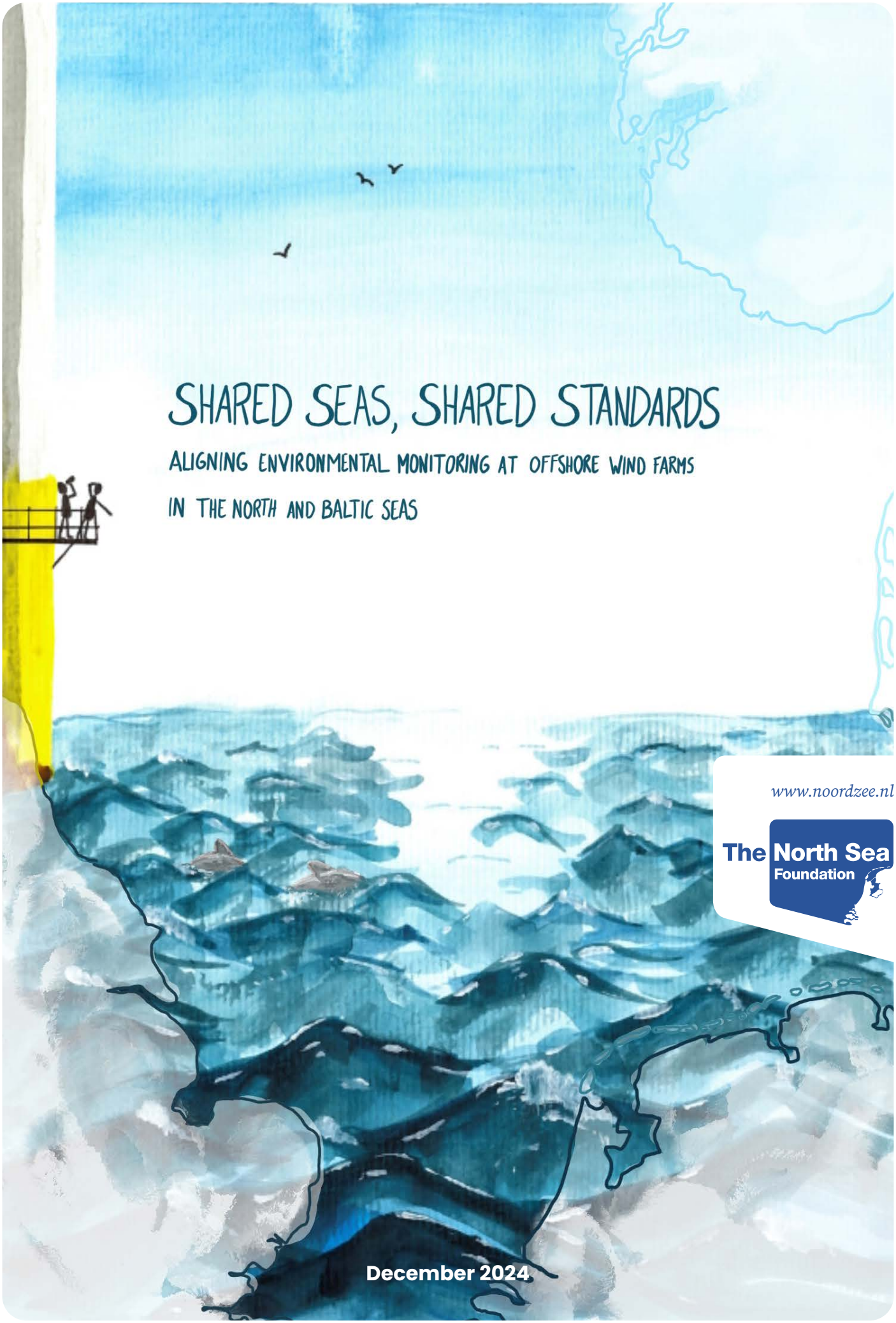

SHARED SEAS, SHARED STANDARDS

ALIGNING ENVIRONMENTAL MONITORING AT OFFSHORE WIND FARMS IN THE NORTH AND BALTIC SEAS

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The North Sea Foundation

December 2024

Shared Seas, Shared Standards: Aligning Environmental Monitoring at Offshore Wind Farms in the North and Baltic Seas

Collecting Essential Knowledge for Informed Decision-Making

17 december 2024

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We also want to thank the interviewees and participants of the workshop for their cooperation and support. Your commitment to advancing research and initiatives that address pressing environmental challenges is deeply commendable.

Summary

This report examines the current practices of ecological monitoring for offshore wind farms in North Sea and Baltic Sea countries, emphasising the need for standardised guidelines to enhance environmental protection and decision making, while supporting the renewable energy transition. Key insights are drawn from interviews with stakeholders, consultations, extensive desk research, and active participation in both national and international conferences. Overall, the outcome reflects a collective agreement that environmental protection is a key responsibility that must be embedded into the practices and strategies of each organisation involved in the offshore wind development in the North Sea and the Baltic Sea.

Key Findings

1. **Fragmented monitoring guidelines**
   North Sea and Baltic Sea countries have different regulatory frameworks. There are differences in, a.o., considered risks, monitoring duration, sharing of data and in who is financially or organisationally responsible for the monitoring.
2. **Gaps in baseline data and impact assessment**
   Across all regions, there is a lack of sufficient baseline data, difficulties in assessing cumulative impacts, and non-standardised protocols. This leads to significant ecological knowledge gaps, particularly in assessing impacts on marine life.
3. **Data sharing gaps**
   While efforts exist to make ecological data accessible (such as the Marine Data Exchange in the UK and WinMon.BE in Belgium), fragmented platforms and differing standards hinder effective regional and international data sharing.

Recommendations

1. **Standardise monitoring guidelines**
   Align monitoring protocols across countries through frameworks like OSPAR, ICES and HELCOM to ensure consistent data collection.
2. **Implement adaptive management**
   Introduce flexible management within the government that allows for corrective action when (unexpected) significant negative ecological impacts are observed during monitoring.

3. **Promote the use of a centralised data sharing platform**
   Connect the information gathering parties to a centralised platform for ecological data, making it accessible to all stakeholders and enhancing transparency, preferably at both the sea basin and European level.
4. **Maintain environmental safeguards in Renewable Acceleration Areas**
   Ensure that accelerated wind development does not compromise environmental protection, particularly in Renewable Acceleration Areas.

Photo: © Dutch Maritime Productions | De Wilde Noordzee

Abbreviations

BACI	Before After Control Impact
BE	Belgium
BNatSchG	German Federal Nature Conservation Act
BSAP	Baltic Sea Action Plan
BSH	Federal Maritime and Hydrographic Agency of Germany
CEMP	Coordinated Environmental Monitoring Programme
CIA	Cumulative Impact Assessments
DAERA	Department of Agriculture, Environment and Rural Affairs
DCO	Development Consent Order
DE	Germany
DEA	Danish Energy Agency
DEFRA	Department for Environment, Food and Rural Affairs
DESNZ	The Department for Energy Security and Net Zero
DK	Denmark
EIA	Environmental Impact Assessments
EMF	Electromagnetic fields
EORs	Environmental Outcome Reports
EU	European Union
GBE	Great British Energy
GES	Good Environmental Status
GW	Gigawatt
HELCOM / HE	The Baltic Marine Environment Protection Commission
HELCOM MADS	HELCOM Monitoring and Assessment System
HRA	Habitat Regulation Assessment
ICES	International Council for the Exploration of the Sea
ISO	International Organization for Standardization
JAMP	Joint Assessment and Monitoring Programme
JNCC	Joint Nature Conservation Committee
KEC	Knowledge and Ecological Effects Centre
MDE	Marine Data Exchange
MEDIN	Marine Environmental Data and Information Network

MMO	Marine Management Organisation
MONS	Monitoring-Research-Nature enhancement-Species protection
MSFD	Marine Strategy Framework Directive
MSP	Marine Spatial Planning
MWTL	Monitoring the Water Management Status of the Country
NGO	Non-Governmental Organisation
NL	The Netherlands
NRW	Natural Resources Wales
NSEC	North Seas Energy Cooperation
OCEaN	Offshore Coalition for Energy and Nature
OSPAR	The Convention for the Protection of the Marine Environment of the North-East Atlantic
OWEC	Offshore Wind Evidence and Change Programme
OWF	Offshore Wind Farms
PAM	Passive Acoustic Monitoring
PL-HRA	Plan-Level Habitat Regulations Assessment
RAA	Renewable Acceleration Area
RBINS	Royal Belgian Institute of Natural Sciences
RED3	The Renewable Energy Directive 3
RSPB	Royal Society for the Protection of Birds
RVO	Netherlands Enterprice Agency
ScotMER	Scottish Marine Energy Research
SACs	Special Areas of Conservation
SEA	Strategic Environmental Assessment
SNCBs	Statutory Nature Conservation Bodies
SPA	Special Protection Area
StUK	Standard Investigation of the Impacts of Offshore Wind Turbines on the Marine Environment
TIMES	Techniques in Marine Environmental Science
TSO	Transmission System Operator
UK	United Kingdom
WinMon.BE	Belgian offshore wind farm environmental monitoring programme
WOT	Statutory Research Tasks
Wozep	Wind at Sea Ecological Programme

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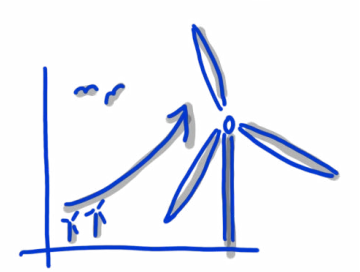
Introduction

Upscaling offshore wind energy in degraded ecosystems



Offshore wind energy is growing rapidly and has become a focal point for generating sustainable electricity in Europe. Northern European countries, including Germany, Belgium, the Netherlands, and Denmark, have committed to ambitious targets for the North Sea, with the Esbjerg Declaration setting goals of 65 GW by 2030 and 150 GW by 2050 for offshore wind capacity. In the Baltic Sea region, countries aim to increase capacity from 2.8 GW to 19.6 GW by 2030. The European Union aims to have 300 GW of offshore wind in its waters in 2050.

While renewable energy is crucial for addressing climate change, this growth is occurring alongside a biodiversity crisis. The ecosystems of the North Sea and the Baltic Sea are already under considerable stress. Seabird populations are declining due to prey shortages, many fish stocks are in poor condition, marine mammals are affected by underwater noise, and benthic habitats are disturbed by human activities such as bottom trawling. Moreover, cumulative impacts from various human pressures exacerbate these issues, as evidenced by recent evaluations from HELCOM (2023) and OSPAR (2023). Protecting and restoring healthy marine ecosystems is essential, not only to support human activities but also to maintain ecosystem services, such as global climate stability, as oceans serve as the planet's largest carbon sink. The role of ecosystem health becomes increasingly important as offshore wind expansion accelerates.

The importance of ecosystem health for offshore wind expansion

There is a growing recognition that healthy ecosystems are vital to accommodate the rapid expansion of offshore renewable energy. National policies are being set in place to minimise pressures, and tender processes for new wind sites are increasingly incorporating qualitative award criteria, including ecological considerations. To facilitate offshore wind development without compromising ecological integrity, adherence to the mitigation hierarchy is paramount.

To support this expansion, it is crucial to have a comprehensive and up-to-date understanding of the ecological impacts of offshore wind farms (OWFs). Cumulative ecological effects caused by the offshore energy transition may impact ecosystem functioning. Caused by pushing species interactions and biophysical variables beyond natural variability (Isakson et al. 2023). Specific research and modelling has been conducted for individual wind farms and environmental

impact assessments, yet a more coordinated approach to monitoring impacts at a sea basin scale is required across the North and Baltic Seas in order to fill important scientific knowledge gaps.

The need for standardised monitoring

In order to effectively address both the climate and biodiversity crises, a solid grasp of the environmental impacts caused by offshore wind and grid infrastructure is needed. Avoiding adverse environmental impacts and taking opportunities for ecology can only be effectively done based on a sound knowledge base. Watson et al. (2024) identified that over 86% of potential effects of offshore wind farms on ecosystem services remain unexplored, indicating that decision-making processes may not fully account for the breadth and implications of ecological changes. In order for the Good Environmental Status (GES) to be achieved alongside and avoid that it is undermined by the development of offshore wind, strategic monitoring at a European level and a sea basin scale is necessary.

Objectives and scope

This report examines the ecological monitoring practices for offshore wind farms in countries bordering the North Sea and Baltic Sea, with a focus on investigating the need for standardised minimum monitoring guidelines.

Definition of Monitoring

In this report, monitoring refers to long-term environmental measurements (abiotic and biotic) carried out systematically, such as the tracking of bird populations around wind turbines over several years. This differs from short-term research or mitigation validation studies, as it focuses on gathering baseline environmental data and measuring impacts throughout the lifecycle of offshore wind projects, from pre-construction to post-construction.

Objectives

The primary objectives of this report are as follows:

1. **To Provide a Comparative Overview of Monitoring Practices**
   To provide an analysis of the current ecological monitoring practices, including processes, guidelines, challenges, and data usage in Germany, the Netherlands, Belgium, Denmark, the UK, and HELCOM-regulated regions, identifying what works well and where improvements are needed.
2. **To Develop Policy Recommendations**
   To propose, based on identified gaps, actionable recommendations for standardising ecological monitoring guidelines across Europe to ensure that

monitoring efforts are consistent, scientifically robust, and adaptable to various environmental conditions.

3. **To Foster Discussion on Standardisation**
   To encourage dialogue on the necessity of establishing a standardised framework for monitoring across the North Sea, Baltic Sea, and EU regions, focusing on ensuring data transparency and accessibility for all stakeholders.

Scope

The focus of this report is limited to offshore wind farms and their associated infrastructure, such as inter-array cables, export cables, and offshore substations, within the North Sea and Baltic Sea regions (Figure 1). Onshore wind farms and floating wind technologies are excluded from this report. Additionally, while mitigation measures are touched upon, the validation of these measures is not within the scope.

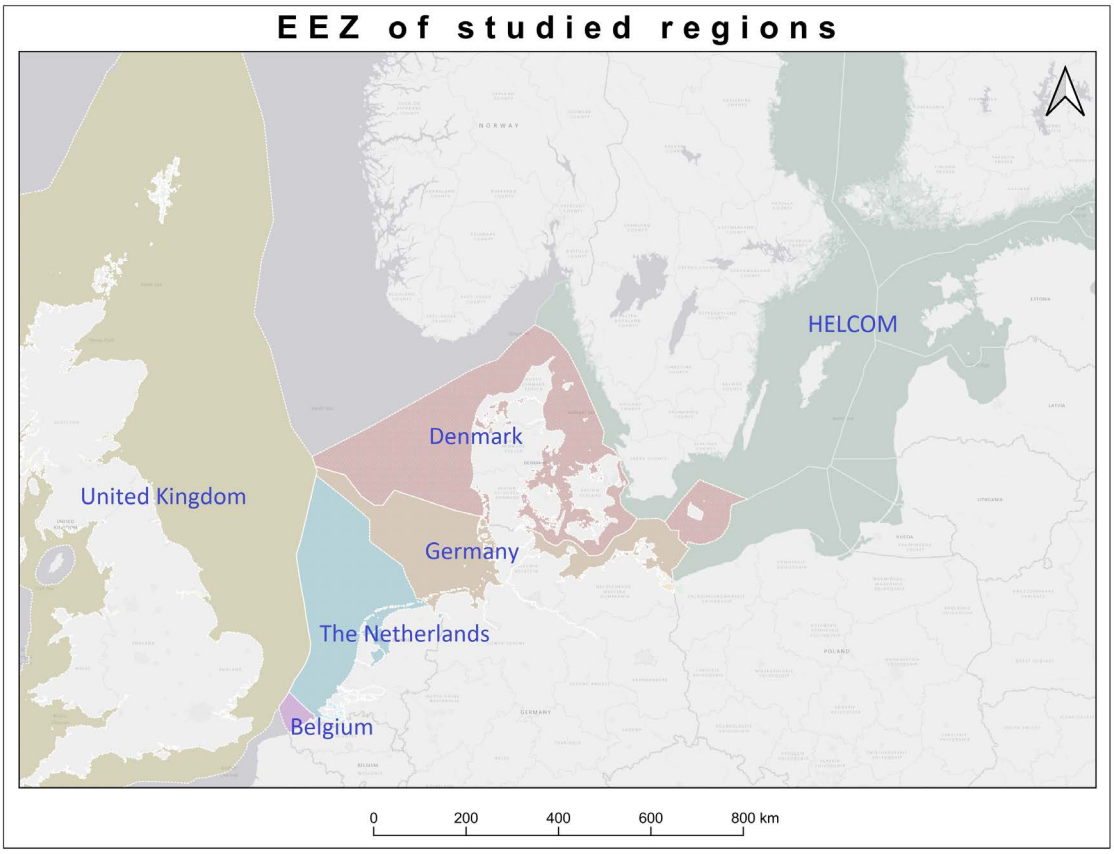


Figure 1. Countries investigated, supplemented with HELCOM as general information party for the Baltic area.

Starting point and approach

The North Sea Foundation published a report on the ecological risks and opportunities of offshore wind farms in 2018. After this publication, The Rich North Sea programme was set up to focus on the opportunities of OWFs for nature. Meanwhile, The North Sea Foundation published a follow-up and more detailed report on the ecological risks and knowledge gaps of OWFs. Main topics were abiotic changes, leading to biotic changes in the system, underwater noise, habitat loss and gain, bird and bat collisions or barotrauma, electromagnetic fields and pollution. An updated infographic on the different environmental impacts of OWFs in the North Sea has recently been published (Figure 2). How these environmental impacts can be avoided or mitigated is identified and published in a detailed report by Offshore Coalition for Energy and Nature (OCEaN). Additionally, the Global Initiative for Nature, Grids and Renewables (GINGR) has created a Nature- and People-Positive Navigator series in which, among other things, a discussion paper on the development and implementation of biodiversity monitoring strategies has been published (GINGR, 2024).

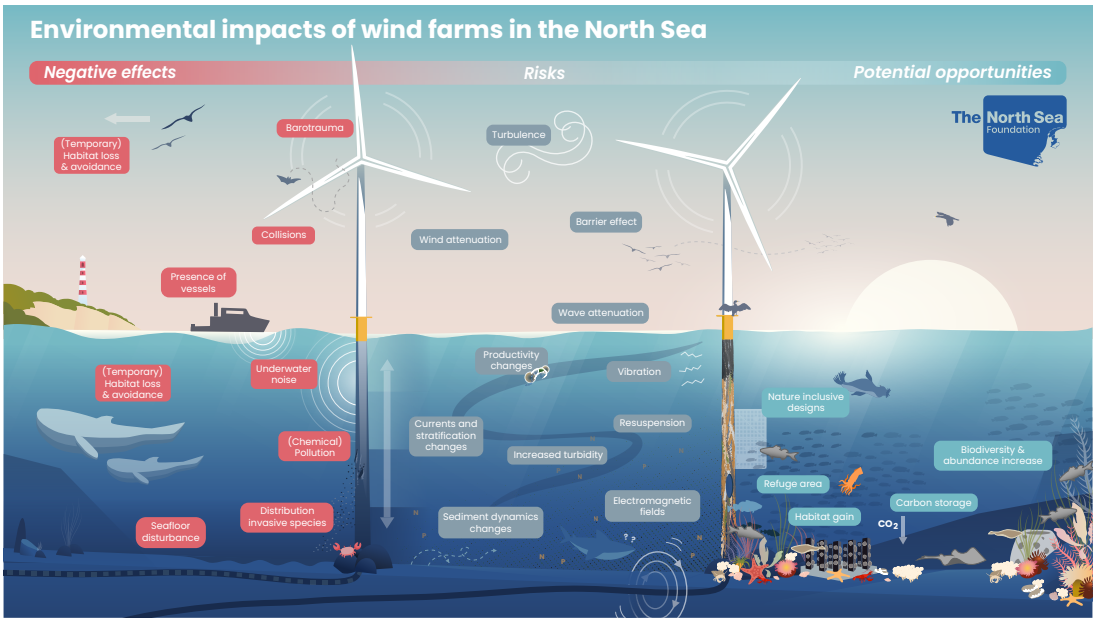


Figure 2. Environmental impacts of wind farms in the North Sea, divided into negative effects, risks, which are more uncertain and potential opportunities for nature.

Improving ecological monitoring would help to decrease knowledge gaps and the risks that are currently being taken. Therefore, in this report, an overview of the ecological monitoring practices in North Sea and Baltic Sea countries was gathered. For each country, at least three different stakeholders were interviewed (Appendix II). These interviews included amongst others, representatives from OCEaN members, which comprise NGOs, wind developers, and grid developers.

The following core questions were asked during the interviews

1. Are the ecological risks identified by the 2022 report of The North Sea Foundation in the Netherlands similar in your country? If not, what other risks exist for different ecological groups, and how are these risks assessed?
2. Are there national standardised guidelines for monitoring the ecological impacts of offshore wind farms? If so, could you provide a link for comparative research? Do you believe these guidelines offer sufficient depth in their monitoring?
3. To what extent are research findings used to improve current monitoring guidelines?
4. Should ecological monitoring guidelines be standardised across the North Sea, Baltic Sea, or EU-wide? If so, how and by whom should this be done?
5. What are the main barriers to further monitoring (e.g., legal, financial, capacity, political will)?

One-Pagers and Monitoring Analysis

The first three questions were used to create one-page summaries of the monitoring practices for each country (see Chapter 3). These one-pagers were co-reviewed by (some of) the interviewees from each respective country to ensure accuracy. The aim was to understand if monitoring covered both above-water and underwater species, including bats, migratory and local birds, fish (pelagic and demersal), marine mammals, plankton and benthos. We also investigated when monitoring starts and ends, who conducts the monitoring, how countries organise monitoring financially and whether the data is openly shared.

These one-pagers consolidate over 25 years of collective knowledge and experience in offshore developments in the North and Baltic Seas. Through this process, we identified knowledge gaps and good practices in monitoring guidelines for each country. It also became clear that each country has its own governance structure, with varying monitoring requirements in place.

Standardisation of Monitoring Guidelines

Questions 4 and 5 were used to inform the recommendations on the possibility of standardising environmental monitoring guidelines. From the interviews with OCEaN industry partners, there is growing consensus on the need for a minimum level of standardisation in environmental monitoring requirements, while allowing flexibility for location-specific adaptive monitoring.

Stakeholder views

In October 2022, a workshop took place in Brussels with approximately 25 participants, including representatives from the wind industry, transmission system operators (TSOs), contractors, as well as a few NGOs and a research institution from various North Sea countries. The workshop focused on ecological monitoring guidelines. Prior to the event, around 20 expert interviews were conducted, involving representatives from science, industry and NGOs in the UK, the Netherlands, Belgium, Germany, and Denmark (Appendix VI). The participants' responses during the workshop were categorised based on the type of organisation they represented. Below is a summary of the key topics discussed and the questions raised.

Organisational responsibility for environmental protection

Generally, there is a shared sense of responsibility for environmental protection among all stakeholders involved in offshore wind farm development. **Wind farm operators** commit to ambitious goals like becoming biodiversity-positive by 2030, while **TSOs** stress the importance of aligning sustainable promises with a clear vision and ensuring fairness in implementation, including the creation of a level playing field in which competitive disadvantages are avoided. **Contractors** highlight their role in protecting crucial species and ecosystems, viewing nature conservation as an integral part of their operations. **Other stakeholders**, such as researchers and NGOs, also emphasise the necessity of sustainable resource use and nature conservation, positioning it as a core priority. Overall, the outcome reflects a collective agreement that environmental protection is a key responsibility that must be embedded into the practices and strategies of each organisation involved in the offshore wind development in the North Sea and Baltic Sea.

Knowledge gaps and the role of monitoring

In general, stakeholders identify significant **knowledge gaps** across all phases of offshore wind development—planning phase, construction, operation, and decommissioning—that could hinder effective decision-making and environmental protection. There is a consensus that **monitoring** is a critical tool for addressing these gaps.

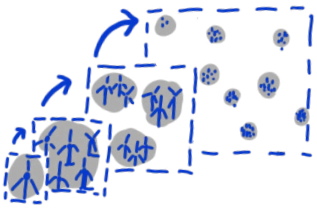
- **Planning phase**: Wind farm operators and TSOs emphasise the need for clear baseline data and an understanding of all variables. Operators question what the desired end-state is for the environment, but also do not see many options for baseline monitoring while there is no permit. Contractors point to the lack of communication between stakeholders, indicating that sometimes existing

knowledge isn't fully shared or utilised for various reasons. Other stakeholders, such as researchers, raise concerns about understanding the carrying capacity of the environment to handle wind farm construction and operation.

- **Construction phase**: In this phase, some TSOs see a problem in gaining the right knowledge due to the fact that some monitoring techniques are not allowed due to legislation and safety reasons during the construction and/or operational phases. Contractors highlight the need for standardised data sharing to improve collaboration and innovation.
- **Operational phase**: Wind farm operators and stakeholders see the need for monitoring species behaviour to predict population-level responses across the phases. Knowledge gaps include the impact of electromagnetic fields (EMF) and species interaction with wind farms, such as birds being attracted to turbines due to benthic protection, increasing collision risks. Concerns also extend to bats and the broader effect on food webs due to changes in hydrodynamics and primary productivity.
- **Decommissioning phase**: Wind farm operators stress the need for clear assessment criteria to evaluate the "end state" of the environment. There are concerns about whether decommissioning will disturb "new nature" formed around the structures and disturbing the environment again. Other stakeholders point out the lack of data and knowledge about the environmental impacts during this phase.

Monitoring scale: wind farm, national, regional or North Sea-wide

In general, stakeholders see the need for multi-level monitoring in offshore wind projects, covering everything from individual wind farms to country, regional, and North Sea-wide scales.



Wind farm operators acknowledge that local, site-specific monitoring is crucial but also recognise the importance of broader, coordinated efforts across the North Sea and Baltic Sea to address cumulative ecological impacts, particularly on species populations. **TSOs** stress the challenges in monitoring cumulative impacts across multiple projects and highlight the importance of moving beyond single wind farm evaluations. **Contractors** focus on localised data for operational purposes but support the idea that governments should take responsibility for regional-level monitoring. **NGOs and a knowledge institute** stress the importance of harmonised guidelines and North Sea-wide data collection to ensure consistent and meaningful ecological assessments.

Overall, the outcome underscores the consensus that effective environmental monitoring requires a coordinated approach across multiple scales to fully capture the impacts of offshore wind development on the North Sea ecosystem.

Areas requiring standardisation

There is a recognised need for standardisation across various aspects of offshore wind farm development, particularly in the areas of data sharing, risk assessment, and monitoring. Wind farm operators emphasise the need for standardised data formats to facilitate data sharing, as well as clear guidelines for assessing risks and impacts. They also highlight the importance of having established methodologies for evaluating impacts, also keeping in mind all the biodiversity positive goals that wind farm operators set for themselves. TSOs stress the need for a scientific approach to monitoring, including peer review and data sharing, along with clarity around societal obligations and the acceptance of risk. They also suggested policies across countries, for example for bird mitigation.

For constructors and contractors, the inclusion of monitoring during the design phase and clarity regarding the impacts of wind farm installations are key areas for standardisation, with risks outlined and agreed upon in contracts.

Additionally, there is a broader call for the standardisation of data availability before tender processes, the publication of raw data on a public platform (such as EMODnet), and consistent measurements of electromagnetic fields (EMF), noise, and other abiotic factors. Standardised guidelines should work as a minimum, with options for adaptivity towards country specific risks and species or habitats. There is also a need for government-organised funding and integration of initiatives into a big "North Sea campaign" for monitoring, supported by European funding and databases. Finally, translating research and findings into policy, as well as conducting meta-analyses for governments, is seen as essential for ensuring consistent and effective offshore wind farm monitoring and development.

Responsibility and Financial Accountability for Offshore Wind Farm Monitoring

At the moment, the responsibility for executing the monitoring in offshore wind farms lies with the operators, as this is often stipulated in permit requirements. But often, they will do this in partnerships. For instance, in Belgium, permits require operators to provide access to third parties for monitoring, which encourages cooperation. This model is seen to be more effective at the national level, while implementation across the EU remains more complex. To improve the process, it is recommended that governments set clear frameworks to cover the costs of granting access to offshore wind farms and standardise monitoring methodologies.

On the question of financial responsibility, some argue that operators should bear the costs of monitoring, while others contend that governments, as the permit providers, should shoulder this expense. Additionally, it has been highlighted that society benefits from green energy, so the question arises as to why companies alone should be responsible for these costs.

Improving Data Accessibility and Centralisation in Offshore Wind Development

Improving the openness and accessibility of data related to offshore wind farms requires the development of a central platform for data storage and access. Currently, several data-sharing platforms exist, but they are fragmented by country and sector, making it challenging to consolidate and share data across Europe. A significant issue is that "data is everywhere," and there is a need for centralisation to combine these disparate sources. Standardising data-sharing processes and financing the databases and platforms is crucial to address this fragmentation.

Industry players acknowledge that they can share substantial amounts of data, but without centralised responsibility or need, it remains fragmented. Also, some data is privately owned by companies and could be valuable for non-price criteria auctions. Governments, too, often lack the capacity to manage the data effectively. The challenge is not the willingness to share data, as companies are generally cooperative. However, once data is shared, it is unclear what happens next—who handles it, who uses it, and how it is managed remain unresolved issues.

It is also important to note that not all data can be openly shared. For instance, data on underwater sound monitoring in Germany is restricted due to defence regulations, highlighting the need to balance transparency with security concerns.

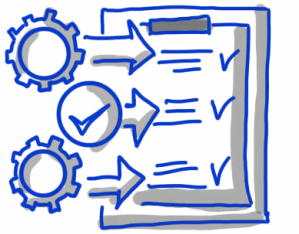
Steps to Address Standardisation Needs in Offshore Wind Monitoring

To meet standardisation needs in offshore wind monitoring, it is essential to clearly define what is being monitored and establish goals upfront, ensuring that there is a good understanding of when those goals are achieved. Monitoring should be ongoing, with the mindset that "good monitoring is a never-ending story." Satisfaction is reached when there is scientific confidence that there are no major risks remaining for specific species or environmental factors.
A significant part of the responsibility for achieving the standardisation in monitoring should be assumed by the governments, but they could be guided by OSPAR and HELCOM. Also, ICES might support the scientific background.

Examining Monitoring Practices, Guidelines, Challenges, and Data Policies in North Sea and HELCOM Regions

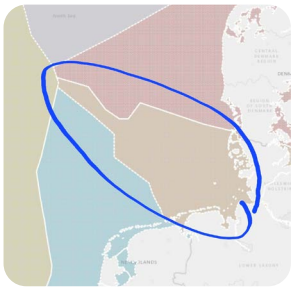
This analysis is based on desk research and insights gathered from expert interviews with representatives from each of the North Sea countries—**Germany (DE)**, **the Netherlands (NL)**, **Belgium (BE)**, **Denmark (DK)**, and **the United Kingdom (UK)**—as well as **HELCOM**, which oversees the Baltic Sea region. These interviews provided detailed information on each country's approach to offshore wind development and marine environmental protection. Short country-specific overviews, which were reviewed by individuals from these countries, can be found in the appendix of this report. This chapter synthesises all this work, offering a comparative analysis of **process and guidelines**, **monitoring and challenges**, and **data usage and sharing** across these regions.

Process and guidelines



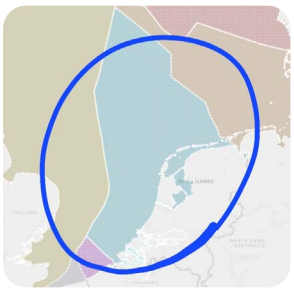
The process and regulatory guidelines for offshore wind farm monitoring differ across countries, although they generally follow a framework that involves pre-construction assessments, permitting, and post-construction monitoring. However, the extent to which these processes are implemented, and the stringency of guidelines, varies by country.

Germany



In Germany, offshore wind farm development is guided by comprehensive assessments, starting with a Strategic Environmental Assessment (SEA) and followed by Environmental Impact Assessments (EIAs). These assessments are required to comply with both the Federal Maritime and Hydrographic Agency (BSH) and European Union directives, such as the Habitat and Birds Directives. However, concerns remain about the influence of political decisions on the scientific independence of **guidelines** like the Standard Investigation of the Impacts of Offshore Wind Turbines on the Marine Environment **(StUK) standards** for ecological monitoring. For example, the approval authority will provide the scope of investigations, and the results of the baseline study are submitted to the approval authority in form of comprehensible expert reports. The raw data shall be stored and shall be made available to the approval authority upon request.

The Netherlands

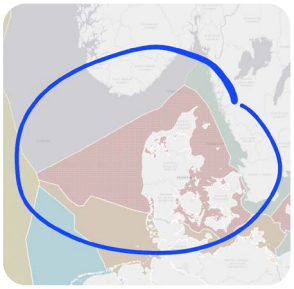


In the Netherlands, offshore wind development currently includes extensive pre-construction ecological surveys, EIAs, and ongoing monitoring obligations during and after construction. In the Netherlands, this has already started, with the assignment of search areas for Offshore Wind Farms. There is also **pre-construction monitoring** being performed by RVO. However, time pressure sometimes results in decisions being made before all necessary data is collected. Currently, there is no systematic gathering and comparison of pre- and post-construction monitoring data.

Belgium

In Belgium, the federal government directly oversees the regulation and monitoring of offshore wind farms. Developers contribute financially to research programs like **WinMon.BE**, which monitors long-term ecological impacts, but also answers specific research questions. The government prioritises protected species, and while Belgium has a **well-established monitoring framework**, it lacks a unified set of standardised guidelines, relying on protocols from various scientific institutions and ICES guidelines for certain species groups.

Denmark



In Denmark, offshore wind farm regulation is managed by the **Danish Energy Agency (DEA)**, which oversees permitting, including EIAs for both the wind farm and its grid connection. Denmark has recently introduced Strategic Environmental Assessments (SEAs) and requires that monitoring continue for three years post-construction to track species like birds, marine mammals, and bats. Unlike other countries, Denmark **integrates the grid connection** within the tender process to foster innovation and reduce project costs. However, Denmark has not fully adopted an ecosystem-based approach or standardised guidelines.

The UK

In the UK, offshore wind projects are regulated by a mix of national and devolved authorities. The **Marine Management Organisation (MMO)** manages marine planning in England, while agencies like **Scottish Government Marine Directorate**, the **Department of Agriculture, Environment and Rural Affairs (Northern Ireland)** and

Natural Resources Wales (NRW) oversee their respective regions. The regulatory process begins with surveys and assessments developed through stakeholder engagement, followed by EIAs, **Cumulative Impact Assessments (CIAs)**, and **Habitat Regulation Assessments (HRAs)**. Developers must comply with these guidelines throughout the construction and operational phases, but fragmented responsibilities across devolved administrations complicate compliance and monitoring. In order to simplify the process, the Levelling up and Regeneration Act (2023) suggested to transform EIAs into Environmental Outcome Reports (EORs) in an attempt to streamline the impact assessment approach. Even though this could create a more goal-oriented approach rather than a compliance-driven approach, there are also huge risks involved. These risks involve the lack of an established legal framework around EORs. Additionally, it creates the risk of creating precedent to further changes, including weakening or scrapping of HRAs.

Helcom

HELCOM, which oversees the Baltic Sea region, does not issue direct offshore wind guidelines but provides overarching recommendations through the **Baltic Sea Action Plan (BSAP)**. The plan sets broad goals for protecting biodiversity, reducing pollution, and promoting sustainable sea-based activities. HELCOM's influence is in guiding member states to adopt an ecosystem-based approach to marine planning, although the responsibility for issuing permits and conducting EIAs remains with national authorities. HELCOM's guidelines are especially relevant for cumulative impact assessments in transboundary areas.

In addition to HELCOM, also the OSPAR Commission has developed a **Coordinated Environmental Monitoring Programme (CEMP)**, which includes guidelines for monitoring and assessment approaches across several environmental themes. **Theme B** provides guidance on monitoring species and ecosystems in relation to the Marine Strategy Framework Directive (MSFD) descriptors, **focusing on species in their natural habitats** rather than in offshore wind farms. Furthermore, the CEMP guidelines include "Environmental Impact of Human Activities" that are primarily focused on waste and marine litter. There are two guidelines concerning underwater noise, but none for monitoring the impacts on nature or species within offshore wind farms. The **International Council for the Exploration of the Sea (ICES)** has also developed guidelines to assist in data collection, processing, and quality control. These guidelines cover abiotic factors, though not specifically for offshore wind farms. ICES' Techniques in Marine Environmental Science (TIMES) includes multiple guidelines for fisheries, waste, and litter, but **none are currently available for offshore wind farms**.

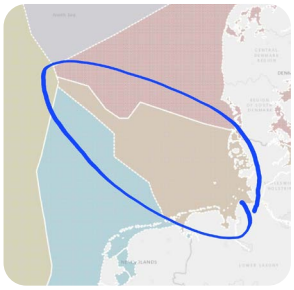
Overall, countries have different strategies to organise environmental monitoring around OWFs. Some have guidelines, but these are often not ecosystem-based or

focusing on a good Before-After-Control-Impact approach. Also, OSPAR, HELCOM and ICES do not seem to have specific guidelines for standardised monitoring in offshore wind farms.

Monitoring and challenges

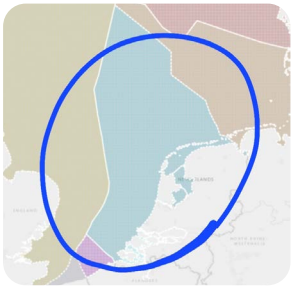
The expansion of offshore wind farms across Europe has brought significant environmental benefits in terms of combatting climate change, but it also presents complex challenges in monitoring their ecological impacts. Ensuring that marine ecosystems are protected while facilitating the growth of renewable energy infrastructure requires robust data collection and long-term assessments. Countries around the North and Baltic Seas have their own strategies.

Germany



In Germany, monitoring challenges stem from insufficient baseline data and inadequate long-term monitoring, which hinders the ability to assess the cumulative impacts of offshore wind farms on marine life. For the StUK4 various risks have been identified for the different phases, for example **pollutant emissions, changed sediment distribution and dynamics and changed current patterns**. A baseline study should be done over two successive, complete seasonal cycles before submitting the EIA. The introduction of **Renewable Acceleration Areas (RAAs)** (see REDIII Directive) reduces the scope of EIAs, resulting in less data collection and further complicating cumulative impact assessments.

The Netherlands

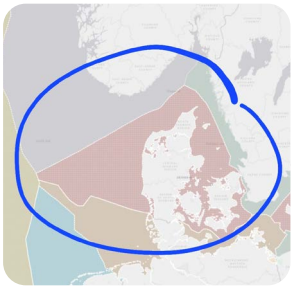


In the Netherlands, monitoring is primarily driven by the **Wind at Sea Ecological Programme (Wozep),** which is also closely related to the **Monitoring-Research-Nature enhancement-Species protection (MONS)**-programme**.** At the moment, MONS is busy setting up extensive monitoring where big knowledge gaps are limiting, e.g. phyto and zooplankton. Most of the current investigations is not actual monitoring but research for a few years. Some of this is performed by research institutes or companies, while other research is done by the wind farm operators themselves. This is sometimes requested in the tenders, but not always and not always mandatory either. The challenge lies in starting up real and long-term monitoring, especially for the risks that are indirect (e.g. hydrodynamic changes).

Belgium

In Belgium, the federal government organises offshore wind farm monitoring within the framework of environmental permit requirements. This monitoring is coordinated through the **long-term WinMon.BE programme**, involving institutions like the Royal Belgian Institute of Natural Sciences (RBINS) and other research bodies. Developers are required to fund and participate in monitoring, as stated in their permits, which includes granting access to their wind farms for research. There are no standardised guidelines in Belgium, but monitoring typically **follows consistent methods**, such as using ICES protocols for fish and epibenthos. Despite Belgium's strong national monitoring framework, challenges remain, especially in terms of harmonising international monitoring and assessing cumulative impacts.

Denmark



In Denmark, the Danish Energy Agency (DEA) serves as a **one-stop shop** for managing offshore wind farm projects, streamlining the permitting process. However, Denmark faces challenges with its lack of a standardised long-term monitoring programme. Current efforts **focus on protected species** like migrating birds and marine mammals, but there is also some attention to broader ecosystem impacts such as **hydrographical changes**. While monitoring is required during construction and operation, often for only three years, long-term assessments of impacts are lacking, and monitoring of bat populations is minimal, despite evidence of potential effects on migrating bats. Developers in Denmark are also required to investigate the environmental impacts of the export cable. More comprehensive, ecosystem-wide monitoring is needed to ensure the long-term sustainability of offshore wind projects.

The UK

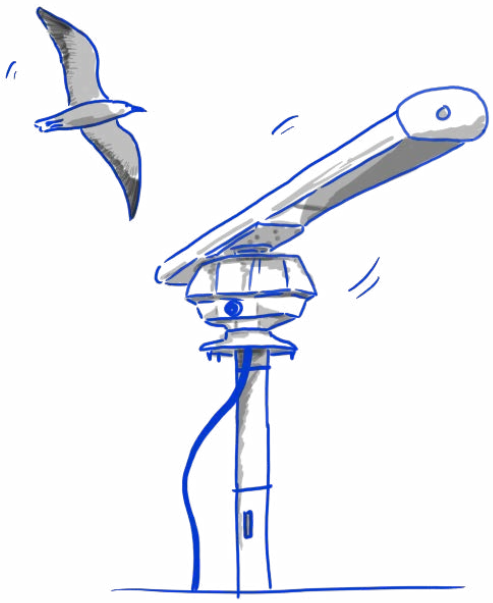
In the UK, the main challenges arise from the fragmentation of responsibilities across devolved administrations, leading to inconsistencies in monitoring practices. While monitoring is extensive during the **Development Consent Order (DCO)** application process, it often fails to address appropriate spatial and temporal scales, particularly for **Cumulative Impact Assessments (CIAs)**. Stakeholders have expressed concerns that these assessments tend to focus on individual species or habitats, rather than taking a broader ecological perspective. The absence of reliable long-term datasets compounds these issues, as shifting baselines complicate the accurate measurement of ecological changes over time, especially for sensitive species like seabirds and marine

mammals. Best practices in the UK include initiatives such as the **Offshore Wind Evidence and Change Programme (OWEC)** and the **Scottish Marine Energy Research (ScotMER) Programme**, which aid in standardised monitoring requirements across regions. However, ensuring long-term consistency and improving cumulative impact assessments remain key challenges. In order to work towards standardisation and streamline data gathering the Offshore Renewable Energy Catapult calls for the adoption of a **Regional Ecosystem Monitoring Programme (REMP)**.

HELCOM

In HELCOM-regulated areas, the lack of standardised monitoring protocols across countries complicates efforts to compare data and assess cumulative impacts. HELCOM's coordination of long-term ecological monitoring is vital, but **inconsistencies between member states** and technical complexities in offshore environments make comprehensive data collection challenging. HELCOM primarily focuses on protecting migratory bird habitats and mitigating underwater noise impacts, but broader ecosystem-wide assessments are still needed.

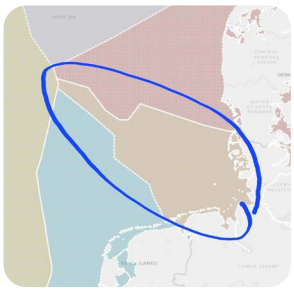
Across the investigated regions, common and country-specific issues include insufficient baseline data, difficulties in assessing cumulative impacts, and the lack of standardised monitoring protocols. Resulting in **key gaps in monitoring** across the North Sea and Baltic regions include the assessment of electromagnetic fields (EMF), the hydrodynamic impacts of offshore wind farms, and cumulative impacts, especially with other marine users. Long-term, standardised ecosystem monitoring remains essential to address these challenges effectively.



Data usage (policy) and sharing

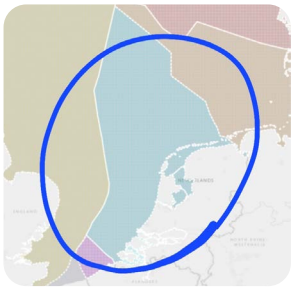
Effective data collection, usage, and sharing play a critical role in managing and mitigating the environmental impacts of offshore wind farms across all countries. At the moment, approaches to data management vary significantly between nations, and challenges remain in ensuring that data is accessible, standardised, and used effectively for environmental protection and policy development.

Germany



In Germany, ecological data related to offshore wind farms is systematically collected during pre-construction, construction, and post-construction phases. This data is submitted to regulatory authorities such as the **Federal Maritime and Hydrographic Agency (BSH)** for analysis, and compliance reports are shared with the public and stakeholders. The raw data are stored by the applicant and are made available to the approval authority upon request. The raw data from underwater noise measurements has to be archived exclusively by the planning approval authority and the exchange of this raw data is prohibited. However, the new Renewable Acceleration Areas (RAAs) under RED3 complicate data acquisition, **reducing the scope of required Environmental Impact Assessments** (EIAs) and potentially resulting in less data being gathered. While data is theoretically available for public and research use, the shift in policy raises concerns about the long-term availability and quality of ecological data.

The Netherlands

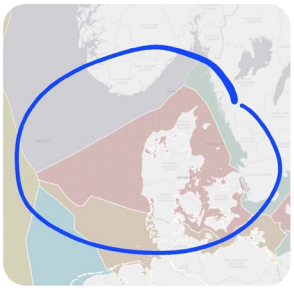


In the Netherlands, ecological data collection is managed through centralised government research programs such as **Wozep** and **MONS**, which collaborate with industry stakeholders and research institutions. The data is used to inform regulatory decisions and is **made publicly accessible through reports**. However, maintaining data quality and standardising methodologies across projects remain significant challenges, also because methodologies improve and innovation is ongoing. Additionally, the Netherlands participates in regional data-sharing initiatives with neighbouring countries to promote a comprehensive understanding of offshore wind impacts, although fully integrating data from different sources remains difficult.

Belgium

In Belgium, data sharing is primarily driven by the **WinMon.BE** programme, which produces annual reports and scientific papers that disseminate monitoring results. The government ensures that the data collected from offshore wind farm monitoring is available to stakeholders and the public through platforms like the **Open Marine Archive** from the Flanders Marine Institute. However, despite this progress, there are still challenges in making data better accessible, harmonising data across international borders and aligning the data collected from different projects. There is a need for better integration of raw data into regional or international systems to facilitate broader environmental assessments.

Denmark



In Denmark, ecological data is **frequently owned by developers**, but recent policy changes require developers to make data publicly available through government platforms. The Danish Energy Agency (DEA) oversees the sharing of this data and should ensure that it is used for research and policy purposes. No central, public website was found for this type of environmental data. Also, data sharing from older projects remains inconsistent, and there is **limited integration across projects**. There is also a recognised need for better data on ecosystem-wide cumulative impacts, particularly for assessing the effects of multiple marine activities.

The UK

In the UK, data sharing is managed through the **Marine Data Exchange (MDE)**, a repository for environmental and geophysical data collected from offshore wind projects. Developers are required to submit data throughout the project lifecycle, including pre-construction, construction, and post-construction phases. While the **MDE** aims to standardise data formats and ensure accuracy, achieving full standardisation has been difficult due to jurisdictional differences and the use of legacy systems. However, the data is widely accessible to the public, researchers, and policymakers, contributing to a transparent approach to monitoring and environmental management. Additionally, the **Offshore Wind Evidence and Change Programme (OWEC)** funds the **Offshore Wind Evidence & Knowledge Hub**, which provides guidance and support documents next to relevant data and reports from the MDE.

Helcom

HELCOM emphasises the importance of open access to ecological data for assessing the environmental impacts of human activities, including offshore wind farms. The **HELCOM Monitoring and Assessment System (HELCOM MADS)** facilitates the sharing of data collected by member countries, promoting transparency and regional cooperation. However, there are still challenges in ensuring that data collection methods are standardised across different countries, making it difficult to compare data consistently. HELCOM also collaborates with international bodies like **OSPAR** to promote data-sharing across regional seas, although technical barriers and differences in data quality continue to hinder seamless integration.

Overall, there is a widespread recognition across all countries of the need for improved data sharing practices. Standardising methodologies, enhancing cross-border cooperation, and ensuring long-term data accessibility and European (and sea basin) level platforms remain critical to advancing environmental protection in offshore wind development.

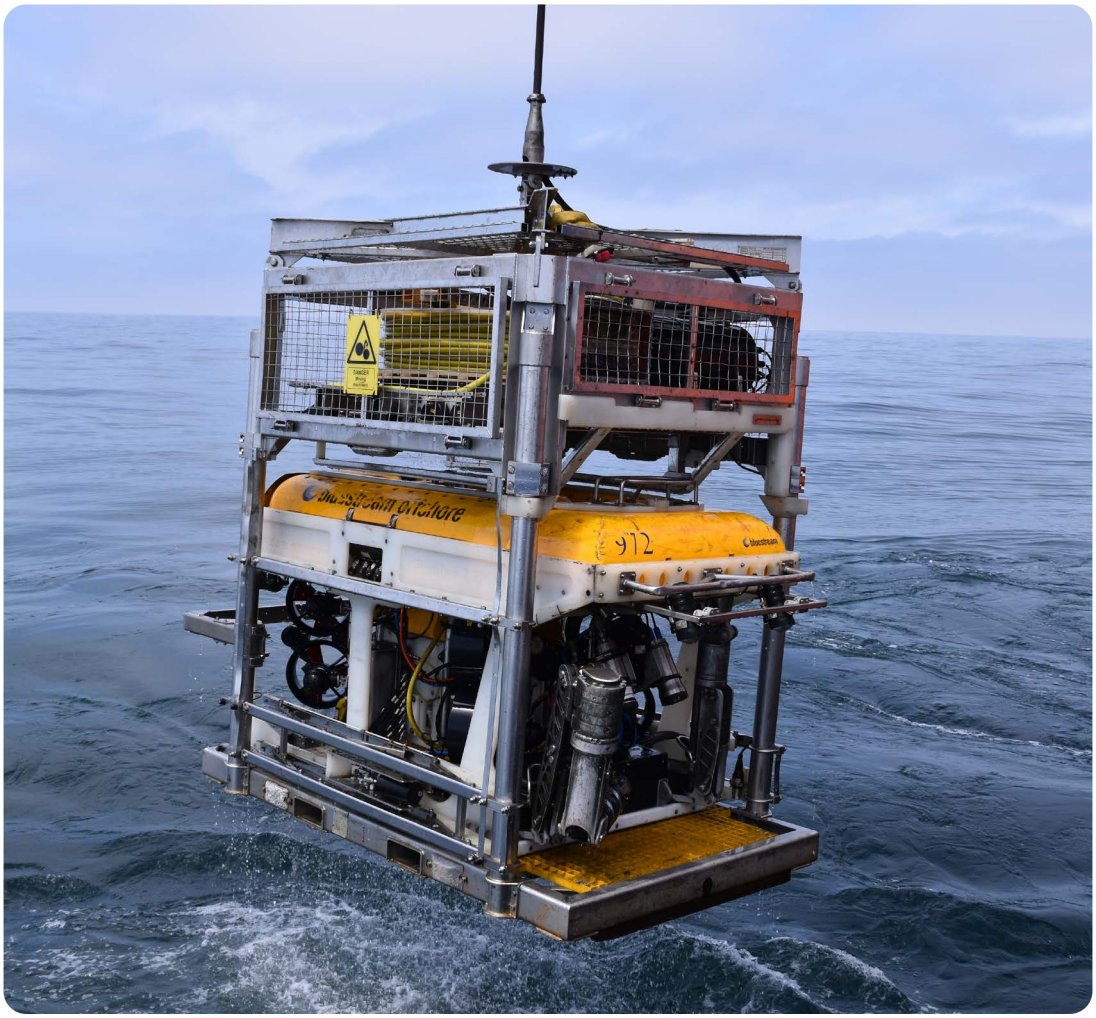


Photo: De Rijke Noordzee

Recommendations for standardising ecological monitoring guidelines in offshore wind energy

As offshore wind farms continue to expand and accelerate across Europe, the need for standardised ecological monitoring guidelines has become increasingly critical. The following recommendations highlight key steps towards standardising monitoring processes to ensure the sustainable development of offshore wind energy while safeguarding marine ecosystems.

1. Standardise ecosystem-based ecological monitoring guidelines across Europe

Policymakers should enforce standardised ecological monitoring protocols across Europe, particularly in shared marine regions like the North Sea and the Baltic Sea, where a lack of consistency in monitoring methods complicates the assessment of cumulative environmental impacts. To address this, a uniform system for baseline data collection, ongoing monitoring, and post-construction assessment must be established, covering the pre-construction, construction, operational and decommissioning phases of offshore wind farms. This baseline should be considered as a minimum and should not become a maximum. It is always better to monitor more or consider other potential risks. Also, some countries have other habitat types, endangered species etc., which is why there is a need for some adaptability of the standardised guidelines and why there needs to be a minimum.

Standardised monitoring guidelines should address changes within the ecosystem at multiple spatial and temporal scales in order to monitor effects on both biodiversity and ecosystem functioning. This ecosystem-based monitoring will also allow for the integration of regionally driven environmental indicators and local stakeholder engagement.

A key framework for achieving uniform baseline data collection is the OSPAR Convention, which governs the protection of the marine environment of the North-East Atlantic, and HELCOM for the Baltic Sea. OSPAR has historically focused on regulating offshore oil and gas activities, but its guidelines could be adapted to better cover offshore wind energy installations. By revising OSPAR's guidelines, reflecting on the needs of the offshore wind sector and science, Contracting Par-

ties can ensure that ecological monitoring for wind farms is harmonised across the region.

This revision should also integrate the Coordinated Environmental Monitoring Programme (CEMP). This programme of OSPAR provides standardised methodologies for collecting data on marine pollutants and biodiversity indicators, ensuring that all contracting parties are using consistent approaches. Applying this framework to offshore wind energy would ensure consistent data collection, enabling more accurate cross-border comparisons and cumulative impact assessments.

The International Council for the Exploration of the Sea (ICES) should be engaged to support the scientific development of these guidelines. ICES has extensive expertise in marine ecosystems, fisheries, and environmental monitoring and could play a crucial role in advising on best practices for monitoring the environmental effects of offshore wind farms. OSPAR and HELCOM could formally request ICES to collaborate in developing detailed and scientifically rigorous monitoring protocols that are specifically tailored to the needs of the wind energy sector or regulatory bodies. ICES' involvement would ensure that these guidelines are grounded in the latest scientific research and aligned with broader marine management efforts. These guidelines should be grounded in (regionally) relevant hypotheses, focus on ecosystem-wide key biological indicators and apply experimental designs that are capable of detecting change. This is essential to prevent an outcome that is data-rich but information-poor (Wilding et al. 2017).

By integrating OSPAR and HELCOM's regulatory frameworks with ICES' scientific expertise, countries can develop a robust, standardised system for monitoring the ecological impacts of offshore wind farms. This approach would ensure that data collected across regions is comparable, reliable, and capable of informing both national and international policies on marine ecosystem protection.

As this process won't be a short-term solution, countries could already start learning from each other. For example, the German StUK guidelines could be further explored and expanded. Another example: if it does not seem possible to develop a good government funded programme (such as WinMon or OWEC) for offshore wind environmental monitoring, non-price criteria, where points could be earned for incorporating long term monitoring, could be created in the tender.

2. Ensure adaptive management is standard practice

To keep up with evolving ecological conditions, adaptive management (by the government) should be a standard and enforceable requirement for offshore wind projects. It allows for real-time adjustments to monitoring and mitigation efforts based on new data and scientific insights, without disturbing long-term datasets. Governments must

ensure that these plans are dynamic and integrated into project development from the start, ensuring that offshore wind projects remain flexible and responsive to emerging environmental risks throughout the project lifecycle and particularly in sensitive marine ecosystems. This approach would ensure that the environmental risks of offshore wind farms are continuously assessed and mitigated as projects develop.

3. Establish a centralised platform for data sharing and accessibility

Effective ecological monitoring requires seamless access to high-quality data. Currently, several data-sharing platforms exist across Europe, but they are fragmented, making it difficult to consolidate data at a regional level. Policymakers should establish a centralised, standardised and open-access platform on a European level (and a sea basin level) for storing and sharing environmental data including those on offshore wind farms. This platform would allow for cross-border cooperation, improve transparency, and facilitate comprehensive analysis of ecological impacts. It would be best if existing national platforms (such as MDE and the Metadata portal of Belgium) would be sharing data to more centralised European platforms such as EMODnet.

Governments should mandate that data collected by developers is made publicly accessible and shared with research institutions to enable robust scientific analysis. Establishing a standardised data-sharing process would not only enhance transparency but also improve collaborative efforts between countries. Inspiration for data management guidelines can be drawn from networks like the Marine Environmental Data and Information Network (MEDIN) in the UK. MEDIN sets standardised data formats, metadata requirements (which align with ISO 19115), quality assurance, data sharing and accessibility, and long-term data preservation. Clear responsibilities for data handling, management, and usage must be outlined to ensure that shared data leads to actionable insights.

4. Maintain environmental safeguards in Renewable Acceleration Areas

While the acceleration of offshore wind development is essential for the energy transition, environmental protections must not be compromised in areas designated for rapid development, as is currently the case in Germany, and potentially could happen in other EU countries in the future. In these fast-track zones, environmental safeguards should be strengthened rather than reduced. Policymakers should implement adaptive

management strategies and continuous ecological monitoring to ensure that environmental risks are managed in real-time, even as wind farms are developed at an accelerated pace.

Countries should resist the temptation to lower Environmental Impact Assessment (EIA) standards in RAAs, as this could lead to a significant loss of critical ecological data and increased risks for the environment. Instead, a balanced approach is needed where development speed is matched by robust environmental protections and monitoring practices, ensuring that renewable energy growth does not come at the expense of marine ecosystems. EIA should also be more focused on contributing to the GES of the North and Baltic Seas instead of just minimising the activities impact.

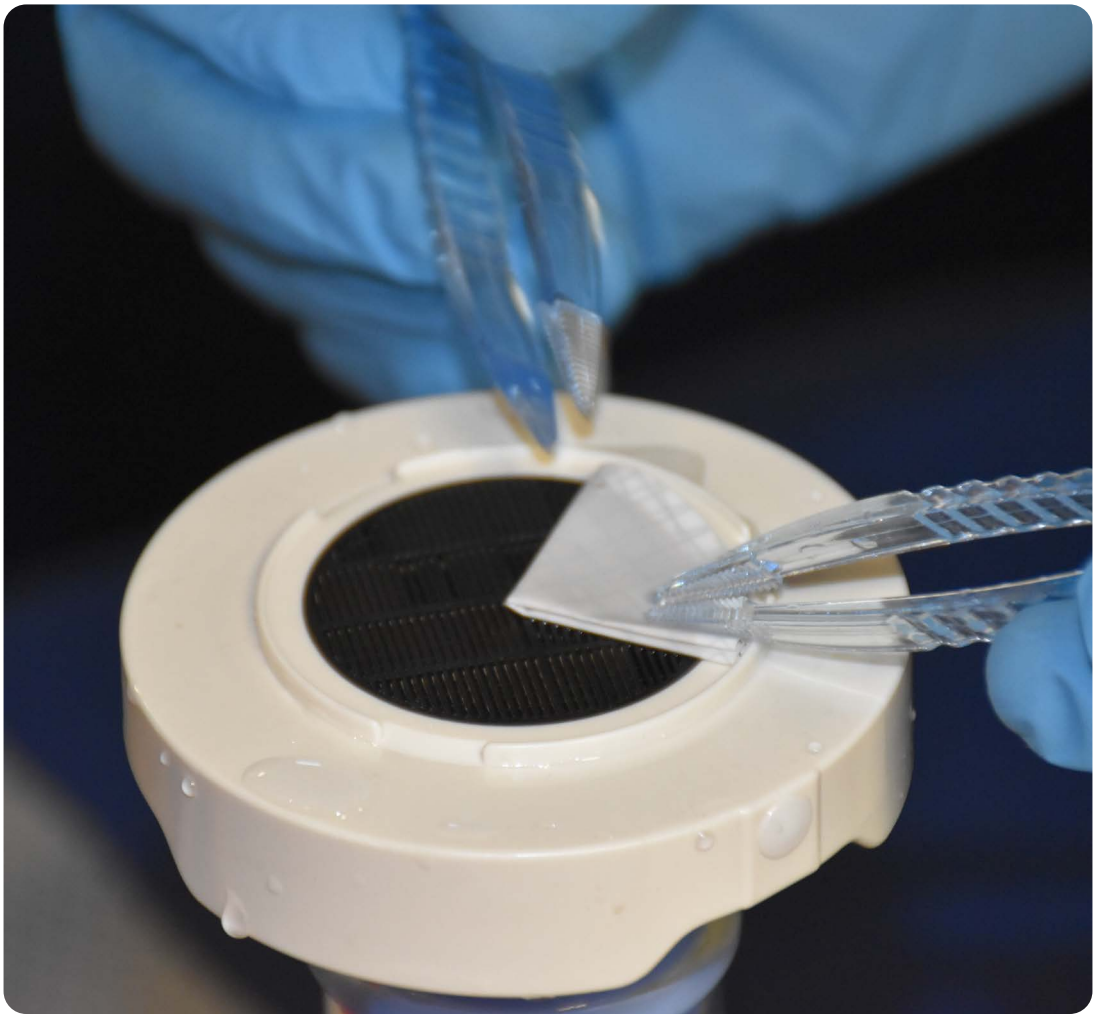


Photo: De Rijke Noordzee

Conclusions

The rapid expansion of offshore wind energy in the North Sea and Baltic Sea regions presents both an opportunity and a challenge. While it is essential to meet the growing demand for renewable energy to combat climate change, it is equally important to ensure that this development does not come at the expense of marine biodiversity and ecosystem health. This report has highlighted the varied approaches to ecological monitoring across different countries, revealing both good practices and significant gaps. Monitoring is essential for healthy marine ecosystems. A healthy marine ecosystem not only support human activities but also maintains ecosystem services, such as global climate stability, as oceans serve as the planet's largest carbon sink.

One of the most critical takeaways is the need for standardised ecological minimum monitoring guidelines for OWFs across Europe. The significance of environmental impacts of OWFs lies in the complete overview of human activities, wherefore cumulative impacts should be taken seriously. Fragmented monitoring efforts make it difficult to compare data, assess these cumulative impacts, and implement coordinated strategies to protect marine life. By developing and implementing standardised monitoring protocols, countries can improve data quality, enhance cross-border cooperation, and ensure that the growth of offshore wind farms is sustainable in the long term.

OSPAR, ICES and HELCOM are key players in this effort, as all of these organisations have established frameworks (currently only for other human activities) that can help guide the standardisation process, ensuring that ecological monitoring meets international best practices. OSPAR's Coordinated Environmental Monitoring Programme (CEMP) and ICES' expertise in marine science offer valuable resources for improving data collection and cross-border collaboration. In the meantime, countries could learn from each other's best practices.

The creation of a centralised data-sharing platform would promote transparency, making ecological data available to all relevant stakeholders, from governments to researchers, industries and NGOs. This would improve data integration, decision-making and facilitate the development of more effective mitigation measures.

In conclusion, while the offshore wind sector is making strides towards a greener energy future, the protection of marine ecosystems must be at the forefront of this transition. A balanced approach that integrates renewable energy development with robust environmental safeguards is not only possible but necessary. Through better collaboration, improved data sharing, and minimum standardised monitoring practices, Europe can lead the way in sustainable offshore wind energy development that preserves the health of its seas for future generations.

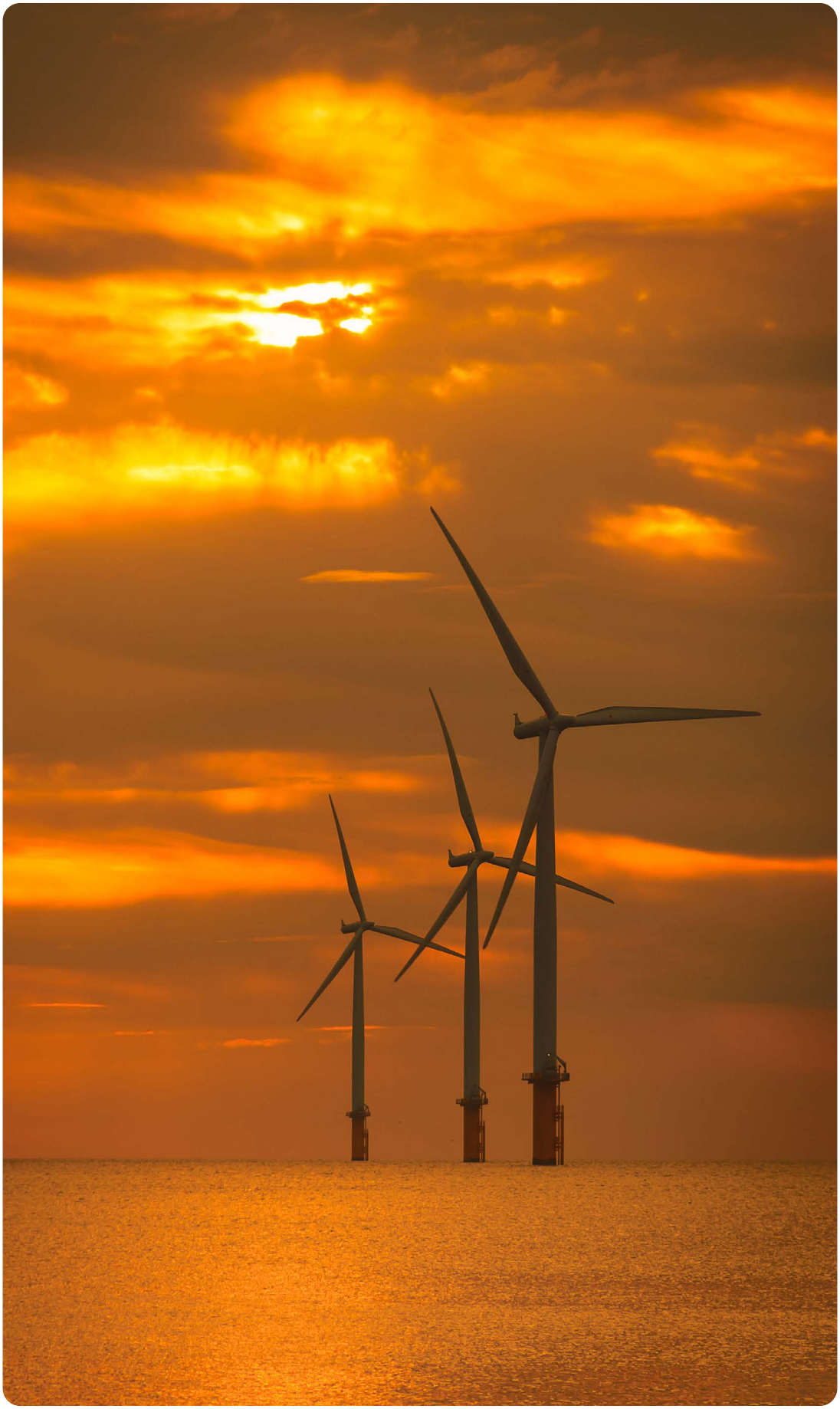


Photo: Kapook2981 | iStock

Appendices

Appendix I: List of interviews

Appendix II: Analysis per country or region

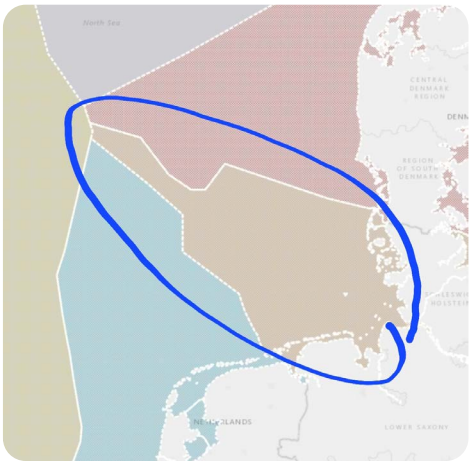
Appendix I - List of interviews

Country	Name of organisation	Stakeholder type	OCEaN member
Germany	50 Hertz	TSO	Yes
	Vattenfall	Company	Yes
Netherlands	Tennet NL	TSO	Yes
	Van Oord	Company	No
	Eneco	Company	No
	Boskalis	Company	No
Belgium	Natuurpunt	NGO	No
	Royal Belgian Institute of Natural Sciences	Science	No
Denmark	Orsted	Company	Yes
	The Ocean Institute	NGO	Yes
	Aarhus University	Science	No
United Kingdom	National Grid Ventures	TSO	Yes
	JNCC	Science	No
	The Wildlife Trusts	NGO	Yes
	RSPB / Birdlife	NGO	Yes
	Blue Marine Foundation	NGO	No
	The Crown Estate	Public corporation	No
	Howell Marine Consulting	Company	No
Others	WindEurope	Wind	Yes
	World Wide Fund for Nature - Europe	NGO	Yes

Appendix II
Analysis per country or region

Germany

GE - Process and Guidelines



Monitoring ecological risks related to offshore wind farms in Germany is governed by a comprehensive process that follows strict guidelines and regulatory requirements. The process begins with a Strategic Environmental Assessment (SEA), followed by an Environmental Impact Assessment (EIA) during the permitting phase. Public consultations and permit approvals are handled by the Federal Maritime and Hydrographic Agency (BSH). Pre-construction monitoring as part of the SEA establishes baseline data, while continuous monitoring during construction assesses the immediate impacts of visual and acoustic stress, sound and light emissions, habitat loss, pollutant emissions, and water turbidity, among other factors. Post-construction monitoring evaluates long-term ecological effects, with regular reports submitted to ensure compliance and adaptive management. During the operational phase, monitoring is required for 3-5 years, depending on the specific conditions of the site and the conservation features involved. Some research is carried out by the government, while other parts are conducted by developers under the supervision of the BSH.

Key guidelines include the BSH's Standard Investigation of the Impacts of Offshore Wind Turbines on the Marine Environment (StUK), which provides detailed protocols for data collection and analysis. However, it is important to note that StUK is the result of expert discussions during which the BSH or the relevant approval authority made political decisions on specific versions. As a result, there is no fully independent scientific study or established guidelines from the BSH. The baseline study that needs to be done from the StUK is something that should be done for every offshore wind park that is build and should not be skipped due to the RAAs. However the sharing of the raw data of the baseline study can be done better.

Additionally, ISO standards and the German Federal Nature Conservation Act (BNatSchG) provide the legal framework for nature conservation. An adaptive management approach is employed in general, allowing for adjustments based on monitoring results and new scientific knowledge, with stakeholder engagement theoretically ensuring transparency and incorporating feedback into the monitoring and management process.

Despite the push for rapid offshore wind expansion, basic environmental data collection is often being neglected in efforts to expedite development. There is already a lack of sufficient data on the impacts of offshore wind projects, and further reducing data collection—such as by discarding EIA results—will worsen the already inadequate understanding of the affected ecosystems, leaving insufficient information to implement effective ocean protection measures.

GE - Monitoring and Challenges

Concerns have been raised about the ecological monitoring process for offshore wind farms in Germany. These criticisms include inadequate baseline data, insufficient long-term monitoring, and a lack of focus on the cumulative impacts of multiple wind farms on marine life. Specific issues include noise pollution during construction, seabed habitat disruption, and insufficient measures to protect species like birds and marine mammals. There are also concerns about transparency, stakeholder involvement in decision-making, and the effectiveness of mitigation measures. While the importance of renewable energy is widely acknowledged, scepticism exists over whether current practices are sufficient to preserve marine ecosystems, leading to calls for more comprehensive monitoring, stricter impact assessments, and stronger mitigation strategies to protect marine life.

The Renewable Energy Directive 3 (RED3) is currently being implemented into national law, with the offshore area plan being further developed. According to current BSH plans, 36 GW out of the 60 GW of offshore wind development areas planned by 2038 are set to be designated as Renewable Acceleration Areas (RAA). These areas will entail reduced environmental standards, including the absence of Environmental Impact Assessments (EIAs) and special species protection assessments under §44 of the Federal Nature Conservation Act (BNatSchG). If more than half of the German offshore areas are classified as RAAs, there will be no EIA, leading to significantly less data acquisition. Although the SEA remains, this reduction in data collection poses a significant risk by exacerbating the already insufficient baseline data. Therefore, continuous monitoring is essential.

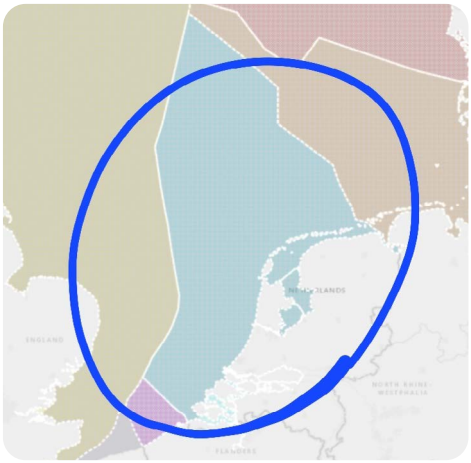
GE - Data Usage (Policy) and Sharing

In Germany, ecological data related to offshore wind farms is systematically collected through pre-construction surveys and continuous monitoring during and after construction to assess environmental impacts. However, with the introduction of RAAs under RED3, data acquisition is becoming increasingly complex. Data is analysed to compare pre- and post-construction conditions and ensure compliance with environmental regulations, with reports submitted to authorities such as the Federal Maritime and Hydrographic Agency (BSH). This data is shared with regulatory bodies, research institutions, and the public to ensure transparency and inform stakeholders. It supports scientific research, policymaking, and

the development of adaptive management strategies to mitigate environmental impacts and promote sustainable offshore wind energy development.

Netherlands

NL - Process and guidelines



In the Netherlands, monitoring ecological risks related to offshore wind farms involves a comprehensive process that includes pre-construction surveys to gather baseline ecological data for the site decision and detailed Environmental Impact Assessments (EIAs) to evaluate potential negative environmental impacts. Also, mitigation measures and monitoring during and after construction are performed to track changes in marine ecosystems; however, this is not done for all species and ecosystem functions and also the timeframe after constructions varies. It's mostly about answering short-term research questions and not about continuous monitoring. In the Netherlands, there is some baseline monitoring such as MWTL and WOT. After a wind farm is constructed, this monitoring continues, if possible (MWTL airplane countings are not allowed in offshore wind farms). In the Netherlands, a central government research programme has been active since 2016: the Wind at Sea Ecological Programme (Wozep), which does research into the environmental impact of offshore wind. Wozep is funded by the Ministry of Climate and Green Growth. At the moment, there is no comparison of the monitoring data before and after a construction of an OWF. This is something Wozep wants to look into, as well as whether the trend monitoring suffices for this purpose. Wind farms must perform monitoring if this is prescribed in the site decisions and/or if they stated it in the tender. If insufficient effective monitoring has been laid out (the pre-qualification), operators do not get points and might not be able to win the permit of that wind farm. The method which is used to measure the effectiveness of the monitoring is the BACI (Before–After–Control–Impact) method.

NL - Monitoring and challenges

A big challenge in the Netherlands is that the site decisions have to be made quite a long time in advance, and that knowledge development takes a long time. This means that, at the moment, decisions have to be made when not all the knowledge is available. Time pressure is a big challenge.

Insufficient baseline data and natural temporal variability complicate the assessment of pre-construction ecosystem states. Attributing observed ecological changes specifically to wind farm activities is difficult due to cumulative impacts and other environmental stressors. Long-term monitoring requires sustained fun-

ding and consistent methodologies, while biodiversity assessment must account for a wide range of species, including cryptic ones. At the moment the Monitoring-Research-Nature enhancement-Species protection (MONS) programme is starting up a broader package of monitoring and research, which focusses on the three transitions in the Dutch North Sea (Energy, Nature and Food transition).

NL - Data usage (policy) and sharing

In the Netherlands, ecological data related to offshore wind farms are collected through extensive research programmes (Wozep and MONS) and shared among government agencies, research institutions, (industry) stakeholders, and the public. The data is used to assess environmental impacts, inform policy and regulatory decisions, and guide adaptive management practices. Results from these research and monitoring activities are made publicly accessible through reports, databases, and scientific publications. Collaboration with international bodies and neighbouring countries helps to ensure a comprehensive understanding of ecological impacts and promotes regional cooperation. However, challenges include maintaining data quality, standardising methodologies across different projects, and effectively integrating various data sources for thorough analysis and decision-making.

Belgium

BE - Process and guidelines

In Belgium, the federal government is responsible for everything offshore, except for certain parts of coastal protection, port accessibility etc. It is also the federal government that organises the monitoring of offshore wind farms in the context of the environmental permit requirements. The government decides where money paid by developers goes to, focusing on the knowledge gaps and priority environmental concerns. There is a long-term (>15 years) offshore wind effects programme: WinMon.BE. This programme is executed and coordinated by the "Marine Ecology and Management" team of the Institute of Natural Sciences (RBINS), in collaboration with e.g. the Marine Biology research group of the University of Gent, the Research Institute for Nature and Forest and the Flanders Research Institute for Agriculture, Fisheries and Food. Wind farm operators have no obligation for ecological monitoring during the 35 years of their licence, other than for the EIA and its appropriate assessment. Also, they must grant access to other parties for monitoring, this is stated in the permits.

There is no a single document with standardised guidelines, but scientific institutes organise the monitoring and the federal government is controlling

it. Monitoring is required and detailed in the environmental licence. Most monitoring does have standardised practices, e.g. macrobenthos monitoring of soft sediment and scour protection has been carried out for 13 years using the same methods. For epibenthos and fish, ICES guidelines are used. Besides basic monitoring, targeted monitoring or research too is performed in WinMon.BE. There is potential for adaptation to new technologies or a focus on other knowledge gaps within the programme.

BE - Monitoring and challenges

In Belgium, monitoring includes or has included (non-exhaustive list): radar and field bird observations, tagging and models, fish telemetry, trawling, noise measurements, acoustic monitoring of harbour porpoise and field observations, sandy sediment and artificial substrate benthos sampling and video footage of soft sediment and assets. Also, more specific research has been done on fishing activities in and around wind farms and pollution from e.g. anodes. With bird curtailment starting in a few years, (song)bird migration is already being monitored. Advantages of the Belgian system of OWF monitoring are described in an OCEaN case study.

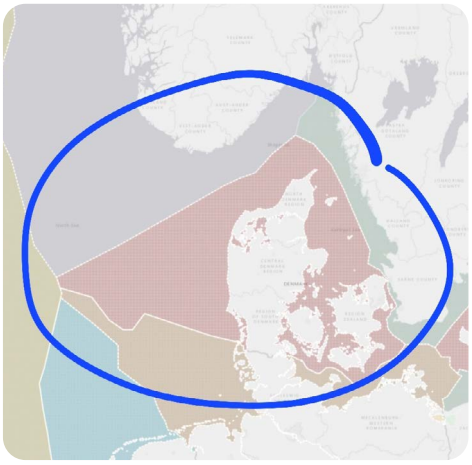
All OWFs in Belgium are grid connected by operator Elia, no pipelines are used for transportation of renewable energy yet. Grid risks for nature are covered by the EIA and recently, EMF is considered in the national monitoring programme as targeted research. However, no consistent field monitoring is currently being performed. As the Belgian part of the North Sea is well-mixed throughout the year, there is no risk of destratification. As no OWF has been decommissioned in Belgium yet, no monitoring has been performed, but this is likely to be included in the WinMon.BE programme. There is much knowledge on local scale, but challenging is international monitoring as well as translation of effects up to production level (of fish) at this scale and cumulative impacts, also with other uses.

BE - Data usage (policy) and sharing

Due to the federal research programme, there is a relatively good interpretation and usage of data for policy choices. A yearly report and scientific papers are used to spread the knowledge of WinMon.BE. Some chapters in the report are directly written as scientific advice, for example on decommissioning. These are based on the results of the long-term monitoring programme. Also, advice for the new offshore wind farm areas, a.o. about design, risks for nature, mitigation measures and measures that promote biodiversity has been reported and is fully based on the knowledge developed in the WinMon.BE programme. Reports are also made available in the Open Marine Archive from the Flanders Marine Institute. Raw data is (being) entered into the Metadata portal and Oceanographic portal.

Denmark

DK - Process and Guidelines



The Danish Energy Agency (DEA) coordinates offshore wind projects in Denmark by working with various national authorities, such as the Ministry of Environment, Ministry of Defence, Ministry of Food, Agriculture, and Fisheries, Danish Maritime Authority, Danish Business Authority, and Energinet. This centralised approach efficiently manages operational challenges related to wind farms, offshore substations, and export cables, ensuring compliance with environmental and construction regulations.

The DEA initiates the tender process, starting with site selection and coordination with relevant authorities. This is followed by a Strategic Environmental Assessment (SEA) to evaluate the potential environmental impacts of offshore wind projects, including wind farms and export cables. Developers are then granted permits to conduct more detailed Environmental Impact Assessments (EIAs), which focus on specific effects on marine ecosystems, seabeds, and local communities.

During the construction phase, the DEA works closely with other agencies to ensure that all environmental investigations are completed and that final permits are in place. This includes overseeing compliance with conditions for constructing offshore wind farms (OWFs) and ensuring environmental standards are adhered to. The DEA continues to monitor the project throughout its lifecycle, including licensing for decommissioning or repowering the wind farms.

The Marine Conservation Fund, introduced in 2023, supports projects focused on marine biodiversity restoration and plays a vital role in ensuring the balance between offshore energy production and the protection of marine ecosystems. This fund encourages developers to contribute to initiatives that foster coexistence between offshore wind farms and marine conservation efforts.

Denmark is currently tendering at least 6 GW of offshore wind capacity, with bid deadlines for North Sea projects in December 2024 and for projects in the Inner Danish Waters and Baltic Sea in April 2025. Notably, acceleration areas for offshore wind development have not yet been established in Denmark.

Recent policy changes have replaced the previous “open-door” system with a more structured tender process, ensuring that environmental factors are addressed early on. While current monitoring focuses on specific (protected) species,

there is increasing recognition of the need for an ecosystem-based approach in future offshore wind projects.

DK - Monitoring and Challenges

Developers are required to assess the impacts on birds, marine mammals, seabeds, and hydrographical changes. While Denmark mandates post-construction monitoring for at least three years, there are some gaps in the overall approach, particularly when it comes to addressing broader ecosystem concerns. For example, there is no standardised long-term monitoring programme in place for many species, and certain areas, like bat populations, are not consistently included in environmental assessments despite their potential vulnerability.

From a recent EIA (Vesterhav Syd), it is clear that during the operational phase, no fishing using regular trawls or boom trawls is allowed within the wind farm and across the export cables. However, passive fishing is expected to be allowed, reflecting Denmark's balanced approach to both energy development and the protection of marine resources.

The Transmission System Operator (TSO), Energinet, is responsible for environmental impact assessments (EIAs) of the land-based sections of export cables, ensuring that these transitions from offshore to onshore adhere to environmental standards. The DEA oversees the entire process, including the publication of final EIA reports for public consultation. Licences for wind farms, substations, and cables are granted for an initial period of 30 years, with the possibility of an extension for five additional years.

Monitoring is required for at least three years post-construction, although there is currently no standardised long-term monitoring programme. Developers must not only monitor wind farms but also track the environmental impacts of export cables, particularly their effects on seabed habitats during installation and operation. A significant challenge for Denmark's offshore wind sector is the lack of comprehensive data on the cumulative effects of multiple pressures on marine ecosystems. While current monitoring focuses on specific species, broader ecosystem-wide data collection is needed to gain a full understanding of environmental impacts.

There is also increasing interest in gathering data from other maritime activities, such as fishing and shipping, to better assess cumulative impacts. These activities could provide valuable insights for improving the accuracy of cumulative impact assessments, currently limited by data gaps.

DK - Data Usage (Policy) and Sharing

Developers are required to gather and share high-quality environmental data with relevant authorities, including the Geological Survey of Denmark and Green-

land (GEUS) for geophysical and geotechnical data related to export cables. Raw meteorological and oceanographic data must also be made publicly available during the operational phase of wind farms, contributing to transparency and supporting research.

Denmark's tenders require environmental data to be quality-assured and transferred to public databases, ensuring transparency and accountability. This data is vital for policymaking, especially in determining optimal wind farm locations, and assessing their environmental impacts.

Despite these advances, the lack of comprehensive data on ecosystem-wide cumulative impacts remains a challenge. There is a need for more data sharing from other maritime activities, which would greatly enhance the accuracy and effectiveness of cumulative impact assessments. Expanding data collection efforts across various maritime activities will be essential for building a more comprehensive understanding of cumulative effects, ultimately leading to more informed environmental and industrial policies.

HELCOM

The Baltic Marine Environment Protection Commission, also known as the Helsinki Commission (HELCOM), is an intergovernmental organisation and a regional sea convention in the Baltic Sea area. HELCOM was established in 1974 to protect the marine environment of the Baltic Sea from all sources of pollution from land, air and sea. The 10 Contracting Parties to HELCOM are Denmark, Estonia, European Union, Finland, Germany, Latvia, Lithuania, Poland, Russia and Sweden.

HELCOM organises regular assessments of the state of the marine environment and environmental pressures on a Baltic Sea basin scale. Its role in guiding and regulating offshore wind developments in the Baltic Sea is limited. The process and guidelines to achieve a good environmental status are embedded within the broader framework of the Baltic Sea Action Plan (BSAP), which was updated in 2021 and the regional MSP roadmap 2021-2030.

The 2021 BSAP is divided into four segments with specific goals to be achieved by 2030:

1. Biodiversity, with its goal of a "Baltic Sea ecosystem is healthy and resilient"
2. Eutrophication, with its goal of a "Baltic Sea unaffected by eutrophication"

3. Hazardous substances and litter, with its goal of a "Baltic Sea unaffected by hazardous substances and litter", and
4. Sea-based activities, with its goal of "Environmentally sustainable sea-based activities"

HE - Key Guidelines and Processes in relation to offshore wind developments

HELCOM is not directly mandated to issue specific guidelines for EIAs related to offshore wind farms, as the responsibility for environmental permitting rests with national authorities. However, HELCOM provides overarching guidance through its action plans, monitoring guidelines, and recommendations, focusing on the marine environment, including biodiversity and water quality, as well as pressures such as pollution, underwater noise or habitat disruption. Offshore wind farms are regarded as one of several human activities that exert pressures on the marine environment. This is reflected in various HELCOM monitoring guidelines e.g. HELCOM's guidelines for monitoring continuous noise. The BSAP includes a timeline and actions to address underwater noise from wind farms. Specifically for birds, HELCOM issued a recommendation as part of the 2013 Ministerial Declaration on safeguarding critical bird habitats and migration routes from the negative impacts of wind (and wave) energy production. This recommendation emphasises an ecosystem-based approach and encourages the sharing of data on seabird habitats and migratory routes for maritime spatial planning, along with joint assessments of the cumulative impacts of wind farms on bird populations. In addition, the BSAP recommends using sensitivity maps of migratory birds in EIA procedures to help protect these species.

Implementation and Compliance

All actions under the BSAP are to be fully implemented by 2030. Related to offshore wind developments, this is limited to underwater noise and birds. HELCOM remains the central body coordinating these efforts across the Baltic Sea region, ensuring a consistent and cooperative approach to offshore wind energy development.

HE - Monitoring and challenges

Ecological monitoring of the state of the environment, yet not exclusive to offshore wind farms, as outlined by HELCOM, is crucial for understanding the environmental impacts on the marine environment, including underwater noise and seabed integrity. HELCOM promotes long-term monitoring programs that assess changes in marine ecosystems both during and after wind farm construction, with a focus on minimising human disturbance. In 2013, the HELCOM Monitoring and Assessment Strategy was adopted. Current monitoring and assessments are still guided by this strategy. To support the HELCOM Monitoring and Assessment Strategy the HELCOM Monitoring Manual is developed. The Monitoring Manual provides a catalogue with all the existing marine monitoring which is carried

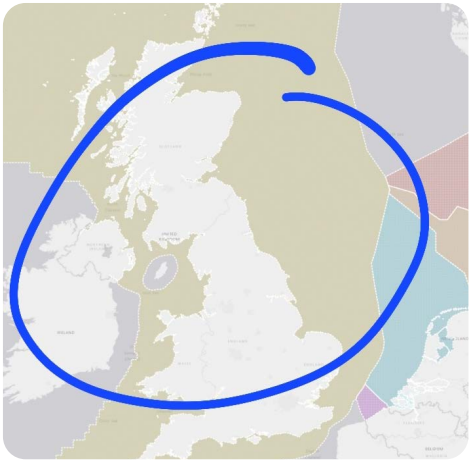
out in the Baltic Sea to get to a GES. One of the main challenges is the lack of standardised monitoring protocols across countries and projects, making it difficult to compare and assess impacts consistently. Additionally, the high costs and technical complexities of deploying monitoring technologies in harsh offshore environments pose significant hurdles. Moreover, cumulative impact assessments, which are essential for evaluating the combined effects of multiple environmental pressures in transboundary context, often suffer from data gaps and limited coordination between projects.

HE - Data usage (policy) and sharing

HELCOM's policy on data usage and sharing related to ecological monitoring emphasises open access, harmonised data collection, and regional collaboration. The data collected from ecological monitoring has to be reported to HELCOM by the Contracting Parties, ensuring transparency and facilitating informed environmental management decisions. Environmental impacts related to construction and operation of offshore wind farms primarily contribute to datasets on underwater noise, sea floor integrity and birds. HELCOM promotes standardised methods of data collection across Baltic Sea countries to ensure comparability and integration of datasets. It provides platforms such as the HELCOM Monitoring and Assessment System (HELCOM MADS) for sharing information. These platforms are vital for assessing the cumulative impacts of the various existing human pressures on the marine environment. HELCOM also works with other Minternational bodies such as OSPAR to ensure broader data-sharing and collaborative efforts across regions. However, challenges persist in ensuring consistent data quality and overcoming technical barriers in data exchange across different jurisdictions.

United Kingdom

UK - Process and guidelines



In the UK, the policy for environmental monitoring of offshore wind and grid projects is set by various governmental and regulatory bodies, with distinct responsibilities across the devolved administrations (Scotland, Wales, and Northern Ireland).

UK-wide

The Department for Energy Security and Net Zero (DESNZ) oversees the general policy framework for energy, including offshore wind, across the UK. DESNZ owns the offshore renewable energy target, but the Department for Environment, Food and Rural Affairs (DEFRA) owns the offshore wind consenting process. The Marine Management Organisation (MMO) is responsible for marine planning, licensing, and enforcement in English waters and parts of the offshore areas of Northern Ireland, Scotland, and Wales. The Crown

Estate owns and leases the seabed around England, Wales, and Northern Ireland, leasing areas for offshore wind projects, and other sectors. Great British Energy (GBE; formed in 2024), owned by DESNZ, will support energy project developments in all four nations and work closely with The Crown Estate and Crown Estate Scotland in order to bridge some of the fragmented responsibilities.

Devolved administrations
In Scotland, Scottish Government Marine Directorate handles marine planning, licensing, and monitoring, with Crown Estate Scotland managing seabed leasing. Welsh Government, Natural Resources Wales (NRW) and the Department of Agriculture, Environment and Rural Affairs (DAERA) fulfil similar roles in Wales and Northern Ireland, respectively.

Guidelines for monitoring
Project development areas are surveyed through pre-consent surveys commissioned by The Crown Estate. The scope of these surveys is developed through stakeholder engagement with developers, Statutory Nature Conservation Bodies (SNCBs) and Non-Governmental Organisations (NGOs). These surveys typically consist of Geophysics, Metocean, Passive Acoustic Monitoring (PAM) and Digital Aerial Surveys. This monitoring data feeds into the leasing round auctions. Additionally, a plan-level Habitat Regulations Assessment (PL-HRA) is performed alongside the tendering process. This additional monitoring is important for assessing whether the plan is likely to impact features of sites protected under the Habitats Regulations. Additionally, the PL-HRA is important to build momentum and investment confidence.

As part of the Development Consent Order (DCO) application, the winning developer needs to perform Environmental Impact, and Cumulative Impact Assessments (EIA, CIA respectively), next to the Habitat Regulation Assessment (HRA). When the project is capable of affecting a Marine Conservation Zone, a special assessment for these areas also needs to be performed. As part of the EIA, the developer is obliged to consult with statutory bodies responsible for marine licensing. Consultation with SNCBs is part of the HRA. All these assessments will feed into the project specific monitoring plans and adaptive management plans as part of the DCO. The monitoring plan, informed by Environmental Impact Assessments (EIA), cover baseline surveys, construction phase monitoring, operational monitoring, and post-construction monitoring. Regulatory bodies such as the MMO, Scottish Government, NRW, and DAERA, and SNCBs such as JNCC, Natural England and Nature Scot provide expert input and recommendations on monitoring requirements, ensuring that the plans address the unique environmental impacts of each project.

The DCO application is assessed by the responsible consenting organisation, the Planning Inspectorate. In Scotland the consenting is performed by the Energy Consent Unit. NRW and DAERA fulfil similar roles in Wales and Northern Ireland, respectively.

Developers are required to submit regular monitoring reports to these regulatory bodies, detailing their activities and findings to ensure compliance with the DCO conditions. This comprehensive approach and adaptive management plans allow for rigorous environmental monitoring that can adapt to the unique challenges and impacts of each offshore wind and grid project.

UK - Monitoring and challenges

Monitoring requirements for offshore wind and grid projects in the UK are often tailored to specific projects based on expert input during the Development Consent Order (DCO) application process. This process involves comprehensive environmental assessments and stakeholder consultations, leading to the inclusion of project-specific monitoring plans in the DCO and marine licence conditions. However, the fragmentation of responsibilities across the devolved administrations can result in an impenetrable and opaque process that frustrates stakeholders. As part of the HRA, required for the DCO, species and habitats that typically need monitoring are linked to Special Areas of Conservation (SACs) and Special Protection Areas (SPA). This typically includes marine mammals (harbour porpoises, grey and harbour seals), birds (seabirds such as gannets, and migratory birds such as common terns), fish (e.g. Atlantic cod), benthic invertebrates (e.g. *Sabellaria spinulosa*), and different coastal, sub- and intertidal habitats. Even though multiple assessments are part of the DCO application, some stakeholders argue that these assessment types address the wrong questions. CIAs consider individual receptors and do not account for appropriate temporal and spatial scales to assess the actual impacts at play at the ecosystem level. Reliable long-term datasets are needed to overcome the problem of shifting baselines. Monitoring method standardisation, data management, archiving and accessibility also pose significant challenges.

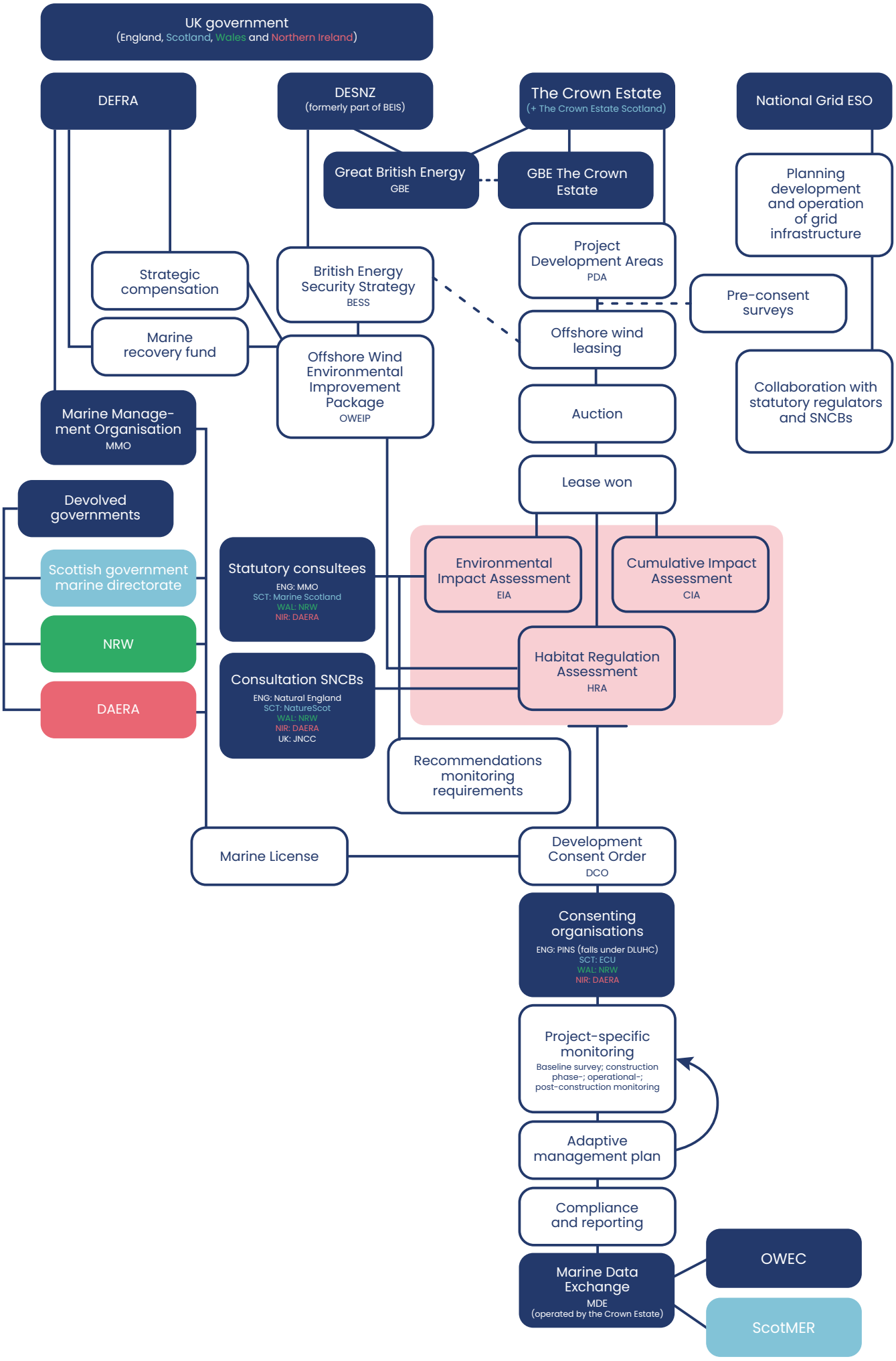
Fragmentation is also evident in the governance of offshore sectors, characterised by a siloed approach. The free market model has led to governance dependent on the private sector, with limited government coordination. This lack of coordination has created a disconnect between overarching strategic objectives and detailed, project-level information. As a result, aligning high-level policies with the practical realities of project implementation has become a significant challenge. Moreover, the introduction of new ideas and findings often leads to the creation of additional, isolated workstreams rather than enhancing integration within a cohesive framework.

UK - Data usage (policy) and sharing

Regulatory bodies often mandate data sharing with the Marine Data Exchange (MDE), managed by The Crown Estate, as part of marine licensing conditions. The MDE is a repository for environmental and geophysical data collected from offshore renewable energy projects. Developers collect and submit data during various phases of the project, including pre-construction, construction,

and post-construction, ensuring accuracy and completeness with the help of environmental consultants. Data submitted to the MDE includes environmental data (e.g., marine mammals, birds, benthic habitats, fish, and water quality) and geophysical and metocean data (e.g., seabed surveys, hydrodynamic data, and meteorological information). All data delivered to MDE must adhere to the Marine Environmental Data and Information Network (MEDIN) Guidelines. Despite efforts to standardise data formats for MDE, such as those by The Crown Estate and various regulatory bodies, achieving complete standardisation remains challenging. Legacy systems, jurisdictional differences, and technological advancements contribute to inconsistencies.

Collaborative initiatives like the Offshore Wind Evidence and Change Programme (OWEC) and the Scottish Marine Energy Research (ScotMER) Programme also feed into MDE. OWEC funds the Offshore Wind Evidence & Knowledge Hub, which provides guidance and support documents next to relevant data and reports from the MDE. Next to academic research into effects of offshore wind and grid projects, OWEC and ScotMER aim to align monitoring requirements and data standards across jurisdictions, promoting a more unified approach to environmental monitoring that will allow important questions to be answered with sufficient confidence to inform robust decision making.


UK government
(England, Scotland, Wales and Northern Ireland)
DEFRA
DESNZ
(formerly part of BEIS)
The Crown Estate
(+ The Crown Estate Scotland)
National Grid ESO
Great British Energy
GBE
GBE The Crown Estate
Planning development and operation of grid infrastructure
Project Development Areas
PDA
Strategic compensation
British Energy Security Strategy
BESS
Pre-consent surveys
Marine recovery fund
Offshore wind leasing
Offshore Wind Environmental Improvement Package
OWEIP
Collaboration with statutory regulators and SNCBs
Marine Management Organisation
MMO
Auction
Lease won
Devolved governments
Scottish government marine directorate
NRW
DAERA
Statutory consultees
ENG: MMO
SCT: Marine Scotland
WAL: NRW
NIR: DAERA
Environmental Impact Assessment
EIA
Cumulative Impact Assessment
CIA
Habitat Regulation Assessment
HRA
Consultation SNCBs
ENG: Natural England
SCT: NatureScot
WAL: NRW
NIR: DAERA
UK: JNCC
Recommendations monitoring requirements
Marine License
Development Consent Order
DCO
Consenting organisations
ENG: PINS (falls under DLUHC)
SCT: ECU
WAL: NRW
NIR: DAERA
Project-specific monitoring
Baseline survey; construction phase-; operational-; post-construction monitoring
Adaptive management plan
Compliance and reporting
Marine Data Exchange
MDE
(operated by the Crown Estate)
OWEC
ScotMER

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The North Sea Foundation / Stichting De Noordzee is an environmental non-governmental organization advocating the protection and sustainable use of the North Sea marine ecosystem. The goal is a clean, healthy sea and a well-functioning ecosystem. Its activities are focused on clean seas and beaches, clean shipping, sustainable fisheries, eco-friendly energy production, and protected nature.

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