EMEC Billia Croo Test Site – Project Envelope for Devices and Operations

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Document History

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1	04/09/18	First version	SL/CL	CL, MH, MF, JS, JL, NK	NK
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5	15/03/19	Editing notes from SNH	SL	CL	CL
6	15/05/19	Addition of generating capacity and date	SL	CL	CL

Disclaimer

Contents

Glossary of Terms

ADCP	Acoustic Doppler Current Profiler
AIS	Automatic Identification System
Array	A combination of assemblages
Assemblages	The device components and individual converters necessary to have a fully functioning wave energy converter
EIA	Environmental Impact Assessment
EMEC	European Marine Energy Centre
ERP	Emergency Response Procedure
ES	Environmental Statement
GPS	Global Positioning System
HRA	Habitats Regulations Appraisal
IMS	Integrated Management System
MHWS	Mean High Water Spring
MetOcean	Meteorology and Oceanography study
MS	Marine Scotland
NRA	Navigational Risk Assessment
NtM	Notice to Mariners
OIC	Orkney Islands Council
O&M	Operations and Maintenance
ROV	Remotely Operated Vehicle
Section 36	Section 36 Consent under the Electricity Act 1989
SNH	Scottish Natural Heritage
SOP	Standard Operating Procedure
SPA	Special protection Areas
UKAS	United Kingdom Accreditation Service
WEC	Wave Energy Convertor

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1 Introduction

As part of the European Marine Energy Centre's (EMEC) vision for a globally successful marine energy industry, EMEC provides testing facilities at Billia Croo, Orkney, for developers of the marine energy industry to deploy and test in real-sea conditions. The site was established in 2003 and consists of five cabled test berths. Testing at the site typically consists of entire devices with associated moorings or foundation system, but may also include testing of device components, mooring systems, marine operations associated with installation, maintenance and/or decommissioning.

To date, EMEC has been granted all necessary licences and consents to establish the site infrastructure and deploy scientific monitoring and data collection equipment at Billia Croo. In 2002, Highlands and Islands Enterprise (HIE) commissioned a high-level environmental assessment to establish EMEC's Billia Croo test site, resulting in the production of an Environmental Statement. In 2004, a summary Environmental Description of the site was produced to inform prospective developers of the test site's environment. Each developer interested in testing at EMEC's full-scale test sites is required to obtain a Marine Licence from the Regulator, Marine Scotland. For certain activities, it may be appropriate to apply for a scientific exemption as well. To date, number of developers have been granted licences and consents to deploy devices at Billia Croo.

This document describes the various types and associated characteristics of devices and components likely to be tested at the EMEC grid-connected test site, Billia Croo. It also describes the types of marine operations and activities likely to be associated with the installation, operation, maintenance and decommission of such devices and components. This information provides a 'project envelope' description against which the potential environmental impacts of installation, operation, maintenance and decommissioning will be assessed, in an Environmental Appraisal and Navigational Risk Assessment. The project envelope is based on parameters from existing deployments at EMEC, as well as deployments emerging elsewhere in the UK and beyond.

2 Purpose

The following project envelope has been developed to support an application for the Section 36 consent under the Electricity Act 1989 to generate up to 20 MW of electricity for a period up to 2040. The information provided exclusively relates to infrastructure below the Mean High Water Spring (MHWS), including intertidal, and does not include onshore infrastructure as any such proposals require consideration under the Town and Country Planning (Scotland) Act 1997.

The established Design Envelope approach has been used, legally known as the Rochdale Envelope approach[1]. The approach is an affirmed legal principle stating that the consent for a development requiring an Environmental Impact Assessment cannot exceed the scope of the Design Envelope developed due to difficulties in determining detailed elements of the project at the time of submission. The adopted approach is to define a wide-ranging Design Envelope, comprising of worst-case scenarios to provide scope for the assessment and in turn scope for any consent.

This approach involves reviewing potential variances in designs and taking forward to the impact assessment, the design which is predicted to result in the greatest impact (realistic

[1] Refer to Case Law – Rochdale MBC Ex. Parte C Tew 1999.

worst-case scenario). If project designs subsequently change, there is confidence that design changes will not result in greater impacts than those already assessed.

The project envelope has been developed to enable a wide-range of projects likely to utilise EMEC's testing facilities, whilst taking into consideration the inevitable improvements in technology, infrastructure and installation and operation techniques to come. Due to the innovative nature of testing activities at EMEC, it is not possible to commit to a detailed project envelope at this stage; however, where possible, a likely scenario has been presented alongside the envelope that would result in the greatest environmental impact.

Whilst this approach results in a conservative impact assessment, careful consideration must be taken throughout the assessment to ensure the impacts predicted to arise are not over estimated, such that they are intangible, therefore undermining the Environmental Impact Assessment process.

3 Site Location

EMEC's grid-connected test site, Billia Croo, is ideally located on the western coast of Mainland Orkney, outside Stromness. The test site's location subjects it to the powerful forces of the North Atlantic Ocean, giving it one of the highest wave energy potentials in Europe with an average wave height of 2-3 m and extremes of up to 17 m. The site is located approximately 2 km offshore with each test berth roughly 0.5 km apart. The following figure provides an indication of the boundary of the Billia Croo test site however, this is currently being extended.

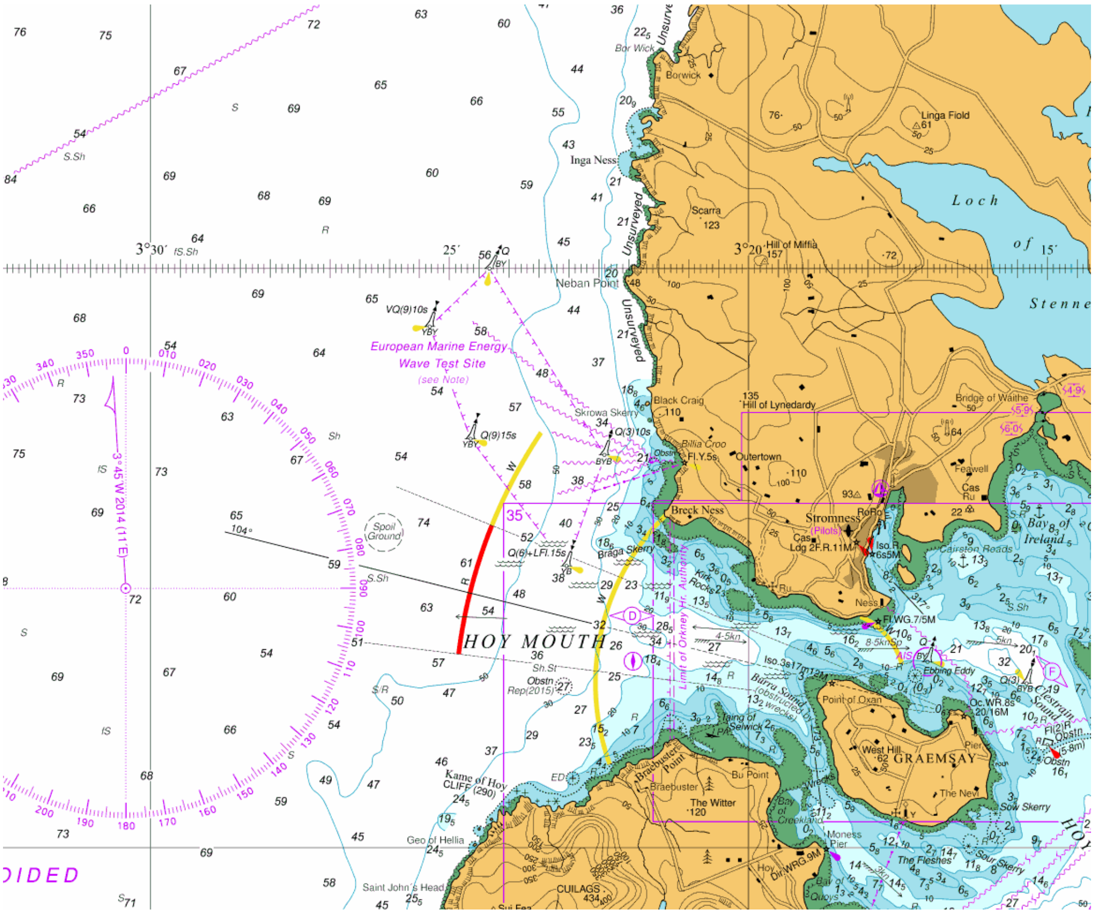


Figure 1. EMEC's Billia Croo wave test site © Crown copyright

The updated site boundaries are provided in Figure 2. The coordinates for the site's outermost points on the perimeter are provided in Table 1.

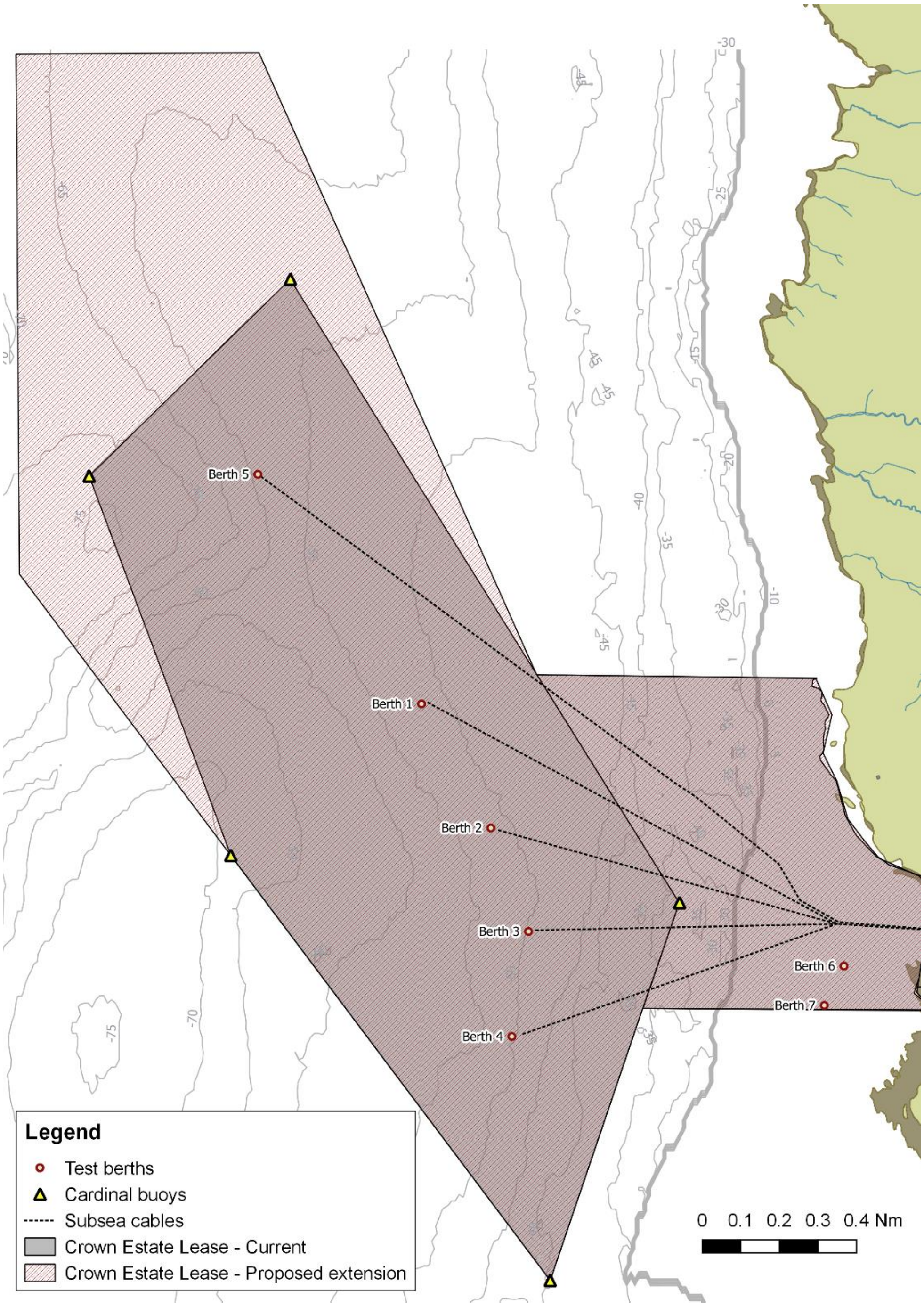


Figure 2. EMEC's Billia Croo wave test site with proposed extension area

Proposed extension boundary perimeter	WGS 84 / ETRS 89	
	Latitude	Longitude
W	58° 59.240’ N	003° 25.694’ W
NW	59° 00.587’ N	003° 25.711’ W
NE	59° 00.587’ N	003° 24.491’ W
E	58° 58.393’ N	003° 22.391’ W
S	58° 57.418’ N	003° 23.038’ W

Table 1. Billia Croo test site perimeter

4 Facilities and Site Infrastructure

The grid-connected test site at Billia Croo occupies an area of approximately 11 km^2 (maximum distance offshore is 4.5 km and length of the site is roughly 5.8 km) and consists of five individually cabled test berths offshore plus a shallower inshore area[2] which is not, at the time of writing, served by a grid-connected cable. Each test berth is located at the offshore end of subsea cable, developers typically install their device(s)/components and carry out testing-related activities within approximately a 500m radius from the cable end.

There are currently five armoured 11 kV subsea cables installed onsite which feed into the EMEC substation housing the main switchgear, backup generator and communications room. Energy generated at each test berth is transmitted via the armoured subsea cables back to a shore-based substation for onward transmission to the National Grid. The subsea cables 1-4, provided by AEI Cables, are wet-type composite cables consisting of three EPR-insulated stranded copper power cores designed for alternating current, three 2.5 mm^2 copper signal/pilot trip cables and a 12-core single-mode fibre-optic bundle. The cable is then armoured with two layers of galvanised steel wire. Cable 5, installed in 2010, is of similar specification to the other subsea cables but includes an additional 4 core 4 mm^2 auxiliary power cable. The conductors on the cables are 50 mm^2, giving a nominal rating of 2.2 MW. When the berth is not occupied by a developer, the cable is terminated using a specially designed connector provided by Systems Engineering & Assessment Ltd. This allows routine monitoring of the cables when not in use. The subsea cables connecting each test berth to the substation are laid directly onto the seabed. Cast iron cable protectors are installed from 15m depth to shore to provide additional protection within the surf zone area due to increased potential for abrasion. At the MLWS, each passes into a trench dug 12 m into the seabed and beach. In total, there is approximately 11km of subsea cable installed at the site, at the time of writing.

The inshore test berths have subsea pipeline infrastructure running from the test berth area to the onshore substation that can be used to service onshore hydro-electric generating facilities. The test berths are monitored by CCTV situated at our observations point at Black Craig, to the north of the site. Black Craig houses powerful cameras controlled remotely from our data centre and office facilities, for monitoring the activity out at sea.

There are two waverider buoys located on site, which measure the wave height, period and direction. Waverider buoys have been deployed at the site, almost continuously, since November 2002. The location of the buoys within the site may vary depending on our client’s requirements. There is also an onshore, purpose-built weather station which provides real-time met data for the site. This data is fed into a SCADA (Supervisory, Control and Data Acquisition) system, which provides live data feeds on the marine and met conditions.

[2] Currently accommodation test berths 6 and 7.

EMEC's existing Embedded Generation Connection Agreement currently limits the total export capacity of the grid connection at the Billia Croo test site to 7MW. Under a site-wide generation scenario of >7MW, the environmental assessment and associated consent will still apply provided that the application details are within the bounds of the project envelope within this document.

5 Device and Operations Envelope

The Billia Croo test site was developed as a wave energy test site, and this remains the principle form of testing activity at the site. However, due to similarities in required infrastructure across the offshore renewable energy industry, the test site may be offered for testing components and mooring/foundation systems for other forms of renewable energy, e.g. foundations for offshore wind. The test berths have been designed to accommodate both single devices or small arrays as well as components or mooring structures and scientific instrumentation. The inshore area of the site can also offer the option for device(s) or component testing and mooring testing in shallower waters.

This project envelope will be used to assess the potential positive and negative environmental and navigational impacts of devices and operations at EMEC's Billia Croo test site (for purposes of EIA, HRA, etc.). The following sections describe testing and deployment activities and device parameters to be included within the envelope.

5.1 Potential Activities and Deployments

The following activities and deployments are further explained and included within the project envelope, and must be taken into consideration during any future assessments of the site:

- Testing activities associated with single devices and arrays deployments, including installation, maintenance and decommissioning works.
- Installation, maintenance, and testing of subsea cables.
- Testing of device components.
- Buoys and scientific instrument/equipment deployments and surveys.
- Marine works including site preparation and simultaneous operations.

The followings activities are **not** covered by this project envelope and would require further consultation and assessment/appraisal:

- Deployment and operational activities outside the parameters defined in this document.
- Percussive drilling and pile driving.
- Device and foundation installations in the intertidal area (between MLWS and MHWS).
- Seabed clearance such as kelp clearance and rock grinding/blasting.
- Beach excavation.

The use of active acoustics and above water turbines[3] will require further assessment on a case by case basis.

Any deployment and operational activities outside the parameters defined in this document may require additional assessment to understand the potential positive and negative environmental and navigational impacts directly associated with the activity. This will be determined by the Regulator and EMEC.

[3] Typically associated with oscillating water column devices.

5.2 Device Characterisation

Considering EMEC operates as a test centre with multiple clients and device types, this project envelope is both technology and manufacturer neutral. Due to the wide design divergence within the wave energy sector and the rapid technology advancement, it is not possible to define specific devices that will be included within the project envelope. Instead, EMEC has considered the varying device types within the sector, to select parameters across device types that should allow the necessary assessments to be completed.

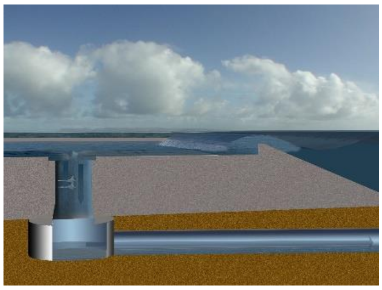
Device type can generally be categorised with respect to their interaction with the waves to capture energy. The method of energy capture generally determines the way the device needs to interact with the sea surface, the water column, and the seabed, and strongly influences the structural design of devices. Categories of wave energy converters (WECs) can therefore be defined and described according to both the type of device, and the way they are moored or attached to the seabed.

The potential for environmental impact of a WEC will be partially dependent on the manner of interaction with the seabed, and the areas of the water column in which the device and its moorings are physically located, collectively, the ‘physical presence’ of the device when deployed and in operation.

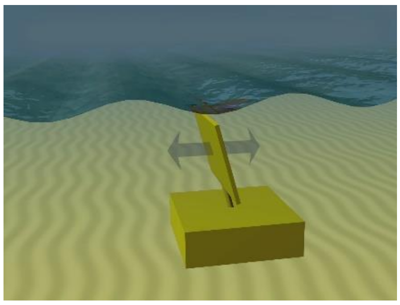
5.2.1 Device Type

The following characterisation of general categories of WECs is used. Device type will influence the overall physical structure, the method by which it is fixed or moored to the seabed, and its physical presence within the water column.

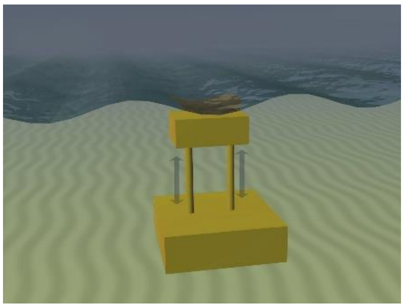
Over-topping Device | As waves break over the device, water is captured (sometimes utilising ‘collectors’) into a storage reservoir where the water is then returned to the sea via conventional low-head turbines, thus generating power. Over-topping devices tend to be moored offshore using gravity anchors or pins.



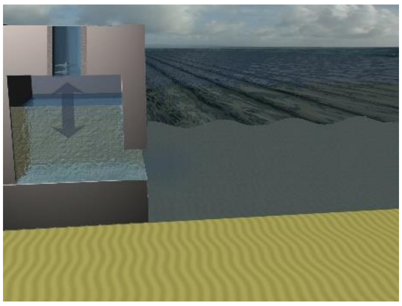
Oscillating Wave Surge Converter | Energy is extracted from wave surges via an oscillating arm which moves as a pendulum mounted on a pivoted joint. This type of device tends to be mounted on the seabed either through a gravity-based system or piles.



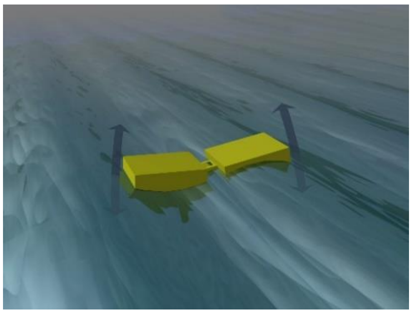
Submerged Pressure Differential | Wave motion results in the sea level rising and falling above the device, inducing a pressure differential in the device which causes fluid to be pumped around the system. Devices tend to be in 20-40m water depth and are typically attached to the seabed using mooring lines/rods to a seabed mounted plate.



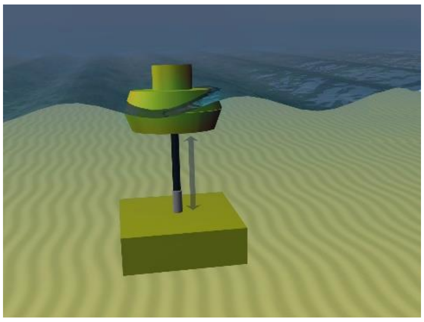
Oscillating water column | Incoming waves cause the water column within a partially submerged hollow structure to rise and fall which in turn compresses and decompresses an enclosed column of air (located above the water column) which can flow through a turbine thus generating electricity. This device type can be located on the shoreline or inshore and tends to be a gravity-based structure that stretches the entire height of the water column.



Attenuator | This floating device type tends to operate parallel to the wave direction and can capture the energy from the relative motion of two sections of the device as the wave passes. The devices are generally tethered to the seabed via mooring lines to gravity-based anchors, pins or embedment anchors.



Point Absorber | The motion of a floating structure as it absorbs energy from all directions, relative to the device's base, can produce electricity through a variety of power take-off mechanisms. The structure(s) tend to have a seabed mounted base with a buoyant top structure connected via mooring chains, lines or rods. Some instances of this type of device comprise several modules within the overall single device[4].



[4] Installations of this nature are included in this pre-appraised project envelope

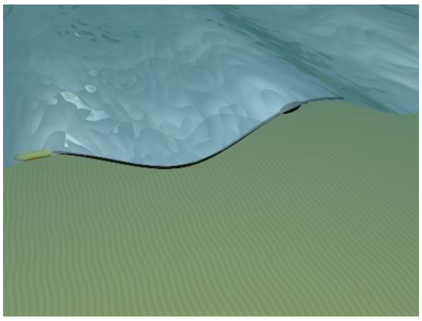
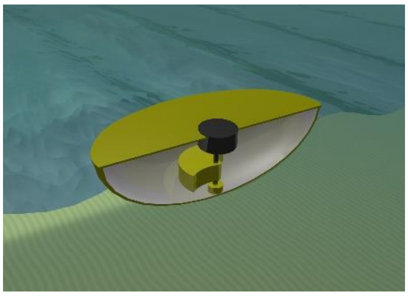
Bulge Wave | Wave passing through a flexible tube induce pressure variations which create a 'bulge' in the tube. Energy is captured as the 'bulge' travels along the length of the tube which drives a standard low-head turbine located at the bow of the tube. The technology generally comprises a rubber tube moored to the seabed via mooring lines and attached via gravity-based anchors, pins or embedment anchors.	
Rotating Mass | Energy is captured through the swaying and heaving of the device in the waves, which motion drives either an eccentric weight or a gyroscope to produce rotational movement that in turn can be attached to an electric generator. This type of device tends to comprise a floating generating unit attached to the seabed via mooring lines and either pins, embedment anchors or gravity-based anchors.	

Table 2. Device type characterisations

5.2.2 Device Structure

Within each broad category of the device types described in 5.2.1, the method of power take-off may be similar, but the detailed designs can vary significantly with respect to their mooring arrangement and the position they occupy within the water column.

For the purposes of the project envelope it is important to capture generalities about the structure of devices, regarding the manner in which they are attached to the seabed, and to describe the position of the deployment within the water column. In this respect the following types of categorisations are included in the project envelope:

- Floating surface structure.
- Subsurface floating (neutrally buoyant) structure.
- Seabed mounted subsurface structure.
- Seabed mounted structure with surface-piercing elements.

The key device parameters permitted within the Project Envelope are outlined in Table 3. Further explanation of device mooring systems and their installation is described in Section 5.3.

Device Parameter	Project Envelope Maxima
Total materials and weight used in device and substructure, excluding moorings/foundation	Total weight of material used per device: Concrete/densecrete – 2000 tonnes Steel/carbon steel – 2000 tonnes Plastic/synthetic – 100 tonnes

Distance above sea surface for surface-piercing elements	Maximum distance protruding from sea surface should not exceed 12 metres (at MLWS), excluding navigational and communication equipment[5].
Length of floating structures*	Maximum length of 200 metres for surface piercing elements of floating devices[6,7].
Width of floating structures*	For a maximum length of 200 meters, a maximum width of 12 meters is allowed. For devices under 50 meters length, a width of 30 meters is allowed.

Table 3. Key device envelope maxima for the EMEC Billia Croo test site

* Floating structures includes floating platforms, detailed in Section 5.2.3.

5.2.3 Device lighting and marking

All devices, equipment and infrastructure deployed at the test site will be marked and lit in accordance with marine safety standards and as specified by the Northern Lighthouse Board and Maritime and Coastguard Agency. It is anticipated that all infrastructure protruding above the water surface will be predominantly yellow in colour and, where required, be fitted with flashing lights of a similar brightness (4 nautical miles) to those required on the site's cardinal buoys.

5.2.4 Testing of device components

As part of testing activities, developers may test individual stand-alone components of the devices rather than the entire concept. Undertaking a phased approach when testing can offer significant cost savings and prove invaluable to developer's technology development. If a developer conducts tests on a single component, all testing activities will be treated in the same manner as an entire device and will therefore be subject to the same assessment and conditions.

To support component and equipment testing or small-scale device testing, it may be necessary to temporarily deploy floating platforms within the site. A maximum of two floating platforms[8] will be deployed at any one time on the site and the deployment location will be determined with due consideration to navigational hazards. The platform would be moored using a temporary gravity-based solution such as clump weights and is therefore not expected to have significant seabed footprint. Further details regarding such a floating platform would be provided in a separate marine licence application, if determined necessary.

[5] In the case of a proposal for a device that extends above the water surface greater than 12 metres, it may be necessary to conduct additional assessment in terms of seascape, landscape and visual impact and navigational impact.

[6] In cases where devices have floating components of greater than 20 metres long the height in which such components can extend above the sea surface is limited to 8 metres.

[7] Please note, a proposed project with a device length of greater than 200m, or a height greater than 12m from the sea surface, may require additional assessment, particularly SLVIA.

[8] Excluding floating devices and device components.

5.2.5 Array configuration

The test site may be expanded to have a maximum of ten test berths[9], accommodating 15 developers at any one time. From the current envelope of existing device types, EMEC anticipates no more than 20 wave energy converter assemblages on the site at any one time. Some wave energy converters require numerous converter components to function; therefore, an assemblage is considered the device components and individual converters necessary to have a fully functioning wave energy converter. This allows the testing of small arrays and non-grid connected devices. It is anticipated that arrays will be allocated on a maximum of five test berths, but it is not possible to determine which test berths are most appropriate for arrays without taking into consideration the size or type of device to be tested.

There is a limited literature available on wave energy array configurations and there is a degree of uncertainty that exists in array design. In general, it is anticipated that device spacing, and positioning will be predominantly dependent on resource availability and inter-array effects. However, array developers will also require considering specific seabed conditions and localised hydrodynamic effects on the site.

The minimum spacing between devices has been notionally set at 50m within a radius of the centre point of the device. This is to allow for vessel access in an emergency. However, it will be essential to consider device design and appropriate array spacing when applying for a project-specific marine licence.

5.2.6 Testing of electrical hubs

Due to the presence of device arrays onsite, it may be necessary to install, test, operate and decommission electrical hubs. Electrical hubs may offer an economically-viable option of arrays and can act as an off-grid solution, making them a common route for commercial-scale developments. Electrical hubs collect (and may transform) the power from wave devices and can be a central component of arrays. Electrical hubs are commonly used for offshore wind turbine arrays, but the design for wave device arrays has yet to converge. The following table provides an overview of the dimensions and materials anticipated for electrical hubs. Electrical hubs may be seabed mounted or floating. Seabed mounted hubs may be installed on gravity-based foundations or pinned piled foundation. There is a possibility that electrical hub may have surface piercing elements. Please refer to Section 5.3 for further information on mooring and foundations permitted within the Project Envelope.

A maximum of ten electrical hubs may be installed on the site at any one time. Please note, electrical hubs may be installed at the site for testing purposes and may not be connected to a device.

Electrical Hub Parameter	Project Envelope Maxima
Total materials and weight used in electrical hub	Total weight of material used per hub: Concrete/densecrete – 500 tonnes Steel/carbon steel – 1000 tonnes Plastic/synthetic – 100 tonnes
Total direct seabed coverage†	Maximum total area of 400m^2 per hub

[9] The 10 test berths will all be located within the test site and include the current 7 test berths that are already present on the site. The three additional test berths may be grid-connected via a subsea cable.

Electrical Hub Parameter	Project Envelope Maxima
Distance above sea surface for surface-piercing electrical hub	Maximum distance from sea surface should not exceed 12m, excluding navigational and communication equipment[10].

Table 4. Key electrical hub envelope maxima for the EMEC Billia Croo test site

†The area of seabed with which the electrical hub, mooring/foundation mechanism, and associated umbilical cables have direct contact.

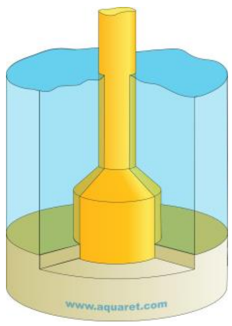
5.3 Mooring / Foundation Infrastructure Characterisation

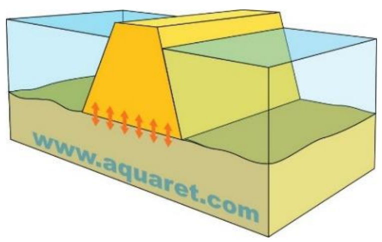
The installation, operation and decommissioning of mooring systems and foundations for offshore renewable energy devices is included within testing activities at the site. Methods typically employed by developers at EMEC include gravity-based anchors with mooring line(s) attached, embedment anchor(s) with mooring line(s) attached, and a foundation structure pinned to the seabed. Foundation/mooring methods included in the project envelope comprise:

- Foundation structure fixed into the seabed via piles/pins (non-percussive drilling only).
- Foundation structure held on to the seabed by gravity.
- Gravity-based anchor(s) with mooring line(s) attached.
- Rock anchor(s) with mooring line(s) attached.
- Suction anchor(s) with mooring lines attached.
- Embedment anchor(s) with mooring line(s) attached.
- Pin(s) (e.g. rock bolts) with mooring line(s) attached.
- Other mooring structure pinned (non-percussive drilling only[11]), or held on, to the seabed by gravity.

There are various methodologies for securing the WEC in position, including a gravity base, piled, pin-piled fixed structure or a moored floating device. The structure may be surface or non-surface piercing, both for operation and maintenance. Schematic examples of such methodologies are shown.

Gravity Base | Surface laying barrier, gravity-based anchorage. Surface area range: 750m^2 per device.

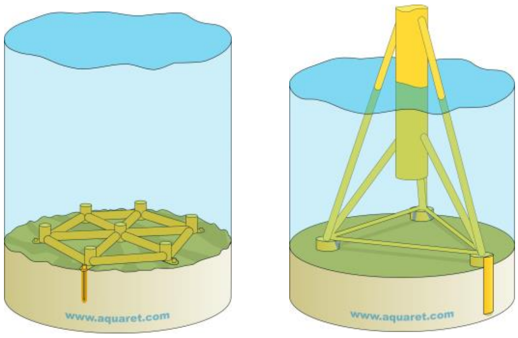




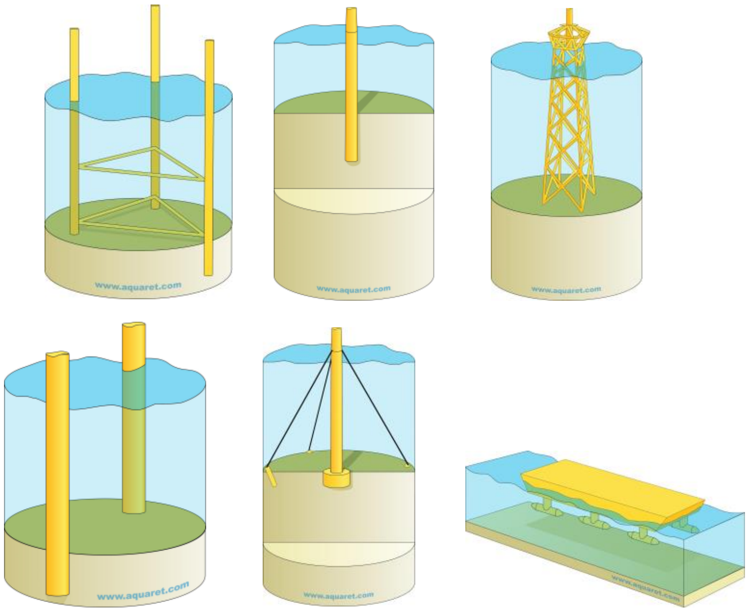
[10] In the case of a proposal for an electrical hub that extends above the water surface greater than 12 metres, it may be necessary to conduct additional assessment in terms of seascape, landscape and visual impact and navigational impact.

[11] Additional assessment would be required if pile driving is the proposed installation method.

Pins/Anchor | Structural base secured to the seafloor by rock pins or rock anchors. Range of number of pins/anchors: 8 pins per device. The envelope restricts pin insertion to non-percussive methods.



Piled | Piles or towers drilled into seabed. Possibility of monopile, twin piles or more with additional links for enhanced stability. There is also the option for a guyed tower. Maximum number of 4 piles per device with a maximum diameter of 4 metre for each pile. The envelope restricts pile insertion to non-percussive methods.



Moorings | Possibility of tension-legged, taut-legged, catenary or single-point mooring. Anchors can range from pile, pin, gravity-based suction bucket, and embedment. Typically, devices will be expected to utilise at least a 4-point mooring system.

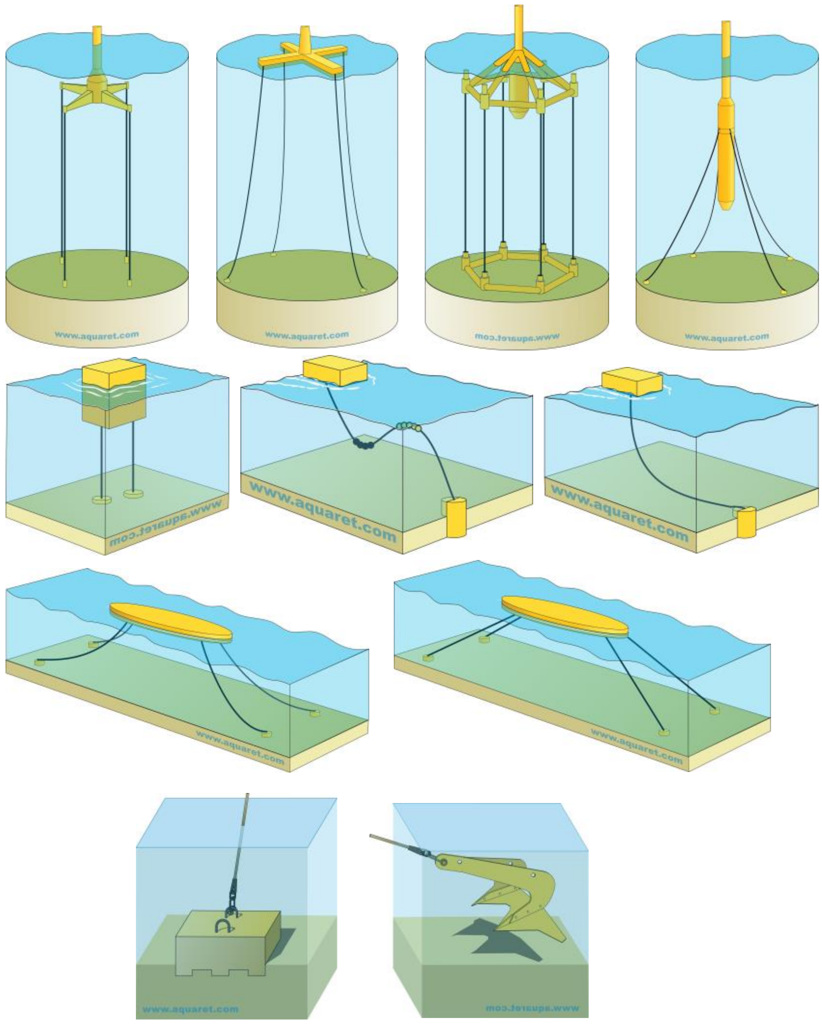


Table 5. Mooring / foundation characterisation

EMEC does not generally provide mooring or foundation infrastructure at the Billia Croo test site for developer use. Typically, devices deployed at the site are installed utilising developers' own custom-made foundations/moorings. However, infrastructure acquired by developers (e.g. anchorage) may be reused by incoming developers at the site. This reuse may take a similar form to the previous use or the infrastructure may take on a new use (e.g. research platform). In addition, EMEC may acquire developers' infrastructure for either research and development purposes or to support a prospective client.

A maximum of three mooring systems or foundations, that are not directly linked to devices, can be installed at the site at any one time. It is anticipated that such testing will include multiple deployment and recovery scenarios as well as fatigue testing.

The fixing of piles and/or pins into the seabed at this site involves the drilling of holes, followed by insertion of the pile/pin with grouting to secure its position. As such, the project envelope restricts pile/pin insertion to non-percussive methods.

As the seabed attachment mechanism for devices can be easily categorised into moorings and foundations, a summary of the default mooring and foundation maxima and other key envelope parameters are provided in Table 6 and Table 7 below.

Mooring Parameter	Project Envelope Maxima
Total weight of mooring mechanism	Maximum of 4000 tonnes per device
Total materials and weight used in mooring weights/anchors/pins	Total weight of material used per device: Concrete/densecrete – 4000 tonnes Steel/carbon steel – 4000 tonnes Plastic/synthetic – 100 tonnes
Total footprint*	Maximum total area of 0.1km^2 per array
Total direct seabed coverage†	Maximum total area of 3000m^2 per device

Table 6. Key mooring envelope maxima for the EMEC Billia Croo test site

*Device footprint equates to the area of seabed directly below the device or mooring spread. This excludes any developer-owned electrical cable or pipeline.
†The area of seabed with which the mooring mechanism has direct contact. This excludes any developer-owned electrical cable or pipeline.

Foundation Parameter	Project Envelope Maxima
Total weight of seabed attachment mechanism excluding foundation substructure	Maximum of 4000 tonnes per device
Total materials and weight used in foundation structure	Total weight of material used per device: Concrete/ densecrete - 4000 tonnes Steel/carbon steel - 4000 tonnes
Total direct seabed coverage*	Maximum total area of 750m^2 per device

Table 7. Key foundation envelope maxima for the EMEC Billia Croo test site

*The area of seabed with which the foundation structure has direct contact. This excludes any developer-owned electrical cable or pipeline.

5.3.1 Size of devices and materials used

Full details of each WEC, including its design, structure, materials and weights, and any device-specific mooring arrangement and foundation materials will be specified by the developer in the project-specific supporting documentation that will be submitted to Marine Scotland as part of the marine licence application.

5.4 Marine Works

The term ‘Marine Works’ is used in this document to describe any operational activities across all phases of a project (i.e. pre-installation, installation, testing, maintenance and decommissioning). All deployment/retrieval methods will be in accordance with EMEC's

Standard Operating Procedures (SOPs) and subject to EMEC's Emergency Response Procedure (ERP). 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 under EMEC's Control of Work procedure. Notice to Mariners describing appropriate works will be issued in a timely manner as part of this process.

5.4.1 Range of marine works

Typical operational activities associated with the deployment and testing of WECS and associated components and activities at the Billia Croo test site, together with their typical duration, are detailed in Table 8 below.

Activity	Likely Vessels	Typical Frequency/ Duration*
Pre-installation† • ROV/diver surveys • ADCP and Waverider deployment/retrieval • Bathymetry surveys • Sub-bottom profiling • Acoustic surveys	Workboat, survey vessel, dive support vessel	≤ 1 week
Installation • Drilling and grouting • Lowering foundation/ anchors/ device • Cable works and connection to device	Tug, workboat, multicat workboat, dive support vessel, crane barge, DP vessel	≤ 1 month
Testing of device, gravity foundations, anchors or scientific equipment • ADCP and Waverider deployments/retrieval • Acoustic surveys	N/A	This will be specified in a schedule submitted by each developer as supporting documentation to Marine Scotland in support of seeking approval to install.
Inspection and maintenance of devices • ROV inspection • Diver activities • Repairs below/above surface on site • Biofouling removal	Tug, workboat, multicat workboat, dive support vessel	This will be specified in a schedule submitted by each developer as supporting documentation to Marine Scotland in support of seeking approval to install. Likely to be visits at regular intervals.

Activity	Likely Vessels	Typical Frequency/ Duration*
Temporary retrieval and redeployment of device, components, gravity foundations, anchors or scientific equipment.	Tug, workboat, multicat workboat, dive support vessel, crane barge, DP vessel	≤ 1 month
Decommissioning • ROV inspection • Diver activities • Grappling operation • Drilling and cutting • Lifting foundation/ anchors/ device • Cable works and disconnection to device • Forensic/failure analysis	Tug, workboat, multicat workboat, dive support vessel, crane barge, DP vessel	≤ 1 month
Inspection, maintenance and replacement of cables and protection. • ROV inspection • Diver activities • Cable lifting/laying[12] • Placement of mattressing/ rock armouring	Tug, workboat, multicat workboat, dive support vessel, specialist cable-laying vessel	≤ 1 week

Table 8. Typical operational activities undertaken at the Billia Croo test site

*All schedules will be subject to suitable environmental conditions, and thus adverse weather may affect operations at the test site. This may result in works having to be rescheduled and, as a consequence, potentially falling within environmentally sensitive periods.
† Geophysical and geotechnical surveys are outwith the scope of the project envelope – Notification for Site Survey will be submitted to Marine Scotland for case-by-case consideration.

Table 9 below details some typical vessels which may frequently feature at the Billia Croo test site. These vessel specifications are not given as maximum envelope figures but are typical specifications (for information only) for vessels used to support activities listed in Table 8. Other vessels not listed below may be used at the site (specific vessels will be detailed in individual developer's project descriptions). EMEC requires all vessels which engage in works at its test sites to use Automatic Identification System (AIS) to aid location and tracking. EMEC holds a register of all vessels permitted to work on the site. In order for a vessel to be included

[12] This envelope does not include any onshore works required during cable installation.

on the register EMEC must hold a copy of the vessel's insurance and vessel's examination/registration certificate.

Vessel Type	Example Vessel	Length (m)	Max. Draft (m)	Gross Tonnage (t)
Tug	MV Green Chief	23.98	4.8	-
Workboat	MV Flamborough Light	17	2.2	21
Workboat (Cat 2)	MV Uskmoor	16	1.7	-
Workboat (Cat 2) with dive support capability	MV Sunrise	21	3	-
Dive support boat	MV Karin	24	3	-
Survey vessel (ROV compatible)	MV Lodesman	22	-	-
Multicat workboat (Class 1)	MV Voe Viking C-Odyssey Orcadia	26 26 24	2.3 2.5 2	350 350 370
Gantry barge	GM700	55	-	-
Crane barge	MV BD6074 (Smit)	42	2.5	750
DP Class II Anchor Handler Tug	MV Olympic Zeus	94	7.5	6839
Specialist cable-laying vessel	CS Sovereign	130	7.0	11242

Table 9. Typical vessels employed in activity at the Billia Croo test site

The type of vessel used can often be driven by availability rather than function (e.g. workboat used as a dive support boat). Many of the activities listed in Table 8 above may require the presence of more than one vessel type on-site at the same time.

5.4.2 Site preparation

Prior to device installation, it may be necessary to conduct site preparation works to ensure the seabed conditions are appropriate for the mooring system or foundation to be installed. This activity may include seaweed clearance[13] or rock grinding/blasting. Foundation and

[13] Particularly kelp clearance in the inshore areas of the site.

pipeline installation may require drilling and/or directional drilling. Further details of such work would be specified in the appropriate marine licence application[14].

5.4.3 Installation, maintenance and testing of subsea cables

There is the potential that during the operational lifetime of the Billia Croo test site, that it will be necessary to install new subsea cables and/or pipelines and the associated protection systems (such as mattresses, armour, ducting). The number of subsea cables at the site will not exceed the number of test berths, which will be capped at ten. As a single test berth has the capacity to accommodate an array of devices, it is likely that inter-array cabling will require to be installed onsite.

EMEC is committed to maintaining the site and therefore conducts regular repair and maintenance work on the subsea cables and pipeline, as necessary. In some instances, significant repair may be required resulting in recovery and replacement work on the existing subsea cables and pipelines. This work may extend from the test berth end to shore.

As part of the monitoring of the subsea cables, it is sometime necessary to conduct tests on the cable ends or replace cable ends. This is constituted as a *De minimis* activity and within the normal operation of the test site.

5.4.4 Simultaneous Marine Works

Developer access to EMEC test sites to undertake works of any kind is strictly controlled by EMEC under a Permit to Access the site system. Under this system, EMEC ensures that all work is carried out in a safe environment with minimal risk to health and safety and marine navigation. In addition to this, EMEC has Standard Operating Procedures (SOPs) in place to ensure that simultaneous activities and operations carried out at EMEC sites are conducted using safe management and communication processes which, so far as reasonably practicable, are safe and without risk to health, safety or the environment (EMEC SOP093 & SOP095).

For the purposes of the environmental appraisal, the worse-case scenario for simultaneous marine works at the test site would be for noisy activity (e.g. drilling for pile installation or pile cutting during decommissioning) to be taking place at two berths over the same period. Such a scenario however would be highly unlikely due to practical operational constraints (vessel/crew availability) and would not be permitted by EMEC on the grounds of navigational safety. A more realistic maximum scenario to consider would be noisy activity taking place at a maximum of two berths at the same time, with inspection/maintenance activities happening at a maximum of two other berths simultaneously (although in practice even this scenario would be unlikely due to the constraints mentioned above).

Table 10 below describes the maximum simultaneous marine works likely to occur at the test site based upon consideration of a worse-case scenario as described above and experience to date. Further assessment may be required if a proposal would result in worse-case simultaneous marine works in excess of this envelope.

[14] Please note, additional assessment to consider the environmental impacts associated with site preparation work may be required to support a licence application.

Activity	Marine Works	Likely Types of Associated Vessels
Pre-installation	Seabed survey ADCP deployment/recovery	Survey vessel Dive support boat Workboat
Installation	Drilling Lowering gravity anchors or mooring system Lowering device	DP vessel Multicat workboat Dive support boat
O&M	Device/infrastructure inspection Device removal Device redeployment	Survey vessel Dive support boat Multicat workboat
Decommissioning	Cutting Lifting gravity anchors or mooring system Lifting device	DP vessel Multicat workboat Dive support boat
Other	Subsea cable installation/maintenance ADCP deployment/recovery Scientific survey Acoustic survey	DP vessel Multicat workboat Dive support boat Workboat Survey vessel
Maximum number of vessels operating simultaneously at the site:		**12***

Table 10. Worse-case maximum simultaneous marine works based on experience to date

* Note, a maximum of 12 vessels will be permitted to operate at the site at any one time. This will be maintained through EMEC's Control of Work procedure.

Marine works at the Billia Croo test site typically involve periods of inactivity due to weather/wave conditions, during which vessels may move away from the berth/site. Therefore, in the scenario described above, all vessels would not necessarily be working concurrently all of the time.

5.5 Scientific Instruments and Surveys

Developers planning to deploy devices at the EMEC test sites need to have a good understanding of the resource into which deployment will be made, so data gathering using, e.g., wave measurement buoys and acoustic doppler current profilers is essential for device design and planning of operations. In addition to developers' need for resource data, EMEC operates as a UKAS-accredited performance assessment facility for the testing of wave and tidal energy conversion devices, which requires real-time resource assessment of the MetOcean conditions at its test sites. Furthermore, there is an increasing requirement for studies involving acoustic measurement, benthic investigations (e.g. ROV survey, grab samples, etc.) and geological investigation (e.g. core sampling) at the test sites.

It is envisaged that the following categories of scientific instruments/procedures will need to be deployed at the Billia Croo test site from time to time and will be included within the project envelope for the purposes of the environmental appraisal:

- Wave Measurement Buoys - e.g. Waverider buoys, Triaxys buoys (combined wave and current measurement).
- Acoustic Doppler Current Profilers - various types may be deployed.
- Acoustic measurement devices (passive recorders) - may be seabed mounted, mid-water moored buoys, device-mounted or drifting hydrophones and associated equipment.
- Active acoustic devices[15,16] (speaker, sonar or echosounder) - may be seabed mounted, mid-water moored buoys, device-mounted or installed on device and associated equipment.
- Acoustic communication devices[15] – may be seabed mounted, mid-water moored buoys, device-mounted or installed on device and associated equipment.
- Marine robotics, including but not limited to, ROVs, AUVs, and drop camera surveys.
- Installation, operation, testing and decommissioning of marine datacentres housed in appropriate container.
- Testing of anti-fouling systems, biofouling and corrosion tests – this may be on static frames mounted on devices or on specific frames deployed for such tests.
- Underwater cameras including baited cameras – this may be static, towed or device-mounted.
- CTD measurement instruments (to measure conductivity, temperature and water depth).
- Integrated monitoring pod which houses an array of the above instrumentation, including associated cabling or battery, to allow deployment across the test site.

The instruments described above may be deployed as single devices or in combination as part of a scientific monitoring package (e.g. ADCP, acoustic recorder, underwater camera and active sonar). Deployed instrumentation may require data-transfer to shore, which may be via wireless/acoustic communication (e.g. Waverider buoys) or cabled to shore (e.g. a seabed-mounted monitoring pod, long-term deployment of hydrophones, long-term ADCP deployment, etc.).

All equipment will be appropriately marked and lit where required. Instrumentation may be housed in or attached to a suitable foundation structure. Instrumentation will be anchored with gravity bases or clump weights as appropriate, but not drilled into the sea floor.

For any scientific instrument deployments which may have the potential to cause an obstruction or danger to navigation, EMEC will consult with the Northern Lighthouse Board, Maritime and Coastguard Agency and Orkney Islands Council Marine Services and comply with any advice on marking and lighting requirements.

5.5.1 Surveys

To gain a greater understanding of the environmental conditions at the test site or for infrastructure monitoring purposes, it may be necessary to undertake geotechnical or geophysical surveys of the site (these are considered and, where necessary, licensed through

[15] The operating frequency of such devices will be agreed with Marine Scotland and Scottish Natural Heritage prior to use.

[16] Note that instrumentation with active acoustic properties (e.g. sonar) will require consideration on a case-by-case basis to determine the need for a licence to disturb European Protected Species. Where such acoustic devices are part of pre-installation surveys (e.g. geophysical surveys), Marine Scotland will be consulted via the Notification of Site Survey process.

the Notification of Site Survey procedures). A Notification of Site Survey will be submitted to Marine Scotland for case-by-case consideration[17]. Such surveys will be closely coordinated with relevant personnel at EMEC, to ensure any obstructions are considered during survey planning.

Other surveys such as species sampling, benthic sampling etc. may be organised to characterise the site and monitor potential environmental impacts.

[17] Note, a European Protected Species licence may be required to conduct the survey, as advised by the Regulator.

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