

FLOATING OFFSHORE WIND
CENTRE OF EXCELLENCE

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CATAPULT
Offshore Renewable Energy

FLOATING OFFSHORE WIND ENVIRONMENTAL INTERACTIONS ROADMAP – 2nd EDITION



Credit: Equinor Hywind
Floating Wind Farm

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Date: 24/06/2026

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NOMENCLATURE

BHA	British Helicopter Association
CAA	Civil Aviation Authority
CCUS	Carbon Capture, Utilisation, and Storage
CES	Crown Estate Scotland
CIFA	Community Inshore Fisheries Alliance
CoE	Centre of Excellence
DESNZ	Department for Energy Security and Net Zero
Defra	Department for Environment, Food & Rural Affairs
eDNA	environmental DNA
EIA	Environmental Impact Assessment
EISP	Environmental Interactions Strategic Programme
EMF	Electromagnetic Field
EPC	Engineering, Procurement and Construction
ESCA	European Subsea Cables Association
FEED	Front End Engineering Design
FOW	Floating Offshore Wind
FOWT	Floating Offshore Wind Turbine
GW	Gigawatt
HRA	Habitats Regulations Assessment
HVDC	High Voltage Direct Current
IFCA	Inshore Fisheries Conservation Authority

INTOG	Innovation and Targeted Oil and Gas
JNCC	Joint Nature Conservation Committee
LCoE	Levelised Cost of Energy
LiDAR	Light Detection and Ranging
MCA	Maritime & Coastguard Agency
MGN	Marine Guidance Note
MMO	Marine Management Organisation
MRF	Marine Recovery Fund
MS-LOT	Marine Scotland - Licensing Operations Team
MSP	Marine Spatial Planning
MSS	Marine Scotland Science
NRA	Navigational Risk Assessment
NRW	Natural Resource Wales
ORE	Offshore Renewable Energy
ORJIP	Offshore Renewables Joint Industry Programme
OWEC	Offshore Wind Evidence and Change
OWEER	Offshore Wind Environmental Evidence Register
OWEIP	Offshore Wind Environmental Improvement Package
OWES	Offshore Wind Environmental Standards
O&G	Oil and Gas
O&M	Operations and Maintenance
PINS	Planning Inspectorate

PMSC	Port Marine Safety Code
SAR	Search and Rescue
SFF	Scottish Fishermen’s Federation
SMRU	Sea Mammal Research Unit
SPA	Special Protection Area
UXO	Unexploded Ordnance

1 BACKGROUND

1.1 Context

The UK Government has set ambitious targets associated with the decarbonisation of the energy system and investment in the growth of low carbon, renewable technologies. Offshore wind is critical to this process, and the UK is already positioned as a global leader with an operational capacity of 16.1 Gigawatt (GW) (Renewable UK, 2026). The Clean Power 2030 Action Plan outlines an ambition of 43-50 GW of offshore wind by 2030, and the plan highlights the longer-term role of floating offshore wind (FOW) technology in unlocking strong wind resources at deeper water depths, particularly as marine spatial planning constraints increase (Department for Energy Security and Net Zero, 2025).

At the time of writing, the UK has two operational demonstrator FOW arrays: Hywind Scotland and Kincardine, both located in Scotland. Furthermore, Crown Estate Scotland has granted seabed exclusivity agreements for FOW projects totalling around 25 GW of potential generating capacity in Scottish waters (Crown Estate Scotland, 2025).

In England and Wales, The Crown Estate has awarded rights to three FOW projects in the Celtic Sea totalling 4.5 GW of capacity through its Floating Offshore Wind Leasing Round 5 (The Crown Estate, 2025). In parallel, The Crown Estate is also facilitating Test and Demonstration leases for pilot-scale (100MW) FOW projects with the aim of supporting the commercialisation of new FOW technologies. Test and Demonstration projects in development at the time of writing include: Erebus, which has been awarded planning consent and a Contract for Difference (Blue Gem Wind, 2026); White Cross, which has secured full planning consent (Flotation Energy, 2025); and the Llŷr 1 and Llŷr 2 projects, which are variously undergoing the planning and consent application process (Llŷr, n.d.).

As the pace of FOW development increases it is recognised that, due to the technology's earlier commercial status relative to traditional bottom-fixed wind, a range of technical, commercial, and consenting challenges will need to be addressed. One important area of focus is the interaction between FOW technology and the environment, including the associated uncertainties that must be resolved through targeted monitoring and research.

For the UK FOW industry to scale up swiftly, it is crucial to address these environmental uncertainties proactively, enabling an efficient, timely, and transparent development and consenting process for future large-scale FOW projects. A key element of this will be the Environmental Impact Assessment (EIA) process, informed by a relevant, robust and proportionate body of knowledge regarding environmental impacts.

1.2 Project Overview and Related Work

With this context in mind, the Offshore Renewable Energy (ORE) Catapult's Floating Offshore Wind Centre of Excellence (FOW CoE) launched the Floating Offshore Wind Environmental Interactions project in September 2021, as part of its Development and Consent workstream. Fundamentally, this multi-phase initiative sought to:

- Identify potential knowledge gaps and the requisite activities to address them; and
- Coordinate onward workstreams to address these gaps, including relevant research initiatives and leading the development of innovative solutions.

In line with the first of these objectives, the FOW CoE published its Floating Offshore Wind Environmental Interactions Roadmap in June 2022. The Roadmap identified a range of potential knowledge gaps related to FOW environmental interactions across several topic areas and proposed corresponding research and activities to address them. A prioritisation exercise conducted during its development highlighted the areas representing the most pressing need for industry intervention. Figure 1 outlines the updated priority themes, as set out in this new edition of the Roadmap.

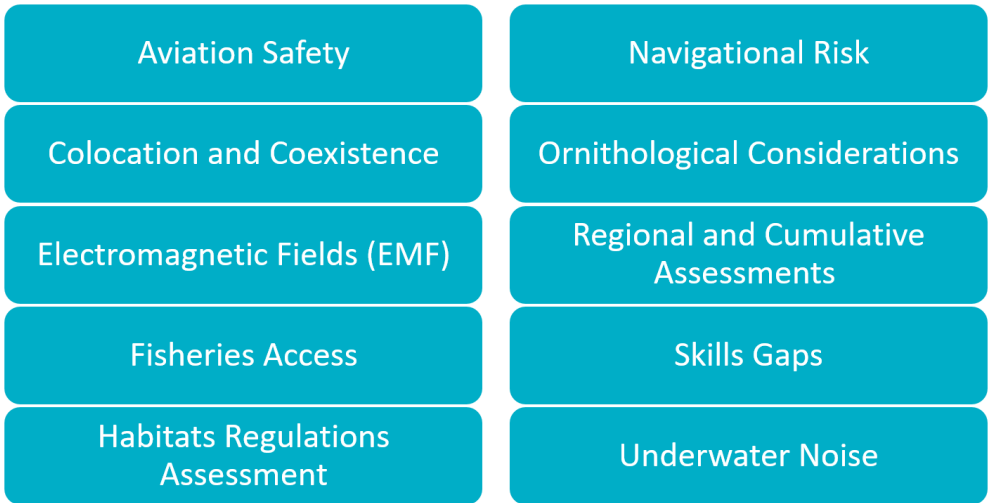


Figure 1 Floating Offshore Wind Environmental Interactions Roadmap Priority Themes

Given the breadth and multidisciplinary nature of these priority topics, the FOW CoE launched its [Environmental Interactions Strategic Programme](#) (EISP) alongside the publication of the Roadmap to coordinate projects and activities aligned with the second objective. To date, the FOW CoE has delivered a range of development and consent focussed projects, both prior to and following the launch of the EISP, and has published associated summary reports.

- [Floating Offshore Wind Development and Consenting Process – Risks and Opportunities](#) (published 2021)
- [Floating Offshore Wind and Fishing Interactions Roadmap](#) (published 2021)
- [An Overview of Scottish Fisheries Prepared for the Floating Offshore Wind Industry](#) (published 2021)
- [Floating Offshore Wind Environmental Interactions Roadmap](#) (original roadmap version, published 2022)
- [Floating Offshore Wind Navigational Planning and Risk Assessment](#) (published 2023)
- [Floating Offshore Wind Colocation and Coexistence – Risk and Opportunities](#) (published 2024)
- [Floating Offshore Wind Underwater Noise Monitoring and Mitigation](#) (launched 2024, project ongoing)
- [Floating Offshore Wind and Fishing Framework for Coexistence](#) (published 2025)
- [Floating Offshore Wind Dynamic Cable Electromagnetic Field \(EMF\) Environmental Review](#) (published 2025)

- Floating Offshore Wind Wet Storage in the UK – Environmental Interactions Review (launched 2025, project ongoing)
- Simulating Fishing Within Virtual Floating Offshore Wind Farms (launched 2025, project ongoing)

Since the publication of the Floating Offshore Wind Environmental Interactions Roadmap in 2022, research activity and knowledge within this field have grown significantly. The EISP and other industry initiatives and academic research projects have collectively advanced understanding across several key areas identified in the original Roadmap. As a result, the need to review and refine the programme's priority areas has increased. **This updated version of the Floating Offshore Wind Environmental Interactions Roadmap therefore builds on the work undertaken in 2022 and will inform the focus of the EISP going forward.**

The intended benefits of this coordinated approach are as follows:

1. Addressing environmental uncertainties in advance of full-scale commercial FOW deployment will help to anticipate and mitigate key consenting challenges, thereby reducing the time, cost and risk associated with the development process;
2. Strengthening the shared understanding of the environmental interactions specific to FOW will enable both the FOW industry and key environmental stakeholders to mitigate the potential impacts of FOW, thereby supporting sustainable development; and
3. By holding early discussions with key regulatory bodies and working toward agreement on the key FOW issues, the FOW CoE hopes to drive efficiencies in the consenting process for future large-scale FOW farms.

The development of the original draft of the Floating Offshore Wind Environmental Interactions Roadmap in 2022 was led by ORE Catapult and Xodus Group Limited, on behalf of the FOW CoE. The updated version outlined in this report was prepared by ORE Catapult. ORE Catapult gratefully acknowledges Xodus Group's contribution to the original development of this work.

1.3 Floating Offshore Wind Centre of Excellence

The Floating Offshore Wind Centre of Excellence was established in 2020 by the Offshore Renewable Energy (ORE) Catapult with the vision:

To establish an internationally recognised centre of excellence in floating offshore wind which will work towards reducing the Levelised Cost of Energy (LCoE) from floating wind to a commercially manageable rate, cut back development time for FOW farms and develop opportunities for the local supply chain, driving innovation in manufacturing, installation and Operations and Maintenance (O&M) methodologies in floating wind.

The FOW CoE is a collaborative programme with industry, academic and stakeholder partners. At the time of writing, the following organisations are Industry Partners in the FOW CoE:



Figure 2 Floating Offshore Wind Centre of Excellence Industrial Partners

Further information on the FOW CoE's broader project portfolio, including its other workstreams and strategic programmes, is available [here](#).

1.4 Environmental Interactions Strategic Programme

Since its inception, the FOW CoE has established a number of Strategic Programmes in high priority areas. Included among these is the Environmental Interactions Strategic Programme (EISP), which was launched in 2022 with the aim of coordinating and delivering a range of activities to address FOW-specific environmental and consenting knowledge gaps. The FOW and Fishing Framework for Coexistence project will be delivered under the FOW CoE's EISP.

In order to facilitate additional strategic guidance and input during the development and delivery of the EISP's project portfolio, a Steering Group was established including Crown Estate Scotland, Defra, DESNZ, Marine Scotland, Natural Resources Wales and The Crown Estate.



Figure 3 Project Steering Group Members

2 METHODOLOGY

2.1 Initial Roadmap Development

The initial development of the Floating Offshore Wind Environmental Interactions Roadmap in 2021 was structured around 3 principal stages.



Figure 4 Initial development of the Floating Offshore Wind Environmental Interactions Roadmap

Environmental Review - An evaluation of the EIA process applicable to FOW developments established the necessary context and identified the environmental receptors (both in respect of ecology and impacts on other sea users) that would form the Roadmap's key areas of focus. Legislation applicable to the whole UK and to the devolved regions was reviewed to ensure that pertinent regulatory considerations were included. Then an analysis was conducted of consenting and environmental data, peer reviewed literature, and emerging research.

Technical Engagement - The scope of the Technical Engagement process was guided by the outcomes of the Environmental Review: key environmental stakeholders and subject matter experts participated in topic-specific workshops and one-to-one engagements with the project team.

Roadmap Development - The outputs of the Environmental Review and Technical Engagement confirmed the priority areas of focus in relation to current knowledge gaps and areas of uncertainty concerning the specific environmental interactions of FOW developments in the UK.

2.1.1 Environmental Review

The environmental review was divided into two discrete activities; (1) a review of the legislative and consenting process, and; (2) a review of the existing evidence associated with environmental interactions of FOW arrays.

1. A high-level overview of the general EIA process reviewed existing legislation, regulatory guidance, consenting precedent and author experience. The principal objective was to identify FOW-specific considerations relevant to the EIA and broader consenting process. In the case of the broader consenting process, the FOW CoE report [Floating Offshore Wind Development and Consenting Process – Risks and Opportunities](#) provided guidance on the UK marine planning and consenting process for FOW.
2. A detailed review of existing consenting and environmental data, peer reviewed literature, and emerging research, investigated how the impacts of FOW farm interactions with the environment are assessed in the UK.

2.1.2 Technical Engagement

A detailed stakeholder mapping exercise built on the outputs the Environmental Review, led to the development of a series of technical workshops:

- Licensing & Consenting
- Physical Environment (Including Water Quality, Benthic and Coastal Process)
- Marine Ecology (Including Ornithology & Marine Mammals)
- Fish and Shellfish Ecology, and
- Other Sea Users / Human Environment

The technical engagement process took input from topic-specific specialists (Table 1 including regulators, statutory consultees, regulatory advisors and industry organisations; Table 1) to confirm current knowledge gaps and areas of uncertainty in relation to environmental interactions specific to FOW technology, and where further research, data collection and/or technical innovation would enable these to be addressed.

In addition to workshop participants, Industry Partners of the FOW CoE provided input, advice, and technical guidance to inform and support the roadmap development. As a result, the roadmap's findings and recommendations present a balanced reflection of the priorities and concerns of environmental stakeholders, regulators, and the FOW industry.

Table 1 Stakeholder Overview

Attendees of the technical workshops and/or one-to-one interviews	
British Helicopter Association (BHA)	North East Inshore Fisheries Conservation Authority (IFCA)
Civil Aviation Authority (CAA)	Northern Lighthouse Board
Community Inshore Fisheries Alliance (CIFA)	RSPB
Crown Estate Scotland	Scottish Fishermen's Federation (SFF)
European Subsea Cables Association (ESCA)	Scottish Regional Inshore Fisheries Group
Historic England	Sea Mammal Research Unit (SMRU)
Joint Nature Conservation Committee (JNCC)	Simply Blue Group
Marine Management Organisation (MMO)	St Abbs Marine Station
Marine Scotland - Licensing Operations Team (MS-LOT)	The Crown Estate
Marine Scotland Science (MSS)	The Planning Inspectorate (PINS) / BEIS
Maritime and Coastguard Agency	The Wildlife Trust
Natural England	Trinity House
Natural Resources Wales (NRW)	Wales Marine Fisheries Advisory Group
NatureScot	Welsh Government – Marine Planning & Licensing

2.1.3 Roadmap Development

The FOW environmental interactions Roadmap (Section 3) details the principal areas of uncertainty and recommended actions identified through the environmental review and technical engagement.

2.2 Roadmap Review and Updates

Since the Roadmap's original publication in 2022, the research landscape has evolved significantly. The ongoing, proactive maintenance of the FOW CoE's Environmental Interactions Roadmap is central to ensuring the programme remains at the forefront of FOW environmental research. By monitoring and reviewing its research priorities, the EISP can respond to emerging evidence, evolving industry needs, and stakeholder input.

2.2.1 Creating a FOW Research Database

The ORE Catapult team has developed an internal research database to document and track relevant external research projects and initiatives, providing insights into recent areas of focus and highlighting topics that remain under-researched. It also supports the work of the EISP by helping to identify research duplication risks and potential collaboration opportunities.

A refreshed literature review brought work completed during the Roadmap's original development (Section 2.1.1) up to date. The review considered both industrial and academic projects covering a broad range of environmental interaction topics relevant to FOW. Examples of the resources consulted to identify projects for inclusion in the database include:

- [ARPA-E](#)
- [CORDIS](#)
- [EEA and Norway Grants](#)
- [Energiforskning.dk](#)
- [ECOFlow](#)
- [France Energies Marines](#)
- [Interreg Atlantic Area](#)
- [Interreg North Sea Europe](#)
- [Interreg North West Europe](#)
- [Pôle Mer Bretagne Atlantique](#)
- [Pôle Mer Méditerranée](#)
- [Research Council of Norway](#)
- [Topsector Energies](#)
- [UKRI](#)
- [WEAMEC](#)

Key details documented for each relevant project include, where available, start and end dates, delivery partners, project value, funding source, research focus, objectives, findings, and recommendations. To provide a clear and logical structure for the database, a taxonomy of research topics was developed. This taxonomy enables users to search for projects by topic (for example, ecological receptor, other sea user, policy issue) and to conduct gap analyses across the research landscape by theme. It should be noted that a low number of projects within a particular research area was not automatically interpreted as a gap in knowledge; rather, it indicated potential areas for further consideration.

2.2.2 Academic Engagement

ORE Catapult collaborated with the [Supergen ORE Hub](#) to host a hybrid workshop at the University of Plymouth bringing together academics with relevant expertise to review the original Roadmap,

identify additional academic research, and to discuss outputs from earlier stages. The outputs of this workshop informed the Roadmap’s review process and are reflected in the updated draft.

2.2.3 FOW Project Development

Public documentation relating to the planning and consenting of active FOW projects provided crucial insight into the principal environmental and consenting uncertainties facing current FOW project developments. At the time of the original publication, Hywind Scotland and Kincardine were the only two active FOW farms to have received full consents. In the intervening period, a number of other projects have made significant progress with their consent applications (Table 2).

Table 2 Overview of Consented FOW Farms in the UK

FOW Farm	Location	Maximum Capacity	Leasing Process	Consents Status	Current Lifecycle Phase
Erebus	Celtic Sea	100MW	Test and Demonstration (The Crown Estate)	Granted 2023	Development
Green Volt	Scottish North Sea	560MW	INTOG (Crown Estate Scotland)	Granted 2024	Development
Hywind Scotland	Scottish North Sea	30MW	Site-specific lease (Crown Estate Scotland)	Granted 2015	Operational
Kincardine	Scottish North Sea	50MW	Site-specific lease (Crown Estate Scotland)	Granted 2017	Operational
Pentland	North Atlantic Ocean	100MW	Site-specific lease (Crown Estate Scotland)	Granted 2023 (variation approved 2024)	Development
Salamander	Scottish North Sea	100MW	INTOG (Crown Estate Scotland)	Granted 2025	Development
White Cross	Celtic Sea	100MW	Test and Demonstration (The Crown Estate)	Granted 2025	Development

2.2.4 Roadmap Updates

The project team revised and updated the existing Roadmap draft (Section 3) based on the insights gained from the FOW research database and the expertise shared by the Supergen ORE Hub, to ensure that the characterisation of knowledge gaps and recommendations for future work offer a more accurate reflection of the current research landscape.

3 FLOATING OFFSHORE WIND ENVIRONMENTAL INTERACTIONS ROADMAP

The revised and updated Floating Offshore Wind Environmental Interactions Roadmap reflects the insights gained through the development of the new FOW environmental database and the academic engagements undertaken by the project team.

The prioritisation criteria of the original Roadmap (Table 3) have been retained for this new edition. As such, the inclusion of an interaction as a priority topic reflects the following:

- The extent to which an interaction is unique to FOW, or has particular nuances that require careful consideration in the case of FOW developments.
- The potential impact of an interaction’s occurrence.
- The perceived likelihood of its potential occurrence.
- The ability of key stakeholders to intervene to mitigate the associated challenges or exploit an opportunity.

Table 3 Interaction Priority Scale

Priority	Explanation
Low	Indicates a general consensus that, although the interaction may still require some further work, there is no immediate requirement to investigate further.
Medium	Indicates a broader range of views obtained throughout the project, with at least some stakeholders believing that further investigation is required.
High	Indicates a general consensus that the interaction should be investigated further.

In order to help provide structure to the recommendations within the report, potential actions to help address an evidence gap are categorised as follows:

Table 4 Recommended Action Categories

Recommended Action Category	Explanation
Environmental	Addressing knowledge gaps through application of environmental
Technical Innovation	Technological solutions, such as advancements in environmental
Policy	Broader enabling actions.

With the above considerations in mind, Table 5 to Table 14 present a summary of the key themes of the Floating Offshore Wind Environmental Interactions Roadmap. Ten key themes are discussed in total and the same general topics from the original Roadmap draft are retained in this updated version, with some slight updates to their categorisation. The specifics of each theme have been elaborated and the relevance of new research work undertaken in the interim is reflected in this new Roadmap edition.

The ten priority themes are:

- Aviation Safety
- Colocation and Coexistence
- Electromagnetic Fields (EMF)
- Fisheries Access
- Habitats Regulations Assessment
- Navigational Risk
- Ornithological Considerations
- Regional and Cumulative Assessments
- Skills Gaps
- Underwater Noise

Table 5 Aviation Safety

Theme / Knowledge Gap	Aviation Safety
Receptor	Other Sea Users / Aviators
Background	As with maritime navigational risk, future large-scale FOW farms present new questions regarding potential aviation impact pathways. Further analysis and investigation will support the industry and key stakeholders in addressing these uncertainties. Based on the recommendations of the first iteration of this Roadmap, the FOW CoE undertook a project examining the implications of future commercial FOW developments on maritime and aviation navigation. The resulting FOW Navigational Planning and Risk Assessment report (2023; NASH Maritime and Osprey CSL, addressing maritime and aviation topics respectively) undertook a gap analysis assessing potential impacts across a range of factors, rating them from <i>no gap</i> to <i>major gap</i>.
Evidence Base / Key Outcomes	<u>FOW Wet Storage</u> The most significant factor for aviation safety related to potential future FOW is wet storage logistics, whereby FOW turbines might be temporarily stored within inshore areas during construction and heavy maintenance activities. This was rated as a moderate gap during the FOW CoE's Navigational Planning and Risk Assessment project, reflecting the lack of precedent for assessing wet storage impacts during the wind farm consenting process. Revisions to existing guidance and potential updates to the assessment process could help to ensure that wet storage operations are appropriately considered. Circumstances where key project decisions may occur after consents have been secured, such as the final selection of an integration port, should also be considered. The progress of initiatives focussed on the coordination of FOW wet storage sites, such as the TS-FLOW™ joint industry programme, should be closely monitored. All other aviation-related impacts were rated as minor or negligible. In response, the FOW CoE has launched a follow-on project to explore the broader interactions of FOW wet storage risks in greater detail. <u>Radar</u> It is understood that the movement of turbine rotors can act to mimic low-level aircraft activity, with implications for air traffic control radar systems. Some uncertainty remains whether the specific characteristics of FOW technology, in particular the heave and roll motions of FOW turbines, might alter these impacts to any meaningful extent. The FOW CoE's Navigational Planning and Risk Assessment project concluded that FOW-specific risks for

	radar are likely to be minimal, and this position appears to have been reflected in recent FOW Farm EIAs. The University of Manchester has received funding for a project in this subject area: Modelling the Impact of Large Floating Wind Turbines on Offshore Navigation and Safety Critical Radar Systems, although no results appear to have been published at the time of writing. <u>Search and Rescue</u> FOW arrays will be subject to the same requirements as conventional bottom fixed offshore wind regarding lines of orientation ('safe lanes') for search and rescue (SAR) access. Given the typical distances expected between tethered FOW turbines, it is not anticipated that compliance with the requirement for SAR access will be problematic for FOW projects. Nonetheless, a continued monitoring of this topic informed by subject matter experts in the field of offshore (rotary) aviation, as well as relevant SAR bodies, would be beneficial in confirming these assumptions.
Recommendations	Policy: • Assess opportunities to update / refine FOW wet storage guidance in respect of aviation safety to address any potential impact pathways and minimise consenting risk. • Determine whether the consenting process for FOW wet storage could be streamlined by centralising the management of wet storage areas, rather than coordinating them on a project-by-project basis.

Table 6 Colocation and Coexistence

Theme / Knowledge Gap	Colocation and Coexistence
Receptor	Other Sea Users / Commercial Fisheries
Background	As the FOW industry scales up, cross-sector engagement with other sea users will be required to manage the risks and opportunities associated with future coexistence. This will include established maritime industries, including commercial fisheries (Table 8), oil and gas (O&G), and subsea cables, as well as emerging sectors such as carbon capture and storage. Acting on the recommendations of the first iteration of this Roadmap, the FOW CoE delivered the Floating Offshore Wind Co-Location and Co-Existence Risks and Opportunities project, with the public summary report published in 2024. The study focussed on potential interactions between the FOW industry and other sea users, with a specific focus on FOW technology. A series of recommendations were set out in relation to each industry. (It should be noted that to avoid duplication with the FOW CoE's separate project activities addressing aviation and maritime navigation [Table 5 and Table 10, respectively] as well as commercial fisheries [Table 8], these industries were not included in the review undertaken during the Floating Offshore Wind Co-Location and Co-Existence Risks and Opportunities project.) Beyond the FOW CoE programme, there are additional ongoing projects and initiatives whose outcomes will be relevant to these considerations and therefore warrant a watching brief. Examples include: • INTOG Innovation Network: Launched by ORE Catapult in 2024 to maximise the impacts of FOW projects through the INTOG leasing process. This work will build collaborative relationships between projects to address innovation challenges and opportunities, and to share lessons learned for future projects. • Project Anemone: Established by The Crown Estate's Offshore Wind and Carbon Capture and Storage Colocation Forum to explore mutually beneficial opportunities arising from the colocation of CCUS with oil and gas and offshore wind. While Anemone, which is scheduled to conclude in 2026, considers the offshore wind sector as a whole, some of the outcomes will nevertheless be applicable to FOW development areas.
Evidence Base / Key Outcomes	The Floating Offshore Wind Co-Location and Co-Existence Risks and Opportunities report identified a range of gaps and outlined relevant enabling actions relating to each maritime industry. Examples include: • Aquaculture:

	• Gap analysis of applicable guidance, design standards and regulations, particularly for potential installations beyond the 12 nautical mile (nm) territorial waters limit; • Technical feasibility assessment for colocated FOW-aquaculture projects; • Environmental review assessing potential ecological risks (e.g. attraction effects associated with aquaculture, and the risk of FOW farm interactions). • Carbon Capture, Utilisation, and Storage (CCUS): • Assessment of potential financing risks for colocated FOW-CCUS projects, and the development of appropriate guidance; • Technical feasibility assessment of powering CCUS infrastructure via colocated FOW; • Logistical and economic review of vessel-sharing opportunities for colocated FOW-CCUS projects. • Defence: • Proactive cross-sector engagement to improve the shared understanding of each industry's spatial requirements; • Review of each industry's respective port requirements to assess potential risks and relevant mitigations. • Oil & Gas: • Review of initial development and consenting lessons learned from the Innovation and Targeted Oil and Gas (INTOG) leasing process for colocated FOW-O&G projects. • Subsea Cables: • Update of best practice guidance on the colocation of offshore wind with subsea cables to reflect the specifics of FOW technology; • Risk assessment for subsea cable repair operations in the vicinity of FOW installations; • Support for spatial planning initiatives to effectively manage the colocation of subsea cables and FOW projects.
Recommendations	Environmental Science: • Conduct environmental reviews for colocated FOW-aquaculture projects, assessing relevant ecological risks including attraction effects and FOW interactions. Policy: • Continue collaboration with key stakeholders in aquaculture, CCUS, O&G and subsea cable experts to understand how policy can be shaped to meet the challenges of co-existence/co-location. • Review current regulatory gaps that would inhibit the development of colocated sites, such as FOW-aquaculture projects, beyond the 12nm territorial waters limit. • Engagement with seabed leasing authorities to further advance understanding of topic-specific coexistence issues. • Maintain watching brief on INTOG Innovation Network and Project Anemone for cross-sector collaboration outcomes applicable to FOW.

	Technical Innovation: • Technical feasibility assessment for colocated FOW-aquaculture and FOW-CCUS projects, including logistical/economic review of vessel-sharing options, and assessment of shared infrastructure and co-powering opportunities. • Cross-industry engagement between FOW and defence sectors on spatial/port requirements; mitigation reviews. • Review / develop best practice guidance for FOW-subsea cable co-location; risk assessment for cable repairs near FOW; support spatial planning initiatives.
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Table 7 Electromagnetic Fields

Theme / Knowledge Gap	Electromagnetic Fields (EMF)
Receptor	Marine Organisms
Background	Studies on the environmental interactions of subsea power cable electromagnetic field (EMF) emissions have primarily focussed on static cables on the seabed and the possible implications on benthic ecology. Although it is anticipated that the highly mobile nature of pelagic species would reduce the scale of any potential effects, relative to benthic ecology, the question of how FOW dynamic cable EMF emissions may interact with pelagic species in the water column remains subject to uncertainty. Acting on the recommendations from the first iteration of this Roadmap, the FOW CoE delivered the Floating Offshore Wind Dynamic Cable EMF Environmental Review project. This study provided an assessment of the current state of technical and environmental knowledge relating to EMF emissions from dynamic cables. The project's public summary report (2025) collates expert technical input provided by Evolv Energies and St Abbs Marine Station (addressing the technical and environmental components, respectively) and sets out a series of recommendations to address the key knowledge gaps in this area. Beyond the FOW CoE programme, relevant projects and initiatives that warrant close attention include: • Floating Offshore Wind Environmental Response to Stressors (FLOWERS): Launched by Cefas in 2023 with funding from The Crown Estate's Offshore Wind Evidence and Change programme. One of the principal aims of FLOWERS is to strengthen the understanding of EMF as an environmental stressor associated with floating offshore wind, and to assess the encounter rate between receptors and dynamic cable EMF emissions. In 2026, the FLOWERS project published its outputs, including a report on environmental responses to EMFs. • A Targeted Approach to Characterising EMF From Subsea Cables and Understanding Potential Impacts on Fish and Benthic Species: Launched in 2025, this study is funded by the Scottish Government's Scottish Marine Energy Research (ScotMER) programme, and its delivery is led by Xodus. The principal aim is to assess current EMF modelling capabilities, available datasets, and potential monitoring opportunities for operational cables. Methods for assessing EMF impacts on marine species will also be reviewed. The study will conclude with the development of roadmaps for measuring EMFs for both fixed and dynamic cables, and for assessing EMF effects on select species. • BOWIE: Funded by the Ecological Consequences of Offshore Wind research programme (ECOWind), the aim of BOWIE is to assess the impact of offshore wind development on seabed invertebrate and fish

	species, including the effects of EMF emissions from wind farm power cables. The project aims to develop a decision support tool to support policy makers in the consenting of future offshore wind farms.
Evidence Base / Key Outcomes	There is a need for further refinement of modelling capabilities for predicting EMF emissions from dynamic cables. EMF field measurements from pilot FOW projects are required to support the validation of these models. Targeted research is required to address knowledge gaps concerning the responses of pelagic invertebrates and fish, in particular elasmobranchs, to EMFs generated by dynamic cables. Studies into the cumulative effects of EMF exposure from arrays of dynamic and static cables, and in-combination effects of this with other anthropogenic EMF sources in the marine environment, would also be beneficial. Although early laboratory-based studies have demonstrated causal relationships between EMF exposure and developmental effects in certain juvenile benthic invertebrates, the field strengths applied in these experiments were substantially higher than those expected within future FOW developments. Further research is therefore recommended to determine whether: - Effects observed under elevated laboratory EMF conditions are applicable to pelagic species exposed to lower, FOW-specific, field strengths; or - In practice, any effects are limited to behavioural responses (for example, avoidance) or are negligible. Strategically, there is a growing need to understand the cumulative impacts of multiple cables, the influence of floating structure movement on EMF propagation, and potential contributions from HVDC systems. These technical priorities will be complemented by a strong ecological research focus. This includes the identification of key marine species across trophic levels most likely to interact with EMFs, the development of dose-response models, and the deployment of long-term environmental monitoring at floating wind sites. To ensure that future assessments are robust, representative, and scalable, the programme will also work towards creating interdisciplinary monitoring frameworks and industry-wide laboratory protocols. These efforts aim to strengthen scientific understanding and inform the future work of our programme.
Recommendations	Environmental Science: Ecological research priorities include further investigation into the potential impact pathways for key pelagic species. This is likely to be supported through a combination of targeted laboratory studies and future field measurement campaigns.

	• The development of shared research framework for pelagic species EMF impact pathways would support a coherent and standardised approach to this topic. Technical Innovation: • Technical research priorities include the continued development of dynamic cable EMF modelling capabilities, targeted monitoring campaigns within operational FOW farms, and the benchmarking of dynamic cable EMF models using measurement data from the field. • Opportunities to support the development of technologies and methodologies for the safe and cost-efficient monitoring of dynamic cable EMF emissions within operational FOW farms. • The use of validated dynamic cable EMF models could also be used to help cable manufacturers understand how mechanical design influences EMF emissions and their attenuation. Policy: • Alignment and collaboration with broader research initiatives to maximise impact when addressing priority knowledge gaps, recognising the relevance of this issue across sectors such as power transmission, interconnectors, and conventional offshore wind.
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Table 8 Fisheries Access

Theme / Knowledge Gap	Fisheries Access
Receptor	Commercial Fisheries
Background	The more complex subsea infrastructure of FOW farms (relative to bottom-fixed offshore wind) and the ability of FOW technology to access greater areas of the sea with deeper waters beyond the reach of bottom-fixed turbines raises additional considerations regarding potential interactions with commercial fisheries. Continued collaborative engagement between the FOW and fishing industries will be key to ensuring that the risks and opportunities associated with their future coexistence are managed appropriately and successfully. Initial work undertaken by the FOW CoE examined how bottom-fixed and FOW technologies differ in respect of fisheries co-existence. The Floating Offshore Wind and Fishing Interaction Roadmap (published 2021) identified the priority risks, opportunities and knowledge gaps associated with potential future coexistence, and proposed a range of enabling actions and project activities to address these. The subsequent FOW and Fishing Framework for Coexistence project (published 2025) held cross-industry workshops in Aberdeen and Hayle, focusing on the Scottish North Sea and the Celtic Sea regions respectively. The workshops assessed whether decisions made during a FOW farm's front end engineering design (FEED) studies (occurring after the spatial planning and seabed lease award processes have concluded) could influence the potential for coexistence with commercial fisheries. In Scotland, the Sectoral Marine Plan for Offshore Wind Energy, established in 2020, was instrumental in guiding the ScotWind leasing process. Through an iterative stakeholder engagement process, leasing zones for potential offshore wind development were identified with the aim of supporting coexistence with other sea users, including commercial fisheries. A similar approach was subsequently adopted for the FOW-focussed Round 5 leasing process in the Celtic Sea, involving direct input from the local fishing industry. As such, continuing to manage the spatial planning process, with collaborative input from both industries, will be crucial aspect of managing the coexistence of the FOW and fishing sectors in the future.
Evidence Base / Key Outcomes	Opportunities to create additional space within FOW arrays for fishing activities include the use of larger turbines and smaller mooring profiles, such as nylon taut mooring systems. The simulation of fishing activities within virtual FOW array environments would be an important next step towards more practical assessments relating to coexistence, and the FOW CoE launched the Simulating Fishing Within Virtual FOW Farms project in early 2026 in order to facilitate this.

	Beyond the targeted, design-focussed activities described above, an effective marine spatial planning (MSP) process has a critical and ongoing role to play in managing the risks and opportunities associated with FOW and fishing coexistence. Looking further ahead, it is possible that practical experience from operational FOW farms may ultimately be required to achieve cross-industry consensus on any areas of uncertainty that might persist following roundtable industry discussions, desk-based activities, and targeted simulations. Equinor’s SeaShare project, which undertook static fishing gear trials at Hywind Scotland, provides an early example of how operational FOW assets could be used to gain valuable insights into potential co-existence strategies between FOW installations and fishing activities. Where relevant and appropriate, the ongoing research and cross-industry engagements outlined above should continue to inform policy adjustments, ensuring that the MSP process remains responsive to the evolving dynamics of FOW growth and its implications for fisheries across the UK.
Recommendations	Environmental Science: • Delivery of the environmental research recommendations outlined in the Floating Offshore Wind and Fishing Interaction Roadmap to understand the potential ecological interactions between FOW infrastructure and commercially targeted fish stocks (examples include possible fish aggregation effects, implications on the distribution of key species, the potential for benthic recovery, and implications on local predator-prey interactions). Technical Innovation: • Assess the feasibility of fishing within different layout designs through cross-industry participation in fishing simulations within virtual FOW farm environments. • Continued consideration of the implications of technology selection and design choices on the potential for future coexistence. Policy: • Continued consideration of FOW and fishing coexistence during the marine spatial planning process, across the devolved jurisdictions. • A sectoral position setting out guidance on robust engagement across the UK jurisdictions would be advantageous.

Table 9 Habitats Regulations Assessment

Theme / Knowledge Gap	Habitats Regulations Assessment (HRA)
Receptor	Protected Habitats and Species Within Designated Sites
Background	Habitats Regulations Assessment (HRA) precedent for commercial-scale FOW is limited, though growing. The greater offshore distances enabled by FOW and the differing technologies involved prevent direct comparison with shallow-water, bottom-fixed developments. The plan-level HRA required in support of future seabed leasing is used to assess potential impacts on legally protected habitats and species within the UK national site network before seabed rights for development are awarded. Separate project-specific HRA are required for individual consents. Following the screening and assessment process, mitigation measures will be considered for potential adverse effects, and derogation and compensatory measures will be explored where required. The overall HRA process is now well established for offshore wind, and while there are no fundamental process differences for FOW, some additional uncertainties (for example in relation to novel infrastructure, deeper-water habitats and cumulative effects) must be explicitly considered and accommodated at plan level and then further refined at project level.
Evidence Base / Key Outcomes	At a technical receptor level, the continued engagement between respective conservation authorities (i.e., NatureScot, Natural England, NRW and their European counterparts) regarding the HRA considerations of FOW technology would be valuable. More complex questions relating to in-combination impacts and the continued development of regional ecosystem approaches to offshore wind consenting should also be considered. As receptor-specific considerations will vary from project to project, a continual review of the emerging body of evidence associated with HRA at a project-level would inform the future decision making undertaken by competent authorities on plan-level HRA. For example, the Green Volt project, which completed its HRA process in 2023 ahead of receiving full licence approvals in 2024, presents some valuable insights relating to FOW projects. Notably, it identified adverse effects on key seabird species at a number of special protection areas (SPAs) due to in-combination effects with other wind farms, requiring compensatory measures at nesting habitats. At a broader level, policy reforms applicable to the HRA process, such as those being carried forward through the Offshore Wind Environmental Improvement Package (OWEIP), should be reflected in future strategic planning. These reforms are intended to make assessments more efficient, enable earlier identification of key environmental risks, and allow some

	compensatory measures to be designed and delivered at a strategic level rather than project by project. For example, Defra’s launch of the Marine Recovery Fund (MRF) in late-2025 provides an opportunity for developers in England and Wales to collectively fund centrally managed strategic compensation measures such as artificial nesting sites and invasive species control measures at breeding sites for key seabirds. The Scottish Government is also in the process of developing an equivalent MRF for projects developed in Scotland. It will be important to monitor any early successes and/or lessons learned from the initial implementation of these MRFs, particularly where these strategic measures might help to address the challenges around securing suitable compensation for FOW projects. Further, industry coordination with policymakers to support the development of the Offshore Wind Environmental Standards (OWES) will be key to ensuring that appropriate and proportionate mitigation hierarchies are established to support the avoidance, reduction and mitigation of environmental impacts of offshore wind projects (in England and Wales). This will provide greater clarity regarding the necessary steps required before compensatory measures must be explored. As the OWES are intended to be implemented from Leasing Round 5 onwards, they will be highly pertinent to the planned large-scale FOW projects in the Celtic Sea. In the medium-term, there is an opportunity for the OWES to support the assessment of cumulative and in-combination impacts, which should in turn support the delivery of proportionate plan-level HRAs.
Recommendations	Policy: • Ongoing and targeted engagement between respective conservation authorities regarding FOW-specific HRA considerations. • Review of the initial implementation of Defra’s Marine Recovery Fund (and its Scottish equivalent, once launched) to identify lessons learned concerning strategic compensation measures relevant to large-scale FOW projects. • Continued collaboration between regulators and industry regarding the development of the Offshore Wind Environmental Standards to ensure the development of appropriate and proportionate mitigation hierarchies and inform future plan-level HRAs. Environmental Science: • Ongoing review of the emerging body of evidence associated with project-level HRA for commercial FOW developments, including any successes and/or lessons learned from early FOW-specific compensation measures.

Table 10 Navigational Risk

Theme / Knowledge Gap	Navigational Risk
Receptor	Other Sea Users / Shipping and Navigation
Background	Technology differences between FOW and bottom-fixed wind present new considerations from a maritime navigational risk perspective, particularly as the FOW industry grows. Specific points of interest include the ability to tow FOW turbines between the wind farm and port for heavy maintenance and major repairs, and the potential to temporarily store FOW substructures (with or without integrated turbines) within inshore areas to support the marshalling and assembly process. The FOW CoE's Navigational Planning and Risk Assessment project (delivered by NASH Maritime and Osprey Limited) assessed the key maritime and aviation navigational considerations for future large-scale FOW developments. For further background on the study, see Table 5 on Aviation Safety.
Evidence Base / Key Outcomes	<u>FOW Wet Storage</u> The primary area of uncertainty for maritime navigation concerns the potential temporary, or “wet”, storage of FOW turbines in inshore areas during construction and/or heavy maintenance activities. There is limited precedent for addressing wet storage logistics within navigational risk and impact assessment processes, and uncertainty remains regarding the applicability of existing guidance. As such, where appropriate and applicable, existing guidance should be adapted, or new guidance be developed to support the assessment of wet storage logistics at the licence application stage. Opportunities to centralise the management of wet storage sites should be explored, with consideration given to the relative merits and drawbacks of this approach compared with individual project-level assessments. The progress of initiatives focussed on the coordination of FOW wet storage sites, such as the TS-FLOW™ joint industry programme, should be closely monitored. <u>Towage and Port Logistics</u> Lower priority knowledge gaps concern the interface between FOW activities and port and harbour operations, and towage operations between ports and wind farm sites. To address these uncertainties, it is recommended that an industry and regulatory working group (either existing or newly established) be tasked with identifying operational solutions and informing best practice guidance aligned with the Port Marine Safety Code, with these solutions then tested through simulation exercises in full bridge simulators.

	<u>Safety Zones</u> It is not clear that the current framework for establishing operational safety zones is optimal for FOW infrastructure. Regulations allow for establishment of 50-metre safety zones during operation to restrict third party vessel traffic. However, it is not apparent how this approach accounts for FOW platform excursions, which can extend tens of metres depending on water depth and mooring design. Nor is it clear how safety zones intended to protect surface navigation can be effectively applied to mooring systems that may extend several hundred metres through the water column and along the seabed. Continued engagement on this topic between the wind industry and the relevant navigational safety bodies is therefore recommended in order to strengthen confidence around the application of FOW safety zones. <u>Navigational Risk and Cumulative Assessments</u> At a broader level, a more coordinated approach to navigational risk assessment, including regional cumulative assessments, could enhance the understanding of long-term impacts and improve mitigation strategies. Additionally, further engagement with navigational stakeholders, including the Maritime & Coastguard Agency (MCA), port authorities, and vessel operators, will be essential to ensuring that evolving industry practices are effectively integrated into future guidance. <u>Guidance</u> Where relevant and appropriate, opportunities should be explored for updating existing industry guidance on Navigational Safety for offshore wind to reflect the nuances associated with FOW. This may include formal documents, such as Marine Guidance Note (MGN) 654 (MCA, 2021), MGN 372 (MCA, 2008) and the Maritime & Coastguard Agency (MCA) 'Methodology for Assessing the Marine Navigational Safety Risks & Emergency Response of Offshore Renewable Energy Installations' (MCA, 2021).
Recommendations	Policy: • Review and adapt existing guidance, or develop new guidance, to support FOW wet storage logistics assessments at the licence application stage. • Assess opportunities to centralise management of FOW wet storage sites, comparing merits and drawbacks against project-by-project assessments. • Establish (or leverage existing) industry/regulatory working group to identify port/harbour interface and towage solutions and inform best practice guidance aligned with the Port Marine Safety Code (PMSA). • Continued dialogue concerning the application of safety zones to support FOW maintenance activities.

	• Pursue coordinated regional cumulative navigational risk assessments and enhanced stakeholder engagement with MCA, port authorities, and vessel operators. Technical Innovation: • Test port/harbour and towage operational solutions through simulation exercises in full bridge simulators.
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Table 11 Ornithological Considerations

Theme / Knowledge Gap	Ornithological Considerations
Receptor	Ornithology
Background	Considerations of the effects of offshore wind development on bird ecology are not unique to FOW technology. However, the distinct characteristics of FOW developments present new questions that would benefit from further attention to address any associated uncertainty. One such consideration relates to barrier effects, whereby the presence of a wind farm may cause birds to divert around the site, potentially disrupting ecological connectivity. In the case of bottom-fixed offshore wind, these interactions have typically been considered in respect of roosting or feeding grounds, and inshore disruptions effects have been the subject of more detailed analysis work to date. However, the ability to install FOW technology in deeper waters poses questions about the potential significance of any effects on migratory routes in locations further offshore, where existing baseline data can be more limited. Another topic of uncertainty concerns the blade clearance (or "air gap") between a turbine's rotor system and the water surface. Wind farm developers are required to maintain a 22-metre blade clearance in accordance with navigational safety guidance (MGN 654). While not unique to FOW, blade clearance is also considered relevant to the management of seabird collision risk (particularly for low-altitude flight paths), and it has been discussed across multiple FOW farm assessments (Atkins, 2014; Royal HaskoningDHV, 2023; RPS, 2024). Currently, this question is addressed on a project- and species-specific level, however it is a topic that could benefit from greater consensus. An additional consideration concerns evidence gaps around birds being potentially attracted to floating substructures for resting or roosting. The extent of this attraction and its influence on turbine blade collision risk remains unclear. At a regional and cumulative level, the Green Volt FOW farm provides an early example of ornithological considerations raised during the HRA process. In that case, in-combination effects were identified for key seabird species at a number of SPAs, requiring compensatory measures at nesting habitats. While this is not a FOW-specific issue, it nevertheless highlights the challenges that future FOW farms might face if they are developed in proximity to existing fixed-wind sites (for instance, in transition zones where water depths begin to exceed those suitable for fixed-wind). As the FOW industry grows, continued engagement with regulators will be key to ensuring that in-combination effects between wind farms are accurately

	understood in the context of broader spatial constraints, and that compensatory measures are targeted and proportionate. The increased distance from shore may present additional challenges when establishing ornithological baselines in support of the EIA process for UK FOW farms. Aerial surveys from specialist UK providers are increasingly complementing traditional boat-based methods, and it is possible that greater offshore distances (with greater transit times and more limited weather windows) could constrain survey logistics, with implications on data coverage and confidence. Advances in technologies such as marine radar, LiDAR (light detection and ranging), and eDNA (for detecting bird presence via analysis of genetic material in seawater) could also play an important role in understanding bird movements further offshore, although their offshore application requires further validation.
Evidence Base / Key Outcomes	Engagement should be sought with ornithology experts on offshore distribution, as well as specialist ornithological advisers to regulators, to assess FOW-specific uncertainties relating to barrier and attraction effects, air gap requirements, and appropriate compensatory measures. On a technical level, research and development into innovations for conducting ornithological surveys at greater offshore distances should be supported to strengthen evidence collection for FOW developments. Lessons learned from other industries, such as evidence associated with North Sea O&G assets, should also be considered. Where specific data gaps are identified, opportunities for targeted monitoring studies at pilot- and early-commercial FOW farms should be considered. Monitoring studies at Vattenfall’s Aberdeen offshore wind farm concluded that bird collision rates were much lower than anticipated, and that seabirds adjust their flight paths to steer clear of turbine blades (Vattenfall, 2023, 2026). Replicating such studies at FOW installations would help address uncertainty regarding how air-gap variability arising from heave, roll and pitch motions may influence seabird avoidance behaviour. A benchmarking exercise comparing pre-construction modelling predictions against empirical operational monitoring data would be valuable for informing the assessments for future FOW projects. A watching brief should be maintained on relevant ongoing research initiatives. Examples include: • The Defra-led POWEM project, which includes a pilot study focussed on turbine blade painting to reduce bird collisions. • The ECOWINGS project (led by the UK Centre for Ecology & Hydrology), addressing uncertainties in offshore wind impacts on seabird populations, including cumulative effects and compensation measures.

	• ORJIP-coordinated research such as the AssESs project, evaluating how uncertainty affects ornithological impact assessments.
Recommendations	Environmental Science: • Engagement with subject matter experts and ornithological specialists to appraise the questions of potential barrier and attraction effects in relation to FOW developments. • Adapt and apply the seabird collision monitoring research framework developed for fixed-bottom wind farms to FOW turbines. • Benchmarking analysis comparing pre-construction seabird collision modelling against operational monitoring data. • Consider lessons learned from other sectors, e.g. North Sea O&G ornithological data, to inform FOW evidence gaps. • Where data gaps are identified, the potential for monitoring studies within pilot and early commercial FOW farms should be explored. Policy: • Industry engagement with regulators and regulatory advisors to identify the principal consenting concern and collaborate on proportionate compensatory measures. Technical innovation: • An assessment of the technical challenges and innovation requirements in respect of ornithology surveys far from shore. • Where innovation requirements are identified, these should be supported with targeted research and development.

Table 12 Regional Assessments

Theme / Knowledge Gap	Regional and Cumulative Assessments
Receptor	Multiple Environmental Receptors
Background	Despite growing experience within the wind industry and regulatory bodies in assessing regional, cumulative and in-combination impacts from bottom-fixed offshore wind development, a consensus is yet to emerge regarding the most appropriate methods for their assessment, and access to comprehensive, large-scale regional environmental datasets also remains limited. A recent report by ORE Catapult provides a detailed discussion of the current challenges and opportunities associated with this topic: Accelerating Offshore Wind: Developing a regional ecosystem monitoring programme for the UK offshore wind industry. The ability of FOW technology to access deeper waters farther from shore, relative to bottom-fixed wind, presents a further degree of uncertainty. Furthermore, there is a growing body of academic research assessing the potential effects of installing dynamic infrastructure in deeper, seasonally stratified seas, with the newly launched Ecological Effects of Floating Offshore Wind (ECOFlow) research programme being a key example. These questions were also echoed by the Supergen ORE Hub during the academic engagements hosted to support the revision of this Roadmap (Section 2.2.2).
Evidence Base / Key Outcomes	A receptor-specific review would enhance understanding of whether the distinct characteristics of FOW technology result in differences in cumulative or in-combination impacts compared to bottom-fixed wind. Cumulative impact assessments should be scoped with clearly defined boundaries at the earliest opportunity, drawing on best practices from Scottish, Welsh, and English marine consenting processes. The potential for nature-positive design should also be explored within cumulative impact assessments. Ecosystem-level monitoring complements the targeted insights of receptor-specific approaches, providing a broader understanding of how multiple stressors and their cumulative effects influence entire ecosystems. The launch by ORE Catapult of the ‘Accelerating Consenting for Offshore Renewables Deployment’ (ACORD) project is intended to support the development of an ecosystem-based approach to regional monitoring, as recommended by the Accelerating Offshore Wind report, and the progress of this project should therefore be monitored closely. The two initial ECOFlow programme projects, EQUIFy and Frontline, are assessing the potential cumulative ecological effects of FOW, and the potential implications of FOW infrastructure on ocean front dynamics, respectively. This academic led work warrants close observation, as well as the provision of industry input where relevant and applicable.

	Given that receptor-specific impacts will vary between projects, the appropriate integration of receptor-specific concerns within an ecosystem-based monitoring framework will be required to improve the robustness of cumulative impact assessments and support more effective decision-making. Engagement with key decision-makers will be crucial to ensuring that cumulative and in-combination assessment methodologies align with evolving policy frameworks.
Recommendations	Environmental Science: • Targeted assessment of potential FOW cumulative and in-combination impacts on a receptor-by-receptor basis. • Support the development of ecosystem-level monitoring approaches to improve consenting efficiency. • Support ongoing research into the interactions of FOW with ecosystem functions and ocean physics. Policy: • Engagement with key decision makers to understand and strategically address emerging cumulative and in-combination challenges. • Monitor updates to policy frameworks to ensure alignment of monitoring approaches with evolving regulatory requirements.

Table 13 Skills Gaps

Theme / Knowledge Gap	Skills Gaps
Receptor	Socioeconomic
Background	The earlier commercial status of FOW technology relative to traditional bottom-fixed wind increases the prospect of skills and experience gaps in the environmental assessment and consenting process. These gaps may exist within parts of the regulatory community and also within some developer organisations where there is not yet an established track record for applying for FOW farm consents. At the time of writing, regulators in Scotland have completed full consenting processes for the Hywind Scotland, Kincardine, Green Volt and Salamander FOW farms. In England and Wales, the Erebus and White Cross test and demonstration projects have been awarded their consents. Three large-scale FOW farms awarded seabed rights via the Round 5 Celtic Sea process are yet to complete their consenting processes. The FOW industry is anticipated to commercialise at an accelerated rate compared to the bottom-fixed wind sector, placing greater pressure on regulators and developers.
Evidence Base / Key Outcomes	Continued proactive engagement with the regulatory community across the key jurisdictions will allow any priority skills gaps and uncertainties to be identified and addressed. Where possible, opportunities should be explored to enhance existing strategic links between regulators so that insights and experience from the first major FOW consenting processes can benefit the processing of future applications. The development of guidance and outreach resources would help to capture existing experience from mature consenting processes in order to support an efficient FOW development process, while at the same time advocating the FOW sector's case to regulators and stakeholders. Further, there is an opportunity for industry to share technical insights with regulators so that the technical and economic feasibility of any proposed design-based mitigations or operational monitoring requirements requested by regulators can be fully understood. In the longer-term, industry collaboration with the educational system now would support the development of the appropriate skills required to meet the demands of the offshore wind installation targets over the course of the next decade, and beyond. A Natural England report on boosting offshore wind skills for environmental professions recommended promoting access to marine environmental courses with up-to-date modules, and greater industry involvement in academia. While these will help the wider offshore renewable energy sector, there are still unknown requirements relating to FOW and industry skills gaps.

	The FOW CoE’s Risks to Project Development – People, Skills and Vocations (published 2022) project assessed the UK market’s capacity and capabilities and outlined recommendations for supporting a skilled workforce. The report examines a range of job categories, including those applicable to the consenting process. Recommendations include STEM engagement at a school level, supporting career pathways for young professionals (e.g. via apprenticeships), and establishment of training centres focussed on developing skills that are known to be in shortage.
Recommendations	Policy: • Maintain proactive regulatory engagement to identify and address skills gaps and uncertainties in FOW environmental assessment and consenting. • Develop / strengthen guidance materials on FOW-specific environmental interactions, mitigation options, and monitoring requirements. • Support strategic links between regulators across key jurisdictions to support knowledge sharing and from early FOW consenting processes. • Facilitate collaboration between industry and academia to shape environmental courses and modules, and explore broader workforce development initiatives (e.g. STEM engagement, apprenticeships, specialised training centres) to build skills relevant to the consenting process.

Table 14 Underwater Noise

Theme / Knowledge Gap	Underwater Noise
Receptor	Marine mammals / fish ecology
Background	FOW technology is anticipated to generate a distinct underwater noise profile compared to bottom-fixed wind farms, during both the construction and operational phases. The FOW farm construction process will involve the installation of multiple smaller anchor points per turbine, rather than single large-scale monopiles. During the operational phase, FOW platform dynamics and their associated mooring system and dynamic cable motions are anticipated to present novel acoustic considerations. The installation of FOW turbines in deeper waters further offshore, compared to bottom-fixed designs, may also have implications on the extent of underwater noise propagation and the particular species that must be considered. The precise nature and extent of these differences remain an area of ongoing study. Recent acoustic monitoring campaigns and analysis are providing a clearer picture of FOW underwater noise levels and their ecological significance for key marine species.
Evidence Base / Key Outcomes	Acting on the recommendations of the first iteration of this Roadmap, the FOW CoE launched the FOW Underwater Noise Monitoring and Mitigation (FLOWN-MIT) project in 2024. The project received match funding from The Crown Estate's Offshore Wind Evidence and Change (OWEC) programme, alongside in-kind contributions from Equinor. At the time of writing, FLOWN-MIT has delivered: • Underwater acoustic monitoring campaigns at the Kincardine and Hywind Tampen FOW farms. • A comprehensive review and supplementary analysis of data from Equinor and JASCO's prior monitoring study at Hywind Scotland. • Sound source characterisation analyses of the collected datasets. • Structural acoustic modelling of the studied turbine designs. • Wide area modelling to simulate future GW-scale FOW farm underwater noise. • Animal response simulations for the modelled GW-scale wind farms. FLOWN-MIT is scheduled for completion in 2026. The remaining project stages will include acoustic modelling of FOW anchor installations, an ecological review of the project's monitoring and modelling outcomes, and recommendations on potential innovations and noise management solutions. FLOWN-MIT's forthcoming final report will outline targeted next steps, including relevant technical developments and environmental research to address remaining potential uncertainties and risks. The findings will also

	support the development of standardised monitoring and mitigation techniques, helping to refine the environmental impact assessment (EIA) process for FOW.
Recommendations	Technical innovation: • Ongoing review of the innovation landscape applicable to FOW and deep-water noise abatement solutions. • Consideration of the design-based innovation recommendations outlined in the forthcoming FLOWN-MIT report. Environmental Science: • Continued industry engagement with environmental stakeholders regarding potential impact pathway concerns relating to underwater noise. Policy: • Continued collaboration between regulators and industry regarding the implementation of proportionate FOW noise monitoring requirements. Where appropriate, these should consider the outcomes of the FLOWN-MIT project.

4 CONCLUSIONS AND NEXT STEPS

This new revision of the Floating Offshore Wind (FOW) Environmental Interactions Roadmap has reappraised and updated the key knowledge gaps related to FOW technology's environmental interactions. It provides a framework for addressing these gaps through targeted research, collaboration, and policy development.

Since this roadmap was first published in 2022, the industry has made significant progress in understanding the environmental interactions of FOW. However, further targeted research will be required as commercial-scale deployment accelerates, and new challenges and uncertainties continue to emerge. The FOW CoE's Environmental Interactions Strategic Programme (EISP) will continue to advance knowledge within this field and ensure that industry efforts remain aligned with regulatory needs and best practices.

The key actions identified in this roadmap fall into three primary categories:

Environmental Science

- **Harnessing operational data:** Insights from pilot-scale and early commercial FOW projects should be leveraged to build a stronger evidence base.
- **Addressing knowledge gaps:** Further research is required in areas such as cumulative impacts, underwater noise, and fisheries interactions, with an emphasis on receptor-specific studies.
- **Enhancing data sharing:** Improved coordination across projects will maximise the value of existing and future environmental datasets.

Technical Innovation

- **Developing advanced monitoring tools:** More sophisticated approaches, including remote sensing and in situ testing, will support more accurate impact assessments.
- **Exploring mitigation and adaptive approaches:** Where possible and practical, strategies such as nature-positive design principles and adaptive management techniques should be incorporated into environmental impact assessments.
- **Standardising methodologies:** Greater consistency in regional assessments and other key evaluation processes will improve regulatory efficiency and industry alignment.

Policy and Regulation

- **Engagement with policymakers and regulators:** Continued dialogue with key decision-makers will help to ensure that emerging research informs regulatory updates.
- **Supporting marine spatial planning (MSP):** The expansion of FOW should be integrated into MSP frameworks across the UK, balancing development with existing marine activities such as fishing.
- **Alignment with environmental reforms:** Industry should remain engaged with initiatives such as the Offshore Wind Environmental Improvement Package (OWEIP) to ensure that policy developments reflect the unique characteristics of FOW.

Next Steps

To ensure the successful implementation of this roadmap, the following next steps have been identified:

Strategic Research Coordination

- The FOW CoE will continue to update its Environmental Research Database to track ongoing projects and identify remaining gaps.
- Collaboration with academic and industry research initiatives will be expanded to avoid duplication of efforts and enhance cross-sector knowledge sharing.

Targeted Industry Workshops and Stakeholder Engagement

- Further engagement sessions with regulators, environmental organisations, and industry stakeholders will be held to refine research priorities and facilitate knowledge exchange.
- Direct engagement with policymakers will support the development of standardised environmental assessment methodologies for FOW.

Pilot-Scale Testing and Evidence Gathering

- Opportunities for real-world monitoring and data collection at operational FOW sites will be prioritised.
- New research projects, including the FLOWN-MIT programme, will contribute to a clearer understanding of underwater noise impacts and mitigation strategies.

Regulatory Alignment and Guidance Development

- Updates to industry guidance, including best practice documents for environmental impact assessments, will be pursued in collaboration with key regulatory bodies.
- The roadmap findings will be disseminated across the sector to support an evidence-based approach to environmental decision-making.

Through the execution of these next steps, the UK FOW sector will be better positioned to address environmental challenges proactively, support an efficient consenting process, and facilitate the sustainable growth of floating offshore wind.

The FOW CoE extends its gratitude to Supergen for their support in delivering this project. It also thanks all stakeholders who contributed to this roadmap update, whose expertise and insights have been invaluable in shaping future research priorities and reinforcing the UK's leadership in the responsible development of floating offshore wind.

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