



Shetland Tidal Array Project Environmental Monitoring Plan (PEMP)

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1.0	30/04/2019	First draft
2.0	07/02/2020	Updated following feedback on Version 1.0 and monitoring field trials
3.0	29/05/2020	Updated following feedback from Marine Scotland, Shetland Islands Council and SNH on Version 0.2 and further field trials
4.0	30/07/2020	Final version for approval. Updated following feedback from Marine Scotland, Shetland Islands Council and SNH on Version 0.3.
5.0	16/12/2021	Updated with details of Marine Licence 00009110 issued 12/02/2021.
6.0	25/05/2022	Updated to amend monitoring reporting schedule.
7.0	17/01/2024	Updated to amend array details and monitoring methods following feedback from Marine Directorate and NatureScot.
8.0	28/08/2025	Updated to amend monitoring methods following feedback from Marine Directorate and NatureScot.

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1 Non-technical summary

Nova Innovation has produced this Project Environmental Monitoring Plan (PEMP) to describe the methods and techniques that will be employed to monitor and proactively manage the environmental effects of the Shetland Tidal Array in the Bluemull Sound near Cullivoe in Shetland (the “Shetland Tidal Array”).

The PEMP is a requirement of conditions attached to the following licences for the Shetland Tidal Array:

- Marine Licence 00009110, issued under the Marine (Scotland) Act 2010, part 4
- Shetland Islands Council (SIC) Works Licence 2023/015/WL, issued under the Zetland County Council Act 1974

Nova is committed to best environmental practice and avoiding adverse environmental effects in all aspects of its business. Therefore, in addition to being a requirement of Project licences, the PEMP and the environmental management and monitoring measures it sets out are core Project components of the Shetland Tidal Array.

The PEMP provides an overarching framework for environmental mitigation and monitoring throughout operation and maintenance (O&M) phase of the remaining three turbine in the Shetland Tidal Array, to avoid adverse harm to marine habitats and species. It sets out the measures by which Nova will gather information on interactions between marine wildlife in Bluemull Sound and the turbines in the array. In doing so, the PEMP builds on the environmental monitoring Nova has already carried out in Bluemull Sound and around the Shetland Tidal Array since November 2010. Details of how this growing evidence base will be shared with Marine Directorate Licensing Operations Team (MD-LOT) and Shetland Islands Council (SIC) are provided. Finally, the PEMP details actions Nova will take to avoid or minimise the potential risk of damage to the Scottish marine area as a result of undertaking the licensed activities.

The PEMP is an iterative, live document to be kept under constant review throughout the lifetime of the Shetland Tidal Array to ensure it remains fit for purpose. As knowledge and the evidence base grows on the environmental effects of the Shetland Tidal Array and tidal stream energy more generally, monitoring objectives and methods may evolve and change over time.

This version (8.0) of the PEMP incorporates changes to the monitoring methods to reflect the new offshore works schedule for the Shetland Tidal Array now that the Project is in O&M phase, with no further planned turbine installations. The following key change to the monitoring methodologies has been incorporated into this version of the PEMP:

1. Changes in the subsea video monitoring methodology to reflect the new offshore works schedule, to ensure that monitoring effort focuses on acquiring and analysing good quality video data.

2 Introduction

2.1 Structure and scope

The primary function of this Project Environmental Monitoring Plan (PEMP) for the Shetland Tidal Array is to meet the requirements and enable discharge of relevant conditions of Project licences. These include conditions referring specifically to the PEMP and environmental monitoring, as well as conditions to safeguard the natural environment more generally.

The PEMP is a requirement of conditions attached to the following licences for the Shetland Tidal Array:

- Marine Licence 00009110, issued by Marine Scotland Licensing Operations Team on behalf of the Scottish Ministers, under the Marine (Scotland) Act 2010, part 4
- Shetland Islands Council Works Licence 2023/015/WL, issued under the Zetland County Council Act 1974

This version (8.0) of the PEMP provides an overarching framework for ongoing environmental mitigation and monitoring during the operation and maintenance phase of the three remaining turbines in the Shetland Tidal Array, to avoid adverse harm to marine habitats and species. It sets out the measures by which Nova will gather information on interactions between marine wildlife in Bluemull Sound and the turbines in the array, with a focus on understanding the potential for collisions between diving birds and marine mammals. In doing so, the PEMP builds on the environmental monitoring Nova has already carried out in Bluemull Sound and around the Shetland Tidal Array since November 2010. Details of how this growing evidence base is shared with Marine Directorate Licensing Operations Team (“MD-LOT”), formally known as Marine Scotland Licensing Operations Team (“MS-LOT”), Shetland Islands Council and more widely are provided. Finally, the PEMP provides details of actions Nova will take to avoid or minimise the potential risk of damage to the Scottish marine area as a result of undertaking the licensed activities.

This information is structured in the following sections in this document:

Section 1: Non-technical summary

Section 2: Introduction

Structure and scope of the PEMP. Detailed requirements of Project licences of relevance to the PEMP, summary of document history and details of relationship between PEMP and other documents required under licence conditions.

Section 3: The Shetland Tidal Array

Overview of the location and technical details of the Project, with a focus on offshore components.

Section 4: Principles and objectives of environmental monitoring

Overarching principles for environmental monitoring activity to be carried out at the Shetland Tidal Array, including high-level aims and objectives.

Section 5: Subsea video monitoring methods

Objectives and methods of the subsea video monitoring using turbine-mounted cameras. Details of data retention and storage arrangements are also provided.

Section 6: Subsea video processing and analysis

Details of the use of machine learning and manual review for analysing the video footage.

Section 7: Reporting strategy

Overview of how information and outputs from the subsea video monitoring and monitoring of compliance with project licence conditions will be shared with Marine Directorate and Shetland Islands Council.

Section 8: PEMP review process

Details of the ongoing review process to ensure that the PEMP and monitoring activity remain fit for purpose.

Annex A: Shetland Tidal Array Biosecurity Plan

Annex B: Priority habitat reference cards

Annex C: Copy of Marine Licence and Shetland Islands Council Works Licence

2.2 Requirements of Project licences

Conditions of Marine Licence 00009110 and Works Licence 2023/015/WL relating explicitly to the PEMP, and environmental monitoring are detailed in Table 2-1¹. Full copies of Marine Licence 00009110 and Works Licence 2023/015/WL are provided in Annex C.

Table 2-1 Conditions of Project licences relating to the need for and scope of the PEMP.

Condition reference	Detail of condition requirement	Action undertaken or required
Marine Licence 00009110		
3.2.1.1	Nova must, within 3 months of the issue of this licence, unless otherwise agreed with Marine Scotland, submit a PEMP in writing to Marine Scotland for approval.	Various iteration of the PEMP have been shared with MS-LOT for approval over the lifetime of the Project..
3.2.1.1	Approval of the PEMP may only be granted following consultation by Marine Scotland with other ecological advisors or organisations as required. Marine Scotland must approve all methodologies for monitoring and where appropriate, in consultation.	MS-LOT consults on updated versions of the PEMP.
3.2.1.1	The PEMP must set out measures by which Nova must monitor the environmental impacts of the Works. Monitoring is required throughout the lifespan of Project where this is deemed necessary by Marine Scotland.	The process for reviewing the need for and nature of monitoring throughout the lifespan of the Project is set out in Section 8.
3.2.1.1	Monitoring must ensure that the data collected allows useful and valid comparisons between different phases of the Works. Monitoring may also verify predictions in the Application. In the event that further potential adverse environmental effects are identified, not predicted in the Application, Marine Scotland may require Nova to undertake additional monitoring.	Methods for monitoring and analysis set out in this version of the PEMP incorporate consideration of value and usefulness of the data, incorporating previous discussion with Marine Directorate, NatureScot and key technical experts.

¹ Marine Directorate and NatureScot are referred to as Marine Scotland/MS-LOT and Scottish Natural Heritage/SNH respectively in the table, as their operational names when the marine licence was issued.

Condition reference	Detail of condition requirement	Action undertaken or required
3.2.1.1	The PEMP must cover, but not be limited to, the following matters: pre-construction, construction, operation and maintenance monitoring or data collection as relevant in terms of the environmental assessment report and any subsequent monitoring or data collection for marine mammals and birds.	This version of the PEMP covers the operation and maintenance phase of the Project.
3.2.1.1	The PEMP is a live document and must be regularly reviewed by Marine Scotland, at timescales to be determined by them to identify the appropriateness of ongoing monitoring. Following such reviews, Marine Scotland may require Nova to amend the PEMP for Marine Scotland approval following consultation with ecological, or such other advisors as may be required at the discretion of Marine Scotland.	The PEMP is an iterative document which will be reviewed in line with the process set out in Section 8 to ensure monitoring continues to be useful, necessary, appropriate and proportionate. This is the 8 th iteration of the PEMP.
3.2.1.1	Nova must submit monitoring reports to Marine Scotland at timescales to be determined by them. Subject to any legal restrictions regarding the treatment of the information, results are to be made publicly available by Marine Scotland.	Monitoring reports will be submitted to MS-LOT in line with the process set out in Section 7.2.
3.2.1.1	Where appropriate and reasonable, the PEMP must take account of, and implement recommendations from, the Construction Method Statement (CMS) and any other such plans required by the terms of this licence.	The PEMP is a central repository for all measures relating to monitoring and safeguarding the environment. Cross-reference to the PEMP is provided in other plans relevant to the O&M phase of the project.
3.2.1.1	Marine Scotland may agree that monitoring may be reduced or ceased before the end of the lifespan of the Works.	The monitoring review process to ensure it continues to be useful, necessary, appropriate and proportionate is set out in Section 8.
Work Licence 2023/015/WL		
3	During the lifespan of this works licence the sea area around the array should be monitored to assess the effect of the device if any on movements of seabirds and marine mammals. The survey methodology should be agreed with Shetland Islands Council under advisement from NatureScot.	The monitoring methods set out in this PEMP and have been agreed with SIC, Marine Directorate, NatureScot and key technical experts through the iterative process of PEMP development.
3, 11	Nova must submit before installation of the sixth turbine or movement of the existing turbines a PEMP detailing activities to improve the evidence base on the environmental impact of the array. Monitoring will be used to identify risk factors for key impacts such as collision risk. Central to the PEMP will be video monitoring to observe underwater interactions of wildlife with turbines.	The PEMP was agreed and approved by SIC and MD-LOT in advance of Turbine 6 installation in January 2023.
3, 11	The PEMP will be developed and agreed in writing by Shetland Islands Council with guidance from Marine Scotland and NatureScot.	The monitoring methods set out in this PEMP and have been agreed with SIC, Marine Directorate and NatureScot. This includes agreement on the cessation of vantage point surveys and use of automated video analysis.
6	The PEMP will be adhered to. This iterative document accounts for final details within the CMS. The PEMP will take account of the CMS, phased approach and operation and maintenance aspects and provide detailed information on how environmental interest are being considered.	This document details all measures relating to monitoring, safeguarding the environment and how environmental interests are being considered.

Conditions of Marine Licence 00009110 and Works Licence 2023/015/WL relating to safeguarding the marine environment are detailed in Table 2-2. Full copies of Marine Licence 00009110 and Works Licence 2023/015/WL are provided in Annex C.

Table 2-2 Conditions of Project licences relating to safeguarding the environment.

Condition reference	Detail of condition requirement	Action undertaken or required
Marine Licence 00009110		
3.1.7	Submit all reports and notifications to Marine Scotland, as required and within time periods specified in this licence.	Environmental monitoring reports and reports on environmental conditions will be submitted to MS-LOT in line with the process set out in Section 7.2.
3.1.8	Ensure all chemicals to be utilised in the Works have been approved prior to use.	All materials to be used detailed in CMS. No hazardous substances will be utilised
3.1.9	Take precautions to prevent the unintentional release of fluorinated greenhouse gases.	No fluorinated greenhouse gases will be used at any stage in the Project.
3.1.10	Take all reasonable, appropriate and practicable steps to avoid or minimise any damage to the Scottish marine area caused as a result of the licensed activities.	Specific measures detailed in this table. Environmental sensitivities in all site briefings.
3.1.10	Ensure all personnel adhere to the Scottish Marine Wildlife Watching Code during all installation, operation and maintenance activities.	SMWWC carried by Offshore Manager during all works and onboard all vessels engaged in Works. Environmental sensitivities included in all site briefings.
3.1.10	All debris or waste material below MHWS will be removed from site.	All waste material removed from site and disposed of responsibly.
3.1.10	Ensure the risk of transferring marine non-native species to and from the Site is kept to a minimum by ensuring bio-fouling management practices are implemented.	Measures detailed in Project Biosecurity Plan (Annex A).
3.1.10	Oil-based drilling muds (if utilised) must be contained within a zero discharge system.	No oil-based drilling muds will be used at any stage in the Project.
3.2.1.2	Any breach of environmental obligations relating to the Works should be reported to Marine Scotland within 24 hours of the incident occurring.	Any breaches will be reported to MD-LOT within 24 hours.
3.2.1.3	Suitable bunding and storage facilities should be employed to prevent release of fuel oils and lubricating fluids associated with the plant and equipment into the marine environment.	Storage of fuel oils and lubricating fluids not envisaged but will be kept under review and best practice followed.
3.2.1.4	All reasonable, appropriate and practicable steps to restore the Site to its original condition before the Works were undertaken, or to as close to its original condition as is reasonably practicable, in accordance with the PEMP.	The Decommissioning Plan for T4-T6 will be agreed with MD-LOT.
3.2.2.2	Construction of the Works may not commence until the Licensee has submitted a Decommissioning Plan in accordance with Section 105 notice.	The Decommissioning Plan for T4-T6 will be agreed with MD-LOT.
3.2.2.5	Submit a Proposed Activity Form for all aspects of the Works that will produce loud, low to medium frequency (10Hz-10kHz) impulsive noise.	No loud, low to medium frequency noise will be produced by the Works. No drilling or piling to be undertaken.

Condition reference	Detail of condition requirement	Action undertaken or required
Works Licence 2023/015/WL		
Site specific conditions		
4	Siting of turbines and cables undertaken utilising visual feedback system such as a camera or ROV, to prevent placing in or on maerl or horse mussel beds.	Video surveys were conducted prior to device and cable installation using a subsea camera lowered from a survey vessel. No maerl or horse mussel beds were observed.
5	The construction method statement provided to Shetland Islands Council will be adhered to and should be cross-referenced with the Environmental Management and Mitigation Plan ² .	PEMP details all measures relating to monitoring, safeguarding the environment and how environmental interests are being considered. Cross-references to the PEMP are provided in the CMS and other relevant documents.
7	Benthic survey to identify benthic habitats or species on the recommended Priority Marine Features list prior to commencement of works to identify micro-siting of device foundations and final turbine layout/location of all infrastructure.	Video surveys were conducted prior to device and cable installation using a subsea camera lowered from a survey vessel. No sensitive habitats were observed.
8	Adherence to good practice guidelines associated with the Scottish Marine Wildlife Watching Code SMWWC (www.marinecode.org) at all times during the Works.	SMWWC carried by Offshore Manager during all works and onboard all vessels engaged in Works. Environmental sensitivities included in all site briefings.
9	Good practice measures to minimise the introduction and spread of marine non-native species, as per the Scottish Government Code of Practice and International Maritime Organisation (IMO) Guidelines.	Measures detailed in Project Biosecurity Plan (Annex A).
Standard conditions		
3	All measures considered reasonably necessary for the clearance and removal of any environmental pollution causing a nuisance, on land or ashore or in the sea, in connection the Works.	All waste material removed from site and disposed of responsibly. Any pollution incident resulting from the Project will be dealt with in accordance with the Shetland Islands Council Marine Pollution Contingency Plan ³ .

2.3 Document history

This PEMP for the Shetland Tidal Array has been developed through an iterative, collaborative process, which has included the following key components and stages:

- a. Discussion and formal consultation with MD-LOT, Shetland Islands Council, Marine Directorate Science and NatureScot, and consideration of previous advice on monitoring in Bluemull Sound.
- b. Analysis of the data gathered and lessons learnt from environmental monitoring in Bluemull Sound since November 2010 (results presented in separate reports).
- c. Discussions and input from technical experts, in particular Dr James Waggitt, marine ornithologist at Bangor University.

² The reference in Works Licence 2022/015/WL to an Environmental Management and Mitigation Plan is taken to mean Project Environmental Monitoring Plan.

³ Shetland Islands Council (2015). Shetland Marine Pollution Contingency Plan. Available at: <https://www.shetland.gov.uk/ports/contingencyplans/marinepollution.asp>

- d. Trials of new methodologies and feedback to inform evolution of design.

This iterative and collaborative approach ensures that environmental monitoring of the Shetland Tidal Array remains fit for purpose, deliverable, with a clear purpose and defined objectives.

This version (8.0) of the PEMP incorporates amendments to the monitoring methods to reflect the new offshore works schedule for the Shetland Tidal Array now that the Project is in “Operation and Maintenance” phase for the three remaining turbines. The following key change to the monitoring methodologies has been incorporated into this version of the PEMP:

1. Changes in the subsea video monitoring methodology to reflect the new offshore works schedule, to ensure that monitoring effort focuses on acquiring and analysing good quality video data.

2.4 Relationship with other documents

The PEMP takes account of and implements recommendations from other plans required under the terms of the licences for the Shetland Tidal Array. Table 2-3 sets out these other plans and their relationship with the PEMP. Nova Innovation also maintains an Excel-based record of the status of licence conditions for the Shetland Tidal Array, which is regularly shared with MD-LOT and Shetland Islands Council, to ensure that all relevant consent conditions including the submission and adherence to other plans required under the terms of the Project licences are being met.

Table 2-3 Details of other plans and reports required under the terms of Project licences and relationship with PEMP.

Plan or report	Details and relationship with PEMP
Annual reports on Shetland Tidal Array environmental monitoring programme	Set out the results of Nova’s programme of environmental monitoring for the Shetland Tidal Array, to meet reporting requirements. Include analysis of data, knowledge gained about the impacts of the Project and lessons learnt about the efficacy of the methodologies, to feed into ongoing review of the PEMP.
Shetland Tidal Array Construction Method Statement: EnFAIT-0322	Describes the methods and techniques that will be employed to install, operate, reconfigure and decommission the 6-turbine Shetland Tidal Array, including cables and offshore infrastructure. Includes details of all environmental mitigation and good practice measures that will be employed throughout the construction phase of the Project to protect and safeguard the environment. NB: construction phase of the Shetland Tidal Array has now been completed, with no further installations or reconfiguration of turbines planned.
Shetland Tidal Array Cable Plan: EnFAIT-0234	Describes the measures in place for the Project to ensure that all environmental and navigational issues are considered for the location and construction of the subsea cables for the Development. Includes details of all environmental mitigation and good practice measures that will be employed in relation to subsea cables throughout all Project phases to protect and safeguard the environment. NB: cables for T1-T3 have been removed. Cables for T4-T6 have been fully installed.

Plan or report	Details and relationship with PEMP
Shetland Tidal Array ERCoP Version 8.0: STA-003	Operational Phase Emergency Plan between Nova Innovation and the Maritime and Coastguard Agency. Includes details of counter-pollution measures in place for the operational Project (construction work has been completed). A separate decommissioning ERCoP covered offshore works to remove T1-T3 and associated infrastructure. This work has also been completed.
Shetland Tidal Array Navigational Risk Assessment: EnFAIT-0325	Describes the measures in place for the Project to ensure that all navigational issues are considered and hazards avoided. Includes details of measures to avoid the Project creating a navigational (and resulting environmental) hazard.
Shetland Tidal Array Operational Phase Method Statement: STA-017	Describes the methods and techniques that will be employed during the Operational Phase of the 3-turbine Shetland Tidal Array, including scheduled and unscheduled maintenance. Includes details of all environmental mitigation and good practice measures that will be employed throughout the construction phase of the Project to protect and safeguard the environment. NB: construction phase of the Shetland Tidal Array has now been completed, with no further installations or reconfiguration of turbines planned.

3 The Shetland Tidal Array

3.1 Project description

In 2016/2017 three geared 100 kW Nova M100 tidal turbines (T1 to T3) were installed in the Bluemull Sound, Shetland. In August 2020 a single direct-drive 100kW Nova M100D turbine (T4) was installed, followed by two further M100D turbines (T5 and T6) in January 2023. In April 2023 the original three M100 turbines were successfully decommissioned.

The Shetland Tidal Array now comprises the three M100D turbines (T4-6) and has transitioned to a fully operational and maintenance (O&M) phase. No further installation or reconfiguration of turbines is currently planned.

The improved reliability of the three direct drive turbines now operating means that scheduled maintenance intervals are likely to extend to a minimum of two years for all remaining turbines in the Shetland Tidal Array.

3.2 Project location

The Shetland Tidal Array is situated in Bluemull Sound, between the islands of Unst and Yell, just offshore from the Ness of Cullivoe, as illustrated in Figure 3-1.



Figure 3-1 Location of the Shetland Tidal Array in Bluemull Sound, Shetland. In the final image, the general location is indicated by the red rectangle.

Figure 3-2 shows the as-installed layout of the three turbines (T4-T6) in the Shetland Tidal Array.

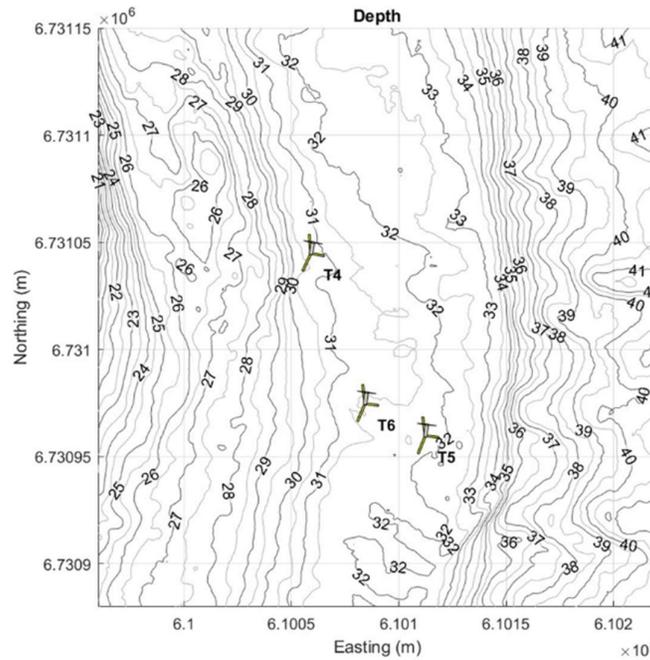


Figure 3-2 As installed location of T4-T6 in the Shetland Tidal Array, with underlying bathymetry.

Figure 3-3 shows the as-installed layout of the three turbines (T4-T6) and associated infrastructure in the Shetland Tidal Array.

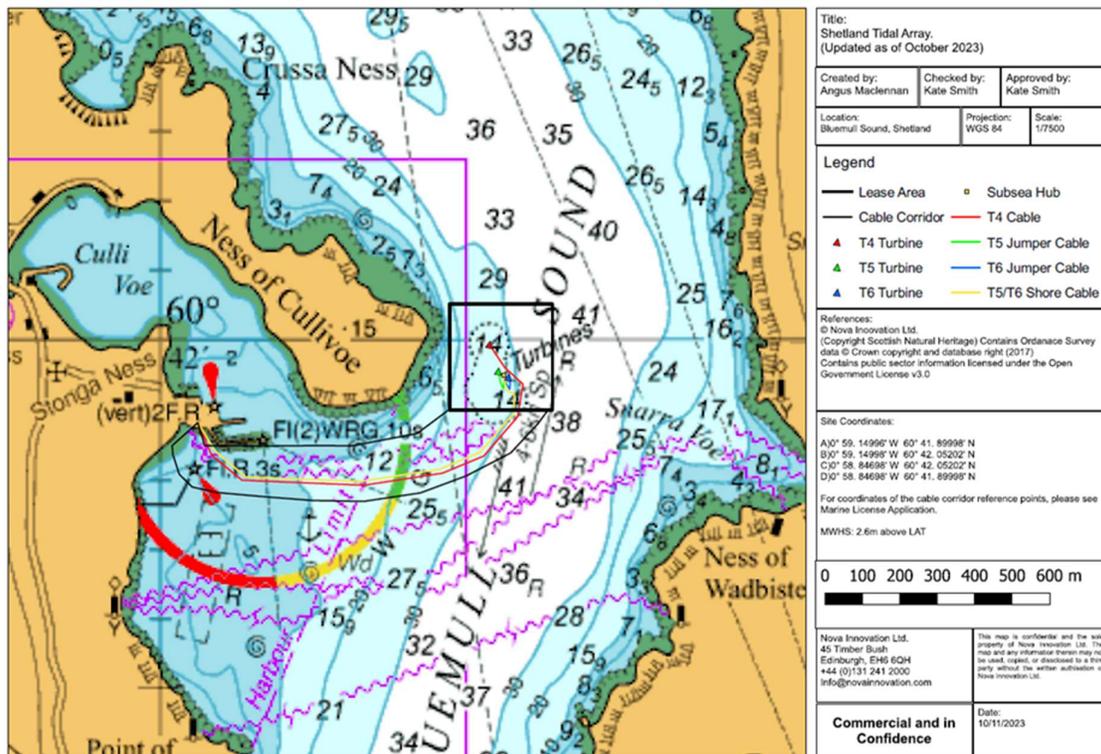


Figure 3-3 Admiralty chart showing the Shetland Tidal Array layout including turbines, hub and cables. Source: Nova Innovation 2023 © Crown Copyright

Nova has developed a tidal model for Bluemull Sound, shown in Figure 3-4.

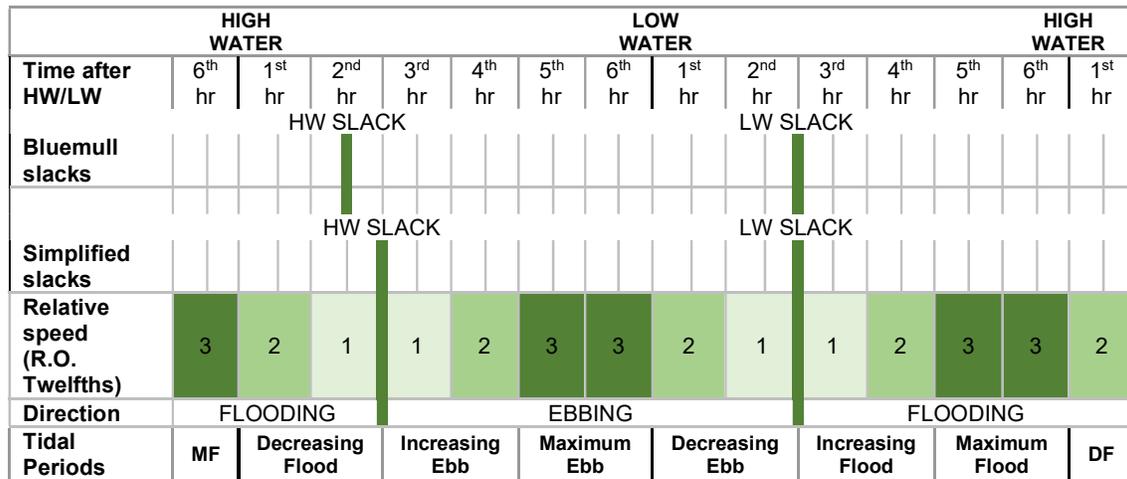


Figure 3-4 Nova’s hydrodynamic model for Bluemull Sound. Source: ©Nova Innovation 2023

This model is used in the analysis and interpretation of wildlife observation data gathered during the Shetland Tidal Array environmental monitoring programme by assigning one of six tidal categories, shown in Table 3-1.

Table 3-1 The six tidal periods in Bluemull Sound, derived from Nova’s hydrodynamic model.

Tidal period	Details
1: Increasing flood	2-4 hours after low water (LW), starts immediately after LW slack in Bluemull Sound.
2: Maximum flood	4-6 hours after LW.
3: Decreasing flood	0-2 hours after high water (HW), starts 1.5 hours before and straddles HW slack in Bluemull Sound.
4: Increasing ebb	2-4 hours after HW, starts around 30 minutes after HW slack in Bluemull Sound.
5: Maximum ebb	4-6 hours after HW.
6: Decreasing ebb	0-2 hours after LW, starts 2 hours before LW slack in Bluemull Sound.

3.3 Project environmental good practice measures

Nova is committed to best environmental practice and avoiding adverse environmental effects in all aspects of its business. Nova takes a hierarchical approach to prioritising actions to manage environmental risk, as follows:

1. Eliminate risks to the environment where possible, for example by design changes, elimination of an operation, or selection of a different working methodology.
2. Reduce the potential impact of those risks to the environment that cannot be eliminated.
3. Reduce the likelihood of those risks to the environment happening that cannot be eliminated.

Table 3-2 sets out all of the environmental mitigation and good practice measures which Nova follows to manage environmental risk for the Shetland Tidal Array, based on this hierarchical approach. Cross-references to relevant licence conditions are provided in the table.

Table 3-2 Environmental mitigation and good practice management measures for the Shetland Tidal Array. Fully discharged measures no longer relevant to the O&M phase of the Project are in italics.

Mitigation or good practice measure	Responsible person	Corresponding licence condition(s)
Minimising disturbance to wildlife during site operations		
All personnel to adhere to the Scottish Marine Wildlife Watching Code during all offshore works. Copies of the code kept at Nova offices, carried by Offshore Manager during all works and onboard all vessels engaged in Works. Included in all site briefings.	Nova Offshore Manager	Marine Licence condition 3.1.10 Works Licence condition 8
Avoidance of damage to seabed habitats and species		
All lifting equipment appropriately certified and all lifts and offshore operations appropriately risk assessed to minimise the risk of dropped objects during deployment and retrieval. MS-LOT to be notified within 24 hours in the event of a dropped object event.	Nova Offshore Manager	Marine Licence condition 3.1.10 Works Licence condition 3
Managing collision risk for marine wildlife with operational turbines		
Use of subsea video monitoring to understand interactions of marine wildlife with turbines and collision risk factors.	STA Project Manager	Marine Licence condition 3.1.10 Works Licence condition 3 & 11
Any collision events observed in subsea video footage to be reported immediately to Marine Scotland and Shetland Islands Council.	STA Project Manager	Marine Licence condition 3.1.10
Waste and pollution		
All debris or waste material (including that below MHWS) will be removed from the site at Cullivoe and disposed of responsibly (recycled where possible).	Nova Offshore Manager	Marine Licence condition 3.1.10 Works Licence condition 3
Only contractors with ISO 14001:2015 environmental management systems accreditation to be used in marine operations	Nova Offshore Manager	Marine Licence condition 3.1.10
<i>All turbine and substructure fabrication takes place with appropriate storage and pollution prevention facilities and procedures.</i>	<i>Not relevant to O&M phase</i>	<i>Marine Licence condition 3.1.10</i>
No chemicals or fuel storage on site. If situation changes, materials will be stored appropriately including use of bunding if necessary.	Nova Offshore Manager	Marine Licence condition 3.1.8, 3.1.10 & 3.2.1.3
<i>No drilling or piling to be carried out, avoiding significant underwater noise and associated impacts</i>	<i>Not relevant to O&M phase</i>	<i>Marine Licence condition 3.1.10</i>
Unexpected pollution or breaches of environmental obligations		

Mitigation or good practice measure	Responsible person	Corresponding licence condition(s)
Any accidental pollution or breaches to be reported to Marine Scotland within 24 hours.	Nova Offshore Manager	Marine Licence condition 3.2.1.2
Copy of Shetland Contingency Plan kept at Nova offices, carried by Offshore Manager during all works and onboard all vessels engaged in Works. Measures in the Plan to be followed as appropriate.	Nova Offshore Manager	Marine Licence condition 3.1.10 & 3.2.1.2 Works Licence condition 3
Decommissioning		
All reasonable, appropriate and practicable steps will be taken to restore the Site to its original condition before the Works were undertaken, or to as close to its original condition as is reasonably practicable. Detailed in T4-T6 Decommissioning Programme	Nova Offshore Manager	Marine Licence condition 3.2.1.4
Biosecurity and Invasive Non Natives Species (INNS)		
<i>Turbines and substructures will be shipped to Shetland by road rather than sea to minimise potential for transfer of INNS</i>	<i>Not relevant to O&M phase</i>	<i>Marine Licence condition 3.1.10 Works Licence condition 9</i>
Northern Isles-based vessels used for marine operations, to minimise potential for transfer of INNS	Nova Offshore Manager	Marine Licence condition 3.1.10 Works Licence condition 9
Operators used for marine operations to follow biosecurity good practice and have ISO 14001:2015 environmental management systems accreditation	Nova Offshore Manager	Marine Licence condition 3.1.10 Works Licence condition 9
<i>Turbines, substructures, cables and hub will not be deployed subsea elsewhere before deployment in Bluemull Sound.</i>	<i>Not relevant to O&M phase</i>	<i>Marine Licence condition 3.1.10 Works Licence condition 9</i>
Temporary moorings (e.g., chains) used during deployment will be sourced from Shetland or pressure washed / air dried prior to use in Bluemull Sound.	Nova Offshore Manager	Marine Licence condition 3.1.10 Works Licence condition 9
Turbines and substructures will undergo visual inspections when removed from the water. INNS ID cards to be used during inspections. Biological material is removed as standard (on Cullivoe or Belmont Pier), to avoid dangerous handling conditions. If inspections identify INNS species, care will be taken to avoid contaminated material entering the marine environment. Any INNS identified will be reported to Shetland Islands Council, Marine Scotland and Scottish Natural Heritage.	Nova Offshore Manager	Marine Licence condition 3.1.10 Works Licence condition 9

This table is held alongside all Project consent documentation in site files at Nova offices and included in the operational documentation provided to offshore contractors working on behalf of Nova. All relevant operational procedures relating to environmental protection and best practice are included as standard in site briefings for Nova personnel and sub-contractors.

4 Principles and objectives of environmental monitoring

4.1 Monitoring principles

To ensure that the environmental monitoring carried out at the Shetland Tidal Array is fit for purpose, with clear objectives, a series of monitoring principles have been agreed with Marine Directorate and Shetland Islands Council in consultation with NatureScot⁴:

- a. Monitoring will acknowledge and account for the challenges of gathering information at a small, high energy tidal site such as Bluemull Sound.
- b. Monitoring will be iterative, informed by ongoing analyses of data collected. This evaluation and feedback will inform decisions about the continuing need for monitoring its purpose, objectives and methodologies.
- c. Monitoring will be proportionate, appropriately targeted and achievable, with clearly defined objectives.
- d. Monitoring will be focussed on the key issues identified in the assessment of the environmental effects of the Project and in Project licences⁵.
- e. Monitoring will seek to reduce uncertainty about the environmental effects of the Shetland Tidal Array, with a view to ultimately 'retiring' issues and impacts.
- f. Monitoring will be designed to ensure that the data gathered are appropriate to the defined objectives and of sufficient statistical power to be fit for purpose.

4.2 Monitoring aim and objectives

In accordance with the principles above and ongoing consultation with MD-LOT, SIC and NatureScot, environmental monitoring of the Shetland Tidal Array will continue to focus on near-field interactions between marine wildlife and the turbines to improve understanding for collision risk (the main impact pathway of concern identified in the environmental assessment for the Project).

The objectives for environmental monitoring of the Shetland Tidal Array focus on gathering data to improve the evidence base on the likely nature and consequences of any near-field interactions between marine mammals and diving birds with the operating turbines, as follows:

- a. Refine understanding for and gather information on the nature and frequency of near-field interactions between marine mammals, diving birds, fish and the turbines.
- b. Refine understanding for how near-field interactions vary with turbine operation/non-operation or rotation speed (and therefore risk of collision with rotating blades).
- c. Refine understanding for (and where possible quantify) evasion behaviour of marine wildlife around the operating turbines.
- d. Identify factors influencing encounter and collision risk for marine mammals and diving birds, including:
 - i. Behaviour of mammals and birds around the turbines.

⁴ As set out in Nova Innovation (2018). Shetland Tidal Array Project Environmental Monitoring Programme (PEMP) Scoping Document, pp28.

⁵ Nova Innovation (2018). Shetland Tidal Array Extension – Environmental Assessment Report, pp30.

- ii. Key factors underlying marine wildlife occupancy patterns and around the turbines.
- e. Validate Collision Risk Modelling (CRM) predictions in the environmental assessment and improve understanding for actual (versus predicted) collision risk.
- f. Gather data to proactively manage any unpredicted collision risk for marine mammals and birds, by:
 - i. Identifying any collision or near-miss events.
 - ii. Gathering information to establish the nature and need for additional mitigation measures.

Details of the monitoring methods and techniques that will be used to meet these objectives are provided in the next section.

5 Subsea video monitoring methods

5.1 Objectives

- a. To gather information on the nature and frequency of near-field interactions between marine mammals, diving birds and fish and the turbines to improve understanding for encounter and collision risk.
- b. To gather information to improve knowledge on fine-scale bird and mammal movement around the turbines.
- c. To gather information on any evasive behaviour of marine mammals, birds and fish around the turbines to enable refinement of modelled collision risk for the Project.
- d. To identify any individuals interacting with turbines to species level (where possible) to refine understanding for collision risk.
- e. To gather information to understand whether near-field interactions between marine wildlife and the turbines is different when the turbines are operational (blades rotating) and non-operational.
- f. To gather information to understand whether near-field interactions between marine wildlife and the turbines vary with season, tidal state, flow speed and time of day.
- g. To gather information for co-analysis with vantage point data to better understand the relationship between surface and subsea wildlife observations and, ultimately, collision risk.
- h. To meet the requirements of condition 3.2.1.1 of Marine Licence ML 00009110 (*The PEMP must cover, but not be limited to, the following matters: pre-construction, construction, operation and maintenance monitoring or data collection as relevant in terms of the environmental assessment report and any subsequent monitoring or data collection for marine mammals and birds; Monitoring may also verify predictions in the Application*).
- i. To meet the requirements of conditions 3 and 11 of Works Licence 2023/015/WL (*During the lifespan of this works licence the sea area around the array should be monitored to assess the effect of the device if any on movements of seabirds and marine mammals. The survey methodology should be agreed with Shetland Islands Council under advisement from SNH; Monitoring will be used to identify risk factors for key impacts such as collision risk. Central to the PEMP will be video monitoring to observe underwater interactions of wildlife with turbines*).

5.2 Methodology

Subsea video has been used successfully throughout the operational phase of the Shetland Tidal Array. Water clarity in Bluemull Sound makes this a relatively simple, cost-effective and reliable method for monitoring near-field interactions between marine wildlife and the turbines. To date it has also enabled identification of species observed in footage with very high confidence⁶.

⁶ e.g. Nova Innovation (2020). Shetland Tidal Array monitoring report: Subsea video monitoring. EnFAIT-0364.

One high-definition camera is attached to each of the three M100D turbines in the Shetland Tidal Array to monitor near-field interactions of marine wildlife with the rotors. Key features of the three cameras are as follows:

- High-definition colour images
- High resolution (1000 TV lines)
- Fixed focus wide angle lens, with 65° diagonal and 90° horizontal field of view in water
- Light level sensitivity (0.1 lux colour)
- Focus distance from 10cm (min)

The camera on each turbine is mounted to the nacelle, facing the turbine rotor, as indicated in Figure 5-1.

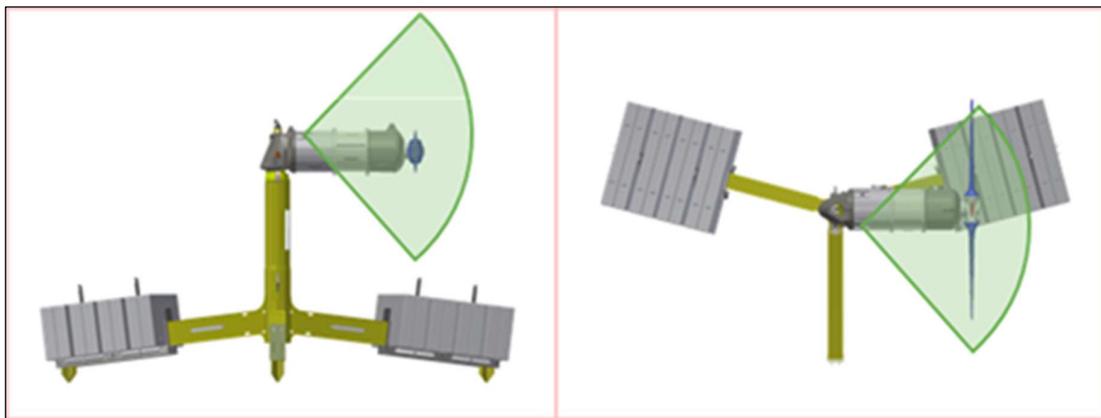


Figure 5-1 Subsea camera system used on turbines in the Shetland Tidal Array. Camera positions and fields of views are indicative only, for illustrative purposes. Cameras are attached to the turbine nacelle.

The field of view of the cameras, based on CAD modelling, is indicated in Figure 5-2, estimated to be 30-35% of the rotor-swept area.

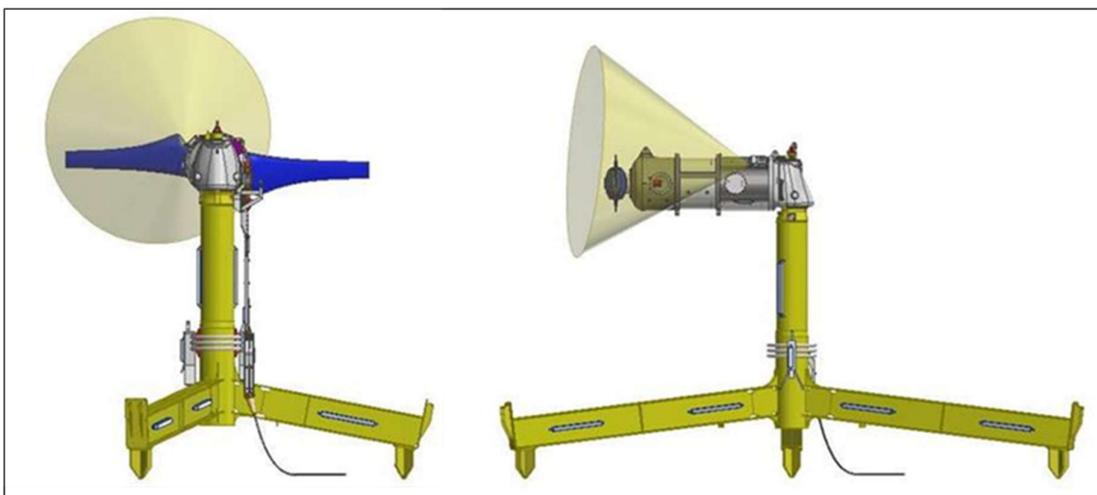


Figure 5-2 Subsea camera system for turbines in the Shetland Tidal Array, showing field of view.

The cameras record continuously during daylight hours (dawn to dusk) but footage retention is triggered by a standard CCTV motion detection system. The trigger system looks for changes in contrast between successive video images. The sensitivity of the trigger and the depth of range depends on light conditions, water quality and the degree of biofouling. The motion trigger system is also sensitive to movements of the blades when turbines are operational.

A review of biofouling on the subsea cameras determined that the growth rate on camera lenses has varied considerably over the ten years or so that Nova has been using turbine-mounted cameras to monitor nearfield interactions between wildlife and turbines in the Shetland Tidal Array⁷. The growth rate of biofouling varies by season and from year-to-year, but camera image quality generally remains high for a period of 3-6 months following turbine installation or maintenance (during which cameras are also cleaned and maintained).

Previously, the observed build-up of biofouling on cameras over a period of several months did not compromise the overall ability to monitor nearfield interactions between marine wildlife and turbines in the Shetland Tidal Array. This was partly due to more frequent turbine maintenance operations, as well as redundancy provided through the use of cameras on multiple turbines which have been deployed or cleaned at different times, creating multiple, overlapping streams of usable camera footage.

The improved reliability of the three direct drive turbines in the Shetland Tidal Array means that they will be deployed for longer periods in Bluemull Sound before the nacelles which house the cameras are brought to the surface for maintenance. This will provide greater opportunity for persistent biofouling taxa such as tunicates and bryozoans to become established on cameras which will affect the quality of video footage over longer deployment periods.

To align with the change in the maintenance regime at the Shetland Tidal Array, the subsea video monitoring approach will shift from one based on continuous (daytime) monitoring with analysis of representative samples of footage, to periods of intensive monitoring effort in the 3-6 months immediately following turbine deployments. A greater proportion of the total footage will be analysed. This will minimise the effects of any deterioration in image quality over time as biofouling builds up on the camera lenses during the prolonged turbine deployments and maximise video quality.

Further details on the approach to video data retention and analysis are provided in the following sections.

5.3 Data retention and storage

Video footage is retained from a few seconds before the motion trigger for a minimum of ten seconds, or until motion is no longer observed, up to a maximum of 15 minutes, at which point the trigger is reset. All retained footage is saved as MPEG video files with a unique code that includes an automatically assigned time and date-stamp (in GMT). A time-stamped thumbnail JPEG image is also saved capturing the motion event. The 'triggered' video clips and thumbnails are stored in folders organised by date and turbine.

The key features of Nova's video footage storage system are:

- Long-term, secure storage of video data – both historic and current: to include design and implementation of system to automatically store and transfer video data from turbine sites to secure data storage.

⁷ Nova Innovation (2024). Review of biofouling on Shetland Tidal Array subsea cameras. STA-012. Pp19.

- Secure, online access to stored video from multiple remote locations to provide a foundation for analysis.
- Organisation and indexing the video data to provide straightforward operator access to any camera and time-period to assist with manual analysis of the data and links to operational and other environmental data.

This storage system facilitates access to video footage to provide a foundation for data analysis and reporting.

To align with the change in the scheduled maintenance regime at the Shetland Tidal Array the 'triggered' video clips and thumbnails will be retained for a period of up to 6 months from the re-installation of turbines following maintenance. If biofouling growth reduces image quality to the extent that cameras are no longer effective for monitoring nearfield interaction of wildlife with the turbine blades during this period, footage will not be retained. Details of the periods over which footage has remained effective for nearfield monitoring for each turbine-mounted camera will be provided in the Shetland Tidal Array monitoring reports (see Section 7 for more details).

6 Subsea video processing and analysis

6.1 Selecting samples for analysis

The Shetland Tidal Array subsea video monitoring generates significant quantities of data, which to date have been analysed by a combination of selecting representative samples for manual review, or more recently using machine learning. In 2022 Nova worked with CGG, a global technology and High Performance Computing leader to automate processing and analysis of the video footage using machine learning. The model provides an operationally ready solution to enable a greater quantity of subsea video to be analysed than is possible through manual review alone. Where possible in future, initial video processing will be automated using the model. If use of the model is not possible (e.g., due to budget restraints or lack of supplier capacity) video analysis will be manual.

As much of the full ‘triggered’ dataset as possible will be processed in any 12-month reporting period. Should subsampling be required (depending on the quantity of data acquired and whether analysis is manual or automated) samples will be selected to provide annual, seasonal, diurnal and tidal state representation in the analysed data.

6.2 Automated video processing

The machine learning-based model developed is based on a pretrained convolutional neural network called EfficientNet⁸ which is widely used for image classification tasks as it has learned representations for a variety of real-life objects, including wildlife occurrences⁹.

Details of the development of automated video processing are provided in a report which was approved by MD-LOT following consultation with NatureScot and others¹⁰. The image analysis workflow is summarised in Figure 6-1.

⁸ MacLeod N, Benfield M and Culverhouse P (2010). Time to automate identification. *Nature* 467:312–315, 154–155. <https://doi.org/10.1038/467154a>

⁹ Mingxing T and Le Q (2019). EfficientNet: Rethinking model scaling for convolutional neural networks. In: *International conference on machine learning*, pp6105–6114. PMLR, 2019.

¹⁰ Nova Innovation (2023). *Shetland Tidal Array Monitoring Report April 2022 to July 2023*. STA-002. pp57.

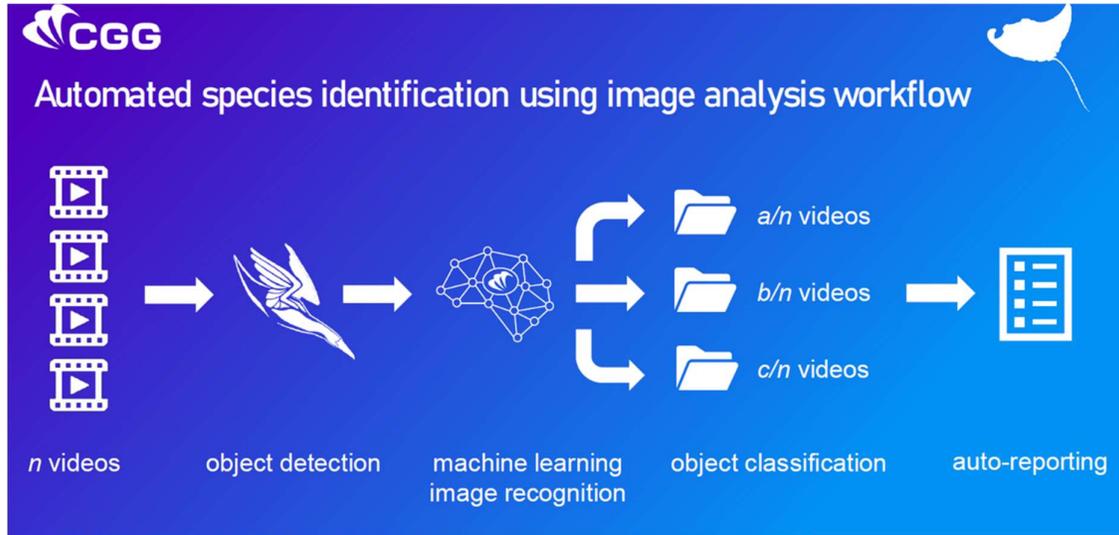


Figure 6-1 Image analysis workflow for automated video analysis and reporting.

The model automatically filters ‘unwanted footage’ and extracts only video files that contain marine mammals, diving birds or fish (‘targets’). Unwanted footage includes video files in which any movement is due to moving turbine blades, seaweed fragments and other detritus drifting in currents, or biofouling on the turbines.

The model currently delivers an accuracy of > 94% in identifying videos containing targets (fish, diving birds or marine mammals) versus non-targets (e.g. background, detritus, moving rotor). This accuracy can be expected to increase as further data are analysed and machine learning refines and improves the model. In some cases the model is already more accurate than a human reviewer at detecting targets¹¹.

Any video file identified by the model to contain true targets (fish, diving birds or marine mammals), as opposed to false targets (e.g. drifting seaweed or the moving turbine blades) will be manually analysed, as detailed in the next section. Random samples of video files identified by the model not to contain targets (fish, diving birds or marine mammals) will also be manually analysed for quality assurance and model improvement purposes.

6.3 Manual analysis of video files

Manual analysis of video files, including those identified by the model to contain ‘true targets’ (marine mammals, diving birds or fish) will involve scrutiny to confirm whether the target/source of CCTV trigger is a fish, bird or mammal or a ‘false target’. Species identification and any notable behaviour, including any nearfield interactions or collisions with turbine rotors will be noted. Whether turbine rotors were moving or stationary in each clip will also be noted. Manual review will be carried out by initial review of JPEG thumbnails of the trigger events followed by more detailed review of the MP4 video files at reduced speeds (x 0.1) and using freeze frames.

The date and time of any video clip in which mobile species are confirmed to occur will be recorded. One of six tidal periods defined in Section 3.2 derived from Nova’s tidal model of the site will be assigned to each video clip.

¹¹ For example, trials demonstrated that fish passing quickly through the camera’s field of view on fast flowing tides are detected by the model but were missed during manual review at the initial processing stage.

The random samples of video files identified by the model not to contain targets will also be manually analysed to confirm that they do not contain (fish, diving birds or marine mammals), for quality assurance and model improvement purposes.

The following data will also be recorded:

- The total number of video files in the reporting period.
- The number of video files from the reporting period analysed.
- The proportion of the full dataset from the reporting period that has been analysed.

Where the machine learning model has been used for partially automated analysis, the following data will be recorded:

- The number of video files identified by the model to contain targets (fish, diving birds or marine mammals) vs non-targets (background, detritus etc).
- Details of any 'false targets' incorrectly identified by the model as fish, diving birds or marine mammals.
- The number of video files identified by the model not to contain targets but manually checked for QA and validation.

6.4 Ongoing analysis of historic video data

During each reporting period, in addition to analysing data from the corresponding 12-month period, some analysis will also be carried out on previous footage. This is with a view to achieving analysis of 100% of the 'good quality' data gathered in the months immediately following turbine deployments.

Nova also continues to actively seek external funding to facilitate analysis of a greater proportion of the full video data set, given the potential strategic value of this in improving the evidence base on collision risk for the tidal energy sector.

7 Reporting strategy

7.1 Data analysis

The monitoring programme for the Shetland Tidal Array continues to gather information to enable further understanding of key factors underlying marine wildlife occupancy patterns and behaviour around the turbines. This information will help to further improve understanding for collision risk.

Detailed analyses will be carried out for any fish, diving bird or marine mammal species observed in the subsea video, as set out in Section 6 of this document. In reporting on the implications of any such wildlife observations in video, including nearfield interactions with turbines, the following protected sites and species features will be a particular focus:

- Yell Sound Special Area of Conservation (SAC): harbour seal (*Phoca vitulina*).
- Hermaness, Saxa Vord and Valla Field Special Protection Area (SPA): gannet (*Morus bassanus*), European shag (*Phalacrocorax aristotelis*), guillemot (*Uria aalge*) and puffin (*Fratercula arctica*).
- Bluemull and Cosgrave Sounds potential Special Protection Area (SPA): red throated diver (*Gavia stellata*).
- All cetaceans, as species subject to strict protection (“European Protected Species” – EPS), as described in Annex IV to Council Directive 92/43/EEC.

7.2 Monitoring reports

All monitoring reports previously submitted to MD-LOT and Shetland Islands Council are available on the Marine Scotland Information website. Monitoring reports will be submitted to Marine Directorate and Shetland Islands Council at 12-month intervals (between 1 August and 31 October), throughout the ongoing operation and maintenance phase of the Shetland Tidal Array.

Reports will detail the results from subsea video monitoring and data analysis carried out within each reporting period. They will detail the key findings in relation to knowledge gained about interactions between marine wildlife and the Shetland Tidal Array, with an emphasis on collision risk. Any issues or challenges experienced in carrying out the monitoring will be set out and if deemed necessary, justifications for the need to amend or adjust monitoring activity presented.

In addition, any required amendments to the PEMP, which is an iterative document, can be discussed and agreed, as set out in Section 8.

7.3 Reporting on compliance with other environmental licence conditions

Nova has established an Excel-based register on the status of licence conditions for the Shetland Tidal Array, to record all actions relating to compliance with conditions of Marine Licence 00009110 and Works Licence 2023/015/WL. Copies of this register will continue to be shared with MD-LOT and Shetland Islands Council at 6-monthly intervals, to report on progress and compliance with licence conditions, including those of relevance to the PEMP and wider measures to safeguard the environment. This simple reporting system will enable Nova, Marine Directorate and Shetland Islands Council to identify any potential areas of concern in relation to commitments under the Project licences or discharge of consent conditions. This audit trail will therefore continue to be an important part of the environmental reporting strategy for the Project.

8 PEMP review process

The PEMP is an iterative, live document which will be kept under review throughout the lifetime of the Shetland Tidal Array to ensure it remains fit for purpose. As knowledge and the evidence base grows on the environmental effects of the Shetland Tidal Array and tidal stream energy more generally, the focus of monitoring may evolve and change over time.

Conditions within Marine Licence 00009110 and Works Licence 2023/015/WL require that the PEMP be regularly reviewed by the Licensing Authorities, to identify the appropriateness of ongoing monitoring. As data from the environmental monitoring are gathered, analysed and reported to the regulatory and advisory bodies, decisions may be taken to retire elements of the monitoring programme, introduce new measures or to adjust methodologies and approaches to gathering and analysing data. This iterative review process for the PEMP is set out in Figure 8-1.

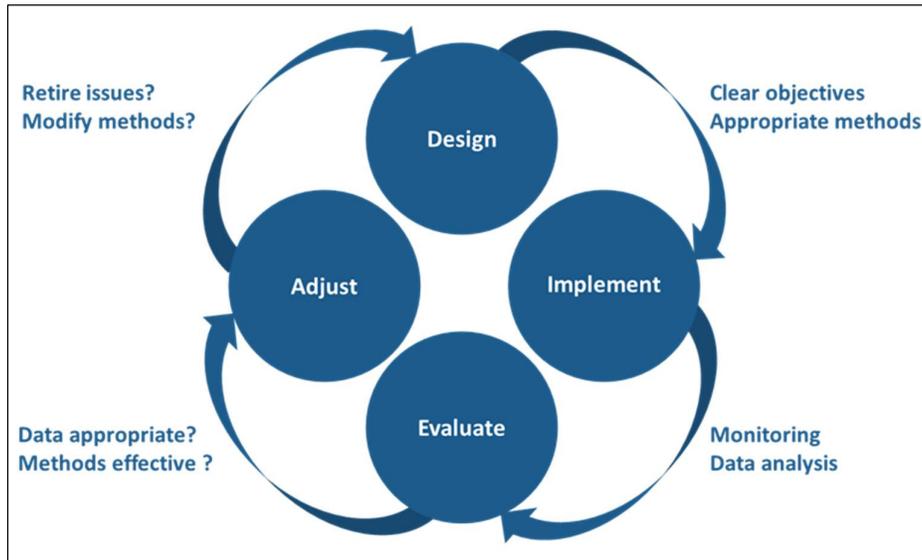


Figure 8-1 Schematic of PEMP iterative review process. The PEMP is a live document and will be kept under constant review.

In line with this iterative review process, the environmental monitoring programme for the Shetland Tidal Array has evolved over time. This version (8.0) of the PEMP incorporates changes to the monitoring methods to reflect the new offshore works schedule for the Shetland Tidal Array now that the Project is in O&M phase, with no further planned turbine installations. The following key change to the monitoring methodologies has been incorporated into this version of the PEMP:

1. Changes in the subsea video monitoring methodology to reflect the new offshore works schedule, to ensure that monitoring effort focuses on acquiring and analysing good quality video data.

Nova is fully committed to an engagement strategy for the Shetland Tidal Array which ensures that the PEMP and the data gathered through monitoring activities and the analyses carried out fully meet the requirements of the Project licences issued by MD-LOT and SIC. Nova will organise meetings with Marine Directorate, SIC and NatureScot, and/or submit formal papers, as appropriate, to discuss and agree data analysis and reporting, as well as any amendments required to the PEMP.

Annex A Shetland Tidal Array Biosecurity Plan

Summary of Biosecurity Risk of Shetland Tidal Array

- a. This Biosecurity Plan for Nova Innovation's Shetland Tidal Array has assessed the risk of introducing non-native species from outside of the Shetland regional area as very low. This is because:
 - the Shetland Tidal Array is now in the operations and maintenance (O&M) phase. Offshore operations will be limited to maintenance;
 - all vessels used in maintenance operations are local to the Northern Isles;
 - vessels not based in Shetland are operated by reputable companies with their own environmental policy statements and good practice procedures;
 - measures are in place to minimise biofouling of epibiota on turbines and substructures.
- b. The overall risk of activities contributing to the further spread of non-native species already present in Shetland has been assessed as low. This is because:
 - although the turbines and substructures within the array provide an artificial habitat for colonisation, significant similar habitat is already present in Bluemull Sound due to aquaculture sites;
 - the tide-swept nature of the Shetland Tidal Array site is likely to limit the settlement of non-native species larvae.
- c. This plan has identified a series of mitigation measures, mostly relating to monitoring and surveillance and good biofouling management to ensure that the overall biosecurity risk of the Shetland Tidal Array is low.

A.1 Introduction

A.1.1 Development name

Shetland Tidal Array, Bluemull Sound, Shetland.

A.1.2 Description of operation

The Shetland Tidal Array now comprises the three M100D turbines (T4-6) and has transitioned to a fully operational and maintenance (O&M) phase. During maintenance operations, only the nacelle of each turbine will be removed and re-installed. It is not anticipated that the cables or structures will need to be removed prior to decommissioning.

A.1.3 Site location

The Shetland Tidal Array is situated in Bluemull Sound, between the islands of Unst and Yell, indicated in Figure A1. The Project is located in a water depth of 30 to 40m offshore from the west coast of the Ness of Cullivoe, a narrow 1 km long headland to the north-east of Yell.



Figure A1 Location of the Shetland Tidal Array (indicated by yellow star).

Bluemull Sound is an active channel for shipping and the Shetland Tidal Array site is located less than 1km from a busy, multiuse harbour at Cullivoe, comprising a pier and small boat marina. In 2017, Cullivoe was the 12th largest whitefish landing port in the UK¹². It is also used as a base by a number of aquaculture operators (mussels and salmon). The small marina currently provides berthing facilities for 14 boats, with plans to expand these facilities along with those at Cullivoe Pier.

A.1.4 Biosecurity plan period

The Biosecurity Plan covers the period 22 August 2025 to 2035 (anticipated decommissioning of T4-T6), with biannual reviews (described in Section A.9). This Site Biosecurity Plan will be supplemented with Operation Biosecurity Plans, as necessary, for any specific activities that fall outside those considered within this plan. None are currently anticipated but this will be kept under review.

The measures in this Biosecurity Plan were considered appropriate for the decommissioning of T1-T3 in 2023. A separate plan may be required for decommissioning the project in 2035, given that 'baseline' conditions' and policy on non-native species in relation to decommissioning offshore infrastructure may have changed in the intervening period.

A.1.5 Responsible persons for biosecurity management

- a. Management of Biosecurity Plan and overview of biosecurity: Nova STA Manager (or equivalent nominated officer).
- b. Management of operations on site: Nova Offshore Manager (or delegated operations manager for a particular task).

¹² Napier I (2017). Shetland Fisheries Statistics 2017. Report produced by the University of the Highlands and Islands, pp35.

A.2 Environmental factors affecting biosecurity

A.2.1 Salinity and environmental conditions

Bluemull Sound is a fully saline site. A number of small burns and land run-off enter the Sound but tidal currents and mixing mean that any effects on salinity are very localized and unlikely to extend beyond the intertidal zone.

A.2.2 Seabed habitat

The seabed in Bluemull Sound at the Shetland Tidal Array site is rocky with little overlying sediment due to tidal scour. The array is located in an area of strong tidal streams which can reach velocities exceeding 3 m/s. This habitat typically supports a community of foliose seaweeds and encrusting animals typical of such tide-swept conditions, with sparse faunal communities dominating in the deeper, most tide-swept parts of the site.

A.2.3 Artificial habitat and biofouling

Although the Shetland Tidal Array provides artificial habitat for potential colonisation by non-native species, significant similar habitat is already present in Bluemull Sound due to aquaculture sites. The species and taxa most commonly observed to colonize the surfaces of structures in the Shetland Tidal Array are mussels, barnacles and kelp¹³.

A.2.4 Non-native species present in Shetland

The northerly location of Shetland and lower water temperatures compared to the mainland UK may inhibit the spread of certain non-native species from the south. Despite this, a number of marine non-native species have been recorded around Shetland, detailed in Table A1, compiled from a variety of sources^{14 15 16}. The known locations of these species in Shetland are detailed, along with an indication of the likelihood that the Shetland Tidal Array could contribute to their spread within Shetland.

Table A1 Non-native species already recorded in Shetland and relevant to the Shetland Tidal Array.

Species	Records in Shetland	Habitat details and relevance to Shetland Tidal Array
Fragile green sponge fingers, <i>Codium fragile</i> ssp. <i>Fragile</i>	Throughout Shetland	Occurs on rock from the mid to lower shore and shallow subtidal. Not relevant to STA, depth and tide-swept nature of site make colonisation unlikely.
Japanese weed, <i>Dasysiphonia japonica</i>	Throughout Shetland	Lower intertidal species. Not relevant to STA, depth and tide-swept nature of site make colonisation unlikely.

¹³ Vezza R (2019). An anti-biofouling strategy for operators: A systems approach for the tidal energy industry. Ph.D. thesis, University of Edinburgh, University of Exeter and University of Strathclyde.

¹⁴ Collin SB, MacIver K & Shucksmith R. (2015). A Biosecurity Plan for the Shetland Islands, pp66.

¹⁵ Collin SB, Tweddle JF & Shucksmith RJ (2015). Rapid assessment of marine non-native species in the Shetland Islands, Scotland. *BioInvasions Records* 4: 147-155.

¹⁶ Shelmerdine RL, Mount B & Shucksmith RJ (2017). The most northerly record of feral Pacific oyster *Crassostrea gigas* (Thunberg, 1793) in the British Isles. *BioInvasions Records* 6(1): 57-60.

Species	Records in Shetland	Habitat details and relevance to Shetland Tidal Array
Hook weed, <i>Bonnemaisonia hamifera</i>	Throughout Shetland	Not relevant to STA, already widespread throughout Shetland. GBNNS consider environmental & economic threat is low.
Harpoon weed, <i>Asparagopsis armata</i>	Throughout Shetland	Not relevant to STA, already widespread throughout Shetland. GBNNS consider environmental & economic threat is low.
Wireweed, <i>Sargassum muticum</i>	West coast of mainland	Occurs on rock, cobbles and boulders from the mid to lower shore and shallow subtidal. Not relevant to STA, depth makes colonisation unlikely.
Orange-tipped sea squirt, <i>Corella eumyota</i>	Yell	Occurs in shallow waters in harbours, marinas and on manmade structures. Could colonise structures of STA, maintain surveillance.
Bryozoan, <i>Schizoporella japonica</i>	Throughout Shetland	Widespread throughout Shetland on manmade structures. Not relevant to STA, already widespread. GBNNS consider environmental & economic threat is low.
Bryozoan, <i>Fenestrulina delicia</i>	Sullom Voe	Only a single record in Shetland. Unlikely to colonise STA. GBNNS consider environmental & economic threat is low.
Bryozoan, <i>Bugula simplex</i>	Lerwick	Colonises marinas, harbours and boat hulls. Could colonise structures of STA, maintain surveillance. GBNNS consider environmental & economic threat is low.
Orange-striped anemone, <i>Diadumene lineata</i>	The Vadills, Mainland	Only a single historical record in Shetland Vadills (coastal lagoons) from 2003. Unlikely to colonise STA.
Darwin barnacle, <i>Austrominius modestus</i>	Throughout Shetland	Not relevant to STA, already widespread throughout Shetland. GBNNS consider environmental & economic threat is low.
Japanese skeleton shrimp, <i>Caprella mutica</i>	Throughout Shetland	Found in areas of human activity on natural and artificial substrata. Limited dispersal potential. Could colonise structures of STA, maintain surveillance.
Pacific oyster, <i>Crassostrea gigas</i>	Sandsound Voe, Mainland	Only two specimens found in Shetland in 2016, on mussel lines. Unlikely to colonise STA due to tide-swept conditions.

A number of other non-native species could potentially be present in the waters around Shetland, without having been formally recorded. Of likely pertinence are those species recorded in Orkney since the spread in distribution of non-native species generally follows a south to north pattern. A number of non-natives not yet recorded in Shetland were recorded in a recent rapid assessment survey of Orkney in 2017. As with species detailed in the table above, not all of these non-native species will be of environmental or economic concern, but it is good practice to maintain watching brief over these and other non-native species not yet record in Shetland.

A.3 Vessels using the site and engaged in operations

Local multi-category ('multicat') workboat vessels of the type shown in Figure A2, and small workboats are utilised for all operations associated with the Shetland Tidal Array. During this O&M phase of the Shetland Tidal Array, operations will most likely comprise nacelle retrievals and re-deployments, until the project is fully decommissioned in 2035.



Figure A2 Representative vessel utilised for Shetland Tidal Array operations. *Source Leask Marine.*

All vessels used in operations are based in the Northern Isles. Those not based in Shetland itself are operated by reputable companies with sound environmental policies and good practice procedures. Turbines and substructures are shipped to site overland via lorry and northern isles freight service.

A.4 Site activities which risk introducing or spreading non-native species

The nature of biosecurity risks for the Shetland Tidal Array, associated activities and mitigation measures are detailed in Table A2.

Table A2 Activities associated with the Shetland Tidal Array, biosecurity risk and mitigation measures.

Activity and nature of risk	Mitigation measures	Risk level
Use of vessels for site operations: Risk of introducing or spreading non-native species	<ul style="list-style-type: none"> - Turbine nacelles are shipped to Shetland by road following maintenance. - Northern Isles-based vessels used for marine operations. - The operators used for provision of multicat vessels follow their own biosecurity good practice, under an environmental policy statement¹⁷. - An 'Operations Biosecurity Plan' will be produced for use of any vessels not based in Northern Isles (not currently anticipated). 	Very low to low
Presence of turbines, substructures, cables and offshore hub: provision of artificial habitat for colonisation by non-native species	<ul style="list-style-type: none"> - Turbine nacelles will not be deployed subsea elsewhere during the remaining O&M phase of the project. - Temporary moorings (e.g., chains) used during turbine maintenance operations will be sourced from Shetland or pressure washed / air dried prior to use in Bluemull Sound. - An anti-fouling strategy is in place involving use of anti-fouling coatings on turbines, substructures and hub. - Visual inspections when turbines are removed from water during maintenance operations - contingency action will be taken if necessary. 	Low to medium

¹⁷ Leask Marine (2019). Environmental Policy Statement. See <https://www.leaskmarine.com/about/company-policy-statements/>

As detailed in Table A2, the introduction of artificial habitat to Bluemull Sound could provide new habitat for colonisation by non-native species. However, the risk that this would contribute significantly to the further spread of species already present in Shetland is considered low, for a number of reasons:

- a. In general, the sheltered habitats of marinas, ports and harbours seems to favour the establishment of non-native species, over habitats in more wave or tide-exposed conditions such as Bluemull Sound.
- b. In a rapid assessment of non-native species in Orkney in 2017, whilst a number of non-native species were found to be colonising structures in harbour and marinas, none were found on marine renewable energy devices sampled.
- c. Turbine nacelles are periodically removed from the water for maintenance, during which any biofouling is removed.
- d. Additional mitigation and good biosecurity measures will be applied to the STA, detailed in the next section.

The biosecurity risk for the Shetland Tidal Array is likely to be considerably lower than that associated with other activities in the area such as national and international shipping, marinas, recreational boating and aquaculture. The use of local vessels means the risk of introducing non-native species from outside Shetland is minimal, though they could contribute to the spread of species already present in Shetland. The presence of turbines and substructures in the Sound creates artificial habitat for potential colonisation by non-native species already present in Shetland. However, similar habitat is available on nearby aquaculture installations.

A.5 Biosecurity control measures

The full range of biosecurity control measures to reduce the risk of the Shetland Tidal Array contributing to the spread or introduction of non-native species are listed below:

- a. The Site Biosecurity Plan will be reviewed on any changes being made to planned offshore operations to ensure its conclusions remain valid.
- b. An 'Operations Biosecurity Plan' will be produced, as necessary, for any specific activities that fall outside those described within this plan. A separate plan may be required for decommissioning the project in 2035, given that 'baseline' conditions' and policy on non-natives in relation to decommissioning offshore infrastructure may have changed in the intervening period.
- c. The Site Biosecurity Plan will be kept under review and updated, as necessary throughout the O&M phase of the Shetland Tidal Array.
- d. None of the turbine nacelles (or other offshore infrastructure) will be deployed subsea elsewhere.
- e. Turbine nacelles are shipped to and from Shetland by road during maintenance operations.
- f. Northern Isles-based vessels used for marine operations.
- g. The operators used for provision of multicat vessels follow their own biosecurity good practice, under an environmental policy statement¹⁴.
- h. Any temporary moorings (e.g., chains) used during offshore operations will either be sourced from Shetland, or pressure washed or air dried prior to use in Bluemull Sound.
- i. An anti-fouling strategy is in place for the project, which includes use of anti-fouling coatings on turbines, substructures and offshore hub.
- j. Turbine nacelles will undergo visual inspections when removed from the water during maintenance operations. Contingency action will be taken if necessary (see Section A.7).

A.6 Site surveillance and reporting procedures

Turbine nacelles will undergo visual inspections when removed from Bluemull Sound during maintenance operations. Any non-native species identified will be reported to Shetland Islands Council, Marine Directorate and NatureScot in the first instance. Records of inspections and any instances of non-native species will be kept within the site biosecurity logbook, maintained and managed by Nova's Offshore Manager.

A.7 Contingency plan

Visual inspections will be carried out following removal of turbine nacelles from Bluemull Sound. Inspections will take place at either Cullivoe or Belmont Pier. Laminated 'pest ID cards', carried by Offshore Manager during all works and onboard all vessels engaged in Works will assist staff carrying out the inspections in identifying particularly invasive non-natives. Not all non-native species will require further action, since many are already well-established in Shetland, or have minimal likely environmental or economic impacts.

If visual inspections of turbines and substructures indicate the presence of a non-native species, this will be reported to Shetland Islands Council, Marine Directorate and NatureScot in the first instance, for discussion on whether further action is required.

Biological material is removed as standard when turbine nacelles are removed from Bluemull Sound, for health and safety reasons, to avoid dangerous handling conditions. This takes place *in situ* at Belmont or Cullivoe pier usually by pressure washing. If inspections have suggested that invasive non-native species may be present, care will be taken during pressure washing to avoid contaminated material entering the marine environment.

Any contingency action taken will be recorded in the site biosecurity logbook kept in Nova's main office.

A.8 Location of biosecurity logbook

The Shetland Tidal Array biosecurity logbook will be maintained and managed by Nova Innovation's Offshore Manager. A hard copy will be kept on-site in Nova's main office.

A.9 Biosecurity plan review process

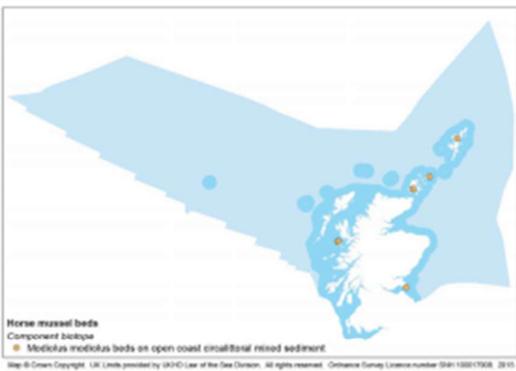
This Site Biosecurity Plan will be reviewed and updated if necessary; for example, if any changes are made to planned offshore operations. The Plan will be reviewed every two years, or sooner if required. More frequent reviews may be triggered by an identified higher risk, such as change in vessel use or record of an invasive non-native species elsewhere in Shetland, for which containment may be required.

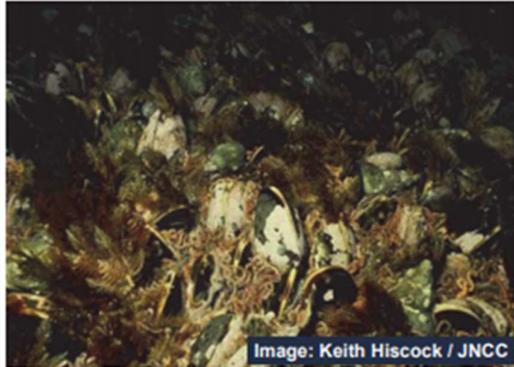
A separate Biosecurity Plan may be required for decommissioning the project in 2035, given that 'baseline' conditions' and policy on non-natives in relation to decommissioning offshore infrastructure may have changed in the intervening period. This will be reviewed and discussed with MD-LOT, SIC and NatureScot nearer the time.

Annex B Priority habitat reference cards

Ref: <https://www.nature.scot/snh-commissioned-report-406-descriptions-scottish-priority-marine-features-pmfs>

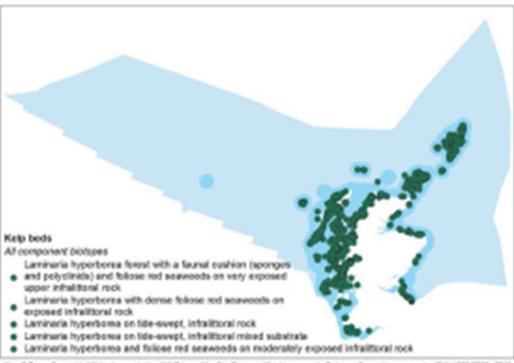
TERRITORIAL WATERS	
Broad habitat	
HORSE MUSSEL BEDS	
Image	Distribution
 <p style="text-align: right; font-size: small;">Image: Rob Cook</p>	 <p style="font-size: x-small;"> Horse mussel beds All component biotopes • <i>Modiolus modiolus</i> beds with hydroids and red seaweeds on tide-swept circalittoral mixed substrata • <i>Modiolus modiolus</i> beds on open coast circalittoral mixed sediment • <i>Modiolus modiolus</i> beds with fine hydroids and large solitary ascidians on very sheltered circalittoral mixed substrata • <i>Modiolus modiolus</i> beds with <i>Chlamys varia</i>, sponges, hydroids and bryozoans on slightly tide-swept very sheltered circalittoral mixed substrata Map © Crown Copyright. UK. Limits provided by Ordnance Survey. All rights reserved. Ordnance Survey Licence number 1001100017000. 2015. </p>
Feature description	
<p>Characteristics - The horse mussel <i>Modiolus modiolus</i> occurs in scattered clumps, thin layers or dense raised beds, which can extend up to several hectares in size. Raised beds are formed of horse mussels bound together by a matrix of byssus threads. Silt, organically rich faeces and shells accumulate within the structure and further increase the bed height. Horse mussel beds significantly modify sedimentary habitats and provide hard substratum, refuge and ecological niches for a wide variety of organisms. The beds increase local biodiversity and may provide settling grounds for commercially important bivalves, such as queen scallops.</p> <p>Environmental preferences - Weak to strong water movement on a variety of mixed substrata. Found at depths of 5-220m.</p> <p>Scottish distribution - Recorded from sea lochs, embayments and open coast in Shetland, Orkney, off Caithness and down the west coast with scattered records from the Outer Hebrides and Moray Firth. Relatively small, dense beds of horse mussels can also occur on steep rocky surfaces within sea lochs.</p> <p>Wider distribution - Recorded from the Ards Peninsula, Strangford Lough, off both ends of the Isle of Man, off north-west Anglesey and north of the Llŷn Peninsula, Wales.</p> <p>Feature status - Scottish waters support 85% of all horse mussel beds in the British Isles which themselves represent most of the habitat within Europe. They are sensitive to physical disturbance and mobile fishing gears may damage and/or remove beds. The extent and quality of habitat has declined since the 1950s with formerly extensive beds in Strangford Lough (N. Ireland) lost as recently as 2007 due to scallop trawling and dredging. The condition of beds in Loch Creran and Loch Duich on the west coast of Scotland has also deteriorated but the cause is currently unknown.</p>	
Natural heritage importance	Information sources
EC Habitats Directive Annex I OSPAR T&D Scottish Biodiversity List UK BAP	MarLIN OSPAR Case Report UK BAP Habitat Definitions UK Marine SACs Overview
Component biotopes in Scottish waters	
<p><i>Modiolus modiolus</i> beds with hydroids and red seaweeds on tide-swept circalittoral mixed substrata - SS.SBR.SMus.ModT.</p> <p><i>Modiolus modiolus</i> beds on open coast circalittoral mixed sediment - SS.SBR.SMus.ModMx.</p> <p><i>Modiolus modiolus</i> beds with fine hydroids and large solitary ascidians on very sheltered circalittoral mixed substrata - SS.SBR.SMus.ModHAs.</p> <p><i>Modiolus modiolus</i> beds with <i>Chlamys varia</i>, sponges, hydroids and bryozoans on slightly tide-swept very sheltered circalittoral mixed substrata - SS.SBR.SMus.ModCvar.</p>	

TERRITORIAL WATERS	
Component biotope name	
<i>MODIOLUS MODIOLUS</i> BEDS ON OPEN COAST CIRCALITTORAL MIXED SEDIMENT (SS.SBR.SMus.ModMx)	
Image	Distribution
 <p style="text-align: right; font-size: small;">Image: Richard Shucksmith</p>	 <p style="font-size: x-small;">Map © Crown Copyright, UK. Limits provided by UKHO/Sea Data. All rights reserved. Ordnance Survey Licence number 100017908, 2015.</p>
Feature description	
<p>Characteristics - Beds of horse mussels (<i>Modiolus modiolus</i>) on or within mixed muddy and gravel sediments in deep water. Clumps of live and dead shells are bound together by byssal threads providing a stabilising effect on the sea bed. The accumulation of silt and mussel faeces upon and around the beds provides a habitat that attracts a rich diversity of organisms, in particular polychaete worms. Venerid bivalves and brittlestars are also commonly present.</p> <p>Environmental preferences - Typically occurs on current swept, moderately sheltered circalittoral mixed sediment (muddy sand and gravel, with shells and stones) at depths of 40-100m.</p> <p>Scottish distribution - Recorded from the Northern Isles (Sullom Voe, Shetland and Hoy Sound, Orkney) as well as from the Small Isles on the west coast, and Isle of May on the east.</p> <p>Wider distribution - There are a number of records in the Irish Sea, with scattered records on the east coast of Ireland, Northern Ireland and England. Records of <i>M. modiolus</i> off Norway, in the Kattegat Sea and off the west coast of France may represent examples of this biotope.</p> <p>Feature status - <i>M. modiolus</i> is a long lived species with poor recruitment. Horse mussel beds are sensitive to physical disturbance which can adversely affect bed integrity. Mobile fishing gears may damage or completely remove beds.</p>	
Natural heritage importance	Information sources
EC Habitats Directive Annex I (Reefs) OSPAR T&D Scottish Biodiversity List UK BAP	JNCC Marine Habitat Classification MarLIN OSPAR Case Report UK BAP Habitat Definitions
Sub-component biotopes in Scottish waters	
No sub-component biotopes	

TERRITORIAL WATERS	
Component biotope name	
MODIOLUS MODIOLUS BEDS WITH HYDROIDS AND RED SEAWEEDS ON TIDE-SWEPT CIRCALITTORAL MIXED SUBSTRATA (SS.SBR.SMus.ModT)	
Image	Distribution
 <p style="text-align: right; font-size: small;">Image: Keith Hiscock / JNCC</p>	 <p style="font-size: x-small;"> Horse mussel beds Component biotope Modiolus modiolus beds with hydroids and red seaweeds on tide-swept circalittoral mixed substrata </p> <p style="font-size: x-small;">Map © Crown Copyright. UK. Limits provided by Ordnance Survey of the Sea Districts. All rights reserved. Ordnance Survey Licence number 100119008. 2015</p>
Feature description	
<p>Characteristics - In strong currents or tide-swept conditions, the horse mussel (<i>Modiolus modiolus</i>) forms raised beds on mixed muddy substrates. The beds are made up of living and dead mussels, bound together with byssus threads, and an accumulation of silt and mussel faeces. In some cases they can be several metres high and many metres long providing refuge for a variety of other organisms. Red seaweeds and sea firs grow on or amongst the horse mussels. Brittlestars are often common in this habitat, along with tube worms, whelks, clams and sea anemones.</p> <p>Environmental preferences - Typically found on the open coast but also in the tide-swept channels of marine inlets on mixed, muddy substrata (cobbles and pebbles) from 5-50m.</p> <p>Scottish distribution - Recorded from Shetland (e.g. Basta Voe and Yell Sound), Orkney (Shapinsay Sound), the Caithness coast (Noss Head), the Moray Firth, the Outer Hebrides (Loch Roag) and within sea lochs of the west coast of Scotland (e.g. Loch Carron, Loch Linnhe and Loch Long).</p> <p>Wider distribution - There are very few records of this biotope outside of Scotland but it has been recorded in the Irish Sea off the north-west LIŷn Peninsula (North Wales) and off Co. Down (Northern Ireland).</p> <p>Feature status - Supporting the majority of horse mussel beds in the British Isles, Scottish waters are nationally important for this habitat which is sensitive to physical disturbance. Mobile fishing gears may damage or completely remove horse mussel beds.</p>	
Natural heritage importance	Information sources
EC Habitats Directive Annex I (Reefs, typical of Large shallow inlets and bays) OSPAR T&D Scottish Biodiversity List UK BAP	JNCC Marine Habitat Classification MarLIN OSPAR Case Report UK BAP Habitat Definitions
Sub-component biotopes in Scottish waters	
No sub-component biotopes	

TERRITORIAL WATERS	
Component biotope name	
MODIOLUS MODIOLUS BEDS WITH <i>CHLAMYS VARIA</i>, SPONGES, HYDROIDS AND BRYOZOANS ON SLIGHTLY TIDE-SWEPT VERY SHELTERED CIRCALITTORAL MIXED SUBSTRATA (SS.SBR.SMus.ModCvar)	
Image	Distribution
 <p style="text-align: right; font-size: small;">Image: SNH</p>	 <p style="font-size: x-small;"> Horse mussel beds Component biotope Modiolus modiolus beds with Chlamys varia, sponges, hydroids and bryozoans on slightly tide-swept very sheltered circalittoral mixed substrata <small>Map © Crown Copyright. UK. Licensed under the Open Government Licence v3.0. All rights reserved. Ordnance Survey Licence number: 100019366. 2015</small> </p>
Feature description	
<p>Characteristics - Beds of horse mussels (<i>Modiolus modiolus</i>) on or in gravelly mud sediments. Beds are made up of living and dead mussels, bound together with byssus threads, and an accumulation of silt and mussel faeces. The beds provide refuge and substratum for a variety of other organisms. The variable scallop (<i>Chlamys varia</i>) is characteristically present amongst the horse mussels. Brittlestars, feather stars, hermit crabs, spider crabs and whelks are also found in this biotope. Sponges, sea firs, sea mats and sea squirts grow on the mussels.</p> <p>Environmental preferences - This biotope forms beds on slightly tide-swept, very sheltered circalittoral mixed sediment (pebbles and shells on sandy mud) at depths of 5-220m.</p> <p>Scottish distribution - Restricted to a small number of sea lochs on the west coast (Loch Fyne, Loch Creran and on Skye), as well as from Orkney and within Bluemull Sound in Shetland. An atypical deep water variant of this biotope has recently been recorded within the Sound of Canna.</p> <p>Wider distribution - There are only a few records of this biotope outside of Scottish waters, these are primarily in the Irish Sea (Northern Ireland and north-west Wales).</p> <p>Feature status - This is a rare horse mussel bed biotope and like all biogenic reefs is sensitive to physical disturbance which can adversely affect bed integrity. Mobile fishing gears may damage or completely remove <i>M. modiolus</i> beds.</p>	
Natural heritage importance	Information sources
EC Habitats Directive Annex I (Reefs, typical of Large shallow inlets and bays) OSPAR T&D Scottish Biodiversity List UK BAP	JNCC Marine Habitat Classification MarLIN OSPAR Case Report UK BAP Habitat Definitions
Sub-component biotopes in Scottish waters	
No sub-component biotopes	

TERRITORIAL WATERS	
Component biotope name	
MODIOLUS MODIOLUS BEDS WITH FINE HYDROIDS AND LARGE SOLITARY ASCIDIANS ON VERY SHELTERED CIRCALITTORAL MIXED SUBSTRATA (SS.SBR.SMus.ModHAs)	
Image	Distribution
 <p style="text-align: right; font-size: small;">Image: Sue Scott / JNCC</p>	 <p style="font-size: x-small;"> Horse mussel beds Component biotope Modiolus modiolus beds with fine hydroids and large solitary ascidians on very sheltered circalittoral mixed substrata <small>Map © Crown Copyright. UK. Limits provided by UKHO. Use of the Sea-Data. All rights reserved. Ordnance Survey Licence number 100017908. 2017</small> </p>
Feature description	
<p>Characteristics - In wave sheltered areas, the horse mussel (<i>Modiolus modiolus</i>) forms beds or scattered clumps on mixed muddy substrates. The beds or clumps consist of living and dead mussels bound together by byssus threads. They provide refuges and substratum for sea firs, solitary sea squirts and fish species. The beds also support a variety of brittlestars, together with commercially important shellfish (e.g. queen scallops), hermit crabs, spider crabs and whelks.</p> <p>Environmental preferences - This biotope typically forms on mixed, muddy substrata (cobbles and pebbles) in sheltered conditions with slight tidal movement at depths of 5-30m.</p> <p>Scottish distribution - Found in sea lochs and voes in Shetland (e.g. Sullom Voe), Orkney (e.g. North Sanday and Shapinsay Sound), the Outer Hebrides (e.g. Loch Roag and Loch Tarbert) and the west coast (e.g. Loch Sunart and Loch Duich).</p> <p>Wider distribution - This biotope is only recorded in Scotland.</p> <p>Feature status - This biotope is unique to Scottish waters and, like the other horse mussel bed biotopes, is sensitive to physical disturbance which can adversely affect bed integrity. Mobile fishing gears may damage or completely remove <i>M. modiolus</i> beds.</p>	
Natural heritage importance	Information sources
EC Habitats Directive Annex I (Reefs, typical of Large shallow inlets and bays) OSPAR T&D Scottish Biodiversity List UK BAP	JNCC Marine Habitat Classification MarLIN OSPAR Case Report UK BAP Habitat Definitions
Sub-component biotopes in Scottish waters	
No sub-component biotopes	

TERRITORIAL WATERS	
Broad habitat	
KELP BEDS	
Image	Distribution
 <p style="text-align: right; font-size: small;">Image: Richard Shucksmith</p>	 <p style="font-size: x-small;"> Kelp beds All component biotopes ● <i>Laminaria hyperborea</i> forest with a faunal cushion (sponges and polyclinids) and foliose red seaweeds on very exposed upper infralittoral rock ● <i>Laminaria hyperborea</i> with dense foliose red seaweeds on exposed infralittoral rock ● <i>Laminaria hyperborea</i> on tide-swept, infralittoral rock ● <i>Laminaria hyperborea</i> on tide-swept, infralittoral mixed substrata ● <i>Laminaria hyperborea</i> and foliose red seaweeds on moderately exposed infralittoral rock </p> <p style="font-size: x-small;">Map © Crown Copyright, UK. Lincs provided by UKHO/Lea of the Sea District. All rights reserved. Ordnance Survey Licence number 100017066. 2015</p>
Feature description	
<p>Characteristics – Beds of the kelp <i>Laminaria hyperborea</i> form as forests and parks in rocky coastal areas, under a variety of wave and tidal conditions. The kelp provides a canopy under which a wide range of animals and other seaweeds thrive. A rich diversity of red seaweeds grow among the kelp and on the kelp stipes, while depending on conditions, sea mats and sea firs may colonise the fronds. The rocks below the kelp are often encrusted with coralline algae or support cushion forming fauna, such as sea anemones, sponges and sea squirts. Small crustaceans and worms live among the kelp holdfasts, while sea urchins and sea snails graze on the seaweeds, and fish find shelter from predators among the fronds.</p> <p>Environmental preferences - Kelp beds occur in shallow waters (to a maximum of 20-30m), on bedrock and boulders in a range of wave exposure regimes and tidal conditions.</p> <p>Scottish distribution - Widely recorded around all coasts of the Scottish mainland and islands. The more exposed biotopes are particularly recorded from Atlantic coasts in the west and the north.</p> <p>Wider distribution - Widely recorded around the coasts of the UK and Ireland, although more exposed biotopes are only found on the west coast of Ireland, off Cornwall and south-west Wales.</p> <p>Feature status - Scotland holds a significant proportion of the UK records of kelp beds and therefore the habitat is considered to be nationally important. The kelp component may be a target for seaweed harvesting, with potential effects on habitat structure and species diversity. Activities which cause changes in wave exposure or tidal flow could also have effects on this habitat.</p>	
Natural heritage importance	Information sources
EC Habitats Directive Annex I (Reefs) Scottish Biodiversity List (IR.MIR.KR.LhypT & IR.MIR.KR.LhypTX only) UK BAP (IR.MIR.KR.LhypT & IR.MIR.KR.LhypTX only)	JNCC Marine Habitat Classification MarLIN
Component biotopes in Scottish waters	
<p><i>Laminaria hyperborea</i> forest with a faunal cushion (sponges and polyclinids) and foliose red seaweeds on very exposed upper infralittoral rock - IR.HIR.KFaR.LhypFa.</p> <p><i>Laminaria hyperborea</i> with dense foliose red seaweeds on exposed infralittoral rock - IR.HIR.KFaR.LhypR, including: IR.HIR.KFaR.LhypR.Ft & IR.HIR.KFaR.LhypR.Pk.</p> <p><i>Laminaria hyperborea</i> on tide-swept, infralittoral rock - IR.MIR.KR.LhypT, including: IR.MIR.KR.LhypT.Ft & IR.MIR.KR.LhypT.Pk.</p> <p><i>Laminaria hyperborea</i> on tide-swept infralittoral mixed substrata - IR.MIR.KR.LhypTX, including: IR.MIR.KR.LhypTX.Ft & IR.MIR.KR.LhypTX.Pk.</p> <p><i>Laminaria hyperborea</i> and foliose red seaweeds on moderately exposed infralittoral rock - IR.MIR.KR.Lhyp, including: IR.MIR.KR.Lhyp.Ft; IR.MIR.KR.Lhyp.Pk; IR.MIR.KR.Lhyp;GzFt & IR.MIR.KR.Lhyp;GzPk.</p>	

TERRITORIAL WATERS	
Broad habitat	
MAERL BEDS	
Image	Distribution
 <p style="text-align: right; font-size: small;">Image: Marine Scotland</p>	 <p style="font-size: x-small;">Maerl beds Component biotope Maerl beds Map © Crown Copyright. UK. Limits provided by (2002) Law of the Sea (2002). All rights reserved. Ordnance Survey Licence number 2001135217008. 2011</p>
Feature description	
<p>Characteristics - Maerl beds are formed by an unusual red seaweed with a hard chalky skeleton that grows as small rounded nodules or short branched twig-like shapes. In high abundance, maerl can form loosely interlocking beds through which water is able to circulate, providing the perfect conditions for the development of diverse communities of plants and animals (on, within or under the beds). Red seaweeds, sea firs, sea urchins, brittlestars, starfish, sea anemones and scallops may colonise the surface. Maerl needs light to grow, so living maerl is restricted to the surface of the beds overlying the chalky skeletons of dead maerl. Three maerl species exist in the British Isles and the relative composition of these within a bed, and the proportion of living / dead maerl within and between beds, varies with factors such as salinity and wave exposure. Maerls are extremely slow growing and extensive beds may be 1000s of years old.</p> <p>Environmental preferences - Coarse clean sands and gravels either on the open coast or in tide-swept channels to a depth of about 20m. Occasional records from muddier sediments e.g. Loch Torridon.</p> <p>Scottish distribution - Widespread on the west coast (e.g. Arran, Loch Sween, Sound of Arisaig and Loch Laxford), the Outer Hebrides (e.g. Sound of Barra and Loch nam Madadh) and in tide-swept areas of Orkney (e.g. Wyre and Hoy Sound) and Shetland (e.g. Bluemull Sound).</p> <p>Wider distribution - Recorded on the south English coast, in Wales, Ireland and Northern Ireland, NW Iceland, NW France, NW Spain and the Canaries. Also known to occur in Sweden and Norway.</p> <p>Feature status - Scotland has approximately 30% of the maerl beds in north-west Europe and most of the beds in the UK. They are sensitive to physical disturbance, smothering, increased suspended sediment and changes in water flow. Pressures are known to include mobile demersal fishing activity, aquaculture, pollution and extraction (for soil conditioner).</p>	
Natural heritage importance	Information sources
EC Habitats Directive Annex I (Subtidal sandbanks) OSPAR T&D Scottish Biodiversity List UK BAP	JNCC Marine Habitat Classification OSPAR Case Report UK BAP Habitat Definitions UK MarineSACs Overview
Component biotopes in Scottish waters	
Maerl beds - SS.SMp.Mrl , including: SS.SMp.Mrl.Pcal (inc. Pcal.R & Pcal.Nmix); SS.SMp.Mrl.Lgla ; & SS.SMp.Mrl.Lcor .	

TERRITORIAL WATERS	
Broad habitat	
MAERL OR COARSE SHELL GRAVEL WITH BURROWING SEA CUCUMBERS	
Image	Distribution
 <p style="text-align: right; font-size: small;">Image: SNH</p>	 <p style="font-size: x-small;">Maerl or coarse shell gravel with burrowing sea cucumbers Component biotope ● <i>Neopentadactyla mixta</i> in circalittoral shell gravel or coarse sand Map © Crown Copyright, UK. Links provided by SHED Use of the Sea Cluster. All rights reserved. Ordnance Survey Licence number 2001-1000-1000 20/11</p>
Feature description	
<p>Characteristics - Gravel, maerl gravel (dead maerl) or coarse sands with high densities of the gravel sea cucumber, <i>Neopentadactyla mixta</i>. Scallops, brittlestars, crabs and dragonets live on the surface of the sediment (some seaweeds may also be present) with widespread species such as tube dwelling sea anemones, sand mason worms and parchment worms living within the coarse substrates. This biotope may occur adjacent to maerl beds. During winter months, the gravel sea cucumbers bury deep in the sediment and become dormant.</p> <p>Environmental preferences - Found in sublittoral clean, gravel, maerl gravel (dead maerl) and / or coarse sands in moderately wave-exposed, fully saline conditions at 10-50m.</p> <p>Scottish distribution - Found primarily along the west coast and the Outer Hebrides, with occasional records from Orkney (Scapa Flow), Shetland (Lunna Ness and Out Skerries) and the Isle of May (outer Firth of Forth).</p> <p>Wider distribution - This habitat is not recorded outside of the British Isles. The gravel sea cucumber itself has a wider recorded distribution, from northern Norway to the Bay of Biscay.</p> <p>Feature status - This habitat is highly sensitive to physical disturbance and pressures are known to include mobile demersal fishing (including scallop dredging) and the extraction of maerl (for soil conditioner).</p>	
Natural heritage importance	Information sources
EC Habitats Directive Annex I (Subtidal sandbanks) Scottish Biodiversity List UK BAP	JNCC Marine Habitat Classification MarLIN
Component biotopes in Scottish waters	
<i>Neopentadactyla mixta</i> in circalittoral shell gravel or coarse sand - SS.SCS.CCS.Nmix.	

Annex C Copies of Marine Licence 00009110 and Shetland Islands Council Works Licence
2023/015/WL.
