Orbital Marine Power Ltd | O2.4 Floating Tidal Turbines

Project-specific Environmental Monitoring Programme

EMEC Fall of Warness Test Site, Berth 3

August 2021

Purpose

Mitigation and monitoring measures have been identified following a review of the project specific environmental impacts, taking into consideration the site-wide environmental appraisal and associated guidance provided by EMEC. This document describes developer-identified mitigation, monitoring and management measures associated with the proposed project including any statutory reporting mechanisms. For a detailed description of the company, device, and project, please refer to the Project Information Document.

This document has been developed to support a marine licence application under the Marine (Scotland) Act 2010. The PEMP is a live document and will be continually updated as further project information becomes available and throughout the various phases of the project.

Document History

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1 Technology

1.1 Project Overview

Orbital Marine Power Ltd (Orbital) is an innovative Scottish engineering company, headquartered in Orkney, and focused on the development of a tidal energy turbine technology capable of producing a dramatic reduction in the cost of energy from tidal currents. The Orbital technology has been under continuous engineering development, including rigorous testing of scaled systems in both tank conditions and open ocean environments since the company was founded in 2002.

The O2.4 floating tidal turbine is a long hull structure with twin power generating nacelles at the end of retractable leg structures held station with a four-point mooring system. The rated capacity of the turbine is c. 2.4 MW.

The proposed project is to be situated at test berth 3, Fall of Warness, and will be composed of the following main components:

- 2 x Orbital O2.4 commercial demonstrator turbines;
- Anchoring and mooring systems; and,
- Temporary vessels involved in installation, maintenance and decommissioning operations.

It should be noted that the subsea connection to shore will be via EMEC's pre-installed subsea cable and therefore is not considered to be part of the project infrastructure. At this stage, it is undetermined whether gravity based anchors or rockbolt anchors will be utilised; this will be determined once further information is gathered regarding ground conditions and site suitability assessments. The potential environmental impact associated with each anchoring methodology has been assessed within this version of the PEMP.

Further details regarding the technology and project are available in the Project Information Document.

2 Environmental Monitoring

The following sections describe the potential key environmental impacts considered relevant to the installation, operation, maintenance and decommissioning of the two O2.4 commercial demonstrator turbines and associated infrastructure at EMEC's test site. Within the following sections is a summary of the proposed monitoring and mitigation measures relating to each potential impact pathway for the relevant project phase. Any key findings from the monitoring will be disseminated to the regulator, Marine Scotland, and appropriate advisors, e.g. NatureScot.

2.1 Disturbance/Displacement

There is potential for displacement of essential activities of marine mammals, seabirds, fish, and basking sharks due to the presence of the two O2.4 turbines and associated moorings. The displacement can be caused by the physical presence of the structures or indirectly caused by the operation of the turbine or through activities during installation, maintenance and decommissioning (such as noise etc.). The presence and operation of the turbines and associated mooring structures could potentially result in the displacement of species out of the test site area and surrounding area. The significance of the displacement will depend on the importance of the habitat, i.e. is it important for essential activity (breeding, foraging, moulting, resting, etc.) and the availability of alternative habitat elsewhere.

Displacement can be a temporary issue, with behavioural patterns changing over time as birds habituate to the presence of turbines. Note, that there is the potential that birds, fish and possibly marine mammals could be attracted to the area due to the presence of the turbines, this may be as roosting location or to exploit new foraging opportunities that may arise if prey species are found to gather around the structures.

The following table summarises the proposed monitoring and mitigation measures for the relevant project phase relating to each potential impact pathway within disturbance/ displacement.

Table 1. Proposed monitoring and mitigation measures relevant to the impact pathway disturbance/displacement

Impact Pathway	Receptor	Proposed Mitigation/Monitoring Measure	Reporting Mechanism
All project phases			
Disturbance – presence or noise from vessel activity (including transiting to and from site)	Cetaceans, basking shark	**Mitigation:** The Scottish Marine Wildlife Watching Code (SMWWC) will be adhered, including the following measures: • Vessel speed will be reduced to 6 knots when a cetacean or basking shark is sighted in close proximity to the immediate vessel transit route. • A steady speed and vessel course will be maintained if a cetacean or basking shark approaches a vessel involved in marine operations. • Utmost care will be taken in ensuring groups / mothers and young are not split up by vessels. • Sudden changes in speed and direction will be avoided to reduce the likelihood of any further disturbance to cetaceans or basking shark in the vicinity. The completion of this mitigation measure will be dependent on ensuring safe navigation throughout activities, crew safety and (where necessary) completion of marine operations which are constrained by tidal or weather windows.	Any non-compliance with the SMWWC will be reported to the regulator as soon as notified by the vessel skipper.
Harassment/ disturbance – presence of vessel activity (including transiting to and from site)	Harbour and grey seals	**Mitigation:** SMWWC will be adhered to including the measures outlined above. In addition, during all vessel activity a minimum approach distance will be complied with when passing designated seal haul-outs.	Any non-compliance with the SMWWC will be reported to the regulator as soon as notified by the vessel skipper.
Disturbance – presence of vessel activity (including transiting to and from site)	Seabirds	**Mitigation:** SMWWC will be adhered to including following particular measures: • Rafts of birds will not be intentionally flushed	Any non-compliance with the SMWWC will be reported to the regulator as soon as notified by the vessel skipper.

Impact Pathway	Receptor	Proposed Mitigation/Monitoring Measure	Reporting Mechanism
		• During seabird breeding season (April to August inclusive), vessel transit corridors will be at least 50m from shore in the vicinity of cliff-nesting seabirds to avoid disturbance.	
Installation			
Disturbance - presence or noise from mooring installation works and vessel presence onsite	Cetaceans, seals, basking shark	**Mitigation:** All operations will be conducted in line with SMWWC.	Any non-compliance with the SMWWC will be reported to the regulator as soon as notified by the vessel skipper.
Disturbance – presence and noise produced by drilling equipment during rockbolt anchors installation	Cetaceans, seals, basking sharks and marine birds	**Mitigation:** All operations will be conducted in line with SMWWC. **Monitoring:** If funding becomes available, static acoustic monitoring equipment may be deployed long term (4-6 weeks) prior to drilling works in order to characterise the noise produced during drilling and other installation noise.	Any non-compliance with the SMWWC will be reported to the regulator as soon as notified by the vessel skipper. Any monitoring conducted would be reported in the appropriate EMR.
Operation and maintenance			
Displacement – barrier effect from the presence of device	Birds and potentially marine mammals, basking shark and fish	**Monitoring:** Should funding be available prior to deployment, recordings of video footage from above-surface infrared cameras monitoring bird and marine mammal observations in the vicinity of the device[1] could be carried out. In addition, roosting behaviour will be monitored. Depending on the availability of cameras, during device operation, an operator will be able to view video screens which show footage from cameras[2]. Opportunistic recording of species behaviour will be recorded by the operator as per an agreed protocol and reporting form.	Any key findings from video analysis will be reported to the regulator within the Environmental Monitoring Report (EMR).

[1] Depending on funding availability, cameras will be mounted on the device will be able to capture the turbine deck and sea surface in the vicinity of the device. The cameras will operate in infrared at night and low-visibility conditions.

[2] Following the commissioning stage, there is unlikely to be a permanent ongoing operator of the machine, with an automated operation process instead.

Impact Pathway	Receptor	Proposed Mitigation/Monitoring Measure	Reporting Mechanism
Decommissioning			
Disturbance - Noise and presence of vessels undertaking decommissioning operations may cause minor disturbance/ displacement (including when transiting to and from site)	Cetaceans, seals, basking sharks, marine birds	**Mitigation:** Compliance with the SMWWC. Vessel presence onsite will be kept to a minimum.	Any non-compliance with the SMWWC will be reported to the regulator as soon as notified by the vessel skipper.
Disturbance – Noise produced during anchor removal or cutting may cause minor disturbance/ displacement	Cetaceans, seals, basking sharks	**Mitigation:** Compliance with the SMWWC. No mitigation or monitoring is proposed.	Any non-compliance with the SMWWC will be reported to the regulator as soon as notified by the vessel skipper.

2.2 Acoustic impact

Underwater sound generated by tidal turbines may affect marine animals, especially those that rely on sound for biological functions, including communication, social interaction, orientation, foraging, and evasion, such as marine mammals (Southall *et al*., 2019). While evidence suggests that underwater noise emitted by operational devices is unlikely to cause acoustic injury (such as non-auditory/auditory tissue damage) to marine animals, some studies suggest a possibility of behavioural responses (Copping and Hemery, 2020). Currently the importance of hearing underwater and hearing thresholds for diving birds is unknown however, many studies have been completed to understand the hearing thresholds for marine mammals and fish. It is anticipated that the noise produced by the device and the installation of rockbolt anchors may have the potential to cause displacement, avoidance, causing a reduction in foraging success. In addition, as the Orbital O2.4 has machinery housed in surface-piercing components, there is the potential to affect diving birds due to the above surface noise generated.

During installation and maintenance work, there is anticipated to be an increased presence of vessels onsite. It is yet to be determined if multi-cat vessel and RHIB or a dynamic positioning (DP) vessel would be used for the installation of the modular gravity based anchor system, however the potential acoustic effects of using a DP vessel has been considered below. The noise generated by vessels onsite has the potential to disturb species in the immediate vicinity of the test site. It is expected that this impact will be temporary in nature.

If rockbolt anchors are to be used, it is anticipated that the drilling operation will be completed in a short timescale (6 hours per drilling operation), therefore, due to the temporary nature of the impact, it is not expected that any significant effects to marine mammals, fish or seabirds will result from the drilling operation.

The following table summarises the proposed monitoring and mitigation measures for the relevant project phase relating to each potential impact pathway within acoustic impact.

Table 2. Proposed monitoring and mitigation measures relevant to the impact pathway acoustic disturbance

Impact Pathway	Receptor	Proposed Mitigation/Monitoring Measure	Reporting Mechanism
All project phases			
Acoustic disturbance – Noise from vessel activity (including transiting to and from site)	Cetaceans, basking shark, seals	**Mitigation:** All operations will be conducted in line with SMWWC	Any non-compliance with the SMWWC will be reported to the regulator as soon as notified by the vessel skipper.
Installation			
Acoustic disturbance – Vessel activity may cause minor acoustic impact	Cetaceans, seals, basking sharks, marine birds	**Mitigation:** All operations will be conducted in line with SMWWC	Any non-compliance with the SMWWC will be reported to the regulator as soon as notified by the vessel skipper.
Acoustic disturbance and/or auditory damage – Drilling activity may cause minor acoustic impact or auditory injury	Cetaceans, seals, basking sharks, marine birds	**Monitoring:** Should funding be available prior to deployment, a characterisation of the acoustic signal of drilling operations over a 6-hour period will be collected. This will inform future environmental assessments if such anchoring mechanisms are to be used at a commercial scale.	Monitoring outputs would be reported to the regulator via the appropriate EMR.
Operation and maintenance			
Acoustic disturbance – Noise produced by operating turbine	Cetaceans, harbour and grey seals	**Monitoring:** An acoustic characterisation of the O2.1 device, currently installed at the Fall of Warness test site is currently undergoing. The outputs of the monitoring will help inform the monitoring requirements for the O2.4 devices and to understand potential cumulative effects due to an array of devices. Should further funding opportunities become available, a baseline assessment may be completed prior to device deployment. It is anticipated monitoring would be conducted utilising drifting acoustic surveys. The methodology will be agreed with NatureScot and Marine Scotland prior to works.	A similar methodology to that employed for the acoustic characterisation around the O2 device is expected to be employed. This will be agreed with NatureScot and Marine Scotland prior to use. Findings from monitoring will be reported in the appropriate EMR.

Impact Pathway	Receptor	Proposed Mitigation/Monitoring Measure	Reporting Mechanism
Decommissioning			
Acoustic disturbance – Vessel activity may cause minor acoustic impact	Cetaceans, seals, basking sharks, marine birds	**Mitigation**: All operations will be conducted in line with SMWWC. Vessel presence onsite will be kept to a minimum.	Any non-compliance with the SMWWC will be reported to the regulator as soon as notified by the vessel skipper.
Acoustic disturbance and/or auditory damage – Drilling activity to remove anchors may cause minor acoustic impact or auditory injury	Cetaceans, seals, baskig sharks	**Mitigation:** All operations wil be conducted in line with SMWWC.	Any non-compliance with the SMWWC will be reported to the regulator as soon as notified by the vessel skipper.

2.3 Collision and Entanglement Risk

There is potential for a physical interaction between marine mammals, basking sharks and seabirds and tidal energy devices and associated moorings. The risk of collision is considered to be a key potential impact for marine mammals and basking sharks during device operation. Direct physical interactions (i.e. collision) with a device has the potential to cause physical injury with potential consequences at a population level. However, there is considerable lack of empirical knowledge on this risk (Macleod *et al*., 2011). Baleen whales and basking sharks are generally slow moving with a relatively low degree of manoeuvrability, potentially putting them at a higher risk of collision with devices. In contrast, being highly mobile underwater, such as small cetaceans and seals, should result in the capacity to both avoid and evade a device. However, this is reliant on a number of factors:

- individuals having the ability to detect the objects,
- perceiving them as a threat, and
- taking appropriate action at a suitable range.

Each species' ability to detect devices will depend on its sensory capabilities, and the visibility and level of noise emitted by the device. The potential for animals to avoid collisions with devices will also depend on their body size, social behaviour, foraging tactics, curiosity, habitat use, underwater agility, and the tidal and environmental conditions present at the test site (Macleod *et al*., 2011). Collision risk is likely to be highest in fast flowing areas where high approach speeds may delay the time available for animals to react, or impede their navigational abilities. Observations of animals in the area, such as seals, show that the density of the marine mammals and their prey (fish) is linked to the tidal flow. Underwater observations in the Fall of Warness area have noted that there are greater densities of prey during slack tide, when the turbine blades would be idle. It is therefore anticipated that marine mammals and seabirds are less likely to be passing through the area when the tide is at full flow and the blades are turning.

Due to declining harbour seal population within Pentland Firth and Orkney Waters, the potential for encounter/collision between a harbour seal and the rotating blades of a tidal turbine is of particular concern. It is anticipated that the marine mammals actively avoid the turbine rotor however, it is desirable to capture evidence that corresponds to this hypothesis.

To inform the consent application, modelling using the ERM model (Wilson *et al*., 2007) has been completed to estimate the maximum encounter rate that may be associated with the project. This has been completed in line with the methodology employed for the Fall of Warness Environmental Appraisal. There are a number of assumptions and discrepancies in the model which limit the use of the model's outputs.

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It is also possible, but unlikely, that collisions may occur with stationary structures e.g. mooring lines, anchors and support structures. These are less likely to cause death but injuries from entanglement may result.

In terms of the entanglement risk, it is considered unlikely that the potential exists for marine megafauna, such as cetaceans and basking shark, to become entangled in the mooring lines and dynamic cable size associated with the O2.4 devices. The O2.4 moorings are composed of studlink chain (125m of 95mm studlink chain and 100m of 115mm studlink chain) and

therefore, it is anticipated that marine megafauna will effectively treat the mooring system as a solid structure. Although the likelihood of this risk is expected to be low, it will be important gain further understanding of this potential impact pathway if an array of complex mooring lines (not under tension) are to be deployed.

Load sensors are present on the mooring lines, however such sensors are incapable of detecting any change in loading of less than 3 Te. It is anticipated that it will not be possible for a marine mammal or basking shark entangled in the mooring system would impact enough load to the moorings for the impact to be detected.

The dynamic cable attaching the devices to the subsea cable is under constant tension and has a weight of 7 Te per km in water. It is therefore anticipated that from the perspective of entanglement, the dynamic cable is also effectively a solid structure. There is not sufficient slack at any time to allow loops within the cable to form, which would have presented an area of greater risk.

An indirect impact pathway is potential for fishing gear (e.g. nets and lines) to become fouled in the mooring system and then act as a further entanglement/entrapment risk and potential act as ghost fishing gear.

There have been recent reports of seals becoming entrapped within the ducts/pipework supply the cable to base structures of an offshore wind farm. A review of this potential impact pathway against the proposed design of the O2.4 has been completed. It is not anticipated that there are any mechanism for entrapment within the O2.4 design and therefore this impact pathway has not been considered further.

The following table summarises the proposed monitoring and mitigation measures for the relevant project phase relating to each potential impact pathway within collision and entanglement risk.

Table 3. Proposed monitoring and mitigation measures relevant to the impact pathway collision risk

Impact Pathway	Receptor	Proposed Mitigation/Monitoring Measure	Reporting Mechanism
All project phases			
Injury or death due to entanglement with mooring system/cable	Cetacean, basking shark	**Monitoring:** The impact likelihood of impact through entanglement is anticipated to be very low. Regular drop camera footage of the mooring lines will be reviewed to look for evidence of entanglement events and entanglement of fishing gear etc. A reporting protocol will be produced for the operator to follow in the event of an entanglement event.	Any entanglement events recorded will be reported to the regulator as soon as possible. Procedures for emergency shutdown will be followed in this event.
Installation			
Vessel collision	Cetacean, seals, basking shark	**Mitigation:** Compliance with the SMWWC . Vessel presence onsite will be kept to a minimum.	Any non-compliance with the SMWWC will be reported to the regulator as soon as notified by the vessel skipper.
Entanglement with temporary vessel moorings	Cetaceans, seals, basking sharks	**Mitigation**: Mooring lines will be kept onsite for as short a period as possible.	N/A
Operation and maintenance			
Behavioural change, injury or death due to the interaction with turbine rotor with the potential for collision.	Diadromous fish; Gadoids, Cetacean, Basking shark or harbour and grey seal; All diving bird species (seaduck, red-throated diver, great cormorant, common guillemot, razorbill, Atlantic puffin,	Continual review of monitoring work carried at other sites with installed tidal turbines to ensure any required mitigation and monitoring measures are effectively employed. **Monitoring:** If possible, four underwater cameras will be mounted on the Orbital O2.4 system such that the full sweep of each blade can be observed. The cameras will only be effective during daylight hours[3]. The video footage can then be sampled at varying tidal states to understand fish, marine mammal, bird behaviour in close proximity to the device. A suitable measure for ensuring the camera lens remains free of biofouling and biofilms will also need to be determined.	Report any additional new information that requires an update to the EMP. Advice from NatureScot will be sought when sourcing underwater cameras and the determining an appropriate sampling regime for the video data

[3] This monitoring measure is dependent on the ability to design a mounting arrangement for the cameras on the device and sourcing suitable underwater cameras.

Impact Pathway	Receptor	Proposed Mitigation/Monitoring Measure	Reporting Mechanism
	black guillemot, northern gannet).		
Decommissioning			
Vessel collision	Cetaceans, seals, basking sharks	**Mitigation**: Compliance with the SMWWC. Vessel presence onsite will be kept to a minimum.	Any non-compliance with the SMWWC will be reported to the regulator as soon as notified by the vessel skipper.
Entanglement with temporary vessel moorings	Cetaceans, seals, basking sharks	**Mitigation**: Mooring lines will be kept onsite for as short a period as possible.	N/A

2.4 Biofouling and non-native species (NNS) introduction

Biofouling is the gradual accumulation of waterborne organisms on the surfaces of objects in the water. Biofouling may consist of microorganisms such as bacteria or protozoa or macro-organisms such as barnacles or seaweed. Biofouling can contribute to surface corrosion and may also reduce the efficiency of moving parts. Orbital O2.4 will utilise appropriate biofoulants to minimise the accumulation of biofouling on the turbine as far as practical.

Various guidelines and standards have been referred to in developing the proposed mitigation and monitoring measures. Despite the use of biofoulants, it is likely that a certain level of biofouling will accumulate, it is unlikely to pose a risk to introducing non-native species as movements will be limited to towing from shipyard to Orkney waters, as outlined below:

- Main hull and legs to be assemble in UK shipyard and towed to Orkney;
- Nacelles and hubs will be assembled in continental Europe and briefly in water on tow from UK shipyard to Orkney.

The spread of non-native organisms can occur through a variety of means including shipping, transport of fish or shellfish, scientific research, and public aquaria. These invasive non-native species can threaten marine diversity. Due to accumulation of non-native species in harbours and ports, during maintenance activities, the turbine and mooring system may act as locations for non-native species to grow and hence be transported to site and thus provide a steppingstone for colonisation.

The following table summarises the proposed monitoring and mitigation measures for the relevant project phase relating to each potential impact pathway within biofouling and the introduction/transfer of non-native species.

Table 4. Proposed monitoring and mitigation measures relevant to the impact pathway biofouling and introduction of non-native species

Impact Pathway	Receptor	Proposed Mitigation/Monitoring Measure	Reporting Mechanism
All project phases			
Biofouling and the introduction of non-native species (including anchors)	Benthic communities	**Mitigation:** Compliance with good practice measures detailed in the 'Alien invasive species and the oil and gas industry – Guidance for prevention and management' produced by the IPIECA in 2010, 'Guidance for minimizing the transfer of invasive aquatic species as biofouling (hull fouling) for recreational craft' produced by the IMO in 2012 and the 'Code of Practice on Non-Native Species' made by Scottish Ministers under section 14C of the Wildlife and Countryside Act 1981. **Mitigation**: Local vessels will be used throughout all installation, maintenance, and decommissioning operations therefore there is not likely to be any potential for the introduction of NNS than those NNS already present in Orkney waters. **Mitigation:** Antifouling paints will be used which comply with the IMO International Convention on the Control of Harmful Anti-fouling Systems on Ships and national legislation.	Any deviance from the good practice measures will be reported on prior to the event occurring via the appropriate documentation. The requirement to use a non-local vessel for any marine operations associated with the project will be agreed with the regulator prior to works.
Biofouling, introduction of non-native species and habitat creation for biofouling species (including anchors)	Sessile communities	**Mitigation:** Opportunistic inspections of biofouling will be implemented which will have a dedicated procedure for removing biofouling species from the device. The organisms removed will be analysed by experts to ensure a comprehensive species list is compiled.	Findings reported to the regulator as soon as reasonably practicable through the appropriate documentation.
Decommissioning			
Habitat removal for biofouling species	Sessile communities	A full device biofouling inspection may be conducted as the device (and moorings) is decommissioned. This inspection will be conducted by an expert in the biofouling field to ensure that a comprehensive species list is compiled.	Findings reported to the regulator as soon as reasonably practicable through the appropriate documentation.

2.5 Habitat Creation

The drilling operation to install rockbolt anchors or the physical presence of the gravity anchors will inherently result in direct habitat loss within the footprint of the anchors. However, colonisation of the introduced structures may have the potential to function as artificial reefs or fish aggregating devices. The increase in the local reef extent may be negligible if rockbolt anchors are employed due to the size of rockbolt anchors therefore diminishing the significance of this impact depending on the type of anchor selection. Anchors are an artificial substrate and could alter the nature and composition of the species present and may enable colonisation. Likewise, this could also be said for the device itself. The device and the mooring lines could act as fish aggregating devices and the surface piercing element of the device may be used as a roosting spot for birds – this was commonly recorded on Orbital Marine Power's SR-2000 device when deployed at the Fall of Warness, see Figure 1.

Figure 1. Guillemots on SR2000 device at 20:08 hrs on 15/05/2018

Cetacean, seal and seabird distribution may be influenced by prey distribution and associated prey habitat. The physical presence of the anchors / device may offer enhanced foraging efficiency for some species.

The following table summarises the proposed monitoring and mitigation measures for the relevant project phase relating to each potential impact pathway within habitat creation.

Table 5. Proposed monitoring and mitigation measures relevant to the impact pathway habitat creation

Impact Pathway	Receptor	Proposed Mitigation/Monitoring Measure	Reporting Mechanism
Operation			
Fish aggregation device (FAD) effect and colonisation of fouling organisms due to introduction of hard structure	Benthic communities (including fish and shellfish), benthic community predators (e.g. marine mammals and seabirds)	**Monitoring: I**f funding opportunities are available prior to deployment, cameras could be mounted below and above the surface of the device. The video can be monitored to assess fish aggregation, bird roosting and predator-prey behaviour.	Findings reported to the regulator as soon as reasonably practicable through the appropriate documentation such as EMR.
Creation of habitat around installed infrastructure for benthic species	Benthic communities (including fish and shellfish)	**Monitoring:** There is a likelihood of reef effects around the installed anchors. There is no proposed monitoring measure however, when the opportunity arises, any video footage of the moorings will be analysed to quantify the level of reefing taking place.	Findings from analysis will be reported in the appropriate EMR.

2.6 Seabed Clearance

There is potential for direct loss of sub-littoral seabed communities if gravity-based moorings are utilised. The installation of the new structures directly on the seabed, will result in the loss of habitat due to the placing of the structures. It may be necessary to conduct seabed clearance prior to installation. Small amounts of lost habitat may diminish populations of species that are recorded as rare.

There is also the potential for abrasion caused by mooring lines dragging or rubbing across the seabed or from vessel anchors during installation. Abrasion is likely to damage or kill species, which are sessile or sedentary.

During the installation of the O2 mooring system at berth 5, it was found that level of direct seabed impact was minimal and no seabed clearance was necessary prior to install. It is anticipated that due to the tidal swept nature of the site, the majority of the deployment location will be bedrock. The footprint of the anchor blocks would be minimal and therefore, if any seabed clearance is necessary this would be limited.

If rockbolt anchors are selected, the deployment may cause a temporary loss of benthic habitat as above. However, as rock anchor technologies have an even smaller footprint in relation to gravity bases, the relative loss in habitat will be at a smaller scale.

The following table summarises the proposed monitoring and mitigation measures for the relevant project phase relating to each potential impact pathway within seabed clearance.

Table 6. Proposed monitoring and mitigation measures relevant to the impact pathway seabed clearance

Impact Pathway	Receptor	Proposed Mitigation/Monitoring Measure	Reporting Mechanism
Installation			
Seabed loss due to the direct footprint	Benthic communities (including fish and shellfish)	**Monitoring:** Pre-installation and post-installation seabed survey will be conducted to understand the extent of the effect on the benthic ecology and seabed character caused during installation activities.	Findings from video footage analysis will be reported to the regulator through the appropriate EMR.
Seabed clearance and habitat loss from installation of rockbolt anchor	Benthic communities (including fish and shellfish)	**Mitigation:** Rockbolt anchor technology has much smaller footprint in comparison with other anchor types.	N/A
Decommissioning			
Colonisation and loss of new habitat	Benthic communities (including fish and shellfish)	**Monitoring:** Pre-decommissioning seabed survey will be conducted 2 months prior to decommissioning of the anchors.	A summary report will be submitted to the regulator prior to decommissioning activities commencing.
Recolonisation	Benthic communities (including fish and shellfish)	**Monitoring:** Post-decommissioning (within 3 months) seabed surveys will be conducted to investigate the effects on the benthic ecology and seabed character caused during decommissioning activities.	Findings from analysis will be reported to the regulator as and when available.

2.7 Discharges to the Marine Environment

Benthic species may be exposed to materials such as paints, hydraulic fuels and antifouling compounds originating directly from the O2.4 devices. Accidental spillages from installation or maintenance vessels could also occur. Spillages pose a risk to marine mammals, fish, seabirds and benthic communities and can cause direct effects at the time of the spill or can result in chemical accumulation in body tissues leading to lagged effects on health and breeding success.

The following table summarises the proposed monitoring and mitigation measures for the relevant project phase relating to each potential impact pathway for discharges to the marine environment.

Table 7. Proposed monitoring and mitigation measures relevant to the impact pathway discharges to the marine environment

Impact Pathway	Receptor	Proposed Mitigation/Monitoring Measure	Reporting Mechanism
Installation			
Leakage of fuel or chemicals from vessels involved with installation can enter the food-web at any trophic level	Potentially whole ecosystem	**Mitigation:** Vessel crews should follow standard procedures to avoid fuel and chemical spills. Suitable spill kits should be onboard all vessels involved in the project.	Any incidents will be reported to the regulator as soon as possible.
Decommissioning			
Leakage of fuel or chemicals from vessels involved with decommissioning can enter the food-web at any trophic level	Potentially whole ecosystem	**Mitigation:** Vessel crews should follow standard procedures to avoid fuel and chemical spills. Suitable spill kits should be onboard all vessels involved in the project.	Any incidents will be reported to the regulator as soon as possible.

2.8 Historic environment

2.8.1 Prehistoric sites

Inferences can be made on the potential for the survival of prehistoric deposits in the area of Fall of Warness from coring, bathymetric, side scan sonar (SSS) and sub-bottom profile (SBP) data obtained by various surveys in and close to the test site and observations made during numerous diving operations at devices and in the general area completed by SULA Diving.

The bedrock is exposed throughout the majority of the test site area, with occasional boulders, but is swept of any bed load transport as there is little mobile material available (Wallingford, 2005). To the north and east of the deep basin there are some deposits up to 11m thick of boulders, cobbles, gravel and interstitial shelly sand, presumed to be glacial till deposits with a reworked surface layer. Dive and ROV surveys show these rocks to be well covered with flora and fauna, indicating long-term stability and minimal transport of sand or gravel. Close to shore there are sand deposits within the gullies formed by the rock ridges that run along the line of the cable route.

In summary, within the offshore area of EMEC's Fall of Warness test site, the potential for the survival of prehistoric deposits is negligible-low, especially because most of the site is exposed bedrock, with occasional boulders.

2.8.2 Shipwrecks, aircraft, and obstructions

No marine cultural heritage statutory designations have been identified in the Fall of Warness test site area. There are no UK Hydrographic Office (UKHO) reports showing the existence of any wrecks within the area and none shown on the relevant UKHO charts.

Considering the tidal flow speeds present in this area, it is unlikely that any shipwrecks, aircraft or other obstructions that have not already been identified would remain intact and in the reported area of foundering, or that any remains survive.

Multi-beam bathymetry and side scan sonar tend not to be able to distinguish between the wreck and the geology of the seabed. Magnetometry is the only method of determining if a wreck may be present. Given that the area is mostly exposed bedrock and any sediment being shallow and mobile, it is unlikely that much, if anything, survives and nothing has been observed during SULA Diving investigations in the area.

No ongoing monitoring other than compliance with EMEC's Archaeological Discoveries SOP (SOP128) is proposed relating to the potential impact pathway on the historic environment.

3 Research Opportunities

Orbital and EMEC will actively pursue any funding opportunities available to expand the proposed monitoring outlined in the PEMP. NatureScot will be consulted on monitoring methodologies before they are implemented to ensure the most appropriate techniques and equipment are employed.

Orbital are committed to working closely with EMEC, the regulator and NatureScot to develop and further the PEMP and associated research opportunities.

4 Conclusion

There are a number of potential impact pathways and receptors described in the sections throughout this PEMP. To reduce the impact on marine megafauna, the Scottish Marine

Wildlife Watching Code will be closely adhered to and any deviations will be reported to the regulator. Keeping vessel activity to a minimum during the project phases will also help to reduce further impacts.

There are several monitoring measures anticipated to be employed throughout the project such as the mounting of cameras of the devices themselves, performing acoustic drifting surveys and undertaking seabed surveys. Orbital will seek further funding opportunities to pursue the proposed monitoring and undertaking further monitoring within the project timeline, if such funding becomes available.

5 References

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