Integrated Offshore Planning

Aligning Energy, Nature and Space

EXPERT WORKSHOP

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Renewables Grid Initiative · WindEurope · Just Wind 4 All · Funded by the European Union · Co-funded by the European Union

Housekeeping & Teams Etiquette

🔇 **Please keep yourself muted** during presentations

📹 **‘Cameras on’ is encouraged** *(if comfortable)*

✋ **Use ‘Raise Hand’** to join the discussion

💬 **Post questions in the chat** anytime

Questions answered in the order they’re received

📹 **This webinar is being recorded** for internal purposes

🔐 **GDPR:** By participating, you consent to the recording and processing of personal data per GDPR and the project’s data protection policy

🙏 Thanks for your cooperation & engagement!

Renewables Grid Initiative

Renewables Grid Initiative

RGI is a unique collaboration of NGOs and Transmission System Operators (TSOs) from **across Europe**

EUROPEAN ORGANISATIONS

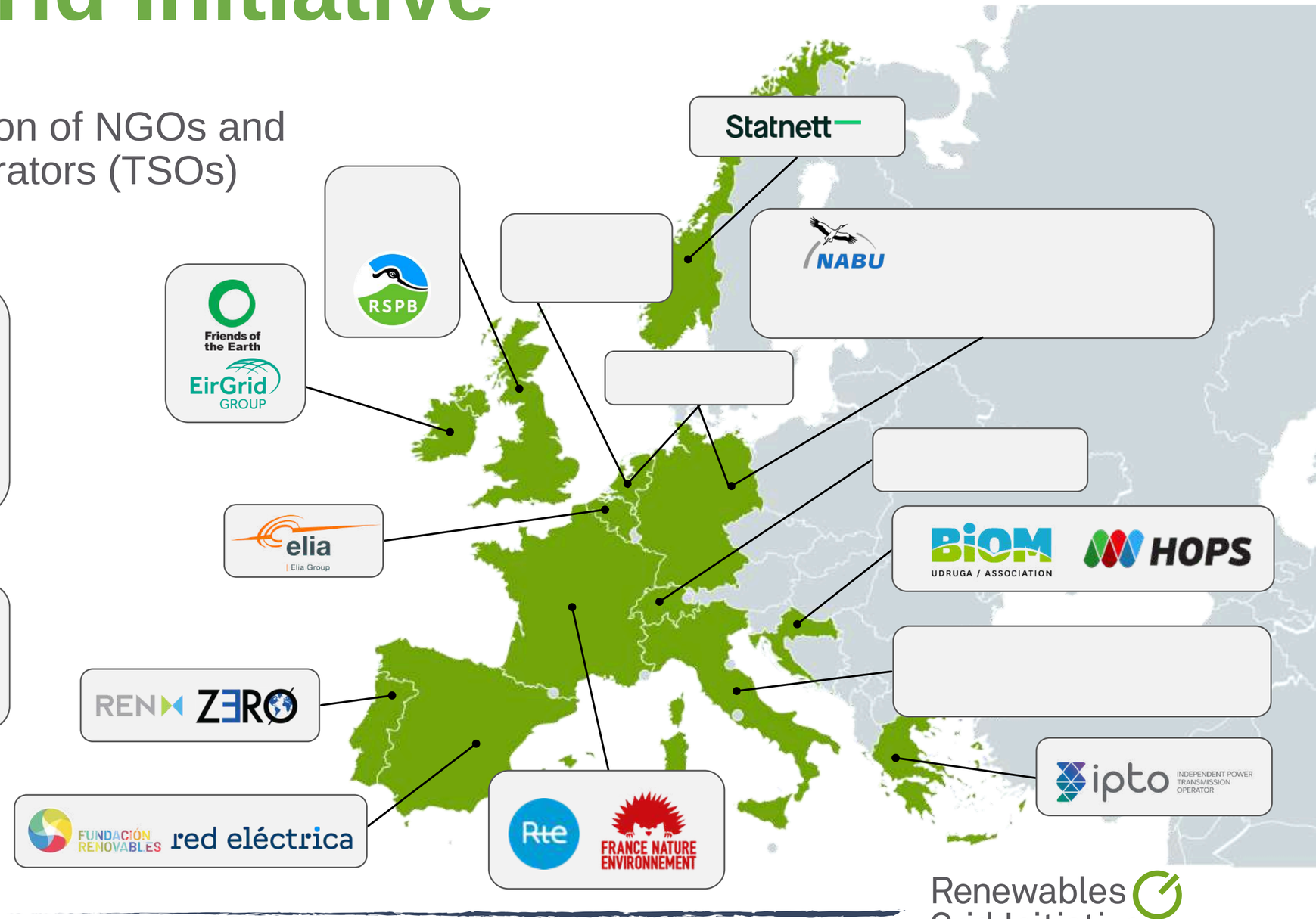
BELLONA EUROPA

EMBER

SUPPORTING MEMBERS

IUCN

T&D europe



Renewables Grid Initiative

HOW IS OUR WORK STRUCTURED?

We foster knowledge exchange, discussions on the grid infrastructure needs, and the implementation of best practices within **three dimensions:**

GRIDS & ENERGY SYSTEMS

We enable discussions on how to **model, plan and implement** decarbonised and optimised clean energy systems, including different voices in the process.

ENERGY & NATURE

We ensure energy systems both onshore and offshore are developed in **coherence with nature and biodiversity**, promoting mitigation, enhancement and restoration measures.

ENERGY & SOCIETY

We include and engage **citizens, civil society and policymakers** on strategies towards full decarbonisation, building capacity on the role of grids within the energy transition.

Renewables Grid Initiative

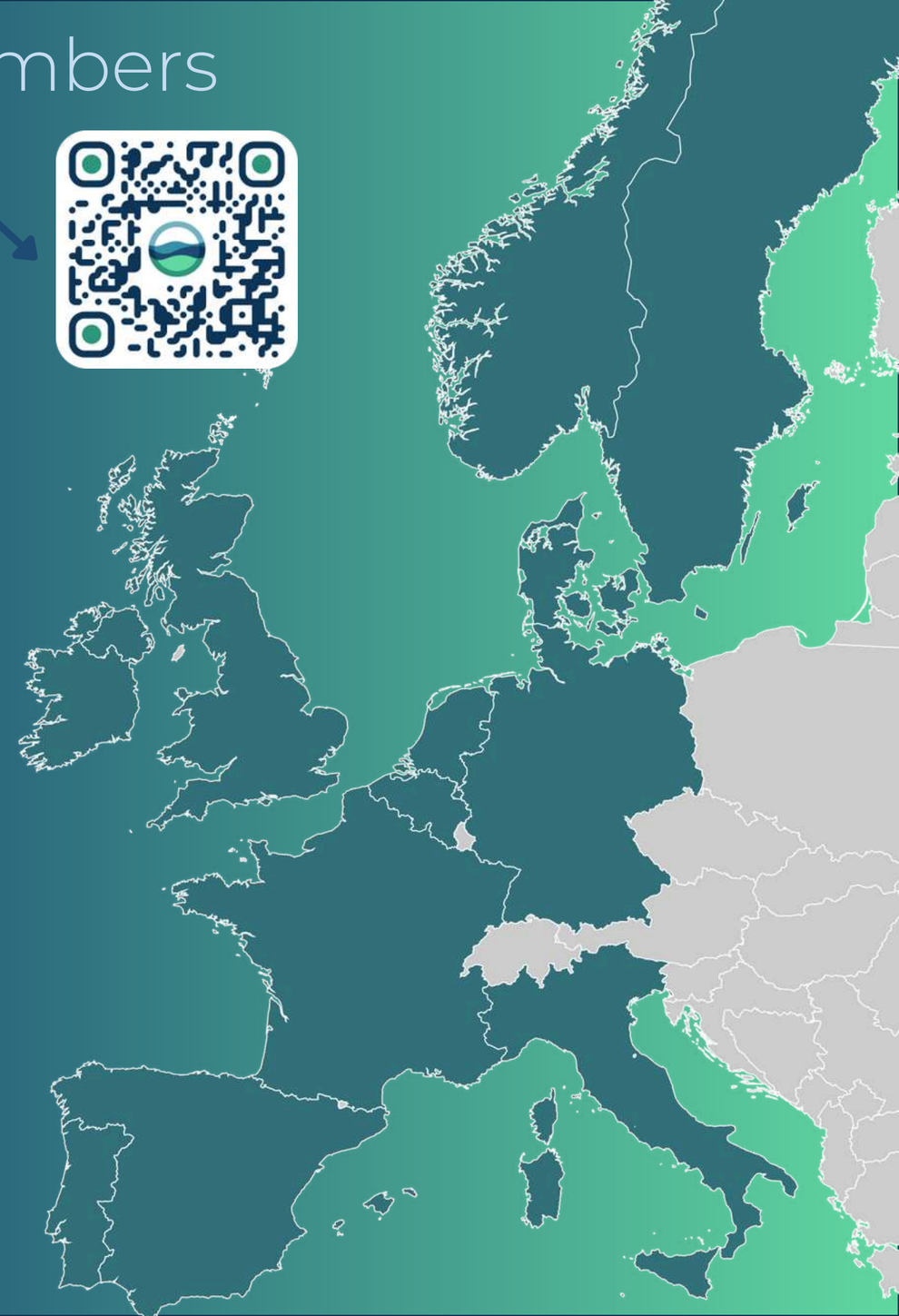
Our Members

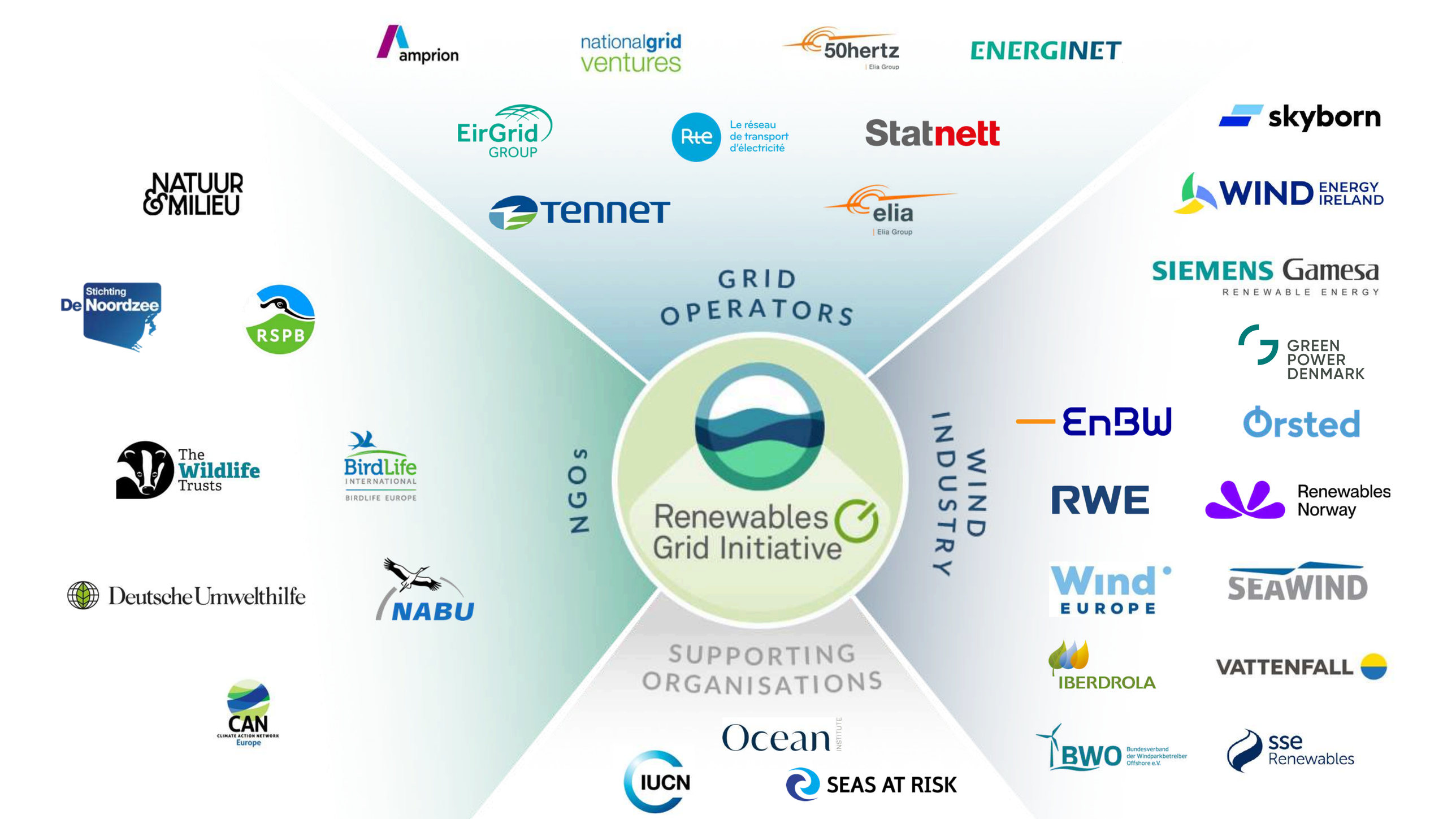
11 Grid Operators
19 Wind Power Companies
20 Civil Society Organisations

Collaborating for a green Europe!

ocean
Offshore Coalition for Energy and Nature
NORTH & BALTIC SEAS

ocean
Offshore Coalition for Energy and Nature
MEDITERRANEAN SEA




amprion
nationalgrid ventures
50hertz
Elia Group
ENERGINET
EirGrid GROUP
Rte Le réseau de transport d'électricité
Statnett
skyborn
NATUUR & MILIEU
TenneT
elia
Elia Group
WIND ENERGY IRELAND
GRID OPERATORS
SIEMENS Gamesa RENEWABLE ENERGY
Stichting De Noordzee
RSPB
GREEN POWER DENMARK
EnBW
Ørsted
The Wildlife Trusts
BirdLife INTERNATIONAL BIRDLIFE EUROPE
NGOs
WIND INDUSTRY
Renewables Grid Initiative
RWE
Renewables Norway
Deutsche Umwelthilfe
NABU
Wind EUROPE
SEAWIND
IBERDROLA
VATTENFALL
SUPPORTING ORGANISATIONS
CAN CLIMATE ACTION NETWORK Europe
Ocean INSTITUTE
IUCN
SEAS AT RISK
BWO Bundesverband der Windparkbetreiber Offshore e.V.
sse Renewables

Facilitate open forum for discussion

Advocate for OW, grids & nature

Showcase solutions

Create common understanding

Fill knowledge gaps

Collect innovative practices

ocean
Offshore Coalition for Energy and Nature

What do we do?

Maritime Spatial Planning

Auctioning – ecological criteria

Nature Inclusive Design

Co-existence with other activities

Mitigation of environmental impacts

Restoration of marine ecosystems

Monitoring and environmental data

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Offshore Coalition for Energy and Nature

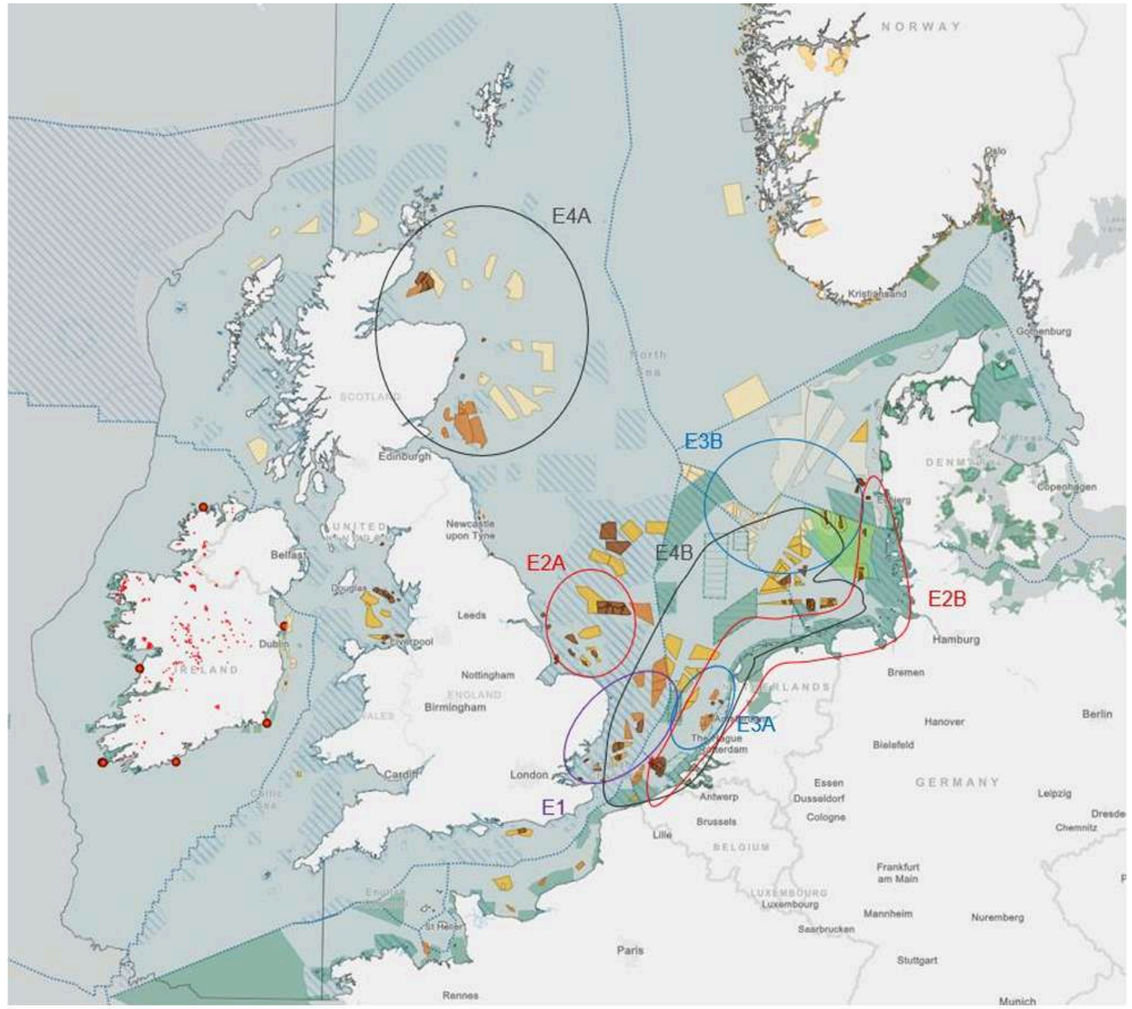
What topics do we cover?

Wind EUROPE

Our 600+ members make wind energy work

Wind Turbine manufacturers	
Wind farm developers	
Power utilities	
Component manufacturers	
Digital solutions & service providers	
EPC, installation and logistics	
Financial & legal services	
Research institutes	
Energy buyers	

Why Integrated Offshore Planning?



Status OWF areas
SIMPLIFIED_STATUS
- Existing windfarm
- Licensed windfarm
- Designated windfarm area
- Other
- Other (partial OWF capacity)

World Exclusive Economic Zone Boundaries
Status
- Agreed
- Disputed

OSPAR Regions II & III

OSPAR MPA 2021 (ODIMS)

Natura 2000 – Habitas and Birds Dieective Sites

Ecology
Ireland (MarinePlan.ie)
- NMPF 5 1 2 Protected Marine Sites – Natural Heritage Area
- NMPF 5 1 2 Protected Marine Sites – Refugees for Local Faunal

Source: ENTSO-E TYNDP 2024 Sea Basin ONDP Report // Spatial Studies North Seas

targets are sharply increasing, especially in the

and **sustainable sea space use** (fisheries, MPAs, shipping, military

coordination, planning will be **slower**, more **conflict-prone**, and more

Re ables
Grid

Workshop background

2022-2025

Funded by the European Union

JUST WiND 4 ALL

April 2024

Oct 2024

ocean
Offshore Coalition for Energy and Nature

3 July 2025

Workshop contextualisation

As Europe accelerates offshore wind deployment, integrated planning is becoming essential:

- Energy targets and grid connections
- Nature protection and restoration
- Sustainable use of sea space (other human activities)

Yet today, offshore energy planning, maritime spatial planning (MSP), and environmental protection and restoration often proceed **in parallel** and **disconnected tracks**.

Workshop contextualisation

Energy and Ecology know no border

- Increasing number of wind farms creates **spatial constraints** and **wake effects**, reducing energy yield and efficiency.
- Marine species, habitats, and ecosystems extend **across national jurisdictions**, requiring coordinated planning at the sea-basin scale.

Scaling up and acceleration bring conflicts and complexity

- Increasing **conflicting potential for energy, human activities** and **nature.**
- Pushing projects **further offshore** — into less studied, ecologically sensitive, and technically complex zones.

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Workshop contextualisation

Transdisciplinary and cross-border collaboration can transform this challenge into a shared opportunity

- **Co-created solutions** by cross-sectoral planners, system operators, conservationists, and policy experts, across spatial, national, technical, and governance silos can help **reducing delays** and **conflicts**
- Integrated planning requires **interoperable tools**, **shared assumptions**, and **common spatial language**

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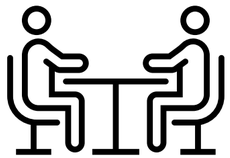
The central dilemma

How can we meet ambitious offshore wind targets while optimising grid design, improving MSP at sea-basin level, and minimising environmental and social impacts?



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Workshop Objectives

Showcase tools and models
Share spatial, energy, and environmental planning tools (e.g., energy system models and GIS, sensitivity maps, MSP tools) to identify overlaps, gaps, and integration needs

Explore options for optimised spatial use
Explore solutions like shared infrastructure, wake-aware design, and distributed siting to strengthen cross-border connectivity and system resilience

Highlight best practices
Learn from regional initiatives (e.g. NSEC, OTC) that demonstrate the value of sea-basin coordination and integrated MSP

Foster cross-sector dialogue
Enable collaboration between grid, wind, and environmental experts to align planning processes and governance across borders and sectors

Co-develop recommendations
Generate actionable proposals to improve site selection, permitting, and conflict reduction, contributing to ONDPs and EU grid planning efforts

Today’s Agenda

10:00-10:10	Welcome and introduction
10:10-10:20	Opening remarks by RGI and WindEurope
10:20-11:30	**Roundtable 1: Governance and Regional Cooperation** Insights from Belgium, as **GNSBI** co-coordinator and **NSEC presidency** holder – ***Jana Caulier*** and ***Kim Pauwels*** Reflections from **ENTSO-E** on first ONDP experience and the needs for further improvement – ***Francesco Celozzi***
11:30-12:45	**Roundtable 2: Grids, Generation, and Wake Effects** Introduction to the wake phenomenon – **WindEurope – *Riccardo Longo*** The system value of cross-border collaboration and spatial design – **Ørsted / Thema Group** – ***Roman Schliszio*** Integrated planning for mitigation of wake and consideration of maritime spatial planning: A TSO perspective for the North Sea – **50Hertz / Elia Group** – ***Felix Fliegner***
12:45-13:45	**Lunch**

Today’s Agenda

13:45-15:15	**Roundtable 3: Nature and Socio-economic Considerations** Cumulative Impacts Assessment tool in the context of offshore developments in the North Sea and North-East Atlantic – **Wageningen University - *Gerjan Piet*** More accurately estimating seabird home range and spatial exposure: implications for offshore wind farm planning – **University of Glasgow - *Holly Niven*** Contributions from MPA Europe on optimal locations for MPAs – **Ocean Biodiversity Information System (OBIS) - *Silas Principe***
15:15-15:30	**Coffee break**
15:30-17:00	**Session 4: Simulation and Recommendations** **Interactive simulation with North C Neutral's tool**, testing spatial planning scenarios Providing input to produce key **recommendations**, feeding into the ONDP process and informing the **Grids Package**
17:00-18:00	**Networking reception**

Roundtable 1

Governance and Regional Cooperation

Insights from Belgium as **GNSBI co-coordinator** and **NSEC presidency –** Jana Caulier and Kim Pauwels
Reflections on first **ONDP** experience from **ENTSO-E** – Francesco Celozzi

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Roundtable 2

Grids, Generation, and Wake Effects

WindEurope's introduction to wake phenomenon – ***Riccardo Longo***

The system value of cross-border collaboration and spatial design **Ørsted** – ***Roman Schliszio***

A TSO perspective in the North Sea: Integrated planning for mitigation of wake and maritime spatial planning – **50Hertz / Elia Group** – ***Felix Fliegner***

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Lunch break 12:45 – 13:45

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Roundtable 3

Nature and Socio-economic Considerations

Cumulative Impacts Assessment tool in the context of offshore developments – **Wageningen University - *Gerjan Piet***

Estimating seabird home range and spatial exposure: implications for offshore wind farm planning – **University of Glasgow - *Holly Niven***

MPA Europe's contributions for optimal MPA locations– **Ocean Biodiversity Information System (OBIS) - *Silas Principe***

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Coffee break 15:15 – 15:30

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Interactive Session

Simulation and Recommendations

Interactive simulation with **North C Neutral's tool**, testing spatial planning scenarios – ***Emile Lemey***
SOLV live demo – ***Roeline Ham***

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Concluding remarks & recommendations

How can we meet ambitious offshore wind targets while optimising grid design, improving MSP at sea-basin level, and minimising environmental and social impacts?

WHAT?

WHO?

HOW?

WHEN?

Concluding remarks

Showcase tools and models
Share spatial, energy, and environmental planning tools (e.g., energy system models and GIS, sensitivity maps, MSP tools) to identify overlaps, gaps, and integration needs

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Generate actionable proposals to improve site selection, permitting, and conflict reduction, contributing to ONDPs and EU grid planning efforts





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tiative

Next steps

July 2025 — **Follow up emails and sharing the content presented today**

Aug 2025 — **Summary report presenting the outcome and main messages from the workshop**

Oct 2025 — **JustWind4All Final Event in Brussels** Power With People: Local Tools for Just Wind Futures

Jan 2026 — **Insights informing the North Sea Summit agenda in Hamburg**

Let’s stay in touch!

Dr. Andrzej Ceglarz
Director – Energy Systems

Cristina Simioli
Director – Offshore Energy and Nature

Amanda Schibline
Manager – Socio-energy systems

RGI social media channels: linktr.ee/renewablesgrid

RGI website: renewables-grid.eu
OCEaN: offshore-coalition.eu/
JustWind4All: justwind4all.eu/

Integrated Offshore Planning

EXPERT WORKSHOP Aligning Energy, Nature and Space

DAY 2 OFFSHORE WIND & GRID WORKSHOP

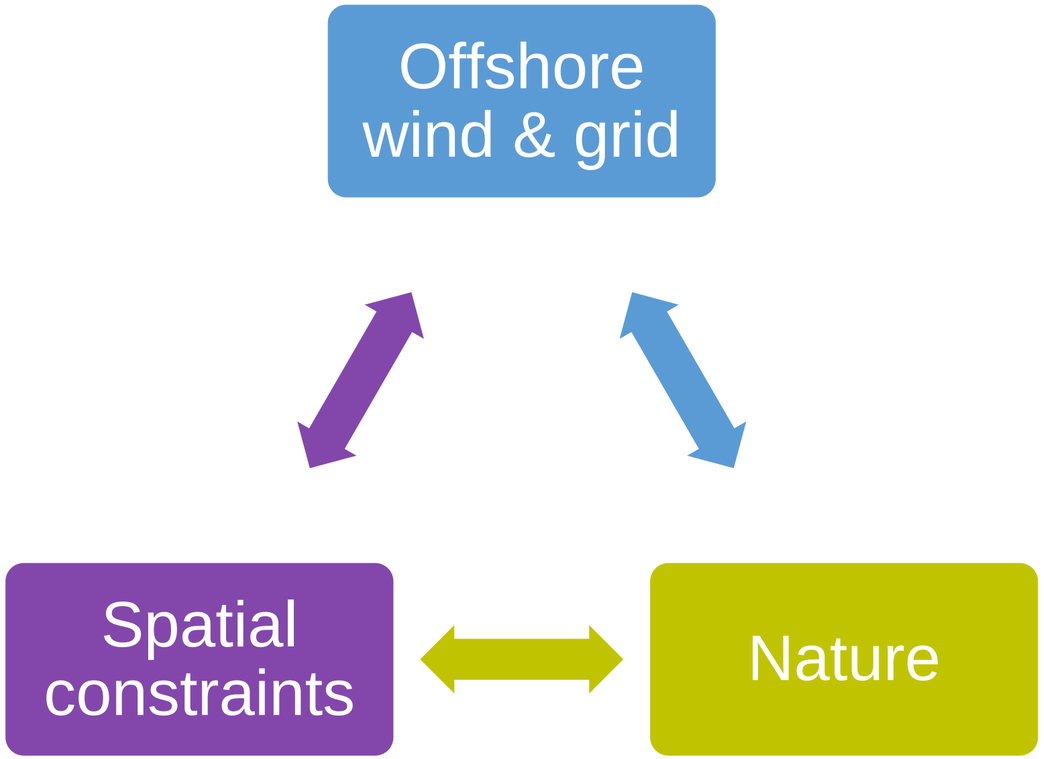
03 July 2025
10:00 - 18:00 CEST

Wind Europe’s office
Rue Belliard 40, 1040 Brussels

Renewables Grid Initiative · Wind EUROPE · ocean Offshore Coalition for Energy and Nature · JUST WiND 4 ALL · Funded by the European Union · Co-funded by the European Union

Acceleration brings complexity

- Offshore energy planning, Maritime Spatial Planning (MSP) and environmental protection in ***parallel but disconnected*** tracks



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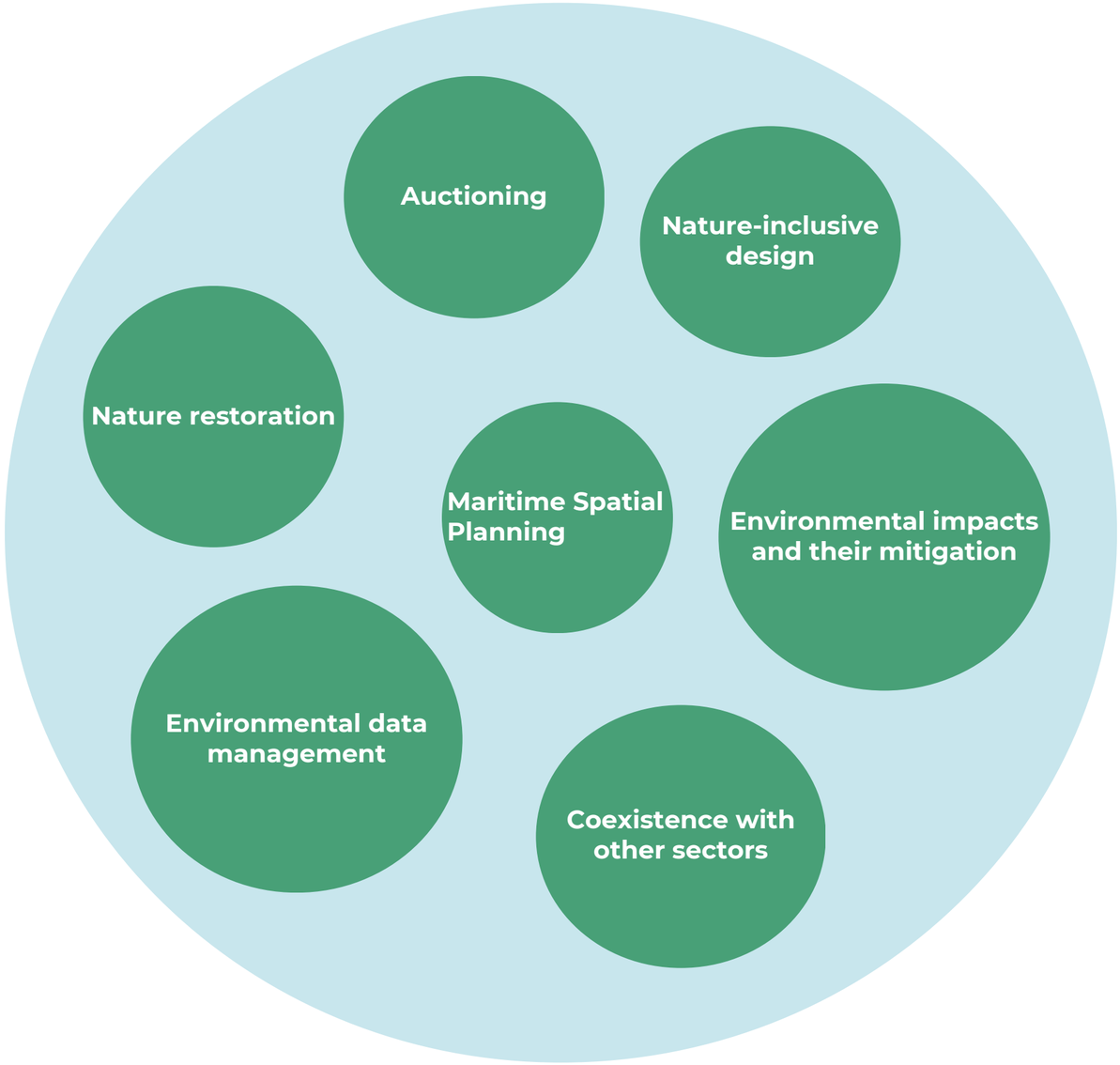
WHAT WE DO

Advocate for OW, grids & nature

Facilitate forum for discussion



Identify and fill knowledge gaps

Showcase solutions and innovations

ocean
Offshore Coalition for Energy and Nature

offshore-coalition.eu

USEFUL ICONS

FROM POWERPOINT

Examples of regional alignment

North Seas Energy Cooperation

Greater North Sea Basin Initiative

North Seas Energy Cooperation

- **Eight countries** (Belgium, Denmark, France, Germany, Ireland, Luxembourgn the Netherlands, Norway) with rotating co-presidency with **European Commission**
- Regional non-binding cooperation framework which aims to advance development of offshore renewable energy
- **Support groups**:
  SG1 - Hybrid and Joint Project
  SG2 - Maritime Spatial Planning and Ecology
  SG3 - Support Framework and Finance
  SG4 - Coordinated Long Term Planning
  SG5 - Offshore Renewable Hydrogen

North Seas Energy Cooperation

- **Presidency priorities**:

1. Financing & de-risking mechanisms
2. Non-price criteria
3. Resilience & Security
4. Offshore Network Development Plans
5. Supply chain & Industry leadership

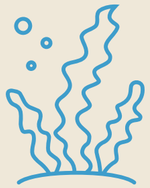
- **Regional perspective**

- NSEC Tender planning
- OTC
- North Sea Summit

Greater North Sea Basin Initiative

- **Nine countries** (Belgium, Denmark, France, Germany, Ireland, the Netherlands, Norway, Sweden, and the United Kingdom) with support from the **European Commission**
- The North Sea is one of the most heavily used seas in the world BUT coordination is often limited to specific sectors or projects
- GNSBI's purpose is to **strengthen cooperation across sectors and across borders.**
  - Brings together Nature, Energy, Fisheries en MSP ministries
  - Focus on early dialogue
- Process itself is just as valuable as the outcome

Five integrated Working Tracks



Nature restoration and conservation (NAT)

Set-up a programme for cooperation regarding conservation, enhancement and restoration of nature.

Cumulative impacts (CIA)

Find a common approach on cumulative impact assessments based on existing work to identify ecological tensions.

Multiple use of space (MUL)

Set-up criteria and sharing best practices on co-use.

Long-term perspective of fisheries (LTPF)

Create insight in key fisheries areas and socioeconomic/food impacts of spatial developments at North Sea scale.

Knowledge sharing (KNOW)

Coodinate the exchange of best practices, (scientific) information, data, plans and assessments.

Challenges and solutions

- Data is often fragmented, incompatible, or locked behind national systems
- Different planning timelines and different legal frameworks
- Regional coordination takes time and resources

Reflections from ENTSO-E on first ONDP experience and the needs for further improvement

Offshore Wind and Grid Workshop, 03 July 2025

entsoe

Reliable Sustainable Connected

The TYNDP is the European long term planning tool for the electricity transmission system

1 | SCENARIOS

Defining up to three most plausible futures, which we call **Scenarios**

2 | NEEDS

Identification of the needs based on our scenarios. Includes Infrastructure Gaps Report and **Offshore Network Development Plans**

3 | PROJECTS

Project collection and identification

4 | COST BENEFIT

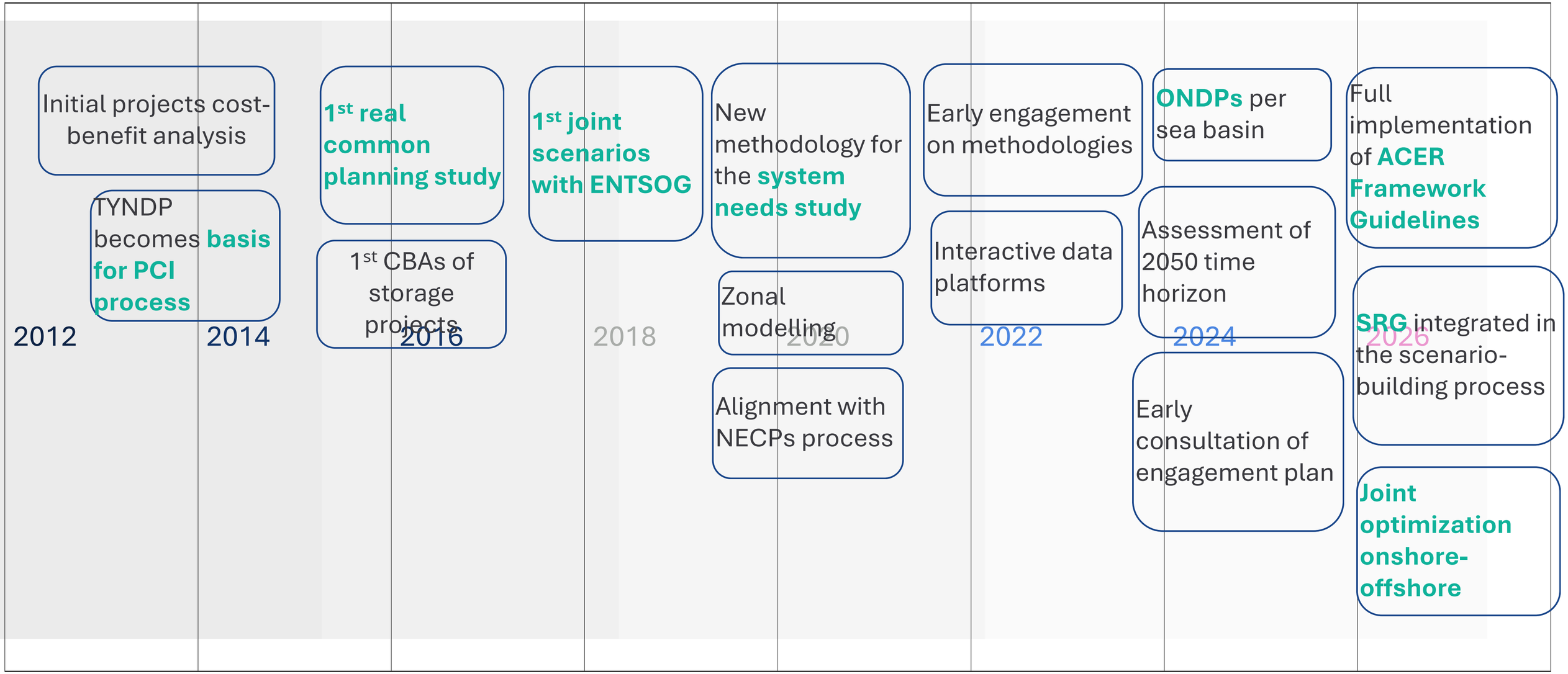
Cost benefits analysis of projects

5 | SELECTION

Union List process led by the European Commission

Projects of Common Interest (PCI) and **Projects of Mutual Interest (PMI)** Process

15 years of continuous improvement

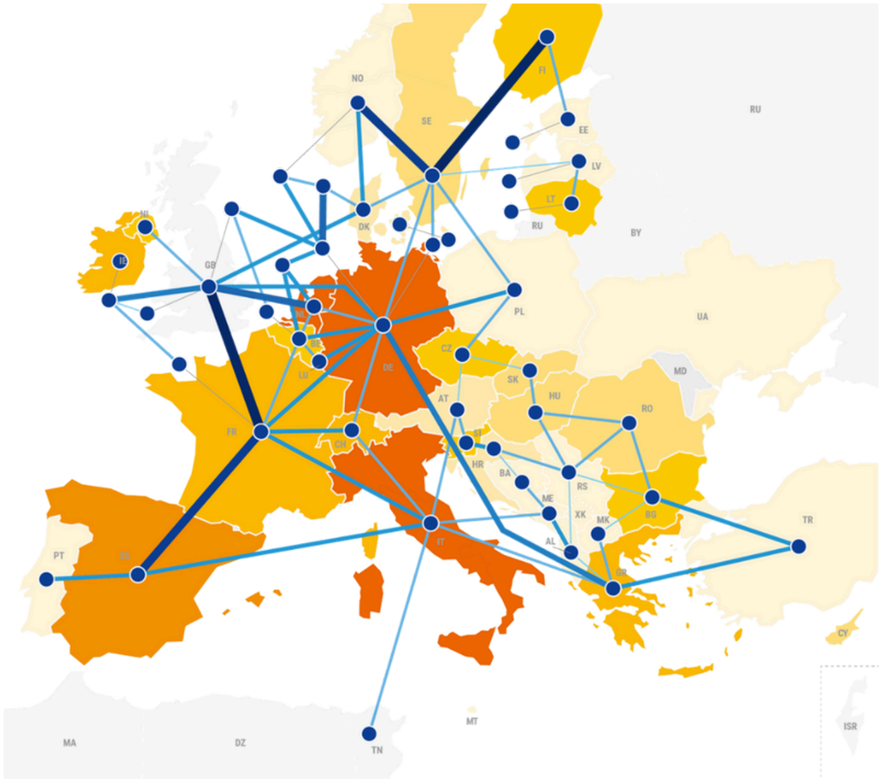


TYNDP 2024 System Needs

The 2024 analysis confirms that the system is getting more complex and a huge amount of infrastructure is needed to support the ambitious targets set for the continent and to make sure that the citizens are provided with the energy they need

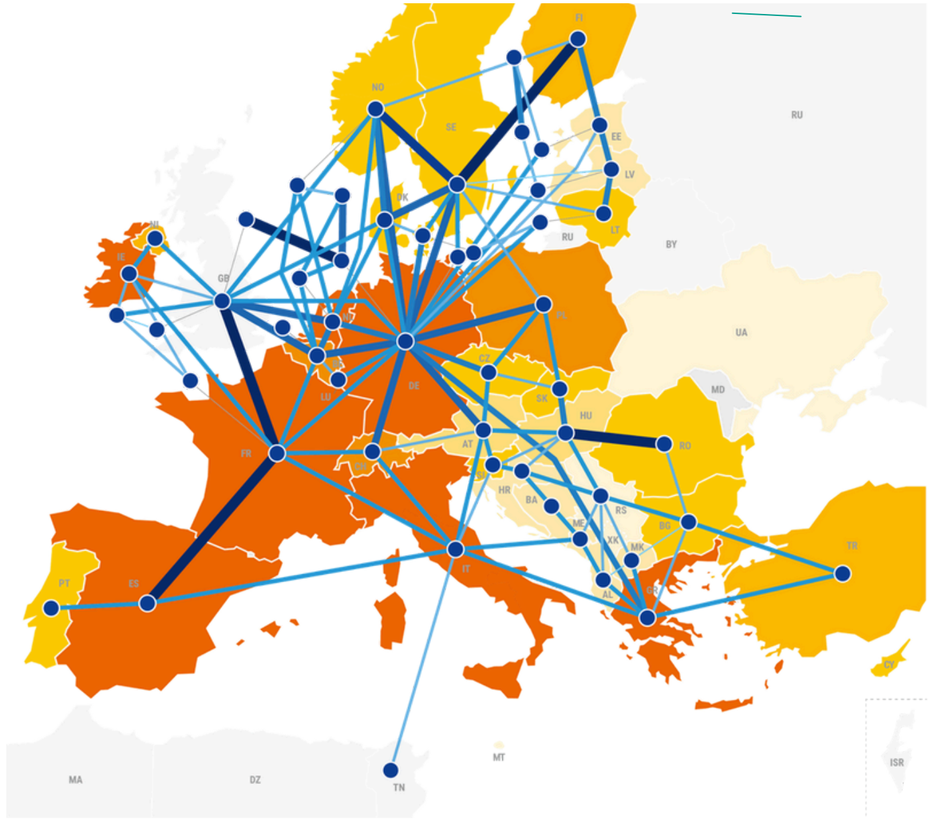
2040 results

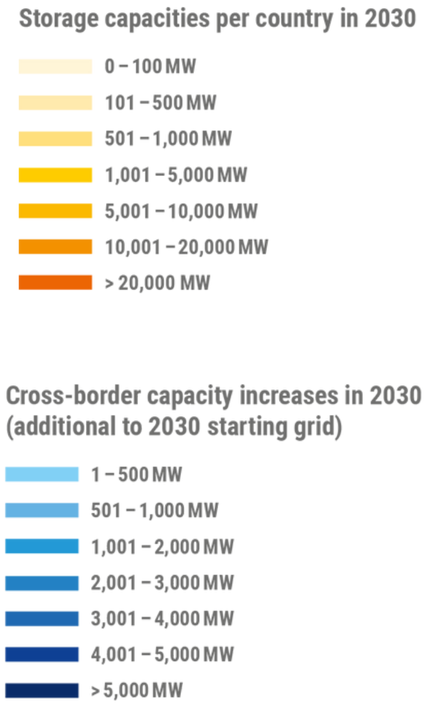
108 GW of additional cross-border capacity increases after 2030,



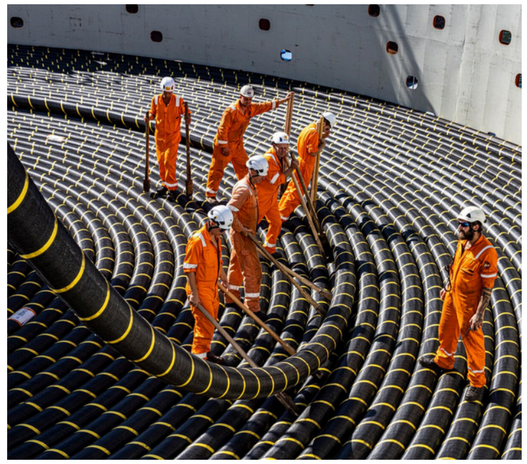
2050 results

224 GW of additional cross-border capacity increases after 2030,





TSOs need to invest at least 403 bn* EUR by 2050



Route length
Up to 54,000 km

DC converter stations offshore
158 units (+ 14)

with (w/o)

AC substations offshore
(123..137 units)

with … w/o

403 bn EUR

DC converter stations onshore
167…176 units
w/o … w

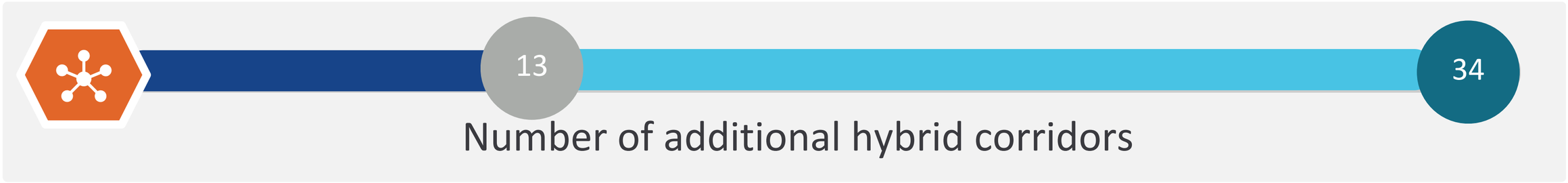
DC circuit breaker sets
Up to 34 units

**costs information from ONDP 2024 are based on 2022 data, it is expected an increase of the figures in the next edition*

Credit images: TenneT NL

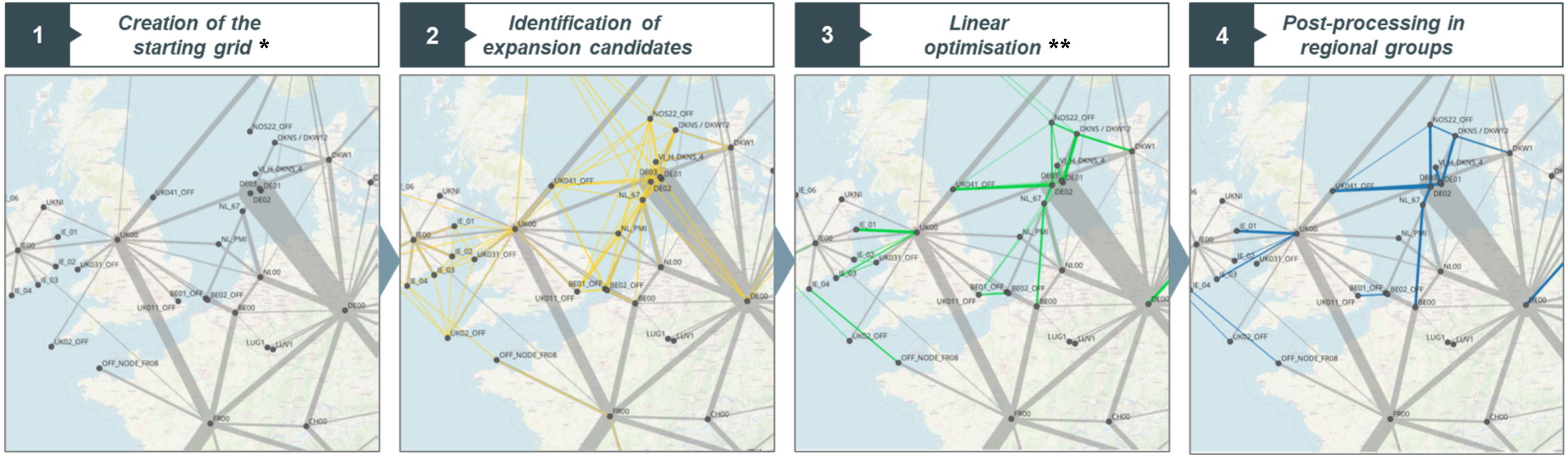
DC Circuit Breakers: A major technological Breakthrough

With a total cost increase of only 3%, DC breakers allow to address the equivalent of 50% of the interconnection needs identified in TYNDP 2022 (up from 16% without DC breakers).



The ONDP 2024 approach, summarized in four steps

Schematic Visualisation:



* 2030 for 2040
2040 for 2050

** minimize TOTEX

*** check plausibility and adjust

TYNDP 2024 System needs study – high level approach

Input

2030 grid

Investment candidates

- Cross-border capacity increases
- Storage
- Offshore corridors identified by the ONDP

PEMMDB*

* Scenario National Trends 2030 and 2040, Distributed Energy 2050

Calculation

Optimisation with Plexos and Antares simulators

Minimum of operational costs + investment costs*

* NTC study 2030, zonal study 2040, simplified zonal 2050

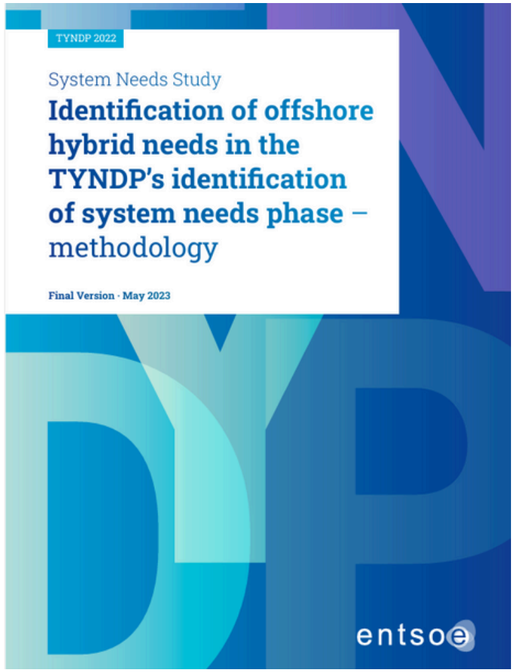
Output

Economic opportunities and infrastructure gaps in 2030, 2040 and 2050

Why does TYNDP 2026 need a new system needs methodology?

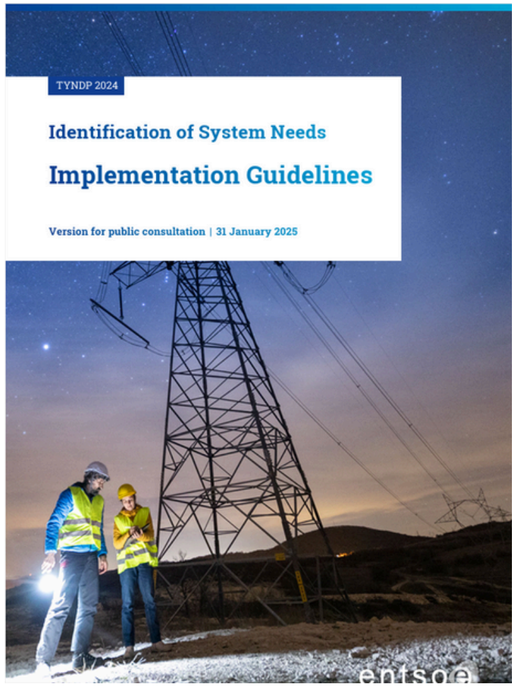
New regulations and expectations impose several innovations on the System Needs Study. In the past editions of the TYNDP several additions were made.

The 2026 methodology should consider the best aspects covered in the past editions in a new way, developing a coordinated modelling approach.



Assessment of offshore project candidates

Assessment of offshore hybrid corridors



Assessment of full zonal system

Guiding questions to define the methodology (1)

- Assessment of the new methodology should start from existing methodologies
- ENTSO-E intends to perform the study on the central scenario NT+ in horizons 2040 and 2050.

Open points:

- **Impact of cross-border expansion on national systems** should be part of the methodology.
  - Internal grid reinforcements are critical for connecting European regions.
  - Consistency with National Development Plans is key.
- **How to ensure consistency between time horizons**? Considering the impact on model flexibility and granularity.
- **Counterfactual discussion** is important for the correct definition of the starting point and of investment candidates. For example, when assessing hybrid candidates do we need to consider generation with transmission?
- **Perimeter of the analysis:** should we explore needs with third (non-EU) countries?

Guiding questions to define the methodology (2)

- **Starting point assumption:** should the starting point of the study include only mature transmission projects?
- **Definition of the candidates:** what criteria should be considered to identify investment candidates? Filtering of candidates through technical review (i.e. aimed at excluding unrealistic ideas)
- **Integration of the ONDP and of the System Needs study** shows challenges given the differences between the mandates: potentially setting a 2 steps process could favor the integration of the different assumptions characterizing the offshore and onshore systems (1) find economical needs (2) define offshore hybrid.
- **Complexity of the model –** computation time, extraction and clarity of the results etc. the complexity of the models is a challenge that need to be considered in the methodological discussion.
- **Maritime Spatial Planning** should be more strongly included in the methodology (i.e. inclusion of pathway study from 50Hertz) this is strongly linked and depends on how the selection of candidates is set up for the expansion model.

Topics to work on in the coming months

Before putting the hands on the keyboard, some discussion is needed on the fundamentals

In the coming weeks ENTSO-E will work on the fundamentals of the methodology discussing the relevant questions that the methodology should answer.

1. Type and number of infrastructure candidates
2. Starting grid and compliance with reference grid
3. Single-year vs multi-year expansion and general flexibility of the zonal model
4. Inclusion of Maritime Spatial Planning
5. Granularity and detail of H2 model

24 June workshop Overview - Key Stakeholder Perspectives

Today's workshop brought together diverse stakeholders to discuss the methodology and perspectives for the TYNDP 2026 System Needs Study.

Multi-Stakeholder Collaboration

European Commission

Role-giving perspective as part of the infrastructure framework, providing regulatory guidance and policy direction.

ACER

Calls for improved transparency, realistic starting grids, early stakeholder consultation, and emphasis on internal reinforcements.

T&D Europe

Demonstration of manufacturer requirements from system needs study outputs for strategic planning.

RGI

Highlights on achieving sustainability in grids through effective spatial planning strategies.

ENTSOG

Presentation on Hydrogen Infrastructure Gaps Identification methodology and output indicators.

EASE & Hydrogen Europe

Focus on storage-transmission complementarity and offshore hydrogen production for REPowerEU targets.

Next steps - TYNDP 2026 milestones

Today
Workshop on system needs study methodology

Ongoing
Public consultation on Scenarios input data, parameters and methodologies

July-Dec 2025
Drafting and testing of system needs methodology

Q4 2025
Draft Scenarios 2026 are shared with Stakeholders Reference Group for consultation

January 2026
Release of draft system needs study methodology, for consultation. Feedback will be considered in TYNDP 2028.

April 2026
Release of draft scenarios

December 2026
Release of draft TYNDP 2026 for consultation

By early Q3 2027
Final TYNDP 2026

>2 years development cycle with multiple consultation phases

Thank you

Our values define who we are, what we stand for and how we behave.
We all play a part in bringing them to life.

EXCELLENCE

We deliver to the highest standards. We provide an environment in which people can develop to their full potential.

TRUST

We trust each other, we are transparent and we empower people. We respect diversity.

INTEGRITY

We act in the interest of ENTSO-E

TEAM

We care about people. We work transversal and we support each other. We celebrate success.

FUTURE THINKING

We are a learning organisation. We explore new paths and solutions.

We are ENTSO-E

INTRODUCTION TO THE WAKE PHENOMENON

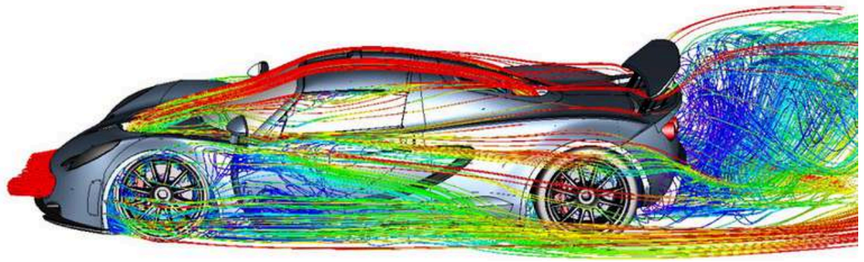
Riccardo Longo

Agenda Items

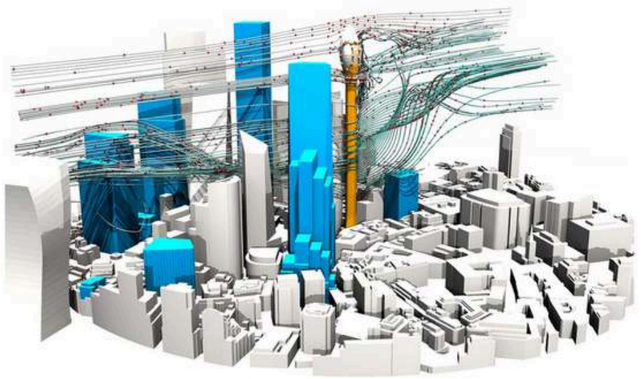
- Introduction to the Wake Phenomenon
- Optimizing Offshore Wind Design
  - At wind farm level
  - At regional level
- How can we account for wake losses in spatial planning?

Wake

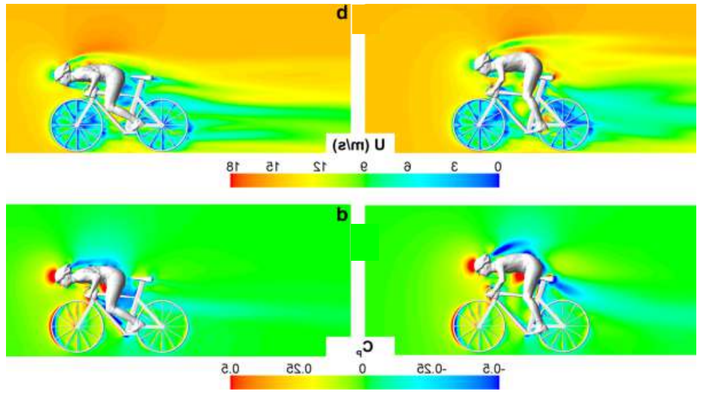
Each body immersed in air produces wakes



Car

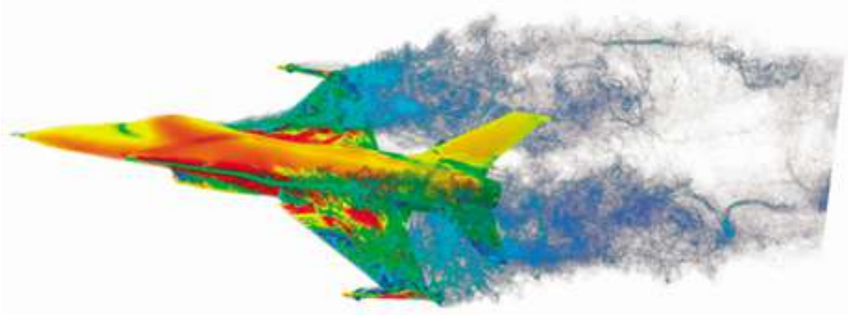


Buildin
g

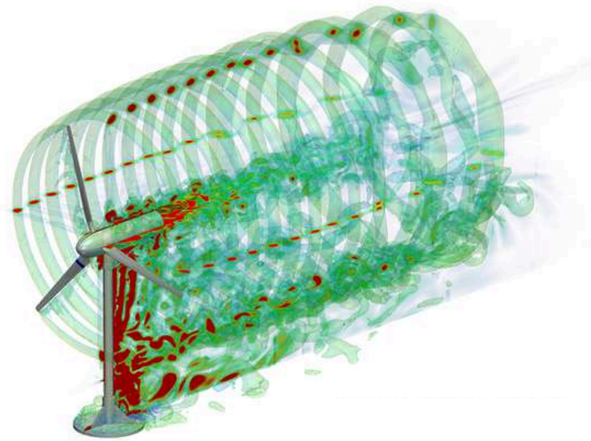


Sport

Drones



Jet

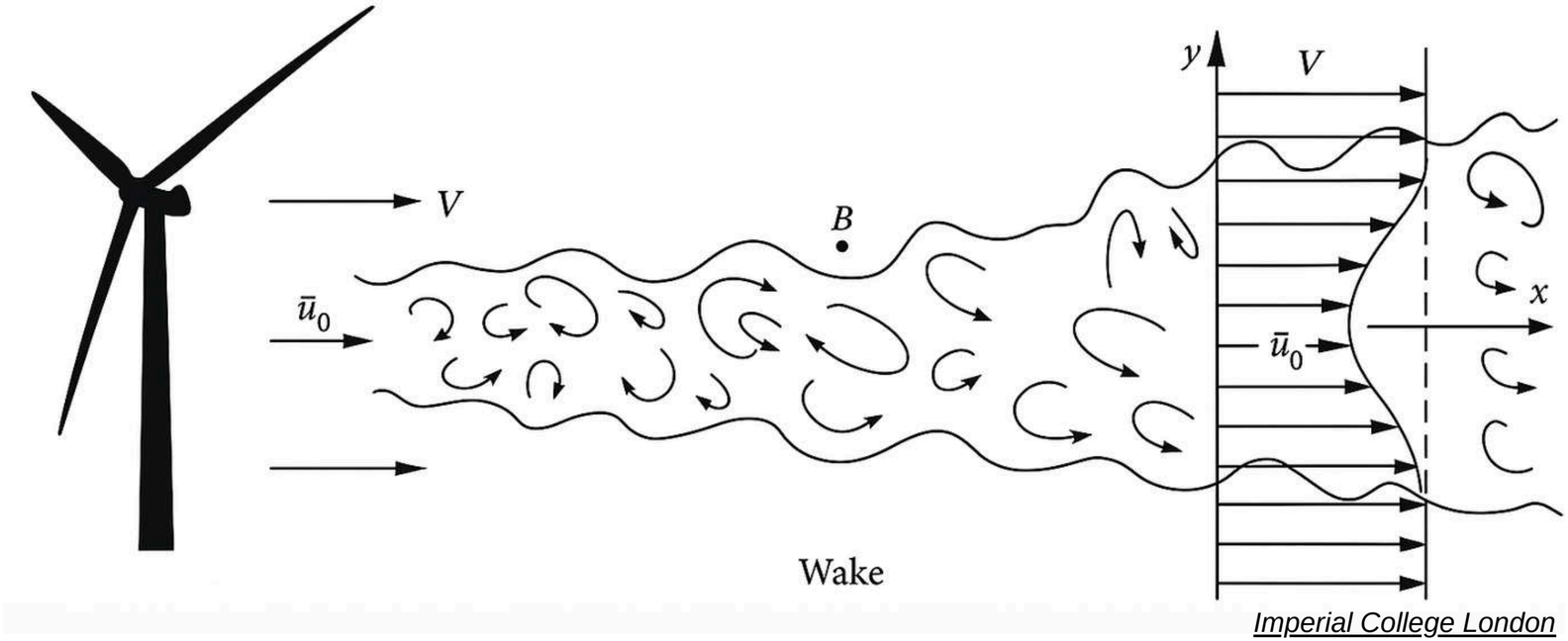


wind
turbine

Wake effects

Wind turbines produce wakes

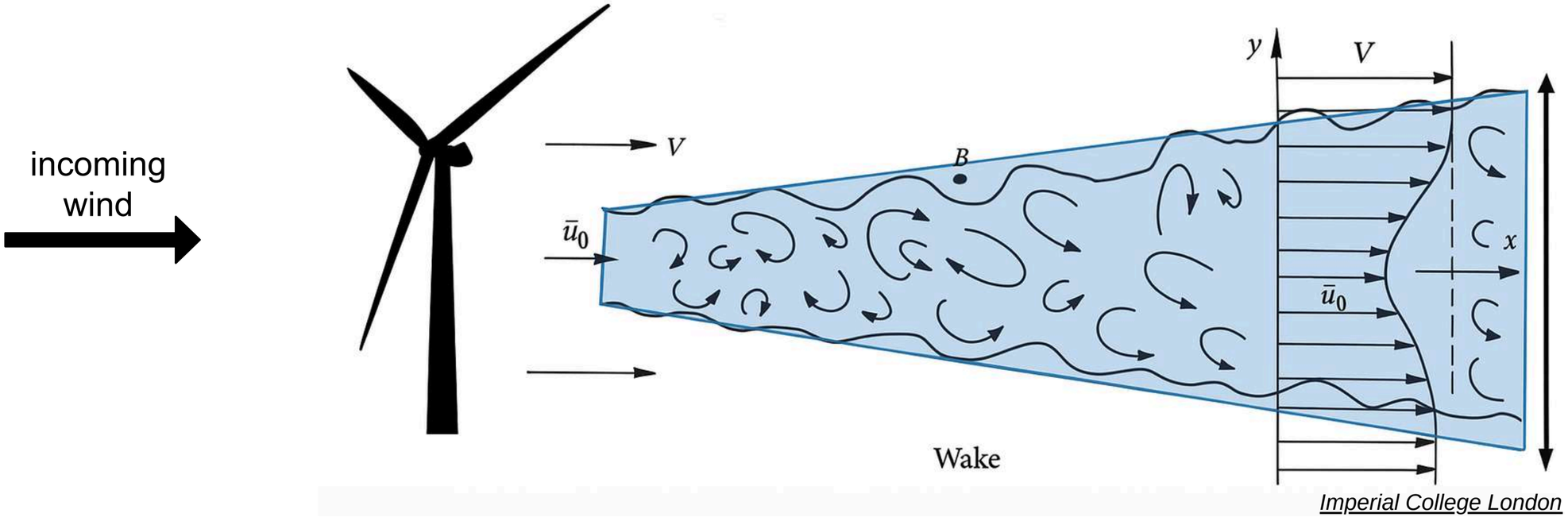
incoming wind



Imperial College London

- Like other objects in airflow, wind turbines generate wakes
- Wakes are regions with reduced wind speed compared to the freestream
- In these areas, the wind is no longer smooth and steady

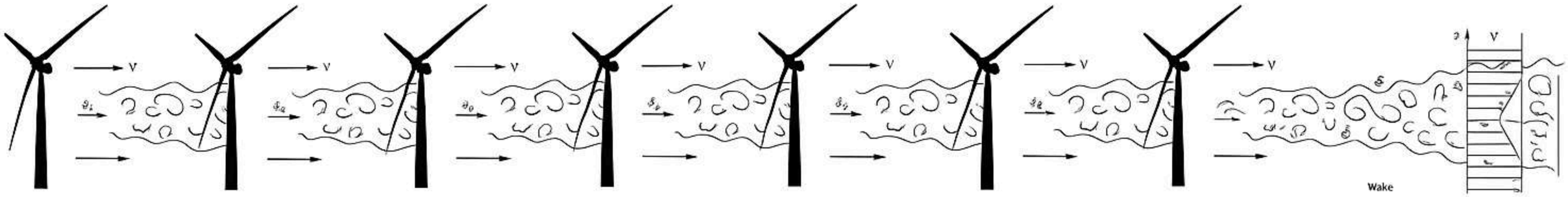
Wind turbines produce wakes



Imperial College London

- Wakes grow as they mix with the surrounding air - a process called entrainment
- Over distance, the wake fades, and the wind gradually returns to its original state
- This distance is greater in offshore than onshore context

Distance and positioning: important factors



- Turbine spacing is crucial to minimize energy losses from wakes
- Optimizing wind farm layout helps reduce wake effects and boost production

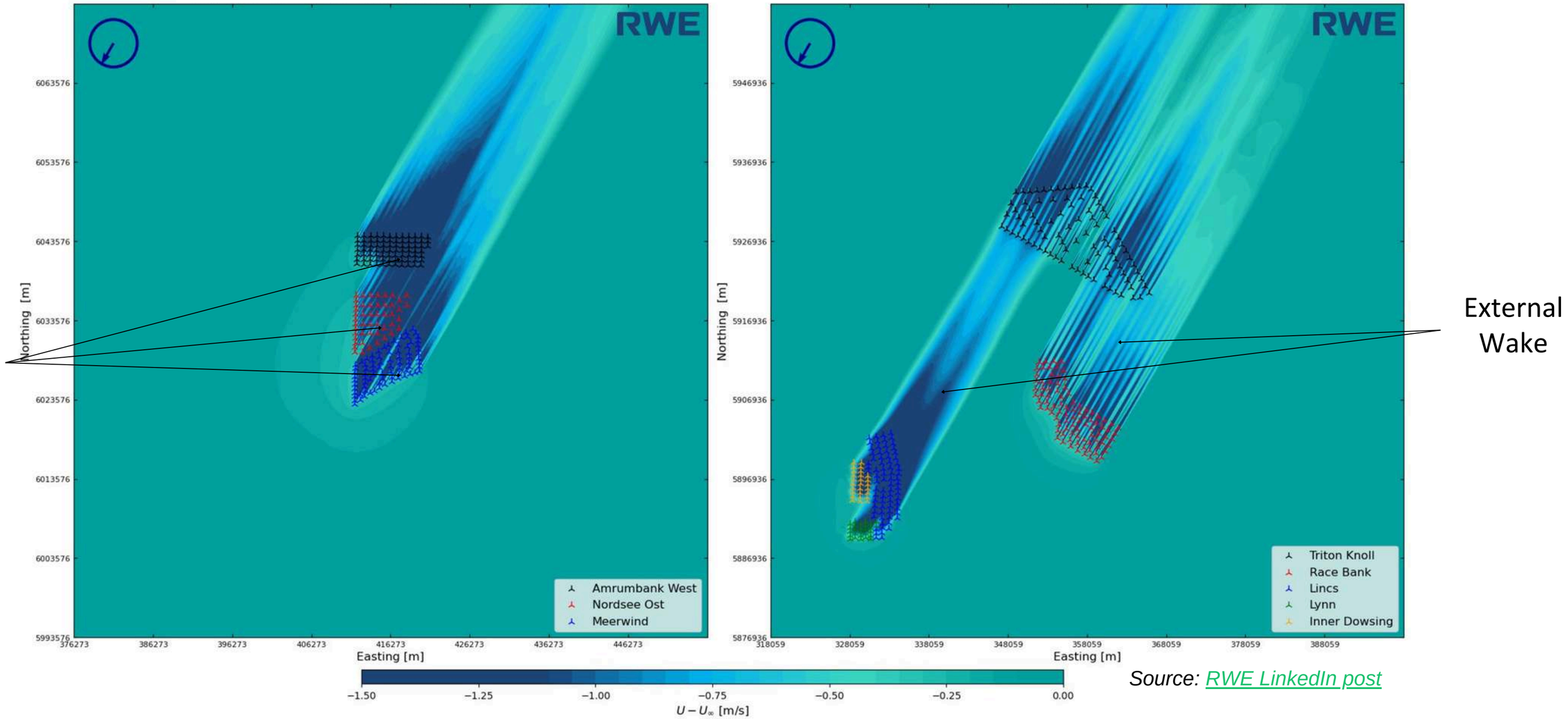
Wakes Within and Among wind farms

Internal

External wakes

Internal Wake

External Wake



Source: [RWE LinkedIn post]

Internal wake:
Wind Farm Layout Design

Wind Intensity and Direction

The wind intensity and direction are critical factors that influence the design of wind farm layout.

Turbine Spacing

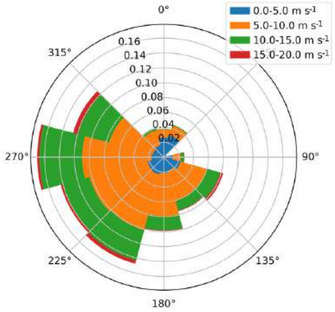
Turbines are spaced to optimize energy output while minimizing wake effects and other factors, such as noise and visual impact.

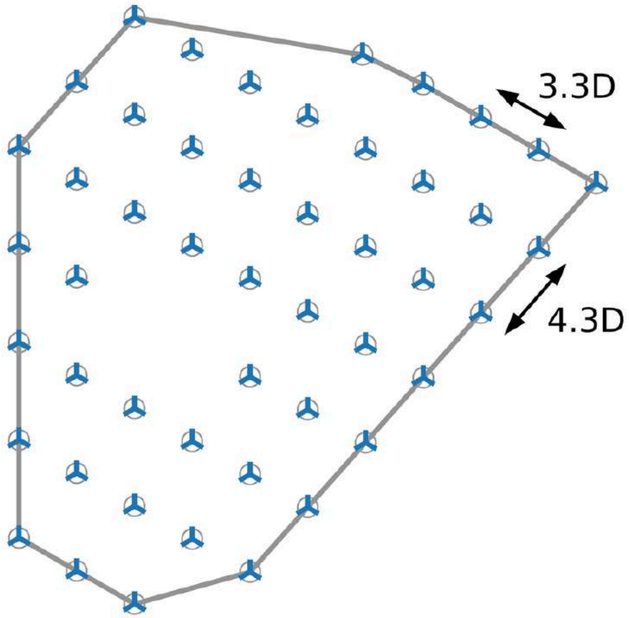
Wake Effects

Wake effects occur when wind turbines interact with the airflow and create turbulence that can affect the performance of nearby turbines.

Until now addressed at wind farm level

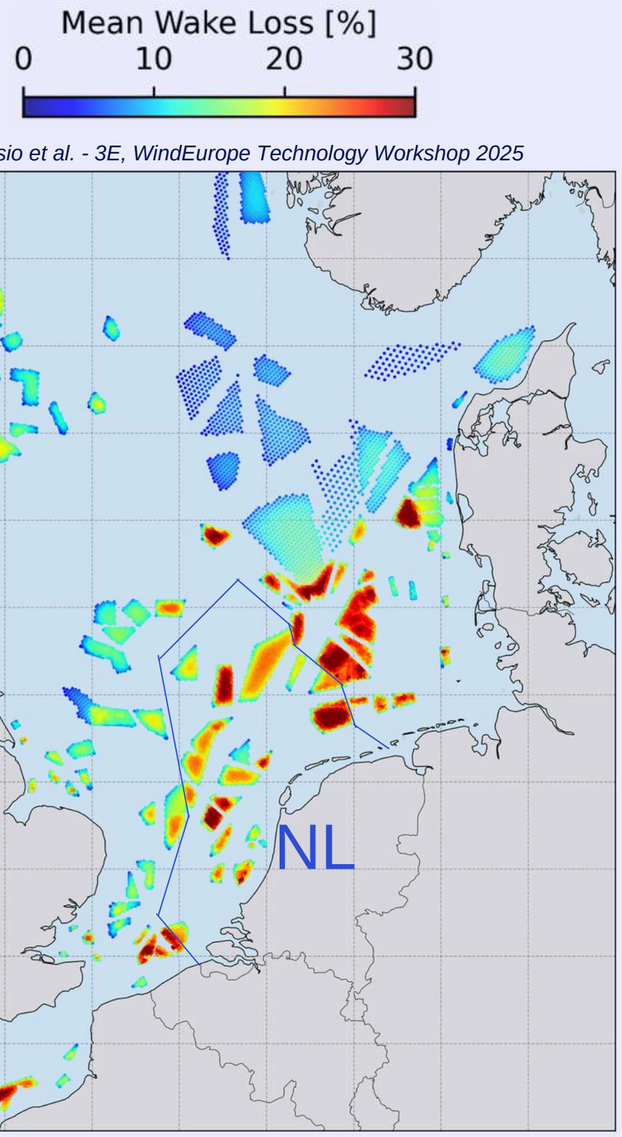
Lillgrund WPP located in Øresund between Denmark and Sweden



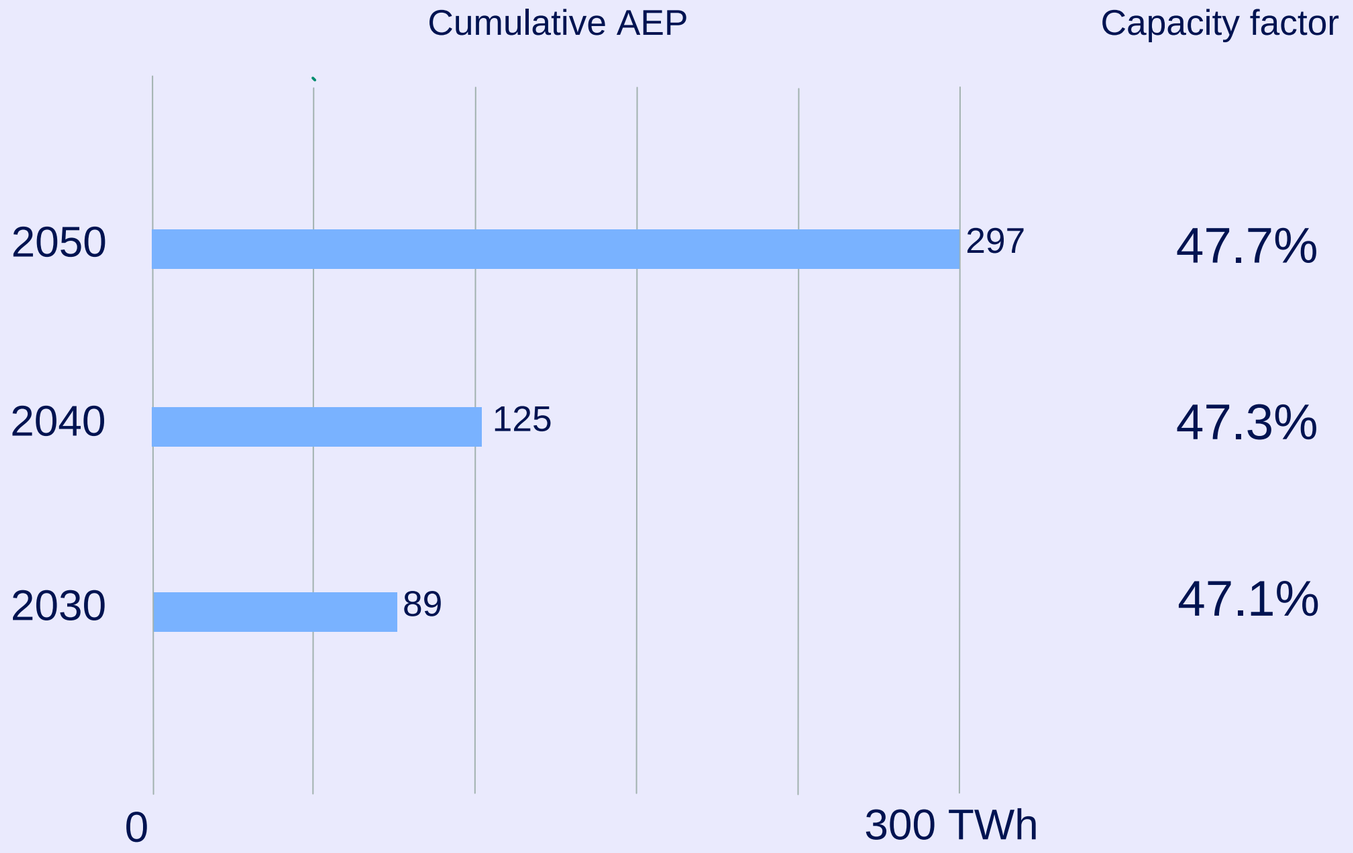


Main wind direction

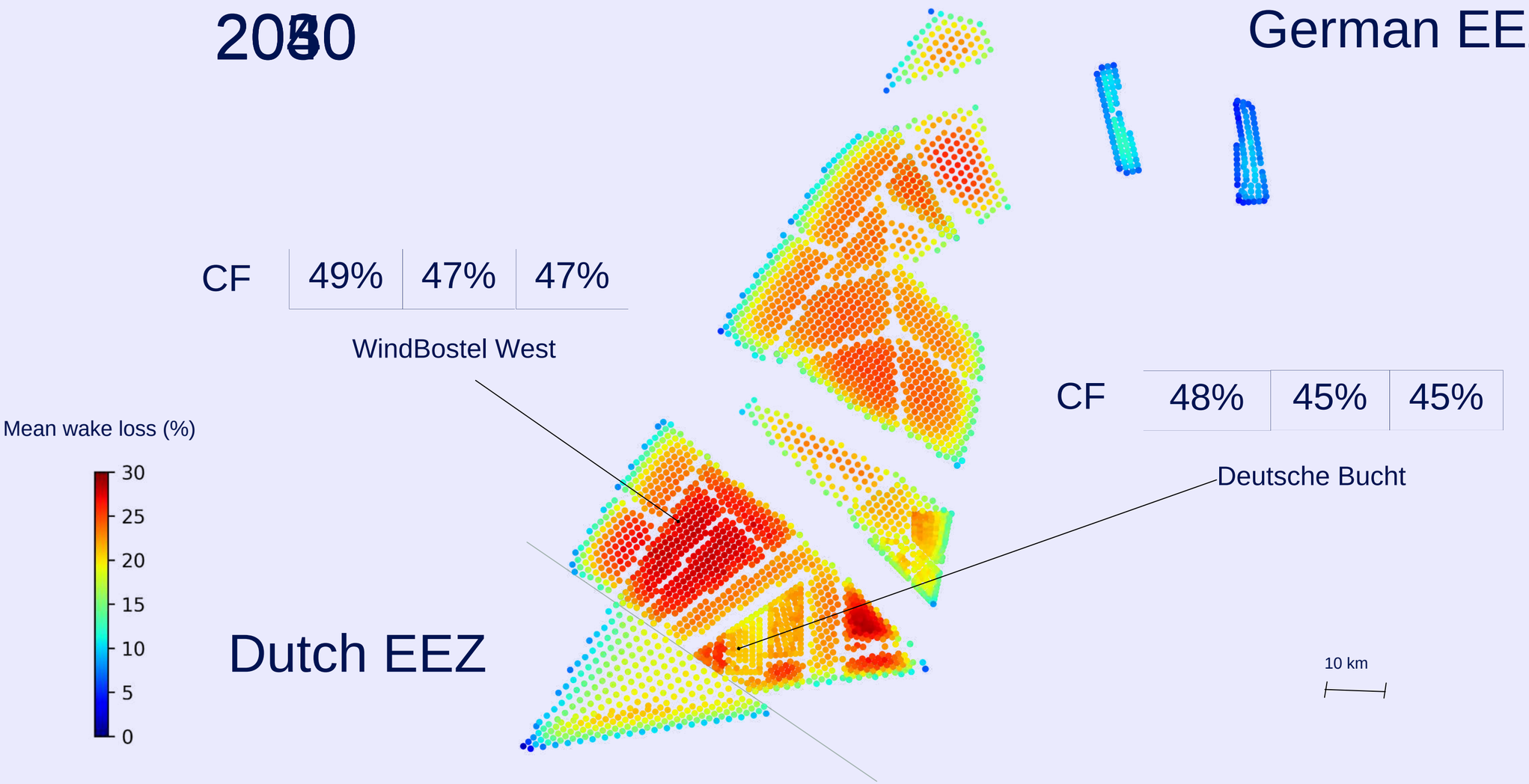
At regional level



Daniele D'Ambrosio et al. - 3E, WindEurope Technology Workshop 2025

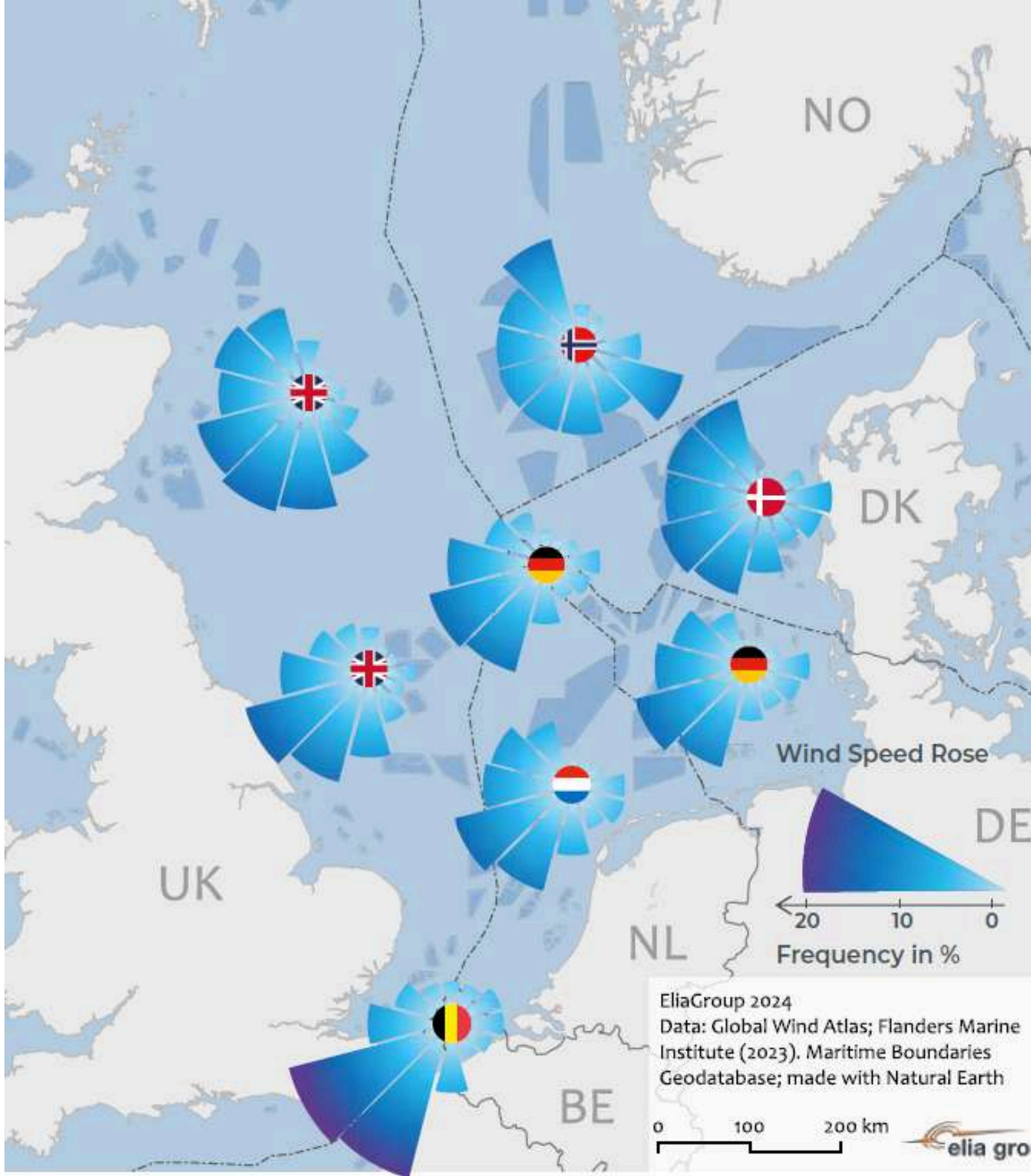


Resource competition impacts high-density clusters



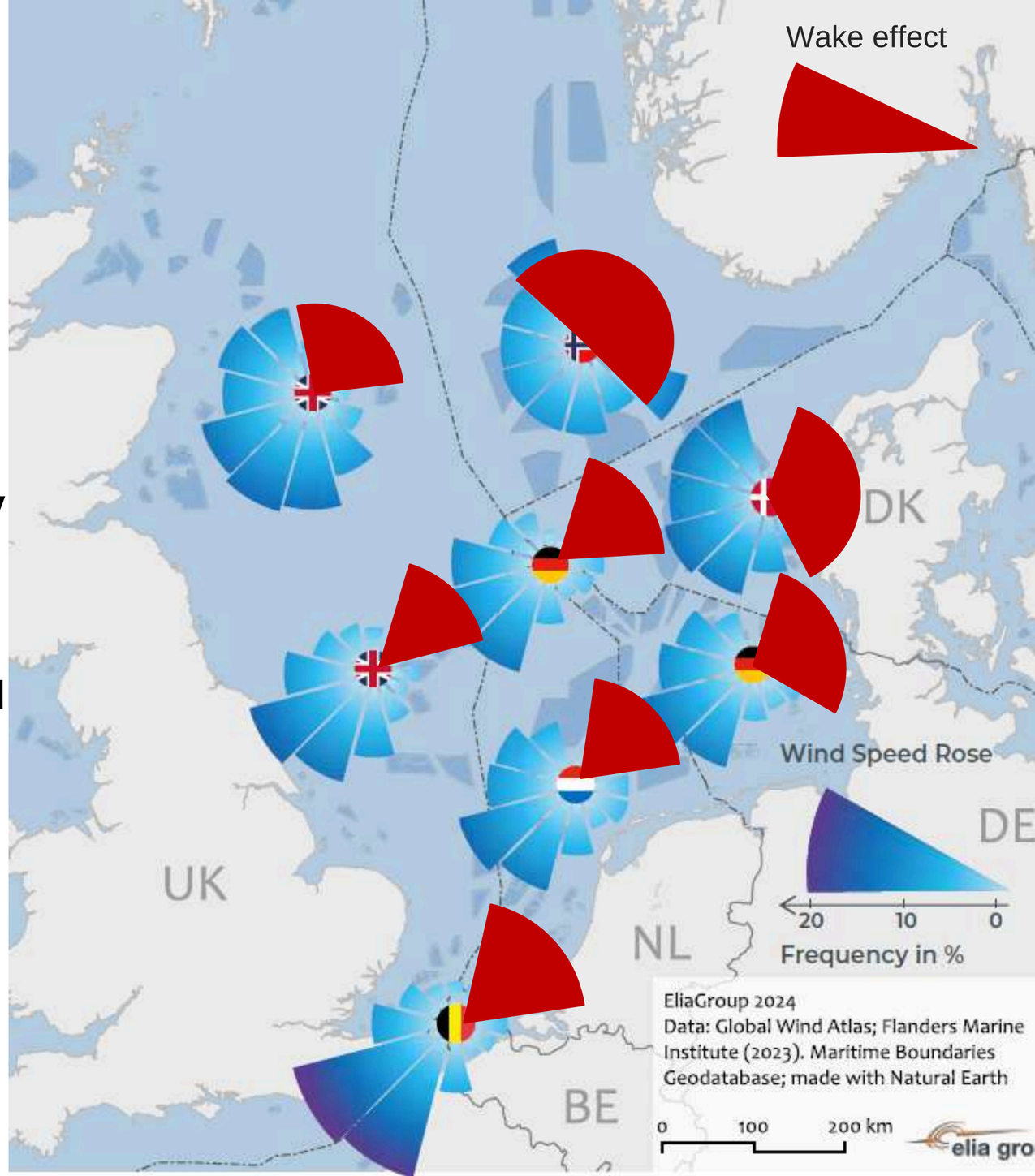
At regional level

More wind farms in the same sea basin =
More wake losses



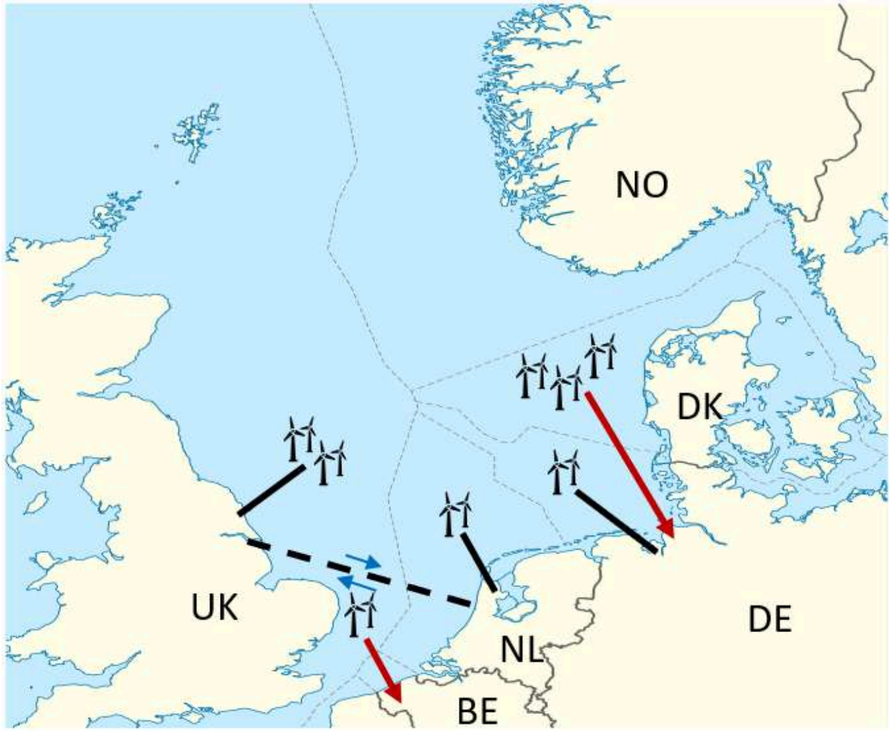
The gain would be great

- **Wind direction Location of Wake affected Area**
- **Improve efficiency and long-term regional energy yield**
- **Enable fair and coordinated offshore wind development**
- **Smarter site selection and marine spatial planning**

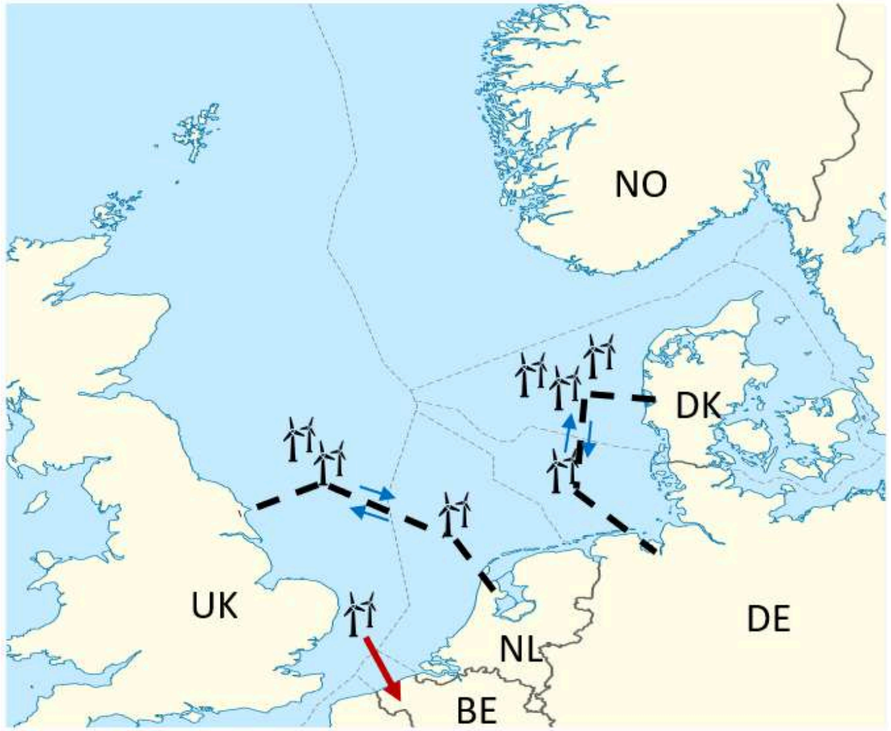


Cross-border radials and Hybrids project can help

CROSS BORDER RADIAL



OFFSHORE HYBRIDS



- More flexibility for wind farm siting and less maritime congestion □ less wake effect

Conclusions

- **We need to act now**
- **Regional wake criteria must be defined and applied consistently**
- **High performance gains are possible with minimal disruption**
- **Cross-border radials and hybrid offshore projects can help**:
  - **Decongest dense areas with more flexible power flows**
  - **Distribute generation to reduce cross-border wake stacking**
  - **Cut cumulative wake losses, unlocking more clean energy with less environmental impact.**
- **Wake mitigation is not just an engineering problem—it's a governance opportunity**

The system value of cross-border collaboration and spatial design

How can we optimise offshore grid design and generation layout to address wake effects and maximise system value?

Agenda

1. Case Study - #OptimusOffshore
2. Preview – Unlocking the potential of Offshore Wind (Thema Study)

03.07.2025 | WindEurope | Offshore Wind and Grid Workshop

Perspective | Cross-border solutions could relieve pressure from offshore wind build-out challenge in DK & DE

Demand outlook & cost efficiency put pressure on OWP expansion

Reduced demand outlook by 5-10% questions cost efficiency of the current RES expansion plan[1]

Wake-, grid, and cost-optimized models found optimal buildout of 50-55 GW in DE[2], in contrast to legally defined target of 70 GW

Political focus of new government on cross-border collaboration

May 2025 Coalition Agreement
Cooperation with other countries bordering the North Sea **to develop generation-optimized area scenarios** and implement a first offshore hybrid as soon as possible

Jun 2025 Meeting Friedrich Merz & Mette Frederiksen
Friedrich Merz: "We want to strengthen and **accelerate cooperation in the areas of offshore wind energy**, hydrogen projects, and electricity grid expansion. (…) We have therefore agreed to continue working on various cross-border cooperation projects. One example is the Bornholm Energy Island."

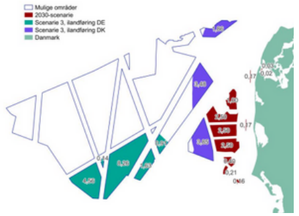
Jun 2025 Meeting Katharina Reiche & Lars Aagard
Katharina Reiche: "We are **strengthening our energy cooperation with Denmark**. The cooperation on the Bornholm Energy Island (…). At the governmental level, we will cooperate to establish the necessary legal and regulatory framework to facilitate Bornholm Energy Island and future offshore and hydrogen cooperation projects."

OWP future up for discussion after failed tenders

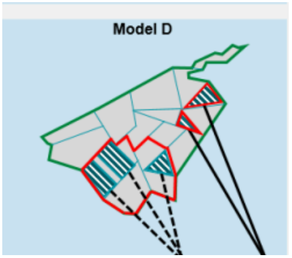
Dec 2024
No bids in DK Tender

Jan 2025
Cancellation of April bidding round

Today
Discussions on Future DK Offshore Wind Buildout



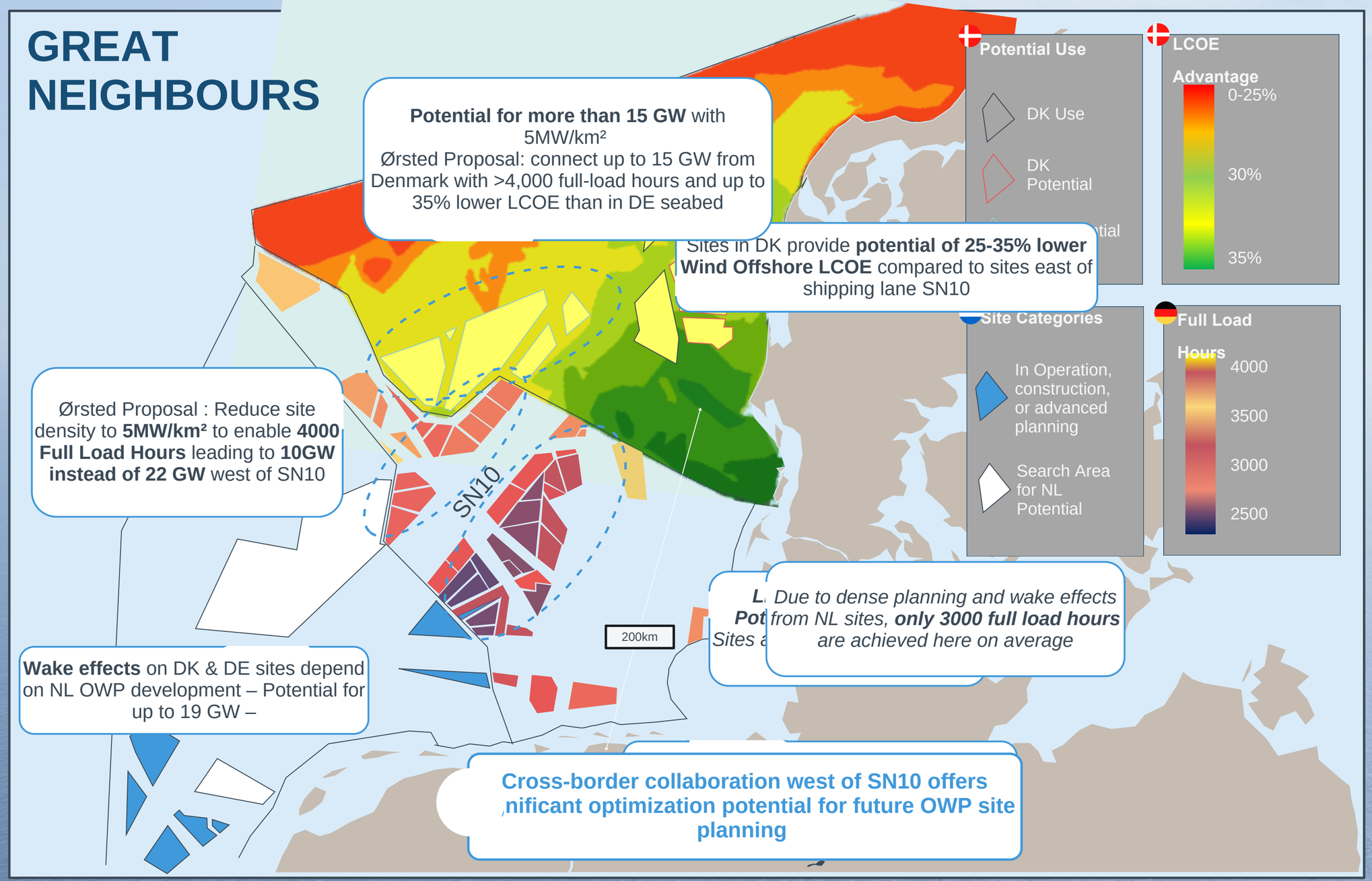
Dec 2024
DEA Memo on long-term DK OWP planning, incl. options to connect OWP to DE



Apr 2025
DEA Analysis on long-term OWP planning
Radial connection of >20GW as one option for utilizing long-term potential

1: McKinsey (2025); TSOs, BNetzA (2025): Draft NEP 2025 - Scenario Framework
2:TenneT, Energienet, Gasunie (2024): Pathways 2.0; 50Hertz (2024): Going like the Wind; Maurer, Hirth, Koenig (2024) ;EnBW, Aurora (2025)

GREAT NEIGHBOURS



Potential for more than 15 GW with 5MW/km²
Ørsted Proposal: connect up to 15 GW from Denmark with >4,000 full-load hours and up to 35% lower LCOE than in DE seabed

Sites in DK provide **potential of 25-35% lower Wind Offshore LCOE** compared to sites east of shipping lane SN10

Ørsted Proposal : Reduce site density to **5MW/km²** to enable **4000 Full Load Hours** leading to **10GW instead of 22 GW** west of SN10

*Due to dense planning and wake effects from NL sites, **only 3000 full load hours** are achieved here on average*

Wake effects on DK & DE sites depend on NL OWP development – Potential for up to 19 GW –

Cross-border collaboration west of SN10 offers nificant optimization potential for future OWP site planning

Sources: DE – Energiewinde (2025) [Link]; NL – IenW: Draft Partial Review North Sea Programme 2022 -2027 (2025) [Link]; DK – DEA: Scenarie for havvindsudbygning frem mod 2050 (2024) [Link]; DK Heat Map – Own Data

Ørsted

Unlocking the Potential of Offshore Wind

A Regional Approach to the Northern Sea

Ørsted

20 June 2025

THEMA Consulting Group

Ørsted

Cooperative offshore wind deployment unlocks potential efficiency gains that reduce the cost of electricity

1. **Allows development of the best projects**
   Utilise the best renewable resource at least cost per generation unit.

2. **Avoid wake losses**
   Distribute offshore wind in the sea basins to reduce total wake losses.

3. **Use transmission capacity efficiently**
   The same cable can both transfer power to shore from an offshore bidding zone but also increase export/import between countries.

4. **More integrated power system**
   Supports least-cost dispatch and improves resilience to weather or commodity price shocks.

The impacts of cooperation have been assessed using a power system model

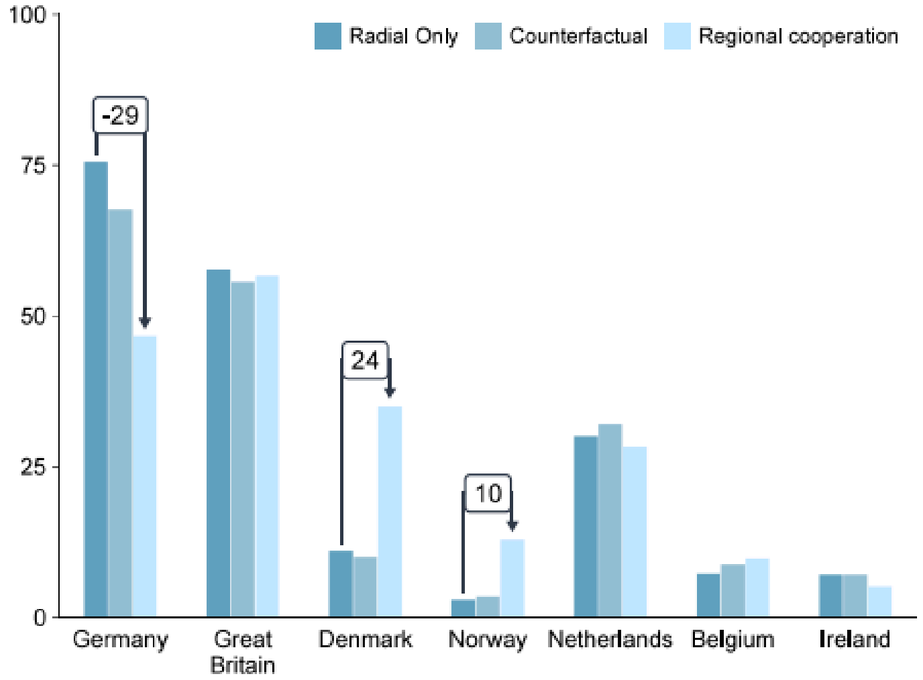
By comparing modelling runs in which hybrid project options are either permitted or forbidden, we can assess the impact of enabling such options.

Radial Only	• We only allow radial connection between hubs and the domestic shore • No cross-border radials or hybrids	Point-to-point interconnectors are allowed, but with a hurdle rate of 20%
Counterfactual	• Norway, Sweden, Denmark and Finland only allow radial offshore wind. • No cross-border radials. • Germany, Belgium and the Netherlands collaborate, making hybrids possible between hubs. • The Baltic states, Poland and Germany can build hybrid projects in the Baltic Sea.	Point-to-point interconnectors are allowed, but with a hurdle rate of 12%
Regional Cooperation	• Allow for hybrids between all zones where reasonable (e.g. not from Finland to the UK). • Allow for cross-border radials (e.g. from North Sea Energy Island to Germany.	Point-to-point interconnectors are allowed, but with a hurdle rate of 6%

In the North Sea, regional cooperation moves offshore wind buildout from the German EEZ to Denmark/Norway

Better wind resources and lower wake effects drive the change in placement

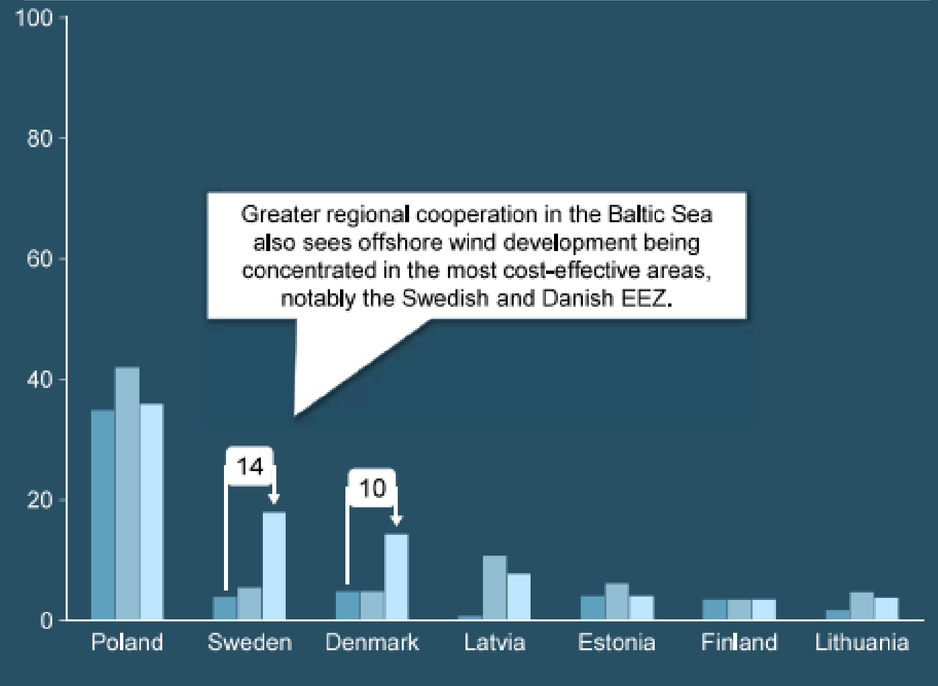
Offshore wind build out distributed by country in 2050 across scenarios [GW]



In the Baltic Sea, cooperation in the counterfactual shifts buildout from the Nordics to the Baltic states and Poland

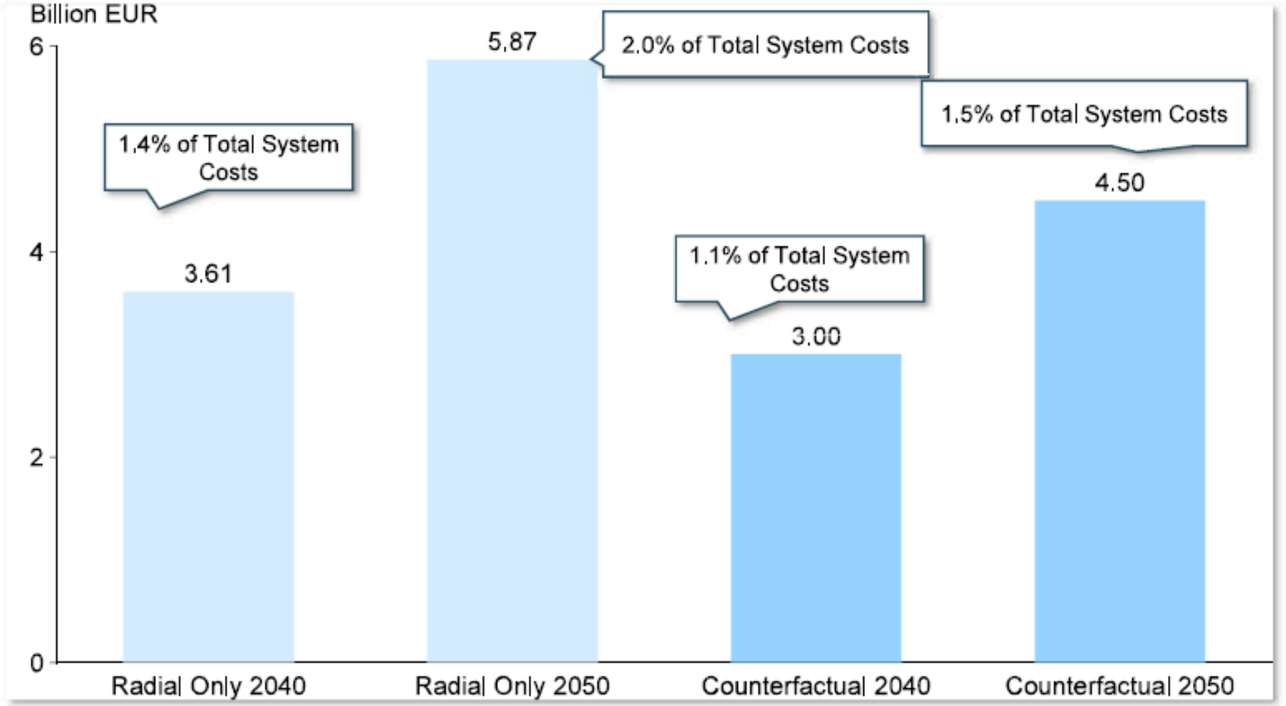
Despite worse wind resources, cooperation in the Baltic Sea can compete with radial build outs in the North Sea

Offshore wind build out distributed by country in 2050 across scenarios [GW]



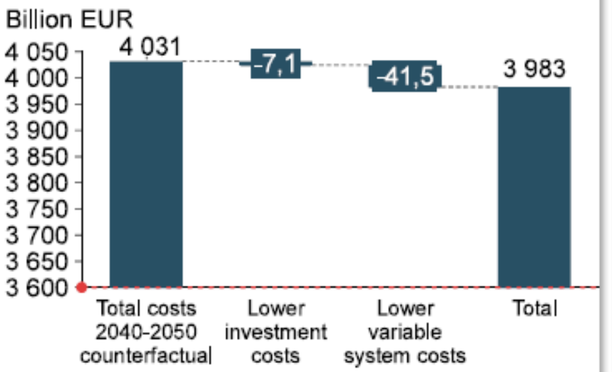
Regional Cooperation reduces total system costs, including annuitized investment costs, by 1.5% relative to the Counterfactual

Increase in annual Total System Costs vs. Regional Cooperation in Europe with annuitized investment costs



Total costs for 2040–50 are 48bn EUR lower

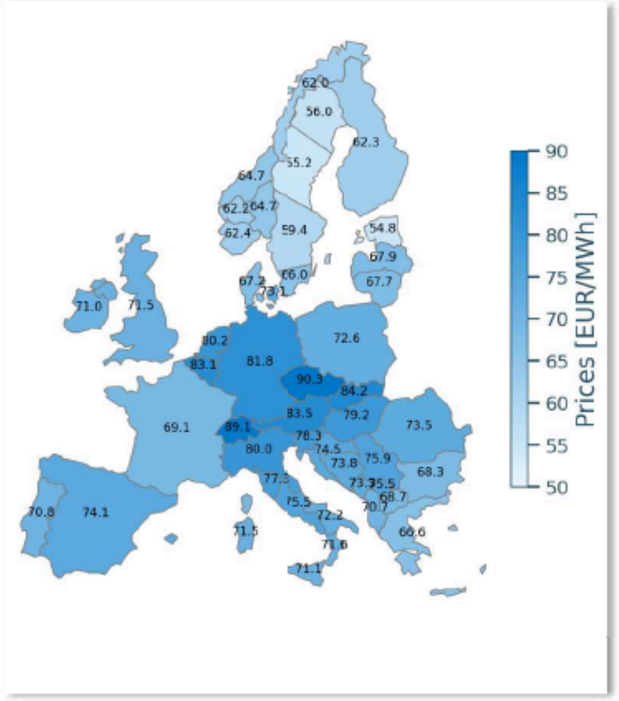
- 3,0 bn EUR reduction in 2040 amounts to 1,1% of European total.
- 4,55 bn EUR reduction in 2050 amounts to 1.5% of European total.
- Total cost savings for 2040-50 (11 years) are 48bn EUR relative to the counterfactual. These are split between lower system costs and lower investment costs.



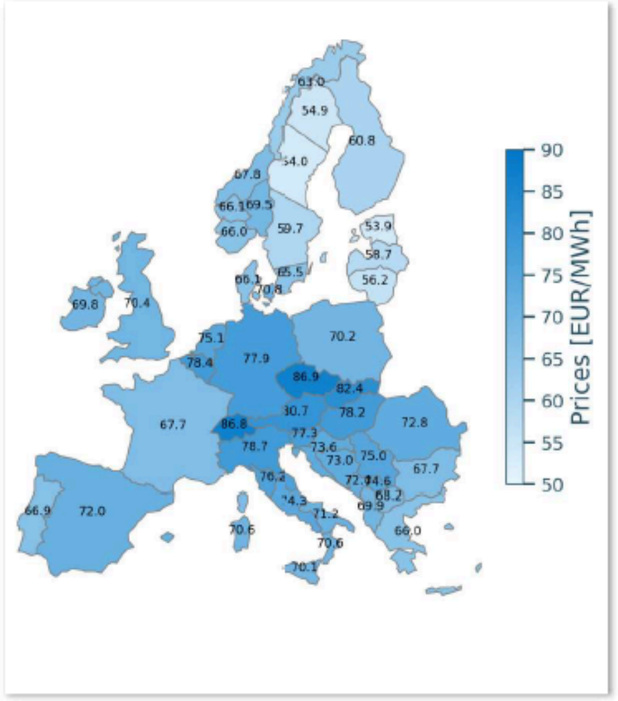
** System cost for Europe as a whole, annuitizing the investment costs. Comparing with the counterfactual for the respective years.*

Greater regional cooperation tends to reduce prices in central-west Europe, while increasing them in the Nordics

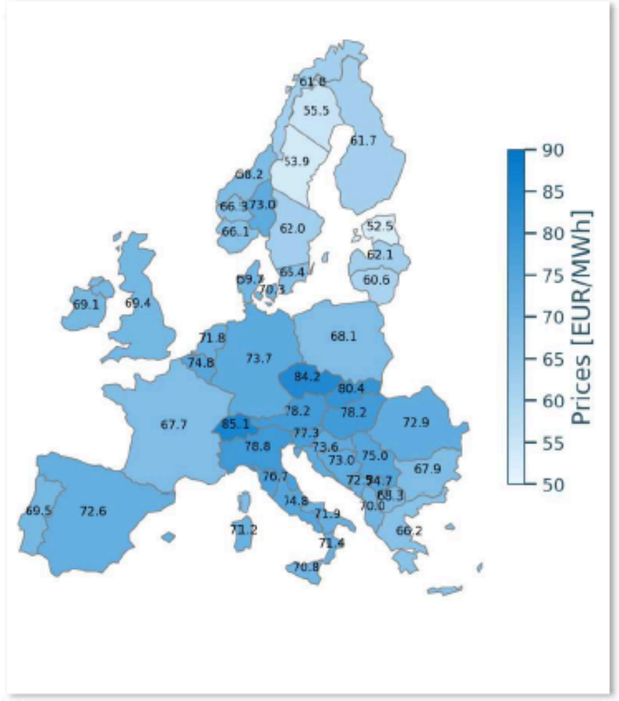
Power price, Radial Only 2050



Power price, Counterfactual 2050



Power price, Regional Cooperation 2050



Integrated (spatial) planning for mitigation of wake

A case study for the North Sea

03.07.2025 Felix Fliegner | 50Hertz

Offshore Wind and Grid Workshop by RGI and ENTSOE in Brussels

Content

1. **The wind knows no borders:** but our spatial planning does
2. **Less is more**: impact of power density and cross-border accumulation
3. **Stronger together**: We need better spatial planning (data) to coordinate our buildout!

Further reading:

International Journal of
Energy Research

Research Article | Open Access

Cross-Border Cooperation to Mitigate Wake Losses in Offshore Wind Energy: A 2050 Case Study for the North Sea

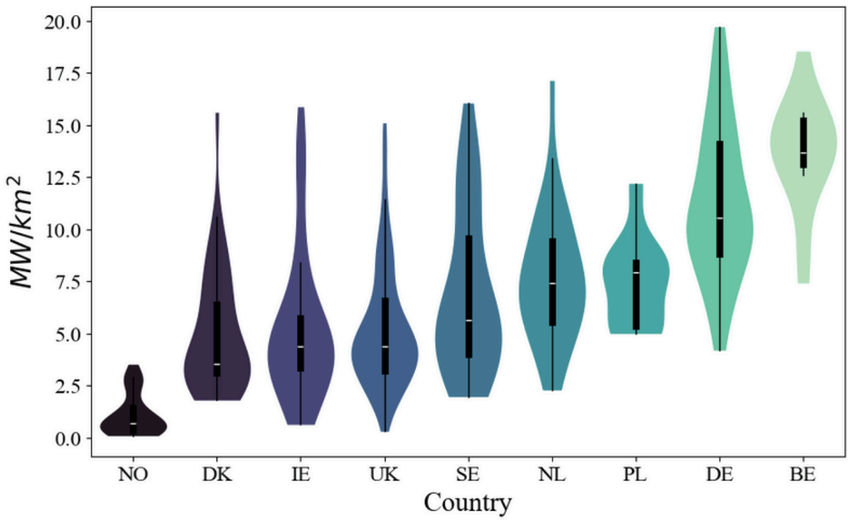
Felix Jakob Fliegner, Axel Kleidon, Thure Traber

First published: 16 June 2025 | https://doi.org/10.1155/er/2518424

Dominant wind direction and power density impact wake losses the most

Power densities per EEZ

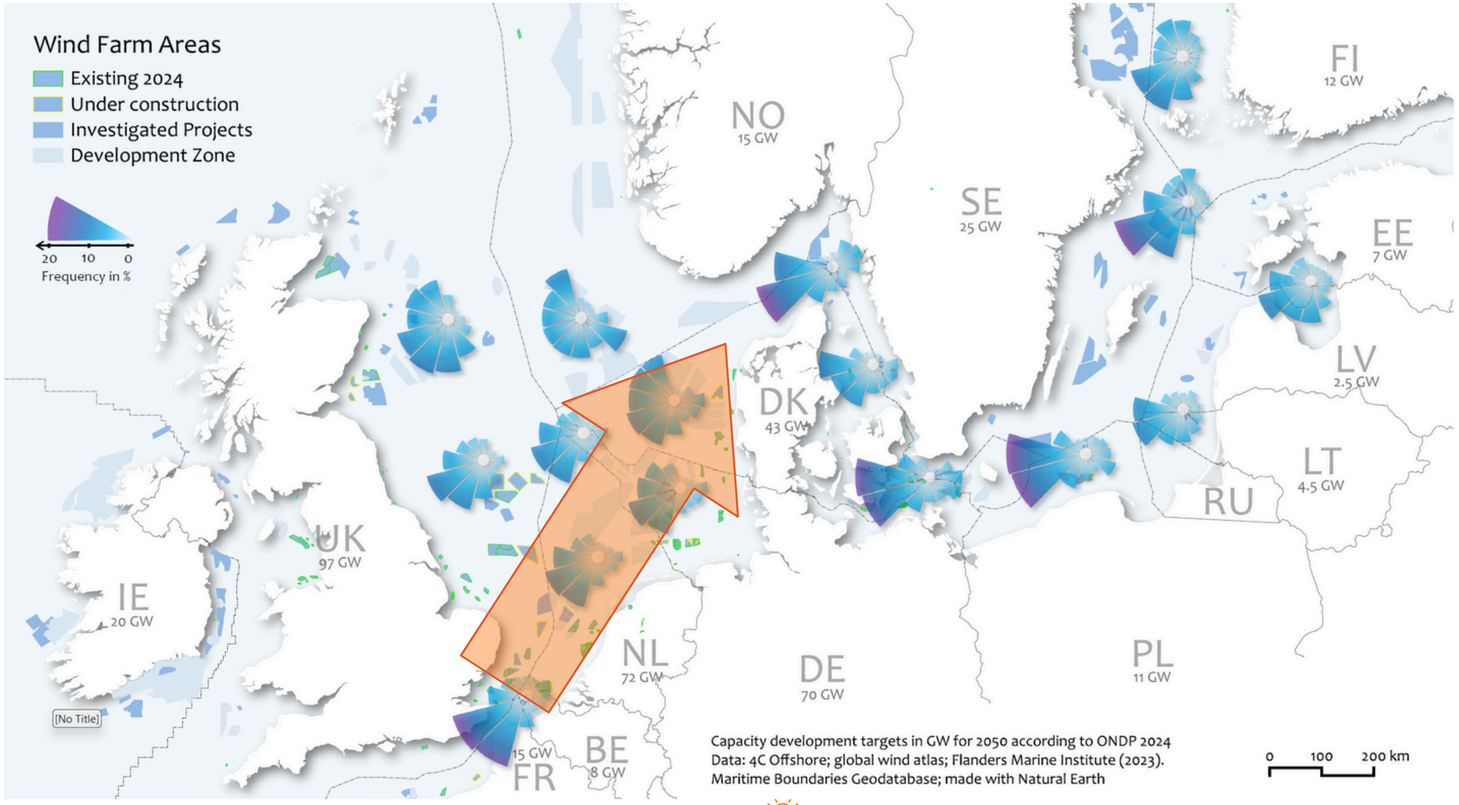
Existing and future wind farms



30% of the future offshore wind capacity in the North Sea will be located in the same wind corridor.

Distribution of wind direction

10 historical climate years

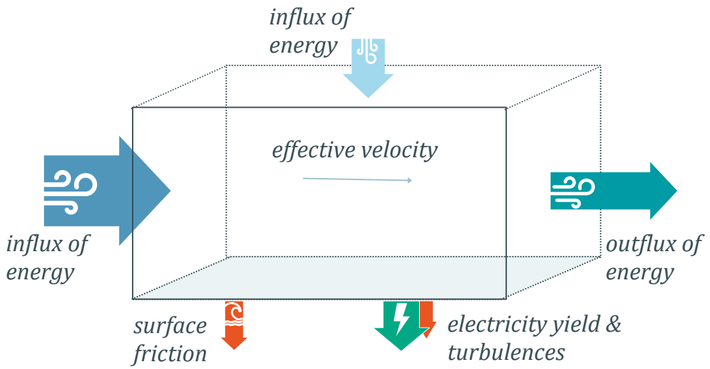


Fliegner et al. 2025 “Cross-Border Cooperation to Mitigate Wake Losses in Offshore Wind Energy: A 2050 Case Study for the North Sea”

Simulation of the kinetic energy budget of the atmosphere (KEBA) to quantify wake losses and mitigation options

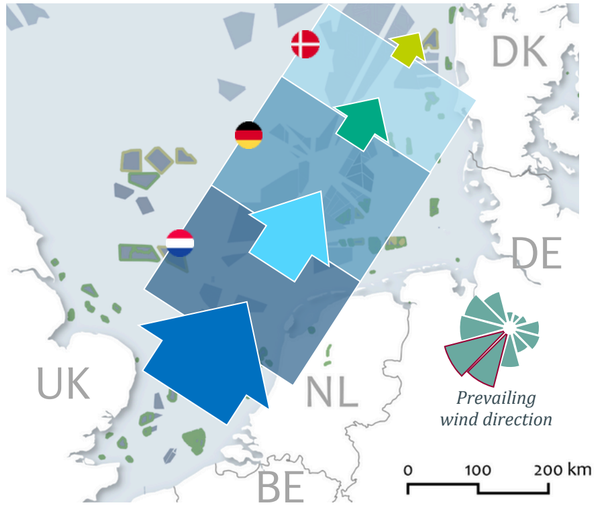
Input/Output simulation model

Kinetic energy budget of the atmosphere



Three coupled boxes in a row

The Netherlands, Germany, Denmark



Three scenarios

1
- 35 GW
- 66 GW
- 72 GW

Base case
Planned wind farm capacities and densities

2
- 35 GW
- 66 GW
- 72 GW

More Space
Same capacity, but lower power densities

3
- 50 GW
- 51 GW
- 72 GW

Redistribution
Same capacity, but some capacity shifted to DK

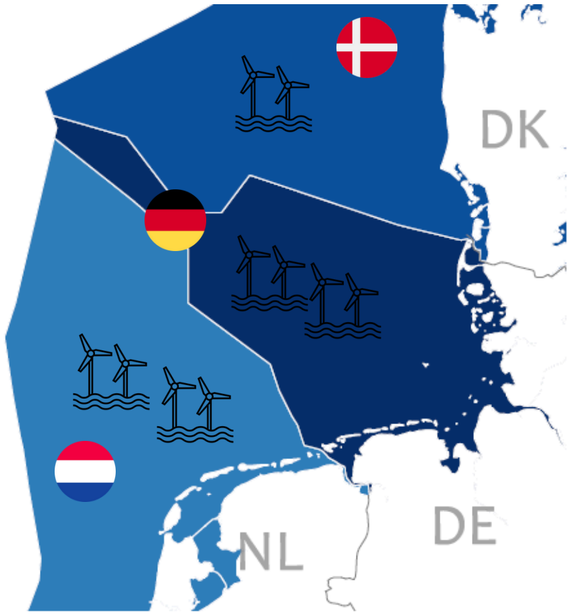
With key assumptions

- Single main wind direction from South-West *representing 25-30% of all hours*
- Three coupled bounding boxes for covering the EEZ of NL, DE and DK respectively
- Simulation of 10 historical climate years in hourly resolution

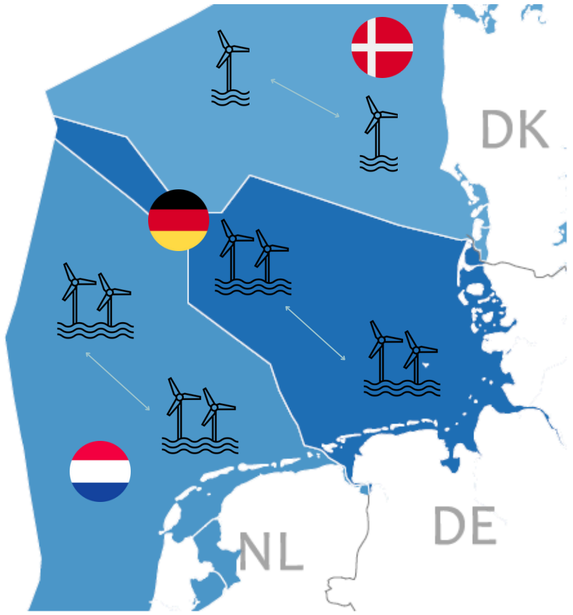
Kleidon, Miller (2020): The Kinetic Energy Budget of the Atmosphere KEBA model 1.0

Reducing power densities and shifting capacity further north can reduce but not eliminate wake losses

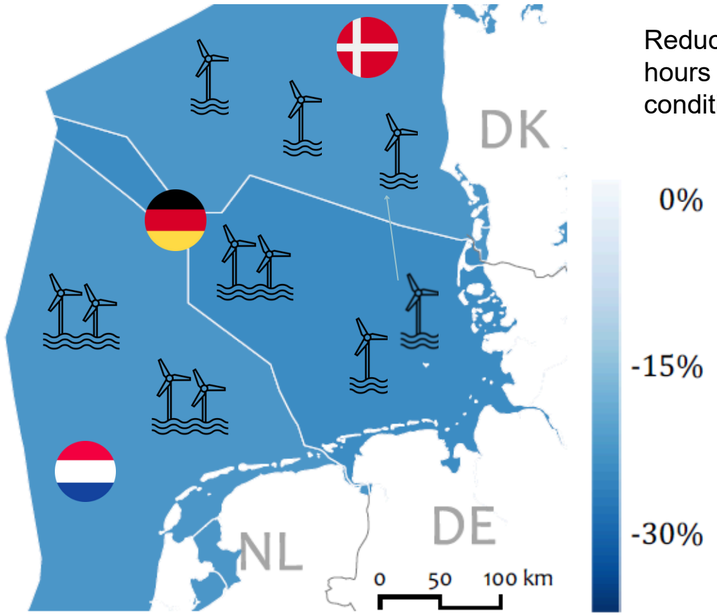
Base case
Current planning



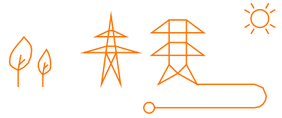
More space for wind farms
Reduced power densities



Redistribution
Cross border shift of some capacity



Reduction in full-load hours compared to idle conditions with no wake

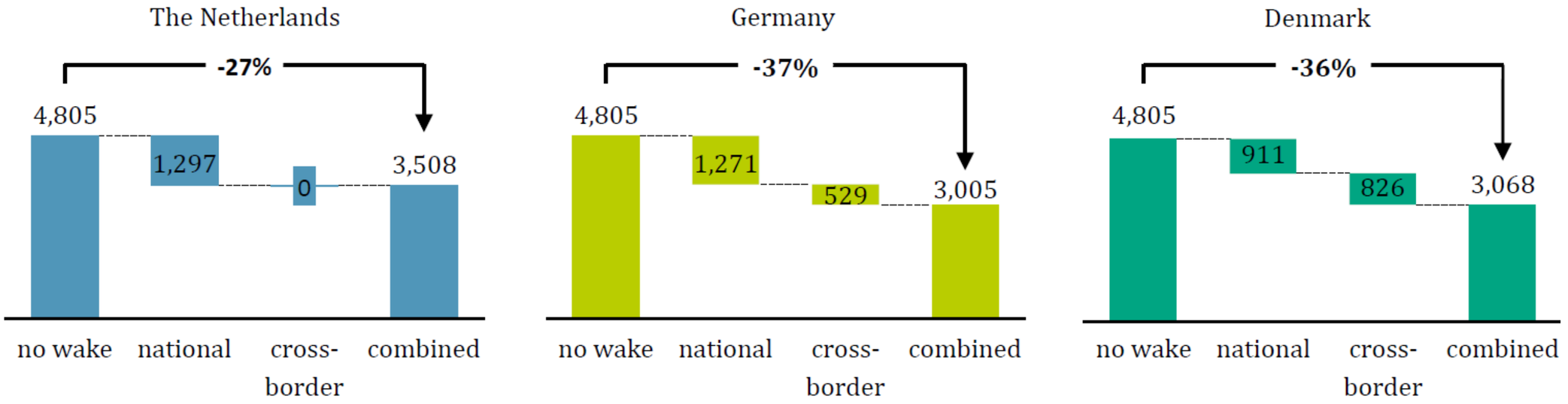


Wake & Spatial

The share of cross-border wakes can accumulate substantially

National and cross-border contribution to the total wake loss

For a 2050 scenario with planned capacities and densities as of ONDP 2024



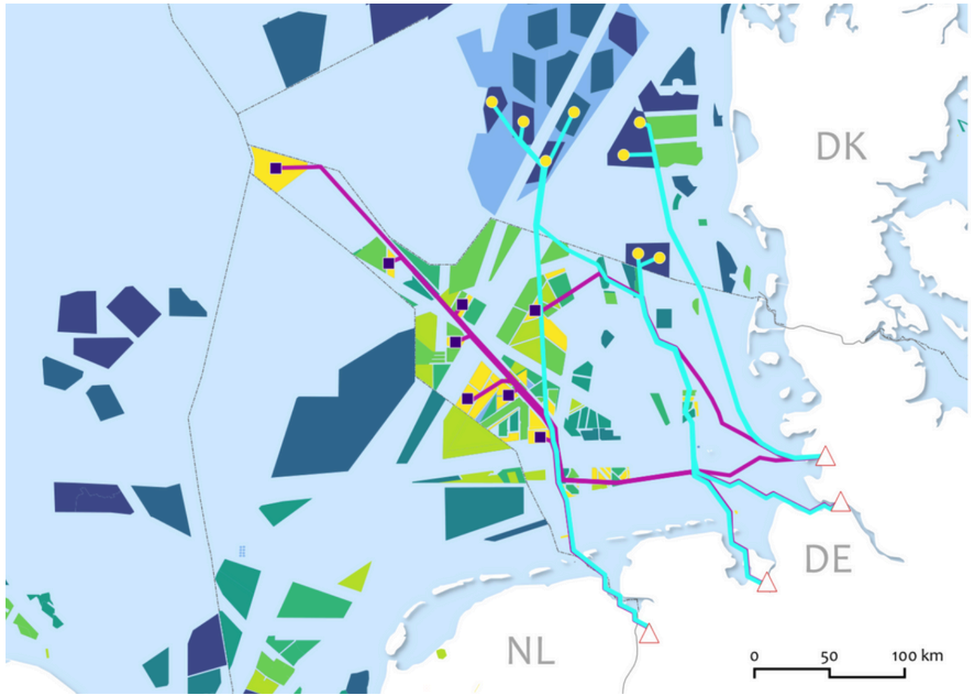
The effects are weaker, in locations where wind directions change more often and power densities are smaller.

Note, the “0” cross border accumulation in NL is an artefact of modelling. In reality there is some shading from BE and UK wind farms.
Fliegner et al. 2025 “Cross-Border Cooperation to Mitigate Wake Losses in Offshore Wind Energy: A 2050 Case Study for the North Sea”

Cross-border shift of capacity can be spatially and economically viable

Possible routes for connecting redistributed wind farms

As a function of power density



Selected Wind Farms
- Base Case
- Redistribution
- Onshore Substations

Transmission Corridors
- Base Case
- Redistribution

Power Densities in MW/km²
< 1
3
6
9
> 12

FJ Fliegner
Data: own analysis; made with Natural Earth

Base case

shortest national connection: 2,320 km

FLH 3,400

LCOE 108 €/MWh

Redistribution of wind farms from DE to DK

shortest national connection: 2,450 km +5%

FLH 4,050 +19%

LCOE 95 €/MWh -12%

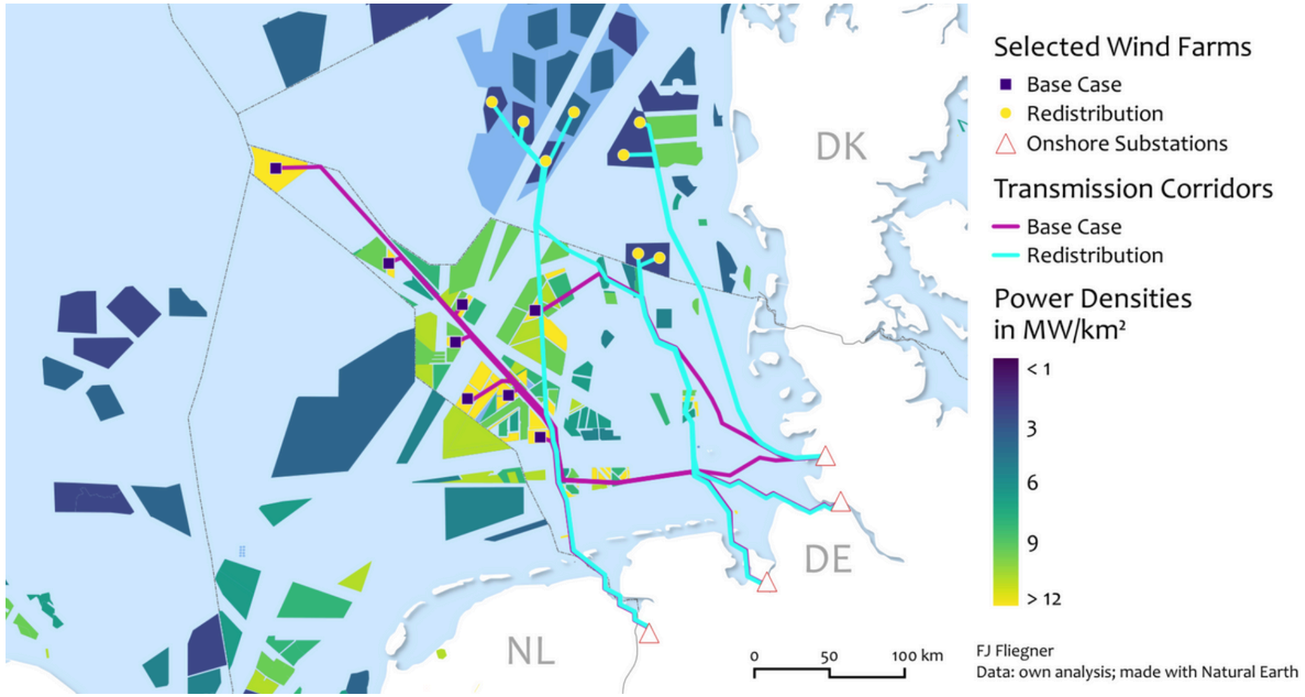
With key assumptions
- Connection only to DE
- No alternative onshore grid DK-DE considered
- Invest in wind farms is the same in DK and DE
- No compensation for DK

Fliegner et al. 2025 “Cross-Border Cooperation to Mitigate Wake Losses in Offshore Wind Energy: A 2050 Case Study for the North Sea”

Cross-border shift of capacity can be spatially and economically viable

Possible routes for connecting redistributed wind farms

As a function of power density

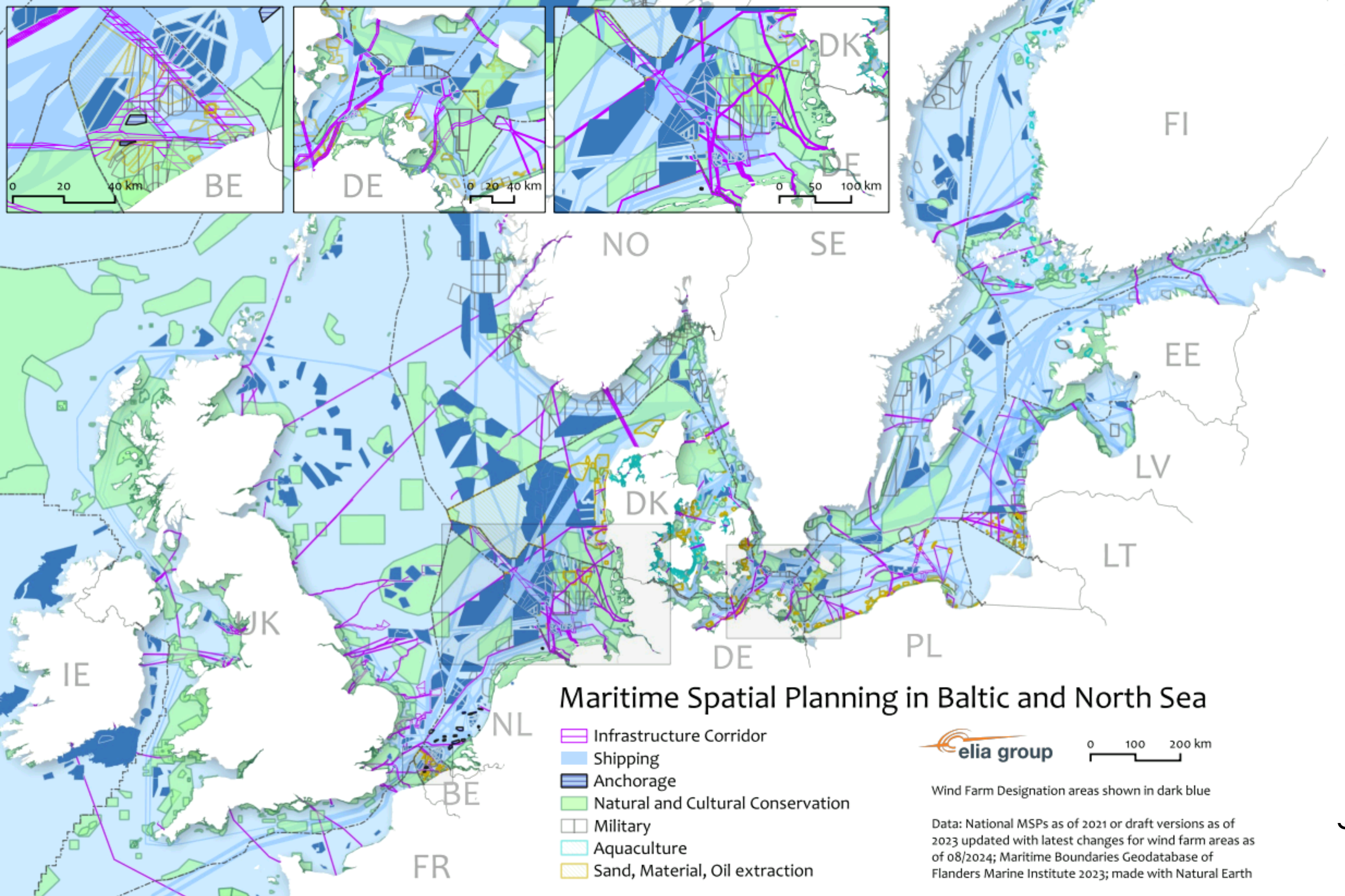


What would be needed to achieve this?

Considerations

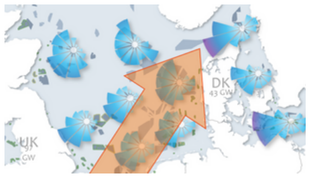
- Grouping with existing or planned future interconnectors
- Permission to connect foreign wind farms to a third country (cross border radials)
- Availability of uniform, consistent and complete spatial planning data across sea basins!
- A balancing of spatial interests such as protection, national defense, infrastructure and other

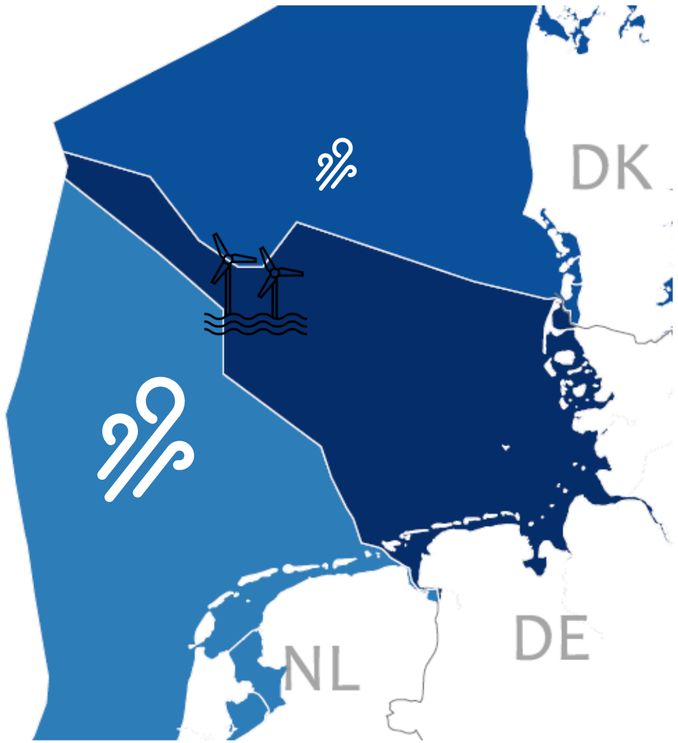
Wake & Spatial


BE
0 20 40 km
DE
0 20 40 km
DK
DE
0 50 100 km
NO
SE
FI
EE
LV
LT
PL
DK
DE
UK
IE
NL
BE
FR
Maritime Spatial Planning in Baltic and North Sea
Infrastructure Corridor
Shipping
Anchorage
Natural and Cultural Conservation
Military
Aquaculture
Sand, Material, Oil extraction
elia group
0 100 200 km
Wind Farm Designation areas shown in dark blue
Data: National MSPs as of 2021 or draft versions as of 2023 updated with latest changes for wind farm areas as of 08/2024; Maritime Boundaries Geodatabase of Flanders Marine Institute 2023; made with Natural Earth

“Less is more” – Acknowledgement of wake losses can help mitigating it and improve overall generation efficiency

- Wake is inextricably linked to the large-scale deployment of offshore wind power
- Neglecting it during system planning or project development can overestimate yields by 20-30%
- A large-scale, long-term and cross-border planning perspective can reduce the losses effectively
- Optimising for an energy target instead of capacity target can incentivise a more efficient development





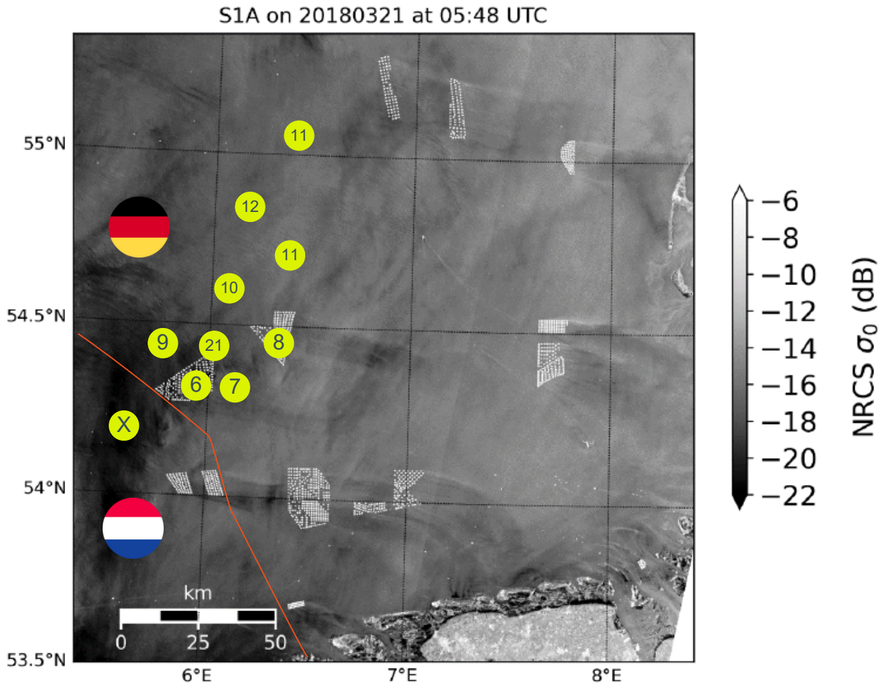
Alternative measures for wake mitigation

- Lower power densities
- Spatial re-location
- Low-wind wind turbines (larger rotors per generator capacity)
  - Strategic decision in expectation of wake losses (chicken-egg situation)
- Different hub heights
- Optimal order of development of wind farms in the sea
- Overplanting of grid connection to shore
- Retrofitting is also a good chance to re-optimise for wake losses

Wake losses concern both, future and existing wind farms

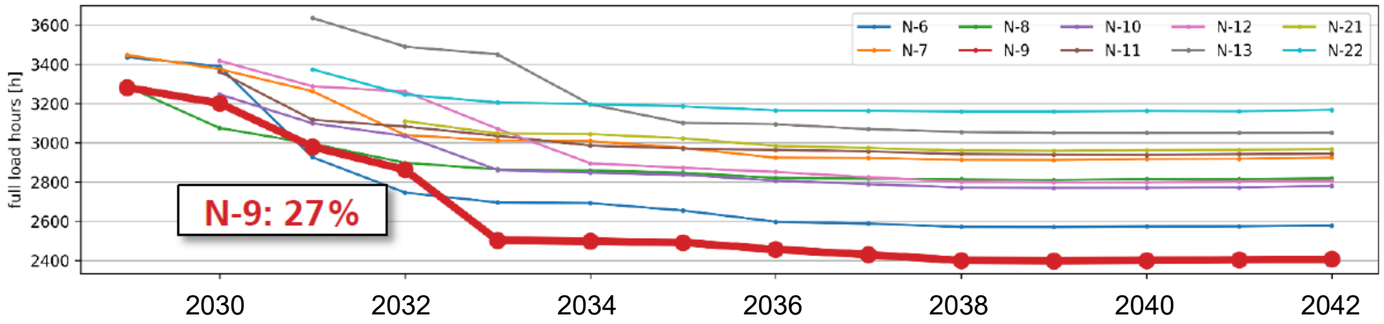
Empirical evidence for wake shadows

German Bight of the North Sea in 2018



Future projections for existing wind farms

German Bight of the North Sea in 2018



Interdependence of cross-border wind farm development will increase significantly past 2030

Fraunhofer IWES (2023): “Estimation of long-term offshore wind energy yield in the German EEZ”

Integrated Marine Spatial Planning: Aligning Energy, Nature and Space

an application of SCAIRM

Gerjan Piet (WMR)

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Aim

To provide technical assistance to OSPAR ICG-ORED in further developing an approach and tool(s) for Cumulative Impact Assessment (CIA), including carrying out different pilot assessments on birds in the OSPAR maritime area as proof of concept.

- can evaluate scenarios of offshore wind and other activities on birds but with the possibility to expand this to include other ecosystem components as well.
- should cover the North Sea, Celtic Sea and Bay of Biscay
- show how available information can be applied within this framework. For these first pilot assessments the CIA will be limited to birds only and includes all pressures from a variety of human activities that may potentially impact birds but with a focus on offshore wind energy development and operations.
- evaluate some multi-sector scenarios.

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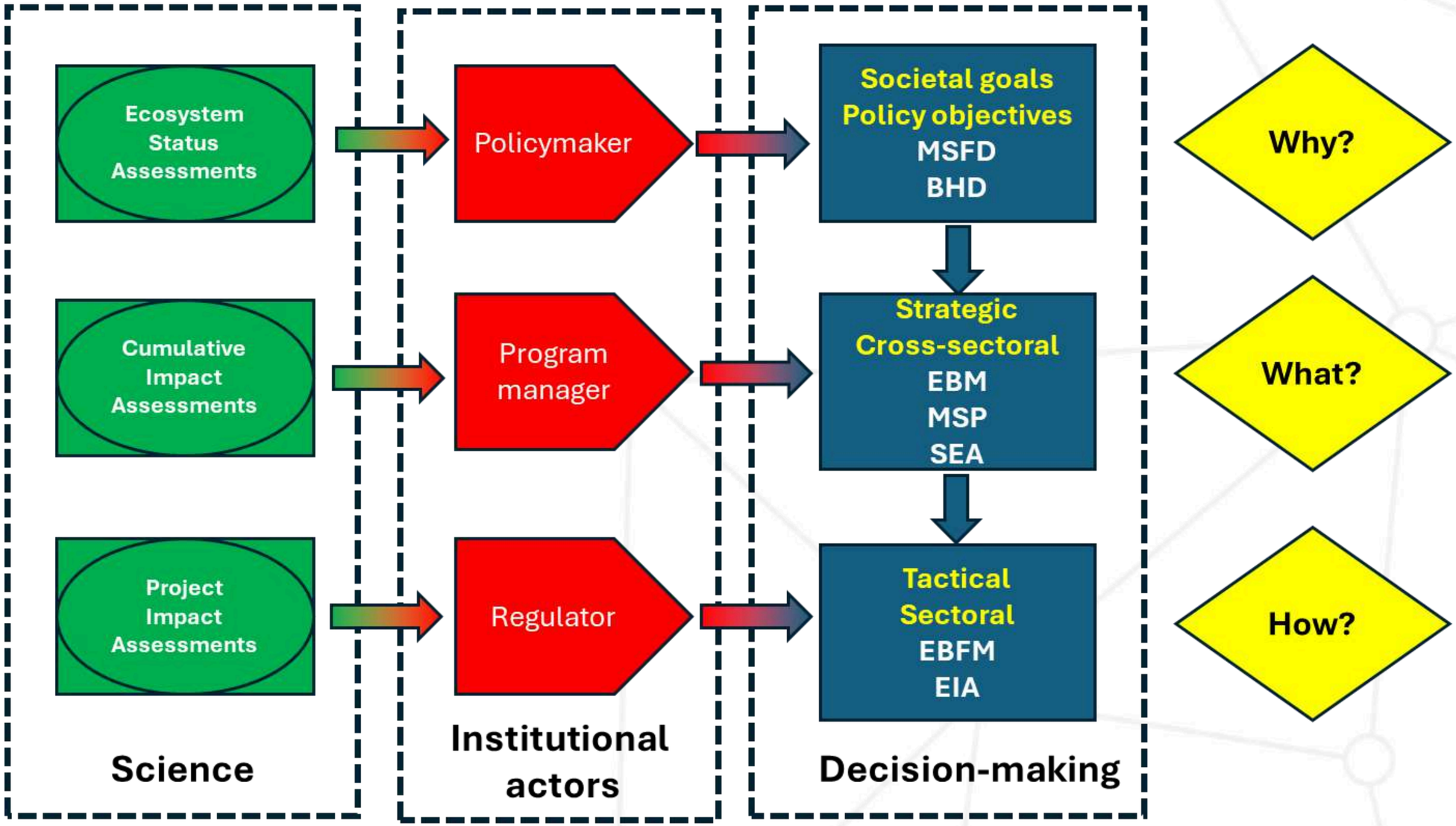
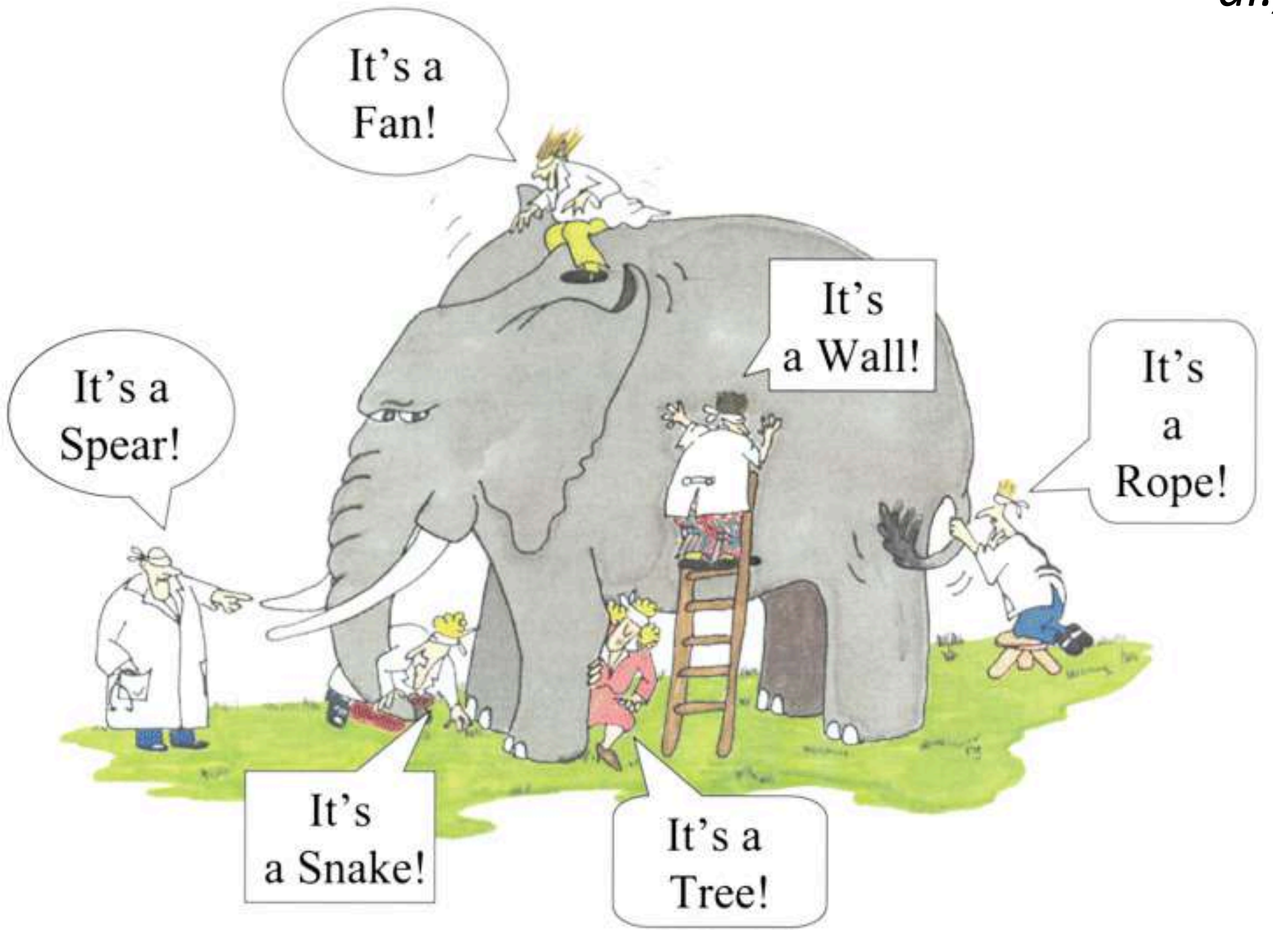
Science advice for offshore wind and MSP



CEA or CIA: what is it? …and why to apply it?

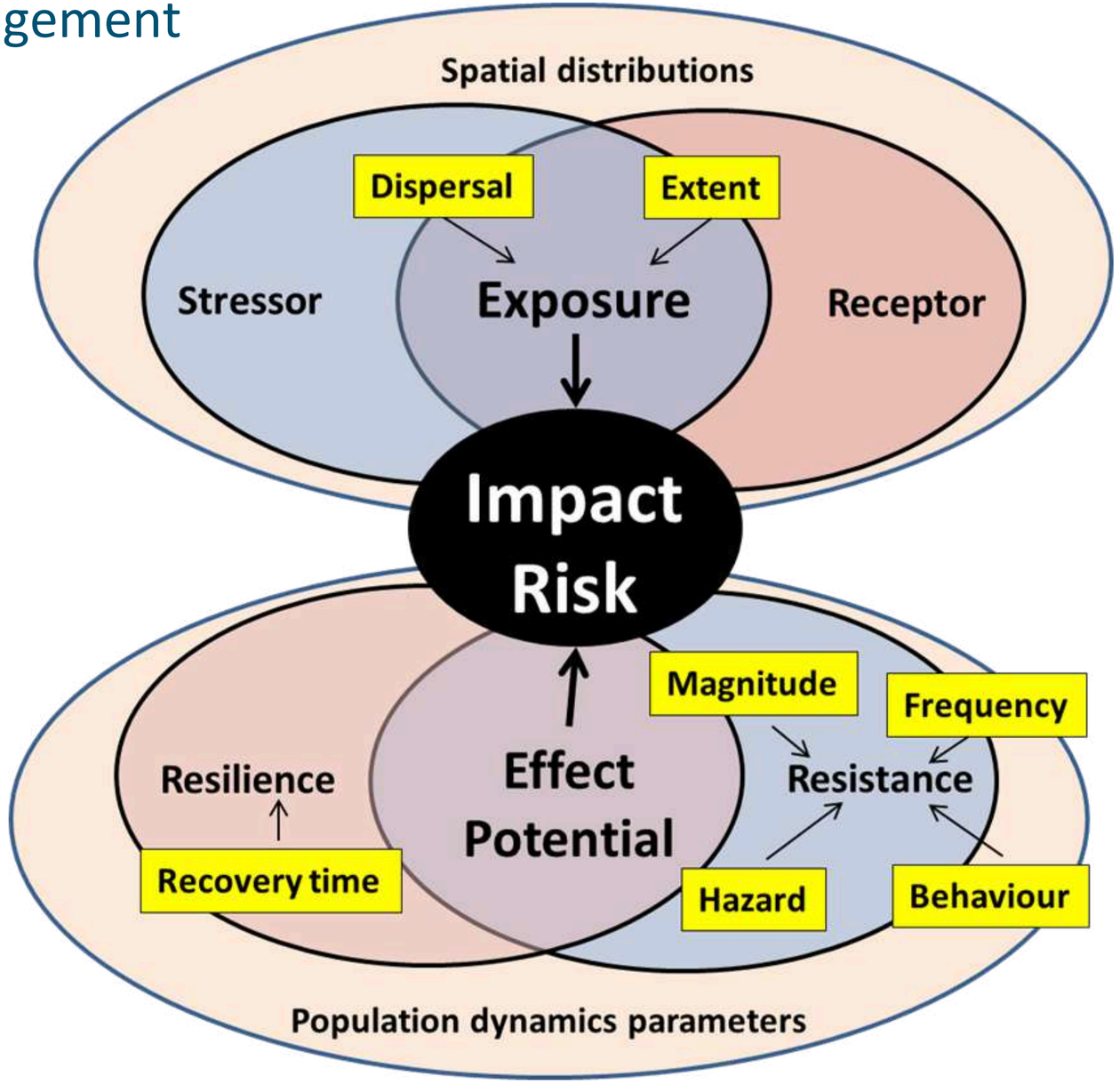


- *"Human activities exert pressures which have effects which may lead to impacts on receptors" (Judd et al., 2015)*
- *" Impact is the change in state of the receptor, as the consequence of some pressure-induced effect" (Piet et al., 2021)*

- *An "effect" is interpreted as the immediate consequence of a pressure, while "impact" is the endpoint of the effect (ICES WKCOMPORE)*
- *Cumulative impacts are interpreted as the combined effects (additive, synergistic, or antagonistic) of a specific sector/activity and its pressures on the ecosystem (components, species or another human activity)*
- *CEA/CIA should include all human activities and their pressures. A single-sector CIA is essentially an EIA done right (WGCEAM)*

SCAIRM

Spatial **C**umulative **A**ssessment
of **I**mpact **R**isk for **M**anagement



Impact Risk

=

Likelihood
Receptor
Exposed to
Stressor

&

Consequence
of the interaction
Effect -> Impact

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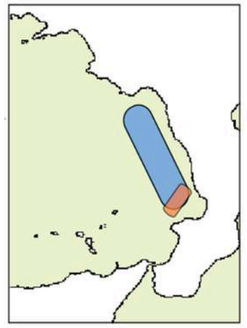
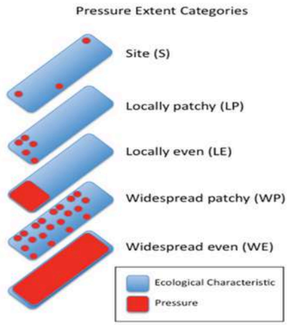
Expert-judgement

Knights et al (2015),

Piet et al. (2017,2019),

Borgwardt et al. (2019)

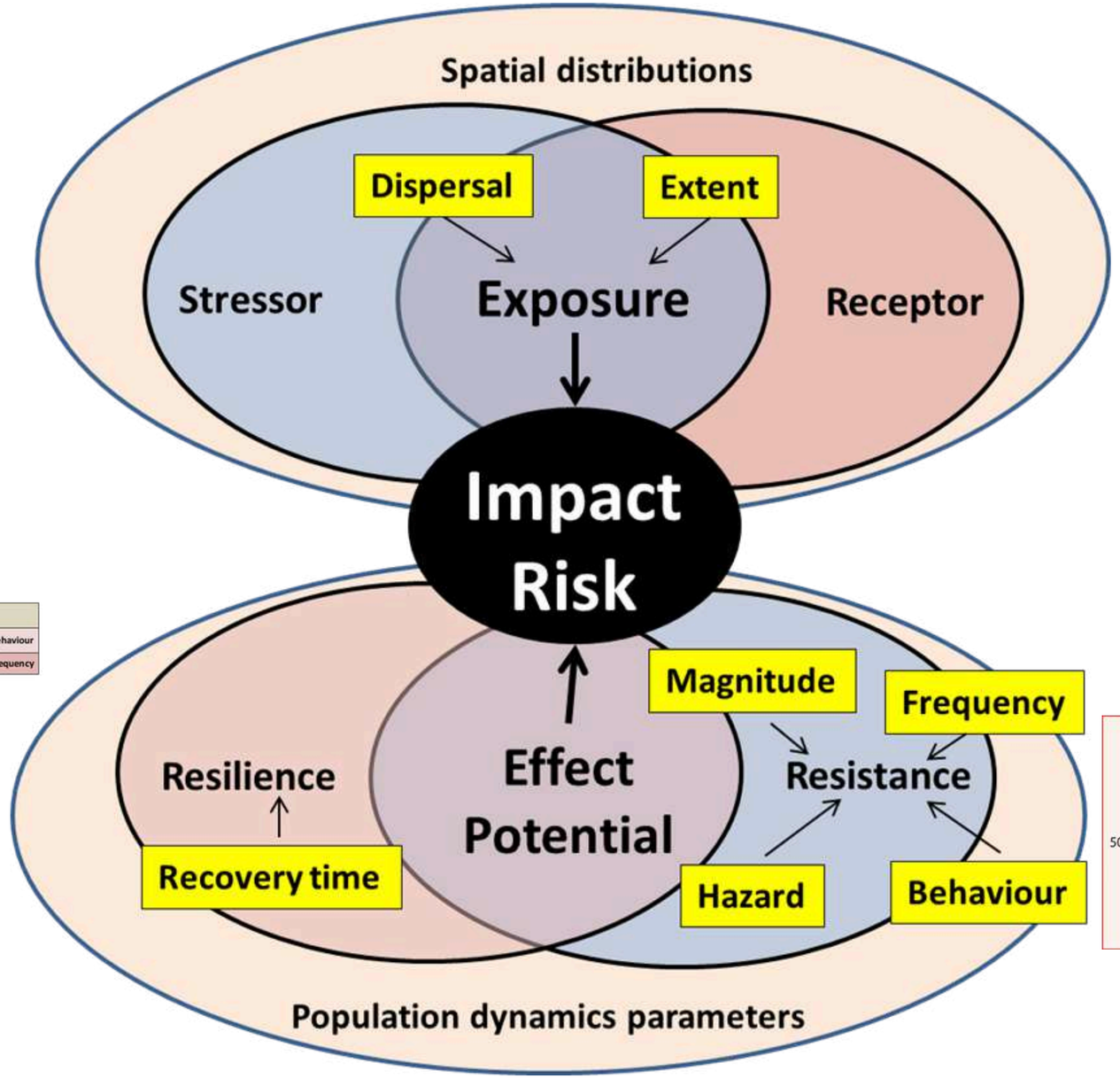




Hazard		Magnitude		Continuous	Intermittent												
					0.5	0.5	0.5	5	5	5	50	50	50	100	100	100	Behaviour
					0.1	1	10	0.1	1	10	0.1	1	10	0.1	1	10	Frequency
Negligible	0.01	Very low	0.1	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	
	0.01	Low	1	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	
	0.01	Medium	10	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	
	0.01	High	50	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.98	100.00	100.00	99.95	
	0.01	Maximum	100	99.99	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.95	99.95	100.00	99.99	99.90	
Sublethal low	0.1	Very low	0.1	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	
	0.1	Low	1	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	
	0.1	Medium	10	99.99	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.95	100.00	99.99	99.90		
	0.1	High	50	99.95	100.00	100.00	100.00	100.00	100.00	99.98	100.00	99.98	99.75	99.99	99.95	99.50	
	0.1	Maximum	100	99.90	100.00	100.00	100.00	100.00	100.00	99.95	99.99	99.95	99.50	99.99	99.90	99.00	
Sublethal high	1	Very low	0.1	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	
	1	Low	1	99.99	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.95	100.00	99.99	99.90	
	1	Medium	10	99.90	100.00	100.00	100.00	100.00	100.00	99.95	99.99	99.95	99.50	99.99	99.90	99.00	
	1	High	50	99.50	100.00	100.00	99.98	100.00	99.98	99.75	99.97	99.75	97.53	99.95	99.50	95.11	
	1	Maximum	100	99.00	100.00	100.00	99.95	99.99	99.95	99.50	99.95	99.50	95.11	99.90	99.00	90.44	
Lethal low	10	Very low	0.1	99.99	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.95	100.00	99.99	99.90	
	10	Low	1	99.90	100.00	100.00	100.00	100.00	100.00	99.95	99.99	99.95	99.50	99.99	99.90	99.00	
	10	Medium	10	99.00	100.00	100.00	99.95	99.99	99.95	99.50	99.95	99.50	95.11	99.90	99.00	90.44	
	10	High	50	95.00	100.00	99.98	99.75	99.97	99.75	97.53	99.75	97.50	77.63	99.49	95.00	59.87	
	10	Maximum	100	90.00	99.99	99.95	99.50	99.95	99.50	95.11	99.49	95.00	59.87	98.95	90.00	34.87	
Lethal high	100	Very low	0.1	99.90	100.00	100.00	100.00	100.00	100.00	99.95	99.99	99.95	99.50	99.99	99.90	99.00	
	100	Low	1	99.00	100.00	100.00	99.95	99.99	99.95	99.50	99.95	99.50	95.11	99.90	99.00	90.44	
	100	Medium	10	90.00	99.99	99.95	99.50	99.95	99.50	95.11	99.49	95.00	59.88	98.95	90.00	34.87	
	100	High	50	50.01	99.97	99.75	97.53	99.75	97.50	77.63	97.16	75.00	5.63	93.30	50.01	0.10	
	100	Maximum	100	0.01	99.95	99.50	95.11	99.49	95.00	59.88	93.30	50.01	0.10	39.81	0.01	0.00	

SCAIRM

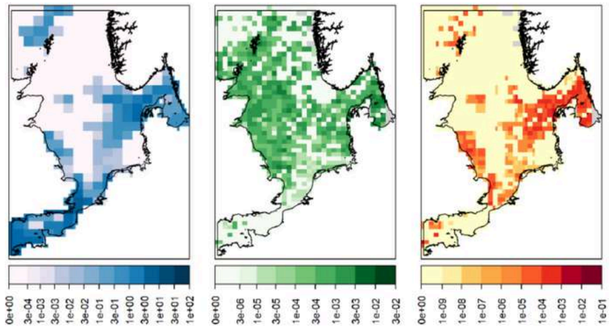
Piet et al. (2023)

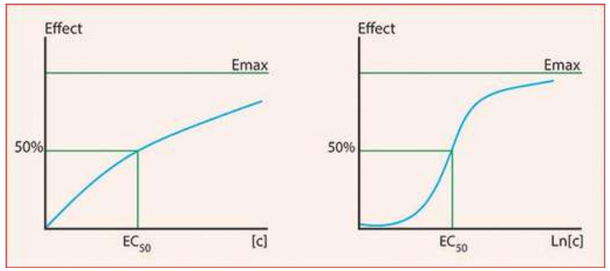


Data-driven

Piet et al. (2021)

Stressor **Receptor**



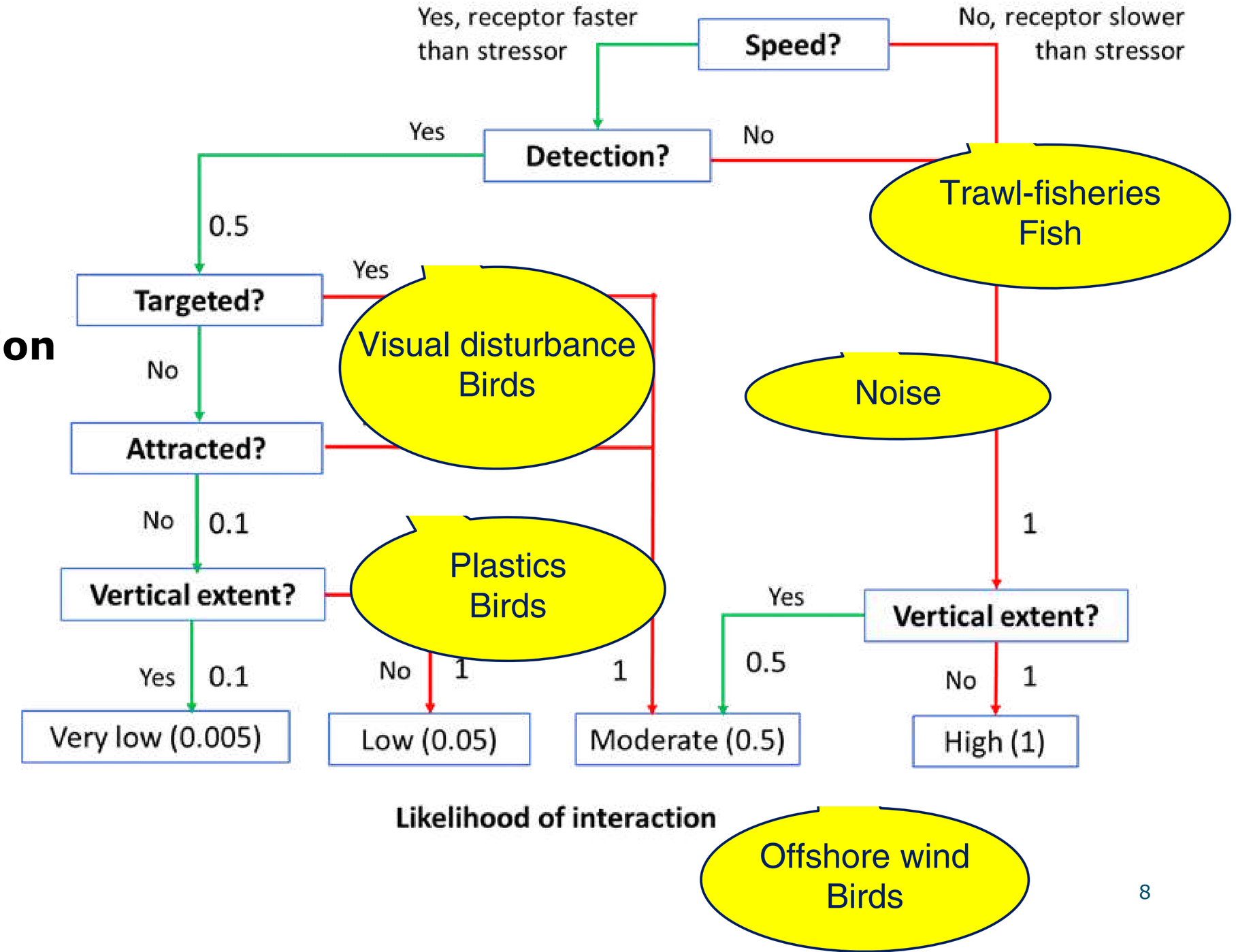


Resistance

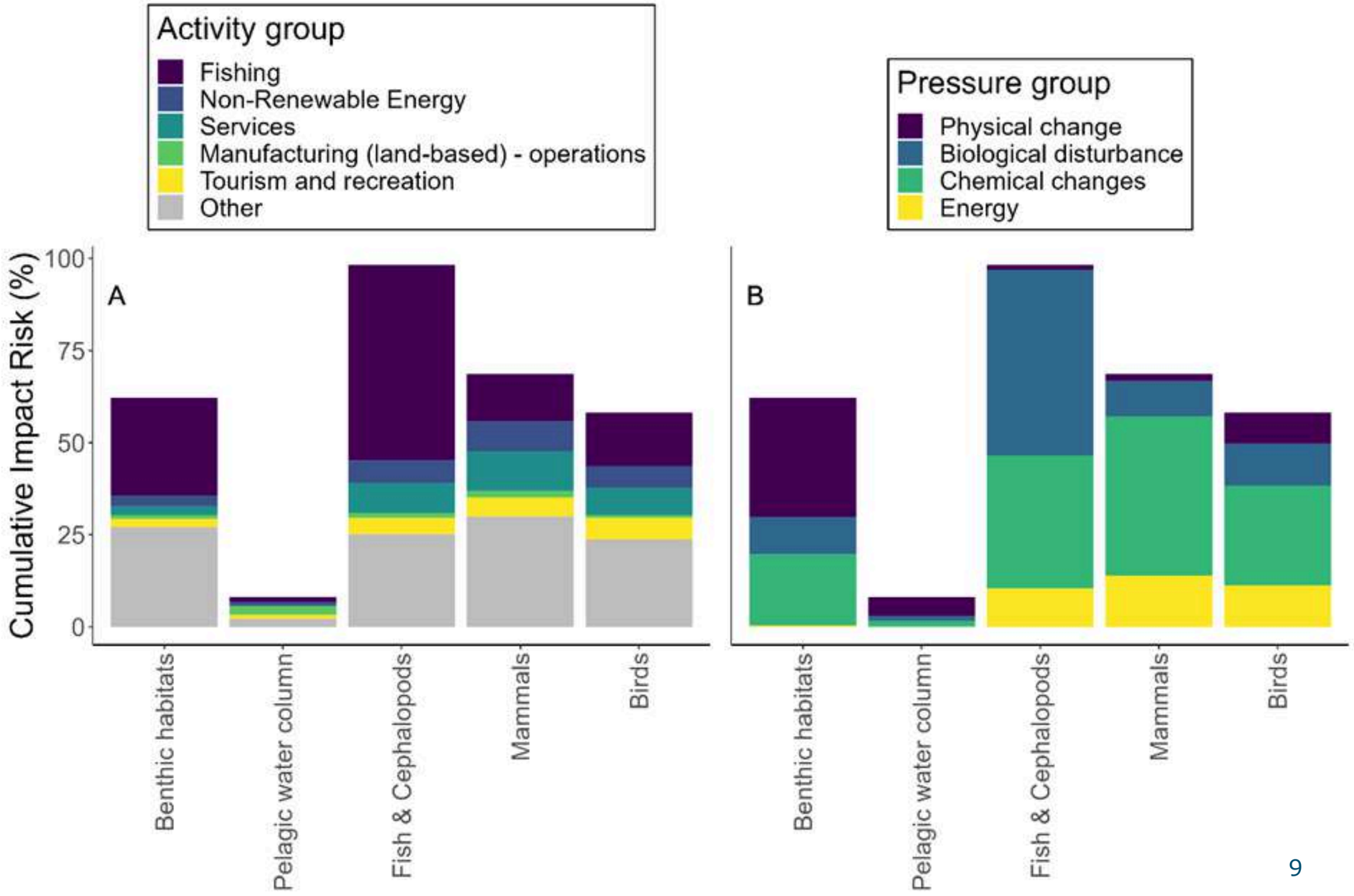
Stressor
to
Receptor

Behaviour (Pressure-Species specific)

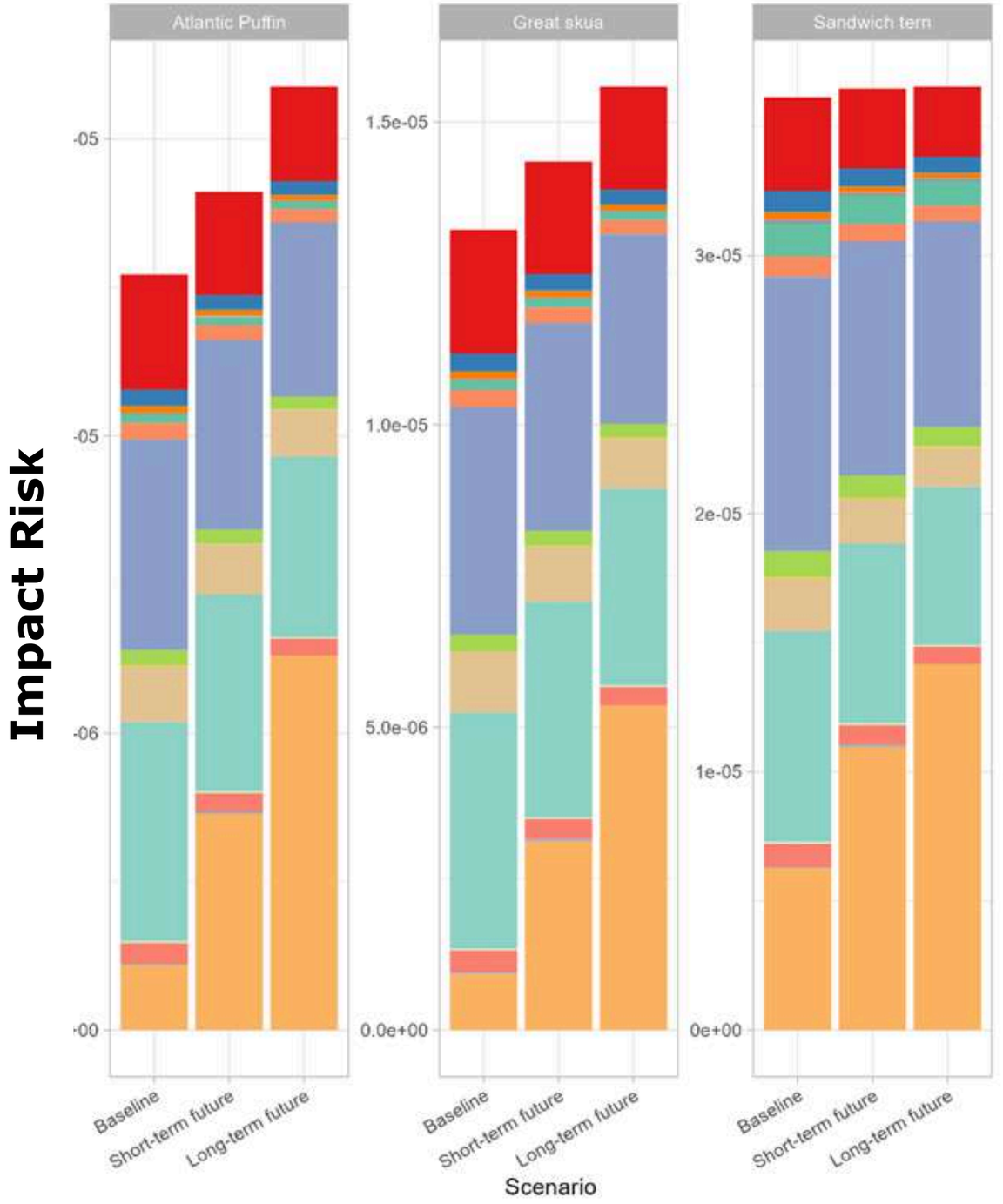
Likelihood of interaction



Science advice: Impact Risk Assessment



Future Scenarios



Activities/Operations

- Benthic trawls an...
- Boating/Yachting ...
- Capital dredging ...
- Fin-fish - operat...
- Fisheries - steaming
- Macro-algae - ope...
- Macro-algae - set...
- Marinas and dock/...
- Marine dumped mun...
- Military: Operati...
- Military: Steamin...
- Nets (fixed/set/g...
- Oil and Gas - con...
- Oil and Gas - ope...
- Operational (effl...
- Pelagic trawls - ...
- Sand/gravel aggre...
- Shipping: Steamin...
- Suction/hydraulic...
- Telecoms and Elec...
- Water sports - st...
- Wind farms - cons...
- Wind farms - oper...

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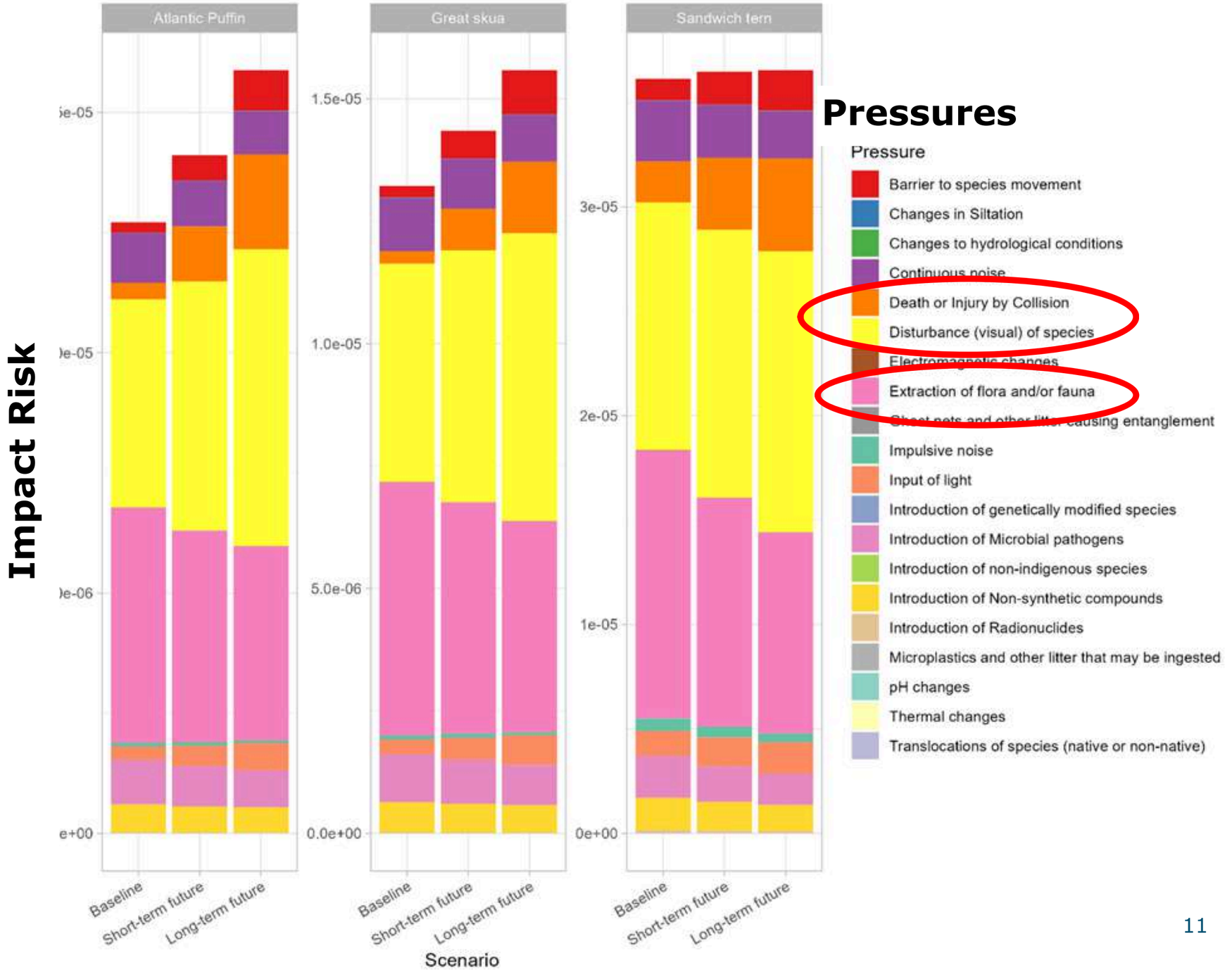
Future Scenarios



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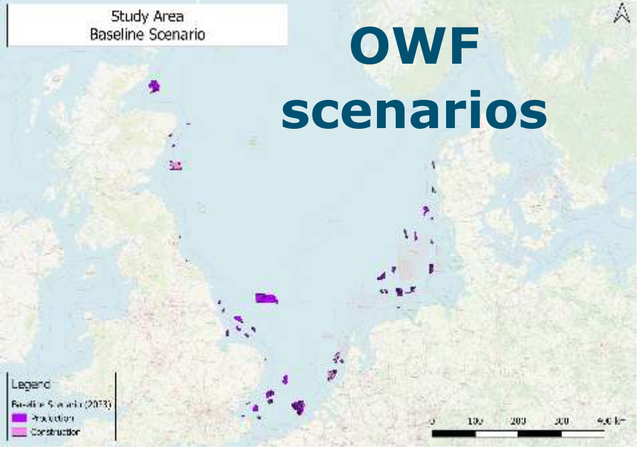
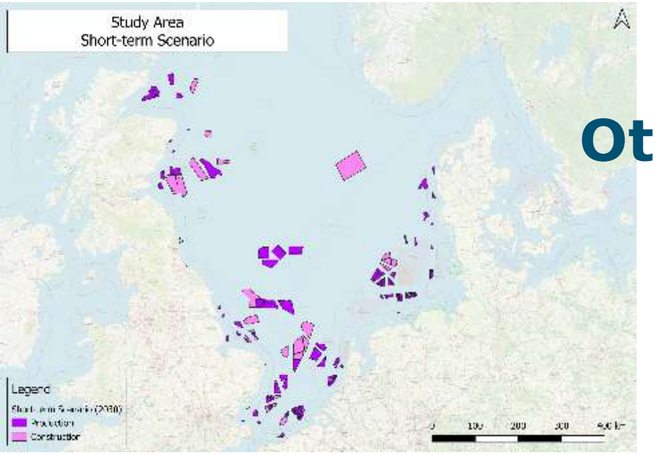
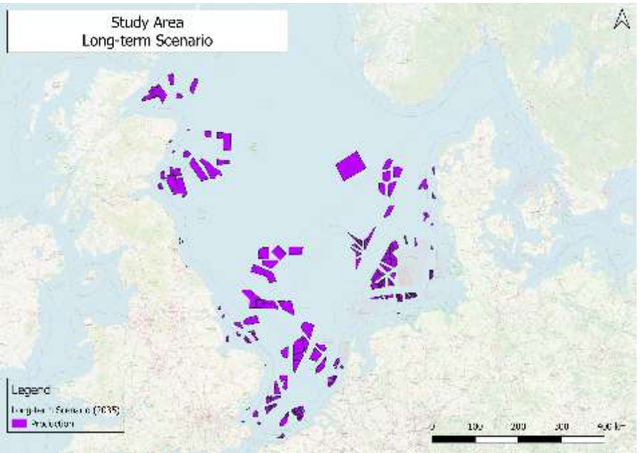
MSP scenarios
Offshore wind
&
Other human activities
on
Birds

OWF scenarios

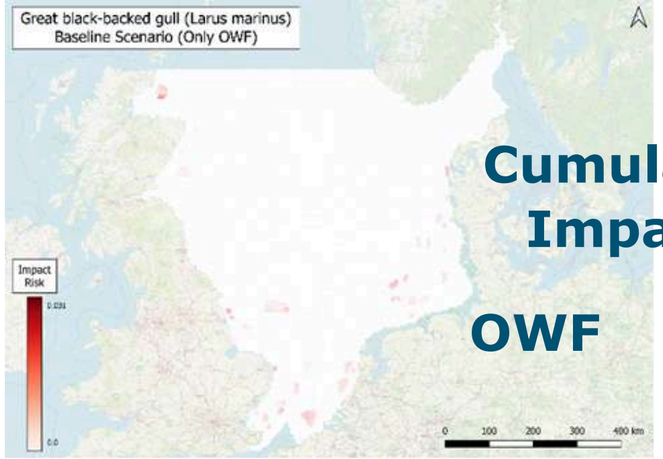


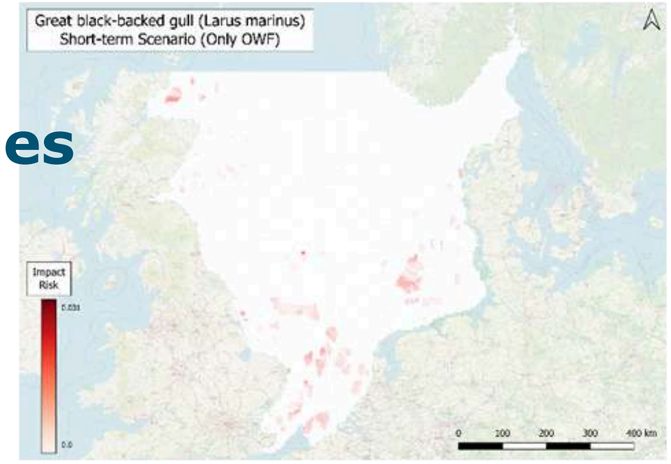


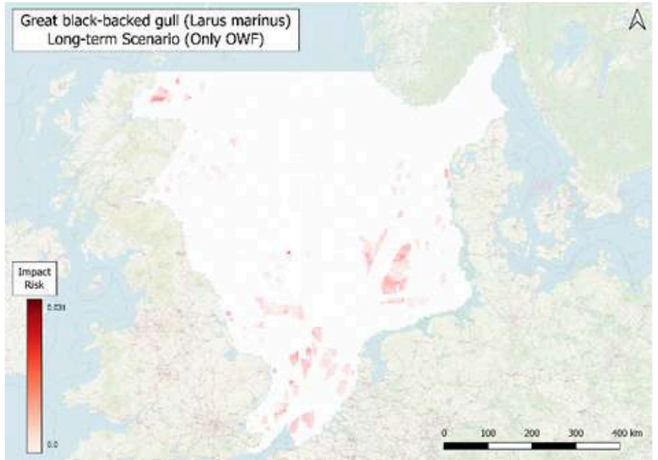


Cumulative Impacts

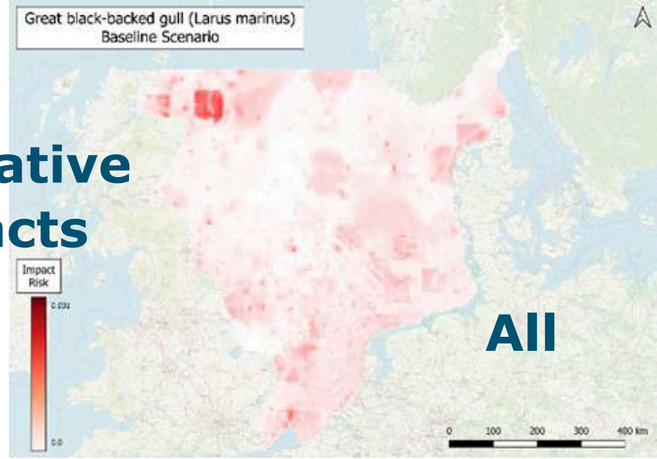
OWF

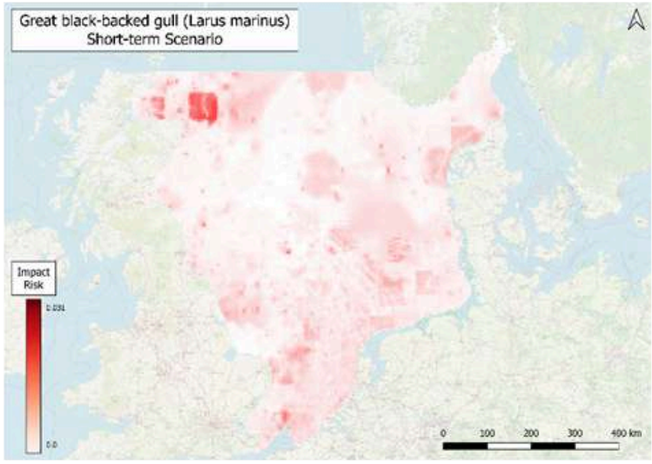


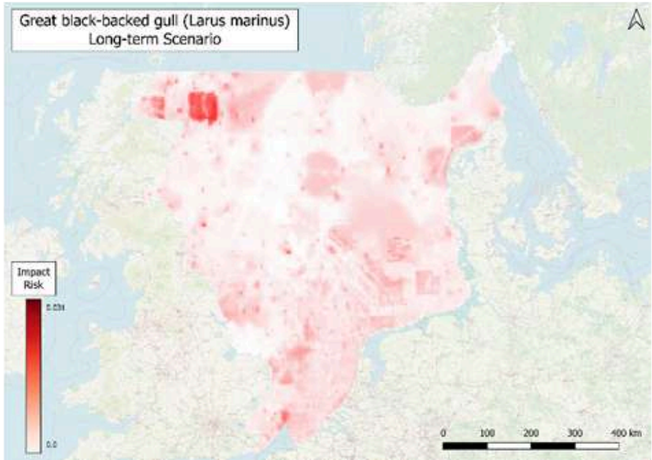




All







MSP scenarios
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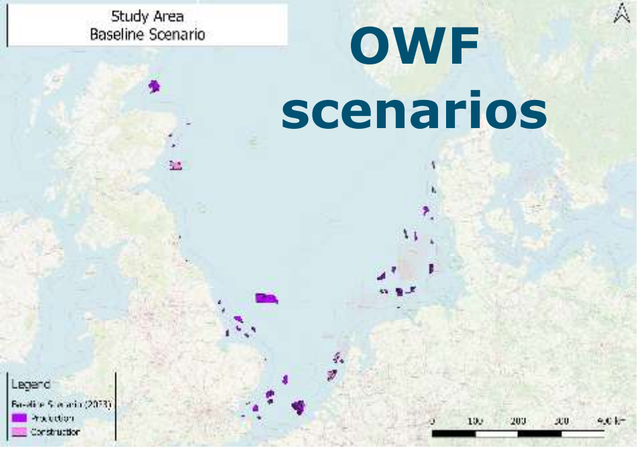
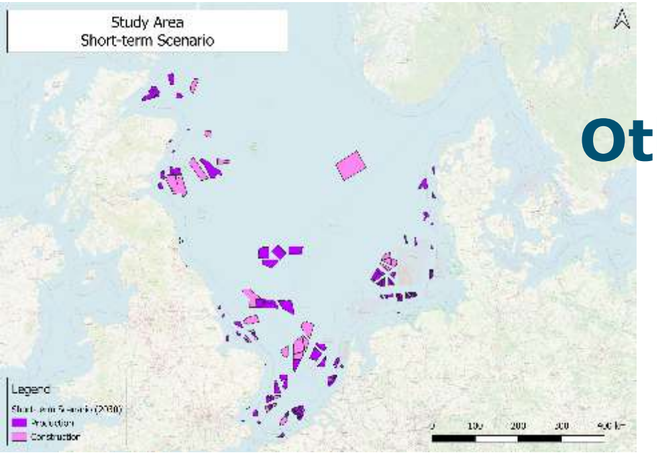
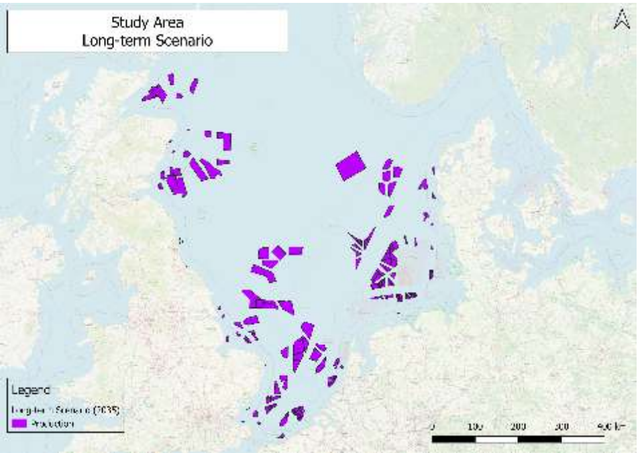
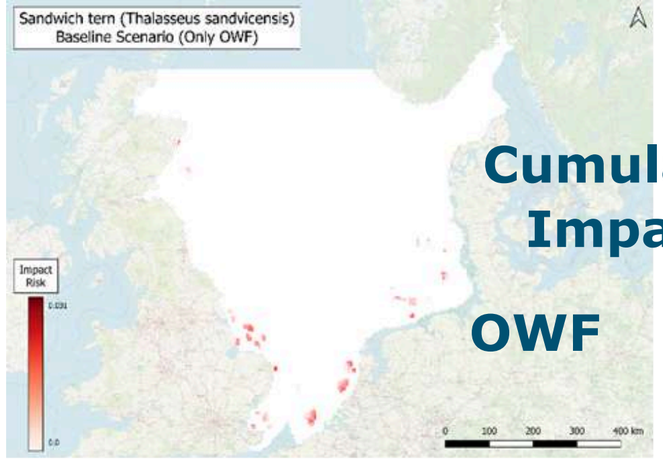


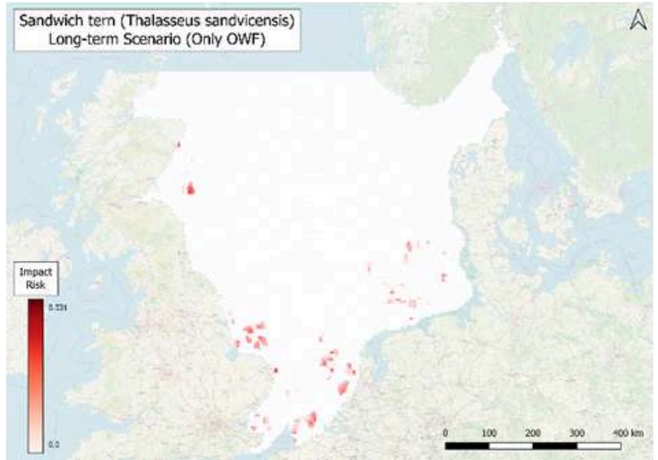




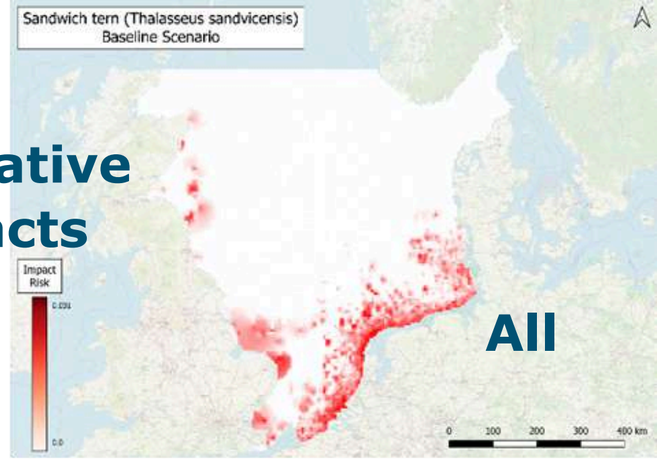
Cumulative Impacts

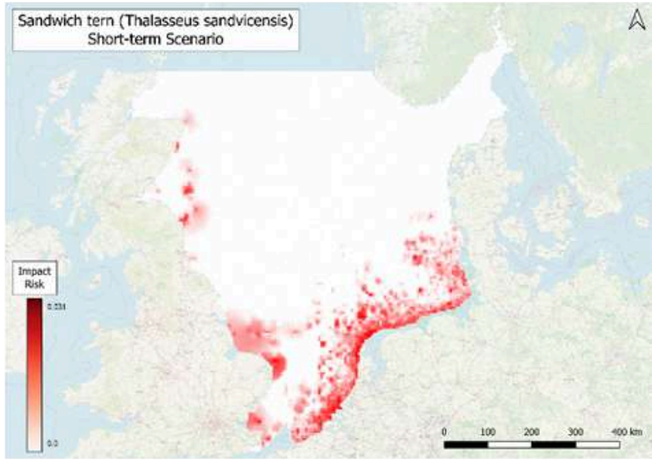
OWF

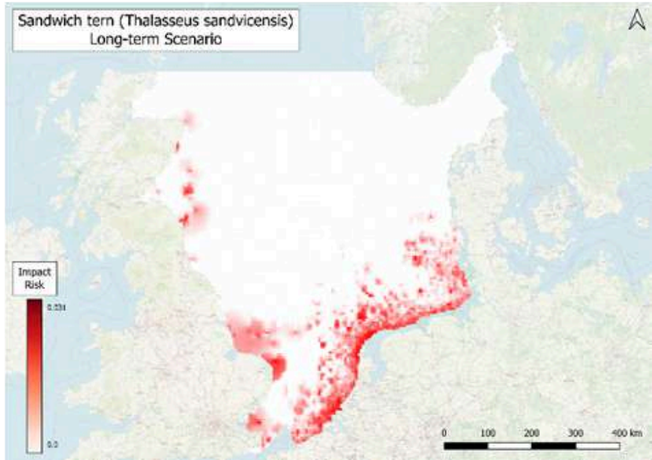




All

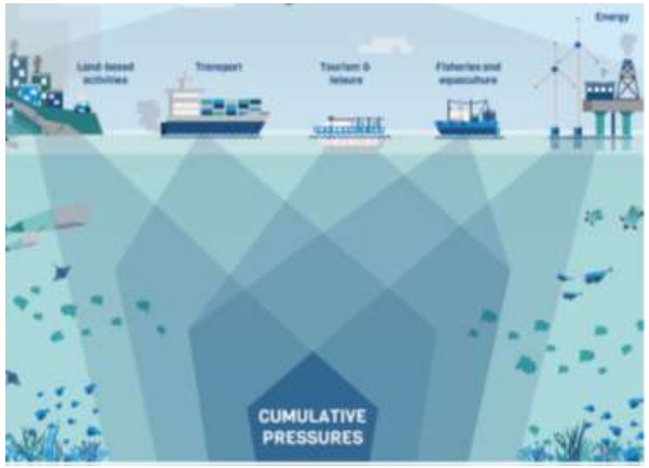


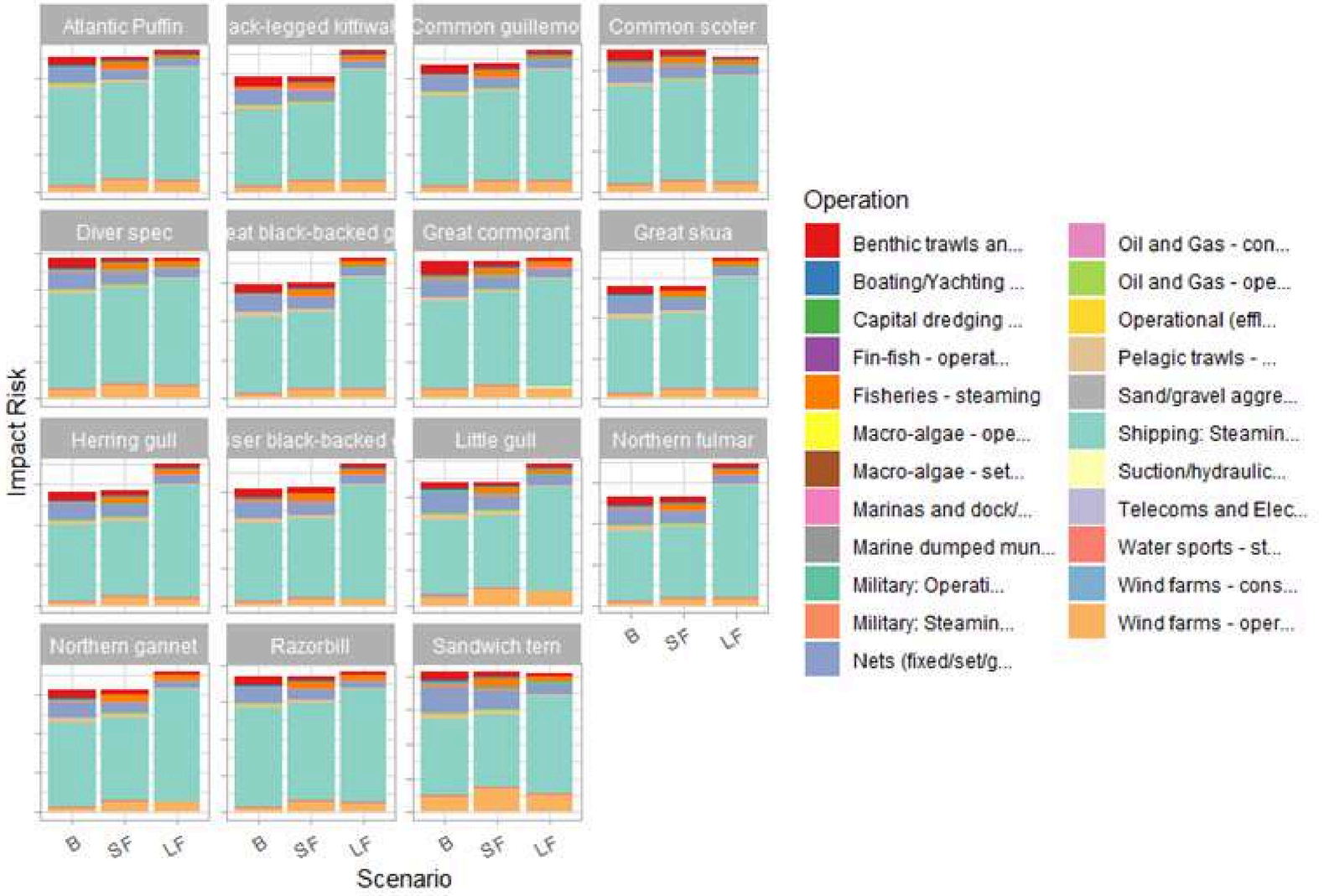


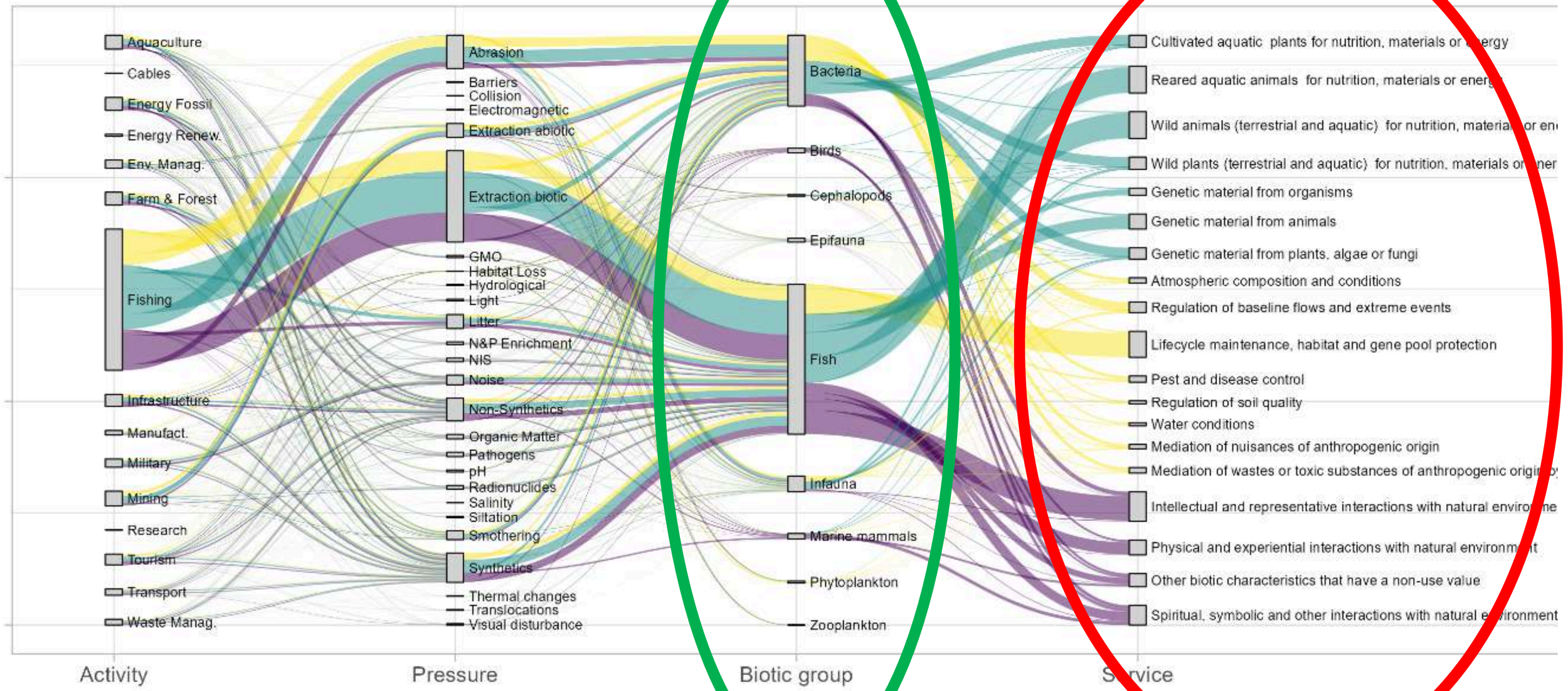


MPAs and Impact Risk

MSP scenarios
Offshore wind
&
Other human activities
on
Birds







WAGENINGEN
UNIVERSITY & RESEARCH

Nature Conservation

Anthropogenic

Cumulative Impact Assessment Rules

- **Comprehensive** covering all
  - Sectoral activities
  - Pressures
  - Ecosystem (or biodiversity) components
- **Risk-based approach**
  - Impact Risk
- **State of the art information**
  - Preferably quantitative
  - Mostly formalised expert-judgement
  - Transparent (FAIR)

Cumulative Impact Assessment Limitations

- **Direct effects only**
  - No indirect, secondary effects like through the foodweb
- **No interaction of pressures**
  - No synergism or antagonism
- **Only manageable stressors**
  - Climate is considered an extraneous driver
- **High-level strategic advice (SIA/SEA)**
  - For tactical sector specific management advice other approaches/models may be more appropriate

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Questions?

A biologically realistic method for estimating seabird home range and spatial exposure

Implications for offshore wind farm planning

Holly Niven, Jana Jeglinski, Geert Aarts, Ewan Wakefield, Jason Matthiopoulos

Department for Energy Security & Net Zero

Hartley Anderson
FOR ENVIRONMENTAL MANAGEMENT & SCIENCE

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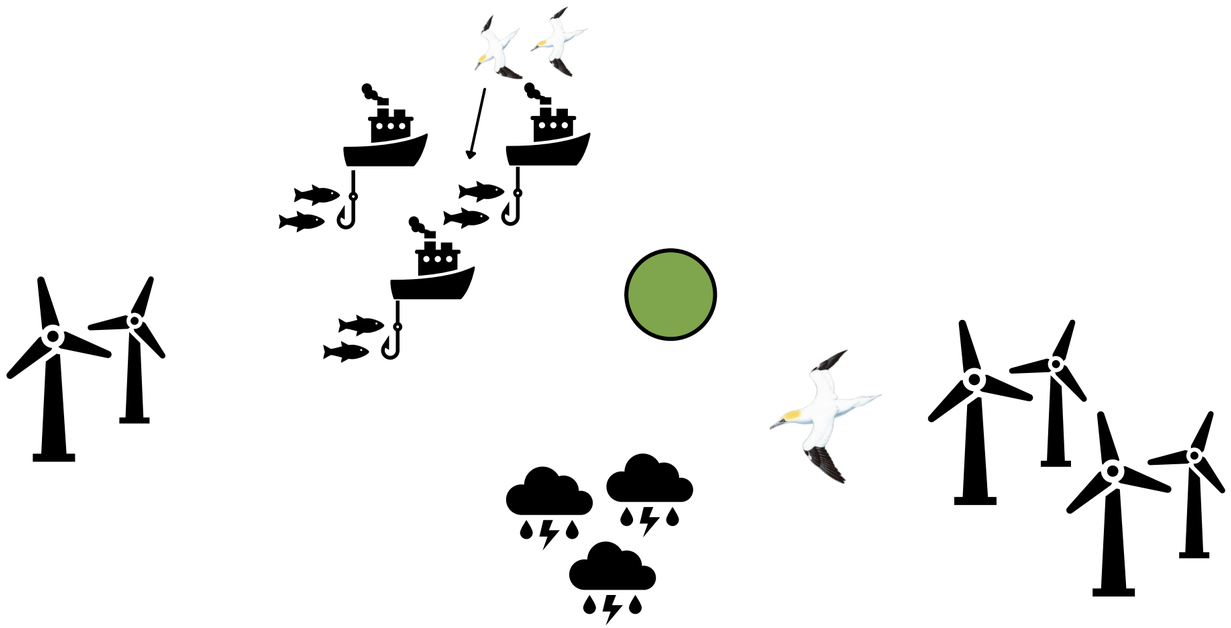
THREATS TO COLONIAL ANIMALS

One of the most threatened bird groups[1]

Displacement

Collision



[1]Dias et al 2019

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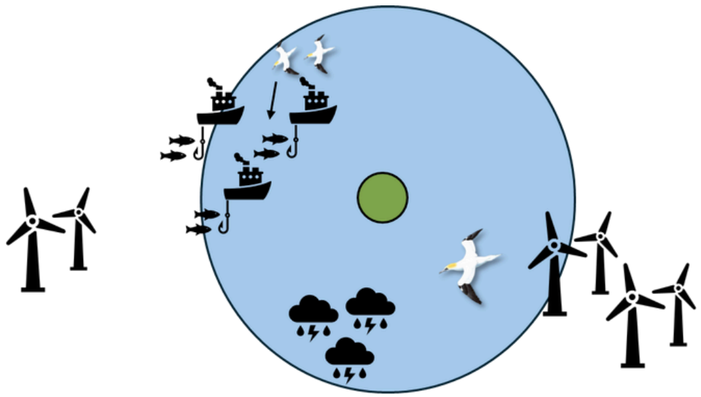
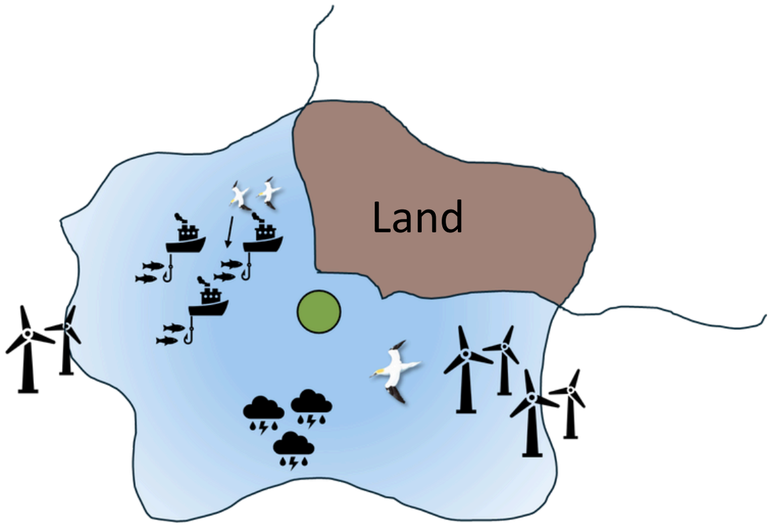
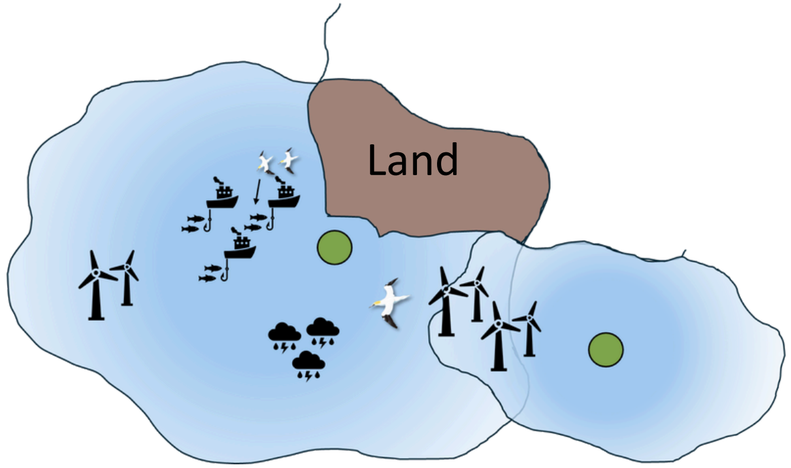
COMPLEXITY IN HOME RANGE ESTIMATION



Within-colony competition



Energetics + Commuting
+ landscape accessibility



Between-colony competition

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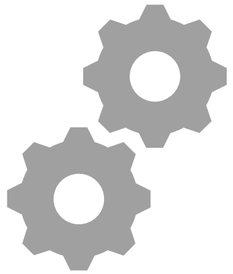
CURRENT METHODS

Individual-level models → Population-level models

Individual-based models (IBMs)

- Fail to capture large-scale movement patterns
- Computationally challenging to fit to data

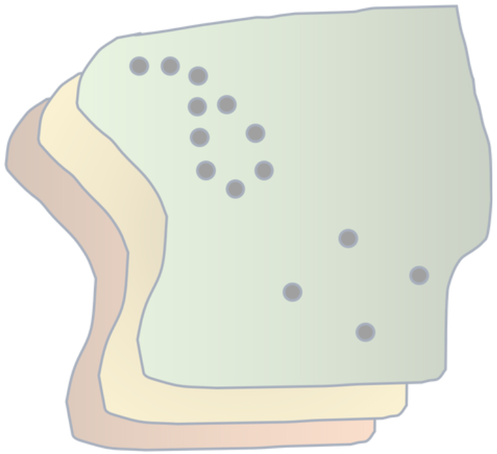


Mechanistic models

- Lacking biological realism
- May not be fitted to data

Kernel smoothing

- Hard to integrate with biological realism
- High data requirements



Species distribution models

OUR METHOD

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OUR METHOD

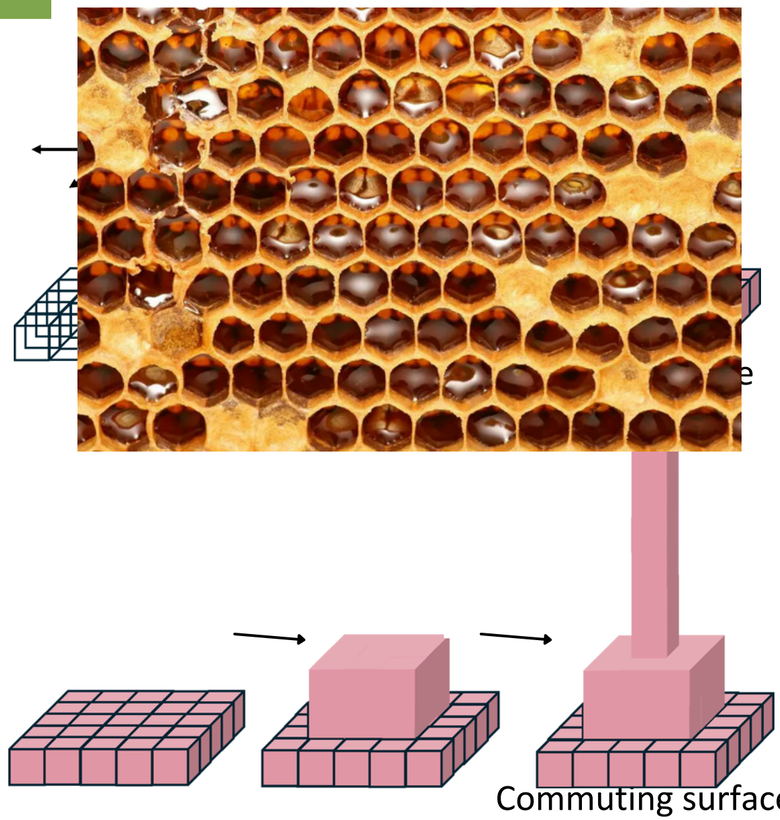
Foraging

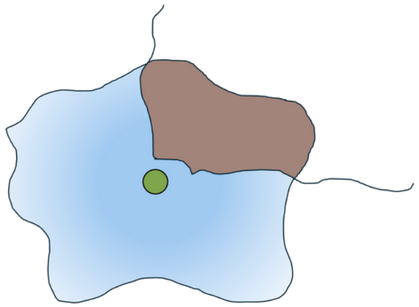
+

Commuting

=

Home range





- Landscape accessibility
- Minimise transport costs
- Within-colony competition
- Between-colony competition

- Landscape accessibility

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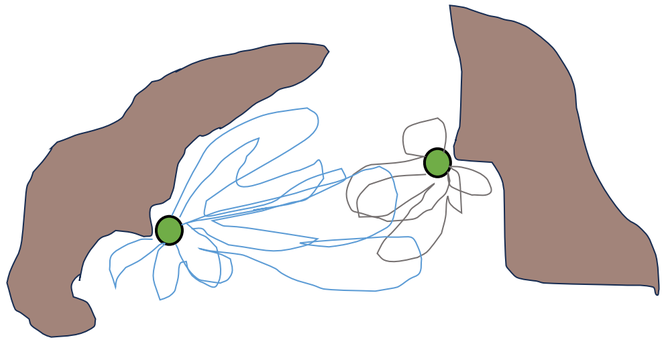
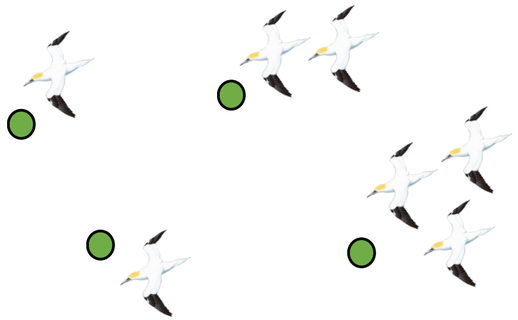
INGREDIENTS

INPUT

1. GPS tracking data from two proximate colonies



2. Colony sizes and locations



OUTPUT

- HR for each colony

Exposure Apportioning

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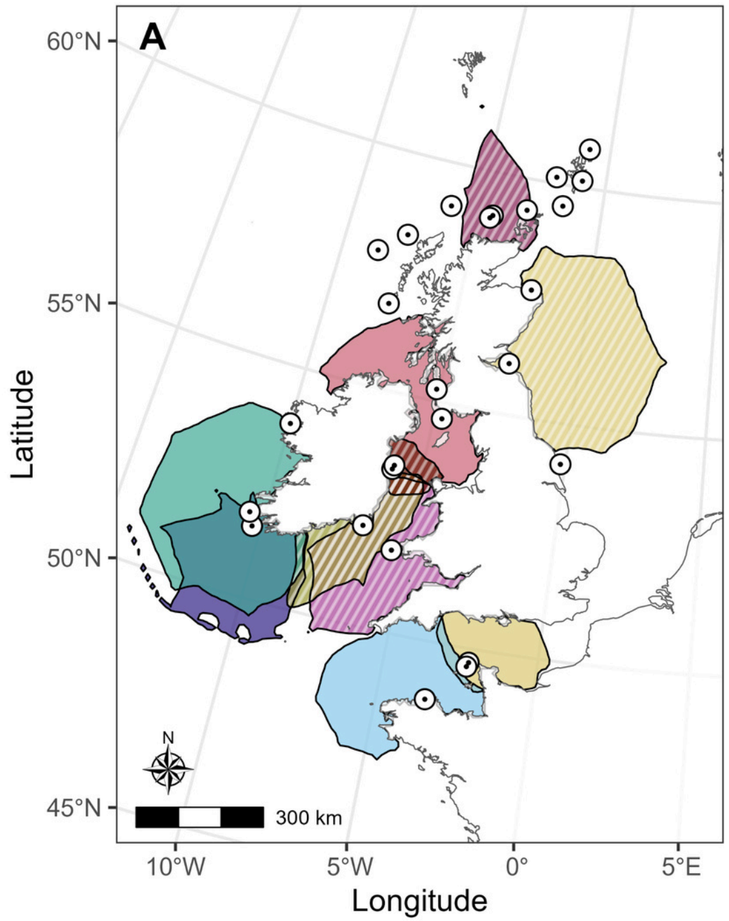
OUR HRs

BirdLife INTERNATIONAL

Seabird Tracking Database
Tracking Ocean Wanderers



Colony
Rouzic
Les Etacs
Bull Rock
Grassholm
Little Skellig
Great Saltee
Lambay
Ailsa Craig
Bass Rock
Sule Skerry

Model efficiently predicts HRs

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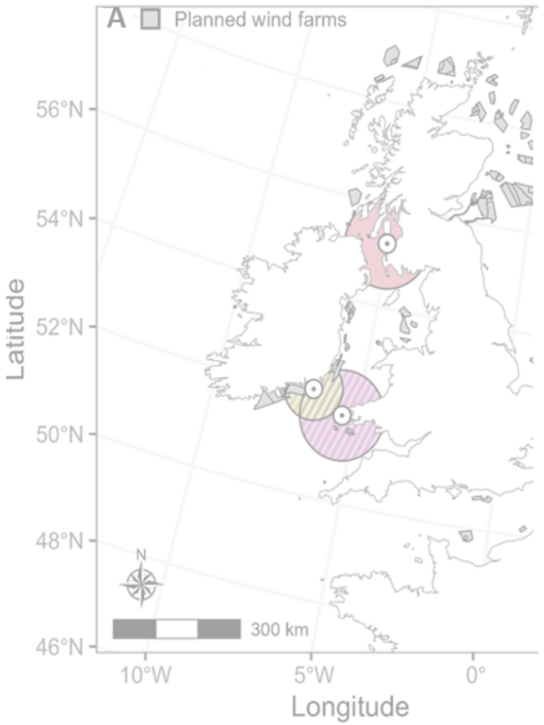
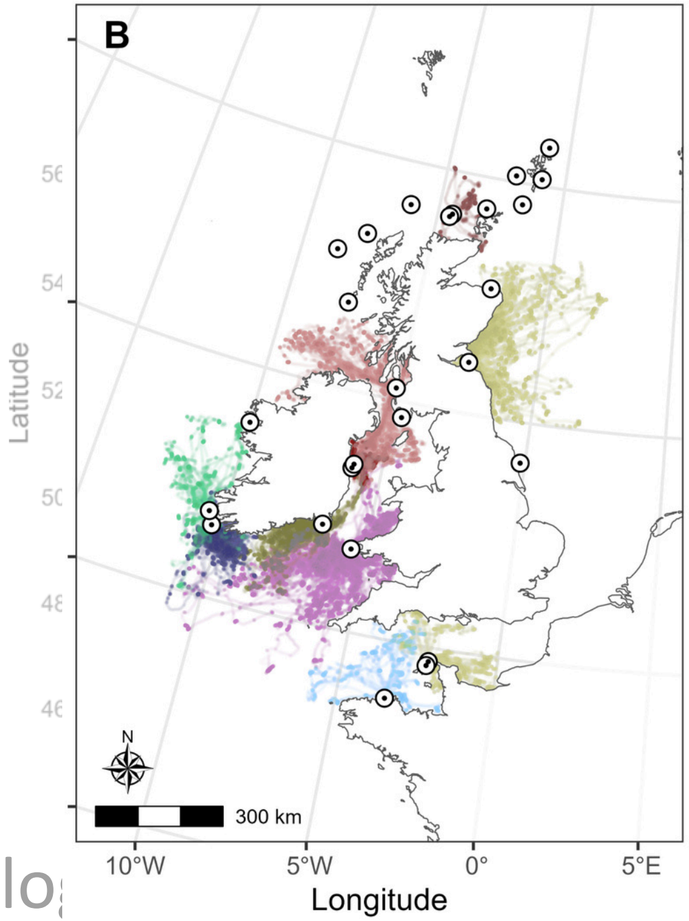
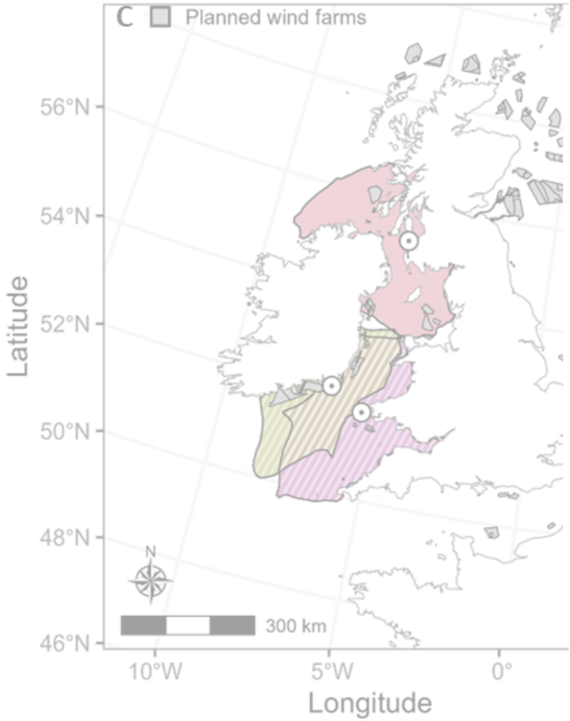
COMPARISON AND EXPOSURE ESTIMATION

41% correctly assigned





73% correctly assigned



Our more biolo d leads to more accurate p ure estimates

Colony: Rouzic, Les Etacs; Bull Rock, Grassholm; Little Skellig, Great Saltee; Lambay, Ailsa Craig; Bass Rock, Sule Skerry

[1]Lewis et al 2001 [2]Critchley et al 2018

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IMPLICATIONS

Increase accuracy of spatial exposure estimation

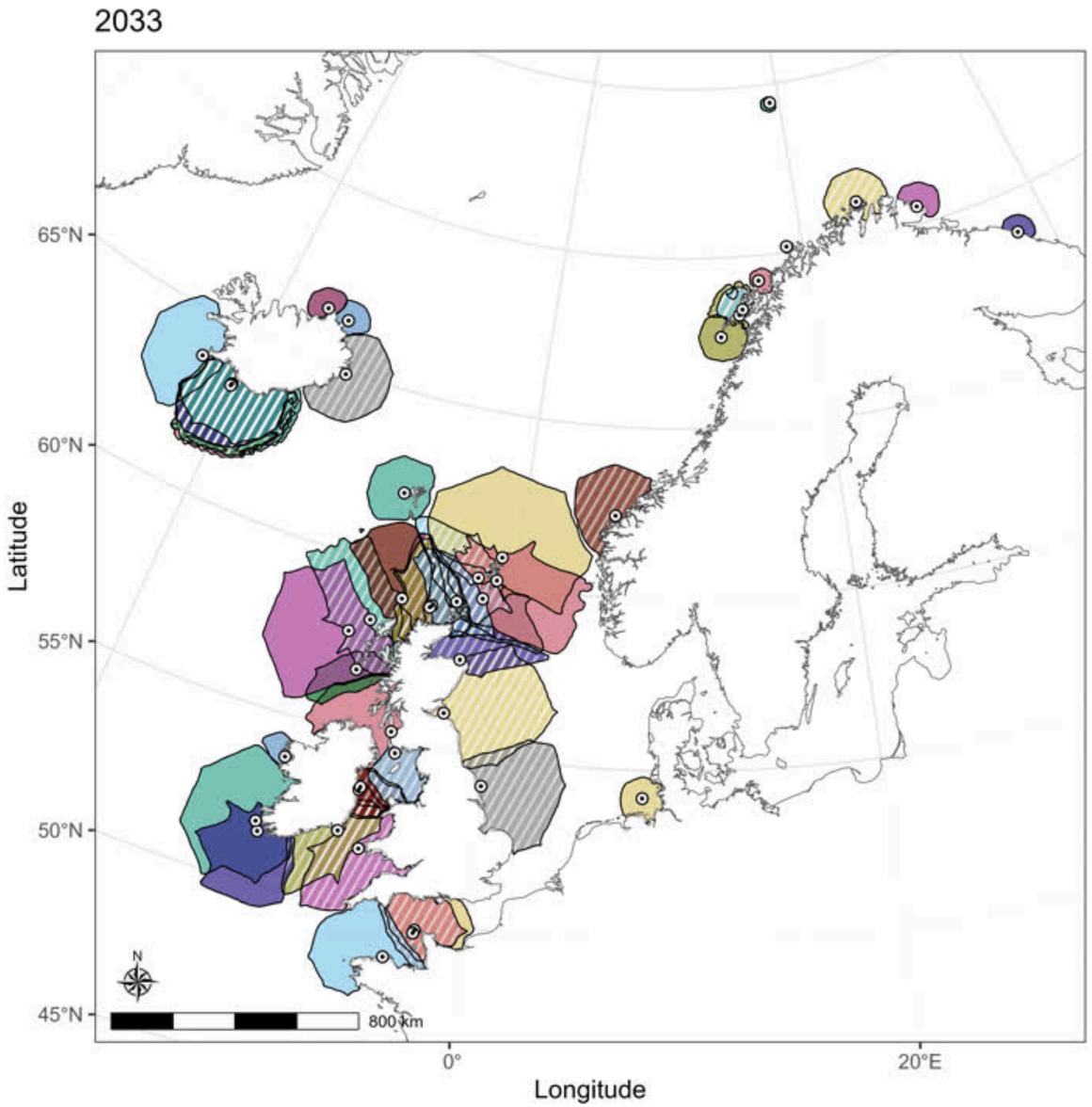
Improve apportionment accuracy

Reduce over- or underestimation of exposure and impacts

More informed decision process:

- Siting
- Environmental impact assessment

PREDICTIONS



- Estimates for colonies and years without tracking data
- Predictions across development timeline
- Validation with new tracking data

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FUTURE DIRECTIONS

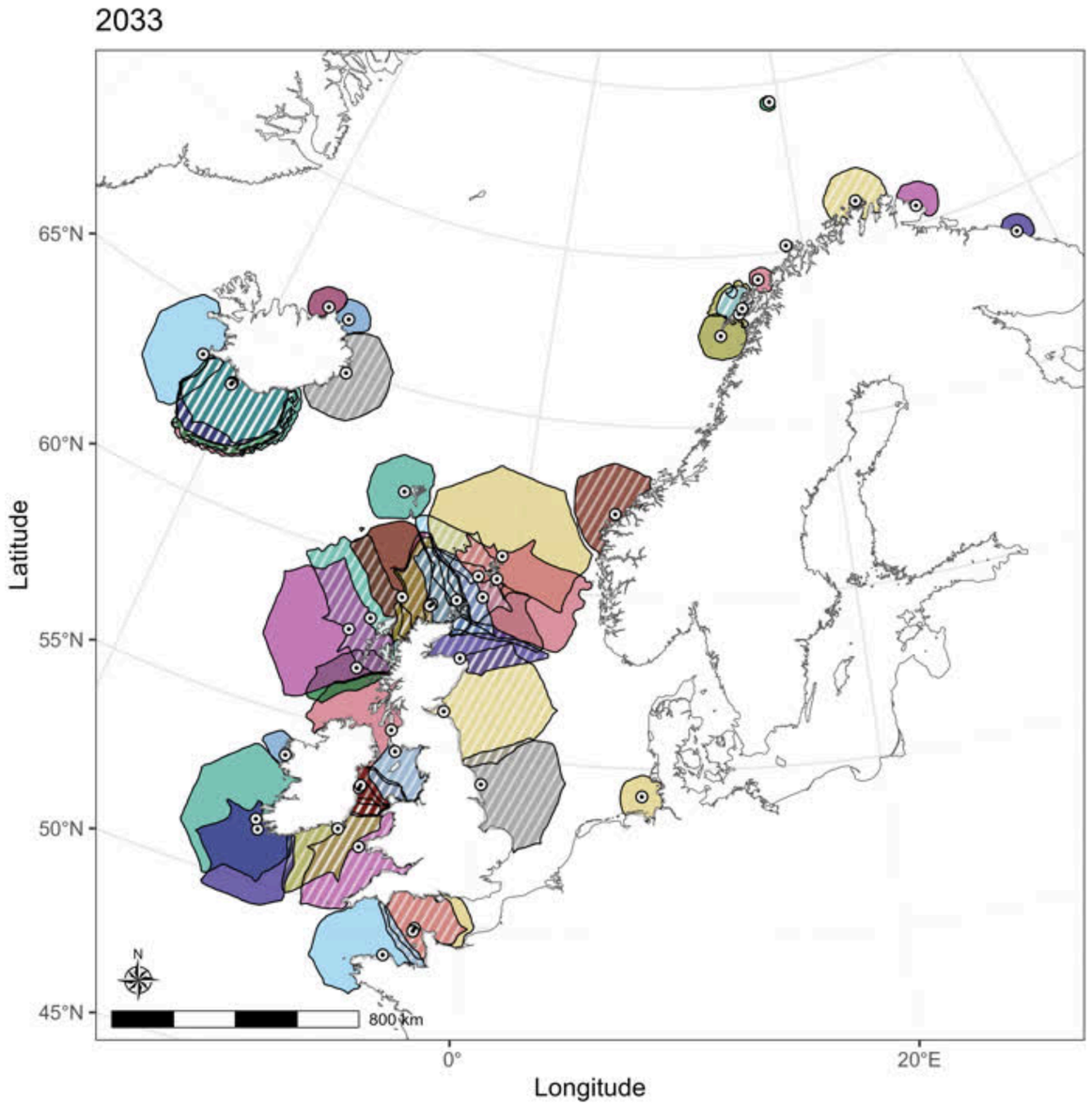
PLANNED

- R Packag 
  - Broader use base
  - Streamline exposure estimation

POTENTIAL

- Habitat suitability
- Displacement from wind farms
- Estimating uncertainty
- Lifetime vs instantaneous impact
  - Colony sizes may change over time and alter HRs
  - Does this matter for exposure/risk assessment?

SUMMARY



- Biologically realistic
- Tuned to minimal data
- Predictive
- Flexible

BRITISH ECOLOGICAL SOCIETY | Methods in Ecology and Evolution

Niven et al 2025

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MARINE PROTECTED AREAS EUROPE

Contributions from MPA Europe on optimal locations for MPAs

Offshore Wind and Grid Workshop, Brussels, 3 July 2025

Silas Principe (OBIS), Anna Addamo (NORD), Thanos Smanis, Belinda Bramley (CLIMAZUL)
PI: Mark J. Costello, Nord University (NORD, Norway)

The MPA Europe project is co-funded by the European Union under the Horizon Europe program (grant agreement no. 101059988)

Co-funded by the European Union
UK Research and Innovation

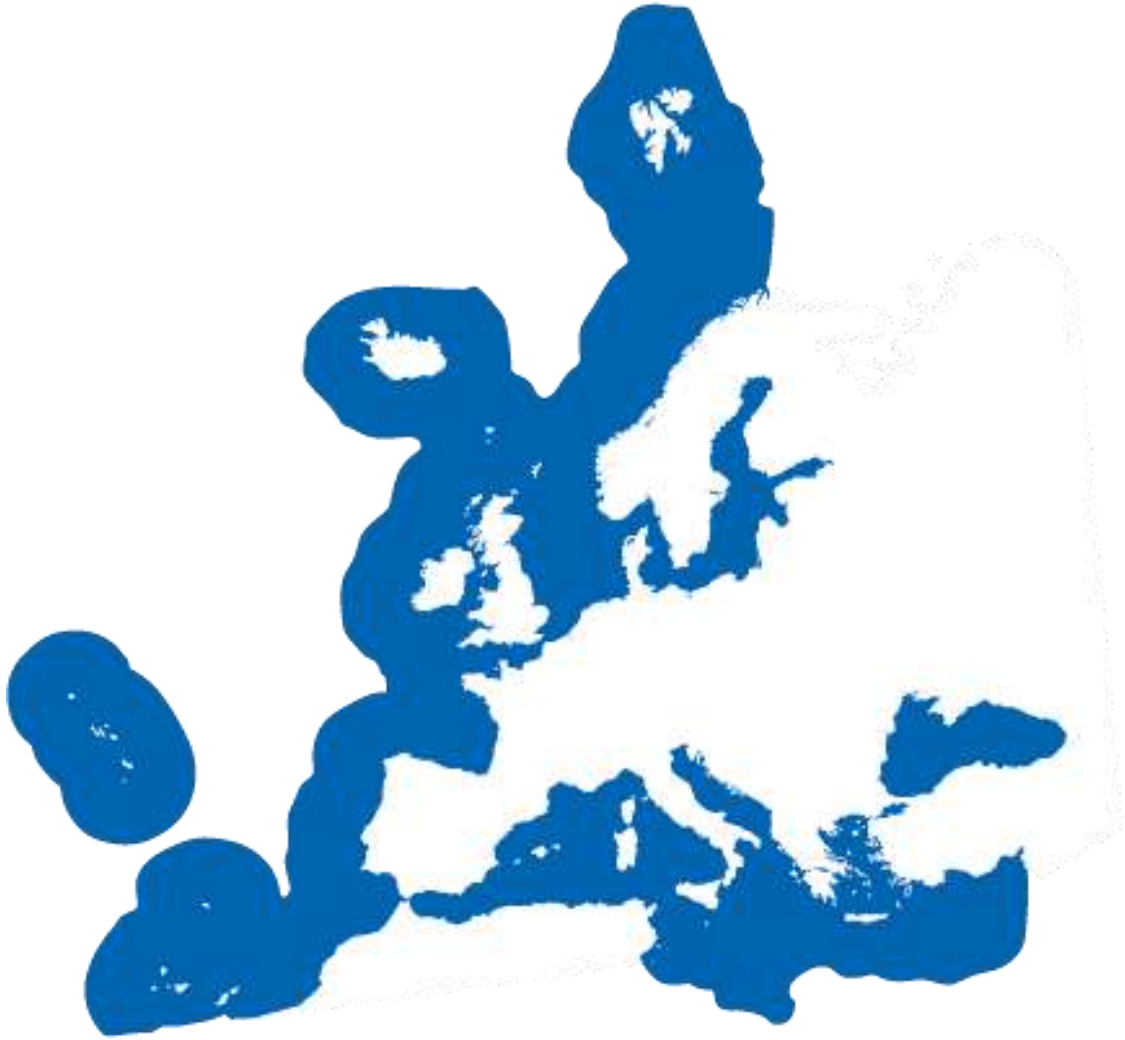
Economic benefits of MPAs for finfish, crustacean, and mollusc fisheries

Countries where benefits have been reported

- **39** studies found **increased catch since MPA designation**
- **13** studies found **increased body size up to 34%**
- **6** studies found **increased catch and body size**
- **0** studies reported **decreased catch**
- **8** studies reported **spillover of larvae and adults**

Costello MJ. 2024. Evidence of economic benefits of Marine Protected Areas. *Scientia Marina*.

Project Study Area & Main Goal



MPA EUROPE IS MAPPING THE OPTIMAL LOCATIONS FOR MARINE PROTECTED AREAS IN EUROPEAN SEAS TO SUPPORT SCIENCE-BASED MARINE SPATIAL PLANNING

BIODIVERSITY + BLUE CARBON

Project Components

Carbon sequestration, storage and deposition based on the environmental conditions, habitats, and species present

Develop **blue carbon scoring system** supporting management of blue carbon

Connectivity modelling (present)

Climate velocity (recent and future)

Design **MPA networks covering 10% and 30% of European seas** that maximise coverage of biodiversity and blue carbon

30 000 SPECIES

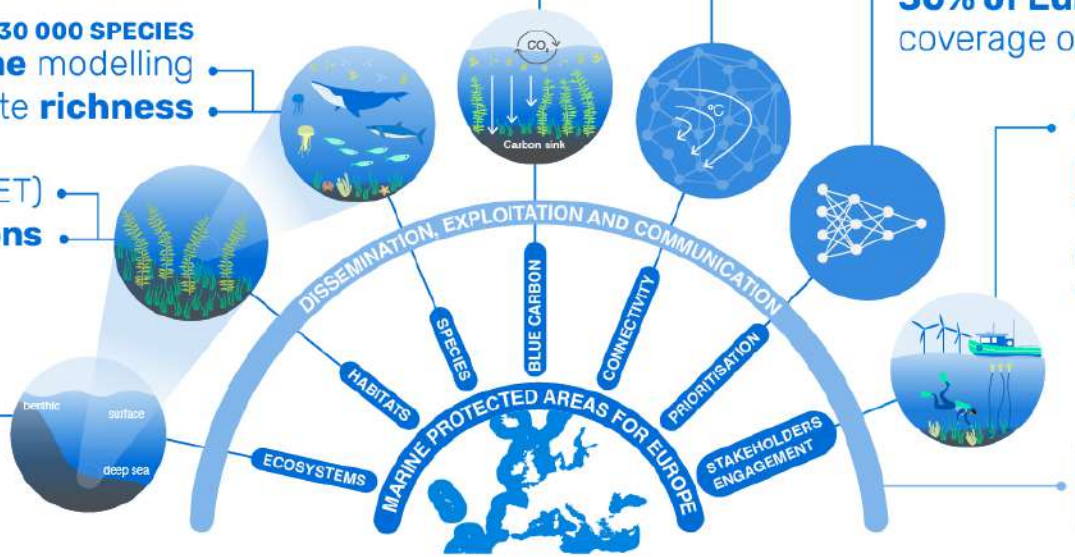
Environmental niche modelling

Estimate **richness**

Benthic habitats (EMODNET)

Modelled **habitat distributions**

Environmental data (Copernicus)

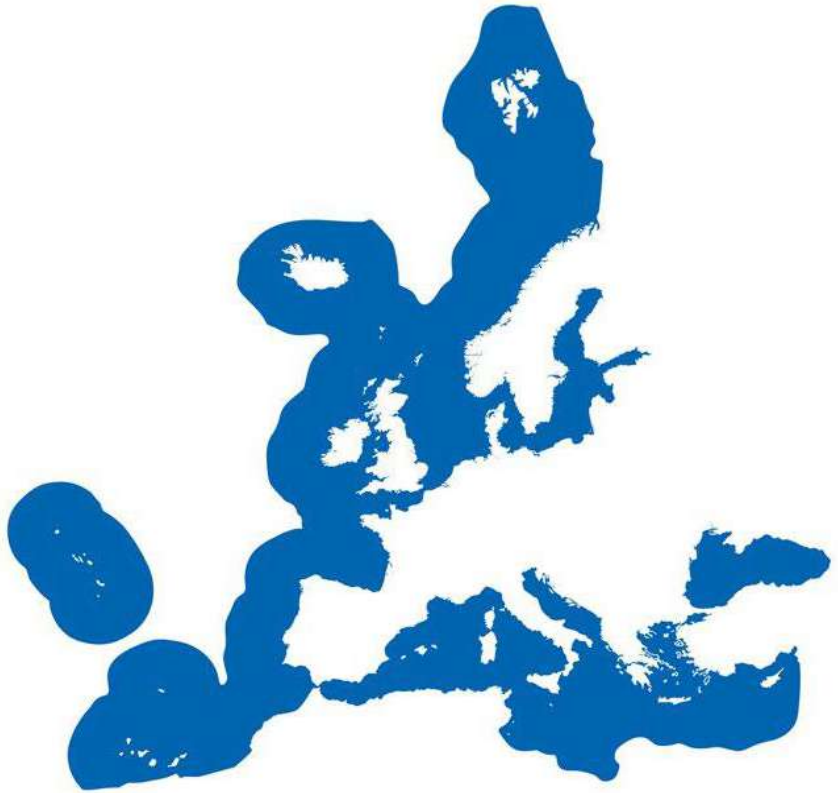


Two way process with marine spatial planners and other interested parties to formulate **regional or national case studies**, ensuring project traceability, transparency and reproducibility

Project website, peer-reviewed scientific papers, workshops, conference, fact sheets, policy brief for stakeholders

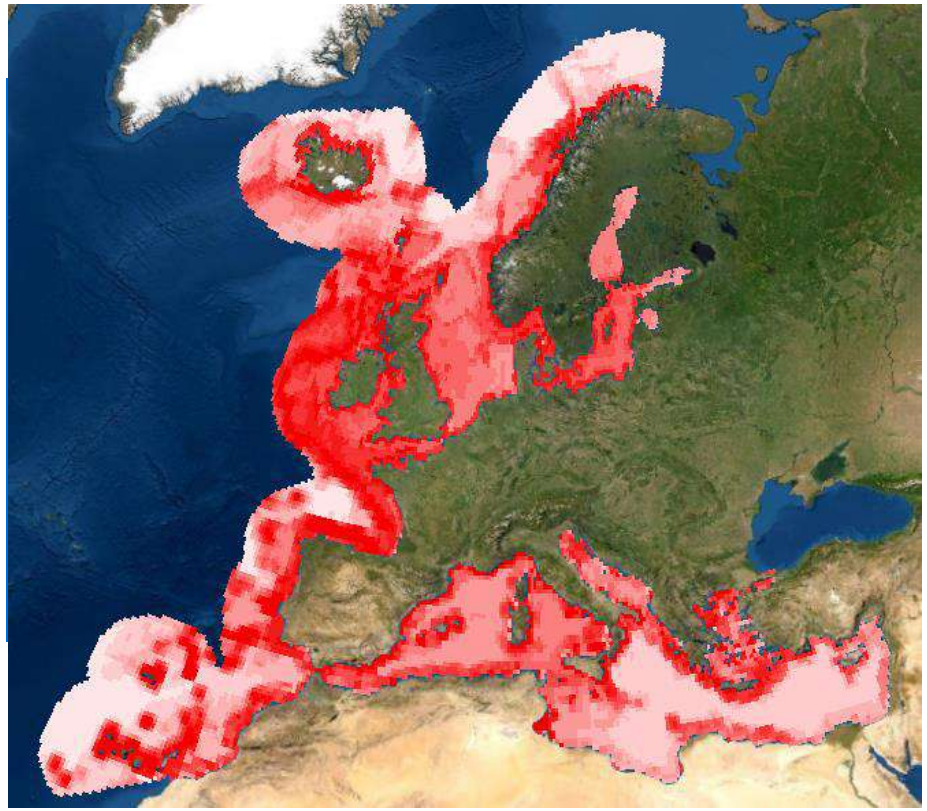
Systematic Conservation Planning (SCP)

Standardised and complete data layers



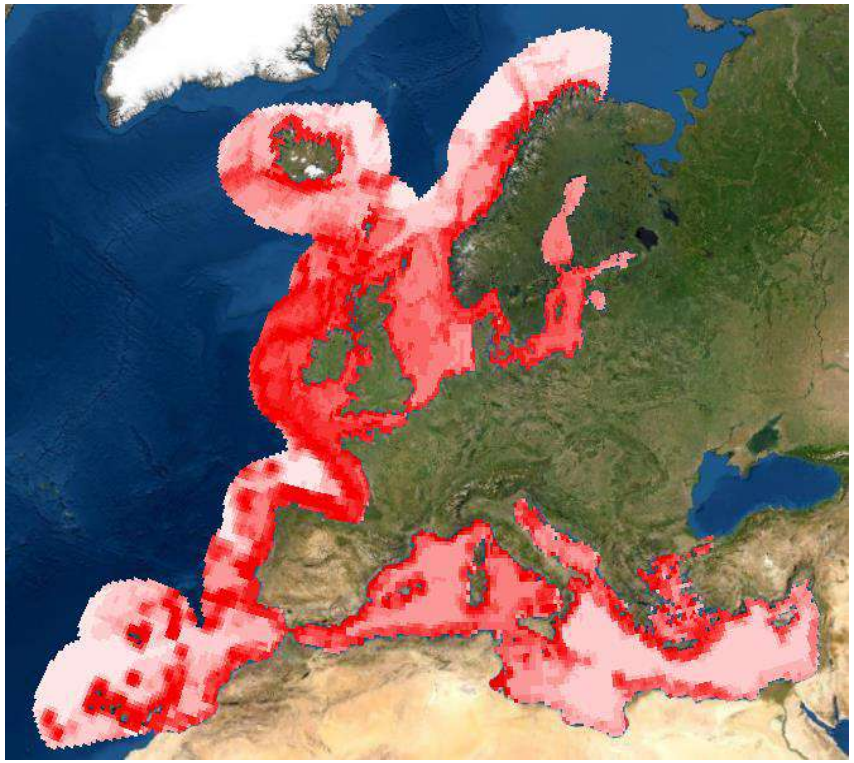
© MPA Europe

Example of prioritised areas (**darker** red = **higher** priority)

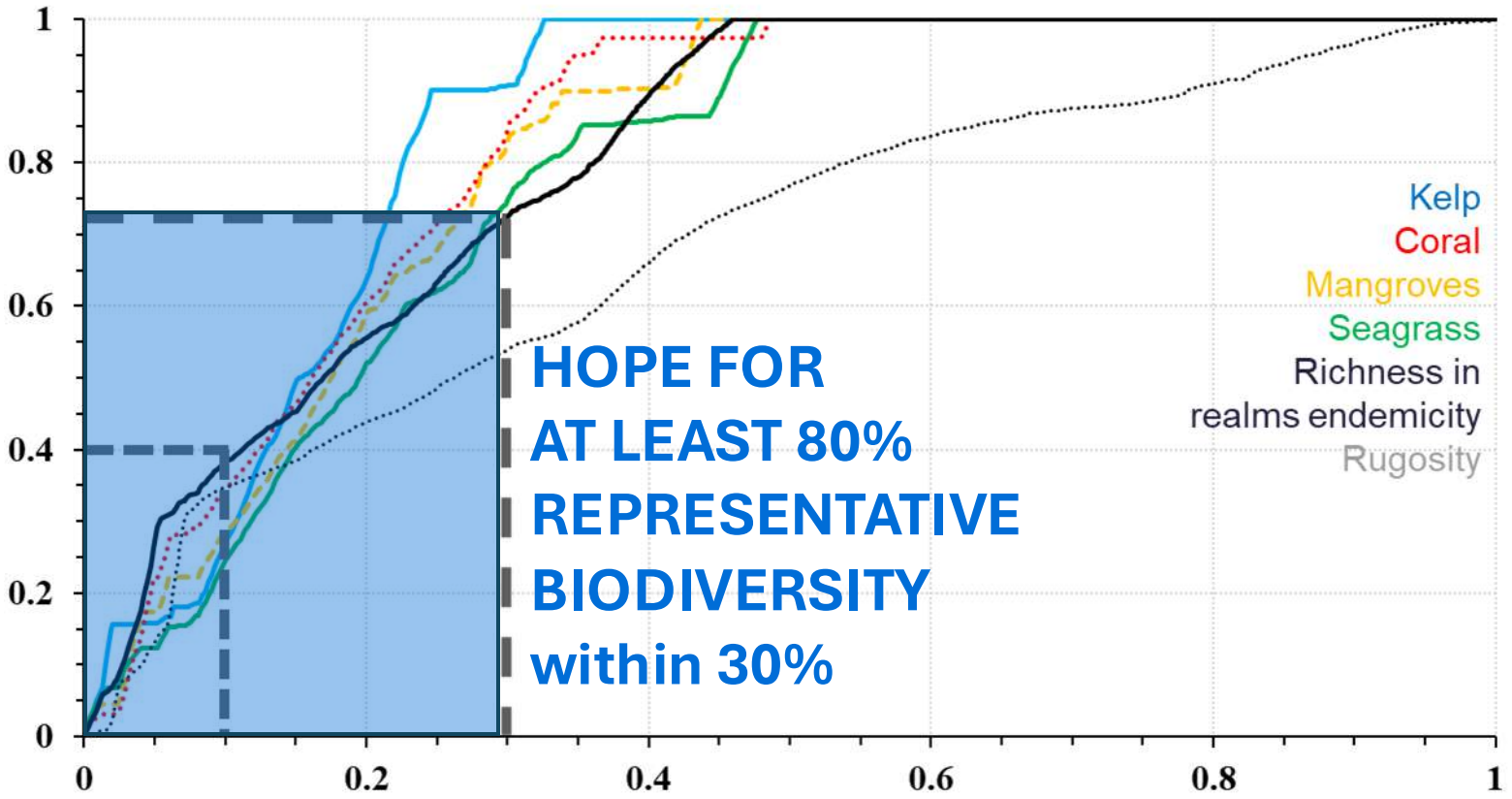


© MPA Europe

Systematic Conservation Planning (SCP)



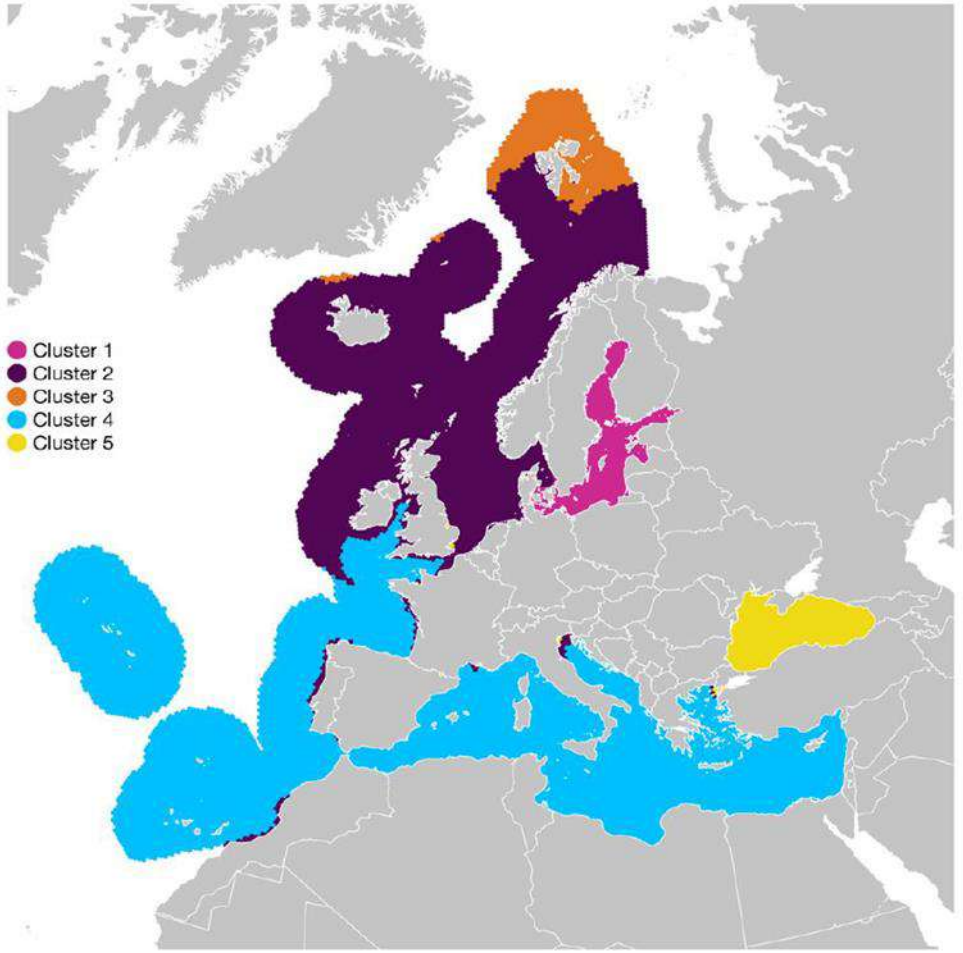
The proportion of **biodiversity** protected



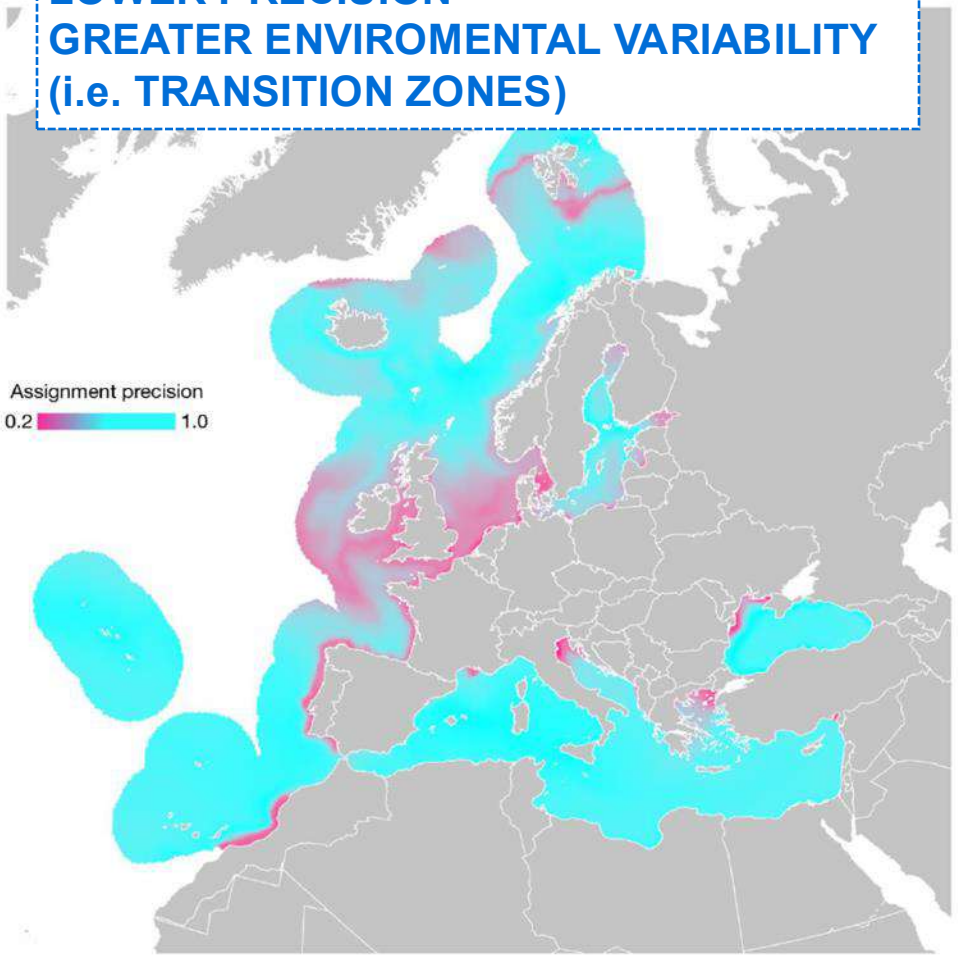
Zhao et al 2020

The proportion of **area** protected

Ecosystem Classification

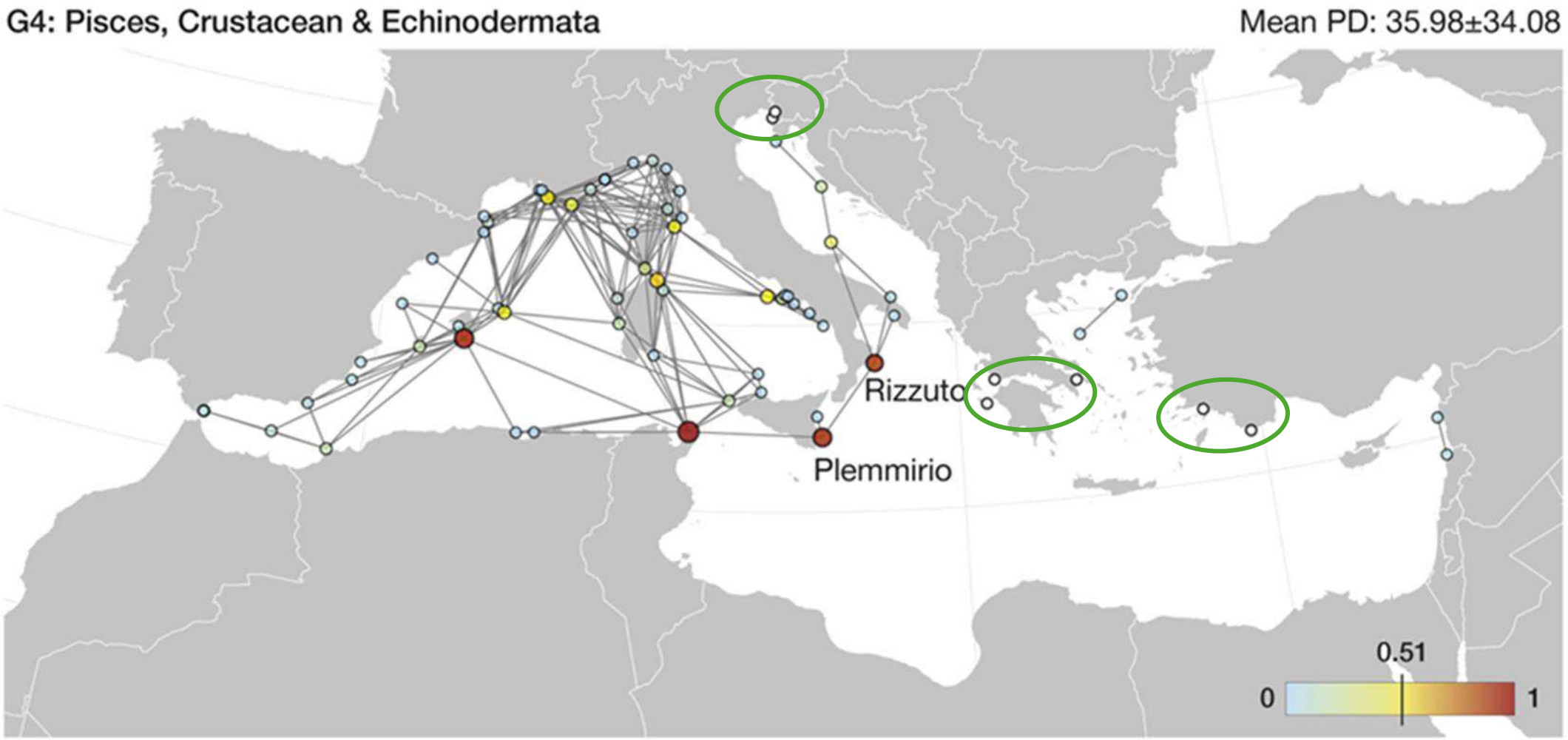


**LOWER PRECISION =
GREATER ENVIROMENTAL VARIABILITY
(i.e. TRANSITION ZONES)**



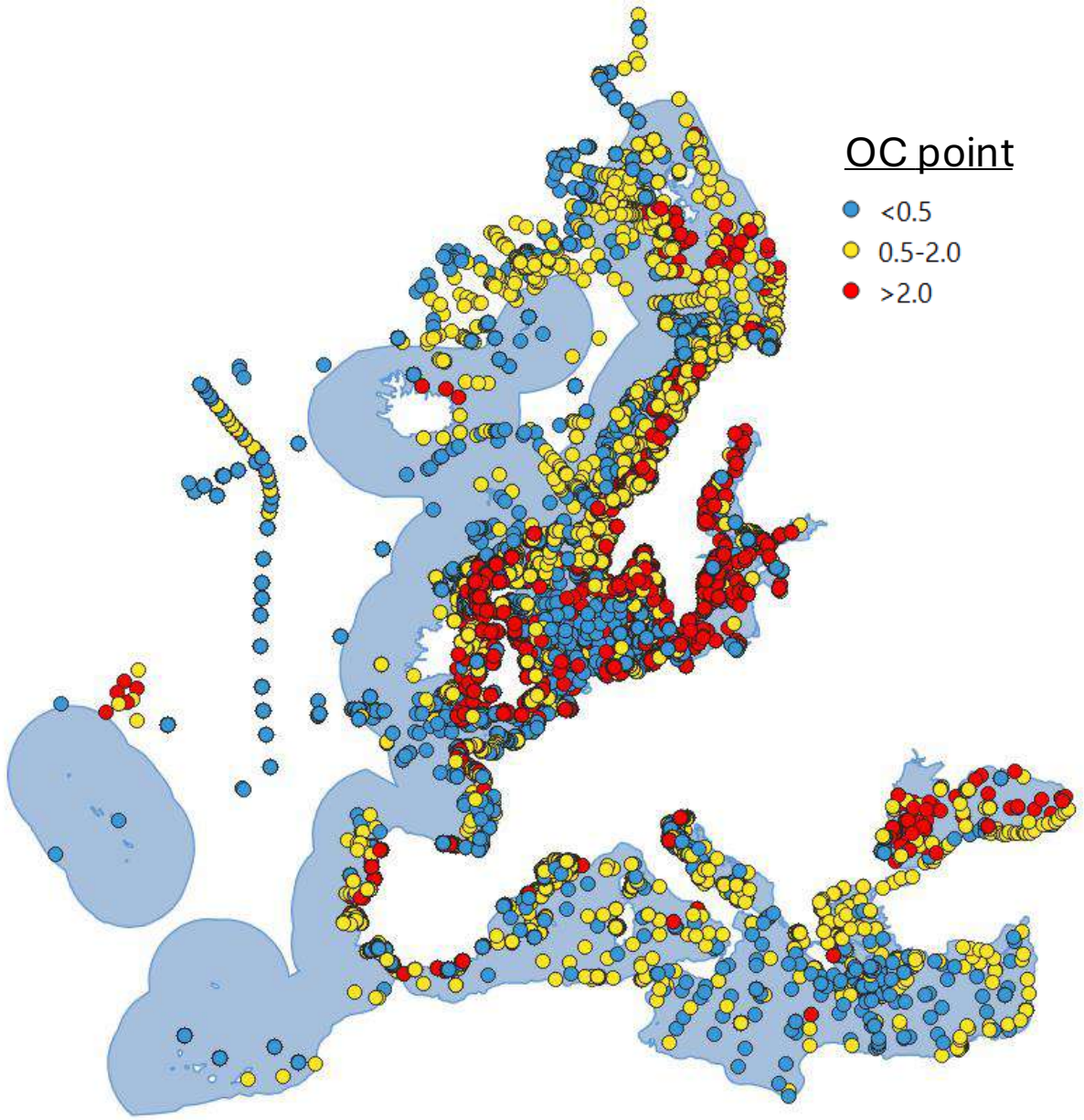
European marine ecosystems of **surface waters** estimated by k-means clustering analysis of environmental data (left) AND clustering assignment precision based on fuzzy logic (right)

Oceanographic Connectivity



Key connectivity hubs in the Mediterranean marine reserve network.
Isolated reserves are shown in white.

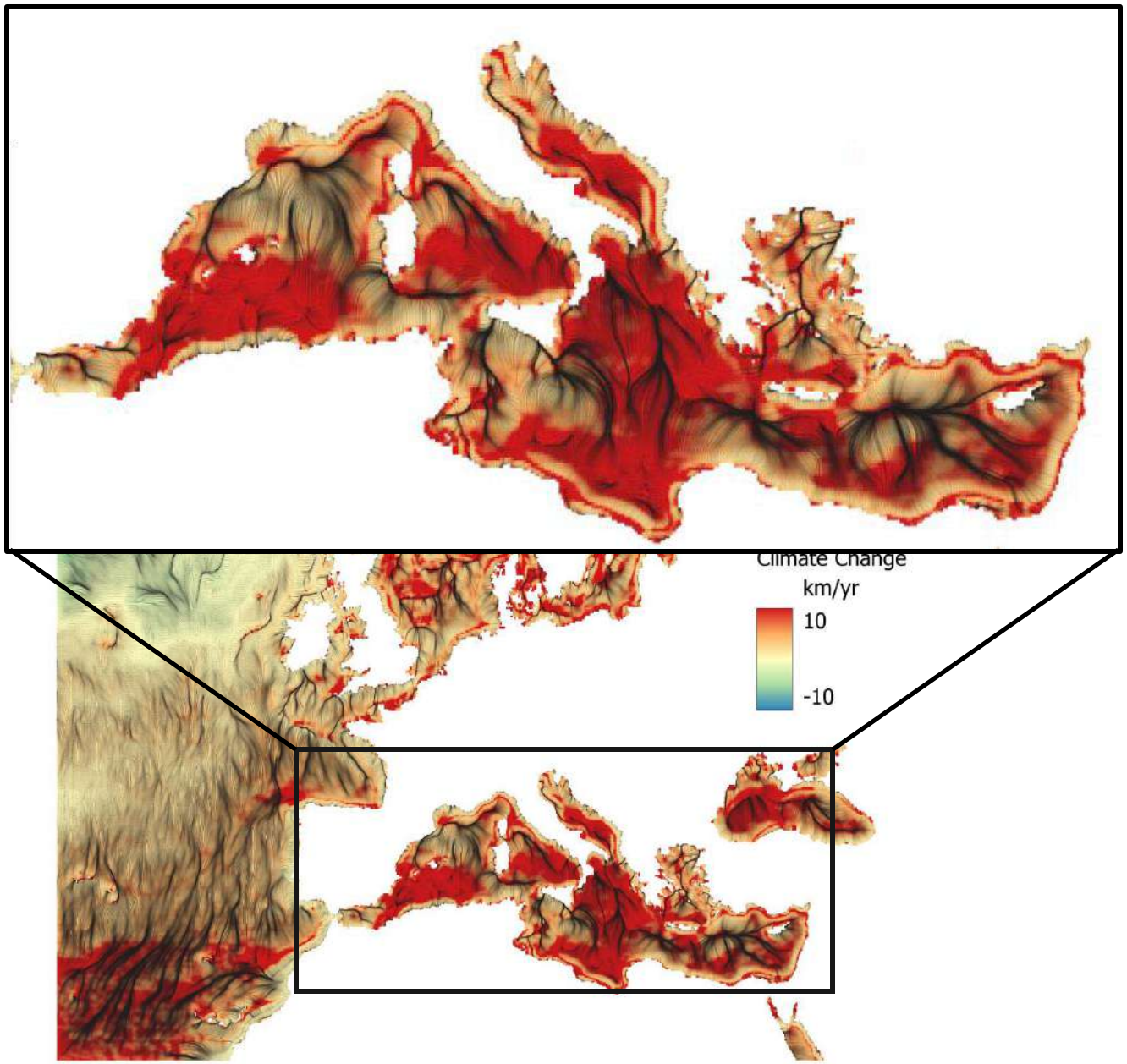
Blue Carbon Data



61,000 sample data points
(update December 2024)

Spatial coverage of **organic carbon content (%OC)** in marine sediment (for **biogenic & non-biogenic habitats** (EUNIS definition) at European scale (and beyond)

Blue Carbon Data



Velocity of projected climate change for sea surface temperature in European seas (SSP370 – 2050).

Magnitude of climate velocity (v):

- red (high (v)),
- yellow (low or zero (v))
- green to blue (negative (v) i.e. cold temperature).

Species & Habitats Range Maps

OBIS OCEAN BIODIVERSITY INFORMATION SYSTEM

The world's largest open-access repository for marine biodiversity data

We are a global community of **34 Regional and Thematic Nodes** representing over **1,000 institutions and over 6,000 scientists and data managers** from 99 countries.

161

million records

196,000

marine species

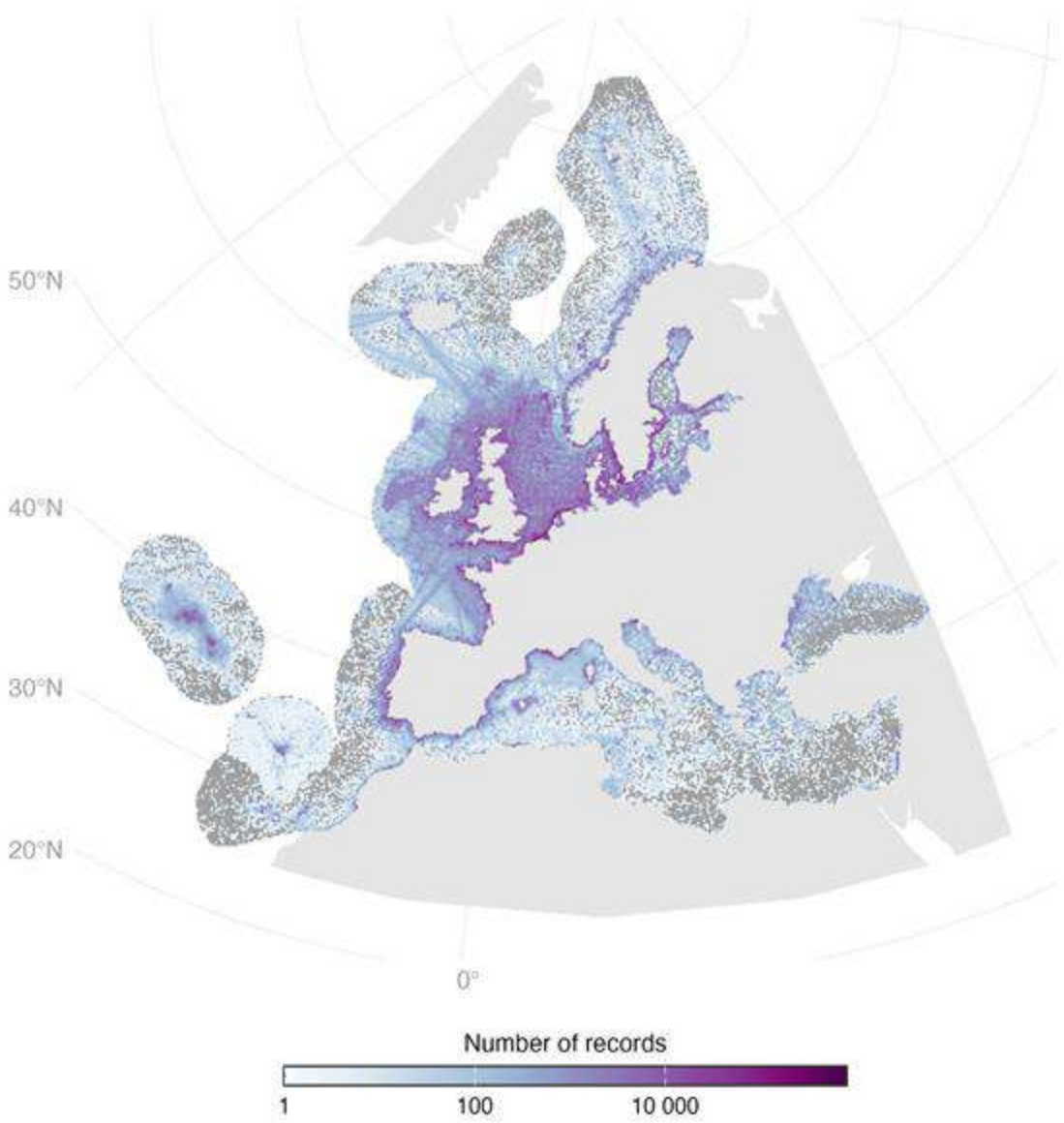
6,610

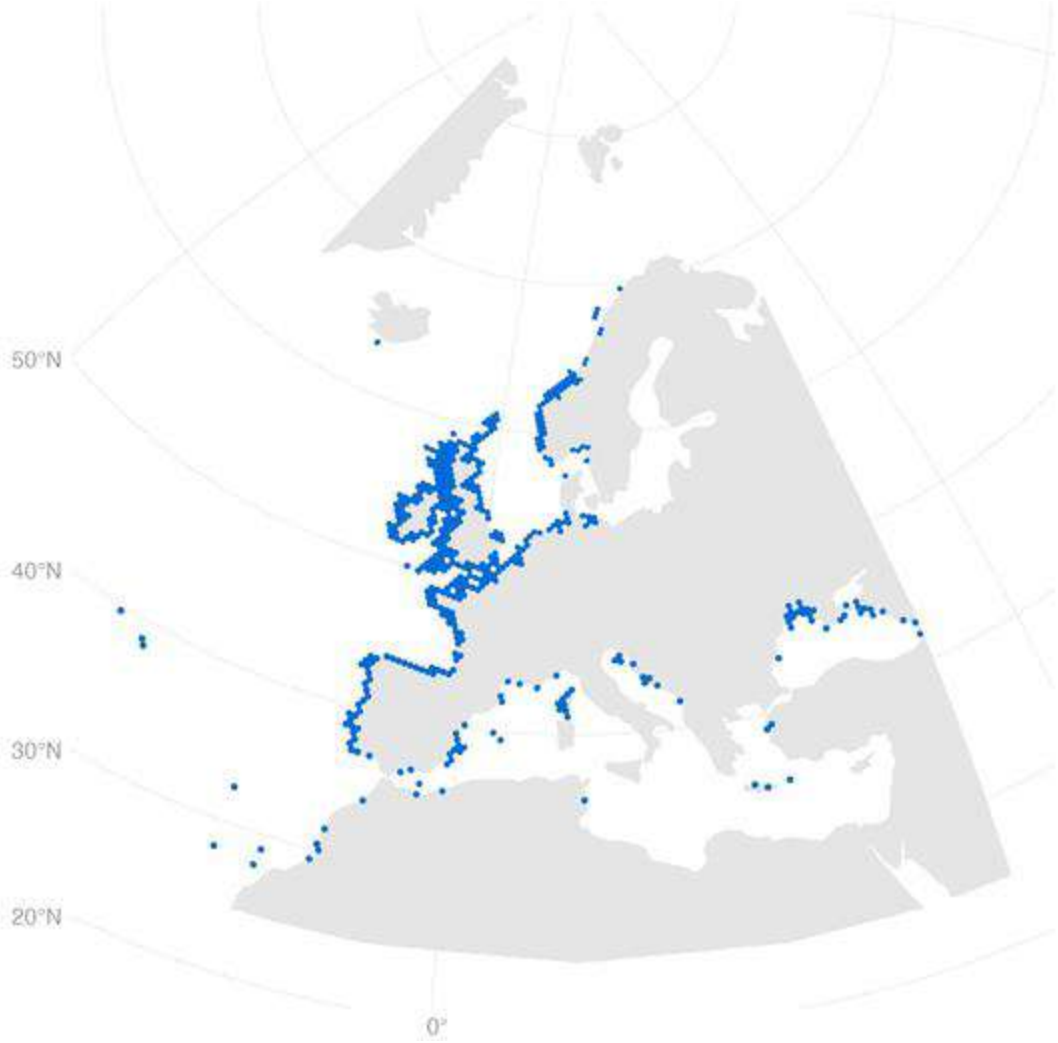
datasets

200

scientific papers/year

What are species & biogenic habitat distribution models?

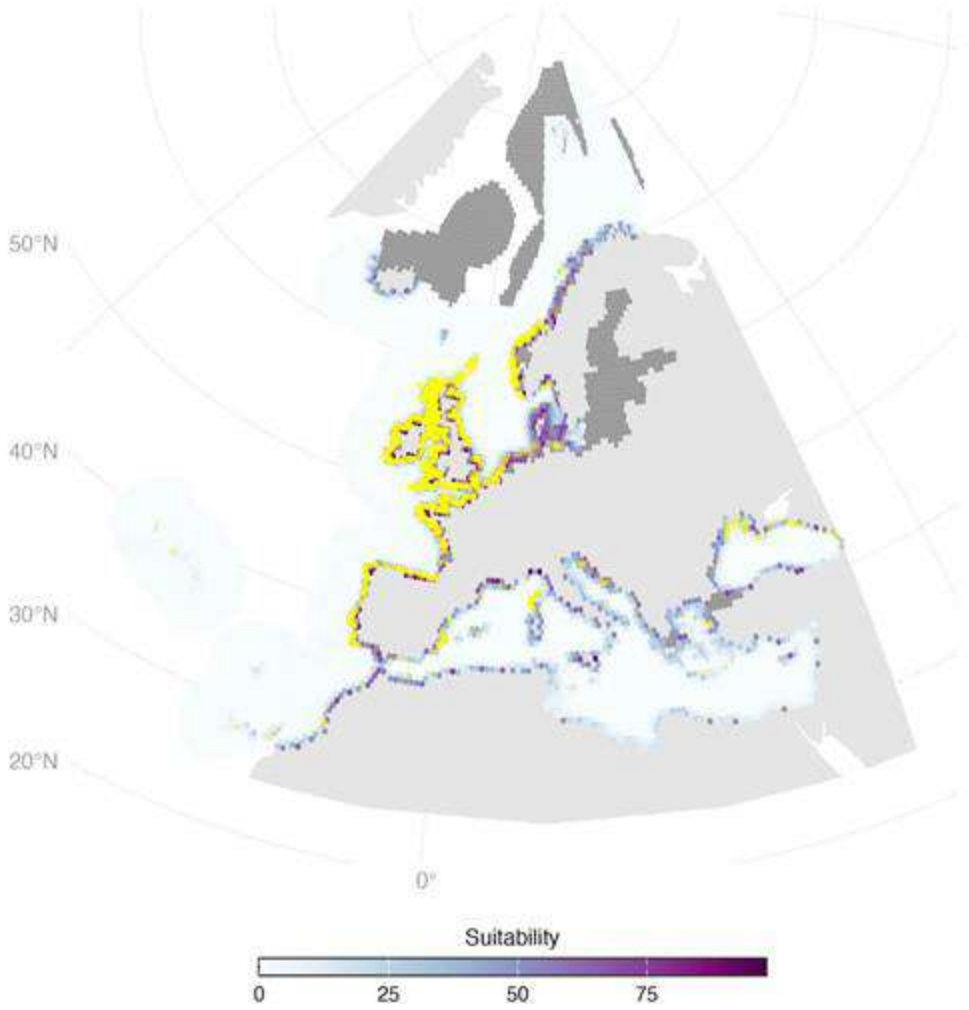




Actinia equina (distribution records)

What are species & biogenic habitat distribution models?

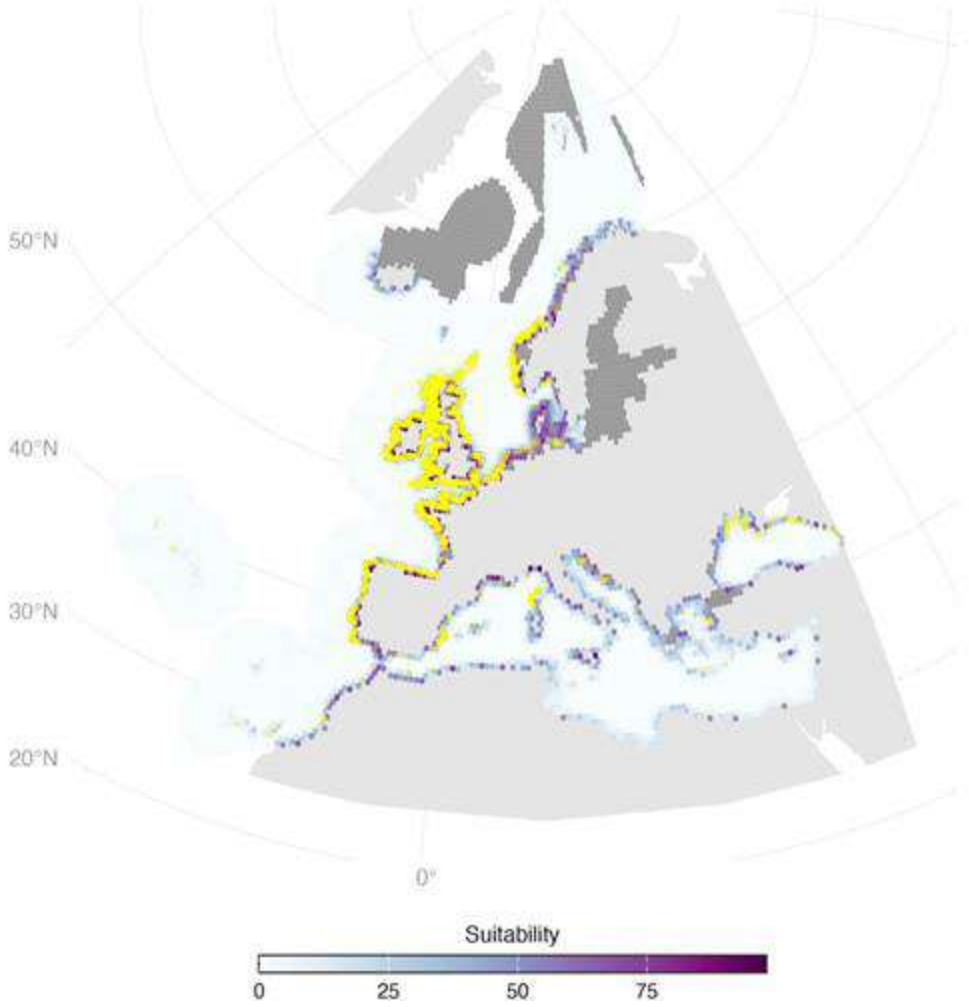
where + on what conditions → models



complete range maps
(e.g. *Actinia equina*)

What are species & biogenic habitat distribution models?

where + on what conditions → models



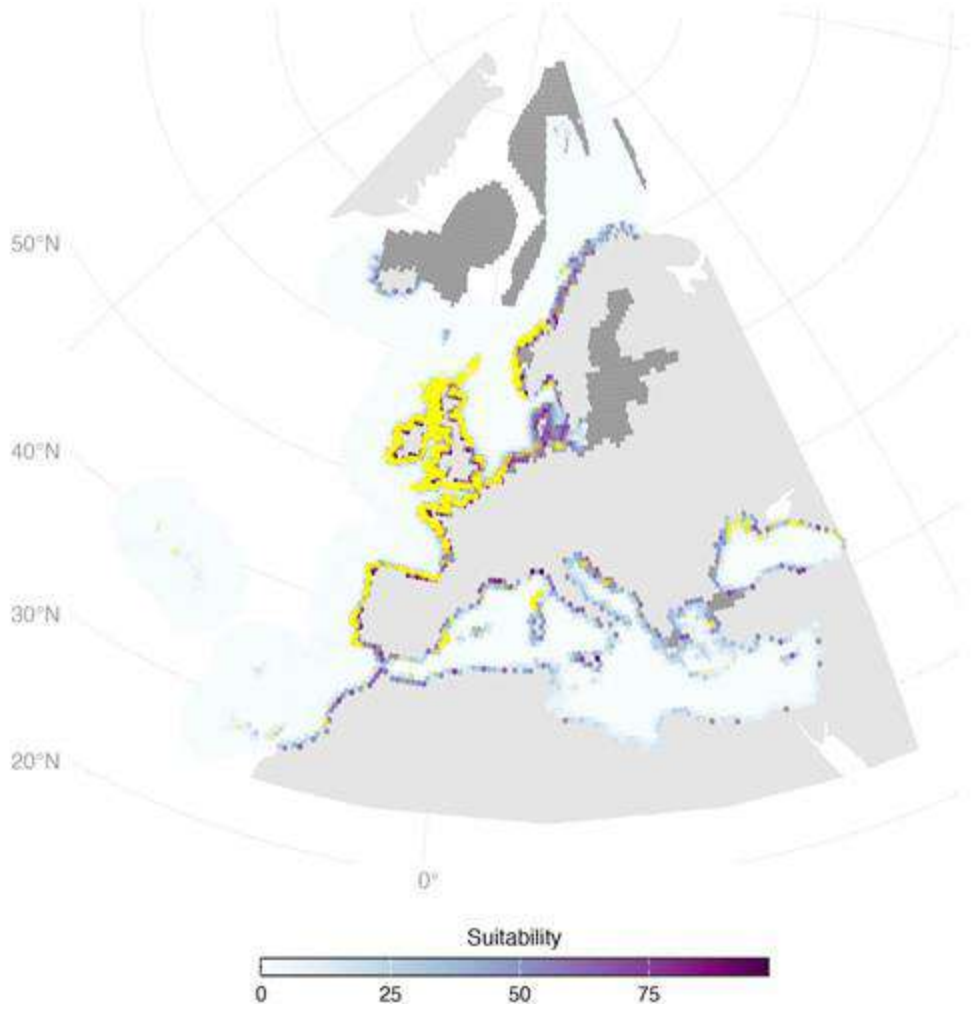
RELATIVE **POTENTIAL**

complete range maps
(e.g. *Actinia equina*)

What are species & biogenic habitat distribution models?

OBIS
GBIF
→ Quality control

where + on what conditions → models



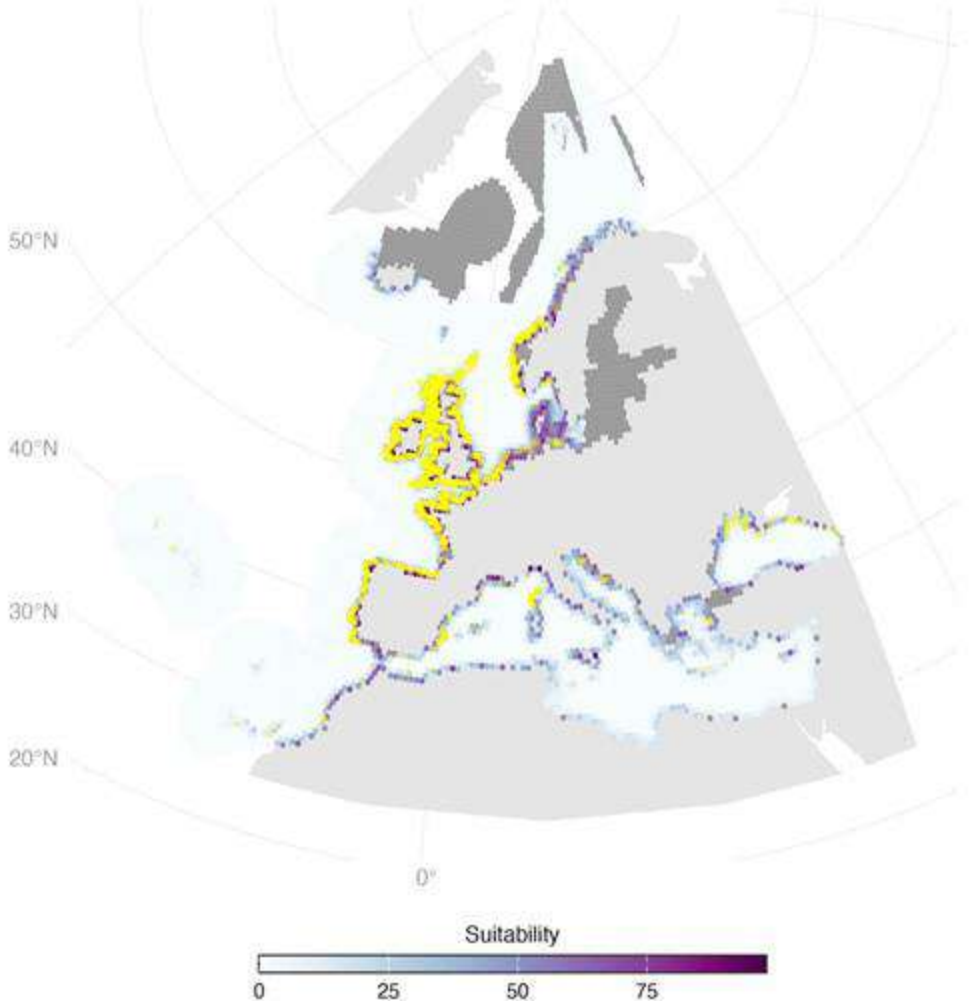
complete range maps
(e.g. *Actinia equina*)

What are species & biogenic habitat distribution models?

where + on what conditions

models →

Bio-ORACLE v3.0 → ~5km

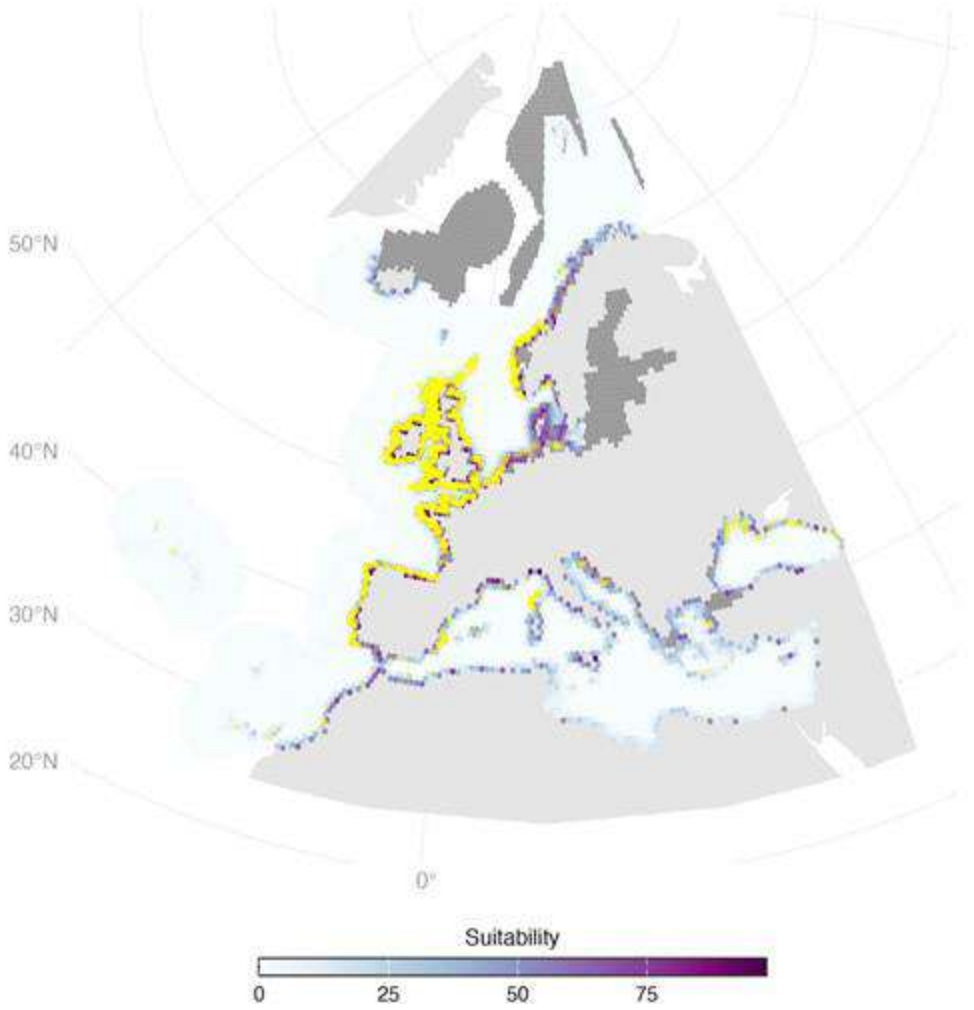


complete range maps
(e.g. *Actinia equina*)

What are species & biogenic habitat distribution models?

Point Process Model
- Maxent
- Random Forest
- XGBoost

where + **on what conditions** → **models**

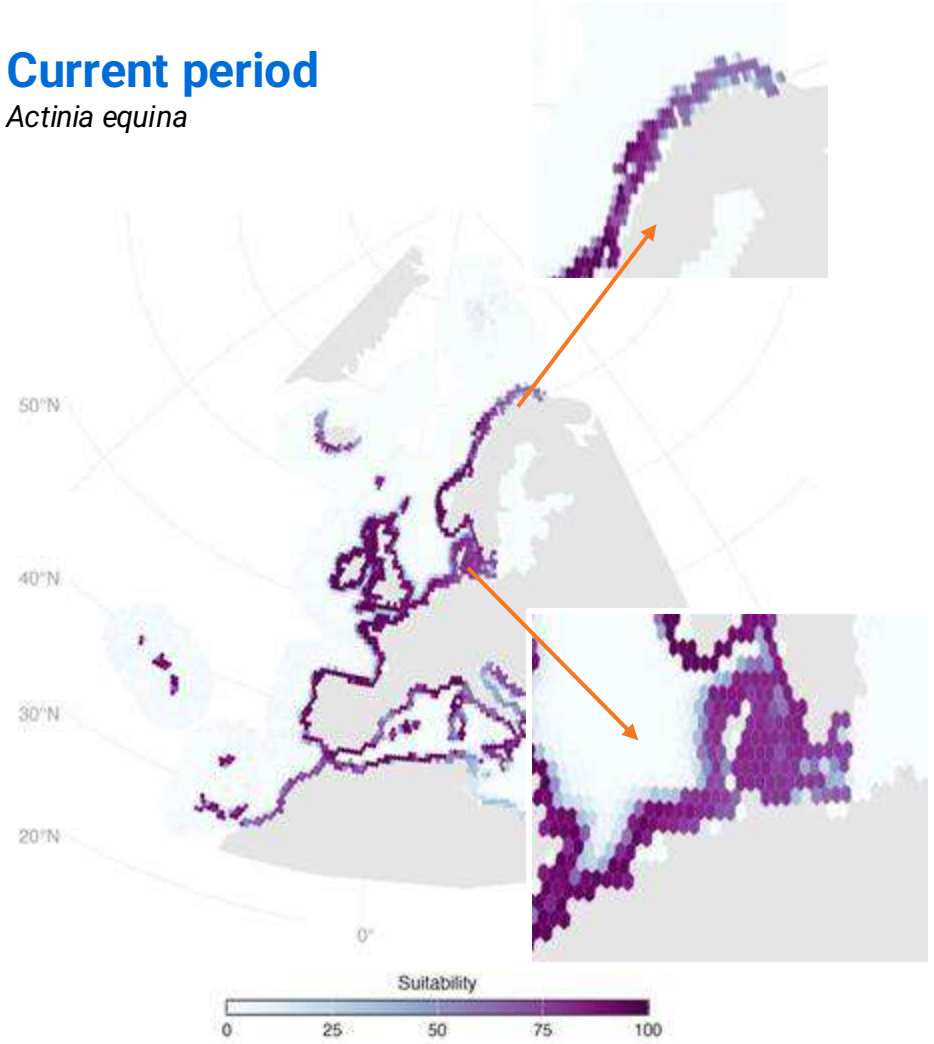


complete range maps
(e.g. *Actinia equina*)

From **today** to **future** → climate resilient MPAs

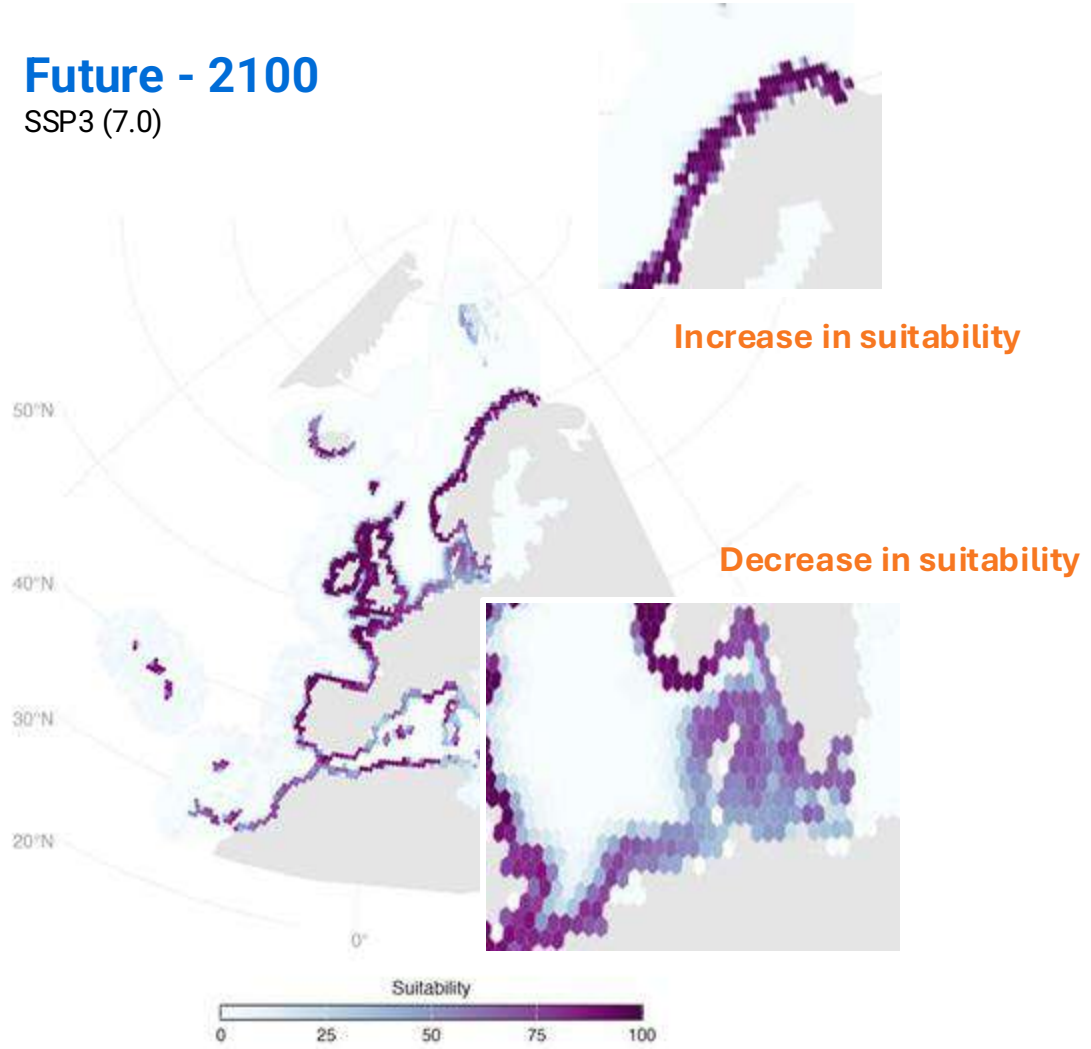
Current period

Actinia equina



Future - 2100

SSP3 (7.0)

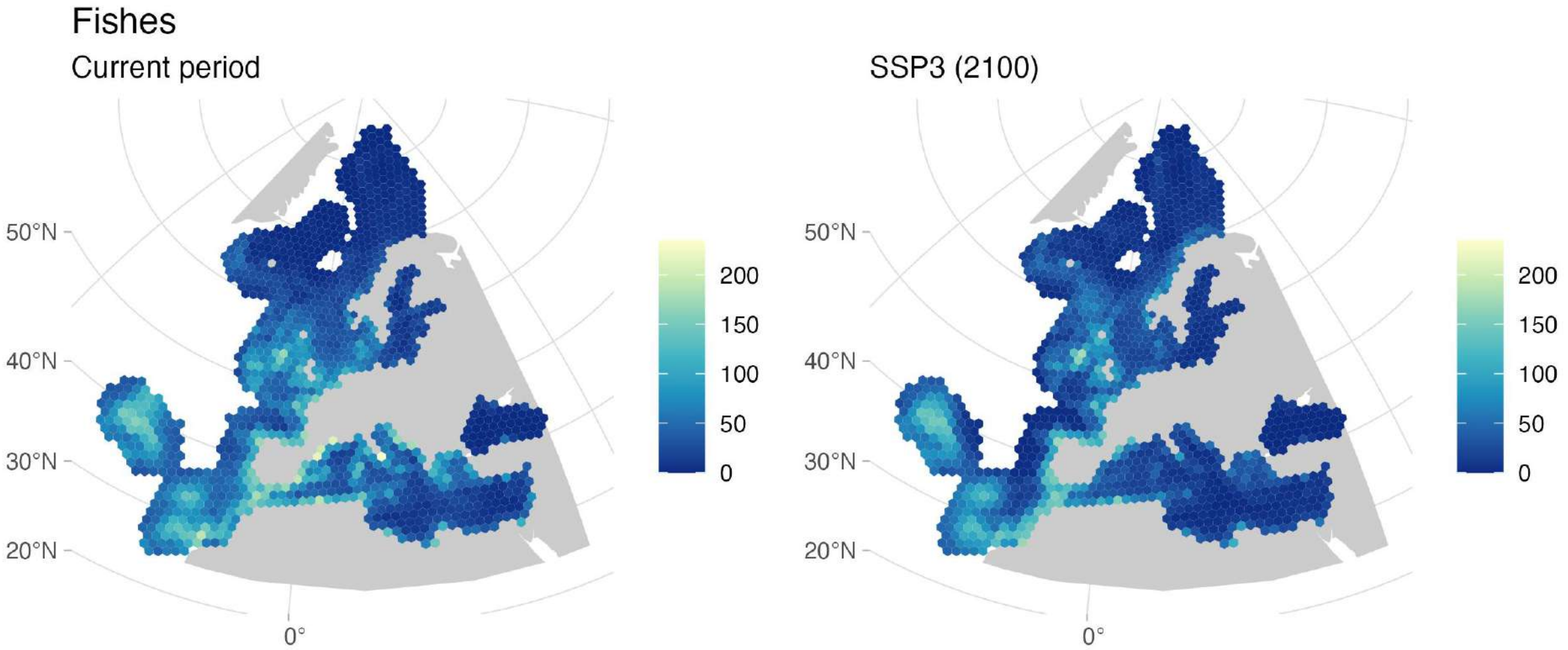


Increase in suitability

Decrease in suitability

CMIP6 SSP (Shared Socio-Economic Pathways) scenarios → 2050 and 2100

From **today** to **future** → climate resilient MPAs



Modelling framework and results

Open | Documented | Fully reproducible

12,684
Species modelled

1,112,742
Files

2,7T
Files

3
Algorithms

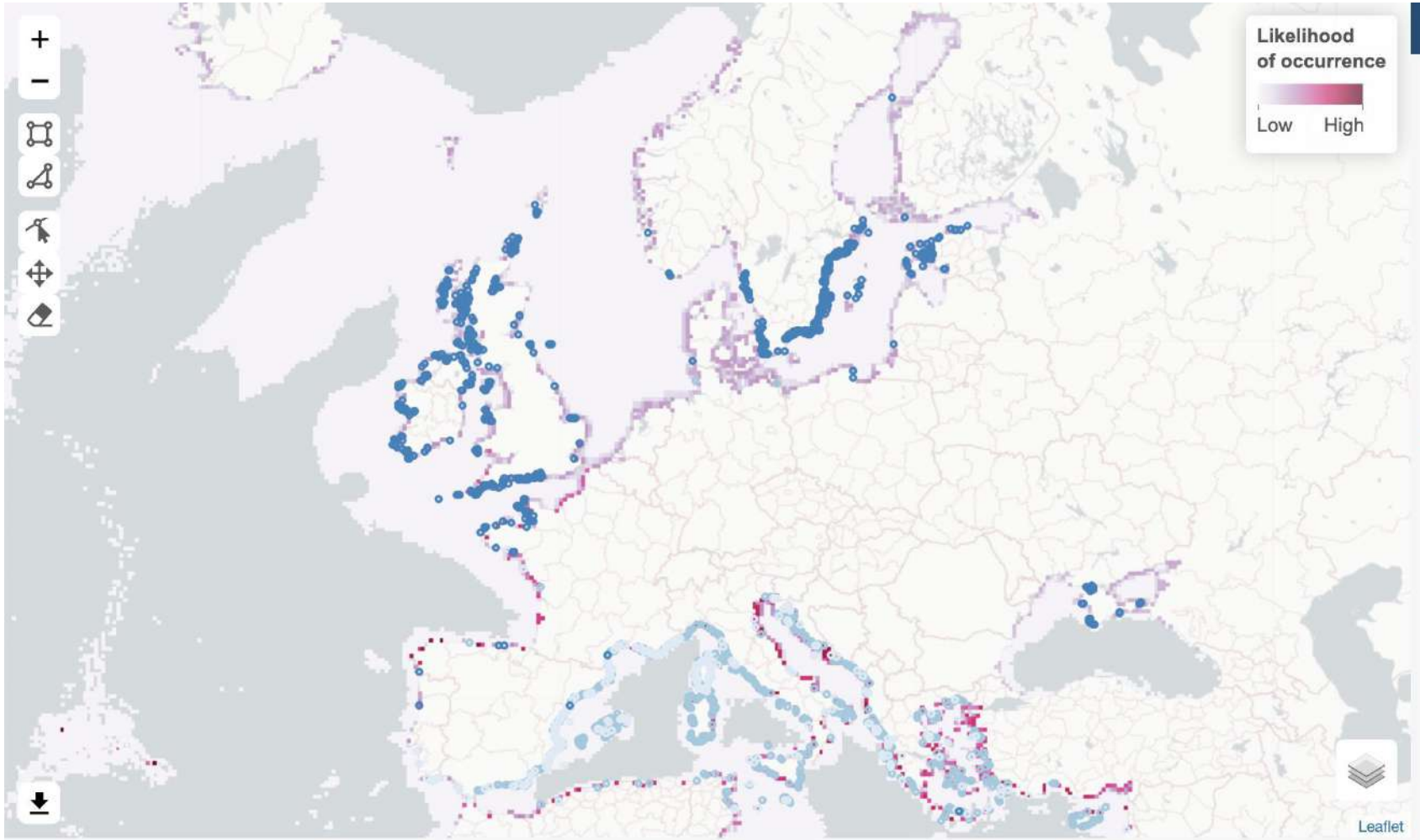
5
Scenarios

2
Periods

6
Habitats

First version completed – version 2 coming soon

With partners: Anna A., Mike B., Mark C., Jorge A.



SPECIES | THERMAL RANGE | HABITAT | DIVERSITY

Select habitat

Seagrass

Binary mode

P10

Show EUNIS biogenic map

Show binary

Seagrass

Definition: long-lived | Species: *Posidonia oceanica*, *Cymodocea nodosa*, *Zostera marina*

Model

MAXENT

Scenario

Current

Period

2050

DOWNLOAD THE DATA

ACCESS THE CODE

Show realms

Show EEZs

Show MPAs

Species information

Show 5 entries

Search:

What is a biogenic habitat?

A biogenic marine habitat is an environment created by living organisms, such as corals, seagrasses, mangroves, or oysters, that form complex structures in marine ecosystems. These habitats provide

Track the project

- **iobis.github.io/mpaeu_docs** :: Documentation
- **github.com/iobis/mpaeu_sdm** :: Modeling
- **shiny.obis.org/distmaps** :: Maps
- **github.com/iobis/mpaeu_*** :: Other developments
- **mpaeu-dist.s3.amazonaws.com/index.html** :: Files

International conference

Thank you

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