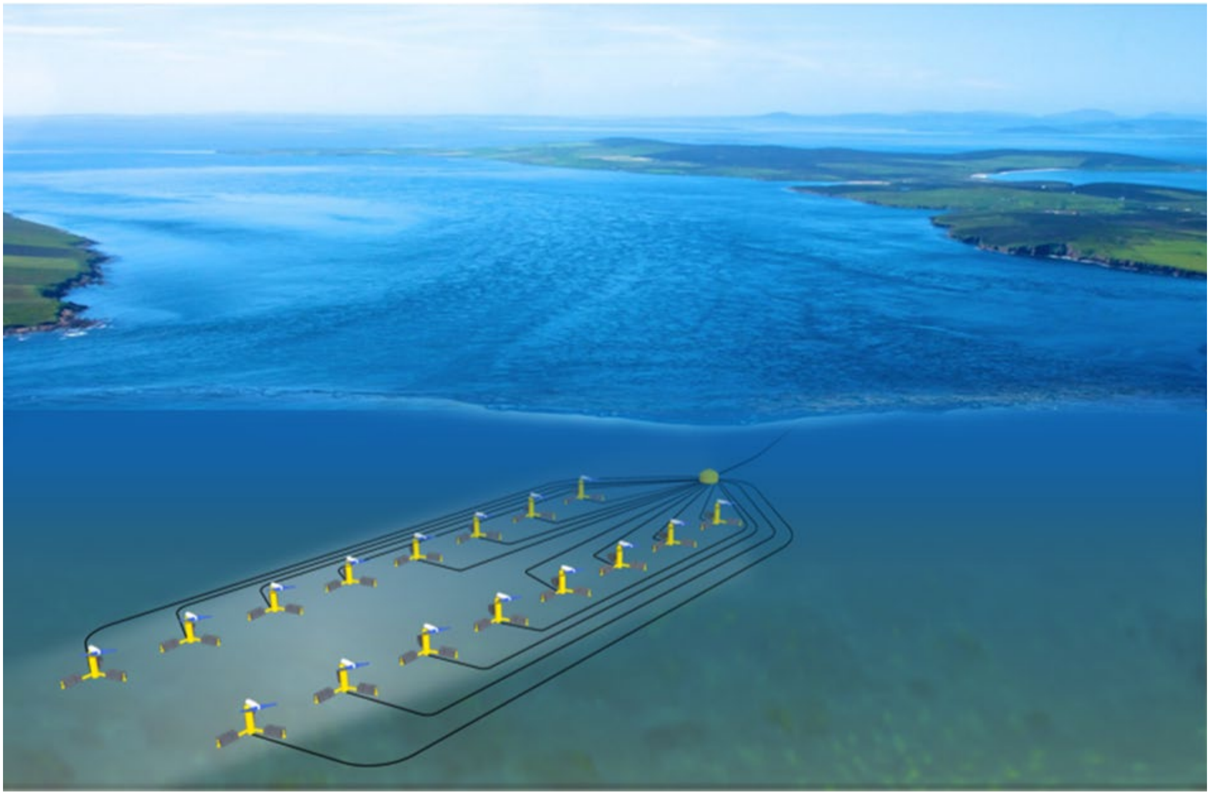
Nova Innovation | SEASTAR Project

Environmental Monitoring & Mitigation Plan

EMEC Fall of Warness

December 2023



Document history

Revision	Date	Description	Originated by	Approved by
1.0	21/12/23	Final draft for issue to MD-LOT	Kate Smith	Gavin McPherson

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Contents

1 Introduction

This Environmental Monitoring and Mitigation Plan (EMMP) sets out the proposed mitigation and monitoring measures for Nova's 4 MW SEASTAR (Sustainable European Subsea Tidal Array) project at Berth 7 in the Fall of Warness site at EMEC, Orkney Islands. The implementation of the measures set out in this document will ensure that any adverse environmental effects of the project are avoided.

The SEASTAR project will be implemented under EMEC's site-wide licence issued by Marine Scotland (operational name) on behalf of Scottish Ministers under Section 36 of the Electricity Act 1989 for the Fall of Warness. This EMMP has been developed to support Nova's project-specific marine licence application to Scottish Government's Marine Directorate for SEASTAR under the Marine (Scotland) Act 2010.

EMEC and Nova will work together to manage installation of SEASTAR Project offshore infrastructure and associated activity to ensure that the project is installed and operates in accordance with site-wide consents. The total number of devices (or any other parameter) will not breach any limit in the overarching section 36 consent for Fall of Warness.

An overview of Nova Innovation and the SEASTAR project are provided in this document. Detailed technical project details are provided in the Project Information Document (Nova Innovation, 2023a). Details of the decommissioning process and methods are provided in the SEASTAR Project Decommissioning Programme (Nova Innovation, 2023b).

The mitigation and monitoring measures detailed in this EMMP have been identified following a review of the potential for the project and associated activities to result in adverse environmental impacts. The mitigation and monitoring measures in the EMMP will be kept under continual review throughout the lifetime of the SEASTAR project, according to principles of adaptive management. This will ensure they remain fit-for-purpose, are 6science-based, drawing on best available evidence and employ best practice. Further details on the process of adaptive review of monitoring and mitigation measures are provided in this document. Details of statutory reporting mechanisms that will be implemented throughout the project are also provided.

2 Project overview

2.1 Nova Innovation

Nova is one of the world's leading players in driving forward the development of the nascent tidal stream energy industry. Nova was the first in the world to deploy an offshore array of tidal stream turbines (in 2016 in Bluemull Sound, Shetland). Of approximately fifteen offshore tidal stream turbines that are currently deployed around the world, three are Nova's: designed and manufactured in Scotland. Headquartered in Edinburgh, Nova currently employs more than 30 staff.

2.2 Project details

The SEASTAR project will have a total installed capacity of 4 MW and involve the deployment of sixteen Nova M250-D 250 kW turbines at Berth 7 in the Fall of Warness site at EMEC, Orkney Islands. The total number of devices deployed will not breach the limit in the overarching section 36 consent for Fall of Warness. An offshore electrical hub, intra-array cabling and a remote observation platform for environmental monitoring will also be installed for the duration of the

SEASTAR project. All SEASTAR offshore infrastructure will be installed at the Fall of Warness in 2026 and will be operated at the site for 20 years, following which decommissioning will take place in 2046.

The M250-D is a seabed-based horizontal axis direct drive 250 kW tidal turbine. It is the culmination of 12 years of technology development, demonstration and refinement and will closely resemble the three Nova M100-D turbines currently deployed in the Shetland Tidal Array, Bluemull Sound, shown in Figure 1.

Figure 1. Nova's M100-D turbine with its substructure being prepared for deployment at the Shetland Tidal Array, Bluemull Sound. *Copyright © Nova Innovation 2020*

The M250-D has been designed by Nova for operation in tidal sites of depths from 15 m to 50 m with maximum spring tide flow speeds of up to 4.5 m/s. The device consists of a gravity moored base structure, with a detachable steel nacelle containing the drive train, and two bladed horizontal axis rotor, designed for bi-directional operation, eliminating the need for a yaw mechanism. The base consists of a steel structure with concrete/steel ballast positioned on three feet.

Full details of the M250-D turbines and other SEASTAR project offshore infrastructure are provided separately in the Project Information Document (Nova Innovation, 2023a). Details of key parameters of the SEASTAR project in relation to the envelope of activity consented under EMEC's site-wide Electricity Act 1989 Section 36 consent are provided in the next section.

2.3 SEASTAR and Fall of Warness project envelope

Table 1 details the key parameters of offshore technologies and associated infrastructure that may be deployed at the EMEC Fall of Warness site under the 10 MW and 50 MW site-wide consents.

Parameters of the 10 MW consent are as stipulated in the site-wide licence issued by Marine Scotland (operational name) on behalf of Scottish Ministers under Section 36 of the Electricity Act 1989 for the Fall of Warness. The details for the 50 MW consent (not yet issued) are based on the project envelope assessed within the supporting Environmental Impact Assessment (EIA). The final column provides the parameters of the SEASTAR project.

Table 1. Key parameters of 10 MW and 50 MW site-wide consents for the Fall of Warness. Final column provides project-specific values for SEASTAR.

Parameter	10 MW consent	50 MW consent	SEASTAR project
Maximum installed capacity	10 MW	50 MW	4 MW
Maximum number of devices	12	35	16
Maximum number of rotors	18	Not specified	16
Maximum rotor diameter	25 m	Not specified	7.5 m
Maximum swept area per device	Not specified	5000 m^2	44.2 m^2
Minimum depth surface clearance	2.5 m	2.5 m	15 m
Total materials deposited per device	Not specified	2000 tonnes concrete/densecrete 2000 tonnes steel/carbon steel 100 tonnes plastic/synthetic	23 tonnes steel 7 tonnes plastic/synthetic
Total materials deposited per substructure	Not specified	4000 tonnes concrete/densecrete 4000 tonnes steel/carbon steel	190 tonnes concrete 28 tonnes steel
Total seabed coverage per device	Not specified	750 m^2	270 m^2 (Direct contact = 3 m^2)
Maximum number of electrical hubs	Not specified	8	1
Maximum seabed coverage of hubs	Not specified	500 m^2	25 m^2
Total material deposited per hub	Not specified	500 tonnes concrete/ densecrete 1000 tonnes steel/carbon steel 100 tonnes Plastic/synthetic	60 tonnes concrete 100 tonnes steel 5 tonnes plastic/synthetic

The offshore infrastructure associated with the SEASTAR Project is within the envelope of parameters specified for the 50 MW Fall of Warness site-wide consent[1]. The 10 MW Section 36 consent allows for a maximum of 12 turbines. **EMEC and Nova will work together to manage installation of SEASTAR offshore infrastructure and associated activity to ensure that the project is installed and operates in accordance with site-wide consents for the Fall of Warness, both alone and in combination with other activities at the site. This includes**

[1] At the time of writing, a site-wide Environmental Impact Assessment (EIA) is underway to support an application for a 50 MW licence under Section 36 of the Electricity Act 1989 for the Fall of Warness.

ensuring that the total number of devices deployed (or any other parameter) does not breach any limits of the overarching section 36 consent for Fall of Warness.

Table 2 details the key parameters of offshore works associated with activities at the Fall of Warness, as included in the 'worse case scenarios' assessed within the EIA for the 10 MW and 50 MW site-wide Section 36 licences. The final column provides the corresponding parameters for the SEASTAR project.

Table 2. Key parameters of offshore works associated with activities carried out under 10 MW and 50 MW site-wide consents for the Fall of Warness. Final column provides project-specific values for SEASTAR.

Parameter	10 MW consent	50 MW consent	SEASTAR project
Pre-installation activities at Berth	Not specified	Up to 1 week	Up to 1 week
Installation activities	Not specified	Typical duration of up to 1 month per device (maximum of 7 days of drilling per device)	Typical duration of up to 6 days per device.
Inspection and maintenance activities	Not specified	Regular intervals over 3-12 months	Scheduled maintenance once every 5 years (all turbines in one operation). Unscheduled maintenance up to 2-3 times per year (worst case scenario)
Temporary retrieval and redeployment of nacelle, gravity foundations, anchors or scientific equipment	Not specified	Typical duration of up to 1 month	Typical duration of up to 3 neap tides per turbine (allowing contingency)
Inspection, maintenance and replacement of cables and protection	Not specified	Typical duration of up to 1 week	Typical duration of up to 3 neap tides (allowing contingency)

The offshore works and activities associated with the SEASTAR project are within the 10 MW and 50 MW consented envelopes for the Fall of Warness.

EMEC and Nova will work together to manage installation of SEASTAR offshore infrastructure and associated activity to ensure that the project is installed and operates in accordance with site-wide consents. Any interaction with Nova's OCEANSTAR project will also be managed, as well as other developer activity at EMEC, to ensure that any limits of site-wide consents are not exceeded.

3 Potential for environmental effects

At the time of writing, a site-wide Environmental Impact Assessment (EIA) is underway to support an application for a 50 MW licence under Section 36 of the Electricity Act 1989 for the Fall of

Warness. This will build on the Environmental Appraisal and EIA for the existing site-wide 10 MW Section 36 licence (EMEC, 2014a; 2014b).

The Environmental Impact Assessments for 10 MW and 50 MW installed tidal capacity at the Fall of Warness were based on project envelopes, as described in Section 2.3 of this document, and detailed the Project Information Document (Nova Innovation, 2023a).

The offshore infrastructure associated with the SEASTAR project is within the envelope specified for the 50 MW Fall of Warness site-wide consent. The 10 MW Section 36 consent allows for a maximum of 12 turbines.

EMEC and Nova will work together to manage installation of SEASTAR offshore infrastructure and associated activity to ensure that the project is installed and operates in accordance with site-wide consents for the Fall of Warness, both alone and in combination with other activities at the site. The total number of devices deployed (or any other parameter) will not breach any limit in the overarching section 36 consent for Fall of Warness.

Annex A details a project-specific assessment of the potential for the SEASTAR project and associated activities to result in adverse environmental effects, taking account of the site-wide EIAs for the Fall of Warness. This concluded that the SEASTAR project and associated offshore activities have the potential to result in the following environmental effects:

1. Disturbance to sensitive species during offshore works (construction, maintenance or decommissioning activities).
2. Disturbance or displacement of sensitive species during turbine operations caused by turbine noise, or the physical presence of turbines.
3. Harm to diving birds, marine mammals or fish as a result of collisions with operating turbines.

Mitigation and monitoring measures for these potential environmental effects will be implemented throughout the SEASTAR project, detailed in the following sections of the EMMP.

Nova has produced a separate Navigational Risk Assessment to identify and assess project-specific navigational risks and identify any control measures required (Nova Innovation, 2023c).

4 Disturbance to sensitive species during offshore works

4.1 Risk assessment

No subsea piling or drilling will be required during installation of any SEASTAR project offshore infrastructure. Turbines will be gravity-based. The offshore electrical hub will either be gravity-based on the seabed with the ability to be easily raised to the surface using temporary flotation, or floating and fixed in place using an appropriate gravity-based mooring or anchoring system.

Intra-array cabling between turbines and the electrical hub will be laid on the seabed, with protection where necessary. The cables will incorporate double wire armouring, which has been proven to be stable under its own weight on the seabed at the Shetland Tidal Array in Bluemull Sound.

There is therefore limited potential for the creation of subsea noise leading to species disturbance during offshore works.

The small size of Nova's turbine (comprising modular substructures, ballast and nacelles) enables these, along with the offshore electrical hub and intra-array cables to be installed in separate operations. This allows small vessels to be utilised for all construction, maintenance and decommissioning activities.

All SEASTAR offshore infrastructure will be installed at the Fall of Warness in 2026. Following the installation and commissioning phase of approximately 12 months, the 16-turbine array will be operated for up to 20 years, following which decommissioning will take place in 2046. Decommissioning is scheduled to take place over 28 weeks during 14 neap tides in the summer of 2046.

All offshore works associated with each equivalent turbine installation in Shetland took less than 6 days to complete, while turbine nacelle installation can be completed in a single slack water period. Scheduled maintenance for the SEASTAR Project is planned to take place once every 5 years, during which all sixteen turbines will be serviced. It is likely that there may be a need for some form of unscheduled maintenance up to 2-3 times per year. However, the limited duration of such activities further reduces the potential for disturbance to marine species as a result of offshore works associated with the SEASTAR project.

Nevertheless, the introduction of noise and vessel disturbance during offshore works could result in some minor temporary and localised disturbance to marine species. Given their sensitivity to noise and vessel presence marine mammals and basking shark are at most risk of disturbance.

4.2 Mitigation measures

Table 3 sets out the mitigation measures that will be implemented throughout the SEASTAR project to ensure such effects are reduced or avoided or, if they do occur, are lawful.

Table 3. Mitigation measures to minimise or avoid disturbance to sensitive species during offshore works associated with the SEASTAR project.

Mitigation/monitoring measure	Effectiveness	Residual potential for adverse effects
All personnel will adhere to the Scottish Marine Wildlife Watching Code (SMWWC) during all offshore operations. Copies of the code will be kept in Nova's site files at EMEC and Nova's main office and onboard all vessels engaged in Works. Adherence to the code will be included as standard in all site briefings.	Highly effective.	None.
All vessels engaged in works will apply a minimum 500 m buffer to 'occupied' seal haul-outs during sensitive periods for harbour and grey seal (early June to end August and late September to end December respectively) to avoid disturbance.	Highly effective.	None.

Mitigation/monitoring measure	Effectiveness	Residual potential for adverse effects
Nova will consult with MD-LOT/NatureScot on the need for EPS/Basking shark licences, in advance of commencement of offshore works to ensure that any disturbance is lawful. Any licence applications would be supported by risk assessments.	Highly effective. Licences would only be issued if the three EPS licensing tests are met[2].	None.

5 Disturbance to sensitive species during turbine operations

5.1 Risk assessment

There is some potential for minor localised avoidance of turbines in the SEASTAR project by sensitive species as a result of turbine-generated noise or the physical presence of turbines.

In 2023 Seiche Ltd measured underwater sound levels at Nova's Shetland Tidal Array in Bluemull Sound (Pierpoint et al, 2023), following IEC Standard 62600-40 (BSI, 2019) and assessed the likely implications for effects on marine wildlife. The study concluded that the noise generated by the turbines is well below levels likely to result in injury to marine mammals, based on the Southall et al. (2019) thresholds. It also concluded that some localised disturbance may be possible, particularly to very sensitive species at close ranges to the turbines. Any such disturbance is unlikely to be significant over a wider area. These conclusions were based on a 6-turbine array.

In 2010, Nova commenced a programme of regular land-based bird and mammal surveys in Bluemull Sound, prior to installing any turbines. These surveys have not identified any disturbance to, or any change in the distribution of, any species in Bluemull Sound as a result of the Shetland Tidal Array or associated activities (Nova Innovation, 2022). On this basis, these land-based surveys in Bluemull Sound have now ceased.

Significant disturbance caused by the SEASTAR project, either as a result of turbine-generated noise or the physical presence of turbines is highly unlikely, including when implemented under the existing 10 MW site-wide Section 36 consent. The hypothetical potential for disturbance or displacement of birds and mammals in the Fall of Warness area is likely to increase as the number of installed turbines across the site increases, particularly if a 50 MW site-wide Section 36 consent is awarded. The EIA for the 50 MW consent application will consider this issue and the need for site-wide, EMEC-led mitigation in greater detail.

Significant disturbance or displacement, if it exists at all, is likely to be greater for species that are sensitive to (i.e., overtly avoid) turbines, but little evidence is currently available on what those

[2] EPS Licensing tests are as follows: Test 1: There must be a licensable purpose for which licences can be granted; Test 2: There must be no satisfactory alternative; Test 3: The proposed action must not be detrimental to maintaining the species at 'favourable conservation status'.

species might be (if any). Species with small populations would be more vulnerable to population-level impacts resulting from any such disturbance (Booth et al, 2020).

Species which are persistently present in the Fall of Warness, and which utilise habitats in the area for key activities such as feeding, foraging or raising young may be vulnerable to any disturbance or displacement during the SEASTAR project. Observations during EMEC's long-running programme of site-wide bird and mammal surveys at the Fall of Warness do not indicate that the area provides habitat that is either unique or critical in its functional importance for any species of marine birds and mammals.

5.2 Mitigation and monitoring measures

Table 4 sets out the mitigation and monitoring measures that will be implemented throughout the SEASTAR project to ensure such effects are reduced or avoided or, if they do occur, are lawful.

Table 4. Mitigation and monitoring measures to minimise or avoid disturbance to species during turbine operations associated with the SEASTAR project.

Mitigation/monitoring measure	Effectiveness	Residual potential for adverse effects
Monitoring of operational turbine noise will be carried out to determine the noise levels generated by the array.	Highly effective. Further details on methods provided in Section 5.3.	None.
Nova will consult with MD-LOT/NatureScot on the need for EPS/Basking shark licences, in advance of commencement of turbine operations to ensure that any disturbance is lawful. Any licence applications would be supported by risk assessments.	Highly effective. Licences would only be issued if the three EPS licensing tests are passed.	None.
The low disturbance risk presented by SEASTAR alone does not justify project-specific disturbance monitoring. As activity at the Fall of Warness increases (particularly if 50 MW consent is issued for the FoW), Nova will work with EMEC to understand the need for site-wide monitoring for cumulative disturbance.	Highly effective. Further details provided in EMEC's site wide Environmental Monitoring Plan.	None.

5.3 Turbine noise monitoring

Acoustic measurement in highly dynamic tidal environments like the Fall of Warness poses certain challenges. The methodologies that will be used to measure turbine/array noise for the SEASTAR project will be finalised in discussion with specialist contractors. However, they are likely to be based on the methods used successfully at the Shetland Tidal Array in Bluemull Sound, using drifting rather than static hydrophones.

Using static hydrophones presents logistical difficulties in anchoring moorings to the seabed. Furthermore, static hydrophone installations are exposed to turbulent water flow across their surface which results in spurious 'flow noise' that may mask sounds of interest. Flow noise affects lower frequencies (up to ~1000 Hz) in particular, which are important in characterising tidal turbine signals.

Using drifting hydrophones reduces flow noise but interweaves temporal and spatial patterns. Collecting enough data through multiple drifts across areas of the same spatial extent at different times of the tidal cycle can help to account for observed variability. Drifting hydrophones have the advantage of measuring the turbine sound field as a function of range, aiding in estimating local propagation loss. Accurate measurements of turbine sound at a series of distances and estimates of propagation loss are both necessary to back-calculate the source level of the turbines.

In the measurements at Bluemull Sound, the hydrophone was suspended below a float that housed a high resolution (10 Hz) GNSS logger. The float was tethered to a drifting workboat on a 30-m rope, and the hydrophone was cabled to a PAM-Go data-acquisition system onboard the boat to enable the acoustic signal to be monitored in real-time. This method had advantages over using an independent drift buoy. Successful data collection could be verified, and signal gain modified if necessary to avoid clipping or low signal level. The tethered hydrophone method enabled the drift path to be monitored while targeting 25 x 25 m data collection zones. Drifts could be restarted and start positions adjusted, should eddies carry the hydrophone off course. Figure 2 shows the data collection system used in Bluemull Sound, which is likely to be similar to that used for SEASTAR turbine/array noise measurements.

As an emerging area of research, the methods will be finalised nearer the time, based on best practice and best available evidence.

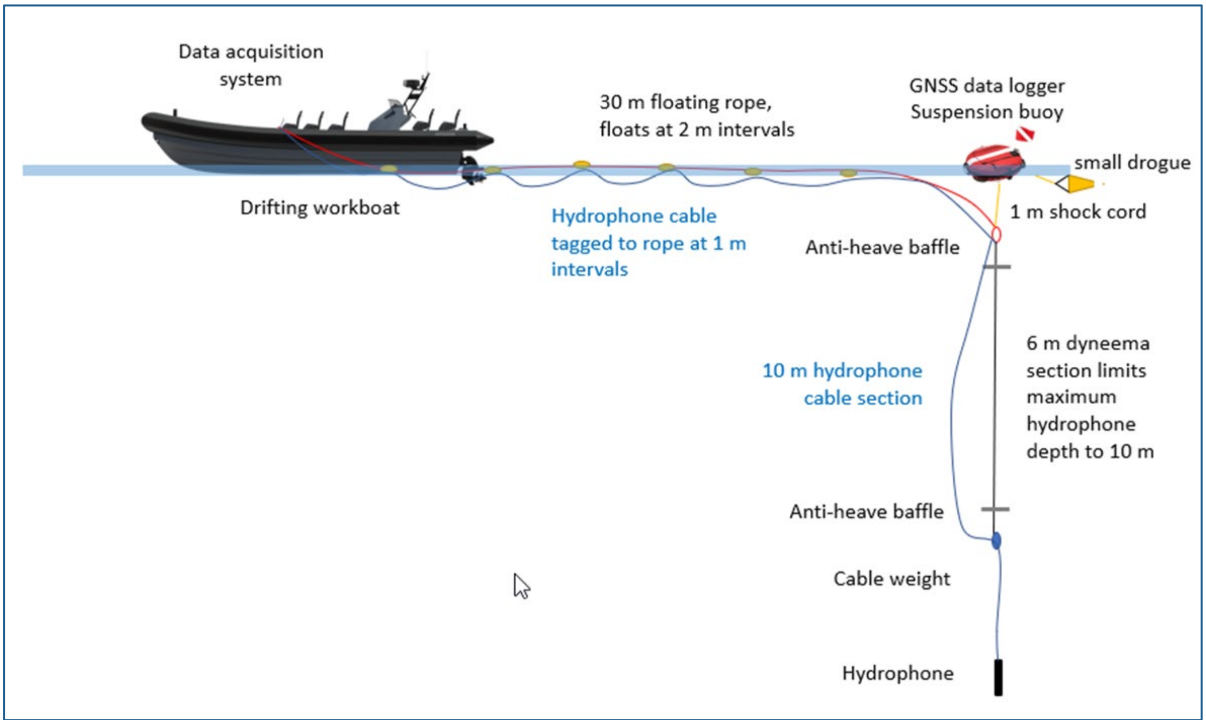

Figure 2. Schematic drawing of the data collection system used in Bluemull Sound and likely to be used for the SEASTAR project. *Source: Nova Innovation and Seiche Ltd 2023*

6 Collision risk during turbine operations

6.1 Summary of risk

Copping et al (2023, in press) have proposed a conceptual probabilistic framework for quantifying the likelihood of collision risk for marine animals and operational tidal energy turbines. The framework is illustrated in Figure 3 and is represented by a series of sequential events (steps) that must take place, each with an associated probability, for a marine animal to approach an operational turbine, be struck by a turbine blade and be harmed (i.e., suffer a critical injury or mortality).

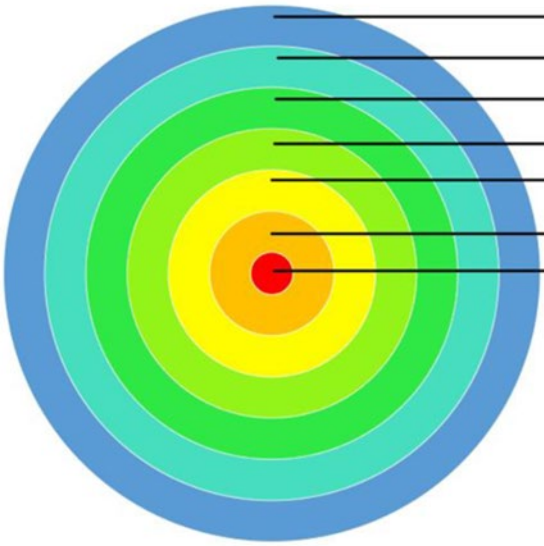

Figure 3. Conceptual probabilistic framework for quantifying the likelihood of collision risk for marine animals and operational tidal turbines. From Copping et al, 2023 (in press).

No collisions (Step 6 in the framework) have been observed globally in comprehensive and extensive monitoring of deployed in-stream tidal turbines carried out to date, as summarised in Sparling et al (2020). This includes the ongoing environmental monitoring of Nova's Shetland Tidal Array, Bluemull Sound, full details of which are provided in the Project Environmental Monitoring Plan (PEMP) and environmental monitoring report series, which are all in the public domain[3].

Analysis of data gathered during Nova's long-running environmental monitoring programme at the Shetland Tidal Array has demonstrated that actual collision risk is much lower than was originally predicted for the project by Collision Risk Modelling (Scottish Natural Heritage, 2016; Nova Innovation, 2018). Nova's subsea video monitoring of the turbines has seen no evidence of diving birds occurring around turbines in the array when the turbines are operating (Step 3). Fish occasionally occur around turbines when they are operating, but such interactions have never been observed to progress to Step 6 of the probabilistic framework (collisions with rotating blades). The small turbine size might also be expected to help with evasion (step 4), since animals that perceive the turbine will have less far to travel to avoid it compared to larger turbines.

[3] Available at https://marine.gov.scot/ml/marine-licence-shetland-tidal-array-extended-bluemull-sound-shetland-0664200009110

This growing dataset gathered from Nova's monitoring at Bluemull Sound, combined with monitoring of other deployed turbines and global research into collision risk is increasingly demonstrating that the risk of incidental collisions between marine wildlife and operational turbines is very low to negligible.

The collision risk modelling in the Environmental Appraisal for the 10 MW Section 36 consent for the Fall of Warness was based on turbines with a rotor diameter of 25 m. The rotor diameter of Nova's M250-D turbine is 7.5 m. The total rotor swept area of twelve 25 m diameter turbines would be 5,890 m^2, while the total rotor swept area of the sixteen turbines in the SEASTAR Project would be 707 m^2, an equivalent swept area to less than two (1.44) of the much larger 25 m turbines. The reduced rotor swept area of Nova's turbines and corresponding lower modelled collision risk for diving birds, marine mammals and basking shark, means that the overall magnitude of predicted impact is highly unlikely to exceed that considered in the 10 MW Section 36 consented envelope. **Nevertheless, EMEC and Nova will work together to manage installation of the SEASTAR Project so that the total number of devices deployed (or any other parameter) will not breach any limit in the overarching section 36 consent for Fall of Warness.**

Nevertheless, some uncertainty remains about the potential for incidental collisions to occur between fish, diving birds and mammals and tidal turbines, such that the risk cannot be completely dismissed for the SEASTAR project at this stage.

6.2 Summary of mitigation and monitoring measures

A hierarchy of mitigation and monitoring measures will be used to avoid, mitigate and monitor incidental collisions with operating turbines for the SEASTAR project. This hierarchy of measures takes account of the complexity and uncertainty surrounding collision risk, and the conceptual probabilistic framework detailed in Figure 6-1. The hierarchy of measures are as follows:

- Nearfield turbine monitoring.
- Incremental turbine installation and commissioning.
- Extended turbine commissioning procedure.
- Use of best available evidence to avoid collisions.

These measures, detailed in the following sections, will be applied as necessary and appropriate throughout the SEASTAR project to avoid, mitigate and monitor collision risk.

6.3 Nearfield turbine monitoring

6.3.1 Objectives

Nearfield turbine monitoring will be a core component of the SEASTAR project and will be based on the following objectives, to ensure that it is focussed and fit-for-purpose:

1. To gather information on the presence and behaviour of fish, birds and mammals around the turbines when they are operating.
2. To identify any collision or near miss events between fish, birds and mammals and operational turbines.

3. To inform the need for any additional intervention or contingency measures, to avoid or reduce collision risk for fish, birds and mammals.

To address these objectives, the nearfield turbine monitoring must have the ability to detect fish, birds and mammals around the turbines when they are operating. Designing a system capable of doing so with a high degree of confidence and reliability must take account of the following technical and practical issues:

- Evidence to date (e.g., Sparling et al, 2020) indicates that nearfield interactions between fish species and aquatic species at risk and turbines are likely to be very low probability events. The monitoring and data processing systems therefore need to be capable of handling large quantities of data to screen for and detect very rare events.

- The monitoring equipment must be durable and capable of surviving the relatively harsh environmental conditions in the Fall of Warness.

- The monitoring sensors, including power and communications systems must be compatible with deployment on or in association with Nova's turbines in the SEASTAR project.

- The instruments and sensors must provide capability to carry out nearfield turbine monitoring, including during low light conditions and poor visibility.

6.3.2 Overview of monitoring methods

Technological advancements by Nova and others in different instrument classes, the integration of instruments on subsea monitoring platforms, and improvements of methodologies have significantly increased understanding for how the challenges in monitoring tidal turbines can most effectively be addressed (e.g., Hasselman et al, 2020).

Nova has made significant progress in this area through the practical delivery of environmental monitoring at the Shetland Tidal Array and in Petit Passage, Nova Scotia in the Bay of Fundy. This expertise and knowledge has been applied to develop effective and reliable methodologies for delivering nearfield monitoring of turbines for the SEASTAR project.

The nearfield turbine monitoring for the SEASTAR project will be delivered through turbine-mounted high-definition optical cameras and a standalone subsea monitoring platform, or Remote Observation Platform (ROP), on which monitoring instruments will be mounted, including optical cameras, a multibeam sonar and an ultraviolet anti-biofouling light to minimise instrument biofouling.

The use of turbine-mounted cameras and the ROP-mounted instruments will provide single turbine and array monitoring capabilities, as well as contingency in monitoring capabilities.

Further details on the monitoring methods are provided in Table 5.

Table 5. Details of nearfield turbine monitoring methods for the SEASTAR project.

Monitoring method	Details and effectiveness
Single turbine-mounted camera on each turbine in the array. Camera will be mounted on the turbine nacelle, directed towards the rotor swept area	Subsea video has been used successfully throughout the operational phase of the Shetland Tidal Array to monitor nearfield interactions between marine wildlife and the turbines. To date it has also enabled identification of species observed in footage with very high confidence (e.g., Nova Innovation, 2023d). Water clarity at the Fall of Warness is not likely to differ significantly from that in Bluemull Sound, so is expected to be highly effective for nearfield turbine monitoring for the SEASTAR project. Further details are provided in Section 6.4.
Remote Observation Platform (ROP) mounted with optical cameras and multibeam sonar	A ROP has been successfully installed at Nova's tidal project site in the Bay of Fundy (Petit Passage, Nova Scotia) since March 2022. It has been successfully gathering data on marine species presence and behaviour in the project site. The use of optical cameras combined with the Tritech Gemini multibeam sonar has enabled synchronisation of instruments for more effect target detection. The use of the ROP is expected to be highly effective for nearfield turbine monitoring for the SEASTAR project. Further details are provided in Section 6.5.

6.4 Turbine-mounted cameras

A single high-definition optical camera mounted to each turbine will form a core component of the multi-instrument approach to delivering effective nearfield turbine monitoring for the SEASTAR project. Nova has successfully used a single high-definition optical camera with capabilities in low light conditions to gather high quality footage from the three direct-drive turbines in the Shetland Tidal Array. A final decision on the camera system that will be used will be made nearer the time of turbine installation, based on best available evidence.

As with the three direct turbines in the Shetland Tidal Array, a single camera will be mounted to the side of each turbine in the SEASTAR project, facing the turbine rotor, as shown in Figure 4.

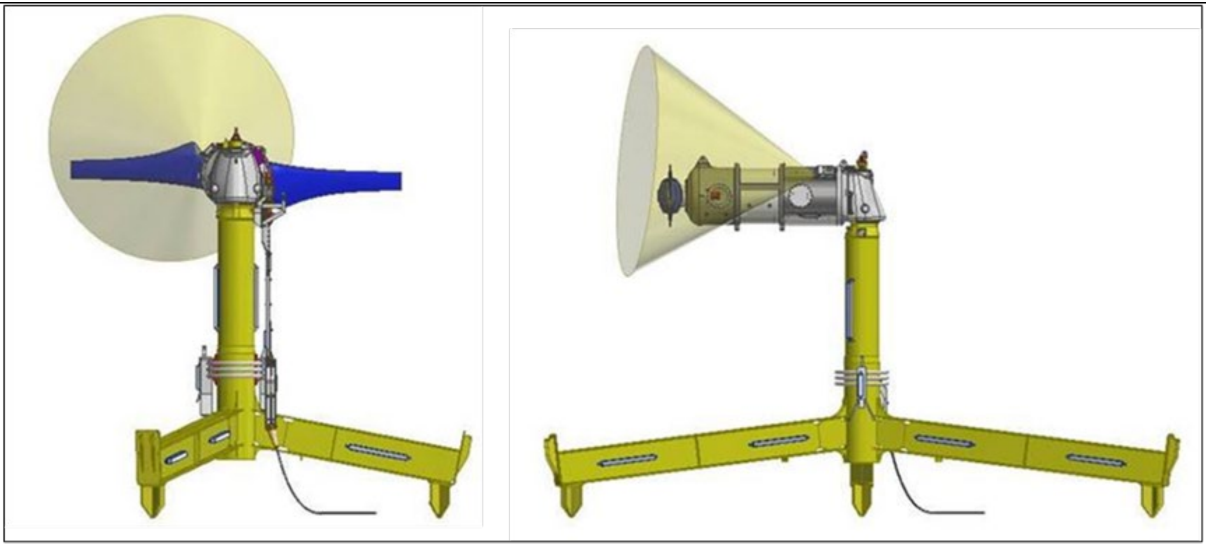

Figure 4. Turbine-mounted subsea camera system for turbines in the SEASTAR project.
Source: Copyright © Nova Innovation 2023

This side-mounted camera position is used on turbines in the Shetland Tidal Array. Examples of the images obtained are shown in Figure 5, including a rare seal observation made during slack tide, when the turbine was not rotating.

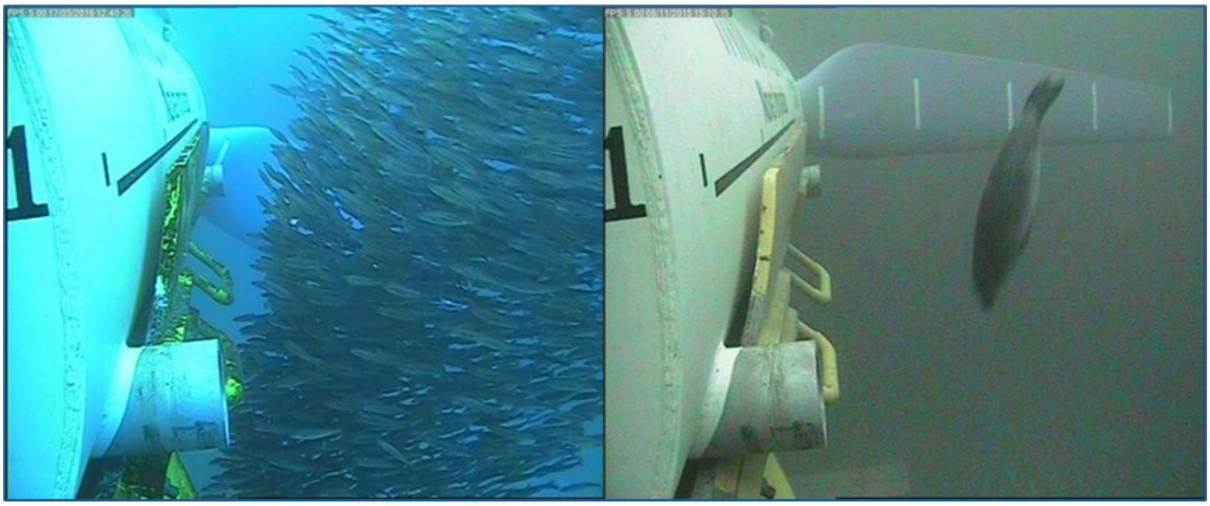

Figure 5. Examples of images acquired from side-mounted optical camera one of the turbines in Nova's Shetland Tidal Array. *Source: Copyright © Nova Innovation 2023*

The nacelles for the turbines in the SEASTAR project will incorporate connectors for the optical cameras, providing power and communications capabilities.

The turbine-mounted cameras can operate 24 hours a day, though are expected to only provide data of value during periods of sufficient light conditions. Contingency in the multi-instrument approach will offer additional nearfield turbine monitoring capabilities, including when the effectiveness of optical cameras is compromised by light levels or water clarity.

6.5 Remote Observation Platform

A key component of the nearfield turbine monitoring is the use of a standalone subsea monitoring platform, or Remote Observation Platform (ROP), on which the following instruments will be mounted:

- High-definition subsea cameras.
- A Tritech Gemini 720is multibeam sonar[4].
- An ultraviolet anti-biofouling light to minimise instrument biofouling.

The design of the SEASTAR ROP will be finalised nearer the time of deployment, but it is likely to resemble the ROP deployed in Petit Passage in March 2022, which comprises a low profile steel frame with ballast, providing a stable base to which the sensor hardware and a junction box will be fixed in position. A single cable will enable the ROP to be connected directly to turbines in the SEASTAR project for power supply and data transfer.

The optimal configuration of the optical cameras and multibeam sonar on the ROP will be determined during the initial commissioning stages of the first installed turbine in the SEASTAR project. The configuration will depend on the positioning of the ROP in relation to the turbine and will aim to provide optimal overlap between the sonar and cameras' FOV, whilst also providing good coverage of the nearfield environment around the turbine. An indicative illustration of the anticipated configuration of the optical cameras and sonar in relation to turbines in the SEASTAR project shown in Figure 6.

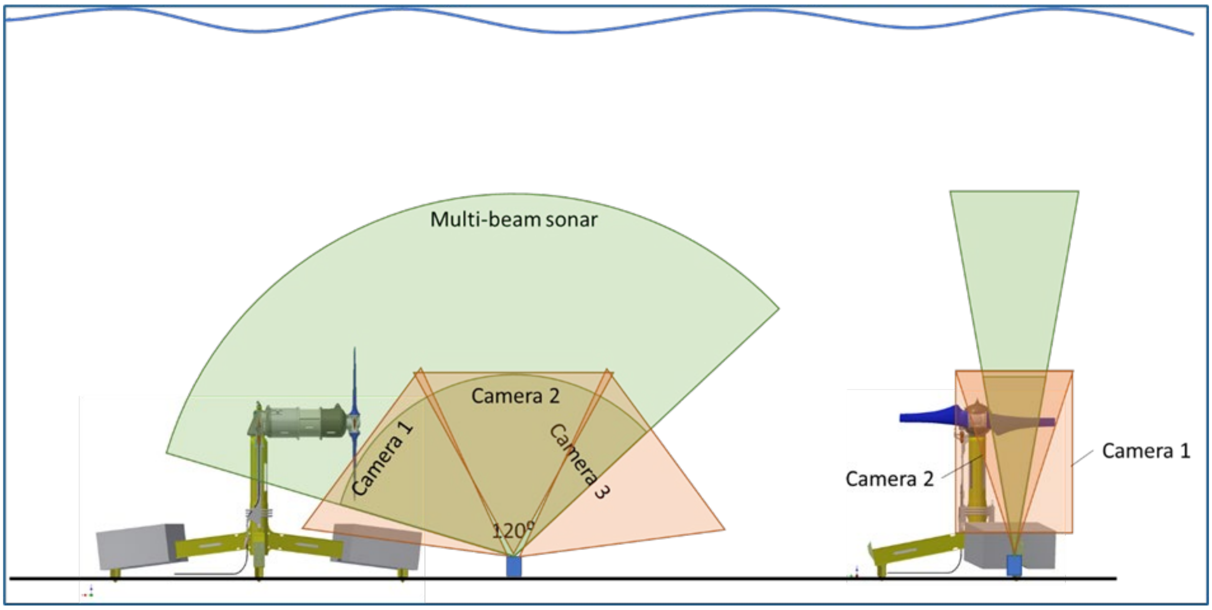

Figure 6. Schematic of ROP and turbine to illustrate configuration of optical cameras and multibeam sonar and fields of view. *Source: Copyright © Nova Innovation 2023*

[4] The Tritech Gemini 720is is currently widely recognised at the 'best in class' for nearfield turbine monitoring. The ROP-mounted instruments will be confirmed with MD-LOT finalised nearer the time, based on best available evidence and technologies.

The ROP will be deployed on the seabed adjacent to turbines in the SEASTAR project at a distance of between 10 m and 20 m. The position and orientation of the ROP will be determined during initial commissioning of the first installed turbine(s). The ROP location will be determined according to seabed characteristics to ensure stability, and to optimize coverage by the sonar of the rotor swept area of the turbine. The ROP may be positioned centrally to the turbine, or offset, illustrated in Figure 7.

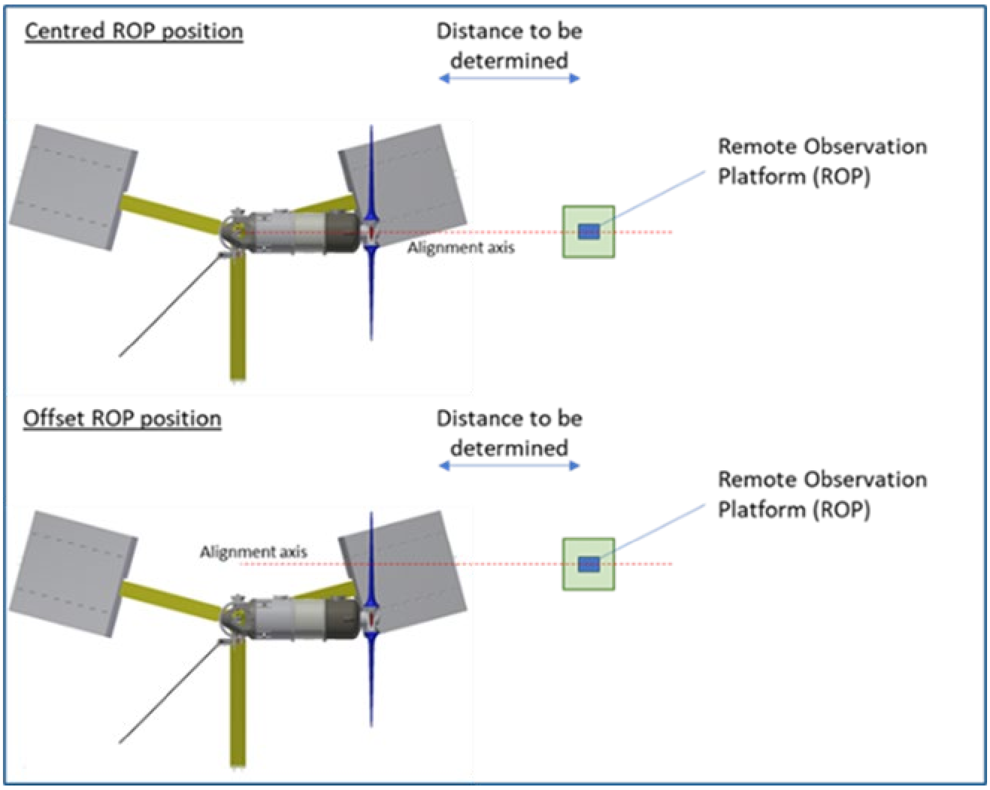

Figure 7. Indicative illustration of ROP deployment adjacent to a turbine in the SEASTAR project in centred and offset positions. *Source: Copyright © Nova Innovation 2023*

The bidirectional nature of Nova's turbine means that the instruments on the ROP will provide monitoring capabilities up and downstream of turbines, according to tidal state.

The ROP combined with the turbine-mounted cameras will provide effective and reliable methodologies for delivering nearfield monitoring of turbines for the SEASTAR project at single turbine and array scale.

6.6 Incremental turbine installation and extended turbine commissioning

The sixteen turbines in the SEASTAR project will be installed incrementally, while the programme of nearfield turbine monitoring will be implemented on installation of the first turbine(s). Nova will also carefully manage and control commissioning of turbines using a stepwise procedure implemented over a three to four week period, during daylight hours and encompassing a full neap-spring tidal cycle. The initial stages of turbine commissioning are externally powered (motoring mode). Active blade rotation powered by tidal flow (generating mode) is introduced in later stages. Turbine commissioning during daylight will ensure accurate visual feedback from turbine-mounted cameras on any presence and behaviour of mobile species.

Incremental turbine installation and commissioning will ensure that the development of the SEASTAR project is aligned with, and informed by, scientific evidence gathered through the environmental monitoring measures set out in this EMMP. **The total number of devices deployed (or any other parameter) will not breach any limit in the overarching section 36 consent for Fall of Warness**.

6.7 Use of best available evidence to avoid collisions

Nova has the ability throughout the duration of the SEASTAR project to actively control turbine operations remotely from an onshore base. This includes the ability to slow turbine rotation speed, or to cease turbine operations altogether. This measure would only be implemented in cases of severe and imminent collision risk if, for example, large numbers of cetaceans are sighted in the immediate vicinity of the Fall of Warness. Local knowledge, including Orkney Islands and wildlife watching groups and social media channels would provide reliable sources of intelligence on any such occurrences, as has proven to be the case in Shetland.

7 Statutory reporting

7.1 Environmental monitoring reporting

Results from the SEASTAR environmental monitoring will be presented in formal reports which will be submitted to MD-LOT according to an agreed schedule. It is proposed that reports in the first instance are submitted on an annual basis.

In analysing monitoring data gathered to date from the Shetland Tidal Array, Nova has found it useful to take an exploratory, iterative approach, informed by discussion and feedback from Marine Directorate and NatureScot. Nova is fully committed to an engagement strategy for the SEASTAR project which ensures that the data gathered through monitoring activities and the analyses carried out fully meet the requirements of the Project licences and consents. This is detailed further in Sections 9.3 and 10, but an overview of the principles that will guide the data analysis is set out below.

The monitoring programme for the SEASTAR project will gather information to enable further exploration of key factors underlying marine wildlife occupancy patterns and behaviour in the sea area occupied by turbines and around the turbines themselves. This information will be used to refine understanding for collision risk.

7.2 Other statutory reporting

Nova has established an Excel-based register on the status of licence conditions for the Shetland Tidal Array. This register maintains a record all actions relating to compliance with conditions of the Marine Licence for the project. Nova proposes that a similar register will be created for the SEASTAR project and copies will be shared with MD-LOT at regular intervals, to report on progress and compliance with licence conditions.

This simple reporting system will enable Nova, Marine Directorate and EMEC to identify any potential areas of concern in relation to commitments under SEASTAR project licences or discharge of conditions.

8 Ongoing EMMP review

The mitigation and monitoring measures in the EMMP will be kept under continual review throughout the lifetime of the SEASTAR project, according to principles of adaptive management. This will ensure they remain fit-for-purpose, are science-based, draw on best available evidence and employ best practice.

Nova will consult with MD-LOT, NatureScot and other key stakeholders about any proposed changes to the EMMP (and mitigation and monitoring measures therein). Where appropriate, and as agreed with MD-LOT and its advisors, revised versions of the EMMP will be submitted to MD-LOT for approval. The iterative review process for the EMMP is shown in Figure 8.

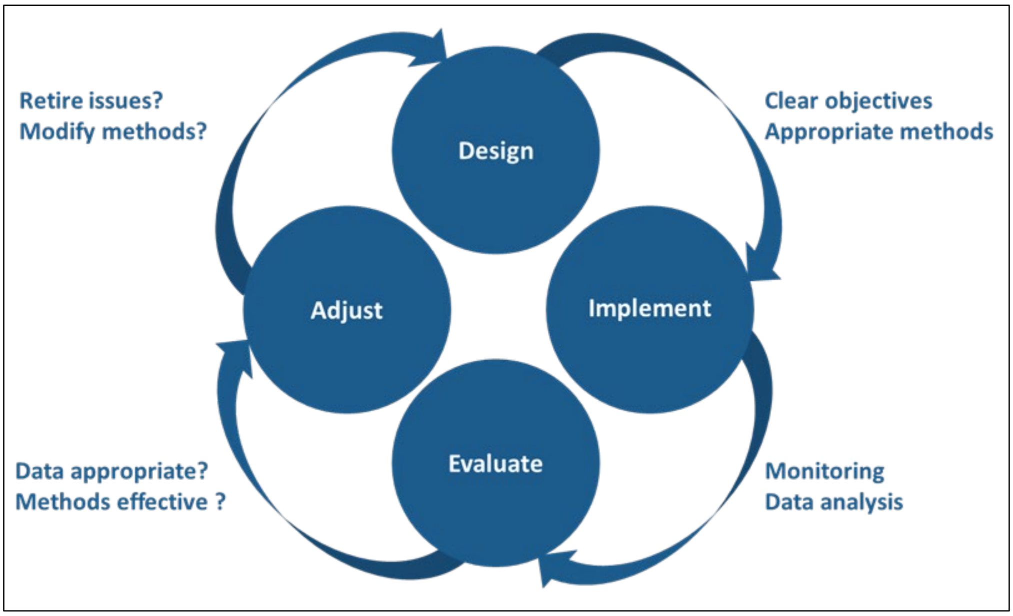

Figure 8. SEASTAR project EMMP review process, based on principles of adaptive management.

The EMMP will be also updated as appropriate, as further project information and wider evidence on the environmental effects of tidal energy becomes available throughout the project lifetime.

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Annex A Project-specific environmental assessment

The table below provides a project-specific assessment of the potential for the SEASTAR project and associated activities to result in environmental impacts, taking account of site-wide Environmental Appraisals and EIA carried out by EMEC. Details of the mitigation or monitoring measures required for any potential environmental effects identified are provided in the main body of this EMMP, in the sections indicated.

Impact pathway	Assessment and potential for adverse environmental effects	Requirement for mitigation or monitoring
Disturbance to species during offshore works	The introduction of noise and vessel disturbance during offshore works has the potential to cause some minor temporary and localised disturbance to particularly sensitive species. See Section 4.1 for a detailed assessment. **Potential for adverse environmental effects.**	Mitigation and Monitoring. See Section 4.2 for further details.
Increased turbidity	No subsea piling or drilling is required during installation of offshore infrastructure. Turbines will be gravity-based. The offshore electrical hub will either be gravity-based on the seabed with the ability to be easily raised to the surface using temporary flotation, or floating and fixed in place using an appropriate gravity-based mooring or anchoring system. Intra-array cabling between turbines and the electrical hub will be laid on the seabed, with protection where necessary. The cables will incorporate double wire armouring, which has been proven to be stable under its own weight on the seabed at the Shetland Tidal Array in Bluemull Sound. There is therefore very limited potential for the creation of sediment plumes or increased turbidity during offshore works. **No potential for adverse environmental effects.**	None required

Impact pathway	Assessment and potential for adverse environmental effects	Requirement for mitigation or monitoring
Loss or alteration of benthic habitat	Turbines and the offshore electrical hub (including the mooring/anchoring system if a floating hub is used) will be gravity-based, so no subsea piling or drilling is required. Drop-down cameras will be used during installation to enable accurate micro-siting and placement of all seabed infrastructure. Direct habitat loss will be limited to the immediate footprint of substructures, the electrical hub (or its associated mooring/anchoring system) and intra-array cables. Some scouring may occur immediately around seabed infrastructure, but benthic habitats in the Fall of Warness largely consist of scoured and tide-swept bedrock and boulders, typical of those in tide-swept areas (EMEC, 2014). The species and communities that develop in these areas are highly resilient, composed of mosaics of opportunistic species adapted to significant physical disturbance. Turbine substructures will create a habitat for marine species and are likely to result in an 'artificial reef' effects. **No potential for adverse environmental effects.**	None required
Change in turbulence around turbines	Turbines will be non-surface piercing, so there is no mechanism for the creation of a surface wake. Turbine blades are also designed to minimize turbulence, which can quickly damage rotors. Research on wake effects around other bottom-mounted turbines have found turbulence downstream of turbines is negligible, with any effects quickly lost in natural variability (Keenan et al, 2012; Whiting & Chang, 2020). **No potential for adverse environmental effects.**	None required
Change in tidal flow (including changes to sedimentary patterns)	The presence of the turbine and the resulting energy removal from the environment are likely to lead to small, localized changes in hydrodynamic conditions immediately around turbines. Any changes are highly unlikely to be of sufficient magnitude to lead to discernible changes in sediment dynamics, or deposition, or adverse effects on habitats and species. Published literature has concluded that any changes to flow from tidal energy turbines of less than 50 MW in size are likely to be negligible and quickly lost in natural variability (Robins et al, 2014; Whiting & Chang, 2020). **No potential for adverse environmental effects.**	None required

Impact pathway	Assessment and potential for adverse environmental effects	Requirement for mitigation or monitoring
Accidental introduction/transfer of Invasive Non Native Species (INNS)	Turbines and other subsea infrastructure will provide new habitat for colonisation by marine species, which could include INNS if they are already present in the area. Subsea infrastructure will not have been deployed subsea elsewhere before deployment at EMEC, so this will prevent the spread of any new INNS to the area. To avoid the project exacerbating the spread of any INNS already present in the area, or creating 'stepping stones' for their spread, appropriate anti-fouling management will be employed throughout the lifetime of the project. This will be balanced with the need to avoid the introduction of toxic materials to the environment which could harm native species. Only EMEC-approved vessels will used for marine operations, to minimise potential for transfer of INNS. Operators will follow biosecurity good practice and have ISO 14001:2015 environmental management systems accreditation. Any temporary moorings (e.g., chains) used during offshore operations will be sourced from within Orkney Islands or pressure washed / air dried prior to use at EMEC. Turbines and substructures will undergo visual inspections when removed from the water. INNS Identification cards will be used during inspections, similar to those used by Nova at the Shetland Tidal Array. Any INNS identified will be reported to EMEC, Marine Directorate, NatureScot and Orkney Islands Council, as appropriate. **No potential for adverse environmental effects.**	None required
Introduction of electro-magnetic fields (EMF)	Low-power Alternating Currents (AC) will be utilised, which produce much lower EMF than the common high-power subsea Direct Current (DC) transmission systems. Nova's systems are also delta-connected which means the three electrical phases are always balanced and no external electrical field should be present. If a fault occurred it would only be transient until the electrical protection would trip, during which time, a small electrical field may be produced (<100ms). The earthed double-armour and integral drain wires act as a screen for these emissions. Nova's currents are < 25A at full power. A study carried out to inform the assessment of the effects of EMF at the FORCE site in the Bay of Fundy, Canada (Collins, 2012) indicated that even 350A only produces μT's at the cable which are likely to have only very localised effects even on species considered particularly sensitive to the effects of EMF. **No potential for adverse environmental effects.**	None required

Impact pathway	Assessment and potential for adverse environmental effects	Requirement for mitigation or monitoring
Disturbance or displacement of species during turbine operations	The introduction of noise or the physical presence of turbines has the potential to cause some minor temporary and localised disturbance to particularly sensitive species. Significant disturbance caused by the SEASTAR project alone is highly unlikely, including when implemented under the existing 10 MW site-wide consent. Until the EIA for the 50 MW site-wide consent has been completed and the application determined, there is some residual uncertainty about the potential for cumulative disturbance at a site-wide scale as activity at the Fall of Warness increases to full 50 MW capacity. See Section 5.1 for a detailed assessment. **Potential for adverse environmental effects.**	Mitigation and Monitoring. See Sections 5.2 and 5.3 for further details.
Barrier to species movements	While there is some potential for localised avoidance of turbines by fish and mammals, the project is not located in a restricted channel, so will not create a complete barrier to movements of even very large and sensitive species. **No potential for adverse effects.**	None required
Collision risk	Uncertainty remains about the potential for incidental collisions to occur between fish, diving birds and mammals and tidal turbines, such that the risk cannot be completely dismissed for the SEASTAR project. See Section 6.1 for a detailed assessment. **Potential for adverse environmental effects.**	Mitigation and Monitoring. See Section 6.2 to 6.7 for further details.

Impact pathway	Assessment and potential for adverse environmental effects	Requirement for mitigation or monitoring
Accidental discharges or release of material to the marine environment	The turbines are sealed, so there is no potential for any chemical or fluid discharge to the marine environment. All substances deposited below MHWS will be inert, or appropriately coated or protected so that they are rendered inert and non-toxic to marine life or human health. Antifouling coatings will be used on turbine components but will be approved substances only. Any debris or waste material placed below MHWS during construction and decommissioning phases will be removed from the site and disposed of responsibly. There is potential for accidental spillages from vessels engaged in offshore work. Only responsible vessel operators approved by EMEC will be used. In the event of any accidental spills, measures set out in the vessel operator/EMEC's pollution contingency procedures will be adhered to avoid adverse environmental effects. **No potential for adverse environmental effects.**	None required
Effects on the historic environment	Studies carried out to inform the Environmental Appraisal for the 10 MW Section 36 consent application for the Fall of Warness have not identified any wreck sites or features of archaeological interest in the area. The baseline desk-studies and seabed surveys and subsequent operation of the site since 2005 have not identified any evidence of wreckage or obstructions or features of archaeological interest in the vicinity of the test site area or along cable routes. The strong seas in the area mean there is a high probability for unknown, unrecorded vessels to have sunk in Orkney over the centuries. If these have not been destroyed by the marine environment, the remains of such vessels and their associated artefacts may be buried beneath the surface of the seabed. However, based on results from the surveys conducted and the scoured and tide-swept nature of the seabed as shown by the surveys at the Fall of Warness site, it is considered extremely unlikely that any unknown archaeological or historical remains will be located at the site, including Berth 7 and the proposed locations of SEASTAR infrastructure. **No potential for adverse environmental effects.**	
Effects on navigation in the area	See SEASTAR Project Navigational Risk Assessment (Nova Innovation, 2023b)	

Source: Nova Innovation, 2023