Gorsten, Loch Linnhe

Hydrographic Data Report: Deployment ID280

26th July to 14th October 2019

February 2023
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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 temporary modification to CAR/L/1009968 Mowi Scotland Ltd. propose to give a temporary increase to the consented maximum biomass at the Gorsten fish farm, on Loch Linnhe. No change to the equipment will be applied for.

Mowi Scotland Ltd. have carried out hydrographic surveys at the site in 2019 and 2020. Hydrographic data at Gorsten was gathered during this time in two deployments:

i. 26th July to 14th October 2019 (ID280)
ii. 5th November 2019 to 17th January 2020 (ID311)

This report describes the data from the 26th July to 14th October 2019 deployment at Gorsten. The purpose of this report is to assess the suitability of the collected hydrographic data for input into the NewDepomod model.

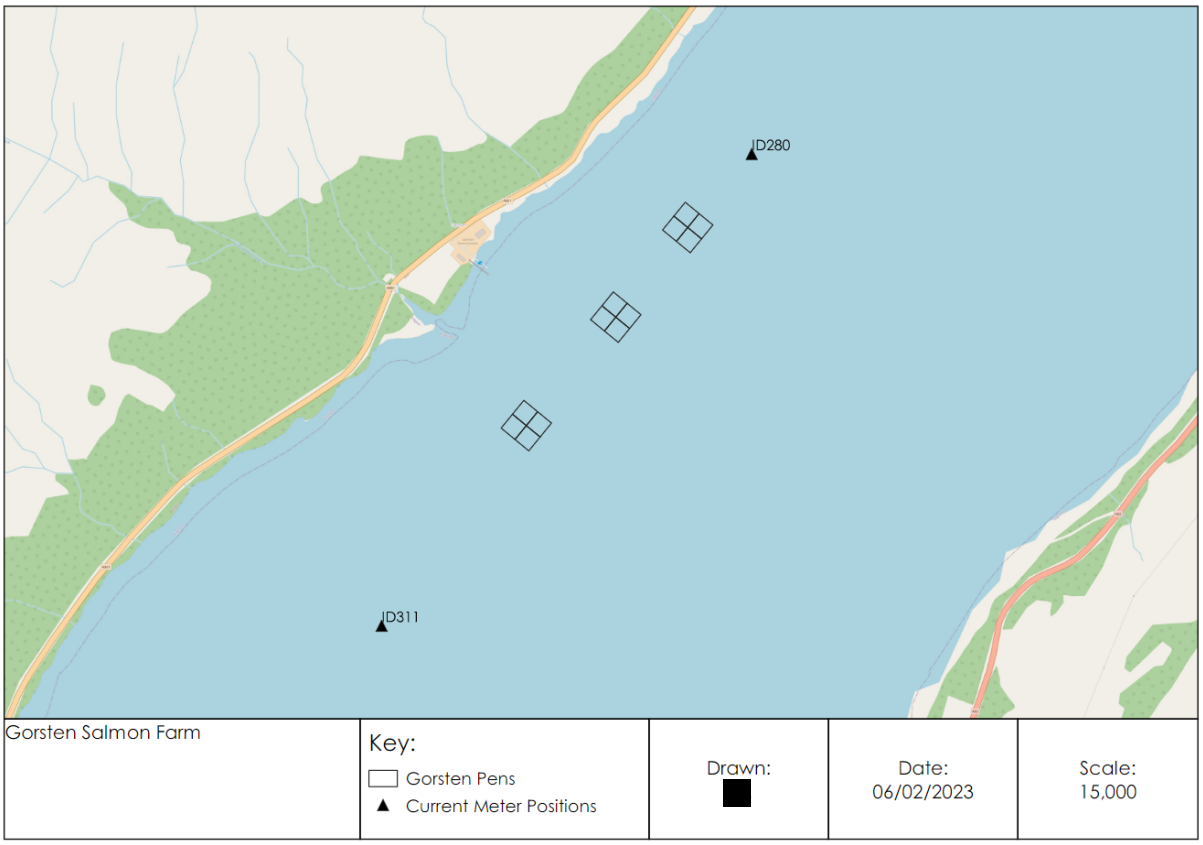


Figure 1. Site layout of the salmon farm at Gorsten, Loch Linnhe. The current meter deployment locations are marked by the black triangles.

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).

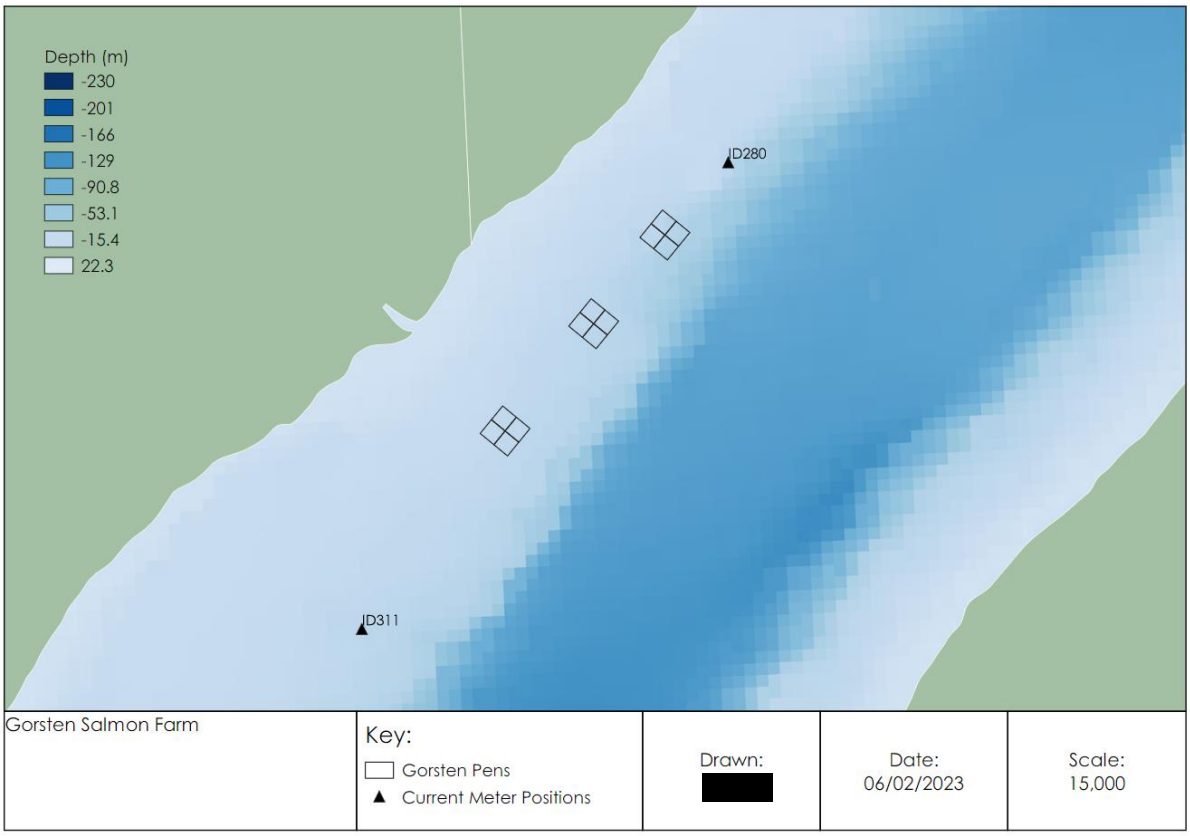


Figure 2. Bathymetry in the region around the Gorsten salmon farm.

2.2 Current Data

Mowi staff carried out hydrographic surveys at the site during 2019 and 2020. The purpose of this hydrographic report is to assess the suitability of the collected hydrographic data for use with the NewDepomod model. The data contained in this report were recorded at the site from 26th July to 14th October 2019 (79 days and 12 hours of data; deployment ID280). The data from another deployment (ID311) are presented in a separate hydrographic report.

The Sentinel V100 (Wide) ADCP (Table 1), within its mooring frame, was positioned at 56.78995N, -5.17067W (206437E 770976N), which was approximately 240m from the nearest shoreline and approximately 450m 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 20.42 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 59.

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 -2.93°; 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 12 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 5.7 m (cell 12), and cage-bottom data at 14.7 m (cell 3). Surface and middle cell heights were 14..72 m and 5.72 m from the seabed respectively. The bottom cell (cell 1) was at a depth of 16.7 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

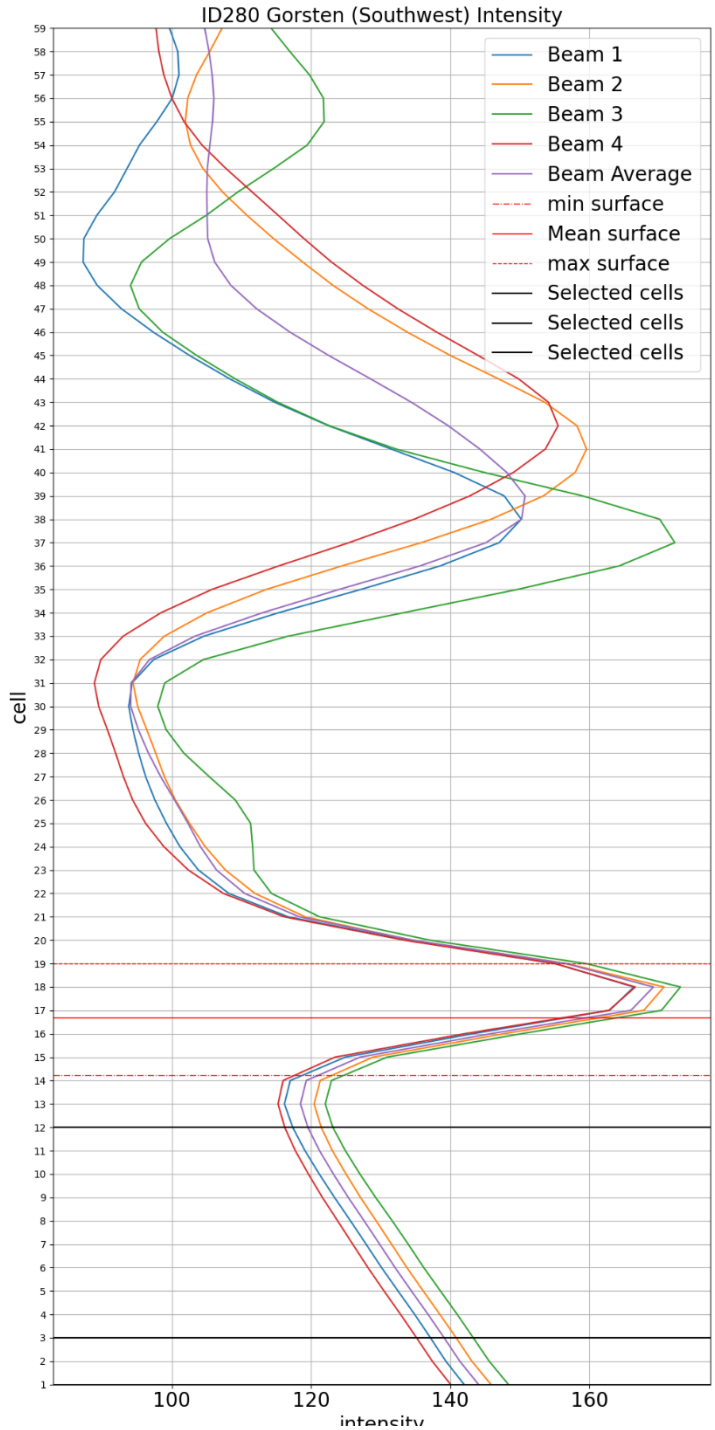


Figure 3. Mean intensity of the ADCP signal for the ID280 dataset plotted by bin number

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 0.63cm/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 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 9.96 cm/s, 7.88 cm/s and 7.01 cm/s respectively. This gave an overall average of 8.28 cm/s. The orientation of the tidal velocities was north-east – south-west.

Residual currents at the surface, mid-depth and near-bottom were all toward the north-west (222°G, 306°G and 342°G respectively, Figure 7, Figure 8 & Figure 9). The magnitude of the residual current for the surface, middle and bottom cells were moderate, with mean values of 0.033 m/s, 0.004 m/s and 0.006 m/s respectively.

4. Hydrographic Data Summary Sheets

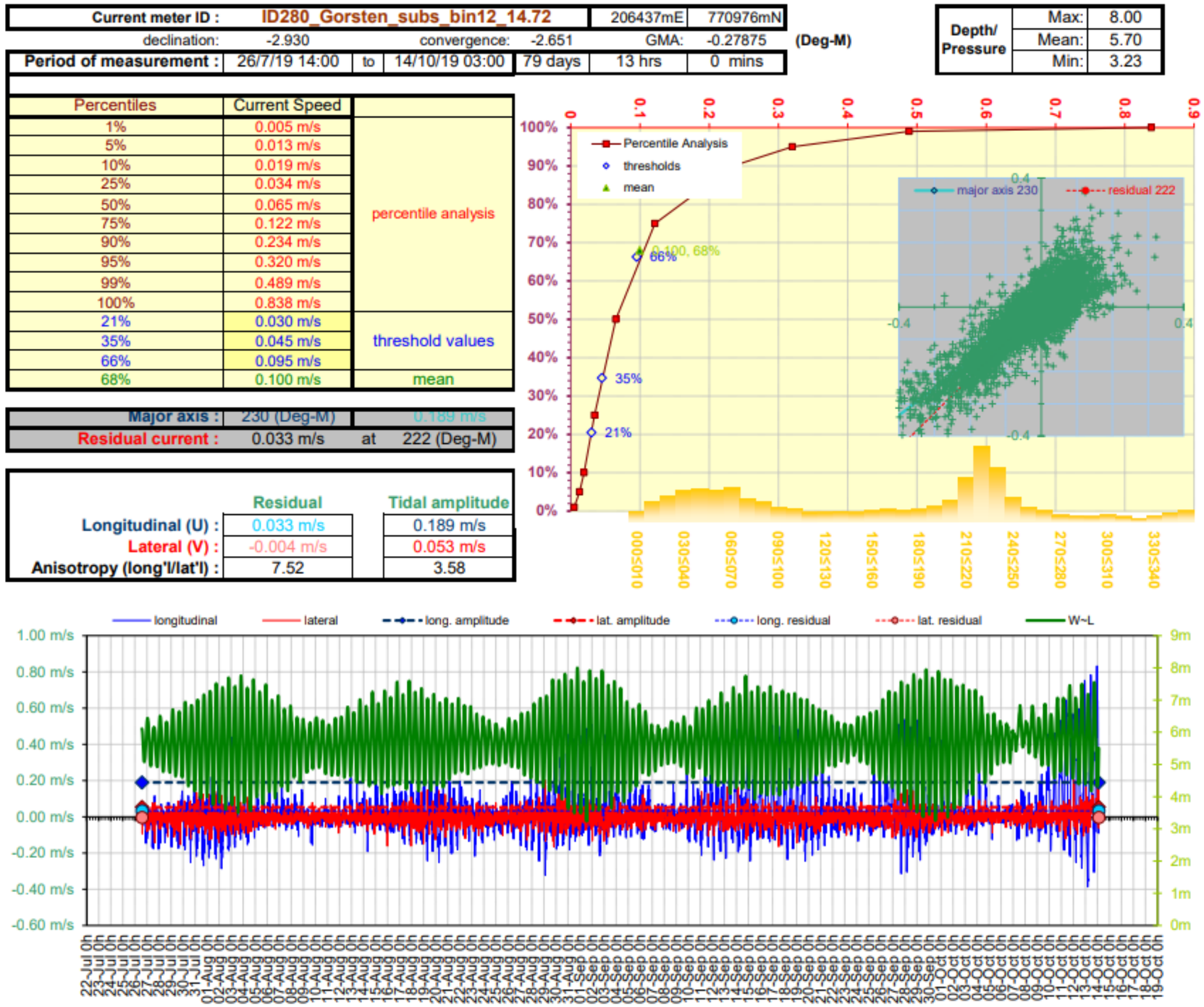


Figure 4. Current Data Summary Sheet for the surface current cell 12, 14.72m from seabed, 26th July to 14th October 2019 inclusive (ID280).

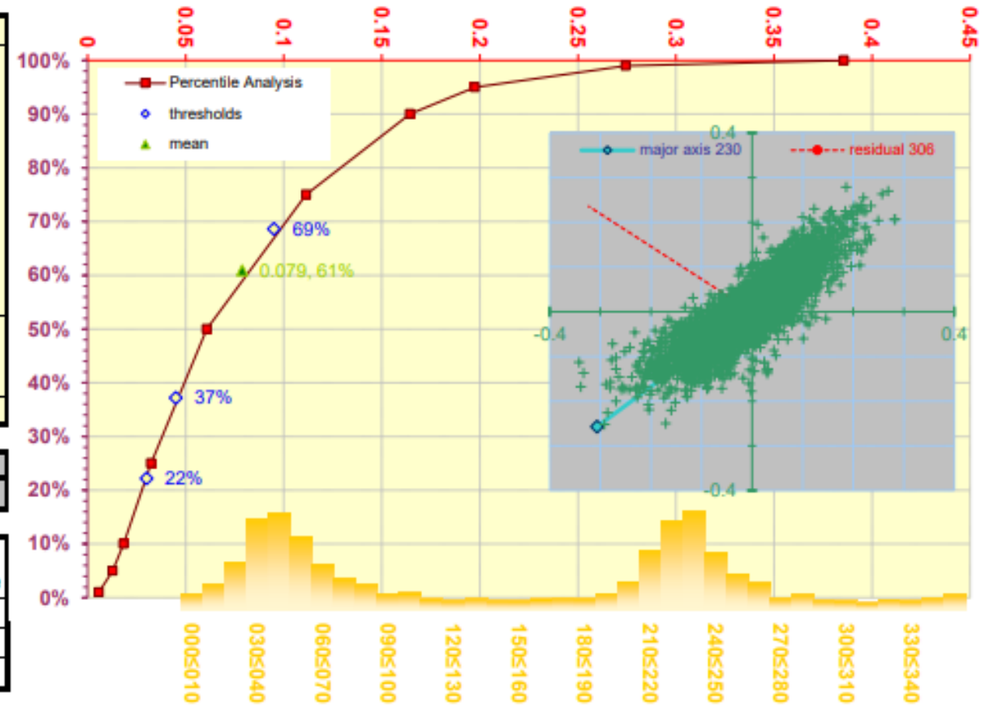
Current meter ID :	ID280_Gorsten_cbot_bin3_5.72m			206437mE	770976mN
declination:	-2.930	convergence:	-2.651	GMA:	-0.27875 (Deg-M)
Period of measurement :	26/7/19 14:00	to	14/10/19 03:00	79 days	13 hrs	0 mins

Depth/ Pressure		
	Max:	17.00
	Mean:	14.70
	Min:	12.23

Percentiles	Current Speed	
1%	0.006 m/s	percentile analysis
5%	0.013 m/s	
10%	0.018 m/s	
25%	0.032 m/s	
50%	0.061 m/s	
75%	0.111 m/s	
90%	0.164 m/s	
95%	0.198 m/s	
99%	0.274 m/s	
100%	0.386 m/s	
22%	0.030 m/s	threshold values
37%	0.045 m/s	
69%	0.095 m/s	
61%	0.079 m/s	mean

Major axis :	230 (Deg-M)	0.135 m/s
Residual current :	0.004 m/s	at 306 (Deg-M)

	Residual	Tidal amplitude
Longitudinal (U) :	0.001 m/s	0.135 m/s
Lateral (V) :	0.004 m/s	0.039 m/s
Anisotropy (long'l/lat'l) :	0.25	3.51



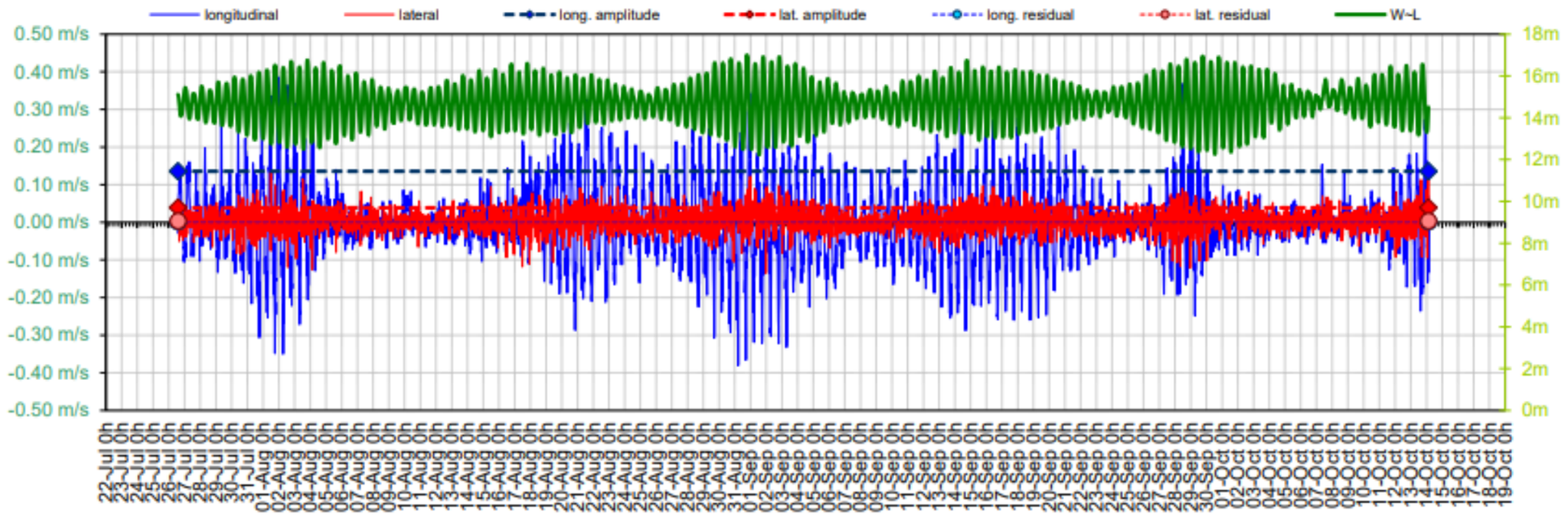


Figure 5. Current Data Summary Sheet for the cage bottom current cell 3, 5.72m from seabed, 26th July to 14th October 2019 inclusive (ID280).

Current meter ID :	ID280_Gorsten_nrbd_bin1_3.72m			206437mE	770976mN
declination:	-2.930		convergence: -2.651	GMA:	-0.27875 (Deg-M)
Period of measurement :	26/7/19 14:00	to	14/10/19 03:00	79 days	13 hrs	0 mins

Depth/ Pressure		
	Max:	19.00
	Mean:	16.70
	Min:	14.23

Percentiles	Current Speed	
1%	0.006 m/s	percentile analysis
5%	0.012 m/s	
10%	0.018 m/s	
25%	0.031 m/s	
50%	0.054 m/s	
75%	0.097 m/s	
90%	0.145 m/s	
95%	0.178 m/s	
99%	0.239 m/s	
100%	0.352 m/s	
24%	0.030 m/s	threshold values
41%	0.045 m/s	
74%	0.095 m/s	
62%	0.070 m/s	mean

Major axis :	050 (Deg-M)		0.118 m/s
Residual current :	0.006 m/s	at	342 (Deg-M)

	Residual	Tidal amplitude
Longitudinal (U) :	0.002 m/s	0.118 m/s
Lateral (V) :	-0.006 m/s	0.037 m/s
Anisotropy (long'l/lat'l) :	0.40	3.18

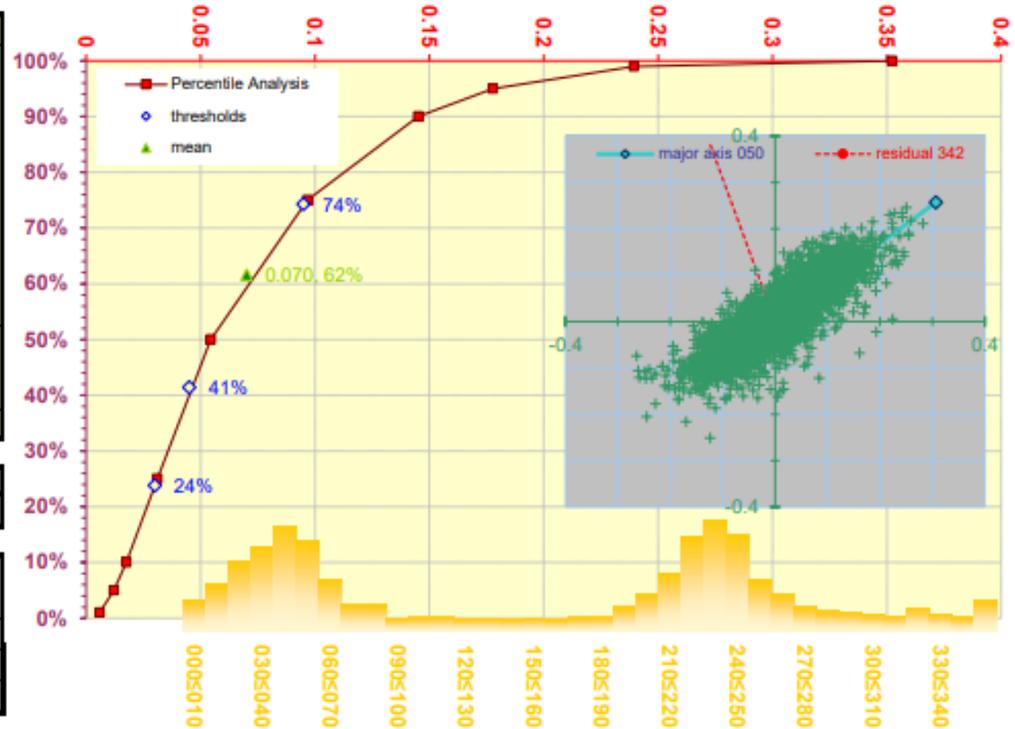


Figure 6. Current Data Summary Sheet for the near bottom current cell 1, 3.72m from seabed, 26th July to 14th October 2019 inclusive (ID280).

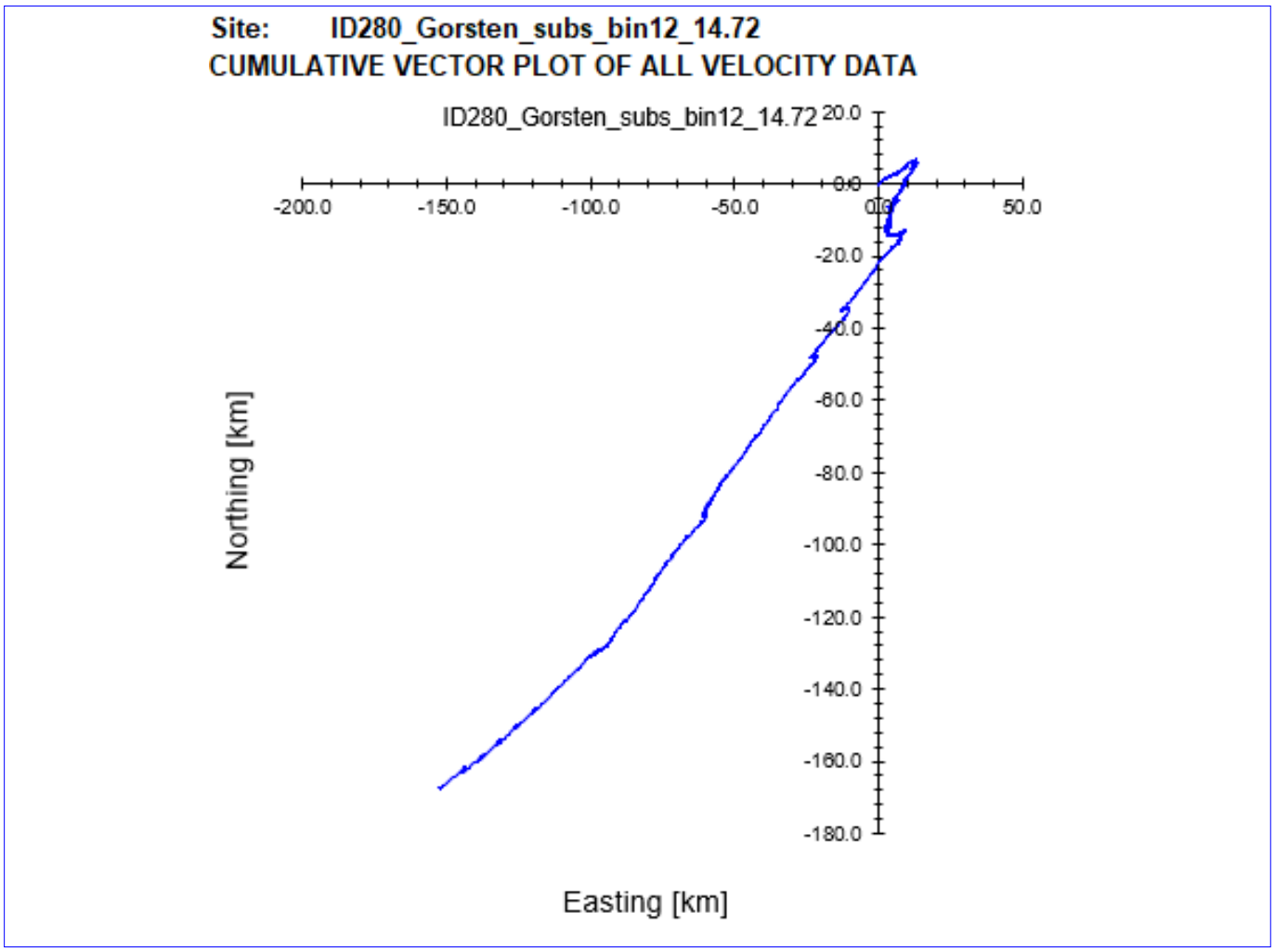


Figure 7. Cumulative Vector Plot of all velocity data from near surface cell for ID280.

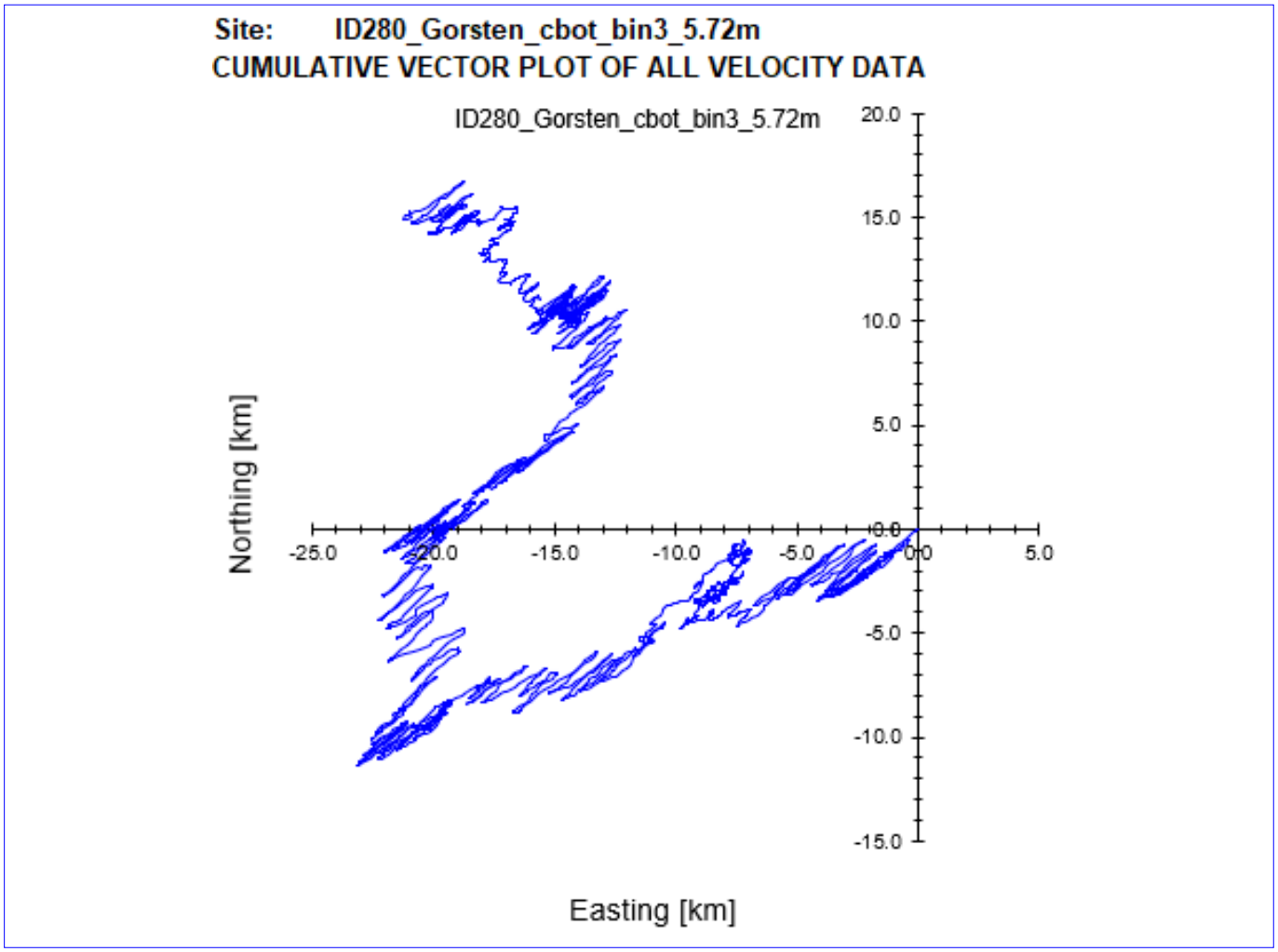


Figure 8. Cumulative Vector Plot of all velocity data from cage bottom cell for ID280.

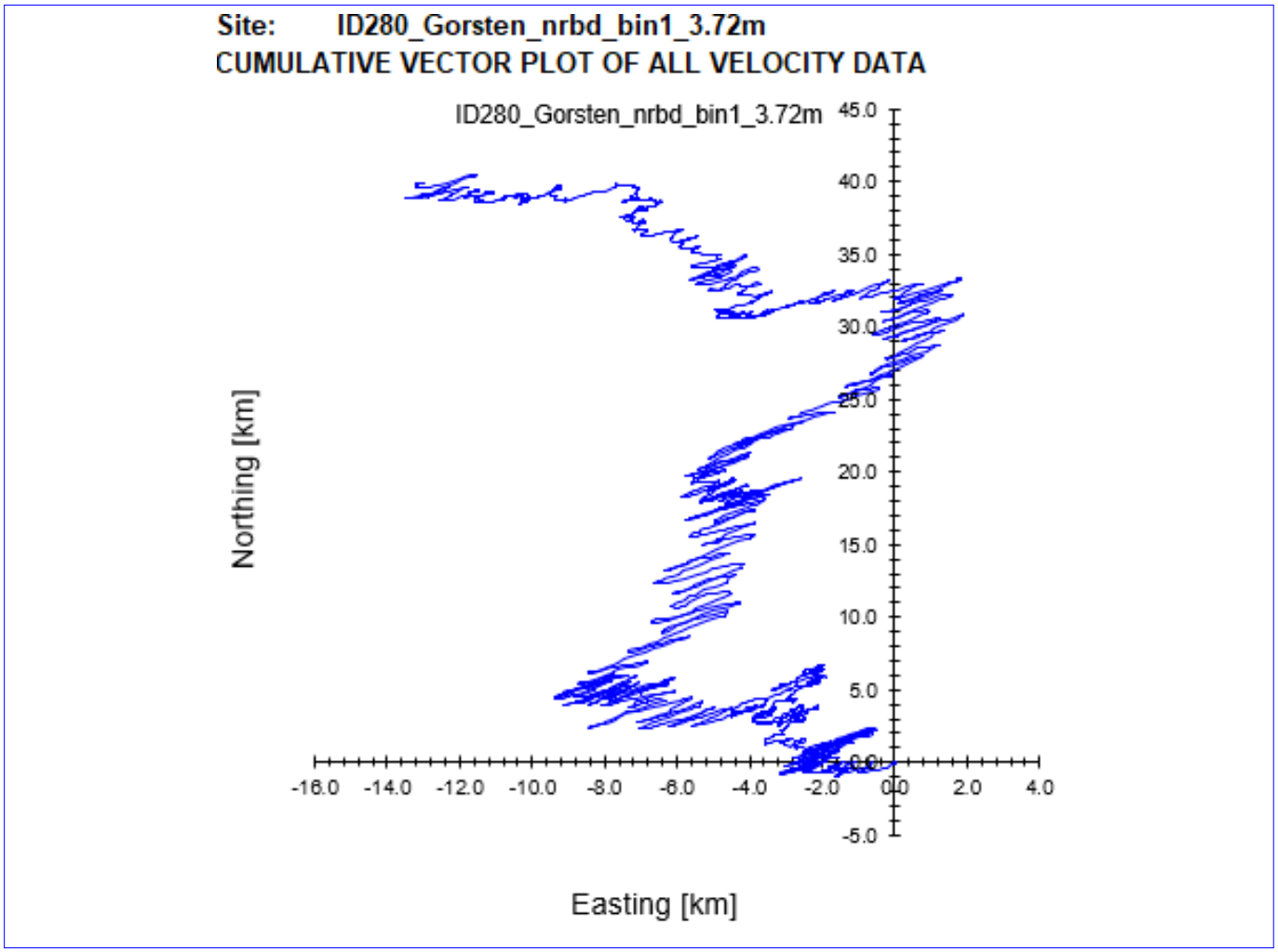


Figure 9. Cumulative Vector Plot of all velocity data from near bottom cell for ID280.

5. Summary of Current Data – ID280

Site Name: Gorsten
Data start date: 26/07/2019
Data end date: 14/10/2019
Mean Water Depth: 20.42m

Table 2. Summary of current meter deployment

	Cell	Depth Below Surface (m)	Distance from Seabed (m)	Mean current speed (cm/s)
Near surface:	12	3.23	14.72	9.96
Cage bottom:	3	12.23	5.72	7.88
Near bed:	1	14.23	3.72	7.01
			Average current speed:	8.28

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:	68	21	65	34
Cage bottom:	61	22	63	31
Near bed:	62	24	59	26

Table 4. Major axis

Cell	Major Axis (Deg-G)
Near surface:	230
Cage Bottom:	306
Near bed:	050

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:	0.100	0.033	0.033	-0.004	0.189	0.053
Cage Bottom:	0.079	0.004	0.001	0.004	0.135	0.039
Near Bed:	0.070	0.006	0.002	-0.006	0.118	0.037

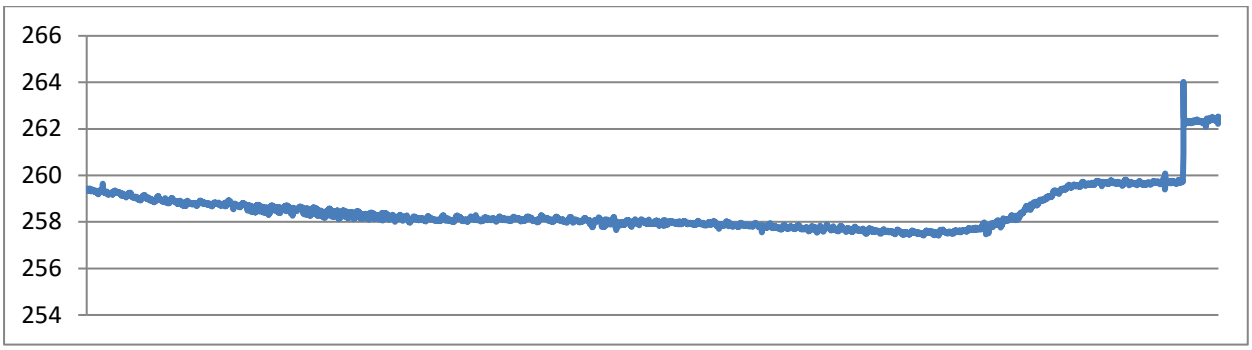


Figure 10. Summary of heading data from deployment ID280.

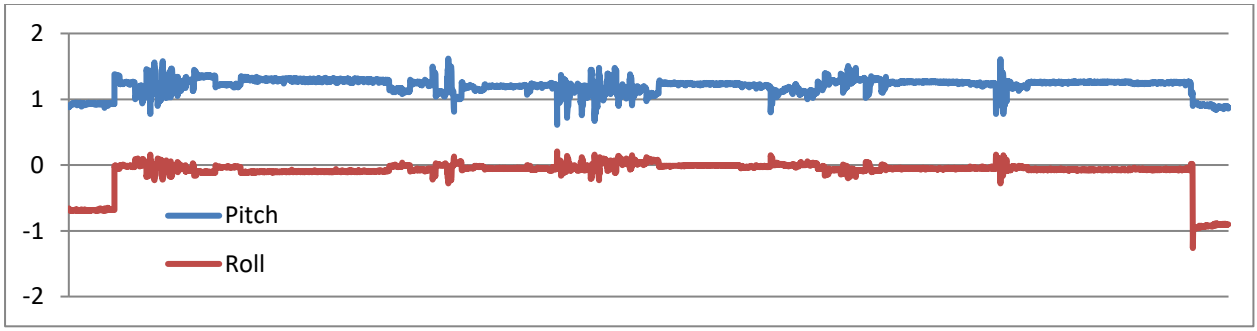


Figure 11. Summary of pitch and roll data from deployment ID280.

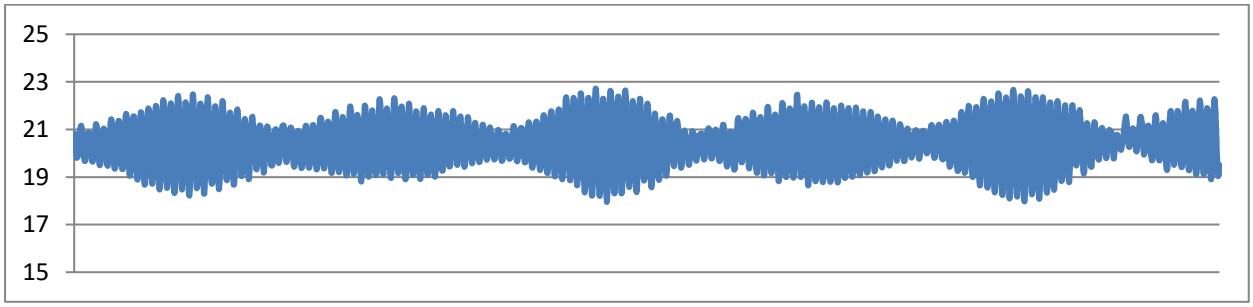


Figure 12. Pressure data from deployment ID280.

6. Conclusion

MOWI has collected and analysed current and bathymetric data for the proposed temporary biomass increase at Gorsten. The analysed current data for the 79 days and 12 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:	Gorsten
Nearest tidal port:	Corran
Time zone:	UTC
Meter switched on:	14:00 26/07/2019
Meter switched off:	03:00 14/10/2019
Period used for this report:	14:00 26/07/2019 – 03:00 14/10/2019
ADCP serial number:	24563
Meter position:	56.78995N, -5.17067W
	206437 E 770976 N
Minimum water depth:	17.25 m (17.95m measured by ADCP + 0.7 m *)
Water depth (Chart Datum):	17.25 m (minimum water depth – 0.1 m tide timetable)
Mean water depth:	21.12 m (20.42 measured by ADCP + 0.7 m *)
Depth of meter from surface:	16.55 m (below chart datum to transducer)
Height of meter from seabed:	0.7 m to transducer head
Sounding at deployment:	21 m @ 11:35 on 26/07/2019

Table A1. ADCP meter settings:

Reference:	Transducer
Bin size (m):	1.0
Dist to 1st bin (m):	3.02
Number of bins:	59
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