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EXPANSION PROJECT
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Appendices*

APPENDIX 6-A OCEANOGRAPHIC WORKS



**FINAL REPORT
OCEANOGRAPHIC WORKS
ABERDEEN HARBOUR EXPANSION EIA**

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Fugro EMU Limited
On Behalf of the Aberdeen Harbour Board

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EXECUTIVE SUMMARY

Fugro EMU's MetOcean Department was contracted to conduct oceanographic and meteorological monitoring at Nigg Bay in order to support the Environmental Impact Assessment process for the proposed harbour expansion. The monitoring programme was approximately four months in duration with a service visit separating two deployments. This report provides results from the entire dataset. Two seabed frames were deployed on the 20th February 2015 and recovered on 11th June 2015; one at the "West" Location inside Nigg Bay on the 5 m depth contour and one at the "East" Location outside Nigg Bay on the 20 m depth contour. Each housed a suite of oceanographic instrumentation. In addition, a meteorological station was installed in the vicinity of the study location. Vertical profile measurements and water samples were also taken on each offshore operational visit.

In summary, the following data were collected:

- Wave Statistics
- Tidal Levels
- Current Velocity (Speed and Direction)
- Suspended Sediment Concentration
- Sea Temperature
- Salinity and Dissolved Oxygen
- Vertical Water Quality Profiles (Temperature, Salinity, Dissolved Oxygen and Turbidity)
- Meteorological Data (Wind Speed, Wind Direction, Air Temperature, Air Pressure, Humidity and Rainfall Intensity)

The seabed frames were serviced on the 6th April 2015 and redeployed with identical instrumentation on the 7th April 2015 in order to continue the monitoring programme. The meteorological station was serviced on the 8th April 2015 and configured to continue logging thereafter. This report describes the operational activities, processing and quality control of the returned data and presents the results from both Deployment One and Deployment Two.

High quality data were collected at both the West and East Locations and the meteorological station for the duration of Deployment One. During Deployment Two, high quality data were collected for all parameters at the East Location and the meteorological station. However, the seabed frame at the West Location was outside of the acceptable tilt range resulting in invalid current, AST wave and acoustic backscatter data. Some data from the Seaguard sensors were also rejected during quality control. It is possible that the sensors were covered with sediment at times due to the incorrect orientation of the seabed frame. Non-directional wave parameters from the West Location were derived using pressure signal processing techniques.

In total, eight spring tide and neap tide events were observed during the metocean monitoring programme. A range of sea state conditions were captured; from 0.1 m H_s to 3.2 m H_s /4.8 m H_{max} at the West Location and 4.0 m H_s /6.7 m H_{max} at the East Location. The mean H_s over the monitoring period was 0.6 m at the West Location and 0.7 m at the East Location. The maximum observed depth averaged current speeds were 0.55 and 1.34 ms^{-1} at the West and East Locations respectively. The residual or non-tidal component of the current velocity is relatively high compared to the tidal component throughout the deployment period at the West Location, reaching up to 0.34 ms^{-1} . At the

East Location, a clear rectilinear flood/ebb pattern with an approximately north-south orientation is exhibited. The tidal signal is occasionally distorted during high wave energy events resulting in residual velocities up to 0.56 ms^{-1} .

The Mean Spring Range resulting from a tidal harmonic analysis is 3.47 m and 3.48 m at the West and East Locations respectively.


Suspended sediment concentration estimates as derived from optical backscatter measurements reached up to 899 mg l^{-1} at the West Location and 529 mg l^{-1} at the East Location. These high concentrations are in poor agreement with the acoustic backscatter-derived results from the near seabed bin of the AWAC profile (126 mg l^{-1} / 82 mg l^{-1} maxima at the West and East Locations respectively). This suggests that the sediment type in suspension is very fine and therefore incompatible with acoustic measurements. In order to further clarify the discrepancy seen in the two measurement techniques, Laser Diffraction analysis was conducted on one of the water samples collected at each location confirming that the D_{50} grain sizes were $27 \mu\text{m}$ and $22 \mu\text{m}$ at the West and East Locations respectively. The mean OBS-derived concentrations were 144 mg l^{-1} at the West Location, compared with 18 mg l^{-1} as derived through ABS. At the East Location, the mean concentrations compare more closely; 24 mg l^{-1} from OBS and 25 mg l^{-1} from ABS.

Events of elevated suspended sediment concentration typically show reasonable correlation with the wave height time series. However, instances of high turbidity during calm sea state conditions were also observed. This suggests that other forcing factors exist within Nigg Bay. Similarly, there is insufficient information to explain the low salinity events which were observed. As such, Fugro EMU suggest that further investigation is required into the effects of waste water discharge on the study area and other fresh water and sediment inputs. Dissolved oxygen concentrations averaged 8.4 mg l^{-1} at the West and East Locations or 86 % and 88 % saturation respectively. The West Location displays a greater degree of variability in dissolved oxygen concentration however the Deployment Two data have a lower confidence level associated with them due to the incorrect orientation of the seabed frame. Near-seabed sea temperature steadily increased throughout the deployment period and averaged $7 \text{ }^{\circ}\text{C}$ at both locations. The water quality profiles at the West Location were all fully mixed. At the East Location, a weak (change of less than 1 ppt) halocline was observed on the 6th April 2015. On the 11th June, a decrease in salinity of approximately 2 ppt and an increase in temperature of approximately 1°C were observed in the surface 6 – 7 m.

Wind speeds up to 15.3 ms^{-1} (Beaufort Force 7) and gust speeds up to 20.3 ms^{-1} (Beaufort Force 8) were measured by the meteorological station. The fastest wind speeds were associated with southerly and south westerly direction bands. The mean wind speed over the duration of the study was 4.5 ms^{-1} and the dominant wind direction was south westerly.

AMENDMENTS PAGE

This table contains a record of amendments.

Issue Number	Amendment Number	Section/Paragraph	Date	Authoriser's Signature
2	1	Executive Summary and Introduction – list of meteorological parameters added Executive Summary – values for average H _s , max and average SSC, wind speed and direction added	03/09/2015	
2	2	Introduction – project introduction amended with standard text “Current velocity” amended to “current velocity (speed and direction)”	03/09/2015	
2	3	Figure 1.1 – EIA boundary updated	03/09/2015	
2	4	Table 1.1 – Position format changed	03/09/2015	
2	5	Figure A032 added to Appendix A	03/09/2015	
2	6	Section 5.2 – Further information added on the effect of changing salinity on the pressure-depth conversion	03/09/2015	
2	7	Section 5.6 and 6.5 – Details added regarding suspect salinity data from West Location	03/09/2015	
2	8	Section 6.3 – A comment added on the residual easting vector	03/09/2015	
2	9	Section 5.4 – Text added on accuracy of suspended sediment concentration data	03/09/2015	
2	10	Table 6.3 – Table caption amended	03/09/2015	
2	11	Section 5 – Information on water samples added	03/09/2015	
2	12	Section 6.1 – Mean H _s value added to text	03/09/2015	



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1. INTRODUCTION

Aberdeen Harbour Board have proposed the design and construction of a new harbour facility at Nigg Bay, immediately south of the existing harbour. The purpose of the new facility is to complement and expand the capabilities of the existing harbour, accommodate larger vessels, retain existing custom, and attract increased numbers of vessels and vessel types to Aberdeen.

The new harbour development shall include but is not limited to:

- Dredging the existing bay to accommodate vessels up to 9m draft with additional dredge depth of 10.5m to the east quay and entrance channel;
- Construction of new North and South breakwaters to form the harbour;
- Provision of approximately 1500 m of new quays and associated support infrastructure. The quay will be constructed with solid quay wall construction and suspended decks over open revetment;
- Construction of areas for development by others to facilitate the provision of fuel, bulk commodities and potable water;
- Land reclamation principally through using materials recovered from dredging operations and local sources, where possible;
- Provision of ancillary accommodation for the facility;
- Off-site highway works to the extent necessary to access the facility and to satisfy statutory obligations;
- Diversions and enabling works necessary to permit the development.

Fugro EMU Limited (Fugro EMU), with support from the Waterman Group has been appointed by Aberdeen Harbour Board to undertake a full Environmental Impact Assessment (EIA) and prepare an Environmental Statement in relation to the proposed construction of the new harbour facility.

Fugro EMU's MetOcean Department were contracted to conduct oceanographic and meteorological monitoring at Nigg Bay in order to contribute to a number of technical studies which will support the EIA process. Two locations were identified for the deployment of sea bed mounted instrumentation, and an onshore meteorological station was installed within the vicinity of Nigg Bay. In addition to the fixed equipment, *in situ* measurements were taken on each offshore operational visit, in order to obtain vertical water quality profiles.

In summary, the following data were collected:

- Wave Statistics
- Tidal Levels
- Current Velocity (Speed and Direction)
- Suspended Sediment Concentration
- Sea Temperature
- Salinity and Dissolved Oxygen
- Vertical Water Quality Profiles (Temperature, Salinity, Dissolved Oxygen and Turbidity)
- Meteorological Data (Wind Speed, Wind Direction, Air Temperature, Air Pressure, Humidity and Rainfall Intensity)

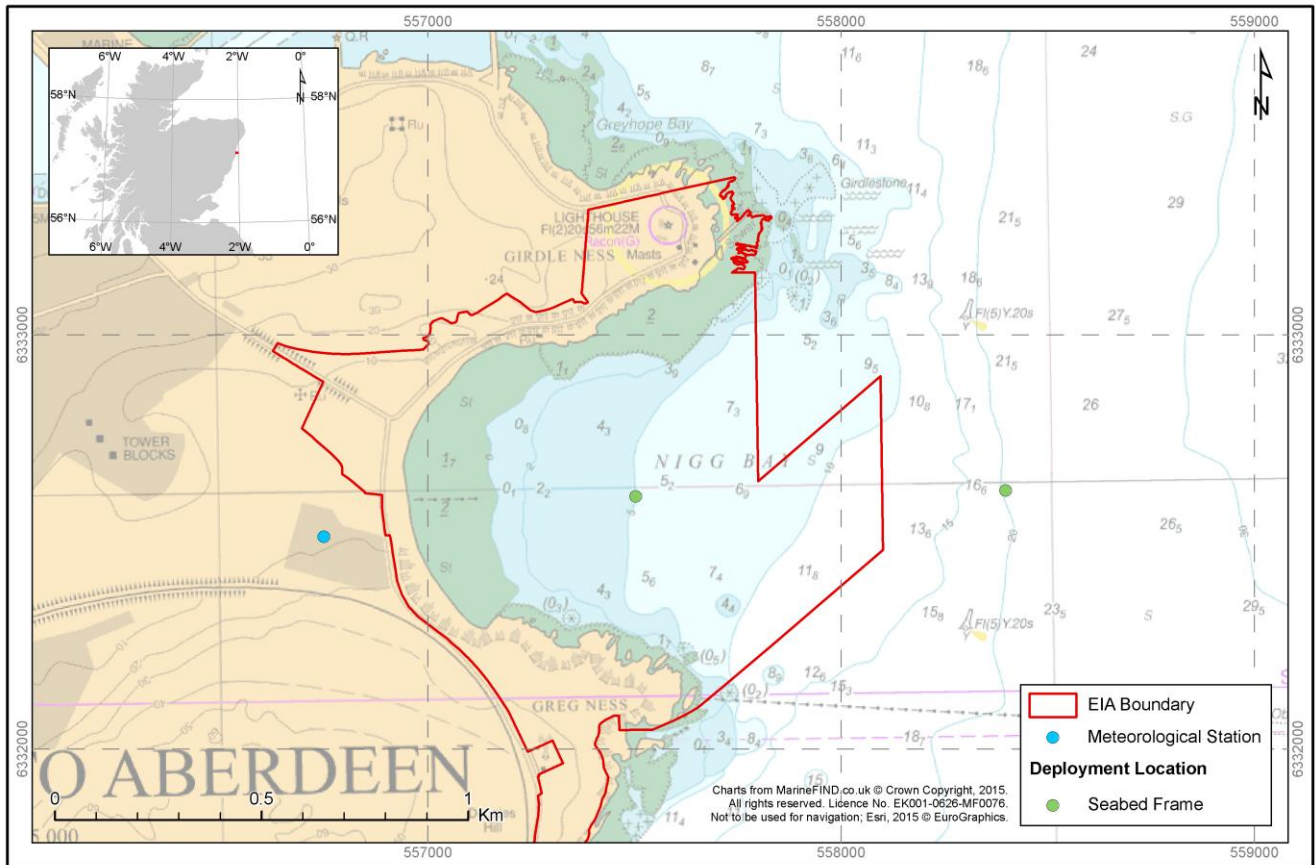
The two seabed frames were each fitted with the following instrumentation:

- Nortek AWAC (measuring water level, current velocity profiles and waves)
- AADI Seaguard (measuring dissolved oxygen concentration, temperature and conductivity)
- Aqualogger 210 (measuring optical backscatter/turbidity and temperature)

A lightweight release transponder with tilt switch and a pop-up release system were also fitted to each frame to assist recovery in the event of a missing surface marker buoy or damaged mooring.

The meteorological instrumentation (a Vaisala WXT 520) was installed at the Kelda Water wastewater treatment works at Nigg Bay. The measurement locations are shown in Figure 1.1 and Table 1.1.

An Idronaut multiparameter probe and a Niskin water sampler were used to gather vertical profiles and water samples during vessel operations.



Map Document: (V:\J3132582_Nigg_Bay_EIA\3_Plots1_SurveyArray\MetOcean\Q2582_NTM_SXC_20150302.mxd)
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Figure 1.1 Equipment Locations

Table 1.1 Equipment Locations

Location Name	Position	
Meteorological Station	57°07'56.58"N, 002°03'44.94"W	
	Seabed Frame	Surface Marker Buoy
West Deployment 1	57°07'59.64"N, 002°02'57.60"W	57°07'59.94"N, 002°02'55.86"W
East Deployment 1	57°08'00.84"N, 002°02'08.10"W	57°08'01.74"N, 002°02'06.60"W
West Deployment 2	57°08'00.96"N, 002°02'59.76"W	57°08'00.30"N, 002°02'57.18"W
East Deployment 2	57°08'00.72"N, 002°02'08.28"W	57°08'00.54"N, 002°02'06.06"W

2. CONVENTIONS AND DEFINITIONS

- All co-ordinates are referenced to WGS84, unless otherwise stated;
- Current direction is presented as the direction towards which the current is flowing;
- Wave and wind directions are the direction from which the wave or wind is approaching;
- All times are in GMT, unless otherwise stated.

Table 2.1 Abbreviations

Abbreviation	Definition
General	
ABS	Acoustic Backscatter
AST	Acoustic Surface Tracking
AWAC	Acoustic Wave and Current Meter
DO	Dissolved Oxygen
EIA	Environmental Impact Assessment
FTU	Formazin Turbidity Units
OBS	Optical Backscatter
SSC	Suspended Sediment Concentration
TSS	Total Suspended Solids
Water Levels	
HAT	Highest Astronomical Tide
MHWS	Mean High Water Springs
MHWN	Mean High Water Neaps
MSL	Mean Sea Level
MLWN	Mean Low Water Neaps
MLWS	Mean Low Water Springs
LAT	Lowest Astronomical Tide
MSR	Mean Spring Range
MR	Mean Range
MNR	Mean Neap Range
MHWI	Mean High Water Interval
MLWI	Mean Low Water Interval
Current Velocity	
MSR	Mean Spring Rate
MNR	Mean Neap Rate

Table 2.2 Definitions

Term	Definition
D ₅₀	Median grain size (average particle diameter by mass)
Metonic Maximum	The maximum value predicted to occur in a 19 year celestial cycle (refers to current speed)

3. SUMMARY OF OPERATIONS

The vessel-based deployment and service visit operations were undertaken using the Briggs Marine vessel Forth Fighter. The recovery of the seabed frames was undertaken using the vessel UKD Seahorse. A summary of all onshore and offshore operations is provided in Table 3.1.

Table 3.1 Summary of Field Operations

Date	Activity
20/02/2015	Deployment of seabed frames, water sampling and Idronaut profiles conducted
25/02/2015	Meteorological station installed
06/04/2015	Seabed frames recovered for maintenance. Water sampling and Idronaut profiles conducted
07/04/2015	Seabed frames redeployed following maintenance
08/04/2015	Maintenance and data recovery completed at the meteorological station
11/06/2015	Recovery of seabed frames, water sampling and Idronaut profiles conducted
12/06/2015	Recovery of meteorological station

3.1 West Location

Table 3.2 West Seabed Frame Instrumentation Configurations

Instrument	Configuration Summary	
Nortek AWAC 1 MHz	Tide and Current Sample Interval	10 minutes
	Tide and Current Average Period	60 seconds
	Number of Bins and Size	40 x 0.5 m
	Blanking Distance	0.4 m
	Wave Sample Interval	30 minutes
	Wave Sampling Frequency and Number of Samples	1 Hz (2 Hz AST) 512 samples (1024 samples AST)
AADI Seaguard	Sample Interval	10 seconds (averaged to 1 sample per 10 minutes)
Aqualogger 210	Burst Sample Interval	10 minutes
	Samples Per Burst and Frequency	60 samples at 1 Hz

3.1.1 Instrument Condition at the Service Visit

During the service visit, very little biofouling of the instruments at the West Location was noted. Some fine sediment was present on the seabed frame. Due to time constraints, the AWAC was exchanged for a spare unit of the same specification. All other instruments were serviced and redeployed.



Plate 3.1 West Seabed Frame Before and After Deployment One

3.1.2 Instrument Condition on Recovery

On recovery, mud was seen to be covering the sensors of the AADI Seaguard instrument. Seaweed was also seen to be obscuring the OBS.

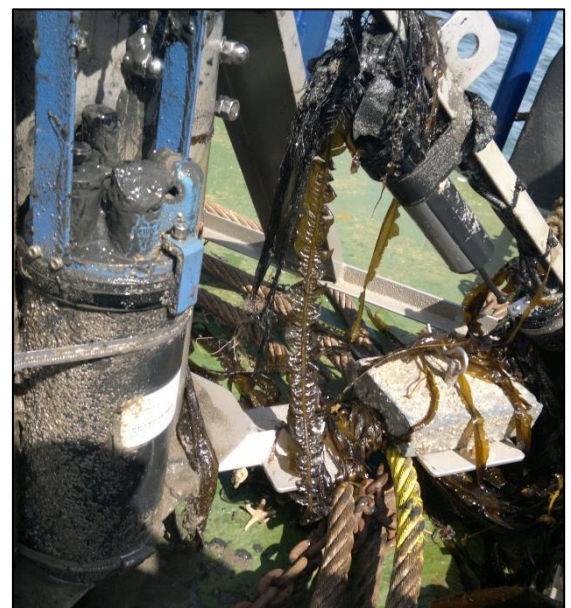


Plate 3.2 West Seabed Frame on Recovery Showing Sediment Covering Seaguard Sensors

3.2 East Location

Table 3.3 East Seabed Frame Instrumentation Configurations

Instrument	Configuration Summary	
Nortek AWAC 600 KHz	Tide and Current Sample Interval	10 minutes
	Tide and Current Average Period	60 seconds
	Number of Bins and Size	40 x 1 m
	Blanking Distance	0.5 m
	Wave Sample Interval	30 minutes
	Wave Sampling Frequency and Number of Samples	1 Hz (2 Hz AST) 512 samples (1024 samples AST)
AADI Seaguard	Sample Interval	10 seconds (averaged to 1 sample per 10 minutes)
Aqualogger 210	Burst Sample Interval	10 minutes
	Samples Per Burst and Frequency	60 samples at 1 Hz

3.2.1 Instrument Condition at the Service Visit

Little biofouling was present on the instruments on the East seabed frame following Deployment One. All instruments were in good condition. Due to time constraints, the AWAC was exchanged for a spare unit of the same specification. All other instruments were serviced and redeployed.

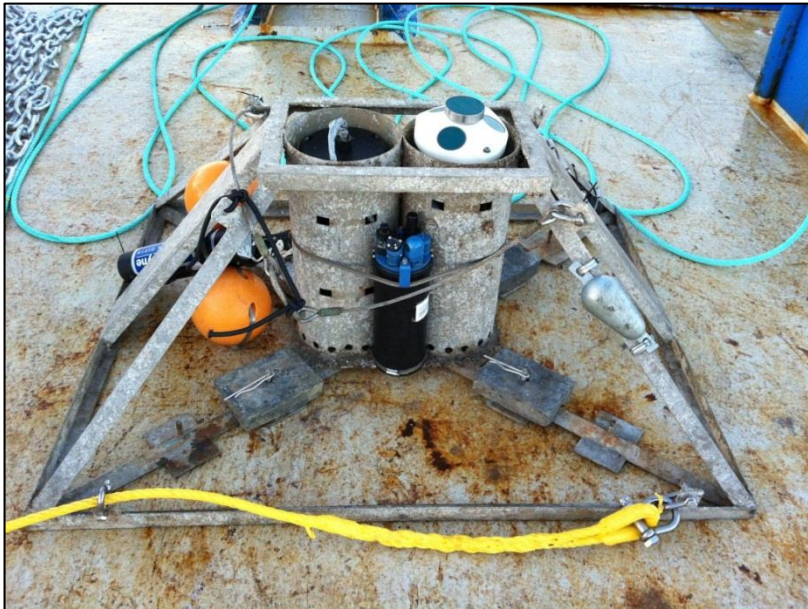


Plate 3.3 East Seabed Frame Before and After Deployment One

3.2.2 Instrument Condition on Recovery

A small amount of biofouling was noted on the instruments after recovery. However, the lens of the OBS remained clear on account of the wiper.

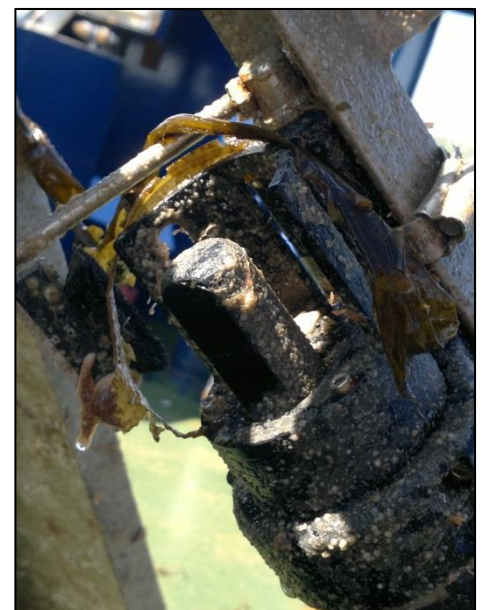


Plate 3.4 East Seabed Frame on Recovery After Deployment Two

3.3 Meteorological Station

A Vaisala WXT 520 meteorological station was installed on top of a silo on the Kelda Water wastewater treatment site at Nigg Bay. Access to the installation location was via a series of ladders and required working at height techniques to be used. The height of the meteorological station was approximately 20 m above ground level.



Plate 3.5 Meteorological Station at Kelda Water site



Plate 3.6 View Towards Nigg Bay from the Meteorological Station Location

4. SUMMARY OF RECOVERED DATA

High quality data were collected at both the West and East Locations and the meteorological station for the duration of Deployment One. During Deployment Two, the seabed frame at the West Location was outside of the acceptable tilt range resulting in invalid current, AST wave and acoustic backscatter data. Table 4.1 summarises the number of days of good data returned for each data type. Further details on data quality control can be found in Section 5 – Data Processing and Quality Control.

The data files delivered in conjunction with this report are as follows:

Wave Data

M2774_WEST_D1-D2_AWAC_Waves_Summary.csv

M2774_EAST_D1-D2_AWAC_Waves_Summary.csv

With the following columns:

Year, Month, Day, Hour, Minute, Second, Julian Day, Significant Wave Height (m), Observed Maximum Wave Height (m), Peak Period (sec), Zero Up Crossing Period (sec), Maximum Likelihood Mean Coming Direction (°T), Maximum Likelihood Peak Coming Direction (°T), Maximum Likelihood Spreading Angle (°)

Tide Data

M2774_WEST_D1-D2_AWAC_T_LAT_R_P.csv

M2774_EAST_D1-D2_AWAC_T_LAT_R_P.csv

With the following columns:

Year, Month, Day, Hour, Minute, Second, Julian Day, Depth (m), Height to LAT (m), Residual Height (m), Predicted Height (m)

Current Profiles

M2774_WEST_D1_AWAC_Current Profile.csv

M2774_EAST_D1-D2_AWAC_Current Profile.csv

With the following columns:

Year, Month, Day, Hour, Minute, Second, Julian Day, Velocity N (m/s), Direction N (°T), Easting Vector N (m/s), Northing Vector N (m/s), Vertical Vector N (m/s)

Where N is the current profile bin number increasing from 1 closest to the instrument.

Depth Averaged Current Data

M2774_WEST_D1_AWAC_Current Profile_DA_R_P.csv

M2774_EAST_D1-D2_AWAC_Current Profile_DA_R_P.csv

With the following columns:

Year, Month, Day, Hour, Minute, Second, Julian Day, Depth Average Velocity (m/s), Depth Average Direction (°T), Depth Average Easting Vector (m/s), Depth Average Northing Vector (m/s), Depth Average Vertical Vector (m/s), Residual Velocity (m/s), Residual Direction (°T), Residual Easting (m/s), Residual Northing (m/s), Predicted Velocity (m/s), Predicted Direction (°T), Predicted Easting (m/s), Predicted Northing (m/s)

Optical Backscatter (OBS)

M2774_WEST_D1-D2_AQL_Turbidity.csv
M2774_EAST_D1-D2_AQL_Turbidity.csv

With the following columns:

Year, Month, Day, Hour, Minute, Second, Julian Day, Temperature (°C), Turbidity (Counts), Turbidity (mg/l)

Acoustic Backscatter (ABS)

M2774_WEST_D1_AWAC_Turbidity.csv
M2774_EAST_D1-D2_AWAC_Turbidity.csv

With the following columns:

Year, Month, Day, Hour, Minute, Second, Julian Day, Turbidity N (mg/l)
Where N is the bin number increasing from 1 closest to the instrument

Seabed Dissolved Oxygen and Salinity

M2774_WEST_D1-D2_SGD.csv
M2774_EAST_D1-D2_SGD.csv

With the following columns:

Year, Month, Day, Hour, Minute, Second, Julian Day, Conductivity (mS/cm), Salinity (ppt), Dissolved Oxygen (mg/l), Dissolved Oxygen (%), Temperature (°C)

Idronaut Profiles

M2774_WEST_D1_IDR_20150220.csv
M2774_WEST_D1_IDR_20150406.csv
M2774_WEST_D1_IDR_20150611.csv
M2774_EAST_D1_IDR_20150220.csv
M2774_EAST_D1_IDR_20150406.csv
M2774_EAST_D2_IDR_20150611.csv

With the following columns:

Year, Month, Day, Hour, Minute, Second, Julian Day, Depth (m), Temperature (°C), Conductivity (mS/cm), Salinity (ppt), Density (kg/m³), Dissolved Oxygen (mg/l), Turbidity (Counts)

Meteorological Data

M2774_MET_D1-D2_AHB.csv

With the following columns:

Year, Month, Day, Hour, Minute, Second, Julian Day, Wind Speed (m/s), Gust Speed (m/s), Wind Direction (°T), Air Temperature (°C), Air Pressure (mbar), Humidity (%), Rain Fall Intensity (mm/hr)

Table 4.1 Data Return Summary

Data Type		West	East
Wave Heights and Periods	No. of days good data (approximate percentage of total)	112 (100%)	112 (100%)
Wave Directions and Spreading Angle		46 (41%)	112 (100%)
Tide		112 (100%)	112 (100%)
Current		46 (41%)	112 (100%)
OBS		112 (100%)	112 (100%)
ABS		46 (41%)	112 (100%)
Seabed DO		92 (82%)	112 (100%)
Seabed Salinity		92 (82%)	112 (100%)
Overall Percentage Return (Seabed Instruments)			73 %
Number of Idronaut Profiles		3	3
Number of Water Samples		44	47
Meteorology		108 (100%)	

5. DATA PROCESSING AND QUALITY CONTROL

All data have been processed according to Fugro EMU Limited's Method Statement; MET 35. All raw instrument files are imported into Fugro EMU's MetOcean data processing software; Ocean V3. This allows all processed data files to be presented in a uniform *.csv file format.

5.1 Wave Data

Individual files were created for each wave burst data set from the Nortek AWAC. These are a 512 record time series of all sensors taken at 1 Hz for the pressure signal and the orbital currents, plus a 1024 record time series at 2 Hz for the Acoustic Surface Tracking (AST). A new file was collected every 30 minutes. An additional sensor provides temperature readings so that fluctuations in water density and sound velocity can be computed. The wave heights and frequency are deduced by rapid measurement of instantaneous head of water measured either as pressure, using a precision strain gauge sensor, or range, using a vertical acoustic beam.

Processed wave statistics from the East Location are based on the AST data for both Deployment One and Deployment Two. Deployment One data from the West Location are also based on AST. Due to the seabed frame being incorrectly orientated for Deployment Two at the West Location; AST data were unavailable. However, it was possible to derive non-directional wave data through the following process:

- Wave statistics were created for Deployment One data using both AST and pressure signal techniques.
- The results generated using the two techniques were compared. Peak period was found to compare well overall when viewed as a time series and so the pressure - generated version was deemed to be acceptable.
- Regressions were established for the other key parameters as follows:
 - $AST H_s = Pressure H_s \times 1.286$
 - $AST H_{max} = Pressure H_{max} \times 1.473$
 - $AST T_z = Pressure T_z \times 0.8154$

The above process was used to quantify and compensate for the error inherent in scaling up the pressure signal to the expected surface signal; further details of which are included in paragraph 5.1.1 below. The regressions are presented as Figure A032 in Appendix A.

5.1.1 Wave Data Processing from a Pressure Signal

Raw pressure values from the wave burst are first de-trended to remove the longer term effects of the tidal slope as this can weight the spectrum toward the longer period data. Once de-trended, passing the pressure data through a Fourier curve fitting routine produces a one dimensional wave energy spectrum. The spectrum is then scaled up to remove the effect of depth attenuation of the pressure signal and the effects of signal loss due to damping effects. This scaled spectrum is used to calculate the non-directional components of the wave climate, such as H_s (Significant Wave Height), T_z (Zero

Up Crossing Period) and T_p (Peak Period). Additionally the expected surface signal is produced; this can be compared with the calculated wave parameters to allow data verification.

To recreate the surface conditions from the pressure data, the linear wave theory equations are used. These are applied directly to the recorded data in addition to the spectral data. The pressure spectrum is related to the surface wave spectrum using the following equations:

$$P_s = \left[\frac{\cosh kh}{\cosh k(h+z)} \right]^2 \frac{P_d}{\rho^2 g^2}$$

Where: P_s = pressure signal at surface
 P_d = pressure signal at sensor
 k = wave number
 h = mean depth of burst
 z = sensor height above seabed
 ρ = water density (not required if values previously converted to depths)
 g = local gravity (not required if values previously converted to depths)

The wave number (k) is derived from the following equations:

$$c^2 = gk \tanh kh$$

Where: c = wave speed (celerity)
 k = wave number
 h = mean depth of burst
 g = local gravity (not required if values previously converted to depths)

Using the relationships:

$$k = \frac{2\pi}{L} \quad \text{and} \quad c = \frac{L}{T}$$

the derivation of L can be used:

$$L = \frac{gT^2}{2\pi} \tanh\left(\frac{2\pi}{L}\right)$$

Where: L = wavelength
 T = wave period

It is not possible to directly solve this equation therefore it is solved by iteration taking the deep water value for L and iterating until the answer stabilises. The deep water wavelength is calculated from:

$$L = L_0 \tanh\left(\frac{2\pi}{L}\right)$$

$$L_0 = \frac{gT^2}{2\pi}$$

Where: L_0 = deep water wavelength

k can now be derived from the relationship $k = 2\pi/L$.

These equations are applied to the pressure spectral data to calculate the expected surface spectra. However if they are applied directly the attenuation coefficient $(\cosh kh / \cosh k(h+z))^2$ rapidly exceeds workable numbers. To avoid this, an artificial cut off is used such that if the multiplier exceeds 10x it is truncated. Additionally if the multiplier exceeds 10x and the period is less than 5 seconds the multiplier is reduced linearly to 0 at a period 0.

5.1.2 Wave Data Processing from an Acoustic Signal

Raw acoustic ranges are converted to heights by the instrument manufacturer’s software; these values from the wave burst are de-trended and de-meant to produce a surface wave trace. The de-trended data are stored for comparison to the calculated wave parameters and are then analysed to produce a one dimensional wave energy spectrum. All files produced during processing have been archived by Fugro EMU but due to the quantity of data these will not be delivered unless required for further analysis.

5.1.3 Wave Data Processing Algorithms

Once files of the surface elevations are processed (either calculated from acoustic or pressure signals), these are combined with the easting and northing current vectors to generate three dimensional data. The three dimensional wave measurements (depth / height, easting component and northing component) are then passed through an additional series of routines that produces a cross-spectral density matrix allowing the wave energy to be broken down by direction as well as by frequency. From this the peak direction (coming direction) of the waves can be extracted along with energy against direction spectra.

The procedure adopted for processing can be summarised as:

- Input n points of water level, u and v vector data
- De-mean and de-trend data. The tidal slope is calculated from the average of the first and last thirds of the raw pressure readings in the burst
- Apply Fourier Transforms to the adjusted water level, u and v data series
- Apply pressure compensation algorithms where applicable
- Compute and smooth cross-spectra
- Compute cross-spectral density matrix
- Compute inverse cross-spectral density matrix
- Apply directional analysis equations to inverse matrix

- Normalise spectra
- Output the energy at each period and direction
- Compute spectral moments (m_n) for the major directional axis

The spectral moments are derived using the following equations:

$$m_n = \sum_z^1 [f_i^n E(f_i) \Delta f_i]$$

- where m_n is the moment (m_{-2} , m_{-1} , m_0 , m_1 , m_2 , m_3 or m_4)
 i is the spectral band (1 to z)
 f_i is centre frequency of band I [$f_i = 0.5 * (f_i \text{ lower} + f_i \text{ upper})$]
 $E(f_i)$ is the energy density in band i
 Δf_i is the width of band I [$\Delta f_i = (f_i \text{ lower} + f_i \text{ upper})$]

Statistics generated using the spectral moments are as follows:

- calculated significant wave (H_s) = $4 * \sqrt{m_0}$, where m_0 (zeroth moment) is the variance and $\sqrt{m_0}$ is the standard deviation
- calculated mean period T_1 = defined as m_0/m_1
- calculated zero-up crossing period (T_z) = defined as $(m_0/m_2)^{1/2}$
- peak period (T_p) = taken from spectral frequency bands
- calculated total energy (E_t) = total energy by density * gravity * variance (m_0)
- calculated significant wave period (T_{sig}) = the average period of the waves defined by the significant wave height

Fugro EMU’s software is used to determine the main axis of the orbital motion. The 512 by 1 Hz records of current speed and direction give a scatter, which may or may not have a distinct orientation depending on how ordered the sea waves are as they pass overhead. A well-ordered wave train with a constant frequency will generate orbital currents along one tight axis but most seas are a broad spectrum of wave directions and frequencies. To resolve a peak direction for the axis of the orbital motion a maximum radius elliptical linear regression line is fitted to the scatter of observations. The mean point of this scatter represents the tidal stream and drift current at this time while the slope of the regression line is taken as the major axis of the orbital current scatter. The maximum, minimum and standard deviation of each data set are also extracted. The significant orbital velocity (U_s) is defined here as 4 x the standard deviation of the instantaneous velocity measurements over the 512 records; equivalent to the significant wave height (H_s) which is 4 x the standard deviation of the sea surface. The vector components of the significant orbital velocity are calculated as 2 x the standard deviation of the instantaneous velocity measurements over the 512 records.

5.2 Tidal Data

Raw pressure data are converted to height above the sensor using density values calculated using a pre-set water column mean salinity value (35 ppt) and measured temperatures. Atmospheric pressure data from the meteorological station installed at Nigg Bay were also used to compensate for local atmospheric pressure variations. For the records which were collected prior to the installation of the meteorological station, the dataset average (1011 mb) was applied. The mean salinity value used in the pressure to depth conversion can be a source of error. However, the effect is small (a difference in resulting depth of approximately 2% for a 15 ppt change in salinity). The calculated depths are also quality checked against the acoustic range depths from the AWAC's AST wave burst. Regressions for the East Location data showed a 1:1 relationship, whereas a ratio of 0.98 was found at the West Location.

The calculated heights above the instrument are reduced to the mean of the data set for harmonic analysis. The extracted harmonics are then used to extrapolate the Lowest Astronomical Tide (LAT) and Highest Astronomical Tide (HAT) values with reference to the data set mean. The LAT offset is applied to the mean data to reduce the tidal records to LAT. The data are then re-analysed and the new LAT value extrapolated; if the LAT value is 0 then the analysis is held to be good.

In order to combine Deployment One and Deployment Two data into one time series for analysis, the slight change in sensor height from one deployment to the next has to be accounted for. This is achieved by creating predicted heights for the Deployment Two time period using the Deployment One data. The difference between the mean of the Deployment Two observations and the predictions is calculated and applied to the dataset in order to reduce the Deployment Two observations to the Deployment One LAT. Once this height change has been corrected, the complete dataset can then be re-analysed in order to establish the final LAT value.

Total observed tidal heights are considered to be a combination of two components in order that they may be described and re-predicted.

- 1) The pure tidal component; the predictable oscillation driven by astronomical forces.
- 2) An inconsistent residual height variation; the variability of the non-tidal surge passing over the site.

This variability may include "instrument noise" but it is usually a measure of the meteorologically-induced residual variability. Local and brief atmospheric disturbances will generate fluctuations in the tidal heights which will be detected in this component after the tidal components have been extracted from the observations.

In order to separate these components, the data set is subjected to harmonic analysis extracting a series of periodic curves with the frequency of the major tidal constituents. The number of constituent cosine curves that can be derived depends on the length of the observed data set. From one month (a lunar cycle) of observations, it is reasonable to extract 26 tidal constituents as well as the mean sea level for the month. However, the tidal energy spectrum includes several peaks which are, in fact, unresolved complexes of tidal constituents with very close frequencies. They cannot be separated

reliably from a single lunar period but their amplitude relationships are often known at a nearby Standard Port or at a previously monitored tidal site in the region. By transferring these relationships, it is possible to resolve 8 additional “related” constituents within the analysis to produce a final table of 34 constituent constants. An analysis on one year of tidal data from the National Tide and Sea Level Facility site at Aberdeen was used to establish these relationships.

Fugro EMU uses a PC-compatible harmonic analysis program based on the mathematical algorithms developed by Hunter for the Australian Oceanographic Research Organisation: CSIRO. It is a revision of the least-squares, best-fit method used in ELSIE and TIRA, the analysis and predictive programs originally developed by the UK Government research laboratories of the Institute of Oceanographic Sciences (IOS). The Hunter program has been fully verified and is in use by government institutes and commercial companies world-wide.

The cosine curve for each derived constituent is defined by amplitude and phase lag (relative to phase at the Greenwich Meridian). The frequency of the constituent is an astronomically-derived global constant. After the constants for the tidal constituents have been derived, they are used to reconstruct a “pure” tidal stream curve for the observation period. Subtraction of this curve and the mean height from the observed data leaves the non-tidal residual heights. This is again examined as a time series plot and if any sinusoidal pulse remains in the residuals, a poor analysis is indicated. At most sites, the tidal component is predominant and residuals are expected to be small by comparison. Periods of prolonged high residuals generally relate to storm surges and are a genuine non-tidal component of water level. If the residuals are relatively small and either random or slowly changing, predictions for any period may be made with reasonable confidence in their accuracy.

5.3 Current Data

The Nortek AWAC profiler uses three acoustic signals produced from acoustic transceivers mounted on the head of the instrument. The three acoustic transceivers are offset at an angle of 25° to the vertical thus producing 3 divergent acoustic signals that are propagated through the water column. The signals are reflected back to the instrument by particulate material in the water column. The returned signal is binned (divided into separate depths) with respect to the return interval. This interval is calculated from the pre-set range and the speed of sound as calculated by the instrument, using the pre-set salinity value (35 ppt) and the measured temperature. The binned data are then processed using Doppler technology and the relative movement of the particulate material in the water column can be ascertained with reference to each beam. The movement of this particulate material is assumed to be caused by the water flow through the field. This movement is converted first to a general flow through the 3 beam field referenced to an arbitrary zero direction on the instrument. This is then converted to a true speed and direction (to magnetic north) by reference to an integral flux gate compass.

The acoustic signals are produced at 34 Hz and the averaged return signal is stored at 2 Hz. To reduce the effect of turbulence it is necessary to average the data over a period long enough to compensate for the local conditions. Thus, a minimum of a 30 second burst is usually considered necessary in coastal waters to extract the mean flow and remove the effects of wave induced turbulence. A 60 second burst was chosen for the AWACs at Nigg Bay. Once extracted, the average

data are converted to directions to True North ($^{\circ}T$) by applying the local magnetic to true north variation for the site in Fugro EMU Limited's bespoke software.

Erroneous data can occur either when the signal return strength is reduced such that it is impossible to distinguish the movement correctly, or in areas of high turbulence. Thus the data closest to the surface, furthest from the instrument, are the least reliable whereas data closer to the instrument are considered to be the most robust. The data from bin 1 can be expected to be accurate to within 0.02 ms^{-1} . However in the surface cells this accuracy is significantly reduced such that values derived at less than 10% of the depth can only be considered indicative values with a nominal accuracy of $0.10 - 0.30 \text{ ms}^{-1}$. The compass has a nominal accuracy quoted to 2° and thus the directions cannot be more accurate than this. The error inherent in the measurement technique should also be taken into account such that the directions are considered good to $\pm 5^{\circ}$. During examination of the current profile data from both locations, high acoustic return values were observed in the surface bin of each dataset indicating side-lobe interference. As a result, the last data bin in the profile (closest to the surface) was removed from each dataset. These trimmed profiles were depth-averaged prior to completing the harmonic analysis.

Total observed currents are considered to be a combination of three components in order that they may be described and re-predicted.

1) The tidal stream component;

The predictable oscillation driven by astronomical forces. This may include shallow water or coastal components, sometimes referred to as "tidal residuals". Circulation in bays and around headlands or sandbanks often results in severe distortions of the typical open-water tidal ellipse. Often a local eddy system will only develop on one stage of the tide and the movement of the water over a point within this eddy may be in the same general direction on both the flood and ebb tide.

2) A mean drift component;

The consistent trend in the data reflecting a steady offset distorting the tidal ellipse. The mean net drift over the site does not always indicate an oceanic current is affecting the water column for the reasons mentioned in (a) above. However, by considering the local topography, it is usually possible to assess whether an eddy circulation is responsible for the net movement over the site.

3) An inconsistent residual drift;

The variability of the non-tidal current passing over the site. This variability may include "instrument noise" but it is usually a measure of the meteorologically-induced residual variability. Seasonal winds tend to generate oceanic currents which will be detected mainly as the mean drift current (2). More local and brief atmospheric disturbances will generate fluctuations in the currents which will be detected in this component after the tidal components and mean drift have been extracted from the observations.

In order to separate these three components, the current data set is subjected to harmonic analysis extracting a series of periodic curves with the frequency of the major tidal constituents. While tidal heights are analysed as a single amplitude variable, currents have to be analysed as two amplitude variables (easting and northing vectors) because of changing speed and direction with time. After

analysis, easting and northing components can be recombined to give predictions as speed and direction.

After the constants for the tidal constituents have been derived, they are used to reconstruct a “pure” tidal stream curve for the observation period. Subtraction of this curve and the mean drift current from the observed data leaves the non-tidal residual flows. This is again examined as a time series plot and if any sinusoidal pulse remains in the residuals, a poor analysis is indicated. At most sites, the tidal component is predominant and residuals are expected to be small by comparison. Periods of prolonged high residuals generally relate to storm surges and are a genuine non-tidal component of velocity. If the residuals are relatively small and either random or slowly changing, predictions for any period may be made with reasonable confidence in their accuracy.

5.4 Suspended Sediment Concentration Data

Suspended sediment concentration information have been derived through the use of optical backscatter and acoustic backscatter measurement techniques. Due to the indirect nature of the measurements, individual values should be considered indicative or accurate to within an order of magnitude.

A small number of direct measurements are available in the form of laboratory analysis of on-site water samples giving an accurate suspended sediment concentration value in mg l^{-1} . However, sampling activities took place in conjunction with equipment deployment and maintenance work which required calm weather and low tidal flow conditions. As such, higher suspended sediment concentration values are not seen in water sample results and a limited range of values are available for the regressions, thus placing limitations on their applicability.

Optical and acoustic sensors respond differently to grain characteristics such as size, shape, density and colour. Therefore, values derived from the two techniques are not expected to show close correlation. In this study, it appears that acoustic backscatter is a less suitable technique for quantifying suspended sediment concentration due to the fine particle sizes present in this environment.

5.4.1 Optical Backscatter

The raw Aqualogger data files include 60 samples every 10 minutes at 1 Hz. These data bursts were first averaged to produce one value for each 10 minute record. Pre and post-deployment data were removed from the data file.

The observed data were graphed as time series plots for examination. Spikes, flat-spots and other unreasonable data points are usually clear. During this stage, a number of erroneous values were identified in the East instrument's time series as detailed below in Table 5.1. These values exhibited an excessive rate of change from surrounding values and were therefore replaced with a null value (-999).

Table 5.1 Records replaced with null values in the East Location OBS time series

Date	Time	FTU Value
05/04/2015	21:11	1328
23/04/2015	11:20	896
25/04/2015	11:30	953
03/06/2015	11:50	60
03/06/2015	17:30	539
03/06/2015	18:00	406
06/06/2015	08:50	512
08/06/2015	10:20	557
08/06/2015	10:30	458
08/06/2015	21:10	407

5.4.2 Optical Backscatter Calibration

In order to “calibrate” the turbidity data recorded by the Aqualoggers (convert them from Formazin Turbidity Units (FTU) to concentration values), the data were examined in parallel with the results of the Total Suspended Solids analysis on the water samples. A regression was compiled, whereby the water sample concentrations (in mg l^{-1}) were plotted against the corresponding turbidity values (in FTU) from the instrument. A linear best-fit line was applied to the scatter of values. The resulting regression equations were applied to the time series of FTU values in order to convert them to indicative mg l^{-1} values. In the case of the West Location, the results from the water samples taken immediately prior to recovery on the 11th June 2015 were found to worsen the regression fit and were therefore rejected from the process. The sensor may have been affected by interference from marine growth, altering its response (see Plate 3.2). Six samples taken on the 20th February and six taken on the 6th April 2015 were included in the calibration. All samples collected for the purpose of the OBS calibration were collected as close as practicable to the instrument height (approximately 1.0 m above the seabed). One water sample result from the East Location of those taken on the 11th June was rejected as an outlier. 15 samples were incorporated into the East Location’s calibration taken on three dates; 20th February, 6th April and 11th June. Table 5.2 presents the maximum and mean values of the water sample concentrations. Laboratory test certificates are also included in Appendix H. The following figures show the regressions applied to the two Aqualogger datasets and illustrate the results rejected from the West Location calibration. In the case of the East Location where the regression equation has changed with the addition of more sample results, the new equation has been applied to both the Deployment One and Deployment Two data. As a result, the concentration values will be different to those delivered with the Service Visit and Data Report (ref 15/J/3/01/2774/1823).

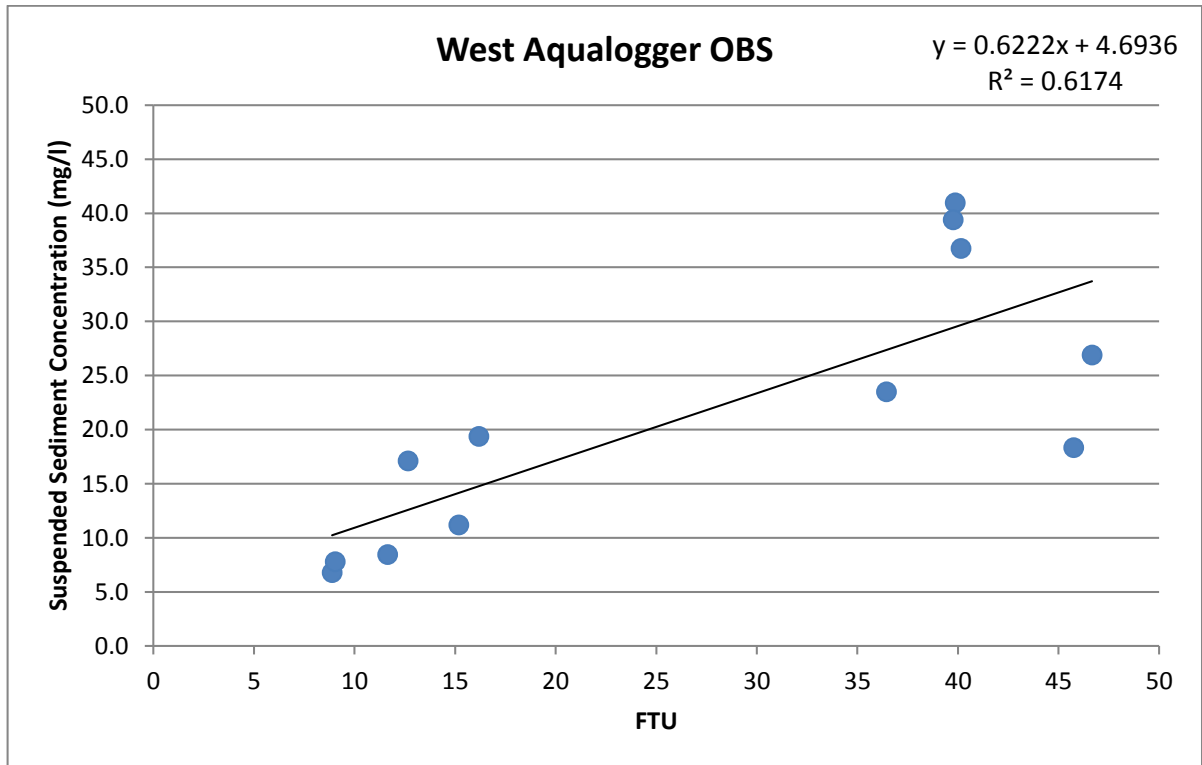


Figure 5.1 Regression Used to Convert OBS Data – West (Deployment One Data Only)

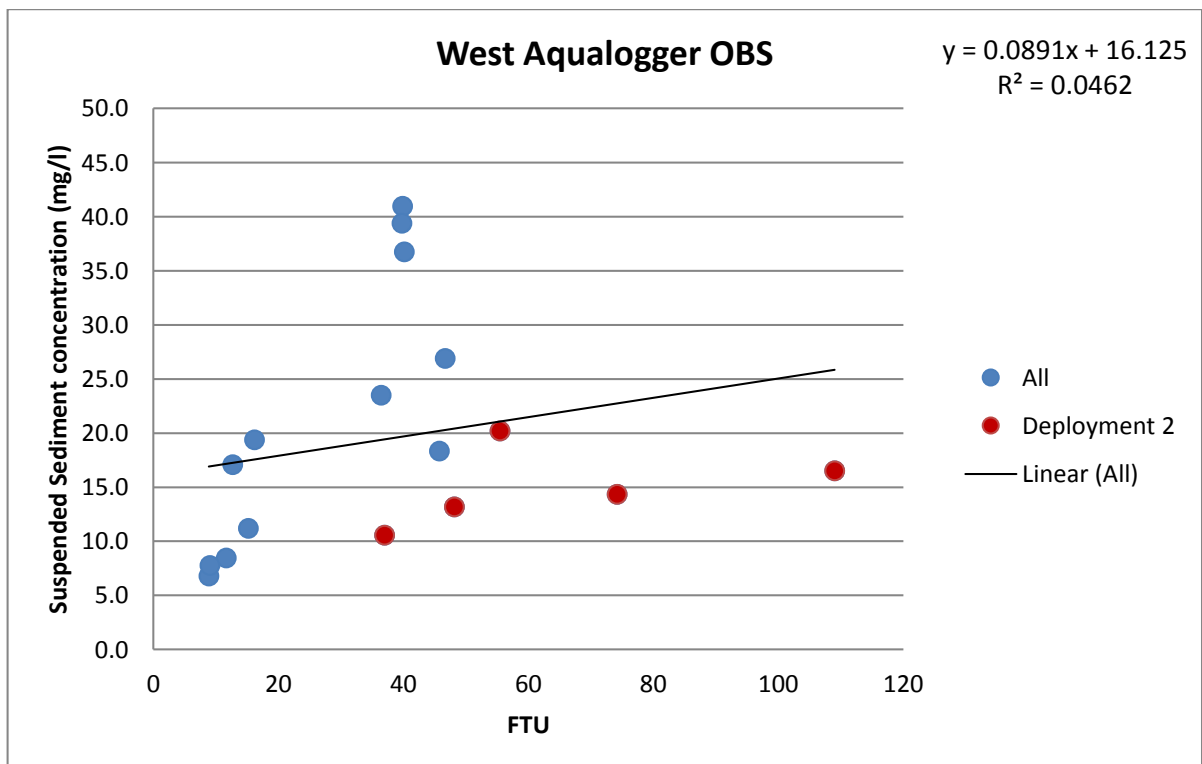


Figure 5.2 Rejected Regression for West OBS Including Deployment Two Data.

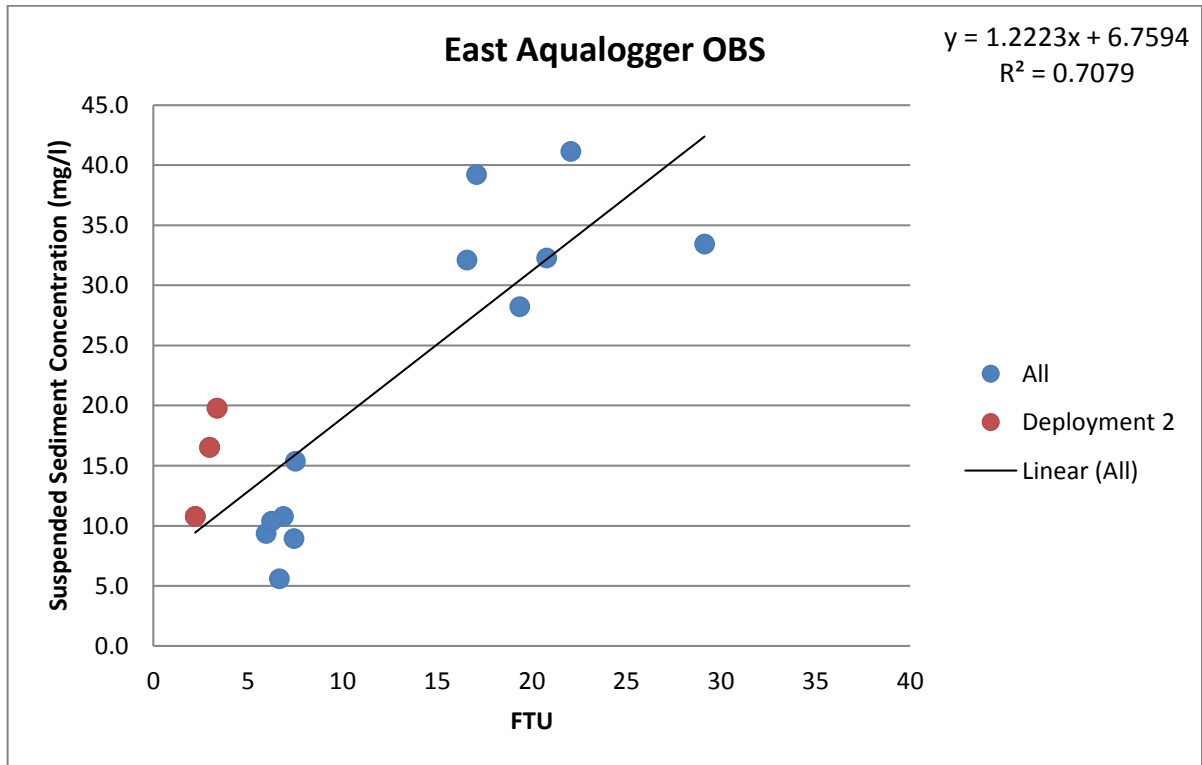


Figure 5.3 Regression Used to Convert OBS Data – East

Table 5.2 Suspended Sediment Concentration Statistics – OBS Water Samples

SSC (mg ^l ⁻¹)	West	East
Mean	19.5	21.4
Maximum	41.0	41.2

5.4.3 Acoustic Backscatter

The acoustic return values from each of the three AWAC beams were first averaged to produce one acoustic return value per profile bin, per time-stamp. These raw values were then converted to Normalised Decibels, to remove the effect of signal attenuation through the water column. This was achieved using the method described in Nortek Technical Note 003 (2001) *Monitoring sediment concentration with acoustic backscattering instruments*.

5.4.4 Acoustic Backscatter Calibration

Normalised Decibel values which correspond both in time and water column height to the water sample results were extracted from the data file. The scatter of values was examined to establish whether the ABS data could be converted into estimated mg^l⁻¹ concentration values. Both linear and exponential regression lines were applied to the scatter of results. Fugro EMU have previously found that acoustic backscatter data conform more robustly to an exponential best-fit line. A satisfactory calibration could not be established purely with the results of the local water samples. Therefore, the pairs of values from the site-specific calibration were added to Fugro EMU Limited’s previous acoustic backscatter calibrations appropriate to the frequency of the AWAC at each location (1 MHz at the

West Location, 600 KHz at the East Location). A better fit was established and so these regression equations were used to convert the NdB values to estimated mg/l⁻¹ values.

Water samples were collected at three water column heights on three sampling occasions; 20th February, 6th April and 11th June. On each occasion, the near surface samples were taken 0.5 m below the surface, mid-water samples were taken at half of the water column depth at the time of sampling and near-bed samples were taken 1.0 m above the seabed. Table 5.3 presents the maximum and mean concentration values of the sets of water samples. Laboratory test certificates are also presented in Appendix H.

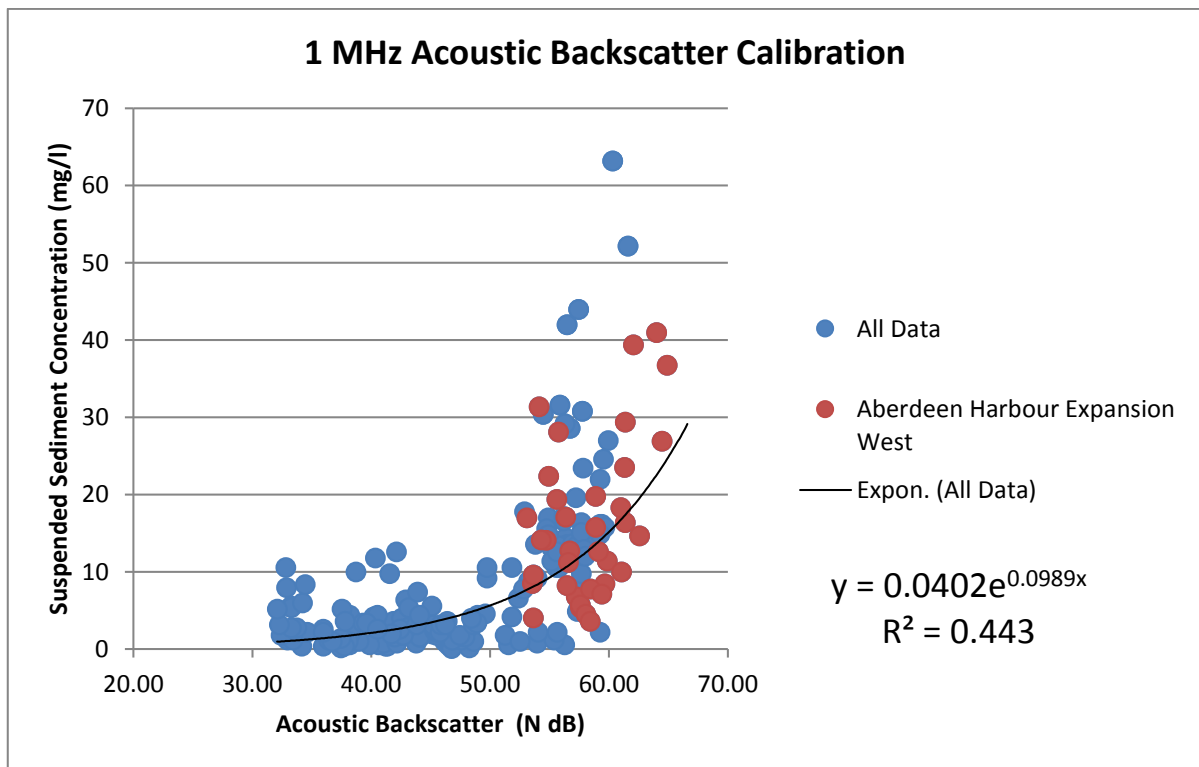


Figure 5.4 ABS Calibration – West Location

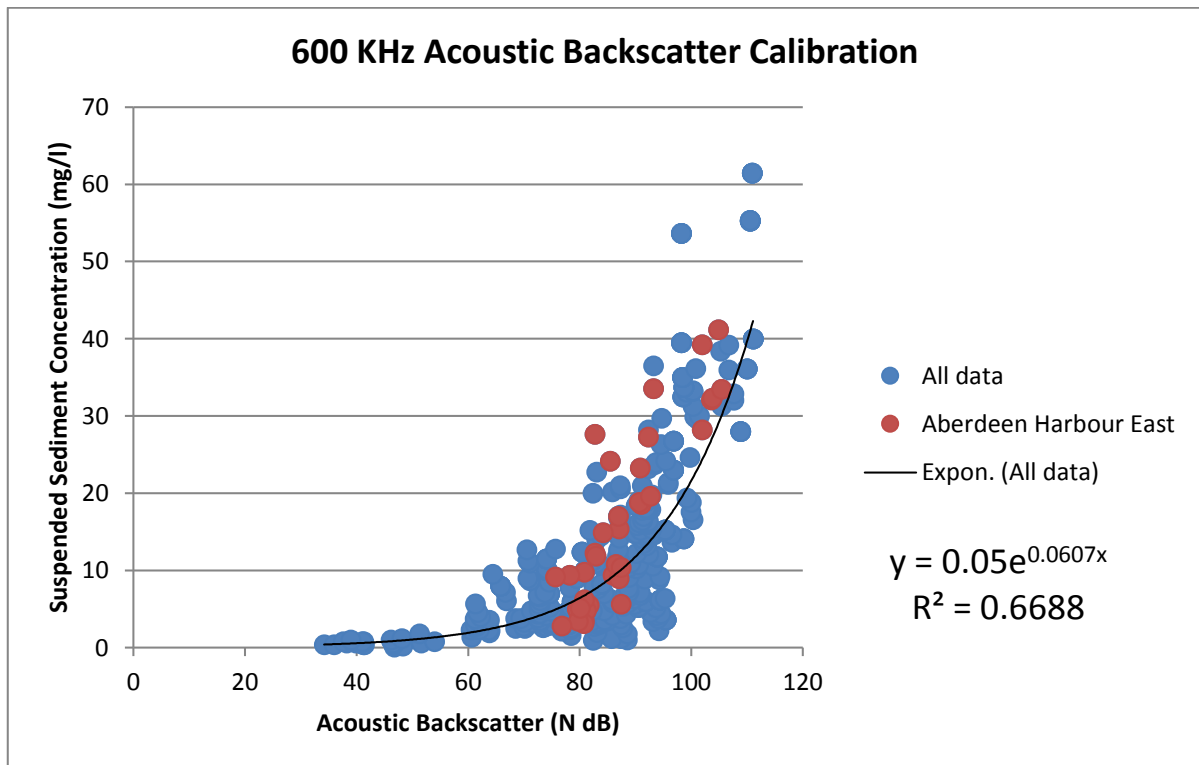


Figure 5.5 ABS Calibration – East Location, Deployment One

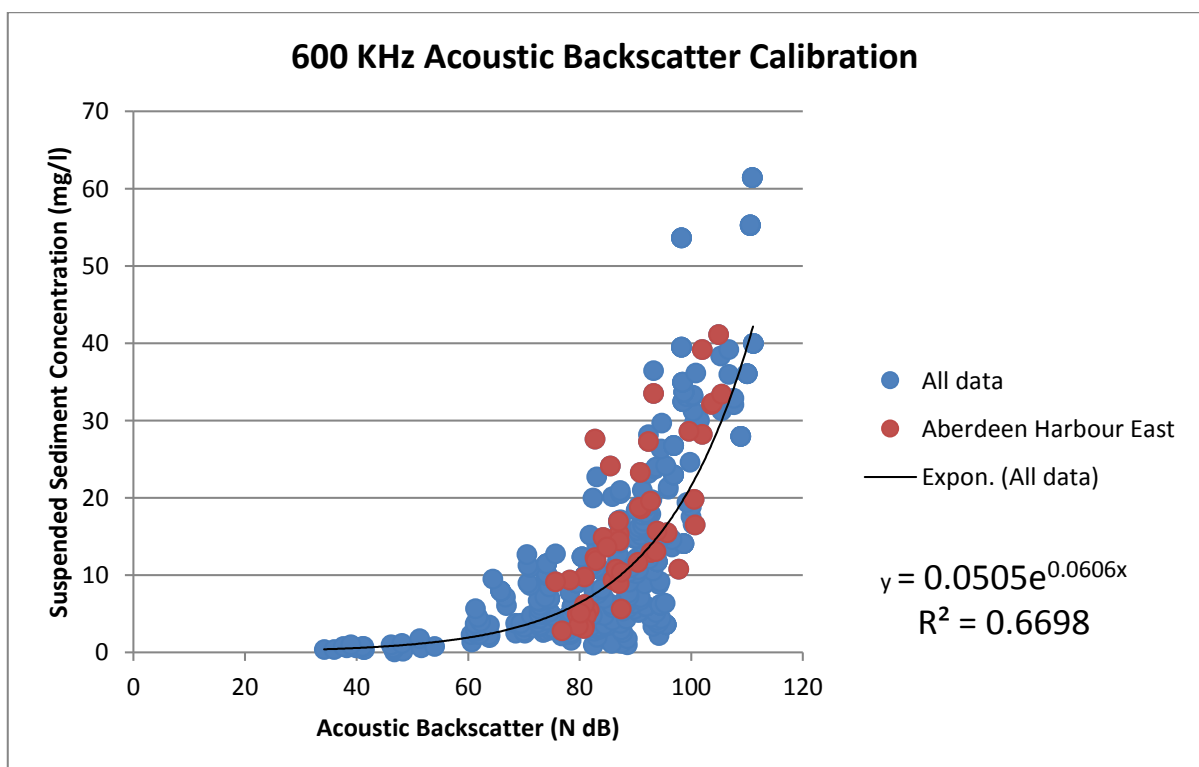


Figure 5.6 ABS Calibration – East Location, Deployment Two

Table 5.3 Suspended Sediment Concentration Statistics – ABS Water Samples

SSC (mg l ⁻¹)	West	East
Mean	16.2	16.1
Maximum	41.0	41.2

5.4.5 Total Suspended Solids Analysis of Water Samples

Water Samples were analysed for total suspended solids concentration in Fugro EMU Limited’s sediment laboratory facility. A 1.2 µm glass fibre paper filtration method was employed, as described in Fugro EMU Limited Method Statement; MET 17. Test certificates are provided in Appendix H.

5.5 Water Quality Vertical Profiles

The raw turbidity profiles collected by the Idronaut instrument consisted of multiple “casts” (upwards or downwards profiles through the water column). The pre and post-deployment data were removed, and the file trimmed down to a single cast using Fugro EMU’s bespoke profile processing tool. All casts are visualised at this stage to allow the selection of the best available cast for each profile. A rolling average over 3 records was then applied to the data file in order to smooth the high frequency variations. These trimmed and averaged files were then exported for plotting.

5.6 Salinity and Dissolved Oxygen

The AADI Seaguard instruments were programmed to collect one sample every 10 seconds throughout the deployment period. An average over 60 samples was performed during post processing to create a file with one record every ten minutes.

Dissolved oxygen values are downloaded from the instrument in µM. These values were subsequently converted to mg l⁻¹ and percentage saturation values using AADI’s Oxygen Optode Calculation Spreadsheet available at:

<http://www.aanderaa.com/productsdetail.php?SeaGuard-O2-29>

During quality control procedures, data from two time periods were classified as bad data and removed from the West time series; 07:06 on the 18th May 2015 – 19:19 on the 1st June 2015 and 00:08 on the 6th June 2015 to the end of the data file. It is possible that the sensors were covered with mud on account of the incorrect orientation of the seabed frame. As a result of this, the data from the remainder of Deployment Two at the West Location should be treated with a lower confidence level than those from the East Location. A further time period of data from the West Location was identified as suspect; 04:56 on the 11th March 2015 – 20:27 on the 18th March 2015 during which a decrease in salinity is observed. It is possible for salinity data to be corrupted by the presence of marine organisms on the sensor, due to the nature of the sensor design (which has a small hole). However, there was no evidence to support the classification of the data as bad and as such, the data from this time period has not been removed from the file but should be treated as suspect.

5.7 Meteorological Data

The meteorological station logger creates one file per day of data collection. Each file was imported into Fugro EMU’s software and concatenated to create one file for the duration of the deployment. The number of expected and returned records was compared. During this stage it was noted that three records in the time series contained no values for the measurement parameters; 22:40 on 07/03/2015, 14:10 on 03/05/2015 and 11:00 on 30/05/2015. These records remain in the processed data file with null values (-999) for all parameters. Data were visualised to check for flat lines and data spikes and compared with daily averages of meteorological parameters from the Aberdeen Airport METAR station as a quality indicator. One value for rainfall intensity was nulled as it appeared to show an unreasonable rate of change from the surrounding records; 14:00 on 29/05/2015 (60.3 mmhr⁻¹).

6. RESULTS

6.1 Wave Data

Waves of up to 4.8 m and 6.7 m H_{max} were observed at the West and East Locations respectively. The mean H_s over the duration of the measurement period was 0.6 m at the West Location and 0.7 m at the East Location. The largest wave heights were observed on the 11th March 2015 and the 3rd – 4th May 2015. From approximately 06:00 on the 11th March, the wave directions change from easterly to south easterly showing excellent correlation with the meteorological data; a change in wind direction to south easterly occurred at this time.

Time series graphs of the key wave statistics are presented in Appendix A along with a wave rose diagram, spectral time series plots and frequency tables for each location. The wave rose diagrams and frequency tables show that all of the wave energy at the West Location approached from between 50 and 170 °T. The wider direction band observed at the East Location reflects the greater level of exposure of this location; records were observed in all but 2 of the 10° direction bands. The largest waves approach both locations from a south easterly direction band; 140-150 °T and 120–130 °T at the West and East Locations respectively.

Waves of up to 21 s T_p were observed at the West Location, compared to 14.2 s maximum T_p at the East Location. Waves of greater than 10 s T_p appear to occur more frequently at the West Location. This could be due to the filtering out of shorter period energy as waves are refracted into the Bay. However, in some instances it may be due to noise in the wave spectrum on account of very low energy levels. The spectral time series plots show wave energy against period and period against direction. These further demonstrate the dominance of the south easterly wave direction and can highlight any periods of bimodality in the wave spectra; times when there are two peaks in energy at different periods or directions. There are no clear examples of bimodality during the measurement period. Table 6.1 and Table 6.2 below provide a summary of the wave observations for each location. The notation “D1 – D2” or “D1 only” identifies where data from both deployments have been used to derive the statistics and where only Deployment One data were available for the parameter in question.

Table 6.1 Summary of Wave Measurement Results – West Location

	Minimum	Mean	Maximum	Standard Deviation
H_s (m) (D1 – D2)	0.1	0.6	3.2	0.5
H_{max} (m) (D1- D2)	0.1	0.9	4.8	0.8
T_p (s) (D1 - D2)	2.0	8.7	21.3	3.1
T_z (s) (D1 – D2)	2.5	4.5	7.3	0.7
Most frequently occurring T_z (s) (D1 – D2)	4 - 5			
T_z associated with largest H_s values (s) (D1 – D2)	3 - 5			
Most frequently occurring Mean Direction (°T) (D1 only)	90 - 100			
Mean Direction Band Accounting for ~68% of records (°T) (D1 only)	90-140			
Mean Direction Band Associated With Largest H_s Values (°T) (D1 only)	140 - 150			

Table 6.2 Summary of Wave Measurement Results – East Location

	Minimum	Mean	Maximum	Standard Deviation
H_s (m) (D1 – D2)	0.1	0.7	4.0	0.5
H_{max} (m) (D1 – D2)	0.2	1.2	6.7	0.8
T_p (s) (D1 – D2)	2.0	5.8	14.2	2.0
T_z (s) (D1 – D2)	2.5	4.1	6.6	0.8
Most frequently occurring T_z (s) (D1 – D2)	3 - 4			
T_z associated with largest H_s values (s) (D1 – D2)	5 - 6			
Most frequently occurring Mean Direction (°T) (D1 – D2)	130 - 140			
Mean Direction Band Accounting for ~68% of records (°T) (D1 – D2)	50 -160			
Mean Direction Band Associated With Largest H_s Values (°T) (D1 – D2)	120 - 130			

6.2 Tidal Data

As described in paragraph 5.2, a harmonic analysis was undertaken on the water level time series from the AWAC at each measurement location; resulting in a separation of the purely astronomical tidal heights and the non-tidal residual or “surge” component. The data from Deployment Two were first reduced to the Deployment One LAT using a mean transfer technique, prior to analysis of the two datasets as a whole. The study area can be classified as mesotidal (Mean Spring Range between 2 and 4 m) and semidiurnal.

The non-tidal component is relatively small in comparison to the tidal signal as expected. The residuals do not display a tidal signal indicating that the harmonic analysis (based on a 60 point analysis of the Aberdeen National Tide and Sea Level Facility dataset) was able to successfully assign a large proportion of the tidal energy into the harmonic constituents. The largest residual observed (on the 10th March 2015) was 0.78 m at both locations.

Table 6.3 Summary of Tidal Height Results Relative to Lowest Astronomical Tide – West and East Locations

	WEST (D1-D2)	EAST (D1-D2)
HAT (m)	4.77	4.80
MHWS (m)	4.29	4.31
MHWN (m)	3.42	3.43
MSL (m)	2.56	2.57
MLWN (m)	1.69	1.70
MLWS (m)	0.82	0.83
LAT (m)	0.00	0.00
MSR (m)	3.47	3.48
MR (m)	2.60	2.61
MNR (m)	1.73	1.73
MHWI (hours)	0.98	0.85
MLWI (hours)	7.00	7.16
Maximum Positive Residual (surge) (m)	0.78	0.78
Maximum Negative Residual (surge) (m)	0.74	0.55

6.3 Current Data

Appendix C presents colour contour time series plots of current speed and direction through the water column and time series graphs of depth averaged speed, direction, easting, northing and residuals. A harmonic analysis was undertaken on the depth averaged easting and northing data from each location and the harmonic report tables are included in Appendix C. The scatter plots of observed and predicted current velocity provide an overview of the magnitude of the residual component compared to the tidal stream. No current data were available from the West Location for the Deployment Two time period; the statistics presented below are based on Deployment One data only. Data from both deployments at the East Location were first combined into one file prior to undertaking the harmonic analysis on the depth averaged values of the whole dataset.

The current velocity observed at the West Location is approximately one third of the magnitude observed at the East Location. The time series of depth averaged values at the West Location shows that a tidal signal remains in the residual velocity following the harmonic analysis. This indicates that the harmonic analysis was less successful in attributing the energy to the tidal constituents, which is to be expected from a short dataset in a shallow, confined environment. The colour contour profile plots demonstrate that the current directions are highly variable, with a poorly defined flood and ebb pattern. Occasionally (for example on the 12th March 2015), both the flood and ebb flow are in the same direction (north easterly). This corresponds with a high wave energy event, indicating that wave action entering the Bay can significantly distort the current flow throughout the whole water column.

The East Location displays a clear rectilinear tidal signal; flooding to the south and ebbing to the north. The slack water times occur approximately one hour after high and low waters. Flood and ebb are typically of equal magnitude. Some large residual velocities are also observed at the East Location, (for example the 23rd February, 9th and 11th March). Again these dates correspond to high wave energy events. A discrepancy was found in the major axis of the observed current velocity scatter between Deployments One and Two. This could be a result of a slightly different deployment location or the change in instrument deployed. A sinusoidal signal is present in the residual easting vector following harmonic analysis, which is likely to be as a result of this direction discrepancy. Scatter plots for Deployment One and Two are presented separately (Figures C026 – C027) to illustrate this error margin (approximately 15 °T) on the current directions. Table 6.4 below gives a summary of current measurement results from the AWAC at each location.

Table 6.4 Summary of Depth Averaged Current Results – West and East Locations

	WEST (D1 only)	EAST (D1 – D2)
Metonic Maximum (ms⁻¹)	0.27	1.14
MSR (ms⁻¹)	0.12	0.90
MNR (ms⁻¹)	0.09	0.44
Bearing of Tidal Current (°T)	18	174
Mean Drift (ms⁻¹)	0.03	0.05
Bearing of Mean Drift (°T)	11	108
Maximum Observed Depth Average Velocity (ms⁻¹)	0.55	1.34
Maximum Depth Averaged Residual Velocity (ms⁻¹)	0.34	0.56

6.4 Turbidity

An Aqualogger 210 Optical Backscatter Sensor was installed on each seabed frame in order to measure turbidity near the seabed. In conjunction, the acoustic backscatter observations collected by the AWAC were utilised to examine turbidity variations throughout the water column. Water samples were collected during the deployment, maintenance and recovery visits using a Niskin water sampler in order to obtain direct observations of Total Suspended Solids Concentration. These concentration values were used to “calibrate” the turbidity measurements (convert them to estimated concentration values in mg l^{-1}). Further details of the calibrations can be found in paragraph 5.4 above. The regressions created for the OBS data using only the site-specific water sample results were of acceptable quality. Where the scatter of values is insufficient to create a reasonable site-specific regression, Fugro EMU’s approach is to examine the site specific data alongside historical data from other locations. This was the approach taken for the ABS data.

There is a poor level of agreement between the results derived from the OBS and ABS. OBS-derived suspended sediment concentrations reach 899 mg l^{-1} at the West Location, in comparison to a maximum of 126 mg l^{-1} as derived from the near-seabed bin of the ABS profile. The different measurement techniques respond differently to any given sediment type; OBS responds more strongly to fine sediment sizes and ABS more strongly to coarser sediment sizes. A regression with a slope (multiplier) less than 1 was established for the West Location OBS data suggesting that the sediment type induced a strong response from the OBS sensor and is therefore likely to be very fine. Some fine sediment was noted to be present on the recovered seabed frame from this location. Laser Diffraction analysis was undertaken on one of the water samples from each location collected on the recovery visit, in order to further investigate the reason for the disparity between the OBS and ABS measurement techniques. The results were flagged with a low confidence level, on account of very low concentrations of suspended sediment in the samples. However, the D_{50} (median grain size) was $27 \mu\text{m}$ and $22 \mu\text{m}$ at the West and East Locations respectively which supports the hypothesis that the suspended sediment is too fine to be quantified using acoustic techniques.

A time series of OBS-derived and ABS-derived suspended sediment concentration data from near the seabed is provided in Appendix D. The data are presented alongside wave height, wave period and current speed data in order to facilitate comparison with possible forcing factors. Reasonable correlation is seen between suspended sediment concentration and wave height. However, there are also instances of high turbidity events at the West Location which occur during calm sea state conditions (e.g. 24th May 2015). This suggests that there are likely to be additional influences on turbidity such as fresh water run-off or outfall discharge. A colour contour plot of ABS-derived concentration throughout the water column is also provided in Appendix D.

Table 6.5 Summary of Suspended Sediment Concentration Results – West and East Locations

		West	East
OBS- Derived Suspended Sediment concentration (mg l⁻¹) (West D1 – D2) (East D1 – D2)	Minimum	5	7
	Mean	144	24
	Maximum	899	529
	Standard Deviation	174	31
ABS-Derived Suspended Sediment Concentration (mg l⁻¹) - Bin 1 (Near-seabed) (West D1 only) (East D1 – D2)	Minimum	3	4
	Mean	18	25
	Maximum	126	82
	Standard Deviation	7	16

6.5 Near-Seabed Salinity, Dissolved Oxygen and Temperature

An AADI Seaguard instrument was installed on each seabed frame in order to provide observations of salinity, dissolved oxygen and temperature near the seabed.

Near seabed salinity values show a high level of variability at the West Location. Here, a possible low salinity event was observed between the 11th and 18th March 2015. Salinity decreased from 35 ppt to less than 20 ppt and remained between 15 and 20 ppt for most of this period. This could be the result of a storm discharge from the sewage outfall at Girdle Ness; the 11th March is characterised by storm conditions and rainfall intensity reached 15 mmhr⁻¹. However, there is insufficient evidence currently available to confirm this and these data should be regarded as suspect. Fugro EMU recommend that the salinity data are examined further in conjunction with information on fresh water inputs if available. Some variability is also seen at the East Location with salinity levels dropping to a minimum of 23.8 ppt.

Average dissolved oxygen levels are similar at the two locations, though the West Location shows greater variability. Since oxygen solubility decreases with salinity, a greater level of variability is to be expected at the West Location. It must be noted that a proportion of the Seaguard data from the West Location was discarded during the quality control process. Due to the incorrect orientation of the seabed frame, it is possible that the Seaguard sensors were covered with seabed sediment at times. As such, the Deployment Two data from the West Location should be considered to have a lower confidence level associated with them. The following tables provide summary statistics for the two Seaguard datasets.

Table 6.6 Summary of Salinity, Dissolved Oxygen and Temperature Results – West Location (D1-D2)

	Minimum	Mean	Maximum	Standard Deviation
Salinity (ppt)	15.1	32.3	35.1	4.7
Dissolved Oxygen (% Saturation)	55.6	85.9	100.2	4.5
Dissolved Oxygen (mg l⁻¹)	5.4	8.4	10.6	0.6
Temperature (°C)	5.7	6.9	9.5	0.9

Table 6.7 Summary of Salinity, Dissolved Oxygen and Temperature Results – East Location (D1-D2)

	Minimum	Mean	Maximum	Standard Deviation
Salinity (ppt)	23.8	34.2	35.1	1.3
Dissolved Oxygen (% Saturation)	57.1	87.5	103.0	3.7
Dissolved Oxygen (mg l⁻¹)	5.4	8.4	9.7	0.4
Temperature (°C)	5.8	7.3	9.9	1.1

6.6 Water Quality Profiles

Vertical profiles of water quality parameters were collected during the deployment, service and recovery visits using an Idronaut multiparameter probe. All vertical profile graphs (presented in Appendix F) for the West Location show a large degree of vertical mixing. The profile collected at the East Location on the 6th April 2015 shows slightly lower salinity in the upper 4 m of the water column. On the 11th June 2015, a salinity minimum of 32 ppt and a temperature maximum of 10.7°C were seen at the surface at the East Location.

6.7 Meteorology

A time series of meteorological measurements, a wind rose diagram and a frequency distribution of wind speed against direction are presented in Appendix G. The most common wind direction is south westerly, in agreement with the dominant wind direction across the U.K. The fastest wind speeds were observed to approach from the south west and the south. Table 6.8 below presents summary statistics for the meteorological dataset.

Table 6.8 Meteorological Data Summary

	Minimum	Mean	Maximum	Standard Deviation
Wind Speed (ms ⁻¹)	0.0	4.5	15.3	2.3
Gust Speed (ms ⁻¹)	0.0	6.2	20.3	3.1
Air Temperature (°C)	-1.0	7.6	16.9	2.9
Air Pressure (mbar)	964	1011	1037	14
Relative Humidity (%)	34	72	95	13
Rainfall Intensity (mmhr ⁻¹)	0.0	0.1	43	0.8
Most Frequently Occurring Wind Direction (°T)	240-250			
Wind Direction Band Accounting for 68% of Readings (°T)	160 -290			
Wind Direction Bands Associated with Fastest Wind Speeds (°T)	160-170 and 270-280			



7. HEALTH AND SAFETY SUMMARY

Fugro EMU is committed to achieving and maintaining excellence in all aspects of its operations and has fully assessed, recognised and accepted a mandate to conduct all company activities in a safe and responsible manner. The company provides, and will continue to provide, a system of work which protects the health and safety of its own employees, visitors, contractors and the public; and at the same time minimises the impact of its activities on the environment.

Fugro EMU has invested in the promotion and development of a culture of safety and environmental awareness throughout the company. All individuals within the company are aware of their responsibilities and are provided with sufficient and correct resources to enable safe working practices. To achieve excellence in the business and work environment, the commitment and co-operation of all management, staff, contractors and visitors is essential.

During operations carried out:

- All fieldwork was undertaken under suitable weather conditions
- All relevant authorities were notified of our survey intentions aboard the deployment vessel

Fugro EMU operates a stringent Health and Safety Policy. A component part of this policy is to prepare a Project Safety Plan document for all fieldwork-based projects. This identifies all possible risks to personnel and property, whilst also providing lists of key personnel contact numbers. A copy of the document prepared for this project was read and carried by all Fugro EMU personnel involved and made available to all members of the vessel crew.

7.1 HSE Procedure during Operations

A pre-work safety briefing was held on the vessel with all crew members present. The brief was carried out by the Fugro EMU Survey Supervisor to discuss the intended deployment methods, location, and monitoring system configuration, as well as health, safety and risk considerations. All attendees of this briefing were recorded on the Pre-Job Health and Safety briefing. In addition, a vessel crew member conducted a vessel safety briefing, which identified the location of emergency and survival equipment to the survey team.

Table 7.1 Project Health and Safety Summary

Number of safety briefings and toolbox talks to date	7
Number of near misses/hazard observations to date	0
Number of incidents to date	0

8. CONCLUSION

High quality data were collected at both the West and East Locations and the meteorological station for the duration of Deployment One. During Deployment Two, high quality data were collected for all parameters at the East Location and the meteorological station. However, the seabed frame at the West Location was outside of the acceptable tilt range resulting in invalid current, AST wave and acoustic backscatter data. Some data from the Seaguard sensors were also rejected during quality control. It is possible that the sensors were covered with sediment during times due to the incorrect orientation of the seabed frame. Non-directional wave parameters from the West Location were derived using pressure signal processing techniques.

In total, eight spring tide and neap tide events were observed during the monitoring period which spanned late February to early June 2015. A range of sea state conditions were captured; from 0.1 m H_s to 3.2 m H_s /4.8 m H_{max} at the West Location and 4.0 m H_s /6.7 m H_{max} at the East Location.

Suspended sediment concentration estimates as derived from optical backscatter measurements reached up to 899 $mg\ l^{-1}$ at the West Location and 529 $mg\ l^{-1}$ at the East Location. These high concentrations are in poor agreement with the acoustic backscatter derived results from the near seabed bin of the AWAC profile. This suggests that the sediment type in suspension is very fine and is incompatible with acoustic measurements. In order to further investigate this, Laser Diffraction analysis was conducted on one of the water samples collected at each location on the final field visit. The D_{50} result was 27 μm and 22 μm at the West and East Locations respectively which supports the hypothesis that the suspended sediment is too fine to be quantified using acoustic techniques.

Most high turbidity events were seen to correspond with elevated wave height conditions, however instances of high turbidity at times of calm sea state were also observed. In addition, there is insufficient information to explain the low salinity events which were observed. As such, Fugro EMU suggest that further investigation is required into the effects of waste water discharge on the study area and other fresh water and sediment inputs.

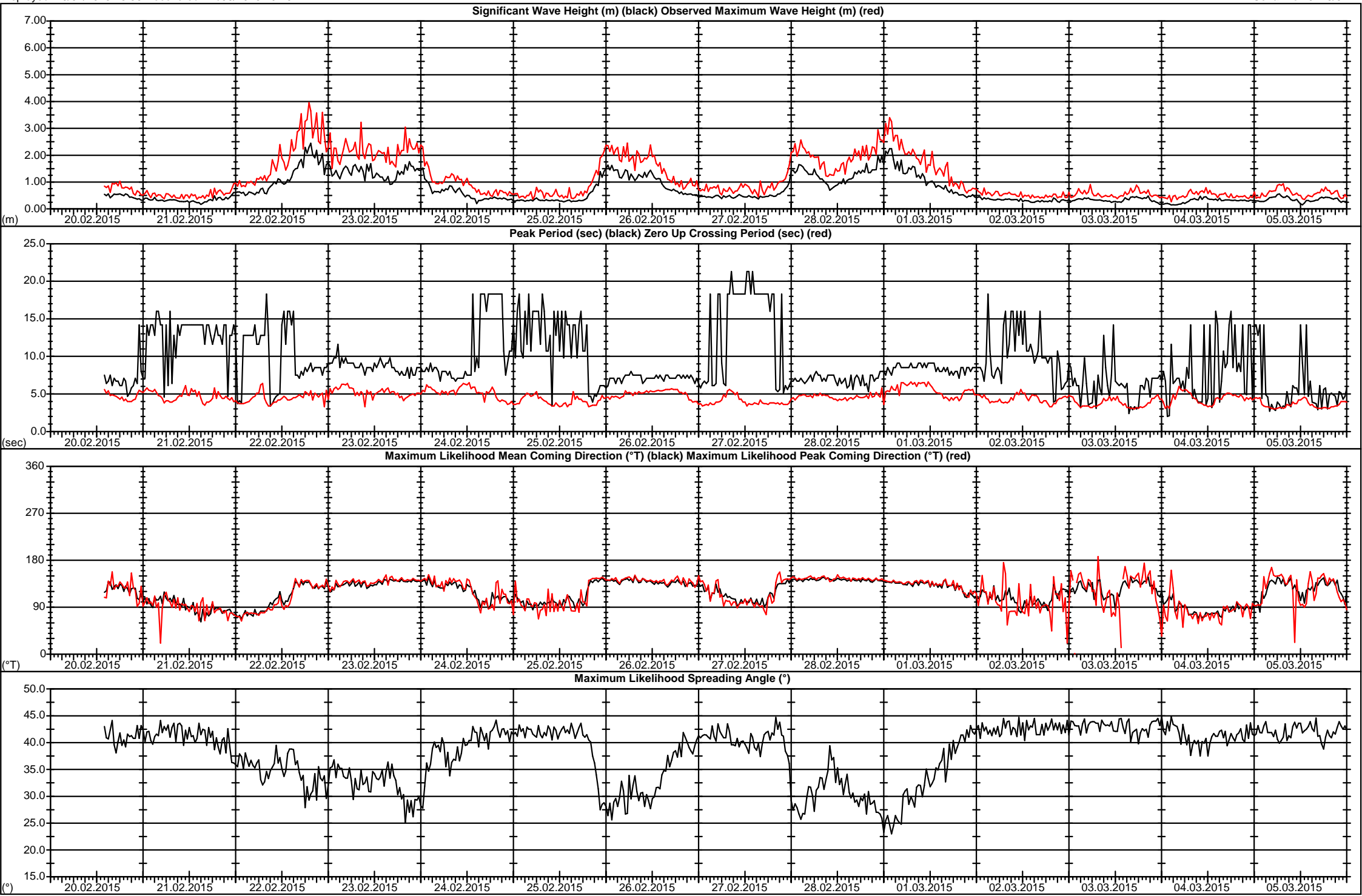
**APPENDIX A
WAVE DATA PRESENTATION**

CONTENTS

Figure or Table Number	Location	Data Presentation Type	Description
Figure A001 – A008	West	Time Series	H_s , H_{max} , T_p , T_z , Mean and Peak Wave Direction, Spreading Angle
Figure A009	West	Hodogram (Rose Diagram)	Percentage occurrence of H_s for every 5° bin of wave direction
Figure A010 – A013	West	Wave Spectral Time Series	Wave Spectral Energy against Period and Period against Direction
Table A001	West	Frequency Distribution Table	H_s against Mean Wave Direction
Table A002	West	Frequency Distribution Table	T_z against Mean Wave Direction
Table A003	West	Frequency Distribution Table	H_s against T_z
Figure A014 – A021	East	Time Series	H_s , H_{max} , T_p , T_z , Mean and Peak Wave Direction, Spreading Angle
Figure A022	East	Hodogram (Rose Diagram)	Percentage occurrence of H_s for every 5° bin of wave direction
Figure A023 – A031	East	Wave Spectral Time Series	Wave Spectral Energy against Period and Period against Direction
Table A004	East	Frequency Distribution Table	H_s against Mean Wave Direction
Table A005	East	Frequency Distribution Table	T_z against Mean Wave Direction
Table A006	East	Frequency Distribution Table	H_s against T_z
Figure A032	West	Regressions	Pressure-based against AST wave statistic regressions

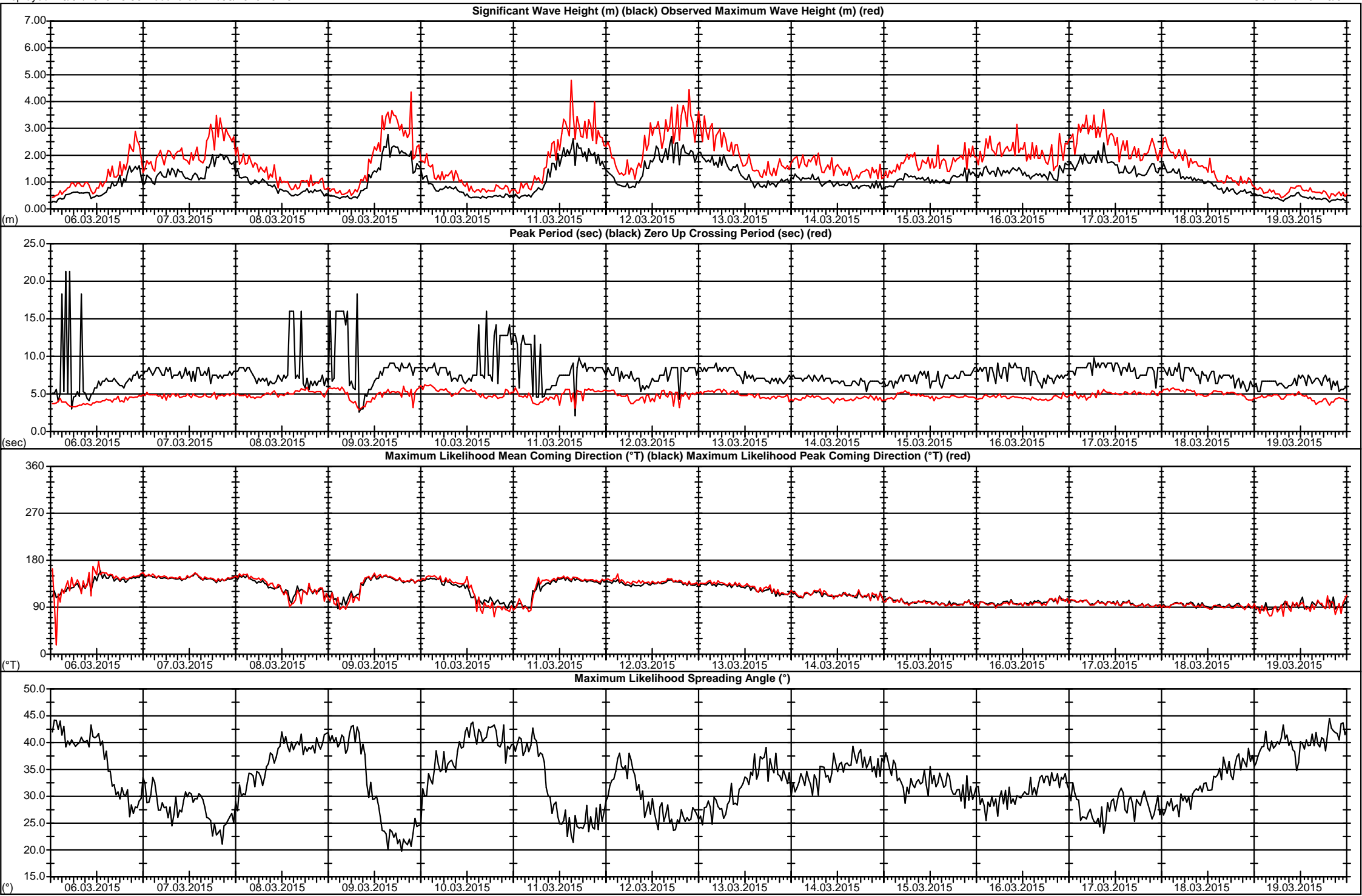
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Deployed: 20/02/2015 13:36 Recovered: 11/06/2015 10:46

Current Meter / AWAC
Serial No.: 5115/5112



D1 Latitude: 57°07'59.64"N D1 Longitude: 002°02'57.60"W, D2 Latitude: 57°08'0.96"N Longitude: 002°02'59.76"W D1 Site depth below LAT: 5.75m D2 Site depth below LAT: 6.16m Instrument height off seabed: 0.68m
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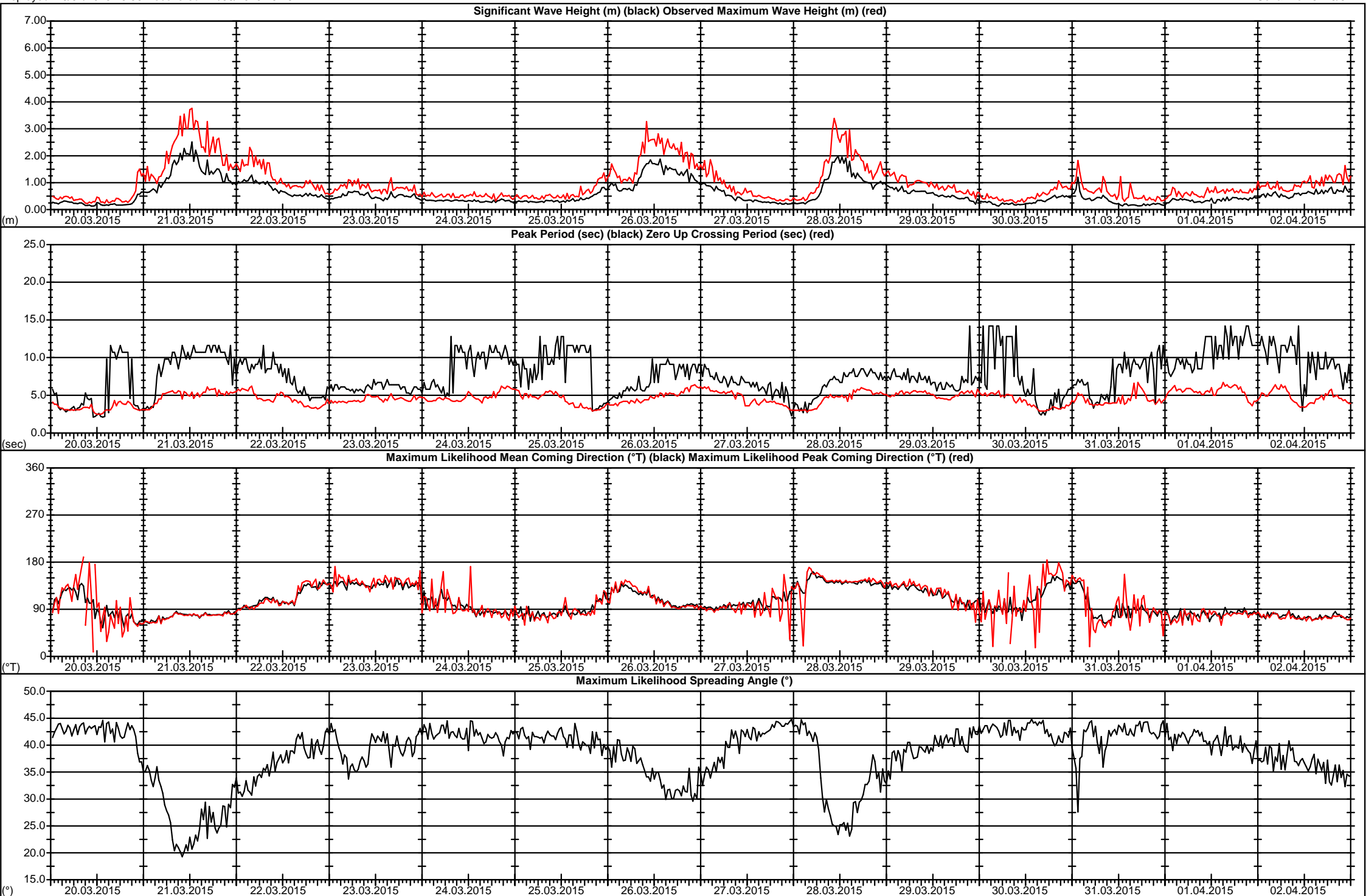
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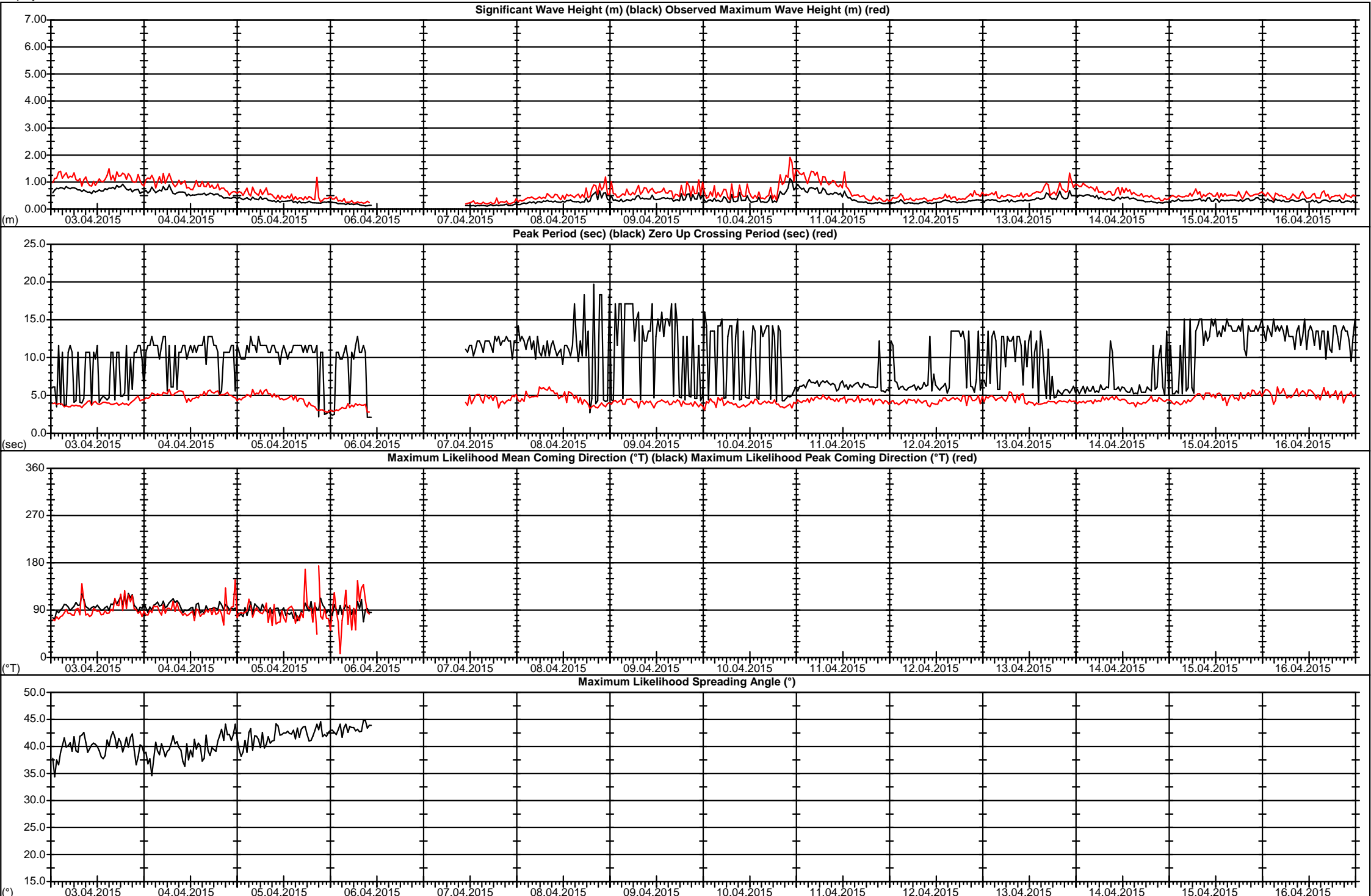
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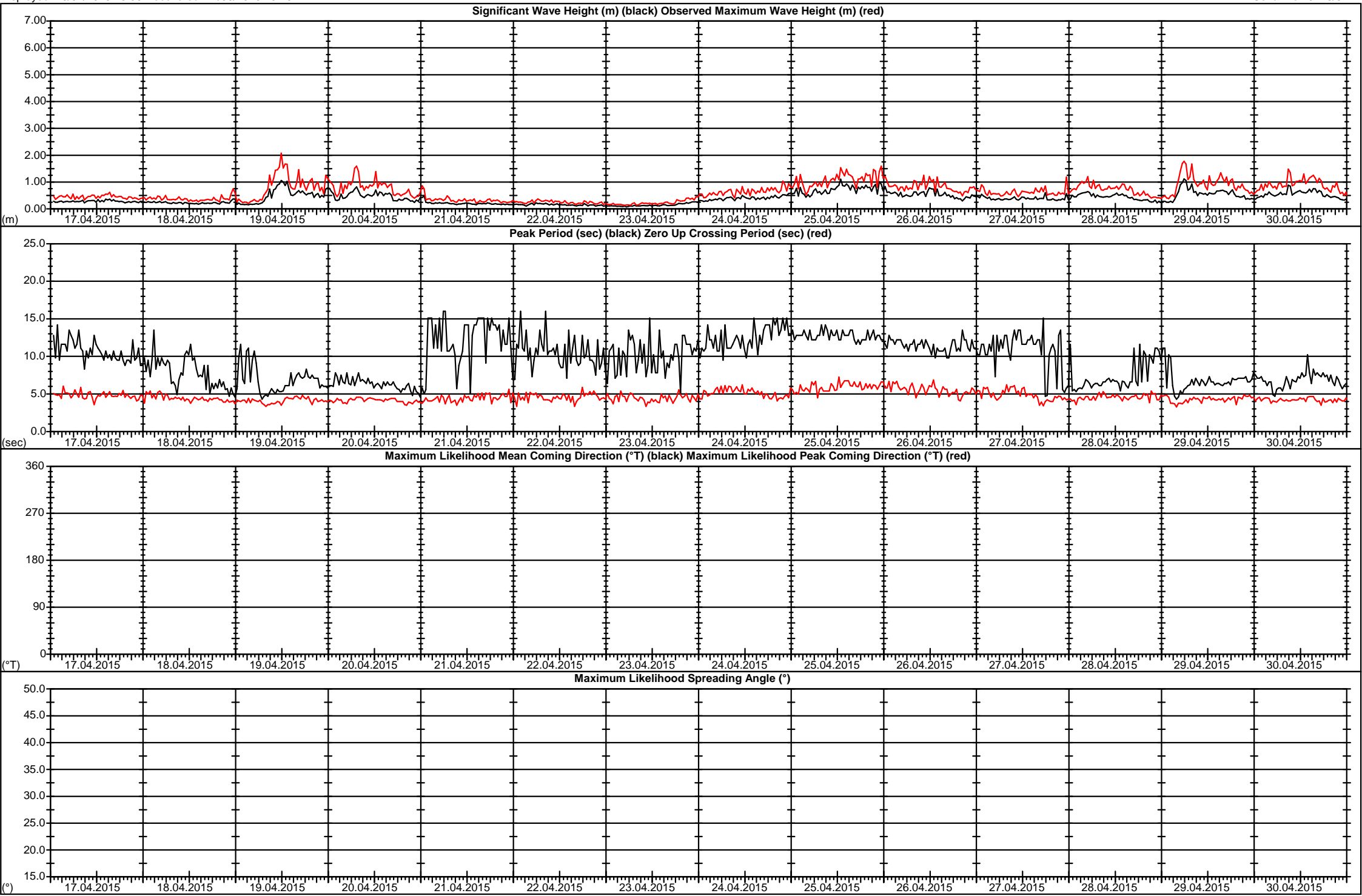
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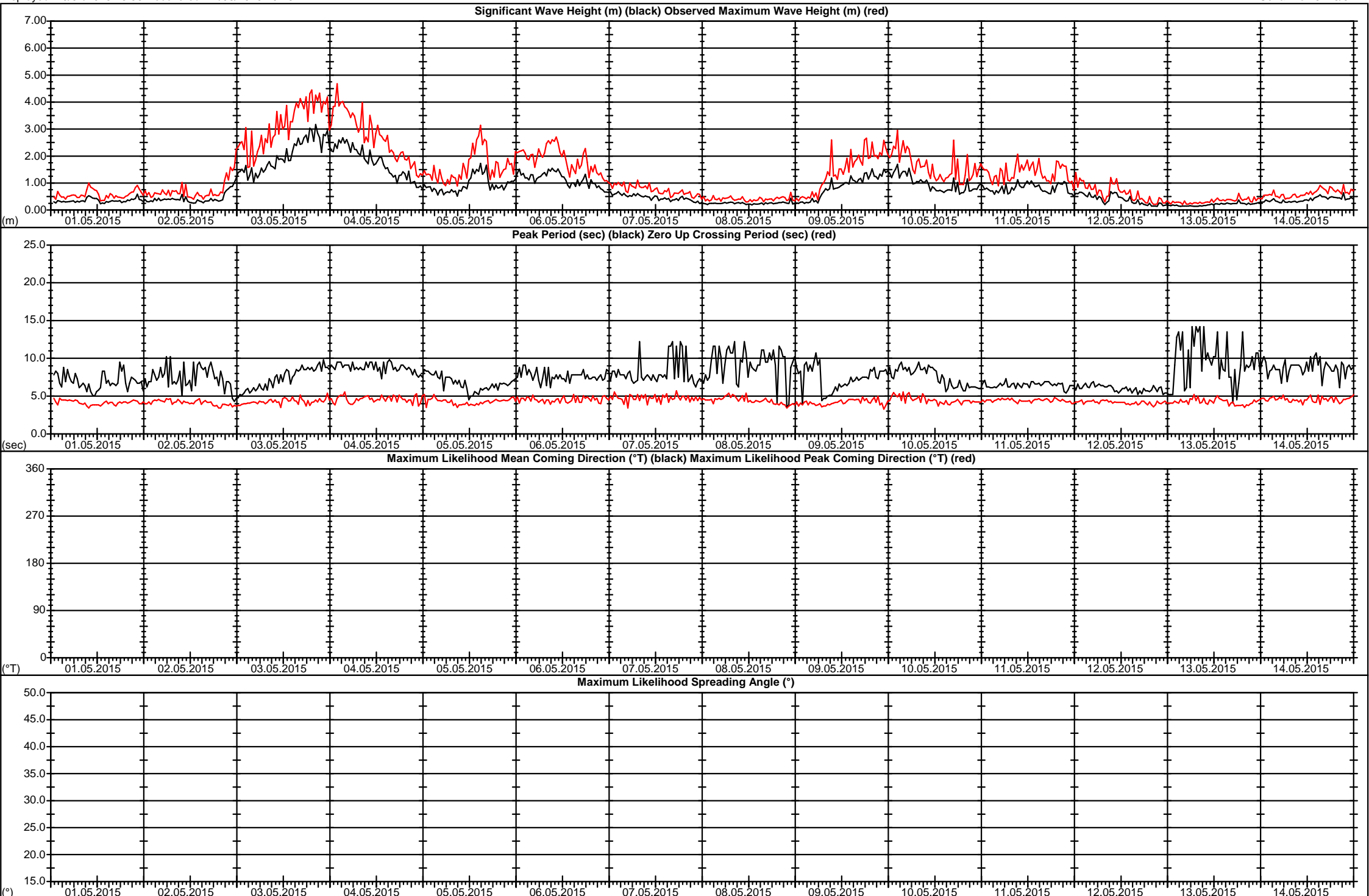
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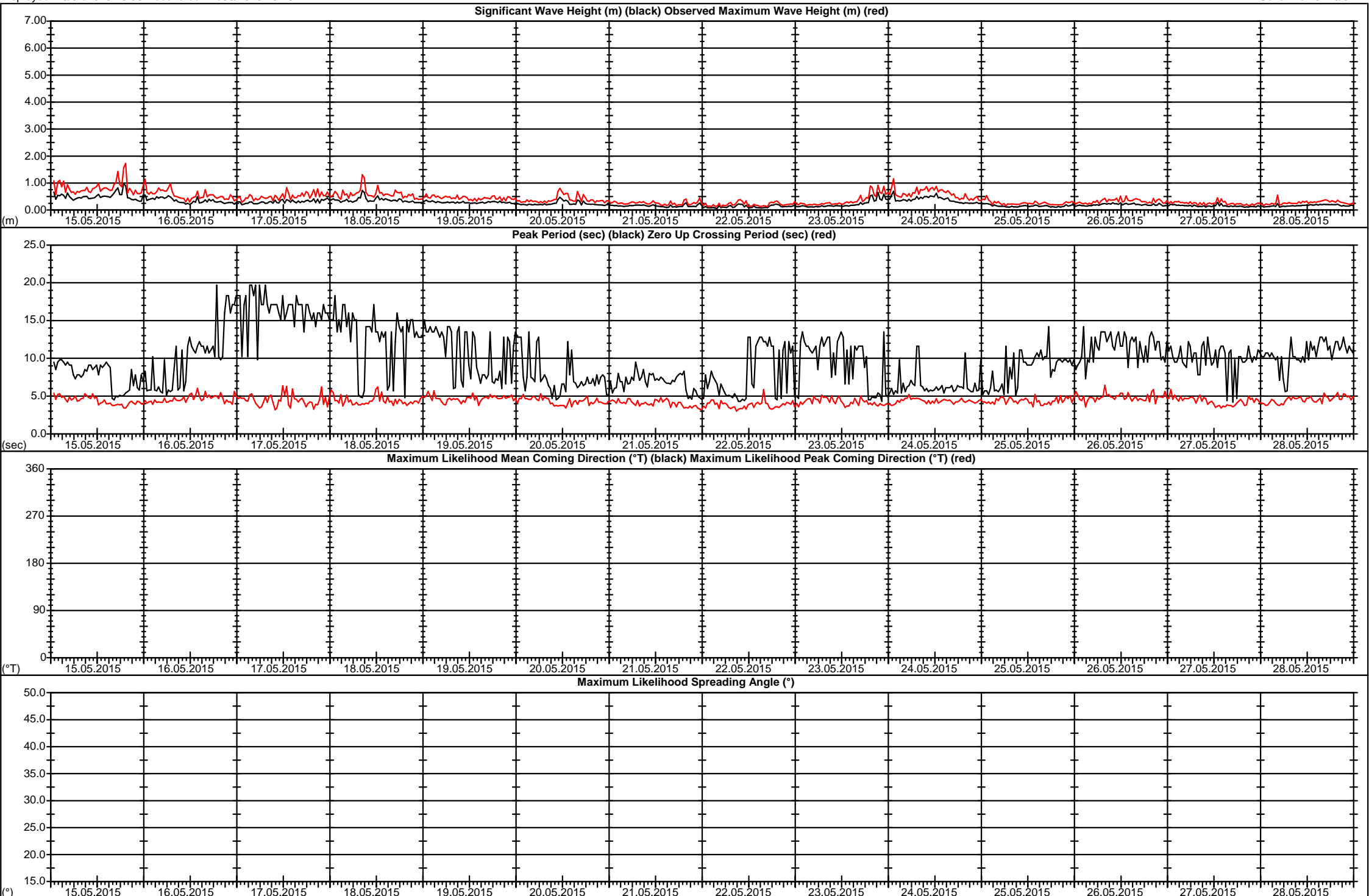
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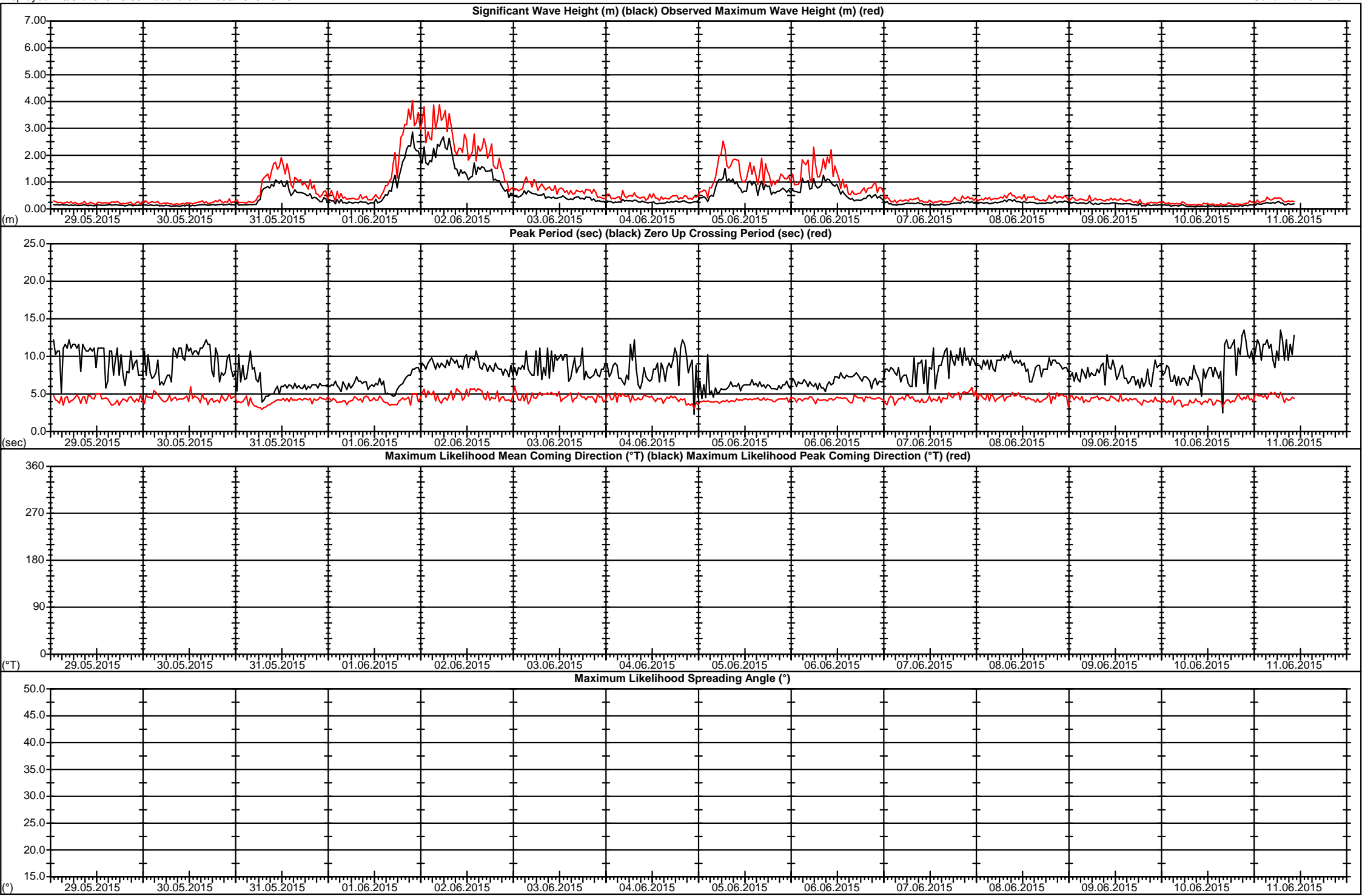
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Wave Data Time Series Aberdeen Harbour Expansion EIA, West, D1 - D2

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Deployed: 20/02/2015 13:36 Recovered: 11/06/2015 10:46

Current Meter / AWAC
Serial No.: 5115/5112



Wave Data Hodogram (Rose Diagram) Aberdeen Harbour Expansion EIA, West, D1

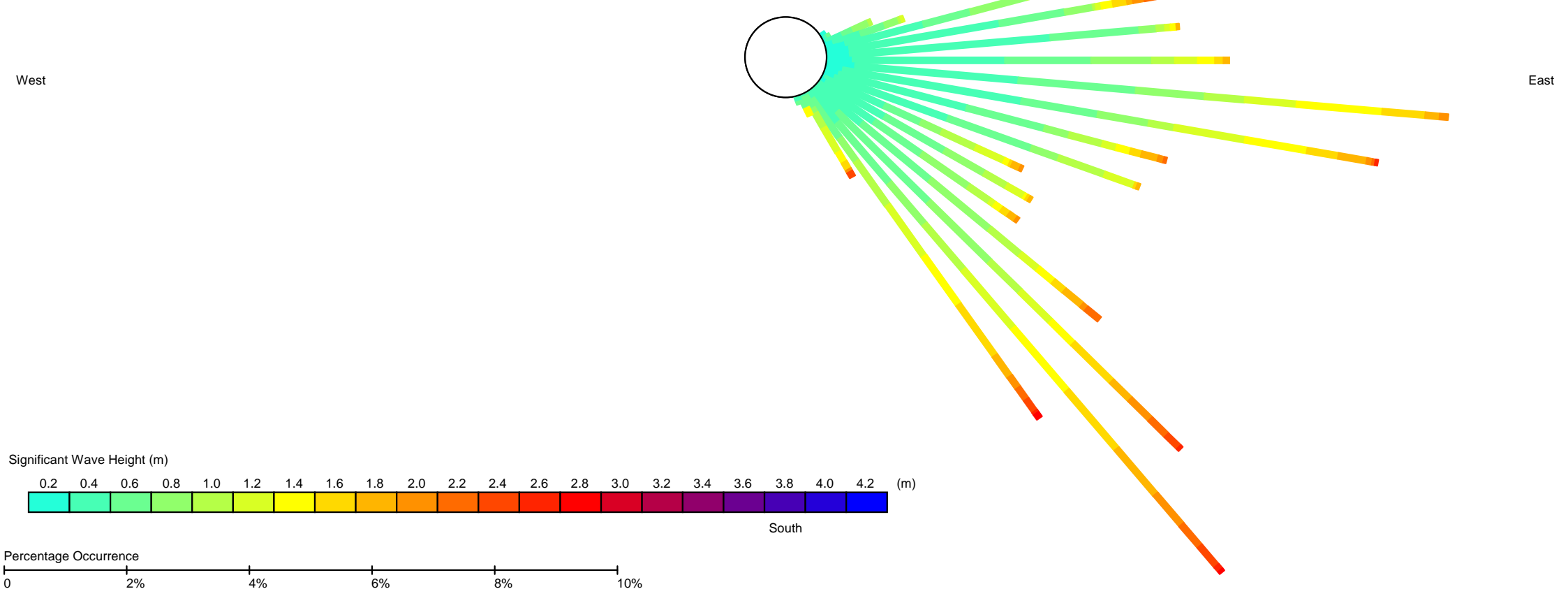
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Current Meter / AWAC

Deployed: 20/02/2015 13:36 Recovered: 06/04/2015 10:30

Serial No.: 5115

Maximum Likelihood Mean Coming Direction (°T)
True North

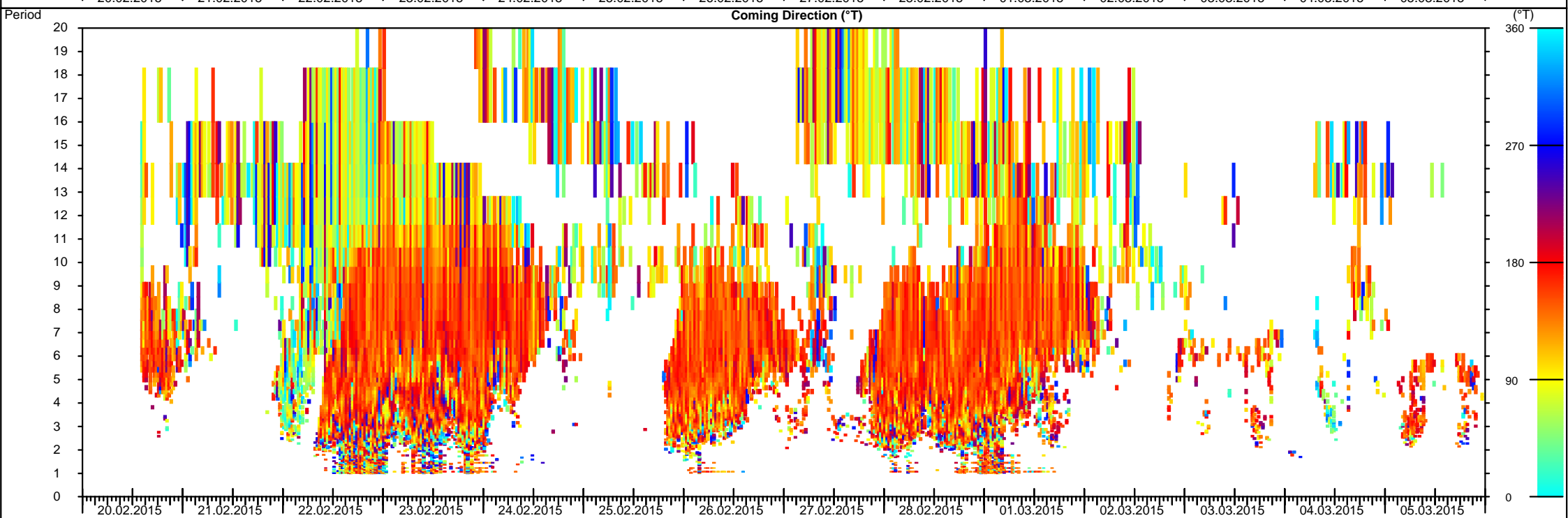
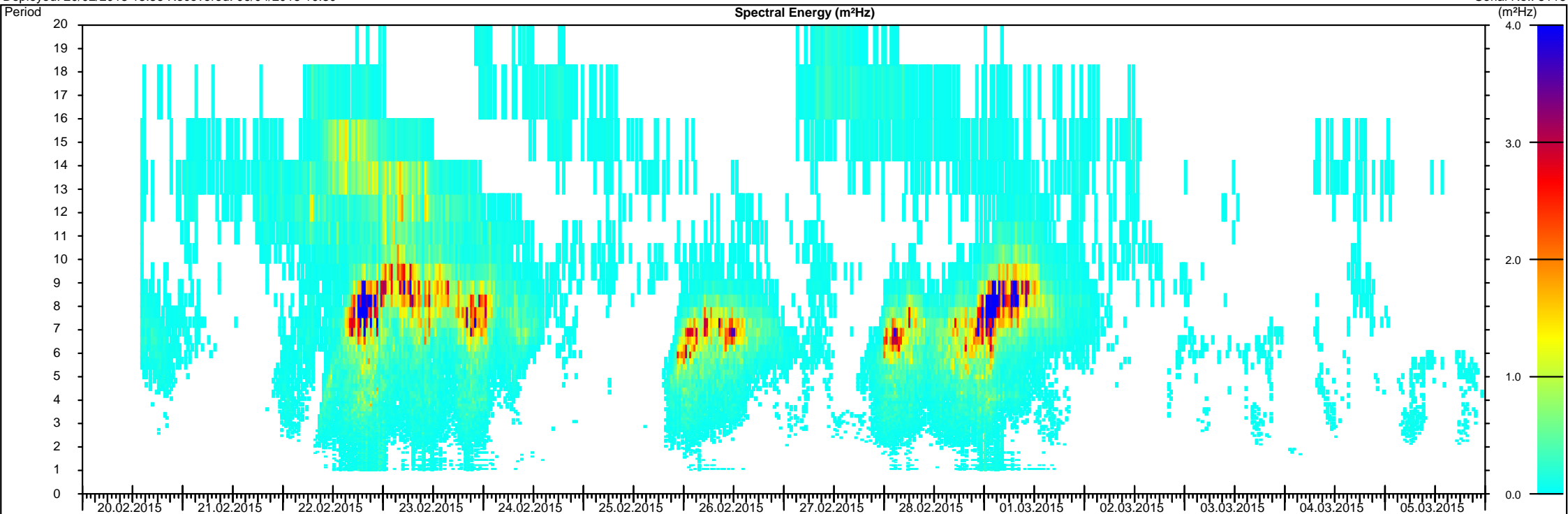


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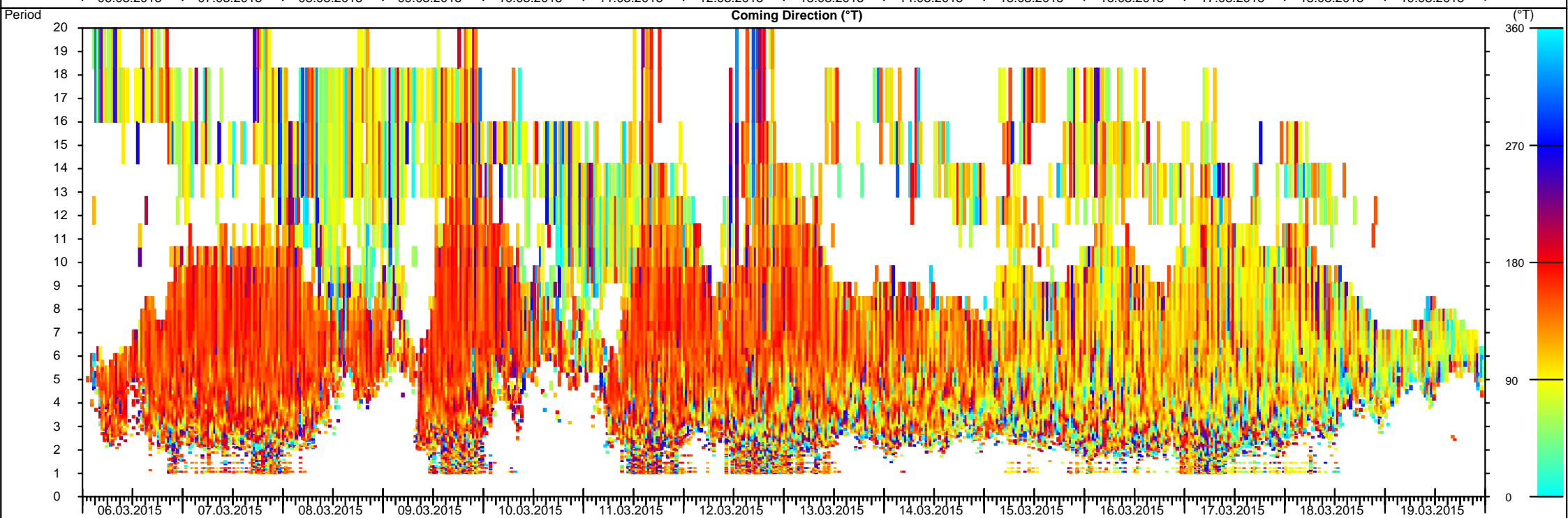
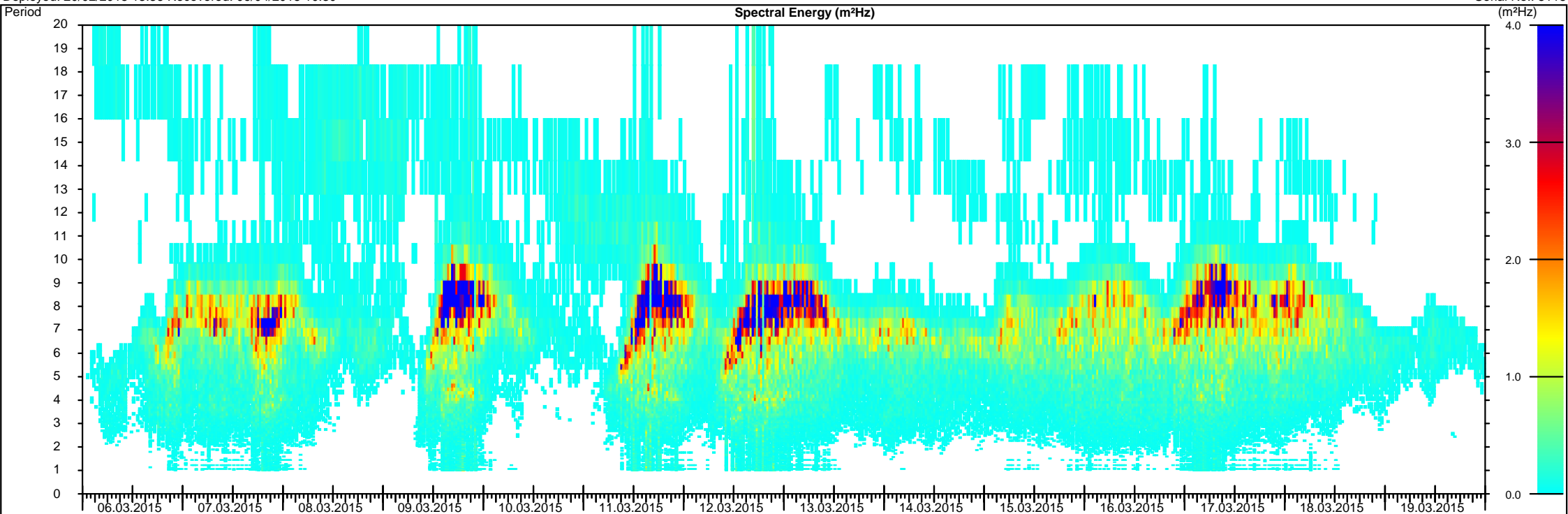


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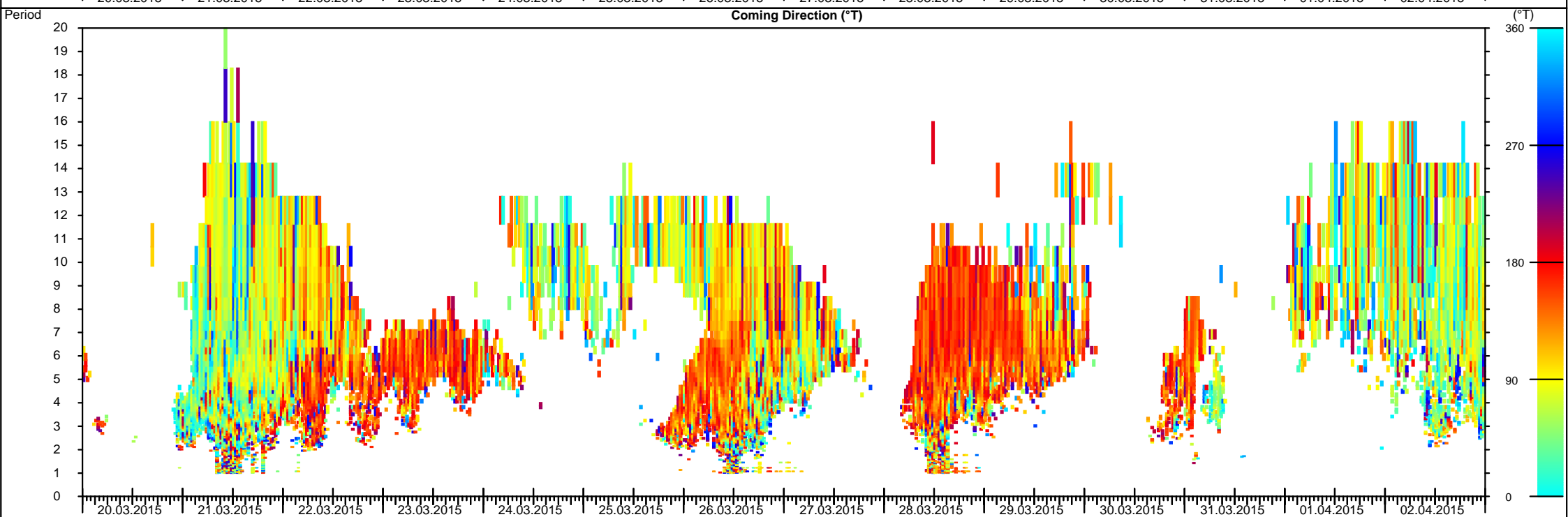
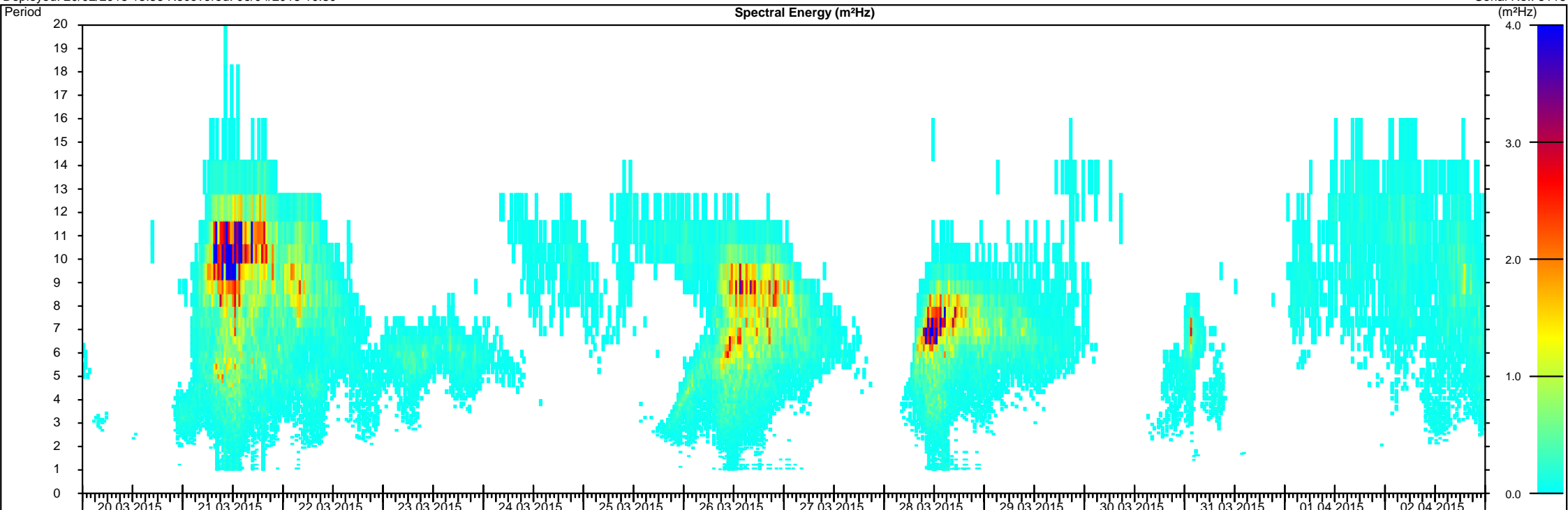


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Current Meter / AWAC

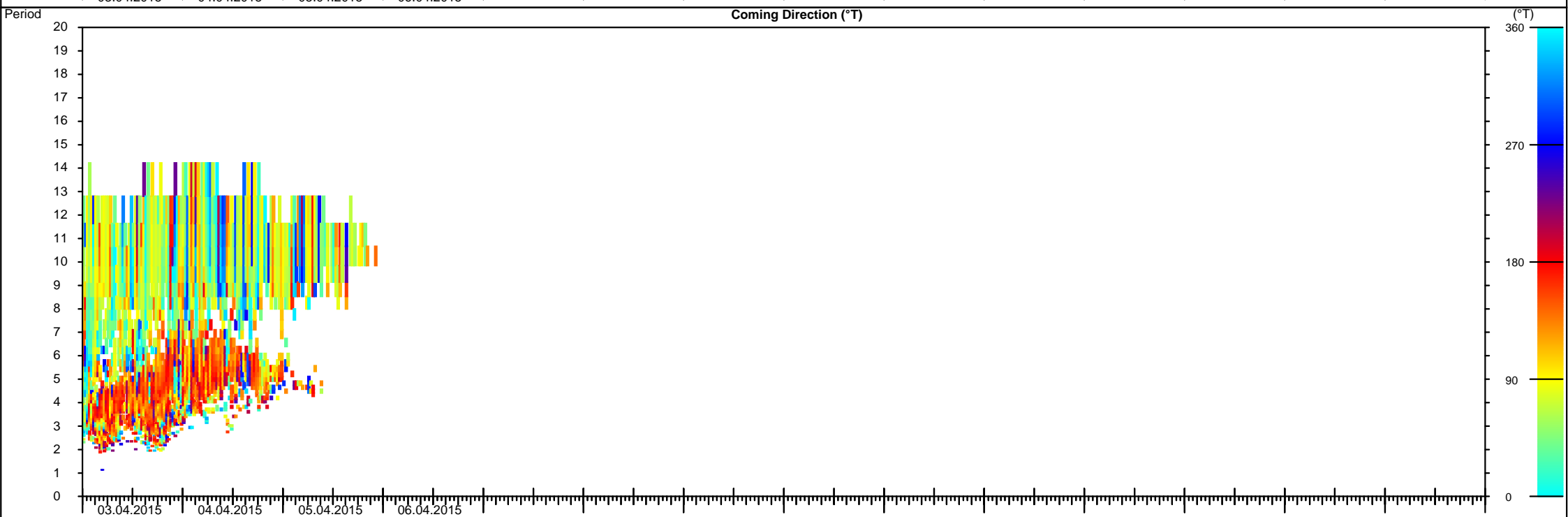
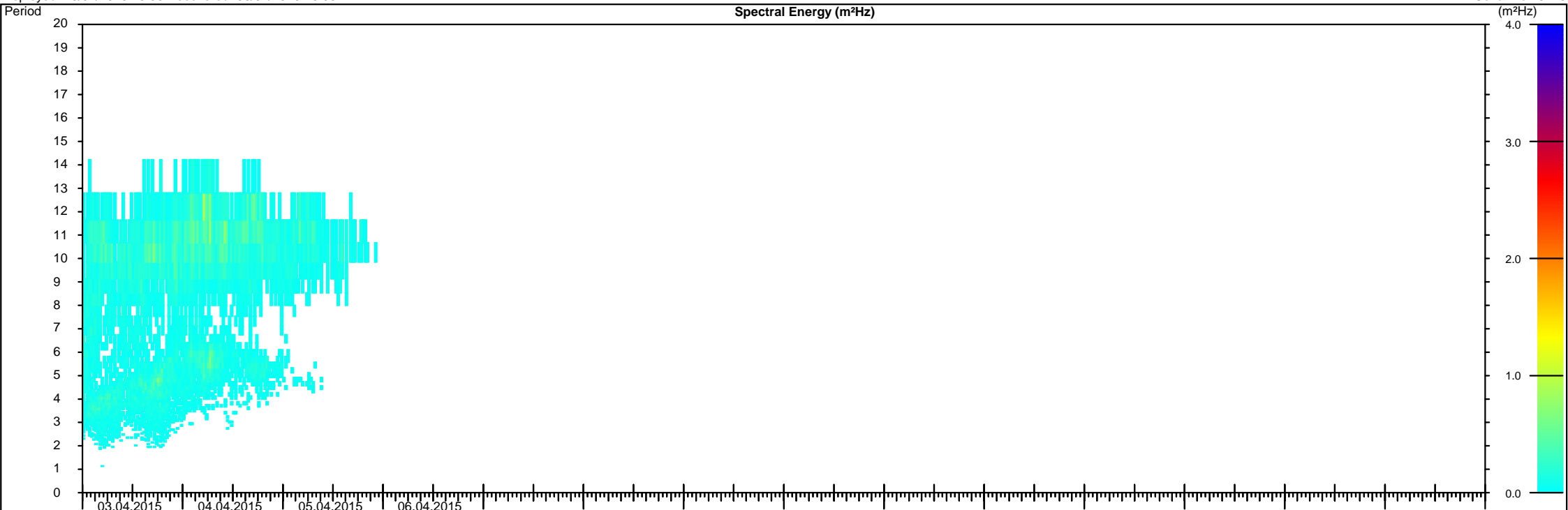
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Serial No.: 5115



Latitude: 57°07'59.64"N Longitude: 002°02'57.60"W Site depth below LAT: 5.75m Instrument height off seabed: 0.68m
Deployed: 20/02/2015 13:36 Recovered: 06/04/2015 10:30

Current Meter / AWAC
Serial No.: 5115



Wave Data Frequency Table

Aberdeen Harbour Expansion EIA, West, D1

Latitude: 57°07'59.64"N Longitude: 002°02'57.60"W Site depth below LAT: 5.75m Instrument height off seabed: 0.68m
 Deployed: 20/02/2015 13:36 Recovered: 06/04/2015 10:30

Current Meter / AWAC
 Serial No.: 5115

Frequency Distribution of Significant Wave Height (m) against Maximum Likelihood Mean Coming Direction (°T)

	<0.2	<0.4	<0.6	<0.8	<1	<1.2	<1.4	<1.6	<1.8	<2	<2.2	<2.4	<2.6	<2.8	<3	Count	%
<10																0	0.000
<20																0	0.000
<30																0	0.000
<40																0	0.000
<50																0	0.000
<60	2															2	0.093
<70	4	12	7	10	1											34	1.579
<80	10	54	33	26	4	4	4	6	1	2	2	1	1			148	6.874
<90	24	133	56	22	5	4	3	1	3	2	2	1				256	11.890
<100	25	116	72	43	24	39	50	24	9	4			1			407	18.904
<110	10	94	60	25	26	21	13	9	14	3	2					277	12.866
<120	6	56	37	15	28	22	2	2	5	1						174	8.082
<130	1	50	47	42	18	6	6	7	7	1	3					188	8.732
<140		32	80	59	36	31	28	36	23	18	17	10	3			373	17.325
<150		11	33	17	30	46	40	35	20	14	9	12	1	3		271	12.587
<160		2	6	2	3	3	5	1								22	1.022
<170		1														1	0.046
<180																0	0.000
<190																0	0.000
<200																0	0.000
<210																0	0.000
<220																0	0.000
<230																0	0.000
<240																0	0.000
<250																0	0.000
<260																0	0.000
<270																0	0.000
<280																0	0.000
<290																0	0.000
<300																0	0.000
<310																0	0.000
<320																0	0.000
<330																0	0.000
<340																0	0.000
<350																0	0.000
<360																0	0.000
Count	82	561	431	261	175	176	151	121	82	45	35	24	6	3	0	2153	
%	3.809	26.057	20.019	12.123	8.128	8.175	7.013	5.620	3.809	2.090	1.626	1.115	0.279	0.139	0.000	100	
100.0	96.2	70.1	50.1	38.0	29.9	21.7	14.7	9.1	5.2	3.2	1.5	0.4	0.1	0.0	0.0		% Exceedence

Frequency Table

Aberdeen Harbour Expansion EIA, West, D1

Latitude: 57°07'59.64"N Longitude: 002°02'57.60"W Site depth below LAT: 5.75m Instrument height off seabed: 0.68m
 Deployed: 20/02/2015 13:36 Recovered: 06/04/2015 10:30

Current Meter / AWAC
 Serial No.: 5115

Frequency Distribution of Zero Up Crossing Period (sec) against Maximum Likelihood Mean Coming Direction (°T)

	<1	<2	<3	<4	<5	<6	<7	<8	<9	<10	Count	%
<10											0	0.000
<20											0	0.000
<30											0	0.000
<40											0	0.000
<50											0	0.000
<60			1	1							2	0.093
<70			2	23	4	5					34	1.579
<80			3	43	50	47	5				148	6.874
<90			7	33	119	83	14				256	11.890
<100			6	62	205	124	10				407	18.904
<110			3	75	135	63	1				277	12.866
<120			2	47	102	23					174	8.082
<130			5	68	64	46	5				188	8.732
<140			9	81	139	123	21				373	17.325
<150			4	41	148	74	4				271	12.587
<160			1	8	12	1					22	1.022
<170				1							1	0.046
<180											0	0.000
<190											0	0.000
<200											0	0.000
<210											0	0.000
<220											0	0.000
<230											0	0.000
<240											0	0.000
<250											0	0.000
<260											0	0.000
<270											0	0.000
<280											0	0.000
<290											0	0.000
<300											0	0.000
<310											0	0.000
<320											0	0.000
<330											0	0.000
<340											0	0.000
<350											0	0.000
<360											0	0.000
Count	0	0	43	483	978	589	60	0	0	0	2153	
%	0.000	0.000	1.997	22.434	45.425	27.357	2.787	0.000	0.000	0.000	100	
100.0	100.0	100.0	98.0	75.6	30.1	2.8	0.0	0.0	0.0	0.0	% Exceedence	

Frequency Table

Aberdeen Harbour Expansion EIA, West, D1 - D2

D1: 57°07'59.64"N, 002°02'57.60"W D2: 57°08'0.96"N, 002°02'59.76"W D1 Site depth below LAT: 5.75m D2 Site depth below LAT: 6.16m
 Deployed: 20/02/2015 13:36 Recovered: 11/06/2015 10:46 Instrument height off seabed: 0.68m

Current Meter / AWAC
 Serial No.: 5115/5112

Frequency Distribution of Significant Wave Height (m) against Zero Up Crossing Period (sec)

	<0.2	<0.4	<0.6	<0.8	<1	<1.2	<1.4	<1.6	<1.8	<2	<2.2	<2.4	<2.6	<2.8	<3	<3.2	<3.4	<3.6	<3.8	<4	Count	%	
<1																						0	0.000
<2																						0	0.000
<3	9	26	8	1																		44	0.834
<4	233	454	249	132	48	23	13	10	6	3	2	2	3	2			1					1181	22.397
<5	500	1037	477	238	174	176	123	91	59	36	20	20	8	7	2	1						2969	56.306
<6	57	283	180	112	55	61	57	53	35	20	22	20	9	4	2							970	18.396
<7	3	20	22	18	16	7	11	8	1	2												108	2.048
<8					1																	1	0.019
<9																						0	0.000
<10																						0	0.000
Count	802	1820	936	501	294	267	204	162	101	61	44	42	20	13	4	2	0	0	0	0		5273	100
%	15.210	34.515	17.751	9.501	5.576	5.064	3.869	3.072	1.915	1.157	0.834	0.797	0.379	0.247	0.076	0.038	0.000	0.000	0.000	0.000		100	
100.0	84.8	50.3	32.5	23.0	17.4	12.4	8.5	5.4	3.5	2.4	1.5	0.7	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0		% Exceedence	

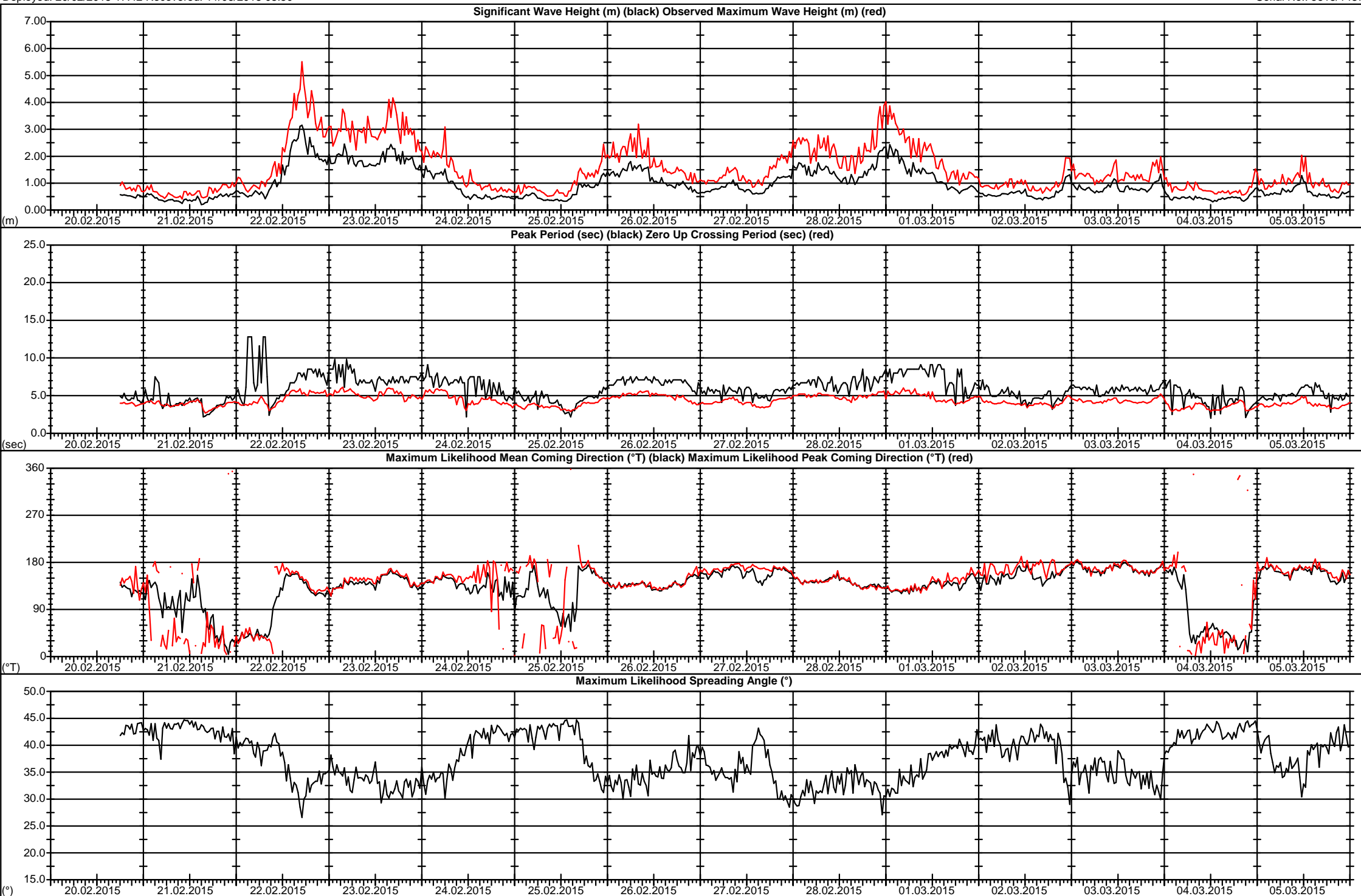
Aberdeen Harbour Expansion EIA, East, D1 - D2

D1 Latitude: 57°08'0.84"N D1 Longitude: 002°02'8.10"W D2 Latitude: 57°08'0.72"N D2 Longitude: 002°02'8.28"W D1 Site depth below LAT: 18.15m D2 Site depth below LAT: 19.06m Instrument height off seabed: 0.66m

Current Meter / AWAC

Deployed: 20/02/2015 17:42 Recovered: 11/06/2015 08:50

Serial No.: 5615/1487



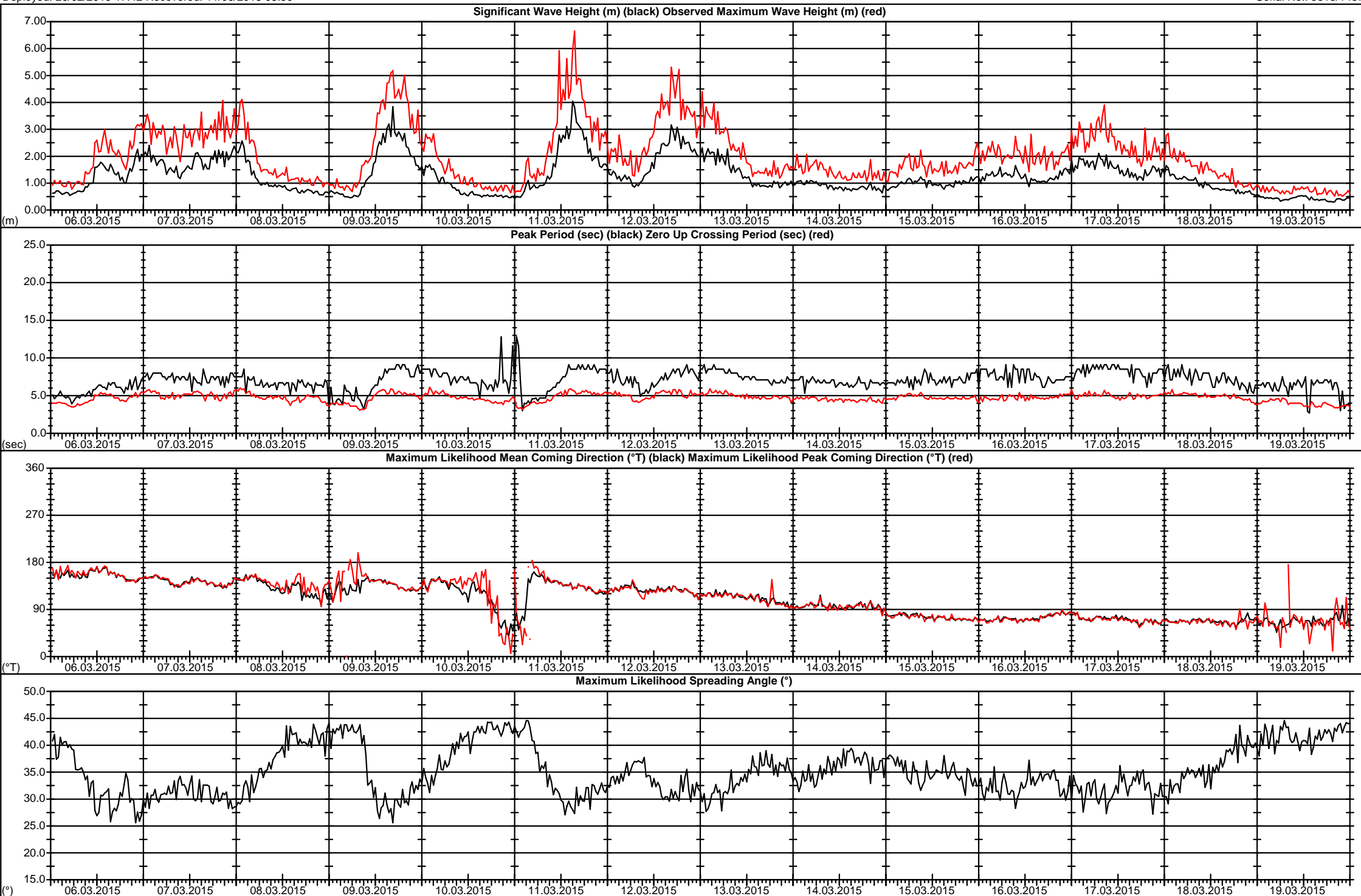
Aberdeen Harbour Expansion EIA, East, D1 - D2

D1 Latitude: 57°08'0.84"N D1 Longitude: 002°02'8.10"W D2 Latitude: 57°08'0.72"N D2 Longitude: 002°02'8.28"W D1 Site depth below LAT: 18.15m D2 Site depth below LAT: 19.06m Instrument height off seabed: 0.66m

Current Meter / AWAC

Deployed: 20/02/2015 17:42 Recovered: 11/06/2015 08:50

Serial No.: 5615/1487



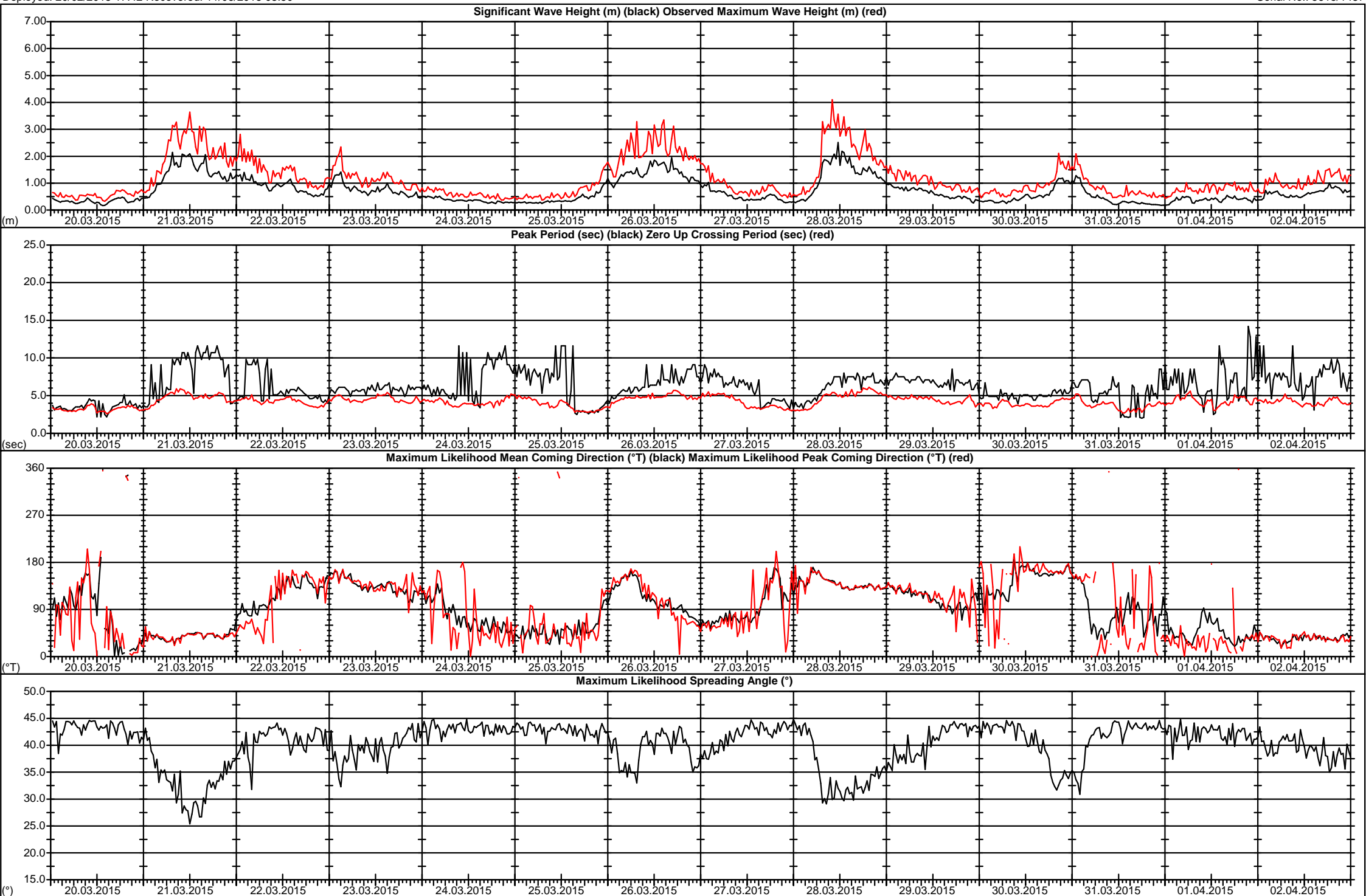
Aberdeen Harbour Expansion EIA, East, D1 - D2

D1 Latitude: 57°08'0.84"N D1 Longitude: 002°02'8.10"W D2 Latitude: 57°08'0.72"N D2 Longitude: 002°02'8.28"W D1 Site depth below LAT: 18.15m D2 Site depth below LAT: 19.06m Instrument height off seabed: 0.66m

Current Meter / AWAC

Deployed: 20/02/2015 17:42 Recovered: 11/06/2015 08:50

Serial No.: 5615/1487



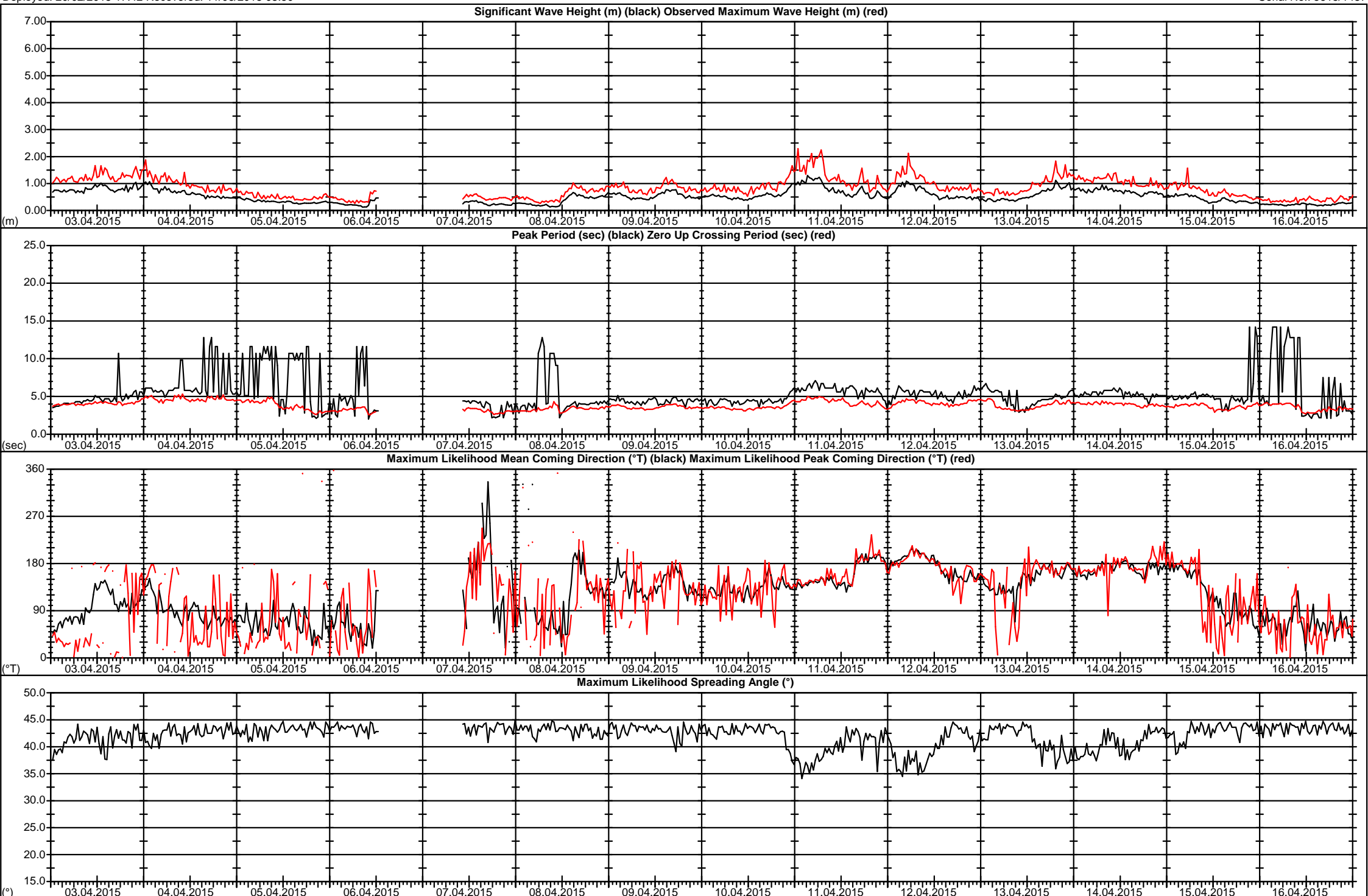
Aberdeen Harbour Expansion EIA, East, D1 - D2

D1 Latitude: 57°08'0.84"N D1 Longitude: 002°02'8.10"W D2 Latitude: 57°08'0.72"N D2 Longitude: 002°02'8.28"W D1 Site depth below LAT: 18.15m D2 Site depth below LAT: 19.06m Instrument height off seabed: 0.66m

Current Meter / AWAC

Deployed: 20/02/2015 17:42 Recovered: 11/06/2015 08:50

Serial No.: 5615/1487



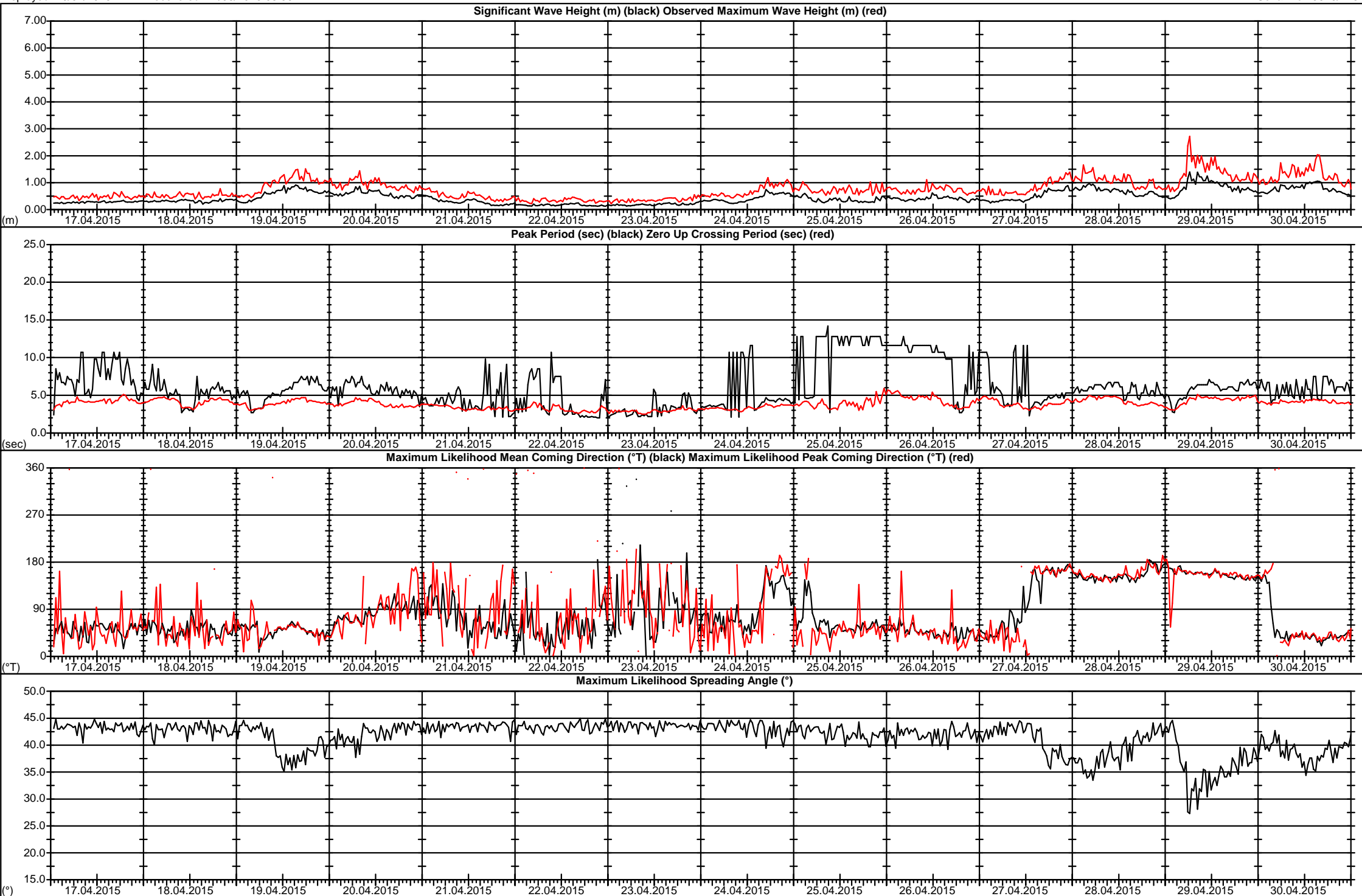
Aberdeen Harbour Expansion EIA, East, D1 - D2

D1 Latitude: 57°08'0.84"N D1 Longitude: 002°02'8.10"W D2 Latitude: 57°08'0.72"N D2 Longitude: 002°02'8.28"W D1 Site depth below LAT: 18.15m D2 Site depth below LAT: 19.06m Instrument height off seabed: 0.66m

Current Meter / AWAC

Deployed: 20/02/2015 17:42 Recovered: 11/06/2015 08:50

Serial No.: 5615/1487



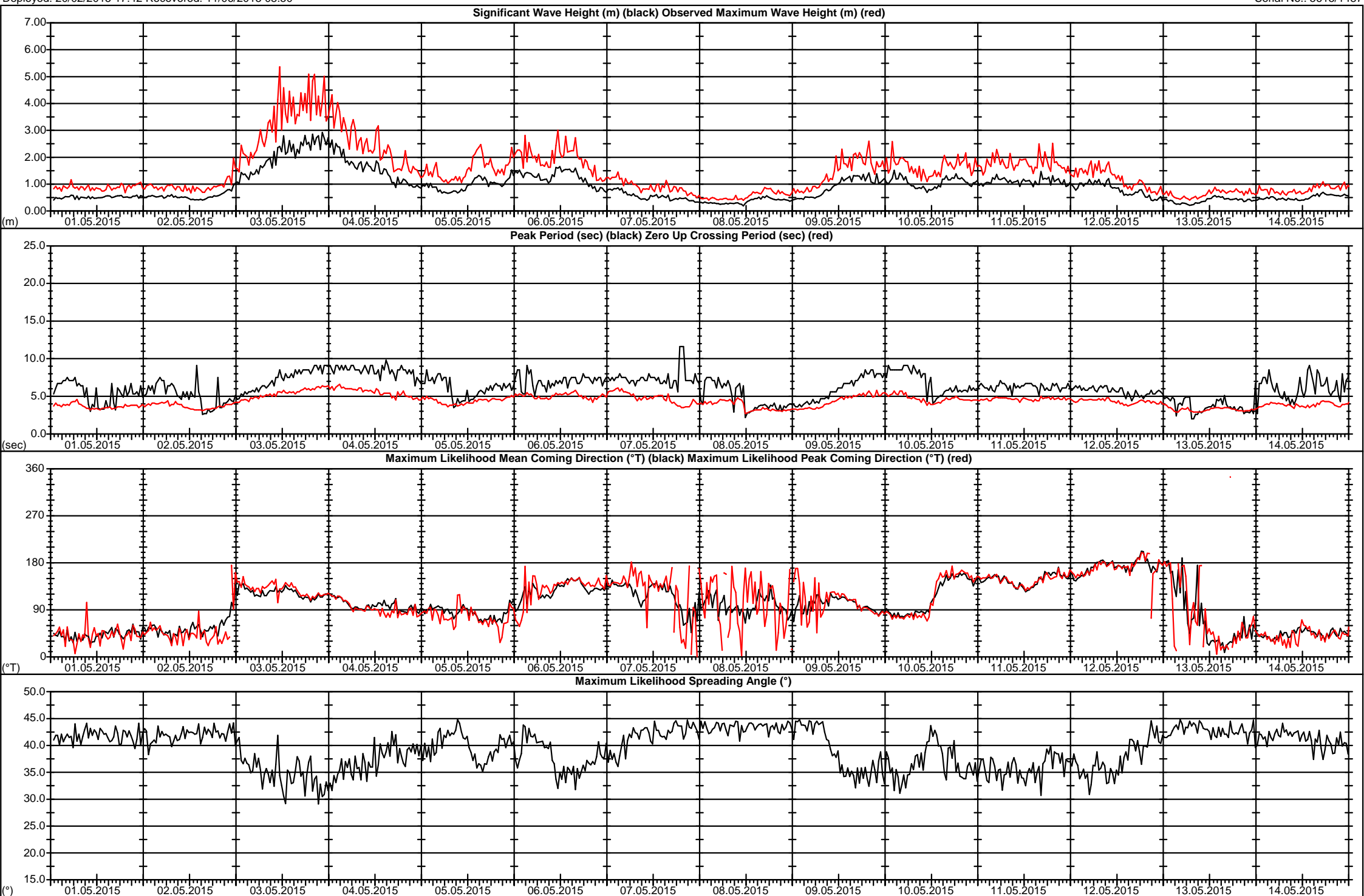
Aberdeen Harbour Expansion EIA, East, D1 - D2

D1 Latitude: 57°08'0.84"N D1 Longitude: 002°02'8.10"W D2 Latitude: 57°08'0.72"N D2 Longitude: 002°02'8.28"W D1 Site depth below LAT: 18.15m D2 Site depth below LAT: 19.06m Instrument height off seabed: 0.66m

Current Meter / AWAC

Deployed: 20/02/2015 17:42 Recovered: 11/06/2015 08:50

Serial No.: 5615/1487



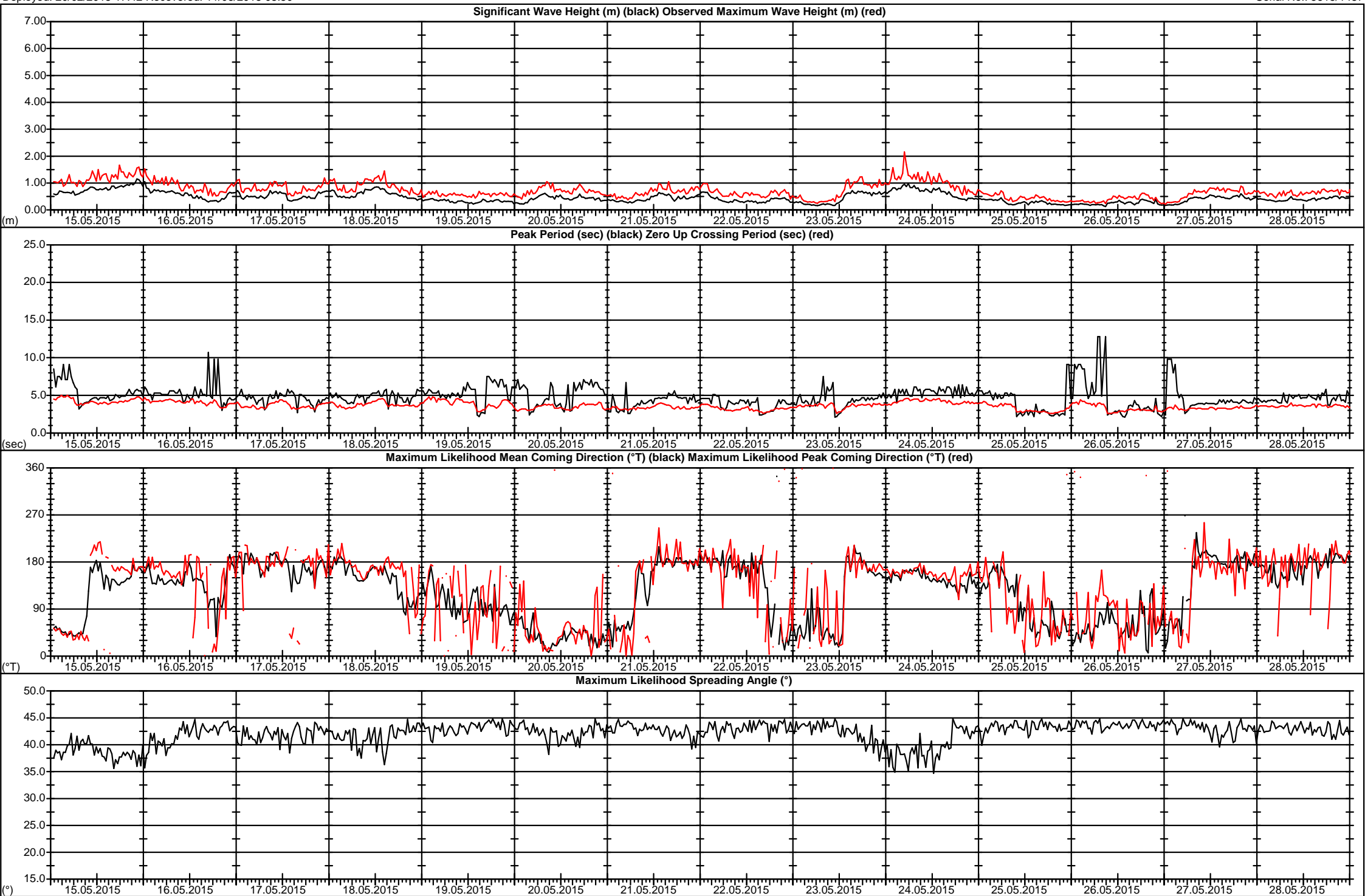
Aberdeen Harbour Expansion EIA, East, D1 - D2

D1 Latitude: 57°08'0.84"N D1 Longitude: 002°02'8.10"W D2 Latitude: 57°08'0.72"N D2 Longitude: 002°02'8.28"W D1 Site depth below LAT: 18.15m D2 Site depth below LAT: 19.06m Instrument height off seabed: 0.66m

Current Meter / AWAC

Deployed: 20/02/2015 17:42 Recovered: 11/06/2015 08:50

Serial No.: 5615/1487



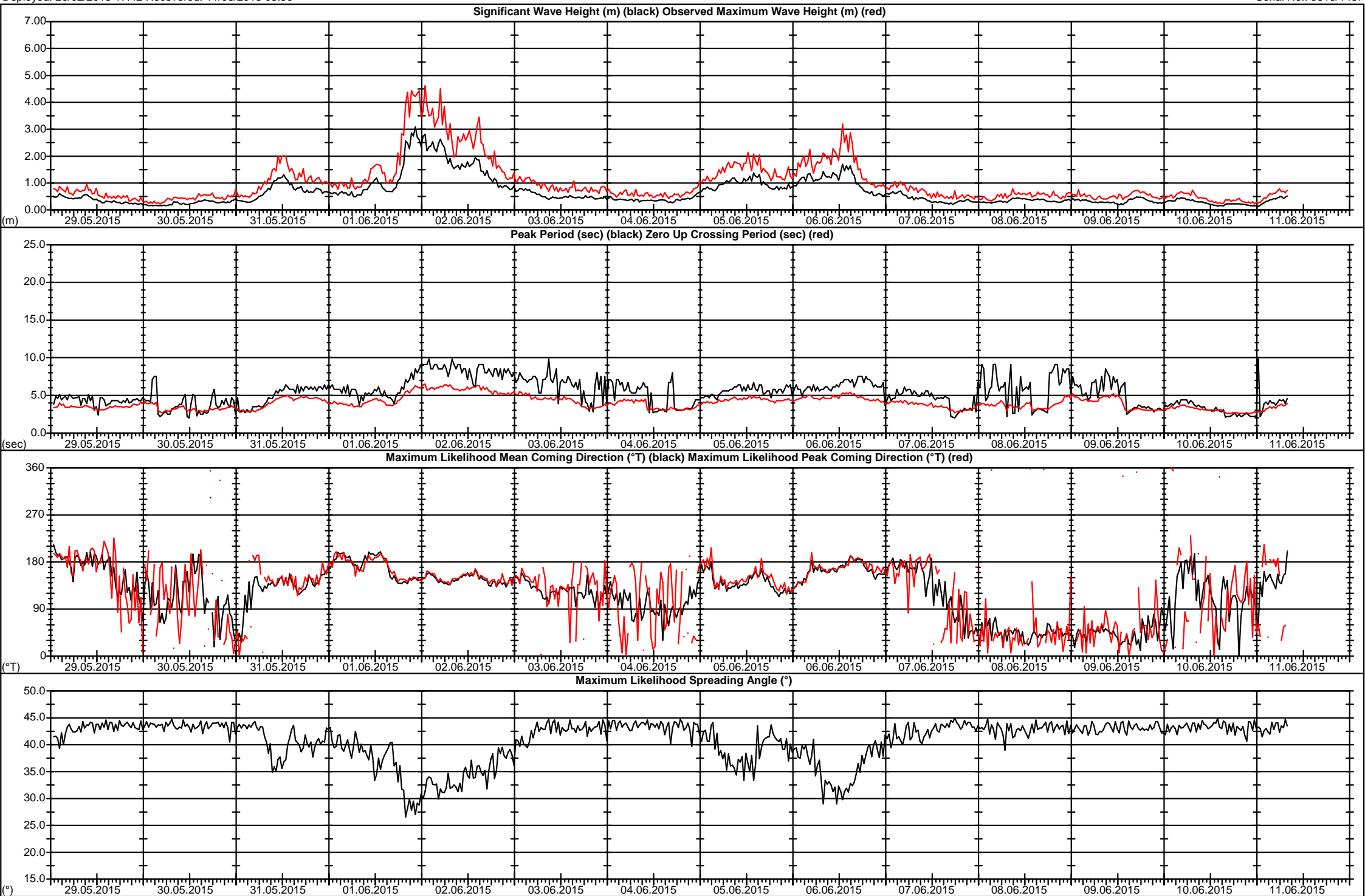
Aberdeen Harbour Expansion EIA, East, D1 - D2

D1 Latitude: 57°08'0.84"N D1 Longitude: 002°02'8.10"W D2 Latitude: 57°08'0.72"N D2 Longitude: 002°02'8.28"W D1 Site depth below LAT: 18.15m D2 Site depth below LAT: 19.06m Instrument height off seabed: 0.66m

Current Meter / AWAC

Deployed: 20/02/2015 17:42 Recovered: 11/06/2015 08:50

Serial No.: 5615/1487

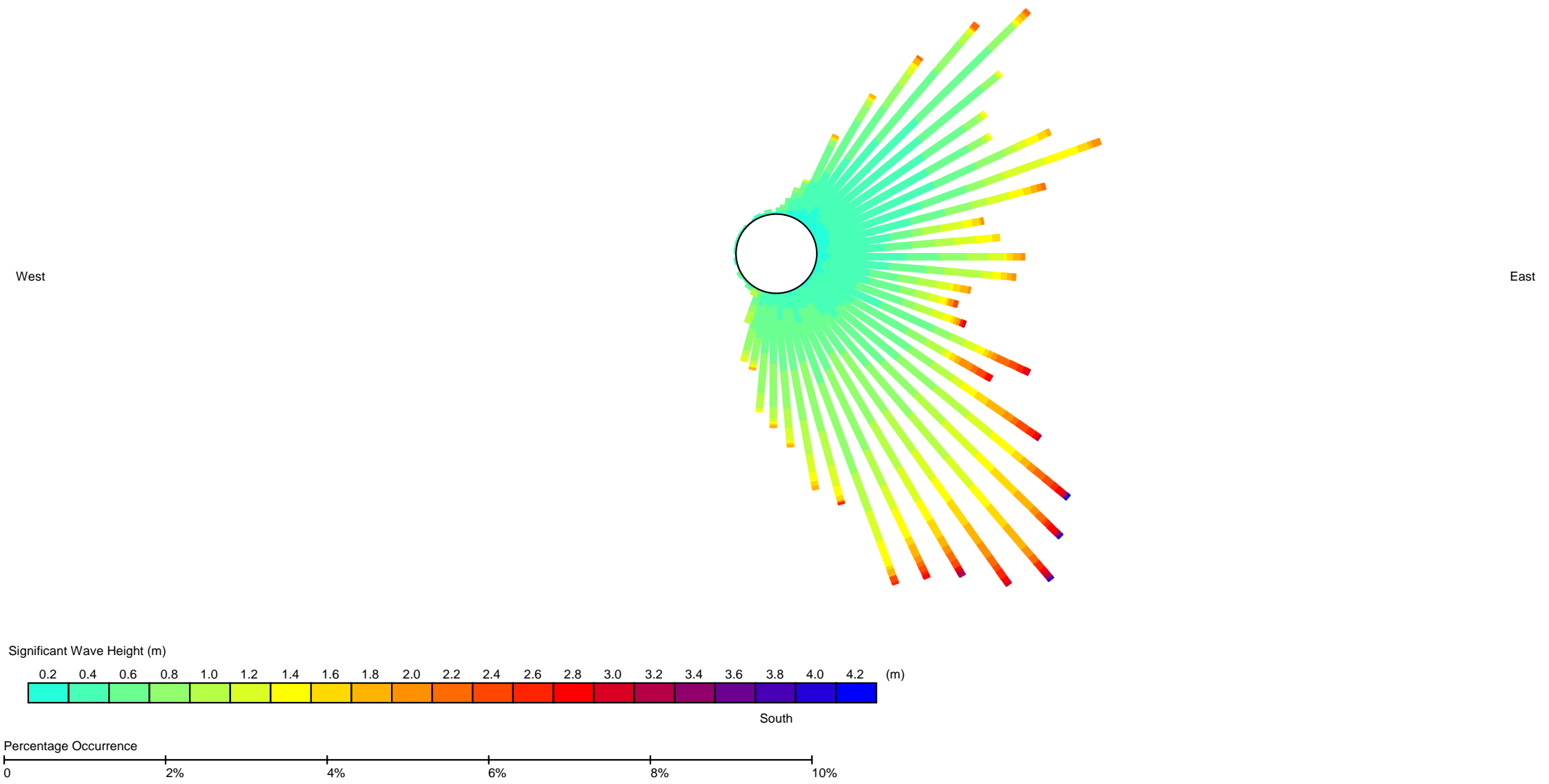


Wave Data Hodogram (Rose Diagram) Aberdeen Harbour Expansion EIA, East, D1 - D2

D1 Latitude: 57°08'0.84"N D1 Longitude: 002°02'8.10"W D2 Latitude: 57°08'0.72"N D2 Longitude: 002°02'8.28"W D1 Site depth below LAT: 18.15m D2 Site depth below LAT: 19.06m Instrument height off seabed: 0.66m
Deployed: 20/02/2015 17:42 Recovered: 11/06/2015 08:50

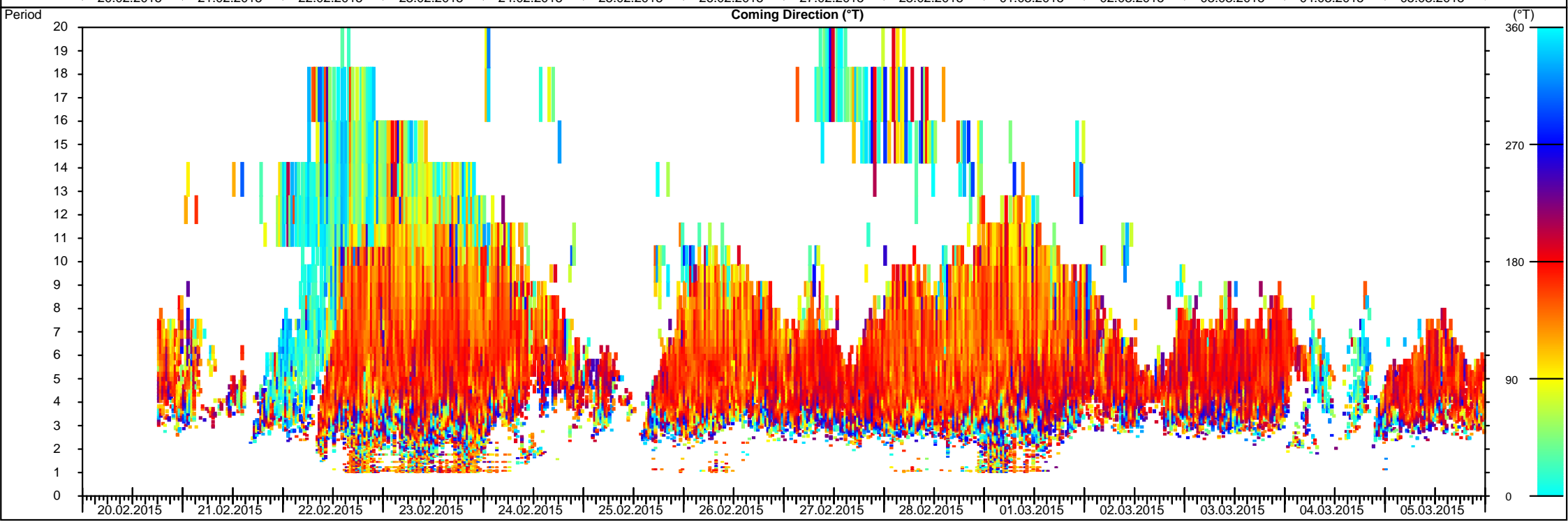
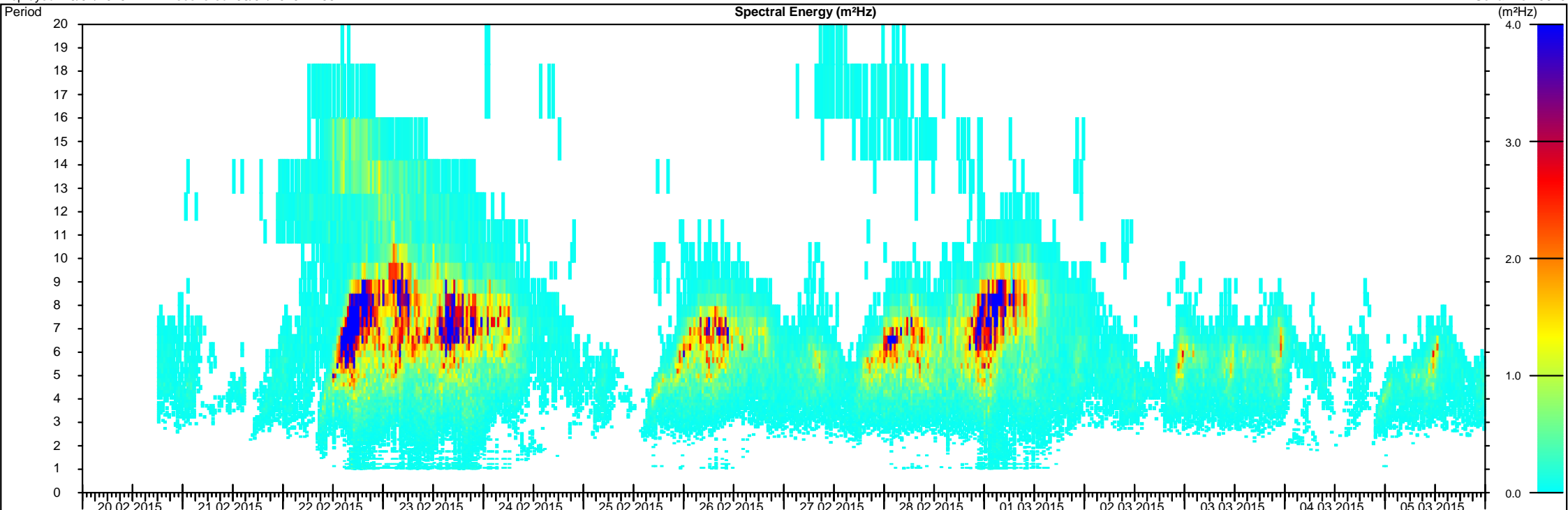
Current Meter / AWAC
Serial No.: 5615/1487

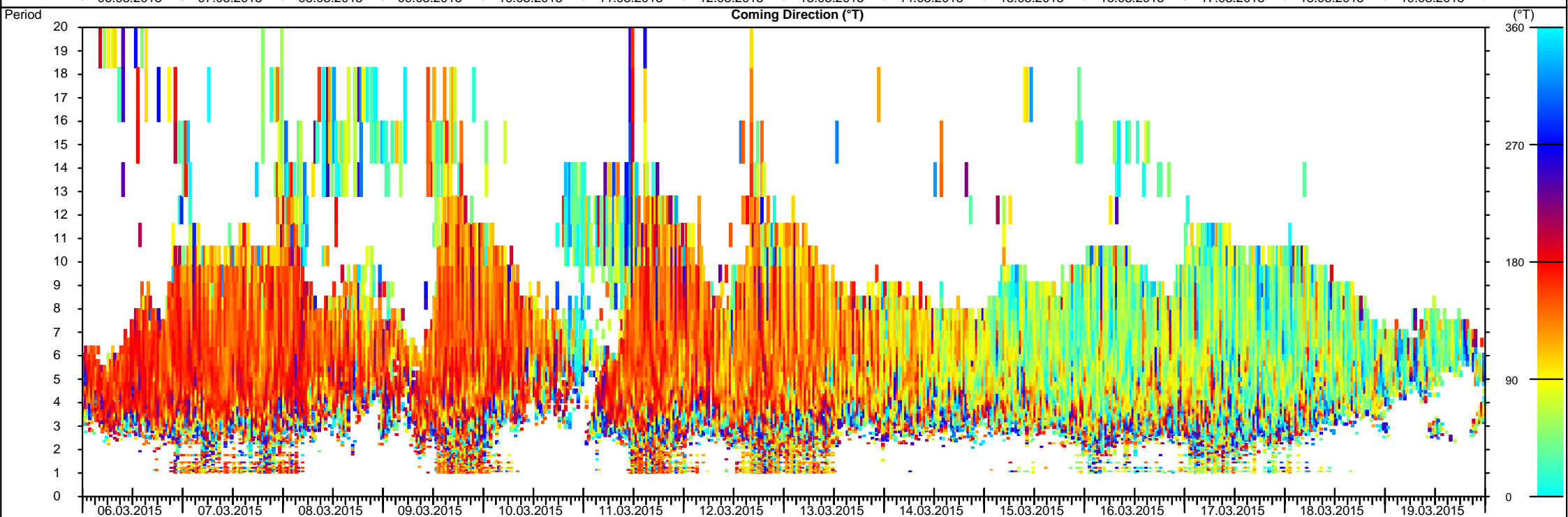
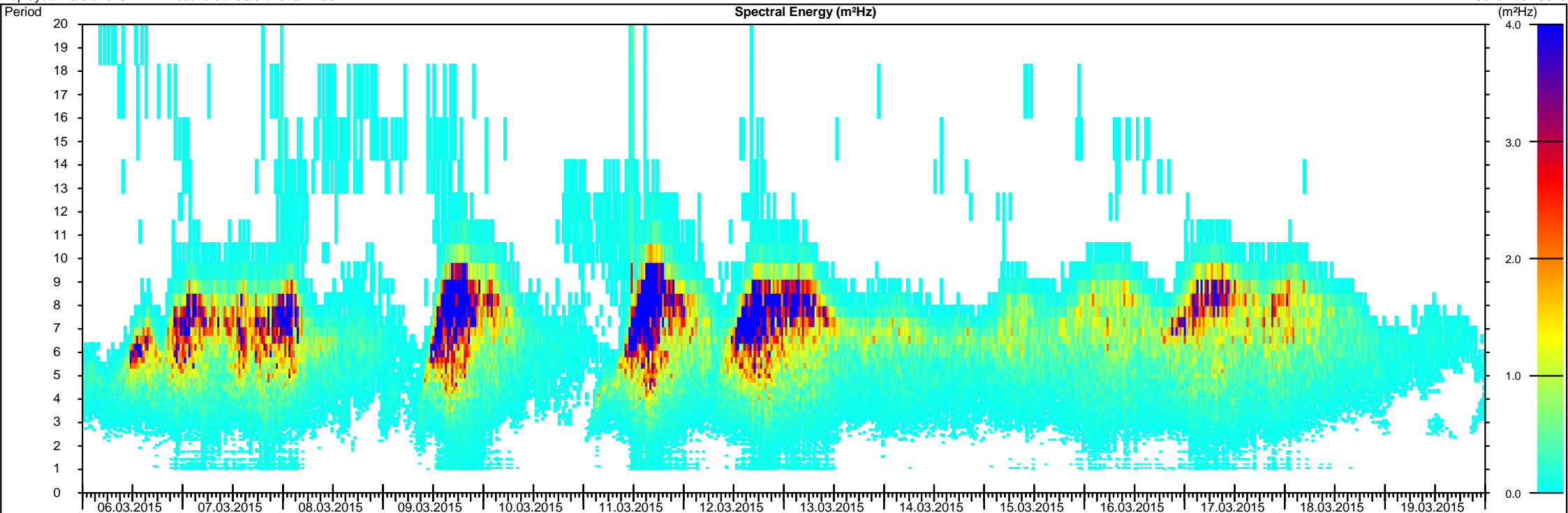
Maximum Likelihood Mean Coming Direction (°T)
True North



Latitude: 57°08'0.84"N Longitude: 002°02'8.10"W Site depth below LAT: 18.15m Instrument height off seabed: 0.66m
Deployed: 20/02/2015 17:42 Recovered: 06/04/2015 12:55

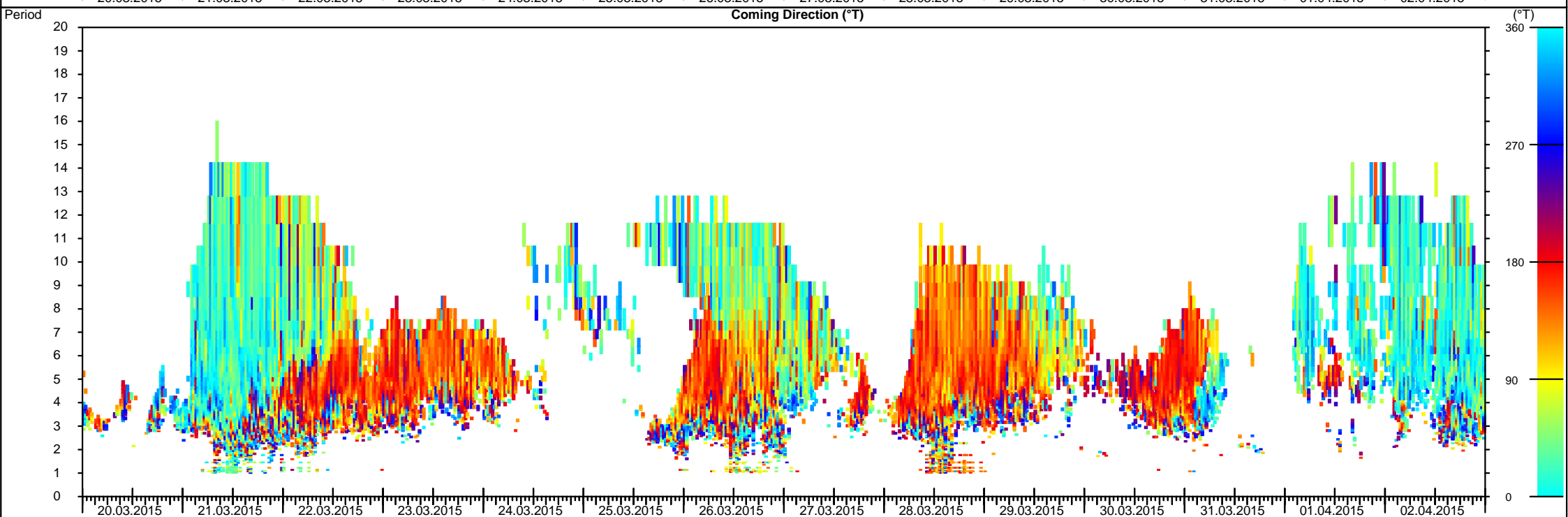
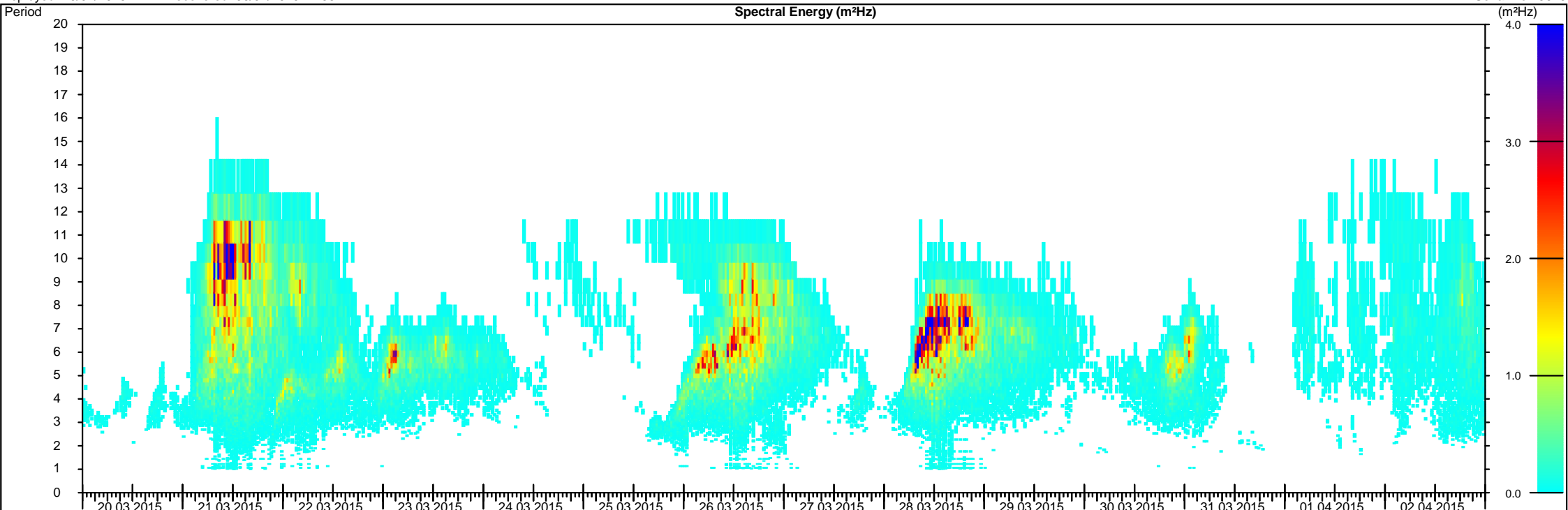
Current Meter / AWAC
Serial No.: 5615



Latitude: 57°08'0.84"N Longitude: 002°02'8.10"W Site depth below LAT: 18.15m Instrument height off seabed: 0.66m
Deployed: 20/02/2015 17:42 Recovered: 06/04/2015 12:55Current Meter / AWAC
Serial No.: 5615

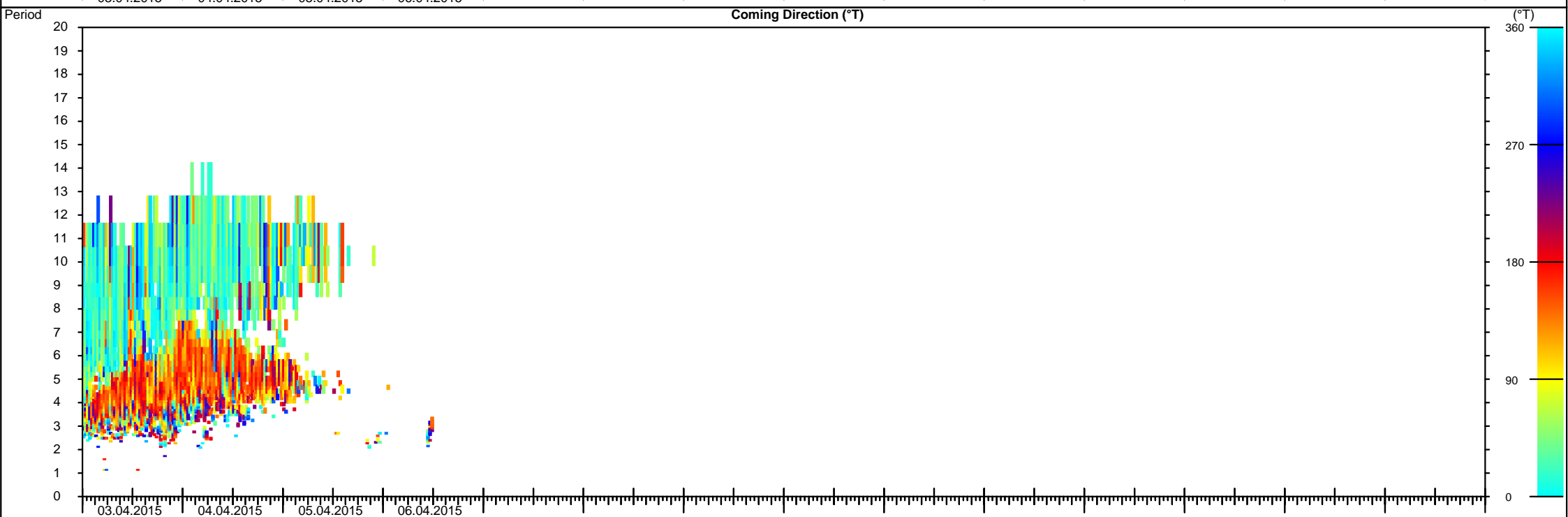
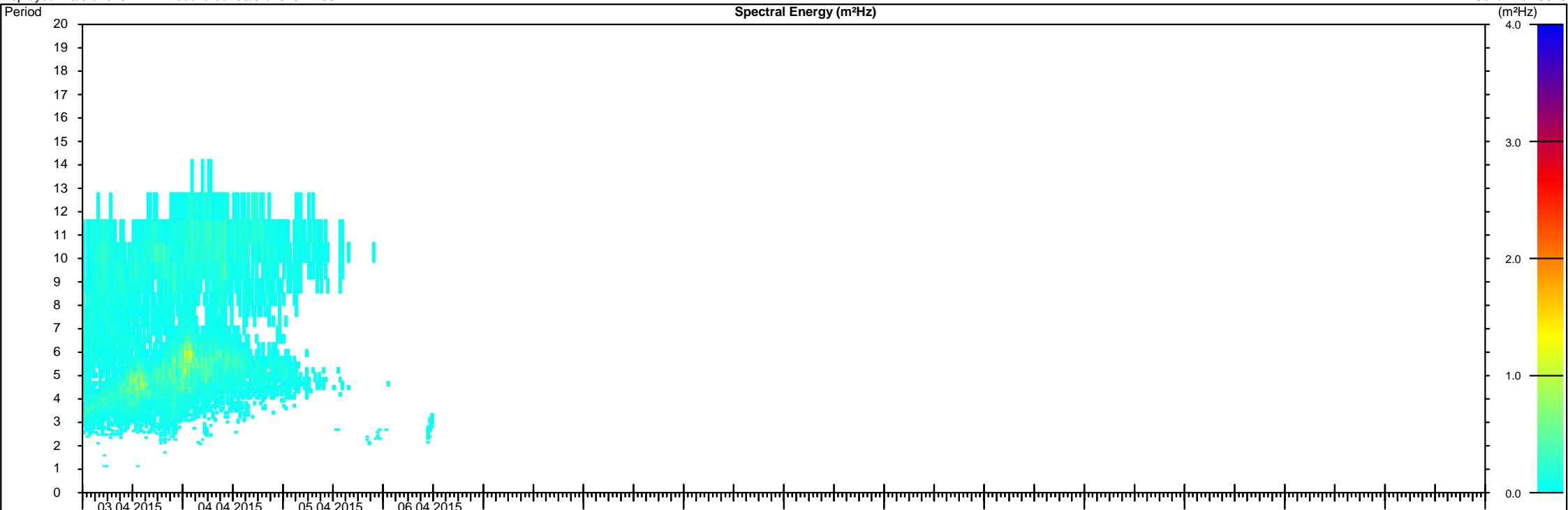
Latitude: 57°08'0.84"N Longitude: 002°02'8.10"W Site depth below LAT: 18.15m Instrument height off seabed: 0.66m
 Deployed: 20/02/2015 17:42 Recovered: 06/04/2015 12:55

Current Meter / AWAC
 Serial No.: 5615



Latitude: 57°08'0.84"N Longitude: 002°02'8.10"W Site depth below LAT: 18.15m Instrument height off seabed: 0.66m
Deployed: 20/02/2015 17:42 Recovered: 06/04/2015 12:55

Current Meter / AWAC
Serial No.: 5615

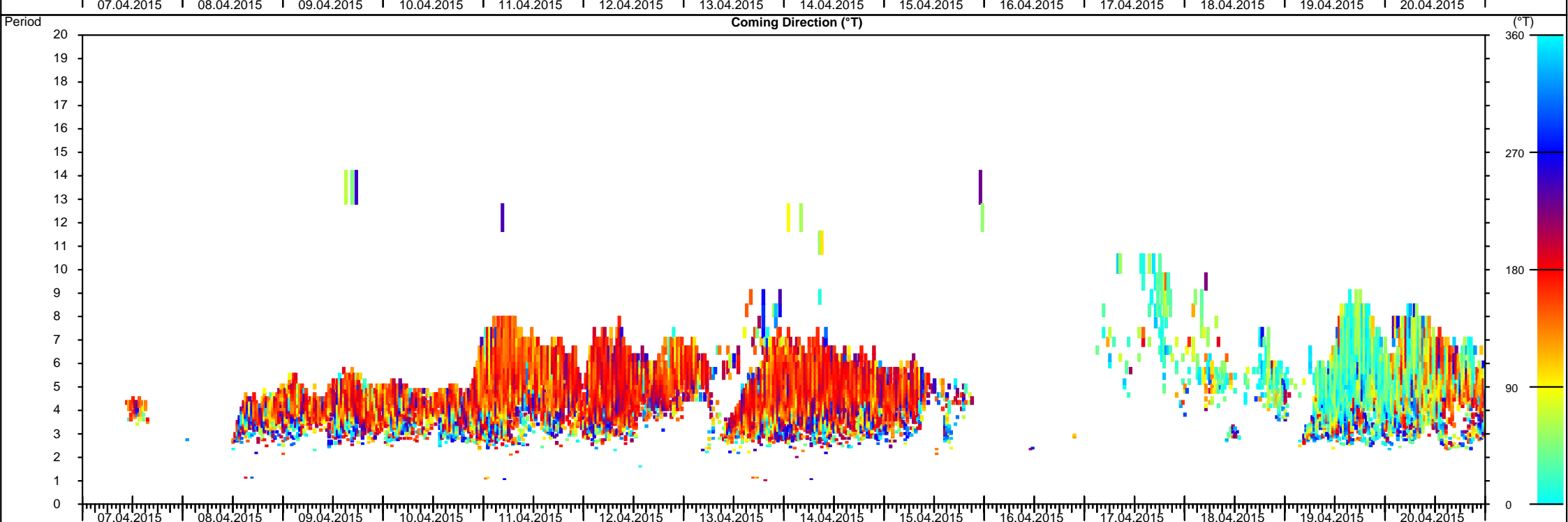
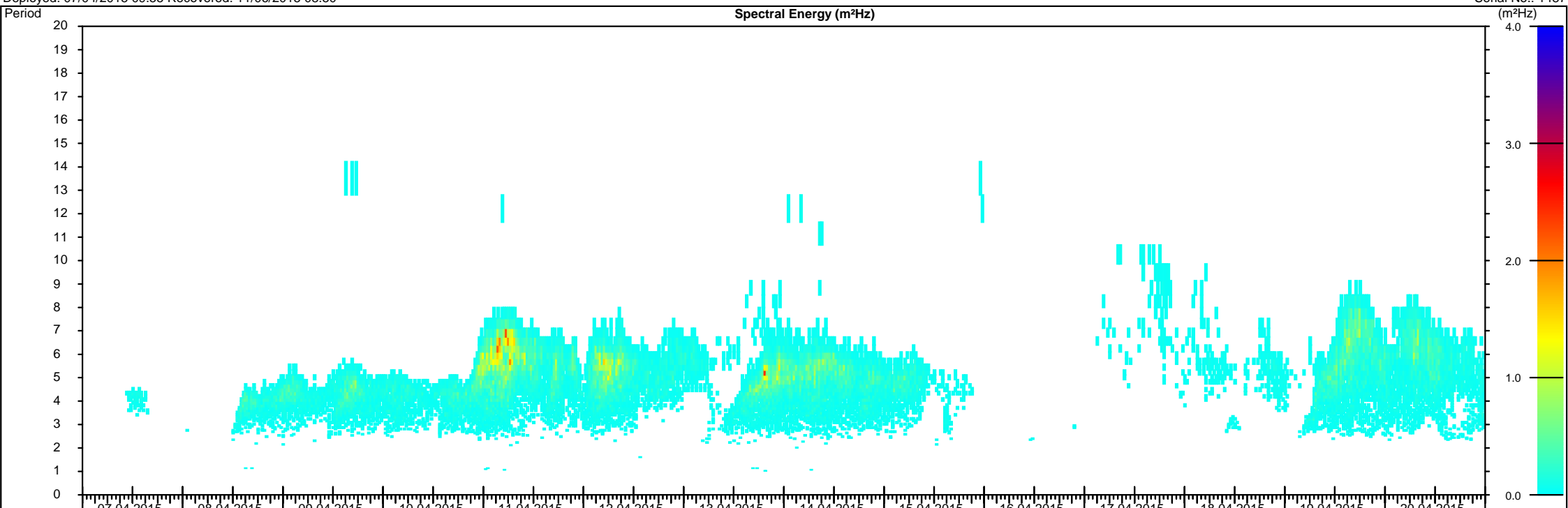


Latitude: 57°08'0.72"N Longitude: 002°02'8.28"W Site depth below LAT: 19.06m Instrument height off seabed: 0.66m

Current Meter / AWAC

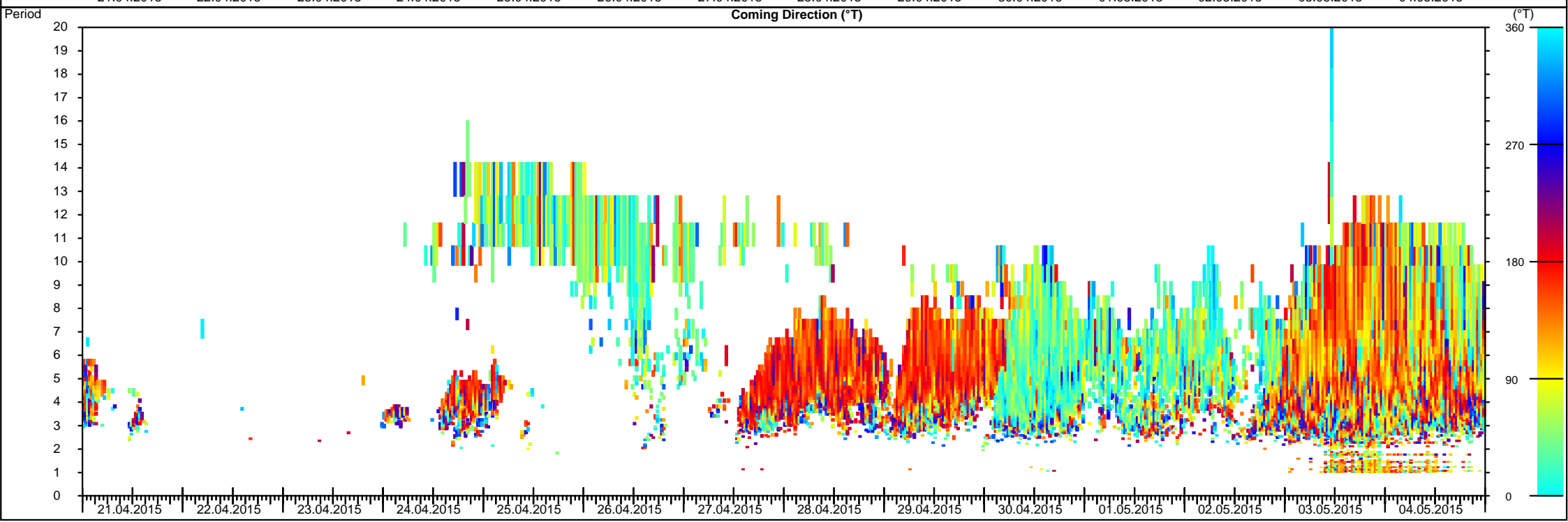
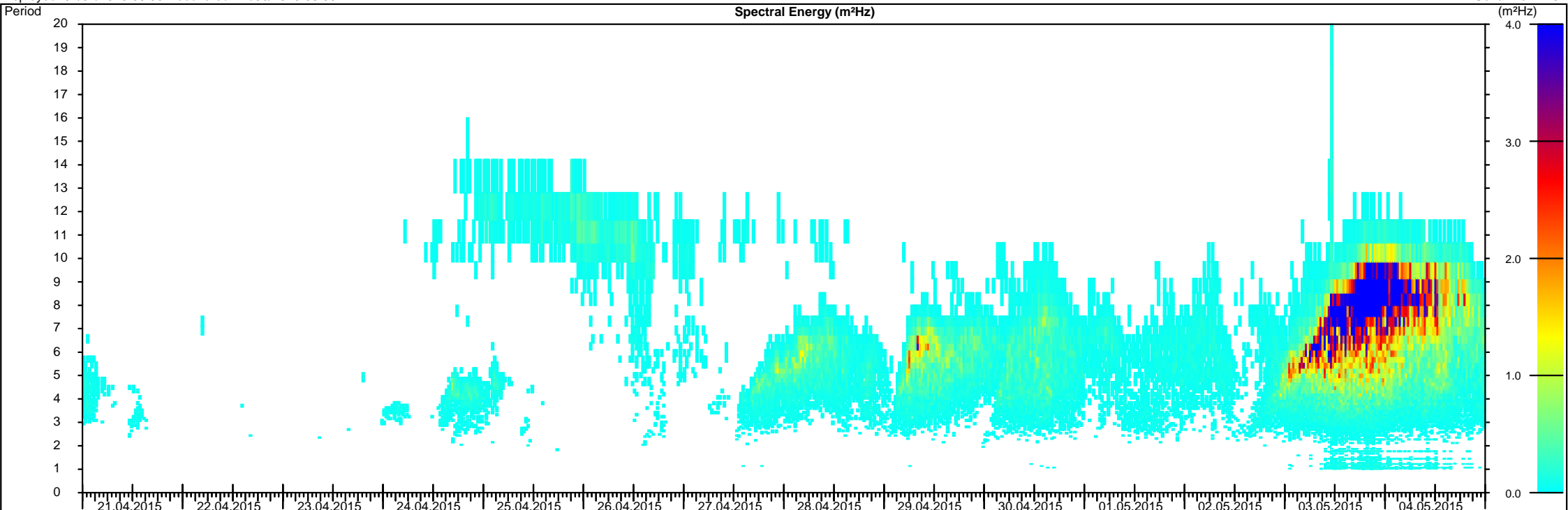
Deployed: 07/04/2015 09:55 Recovered: 11/06/2015 08:50

Serial No.: 1487



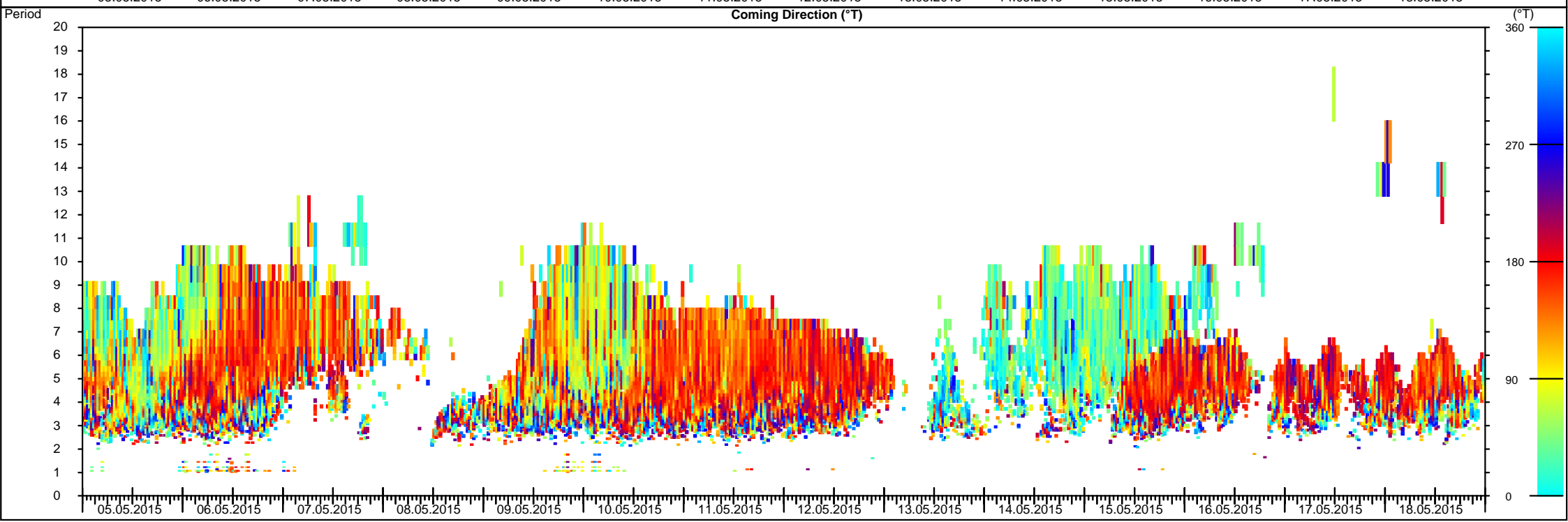
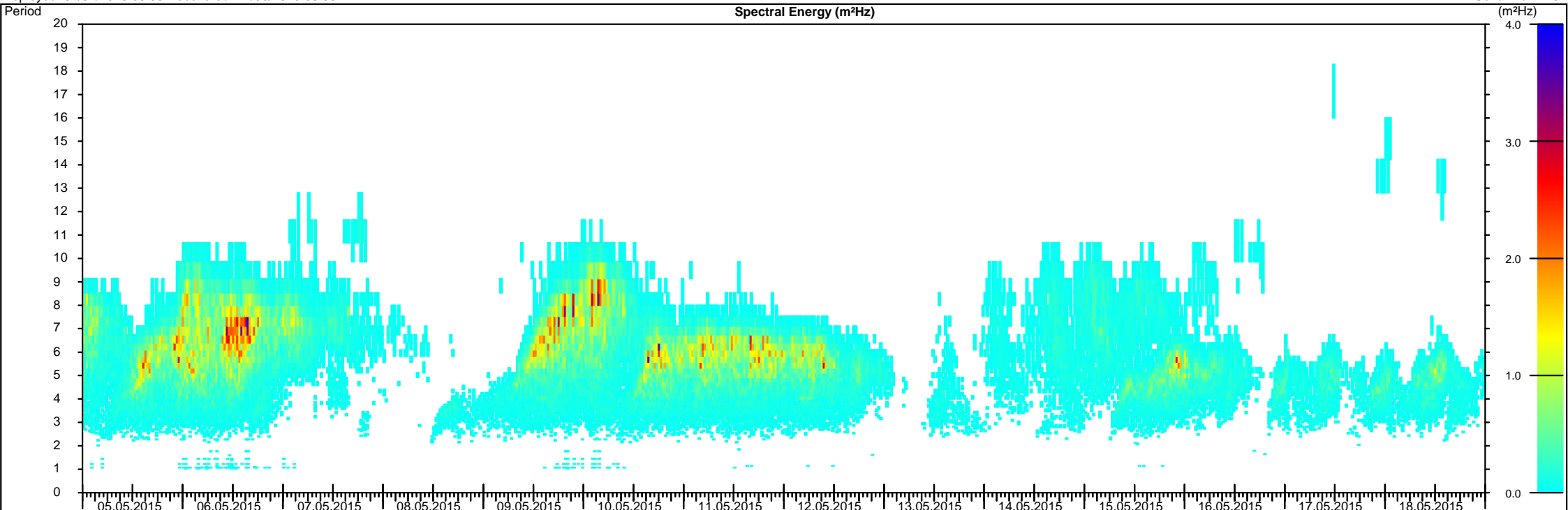
Latitude: 57°08'0.72"N Longitude: 002°02'8.28"W Site depth below LAT: 19.06m Instrument height off seabed: 0.66m
Deployed: 07/04/2015 09:55 Recovered: 11/06/2015 08:50

Current Meter / AWAC
Serial No.: 1487



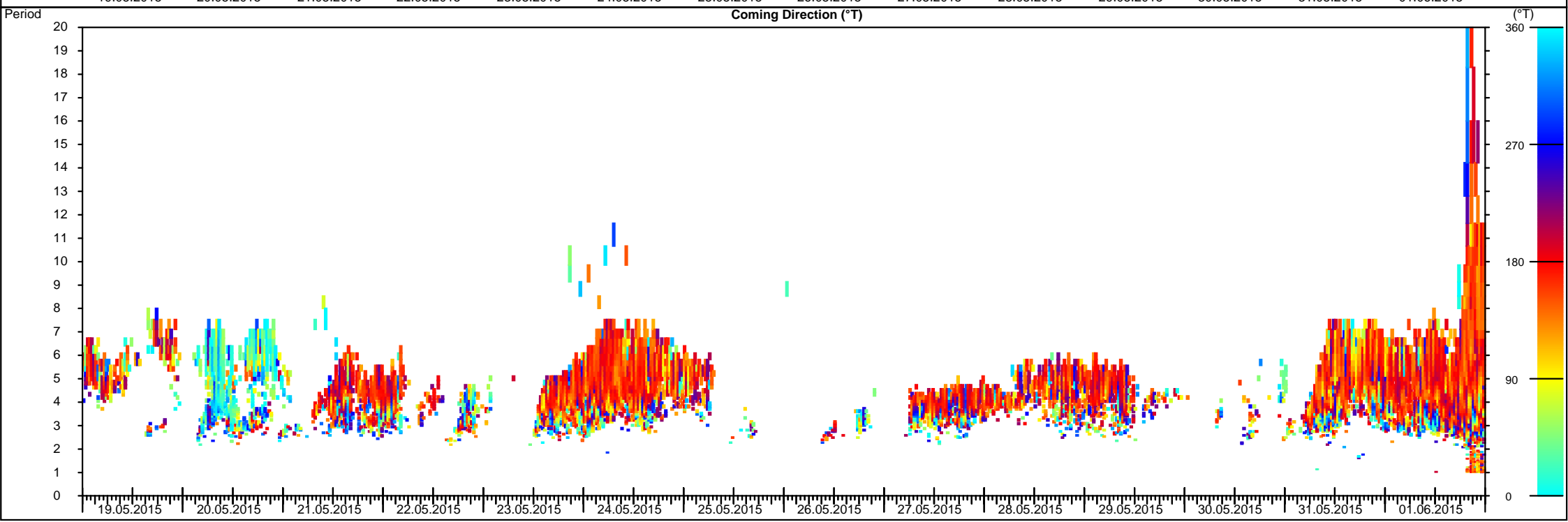
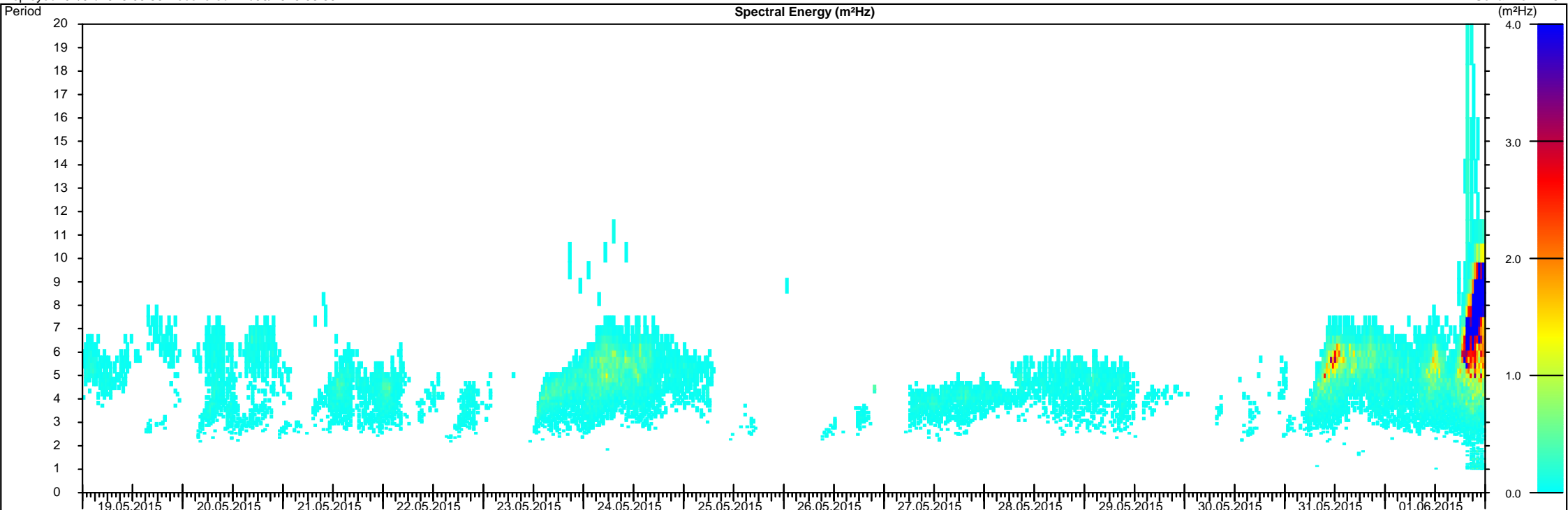
Latitude: 57°08'0.72"N Longitude: 002°02'8.28"W Site depth below LAT: 19.06m Instrument height off seabed: 0.66m
Deployed: 07/04/2015 09:55 Recovered: 11/06/2015 08:50

Current Meter / AWAC
Serial No.: 1487



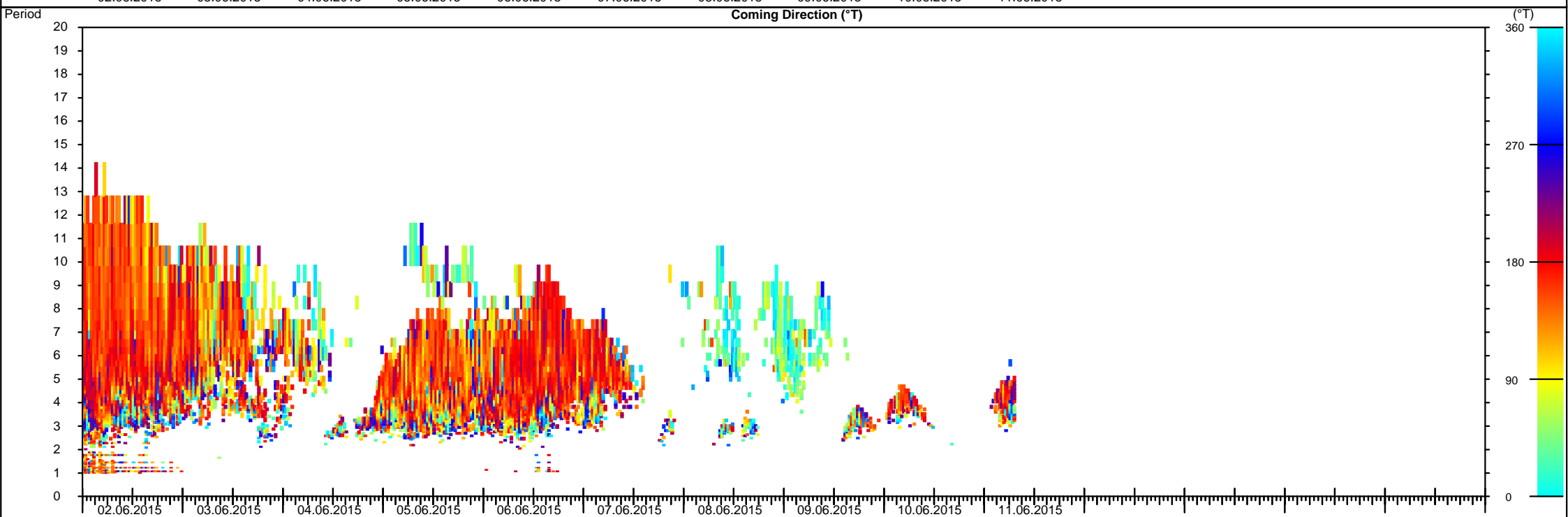
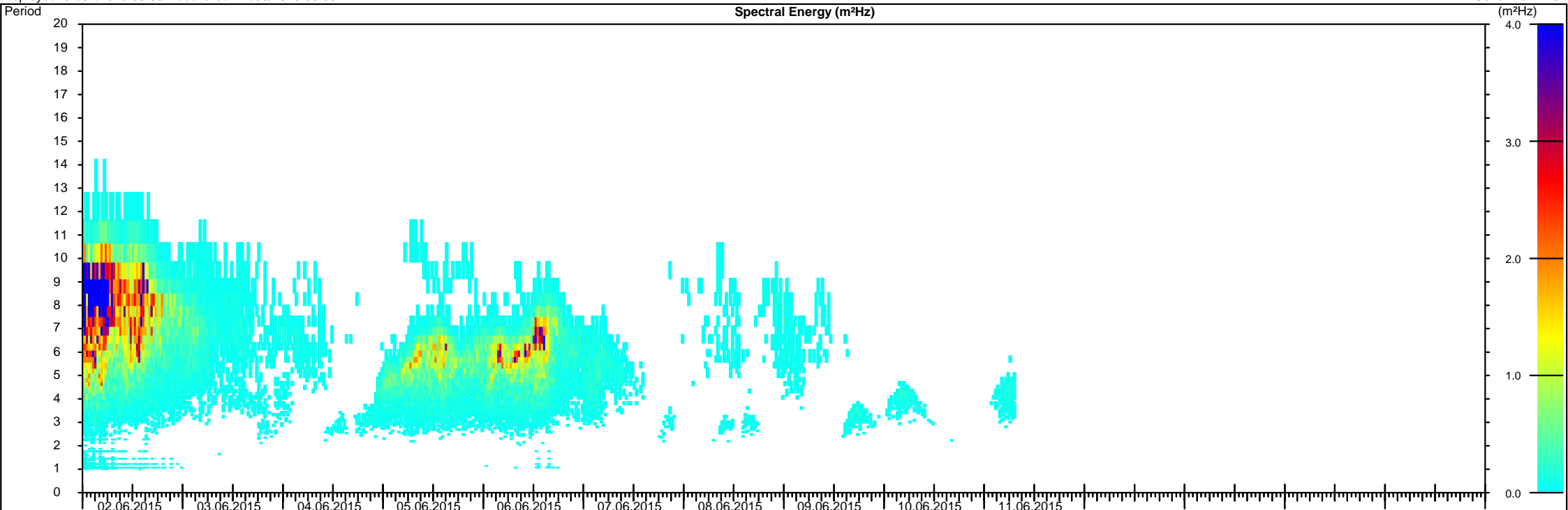
Latitude: 57°08'0.72"N Longitude: 002°02'8.28"W Site depth below LAT: 19.06m Instrument height off seabed: 0.66m
Deployed: 07/04/2015 09:55 Recovered: 11/06/2015 08:50

Current Meter / AWAC
Serial No.: 1487



Latitude: 57°08'0.72"N Longitude: 002°02'8.28"W Site depth below LAT: 19.06m Instrument height off seabed: 0.66m
Deployed: 07/04/2015 09:55 Recovered: 11/06/2015 08:50

Current Meter / AWAC
Serial No.: 1487



Wave Data Frequency Table

Aberdeen Harbour Expansion EIA, East, D1 - D2

D1: 57°08'0.84"N, 002°02'8.10"W D2: 57°08'0.72"N, 002°02'8.28"W D1 Site depth below LAT: 18.15m D2 Site depth below LAT: 19.06m
 Deployed: 20/02/2015 17:42 Recovered: 11/06/2015 08:50 Instrument height off seabed: 0.66m

Current Meter / AWAC
 Serial No.: 5615/1487

Frequency Distribution of Significant Wave Height (m) against Maximum Likelihood Mean Coming Direction (°T)

	<0.2	<0.4	<0.6	<0.8	<1	<1.2	<1.4	<1.6	<1.8	<2	<2.2	<2.4	<2.6	<2.8	<3	<3.2	<3.4	<3.6	<3.8	<4	<4.2	<4.4	<4.6	<4.8	<5	Count	%
<10	3	2	10																							15	0.285
<20	6	14	12	2																						34	0.646
<30	14	40	51	6	1	3		2	1																	118	2.241
<40	22	81	101	41	16	5	4	1	5		3															279	5.299
<50	23	165	125	39	6	3	4	3	3	2	3															376	7.142
<60	19	166	61	17	5	1	3																			272	5.166
<70	20	147	69	36	15	21	20	10	2																	340	6.458
<80	19	104	44	30	25	42	27	10	7	8	2															318	6.040
<90	15	81	31	22	20	25	14	8	2	2																220	4.179
<100	13	82	49	29	45	15	9	11	11	4																268	5.090
<110	11	58	50	21	17	14	9	3	2	5		2	1													193	3.666
<120	7	71	67	25	19	17	10	8	6	8	10	7	5	4	3											267	5.071
<130	4	59	97	35	38	22	22	13	17	14	8	16	8	7	2	2								1		365	6.933
<140	4	52	104	69	65	48	32	33	28	11	16	7	6	6	3	4	1									491	9.326
<150	4	34	73	94	58	45	34	32	26	18	11	6	10	7	5	4										461	8.756
<160	1	34	86	124	65	46	34	15	17	5	7	11	3	2												450	8.547
<170	3	24	84	94	44	29	22	4	5	1			1													311	5.907
<180		31	71	55	29	14	6	3	1																	210	3.989
<190	3	13	64	48	16	3	3	1	1																	152	2.887
<200	1	12	34	24	11	6			1																	89	1.690
<210		1	4	5	3																					13	0.247
<220	2		1	1																						4	0.076
<230		2																								2	0.038
<240		1	1																							2	0.038
<250																										0	0.000
<260	1																									1	0.019
<270		1																								1	0.019
<280		1																								1	0.019
<290		1																								1	0.019
<300		1																								1	0.019
<310		1																								1	0.019
<320																										0	0.000
<330	1																									1	0.019
<340	3	1																								4	0.076
<350		2	1																							3	0.057
<360	1																									1	0.019
Count	200	1282	1290	817	498	359	253	157	135	78	60	49	34	26	13	10	1	0	0	2	1	0	0	0	0	5265	100
%	3.799	24.349	24.501	15.518	9.459	6.819	4.805	2.982	2.564	1.481	1.140	0.931	0.646	0.494	0.247	0.190	0.019	0.000	0.000	0.038	0.019	0.000	0.000	0.000	0.000	100	
100.0	96.2	71.9	47.4	31.8	22.4	15.6	10.8	7.8	5.2	3.7	2.6	1.7	1.0	0.5	0.3	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	% Exceedence	

Wave Data Frequency Table

Aberdeen Harbour Expansion EIA, East, D1 - D2

D1: 57°08'0.84"N, 002°02'8.10"W D2: 57°08'0.72"N, 002°02'8.28"W D1 Site depth below LAT: 18.15m D2 Site depth below LAT: 19.06m
 Deployed: 20/02/2015 17:42 Recovered: 11/06/2015 08:50 Instrument height off seabed: 0.66m

Current Meter / AWAC
 Serial No.: 5615/1487

Frequency Distribution of Zero Up Crossing Period (sec) against Maximum Likelihood Mean Coming Direction (°T)

	<1	<2	<3	<4	<5	<6	<7	<8	<9	<10	Count	%
<10			5	9	1						15	0.285
<20			7	21	4	2					34	0.646
<30			11	65	36	6					118	2.241
<40			25	148	91	15					279	5.299
<50			36	204	124	12					376	7.142
<60			31	154	82	5					272	5.166
<70			44	137	122	37					340	6.458
<80			24	124	132	38					318	6.040
<90			24	98	72	26					220	4.179
<100			20	113	102	31	2				268	5.090
<110			27	74	79	12	1				193	3.666
<120			16	108	92	40	11				267	5.071
<130			13	109	154	87	2				365	6.933
<140			13	123	231	116	8				491	9.326
<150			6	127	201	119	8				461	8.756
<160			13	176	205	53	3				450	8.547
<170			8	160	133	9	1				311	5.907
<180			4	131	72	3					210	3.989
<190			6	98	44	4					152	2.887
<200			3	62	23	1					89	1.690
<210				7	6						13	0.247
<220			2	2							4	0.076
<230			1	1							2	0.038
<240			1	1							2	0.038
<250											0	0.000
<260			1								1	0.019
<270			1								1	0.019
<280			1								1	0.019
<290			1								1	0.019
<300				1							1	0.019
<310				1							1	0.019
<320											0	0.000
<330			1								1	0.019
<340			1	3							4	0.076
<350				3							3	0.057
<360			1								1	0.019
Count	0	0	347	2260	2006	616	36	0	0	0	5265	
%	0.000	0.000	6.591	42.925	38.101	11.700	0.684	0.000	0.000	0.000	100	
100.0	100.0	100.0	93.4	50.5	12.4	0.7	0.0	0.0	0.0	0.0	% Exceedence	

Frequency Table

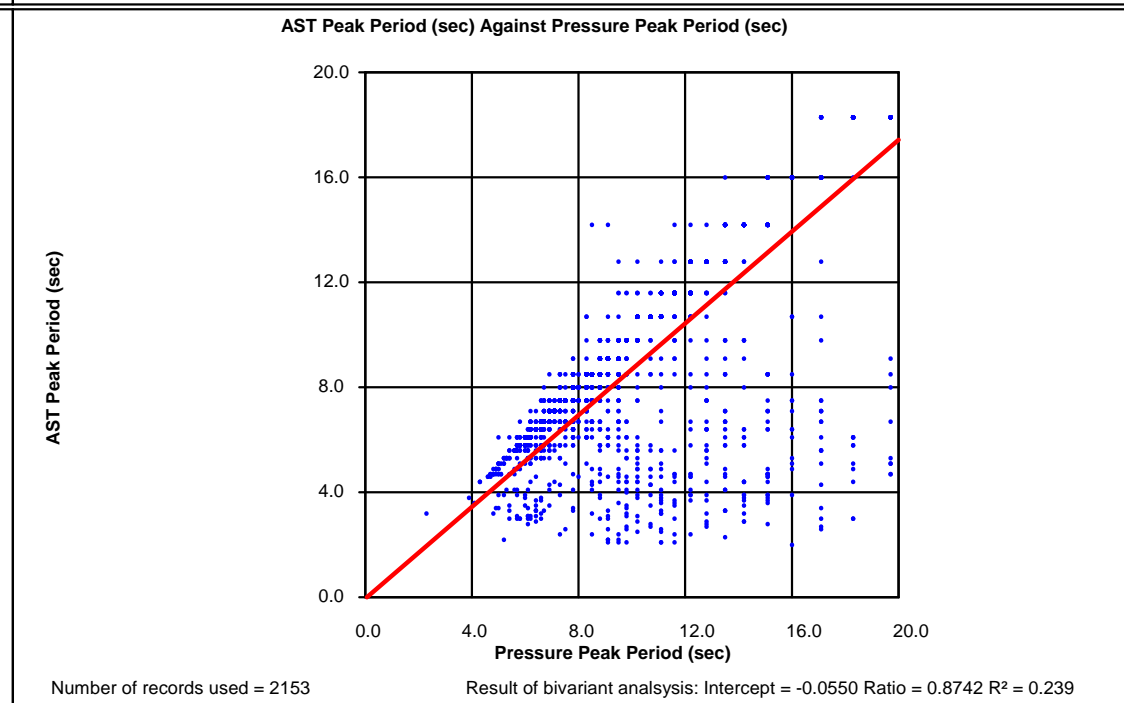
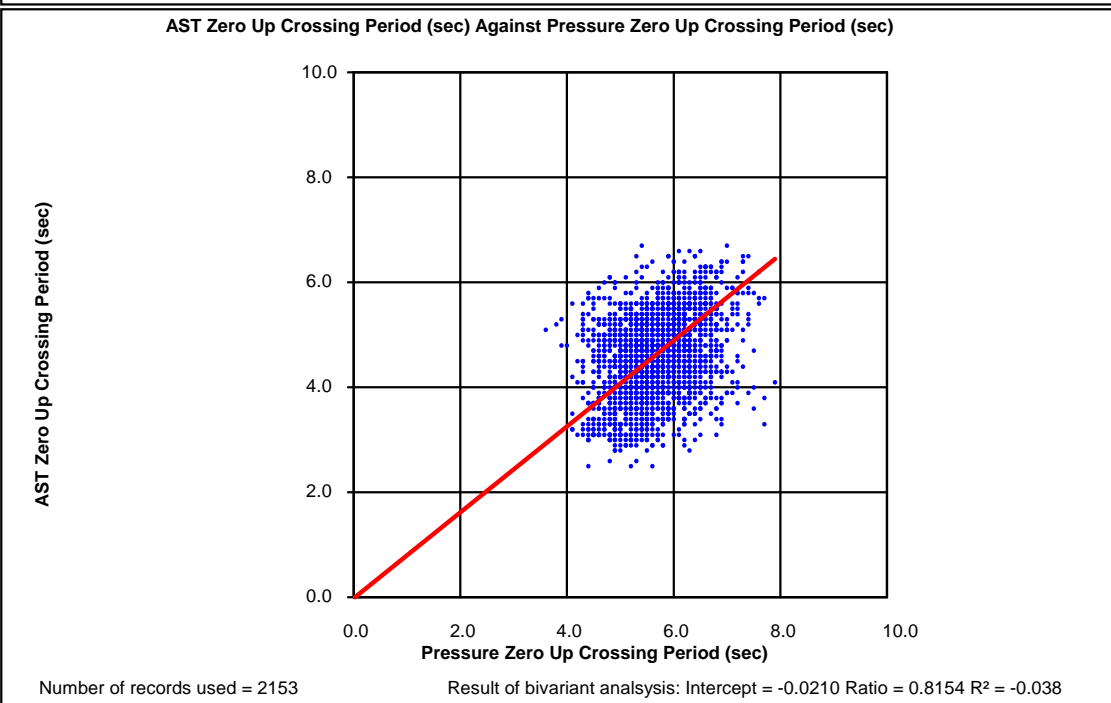
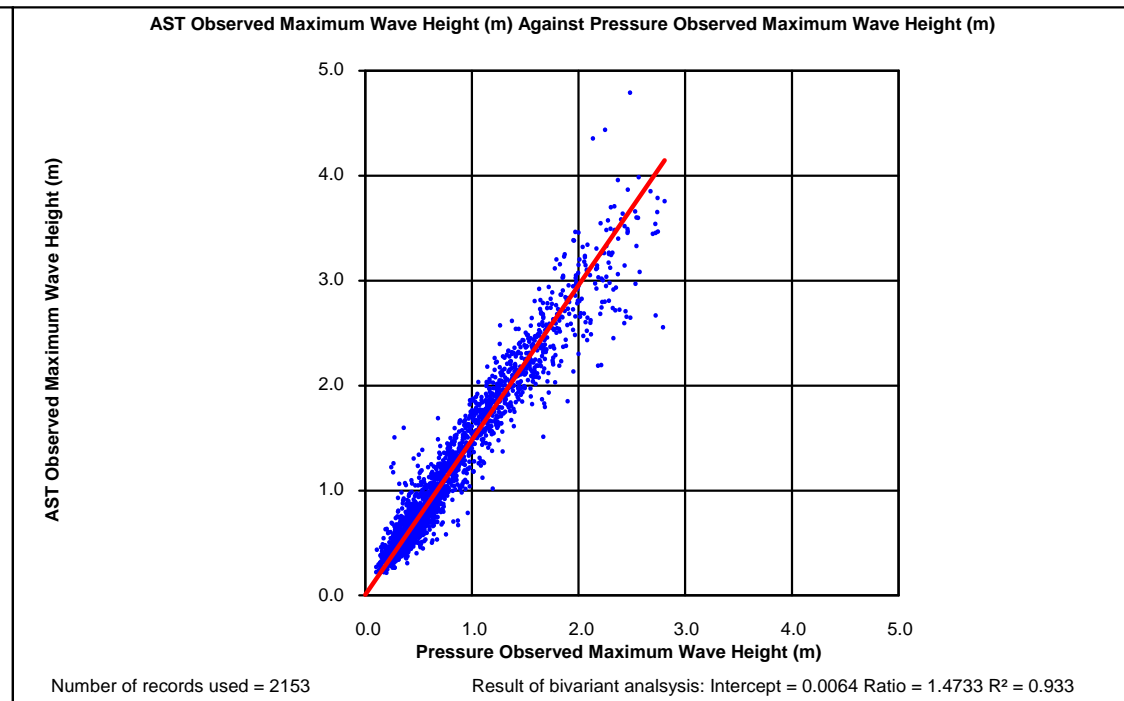
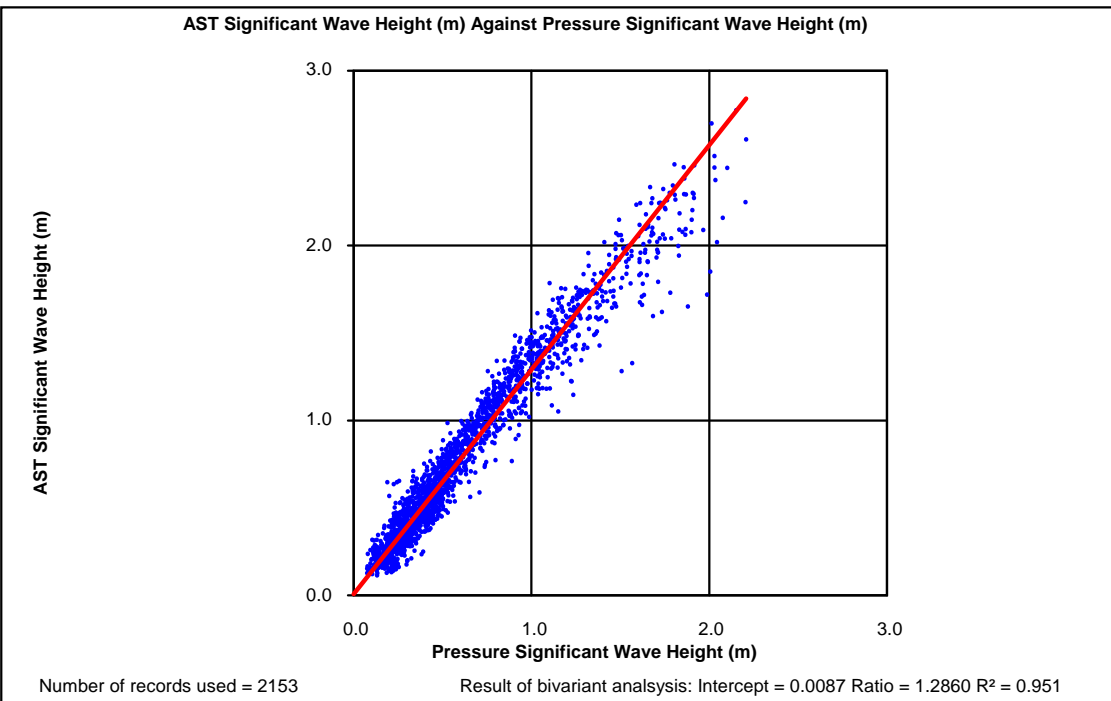
Aberdeen Harbour Expansion EIA, East, D1 - D2

D1: 57°08'0.84"N, 002°02'8.10"W D2: 57°08'0.72"N, 002°02'8.28"W D1 Site depth below LAT: 18.15m D2 Site depth below LAT: 19.06m
 Deployed: 20/02/2015 17:42 Recovered: 11/06/2015 08:50 Instrument height off seabed: 0.66m

Current Meter / AWAC
 Serial No.: 5615/1487

Frequency Distribution of Significant Wave Height (m) against Zero Up Crossing Period (sec)

	<0.2	<0.4	<0.6	<0.8	<1	<1.2	<1.4	<1.6	<1.8	<2	<2.2	<2.4	<2.6	<2.8	<3	<3.2	<3.4	<3.6	<3.8	<4	<4.2	<4.4	<4.6	<4.8	<5	Count	%		
<1																											0	0.000	
<2																												0	0.000
<3	79	239	27	2																							347	6.591	
<4	113	743	963	387	47	7																					2260	42.925	
<5	8	293	275	396	428	292	175	55	51	15	9	3	4	2													2006	38.101	
<6		7	25	32	22	60	78	101	78	57	49	41	27	16	10	9	1					2	1				616	11.700	
<7					1																						36	0.684	
<8																											0	0.000	
<9																											0	0.000	
<10																											0	0.000	
Count	200	1282	1290	817	498	359	253	157	135	78	60	49	34	26	13	10	1	0	0	2	1	0	0	0	0	0	5265	100	
%	3.799	24.349	24.501	15.518	9.459	6.819	4.805	2.982	2.564	1.481	1.140	0.931	0.646	0.494	0.247	0.190	0.019	0.000	0.000	0.038	0.019	0.000	0.000	0.000	0.000	0.000	100		
100.0	96.2	71.9	47.4	31.8	22.4	15.6	10.8	7.8	5.2	3.7	2.6	1.7	1.0	0.5	0.3	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	% Exceedence		



**APPENDIX B
TIDAL DATA PRESENTATION**

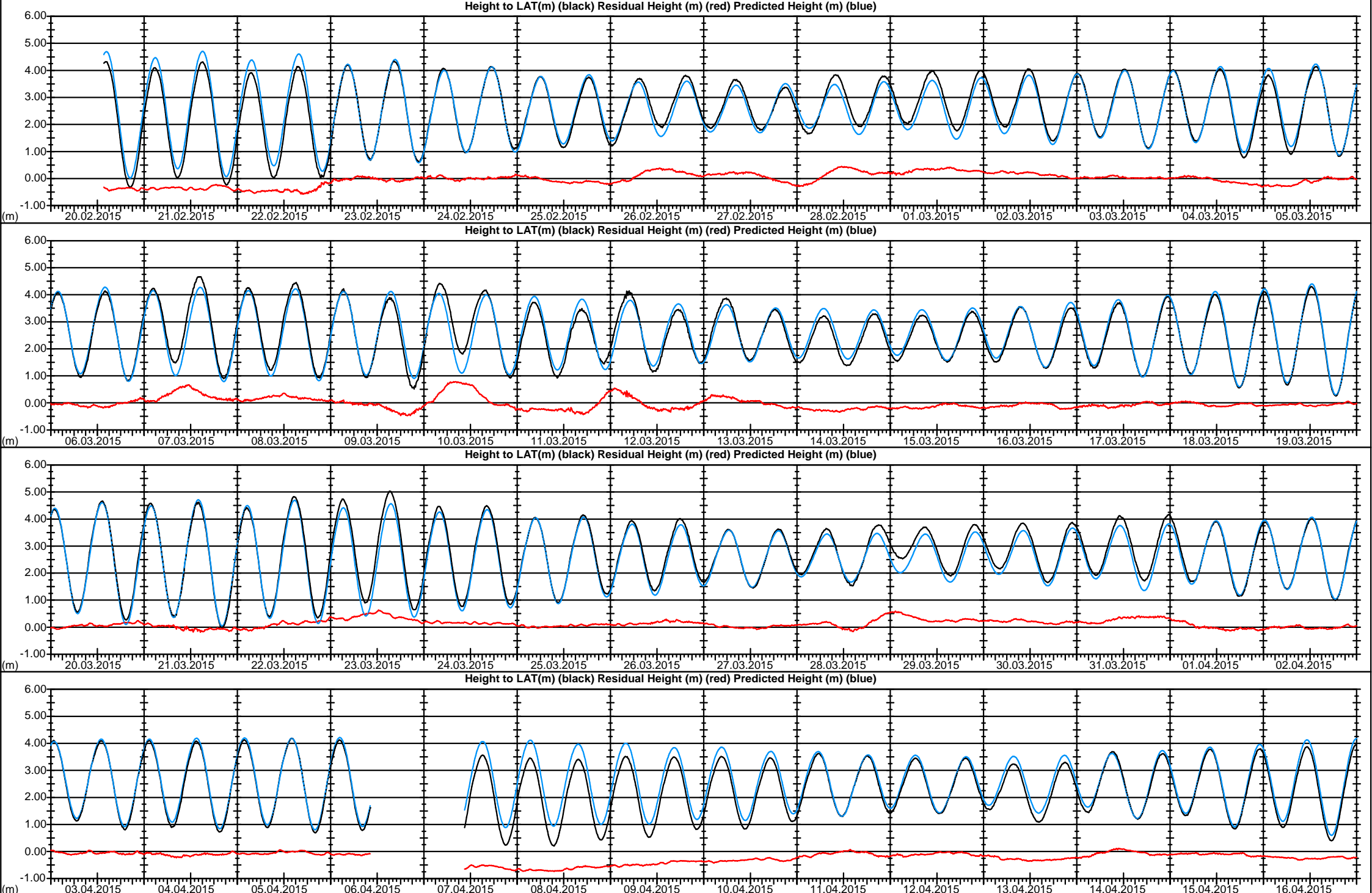
CONTENTS

Figure or Table Number	Location	Data Presentation Type	Description
Figure B001 – B002	West	Time Series	Tidal height to LAT, residual and predicted height
Table B001	West	Tidal Height Harmonic Analysis Report	Speed, amplitude and phase lag of tidal constituents
Figure B003 – B004	East	Time Series	Tidal height to LAT, residual and predicted height
Table B002	East	Tidal Height Harmonic Analysis Report	Speed, amplitude and phase lag of tidal constituents

Aberdeen Harbour Expansion EIA, West, D1 - D2

D1 Latitude: 57°07'59.64"N D1 Longitude: 002°02'57.60"W, D2 Latitude: 57°08'0.96"N Longitude: 002°02'59.76"W D1 Site depth below LAT: 5.75m D2 Site depth below LAT: 6.16m Instrument height off seabed: 0.68m
Deployed: 20/02/2015 13:36 Recovered: 11/06/2015 10:46

Current Meter / AWAC
Serial No.: 5115/1487



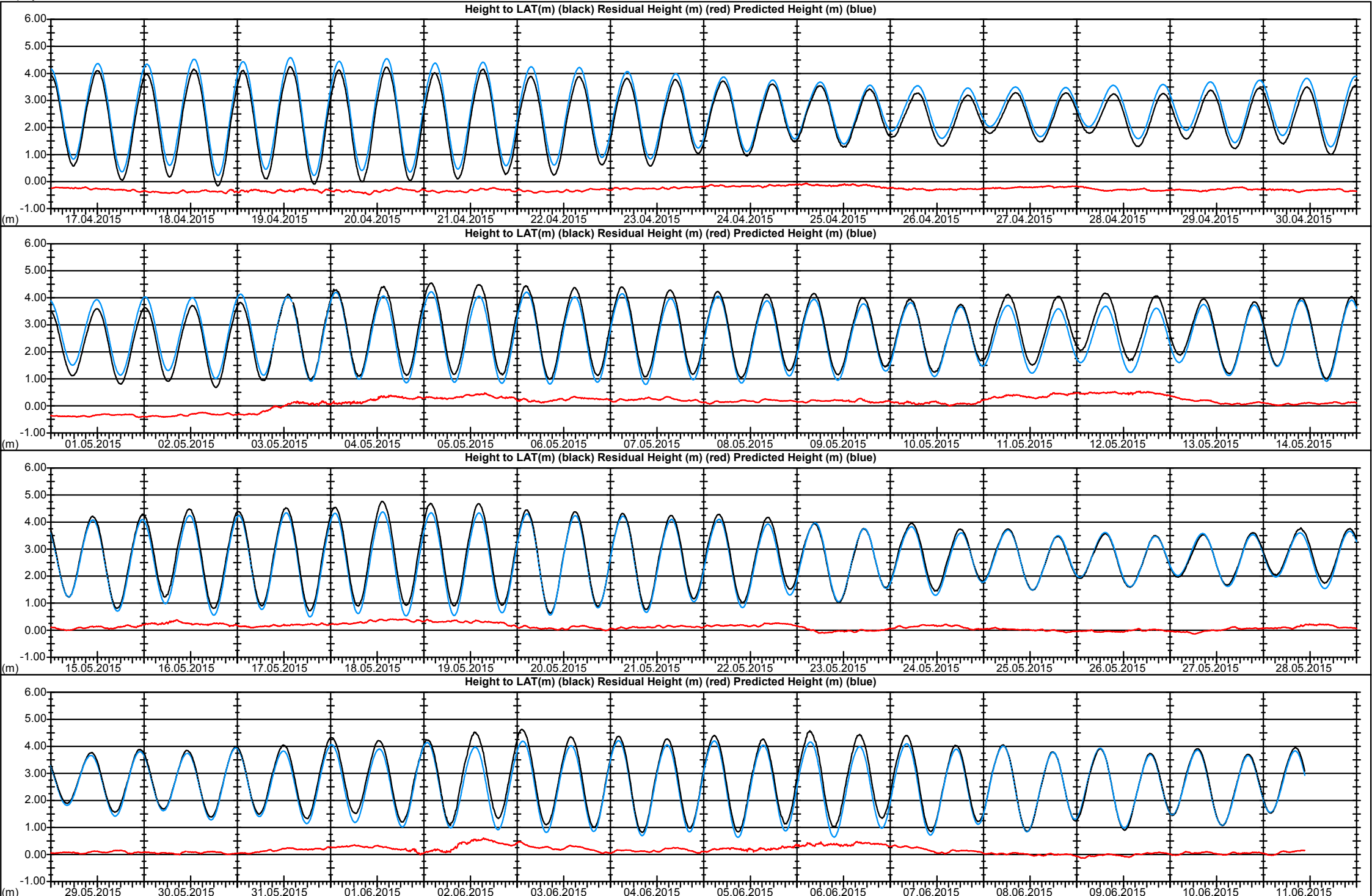
Aberdeen Harbour Expansion EIA, West, D1 - D2

D1 Latitude: 57°07'59.64"N D1 Longitude: 002°02'57.60"W, D2 Latitude: 57°08'0.96"N Longitude: 002°02'59.76"W D1 Site depth below LAT: 5.75m D2 Site depth below LAT: 6.16m Instrument height off seabed: 0.68m

Current Meter / AWAC

Deployed: 20/02/2015 13:36 Recovered: 11/06/2015 10:46

Serial No.: 5115/1487



TIDAL HEIGHT HARMONIC ANALYSIS REPORT

Job Number: J/3/01/2774 Aberdeen Harbour Expansion EIA, West, D1 - D2

Analysis of Current Meter / AWAC Serial No. 5115

Geographical Position: D1 Latitude: 57°07'59.64"N D1 Longitude: 002°02'57.60"W

D2 Latitude: 57°08'0.96"N Longitude: 002°02'59.76"W

Analysis of observations for period: Deployed: 20/02/2015 13:36 Recovered: 11/06/2015 10:46

Seed file for separation of related constituents: NTSLF_AB (60)

Speed is in degrees per hour: a constant for each constituent.

Amplitude (H) is in cm.

Phase lag (g) is in degrees and synchronises the harmonic to GMT (UT).

Tidal form factor: 0.15 indicative of a Semidiurnal tide

RELATED CONSTITUENTS

Number	Constant	Reference	Speed(°/h)	Amplitude	Phase lag
1	PI1	K1	14.9178647	0.5	170.1
2	P1	K1	14.9589314	3.7	192.9
3	PSI1	K1	15.0821353	0.2	110.4
4	PHI1	K1	15.1232059	0.5	26.1
5	2N2	N2	27.8953548	3.3	347.4
6	NU2	N2	28.5125831	5.3	6.5
7	T2	S2	29.9589333	2.1	56.4
8	K2	S2	30.0821373	12.1	63.4

MAJOR CONSTITUENTS

Number	Constant	Speed(°/h)	Amplitude	Phase lag
1	Mean		255.6	
2	MM	0.5443747	6.7	188.5
3	MSF	1.0158958	4.0	242.6
4	Q1	13.3986609	4.4	346.9
5	O1	13.9430356	12.4	51.9
6	M1	14.4920521	1.1	251.6
7	K1	15.0410686	12.9	199.1
8	J1	15.5854433	1.3	8.2
9	OO1	16.1391017	3.2	297.0
10	MU2	27.9682084	2.1	311.5
11	N2	28.4397295	26.3	2.3
12	M2	28.9841042	130.1	25.7
13	L2	29.5284789	5.4	60.3
14	S2	30.0000000	43.5	64.5
15	2SM2	31.0158958	0.6	282.3
16	MO3	42.9271398	1.4	9.5
17	M3	43.4761563	0.9	324.6
18	MK3	44.0251729	0.7	119.2
19	MN4	57.4238337	0.9	136.3
20	M4	57.9682084	3.9	166.7
21	SN4	58.4397295	0.8	242.5
22	MS4	58.9841042	3.2	239.8
23	2MN6	86.4079380	0.3	74.3
24	M6	86.9523127	0.6	124.4
25	MSN6	87.4238337	0.1	173.5
26	2MS6	87.9682084	0.4	183.4
27	2SM6	88.9841042	0.1	45.7

VARIANCE ORIGINAL (VO)	1.139	HAT:	4.766m	MSR:	3.472m
VARIANCE RESIDUAL (VR)	0.05788	MHWS:	4.292m	MR:	2.602m
RATIO VR/VO	0.0508	MHWN:	3.422m	MNR:	1.732m
SQRT(VO)	1.067	MSL:	2.556m	MHWI:	0.979 Hours
SQRT(VR)	0.24059	MLWN:	1.690m	MLWI:	6.995 Hours
RATIO SQRT(VR)/SQRT(VO)	0.2254	MLWS:	0.820m		
		LAT:	0.000m		

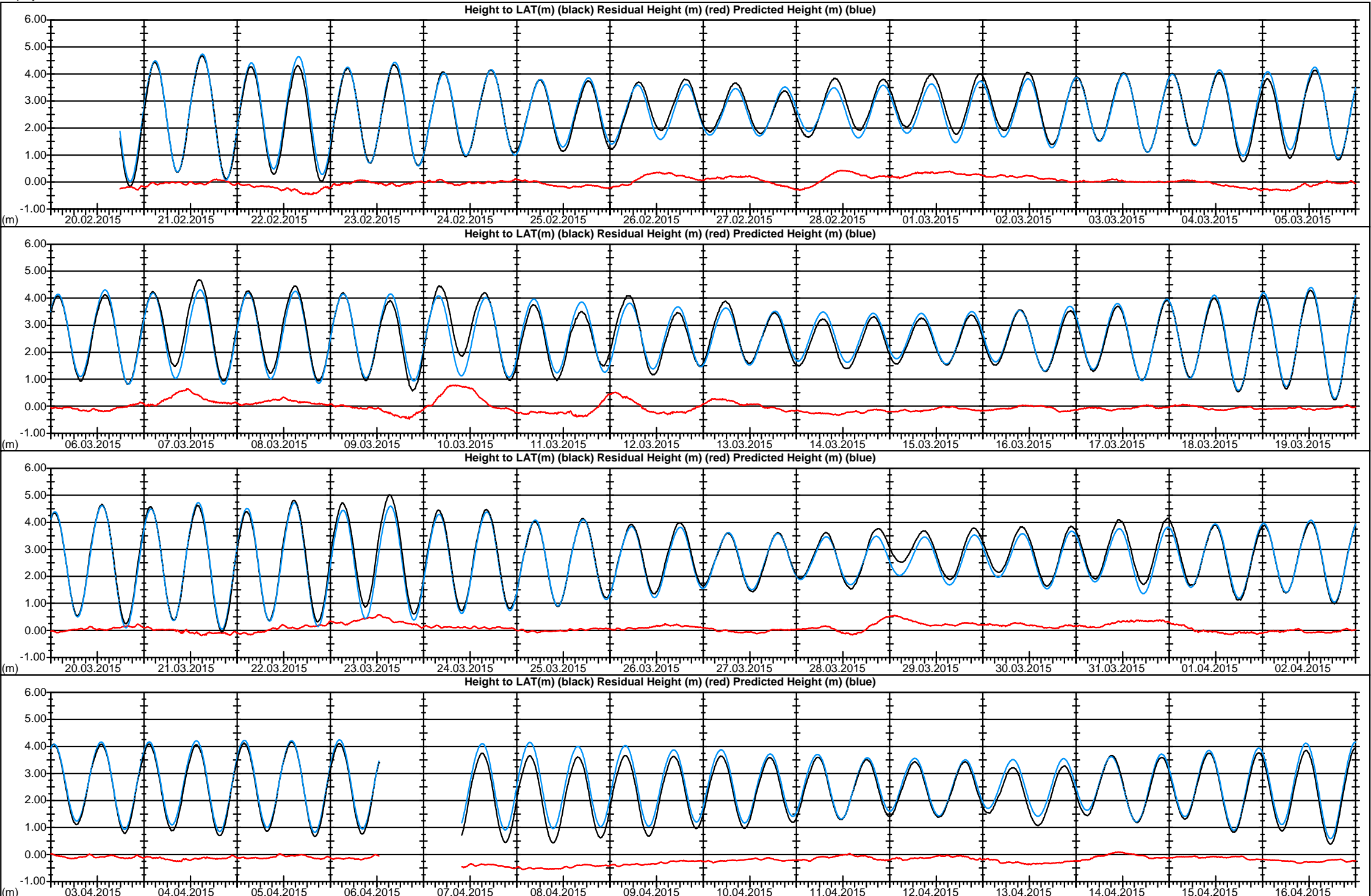
Aberdeen Harbour Expansion EIA, East, D1 - D2

D1 Latitude: 57°08'0.84"N D1 Longitude: 002°02'8.10"W D2 Latitude: 57°08'0.72"N D2 Longitude: 002°02'8.28"W D1 Site depth below LAT: 18.15m D2 Site depth below LAT: 19.06m Instrument height off seabed: 0.66m

Current Meter / AWAC

Deployed: 20/02/2015 17:42 Recovered: 11/06/2015 08:50

Serial No.: 5615/1487



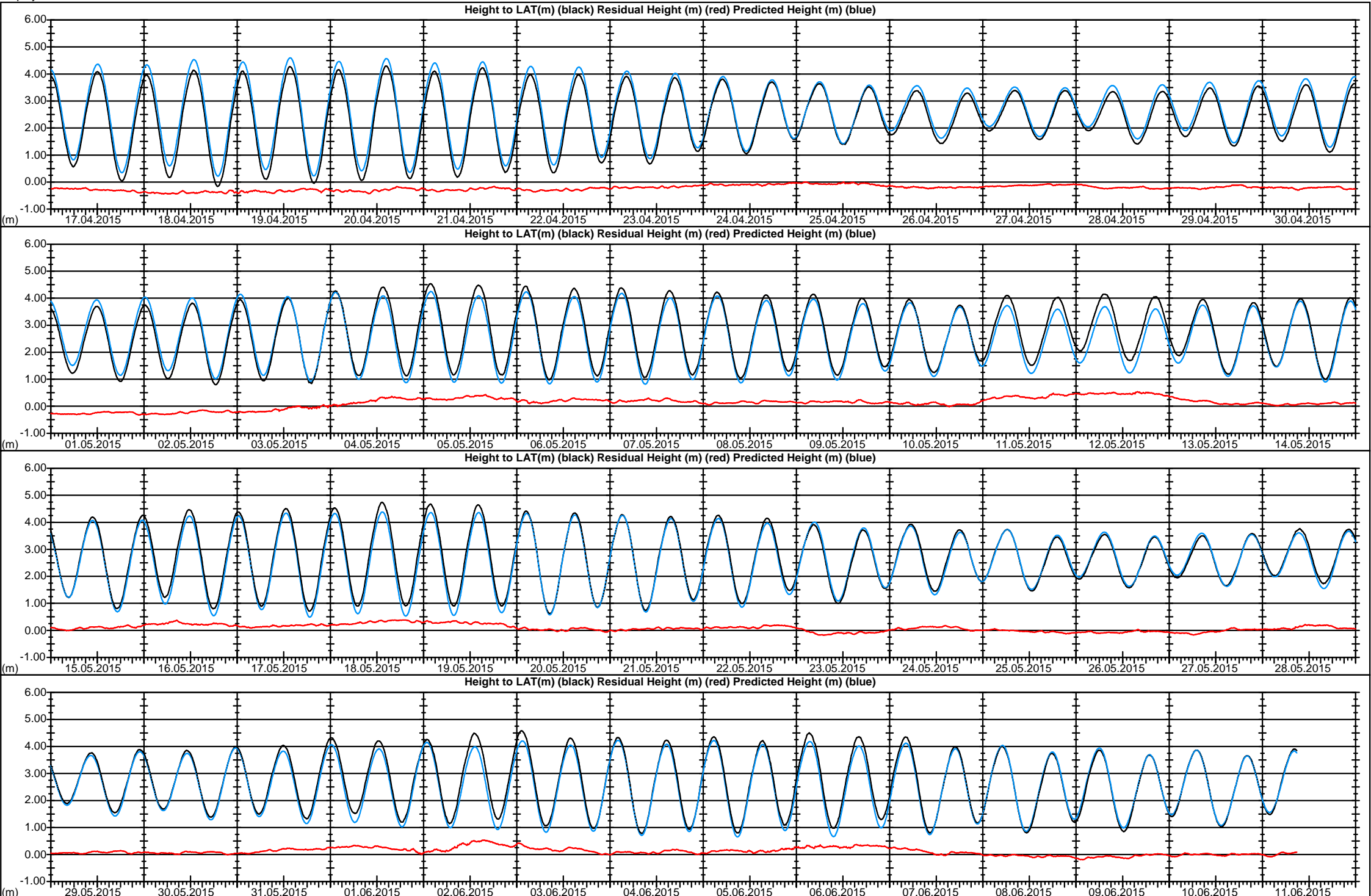
Aberdeen Harbour Expansion EIA, East, D1 - D2

D1 Latitude: 57°08'0.84"N D1 Longitude: 002°02'8.10"W D2 Latitude: 57°08'0.72"N D2 Longitude: 002°02'8.28"W D1 Site depth below LAT: 18.15m D2 Site depth below LAT: 19.06m Instrument height off seabed: 0.66m

Current Meter / AWAC

Deployed: 20/02/2015 17:42 Recovered: 11/06/2015 08:50

Serial No.: 5615/1487



TIDAL HEIGHT HARMONIC ANALYSIS REPORT

Job Number: J/3/01/2774 Aberdeen Harbour Expansion EIA, East, D1 - D2

Analysis of Current Meter / AWAC Serial No. 5615

Geographical Position: D1 Latitude: 57°08'0.84"N D1 Longitude: 002°02'8.10"W

D2 Latitude: 57°08'0.72"N D2 Longitude: 002°02'8.28"W

Analysis of observations for period: Deployed: 20/02/2015 17:42 Recovered: 11/06/2015 08:50

Seed file for separation of related constituents: NTSLF_AB (60)

Speed is in degrees per hour: a constant for each constituent.

Amplitude (H) is in cm.

Phase lag (g) is in degrees and synchronises the harmonic to GMT (UT).

Tidal form factor: 0.15 indicative of a Semidiurnal tide

RELATED CONSTITUENTS

Number	Constant	Reference	Speed(°/h)	Amplitude	Phase lag
1	PI1	K1	14.9178647	0.5	170.5
2	P1	K1	14.9589314	3.7	193.3
3	PSI1	K1	15.0821353	0.2	110.8
4	PHI1	K1	15.1232059	0.5	26.5
5	2N2	N2	27.8953548	3.3	347.4
6	NU2	N2	28.5125831	5.3	6.5
7	T2	S2	29.9589333	2.1	56.5
8	K2	S2	30.0821373	12.2	63.5

MAJOR CONSTITUENTS

Number	Constant	Speed(°/h)	Amplitude	Phase lag
1	Mean		256.9	
2	MM	0.5443747	7.5	186.5
3	MSF	1.0158958	3.0	222.7
4	Q1	13.3986609	4.4	347.7
5	O1	13.9430356	12.4	51.5
6	M1	14.4920521	1.1	250.0
7	K1	15.0410686	12.9	199.5
8	J1	15.5854433	1.4	2.0
9	OO1	16.1391017	3.4	293.3
10	MU2	27.9682084	2.3	312.9
11	N2	28.4397295	26.3	2.3
12	M2	28.9841042	130.3	25.7
13	L2	29.5284789	5.3	60.2
14	S2	30.0000000	43.7	64.6
15	2SM2	31.0158958	0.5	273.0
16	MO3	42.9271398	1.3	10.5
17	M3	43.4761563	0.9	325.8
18	MK3	44.0251729	0.7	113.4
19	MN4	57.4238337	0.9	134.8
20	M4	57.9682084	3.8	168.1
21	SN4	58.4397295	0.7	236.7
22	MS4	58.9841042	3.2	240.6
23	2MN6	86.4079380	0.3	77.1
24	M6	86.9523127	0.6	123.7
25	MSN6	87.4238337	0.1	188.2
26	2MS6	87.9682084	0.5	187.4
27	2SM6	88.9841042	0.1	16.0

VARIANCE ORIGINAL (VO)	1.126	HAT:	4.801m	MSR:	3.480m
VARIANCE RESIDUAL (VR)	0.04269	MHWS:	4.309m	MR:	2.606m
RATIO VR/VO	0.0379	MHWN:	3.435m	MNR:	1.732m
SQRT(VO)	1.061	MSL:	2.569m	MHWI:	0.849 Hours
SQRT(VR)	0.20661	MLWN:	1.703m	MLWI:	7.163 Hours
RATIO SQRT(VR)/SQRT(VO)	0.1947	MLWS:	0.829m		
		LAT:	0.000m		

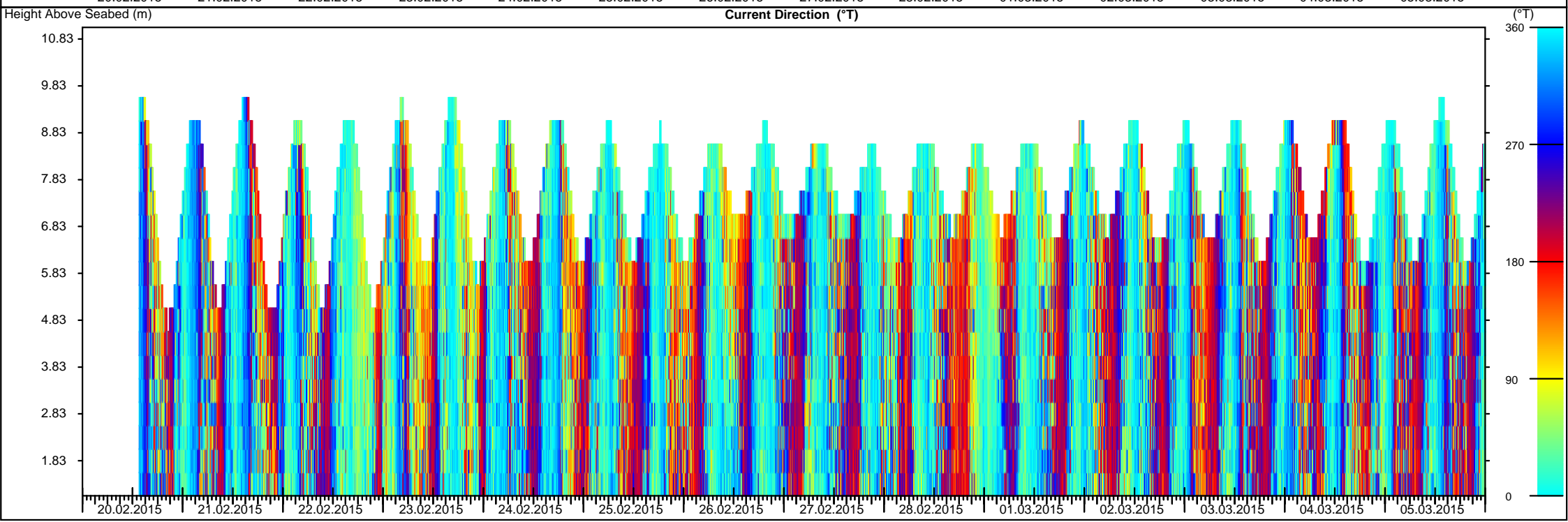
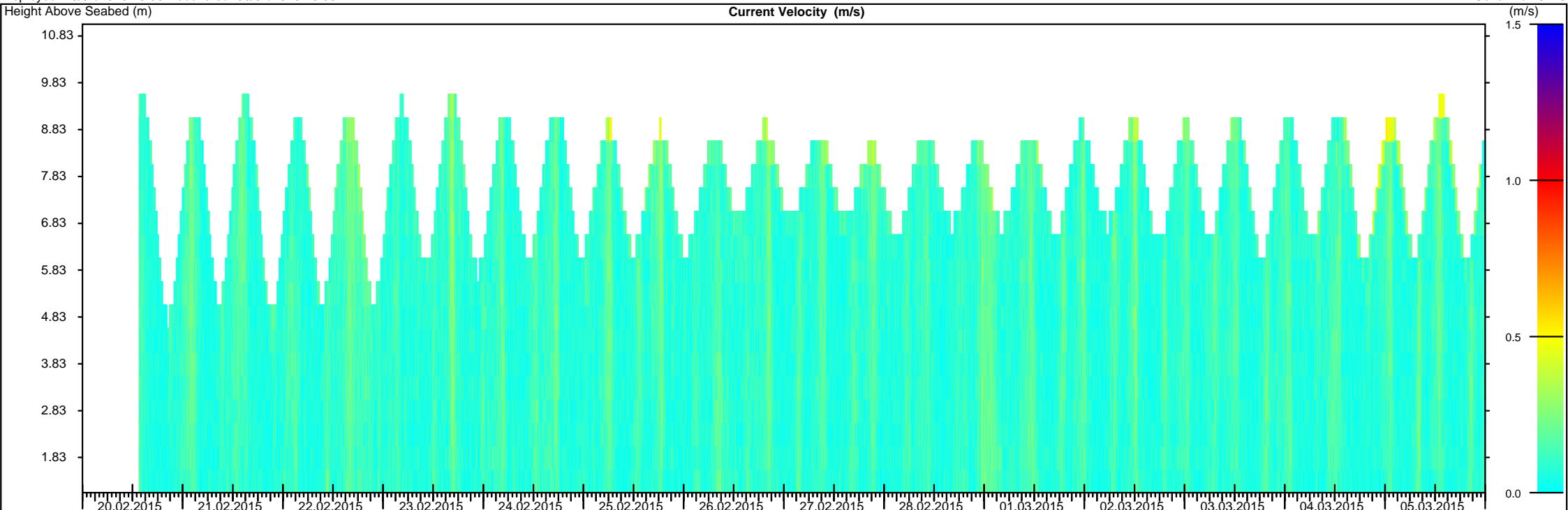
**APPENDIX C
CURRENT DATA PRESENTATION**

CONTENTS

Figure or Table Number	Location	Data Presentation Type	Description
Figure C001 – C004	West	Colour Contour Time Series	Current velocity and direction throughout the water column
Figure C005 – C008	West	Time Series	Depth averaged velocity, direction, easting and northing with residual velocity, easting and northing
Figure C009	West	Scatter Plot	Depth averaged current velocity with predicted velocity
Table C001	West	Current Speed Harmonic Analysis Report	Speed, amplitude and phase lag of the easting and northing components of each harmonic constituent
Figure C010 – C017	East	Colour Contour Time Series	Current velocity and direction throughout the water column
Figure C018 – C025	East	Time Series	Depth averaged velocity, direction, easting and northing with residual velocity, easting and northing
Figure C026	East	Scatter Plot	Depth averaged current velocity with predicted velocity
Table C002	East	Current Speed Harmonic Analysis Report	Speed, amplitude and phase lag of the easting and northing components of each harmonic constituent

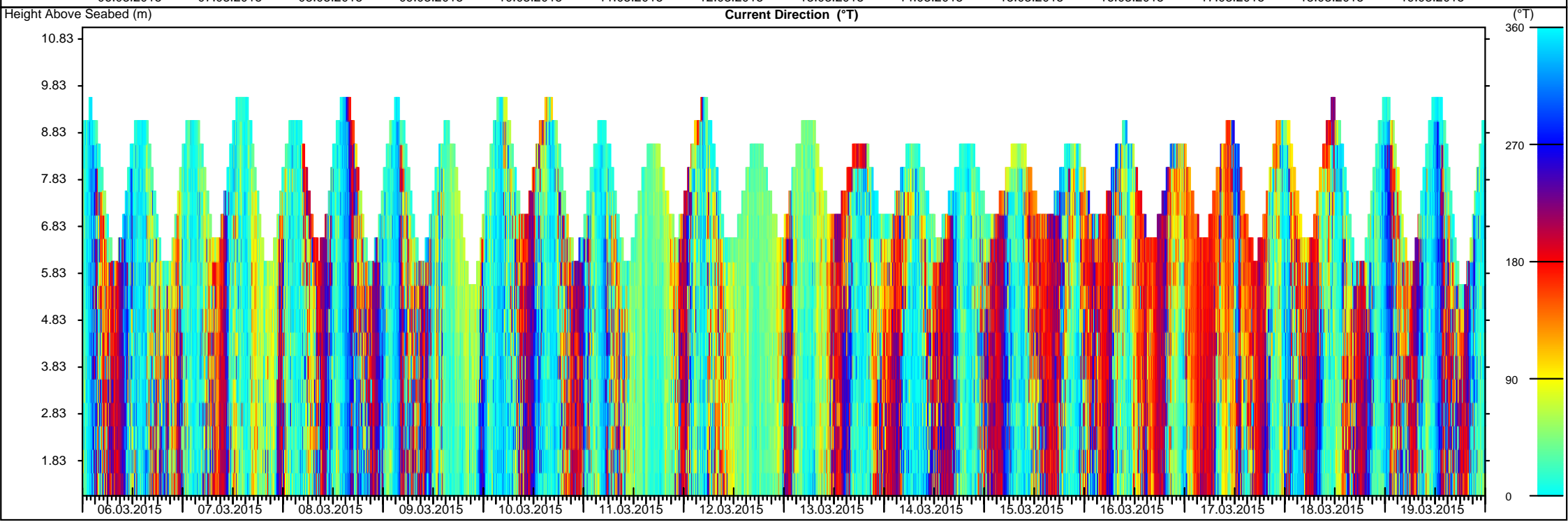
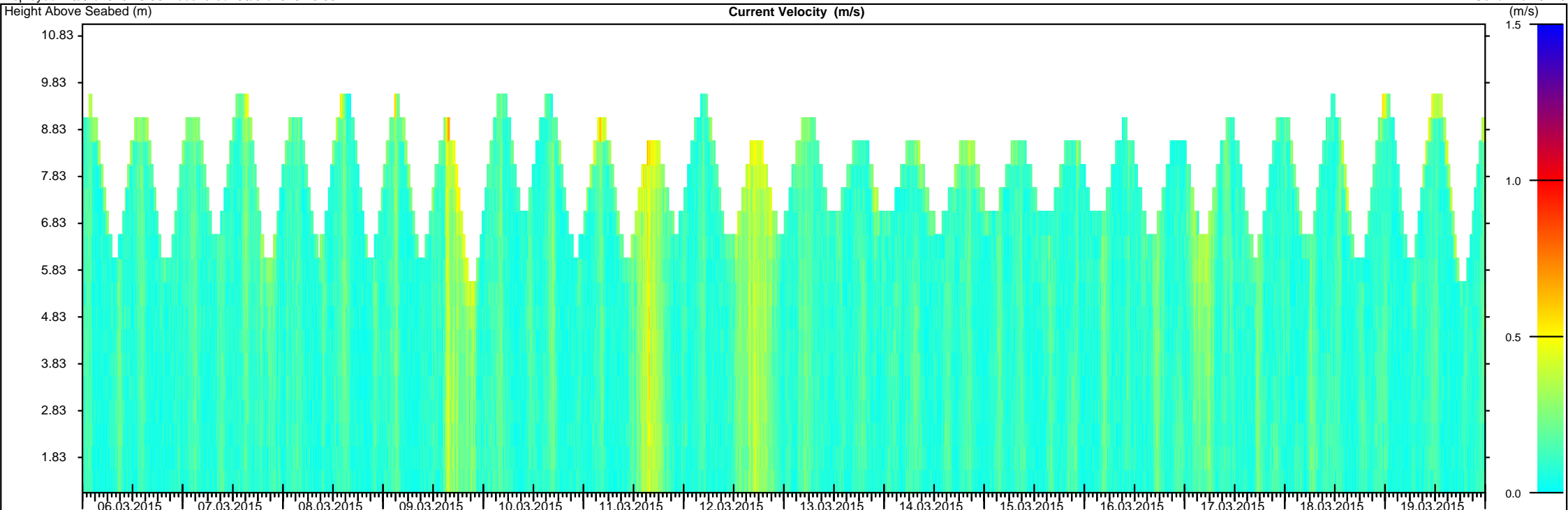
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Deployed: 20/02/2015 13:36 Recovered: 06/04/2015 10:30

Current Meter / AWAC
Serial No.: 5115



Latitude: 57°07'59.64"N Longitude: 002°02'57.60"W Site depth below LAT: 5.75m Instrument height off seabed: 0.68m
Deployed: 20/02/2015 13:36 Recovered: 06/04/2015 10:30

Current Meter / AWAC
Serial No.: 5115

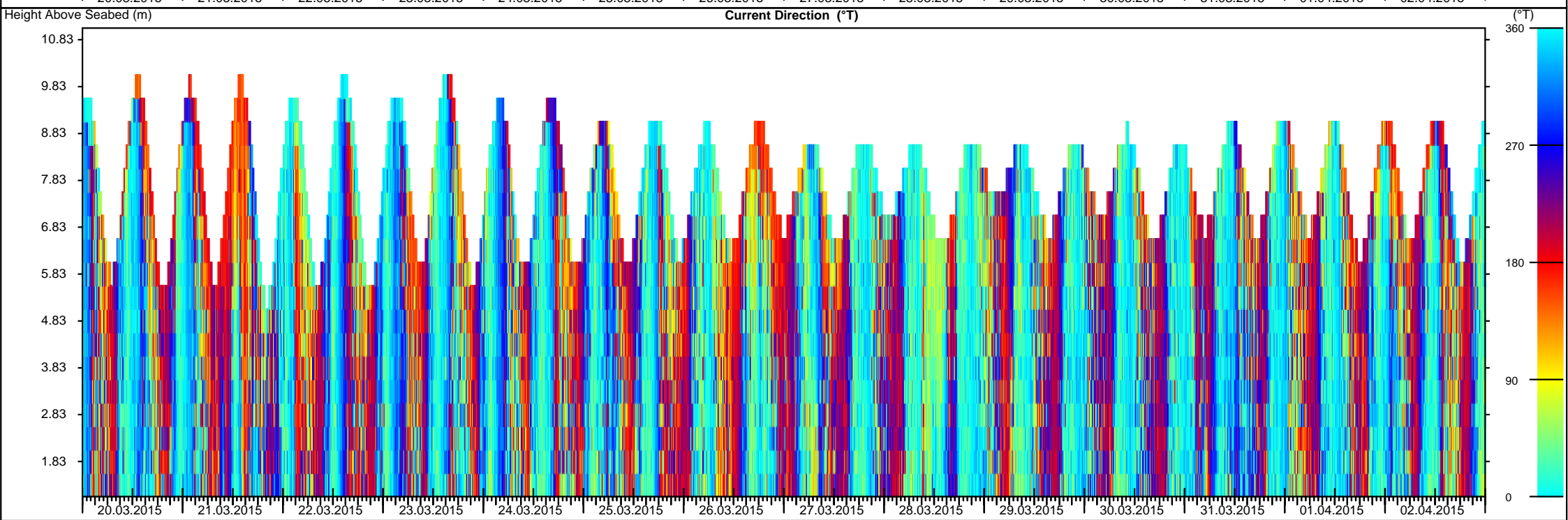
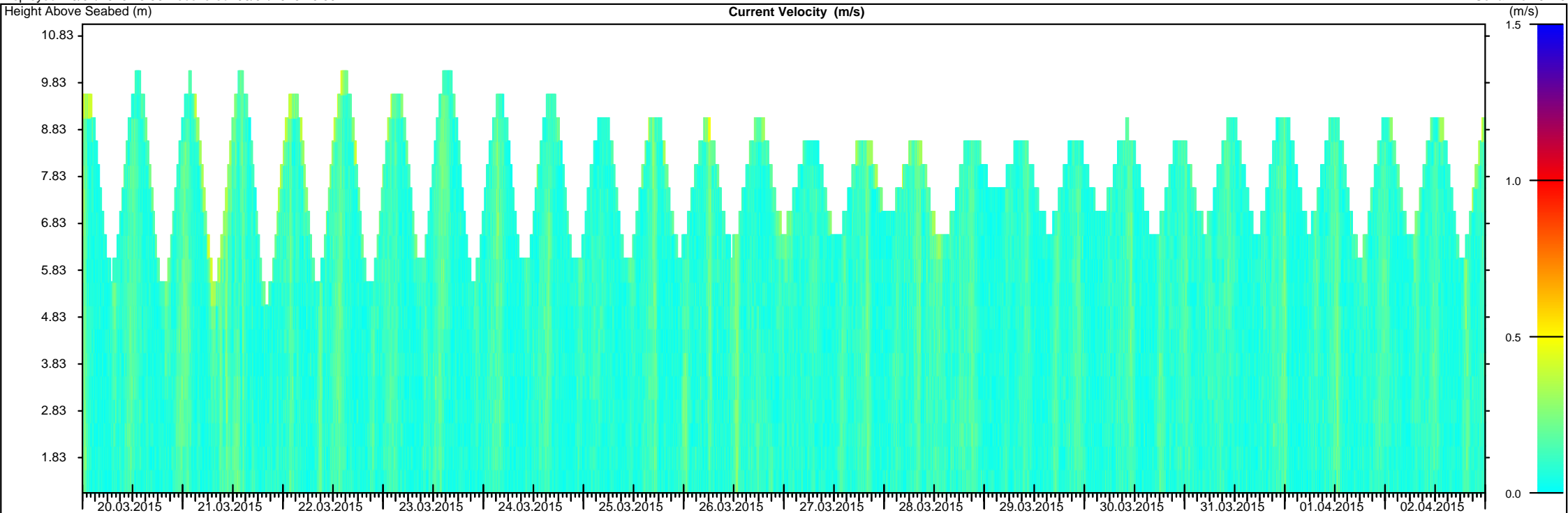


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Current Meter / AWAC

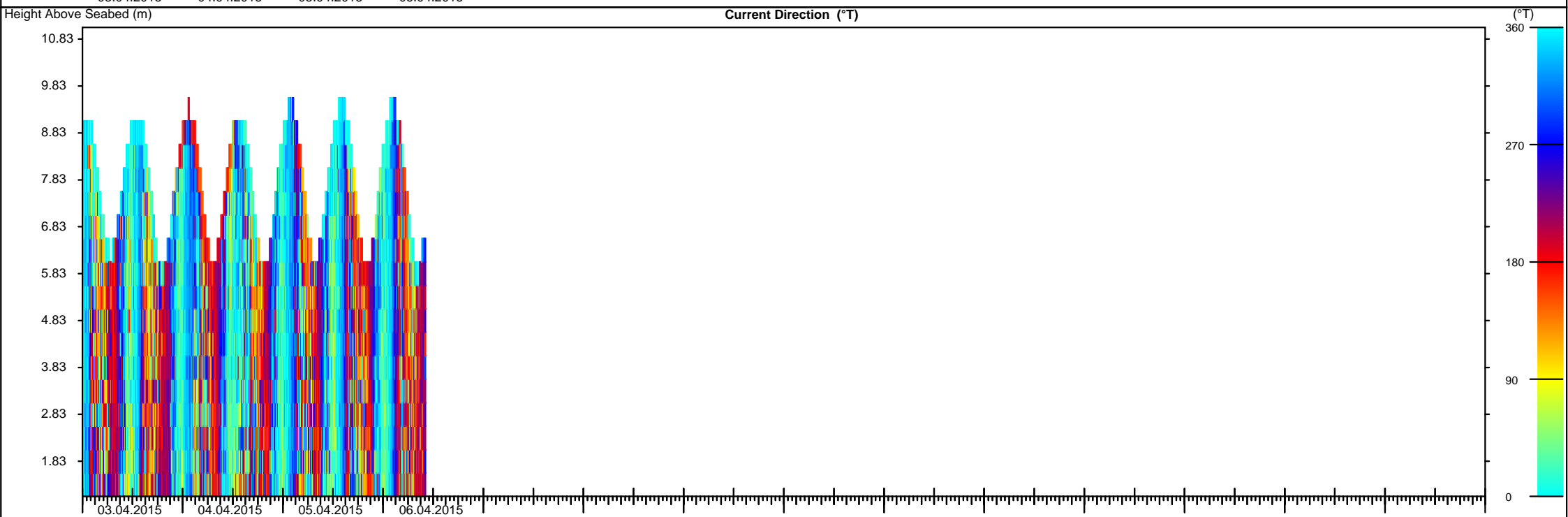
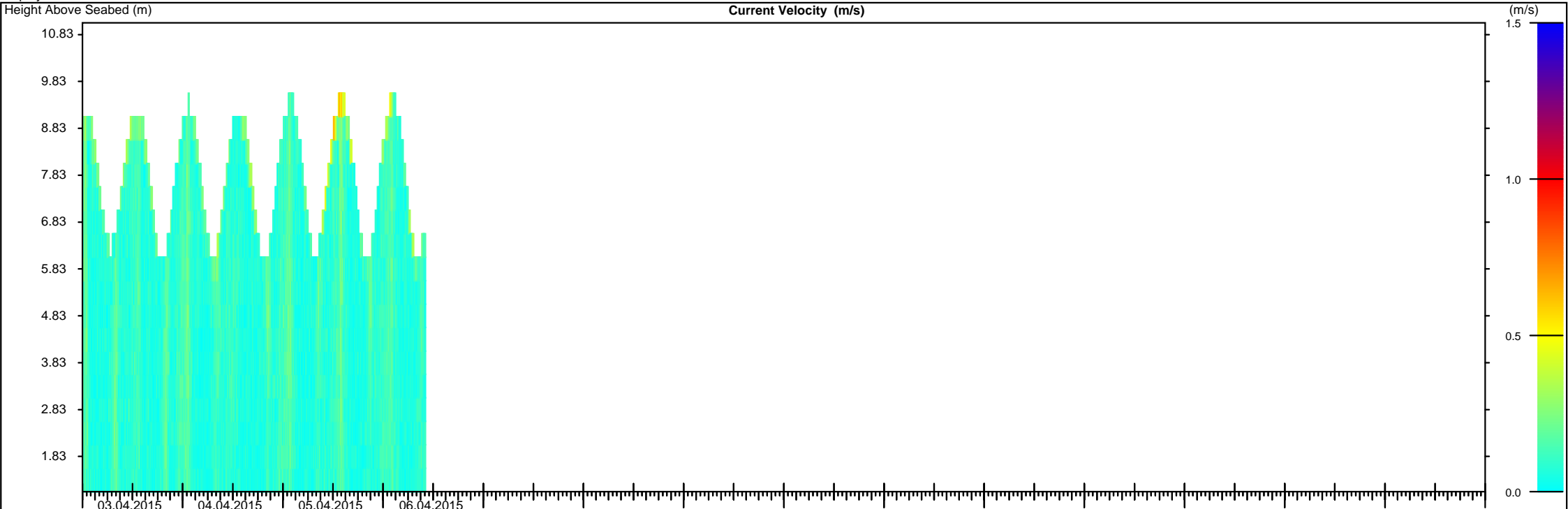
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Serial No.: 5115



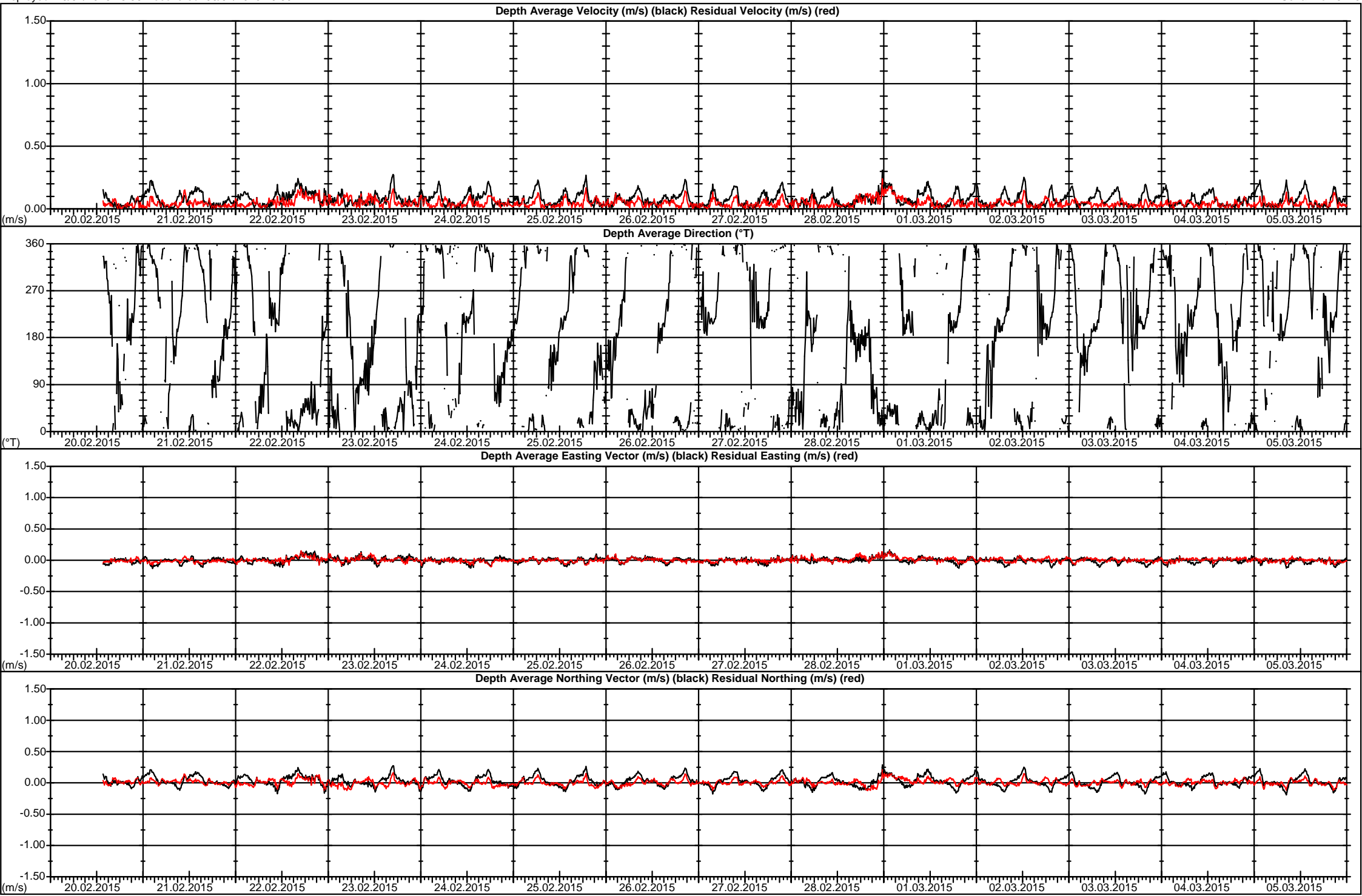
Latitude: 57°07'59.64"N Longitude: 002°02'57.60"W Site depth below LAT: 5.75m Instrument height off seabed: 0.68m
Deployed: 20/02/2015 13:36 Recovered: 06/04/2015 10:30

Current Meter / AWAC
Serial No.: 5115



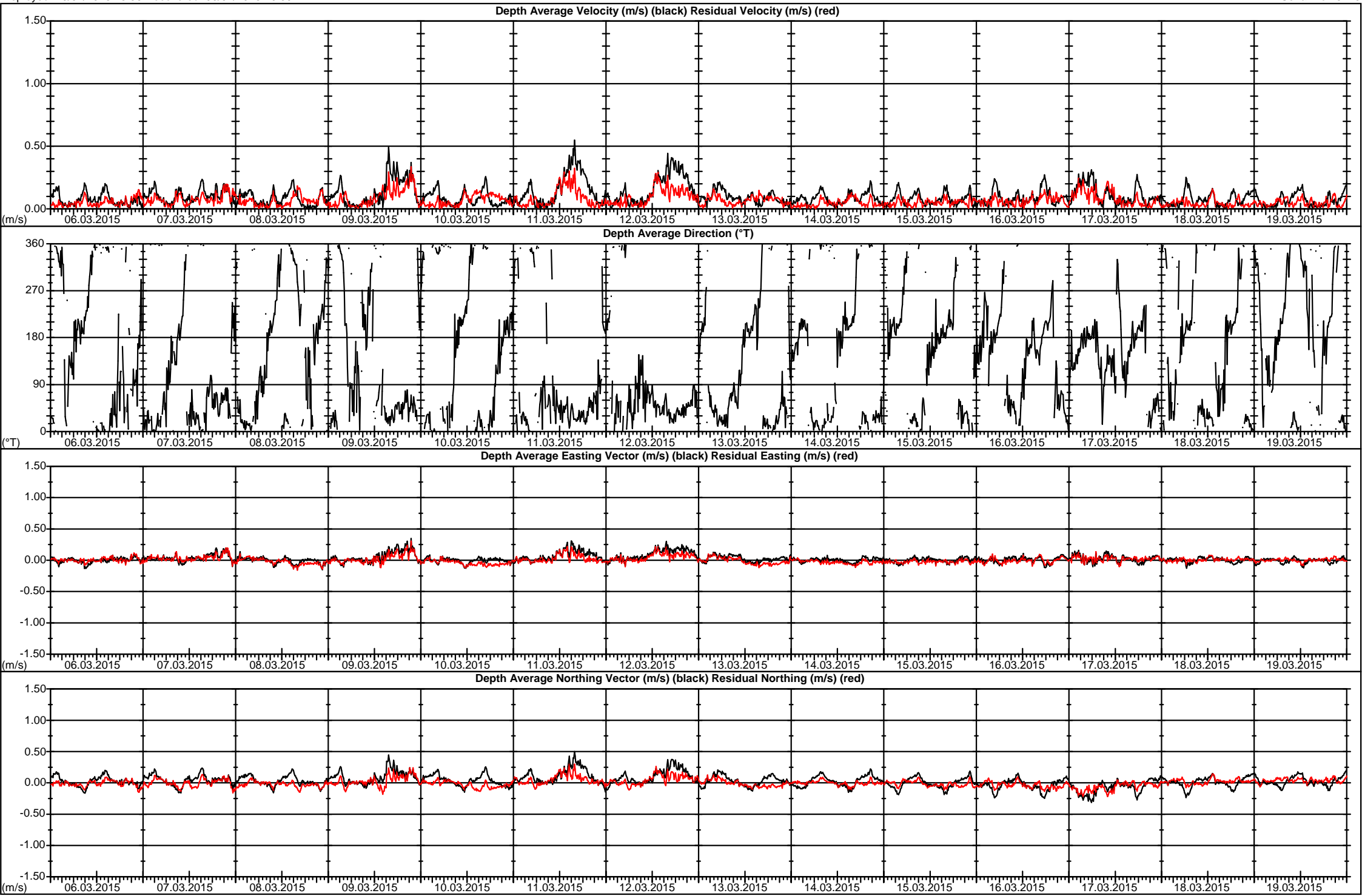
Latitude: 57°07'59.64"N Longitude: 002°02'57.60"W Site depth below LAT: 5.75m Instrument height off seabed: 0.68m
Deployed: 20/02/2015 13:36 Recovered: 06/04/2015 10:30

Current Meter / AWAC
Serial No.: 5115



Latitude: 57°07'59.64"N Longitude: 002°02'57.60"W Site depth below LAT: 5.75m Instrument height off seabed: 0.68m
Deployed: 20/02/2015 13:36 Recovered: 06/04/2015 10:30

Current Meter / AWAC
Serial No.: 5115

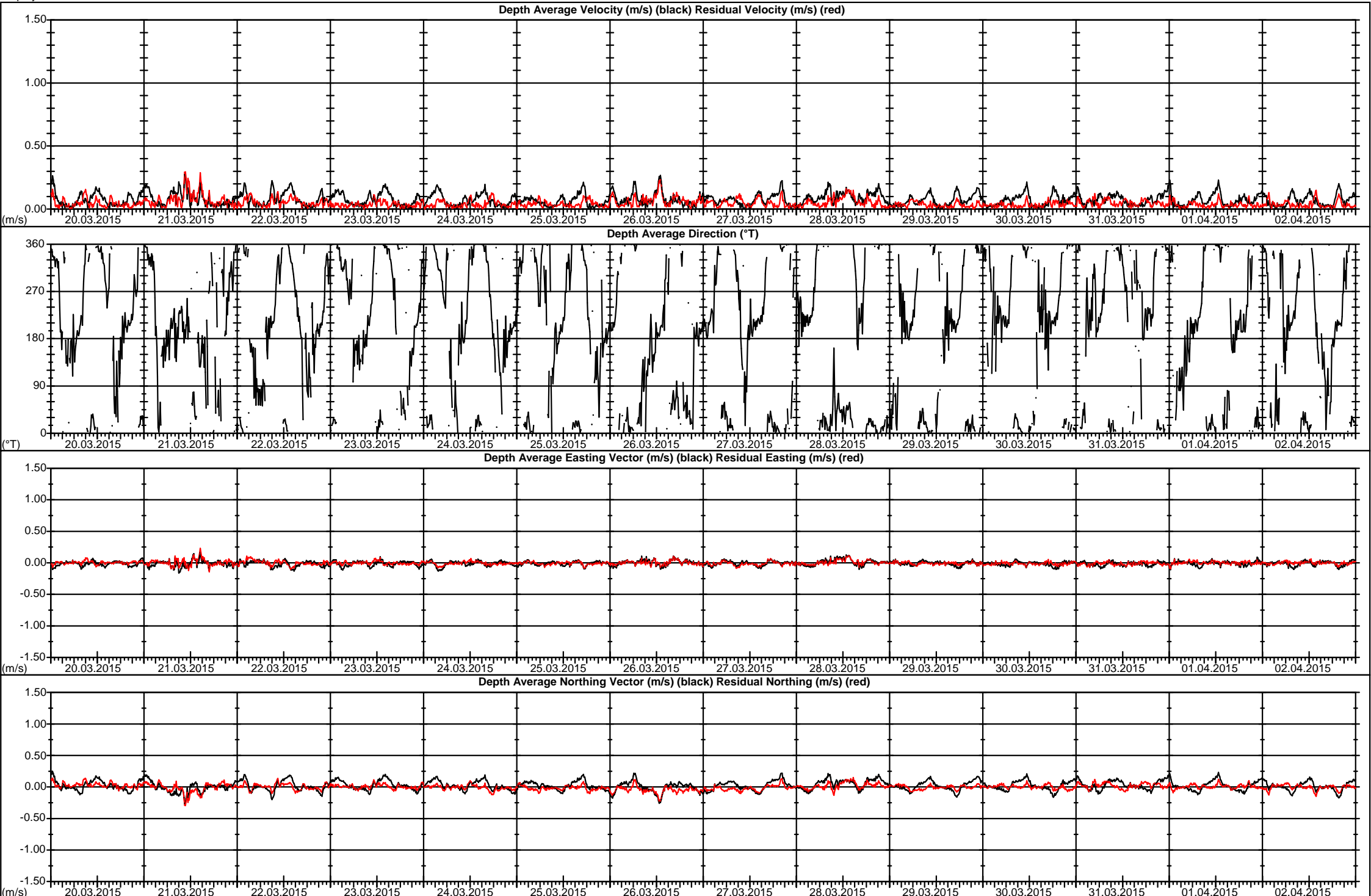


Latitude: 57°07'59.64"N Longitude: 002°02'57.60"W Site depth below LAT: 5.75m Instrument height off seabed: 0.68m

Current Meter / AWAC

Deployed: 20/02/2015 13:36 Recovered: 06/04/2015 10:30

Serial No.: 5115

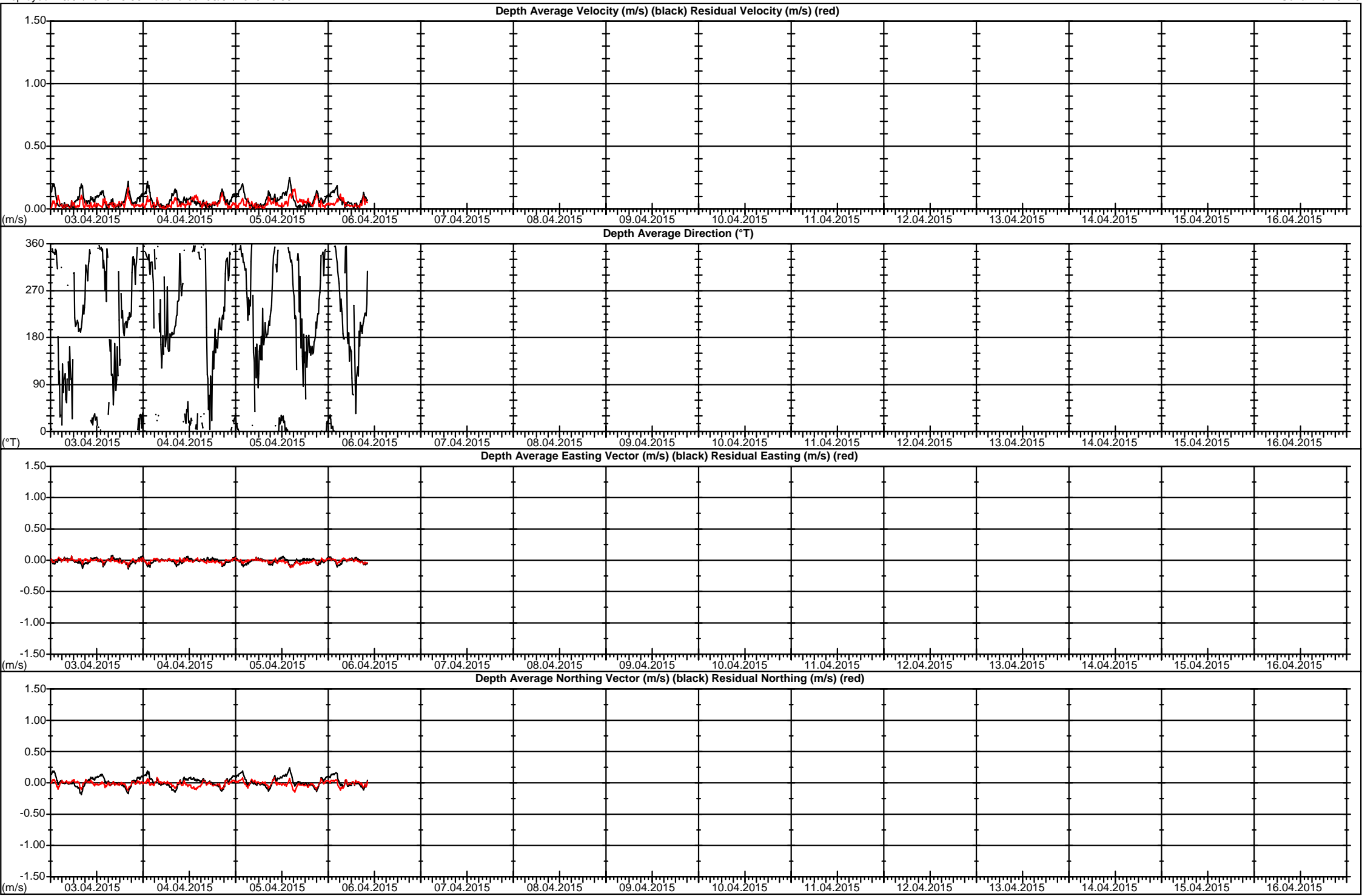


Latitude: 57°07'59.64"N Longitude: 002°02'57.60"W Site depth below LAT: 5.75m Instrument height off seabed: 0.68m

Current Meter / AWAC

Deployed: 20/02/2015 13:36 Recovered: 06/04/2015 10:30

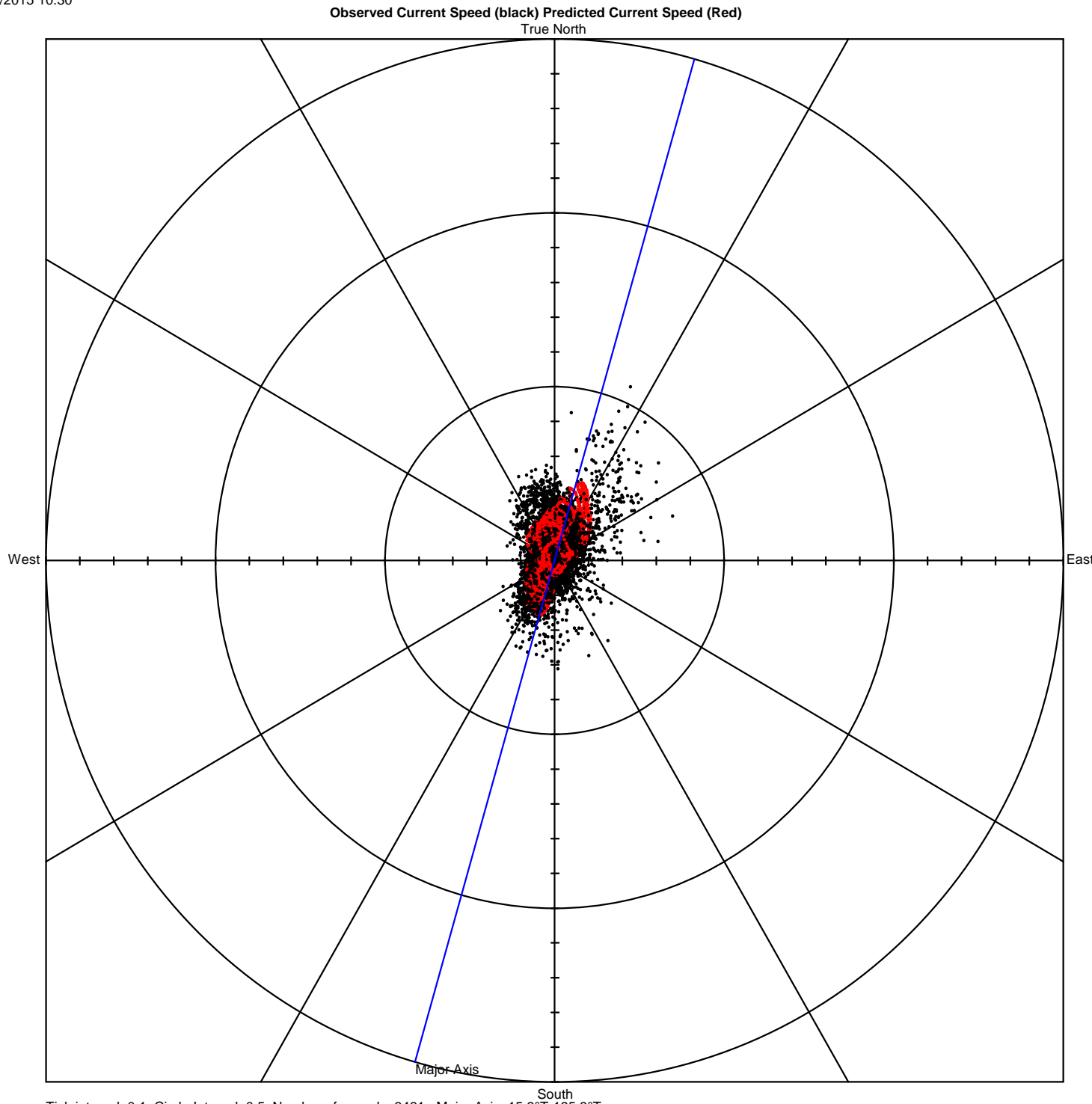
Serial No.: 5115



Current Data Speed and Direction Scatter Plot Aberdeen Harbour Expansion EIA, West, D1

Latitude: 57°07'59.64"N Longitude: 002°02'57.60"W Site depth below LAT: 5.75m Instrument height off seabed: 0.68m
Deployed: 20/02/2015 13:36 Recovered: 06/04/2015 10:30

Current Meter / AWAC
Serial No.: 5115



Tick interval: 0.1 Circle Interval: 0.5 Number of records: 6461 Major Axis: 15.9°T-195.9°T

Table C001

CURRENT SPEED HARMONIC ANALYSIS REPORT

Job Number: J/3/01/2774Aberdeen Harbour Expansion EIA, West, D1

Analysis of Current Meter / AWAC Serial No. 5115

Geographical Position: Latitude: 57°07'59.64"N Longitude: 002°02'57.60"W

Analysis of observations for period: Deployed: 20/02/2015 13:36 Recovered: 06/04/2015 10:30

Seed file for separation of related constituents: NTSLF_AB (60)

Speed is in degrees per hour: a constant for each constituent.

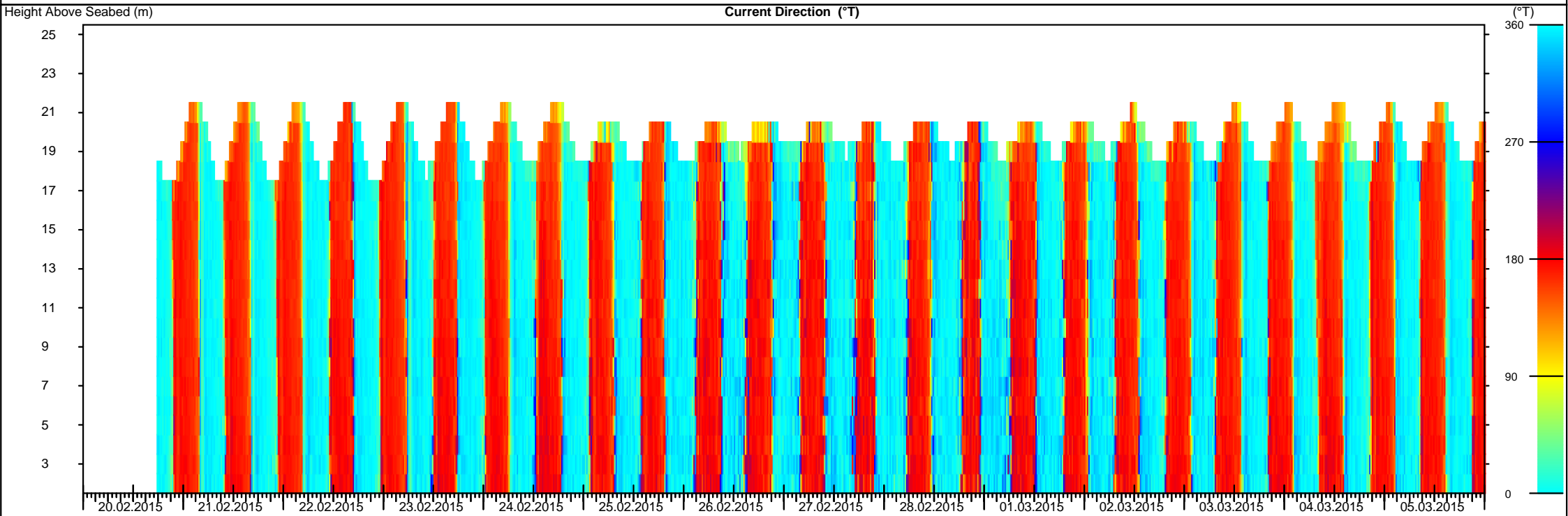
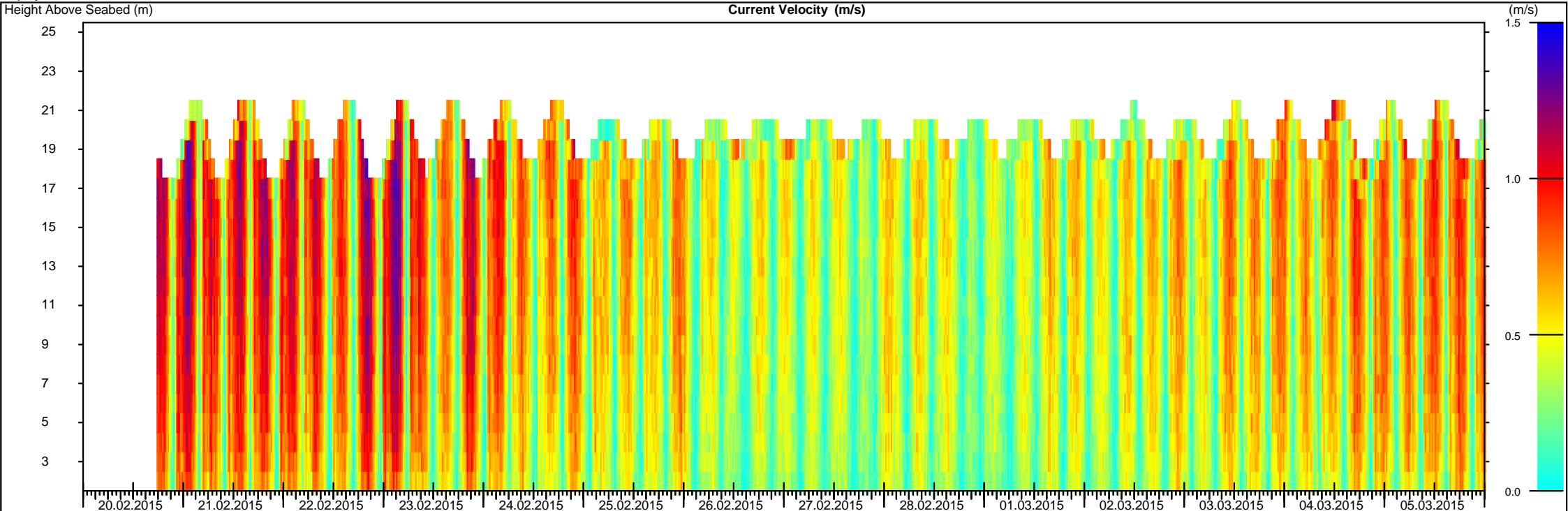
Amplitude (H) is in cm/s.

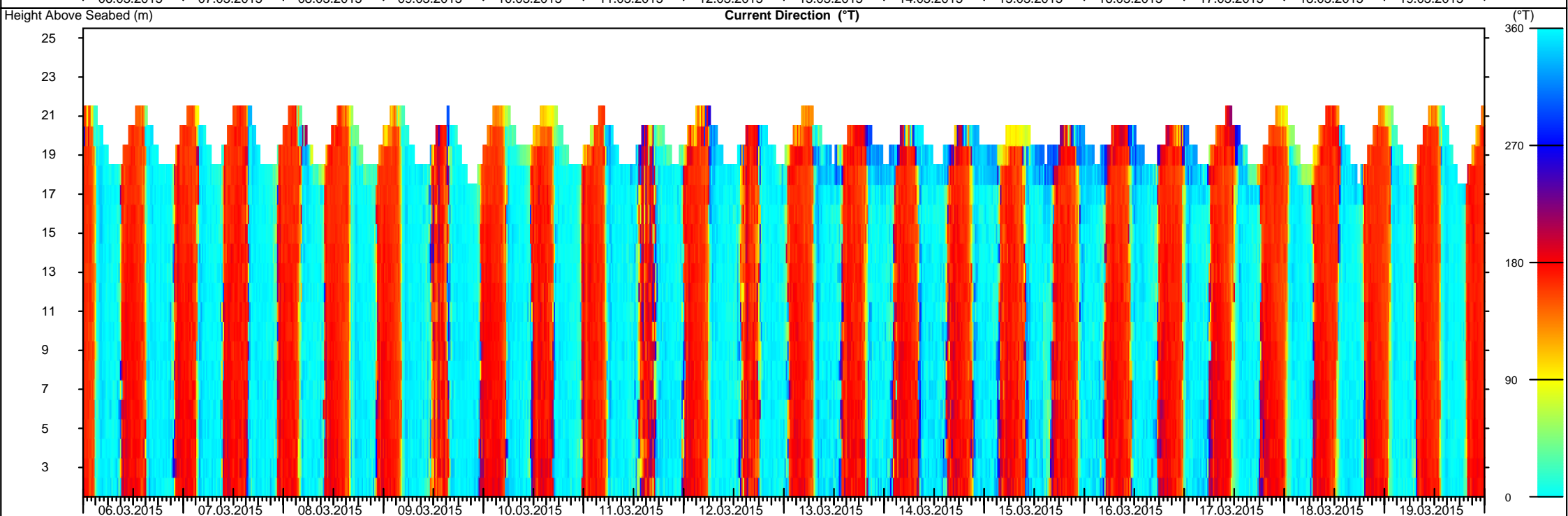
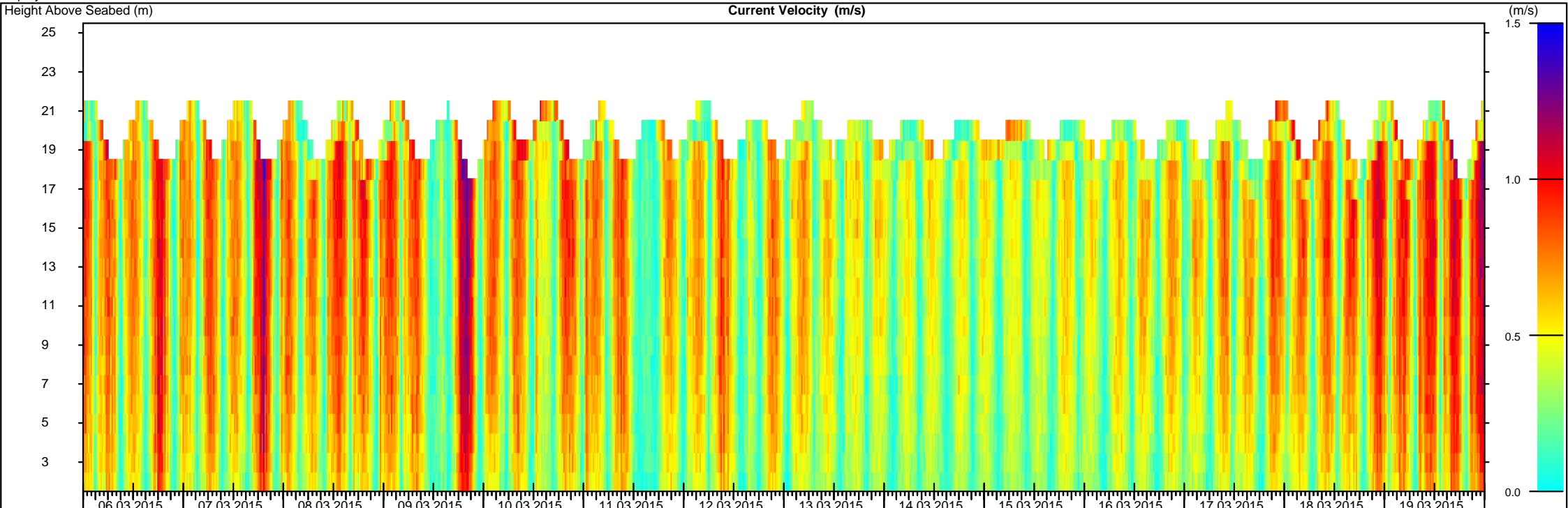
Phase lag (g) is in degrees and synchronises the harmonic to GMT (UT).

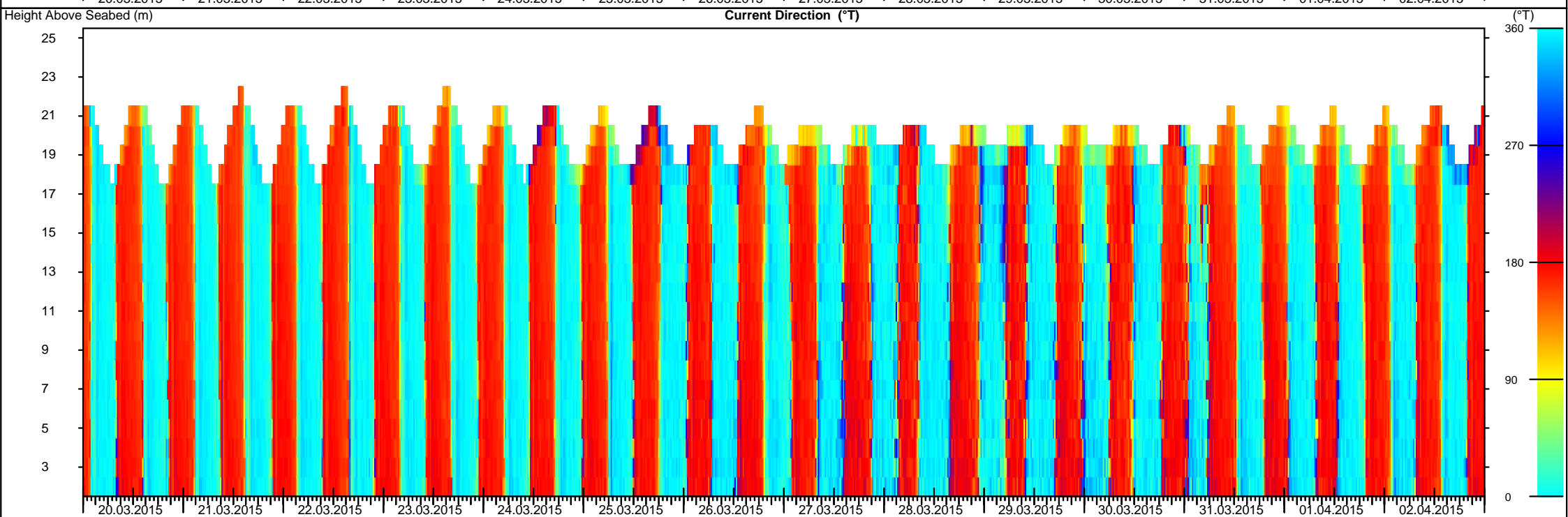
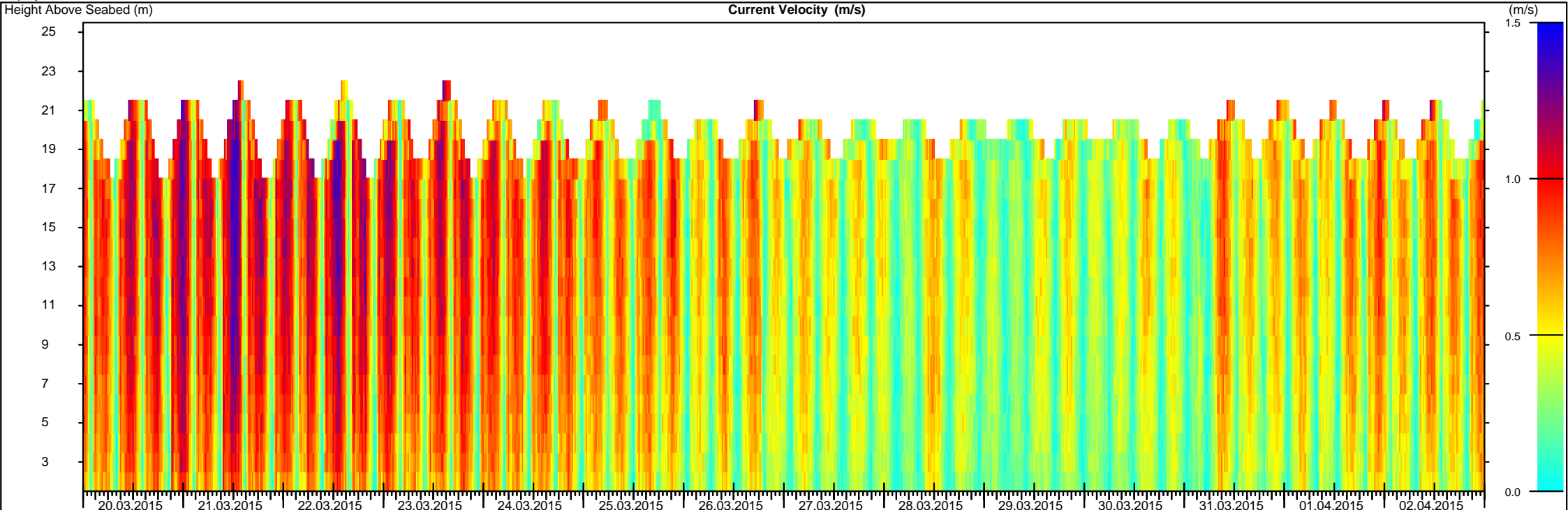
RELATED CONSTITUENTS				Easting		Northing	
Number	Constant	Reference	Speed(°/h)	H	g	H	g
1	PI1	K1	14.9178647	0.10	308.4	0.10	323.1
2	P1	K1	14.9589314	0.50	331.2	0.60	345.9
3	PSI1	K1	15.0821353	0.00	248.7	0.00	263.4
4	PHI1	K1	15.1232059	0.10	164.4	0.10	179.1
5	2N2	N2	27.8953548	0.10	48.0	0.20	2.9
6	NU2	N2	28.5125831	0.10	67.1	0.30	22.0
7	T2	S2	29.9589333	0.00	260.0	0.10	13.0
8	K2	S2	30.0821373	0.10	267.0	0.50	20.0

MAJOR CONSTITUENTS				Easting		Northing	
Number	Constant		Speed(°/h)	H	g	H	g
1	Mean			0.50		2.50	
2	MM		0.5443747	1.80	273.0	1.50	213.9
3	MSF		1.0158958	1.70	167.1	2.30	126.8
4	Q1		13.3986609	0.70	105.4	0.50	92.8
5	O1		13.9430356	0.60	51.9	0.70	357.1
6	M1		14.4920521	0.30	90.4	0.60	77.2
7	K1		15.0410686	1.60	337.4	2.20	352.1
8	J1		15.5854433	1.00	240.7	0.90	264.9
9	OO1		16.1391017	1.80	93.8	1.80	87.2
10	MU2		27.9682084	0.70	192.8	2.20	205.9
11	N2		28.4397295	0.50	62.9	1.20	17.8
12	M2		28.9841042	1.80	83.2	7.60	27.7
13	L2		29.5284789	0.50	119.6	2.00	92.8
14	S2		30.0000000	0.30	268.1	1.70	21.1
15	2SM2		31.0158958	0.30	301.2	0.90	294.5
16	MO3		42.9271398	0.30	126.2	0.40	43.5
17	M3		43.4761563	0.10	20.5	0.20	255.3
18	MK3		44.0251729	0.10	290.1	0.20	164.2
19	MN4		57.4238337	0.80	265.3	1.10	300.2
20	M4		57.9682084	1.80	312.1	2.10	341.4
21	SN4		58.4397295	0.20	190.1	1.00	247.7
22	MS4		58.9841042	1.60	329.7	1.20	353.2
23	2MN6		86.4079380	0.50	249.0	0.20	138.5
24	M6		86.9523127	0.50	277.9	0.50	149.8
25	MSN6		87.4238337	0.20	211.3	0.20	55.4
26	2MS6		87.9682084	0.90	314.3	1.00	156.0
27	2SM6		88.9841042	0.30	318.8	0.50	124.9

VARIANCE ORIGINAL (VO)	0.003	0.008	Metonic Max:	0.272m/s
VARIANCE RESIDUAL (VR)	0.00159	0.00282	MSRate:	0.121m/s
RATIO VR/VO	0.5958	0.3749	MNRate:	0.086m/s
SQRT(VO)	0.052	0.087	Bearing:	18.1°T
SQRT(VR)	0.03982	0.05306	Mean Drift:	0.025m/s
RATIO SQRT(VR)/SQRT(VO)	0.7719	0.6123	Bearing:	11.3°T

D1 Latitude: 57°08'0.84"N D1 Longitude: 002°02'8.10"W D2 Latitude: 57°08'0.72"N D2 Longitude: 002°02'8.28"W D1 Site depth below LAT: 18.15m D2 Site depth below LAT: 19.06m Instrument height off seabed: 0.66m
Deployed: 20/02/2015 17:42 Recovered: 11/06/2015 08:50Current Meter / AWAC
Serial No.: 5615/1487

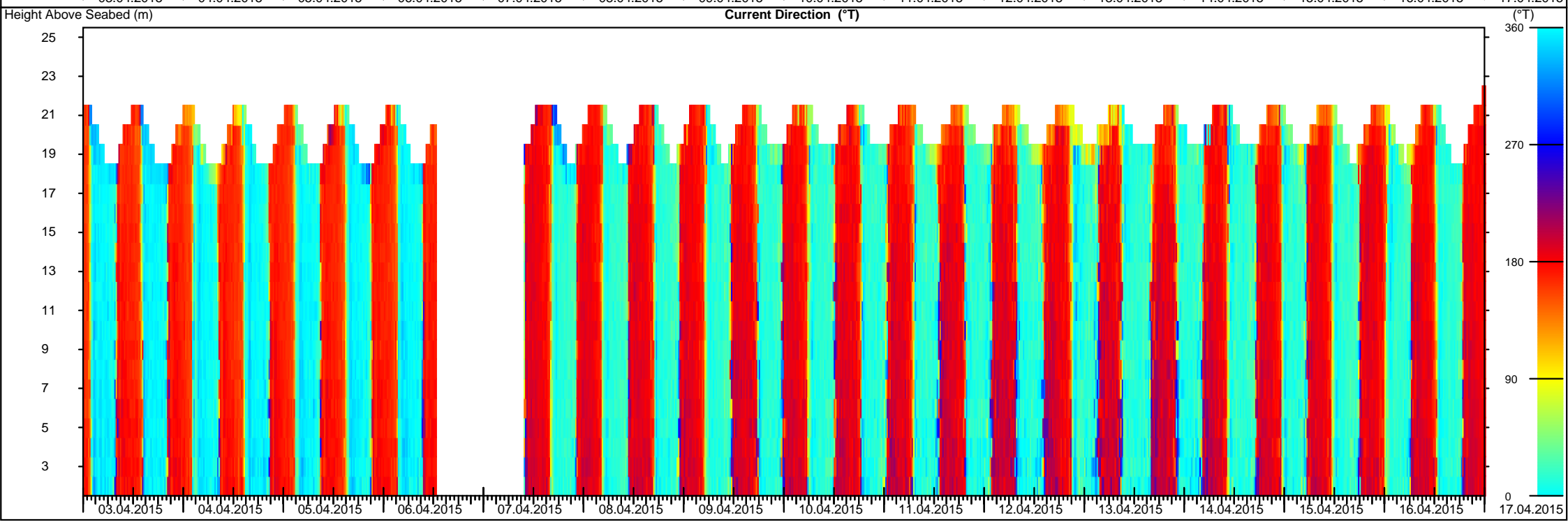
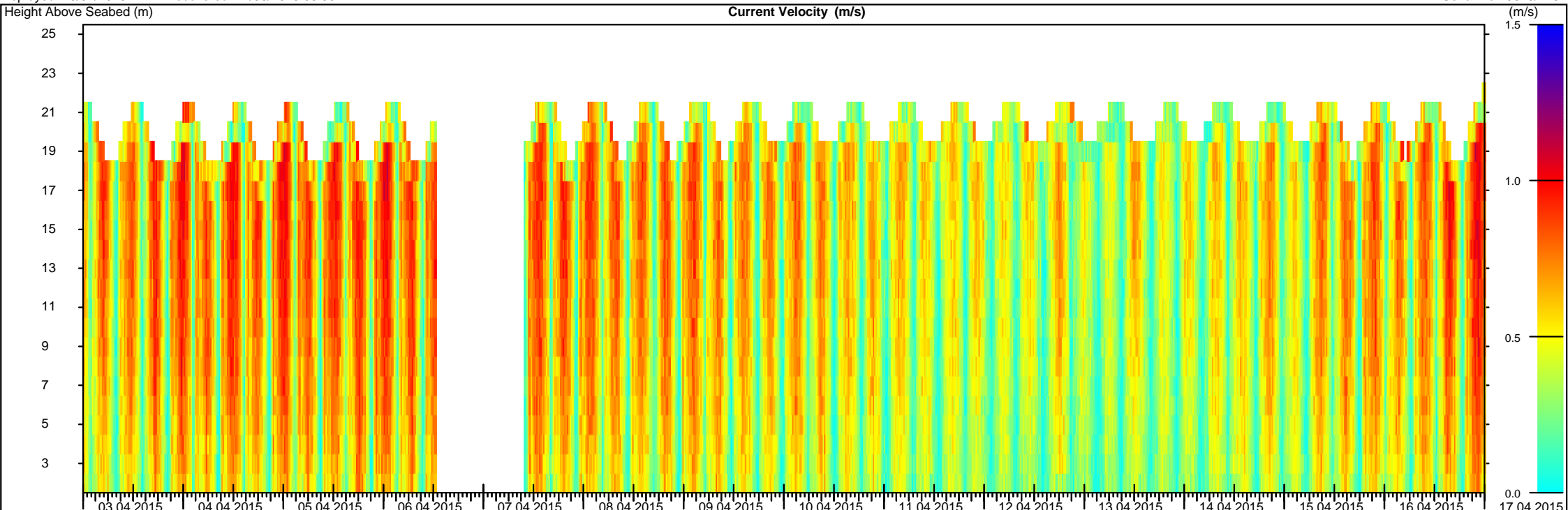
D1 Latitude: 57°08'0.84"N D1 Longitude: 002°02'8.10"W D2 Latitude: 57°08'0.72"N D2 Longitude: 002°02'8.28"W D1 Site depth below LAT: 18.15m D2 Site depth below LAT: 19.06m Instrument height off seabed: 0.66m
Deployed: 20/02/2015 17:42 Recovered: 11/06/2015 08:50Current Meter / AWAC
Serial No.: 5615/1487

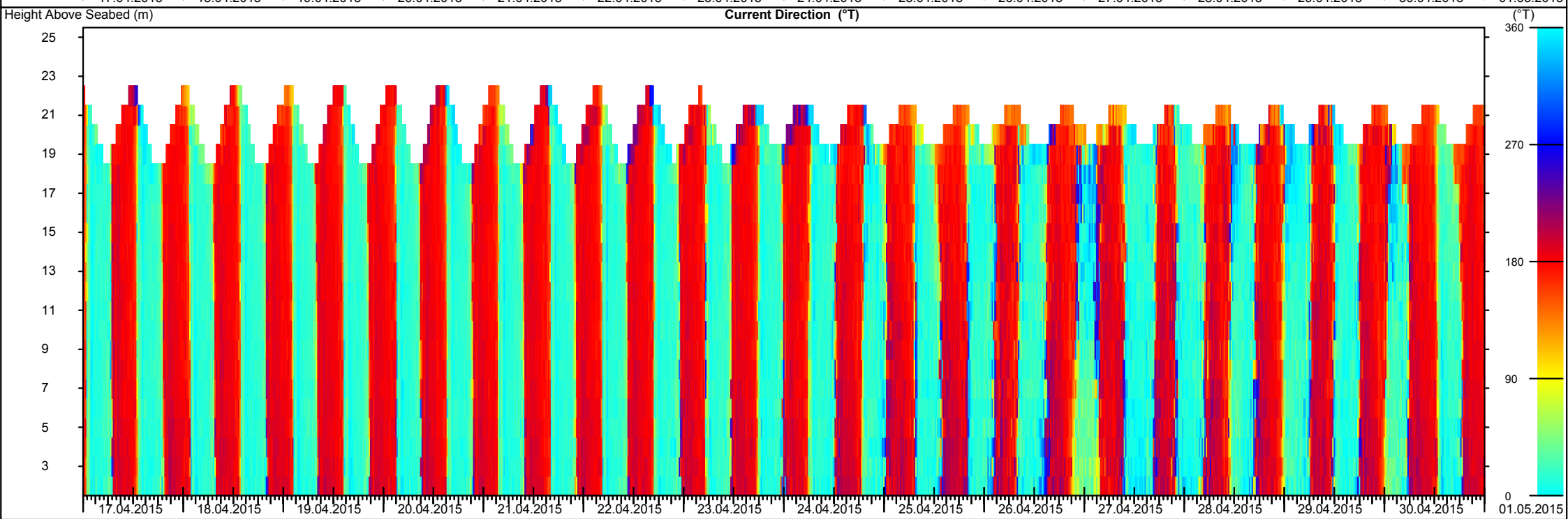
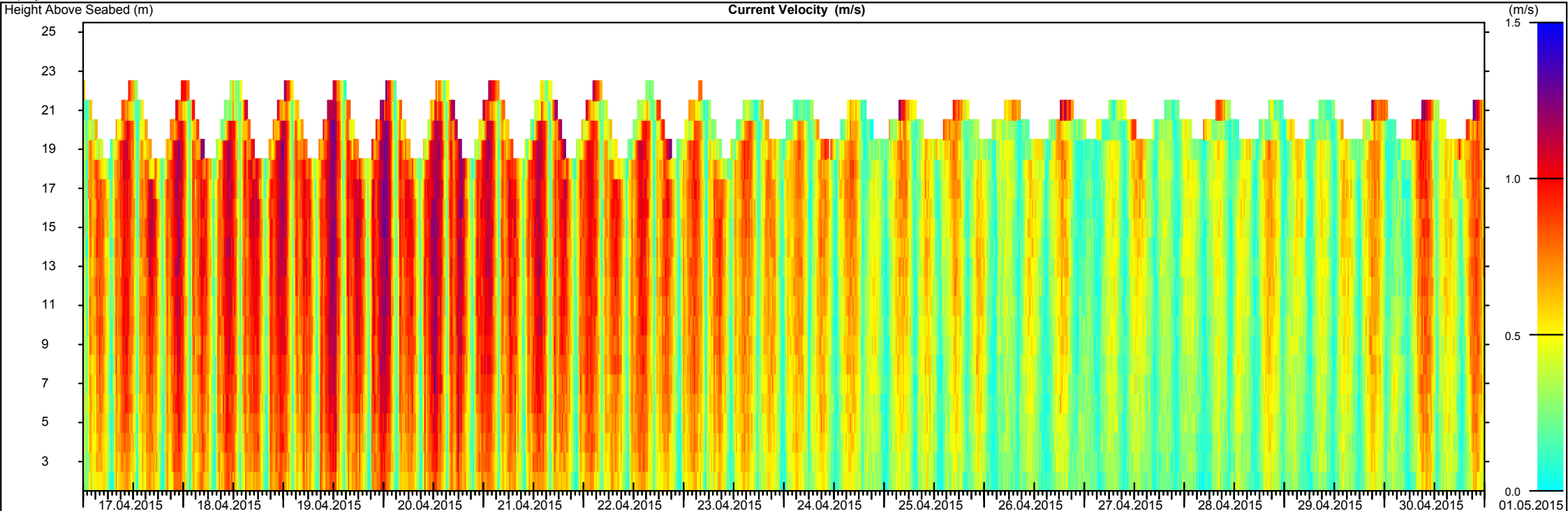
D1 Latitude: 57°08'0.84"N D1 Longitude: 002°02'8.10"W D2 Latitude: 57°08'0.72"N D2 Longitude: 002°02'8.28"W D1 Site depth below LAT: 18.15m D2 Site depth below LAT: 19.06m Instrument height off seabed: 0.66m
Deployed: 20/02/2015 17:42 Recovered: 11/06/2015 08:50Current Meter / AWAC
Serial No.: 5615/1487

Current Data Colour Contour Time Series Aberdeen Harbour Expansion EIA, East, D1 - D2

D1 Latitude: 57°08'0.84"N D1 Longitude: 002°02'8.10"W D2 Latitude: 57°08'0.72"N D2 Longitude: 002°02'8.28"W D1 Site depth below LAT: 18.15m D2 Site depth below LAT: 19.06m Instrument height off seabed: 0.66m
Deployed: 20/02/2015 17:42 Recovered: 11/06/2015 08:50

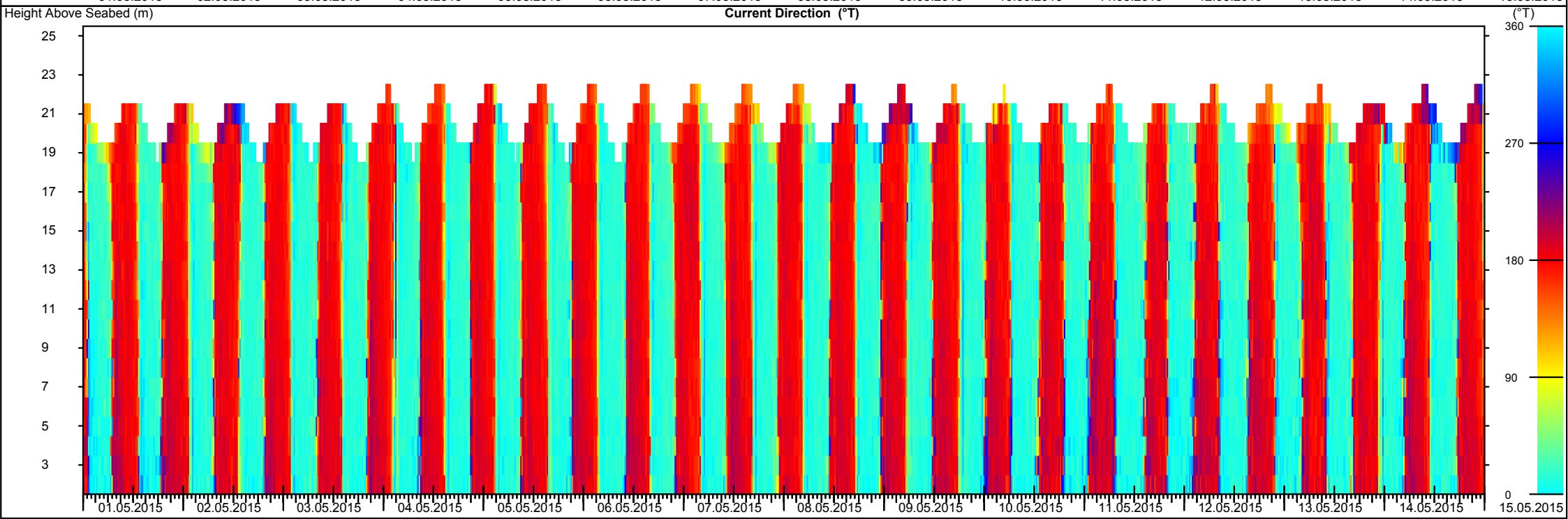
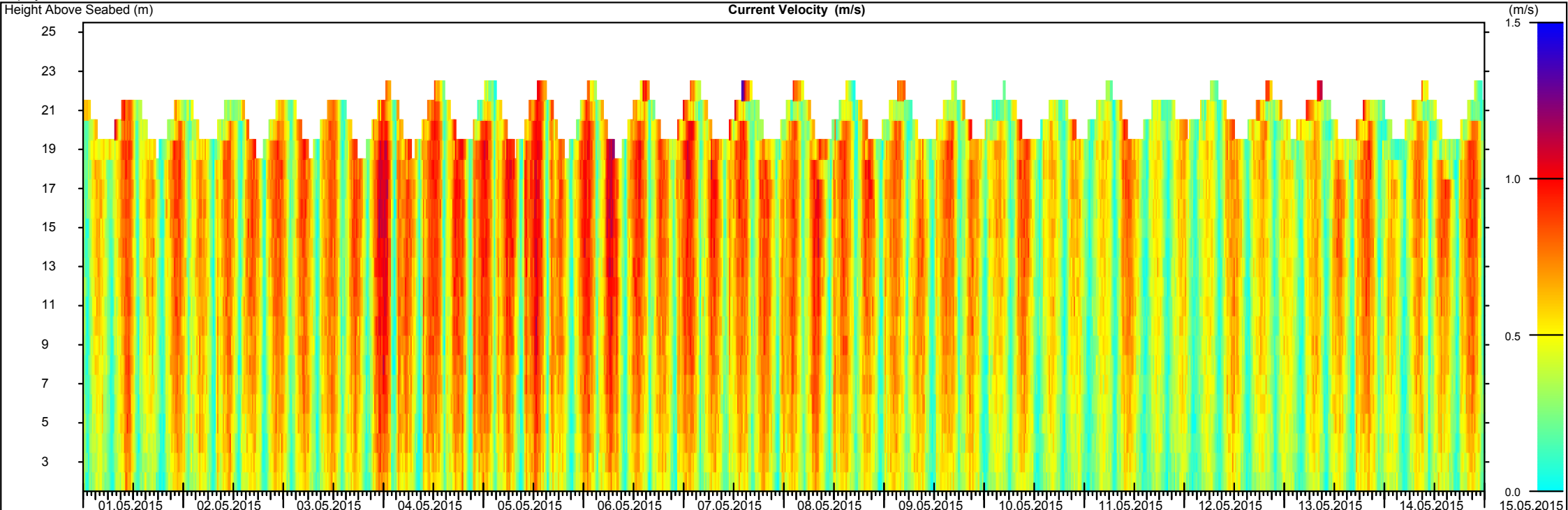
Current Meter / AWAC
Serial No.: 5615/1487



D1 Latitude: 57°08'0.84"N D1 Longitude: 002°02'8.10"W D2 Latitude: 57°08'0.72"N D2 Longitude: 002°02'8.28"W D1 Site depth below LAT: 18.15m D2 Site depth below LAT: 19.06m Instrument height off seabed: 0.66m
Deployed: 20/02/2015 17:42 Recovered: 11/06/2015 08:50Current Meter / AWAC
Serial No.: 5615/1487

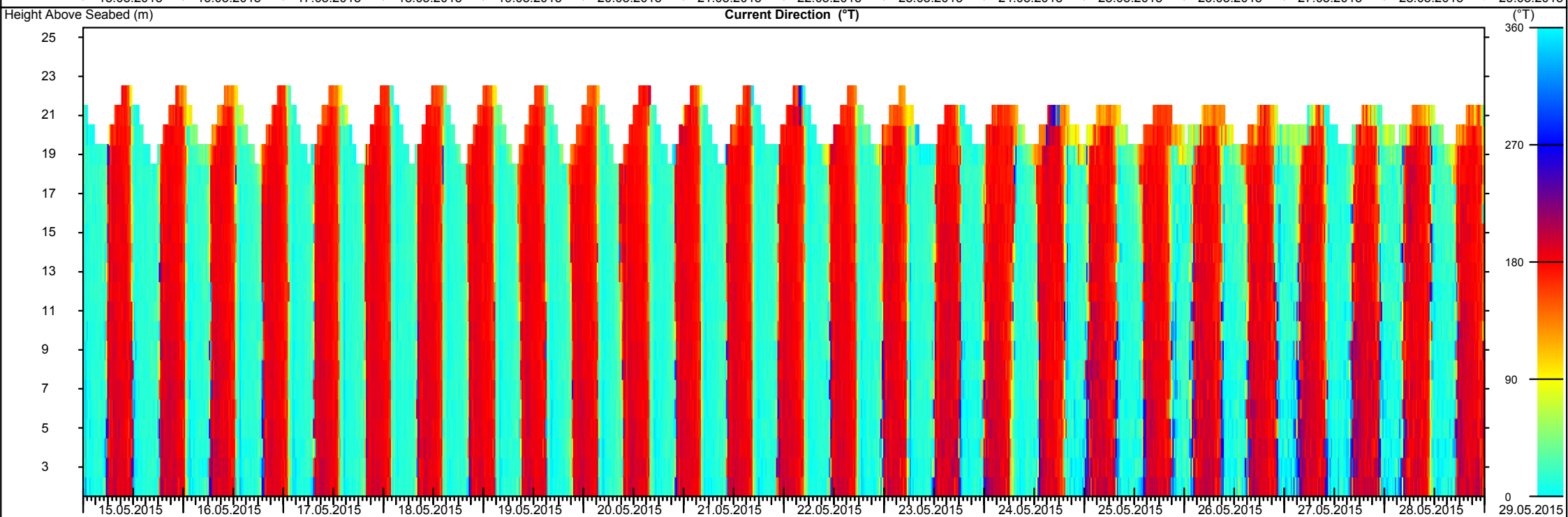
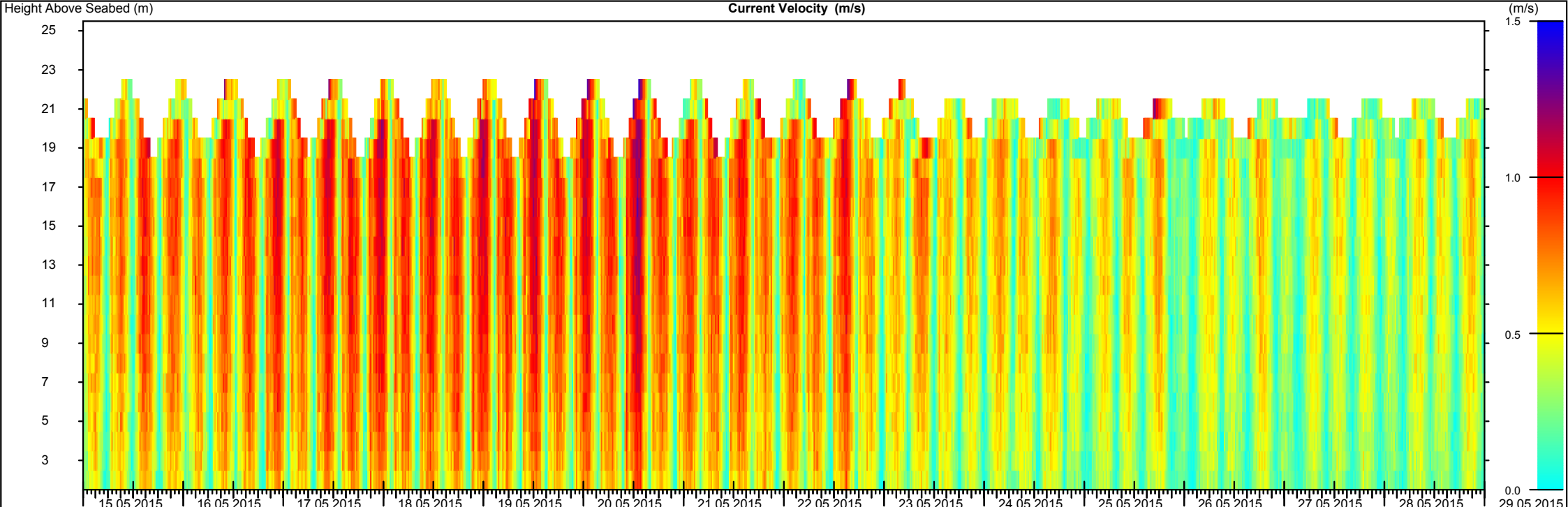
D1 Latitude: 57°08'0.84"N D1 Longitude: 002°02'8.10"W D2 Latitude: 57°08'0.72"N D2 Longitude: 002°02'8.28"W D1 Site depth below LAT: 18.15m D2 Site depth below LAT: 19.06m Instrument height off seabed: 0.66m
Deployed: 20/02/2015 17:42 Recovered: 11/06/2015 08:50

Current Meter / AWAC
Serial No.: 5615/1487



D1 Latitude: 57°08'0.84"N D1 Longitude: 002°02'8.10"W D2 Latitude: 57°08'0.72"N D2 Longitude: 002°02'8.28"W D1 Site depth below LAT: 18.15m D2 Site depth below LAT: 19.06m Instrument height off seabed: 0.66m
Deployed: 20/02/2015 17:42 Recovered: 11/06/2015 08:50

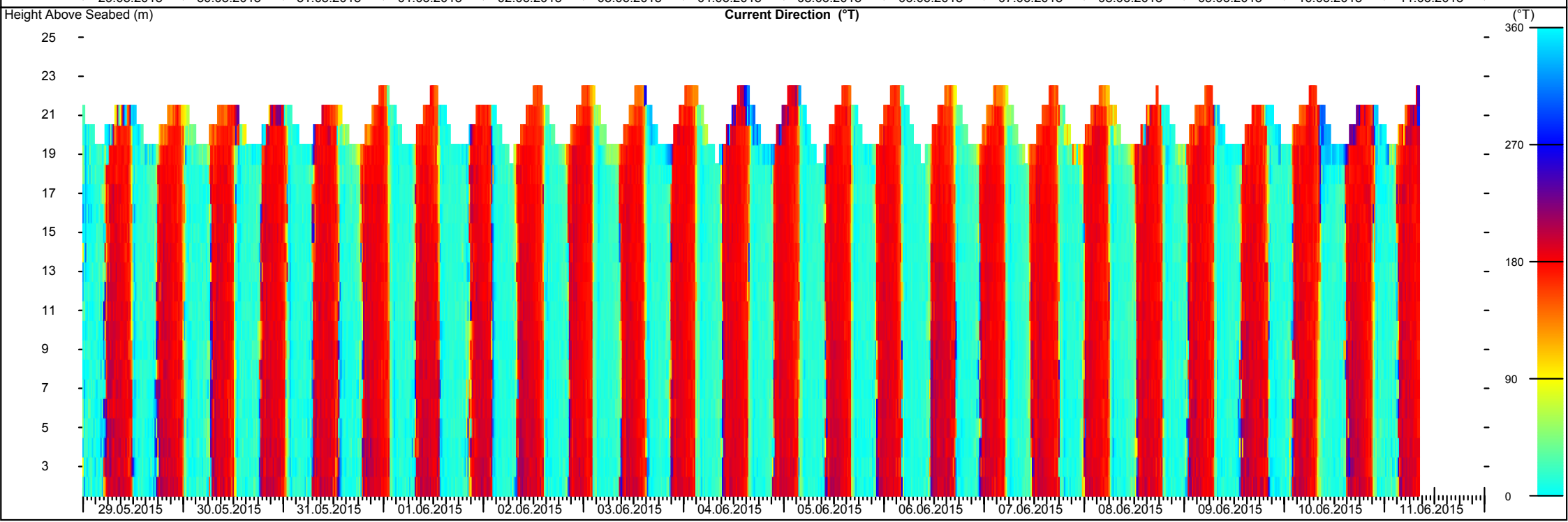
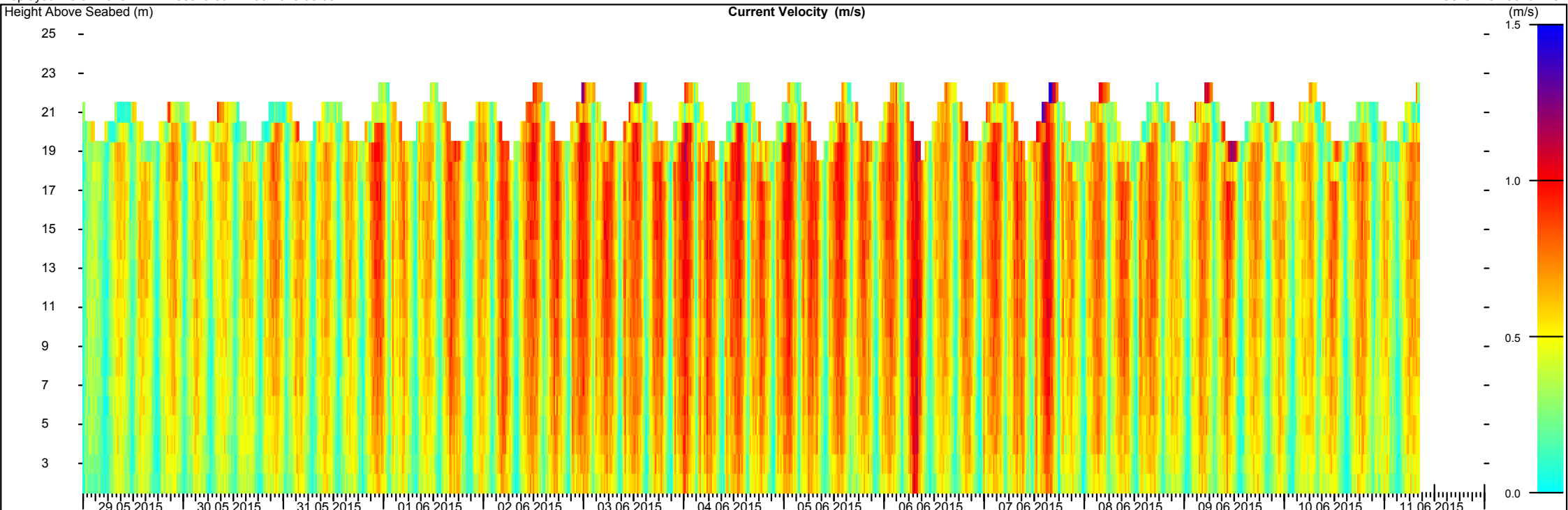
Current Meter / AWAC
Serial No.: 5615/1487



Current Data Colour Contour Time Series Aberdeen Harbour Expansion EIA, East, D1 - D2

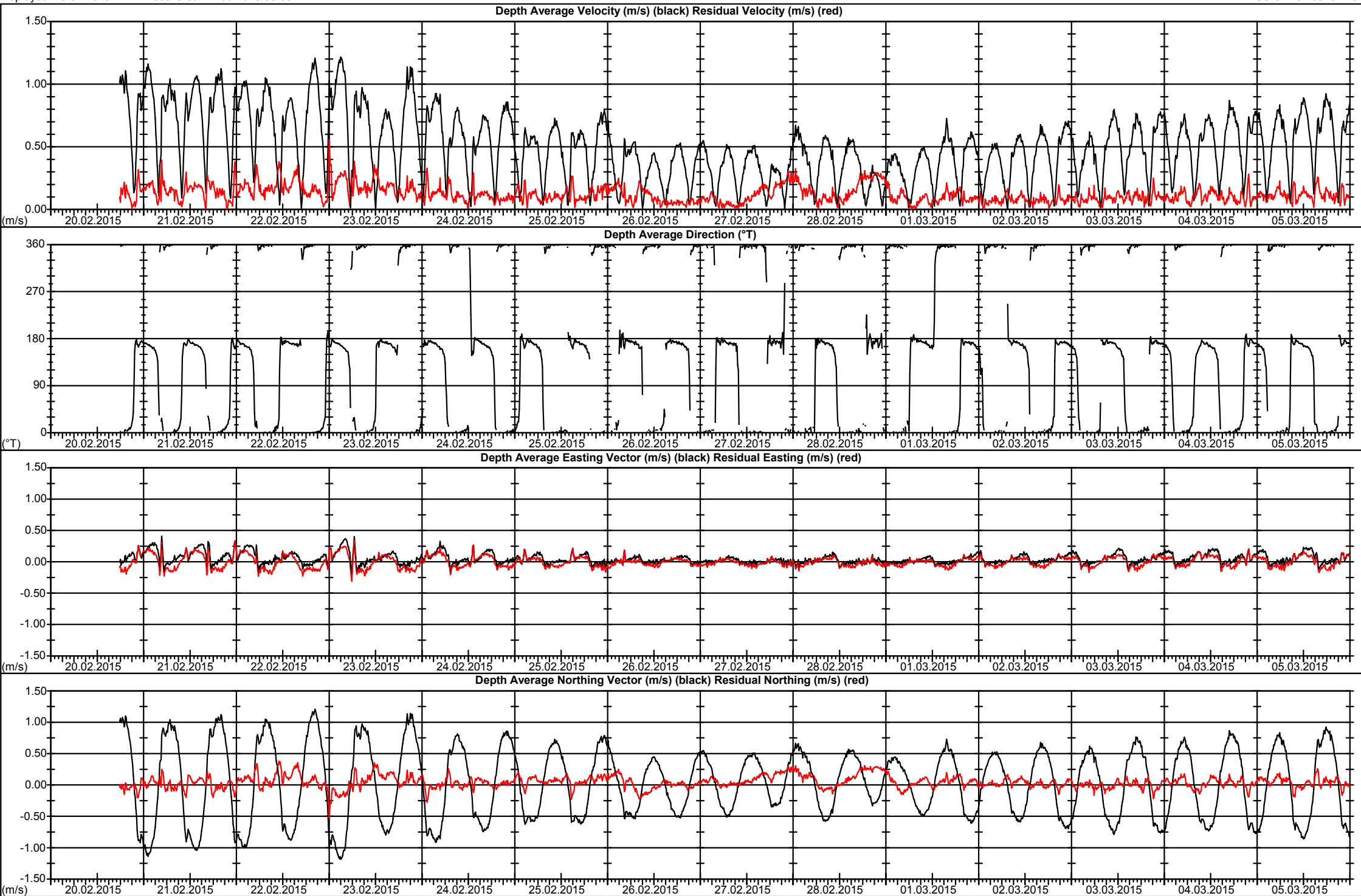
D1 Latitude: 57°08'0.84"N D1 Longitude: 002°02'8.10"W D2 Latitude: 57°08'0.72"N D2 Longitude: 002°02'8.28"W D1 Site depth below LAT: 18.15m D2 Site depth below LAT: 19.06m Instrument height off seabed: 0.66m
Deployed: 20/02/2015 17:42 Recovered: 11/06/2015 08:50

Current Meter / AWAC
Serial No.: 5615/1487



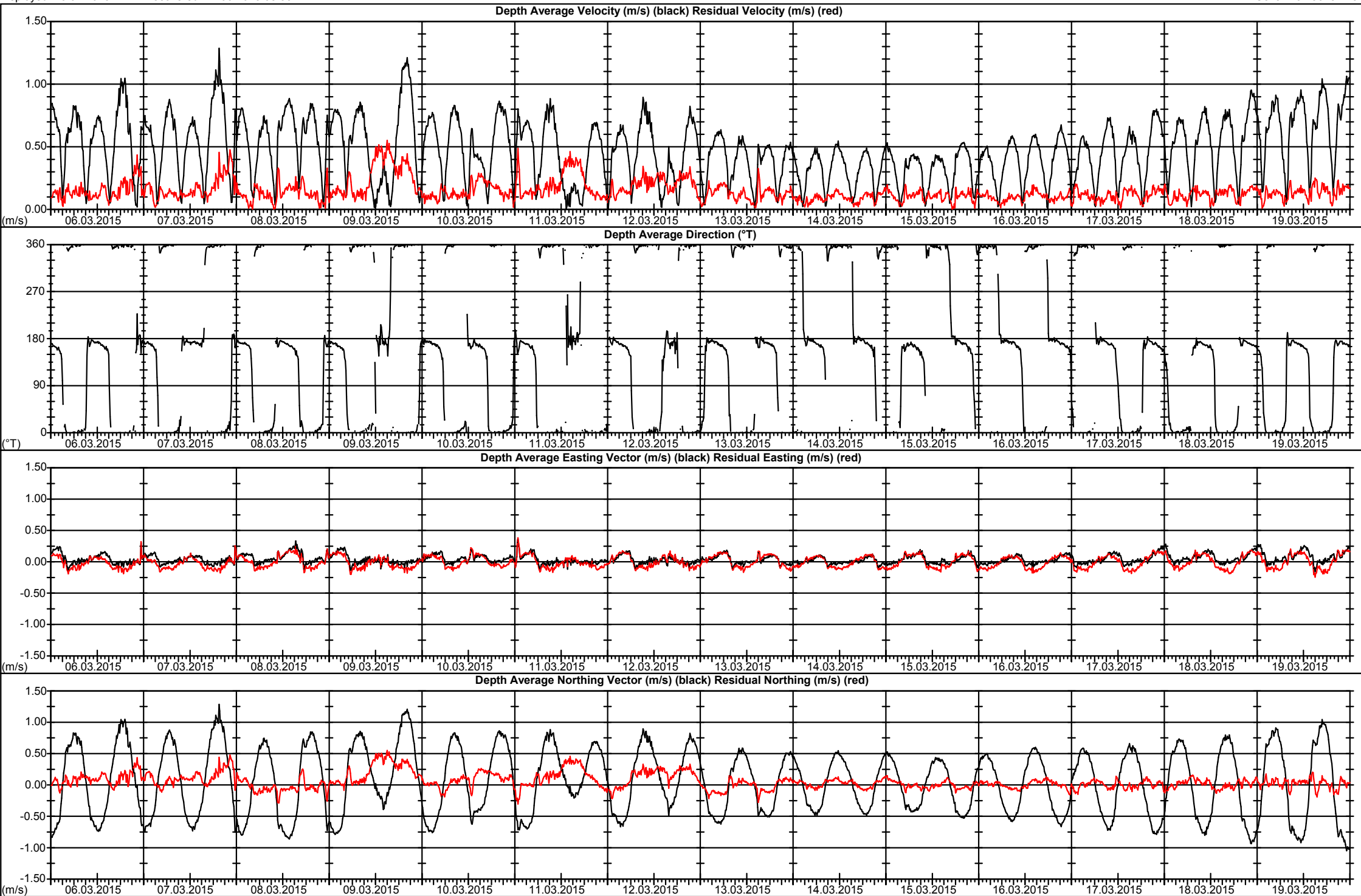
D1 Latitude: 57°08'0.84"N D1 Longitude: 002°02'8.10"W D2 Latitude: 57°08'0.72"N D2 Longitude: 002°02'8.28"W D1 Site depth below LAT: 18.15m D2 Site depth below LAT: 19.06m Instrument height off seabed: 0.66m
Deployed: 20/02/2015 17:42 Recovered: 11/06/2015 08:50

Current Meter / AWAC
Serial No.: 5615/1487



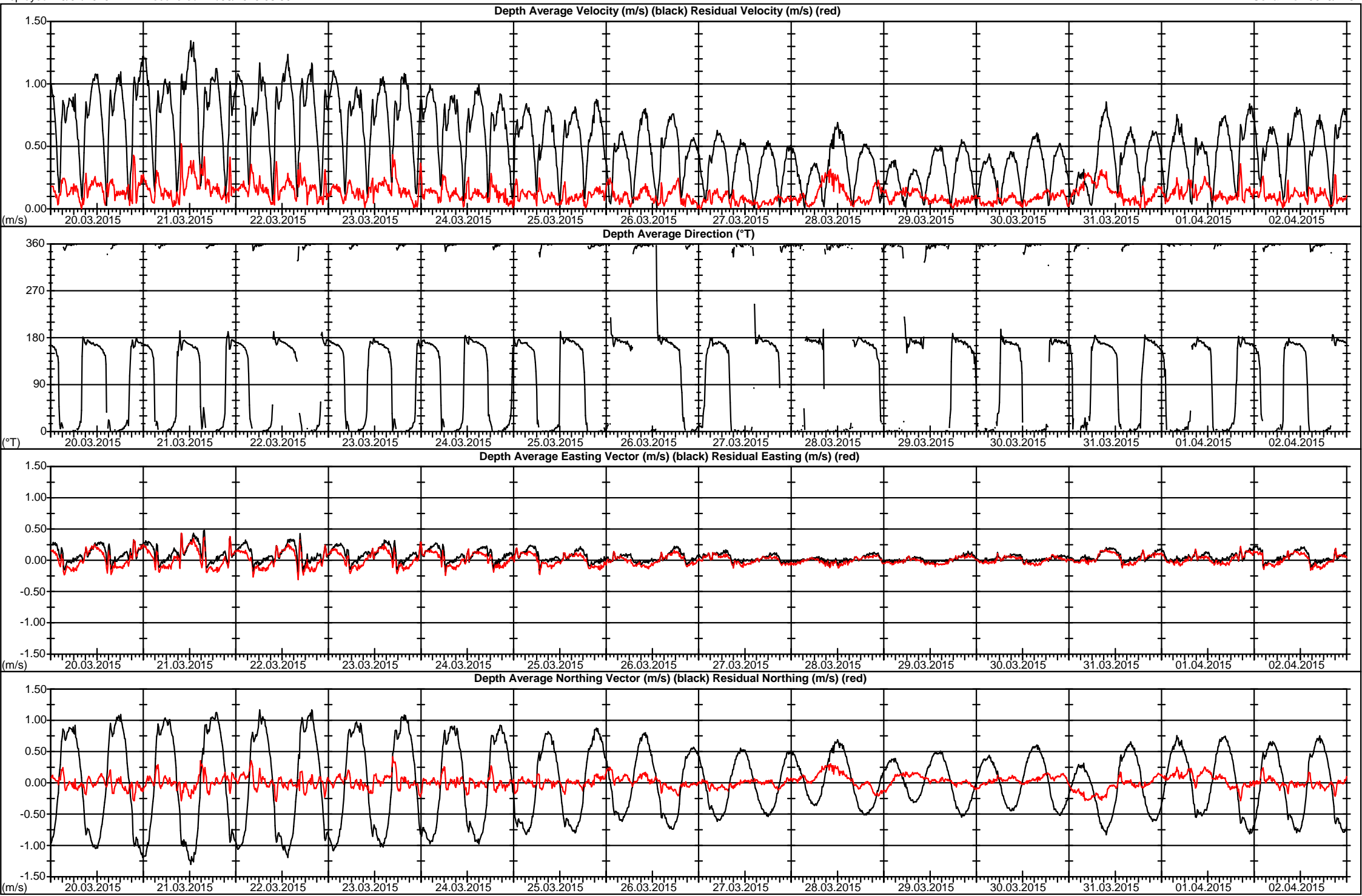
D1 Latitude: 57°08'0.84"N D1 Longitude: 002°02'8.10"W D2 Latitude: 57°08'0.72"N D2 Longitude: 002°02'8.28"W D1 Site depth below LAT: 18.15m D2 Site depth below LAT: 19.06m Instrument height off seabed: 0.66m
Deployed: 20/02/2015 17:42 Recovered: 11/06/2015 08:50

Current Meter / AWAC
Serial No.: 5615/1487



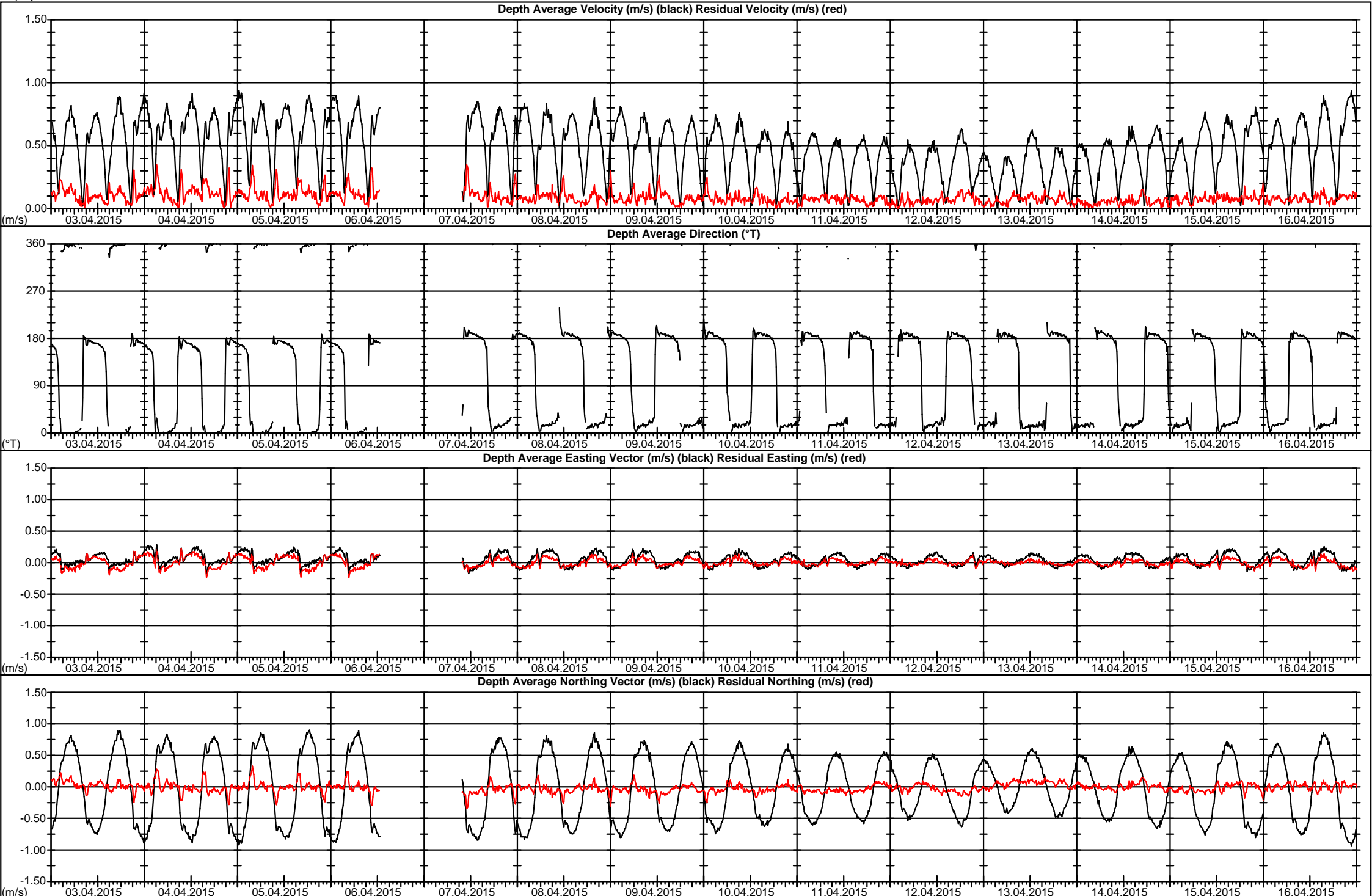
D1 Latitude: 57°08'0.84"N D1 Longitude: 002°02'8.10"W D2 Latitude: 57°08'0.72"N D2 Longitude: 002°02'8.28"W D1 Site depth below LAT: 18.15m D2 Site depth below LAT: 19.06m Instrument height off seabed: 0.66m
Deployed: 20/02/2015 17:42 Recovered: 11/06/2015 08:50

Current Meter / AWAC
Serial No.: 5615/1487



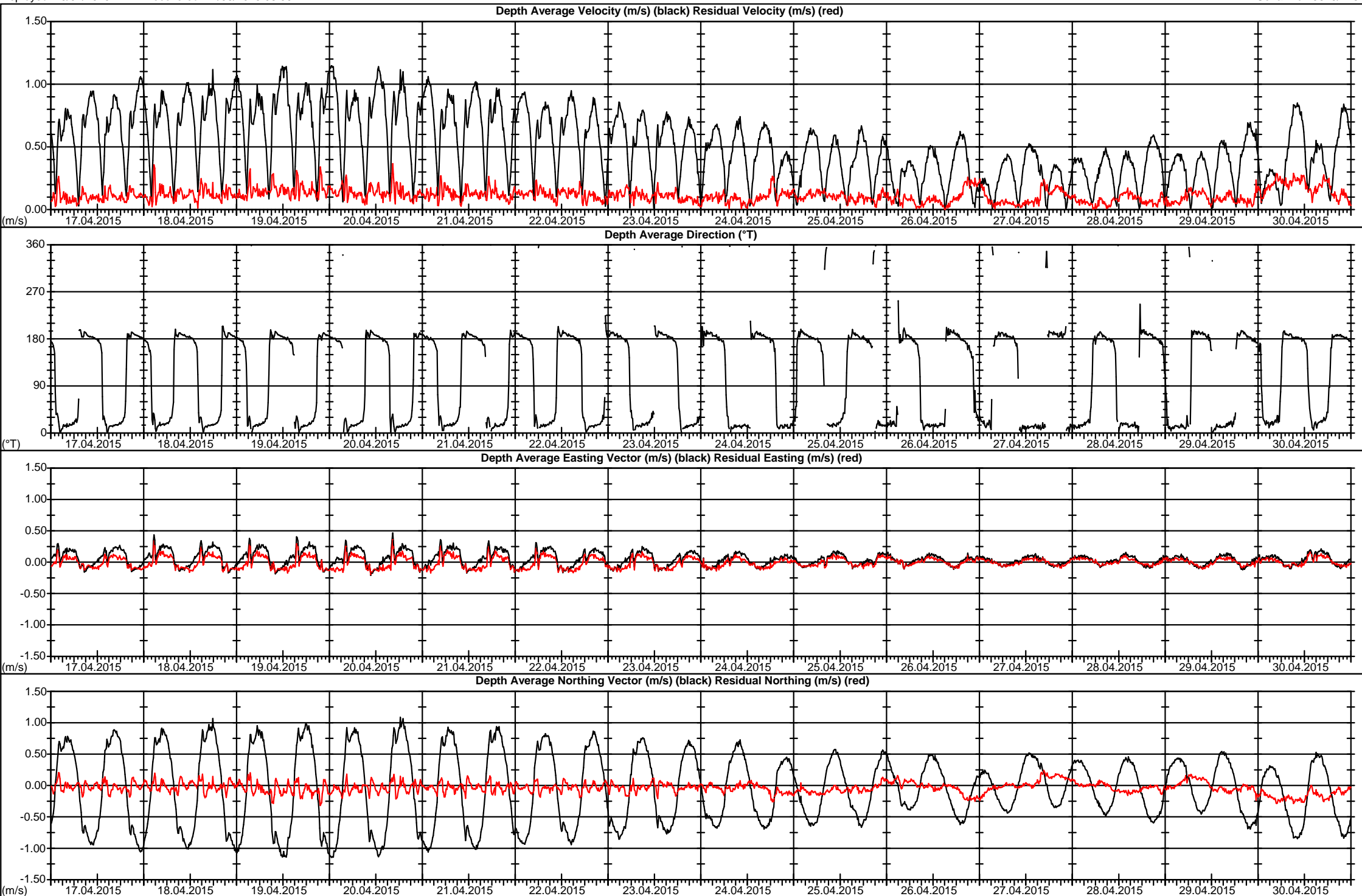
D1 Latitude: 57°08'0.84"N D1 Longitude: 002°02'8.10"W D2 Latitude: 57°08'0.72"N D2 Longitude: 002°02'8.28"W D1 Site depth below LAT: 18.15m D2 Site depth below LAT: 19.06m Instrument height off seabed: 0.66m
Deployed: 20/02/2015 17:42 Recovered: 11/06/2015 08:50

Current Meter / AWAC
Serial No.: 5615/1487



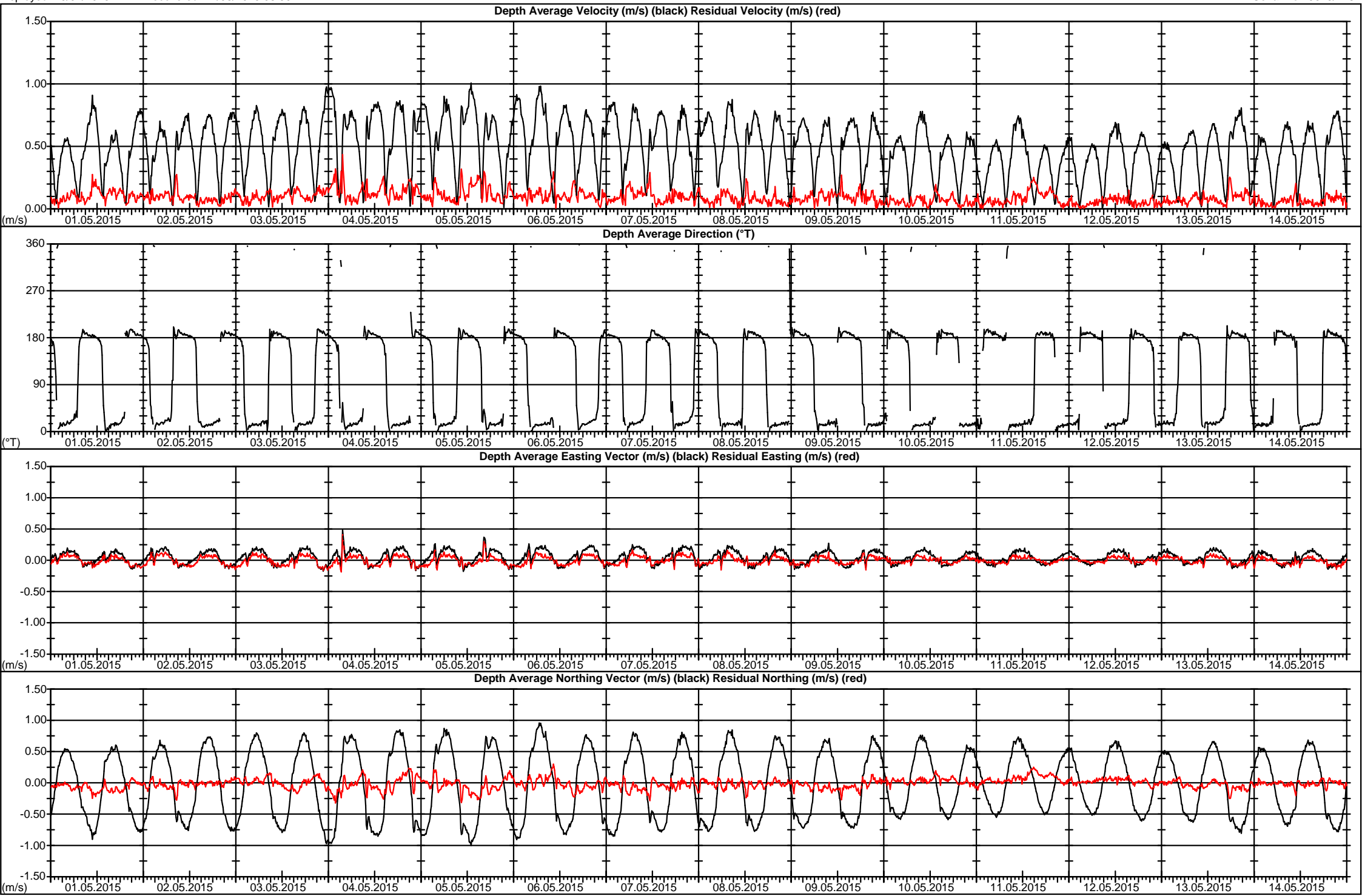
D1 Latitude: 57°08'0.84"N D1 Longitude: 002°02'8.10"W D2 Latitude: 57°08'0.72"N D2 Longitude: 002°02'8.28"W D1 Site depth below LAT: 18.15m D2 Site depth below LAT: 19.06m Instrument height off seabed: 0.66m
Deployed: 20/02/2015 17:42 Recovered: 11/06/2015 08:50

Current Meter / AWAC
Serial No.: 5615/1487



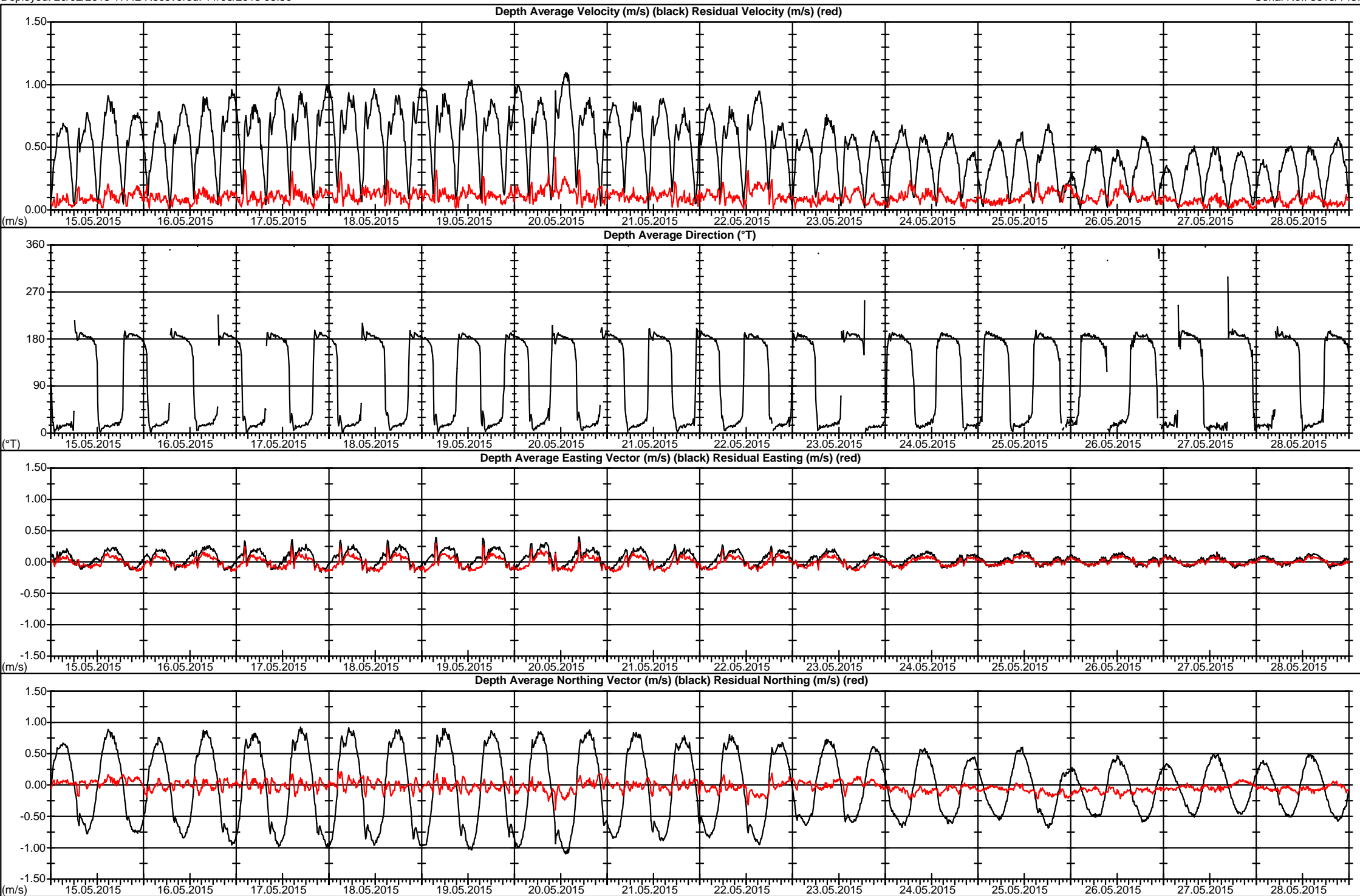
D1 Latitude: 57°08'0.84"N D1 Longitude: 002°02'8.10"W D2 Latitude: 57°08'0.72"N D2 Longitude: 002°02'8.28"W D1 Site depth below LAT: 18.15m D2 Site depth below LAT: 19.06m Instrument height off seabed: 0.66m
Deployed: 20/02/2015 17:42 Recovered: 11/06/2015 08:50

Current Meter / AWAC
Serial No.: 5615/1487



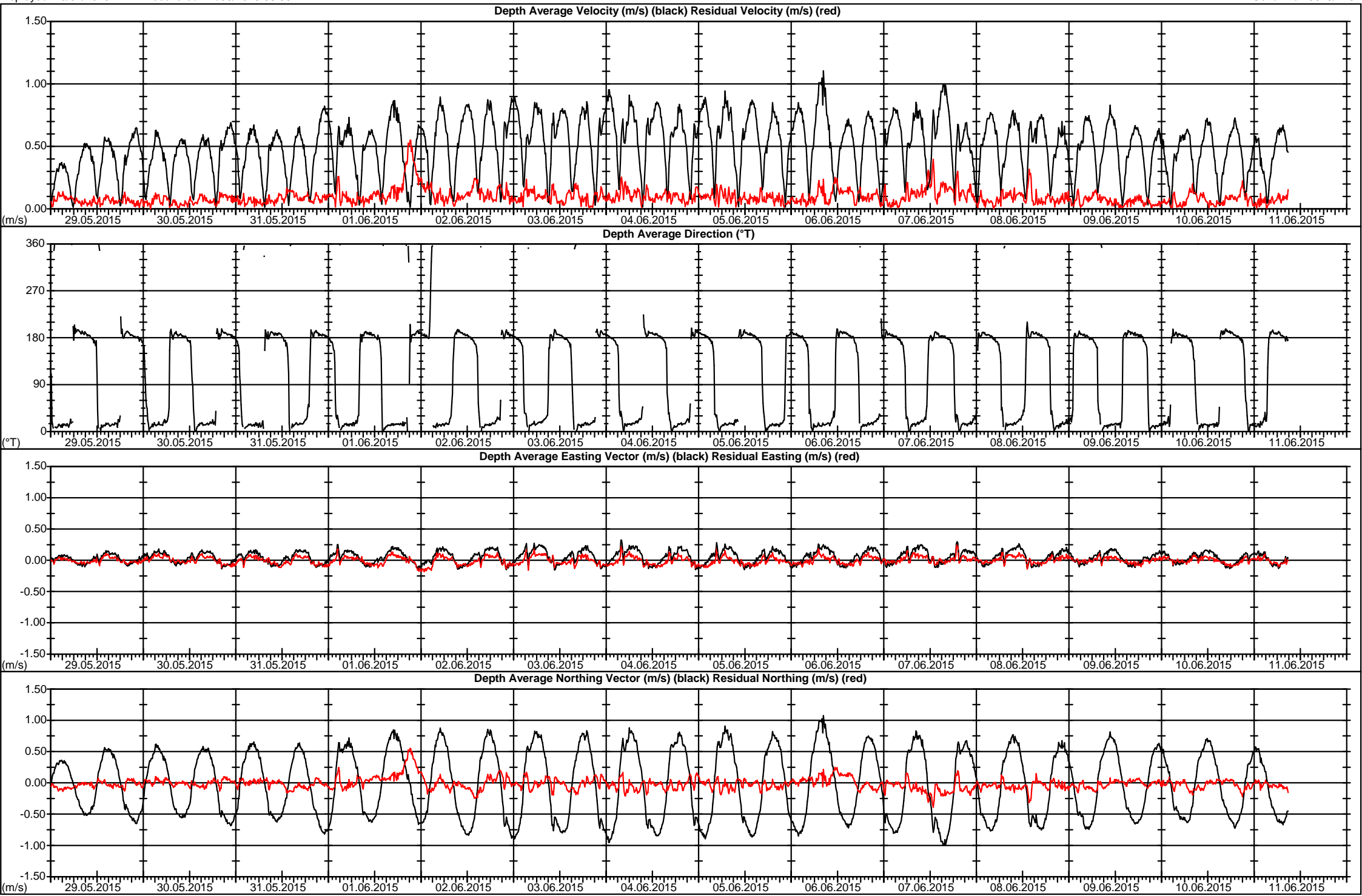
D1 Latitude: 57°08'0.84"N D1 Longitude: 002°02'8.10"W D2 Latitude: 57°08'0.72"N D2 Longitude: 002°02'8.28"W D1 Site depth below LAT: 18.15m D2 Site depth below LAT: 19.06m Instrument height off seabed: 0.66m
Deployed: 20/02/2015 17:42 Recovered: 11/06/2015 08:50

Current Meter / AWAC
Serial No.: 5615/1487



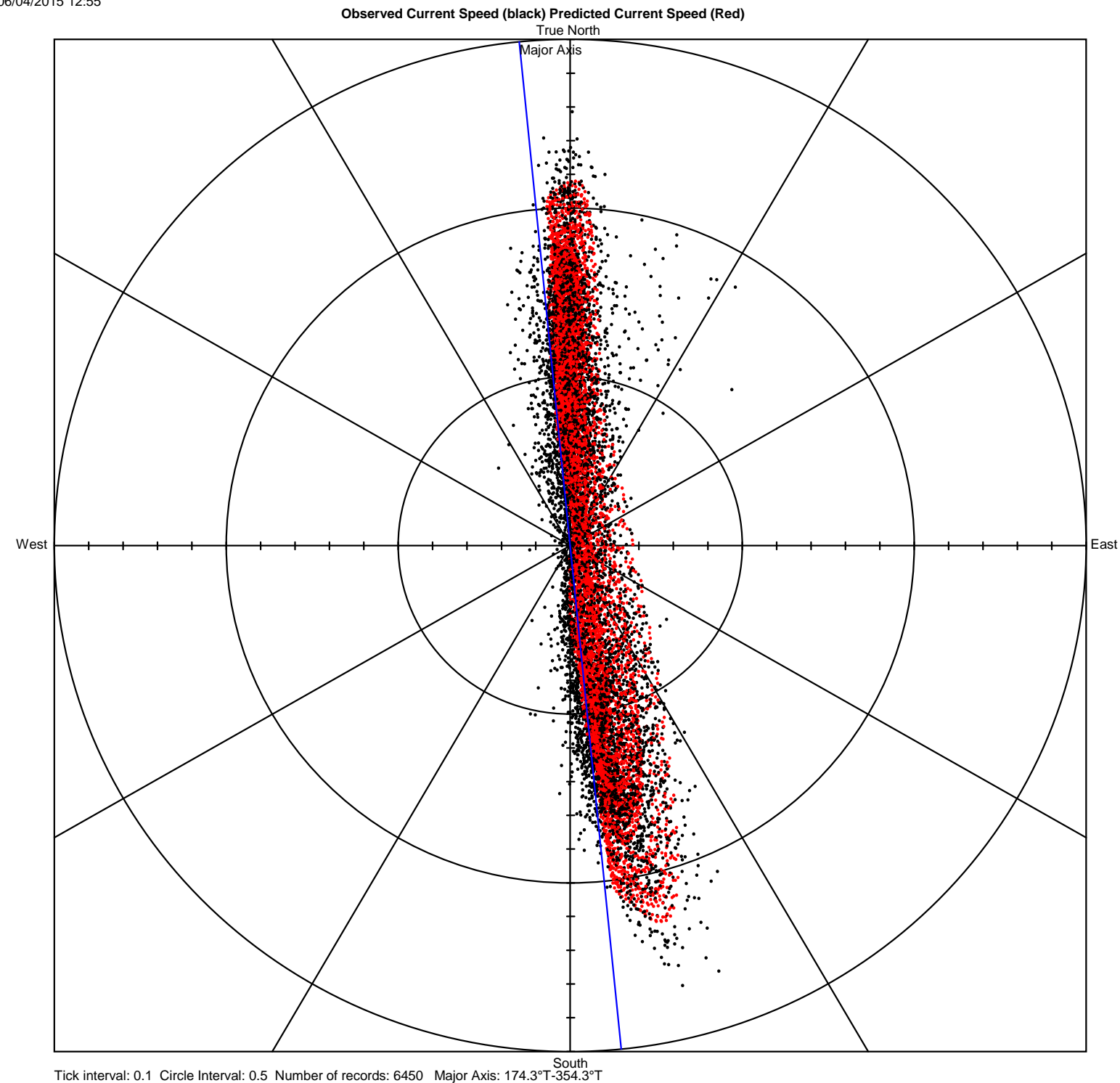
D1 Latitude: 57°08'0.84"N D1 Longitude: 002°02'8.10"W D2 Latitude: 57°08'0.72"N D2 Longitude: 002°02'8.28"W D1 Site depth below LAT: 18.15m D2 Site depth below LAT: 19.06m Instrument height off seabed: 0.66m
Deployed: 20/02/2015 17:42 Recovered: 11/06/2015 08:50

Current Meter / AWAC
Serial No.: 5615/1487



Latitude: 57°08'0.84"N Longitude: 002°02'8.10"W Site depth below LAT: 18.15m Instrument height off seabed: 0.66m
Deployed: 20/02/2015 17:42 Recovered: 06/04/2015 12:55

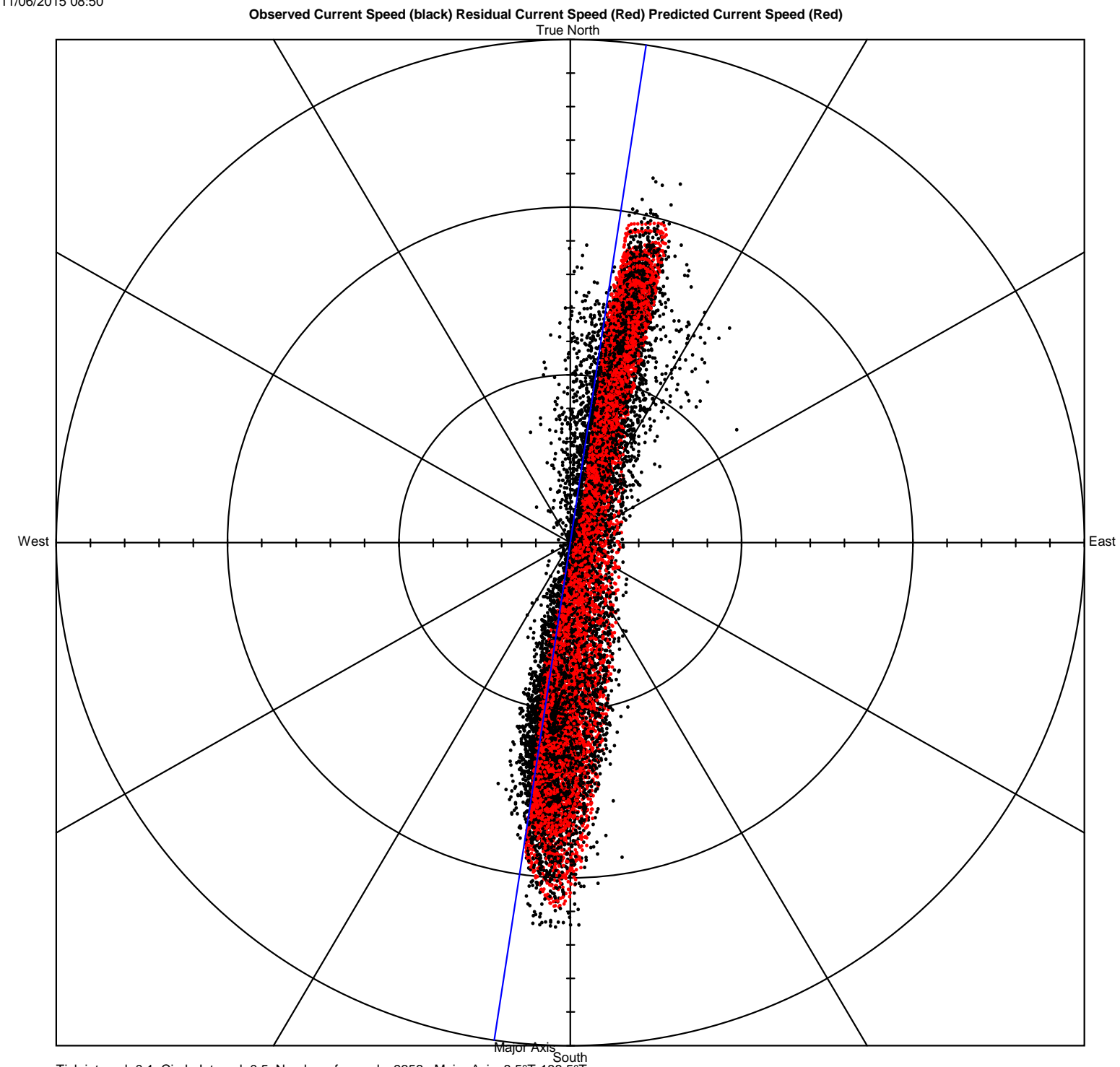
Current Meter / AWAC
Serial No.: 5615



Current Data Speed and Direction Scatter Plot Aberdeen Harbour Expansion EIA, East, D2

Latitude: 57°08'0.72"N Longitude: 002°02'8.28"W Site depth below LAT: 19.06m Instrument depth: 0.66m
Deployed: 07/04/2015 09:55 Recovered: 11/06/2015 08:50

Current Meter / AWAC
Serial No.: 1487



Observed Current Speed (black) Residual Current Speed (Red) Predicted Current Speed (Red)

Tick interval: 0.1 Circle Interval: 0.5 Number of records: 9356 Major Axis: 8.5°T-188.5°T

Table C002

CURRENT SPEED HARMONIC ANALYSIS REPORT

Job Number: J/3/01/2774Aberdeen Harbour Expansion EIA, East, D1 - D2

Analysis of Current Meter / AWACSerial No. 5615

Geographical Position: D1 Latitude: 57°08'0.84"N D1 Longitude: 002°02'8.10"W

D2 Latitude: 57°08'0.72"N D2 Longitude: 002°02'8.28"W

Analysis of observations for period: Deployed: 20/02/2015 17:42 Recovered: 11/06/2015 08:50

Seed file for separation of related constituents: NTSLF_AB (60)

Speed is in degrees per hour: a constant for each constituent.

Amplitude (H) is in cm/s.

Phase lag (g) is in degrees and synchronises the harmonic to GMT (UT).

RELATED CONSTITUENTS

Number	Constant	Reference	Speed(°/h)	Easting		Northing	
				H	g	H	g
1	PI1	K1	14.9178647	0.00	61.4	0.20	290.7
2	P1	K1	14.9589314	0.00	84.2	1.40	313.5
3	PSI1	K1	15.0821353	0.00	1.7	0.10	231.0
4	PHI1	K1	15.1232059	0.00	277.4	0.20	146.7
5	2N2	N2	27.8953548	0.10	164.2	1.70	109.3
6	NU2	N2	28.5125831	0.20	183.3	2.70	128.4
7	T2	S2	29.9589333	0.00	127.8	1.10	180.2
8	K2	S2	30.0821373	0.20	134.8	6.50	187.2

MAJOR CONSTITUENTS

Number	Constant	Speed(°/h)	Easting		Northing	
			H	g	H	g
1	Mean		5.00		-1.60	
2	MM	0.5443747	1.20	38.9	1.20	250.2
3	MSF	1.0158958	2.50	31.2	2.10	166.3
4	Q1	13.3986609	0.20	245.8	1.90	76.1
5	O1	13.9430356	0.70	195.8	2.50	157.0
6	M1	14.4920521	0.20	304.6	0.30	22.0
7	K1	15.0410686	0.00	90.4	4.70	319.7
8	J1	15.5854433	0.20	81.2	1.30	176.9
9	OO1	16.1391017	0.30	227.0	1.20	49.2
10	MU2	27.9682084	0.60	355.3	5.10	43.4
11	N2	28.4397295	1.00	179.1	13.20	124.2
12	M2	28.9841042	4.30	128.4	67.60	158.4
13	L2	29.5284789	1.20	283.2	3.80	253.9
14	S2	30.0000000	0.80	135.9	23.20	188.3
15	2SM2	31.0158958	0.20	45.5	1.10	139.0
16	MO3	42.9271398	0.30	69.5	0.10	194.0
17	M3	43.4761563	0.10	9.6	0.70	122.7
18	MK3	44.0251729	0.50	179.8	0.50	196.6
19	MN4	57.4238337	1.20	11.6	0.90	177.6
20	M4	57.9682084	3.00	54.9	2.90	238.6
21	SN4	58.4397295	0.30	93.1	0.30	343.5
22	MS4	58.9841042	2.00	86.3	0.50	298.0
23	2MN6	86.4079380	0.10	127.2	2.40	228.5
24	M6	86.9523127	0.50	164.9	4.20	267.2
25	MSN6	87.4238337	0.30	232.1	1.30	251.9
26	2MS6	87.9682084	0.50	202.8	4.20	301.6
27	2SM6	88.9841042	0.00	203.1	1.50	316.4

VARIANCE ORIGINAL (VO)	0.009	0.305	Metonic Max:	1.144m/s
VARIANCE RESIDUAL (VR)	0.00648	0.00996	MSRate:	0.898m/s
RATIO VR/VO	0.7272	0.0327	MNRate:	0.436m/s
SQRT(VO)	0.094	0.552	Bearing:	173.6°T
SQRT(VR)	0.08052	0.09981	Mean Drift:	0.052m/s
RATIO SQRT(VR)/SQRT(VO)	0.8527	0.1808	Bearing:	107.7°T

**APPENDIX D
TURBIDITY DATA PRESENTATION**

CONTENTS

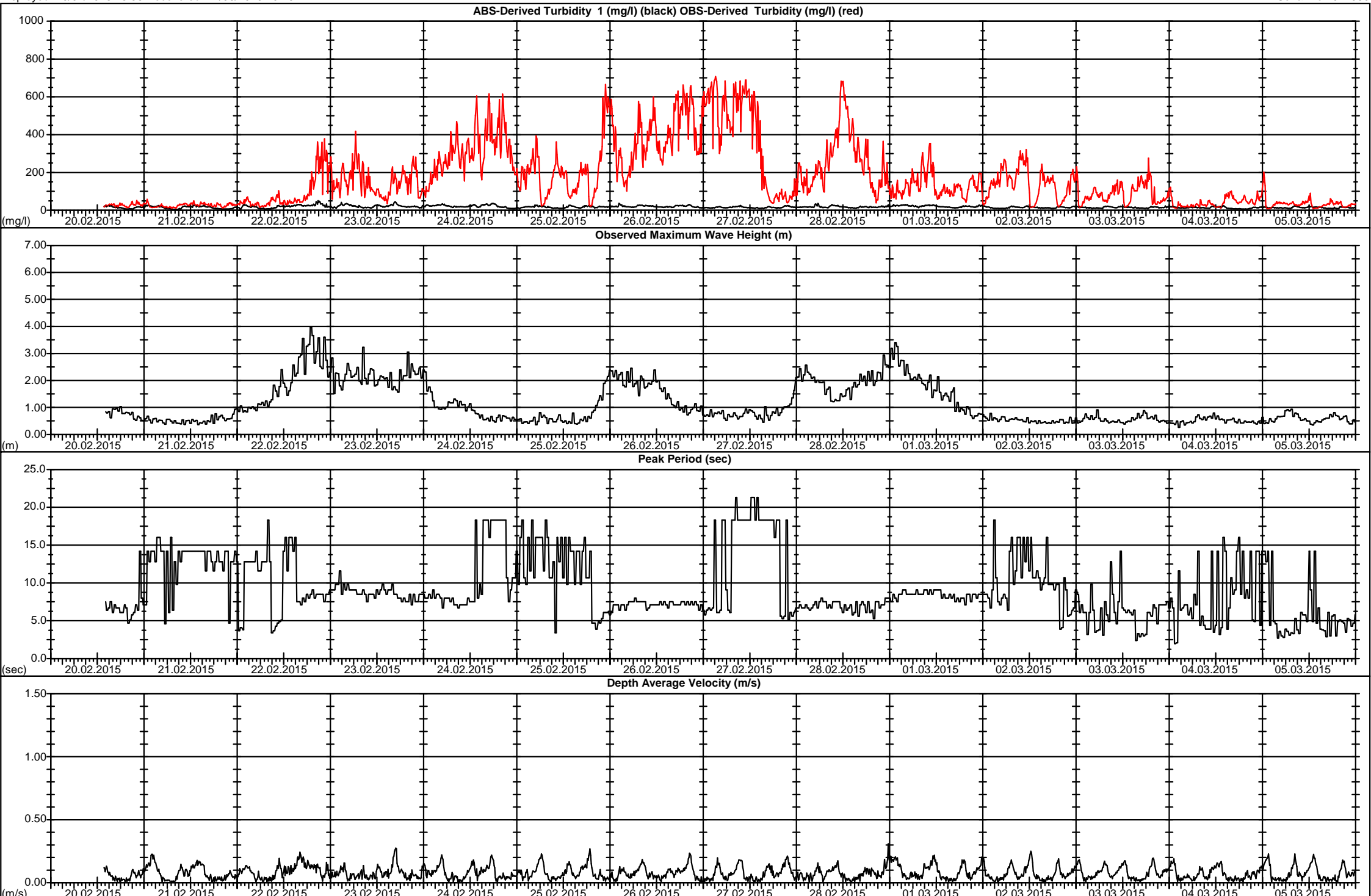
Figure or Table Number	Location	Data Presentation Type	Description
Figure D001 – D008	West	Time Series	ABS derived turbidity (Bin 1), OBS derived turbidity, H_{max} , T_p , depth averaged current velocity
Figure D009 – D012	West	Colour Contour Time Series	ABS derived turbidity throughout the water column
Figure D013 – D020	East	Time Series	ABS derived turbidity (Bin 1), OBS derived turbidity, H_{max} , T_p , depth averaged current velocity
Figure D021 – D028	East	Colour Contour Time Series	ABS derived turbidity throughout the water column

D1 Latitude: 57°07'59.64"N D1 Longitude: 002°02'57.60"W, D2 Latitude: 57°08'0.96"N Longitude: 002°02'59.76"W D1 Site depth below LAT: 5.75m D2 Site depth below LAT: 6.16m Instrument height off seabed: 0.45m

EnvironmentalSensors / Aqualogger OBS P

Deployed: 20/02/2015 13:36 Recovered: 11/06/2015 10:46

Serial No.: 024359

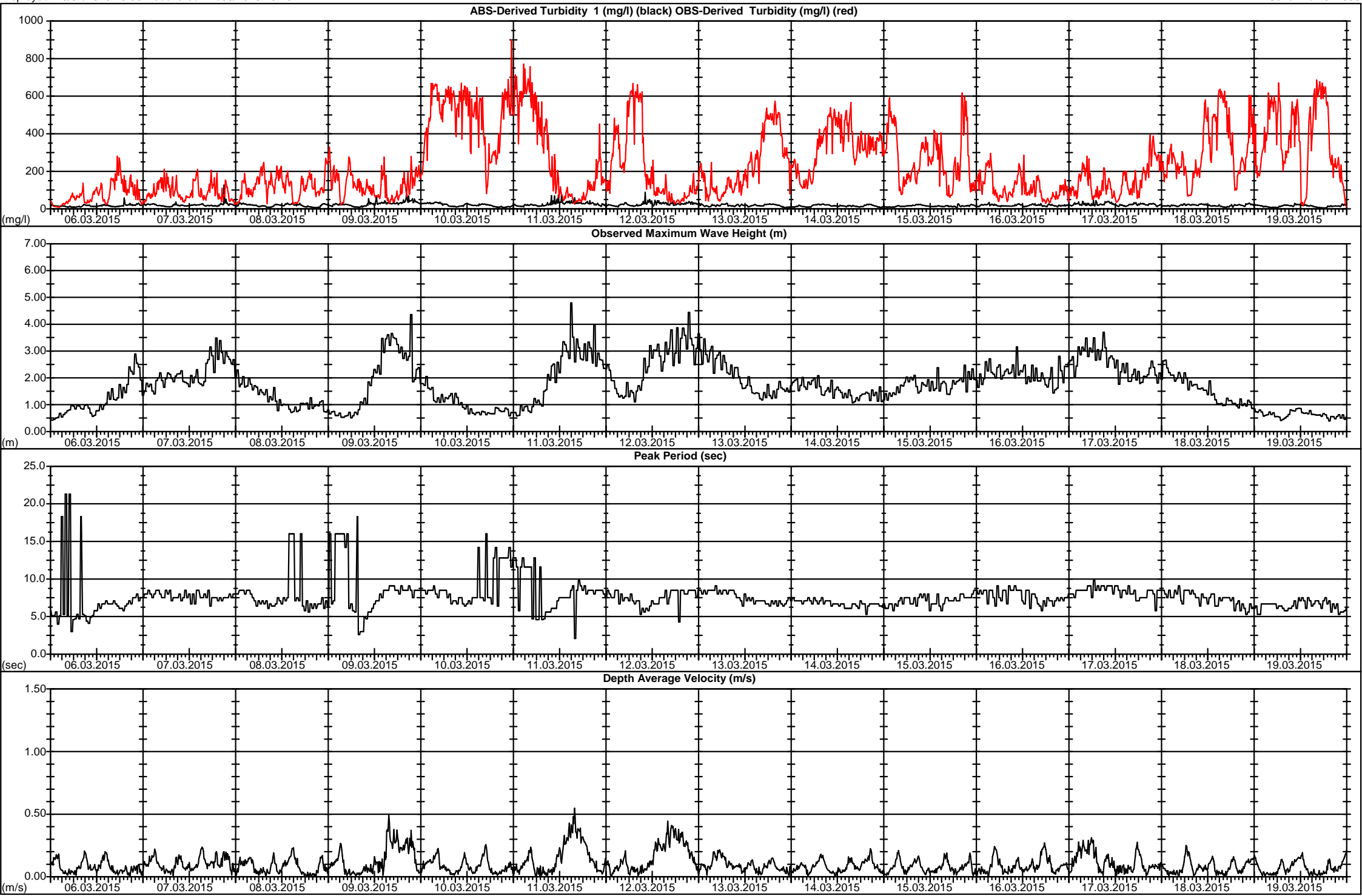


D1 Latitude: 57°07'59.64"N D1 Longitude: 002°02'57.60"W, D2 Latitude: 57°08'0.96"N Longitude: 002°02'59.76"W D1 Site depth below LAT: 5.75m D2 Site depth below LAT: 6.16m Instrument height off seabed: 0.45m

EnvironmentalSensors / Aqualogger OBS P

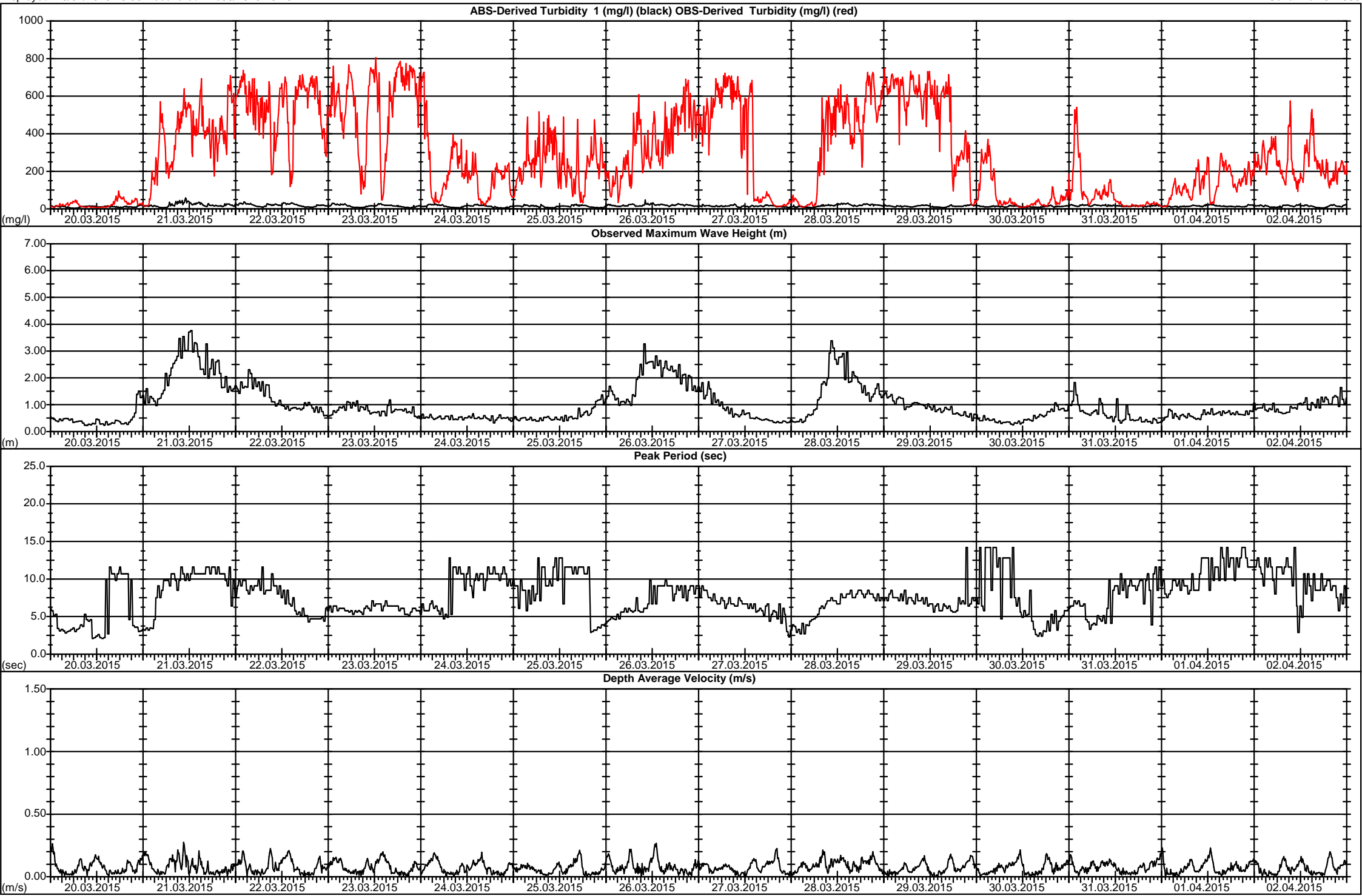
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Serial No.: 024359



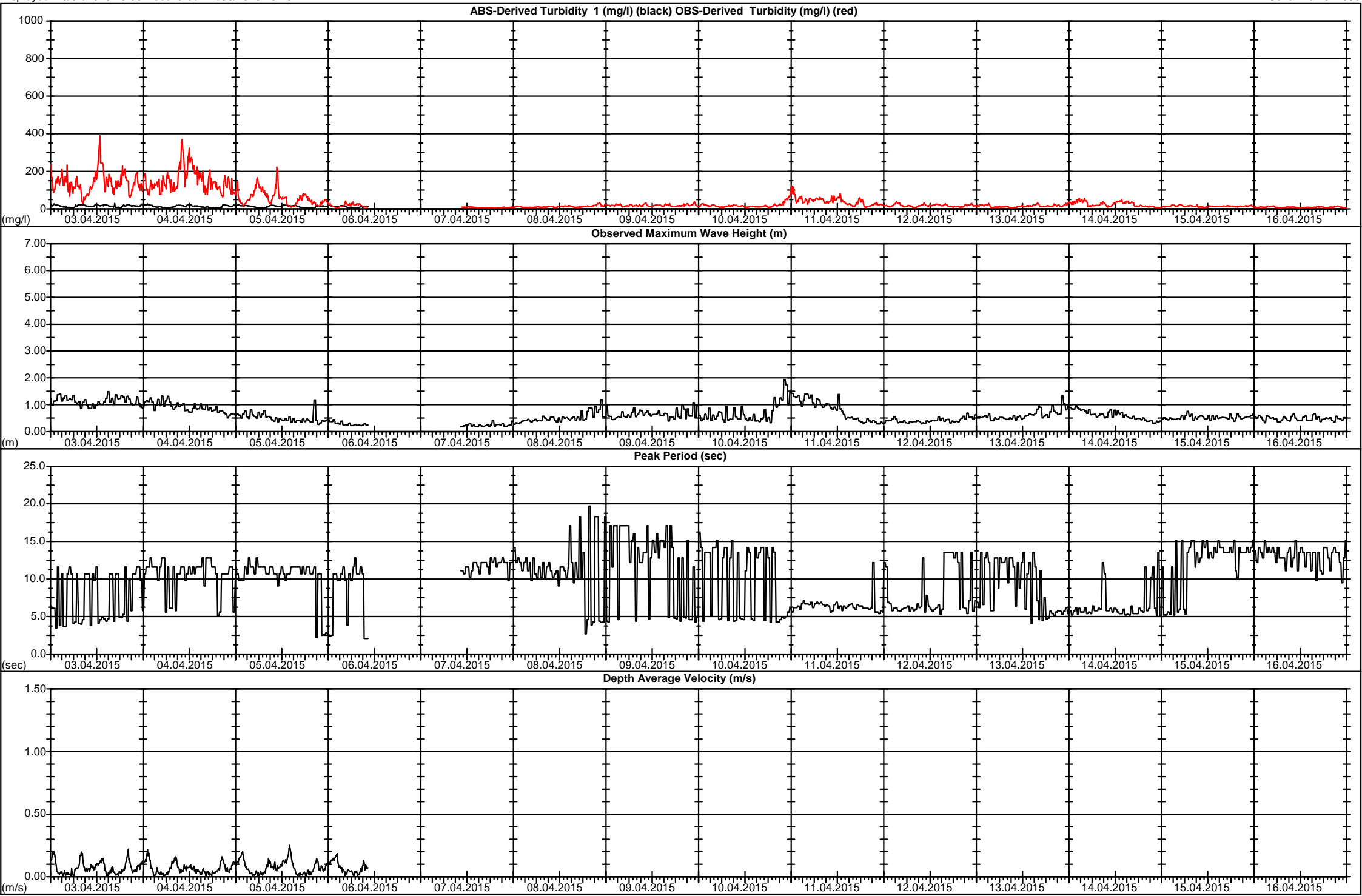
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Deployed: 20/02/2015 13:36 Recovered: 11/06/2015 10:46

EnvironmentalSensors / Aqualogger OBS P
Serial No.: 024359



D1 Latitude: 57°07'59.64"N D1 Longitude: 002°02'57.60"W, D2 Latitude: 57°08'0.96"N Longitude: 002°02'59.76"W D1 Site depth below LAT: 5.75m D2 Site depth below LAT: 6.16m Instrument height off seabed: 0.45m
Deployed: 20/02/2015 13:36 Recovered: 11/06/2015 10:46

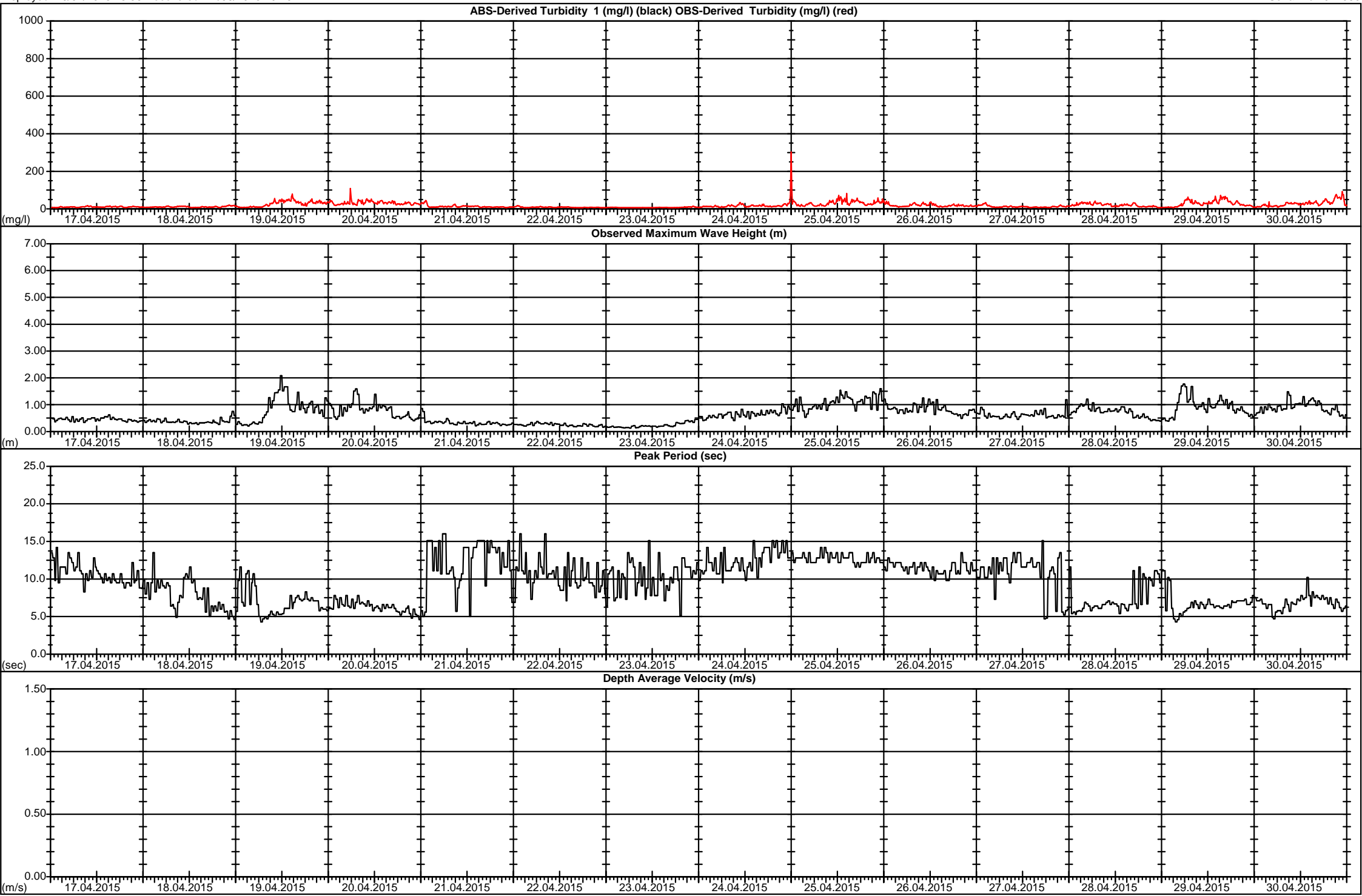
EnvironmentalSensors / Aqualogger OBS P
Serial No.: 024359



Turbidity Data Time Series Aberdeen Harbour Expansion EIA, West, D1 - D2

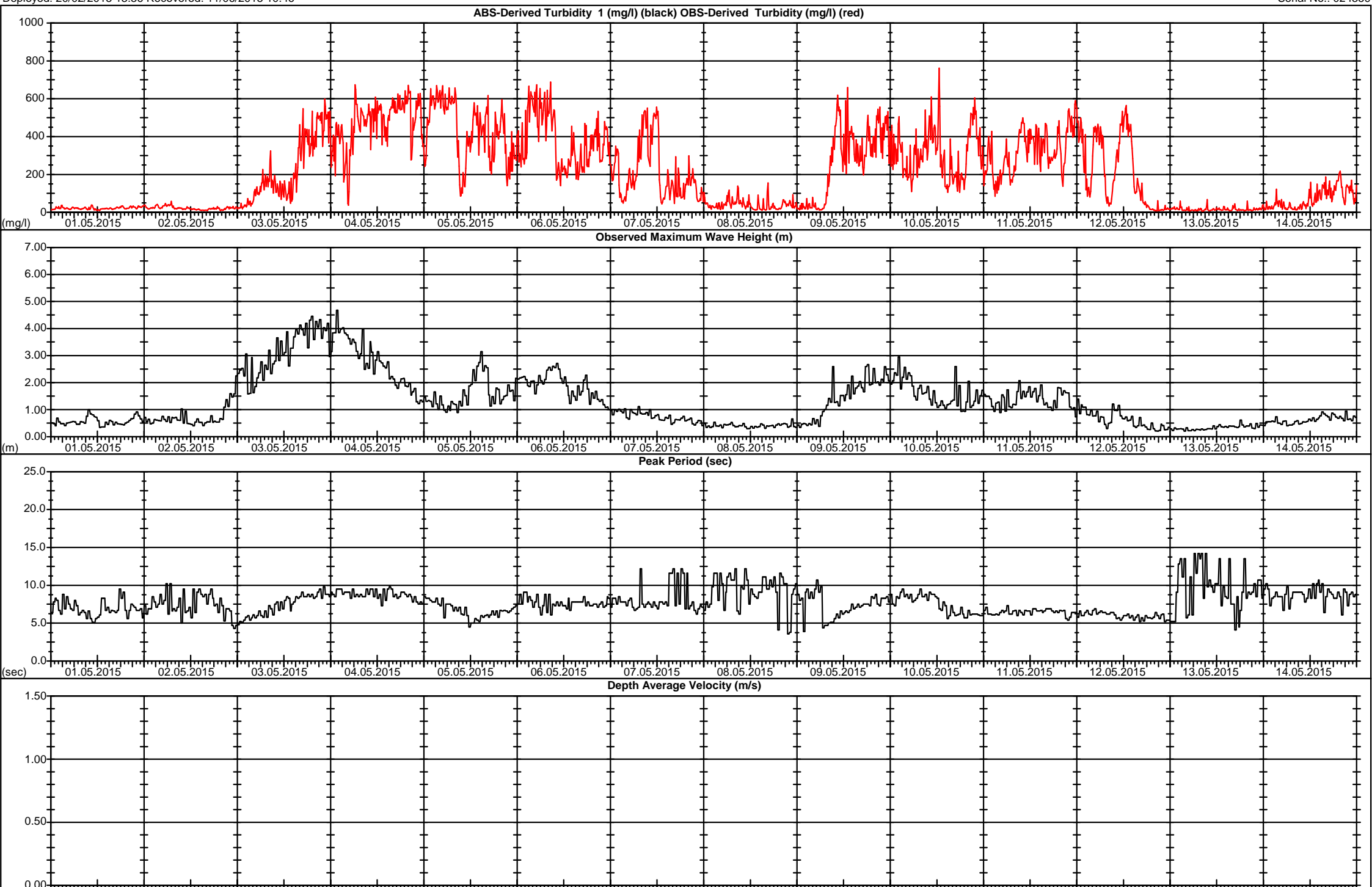
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Deployed: 20/02/2015 13:36 Recovered: 11/06/2015 10:46

EnvironmentalSensors / Aqualogger OBS P
Serial No.: 024359



D1 Latitude: 57°07'59.64"N D1 Longitude: 002°02'57.60"W, D2 Latitude: 57°08'0.96"N Longitude: 002°02'59.76"W D1 Site depth below LAT: 5.75m D2 Site depth below LAT: 6.16m Instrument height off seabed: 0.45m
Deployed: 20/02/2015 13:36 Recovered: 11/06/2015 10:46

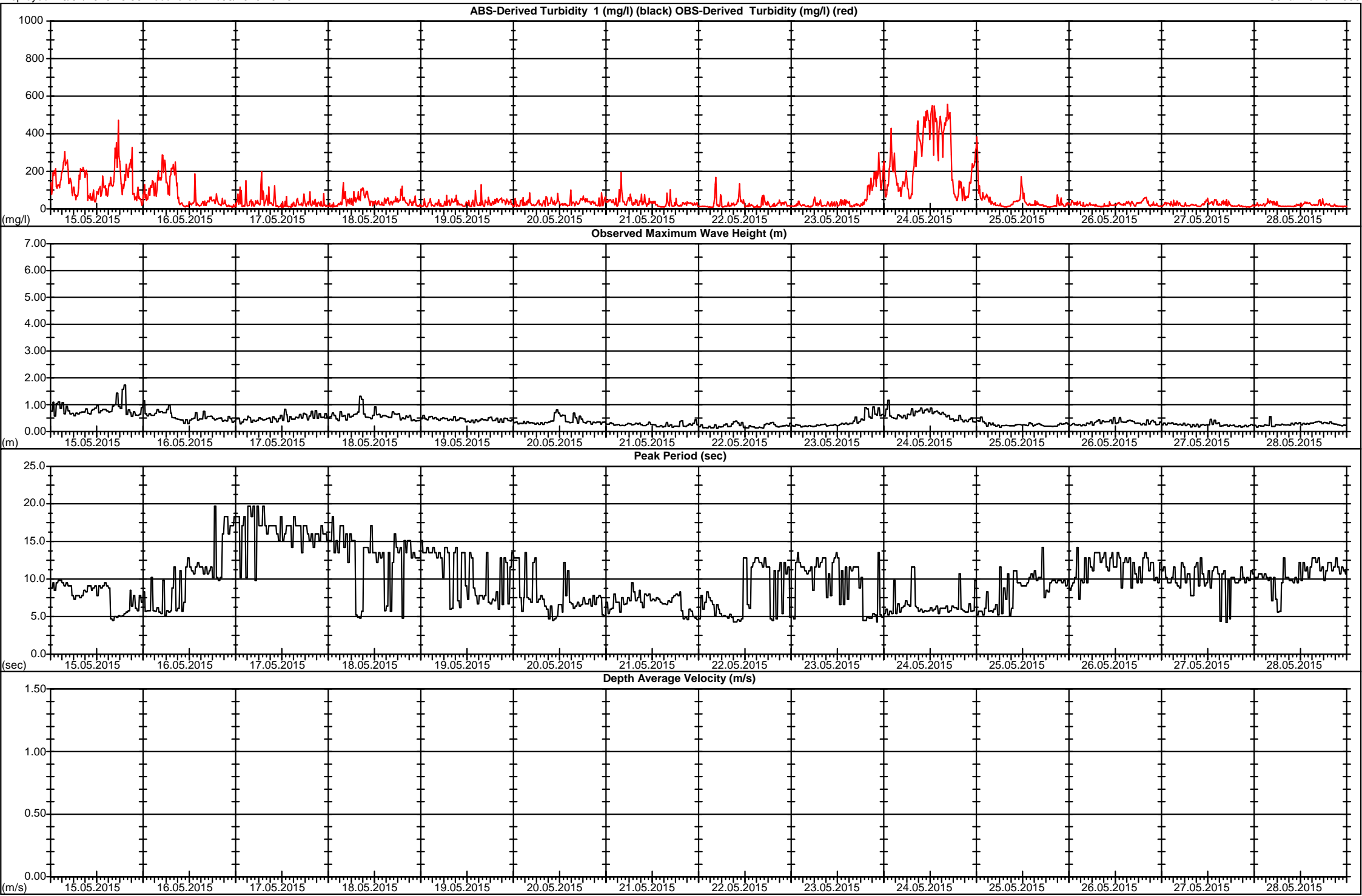
EnvironmentalSensors / Aqualogger OBS P
Serial No.: 024359



Turbidity Data Time Series Aberdeen Harbour Expansion EIA, West, D1 - D2

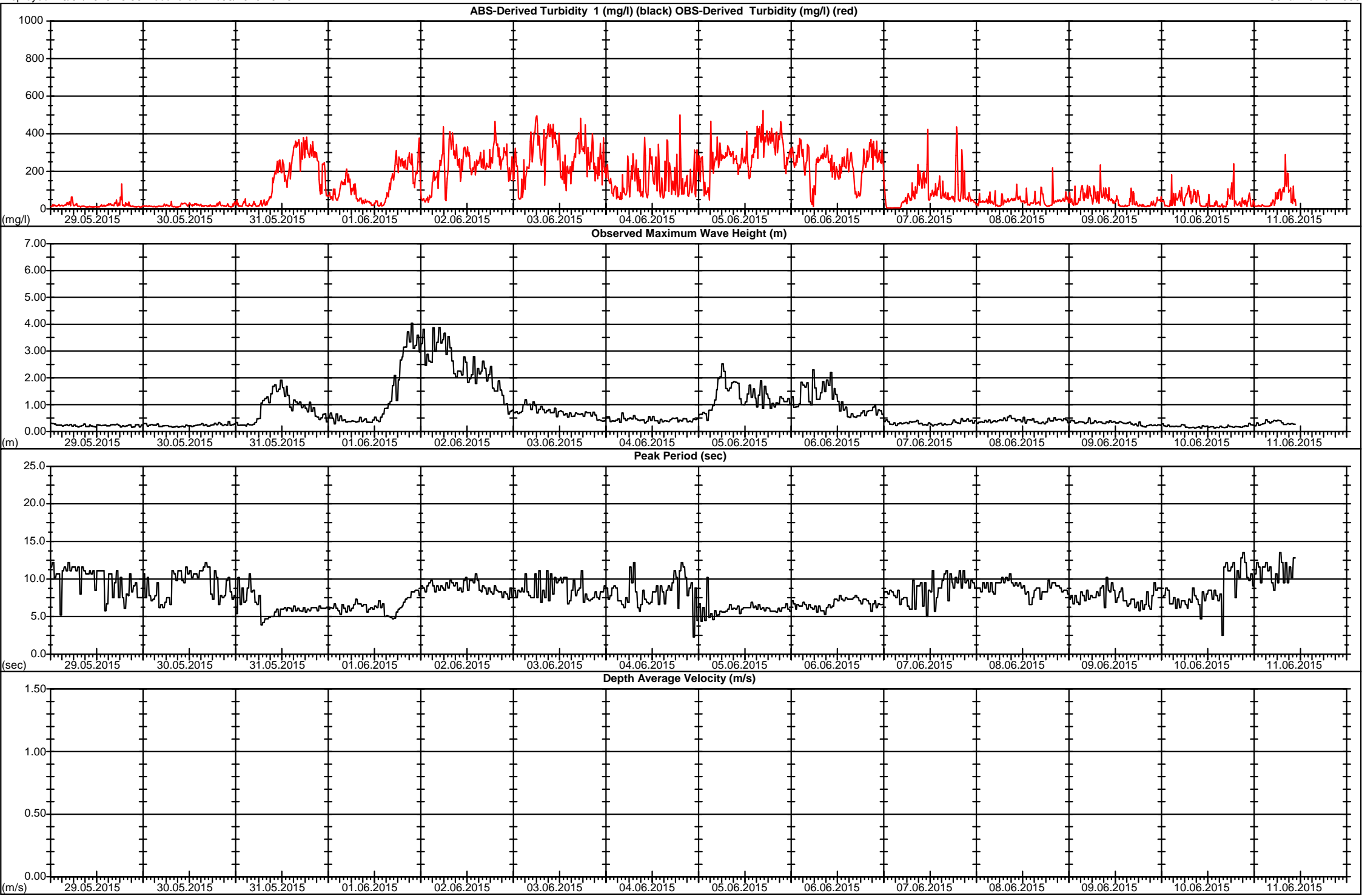
D1 Latitude: 57°07'59.64"N D1 Longitude: 002°02'57.60"W, D2 Latitude: 57°08'0.96"N Longitude: 002°02'59.76"W D1 Site depth below LAT: 5.75m D2 Site depth below LAT: 6.16m Instrument height off seabed: 0.45m
Deployed: 20/02/2015 13:36 Recovered: 11/06/2015 10:46

EnvironmentalSensors / Aqualogger OBS P
Serial No.: 024359



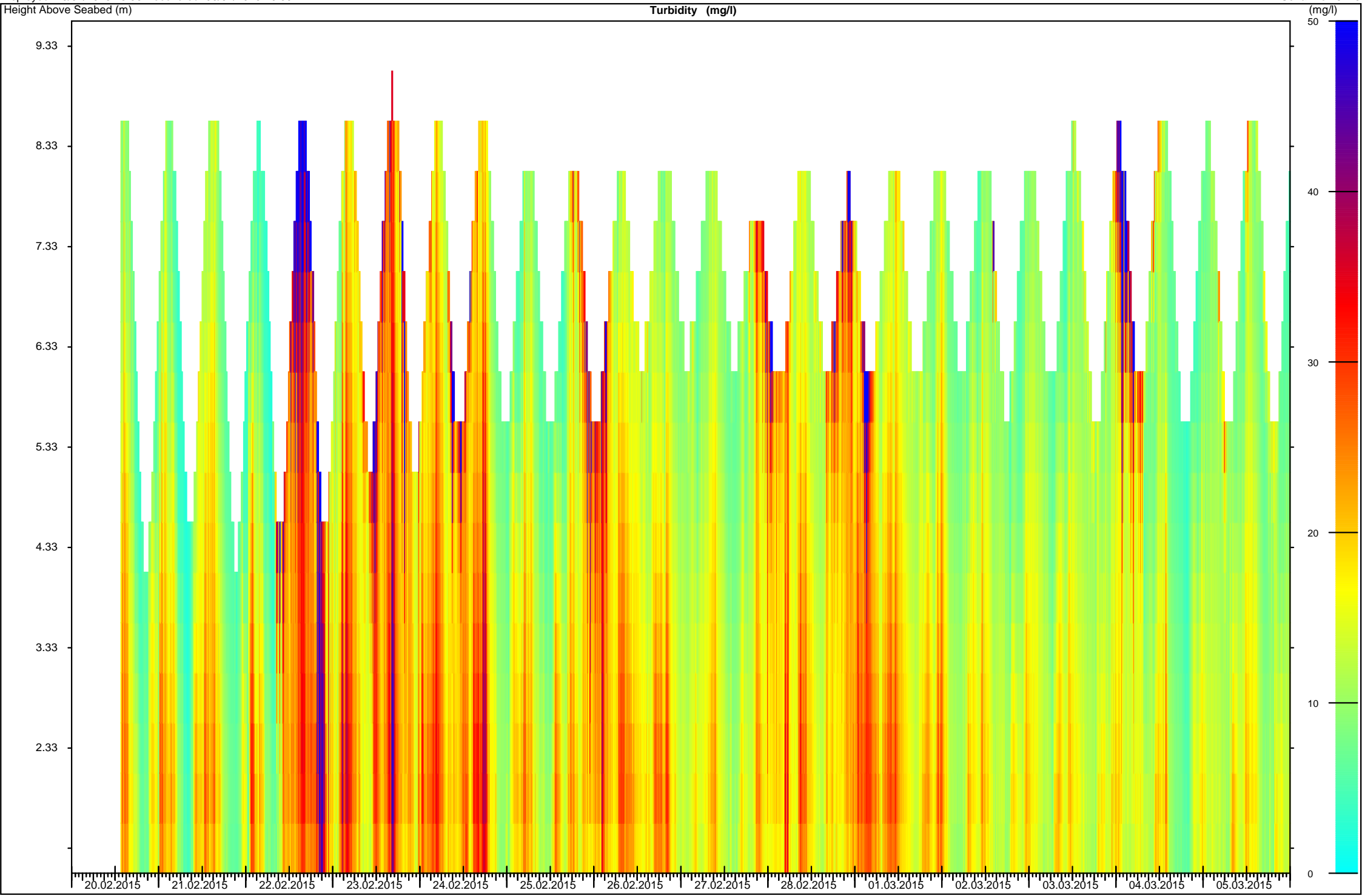
D1 Latitude: 57°07'59.64"N D1 Longitude: 002°02'57.60"W, D2 Latitude: 57°08'09.96"N Longitude: 002°02'59.76"W D1 Site depth below LAT: 5.75m D2 Site depth below LAT: 6.16m Instrument height off seabed: 0.45m
Deployed: 20/02/2015 13:36 Recovered: 11/06/2015 10:46

EnvironmentalSensors / Aqualogger OBS P
Serial No.: 024359



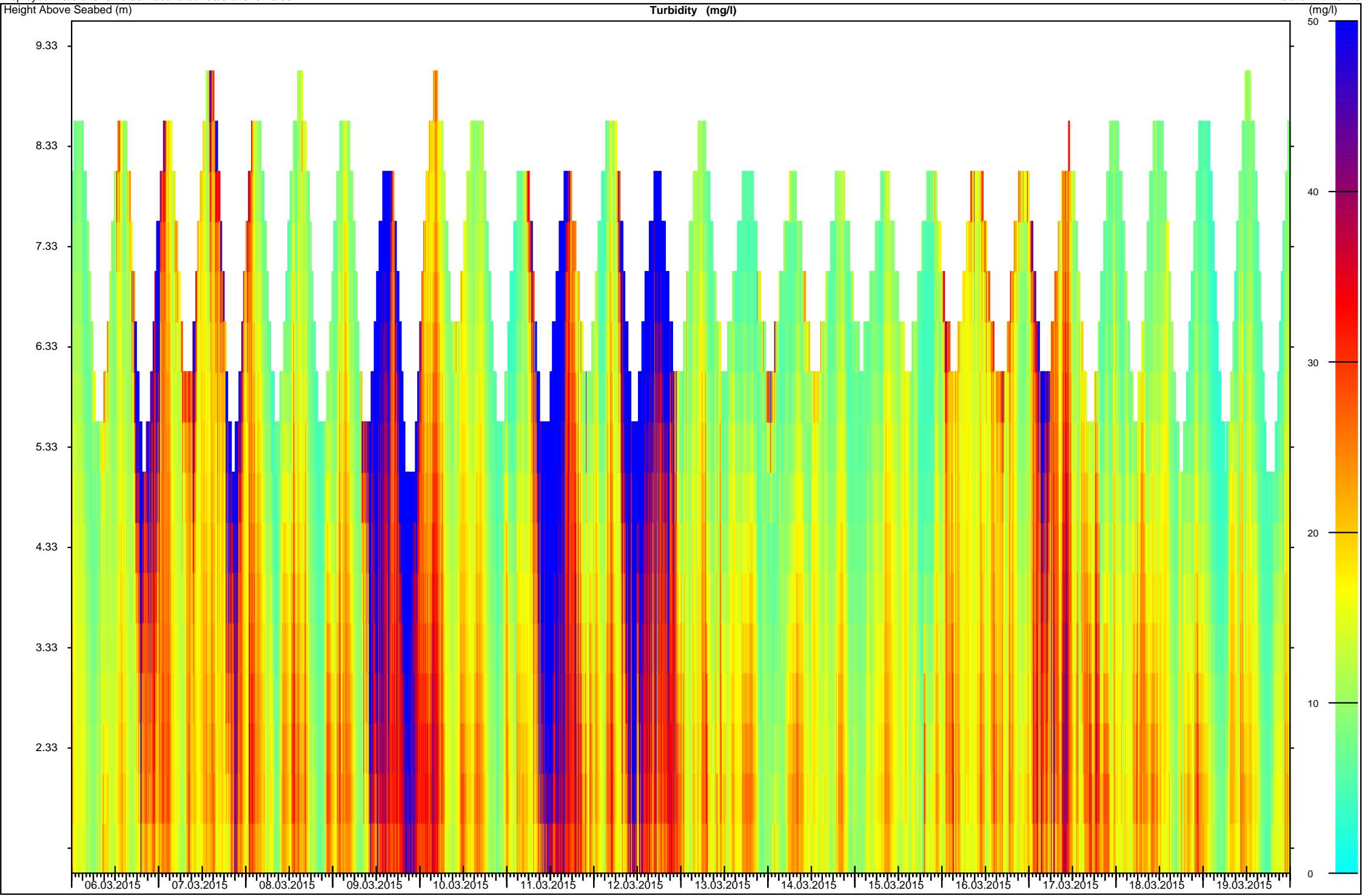
Latitude: 57°07'59.64"N Longitude: 002°02'57.60"W Site depth below LAT: 5.75m Instrument height off seabed: 0.68m
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Height Above Seabed (m)

Current Meter / AWAC
Serial No.: 5115



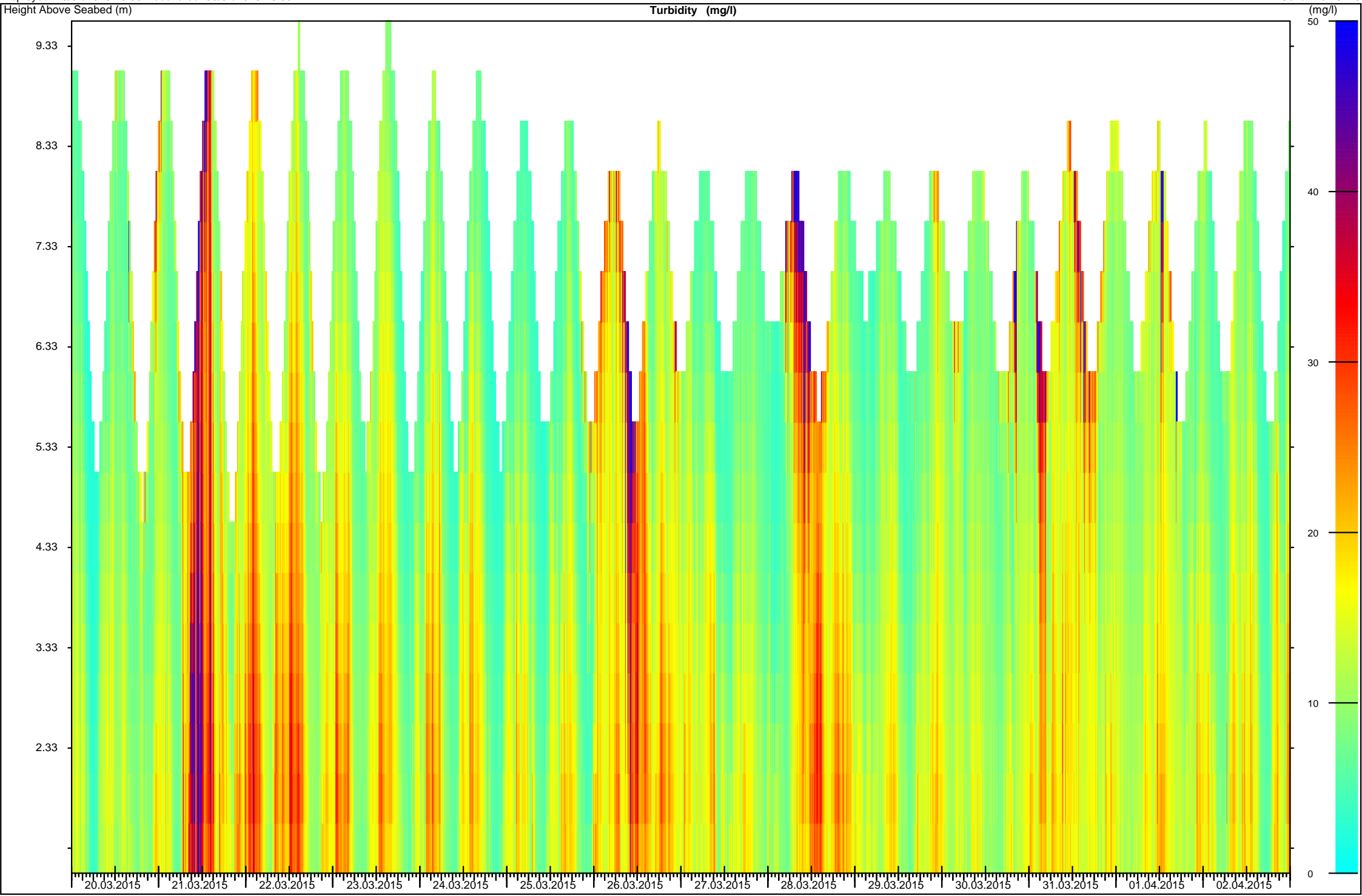
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Height Above Seabed (m)

Current Meter / AWAC
Serial No.: 5115



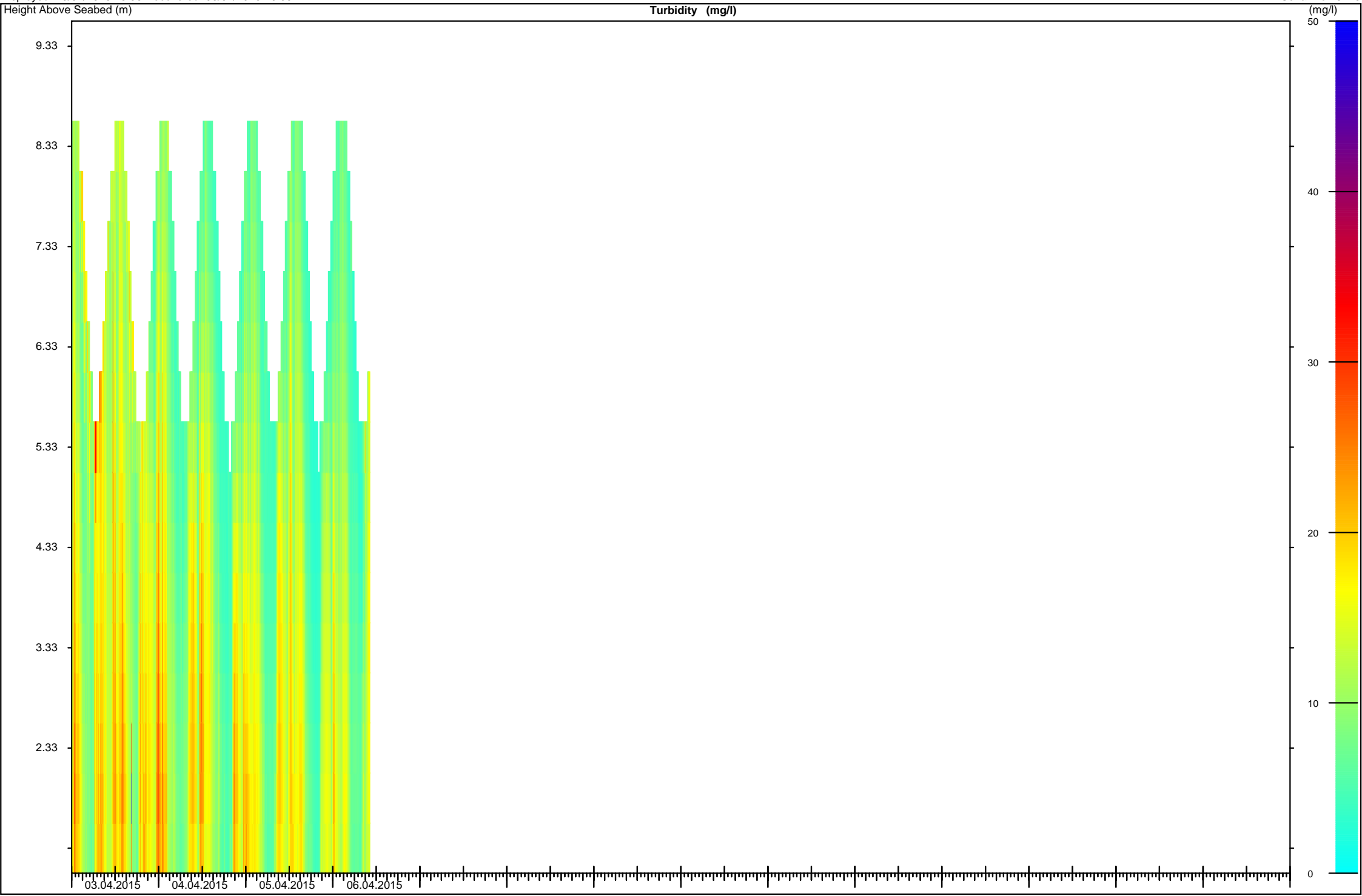
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Deployed: 20/02/2015 13:36 Recovered: 06/04/2015 10:30
Height Above Seabed (m)

Current Meter / AWAC
Serial No.: 5115



Latitude: 57°07'59.64"N Longitude: 002°02'57.60"W Site depth below LAT: 5.75m Instrument height off seabed: 0.68m
Deployed: 20/02/2015 13:36 Recovered: 06/04/2015 10:30
Height Above Seabed (m)

Current Meter / AWAC
Serial No.: 5115



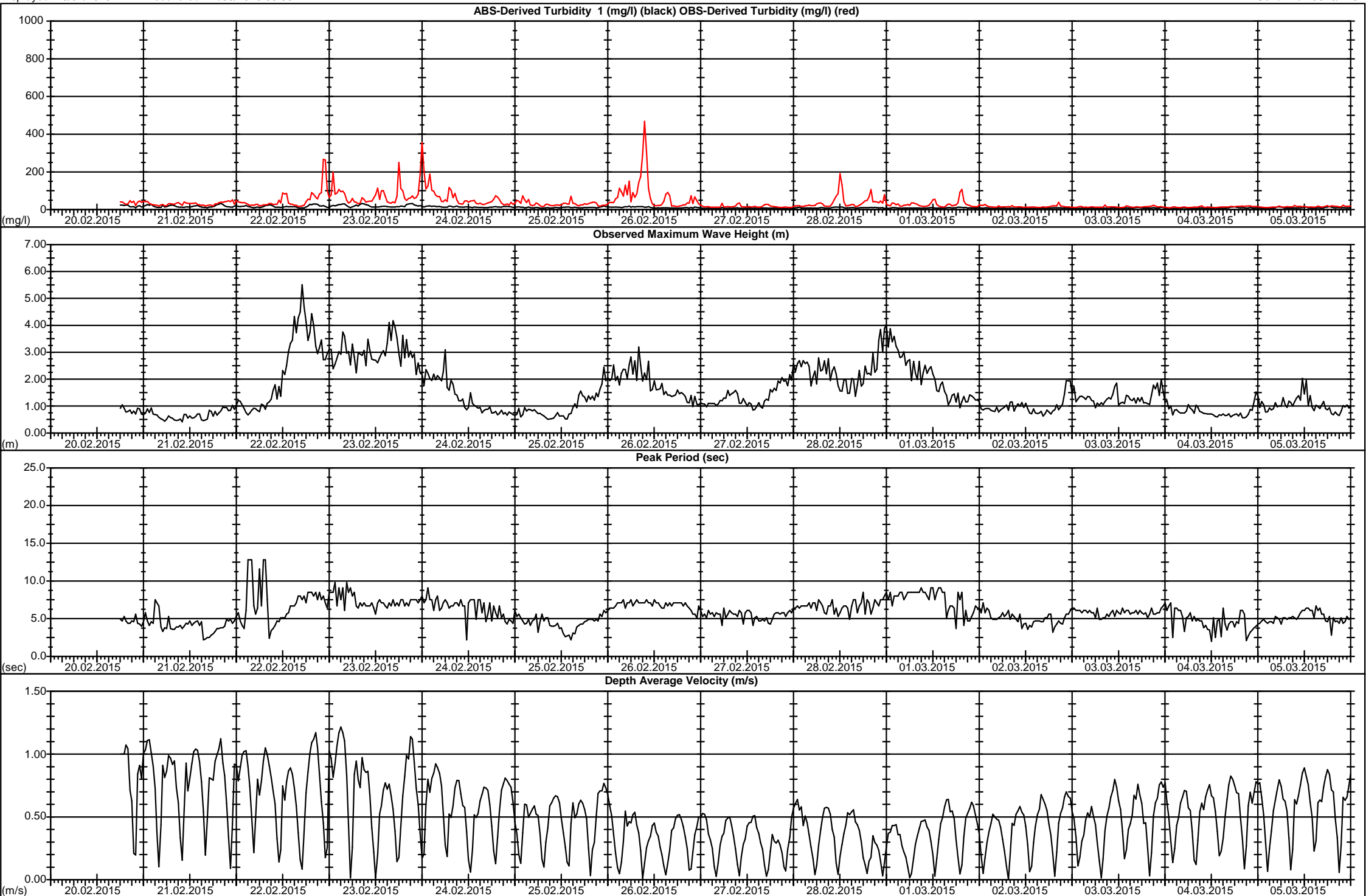
Aberdeen Harbour Expansion EIA, East, D1 - D2

D1 Latitude: 57°08'0.84"N D1 Longitude: 002°02'8.10"W D2 Latitude: 57°08'0.72"N D2 Longitude: 002°02'8.28"W D1 Site depth below LAT: 18.15m D2 Site depth below LAT: 19.06m Instrument height off seabed: 0.66m

Current Meter / AWAC

Deployed: 20/02/2015 17:42 Recovered: 11/06/2015 08:50

Serial No.: 5615/1487



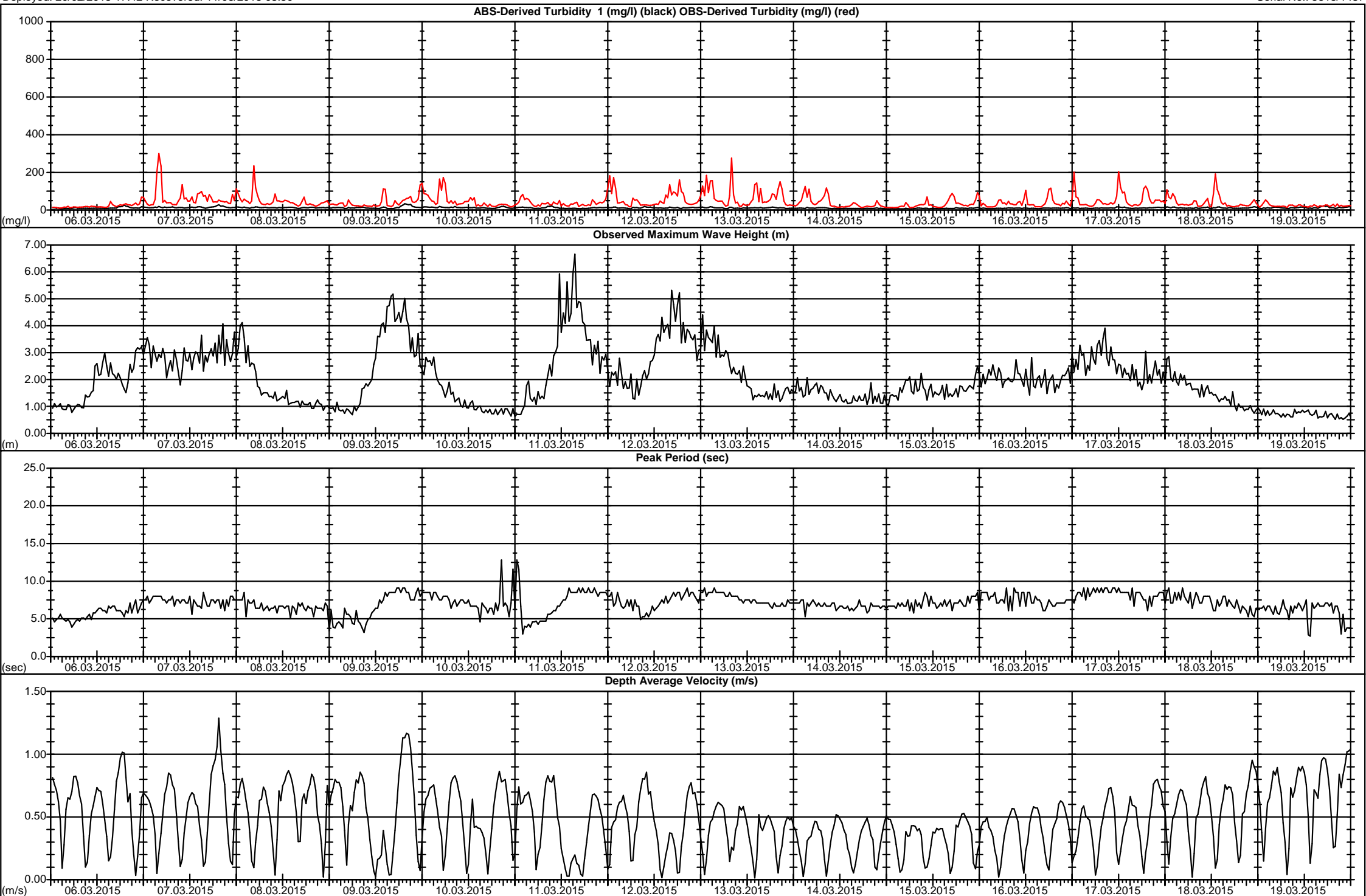
Aberdeen Harbour Expansion EIA, East, D1 - D2

D1 Latitude: 57°08'0.84"N D1 Longitude: 002°02'8.10"W D2 Latitude: 57°08'0.72"N D2 Longitude: 002°02'8.28"W D1 Site depth below LAT: 18.15m D2 Site depth below LAT: 19.06m Instrument height off seabed: 0.66m

Current Meter / AWAC

Deployed: 20/02/2015 17:42 Recovered: 11/06/2015 08:50

Serial No.: 5615/1487



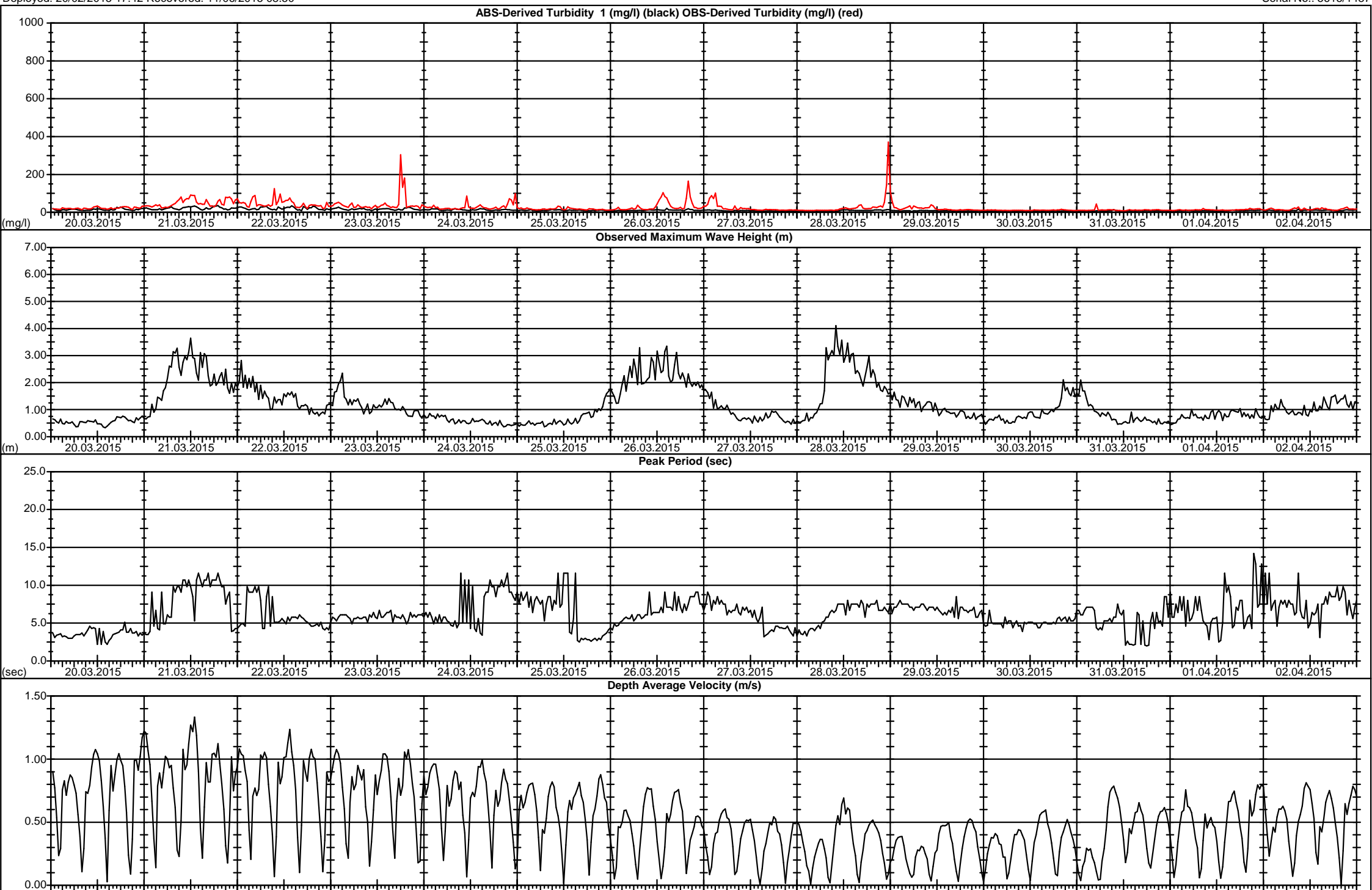
Aberdeen Harbour Expansion EIA, East, D1 - D2

D1 Latitude: 57°08'0.84"N D1 Longitude: 002°02'8.10"W D2 Latitude: 57°08'0.72"N D2 Longitude: 002°02'8.28"W D1 Site depth below LAT: 18.15m D2 Site depth below LAT: 19.06m Instrument height off seabed: 0.66m

Current Meter / AWAC

Deployed: 20/02/2015 17:42 Recovered: 11/06/2015 08:50

Serial No.: 5615/1487



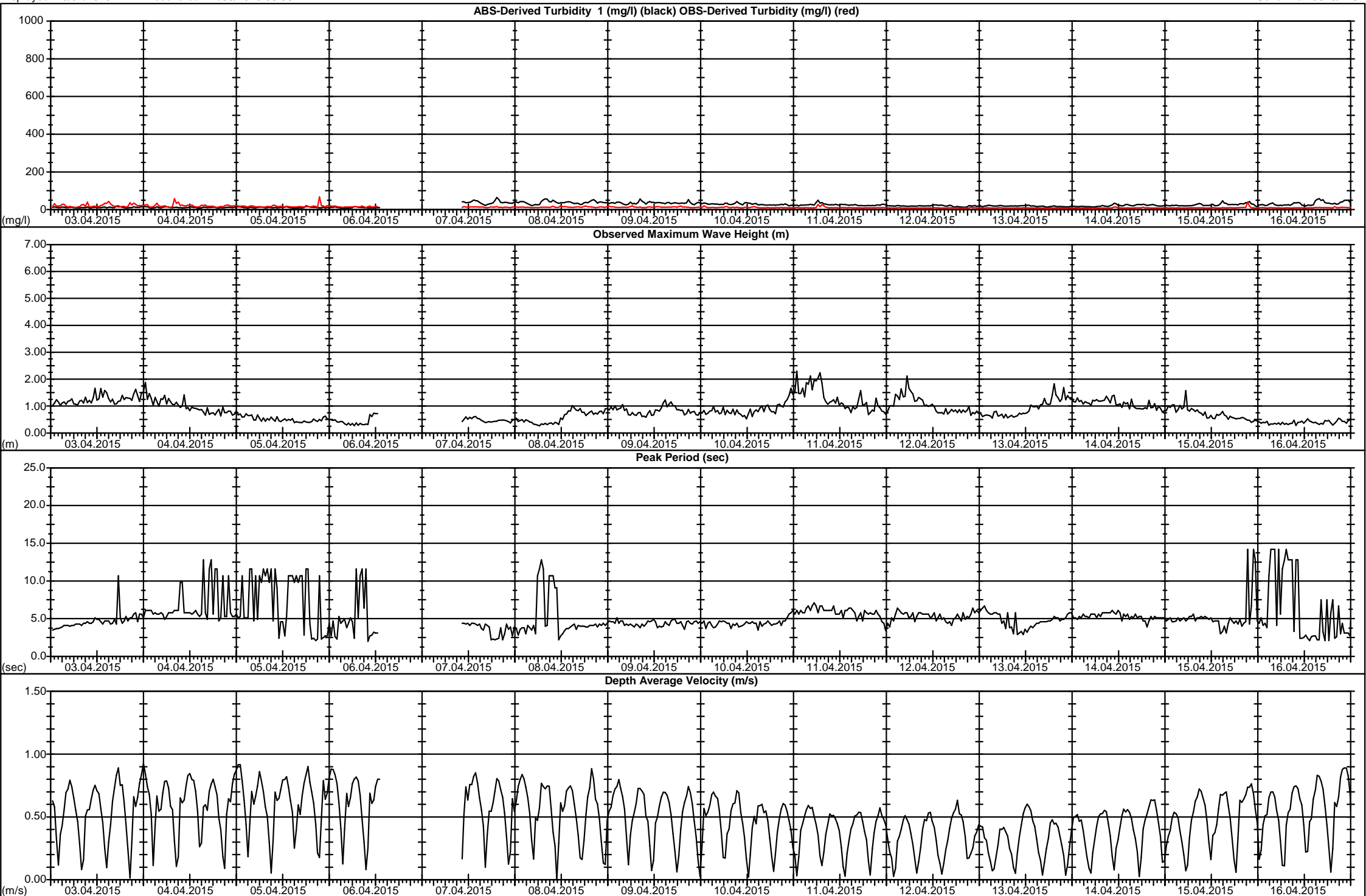
Aberdeen Harbour Expansion EIA, East, D1 - D2

D1 Latitude: 57°08'0.84"N D1 Longitude: 002°02'8.10"W D2 Latitude: 57°08'0.72"N D2 Longitude: 002°02'8.28"W D1 Site depth below LAT: 18.15m D2 Site depth below LAT: 19.06m Instrument height off seabed: 0.66m

Current Meter / AWAC

Deployed: 20/02/2015 17:42 Recovered: 11/06/2015 08:50

Serial No.: 5615/1487



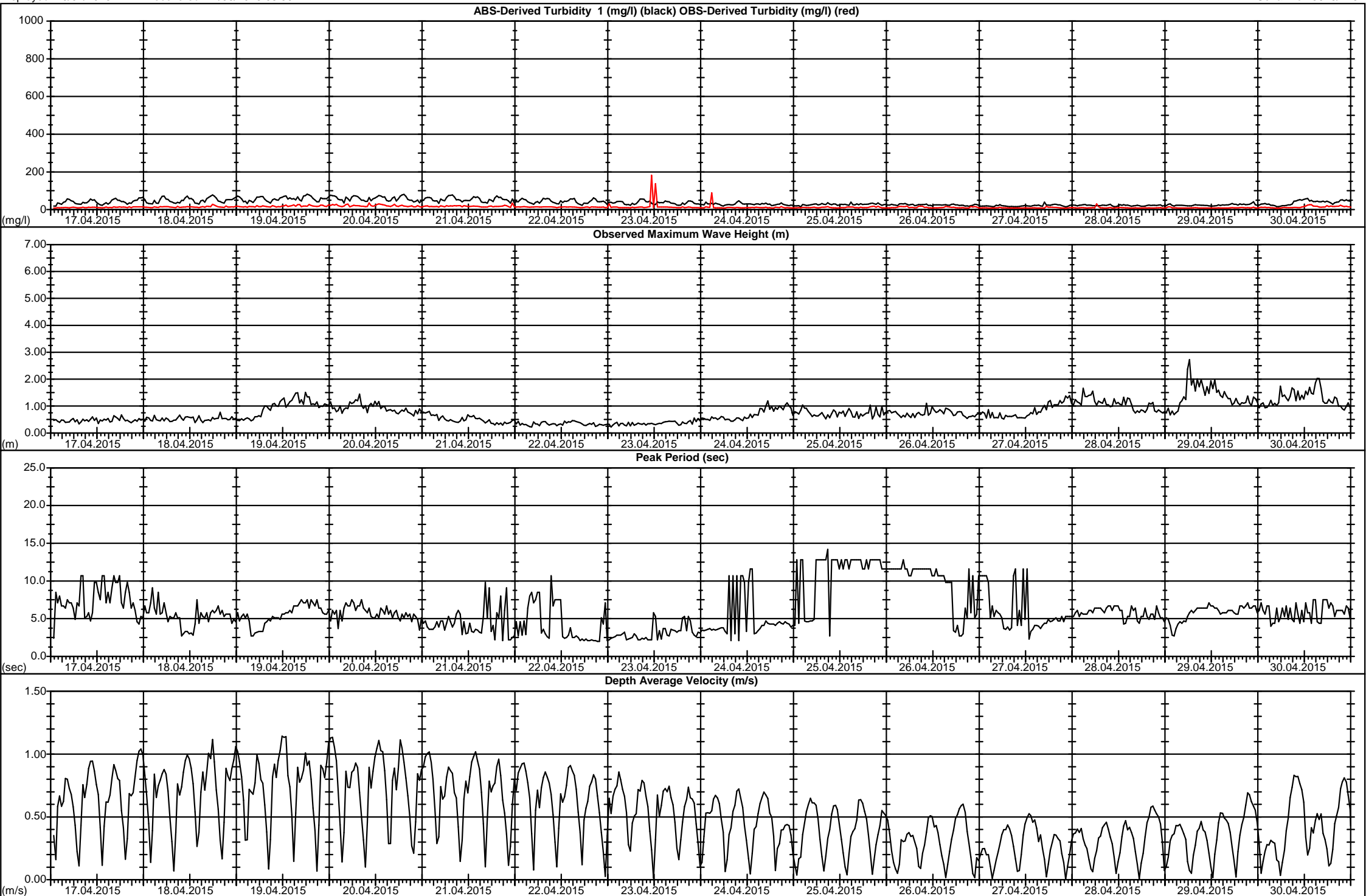
Aberdeen Harbour Expansion EIA, East, D1 - D2

D1 Latitude: 57°08'0.84"N D1 Longitude: 002°02'8.10"W D2 Latitude: 57°08'0.72"N D2 Longitude: 002°02'8.28"W D1 Site depth below LAT: 18.15m D2 Site depth below LAT: 19.06m Instrument height off seabed: 0.66m

Current Meter / AWAC

Deployed: 20/02/2015 17:42 Recovered: 11/06/2015 08:50

Serial No.: 5615/1487



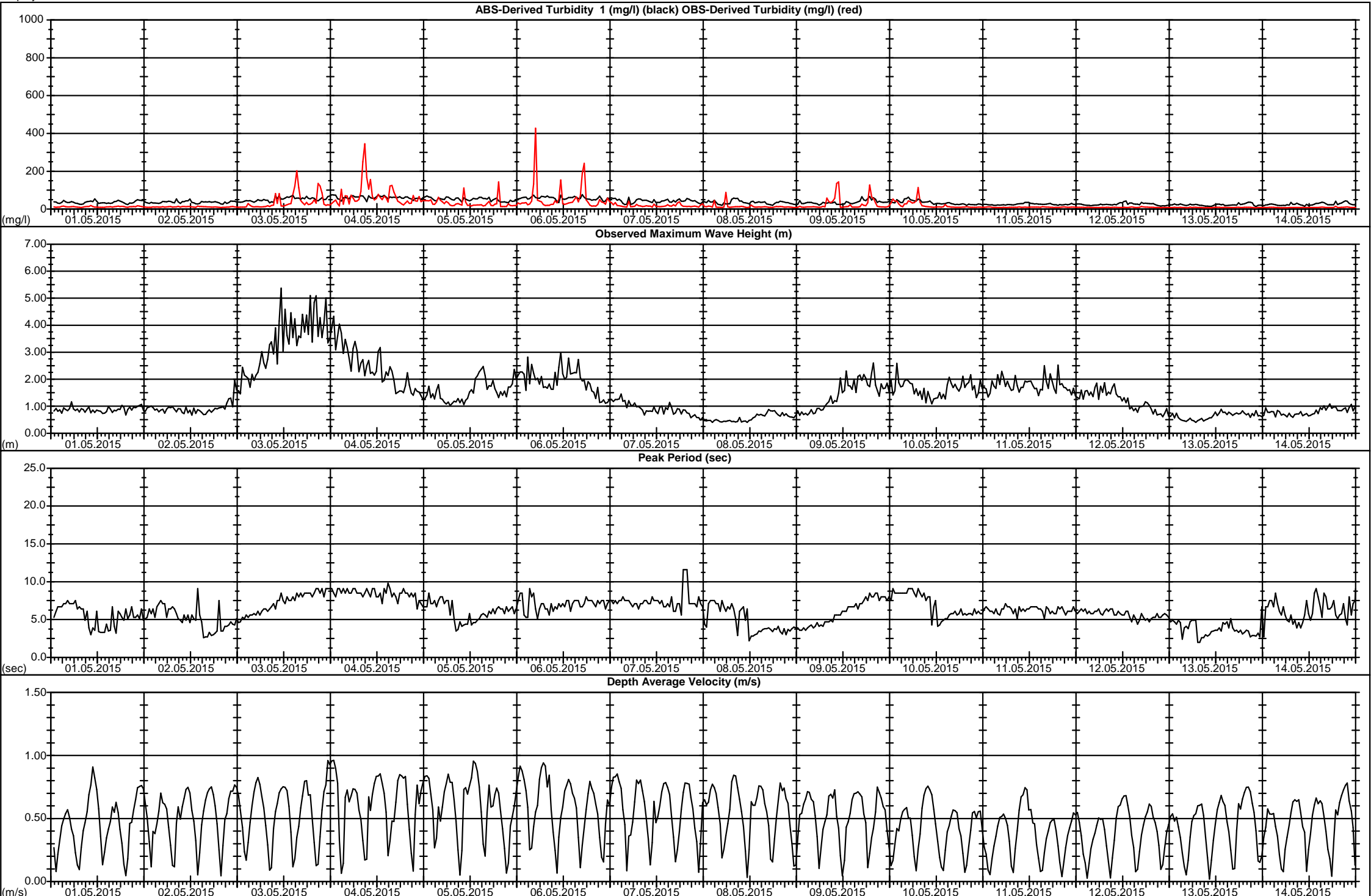
Aberdeen Harbour Expansion EIA, East, D1 - D2

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Current Meter / AWAC

Deployed: 20/02/2015 17:42 Recovered: 11/06/2015 08:50

Serial No.: 5615/1487



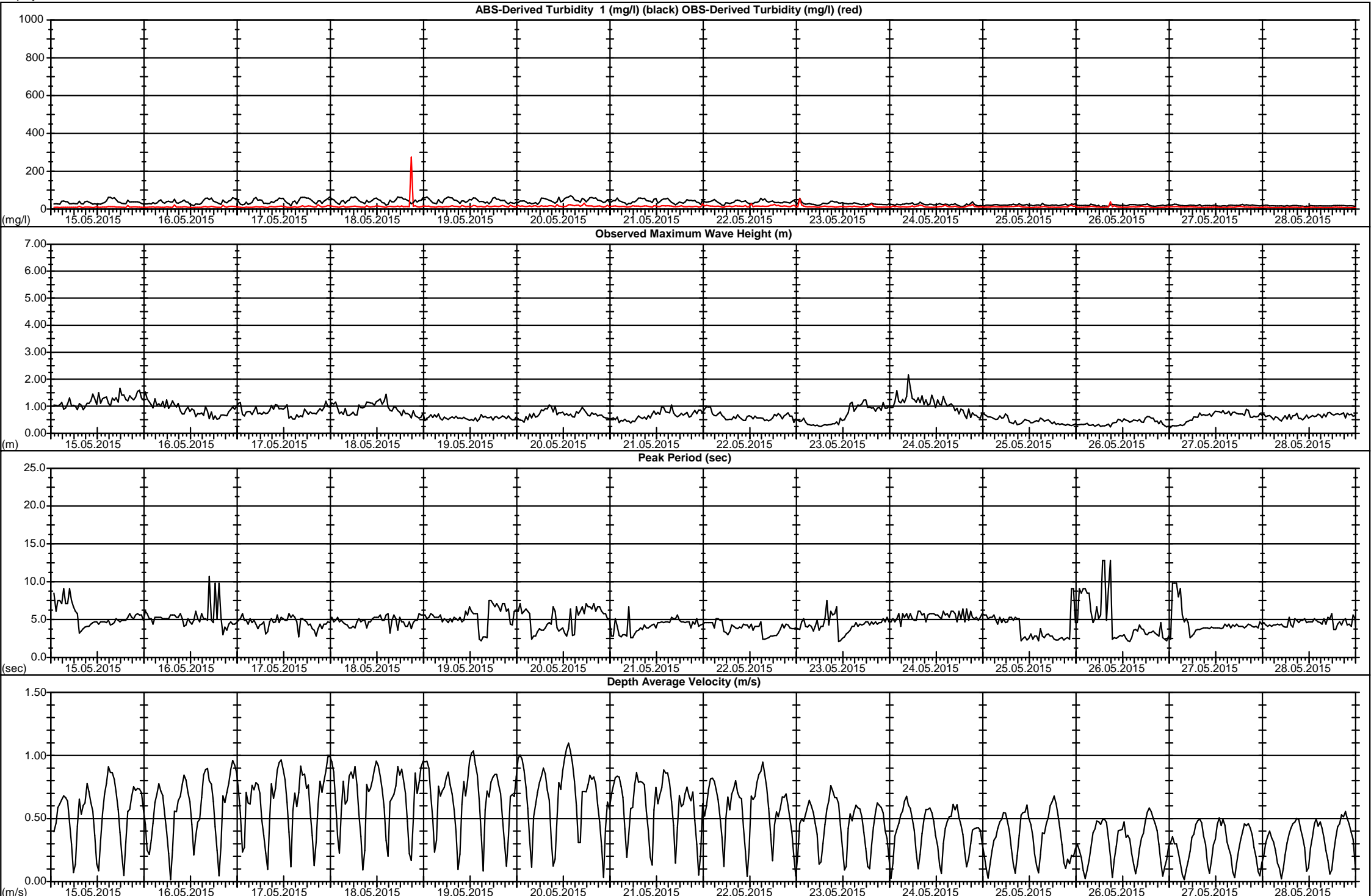
Aberdeen Harbour Expansion EIA, East, D1 - D2

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Current Meter / AWAC

Deployed: 20/02/2015 17:42 Recovered: 11/06/2015 08:50

Serial No.: 5615/1487



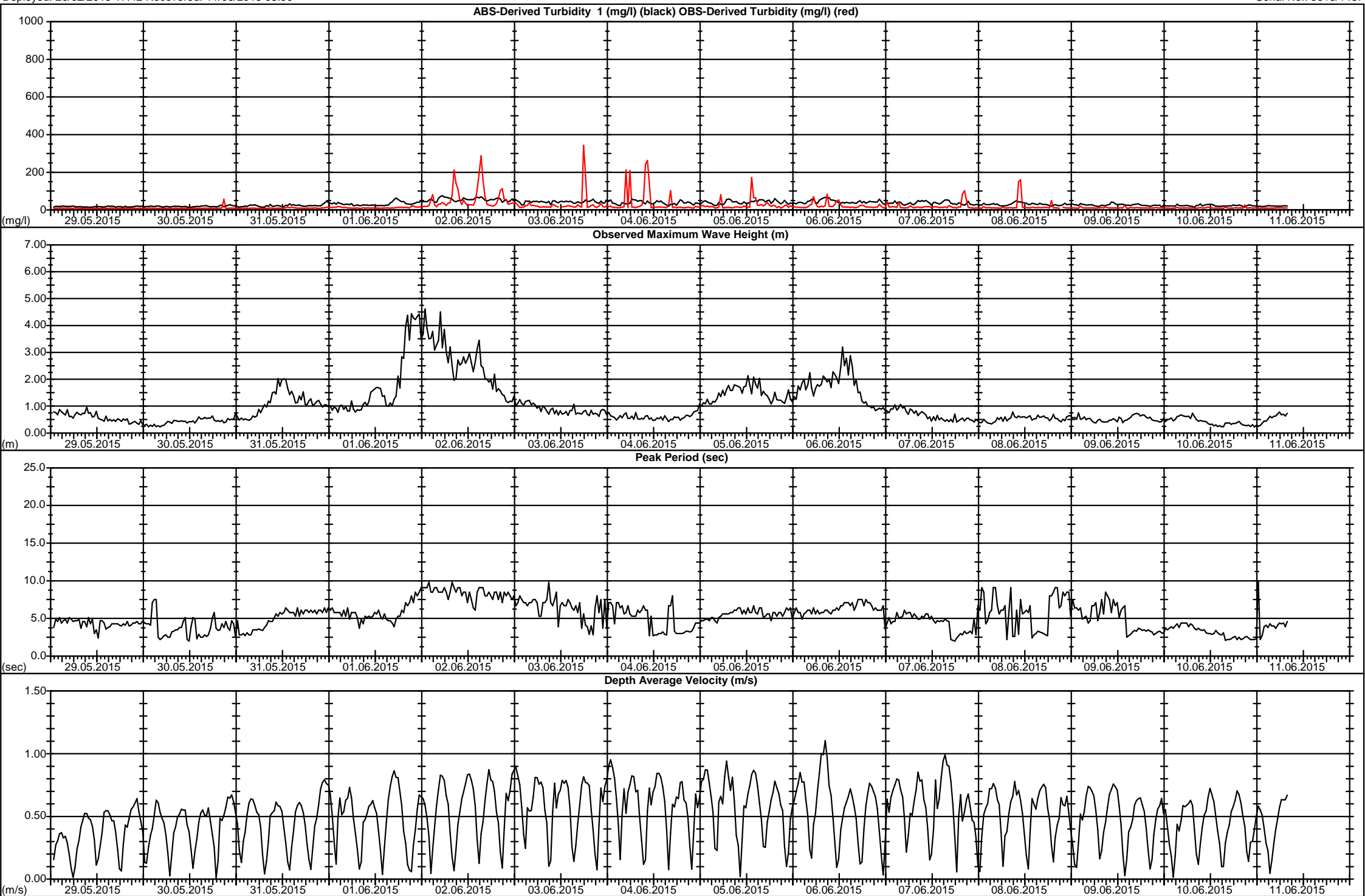
Aberdeen Harbour Expansion EIA, East, D1 - D2

D1 Latitude: 57°08'0.84"N D1 Longitude: 002°02'8.10"W D2 Latitude: 57°08'0.72"N D2 Longitude: 002°02'8.28"W D1 Site depth below LAT: 18.15m D2 Site depth below LAT: 19.06m Instrument height off seabed: 0.66m

Current Meter / AWAC

Deployed: 20/02/2015 17:42 Recovered: 11/06/2015 08:50

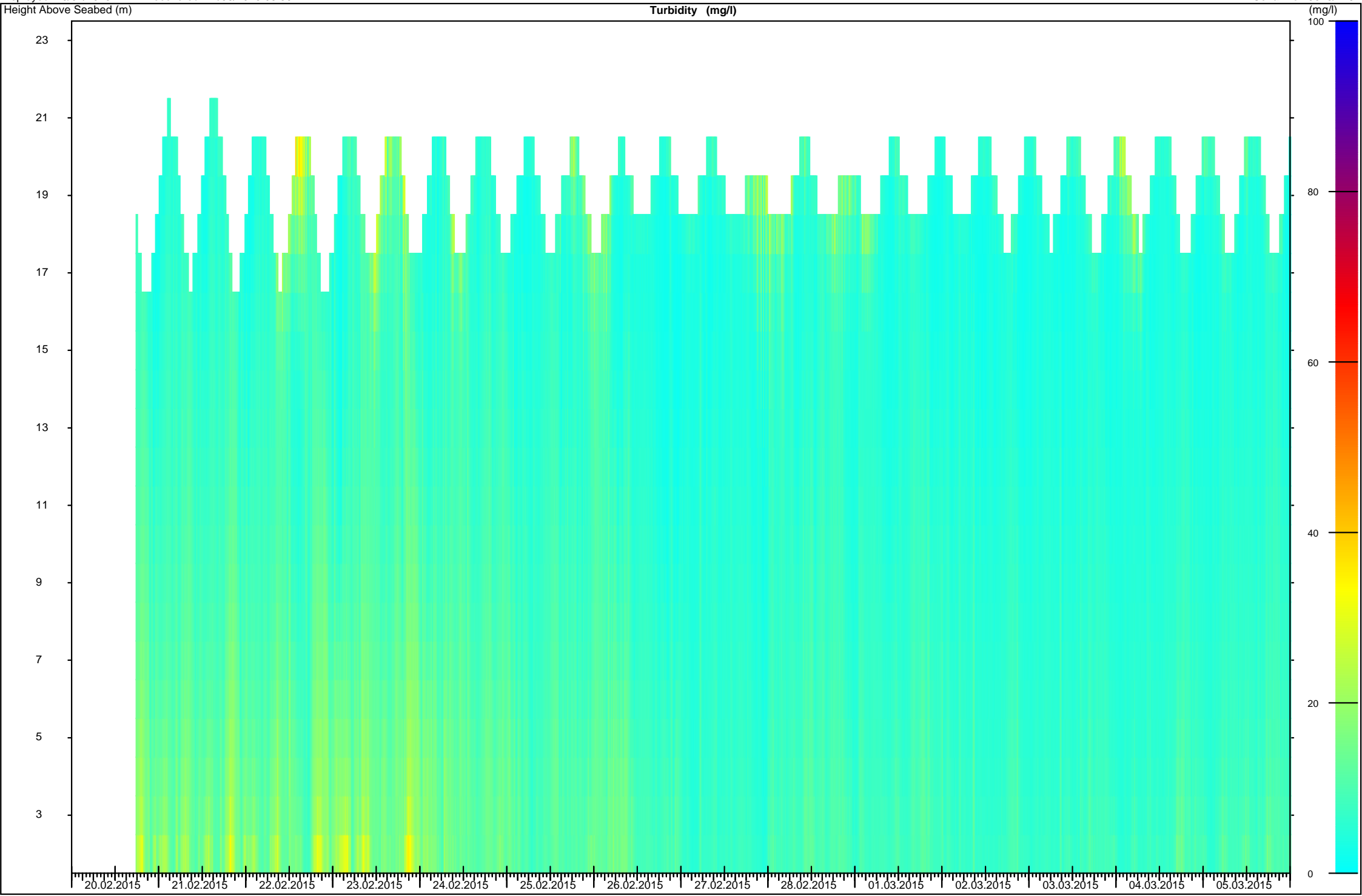
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Turbidity Data Colour Contour Time Series Aberdeen Harbour Expansion EIA, East, D1 - D2

D1 Latitude: 57°08'0.84"N D1 Longitude: 002°02'8.10"W D2 Latitude: 57°08'0.72"N D2 Longitude: 002°02'8.28"W D1 Site depth below LAT: 18.15m D2 Site depth below LAT: 19.06m Instrument height off seabed: 0.66m
Deployed: 20/02/2015 17:42 Recovered: 11/06/2015 08:50

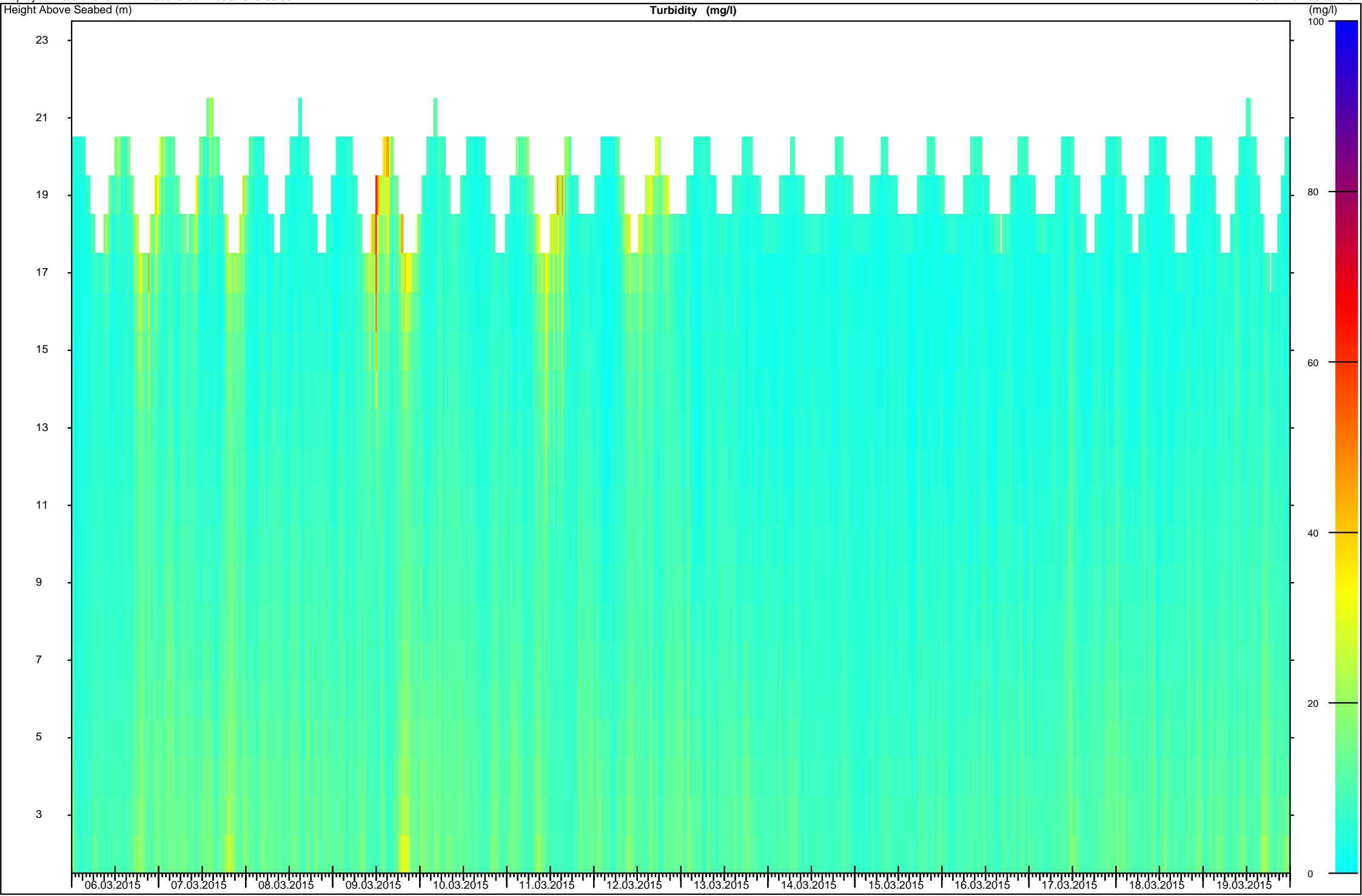
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Turbidity Data Colour Contour Time Series Aberdeen Harbour Expansion EIA, East, D1 - D2

D1 Latitude: 57°08'0.84"N D1 Longitude: 002°02'8.10"W D2 Latitude: 57°08'0.72"N D2 Longitude: 002°02'8.28"W D1 Site depth below LAT: 18.15m D2 Site depth below LAT: 19.06m Instrument height off seabed: 0.66m
Deployed: 20/02/2015 17:42 Recovered: 11/06/2015 08:50
Height Above Seabed (m)

Current Meter / AWAC
Serial No.: 5615/1487



Turbidity Data Colour Contour Time Series Aberdeen Harbour Expansion EIA, East, D1 - D2

D1 Latitude: 57°08'0.84"N D1 Longitude: 002°02'8.10"W D2 Latitude: 57°08'0.72"N D2 Longitude: 002°02'8.28"W D1 Site depth below LAT: 18.15m D2 Site depth below LAT: 19.06m Instrument height off seabed: 0.66m

Deployed: 20/02/2015 17:42 Recovered: 11/06/2015 08:50

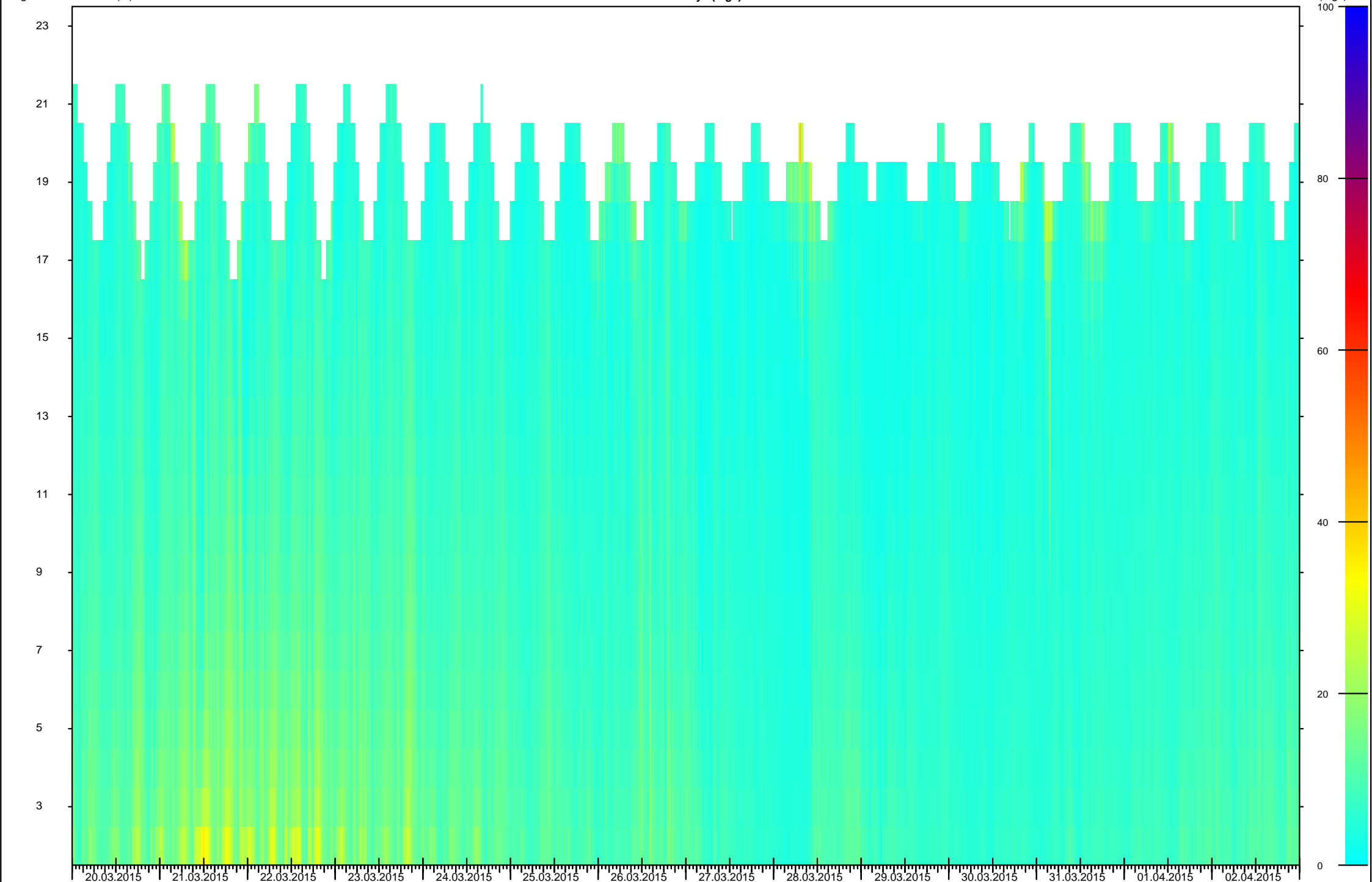
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Serial No.: 5615/1487

Height Above Seabed (m)

Turbidity (mg/l)

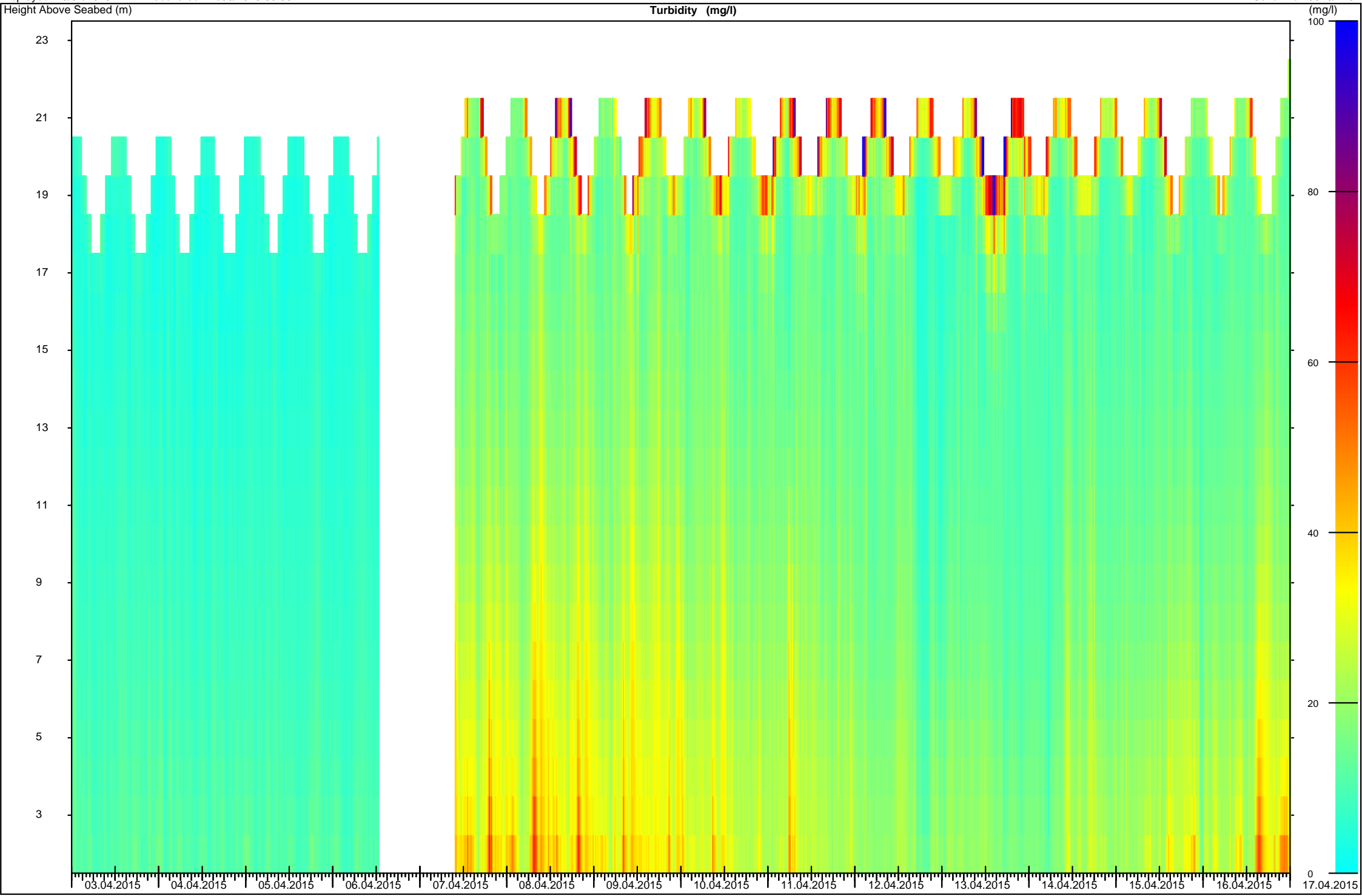
(mg/l)



Turbidity Data Colour Contour Time Series Aberdeen Harbour Expansion EIA, East, D1 - D2

D1 Latitude: 57°08'0.84"N D1 Longitude: 002°02'8.10"W D2 Latitude: 57°08'0.72"N D2 Longitude: 002°02'8.28"W D1 Site depth below LAT: 18.15m D2 Site depth below LAT: 19.06m Instrument height off seabed: 0.66m
Deployed: 20/02/2015 17:42 Recovered: 11/06/2015 08:50

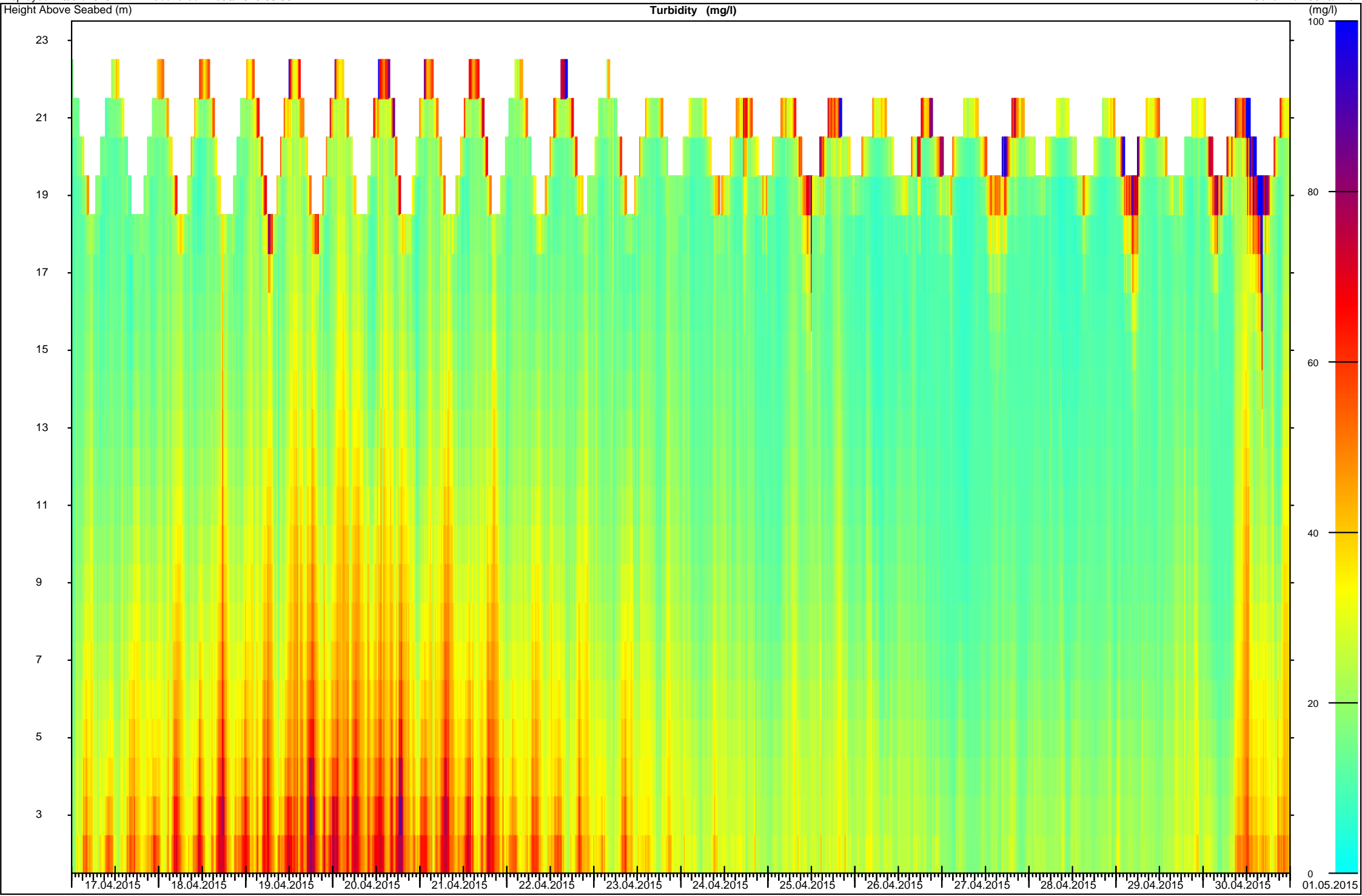
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D1 Latitude: 57°08'0.84"N D1 Longitude: 002°02'8.10"W D2 Latitude: 57°08'0.72"N D2 Longitude: 002°02'8.28"W D1 Site depth below LAT: 18.15m D2 Site depth below LAT: 19.06m Instrument height off seabed: 0.66m
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Height Above Seabed (m)

Current Meter / AWAC
Serial No.: 5615/1487



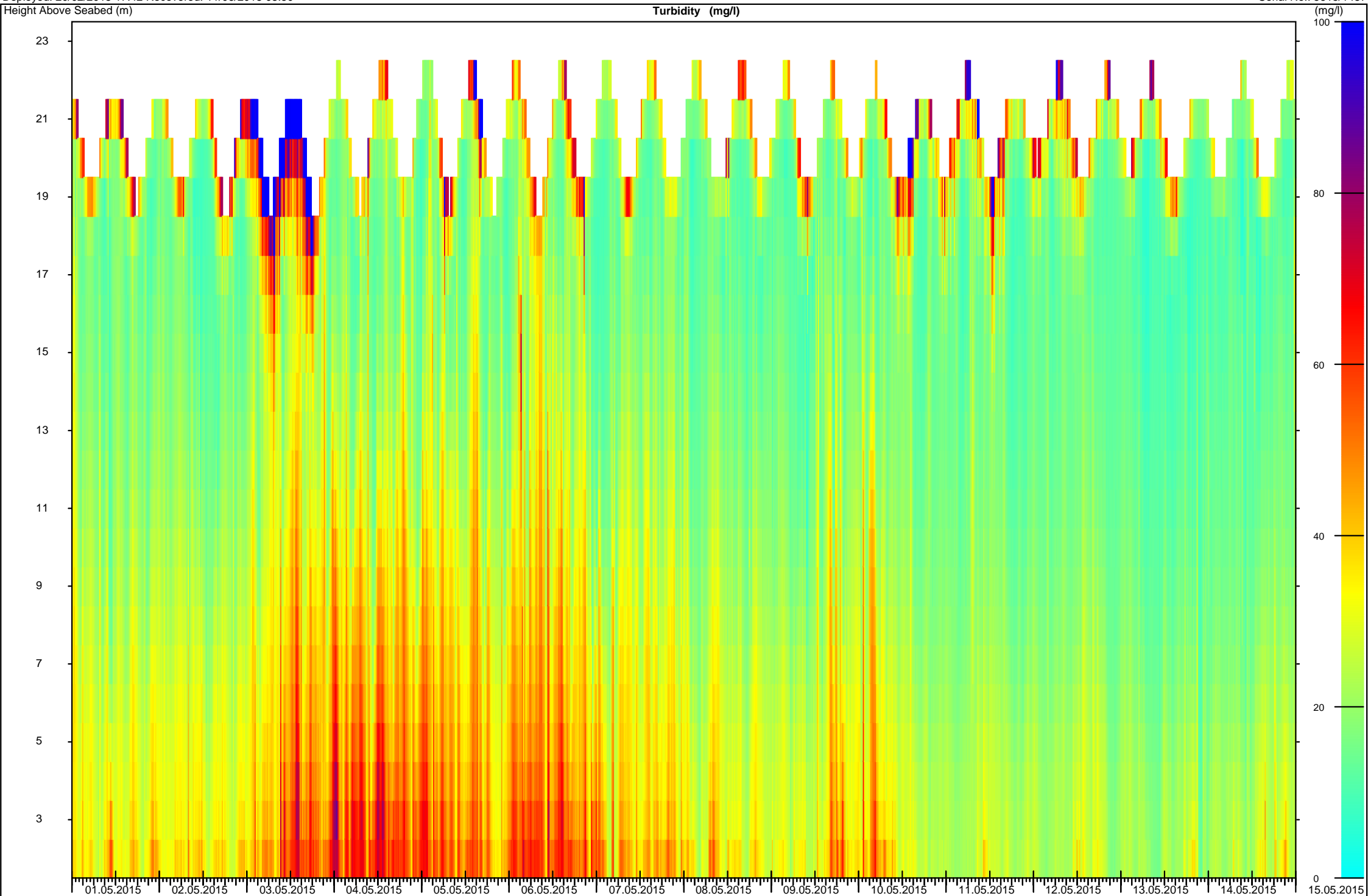
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Deployed: 20/02/2015 17:42 Recovered: 11/06/2015 08:50

Current Meter / AWAC

Serial No.: 5615/1487



Turbidity Data Colour Contour Time Series Aberdeen Harbour Expansion EIA, East, D1 - D2

D1 Latitude: 57°08'0.84"N D1 Longitude: 002°02'8.10"W D2 Latitude: 57°08'0.72"N D2 Longitude: 002°02'8.28"W D1 Site depth below LAT: 18.15m D2 Site depth below LAT: 19.06m Instrument height off seabed: 0.66m

Current Meter / AWAC

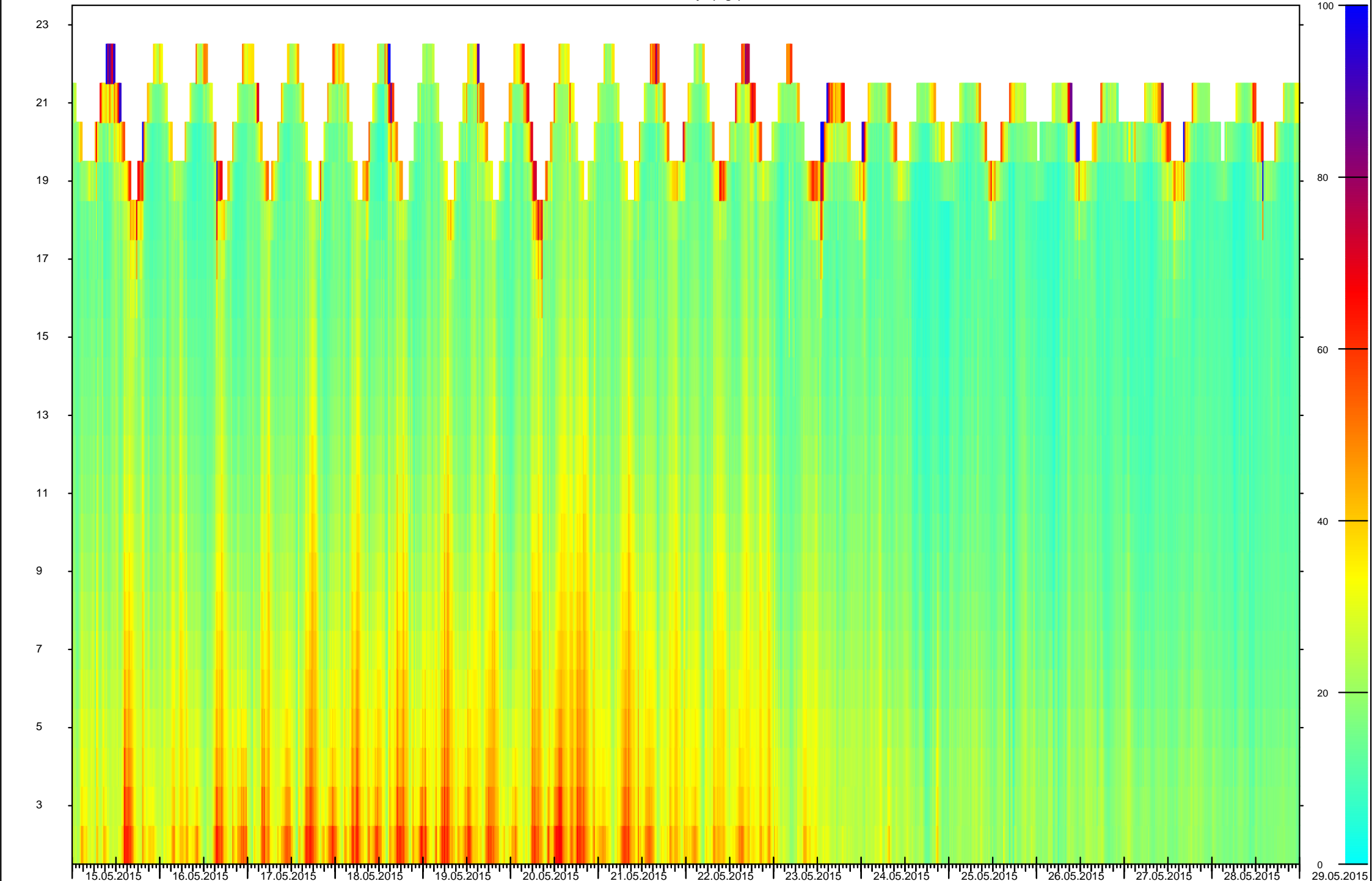
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Serial No.: 5615/1487

Height Above Seabed (m)

Turbidity (mg/l)

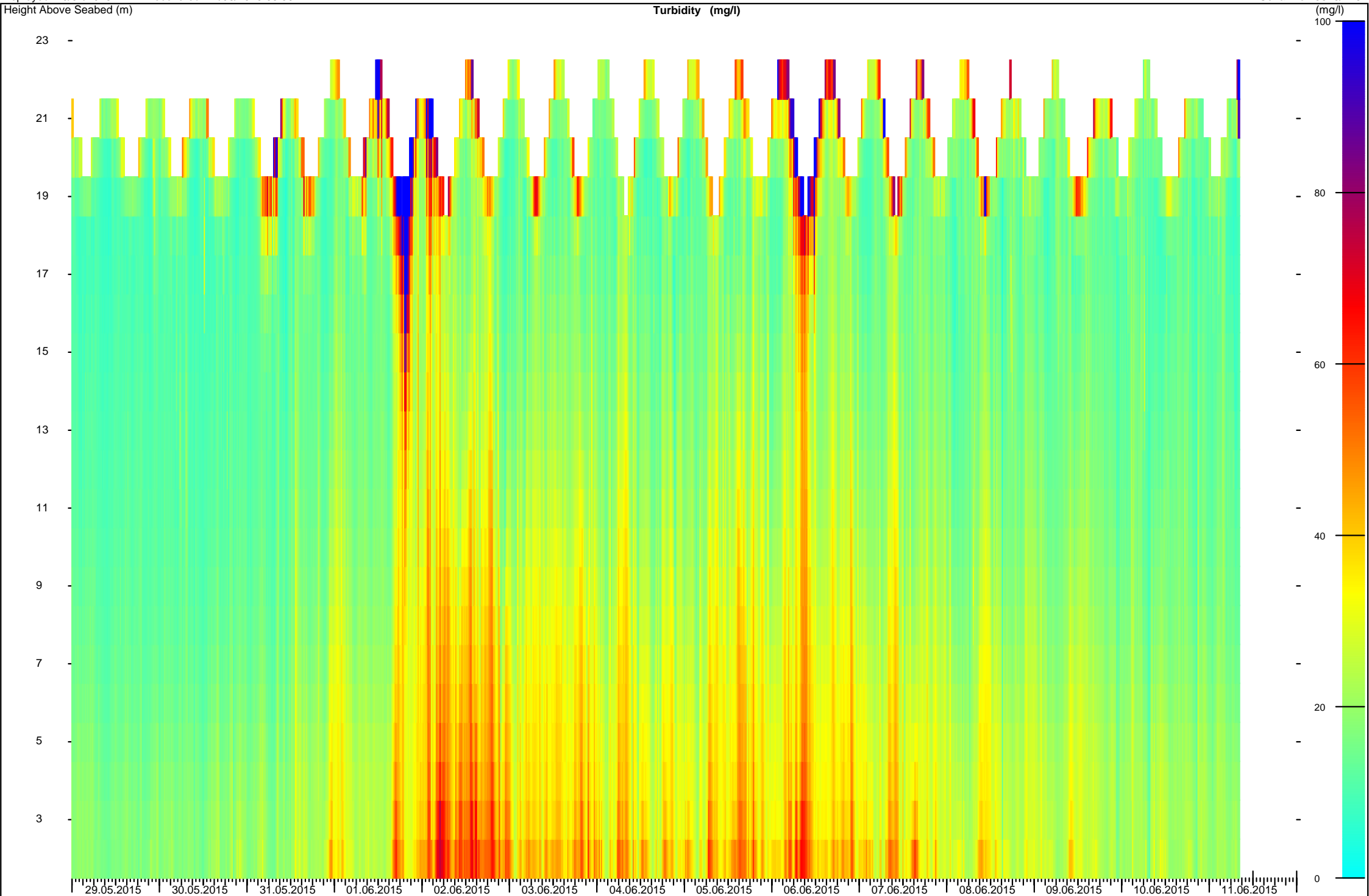
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Turbidity Data Colour Contour Time Series Aberdeen Harbour Expansion EIA, East, D1 - D2

D1 Latitude: 57°08'0.84"N D1 Longitude: 002°02'8.10"W D2 Latitude: 57°08'0.72"N D2 Longitude: 002°02'8.28"W D1 Site depth below LAT: 18.15m D2 Site depth below LAT: 19.06m Instrument height off seabed: 0.66m
Deployed: 20/02/2015 17:42 Recovered: 11/06/2015 08:50

Current Meter / AWAC
Serial No.: 5615/1487



APPENDIX E
NEAR-SEABED SALINITY, DISSOLVED OXYGEN AND TEMPERATURE DATA PRESENTATION

CONTENTS

Figure or Table Number	Location	Data Presentation Type	Description
Figure E001 – E008	West and East	Time Series	Temperature, salinity and dissolved oxygen

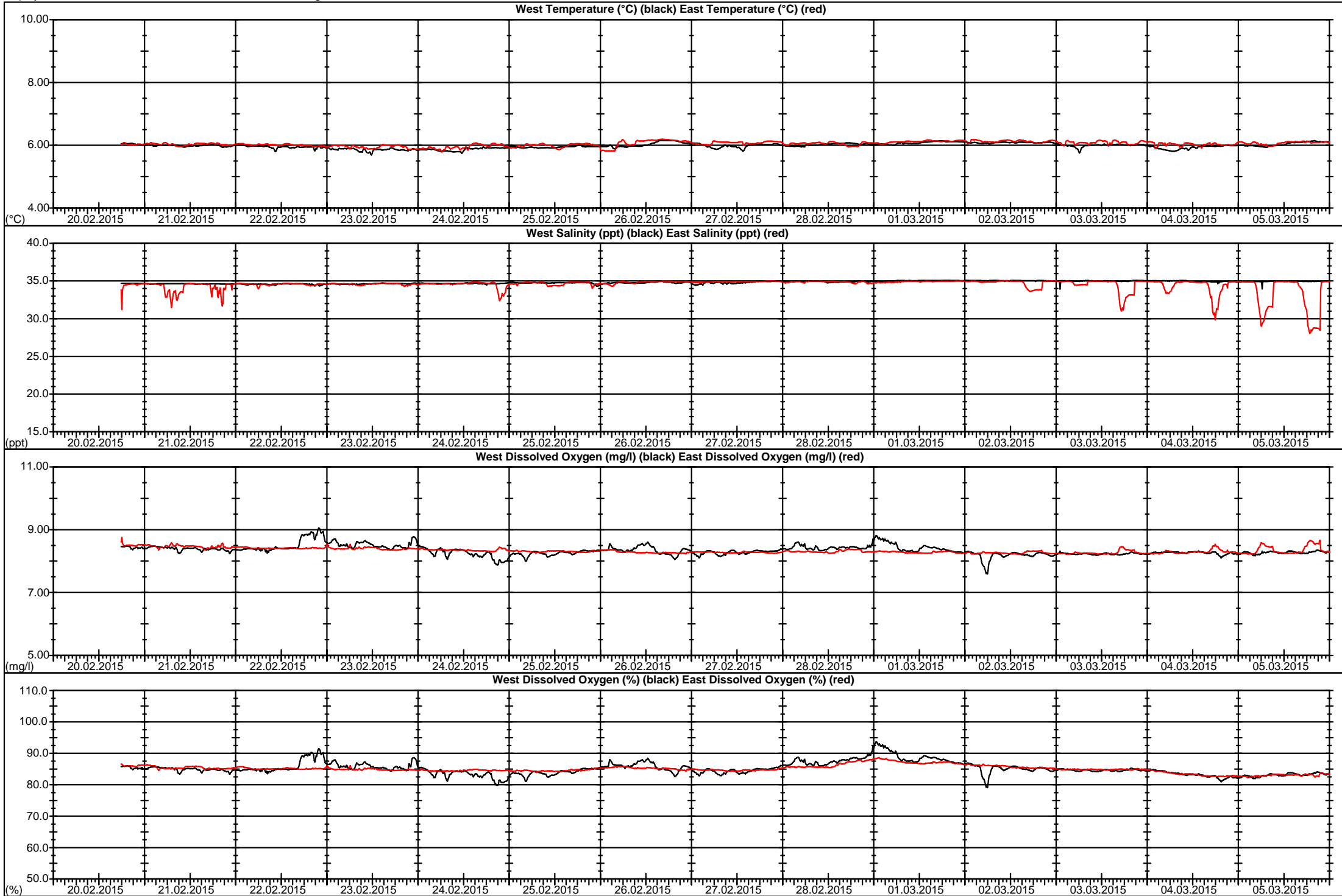
Aberdeen Harbour Expansion EIA, West and East, D1 - D2

West D1: 57°07'59.64"N, 002°02'57.60"W West D2: 57°08'0.96"N, 002°02'59.76"W, East D1: 57°08'0.84"N, 002°02'8.10"W, East D2: 57°08'0.72"N, 002°02'8.28"W

EnvironmentalSensors / AADI Seaguard

Deployed: 20/02/2015 Recovered: 11/06/2015. Instrument height off seabed 0.43m

Serial No.: 1235,1233



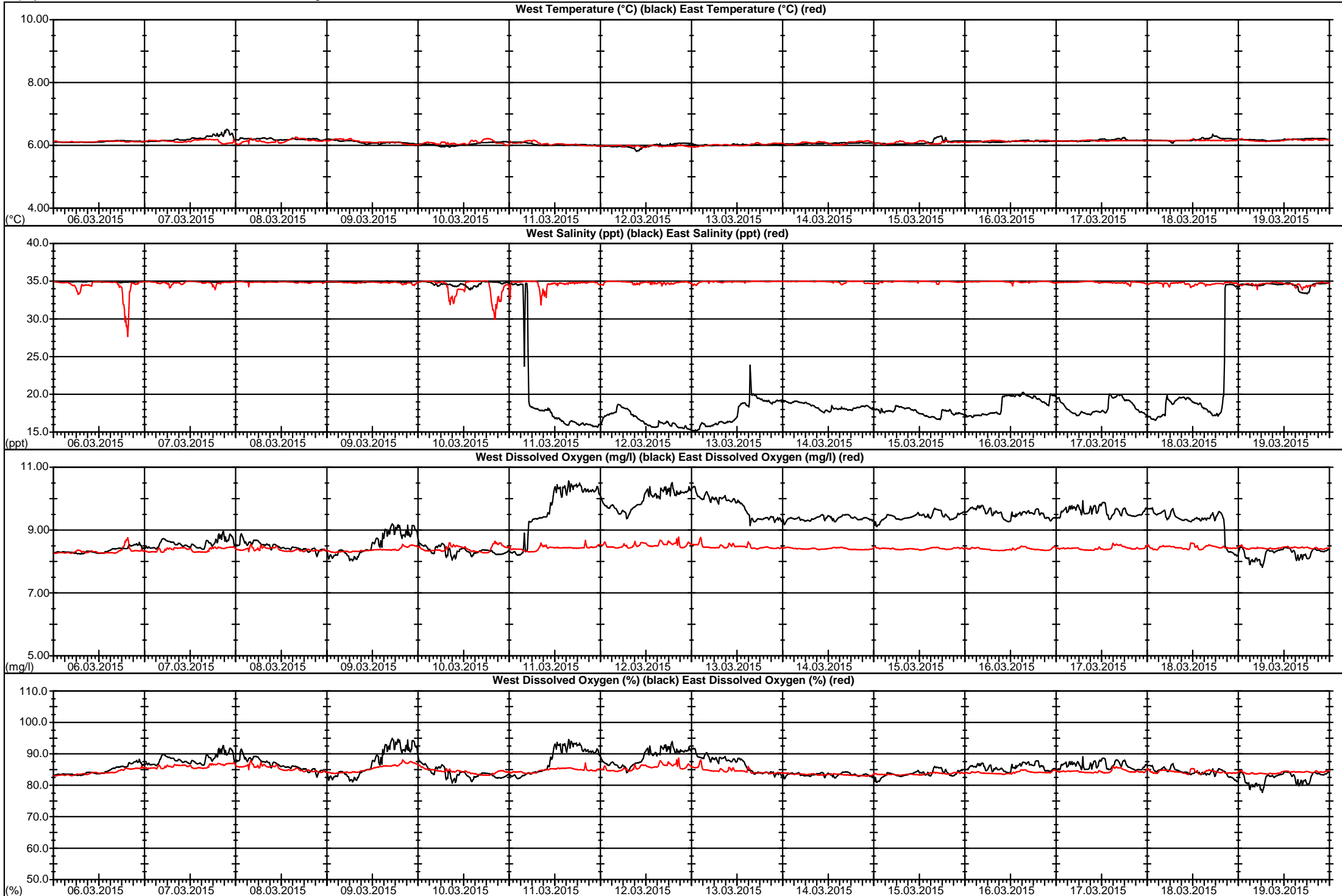
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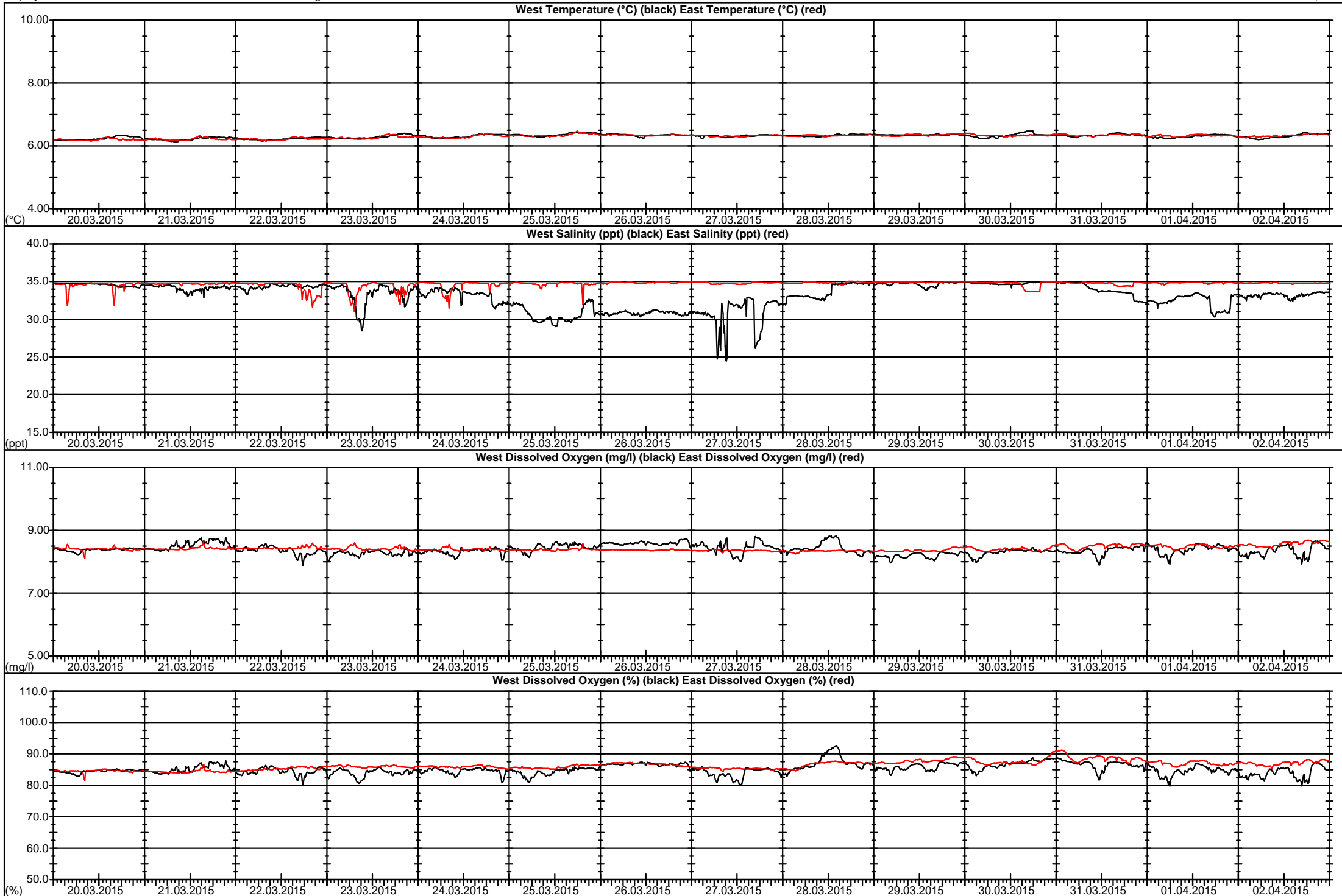
EnvironmentalSensors / AADI Seaguard

Deployed: 20/02/2015 Recovered: 11/06/2015. Instrument height off seabed 0.43m

Serial No.: 1235,1233



Aberdeen Harbour Expansion EIA, West and East, D1 - D2



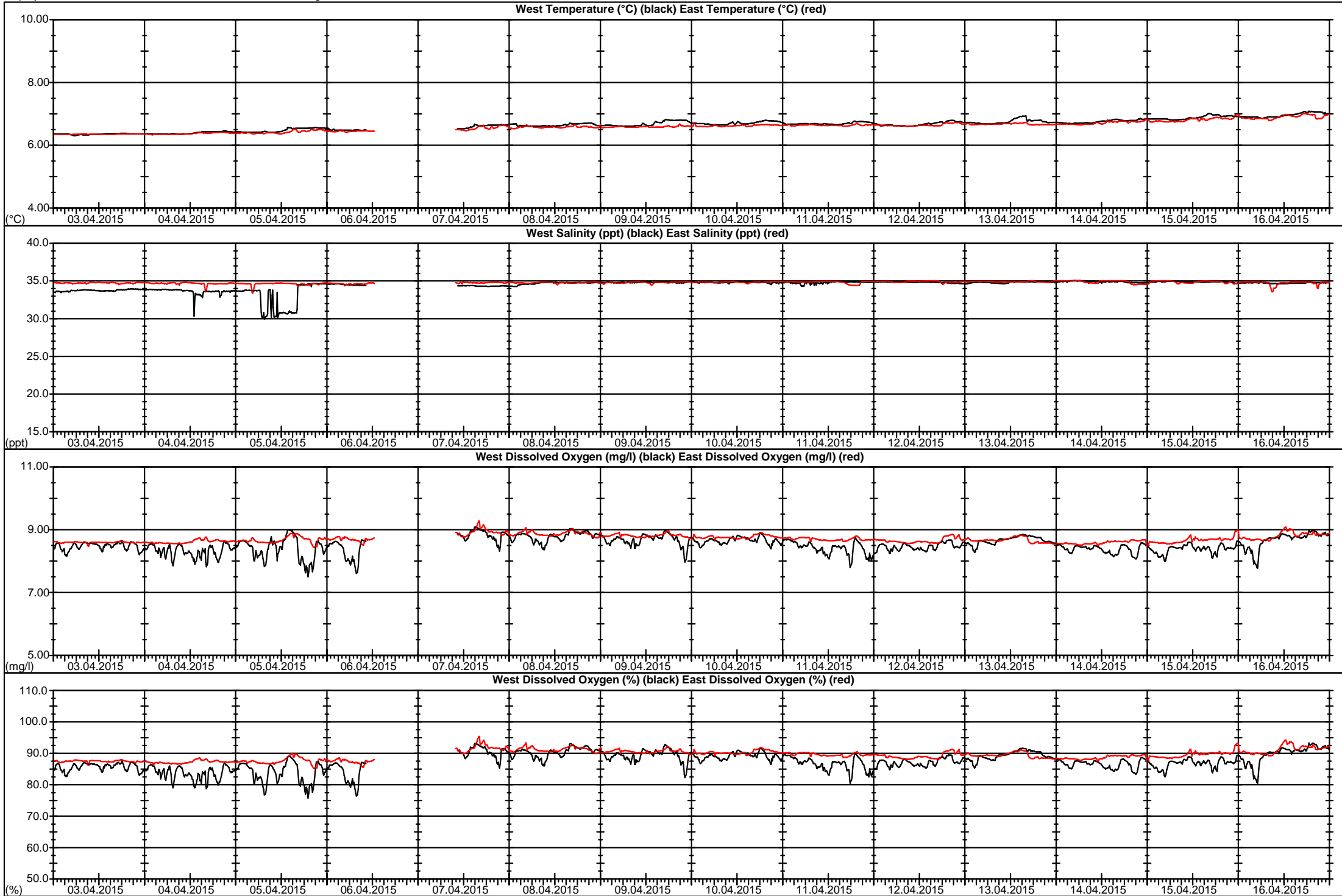
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EnvironmentalSensors / AADI Seaguard

Deployed: 20/02/2015 Recovered: 11/06/2015. Instrument height off seabed 0.43m

Serial No.: 1235,1233



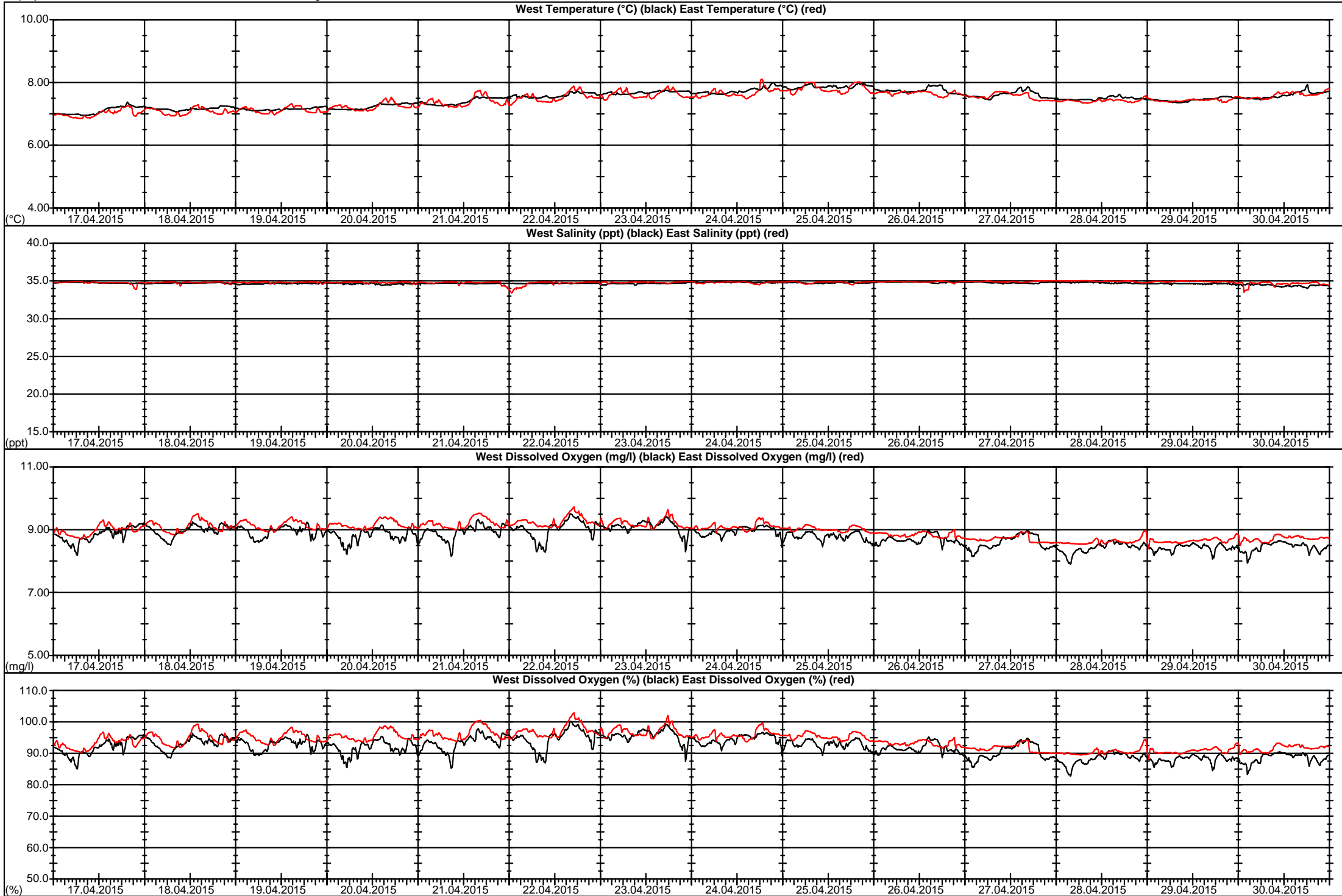
Aberdeen Harbour Expansion EIA, West and East, D1 - D2

West D1: 57°07'59.64"N, 002°02'57.60"W West D2: 57°08'0.96"N, 002°02'59.76"W, East D1: 57°08'0.84"N, 002°02'8.10"W, East D2: 57°08'0.72"N, 002°02'8.28"W

EnvironmentalSensors / AADI Seaguard

Deployed: 20/02/2015 Recovered: 11/06/2015. Instrument height off seabed 0.43m

Serial No.: 1235,1233



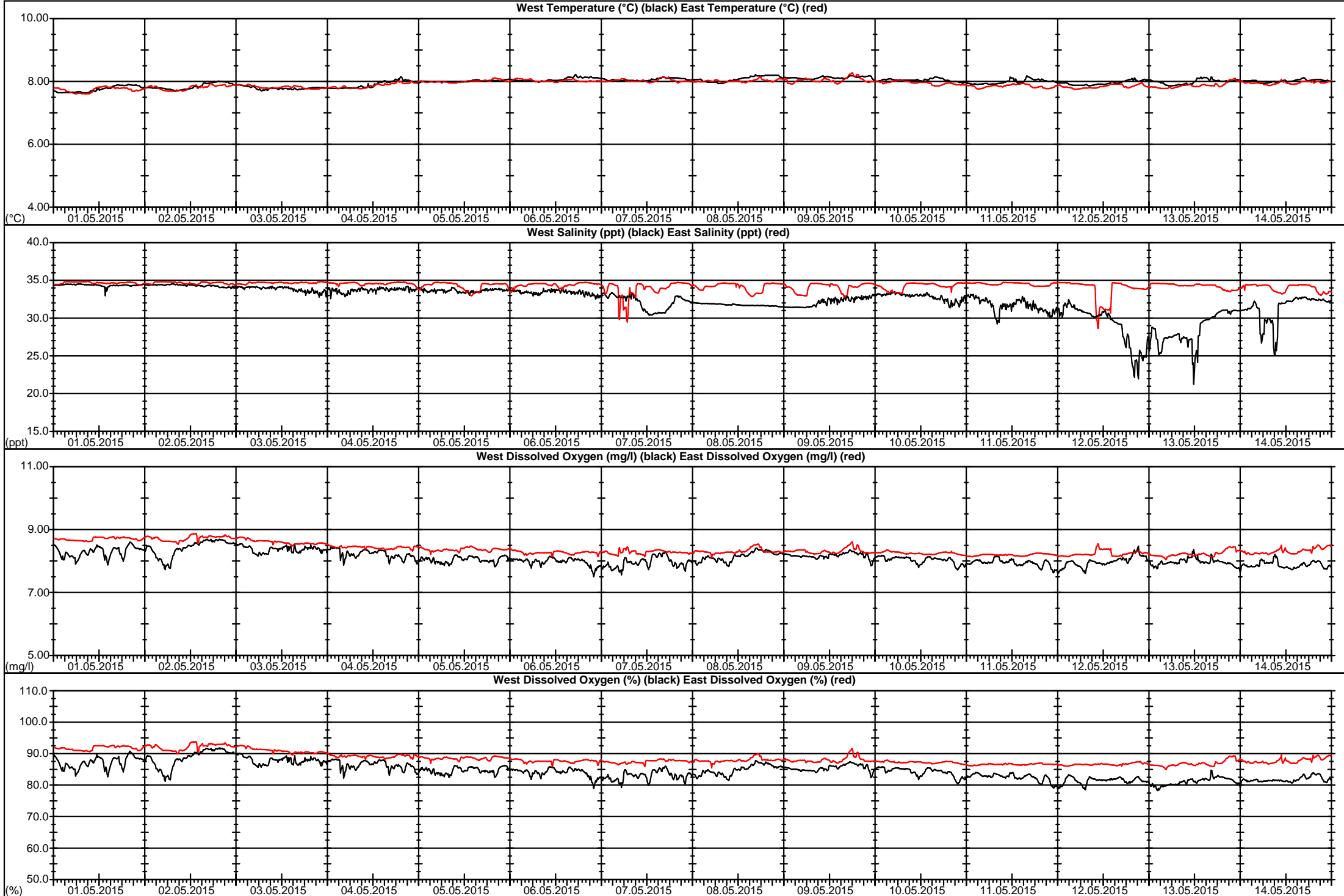
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EnvironmentalSensors / AADI Seaguard

Deployed: 20/02/2015 Recovered: 11/06/2015. Instrument height off seabed 0.43m

Serial No.: 1235,1233



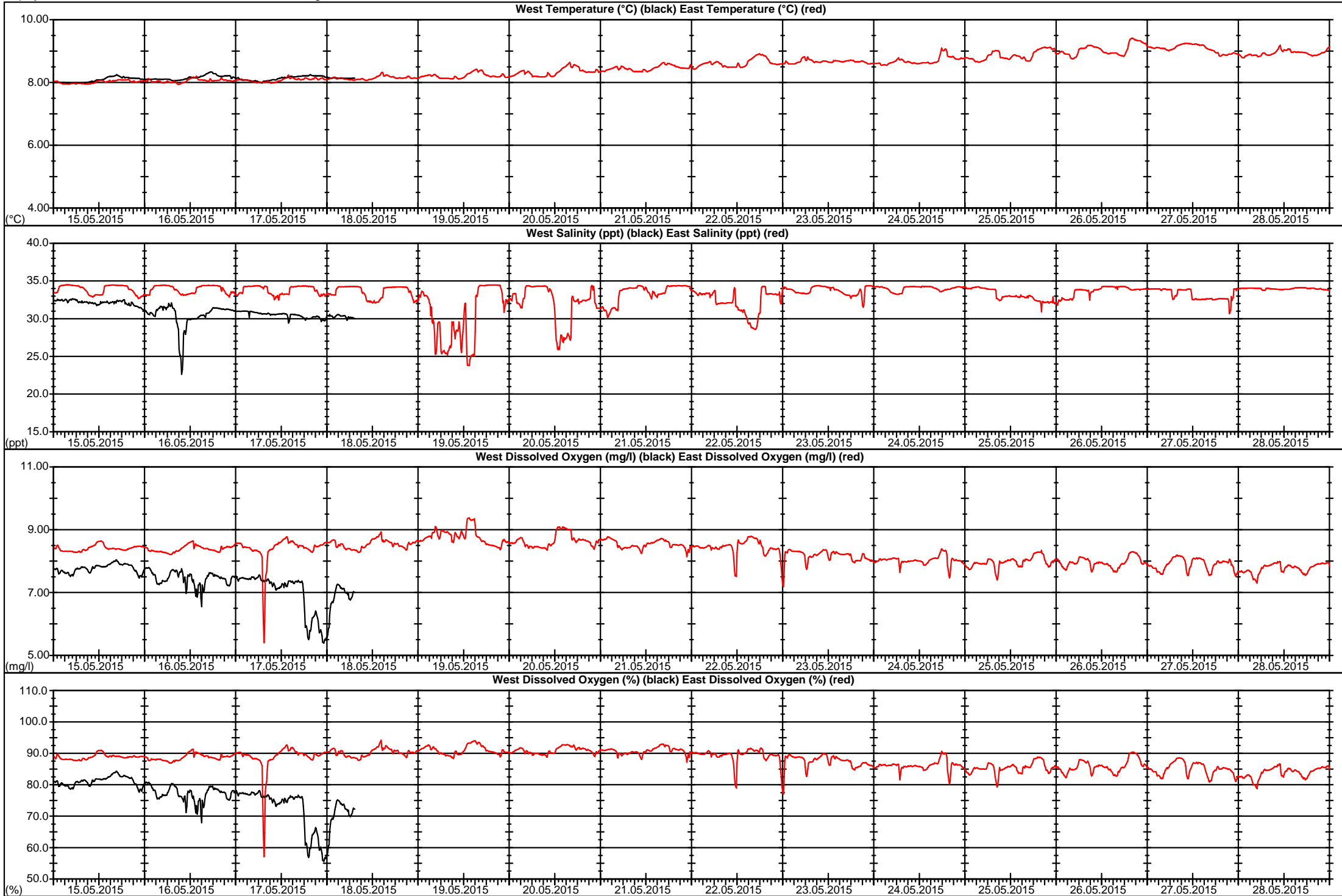
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EnvironmentalSensors / AADI Seaguard

Deployed: 20/02/2015 Recovered: 11/06/2015. Instrument height off seabed 0.43m

Serial No.: 1235,1233



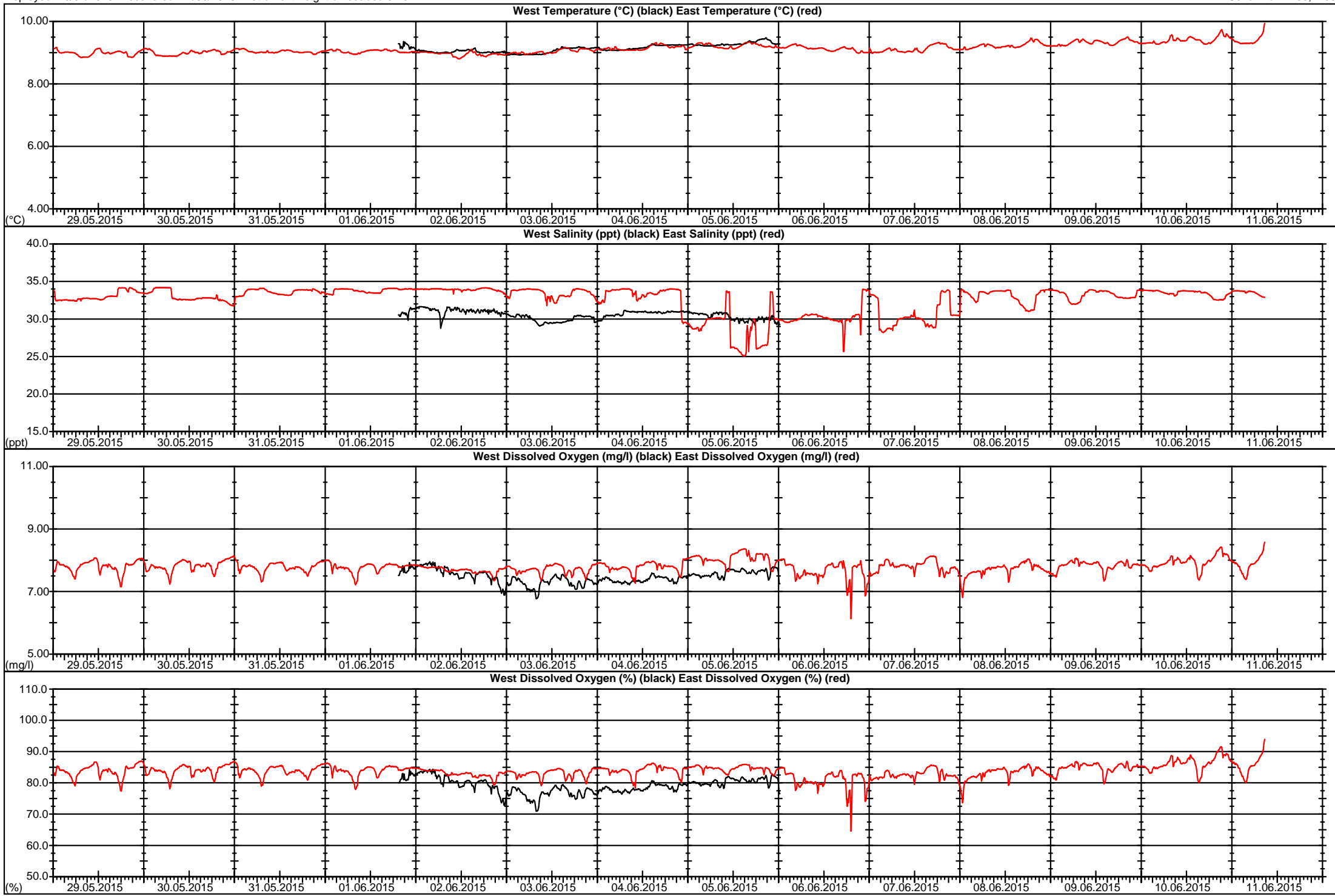
Aberdeen Harbour Expansion EIA, West and East, D1 - D2

West D1: 57°07'59.64"N, 002°02'57.60"W West D2: 57°08'0.96"N, 002°02'59.76"W, East D1: 57°08'0.84"N, 002°02'8.10"W, East D2: 57°08'0.72"N, 002°02'8.28"W

EnvironmentalSensors / AADI Seaguard

Deployed: 20/02/2015 Recovered: 11/06/2015. Instrument height off seabed 0.43m

Serial No.: 1235,1233

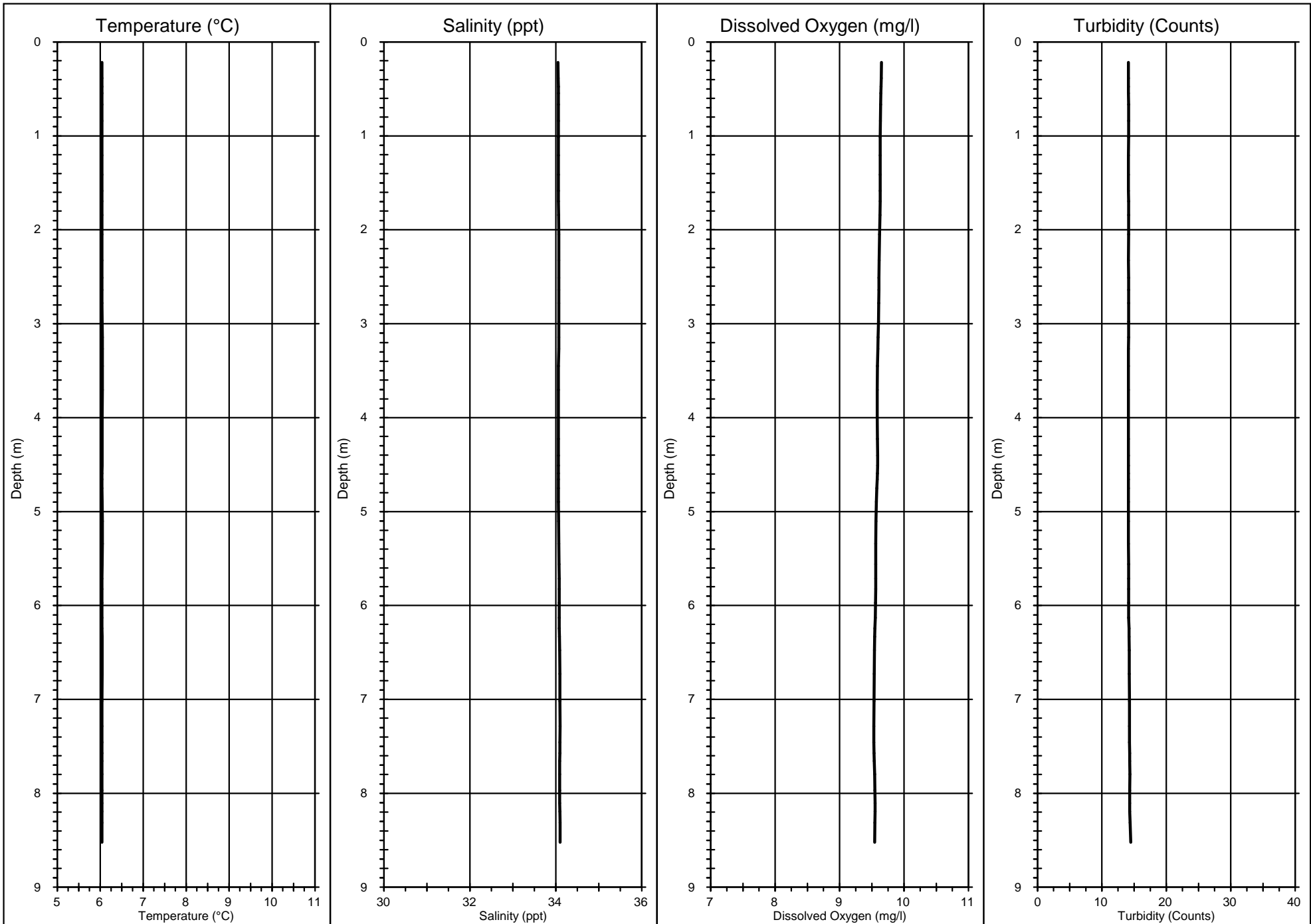


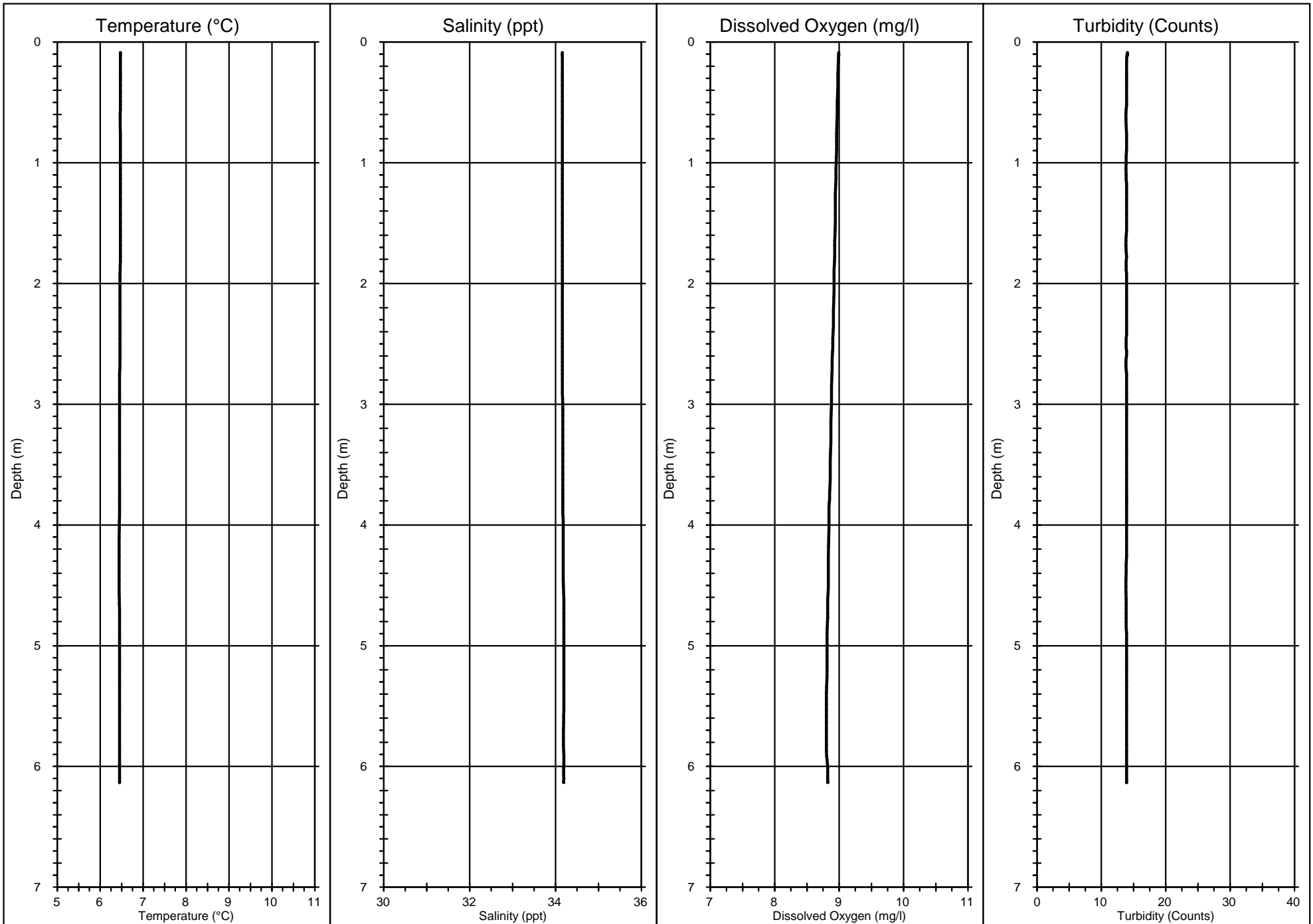
**APPENDIX F
WATER QUALITY PROFILE DATA PRESENTATION**

CONTENTS

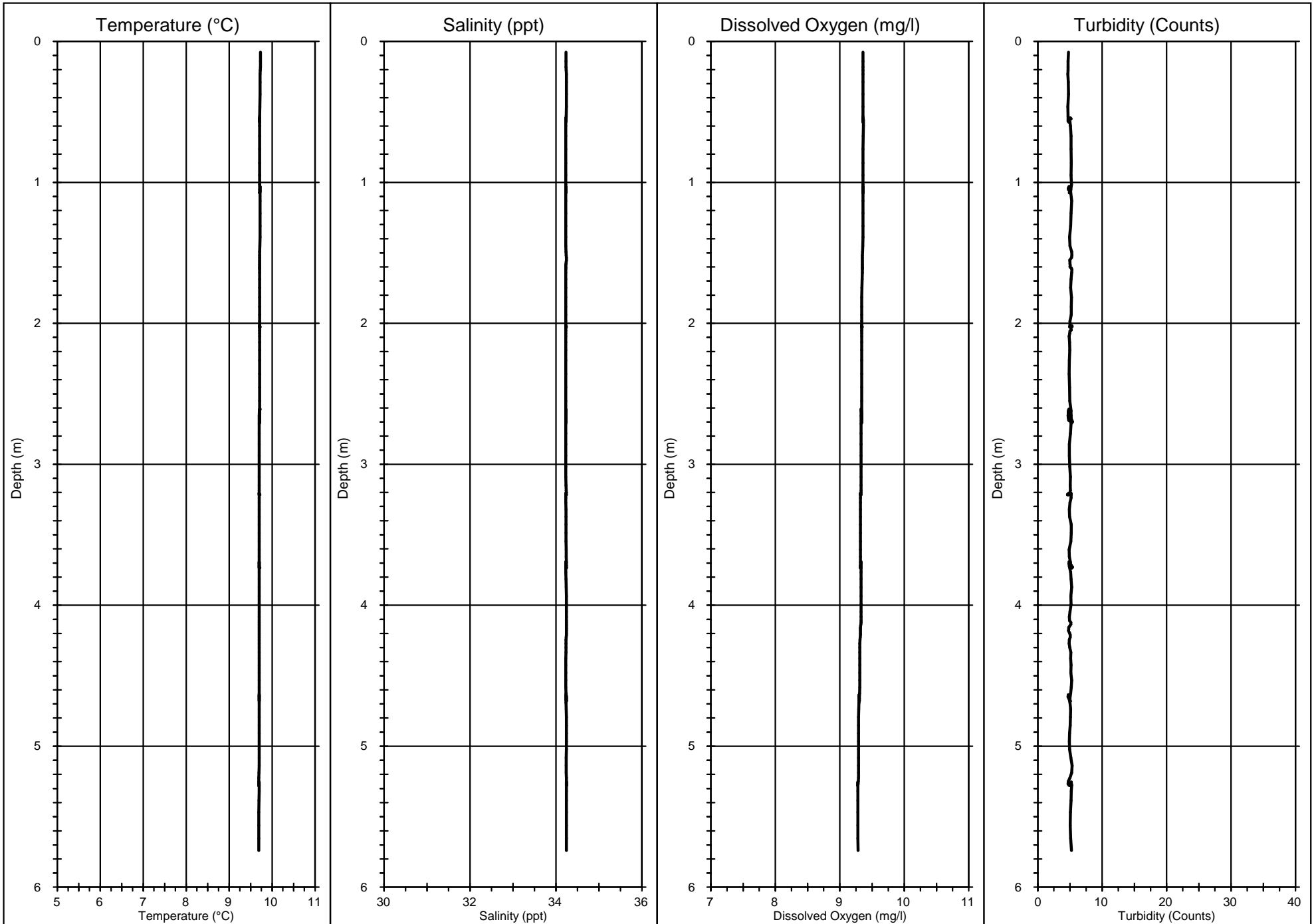
Figure or Table Number	Location	Data Presentation Type	Description
Figure F001 – F003	West	Vertical Profile Graphs	Temperature, salinity, dissolved oxygen and turbidity
Figure F004 – F006	East	Vertical Profile Graphs	Temperature, salinity, dissolved oxygen and turbidity

Latitude: 57°07'59.64"N Longitude: 002°02'57.60"W Site Depth: 8.8m
Deployed: 20/02/2015 14:46:07 Recovered: 20/02/2015 14:46:53

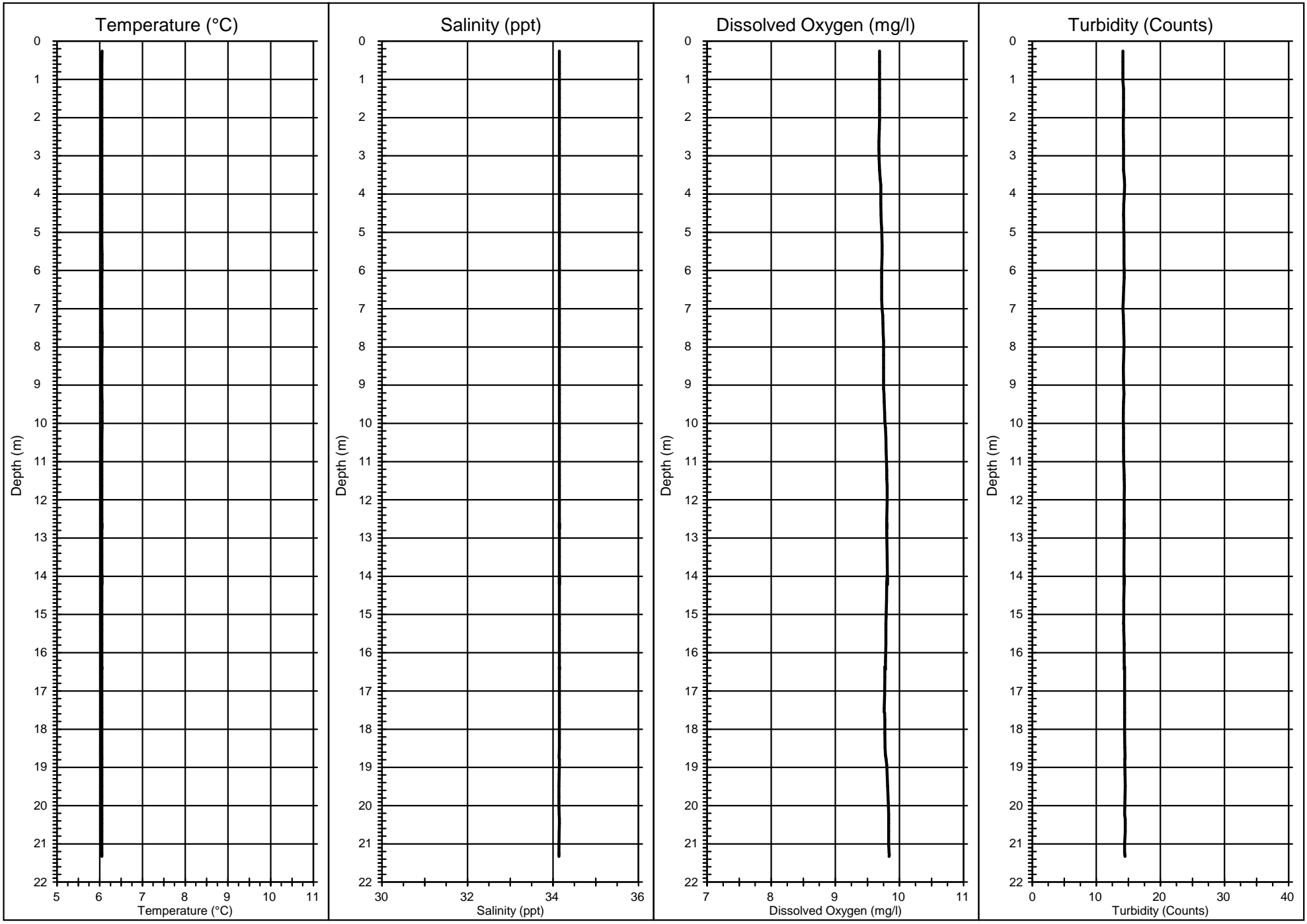




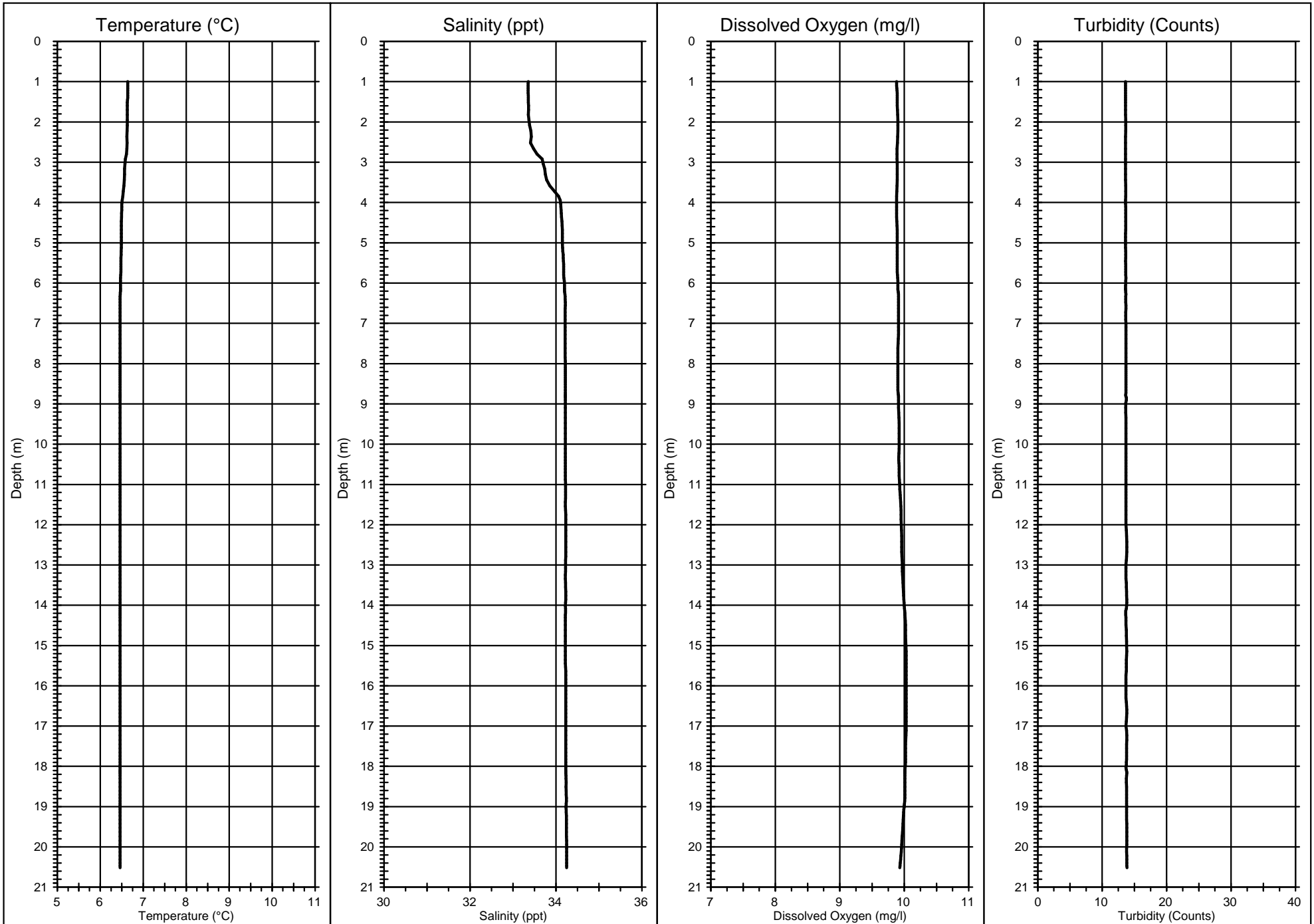
Latitude: 57°08'0.96"N Longitude: 002°02'59.76"W Site Depth: 6.1m
Deployed: 11/06/2015 10:05:15 Recovered: 11/06/2015 10:05:46



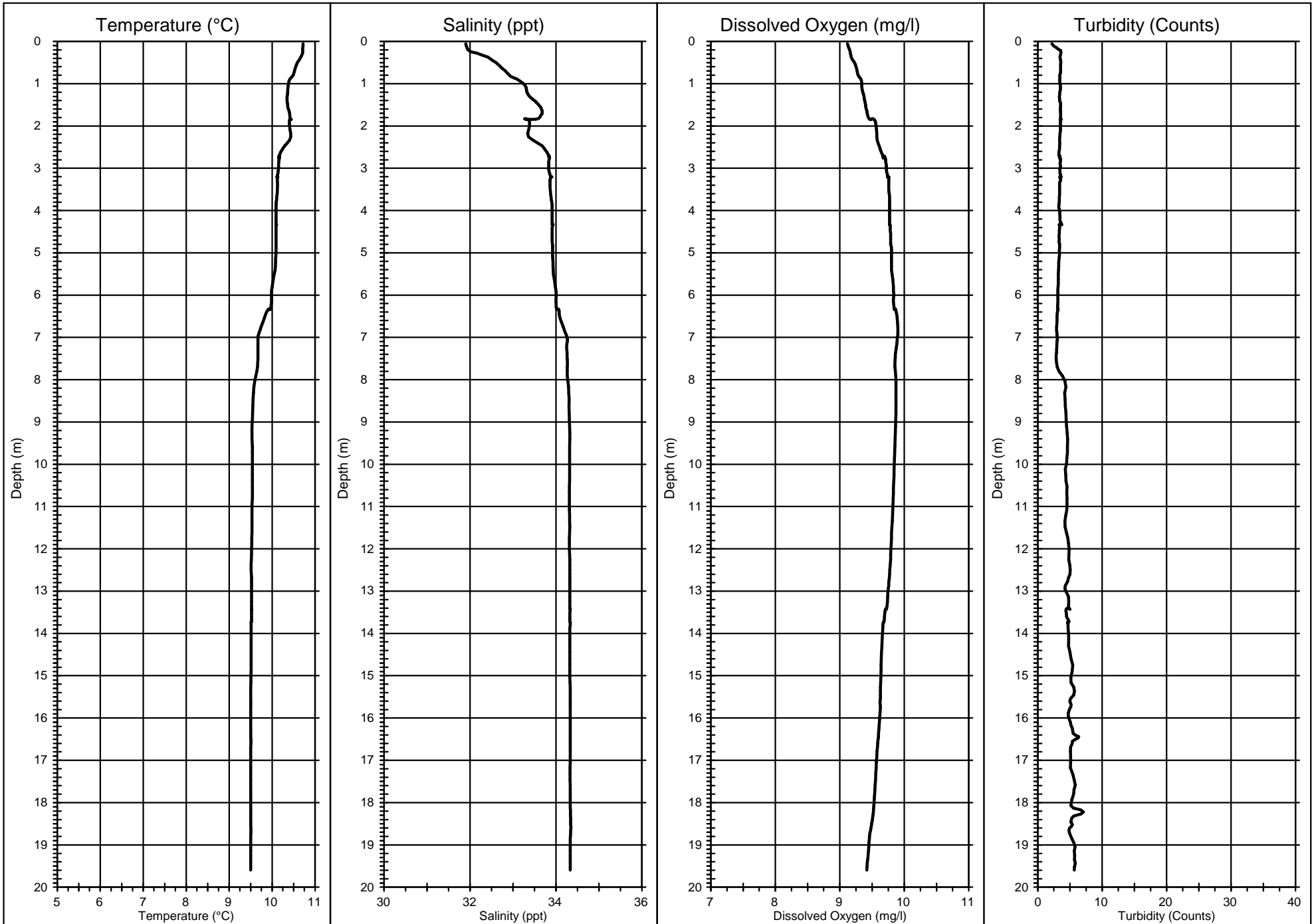
Latitude: 57°08'0.84"N Longitude: 002°02'8.1"W Site Depth: 22.0m
Deployed: 20/02/2015 18:19:44 Recovered: 20/02/2015 18:21:09



Latitude: 57°07'54.96"N Longitude: 002°02'03.30"W Site Depth: 20.5m
Deployed: 06/04/2015 10:48:55 Recovered: 06/04/2015 10:49:32



Latitude: 57°08'0.72"N Longitude: 002°02'8.28"W Site Depth: 20.5m
 Deployed: 11/06/2015 07:20:21 Recovered: 11/06/2015 07:21:10



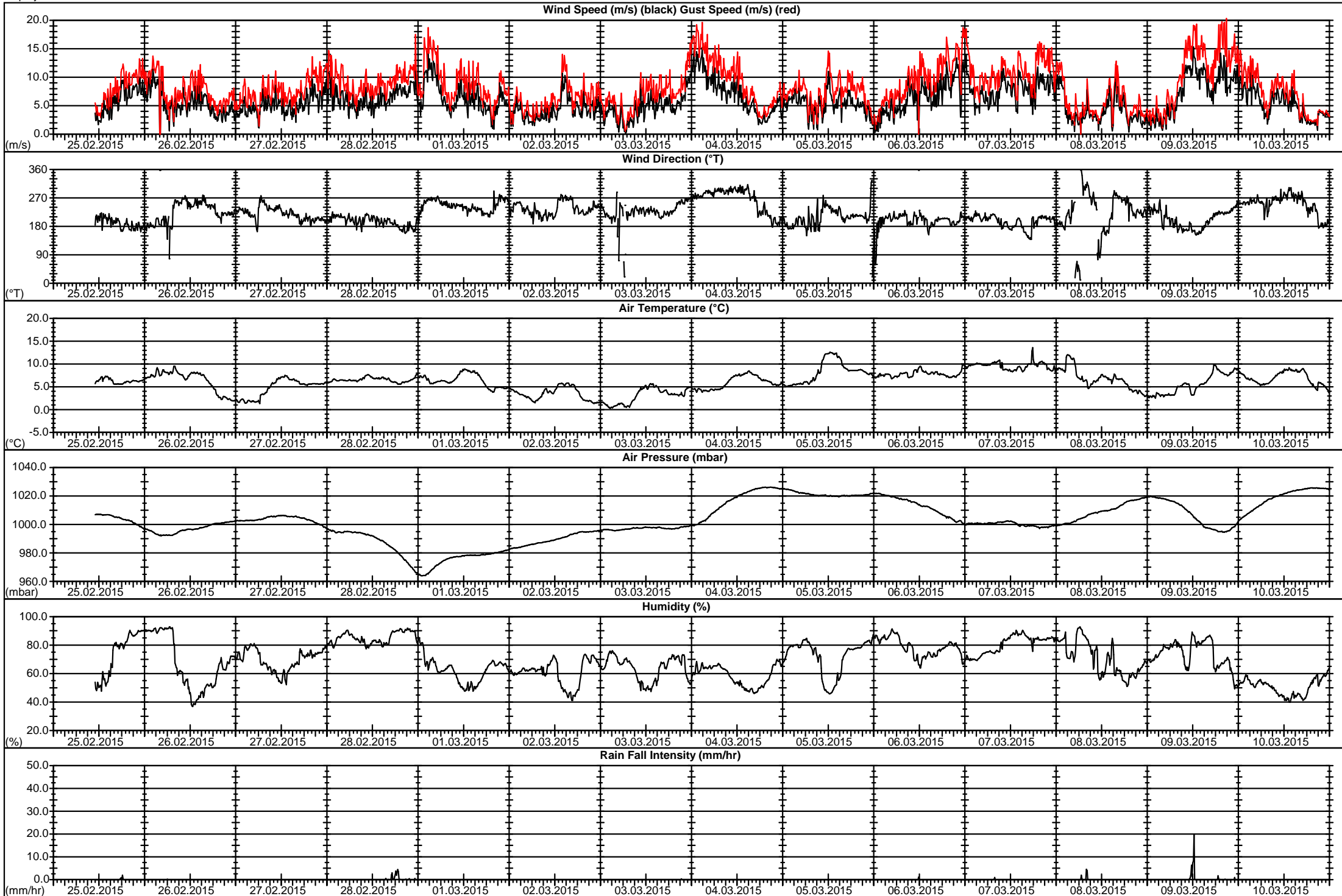
**APPENDIX G
METEOROLOGICAL DATA PRESENTATION**

CONTENTS

Figure or Table Number	Location	Data Presentation Type	Description
Figure G001 – G008	Meteorological Station	Time Series	Wind speed, gust speed, wind direction, air temperature, air pressure, humidity and rainfall intensity
Figure G009	Meteorological Station	Hodogram (Rose Diagram)	Percentage occurrence of wind speed for every 5° direction band
Table G001	Meteorological Station	Frequency Distribution	Wind speed against wind direction

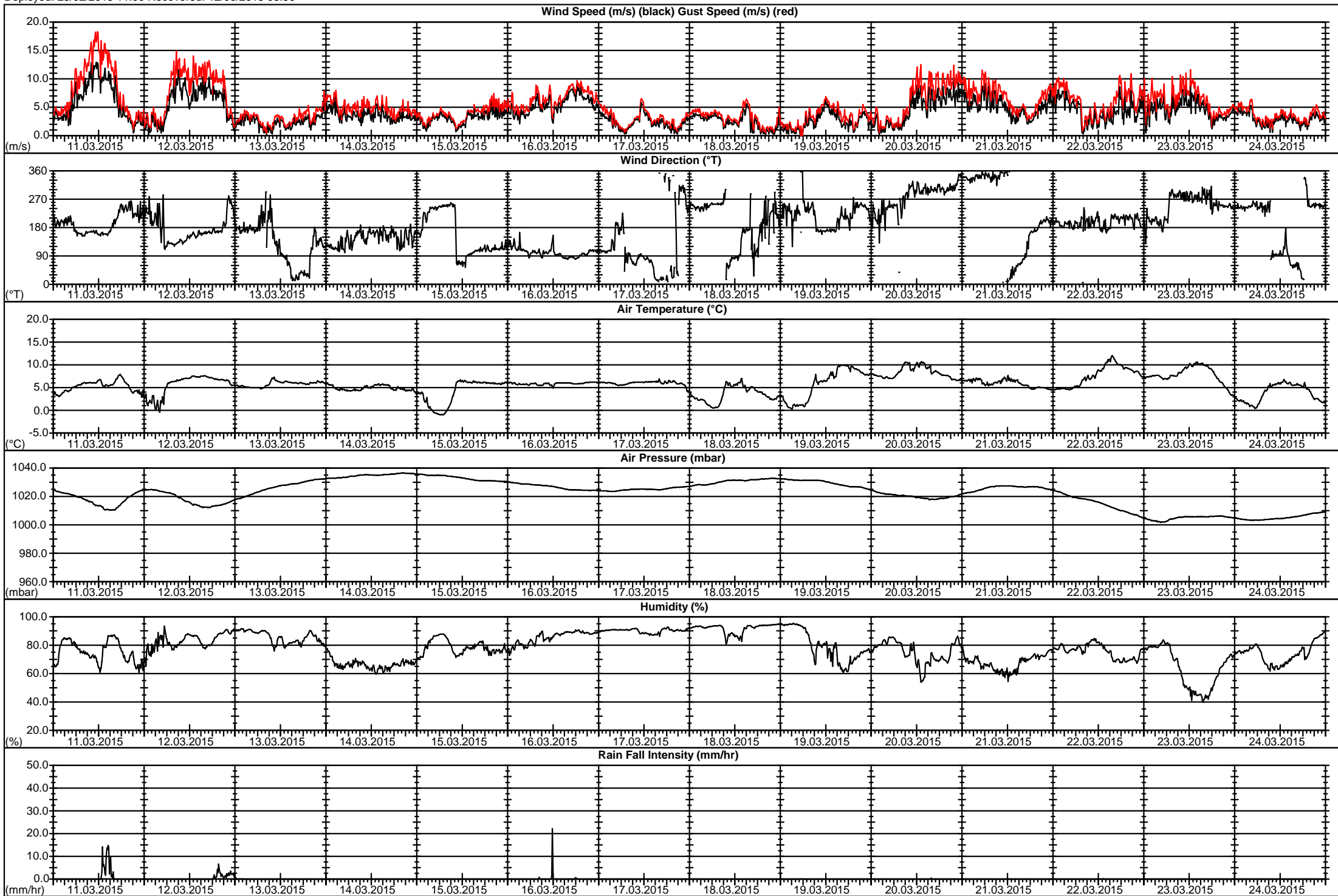
Latitude: 57°07'57"N Longitude: 002°03'45"W Instrument height off ground level: 20m
Deployed: 25/02/2015 11:00 Recovered: 12/06/2015 08:50

Meteorological Station / AHB_Vaisala



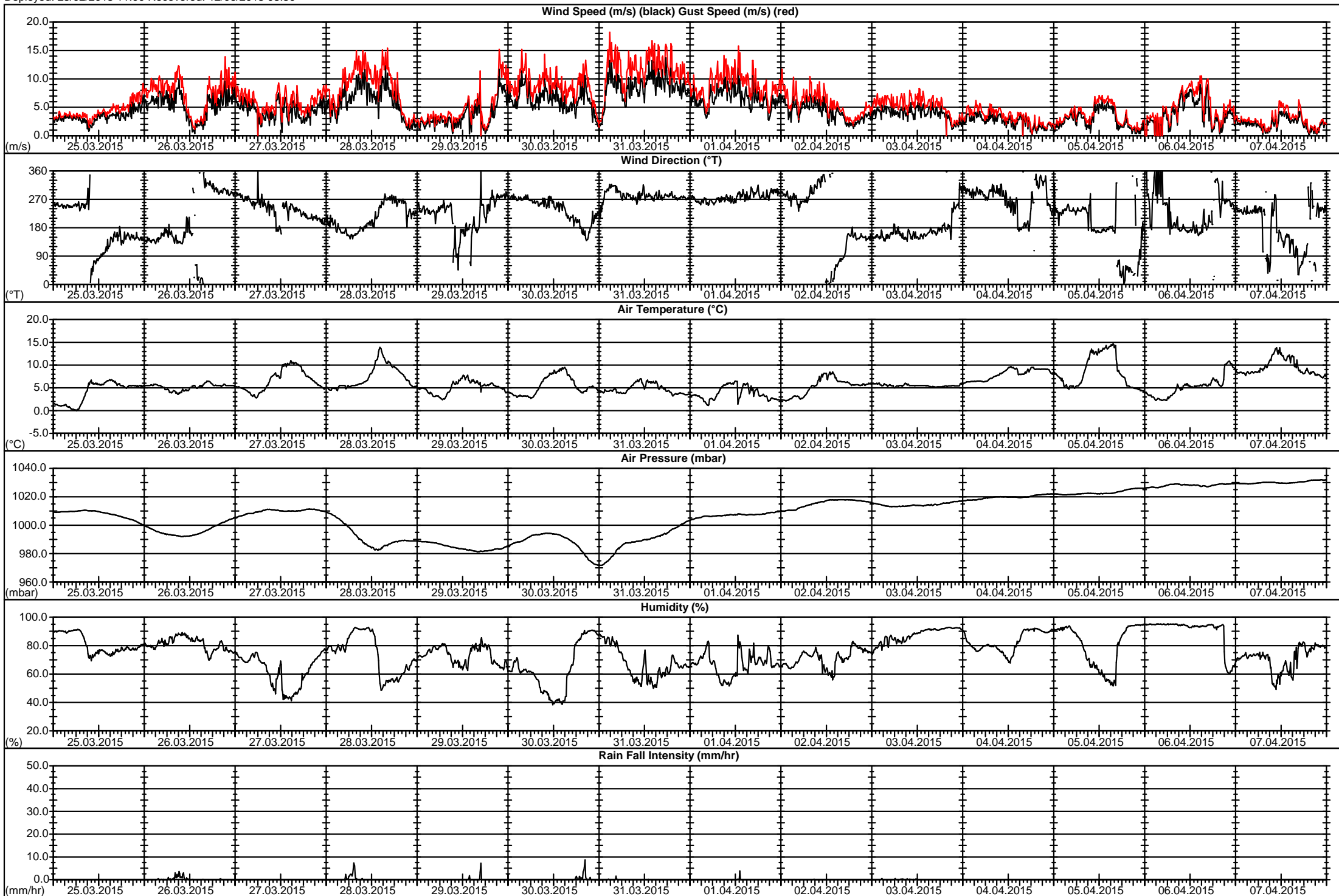
Latitude: 57°07'57"N Longitude: 002°03'45"W Instrument height off ground level: 20m
Deployed: 25/02/2015 11:00 Recovered: 12/06/2015 08:50

Meteorological Station / AHB_Vaisala



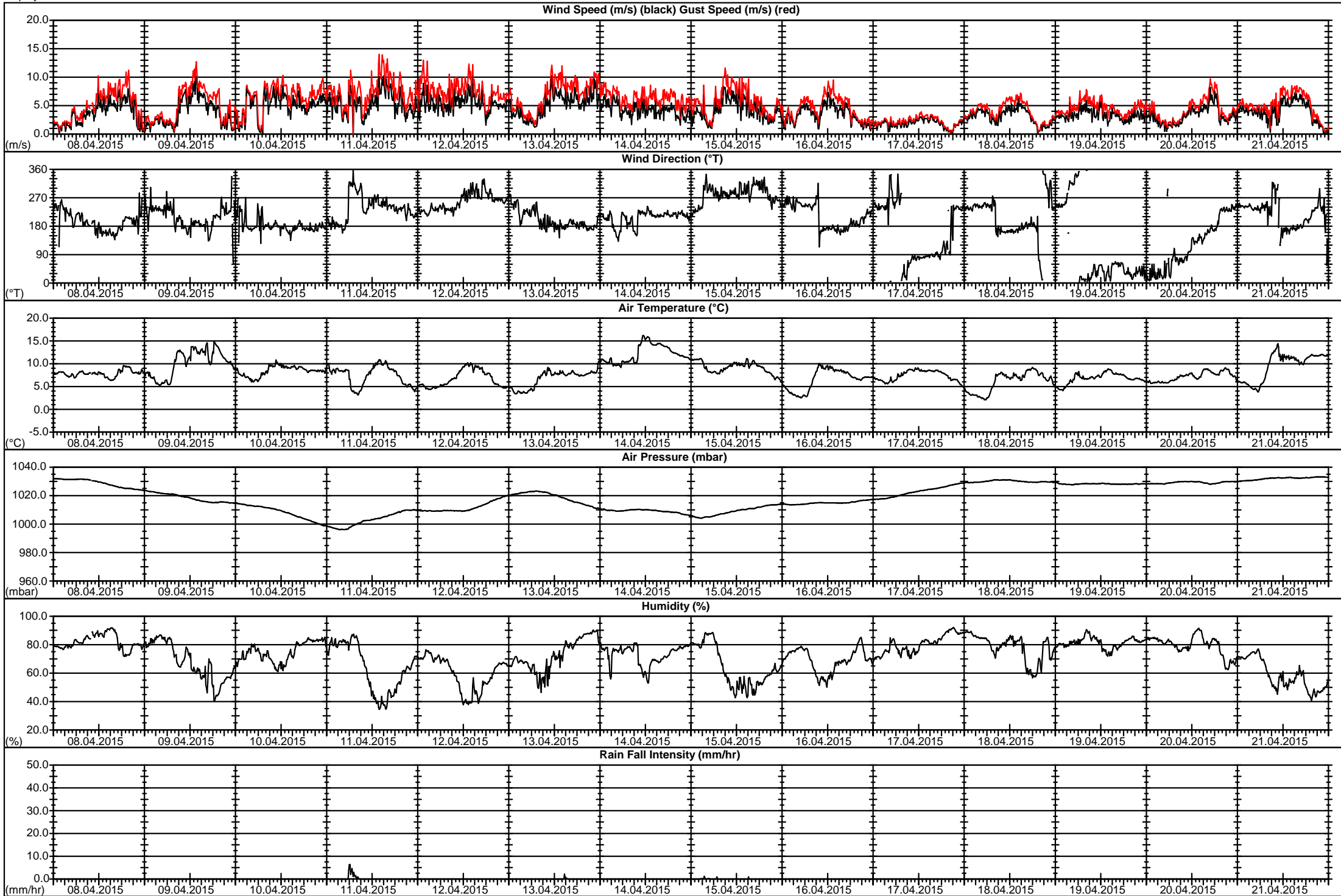
Latitude: 57°07'57"N Longitude: 002°03'45"W Instrument height off ground level: 20m
Deployed: 25/02/2015 11:00 Recovered: 12/06/2015 08:50

Meteorological Station / AHB_Vaisala



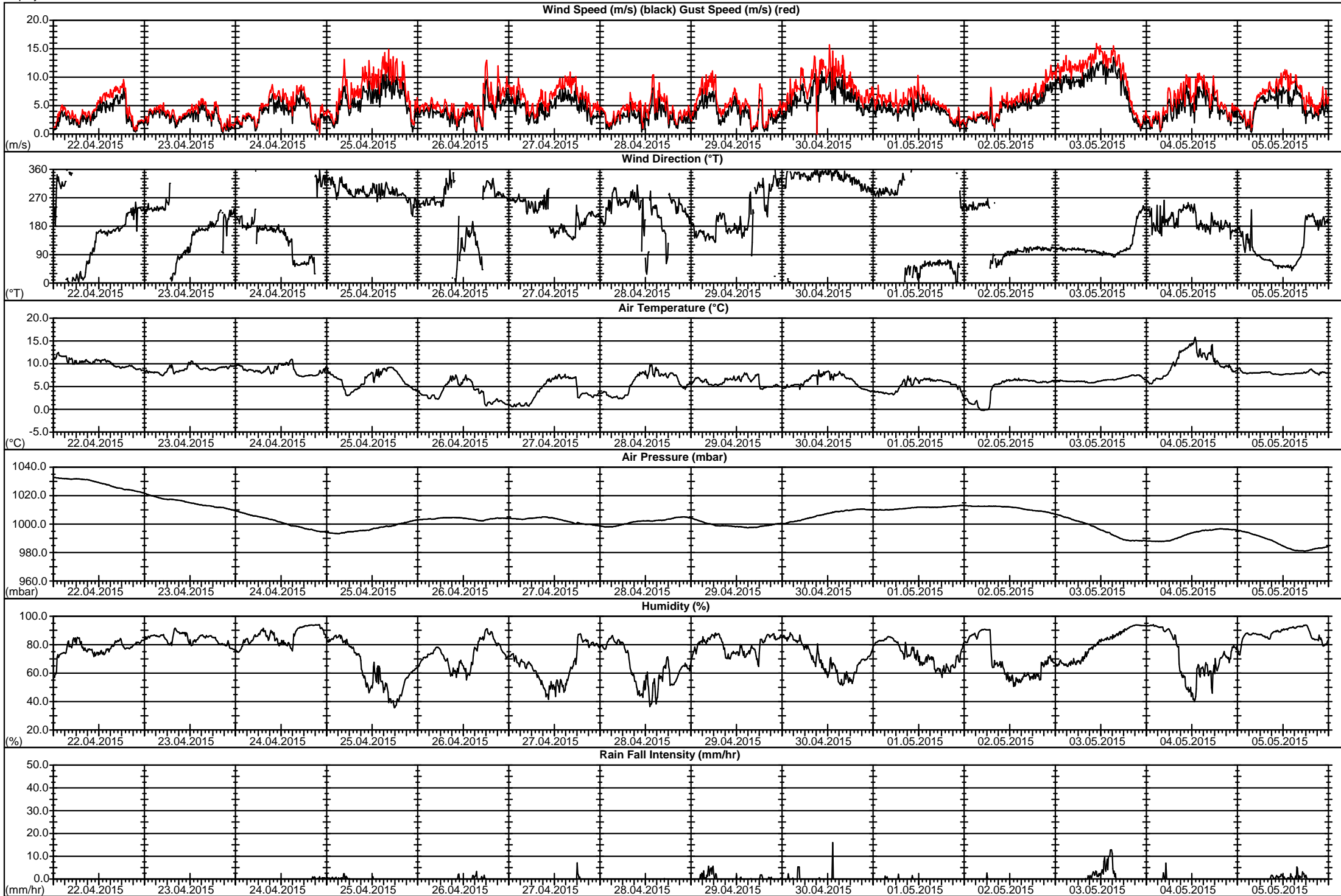
Latitude: 57°07'57"N Longitude: 002°03'45"W Instrument height off ground level: 20m
Deployed: 25/02/2015 11:00 Recovered: 12/06/2015 08:50

Meteorological Station / AHB_Vaisala



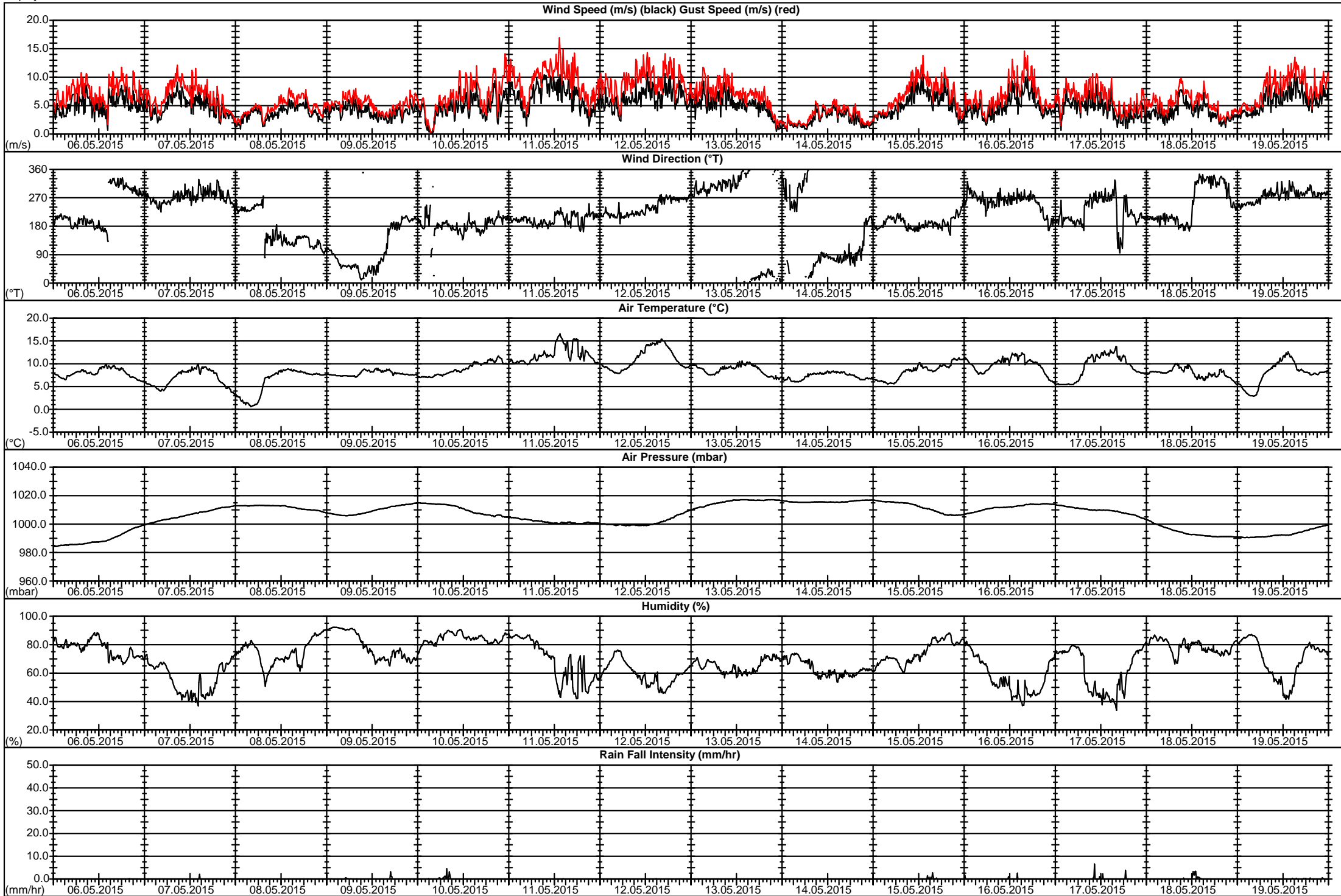
Latitude: 57°07'57"N Longitude: 002°03'45"W Instrument height off ground level: 20m
Deployed: 25/02/2015 11:00 Recovered: 12/06/2015 08:50

Meteorological Station / AHB_Vaisala



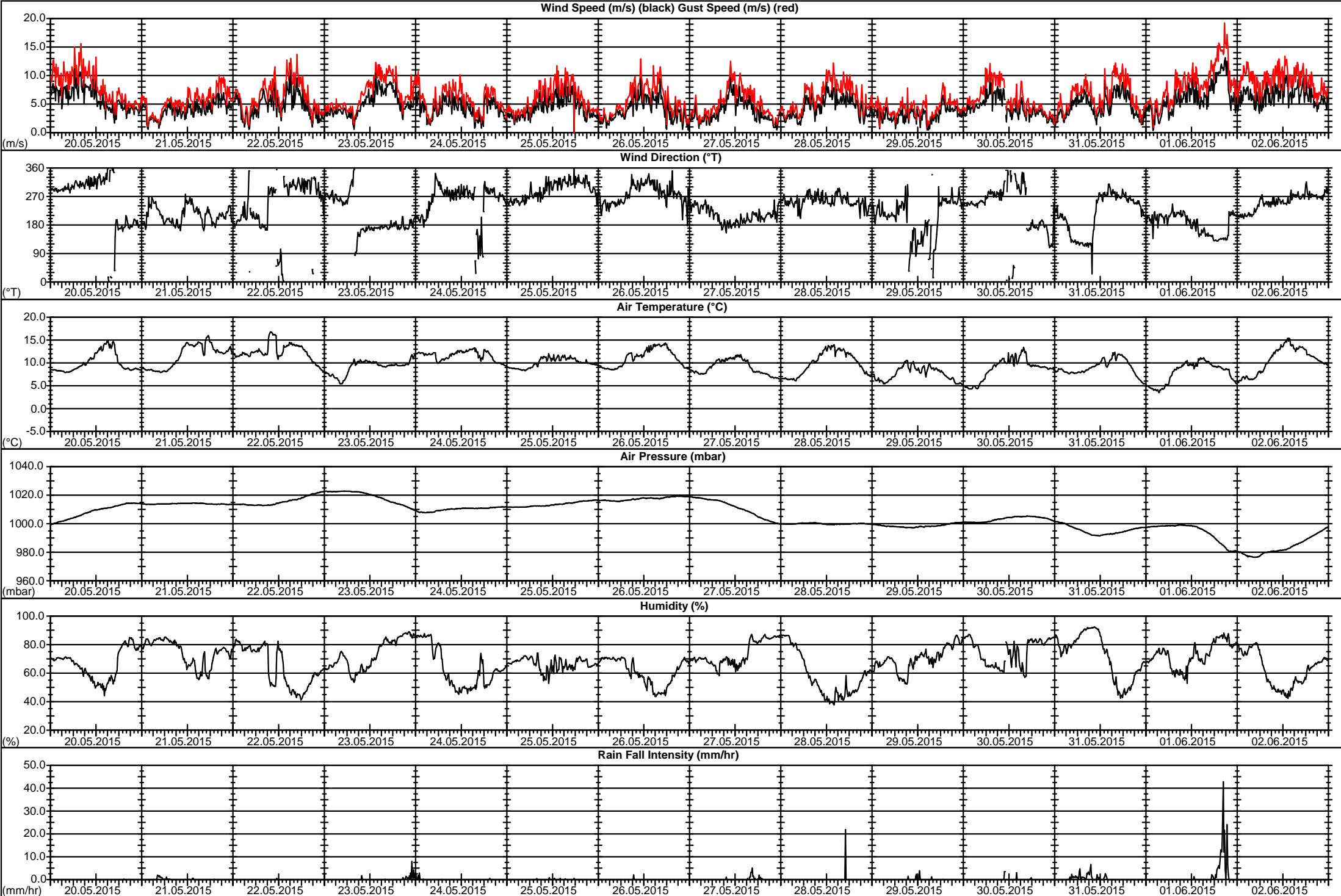
Latitude: 57°07'57"N Longitude: 002°03'45"W Instrument height off ground level: 20m
Deployed: 25/02/2015 11:00 Recovered: 12/06/2015 08:50

Meteorological Station / AHB_Vaisala



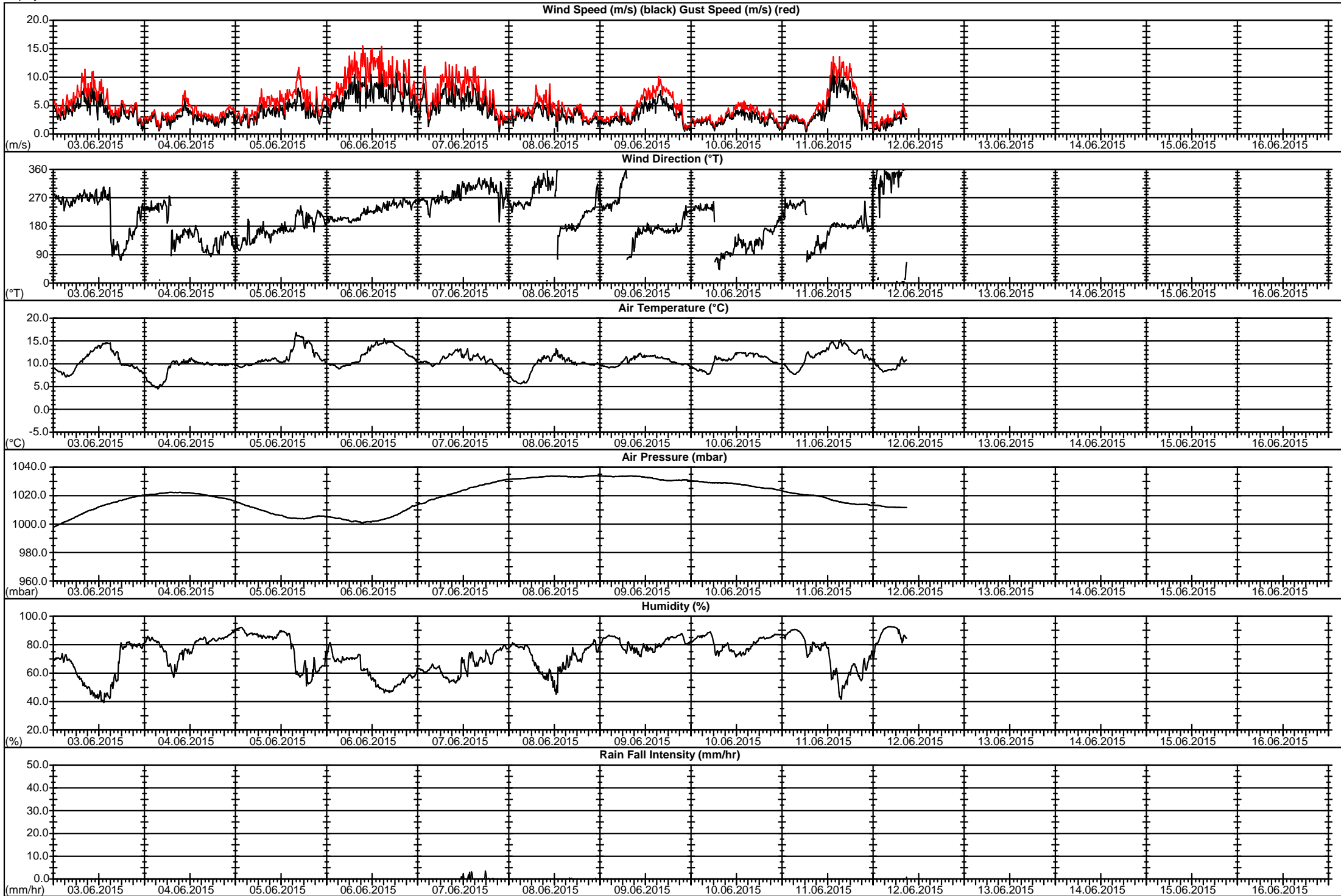
Latitude: 57°07'57"N Longitude: 002°03'45"W Instrument height off ground level: 20m
Deployed: 25/02/2015 11:00 Recovered: 12/06/2015 08:50

Meteorological Station / AHB_Vaisala



Latitude: 57°07'57"N Longitude: 002°03'45"W Instrument height off ground level: 20m
Deployed: 25/02/2015 11:00 Recovered: 12/06/2015 08:50

Meteorological Station / AHB_Vaisala



Meteorological Data Hodogram (Rose Diagram) Aberdeen Harbour Expansion EIA

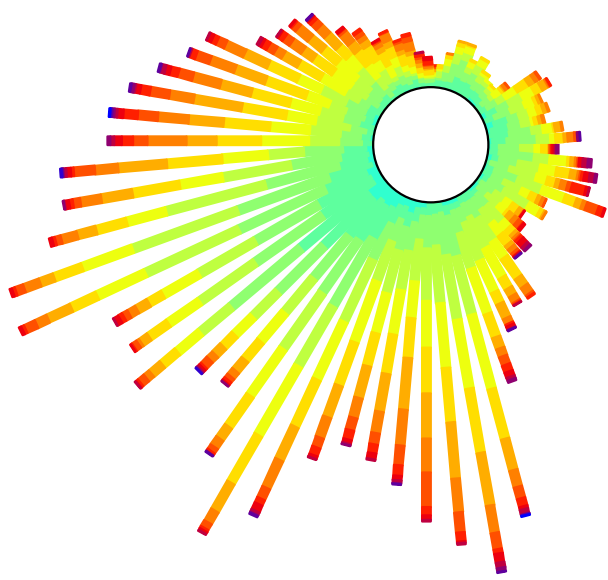
Latitude: 57°07'57"N Longitude: 002°03'45"W Instrument height off ground level: 20m
Deployed: 25/02/2015 11:00 Recovered: 12/06/2015 08:50

Meteorological Station / AHB_Vaisala

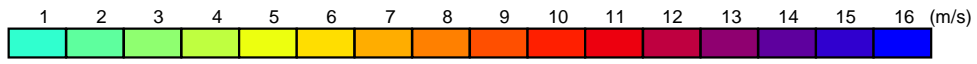
Wind Direction (°T)
True North

West

East

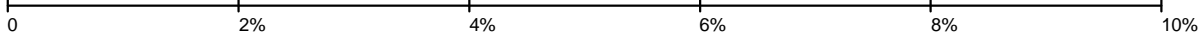


Wind Speed (m/s)



South

Percentage Occurrence



Frequency Table Aberdeen Harbour Expansion EIA

Latitude: 57°07'57"N Longitude: 002°03'45"W Instrument height off ground level: 20m
Deployed: 25/02/2015 11:00 Recovered: 12/06/2015 08:50

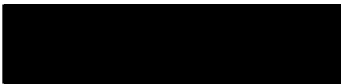
Meteorological Station / AHB_Vaisala


Frequency Distribution of Wind Speed (m/s) against Wind Direction (°T)																		
	<1	<2	<3	<4	<5	<6	<7	<8	<9	<10	<11	<12	<13	<14	<15	<16	Count	%
<10	3	17	12	15	10	9											66	0.429
<20	6	26	45	25	19	8	2	1									132	0.858
<30	7	35	32	21	15	3											113	0.734
<40	6	28	27	18	11	3											93	0.604
<50	9	16	20	11	8	3	1	3									71	0.461
<60	7	23	31	26	39	27	17	10	3	1							184	1.196
<70	11	31	39	38	24	14	9	3	1								170	1.105
<80	14	42	38	27	18	10	11	4									164	1.066
<90	7	38	74	32	16	19	11	11	6		2	1	5	1			223	1.449
<100	10	22	77	52	38	17	14	5	3	3	8	12	7				268	1.741
<110	9	12	52	71	48	29	15	14	16	29	11	4	2				312	2.027
<120	8	21	40	65	34	22	11	7	8	1							217	1.410
<130	10	5	48	40	30	16	12	4	2	1	3						171	1.111
<140	10	12	32	55	29	18	13	10	10	5	10	6	2	1			213	1.384
<150	3	22	43	72	59	51	23	23	6	3		1					306	1.988
<160	13	16	46	104	101	39	32	14	5	7	7	4	2	1			391	2.540
<170	10	22	112	154	190	148	89	49	37	22	18	12	4	2		1	870	5.653
<180	4	29	83	150	156	145	151	95	61	20	8	5	3				910	5.913
<190	15	30	75	110	107	97	117	75	55	26	11	6	1	1			726	4.717
<200	25	35	58	118	128	106	101	59	31	25	12	3	1				702	4.561
<210	32	61	135	177	194	142	90	64	26	12	12	5	1	2			953	6.192
<220	41	126	178	158	148	98	43	24	16	8	5	1	1	1			848	5.510
<230	50	189	184	100	71	45	35	21	19	7	4	3	2		1		731	4.750
<240	34	173	211	170	94	59	30	13	15	5	6	1					811	5.269
<250	25	122	244	267	147	67	58	41	31	9	6						1017	6.608
<260	16	91	201	247	116	97	50	46	13	9	9	1	1				897	5.828
<270	16	51	92	102	123	136	112	73	47	15	17	8	4	1	2		799	5.191
<280	8	18	50	84	97	119	101	81	51	35	16	6	7	3	1	1	678	4.405
<290	6	30	49	69	79	104	91	69	38	18	8	8	2	4			575	3.736
<300	16	26	49	60	75	97	67	51	30	17	10	3					501	3.255
<310	6	21	37	49	60	61	47	37	20	10	3	3					354	2.300
<320	6	18	39	43	50	39	38	34	15	7	6		1	1			297	1.930
<330	8	24	20	34	22	50	22	17	8	4	1						210	1.364
<340	7	18	24	16	32	32	12	18	3	1							163	1.059
<350	8	21	16	9	15	21	12	19	10	4		1					136	0.884
<360	28	12	17	6	10	14	7	6	4	11	4						119	0.773
																	15391	100
Count	494	1483	2530	2795	2413	1965	1444	1001	590	315	197	94	46	18	4	2	15391	
%	3.210	9.636	16.438	18.160	15.678	12.767	9.382	6.504	3.833	2.047	1.280	0.611	0.299	0.117	0.026	0.013	100	
100.0	96.8	87.2	70.7	52.6	36.9	24.1	14.7	8.2	4.4	2.3	1.1	0.5	0.2	0.0	0.0	0.0	% Exceedence	



**APPENDIX H
TSS AND PSD ANALYSIS CERTIFICATES**

Certificate Number:	EP/15/4618	Fugro EMU Job Number:	J/3/08/2774
Job Reference:	Aberdeen Harbour Expansion EIA		
Prepared For	Prepared By		
Fugro EMU Limited on behalf of the Aberdeen Harbour Board	James Hutchinson Fugro EMU Limited Trafalgar Wharf (Unit 16) Hamilton Road Portchester Portsmouth PO6 4PX United Kingdom		
Phone: +44 (0) 2392 205500 Web: www.fugroemu.com	Phone: +44 (0) 2392 205500 Email: sediment@fugroemu.com Web: www.fugroemu.com		

Sampling Undertaken By:	Fugro EMU	Sampling Date:	20/02/2015
Date of Receipt:	21/02/2015	Date of Analysis:	23/02/2015
Sample Matrix:	Marine Sediments		
Method Reference:	Total Suspended Solids by 1.2µm Glass Fibre Paper Filtration – Fugro EMU MET/17 based on HMSO Methods 1980 and BS EN 872: 2005.		
Test Results:	Refer to pages 2-3 of 3		
Laboratory Comments:	Deviating Codes: DS7 – The holding time expired prior to analysis being undertaken. The results reported may not be representative of conditions at the time of sampling.		
Authorised Signature:			
Name:	James Hutchinson		
Position:	Sediment Laboratory Manager		
Issue Date:	04/03/2015		

<ul style="list-style-type: none"> • Further information on methods of analysis may be obtained from the above address • Opinions and interpretations expressed herein are outside the scope of UKAS accreditation • Test results reported relate only to those items tested • ^{Sub} indicates subcontracted test 	<p>A UKAS TESTING LABORATORY</p> 
Fugro EMU Limited. Incorporated in England No. 3469947. Reg. Office: Fugro House, Hithercroft Road, Wallingford, Oxfordshire, OX10 9RB	

**FUGRO EMU LIMITED
CERTIFICATE OF ANALYSIS**



Test Results: Total Suspended Solids - 1.2 µm glass fibre paper filtration dried @ 105°C
Fugro EMU Job Number: J/3/08/2774
Job Reference: Aberdeen Harbour Expansion EIA

Sample ID	Lab ID	Date Taken	Time Taken	Depth [m]	Analysis Date	Analysis Time	Total Suspended Solids [105°C] [mg/l]
WS1	WL030007	20/02/2015	15:12	0.5	23/02/2015	10:54	31.4
WM1	WL030008	20/02/2015	15:18	4	23/02/2015	10:55	16.4
WB1	WL030009	20/02/2015	15:20	8	23/02/2015	10:56	36.8
WS2	WL030010	20/02/2015	15:21	0.5	23/02/2015	10:57	28.1
WM2	WL030011	20/02/2015	15:28	4	23/02/2015	10:58	29.4
WB2	WL030012	20/02/2015	15:29	8	23/02/2015	10:59	41.0
WS3	WL030013	20/02/2015	15:30	0.5	23/02/2015	11:10	14.1
WM3	WL030014	20/02/2015	15:39	4	23/02/2015	11:11	14.7
WB3	WL030015	20/02/2015	15:40	8	23/02/2015	11:12	26.9
WS4	WL030016	20/02/2015	15:41	0.5	23/02/2015	11:13	12.7
WM4	WL030017	20/02/2015	15:49	4	23/02/2015	11:14	11.4
WB4	WL030018	20/02/2015	15:50	8	23/02/2015	11:16	39.4
WS5	WL030019	20/02/2015	15:51	0.5	23/02/2015	11:24	22.4
WM5	WL030020	20/02/2015	15:59	4	23/02/2015	11:25	12.7
WB5	WL030021	20/02/2015	16:00	8	23/02/2015	11:26	23.5
WS6	WL030022	20/02/2015	16:01	0.5	23/02/2015	11:27	8.5
WM6	WL030023	20/02/2015	16:09	4	23/02/2015	11:28	10.0
WB6	WL030024	20/02/2015	16:10	8	23/02/2015	11:29	18.4
ES1	WL030025	20/02/2015	18:30	0.5	23/02/2015	12:34	27.6
EM1	WL030026	20/02/2015	18:31	11	23/02/2015	12:35	23.3
EB1	WL030027	20/02/2015	18:33	22	23/02/2015	12:36	39.2
ES2	WL030028	20/02/2015	18:40	0.5	23/02/2015	12:37	12.3
EM2	WL030029	20/02/2015	18:41	11	23/02/2015	12:38	18.6
EB2	WL030030	20/02/2015	18:42	22	23/02/2015	12:39	28.2
ES3	WL030031	20/02/2015	18:49	0.5	23/02/2015	12:50	14.9
EM3	WL030032	20/02/2015	18:51	11	23/02/2015	12:51	18.8
EB3	WL030033	20/02/2015	18:52	22	23/02/2015	12:52	32.1
ES4	WL030034	20/02/2015	19:00	0.5	23/02/2015	12:53	11.9
EM4	WL030035	20/02/2015	19:01	11	23/02/2015	12:54	19.6


**FUGRO EMU LIMITED
CERTIFICATE OF ANALYSIS**




Test Results: Total Suspended Solids - 1.2 µm glass fibre paper filtration dried @ 105°C
Fugro EMU Job Number: J/3/08/2774
Job Reference: Aberdeen Harbour Expansion EIA

Sample ID	Lab ID	Date Taken	Time Taken	Depth [m]	Analysis Date	Analysis Time	Total Suspended Solids [105°C] [mg/l]
EB4	WL030036	20/02/2015	19:02	22	23/02/2015	12:55	32.3
ES5	WL030037	20/02/2015	19:09	0.5	23/02/2015	13:08	24.2
EM5	WL030038	20/02/2015	19:11	11	23/02/2015	13:09	27.3
EB5	WL030039	20/02/2015	19:12	22	23/02/2015	13:10	41.2
ES6	WL030040	20/02/2015	19:19	0.5	23/02/2015	13:11	17.0
EM6	WL030041	20/02/2015	19:20	11	23/02/2015	13:12	33.5
EB6	WL030042	20/02/2015	19:22	22	23/02/2015	13:13	33.5

Certificate Number:	EP/15/4623	Fugro EMU Job Number:	J/3/08/2774
Job Reference:	Aberdeen Harbour Expansion EIA		
Prepared For	Prepared By		
Fugro EMU Limited on behalf of the Aberdeen Harbour Board	James Hutchinson Fugro EMU Limited Trafalgar Wharf (Unit 16) Hamilton Road Portchester Portsmouth PO6 4PX United Kingdom		
Phone: +44 (0) 2392 205500 Web: www.fugroemu.com	Phone: +44 (0) 2392 205500 Email: sediment@fugroemu.com Web: www.fugroemu.com		

Sampling Undertaken By:	Fugro EMU	Sampling Date:	06/04/2015
Date of Receipt:	09/04/2015	Date of Analysis:	09/04/2015
Sample Matrix:	Marine Waters		
Method Reference:	^{DS6} Total Suspended Solids by 1.2µm Glass Fibre Paper Filtration Dried at 105°C – Fugro EMU MET/17 based on HMSO Methods 1980 and BS EN 872: 2005.		
Test Results:	Refer to pages 2-3 of 3		
Laboratory Comments:	Deviating Codes: DS6 – Samples were received outside analysis holding time. The results reported may not be representative of conditions at the time of sampling.		
Authorised Signature:			
Name:	James Hutchinson		
Position:	Sediment Laboratory Manager		
Issue Date:	10/04/2015		

<ul style="list-style-type: none"> • Further information on methods of analysis may be obtained from the above address • Opinions and interpretations expressed herein are outside the scope of UKAS accreditation • Test results reported relate only to those items tested • ^{Sub}indicates subcontracted test • ^{DS}Indicates relevant Deviating Code applies to test results 	<p>A UKAS TESTING LABORATORY</p> 
Fugro EMU Limited. Incorporated in England No. 3469947. Reg. Office: Fugro House, Hithercroft Road, Wallingford, Oxfordshire, OX10 9RB	

**FUGRO EMU LIMITED
CERTIFICATE OF ANALYSIS**



Test Results: Total Suspended Solids - 1.2 µm glass fibre paper filtration dried @ 105°C
Fugro EMU Job Number: J/3/08/2774
Job Reference: Aberdeen Harbour Expansion EIA

Sample ID	Lab ID	Date Taken	Time Taken	Depth [m]	Analysis Date	Analysis Time	Total Suspended Solids [105°C] [mg/l]
WEST B1	WL030172	06/04/2015	08:50	6.2	09/04/2015	14:05	19.4
WEST M1	WL030173	06/04/2015	08:52	3	09/04/2015	14:06	17.0
WEST S1	WL030174	06/04/2015	08:56	0.5	09/04/2015	14:07	15.8
WEST B2	WL030175	06/04/2015	09:00	6.2	09/04/2015	14:08	17.1
WEST M2	WL030176	06/04/2015	09:02	3	09/04/2015	14:09	14.1
WEST S2	WL030177	06/04/2015	09:03	0.5	09/04/2015	14:10	19.8
WEST B3	WL030178	06/04/2015	09:15	6.2	09/04/2015	14:23	11.2
WEST M3	WL030179	06/04/2015	09:17	3	09/04/2015	14:24	5.4
WEST S3	WL030180	06/04/2015	09:18	0.5	09/04/2015	14:25	4.0
WEST B4	WL030181	06/04/2015	09:20	6.2	09/04/2015	14:26	6.8
WEST M4	WL030182	06/04/2015	09:21	3	09/04/2015	14:27	5.7
WEST S4	WL030183	06/04/2015	09:23	0.5	09/04/2015	14:28	9.6
WEST B5	WL030184	06/04/2015	09:30	6.2	09/04/2015	14:37	8.5
WEST M5	WL030185	06/04/2015	09:31	3	09/04/2015	14:38	4.6
WEST S5	WL030186	06/04/2015	09:33	0.5	09/04/2015	14:39	3.6
WEST B6	WL030187	06/04/2015	09:40	6.2	09/04/2015	14:40	7.8
WEST M6	WL030188	06/04/2015	09:42	3	09/04/2015	14:41	7.1
WEST S6	WL030189	06/04/2015	09:43	0.5	09/04/2015	14:42	8.3
EAST B1	WL030154	06/04/2015	11:03	20	09/04/2015	14:49	9.4
EAST M1	WL030155	06/04/2015	11:05	10	09/04/2015	14:50	5.5
EAST S1	WL030156	06/04/2015	11:07	0.5	09/04/2015	14:53	3.5
EAST B2	WL030157	06/04/2015	11:11	20	09/04/2015	14:54	9.0
EAST M2	WL030158	06/04/2015	11:14	10	09/04/2015	14:55	9.8
EAST S2	WL030159	06/04/2015	11:16	0.5	09/04/2015	14:56	4.8
EAST B3	WL030160	06/04/2015	11:20	20	09/04/2015	15:05	15.4
EAST M3	WL030161	06/04/2015	11:22	10	09/04/2015	15:06	6.2
EAST S3	WL030162	06/04/2015	11:23	0.5	09/04/2015	15:07	3.1
EAST B4	WL030163	06/04/2015	11:30	20	09/04/2015	15:08	10.8
EAST M4	WL030164	06/04/2015	11:32	10	09/04/2015	15:09	5.0

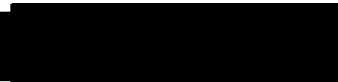
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Test Results: Total Suspended Solids - 1.2 µm glass fibre paper filtration dried @ 105°C
Fugro EMU Job Number: J/3/08/2774
Job Reference: Aberdeen Harbour Expansion EIA

Sample ID	Lab ID	Date Taken	Time Taken	Depth [m]	Analysis Date	Analysis Time	Total Suspended Solids [105°C] [mg/l]
EAST S4	WL030165	06/04/2015	11:34	0.5	09/04/2015	15:10	9.4
EAST B5	WL030166	06/04/2015	11:40	20	09/04/2015	15:18	5.6
EAST M5	WL030167	06/04/2015	11:42	10	09/04/2015	15:19	3.4
EAST S5	WL030168	06/04/2015	11:45	0.5	09/04/2015	15:20	2.8
EAST B6	WL030169	06/04/2015	11:52	20	09/04/2015	15:21	10.4
EAST M6	WL030170	06/04/2015	11:54	10	09/04/2015	15:22	5.1
EAST S6	WL030171	06/04/2015	11:56	0.5	09/04/2015	15:23	9.2

Certificate Number:	EP/15/4630	Fugro EMU Job Number:	J/3/08/2774
Job Reference:	Aberdeen Harbour Expansion EIA		
Prepared For	Prepared By		
Fugro EMU Limited on behalf of the Aberdeen Harbour Board	James Hutchinson Fugro EMU Limited Trafalgar Wharf (Unit 16) Hamilton Road Portchester Portsmouth PO6 4PX United Kingdom		
Phone: +44 (0) 2392 205500 Web: www.fugroemu.com	Phone: +44 (0) 2392 205500 Email: sediment@fugroemu.com Web: www.fugroemu.com		

Sampling Undertaken By:	Fugro EMU	Sampling Date:	11/06/2015
Date of Receipt:	13/06/2015	Date of Analysis:	15/06/2015 – 16/06/2015
Sample Matrix:	Marine Waters		
Method Reference:	DS6 [†] Total Suspended Solids by 1.2µm Glass Fibre Paper Filtration Dried at 105°C – Fugro EMU MET/17 based on HMSO Methods 1980 and BS EN 872: 2005. *Particle Size Distribution by Laser Diffraction – Fugro EMU MET/50 based on BS ISO 13320: 2009.		
Test Results:	Refer to pages 2-5 of 5		
Laboratory Comments:	Deviating Codes: DS6 – Samples were received outside analysis holding time. The results reported may not be representative of conditions at the time of sampling.		
Authorised Signature:			
Name:	James Hutchinson		
Position:	Sediment Laboratory Manager		
Issue Date:	17/06/2015		

<ul style="list-style-type: none"> • Further information on methods of analysis may be obtained from the above address • Opinions and interpretations expressed herein are outside the scope of UKAS accreditation • [†]Indicates determinand not included in UKAS accreditation • Test results reported relate only to those items tested • ^{Sub}Indicates subcontracted test • ^{DS}Indicates relevant Deviating Code applies to test results 	<p>A UKAS TESTING LABORATORY</p> 
Fugro EMU Limited. Incorporated in England No. 3469947. Reg. Office: Fugro House, Hithercroft Road, Wallingford, Oxfordshire, OX10 9RB	

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Test Results: Total Suspended Solids - 1.2 µm glass fibre paper filtration dried @ 105°C
Fugro EMU Job Number: J/3/08/2774
Job Reference: Aberdeen Harbour Expansion EIA

Sample ID	Lab ID	Date Taken	Time Taken	Depth [m]	Analysis Date	Analysis Time	Total Suspended Solids [105°C] [mg/l]
NES1	WL030352	11/06/2015	06:16	Surface	15/06/2015	11:46	14.5
NEM1	WL030353	11/06/2015	06:31	Mid	15/06/2015	11:47	15.5
NEB1	WL030354	11/06/2015	06:35	Bottom	15/06/2015	11:48	28.6
NES2	WL030355	11/06/2015	06:37	Surface	15/06/2015	11:49	12.9
NEM2	WL030356	11/06/2015	06:46	Mid	15/06/2015	11:50	15.7
NEB2	WL030357	11/06/2015	06:53	Bottom	15/06/2015	11:51	19.8
NES3	WL030358	11/06/2015	06:55	Surface	15/06/2015	12:06	11.7
NEM3	WL030359	11/06/2015	07:04	Mid	15/06/2015	12:07	13.1
NEB3	WL030360	11/06/2015	07:06	Bottom	15/06/2015	12:08	16.5
NES4	WL030361	11/06/2015	07:37	Surface	15/06/2015	12:09	13.7
NEB4	WL030362	11/06/2015	08:17	Bottom	15/06/2015	12:10	10.8
NWB1	WL030364	11/06/2015	09:25	Bottom	15/06/2015	12:11	16.5
NWB2	WL030366	11/06/2015	09:30	Bottom	15/06/2015	12:26	13.2
NWS1	WL030368	11/06/2015	09:34	Surface	15/06/2015	12:27	13.2
NWB3	WL030369	11/06/2015	09:39	Bottom	15/06/2015	12:28	14.4
NWS2	WL030371	11/06/2015	09:43	Surface	15/06/2015	12:29	12.0
NWB4	WL030372	11/06/2015	09:50	Bottom	15/06/2015	12:30	10.6
NWS3	WL030374	11/06/2015	09:51	Surface	15/06/2015	12:31	15.4
NWB5	WL030375	11/06/2015	10:20	Bottom	15/06/2015	12:39	20.2

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Test Results: Particle Size Distribution by Laser Diffraction (< 2000 - < 0.086 µm) @ 0.5 Phi Intervals
Fugro EMU Job Number: J/3/08/2774
Job Reference: Aberdeen Harbour Expansion EIA

Sample ID	Lab ID	Date Taken	Time Taken	Depth [m]	Analysis Date and Time	Obscuration [%]	Residual [%]	Concentration [%]	d [0.1]	d [0.5]	d [0.9]
NEB4	WL030363	11/06/2015	08:17	Bottom	16/06/2015 15:24	0.74	2.41	0.0012	6.18	22.46	73.44
NWB1	WL030365	11/06/2015	09:25	Bottom	16/06/2015 15:15	0.53	2.05	0.0010	6.76	26.63	101.44

Notes:

The derived distributions indicate that the laser diffraction results are likely to be dubious due to low particle concentrations for the following reasons:

The residual values were high coupled with low obscuration values: The residual is a description of the goodness of fit between the software model and the actual data from the analysis and should ideally be <1.0% for a good analysis, and <0.3% for a very good analysis. The obscuration is a description of the quantity of particles within the sample and should ideally be between 10 and 30% for a good analysis, although obscurations of <10% are acceptable providing the residual is generally <1.0, and the concentration is >0.0001%.

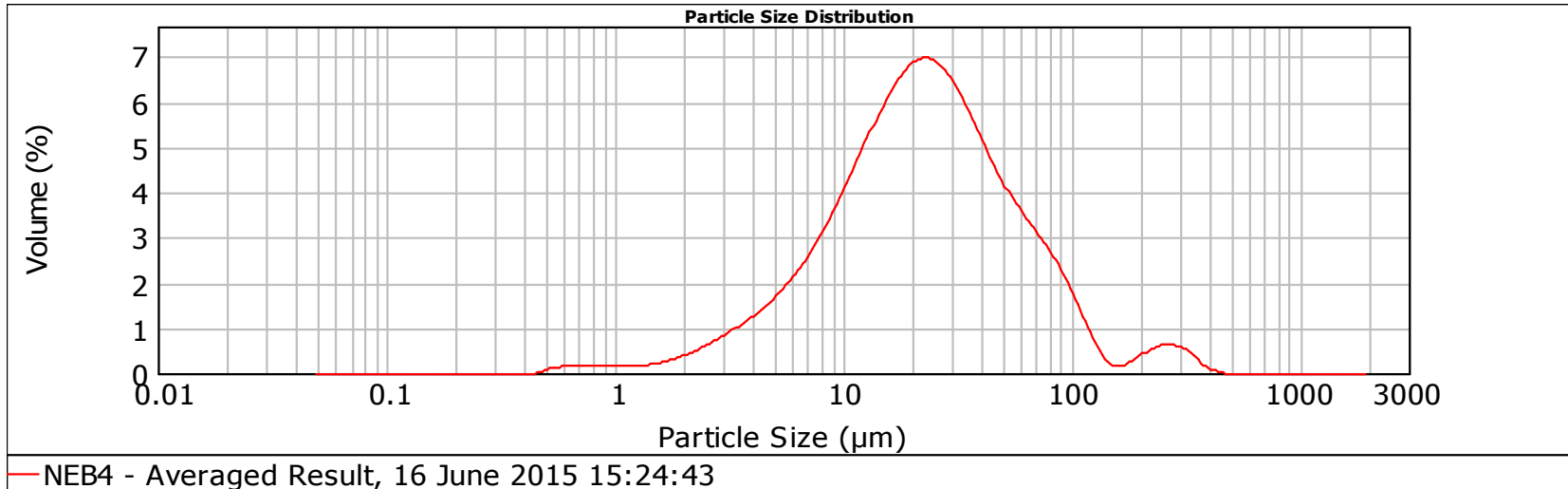
The concentration values were very low: Concentration describes the % of particles suspended within the water passed through the laser diffractor. This is calculated from the Beer-Lambert Law. Results showing concentrations of or near to 0.0001% indicate minimal particle concentrations within the sample.

The residual values for all sites were >1.0% coupled with very low obscuration values of <1.0% - indicating low particle concentrations within all of the samples. The concentration values were between 0.0010% (NWB1) and 0.0012% (NEB4) - which again indicates low particle concentrations within the samples. As such the results for all sites suggest that the displayed results are likely to have been affected by background interference, which is primarily caused by scattered light, and therefore are likely to be dubious.

**FUGRO EMU LIMITED
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Test Results: Particle Size Distribution by Laser Diffraction (< 2000 - < 0.086 μm) @ 0.5 Phi Intervals
Fugro EMU Job Number: J/3/08/2774
Job Reference: Aberdeen Harbour Expansion EIA



Size (μm)	Volume In %
0.020	0.00
0.086	0.00
0.122	0.00
0.173	0.00
0.244	0.00
0.345	0.00
0.488	0.00

Size (μm)	Volume In %
0.488	0.31
0.691	0.41
0.977	0.38
1.381	0.58
1.953	1.19
2.762	2.16
3.906	3.47

Size (μm)	Volume In %
3.906	3.47
5.524	5.38
7.812	8.30
11.049	12.02
15.625	15.06
22.097	15.39
31.250	12.72

Size (μm)	Volume In %
31.250	12.72
44.194	9.24
62.500	6.64
88.388	3.62
125.000	0.66
176.777	1.00
250.000	1.27

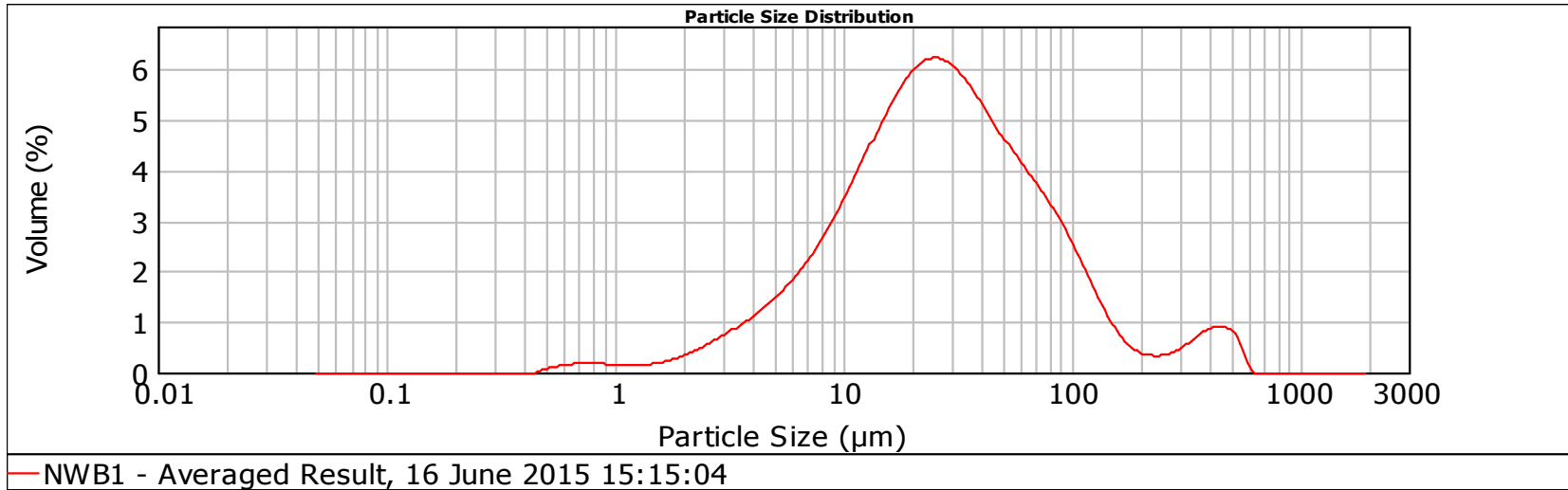
Size (μm)	Volume In %
250.000	1.27
353.553	0.20
500.000	0.00
707.107	0.00
1000.000	0.00
1400.000	0.00
2000.000	0.00

Size (μm)	Volume In %
2000.000	0.00

**FUGRO EMU LIMITED
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Test Results: Particle Size Distribution by Laser Diffraction (< 2000 - < 0.086 μm) @ 0.5 Phi Intervals
Fugro EMU Job Number: J/3/08/2774
Job Reference: Aberdeen Harbour Expansion EIA



Size (μm)	Volume In %
0.020	0.00
0.086	0.00
0.122	0.00
0.173	0.00
0.244	0.00
0.345	0.00
0.488	0.00

Size (μm)	Volume In %
0.488	0.30
0.691	0.39
0.977	0.34
1.381	0.48
1.953	1.03
2.762	1.91
3.906	3.06

Size (μm)	Volume In %
3.906	3.06
5.524	4.65
7.812	7.04
11.049	10.17
15.625	13.02
22.097	14.02
31.250	12.67

Size (μm)	Volume In %
31.250	12.67
44.194	10.30
62.500	8.07
88.388	5.45
125.000	2.43
176.777	0.89
250.000	1.10

Size (μm)	Volume In %
250.000	1.10
353.553	1.95
500.000	0.71
707.107	0.00
1000.000	0.00
1400.000	0.00
2000.000	0.00

Size (μm)	Volume In %
2000.000	0.00