FLOATING OFFSHORE WIND CENTRE OF EXCELLENCE

Delivered by CATAPULT Offshore Renewable Energy

FLOATING OFFSHORE WIND CO-LOCATION AND CO-EXISTENCE RISKS AND OPPORTUNITIES

Public Summary Report

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NOMENCLATURE

CCSA	Carbon Capture and Storage Association
CCUS	Carbon Capture, Utilisation & Storage
EMF	Electromagnetic Field
ESCA	European Subsea Cables Association
FAD	Fish Aggregation Device
FOW	Floating Offshore Wind
FOW CoE	Floating Offshore Wind Centre of Excellence
GW	Gigawatt
INTOG	Innovation and Targeted Oil & Gas
LCOE	Levelised Cost of Energy
MoD	Ministry of Defence
MW	Megawatt
NSTA	North Sea Transition Authority
O&G	Oil & Gas
O&M	Operations & Maintenance
ORE	Offshore Renewable Energy
PEXA	Practice and Exercise Areas
SEPA	Scottish Environment Protection Agency
SUDG	Seabed User & Developer Group
UXO	Unexploded Ordinance

EXECUTIVE SUMMARY

The recent launches of the ScotWind and Round 5 leasing processes marked the beginning of the leasing and development process for large scale floating offshore wind (FOW) in Scotland and the Celtic Sea, respectively. Both leasing processes incorporated an extensive and iterative consultation process in order to anticipate and mitigate a range of possible sectoral conflicts. Nevertheless, the potential remains for future offshore wind developments in the UK to have some form of impact on other sea users, and given the early commercial status of FOW technology relative to fixed wind, the exact nature of these potential impacts are currently unclear.

With this in mind, the Floating Offshore Wind Centre of Excellence (FOW CoE) launched the Floating Offshore Wind Co-location and Co-existence Risks and Opportunities project. The aim was to facilitate a stakeholder engagement process that would identify potential interactions between future commercial-scale FOW farms and a range of other sea users, and to assess the associated challenges and potential opportunities. The principal objective was to develop a roadmap outlining a portfolio of activities which, if carried out in a timely manner, could deliver benefits that coincide with commercial-scale FOW deployment over the course of the next decade, and would support constructive engagement between the two sectors both throughout this period and beyond.

The FOW Co-location and Co-existence Risks and Opportunities project is intended to accompany the previous FOW CoE study, the Floating Offshore Wind and Fishing Interaction Roadmap, the findings of which were published in November 2021. As such, both projects follow a similar approach and format. **The scope of the FOW Co-location and Co-existence Risks and Opportunities project principally focusses on the following maritime industries: aquaculture, carbon capture and storage, defence, oil and gas, and subsea cables.** To avoid duplication with the FOW and Fishing Interaction Roadmap, and the FOW CoE's Floating Offshore Wind Navigational Planning and Risk Assessment project (published in September 2023), the fishing, maritime navigation, and aviation industries were excluded from the scope of this project.

The findings of the FOW Co-location and Co-existence Risks and Opportunities project are set out within this document, with a discussion of priority interactions and a roadmap of recommended actions set out in Sections 3 and 4.

Throughout this roadmap, the term “interaction” is used to reflect any potential interface between the FOW industry and other sea users that could result in some form of impact, either positive or negative. A number of key considerations should be borne in mind when assessing these interactions, and when reviewing the roadmap in general:

- Each interaction has been identified on a hypothetical basis by the project’s stakeholder participants. Given the FOW industry’s early commercial status, it remains to be seen whether a given interaction will be borne out in practice as the industry commercialises;

- The interactions were prioritised based on the input of a broad range of stakeholder organisations. Where an interaction has been marked as high priority, this may reflect: the potential impact of its occurrence; the perceived likelihood of its potential occurrence; and/or the ability of key stakeholders to intervene in order to mitigate the associated challenges or exploit an opportunity;

- On an individual level, each interaction is considered to be possible in principle. However, in certain cases, the occurrence of one interaction would impact the likelihood of another taking place. With this in mind, each interaction has been addressed within this roadmap on a case-by-case basis;

- Due to the lack of technology distinction between the static (i.e. buried) section of FOW and bottom fixed offshore wind farm export cables, this FOW farm subsystem was excluded from the project’s scope from the outset.

In disseminating the outputs of the FOW Co-location and Co-existence Risks and Opportunities project through this report, the FOW CoE intends to deliver an accessible reference document that maps some of the key considerations of co-existing with other sea users within the UK. The ambition is that this resource will provide a foundation for coordinating a programme of further activities that address these risks and opportunities and will ultimately help to support collaborative relationships with other maritime industries over the course of the next decade and beyond.

1 BACKGROUND

1.1 Context

The UK offshore wind industry shares the marine space with a range of other sea users. The operational requirements of these other established maritime industries must be considered and addressed during the development phase of any new wind farm, and as such these other sea users should be regarded as key stakeholders relevant to the offshore wind development and consenting process.

The UK has ambitious growth ambitions for offshore wind generating capacity, and it is anticipated that as much as 50% of the 100GW by 2050 target could be delivered by floating offshore wind (FOW). The greater complexity of FOW subsea infrastructure, and the ability of FOW technology to access new areas of the sea with deeper waters, relative to fixed wind, means that FOW developments could be subject to novel consenting risks in respect of its interactions with these other sea users. Therefore, in order to facilitate a timely and efficient development and consenting process for future commercial-scale FOW developments, and to reduce the risk of delays brought about by uncertainty, the challenges and opportunities associated with coexisting with other sea users should be reassessed in respect of FOW technology.

This concern was highlighted in the Floating Offshore Wind Centre of Excellence's (FOW CoE) Floating Offshore Wind Environmental Interactions Roadmap, which recommended that further, targeted work is required in order to address the current knowledge gaps relating to FOW-specific co-location and co-existence challenges and opportunities.

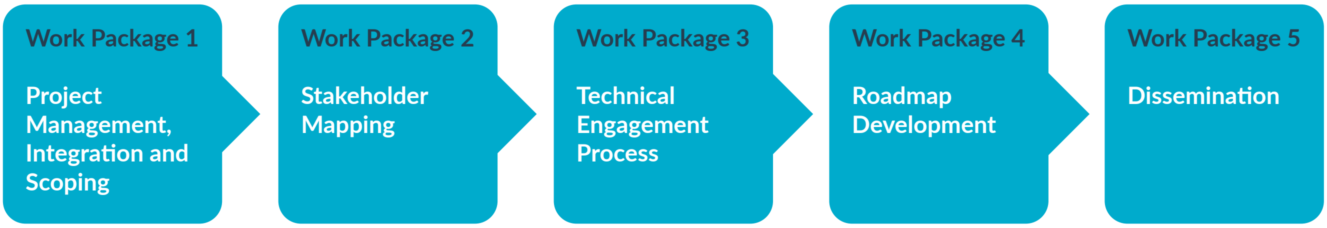
To date, the FOW CoE has delivered two projects relevant to this question: Floating Offshore Wind and Fishing Interaction Roadmap, and Floating Offshore Wind Navigational Planning and Risk Assessment. The outcomes of these two projects have supported the FOW industry's understanding of the challenges and opportunities associated with coexisting with the fishing industry, and the maritime and aviation industries, respectively, and will inform the scope of related future FOW CoE activities.

However, there remain a number of additional industries – including, for example, oil and gas, carbon capture and storage, subsea cables, aquaculture, defence etc. – with whom the FOW CoE's engagement to date has been comparably limited. The FOW Co-location and Co-existence Risks and Opportunities project is therefore intended to specifically address potential consenting risks associated with co-locating with these additional other sea users, and to provide needed clarity on the means by which this might be achieved.

1.2 Project Overview

The FOW Co-location and Co-existence Risks and Opportunities project utilised the approach and stakeholder engagement framework previously developed for the Floating Offshore Wind Environmental Interactions Roadmap project. Figure 1 outlines the project's structure and core Work Packages.

Figure 1 - Project Structure



Work Package 2 facilitated a review of potential other sea users and maritime industries who could potentially present co-location and co-existence considerations for future commercial FOW developments. The input of the project's Focus and Steering Groups (see Section 1.4) was sought during this stakeholder review process. Where relevant stakeholders were identified, a review of relevant guidance documents and resources (specific to those other sea users and maritime industries) was undertaken to ensure that the subsequent stages of the project were conducted on as fully informed a basis as possible.

In Work Package 3, a series of 1-2-1 engagements were undertaken with key stakeholders. Attendees were invited based on the outcomes of Work Package 2. The aim of these engagements was to identify potential interactions between the FOW industry and the other sea users identified in Work Package 2, assess the potential risks and opportunities associated with those interactions, and to scope relevant future research and project activities to mitigate the identified risks and exploit the potential opportunities. Section 2 outlines the stakeholder engagement framework in further detail.

In Work Package 4, the priority interactions identified and recommendations for follow-on work developed during the workshops were set forth in a Roadmap (Section 4). Work Package 5 oversaw the public dissemination of these findings.

1.3 Floating Offshore Wind Centre of Excellence

The Floating Offshore Wind Centre of Excellence (FOW CoE) 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 Industry Partners

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, 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 Co-location and Co-existence Risks and Opportunities project was delivered under the Environmental Interactions Strategic Programme.

1.4 Project Partners

The Offshore Renewable Energy Catapult is the principal delivery partner of the FOW Co-location and Co-existence Risks and Opportunities project.

In order to facilitate the technical input and guidance of the FOW CoE's Industry Partners, a Focus Group of partner representatives with relevant subject matter expertise was established at the outset of the project. This Focus Group included representatives from BP, CIP, EDF, Equinor, ESB, Mainstream Renewable Power, Northland Power, Ocean Winds, Ørsted, RWE, SSE, and TotalEnergies.

Additionally, a project Steering Group including Crown Estate Scotland, Defra, Department for Energy Security and Net Zero, Marine Scotland, Natural Resources Wales and The Crown Estate was established in order to provide additional strategic guidance and input during the project's development and delivery.

Figure 3 - Floating Offshore Wind Centre of Excellence Industry Partners

Crown Estate Scotland
Oighreachd a' Chrùin Alba

Department for Energy Security & Net Zero

Department for Environment Food & Rural Affairs

marine scotland

Cyfoeth Naturiol Cymru
Natural Resources Wales

THE CROWN ESTATE

2 STAKEHOLDER ENGAGEMENT FRAMEWORK

The identification key FOW co-location and co-existence risks and opportunities (interactions), and the development of the Roadmap to mitigate and exploit those interactions was directly informed by a series of 1-2-1 structured stakeholder engagement sessions. Figure 4 outlines the approach undertaken in these engagements during Work Package 3, whereby the participants were invited to identify potential interactions between the FOW industry and other sea users in the first instance, then assess these in terms of their priority, and then finally develop high-level scopes for relevant future research activities. These engagements were held remotely via Microsoft Teams.

Figure 4 - Stakeholder Engagement Structure

1. **Identify potential interactions between FOW and Other Sea Users.**
2. **Assess the effect of each interaction, identifying the priority areas.**
3. **Identify relevant research activities, including potential delivery partners.**

The first step of the stakeholder engagement process focussed on identifying potential interactions between the FOW industry and the other sea users identified during Work Package 2. The identified interactions were grouped into six "types": Physical & Technology; Operations & Navigation; Ports & Infrastructure; Policy & Regulation; Environmental; People & Skills.

The second step of the engagement process involved assessing the priority status of the identified interactions. In the case of each interaction, the participants addressed the following questions:

1 Assuming no actions are taken, how likely (i.e. Low/Medium/High) is this interaction to occur, and why?

2 What would the likely impact (i.e. Low/Medium/High) be on each stakeholder group?

3 What could be done to either mitigate the impact on each stakeholder group, or exploit any potential opportunities?

4 Based on these considerations, should this interaction be a priority area for further project work?

Table 1 and Table 2 outline how the priority scores were assigned based on a combination of likelihood and impact. The interactions identified, and the priority scores they were subsequently assigned, are summarised in Section 3 of this report.

Table 1 - Interaction Priority Matrix

			Impact		
			Low	Medium	High
			1	2	3
Likelihood	High	3	3	6	9
	Medium	2	2	4	6
	Low	1	1	2	3

Table 2 - Interaction Priority Scores

Score	Prioritisation
9	High
6	
4	Medium
3	
2	Low
1	

The final step of the engagement process focussed on determining the research activities that would address the potential impacts of the high and medium priority interactions identified in the previous steps. In the case of each interaction, the participants addressed two key tasks:

1. Scope out relevant research activities to help mitigate the impact on each stakeholder group or exploit any potential opportunities.

2. Identify, for each activity, potential suitable project delivery partners.

The outputs of these engagements were subsequently used to form the basis of the Roadmap set out in Section 4 of this report.

2.1 Key Stakeholders

The following external stakeholder accepted invitations to participate in the project's stakeholder engagement process: Aquaculture Industry Wales, Carbon Capture and Storage Association (CCSA), Cefas, European Subsea Cables Association (ESCA), North Sea Transition Authority (NSTA), Ofcom, Scottish Environment Protection Agency (SEPA), Seabed User & Developer Group (SUDG), and Vodafone. Frazer-Nash Consultancy provided input on defence industry considerations. In addition to these external stakeholders, the project's Focus and Steering Group members were invited to participate in the technical engagement process.

3 FOW CO-LOCATION & CO-EXISTENCE PRIORITY INTERACTIONS

The potential interactions summarised in this section were identified during 1-2-1 engagements with stakeholders from the Aquaculture, Carbon Capture, Utilisation and Storage (CCUS), Defence, Oil and Gas (O&G) and Subsea Cables sectors. Stakeholders were asked to rank the likelihood and impact of each potential interaction as either **high, medium** and **low**. Additionally, stakeholders were invited to comment on possible activities to mitigate impacts and/or exploit opportunities that may result from the interactions between the FOW sector and the specified maritime industry.

Potential interactions for each maritime industry are outlined in Table 3. These have been grouped into six interaction "types": Physical & Technology; Operations & Navigation; Ports & Infrastructure; Policy & Regulation; Environmental; People & Skills. Section 4 sets out further detailed discussions for the high and medium priority interactions on an industry-by-industry basis.

It is important to note that these interactions have been identified on a **hypothetical basis**, and it remains to be seen whether a given interaction will be borne out in practice as the FOW industry commercialises.

Table 3 - High, Medium and Low Priority Potential Interactions Between Floating Offshore Wind and Other Sea Users

Aquaculture			
	Interaction Type	**Interaction Description**	**Priority Score**
A1	Policy & Regulation	Absence of relevant and/or applicable design standards could delay or prevent investment in, and the development of, co-located FOW and aquaculture farms.	High
A2	Environmental	Attraction effects due to aquaculture farm draws additional marine life to the area, potentially increasing the risk of interactions with FOW infrastructure.	High
A3	Physical & Technology	Co-location of aquaculture cages and FOW turbines presents an opportunity for the two industries to share anchors, thereby reducing CAPEX costs.	High
A4	Operations & Navigation	Scheduling of FOW farm vessel operations presents opportunities to support aquaculture logistics (e.g., vessel sharing arrangements for co-located FOW-aquaculture facilities).	High
A5	Physical & Technology	The potential for storm damage in deep water locations, further from shore, raises the risk profile for co-located projects	High
A6	Policy & Regulation	Gaps in the regulatory process for co-located FOW-aquaculture farms increase the development risk for these projects.	High
A7	Environmental	The installation of aquaculture cages further offshore (as a result of co-location with FOW turbines) may influence the risk of parasitic pathogens experienced by farmed fish species.	Medium
A8	Environmental	The opportunity to install aquaculture facilities further offshore, as a result of co-location with FOW farms, could help to mitigate potential environmental risks associated with aquaculture effluent.	Medium
A9	Policy & Regulation	Interest in aquaculture co-location opportunities leads FOW farm developers to develop internal aquaculture business divisions, thereby limiting collaboration opportunities with traditional aquaculture companies.	Medium
A10	Ports & Infrastructure	The development of a pipeline of commercial scale FOW farms, and the portside infrastructural developments that may accompany that, present an opportunity to develop and invest in existing onshore aquaculture processing facilities.	Medium
A11	Environmental	Potential environmental interactions associated with FOW technology (for example, relating to operational noise and dynamic cable electromagnetic field emissions) present possible risks to farmed fish.	Medium

Carbon Capture & Storage			
	Interaction Type	Interaction Description	Priority Score
CCS1	Policy & Regulation	Due to the early commercial status of CCUS technology, it is possible that any attempt to co-locate it with other industries will be viewed as inherently high-risk, thereby raising the cost of finance for co-located projects.	High
CCS2	Policy & Regulation	Lack of clarity regarding the appropriate process for navigating the inherent potential challenges and disputes associated with co-location could impact developer and investor confidence in co-located FOW-CCUS projects.	High
CCS3	Physical & Technology	Co-location of FOW and CCUS infrastructure presents opportunity for electrical powering of CCUS facilities.	High
CCS4	Operations & Navigation	Scheduling of FOW farm logistics presents opportunities to support CCUS operations (e.g., helicopter or vessel sharing arrangements for co-located FOW-CCUS projects).	High
CCS5	People & Skills	The joint growth of the FOW and CCUS industries could create competition for skilled offshore workforces.	High
CCS6	Physical & Technology	A FOW loss of station scenario poses potential risk to CCUS subsea and surface infrastructure. Similarly, damaged or lost CCUS equipment/ infrastructure could present a significant operational risk to co-located FOW infrastructure.	High
CCS7	Physical & Technology	The spatial requirements of FOW farms, which have larger mooring footprints compared to traditional fixed wind, could present a practical barrier to seismic monitoring requirements of the CCUS project.	Medium
CCS8	Physical & Technology	Co-location of FOW and CCUS projects presents potential opportunities for FOW infrastructure to host and/or support additional CCUS seismic monitoring activities.	Medium

Defence			
	Interaction Type	Interaction Description	Priority Score
D1	Ports & Infrastructure	Increased spatial footprint associated with FOW turbine assembly, marshalling and installation could lead to competition for port space, infrastructure and resources between both industries.	High
D2	Physical & Technology	Potential FOW loss of station scenario could create an unforeseen navigational hazard for defence vessels.	High
D3	Physical & Technology	Acoustic emissions of operational FOW farms could have potential implications on the effective range of sonar in the vicinity of FOW sites.	Medium
D4	Physical & Technology	Potential risk to FOW infrastructure due to the presence of unexploded ordnance (UXO) on the seabed.	Medium
D5	Operations & Navigation	Tow to port/tow to site of FOW turbines presents a navigational hazard for MoD vessel activities.	Medium
D6	Policy & Regulation	The presence of established Practice and Exercise Areas (PEXAs) creates spatial planning constraints for future FOW farms.	Medium
D7	Physical & Technology	FOW turbine heave, roll and pitch motions could interact with defence radar coverage to create ‘dead zones’.	Medium

Oil & Gas			
	Interaction Type	**Interaction Description**	**Priority Score**
OG1	Physical & Technology	Increasing levels of co-location of FOW and O&G leads to greater interaction risk between FOW infrastructure and O&G pipelines.	High
OG2	Policy & Regulation	The limited precent for co-locating FOW and O&G facilities could lead to developer and/or investor uncertainty (due to potential gaps in the regulatory process and associated development risk).	
OG3	Environmental	The co-location of FOW and O&G facilities presents opportunities to share environmental monitoring responsibilities and data.	Medium
OG4	Physical & Technology	The spatial requirements of FOW farms, which have larger mooring footprints compared to traditional fixed wind, could present a practical barrier to the seismic monitoring requirements of the O&G project.	
OG5	Physical & Technology	Electromagnetic field (EMF) emissions from FOW inter-array cables could present a potential risk to O&G pipelines (e.g., hypothetical risk of pipeline corrosion).	
OG6	Physical & Technology	A FOW farm's multiple anchor and dynamic cable seabed touchdown points presents interaction risk with old/abandoned O&G wells and pipelines	Low

Subsea Cables			
	Interaction Type	**Interaction Description**	**Priority Score**
SC1	Physical & Technology	Introduction of new subsea cable leases in proximity to existing FOW turbine arrays increases complexity and risk for new cable installations.	High
SC2	Operations & Navigation	Potential displacement of fishing vessels from FOW development areas leads to an increase in fishing activity over nearby/adjacent subsea cables, increasing the spatial constraints and risk profile of surrounding waters.	
SC3	Physical & Technology	Repair of subsea cables in the vicinity of FOW arrays poses a risk of damage to the wind farm's network of mooring and dynamic cable systems.	
SC4	Physical & Technology	Installation of FOW anchors and dynamic inter-array cables within the vicinity of existing subsea cables creates the risk of damage to subsea cables.	
SC5	Physical & Technology	Installation, operation and maintenance of FOW farms presents an operational risk for subsea cables.	Medium
SC6	Physical & Technology	Potential FOW loss of station scenario could lead to significant asset damage to co-located subsea cables.	
SC7	Physical & Technology	Subsea cable maintenance vessel operations lead to potential damage of FOW subsea infrastructure (e.g. due to deployment of emergency anchor onto a FOW mooring line).	
SC8	Physical & Technology	Subsea cables repairs lead to increased complexities of co-location due to the larger seabed footprint of post-repair cable configurations.	

4 FOW CO-LOCATION & CO-EXISTENCE PRIORITY INTERACTIONS DISCUSSION & ROADMAP

This chapter expands on each of the potential interactions identified in Section 3. For each interaction, the key considerations are discussed and a Roadmap proposing a timeline of recommended actions is set out. These are addressed on a per-industry basis: Aquaculture, CCUS, Defence, O&G, and Subsea Cables.

A high-level delivery timeline has been developed to reflect the appropriate order and rate at which these activities are conducted:

- **Short-term** – Activity that can be delivered from the outset, in anticipation of commercial-scale FOW arrays; the delivery of work is not dependent on further studies or projects being undertaken beforehand.

- **Medium-term** – Activity that can be initiated in the short-term, whilst additionally supplemented from lessons learned by the deployment of early commercial arrays (e.g. 100 MW – 500 MW). Outputs of these activities are intended to further support the design and development of future, full-scale commercial FOW arrays (e.g. 500 MW – 1GW and beyond).

- **Long-term** – Activity that should not be limited to the short- to medium-term and should also coincide with the development of full-scale commercial FOW arrays (e.g. 500 MW – 1GW and beyond).

Each interaction has been categorised according to the following “types”: Physical & Technology; Operations & Navigation; Ports & Infrastructure; Policy & Regulation; Environmental; People & Skills. In each case, the most relevant or applicable phase of the FOW farm life cycle is also noted, i.e.: Development, Installation, Operational, or Decommissioning (where an interaction might apply generally across all phases, this is denoted as Whole Life Cycle).

4.1 Aquaculture

Table 4 - Interaction A1

Interaction A1	Absence of relevant and/or applicable design standards could delay or prevent investment in, and the development of, co-located FOW and aquaculture farms.
Industry	Aquaculture
Type	Policy & Regulation
Life Cycle Phase	Development
Priority	High
Background	Given the significant levels of investment that will be required to develop large scale co-located FOW-aquaculture farms, developers and investors will need to be confident in the viability and survivability of the technologies utilised. In the absence of relevant and/or applicable design standards, it is possible that investment in the co-location of both industries would be regarded as high risk. FOW and commercial aquaculture are nascent industries relative to other more established maritime sectors; therefore, most development and investment opportunities will likely be directed to supporting the growth of the industries individually. A lack of incentive to invest in co-located FOW and aquaculture farms could prevent both industries benefitting from the potential opportunities that co-location presents. For the aquaculture industry, this could mean the loss of opportunities to expand into some deep-water locations alongside FOW farms. For the FOW industry, reduced co-location opportunities could lead to increased marine spatial planning constraints.
Future Activities/ Research	A review of current design standards would determine whether these are applicable to co-located FOW-aquaculture farms, or if there are current gaps in the guidance that need to be addressed. Where gaps are identified, engagement with classification societies would be required in order to address these.
Research Stakeholders	Aquaculture industry groups; classification societies; marine management organisations; offshore wind developers

Table 5 - Interaction A2

Interaction A2	Attraction effects due to aquaculture farm draws additional marine life to the area, potentially increasing the risk of interactions with FOW infrastructure .
Industry	Aquaculture
Type	Environmental
Life Cycle Phase	Operational
Priority	High
Background	The attraction of marine life to aquaculture farms is a known effect (for example, it is possible to apply for licences to cull seals that target fish farms). The presence of FOW infrastructure could present environmental considerations for key marine species, such as potential collision risks and noise effects. FOW infrastructure in combination with the attraction effects of aquaculture infrastructure could potentially increase the risk profile to the surrounding environment. If an increased risk to marine life can be demonstrated, then this is likely to increase consenting risk to co-located FOW-aquaculture farms. These effects will to a certain extent be dependent on location, and it is also possible that the installation of aquaculture farms further offshore, as a result of co-location with FOW, may influence whether licences to cull are granted (for example, if the development is located in a migration route, or an important area for marine life). Furthermore, the potential for FOW turbines to act as fish aggregation devices (FADs) is not fully understood, and it is possible that this effect could present an additional complexity in relation to this interaction (for example, due to unforeseen in-combination effects).
Future Activities/ Research	An initial review of current research and literature will add clarity regarding the nature and extent of these potential risks. Where required, further research could be undertaken to address knowledge gaps identified by the literature review. The development of relevant mitigation measures (e.g. the use of acoustic deterrents) may help to address consenting risk. Further, the development of best practice guidance for the environmental monitoring of co-located FOW-aquaculture facilities will help owner-operators to understand and manage specific risks.
Research Stakeholders	Aquaculture industry groups; consenting authorities, marine research institutes; offshore wind developers

Table 6 - Interaction A3

Interaction A3	**Co-location of aquaculture cages and FOW turbines presents an opportunity for the two industries to share anchors, thereby reducing CAPEX costs.**
Industry	Aquaculture
Type	Physical & Technology
Life Cycle Phase	Development
Priority	High
Background	The co-location FOW and aquaculture infrastructure presents a potential opportunity for the sharing of anchors. This approach has been used for Equinor's Tampen floating wind project in the North Sea, in which 19 anchors are used to secure 11 floating wind turbines, thereby demonstrating the practical viability of shared anchor technology. However, there is little-to-no practical experience of utilising shared anchors between FOW turbines and other floating structures, such as aquaculture cages, therefore further work would be required to assess the specific challenges of this application. Whilst anchors do not account for a large proportion of a FOW farm's CAPEX, potential cost savings would nevertheless be viewed as a positive opportunity, assuming that any design challenges and associated risks could be suitably mitigated.
Future Activities/ Research	Further design analysis is required to fully understand the challenges and practical feasibility of shared anchors between FOW turbines and aquaculture cages. Similarly, an economic analysis of potential solutions would be necessary to understand the extent of any resulting CAPEX reduction, in the form of a techno-economic impact review to explore varying shared anchor configurations to determine cost effective approach to sharing of anchors between FOW and aquaculture farms.
Research Stakeholders	Aquaculture industry groups; offshore wind developers

Table 7 - Interaction A4

Interaction A4	**Scheduling of FOW farm vessel operations presents opportunities to support aquaculture logistics (e.g. vessel sharing arrangements for co-located FOW-aquaculture facilities).**
Industry	Aquaculture
Type	Operations & Navigation
Life Cycle Phase	Operational
Priority	High
Background	Assuming co-located FOW-aquaculture facilities are developed, it is likely that operational teams would seek to reduce costs by sharing vessel time whenever opportunities present themselves. The combining of vessel operations wherever possible could present a modest yet meaningful opportunity to reduce operational costs for both industries. Additionally, management of vessel traffic within a given area through vessel sharing, may help to mitigate potential logistical risks for both industries. Additionally, sharing of vessels would reduce competition between resources that could be operating at peak capacity in the short- to medium-term in order to meet net zero goals.
Future Activities/ Research	A more detailed cost analysis would be required to determine the extent of this opportunity, and to enable both industries to understand the scale of the potential cost savings. Additionally, while there may currently be a reasonable understanding of the operational requirements of deep-water aquaculture sites (including the potential split of manual vs automated tasks), further work is required to develop a more detailed overview of this.
Research Stakeholders	Aquaculture industry groups; maritime and lighthouse authorities, offshore wind developers.

Table 8 - Interaction A5

Interaction A5	The potential for storm damage in deep water locations, further from shore, raises the risk profile for co-located projects.
Industry	Aquaculture
Type	Physical & Technology
Life Cycle Phase	Development
Priority	High
Background	It is likely that a co-located FOW-aquaculture project would only proceed in the event that developers and investors were confident in the survivability of the infrastructure, and that the project was built in accordance with the applicable design standards. Nevertheless, potential damage (e.g. a mooring system failure) can never be fully ruled out. Secondary risks resulting from storm damage to either the FOW or aquaculture infrastructure could range from minor asset damage to serious/catastrophic scenarios. With FOW infrastructure being deployed further offshore, and exposed to more unpredictable/extreme weather windows, this could increase potential incidences of infrastructure damage for co-located projects. Costs would also be incurred by the operators, ranging from minor to major, respectively.
Future Activities/ Research	A review of current design standards would determine whether these would be applicable to co-located FOW-aquaculture farms, or if there are current gaps in the guidance that need to be addressed. Where gaps are identified, engagement with classification societies would be required in order to address these. Developers will need to assess the appropriate level of redundancy in their designs that sufficiently mitigates risk without incurring prohibitively high CAPEX costs.
Research Stakeholders	Aquaculture industry groups; classification societies, offshore wind developers.

Table 9 - Interaction A6

Interaction A6	Gaps in the regulatory process for co-located FOW-aquaculture farms increase the development risk for these projects.
Industry	Aquaculture
Type	Policy & Regulation
Life Cycle Phase	Development
Priority	High
Background	The current lack of precedent for the development of co-located facilities raises the likelihood that specific gaps and/or unidentified risks in the consenting process could present challenges to potential future project applications. The potential failure of project applications resulting from development and consenting risks would represent a significant opportunity cost for both sets of stakeholders. Further, the impacted ability to collocate FOW and aquaculture facilities could place additional pressure on the spatial planning process, thereby increasing consenting risk for both industries in the medium-to-long term.
Future Activities/ Research	A review of the development and consenting process applicable to co-located FOW-aquaculture facilities would enable both industries to identify specific risks and opportunities. Where gaps are identified, work should be undertaken to deliver the appropriate guidance.
Research Stakeholders	Aquaculture industry groups; consenting authorities, marine management organisations; offshore wind developers.

Table 10 - Interaction A7

Interaction A7	**The installation of aquaculture cages further offshore (as a result of co-location with FOW turbines) may influence the risk of parasitic pathogens experienced by farmed fish species.**
Industry	Aquaculture
Type	Environmental
Life Cycle Phase	Operational
Priority	Medium
Background	The impacts of sea lice and other pathogens are a significant source of cost to the aquaculture industry. The deployment of aquaculture cages in a new environment could potentially change the risk profile of sea lice infestation. If installation further offshore helps to mitigate this, potentially as a result of the hydrodynamic conditions found in less sheltered deeper waters, then the business case for co-located FOW-aquaculture farms could be more attractive.
Future Activities/ Research	A review of the literature on the spatial distribution of sea lice would help to clarify both the likelihood and impact of this effect. It may be necessary to subsequently undertake further environmental research to address any current knowledge gaps identified in the literature review.
Research Stakeholders	Aquaculture industry groups; marine research institutes.

Table 11 - Interaction A8

Interaction A8	**The opportunity to install aquaculture facilities further offshore, as a result of co-location with FOW farms, could help to mitigate potential environmental risks associated with aquaculture effluent.**
Industry	Aquaculture
Type	Environmental
Life Cycle Phase	Operational
Priority	Medium
Background	Currently, aquaculture farms are typically installed within more sheltered inshore locations. This can result in potential concerns relating to the environmental effects of aquaculture effluent. Co-located FOW-aquaculture facilities would likely be installed in deeper waters with more dynamic metocean conditions, and it is possible that this could assist with the dilution of effluent. The extent and nature of this effect is currently unclear. However, if it can be demonstrated that the installation of aquaculture farms further offshore could have a positive effect on the environmental risks associated with aquaculture effluent, this could assist with the consenting of co-located FOW-aquaculture farms.
Future Activities/ Research	An initial review of current research and literature will add clarity regarding the nature and extent of this potential effect. Where required, further environmental research could be undertaken to address knowledge gaps identified by the literature review.
Research Stakeholders	Aquaculture industry groups; marine research institutes.

Table 12 - Interaction A9

Interaction A9	Interest in aquaculture co-location opportunities leads FOW farm developers to develop internal aquaculture business divisions, thereby limiting collaboration opportunities with traditional aquaculture companies.
Industry	Aquaculture
Type	Policy & Regulation
Life Cycle Phase	Development
Priority	Medium
Background	At the time of writing, it is unclear the extent to which FOW farm developers would typically pursue this strategy. There is nevertheless the potential to see diversification within the FOW industry, if there is a compelling business case to do so. In respect of potential impacts on the aquaculture industry, the diversification of FOW developers into aquaculture operations could represent both a significant opportunity cost for established aquaculture companies and an additional source of competition, thereby impacting revenue. For FOW developers, any project decisions that might negatively impact established local businesses could potentially negatively impact consenting applications.
Future Activities/ Research	Early engagement between the two sectors will be key to ensuring that collaborative co-location opportunities are thoroughly explored, understood and exploited wherever it is practically and economically feasible to do so. A detailed understanding of the applicable policy landscape will also be important.
Research Stakeholders	Aquaculture industry groups; government departments; offshore wind developers.

Table 13 - Interaction A10

Interaction A10	**The development of a pipeline of commercial scale FOW farms, and the portside infrastructural developments that may accompany that, present an opportunity to develop and invest in existing onshore aquaculture processing facilities.**
Industry	Aquaculture
Type	Ports & Infrastructure
Life Cycle Phase	Whole Life Cycle
Priority	Medium
Background	The FOW industry is currently working to determine the scale of the infrastructural investment and development needed to support the marshalling and assembly of future FOW farms. If FOW and aquaculture farms can be co-located, the portside requirements of both sectors must be met. Without a strong strategic approach and relevant support, it could be challenging to secure this opportunity. It is possible that onshore infrastructure investment is a necessary condition of the expansion of the aquaculture industry into larger facilities, further from shore.
Future Activities/ Research	Targeted engagement with the aquaculture sector would be required to understand the extent to which investment in onshore infrastructure is required to facilitate the co-location of the two industries. If such investment is a necessary condition of co-location, active engagement between the aquaculture sector, FOW developers and government/ local authorities will likely be required to secure the necessary strategic support.
Research Stakeholders	Aquaculture industry groups; government departments, harbour authorities, marine management organisations, offshore wind developers

Table 14 - Interaction A11

Interaction A11	**Potential environmental interactions associated with FOW technology (for example, relating to operational noise and dynamic cable electromagnetic field emissions) present potential risks to farmed fish.**
Industry	Aquaculture
Type	Environmental
Life Cycle Phase	Operational
Priority	Medium
Background	There is currently some uncertainty relating to the specific environmental interactions of FOW technology. While these effects are not fully understood, both in terms of their likelihood or the extent of their impact, it is nevertheless possible that they could pose risks to the health of farmed fish, thereby impacting the viability of co-located FOW-aquaculture projects.
Future Activities/ Research	Further research is required to assess the extent of the risks that FOW technology could pose to the health of farmed fish. In the first instance, a review of existing literature would determine the current understanding of these potential effects. Where the existence of knowledge gaps is confirmed, targeted environmental research would be required to address these.
Research Stakeholders	Aquaculture industry groups; marine research institutes, offshore wind developers

Table 15 - Recommended Activity Categories

Key	Activity Type
	Operational risk review
	Licensing/planning review
	Environmental monitoring studies
	Insurance policy review
	Technology review and development
	Developing best practice and industry guidance
	Review of economic opportunities

Table 16 - Floating Offshore Wind and Aquaculture Interaction Roadmap

<table>
<tr><th>Industry</th><th colspan="6">Aquaculture</th></tr>
<tr><td>Interaction</td><td>Type</td><td>Description</td><td>Priority</td><td>Short-Term (2024-2025)</td><td>Medium-Term (Early Commercial Arrays)</td><td>Long-Term (Full Commercial Arrays)</td></tr>
<tr><td rowspan="3">A1</td><td rowspan="3">Policy & Regulation</td><td rowspan="3">Absence of relevant and/or applicable design standards could delay or prevent investment in, and the development of co-located FOW and aquaculture farms.</td><td rowspan="3">High</td><td colspan="2">Review of applicable design standards for co-located FOW and aquaculture farms. Where gaps exist, collaboration between key stakeholders to develop appropriate guidance.</td><td></td></tr>
<tr><td colspan="2">Technology review and feasibility assessment of co-located FOW and aquaculture infrastructure.</td><td></td></tr>
<tr><td colspan="3">Effective engagement between both industries to manage co-location considerations during co-located FOW-aquaculture project development stage.</td></tr>
<tr><td rowspan="3">A2</td><td rowspan="3">Environmental</td><td rowspan="3">Attraction effects due to aquaculture farm draws additional marine life to the area, potentially increasing the risk of interactions with FOW infrastructure.</td><td rowspan="3">High</td><td>Review of existing literature to identify and confirm further research requirements.</td><td colspan="2"></td></tr>
<tr><td colspan="2">Further laboratory monitoring studies (if relevant and required).</td><td></td></tr>
<tr><td colspan="2">Environmental monitoring studies within early commercial FOW – Aquaculture farms to assess attraction effects.</td><td></td></tr>
</table>

<table>
<tr><th>Industry</th><th colspan="6">Aquaculture</th></tr>
<tr><th>Interaction</th><th>Type</th><th>Description</th><th>Priority</th><th>Short-Term (2024-2025)</th><th>Medium-Term (Early Commercial Arrays)</th><th>Long-Term (Full Commercial Arrays)</th></tr>
<tr><td rowspan="2">A3</td><td rowspan="2">Physical & Technology</td><td rowspan="2">Co-location of aquaculture cages and FOW turbines presents an opportunity for the two industries to share anchors, thereby reducing CAPEX costs.</td><td rowspan="2">High</td><td>Review of FOW and aquaculture industry requirements for shared anchors and delivery of initial technical feasibility studies. Assess scale of potential economic opportunity based on both industries' deployment pipeline.</td><td></td><td></td></tr>
<tr><td colspan="2">Develop guidance for FOW and aquaculture industry outlining the requirements and applicable design standards for shared anchors, as well as the potential scale of economic opportunity.</td><td></td></tr>
<tr><td>A4</td><td>Operations & Navigation</td><td>Scheduling of FOW farm vessel operations presents opportunities to support aquaculture logistics (e.g. vessel sharing arrangements for co-located FOW-aquaculture facilities).</td><td>High</td><td>Review logistical and economic feasibility of vessel-sharing between FOW and aquaculture.</td><td></td><td></td></tr>
<tr><td rowspan="2">A5</td><td rowspan="2">Physical & Technology</td><td rowspan="2">The potential for storm damage in deep water locations, further from shore, raises the risk profile for co-located projects.</td><td rowspan="2">High</td><td>Risk assessment of storm damage for co-located FOW and aquaculture infrastructure.</td><td></td><td></td></tr>
<tr><td colspan="2">Engage with classification societies to review applicable design standards. Where necessary and appropriate, develop updated standards to address key gaps.</td><td></td></tr>
</table>

Industry	Aquaculture					
Interaction	Type	Description	Priority	Short-Term (2024-2025)	Medium-Term (Early Commercial Arrays)	Long-Term (Full Commercial Arrays)
A6	Policy & Regulation	Gaps in the regulatory process for co-located FOW-aquaculture farms increase the development risk for these projects.	High	Review current regulatory process for potential co-located FOW-aquaculture farms.		
				Where necessary and appropriate, engage with regulatory bodies to address risks/gaps in the consenting process.		
A7	Physical & Technology	The installation of aquaculture cages further offshore (as a result of co-location with FOW turbines) may influence the risk of parasitic pathogens experienced by farmed fish species.	Medium	Review of existing research to identify and confirm further research requirements.		
				Environmental monitoring studies to assess potential attraction effects.		
A8	Environmental	The opportunity to install aquaculture facilities further offshore, as a result of co-location with FOW farms, could help to mitigate potential environmental risks associated with aquaculture effluent.	Medium	A review of existing literature and current research to establish the current understanding of this effect.		
				Environmental monitoring studies to address any current gaps in the literature.		

Industry	Aquaculture					
Interaction	Type	Description	Priority	Short-Term (2024-2025)	Medium-Term (Early Commercial Arrays)	Long-Term (Full Commercial Arrays)
A9	Policy & Regulation	Interest in aquaculture co-location opportunities leads FOW farm developers to develop internal aquaculture business divisions, thereby limiting collaboration opportunities with traditional aquaculture companies.	Medium	Continuous engagement and collaboration between both industries to effectively manage expectations and monitor co-location opportunities. Engagement with appropriate government departments to ensure that the development and consenting process sufficiently addresses this consideration.		
A10	Physical & Technology	The development of a pipeline of commercial scale FOW farms, and the portside infrastructural developments that may accompany that, present an opportunity to develop and invest in existing onshore aquaculture processing facilities.	Medium	Review of FOW portside requirements, in respect of existing onshore aquaculture processing facilities and associated economic opportunities.		
				Following an initial review, guidance on the integration of FOW portside infrastructure with existing aquaculture facilities, and engagement with the supply chain to manage these requirements and their feasibility.		
A11	Environmental	Potential environmental interactions associated with FOW technology (for example, relating to operational noise and dynamic cable electromagnetic field emissions) present possible risks to farmed fish.	Medium	A review of existing research to identify and confirm further research requirements.		
				Environmental monitoring studies within early commercial FOW farms to assess potential noise impacts.		

4.2 Carbon Capture & Storage

Table 17 - Interaction CCS1

Interaction CCS1	Due to the early commercial status of CCUS technology, it is possible that any attempt to co-locate with other industries will be viewed as inherently high-risk, thereby raising the cost of finance for co-located projects.
Industry	CCUS
Type	Policy & Regulation
Life Cycle Phase	Development
Priority	High
Background	Given the relatively early commercial status of FOW technology, and the novel status of CCUS, lenders may view co-located projects as risky, at least in the short-to-medium term. Continued uncertainty surrounding this question could ultimately impact developers' and investors' appetite for supporting co-located FOW-CCUS projects. As marine spatial planning constraints increase, the inability to co-locate the two technologies could represent a significant opportunity cost for both industries.
Future Activities/ Research	The development of targeted guidance would help to address the inherent uncertainty surrounding this issue. Early and targeted engagement between regulators and the FOW and CCUS sectors would be key to facilitating this.
Research Stakeholders	Consenting authorities; CCUS industry groups; marine management organisations; offshore wind developers.

Table 18 - Interaction CCS2

Interaction CCS2	Lack of clarity regarding the appropriate process for navigating the inherent potential challenges and disputes associated with co-location could impact developer and investor confidence in co-located FOW-CCUS projects.
Industry	CCUS
Type	Policy & Regulation
Life Cycle Phase	Development
Priority	High
Background	A lack of clarity on the appropriate process for navigating the inherent challenges and potential disputes associated with co-location could impact developer and investor confidence in co-located FOW-CCUS projects. As the marine space continues to get busier, the absence of an appropriate agreement between the two sectors will increase the potential for uncertainty surrounding this issue, which in the worst case scenario could dissuade developers and investors from supporting co-located FOW-CCUS projects. As marine spatial planning constraints continue to increase, the inability to co-locate the two technologies could represent a significant opportunity cost for both industries.
Future Activities/ Research	The development of targeted guidance would help to address the inherent uncertainty surrounding this issue. Early and targeted engagement between regulators and the FOW and CCUS sectors would be key to facilitating this.
Research Stakeholders	CCUS industry groups; marine management organisations; offshore wind developers

Table 19 - Interaction CCS3

Interaction CCS3	**Co-location of FOW and CCUS infrastructure presents opportunity for electrical powering of CCUS facilities.**
Industry	CCUS
Type	Physical & Technology
Life Cycle Phase	Whole Life Cycle
Priority	High
Background	Should FOW and CCUS projects be co-located, developers may seek opportunities to electrically power the CCUS infrastructure using the on-site FOW turbines. While this opportunity is relevant to both traditional fixed wind and FOW technology, should CCUS projects be developed in deeper waters beyond the reach of fixed turbines, then the ability for the FOW farm to power the CCUS infrastructure could reduce the reliance of a CCUS site on a long-distance power connection to shore. This in turn could have a significant impact on a co-located project's economic viability.
Future Activities/ Research	In the first instance, a technical feasibility assessment would provide further detail on the practical potential for CCUS infrastructure (including its crewed platform and seabed injection wells) to be powered by an adjoining but inherently intermittent FOW power supply. A subsequent economic analysis would provide clarity on the potential impact on the business case for co-located projects. Further research and development may be required to address technical knowledge gaps identified in the feasibility assessment, and to address potential investor and developer uncertainty.
Research Stakeholders	Consenting authorities; CCUS industry groups; marine management organisations; offshore wind developers

Table 20 - Interaction CCS4

Interaction CCS4	**Scheduling of FOW farm logistics presents opportunities to support CCUS operations (e.g. helicopter or vessel sharing arrangements for co-located FOW-CCUS projects).**
Industry	CCUS
Type	Operations & Navigation
Life Cycle Phase	Installation; Operational
Priority	High
Background	Assuming co-located FOW-CCUS facilities are developed, it is likely that operational teams would seek to reduce costs by sharing vessel time whenever opportunities present themselves. The combining of vessel operations wherever possible could present a modest yet meaningful opportunity to reduce operational costs for both industries.
Future Activities/ Research	A more detailed cost analysis would be required to determine the full extent of this interaction's impact, and to enable both industries to understand the scale of the potential cost savings.
Research Stakeholders	CCUS industry groups; maritime and lighthouse authorities, offshore wind developers

Table 21 - Interaction CCS5

Interaction CCS5	**The joint growth of the FOW and CCUS industries could create competition for skilled offshore workforces.**
Industry	CCUS
Type	People & Skills
Life Cycle Phase	Whole Life Cycle
Priority	High
Background	Should multiple maritime industries expand concurrently (for example, due to the potential co-location of FOW and CCUS projects), this presents possible bottleneck risks in the availability of workforces across those industries. Thereby, a lack of sufficient workforce capacity for either industry could have significant impacts on both the development and delivery of new projects.
Future Activities/ Research	A review of the skills landscape with respect to the FOW and CCUS industries and their projected growths would help to clarify the nature of any workforce shortfall risk. Support for established, government-led training initiatives, and/or the development of new programmes, may be required in order to address these.
Research Stakeholders	CCUS industry groups; government departments, offshore wind developers

Table 22 - Interaction CCS6

Interaction CCS6	**A FOW loss of station scenario poses potential risk to CCUS subsea and surface infrastructure. Similarly, damaged or lost CCUS equipment/infrastructure could present a significant operational risk to co-located FOW infrastructure.**
Industry	CCUS
Type	Physical & Technology
Life Cycle Phase	Operational
Priority	High
Background	Both FOW and CCUS would be designed with the appropriate level of redundancy to minimise the likelihood of these scenarios. However, potential incidents can never be fully ruled out, and the comparative novelty of CCUS technology means that operational experience is inherently limited.
Future Activities/ Research	A review of current design standards would determine whether these are applicable to co-located FOW-CCUS farms, or if there are current gaps in the guidance that need to be addressed. Where gaps are identified, engagement with classification societies would be required in order to address these.
Research Stakeholders	CCUS industry groups; marine management organisations, maritime and lighthouse authorities, offshore wind developers

Table 23 - Interaction CCS7

Interaction CCS7	The spatial requirements of FOW farms, which have larger mooring footprints compared to traditional fixed wind, could present a practical barrier to seismic monitoring requirements of the CCUS project.
Industry	CCUS
Type	Physical & Technology
Life Cycle Phase	Operational
Priority	Medium
Background	CCUS projects require seismic monitoring to be undertaken at the site, both at the project appraisal stage and intermittently throughout the project lifecycle. The surveying process typically involves the towing by boat of long seismic streamers, which can be multiple kilometers in length, at the water's surface level. As such, a FOW farm's complex network of subsea infrastructure could potentially obstruct these operations for co-located FOW-CCUS projects. Potential obstruction effects associated with the complexity of FOW subsea infrastructure could feasibly restrict options and limit flexibility for seismic monitoring activities. However, the development of innovative ocean bottom monitoring methods presents an opportunity for an alternative, if less widely demonstrated, approach.
Future Activities/ Research	A technical feasibility review of the use of both surface level streamers and ocean bottom nodes for the seismic monitoring of co-located FOW-CCUS sites would provide greater clarity of the risks and benefits associated with these approaches. If necessary/appropriate, the development of best practice guidelines for monitoring co-located projects could support both regulators and developers.
Research Stakeholders	CCUS industry groups; marine research institutes; offshore wind developers

Table 24 - Interaction CCS8

Interaction CCS8	Co-location of FOW and CCUS projects presents potential opportunities for FOW infrastructure to host and/or support additional CCUS seismic monitoring activities.
Industry	CCUS
Type	Physical & Technology
Life Cycle Phase	Operational
Priority	Medium
Background	As outlined in above in Table 23 (Interaction CCS7), CCUS projects require seismic monitoring to be undertaken at the site throughout the project lifecycle. However, the presence of FOW infrastructure may obstruct these operations. In addition to the consideration of novel seismic monitoring opportunities, it could be worth investigating whether the deployment and maintenance of FOW infrastructure presents opportunities for hosting or supporting additional seismic monitoring efforts.
Future Activities/ Research	Further to the recommended activities outlined in above in Table 23 (Interaction CCS7), a technical feasibility assessment of the potential for FOW farms to host or support further seismic monitoring activities would help to clarify the nature and extent of this potential opportunity.
Research Stakeholders	CCUS industry groups; marine research institutes; offshore wind developers

Table 25 - Recommended Activity Categories

Key	Activity Type
	Operational risk review
	Licensing/planning review
	Environmental monitoring studies
	Insurance policy review
	Technology review and development
	Developing best practice and industry guidance
	Review of economic opportunities

Table 26 - Floating Offshore Wind and Carbon Capture & Storage Interaction Roadmap

Industry	Carbon Capture & Storage					
Interaction	Type	Description	Priority	Short-Term (2024-2025)	Medium-Term (Early Commercial Arrays)	Long-Term (Full Commercial Arrays)
CCS1	Policy & Regulation	Due to the early commercial status of CCUS technology, it is possible that any attempt to co-locate it with other industries will be viewed as inherently high-risk, thereby raising the cost of finance for co-located projects.	High	Engagement with insurance and financing stakeholders to determine the nature of any perceived risks, and the development of appropriate guidance and initial mitigative actions to address these risks.		

Industry	Carbon Capture & Storage					
Interaction	Type	Description	Priority	Short-Term (2024-2025)	Medium-Term (Early Commercial Arrays)	Long-Term (Full Commercial Arrays)
CCS2	Policy & Regulation	Lack of clarity regarding the appropriate process for navigating the inherent potential challenges and disputes associated with co-location could impact developer and investor confidence in co-located FOW-CCUS projects.	High	Collaboration between both industries in order to identify and mitigate potential risks associated with co-location.		
				Development of targeted guidance to address key uncertainties.		
CCS3	Physical & Technology	Co-location of FOW and CCUS infrastructure presents opportunity for electrical powering of CCUS facilities.	High	A review to determine the economic and technical feasibility of powering CCUS infrastructure via collocated FOW.		
CCS4	Operations & Navigation	Scheduling of FOW farm logistics presents opportunities to support CCUS operations (e.g., helicopter or vessel sharing arrangements for co-located FOW-CCUS projects).	High	Review logistical and economic feasibility of vessel-sharing between FOW and CCUS projects.		
CCS5	People & Skills	The joint growth of the FOW and CCUS industries could create competition for skilled offshore workforces.	High	Review of skills requirements for both FOW and CCUS, identifying areas where skills are likely to overlap.		
				Following a review of skills required for industry growth, identify opportunities and/or initiatives to support the growth of a skilled workforce.	Following a review of skills required for industry growth, identify opportunities and/or initiatives to support the growth of a skilled workforce.	

<table>
<tr><th>Industry</th><th colspan="6">Carbon Capture & Storage</th></tr>
<tr><th>Interaction</th><th>Type</th><th>Description</th><th>Priority</th><th>Short-Term (2024-2025)</th><th>Medium-Term (Early Commercial Arrays)</th><th>Long-Term (Full Commercial Arrays)</th></tr>
<tr><td rowspan="2">CCS6</td><td rowspan="2">Physical & Technology</td><td rowspan="2">A FOW loss of station scenario poses potential risk to CCUS subsea and surface infrastructure. Similarly, damaged or lost CCUS equipment/ infrastructure could present a significant operational risk to co-located FOW infrastructure.</td><td rowspan="2">High</td><td>Risk assessment of potential loss of station scenarios co-located FOW and CCUS infrastructure under varying weather conditions.</td><td colspan="2"></td></tr>
<tr><td colspan="2">If potential risks are identified, the development of design standards/recommendations (for example, relating to mooring system redundancy) for collocated projects</td><td></td></tr>
<tr><td rowspan="2">CCS7</td><td rowspan="2">Physical & Technology</td><td rowspan="2">The spatial requirements of FOW farms, which have larger mooring footprints compared to traditional fixed wind, could present a practical barrier to the seismic monitoring requirements of the CCUS project.</td><td rowspan="2">Medium</td><td>Early engagement between both industries to determine the spatial requirements of CCUS seismic monitoring, and to identify potential practical constraints for collocated projects.</td><td colspan="2"></td></tr>
<tr><td colspan="2">Identify potential FOW array layout design requirements for facilitating CCUS seismic monitoring.</td><td></td></tr>
<tr><td>CCS8</td><td>Operations & Navigation</td><td>Co-location of FOW and CCUS projects presents potential opportunities for FOW infrastructure to host and/or support additional CCUS seismic monitoring activities.</td><td>Medium</td><td colspan="2">Initial review to determine the viability of FOW infrastructure hosting CCUS monitoring equipment and/or supporting monitoring equipment. Additionally, this could be supplemented by a technology review to determine the applicable design standards required to make co-location of infrastructure feasible.</td><td></td></tr>
</table>

4.3 Defence

Table 27 - Interaction D1

Interaction D1	**Increased spatial footprint associated with FOW turbine assembly, marshalling and installation could lead to competition for port space, infrastructure and resources between both industries.**
Industry	Defence
Type	Physical & Technology
Life Cycle Phase	Installation; Operational
Priority	High
Background	During the installation phase, FOW technology presents the opportunity to undertake a greater degree of turbine and substructure integration within the harbour before the assembled FOW turbines are towed to the wind farm location and connected to their moorings. This is in contrast to traditional fixed wind, where turbine assembly and integration takes place fully offshore. As such, the assembly, marshalling and installation of FOW may require a larger share of the quayside compared to fixed wind. Furthermore, FOW tow-to-port maintenance activities, and the potential use of FOW wet-storage sites, could increase vessel traffic and activity within proximity to port. In principle, this additional quayside activity could lead to potential competition between both industries in terms of access to port, infrastructure and resources. If potential conflict is not effectively managed, competition between both industries could lead to delays in operation and idle times could prove costly. It is not clear how the logistics of each industry will be prioritised (i.e. in the interest of managing national security vs energy security requirements).
Future Activities/ Research	Coordination between both industries will be key to minimising conflict and developing an understanding of the needs of each industry in order to coordinate shared marine spaces. The development of best practice guidance may also be beneficial (e.g. addressing the prioritisation of access to ports and infrastructure during weather windows most appropriate for the marshalling and assembly of FOW).
Research Stakeholders	Defence sector; harbour authorities; offshore wind developers

Table 28 - Interaction D2

Interaction D2	Potential FOW loss of station scenario could create an unforeseen navigational hazard for defence vessels.
Industry	Defence
Type	Operations & Navigation
Life Cycle Phase	Operational
Priority	Medium
Background	A FOW turbine mooring and anchor system will be designed to minimise the risk of a loss of station keeping situation. However, a potential FOW turbine mooring system failure cannot be completely ruled out. The failure of a mooring line(s) could lead to the drifting of a FOW turbine, and the unknown trajectory of a lost turbine could pose significant risk to maritime defence vessels.
Future Activities/ Research	Engagement between both industries during the project planning process will be key to assessing the nature and extent of this risk. Where relevant, design-based mitigation (e.g. sufficient mooring redundancy) and new/updated industry guidance may be required in order to limit the extent of the risk.
Research Stakeholders	Defence sector; maritime and lighthouse authorities; offshore wind developers.

Table 29 - Interaction D3

Interaction D3	Acoustic emissions of operational FOW farms could have potential implications on the effective range of sonar in the vicinity of FOW sites.
Industry	Defence
Type	Policy and Regulation
Life Cycle Phase	Operational
Priority	Medium
Background	FOW sites may have a different operational acoustic profile to traditional fixed turbines (for example, due to coupled frequency effects, mooring line effects and different substructure designs). It is not clear the extent to which these acoustic emissions will increase as turbines and foundations increase in scale. The acoustic emissions of FOW turbines could hypothetically have implications on the effective range of sonar in the vicinity of FOW farms, which would be a key consideration for co-locating FOW with existing Ministry of Defence (MoD) operations.
Future Activities/ Research	Early engagement with the MoD on this topic would be recommended to manage any potential implications on FOW development. Further work would be required to fully characterise the underwater acoustic profile of operational FOW turbines, and to determine how this might propagate, and could be mitigated, at large (i.e. GW) scale deployments.
Research Stakeholders	Consenting authorities, defence sector; offshore wind developers.

Table 30 - Interaction D4

Interaction D4	Potential Risk to FOWT infrastructure due to presence of unexploded ordnance (UXO) on the seabed.
Industry	Defence
Type	Physical & Technology
Life Cycle Phase	Development; Installation
Priority	Medium
Background	The removal of UXOs prior to the development of an offshore wind farm is a requirement for both fixed and floating wind technologies, and is therefore a shared risk. However, FOW can be deployed in deeper areas of sea that would be inaccessible to fixed wind technology. UXO assessments for FOW sites may therefore present additional considerations in comparison to fixed wind due to increased water depths, differences in seabed terrain and the larger spatial footprints of FOW mooring systems. As such, floating-specific UXO assessments could present additional challenges and complexities which could represent development and consenting risks for future FOW farms.
Future Activities/ Research	Early engagement with the defence sector and marine management organisations on this topic would be key to identifying potential risks early and mitigating these in order to reduce the potential impact on FOW developments.
Research Stakeholders	Defence sector; marine management organisations; offshore wind developers

Table 31 - Interaction D5

Interaction D5	Tow to port/tow to site of FOW turbines presents a navigational hazard for MoD vessel activities.
Industry	Defence
Type	Operations
Life Cycle Phase	Whole Life Cycle
Priority	Medium
Background	In principle, vessel-to-vessel navigational hazards from FOW operations and MoD vessel movements should be no greater than those associated with merchant vessels. However, towing operations for FOW turbines, especially those with deeper drafts (e.g. spar substructures), could present a larger navigational hazard. It is likely that FOW turbine towing operations will be most frequent during the installation and decommissioning phases, although may also occur during the operational phase. For navigational purposes, defence operations will typically account for the deepest draught vessel operating in that region, therefore any FOW turbine towing operations will need to be taken into consideration.
Future Activities/ Research	Early engagement with defence stakeholders on this topic would be recommended to reduce the impact of FOW towing operations on both sectors. If required, this could include the development of best practice guidance for notifying the defence sector (and other stakeholder) of planned FOW towing operations.
Research Stakeholders	Defence representatives; marine management organisations; maritime and lighthouse authorities; offshore wind developers

Table 32 - Interaction D6

Interaction D6	The presence of established Practice and Exercise Areas (PEXAs) creates spatial planning constraints for future FOW farms.
Industry	Defence
Type	Policy & Regulation
Life Cycle Phase	Development
Priority	Medium
Background	Given the extensive/expansive nature of existing PEXAs, potential co-existence with future FOW developments could be a significant consideration. This issue is somewhat technology agnostic (i.e. fixed vs FOW), however FOW will enable the expansion of offshore wind further offshore into areas of deeper water, meaning additional considerations may arise. If not managed correctly through early stakeholder engagement and clear communication, this could present a meaningful development risk for future FOW farms. The MoD/navy has experience of managing its practice operations in respect of other offshore infrastructure (e.g. O&G, aquaculture), meaning that co-existence is possible in principle.
Future Activities/ Research	A review of the consenting process for existing relevant offshore infrastructure would help to determine how this risk has been managed historically and whether there are key lessons learned applicable to FOW. It would also be important to understand how this risk may vary between North Sea and Celtic Sea. Furthermore, a review of marine spatial planning process (including, for example, the ScotWind zone mapping process) would support an understanding of the precedent for how this has been approached for FOW. Clear and early engagement with defence sector regarding any future FOW developments will also be key.
Research Stakeholders	Consenting authorities; defence sector; marine management organisations; maritime and lighthouse authorities; offshore wind developers.

Table 33 - Interaction D7

Interaction D7	FOW heave, roll and pitch motions could interact with defence radar coverage to create 'dead zones'.
Industry	Defence
Type	Physical & Technology
Life Cycle Phase	Development; Operational
Priority	Medium
Background	Bottom-fixed wind technology can potentially obstruct radar pathways to create 'dead zones'. It is currently not completely clear the extent to which radar scatter from FOW technology may differ from bottom-fixed infrastructure due to differences in platform motion and installation location. Without understanding the interaction between FOW motions and radar obstruction/reflectivity, potential impacts on defence operations and navigation, and the appropriate mitigations for this, it is possible that this interaction could present a consenting risk for future FOW developments.
Future Activities/ Research	Establishing the potential effect of FOW on radar coverage, either through novel research or through support for existing relevant projects or programmes, and exploring opportunities to minimise potential risks.
Research Stakeholders	Defence representatives; offshore wind developers.

Table 34 - Recommended Activity Categories

Key	Activity Type
	Operational risk review
	Licensing/planning review
	Environmental monitoring studies
	Insurance policy review
	Technology review and development
	Developing best practice and industry guidance
	Review of economic opportunities

Table 35 - Floating Offshore Wind and Defence Interaction Roadmap

Industry	Defence					
Interaction	Type	Description	Priority	Short-Term (2024-2025)	Medium-Term (Early Commercial Arrays)	Long-Term (Full Commercial Arrays)
D1	Physical & Technology	Increased spatial footprint associated with FOW turbine assembly, marshalling and installation could lead to competition for port space, infrastructure and resources between both industries.	High	Early collaboration between industries to determine their respective spatial requirements.		
				Review of port requirements for both FOW and defence to identify potential risks and appropriate mitigations.		
D2	Physical & Technology	Potential FOW loss of station scenario could create an unforeseen navigational hazard for defence vessels.	Medium	Risk assessment of potential loss of station scenarios, utilising desk-based simulations where required.		
				Develop new / update existing industry guidance on relevant emergency procedures and, where appropriate, the design of FOW mooring solutions.		

Industry	Defence					
Interaction	Type	Description	Priority	Short-Term (2024-2025)	Medium-Term (Early Commercial Arrays)	Long-Term (Full Commercial Arrays)
D3	Regulation & Policy	Acoustic emissions of operational FOW farms could has potential implications on the effective range of sonar in the vicinity of FOW sites.	Medium	Monitoring and characterisation of FOW operational noise profile for various mooring configurations.		
				Simulation of large scale FOW noise emissions and identification/development of relevant mitigations.		
				Continued engagement with defence sector and regulators to ensure that this knowledge gap is appropriately managed and addressed.		
D4	Physical & Technology	Potential Risk to FOW infrastructure due to presence of unexploded ordnance (UXO) on the seabed.	Medium	Assessment of relevant risks posed by UXOs for commercial FOW developments, and development of appropriate mitigations.		
D5	Operations & Navigation	Tow to port/tow to site of FOW turbines presents a navigational hazard for MoD vessel activities	Medium	Risk assessment of tow-to-port operations and impact on defence operations. Identify potential mitigations.		
				Review and propose potential updates to current guidance/ regulations to ensure relevance to FOW tow-to-port operations.		
				Effective engagement between both industries to manage the risks of tow-to-port operations at the FOW farm design stage		

<table>
<tr><th>Industry</th><th colspan="6">Defence</th></tr>
<tr><td>Interaction</td><td>Type</td><td>Description</td><td>Priority</td><td>Short-Term (2024-2025)</td><td>Medium-Term (Early Commercial Arrays)</td><td>Long-Term (Full Commercial Arrays)</td></tr>
<tr><td rowspan="2">D6</td><td rowspan="2">Policy & Regulation</td><td rowspan="2">The presence of established Practice and Exercise Areas (PEXAs) creates spatial planning constraints for future FOW farms.</td><td rowspan="2">Medium</td><td>Review of relevant marine spatial planning process to determine the precedent for managing this risk for previous offshore wind developments.</td><td></td><td></td></tr>
<tr><td colspan="3">Early and continued engagement with defence sector and regulators to mitigate potential developmental risks to FOW farms.</td></tr>
<tr><td rowspan="2">D7</td><td rowspan="2">Physical & Technology</td><td rowspan="2">FOW heave, roll and pitch motions could interact with defence radar coverage to create 'dead zones'.</td><td rowspan="2">Medium</td><td>Technical assessment of FOW's effect on radar coverage.</td><td></td><td></td></tr>
<tr><td colspan="3">Early and continued engagement with defence sector and regulators to mitigate potential developmental risks to FOW farms.</td></tr>
</table>

4.4 Oil & Gas

Table 36 - Interaction OG1

Interaction OG1	**Increasing levels of co-location of FOW and O&G leads to greater interaction risk between FOW infrastructure and O&G pipelines.**
Industry	Oil & Gas
Type	Physical & Technology
Life Cycle Phase	Whole Life Cycle
Priority	High
Background	In principle this risk applies equally to both traditional fixed wind and FOW technology, however the greater complexity of FOW subsea infrastructure presents additional considerations. While it is possible to mitigate these risks (e.g. through the use of bridges or mattresses), a degree of practical risk may be unavoidable. There are also hypothetical concerns regarding the potential impact of cable electromagnetic field (EMF) emissions on pipelines (see Interaction OG5, table 40, regarding these potential corrosion effects).
Future Activities/ Research	Early engagement between the two industries regarding potential co-location opportunities will be key to managing this risk. A review of current applicable guidance would enable the identification of potential gaps, and further work could be undertaken to address these.
Research Stakeholders	Marine management organisations; O&G industry groups; offshore wind developers.

Table 37 - Interaction OG2

Interaction OG2	The limited precedent for co-locating FOW and O&G facilities could lead to developer and/or investor uncertainty (due to potential gaps in the regulatory process and associated development risk).
Industry	Oil & Gas
Type	Policy & Regulation
Life Cycle Phase	Development
Priority	High
Background	The development of the Hywind Tampen project in Norway provides some initial experience of co-located FOW-O&G facilities. However, the lack of experience specific to the UK market means that general uncertainty remains, and it is possible that specific gaps and/or unidentified risks in the consenting process could present challenges to potential future project applications. In principle this risk applies equally to both traditional fixed wind and FOW technology, however the greater complexity of FOW subsea infrastructure presents additional complexities and considerations. The potential failure of project applications resulting from development and consenting risks would represent a significant opportunity cost for both sets of stakeholders. Further, the impacted ability to co-locate FOW-O&G facilities could place additional pressure on the spatial planning process, thereby increasing consenting risk for both industries in the medium-to-long term. Developer and investor confidence could also be impacted.
Future Activities/ Research	A review of the development and consenting applicable to co-located FOW-O&G facilities would enable both industries to identify specific risks and opportunities. This would include initial experience through the Innovation and Targeted Oil & Gas (INTOG) leasing process. Where gaps are identified, work should be undertaken to deliver the appropriate best practice guidance.
Research Stakeholders	Consenting authorities; maritime and lighthouse authorities; marine management organisations; O&G industry groups; offshore wind developers.

Table 38 - Interaction OG3

Interaction OG3	The co-location of FOW and O&G facilities presents opportunities to share environmental monitoring responsibilities and data.
Industry	Oil & Gas
Type	Environmental
Life Cycle Phase	Whole Life Cycle
Priority	Medium
Background	The ability to share environmental monitoring responsibilities could enable modest yet meaningful cost savings for both industries. Further, if it can be demonstrated that, through collaboration, our knowledge of and ability to protect and enhance the marine environment is strengthened, this could in turn support the consenting process for co-located FOW and O&G developments.
Future Activities/ Research	A review of the typical environmental monitoring activities for FOW and O&G developments would identify overlaps in the respective responsibilities, which could represent collaboration opportunities.
Research Stakeholders	Consenting authorities; marine research institutes; O&G industry groups; offshore wind developers.

Table 39 - Interaction OG4

Interaction OG4	**The spatial requirements of FOW farms, which have larger mooring footprints compared to traditional fixed wind, could present a practical barrier to the seismic monitoring requirements of the O&G project.**
Industry	Oil & Gas
Type	Physical & Technology
Life Cycle Phase	Development; Operational
Priority	Medium
Background	The seismic monitoring requirements for oil and gas projects are less frequent than for CCS sites. Nevertheless, the complexity of FOW infrastructure presents operational risks for the use of traditional seismic streamers, which can be multiple kilometers in length. Potential obstruction effects associated with the complexity of FOW subsea infrastructure could feasibly restrict options and limit flexibility for O&G seismic monitoring activities. However, the development of innovative ocean bottom monitoring methods presents an opportunity for an alternative, if less widely demonstrated, approach.
Future Activities/ Research	A technical feasibility review of the use of both surface level streamers and ocean bottom nodes for the seismic monitoring of co-located FOW-O&G sites would provide greater clarity of the risks and benefits associated with these approaches. If necessary/appropriate, the development of best practice guidelines for monitoring co-located projects could support both regulators and developers.
Research Stakeholders	Marine research institutes; O&G industry groups; offshore wind developers.

Table 40 - Interaction OG5

Interaction OG5	**Electromagnetic field (EMF) emissions from FOW inter-array cables could present a potential risk to O&G pipelines (e.g. hypothetical risk of pipeline corrosion).**
Industry	Oil & Gas
Type	Environmental
Life Cycle Phase	Operational
Priority	Medium
Background	Concerns regarding potential EMF effects on pipelines have been raised by some stakeholders, however there is a lack of consensus regarding the extent of these risks. Despite the uncertainty regarding the risks associated with this interaction, it is still possible that future projects could face challenges at the consenting stage relating to this effect.
Future Activities/ Research	A review of relevant literature and/or engagement with subject matter experts would support the development of a stronger shared understanding of any potential risks. If required, follow-on work may be required to address any knowledge gaps or develop potential mitigation solutions.
Research Stakeholders	Marine research institutes; O&G industry groups; offshore wind developers

Table 41 - Interaction OG6

Interaction OG6	A FOW farm's multiple anchor anchors and dynamic cable seabed touchdown points presents interaction risk with old/abandoned O&G wells and pipelines.
Industry	Oil & Gas
Type	Physical & Technology
Life Cycle Phase	Operations & Maintenance
Priority	Low
Background	Abandoned O&G infrastructure should be thoroughly mapped, however older data may not be fully accurate. FOW anchors and cables are expected to present a lower risk compared to fixed wind monopiles.
Future Activities/ Research	Should any persisting concerns present potential challenges to co-located FOW and O&G facilities, further technical engagement between the two industries would support a more detailed understanding of the risk.
Research Stakeholders	Marine management organisations; O&G industry groups; offshore wind developers.

Table 42 - Recommended Activity Categories

Key	Activity Type
	Operational risk review
	Licensing/planning review
	Environmental monitoring studies
	Insurance policy review
	Technology review and development
	Developing best practice and industry guidance
	Review of economic opportunities

Table 43 - Floating Offshore Wind and Oil & Gas Interaction Roadmap

Industry	Oil & Gas					
Interaction	Type	Description	Priority	Short-Term (2024-2025)	Medium-Term (Early Commercial Arrays)	Long-Term (Full Commercial Arrays)
OG1	Physical & Technology	Increasing levels of co-location of FOW and O&G leads to greater interaction risk between FOW infrastructure and O&G pipelines.	High	Develop/ update industry best practice to identify potential interactions in order to minimise risk and exploit opportunities.		
				Early and continued engagement with O&G sector and regulators to mitigate potential developmental risks associated with FOW-O&G co-location.		
OG2	Policy & Regulation	The limited precent for co-locating FOW and O&G facilities could lead to developer and/or investor uncertainty (due to potential gaps in the regulatory process and associated development risk).	High	A review of the development and consenting process applicable to co-located FOW-O&G facilities to identify specific risks and opportunities.		
				Where gaps are identified, undertake work to deliver the appropriate best practice guidance.		

<table>
<tr><th>Industry</th><th colspan="6">Oil & Gas</th></tr>
<tr><th>Interaction</th><th>Type</th><th>Description</th><th>Priority</th><th>Short-Term (2024-2025)</th><th>Medium-Term (Early Commercial Arrays)</th><th>Long-Term (Full Commercial Arrays)</th></tr>
<tr><td rowspan="2">OG3</td><td rowspan="2">Environmental</td><td rowspan="2">The co-location of FOW and O&G facilities presents opportunities to share environmental monitoring responsibilities and data.</td><td rowspan="2">Medium</td><td>Review current environmental monitoring responsibilities of both industries and identify areas of potential overlap and identify synergies.</td><td></td><td></td></tr>
<tr><td colspan="2">Where relevant, support the development of novel environmental monitoring methods/technologies applicable to deeper water sites further from shore.</td><td></td></tr>
<tr><td rowspan="3">OG4</td><td rowspan="3">Physical & Technology</td><td rowspan="3">The spatial requirements of FOW farms, which have larger mooring footprints compared to traditional fixed wind, could present a practical barrier to the seismic monitoring requirements of the O&G project.</td><td rowspan="3">Medium</td><td>Early collaboration between industries to determine their spatial requirements and assess the practical feasibility of seismic monitoring activities within collocated projects.</td><td></td><td></td></tr>
<tr><td colspan="2">If required, undertake a technical feasibility assessment of innovative seismic monitoring methods (e.g. ocean bottom nodes) that mitigate any identified practical risks or barriers.</td><td></td></tr>
<tr><td colspan="2">Where necessary/appropriate, the development of best practice guidelines for monitoring co-located projects could support both regulators and developers.</td><td></td></tr>
</table>

Industry	Oil & Gas					
Interaction	Type	Description	Priority	Short-Term (2024-2025)	Medium-Term (Early Commercial Arrays)	Long-Term (Full Commercial Arrays)
OG5	Environmental	Electromagnetic field (EMF) emissions from FOW inter-array cables could present a potential risk to O&G pipelines (e.g. hypothetical risk of pipeline corrosion). cables could have negative consequences on oil and gas pipelines – potential risk of corrosion.	Medium	A review of relevant literature and/or engagement with subject matter experts would support the development of a stronger shared understanding of any potential risks.		
				Follow-on research may be required to address any knowledge gaps and/or develop potential mitigation solutions.		
OG6	Physical & Technology	A FOW farm's multiple anchor and dynamic cable seabed touchdown points presents interaction risk with old/abandoned O&G wells and pipelines.	Low	Technical engagement between the two industries would support a more detailed understanding of the risk, and support the development of relevant mitigations		

4.5 Subsea Cables

Table 44 - Interaction SC1

Interaction SC1	**Introduction of new subsea cable leases in proximity to existing FOW turbine arrays increases complexity and risk for new cable installations.**
Industry	Submarine Cables
Type	Physical & Technology
Life Cycle Phase	Development; Installation
Priority	High
Background	It is unlikely that new submarine cable licenses would be installed within a FOW farm's parameter; rather, they would be routed around the turbine array due to the presence of FOW dynamic inter-array cables, mooring lines and anchors. The requirement to be routed around a FOW farm (rather than taking the most direct route) could have implications associated with the cost and latency of a new submarine cable installation. The installation, operation and maintenance of subsea cable infrastructure in the vicinity of an existing FOW farm would pose a risk to both the dynamic and buried sections of floating inter-array cables. Further, a FOW array's mooring and anchor systems would present an additional consideration for subsea cables in the vicinity of a FOW farm.
Future Activities/ Research	Early intervention is paramount in addressing the challenges associated with installing new subsea cables in the vicinity of FOW arrays. Engagement between wind farm developers, subsea cable owners, and key stakeholders (e.g. seabed leasing authorities) during the pre-application stage is essential to determine requirements and approach to co-located projects.
Research Stakeholders	Seabed leasing authorities, subsea cable associations; offshore wind developers.

Table 45 - Interaction SC2

Interaction SC2	**Potential displacement of fishing vessels from FOW development areas leads to an increase in fishing activity over nearby/adjacent subsea cables, increasing the spatial constraints and risk profile of surrounding waters.**
Industry	Submarine Cables
Type	Operations & Navigation
Life Cycle Phase	Development; Operational
Priority	High
Background	It is possible that the installation of FOW farm infrastructure may have a displacement effect on existing fishing activities, either due to the complete obstruction of fishing operations, or unacceptable operational risk. In an increasingly congested marine space, it is possible that the displacement of fishing vessels from new FOW development areas could lead to a relocation, or increase in frequency, of fishing activity within areas of the sea that were previously preferentially avoided, such as submarine corridors. As a consequence, this could lead to a general increase in competition between sea users within areas of the sea outside of FOW developments, and the risk profile of those areas could be increased.
Future Activities/ Research	Consideration of this risk during the marine planning spatial process will be key. Early engagement between the FOW, subsea cable and fishing industries will also be critical to managing the risk, and also supporting the development of potential best practice guidance and mitigation measures.
Research Stakeholders	Fishing federations and associations; marine management organisations; seabed leasing authorities, subsea cable associations, offshore wind developers.

Table 46 - Interaction SC3

Interaction SC3	Repair of subsea cables in the vicinity of FOW arrays poses a risk of damage to the wind farm's network of mooring and dynamic cable systems.
Industry	Submarine Cables
Type	Physical & Technology
Life Cycle Phase	Operational
Priority	High
Background	It is highly possible that during the lifecycle of a subsea cable, incidences of repair will be required. Subsea cable repairs require the use of grapnel lines to hook and retrieve the section of damaged cable. Grapnel lines need to be initially deployed adjacent to the cable by a distance of approximately 2-3 times the water depth before being drawn across the seabed to hook and retrieve the cable. In the presence of co-located FOW farms, these operations could pose the risk of mechanical damage to the farm's subsea infrastructure. For instance, a snagging incident could cause damage to a FOW turbine’s mooring line(s) (potentially impacting its station keeping ability) and/or dynamic inter array cables (potentially causing a loss of power output from the FOW farm). An additional consideration of submarine cable repair is the final splice configuration that is laid on the seabed post-repair and sits adjacent to the cable route. Final splices are formed from the introduction of new cable section that extends from the seabed to the cable ship, and result in a V-shape diversion of the cable route on the seabed post-repair. Furthermore, the burial of this section of the cable route is often not completely successful, and the crown of the cable bight may be located outside of the charted cable route by a distance of up to twice the water depth. This new configuration on the seabed could potentially increase spatial constraint for neighbouring marine industries.
Future Activities/ Research	Clear and early engagement between the two industries both at the project development stage, and in advance of any required cable repair operations, will be critical to mitigating this risk. The clear marking of FOW subsea infrastructure (incl. anchor locations, mooring lines and inter array cable routes) on the appropriate charts and databases (e.g. KIS-ORCA) will also be key. The review and potential updating of relevant guidance to reflect potential FOW-specific scenarios may also be required.
Research Stakeholders	Marine management organisations, seabed leasing authorities, subsea cable associations; offshore wind developers

Table 47 - Interaction SC4

Interaction SC4	Installation of FOW anchors and dynamic inter-array cables within the vicinity of existing subsea cables creates the risk of damage to subsea cables.
Industry	Submarine Cables
Type	Physical & Technology
Life Cycle Phase	Installation
Priority	High
Background	Citing of offshore wind infrastructure within the vicinity of existing subsea licenses may to be necessary as the industry grows, and the co-location of FOW and subsea cables should be anticipated. The deployment of commercial FOW farms within the vicinity of existing subsea cables presents additional considerations, compared to traditional fixed wind, due to the complexity of their subsea infrastructure. The installation and operation of FOW anchors (such as drag embedment), mooring lines and inter-array cables involves a greater amount of seabed interaction, raising the potential for interaction with co-located subsea cables. Without sufficient communication and the application of mitigation measures, this could raise the risk of potential damage to existing subsea cables.
Future Activities/ Research	Early engagement between FOW and the subsea cable industries will be paramount in mitigating potential risks associated with the installation and operation of FOW turbines in the vicinity of subsea cables. Consideration of this risk, particularly during the marine spatial planning process in order to understand the requirements of both industries will be key to understanding the requirements of both industries. Where appropriate, the development/updating of potential best practice guidance and mitigation measures could help to manage these risks.
Research Stakeholders	Marine management organisations, seabed leasing authorities, subsea cable associations; offshore wind developers.

Table 48 - Interaction SC5

Interaction SC5	Installation, operation and maintenance of FOW farms presents an operational risk for subsea cables.
Industry	Submarine Cables
Type	Physical & Technology
Life Cycle Phase	Whole Life Cycle
Priority	Medium
Background	The marshalling, assembly and towing of FOW turbines would result in increased activity in and around a FOW farm during the installation phase of the project. Additionally, an increase in vessel traffic would be attributed to potential wet-storage, tow-to-port operations and subsequent reconnection of mooring and dynamic cables, all of which could pose additional risk to any co-located subsea cables. Without sufficient communication and application of mitigation measures, this risk could potentially lead to a higher rate of subsea cable damage incidents.
Future Activities/ Research	Consideration of this potential interaction during the marine planning spatial process will be key in mitigating this risk. Early engagement between the FOW and subsea cable industries will also be important, and the development of best practice guidance and mitigation measures may also be beneficial. During the operational phase, engagement regarding scheduled and unplanned marine operations would be an important feature of a risk management strategy.
Research Stakeholders	Marine management organisations, maritime and lighthouse authorities, seabed leasing authorities, subsea cable associations; offshore wind developers.

Table 49 - Interaction SC6

Interaction SC6	Potential FOW loss of station scenario could lead to significant asset damage to nearby subsea cables.
Industry	Submarine Cables
Type	Physical & Technology
Life Cycle Phase	Operational
Priority	Medium
Background	It is likely that FOW deployment would only proceed in the event that developers, insurers and investors are confident in the survivability of the infrastructure, and that the project meets applicable design standards. It is possible that some developers may opt to incorporate redundancy into a FOW farm's mooring system, at least in the short-to-medium term. Nevertheless, a potential loss of station scenario (e.g. due to a mooring system failure) can never be fully ruled out. The failure of a FOW mooring line(s) could potentially lead to the dragging of the remaining anchor(s) across any co-located subsea cable, causing significant damage.
Future Activities/ Research	Engagement between both industries during the project development process will be key to assessing the nature and extent of this risk. Where relevant, the inclusion of design-based mitigations (e.g. the incorporation of mooring system redundancy) might be explored. The delivery of appropriate engineering analyses would help to establish the relative potential merits of possible design based mitigations, and could help to support informed engagements with stakeholders from co-located marine industries.
Research Stakeholders	Maritime and lighthouse authorities, subsea cable associations; offshore wind developers.

Table 50 - Interaction SC7

Interaction SC7	Subsea cable maintenance vessel operations lead to potential damage of FOW subsea infrastructure (e.g., due to deployment of emergency anchor onto a FOW mooring line).
Industry	Submarine Cables
Type	Physical & Technology
Life Cycle Phase	Operational
Priority	Medium
Background	Where subsea cables are co-located with FOW farms, it is possible that subsea cable maintenance operations could pose a risk to FOW subsea infrastructure. Without sufficient communication and the application of mitigation measures, this could potentially increase the risk of damage to FOW mooring and/or dynamic cables.
Future Activities/ Research	Consideration of this risk during the marine planning spatial process will be key. Early engagement between the FOW and subsea cable industries will also be critical to managing the risk and supporting the development of potential best practice guidance and mitigation measures.
Research Stakeholders	Marine management organisations, seabed leasing authorities, subsea cable associations; offshore wind developers.

Table 51 - Interaction SC8

Interaction SC8	Subsea cables repairs lead to increased complexities of co-location due to the larger seabed footprint of post-repair cable configurations.
Industry	Submarine Cables
Type	Physical & Technology
Life Cycle Phase	Operational
Priority	Medium
Background	The repair of subsea cables will likely result in the introduction of additional cable length, which must be accommodated through the introduction of a V-shaped diversion in the cable route. This post-repair cable configuration could in turn increase seabed constraints for the surrounding environment. The extent to which post-repair cable configurations lead to increased spatial constraints will partly depend on its proximity to a FOW farm.
Future Activities/ Research	Clear and early engagement between the FOW and subsea cable industries, as well as other relevant maritime industries (e.g. fishing), both at the project development stage and in advance of any required cable repair operations, will be critical to mitigating this risk. The review and potential updating of relevant guidance to reflect potential FOW-specific scenarios may also be required.
Research Stakeholders	Marine management organisations, seabed leasing authorities, subsea cable associations; offshore wind developers.

Table 52 - Recommended Activity Categories

Key	Activity Type
	Operational risk review
	Licensing/planning review
	Environmental monitoring studies
	Insurance policy review
	Technology review and development
	Developing best practice and industry guidance
	Review of economic opportunities

Table 53 - Floating Offshore Wind and Subsea Cables Interaction Roadmap

Industry	Subsea Cables			Research Activity Timeline		
Interaction	Type	Description	Priority	Short-Term (2024-2025)	Medium-Term (Early Commercial Arrays)	Long-Term (Full Commercial Arrays)
SC1	Operations & Navigation	Introduction of new subsea cable leases in proximity to existing FOW turbine arrays increases complexity and risk for new cable installations.	High	Collaborative, large-scale spatial planning approach to effectively manage the co-location of both industries in order to mitigate risks and exploit opportunities.		
				Develop/ update best practice guidance on the co-location of FOW/subsea cables; identify and address key knowledge gaps in relation to the installation, maintenance and operation of both industries.		
				Continued engagement between both industries to manage and mitigate spatial constraint risks associated with co-location.		

<table>
<tr><th>Industry</th><th colspan="3">Subsea Cables</th><th colspan="3">Research Activity Timeline</th></tr>
<tr><th>Interaction</th><th>Type</th><th>Description</th><th>Priority</th><th>Short-Term (2024-2025)</th><th>Medium-Term (Early Commercial Arrays)</th><th>Long-Term (Full Commercial Arrays)</th></tr>
<tr><td rowspan="4">SC2</td><td rowspan="4">Operations & Navigation</td><td rowspan="4">Potential displacement of fishing vessels from FOW development areas leads to an increase in fishing activity over nearby/adjacent subsea cables, increasing the spatial constraints and risk profile of surrounding waters.</td><td rowspan="4">High</td><td>Review and feasibility assessment of FOW array layout configurations to determine how the FOW farm design process could mitigate this risk.</td><td colspan="2"></td></tr>
<tr><td colspan="2">Collaborative, large-scale spatial planning approach to effectively manage the co-location of both industries in order to mitigate risks and exploit opportunities.</td><td></td></tr>
<tr><td colspan="2">Develop/ update best practice guidance on the co-location of FOW/subsea cables; identify and address key knowledge gaps in relation to the installation, maintenance and operation of both industries.</td><td></td></tr>
<tr><td colspan="3">Continued engagement between both industries to monitor and manage spatial constraint risks associated with co-location.</td></tr>
<tr><td rowspan="2">SC3</td><td rowspan="2">Physical & Technology</td><td rowspan="2">Repair of subsea cables in the vicinity of FOW arrays poses a risk of damage to the wind farm's network of mooring and dynamic cable systems.</td><td rowspan="2">High</td><td>Risk assessment for subsea cable repair operations against a range of FOW mooring and cable configurations (utilise desk-based simulations where required).</td><td colspan="2"></td></tr>
<tr><td colspan="3">Engagement between industries to consider risks associated with co-location, e.g. entanglement risk due to grapnel lines, at FOW farm design stage.</td></tr>
</table>

Industry	Subsea Cables			Research Activity Timeline		
Interaction	Type	Description	Priority	Short-Term (2024-2025)	Medium-Term (Early Commercial Arrays)	Long-Term (Full Commercial Arrays)
SC4	Physical & Technology	Installation of FOW anchors and dynamic inter-array cables within the vicinity of existing subsea cables creates the risk of damage to subsea cables.	High	Engagement and collaboration between interested parties prior to FOW leasing in order to manage displacement effects as a result of commercial FOW development.		
				Continuation of the collaborative, large-scale spatial planning approaches undertaken in support of the recent Scottish and Celtic Sea leasing processes to manage this spatial constraint.		
SC5	Physical & Technology	Installation, operation and maintenance of FOW farms presents an operational risk for subsea cables.	Medium	Risk assessment of FOW installation, operation and maintenance activities on surrounding subsea cables (utilise desk-based simulations where required).		
				Review current navigational risk procedures and, if required, propose potential updates to to ensure relevance to FOW operations, including tow-to-port logistics.		
				Effective engagement between both industries to consider key risks at FOW farm design stage.		

Industry	Subsea Cables			Research Activity Timeline		
Interaction	Type	Description	Priority	Short-Term (2024-2025)	Medium-Term (Early Commercial Arrays)	Long-Term (Full Commercial Arrays)
SC6	Physical & Technology	Potential FOW loss of station scenario could lead to significant asset damage to co-located subsea cables.	Medium	Risk assessment of potential loss of station scenarios, utilising desk-based simulations where required.		
				Develop new / update existing industry guidance on relevant emergency procedures and, where appropriate, the design of FOW mooring solutions.		
SC7	Physical & Technology	Subsea cable maintenance vessel operations lead to potential damage of FOW subsea infrastructure (e.g., due to deployment of emergency anchor onto a FOW mooring line).	Medium	Review of marine spatial planning process to identify opportunities for managing applicable risks from the outset of the project development process.		
				Where required, develop / update industry best practice guidance for subsea cable maintenance operations within the vicinity of FOW infrastructure.		
				Early and continued engagement between both industries to determine the considerations of subsea cable vessel operations for collocated projects, and to identify associated potential practical constraints.		

Industry	Subsea Cables			Research Activity Timeline		
Interaction	Type	Description	Priority	Short-Term (2024-2025)	Medium-Term (Early Commercial Arrays)	Long-Term (Full Commercial Arrays)
SC8	Physical & Technology	Subsea cables repairs lead to increased complexities of co-location due to the larger seabed footprint of post-repair cable configurations.	Medium	Develop / update industry best practice guidance to reflect the complexities of this consideration for FOW-specific scenarios.		
				Effective engagement between both industries to manage the co-location considerations of post-repair cable configurations, both during the project development stage and in advance of cable repairs.		

5 CONCLUSIONS

The Floating Offshore Wind Co-location and Co-existence Risks and Opportunities project was delivered by ORE Catapult on behalf of the Floating Offshore Wind Centre of Excellence. The aim of the project was to identify and prioritise potential interactions between the FOW industry and other marine users, including the Aquaculture, Carbon Capture, Utilisation & Storage (CCUS), Defence, Oil & Gas (O&G) and Subsea Cable sectors, and to deliver a portfolio of recommended future actions to address the associated risks and opportunities. To avoid duplication with prior FOW CoE project activity – namely the Floating Offshore Wind and Fishing Interaction Roadmap, and Floating Offshore Wind Navigational Planning and Risk Assessment projects – the fishing, maritime navigation, and aviation industries were excluded from the scope of this study.

Potential interactions and future activities were captured during a collaborative stakeholder engagement process with representatives of the identified marine industries; outputs from this process are disseminated in the form of a series of sector-specific roadmaps. These roadmaps identified future actionable project activities within short-, medium- and long-term timeframes to address the considerations associated with each potential interaction.

It was clear from the stakeholder engagement process that a collaborative, cross-sector approach will be key to developing and delivering the relevant methods and approaches for minimising the challenges and exploiting the opportunities that may be associated with the co-location and co-existence of commercial-scale FOW farms with other sea users.

The priority interactions identified in this report are hypothetical, and it remains to be seen whether they are borne out in practice as the FOW industry commercialises. Further, it is anticipated that the list of interactions identified and reviewed during the project is by no means exhaustive, and continued dialogue between the FOW industry and other sea users will be vital for identifying further considerations, and for understanding which enabling actions should be prioritised.

Additionally, the roadmap is intended to be utilised as a guide to key stakeholders regarding the co-location and co-existence considerations of commercial scale FOW farms. The project aims to supplement and support related work in this space in order to minimise a duplication of efforts, and to support the development of constructive relationships between the FOW industry and key maritime stakeholders.

The project team would like to extend their gratitude to the stakeholders who offered their time and input to support the delivery of this study, as well participants of the FOW CoE's steering and working groups whose input during the scoping and delivery of this project was critical to the development of the roadmap.

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