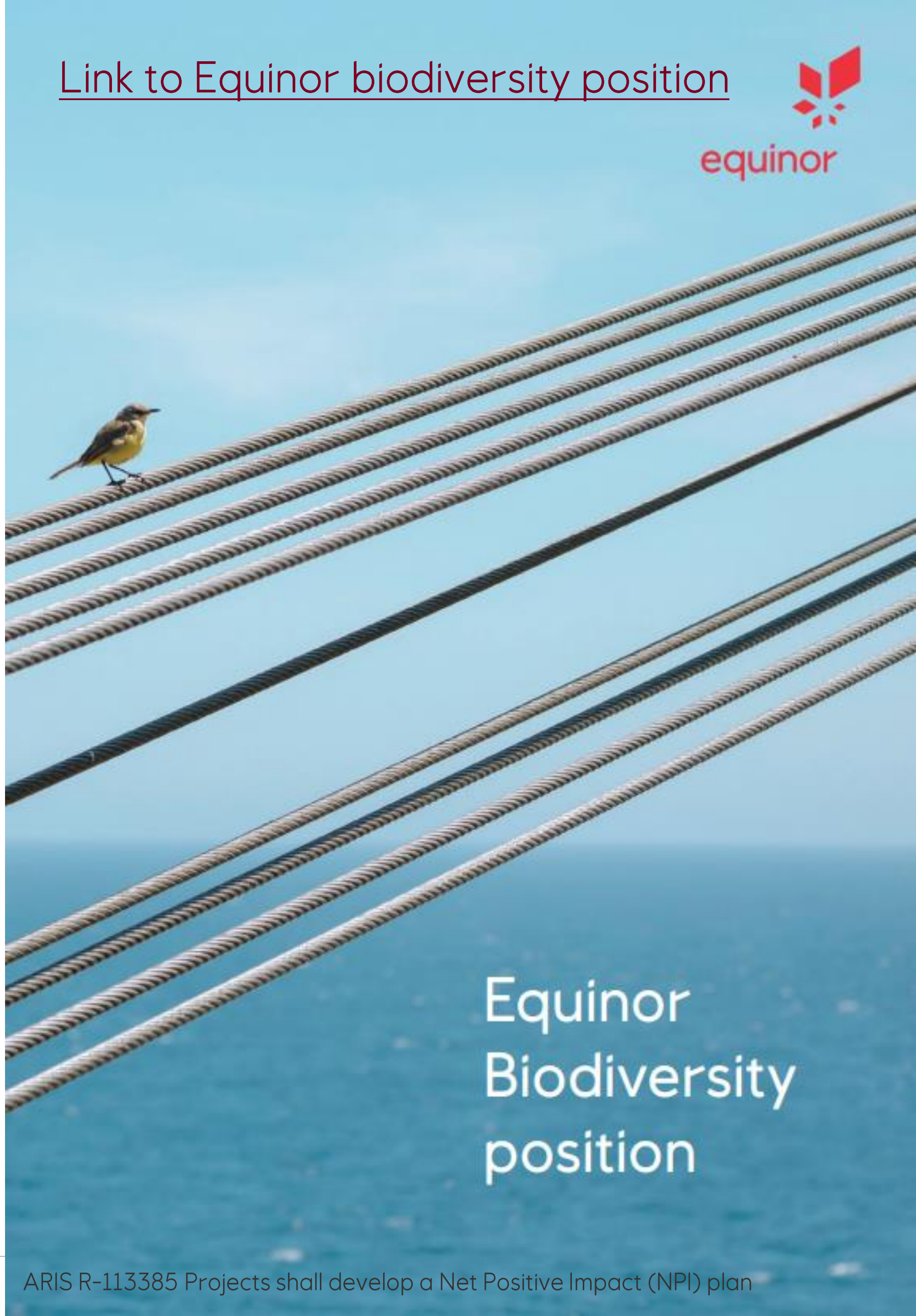
Equinor biodiversity position (published equinor.com)

- Equinor supports the global ambition of reversing nature loss by 2030

- To be successful, the energy transition must go hand in hand with practices that protect the environment and enhance biodiversity

- Five areas of actions for Equinor´s strengthened biodiversity commitment:
    - Establishing voluntary exclusion zones
    - Developing a net-positive approach
    - Increasing knowledge and access to biodiversity data
    - Investing in nature-based solutions
    - Advocating for ambitious biodiversity policy

Link to Equinor biodiversity position



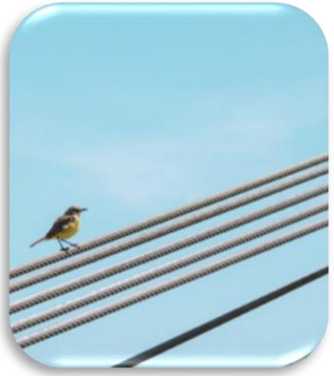
ARIS R-113385 Projects shall develop a Net Positive Impact (NPI) plan

Research portfolio I Offshore Wind Sustainability

Improved understanding of bird displacement and collision risk for offshore wind farms

Reducing consenting risk related to underwater noise of offshore wind farms

Offshore wind farms and the marine environment - impact and dependencies



Solutions for offshore wind to support the biodiversity net-positive approach

Offshore wind farm coexistence and just transition

Solutions for circular offshore wind farms to conserve natural resources

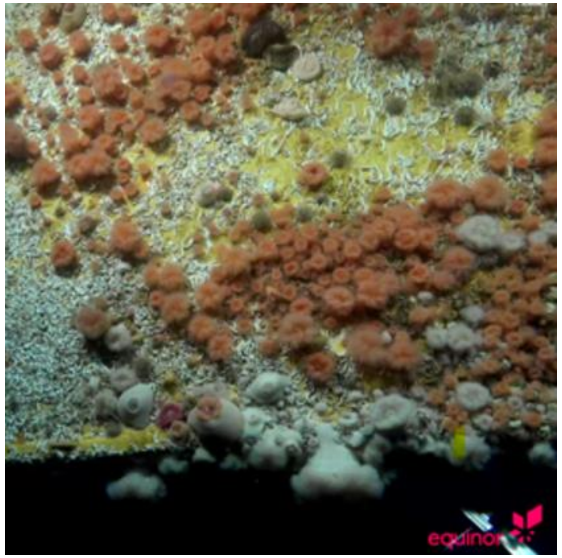
Improved sustainability performance by development of digitized data and tools

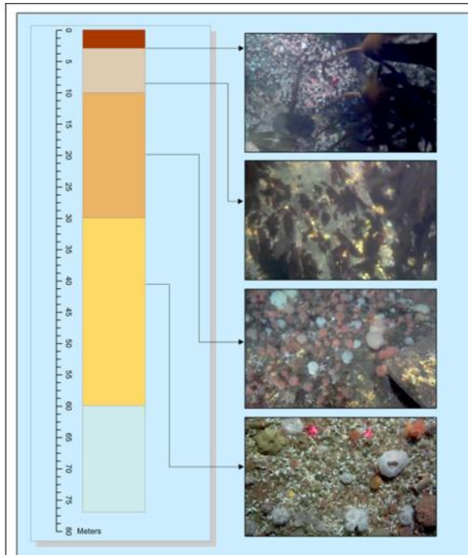
Ecosystem impact and risk

Coexistence

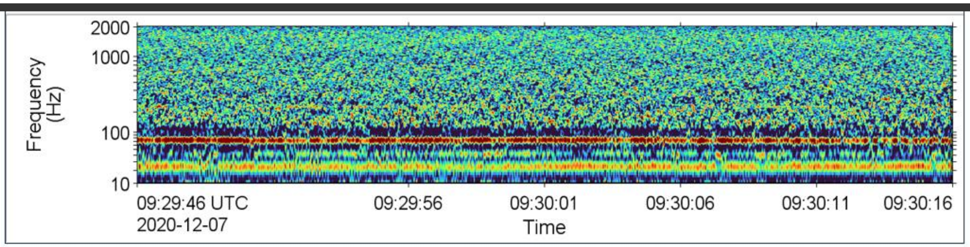
Circularity

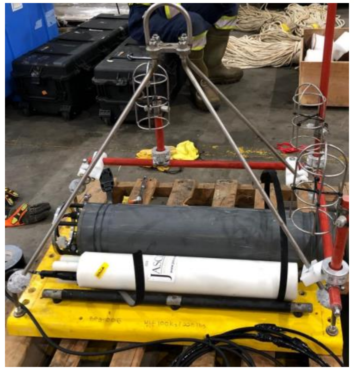
Sustainability data quantification and analysis

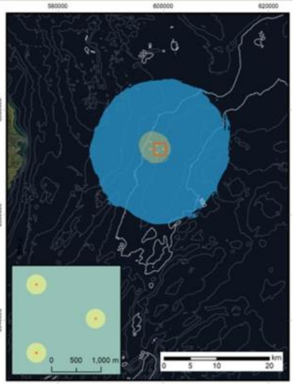




Report from colonization study Paper in Wind Energy Science





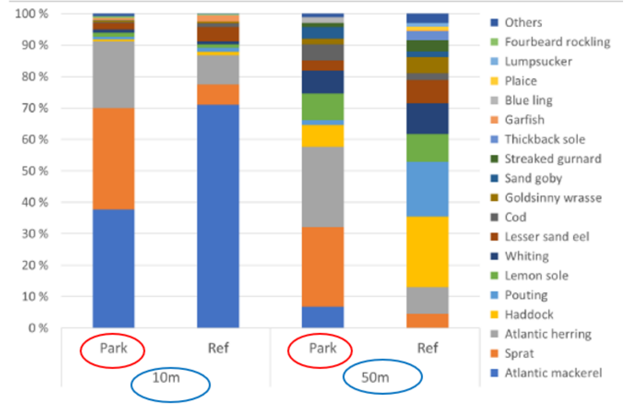


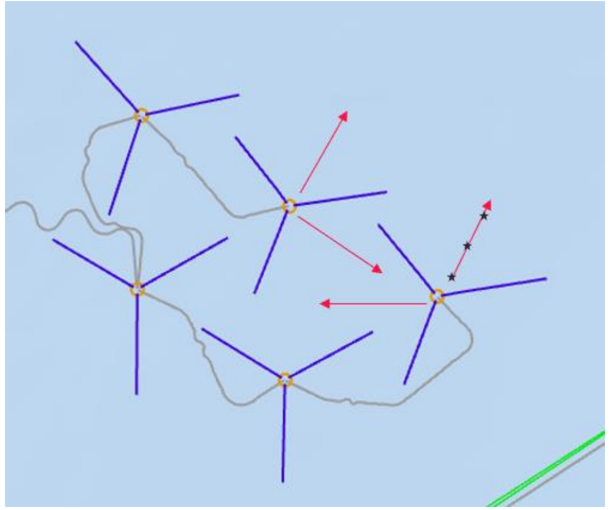
Report from sound measurement study

Equinor pilots autonomous glider survey to map fish presence and biomass quantity - equinor.com

Equinor pilots study to understand effects from floating wind on marine biodiversity – equinor.com

Report from Sailbuoy campaign Report from eDNA campaign



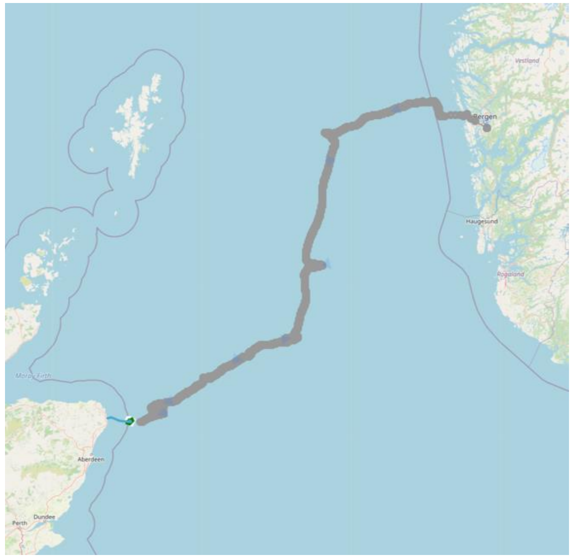


Benthos sediment sampling incl. video transects, eDNA and microplastic analysis

Sailbuoy campaign in Hywind Scotland – Summer 2021

- Sailbuoy campaign performed 8 June – 15 August 2021, with data gathering 25 June – 23 July in Hywind Scotland
- Purpose: help maturing new technology and map biomass and presence of fish in a floating offshore wind farm
- Research question: Are more fish present close to structures in the farm due to shelter and nutrients (marine growth)? (reef effect)

- *Note: Fish stocks fluctuates hugely between seasons and years. Applies for old and new technologies!*



Equinor pilots autonomous glider survey to map fish presence and biomass quantity - equinor.com

Equinor pilots study to understand effects from floating wind on marine biodiversity – equinor.com

Report from Sailbuoy campaign

Report from eDNA campaign

Vendor: Akvaplan-niva

Collision proof- https://youtu.be/wMbAxejlDAM

Reef effects in wind farms

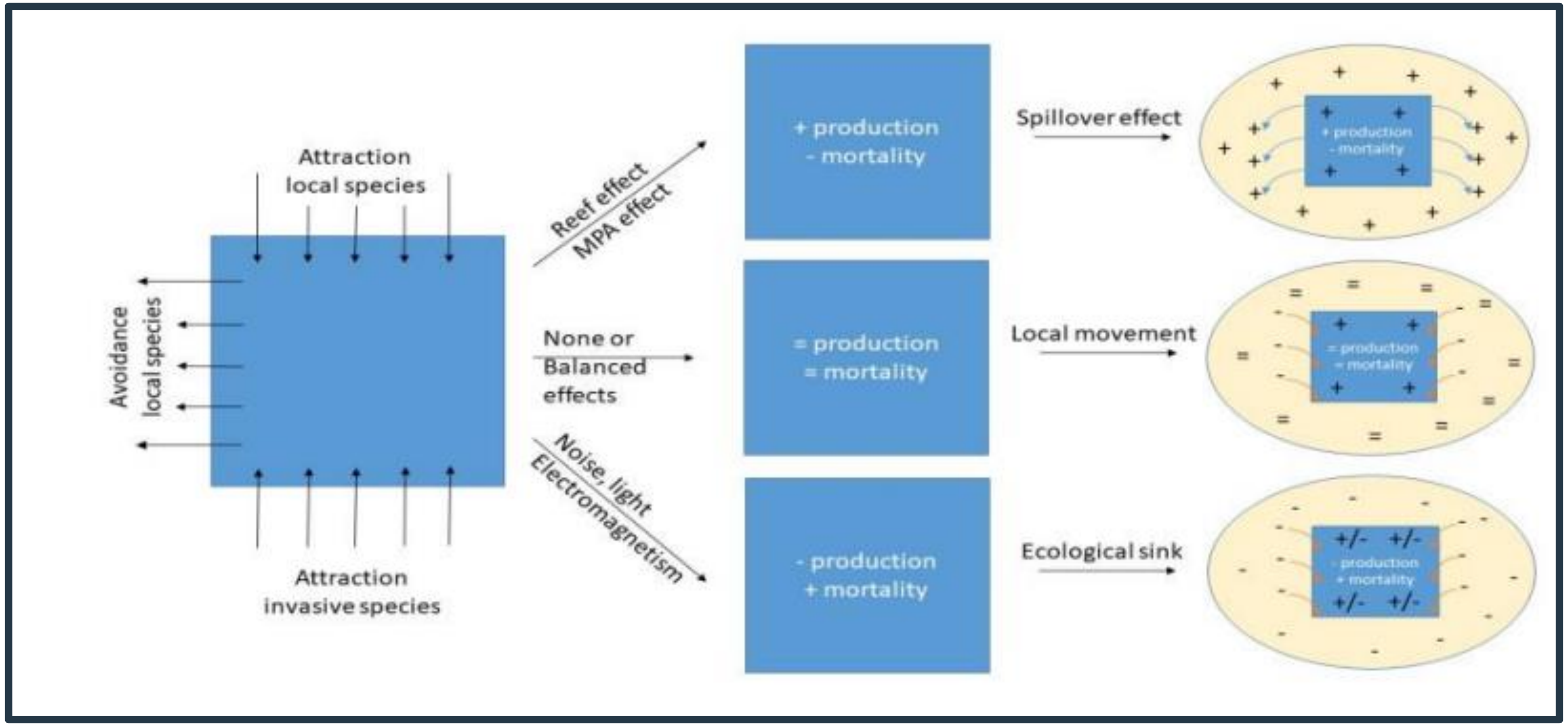


Figure from Institute of Marine Research publication «Potential effects of offshore wind farms on the marine life» 2020

Definition of distance gradients

Four distances defined:

1. Near installations (< 100 meters from turbines, light blue in figure) ***low fishing activity***
2. In the farm (the area around the 5 turbines with a 500 meter buffer zone, dark blue in figure) ***low fishing activity***
3. Low traffic area (the area outside the farm with low traffic, light grey in figure) ***likely low fishing activity***
4. Outside (outside the aforementioned areas) ***high fishing activity***

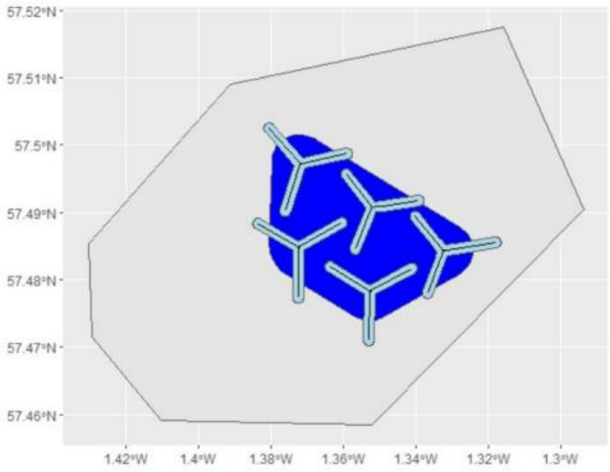


Figure 8 The different areas used to categorize distance from the installations and level of traffic/fishing pressure. 1) A "near installation" area was defined as the area within 100 m of any installation (turbine body or anchoring chain, light blue), 2) the park area was defined as the area within the perimeter of the 5 turbine bodies (with a buffer of 500 m, dark blue), 3) a "low traffic" area was visually identified from Marine Traffic (light grey here, corresponding to dark blue area in Figure 9).

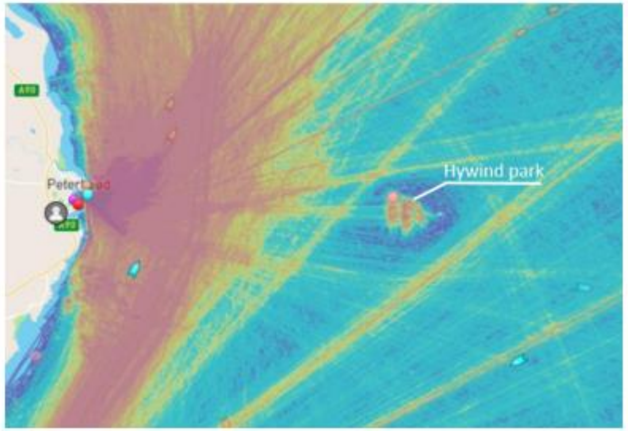
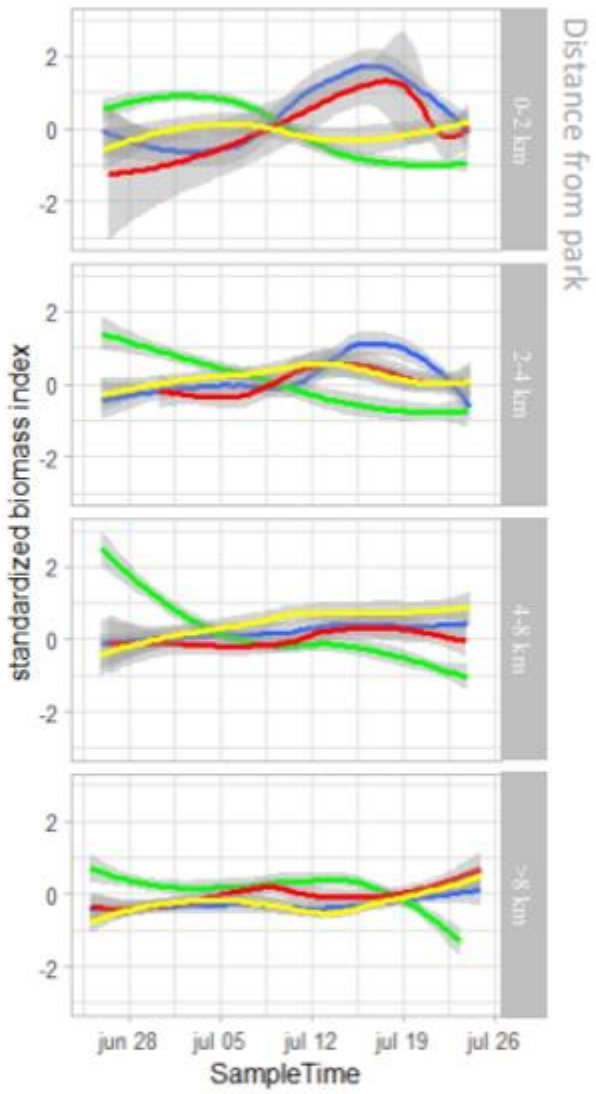


Figure 9 Screenshot from Marine Traffic of 1 year traffic data in the area around Hywind Scotland. The area outside of Peterhead is characterized by high vessel traffic (all vessel types, increasing form yellow to red), as well as the area between the turbines, due to vessels servicing the park. A low traffic area with little traffic (dark blue) is seen around the wind park, probably as a consequence of vessels avoiding the park.

Biomass of zooplankton and fish with increasing distances from turbines



Close to the farm

- Peaks of biomass are stronger close to turbines than at further distances
  - Applies for phytoplankton (green line), zooplankton (blue line) and fish schools (red line)
  - Phytoplankton concentrations peak earliest, followed by zooplankton and fish
  - No constant «reef effect», but temporal boost of production, followed by attraction of fish

eDNA pilot study in Hywind Scotland – Summer 2021

- Water sampling performed 10 August 2021
- Purpose: to help maturing the eDNA technology in marine waters and to map pelagic fish species in the farm area
- Using traditional methods (gill nets) are difficult in floating offshore wind farms
- eDNA is a non-destructive technology
- Knowledge about *biodiversity* in areas Equinor operates is crucial

Sampling and analysis

- Water sampling by Niskin bottles (10 and 50 meter) in Hywind Scotland wind farm and in reference area (10 km from wind farm)
- Analysis
  - Metaborcoding (MiFish/18 S, qualitative approach)
  - ddPCR (semi-quantitative approach for mackerel and herring abundance)

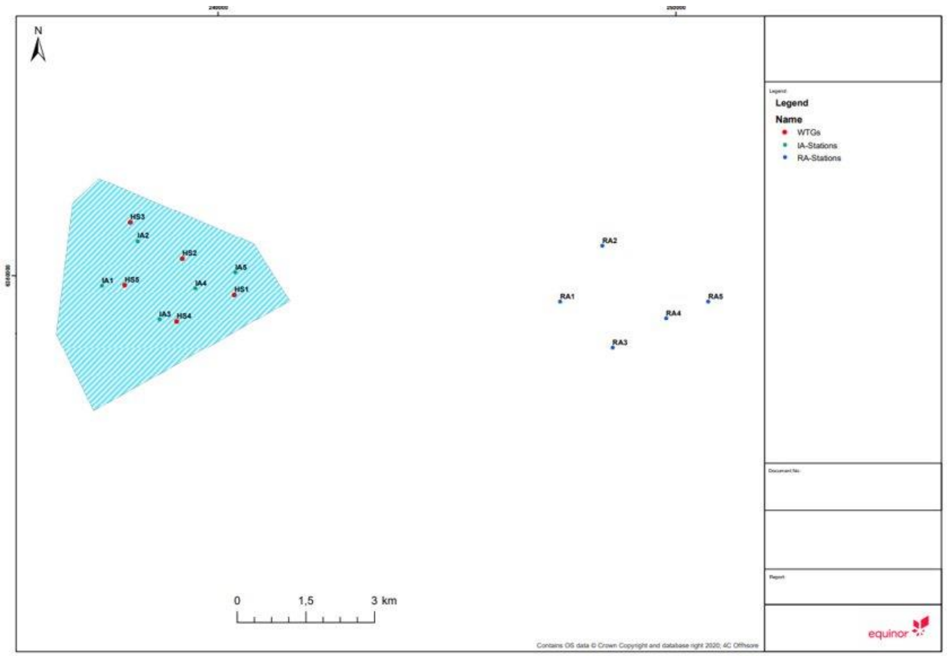


Table 2. Primers and probes used in the study. *References for all primer and probe sequences can be found in Section 2.4 and 2.5 of the Materials & Methods.*

Oligo name	5'-3' DNA sequence	Final conc.	Function
ddPCR *Scomber scombrus* (Atlantic mackerel)			
Scosco_CYBF14517	TTCCCTGCTTGGTCTCTGTT	400 nM	forward primer
Scosco_CYBR14597	GGCGACTGAGTTGAATGCTG	800 nM	reverse primer
Scosco_CYBP14541*	TTCCCAAATCCTCACAGGACTATTC	200 nM	probe
ddPCR *Clupea harengus* (Atlantic herring)			
Cluhar_CYBF14928	CCCATTTGTGATTGCAGGGG	200nM	forward primer
Cluhar_CYBR15013	CTGAGTTAAGTCCTGCCGGG	1000 nM	reverse primer
Cluhar_CYBP14949*	TACTATTCTCCACCTTCTGTTCCTC	200 nM	probe
Metabarcoding 18S (V1-V2) ribosomal RNA gene			
SSU_F04mod	GCTTGWCTCAAAGATTAAGCC	240 nM	forward primer
SSU_R22	CCTGCTGCCTTCCTTRGA	240 nM	reverse primer
Metabarcoding MiFish			
MiFish-U-F	GTCGGTAAAACTCGTGCCAGC	300 nM	forward primer
MiFish-U-R	CATAGTGGGGTATCTAATCCCAGTTTG	300 nM	reverse primer

* ddPCR probes were modified at the 5'-end with the 6-FAM fluorophore and at the 3'-end with the BHQ1 fluorescence quencher

Results: diversity (species composition) and relative abundance (MiFish), cont.

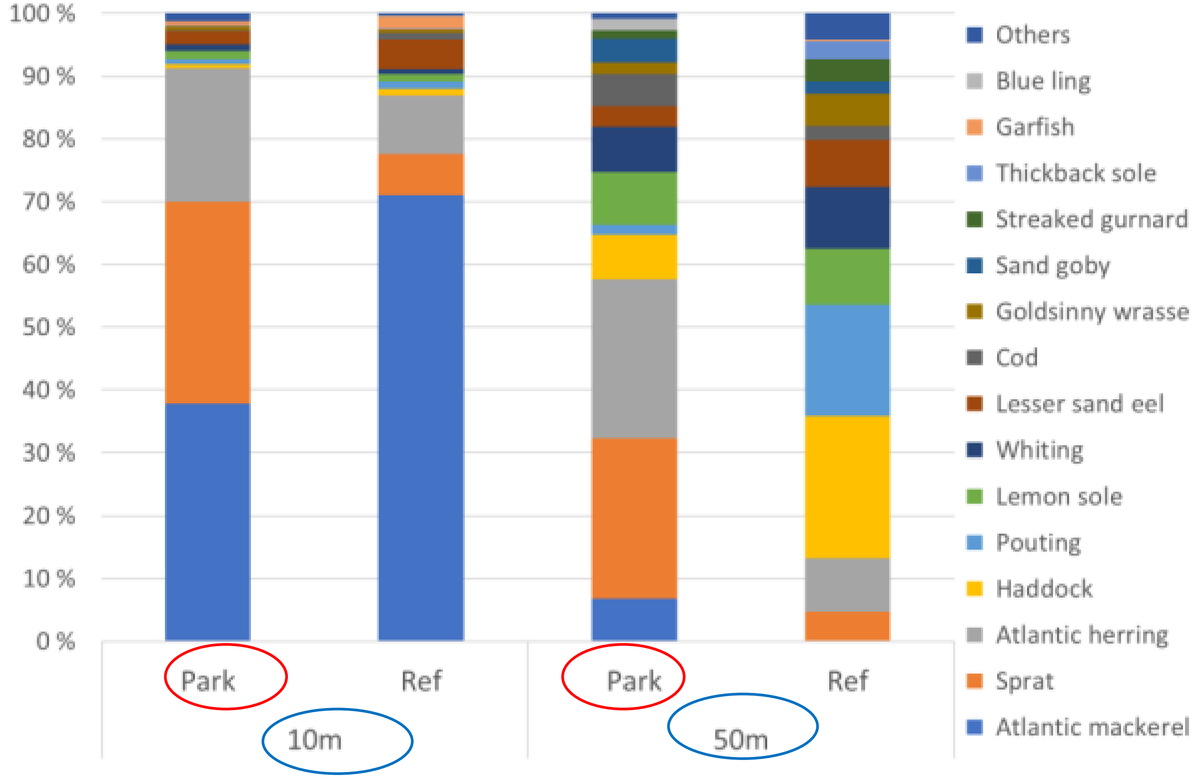


Figure 12. *Comparison of relative abundance of the 15 species with highest number of identified sequences in the MiFish dataset at 10 and 50 m depth, and between wind farm and reference area.*

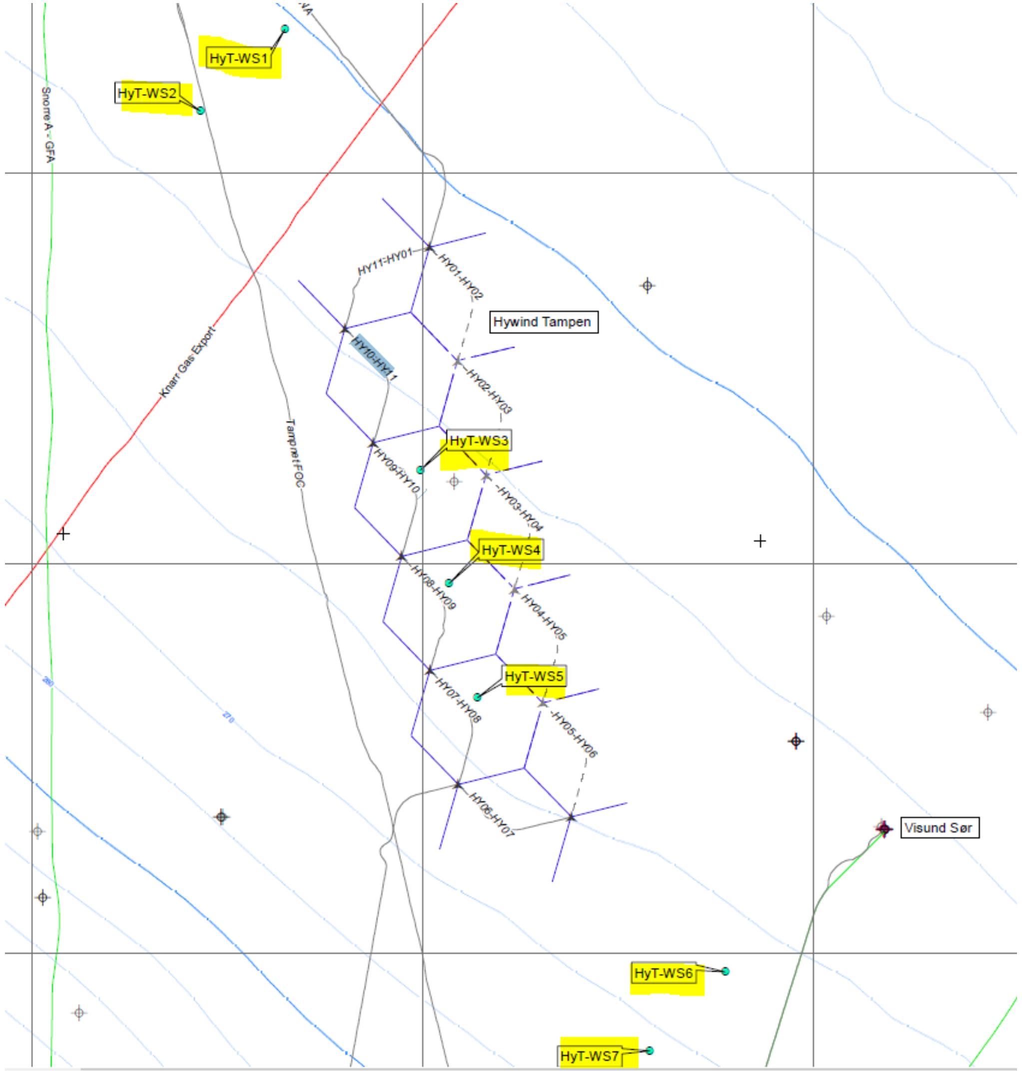
26 fish species detected

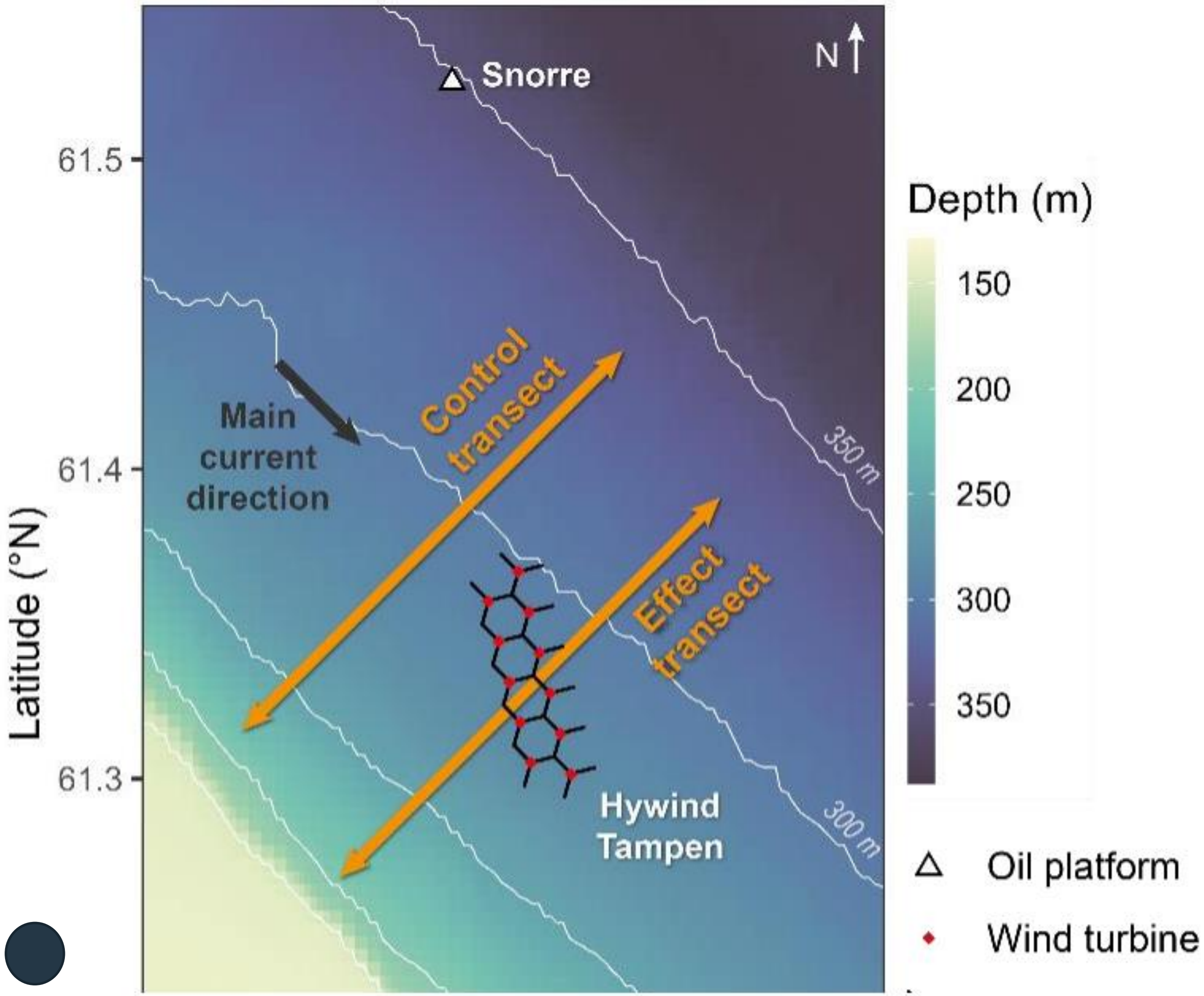
Compared to the reference area, the wind farm area had higher abundances of sprat and herring

The method is able to detect differences in relative abundance at the time of sampling

Note: this is no exact estimation of biomass. The results cover the species identified and their relative abundance (from the strength of signals/number of sequences read)

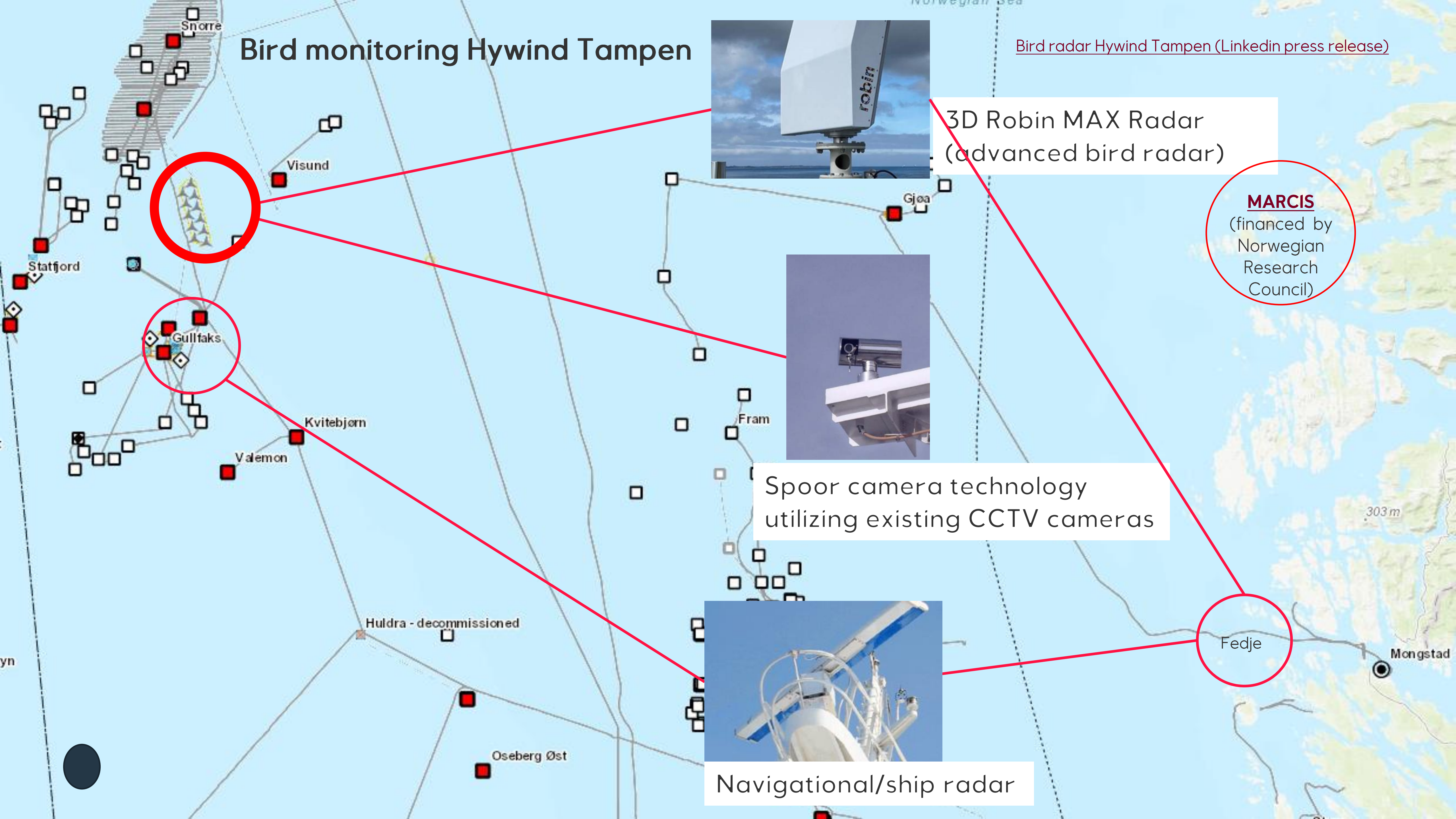
Follow-up Hywind Tampen May 2023





Bird monitoring Hywind Tampen

[Bird radar Hywind Tampen (Linkedin press release)]



3D Robin MAX Radar (advanced bird radar)

Spoor camera technology utilizing existing CCTV cameras

Navigational/ship radar

MARCIS (financed by Norwegian Research Council)

Testing of New Mapping and Monitoring Technologies for Pelagic Fish in Marine Waters

Kari Mette Murvoll