

Trilleachan Mor, Loch Seaforth

Hydrographic Data Report: Deployment ID440

18th June – 21st September 2024

CAR/L/1013016

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CONTENTS

1.	INTRODUCTION	5
2.	MATERIALS & METHODS.....	6
	<i>2.1 Bathymetry.....</i>	<i>6</i>
	<i>2.2 Current Data</i>	<i>6</i>
	<i>2.3 Magnetic Variation</i>	<i>6</i>
	<i>2.4 Data Processing.....</i>	<i>6</i>
	<i>2.5 Meteorological Data</i>	<i>8</i>
3.	RESULTS AND DISCUSSION	8
4.	HYDROGRAPHIC DATA SUMMARY SHEETS	9
5.	CONCLUSION.....	14
	ANNEX 1. SURVEY EQUIPMENT DEPLOYMENT LOG.....	15

LIST OF FIGURES

Figure 1. Location of the Trilleachan Mor site in Loch Seaforth along with neighbouring sites at Noster and Seaforth (top); The pen layout (●) and ID440 current meter deployment location (▲) in Loch Seaforth (bottom).	5
Figure 2. Mean beam intensity of the ADCP signal for the ID440 dataset from 18 th June to 21 st September 2024 plotted by cell number and depth.	8
Figure 3. Current Data Summary Sheet for the near-surface bottom-referenced current cell 8, 18 th June – 21 st September 2024 inclusive (ID440).	9
Figure 4. Current Data Summary Sheet for the middle bottom-referenced current cell 4, 18 th June – 21 st September 2024 inclusive (ID440).	10
Figure 5. Current Data Summary Sheet for the lowest bottom-referenced current cell 1, 18 th June – 21 st September 2024 inclusive (ID440).	11
Figure 6. Cumulative vector plot of all velocity data from cell 8 for ID440.	12
Figure 7. Cumulative vector plot of all velocity data from cell 4 for ID440.	12
Figure 8. Cumulative vector plot of all velocity data from cell 1 for ID440.	13
Figure 9. Current meter heading data throughout deployment ID440.	13
Figure 10. Current meter pitch and roll data throughout deployment ID440.	14
Figure 11. Current meter pressure data throughout deployment ID440.	14

LIST OF TABLES

Table 1. Nortek Signature 1000 ADCP Specifications.	7
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QUALITY ASSURANCE

Mowi Scotland Ltd is ISO9001 and ISO14001 accredited and all project management follows policies designed to ensure that the collection, collation and reporting of information produced in the course of our operations is done to a consistently high standard meeting the requirements of the end user.

1. Introduction

Mowi Scotland Ltd. is preparing an application to the Scottish Environmental Protection Agency (SEPA) for an increased bath medicine consent at the **Trilleachan Mor** salmon farm site in Loch Seaforth (Figure 1), to be viable for the 160 m circumference pens. There is no intention to change the equipment at the site.

Mowi Scotland Ltd carried out a hydrographic survey at the site from 18th June to 21st September 2024 (ID440). This report describes the data from this deployment at Trilleachan Mor and assesses the suitability of the collected hydrographic data for calibration of a hydrodynamic model of Loch Seaforth.



Figure 1. Location of the Trilleachan Mor site in Loch Seaforth along with neighbouring sites at Noster and Seaforth (top); The pen layout (●) and ID440 current meter deployment location (▲) in Loch Seaforth (bottom).

2. Materials & Methods

2.1 Bathymetry

Bathymetry data for the study area was obtained from the UK Hydrographic Office which utilises a variety of source (e.g. digital bathymetry datasets, Admiralty charts, and multibeam surveys). Further information about this data source can be found at:

<https://www.gov.uk/government/news/ukho-data-archiving-centre-inspire-portal-data-refresh>

<http://aws2.caris.com/ukho/mapViewer/map.action>

A multibeam bathymetric survey of the seabed around the Seaforth and Noster sites was commissioned by Mowi Scotland in December 2020. An R2Sonic 2022 multibeam system was used and the data corrected to chart datum. The UKHO and multibeam bathymetric data were combined and interpolated on to the model mesh.

2.2 Current Data

Mowi staff carried out a hydrographic survey at the site during 2024. The purpose of this hydrographic report is to assess the suitability of the collected hydrographic data for use with the hydrodynamic model. The data contained in this report were recorded at the site from 18th June – 21st September 2024.

The instrument used was a Nortek Signature 1000 (Table 1), and was suspended in mid-water about 8 m below mean sea level. The deployment location was positioned at 57.9694°N, 6.7184°W (121091 E, 907540 N), which was approximately 400 m from the nearest shoreline and 80 m from the centre of the pen group (Figure 1).

The instrument was deployed as close to the sea surface as possible, to improve measurement ability in the near-surface layer, while avoiding surface effects such as water column aeration and potential knockdown due to wind/waves. The water depth at deployment was 49 m. The mean depth of the meter was 8.05 m and hence the meter was approximately 40.95 m from the seabed. The cell size was set at 0.5 m and the number of cells to 54. The horizontal and vertical precision of the deployment were 0.5 cm/s and 0.16 cm/s respectively and the data were averaged at 300 s intervals (5 minutes). The blanking distance above the transducers was 0.5 m, giving a first cell height of 1.0 m above the transducer heads.

Data was automatically written and stored to the internal memory within the Signature 1000 ADCP main body and then downloaded to computer after completion of the deployment period via a USB cable.

2.3 Magnetic Variation

No magnetic variation correction was made to the Signature 1000 ADCP during deployment, this was undertaken to the data after the instrument was recovered and data downloaded. The magnetic variation used was 1.35°; this was determined using the British Geological Survey Grid Magnetic Angle Calculator. Further details can be found at https://geomag.bgs.ac.uk/data_service/models_compass/gma_calc.html.

2.4 Data Processing

Upon retrieval of the Signature 1000 ADCP current meter, all data was downloaded to a computer for analysis. The raw data were exported as a MATLAB file. Deployment diagnostic data (beam intensity, correlation, pitch and roll) were analysed to confirm that the deployment was successful with the instrument orientated upright. The valid data lasted 94 days and 16 hours.

For this application, the data were processed in a standard fashion. The near-surface cell was selected as the shallowest cell which contained valid data throughout the deployment. The diagnostic data suggested that velocities from the first 8 bins were valid at all times (Figure 2), therefore data from cell 8 was selected as the near-surface cell. The other cells selected for HG analysis were cells 1 and 4, at depths ~7.0 m and ~5.5 m respectively.

Table 1. Nortek Signature 1000 ADCP Specifications.

Nortek Signature 1000 Current Profiler	
> Water Velocity Measurements	
Maximum profiling range	25 m (burst mode), 30 m (average mode)
Cell Size	0.2 - 2 m
Minimum Blanking	0.1 m
Maximum Number of Cells	256 (burst), 200 (average)
Velocity Range (along beam)	User-selectable 2.5 or 5.0 m/s
Minimum Accuracy	0.3 % of measured value +/- 0.3 cm/s
Velocity Precision	Broadband processing, consult instrument software
Velocity Resolution	0.1 cm/s
Maximum Sampling Rate	16 Hz (8 Hz using 5 beams)
> HR Option (on 5th beam only)	
Velocity Range	3 cm/s - 1.4 m/s
Cell Size	2 - 25 cm
Profiling Range	10 cm - 8 m
Range Velocity Limitations	Product of profiling range and velocity should not exceed 3 m ² /s
> AD2CP Measurement Modes (US Patent 8223588)	
Single	Burst or Average
Concurrent	Burst or Average
Alternate	Single and/or Concurrent
> Echo Intensity (Along slanted beams)	
Sampling	Same as velocity
Resolution/Dynamic Range	0.5 dB / 70 dB
Transducer Acoustic Frequency	1 MHz
Number of Beams	5; 4 slanted at 25°, 1 vertical
Beam Width	2.9°
> Echo Sounder Option	
Resolution	3 mm - 0.25 m
Number of Bins	10,000
Transmit Pulse Length	16 μs - 0.5 ms
Transmit Pulse	Monochromatic or Pulse Compressed (25 % BW)
Resolution/Dynamic Range	0.01 dB / 70 dB
> Wave Measurement Option	
AST Frequency	1 MHz
AST Maximum Distance	34 m
Maximum Wave Measurement Depth	30 m
Height Range	-15 m to +15 m
Accuracy/Resolution (Hs)	< 1 % of measured value / 2 cm
Accuracy/Resolution (Dir)	2° / 0.1°
Period Range	0.5 - 50 s
Cut-off Period (Hs)	5 m depth; 0.6 s, 20 m depth; 1.1 s
Cut-off Period (Dir)	5 m depth; 1.5 s, 20 m depth; 3.1 s
Sampling Rate (Velocity and AST)	8 Hz
> Ice Measurement Option	
Parameters	N/A
> Sensors	
Temperature	Thermistor in head (sampled at meas. rate)
Temperature Range	-4 to +40°C
Temperature Accuracy/Resolution	0.1°C / 0.01°C
Temperature Time Response	2 min
Compass	Solid state magnetometer (max 1 Hz sample rate)
Accuracy/Resolution	2° for tilt < 30°/0.01°
Tilt	Solid state accelerometer (max 1 Hz sample rate)
Accuracy/Resolution	0.2° for tilt < 30°/0.01°
Maximum Tilt	Full 3D
Up or Down	Automatic Detect
Pressure	Piezoresistive (sampled at meas. rate)
Standard Range	0 - 100 m (Inquire for options)

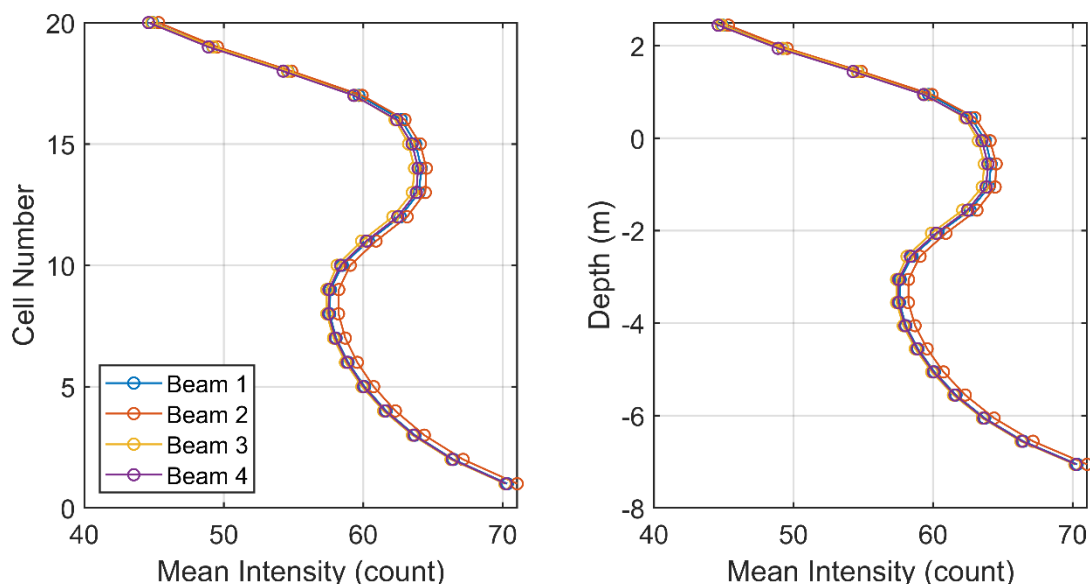


Figure 2. Mean beam intensity of the ADCP signal for the ID440 dataset from 18th June to 21st September 2024 plotted by cell number and depth.

Some repairs were required to the raw data. In bin 8, 97 records (0.36% of the total number of records) had a northward velocity of less than -30 m s^{-1} , clearly erroneous values. Values of both East and North components of velocity at these times were deleted, and replaced by linearly interpolating the velocity in time. The difference in mean speed between the uncorrected (excluding the bad data) and the corrected data was 0.00016 m s^{-1} . From bin 4, just three records were similarly erroneous and were corrected. For bin 1, no repairs were required.

Additional processing was undertaken to average the measured 5-minute data (Table A1, Annex 1) into 20-minute averages. This was performed by applying a running-mean filter to the East and North components of velocity and the pressure data, and sub-sampling every fourth data point. The resulting 20-minute dataset was input to the HG Analysis spreadsheets and produced the results shown here. In addition, the time stamp in the raw data file is in BST; times have been converted to GMT for processing.

2.5 Meteorological Data

The collection of meteorological data is no longer required to support the assessment process and consequently has not been undertaken. The current data used is collected using multiple deployments and over a longer period and thus provides a more realistic representation of site conditions than short deployments, thus allowing an assessment of the influence of meteorological conditions.

3. Results and Discussion

Summary plots of the current data are shown in Figure 3 – Figure 11. Over the period analysed for this report, the currents at 3.5 m, 5.0 m and 7.0 m below the sea surface had average speeds of 6.5 cm s^{-1} , 7.4 cm s^{-1} and 9.3 cm s^{-1} respectively. This gave an overall average of 7.7 cm/s . The orientation of the tidal velocities was NNW – SSE.

The residual currents at all three depths were toward the south-east, toward 166°N , 163°N and 158°N at the 3.5 m, 5.0 m and 7.0 m depths respectively (Figure 6 – Figure 8). The magnitude of the residual currents for the three analysed depths were moderate, with mean values of 3.8 cm s^{-1} , 2.9 cm s^{-1} and 2.0 cm s^{-1} respectively.

Time series of the instrument heading, pitch and roll, and measured pressure are shown in Figure 9 – Figure 11 respectively and demonstrate that the deployment was stable and the data are reliable.

4. Hydrographic Data Summary Sheets

Site Name		Trilleanan Mor	
CAR Licence Number (if applicable)	CAR/L/1013016		
Easting	121091		
Northing	907540		
Latitude (decimal deg)	57.9694		
Longitude (decimal deg)	-6.7184		
Bin (surface/middle/bottom)	Surface		
Bin Number	8		
Bin Depth (height above bed) (m)	n/a		
Deployment Depth (m)	49		
ADCP Model	Signature 1000		
ADCP Serial Number	105117		

Deployment Details	
Number of Records	6817
Start Time (GMT)	18/06/2024 15:10:00
End Time (GMT)	21/09/2024 07:10:00
Number of Days	94.67
Interval (mins)	20

Depth Analysis (m)	
Max	6.30
Mean	3.56
Min	0.68

Velocity Analysis				
	Scalar Speed (m/s)	Parallel Component (m/s)	Normal Component (m/s)	Residual Current (m/s)
Max	0.486	0.460	0.178	0.038
Mean	0.093	0.038	-0.003	Residual Direction (deg)
Min	0.000	-0.415	-0.219	166

Direction Analysis				
Major Axis (+ve) (Deg)	170	Parallel Amplitude	0.143	Amplitude Anisotropy
Minor Axis (+ve) (Deg)	260	Normal Amplitude	0.049	2.943

Bath Model Input Data		
Mean Speed (m/s)	0.093	
Residual Speed (m/s)	Parallel Component	0.038
	Normal Component	-0.003
Tidal Amplitude	Parallel Component	0.143
	Normal Component	0.049

Fishfarm Database Input Data							
Number of Days	Mean Speed (m/s)	% <= 0.095 m/s	Major Axis (deg)	Major Amp/Minor Amp	Residual Speed (m/s)	Residual Direction (deg)	% <= 0.030 m/s
94.67	0.093	60%	170	2.943	0.038	166	15%

Figure 3. Current Data Summary Sheet for the near-surface bottom-referenced current cell 8, 18th June – 21st September 2024 inclusive (ID440).

Site Name	Trilleachan Mor
CAR Licence Number (if applicable)	CAR/L/1013016
Easting	121091
Northing	907540
Latitude (decimal deg)	57.9694
Longitude (decimal deg)	-6.7184
Bin (surface/middle/bottom)	Surface
Bin Number	4
Bin Depth (height above bed) (m)	n/a
Deployment Depth (m)	49
ADCP Model	Signature 1000
ADCP Serial Number	105117

Deployment Details	
Number of Records	6817
Start Time (GMT)	18/06/2024 15:10:00
End Time (GMT)	21/09/2024 07:10:00
Number of Days	94.67
Interval (mins)	20

Depth Analysis (m)	
Max	8.30
Mean	5.56
Min	2.68

Velocity Analysis				
	Scalar Speed (m/s)	Parallel Component (m/s)	Normal Component (m/s)	Residual Current (m/s)
Max	0.386	0.376	0.196	0.029
Mean	0.074	0.028	-0.004	Residual Direction (deg)
Min	0.001	-0.340	-0.119	163

Direction Analysis				
Major Axis (+ve) (Deg)	170	Parallel Amplitude	0.114	Amplitude Anisotropy
Minor Axis (+ve) (Deg)	260	Normal Amplitude	0.040	2.856

Bath Model Input Data		
Mean Speed (m/s)		0.074
Residual Speed (m/s)	Parallel Component	0.028
	Normal Component	-0.004
Tidal Amplitude	Parallel Component	0.114
	Normal Component	0.040

Fishfarm Database Input Data							
Number of Days	Mean Speed (m/s)	% <= 0.095 m/s	Major Axis (deg)	Major Amp/Minor Amp	Residual Speed (m/s)	Residual Direction (deg)	% <= 0.030 m/s
94.67	0.074	72%	170	2.856	0.029	163	21%

Figure 4. Current Data Summary Sheet for the middle bottom-referenced current cell 4, 18th June – 21st September 2024 inclusive (ID440).

Site Name	Trilleachan Mor
CAR Licence Number (if applicable)	CAR/L/1013016
Easting	121091
Northing	907540
Latitude (decimal deg)	57.9694
Longitude (decimal deg)	-6.7184
Bin (surface/middle/bottom)	Surface
Bin Number	1
Bin Depth (height above bed) (m)	n/a
Deployment Depth (m)	49
ADCP Model	Signature 1000
ADCP Serial Number	105117

Deployment Details	
Number of Records	6817
Start Time (GMT)	18/06/2024 15:10:00
End Time (GMT)	21/09/2024 07:10:00
Number of Days	94.67
Interval (mins)	20

Depth Analysis (m)	
Max	9.80
Mean	7.06
Min	4.18

Velocity Analysis				
	Scalar Speed (m/s)	Parallel Component (m/s)	Normal Component (m/s)	Residual Current (m/s)
Max	0.371	0.371	0.137	0.020
Mean	0.064	0.019	-0.004	Residual Direction (deg)
Min	0.001	-0.325	-0.130	158

Direction Analysis				
Major Axis (+ve) (Deg)	170	Parallel Amplitude	0.102	Amplitude Anisotropy
Minor Axis (+ve) (Deg)	260	Normal Amplitude	0.036	2.851

Bath Model Input Data		
Mean Speed (m/s)		0.064
Residual Speed (m/s)	Parallel Component	0.019
	Normal Component	-0.004
Tidal Amplitude	Parallel Component	0.102
	Normal Component	0.036

Fishfarm Database Input Data							
Number of Days	Mean Speed (m/s)	% <= 0.095 m/s	Major Axis (deg)	Major Amp/Minor Amp	Residual Speed (m/s)	Residual Direction (deg)	% <= 0.030 m/s
94.67	0.064	80%	170	2.851	0.020	158	24%

Figure 5. Current Data Summary Sheet for the lowest bottom-referenced current cell 1, 18th June – 21st September 2024 inclusive (ID440).

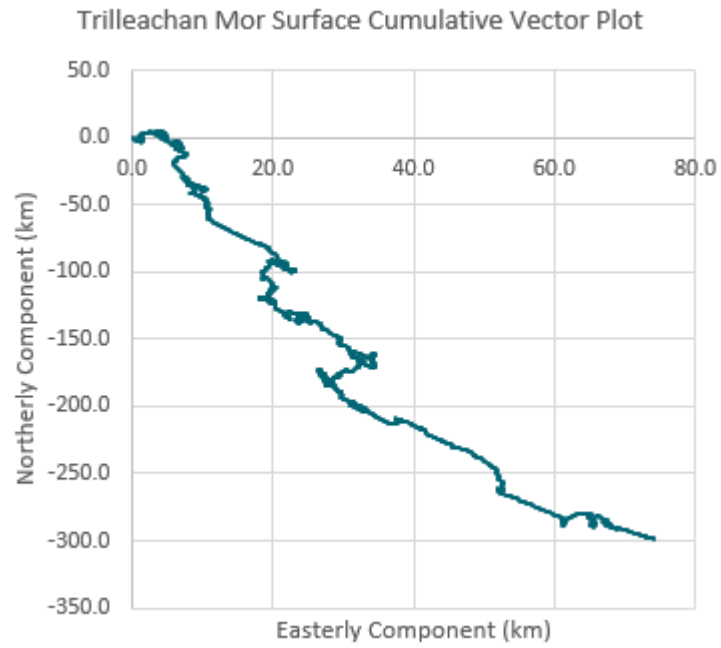


Figure 6. Cumulative vector plot of all velocity data from cell 8 for ID440.

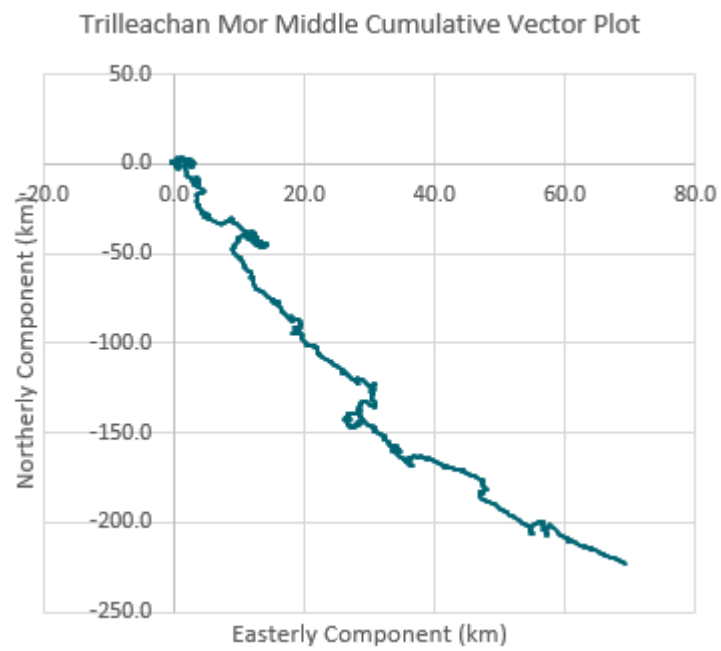


Figure 7. Cumulative vector plot of all velocity data from cell 4 for ID440.

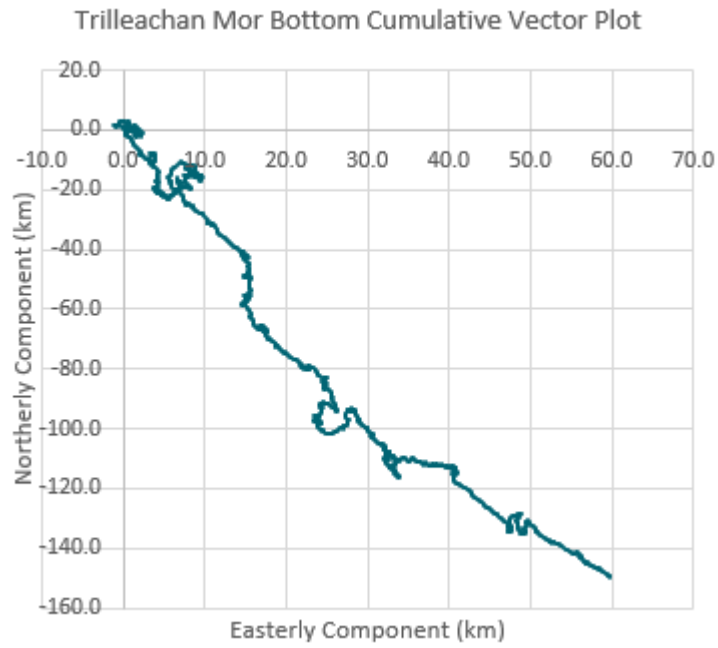


Figure 8. Cumulative vector plot of all velocity data from cell 1 for ID440.

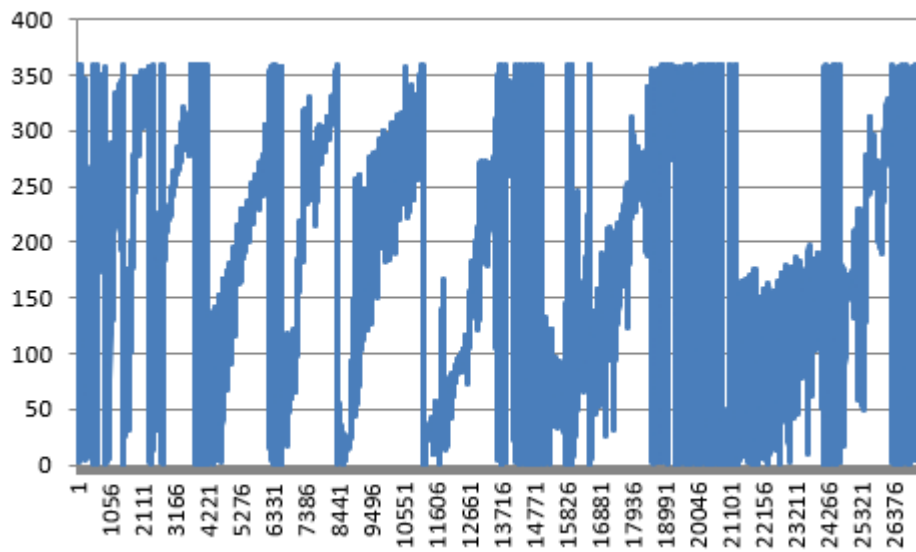


Figure 9. Current meter heading data throughout deployment ID440.

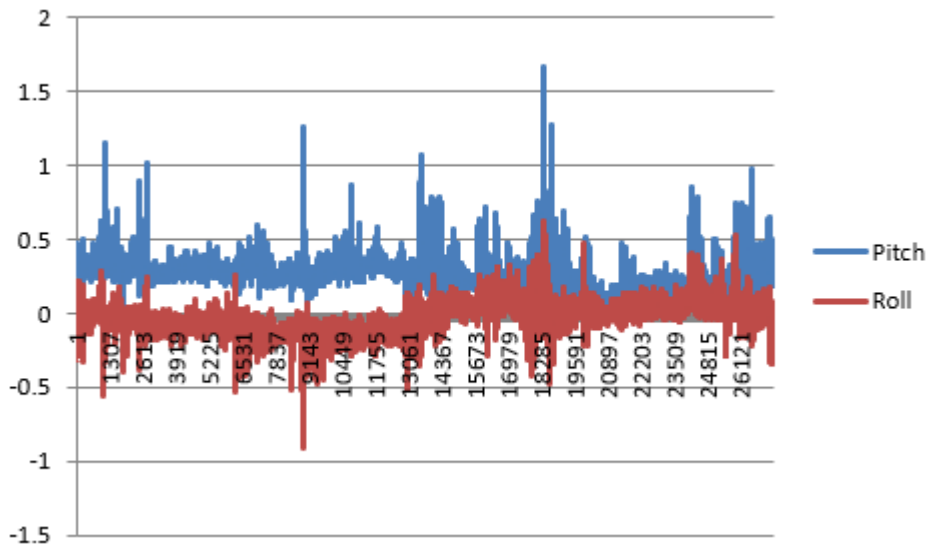


Figure 10. Current meter pitch and roll data throughout deployment ID440.

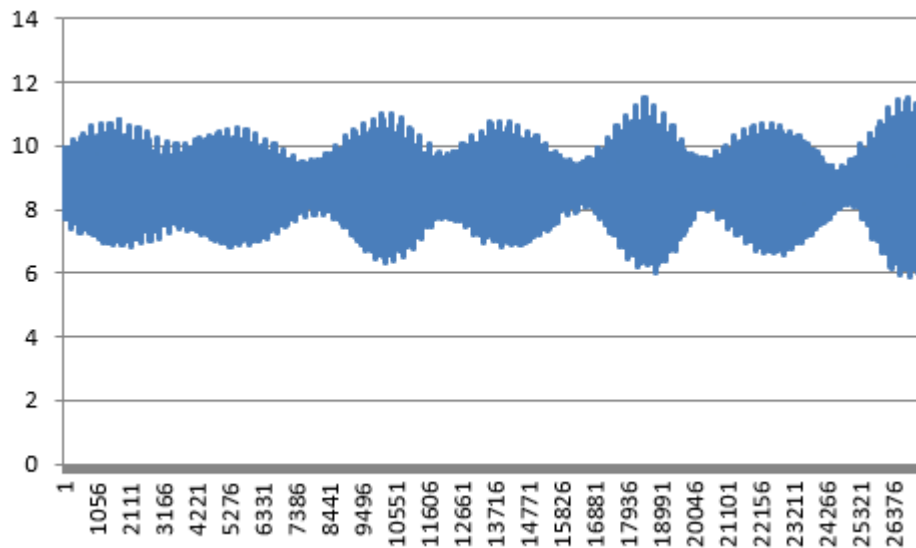


Figure 11. Current meter pressure data throughout deployment ID440.

5. Conclusion

Mowi Scotland Ltd. has collected and analysed current and bathymetric data for the salmon farm at Trilleachan Mor. The analysed current data for the 94 days and 16 hours period are believed to be reliable and representative of the proposed location. The bathymetric data from the UK Hydrographic Office, provided a coherent bathymetric dataset for the site.

Annex 1. Survey Equipment Deployment Log

Location:	Trilleachan Mor, Loch Seaforth
Nearest tidal port:	East Loch Tarbert
Time zone:	UTC (raw data in BST)
Meter switched on:	16:00:00 18/06/2024
Meter switched off:	07:20:00 21/09/2024
Period used for this report:	16:00:00 18/06/2024 – 07:20:00 21/09/2024
ADCP serial number:	105117
Meter position:	57.9694°N, -6.7184°W 121091 E, 907540 N
Minimum water depth:	mid-water deployment
Water depth (Chart Datum):	mid-water deployment
Mean water depth:	mid-water deployment
Depth of meter from surface:	8.05 m (below mean sea level)
Height of meter from seabed:	49.0 m (estimated)

Table A1. ADCP meter settings.

Reference:	Transducer
Bin size (m):	0.5
Dist to 1 st bin (m):	1.0
Number of bins:	54
Frequency (kHz):	1 MHz
Recording interval (mins):	5
No. pings per ensemble:	853
Magnetic correction:	0
Ensemble (s):	300
Velocity Precision (cm/sec):	0.50
Time/Ping (seconds):	0.35