Shetland Tidal Array Monitoring Report July 2024 to June 2025

Revision 1.0

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1.0	10/09/2025	First draft for circulation to MD-LOT and Shetland Islands Council

Notice

Contents

1 Non-Technical Summary

This report provides details of environmental monitoring activity at the Shetland Tidal Array from July 2024 to June 2025. It is the latest in a series of reports produced by Nova since monitoring of the operational tidal stream array in Bluemull Sound started in 2016.

The data analysed in this report gathered from turbine-mounted cameras between July 2024 and June 2025 continues to show that the likelihood of collisions between mobile species and turbines in the Shetland Tidal Array is extremely low. Analysis focused on diving birds and marine mammals, as the receptors of greatest nature conservation importance[1] and those at the core of the objectives of the environmental monitoring[2].

Fish were not included in the analysis within this report. Previous monitoring reports have extensively documented fish presence and occupancy patterns around the turbines. Prioritising the analysis for diving birds and mammals enabled a greater proportion of the full dataset to be analysed (100%) than has been possible in previous reporting years.

No collisions or near misses were observed between diving birds and wildlife and turbines (either when operating or not operating) in any of the footage analysed, comprising fourteen thousand, nine hundred and ninety-eight (14,998) files.

An individual harbour seal (*Phoca vitulina*) was observed three times in one video file captured from the camera on T5 on 06/02/2025. The animal was observed surfacing past the turbine nacelle, then diving past the camera towards the seabed, before resurfacing again. The turbine blades were stationary and the tidal state based on Nova's hydrodynamic model for Bluemull Sound was decreasing ebb/low water slack. Possibly the same animal was potentially seen 10 minutes earlier (10:14) on the camera mounted to T6, where an object which may have been a diving seal was seen some distance to the north of the turbine. Again, the turbine blades were stationary, as the tidal state was decreasing ebb, approaching low water slack.

No diving birds were observed in any of the footage.

This report also examines the proportion of good quality data acquired from subsea cameras that has been analysed over the lifetime of the Shetland Tidal Array monitoring programme (i.e. excluding footage in which biofouling compromises the ability to detect nearfield animal interactions). This exercise follows on from a systematic review of historic biofouling on turbine-mounted cameras from 2015 through to 2024[3]. The recalculation of previous data analysis determined that 62% of the good quality footage has been analysed up to and including the current reporting period. Previous estimates that between 20% and 25% of the full dataset have been analysed were therefore a gross underestimate. This further highlights the rarity of nearfield encounters between animals and turbines and the extremely low probability of collisions.

This report further contributes to the growing evidence base that **the risk of collisions between marine wildlife and tidal turbines is very low (probably close to zero)**.

[1] As detailed in the Shetland Tidal Array Extension Environmental Assessment Report (Nova Innovation, 2018) and Marine Scotland Appropriate Assessment (Marine Scotland, 2018).

[2] As detailed in the Shetland Tidal Array Project Environmental Monitoring Plan (Nova Innovation, 2025a)

[3] See Nova Innovation (2024a)

2 Introduction

This report is provided in support of discharge of conditions attached to the following licences for Nova Innovation's Shetland Tidal Array in Bluemull Sound between the islands of Yell and Unst:

1. Marine Licence MS-00009110, issued by Marine Scotland Licensing Operations Team on behalf of the Scottish Ministers, under the Marine (Scotland) Act 2020.
2. Shetland Islands Council (SIC) Works Licence 2023/015/WL, issued by Shetland Islands Council under the Zetland County Council Act 1974.

This monitoring report is the latest in a series produced by Nova Innovation since monitoring of turbines in the array commenced in 2016.

The Project Environmental Monitoring Plan (PEMP) (Nova Innovation, 2025a) provides full details of all environmental monitoring activities for the Shetland Tidal Array, including the monitoring objectives. The key objective of the environmental monitoring is to gather data to improve the evidence base on the likely nature and consequences of any nearfield interactions between marine mammals and diving birds with the operating turbines.

Environmental monitoring activities carried out in the current reporting period (July 2024 to June 2025) focused on the following:

1. Use of turbine-mounted optical video cameras to monitor any nearfield interactions between turbines in the array and marine wildlife (including collisions or near misses) between July 2024 and June 2025.
2. Examination of the proportion of good quality data acquired from subsea cameras that has been analysed over the lifetime of the Shetland Tidal Array monitoring programme. This was carried out following on from a systematic review of biofouling on the subsea cameras carried out by Nova in 2024, the results of which were presented to MD-LOT in a separate monitoring report in October 2024 (Nova Innovation, 2024a).
3. Further exploration of options for managing the effects of biofouling on subsea cameras and monitoring capabilities, including the trial of an anti-fouling film applied to camera lenses. The results of this have been provided to MD-LOT in a separate commercially sensitive monitoring report (Nova Innovation, 2025b).

This report presents the results from activities 1 and 2 above. Details of monitoring activities related to biofouling (activity 3) have been presented to MD-LOT in separate reports that are commercially sensitive, so were provided in confidence.

3 The Shetland Tidal Array

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

Figure 3-1: Location of the Shetland Tidal Array in Bluemull Sound, Shetland. *Source: Nova Innovation.*

During the current reporting period (July 2024 to June 2025), the Shetland Tidal Array comprised three Nova M100-D 100 kW direct drive tidal turbines.

Figure 3-2 shows an M100-D turbine on the quayside in Bluemull Sound, before being installed in the Shetland Tidal Array.

Figure 3-2: The Nova M100-D turbine. *Source: Nova Innovation.*

Turbines in the Shetland Tidal Array are installed subsea at a depth of 30-40m. Figure 3-3 shows the 'as installed' position of the three turbines (T4, T5 and T6) and associated infrastructure.

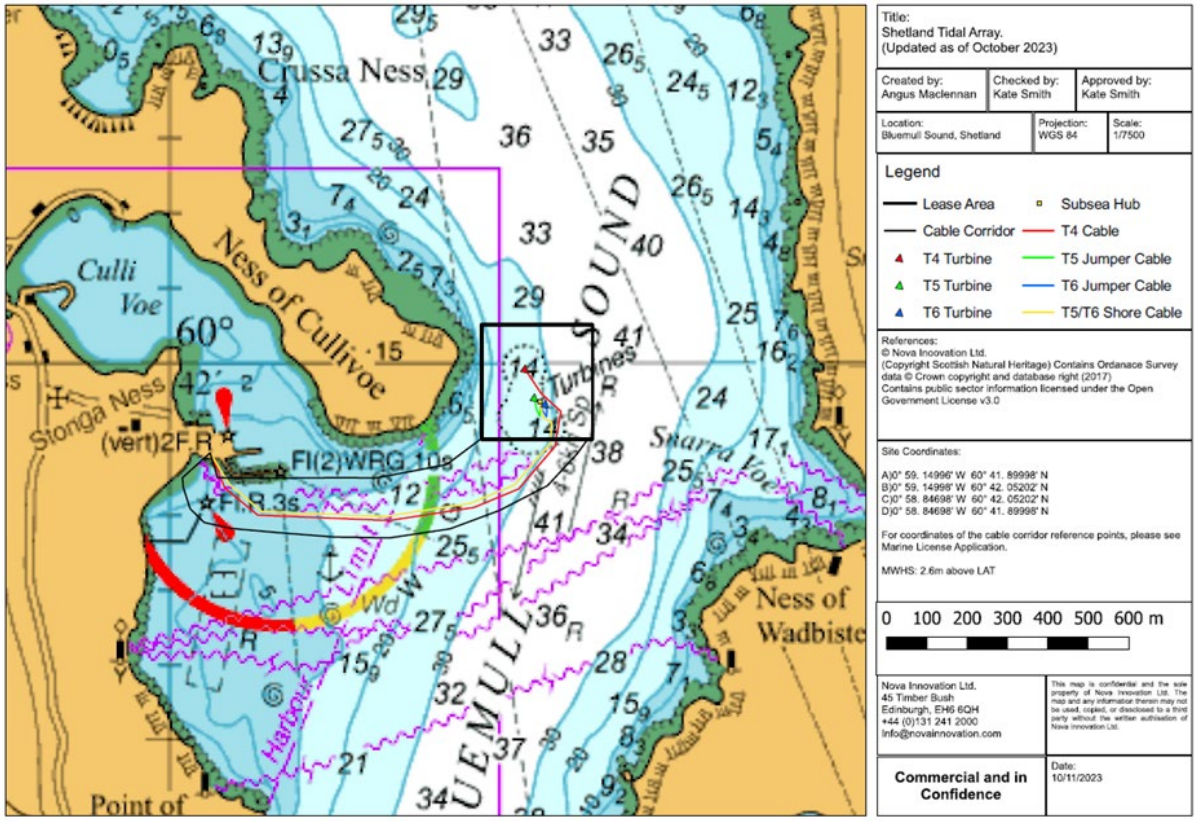

Figure 3-3: Position of turbines and infrastructure in the Shetland Tidal Array. *Source: Nova Innovation.*

4 Monitoring activity July 2024 to June 2025

4.1 Subsea video monitoring

Each of the three turbines in the Shetland Tidal Array is equipped with a single turbine-mounted camera with a horizontal field of view in water of 90^0, a sensitivity LUX rating of 0.1 and a resolution of 412,000 pixels. The camera configuration is illustrated in Figure 4-1.

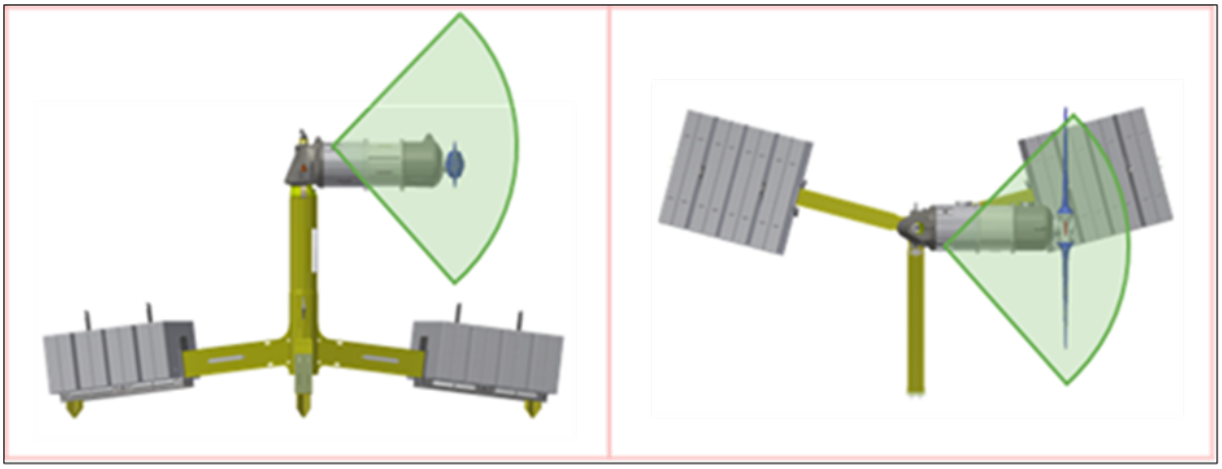

Figure 4-1: Turbine-mounted subsea camera system. Camera position and field of view is indicative only, for illustrative purposes. *Source: Nova Innovation.*

The field of view of the cameras, based on CAD modelling, is indicated in Figure 4-2, estimated to be 30-35% of the rotor-swept area.

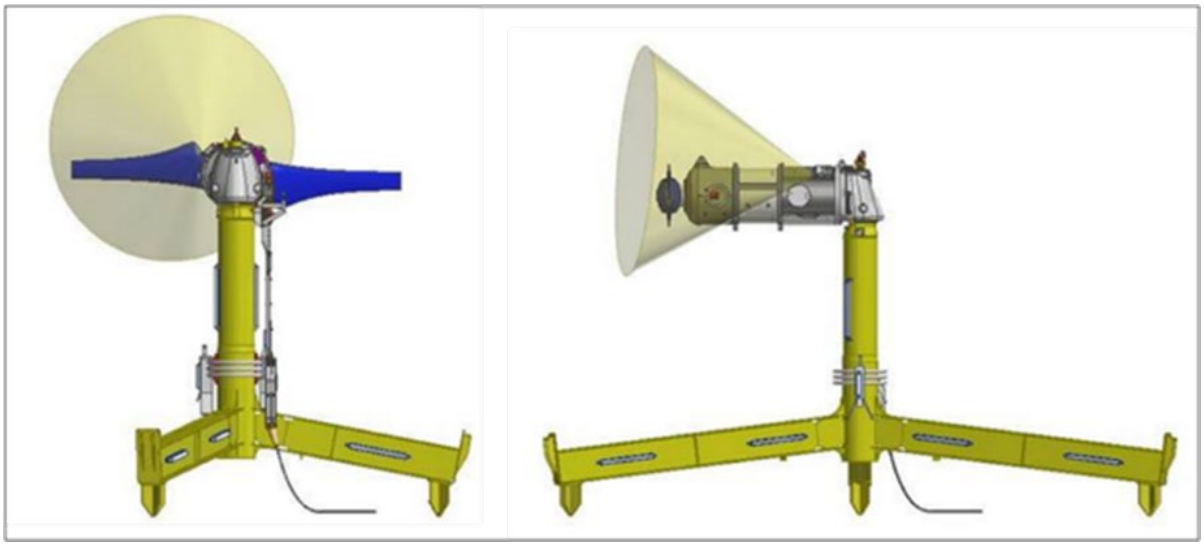

Figure 4-2: Field of view of turbine-mounted cameras in the Shetland Tidal Array. *Source: Nova Innovation.*

The three turbine-mounted cameras record continuously during daylight hours (dawn to dusk). Footage triggered by a standard CCTV CCD motion detection system based on differences of contrast of light and dark across successive frames is retained and stored. Video is retained from a few seconds before the trigger up to a minimum of 10 seconds, or until motion was no longer observed, up to a maximum of 15 minutes, at which point the trigger is reset.

All retained (triggered) footage is saved as MPEG video files with a unique code that includes an automatically assigned time and date-stamp (in GMT). A time and date-stamped JPEG thumbnail image captured at the point of the motion-trigger is also automatically saved. The video clips and thumbnails are automatically stored in folders organised by date and turbine in a secure cloud-based system.

The reliability of Nova's direct drive turbines currently operating in the Shetland Tidal Array has extended the intervals between scheduled maintenance events by many months. Prior to the start of the current monitoring period in July 2024 the three turbines had been installed and operating for several months (T4 = 9 months; T5 & T6 = 18 months). Biofouling on the three subsea cameras therefore affected the quality of video footage during this reporting period.

Full details of biofouling on cameras from July 2024 to October 2024 were included in a systematic review of historic biofouling on the subsea cameras, the results of which were presented to MD-LOT in a separate commercially sensitive monitoring report (Nova Innovation, 2024a). Biofouling continued to affect camera image quality until January 2025, when the three turbine nacelles were removed from Bluemull Sound for scheduled maintenance (which included cleaning and servicing the cameras). The nacelles of T5 and T6 were reinstalled in late January 2025. An anti-fouling film was applied to the lens of the camera on T5, with the lens of T6 left untreated as a control for comparison[4]. The nacelle of T4 was not reinstalled in the January operations as Storm Éowyn prematurely ended the offshore works.

Analysis of data from the current reporting period in this report has focused on the good quality data acquired from turbine deployment in January 2025, until image quality on the two cameras deteriorated due to biofouling.

4.2 Proportion of historic data analysed

Previous Shetland Tidal Array monitoring reports have estimated that between 20% and 25% of the full historic subsea video dataset has been analysed (Nova Innovation, 2021; 2022; 2023; 2024b). This estimate was based on the full video dataset covering the period from 2015 when the subsea cameras were first used on turbines up to July 2024. MD-LOT and NatureScot have advised that Nova should seek to increase percentage so that a greater proportion of historic data has been analysed.

The previous estimates are based on the total size of the retained dataset, which includes footage affected by levels of biofouling that compromise the ability to detect nearfield interactions between wildlife and the turbine blades. While such footage was excluded from detailed analysis in monitoring reports, it was included in calculations of how much of the full dataset had been analysed.

Nova's review of historic biofouling on the subsea cameras systematically assessed the periods over which footage was effective for monitoring nearfield interaction of wildlife with the turbine blades (Nova Innovation, 2024a). This has enabled Nova to conduct a more accurate assessment of the proportion of good quality historic data that have been analysed to date.

[4] The anti-fouling film was not applied to the lens of T6 to provide a comparative control. For full details see Nova Innovation, 2025b).

5 Data analysis

5.1 July 2024 to June 2025 camera data

Table 5-1 provides details of the quantity of data acquired from turbines during the current monitoring period when images were not affected by biofouling to the extent that they are no longer effective for monitoring nearfield interaction of wildlife with the turbine blades.

Table 5-1: Good quality data acquired from turbines during the current monitoring period.

Turbine	Period not affected by significant biofouling	Number of files
T5	29/01/2025 to 31/05/2025	11,103
T6	29/01/2025 to 30/04/2025	3,895
	TOTAL NUMBER OF FILES	**14,998**

All analysis was carried out by Nova's Environmental Manager.

All of the data in Table 5-1 has been analysed by initial review of JPEG thumbnails captured at the point of the motion-trigger. More detailed scrutiny was carried out of MPEG video files corresponding to thumbnails containing diving birds or marine mammals, or those for which the cause of the trigger was unclear.

Analysis focused on diving birds and marine mammals, as the receptors of greatest nature conservation importance[5] and those on which the environmental monitoring objectives focus[6]. Fish were not included in the analysis, as previous monitoring reports have comprehensively documented fish presence and occupancy patterns around the turbines (e.g. Nova Innovation, 2021; 2022; 2023; 2024b).

Prioritising the analysis for diving birds and mammals enabled a greater proportion of the full dataset to be analysed (100%) than has been possible in previous reporting years.

Files were analysed to identify any occurrences of diving birds or marine mammals. Any individuals occurring were examined to identify to species level, where possible. Footage containing diving birds or mammals was scrutinised at slow speed to establish whether any collisions or near misses with turbine blades had occurred. Any notable behaviours exhibited by animals in videos were also recorded.

Any file that manual scrutiny confirmed to contain diving birds or marine mammals was assigned categories denoting turbine operational status and tidal state using Nova's hydrodynamic model of Bluemull Sound, shown in Figure 5-1.

[5] As detailed in the Shetland Tidal Array Extension Environmental Assessment Report (Nova Innovation, 2018) and Marine Scotland Appropriate Assessment (Marine Scotland, 2018).

[6] As detailed in the Shetland Tidal Array Project Environmental Monitoring Plan (Nova Innovation, 2025a)

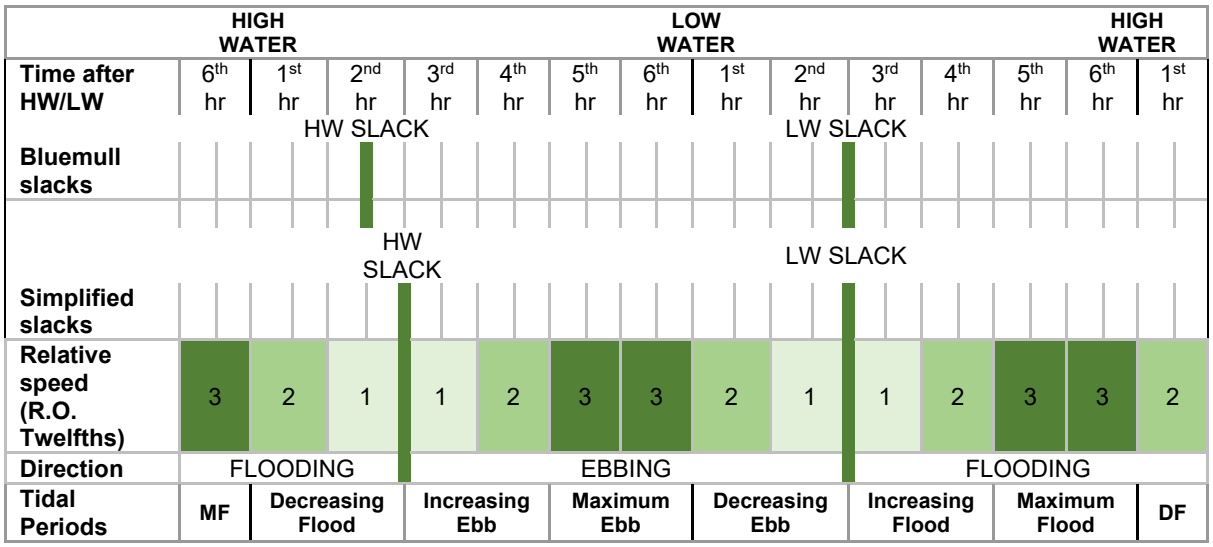

Figure 5-1: Bluemull Sound hydrodynamic model detailing the tidal cycle.

Tidal categories are always validated through observations of drifting detritus in videos, since tides in Bluemull Sound (particularly timings of slack) can be unpredictable and influenced by prevailing meteorological conditions.

Details of the categories assigned to video files containing marine wildlife are provided in Table 5-2.

Table 5-2: Categories assigned to video files containing marine wildlife.

Factor	Category	Detail
Turbine status	Operating	Rotor is moving for the entire video.
	Not operating	Rotor is stationary for the entire video.
	Powers up (starts)/down (stops)	Rotor starts to turn or slows to a halt during the video.
Tidal state	Flood: decreasing/ increasing/maximum	Tide runs from north to south past the turbines. Subcategory assigned using Nova's hydrodynamic model of Bluemull Sound.
	Ebb: decreasing/ increasing/maximum	Tide runs from south to north past the turbines. Subcategory assigned using Nova's hydrodynamic model of Bluemull Sound.

5.2 Historic camera data

Nova's systematic review of biofouling on the Shetland Tidal Array subsea cameras (Nova Innovation, 2024a) has enabled a more accurate assessment of the proportion of good quality data acquired from subsea cameras that has been analysed over the lifetime of the Shetland Tidal Array monitoring programme.

The reassessment was based on the following steps:

1. The biofouling review calculated the total months from each installation and recovery event for each turbine ("operational months").

2. The review also identified, for each camera on each turbine[7] the number of operational months during which images were of sufficient quality to monitor nearfield interactions between marine wildlife and the turbines ("good quality months").

3. Details of the data analysed in the Shetland Tidal Array monitoring reports and data on the number of good quality months were used to recalculate the proportion of the full good quality dataset analysed from the monitoring period covered by each report.

4. The revised proportions of data analysed from the periods covered by each monitoring report were combined to provide an overall proportion of the full good quality dataset analysed over the course of the Shetland Tidal Array subsea video monitoring programme.

The proportion of good quality data analysed (rather than the proportion of the full dataset) is a much more accurate representation of how much of the historic data has been analysed over the course of Shetland Tidal Array subsea video monitoring programme.

[7] T1, T2 and T3 each had three turbine-mounted cameras. T4, T5 and T6 each has a single turbine-mounted camera.

6 Results

6.1 System performance

The typically excellent water clarity in Shetland year-round and the relatively simple monitoring approach means that optical cameras continue to be an effective method for monitoring nearfield interactions between turbines and marine wildlife. The cameras operate 24 hours a day, but only footage from dawn to dusk is retained. Daylight in winter in Shetland averages between 6 and 7 hours, while in summer it averages between 17 and 18 hours.

Some of the footage over the reporting period (July 2024 to June 2025) was affected by biofouling on cameras (detailed in a separate commercially sensitive report to MD-LOT). Fourteen thousand, nine hundred and ninety-eight (14,998) files were captured during periods when biofouling was not at levels that prevented the ability to monitor nearfield encounters.

6.2 July 2024 to June 2025 camera data

No collisions or near misses between diving birds or marine mammals and the turbines (operating or not operating) occurred in any of the video footage analysed in this report.

Of the fourteen thousand, nine hundred and ninety-eight (14,998) files analysed in this report only one contained a confirmed occurrence of a single harbour seal (*Phoca vitulina*). The animal was observed three times in one 14 second video file at 10:24AM on 06/02/2025. The seal was observed surfacing past the nacelle of T5, then diving towards the seabed before resurfacing again. The turbine blades were stationary and the tidal state based on Nova's hydrodynamic model for Bluemull Sound was decreasing ebb/low water slack. Figure 6-1 shows still images of the sequence of harbour seal observations from this video file.

a) Harbour seal surfacing past the nacelle of T5.

b) Harbour seal diving past the nacelle of T5.

c) Harbour seal surfacing again past the nacelle of T5.

Figure 6-1: Harbour seal (*Phoca vitulina*) observed in video footage from T5 on 06/02/2025 at 10:24AM a) surfacing past the turbine nacelle, b) diving towards the seabed and c) resurfacing again past the nacelle.

Ten minutes earlier on the same day a dark object which appeared to be a seal diving towards the seabed was observed in a file captured from the camera on T6. The seal, shown in Figure 6-2, was some distance north of the turbine but may have been the same animal seen diving around the nacelle of T5, which is located to the north-west of T6 (see Figure 3-3). As with the images captured from T5, the turbine blades of T6 were stationary and the tidal state was decreasing ebb.

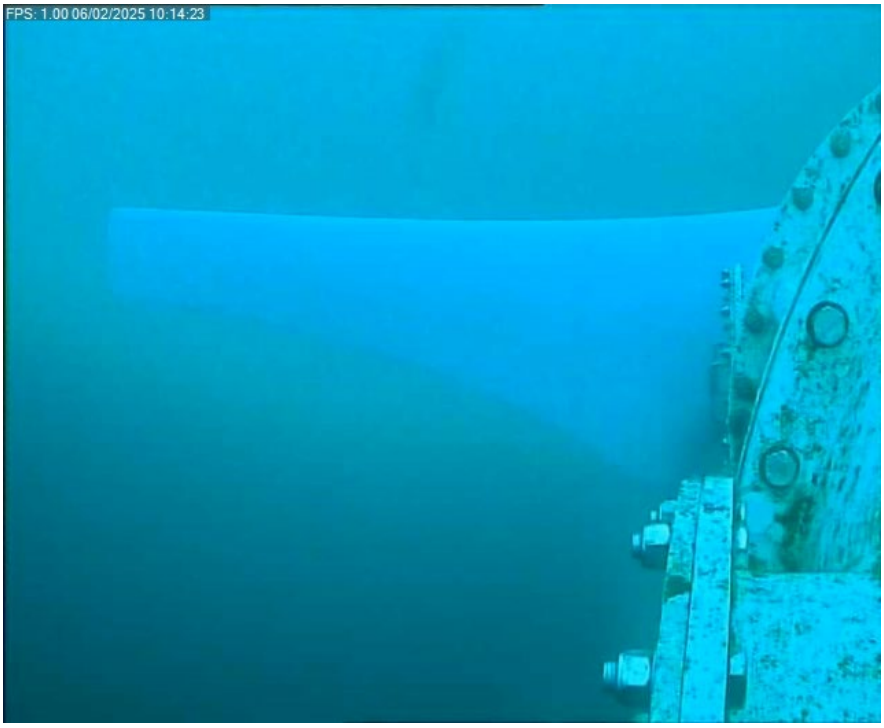

Figure 6-2: Possible harbour seal (*Phoca vitulina*) in video footage on 06/09/2024 at 10:14AM diving towards the seabed some distance to north of the turbine (T6).

No diving birds were observed in any of the fourteen thousand, nine hundred and ninety-eight (14,998) files analysed.

6.3 Proportion of historic data analysed

Table 6-1 summarises the re-assessment of the proportion of historic data acquired from subsea cameras that has been analysed over the lifetime of the Shetland Tidal Array monitoring programme. Further stepwise explanation of the calculations is provided in the text beneath the table. The re-assessment is based on the methodology outlined in Section 5.2 and considers the proportion of good quality data acquired that has been analysed, rather than the proportion of the full dataset, some of which is affected by biofouling. This is a more accurate representation of how much of the historic data has been analysed over the course of Shetland Tidal Array subsea video monitoring programme.

Based on the calculations in Table 6-1approximately **62%** of the historic good quality data from the Shetland Tidal Array video monitoring programme has been analysed, up to and including the current reporting period. Previous estimates that between 20% and 25% of the full dataset have been analysed are therefore a gross underestimate. This further highlights the rarity of nearfield encounters between animals and turbines and the extremely low probability of collisions.

Table 6-2: The proportion of good quality data acquired from subsea cameras analysed in each reporting period throughout the lifetime of the Shetland Tidal Array. Numbers of "Operational months" and "Good quality months" are derived from Nova's systematic review of biofouling on subsea cameras (Nova Innovation, 2024a). Details of data analysed are derived from the Shetland Tidal Array monitoring reports.

Monitoring Report	Reporting period	Size of full dataset[1]	Size of dataset analysed	Proportion of full dataset analysed	[Redacted]	[Redacted]	Proportion of good quality data analysed
2021	Oct 2015 to mid-Mar 2020	≈ 20,000 hours	4,049 hours	20%	[Redacted]	[Redacted]	74%
2022	Mid-Mar 2020 to Mar 2022	≈ 28,000 hours	1,685 hours	6%	[Redacted]	[Redacted]	24%
2023	Apr 2022 to Jul 2023	≈ 5 TB	40 GB	1%	[Redacted]	[Redacted]	10%
2024	Jul 2023 to Jun 2024	≈ 0.4 TB	50 GB	12.5%	[Redacted]	[Redacted]	100%
2025	Jul 2024 to Jun 2025	14,998 files	14,998 files	100%	[Redacted]	[Redacted]	100%

[1] *The metric used to estimate the size of the full dataset varied by each report. This was due to differing storage arrangements for data over the course of the monitoring programme and the ease by which the dataset size could be calculated by different units of measurement.*

Further explanation for calculations:

2021 report: 20% of the full 20,000 hours dataset from the period October 2015 to mid-March 2020 were analysed. [Redacted]

74% of the good quality data were analysed.

2022 report: 6% of the full 28,000 hours dataset from the period mid-March 2020 to March 2022 were analysed. [Redacted]

24% of the good quality data were analysed.

2023 report: 1% of the full 5 TB dataset from the period April 2022 to July 2023 were analysed. [Redacted]

10% of the good quality data were analysed.

2024 report: 12.5% of the full 0.4 TB dataset from the period July 2023 to June 2024 were analysed. [Redacted]

100% of the good quality data were analysed.

2025 report: 100% of the good quality data were analysed. [Redacted]

7 Conclusions and next steps

7.1 Conclusions

This report provides details of environmental monitoring activity at the Shetland Tidal Array from July 2024 to June 2025. It is the latest in a series of reports produced by Nova since monitoring of the operational tidal stream array in Bluemull Sound started in 2016.

No collisions or near misses were observed between diving birds and marine mammals and turbines (either when operating or not operating) in any of the footage analysed, comprising 100% of the fourteen thousand, nine hundred and ninety-eight (14,998) files. This report further contributes to the growing evidence base that **the risk of collisions between marine wildlife and tidal turbines is very low (probably close to zero)** (e.g., Garavelli et al, 2024; Edwards et al, 2025; Phillips et al, 2025).

A confirmed harbour seal (*Phoca vitulina*) was observed three times in one video from T5 on the decreasing ebb/low slack tide, when tidal flow was less than 0.8 m/s and the turbine blades were stationary. There was a second possible occurrence of a seal (potentially the same animal), in a video from T6 also on 06/02/2025 at 10:14AM (decreasing ebb tide and stationary blades) some distance to the north of the turbine.

The re-assessment of how much of the subsea video data from the Shetland Tidal Array has been analysed showed that 62% of the good quality footage has been analysed to date (including in this report). Previous estimates that between 20% and 25% of the full dataset have been analysed are therefore a gross underestimate. This further highlights the rarity of nearfield encounters between animals and turbines and the extremely low probability of collisions.

7.2 Next steps

Monitoring nearfield interactions between marine wildlife and the three turbines in the Shetland Tidal Array using subsea cameras will continue. However, following the systematic review of biofouling on cameras (Nova Innovation, 2024a) and to align with the change in the scheduled turbine maintenance regime, 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, or until biofouling renders video monitoring ineffective.

Nova will continue to try to analyse as great a proportion of this full good quality dataset from each reporting period as resources allow. Both manual and automated analysis have significant cost and resource implications which should be carefully balanced with the likely probability of collisions. Analysis to date and presenting the results in the context of probabilistic modelling frameworks (e.g. Copping et al, 2023) has consistently shown collision risk to be extremely low to negligible. **No near misses or collisions have been observed in the 62% of the full good quality dataset acquired that has been analysed to date.**

Future data analysis will focus on diving birds and marine mammals, as the receptors of greatest nature conservation importance (Marine Scotland, 2018; Nova Innovation, 2018) and those on which the environmental monitoring objectives focus (Nova Innovation, 2025a). Fish presence and occupancy patterns around the turbines are now well-understood and have been documented extensively in previous monitoring reports.

Nova will take action to facilitate analysis of 100% of the good quality dataset acquired from subsea cameras. Based on the review of biofouling on cameras, the reassessment of the proportion of good quality

data analysed to date detailed in this report, and practicalities around ease of access to the historic data, the priority for further analysis is data from the period April 2022 to July 2023. The best quality data from this period is footage from T4-T6 from December 2022 through to March 2023. This equates to:

- T4 = 55 days, around 4 GB data per day. Total 220 GB.
- T5 = 49 days, around 4 GB data per day. Total 196 GB.
- T6 = 53 days, around 4 GB data per day. Total 212 GB.

Nova considers that analysis of this additional data is of strategic importance to de-risk consenting and unlocking tidal projects in Scotland, the wider UK and globally, rather than necessarily being critical to regulatory compliance of the Shetland Tidal Array. Nova will therefore continue to seek to leverage the strategic funding and resource required to enable analysis of a greater proportion of the good quality data from subsea cameras, with a view to achieving 100%.

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