JBA

Stonehaven MetOcean Survey - Data Report

July 2014

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Daniel Rodger – Senior Engineer JBA		X	

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Units of Measurement and Abbreviations

All units of measurement used within this report are detailed in Table 1.

Table 1. Units of measurement and abbreviations within report.

Symbol	Description	Unit
-	Date and Time	DD/MMM/YYYY hh:mm (GMT)
-	Geographical Position	Degrees and Minutes WGS84
-	Distance/Height	Metres (m)
-	Current Direction (to)	Degrees True (°)
-	Current Speed	Metres per second ($m\ s^{-1}$)
-	WaveDirection (from)	Degrees True (°)
-	Date and Time	DD/MMM/YYYY hh:mm (GMT)
AST	Acoustic Surface Tracking	-
AWAC	Acoustic Wave and Current	-
Cefas	Centre for Environment, Fisheries and Aquaculture Science	-
DirTp	Peak Period Direction	Degrees True (°)
Hm0	Significant wave height	Metres (m)
Hmax	Maximum wave height	Metres (m)
IOC	Intergovernmental Oceanographic Commission	-
MeanDir	Mean Wave Direction	Degrees True (°)
NTU	Nephelometric Turbidity Units	Dimensionless
PSD	Particle Size Distribution	-
QA	Quality Assurance	-
QC	Quality Control	-
SprTp	Wave Spread	Degrees
Tm02	Mean Period	Seconds (s)
Tp	Peak Period	Seconds (s)
TSS	Total Suspended Solids (Concentration)	$mg\ l^{-1}$

EXECUTIVE SUMMARY

JBA Consulting awarded Partrac Ltd a contract for the provision of professional consultancy related to metocean and river-level survey services at Stonehaven, Scotland, UK, as part of the Stonehaven Flood Alleviation Study (FAS).

The purpose of the survey was to provide offshore wave and current profile data along with river-level data at a location close to the mouth of the River Carron in Stonehaven, to investigate the influence of waves on flooding in the river.

This report details the data obtained from a bottom mounted acoustic wave and current profiler (AWAC - Nortek 600 kHz) located off Stonehaven Bay at Site 1 and that of a water level gauge (Valeport Tidemaster) deployed in the River Carron at Site 2.

CONTENTS

1. INTRODUCTION

1.1 Background

JBA Consulting awarded Partrac Ltd a contract for the provision of professional consultancy related to metocean and river-level survey services at Stonehaven, Scotland, UK, as part of the Stonehaven Flood Alleviation Study (FAS).

The purpose of the survey was to collect wave and current data along with river-level data at a location close to the mouth of the River Carron in Stonehaven, to investigate the influence of waves on flooding in the river.

This report details the data obtained from a bottom mounted acoustic wave and current profiler (AWAC - Nortek 600 kHz) located off Stonehaven Bay at Site 1 and that of a water level gauge (Valeport Tidemaster) deployed in the River Carron at Site 2. Deployment locations of both instruments at Site 1 and Site 2 are presented in Figure 1 and Table 2.

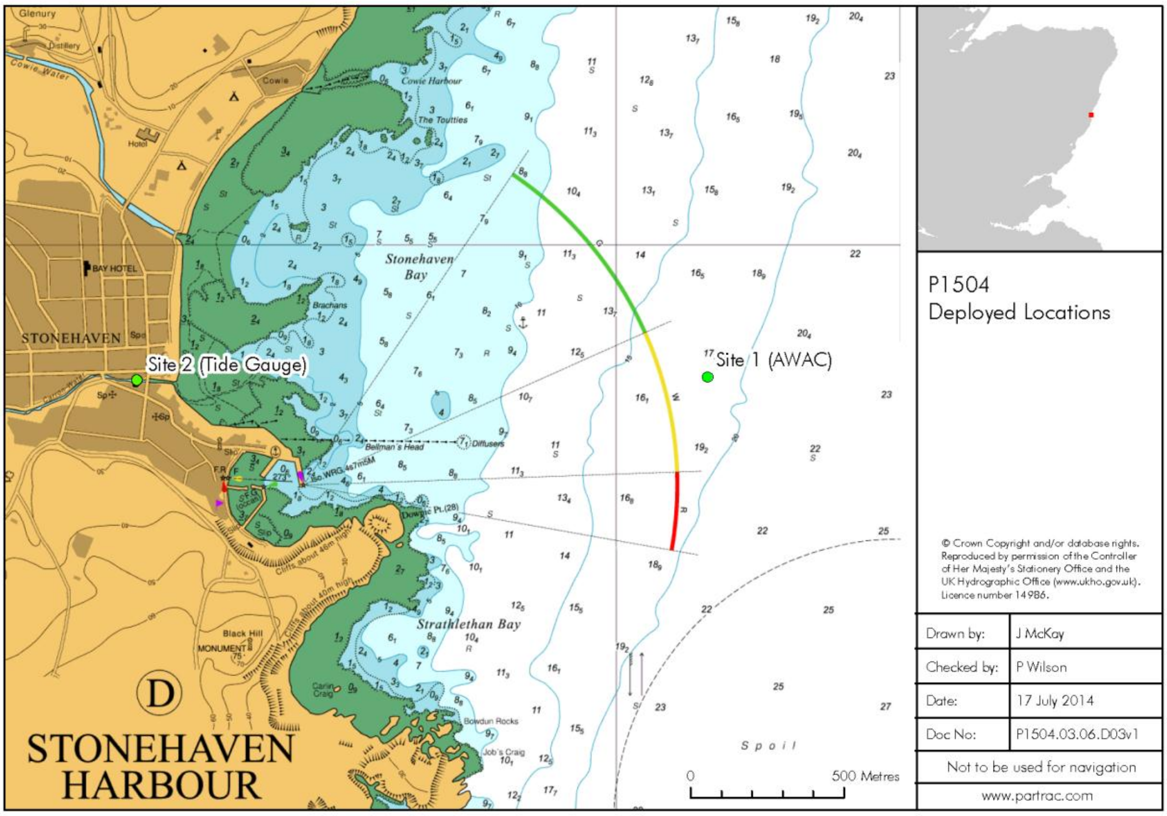

Figure 1. Nortek AWAC and Valeport Tide gauge deployment locations at Site 1 and Site 2, respectively.

Table 2. Instrument deployment location data.

Site	Equipment	Location		Date	Time GMT
Site 1	Sea bed frame with AWAC	56º 57.7664'N	002º 10.6997'W	20-May-2014	10:00
	Ground weight	58º 57.7789'N	002º 10.6696'W		
Site 2	Water Level Gauge	56º 57.7650'N	002º 12.5360'W	20-May-2013	15:00

The following parameters are presented within the report:

- AWAC QC parameters (instrument tilt, roll and heading).
- Current Speed and Direction (as a profile through the water column)
- Depth-Averaged Current Speed and Direction
- Water Depth (Site 1).
- Wave Parameters
    - Wave Height
    - Wave Period
    - Wave Direction
    - Wave Spread
- Water level data in the River Carron (sampled at 0.5 Hz).

2. DATA PROCESSING AND QUALITY CONTROL

2.1 AWAC Current Data

AWAC current data are initially exported from the raw binary files using Nortek Storm software, before being run through Partrac developed scripts for quality control and presentation. This process includes IOC (Intergovernmental Oceanographic Commission) quality control procedures defining rate of change checks and the application and inspection of internal AWAC flags. These thresholds and ranges are presented in Appendix A, Section 4.1.

2.2 AWAC Wave Data

Wave data are initially exported from Nortek Storm before being run through Partrac scripts. This data is then quality controlled using the CEFAS (Centre for Environment, Fisheries and Aquaculture Science) WaveNet QA/QC procedures for data obtained from directional Waverider buoys. This consists of range checking and rate of change analysis; these thresholds are outlined in Appendix A, Section 4.1.

2.3 Directional Data

All directional data for waves and currents have been converted from magnetic direction to true north by applying a magnetic variation correction of 2º W obtained from the BGS local model (http://www.geomag.bgs.ac.uk/gifs/gma_calc.html) for the region

2.4 Data Return

Table 3 summarises the data return at both sites. The ‘records expected’ are based on the assumption that between valid data starting there is one record every 30 minutes until the valid data ending for currents and one record every 30 minutes for waves.

Data return for depth averaged data was 100 % at both sites. Full water profile return statistics at Site 1 are harder to quantify due to the limitations of the AWAC instrument (in respect to side lobe interference and blanking distance); however an indication of the data removed during processing can be seen in section 3.1.4.

Data from the water level gauge was collected at 0.5 Hz, whereby a record of the water level above the submerged gauge was collected at two second intervals. Raw data from the instrument was processed using Partrac Matlab scripts.

Table 3. Summary of data return of deployments.

Site	Data	Period of Valid Data (GMT)		Data Return (full days)
		Start	Finish	
Site 1	General	20-May-2014 10:00	24-Jun-2043 10:00	35
	Data	**Records Expected**	**Records Returned**	**Data Return %**
	Current: 30 Minute Average	1680	1675	99.7
	½ Hourly Wave Data	1678	1675	99.8
Site	**Data**	**Period of Valid Data (GMT)**		**Data Return**
		Start	**Finish**	
Site 2	General	20-May-2014 15:00	24-Jun-2043 11:00	34 days 20 hrs
	Data	**Records Expected**	**Records Returned**	**Data Return %**
	Water level 0.5 Hz	1504800	1504456	99.9

3. DATA ANALYSIS

3.1 Site 1 - AWAC

Current and wave data from Site 1 are presented in the subsequent sections as figures and the principal oceanographic statistics in tables. Summaries of current and wave parameter statistics are shown in Table 4 and Table 5 respectively.

3.1.1 Current Data

Table 4. Summary of current statistics.

Parameter	Min	Date	Max	Date	Mean	StDev
Depth-Averaged Current (m s^{-1})	0.00	Multiple Occurrences	0.68	03-Oct-2013 02:20	0.28	0.13
Current Magnitude (m s^{-1})	0.00	Multiple Occurrences	0.94	03-Oct-2013 02:20	0.3	0.14
Water depth (m)	20.66	15-Jun-2014 09:00	24.97	16-Jun-2014 03:30	22.80	1.11
Predominant Tidal Axis	NNE/SSW					

3.1.2 Ancillary Data

Ancillary data plots for heading, pitch/roll and water depth are presented in Figure 2, Figure 3 and Figure 4 respectively. Figure 2 shows the frame initially settling on the seabed before stabilising. There is a clear indication from the heading data that the seabed frame moved during the deployment period. This can also be seen in Figure 3, where there is a sudden deviation in the pitch and roll recorded. Despite this movement, the data remains within the Nortek defined quality thresholds and the data quality was not compromised.

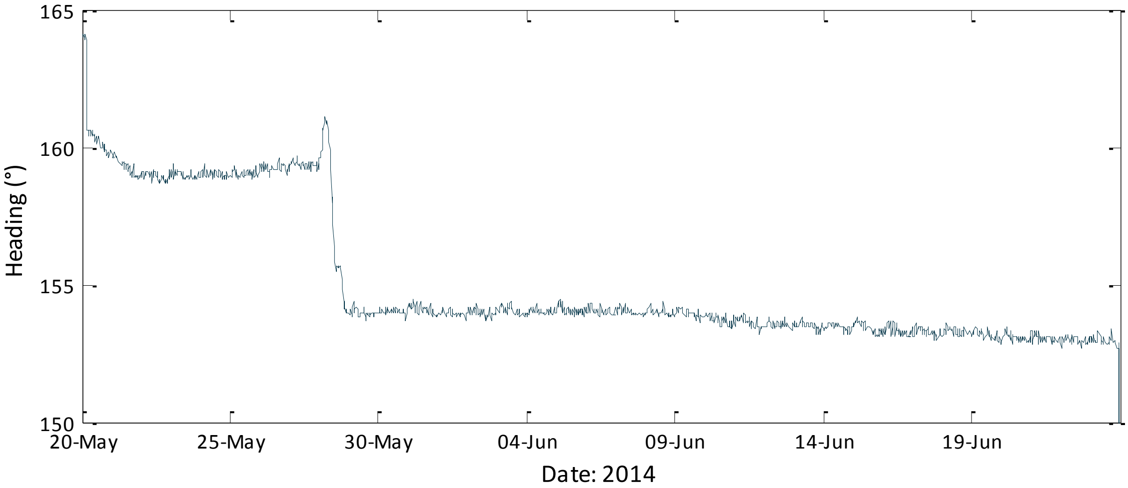

Figure 2. Instrument heading at Site 1.

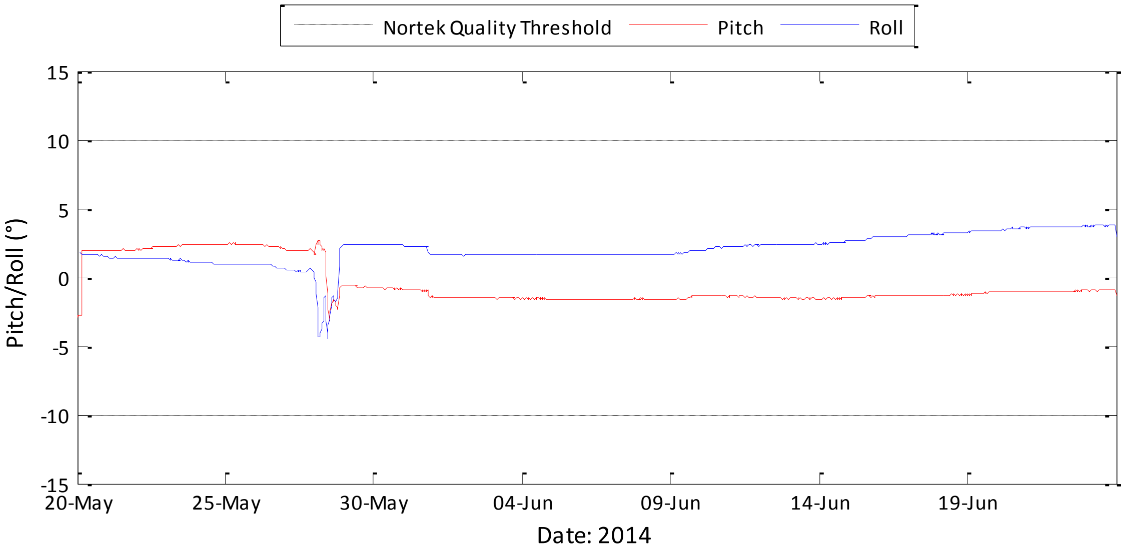

Figure 3. Instrument pitch and roll at Site 1 with Nortek defined AST data quality limits.

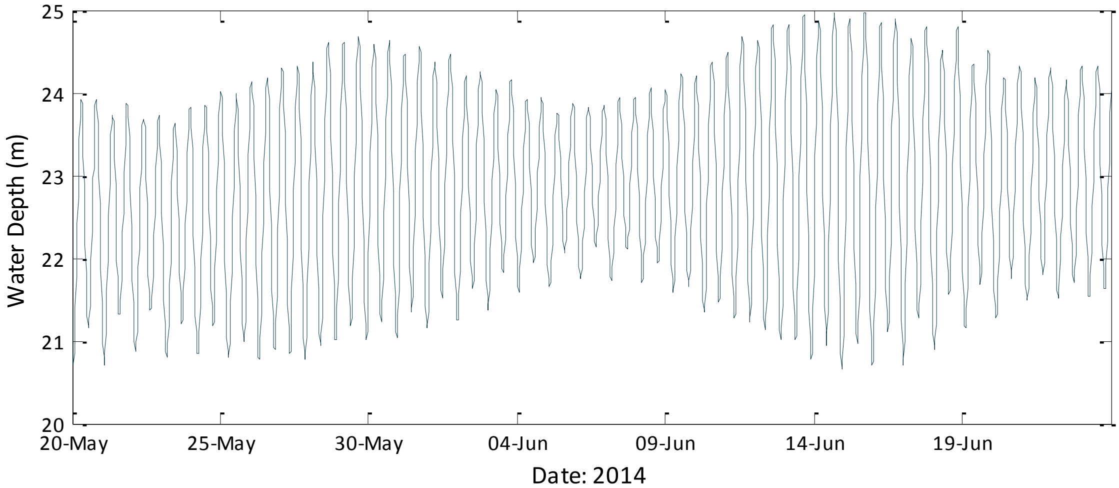

Figure 4. Water depth time-series throughout the deployment period at Site 1.

3.1.3 Depth-Averaged Current Data

Depth-averaged current velocity magnitude and direction time-series for the deployment period are shown in Figure 5 and Figure 6 respectively. Figure 7 presents a current rose of depth-averaged current magnitude and direction. The deployment period encompassed two neap and two spring phases of the tide. Variation in current magnitude over the tidal cycle is low, with peaks in current magnitude occurring during spring tides.

The tidal ellipse is rectilinear and oriented on a NNE – SSW axis. The strongest currents can also be seen to occur along this directional axis.

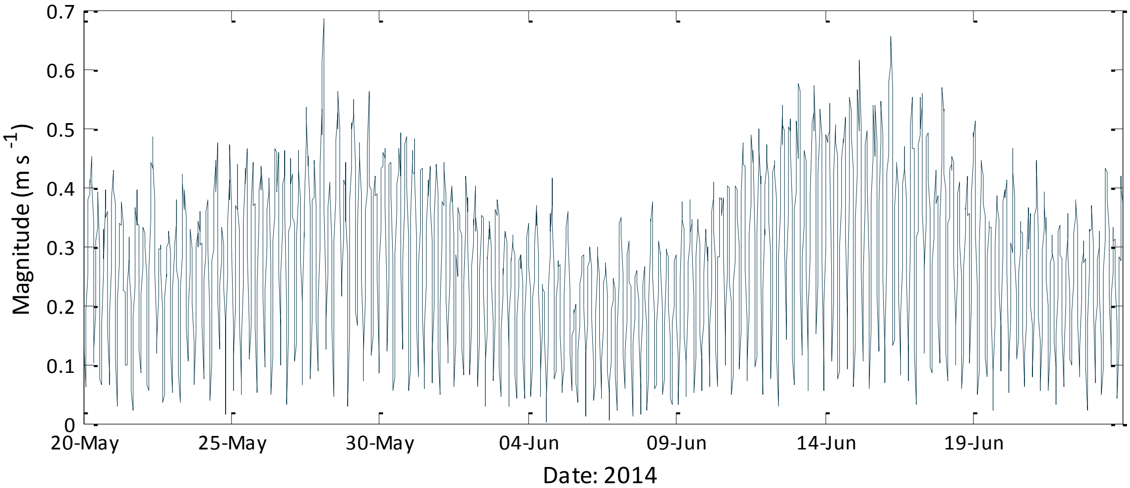

Figure 5. Depth-averaged velocity magnitude (m s^{-1}) throughout deployment period at Site 1.

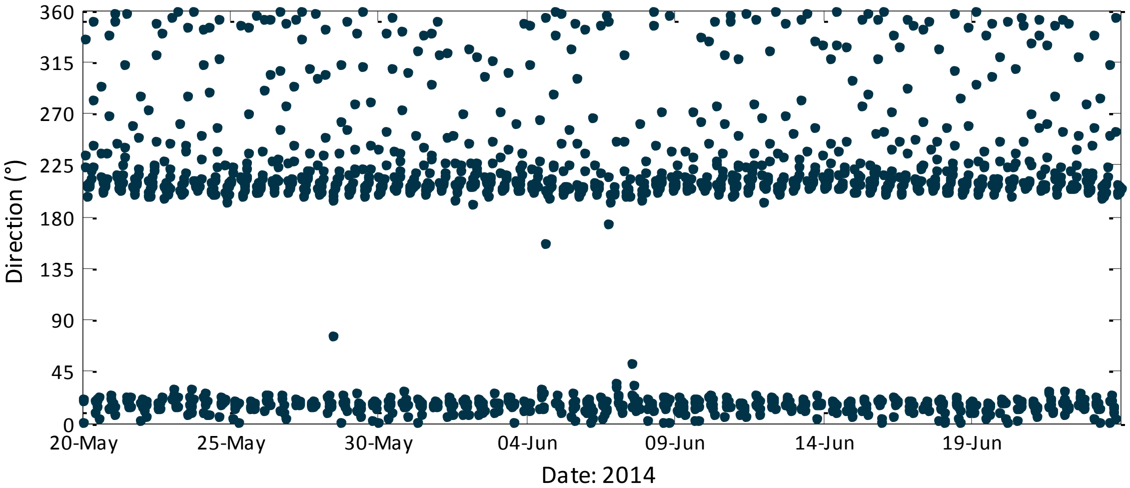

Figure 6. Depth-averaged velocity direction at Site 1 throughout the deployment period.

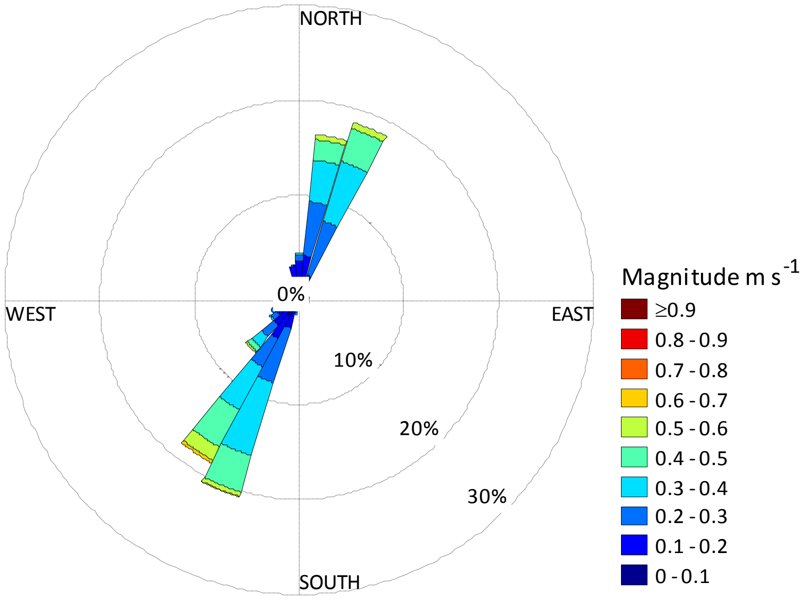

Figure 7. Current rose of depth-averaged current magnitude and direction at Site 1.

3.1.4 Water Column Time-Series

Current magnitude and direction through the water column are shown in Figure 8 and Figure 9 respectively. A tidal curve is superimposed on both of these plots to give an indication of the data removed due to sidelobe interference[1] and to present variability in current magnitude and direction at different phases of the tide. Individual bin data that is removed through QC procedures can also be observed here.

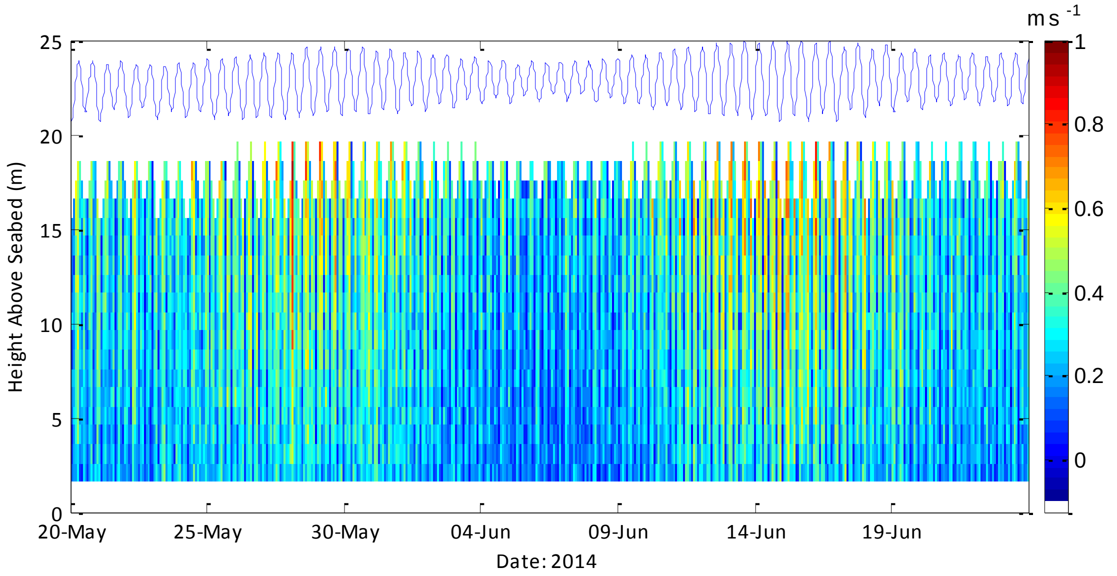

Figure 8. Time-series profile of current magnitude with water depth at Site 1.

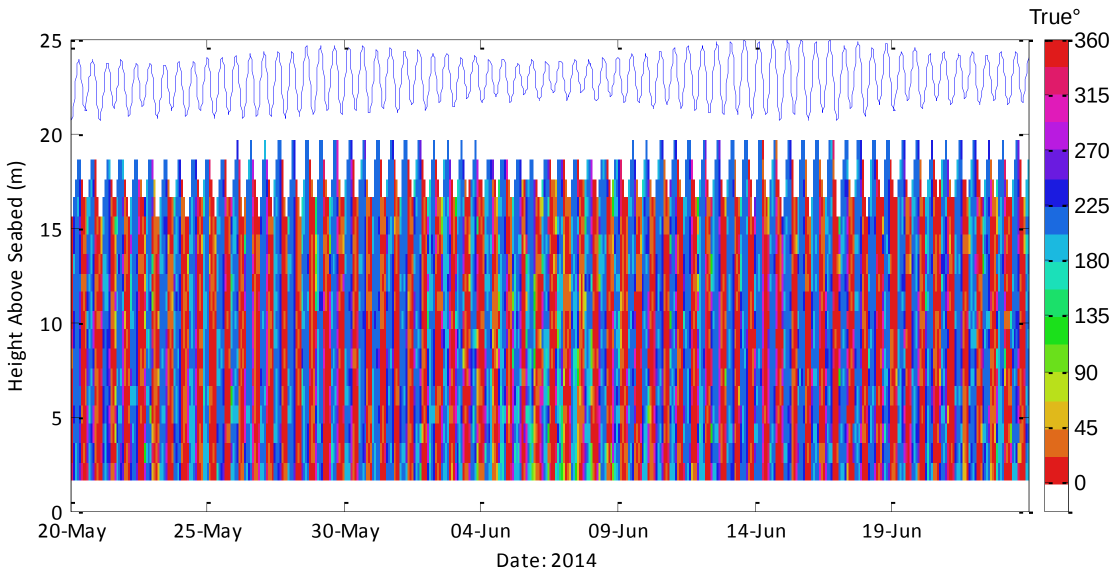

Figure 9. Time-series profile of current direction with water depth at Site 1.

[1.] Sidelobe Interference is an artefact of using acoustic Doppler profilers (ADP) close to a boundary. The ***beam angle*** *of the main lobe of an ADP transducer is 20o or 30o off the vertical, which means that the distance to the boundary along the ADCP centreline is shorter than the distance to the boundary along a beam. Because most boundaries will reflect very strongly (much more strongly than the scatterers),* **sidelobe** *energy can travel the shorter path directly to the surface and thereby include the "velocity" of the boundary with the velocity measurements taken along the beams at any longer distance.*

3.1.5 Wave Data

Derived wave parameter statistics are presented in Table 5. Wave data over the entire deployment period is presented in the time-series of wave height, wave period, wave direction and wave spread (Figure 10 to Figure 13). Wave roses displaying significant wave height and mean period against mean direction are presented in Figure 14 and Figure 15, respectively.

During the deployment period a 'significant wave event' (significant in comparison to the remaining time series for the period of study) is observed on 29th May 2014, whereby Hm0 is observed to peak at 2.21 m, with the waves arriving predominantly from due East. Times of low energy waves display a range of directions from the E to SE. These lower wave heights also coincide with peak period noise. This is caused by two or more peaks in the energy spectrum and therefore, these data have not been removed during the QC process.

Table 5. Wave parameter statistics at Site 1.

Parameter	Min	Date	Max	Date	Mean	StDev
Hm0 (m)	0.12	13-Jun_2014 07:01	2.21	29-May-2014 00:01	0.64	0.32
Tp (s)	2.10	13-Sep-2014 06:31	11.23	23-Jun-2014 15:01	6.10	1.58
Tm02 (s)	2.35	21-Jun-2014 16:31	6.61	29-May-2014 01:31	4.01	0.79
SprTp (degrees)	22.20	22-May-2014 11:31	81.01	13-Jun-2014 06:31	49.16	10.99
Predominant Direction	NE - SE					

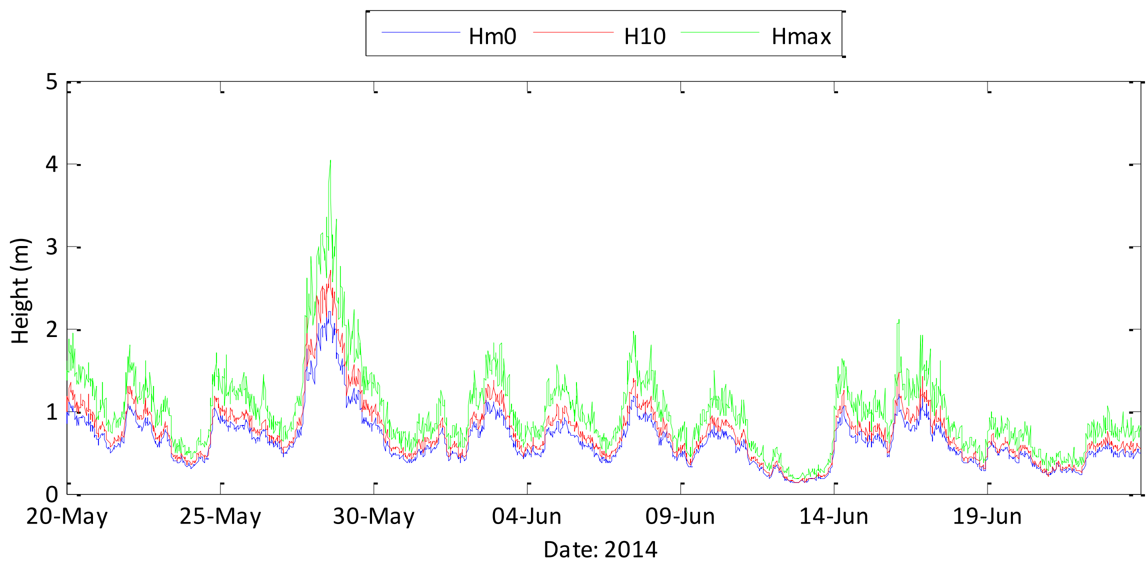

Figure 10. Significant (Hm0), zero-crossing (H10) and maximum (Hmax) wave height throughout the deployment period at Site 1.

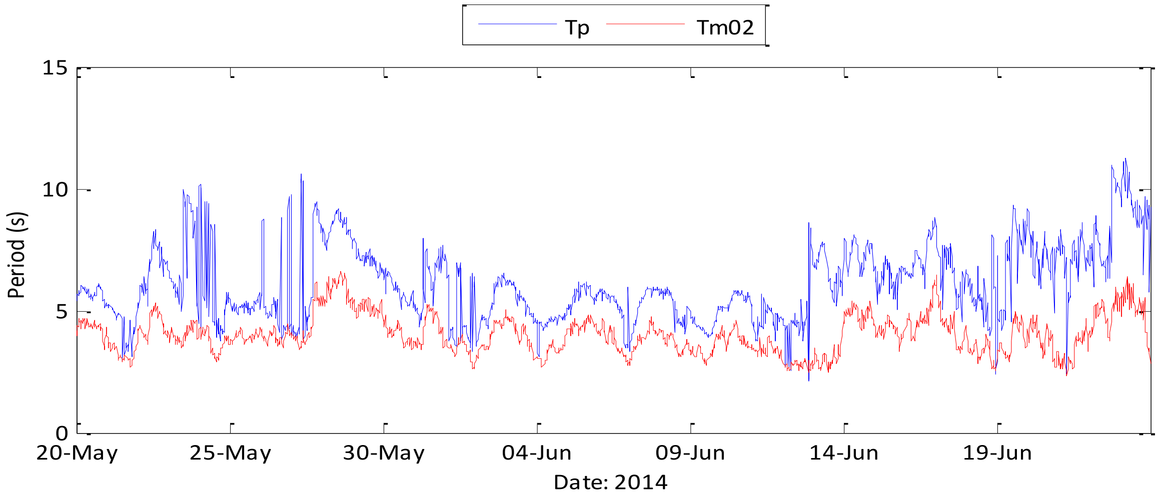

Figure 11. Peak (Tp) and mean (Tmo2) wave period throughout the deployment period.

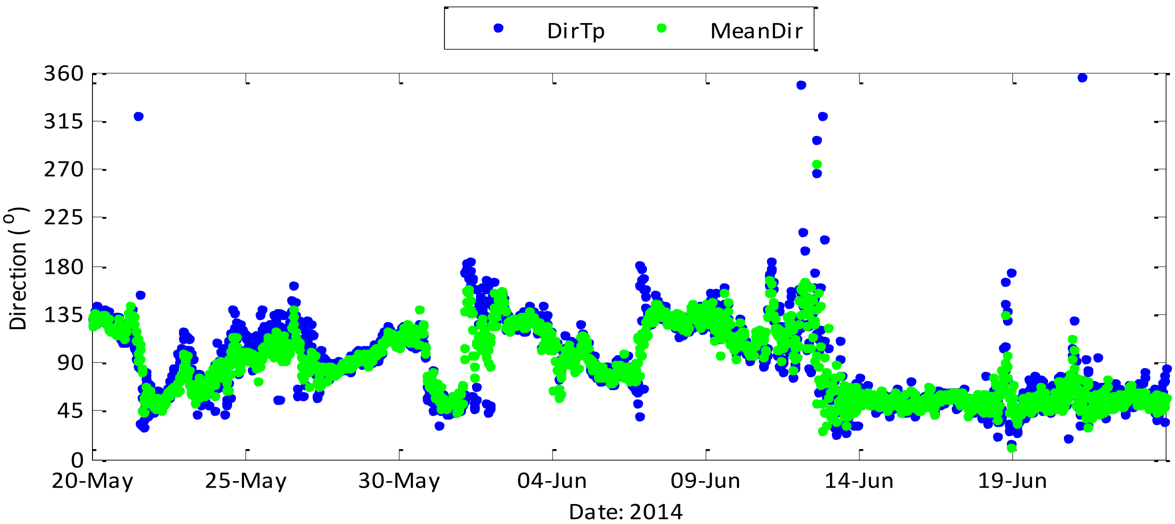

Figure 12. Peak period (DirTp) and mean (MeanDir) wave direction throughout the deployment period.

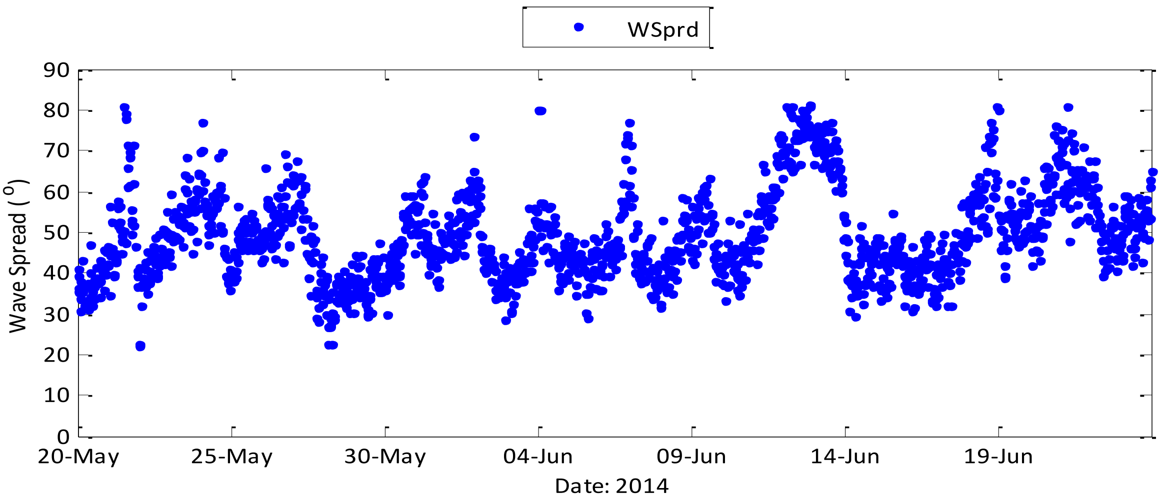

Figure 13. Wave spread (SprTp) throughout the deployment period.

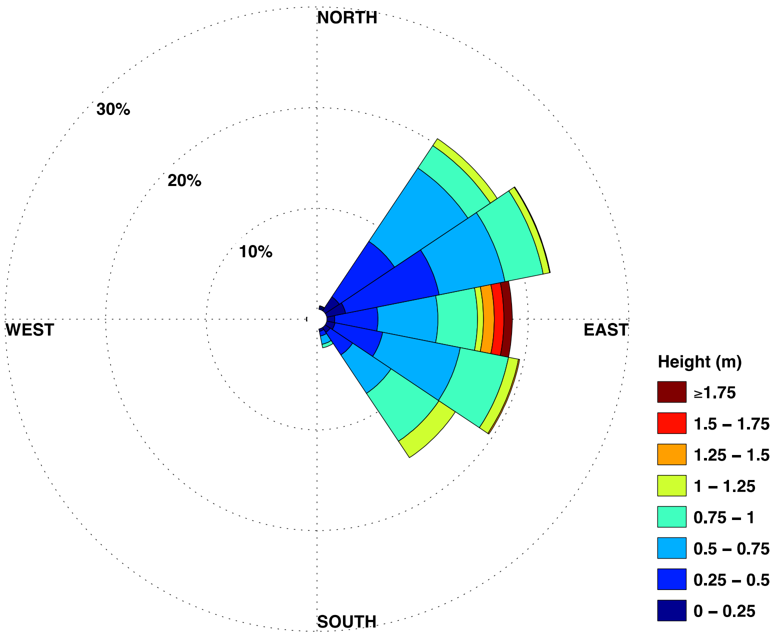

Figure 14. Wave rose of wave height (Hm0) and direction (MeanDir).

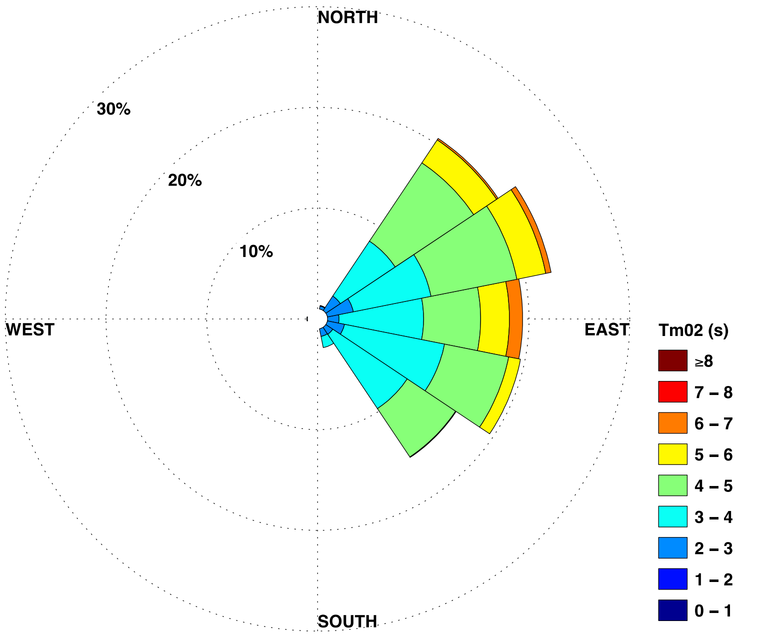

Figure 15. Wave rose of wave period (Tmo2) and direction (MeanDir).

3.2 Site 2

Data on water level in the River Carron (Site 2) throughout the survey period are displayed below in Figure 16 and statistics are presented in Table 6. Water level is described as height above the tide gauge sensor (m).

3.2.1 River Carron Water Level Data

Table 6 presents the water level statistics during the deployment period in the River Carron at Site 2. It should be noted that the peak in river level (0.54 m) is not coincident with any significant wave event. The significant wave event observed in Figure 10 appears to have no influence on the water level in the river.

Table 6. Water level statistics in the River Carron at Site 2.

Parameter	Min	Date	Max	Date	Mean	StDev
Depth above tide gauge sensor (m)	0.28	Multiple occurrences	0.54	08-Jun-2014 01:39	0.32	0.02

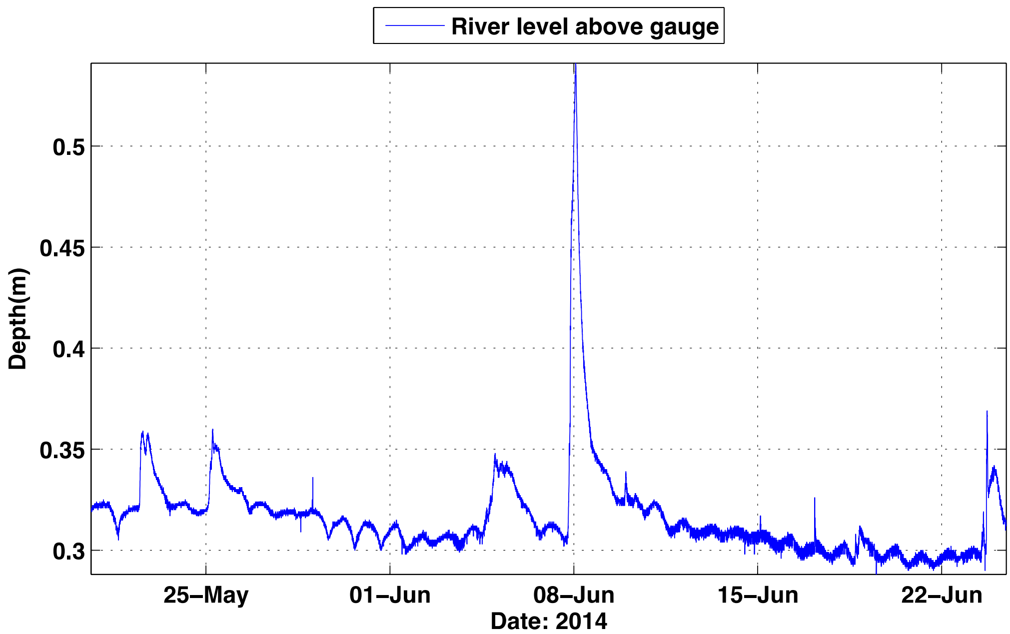

Figure 16. Water level in the River Carron at Site 2 during the deployment period

4. APPENDICES

4.1 Appendix A – Data Quality Control

4.1.1 AWAC Current Data

Nortek Storm software and recommended QC settings were used in processing of the current data; these settings are shown in Table 7 below.

Table 7. Nortek Storm QC parameters

Parameter	Purpose	Units	Value
Signal to Noise Ratio (SNR) Threshold Limit	Low SNR values have high variability: specifies when estimates are invalid.	dB	3
SNR Spike Rejection level	Removes current spikes caused by fish.	dB	70
Statistical Threshold	Rejects data outside of specified number of standard deviations. Used for fish and anomaly rejection.	#StDev	5

The theoretical difference between two consecutive current speed samples u1 and u2 for various sampling intervals (Δt) assuming a smooth sinusoidal semi-diurnal tidal current with a period of 12.24 hours are given in Table 8, where *u* is the orthogonal tidal current amplitude.

Table 8. IOC theoretical differences.

Δt (min)	Theoretical	Factor	Allowable
	$u_1 - u_2$		$u_1 - u_2$
5	0.0422 u	2.0	0.08 m s^{-1}
10	0.0843 u	1.8	0.15 m s^{-1}
15	0.1264 u	1.6	0.20 m s^{-1}
20	0.1685 u	1.5	0.25 m s^{-1}
30	0.2523 u	1.4	0.35 m s^{-1}
60	0.5001 u	1.2	0.60 m s^{-1}

In order to allow for some inherent variability in current speed and direction signal and for asymmetric tidal current speed curves, these difference have been increased by the above factors whilst *u* has been set at 1.0 m s^{-1} since the variability will increase with decreasing *u.*

The resulting allowable maximum difference between samples for particular sampling intervals, are provided above.

4.1.2

The AWAC produces binary error codes during processing; these can be seen within the "Raw Data" tab of submitted data. The errors are then analysed manually by Partrac and data is deemed reliable, flagged or removed, the error descriptions are shown in Table 9 and can contain a combination of errors. Error codes can contain a combination of errors for example an error code of 208 is a combination of errors 16, 64 and 128.

Table 9. Binary error codes in AWAC.

Error	Binary Code	Error Code
No Errors	0	0
No Pressure	0000 0001	1
Low Pressure	0000 0010	2
Low Amplitude	0000 0100	4
White Noise Test	0000 1000	8
Unreasonable Estimate	0001 0000	16
Never Processed	0010 0000	32
AST Out of Bounds	0100 0000	64
Directional Ambiguity	1000 0000	128
No Pressure Peak	1 0000 0000	256
Close to clipping	10 0000 0000	512
High AST Data Loss	100 0000 0000	1024
Excessive tilt	1000 0000 0000	2048

4.1.3 Wave Data

Wave data have been quality controlled using Cefas (Centre for Environment, Fisheries and Aquaculture Science) WaveNet QA/QC procedures for data obtained from directional Waverider buoys.

Quality control checks consist of range checking and removal of spikes for various parameters. These are listed in Table 10 and any data that fail are removed from the dataset. Any flagged data are inspected closely to determine their inclusion.

Table 10. Cefas data quality control range checks

<table>
<tr><th rowspan="2">Parameter</th><th rowspan="2">Units</th><th>Flagged Data</th><th colspan="2">Failed Data</th></tr>
<tr><th>Maximum
Rate of Change Per Hour</th><th>Minimum</th><th>Maximum</th></tr>
<tr><td>Wave Height</td><td>Metres</td><td>1</td><td>0</td><td>20</td></tr>
<tr><td>Wave Period (Tp)</td><td>Seconds</td><td>4</td><td rowspan="2">1.6</td><td rowspan="2">20</td></tr>
<tr><td>Wave Period (Tm02)</td><td>Seconds</td><td>2</td></tr>
<tr><td>Wave Direction</td><td>Degrees</td><td>150</td><td rowspan="2">0</td><td rowspan="2">360</td></tr>
<tr><td>Wave Spread</td><td>Degrees</td><td>90</td></tr>
</table>

4.2 Appendix B – References

CEFAS. (2011). QA/QC procedure. Available: http://www.cefas.defra.gov.uk/ourscience/observing-and-modelling/monitoring-programmes/wavenet/qaqcprocedure.aspx.
Last accessed: 11/12/2013.

IOC (1993). Manual of Quality Control Procedures for Validation of Oceanographic Data. Available:
http://www.iode.org/components/com_oe/oe.php?task=download&id=20423&version=1st%20edition&lang=1&format=1

Last accessed: 11/12/2013