



MODELLING DATA COLLECTION REPORT  
EAST MOCLETT

Survey: September 2020-January 2021

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Report date: 18 March 2021

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**Table of Contents**

Summary .....	3
1.Quality Assurance Statement .....	5
2.Site Description .....	5
3.Scope of Report.....	6
3.1 Required Data.....	6
3.2 Existing Data .....	6
4.Methods.....	6
4.1 Hydrographic Measurements .....	6
4.2 Hydrographic Data: 10/09/2020-14/01/2021.....	7
4.3 Data Processing .....	7
5.Site Infrastructure .....	8
6.Bathymetry .....	9
7.Flow Data .....	9
8.Discussion .....	15
9.Equipment List .....	17
10.Calibration Reports .....	17
11.List of Data Files and Description.....	20
12.References .....	20

## Summary

A hydrographic survey was carried out by Cooke Aquaculture Scotland for a proposed new marine caged fish farm site, East Moclett, located off the south east coast of Papa Westray, Orkney.

An acoustic profiling current meter was deployed at the proposed site for 126 days, from the 10<sup>th</sup> September 2020 to the 14<sup>th</sup> January 2021, from which a 90-day subset was selected. The meter recorded 118 days of usable data from the 10/09/2020- 06/01/2021 before increased errors occurred towards the end of the deployment. The data presented is 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 that there were minor disturbances around the mooring during the deployment that resulted in pitch and roll changes, however these were all <3 degrees. There was a distinct mooring disturbance on 29<sup>th</sup> September between 04:50 and 05:10 which caused a heading shift of approximately 9.8 degrees. These variations are well within the post-processing corrections limits and do not cause any deterioration in the data.

The current meter dataset describes an area with strong tidal influence, where flows regularly exceed 0.1m/s. Semi-diurnal patterns are present within the current data with 7 spring/neap cycles. There is a reduction in mean velocity as you move down through the water column towards the seabed. Maximum current speed and residual current speed are greatest in the near surface layer.

Due to the large average flow speeds, it is expected that this site will be highly dispersive, where large amounts of solid waste transport is anticipated. Near bed residual velocities suggest transport is likely to occur in a north west 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: 14/09/20-13/12/20</b>				
<b>Deployment Position (OSGB - Easting, Northing)</b>	<b>352757, 1048531</b>			
	<b>Unit</b>	<b>Near Surface (47.1m)</b>	<b>Cage Bottom (34.1m)</b>	<b>Near Seabed (2.1m)</b>
<b>Mean speed</b>	m/s	0.167	0.165	0.117
<b>Ranked percentage of 0.030 m/s</b>	%	2.2	2	4.7
<b>Ranked percentage of 0.095 m/s</b>	%	22.4	22.1	40.5
<b>Maximum speed</b>	m/s	0.478	0.456	0.346
<b>Residual direction</b>	°Grid	306.9	305	304.4
<b>Residual speed</b>	m/s	0.078	0.078	0.046
<b>Parallel Amplitude</b>	m/s	0.234	0.233	0.166
<b>Normal Amplitude</b>	m/s	0.069	0.050	0.052
<b>Amplitude anisotropy</b>	-	3.38	4.63	3.20

## 1. 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 the 2019 Regulatory Guidance documents (SEPAa & SEPAb).

## 2. Site Description

East Moclett is a proposed new site to be operated by Cooke Aquaculture Scotland. The site location shown in Figure 1 and is situated in North Sound approximately 2.92km south east of the coast of Papa Westray, Orkney. The seabed around the proposed site is circalittoral coarse sediment largely made up of sandy gravel (Marine Scotland Maps NMPI 2021). North Sound is a relatively deep sound with fast flowing currents and high wave exposure to the north.

The proposed site is located (OSGB 1936) 352757, 1048516 and consists of 6 x 160m (circumference) cages. The cage layout is orientated north to south (bearing 0°) and consists of two rows of three cages.

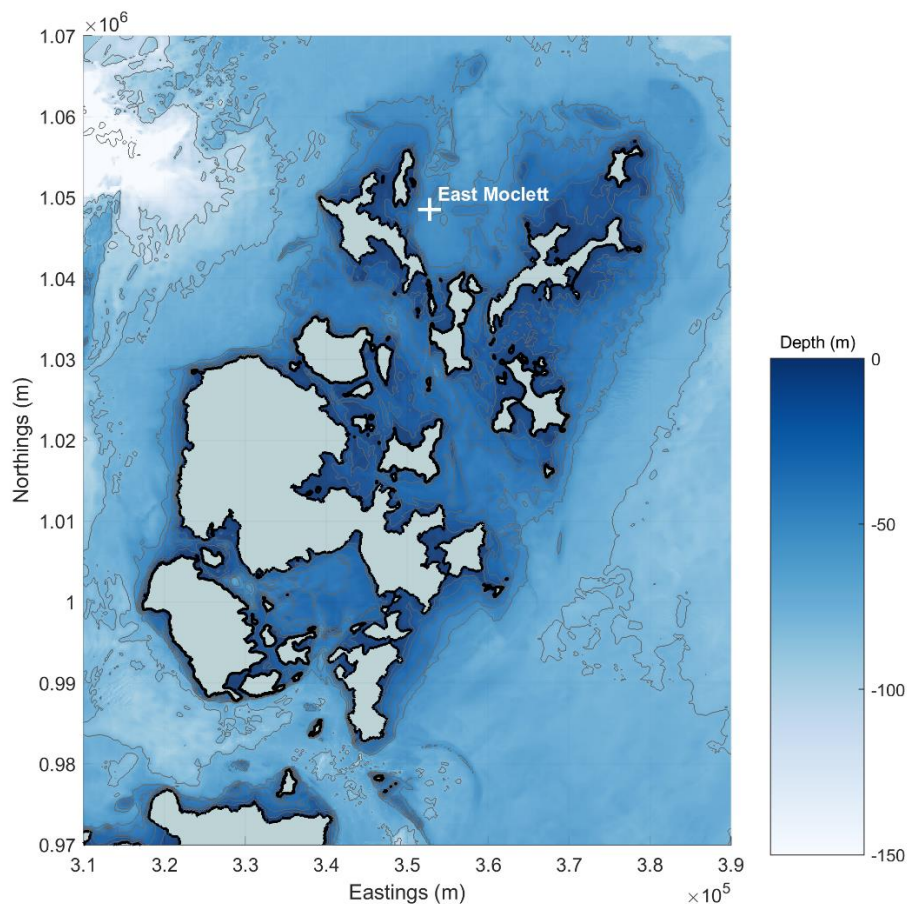


Figure 1 Site location

**Table 1 Site Infrastructure and pen layout**

Total number of pens	6
Number of pen groups	1
Formation	2 x 3
Dimension	Circular pen with diameter of 50.9m
Grid spacing	110m
Group orientation	0°
Centre location (OSGB Easting, Northing)	352757 1048516

### 3.Scope of Report

#### 3.1 Required Data

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.

#### 3.2 Existing Data

Hydrographic data collected in 2020 has been assessed with a 90-day subset of data being selected for analysis. UK Hydrographic Office (UKHO) data was used to create the bathymetry around the site for future modelling work.

### 4.Methods

#### 4.1 Hydrographic Measurements

A hydrographic survey was undertaken at the proposed East Moclett site. The sensor was deployed between the 10<sup>th</sup> September 2020 to the 14<sup>th</sup> January 2021, however irregular data records starting on the 6<sup>th</sup> January 2021 provided only 118 days of usable data.

The sensor was mounted in a weighted mooring frame with a gimble. The transducer head was located 0.62m from the seabed. The sensor configuration is shown in Table 2.

**Table 2. Sensor configuration for the deployment**

<b>Signature500 – Serial no. 101502</b>	
Site Name	East Moclett
Measurement interval (minutes)	10 (600 secs)
Average interval (minutes)	5 (300 secs)
Number pings	480
Orientation	Up looking
Salinity (ppt)	35

Cell size (m)	1
Number cells	65
Coordinate system	BEAM
Blanking distance (m)	0.5
Vertical precision (cm/s)	0.27
Measurement load (%)	40

#### 4.2 Hydrographic Data: 10/09/2020-14/01/2021

A Nortek Signature 500kHz Acoustic Doppler Current Profiler (Signature500) was deployed at (OSGB 1936) 352757, 1048531, situated 16m from the proposed site centre. The deployment period covered 126 days from the 10<sup>th</sup> September 2020 to the 14<sup>th</sup> January 2021. This device has a serial number of 101502.

Data is recorded and calculates flow profiles every 600 seconds. 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	Resolution	Range
<b>Speed</b>	0.3% of 0.3cm/s	0.1cm/s	2.5m/s
<b>Compass</b>	2° tilt <30°	0.01°	-
<b>Tilt</b>	0.2° tilt <30°	0.01°	-
<b>Pressure</b>	0.1% full scale	-	0-100m
<b>Heading</b>	± 3° (dynamic)	0.01°	360° all axis
<b>Pitch/roll</b>	± 2° (dynamic)	0.01°	± 90°(p) ± 180°(r)
<b>Temperature</b>	0.1°	0.01°	-4 to +40°

#### 4.3 Data Processing

Raw data recorded on the Signature500 was downloaded as binary data files using the Nortek AS Signature Deployment programme. The Deployment programme was then used to convert and export the binary files into Matlab and CSV format files.

The averaged current data was assessed in Signature Viewer, a post processing software programme, to ensure the data was of high quality. Quality control checks of the data were carried out on the exported data in Excel. The qualitative checks included assessment of:

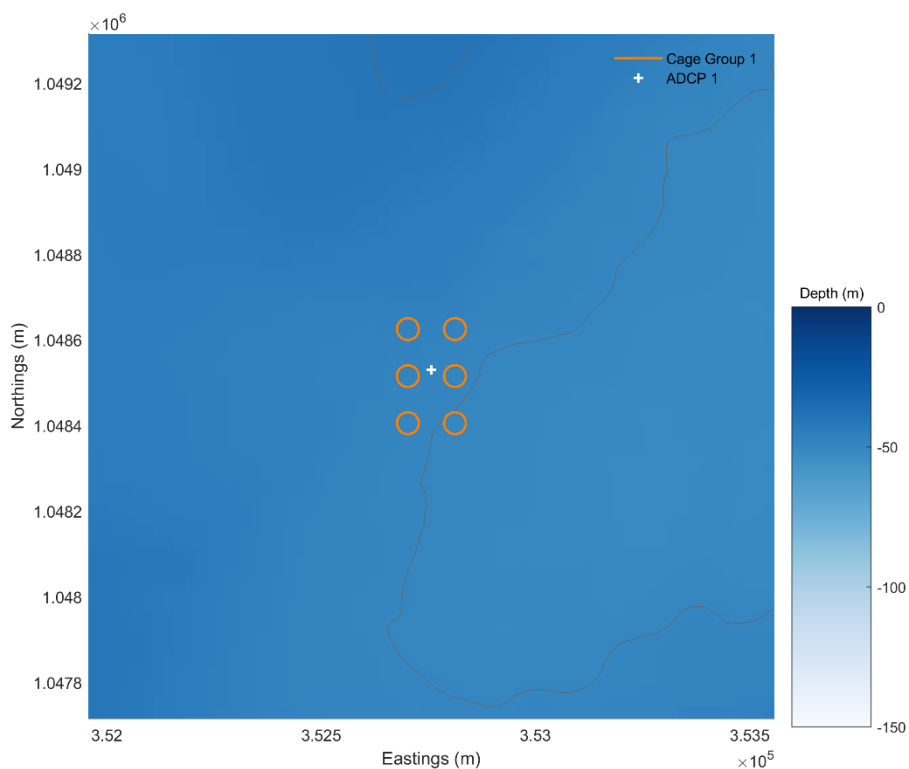
- Heading, Pitch and Roll (°) – checking the meter has an upward orientation and limited frame movement during the survey using a threshold exceedance method with a range of ± 10°.

- Pressure record (m) – comparing the depth recorded by the meter with the bathymetry for the area. Clear spring and neap tides observed in the pressure record with no unusual increases or decreases in the record.
- Amplitude (Signal Strength - dB) – should be decreasing with distance from the sensor. Be aware of any unusual spikes, large increases or the amplitude becoming constant. Dramatic increases in amplitude will be seen when the signal meets a boundary such as the surface or seabed. Minimum amplitude threshold = 30dB.
- Correlation (%) – quality measure of velocity data, a decrease in correlation means a decrease in data accuracy. Minimum correlation threshold = 50% of the maximum correlation.

The data was then imported into MATLAB, where in-house scripts performed quality control and post processing using the parameters above. Any data out with the QC parameters were removed and replaced with NaN values. These were later interpolated to repair any missing values. Only depth cells with less than <5% missing/repared data are considered for use in further modelling work.

## 5.Site Infrastructure

The proposed cage layout is shown in Figure 2.



**Figure 2 Proposed cage layout and ADCP location at East Moclett.**



## 6. Bathymetry

Figure 2 shows the bathymetry around the site sourced from UKHO. This shows a relatively flat featureless bed with a depth of around 50m. This data will be used for modelling purposes.

## 7. Flow Data

During the period from the 10/09/2020-06/01/2021 a mean water depth of 54.8m was recorded. To comply with SEPA's NewDepomod regulatory modelling guidelines, a total of 90 days of current meter data must be used. This provides a total number of 12,960 times steps, forming 90 days of data. The length of the usable dataset exceeds the 90-day minimum by 28 days. The 90-day period selected was from the 14/09/2020 23:30-13/12/2020 23:20.

The quality control process identified no pitch and roll exceedances and 177 water column errors (0.03%). The sensor heading, pitch and roll for the 90-day period are shown in Figure 3. There are minor disturbances recorded in the sensors heading, pitch and roll. This suggests minimal sensor movements, where any fluctuations remain within the operational constraints. These measurements suggest it is unlikely that any large repeated frame movements occurred.



**Figure 3. Sensor heading, pitch and roll for the 90-day period.**

The flow statistics are shown in Table 5. This identifies the near surface, cage bottom and near bed depth cells as 46.62m (cell 46), 33.62m (cell 33), and 1.62m (cell 1) respectively. The near surface cell is located approximately 7.5m below the low water level. This is due to the increased wave exposure at the site, where cell 46 is the nearest cell to the surface where errors occur less than 5%.

Current measurements at the site experience high flow speeds with larger velocities near the surface. Residual currents speeds are shown to be relatively high, where at the seabed residual currents are 39% of the mean current speed. Ranked percentage of velocity 0.03, 0.045 and 0.095m/s represents the proportion of data below these speeds. This indicates whether a site is quiescent and determines the proportion of resuspension velocities. This data represents a site with very low quiescent tendencies, with a large proportion of resuspensions events. A stronger residual current is observed at the surface and cage bottom that decrease towards the bed. This flows in a predominantly north-westerly direction for all depths cells as shown in Figure 7, where residual flow is observed at 305 degrees. Mean depth profiles show lower velocities at the seabed. This shear layer indicates the presence of boundary layer mixing.

**Table 5. Flow statistics**

	Near Surface	Cage Bottom	Near Bed
z (m)	46.62	33.62	1.62
Mean Speed (m/s)	0.167	0.165	0.117
Ranked Percentage at 0.03 m/s (%)	2.2	2	4.7
Ranked Percentage at 0.045 m/s (%)	5	4.7	10.3
Ranked Percentage at 0.095 m/s (%)	22.4	22.1	40.5
Maximum Speed (m/s)	0.478	0.456	0.346
Residual Speed (m/s)	0.078	0.078	0.046
Residual direction (degrees)	306.9	305	304.4

The near surface, cage bottom and near bed flow conditions are presented in Figures 4-6.

Plot descriptions:

- A - Percentile current speed with 0.03, 0.045 and 0.095m/s indicated by black cross markers.
- B - Polar scatter plot of all speed and direction data points with residual marker in red.
- C - Percentage occurrence flow direction.
- D - Cumulative 3-dimensional particle displacement.
- E - Time series of current speed and water level.
- F - Time series of direction and water level.



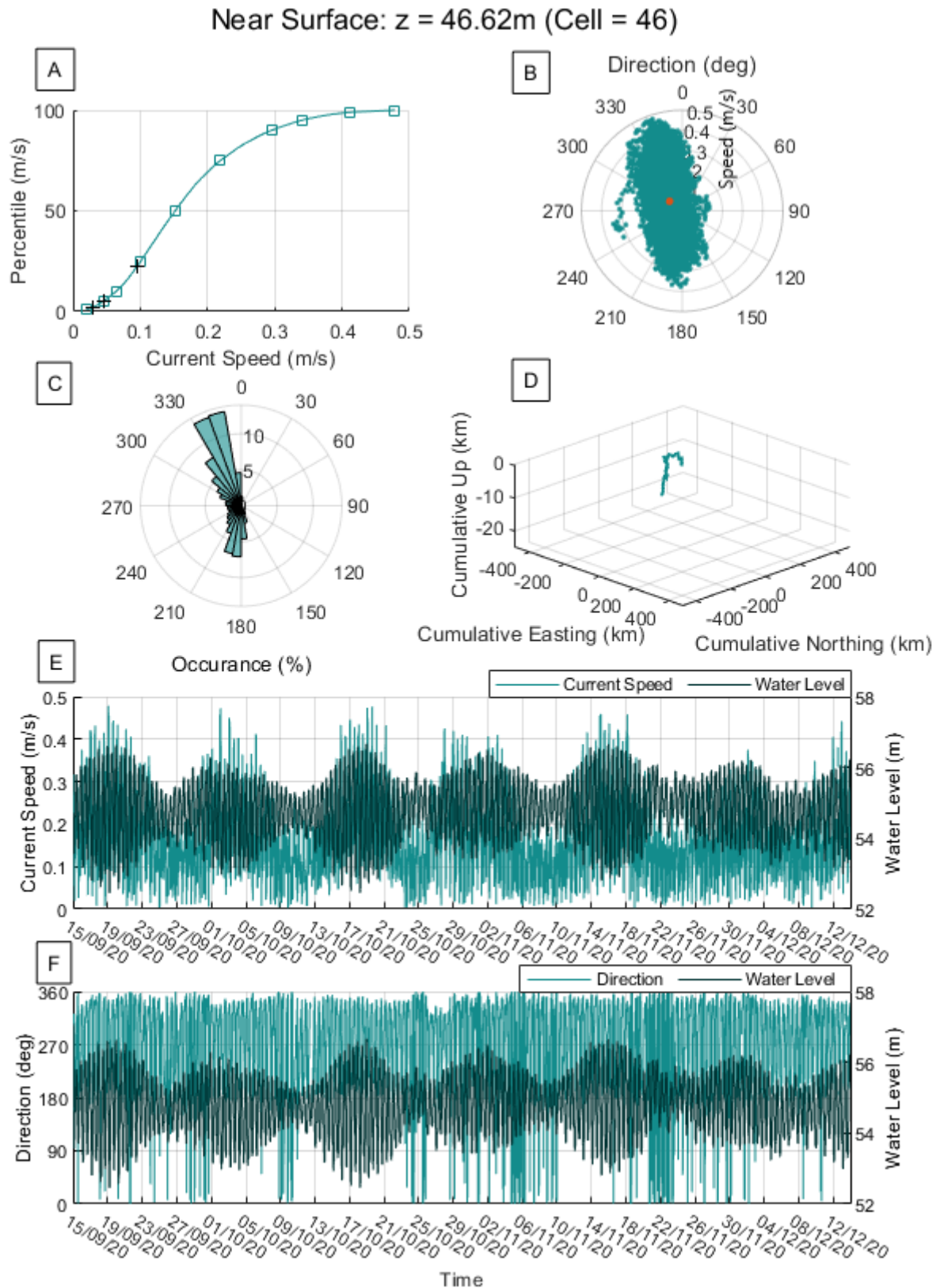


Figure 4. Near surface flow information.

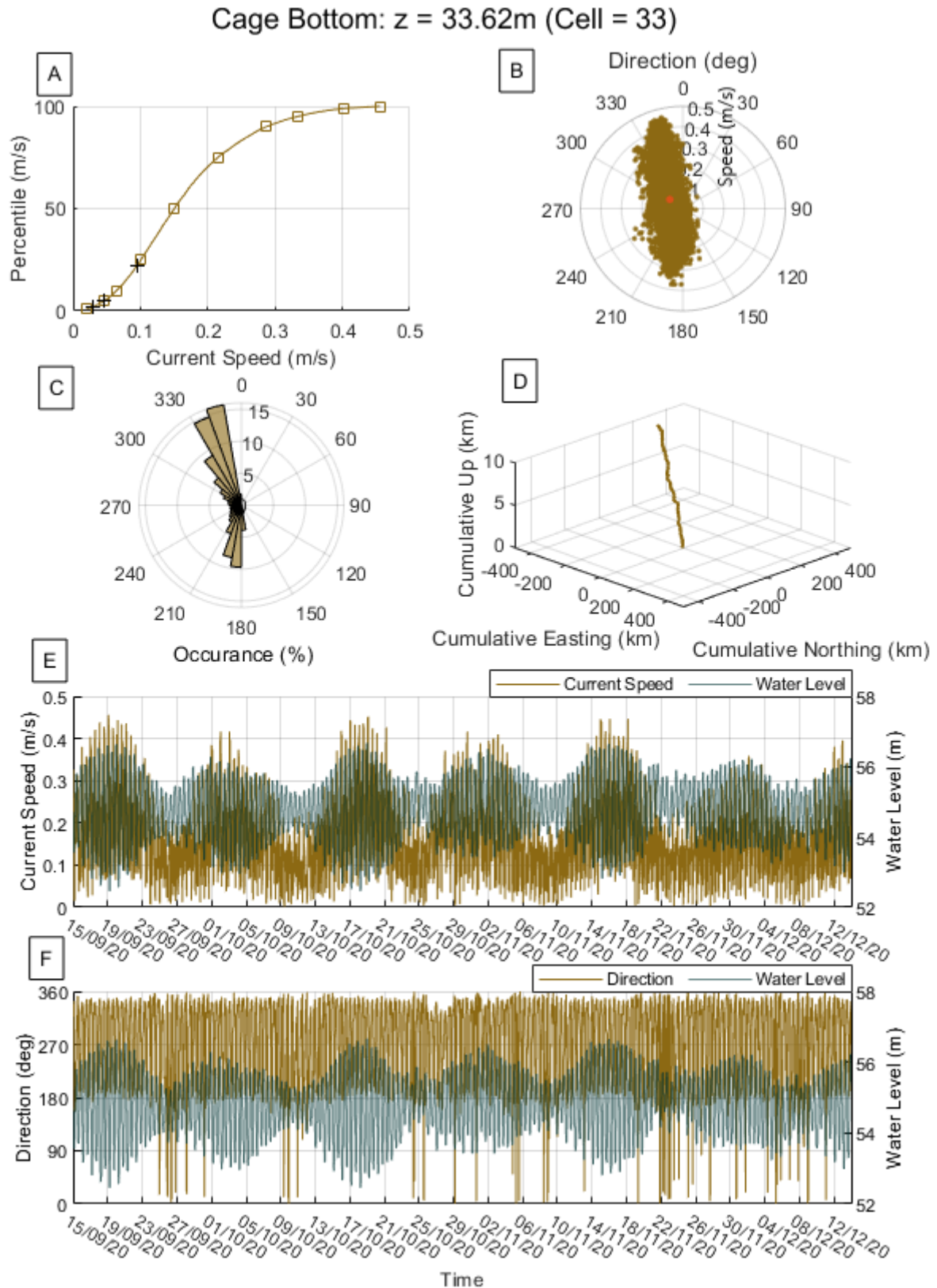


Figure 5. Cage bottom flow information.

Near Bed: z = 1.62m (Cell = 1)

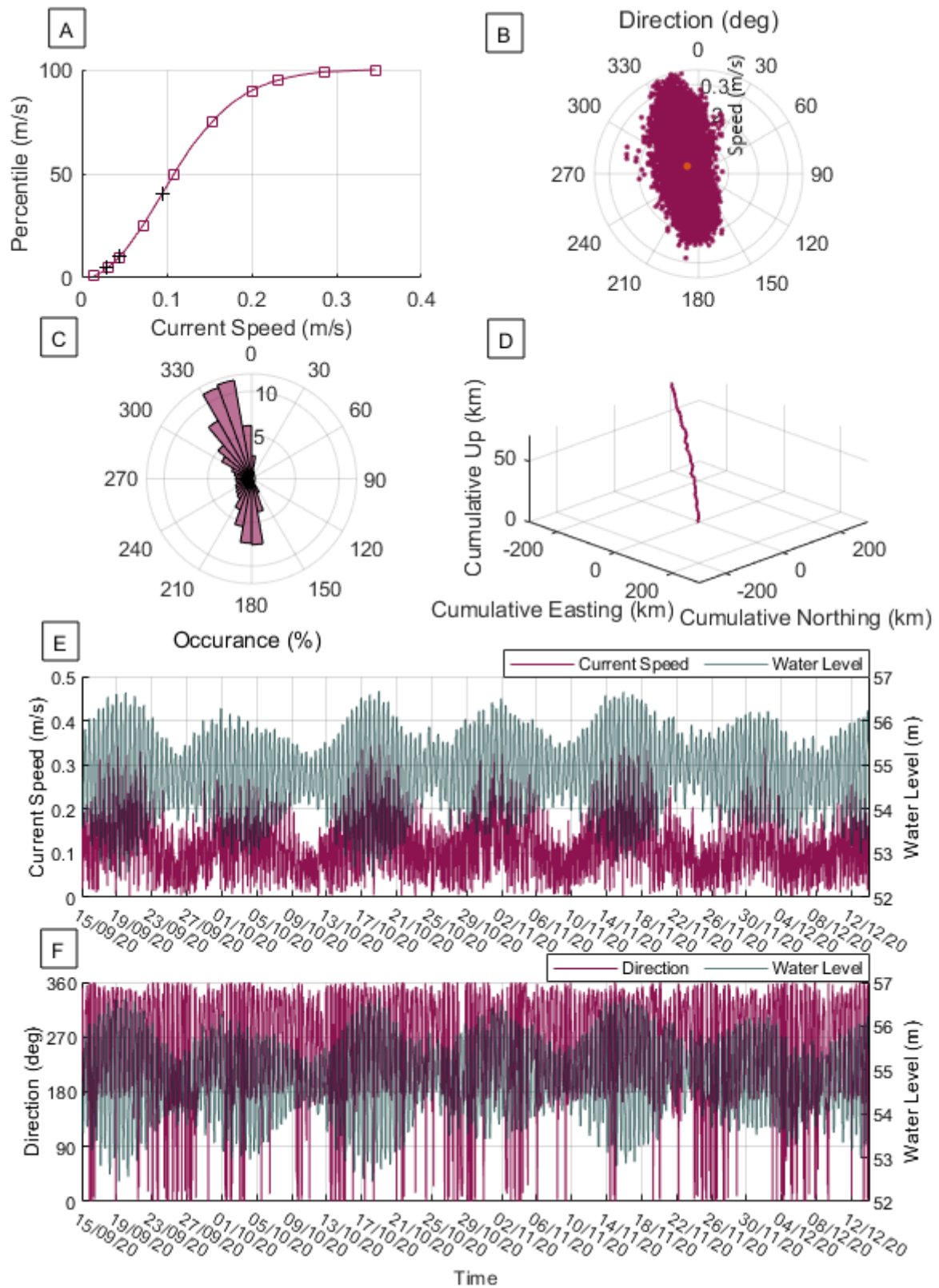
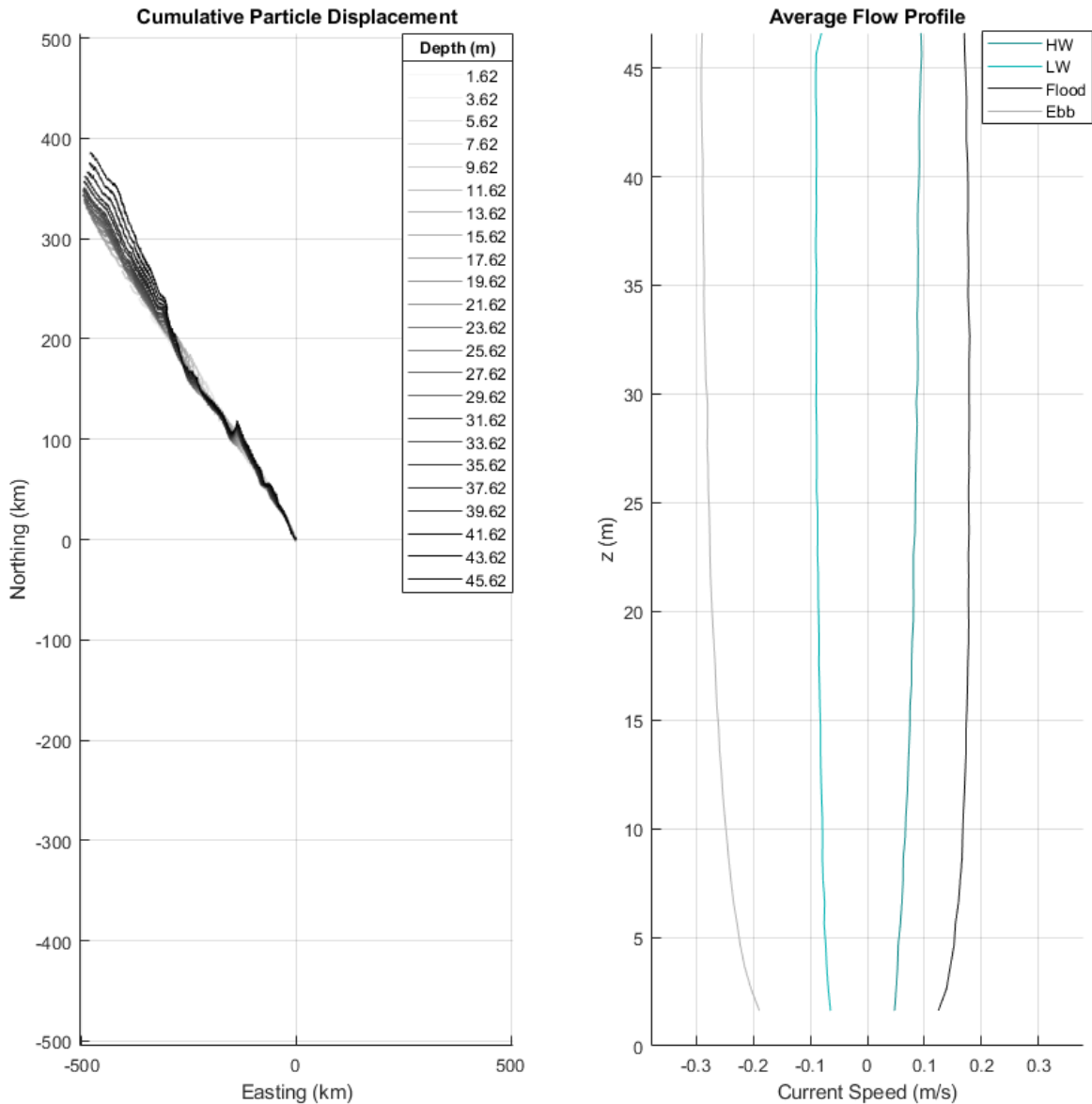


Figure 6. Near bed flow information.

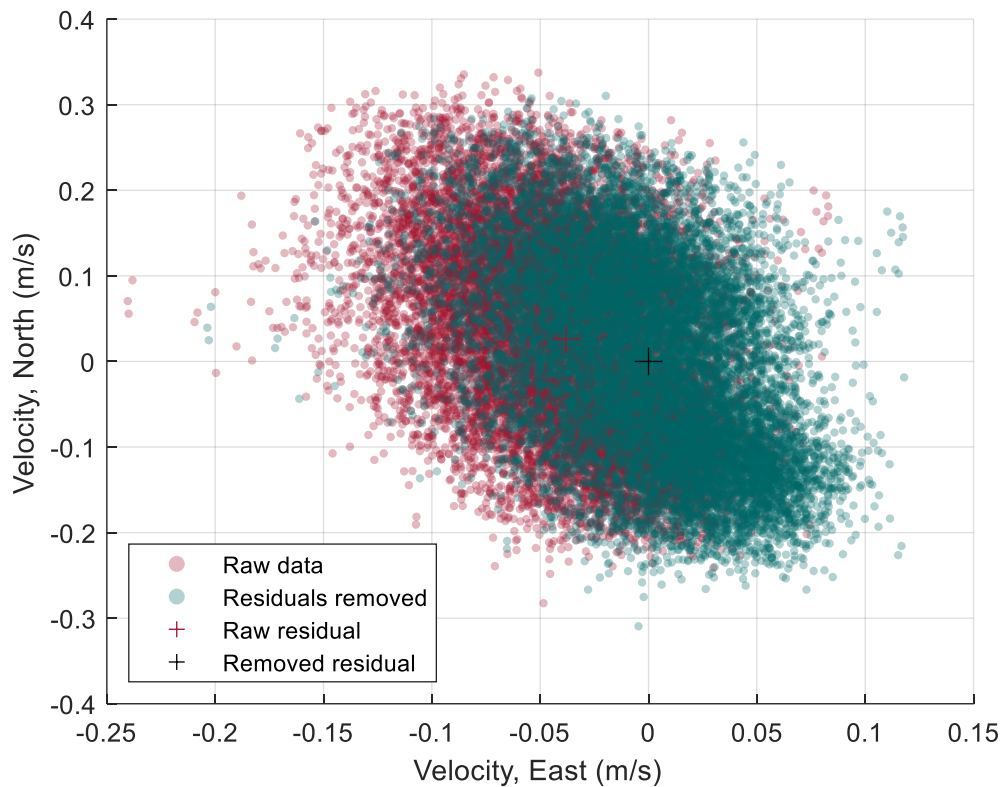


**Figure 7 Left: Cumulative particle displacement with depth. Right: Average velocity depth profile for high water (HW), low water (LW), flood tide (Flood) and ebb tide (Ebb).**

### 8.Flow Data – Residuals Removed

As residual current speeds exceed 35% of the mean bed velocity, the mean residual current speeds must be removed from the dataset to comply with SEPAb (2019) for use in the default model. This is only done for the near bed cell. Figure 8 shows the processed data containing all residual flow components and the velocity vectors once the residual flows speeds have been removed. This subtracts 0.0462 m/s with a direction of 304.4 degrees

from the velocity data, this effectively centralizes the scatter data around 0m/s.



**Figure 8 Residual currents removed from bed cell.**

## 8. Discussion

An ADCP was deployed near the proposed site centre for over 90-days. During this time, the sensor recorded minimal gimbal and heading movements. Additional quality control techniques found 0.03% errors within the data. This suggests a successful deployment with results suitable for use in further applications.

The site experiences mean velocities that exceed 0.1m/s at all depth intervals. Average velocity decreases as depth increases producing a minor shear profile. Residual currents show an increase in magnitude as you move towards the surface and are in the order of approximately 39-48% of the mean velocity. Residual current direction is very uniform across all three depth intervals with a residual current direction between 304.4-306.9 degrees.

The hydrographic results can be used to classify the site in terms of flushing, quiescence and resuspension. The mean current speed is above 0.1m/s, making East Moclett 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 periods of the measured data show values <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 0.095m/s 40% of the time, making the site highly resuspensive.

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

These parameters classify the site as an active dispersive site, where sediment will be regularly transported away. The net sediment transport is likely to occur in a north-west direction, due to the large residual currents.

## 9. Equipment List

- Garmin eTrex 10 handheld GPS
- Nortek Signature 500kHz Acoustic Doppler Current Profiler (Serial no. 101502)

## 10. Calibration Reports

**Nortek Signature500 - Serial no. 101502**

Final test checklist AD2CP



Vengstretet 2  
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Fax: +47 5213 8770  
mailto:info@nortek-as.com  
www.nortek.as

Order number:  
**42931-1-76**

Name: [Redacted]  
Instrument serial number: **101502**  
Frequency: **500 kHz** Main board: **AD2CP-1743**  
Firmware version: **1.4.5217.2211-4/169**

Label checked  OK  
Dock test  OK  
Baudrate 115200  OK

Comments:

Tilt check  
 Pitch up  
 Roll up  
 Status bit  
 Pitch down  
 Roll down  
pitch & roll within +/- 0.2 °

Clock  
 Set clock **UTC**  
Heading  
 Up  
 Down  
tolerance: +/- 2 °

Pressure  
0.5  
0.2  
0.7  
Pensortemp  
 OK  
tolerance: +/- 0.1 % of  
**300** m

Temperature  
 OK  
tolerance: +/- 0.1 °

Beam check

Correct order	Beam Imp	Noise floor	Amplitude in tank	Range
Beam 1	<input checked="" type="checkbox"/> OK	<input type="checkbox"/> Ω	<b>26</b> dB	> <b>80</b> dB <input checked="" type="checkbox"/> OK
Beam 2	<input checked="" type="checkbox"/> OK	<input type="checkbox"/> Ω	<b>26</b> dB	> <b>80</b> dB <input checked="" type="checkbox"/> OK
Beam 3	<input checked="" type="checkbox"/> OK	<input type="checkbox"/> Ω	<b>26</b> dB	> <b>80</b> dB <input checked="" type="checkbox"/> OK
Beam 4	<input checked="" type="checkbox"/> OK	<input type="checkbox"/> Ω	<b>26</b> dB	> <b>80</b> dB <input checked="" type="checkbox"/> OK
Beam 5	<input checked="" type="checkbox"/> OK	<input type="checkbox"/> Ω	<b>26</b> dB	> <b>80</b> dB <input checked="" type="checkbox"/> OK

Velocity direction

XYZ coordinate system		ENU coordinate system	
X	<input checked="" type="checkbox"/> OK	E	<input checked="" type="checkbox"/> OK
Y	<input checked="" type="checkbox"/> OK	N	<input checked="" type="checkbox"/> OK
Z	<input checked="" type="checkbox"/> OK	U	<input checked="" type="checkbox"/> OK
Z <sub>2</sub>	<input checked="" type="checkbox"/> OK	U <sub>2</sub>	<input checked="" type="checkbox"/> OK

Head file  
 Headfile checked  
 Saved as read only

Serial communication  
 RS422  
 RS232 **N/A**

Recorder erased  
 OK  
Rec size: **16 GB**

Ethernet  
MAC address: **8C:68:78:00:06:CF**  
Static IP address:  
Set host name: **101502**

DHCP enabled   
FTP OK

Licenses

Averaging mode <input checked="" type="checkbox"/>	Wave mode <input checked="" type="checkbox"/>	Vertical velocity <input type="checkbox"/>	64GB recorder <input type="checkbox"/>	Calibration license erased <input checked="" type="checkbox"/>
Burst Five beams <input checked="" type="checkbox"/>	Echo Sounder <input type="checkbox"/>	Dual frequency low <input type="checkbox"/>	128GB recorder <input type="checkbox"/>	Production license erased <input checked="" type="checkbox"/>
Bottom track <input type="checkbox"/>	Ice Measurement <input type="checkbox"/>	Dual frequency high <input type="checkbox"/>	256GB recorder <input type="checkbox"/>	Default configuration set <input checked="" type="checkbox"/>
High Resolution <input type="checkbox"/>	Altimeter <input type="checkbox"/>	16GB recorder <input checked="" type="checkbox"/>		

Cable/Harness  
Cable Communication  Harness Communication   
Battery  Battery

Electrical isolation test  
50V Ok

External sensors

Power down  
 OK

Date  
Day **23** Month **07** Year **2019**





## Certificate of Calibrations and Tests

Page 1 of 3

### Instrument Information

Customer Reference No.	42931-1-76
RMA No.	0
Instrument Type	Signature500
Instrument Frequency	500 kHz
Instrument S/N	101502
Head S/N	D-1502
Interface Board S/N	1743
Interface Board Mfr. S/N	4MQ0613760064
Digital Board Mfr. S/N	4MQ0619160078
Analog Board Mfr. S/N	4MQ0619860010
Sensor Board Mfr. S/N	4MQ0615010035
Interface Board Rev.	H-2
Digital Board Rev.	I-3
Analog Board Rev.	G-1
Sensor Board Rev.	I-0

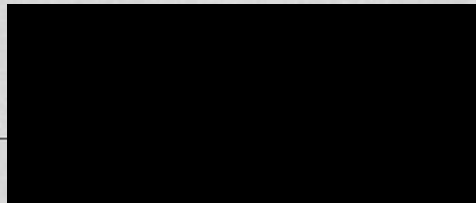
### Calibrations and tests performed

Pressure	Passed
Tilt and Compass	Passed

All the tested values are within Nortek AS specifications

July 23, 2019

Date



## 11. List of Data Files and Description

HG data sheets (NS, CB, NB)

- East Moclett\_NB\_HGdata\_analysis\_v7.11.xls
- East Moclett\_NB\_ResidualsRemoved\_HGdata\_analysis\_v7.11.xls
- East Moclett\_CB\_HGdata\_analysis\_v7.11.xls
- East Moclett\_NS\_HGdata\_analysis\_v7.11.xls

Raw instrument files

- S101510A005\_East.ad2cp
- S101510A005\_East\_0001.ad2cp
- S101510A005\_East\_0002.ad2cp
- S101510A005\_East\_0003.ad2cp
- S101510A005\_East\_0004.ad2cp
- S101510A005\_East\_0005.ad2cp
- S101510A005\_East\_avgd.ad2cp
- S101510A005\_East.cfg

Post processing log file

- Log\_HGdata\_analysis.txt

Files used for NewDepomod modelling

- HGmodellingData.mat
- Data\_ResidualCurrentsRemoved.mat

## 12. 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>

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>

<https://marinescotland.atkinsgeospatial.com/nmpi/>