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ENFAIT
ENABLING FUTURE ARRAYS IN TIDAL

Y1 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 background, methodologies and outcomes from the environmental monitoring in year 1 of the EnFAIT project. It satisfies deliverable D8.5 of the EnFAIT project and will also be made available for public dissemination.

Since this is the first in a series of three environmental monitoring reports required for the EnFAIT project, an overview is provided of the longer-term environmental monitoring programme that Nova has been conducting around the Shetland Tidal Array since 2010, to provide additional context. This provides a foundation on which further monitoring undertaken as part of the EnFAIT project will be built and refined. An overview of the scope and objectives for the ongoing monitoring programme, as the number of deployed turbines increases and device configuration within the array is altered, is also provided.

2 Summary of environmental monitoring to date

2.1 Overview

Nova has been conducting environmental survey and monitoring activity in Bluemull Sound, Shetland since November 2010. Initial environmental surveys were carried out to gather information in support of consent applications for Nova's existing turbine deployments in Bluemull Sound. Following turbine deployments, the focus of environmental monitoring shifted to activity required under the consent conditions, to monitor the effects of the deployed turbines on marine wildlife.

To date, environmental monitoring in Bluemull Sound has focussed on possible effects of the project on marine mammals, diving birds and the avoidance of impacts on sensitive seabed habitats during installation, utilising underwater cameras and land-based vantage point surveys.

Prior to commencement of site works the full details of the environmental monitoring programme were set out by Nova 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).[1]

[1] 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

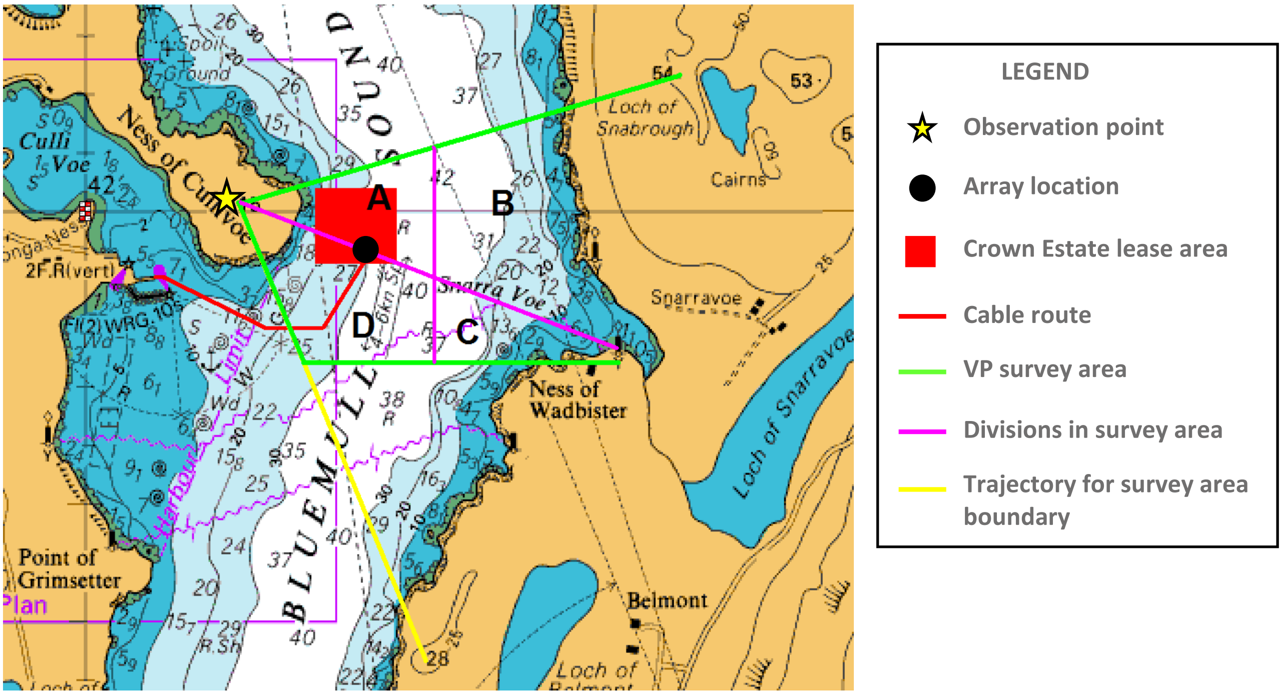
2.2 Monitoring methodologies

2.2.1 Vantage point surveys

Land-based vantage point surveys have been carried out each month since November 2010 to monitor the presence and activity of birds and marine mammals within the turbine array location and wider area in Bluemull Sound, as well as notable observations such as vessel activity. 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.

Figure 2.1 shows the survey area (delineated by green lines) and the observation (vantage) point on the Ness of Cullivoe (yellow star). The survey area is subdivided into four areas A, B, C and D (indicated by purple subdivisions), marked out using transit sticks from the observation point and markers on the Unst shore. Figure 2.1 also indicates the location of the turbines (black dot) and the cable route back to shore (red line). The yellow line illustrates the trajectory of the marking point for the survey boundary.

Figure 2.1 Location of observation point and survey area in Bluemull Sound. The survey area is subdivided into four areas A, B, C and D. The location of turbines, cable route and Crown Estate Scotland seabed lease area are also indicated.



Source: Nova Innovation 2015 © and Admiralty Charts

Pre-application (baseline) surveys were initiated in November 2010, to ensure collection of data before any site activity commenced. Operational surveys have continued since July 2014 and are ongoing. Surveys are divided into 3-month survey periods, roughly equating to seasons, as follows;

- Spring (February to April)
- Summer (May to July)
- Autumn (August to October)
- Winter (November to January)

Within each 3-month survey period (or season), nine 4-hour counts are conducted. Each 4-hour count consists of 24 scans for birds (one every 10 minutes) and 12 scans for mammals (one every 20 minutes) across the survey area (incorporating the array area and wider survey area). For the first 2 or 3 minutes of each scan any birds or marine mammals within the array area are recorded. For the reminder of the scan the wider survey area is observed using binoculars, with a telescope being used where necessary to confirm species identification.

All counts are conducted in sea state 2 or less (to maximise the chance of spotting and being able to follow animals) and good light (to maximise visibility). Counts within each 3-month survey period are conducted across a range of times of day and states of tide.

Across the entire survey area, only birds that are diving or loafing on the surface of the water are recorded. Those transiting the area (i.e. flying) are not recorded. All marine mammals observed in the survey area during scans are recorded. Birds and mammals are recorded to species level, if possible[2]. The number of sightings was recorded along with an estimation of the number of individuals and any general behaviour, direction of travel and other relevant observations. Any notable observations outside of scans are also recorded (for example marine mammal activity, vessel activity, bird feeding activity).

2.2.2 Underwater video

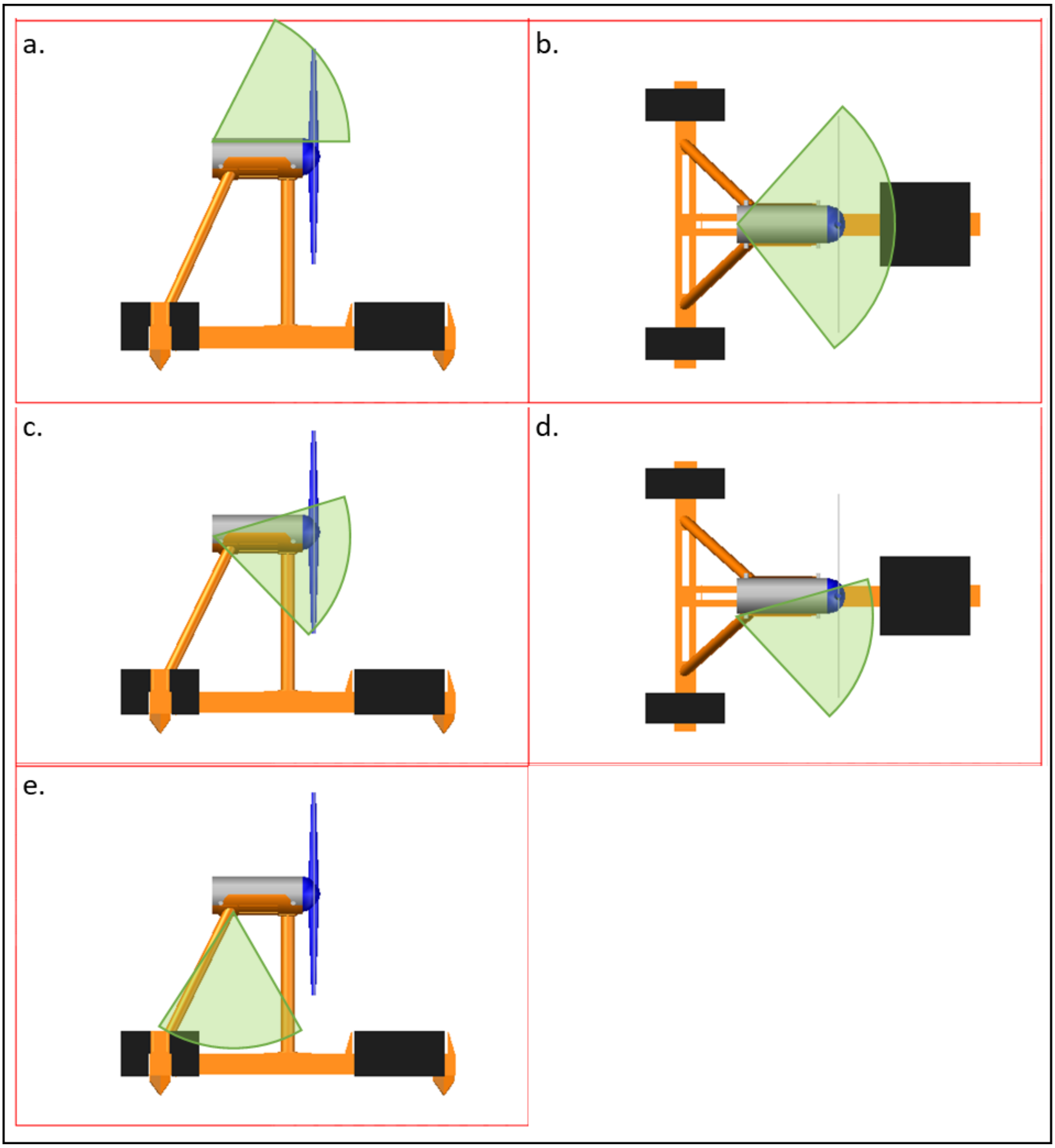
Underwater video has been used throughout the operational phase of the project to monitor near-field behaviour of marine wildlife around the turbines. Three cameras are attached to each of the deployed turbines. One camera is attached to the side of the nacelle looking towards the blades; one is attached 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 (over) 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. Triggering is not sensitive to movement of the blades, to avoid constant recording during operational periods.

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, or biofouling on the camera lens. Relevant footage is further analysed to establish species identity and any notable behaviour, including any interactions with moving parts of the turbines.

[2] All birds and mammals in surveys to date have been identified with confidence to species level.

Figure 2.2 Location of cameras utilised for near-field operational monitoring of turbines showing camera attached to the top of the nacelle looking towards the blades (a. & b.), camera attached to the side of the nacelle looking towards the blades (c. & d.) and camera attached on the bottom of the turbine looking towards the seabed (e.). This figure is provided for illustrative purposes only and is not an accurate reflection of the fields of view for each of the cameras.



3 Outcomes from EnFAIT year 1 monitoring

3.1 Overview

This section provides an overview of the outcomes from environmental monitoring conducted in year 1 of the EnFAIT project. The key outcomes from vantage point surveys undertaken for the 12 months between May 2017 and April 2018 are provided. Analysis of the underwater video footage gathered to date is ongoing, so a summary of preliminary results to date is presented.

3.2 Vantage point surveys

3.2.1 Birds

During vantage point surveys conducted between May 2017 and April 2018, all birds observed were identified with confidence to species level. A total of twenty-four different species were recorded, as listed below;

- Whooper swan, *Cygnus cygnus*
- Greylag goose, *Anser answer*
- Mallard, *Anas platyrhynchos*
- Long-tailed duck, *Clangula hyemalis*
- Common goldeneye, *Bucephala clangula*
- Red-breasted merganser, *Mergus serrator*
- Red-throated diver, Gavia stellata
- Great northern diver, *Gavia immer*
- White-billed diver, Gavia adamsii
- Northern fulmar, *Fulmarus glacialis*
- Northern gannet, *Morus bassanus*
- Great cormorant, *Phalacrocorax carbo*
- European shag, *Phalacrocorax aristotelis*
- Arctic skua, *Stercorarius parasiticus*
- Great skua, *Stercorarius skua*
- Atlantic puffin, *Fratercula articulata*
- Black guillemot, *Cepphus grylle*
- Razorbill, *Alca torda*
- Common guillemot, *Uria aalge*
- Arctic tern, *Sterna paradisaea*
- Black-legged kittiwake, *Rissa tridactyla*
- Common gull, *Larus canus*
- European herring gull, *Larus argentatus*
- Great black-backed gull, *Larus marinus*

Of these, seven species (European shag, black guillemot, Atlantic puffin, red-throated diver, great black-backed gull, Arctic tern and red-breasted merganser) were observed within the array area. Of these, only European shag, black guillemot and Atlantic puffin are capable of regularly diving down to depths that might bring them into contact with the turbines[3]. All other bird species were only observed within the wider survey area. Table 3.1 details the bird results from vantage point surveys conducted in Bluemull Sound between May 2017 and April 2018, inclusive.

Table 3.1 Results from vantage point surveys conducted in Bluemull Sound between May 2017 and April 2018, inclusive, showing numbers of individual birds recorded* diving or loafing within the array area (AA) and wider survey area (WSA) across each season (comprising a 3-month survey period).

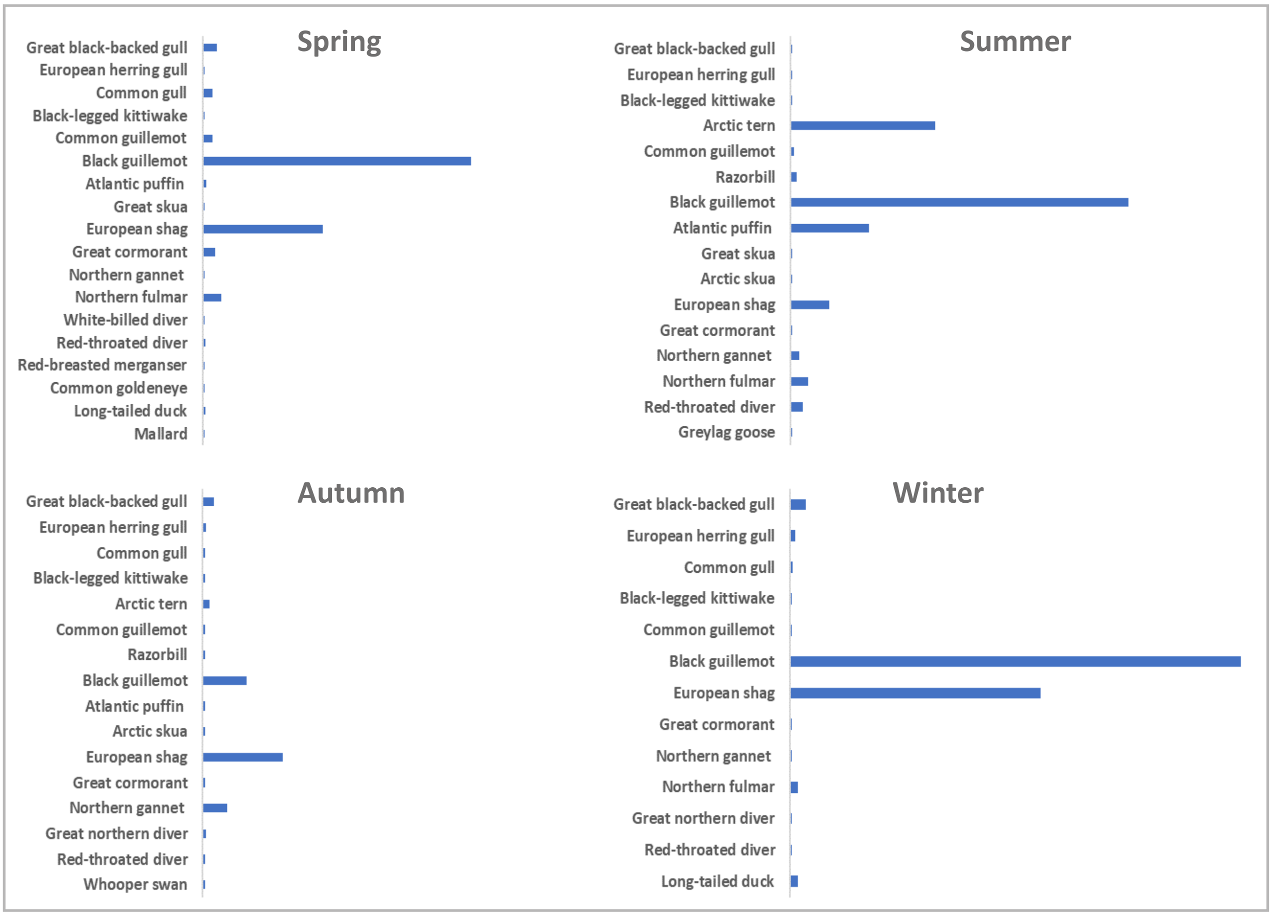
	Summer		Autumn		Winter		Spring	
	AA	WSA	AA	WSA	AA	WSA	AA	WSA
Whooper swan	-	-	-	12	-	-	-	-
Greylag goose	-	6	-	-	-	-	-	-
Mallard	-	-	-	-	-	-	-	1
Long-tailed duck	-	-	-	-	-	40	-	15
Common goldeneye	-	-	-	-	-	-	-	5
Red-breasted merganser	-	-	-	-	-	-	1	3
Red-throated diver	-	63	-	6	-	1	1	17
Great northern diver	-	-	-	15	-	3	-	-
White-billed diver	-	-	-	-	-	-	-	1
Northern fulmar	-	90	-	-	-	40	-	98
Northern gannet	-	47	-	125	-	1	-	10
Great cormorant	-	3	-	1	-	3	-	67
European shag	2	201	2	411	3	1289	4	629
Arctic skua	-	8	-	2	-	-	-	-
Great skua	-	6	-	-	-	-	-	1
Atlantic puffin	10	404	-	17	-	-	-	20
Black guillemot	7	1739	19	2227	16	2316	13	1406
Razorbill	-	30	-	4	-	-	-	-
Common guillemot	-	18	-	1	-	3	-	50
Arctic tern	9	743	-	34	-	-	-	-
Black-legged kittiwake	-	5	-	1	-	4	-	6
Common gull	-	-	-	7	-	10	-	51
European herring gull	-	4	-	16	-	27	-	11
Great black-backed gull	-	8	-	57	1	81	-	75

* Note that numbers are total numbers of individual birds counted, so may include multiple observations of the same birds across different counts.

Figure 3.1 (over) summarises the results of the vantage point surveys conducted in Bluemull Sound between May 2017 and April 2018, inclusive. Black guillemot has been by far the most frequently observed and abundant bird species throughout the year during vantage point surveys. Relatively high numbers of European shag have also been observed throughout the year. Atlantic puffin, Arctic tern, fulmar and red-throated diver occurred in relatively high numbers during the summer, whilst gannet numbers were greatest during the autumn. Other species have been observed in relatively low numbers.

[B] Based on BirdLife International Species Factsheets (2018). Downloaded from http://www.birdlife.org on 20/06/2018.

Figure 3.1 Results of the vantage point surveys conducted in between May 2017 and April 2018, inclusive, showing numbers of individuals per species, per season. Seasonal abundance for each species is plotted on a common horizontal axis to enable relative comparisons. For precise abundance figures, refer to Table 3.1.



3.2.2 Mammals

During vantage point surveys conducted between May 2017 and April 2018, all mammals observed were identified with confidence to species level. A total of five mammal species were recorded, as listed below;

- Harbour or common seal, *Phoca vitulina*
- Grey seal, *Halichoerus grypus*
- Harbour porpoise, *Phocoena phocoena*
- Minke whale, *Balaenoptera acutorostrata*
- Otter, *Lutra lutra*

Of these five species, only harbour seal and harbour porpoise were observed within the array area itself.

Table 3.2 (see over) details the mammal results from vantage point surveys conducted in Bluemull Sound between May 2017 and April 2018, inclusive.

Table 3.2 Results from vantage point surveys conducted in Bluemull Sound between May 2017 and April 2018, inclusive, showing numbers of individual mammals recorded within the array area (AA) and wider survey area (WSA) across each season (comprising a 3-month survey period).

	Summer		Autumn		Winter		Spring	
	AA	WSA	AA	WSA	AA	WSA	AA	WSA
Harbour seal	-	16	1	45	-	88	-	37
Grey seal	-	2	-	11	-	10	-	14
Harbour porpoise	-	26	2	6	3*	47	6*	27
Minke whale	-	-	-	-	-	3	-	-
Otter	-	9	-	14	-	29	-	2

* In both these cases, harbour porpoises were observed travelling towards the array area from the north but did not resurface again before reaching it. Therefore, uncertain whether animals passed through array area.

3.3 Underwater video

Over 10,000 hours of underwater video footage have been collected from the cameras attached to turbines at the Bluemull Sound site to date, with monitoring ongoing. Analysis of the underwater video footage gathered to date is ongoing, so a summary of preliminary results to date is presented.

The video cameras provide regular sightings of fish, and occasionally of birds and mammals. The following four species have been identified from underwater video footage;

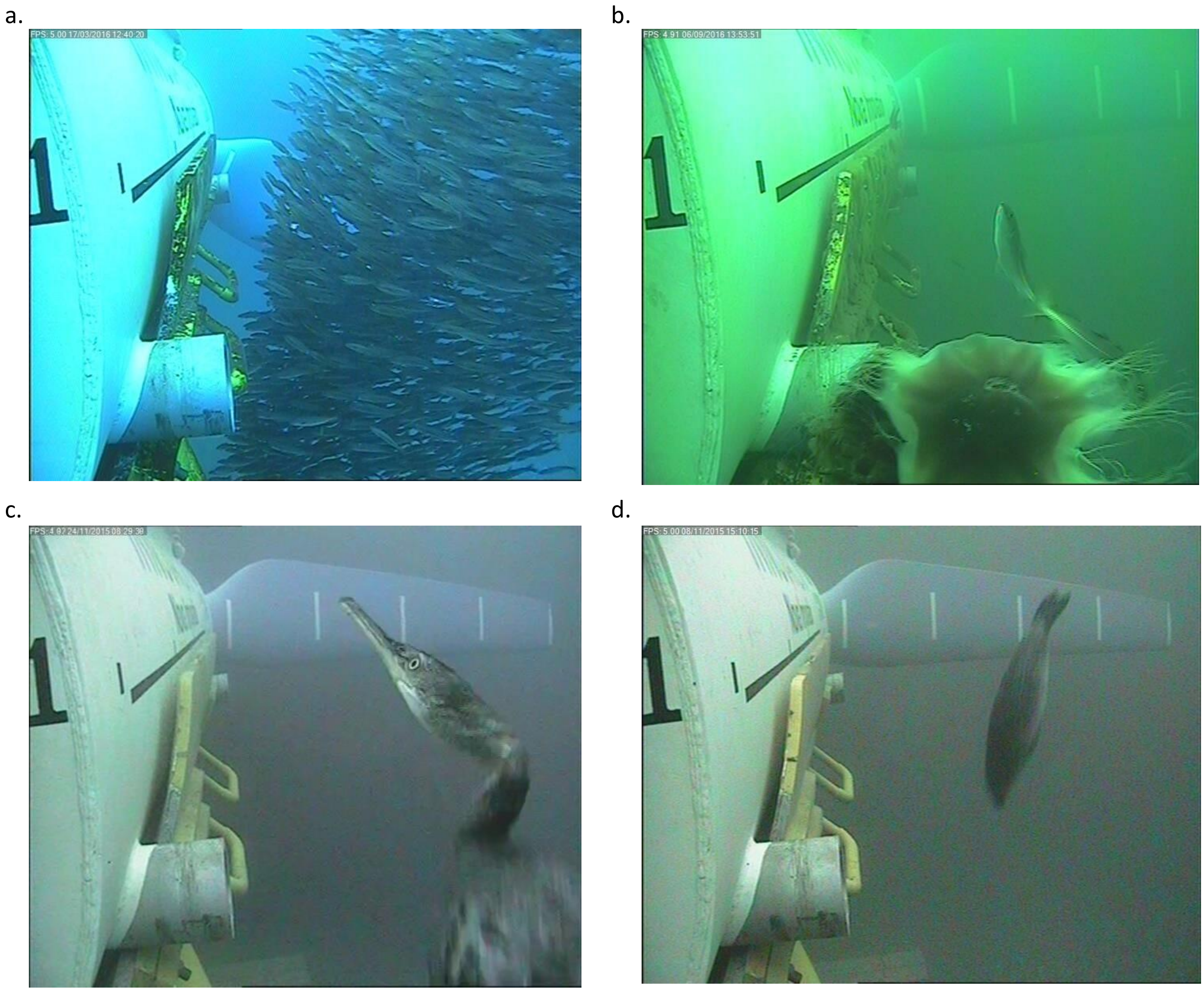
- Harbour or common seal, *Phoca vitulina*
- European shag, *Phalacrocorax aristotelis*
- Black guillemot, *Cepphus grylle*
- Atlantic pollack, *Pollachius pollachius*

Fish are by far the most frequently sighted fauna, the majority of which are pollack, most likely *Pollachius pollachius*, but possibly also coalfish (*Pollachius virens*). Birds and seals are relatively infrequently observed on the underwater cameras. No cetaceans or basking sharks have been observed in any of the video footage analysed to date.

Shoals of pollack appear at times to shelter near the seabed, in the lee of the turbine base when the tidal flow is strong and rise into the water column at slack tide. Jellyfish such as Lion's mane jellyfish, *Cyanea capillata*, are occasionally recorded either at slack tide or being carried passively past the turbines by the flowing tide. Figure 3.2 (over) shows some typical images from underwater video footage.

In footage analysed to date birds and mammals have only been observed when the turbine is not generating, and the blades are therefore not rotating, corresponding to slack water or times of slow current speed. The lack of movement in turbine blades at times when fauna is observed is demonstrated in the images in Figure 3.2 (over). There have been no observed cases of any collisions or near miss events between fauna and the turbine blades.

Figure 3.2 Images from underwater video footage, showing a) a school of pollack *Pollachius pollachius or P. virens* b) Lion's mane jellyfish *Cyanea capillata* with pollack c) European shag, *Phalacrocorax aristotelis* and d) harbour or common seal, *Phoca vitulina.* Turbine blades were stationary during all observations.



3.4 Efficacy of methods

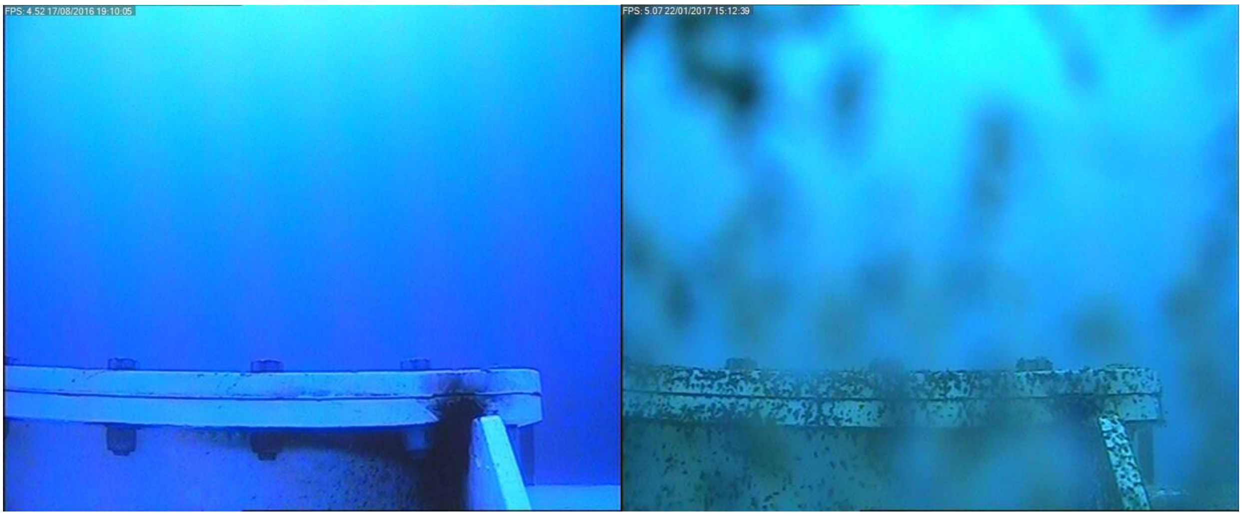
3.4.1 Vantage point surveys

Vantage point surveys have provided valuable information to date on the presence and abundance of birds and mammals in and around the array area, as well as information on their behaviour. All birds and mammals observed in surveys to date have been identified to species level with confidence.

3.4.2 Underwater video

Visibility at the project site was generally very good, such that the subsea 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).



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.

Biofouling is therefore an important consideration for this element of the ongoing monitoring programme for the Shetland Tidal Array. Camera maintenance has so far been by diver cleaning and during routine shoreside maintenance. Options for maintenance include physical removal of the cameras from the water for cleaning, as well as mechanical and various biocide approaches[4]. Nova will consider whether any of these are necessary or appropriate in relation to ongoing use of subsea cameras for the STA.

[4] Delauney L, Comp`ere C and Lehaitre M (2010). Biofouling protection for marine environmental sensors. Ocean Science **6:** 503–511.

4 Further environmental monitoring during EnFAIT

4.1 Opportunities with EnFAIT

Monitoring programmes undertaken to date around tidal stream energy projects have generally focused on the environmental effects of single devices[5]. The EnFAIT project and a continuation of the monitoring programme already established in Bluemull Sound, presents a unique opportunity to gather information from an array of operating tidal turbines. Such information will improve understanding about the individual and combined environmental effects of turbines within an array and provide an evidence base on which future consenting decisions can be based.

The Offshore Renewable Energy Joint Industry Programme for Ocean Energy (ORJIP OE)[6] has undertaken a systematic process to identify the key consenting risks for early tidal array deployments and the corresponding monitoring and research priorities. These monitoring and research priorities include:

- Development of suitable instrumentation and methodologies for monitoring near-field behaviour of diving birds, marine mammals, basking shark and migratory fish around operational tidal turbines;
- Undertaking monitoring around operational tidal turbine arrays to gather information on the behaviour of diving birds, marine mammals, basking shark and migratory fish;
- Gathering acoustic data from operational arrays; and
- Development of hydrographic models to predict the effects of changes in water flow and energy removal of tidal arrays caused by (a) the physical presence of arrays and (b) the removal of energy and secondary effects of changes in water flow and energy removal.

The monitoring programme associated with Nova's Shetland Tidal Array to date already provides a significant body of evidence on many of these priority research areas. In finalising the ongoing monitoring programme for the Shetland Tidal Array and EnFAIT, Nova will consider opportunities to further address these key areas.

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[5] For example Marine Current Turbines' SeaGen project in Strangford Lough, Northern Ireland https://tethys.pnnl.gov/publications/seagen-environmental-monitoring-programme-final-report and OpenHydro and Emera's Cape Sharp project in the Bay of Fundy, Nova Scotia http://capesharptidal.com/eemp/

[6] See http://www.orjip.org.uk/oceanenergy/about

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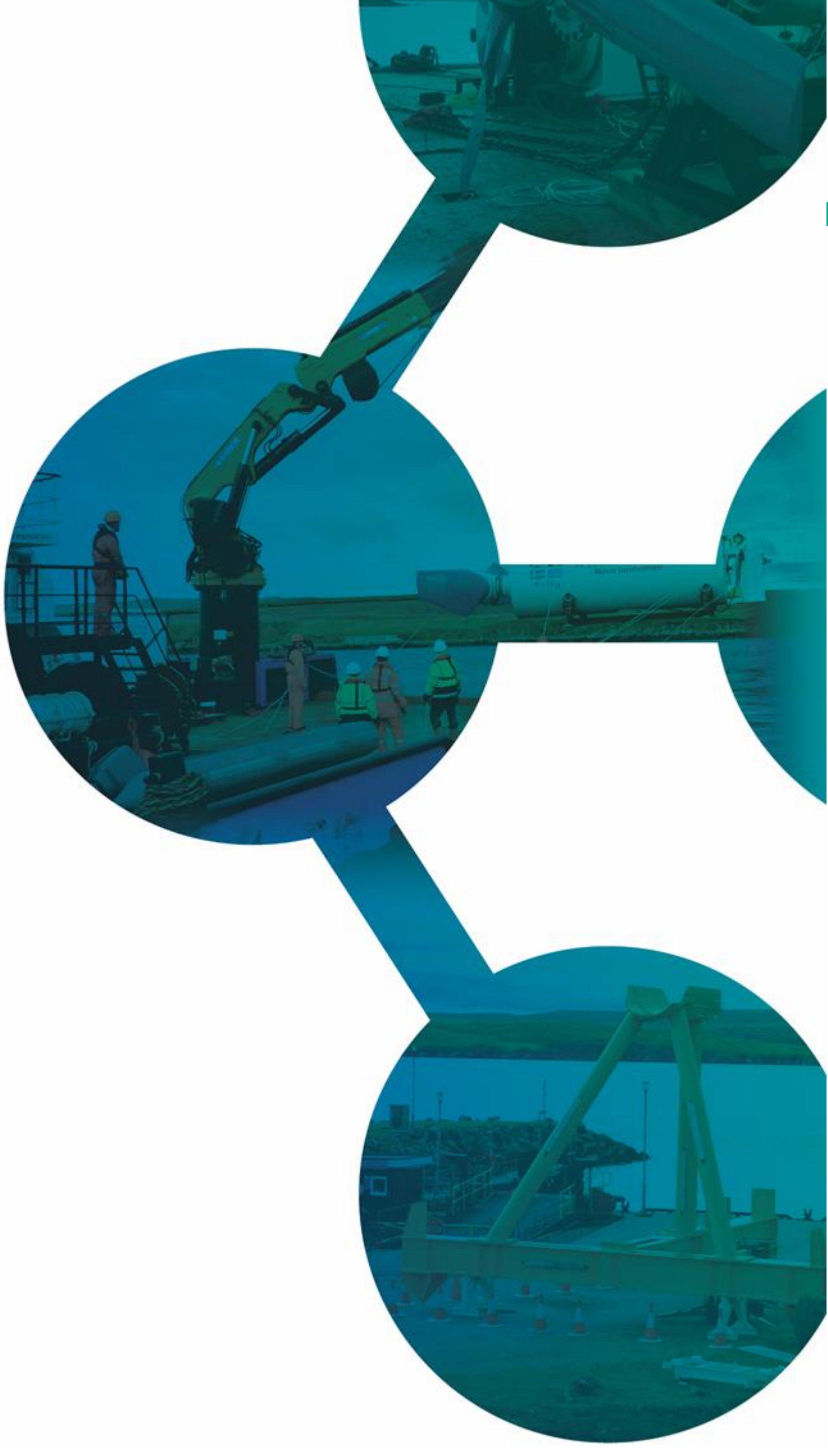

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