ANNEX 2 – TASK 4, THE REVIEW AND ANALYSIS OF EXISTING UNDERWATER VIDEO DATA TO ESTABLISH WHAT CAN BE LEARNED REGARDING NEAR-FIELD BEHAVIOUR

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1. INTRODUCTION

This Annex presents the results of Task 4 (refer to Section 3 of the Main Report), the aim of which was to undertake a review and analysis of existing underwater video data to establish what can be learned regarding near-field behaviour from previously collected underwater video data around operational tidal turbines.

The following objectives formed the focus of Task 4:

- Undertake an initial (manual) review of the available video data to determine whether it has the potential to help reduce scientific uncertainty regarding near-field behaviour around operational tidal turbines;
- Analyse representative samples of footage recording presence / absence of marine wildlife and near-field behaviour of marine wildlife in relation to key technical and environmental information e.g. turbine operational status, tidal state and time of day;
- Record any marine wildlife interactions with turbines observed during the analysis of selected samples; and
- Prepare a briefing note summarising the key findings (refer to Section 3 of the Main Report and Section 4 of this Annex).

This Annex presents the results of Task 4.

2. APPROACH

As detailed in the Main Report, the following datasets were reviewed during this task:

- MeyGen – Andritz Hydro Hammerfest (AHH) Tidal Turbine Generators (TTG) 2 and TTG 3 deployment at the Pentland Firth (Section 3.1);
- Scotrenewables – SR2000 deployment at EMEC (Section 3.2); and
- Voith Hydro – HyTide deployment at EMEC (Section 3.3).

Datasets provided by each developer were reviewed using Protocol 2 (Environmental analysis of underwater video data) developed during Task 2: 'Establishment of protocols for analysing underwater video data' (see Section 1.3 of the Main Report; Protocol 2 is available via the wave and tidal energy page of the SNH website and is due, subsequently, to be accessible also via the ORJIP Ocean Energy website.

3. RESULTS

Results from the analysis and review of the three datasets are summarised in the following sections.

3.1 MeyGen – AHH TTG 2 and TTG 3 deployment at the Pentland Firth

Data which had been collected around two of the AHH turbines, namely TTG 2 and TTG 3, was provided to the project by SIMEC Atlantis. The time period and format of the data differed between TTG 2 and TTG 3. For TTG 3, individual camera feed data were available for 22 February 2017 – 04 March 2017 while an incorporated feed of all three cameras was available from 10:00 on 13 July 2017 – 11:00 on 14 July 2017. For TTG 2, data incorporating all three cameras was provided from 14:00 on 12 July 2017 – 11:00 on 14 July 2017. Please refer to Annex 1 for full details on data, schematics and camera setup.

A total of 32 two-minute samples were reviewed and analysed from the MeyGen AHH TTG 2 and TTG 3 video data. These 32 samples include three test samples[1] and covered the first two minutes in each hour of available footage. Video data were analysed from one day, only, in July of 2017 due to limitations in available data. A summary of the MeyGen AHH TTG 2 and TTG 3 video data reviewed is provided in Table 3.1:

Table 3.1. Summary of MeyGen AHH TTG 2 and TTG 3 data reviewed

AHH turbine number	Date	Hours of available footage	No. of sample clips
TTG 2	13 July 2017	Full 24 hour period	17 (05:00 – 22:00)*
TTG 3	13 July 2017	10:00-23:00	12 (11:00 – 22:00)
TTG 2 and TTG 3	14 July 2017	Full breadth of data (test samples)	3

*Excluding 10:00, for which there was no footage available on the hour.

Possible wildlife was observed in one sample out of the 32 reviewed from the MeyGen AHH TTG 2 and TTG 3 dataset. This observation is summarised in Table 3.2 below, which provides a high-level description of the observation in relation to turbine operational status and tidal current speed:

Table 3.2. Summary of wildlife observations from MeyGen AHH TTG 2 and TTG 3 data samples

Turbine status	Receptor	Observation	Number of receptors in one sample	Tide (m/s)	Number of events
Operational	Fish (possible flatfish)	Moving with / against current through turbine blades	1	0.9	1

No collision events were observed during the analysis of the MeyGen AHH TTG 2 and TTG 3 data. Only a single fish was observed to move between the rotating blades of TTG 2 during the review, when the current was 0.9 m/s. No shoaling events were observed in the footage.

Comparative to other datasets, significantly less wildlife observations were recorded during the review of the MeyGen AHH TTG 2 and TTG 3 data samples.

3.2 Scotrenewables – SR2000 deployment at EMEC

The Scotrenewables SR2000 dataset consists of 19 TB of continuous video monitoring data filed as five minute segments under each hour and day from 17 January 2018 – 2 July 2018 (equating to 167 days or 4008 hours).

The dataset encompasses video footage from 13 different cameras of which five provided footage of interest from an environmental monitoring perspective. Three of these cameras were situated underwater and a further two on the surface mast. Three additional cameras were present underwater but remained non-functional during deployment.

[1] In the initial assessment of the MeyGen AHH TTG 2 and TTG 3 video data, and as with the other datasets, a number of test sample clips were isolated to ensure consistency between data reviewers. These test sample clips were included for the review and analysis of Task 4.

For the purposes of Task 4, only footage from cameras which were positioned to observe the rotors was analysed. The review therefore focussed on video footage from two underwater cameras; one on the port side nacelle (camera 3), and one on the leg brace (camera 5).

Camera 4, on the starboard side nacelle, was not operational during deployment (as were cameras 6 & 7) and camera 2 did not capture the turbine blades. Please refer to Annex 1 for full details on data, schematics and camera setup.

A total of 44 two-minute samples were reviewed and analysed from the Scotrenewables SR2000 video data[2]. These 44 samples include three test samples[3] and covered the first two minutes in each hour of available, adequately lit footage, for three days near the start, middle and end of camera operation between January and July 2018. Two of the 44 samples reviewed only had one functional camera (channel 5 on 2 July). A summary of the SR2000 video data reviewed is provided in Table 3.3:

Table 3.3. Summary of Scotrenewables data reviewed

Camera channel number	**Date**	**Hours of available footage**	**No. of sample clips**
3	18 January 2018	05:00 – 20:00	8 (09:00 – 16:00)
	15 April 2018	05:00 – 20:00	15 (06:00 – 20:00)
	2 July 2018	05:00 – 20:00	16 (05:00 – 20:00)
5	18 January 2018	Full 24 hour period	8 (09:00 – 16:00)
	15 April 2018	Full 24 hour period	15 (06:00 – 20:00)
	2 July 2018	Full 24 hour period	18 (05:00 – 22:00)
3 and 5	17 January 2018 – 2 July 2018	Full breadth of data (test samples)	3

[2] Note: In order to maximise the efficiency of the data review process, all two-minute samples from channels 3 and 5, which were recorded on the same day and time, were paired together for reviewing and test footage reviews.

[3] A number of test sample clips were isolated to ensure consistency between data reviewers. These test sample clips were included for the review and analysis of Task 4.

Wildlife was observed in 12 samples out of the 44 reviewed from the Scotrenewables dataset. These observations are summarised in Table 3.4 below, which provides a high-level description of the observations in relation to turbine operational status and tidal current speed:

Table 3.4. Summary of wildlife observations from Scotrenewables SR2000 data samples[4]

Turbine status	Receptor	Observation	Number of receptors in one sample	Tide (m/s)	Number of events[5]
Operational	Unclear	Moving with current	1	2.3	1
Operational	Unclear	Moving with current	1	2.0	1
Operational	Unclear (possibly bird)	Moving with current (upwards between legs)	1	1.7 – 2.8	4
Operational	Unclear	Moving with current (upwards between legs)	1	1 – 2.1	2
Operational	Unclear	Moving with current (between legs towards portside)	1	2.8	1
Non-operational	Unclear (possibly bird)	Moving with current	1	1.3	1
Non-operational	Unclear (possibly jellyfish)	Moving with current	1	0.5	1
Non-operational	Unclear	Moving with current	1	1.3	1

No collision events were observed during the analysis of the SR2000 data.

Due to video image quality, possible receptors were less confidently identified in comparison to the other datasets; there are no events that can definitively identify wildlife to a basic ecological level (e.g. bird, fish or mammal).

Possible receptors were observed marginally more frequently during operation than during non-operational periods and all were observed to be moving with the current.

Comparative to the video data collected around the Voith Hydro turbine, with a similar temporal range of available data, Scotrenewables' data show fewer instances of definitive wildlife observations. This is partly due to video image quality; where possible receptors were less confidently identified. The SR2000 is also located at the water surface whereas the nacelle of the Voith Hydro turbine is positioned approximately 15m above the seabed, in water depths of 33m (lowest astronomical tide).

[4] Some samples from the SR2000 dataset started off with the turbine non-operational before transitioning into an operational state. For the purposes of this report, receptors have been recorded in this table specific to the turbine operational state at the time of the event.

[5] In line with methods used in the development of Protocol 2, behavioural 'archetypes' (e.g. moving with current) were used to further categorise each wildlife observation. The 'number of events' in this table therefore describes the number of samples where a particular behavioural archetype was observed.

3.3 Voith Hydro HyTide

The Voith dataset incorporates data from three cameras from which footage is displayed simultaneously. Two cameras were installed on the nacelle and one was installed on the monopile (see Annex 1 for full details on schematics and camera setup).

Data were gathered from 12-18 May 2014, 20 May and 28 May-13 July 2014. Between 12 May and 1 June, video footage was recorded during discrete periods only whereas footage was recorded continuously from 2 June to 13 July.

A total of 52 two-minute samples were reviewed and analysed from the Voith Hydro HyTide video data. These 52 samples include six test samples[6] and covered the first two minutes in each hour of available, adequately lit footage, for three days near the start, middle and end of camera operation between May and July 2014. A summary of the Voith Hydro HyTide data reviewed is provided in Table 3.5:

Table 3.5. Summary of available Voith Hydro HyTide data

Date	Hours of available footage	No. of sample clips
13 May 2014	08:17:12 – 20:40:16	12 (09:00 – 20:00)
8 June 2014	02:02:45 – 20:47:47	16 (05:00 – 20:00)
7 July 2014	Full 24 hour period	18 (05:00 – 22:00)
12 May 2014 – 08 July 2014	Full breadth of data (test samples)	6

Wildlife was observed in 15 samples out of the 52 reviewed from the Voith Hydro dataset. A summary of these observations is presented in Table 3.6:

Table 3.6. Summary of wildlife observations from Voith Hydro HyTide data samples

Turbine status	Receptor	Observation	Number of receptors in one sample	Tide (m/s)	Number of events
Operational	Fish	Moving across current	1	2.6	1
Operational	Bird	Moving across current	1	1.2	1
Operational	Bird	Moving across current	1	0.9	1
Operational	Bird (possible auk)	Moving with current towards blades	1	1.3	1
Non-operational	Fish	Passing nacelle in slack water	1	0.4	1

[6] In the initial assessment of the Voith Hydro video data, and as with the other datasets, a number of test sample clips were isolated to ensure consistency between data reviewers but are outside of the sampling schedule as laid out by Protocol 2. These test sample clips were included for the review and analysis of Task 4.

Non-operational	Fish	Passing nacelle	1	0.7	1
Non-operational	Fish	Investigating nacelle and cameras, possibly feeding	12	0.3	1
Non-operational	Fish	Investigating nacelle and cameras, possibly feeding	7	0.3	1
Non-operational	Fish	Feeding off nacelle	1	0.8	1
Non-operational	Fish	Moving against current	3	0.9	1
Non-operational	Fish	Moving against current	1	1.1	1
Non-operational	Fish	Shoaling around camera / turbine – possible fish aggregating device effect	20	0.2	1
Non-operational	Fish	Shoaling around camera / turbine – possible fish aggregating device effect	30	0.5	1
Non-operational	Fish	Feeding off nacelle	2	1.0	1
Non-operational	Bird (possible auk)	Moving with current	1	1.3	1

No collision events were observed during the analysis of the Voith Hydro data samples.

Fish were observed more frequently in current speeds up to 1.1 m/s, where all ten observation events at 1.1 m/s and below were made when the turbine was non-operational, with one observation of a single fish moving across the current at 2.6 m/s when the turbine was operational. Birds were observed more frequently when the turbine was operating, at around 1 m/s current speeds.

During current speeds of 0.8 m/s and below, fish were observed to show a range of behaviours; transiting the area, investigating the nacelle, shoaling and feeding around the nacelle. This would suggest that the turbine was acting as a fish aggregating device (FAD).

During increasing current speeds of 0.9 m/s and above, fish and birds were observed to move with or across the current.

4. SUMMARY OF NEAR-FIELD BEHAVIOUR OBSERVATIONS

Data from the Voith Hydro HyTide dataset is the most comprehensive; the dataset contains recordings from a number of months and the video data quality allows for accurate categorisation of receptors to a basic ecological level. There were more uncertainties around observations made from the MeyGen AHH TTG 2 and TTG 3 datasets and Scotrenewables SR2000 dataset due to respective limitations in data collection, field of view and video image quality. There were a total of 128 samples reviewed and analysed, of which 28 contained observations of wildlife. These are summarised below in Table 4.1:

Table 4.1. Summary of wildlife observations from all datasets

Turbine status	Receptor	Observation	Number of receptors	Number of events	Dataset
Operational	Fish (possibly flatfish)	Moving with / against current through turbine blades	1	1	MeyGen
Operational	Unclear	Moving with current	1	1	Scotrenewables
Operational	Unclear	Moving with current	1	1	Scotrenewables
Operational	Unclear (possibly bird)	Moving with current (upwards between legs)	1	4	Scotrenewables
Operational	Unclear	Moving with current (upwards between legs)	1	2	Scotrenewables
Operational	Unclear	Moving across current (between legs towards portside)	1	1	Scotrenewables
Operational	Fish	Moving across current	1	1	Voith
Operational	Bird	Moving across current	1	1	Voith
Operational	Bird	Moving across current	1	1	Voith
Operational	Bird (possibly auk)	Moving with current towards blades	1	1	Voith
Non-operational	Unclear (possibly bird)	Moving with current	1	1	Scotrenewables
Non-operational	Unclear (possibly jellyfish)	Moving with current	1	1	Scotrenewables
Non-operational	Unclear	Moving with current	1	1	Scotrenewables
Non-operational	Fish	Passing nacelle in slack water	1	1	Voith
Non-operational	Fish	Passing nacelle	1	1	Voith
Non-operational	Fish	Investigating nacelle and cameras, possibly feeding	12	1	Voith
Non-operational	Fish	Investigating nacelle and cameras, possibly feeding	7	1	Voith

Non-operational	Fish	Feeding off nacelle	1	1	Voith
Non-operational	Fish	Moving against current	3	1	Voith
Non-operational	Fish	Moving against current	1	1	Voith
Non-operational	Fish	Shoaling around camera / turbine – possible fish aggregating device effect	20	1	Voith
Non-operational	Fish	Shoaling around camera / turbine – possible fish aggregating device effect	30	1	Voith
Non-operational	Fish	Feeding off nacelle	2	1	Voith
Non-operational	Bird (possibly auk)	Moving with current	1	1	Voith
Total				**28**	

Of these events:

- At current speeds of 0.8 m/s and below, certain fish behaviours were observed which included passing the nacelle, investigating the nacelle, or feeding off the nacelle, and shoaling around the device within the camera's field of view. Turbines were static during each of the eight observation events made at 0.8 m/s and below (this may be due to the turbine being non-operational or the current being below the necessary 'cut-in speed'). These observations demonstrate fish acclimation behaviour and FAD effects;
- As current speed increased higher than 0.9 m/s, fish and birds were more frequently observed to move with or across the current. The turbine was operational during fifteen out of the 20 observation events made at 0.9 m/s and above;
  - At maximum observed current speeds of 2.7 – 2.9 m/s, all receptors were noted to move with the current;
  - Birds were more likely to be observed in greater current velocities between 1.2 – 2.9 m/s. Six out of eight of observations of birds within this current range were made during operational periods; and
- No collision events were observed in any of the samples reviewed.

5. CONCLUSIONS

The specific aim of Task 4 was the review and analysis of existing underwater video data to establish what can be learned regarding near-field behaviour from previously collected data around operational tidal turbines.

The amount of time and resources required to manually review these data with a robust scientific methodology is extensive. In addition, the quality of the data from the MeyGen and Scotrenewables datasets restricted definitive identification of wildlife and the analysis of near-field behaviour; it is therefore concluded that further manual analysis of these datasets reviewed during this study will not help to further reduce scientific uncertainty regarding the potential environmental interactions between marine wildlife and operational tidal turbines. It is, however, felt that further information regarding near-field behaviour could be gained from data collected around the Voith Hydro HyTide turbine installed at EMEC. It is hoped that this analysis can be undertaken at a future date when suitable resources are available.

It can be concluded that some (but limited) useful information regarding near-field behaviour around operating tidal turbines can be gained from existing data which was available to the project (refer to the key findings set out above). However, it was clear during the review that most monitoring systems which had been implemented around operational tidal turbines to date had been designed primarily to collect technical and other performance related data, rather than for environmental wildlife monitoring purposes, thereby compromising their value for this latter purpose.

It should also be noted that the ability of each dataset to help to reduce scientific uncertainty regarding marine wildlife behaviour around operating tidal turbines has only been considered in relation to manual visual analysis of a limited number of pre-selected samples during this study. Though considered representative of the full video datasets, the samples comprise just a small proportion of the video footage captured. It is highly possible that more useful data and information could be gained from each dataset via other means of analysis such as automated image analysis techniques, which are out with the scope of this project.

Subsequent to the data analysis completed during this study, a number of new monitoring systems around operational tidal turbines were identified. These are producing high quality underwater video data suitable for investigating near field wildlife behaviour and possible interactions with tidal turbines. A number of these monitoring systems have been designed to incorporate some of the recommendations provided in Task 3 (‘Assessment of the effectiveness of techniques, equipment, and processes to date’) (refer to Section 2 of the Main Report).

It is recommended that these and other suitable new datasets are reviewed using the Protocols designed during this study at the earliest possible opportunity to help reduce scientific uncertainty and build an evidence base regarding the potential effects of tidal energy developments on marine wildlife and the wider environment.