Caolas A Deas West, Loch Shell

Hydrographic Data Report: Deployment ID357

10th September – 8th November 2020

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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 equipment change at the site, Caolas A Deas East on Loch Shell, located on the East coast of the Isle of Lewis. Mowi Scotland Ltd. propose to swap the 10 x 100m circumference pens to 4 x 160m circumference pens with a 20m side wall, 15m cone with a 100m grid. The same will be applied for at the neighbouring site at Caolas A Deas West.

Mowi Scotland Ltd have carried out hydrographic surveys at the site in 2020. Hydrographic data at Caolas A Deas East was gathered during this time in two deployments:

i. 10th September – 8th November 2020 (ID357)
ii. 9th February – 6th May 2021 (ID367)

This report describes the data from the 10TH September – 8th November 2020 deployment at Caolas A Deas East. The purpose of this report is to assess the suitability of the collected hydrographic data for calibration of a hydrodynamic model of the East Lewis region and input into the NewDepomod model. A second report will cover the data from ID367. Two other hydrographic surveys were undertaken at the neighbouring site Caolas A Deas West (ID346 and ID358).

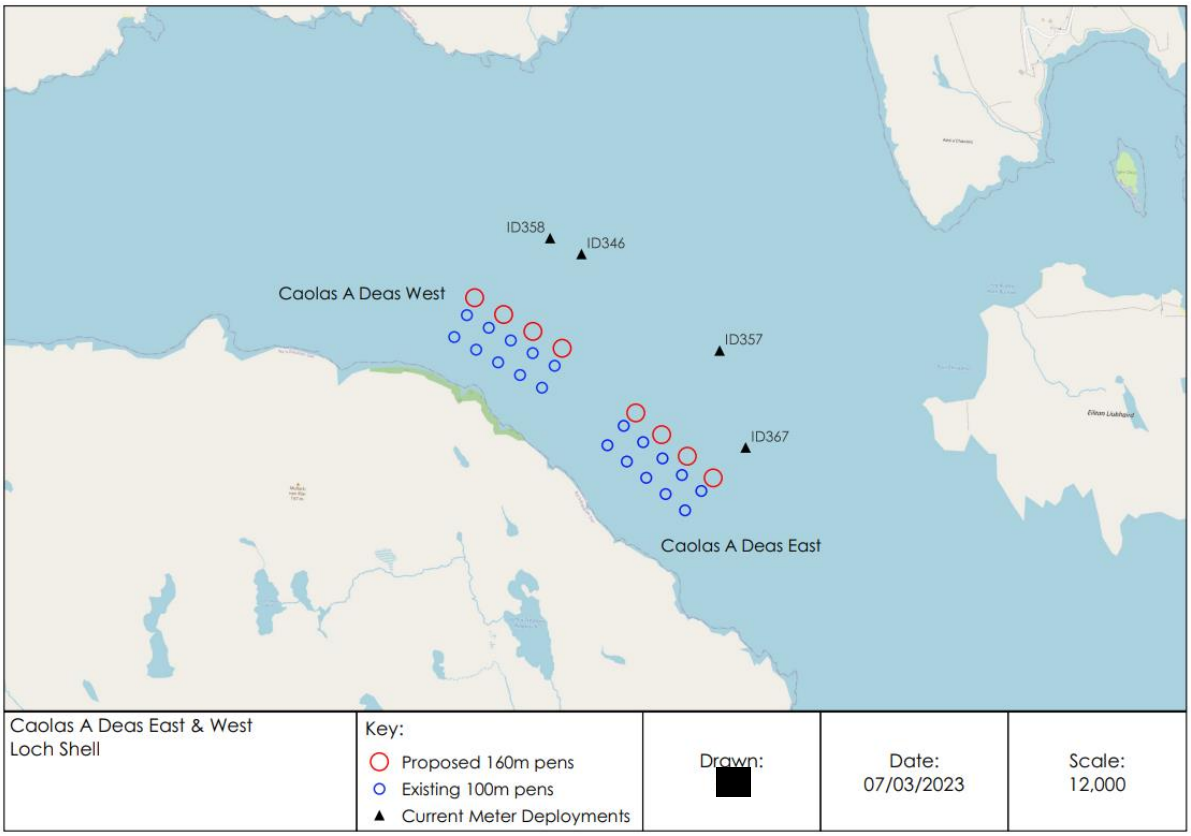


Figure 1. Both Caolas A Deas East and West existing and proposed layouts. The current meter deployment locations are marked by the black triangles.

2. Materials & Methods

2.1 Bathymetry

Bathymetry was taken from the WeStCOMS2 model which has reasonably high spatial resolution around Lewis, which was then supplemented by a local depth survey (Figure 2). The combined data were interpolated onto the Loch Shell model mesh.

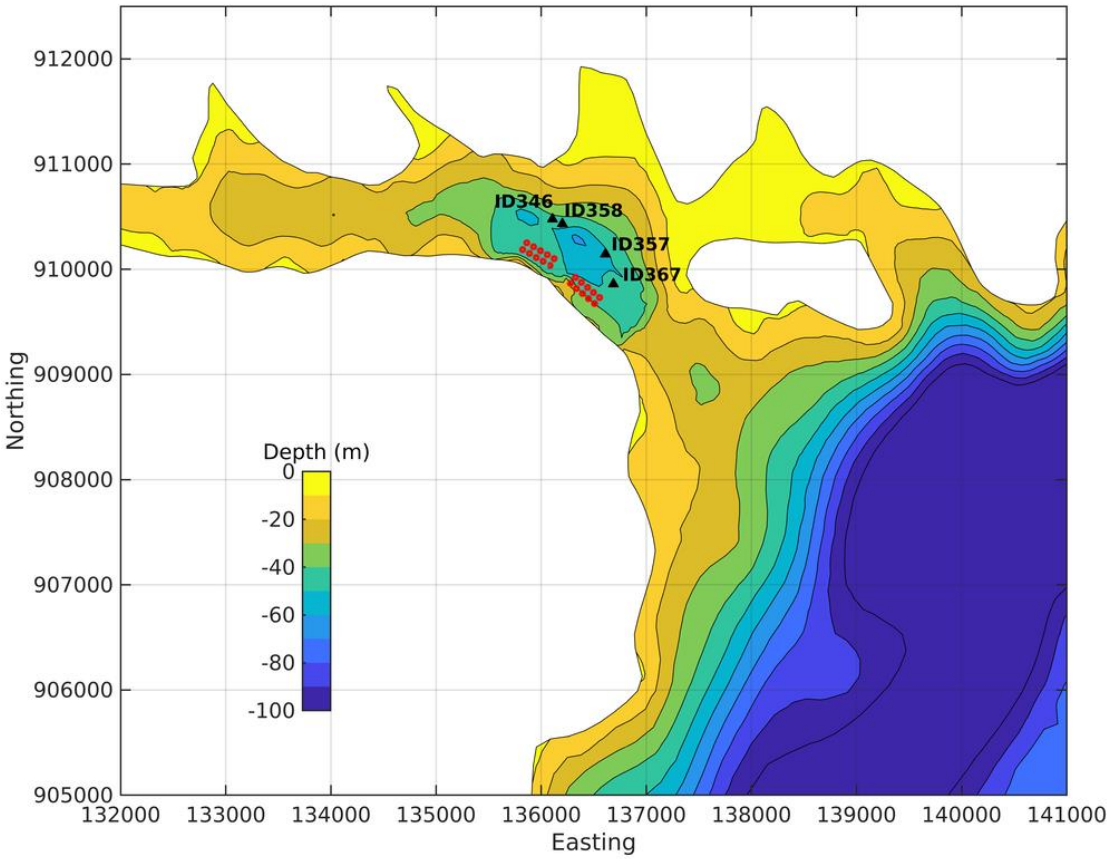


Figure 2. Bathymetry around the Caolas A Deas sites. Current meter locations are marked with black triangles and existing pen locations are marked with red circles.

2.2 Current Data

Mowi staff carried out hydrographic surveys at the site during 2020 and 2021. The purpose of this hydrographic report is to assess the suitability of the collected hydrographic data for use with the NewDepomod and Hydrodynamic models. The data contained in this report were recorded at the site from 10th September – 8th November 2020 (58 days and 16 hours of data; deployment ID357). The data from another deployment (ID367) are presented in a separate hydrographic report.

The Sentinel V100 (Wide) ADCP (Table 1), within its mooring frame, was positioned at 58.00217N, -6.45978W (136610E 910147N), which was approximately 580m from the nearest shoreline and approximately 300m 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 53.11 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 49.

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 -3.53°; 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 42 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 8.39 m (cell 42), and cage-bottom data at 17.39 m (cell 33). Surface and middle cell heights were 44.72 m and 35.72 m from the seabed respectively. The bottom cell (cell 1) was at an average depth of 49.39 m and 3.72 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] Wide/Narrow	Std Dev (cm/s)[3,4] Wide/Narrow	Range (m)[2,3] Wide/Narrow	Std Dev (cm/s)[3,4] Wide/Narrow	Range (m)[2,3] Wide/Narrow	Std Dev (cm/s)[3,4] 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	802.11b/g/n					
	Internal memory	One 16GB Micro SD Card included					
Profile Parameters	Velocity accuracy	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					
	Velocity resolution	0.1cm/s					
	Velocity range	±5m/s (default); ±20m/s (maximum)					
	Ping rate	Up to 4Hz					
Echo Intensity Profile	Vertical resolution	Depth cell size					
	Dynamic range	80dB					
	Precision	±1.5dB					
Transducer and Hardware	Beam angle	25°					
	Configuration	4-beam, convex; 5th beam vertical					
	Depth rating	200m					
	Materials	Transducer, housing, and end cap: plastic Connector: metal shell					
Standard Sensors	Temperature (mounted on transducer)	Range -5° to 45°C, precision ±0.4°C, resolution 0.1°					
	Compass (magneto-inductive sensor)	Accuracy 2° RMS, resolution 0.1°, max. dip angle 85°					
	Tilt (MEMS accelerometers)	Pitch range ±90°, roll range ±180°, accuracy 2° RMS, precision 0.05° RMS, resolution 0.1°					
	Pressure sensor (mounted on transducer)	Range 300m, accuracy 0.1%FS					
Power	External DC input	12–20VDC					
	Internal battery voltage	18VDC new					
	Battery capacity; over-the-counter @0°C	100 watt hours (typical)					
	Battery pack @5°C	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	200m					
	Operating temperature	-5° to 45°C					
	Storage temperature (without batteries)	-30° to 60°C					
	Weight in air	7.5kg – 16.0kg					
	Weight in water	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.

Specifications subject to change without

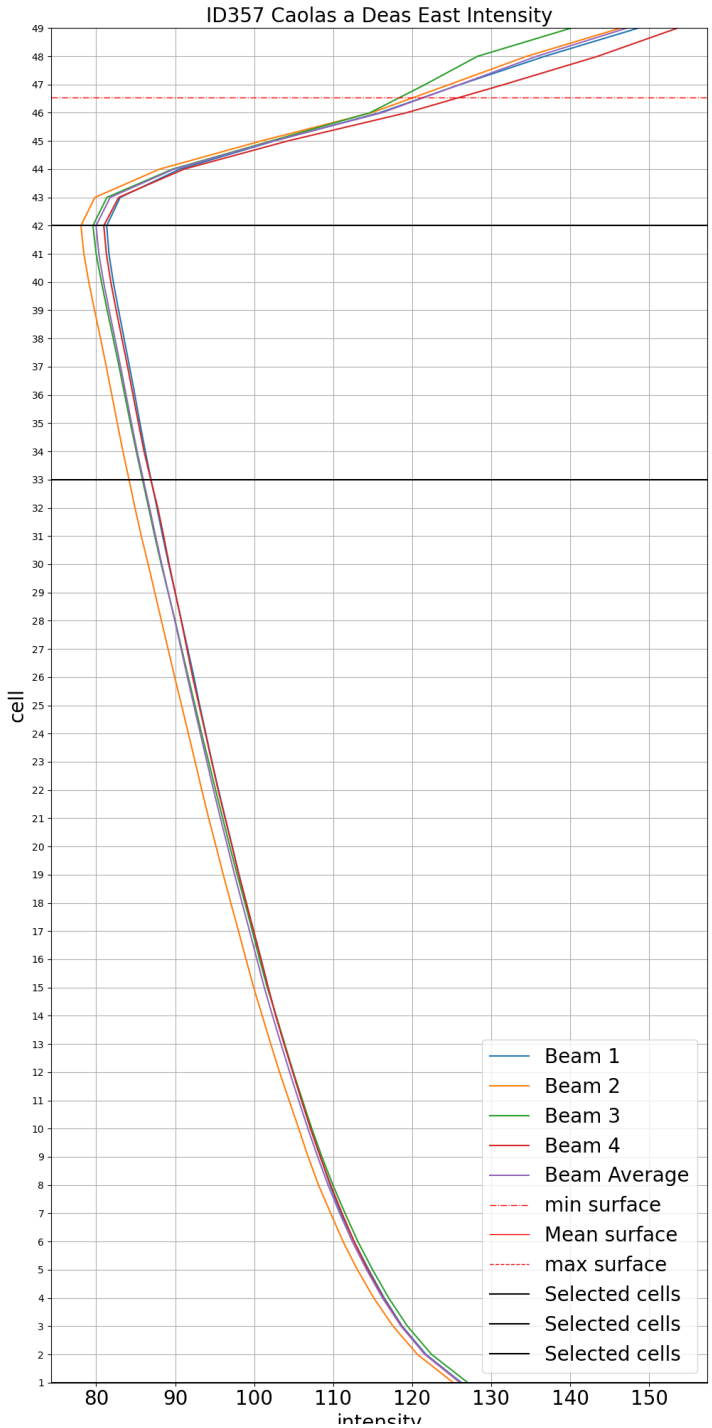


Figure 3. Mean intensity of the ADCP signal for the ID357 dataset plotted by bin number

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 3.02 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 3.72 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:

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

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 0.64cm/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 mulitple 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 meterological conditions.

3. Results and Discussion

A summary of the current data is shown in Figure 4 to Figure 12 and in Table 2 to Table 5. Over the period analysed for this report, the near-surface, middle and bottom cells had current speed averages of 5.16 cm/s, 4.26 cm/s and 5.91 cm/s respectively. This gave an overall average of 5.11 cm/s. The orientation of the tidal velocities was north-east – south-west.

Residual current at the surface (165°G Figure 7) was toward the south while mid-depth and near-bottom cells were toward the north-west (311°G, 343°G, Figure 8, Figure 9). The magnitude of the residual currents for the surface, middle and bottom cells were moderate, with mean values of 0.009 m/s, 0.010 m/s and 0.036 m/s respectively.

4. Hydrographic Data Summary Sheets

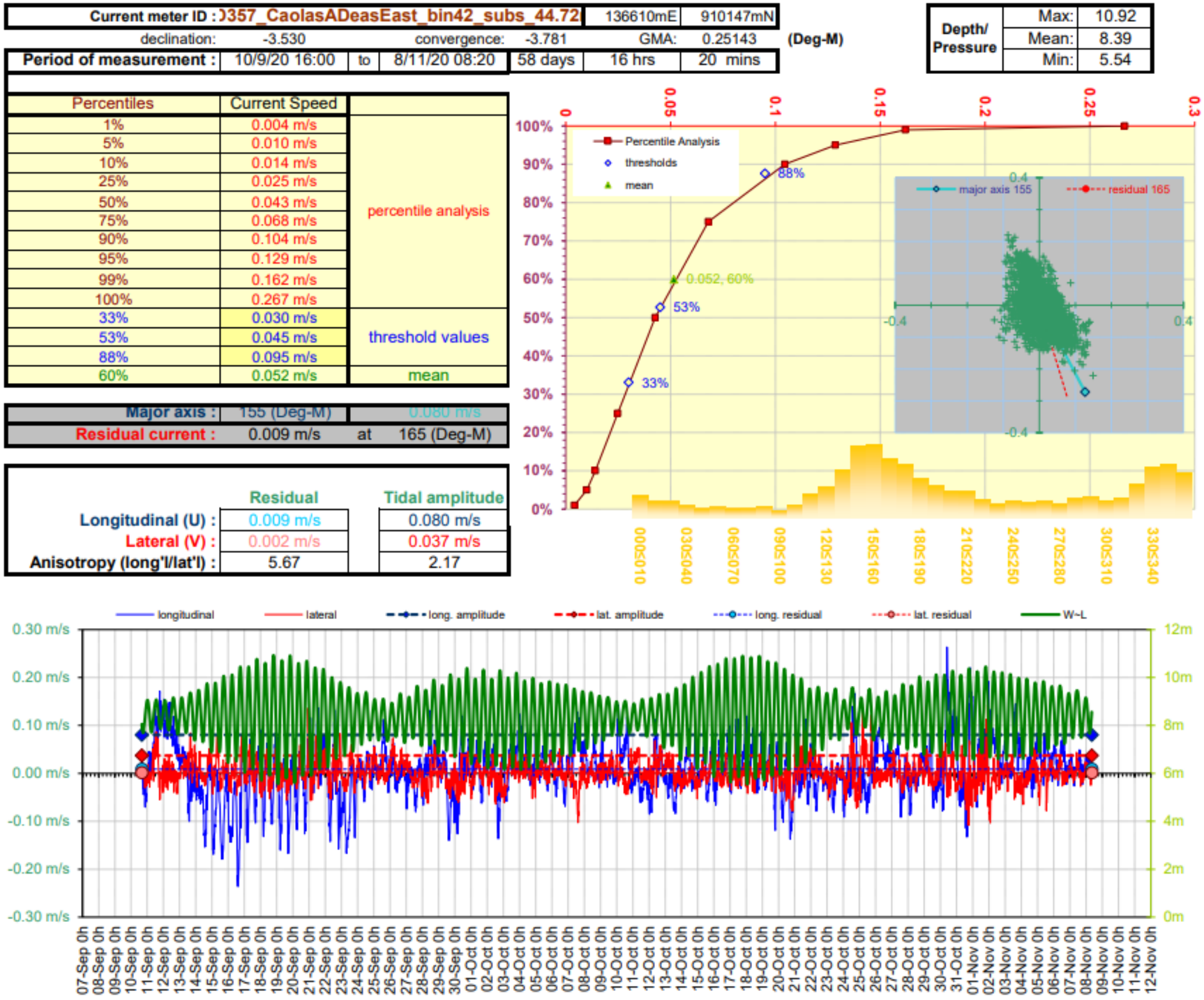


Figure 4. Current Data Summary Sheet for the surface current cell 42, 44.72m from seabed, 10th September to 8th November 2020 inclusive (ID357).

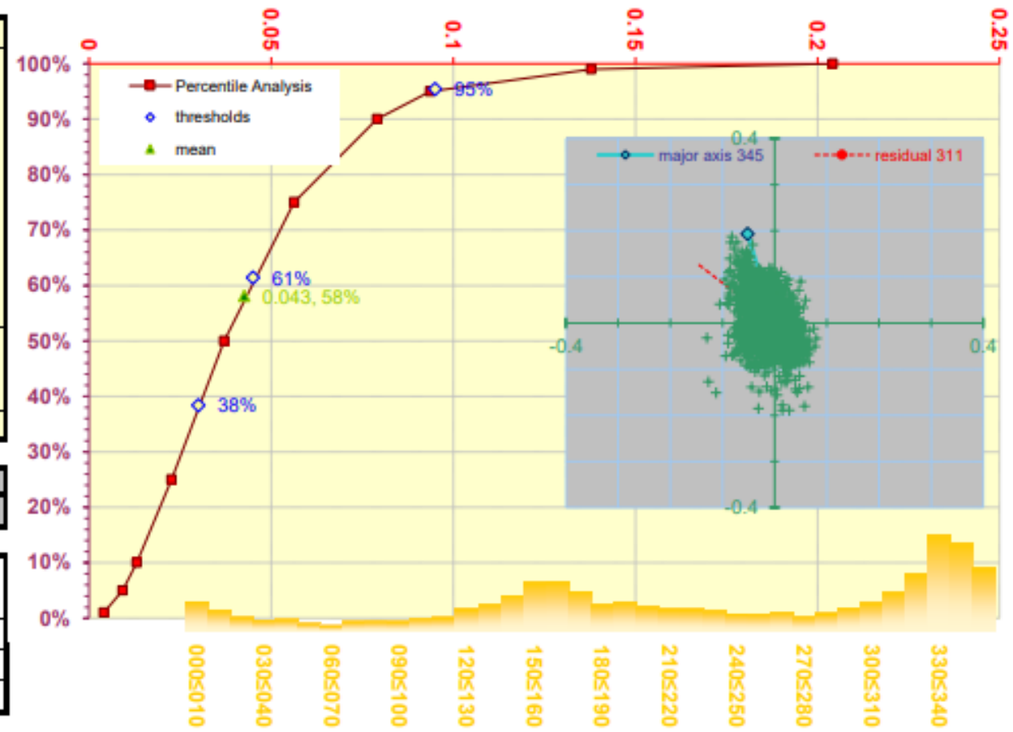
Current meter ID :	D357_CaolasADeasEast_bin33_cbot_35.72			136610mE	910147mN
declination:	-3.530		convergence:	-3.781	GMA: 0.25143 (Deg-M)
Period of measurement :	10/9/20 16:00	to	8/11/20 08:20	58 days	16 hrs 20 mins

Depth/ Pressure	Max:	19.92
	Mean:	17.39
	Min:	14.54

Percentiles	Current Speed	
1%	0.004 m/s	percentile analysis
5%	0.009 m/s	
10%	0.013 m/s	
25%	0.023 m/s	
50%	0.037 m/s	
75%	0.056 m/s	
90%	0.079 m/s	
95%	0.094 m/s	
99%	0.138 m/s	
100%	0.204 m/s	
38%	0.030 m/s	threshold values
61%	0.045 m/s	
95%	0.095 m/s	
58%	0.043 m/s	mean

Major axis :	345 (Deg-M)	0.063 m/s
Residual current :	0.010 m/s	at 311 (Deg-M)

	Residual	Tidal amplitude
Longitudinal (U) :	0.008 m/s	0.063 m/s
Lateral (V) :	-0.006 m/s	0.031 m/s
Anisotropy (long'l/lat'l) :	1.48	2.04



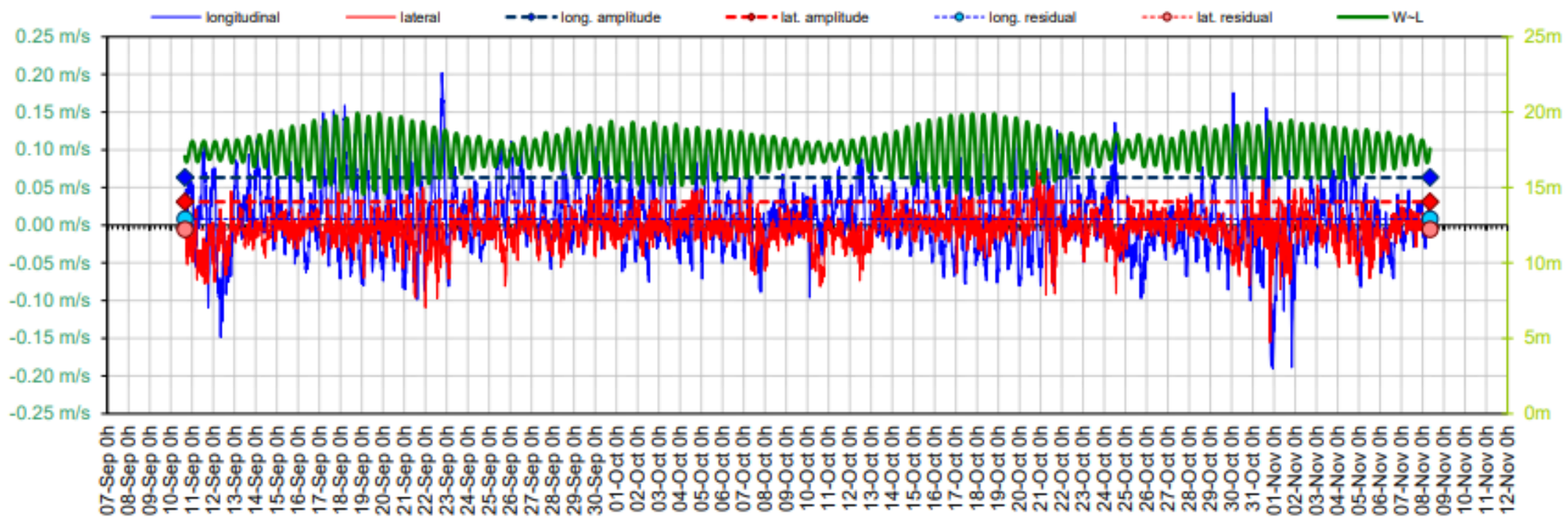


Figure 5. Current Data Summary Sheet for the cage bottom current cell 33, 35.72m from seabed, 10th September to 8th November 2020 inclusive (ID357).

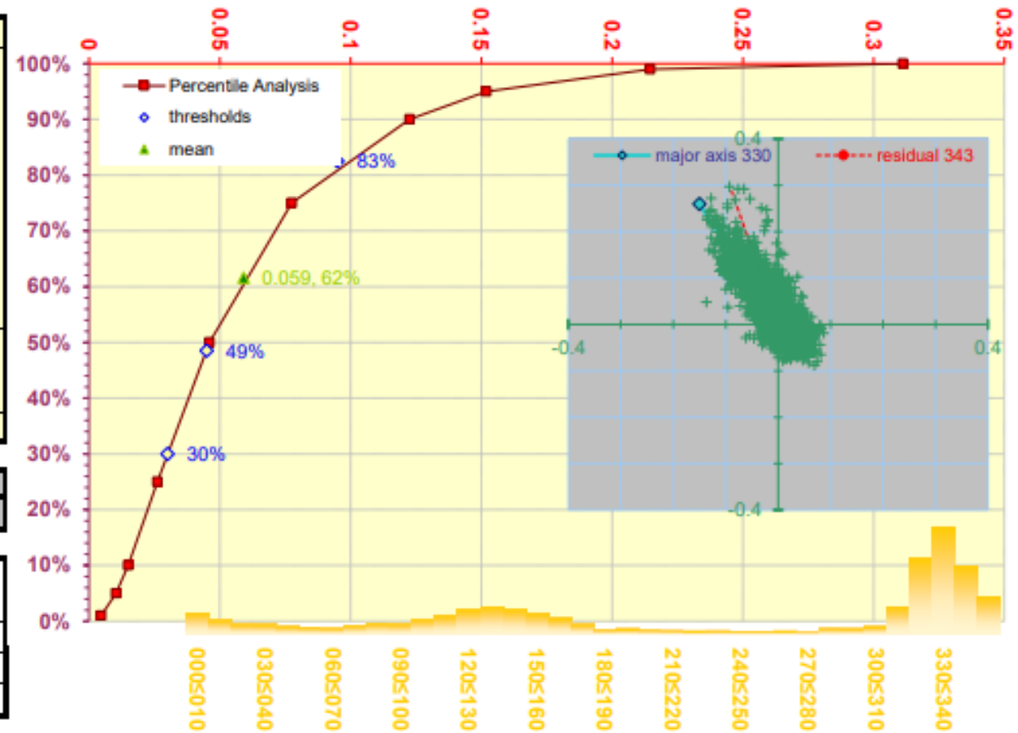
Current meter ID :	D357_CaolasADeasEast_bin01_nrbd_3.72m			136610mE	910147mN
declination:	-3.530		convergence:	-3.781	GMA: 0.25143 (Deg-M)
Period of measurement :	10/9/20 16:00	to	8/11/20 08:20	58 days	16 hrs 20 mins

Depth/ Pressure		
	Max:	51.92
	Mean:	49.39
	Min:	46.54

Percentiles	Current Speed	
1%	0.005 m/s	percentile analysis
5%	0.010 m/s	
10%	0.015 m/s	
25%	0.026 m/s	
50%	0.046 m/s	
75%	0.078 m/s	
90%	0.123 m/s	
95%	0.152 m/s	
99%	0.215 m/s	
100%	0.311 m/s	
30%	0.030 m/s	threshold values
49%	0.045 m/s	
83%	0.095 m/s	
62%	0.059 m/s	mean

Major axis :	330 (Deg-M)		0.089 m/s
Residual current :	0.036 m/s	at	343 (Deg-M)

	Residual	Tidal amplitude
Longitudinal (U) :	0.035 m/s	0.089 m/s
Lateral (V) :	0.008 m/s	0.025 m/s
Anisotropy (long'l/lat'l) :	4.38	3.56



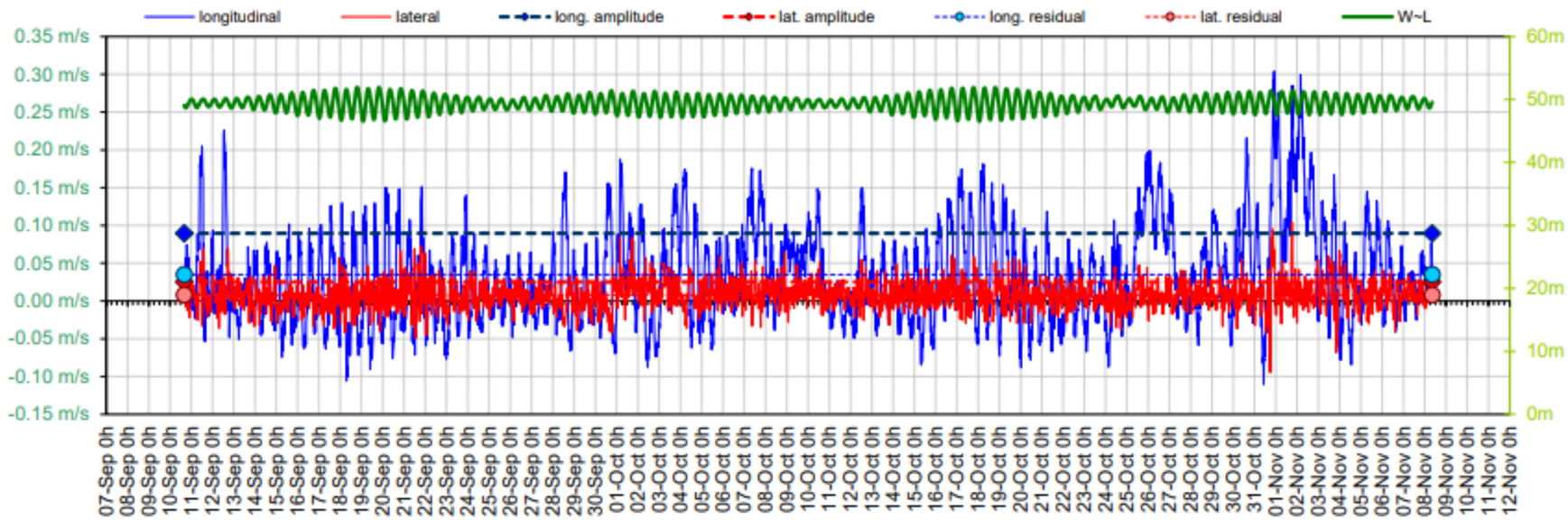


Figure 6. Current Data Summary Sheet for the near bottom current cell 1, 3.7m from seabed, 10th September to 8th November 2020 inclusive (ID357).

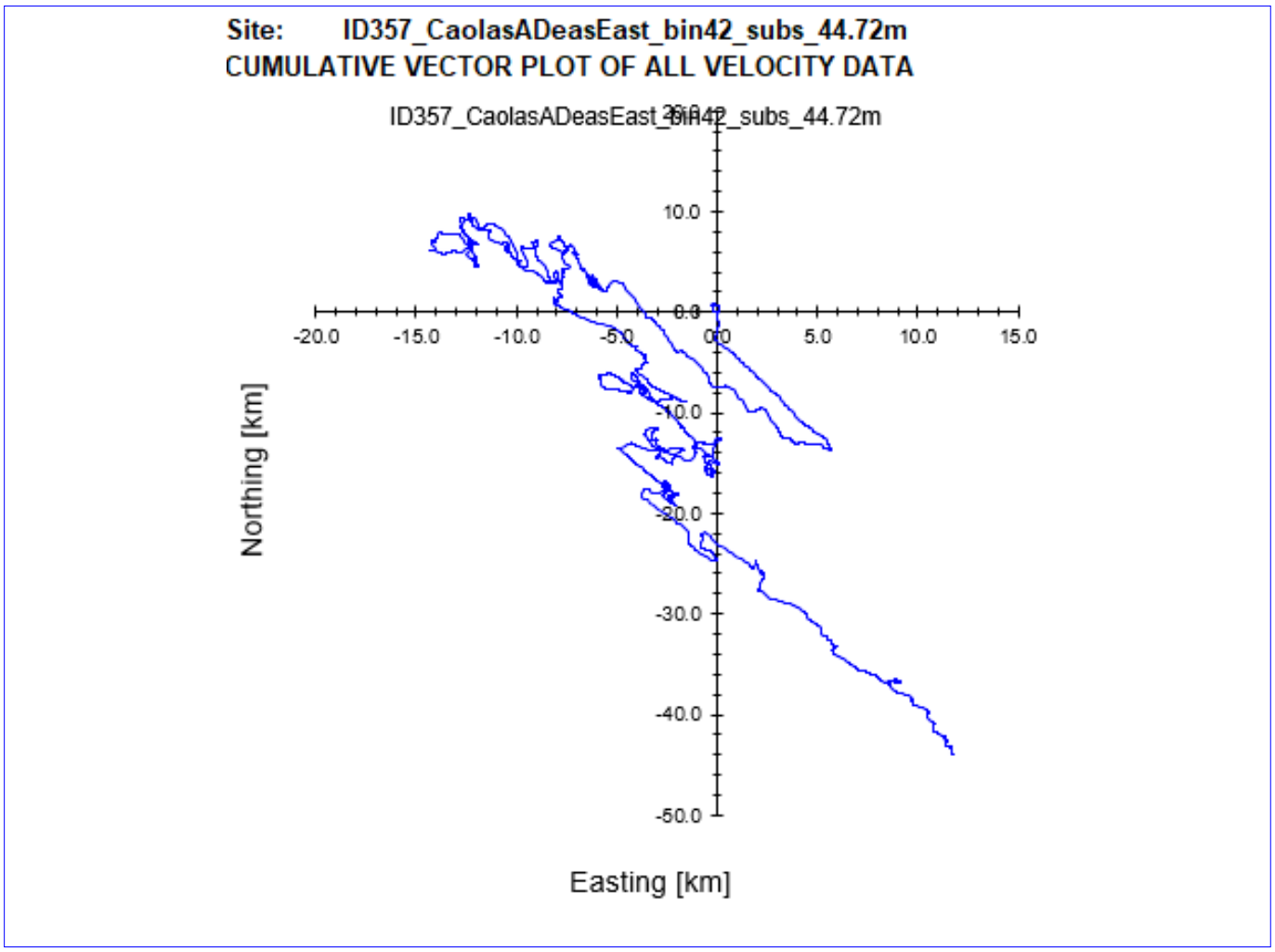


Figure 7. Cumulative Vector Plot of all velocity data from near surface cell for ID357.

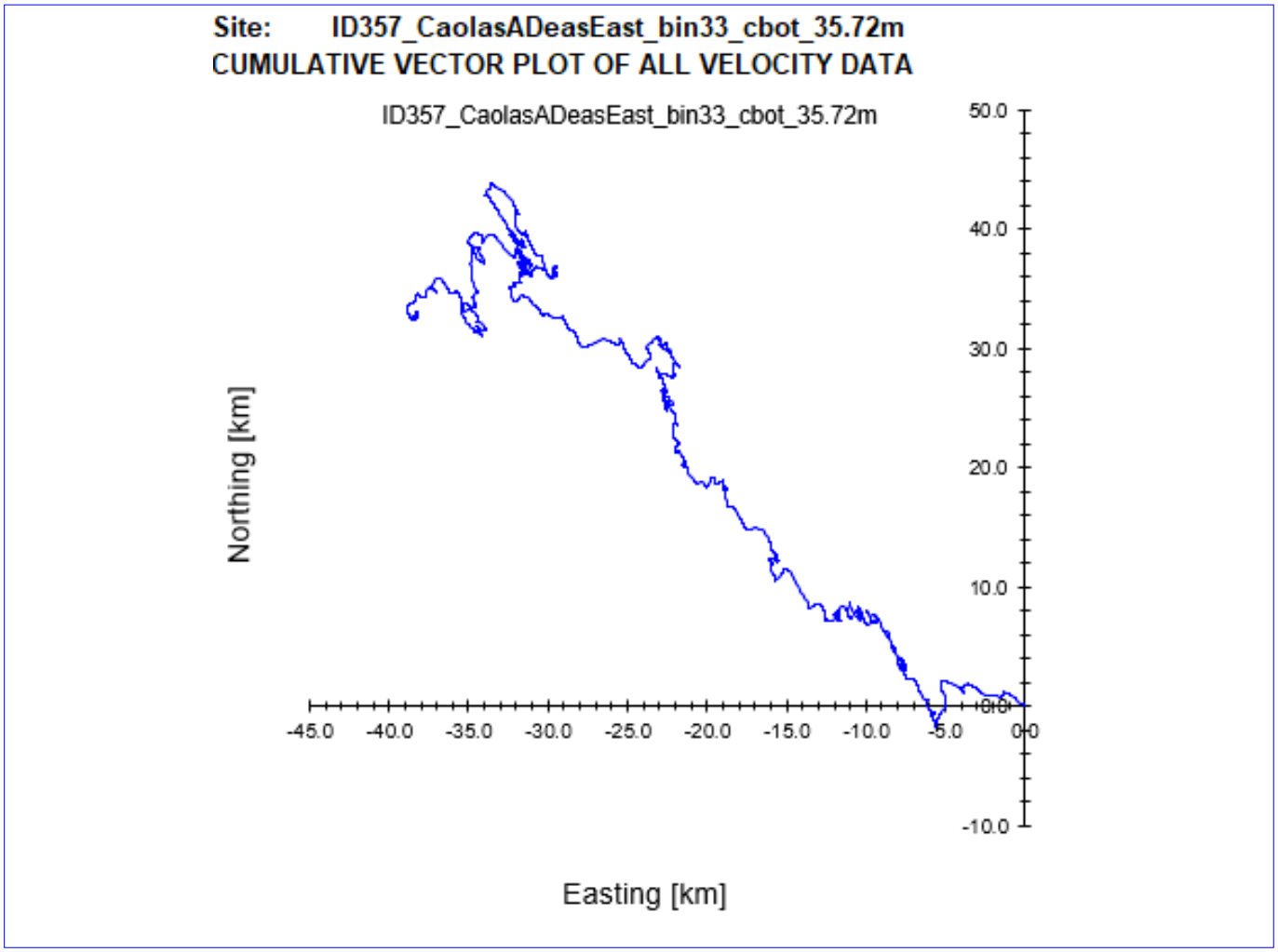


Figure 8. Cumulative Vector Plot of all velocity data from cage bottom cell for ID357.

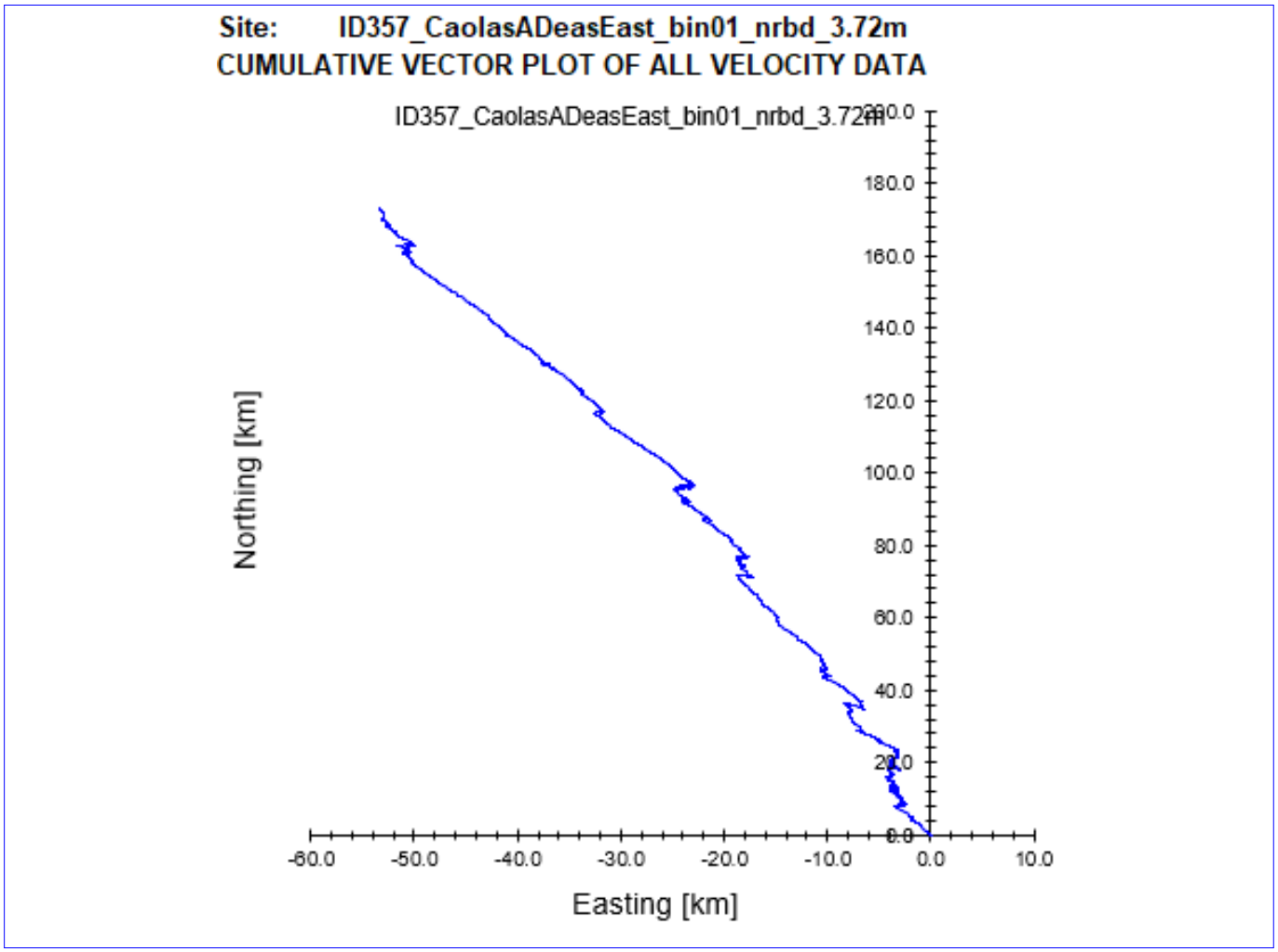


Figure 9. Cumulative Vector Plot of all velocity data from near bottom cell for ID357.

5. Summary of Current Data – ID357

Site Name: Caolas A Deas East
Data start date: 10/09/2020
Data end date: 08/11/2020
Mean Water Depth: 53.11m

Table 2. Summary of current meter deployment

	Cell	Depth Below Surface (m)	Distance from Seabed (m)	Mean current speed (cm/s)
Near surface:	42	5.54	44.72	5.16
Cage bottom:	33	14.54	35.72	4.26
Near bed:	1	46.54	3.72	5.91
			Average current speed:	5.11

Table 3. Ranked percentiles for current speed at all three depths

Cell	Ranked Percentile (%) for mean speed	≤3cm/s (%)	≥4.5cm/s (%)	≥9.5cm/s (%)
Near surface:	60	33	47	12
Cage bottom:	58	38	39	5
Near bed:	62	30	51	17

Table 4. Major axis

Cell	Major Axis (Deg-G)
Near surface:	155
Cage Bottom:	345
Near bed:	330

Table 5. 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:	0.009	0.009	0.002	0.080	0.037
Cage Bottom:	0.010	0.008	-0.006	0.063	0.031
Near Bed:	0.036	0.035	0.008	0.089	0.025

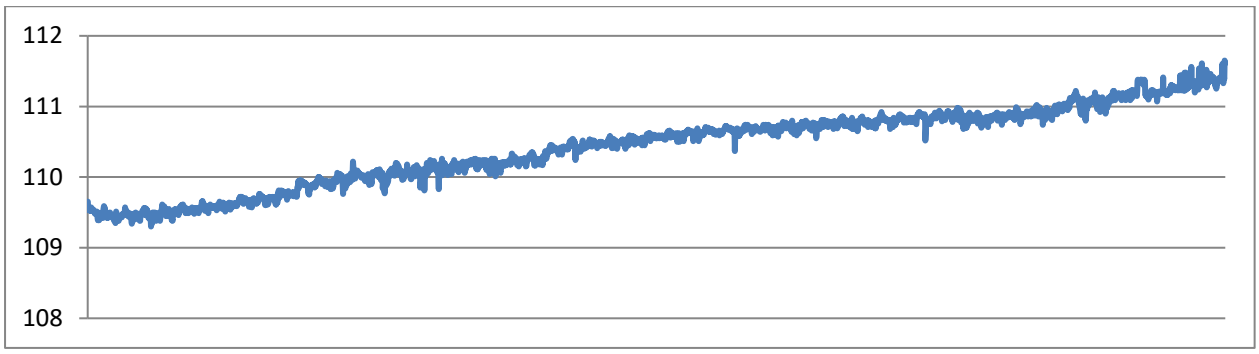


Figure 10. Summary of heading data from deployment ID357.

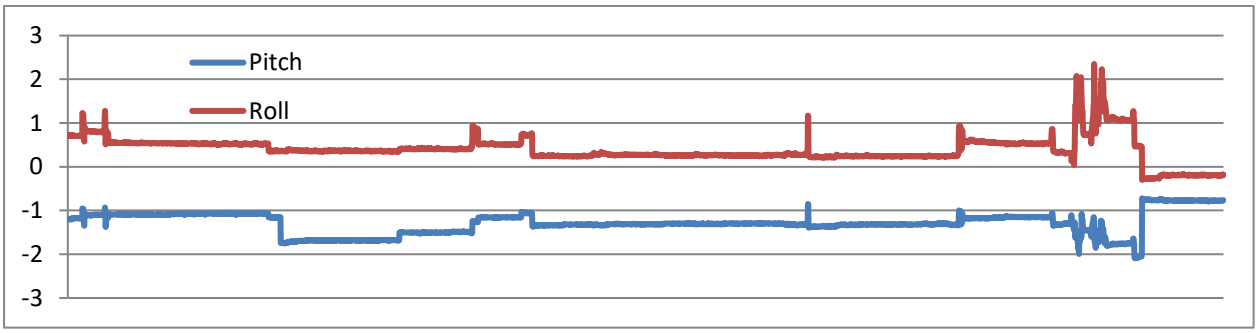


Figure 11. Summary of pitch and roll data from deployment ID357.

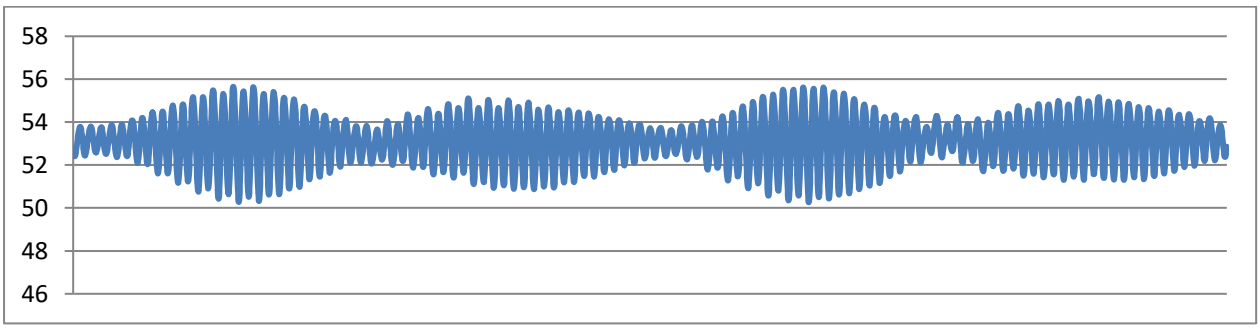


Figure 12. Pressure data from deployment ID357.

6. Conclusion

MOWI has collected and analysed current and bathymetric data for the salmon farm at Caolas A Deas East. The analysed current data for the 58 days and 16 hours period are believed to be reliable and representative of the proposed location. The bathymetric data from the WeStCOMS model, combined with the local depth survey provided a coherent bathymetric dataset for the site.

Annex 1. Survey Equipment Deployment Log

Location:	Caolas A Deas East
Nearest tidal port:	Loch Shell
Time zone:	UTC
Meter switched on:	16:00 10/09/2020
Meter switched off:	08:20 08/11/2020
Period used for this report:	16:00 10/09/2020 – 08:20 08/11/2020
ADCP serial number:	108
Meter position:	58.00217N, -6.45978W
	136610 E 910147 N
Minimum water depth:	48.26 m (49.56 m measured by ADCP + 0.7 m *)
Water depth (Chart Datum):	48.06 (minimum water depth - 0.2 m tide timetable)
Mean water depth:	53.81 m (53.11 measured by ADCP + 0.7 m *)
Depth of meter from surface:	47.36 m (below chart datum to transducer)
Height of meter from seabed:	0.7 m to transducer head
Sounding at deployment:	48 m @ 11:25 on 10/09/2020

Table A1. ADCP meter settings:

Reference:	Transducer
Bin size (m):	1.0
Dist to 1st bin (m):	3.02
Number of bins:	49
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