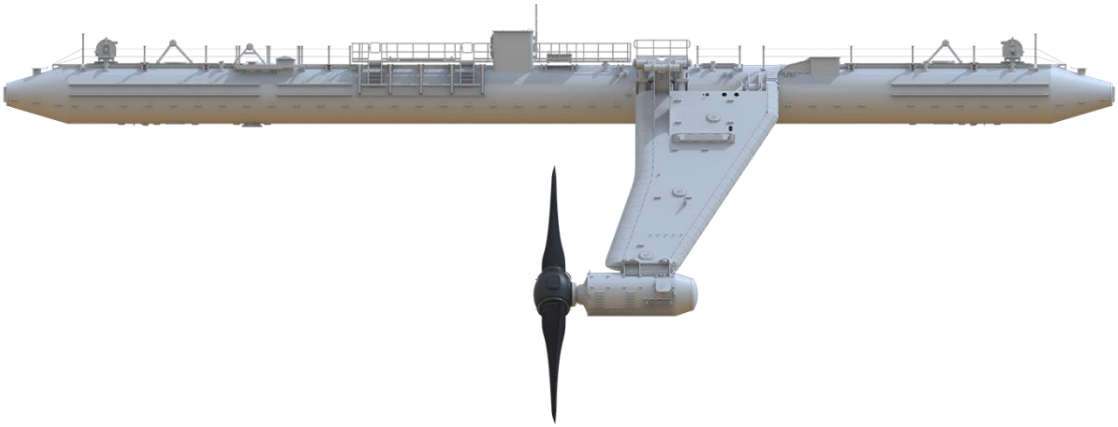
Orbital | O2-X Tidal Turbine

Project Environmental Monitoring Programme

Orbital Eday 3, Fall of Warness, Eday, Orkney

November 2023



Purpose

Mitigation and monitoring measures have been identified following a review of the project specific environmental impacts, taking into consideration the site-wide environmental description or 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 Summary.

Document History

Revision	Date	Description	Originated by	Reviewed by	Approved by
1	19/10/2023	For discussion with EMEC	James Murray		
2	31/10/2023	EMEC draft additions	Amy Sutcliffe	Donald Leaver	
3	10/11/2023	For submission with Marine License	James Murray		

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1 Technology

1.1 Device Overview

Orbital Marine Power's Tidal Technology is a floating tidal stream energy generator. A cylindrical floating steel superstructure, which houses power conversion and auxiliary systems, provides reference and attachment for two leg structures with nacelles mounted at their ends. The leg structures have hinge attachments to the superstructure such that, with an actuation system, they can be lowered to position the nacelles and contra-rotating rotors in the optimal part of the tidal stream resource to generate power or be raised to bring the legs, nacelles and rotors to the surface for the purpose of servicing and turbine towing. Station keeping is provided to the superstructure via a multi-anchor catenary mooring system consisting of rope tethers, mooring chain, and anchors. Power is exported from the turbine via a dynamic cable from the superstructure to the seabed where it connects to seabed static cabling infrastructure that exports power ashore to the EMEC substation.

The O2-X will be anchored either with gravity anchors or rock bolt anchors using the Leask Marine Ltd Submersible Drilling Rig (SDR).

2 Environmental Monitoring

As the O2-X will be the fifth orbital device at the Fall of Warness (FoW) site, this Project Environmental Monitoring Programme (PEMP) has been written with multiple device/array effects in mind.

The following sections describe the potential key environmental impact(s) considered relevant to the installation, operation, maintenance and decommissioning of the devices 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 device and associated moorings. Displacement can be caused by the physical presence of the structures or other disturbances caused by the installation (such as noise etc.). The presence and operation of devices and associated mooring structures could potentially result in the displacement of species out of the test site 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 is an effect that is not expected to be observed at the current scale of the tidal industry, around a single device; however, as arrays are deployed this potential impact may become more evident. It is anticipated that displacement will be observed at a certain threshold of devices (Hasselman *et al*., 2023); however, the number of orbital devices as proposed are not expected to cause significant effects in terms of displacement of marine animals in the FoW. This is due to the fact that the devices will be spread out across the site.

Displacement can be a temporary issue, with behavioural patterns changing over time as birds habituate to the presence of a device. 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 devices, 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 speeds will be reduced to 6 knots when a cetacean is sighted in close proximity to the immediate vessel transit route. • A steady speed and vessel course will be maintained if a cetacean 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 in the vicinity. The completion of this mitigation measure will be dependent on ensuring safe navigation throughout activities, crew safety and 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.

Impact Pathway	Receptor	Proposed Mitigation / Monitoring Measure	Reporting Mechanism
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 the behavioural state of seals on haul-outs will be monitored and the vessel speed and heading will be adjusted accordingly. If seals appear alert upon passage past or relatively close to the haul-out (heads raised and exaggerated movement towards the water line) the vessel speed will be reduced and course diverted away from the haul-out until seals appear to ignore the vessel.	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 • 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	Any non-compliance with the SMWWC will be reported to the regulator as soon as notified by the vessel skipper.
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.
Rock Anchor installation – drilling may cause minor disturbance / displacement	Cetaceans, seals, basking sharks and marine birds	**Mitigation:** All operations will be conducted in line with SMWWC. Drilling operations will only up to six hours per anchor	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
		and only four anchors are likely to be installed therefore no mitigation or monitoring is proposed.	
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, data will be collected using multibeam sonars focused on the nearfield behaviour of fish, marine mammals, and diving birds in the vicinity of the device. The sonar data will be validated using high-definition underwater cameras onboard the tidal device. Consideration will be given to combining with monitoring programmes for other O2-X installations at the EMEC site to get optimum research outcomes for the available funding.	Findings will be reported to the regulator upon completion.
Decommissioning			
Vessel activity – noise and presence 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.
Anchor removal – noise 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

There are potential effects on marine mammals, basking sharks, fish and seabirds from underwater noise generated by tidal device operation (from machinery housed subsurface structures) and the installation of rock anchors. There is a growing body of evidence that suggests operational noise is unlikely to cause acoustic injury to marine animals; however, behavioural responses are possible (Polagye & Bassett, 2020) and it has been shown that harbour seals (*Phoca vitulina*) avoid sounds from operational devices (Hastie *et al*., 2018) and harbour porpoise (*Phocoena phocoena*) activity was significantly reduced around operational devices compared to baseline levels (Tollit *et al*., 2019). 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. In addition, as the Orbital O2-X has machinery housed in surface-piercing components, there is the potential to affect diving birds due to the above surface noise generated.

It is anticipated that the noise produced by an array/group of devices may have the potential to cause displacement, avoidance, or a reduction in foraging success. Underwater noise from an array is expected to exceed baseline conditions greater than a single device; however, the elevation in received levels is expected to be low; although greater at lower frequencies (Felix *et al*., 2021). The bathymetry, array configuration and technology type will also influence how noise propagates around an array (Harding *et al*., 2023). Given that the Orbital devices will be spread out over the site and one of the devices is already on site, it is not expected that the noise they generate will cause significant effects to marine animals in the vicinity.

During installation and maintenance work, there is anticipated to be an increased presence of vessels onsite though only one multi-cat and one RHIB are planned to be on site at any one time. The noise generated by vessels onsite has the potential to disturb species in the immediate vicinity of the test site; however, it is expected that this impact will be temporary in nature.

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 impact

Impact Pathway	Receptor	Proposed Mitigation / Monitoring Measure	Reporting Mechanism
All project phases			
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			
Anchor installation – drilling and vessel activity may cause minor acoustic impact or auditory injury	Cetaceans, seals, basking sharks and marine birds	**Mitigation:** All operations will be conducted in line with SMWWC Drilling operations will only last up to 6 hours per anchor and only four anchors are likely to be installed, therefore 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.
Operation and Maintenance			

Impact Pathway	Receptor	Proposed Mitigation / Monitoring Measure	Reporting Mechanism
Disturbance – Noise from operating turbine	Cetaceans, Harbour and grey seals	**Monitoring:** Subject to funding being available, the acoustic impact of the tidal turbine across the range of operational periods will be evaluated, providing an acoustic signature of the tidal turbine. EMEC will use the outputs of this work to generate feedback to the international marine energy standards related to acoustic characterisation (IEC TS 62600-40:2019). This campaign would build upon a re-design of the Drifting Acoustic Recorder and Tracker (DART) system previously deployed at EMEC and will optimise the approach by investigating suitable ways to reduce the common issue of 'flow noise contamination'. It may also be combined will acoustic monitoring of other O2-X devices to validate cumulative acoustic output modelling. The methodology will be agreed with NatureScot and Marine Scotland prior to works.	Methodology for acoustic monitoring will be provided based on berth 5 O2 acoustic monitoring success. This will be agreed with NatureScot and Marine Scotland prior to use. This will be based on the potential of funding opportunities prior to deployment.
Decommissioning			
Vessel activity – noise from increased activity will 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.
Anchor removal – drilling may cause	Cetaceans, seals, basking sharks	**Mitigation:** All operations will be	Any non-compliance with the SMWWC will be reported to the regulator

Impact Pathway	Receptor	Proposed Mitigation / Monitoring Measure	Reporting Mechanism
minor acoustic impact or auditory injury		conducted in line with SMWWC.	as soon as notified by the vessel skipper.

2.3 Collision and Entanglement Risk

It is considered unlikely that the potential exists for cetaceans and basking sharks to become entangled in the mooring lines and dynamic cable of size and dimension required to support the Orbital O2-X devices. The Orbital O2-X moorings are made up of c. 95mm and 115mm studlink chain with a total dry weight of around 55 tonnes per line. It is anticipated that a marine mammal will effectively treat the mooring system as a solid structure, and therefore the likelihood of entanglement in the mooring lines is reduced significantly. Understanding this impact pathway further will be particularly important if an array of complex mooring lines (not under tension) is to be deployed.

The sensors on the mooring lines used to detect mooring loads on the machine cannot detect any change in loading of less than 3Te. Therefore, it is anticipated that it will not be possible that any marine mammal or basking shark would be able to impart enough load to the moorings for the impact to be detected.

The dynamic cable that is below the machine is 71mm in diameter, is under constant tension and weighs 7 Tonnes per km in water, therefore, from a risk of entanglement viewpoint, the dynamic cable is also effectively a solid structure. There is not sufficient slack at any time enough to allow loops to form in the water column.

There is a secondary concern that fishing lines, nets or other items could get fouled in the mooring system and then cause entanglement/entrapment or potentially act as ghost fishing gear.

There is also potential for collision 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 with a device has the potential to cause physical injury with potential consequences at a population level.

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 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. Should funding / research opportunities become available prior to deployment, there may be some potential to add collision risk monitoring to the deployment.

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 and entanglement risk

Relevant Project Phase	Impact Pathway	Receptor	Proposed Mitigation/Monitoring Measure
All project phases			
Injury or death due to entanglement with mooring system/cable	Cetacean, Basking shark	**Monitoring:** The 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 immediately. Procedures for emergency shutdown will be followed in this event.
Installation			
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
Entanglement with SDR lifting lines	Cetaceans, seals, basking sharks	**Monitoring:** Cameras and sensors on the SDR device will provide alerts if entanglement event was to occur during removal	Any events will be reported to the regulator as soon as possible on return to shore.
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-	Continual review of monitoring work carried at other sites with installed tidal turbines to ensure any required mitigation and monitoring measures	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

Relevant Project Phase	Impact Pathway	Receptor	Proposed Mitigation/Monitoring Measure
	throated diver, great cormorant, common guillemot, razorbill, Atlantic puffin, black guillemot, northern gannet).	are effectively employed. **Monitoring:** Subject to funding being available, data will be collected using multibeam sonars focused on the nearfield behaviour of fish, marine mammals, and diving birds in the vicinity of the device. The sonar data will be validated using high-definition underwater cameras onboard the tidal devices. Furthermore, work will be progressed towards understanding how to incorporate the empirical data into a collision risk model which can be applied to farms. Onboard deck surveillance cameras dedicated to monitoring seabird interactions with devices in the farm will be implemented. The monitoring would be considered with respect to other O2-X style deployments at the EMEC site, to make best use of available funding to achieve research outcomes.	sampling regime for the video data
Decommissioning			
Vessel collision	Cetaceans, seals, basking sharks	**Mitigation**: Compliance with the	Any non-compliance with the SMWWC will be reported to

Relevant Project Phase	Impact Pathway	Receptor	Proposed Mitigation/Monitoring Measure
		SMWWC. Vessel presence onsite will be kept to a minimum.	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
Entanglement with SDR lifting lines	Cetaceans, seals, basking sharks	**Monitoring**: Cameras and sensors on the SDR will provide alerts if entanglement event was to occur during removal	Any events will be reported to the regulator as soon as possible on return to shore.

2.4 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 locations will be bedrock. The footprint of the anchors will be minimal and therefore, if any seabed clearance is necessary this will be limited. In addition, the footprint effect of the devices on the benthic communities is likely to be limited to the seabed in the immediate vicinity of the device infrastructure, with any direct effects being minor/negligible with distance (Copping & Hemery, 2020).

If rock 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 4. 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 as and when available.
Seabed clearance and habitat loss from installation of rock anchor	Benthic communities (including fish and shellfish)	**Mitigation:** Rock anchor technology has much smaller footprint in comparison with other anchor types.	N/A
Decommissioning			
Colonisation and loss of new habitat	Benthic communities	**Monitoring:** Pre-decommissioning	A summary report will be submitted to the Regulator

Impact Pathway	Receptor	Proposed Mitigation/Monitoring Measure	Reporting Mechanism
	(including fish and shellfish)	seabed survey will be conducted 2 months prior to decommissioning the anchors.	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.

2.5 Habitat Creation

The drilling operation and physical presence of the 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 rock anchors are employed due to the size of rock anchors therefore diminishing the significance of this impact depending on the type of anchor selection. This artificial substrate 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 a roosting spot for birds – this was common on the SR-2000 device.

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; however, due to the scale of this project it is not expected to have significant effects.

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 Monitoring/Mitigation 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.	**Monitoring:** Similarly to section 2.1, if funding opportunities are available data will be collected using multibeam sonars focused on the	Findings reported to the regulator as soon as reasonably practicable through the appropriate documentation.

Impact Pathway	Receptor	Proposed Monitoring/Mitigation Measure	Reporting Mechanism
	marine mammals and seabirds)	nearfield behavior of fish in the vicinity of a device; allowing collision risk monitoring across the tidal farm. The sonar data will be validated using high-definition underwater cameras onboard the tidal devices.	
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 to the regulator as and when available.

2.6 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 micro-organisms 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-X will utilise appropriate biofoulants to minimise the accumulation of biofouling on the turbine as far as practical.

While biofouling is a natural process, it can facilitate a foothold for non-native species (NNS). The spread of NNS can occur through a variety of means including shipping, transport of fish or shellfish, scientific research, and public aquaria (Copping & Hemery, 2020). These invasive NNS 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 NNS to grow and hence be transported to site and thus provide a stepping-stone for colonisation.

Various guidelines and standards have been referred to in developing the proposed mitigation and monitoring measures (IMO, 2011). 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 shipyard and towed to Orkney;

• Nacelles and hubs will be assembled in continental Europe and will not be put into the water before they reach Orkney.

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

Relevant Project Phase	Impact Pathway	Receptor	Proposed Mitigation/Monitoring Measure
All project phases			
Biofouling and the introduction of non-native species (including rock 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	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.

Relevant Project Phase	Impact Pathway	Receptor	Proposed Mitigation/Monitoring Measure
		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.	
Biofouling, introduction of non-native species and habitat creation for biofouling species (including rock 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.

2.7 Discharges to the Marine Environment

Benthic species may be exposed to materials such as paints, hydraulic fuels and antifouling compounds originating directly from the SDR or tidal device. 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 Monitoring/Mitigation 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.
Operation			
Corrosion of SDR polluting environment	Benthic communities (including fish and shellfish)	**Mitigation:** Cathodic protection using sacrificial anodes will prevent accelerated degradation of metal structure.	N/A
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.

3 Research Opportunities

The following research activities are likely to be progressed if funding is available. Priority research activities would be discussed with regulators and in the context of potentially

combining with other O2-X style deployments at the EMEC site to maximise research outputs for the available budget.

- Data would be collected using multibeam sonars focused on the nearfield behaviour of fish in the vicinity of a device; allowing collision risk monitoring of the tidal turbine. The sonar data would be validated using high-definition underwater cameras onboard the tidal devices. Furthermore, work would be progressed towards understanding how to incorporate the empirical data into a collision risk model which can be applied to farms.
- EMEC could also monitor the presence of marine mammals around the farm via the use of hydrophones.
- To date, onboard surveillance has largely been focused on an O&M perspective, onboard deck surveillance cameras dedicated to monitoring seabird interactions could be implemented with devices in the farm.
- There could be further investigation of the influence of the turbulence features of the farm on seabird interactions, with at least one drone survey carried out to understand the location of seabirds relative to the turbulence of the farm. In parallel with the drone campaign, a sea-bed mounted ADCP with echosounder capability could be deployed. This would allow for a better understanding of fish presence in relation to seabird activity and the turbulence features.
- In addition, vantage point surveys could be carried out, which would contribute to data to further understand bird-farm interactions.
- Further work would be progressed on a protocol and hardware for environmental data management of farms. This would include consideration of the range of data required for environmental monitoring and the quantities associated in the farm context. Methods of how the data can be collected simultaneously would be explored as well as how a quality control plan will be integrated to ensure that the data is managed to a high standard.

4 Conclusion

There are a number of potential impact pathways and receptors described in the sections throughout this EMP. To reduce the impacts on marine megafauna, the SMWWC 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 have been several monitoring measures mentioned throughout the project such as the multibeam sonar and underwater cameras. Should funding become available to Orbital Marine Power prior to deployment, these monitoring methods may be pursued throughout the project timeline.

5 References

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