FLOATING OFFSHORE WIND
CENTRE OF EXCELLENCE

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FLOATING OFFSHORE WIND AND FISHING INTERACTION ROADMAP

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DATE // 04-08-2021

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CONTENTS

EXECUTIVE SUMMARY 6

1 BACKGROUND 8
- 1.1 Context 8
- 1.2 Project Overview 8
- 1.3 Project Partners 9
- 1.4 Floating Offshore Wind Centre of Excellence 10

2 METHODOLOGY 11
- 2.1 Overview 11
- 2.2 Roadmap Development Process 11

3 PRIORITY INTERACTIONS 14
- 3.1 Priority Interactions Overview 14
- 3.2 Priority Interactions Discussion 17

4 FLOATING OFFSHORE WIND AND FISHING INTERACTION ROADMAP 41
- 4.1 Delivery Timeline 41
- 4.2 Activity Types 41
- 4.3 Delivery Partners 41
- 4.4 Floating Offshore Wind and Fishing Interaction Roadmap 43

5 CONCLUSION 50

6 REFERENCES 51

LIST OF FIGURES

Figure 1	Project Steering Group members	9
Figure 2	Floating Offshore Wind Centre of Excellence Industry Partners	10
Figure 3	Roadmap development workshops	12
Figure 4	Workshop 1 matrix key topics	12

LIST OF TABLES

Table 1	Interaction priority scores	13
Table 2	High and medium priority potential interactions between the floating offshore wind and fishing industries	15
Table 3	Interaction 1	17
Table 4	Interaction 2	18
Table 5	Interaction 3	19
Table 6	Interaction 4	20
Table 7	Interaction 5	21
Table 8	Interaction 6	22
Table 9	Interaction 7	23
Table 10	Interaction 8	24
Table 11	Interaction 9	25
Table 12	Interaction 10	26
Table 13	Interaction 11	27
Table 14	Interaction 12	28
Table 15	Interaction 13	29
Table 16	Interaction 14	30
Table 17	Interaction 15	31
Table 18	Interaction 16	32
Table 19	Interaction 17	33
Table 20	Interaction 18	34
Table 21	Interaction 19	35
Table 22	Interaction 20	36
Table 23	Interaction 21	37
Table 24	Interaction 22	38
Table 25	Interaction 23	39
Table 26	Activity type colour key	40
Table 27	Research stakeholder key	42
Table 28	Floating Offshore Wind and Fishing Interaction Roadmap	43

NOMENCLATURE

AIS	Automatic Identification System
AtoN	Aid to Navigation
EMF	Electromagnetic Field
FAD	Fish Aggregation Device
FOW	Floating Offshore Wind
FOW CoE	Floating Offshore Wind Centre of Excellence
GW	Gigawatt
LCoE	Levelised Cost of Energy
MGN	Marine Guidance Note
MW	Megawatt
NtM	Notice to Mariners
O&M	Operations and Maintenance
ORE	Offshore Renewable Energy
PO	Plan Option
SMP	Sectoral Marine Plan
WP	Work Package

EXECUTIVE SUMMARY

The launch of the ScotWind leasing round in 2020 by Crown Estate Scotland marked the beginning of the leasing and development process for large scale bottom-fixed and floating offshore wind (FOW) in Scotland. The areas of seabed available for development have been identified through an extensive and iterative consultation process, as outlined in the Scottish Government's Sectoral Marine Plan for Offshore Wind. Although this process has undoubtedly anticipated and mitigated a range of possible sectoral conflicts, there nevertheless remains the potential for future offshore wind developments in Scotland to have some form of impact on the fishing industry. Further, given FOW technology's early commercial status, the exact nature of its impact on fishing is currently unclear.

With this in mind, the Floating Offshore Wind Centre of Excellence (FOW CoE) launched the Floating Offshore Wind and Fishing Interaction Roadmap project, or FOW-Fishing Interaction project, in November 2020. The aim was to facilitate a stakeholder engagement process that would identify potential interactions between the Scottish fishing sector and future commercial FOW farms, and to assess the associated challenges and potential opportunities. The project's 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 findings of the FOW-Fishing Interaction project are set out within this document. The purpose of this roadmap is to: (a) outline the stakeholder engagement process undertaken during the course of the project (Sections 1 and 2); (b) identify and prioritise a list of potential interactions between the FOW and fishing industries in Scotland (Section 3); and (c) propose a timeline of further activities and research intended to mitigate the potential risks and exploit the opportunities associated with these interactions (Section 4).

Throughout this roadmap, the term "interaction" is used to reflect any potential interface between the FOW and fishing industries 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. These include fishermen's federations and associations, FOW farm developers, marine management organisations, seabed leasing authorities, and navigational safety groups. Where an interaction has been marked as high priority, this indicates a general consensus across these stakeholder organisations, but does not necessarily imply a unanimous agreement;
- 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-Fishing Interaction project by way of this roadmap, the FOW CoE intends to deliver an accessible reference document that maps the key risks and opportunities associated with FOW and fishing industry interactions in Scotland. 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 between the two industries over the course of the next decade and beyond.

1 BACKGROUND

1.1 CONTEXT

The launch of the ScotWind leasing process in 2020 by Crown Estate Scotland marked the beginning of the leasing and development process for large-scale bottom-fixed and floating offshore wind (FOW) in Scotland. To ensure that the development of Scotland's waters strikes an appropriate balance between national economic, social, and environmental objectives, Marine Scotland's Sectoral Marine Plan (SMP) for Offshore Wind has identified a number of Plan Option (PO) areas that can be leased by offshore wind developers through the ScotWind process. These POs were developed through an iterative consultation process that incorporated the feedback of a range of key stakeholders and marine industries. This collaborative engagement approach was adopted to ensure that the views and concerns of all stakeholders can be considered in the marine planning process and to help to minimise the negative impacts across the environment and marine sectors, including the fishing and offshore wind industries.

While this approach to developing the POs will have undoubtedly anticipated and mitigated a range of possible conflicts, there nevertheless remains the potential for future offshore wind developments in Scotland to have some form of impact on the fishing industry. Given that FOW technology is less commercially mature than bottom-fixed offshore wind, the exact nature of its impact on fishing currently remains unclear. As such, the development of a strong Scottish FOW sector will depend on a constructive and successful collaboration with the Scottish fishing industry. With these factors in mind, the Floating Offshore Wind Centre of Excellence (FOW CoE) launched the Floating Offshore Wind and Fishing Interaction Roadmap project in November 2020 to develop a stronger understanding of how the FOW and fishing industries in Scotland might interact in the short to medium term.

1.2 PROJECT OVERVIEW

The Floating Offshore Wind and Fishing Interaction Roadmap project, or FOW-Fishing Interaction project, was established with the aim of facilitating a stakeholder engagement process that would identify potential interactions between the Scottish fishing sector and future commercial FOW farms and assess the associated challenges and potential opportunities.

The project's principal objective was to develop a roadmap outlining a portfolio of activities to address these challenges and opportunities and support constructive interaction between the two sectors in the future. A flexible view was taken from the outset with regards to the format that the roadmap activities might take (for example, research and development projects focussed on addressing knowledge gaps, building datasets, developing technology concepts and designs, issuing relevant guidance, establishing new forums and industry roles etc.). By facilitating early and collaborative engagement between the FOW and fishing industries, it is hoped that the activities identified in the roadmap could be developed and delivered in a timely manner so that their benefits coincide with commercial-scale FOW deployment over the course of the next decade.

For the purposes of this work, the term "interaction" is used to reflect any potential interface between the FOW and fishing industries that could result in some form of impact, either positive or negative. The project scope was focussed on identifying potential interactions specific to FOW technology and operations, with a focus on Scottish fisheries.

Due to the lack of technology distinction between the static (i.e. buried) section of FOW and bottom-fixed offshore wind farm export cables, the buried section of FOW farm export cables was excluded from the project's scope from the outset. Further detail on the roadmap development process is provided in Section 2.

1.3 PROJECT PARTNERS

The principal delivery partners of the FOW-Fishing Interaction project are the Offshore Renewable Energy (ORE) Catapult, who led the development of the roadmap, and Quaybridge Scotland Ltd., who led the facilitation of the stakeholder engagement process.

A project Steering Group including Crown Estate Scotland, Marine Scotland, ORE Catapult and Quaybridge was established at the outset to provide guidance and strategic advice throughout project delivery, ensuring that a balanced approach was adopted.

Figure 1: Project Steering Group members

In addition to the Steering Group and the principal delivery partners, a Working Group was also convened to directly support the roadmap's development. The primary role of this Working Group was to provide relevant knowledge and expertise during project delivery and contribute to development of future activities and project concepts. This input was captured principally through a series of planned workshops held between January and March 2021. Membership of the Working Group was intended to reflect a balance of fishing and FOW industry representatives, whilst also including the perspectives of key stakeholders relevant to the development of Scotland's marine environment. Working Group members include: Scottish Fishermen's Federation, Scottish White Fish Producers Association, National Federation of Fishermen's Organisations, Communities Inshore Fisheries Alliance, Northern Lighthouse Board, Maritime and Coastguard Agency, Quaybridge, EDF, ESB, RIDG, Total, Mainstream, SSE, Equinor, CIP, Marine Scotland, Crown Estate Scotland, The Crown Estate, Brown & May Marine Ltd., ORE Catapult.

1.4 FLOATING OFFSHORE WIND CENTRE OF EXCELLENCE

The Floating Offshore Wind Centre of Excellence (FOW CoE) was established in 2020 by the Offshore Renewable Energy 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

2 METHODOLOGY

2.1 OVERVIEW

The FOW-Fishing Interaction project was structured around two main delivery phases. The objective of the first phase was to support the roadmap development process by providing a high-level overview of both FOW technology and operations and Scottish fisheries. This took the form of two summary reports that were issued to the Working Group members in advance of the project workshops:

- Floating Offshore Wind Technology and Operations Review [prepared by ORE Catapult]
- An Overview of Scottish Fisheries Prepared for the Floating Offshore Wind Industry [prepared by Brown & May Marine Ltd]

These summary reports were intended to support collaborative discussions and ensure that all participants had an appropriate overview of the relevant stakeholder groups. Feedback was sought from the Steering and Working Groups during the drafting process to confirm that the summaries were fully aligned with the project's scope. When developing the scope of the Overview of Scottish Fisheries report, the decision was made to primarily focus on the fishing activities that are most likely to take place within the PO areas identified in the SMP for offshore wind development in Scotland.

The second phase of the project focussed on the development of the roadmap itself, which was driven by a series of three planned workshops involving both the Steering and Working Groups. During these workshops, potential areas of interaction between the FOW and Fishing industries were identified, prioritised, and relevant future research activities subsequently proposed. Full details of these workshops are outlined in Section 2.2.

These two phases of the project formed the basis of the project's first two work packages (WP), with a third work package accounting for Quaybridge's role in facilitating the stakeholder engagement:

- WP1 – Overview of FOW technology and operations and Scottish fisheries;
- WP2 – Roadmap to support positive interaction between FOW and fishing in Scotland;
- WP3 – Facilitation.

2.2 ROADMAP DEVELOPMENT PROCESS

Development of the roadmap was driven principally by a series of three collaborative workshops involving the Steering and Working Groups. Figure 3 outlines the approach taken during these sessions, by which potential areas of interaction between the FOW and fishing industries were identified in the first instance, then assessed in terms of their priority, before high-level scopes were subsequently drafted for relevant future research activities.

During the collaborative sessions within these workshops, the attendees each participated in a series of smaller "breakout" discussion groups. This approach was adopted to maximise the outputs captured during the workshops and to provide each stakeholder with a more open platform to share and document their views.

Workshop 1
Identify potential interactions between FOW and Fishing.

Workshop 2
Assess the effect of each interaction, identifying the priority areas.

Workshop 3
Identify relevant research activities, including potential delivery partners.

Figure 3: Roadmap development workshops

Workshop 1

To assist the dialogue during Workshop 1, a matrix was developed with a series of fundamental FOW and fishing topics listed across its two axes, respectively. This was used to both prompt discussion points and record the key outputs, and participants were invited to populate the matrix where relevant to indicate where interactions might occur between the two industries. The objective was not to fill the entire matrix, but to see if and where any patterns of interaction emerge. Figure 4 lists the high-level topics included on the Workshop 1 matrix (an additional level of detail was included on the matrix used during discussions).

FLOATING OFFSHORE WIND	SCOTTISH FISHERIES
• Substructure	• Demersal Fishery
• Mooring System	• Pelagic Fishery
• Inter-array Cables	• Nephrops Fishery
• Marine Operations & Navigation	• Scallop Dredge Fishery
• Port Requirements	• Squid Fishery
• Development & Consent	• Creel Fishery
• Regulation	• Port Requirements
	• Regulation

Figure 4: Workshop 1 matrix key topics

Following Workshop 1, the comments and feedback captured across the breakout groups were reviewed and a list of potential interactions was drafted. These were grouped into six interaction "types": Physical & Technology; Operations & Navigation; Ports & Infrastructure; Policy & Regulation; Environmental; People & Skills. This list was circulated with the Steering and Working Groups for further comment ahead of Workshop 2.

Workshop 2

The principal objective for Workshop 2 was to collaboratively assess the list of interactions and identify the priority areas. In the case of each interaction, the participants addressed the following questions:

1. Assuming no actions are taken, how likely is this interaction to occur, and why?
2. What would the likely impact 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? (I.e. Low/Medium/High priority?)

The outputs from these discussions were subsequently reviewed and collated, and average priority scores applied to each interaction. Table 1 outlines how these average priority rankings were used to determine whether an interaction would be included on the roadmap as the focus of further research activity, with all high and medium priority interactions focussed upon in the subsequent discussions.

Priority Score	Outcome
High	Indicates a general consensus across the working group that the interaction should be investigated further through future project work.
Medium	Indicates a broader range of views across the group, with at least some stakeholders believing that further investigation is required.
Low	Indicates a general consensus across the working group that there is no immediate requirement to investigate through further project work.

Table 1: Interaction priority scores

Workshop 3

In the final of the project workshops, the collaborative discussions 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 Workshop 3, representing the culmination of project's collaborative engagements, were subsequently used to form the basis of the roadmap set out in the following sections of this document.

3 PRIORITY INTERACTIONS

3.1 PRIORITY INTERACTIONS OVERVIEW

Table 2 outlines the potential interactions between the FOW and fishing sectors that were identified during the course of the project workshops. Further detailed discussion is included in Section 3.2 for each interaction that was categorised as high or medium priority by the Steering and Working Group participants. The priority list features interactions from across the six type categories and includes both potential risks and opportunities.

A number of factors should be considered when reviewing these interactions:

- **Each interaction has been identified on a hypothetical basis** by the Steering and Working Group 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 and deployment rates increase (and, if so, at what frequency);
- **The priority scores have been assigned on an average basis**, as outlined in Section 2.2. Therefore, whilst a high priority score might indicate a general consensus across the Steering and Working Group participants with regards to an interaction's priority level, that does not imply a unanimous agreement;
- **The priority score assigned to a given interaction may reflect a number of considerations**, for instance: the **potential impact** of its occurrence; the **perceived likelihood** of its potential occurrence; the **ability of key stakeholders to intervene** to mitigate the associated challenges or exploit an opportunity. (It should be noted that a high priority score does not necessarily indicate that all of these factors apply. For example, an interaction may be considered low in likelihood, but the potential impact of its occurrence sufficiently high to warrant further examination.)
- **Whilst on an individual level each interaction is possible in principle, it is clear that in certain cases the occurrence of one interaction would impact the likelihood of another taking place.** For example, if Interaction 2 was borne out in practice, then the likelihood of Interaction 1 occurring would decrease substantially. In order to afford each interaction due consideration, the stakeholder workshops addressed each one on a case-by-case basis; the same applies to the discussion points included in Section 3.2.

Interaction	Interaction Type	Interaction Description	Average Score
1	Physical & Technology	Fishing vessel hull collides with the floating substructure of a FOW turbine.	High
2	Operations & Navigation	Presence of FOW farm infrastructure has displacement effect on existing fishing activities, either due to the complete obstruction of fishing operations, or unacceptable operational risk.	
3	Environmental	Electromagnetic fields (EMFs) generated by a FOW farm's inter-array cables affect local species sensitive to EMFs, with direct or indirect effects on the distribution of target species.	
4	Policy & Regulation	Insurance liability prevents fishing vessels from operating within or in the vicinity of FOW farms.	
5	Environmental	Presence of FOW farm allows fish to accumulate within the project's perimeter (e.g. due to increase in available food, FOW turbines acting as fish aggregation [FAD] devices etc.).	
6	Environmental	Presence of FOW farm leads to benthic recovery due to reduced fishing activity and vessel navigation, with potential overspill into adjacent areas.	
7	Environmental	The presence of a FOW farm otherwise alters the distribution of one or more target species.	
8	Physical & Technology	Fishing gear becomes entangled with FOW mooring systems and/or dynamic (i.e., suspended) cables during mobile fishing operations.	
9	Physical & Technology	Static fishing gear moves due to unintended vessel interaction (e.g. collision between vessel and static gear marker buoy), or tide and wave effects, and becomes entangled with FOW mooring systems and/or cables.	Medium
10	Operations & Navigation	Mooring lines and/or dynamic cables temporarily wet stored on the seabed during tow-to-port maintenance operations create an additional, non-visible hazard, increasing the risk fishing operations.	
11	Physical & Technology	The decommissioning process for FOW anchor systems, or any other FOW infrastructure, causes ongoing operational risk to fishing after a wind farm's lifecycle.	
12	Physical & Technology	Fishing vessel collides with a vessel associated with the installation or operation and maintenance of a FOW farm.	

Interaction	Interaction Type	Interaction Description	Average Score
13	Physical & Technology	Dredging or trawled fishing gear damages, is damaged by, or becomes entangled with static (i.e. on the seabed) sections of inter-array cables (including any applied rock protection).	Medium
14	Physical & Technology	Fishing vessel drops its anchor onto, or drags its anchor over, FOW mooring systems and/or dynamic cables.	
15	Physical & Technology	Failure of a FOW turbine's mooring system leads to a loss of station scenario, creating an unforeseen navigational hazard for fishing vessels.	
16	People & Skills	The requirement for guard / support vessels during FOW farm construction presents a potential economic opportunity for fishing vessels and/or crew (permanent or seasonal).	
17	People & Skills	FOW farm pre-construction and operational work presents a potential economic opportunity for fishing vessels and/or crew (permanent or seasonal).	
18	Physical & Technology	Dropped objects during FOW operations become entangled with and/or damages fishing gear.	
19	Environmental	Noise emitted during FOW farm installation (including any piled components) and/or operation impacts the population or distribution of one or more target species.	
20	Physical & Technology	Lost fishing gear becomes entangled with FOW mooring systems and/or dynamic cables.	
21	Operations & Navigation	Presence of FOW farm causes fishing vessel transit routes to be altered, either due to the obstruction of navigation, or levels of risk.	
22	Operations & Navigation	FOW tow-to-port maintenance operations create additional restrictions to fishing activities due to transit of turbines between port and FOW farm.	
23	Ports & Infrastructure	FOW industry's use of traditional harbours as O&M bases causes existing fishing industry to compete for these facilities.	
n/a	Operations & Navigation	Temporary safety zones established during FOW farm construction (or other key activities) has displacement effect on existing fishing activities.	Low
n/a	Ports & Infrastructure	FOW industry's use of traditional harbours as O&M bases creates additional revenue for these facilities, benefitting other sectors.	
n/a	Policy & Regulation	Policy / regulation is introduced which restricts fishing activities in certain areas due the presence of FOW or associated infrastructure.	

Table 2: High and medium priority potential interactions between the floating offshore wind and fishing industries

3.2 PRIORITY INTERACTIONS DISCUSSION

Further discussion in relation to each high and medium priority interaction is included in Tables 3 to 25. These discussions address each interaction on a case-by-case basis. However, synergies and/or inter-dependencies between interactions are noted where relevant. The discussion points and recommendations outlined in Tables 3 to 25 are subsequently brought together in the roadmap set out in Section 4.

Interaction	1. Fishing vessel hull collides with the floating substructure of a FOW turbine.
Type	Physical & Technology
Priority	High
Background	A FOW substructure's inherent accelerations and resulting variation in position present an additional navigational consideration for fishermen. If these movements are not fully monitored and understood, the risk of collision between a fishing vessel and FOW turbine may increase. Moreover, the complexity of FOW subsea infrastructure – namely the mooring and dynamic cable systems – presents an additional snagging risk, should trawling or dredging activities be conducted within or close to a FOW farm (see Interaction 8). Such snagging events could lead to a loss of vessel control and a potential collision incident. It currently remains unclear whether fishermen would be willing to undertake fishing activities within the vicinity of commercial FOW farms, and there are concerns that without effective mitigations, FOW farms would effectively be closed to fishing activity (see Interaction 2 for further discussion). Nevertheless, a collision event between a fishing vessel and FOW turbine would be a serious incident for both sets of stakeholders, and mitigations could be considered, where appropriate, as the focus of future research activities.
Future Activities / Research	Collaborative engagement between key stakeholders and interested parties may help to determine whether current marine licensing conditions and active marine guidance notes (MGNs; e.g. MGN 654 [1]) are sufficient for FOW or require further review and development. Key factors in managing collision risks include: • Appropriate consideration of collision risk at the FOW farm planning stage (e.g. assessing collision likelihood and the scale of the impact, allowing for coastguard access etc.); • Understanding the regulatory requirements (including potential future changes) to creating safety / exclusion around FOW turbines, including the evidence required and the commitments needed by key stakeholders; • A thorough understanding and appropriate communication of FOW substructure motions (accounting for typology and design variations); • Ability to track FOW turbine positions in low visibility conditions; • Appropriate guidance and legislation regarding the use of marking, lighting, AIS systems etc. on both vessels and FOW assets; • Timely and judicious updating of fishing industry databases.
Research Stakeholders	Fishermen's federations and associations; marine management organisations; maritime and lighthouse authorities; offshore wind developers and trade associations.

Table 3: Interaction 1

Interaction	2. Presence of FOW farm infrastructure has displacement effect on existing fishing activities, either due to the complete obstruction of fishing operations, or unacceptable operational risk.
Type	Physical & Technology
Priority	High
Background	Analysis of mobile fishing vessel activity prior to, during and following the installation of bottom-fixed offshore wind farms indicates that fishing activity significantly has declined within wind farm development areas [2]. This is most markedly the case during the construction phase (during which safety zones are applied to create a temporary legislative barrier), but the displacement effects also continue post-commissioning. Engagement with the fishing industry to date has highlighted that fishing within bottom-fixed offshore wind farms is largely avoided due to discerned risks [2], particularly for mobile fishing activities. It is possible that this effect could be more pronounced for FOW farms, where the subsea infrastructure of mooring lines and dynamic cables will pose a more complex network of potential snagging hazards. At the very least, fishing vessel skippers would avoid deploying or trawling fishing gear within a FOW turbine's mooring and dynamic cable footprint. What is currently less clear is whether suitable mitigations could be determined that would enable a certain level of fishing activity to take place either within, or within the vicinity of, a FOW farm, while satisfactorily avoiding the snagging hazards presented by each individual turbine's mooring and dynamic cable configuration.
Future Activities / Research	The effects of this interaction will depend on the types of existing fishing activities ordinarily conducted within a FOW farm's development area [3], as well as the design of the FOW farm itself. At the project level, engagement between both industries from the outset of the consenting process would inform the environmental impact assessment and may allow appropriate mitigations to be factored in at the design stage. For example, the viability of fishing-friendly array layout designs (i.e., sufficiently spaced turbines, the inclusion of cable-free corridors etc.) is a question around which there is a current lack of industry consensus. A targeted feasibility study would therefore support a cross-sector understanding of the techno-economic viability of such array layout designs, and may help to determine whether a workable solution could be found. The development and utilisation of mooring technologies that minimise FOW turbine footprints will also be relevant to this question and should be monitored and assessed accordingly. At an industry level, a continuation of the collaborative, large-scale spatial planning approach adopted by the SMP would allow the broader impacts of future FOW developments on Scottish fisheries to be evaluated as the industry matures. For instance, during the development of the SMP the complete cessation of fishing activities within offshore wind farms was assumed; if potential project level mitigations are indeed developed in due course, then this particular assumption could be reviewed. It would be important for these spatial planning efforts to continue monitoring the potential squeeze effects on other fishing areas due to displacement, and the integration of up-to-date fishing activity data would be key to its success. Again, a clear understanding of the regulatory requirements (including potential future changes) to creating safety / exclusion around FOW turbines would be important. The development of good practice guidance for assessing fisheries displacement is a current area of focus of the ScotMER research programme [4]. As such, potential synergies with / opportunities to support this ongoing work, as well as other relevant research initiatives, should be considered and explored.
Research Stakeholders	Fishermen's federations and associations; marine management organisations; maritime and lighthouse authorities; offshore wind developers and trade associations.

Table 4: Interaction 2

Interaction	3. Electromagnetic fields (EMFs) generated by a FOW farm's inter-array cables affect local species sensitive to EMFs, with direct or indirect effects on the distribution of target species.
Type	Environmental
Priority	High
Background	The effect of EMFs on the local species within a FOW farm has been identified as a current knowledge gap due to the lack of clarity surrounding both the nature and significance of any potential impacts [4]. While this risk also applies in principle to bottom-fixed wind, it is possible that the configuration of dynamic inter-array cables may increase its significance for FOW farms. The extension of dynamic cables through the water column from the floating substructure to the seabed connection point may increase the number of potential receptors to include pelagic species in addition to benthic species. Further, the potential EMF shielding effects resulting from cable burial cannot be applied to the dynamic sections of inter-array cables. A number of UK species, including salmon, eel, brown crab, and some elasmobranchs are understood to be electroreceptive and may rely on naturally occurring EMFs for both migration and orientation [5] [6] [7]. As such, the lack of clarity surrounding this interaction has the potential to cause delays in the consenting process for commercial-scale FOW farms. If relevant mitigations are not enacted, this may result in environmental damage, with potential implications for the fishing industry. NB Although FOW farm export cables are not considered in the scope of this project (see Section 1.2), it should be noted that any interactions related to EMFs generated by a FOW farm's inter-array cables will likely also be relevant to its export cable(s).
Future Activities / Research	This topic has been the focus of early-stage research, whereby the effects of simulated EMFs from subsea power cables were observed on select benthic species within controlled environments [6] [8]. However, to understand the full extent of the potential impacts, there is also a requirement for the effects of EMFs from FOW dynamic cables on key benthic and pelagic species to be monitored within representative environments, whereby the effects of an installation can be compared against pre-development baselines. An initial literature review would be required to assess the full extent of the early research conducted to date, and current research initiatives, to ensure that these efforts are not duplicated and that relevant recommendations for future research are acknowledged. Requirements for both monitoring studies in the field as well as further laboratory studies should be identified. The requirement for further research on the impacts of EMFs on a range of marine species is highlighted in the ScotMER evidence maps [4]; this should be referred to during any literature review with a view to identifying potential synergies with / opportunities to support the ScotMER research programme (as well as additional relevant existing studies). Further, in addition to a real-sea monitoring campaign, studies in this area should also consider potential mitigations, where relevant and appropriate.
Research Stakeholders	Marine research institutes; marine management organisations.

Table 5: Interaction 3

Interaction	4. Insurance liability prevents fishing vessels from operating within or in the vicinity of FOW farms.
Type	Policy & Regulation
Priority	High
Background	Discernible operational risk has been identified as a driving factor behind the displacement of fishing activity from bottom-fixed offshore wind farms, and there are concerns that this effect will be greater for FOW farms (see Interaction 2). These anxieties are amplified by a perceived lack of clarity regarding the status of liability, should a claim be made following an incident, and there is a shared concern that the relevant legislation is outdated and would require re-evaluation before fishermen would consider operating in the vicinity of a FOW farm.
Future Activities / Research	A timely review of the allocation of liability between FOW project developers and fishing vessel operators would be required to address these broader concerns before the development of commercial-scale FOW farms. This would include an examination of: • Typical insurance clauses for fishing vessels and FOW farm developers, including their likely implications on fishing activity around FOW farms; • Whether mooring system warranties will be valid if fishing activities occur within a FOW farm's perimeter; • Relevant existing insurance guidance on the approach to fishing around subsea hazards; • Examples from other industries and the approach taken to insurance in similar scenarios. Engagement with the insurance sector during the course of the review would be key to effective scenario planning and understanding the implications of different scenarios playing out. Potential mitigations should also be considered should it transpire that insurance costs act as a barrier to fishing activities within the vicinity of FOW farms.
Research Stakeholders	Fishermen's federations and associations; government departments (relevant to associated legislation); insurers of fishing vessels and offshore wind farms; maritime and lighthouse authorities; offshore wind developers and trade associations.

Table 6: Interaction 4

Interaction	5. Presence of FOW farm allows fish to accumulate within the project's perimeter (e.g. due to increase in available food, FOW turbines acting as fish aggregation devices [FAD] etc.).
Type	Environmental
Priority	High
Background	The effect of an offshore wind farm development on the behaviour of target fish species is difficult to assess. There is a current lack of evidence on the extent to which wind farms may encourage, or discourage, fish from nearby areas to aggregate within the project perimeter (if at all), whether fish stocks might grow within the wind farm area due to the exclusion of fishing (see Interaction 2) and other marine activities, and, if so, whether this would lead to observable overspill effects outside of the wind farm. While this uncertainty applies to both bottom-fixed wind and FOW farms, it is unclear whether technology differences between fixed and floating foundations would lead to variations in the extent of these effects (for example, do FOW substructures serve as more effective FADs than bottom-fixed monopiles?).
Future Activities / Research	The potential aggregation of fish within FOW farm perimeters is a knowledge gap that requires targeted monitoring programmes in order to be addressed. The development of early commercial FOW farms provides an opportunity to perform fish surveys both prior to and throughout the key stages of the project lifecycle to determine whether any positive or negative effects are observed. By establishing a pre-construction baseline, the impact of the development can be monitored through the construction and subsequent operational phases. It will be necessary at the outset of a monitoring programme to outline what can and cannot be reasonably understood in terms of FOW-specific aggregation effects. Additional questions for consideration include whether: • Significant aggregation effects could be observed within the course of a wind farm lifecycle; • Any aggregation effects are farm- or substructure-specific; • The extent to which these effects depend on existing habitats and fish communities; • Predator-prey interactions are subsequently affected. Relevant existing research (e.g. the Hywind Tampen fish survey) should be reviewed to ensure that the study compliments rather than duplicates these efforts, and potential synergies with / opportunities to support these existing research initiatives ought to be highlighted within the study's outputs alongside any recommendations for future activities. There would also be value in considering whether lessons learned in existing industries, such as bottom-fixed wind and oil and gas, could inform the scope of this work.
Research Stakeholders	Marine research institutes; marine management organisations; offshore wind developers.

Table 7: Interaction 5

Interaction	6. Presence of FOW farm leads to benthic recovery due to reduced fishing activity and vessel navigation, with potential overspill into adjacent areas.
Type	Environmental
Priority	High
Background	In addition to the uncertainty surrounding potential fish aggregation effects (Interaction 5), there are also knowledge gaps relating to the possible impacts, if any, of FOW developments on the benthic ecology within project perimeters. Should the presence of a FOW farm result in a reduction in fishing activity in the area (Interaction 2), it is unclear whether this would lead to a recovery in the local benthic ecology, and, if so, what the predator-prey implications might be for target fish species. The potential for resulting overspill effects into adjacent areas is also not currently understood. While this uncertainty applies to both bottom-fixed wind and FOW farms, it is unclear whether technology differences between fixed and floating foundations would lead to variations in the extent of these effects. For example, the dynamics of catenary mooring lines on the seabed could lead to scour effects, potentially resulting in negative impacts on the local benthic ecology.
Future Activities / Research	Understanding the potential impacts of a FOW development on benthic ecology requires targeted monitoring studies to be conducted. The development of early commercial FOW farms provides an opportunity to conduct benthic surveys to monitor potential changes in species distribution during the course of a project lifecycle. Establishing the pre-project baseline (both within and outside of the project perimeter) will be critical to understanding any causal changes and possible overspill effects. Additional questions that fall within the scope of the study include: • Whether potential benthic recovery effects impact the distribution of target fish species; • If these effects are FOW-specific (i.e. due to the larger footprint of FOW mooring systems) or comparable to bottom-fixed wind; • If potential benefits may be offset (partially or fully) by scour effects resulting from mooring line dynamics; • The respective implications on mobile and static fishing; • The time required for any recovery effects to be observed, and whether these would fall within the project lifecycle. Existing relevant research should be reviewed to ensure that any current lessons learned are factored into the scope of the study, and that previous or current efforts are not duplicated. It should also be considered whether comparable studies on marine protected areas have published relevant findings. Where potential synergies with / opportunities to support existing research initiatives are identified, these ought to be highlighted within the study's outputs alongside any recommendations for future activities.
Research Stakeholders	Marine research institutes; marine management organisations; offshore wind developers.

Table 8: Interaction 6

Interaction	7. The presence of a FOW farm otherwise alters the distribution of one or more target species.
Type	Environmental
Priority	High
Background	It is possible that the installation of a FOW farm could alter the distribution of a target species for reasons other than refuge effects (Interaction 5) or benthic recovery and overspill (Interaction 6). For example, compared to bottom-fixed wind, the footprint of a FOW mooring system is larger and the mooring lines are more evenly spread throughout the project area. It is currently unclear whether the accumulation of marine growth on this distributed infrastructure could lead to benthic enrichment within the project perimeter (potentially due to organic matter falling to the seabed, or the requirement to periodically clean structures of marine growth), and, if so, whether there would be any impact on local fish stocks. Additionally, some bottom-fixed wind farms have reported an increase in predator bird presence within the project perimeter [9], and it is currently unclear whether the same effects might be observed in further from shore FOW farms. There may be further, as yet unconsidered, effects of a FOW development that would be relevant to the distribution of target fish species.
Future Activities / Research	A literature review of relevant existing research would be required to identify any additional, as yet unconsidered potential positive or negative effects of a FOW farm on the distribution of target species. A review of any lessons learned from the oil and gas industry as well as studies on marine protected areas could also identify further considerations. The development of early commercial FOW farms within Scottish and UK waters provides an opportunity to monitor any identified potential additional effects (such as benthic enrichment due to marine growth) within representative environments. Potential synergy should be considered between these additional monitoring studies, and the further research identified in relation to Interactions 5 and 6.
Research Stakeholders	Marine research institutes; marine management organisations; offshore wind developers.

Table 9: Interaction 7

Interaction	8. Fishing gear becomes entangled with FOW mooring systems and/or dynamic (i.e. suspended) cables during mobile fishing operations.
Type	Physical & Technology
Priority	High
Background	The complexity of a FOW farm's subsea array of mooring lines and dynamic cables may present a greater snagging risk for mobile fishing gear, compared to a bottom-fixed wind farm. While it is currently unclear whether suitable mitigations could reduce the risk of carrying out mobile fishing operations within the vicinity of a FOW farm to acceptable levels (and it is acknowledged that fishing within a FOW turbine's mooring footprint would always be actively avoided – see Interaction 2 for further discussion), a snagging incident would nevertheless represent a serious incident for both sets of stakeholders and could pose a material risk to both life and critical assets. Furthermore, the underwater spread of a FOW turbine's mooring footprint means that the potential snagging risk extends beyond an array's outermost turbines (at the water level) and into the adjacent areas. As such, and where appropriate, mitigations could be considered as the focus of future research activities.
Future Activities / Research	A targeted risk assessment study would help the FOW and fishing industries to quantify the likelihood and potential impact of a snagging event and could facilitate a greater understanding of the scenarios that might lead to these incidents. This study would include a review of different mooring and dynamic cable configurations, and the relative implications of each arrangement (making use of desk-based simulations, where applicable). A review of relevant oil and gas industry best practice and lessons learned should also be considered. Where appropriate, recommendations would be made for potential future gear trials to address knowledge gaps and areas of uncertainty. The role of technology innovations (for example, alarm or monitoring systems for mooring lines that notify of snagging events) should also be explored. There is also an opportunity for mitigations to be factored into the FOW farm development process. It is critical that FOW developers are clear about, and that fishing industry is fully aware of, the exact location of a FOW farm's mooring lines and dynamic cables. A review of the fisheries engagement process, particularly at the screening and scoping stages of a FOW development, could facilitate the development of FOW-specific guidance for liaising with fishermen, or the updating of current advice (e.g. the The Fishing Liaison with Offshore Wind and Wet Renewables Group [FLOWW] guidance) to address FOW-specific factors. For example, this would address the preferred format of engagement, the specific information shared, the process for updating the relevant fishing databases etc.
Research Stakeholders	Fishermen's federations and associations; marine management organisations; maritime and lighthouse authorities; offshore wind developers and trade associations.

Table 10: Interaction 8

Interaction	9. Static fishing gear moves due to unintended vessel interaction (e.g. collision between vessel and static gear marker buoy), or tide and wave effects, and becomes entangled with FOW mooring systems and/or cables.
Type	Physical & Technology
Priority	Medium
Background	Given the concerns surrounding the risk of entanglement for mobile fishing operations, it is possible that static fishing may become the more common activity within the vicinity of FOW farms. While static gear would undoubtedly be installed at an appropriate distance from FOW turbines, following installation static equipment can sometimes move in response due to metocean conditions or accidental vessel interactions. Should static fishing gear stray too close to the turbines within a FOW farm, there is the potential for it to become entangled with their mooring lines or dynamic cables.
Future Activities / Research	A targeted risk assessment study would help the FOW and fishing industries to quantify the likelihood and potential impact of an entanglement incident involving static fishing gear. This would include a review of different mooring and dynamic cable configurations, the range of line lengths used to deploy creel pots, the locational accuracy that can realistically be expected when shooting creel pots from vessels, as well as the potential impact of site-specific metocean conditions. Desk-based simulations may be used to assess how each arrangement would respond to an entanglement event. Where possible, available information from bottom-fixed wind farms where static gear has been installed would be taken into account. The outcomes of the static fishing gear pilot trials at Hywind Scotland [10] will be highly relevant to understanding the industry requirements relating to this interaction. Based on these considerations, the review should seek to outline appropriate guidance on the safe installation of static fishing gear within FOW farms (including preferred locations within arrays, minimum distances from turbines etc.). Broader best practice recommendations and the role of potential innovations should also be considered; for example, the appropriate marking of static gear and notification of marine coordination centres, the potential use of affordable trackers for static gear (to alert stakeholders in the event of gear movement) etc.
Research Stakeholders	Fishermen's federations and associations; marine management organisations; maritime and lighthouse authorities; offshore wind developers and trade associations.

Table 11: Interaction 9

Interaction	**10. Mooring lines and/or dynamic cables temporarily wet stored on the seabed during tow-to-port maintenance operations create an additional, non-visible hazard, increasing the risk fishing operations.**
Type	Operations & Navigation
Priority	Medium
Background	The current lack of FOW operational experience means that there is some uncertainty surrounding the handling procedures for mooring lines and dynamic cables if FOW turbines are towed to port for maintenance. One possibility is that they may be wet stored on the seabed while the turbines are absent. Should this be the case, the submerged components could present a slightly different risk compared to normal operation (see Interaction 8), as there will be no turbine to visually indicate their location. The risk may be greater still if the outermost turbines at the project perimeter have been removed. Although it is currently uncertain whether fishermen would be willing to operate within the vicinity of a FOW farm, entanglement between mobile fishing gear and wet stored chains and cables could cause significant damage to fishing equipment and FOW infrastructure, as well as a possible risk to life. As such, appropriate mitigations should be considered, and there is likely to be an important role for suitable safety procedures in order to minimise any risks.
Future Activities / Research	Mitigations for this interaction could be investigated as an extension to the research outlined in relation to Interaction 8. This could consider: • The use of guard ships or cardinal buoys when turbines are absent; • Adaptations to fishing databases to reflect temporarily wet stored components, and the issuing of the appropriate notice to mariners (NtM); • Best practice for addressing this risk during the FOW farm design stage; • The implications of extreme weather scenarios etc. The principle aim of this review would be to support a shared understanding between both industries on the best approach for managing the risks posed by wet stored FOW subsea infrastructure.
Research Stakeholders	Fishermen's federations and associations; marine management organisations; maritime and lighthouse authorities; offshore wind developers and trade associations.

Table 12: Interaction 10

Interaction	11. The decommissioning process for FOW anchor systems, or any other FOW infrastructure, causes ongoing operational risk to fishing after a wind farm's lifecycle.
Type	Physical & Technology
Priority	Medium
Background	There is an obligation on FOW farm developers for a site to be made safe post-decommissioning, and the requirement for the full recovery of infrastructure is recognised by all parties. FOW mooring system designs are not yet fully mature, and, as such, a range of mooring configurations could yet be deployed within commercial-scale FOW farms. The FOW industry anticipates that the decommissioning process for mooring systems will be less environmentally invasive compared to the removal of bottom fixed monopile foundations. That said, while some anchor designs, such as drag embedment, are expected to be relatively easy to remove, other designs, such as pile driven, may present a greater technical challenge. As such, there is an opportunity to address the question of safe removal and its implications on the fishing industry before FOW is deployed at a commercial scale in Scotland's waters.
Future Activities / Research	There is an opportunity to assess the best practice for minimising the impact of FOW decommissioning plans on the fishing industry. The potential impacts of decommissioning need to be addressed at the early planning and consenting stages, and effective engagement between the two industries during this process would be critical. Consideration could also be given to whether design for removal is always desirable, or whether there may be scenarios in which it might be safer to leave sections of an anchor system in the seabed – for instance, if full removal may cause significant disturbance to the seabed – provided that this is compliant with the current draft guidance [11]. Any such consideration should also address the broader question of whether a FOW development could ever go ahead if full removal is not possible.
Research Stakeholders	Consenting authorities; fishermen's federations and associations; marine management organisations; maritime and lighthouse authorities; offshore wind developers and trade associations.

Table 13: Interaction 11

Interaction	12. Fishing vessel collides with a vessel associated with the installation or operation and maintenance of a FOW farm.
Type	Operations & Navigation
Priority	Medium
Background	Although the risk of collision incidents is a day-to-day consideration at sea, and it is one that FOW shares with bottom-fixed wind farms, the potential for tow-to-port heavy maintenance operations creates an additional, more complex consideration for FOW farms. The lack of operational experience in this regard means that there is current uncertainty surrounding the exact nature of FOW tow-to-port maintenance strategies (that different FOW farm operators may adopt varying strategies only amplifies this). While experience at sea suggests that the likelihood of a collision occurring between vessels would be low, the impact of any such incident would nevertheless be serious to both sets of stakeholders, with potential risk to life. As such, appropriate mitigations should be considered.
Future Activities / Research	Engagement between both the FOW and fishing industries will be key to managing this interaction, particularly as greater understanding emerges of tow-to-port strategies. There is an opportunity for both stakeholders to collaboratively assess the nature of the risk and potential likelihood of its occurrence, giving consideration to FOW-specific factors and relevant mitigations such as: • A possible reduced ability to manoeuvre due to the presence of mooring lines and dynamic cables; • The potential use of AIS trackers on FOW substructures in addition to vessels etc.; • Communicating the details of tow-to-port operations through NtMs, and ensuring these successfully reach all fishing vessels concerned (including both members of the fishing federations and inshore fisheries groups, as well those who may not be members of an organisation). Appropriate recommendations could subsequently be issued to both industries, either in the form of new, dedicated guidance, or through the update of existing relevant industry guidance. This, in turn, could inform the health and safety strategies of future FOW farms so that the risk is suitably addressed early in the wind farm lifecycle.
Research Stakeholders	Fishermen's federations and associations; marine management organisations; maritime and lighthouse authorities; offshore wind developers and trade associations.

Table 14: Interaction 12

Interaction	13. Dredging or trawled fishing gear damages, is damaged by, or becomes entangled with static (i.e. on the seabed) sections of inter-array cables (including any applied rock protection).
Type	Physical & Technology
Priority	Medium
Background	Due to the relatively shallow water depths of the UK continental shelf (compared to other potential global FOW markets), the inter-array cables of FOW farms installed in Scottish waters will most likely have static lengths that run along the seabed between the dynamic sections. Depending on their burial depth, these static sections present a potential entanglement risk for dredging activities or demersal trawling fishing operations. While it is currently unclear whether these operations would be conducted within the vicinity of a FOW farm (see Interaction 2), a snagging incident would nevertheless represent a serious incident for both sets of stakeholders and could pose a material risk to both life and critical assets. As such, and where appropriate, mitigations could be considered as the focus of future research.
Future Activities / Research	A targeted risk assessment study would help the FOW and fishing industries to quantify the likelihood and potential impact of a snagging event and could support a greater understanding of the scenarios that might lead to these incidents. As this risk is shared with bottom-fixed wind a review of any available information from existing UK windfarms would provide valuable input to this analysis, as would a review of any relevant studies conducted for the oil and gas sector. The potential for the static sections of inter-array cables to be raised through the dynamic movements of FOW turbines should also be considered; to quantify this risk, simulations could be conducted for a range of metocean and seabed conditions as well as substructure, mooring and dynamic cable configurations. Outputs of this analysis would include guidance on: ideal cable burial depths and requirements for rock protection; the design of the dynamic cable seabed touchdown point; and, where appropriate, potential future field tests for fishing gear and burial/protection techniques. Effective and early engagement between the two industries is key to managing this interaction, and there is also an opportunity to consider the best practice for managing this engagement at the planning and consenting stages of a FOW farm. This would cover: site-specific assessments (addressing current fishing practices in the area, safe burial depths etc.); updating appropriate fishing databases with cable locations; techno-economic-environmental assessments for potential cable-free corridors for fishing; processes for ongoing monitoring of cable burial depths. This guidance could be used to inform the health and safety strategies of future FOW farms so that the risk is suitably addressed early in the wind farm lifecycle. NB Although FOW farm export cables are not considered in the scope of this project (see Section 1.2), it should be noted that the outputs of this proposed work would likely be relevant to potential interactions associated with the static section of a FOW farm's export cable(s).
Research Stakeholders	Fishermen's federations and associations; marine management organisations; maritime and lighthouse authorities; offshore wind developers and trade associations.

Table 15: Interaction 13

Interaction	14. Fishing vessel drops its anchor onto, or drags its anchor over, FOW mooring systems and/or dynamic cables.
Type	Physical & Technology
Priority	Medium
Background	While a fishing vessel skipper would avoid making a routine anchor deployment within the vicinity of a FOW farm, the potential for an emergency deployment (e.g. in a loss of power scenario) remains a possibility. Experience at sea suggests that the likelihood of this interaction would be low. However, should a vessel's anchor interact with a FOW turbine's mooring system or dynamic cables, it would represent a serious incident to both sets of stakeholders and could pose a material risk to both life and critical assets. As such, potential mitigations should be considered where possible and appropriate.
Future Activities / Research	Early and effective engagement between the FOW and fishing industries is important for mitigating the risks of this interaction. A review of the emergency procedures (e.g. MGN 654 [1]) would identify whether existing processes are appropriate for FOW farms (and their more complex subsea infrastructure). Where appropriate, existing guidance could be updated, or new guidance issued in relation to: immediate emergency response protocols; the relative safety of losing vs retrieving anchors (and the potential damage caused in each scenario); procedures for reporting incidents etc. This guidance may then inform the health and safety strategies of future FOW farms so that the risk is suitably addressed early in the wind farm lifecycle. Ensuring that relevant fishing databases are updated with mooring and dynamic cable locations will also be important for managing this risk, as will ongoing and relevant communication between the two industries throughout the FOW farm lifecycle.
Research Stakeholders	Fishermen's federations and associations; marine management organisations; maritime and lighthouse authorities; offshore wind developers and trade associations.

Table 16: Interaction 14

Interaction	15. Failure of a FOW turbine's mooring system leads to a loss of station scenario, creating an unforeseen navigational hazard for fishing vessels.
Type	Physical & Technology
Priority	Medium
Background	The principal function of a FOW turbine's mooring system is to provide its station keeping capability. Statistical analysis of reliability data relating to the use of mooring systems within the oil and gas industry suggests that mooring line failures are likely to occur within FOW farm arrays during the course of a project's 25-year (minimum) lifecycle [12]. At present, it is not certain exactly how applicable this data is to FOW, and it also remains to be seen whether FOW developers will opt to build redundancy into the mooring systems of commercial farms. Nevertheless, however unlikely, the implications of a loss of station scenario on the fishing industry, and potential relevant mitigations, both warrant further consideration.
Future Activities / Research	Given the current uncertainty regarding the scenarios that could lead to a loss of station situation, there would be value in continued engagement between the FOW and fishing industries to monitor the development of commercial mooring solutions as the FOW industry matures. There is an opportunity to perform a risk analysis of potential loss of station scenarios, the outputs of which could subsequently inform the relevant FOW farm emergency procedures and may also provide useful input to the current development of FOW mooring solutions.
Research Stakeholders	Fishermen's federations and associations; marine management organisations; maritime and lighthouse authorities; offshore wind developers and trade associations.

Table 17: Interaction 15

Interaction	16. The requirement for guard / support vessels during FOW farm construction presents a potential economic opportunity for fishing vessels and/or crew (permanent or seasonal).
Type	People & Skills
Priority	Medium
Background	This interaction is not unique to FOW, as fishing vessels have received guard ship duty work during the development of bottom-fixed offshore wind farms as well as from the oil and gas industry. While it is possible that this could also happen naturally during the development of FOW farms, there are concerns that the requirements placed on fishing vessels by the offshore wind industry could be prohibitive and deter fishermen from bidding for the work. Further dialogue is therefore required so that all stakeholders are fully aware of the complexities that surround this issue.
Future Activities / Research	Early engagement between both industries would facilitate a review of the exiting requirements placed on fishing vessels to secure guard ship work (e.g. RenewableUK's Vessel Safety Guide [13]), and appropriate guidance could subsequently be made available to the industry. This would likely include: the offshore wind industry's general requirements for guard ship duties; advice on the appropriate registrations and certifications, including an overview of those that already apply in the fishing industry, highlighting possible transferable qualifications; the likelihood of FOW developers procuring guard ships as the industry matures (versus remote solutions including cardinal buoys, AIS trackers, AtoNs etc.); advice on the guard ship procurement process; the likely seasonality of the work; lessons learned from the bottom-fixed wind and oil and gas industries etc. A review of the potential FOW deployment pipeline for Scottish waters would be useful for outlining the scale of the potential economic opportunity for the fishing industry, which may inform or support decisions to bid for guard ship work. The risk that this opportunity may prompt a more permanent transfer of personnel from the fishing to the FOW industry – and the subsequent long-term impacts on the fishing industry – should also be assessed.
Research Stakeholders	Fishermen's federations and associations; marine management organisations; maritime and lighthouse authorities; offshore wind developers and trade associations.

Table 18: Interaction 16

Interaction	17. FOW farm pre-construction and operational work presents a potential economic opportunity for fishing vessels and/or crew (permanent or seasonal).
Type	People & Skills
Priority	Medium
Background	In addition to the potential opportunity to provide guard ship services (see Interaction 16), the development FOW farms may also represent broader economic opportunities for fishing vessels and crews. Targeted engagement between the two industries would enable these potential opportunities to be identified and gauge the appetite of key stakeholders to pursue them. Further dialogue is therefore required so that all stakeholders are fully aware of the complexities that surround this issue.
Future Activities / Research	There are clear synergies between the discussions required to identify these broader opportunities and the proposed follow-up review outlined in relation to Interaction 16. In addition to discussing the nature of these opportunities and potential interest of both industries, the potential risks to key stakeholders should also be explored (including the possibility that these opportunities may prompt a more permanent transfer of personnel from the fishing to the FOW industry).
Research Stakeholders	Fishermen's federations and associations; marine management organisations; maritime and lighthouse authorities; offshore wind developers and trade associations.

Table 19: Interaction 17

Interaction	18. Dropped objects during FOW operations become entangled with and/or damages fishing gear.
Type	Physical & Technology
Priority	Medium
Background	The risk of dropped objects at sea is not specific to FOW farms. Procedures for reporting these incidents have been developed for the oil and gas sector, and modified versions of these have been applied within bottom-fixed offshore wind industry. While it is recognised that every reasonable measure should be taken to retrieve dropped objects, it remains to be seen whether the level of risk is consistent across bottom-fixed and FOW farms, or whether technology and operational differences will have an effect on the frequency of dropped objects.
Future Activities / Research	An initial risk assessment of the potential for dropped objects during the construction and operation of FOW farms would help both sets of stakeholders to identify whether or not FOW developments might see a comparable incident rate to bottom-fixed farms. This would consider the implication of key technology and operational differences, such as floating substructure motions, floating-to-floating transfer and lifting operations, FOW-specific installation methods, tow-to-port maintenance operations etc. Likely remedial action and proposals for recovery in the event of dropped objects at FOW farms should also be outlined. It is likely that data and lessons learned from the bottom-fixed wind industry would be heavily relied upon initially, however, as FOW operational experience grows, the analysis could be updated and more accurate outputs communicated to the fishing industry. In light of any key findings, it should also be considered whether FOW-specific measures are required for reporting and mitigating dropped object incidents. Any recommendations should be developed with input from the fishing industry to ensure that reporting requirements are relevant and appropriate.
Research Stakeholders	Fishermen's federations and associations; marine management organisations; maritime and lighthouse authorities; offshore wind developers and trade associations.

Table 20: Interaction 18

Interaction	19. Noise emitted during FOW farm installation (including any piled components) and/or operation impacts the population or distribution of one or more target species.
Type	Environmental
Priority	Medium
Background	The level of noise emitted during the installation of a FOW farm will be specific to the anchor type selected for the turbine mooring systems. Some anchor types, such as drag embedment, are expected to be less noisy to install than bottom-fixed monopile foundations, whereas others, such as driven pile, are likely to have significant installation noise emissions. Furthermore, during the operational phase, it is possible that the subsea network of mooring lines and dynamic cables within FOW arrays will have a different noise profile to bottom-fixed wind farms. Further research is required to reveal the potential sources and extent of FOW underwater noise emissions, and the possible effect on target fish species.
Future Activities / Research	An investigation into the potential sources and levels of FOW underwater noise emissions would strengthen the industry's understanding of the potential effects on target fish species. The development of early commercial FOW farms in UK waters provides an opportunity to record initial measurements of noise levels, both during construction and operation. The potential to use these measurements to simulate the noise emissions of future full-scale commercial arrays should be explored, and, where appropriate, guidance should be shared on the implications of mooring design decisions on environmental noise emissions. Whilst the topic of noise impacts on fish has been the focus of initial laboratory-based studies, at present there has been limited research on these impacts in the field. Furthermore, existing noise mitigation measures are primarily focussed on impacts on marine mammals, and it is unclear how effective they are for fish. Early commercial FOW developments therefore provide an opportunity to conduct relevant monitoring studies within the field to build upon early research and address knowledge gaps in these areas. Where potential impacts on fish are identified, relevant mitigations should be considered. The requirement for further research on the impacts of underwater on a range of marine species was highlighted in the ScotMER evidence maps [4]; this should be referred to ahead of any further investigative work, with a view to identifying potential synergies with the ScotMER research programme.
Research Stakeholders	Marine research institutes; marine management organisations; offshore wind developers.

Table 21: Interaction 19

Interaction	20. Lost fishing gear becomes entangled with FOW mooring systems and/or dynamic cables.
Type	Physical & Technology
Priority	Medium
Background	In addition to the potential for mobile or static gear to become entangled with a FOW turbine's mooring lines and inter-array cables during the course of normal fishing operations (see Interactions 8 and 9), it is possible that the same risk applies to lost fishing gear. Further investigation is required to assess the likelihood and potential implications of an entanglement incident with lost fishing gear.
Future Activities / Research	There would be an opportunity to expand the further research outlined in relation to Interactions 8 and 9 to include an assessment of the entanglement risks posed by lost mobile and static fishing gear. Relevant data from the fishing industry would be reviewed to assess the frequency of lost gear events, the types of gear that might typically be lost, and potentially also the fishing fleets that experience lost gear events most frequently. The same range of mooring and dynamic cable configurations and metocean conditions would be considered. The potential for this to lead to the creation of ghost nets (whereby lost gear presents an entanglement risk for fish, marine mammals and seabirds) could also be assessed. Where applicable, guidance would be issued regarding the proper channels for reporting lost fishing gear within the vicinity of FOW farms, as well as the appropriate steps that each industry should an entanglement incident occur with lost fishing gear.
Research Stakeholders	Fishermen's federations and associations; marine management organisations; maritime and lighthouse authorities; offshore wind developers and trade associations.

Table 22: Interaction 20

Interaction	21. Presence of FOW farm causes fishing vessel transit routes to be altered, either due to the obstruction of navigation, or levels of risk.
Type	Operations & Navigation
Priority	Medium
Background	It is currently unclear whether development of FOW farms will impact the transit routes taken by fishing vessels. It is possible that mooring systems and dynamic cables will be viewed as less of a risk when vessels are simply navigating, and not towing mobile fishing gear (see Interaction 2). A decision on whether or not to navigate through a FOW farm will therefore likely be based on concerns about the risk of collision with a floating substructure (see Interaction 1), rather than entanglement of fishing gear. With this in mind, collaborative engagement between the two industries would help to determine the extent to which transit routes for fishing vessels might be impacted by the development of commercial FOW farms.
Future Activities / Research	The further research proposed in relation to Interactions 1 and 2 (which included investigation into the appropriate the use of marking, lighting, AIS systems on vessels and FOW assets, requirements for updating fishing industry databases (e.g. KIS-ORCA, FishSAFE), consideration of collision risk at the FOW farm planning stage etc.) would also be directly relevant to managing the impacts of FOW farms on fishing vessel transit routes. A continuation of the collaborative, large-scale spatial planning approach adopted by the SMP would help to identify specific recommendations for managing the impacts of future FOW developments on navigational (i.e. transit only) routes for fishing vessels. This would include consideration early in the planning stage of the impacts of array layout design on navigation, and whether existing guidance (e.g. MGN 654 [1]) requires updating so that it is relevant to FOW.
Research Stakeholders	Fishermen's federations and associations; marine management organisations; maritime and lighthouse authorities; offshore wind developers and trade associations.

Table 23: Interaction 21

Interaction	22. FOW tow-to-port maintenance operations create additional restrictions to fishing activities due to transit of turbines between port and FOW farm.
Type	Operations & Navigation
Priority	Medium
Background	A clear distinction between bottom-fixed and FOW farms is the potential for FOW turbines to be disconnected and towed to port for major repairs and maintenance. A consensus is yet to emerge within the industry whether FOW farm operators will adopt this strategy or elect to carry out major repair work in situ, and it is possible that different FOW farms will use different strategies. With this in mind, engagement between the two industries is required to understand the potential impact of FOW tow-to-port repair strategies on the fishing sector, and whether guidance and mitigations are required.
Future Activities / Research	Targeted and collaborative engagement between the FOW and fishing industries would allow both sets of stakeholders to identify the potential risks of tow-to-port strategies in respect of fishing activities and subsequently outline best practice recommendations for mitigating these. This would consider whether current collision regulations are sufficient or require updating to account for tow-to-port strategies. The respective impacts on mobile and static fisheries should also be explored, and the relevant steps for communicating FOW towing strategies to the fishing industry should also be outlined (e.g. issuing appropriate Notices to Mariners to minimise potential risk) to ensure that all relevant stakeholders have sufficient access to the necessary information.
Research Stakeholders	Fishermen's federations and associations; marine management organisations; maritime and lighthouse authorities; offshore wind developers and trade associations.

Table 24: Interaction 22

Interaction	23. FOW industry's use of traditional harbours as O&M bases causes existing fishing industry to compete for these facilities.
Type	Ports & Infrastructure
Priority	Medium
Background	The future development of commercial FOW farms will significantly increase the offshore wind capacity installed in Scottish waters. Each FOW farm will require the use of a construction port during the installation phase, as well as continued access to a nearby harbour for operations and maintenance activities once commissioned. There is therefore a need for early engagement between the FOW and fishing industries ensure that this shared requirement to access local harbours is managed in the best interest of all key stakeholders, and that all new developments comply with the principles of co-existence and fairness as outlined in the Scottish National Marine Plan [14].
Future Activities / Research	Targeted and collaborative engagement between the FOW and fishing industries would allow both sets of stakeholders to identify the risks and opportunities of shared harbour use and outline the best approach for managing these. This would take into account the expected pipeline of future FOW farms and the associated requirements for portside access. Operational risks would be assessed and potential requirements for infrastructure investment outlined so that harbour facilities can be managed to suit the needs of both industries going forward.
Research Stakeholders	Fishermen's federations and associations; local harbour authorities; offshore wind developers and trade associations.

Table 25: Interaction 23

4 FLOATING OFFSHORE WIND AND FISHING INTERACTION ROADMAP

The Floating Offshore Wind and Fishing Interaction Roadmap outlines a proposed programme of activities in relation to each of the identified priority interactions. The focus and scope of these activities has been guided by the feedback and recommendations captured during the course of the stakeholder workshops. It should be noted that while the roadmap set out in Section 4.4 provides a high-level summary of the future activities proposed in relation to the priority interactions, a more detailed discussion of each interaction is included in Section 3.2 for further context.

4.1 DELIVERY TIMELINE

A high-level delivery timeline is set out in the roadmap to reflect the appropriate order and rate at which these activities are conducted. The proposed timescales are as follows:

- **Short-term** – Activity could be initiated forthwith and is not dependent on further studies or projects being conducted in advance.
- **Medium-term** – Activity might be initiated in the short-term but may also depend on data and lessons learned from early commercial-scale FOW farms (e.g. 100 MW – 500 MW arrays). Outputs from these activities are intended to further support the design and development of future, full-scale commercial FOW farms (e.g. 500 MW – 1 GW arrays and beyond).
- **Long-term** – Activity might be initiated within, but should not be restricted to, the short- to medium-term. In order to realise the full benefits, these activities should also coincide with the development of full-scale commercial FOW farms (e.g. 500 MW – 1 GW arrays and beyond).

The timescales have been defined in order to mirror the key stages in the commercialisation of the FOW industry, rather than prescribing specific numbers of months or years. This approach was adopted in order to reflect:

a. The role that certain short-term activities might have in informing the subsequent development of the FOW industry in respect of its interactions with Scottish fisheries;

b. The dependency that some activities may have on earlier work being performed as a prerequisite;

c. The necessary conditions required for the work to take place (for instance, some environmental monitoring studies may depend on access to early commercial-scale FOW farms, rather than small-scale demonstrator projects, in order to determine the potential effects of a FOW development more accurately).

While it is not possible at the time of writing to predict the precise scale of FOW deployment that will ultimately result from the 2020/21 ScotWind leasing round, for the purposes of interpreting this roadmap, the early commercial-scale FOW farms referenced in the medium-term definition should be regarded as the early FOW developments that may result from this initial leasing process. The reference to full-scale commercial FOW farms in the long-term definition is intended to reflect the larger commercial projects that are expected to be developed in the subsequent leasing rounds in Scotland. In developing this roadmap, it was assumed that between the early commercial-scale and full-scale commercial developments, FOW farms in Scotland are likely to see further technology convergence (e.g. in the choice of mooring system design, dynamic cable configuration etc.) as the industry matures. Hence, there is an opportunity for the short- and medium-term activities to inform design and development decisions made in the longer-term.

4.2 ACTIVITY TYPES

As described in Section 3, each priority interaction was reviewed on a case-by-case basis, and the associated activities were proposed using the same approach. In order to track the types of research activities, and to monitor potential synergies between these, a colour key has been applied to the roadmap. Table 26 details the colour key applied to these activity categories.

Key	Activity Type
	Collision / entanglement risk review
	Licensing / planning review
	Environmental monitoring studies
	Insurance policy review
	Technology review and development (incl. simulations, gear trials)
	Developing FOW / Fishing best practice and industry guidance
	Review of fishing economic opportunities

Table 26: Activity type colour key

4.3 DELIVERY PARTNERS

Relevant research stakeholder groups have also been identified in relation to each interaction. Table 27 lists the key used to reflect each stakeholder group.

It is anticipated that the activities proposed in the Floating Offshore Wind and Fishing Interaction Roadmap would be led and delivered by a range of organisations across the FOW and fishing sectors, with support from relevant stakeholders as required. Following the development of this roadmap, the FOW CoE will consider how these activities can be progressed through its core work programme and also identify where opportunities exist to integrate these efforts with the existing programmes of external organisations.

It is also recognised that as the FOW industry in Scotland continues to commercialise and deployment rates increase, the administrative burden placed on the fishing industry as a result of the requirement to engage with new developments and provide background information, data, and guidance, will continue to grow. This risk should be duly considered as the proposed future activities are planned and undertaken in order to ensure that that the workload is appropriately balanced between the key stakeholders and industries.

Key	Research Stakeholder
	Consenting authorities
	Fishermen's federations and associations
	Government departments (relevant to associated legislation)
	Harbour authorities
	Insurers of fishing vessels and offshore wind farms
	Marine research institutes
	Marine management organisations (incl. seabed leasing authorities)
	Maritime and lighthouse authorities (incl. navigational safety groups)
	Offshore wind developers and trade associations.
	Indicates suggested lead delivery partner

Table 27: Research stakeholder key

4.4 FLOATING OFFSHORE WIND AND FISHING INTERACTION ROADMAP

				Research Activity Timeline			
Interaction	Type	Description	Priority	Short-Term (2021-22)	Medium-Term (Early Commercial Arrays)	Long-term (Full Commercial Arrays)	Research Stakeholders
1	Physical & Technology	Fishing vessel collides with the substructure of a FOW turbine.	High	1.A. Review current marine licensing conditions for FOW.			
				1.B. Review the use, and role in collision risk mitigation, of marking, lighting, AIS etc. for vessels & FOW turbines.			
				1.C. Develop / update existing industry guidance and identify whether current regulations require further development.			
				1.D. Effective engagement between both industries to Consider collision risk at FOW farm design stage.			
2	Operations & Navigation	Presence of FOW farm infrastructure has displacement effect on existing fishing activities, either due to the complete obstruction of fishing operations, or unacceptable operational risk.	High	2.A. Review and feasibility assessment of fishing-friendly array layout designs.			
				2.B. Continuation of the collaborative, large-scale spatial planning approach adopted by the SMP to manage the broader impacts of commercial FOW developments on Scottish fisheries (including potential squeeze effects on other fishing areas).			
				2.C. Technology assessment and potential development of fishing friendly FOW mooring system options.			
3	Environmental	Electromagnetic fields (EMFs) generated by a FOW farm's inter-array cables affect local species sensitive to EMFs, with direct or indirect effects on the distribution of target species.	High	3.A. Review of existing research to identify and confirm further research requirements.			
				3.B. Further laboratory monitoring studies (if required).			
				3.C. Environmental monitoring studies within early commercial FOW farms.			
4	Policy & Regulation	Insurance liability prevents fishing vessels from operating within or in the vicinity of FOW farms.	High	4.A. Review of existing guidance and current insurance clauses to determine the allocation of liability.			

				Research Activity Timeline			
Interaction	Type	Description	Priority	Short-Term (2021-22)	Medium-Term (Early Commercial Arrays)	Long-term (Full Commercial Arrays)	Research Stakeholders
5	Environmental	Presence of FOW farm allows fish to accumulate within the project's perimeter (due to increase in available food, FOW farm acting as a refuge etc.).	High	5.A. Review of existing research to identify and confirm further research requirements.			
				5.B. Environmental monitoring studies within early commercial FOW farms to assess potential accumulation effects.			
6	Environmental	Presence of FOW farm leads to benthic recovery due to reduced fishing activity and vessel navigation, with potential overspill into adjacent areas.	High	6.A. Review of existing research to identify and confirm further research requirements.			
				6.B. Environmental monitoring studies within early commercial FOW farms to assess potential benthic recovery effects.			
7	Environmental	The presence of a FOW farm otherwise alters the distribution of one or more target species.	High	7.A. Review of existing research to identify and confirm further research requirements.			
				7.B. Further laboratory monitoring studies (if relevant and required).			
				7.C. Environmental monitoring studies within early commercial FOW farms to assess additional identified impacts.			
8	Physical & Technology	Fishing gear becomes entangled with FOW mooring systems and/ or dynamic (i.e. suspended) cables during mobile fishing operations.	High	8.A. Entanglement risk assessment for mobile fishing reviewing a range of FOW mooring and cable configurations (utilise desk-based simulations where required). Evaluate the potential role of relevant innovations.			
				8.B. Perform gear trials (as required, based on the outputs of 8.A.) to address current knowledge gaps.			
				8.C. Develop FOW-specific guidance for FOW and fishing industries on managing mobile fishing entanglement risks.			
				8.D. Effective engagement between both industries to address mobile fishing entanglement risks at the FOW farm design stage.			

				Research Activity Timeline			
Interaction	Type	Description	Priority	Short-Term (2021-22)	Medium-Term (Early Commercial Arrays)	Long-term (Full Commercial Arrays)	Research Stakeholders
9	Physical & Technology	Static fishing gear moves due to unintended vessel interaction, or tide and wave effects, and becomes entangled with FOW mooring systems and/or cables.	Medium	9.A. Entanglement risk assessment for reviewing a range of FOW mooring and cable configurations (utilise desk-based simulations where required). Evaluate the potential role of relevant innovations.			
				9.B. Perform gear trials (as required, based on the outputs of 9.A.) to address current knowledge gaps.			
				9.C. Develop industry guidance for the safe installation of static fishing gear within FOW farms.			
				9.D. Effective engagement between both industries to address static fishing entanglement risks at the FOW farm design stage.			
10	Operations & Navigation	Mooring lines and/or dynamic cables temporarily wet stored on the seabed during tow-to-port maintenance operations create an additional, non-visible hazard, increasing the risk fishing operations.	Medium	10.A. Expand the entanglement risk assessment for mobile fishing (Interaction 8) to consider wet stored mooring and dynamic cable systems.			
				10.B. Develop industry guidance for managing the risks of wet stored mooring and dynamic cable systems.			
				10.C. Effective engagement between both industries to address static fishing entanglement risks at the FOW farm design stage.			
11	Physical & Technology	The decommissioning process for FOW anchor systems, or any other FOW infrastructure, causes ongoing operational risk to fishing after a wind farm's lifecycle.	Medium	11.A. Assess FOW decommissioning best practice in respect of potential fishing impacts, identifying recommendations / updates to current guidance, where relevant.			
				11.B. Effective engagement between both industries to review decommissioning plans at the FOW farm design stage.			
12	Physical & Technology	Fishing vessel collides with a vessel associated with the installation or operation and maintenance of a FOW farm.	Medium	12.A. Vessel collision risk assessment, addressing FOW-specific factors.			
				12.B. Develop new / update existing industry guidance and identify whether current regulations require revision.			
				12.C. Effective engagement between both industries to manage vessel collision risks from the FOW farm design stage.			

				Research Activity Timeline			
Interaction	Type	Description	Priority	Short-Term (2021-22)	Medium-Term (Early Commercial Arrays)	Long-term (Full Commercial Arrays)	Research Stakeholders
13	Physical & Technology	Dredging or trawled fishing gear damages, is damaged by, or becomes entangled with static (i.e. on the seabed) sections of inter-array cables (including any applied rock protection).	Medium	13.A. Risk assessment of potential snagging event involving static sections of array cables. Review possible impact of FOW platform motions on cable burial (utilise desk-based simulations where required).			
				13.B. Where required to address knowledge gaps, conduct field tests of relevant mobile fishing gear and potential cable burial / protection techniques.			
				13.C. Develop new / update existing industry guidance on FOW inter-array seabed touchdown design and cable burial depths.			
				13.D. Effective engagement between both industries to manage inter-array cable design from the FOW farm design stage.			
14	Physical & Technology	Fishing vessel drops its anchor onto, or drags its anchor over, FOW mooring systems and/or dynamic cables.	Medium	14.A. Review relevant existing emergency procedures in respect of FOW-specific risks. Outline potential mitigation measures.			
				14.B. Develop new / update existing relevant industry guidance on emergency response, anchor retrieval and reporting procedures.			
				14.C. Early and continued communication between both industries throughout the FOW farm lifecycle regarding potential incidents.			
15	Physical & Technology	Failure of a FOW turbine's mooring system leads to a loss of station scenario, creating an unforeseen navigational hazard for fishing vessels.	Medium	15.A. Risk assessment of potential loss of station scenarios, utilising desk-based simulations where required.			
				15.B. Develop new / update existing industry guidance on relevant emergency procedures and, where appropriate, the design of FOW mooring solutions.			

				Research Activity Timeline			
Interaction	Type	Description	Priority	Short-Term (2021-22)	Medium-Term (Early Commercial Arrays)	Long-term (Full Commercial Arrays)	Research Stakeholders
16	People & Skills	The requirement for guard / support vessels during FOW farm construction presents a potential economic opportunity for fishing vessels and/or crew (permanent or seasonal).	Medium	16.A. Review of FOW industry requirements for guardship duties. Assess scale of potential economic opportunity based on FOW deployment pipeline.			
				16.B. Develop guidance for the fishing industry outlining the FOW industry's requirements for guardship duties as well as the potential scale of economic opportunity.			
17	People & Skills	FOW farm pre-construction and operational work presents a potential economic opportunity for fishing vessels and/or crew (permanent or seasonal).	Medium	17.A. Expand the FOW requirements review (Interaction 16) to identify broader economic opportunities for the fishing industry.			
				17.B. Expand the guidance developed in relation to Interaction 16 to address additional economic opportunities identified.			
18	Physical & Technology	Dropped objects during FOW operations become entangled with and/or damages fishing gear.	Medium	18.A. Risk assessment of dropped object events, with a specific focus on FOW construction and operations. Review existing procedures for reporting and mitigating dropped object incidents.			
				18.B. Develop new / update existing industry guidance on reporting and mitigating FOW-related dropped object events (if required).			
19	Environmental	Noise emitted during FOW farm installation, including any piled components, impacts the population or distribution of one or more target species.	Medium	19.A. Review of existing research to identify and confirm further research requirements.			
				19.B. Environmental monitoring studies within early commercial FOW farms to assess potential noise impacts			
				19.C. Development of relevant mitigation measures, where applicable.			

				Research Activity Timeline			
Interaction	Type	Description	Priority	Short-Term (2021-22)	Medium-Term (Early Commercial Arrays)	Long-term (Full Commercial Arrays)	Research Stakeholders
20	Physical & Technology	Lost fishing gear becomes entangled with FOW mooring systems and/or dynamic cables.	Medium	20.A. Review available fishing industry data on frequency of lost gear incidents. Assessment of entanglement risk posed by lost mobile and static fishing gear. (NB Likely synergies with risks assessments relating to Interactions 8 and 9.)			
				20.B. Develop guidance on FOW-specific procedures for responding to entanglement incidents with lost fishing gear. Identify the appropriate channels for reporting lost gear incidents in the vicinity of FOW farms.			
21	Operations & Navigation	Presence of FOW farm causes fishing vessel transit routes to be altered, either due to the obstruction of navigation, or levels of risk.	Medium	21.A. Spatial planning review and collision risk assessment with a focus on fishing vessel transit. (NB Likely synergies with further research relating to Interactions 1 and 2.)			
				21.B. Develop / update existing industry guidance and identify whether current regulations require further development.			
				21.C. Effective engagement between both industries to manage and mitigate potential navigation impacts at the FOW farm design stage.			
22	Operations & Navigation	FOW tow-to-port maintenance operations create additional restrictions to fishing activities due to transit of turbines between port and FOW farm.	Medium	22.A. Risk assessment of tow-to-port operations and impact on mobile and static fisheries. Identify potential mitigations.			
				22.B. Review and propose potential updates to current collision regulations to ensure relevance to FOW tow-to-port operations.			
				22.C. Effective engagement between both industries to manage the risks of tow-to-port operations at the FOW farm design stage.			

				Research Activity Timeline			
Interaction	Type	Description	Priority	Short-Term (2021-22)	Medium-Term (Early Commercial Arrays)	Long-term (Full Commercial Arrays)	Research Stakeholders
23	Ports & Infrastructure	FOW industry's use of traditional harbours as O&M bases causes existing fishing industry to compete for these facilities.	Medium	23.A. Operational risk assessment of shared harbour use between fishing and FOW industries. Consider the implications of the scale of the FOW deployment pipeline. Highlight potential opportunities.			
				23.B. Develop / update existing industry guidance on managing shared harbour use.			
				23.C. Effective engagement between both industries at the FOW farm design stage to manage the risks and opportunities of shared harbour use.			
n/a	Operations & Navigation	Temporary safety zones established during FOW farm construction (or other key activities) has displacement effect on existing fishing activities.	Low	n/a	n/a	n/a	n/a
n/a	Ports & Infrastructure	FOW industry's use of traditional harbours as O&M bases creates additional revenue for these facilities, benefitting other sectors.	Low	n/a	n/a	n/a	n/a
n/a	Policy & Regulation	Policy / regulation is introduced which restricts fishing activities in certain areas due to the presence of FOW or associated infrastructure.	Low	n/a	n/a	n/a	n/a

Table 28: Floating Offshore Wind and Fishing Interaction Roadmap

5 CONCLUSION

The FOW-Fishing Interaction project has supported the development of a roadmap that identifies and prioritises potential interactions between the FOW and fishing industries in Scotland and outlines a portfolio of activities to address the associated challenges and opportunities. This roadmap was developed through a collaborative engagement process involving fishing and FOW industry representatives as well as key stakeholders associated with the development of Scotland's marine environment. It is clear from the roadmap's recommendations that certain stakeholder groups – namely, the fishermen's federations and associations, marine research institutes, marine management organisations (incl. seabed leasing authorities), maritime and lighthouse authorities (incl. navigational safety groups), and offshore wind developers and trade associations – have a pivotal role to play in the successful delivery of these activities.

In addition to recommending relevant future activities, the roadmap is also intended to provide guidance to key stakeholders on the priority challenges and opportunities currently relating to FOW and fishing interactions. It is therefore proposed that the roadmap is circulated among the relevant working groups and initiatives to serve as a reference document during related discussions. Examples of such groups would include, but not be limited to, the Fishing Liaison with Offshore Wind and Wet Renewables (FLOWW) Group, the Nautical and Offshore Renewables Energy Liaison (NOREL) Group, and the Scottish Marine Energy Research (ScotMER) programme. Having now developed this FOW-specific roadmap, there is an opportunity to identify synergies with the more broadly focussed ScotMER programme to ensure that any new activities undertaken compliment, rather than duplicate, existing workstreams. There could also be a benefit to circulating the document more widely within the offshore industry, for example by promoting its findings to key industry forums and representative bodies, including Scottish Renewables, RenewableUK and the Offshore Wind Industry Council (OWIC).

Further, the two reports underpinning the roadmap – An Overview of Scottish Fisheries Prepared for the Floating Offshore Wind Industry and the Floating Offshore Wind Technology and Operations Review – provide additional context to the work undertaken during this project. It is intended that these additional reports are also made publicly available so that they can continue to provide practical guidance for non-technical stakeholders following the publication of the roadmap.

Through the timely delivery of the activities outlined in the roadmap, and with the input of the identified relevant stakeholder groups, there is an opportunity to harness the anticipated benefits of this work within a timeframe that coincides with the development of commercial-scale FOW farms in Scottish waters. It is also proposed that the framework established by the project for identifying and addressing interactions could be used to support constructive engagement between the FOW and fishing industries across other regions of the UK.

The FOW CoE would like to extend its gratitude to the participants of the project Steering and Working Groups whose input during the stakeholder workshops was critical to the development of this roadmap.

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