Working Group: Offshore Renewable Energy

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Future Science Brief: Marine Renewable Energy

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In light of the recent geo-political, economic, and environmental drivers this Future Science Brief outlines:

- the **state-of-the-art of offshore renewable energy** (ORE) with emphasis on the European status
- **key research needs** to understand the potential implications of this energy transition

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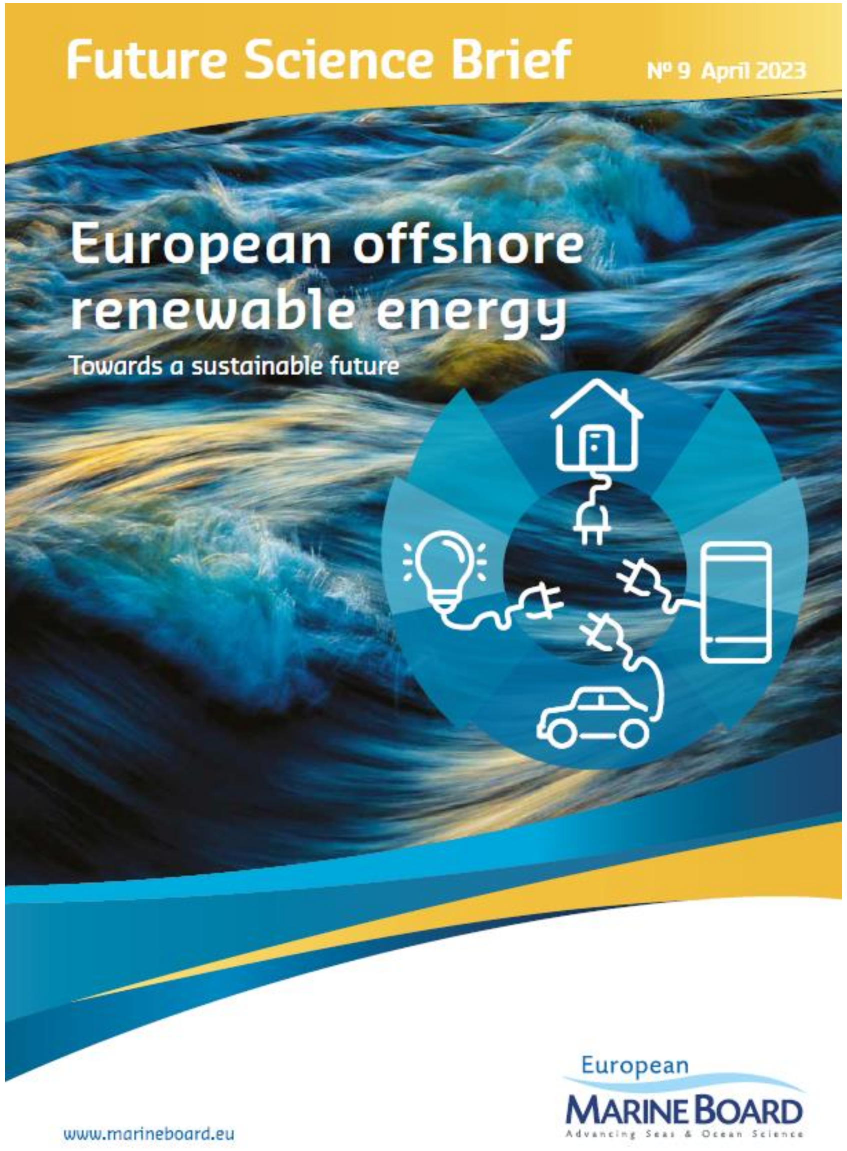

What were the subjects of our study

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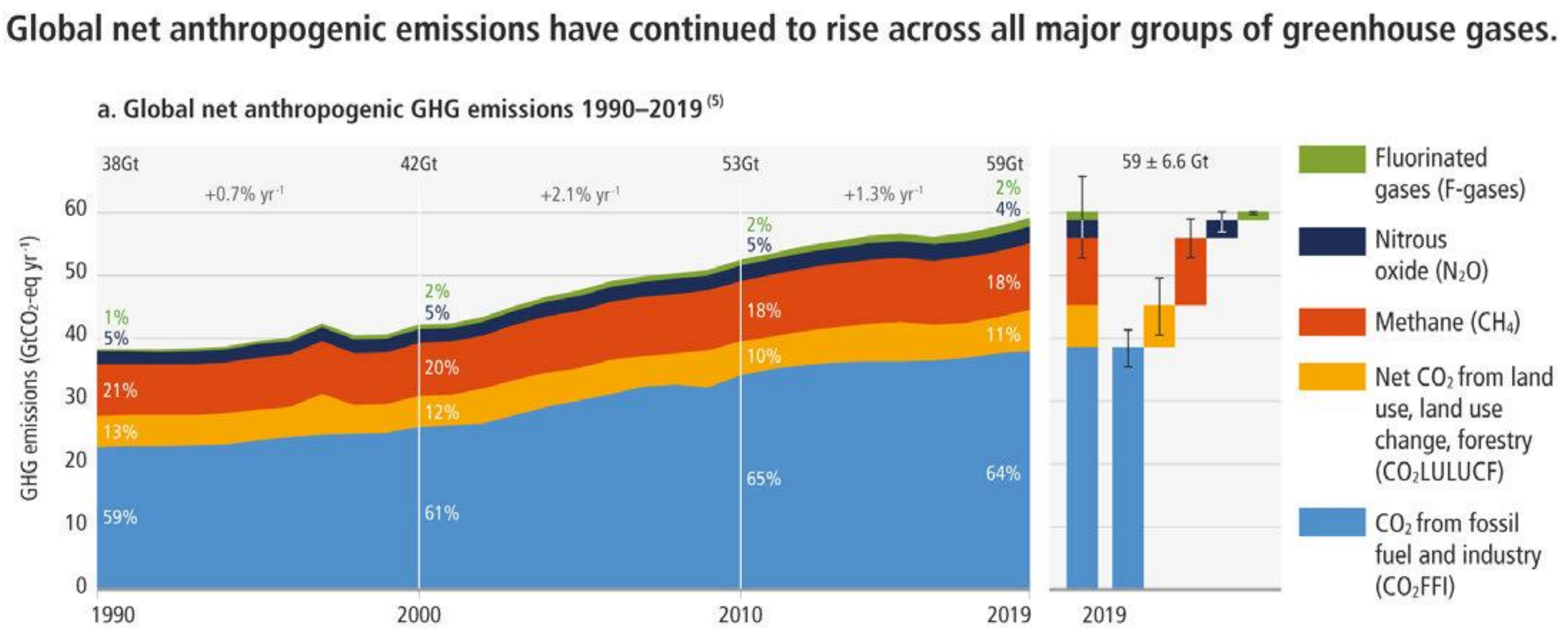
1. Climate change: The need for clean energy
2. State of global offshore renewable energy
3. Review of European offshore renewable energy status
4. Environmental impacts from offshore renewable energy: Lessons learnt
5. Socioeconomic impacts from offshore renewable energy: Lessons learnt
6. Knowledge and capacity gaps
7. Policy, governance, and research recommendations

Climate change: The need for clean energy

A bi-directional analysis is conducted:

1) How large-scale energy extraction from the global Ocean can become efficient in the fight against climate change?
2) How climate change can directly influence the production of offshore renewable energy?



Credit: Figure SPM.1 in (IPCC, 2022b)

Climate change: The need for clean energy

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1. How large-scale energy extraction from the global Ocean can become efficient in the fight against climate change?

Electricity generation approach	Equivalent grams of CO_2 emitted per kWh
Fossil fuel	360 – 1259
Offshore wind energy	11
Onshore wind energy	14.5 – 28.5
Solar energy from solar panels / PVs	8 – 83

Based on (Barthelmie & Pryor, 2021; UNECE, 2021)

Climate change: The need for clean energy

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2. How climate change can influence the production of offshore renewable energy?

Credit: Photo A. Norro / RBINS

- Impacts on ORE technical potential
- Mean sea level rise
- Extreme events probability and magnitude
- Maritime Spatial Planning (MSP) and potentially Ocean zoning
- Environmental impacts
- Biofouling

State of global offshore renewable energy

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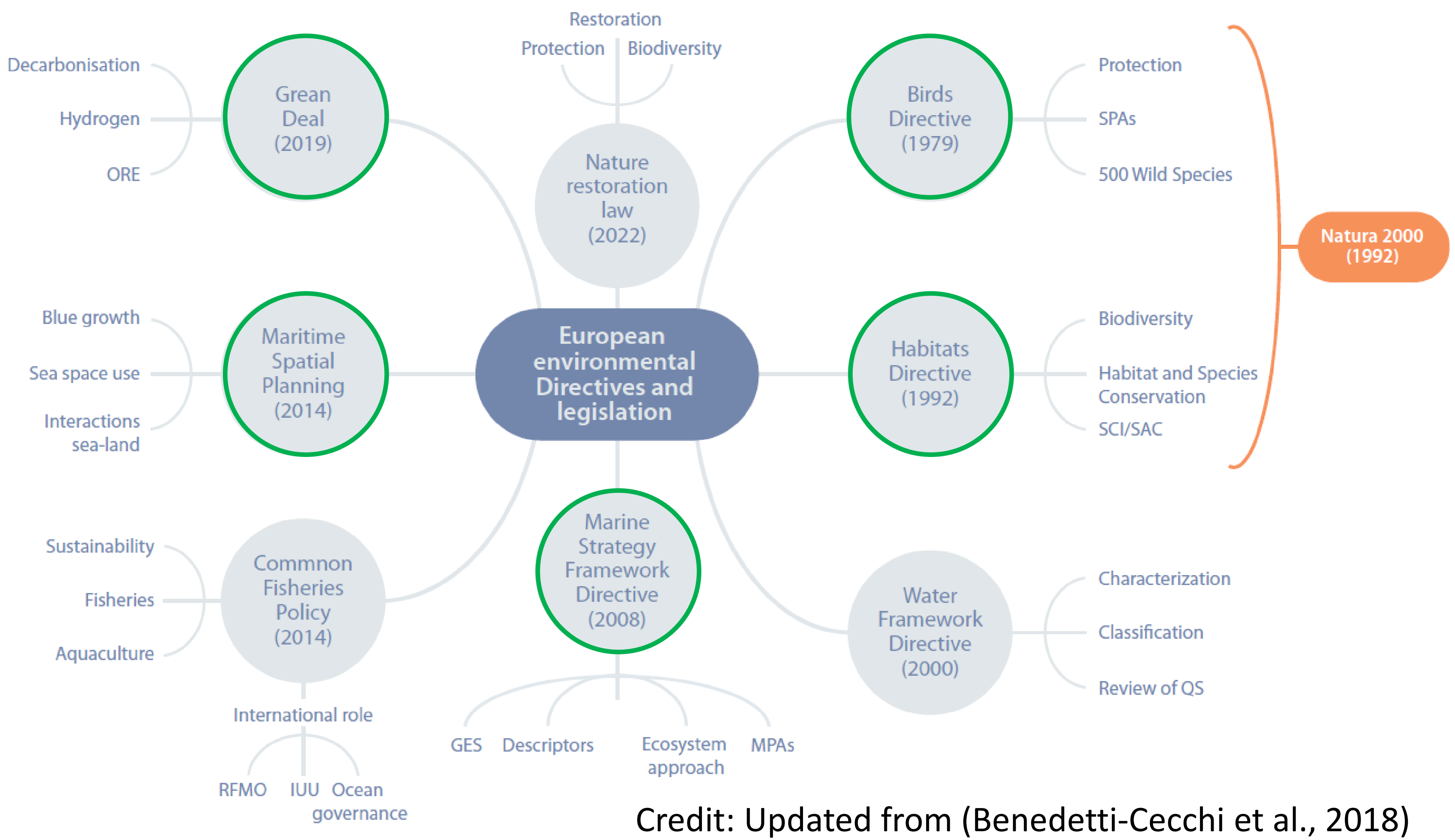
ENERGY TYPE	CAPACITY FACTOR	ESTIMATED AEP TECHNICAL POTENTIAL (TWh/year)	ESTIMATED LCOE ($ US/kWh)
Offshore wind	0.3-0.6	4,000-37,000	0.08
Wave energy	0.25-0.32	5,560	1.46
Tidal current	0.5-0.7	150-1,200	0.2-0.9
Floating solar	0.1-0.3	9,000	0.06-0.11
Thermal gradient	0.9-0.95	83,400	0.03-0.38
Salinity gradient	0.8-0.84	1,650	0.11-2.37

Compiled from (Bhuiyan et al., 2022; IPCC, 2011; IRENA, 2020a; Langer et al., 2020; Newby et al., 2021; Oliveira-Pinto & Stokkermans, 2020; Yang et al., 2022)

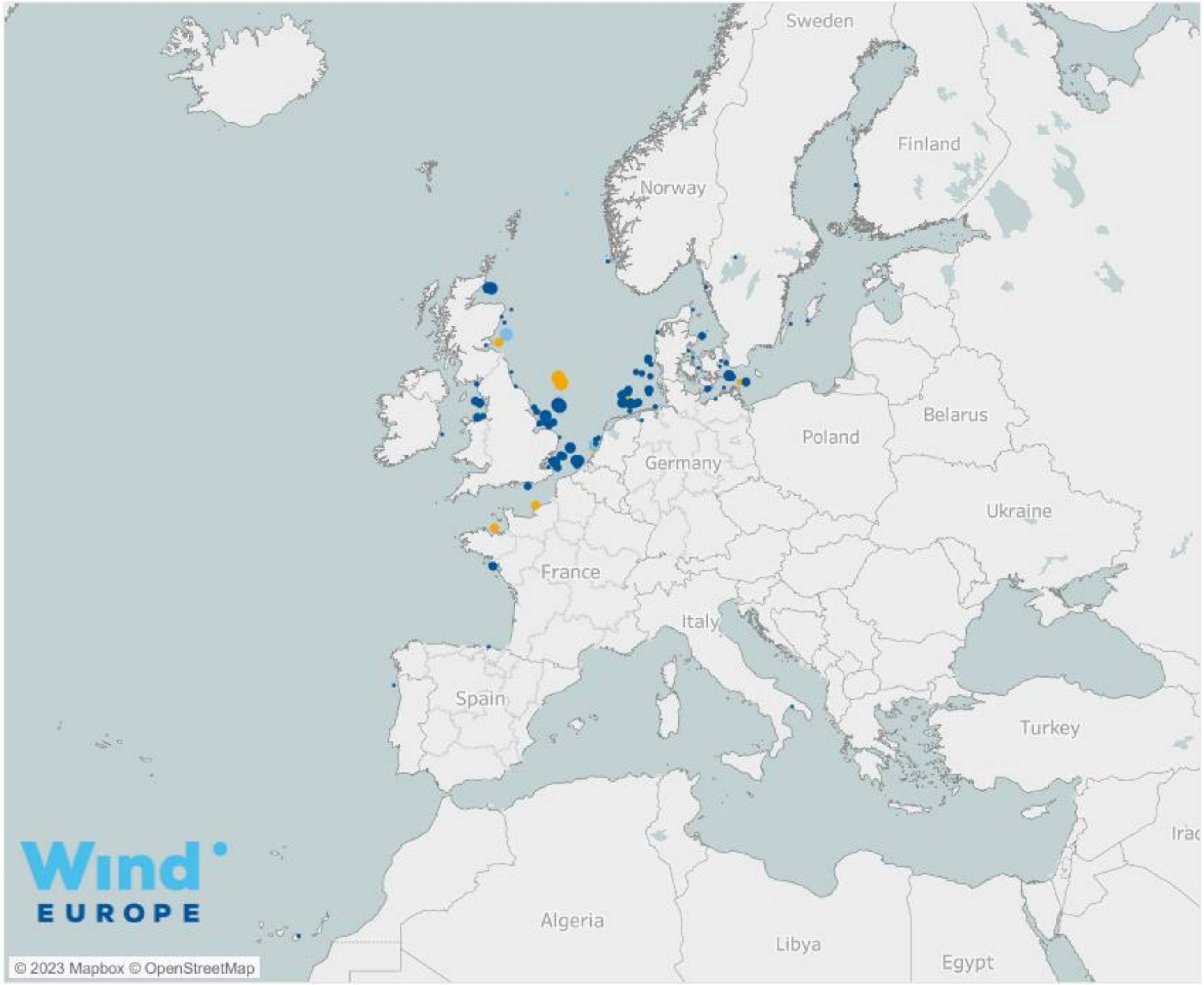
Capacity factor: The average absorbed power (or electricity) divided by the maximum power (or electricity) that a device can produce)
Levelized cost of electricity (LCOE): Average cost of generating electricity over the generation lifetime

European offshore renewable energy status



Credit: Updated from (Benedetti-Cecchi et al., 2018)

European offshore renewable energy status



Europe's offshore wind
30,266 MW installed capacity
5,954 turbines
126 wind farms
13 countries

Status
- Online
- Partially online
- Under construction

Technology
All

Country details

	MW connect..	Turbines con..
UNITED KINGDOM	13,917	2,679
GERMANY	8,055	1,539
NETHERLANDS	2,829	496
DENMARK	2,308	631
BELGIUM	2,261	399
FRANCE	482	81
SWEDEN	192	80
FINLAND	71	19
NORWAY	66	9
ITALY	30	10
IRELAND	25	7
PORTUGAL	25	3
SPAIN	5	1

Status update 14/02/2023

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Maturity

Offshore wind *****
Tidal current and range ****
Wave energy ***

Pilot/demonstration phase

Floating solar energy *****
Salinity gradient ****
Marine biomass ****
Power-to-X (H_2, methanol,…) ***

Barriers: Logistics, port facilities, supply chain

Expansion to key markets: aquaculture, desalination, SIDS, algae, …

Energy Law and Policy

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UNFCCC and Paris Agreement

- **Renewable Energy Directive** - 32% → amount of renewable energy in the EU's energy consumption by 2030
  - National Energy and Climate Plans – targets are achievable
- **European Green Deal** – carbon neutrality by 2050
- Offshore Renewable Energy Strategy (2020)
  - 60 GW of Offshore Wind and 1 GW of Ocean Energy by 2030
- REPowerEU Plan (2022)

Revisions: EU's binding renewable target for 2030 now a minimum of 42.5%

Marine Environmental Policy

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Have to look at this in the context of wider environmental and biodiversity commitments e.g.

- New Global Biodiversity Framework
- EU Biodiversity Strategy - 30% of the sea to be protected and at least 10% of EU seas to be strictly protected
- Proposed Nature Restoration Law - would require Member States to develop nature restoration plans to “cover at least 20% of the EU’s land and sea areas by 2030”
- Marine Strategy Framework Directive – aims to achieve Good Environment Status of Europe’s marine waters

Climate and biodiversity crises

→ Necessitate better and integrated planning and management

Maritime Spatial Planning

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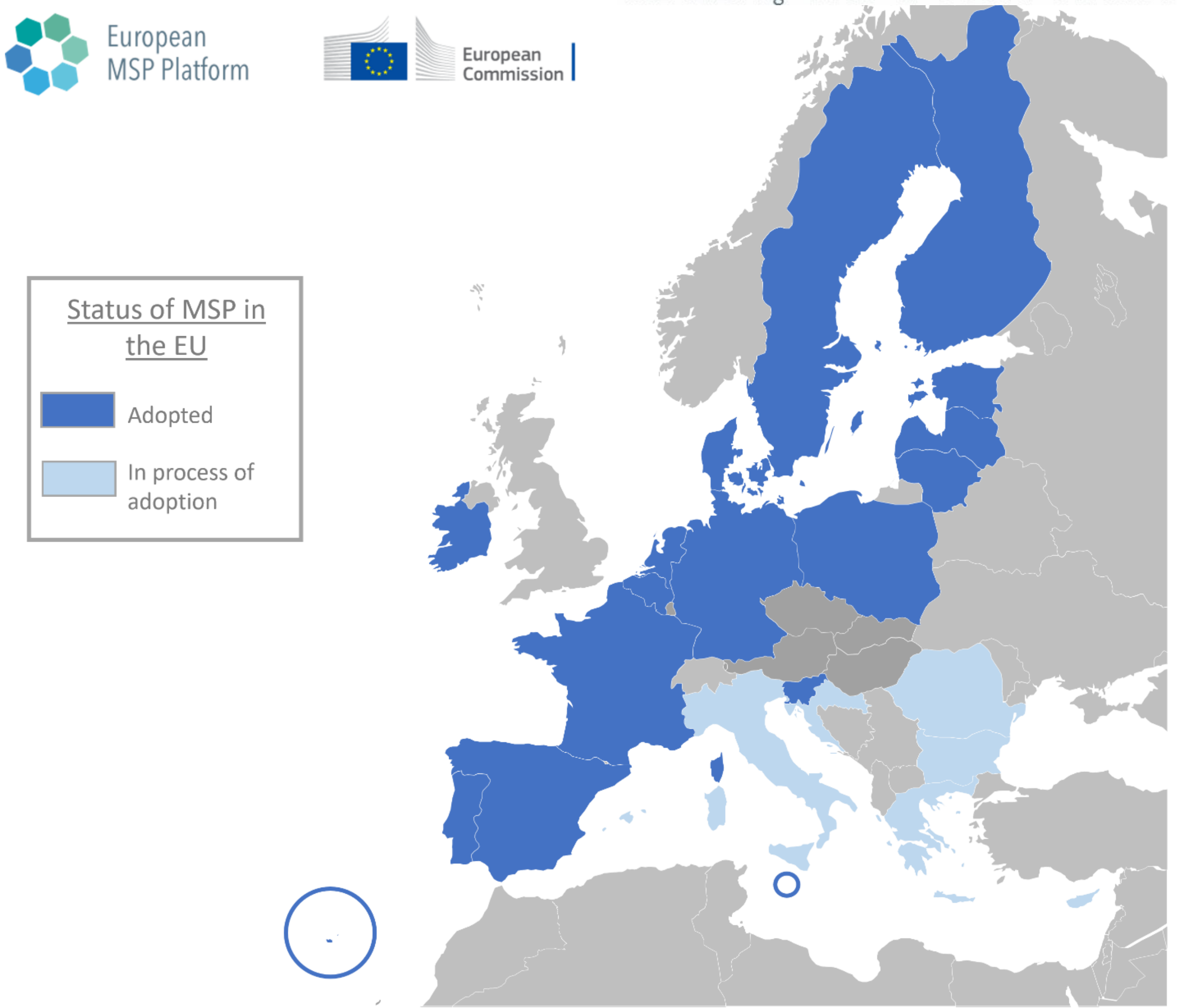
- Maritime Spatial Plans <u>required</u> by March 2021
- Member States need to consider economic, social and environmental aspects to support **sustainable development** of maritime sectors
- Apply an ecosystem-based approach
- Promote the co-existence of relevant activities and uses

European MSP Platform

European Commission



Environmental Impacts

- Future Brief presents the state-of-the-art in understanding the positive and negative impacts of offshore wind installations and mitigation measures
- Current knowledge indicates that fish, marine mammals, invertebrates, seabirds and benthic species can be affected by ORE installations
- Short and long-term impacts on species and ecosystems may be either positive or negative
- Critical that monitoring continues as more development occurs at scale
- Monitoring should take place during all phases of development: project planning through to decommissioning

Environmental Monitoring

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- Currently required as part of EIA and consenting processes
  - Baseline conditions – are they related to development or other stressors on the environment?
- Monitoring should be species-driven
- Post-consent monitoring is necessary where there is uncertainty regarding scientific understanding, in the significance of an impact on a sensitive species or on the effectiveness of the proposed mitigation measure
- We don’t need to monitor everything – need to focus on collecting data that helps to better understand the significance of impacts on marine environments and species
- Monitoring studies should be used to design future research programmes and refine scientific knowledge

Socio-economic Impacts

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- Benefits of commercial-scale deployments are direct economic impacts such as increased jobs and supply chain opportunities
- Indirect benefits are more difficult to define and quantify but could include new training programmes or courses
- No standard approach to Community Benefits schemes – scale, location, technology
- Community ownership – rare in offshore
- Social Impacts are much less studied – need long-term data and opinions also change over time
- Degree to which socio-economic impacts are included in consenting systems varies by location

NMCI Services

Knowledge and capacity gaps

Grid connections:

- European-level connections should be further developed and New Maritime Spatial Plans should include grid planning.
- Interconnection and direct connections to OWFs enables more efficient use of offshore wind resources.
- Next step: multi-terminal and fully meshed offshore grid (Super Grid), including energy hubs, or energy islands.

Stabilization of energy system:

- Improvement of accurate forecasts are beneficial to stabilise delivery to the power system.
- Energy storage (e.g., Power-to-X, offshore storage) is key asset in grid stability and supply and consumption imbalances, while ensuring efficient operation of the system.

Cost reduction and sustainability:

- Large amounts of steel, concrete and composites are needed. There is a shortage of material supply globally
- Critical minerals are not sufficient for future large-scale development of offshore wind and are subject to geopolitical uncertainties; recycling policy is required given the environmental and socioeconomic concerns regarding deep sea mining
- Re-use and/or recyclability of composites/new materials
- Economical and environmentally sustainable alternative anticorrosion and antifouling protections are needed.

Knowledge and capacity gaps

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Full Life Cycle Assessment:

- Energy requirements of ORE components
- Assessment of cumulative environmental effects
- Environmental monitoring

Data sharing:

- Unavailbility of raw data generated at the installation location of the ORE device (a rather common industry's attitude)
- Lack of raw data from previously published work (a rather common scientists' attitude)
- EU policy on data sharing (Copernicus, EMODnet, …) proved extremely beneficial !
- Confidentiality issues

Maritime Spatial Planning:

- The plans must be sufficiently responsive to changes in the environment, Ocean governance, ORE technology, society and economy
- Multi-user approach should be adopted to allocate more space for ORE

Recommendations

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1. Policy

ORE necessitates policy actions in a number of different areas – can be difficult to achieve alignment. Need to facilitate consistent support for ORE.

2. Research and Technology

Considerable capacity across different aspects of ORE and the EU but some gaps remains.

3. Data and Capacity

Difficulties exist in accessing consistent, long-term datasets that can be interrogated by experienced scientists. Must also make better use of existing data and share new data widely.

Thank You

https://www.marineboard.eu/publications/european-offshore-renewable-energy-towards-sustainable-future

http://www.marineboard.eu/

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Recommendations

Policy

- Address policy misalignment
- Create funding mechanisms for TRL advancement
- Make environmental monitoring data more accessible and available
- Add sensors to installations
- Refine variables monitored
- Encourage more transboundary and transdisciplinary cooperation
- Develop best practice guidance on re-use and re-cycling of ORE materials

Research and Technology

- Develop additional modelling capability and tools to predict extreme events
- Conduct case studies to better understand environmental impacts where ORE is less well or not developed
- Develop frameworks to conduct holistic environmental and socio-economic studies and mitigation strategies for multiple devices/cumulative impacts
- When possible, design ORE installations as Other Effective Conservation Measures (OECMs)
- Conduct research into new materials that allow for re-use / recyclability / corrosion prevention

Data and Capacity

- Scale-up data collection and monitoring in areas with high resource availability and/or high potential environmental and/or socioeconomic impacts
- Explore ways to gather/share (long-term) environmental monitoring data
- Explore the gaps in current training, including academic, vocational, continuous professional development, and for re-skilling
- Consolidate data and information on jobs, training and skills needs in Europe
- Make basic ORE-relevant social science awareness training available to STEM professionals and vice versa for social science professionals