

Sailean Ruadh Etive 6, Loch Etive

Hydrographic Data Report: Deployment ID416

27th April to 26th July 2023

February 2024
Mowi Scotland Limited

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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. has submitted an application to the Scottish Environmental Protection Agency (SEPA) for an equipment change at the Sailean Ruadh, Etive 6 salmon farm, located in Loch Etive. Mowi Scotland Ltd. have proposed to change the site from 10 x 80m pens to 6 x 120m circumference pens, with 17m deep nets and held in a 75m grid.

Mowi Scotland Ltd have carried out hydrographic surveys at the site in 2023. Hydrographic data at Sailean Ruadh was gathered during this time in one deployment:

- i. 27th April 2023 to 26th July 2023 (ID416)

This report describes the data from the 27th April 2023 to 26th July 2023 deployment at Sailean Ruadh (ID416). The purpose of this report is to assess the suitability of the collected hydrographic data for calibration of a hydrodynamic model of the Loch Etive region.

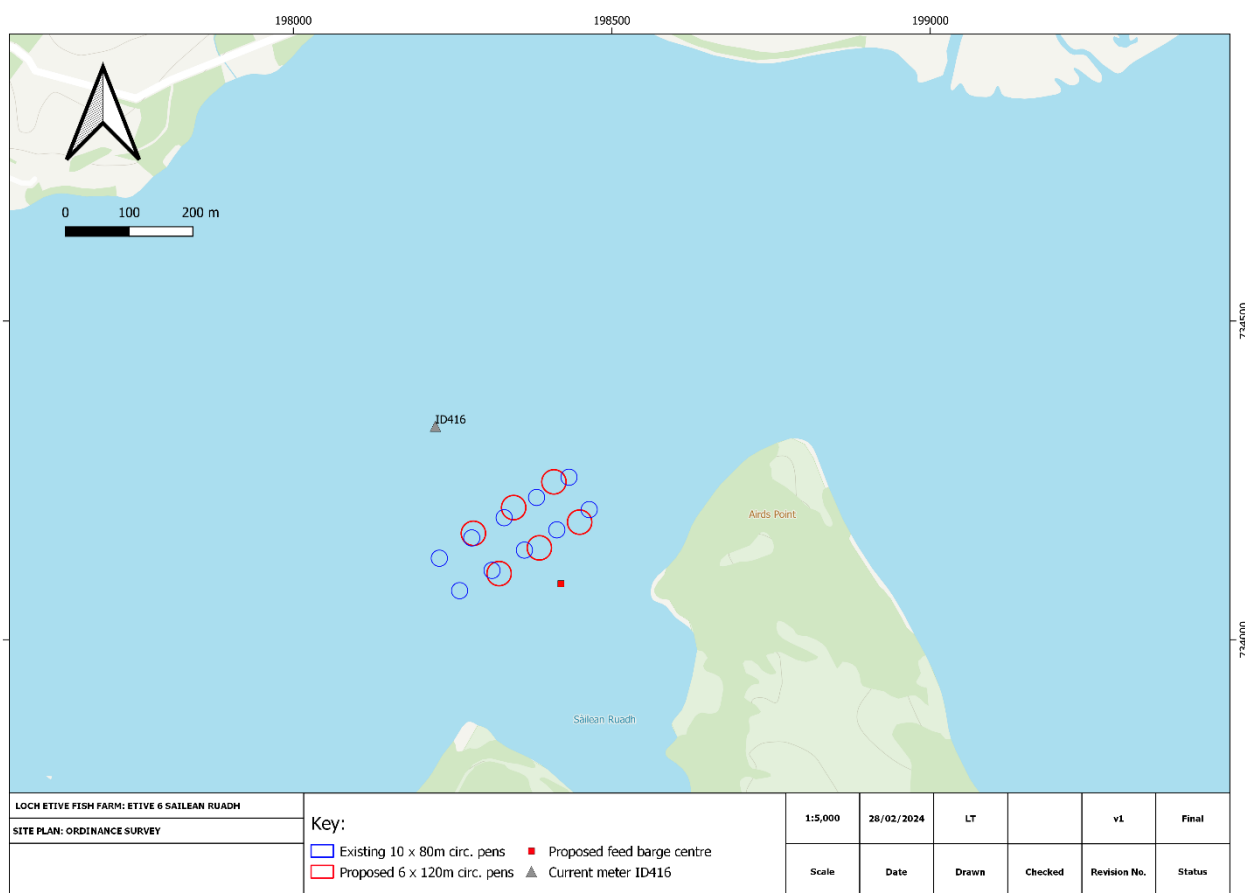


Figure 1. Proposed and existing layouts at the Sailean Ruadh site. The current meter deployment location is marked by the grey triangle.

2. Materials & Methods

2.1 Bathymetry

Figure 2 shows the bathymetry in Loch Etive using publicly available UKHO multibeam data.

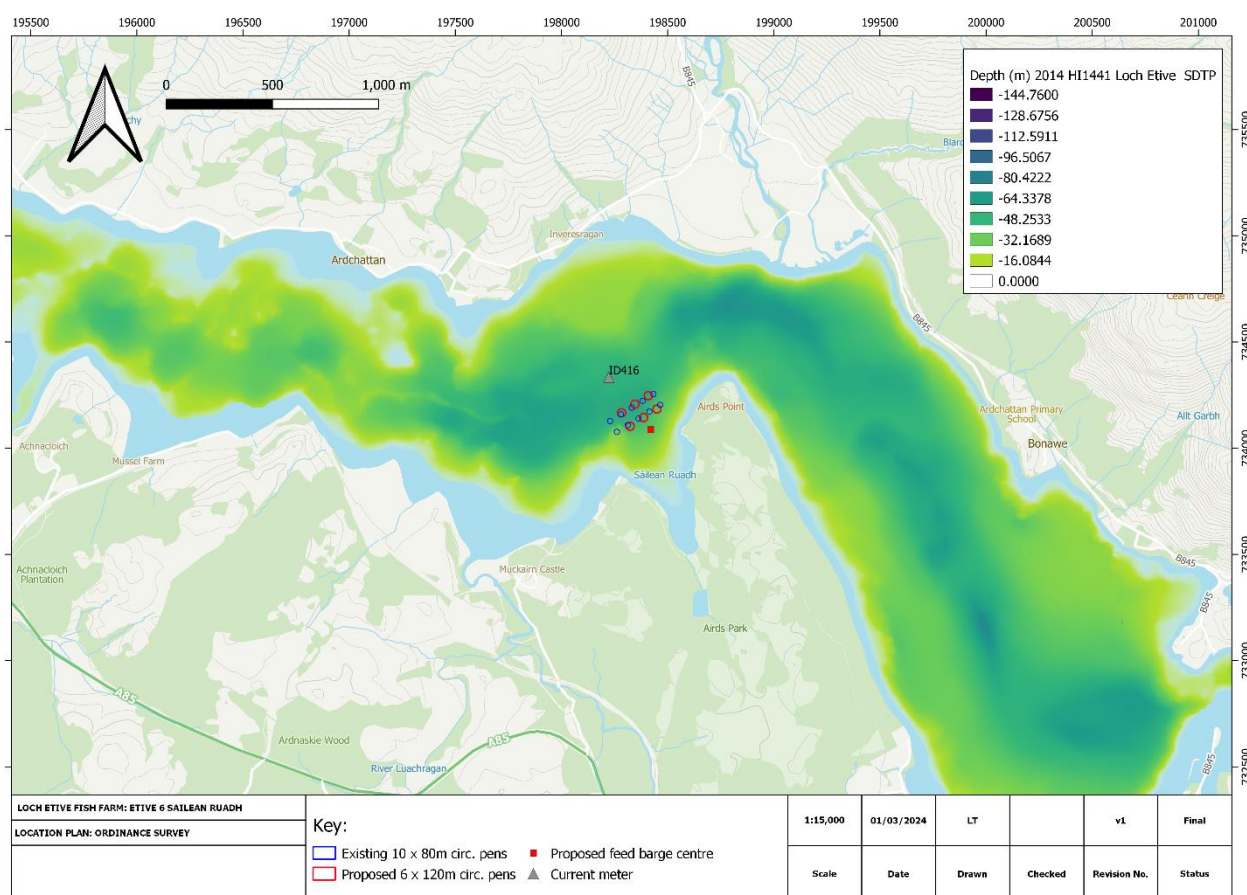


Figure 2. Bathymetry in the region around the proposed Sailean Ruadh salmon farm.

2.2 Current Data

Mowi staff carried out hydrographic surveys at the site during 2023. The purpose of this hydrographic report is to assess the suitability of the collected hydrographic data for calibration of a hydrodynamic model of the Loch Etive region. The data contained in this report were recorded at the site from 27th April 2023 to 26th July 2023 (90 days of data; deployment ID416).

The Sentinel V100 (Wide) ADCP (Table 1), within its mooring frame, was positioned at 56.45783N, -5.27627W (198223E 734335N), which was approximately 425m from the nearest shoreline and approximately 210m from the centre of the proposed cage group (Figure 1). The transducer head was 70 cm from the base of the mooring frame. The mean depth (derived from the pressure sensor) at the Sentinel V100 ADCP position was 52.19 m.

Initial soundings were taken to establish the possible depth the Sentinel V100 ADCP would be situated at during high tide and so that the most appropriate cell size could be determined. The cell size was set at 1.0 m and the number of cells to 69.

Data was automatically written and stored to the internal memory within the Sentinel V100 ADCP main body and then downloaded to computer after completion of the deployment period via WiFi.

2.3 Magnetic Variation

No magnetic variation correction was made to the Sentinel V100 ADCP during deployment, this was undertaken to the data after the instrument was recovered and data downloaded. The magnetic variation used was -2.26°; this was determined using the World Magnetic Model, produced jointly with the US National

Oceanographic and Atmospheric Administration's National Geophysical Data center. Further details can be found at <http://www.geomag.bgs.ac.uk/navigation.html>

2.4 Data Processing

Upon retrieval of the Sentinel V100 ADCP current meter, all data was downloaded to a computer for analysis. The raw data file was opened in Teledyne's "Velocity" software and Matlab. Deployment diagnostic data (beam intensity, correlation, pitch and roll) were analysed to confirm that the deployment was successful with the instrument orientated upright. The heading data were also examined to identify any movement of the Sentinel V100 ADCP mooring frame during the deployment.

The diagnostic data suggested that velocities from the first 43 bins were valid (Figure 3). Calculations were undertaken to identify the cells to be used for surface and middle currents. Surface data was taken at an average depth (derived from the pressure sensor) of 5.57 m (cell 43), and cage-bottom data at 16.57 m (cell 32). Surface and middle cell heights were 45.71 m and 34.71 m from the seabed respectively. The bottom cell (cell 1) was at an average depth of 47.57 m and 3.71 m above the seabed.

Table 1: Sentinel V100 ADCP Specifications.

Depth Cell Size ¹	V20 (1000kHz)			V50 (500kHz)		V100 (300kHz)	
	Depth Cell Size ¹	Range (m) ^{2,3}	Std Dev (cm/s) ^{3,4}	Range (m) ^{2,3}	Std Dev (cm/s) ^{3,4}	Range (m) ^{2,3}	Std Dev (cm/s) ^{3,4}
		Wide/Narrow	Wide/Narrow	Wide/Narrow	Wide/Narrow	Wide/Narrow	Wide/Narrow
	0.25m	18.0/22.6	19.2/36.5				
	0.3m	19.3/24.0	11.1/20.8				
	0.5m	20.2/24.9	7.1/13.4	44.1/57.6	19.2/36.5		
	1.0m	22.1/26.9	3.6/6.7	50.5/64.6	7.1/13.5	94.5/120.6	10.9/20.6
	2.0m	24.5/29.4	1.7/3.2	56.0/70.6	3.6/6.7	103.5/130.4	5.5/10.3
	4.0m	26.9/32.0	0.8/1.6	63.1/78.2	1.7/3.2	114.6/142.3	2.7/5.2
	6.0m			67.4/82.8	1.1/2.1	121.7/151.5	1.8/3.3
Communications and Recording	Wireless Internal memory	802.11b/g/n One 16GB Micro SD Card included					
Profile Parameters	Velocity accuracy Velocity resolution Velocity range Ping rate	V20/V50: 0.3% of the water velocity relative to the ADCP ±0.3cm/s V100: 0.5% of the water velocity relative to the ADCP ±0.5cm/s 0.1cm/s ±5m/s (default); ±20m/s (maximum) Up to 4Hz					
Echo Intensity Profile	Vertical resolution Dynamic range Precision	Depth cell size 80dB ±1.5dB					
Transducer and Hardware	Beam angle Configuration Depth rating Materials	25° 4-beam, convex; 5th beam vertical 200m Transducer, housing, and end cap: plastic Connector: metal shell					
Standard Sensors	Temperature (mounted on transducer) Compass (magneto-inductive sensor) Tilt (MEMS accelerometers) Pressure sensor (mounted on transducer)	Range -5° to 45°C, precision ±0.4°C, resolution 0.1° Accuracy 2° RMS, resolution 0.1°, max. dip angle 85° Pitch range ±90°, roll range ±180°, accuracy 2° RMS, precision 0.05° RMS, resolution 0.1° Range 300m, accuracy 0.1%FS					
Power	External DC input Internal battery voltage Battery capacity; over-the-counter @0°C Battery pack @5°C	12–20VDC 18VDC new 100 watt hours (typical) 510 watt hours					
Software	Teledyne RDI's new software included	ReadyV—Pre-deployment (testing, planning, and data recovery) ⁵ Velocity—Post-processing (data handling, display, and export) ⁶					
Environmental	Standard depth rating Operating temperature Storage temperature (without batteries) Weight in air Weight in water	200m -5° to 45°C -30° to 60°C 7.5kg – 16.0kg 1.6kg – 6.0kg					
Available Options	External battery case • AC/DC power converter • 5th beam (at time of order only) • Waves processing • Straight or right-angle metal shell connector						
Dimensions	Special configuration drawing available upon request						

1. User's choice of depth cell not limited to the typical values specified.

2. Ranges specified are typical at temperature of 5°C and salinity of 35psu; longer ranges are possible.

3. User selects the bandwidth mode; wide = 25% or narrow = 6%.

4. Standard deviations (Std Dev) are typical values for single ping data.

5. Resident in ADCP accessed via a web browser.

6. Windows™ based software program.

1. User's choice of depth cell not limited to the typical values specified.

2. Ranges specified are typical at temperature of 5°C and salinity of 35psu; longer ranges are possible.

3. User selects the bandwidth mode; wide = 75% or narrow = 6%.

4. Standard deviations (Std Dev) are typical values for single ping data.

5. Resident in ADCP accessed via a web browser.

6. Windows[®] based software program.

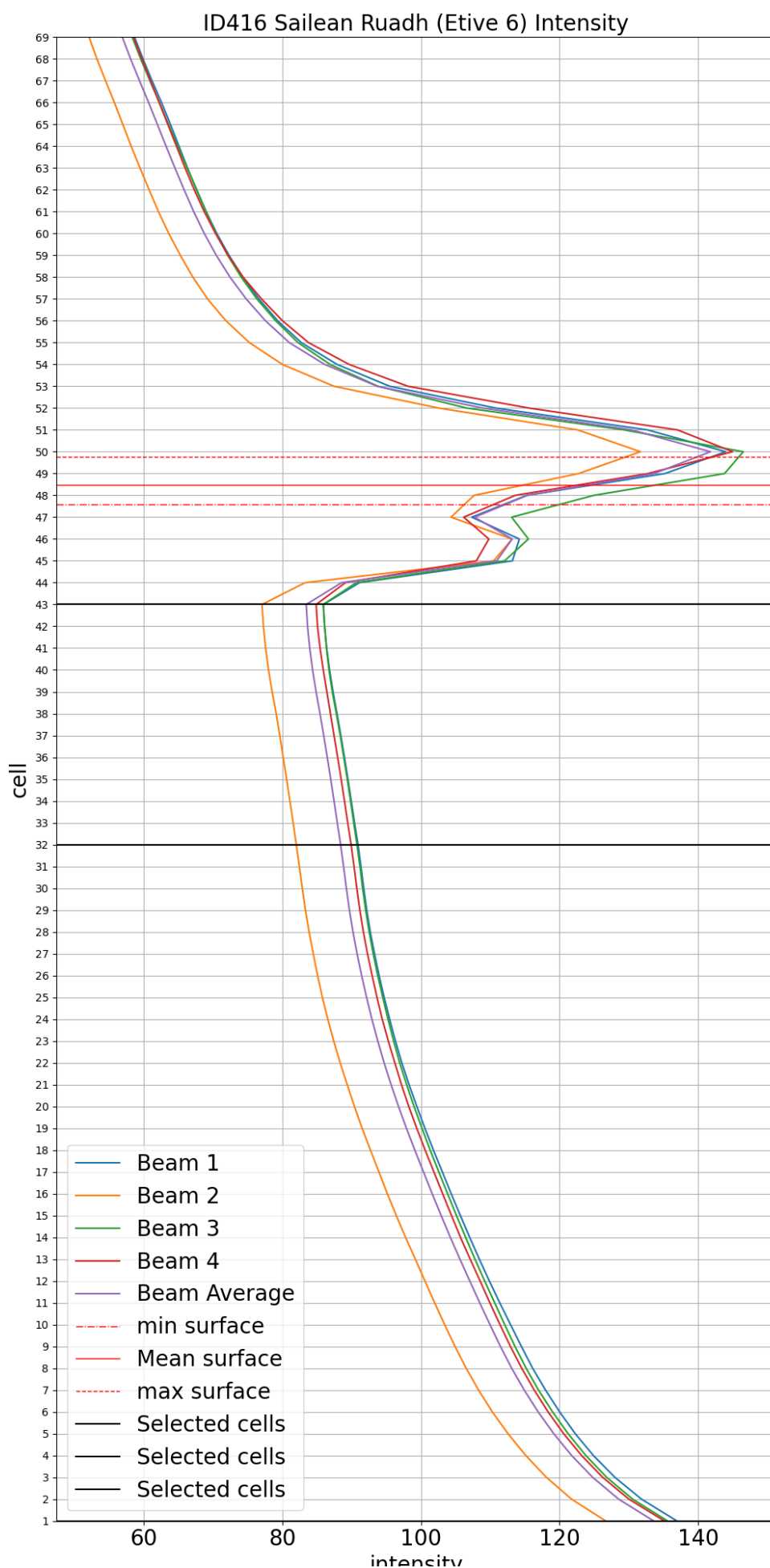


Figure 3. Mean intensity of the ADCP signal for the ID416 dataset plotted by bin number.

The ‘first cell range’ is automatically calculated by the instrument, which is the distance from the transducer head to the first cell. For this deployment, the first cell range was calculated as 3.01 m. This value is then added to the height of the instrument frame (0.7 m) to get the first cell height above the seabed, which equated to 3.71 m

Standard deviation has been assessed throughout the deployment to identify accurate and reliable data for near bed, middle (net depth) and surface cells using the following equation:

$$Cell\ StdDev = \frac{Instrument\ StdDev}{\sqrt{No.\ valid\ pings}} \quad (1)$$

The Instrument Standard Deviation (StdDev) in Equation 1 is determined using the deployment settings when the meter is programmed, examples of the StdDev values for different configurations are shown in Table 1. This deployment had a cell size of 1m which equates to an Instrument StdDev of 10.9 cm/s.

The Percentage of valid pings used to calculate Cell StdDev is derived using “Percentage Good” data which allows us to relate the StdDev to the actual data gathered. The percent good data is available for 1, 2, 3 and 4 beams which represent the following:

- Percent good 1 = % of good data computed from 3 Beams
- Percent good 2 = % of bad data due to more than 2 Beam bad
- Percent good 3 = % of bad data due to error velocity exceeded
- Percent good 4 = % of good data computed from 4 Beams

The method described has been used to calculate the Standard deviation throughout the deployment for the surface, middle and bottom cells; the average StdDev values for the surface, middle and bottom was 0.63cm/s, 0.63cm/s and 0.63cm/s respectively which are all within the SEPA criteria of 2cm/s.

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

A summary of the current data is shown in Figure 4 to Figure 7 and in Table 2 to Table 4. Over the period analysed for this report, the near-surface, middle and bottom cells had current speed averages of 10.9 cm/s, 8.9 cm/s and 6.3 cm/s respectively. This gave an overall average of 8.7 cm/s. The orientation of the tidal velocities was north-east – south-west.

Residual currents at the surface (33.4°G), mid-depth (46.7°G), and near-bottom cells were toward the north-east (70.6°G, Figure 4). The magnitude of the residual currents for the surface, middle and bottom cells were moderate, with mean values of 0.048 m/s, 0.051 m/s and 0.009 m/s respectively.

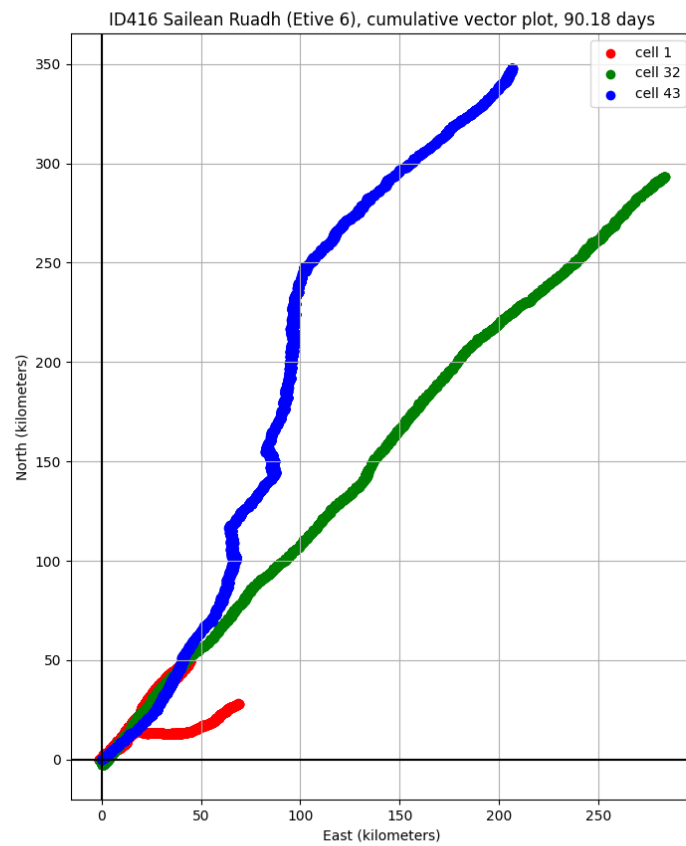


Figure 4. Cumulative Vector Plot of all velocity data from near surface cell, cage bottom cell, and near bottom cell for ID416.

3. Summary of Current Data – ID416

Site Name: Sailean Ruadh, Etive 6
 Data start date: 27/04/2023
 Data end date: 26/07/2023
 Mean Water Depth: 52.19 m

Table 2. Summary of current meter deployment

	Cell	Depth Below Surface (m)	Distance from Seabed (m)	Mean current speed (cm/s)
Near surface:	43	5.57	45.71	10.9
Cage bottom:	32	16.57	34.71	8.9
Near bed:	1	47.57	3.71	6.3
Average current speed:				8.69

Table 3. Major axis

Cell	Major Axis (Deg-G)
Near surface:	055
Cage Bottom:	060
Near bed:	055

Table 4. Mean and residual currents

Cell	Residual Speed (m/s)	Residual Parallel (m/s)	Residual Normal (m/s)	Tidal Amplitude Parallel (m/s)	Tidal Amplitude Normal (m/s)
Near Surface:	0.052	0.048	-0.019	0.095	0.045
Cage Bottom:	0.052	0.051	-0.012	0.12	0.052
Near Bed:	0.01	0.048	0.003	0.144	0.074

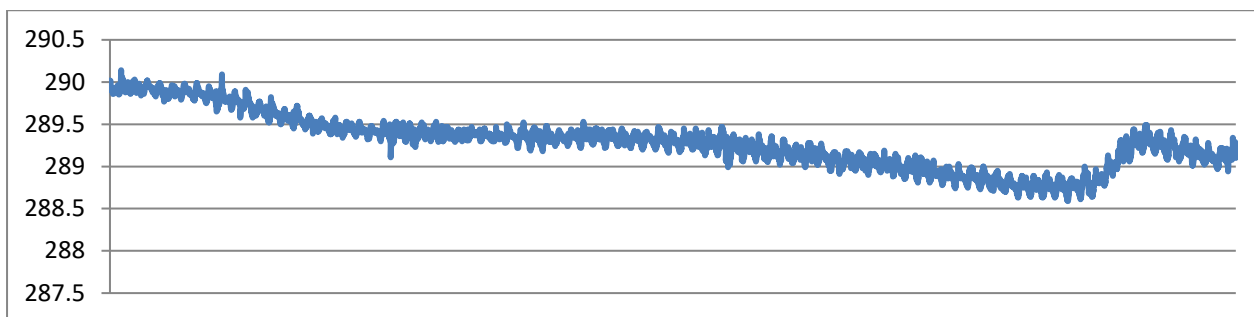


Figure 5. Summary of heading data from deployment ID416.

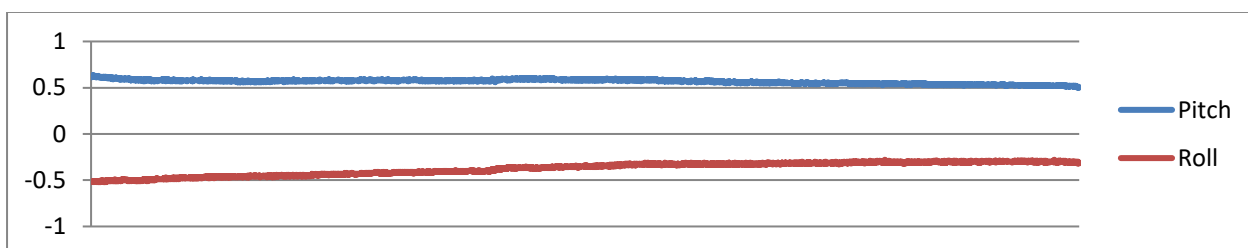


Figure 6. Summary of pitch and roll data from deployment ID416.

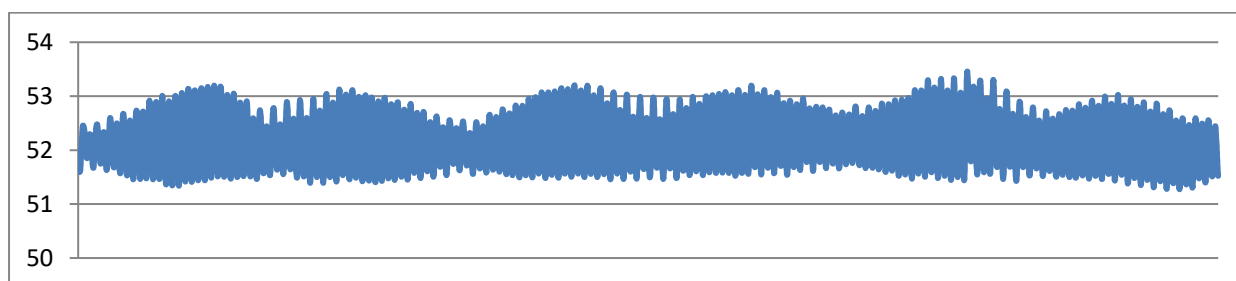


Figure 7. Pressure data from deployment ID416.

4. Conclusion

MOWI has collected and analysed current and bathymetric data for the salmon farm at Sailean Ruadh, Etive 6. The analysed current data for the 90 days period are believed to be reliable and representative of the proposed location.

Annex 1. Survey Equipment Deployment Log

Location:	Sailean Ruadh, Loch Etive
Nearest tidal port:	Loch Etive
Time zone:	UTC
Meter switched on:	15:00 27/04/2023
Meter switched off:	19:20 26/07/2023
Period used for this report:	15:00 27/04/2023 – 19:20 26/07/2023
ADCP serial number:	24616
Meter position:	56.45783N, -5.27627W 198223 E 734335 N
Minimum water depth:	51.28 m (50.58 m measured by ADCP + 0.7 m *)
Mean water depth:	52.19 m (51.49 measured by ADCP + 0.7 m *)
Depth of meter from surface:	47.57 m (depth from minimum water depth)
Height of meter from seabed:	0.7 m to transducer head
Sounding at deployment:	52 m @ 1130 on 27/04/2023

Table A1. ADCP meter settings:

Reference:	Transducer
Bin size (m):	1.0
Dist to 1 st bin (m):	3.01
Number of bins:	69
Frequency (kHz):	307
Recording interval (mins):	20
No. pings per ensemble:	300
Magnetic correction:	0
Ensemble:	300
Standard Deviation (cm/sec):	0.63
Time/Ping (seconds):	2