



Project Title/ Location	MeyGen Tidal Energy Project, Phase 1a. Inner Sound.
Date:	31/10/2024

MeyGen Tidal Energy Project Phase 1

Project Environmental Monitoring Programme - Operations and Maintenance Phase

V9

This document contains proprietary information belonging to MeyGen PLC. and/or affiliated companies and shall be used only for the purpose for which it was supplied. It shall not be copied, reproduced, disclosed, or otherwise used, nor shall such information be furnished in whole or in part to third parties, except in accordance with the terms of any agreement under which it was supplied or with the prior consent of MeyGen PLC. and shall be returned upon request.



MEY-1A-70-HSE-018-I-PEMP

Project Environmental Monitoring Programme

PEMP Versions

Rev	Prepared	Sign Off	Checked	Sign Off	Approved	Sign Off	Date of Issue	Comments
1	Ed Rollings, Cara Donovan, Chris Eastham		David Taaffe		Ed Rollings		27/06/2016	MEY-1A-70-HSE-018-I-PEMP
2	Ed Rollings, Cara Donovan, Chris Eastham		David Taaffe Stephen Ward Martin Dunn		Ed Rollings		08/08/2016	MEY-1A-70-HSE-018-I-PEMP
3	Ed Rollings, Cara Donovan, Chris Eastham		Stephen ward		Ed Rollings		21/09/2016	MEY-1A-70-HSE-018-I-PEMP
4	Ed Rollings, Cara Donovan, Chris Eastham		Stephen ward		Ed Rollings		21/10/2016	MEY-1A-70-HSE-018-I-PEMP
5	Cara Donovan,		Stephen ward		Ed Rollings		20/12/2016	MEY-1A-70-HSE-018-I-PEMP
6	Cara Donovan,		Stephen ward				22/02/2017	MEY-1A-70-HSE-018-I-PEMPV6
7	Cara Donovan						13/12/2019	MEY-1A-70-HSE-018-I-PEMPV7
8	Fraser Johnson		Cara Donovan		Mark Evans		XXX /2023	MEY-1A-70-HSE-018-I-PEMPV8
9	Fraser Johnson		David Taaffe		Fraser Johnson		31/10/2024	MEY-1A-70-HSE-018-I-PEMPV9

1 CONTENTS

Executive Summary 4

1 Introduction.....6

2 Scope of The Project Environmental Monitoring Programme.....8

2.1 Current operational project status.....8

3 PEMP Contributors 12

4 Communication, Roles and Responsibilities 14

4.1 Responsibility and Ownership 14

4.2 Dissemination of Information 14

5 Monitoring System 15

6 Fine Scale interaction of Seals 20

7 Data Management and Reporting 21

7.1 Data Storage 21

7.2 Reporting 21

8 Monitoring Summary..... 22

9 Lessons Learned 25

10 Licences and Legal Requirements..... 28

11 Linkages with Other Conditions 29

12 PEMP Review and consultation 31

13 list of abbreviations 32

Appendix A: Condition 12 of Section 36 consent..... 33

EXECUTIVE SUMMARY

This Project Environmental Monitoring Programme (PEMP) has been prepared by MeyGen Limited (MeyGen) to set out the proposed method for discharging the Condition 12 of the Section 36 Consent for Phase 1 of the Development.

The document details:

- Data collection and monitoring methods conducted for the 1st operational Phase of the Development, Phase 1, and;
- How communication will be maintained between MeyGen, the Advisory Group (established in accordance with Condition 13) and the Regulators.

This initial phase of the development is referred to as Phase 1, consisting of 4 x 1.5MW tidal turbines having single rotors with a diameter of 18m.

The PEMP is submitted to the Scottish Ministers for their approval in consultation with, NatureScot (NS), the MeyGen Advisory Group and any other ecological, or such other advisors as required at the discretion of the Scottish Ministers.

The progress of the monitoring activity and subsequent analytical results derived from data collected will be shared with the Advisory Group to inform decisions relating to subsequent stages of the Development.

This revision of the PEMP (V9) has been generated as an update to the activities referenced in V4 dated 21 October 2016, approved by MD-LOT in correspondence from Roger May dated November 2016. This revision includes a significant revision of the monitoring activities achieved, providing a program for anticipated publication of research manuscripts.

The objective of the monitoring systems has been to provide a data set that captures the interactions between marine animals, seabirds and a tidal turbine to inform collision risk modelling. Where the machine can be considered utility scale, having a rotor diameter which presents a sizeable blockage to transiting marine fauna.

Due to the novelty of the application the monitoring program has required state of the art approaches to the collection of information on fine scale interactions between marine animals and a utility scale tidal turbine. This has incorporated industry standard passive acoustic and active sonar with the data sets recorded being post processed using bespoke software tools.

The potential of the results derived from the data that has now been collected will depend on the quality of the field data and its analysis. It can be reported that researchers at the Sea Mammal Research Unit (SMRU) begun to compile a robust database of encounters from over 11,000 targets collected during 12 months of near continual recording.

The ultimate objective for this work is to:

- Quantify the behaviour of marine fauna interacting with a utility scale tidal turbine, , to inform the definition of appropriate collision avoidance rates, and in doing so reduce the uncertainty

associated with blade strike and subsequent mortality of protected species, and;

- Use the data as input into encounter rate models for marine species passing in close proximity to a turbine with an 18m rotor located within the Inner Sound of the Pentland Firth.

The realisation of relevant parameters for use in Collision Risk Models developed by the Scottish Regulators will provide a means to quantify the risk to which marine animals are exposed from utility scale tidal turbines.

PEMP V8 issued for review in March 2023 provided details on the deployment of the HiCUP MKII environmental monitoring platform in May 2022. This draft, V9, was re-issued after consultation as it was not possible to address many of the comments provided in consultation of V8 as they largely related to data analysis activities not then established as they were reliant on the quality of the data set achieved.

This issue of the PEMP, V9, has been re-drafted with provisional observations output from SMRU now that the quality of the data set is known and some certainty about the a time line for the publication of results is known.

1 INTRODUCTION

The MeyGen Tidal Energy Project Phase 1 (“the Development”) received consent under Section 36 of the Electricity Act 1989 from the Scottish Ministers 9th October 2013 (“the S.36 Consent”). A Marine Licence (ML) was also received on the 31st January 2014. Variations to s36 and ML were sought to reflect the as-built layout in Figure 1, and provide a operational frame work for the operation of large scale tidal array.

The As Built Infrastructure, Inner Sound, Pentland Firth is shown in Figure 2 and Figure 3.

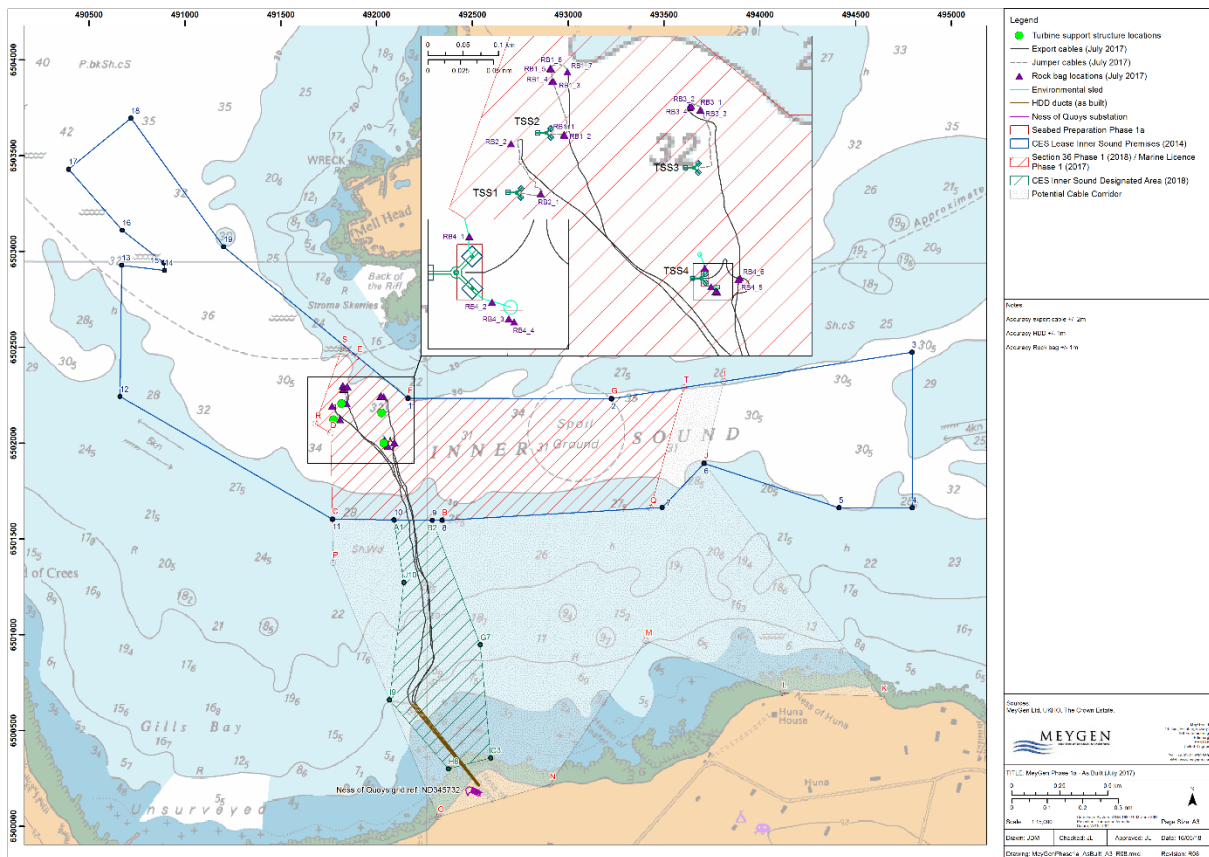


Figure 1 – Marine Licence and S36 Boundary Adjustments

The Project Environmental Monitoring Plan (PEMP) is prepared to enable Condition 12 of the S.36 Consent (“the Condition”) to be discharged. The Marine Licence also refers to the PEMP, but only in relation to the Ecological Clerk of Works (ECoW). The full text of Condition 12 is included in Appendix A. The four main parameters to be monitored include:

- a) *Hydro dynamics / benthic surveys, export cable route and turbine locations and modelling to validate EIA predictions;*
- b) *Collision / encounter interactions with the tidal turbines for diving birds, marine mammals and fish of conservation concern;*
- c) *Disturbance and displacement of birds, marine mammals and basking sharks during*

construction and operation. This must also link to the species protection plan for seals at haul outs; and

d) Migratory salmonids

A Monitoring Steering Report (MEY-1A-54-REP-01-D-SteeringReport v4) was produced and agreed by the Advisory Group on 23rd May 2014. This steering report provides details of the prioritisation of both receptor and potential impact, and refined the above four elements of Condition 12 to the objectives and concepts for the development of the PEMP.

The report takes the lessons learnt from previous research and identifies where current and planned research will contribute to meeting the needs of the consent conditions and wider industry questions. Bringing these together, the report recommends more specific objectives and monitoring, which have been taken forward and developed for the PEMP and are appropriate for addressing the consent condition listed in the S36 consent letter.

Updated lessons learned in the deployment of environmental monitoring platforms with respect to the activities undertaken by MeyGen are presented in section 8. The scope and objectives of the PEMP are described in Section 2. Further details are available in the Monitoring Steering Report.

The PEMP is part of a suite of documents related to the Marine Licence and S36 Consent for the Development. The S36 Consent stipulates that the PEMP must, so far as is reasonably practicable, be consistent with the Environmental Management Plan¹ (EMP) and the Vessel Management & Navigation Safety Plan² (VM&NSP). To ensure that the Development is appropriately constructed and operated, the PEMP must:

- Take into account mitigation measures to protect the environment and other users of the marine area;
- Protect the environment, and;
- Ensure appropriate and effective monitoring of the impacts of the Development.

Table 3 in Section 10 summarises the links between Marine Licence and S36 Consent conditions and the suite of documents described above.

The PEMP has been update to reflect the success or otherwise in monitoring fine scale interaction with the MeyGen turbines. As the development moves from Phase 1 with 4 turbines to Phase 2 with a 50MW array,. the scope of the project monitoring will be revised. This revision of the monitoring priorities would be considered within a revision of the Project Steering Report, with the recommendations of this report forming the bases for the scope of the PEMP relating to Phase 2.

¹ RHK-1A-40-HSE-F-002-EMPCConstructionWorks

² MeyGen Phase1A VM&NSP_O&M Phase_v4a

2 SCOPE OF THE PROJECT ENVIRONMENTAL MONITORING PROGRAMME

MeyGen is committed to safeguarding the environment through the identification, avoidance and mitigation of the potential negative environmental impacts associated with the planning, construction and operation throughout all phases of the Development.

The principal objectives of the PEMP are:

- Detect and quantify potential avoidance and collision rates for harbour seals, verify and improve the accuracy of collision/encounter rate models.
- Provide sufficient monitoring data for impact assessment to inform allow each subsequent stage of the Development to proceed.

Whilst the principal objective is to monitor harbour seals, the technology used has shown capable of monitoring other marine species, such as fish, diving birds and elasmobranchs.

The post processing of the data collected by the HiCUP MkII platform by SMRU has classify target detections by species and certainty rating, 1 to 5. Further investigation of the dataset is being analysed to provide insight into the behaviour of fish and diving birds when encountering the rotor or a tidal turbine in Idle, RPM <2, and Production, RPM ~12-14.

The Monitoring Steering Report (MEY-1A-54-REP-01-D-SteeringReport v4, Appendix B) concluded that:

- 1) Benthic and hydrodynamic impacts (Condition 12 (a)) were low priority for Phase 1 and will not be covered further. Opportunities with larger turbine arrays could be more relevant and possible in future phases of the project.
- 2) Disturbance and displacement impacts (Condition 12 (c)) were low priority for Phase 1 and would not be monitored directly. Opportunities with larger turbine arrays could be more relevant and possible in future phases of the project.

2.1 Current operational project status

The MeyGen array was commissioned in March 2018 which marked the end of the construction phase, with Phase 1 subsequently entering the operational phase. The as-built locations of the turbines are shown in Figure 3.

Maintenance activities covered under the Operations and Maintenance Programme (OMP) are controlled under the EMP. The EMP includes specific mitigation and monitoring for the disturbance of marine mammals by the associated vessels (including seals at haul-outs) as referred to in Condition 12 (c).

The Development will be operated, at all times, in accordance with the approved PEMP, to be reviewed annually and amended as required. Any updates or amendments made to the PEMP by MeyGen must be submitted, in writing, by MeyGen to the Scottish Ministers for their written approval.

In addition to the consent conditions, the PEMP must relate to the Environmental Statement (ES) and Supplementary Environmental Information Statement (SEIS) with regard to the environmental

the operational phase.

Please note this version V9 of the PEMP refers to the operational Phase 1. The monitoring requirements will continue through:

- PEMP (O&M phase V9)
- OMP

The as-built layout of Phase 1 is shown in Figure 3.

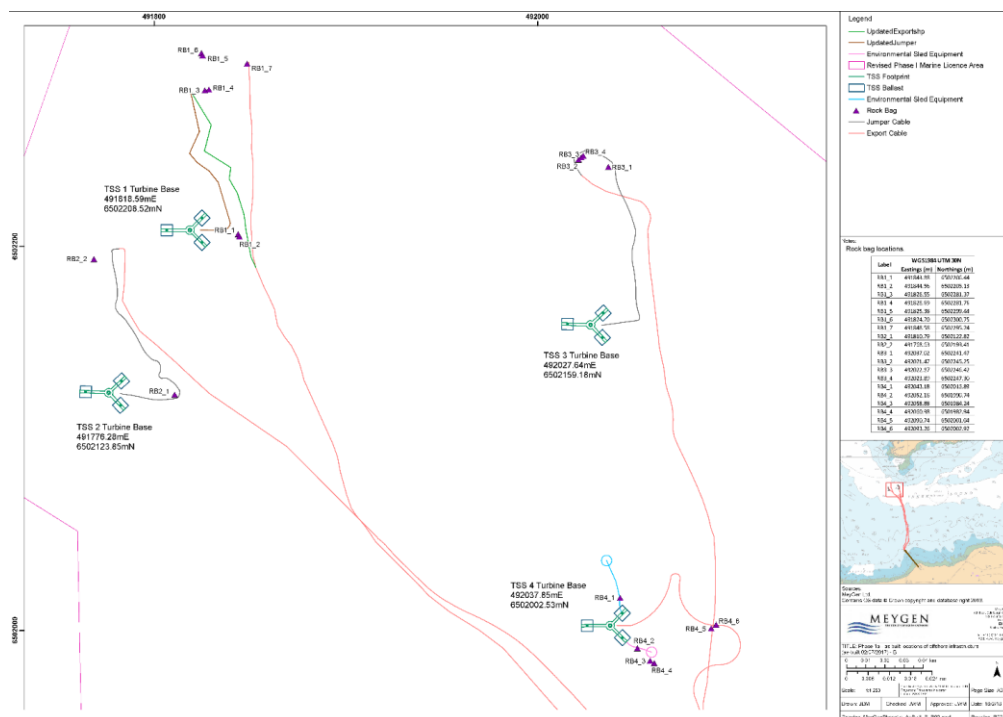


Figure 3 - Phase 1 As Built Infrastructure, Inner Sound, Pentland Firth

Previous versions of the PEMP provided details on the proposed monitoring solutions, which were deployed as part of the Phase 1 installation in 2018 and included:

- Passive Acoustic Monitoring (PAM) System:

The PAM system operated almost continuously from October 2017 to April 2019 and provided a significant amount of information on the interaction between echo locating species (mostly harbour porpoise) and the turbines. Whilst the system remains in situ (attached to the gravity based TSS) it is no longer operational.

- Telemetry:

Tagging and monitoring of harbour seals took place before installation (2011 and 2012) and during operation (2016, 2017, and 2018). This provided valuable information on the pattern of collective behaviour in response to the operational array which is detailed in the report referenced “Harbour seals avoid operational tidal turbine arrays (Onoufriou, Russell, Thompson, Moss & Hastie, 2019).

Project Environmental Monitoring Programme

- FLOWBEC:

Under a Knowledge Transfer Partnership between the University of Aberdeen and MeyGen, the FLOWBEC platform was deployed in 2015 using batteries and onboard data storage collecting a 2-week baseline dataset prior to installation of the Phase 1 turbines.

The FLOWBEC platform collected data on fish, seabirds, marine mammals, and hydrodynamic conditions using a multifrequency echosounder, multibeam echosounder, ADCP, ADV, hydrophones and trialled cameras for target validation. The FLOWBEC platform was then converted to a cabled interface, and ping scheduling was included to avoid crosstalk between the FLOWBEC and HiCUP MkI instruments.

However, upon cabled deployment to the Atlantis turbine, a power failure prevented FLOWBEC operating. The FLOWBEC platform was recovered after 21 months subsea and found to be operational, demonstrating a resilient design and deployment methodology. But highlighting the importance of end to end testing and quality control during assembly and deployment.

- HiCUP MkI:

As part of the Scottish Government Demonstration Strategy (SGDS) the HiCUP platform was deployed with the FLOWBEC platform. The platform failed to gather any meaningful data due to issues similar to those experienced by the FLOWBEC platform relating to the power supply. The platform has since been recovered.

- HiCUP MkII:

Funded by the NERC a MkII monitoring platform was designed and built by SMRU for deployment at MeyGen. The installation of the unit and wet-mate connection into a newly deployed Subsea Hub was funded by MeyGen and undertaken as part of the wider marine operations for turbine recovery and deployment.

The platform supported a PAM unit and 2 active sonar to paint a turbine facing both the Ebb and the Flood. Deployed in 2022 the unit operated from June 2022 for a period of over 12 months.

The platform ceased to operate late July 2023 and will be recovered at the next opportunity.

- Video:

Low light video cameras were mounted on TSS No. 4. However their position and field of vision relative to the rotor swept area meant that no meaningful images to inform environmental monitoring were captured.

A brief summary of the lessons learned from the historical environmental platform deployments in 2018 is presented in section 8.

3 PEMP CONTRIBUTORS

The PEMP V9 has been developed in association with:

- The Sea Mammal Research Unit (SMRU) at the University of St Andrews - researchers at SMRU have been at the forefront of the development and implementation of marine mammal monitoring systems to resolve the challenges surrounding the gathering of sufficient data in turbulent tidal sites.

SMRU have developed a revised High Current Underwater Platform (HiCUP MkII) for the Long-Term Monitoring of Fine-Scale Marine Mammal Behaviour Around Tidal Turbines which was deployed in May 2022 and is discussed in Section 6.

- Natural Environment Research Council HiCUP MkII was developed through NERC grant NE/R014639/1 "*Development of a standardised marine mammal monitoring system for the tidal energy industry*" and supported by funding under the Marine Directorate Marine Mammal Scientific Support programme (MMSS).
- Cabling between the HiCUP MkII platform and the MeyGen Subsea Hub connected to the AR1500 tidal turbine was developed and designed by MeyGen to provide a wet-mate connection with 400v power and 4 x fibre optic connection.
- The HiCUP MkII data will be analysed and presented as part of the MMSS, with results being presented at academic published and conferences.

The data gathered by HiCUP MkII aims to supplement the previous data acquired by SMRU at MeyGen by providing acoustic data capturing the fine scale behaviour of marine mammals in response to the operating turbines.

The data gathered by HiCUP MkII and reported to Scottish Government will be used by MeyGen to meet the PEMP objectives and inform the s36 consent conditions.

Whilst the principal objective is to monitor harbour seals and gain information on the occurrence and fine scale behaviour data of marine mammals around the turbines, data on other species present may also be gathered and included in a wider analysis.

Sonar images extracted from the HiCUP MkII data set show interactions with seal, diving birds, elasmobranchs, individual fish, fish schools and Skate/ray, Figure 4. While acoustic data collected by the HiCUP MkII could also be evaluated to assess the potential interactions with diving birds and fish, there are currently no resources available to conduct these analyses.

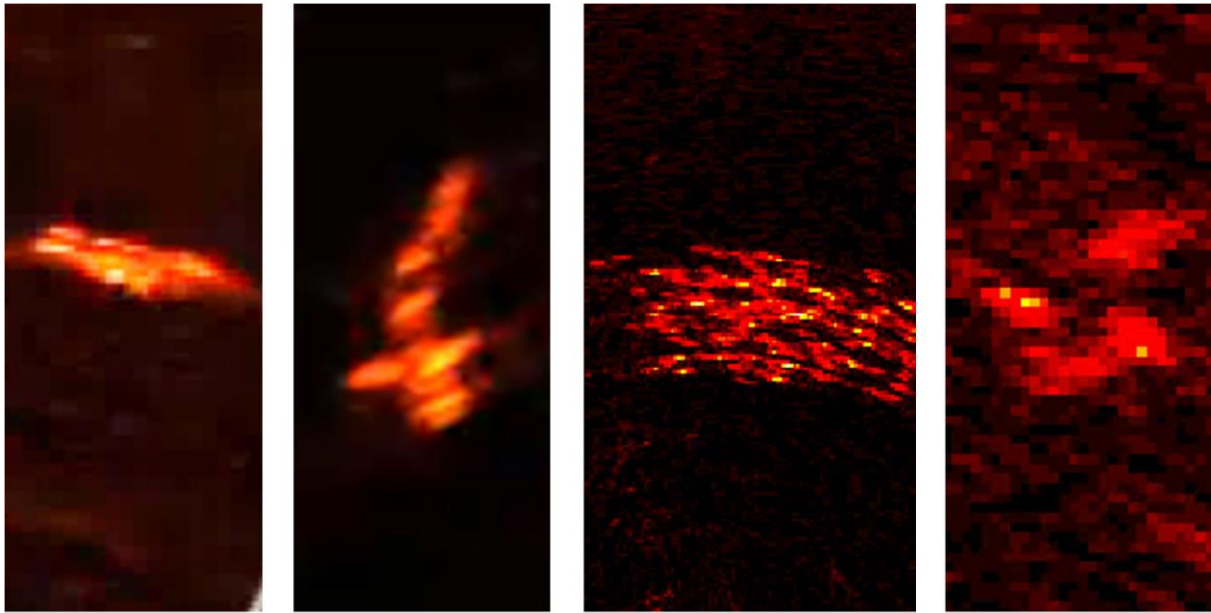


Figure 4 - Sonar images of different targets observed around the tidal turbine. From left to right: seal, shark, fish school and skate/ray

4 COMMUNICATION, ROLES AND RESPONSIBILITIES

This section details MeyGen role and responsibilities and means of information dissemination during the construction and operation of the Development.

4.1 Responsibility and Ownership

MeyGen will have the ultimate responsibility for ensuring the implementation of the PEMP. The company will manage the operations and associated activities required to deliver the PEMP objectives.

MeyGen are responsible for:

- I. Review and audit of the PEMP with subsequent , revising and reporting of proposed revisions to the Scottish ministers for approval.
- II. Collating manuscripts and technical reports for submission to the Advisory Group convened under Condition 13 of the s36.
- III. Administering the meeting of the Advisory Group as specified in Condition 13 of the s36 to permit circulation and dissemination of relevant technical information.

4.2 Dissemination of Information

As the MeyGen project is now in the operational phase, the focus is on data acquisition, analysis and reporting from the HiCUP MkII platform. Manuscripts and reports generated as part of the research into the data set produced are submitted to the MMSS under the terms of the funding. MeyGen are members of the group to which quarterly and annual reports are issued alongside the circulation of manuscripts and reports.

Subsequent circulation of manuscripts and reports, that may be confidential, can be circulated to the advisory group with the permission of the author and MMSS.

5 MONITORING SYSTEM

The monitoring system is built into a gravity mounted platform which incorporates a combination of passive and active acoustic monitoring for the detection and tracking of marine mammals around tidal turbines.

HiCUP MkII platform as deployed May 2022

The High Current Underwater Platform (HiCUP) for the Long-Term Monitoring of Fine-Scale Marine Mammal Behaviour Around Tidal Turbines comprise both; active acoustic and passive acoustic monitoring instruments.

Active acoustic monitoring (AAM) include two Tritech Gemini 720i multi-beam imaging sonars enabling the system to detect target grey and harbour seals, which rarely vocalise underwater. Techniques developed in Hastie et al. (2019b) and Hastie et al. (2019a) can be employed to detect marine mammals and determine 3D movements. This will allow the detection and 3D tracking of marine animals in close range around an operating tidal turbine and therefore increase our understanding of the potential collision risk. The HiCUP MkII data may also be used to inform on behaviour of ; large fish (>0.2m), schools of fish and diving birds. The Tritech system was originally selected over that of other sonar manufacturers, because during trials seals showed no behavioral response to the Tritech sonar. The areas swept by the Tritech Gemini sonars, and examples of target tracks, are shown in Figure 9, Figure 10 & Figure 11. The sonars paint the turbine capturing an area both up and down stream of the turbine.

Passive acoustic monitoring (PAM) data is collected using a single tetrahedral cluster of hydrophones mounted close to the active sonars to detect the sounds made by vocalising cetaceans. This configuration of hydrophones provides horizontal and elevation angles of detected sounds and also aid in species identification, e.g: confirming if vocalisations are derived from porpoises or dolphin species, as well as helping to differentiate transits made by seals or cetaceans. Both PAMGuard and additional software developed for the PAM data acquisition control system are open source and freely available.

The HiCUP MkII platform is designed to be connected by umbilical cable to a subsea hub and integrated into a turbine system with an appropriate port to receive power and export data to shore. The HiCUP MkII platform is connected to the subsea hub using a wet-mate connection system specifically designed for this activity, incorporating lessons learnt from previous unsuccessful monitoring platform deployments.

The HiCUP MkII platform is provided with power from the auxiliary power supplying the turbine and uses fibre optics in the turbine export cable to relay environmental data to shore-based computers in real time.

Long-term monitoring is needed to capture and understand fine scale behaviour. By connecting into turbine array infrastructure for power and data transfer, the HiCUP MkII platform AAM and PAM systems can operate continuously.

The HiCUP MkII platform is shown in Figure 5, and the wet mate connection arrangement Figure 6.

The subsea hub with the wet-mate alignment pins and wet-mate plug are shown in Figure 7. The wet-mate connection being aligned onto the subsea hub is shown in Figure 8.



Figure 5 – HiCUP VMkII platform



Figure 6 - HiCUP MkII Platform wet-mate connector frame



Figure 7 – Subsea hub showing guide pins and wet-mate plug



Figure 8– Wet-mate connector being positioned onto the Subsea Hub

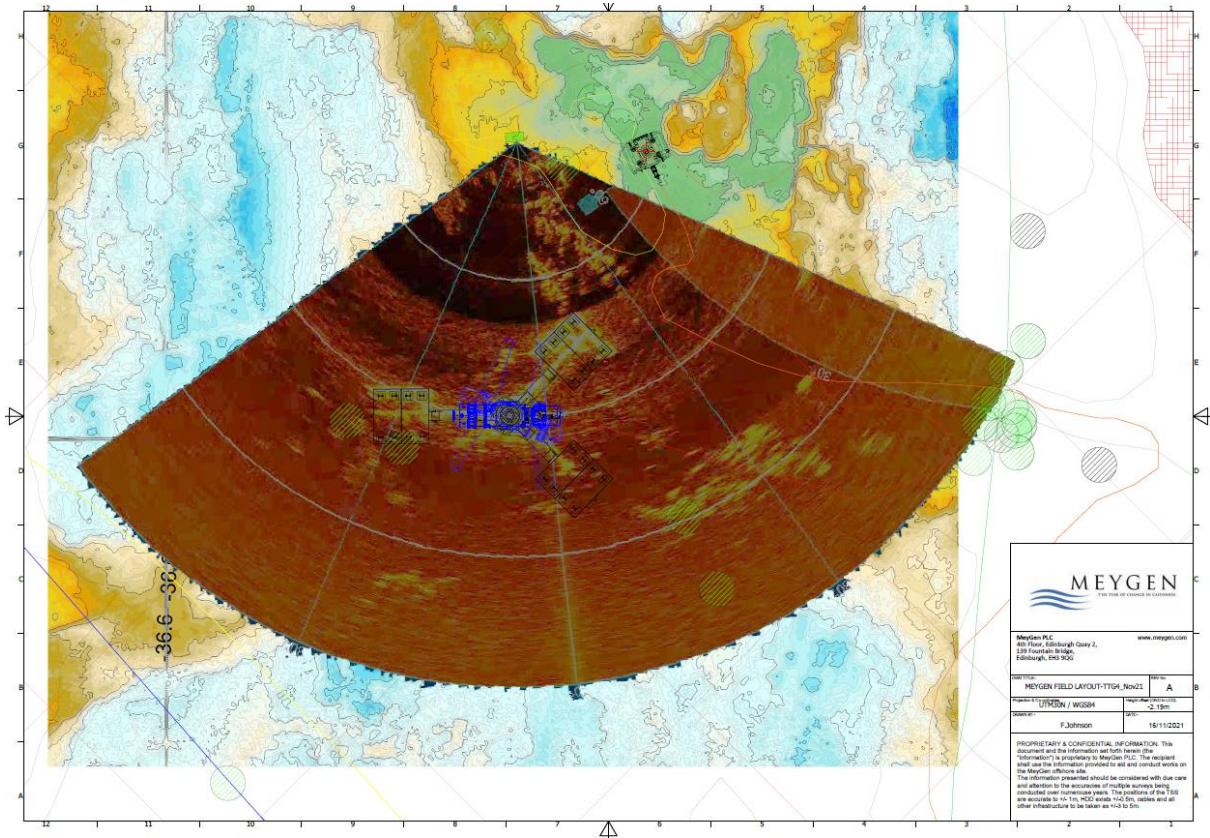


Figure 9 – HiCUP MkII AAM Gemini swept area

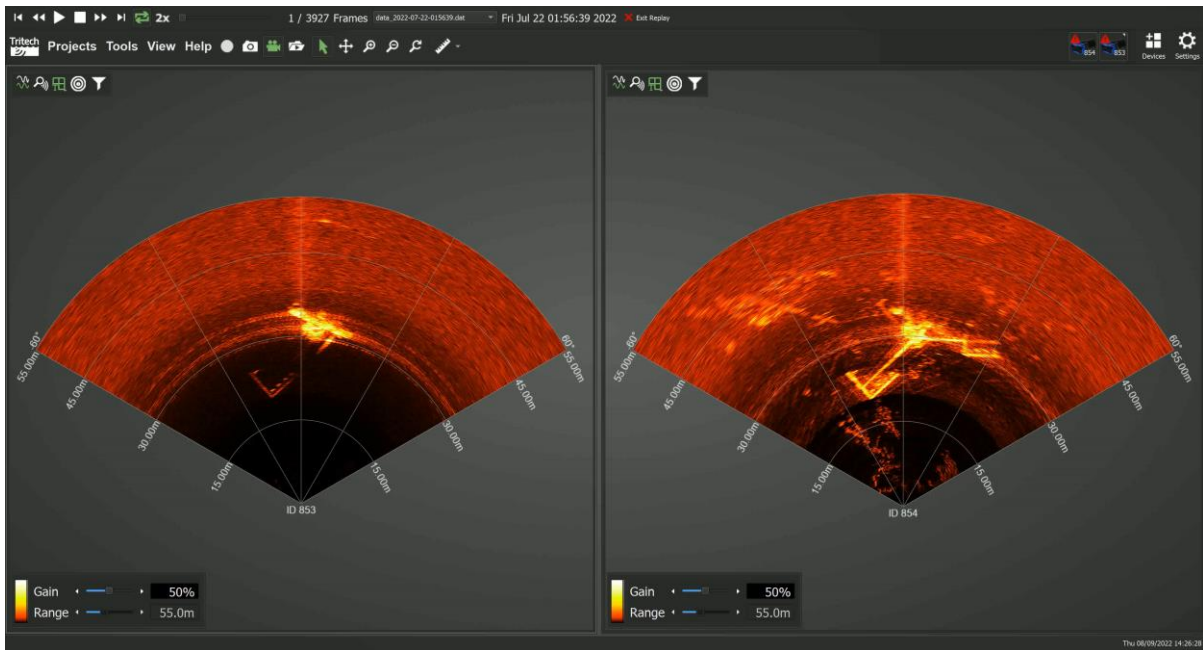


Figure 10 – HiCUP MkII AAM Gemini sonar vertical coverage, Upper right, lower left

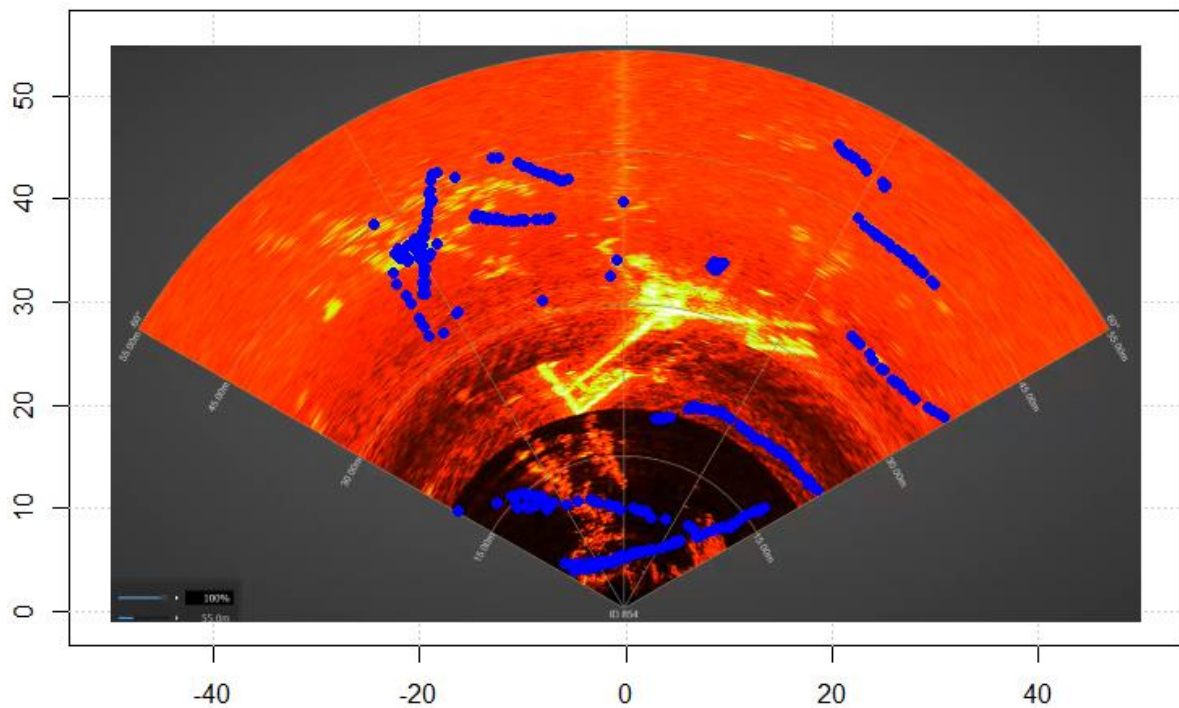
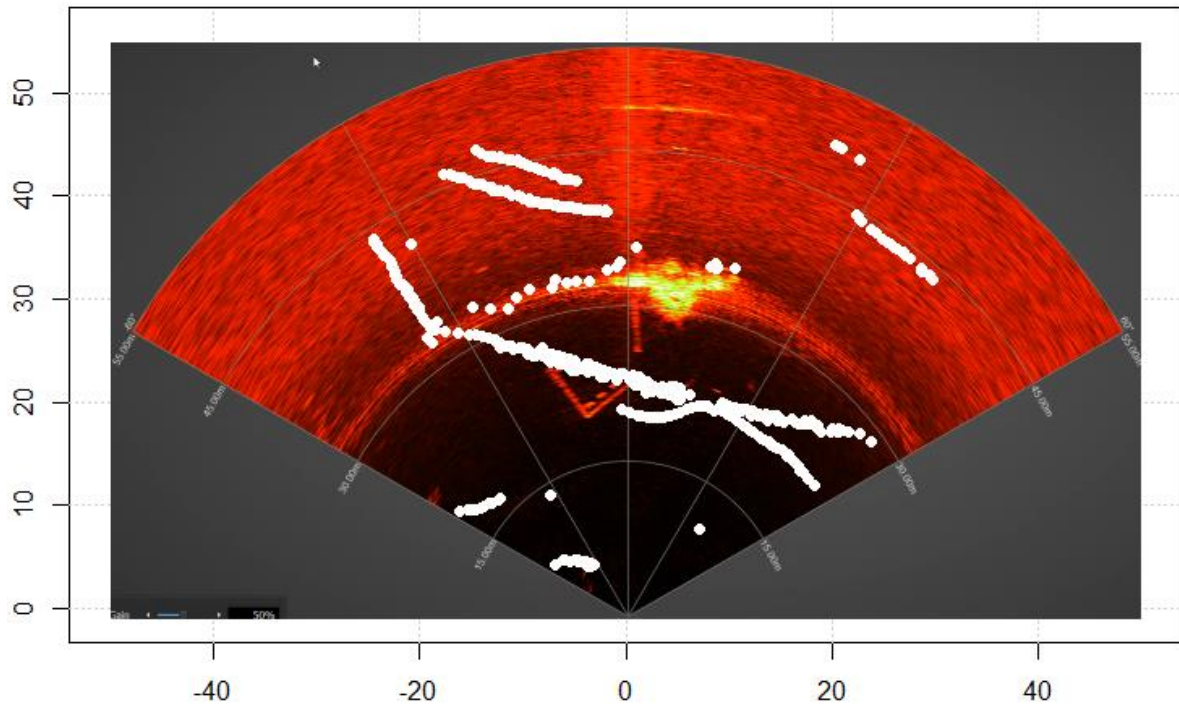


Figure 11 – HiCUP MkII AAM Sonar traces showing target tracks

6 FINE SCALE INTERACTION OF SEALS

The active sonar data obtained from the 2 Tritech Sonar mounted on the HiCUP MkII have provided an innovative insight into seal movement at a utility scale tidal turbine having an 18m rotor and an operational rotation speed of ~14RPM.

With the 12-month data set obtained having been processed is it now possible to consider a post processing methodology and list of parameters that can be output from the data.

Due to the level of noise being received by the Gemini Sonar, data has been viewed manually at 3x speed using software developed by SMRU. Target sightings have been logged in a database for inspection later. The level of noise has however affected the PAM units with the data being collected being considered unusable.

Sightings observed in the active sonar data are given a designation by species groups with the 4 main megafauna groups being Birds, Fish, Marine Mammal and Elasmobranchs. A confidence score of 1 to 5 is applied to each sighting. The time and date of the sighting allows SMRU to add flow speed to each sighting based upon data provide by MeyGen. In addition to the flow speed, turbine heading, rotor speed and power production can also be added to the data assessment matrix.

While the data can be assessed for seasonal and diurnal variations, the sonar video coupled with SMRU PAMGuard and human intervention will be able to derive further details of the fine scale interaction of sonar targets with the turbine rotor and incident flow.

It is possible to isolate individual sonar targets and assess the track for evidence of conscious avoidance or interaction with the turbine as opposed to the track of a passive object moving with the current like a smoke particle being carried along by the wind.

Based upon simple principals of vectors, it is possible to develop a database and to characterise how the seal trajectories develop as they approach and pass the turbine.

- Does the sonar trace commence up tide of the rotor plane?
- What was the original heading and speed through water?
- If this heading and speed was maintained would the course over the ground pass through the swept area of the rotor?
- Does the sonar track indicate an alteration of course or speed with respect to the tidal flow as it progresses across the field of view?

The above list will be developed in more detail by the researchers at SMRU as the data set is further assessed and their understanding of the interaction develops.

Presentation of results and methodology to the Advisory Group provides opportunity for the attending specialists to provide observations and input to subsequent assessment activities.

7 DATA MANAGEMENT AND REPORTING

7.1 Data Storage

Data collection and management from the HiCUP MkII platform, entails storing data on a dual set of external hard drives with one set being held by St Andrews University and the other remaining at the MeyGen substation at Ness of Quoy.

Approximately 10TB of data is generated per month by HiCUP MkII platform. This data is saved to the St Andrews external hard disk drives and a backup remains in the climate-controlled comms room at the MeyGen substation.

7.2 Reporting

Periodic reports issued by SMRU to the MMSS in relation to the data analysis from the HiCUP MkII can also be shared with the Advisory Group having the approval of the MMSS and SMRU. Members of the Advisory Group would be informed of any confidential nature of the content of these reports.

Manuscripts submitted to journal publications and conference presentations of the data analysis from the HiCUP MkII issued to the MMSS can also be issued to the Advisory Group prior to their publication with the approval of MMSS and SMRU. Members of the Advisory Group would be informed of any confidential nature of the content of these reports. The sharing of data from the MMSS and any other relevant source to the members of the Advisory Group is a core objective of the Group.

The Advisory Group is required to meet annually as a minimum, with meetings held more frequently should the need require.

The member of the Advisory Group include representatives from:

- Marine Directorate – Science, Evidence, Data and Digital
- Marine Directorate – Licensing Operations Team
- Marine Directorate – Marine Planning and Policy
- NatureScot
- MeyGen PLC.
- The Crown Estate Scotland

MeyGen expect SMRU to be submitting manuscripts for review by MMSS on the ‘mid-scale’ avoidance Q3 2024 and a further manuscript presenting more detailed fine scale avoidance results Q4 2024.

8 MONITORING SUMMARY

Section 8 provides information on the proposed monitoring for each of the point mentioned in condition 12 of the s36 Consent, and for each receptor identified as presented in the Steering Report.

Section 36 – condition 12	Receptor	Proposed monitoring for Phase 1
<i>a) Hydro dynamics / benthic surveys, export cable route and turbine locations and modelling to validate EIA predictions;</i>	Marine Fauna & Fauna	Benthic surveys were not considered a high priority by the advisory group (see PEMP Steering ReportV4), and are not currently to be monitored as part of the Phase 1 PEMP activity.
<i>b) Collision / encounter interactions with the tidal turbines for diving birds, marine mammals and fish of conservation concern;</i>	Marine mammals	The HiCUP MkII Platform was designed to primary detect the presence of marine mammals in order to describe fine-scale movement in proximity to the operational turbine. The data set recorded by the HiCUP MkII recorded over 9000 individual fish, over 5000 fish schools, over 250 diving birds and more than 5 harbour porpoises. Funding is being sought to permit the detailed assessment of this industry leading data set.
	Diving birds	
	Fish	
<i>c) Disturbance and displacement of birds, marine mammals and basking sharks during construction and operation. This must also link to the species protection plan for seals at haul outs; and</i>	Birds	Tagging of black guillemot and shag (considered to be the two key bird species from the ES) to investigate disturbance and displacement, was discussed by the Advisory Group. The ES considered that disturbance and / or displacement to seabirds would be unlikely to have a significant impact for the entire 61 turbine array . Four turbines have been deployed to date, it is even less likely that there will be any significant disturbance and / or displacement. Therefore, this aspect of monitoring was not considered a high priority in the PEMP Steering Report.

Project Environmental Monitoring Programme

Section 36 – condition 12	Receptor	Proposed monitoring for Phase 1
	Marine mammals	The seal tagging work aims to provide information on potential disturbance and displacement of harbour seals. The proposed monitoring equipment, such as active acoustics, PAM, and the cameras, may provide some information on the disturbance and displacement of marine mammals in close proximity to the turbines.
	Basking shark	<p>Very low numbers of basking shark were recorded during the site surveys. It was considered, therefore, that monitoring of this species for disturbance and displacement is a low priority. However combined monitoring equipment, including active acoustics and cameras, will enable collision risk monitoring of Basking sharks. The HiCUP MkII recorded over 70 Elasmobranchs.</p> <p>Funding is being sought to permit the detailed assessment of this industry leading data set.</p>
	Seals	The seal tagging work provides some further information on seal behaviour in the wider area. Seal haulouts in the Pentland Firth and Orkney were surveyed during the August moult by SMRU in 2013, 2015 and 2016. Future monitoring plans of seal haulouts will be confirmed by the Special Committee on Seals (SCOS).
d) <i>Migratory salmonids</i>	Atlantic salmon	AAM may provide some information on the behaviour of fish schools in close proximity to the tidal array. However species identification is unlikely via sonar data alone.

Project Environmental Monitoring Programme

Section 36 – condition 12	Receptor	Proposed monitoring for Phase 1
		<p>It is considered that the most appropriate way to improve our knowledge regarding the behaviour of migratory Atlantic salmon in the Pentland Firth and Orkney waters, would be through strategic research, which would benefit not just MeyGen but the wider marine renewables industry.</p> <p>The data set recorded by the HiCUP MkII recorded over 9000 individual fish, over 5000 fish school. Funding is being sought to permit the detailed assessment of this industry leading data set.</p>

9 LESSONS LEARNED

The lessons learned from the historical deployments of FLOWBEC and HiCUP platforms were channelled into the design process for the NERC Platform, including those shown in Table 1.

Table 1 - Lessons learned from previous deployments

Issue	Solution
<p>Cross-communication between monitoring devices and interference with results</p>	<p>The original concerns about cross communication and interference were mainly in relation to the presence of the EK60 echosounder on the FLOWBEC platform, however the FLOWBEC platform has been retrieved. There is the possibility for the AAM output to result in false positives in the PAM data, but these would be easily detected and removed from the data during the processing and analysis.</p> <p>Cross talk on the HiCUP MkII device was experienced with the sonar signals saturating the PAM receivers. The presence of the cross talk was identified manually.</p> <p>Searching of the PAM data is carried out automatically using PAMGUARD software. This software can search for acoustic signatures characteristic of specific vocalising species, and disregard other signals. As a routine, a sample of detections is screened manually to confirm that they are consistent with outputs from the target species. The probability that the output from the active acoustic instrumentation would be sufficiently similar to the bioacoustic outputs of target species is very low.</p>
<p>Disturbance of target species by monitoring equipment resulting in flawed data</p>	<p>The monitoring system uses a dual Tritech Gemini active sonar system to track seals around the operating turbine. It is critical that animals do not exhibit aversive movement responses to the active sonars, potentially leading to conflation of seal behaviour responses to the AAM sonar and to the turbines.</p> <p>Although the Tritech sonar has a fundamental frequency (720 kHz) well above the hearing range of seals. Lower frequency components are also produced (Cotter et al. 2019; Hastie et al. 2019b). However, these lower frequency components appear relatively low in amplitude and previous behavioural work suggests that there are no overt responses by seals to the Tritech sonar (Hastie 2012; Hastie et al. 2019a; Hastie et al. 2019b).</p> <p>Recordings made during our development work showed that the newer model of the Gemini (720is) that will be used for monitoring</p>

	<p>has a 'CHIRP' setting that has a different acoustic output compared to older models. This led to concerns about potential audibility of the newer model by seals. Importantly however, the CHIRP mode can be disabled and comparisons of the acoustic outputs between models when the settings are standardised suggest that there are no marked differences in acoustic output. SMRU are therefore comfortable that the new Gemini model does not represent any greater risk in terms of audibility.</p>
<p>Cathodic protection resulting in corrosion issues</p>	<p>Zinc Anodes have been added to the NERC platform based on the following:</p> <p>Calculations were taken from 2 different websites:</p> <ul style="list-style-type: none"> • https://www.katradis.com/anodes/calculations • https://www.boatzincs.com/anode_weight_calculation.html <p>using a surface area of 30 m² and a design life of 3 years.</p> <p>The katradis calculations specified a total anode weight of 5kg.</p> <p>The boatzinc calculations specified a total anode weight of 50kg</p> <p>The large difference is due to the current density value assumed by each site. Current density is primarily a function of the water's flow rate and the quality of the metal's protective paint coating, with different values suggested for different conditions. To remain conservative, 50kg of zinc anode will be used.</p>
<p>The transfer of data from the platform to land and the storage of this data</p>	<p>The HiCUP MkII platform is provided with power from the auxiliary power supplying the turbine and uses fibre optics in the turbine export cable to relay environmental data to shore-based computers in real time</p> <p>Data management will entail a dual set of external hard drives with one set being held by St Andrews University and the other remaining at the MeyGen substation at Ness of Quoy.</p> <p>About 10TB of data is generated per month by HiCUP MkII platform, which is saved to the St Andrews external hard disk drives and a backup is made to remain in the MeyGen substation</p>
<p>End-to-end testing of the hardware and software to ensure compatibility and resilience given the</p>	<p>Onshore end to end testing should be conducted as part of the system FAT prior to deployment</p>

Project Environmental Monitoring Programme

<p>turbulent operating tidal environment</p>	
<p>Testing of the platform once the umbilical cable has been connected to the subsea hub, but prior to the deployment of the environmental platform to confirm that the system is fully functioning</p>	<p>Where practicable remove the use of multiple voltage supply levels, i.e. all outputs to be 400v, to remove the risks of incorrect wiring.</p> <p>Test the voltage being delivered prior to sled being connected offshore.</p> <p>The HiCUP MkII Platform will be powered up on deck after the umbilical cable has been connected, and before sled deployment.</p>
<p>Collection of data from an operational tidal turbine.</p>	<p>After several technical challenges, the data set collected from the HiCUP MkII platform has provided never observed interactions between a tidal turbine rotor over an extended duration.</p> <p>The work conducted by SMRU and MeyGen has moved the state of the art from reliance upon short term battery powered deployments to the collection of long-term continual data sets.</p> <p>Future platforms will learn from the achievements of this groundbreaking work to improve the quality and extent of the data collected. But this will only be possible due to the demonstration of the collection method successfully trailed at MeyGen.</p>

10 LICENCES AND LEGAL REQUIREMENTS

The licence and legal documentation associated with the Development and pertinent to the PEMP are listed in Table 3 below:

Table 2 - Licences

Licence / Consent	Legislation	Granted	Expired
Section 36 Consent	Electricity Act 1989	09/10/2013	
Marine Licence (04577/14/0)	Marine (Scotland) Act 2010	31/01/2014	Superceded by 04577/15/0
Marine Licence (05647/15/0)	Marine (Scotland) Act 2010	04/09/2015	
Marine Licence (06045/16/0)	Marine (Scotland) Act 2010	19/07/2016	
Marine Licence (04577/16/0)	Marine (Scotland) Act 2010	29/07/2016	Superceded by 04577/17/0
Marine Licence (06102/16/0)	Marine (Scotland) Act 2010	25/10/2016	25/10/2018
Marine Licence (06182/16/0)	Marine (Scotland) Act 2010	04/11/2016	05/01/2017
Marine Licence (06234/17/0)	Marine (Scotland) Act 2010	18/01/2017	
Marine Licence (06446/17/0)	Marine (Scotland) Act 2010	15/08/2017	14/08/2018
Decommissioning Programme	Energy Act 2005	Submitted	
Marine Licence (06978/19/0)	Marine (Scotland) Act 2010	01/10/2019	Subsea Hub
Marine Licence (04577/15/0)	Marine (Scotland) Act 2010	17/09/2015	MeyGen Array. Superceded by 04577/16/0
Marine Licence (04577/17/1)	Marine (Scotland) Act 2010	11/09/2017	MeyGen Array Revised Boundary. Superceded by 04577/17/1
Marine Licence (04577/17/1)	Marine (Scotland) Act 2010	11/09/2017	MeyGen Array
MS-00009802	Marine (Scotland) Act 2010	06/05/2022	Licence_Revision of ML04577-17-1
MS-00009804	Marine (Scotland) Act 2010	06/05/2022	Licence_Revision of ML06234-17-0

11 LINKAGES WITH OTHER CONDITIONS

The PEMP is part of suite of consent related documents. Table 2 lists the documents and related conditions that are relevant to the PEMP, excluding condition 12 which is clearly defined in this document.

Table 3 - Linkages with other conditions

Condition	Condition summary/Reason/stage development	Linkage and Document
S36 8	The development to be constructed and operated in accordance with the terms of the ES and SEIS.	Environmental Statement and Supplementary Environmental Information Statement
S36 9	CMS details mitigation measures to prevent adverse impacts to species and habitats during construction Reason - To ensure the appropriate construction management of the Development, considering mitigation measures to protect the environment and other users of the marine area.	CMS must, so far as is reasonably practicable, be consistent with the PEMP, EMP VMP & NSP.
S36 10	ECoW appointment from commencement of the Development until the Final Commissioning of Stage One of the Development	Ensuring all works are carried out in accordance with the CMS, EMP, PEMP, VMP & NSP. ECoW will cover reporting on installation of monitoring equipment in line with CMS, EMP, VMP, NSP. Reporting on PEMP data, results and objectives will be the responsibility of the Head of Environment and Consents.
S36 11	EMP covers monitoring through ALL stages of the Development Reason - In the interests of protecting the environment.	Environmental Management Plan (EMP) must, so far as is reasonably practicable, be consistent with any relevant monitoring requirements during construction taken from the PEMP. The EMP details measures through all stages of the Development, to prevent adverse impacts including, but not limited to, marine mammals, birds, fish, and habitats as outlined in Chapter 25 of the Company's Environmental Statement.
S36 13	Establish an Advisory Group Reason: to ensure effective research and monitoring is undertaken and to review the objectives, outputs, and timescales of the monitoring programme The AG will be in place throughout ALL phases of the Development	The AG will provide advice on and oversee the EMP and PEMP.
S36 14	Submit a Vessel Management Plan. Reason: to minimise the disturbance to seal haul outs, marine mammals, and basking sharks as well as consideration of mitigation measures for corkscrew injuries to seals VMP applies to the construction and operation of the Development	Vessel Management Plan (VMP) must, so far as is reasonably practicable, be consistent the PEMP, EMP, CMS & NSP.
S36 15	Submit an Operations and Maintenance Programme Reason: to mitigate the impacts of operations and maintenance and to fully inform any mitigation and monitoring requirements for natural heritage interests. OMP applies to operation phase of the Development	Operations and Maintenance Programme (OMP).
S36 16	Reporting Protocol for the Discovery of Marine Archaeology. Applies to ALL phases of the Development	Within the Environmental Management Plan (EMP)
S36 17	Submit a Navigational Safety Plan Reason: in the interest of safe navigation	Navigational Safety Plan (NSP)
MS-00009802 Licence_Revision of ML04577-17-1		
ML 3.1.2	Notification of Vessels	Requirement covered in Construction Method Statement (CMS) Vessel Management Plan (VMP)
ML 3.1.9	Environmental Protection	EMP and PEMP

Project Environmental Monitoring Programme

ML 3.2.2.1	Shielding or burial of cables EMF Best Practice Report	Requirement covered in EMF Best Practice Report
ML 3.2.2.3	Marine Pollution Contingency Plan	Requirement covered in Environmental Management Plan
ML 3.2.2.4	Notification of Commencement	Requirement covered in Construction Method Statement
ML 3.2.2.5	ECoW applies to installation and commissioning	Ensuring all works are carried out in accordance with the CMS, EMP, PEMP, VMP & NSP. ECoW will cover reporting on installation of monitoring equipment in line with CMS, EMP, VMP, NSP. Reporting on PEMP data, results and objectives will be the responsibility of the Head of Environment and Consents.
ML 3.2.2.6	Promulgation of navigation warnings	Requirement covered in Navigation Safety Plan
ML 3.2.2.7	Marine Mammal Observer	Requirement covered in Environmental Management Plan
ML 3.2.2.8	Cable Installation Plan	Requirement covered in Construction Method Statement
ML 3.2.2.9	Cable Protection Plan	Requirement covered in Construction Method Statement
ML 3.2.2.11	Communications Plan	Requirement covered in the Vessel Management Plan
ML 3.2.3.1	Transport Audit Sheets	Requirement covered in Construction Method Statement
ML 3.2.3.2	Notification of Deposits	Requirement covered in Construction Method Statement

Table 2 shows how the PEMP sits with the other project plans during the different stages of the project.

Table 2 - Project plans during each stage of the development process

Stage of development	EMP	PEMP	OMP	CMS	VMP & NSP	EMF	DP
Pre-construction	Yes	Yes	No	No	Yes	No	No
Construction	Yes	Yes	No	Yes	Yes	Yes	No
Operation & Maintenance	Yes	Yes	Yes	No	Yes	Yes	No
Decommissioning	Yes	Yes	Yes	No	Yes	Yes	Yes

12 PEMP REVIEW AND CONSULTATION

Under Condition 12 of the s36 Consent the PEMP will be submitted for approval by the Scottish Ministers, in consultation with NS and any other ecological advisors, or such advisors as the Scottish Ministers require.

Any changes the PEMP deemed necessary (working methods or procedures) must be submitted for approval to the Scottish Ministers (as outlined in Figure 12) and reviewed by the Scottish Ministers, NS and the Advisory Group. Any amendments to the PEMP must be approved by the Scottish Ministers.

The PEMP is to be reviewed annually by the Scottish Ministers, at timescales to be determined by the Scottish Ministers, in consultation with NS and the Advisory Group. Following such review, the Scottish Ministers may, in consultation with NS and the Advisory Group, require the PEMP to be amended for the approval of Scottish Ministers, in consultation with NS and any other ecological, or such other advisors as required at the discretion of the Scottish Ministers.

In addition, MeyGen is to review the PEMP on an annual basis to ensure the document remains relevant to the work being undertaken and the status of the operational site. Should any amendments be necessary these should be discussed with the Advisory Group prior to submission of the revised PEMP to the Scottish Ministers for review. This annual review is to take place in September each year. Should any significant changes to the project or work being undertaken as described in the PEMP prior to the annual review, this will be discussed to determine whether an intermediate review is necessary.

The PEMP will be submitted to the Scottish Ministers for distribution to the Advisory Group.

Version control will be conducted by the revision review block on the front page of the PEMP.

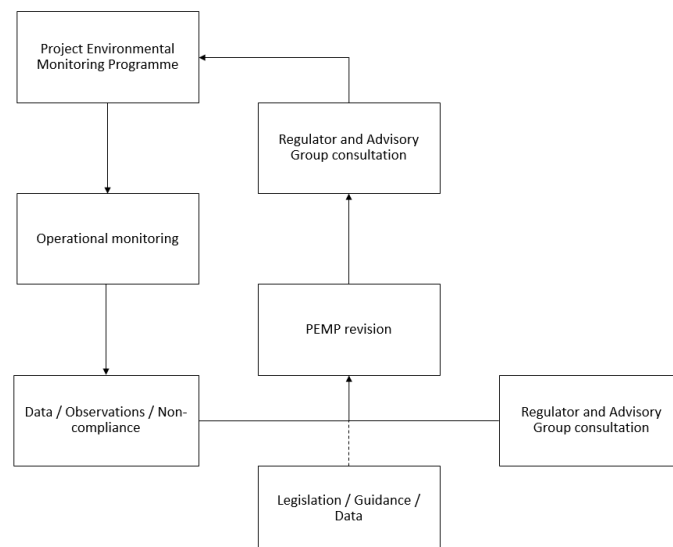


Figure 12 - PEMP Change Process

13 LIST OF ABBREVIATIONS

Abbreviation	
AAM	Active Acoustic Monitoring
AG	Advisory Group
ARL	Atlantis Resources Limited
AHH	Andritz Hammerfest Hydro
CMS	Construction Method Statement
CaMS	Cable Management System
DP	Decommissioning Programme
ECoW	Ecological Clerk of Works
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
ES	Environmental Statement
FLOWBEC	Flow and Benthic Ecology
HICUP	High Current Underwater Platform – DEPLOYED IN 2018
HiCUP MkII	High Current Underwater Platform – DEPLOYED IN 2022
NSP	Navigation Safety Plan
OMP	Operations and Maintenance Programme
ML	Marine Licence under the Marine (Scotland) Act 2010
NERC	National Environmental Research Council
PAM	Passive Acoustic Monitoring
PCUB	Power Conversion Unit Building
PEMP	Project Environmental Monitoring Programme
SEIS	Supplementary Environmental Information Statement
SMRU	Sea Mammal Research Unit
NS	NatureScot
s36	Section 36 of the Electricity Act 1989
TSC	Turbine Submarine Cable
TSS	Turbine Support Structure
TTG	Tidal Turbine Generator
UHI	University of the Highlands and Islands.
VMP	Vessel Management Plan

APPENDIX A: CONDITION 12 OF SECTION 36 CONSENT

The Company must, no later than 3 months prior to the Commencement of the Development, submit a Project Environmental Monitoring Programme (“PEMP”), in writing, for the approval of the Scottish Ministers, in consultation with NS and any other ecological, or such other advisors as required at the discretion of the Scottish Ministers. The PEMP must set out the measures of monitoring the environmental impacts of all stages of the Development, including the pre-construction, construction, and operational stages.

The PEMP must be regularly reviewed by the Scottish Ministers, at timescales to be determined by the Scottish Ministers, in consultation with NS and the Advisory Group referred to in condition 13 of this consent. Following such review the Scottish Ministers may, in consultation with NS and the Advisory Group, require the Company to amend the PEMP and submit such an amended Programme to them, in writing, for their approval, in consultation with NS and any other ecological, or such other advisors as required at the discretion of the Scottish Ministers.

The monitoring set out in the PEMP or, as the case may be, an amended PEMP, (which must be agreed by the Scottish Ministers, in consultation with NS and any other ecological, or such other advisors as required at the discretion of the Scottish Ministers), must be implemented by the Company. The Company must submit written reports of such monitoring to the Scottish Ministers at timescales to be determined by the Advisory Group. In particular, the following aspects should be considered and advice provided regarding the monitoring of the following aspects:

- a) Hydro dynamics / benthic surveys, export cable route and turbine locations and modelling to validate EIA predictions;*
- b) Collision / encounter interactions with the tidal turbines for diving birds, marine mammals and fish of conservation concern;*
- c) Disturbance and displacement of birds, marine mammals and basking sharks during construction and operation. This must also link to the species protection plan for seals at haul outs; and*
- d) Migratory salmonids*

Subject to any legal restrictions regarding the treatment of the information, the results must be made publicly available by the Scottish Ministers, or by such other party appointed at their discretion.