

Magallanes Berth 4 Array

Project Environmental Monitoring Plan – Berth4

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Document History

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1 Introduction

Magallanes have prepared this Project Environmental Monitoring Plan (PEMP) in support of a marine licence application to install and operate the array of three devices at Berth 4, Fall of Warness. Magallanes will be utilising EMECs Section 36 consent to generate electricity at the suite under the Electricity Act 1989, as it is believed that the project falls within the assessed project envelope. The PEMP documents the proposed mitigation and monitoring measures relating to the devices and associated works.

1.1 Requirement and objectives

As part of a marine licence application, it is necessary to identify monitoring and mitigation measures to reduce the likelihood of any potential environmental impacts occurring due to the proposed development and to measure and assess the extent of any existing impacts. The PEMP should be used as the opportunity to propose methods for monitoring the device in respect to issues of concern identified. EMEC encourages developers at its test sites to independently consider environmental impacts, and the potential for developing new and innovative mitigation and monitoring techniques, not least because of the competitive advantage that assurance regarding the nature, or indeed absence, of such impacts could provide.

The PEMP is an iterative document, the framework, principles and details of which will be agreed as part of any consent from the regulator (Marine Scotland). The commitments made therein are likely to be incorporated into licence conditions. The results of mitigation and monitoring carried out in accordance with the PEMP must be submitted to the Marine Scotland in fulfilment of any licence conditions. It is recommended that all mitigation and monitoring actions have a reporting mechanism or dissemination strategy to ensure the Marine Scotland and statutory consultees are aware of compliance and any results or findings.

1.2 Contents and application of PEMP

The PEMP is a project-specific annex to the EMEC Fall of Warness Environmental Appraisal (EMEC, 2014). The PEMP will be formally agreed with Marine Scotland and NatureScot prior to the commencement of any works associated with the Magallanes array at the Fall of Warness.

During the development of the PEMP, the following should occur:

Identify and support delivery of mitigation necessary for ensuring that residual impacts are reduced to an acceptable level;

- Identify and support delivery of mitigation and monitoring that demonstrate best practice in management of environmental impacts at the test site;
- Increase understanding of environmental impacts and how to monitor and analyse them, to the benefit of Magallanes and the wider industry in relation to commercial upscaling and deployment; and
- Provide opportunities for Magallanes, with support from EMEC, NatureScot and Marine Scotland, to seek innovative solutions for mitigating impacts for understanding the importance of interactions between their devices and the environment.

The PEMP is a live document and will be revisited throughout the lifetime of the project and therefore the document has been designed to be reviewed and updated as the testing and environmental monitoring progresses. It is important that the monitoring and research surrounding the devices deployments can be adjusted and amended as information on the device and its interactions with the receiving environment become available. This adaptive management approach should allow new and innovative mitigation and monitoring techniques to consider as the testing programme progresses ensuring the PEMP remains current.

2 Background

2.1 Project description

Full details of the devices and moorings are provided in the accompanying Project Information Summary. The Project Information Summary has been designed to be read alongside the PEMP, but for ease of reference a summary of the device and testing programme has been provided below.

2.1.1 Device specification

The devices are floating energy generation platforms that are fitted with two open-bladed rotors each with a generating capacity of up to 850kW. As shown in Figure 1, the devices are composed of three main elements: upper block, vertical block (otherwise known as the mast) and lower block (otherwise known as the nacelle). The upper block is the visible block of the platform. It is the block through which the platform is accessible for maintenance. The upper block accommodates the pumps, transformers, converters, switchgears and electrical panels. The vertical block is mainly a structural element attaching the lower block to the upper block. It is a hollow space through which the communication and low-voltage cables connect the equipment housed in the lower block with the parts of the systems within the upper block. The lower block is devoted to the mechanical system comprising the shafts, ball bearings, gear boxes and generators.

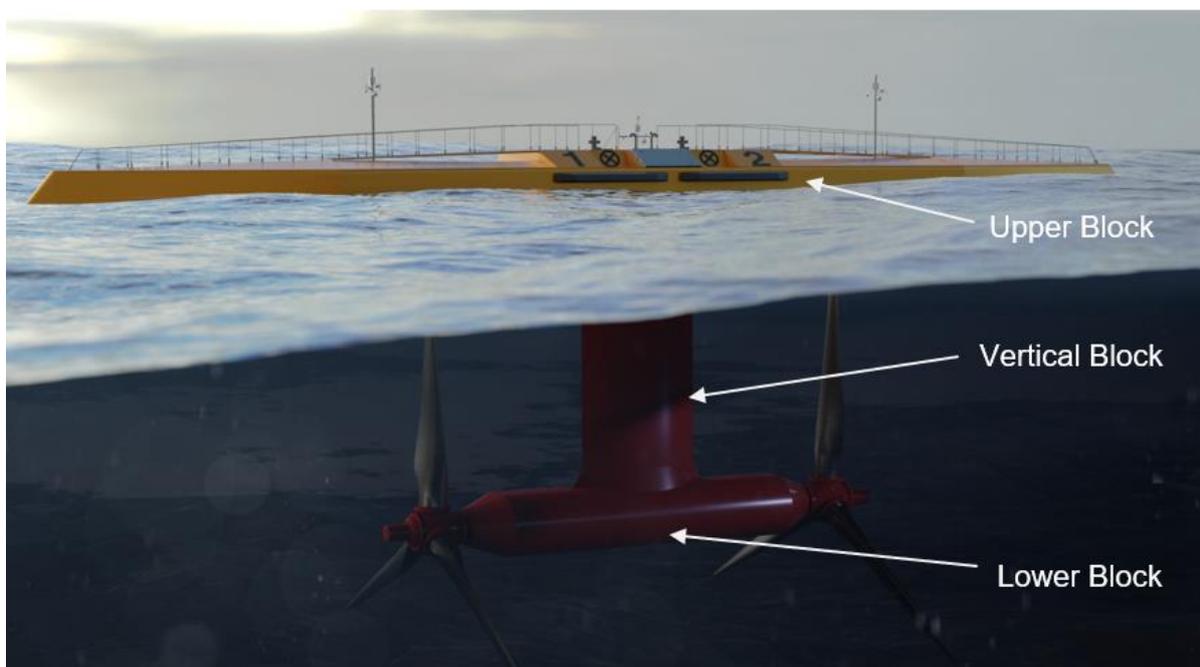


Figure 1| Device layout

The following provides indicative overall dimensions for the structure:

- Overall length: 55 m
- Extreme moulded breadth: 6 m
- Operational draught (including blades): 29 m

The rotors are located at each end of the nacelle and are composed on three blades. Each blade has a length of approximately 11m and the hub is around 2m across. The total rotor diameter is expected to be up to 24m. The rotors are open-bladed and are located directly below the upper block of the platform. The clearance from the sea surface is more than 2.5m and is expected to be in the region of 5m.

The following figure provides indicative dimensions for the ATIR.

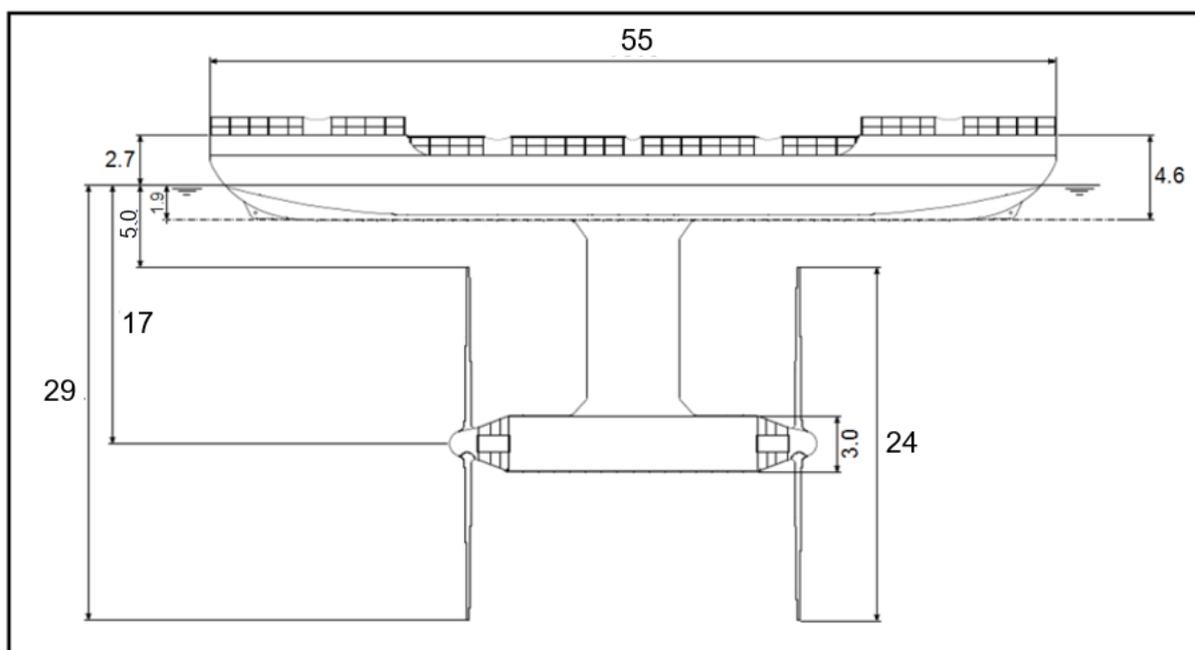


Figure 2| Indicative overall dimensions of the platforms

The platforms are fixed to the seabed with four anchor points, two located at the bow of the platform and the other at the stern, as it can be seen in Figure 3. Each anchor point is composed of a set of drilled piles or gravity-based anchors on the seabed. The platforms will be attached to the anchor points via steel mooring chains. The mooring lines have a length of approximately 300m and attached to the floating platforms at the bow and stern. The mooring lines ensure that the position of the platforms within the berth is maintained.

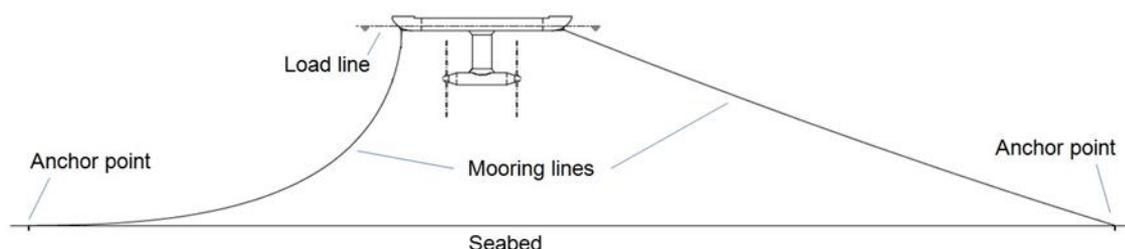


Figure 3| Scheme of the moorings

2.1.2 Device Locations

The platforms are intended to be deployed at the test berth 4 at the EMEC Fall of Warness test site. The below figure shows the intended licence boundary area for the deployment. The final deployment location will be dependent on anchor point micro-siting but will be within the area delineated on the below map. The deployed anchor locations will be confirmed with Marine Scotland post-deployment.

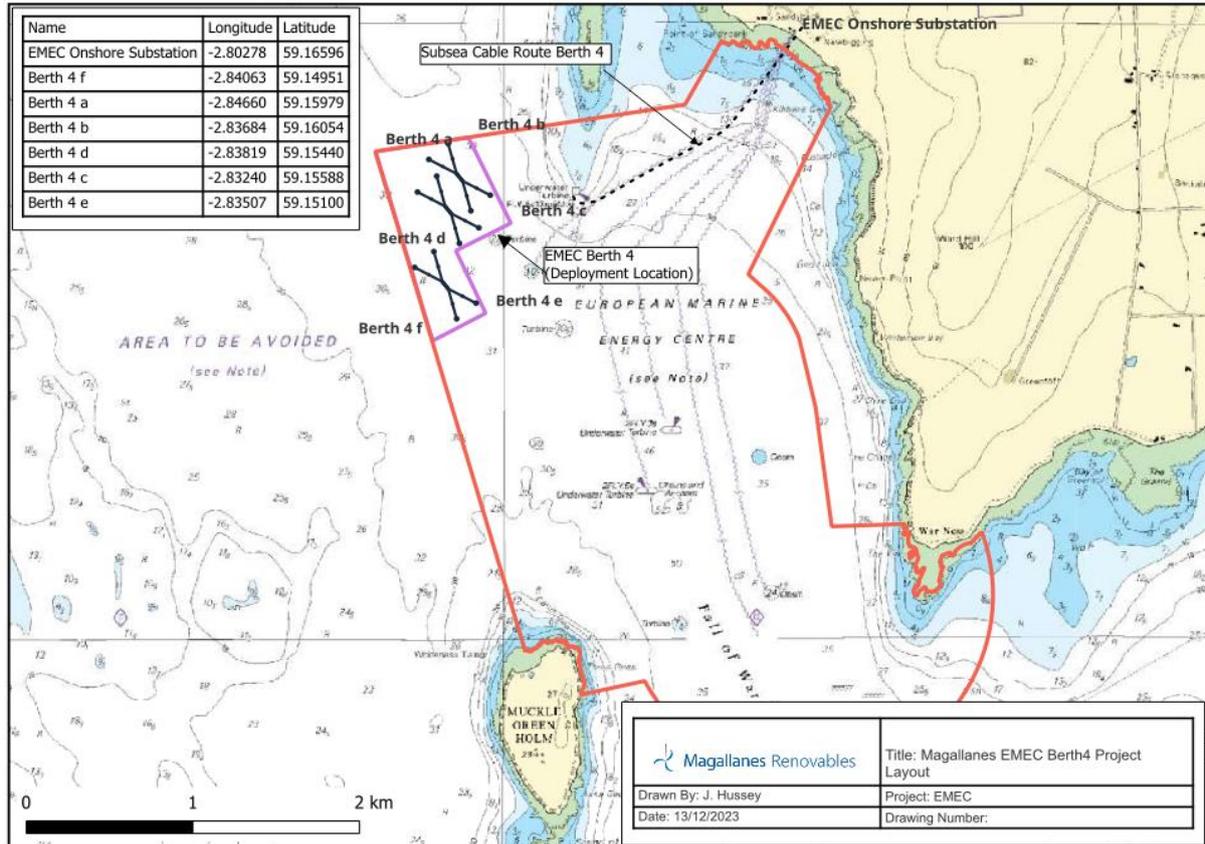


Figure 4| Proposed berth for deploying the platforms

The boundary coordinates are provided in Table 1 below.

Test berth	Latitude (WGS84)	Longitude (WGS84)
Berth 4	59°09'25"N	02°50'25"W
Proposed boundary deployment	59°09'35"N	02°50'48"W
	59°09'38"N	02°50'13"W
	59°09'21"N	02°49'57"W
	59°09'16"N	02°50'17"W
	59°09'04"N	02°50'06"W
	59°08'58"N	02°50'26"W

Table 1| Deployment location at EMEC's Fall of Warness test site

2.2 Project Envelope Analysis

EMEC has developed a project envelope for testing activities at the Fall of Warness. The envelope outlines the type and characteristics of the devices likely to be deployed at the site and the types of marine operations and activities likely to be associated with the installation, operation and maintenance of the devices. An environmental appraisal was undertaken to assess the potential environmental impacts of installation, operation and maintenance of devices within the envelope and cumulative impacts. The appraisal provides a detailed consideration of the potential natural heritage impacts and informs the consenting process for deployment and operation of tidal devices at the Fall of Warness, within the project envelope.

This section provides a comparison between the proposed devices and the project envelope for the site. The following table provides a summary of the key specifications for the ATIR platforms.

Item	Specification
Scale of the device	Full-scale
Overall length	55 m
Extreme moulded breadth	6 m
Operational draught	29 m
Maximum output power	Up to 2 MW
Number of rotors	2
Type of rotor	Open-bladed rotor
Rotor diameter	Up to 24 m
Rotor depth	More than 2.5 m clearance from sea surface (5 m approx.)
Blade/rotor design	Blades with counter-rotating mechanism

Table 2| Main specifications of the platform

From the comparison laid out in Table 4, it is believed that the project falls within EMEC's project envelope. Magallanes are committed to providing the regulator with method statements, if required, prior to undertaking works.

Specification	Project Envelope	ATIR array	Within project envelope?
Site location			
Site boundaries	Crown Estate lease area	Situated at test berth 4 within the Fall of Warness test site.	✓
Facilities			

Subsea cable	Seven of the berths serviced by EMEC-installed/owned cables. Cables servicing the eighth berth currently owned by a developer.	Utilising pre-installed subsea cable 4	✓
Cable protection	Cast iron cable protectors installed where cable free spans over underwater obstructions. Concrete mattresses laid where cables may cross each other.	Utilising pre-installed subsea cable 4	✓
Potential activities / deployments			
Subsea cable	Installation of new subsea cable and associated cable protection systems (mattresses, armour) where required and potential recovery and replacement on the seabed of existing cabling from berths to shore, and repair/maintenance to existing cables or cable protection systems.	Not included in current scope of work. If cable repair work is required a separate licence will be applied for.	N/A
Arrays	A maximum of 9 berths, accommodating up to 12 tidal energy devices at any one time, thereby supporting the testing of small arrays or additional non-grid-connected devices.	Three devices are to be deployed under this project.	✓
Scientific instruments	Deployment of scientific instrumentation and associated cabling.	No scientific instrumentation and associated cabling are expected to be deployed under this project. Please note, a current meter is installed directly on the device which is included in the monitoring and control software.	✓
Buoys	Testing of buoys (maximum of two simultaneous tests).	No buoys are to be tested under the scope of works.	N/A
Mooring arrangement / component testing	Testing of mooring arrangements (e.g. tripod support structures) or individual stand-alone components of devices.	No mooring arrangements are being tested under the scope of works.	N/A
SIMOPS	Potential for simultaneous operations, i.e. installation or maintenance activities, at more than one berth at the same time.	When and where there is a possibility of simultaneous operations, EMEC will advise to ensure adequate measures are being taken. Magallanes will follow EMEC's Standard Operating Procedures (SOPs).	✓
Device characteristics			

Blade/rotor design	<ul style="list-style-type: none"> • Blades with exposed tips (may include multiple rotors, on single or multiple axles) • Blades with enclosed tips (may include multiple rotors, on single or multiple axles), including 'annular' and 'venturi' style devices • Blades with contra-rotating mechanism (may include multiple rotors, on single or multiple axles) • Single or multiple Archimedes rotors 	The rotors of the ATIR have three blades with exposed tips on a single axis. Note the two rotors are located on the same axis.	✓
Rotor diameter	25m (open-bladed rotors)	Rotor diameter is maximum 24m.	✓
Number of simultaneous turbines/rotors	12 devices with up to 18 rotors	The three ATIR devices have two rotors each.	✓ (Dependent on other devices onsite)
Rotor depth	Minimum depth - 2.5m clearance from sea surface	The minimum clearance is more than 2.5m from the sea surface (5m approx.).	✓
Mooring / foundation Infrastructure			
Method	<ul style="list-style-type: none"> • Gravity-based anchor(s) with mooring line(s) attached 	The ATIR will be anchored with gravity-based anchors on seabed.	✓
Pile driving	Project envelope restricts pile/pin insertion to non-percussive methods (i.e. no pile driving).	No percussive drilling methods are included in the scope of works.	✓
Marine works			
Procedures and ERPs	All deployment/retrieval methods will be in accordance with EMEC's Standard Operating Procedures (SOPs) and subject to EMEC's Emergency Response Procedures (ERPs). Methodologies will conform to health and safety and marine navigational safety requirements, and full method statements and risk assessments will be required for review and approval by EMEC prior to issue of a work permit to allow works to proceed. Notice to Mariners describing appropriate works will be issued as part of this process.	Magallanes will produce and follow method statements which are in line with EMEC's SOPs and Emergency Response Plans. Magallanes will follow EMEC's Permit to Access site system and all methodologies will conform to health and safety and marine navigational safety requirements. Notice to Mariners will be issued in line with best practice.	✓

Pre-installation activity	Pre-installation <ul style="list-style-type: none"> • ROV/diver surveys • ADCP deployment/retrieval • Bathymetry surveys • Sub-bottom profiling • Acoustic surveys 	Magallanes may undertake ROV/diver surveys, ADCP deployment, bathymetry surveys and acoustic surveys. The regulator will be informed of upcoming survey work.	✓
Installation activity	Installation <ul style="list-style-type: none"> • Drilling and grouting • Lowering foundation/anchors/nacelle • Cable works and connection to device 	The planned installation work is within the project envelope. Detailed method statements will be provided to EMEC.	✓
Testing activity	<ul style="list-style-type: none"> • Testing of nacelle, gravity foundations, anchors or scientific equipment • ADCP deployments • Acoustic surveys 	Details of all testing activity will be provided to the regulator prior to commencement of the works.	✓
Specification	Project Envelope	ATIR array	Within project envelope?
Inspection and maintenance of devices	Inspection and maintenance of devices <ul style="list-style-type: none"> • ROV inspection • Diver activities • Repairs below/above surface on site • Biofouling removal 	Details of inspection and maintenance activity are provided in the Construction Method Statement.	✓
Temporary retrieval	Temporary retrieval and redeployment of nacelle, gravity foundations, anchors or scientific equipment.	Details of any retrieval works will be provided to the regulator prior to commencement of the works.	✓
Cable works	Inspection, maintenance and replacement of cables and protection <ul style="list-style-type: none"> • ROV inspection • Diver activities • Cable lifting/laying 	It is not anticipated that this type of cable works will be required.	✓

Table 3| Project envelope comparison analysis

3 Receptors

The test site has been well documented including an in-depth description of the receptors at the site and their sensitivities in the *EMEC Tidal Test Facility Fall of Warness Environmental*

Statement (AURORA 2005), Environmental Description for the EMEC Tidal Test Site Fall of Warness (EMEC 2009) and Fall of Warness Environmental Sensitivity Table (EMEC 2010). Recently an environmental appraisal of the site, *EMEC Fall of Warness Test Site Environmental Appraisal (EMEC 2014)* has been conducted. The appraisal identifies the potential receptors and sources of risk to the environment, together with mitigation measures for minimising impacts. The environmental appraisal will be submitted in support of the marine licence application.

Each of the following sections, provides a natural heritage context for the key environment receptors at the Fall of Warness. An overview of the potential impact pathways relevant to the receptors across the project's lifespan has been provided.

3.1 Designated sites

Currently, the Fall of Warness test site does not lie within a protected area but there are several protected sites near to the test facility. These sites are summarised in the following table with an explanation of the reason for their designation.

In addition, the Fall of Warness test site is in close proximity to the proposed Special Protection Area (North Orkney SPA). This site has been proposed due to its qualifying bird species:

Annex 1 species:

- Great northern diver
- Slavonian grebe
- Red-throated diver
- Arctic tern

Migratory species:

- Common eider
- Long-tailed duck
- Velvet scoter
- Red-breasted merganser
- European shag

Site Name	Protection Status	Qualifying Interests/ Notified Features/ Special Qualities
Doomy and Whitemaw Hill, Eday	Site of Special Scientific Interest	The site is one of Orkney's main locations for breeding whimbrel with at least 1% of the British breeding population present. This is a breeding population of national significance. This site is also of national significance for Arctic skua, with again at least 1% of the British breeding population.
Faray and Holm of Faray	Special Area of Conservation	Grey seals.
Faray and Holm of Faray	Site of Special Scientific Interest	The site is one of the most important breeding and haul out sites for grey seals in Orkney. In 2006, an estimated 3,148 pups were produced, equivalent to around 16% of the annual pup production for Orkney, and 7% of the total annual pup production for Britain.
Sanday	Special Area of Conservation	The various marine habitats of Sanday act as qualifying features with reefs, subtidal sandbanks and intertidal mudflats and sandflats. The area also has a qualifying population of harbour seals.
Muckle and Little Green Holm	Site of Special Scientific Interest	Grey seals.

Rousay	Special Protection Area	Aggregations of breeding birds: guillemot, Arctic skua, Arctic tern, kittiwake, fulmar and seabird assemblage.
Rousay	Site of Special Scientific Interest	Various notified habitats: blanket bog, maritime cliff, mesotrophic loch, subalpine wet heath, vascular plant assemblage. There is also a moorland breeding bird assemblage and a breeding seabird colony including Arctic skua, Arctic tern, guillemot and kittiwake.
Mill Loch, Eday	Site of Special Scientific Interest	Aggregation of breeding red-throated diver, one of the densest in the UK.
Calf of Eday	Special Protection Area	Aggregations of breeding birds: nationally important populations of great cormorant, Northern fulmar, common guillemot, blacklegged kittiwake, and great black-backed gull, and extensive seabird assemblages.
Calf of Eday	Site of Special Scientific Interest	Aggregation of breeding cormorant.

Table 4| Description of designated sites near to EMEC’s Fall of Warness test site

3.2 Marine birds

A large number of marine bird species use the area of the test site, many of which are afforded national and international protection and are connected with designated sites. The proposed testing of the devices could affect diving birds and other bird species through the following mechanisms:

- Disturbance/displacement through presence of device and vessels (particularly of breeding birds);
- Risk of collision with operational device causing injury or mortality (relevant to diving species only);
- Risk of entanglement with mooring system (relevant to diving species only);
- Pollution from accidental discharges; and
- Creation of resting habitat at sea.

The most likely species to be affected by the device are those which dive underwater to feed. The main diving bird species at risk from the operation of the device are identified in the table below, includes information on the dive depths which birds are known to feed at and the conservation status of each. A number of the species identified could be connected with designated Special Protected Area (SPA) populations and where relevant these are also listed.

A number of other species which are found in the Fall of Warness area could be affected by the deployment of the turbine. It is therefore important that the monitoring strategy adopted includes all species which could potentially be affected by the turbine.

Species	Conservation status	Designated areas	Diving depth
Cormorants <i>Phalacrocorax carbo</i>	Green	Calf of Eday SPA East Caithness Cliffs SPA (Breeding colony Little Green Holm)	Capable of diving to depths of 35m, usually <10m

Shag <i>Phalacrocorax aristotelis</i>	Amber	East Caithness Cliffs SPA	Benthic foragers Mean dive depth 33m Recorded diving up to 80m
Black guillemots <i>Cepphus grille</i>	Amber		Mean dive depth 32m, maximum 43m
Razorbill <i>Alca torda</i>	Amber	West Westray SPA North Caithness Cliffs SPA East Caithness Cliffs SPA	V shaped dives Range of 510m
Guillemot <i>Uria aalge</i>	Amber	West Westray SPA Calf of Eday SPA Marwick Head SPA Copinsay SPA Hoy SPA North Caithness Cliffs SPA East Caithness Cliffs SPA	Range of 30-60m
Puffin <i>Fratercula arctica</i>	Amber	North Caithness Cliffs SPA East Caithness Cliffs SPA	Depends on food availability Median dive depths of 2530m
Red throated divers <i>Gavia stellate</i>	Amber	Hoy SPA Orkney Mainland Moors SPA	Range of 2-9m
Great northern divers <i>Gavia immer</i>	Amber		Capable of diving to 60m Regularly 4-10m
Gannet <i>Morus bassanus</i>	Amber	St Kilda	With a mean dive depth of 20m

Table 5] Diving bird species present at the Fall of Warness test site

3.3 Marine mammals

A number of marine mammal species are known to frequent the Fall of Warness test site, all of which are afforded national and international protection and could be connected with local designated sites. Marine mammals and basking sharks may be affected by the planned deployment of the devices through the following impact pathways:

- Disturbance and/or displacement due to the presence and operation of the devices and associated vessels;
- Disturbance from the acoustic output from the operational devices and vessels associated with installation, maintenance and decommissioning;
- Risk of interaction/collision with the turbines installed on the devices; and
- Risk of entanglement or entrapment with the mooring system for the devices.

The following table outlines the key marine mammal species that have been observed at the Fall of Warness throughout the EMEC Wildlife Observation Programme. The table also provides an indication of their conservation status, any local designated sites and the most sensitive periods is also included.

Species	Legal protection/designated areas	Sensitive period
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Harbour porpoise <i>Phocoena phocoena</i>	European Protected Species under the 1992 EU Habitats and Species Directive Wildlife and Countryside Act 1981 Natural Conservation (Scotland) Act 2004 ICUN Red List (least concern)	June to September
Minke whales <i>Balaenoptera acutorostrata</i>	European Protected Species under the 1992 EU Habitats and Species Directive Wildlife and Countryside Act 1981 Natural Conservation (Scotland) Act 2004 ICUN Red List (least concern)	May to September
White beaked dolphin <i>Lagenorhynchus albirostris</i>	As above	May to September
Risso's dolphin <i>Grampus griseus</i>	As above	May to September
Killer whale <i>Orcinus orca</i>	As above	March to August
Harbour seal (or common seal) <i>Phoca vitulina</i>	Marine (Scotland) Act 2010 Designated haul out sites – Seal Skerry, the Grand Eday, Muckle and Little Green Holm Sanday SAC	Present all year, Pupping June/July, Moulting July/August
Grey seal <i>Halichoerus grypus</i>	Marine (Scotland) Act 2010 Designated haul out sites – Muckle and Little Green Holm Muckle and Little Green Holm SSSI Faray and Holm of Faray SAC	Present all year, Breeding Oct/Nov, Moulting Female – Jan – Mar, Moulting Male – Mar - May

Table 6| Marine mammal species identified at the Fall of Warness

All of the above species have been included on the NatureScot/JNCC list of Priority Marine Features for Scotland.

3.3.1 Cetaceans

The most frequently occurring cetacean species observed in Orkney waters are harbour porpoise, killer whale, minke whale, Risso's dolphin, white-beaked dolphin and bottlenose dolphin (Evans *et al.*, 2011). More 'casual visitors' are Atlantic white-sided dolphin, shortbeaked common dolphin, sperm whale and long-finned pilot whale (Evans *et al.*, 2011). At the Fall of Warness, harbour porpoise is the most frequently sighted cetacean (Robbins, 2011a). Other species recorded during site surveys at Fall of Warness were minke and killer whales, and white beaked and Risso's dolphin. Although other cetacean species could occur at the site, only these five species undergo specific appraisal. However, due to their higher occurrence, they may be regarded as precautionary proxies for all other possible cetacean species. For information on species range and distribution, including detail within Orkney waters, see Evans *et al.* (2011).

All species of cetaceans are listed in Annex II of CITES, Annex II of the Bern Convention Annex, and in Annex IV of the EC Habitats Directive as species of European Community interest and in need of strict protection. Those species listed on Annex IV are termed European Protected Species (EPS). The harbour porpoise is also covered by the terms of

ASCOBANS (Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas). Under the Habitats Regulations it is an offence to intentionally or recklessly:

- Capture, injure or kill such an animal;
- Harass an animal or group of animals;
- Disturb an animal while it is occupying a structure or place used for shelter or protection;
- Disturb an animal while it is rearing or otherwise caring for its young;
- Obstruct access to a breeding site or resting place, or otherwise deny the animal use of the breeding site or resting place;
- Disturb an animal in a manner that is, or in circumstances which are, likely to significantly affect the local distribution or abundance of the species to which it belongs;
- Disturb an animal in a manner that is, or in circumstances which are, likely to impair its ability to survive, breed or reproduce, or rear or otherwise care for its young; • Disturb an animal while it is migrating or hibernating; and
- Disturb any dolphin, porpoise or whale (cetacean).

This PEMP has been designed to address and minimise the risk of carrying out an activity that could constitute an offence under these regulations.

3.3.2 Seals

3.3.2.1 Harbour seals

Scotland holds around 79% of the UK's population of harbour seals and the UK holds around 30% of Europe's harbour seals, although this proportion has declined from approximately 40% in 2002. They are widespread around the west coast of Scotland and throughout the Hebrides and Northern Isles, with a more limited distribution restricted to concentrations in the major estuaries on the east coast such as Firth of Tay, Moray Firth, The Wash and the Thames. Major declines have been documented around Scotland since 2000 with a 66% reduction in

Orkney, 50% in Shetland, 36% in the Outer Hebrides, 46% in the Moray Firth and 84% in the Firth of Tay. These declines are not thought to be linked to the phocine distemper virus epidemic in 2002 that saw declines around The Wash (SCOS, 2011).

For the Fall of Warness, analysis of data from the EMEC wildlife observations between July 2005 and December 2009 indicates that around a third of all observation days (n=1056) recorded the presence of harbour seals (n=373) (Robbins, 2011a). The hourly encounter rate was highest between May and October, peaking at 0.7 harbour seals per hour in May and falling to 0.4 in October. In addition, unclassified seals were also recorded, peaking at 1.6 per hour in September. The distribution of harbour seals across the survey area was significantly varied, concentrating around Sealskerry Bay on Eday.

Telemetry studies focussing on seals within the PFOW area found harbour seal (tagged with Argos tags) tracks through the Fall of Warness site (SMRU Ltd, 2011).

Counts of harbour seals during moults at surrounding haul outs are notable but lower than for grey seals (see below), with an average of 25 at 'Muckle and Little Greenholm' between 2006 and 2010, to the south-western edge of the test site. Counts from 'Eday & Calf' indicate an average of 59, a high proportion of which is from Seal Skerry, at the north of the Fall of Warness site. Sanday SAC for the same period comprises an average count of 314 individuals (Duck and Morris, 2011). Ongoing tagging studies by SMRU Ltd on individuals tagged near the Fall of Warness should help add further information on the behaviour of

individuals using the test site, although it is likely they are breeding, moulting and foraging in this area.

3.3.2.2 Grey seals

Around 38% of the world's grey seal population breed in the UK, of these 88% breed in colonies in Scotland, with the majority in the Hebrides and Orkney. While numbers of grey seal pups have increased steadily since the 1960s, there is evidence that this growth is levelling off particularly in Orkney and possibly some of the colonies in the North Sea (SCOS, 2011).

At the Fall of Warness, grey seals were more frequently observed (60% of observation days) during the EMEC wildlife observations between 2005 and 2009 in comparison to harbour seals (35% of observation days). The highest proportion of all grey seal observations coincided with their pupping season during the autumn months. The average encounter rate between December and August was less than 1 grey seal per hour (0.2 – 0.9), increasing to 4.3 individuals per hour during October. In addition, unclassified seals were also recorded, peaking at 1.6 per hour in September. Unsurprisingly, grey seal observations have been more frequent in the near-shore parts of the survey area, particularly adjacent to haul-outs. The proximity of the Faray and Holm of Faray SAC together with Muckle and Little Greenholm SSSI and other non-designated nearby haul outs all frequented by grey seals (e.g., Seal Skerry), partly explains the higher numbers of grey seals using the Fall of Warness in comparison to harbour seals. They were also found to significantly vary in their distribution across the site concentrating around Muckle Green Holm to the west of the test site (Robbins, 2011a).

Observations of grey seals during the annual August (harbour seal) moult count surveys at 'Muckle and Little Greenholm' between 2006 and 2010, to the south-western edge of the test site, indicate an average of 47 individuals. Observations from 'Eday & Calf' indicate an average count of 211, a high proportion of which is from Seal Skerry, at the north of the Fall of Warness site. However, the yearly counts show much more variation in comparison to the harbour seal counts. Faray and Holm of Faray SAC (including nearby Rusk Holm) for the same period comprise an average count of 492 individuals (Duck and Morris, 2011).

Based on count data from Muckle and Little Green Holm between 1998 and 2008, the average number of estimated pups was 1161. Telemetry studies (using Argos and GSM/GPS tags) on 44 individuals mostly out with the breeding season indicated that grey seals are capable of moving over large distances; tracks also show the movement of seals through the Fall of Warness (SMRU Ltd, 2011).

Higher numbers of grey seal use the Fall of Warness in comparison to harbour seals and they are present during both the breeding (late September to early October) and moulting periods whereby females moult in the following January to March whereas males generally moult later during March to May. The tagging studies have shown that individuals are transiting through the Fall of Warness, and it is likely that they are also using this area when foraging (SMRU Ltd, 2011).

3.3.2.3 Haul-out sites

Seal haul-out sites are onshore locations where seal typically come out of the water to rest, moult and breed. Under Section 117 of the Marine (Scotland) Act 2010, Scottish Ministers have permitted the designation of specific seal haul-out sites to provide additional protection. The Protection of Seals (Designation of Haul-Out Sites) (Scotland) Order 2014 enforced the designation of 194 sites. In Orkney, 36 sites have been designated as important seal haul out

for either grey or harbour seals or both and 18 sites have been designated due to the presence of a grey seal breeding colony. Figure 5 below indicates the location of such sites in Orkney.

There are several seal haul-out sites that are in close proximity to the likely vessel routes. Detailed vessel routes will be provided in the Vessel Management Plan (VMP). However, when such routes are developed a distance of over 500m from any designated seal haul-site will be maintained. This exclusion zone around haul-out sites will be maintained unless personnel or vessel safety does not permit.

The sensitive periods for grey seals are between September and December whereas for harbour seals, it is late May through to August. These sensitive periods will be considered when planning marine operations involving transiting to and from and whilst conducting work at the EMEC test site.

Both grey and harbour seals are found within the area of the test site throughout the year and are protected under Part 6 of the Marine (Scotland) Act 2010 (the Marine Scotland Act). Under the Marine Scotland Act it is an offence to intentionally or recklessly:

- Kill, injure or take any live seals at any time, except under specific licence or for reasons of animal welfare; and
- Harass seals at listed haul-out sites.

A licencing system is in place for the killing or taking of seals for specific purposes e.g. scientific research or to prevent serious damage to fisheries or fish farms administered by Marine Scotland.

The islands of Muckle Green Holm and Little Green Holm are designated Site of Special Scientific Interest (SSSI) sites, contributing around 3% of UK annual pup production. The islands of Faray and Holm of Faray are also SSSI sites, are a designated Marine Special Area of Conservation (SAC) for the grey seal populations and is the second largest breeding colony in the UK, contributing around 9% on UK annual pup production. The Sanday SAC is also designated for Harbour seals however it is not anticipated that this population would be affected due to its distance from the site and the site faithfulness of the harbour seal.

Due to the number of seals observed within the test area, this PEMP has been designed to comply with the requirements of the Marine Scotland Act and to minimise disturbance to seals as far as possible.

Designated Seal Haul-out Sites in Seal Management Area subdivision 4b Orkney as set out in an order made under section 117 of the Marine (Scotland) Act 2010

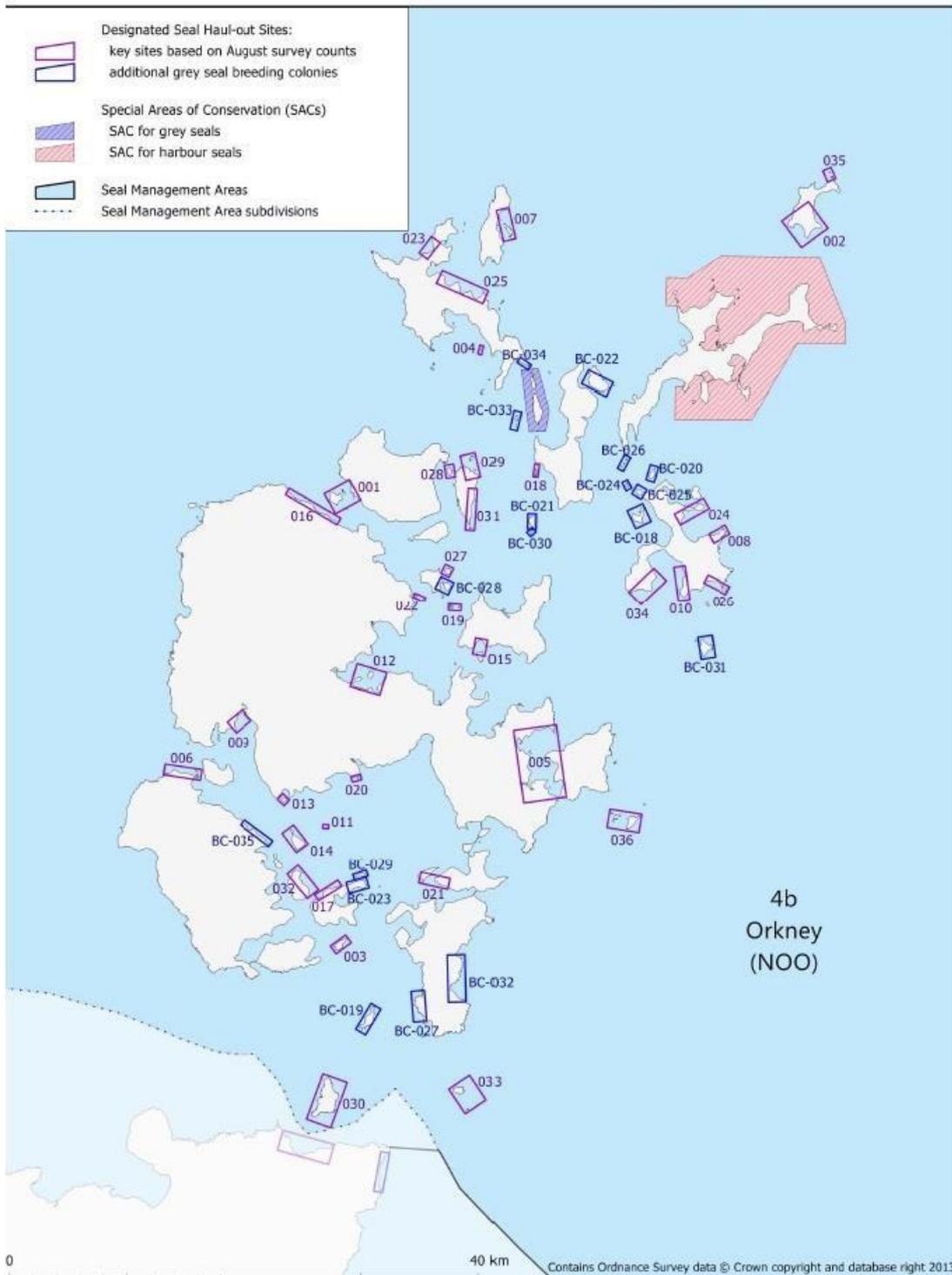


Figure 5| Designated seal haul-out sites within seal management area Orkney

3.4 Fish

A number of fish species are likely to be present within the area of the test site. Large fish species such as skates and rays are likely to transit the area as well as commercial species

such as mackerel, herring, sprats, haddock, ling, saith and cod. Other smaller species representing important food items for marine birds, including sand eels, may also be present at the site.

Fish species could be affected by the proposed testing of the devices through the following impact pathways:

- Disturbance from physical presence of the devices and associated vessels;
- Disturbance from operational noise of the devices and associated vessels;
- Disturbance from breeding/migratory routes through electromagnetic interference;
- Risk of collision with the devices rotors, mooring system or associated vessels causing injury or mortality, and;
- Pollution from accidental discharges.

Aside from anecdotal observations during benthic surveys and seabed investigations, there has been no targeted survey of fish and shellfish. However, it is possible to make reasonable assertions as to the likely species to be present, based primarily upon the habitats and physical conditions at the site. Foubister (2005) provides some further information, but a broad characterisation of the site is as below. Sources such as Coull *et al.* (1998) and Ellis *et al.* (2010) provide broad scale and generic information on spawning and nursery areas and times.

3.4.1 Diadromous fish

Salmon, trout and eels are present in Orkney waters; these species are all included in the PMF list¹. Some of these may utilise rivers on Orkney (for salmon, this is restricted to larger rivers on Orkney Mainland and the island of Hoy). There is a possibility that some diadromous fish in Orkney waters may utilise rivers on mainland Scotland, but based on current knowledge the degree of connectivity of these rivers with Orkney is expected to be low (Malcolm *et al.*, 2010).

3.4.2 Marine fish

The Fall of Warness is likely to support a wide range of marine fish species, some of which are included on the PMF list. Different species will utilise the site in different ways, not only for feeding and transit, but for some potentially for reproduction or as a nursery ground. Pelagic fish are likely to include key species such as herring and mackerel. Demersal species are likely to include various gadoids (e.g., cod, saithe), butterfish, gobies and, on sandier substrates, some flatfish and sandeels. Elasmobranches, including common skate and spurdog, may also be found. Diver observations during benthic surveys have made particular note of shoals of saithe.

3.4.2.1 Marine shellfish

Diver observations during benthic surveys have included scallops (on sandy/gravelly margins of site) and various crustaceans, including lobsters, velvet crab, brown crabs and squat lobsters. The latter two are more likely to occur on the softer sand substrates. A variety of other less conspicuous and/or ubiquitous species are also likely to occur across the site but are not expected to be unique to the locality.

3.4.2.2 Basking shark

Basking sharks are a wide-ranging species occurring from temperate waters of the European continental shelf as far north as the Arctic (Sims, 2008). They are most commonly sighted

¹ [NatureScot](#)

along the western seaboard of British and Irish waters. Recent warming of European seas has resulted in basking sharks occurring further north in recent decades, including around the coasts of Orkney (Sims 2008). Presently no robust estimates exist for the global or regional population size of basking sharks. The global population status of basking sharks is assessed as 'Vulnerable' in the 2000 IUCN Red List. Two subpopulations, the North Pacific and the North-East Atlantic are assessed as Endangered.

Basking shark records from Orkney are widely scattered with no particular concentration in any one area. They have been recorded around Orkney in most months of the year, most frequently between spring and late summer. The peak period for records is between July and September, with sightings between November and April being rare (Evans *et al.* 2003).

At the Fall of Warness test site, Wildlife Observations carried out by EMEC at the Fall of Warness site between 2005 and 2009 show basking sharks recorded between June and October, with peak sightings in July and August. The number of observations has been variable, with more than forty in 2005, to fewer than five in 2009 (Robbins 2011a). Sightings at Fall of Warness reflect the general pattern of records from around Orkney, with peak records at the site being between July and September and very few records between November and April.

3.5 Benthic Environment

3.5.1 Substrate/geogenic habitats

The Fall of Warness subtidal area consists largely of scoured and tide-swept bedrock and boulders, with areas of broken bedrock amongst sublittoral sandbanks in the shallower eastern and northern margins. Although largely bedrock and boulders in deeper areas, interstitial shell-sand is common in-between boulders from depths of 34-40m. Geogenic and sedimentary habitats support a variety of benthic species (see below), but throughout much of the site this comprises communities typical of tidally scoured areas.

3.5.2 Benthic species

Benthic species associated with bedrock and boulder areas at the Fall of Warness are typical of this substrate type in tidally scoured areas of the north of Scotland, with some areas of rock being relatively bare in flora and fauna. From surveys of the more southern and eastern test berths, it is expected they may exhibit slightly denser faunal turfs on top of bedrock, boulders and cobbles. *Laminaria spp.*, and the associated red algae *Rhodymenia palmate*, is present throughout the area although denser in shallower more sheltered areas, with other common species including various encrusting coralline algae species, sea anemones, sea stars and a variety of crustacean species. Benthic species associated with sedimentary substrates are also typical, including common polychaetes, amphipods and bivalves. Infauna is relatively sparse within the mobile sandy substrates in some margins of the site. With the exception of a possible record of some scattered maerl debris (*Lithothamnion corallioi* or *Phymatolithon calcareum*) (Scotrenewables, 2011), there have been no records of any benthic species listed as Priority Marine Features² (PMF) on either the rocky or sandy substrates at Fall of Warness.

3.5.3 Biogenic habitats

Areas of relatively dense seaweed, including *Laminaria spp.*, will provide biogenic habitat that supports a higher diversity and biomass of biota than area of bare rock or mobile sand. Biotope classification has not been completed, but this habitat may represent the PMF 'Kelp beds', or a component of the PMF 'Tide-swept algal communities'. These habitat patches

² [NatureScot](#)

appear to be increasingly patchy with distance from shore. Seaweed habitats aside, there have been no records to date of species that would form subtidal biogenic habitats at the Fall of Warness site from the EMEC surveys in 2005 (Foubister, 2005), from the developer-specific benthic monitoring programmes, or from wider resources. Furthermore, given the tidally scoured nature of the seabed at Fall of Warness, areas of seaweed habitat are likely to be sparse except in some of the relatively sheltered sublittoral margins of the site near the cable landfall.

4 Proposed mitigation, monitoring and reporting strategy

4.1 Impact Pathway: 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. The displacement can be caused by the physical presence of the structures or other disturbances caused by the installation (such as noise etc.) or during operation. There is potential for species to be displaced within the test site and/or surrounding area. There is a requirement to understand the importance of the habitat, i.e. is it important for essential activity (breeding, foraging, moulting, resting, etc.). If the habitat is deemed to be important, it is crucial to understand the availability of alternative habitat elsewhere. In addition, there is the potential to affect birds foraging success or moulting, if the test berth is located within a key foraging area or a moulting site.

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, 3-4 devices 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 current ATIR device is already on site, further disturbance/displacement is not expected.

Displacement can be a temporary issue, with behavioural patterns changing over time as birds habituate to the presence of 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 device, this may be as roosting location or to exploit new foraging opportunities that may arise if prey species are found to gather around the structure.

Due to the presence of the devices and associated moorings at test berth 4, there is the potential for displacement of cetaceans, basking shark, seals and seabirds.

The following table summarises the proposed mitigation measures and monitoring activity relating to each potential impact pathway. All methodologies for mitigation and monitoring will be agreed with the regulator and NatureScot prior to commencing work. Any key events or findings will be disseminated to the regulator and appropriate consultees. The reporting mechanism for each proposed mitigation and monitoring measure are also provided in the below table.

Impact pathway	Receptor	Proposed mitigation/monitoring measure	Reporting mechanism
All project phases			

<p>Disturbance – Presence or noise from vessel activity (including transiting to and from site)</p>	<p>Cetaceans, Basking shark</p>	<p>Mitigation: Comply with the Scottish Marine Wildlife Watching Code (SMWWC), including the following measures:</p> <ul style="list-style-type: none"> • 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 and 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. <p>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.</p>	<p>Any incidents which deviate from this measure will be reported.</p>
<p>Harassment/Disturbance – Presence of vessel activity (including transiting to and from site)</p>	<p>Harbour and grey seals</p>	<p>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.</p>	<p>Any incidents which deviate from this measure will be reported.</p>
<p>Disturbance – Presence of vessel activity (including transiting to and from site)</p>	<p>Seabirds</p>	<p>Mitigation: SMWWC will be adhered to including following particular measures:</p> <ul style="list-style-type: none"> • 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. 	<p>Any incidents which deviate from this measure will be reported.</p>

Installation			
Disturbance – Presence or noise from mooring installation works	Cetaceans	Mitigation: All operations require to be conducted in line with SMWWC.	Observer records and any specific events will be reported.
Disturbance – Presence or noise from mooring installation works	Basking shark	Mitigation: All operations require to be conducted in line with SMWWC.	Observer records and any specific events will be reported.
Harassment/Disturbance – Presence of vessel activity during installation works	Harbour and grey seals	Monitoring: During the breeding seasons of both species of seal, vessels involved in decommissioning works will ensure a 500m distance is consistently maintained from local haul-out sites located near to the test berth and along the vessel transit route.	Any incidents that deviate from this will be reported.
Operation and Maintenance			
Displacement – Barrier effect from presence of devices	Harbour and grey seals	Monitoring: Partake in site-wide monitoring of seal usage of the Fall of Warness, where possible e.g. providing operational data for seal tagging surveys; providing vessel activity data for seal haul-out study.	If funding for strategic site-wide research is obtained, findings relevant to the devices will be provided.
Displacement – Barrier effect from the presence of devices	Cetaceans, Basking shark	Continual review of relevant research to understand if any mitigation/monitoring measures are required. Mitigation: Mitigation only required if other research findings or monitoring indicates unacceptable impact.	
Decommissioning			
Disturbance – Presence of mooring decommissioning vessels	Cetaceans	Mitigation: All operations require to be conducted in line with SMWWC.	Observer records and any specific events will be reported
Disturbance – Presence of mooring decommissioning vessels	Basking shark	Mitigation: All operations require to be conducted in line with SMWWC.	Observer records and any specific events will be reported
Harassment/Disturbance – Presence from vessel activity during decommissioning work	Harbour and grey seals	Monitoring During the breeding seasons of both species of seal, vessels involved in decommissioning works will ensure a 500m distance is consistently maintained from local haul-out sites located near to the	Any incidents that deviate from this will be reported.

		test berth and along the vessel transit route.	
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Table 7| Mitigation, monitoring and reporting actions associated with the impact pathway displacement/disturbance

The Scottish Marine Wildlife Watching Code (SMWWC) was developed by NatureScot and is in line with Section 52 of the Nature Conservation (Scotland) Act 2004. Although the code has been developed to provide recommendations, advice and information relating to commercial and leisure activities involving the watching of marine wildlife, the code outlines best practice to follow when encountering marine wildlife, a likely event at the Fall of Warness site. Magallanes are committed to following the SMWWC throughout all operations onsite and to and from site, providing that the health and safety of personnel is not compromised.

4.2 Impact Pathway: 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 drilling activities during installation. 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 but there is the potential it to cause displacement, avoidance, reduction in foraging success or it may have no effect.

Tidal devices with machinery housed in surface-piercing components have the potential to affect diving birds due to the above surface noise generated.

The following table summarises the proposed mitigation measures and monitoring activity relating to each potential impact pathway relating to underwater noise. It is crucial that all methodologies for mitigation and monitoring are agreed with the regulator and NatureScot prior to commencing work. The reporting mechanism for each proposed mitigation and monitoring measure are also provided in the below table.

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	Mitigation: The Scottish Marine Wildlife Watching Code (SMWWC) will be adhered to.	Observer records and any specific events will be reported.
Harassment/Disturbance – Noise from increased vessel activity	Harbour and grey seals	Mitigation: The SMWWC will be adhered to, where possible.	Observer records and any specific events will be reported.
Installation			

Disturbance – Noise from mooring installation methods	Cetaceans	Mitigation: The SMWWC will be adhered to throughout all operations, where possible.	Observer records and any specific events will be reported.
Disturbance – Noise from mooring installation methods	Basking shark	Mitigation: The SMWWC will be adhered to throughout all operations, where possible.	Observer records and any specific events will be reported.
Disturbance – Noise from mooring installation methods	Harbour and grey seals	Mitigation: The SMWWC will be adhered to throughout all operations, where possible.	Observer records and any specific events will be reported.
Operation and Maintenance			
Disturbance – Noise from operating turbines	Cetaceans	Monitoring: Acoustic monitoring of operational noise output to establish an acoustic signature. Monitoring will be conducted utilising either fixed RTSys or DART surveying. Funding dependant.	Results and findings from surveying will be disseminated.
Disturbance – Noise from operating turbines	Harbour and grey seals	Monitoring: As outlined above, the acoustic monitoring of operational noise output to establish an acoustic signature. Monitoring will be conducted utilising either fixed RTSys or DART surveying.	Results and findings from the acoustic monitoring will be provided.
Decommissioning			
Disturbance – Noise from mooring decommissioning	Cetaceans, Basking shark	The SMWWC will be adhered to throughout all operations, where possible.	Observer records and any specific events will be reported.

Table 8| Mitigation, monitoring and reporting actions associated with the impact pathway underwater acoustic output

4.3 Impact Pathway: Collision 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 blade 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.

There has been much research on potential collisions with single devices and they are expected to be a rare event. Further research into the potential risk of scaling up to arrays could be achieved by using predictive models validated with collision risk data (Copping and Hemery, 2020).

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.

The following table summarises the proposed mitigation measures and monitoring activity relating to risk of encountering a turbine and collision risk. It will be crucial that all methodologies for mitigation and monitoring are agreed with the regulator and NatureScot prior to commencing work. The reporting mechanism for each proposed mitigation and monitoring measure are also provided in the below table.

Impact pathway	Receptor	Proposed mitigation/monitoring measure	Reporting mechanism
Operation and Maintenance			
Behavioural change, injury or death due to the interaction with turbine rotor with the potential for collision.	Diadromous fish; Gadoids	Continual review of monitoring work carried at other sites with installed tidal turbines to ensure any required mitigation and monitoring measures are effectively employed.	Report any additional new information.

	Cetacean, Basking shark or harbour and grey seal	<p>Mitigation: If interaction between a cetacean, basking shark or seal with devices occurs then procedures for emergency shutdown and liaison with regulators should take place prior to a re-start or suitable mitigation is agreed.</p> <p>Monitoring: If strategic funding is obtained, the device may be equipped with accelerometer to ensure any interaction events or near misses are detected.</p> <p>Accelerometer data will be monitored as part of the live monitoring system and may be used as the triggering mechanism.</p>	<p>Periodical data analysis will be summarised, and any finding reported.</p> <p>If any trigger events are found to be due to an interaction between cetacean/basking shark/seal and the operating turbine, the regulator will be informed immediately.</p>
Collision with turbines causing death or injury. There is uncertainty regarding avoidance rate of active turbines exhibited by birds	All diving species (sea duck, red-throated diver, great cormorant, common guillemot, razorbill, Atlantic puffin, black guillemot, northern gannet).	<p>Monitoring: If strategic funding is obtained, the device may be equipped with cameras viewing the operation turbine blades, aimed at detecting an interaction between a diving bird and operational turbine.</p>	Any interaction events recorded will be reported.

Table 9| Mitigation, monitoring and reporting actions associated with collision risk

4.4 Impact Pathway: Entanglement Risk

It is unknown whether the potential exists for cetaceans (particularly baleen whales) and basking sharks to become entangled in the mooring lines of size and dimension required to anchor the devices. It will be necessary to establish if entanglement is possible taking into account size and shape of species present within the test site area, mooring line dimensions, flexibility etc. Understanding this impact pathway further will be particularly important if an array of complex mooring lines (not under tension) is to be deployed.

There is also the potential risk of entrapment of marine mammals and basking sharks within the devices and associated moorings. There is a possibility that such species may become trapped however, after reviewing the design of the devices, this impact pathway is anticipated to be highly unlikely. Routine inspections during operation can be completed whilst undergoing remote monitoring, which are expected to signal such an event.

The following table summarises the proposed monitoring activity relating to entanglement.

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	<p>Mitigation: If interaction of basking shark with devices occurs then procedures for emergency shutdown and liaison with regulators should take place until a re-start or suitable mitigation is agreed.</p> <p>Monitoring: If strategic funding is obtained, strain gauges may be installed on the device and will be capable of alerting the operator to an entanglement event.</p>	Any entanglement events recorded will be reported to the regulator immediately. Procedures for emergency shutdown will be followed in this event.

Table 10| Mitigation, monitoring and reporting actions associated with the impact pathway entanglement risk

4.5 Impact Pathway: 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 macroorganisms such as barnacles or seaweed. Biofouling can contribute to surface corrosion and may also reduce the efficiency of moving parts. The devices will utilise appropriate anti-fouling systems, such as paints recommended for new vessels and maintenance of underwater hulls and boot-up lines for up to 90 months drydocking interval and complying with the International Convention of the Control of Harmful Antifouling Systems on Ships as adopted by IMO October 2001, to minimise the accumulation of biofouling 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. 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 assembled 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.

Magallanes are committed to furthering industry understanding on biofouling and therefore, will make significant effort to collaborate where possible in any strategic research, with partners such as EMEC, ICIT, SAMS and ERI. Any research conducted regarding biofouling, would aim to produce a species list identifying native and non-native species present.

The following table summarises the proposed mitigation measures and monitoring activity relating to each potential impact pathway. Any key events or findings will be disseminated to

the regulator and appropriate consultees. The reporting mechanism for each proposed mitigation and monitoring measure are also provided in the below table.

Impact pathway	Receptor	Proposed mitigation/monitoring measure	Reporting mechanism
All project phases			
Biofouling and the introduction of non-native species	Benthic communities	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.	Any deviance from the good practice measures will be reported.
		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.	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.
		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.	N/A
		When the device is taken to calmer waters for maintenance, biofouling inspections of any surfaces that have potential for biofouling, removal of any biofouling and assessment of the integrity of anti-fouling paint coverage.	Findings will be reported.
Decommissioning			
Habitat removal for biofouling species		A full device biofouling inspection will be conducted as the device is decommissioned.	Findings will be reported.

Table 11| Mitigation, monitoring and reporting actions associated with biofouling

Biofouling inspections will be conducted on an opportunistic schedule when the device is taken to calmer waters for maintenance. Biofouling inspections will not be conducted at the full-scale test site. The technique for conducting biofouling inspections will be agreed with NatureScot prior to conducting the survey.

4.6 Impact Pathway: Habitat creation

The physical presence of the devices will inherently result in some direct habitat loss during device operation. However, the associated seabed moorings and anchors also have the potential to function as artificial reefs or fish aggregating devices. As cetacean, seals and basking shark distribution is influenced by prey distribution and associated prey habitat, this clearly leads to the potential of changes in the distribution of cetaceans and basking sharks. It is anticipated that fish may aggregate around the devices, henceforth a potential increase in prey for marine mammals within the vicinity of a device. In addition, the installation of a device may affect oceanographic conditions within the vicinity, for example, increasing water mixing. This may lead to a localised increase of certain megafauna in the area.

The physical structure of the devices could also offer enhanced foraging efficiency for some species as it may vary the tidal flows producing eddies and areas of slack water in close proximity to the device. Small cetaceans could use these areas to shelter when ambushing prey. Furthermore, the turbines on the devices have the potential to scatter, disorientate or injure prey leading to enhanced foraging efficiency. However, it is currently unclear whether such opportunities would provide enhancements to foraging or would simply lead to the attraction of animals into situations where the risk of collision is increased.

The following table summarises the proposed monitoring activity relating to the potential for alteration in habitat.

Impact pathway	Receptor	Proposed mitigation/monitoring measure	Reporting mechanism
Operation and Maintenance			
Fish aggregation device (FAD) effects due to the introduction of new structures	Fish	As fish are likely to aggregate around the devices during slack water and periods of lower tidal flow, if research funding becomes available, a series of video cameras may be installed on the device to evidence any such occurrence. Otherwise, no mitigation or monitoring measures will be implemented.	Findings from the analysis will be reported.
	Fish predators (e.g. fish, marine mammals)	If research funding becomes available, video cameras will be installed on the hull of the devices to gain a greater understanding of fish attraction and collision risk for predators. Otherwise, no mitigation or monitoring measures will be implemented.	Findings from the analysis will be reported.

Creation of habitat around installed infrastructure for benthic species	Benthic communities	There is a likelihood of reef effects around installed infrastructure, particularly anchoring infrastructure. 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 any analysis conducted will be reported.
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Table 12| Mitigation, monitoring and reporting actions associated with alteration of habitat

4.7 Impact Pathway: Seabed clearance

There is the potential for the direct loss of sub-littoral seabed communities due to the presence of the devices and associated anchoring system on the seabed. The installation of the new structures directly on the seabed, will result in the loss of habitat due the placing of the structures.

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.

It is anticipated that very little to no seabed clearance will be necessary in the installation of the anchors of the devices. It is anticipated that due to tidal swept nature of the site, that the majority of the deployment location will be bedrock.

The following table summarises the proposed mitigation measures and monitoring activity relating to each potential impact pathway.

Impact pathway	Receptor	Proposed mitigation/monitoring measure	Reporting mechanism
Installation			
Seabed loss due to the direct footprint	Benthic communities	Pre-installation and installation seabed survey using a camera will be conducted to understand the extent of the seabed impact on the benthic ecology and seabed character caused during installation activities.	Video footage collected during the survey will be analysed and reported.
Decommissioning			
Colonisation and loss of new habitat	Benthic communities	Decommissioning seabed survey will be conducted during decommissioning.	Findings will be reported.

Table 13| Mitigation, monitoring and reporting actions associated with seabed clearance

All seabed surveys will be conducted using either an ROV, in line with EMEC's approved guidelines on ROV seabed surveys (EMEC, 2010), drop camera or dive team, if possible. During the seabed surveys the area around each anchor will be inspected.

4.7 Impact Pathway: Electromagnetic field (EMF) effects

Basking sharks may be able to detect the magnetic fields associated with subsea cables. The electricity generated by the devices and transmitted through the cables will emit electromagnetic fields (EMFs). Elasmobranchs respond to EMFs and are thought to use the Earth’s magnetic field for migration, whilst they respond behaviourally to electric fields emitted by prey species and conspecifics. The potential for damage to the electrosensory system is considered low as E fields are only detected over short distances and will be encountered as a voltage gradient in the seawater to which the elasmobranch can respond accordingly.

While some scientific experiments have shown that some animals can detect EMFs from submarine cables, there is no conclusive evidence to determine if these EMFs will cause significant negative impacts to an individual animal or population levels (SEER, 2022). There is a consensus among researchers, developers and regulators that EMFs from cables from single or a small number of devices will have relatively low EMF intensity resulting in low risk to sensitive marine animals (Copping *et al.*, 2020).

EMF effects are not expected to be significant around the EMEC subsea cable in which the devices will be connected nor the umbilical cable. Therefore, there are no mitigation or monitoring measures suggested for this unlikely impact however, if research funding is allocated, it may be possible to conduct tests.

Impact pathway	Receptor	Proposed mitigation/monitoring measure	Reporting mechanism
Operation and Maintenance			
Behavioural changes	Diadromous fish; gadoids; elasmobranchs	If research funding becomes available, Magallanes may undertake in situ measurements of strength and range E _i and B fields under different energy generation scenarios. Otherwise, no mitigation or monitoring measures will be implemented.	If such monitoring is undertaken, the methodology will be agreed with regulator and NatureScot prior to commencement of work. Findings will be reported.

Table 14| Mitigation, monitoring and reporting actions associated with EMF effects

4.8 Impact Pathway: Discharges to the marine environment

Contaminant release through spillages or contaminated sediments poses a risk to cetaceans and basking sharks that can have 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 (Ross, 2002). The likelihood of a large-scale contaminate spill associated with a tidal energy device is minimal due to strict current health and safety procedures; although the impacts of any spill have the potential to be significant.

The devices contain a variety of liquids including oils and coolants which if accidentally released could pose a risk to the natural environment. The oils and lubricants contained in the electrical system, gearbox and internal auxiliary system are expected to be contained within their system in the event of any leaks. Nevertheless, any fluid leakage which manages to escape into the main body of the device will be collected and later disposed safely onshore. All oils/lubricants used in the internal auxiliary systems are marine approved.

When onshore, all fluids will be stored in a suitable COSHH store, and all wastes will be disposed of in line with legislative requirements.

5 Research Plan

Magallanes will actively pursue opportunities to undertake and facilitate strategic environmental research around the devices and the wider test site during the project. Where possible, Magallanes will work closely with EMEC, the regulator and NatureScot to develop any research plans. EMEC may coordinate site-wide environmental monitoring with Magallanes and other developers at the Fall of Warness test site. Magallanes, when possible, are willing to supply data to support such environmental monitoring programmes. The aim of such programmes will be to advance industry understanding of the potential environmental effects of tidal energy devices.

Furthermore, Magallanes would welcome any additional research by other interested parties around the devices during its operation at EMEC. Where possible, Magallanes will engage with academia, relevant interest groups and organisations to progress the research programme and aid the identification of the potential research opportunities, during the lifespan of the array at the Fall of Warness test site.

Magallanes has previously taken an active role in projects with environmental monitoring deliverables such as Marinet-2 by providing EMEC the opportunity to monitor the acoustic output of the device. Magallanes and EMEC are excited to continue this monitoring through other projects when funding becomes available.

6 References

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