

Caolas A Deas East, Loch Shell

Hydrographic Data Report: Deployment ID424

6th October – 29th November 2023

January 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. is preparing an application to the Scottish Environmental Protection Agency (SEPA) for increased bath medicine consents at the site, Caolas A Deas East on Loch Shell, located on the East coast of the Isle of Lewis. Mowi Scotland Ltd. Have swapped the 10 x 100m circumference pens to 4 x 160m circumference pens, and require an increased medicine consent to treat each pen. 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, 2021 and 2023. Hydrographic data at Caolas A Deas East was gathered during this time in three deployments:

- i. 10th September – 8th November 2020 (ID357)
- ii. 9th February – 6th May 2021 (ID367)
- iii. 6th October – 29th November 2023 (ID424)

This report describes the data from the 6th October – 29th November 2023 deployment at Caolas A Deas East (ID424). 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.



Figure 1. Caolas A Deas East and West pens (●) and current meter deployment (▲) locations in Loch Shell.

2. Materials & Methods

2.1 Bathymetry

Model bathymetry was taken from the UK Hydrographic Office (UKHO) data portal (<https://datahub.admiralty.co.uk/portal/apps/sites/#/marine-data-portal>), supplemented by a multibeam survey undertaken in June 2021 (Figure 2). The combined data were interpolated onto the Loch Shell model mesh.

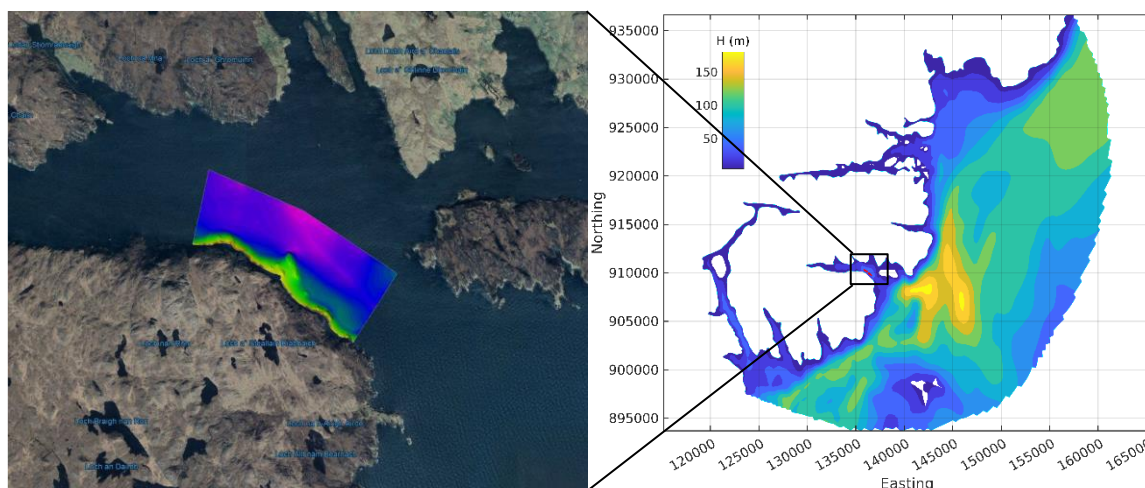


Figure 2. Multibeam survey of bathymetry around Caolas a Deas farm sites from December 2020 (left). Model water depths (H , m) in the model domain (right), incorporating the multibeam data. The proposed cage locations are indicated (●).

2.2 Current Data

Mowi staff carried out hydrographic surveys at the site during 2020, 2021 and 2023. 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 6th October 2023, with the mooring recovered on 6th December 2023.

The instrument used was a Nortek Signature 1000 (Table 1), and was suspended in mid-water about 16.4 m below mean sea level. The deployment location was positioned at 58 00.040N, 006 27.672W (136515E, 909986N), which was approximately 750 m from the nearest shoreline and approximately 220m from the centre of the proposed cage 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 cell size was set at 0.5 m and the number of cells to 43. The ping frequency was about 2.8 Hz, and the data were averaged at 300 s intervals (5 minutes). The blanking distance above the transducers was 0.2 m, giving a first cell height of 0.7 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 1.07°; this was determined using the British Geological Survey Grid Magnetic Angle Calculator. Further details can be found at https://geomag.bgs.ac.uk/cgi-bin/gma_calc.

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 pressure data show that the mooring was disturbed after 54 days; as a result, the final seven days of data following the disturbance were not used in the following analysis. The valid data lasted 53 days and 20 hours.

These data were processed in two ways:

1. The near-surface cell was selected in the usual way, namely as the shallowest cell which contains valid data throughout the deployment. The diagnostic data suggested that velocities from the first 24 bins were valid at all times (Figure 3), therefore data from cell 24 was selected as the near-surface cell. As for standard deployments, this cell was at a depth of a few metres below the lowest measured sea surface height. Given that spring tides in the area have a range of about 4.5 – 5.0 m, the near-surface cell selected in this manner was about 4.5 m below MSL. This is only just within the 0 – 5 m depth water column in which bath medicine dispersion occurs; when the SSH is positive (above MSL) the measured currents will likely lie below the actual near-surface layer in which dispersion is taking place.

Data from Cell 1, at a depth of about 15.7 m below mean sea level are also presented here.

2. To improve the estimation of currents in the near-surface layer (0 – 5 m depth), velocity data were extracted from a fixed depth (2.5 m) relative to the moving water surface (by “surface tracking”). This provided a more accurate estimate of current speed and direction affecting dispersing patches of bath medicine in the top 5 m of the water column, accounting for tidal oscillations in the sea surface height throughout the deployment. The data were processed by identifying the cell at a depth of 2.5 m below the sea surface for each individual record, and building the time series. If the cell at 2.5 m was not valid for a particular record, e.g. due to side lobe interference, lower cells were checked until a valid data cell was found which was used instead. Thus some data used were deeper than 2.5 m relative to the surface; no data shallower than 2.5 m were used.

Data were processed in a similar way for depths of 6.0 m and 10.0 m below the moving sea surface and are presented here also.

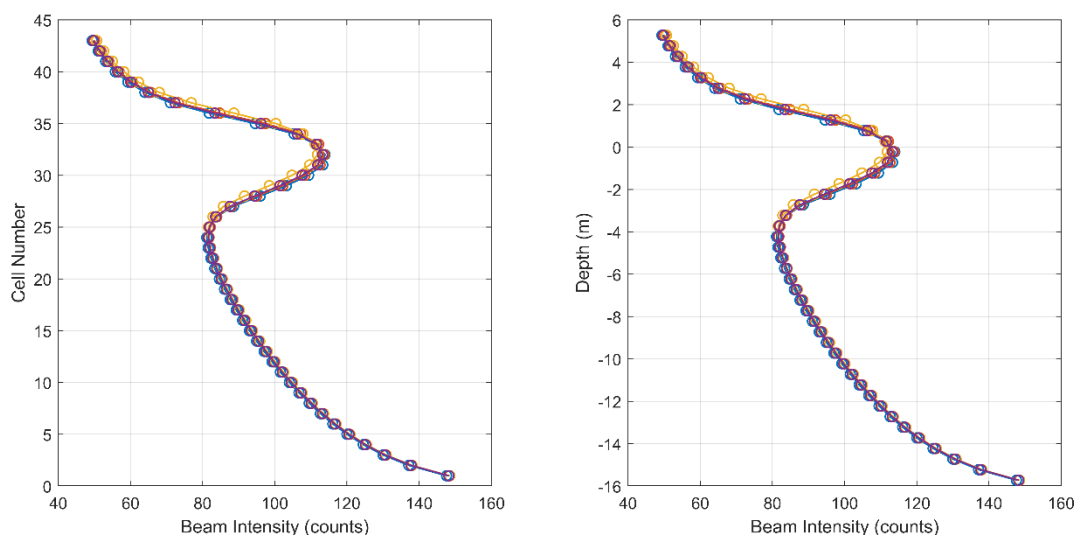


Figure 3. Mean beam intensity of the ADCP signal for the ID424 dataset from 6th October – 29th November 2023 plotted by cell number and depth.

Table 1. Nortek Signature 1000 ADCP Specifications.

CURRENT PROFILER

Signature1000



Technical specifications

| | |
|--|--|
| → Water velocity measurements | |
| Maximum profiling range ¹ | 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 |
| Max 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 3.0 m ² /s. |
| → AD2CP measurement modes (US patent 8223588) | |
| Single | Burst or average |
| Concurrent | Burst and 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 |

Table 2 (cont'd). Nortek Signature 1000 ADCP Specifications.

CURRENT PROFILER

Signature1000



| | |
|----------------------------------|--|
| —> Echo sounder option | |
| Number of bins | 10,000 |
| Transmit pulse length | 16 μ s - 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 max distance | 34 m |
| Maximum wave measurement depth | 30 m |
| Height range | -15 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 sec, 20 m depth; 1.1 sec |
| Cut-off period (dir) | 5 m depth; 1.5 sec, 20 m depth; 3.1 sec |
| Sampling rate (velocity and AST) | 8 Hz |
| —> Ice measurement option | |
| Parameters | N/A |
| —> Sensors | |
| Temperature: | Thermistor in head (sampled at meas. rate) |
| Temp. range | -4 to +40 °C |
| Temp. accuracy/resolution | 0.1 °C/0.01 °C |
| Temp. time response | 2 min |
| Compass: | Solid State magnetometer (max 1 Hz samplerate) |
| 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) |

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 3 to Table 6. Over the period analysed for this report, the currents at 2.5 m, 6.0 m and 10 m below the moving sea surface had speed averages of 5.9 cm/s, 4.7 cm/s and 4.0 cm/s respectively. This gave an overall average of 4.9 cm/s. The orientation of the tidal velocities was north-west – south-east.

The residual currents at all three depths (2.5 m, 6.0 m and 10.0 m) were toward the south-east (124°G, 130°G and 135°G respectively, Figure 6 - Figure 8). The magnitude of the residual currents for the three analysed depths were moderate, with mean values of 0.018 m/s, 0.011 m/s and 0.006 m/s respectively.

Time series of the instrument heading, pitch and roll, and measured pressure are shown in Figure 14 – Figure 16 respectively and demonstrate that the deployment during the selected period of 53.8 days was stable and the data reliable.

4. Hydrographic Data Summary Sheets

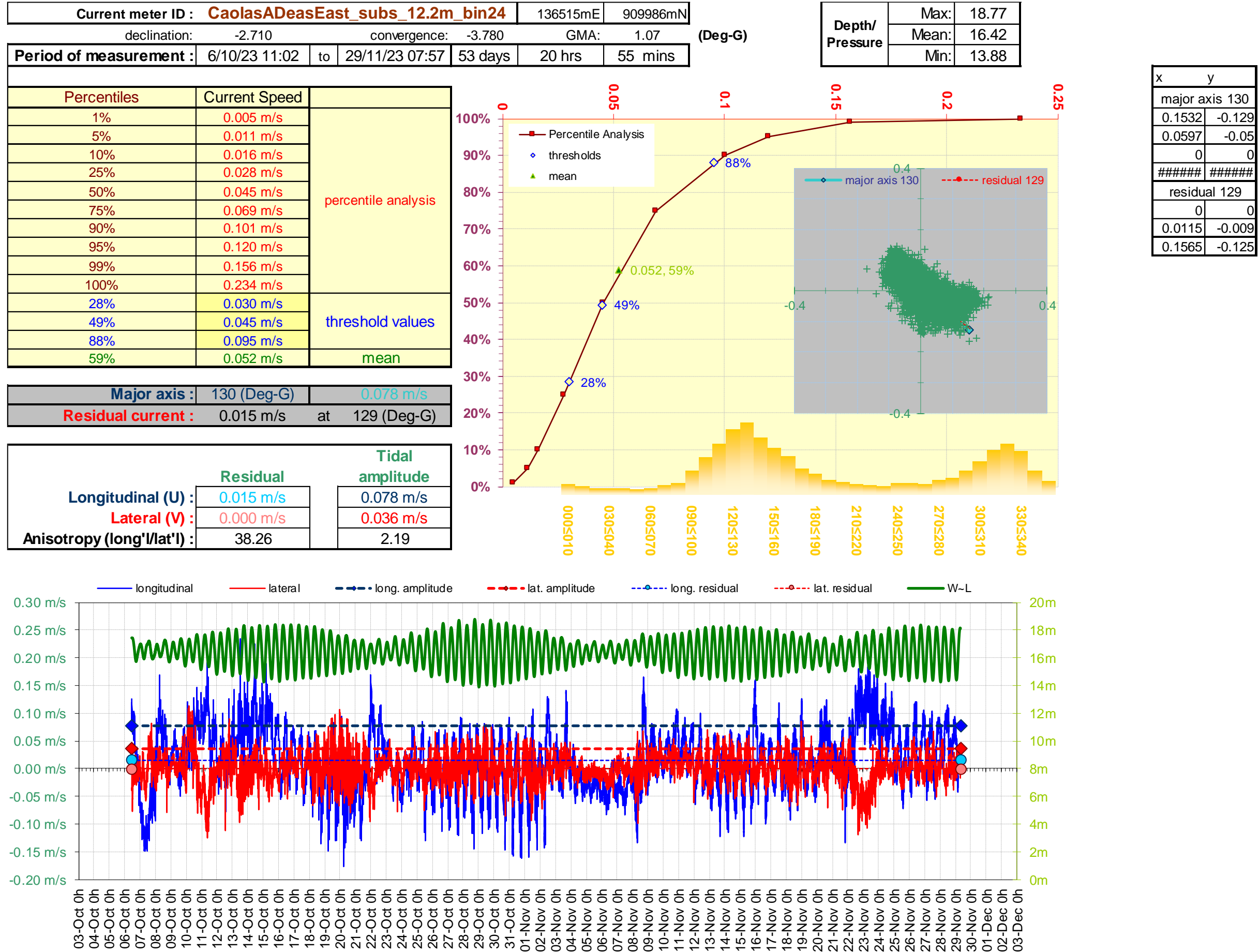


Figure 4. Current Data Summary Sheet for the near-surface current cell 24, 4.2 m below mean sea level, 6th October to 29th November 2023 inclusive (ID424).

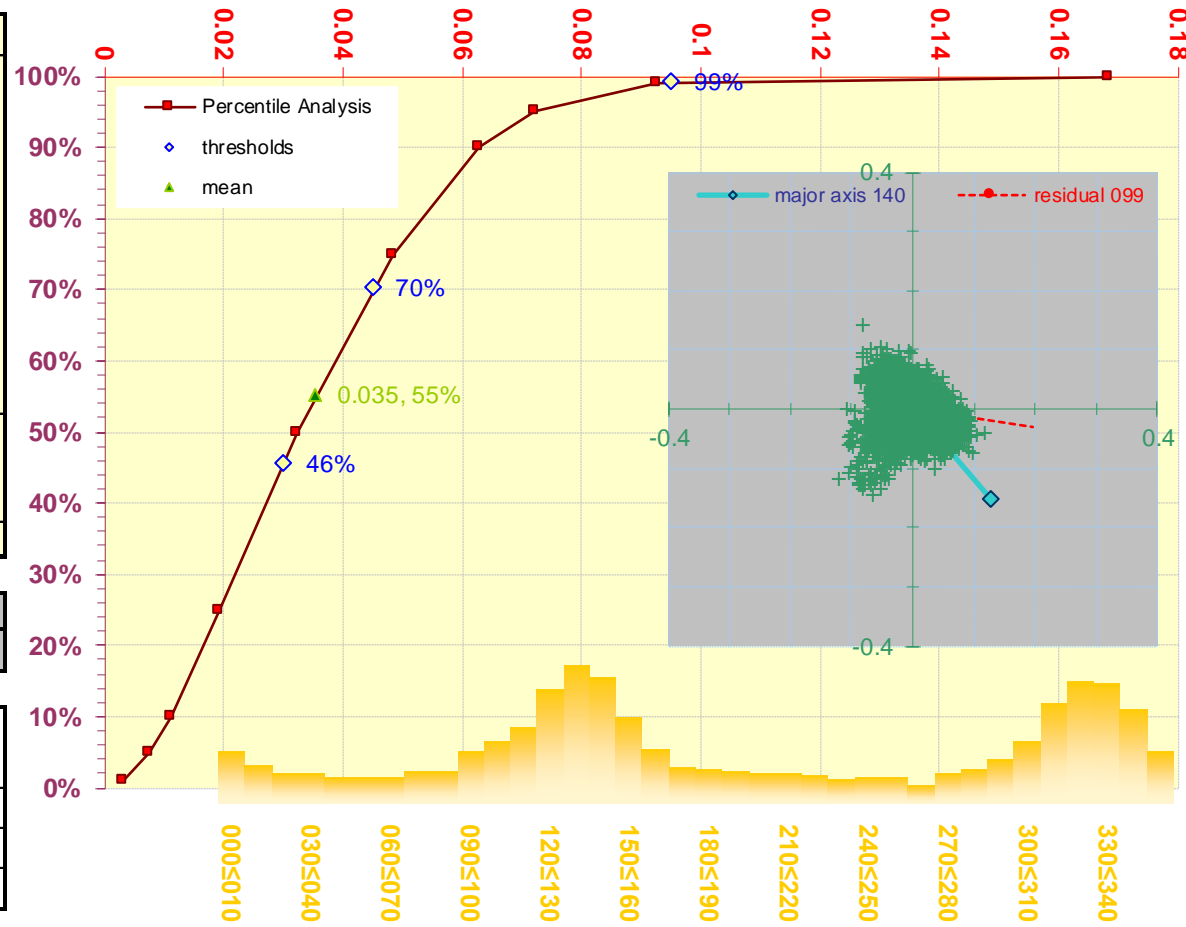
| | | | |
|-------------------------|--|--------------|----------------|
| Current meter ID : | CaolasADeasEast_cbot_0.7m_bin01 | 136515mE | 909986mN |
| declination: | -2.710 | convergence: | -3.780 |
| | | GMA: | 1.07 (Deg-G) |
| Period of measurement : | 6/10/23 11:02 to 29/11/23 07:57 | 53 days | 20 hrs 55 mins |

| | | |
|--------------------|-------|-------|
| Depth/ Pressure | Max: | 18.77 |
| | Mean: | 16.42 |
| | Min: | 13.88 |

| Percentiles | Current Speed | |
|-------------|---------------|---------------------|
| 1% | 0.003 m/s | percentile analysis |
| 5% | 0.008 m/s | |
| 10% | 0.011 m/s | |
| 25% | 0.019 m/s | |
| 50% | 0.032 m/s | |
| 75% | 0.048 m/s | |
| 90% | 0.063 m/s | |
| 95% | 0.072 m/s | |
| 99% | 0.093 m/s | |
| 100% | 0.168 m/s | threshold values |
| 46% | 0.030 m/s | |
| 70% | 0.045 m/s | |
| 99% | 0.095 m/s | |
| 55% | 0.035 m/s | |

| | | |
|--------------------|-------------|----------------|
| Major axis : | 140 (Deg-G) | 0.050 m/s |
| Residual current : | 0.003 m/s | at 099 (Deg-G) |

| | Residual | Tidal amplitude |
|----------------------------|------------|-----------------|
| Longitudinal (U) : | 0.002 m/s | 0.050 m/s |
| Lateral (V) : | -0.002 m/s | 0.029 m/s |
| Anisotropy (long'/lat'I) : | 1.15 | 1.73 |



| x | y |
|----------------|--------|
| major axis 140 | |
| 0.1286 | -0.153 |
| 0.0322 | -0.038 |
| 0 | 0 |
| ##### | ##### |
| residual 099 | |
| 0 | 0 |
| 0.0025 | -4E-04 |
| 0.1976 | -0.031 |

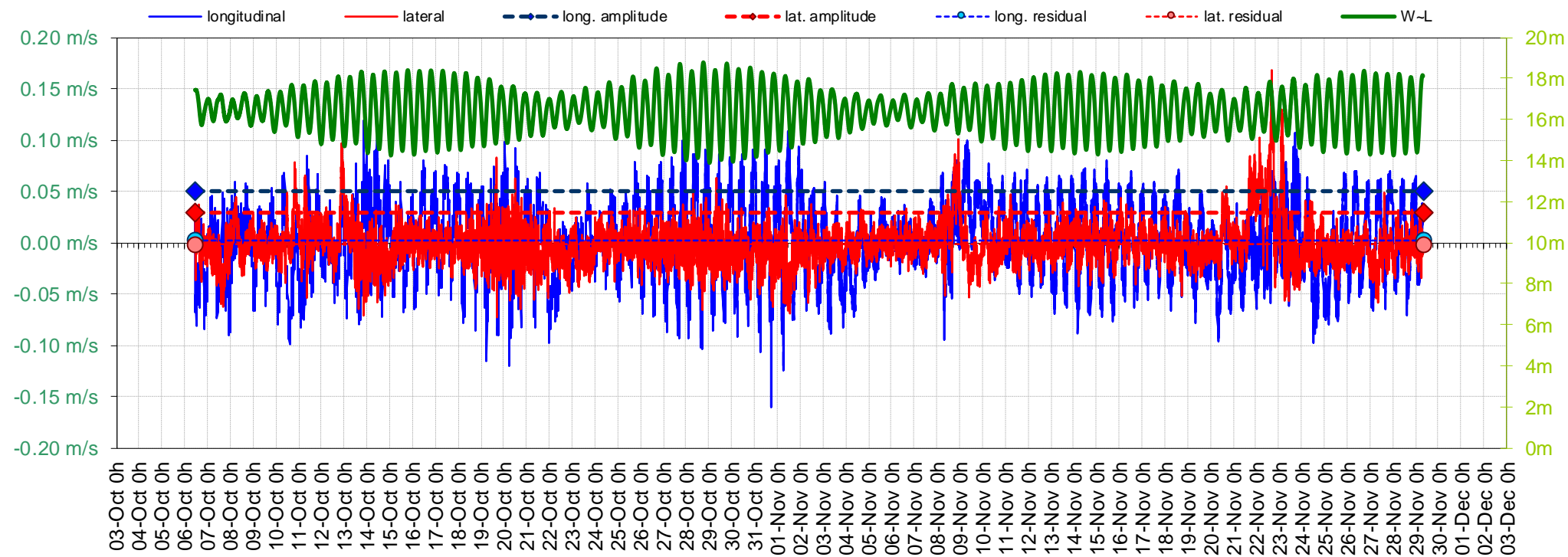


Figure 5. Current Data Summary Sheet for the cage bottom current cell 1, 15.7 m below mean sea level, 6th October to 29th November 2023 inclusive (ID424).

| | | | |
|-------------------------|----------------------------------|--------------|----------------|
| Current meter ID : | CaolasADeasEast_subs_2p5m | 136515mE | 909986mN |
| declination: | -2.710 | convergence: | -3.780 |
| | | GMA: | 1.07 |
| Period of measurement : | 6/10/23 11:02 | to | 29/11/23 07:57 |
| | 53 days | 20 hrs | 55 mins |

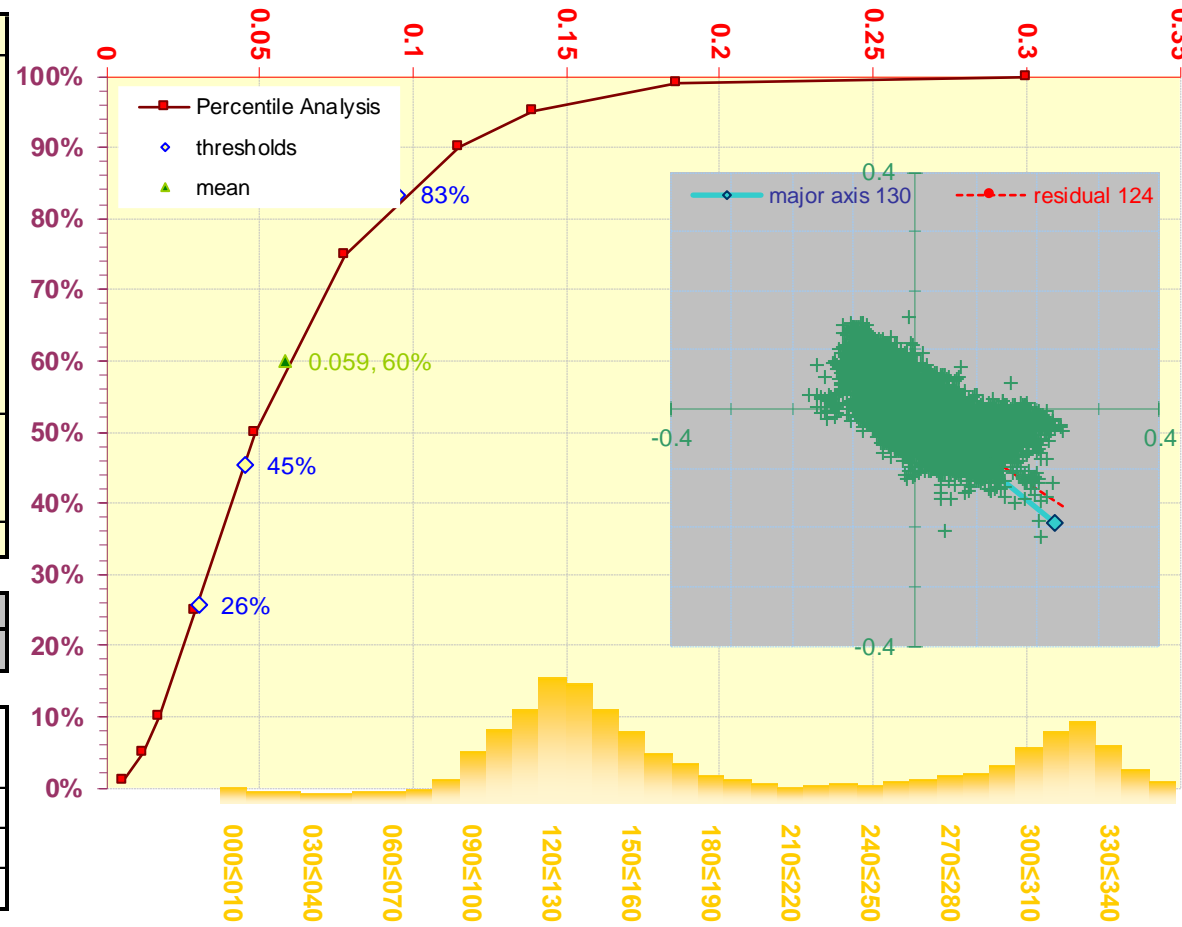
(Deg-G)

| | | |
|--------------------|-------|-------|
| Depth/ Pressure | Max: | 18.77 |
| | Mean: | 16.42 |
| | Min: | 13.88 |

| Percentiles | Current Speed | |
|-------------|---------------|---------------------|
| 1% | 0.005 m/s | percentile analysis |
| 5% | 0.012 m/s | |
| 10% | 0.017 m/s | |
| 25% | 0.029 m/s | |
| 50% | 0.049 m/s | |
| 75% | 0.078 m/s | |
| 90% | 0.115 m/s | |
| 95% | 0.139 m/s | |
| 99% | 0.186 m/s | |
| 100% | 0.300 m/s | |
| 26% | 0.030 m/s | threshold values |
| 45% | 0.045 m/s | |
| 83% | 0.095 m/s | |
| 60% | 0.059 m/s | mean |

| | | |
|--------------------|-------------|----------------|
| Major axis : | 130 (Deg-G) | 0.088 m/s |
| Residual current : | 0.018 m/s | at 124 (Deg-G) |

| | Residual | Tidal amplitude |
|----------------------------|------------|-----------------|
| Longitudinal (U) : | 0.018 m/s | 0.088 m/s |
| Lateral (V) : | -0.002 m/s | 0.040 m/s |
| Anisotropy (long'/lat'I) : | 9.64 | 2.23 |



| x | y |
|----------------|--------|
| major axis 130 | |
| 0.2298 | -0.193 |
| 0.0678 | -0.057 |
| 0 | 0 |
| ##### | ##### |
| residual 124 | |
| 0 | 0 |
| 0.0153 | -0.01 |
| 0.2485 | -0.168 |

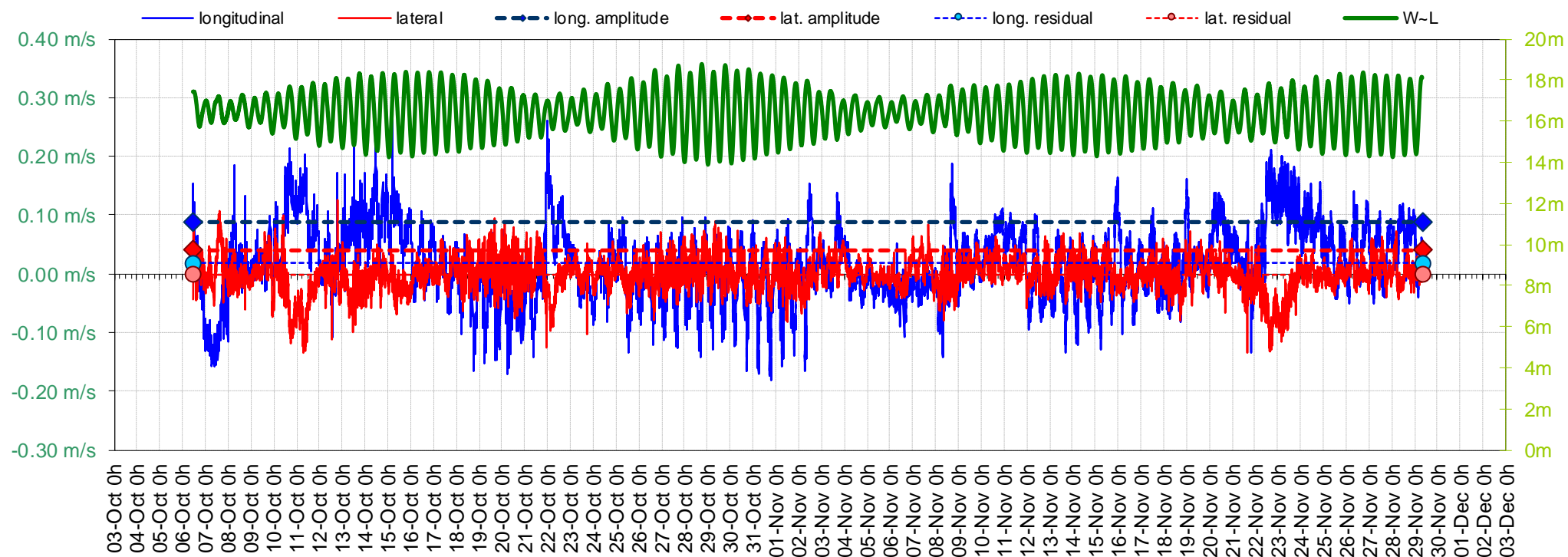


Figure 6. Current Data Summary Sheet for the current at 2.5 m below the moving sea level, 6th October to 29th November 2023 inclusive (ID424).

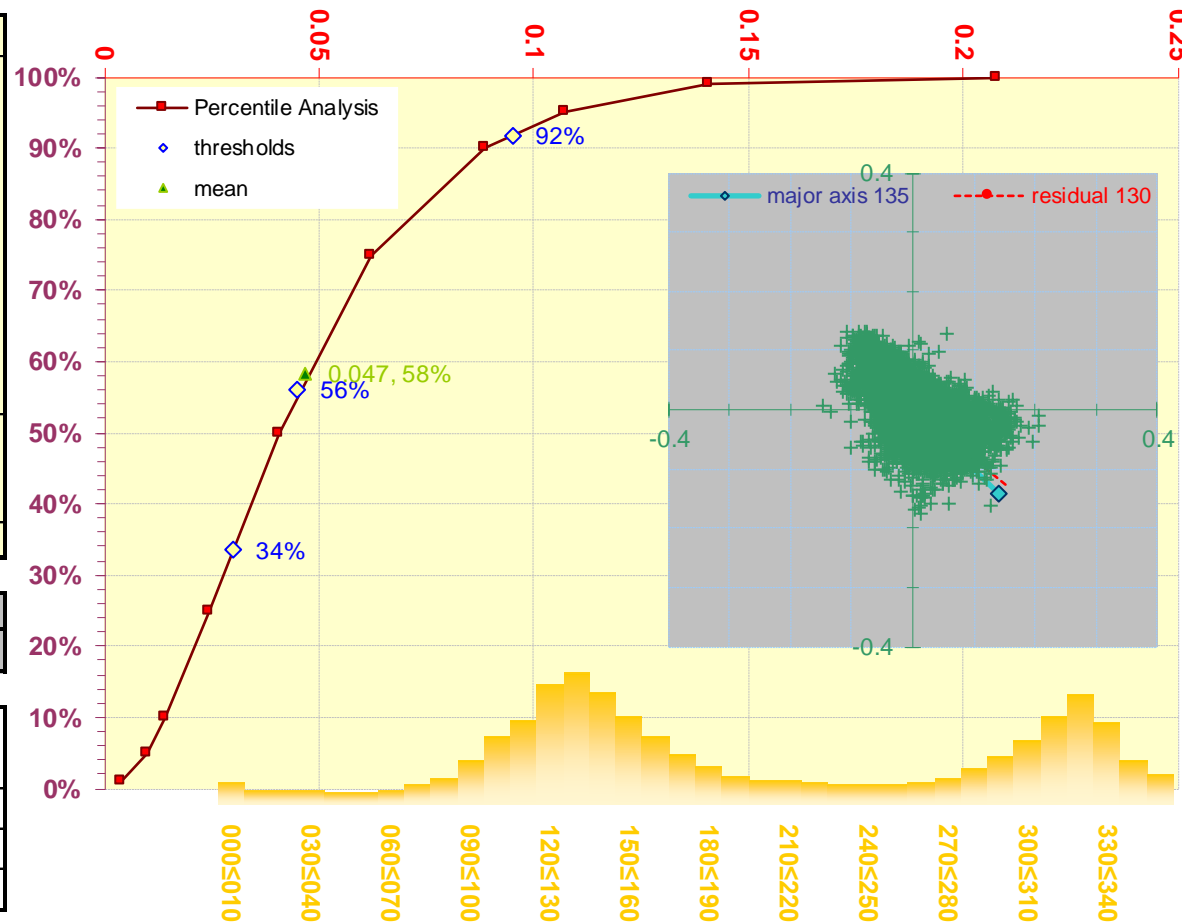
| | | | | |
|-------------------------|---------------------------|--------------|----------------|------------------------|
| Current meter ID : | CaolasADeasEast_6m | | 136515mE | 909986mN |
| declination: | -2.710 | convergence: | -3.780 | GMA: 1.07 |
| Period of measurement : | 6/10/23 11:02 | to | 29/11/23 07:57 | 53 days 20 hrs 55 mins |

| | | |
|--------------------|-------|-------|
| Depth/ Pressure | Max: | 18.77 |
| | Mean: | 16.42 |
| | Min: | 13.88 |

| Percentiles | Current Speed | |
|-------------|---------------|---------------------|
| 1% | 0.004 m/s | percentile analysis |
| 5% | 0.010 m/s | |
| 10% | 0.014 m/s | |
| 25% | 0.025 m/s | |
| 50% | 0.041 m/s | |
| 75% | 0.062 m/s | |
| 90% | 0.089 m/s | |
| 95% | 0.108 m/s | |
| 99% | 0.141 m/s | |
| 100% | 0.208 m/s | |
| 34% | 0.030 m/s | threshold values |
| 56% | 0.045 m/s | |
| 92% | 0.095 m/s | |
| 58% | 0.047 m/s | |
| | | mean |

| | | |
|--------------------|-------------|----------------|
| Major axis : | 135 (Deg-G) | 0.070 m/s |
| Residual current : | 0.011 m/s | at 130 (Deg-G) |

| | Residual | Tidal amplitude |
|----------------------------|------------|-----------------|
| Longitudinal (U) : | 0.011 m/s | 0.070 m/s |
| Lateral (V) : | -0.001 m/s | 0.033 m/s |
| Anisotropy (long'/lat'l) : | 11.54 | 2.11 |



| x | y |
|----------------|--------|
| major axis 135 | |
| 0.1414 | -0.141 |
| 0.0494 | -0.049 |
| 0 | 0 |
| ##### | ##### |
| residual 130 | |
| 0 | 0 |
| 0.0083 | -0.007 |
| 0.1531 | -0.129 |

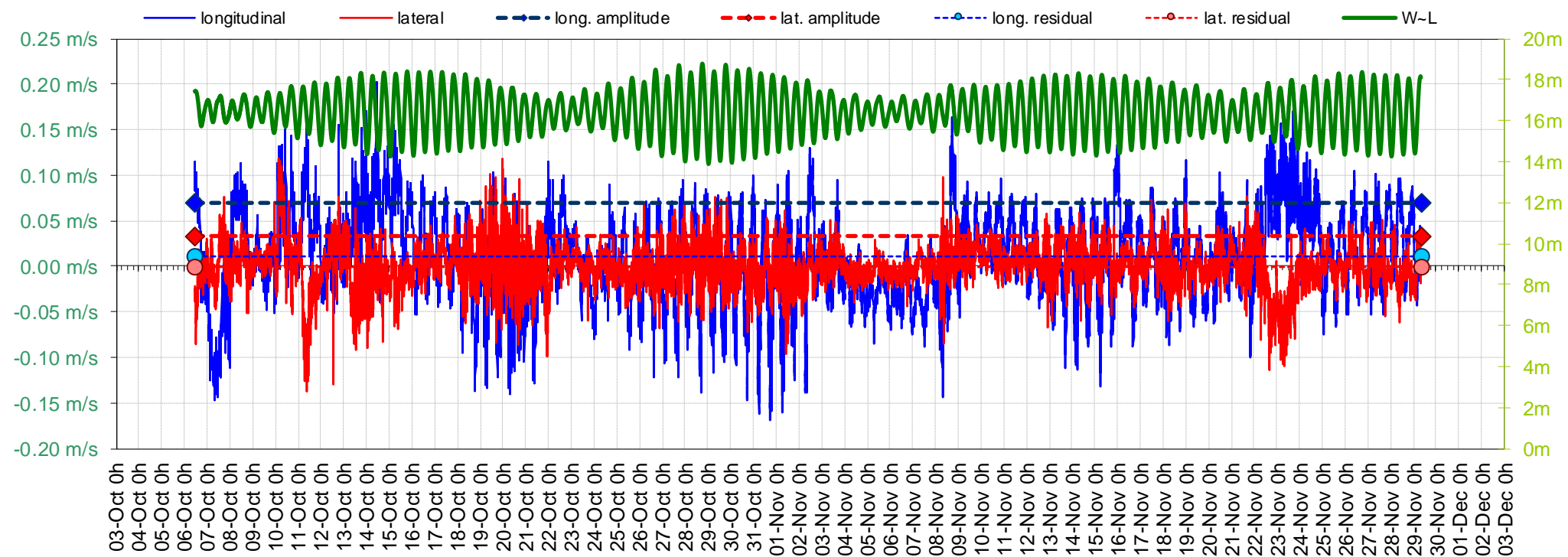


Figure 7. Current Data Summary Sheet for the current at 6.0 m below the moving sea level, 6th October to 29th November 2023 inclusive (ID424).

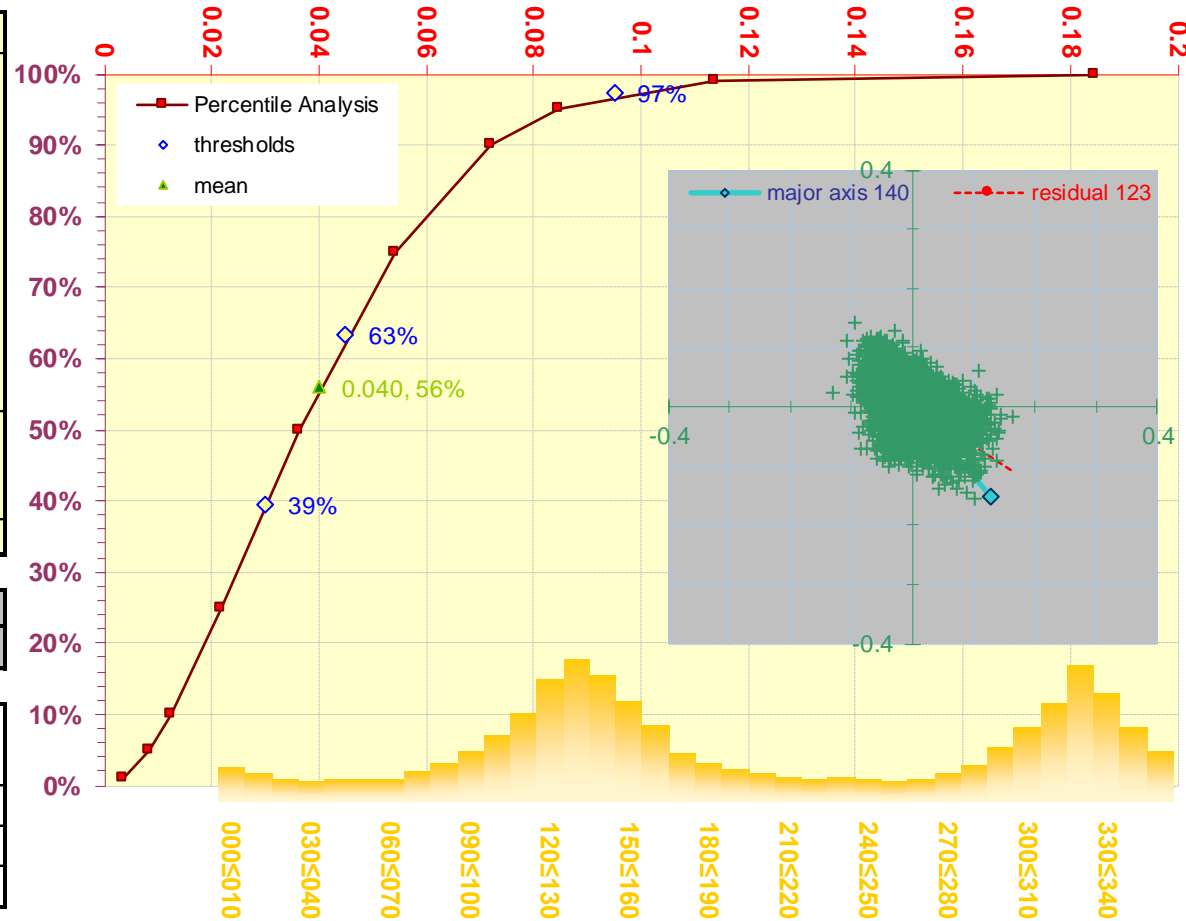
| | | | |
|-------------------------|---------------------------------|--------------|----------------|
| Current meter ID : | CaolasADeasEast_10m | 136515mE | 909986mN |
| declination: | -2.710 | convergence: | -3.780 |
| | | GMA: | 1.07 |
| Period of measurement : | 6/10/23 11:02 to 29/11/23 07:57 | 53 days | 20 hrs 55 mins |

| | | |
|--------------------|-------|-------|
| Depth/ Pressure | Max: | 18.77 |
| | Mean: | 16.42 |
| | Min: | 13.88 |

| Percentiles | Current Speed | |
|-------------|---------------|---------------------|
| 1% | 0.004 m/s | percentile analysis |
| 5% | 0.008 m/s | |
| 10% | 0.012 m/s | |
| 25% | 0.022 m/s | |
| 50% | 0.036 m/s | |
| 75% | 0.054 m/s | |
| 90% | 0.072 m/s | |
| 95% | 0.085 m/s | |
| 99% | 0.114 m/s | |
| 100% | 0.185 m/s | |
| 39% | 0.030 m/s | threshold values |
| 63% | 0.045 m/s | |
| 97% | 0.095 m/s | |
| 56% | 0.040 m/s | mean |

| | | |
|---------------------------|-------------|----------------|
| Major axis : | 140 (Deg-G) | 0.059 m/s |
| Residual current : | 0.006 m/s | at 123 (Deg-G) |

| | Residual | Tidal amplitude |
|-----------------------------------|------------|-----------------|
| Longitudinal (U) : | 0.006 m/s | 0.059 m/s |
| Lateral (V) : | -0.002 m/s | 0.029 m/s |
| Anisotropy (long'/lat'I) : | 3.36 | 2.00 |



| x | y |
|----------------|--------|
| major axis 140 | |
| 0.1286 | -0.153 |
| 0.0377 | -0.045 |
| 0 | 0 |
| ##### | ##### |
| residual 123 | |
| 0 | 0 |
| 0.0053 | -0.004 |
| 0.1669 | -0.11 |

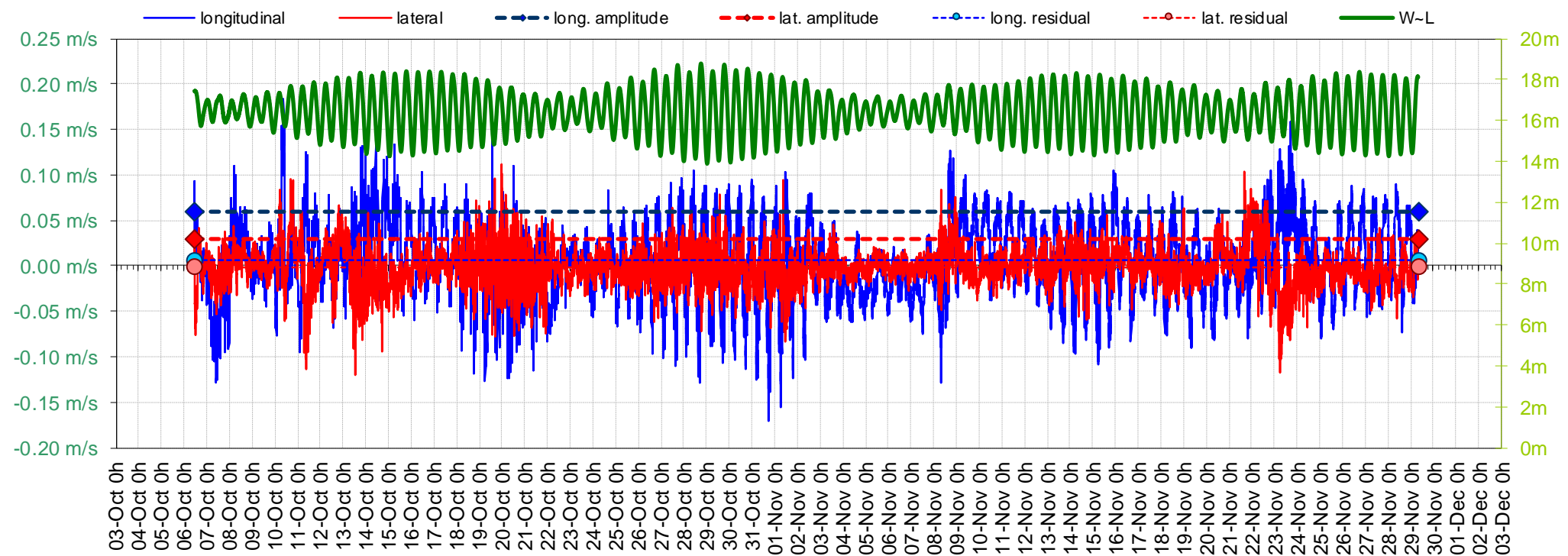


Figure 8. Current Data Summary Sheet for the current at 10.0 m below the moving sea level, 6th October to 29th November 2023 inclusive (ID424).

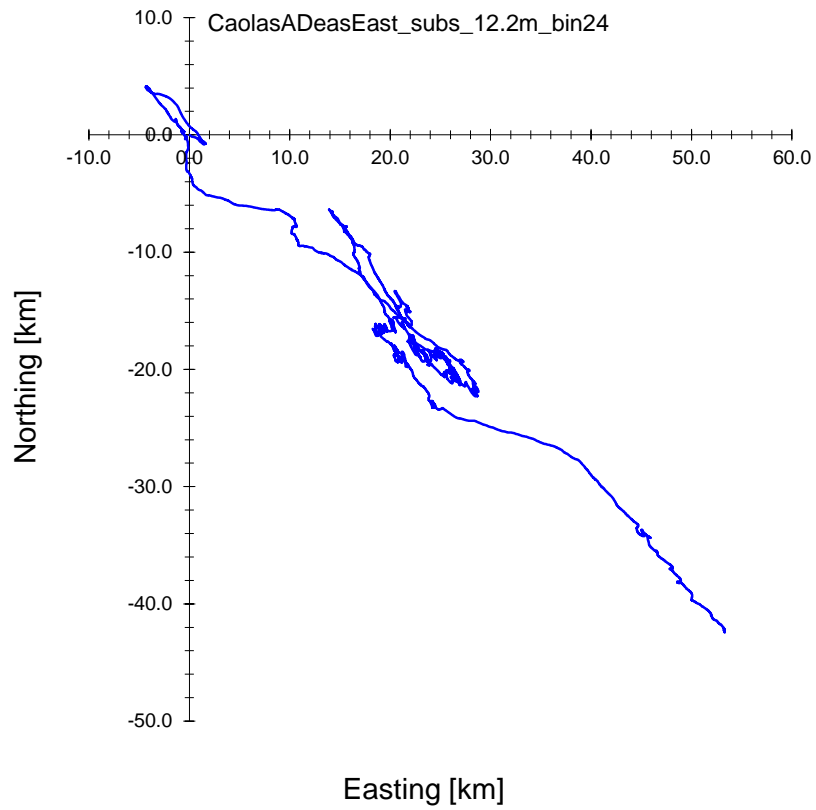


Figure 9. Cumulative vector plot of all velocity data from near-surface cell 24 for ID424.

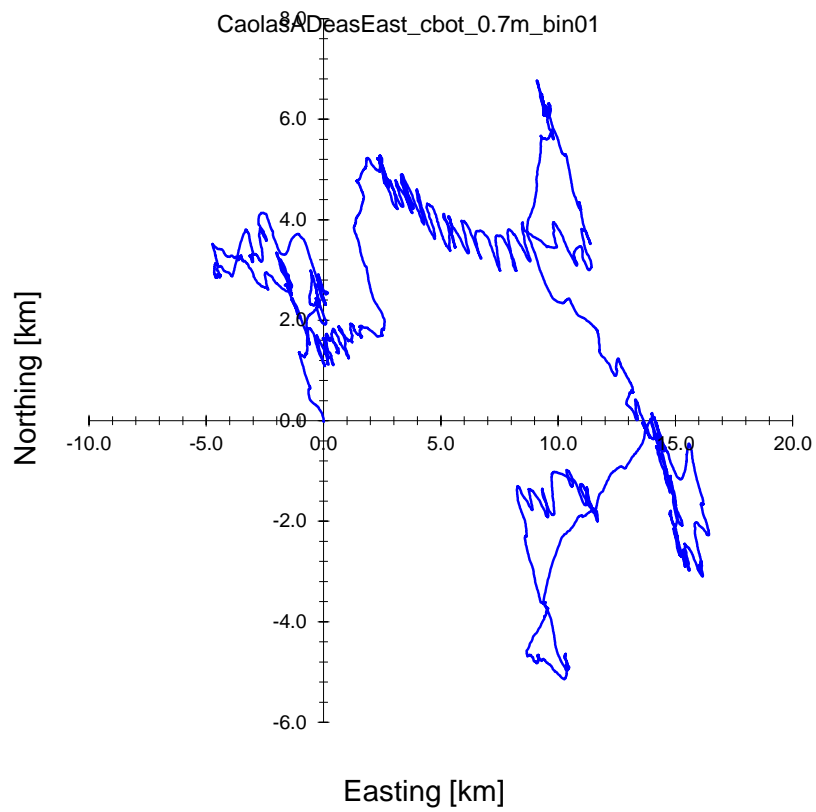


Figure 10. Cumulative vector plot of all velocity data from cell 1 for ID424.

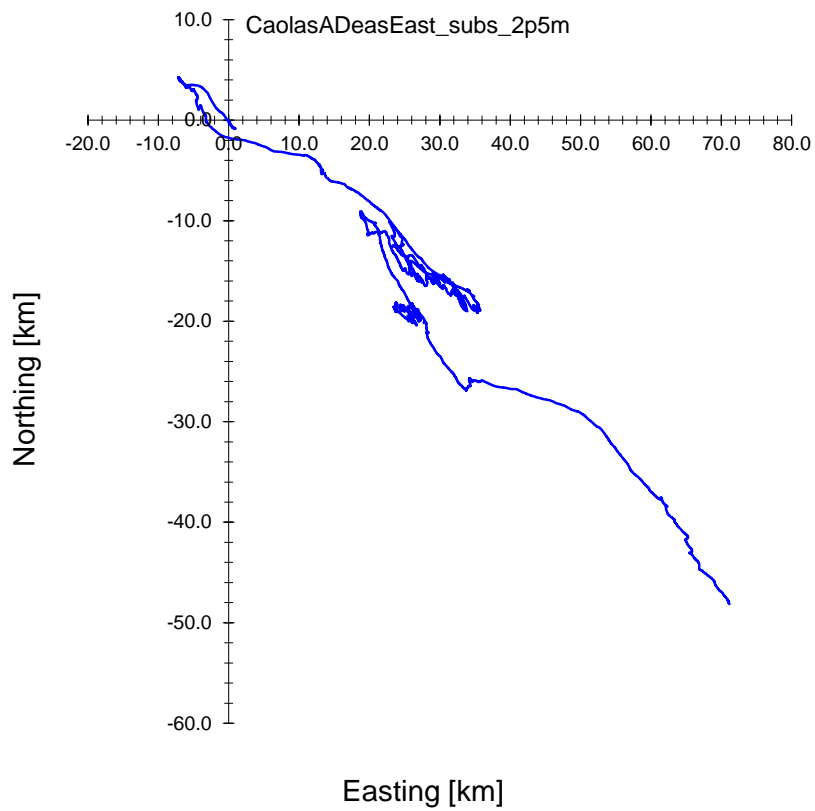


Figure 11. Cumulative vector plot of all velocity data from the current at 2.5 m below the moving sea surface for ID424.

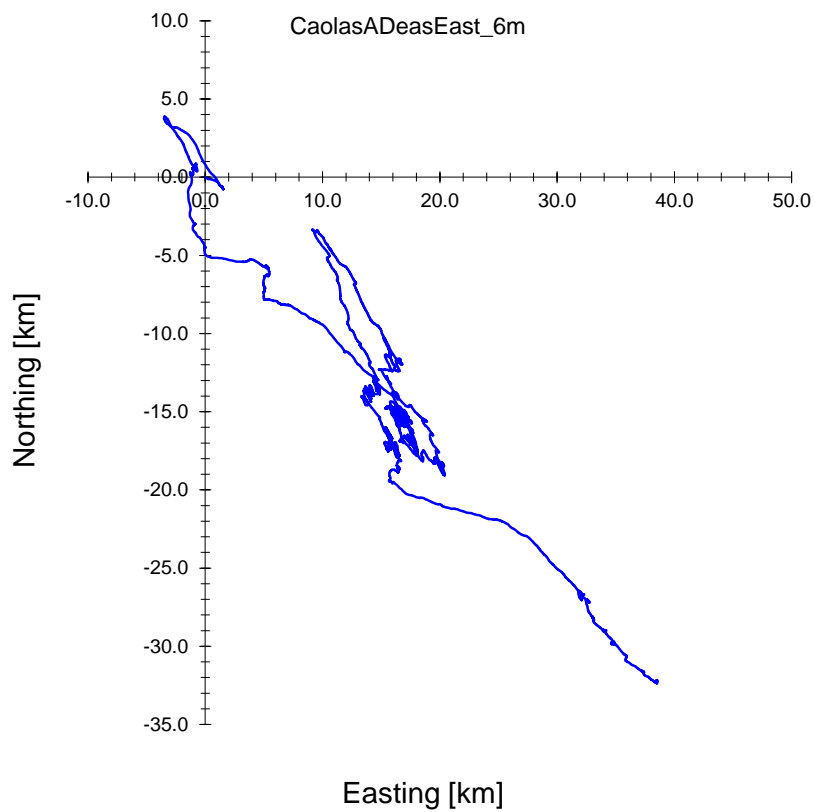


Figure 12. Cumulative vector plot of all velocity data from the current at 6.0 m below the moving sea surface for ID424.

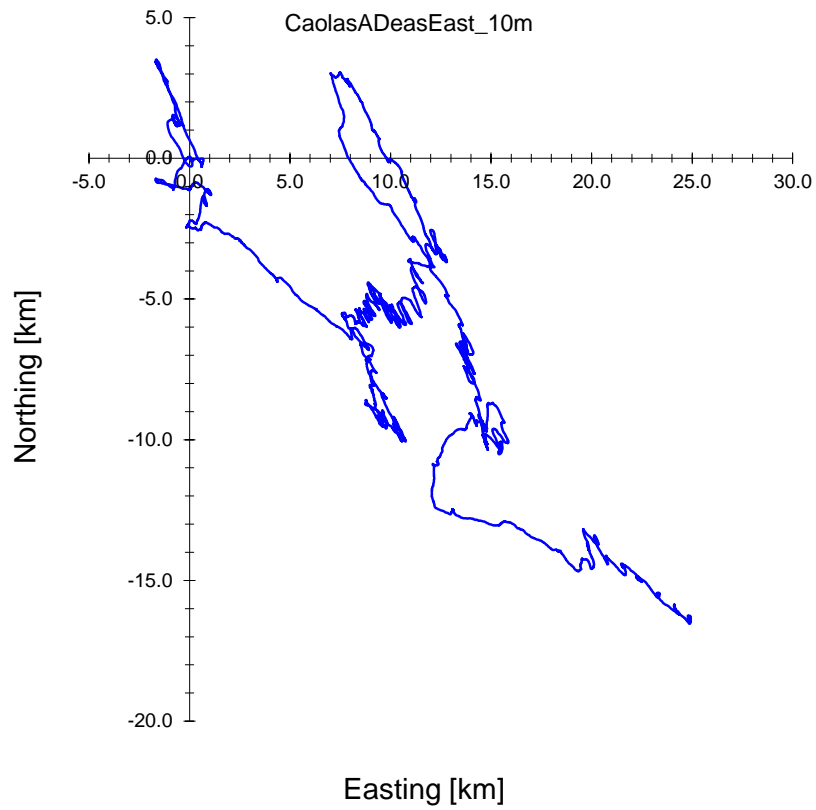


Figure 13. Cumulative vector plot of all velocity data from the current at 10.0 m below the moving sea surface for ID424.

5. Summary of Current Data – ID424

Site Name: Caolas A Deas East
 Data start date: 06/10/2023
 Data end date: 29/11/2023
 Mean Water Depth: approx. 52 m (mid-water deployment)

N.B. This summary relates to the data processed relative to the moving sea surface, since these data were used in the applications to SEPA.

Table 3. Summary of current meter deployment

| | Cell | Depth Below Surface (m) | Distance from Seabed (m) | Mean current speed (cm/s) |
|------------------------|------|-------------------------|--------------------------|---------------------------|
| Near surface: | - | 2.5 | - | 5.9 |
| Middle | - | 6.0 | - | 4.7 |
| Bottom | - | 10.0 | - | 4.0 |
| Average current speed: | | | | 4.9 |

Table 4. 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 | 26 | 55 | 17 |
| Middle | 58 | 34 | 44 | 8 |
| Bottom | 56 | 39 | 37 | 3 |

Table 5. Major axis

| Cell | Major Axis (Deg-G) |
|---------------|--------------------|
| Near surface: | 130 |
| Middle | 135 |
| Bottom | 140 |

Table 6. 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: | 0.018 | 0.018 | -0.002 | 0.088 | 0.040 |
| Middle | 0.011 | 0.011 | -0.001 | 0.070 | 0.033 |
| Bottom | 0.006 | 0.006 | -0.002 | 0.059 | 0.029 |

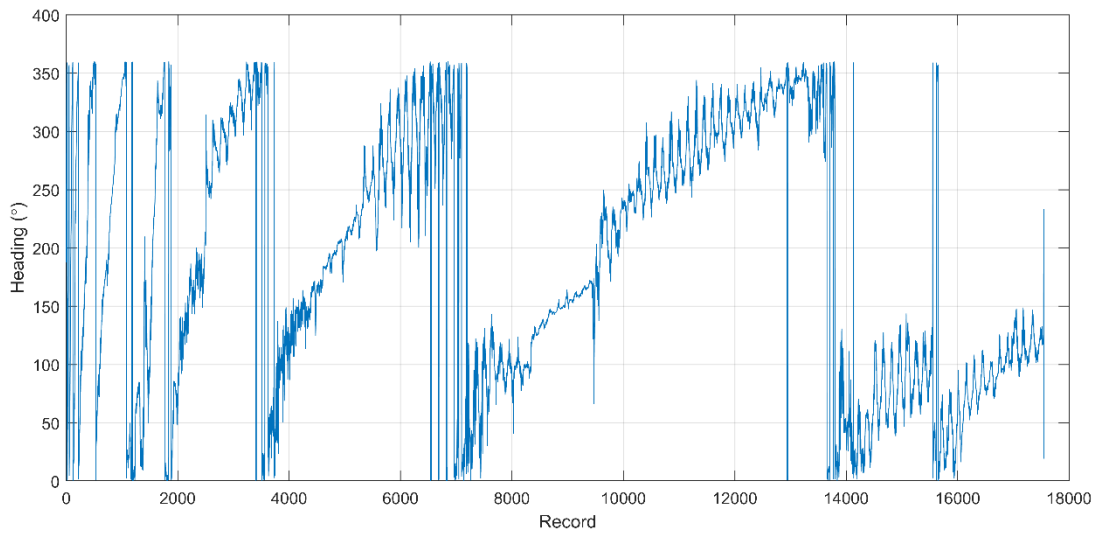


Figure 14. Summary of heading data from deployment ID424.

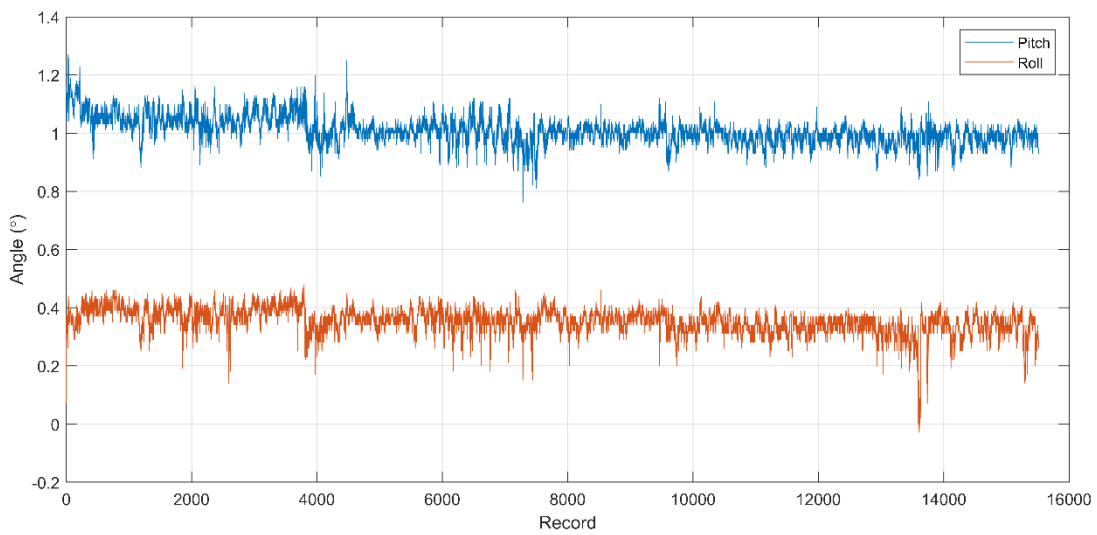


Figure 15. Summary of pitch and roll data from deployment ID424.

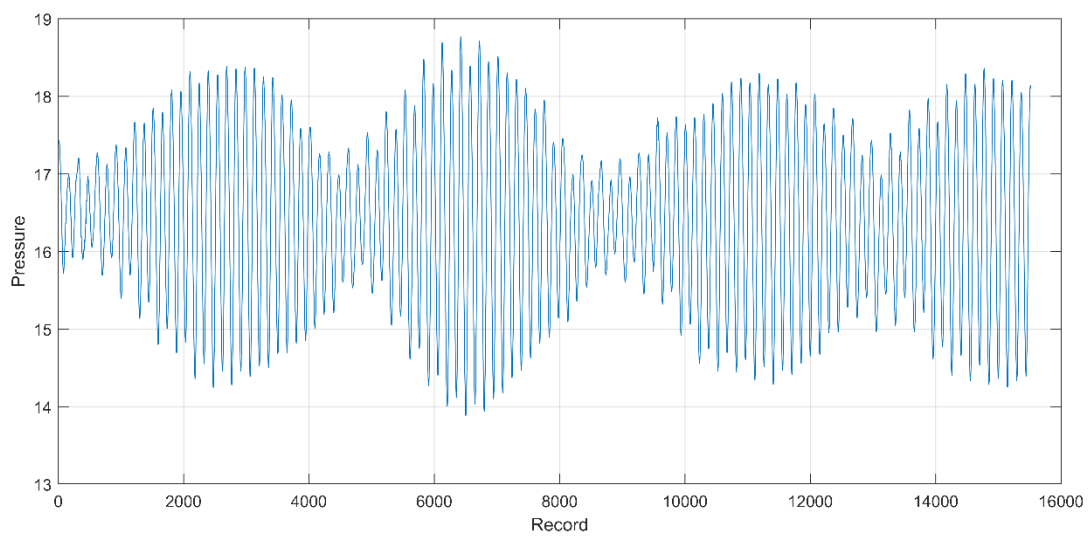


Figure 16. Pressure data from deployment ID424.

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 53 days and 20 hours period are believed to be reliable and representative of the proposed location. The bathymetric data from the UK Hydrographic Office, 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 (raw data in BST)
 Meter switched on: 11:02:29 06/10/2023
 Meter switched off: 09:17:29 06/12/2023
 Period used for this report: 11:02:29 06/10/2023 – 07:57:29 29/11/2023
 ADCP serial number: 105117
 Meter position: 58 00.040N, 006 27.672W
 136515E, 909986N
 Minimum water depth: mid-water deployment
 Water depth (Chart Datum): mid-water deployment
 Mean water depth: mid-water deployment
 Depth of meter from surface: 16.42 m (below mean sea level)
 Height of meter from seabed: mid-water deployment
 Sounding at deployment: 52 m @ 09:50 on 06/10/2023

Table A1. ADCP meter settings.

| Reference: | Transducer |
|----------------------------------|------------|
| Bin size (m): | 0.5 |
| Dist to 1 st bin (m): | 0.7 |
| Number of bins: | 43 |
| 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 |