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Mocean Energy Orkney M100P Test 2023/2024

Project Briefing Note

Final

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V1	05th Mar 19	Draft provided to Mocean
V2	29th Oct 19	Issued to MS-LOT
V3	07th Oct 21	Addition of HALO, HAUV and Umbilical
V4	15th Mar 23	Mocean variation; time extension, material update

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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.

The Renewables for Subsea Power (RSP) system is an offshore renewable power source that charges batteries to supply power and comms to subsea equipment, and it consists of:

- Blue X: wave energy converter (WEC) – Mocean Energy (also referred to as M100P)
- Halo: Subsea battery storage and energy management – Verlume
- Subsea electronics Module (SEM) – Baker Hughes.
- ARV-I and a docking station: Autonomous Underwater Vehicle (AUV): Transmark Subsea.

An umbilical connects Blue X with the Halo, however, the device will not be connected to a subsea cable to provide power onshore. This is a demonstration project.

Testing is planned to be undertaken in an area to the East and offshore of Deerness, Orkney in 2023/2024. The primary purpose of testing is to gather performance data and learnings from deployment of the RSP system in order to inform further development of the system's designs and interfaces.

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.

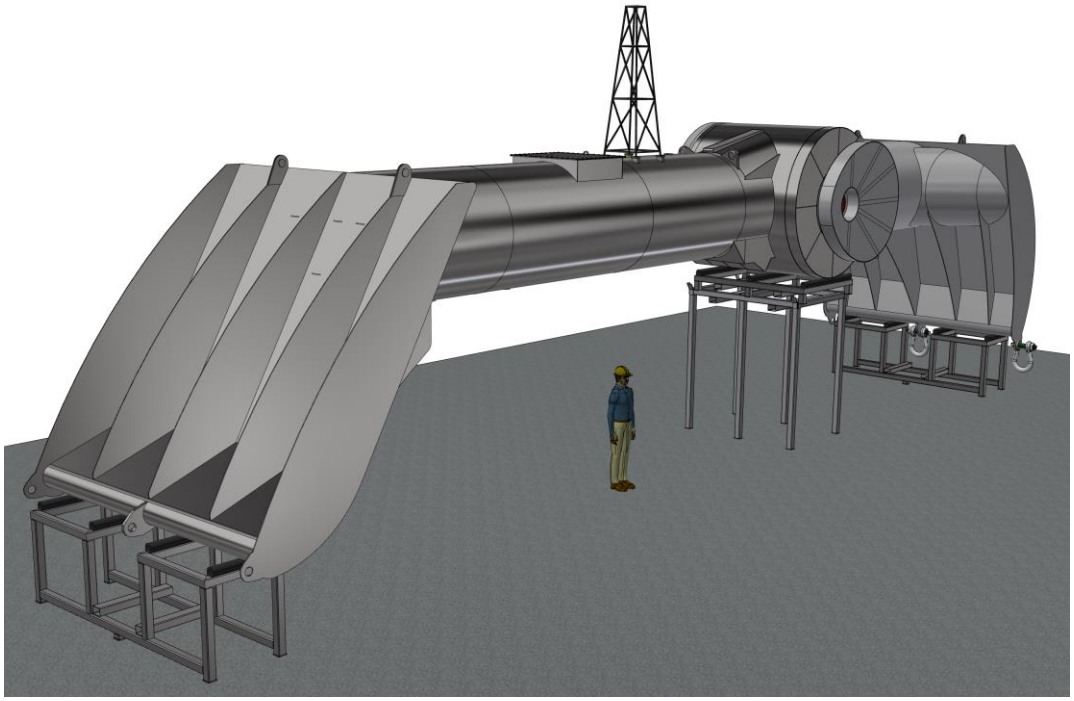


Figure 2-1 M100P visualisation on pier.

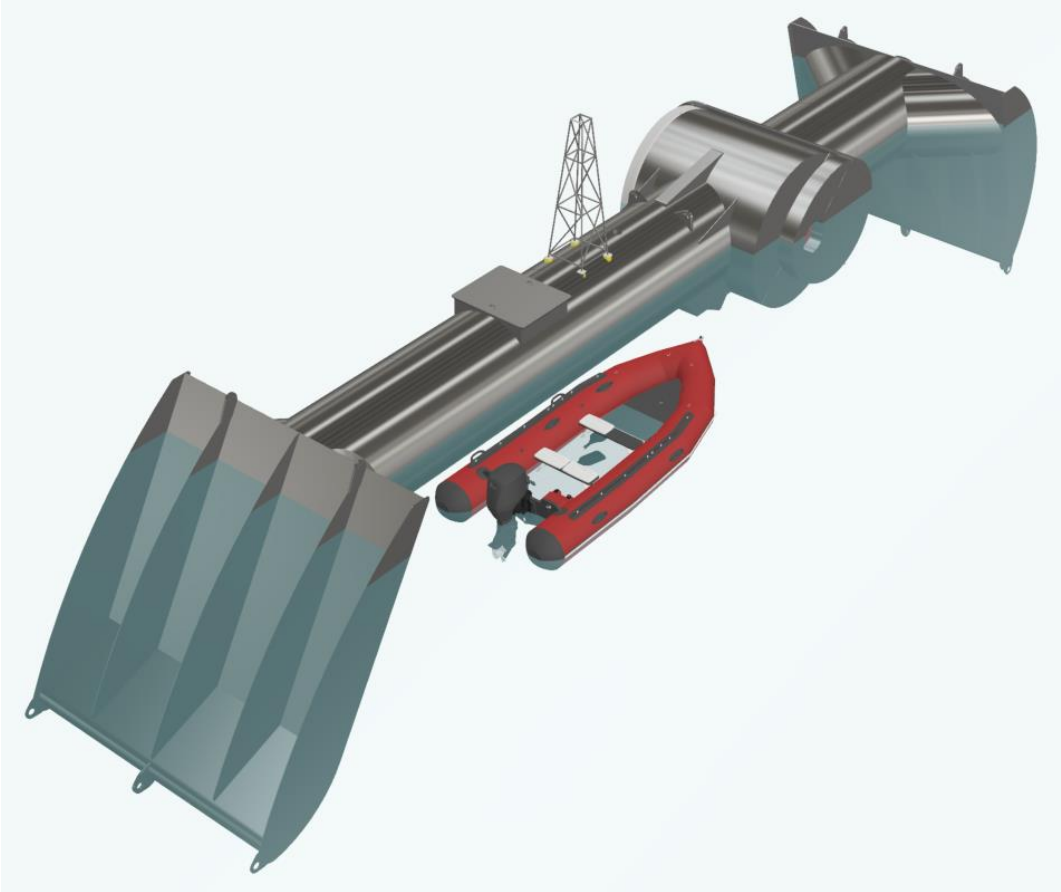


Figure 2-2 M100P visualisation as deployed at sea.

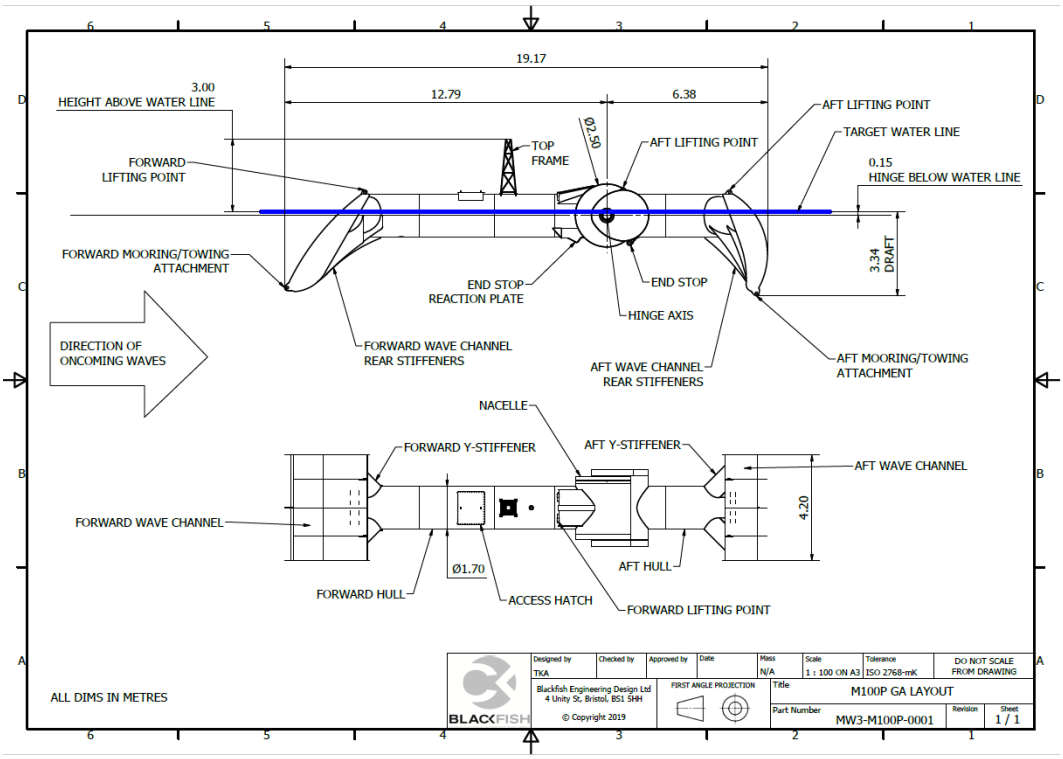


Figure 2-3 M100P Drawing with dimensions

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.

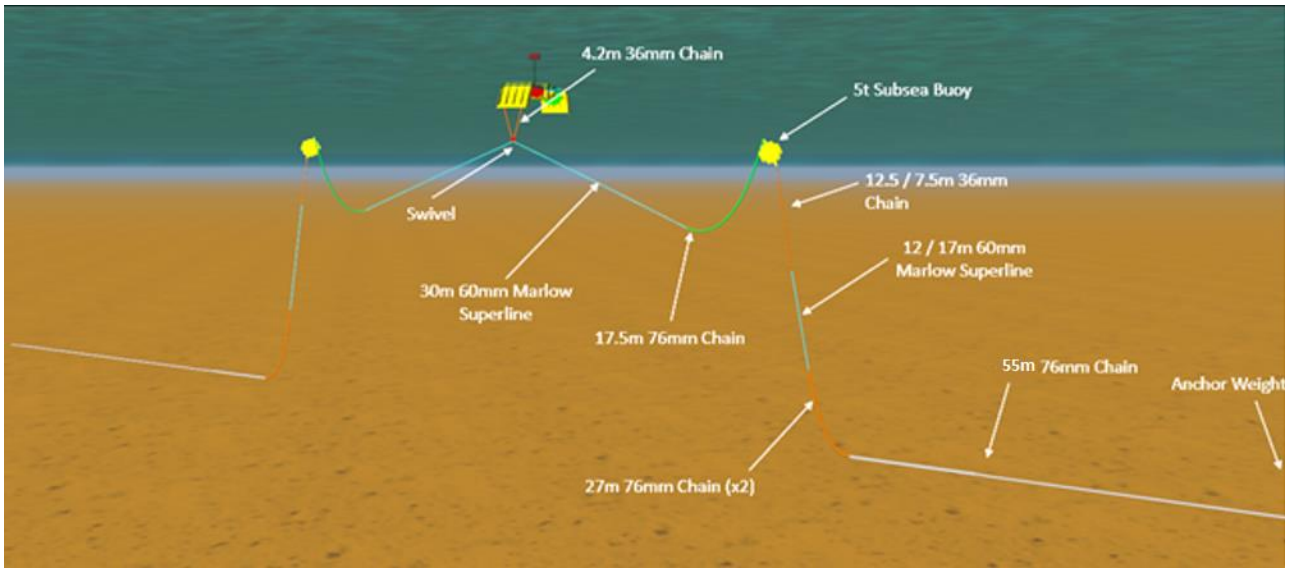


Figure 2-4 Mooring leg structure

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

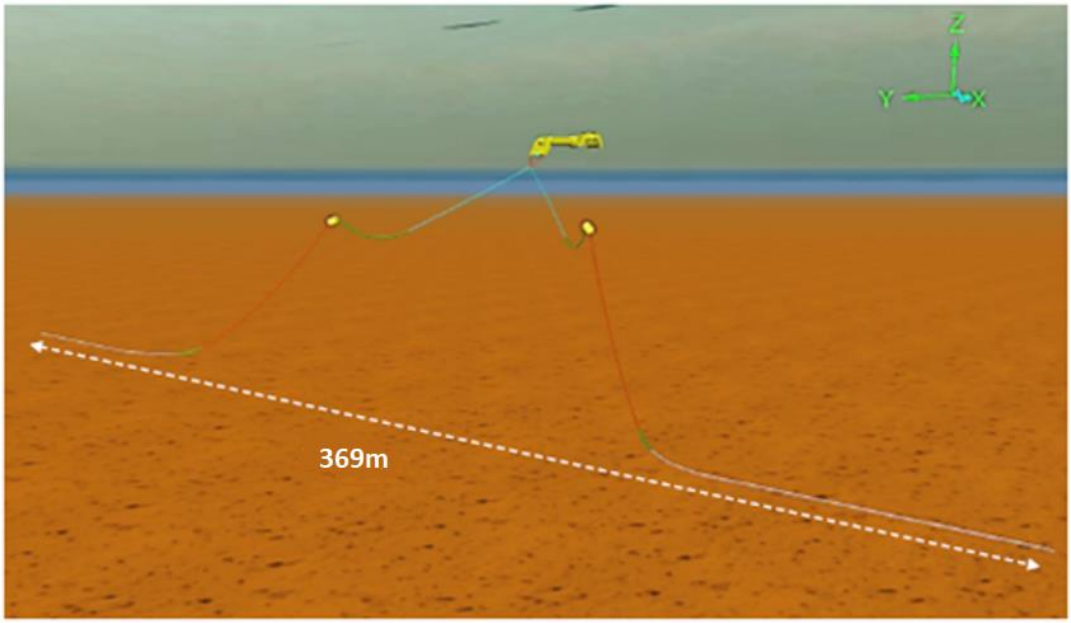


Figure 2-5 The WEC with Mooring Spread

The final site footprint after optimisation in advance of deployment is represented in the As Built drawing in Figure 2-6.

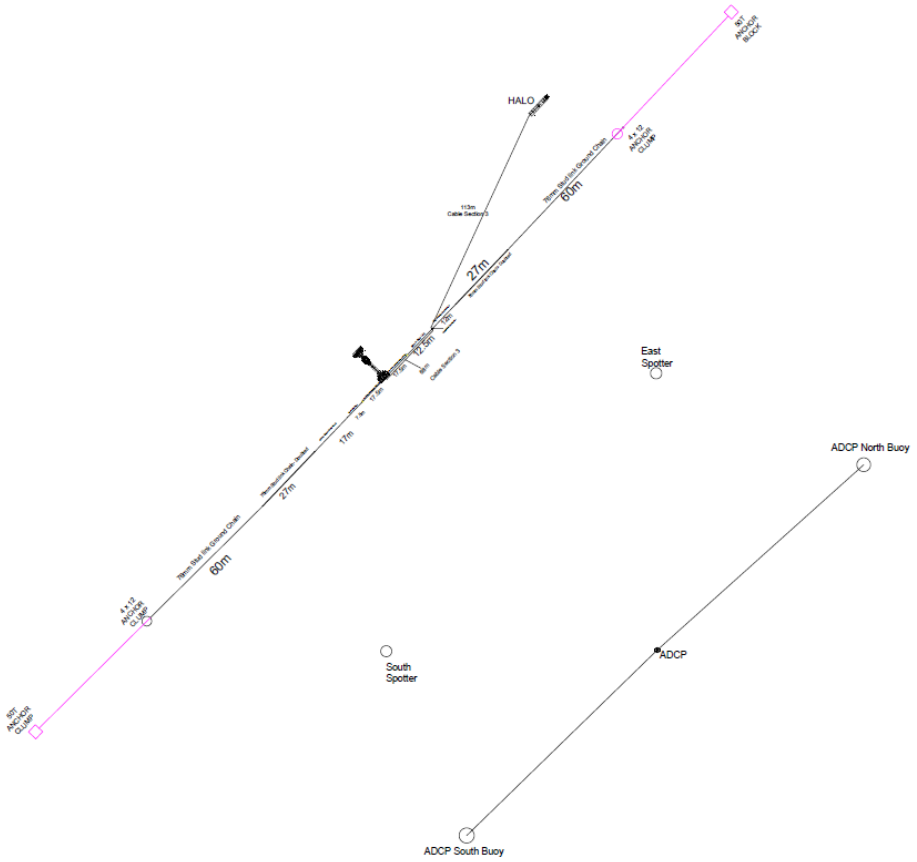


Figure 2-6 As built site footprint

Both concrete anchor blocks and chain clumps have been used as anchors to address the lack of chain available for hire, make safer and faster the deployment and minimise carbon footprint by re-using materials used in previous marine renewable projects. This anchor change was reviewed and approved under the existing TPV certificate issued for the deployment.

When the WEC 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. The batteries and the AUV docking station have now been combined to one structure, the HALO frame, to minimise the footprint as previously cited at the Decommissioning methodology. The final GA of the Halo unit is shown below.

HALO Dimensions	meters
Length	9.5
Height	3.4
Width	1.7
Depth bellow surface	46.6-49.6

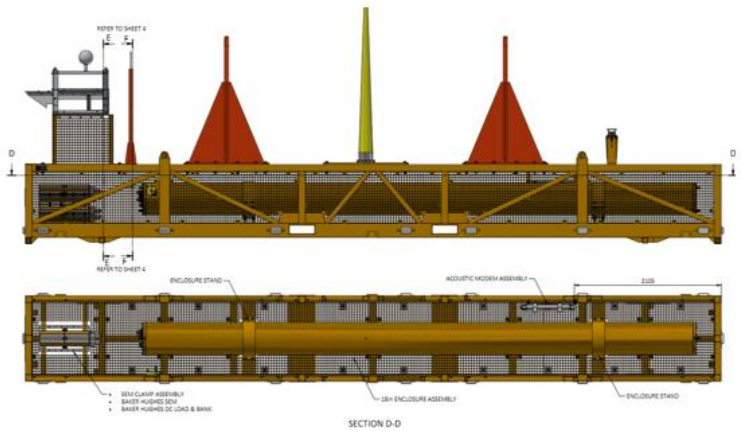


Figure 2-7 HALO Unit

HAUV

The HAUV is an autonomous underwater water vehicle with HD cameras used for supervised autonomy functions and acoustic control supported by navigation camera captured images and schematic positioning. Its dock is installed on the battery pack that is located on the seabed. Info for ARV-I is shown below.

Type:	ARV-i
Dimensions:	610 x 400 x 360 (mm)
Weight in air	24 kg

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 is 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.

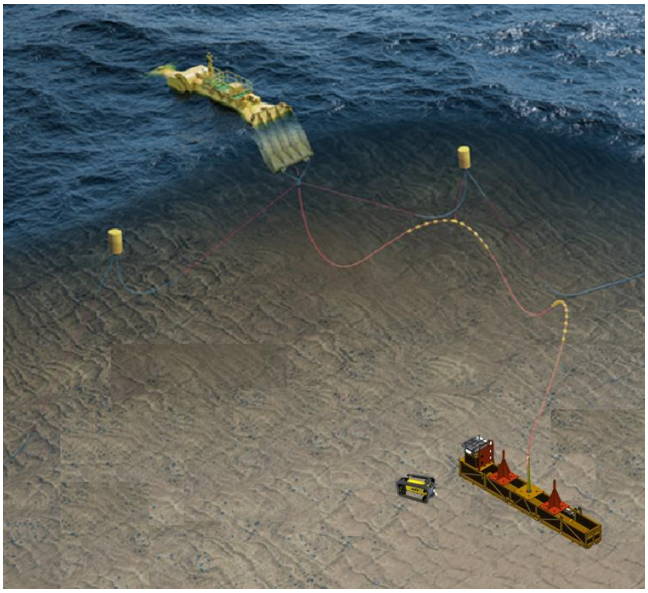


Figure 2-9 Illustration of entire system

Ancillary Scientific Equipment

In addition to the WEC, a system of scientific equipment (ADCP and spotter), including its own mooring and anchor, will be anchored in the vicinity of the WEC within the licence boundary to measure metocean conditions, specifically, wave and current parameters.

2.4 MATERIALS

Table 2: Key Materials

Type of Deposit	WEC	Halo and AUV	Mooring/ anchors	Scientific Equipment with mooring	Total	Deposit Quantity (tonnes, m^3, etc.)
	Nature of Deposit (P = Permanent, T = Temporary)					
Steel/Iron	P: 36.8	P:7.8	P:169.3	P:1.8	**P:215.7**	Tonnes
Concrete	P: 45.54				**P: 45.54**	m^3
Plastic/Synthetic	P: 0.2	P:0.1	P:8	P:0.16	**P:8.5**	Tonnes
Cable	P: 220 (220m long with a weight in air of 2,245kg/km					m

	therefore 0.11 T)					
Other (please detail below):	• **Aluminium ~0.02tn** • **Copper ~ 140kg** • **Gearbox oil ~ 5kg** • **Bearing grease ~5kg** • **Rubber ~ 0.2tn** • **Battery~ 0.8tn** • **Electronics ~ 1.0 tn**					

3 PROJECT DESCRIPTION

3.1 LOCATION

The RSP system is 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) has been submitted to Marine Scotland Licensing Operations Team (MS-LOT) and other authorities (MCA, UKHO,NLB) as requested under the marine licence conditions.

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

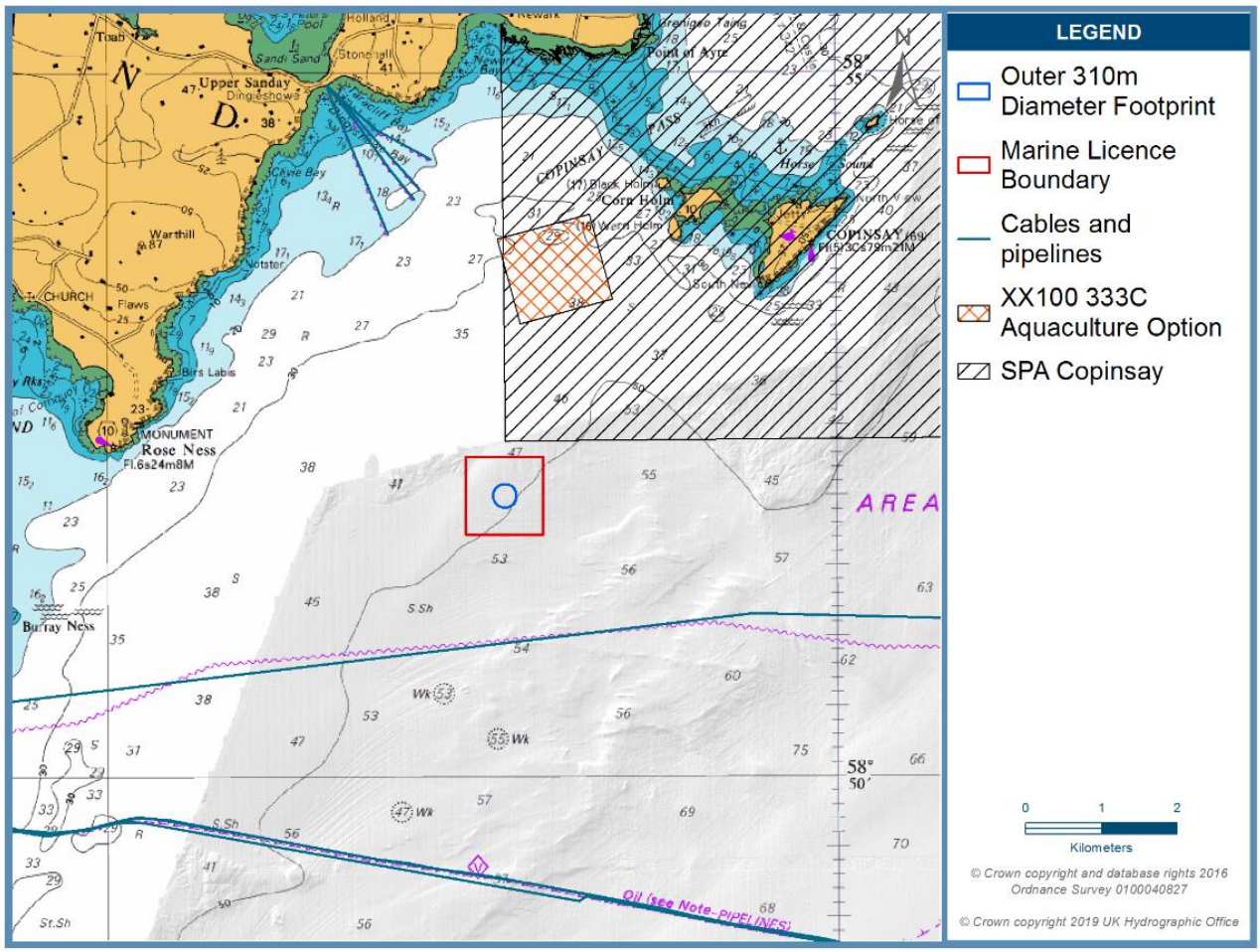


Figure 3-1 Licence and deployment area at Test Site

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 as required by the Mocean Team using the Graphic User Interface ("GUI") and its related alarms. In addition to the GUI, the WEC also includes an AIS transponder which can be monitored in case of communications failure with the device. An emergency response plan is in place which identifies contacts, contractors, process and procedures for responding to any unplanned excursion of the device. Similarly an Emergency Cooperation Plan has been agreed with the MCA and the Police.

3.4 DECOMMISSIONING

Decommissioning will involve the removal of the RSP system 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 scientific equipment 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) has been undertaken by Orcades Marine Consultancy in Orkney and the certificate shared with MS-LOT and Crown Estate Scotland. Any mooring/anchoring changes have been reviewed and approved by Orcades Marine prior the deployment.

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 installation of the RSP system and its associated mooring system was completed on the 28th February 2023. The extended operational period of the test is anticipated to last up to the end of March 2024. To allow some contingency in the programme, the marine licence application will cover the period until (and including) September 2024. Thereafter, taking into consideration the 3 month recovery condition on the current licence 10107 all equipment is planned to be completely removed from site by the 30th June 2024.

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

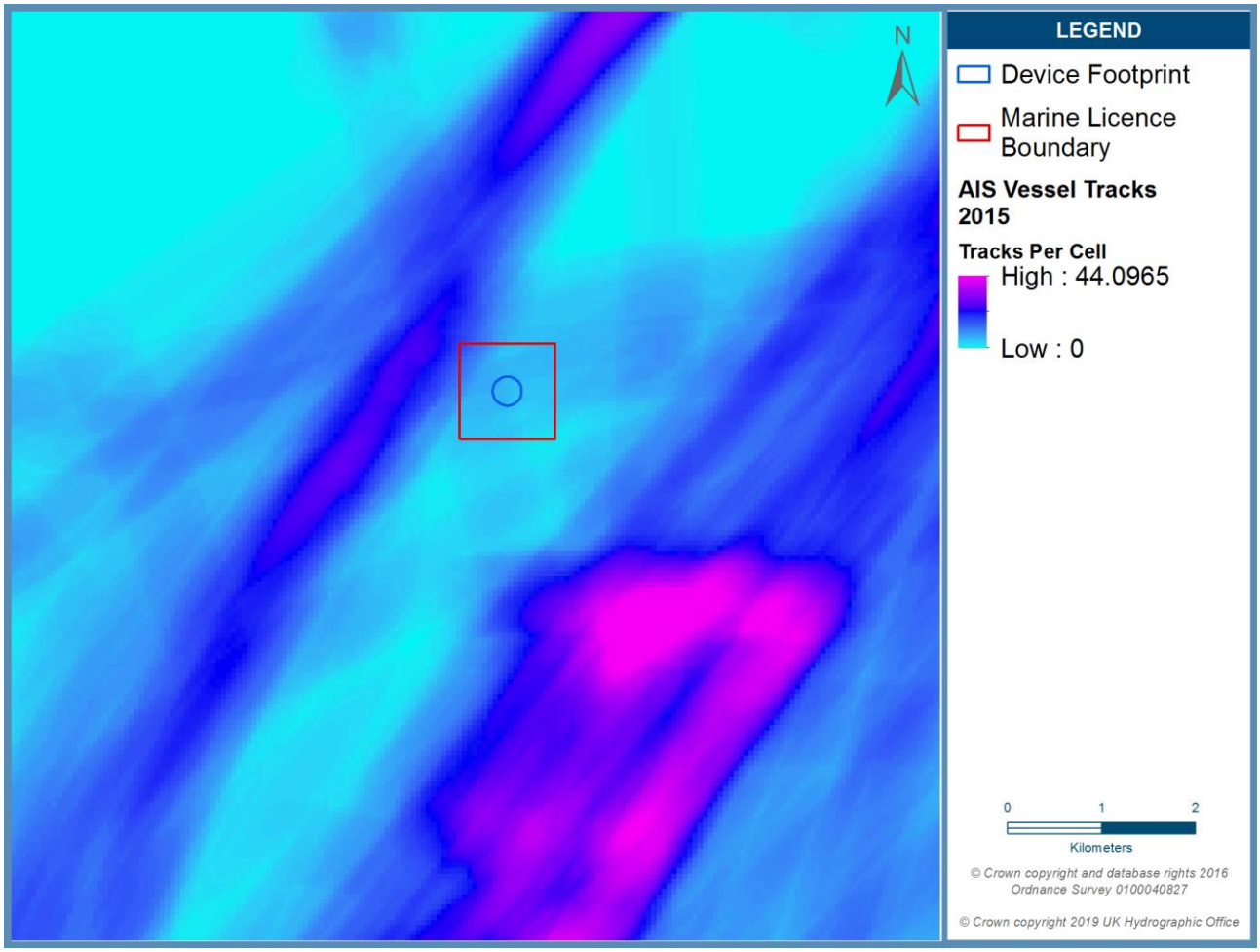


Figure 3-4 Vessel Traffic Analysis

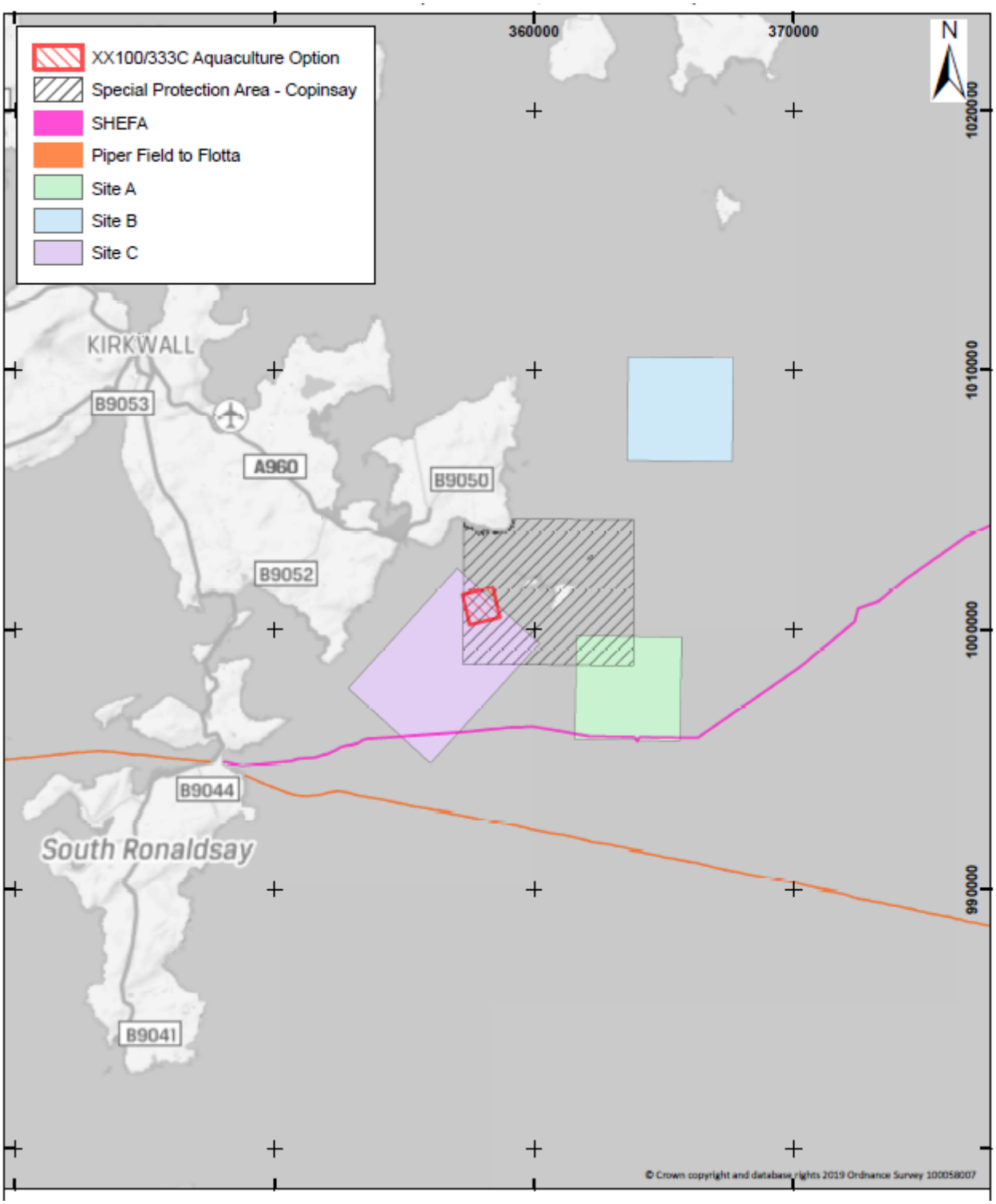


Figure 3-5: CES Proximity Check Results

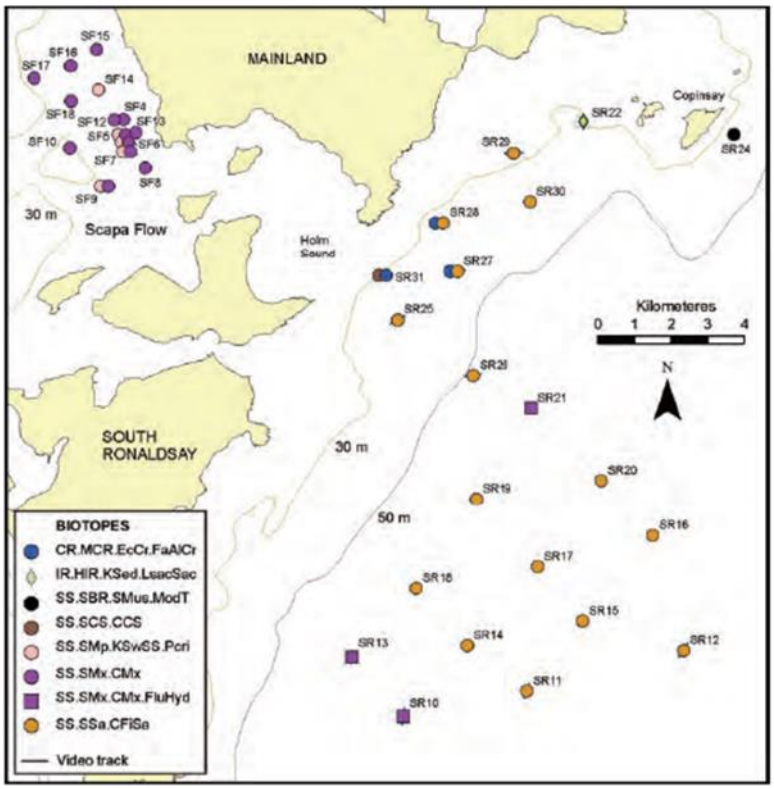


Figure 3-6: Identified biotopes within the area (from SNH report no. 446)

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.

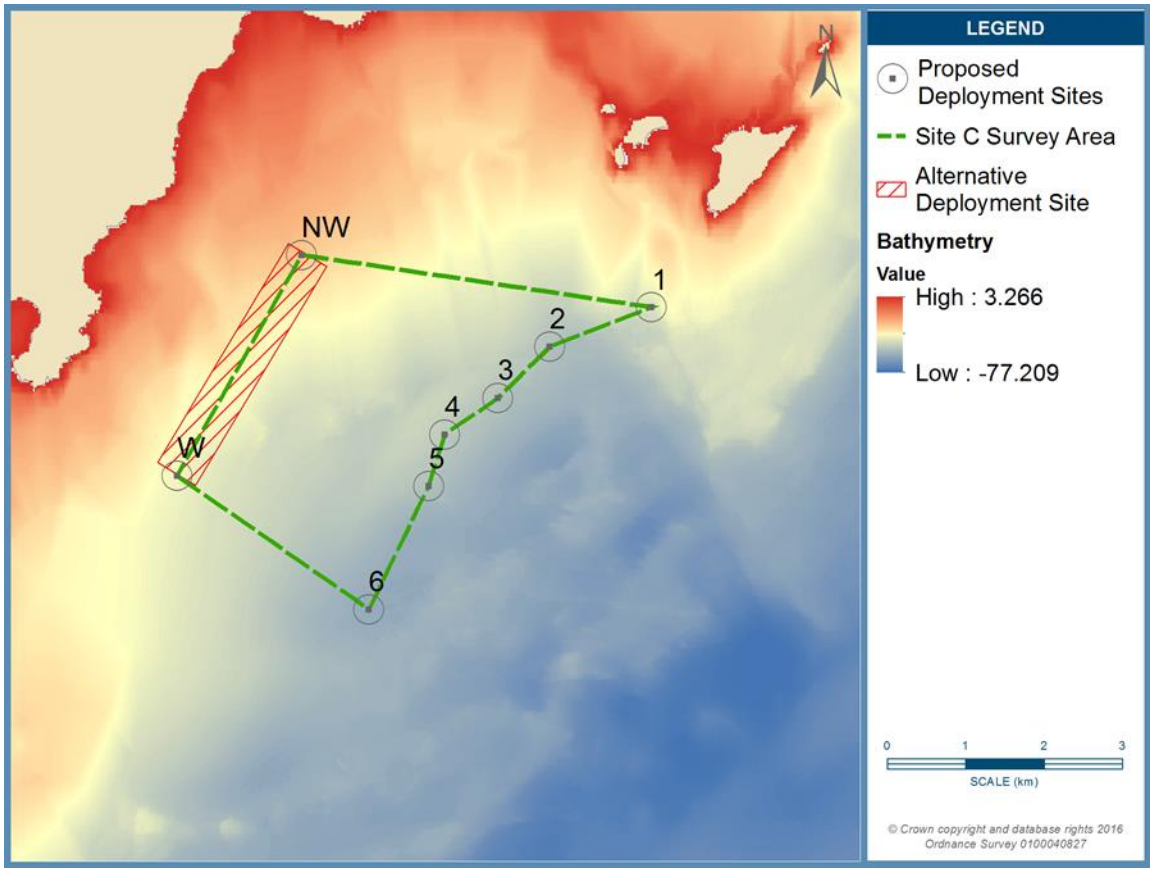


Figure 3-7: Benthic/VMADCP Survey Search Area

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 low-

diversity 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.

APPENDICS

APPENDIX A PROJECT PROGRAMME

Activity	1 02/23	2 03/23	3 04/23	4 05/23	5 06/23	6 07/23	7 08/23	8 09/23	9 10/23	10 11/23	11 12/23	12 01/24	13 02/24	14 03/24	15 04/24	16 05/24	17 06/24	18 07/24	19 08//24	20 09/24
Mooring Installation	X																			
RSP system Installation	X																			
Testing		1	2	3	4		5	6	7	8	9	10	11	12						
Maintenance – On Station			X		X		X		X		X		X							
Maintenance – Sheltered Mooring[2]																				
Maintenance – Hatston Quay[3]						X									x					
Device & Mooring Removal															X					
Contingency[4]																x	x			

[2] Sheltered mooring maintenance as and if required

[3] Temporary recovery to Hatston Quay assumed due to current 10107 marine licence requirement to recover by 30/06/2023

[4] Assuming that offshore site will need to be cleared 3 months prior the extended licence expiry

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 RSP system 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

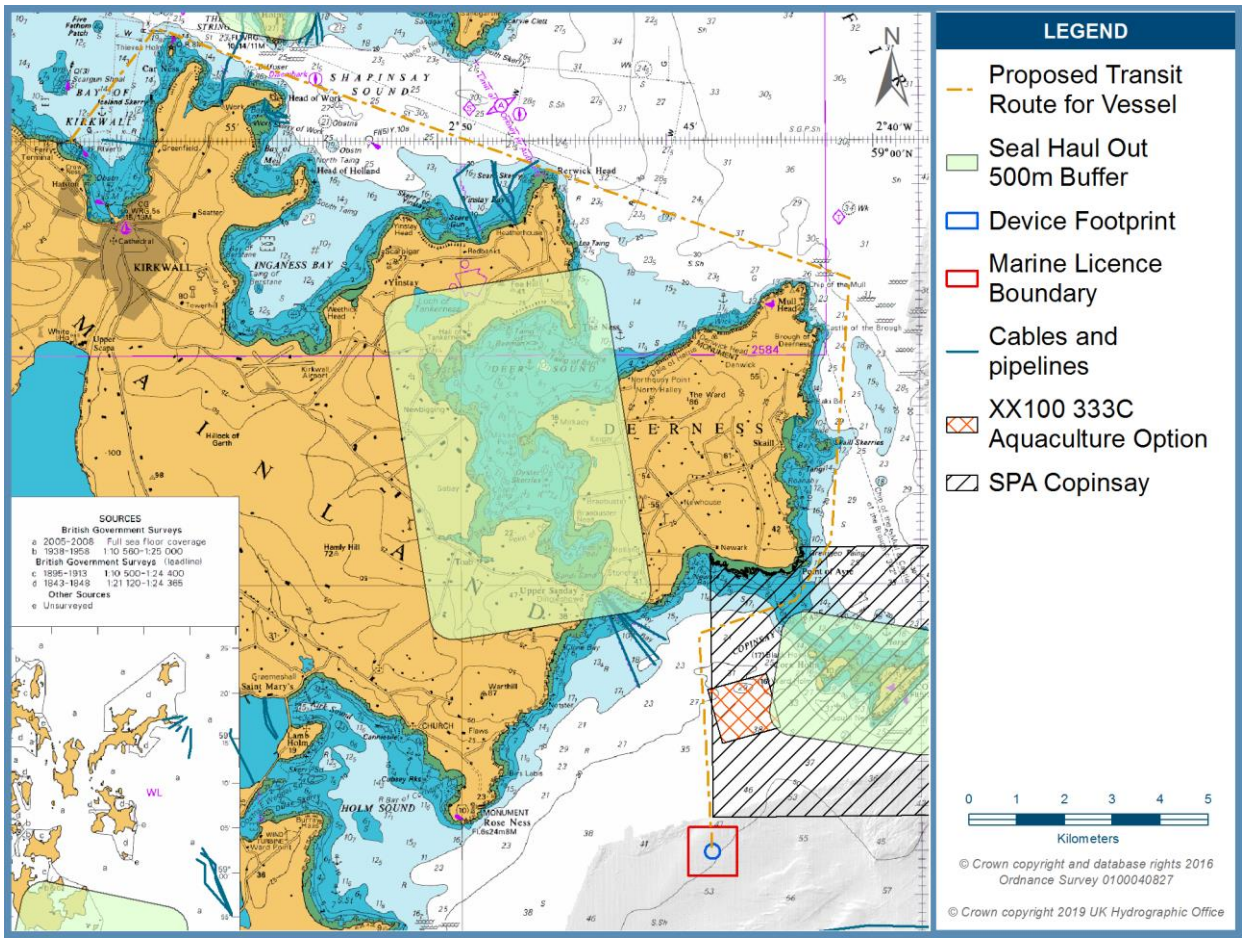
Appendix Figure B.2 Example Rib vessel

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.