Mocean Energy Orkney M100P Test 2022

Project Briefing Note

Final

Report to Mocean Energy

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Members of:

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1 INTRODUCTION

1.1 PROJECT BACKGROUND

Mocean Energy, based in Edinburgh, is developing wave energy converters (WECs) for various applications from small-scale off-grid use to large, utility-scale projects. Its core technology is its hinged raft WEC, which consists of two hulls with novel shapes connected by a single hinge. Wave forcing, and the hulls' dynamics cause a rotation about the hinge, which is converted to electricity via a power take-off system.

Mocean Energy is undertaking a project funded by Wave Energy Scotland (WES) through its Novel WEC Programme to build and test at sea a 1/2-scale prototype of its M100 (i.e. 100 kW) WEC. The 1/2-scale prototype, which is to be tested is referred to as the M100P.

Testing is planned to be undertaken in an area to the East and offshore of Deerness, Orkney in 2022. The primary purpose of testing is to gather performance data and learnings from deployment of the device in order to inform further development of Mocean's Wave Energy Converter designs.

1.2 COMPANY BACKGROUND

Mocean Energy (www.mocean.energy), based in Edinburgh, is developing wave energy converters (WECs) for various applications from small-scale off-grid use to large, utility-scale projects. Its core technology is its hinged raft WEC, which consists of two hulls with novel shapes connected by a single hinge. Wave forcing, and the hulls' dynamics cause a rotation about the hinge, which is converted to electricity via a power take-off system.

Mocean Energy have built an expert team combining scientific principles and real-world experience to develop new technologies which can harness the power of waves – and accelerate the transition to a zero-carbon world.

Mocean's approach utilises numerical modelling and optimisation, rapid prototyping and tank testing – allied to hard-won ocean experience – to deliver wave energy machines that produce high levels of power for their size and work in some of the world's harshest environments.

1.3 TECHNOLOGY BACKGROUND

Blue Horizon is our utility-scale machine – design to deliver reliable green energy to transmission networks around the world. Development of Blue Horizon has been funded through Wave Energy Scotland's Novel Wave Energy Converter Programme, where competing technologies were required to pass through a 'stage gate' selection process where technologies were assessed by industry expert and the most promising concepts were selected to proceed to the next funding stage.

Blue Horizon is one of only two technologies to reach the scale prototype stage, and the £3.3 million support from Wave Energy Scotland has funded the design, manufacture and deployment of a half-scale machine deployed in Orkney in 2021.

2 DEVICE DESCRIPTION

2.1 HULL STRUCTURE

The M100P consists of two yellow painted steel hulls connected at a hinge through a pair of steel hinge pins. The key dimensions of the machine are given in Table 1. Figure 2-1 shows a visualisation of the machine on the pier. Figure 2-2 shows a visualisation of the machine deployed at sea; however, the mooring lines are not shown here. Note that in both figures, the machine will be painted yellow. Figure 2-3 gives the general arrangement of the machine.

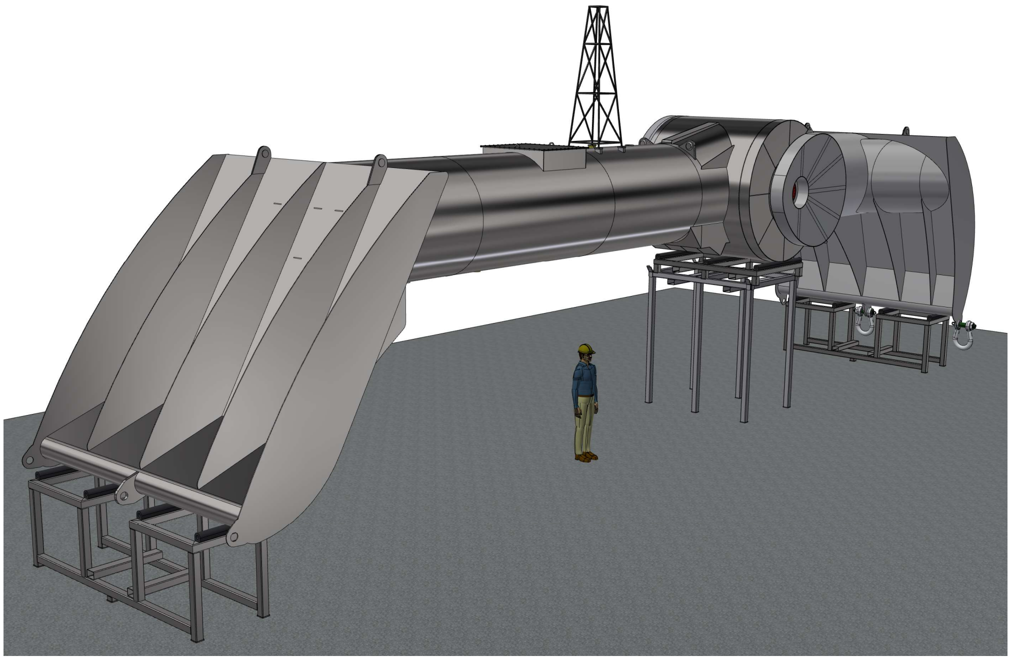


Figure 2-1 M100P visualisation on pier.

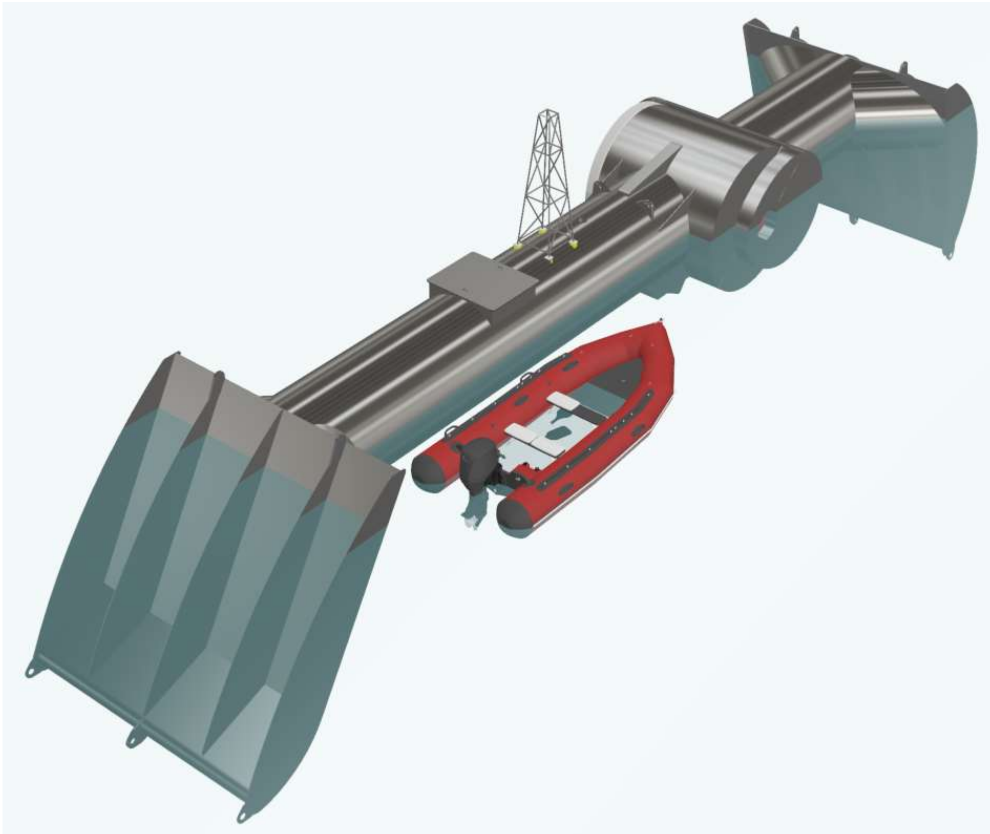


Figure 2-2 M100P visualisation as deployed at sea.

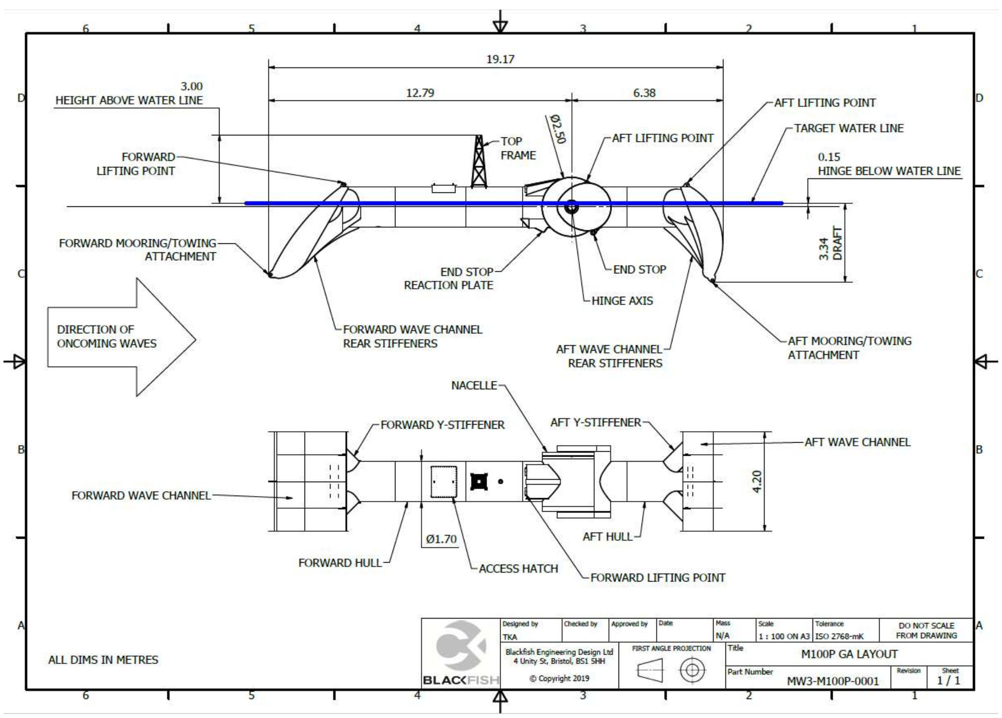


Figure 2-3 M100P Drawing with dimensions

Table 1 Key dimensions of the M100P

Dimension	Units	Value
Length overall	m	19.2
Beam	m	4.2
Draft	m	3.4
Mass	tonnes	37.9

Internal Systems

The rotation of the aft hull with respect to the forward hull drives a gearbox and then a generator. Power from the generator is then conditioned and used onboard the WEC to power local system. Power beyond that needed to power on-board systems is stored in 30 kWh of batteries. Once the batteries are fully charged, excess power is dissipated through an onboard dump resistor. Key onboard systems that use power include: the control, communications, cooling, instrumentation, and navigation lighting.

2.2 MOORING SYSTEM

Figure 2-4 shows the construction of the mooring system. The system is made of 2 mooring lines, the mooring attachment points on the 2 legs are attached to a 4.2m bridle at the forward mooring point on the WEC.

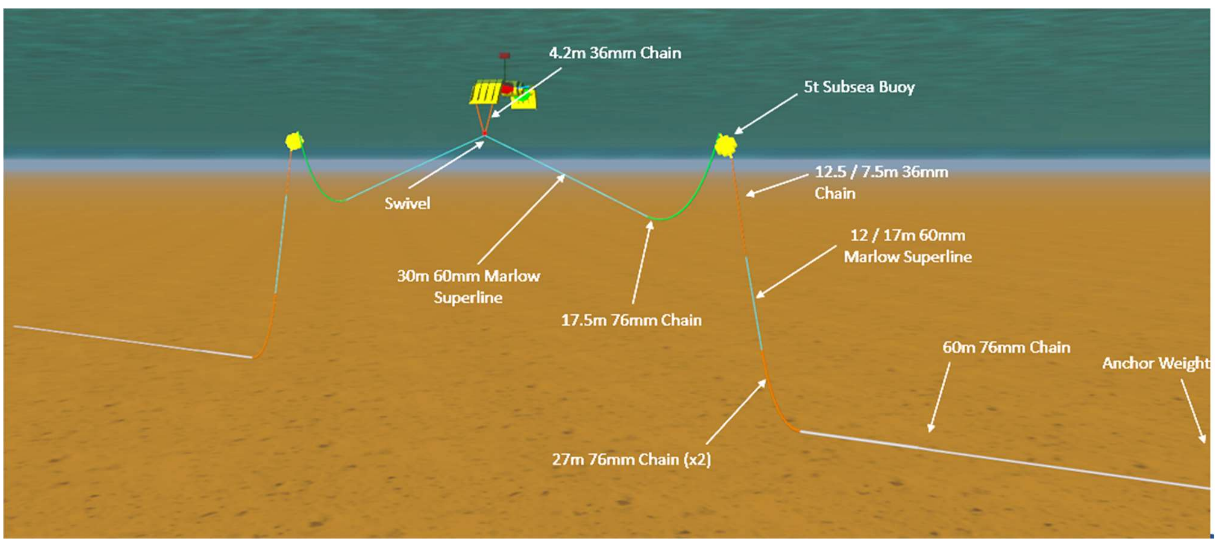


Figure 2-4 Mooring leg structure

The distance between the end points of the mooring legs is shown in Figure 2-5.

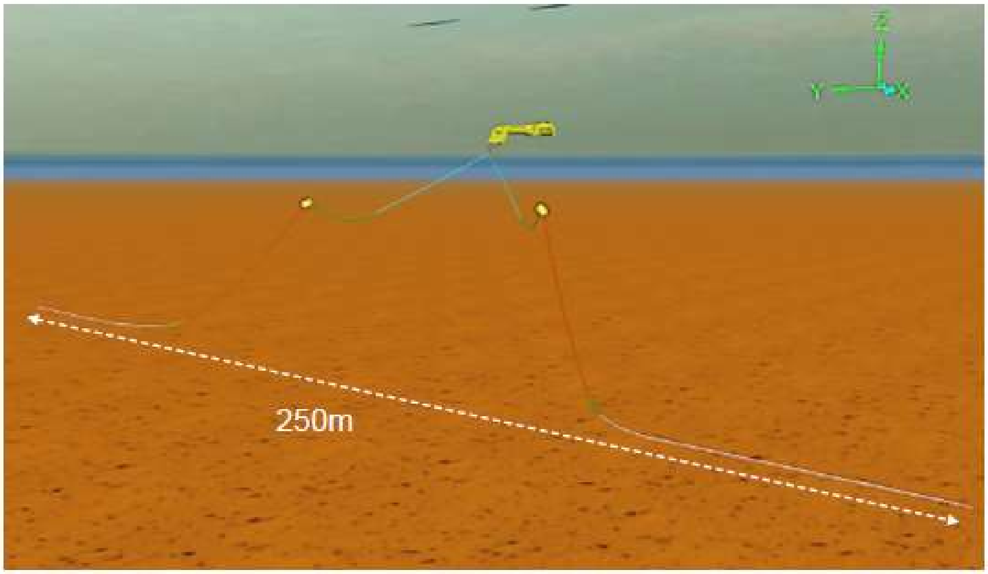


Figure 2-5 The WEC with Mooring Spread

The mooring footprint is represented in the schematic in Figure 2-6.

- The radius of the current mooring design, without contingency for design optimisation is 125m.
- The static position of the moorings is shown by the dashed blue line.
- The static point of the forward mooring point on the WEC is marked by the red cross.
- The dynamic excursion as a result of 6m Hs conditions is measured to be 75m from the static position of the device.
- The maximum 75m excursion is likely to be from East to West, with less excursion from West to East.
- The marker buoys are 45m along the mooring line from the forward mooring attachment point on the WEC.

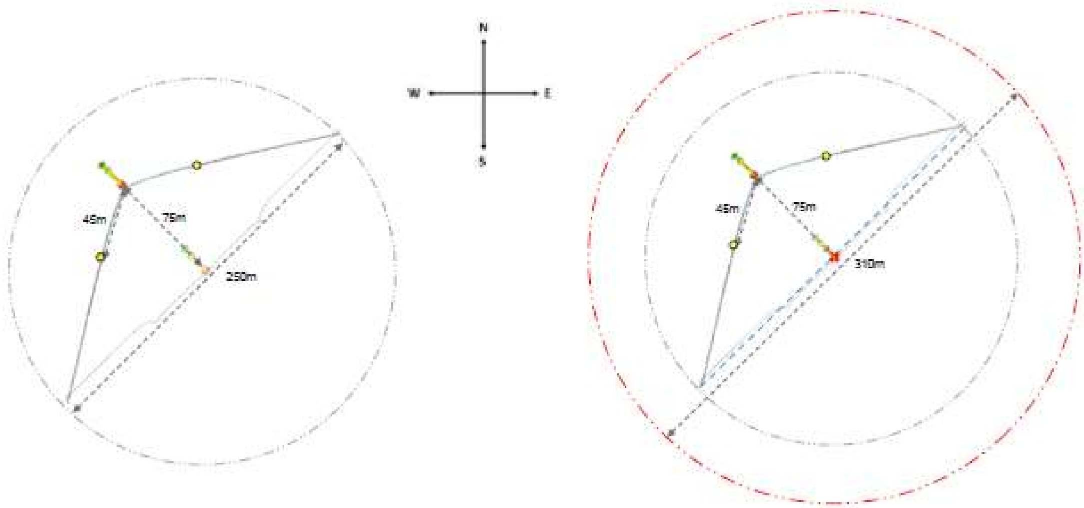


Figure 2-6 Mooring footprint (left), with allowance (right)

The design may be subject to further optimisation in advance of deployment. Therefore, an allowance of 30 m on each mooring leg is presented as this allows for minor changes that may occur during detailed design. This results in an increased radius of the mooring spread to 155 m (310 m diameter).

Depending on the seabed conditions, the anchors will be either drag embedment anchors or gravity-based foundations. No drilling will be required for their installation.

When the M100P is not connected to the mooring system (i.e., prior to installation or during maintenance), the mooring system will be held in place by a surface buoy.

2.3 SUBSURFACE SYSTEM

HALO

The Halo unit is an energy storage and management system comprising of Lithium-ion batteries and electronics housed in a painted structural carbon steel gravity-based skid. A representative skid is shown below.

HALO

Energy Capacity	150 kWh (scalable to 1 MWh+)
Output A (SPCS)	250 VAC 1PH 50 Hz (configurable)
Output B (HAUV)	350 VDC, 3 kW
Dimensions	4m(L) x 2.9m(H) x 2.5m(D)
Total Mass	10 Te

Figure 2-7 HALO Unit

HAUV

The HAUV is an autonomous underwater water vehicle that will be stored in a painted structural carbon steel gravity-based skid. A representative skid is shown below. Its approx. 4.6t

Hybrid AUV

Battery Capacity	30 kWh
Endurance	~14 hrs
Survey Range	~40 km survey / charge
HAUV Dimensions	4.1m(L) x 1.35m(H) x 0.5m(D)
Dock Dimensions	5.04m(L) x 3.94m(H) x 3.2m(D)

Figure 2-8 HAUV Unit

Umbilical

The umbilical is connected from the WEC to the Halo unit described above. The umbilical is 32mm in diameter and will be approximately 220m long. Voltage 400V AC, Single Phase and Power 3KW.

An illustration of how all of the above components work together is provided below.

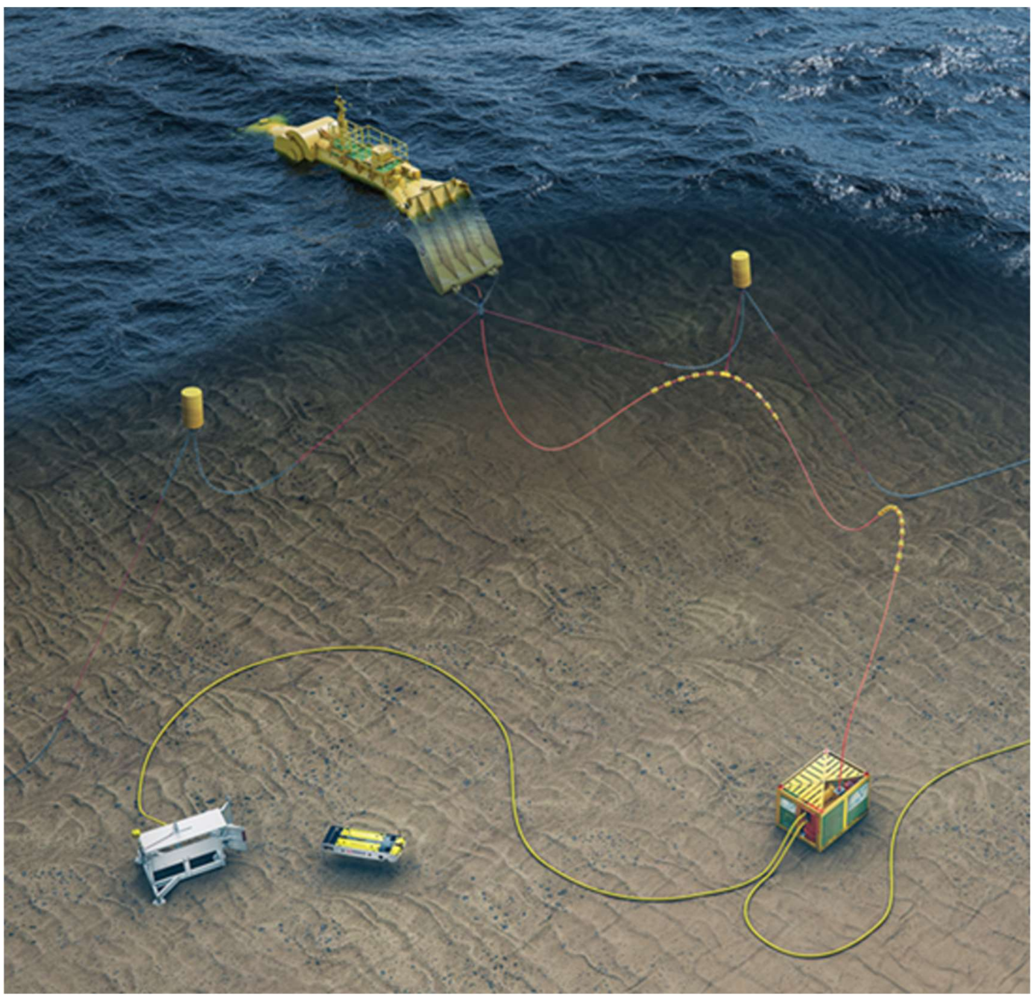


Figure 2-9 Illustration of entire system

Wave Rider

In addition to the WEC, a Wave Rider (or similar) measurement buoy, including its own mooring and anchor, will be anchored in the vicinity of the WEC within the licence boundary to measure metocean conditions.

2.4 MATERIALS

Table 2: Key Materials

Type of Deposit	Nature of Deposit (P = Permanent, T = Temporary)	Deposit Quantity (tonnes, m^3, etc.)
Steel/Iron	P: 290	Tonnes
Plastic/Synthetic	P: 12	Tonnes
Cable	P: 220	m
Other (please detail below): • Aluminium ~120kg (stator segments, anodes) • Copper ~ 140kg (stator windings) • Gearbox oil ~ 5kg • Bearing grease ~5kg • Rubber ~ 50kg (fenders and seals) • Batteries – 1 Tonnes • Electronics – 0.2 Tonnes		

3 PROJECT DESCRIPTION

3.1 LOCATION

The M100P will be installed at a location to the east of Deerness, Orkney (see Figure 3-1). The licence boundary required for installation of the device is specified in Table 3. The precise location of the device and anchors (within the licence boundary provided) will be determined prior to anchor installation and will be confirmed (post-installation) with Marine Scotland Licensing Operations Team (MS-LOT) upon submission of the formal Table of Deposits (Form FEP5). This flexibility in the installation location is required to ensure that no obstructions exist in proximity of the anchoring locations on the seabed.

Table 3 Coordinates of licence boundary

Point	Longitude	Latitude
NW	-2.75142	58.8711
NE	-2.75148	58.86194
SE	-2.7338	58.8619
SW	-2.73373	58.87106

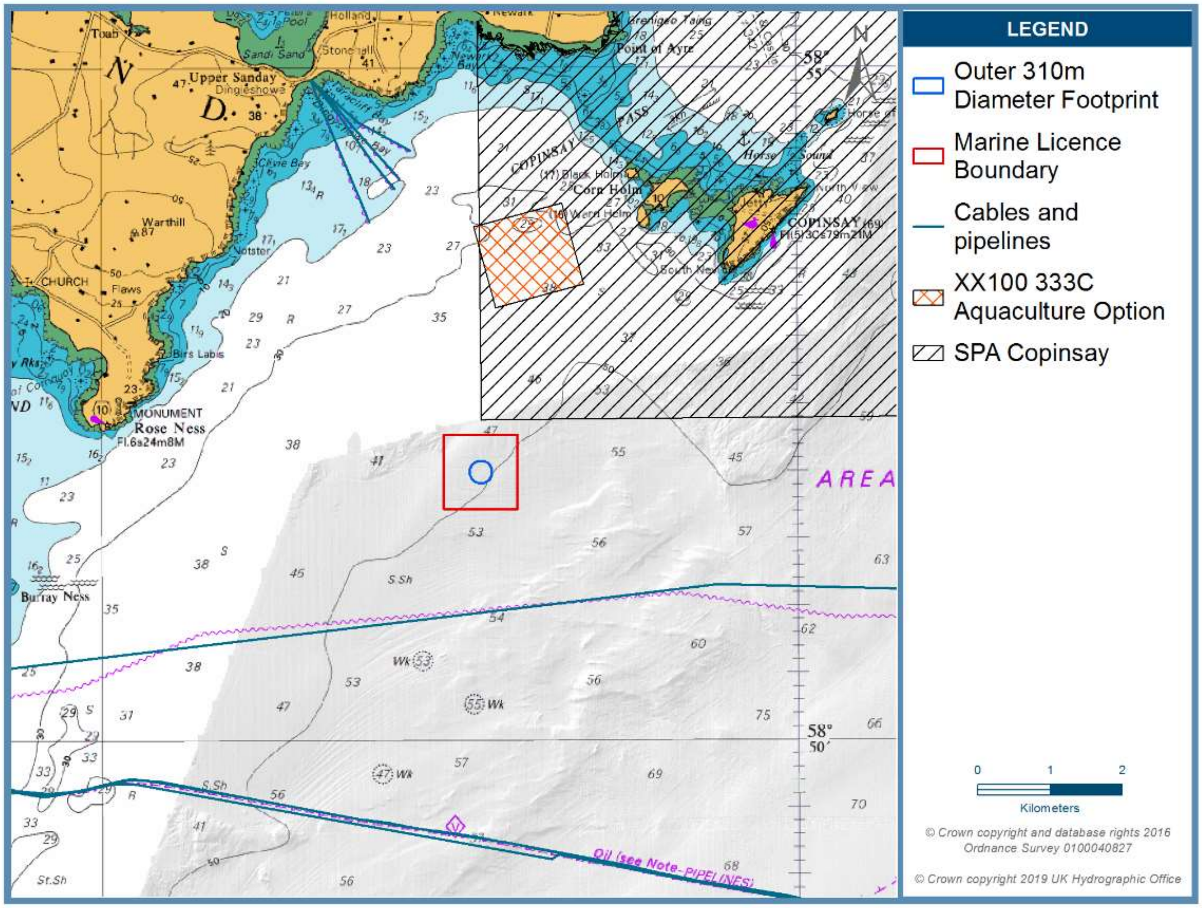


Figure 3-1 Proposed licence and deployment area at Test Site

3.2 INSTALLATION METHOD

The vessel spread required for installation is shown in Table 4. Further details of the vessels likely to be used for the deployment are provided in the Vessel Management Plan in Appendix B.

Table 4 Vessels utilised for installation

Vessel Type	Task
Multi Cat (x1)	Anchor and Mooring installation/removal. Device installation and removal. At-sea battery charging and power demonstration.
Rigid Hulled Inflatable Boat (RHIB) (x1)	At-sea visual inspection. Wave Rider installation and removal.

Figure 3-2 Example vessel of Multi Cat

Figure 3-3 Example vessel of RHIB

3.3 DEVICE MONITORING SYSTEMS

During deployment, the device will be monitored 24/7 by the Mocean Team using the Graphic User Interface ("GUI") and its related alarms. In addition to the GUI, the device will also include an AIS transponder which can be monitored in case of communications failure with the device. An emergency response plan will be in place which will identify contacts, contractors, process and procedures for responding to any unplanned excursion of the device.

3.4 DECOMMISSIONING

Decommissioning will involve the removal of the M100P and all associated equipment. This will be a reverse of the installation procedures as outlined in the Decommissioning Plan. The device and umbilical are planned to be removed from site by a Multi Cat vessel in 1 day, the HAUV and HALO the following day and the mooring lines and anchors, and the Wave Rider buoy are planned to be removed from site by a Multi Cat vessel in the following 2 days.

3.5 THIRD PARTY VERIFICATION

Third Party Verification (TPV) is currently underway and being undertaken by Orcades Marine Consultancy in Orkney. It is anticipated that TPV will be completed in advance of deployment on site. TPV has already been secured for the device deployments in the EMEC test sites in Scapa Flow and Billia Croo.

Orcades uses 360 TPV which provides a holistic approach to readiness assurance covering engineering design, locational suitability, operability, regulatory and license compliance, as well as cost-effectiveness and invest-ability. 360 TPV brings confidence to project developers, insurers, investors, authorising bodies, customers, test facilities, and government. 360 TPV brings an opportunity for you to benefit from the experience of those who have gone before. It provides independent, incisive insight and improves your likelihood of success.

360 TPV maximises opportunities for success, minimizes uncertainty, and manages risk by having an experienced, independent team evaluate your technology, project and/or organisation and provide feedback on the status that exists and consequences that could arise. Orcades 360 TPV team takes a holistic approach; makes use of proven expertise and unparalleled global ocean energy experience.

3.6 PROJECT PROGRAMME

The proposed installation, operations, maintenance and decommissioning schedule (indicative) for the Project is shown in Appendix A. The anticipated date of installation of the M100P and its associated mooring system is the beginning of April 2022. The operational period of the test is anticipated to last up to the end of September 2022. To allow some contingency in the programme, the marine licence application will cover the period until the end of December 2022. Thereafter, all equipment will be completely removed from site.

3.7 ENVIRONMENTAL CONDITIONS AND NAVIGATION

The navigation and lighting plan is available as an appendix in the Project-specific Environmental Monitoring Plan (PEMP). This will be submitted as part of the formal marine licence application for further consultation.

Deployment Area Constraints Analysis

Marine Traffic: The area is used by a variety of marine traffic as illustrated in Figure 3-4. The deployment sites were located such that they avoid the areas of highest recorded traffic density.

Predicted tidal velocities: A model was used to predict the local tidal velocities in the area. The outputs indicated that Copinsay has the effect of increasing tidal velocities to the North-east of the area. In addition, the increased predicted velocity off Copinsay suggests deployment towards the North-East of the deployment area would be less suitable for the device.

Copinsay SPA and SHEFA Cable: Copinsay SPA is approximately 0.2 Km to the North-East and a SHEFA cable approximately 1.3 Km to the South of the proposed site. These are illustrated in Figure 3-5 which was generated from the Proximity Check via Crown Estate Scotland (CES).

Existing Seabed Survey Data: SNH report no. 446: An assessment of the conservation importance of species and habitats identified during a series of recent research cruises around Scotland (2011)[1] had several sample locations in the vicinity of the survey area (Figure 3-6) which lead the survey team to believe that suitable seabed conditions for a deployment were present.

[1] Available from: https://www.nature.scot/snh-commissioned-report-446-assessment-conservation-importance-species-and-habitats-identified

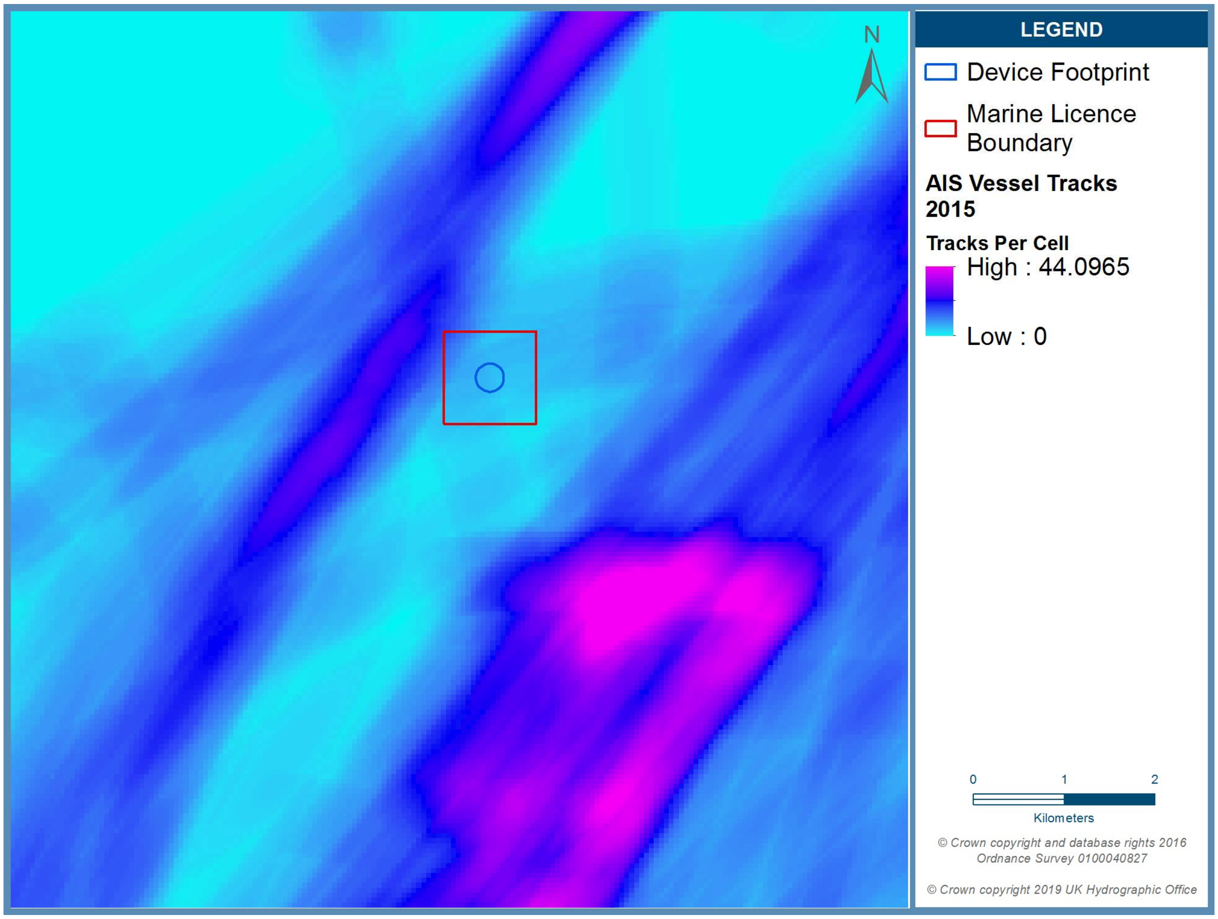


Figure 3-4 Vessel Traffic Analysis

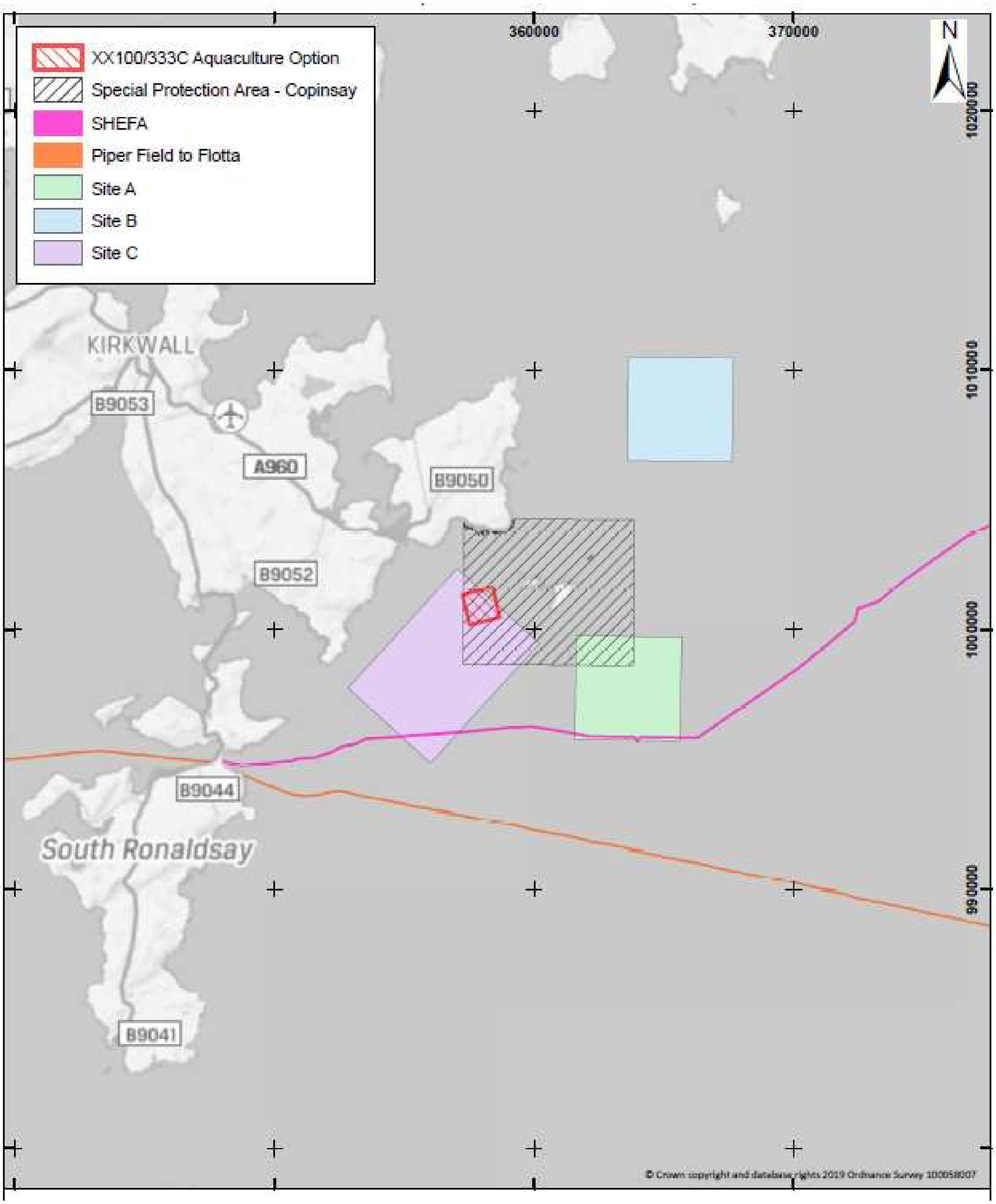


Figure 3-5: CES Proximity Check Results

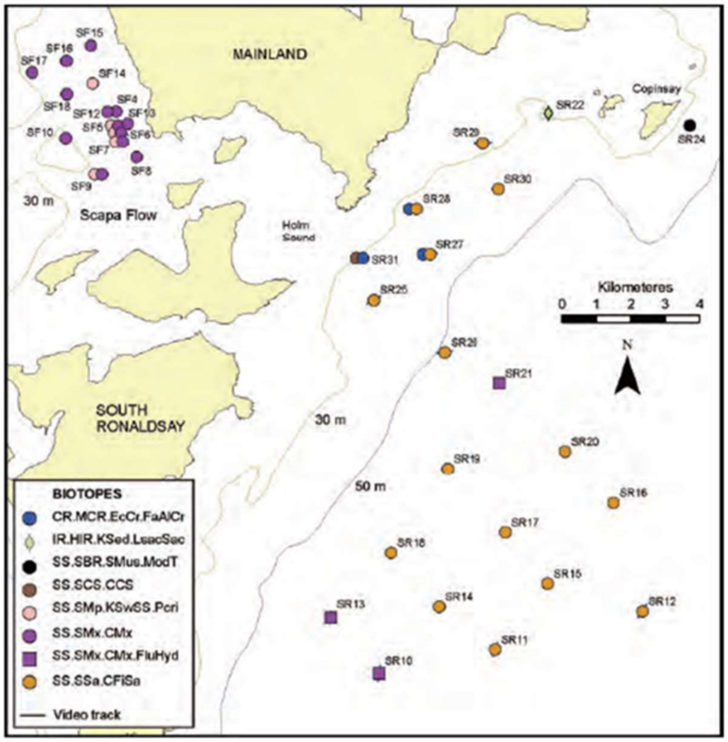


Figure 3-6: Identified biotopes within the area (from SNH report no. 446)

Benthic Survey

A Remotely-Operated Underwater Vehicle (ROV) and Vessel Mounted Acoustic Doppler Current Profile (VMADCP) survey was conducted on behalf of Mocean Energy by Aquatera in an area east of Burray in September 2019 (Figure 3-7). The primary aim of this survey was to identify a potential deployment site that is feasible from both a technical and environmental perspective. Potential sites were initially identified via the VMADCP survey with video footage collected at these preferred sites to investigate the condition of the seabed by characterising seabed habitats and species present within each survey area.

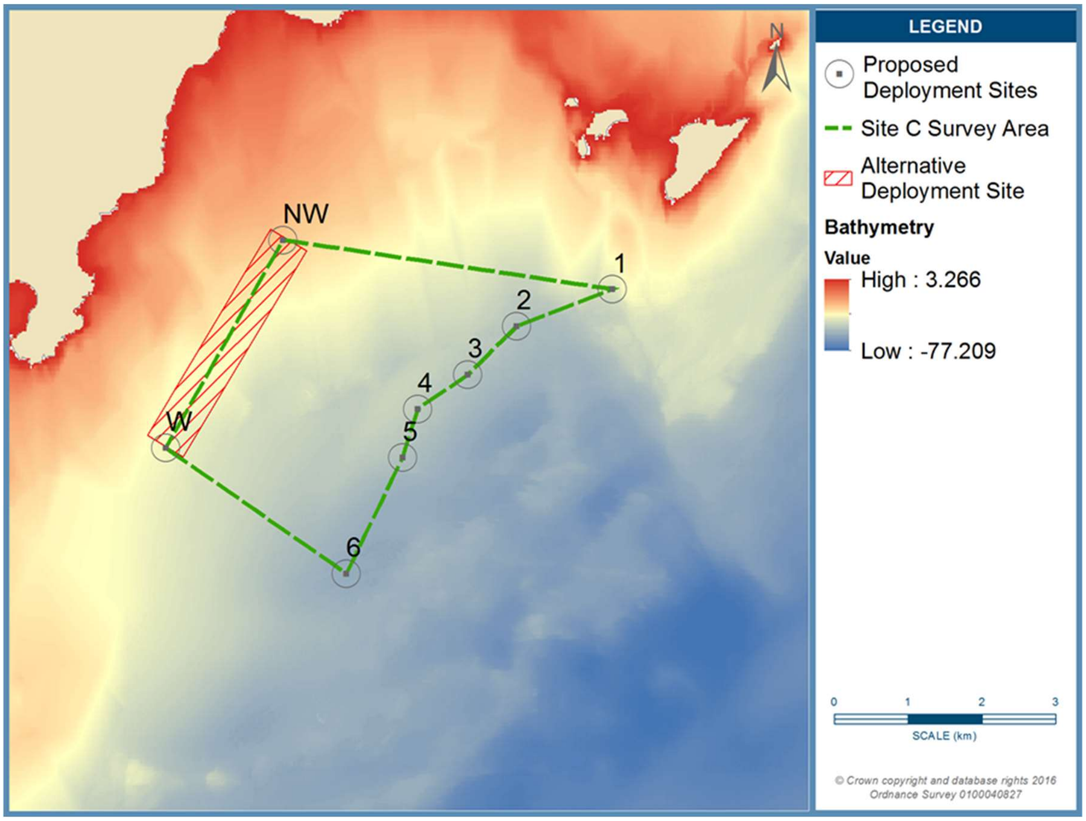


Figure 3-7: Benthic/VMADCP Survey Search Area

Water depths at the deployment site (vicinity of Site 4 and 5) were approximately between 50 and 53 m. Sediment characteristics within this area generally alternated between pronounced fine sandy ripples with sparse echinoderm epifauna, and coarser-grained heterogeneous sands with increased amounts of shell fragments. Throughout the mixed sediments hermit crabs were commonly observed along with (possible) tufts of macroalgae.

The seabed habitats observed at the vicinity of the deployment site displayed characteristics of the following biotopes as described below:

- The majority of the area observed were dominated by pronounced fine sandy ripples and appeared generally barren with regards to faunal diversity, with widely scattered echinoderms including A. rubens and brittle stars (possible Ophiura). This habitat may resemble the SS.SSa.CFiSa ('Circalittoral fine sand') biotope complex, however further in-depth biotope classifications could not be assigned for these areas due to the lack of key characteristic species associated with specific biotope types.

- There were also occasional patches of increased mixed sediments and shell material appears similar to the SS.SCS.CCS ('Circalittoral coarse sediment') biotope complex, however only hermit crabs (Pagurus bernhardus – a characteristic species of the biotope complex) were observed throughout these areas and therefore a more in-depth biotope classification could not be assigned.

The findings of the survey appear consistent with a previous survey conducted by SNH, which reported the presence of SS.SSa.CFiSa to the east of Holm Sound, where there were few signs of infaunal life and a sparse epifaunal community mainly composed of widely scattered echinoderms. Where there was hard rock substrates observed in the study, a lowdiversity encrusting community of serpulid worms, bryozoans, coralline algae and E. esculentus were found association and therefore the rocky habitat was assigned to the CR.MCR.EcCr.FaAlCr biotope.

APPENDIX A PROJECT PROGRAMME

Activity	Project Week																															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
Mooring Installation	X																																
Device Installation		X																															
Testing		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X								
Maintenance – On Station				X				X				X				X				X				X									
Maintenance – Sheltered Mooring						X								X								X											
Maintenance – Hatston Quay										X								X															
Device & Mooring Removal																										X							
Contingency																										X	X	X	X	X	X	X	X

APPENDIX B VESSEL MANAGEMENT PLAN (VMP)

B.1 INTRODUCTION

This VMP details the anticipated type and number of vessels that will be used during the construction and installation, maintenance and decommissioning of the M100P at the Test Site. It also highlights the likely ports and transit routes that will be used during all phases of the deployment.

B.2 VESSEL DETAILS

The selection and contracting of vessels is primarily driven by market conditions, vessel availability and ultimately, cost. Therefore, the actual vessels will be selected near to the time of works. The developer will confirm the project vessel spread at the earliest possible opportunity prior to works commencing as required (as per normal maintenance activities). The vessels presented in the following figures and **Appendix Table B.1** are indicative of the vessels likely to be used.

Appendix Figure B.1 Example Multi Cat vessel

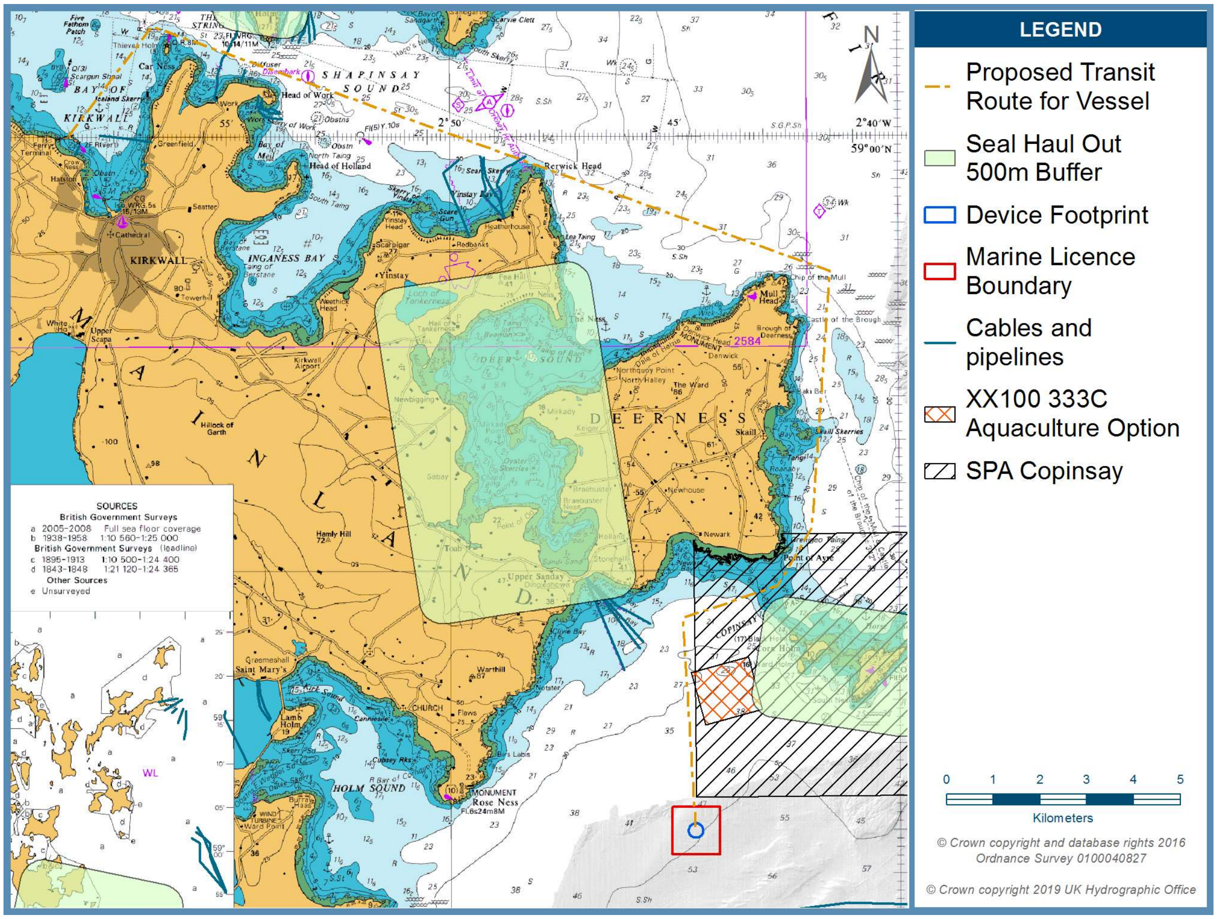
Appendix Figure B.2 Example Rib vessel

Appendix Table B.1 Vessel information (FOR MAIN VESSELS ONLY)

	MV C-FENNA	MV C-ODYSSEY	GREEN ISLE
Flag state	UK	UK	UK
Port	Kirkwall	Kirkwall	Stromness
Year of build	2013	2011	2015
Type	Neptune Eurocarrier 2611	Multiworker Twenty6	Damen
Length	26.5 m	26 m	27.7 m
Beam O.A.	11 m	10.5 m	12.5 m
Draught	2.6 m	2.5 m	2.9 m

B.3 VESSEL ROUTES

Indicative vessel transit routes between Hatston Pier and the Performance Test Site are presented in **Appendix figure B.3**. The same route will be used for all phases of the deployment. Vessels will as far as possible avoid passing within 500m of any identified seal haul-out site when in transit. Seal haul-outs with a 500m buffer and suggested vessel routes in close proximity to the Performance test site are provided in **Appendix figure B.3**.



Appendix figure B.3 Transit Routes

A designated Marine Operations Manager/Marine Superintendent is responsible for the discharge of relevant licence conditions whilst at sea. This will be Mocean Energy's Operations Manager, Yan Gunawardena.