



*Refusing to go with the flow*

# MODELLING DATA COLLECTION REPORT CHALMERS HOPE

Survey: Sept-Dec 2016 & Jun-Jul  
2018

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## Table of Contents

Summary .....	3
Quality assurance statement .....	5
Site Description .....	5
Scope of Report.....	7
Required Data.....	7
Existing Data .....	7
Third Party Data .....	7
Methods.....	7
Hydrographic measurements.....	7
Hydrographic data – 18/09/2016 – 03/12/2016.....	8
Hydrographic data – 06/06/2018 – 27/07/2018.....	8
Data Processing .....	8
Site Infrastructure .....	9
Bathymetry .....	10
Flow Data .....	13
Flow data - 18/09/2016 - 03/12/2016 .....	13
Flow data - 06/06/2018 - 27/07/2018 .....	18
Flow data – Joint 90-days.....	23
Discussion.....	28
Equipment List .....	28
Calibration Reports .....	29
List of datafiles and description .....	33
Data – 2016 .....	33
Data – 2018 .....	33
Data – Joint 90 days .....	34
References .....	34

## Summary

A hydrographic survey was carried out at the proposed Chalmers Hope marine caged fish farm site located towards the west entrance of Scapa Flow, Orkney by Cooke Aquaculture Scotland.

Two acoustic profiling current meter were deployed at a location representative of site conditions for 76 and 51 days, from the 18<sup>th</sup> of September 2016 to the 3<sup>rd</sup> of December 2016 and from the 6<sup>th</sup> of June 2018 to the 27<sup>th</sup> of July 2018. From which, a joint 90-day subset was created. The data presented are considered representative of the period sampled and suitable for determining the impacts due to solid and solute wastes arising from farm operations.

Sensor records confirm there were minor sensor frame disturbances during the 2016 deployment, resulting in a sensor yaw movement of around 0.5 degree. The 2018 deployment experienced two distinct frame disturbances at 11:00 on the 16<sup>th</sup> of June 2018 and at 03:20 on the 18<sup>th</sup> of July 2018. However, these settled within 0.5 degree of the previous values. These variations are well within the post-processing corrections limits and do not cause any deterioration in the data.

A handheld depth sounder was used to obtain soundings from the meter location and 45 additional locations around the proposed cage group. Locational measurements were recorded using a handheld GPS device. These soundings were compared to UK Hydrographic Office multibeam sonar data. A good correlation between the datasets was observed with an offset of -2.7 m. This allowed the corrected UKHO data to be used for model bathymetry, as it provides a much greater spatial coverage of the site.

Both current meter datasets describe an area with strong tidal influence, where flows regularly exceed 0.1m/s. Semi-diurnal patterns are present within the current data, with 6 spring/neap cycles. Flow profiles experience similar mean velocities throughout the water column. Maximum current speed is greatest in the cage bottom layer and residual current speed was greatest in the near bed layer. However, these remain relatively low in comparison to the mean bed speed.

Due to the large average flow speeds, it is expected that this site will be highly dispersive, where large amounts solid waste transport is anticipated. Near bed residual velocities suggest transport is likely to occur in a north-westerly direction.

Data quality parameters indicate that current speed and direction estimates should be of sufficient precision for modelling operational impacts.

A summary of the current meter data is outlined in the table below.

<b>90 Day Analysis Period: 18/09/2016 – 03/12/2016 &amp; 04/07/2018-18/07/2018</b>				
<b>Deployment Position (Easting, Northing)</b>	328663.5, 1001218.7 (2016)			
	328688, 1001269 (2018)			
	<b>Unit</b>	<b>Near Surface (27.7m)</b>	<b>Cage Bottom (21.7m)</b>	<b>Near Seabed (2.7m)</b>
<b>Mean speed</b>	m/s	0.133	0.138	0.122
<b>Ranked percentage of 0.030 m/s</b>	%	6.47	5.22	5.93
<b>Ranked percentage of 0.095 m/s</b>	%	38.04	34.32	40.79
<b>Maximum speed</b>	m/s	0.46	0.49	0.43
<b>Residual direction</b>	°Grid	187.2	238.5	325.8
<b>Residual speed</b>	m/s	0.014	0.016	0.022
<b>Parallel Amplitude</b>	m/s	0.21	0.216	0.187
<b>Normal Amplitude</b>	m/s	0.078	0.067	0.063
<b>Amplitude anisotropy</b>	-	2.66	3.23	2.98

## Quality assurance statement

Cooke Aquaculture Scotland confirms the collection, analysis and reporting of all information is attested by a suitably qualified person and is completed to a consistently high standard, to ensure the data presented is representative of the conditions at the site. This is in line with the current SEPA standards outlined in (SEPA 2019a and SEPA 2019b).

## Site Description

Chalmers Hope is an existing site (CAR/L/1003062/V6) operated by Cooke Aquaculture Scotland. The license was issued in 2007 and permits a maximum biomass of 1000 tons. The site location shown in Figure 1 is situated towards the west entrance to Scapa flow on the north-east coastline of Hoy, Orkney. The coastline surrounding the site varies, with large rocky cliffs towards the north, and a small sandy/pebbly embayment towards the south. Directly offshore from the site at 1.1 km exists a large scoured depression in the seabed, where depths exceed 50 m. This area is known as Bring Deeps.

The current site is located at HY 2861 0011 and consists of 12 x 90m (circumference) cages. The cage layout is orientated along the coastline with two rows both consisting of six cages. The proposed modifications replace all existing equipment and reposition the new cages 250m to the NNE (HY 28734 0130). The proposed modifications will increase cage circumference to 120m and depth to 12m with 70m mooring grids. This information is shown in Table 1, with pen group, water depth, and mooring locations.



**Figure 1 Site location with terrestrial aerial images (Bing maps) and bathymetry (UK hydrographic office) with depth contours shown at 10m intervals.**

**Table 1.0 Site Infrastructure and pen layout**

	Existing	Proposed
No. of pens	12	12
No. pen groups	1	1
Formation	2 x 6	2 x 6
Dimension	Circular pen with diameter of 28.6 m	Circular pen with diameter of 38.2 m
Centre location (OSGB Easting, Northing)	328607, 1001109	328735.3, 1001310.7

## Scope of Report

### Required Data

As the site is being relocated no environmental performance data is available. Once the site is operational benthic sampling will be carried out to measure Infaunal Quality Index (IQI). This can then be used to assess the environmental performance of the site along with the calibration of future modelling work.

### Existing Data

Hydrographic data collected in 2016 and 2018 are joined to form a continuous 90-day dataset. Depth soundings are used to sense check multi-beam sonar data.

### Third Party Data

Bathymetry data from the UK hydrographic office has been applied. This has been compared with sounding data collected at the site. Further information on this can be found in Section labelled Bathymetry.

## Methods

### Hydrographic measurements

Two relevant hydrographic surveys have been undertaken at the Chalmers Hope site. The sensors were deployed between the 18<sup>th</sup> of September 2016 to the 3<sup>rd</sup> of December 2016 and from the 6<sup>th</sup> of June 2018 to the 27<sup>th</sup> of July 2018. Prior to these, additional measurements were taken in 1999 and 2003. However, these older measurements were centered round the existing site and are not suitable for modelling purposes for the proposed location change.

Both the 2016 and 2018 sensors were mounted in a weighted fixed bottom mooring frame with a gimble and deployed in a specific location to avoid interference from site infrastructure or other potential risks to data validity. The transducer head is located 0.7m from the seabed. The sensor configuration remained the same for both deployment and is shown in table 2.

**Table 2. Sensor configuration for both 2016 and 2018 deployment.**

<b>SeaGuardII DCP – Serial no. 1834 (2016) 1803 (2018)</b>	
Location	Chalmers Hope
Recording interval	1200 sec
Ping count	300
Burst mode	Yes
Duty cycle	19%
Transducer direction	Up
Pulse length	2.0m
Power level	Low

Pulse type		Auto attenuation	
Fixed density (kg/m <sup>3</sup> )		1028	
Fixed salinity (PSU)		35	
Fixed speed of sound (m/s)		1468	
Column 1		Column 2	Surface
Surface referred	No	Yes	Yes
Cell size (m)	2.0	2.0	2.0
Distance to column (m)	2.0	2.0	-
Number cells	20	20	1
Cell overlap (%)	50	50	-

### Hydrographic data – 18/09/2016 – 03/12/2016

An Aanderaa Data Instruments 600kHz Recording Doppler Current Profiler (SeaGuardII DCP) was deployed at 328663.5 East 1001218.7 North, situated 81m from the proposed site center. The deployment period cover 76 days from the 18<sup>th</sup> of September to the 3<sup>rd</sup> of December 2016. This device has a serial number of 1834.

### Hydrographic data – 06/06/2018 – 27/07/2018

The second deployment used the same type sensor (Aanderaa Data Instruments 600kHz Recording Doppler Current Profiler (SeaGuardII DCP)) positioned at 328688 East 1001269 North, situated 25m from the proposed site center. The deployment period covers 51 days from the 6<sup>th</sup> of June to the 27<sup>th</sup> of July 2018. This device has a serial number of 1803.

Data is recorded and calculates flow profiles every 1200 s. The results were logged on an internal memory card. The variables outlined in Table 3 are shown to have the following tolerances.

**Table 3. Sensor specifications**

	Accuracy	Precision	Resolution
<b>Speed</b>	0.03 m/s	< 0.03 m/s	0.01 m/s
<b>Direction</b>	± 5°	< 1°	0.1°
<b>Pressure</b>	±0.02%	0.02%	0.0001°
<b>Heading</b>	± 3.5°	< 1°	< 0.1°
<b>Tilt</b>	± 1.5°	< 0.1°	< 0.1°

### Data Processing

Raw data stored on the sensors internal SD card were exported from the binary files to ASCII format through the proprietary software DataStudio 3D. This data was then imported into Matlab, where in-house scripts performed quality control and post processing. This required

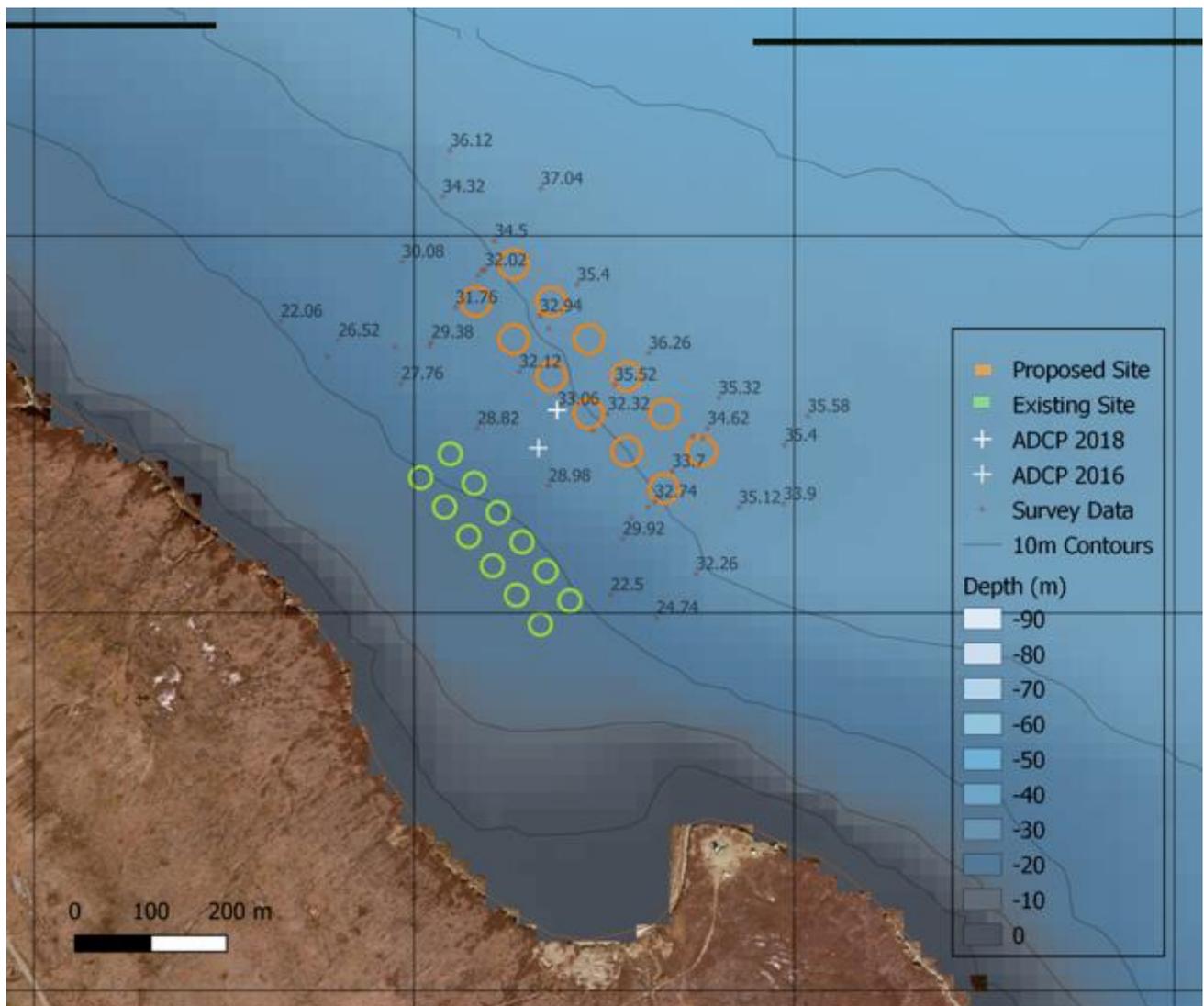
flow data values for velocity to be converted from cm/s to m/s. Basic quality control applied a pitch and roll threshold exceedance method with a range of  $\pm 10^\circ$  around 0. A standard deviation threshold of 30 was also applied to exclude data of poor quality. Data points out-with these tolerances are removed and replaced with NaN values. These NaN values were interpolated using a modified Akima Hermite interpolation to provide a continuous, uninterrupted dataset.

Additional validation protocols compared sensor depth measurements with that of the survey data. Qualitative analysis of the heading data allowed a basic method of identifying frame movements during the deployments. However, this can only be detected if the frame (and sensor) rotates. The tidal ellipse is also compared with surrounding bathymetry and coastline as a sense check for appropriate flow direction and magnitude.

In order to achieve 90 days of current data, two datasets must be joined. To reduce and instabilities within the model, data phase alignment is implemented to ensure tidal elevation and spring and neap cycles merge with minimal step changes. This allows a smooth transition in currents speed and surface elevation between the two datasets.

## Site Infrastructure

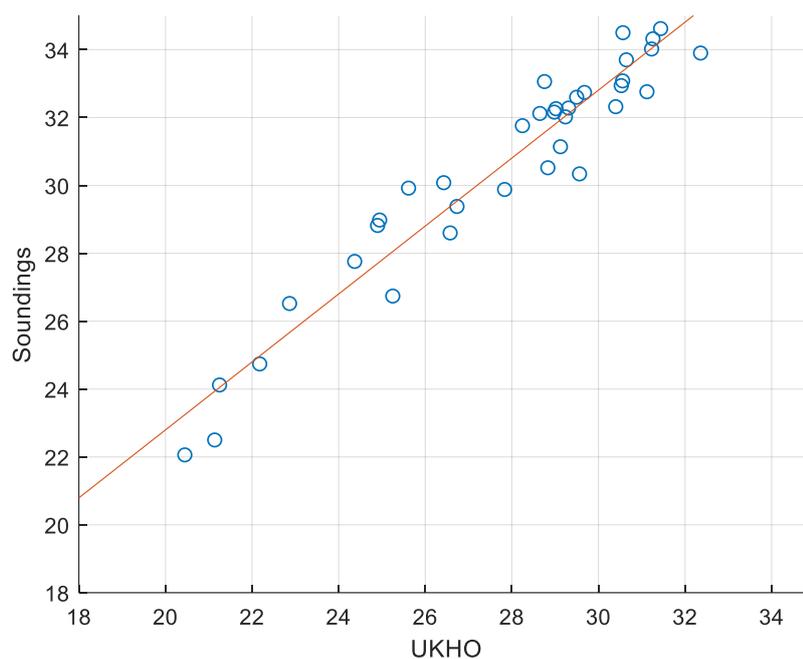
The existing and proposed cage layout is shown in Figure 2. This shows the proposed position of the larger cages on the increased grid size. Depth sounding locations and values are also shown.



**Figure 2.0 Existing and proposed cage layout, survey points and ADCP locations at Chalmers Hope.**

## Bathymetry

The proposed site is positioned further offshore, taking the farm out of the small embayment to the south and into deeper, more exposed water. Figure 2 shows the bathymetry variation around the site from two data sources. This uses soundings presented in Table 4 marked by the scatter points with their depth values adjacent. The second data source uses an interpolated depth surface from the UK Hydrographic Office (UK Hydrographic Office 2014). For the region surrounding Chalmers Hope the UKHO data is provided on a 20m grid resolution. Both datasets show similar values with the average difference between the dataset equaling -2.7m. This is illustrated in Figure 3; where a linear fit is applied, producing a gradient of 1 and an intercept of 2.7m. Due to the large spatial coverage of the UKHO data to is used for modelling purposes.



**Figure 3. Comparison of depth in meters for the measured soundings and UKHO dataset with a linear fit.**

**Table 4. Sounding data.**

No.	Date	Time (GMT)	E	N	Depth CD (m)	No. Sat
1	03/08/2018	09:43	328537.966	1001552.001	34.32	10
2	03/08/2018	09:44	328606.045	1001493.193	34.5	10
3	03/08/2018	09:45	328714.497	1001435.494	35.4	10
4	03/08/2018	09:46	328808.889	1001344.645	36.26	10
5	03/08/2018	09:47	328900.987	1001285.398	35.32	10
6	03/08/2018	09:49	328987.256	1001222.548	35.4	10
7	03/08/2018	09:50	328885.826	1001244.84	34.62	10
8	03/08/2018	09:51	328763.92	1001302.783	35.52	10
9	03/08/2018	09:52	328676.902	1001376.79	33.08	10
10	03/08/2018	09:54	328592.837	1001454.456	32.02	10
11	03/08/2018	09:55	328484.486	1001465.75	30.08	10
12	03/08/2018	09:56	328554.452	1001405.049	31.76	10
13	03/08/2018	09:59	328839.622	1001188.15	33.7	10
14	03/08/2018	10:00	328927.127	1001140.126	35.12	10

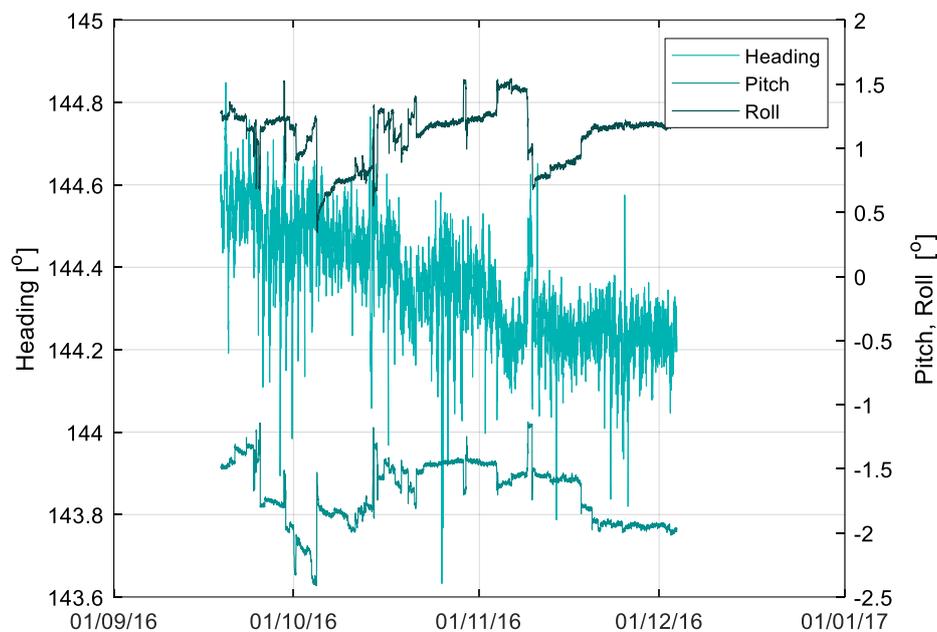
15	03/08/2018	10:02	328816.776	1001147.734	32.74	10
16	03/08/2018	10:03	328734.934	1001242.063	32.6	10
17	03/08/2018	10:04	328638.379	1001319.959	32.12	10
18	03/08/2018	10:05	328522.858	1001359.229	29.38	10
19	03/08/2018	10:07	328399.925	1001361.514	26.52	10
20	03/08/2018	10:09	328483.407	1001304.274	27.76	10
21	03/08/2018	10:10	328583.184	1001244.876	28.82	10
22	03/08/2018	10:11	328676.892	1001168.887	28.98	10
23	03/08/2018	10:12	328774.549	1001098.396	29.92	10
24	03/08/2018	10:13	328870.734	1001052.067	32.26	10
25	31/05/2018	09:21	328688.388	1001270.769	33.06	9
26	07/04/2017	12:20	329017.748	1001260.967	35.58	9
27	07/04/2017	12:23	328547.746	1001613.076	36.12	9
28	07/04/2017	12:26	328386.065	1001339.497	24.12	9
29	07/04/2017	12:29	328818.73	1000993.628	24.74	9
30	07/04/2017	12:30	328807.995	1001140.472	32.28	9
31	07/04/2017	12:31	328879.823	1001231.957	34.02	9
32	07/04/2017	12:33	328588.996	1001454.527	31.14	9
33	07/04/2017	12:34	328520.833	1001353.698	28.6	9
34	07/04/2017	12:35	328695.111	1001270.645	32.16	9
35	07/04/2017	12:42	328665.687	1001393.704	32.94	9
36	13/07/2016	11:05	328754.555	1001263.975	32.32	9
37	13/07/2016	11:10	328785.629	1001126.035	29.88	9
38	13/07/2016	11:12	328474.699	1001352.699	26.74	9
39	13/07/2016	11:14	328584.056	1001447.194	30.52	9
40	13/07/2016	11:16	328866.411	1001234.061	32.76	9
41	13/07/2016	11:19	328707.872	1001285.258	30.34	9
42	13/07/2016	11:22	328324.502	1001387.05	22.06	10
43	13/07/2016	11:24	328666.896	1001562.603	37.04	9
44	13/07/2016	11:28	328985.818	1001144.611	33.9	9
45	13/07/2016	11:31	328758.768	1001024.438	22.5	10

## Flow Data

The deployment locations are shown in Figure 2 by the white plus symbols, where the 2018 deployment is located closer to the center of the proposed site. The measured data is presented first for each individual sensor and then for the combined datasets to form the complete 90-day duration.

### Flow data - 18/09/2016 - 03/12/2016

The sensor was deployed for 76 days from the 18/09/2016 to 03/12/2016 at 328663.5 East and 1001218.7 North. During this time a mean water depth of 34.3m was recorded. The quality control process identified 0 (0%) pitch and roll exceedances and 3411 (2.3%) standard deviation errors. The sensor heading, pitch, and roll are shown in Figure 4. This shows minor variation with fluctuations within 1 degree, indicating no overall frame movement. The pitch and roll measurements suggest the gimble remains stable, with nominal fluctuations that are well within the operating constraints.



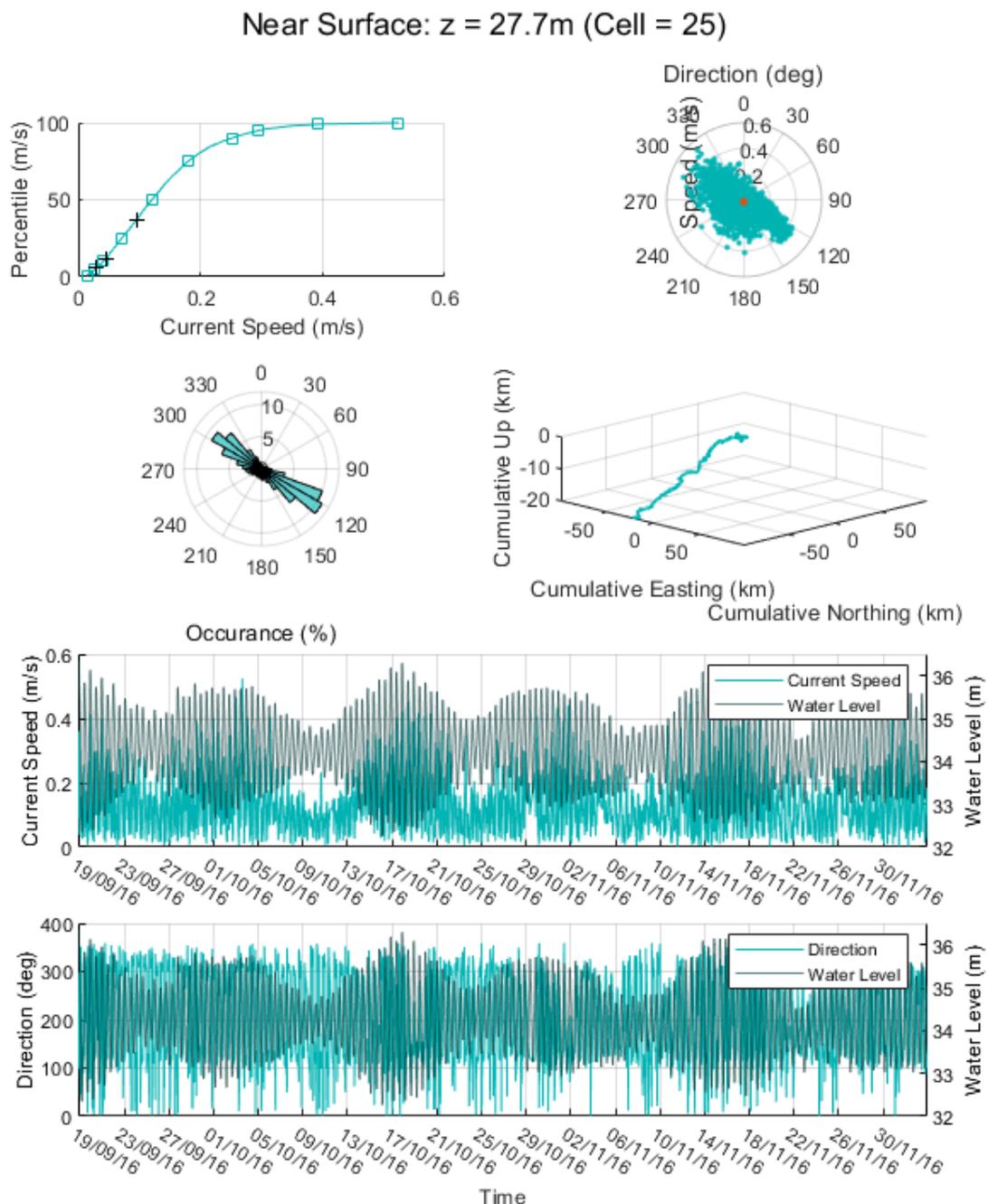
**Figure 4. ADCP 2016: Sensor heading, pitch and roll for the deployment period.**

The near surface, cage bottom and near bed flow conditions are presented in Figures 5-7. The flow statistics are shown in Table 5. The site experiences a reasonable flow speed, with larger velocities towards the surface. Ranked percentage of velocity 0.03, 0.045 and 0.095m/s indicates the proportion of data above these speeds. This indicates if a site is quiescent or determines the proportion of potential sediment resuspension events. This shows very low quiescent tendencies, with a large proportion of potential for sediment resuspension. A small residual current is observed that increases at the bed, this flows in a predominantly north-easterly direction. This is shown to change with depth in Figure 8,

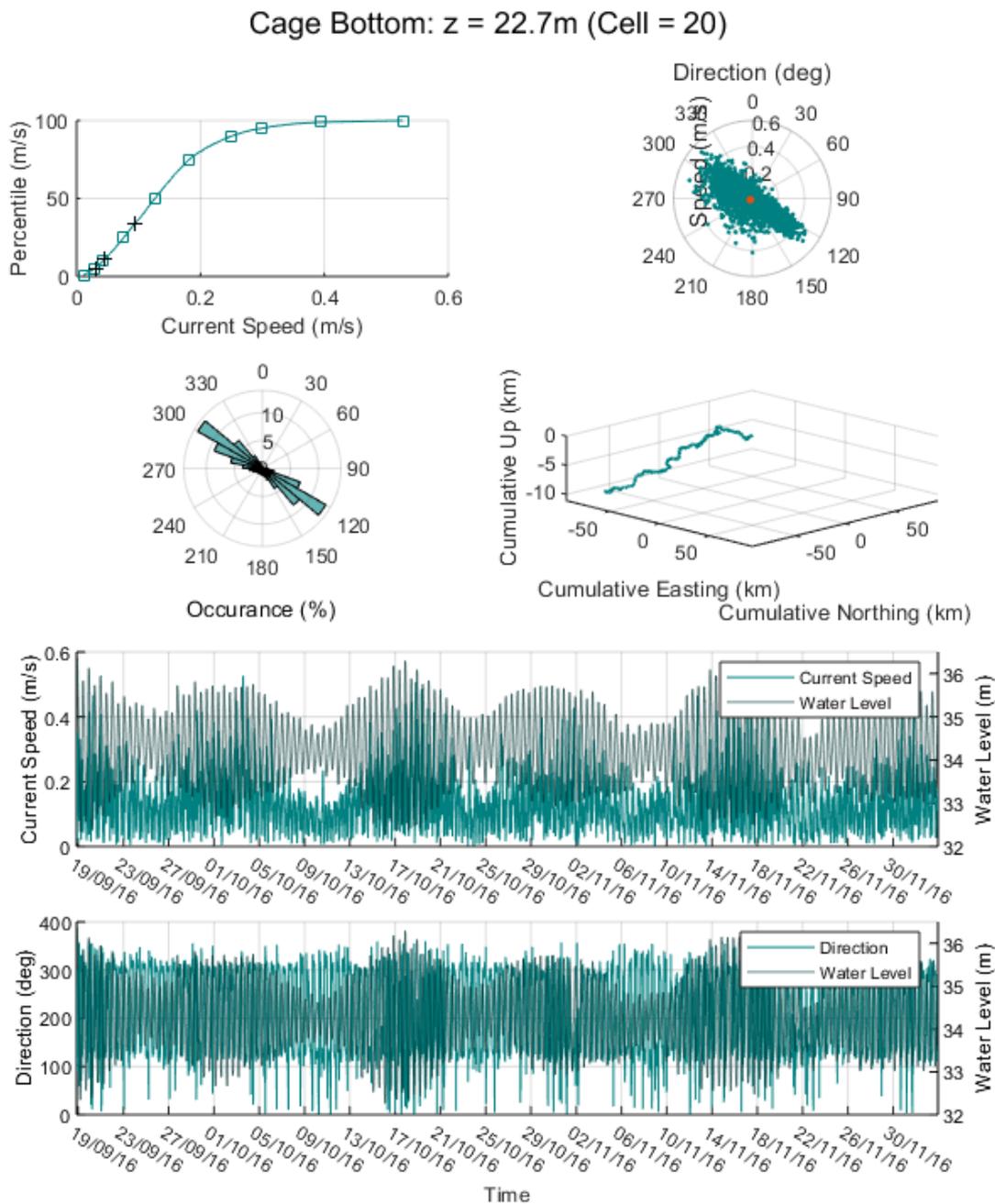
where a residual flow spiral is observed that ends with a net flow movement at 322 degrees at the seabed.

**Table 5. Flow statistics for the 2016 dataset.**

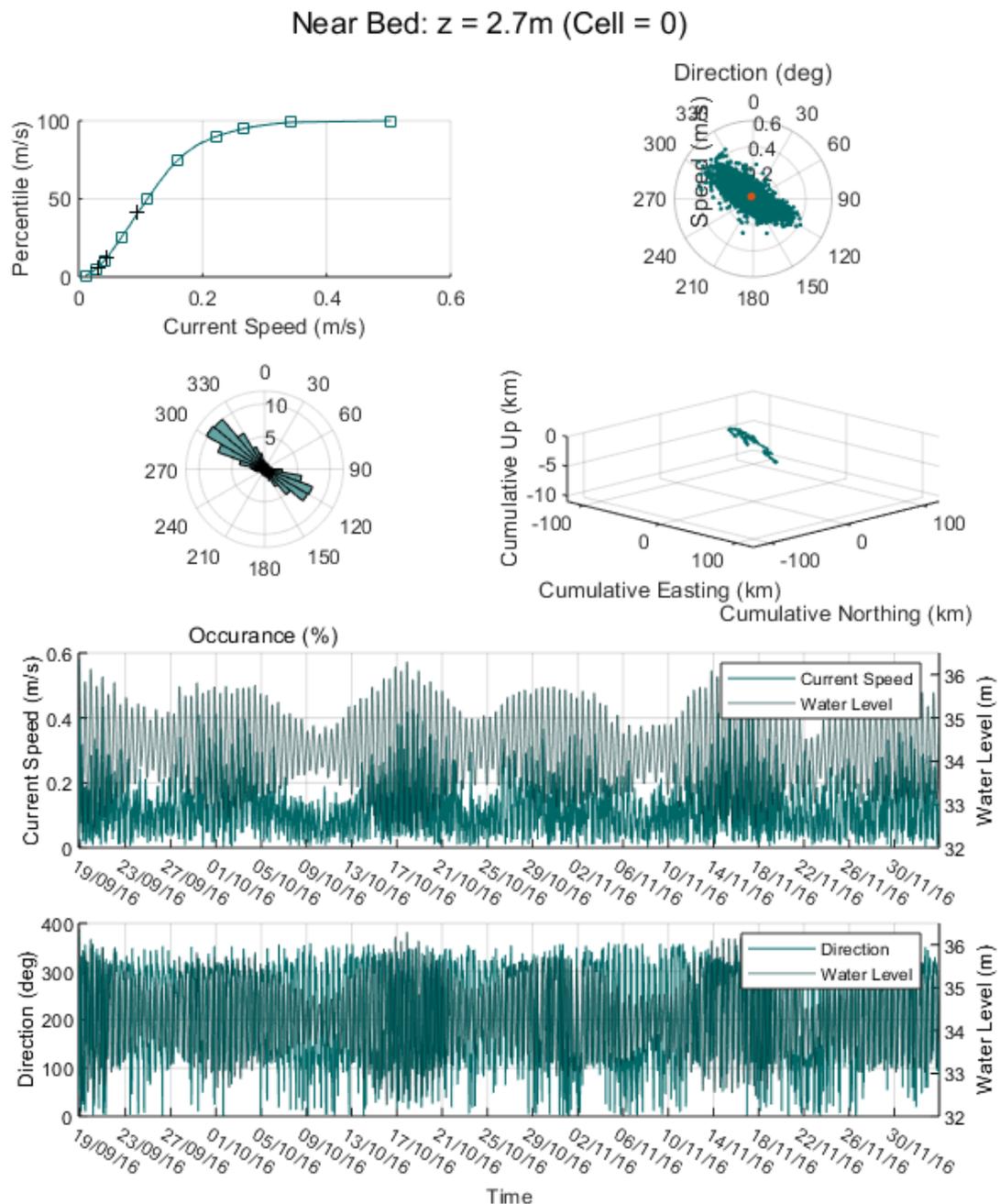
	<b>Near Surface</b>	<b>Cage Bottom</b>	<b>Near Bed</b>
z (m)	27.7	22.7	2.7
Mean Speed (m/s)	0.135	0.138	0.123
Ranked Percentage at 0.03 m/s (%)	5.77	5.26	6.00
Ranked Percentage at 0.045 m/s (%)	11.81	10.82	11.99
Ranked Percentage at 0.095 m/s (%)	36.64	34.38	40.88
Maximum Speed (m/s)	0.52	0.53	0.50
Residual Speed (m/s)	0.015	0.016	0.023
Residual direction (degrees)	191.9	238.6	322.0



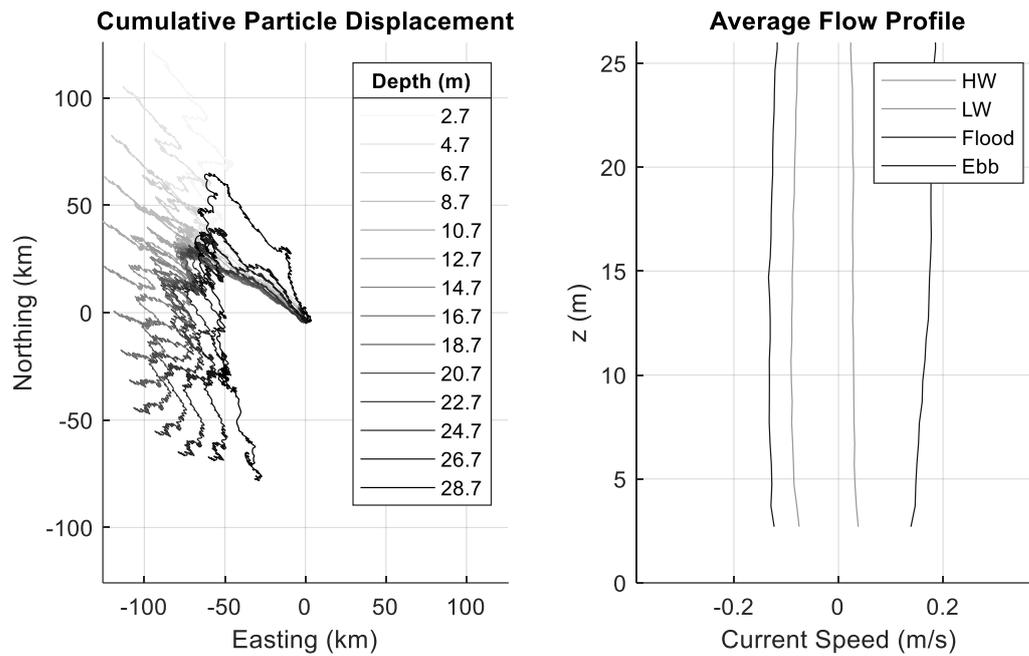
**Figure 5. ADCP 2016: Near surface flow information. Top left: percentile current speed with 0.03, 0.045 and 0.095m/s indicated by cross markers. Top right: polar scatter plot of all speed and direction data points with residual marker in red. Middle upper left: percentage occurrence flow direction. Middle upper right: cumulative 3-dimensional particle displacement. Bottom upper: time series of current speed and water level. Bottom lower: time series of direction and water level.**



**Figure 6. ADCP 2016: Cage bottom flow information. Top left: percentile current speed with 0.03, 0.045 and 0.095m/s indicated by cross markers. Top right: polar scatter plot of all speed and direction data points with residual marker in red. Middle upper left: percentage occurrence flow direction. Middle upper right: cumulative 3-dimensional particle displacement. Bottom upper: time series of current speed and water level. Bottom lower: time series of direction and water level.**



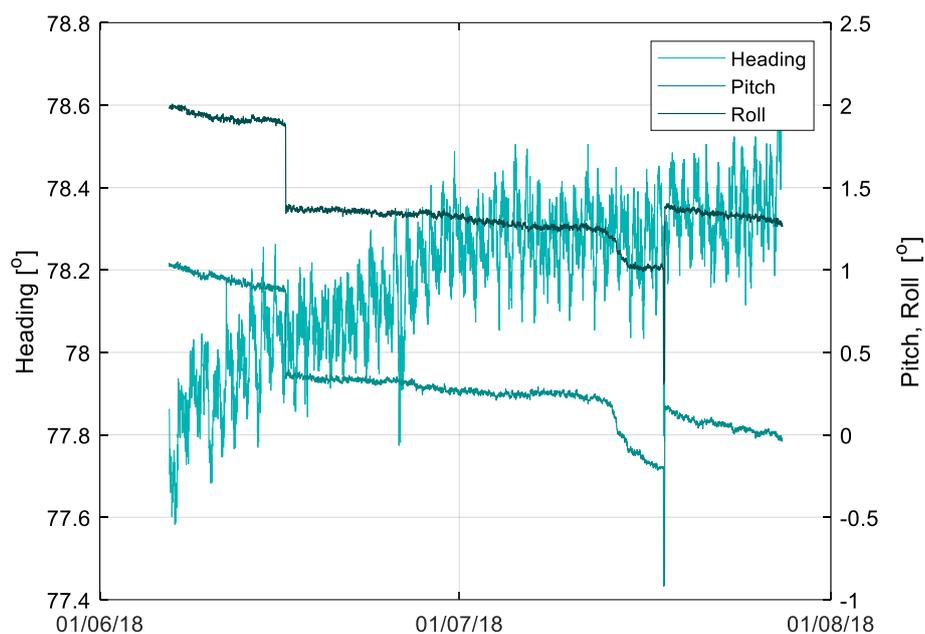
**Figure 7. ADCP 2016: Near bed flow information. Top left: percentile current speed with 0.03, 0.045 and 0.095m/s indicated by cross markers. Top right: polar scatter plot of all speed and direction data points with residual marker in red. Middle upper left: percentage occurrence flow direction. Middle upper right: cumulative 3-dimensional particle displacement. Bottom upper: time series of current speed and water level. Bottom lower: time series of direction and water level.**



**Figure 8. Left: cumulative particle displacement with depth. Right: Average velocity depth profile for high water (HW), low water (LW), flood tide (Flood) and Ebb tide (Ebb).**

#### Flow data - 06/06/2018 - 27/07/2018

The sensor was deployed for 51 days from 06/06/2018 to 27/07/2018 at 328688 East and 1001269 North. During this time, a mean water depth of 33.4m was recorded. The quality control process identified 0 (0%) pitch and roll exceedances and 1632 (1.64%) standard deviation errors. The sensor heading, pitch and roll are shown in Figure 9. This shows minor variations in sensor heading, with a range of less than 1 degree yaw motion, indicating no overall frame movement. The pitch and roll measurements suggest the gimble remains relatively stable, with 2 instances where a small sudden change occurs. However, the values remain well within the operating constraints.

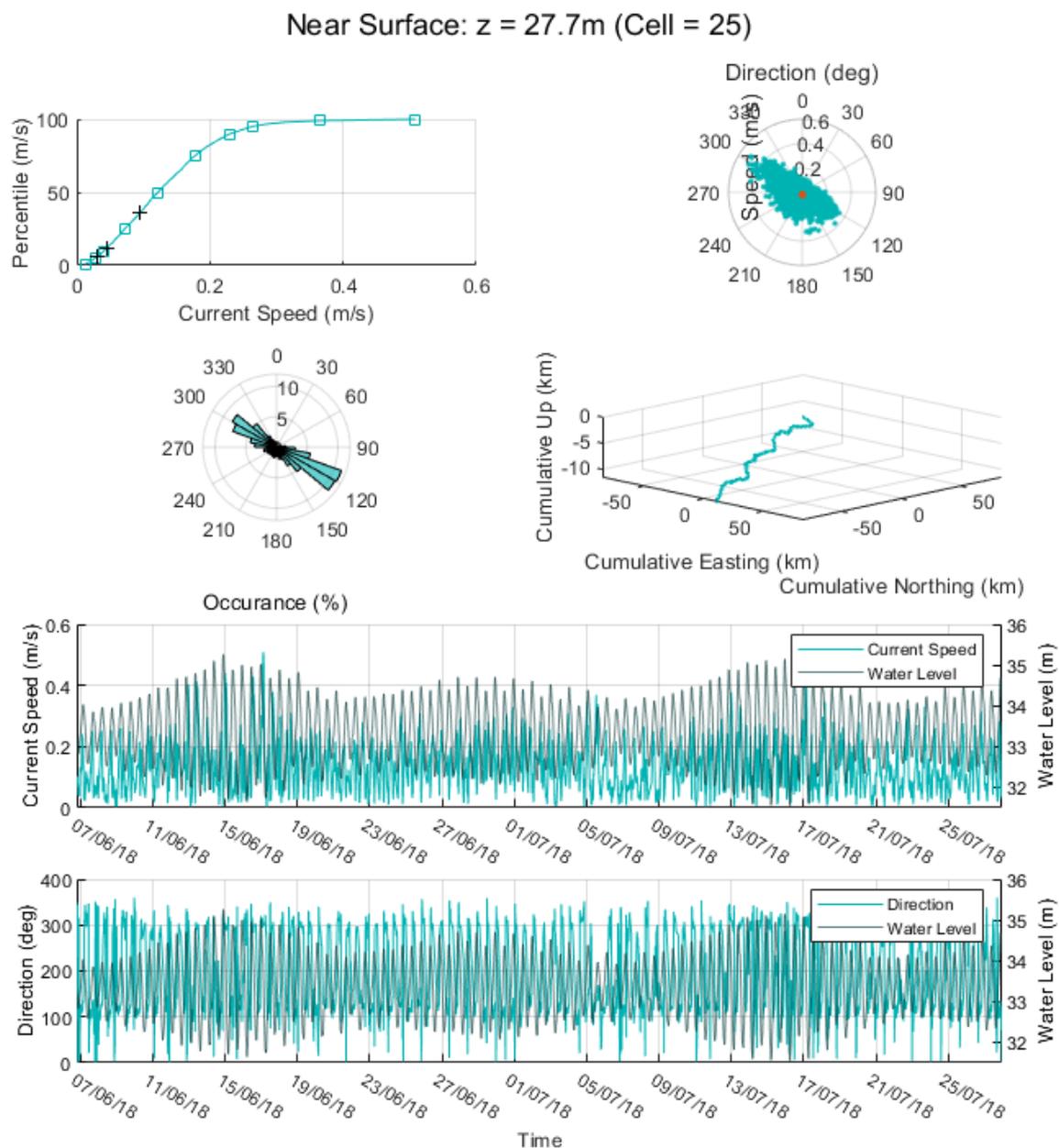


**Figure 9. ADCP 2018: Sensor heading, pitch and roll for the deployment period.**

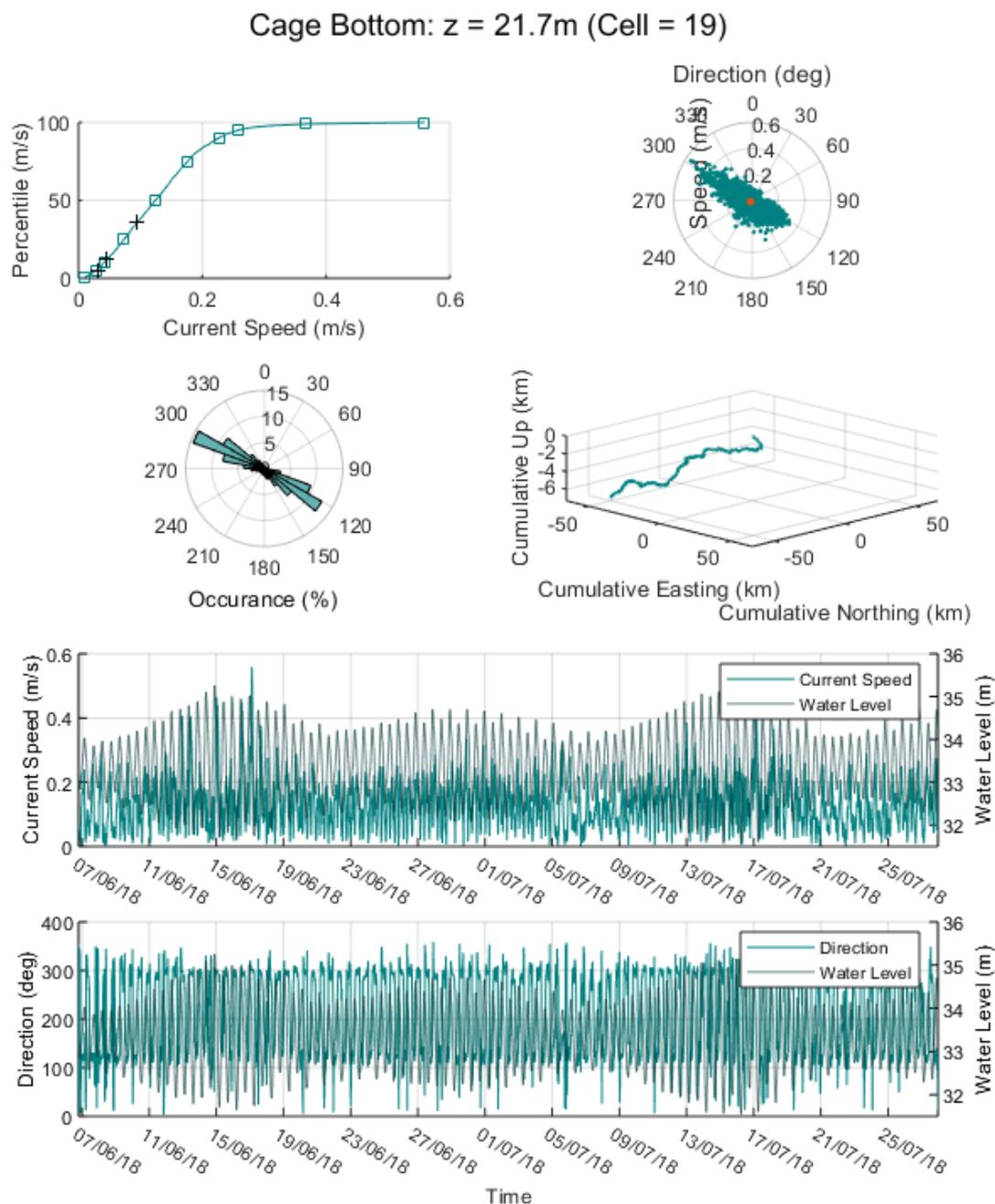
The near surface, cage bottom and near bed flow conditions are presented in Figures 10-12. The flow statistics are shown in Table 6. The site experiences a reasonable flow speed with higher velocities towards the surface. The 2018 deployment records similar flow statistics to the 2016 dataset.

**Table 6. Flow statistics for the 2018**

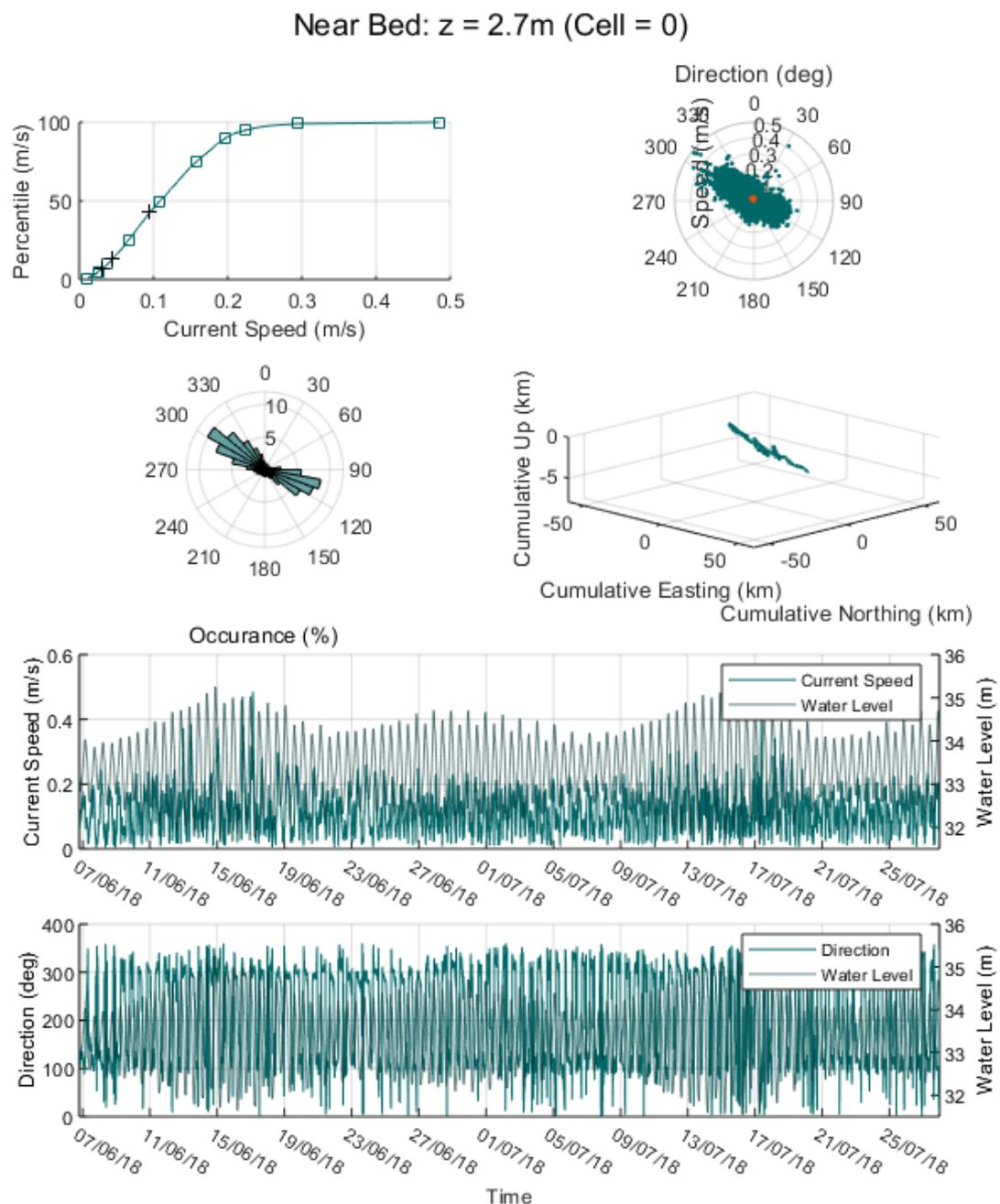
	Near Surface	Cage Bottom	Near Bed
z (m)	27.7	21.7	2.7
Mean Speed (m/s)	0.131	0.131	0.116
Ranked Percentage at 0.03 m/s (%)	5.94	5.32	6.43
Ranked Percentage at 0.045 m/s (%)	12.10	11.83	13.27
Ranked Percentage at 0.095 m/s (%)	36.00	35.87	42.78
Maximum Speed (m/s)	0.51	0.56	0.48
Residual Speed (m/s)	0.019	0.016	0.014
Residual direction (degrees)	171.2	229.8	339.3



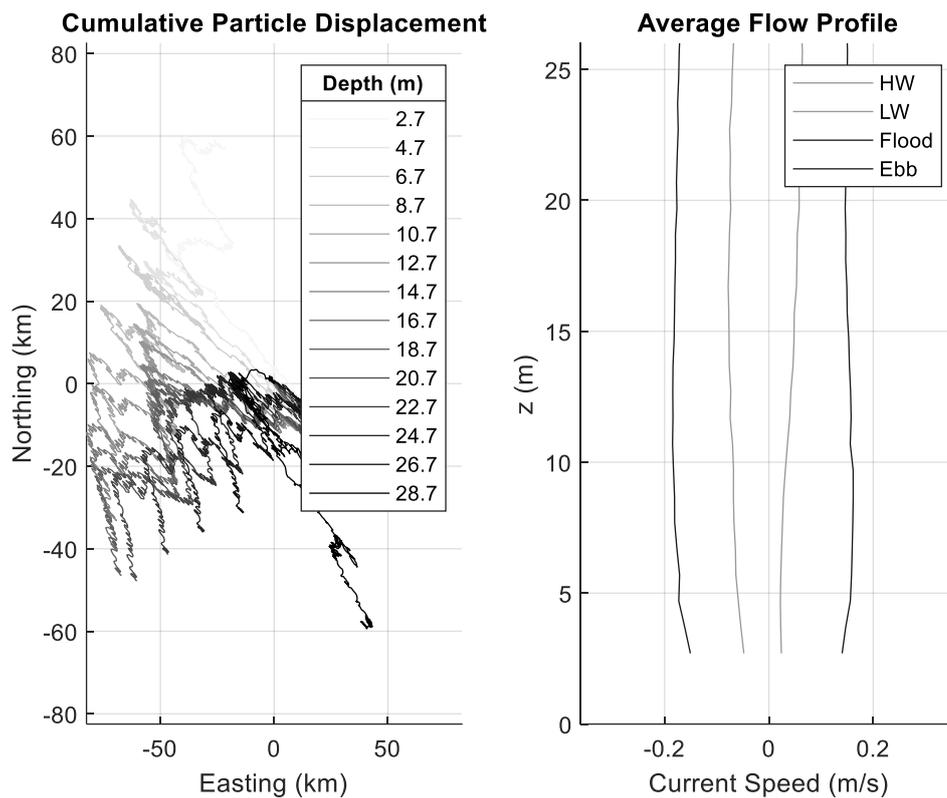
**Figure 10. ADCP 2018: Near surface flow information. Top left: percentile current speed with 0.03, 0.045 and 0.095m/s indicated by cross markers. Top right: polar scatter plot of all speed and direction data points with residual marker in red. Middle upper left: percentage occurrence flow direction. Middle upper right: cumulative 3-dimensional particle displacement. Bottom upper: time series of current speed and water level. Bottom lower: time series of direction and water level.**



**Figure 11. ADCP 2018: Cage bottom flow information. Top left: percentile current speed with 0.03, 0.045 and 0.095m/s indicated by cross markers. Top right: polar scatter plot of all speed and direction data points with residual marker in red. Middle upper left: percentage occurrence flow direction. Middle upper right: cumulative 3-dimensional particle displacement. Bottom upper: time series of current speed and water level. Bottom lower: time series of direction and water level.**



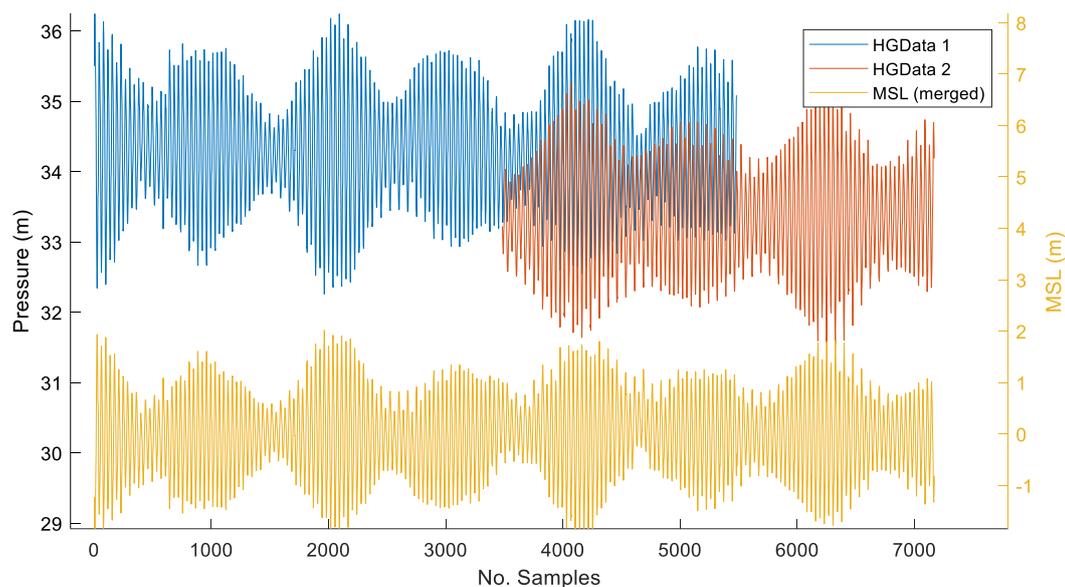
**Figure 12. ADCP 2018: Near bed flow information. Top left: percentile current speed with 0.03, 0.045 and 0.095m/s indicated by cross markers. Top right: polar scatter plot of all speed and direction data points with residual marker in red. Middle upper left: percentage occurrence flow direction. Middle upper right: cumulative 3-dimensional particle displacement. Bottom upper: time series of current speed and water level. Bottom lower: time series of direction and water level.**



**Figure 13. Left: cumulative particle displacement with depth. Right: Average velocity depth profile for high water (HW), low water (LW), flood tide (Flood) and Ebb tide (Ebb).**

### Flow data – Joint 90-days

In order to comply with SEPA's NewDepomod modelling guidelines, a total of 90 days of current meter data must be used. Due to technological constraints of the sensor used in this case, the limited battery life does not permit a full continuous 90-day measurement. In order to achieve the 90 days, two datasets must be stitch together. The joining is done programmatically, where cross correlation is used to provide the smoothest transition from one dataset to another. In order to do this, a dataset is given priority, this is determined based the average standard deviation. The cross-correlation of the data is calculated to provide the best phase alignment of the surface elevation, that results in a total 90-day dataset. For Chalmers Hope, the 2016 deployment was assigned priority (Data 1). This is shown in Figure 14, where the 2018 data is aligned with the highest cross-correlation. This provides good phase alignment high and low water as well as spring and neap cycles.



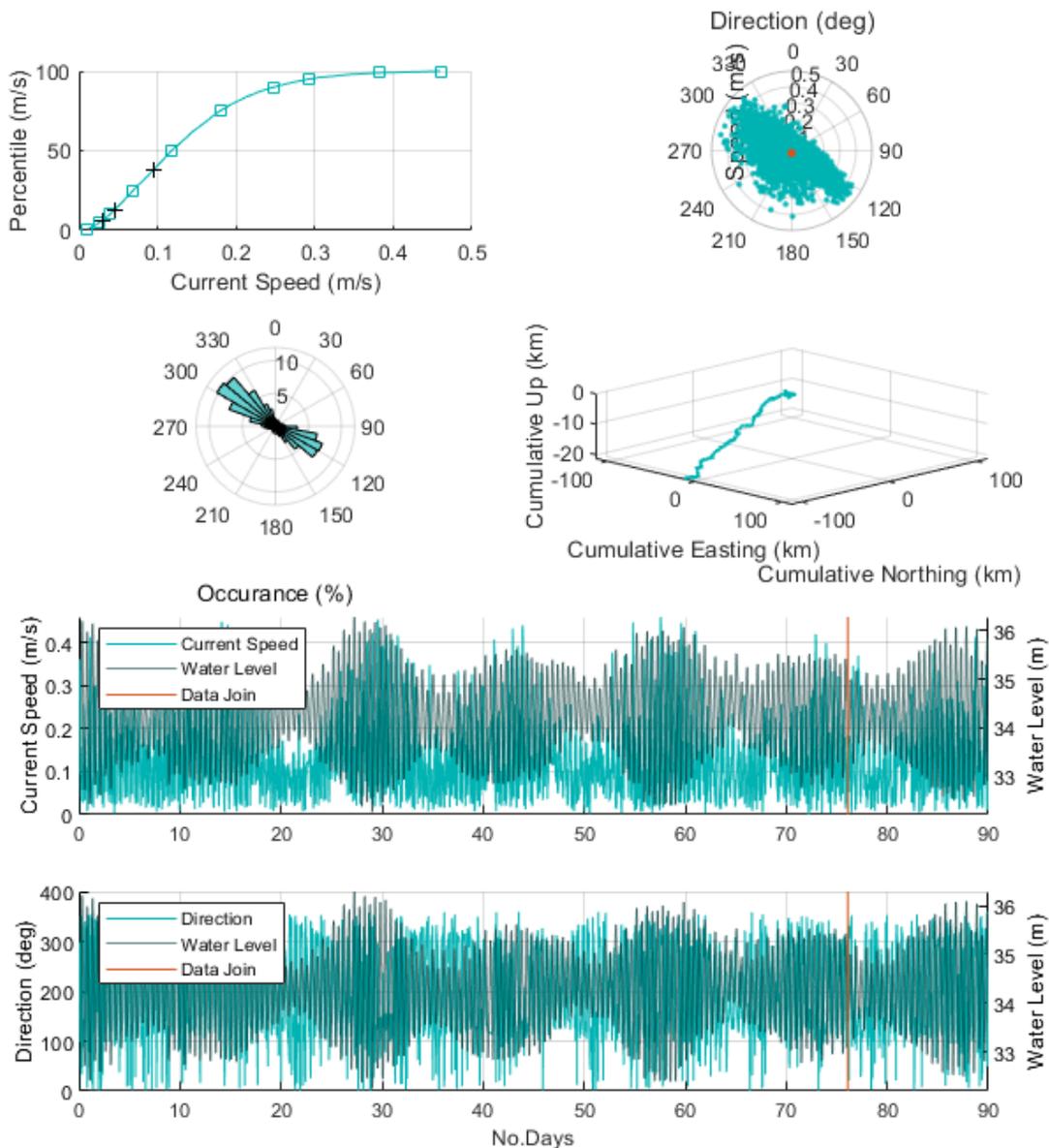
**Figure 14. Sensor pressure and merged Mean Sea Level (MSL) for HGData 1 (2016 ADCP) and HGData 2 (2018 ADCP).**

The near surface, cage bottom and near bed flow conditions are presented in Figures 15-17. The flow statistics are shown in Table 7. The data set is comprised of 76.1 days of data from the 2016 deployment and 13.9 days from the 2018 deployment. This provides a total number of 6480 times steps, forming 90 days of data. When the statistics are compared to the individual deployment, they reflect a ratio of the data origins. This shows statistically, that the 90-day dataset is more similar to the 2016 result.

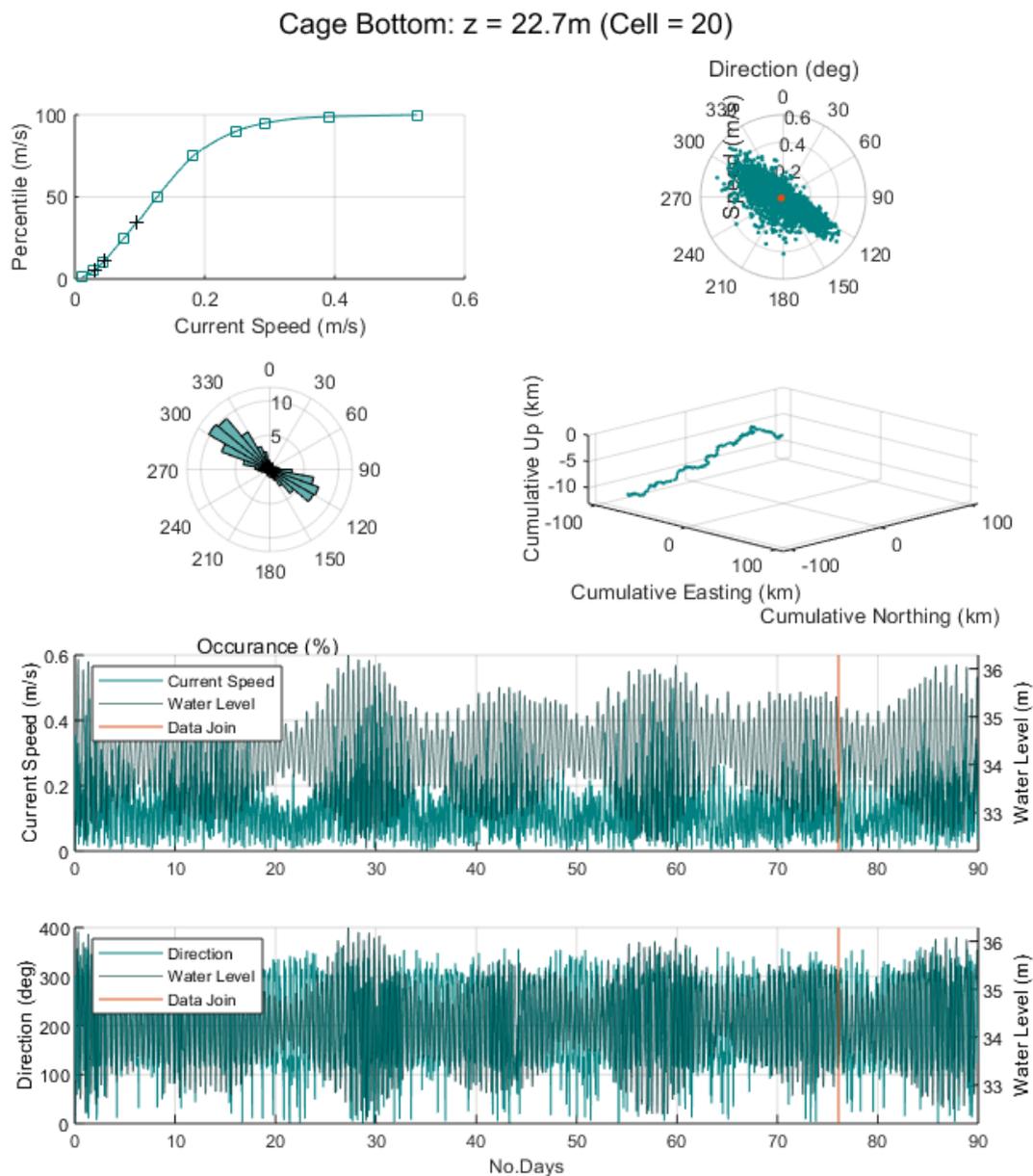
**Table 7. Flow statistics for the joint 90-day data set.**

	Near Surface	Cage Bottom	Near Bed
z (m)	27.7	22.7	2.7
Mean Speed (m/s)	0.133	0.138	0.122
Ranked Percentage at 0.03 m/s (%)	6.47	5.22	5.93
Ranked Percentage at 0.045 m/s (%)	12.58	10.90	11.85
Ranked Percentage at 0.095 m/s (%)	38.04	34.32	40.79
Maximum Speed (m/s)	0.46	0.49	0.43
Residual Speed (m/s)	0.014	0.016	0.022
Residual direction (degrees)	187.2	238.5	325.8

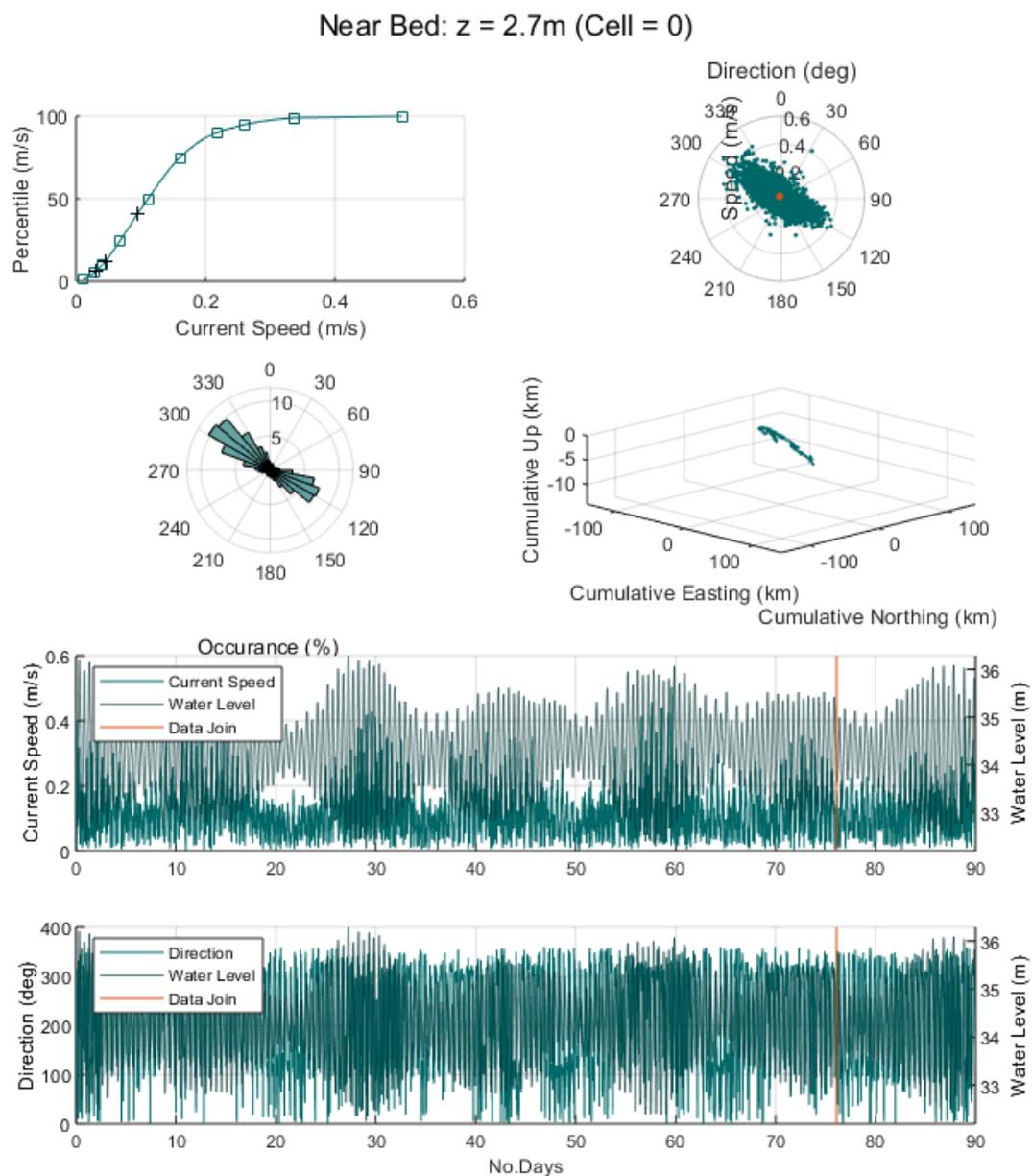
Near Surface: z = 27.7m (Cell = 25)



**Figure 15. Joint 90-days ADCP data: Near surface flow information. Top left: percentile current speed with 0.03, 0.045 and 0.095m/s indicated by cross markers. Top right: polar scatter plot of all speed and direction data points with residual marker in red. Middle upper left: percentage occurrence flow direction. Middle upper right: cumulative 3-dimensional particle displacement. Bottom upper: time series in days of current speed and water level with join line shown in red. Bottom lower: time series in days of direction and water level with join line shown in red.**



**Figure 16. Joint 90-days ADCP data: Cage bottom flow information. Top left: percentile current speed with 0.03, 0.045 and 0.095m/s indicated by cross markers. Top right: polar scatter plot of all speed and direction data points with residual marker in red. Middle upper left: percentage occurrence flow direction. Middle upper right: cumulative 3-dimensional particle displacement. Bottom upper: time series in days of current speed and water level with join line shown in red. Bottom lower: time series in days of direction and water level with join line shown in red.**



**Figure 17. Joint 90-days ADCP data: Near bed flow information. Top left: percentile current speed with 0.03, 0.045 and 0.095m/s indicated by cross markers. Top right: polar scatter plot of all speed and direction data points with residual marker in red. Middle upper left: percentage occurrence flow direction. Middle upper right: cumulative 3-dimensional particle displacement. Bottom upper: time series in days of current speed and water level with join line shown in red. Bottom lower: time series in days of direction and water level with join line shown in red.**

## Discussion

The proposed site experiences mean velocities that exceed 0.1m/s at all depth intervals. Average velocity reduces as depth increases, producing a minor shear profile. Residual currents show an increase in magnitude near the seabed, where residual speed is 18% of the mean bed velocity. A difference of 138 degrees in the residual current direction is shown for the near surface and bed results. This produces a residual current direction of approximately 326 degrees at the seabed.

The hydrographic results can be used to classify the site using flushing, quiescence and resuspension. The mean current speed is above 0.1m/s, making the site a strongly flushed site.

Mean Current Speed			
>0.1m/s	0.05-0.1m/s	0.03-0.05m/s	<0.03m/s
Strongly flushed	Moderately flushed	Weakly flushed	Quiescent

The quiescent period of the measured data shows values constantly >10%, making the site very active.

Quiescent period (0-0.03m/s)		
>50%	30-50%	<30%
Highly quiescent	Moderately quiescent	Slightly quiescent

Resuspension velocities exceed the 0.095m/s 40% of the time, making the site highly suspensive.

Resuspension (<0.095m/s)		
>95%	80-95%	<80%
Depositional/Quiescent	Partially suspensive	Highly suspensive

These parameters classify the site as an active dispersive site, where sediment will be regularly transported away. This will occur predominantly in a NNW heading towards Brings Deep.

## Equipment List

Equipment list

- Garmin e-trex 10 handheld GPS
- Speedtech SM5 depth sounder
- Aandera SeaGuardII current meter (serial no. 1834 and 1803)

## Calibration Reports

Aandera SeaGuardII - Serial no. 1834

# AANDERAA TEST & SPECIFICATIONS

a xylem brand

Form No. 847, Oct 2014

**Product:** SeaGuard II 5650

**Serial No:** 1834

Component	Serial No.	Remarks
Main Assembly SeaGuard II 5655	2380	
DCPS 5400	90	
Tide Sensor 5217B	282	

### 1. Visual and Mechanical Checks

- 1.1. Sensors fixed in correct position
- 1.2. Watertight receptacle and plugs connected
- 1.3. HUB connectors connected to main board
- 1.4. Pressure sensor filled with oil (only if installed)
- 1.5. Epoxy coating intact
- 1.6. Zinc anode installed
- 1.7. O-ring groove inspected, cleaned and greased

### 2. Pre-performance Setup

- 2.1. Hardware and sensors configured
- 2.2. Sensors detected and displayed in Real-Time Collector
- 2.3. Analog channels configured if used
- 2.4. Battery indicator calibrated
- 2.5. SD card operation
- 2.6. S-Flash operation
- 2.7. USB Connection to PC
- 2.8. Clock adjusted to correct UTC
- 2.9. Analog switch in correct position

### 3. Performance test

- 3.1. Current drain idle (max 30 mA) 17.1 mA
- 3.2. Current drain in Power Down Mode (max 1.4 mA) 0.76 mA
- 3.3. Pressure test
- 3.4. Field test and data analysis
- 3.5. Operation test, -5°C to +35°C (all sensors, 16 hours, data on SD)

Windows CE License-Key : 00039-717-372-855

Date: 10 May 2016

Sign:



Production Engineer



# CALIBRATION CERTIFICATE

Certificate no: DCPS 5400\_90\_00116525

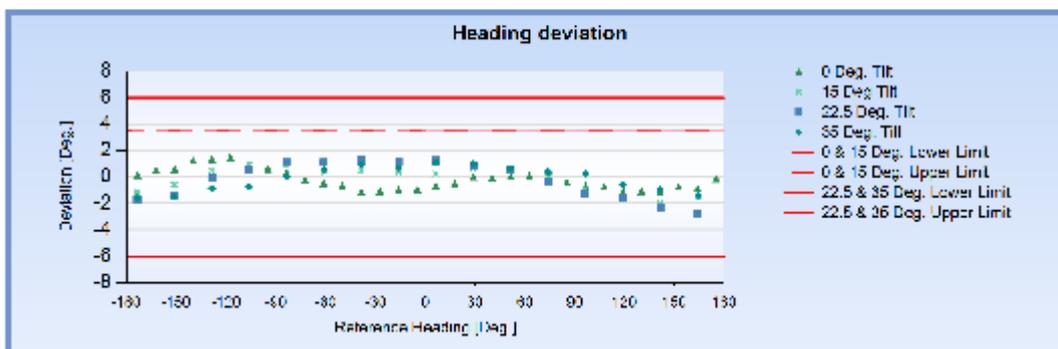
Product: DCPS  
Calibration date: 09.03.2016

Serial no: 90  
Page 1 of 2

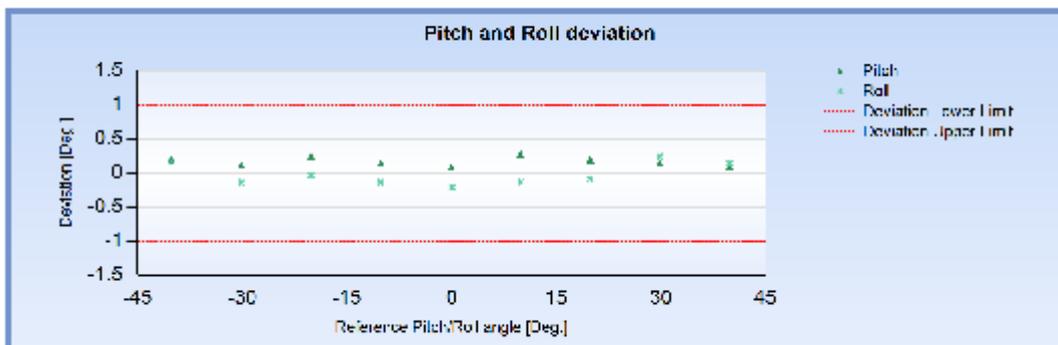
This is to certify that this product has been calibrated and verified using the following reference equipment:

Reference Equipment Description	Serial
Compass HMR3500	13987
Encoder Sendix F3653	1412501654
Encoder Sendix F3653	1412501655
Encoder Sendix F3653	1412501653

Obtained Heading deviation for this product:



Obtained Pitch and Roll deviation for this product:





# TEST & SPECIFICATIONS

Form No. 847, Oct 2014

**Product:** SeaGuard II 5650**Serial No:** 1803

Component	Serial No.	Remarks
Main Assembly SeaGuard II 5655	2425	
HV HUB SeaGuard II	20153961	
DCPS 5400	102	
Tide Sensor 5217	315	

**1. Visual and Mechanical Checks**

- 1.1. Sensors fixed in correct position
- 1.2. Watertight receptacle and plugs connected
- 1.3. HUB connectors connected to main board
- 1.4. Pressure sensor filled with oil (only if installed)
- 1.5. Epoxy coating intact
- 1.6. Zinc anode installed
- 1.7. O-ring groove inspected, cleaned and greased

**2. Pre-performance Setup**

- 2.1. Hardware and sensors configured
- 2.2. Sensors detected and displayed in Real-Time Collector
- 2.3. Analog channels configured if used
- 2.4. Battery indicator calibrated
- 2.5. SD card operation
- 2.6. S-Flash operation
- 2.7. USB Connection to PC
- 2.8. Clock adjusted to correct UTC
- 2.9. Analog switch in correct position

**3. Performance test**

- 3.1. Current drain idle (max 30 mA) 17.2 mA
- 3.2. Current drain in Power Down Mode (max 1.4 mA) 0.7 mA
- 3.3. Pressure test
- 3.4. Field test and data analysis
- 3.5. Operation test, -5°C to +35°C (all sensors, 16 hours, data on SD)

Windows CE License-Key : 02219-016-135-830

Date: 07 Oct 2016

Sign:

Production Engineer



# CALIBRATION CERTIFICATE

Certificate no: 5400\_102\_00121004

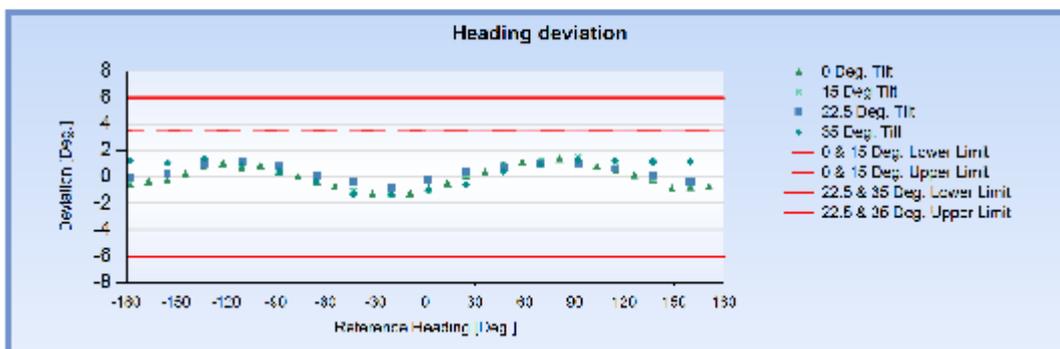
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Calibration date: 30.08.2018

Serial no: 102  
Page 1 of 2

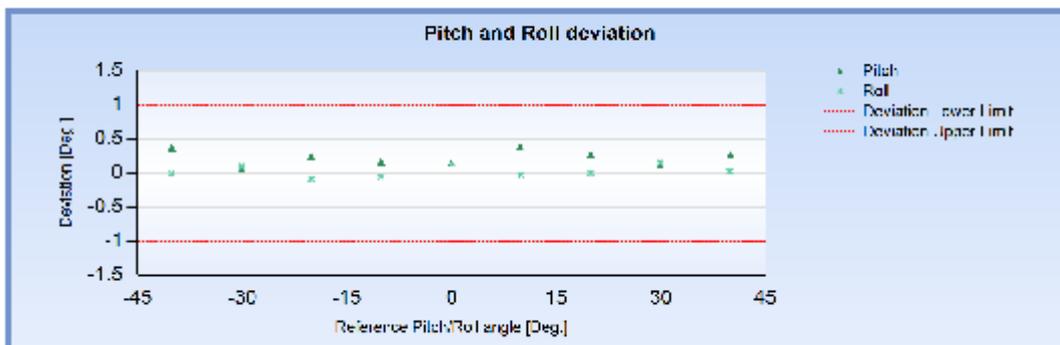
This is to certify that this product has been calibrated and verified using the following reference equipment:

Reference Equipment Description	Serial
Compass HMR3500	13987
Encoder Sendix F3653	1412501654
Encoder Sendix F3653	1412501655
Encoder Sendix F3653	1412501653

Obtained Heading deviation for this product:



Obtained Pitch and Roll deviation for this product:



## List of datafiles and description

### Data – 2016

HG data sheets (NS,CB,NB)

- CurrentMeterData\_ChalmersHope\_Surface2016.xls
- CurrentMeterData\_ChalmersHope\_Middle2016.xls
- CurrentMeterData\_ChalmersHope\_Surface2016.xls

Raw instrument files

- Data000.bin
- Data001.bin
- Data002.bin
- Data003.bin
- Data004.bin
- Data005.bin
- Data006.bin
- Data007.bin
- Data008.bin
- Data009.bin
- Config.xml
- Layot.xml

Post processing log file

- Log\_HGdata\_analysis.txt

### Data – 2018

HG data sheets (NS,CB,NB)

- ChalmersHope\_NS\_2018.xls
- ChalmersHope\_CB\_2018.xls
- ChalmersHope\_NB\_2018.xls

Raw instrument files

- Data000.bin
- Data001.bin
- Data002.bin
- Data003.bin
- Data004.bin
- Data005.bin
- Data006.bin

- Data007.bin
- Data008.bin
- Data009.bin
- Config.xml
- Layot.xml

Post processing log file

- Log\_HGdata\_analysis.txt

### **Data – Joint 90 days**

HG data sheets (NS,CB,NB)

- CurrentMeterData\_ChalmersHopeJoint\_\_Surface2016.xls
- CurrentMeterData\_ChalmersHopeJoint\_\_Middle2016.xls
- CurrentMeterData\_ChalmersHopeJoint\_\_Bottom2016.xls

Post processing log file

- Log\_JoinHGdata\_analysis.txt

## **References**

Scottish Environment Protection Agency (SEPAa) (2019) “Regulatory Modelling Process and Reporting Guidance for the Aquaculture Sector”. Version 1.1. Available at <https://www.sepa.org.uk/media/450278/regulatory-modelling-process-and-reporting-guidance-for-the-aquaculture-sector.pdf>. (Accessed on 11/12/19).

Scottish Environment Protection Agency (SEPAb) (2019) “Regulatory Modelling Guidance for the Aquaculture Sector” Version 1.1. Available at <https://www.sepa.org.uk/media/450279/regulatory-modelling-guidance-for-the-aquaculture-sector.pdf>. (Accessed on 11/12/19).

UK Hydrographic Office (2014) “Admiralty Marine Data” Available at: <https://www.gov.uk/guidance/inspire-portal-and-medin-bathymetry-data-archive-centre> (Accessed 11/12/19).

