

# Carradale South

## Hydrographic Data Report: Deployment ID119

### 30<sup>th</sup> September to 2<sup>nd</sup> December 2016

January 2024  
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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 a technical variation to both CAR/L/1078064 and CAR/L/1131788 to modify the existing salmon farm sites located at Carradale. Mowi Scotland Ltd. propose to change the existing sites from each with 10 x 120 m circumference pens, with 16 m deep nets, held in a 75 m grid (Figure 1) to each with 6 x 160 m circumference pens with 16 m deep nets, held in a 100 m grid. No increase to the biomass will be applied for.

Mowi Scotland Ltd have carried out hydrographic surveys at the site in 2016 and 2017. Hydrographic data at Carradale was gathered during this time in two deployments:

- i. 30<sup>th</sup> September to 2<sup>nd</sup> December 2016 (ID119)
- ii. 7<sup>th</sup> August to 6<sup>th</sup> October 2017 (ID182)

This report describes the data from the 30<sup>th</sup> September to 2<sup>nd</sup> December 2016 deployment at Carradale(South). The purpose of this report is to assess the suitability of the collected hydrographic data for input into a hydrodynamic model of Kilbrannan Sound and into the NewDepomod model.

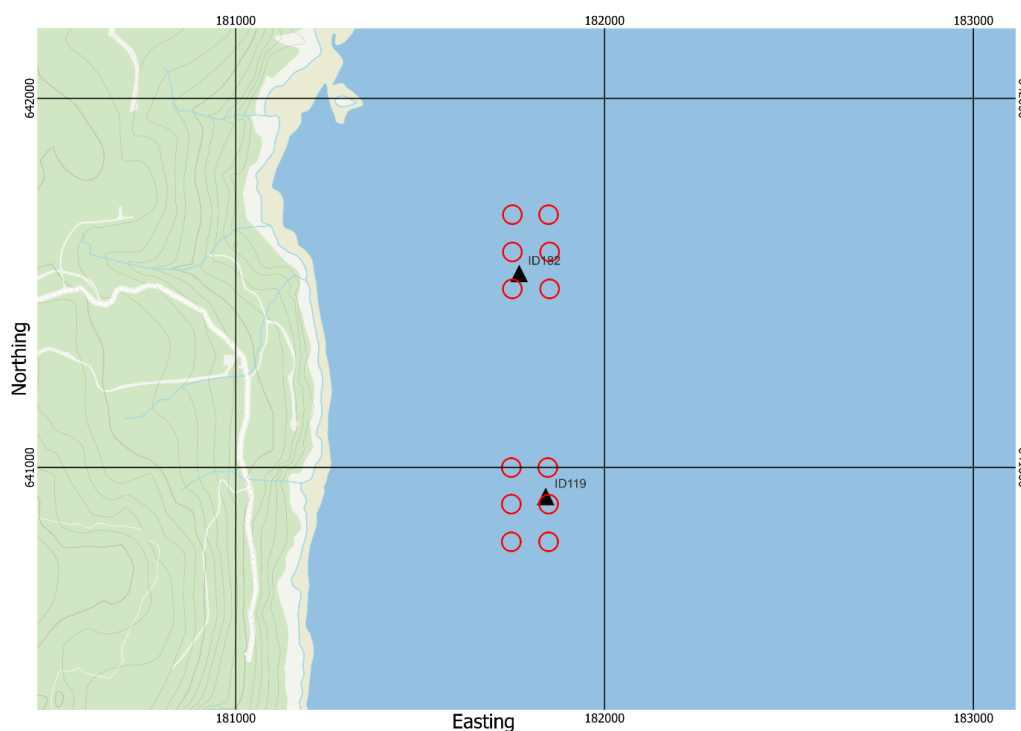


Figure 1. Proposed site layout of the salmon farms at Carradale. The current meter deployment locations are marked by the black triangles.

## 2. Materials & Methods

### 2.1 Bathymetry

Bathymetry for the study area was taken from the UKHO INSPIRE bathymetry data (<http://aws2.caris.com/ukho/mapViewer/map.action>).

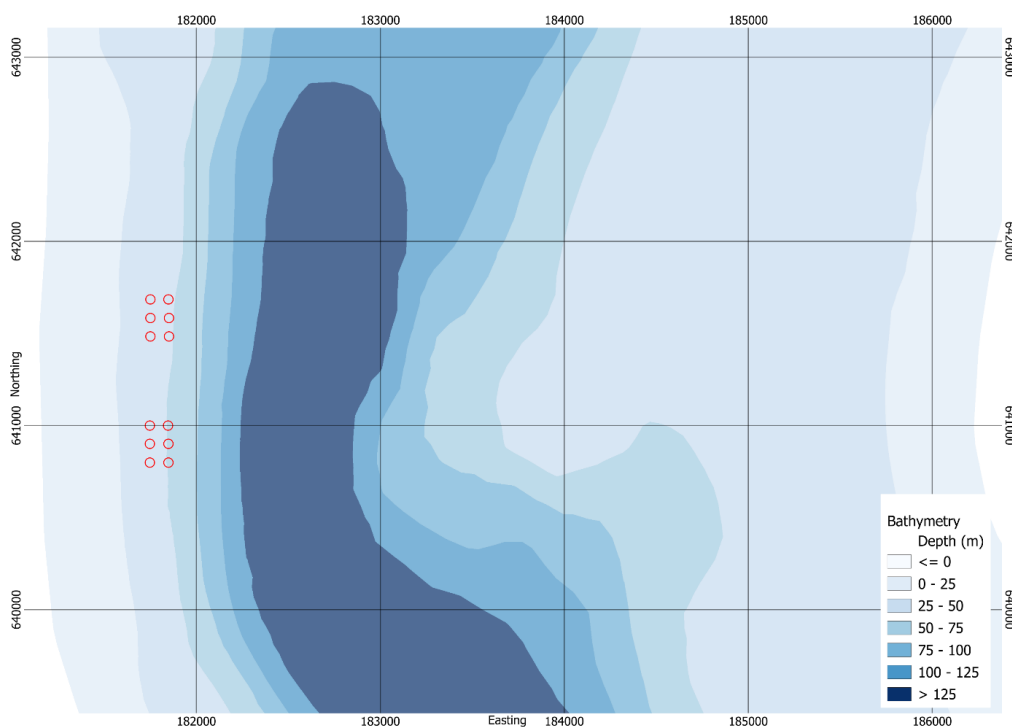


Figure 2. Bathymetry in Kilbrannan Sound, near the Carradale sites.

### 2.2 Current Data

Mowi staff carried out hydrographic surveys at the site during 2016 and 2017. 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 30<sup>th</sup> September to 2<sup>nd</sup> December 2016 (62 days and 22 hours of data; deployment ID182). The data from a later deployment (ID182) are presented in a separate hydrographic report.

The Sentinel V100 (Wide) ADCP (Table 1), within its mooring frame, was positioned at 55.61283 N, -5.4656 W (181840E 640922N), which was approximately 596m from the nearest shoreline and approximately 46 m 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 47.36 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 50.

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  $-3.32^\circ$ ; 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 38 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 7.65 m (cell 38), and cage-bottom data at 17.65 m (cell 28). Surface and middle cell heights were 39.72 m and 29.72 m from the seabed respectively. The bottom cell (cell 1) was at an average depth of 44.65 m and 2.72 m above the seabed.

Depth Cell Size <sup>1</sup>	V20 (1000kHz)		V50 (500kHz)		V100 (300kHz)		
	Depth Cell Size <sup>1</sup>	Range (m) <sup>2,3</sup>	Std Dev (cm/s) <sup>3,4</sup>	Range (m) <sup>2,3</sup>	Std Dev (cm/s) <sup>3,4</sup>	Range (m) <sup>2,3</sup>	Std Dev (cm/s) <sup>3,4</sup>
		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
<b>Communications and Recording</b>	Wireless	802.11b/g/n					
	Internal memory	One 16GB Micro SD Card included					
<b>Profile Parameters</b>	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					
<b>Echo Intensity Profile</b>	Vertical resolution	Depth cell size					
	Dynamic range	80dB					
	Precision	±1.5dB					
<b>Transducer and Hardware</b>	Beam angle	25°					
	Configuration	4-beam, convex; 5th beam vertical					
	Depth rating	200m					
	Materials	Transducer, housing, and end cap: plastic Connector: metal shell					
<b>Standard Sensors</b>	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					
<b>Power</b>	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					
<b>Software</b>	Teledyne RDI's new software included	ReadyV–Pre-deployment (testing, planning, and data recovery) <sup>5</sup> Velocity–Post-processing (data handling, display, and export) <sup>6</sup>					
<b>Environmental</b>	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					
<b>Available Options</b>	External battery case	• AC/DC power converter • 5th beam (at time of order only) • Waves processing • Straight or right-angle metal shell connector					
<b>Dimensions</b>	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 notice.

Table 1: Sentinel V100 ADCP Specifications.



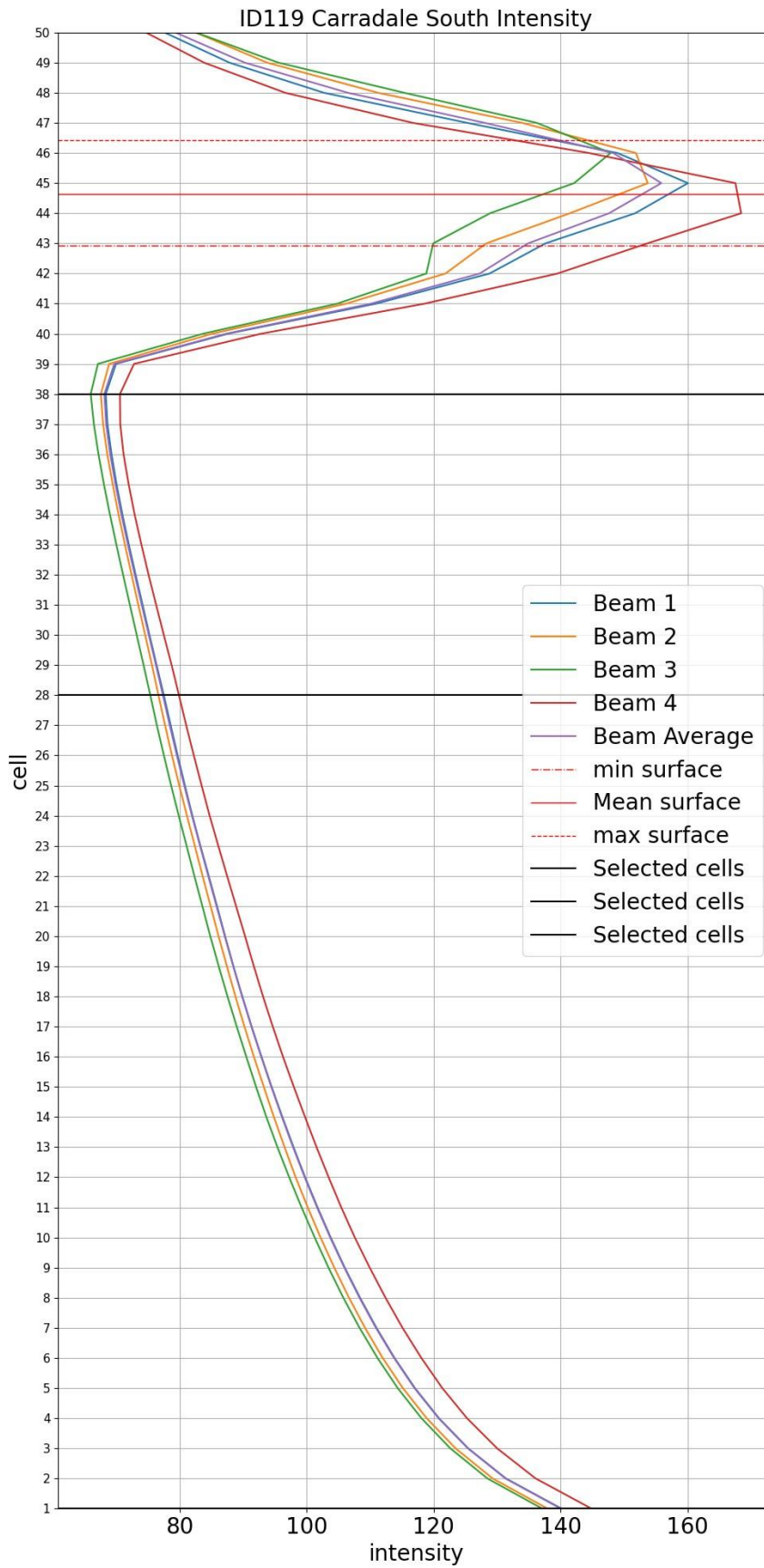


Figure 3. Mean intensity of the ADCP signal for the ID119 dataset plotted by bin number

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 2.02 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 2.72 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:

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

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 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 14.8 cm/s, 14.8 cm/s and 12.2 cm/s respectively. This gave an overall average of 13.93 cm/s. The orientation of the tidal velocities was north – south.

Residual currents at the surface and mid-depth were toward the south (142°G and 122°G respectively); near the seabed, the residual flows during the deployment period were to the north (016°G, Figure 9). The magnitude of the residual currents of the surface, middle and bottom cells had mean values of 0.019 m/s, 0.013 m/s and 0.02 m/s respectively.

## 4. Hydrographic Data Summary Sheets

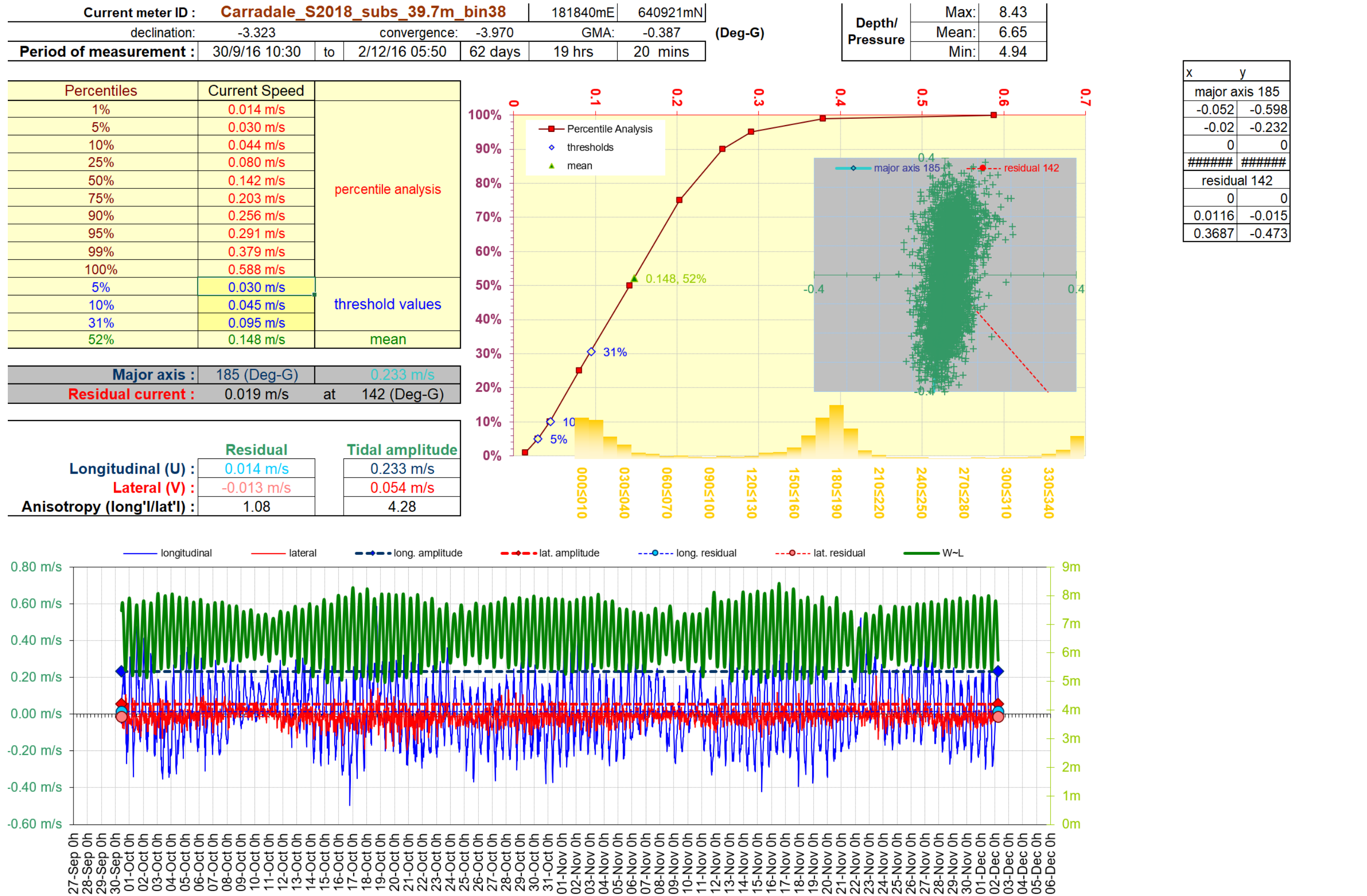


Figure 4. Current Data Summary Sheet for the surface current cell 38, 39.72m from seabed, 30<sup>th</sup> September to 2<sup>nd</sup> December 2016 inclusive (ID119).

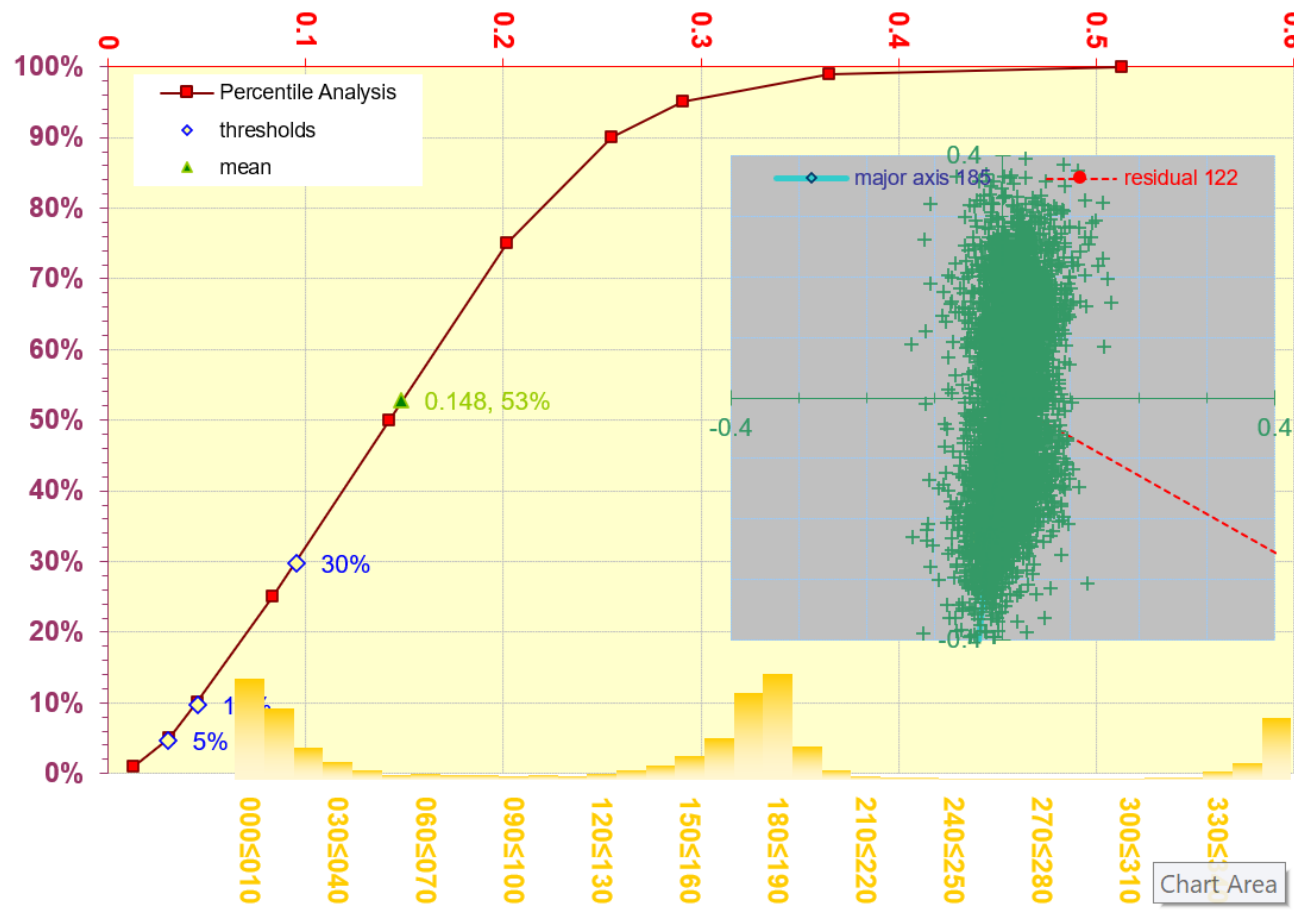
Current meter ID : <b>Carradale_S2018_cbot_29.7m_bin28</b>	181840mE	640921mN	
declination: -3.323	convergence: -3.970	GMA: -0.387	(Deg-G)
Period of measurement : 30/9/16 10:30	to 2/12/16 05:50	62 days 19 hrs 20 mins	

Depth/ Pressure	Max:	18.43
	Mean:	16.65
	Min:	14.94

Percentiles	Current Speed	
1%	0.013 m/s	percentile analysis
5%	0.031 m/s	
10%	0.045 m/s	
25%	0.083 m/s	
50%	0.142 m/s	
75%	0.202 m/s	
90%	0.255 m/s	
95%	0.291 m/s	
99%	0.365 m/s	
100%	0.513 m/s	
5%	0.030 m/s	threshold values
10%	0.045 m/s	
30%	0.095 m/s	
53%	0.148 m/s	
		mean

<b>Major axis :</b>	185 (Deg-G)	0.234 m/s
<b>Residual current :</b>	0.013 m/s at 122 (Deg-G)	

	Residual	Tidal amplitude
<b>Longitudinal (U) :</b>	0.006 m/s	0.234 m/s
<b>Lateral (V) :</b>	-0.012 m/s	0.046 m/s
<b>Anisotropy (long'/lat'l) :</b>	0.52	5.07



x	y
major axis 185	
-0.044	-0.498
-0.02	-0.233
0	0
#####	#####
residual 122	
0	0
0.0113	-0.007
0.4219	-0.268

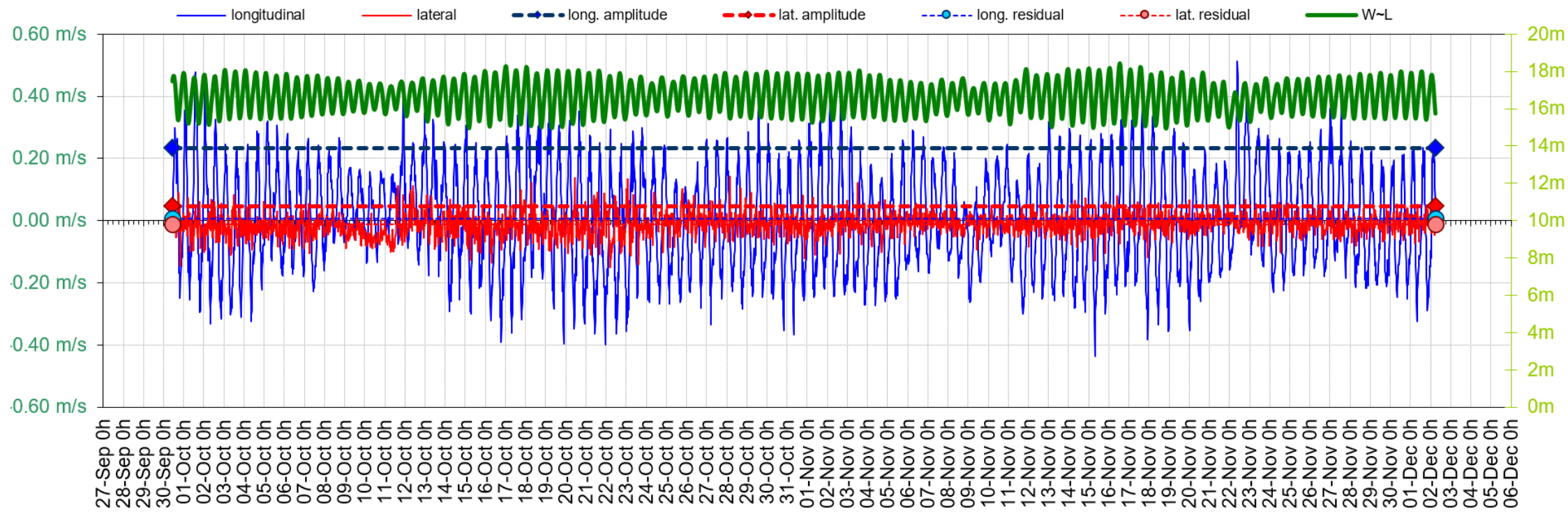


Figure 5. Current Data Summary Sheet for the cage bottom current cell 28, 29.72m from seabed, 30<sup>th</sup> September to 2<sup>nd</sup> December 2016 inclusive (ID119).

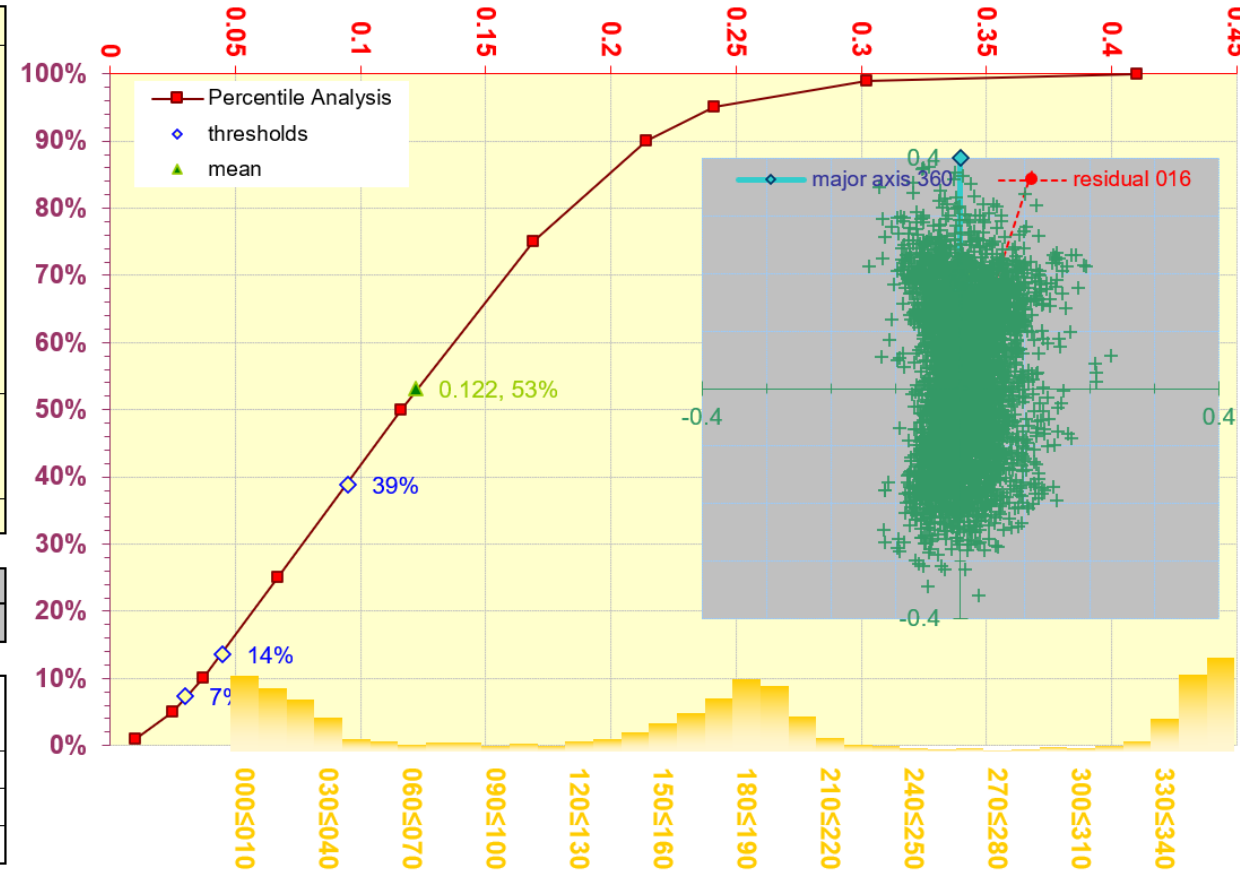
Current meter ID :	<b>Carradale_S2018_nrbd_2.7m_bin01</b>	181840mE	640921mN	
declination:	-3.323	convergence:	-3.970	GMA: -0.39 (Deg-G)
Period of measurement :	30/9/16 10:30 to	2/12/16 05:50	62 days	19 hrs 20 mins

Depth/ Pressure	Max:	46.43
	Mean:	44.65
	Min:	42.94

Percentiles	Current Speed	
1%	0.010 m/s	percentile analysis
5%	0.025 m/s	
10%	0.037 m/s	
25%	0.067 m/s	
50%	0.116 m/s	
75%	0.169 m/s	
90%	0.214 m/s	
95%	0.241 m/s	
99%	0.302 m/s	
100%	0.410 m/s	
7%	0.030 m/s	threshold values
14%	0.045 m/s	
39%	0.095 m/s	
53%	0.122 m/s	
		mean

<b>Major axis :</b>	360 (Deg-G)	0.186 m/s
<b>Residual current :</b>	0.020 m/s at 016 (Deg-G)	

	Residual	Tidal amplitude
<b>Longitudinal (U) :</b>	0.019 m/s	0.186 m/s
<b>Lateral (V) :</b>	0.006 m/s	0.063 m/s
<b>Anisotropy (long'/lat') :</b>	3.44	2.97



x	y
major axis 360	
-1E-16	0.4
-5E-17	0.1861
0	0
#####	#####
residual 016	
0	0
0.0056	0.0192
0.1116	0.3841

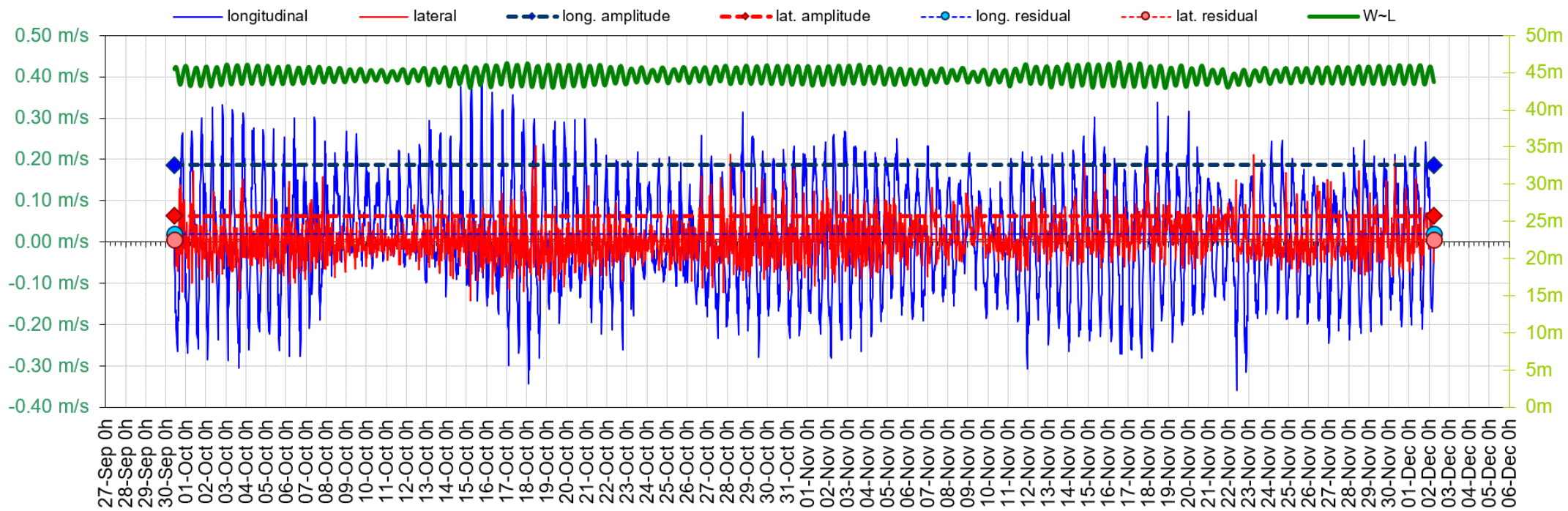


Figure 6. Current Data Summary Sheet for the near bottom current cell 1, 2.72m from seabed, 30<sup>th</sup> September to 2<sup>nd</sup> December 2016 inclusive (ID119).

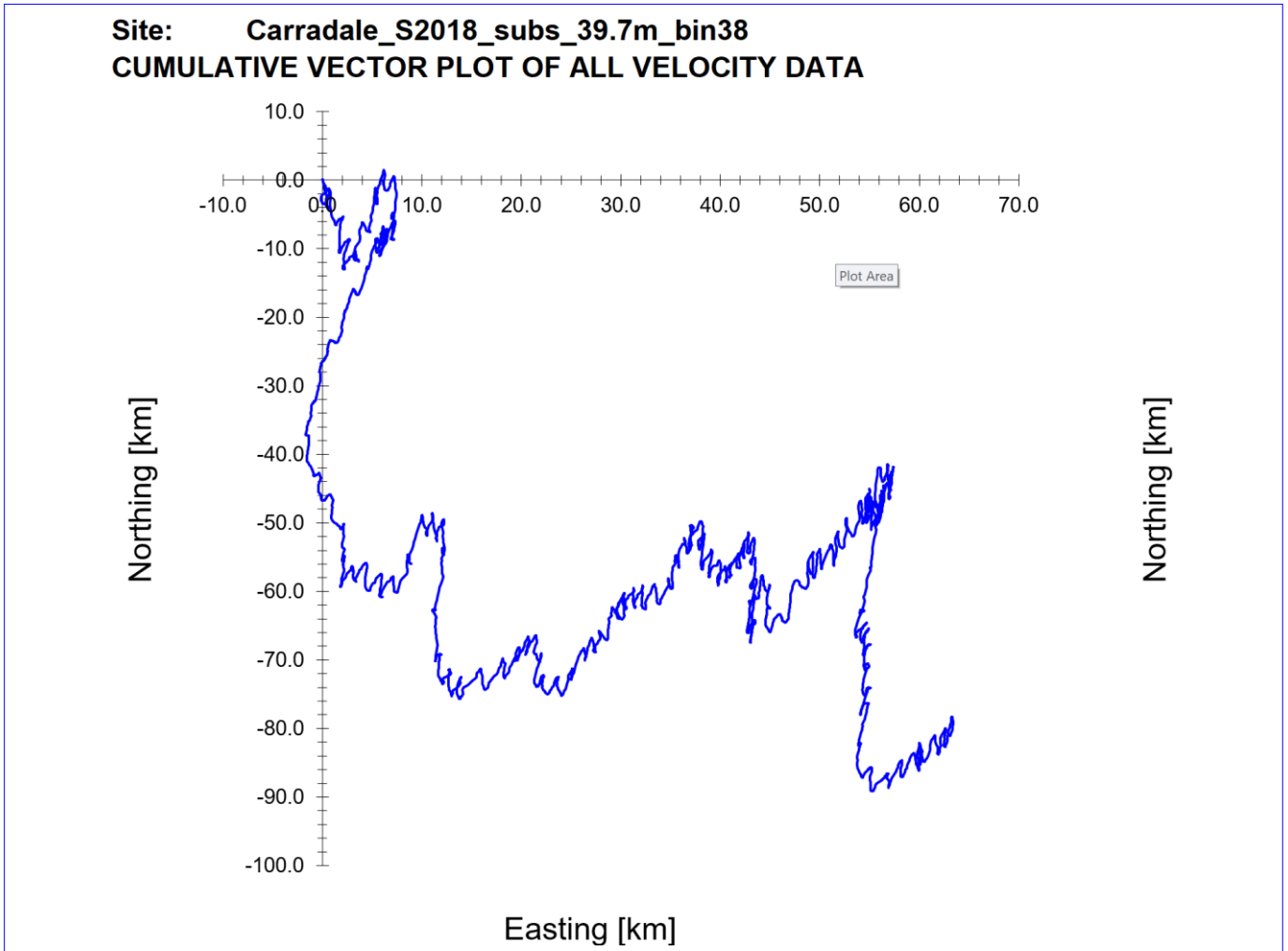


Figure 7. Cumulative Vector Plot of all velocity data from near surface cell for ID119.

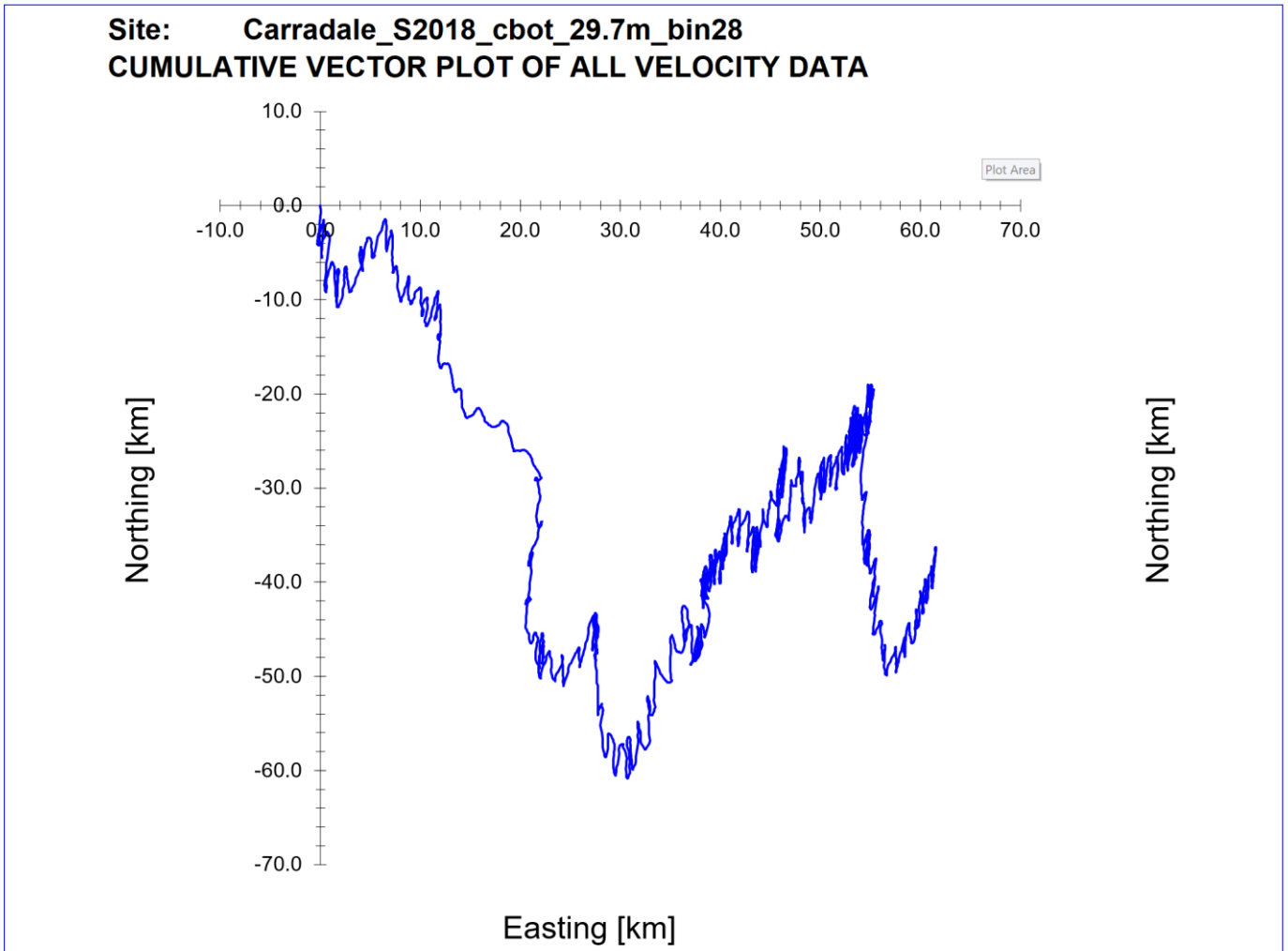


Figure 8. Cumulative Vector Plot of all velocity data from cage bottom cell for ID119.

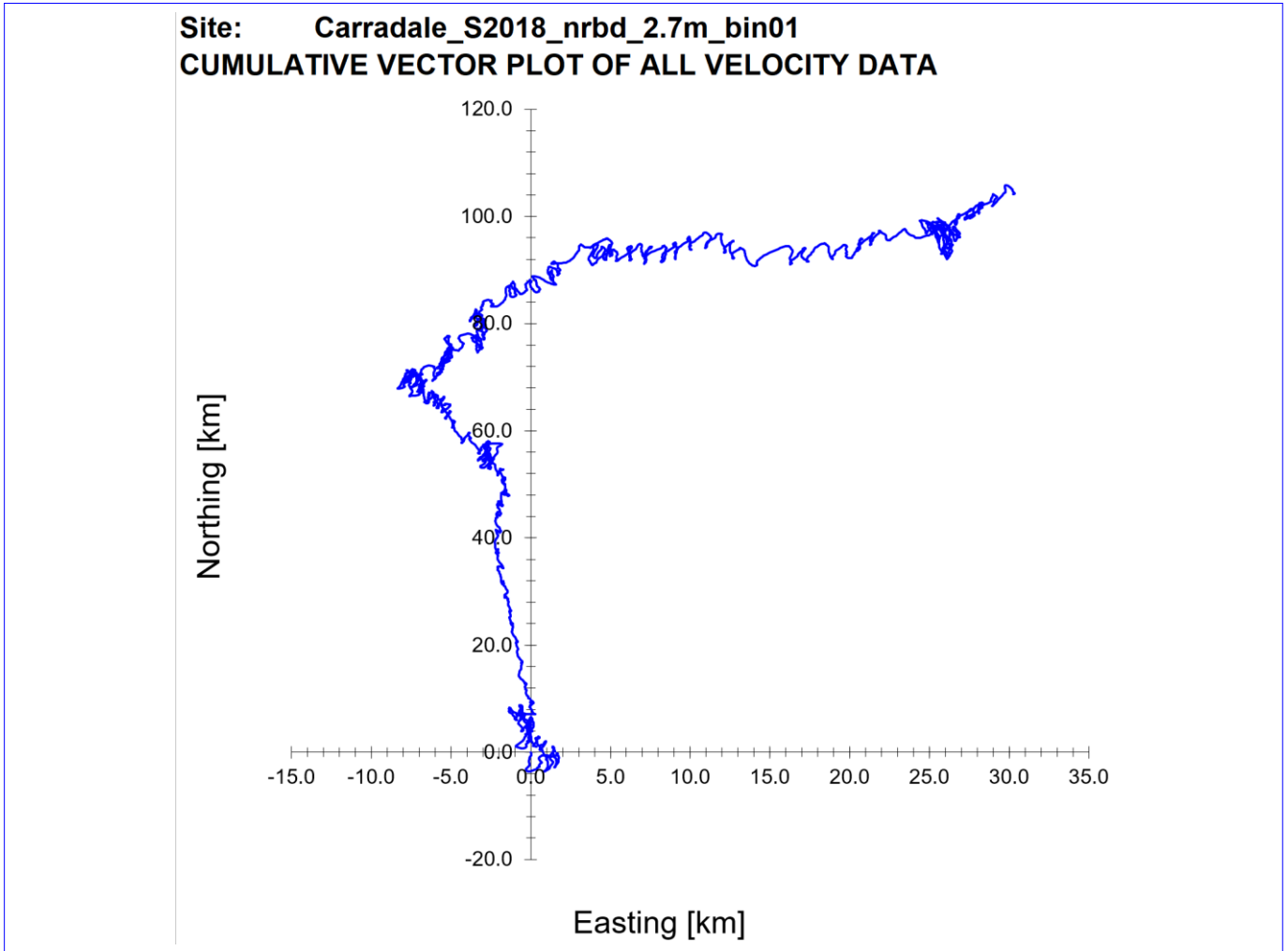


Figure 9. Cumulative Vector Plot of all velocity data from near bottom cell for ID119.



## 5. Summary of Current Data – ID119

Site Name: Carradale  
 Data start date: 30/09/2016  
 Data end date: 02/12/2016  
 Mean Water Depth: 47.36m

Table 2. Summary of current meter deployment

	Cell	Depth Below Mean Surface (m)	Distance from Seabed (m)	Mean current speed (cm/s)
Near surface:	38	7.65	39.72	14.8
Cage bottom:	28	17.65	29.72	14.8
Near bed:	1	44.65	2.72	12.2
Average current speed:				13.93

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:	52	5	90	69
Cage bottom:	53	5	90	70
Near bed:	53	7	86	61

Table 4. Major axis

Cell	Major Axis (Deg-G)
Near surface:	185
Cage Bottom:	185
Near bed:	360

Table 5. Mean and residual currents

Cell	Mean Speed (m/s)	Residual Speed (m/s)	Residual Parallel (m/s)	Residual Normal (m/s)	Tidal Amplitude Parallel (m/s)	Tidal Amplitude Normal (m/s)
Near Surface:	0.148	0.019	0.014	-0.013	0.233	0.054
Cage Bottom:	0.148	0.013	0.006	-0.012	0.234	0.046
Near Bed:	0.122	0.020	0.019	0.006	0.186	0.063

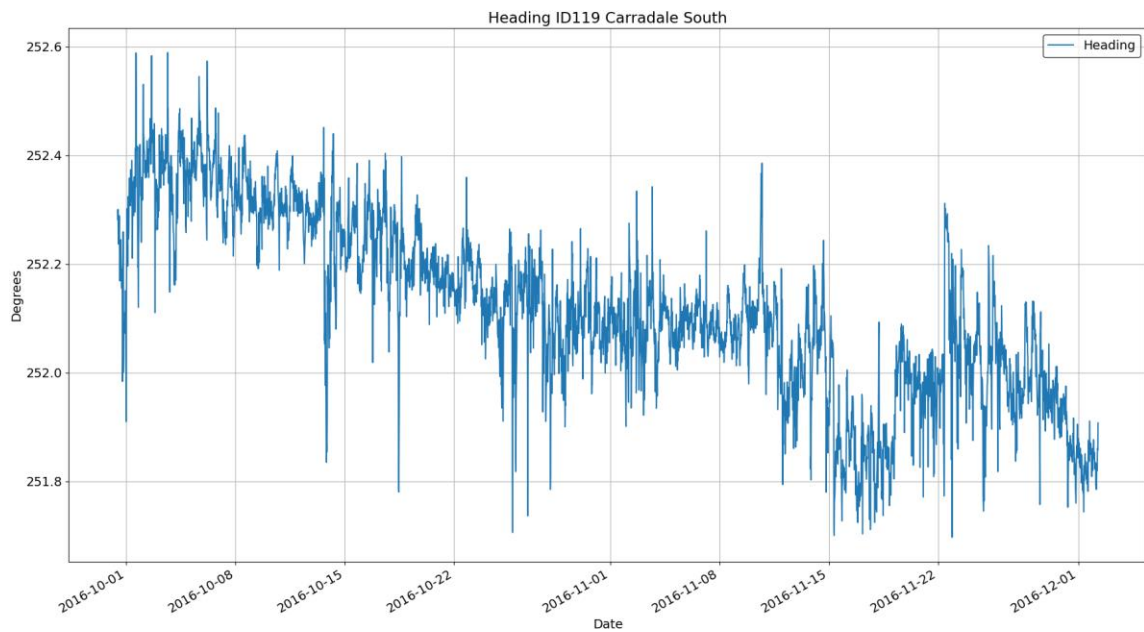


Figure 10. Summary of heading data from deployment ID119.

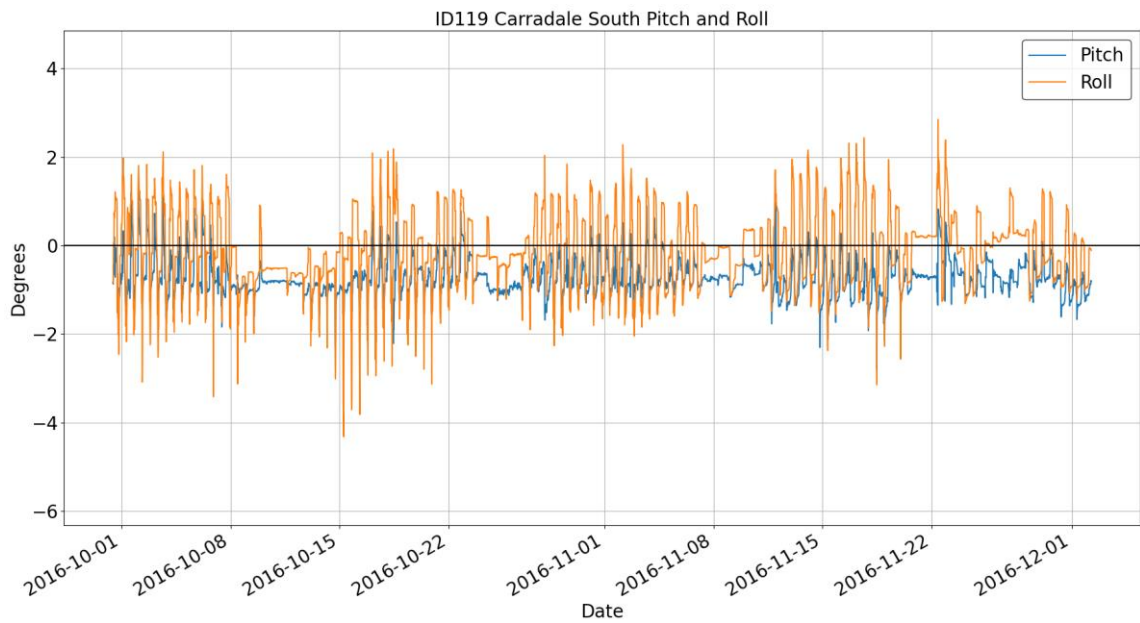


Figure 11. Summary of pitch and roll data from deployment ID119.

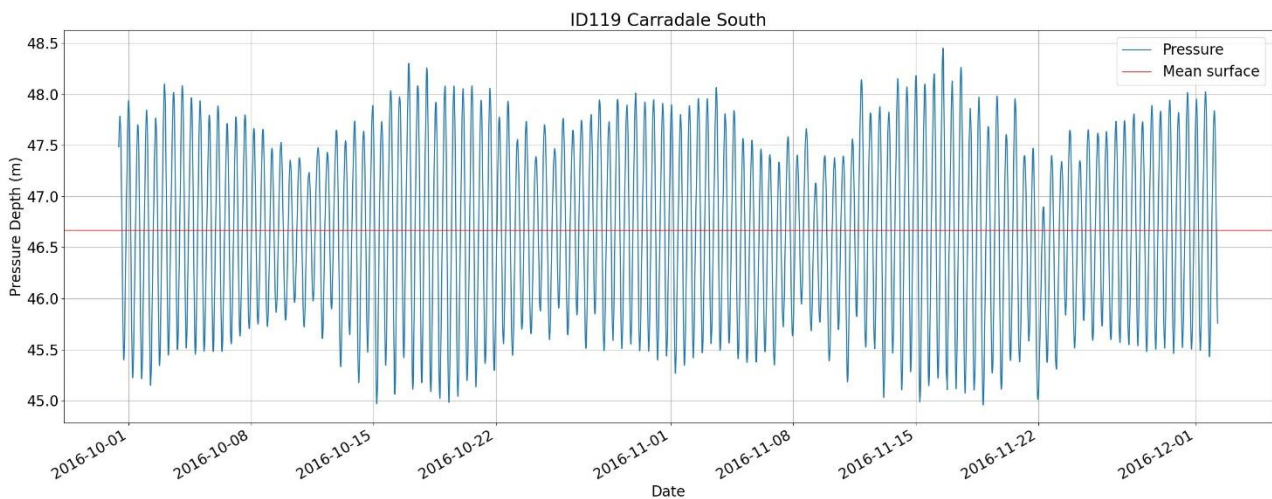


Figure 12. Pressure data from deployment ID119.

## 6. Conclusion

Mowi has collected and analysed current and bathymetric data for the proposed technical variation at the Carradale fish farms. The analysed current data for the 62 days and 22 hours period are believed to be reliable and representative of the proposed location. The bathymetric data from the wider-area UKHO bathymetry data provided a coherent bathymetric dataset for the site.

## Annex 1. Survey Equipment Deployment Log

Location: Carradale  
 Nearest tidal port: Carradale  
 Time zone: UTC  
 Meter switched on: 10:30 30/09/2016  
 Meter switched off: 08:50 02/12/2016  
 Period used for this report: 10:30 30/09/2016 – 05:50 02/12/2016  
 ADCP serial number: 24356  
 Meter position: 55.61283 N -5.4656 W  
 181840 E 640922 N  
 Minimum water depth: 45.66 m (44.96m measured by ADCP + 0.7 m \*)  
 Mean water depth: 47.37 (46.67 measured by ADCP + 0.7 m \*)  
 Height of meter from seabed: 0.7 m to transducer head  
 Sounding at deployment: 40 m @ 09:50 on 30/09/2016

Table A1. ADCP meter settings:

Reference:	Transducer
Bin size (m):	1.0
Dist to 1 <sup>st</sup> bin (m):	2.02
Number of bins:	50
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