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ENFAIT
ENABLING FUTURE ARRAYS IN TIDAL

D8.6 – Y3 Environmental Monitoring Report

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Contents

1 The Project

1.1 Introduction

A Funding Grant was awarded from the European Union's Horizon 2020 research and innovation programme in January 2017 to demonstrate a grid-connected tidal energy array at a real-world tidal energy site, propelling tidal energy towards competing on a commercial basis with alternative renewable sources of energy generation – Enabling Future Arrays in Tidal (EnFAIT). This was in response to the call LCE-15-2016: Scaling up in the ocean energy sector to arrays to generate significant learning through demonstration of cost-effective tidal arrays.

1.2 Purpose of this document

This document summarises the environmental monitoring activity through year 3 of the EnFAIT project. It satisfies deliverable D8.6 of the EnFAIT project and will also be made available for public dissemination. Deliverable D8.5[1] provided the results from monitoring during the first year of the EnFAIT project and was also made available for public dissemination. The year 1 environmental monitoring report covered the key outcomes from vantage point surveys undertaken for the 12 months between May 2017 and April 2018 and a subset of the underwater video footage. At this point, comprehensive analyses of the full datasets had not been carried out, so a simple descriptive analysis of the 12 month subset of data was presented.

As the second in a series of three environmental monitoring reports required for the EnFAIT project, this report details the environmental monitoring activity carried out during years 2 and 3 of the project. Activity during this project phase has focussed on continuing data gathering under the long-running environmental monitoring programmes and carrying out comprehensive analyses of the long-running datasets gathered since 2010. These data and the analysis outputs, summarised in this report, provide a foundation on which further monitoring in years 4 and 5 of the EnFAIT project will be built, as understanding for the environmental effects of the Shetland Tidal Array increases and the questions posed by the monitoring are refined.

This report therefore also provides an overview of the scope and objectives for the ongoing monitoring programme through years 4 and 5 of the EnFAIT project, as the number of deployed turbines increases and device configuration within the array is altered.

2 Summary of environmental monitoring to date

2.1 Overview

Nova Innovation (Nova) has been conducting environmental survey and monitoring activity in Bluemull Sound, Shetland since November 2010, prior to the deployment of turbines or infrastructure. Initial environmental surveys gathered information in support of consent applications. Following turbine deployments, the focus of environmental monitoring shifted to activity required under the consent conditions to monitor the effects of the turbines on marine wildlife.

[1] Nova Innovation Ltd. (2018). EnFAIT - Enabling Future Arrays in Tidal Y1 Environmental Monitoring Report. Available at: https://www.enfait.eu/publications/year-1-environmental-monitoring-report/

To date, environmental monitoring in Bluemull Sound has focussed on possible effects of the project on marine mammals and diving birds, utilising underwater cameras and land-based vantage point surveys. In particular, licences for the Shetland Tidal Array require monitoring to gather data to improve understanding for the likelihood that marine wildlife might occur in close proximity to turbines underwater and the nature of any near-field interactions. Underwater cameras are also used during turbine installation to avoid impacts on sensitive seabed habitats.

Land-based vantage point surveys provide a long-term dataset based on 'snapshot scans', to understand the presence and distribution of seabirds and marine mammals in Bluemull Sound, and how this might affect the likelihood that they might occur in close proximity to turbines underwater. The use of underwater video cameras complements this dataset by enabling monitoring of any near-field interactions of marine wildlife with the turbines, to gather data on the presence and behaviour of animals around the turbines and the nature of any near-field interactions.

Prior to commencement of site works the full details of the environmental monitoring programme were set out in a project Environmental Monitoring and Mitigation Plan (EMMP), which was agreed with the Regulator (Marine Scotland Licencing) and their environmental advisors (Scottish Natural Heritage)[2]. An updated version of this document, the Project Environmental Monitoring Plan (PEMP)[3], has been submitted for approval by the regulators, building on the environmental monitoring and data analysis described in this report.

2.2 Monitoring methodologies

2.2.1 Vantage point surveys

Land-based vantage point surveys have been carried out since November 2010 to monitor the presence and activity of diving birds and marine mammals in the sea area occupied by the turbines and surrounding area in Bluemull Sound. Surveys are conducted by suitably qualified and experienced personnel, from an elevated observation point at the south-eastern tip of the Ness of Cullivoe, from where the surveyor is well placed to undertake observations across the entire survey area.

The survey area, delineated by green lines in Figure 2.1 (over), was defined to provide good coverage of the immediate Project site (the array area or Zone 1) and the wider central section of Bluemull Sound (Zone 2). Zone 2 is further subdivided into four areas A, B, C and D to enable further spatial delineation of observations. The outer boundaries of the survey area are defined by sight-lines to land-markers on Unst. The four subdivisions of Zone 2 (A, B, C and D) are indicated by purple dashed subdivisions in Figure 2.1. Zone 1 indicates the array area, as indicated by the green dot. The green dotted line illustrates the trajectory of the marking point for the survey boundary, with the pink square indicating The Crown Estate seabed lease area.

Vantage point surveys were initiated in November 2010, to enable collection of data before any site activity commenced. They have been continuous to the present date, throughout construction and operational phases of the Shetland Tidal Array. In October 2019 the survey design was amended (as set

[2] Nova Innovation Ltd. (2015). Environmental Monitoring and Mitigation Plan, Shetland Tidal Array, Bluemull Sound, pp13. Available at: http://www.gov.scot/Topics/marine/Licensing/marine/scoping/nova/EMMP

[3] Nova Innovation Ltd. (2020). Shetland Tidal Array Project Environmental Monitoring Plan (PEMP).

out in Section 4.1), to take into account the results of analyses of the long-running vantage point data and corresponding refinement of monitoring objectives.

Surveys are divided into 3-month survey periods, to enable stratification and coverage of surveys throughout the year, as follows:

- February to April
- May to July
- August to October
- November to January

Nine 4-hour surveys were conducted within each 3-month period, on an annual basis. Where possible, surveys within each 3-month period were conducted across a range of times of day and states of tide. All surveys were conducted in sea state 2 or less and in good light conditions. During winter, short daylight hours meant that surveys before 09:00 and after 15:00 were very limited. Each 4-hour survey consisted of 24 snapshot scans for birds (one every 10 minutes) and 12 snapshot scans for marine mammals (one every 20 minutes). Scans were completed in a single sweep to make them as analogous as possible to a snapshot in time.

For the first 3 minutes of each scan all marine wildlife within the array area (Zone 1) was observed, identified to species-level and numbers of individuals counted. Birds were only counted and recorded if they were on the water, diving, or hovering directly above Zone 1. Birds transiting through Zone 1 (flying) were not counted. During each 3 minute scan in Zone 1, the following data were recorded for each bird species observed:

a. Number of birds on the water, either making progress or stationery at the surface
b. Number of birds diving
c. Numbers of mammals/basking sharks

All mammals/basking sharks occurring within Zone 1 were recorded. Where possible, the following behaviours were also noted:

a. Localised foraging: evidence of foraging within array area (e.g. repeated diving and resurfacing behaviour within array area)
b. Transient foraging: evidence of foraging whilst transiting through the array area
c. Transiting: no evidence of foraging (movement on a trajectory through the array area)

For the remainder of each scan birds, mammals and basking shark were identified to species level and counted in Zone 2. If the tide was running, scans were carried out against the tide, to minimise double-counting of individuals.

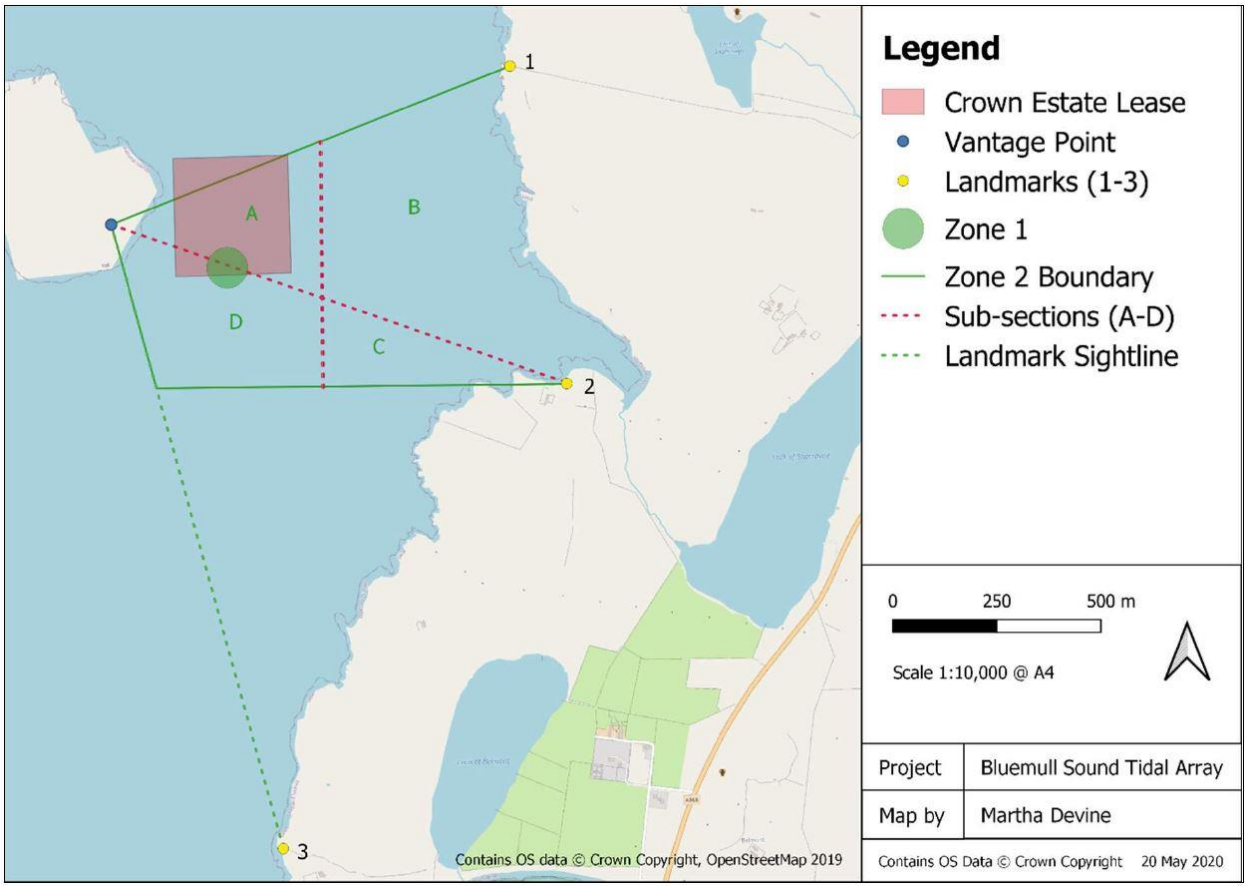

Figure 2.1 Location of observation point and survey area in Bluemull Sound.
Source: Nova Innovation 2020 © and OS data ©

2.2.2 Underwater video

Underwater video has been used throughout the operational phase of the Shetland Tidal Array to monitor near-field behaviour of marine wildlife around the turbines. To date around 20,000 hours of footage has been recorded, comprising nearly 1 million videos.

Three cameras are attached to each of the deployed turbines (T1, T2 and T3). One camera is attached to the side of the nacelle looking towards the blades; one is attached to the top of the nacelle looking towards the blades and a third is attached on the bottom of the turbine looking towards the seabed. Figure 2.2 provides an indicative illustration of the location and field of view of each of these cameras.

Cameras are triggered by a motion-detection system. Video is recorded from a few seconds before the 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.

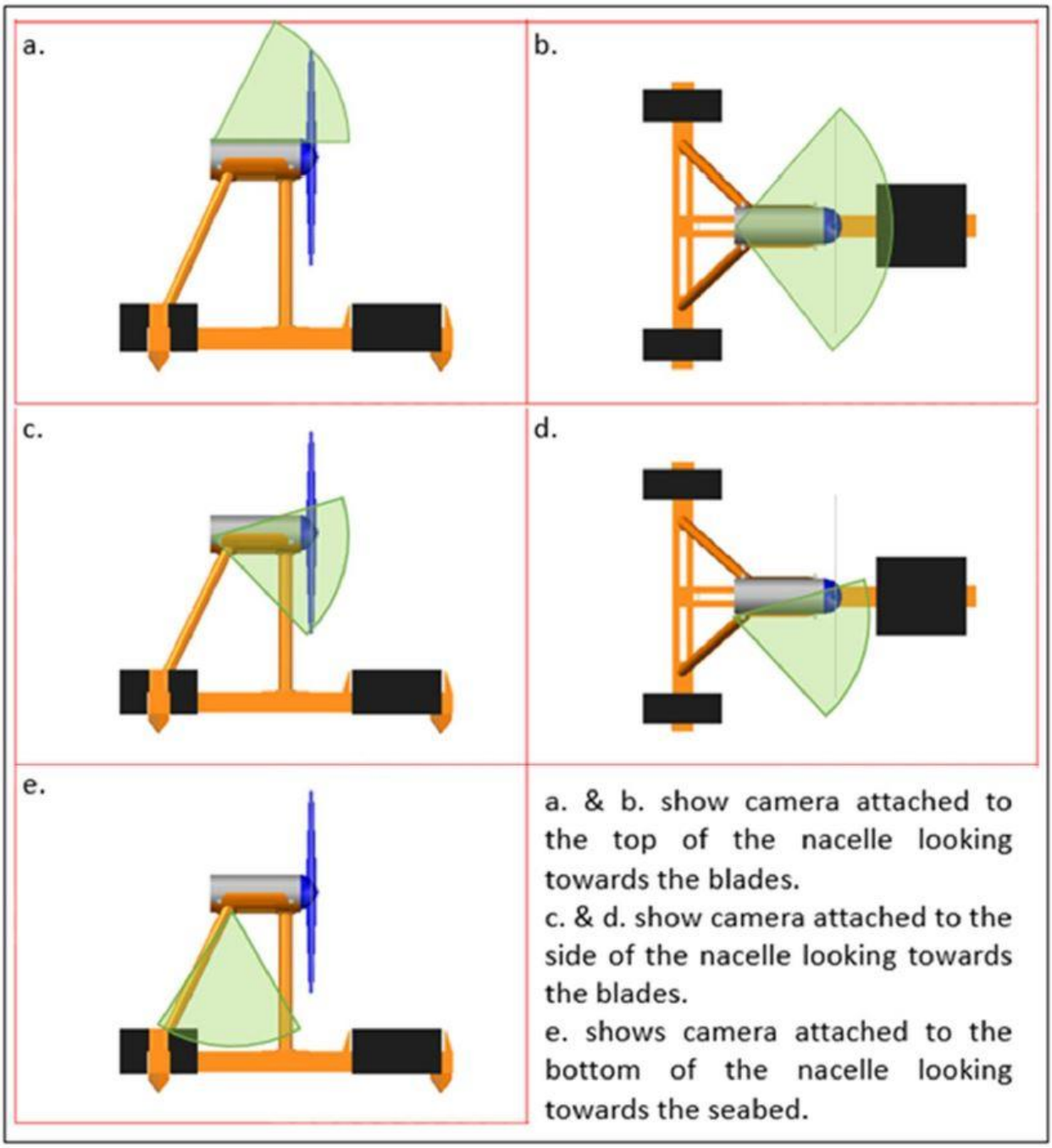

Figure 2.2 Underwater camera system for T1, T2 and T3 in the Shetland Tidal Array. Camera positions and fields of views are indicative only and is not an accurate reflection of the fields of view for each of the cameras. This figure is provided for illustrative purposes only.

Triggered footage is manually reviewed to determine whether the cause of the trigger event was a fish, diving bird, marine mammal, other fauna (e.g. jellyfish) or (more typically) suspended detritus in the water, biofouling on the camera lens or blade movements. Relevant footage is further analysed to establish species identity and any notable behaviour, in particular any interactions with moving turbine blades.

The camera setup will be altered slightly during Phase 2 (addition of T4, T5 and T6) as explained in Section 4.1.

3 Environmental monitoring results

3.1 Overview

This section provides an overview of the outcomes from the comprehensive analyses that have been carried out during years 2 and 3 of the EnFAIT project, for data gathered from the long-running environmental monitoring programme for the Shetland Tidal Array. This includes the vantage point surveys carried out in Bluemull Sound since 2010 and the underwater video monitoring conducted throughout the operational phase of the project to monitor near-field presence and behaviour of marine wildlife around the turbines.

3.2 Vantage point surveys

The vantage point surveys recorded observations of all bird and animal species in the survey area described in the monitoring methodology (Section 2.2.1). A combination of descriptive statistics and modelling techniques were used to analyse the data to assess the likelihood that marine wildlife might occur in close proximity to turbines underwater. The approach to analysis and interpretation was based on understanding site-use at different scales, to understand the likelihood of near-field encounters with the turbines in the Shetland Tidal Array. Near-field encounters are only possible if a bird or animal uses the site. The likelihood increases if the bird or animal uses the area immediately around the turbines. For birds, this likelihood increases again if the bird dives in the area around the turbine. A detailed report setting out the full results of this analysis was submitted to regulators (Marine Scotland Licencing) in June 2020[4].

3.2.1 Nine year summary (covering the period November 2010 to April 2020)

Data from a total of 5208 10-minute snapshot scans for birds and 3120 20-minute scans for marine animals have been analysed in this phase of the EnFAIT project, spanning the full nine-year survey period. All species recorded in vantage point surveys in Bluemull Sound were identified with confidence to species level. A total of thirty-three bird, eight mammal and one fish species were recorded, as detailed in Table 3.1. The final column of the table indicates whether the species recorded are known to dive to the depth of the turbines (minimum 15m below sea level), and therefore capable of interacting with turbines underwater. Fifteen of the bird species recorded and eight of the animal species are capable of diving to turbine depth.

Table 3.1 All species recorded in Bluemull Sound vantage point surveys. Final column indicates those species capable of diving to turbine depth (15m).

Common name	Scientific name	Dives to turbine depth?
Anatidae (ducks, geese, and swans)		
Greylag goose	*Anser answer*	No
Whooper swan	*Cygnus cygnus*	No
Wigeon	*Mareca penelope*	No
Mallard	*Anas platyrhynchos*	No

[4] Nova Innovation Ltd. (2020). Shetland Tidal Array Monitoring Report: Vantage point surveys

Common name	Scientific name	Dives to turbine depth?
Greater scaup	*Aythya marila*	Yes
Common eider	*Somateria mollissima*	Yes
Long-tailed duck	*Clangula hyemalis*	Yes
Common goldeneye	*Bucephala clangula*	No
Red-breasted merganser	*Mergus serrator*	Yes
Podicipedidae (grebes)		
Slavonian grebe	*Podiceps auritus*	No
Phalaropidae (phalaropes)		
Red-necked phalarope	*Phalaropus lobatus*	No
Laridae (gull and terns)		
Black-legged kittiwake	*Rissa tridactyla*	No
Common gull	*Larus canus*	No
Iceland gull	*Larus glaucoides*	No
European herring gull	*Larus argentatus*	No
Great black-backed gull	*Larus marinus*	No
Black headed gull	*Chroicocephalus ridibundus*	No
Arctic tern	*Sterna paradisaea*	No
Stercorariidae (skuas)		
Arctic skua	*Stercorarius parasiticus*	No
Great skua	*Stercorarius skua*	No
Alcidae (auks)		
Little auk	*Alle alle*	Yes
Common guillemot	*Uria aalge*	Yes
Razorbill	*Alca torda*	Yes
Black guillemot	*Cepphus grylle*	Yes
Atlantic puffin	*Fratercula articulata*	Yes
Gaviidae (divers)		
Red-throated diver	*Gavia stellata*	Yes
Great northern diver	*Gavia immer*	Yes
White-billed diver	*Gavia adamsii*	Yes
Procellariidae (tubenoses)		
Northern fulmar	*Fulmarus glacialis*	No

Common name	Scientific name	Dives to turbine depth?
Storm petrel	*Hydrobates pelagicus*	No
Sulidae (gannets)		
Northern gannet	*Morus bassanus*	Yes
Phalacrocoracidae (cormorants and shags)		
Great cormorant	*Phalacrocorax carbo*	Yes
European shag	*Phalacrocorax aristotelis*	Yes
Phocidae (true seals)		
Grey seal	*Halichoerus grypus*	Yes
Harbour seal	*Phoca vitulina*	Yes
Phocoenidae (toothed whales)		
Harbour porpoise	*Phocoena phocoena*	Yes
Delphinidae (oceanic dolphins)		
Killer whale	*Orca orcinus*	Yes
Risso's dolphin	*Grampus griseus*	Yes
Balaenopteridae (rorquals)		
Minke whale	*Balaenoptera acutorostrata*	Yes
Humpback whale	*Megaptera novaeangliae*	Yes
Lutrinae (otters)		
Eurasian otter	*Lutra lutra*	No
Cetorhinidae		
Basking shark	*Cetorhinus maximus*	Yes

Of the fifteen species of bird capable of diving to turbine depth, black guillemot and European shag accounted for over 90% of all bird sightings, with other diving bird species, such as Atlantic puffin (*Fratercula arctica*), northern gannet (*Morus bassanus*), common guillemot (*Uria aalge*) and red-throated diver (*Gavia stellata*), recorded infrequently.

Black guillemot, the most common bird species, was recorded in the area immediately around the turbines in just over 10% of all scans. Birds were observed diving around the turbines on 143 occasions throughout the nine-years of surveys. The second most common species, European shag, was only recorded in the area immediately around the turbines in 150 scans (from the total of over 5200 scans). Birds were only observed diving around the turbines on 54 occasions throughout the nine-years of surveys. The other diving bird species were observed diving around the turbines on fewer than 5 occasions per species over the entire nine-year survey period. This indicates a very low likelihood that diving birds

will occur in close proximity to turbines underwater and therefore a very low likelihood of near-field interactions occurring.

Marine animals (mammals and basking shark) were recorded in the surveys infrequently and in low numbers. Some species such as humpback whale (*Megaptera novaeangliae*), minke whale (Balaenoptera acutorostrata), Risso's dolphin (*Grampus griseus*), killer whale (*Orca orcinus*) and basking shark (*Cetorhinus maximus*) were only recorded in 1 or 2 scans over the entire nine-year survey period. Atlantic grey seal (*Halichoerus grypus*), harbour seal (*Phoca vitulina*) and harbour porpoise (*Phocoena phocoena*) were the most frequently recorded species, but seldom recorded in the array area. Both species of seal were normally recorded as individual animals, while harbour porpoise was generally observed in small family groups.

Harbour porpoise was the most common marine animal recorded in surveys, accounting for 45% of all animal sightings. Despite accounting for this high proportion of overall sightings, the species was only recorded in 5% of scans overall (175 scans from a total of more than 3100 scans). The species was only recorded in the area immediately around the turbines on 22 occasions over the nine-year survey period. Harbour seal was recorded in the area immediately around the turbines on just 10 occasions and grey seal on only 2 occasions throughout the nine-year survey period. This indicates a very low level of spatial overlap between marine mammals and turbines in the Shetland Tidal Array, even when taking into account the most frequently recorded and abundant species.

These results demonstrate that the presence of diving birds and marine animals (mammals and basking shark) in Bluemull Sound is low, and lower still in the area immediately around the turbines. These results indicate that the likelihood of near-field encounters between diving birds and marine mammals and therefore the risk of negative environmental effects is very low.

3.3 Underwater video

A sub-sample of over 4000 hours of the full 20,000 hours of video footage have been examined and analysed during years 2 and 3 of the EnFAIT project, representing approximately 20% of all footage recorded between October 2015 and March 2020. To date, a combination of random and stratified sampling approaches has been used to analyse video footage. The video footage has been split into three subsets; two which used analysed footage sampled from across the full dataset, and one of footage between March 2016 and January 2017.

The first subset (Section 3.3.1) comprised 7000 stills and 1115 videos, totalling 28 hours of footage, and represented video and stills footage of the highest possible quality captured when the turbines were rotating (turbines operational). This subset was generated by selecting footage based on a defined criteria of quality, followed by random sampling.

The second subset (Section 3.3.2) comprised 451 videos totalling 18 hours of footage, and represented footage corresponding to the twenty occasions of the highest surface sightings of the two diving bird species most commonly recorded in the area immediately around the turbines in vantage point surveys (black guillemot and European shag). These occasions were derived from analysis of data gathered from Nova's simultaneous programme of land-based vantage point surveys in Bluemull Sound.

These two subsets were reviewed manually to determine whether the stills and video contained any sightings of wildlife, in particular species of marine mammals, birds or fish interacting with the operational turbines.

The third subset (Section 3.3.3) of the video dataset included all footage recorded between March 2016 and January 2017. This covers times when the turbines were operational as well as periods when the blades were not rotating (non-operational). This subset provides information on nearfield interactions between fish, marine mammals and diving birds and turbines throughout the full tidal cycle.

A detailed report setting out the results of these analyses was submitted to regulators (Marine Scotland Licencing) in May 2020[5].

3.3.1 Subset 1: Turbines operational

No collision or near misses between marine wildlife and the turbines were observed in this sub-sample. The only marine wildlife observed in this subset of video footage and stills images were fish. Approximately 30% of the footage manually reviewed contained fish, with usually more than 5 individuals present. All fish were identified to be a species of genus *Pollachius*, most likely saithe *(Pollachius virens*), following close examination of individuals on video and advice from fish specialists. Other footage in this subset was caused by triggering from turbine motion, or marine growth (biofouling) movement.

3.3.2 Subset 2: High surface bird sightings

No collision or near misses between marine wildlife and the turbines were observed in this sub-sample. Manual review established that there were no occurrences of black guillemot or European shag in the subset of video footage corresponding to periods of the highest surface sightings of these two species, determined from analysis of vantage point data. Less than 20 of the 451 videos in this subset contained occurrences of fish of genus *Pollachius*, with no other marine wildlife observed in the footage.

3.3.3 Subset 3: Full tidal cycle

No collision or near misses between marine wildlife and the turbines were observed in this sub-sample covering the period March 2016 to January 2017. Fish were by far the most frequently sighted fauna, with the majority identified as pollack species, genus *Pollachius*, likely to be saithe. The fish were seen around the nacelle and blades of the turbines at slack tide and the start of the flood and ebb. Fish generally moved closer to the seabed as tidal current speed increased, presumably to shelter from the main flow. There are some exceptions with some individual fish persisting in the vicinity of the nacelle and blades once the turbines had started rotating. However, most fish observations correspond to periods of slower flow speeds.

Jellyfish such as Lion's mane jellyfish (*Cyanea capillata*) were occasionally recorded either actively swimming at slack tide or being carried passively past the turbines by the flowing tide. Additionally, on one occasion, a scorpion fish was observed attached to one of the cameras lenses.

European shag, black guillemot and harbour seal were observed infrequently in the footage and were only seen during slack tide or at low current speeds, when the turbines were not operational. The lack of

[5] Nova Innovation Ltd. (2020). Shetland Tidal Array Monitoring Report: Subsea video monitoring (April 2020).

movement in turbine blades at times when fauna was observed is demonstrated in the images in Figure 3.2. Birds and mammals were never observed when the turbines were operating.

Within this subset there were 11 occurrences of European shag, 7 of black guillemot and 13 of harbour seal. Some of the occurrences are thought to be the same individual, recorded on different cameras. The total number of independent occurrences were European shag (10), black guillemot (5) and harbour seal (10).

No cetaceans or basking sharks have been observed in any of the video footage analysed to date.

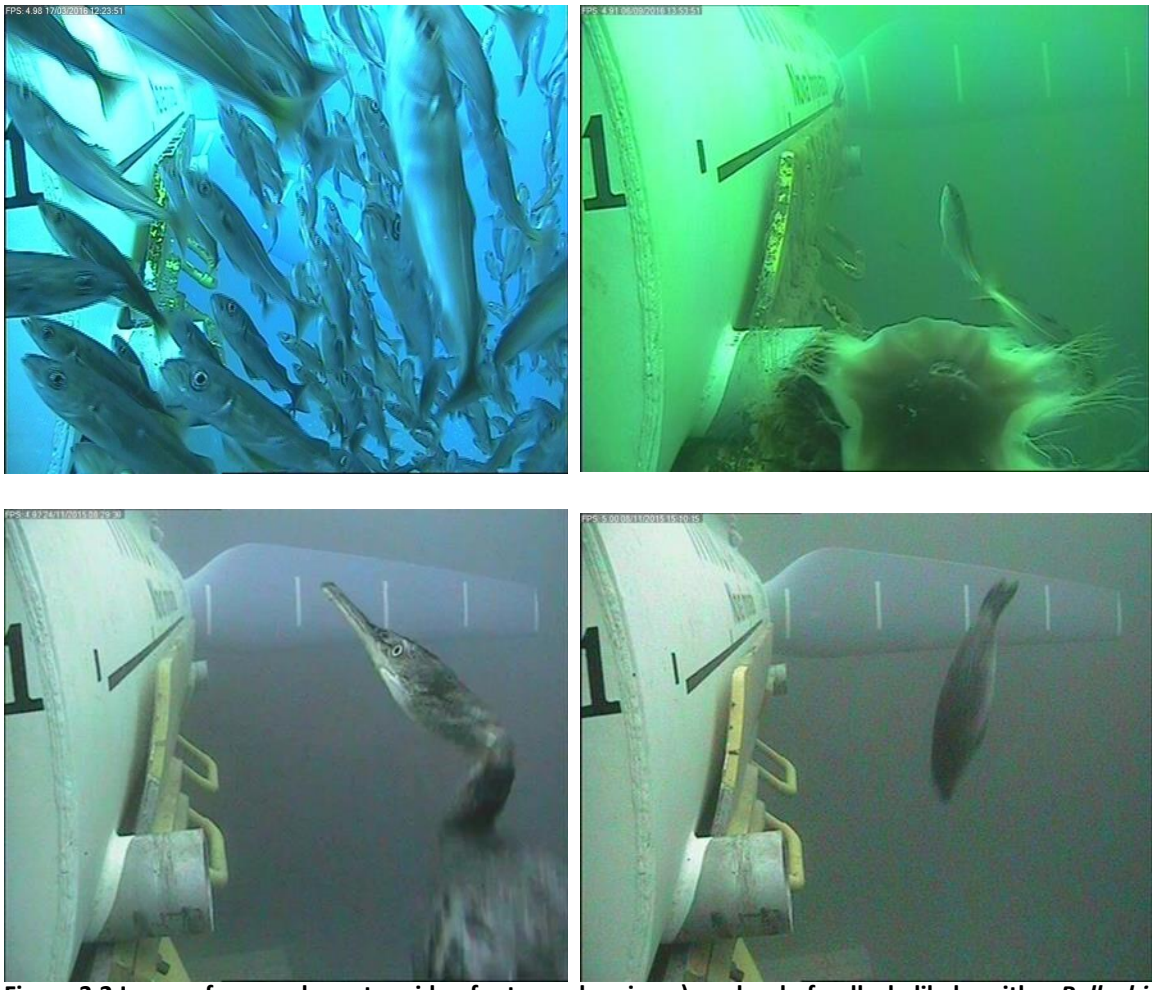

Figure 3.2 Images from underwater video footage, showing a) a school of pollack, likely saithe, *Pollachius virens*, b) Lion's mane jellyfish *Cyanea capillata* with pollack, c) European shag, *Phalacrocorax aristotelis*, and d) harbour seal, *Phoca vitulina*. Turbine blades were stationary during all observations.
Source: Nova Innovation 2017 ©

3.4 Efficacy of methods

3.4.1 Vantage point surveys

The vantage point surveys carried out as part of the Shetland Tidal Array environmental monitoring programme have provided a valuable long-term dataset on the presence, distribution and behaviour of birds and marine animals in and around the Shetland Tidal Array. All birds and mammals observed in surveys to date have been identified to species level with confidence. This long-running dataset has enabled a comprehensive assessment of the likelihood of near-field encounters between diving birds and

marine animals and turbines in the Shetland Tidal Array. This likelihood of interactions has been shown to be very low. Near-field encounters are only possible if a bird or animal uses the site (Bluemull Sound). The likelihood increases if the bird or animal uses the area immediately around the turbines. For birds, this likelihood increases again if the bird dives in the area around the turbine.

Only 10-20% of effort (minutes spent scanning) in vantage point surveys to date has focussed on the sea area immediately around the turbines, with 80-90% covering the wider Bluemull Sound area. This was necessary, to gather data on the presence of birds and animals throughout Bluemull Sound to better understand their overall use of the site. This is now well understood, as summarised in this report, so the design of vantage point surveys has been modified as part of the further environmental monitoring that will be carried out during the EnFAIT project (Section 4.1).

3.4.2 Underwater video

Underwater video has been shown to be a highly effective approach for gathering information on the behaviour and near-field interactions of marine wildlife around turbines throughout operation of the Shetland Tidal Array. This is predominantly due to the high clarity of water experienced at the site and the relative simplicity of the approach, thereby avoiding some of the technical issues associated with more complex monitoring approaches employed for other tidal energy projects. In doing so, a high quality and continuous dataset has been gathered, without long periods of interruption caused by technical failures, as has been experienced at other tidal energy projects.

Visibility at the project site was generally very good, such that the underwater cameras provided clear, high quality images of the area swept by the blades and surrounding area. The quality of the footage did degrade through time due to biofouling of camera lenses. Figure 3.3 illustrates how the image quality of one of the cameras degraded over five months of deployment from August 2016 to January 2017.

Figure 3.3 Illustration of typical biofouling on underwater cameras. Images show biofouling on one of the cameras between August 2016 (left image) and January 2017 (right image).
Source: Nova Innovation 2017 ©

As would be expected, the degree, rate and type of biofouling developing on the subsea cameras appears to depend on a range of factors, including the location of the camera, water clarity and light levels.

Underwater video will continue to be used as part of the further environmental monitoring that will be carried out during the EnFAIT project (Section 4.1), as a highly effective means of gathering information on near-field interactions between turbines and marine wildlife.

4 Further environmental monitoring during EnFAIT

4.1 Changes to monitoring

The environmental monitoring described in the previous sections relates to Phase 1 of the Shetland Tidal Array in Bluemull Sound, Shetland, comprising three operational 100 kW Nova M100 tidal turbines (T1 to T3). Phase 2 (the extension to the array) will involve the addition of three further 100kW Nova M100D turbines (T4 to T6) and associated infrastructure during 2020/21, and the relocation of T4, T5 and T6 in 2021. Environmental monitoring will continue to be an integral component of the Shetland Tidal Array and the EnFAIT project, to understand interactions between the turbines and marine wildlife. Some changes have been made to the design of the environmental monitoring programme for Phase 2 of the Shetland Tidal Array, building on the results and lessons learned from monitoring during Phase 1.

The ongoing environmental monitoring of the Shetland Tidal Array will focus on gathering data to better understand the likelihood, nature, and consequences of near-field interactions between marine wildlife and the operating turbines. Near-field interactions are only possible if a bird or animal uses the area immediately around the turbine. For birds, this likelihood increases again if the bird dives in the area around the turbine. The design of vantage point surveys for Phase 2 of the Shetland Tidal Array has therefore been modified to focus effort on gathering detailed information on the presence and behaviour of diving birds and marine mammals in the area of sea in which the existing and additional turbines are, or will be, located. This will allow a more detailed understanding for the likelihood, nature, and consequences of near-field interactions with turbines.

The new survey area, shown in Figure 4.1 is smaller than the previous survey area, enabling the concentration of survey effort on the area around the turbines. The survey area covers the locations where the three existing turbines are currently sited and where the further three turbines will be placed during 2020/21 and relocated in 2021.

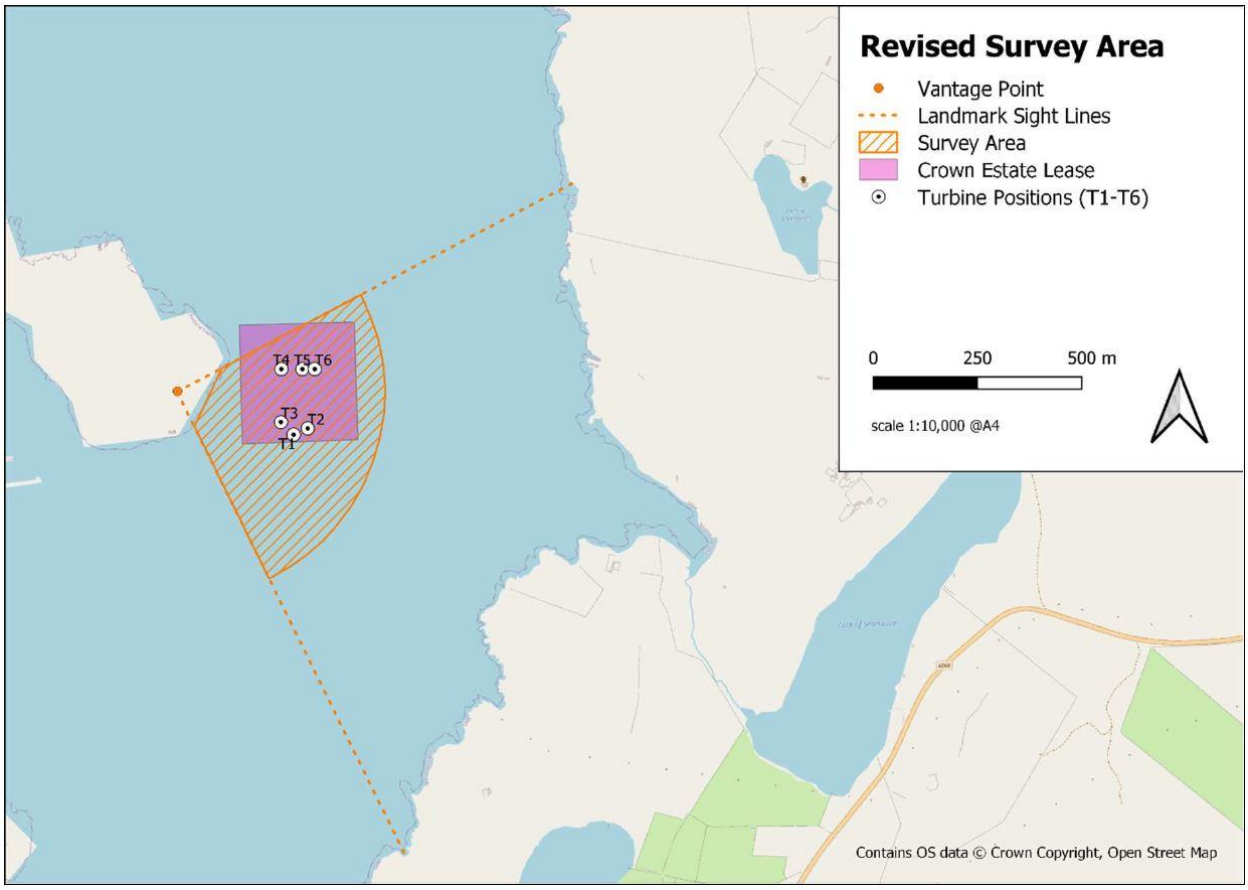

Figure 4.1 New vantage point survey area in Bluemull Sound, showing turbines (T1 to T3) and turbines in the expanded array (T4 to T6).
Source: Nova Innovation 2020 © and OS data ©

The three-camera motion-triggered system will continue to be utilised for monitoring near-field interactions of wildlife with the three existing turbines (T1 to T3) in the Shetland Tidal Array. The downward-facing camera has proved valuable in providing information on the vertical distribution and movements of prey species (fish) around the turbines, so will be retained. For the new turbines (T4 to T6) a single camera will be utilised (Figure 4.2 and Figure 4.3). The new cameras have a wider horizontal field of view in water than those on T1 to T3, higher sensitivity and superior resolution. The same motion-trigger and footage retention system will be used, as has proved successful for cameras on T1 to T3.

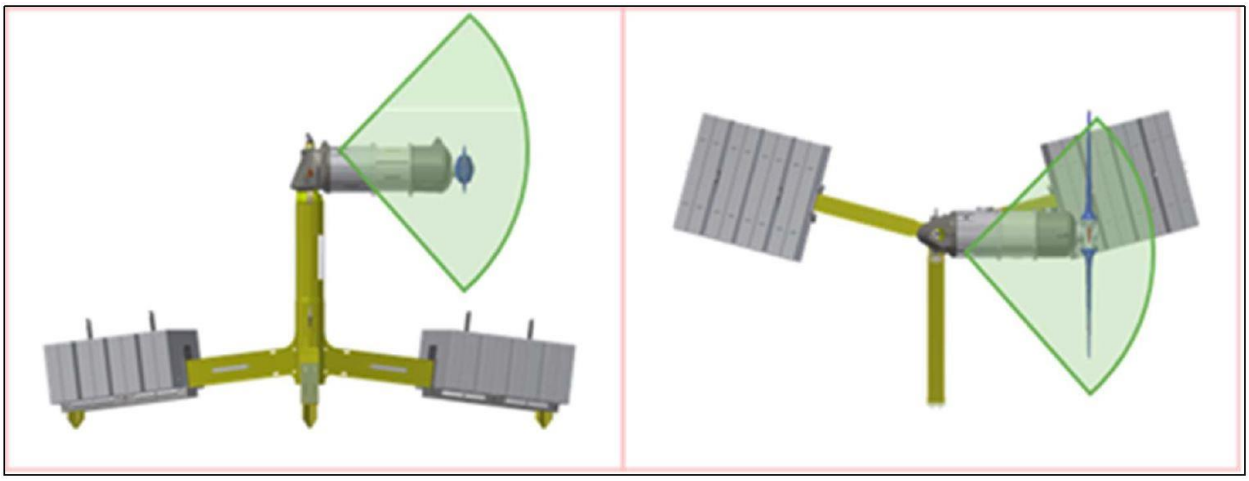

Figure 4.2 Subsea camera system for T4, T5 and T6 in the Shetland Tidal Array, showing field of view.

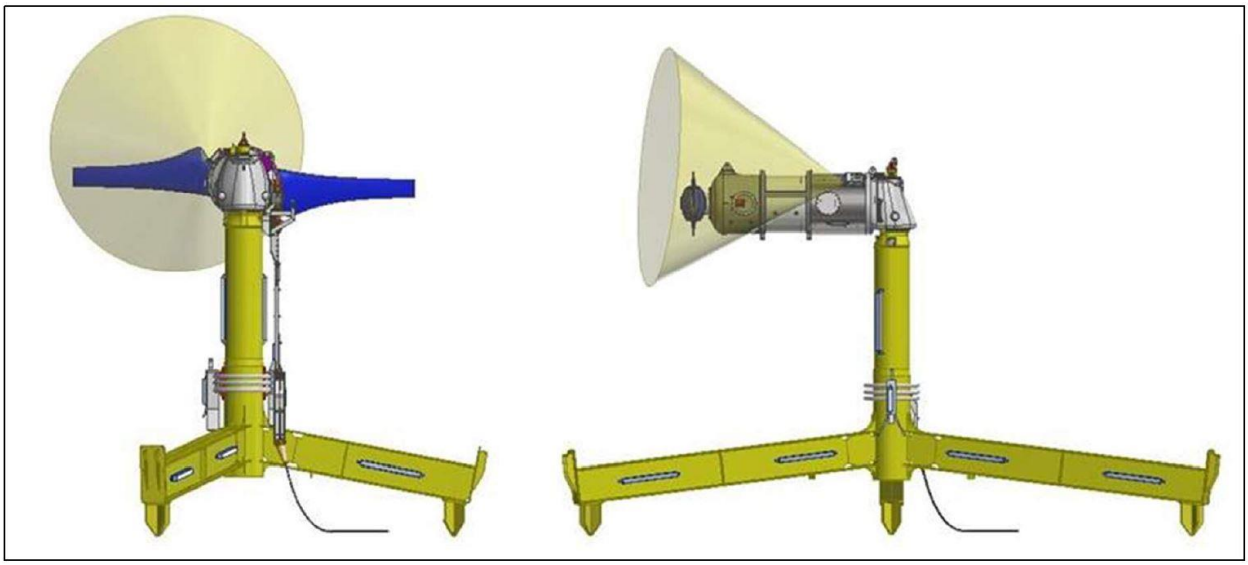

Figure 4.3 Subsea camera system for T4, T5 and T6 in the Shetland Tidal Array. Camera positions and fields of views are indicative only, for illustrative purposes.

Management of biofouling is an important consideration for the ongoing underwater video monitoring programme to reduce maintenance and 'false trigger' events. Camera maintenance to date has been carried out by divers and during routine shoreside maintenance. Options for more cost-effective and safer maintenance including physical removal of the cameras from the water for cleaning, as well as mechanical and various anti-fouling approaches are under consideration.

Further software development will be carried out to reduce the manual processing of video footage and to improve 'event detection' automation. This will improve efficiencies in data processing and reduce storage requirements, through automatic exclusion of 'falsely' triggered footage (e.g. caused by moving blades, biofouling).

4.2 Opportunities with EnFAIT

Ongoing environmental monitoring of the Shetland Tidal Array will focus on gathering further information to improve understanding for the likelihood, nature, and consequences of near-field interactions between marine wildlife and the turbines. This provides an opportunity to address key critical strategic evidence gaps identified for the tidal energy sector in the UK[6], and globally[7]. This will be achieved by:

- Further development of monitoring methodologies for gathering information on near-field interactions between marine wildlife and tidal turbines.
- Further refinement of understanding for, and gathering information on, the nature and frequency of near-field interactions between marine mammals, diving birds, fish, and the turbines.

[6] Offshore Renewables Joint Industry Programme for Ocean Energy (2017). The Forward Look: an ocean energy environmental research strategy for the UK. Report to The Crown Estate, Marine Scotland Welsh Government, Scottish Natural Heritage and Natural Resources Wales.

[7] Ocean Energy Systems Environmental (2020). The State of the Science Report: Environmental Effects of Marine Renewable Energy Development Around the World.

- Further refinement of understanding for how near-field interactions vary with turbine operation/non-operation and/or blade rotation speed.
- Further refinement of understanding for behaviour of marine wildlife in proximity to the turbines, including any evasive behaviour around operational turbines.
- Validation of predictions of encounter risk made in the environmental assessment for the Shetland Tidal Array[8] to improve understanding of actual (versus predicted) risk.
- Gathering data to seek to reduce uncertainty about the environmental effects of the Shetland Tidal Array, with a view to ultimately 'retiring' issues and impacts.

5 Conclusions

5.1 Environmental monitoring summary

5.1.1 Vantage point survey summary

A total of thirty-three bird and nine marine animal species have been recorded in vantage point surveys carried out to date in Bluemull Sound. Only fifteen of the bird and eight of the animal species are capable of diving to depths that might bring them into close proximity with turbines in the Shetland Tidal Array. Black guillemot and European shag accounted for over 90% of all diving bird sightings. Throughout the nine-year survey period, black guillemot were observed diving around the turbines on less than 150 occasions and European shag on just over 50 occasions. All other diving bird species were recorded infrequently in surveys and generally observed diving around the turbines on fewer on than 5 occasions over the entire nine-year survey period.

Marine animals (mammals and basking shark) were recorded in the surveys infrequently and in low numbers. Most species were only recorded in one or two scans over the entire nine-year survey period. Harbour porpoise was the most common marine animal recorded in surveys but was only recorded in the area immediately around the turbines on around 20 occasions over the nine-year period. Harbour seal was recorded in the area immediately around the turbines on just 10 occasions throughout the nine-year survey period and grey seal on 2 occasions.

These results demonstrate that the presence of diving birds and marine animals (mammals and basking shark) in Bluemull Sound is low and even lower again in the area immediately around the turbines. In the case of birds, very few were observed diving around turbines. These results indicate that the likelihood of near-field encounters between diving birds and marine mammals and the turbines and therefore the risk of negative environmental effects is very low.

5.1.2 Underwater video summary

Fish (saithe) were frequently recorded on the underwater video cameras. Shoals of saithe are seen to shelter on the seabed around the base of the turbine when the tidal flow is strong and rise in the water column when the tide slows. Birds (black guillemot and European shag) and mammals (harbour seal) were recorded only very occasionally on underwater cameras. No cetaceans or basking sharks were observed in the video footage. All birds and seals were observed during periods of slack water when the turbines

[8] Nova Innovation (2018). Shetland Tidal Array Extension – Environmental Assessment Report.

were not operational. No collision or near misses between marine wildlife and the turbines have been observed.

The fact that birds and seals were only observed during slack water, when the turbines are not operating supports the theory that both fish and their predators avoid regions of strong tidal flow. These results demonstrate that the presence of diving birds and marine animals in the area immediately around the turbines is extremely low, supporting the findings of the vantage point surveys. Birds and mammals are completely absent at times when the turbines are operational. These results indicate that the likelihood of near-field encounters between diving birds and marine mammals and operational turbines therefore the risk of negative environmental effects is very low.

5.1.3 Additional monitoring

The ongoing environmental monitoring of the Shetland Tidal Array will focus on gathering data to further understand the likelihood, nature, and consequences of near-field interactions between marine wildlife and the operating turbines. Vantage point surveys will be used to gather detailed information on the presence and behaviour of diving birds and marine mammals in the area of sea in which the existing and additional turbines are, or will be, located. The new methodology seeks to address some of the long-recognised limitations of more traditional bird and mammal survey approaches that generally cover much wider areas, leading to weaknesses in their ability to gather detailed information on the fine-scale movements and functional use of small tidal stream development sites by marine wildlife.

The three-camera motion-triggered system will continue to be utilised for monitoring near-field interactions of wildlife with the three existing turbines (T1 to T3) in the Shetland Tidal Array. The downward-facing camera has proved valuable in providing information on the vertical distribution and movements of prey species (fish) around the turbines, so will be retained. For T4 to T6 a single underwater camera will be used on each turbine to monitor near-field interactions between the turbine blades and marine wildlife. These new cameras will have a wider horizontal field of view in water than those on T1 to T3, higher sensitivity and superior resolution.

5.2 Benefits for EnFAIT and the wider offshore renewables industry

The environmental monitoring carried out up to and including Phase 1 of the EnFAIT project, and the comprehensive data analyses carried out, have made significant contributions to the evidence base on a number of critical environmental evidence gaps for the tidal stream sector[9]. Phase 2 of the EnFAIT project will build on this evidence, as detailed in Section 4, delivering benefits across the offshore renewables industry both in the UK and further afield.

No collisions or near misses between marine wildlife and the turbines in the Shetland Tidal Array have been recorded during the environmental monitoring programme. Further, monitoring conducted up to and throughout EnFAIT Phase 1 indicates that the likelihood of near-field encounters between diving birds and marine mammals and operational turbines, and therefore the risk of negative environmental effects, is extremely low. This aligns with observations from monitoring programmes for other operational tidal

[9] Offshore Renewables Joint Industry Programme for Ocean Energy (2017). The Forward Look: an ocean energy environmental research strategy for the UK. Report to The Crown Estate, Marine Scotland Welsh Government, Scottish Natural Heritage and Natural Resources Wales.

turbines[10], which together are contributing to a growing body of evidence indicating that near-field interactions between marine wildlife and operational tidal turbines are likely to be very rare events and are not likely to lead to significant environmental consequences.

This combined knowledge, of which the environmental monitoring and analysis detailed in this report forms a significant part, is building a growing body of evidence indicating that environmental risks associated with tidal projects are very low. This will help deliver strategic planning and consenting processes for tidal energy that are proportionate and risk-based and based on best available scientific evidence about actual, rather than perceived impacts.

In addition, the environmental monitoring programme being delivered as part of the EnFAIT project is making a significant contribution to the development of efficient and cost-effective monitoring techniques and instrumentation to gather information to improve knowledge for near-field interactions between marine wildlife and operational turbines. It is also contributing to the development of a more objective-driven approach to defining environmental monitoring needs for tidal energy projects, by clearly identifying and focusing on critical evidence needs. This will contribute to future improvements in the design and delivery of environmental monitoring programmes for the tidal stream and wider marine energy sectors.

The key evidence and knowledge gained through the environmental monitoring programme delivered under the EnFAIT project, as set out above, have the potential to make a significant contribution to streamlining and accelerating consenting for tidal stream projects to allow increased and responsible deployment of devices. This, in turn, will facilitate commercialisation of the sector and reduce the levelized cost of tidal energy.

[10] Ocean Energy Systems Environmental (2020). The State of the Science Report: Environmental Effects of Marine Renewable Energy Development Around the World. Chapter 3: Collision risk for animals around turbines.

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