



Final Data Report

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Executive Summary

Fugro was commissioned by Sure Partners Ltd to conduct a measurement campaign capturing physical oceanographic conditions at the Arklow offshore wind farm. Data collected included water level, current velocity, wave statistics, turbidity and water quality.

The initial deployments were completed in November 2019. The project programme had scheduled a 3 month interval for maintenance visits, however the first recovery visit was postponed from February to May 2020 due to a combination of unfavourable weather and subsequent restrictions due to the COVID-19 pandemic. A further two deployments were completed and final recovery took place in March 2021.

This report pertains to all data collected during the campaign. Data have been processed, analysed and provided to SSE (Sure Partners Ltd representative). This report should be viewed in conjunction with the data files, as it details the processing techniques and quality control procedures applied.

A brief synopsis of the data is included below:

- Data return of 88 % was achieved as an average across all locations and parameters recorded;
- The largest tidal range and the strongest currents were found at Location A, with a maximum tidal range of 2.71 m and current velocities of 2.71 m/s;
- The currents are tidally dominated with a rectilinear NNE-SSW tidal axis and are greater at the near-surface of the profiles;
- Seabed and surface water temperature values correlated well over the different instruments;
- The maximum wave recorded was at Location E at 6.83 m;
- The highest average significant wave heights occurred at Location A;
- The conductivity data were higher at Location A and were tidally dominant, with more variance occurring during a spring tide;
- The mean values for turbidity range from 15.9 mg/l (Location D1) to 26.9 mg/l (Location A);
- Higher turbidity values coincided with spring tides and display a semi-diurnal pattern.

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Abbreviations

Term	Definition
ABS	Acoustic Backscatter
ASCII	American Standard Code for Information Interchange
AST	Acoustic Surface Tracking
AWAC	Acoustic Wave and Current Profiler
CTD	Conductivity, Temperature and Depth
DA	Depth Average
GMT	Greenwich Mean Time
GPS	Global Positioning System
HA	Harmonic Analysis
HAT	Highest Astronomical Tide <i>The highest tidal water level expected during a 19-year metonic cycle.</i>
H_{max}	Maximum Wave Height <i>The maximum wave height (peak to trough) observed during the measurement period.</i>
H_s	Significant Wave Height <i>Average of the largest third of the wave heights observed during the measurement period.</i>
LAT	Lowest Astronomical Tide <i>The lowest tidal water level expected during a 19-year metonic cycle.</i>
Metonic Maximum	Maximum value predicted to occur in a 19-year celestial cycle
MHWI	Mean High Water Interval <i>The interval in hours between HW at site and HW at Greenwich, UK.</i>
MHWN	Mean High Water Neaps <i>The mean high-water level occurring during neap tide events (derived from the harmonics: $M2-S2+MSL$).</i>
MHWS	Mean High Water Springs <i>The mean high-water level occurring during spring tide events (derived from the harmonics: $M2+S2+MSL$).</i>
MLWI	Mean Low Water Interval <i>The interval in hours between LW at site and HW at Greenwich, UK.</i>
MLWN	Mean Low Water Neaps <i>The mean low-water level occurring during spring tide events (derived from the harmonics: $MSL-M2-S2$).</i>
MLWS	Mean Low Water Springs <i>The average low-water level occurring during neap tide events (derived from the harmonics: $MSL-M2+S2$).</i>
MNR	Mean Neap Range <i>The difference between MHWN and MLWN.</i>
MR	Mean Range <i>The average tidal range throughout a predicted metonic cycle (derived from the harmonics: $M2 \times 2$).</i>
MSL	Mean Sea Level <i>The average (mean) sea level calculated based on metonic cycle predictions, to the datum of the analysed data.</i>

Term	Definition
MSR	Mean Spring Range <i>The difference between MHWS and MLWS.</i>
NA	Not applicable
OD(N)	Ordnance Datum Newlyn
OBS	Optical Backscatter
PSD	Particle Size Distribution
QC	Quality Control
SMB	Surface Marker Buoy
Tidal Form Factor	Type of tide Quantitatively (after Dietrich), where the ratio of $K1 + O1$ to $M2 + S2$ is less than 0.25, the tide is classified as semidiurnal; where the ratio is from 0.25 to 1.5, the tide is mixed, mainly semidiurnal; where the ratio is from 1.5 to 3.0, the tide is mixed, mainly diurnal; and where greater than 3.0, diurnal.
T_{max}	Period of the Maximum Wave <i>The single zero-crossing period associated with the single largest wave.</i>
T_p	Peak Wave Period <i>The period of the waves which represent the peak in spectral energy.</i>
TSS	Total Suspended Solids
T_z	Zero Up-Crossing Wave Period <i>The mean time between zero up-crossing points.</i>
WGS84	World Geodetic System, 1984

- The direction of current flow is towards.
- The direction of wave propagation is from.
- Positions are in WGS84 latitude and longitude unless otherwise stated.
- All times are in GMT unless otherwise stated.

1. Introduction

Fugro were commissioned by Sure Partners Ltd to conduct a measurement campaign within the leased area for the proposed Arklow Offshore Wind Farm, located 12 km east of Arklow, in the Irish Sea. Physical oceanographic conditions were captured at five main locations including the expected cable route and the area surrounding the Arklow Bank.

The data collection locations are displayed in Figure 1.1.

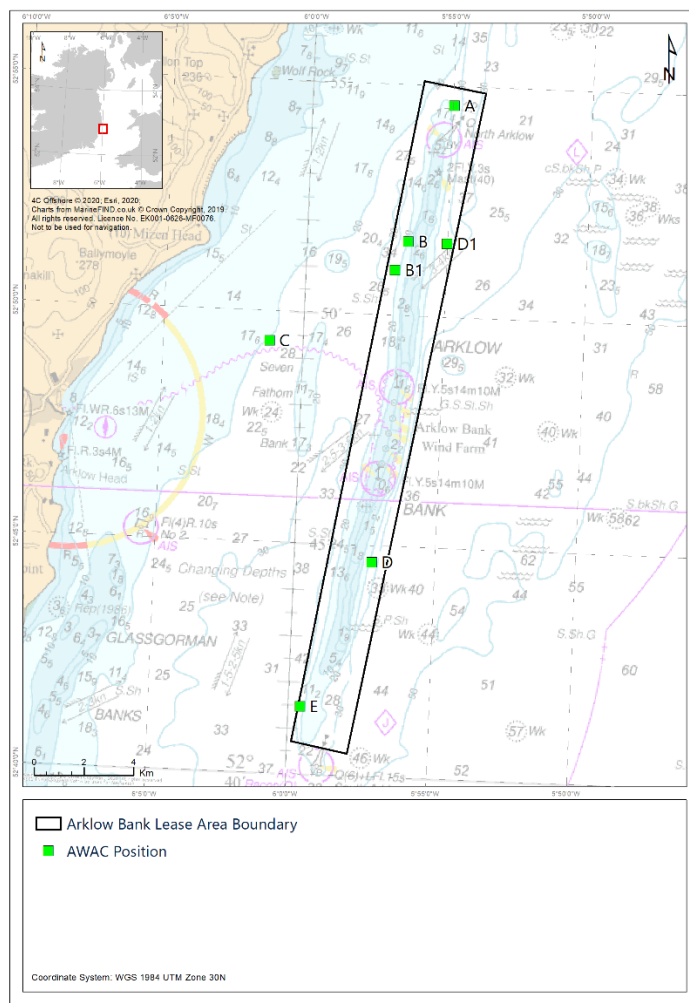


Figure 1.1: Measurement campaign locations

Seabed frames installed at Locations B and D during Deployment 1 were rendered irretrievable because of the dynamic nature of the seabed in these areas on the Arklow Bank. A request was granted to move these measurement locations to harder substrate for the deployments which followed (relabelled as Locations B1 and D1).

Data for the measurement campaign were collected in three deployments (D1, D2 and D3) and cover the period between November 2019 and March 2021. The dates covered by each deployment are listed in Table 1.1.

Table 1.1: Deployment periods of the whole measurement campaign

Deployment period	Location	Deployment Date and Time	Recovery Date and Time
D1	A	6 November 2019 12:35	18 May 2020 08:13
	C	24 November 2019 10:52	19 May 2020 08:25
	E	24 November 2019 14:15	19 May 2020 10:20
D2	A	1 August 2020 10:35	16 October 2020 10:58
	B1	2 August 2020 09:10	15 October 2020 16:15
	D1	1 August 2020 09:07	16 October 2020 09:40
	E	2 August 2020 15:15	15 October 2020 13:45
D3	A	5 November 2020 12:47	7 March 2021 11:17
	B1	7 November 2020 13:22	7 March 2021 17:15
	D1	7 November 2020 14:10	7 March 2021 12:40
	E	22 November 2020 09:00	8 March 2021 11:00

The majority of the instruments were installed in a seabed frame, connected to a surface marker buoy (SMB) on an L-shaped mooring (Figure 1.2). The only instrument installed at the surface was a temperature sensor, fixed on the underside of the SMB.

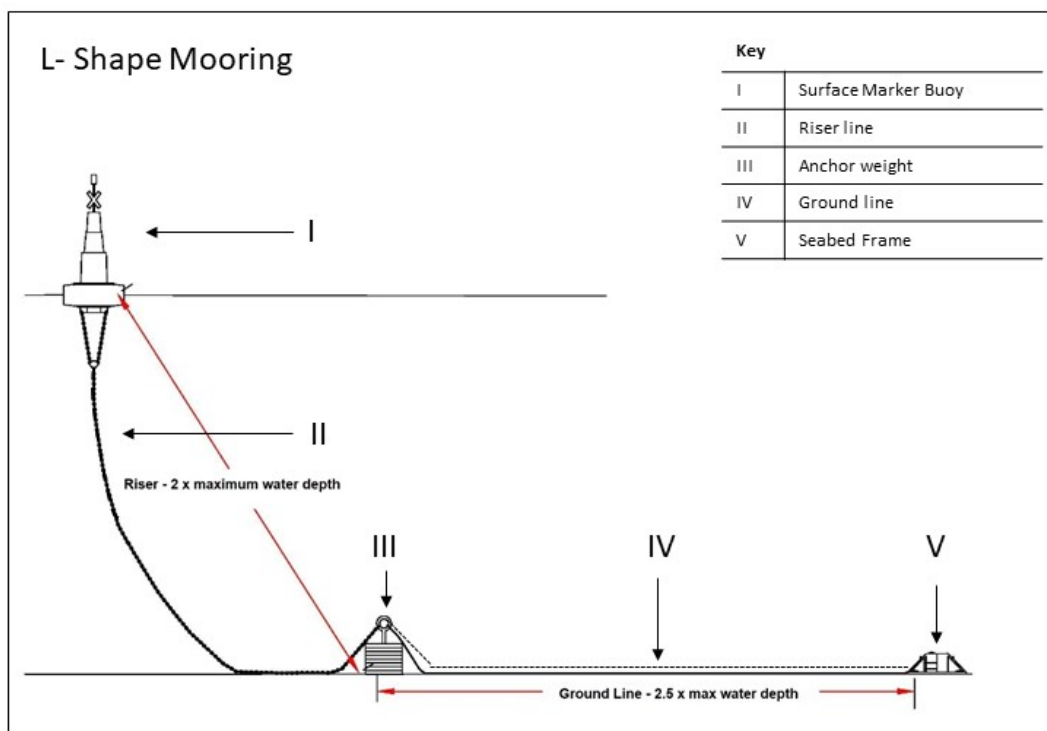


Figure 1.2: Schematic of L-shape mooring deployed on campaign

1.1 Data Parameter Summary / Location

The instrumentation deployed and the data parameters collected at each location are detailed in Table 1.2.

Table 1.2: Deployed instrumentation and data parameters per location

Location	Deployment Period	Data Parameters	Instrument	Average Instrument Height/Depth	Serial Numbers
A	D1, D2, D3	<ul style="list-style-type: none"> ■ Waves ■ Water level ■ Current profiles ■ Seabed water temperature ■ Turbidity (ABS) 	Nortek AWAC 600 KHz	0.65 m	D1: 6178 D2: 6140 D3: 6005
	D1, D2, D3	<ul style="list-style-type: none"> ■ Seabed water temperature ■ Turbidity (OBS) 	Aqualogger 210 TYT	0.60 m	D1: 024019 D2: 024019 D3: 024379
	D1, D2, D3	Surface water temperature	Starmon Mini	0.50 m	D1: T4785 D2: T5643 D3: T5643
	D1	<ul style="list-style-type: none"> ■ Seabed water temperature ■ Conductivity 	SeaGuard SW	0.50 m	849
	D2	<ul style="list-style-type: none"> ■ Seabed water temperature ■ Conductivity 	Seabird SBE 37-SM	0.50 m	10073
	D1, D2, D3	<ul style="list-style-type: none"> ■ Depth ■ Temperature ■ Conductivity ■ Salinity ■ Density ■ Turbidity 	Valeport FastCTD	Full profile	72149
	D1, D2, D3	Water samples	NISKIN bottle	Near bed, mid-depth and near surface	NA
B	D1	<ul style="list-style-type: none"> ■ Depth ■ Temperature ■ Conductivity ■ Salinity 	Valeport FastCTD	Full profile	72149

Location	Deployment Period	Data Parameters	Instrument	Average Instrument Height/Depth	Serial Numbers
		<ul style="list-style-type: none"> ■ Density ■ Turbidity 			
	D1	Water samples	NISKIN bottle	Near bed, mid-depth and near surface	NA
B1	D2, D3	<ul style="list-style-type: none"> ■ Waves ■ Water level ■ Current profiles ■ Seabed water temperature ■ Turbidity (ABS) 	Nortek AWAC 600 KHz	0.58 m	D2: 6178 D3: 6133
	D2, D3	<ul style="list-style-type: none"> ■ Seabed water temperature ■ Turbidity (OBS) 	Aqualogger 210 TYT	0.58 m	D2: 024019 D3: 2554126
	D2, D3	<ul style="list-style-type: none"> ■ Depth ■ Temperature ■ Conductivity ■ Salinity ■ Density ■ Turbidity 	Valeport FastCTD	Full profile	72149
	D2, D3	Water samples	NISKIN bottle	Near bed, mid-depth and near surface	NA
C	D1	<ul style="list-style-type: none"> ■ Waves ■ Water level ■ Current profiles ■ Seabed water temperature ■ Turbidity (ABS) 	Nortek AWAC 600 KHz	0.60 m	1366
	D1	<ul style="list-style-type: none"> ■ Seabed water temperature ■ Turbidity (OBS) 	Aqualogger 210 TYT	0.50 m	024050
	D1	Surface water temperature	Starmon Mini	0.50 m	T3463
	D1	<ul style="list-style-type: none"> ■ Depth ■ Temperature 	Valeport FastCTD	Full profile	72149

Location	Deployment Period	Data Parameters	Instrument	Average Instrument Height/Depth	Serial Numbers
		<ul style="list-style-type: none"> ■ Conductivity ■ Salinity ■ Density ■ Turbidity 			
	D1	Water samples	NISKIN bottle	Near bed, mid-depth and near surface	NA
D	D1	<ul style="list-style-type: none"> ■ Depth ■ Temperature ■ Conductivity ■ Salinity ■ Density ■ Turbidity 	Valeport FastCTD	Full profile	72149
	D1	Water samples	NISKIN bottle	Near bed, mid-depth and near surface	NA
D1	D2, D3	<ul style="list-style-type: none"> ■ Waves ■ Water level ■ Current profiles ■ Seabed water temperature ■ Turbidity (ABS) 	Nortek AWAC 600 KHz	0.65 m	D2: 6133 D3: 6140
	D2, D3	<ul style="list-style-type: none"> ■ Seabed water temperature ■ Turbidity (OBS) 	Aqualogger 210 TYPT	0.37 m	D2: 024379 D3: 024379
	D2, D3	<ul style="list-style-type: none"> ■ Depth ■ Temperature ■ Conductivity ■ Salinity ■ Density ■ Turbidity 	Valeport FastCTD	Full profile	72149
	D2, D3	Water samples	NISKIN bottle	Near bed, mid-depth and near surface	NA
E	D1, D2, D3	<ul style="list-style-type: none"> ■ Waves ■ Water level ■ Current profiles ■ Seabed water temperature 	Nortek AWAC 600 KHz	0.60 m	D1: 6133 D2: 6005 D3: 6031

Location	Deployment Period	Data Parameters	Instrument	Average Instrument Height/Depth	Serial Numbers
		<ul style="list-style-type: none"> ■ Turbidity (ABS) 			
	D1, D2, D3	<ul style="list-style-type: none"> ■ Seabed water temperature 	Aqualogger 210 TYT	0.50 m	D1: 024379 D2: 2554153 D3: 2554153
	D1, D2, D3	<ul style="list-style-type: none"> ■ Turbidity (OBS) 	Aqualogger 310 TYPT		
	D1, D2, D3	Surface water temperature	Starmon Mini	0.50 m	D1: T4792 D2: T5642 D3: T5642
	D1	<ul style="list-style-type: none"> ■ Seabed water temperature ■ Conductivity 	SeaGuard SW	0.60 m	142
	D2	<ul style="list-style-type: none"> ■ Seabed water temperature ■ Conductivity 	Seabird SBE 37-SM	0.60 m	15460
	D1, D2, D3	<ul style="list-style-type: none"> ■ Depth ■ Temperature ■ Conductivity ■ Salinity ■ Density ■ Turbidity 	Valeport FastCTD	Full profile	72149
	D1, D2, D3	Water samples	NISKIN bottle	Near bed, mid-depth and near surface	NA
<p>Notes</p> <p>Data parameters are labelled as "Seabed" or "Surface" however the instruments are at least 0.4 m above the sea floor or below the sea surface, as per the specification in the instrument height/depth column.</p> <p>Seabed frame equipment at Locations B and D were irretrievable due to burial on Deployment 1. However, water samples and CTD cast data from those locations have been provided, as well as Particle Size Distribution analysis.</p>					

1.2 Compliance Matrix

This final data report follows the requirements listed in the original technical scope of work submitted by the client. Additional requirements made by the client representative are also included. All requirements are summarised in Table 1.3 and related to the applicable section within this document or adjoining data.

Table 1.3: Compliance matrix for Final Data Report

Reporting Requirement Item Number	Technical Scope	Fugro Reporting Location
1	Overview of project	See 1 Introduction
2	<ul style="list-style-type: none"> • Deployment locations • Deployment dates • Equipment serial numbers • Location map 	<ul style="list-style-type: none"> • Table 2.1 and Table 2.2 • Table 1.1 • Table 1.2 • Figure 1.1
3	Mooring configuration diagram	See Figure 1.2
4	Instrument sampling regimes	See Table 2.3
5	<ul style="list-style-type: none"> • Statistics of all parameters • Data return as a percentage of the total deployment span 	<ul style="list-style-type: none"> • Table 3.2 • Table 3.1
6	Any functional or sampling problems	See Section 4.2.1 Suspect Data Investigation and Removal
7	Summary of HSE activities and details	See Section 5 Health and Safety
8	The full data listing in ASCII format	See Table 6.1
9	Depth averaging process	See Section 4.3.2 Current Data and Harmonic Analysis
10	Metadata of wave spectra and current profile (bin measurement start, blanking distance, etc.)	See Section 4.3.3 Wave Data Methodology See Section 4.3.2 Current Data and Harmonic Analysis
11	QC process and findings	See Section 4 Quality Control and Data Processing Methods
12	Water level computation	See Section 4.3.1 Water Level and Harmonic Analysis
13	Graphical display requests (several)	See Table 6.2

2. Operational Information

2.1 Location Coordinates

The coordinates of all seabed frame locations throughout the measurement campaign are listed in Table 2.1. The coordinates of the SMB anchor weights are provided in Table 2.2 for Locations A, C and E only as SMBs at these sites were equipped with temperature sensors.

All positions are accurate to within 15 m. Metadata presented within the data files show an average position, calculated over all deployments.

Table 2.1: Seabed frame coordinates

Location	Depth to LAT [m]	Deployment	Seabed Frame Coordinates	
			Latitude [WGS84]	Longitude [WGS84]
A	26.1	D1	52° 54.577' N	005° 54.943' W
		D2	52° 54.475' N	005° 55.030' W
		D3	52° 54.507' N	005° 55.033' W
B	NA	D1	52° 51.539' N	005° 56.415' W
B1	29.1	D2	52° 51.025' N	005° 56.764' W
		D3	52° 50.920' N	005° 56.827' W
C	25.4	D1	52° 49.306' N	006° 01.237' W
D	NA	D1	52° 44.559' N	005° 57.315' W
D1	29.4	D2	52° 51.570' N	005° 55.035' W
		D3	52° 51.499' N	005° 55.011' W
E	38.7	D1	52° 41.462' N	005° 59.581' W
		D2	52° 41.440' N	005° 59.659' W
		D3	52° 41.409' N	005° 59.675' W
Notes Frames at Locations B and D were irretrievable following Deployment 1.				

Table 2.2: SMB anchor weight coordinates

Location	Deployment	SMB Anchor Weight Coordinates	
		Latitude [WGS84]	Longitude [WGS84]
A	D1	52° 54.542' N	005° 54.980' W
	D2	52° 54.528' N	005° 54.975' W
	D3	52° 54.533' N	005° 54.965' W
C	D1	52° 49.300' N	006° 01.232' W
E	D1	52° 41.405' N	005° 59.630' W
	D2	52° 41.429' N	005° 59.660' W
	D3	52° 41.421' N	005° 59.668' W
Notes			
Only Locations A, C and E SMBs positions are presented as they were equipped with temperature sensors			

2.2 Instrument Configurations

The configuration of the instruments deployed throughout the campaign is detailed in Table 2.3 and described per location and data type. All instrumentation was configured in GMT.

Table 2.3: Instrument configurations

Instrument	Parameter	Configuration
Nortek AWAC 600 KHz	Water Level	Every 10 minutes, averaged over a 55 second burst.
	Current Profile	<ul style="list-style-type: none"> ■ Blanking distance 0.5 m; ■ Cell measurement size 1.0 m; ■ 50 m depth / 50 cells; Every 10 minutes, averaged over a 55 second burst.
	Wave	Every 30 minutes over a 512 second burst at 1 Hz (2 Hz for AST measurements).
	Seabed Water Temperature	Every 10 minutes, averaged over a 55 second burst.
	Turbidity (ABS)	Every 10 minutes, averaged over a 55 second burst.
Aqualogger 210 TYT / TYPT	Seabed Water Temperature	Burst sample at 1 Hz over 60 seconds every 10 minutes.
Aqualogger 310 TYPT	Turbidity (OBS)	
Starmon Mini	Surface Water Temperature	Single point measurement every minute for 10 minutes. Processed file has been averaged at 10-minute intervals.

Instrument	Parameter	Configuration
SeaGuard SW	Seabed Water Temperature	Single point measurement every 10 minutes.
	Conductivity	
Valeport FastCTD	Pressure, Water Temperature, Conductivity, Turbidity (Nephelometer and OBS)	Continuous sampling at 16 Hz
Seabird SBE 37-SM	Seabed Water Temperature	Single point measurement every 10 minutes.
	Conductivity	

3. Results and Data Discussion

3.1 Data Return

The data return for the main parameters captured during the measurement campaign is shown in Table 3.1. Data return of 88 % was achieved as an average across all locations and parameters recorded (over the total deployment length).

Table 3.1: Summary of instrument data return

Location	Instrument	Parameter	Good Records in Total Length of Data	Total Data Length [months]	Target Data Length [months]	Good data as % of Total Length	Good data as % of Target Length	
	AWAC	Turbidity (ABS) [mg/l]	35790	13.1	11.5	63	72	
		Current Profile [m/s]	35126			62	71	
		Current DA [m/s]	35126			62	71	
		Seabed Water Temperature [° C]	56405			100	114	
		Water Level [m]	52566			93	106	
		Significant Wave Height [m]	13882			74	84	
	SeaGuard / Seabird	Seabed Water Temperature [°C]	10941	2.5	5.5	100	46	
		Seabed Conductivity [mS/cm]	2097			19	9	
	Aqualogger	Seabed Water Temperature [°C]	33079	7.8	8.5	99	90	
		Turbidity (OBS) [mg/l]	28335			84	77	
		Starmon mini	Surface Water Temperature [°C]	56402	13.1	11.5	100	114
	B1	AWAC	Turbidity (ABS) [mg/l]	21126	6.5	5.5	76	89
Current Profile [m/s]			21114	76			89	

Location	Instrument	Parameter	Good Records in Total Length of Data	Total Data Length [months]	Target Data Length [months]	Good data as % of Total Length	Good data as % of Target Length	
		Current DA [m/s]	21114			76	89	
		Seabed Water Temperature [°C]	27994			100	118	
		Water Level [m]	27910			100	117	
		Significant Wave Height [m]	8104			87	102	
	Aqualogger	Seabed Water Temperature [°C]	10696	6.5	5.5	50	45	
		Turbidity (OBS) [mg/l]	26582			95	112	
	C	AWAC	Turbidity (ABS) [mg/l]	25471	5.9	6.0	100	98
			Current Profile [m/s]	25471			100	98
Current DA [m/s]			25471	100			98	
Seabed Water Temperature [°C]			25471	100			98	
Water Level [m]			25471	100			98	
Significant Wave Height [m]			8490	100			98	
Aqualogger		Seabed Water Temperature [°C]	18158	4.2	3.0	100	140	
		Turbidity (OBS) [mg/l]	12888			71	99	
Starmon mini		Surface Water Temperature [°C]	25468	5.9	6.0	100	98	
D1		AWAC	Turbidity (ABS) [mg/l]	21662	5.6	5.5	90	91

Location	Instrument	Parameter	Good Records in Total Length of Data	Total Data Length [months]	Target Data Length [months]	Good data as % of Total Length	Good data as % of Target Length	
		Current Profile [m/s]	21658			90	91	
		Current DA [m/s]	21658			90	91	
		Seabed Water Temperature [°C]	24117			100	102	
		Water Level [m]	23272			96	98	
		Significant Wave Height [m]	7562			94	95	
	Aqualogger	Seabed Water Temperature [°C]	10945	2.5	5.5	100	46	
		Turbidity (OBS) [mg/l]	10948			100	46	
	E	AWAC	Turbidity (ABS) [mg/l]	43636	11.1	11.5	91	88
			Current Profile [m/s]	43565			91	88
			Current DA [m/s]	43565			91	88
Seabed Water Temperature [°C]			48068	100			97	
Water Level [m]			47508	99			96	
Significant Wave Height [m]			15775	98			95	
SeaGuard / Seabird		Seabed Water Temperature [°C]	21103	6.9	5.5	70	89	
		Seabed Conductivity [mS/cm]	10611			35	45	
Aqualogger		Seabed Water Temperature [°C]	39603	9.3	8.5	99	108	

Location	Instrument	Parameter	Good Records in Total Length of Data	Total Data Length [months]	Target Data Length [months]	Good data as % of Total Length	Good data as % of Target Length
		Turbidity (OBS) [mg/l]	39739			99	108
	Starmon	Surface Water Temperature [°C]	51380	11.9	11.5	100	103
<p>Notes</p> <p>No data are presented from Locations B and D as the seabed frames were irretrievable following Deployment 1.</p> <p>The Good Record count for the current profile is based on Velocity 1 or bin 1 in the profile.</p> <p>The wave data are collected every 30 minutes, whereas all other parameters are collected at 10-minute intervals.</p> <p>The calculation for target length of data is based on contractual agreements with SSE:</p> <p>Deployment 1: AWAC 6 months, OBS 3 months, Seaguard/Seabird 3 months, Starmon 6 months</p> <p>Deployment 2: AWAC 2.5 months, OBS 2.5 months, Seaguard/Seabird 2.5 months, Starmon 2.5 months</p> <p>Deployment 3: AWAC 3 months, OBS 3 months, Starmon 3 months</p>							

3.2 Summary Statistics

Summary statistics for the whole campaign are provided in Table 3.2.

Table 3.2: Summary statistics

Location	Instrument	Parameter	Maximum	Minimum	Mean
A	AWAC	Water level (to LAT) [m]	2.71	-0.15	1.29
		Current profile [m/s]	2.71	0.00	0.91
		Current velocity (Depth Average) [m/s]	2.34	0.00	0.89
		Waves H _s [m]*	4.34	0.19	1.12
		Waves H _{max} [m]	6.68	0.27	1.61
		Turbidity [mg/l]	140.9	1.1	26.9
	Seabed water temperature [°C]	16.60	5.90	10.15	
	Starmon mini	Surface water temperature [°C]	16.9	5.9	10.1
	Seaguard/Seabird	Conductivity [mS/cm]	43.21	41.54	42.55
		Seabed Water Temperature [°C]	16.53	12.96	15.31
Aqualogger	Turbidity [mg/l]	239.9	0.0	37.2	
	Seabed water temperature [°C]	12.9	6.0	9.1	
B1	AWAC	Water level (to LAT) [m]	2.33	-0.10	1.11
		Current profile [m/s]	1.98	0.00	0.73
		Current velocity (Depth Average) [m/s]	1.80	0.00	0.71
		Waves H _s [m]*	3.23	0.09	0.91

Location	Instrument	Parameter	Maximum	Minimum	Mean
		Waves H _{max} [m]	4.66	0.14	1.30
		Turbidity [mg/l]	91.9	1.1	17.9
		Seabed water temperature [°C]	16.50	6.20	11.34
	Aqualogger	Turbidity [mg/l]	240.0	1.8	44.2
		Seabed water temperature [°C]	16.6	13.1	15.4
C	AWAC	Water level (to LAT) [m]	2.04	-0.29	0.94
		Current profile [m/s]	1.70	0.00	0.62
		Current velocity (Depth Average) [m/s]	1.46	0.00	0.62
		Waves H _s [m]*	3.24	0.15	0.95
		Waves H _{max} [m]	4.92	0.18	1.35
		Turbidity [mg/l]	116.9	3.4	20.0
		Seabed water temperature [°C]	11.83	7.13	8.97
	Starmon mini	Seabed water temperature [°C]	11.8	6.9	8.9
	Aqualogger	Turbidity [mg/l]	194.9	8.1	56.0
Seabed water temperature [°C]		11.1	7.1	8.6	
D1	AWAC	Water level (to LAT) [m]	2.26	-0.09	1.10
		Current profile [m/s]	2.35	0.00	0.78
		Current velocity (Depth Average) [m/s]	2.11	0.00	0.78
		Waves H _s [m]*	3.67	0.17	0.96
		Waves H _{max} [m]	6.26	0.21	1.38
		Turbidity [mg/l]	112.5	3.1	15.9
		Seabed water temperature [°C]	16.50	6.52	12.09
	Aqualogger	Turbidity [mg/l]	205.8	0.1	22.7
		Seabed water temperature [°C]	16.6	13.1	15.3
E	AWAC	Water level (to LAT) [m]	2.09	-0.17	0.88
		Current profile [m/s]	1.81	0.00	0.56
		Current velocity (Depth Average) [m/s]	1.49	0.00	0.55
		Waves H _s [m]*	4.62	0.12	1.04
		Waves H _{max} [m]	6.83	0.15	1.48
		Turbidity [mg/l]	116.1	0.2	20.0
		Seabed water temperature [°C]	15.89	6.63	10.47
	Starmon mini	Surface Water Temperature [°C]	16.5	5.7	10.3
	SeaGuard/ Seabird	Conductivity [mS/cm]	42.96	40.29	42.25
		Seabed Water Temperature [°C]	15.97	8.42	12.52

Location	Instrument	Parameter	Maximum	Minimum	Mean
	Aqualogger	Turbidity [mg/l]	209.7	0.0	35.5
		Seabed Water Temperature [°C]	16.0	7.3	10.0

Notes

* Waves Hs – significant wave height spectral

† Current profile velocity statistics are based on the complete velocity profile data

3.3 Suspect Data Investigation and Equipment Performance

This section describes occurrences of equipment malfunction or suspect data identified by Fugro. Unforeseen issues arising during this campaign can largely be attributed to the dynamic environment on the seafloor affecting deployed equipment and the COVID-19 pandemic, hampering or delaying recovery efforts.

The battery life of the majority of the instrumentation was calculated to last three months, to coincide with the planned maintenance schedule. Where maintenance visits were delayed some instruments failed to record data up to the recovery date because of exhausted batteries.

The CTD profiler exhibited intermittent sampling. The manufacturer suspects that the current speeds experienced on site were too strong for the internal connections of the real-time data cable to withstand, causing the observed drop out in the data.

City Analysts environmental laboratories were used following Deployment 1 water sampling for TSS analysis. The results were rejected by Fugro following a comparison with duplicate samples taken for Fugro's own laboratory analysis.

The PSD analysis has been classified as dubious by Fugro laboratories considering the low amount of particulate in the water samples.

AWACs installed during Deployments 2 and 3 at Locations B1, D1 and E suffered from seabed frame movement. This intermittently affected the turbidity, current and wave data return for these locations. Additionally, the internal compass failed to update during the frame movement. An offset was applied to direction parameters for wave and current data. The offsets applied are specified in Table 4.2 and the methodology used is described in Section 4.3.2.

Where a rapid change in depth was observed in conjunction with a movement of the seabed frame the associated depth records were nulled, and the water level file split prior to harmonic analysis (HA). The longest, uninterrupted section of data were chosen for HA. This methodology is described further in Section 4.3.1.

3.3.1 Location A

3.3.1.1 AWAC

The AWAC suffered from excess tilt during Deployment 2. The AWAC measurement accuracy is considerably reduced at angles in excess of 20° from vertical. Consequently, turbidity (ABS), current, wave and conductivity data were nulled and good data returns were considerably reduced.

Water level data from this location showed evidence of the seabed frame settling into the sediment at the beginning of each deployment. These data were nulled; typically four days of data were removed prior to HA.

3.3.1.2 SeaGuard and Seabird

For Deployment 1 no conductivity data were recorded due to the SeaGuard malfunctioning on deployment. For Deployment 2 the Seabird displayed values outside of the expected range when the frame became unstable, possibly due to the instrument being buried. Conductivity sensors were removed after Deployment 2, at client request.

3.3.1.3 Aqualogger

The turbidity data for Deployment 2 were irretrievable from the instrument upon recovery. The instrument was sent to the manufacturers where upon the data was declared unsalvageable because of corruption.

3.3.2 Location B1

3.3.2.1 Aqualogger

The Aqualogger set up for Deployment 3 failed to include temperature data, however backscatter data were unaffected.

3.3.3 Location D1

3.3.3.1 AWAC

The device used in Deployment 3 stopped recording prematurely. It is a possibility that the instability of the frame caused excess stress on the battery cable, ceasing power to the unit.

3.3.3.2 Aqualogger

The Aqualogger installed for Deployment 3 was not present on recovery of the seabed frame. Fugro assume the frame instability caused the fastenings on the instrument to fail.

3.3.4 Location E

3.3.4.1 AWAC

The water level data suggested that there was a slope in the pressure data at the beginning of Deployment 1. These data were removed prior to further HA.

Separately, due to the frame movement, the power supplied to the instrument was interrupted, explaining the intermittent data collection during Deployment 3. This caused a gap in the data file evident from 4 until 27 January 2021.

3.3.4.2 SeaGuard

During Deployment 1 the SeaGuard deployed at Location E displayed low conductivity values. These were considered unrealistic for the deployment location and so the data were rejected.

3.4 Discussion

3.4.1 Water Level

Data from previous deployments were subject to reprocessing following the receipt of atmospheric pressure data supplied by SSE for the length of the deployment campaign.

The maximum recorded water level was at Location A (2.71 m) on 9 February 2020. The maximum positive residual water level (+0.78 m) was recorded at Location B1 on 23 February 2021. The latter was recorded during a high energy wave event characterised by long periods.

The largest HAT is also found at Location A, as shown in Table 3.3.

All Locations exhibit mixed semi-diurnal tides as demonstrated by the form factors found in Table 3.3 (See abbreviations for a definition of tidal form factor). Location E has the highest form factor value (0.42), whilst the other sites are on the threshold of semi-diurnal and mixed classifications. This is reflected in the more complex shape of the tidal curve at Location E.

3.4.2 Currents

Current flows are tidally dominated with the highest velocities occurring on a spring tide. The maximum current velocities at each location happen mid-ebb flow.

The highest velocities are seen to occur at Location A, with the maximum velocity recorded as 2.71 m/s. The highest metonic maxima are present at Locations A and D1 (Table 3.3). On average, the lowest current velocities happen at Location E.

The level of confidence in the current directions was low for Deployments 2 and 3 due to frame movements and a failure in the compass update of the AWAC. Nearby tidal diamonds,

and where possible data from Deployment 1, were used to re-align the directions from Deployments 2 and 3. The methodology for this is described in Section 4.3.2.

Bins from the current profile were extracted to represent the near-bed, near-surface and mid-depth (see Table 4.1 **Error! Reference source not found.** for specific mid-depth bin chosen). Across all Locations the current velocities are seen to decrease with depth, with Metonic Maxima differing by almost 1.0 m/s between the near-surface and near-bed.

Table 3.3: Depth average current and water level harmonics comparison

Location	DA Major Axis [°]	Metonic Max [m/s]	HAT [m]	MHWI [hours]	Tidal Form Factor
A	16.2-196.2	2.2	2.3	11.1	0.26
B1	21.0-201.0	1.8	2.0	10.5	0.29
C	25.9-205.9	1.4	1.8	10.1	0.33
D1	17.1-197.1	2.0	1.9	10.8	0.29
E	17.7-197.7	1.4	1.9	7.0	0.42

Statistical current profiles (maximum velocity, 10% exceedance value and 50% exceedance value from each bin) are shown through Figure 3.1 to Figure 3.5, from Location A to Location E respectively. Also included is the observed current profile at the time of the maximum velocity observation. The plots show 50 % exceedance above 1 m/s is only likely to occur at Location A.

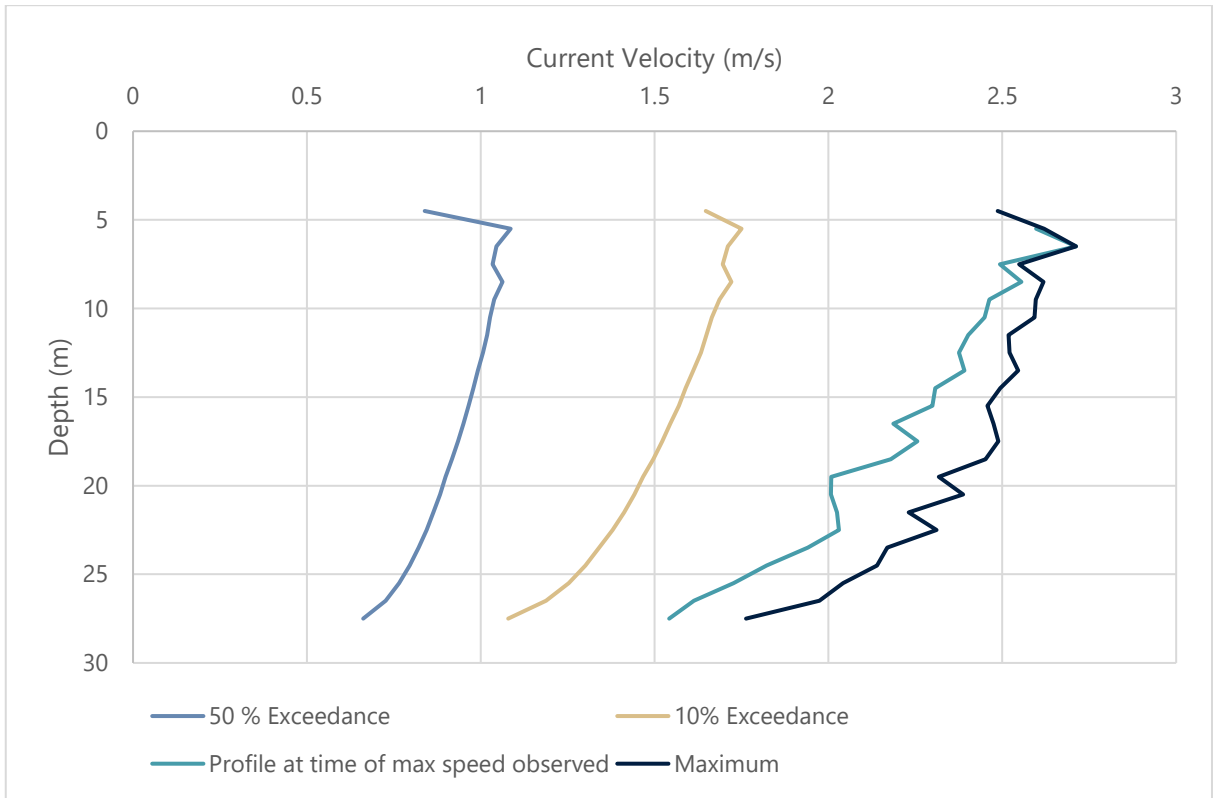


Figure 3.1: Location A Statistical Current Profile

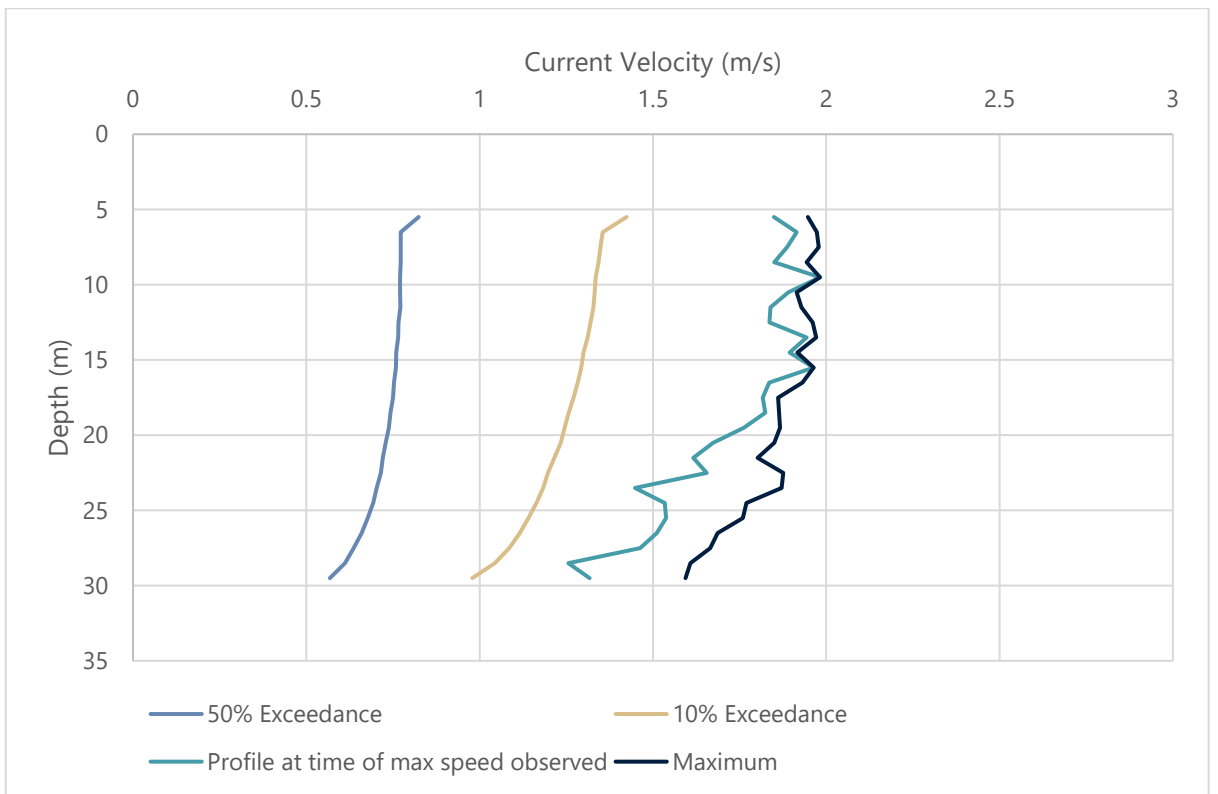


Figure 3.2: Location B1 Statistical Current Profile

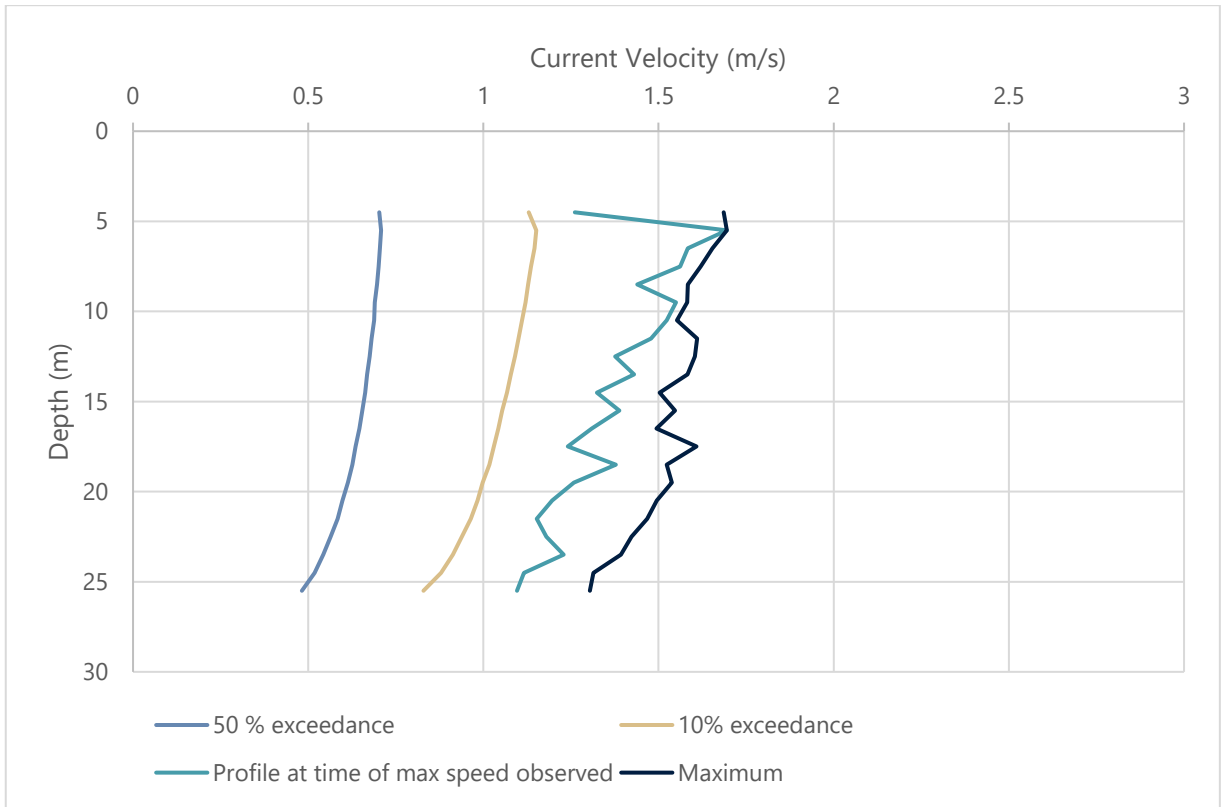


Figure 3.3: Location C Statistical Current Profile

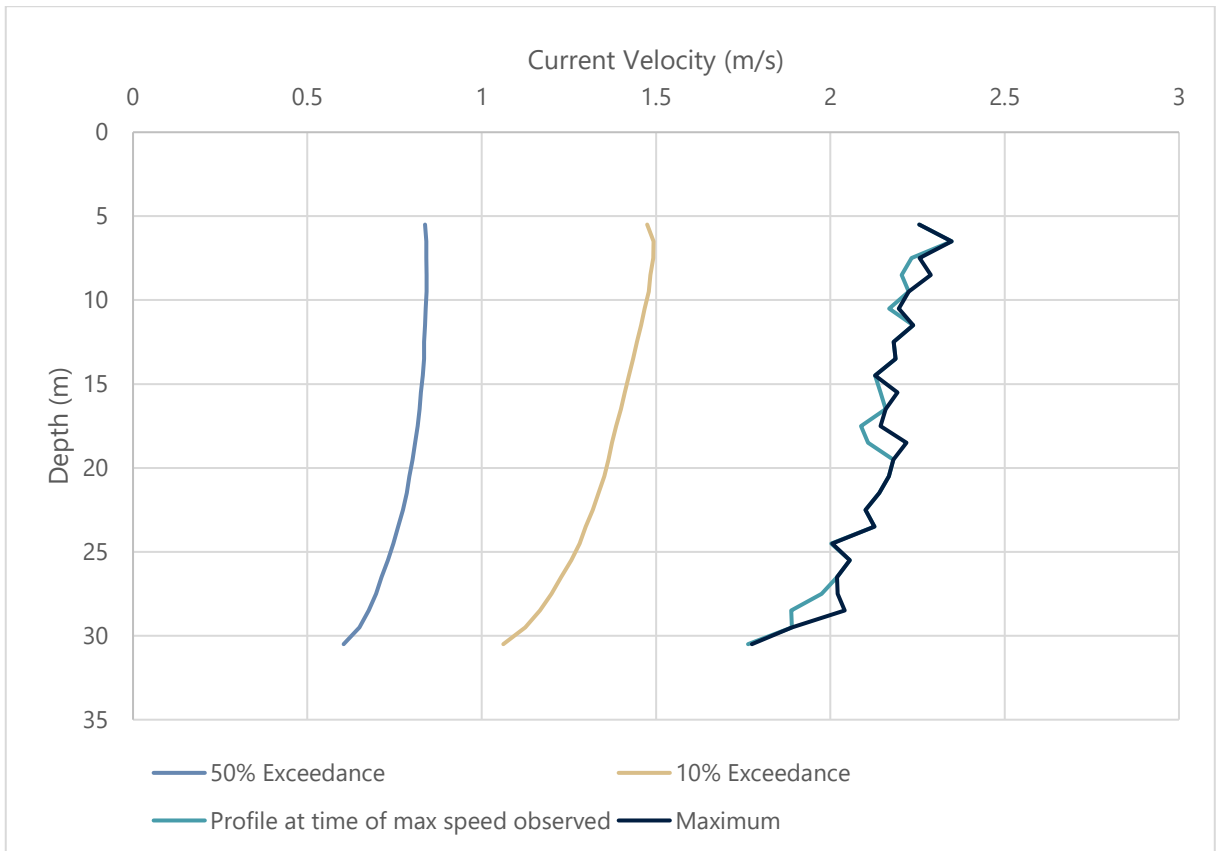


Figure 3.4: Location D1 Statistical Current Profile

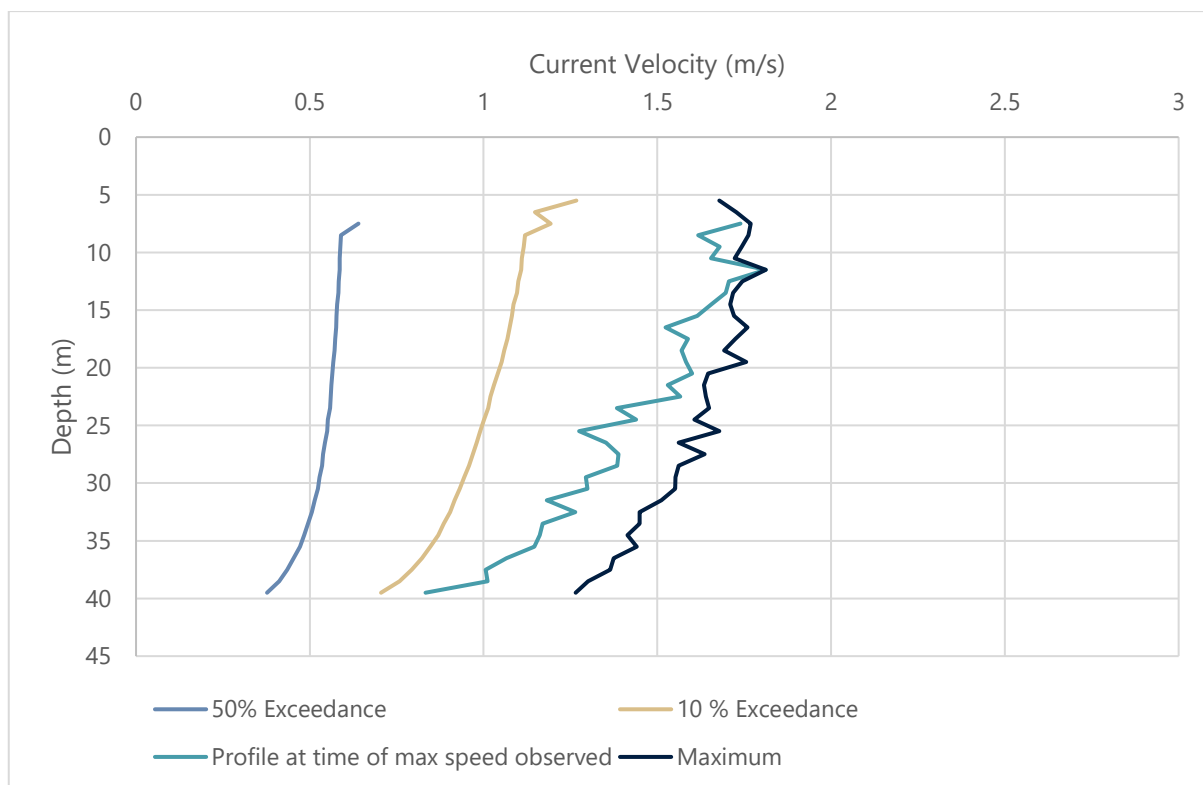


Figure 3.5: Location E Statistical Current Profile

3.4.3 Waves

The majority of the wave observations are associated with a southerly direction band. At Location A for example, 50 % of the wave observations approached from the direction band 150 to 190 °T. At Location E, 55 % of observations approached from 160 – 200 °T. A secondary peak in the distribution is evident to the north-east. Whilst the secondary peak accounts for fewer observations, it accounts for waves of comparable height to those approaching from the south at all locations except C.

The largest waves have a period (T_p) between 7.0 and 9.6 seconds, however most waves have a period of <6 s across the site.

The largest significant (4.62 m H_s) and maximum (6.83 m H_{max}) wave heights recorded were at Location E on 18 December 2019.

3.4.4 Seabed and Surface Water Temperature

There were good correlations between all instruments measuring seabed and surface water temperature data. This is reflected in very similar statistics across all Locations.

The data often have large tidal fluctuations, with the largest variations observed during a spring tide.

The highest (16.9 °C) water temperature was at Location A and lowest (5.9 °C) at Location E.

3.4.5 Turbidity and Total Suspended Sediment

The ABS turbidity values (converted from counts to mg/l by using the TSS results) were lower than the OBS values, however the OBS data had large amounts of noise. Due to a high level of OBS data being removed due to QC, the turbidity plots using the OBS data have the first bin from the ABS profile overlaid.

The mean values for turbidity range from 15.9 mg/l (Location D1) to 26.9 mg/l (Location A);

The highest turbidity values are seen to occur at Location A (140.9 mg/l and 239.91 mg/l from the ABS and OBS respectively).

Higher turbidity values coincide with spring tides and display a semi-diurnal pattern. The larger turbidity values generally occur between the seabed and mid-profile.

3.4.6 Conductivity

The highest conductivity values are seen to occur at Location A; 43.2 mS/cm. The longer data set was from at Location E however, where a tidal signal is clear, with more variance occurring during a spring tide.

3.4.7 Particle Size Distribution – Suspended Sediment

The results of the PSD analysis on the water samples from the Arklow Bank showed similar results across the site. Due to the low particle concentrations in the samples the data were flagged as dubious with the exception being Location C. The Folk grain size description for the sediment in suspension was predominantly "mud". The full results are shown in Appendix F.

4. Quality Control and Data Processing Methods

Data quality control (QC) and processing has been undertaken according to Fugro procedures (EUAF-FGBM-CO-GU01_001), using Fugro's bespoke Meteorological and Oceanographic data processing software, OceanV3. Wave processing was conducted in Nortek's Storm software, prior to import into OceanV3.

During the QC procedures, data are classified as 'good', 'suspect' and 'bad'. Good data pass all the QC checks and are both within a reasonable range and show no sign of being affected by factors other than that which are being measured. Suspect data are data that show no sign of instrument malfunction but appear to have been affected by more than the factor under investigation. Suspect data can pass low level tests and usually become clear during the data visualisation and higher-level QC testing. Bad data are characterised as data that fail the QC testing procedures. For instance, the sensor may fail, either through instrument malfunction or due to an environmental factor such as instrument burial causing smothering of the signal.

4.1 First Level Quality Assurance / Quality Control Testing

Various checks were applied to the time series data to produce a quality-controlled file. These validation checks included the following timing checks:

- The number of records expected between switch-on and switch-off times is calculated and compared to the dataset;
- Dataset timestamps are examined to ensure sample intervals are as expected;
- The observed data listing is examined to match deployment and recovery times with periods of rapid change in values.

The datasets were then trimmed to remove pre- and post-deployment data prior to further analysis. The majority of metocean data often requires further quality control checks due to complexities in the data and measuring techniques.

4.2 Further Quality Assurance / Quality Control Testing

Once data have been imported and passed through initial import and processing, all parameters were visualised in order to identify any suspect readings. Comparisons between study locations and related data types were conducted. External data sources were used for verification where available, for example published tidal diamonds. Where files are combined to produce one dataset for the whole measurement campaign, the values before recovery and after re-deployment are compared.

4.2.1 Suspect Data Investigation and Removal

Data are defined as suspect if they:

- Display an unusually high rate of change (data spikes);
- Have unexpected repeat values (flat lines);

- Are missing records;
- Fall outside of an expected range for the parameter in question.

Both automated and manual processes were used for removal of suspect values, and both are employed in different capacities due to their strengths and limitations.

Automated cleaning operations check data for minimum and maximum expected values, a maximum number of expected repeat values, and the maximum expected difference between two successive values; the thresholds for each can be defined for each dataset under examination. Data outside these thresholds are automatically considered “bad” and replaced by a null value (-999). This technique is good for large datasets where bad records have clearly defined differences to the good records. For example, an intermittent instrumentation malfunction causing occasional readings that are well below the minimum expected values. However, automated removal it is not suitable to be used where there is large variation throughout the data and where suspect data needs further investigation to justify removal.

Manual cleaning procedures give a time-series representation which allows the processor to select and remove individual data points. This method is supported by using other datasets to provide evidence for data removal. For example, when processing data from current profilers, deployment quality indicators (pitch, roll and heading of instrument) are visualised to ascertain whether the instrument was stable and upright throughout the deployment. This allows quick removal of suspect values which are easily identifiable by an experienced oceanographer but may fail to be removed through automated processes. For current data, all linked values within the suspect bin (velocity, direction, easting vector, northing vector, vertical vector) are removed.

Further checks to evidence removal of suspect data included:

- More detailed visualisation of suspect time period to compare the suspect data type to other data types. For example, where current data were suspect, comparisons with wave data may indicate forcing that validates the data;
- Comparisons between the other deployed locations was conducted to establish whether the suspect nature of readings was also reflected there. For example, if the tidal residual signal across the study area is similar, then it can be assumed that any large residual signal is accurate. In contrast, a single residual signal excessively different from the rest may highlight an erroneous reading;
- Where multiple instruments measure the same parameters, comparisons were made to determine whether there were any instrumentation errors. For example, several instruments were measuring sea water temperature. These were compared and were found to be consistent;
- Comparisons to independent datasets were conducted where possible. For example, nearby wave buoys were used to check wave data readings for any potential errors. In this instance the [Irish Marine Data Buoy Observation Network](#) was used for gross error checking;

- Where available, any flags generated by instrument manufacturer's software were reviewed. For example, the Nortek wave processing software generates a flag which indicates the quality of the raw wave burst;
- Current profiler data were investigated in more detail by visualising the acoustic backscatter return for each beam and/or the beam velocity readings for each beam. This was used to determine whether suspect data had been caused by biofouling or debris blocking a transducer, the extent of which can determine whether the data were removed or not;
- Checks against field observations. For example, instrument recovery logs and photographs which show the biofouling level.

Where these checks reveal an instrument malfunction, interference caused by debris or biofouling or comparisons indicate that the data were not valid, the suspect data are then classified as "bad" data, removed and replaced with a null value (-999). Original data, including the "bad" data are available to the client on request. Where comparisons indicate that the suspect readings were present at other locations or corroborated by other data types, the suspect data remained in place and were considered to be "good" data. Some data may remain "suspect" if there is no evidence to classify the data as "good" or "bad". This may be the case with noisy data which are often experienced when conditions are at the lower end of the instrument's detection limit. Where there are "suspect" data present in the dataset, this has been detailed in Section 3.3.

4.3 Data Import and Specific Processing Methodologies

Raw data (or partially processed wave data from AWAC AST) were first imported to OceanV3 for processing.

On import of directional data (i.e. current data, wave directions), directions were converted to True North (°T) by applying the local magnetic to true north variation for the site. The values used at each location are detailed in Table 4.1.

Table 4.1: Values used for AWAC import and analysis

Location	Local Magnetic Variation	Mean Salinity Data from CTD Casts	Distance removed from surface of AWAC profile	Mid-Depth Bin Chosen for Profile
A	D1: -2.30°	34.0 ppt	4 m (4 bins)	Bin 9
B1	D2: -2.15° D3: -2.09°	34.1 ppt	4 m (4 bins)	Bin 12
C	D2: -2.15° D3: -2.09°	33.8 ppt	3 m (3 bins)	Bin 11
D1	D1: -2.32° D2: -2.14° D3: -2.08°	34.1 ppt	4 m (4 bins)	Bin 12

Location	Local Magnetic Variation	Mean Salinity Data from CTD Casts	Distance removed from surface of AWAC profile	Mid-Depth Bin Chosen for Profile
E	D1: -2.29° D2: -2.14° D3: -2.08°	34.4 ppt	5 m (5 bins)	Bin 17

4.3.1 Water Level and Harmonic Analysis

Raw pressure data were converted to height above the sensor using density values calculated using mean salinity values (from site CTD casts) and measured temperature. An atmospheric pressure offset was also applied using a meteorological file supplied by SSE. This calculation is performed according to the methodology defined by the UNESCO Technical Papers in Marine Science 44 (Fofonoff, 1983).

The imported depth data were checked for any underlying slope at the beginning of the deployment period. This may indicate the instrument had been sinking which may influence the validity of the readings. If thought to be affected, the depth data were corrected to remove this influence. The data were also checked for rapid changes in depth (evident where the frames had moved in storms for example) and these periods were nulled. If the change in depth was significant before and after the frame movement then these sections of data were split into separate files.

Calculated heights above the instrument were reduced to the mean of the dataset for harmonic analysis. The longest period of stable data was then selected to harmonically analyse and produce predictions for the other shorter sections of data. These sections of data were then levelled to the longer dataset predictions by applying the difference between the mean of the observations and the mean of the predictions. After this was complete, all sections of data were combined to produce one file spanning all three deployments.

This file was then again subjected to harmonic analysis, where a further small offset was applied in order to level the whole dataset to the final LAT.

The data were then re-analysed, and the new LAT value extrapolated; if this second LAT value is calculated to be zero then the analysis is considered robust.

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

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

This variability may include “instrument noise” but it is usually a measure of the meteorologically induced residual variability (e.g. high pressure causing a lowering of the water surface) and local geomorphological features. Local and brief atmospheric disturbances will generate fluctuations in the 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 dataset was 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 dataset. At Locations A and E, it was possible to extract 60 constituents as they had greater than 11 months of data. At Locations B1 and D1, a table of 35 constituents was generated and from Location C, 34 constituents were reported.

Fugro uses a PC-compatible harmonic analysis program based on the mathematical algorithms developed by Hunter for the Commonwealth Scientific and Industrial Research Organisation, of Australia. 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. The Hunter program has been fully verified and is in use by government institutes and commercial companies worldwide.

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 was 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.

The harmonic analysis for Locations A, B1, C, D1 and E were all found to be of high quality and the residuals recorded were consistent.

4.3.2 Current Data and Harmonic Analysis

The Nortek 600 kHz AWAC was used to measure currents at all five locations. All were configured with comparable sampling regimes to yield comparable data.

The instruments use acoustic signals produced from transceivers mounted on the head of the instrument. The three transceivers are offset at an angle of 25° to the vertical, producing divergent acoustic signals that are propagated through the water. The signals are reflected

back to the instrument by particulate material in the water column. The returned signal is binned (divided into separate sets) with respect to the return interval. This interval is calculated from the pre-set range of 50 m and the speed of sound as calculated by the instrument, using the pre-set salinity value (35 ppt) and the measured temperature.

The returned data for each bin were average values over the range of that bin. For example, the first bin of a 600 kHz Nortek AWAC instrument starts at 0.5 m from the instrument and has a range of 1.0 m. Taking in to account the height of the instrument above the seabed (nominally 0.6 m, see file metadata for site specific heights), the data from bin 1 were averages of data from 1.1 m to 2.1 m above the seabed (Figure 4.1). In addition to the investigation of the full current profile, a depth averaged (velocity and directional data vector-averaged over all good bins in the profile), a near-bed (bin 1), a near-surface (last complete bin in profile) and a mid-depth (dependent on site depth, see Table 4.1) current file were extracted.

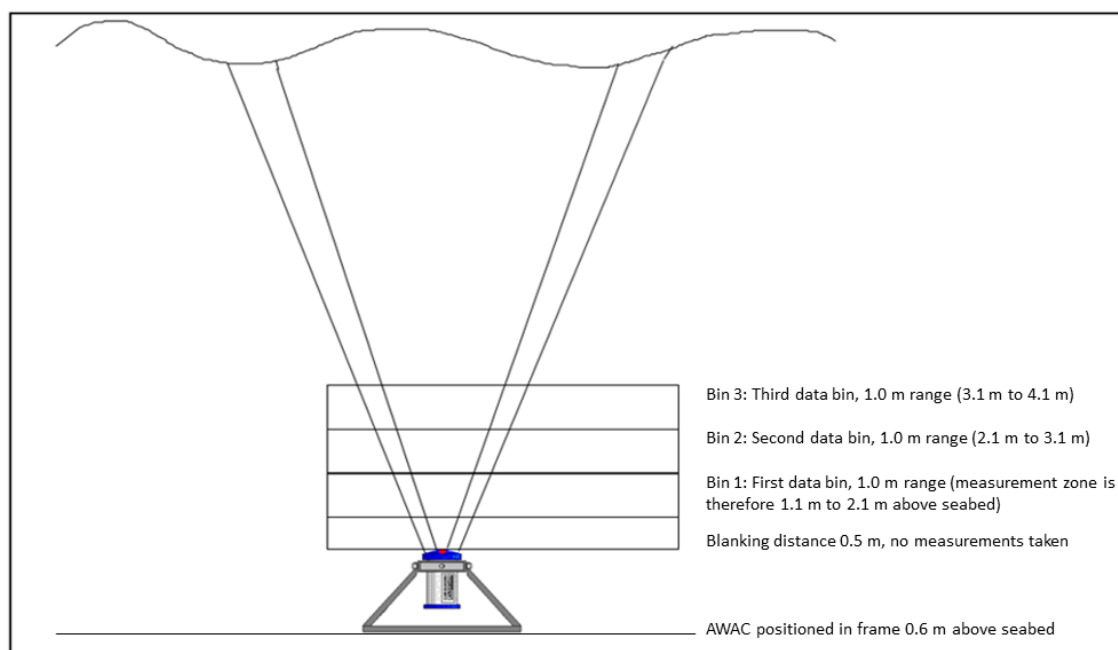


Figure 4.1: Example schematic of AWAC profile data binning

The full current profile, near-bed, near-surface and mid-depth data files contained the binned data, which were processed using Doppler technology and the relative movement of the particulate material in the water which 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 beam field referenced to an arbitrary zero direction on the instrument. This is converted to a true speed and direction (to magnetic north) by reference to an integral flux gate compass.

Although the compass is meant to compensate for small changes in direction should the frame move, the offset was not applied to some data correctly. As it has been noted, the frames moved considerably during Deployments 2 and 3. In this instance, the data were subjected to a further realignment. The major axis chosen to realign the different Locations was based on the following reasoning:

- Location B1 – Deployment 2 and Deployment 3 data were adjusted so that the major axis of the depth average current directions aligned with the combined data major axis of 21.0-201.0°. This axis is also an average of the Location A and C depth average major axes;
- Location D1 – a nearby tidal diamond and a short period of Deployment 2 data where the pitch and roll of the AWAC were stable;
- Location E – data from Deployment 1 where the AWAC was stable.

Peak and mean wave directions were corrected in a similar manner. The specific directional offsets applied are captured in Table 4.2. Note that these offsets already take account of the magnetic variation applicable for each period.

Additionally, the short current dataset from Location A Deployment 2 were nulled as the major axis of the depth average current directions did not align with the depth average major axes of the Deployment 1 or Deployment 3 data.

Table 4.2: Directional offsets applied to Current and Wave data for frame movement

Location	Time Period	Directional Offset Applied
B1	02/08/2020 09:20 to 19/08/2020 11:30	-20.7°
	19/08/2020 11:40 to 15/10/2020 15:50	-9.79°
	07/11/2020 13:30 to 03/12/2020 18:50	19.2°
	03/12/2020 19:00 to 07/12/2020 23:10	7.6°
	07/12/2020 23:20 to 24/12/2020 14:30	16.9°
	24/12/2020 14:40 to 26/12/2020 14:40	-2.7°
	26/12/2020 14:50 to 28/01/2020 18:40	15.0°
	28/01/2020 18:50 to 29/01/2020 12:20	1.0°
	29/01/2020 12:30 to 31/01/2020 08:10	22.4°
	31/01/2020 08:20 to 31/01/2020 20:10	-0.7°
	31/01/2020 20:20 to 04/03/2020 09:30	-11.9°
	04/03/2020 09:40 to 05/03/2020 07:10	-2.8°
	05/03/2020 07:20 to 05/03/2020 21:50	2.1°
	05/03/2020 22:00 to 07/03/2020 16:50	-0.1°
D1	01/08/2020 09:20 to 04/08/2020 16:50	18.9°
	04/08/2020 17:00 to 30/09/2020 23:30	12.4°

Location	Time Period	Directional Offset Applied
	22/11/2020 22:10 to 05/01/2021 23:50 and 16/01/2021 00:00 to 07/03/2021 09:20	3.9°
E	02/08/2020 15:30 to 20/08/2020 23:50	10.7°
	22/11/2020 09:00 to 11/12/2020 14:50	-7.8°
	13/12/2020 00:00 to 08/03/2021 11:00	24.9°

To reduce the effect of turbulence upon the current data it is necessary for the instrument to average the measurements over a period long enough to compensate for the local conditions. Thus, a minimum of a 55 second burst was considered necessary to extract the mean flow and remove the effects of wave induced turbulence. The data binning is calculated using a mean salinity value (see Table 4.1) and the measured temperature. As the temperatures measured were at the seabed this introduces potential errors in the data binning toward the sea surface.

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 sea surface, furthest from the instrument, were 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 m/s. However, in the surface cells this accuracy is significantly reduced such that values derived at less than 10 % of the depth or the two upper most cells can only be considered indicative with a nominal accuracy of 0.10 m/s to 0.30 m/s. The Nortek AWAC 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 $\pm 5^\circ$. The bins removed from the surface of the current profile have been detailed in Table 4.1.

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

- i. 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.
- ii. 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 that an oceanic current is affecting the water column for the reasons mentioned in (i) 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.

iii. An inconsistent residual drift:

The variability of the non-tidal current passing over the site. This variability, which may include "instrument noise", 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 (ii). 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 velocities and directions were converted into easting and northing vectors for harmonic analysis. These vectors were subject to the same process as the water level data described in Section 0, and then recombined to give predicted and residual velocities and directions.

4.3.3 Wave Data Methodology

Nortek Storm software was used to process the raw wave data, with individual files created for each wave burst dataset. These consisted of 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 provided temperature readings so that fluctuations in water density and sound velocity could be computed. The wave heights and frequency were deduced by rapid measurement of instantaneous head of water measured either as pressure, using the precision strain gauge sensor, or range, using a vertical acoustic beam.

The 1024 records of acoustic range were converted to heights by the wave processing software; these values from the wave burst were de-trended to produce a surface wave trace. The surface elevations were combined with the 512 records of easting and northing current vectors to generate three-dimensional data. The three-dimensional wave measurements were then passed through an additional series of routines that produces spectral density matrices allowing the wave energy to be broken down by direction as well as by frequency. The directional wave statistics were then derived from the resultant spectra.

As with the current data, although the internal compass is meant to compensate for small changes to the frame position, the large frame movements caused data of low confidence. In these cases, the peak and mean coming directions had the same directional offset applied as the current data (detailed in Table 4.2) for completeness. However, the wave spectra data files have not been altered.

4.3.4 Turbidity Data

Turbidity and backscatter data were gathered from a range of instruments and were calibrated (converted to mg/l) with water samples.

4.3.4.1 CTD Casts

The Valeport FastCTD profiler was used after deployment of the seabed frames at each location. The CTD casts were taken alongside the water samples. The data files provided were either an upward or downward cast, and collected two values for turbidity by means of an Optical Backscatter (OBS) sensor (denoted as Turbidity 1 in the data files) and a Nephelometer (denoted as Turbidity 2 in the data files). Values where the sensor took time to acclimatise have been removed or nulled (-999) and a rolling average was applied to the data.

4.3.4.2 Water Samples

Water samples were taken three times during the campaign, at each seabed frame location, alongside the CTD casts. A set of 1-litre samples (near-bed, mid and near-surface of the water column) were taken with a Niskin bottle at 30-minute intervals over the course of two hours.

The water samples analysis following Deployment 1 were conducted by a local laboratory. However, the results were rejected by Fugro following a comparison with the duplicate samples taken for Fugro's own laboratories analysis.

The water samples used for the turbidity calibration were based on results from Locations A, B1 and D1 from Deployments 2 and 3, but Location E had results from all three deployments.

4.3.4.3 TSS

Total suspended solids (TSS) analysis was undertaken in accordance with Fugro GB Marine Limited internal procedures based on HMSO Methods 1980 and BS EN 872: 2005.

A measured volume of sample (1 litre) was filtered through a pre-weighed Whatman type GF/C glass-fibre filter paper with a particle size retention of 1.2 μm , and oven dried at 105 °C. The filter paper was subsequently re-weighed with the increase in weight representing the total suspended solids, reported in mg/L.

4.3.4.4 PSD

Particle Size Distribution (PSD) analysis by laser diffraction was undertaken in accordance with the Fugro GB Marine Limited internal procedures based on the NMBAQC best practice guidance document "Particle Size Analysis (PSA) for Supporting Biological Analysis", and Fugro GB Marine Limited in-house methods based on BS ISO 13320: 2009. Laser diffraction was carried out using a Malvern Mastersizer 2000 with a Hydro 2000G dispersion unit.

A measured volume of the water sample (approximately 800 ml) was analysed using the laser sizer at 0.5 phi intervals between 2000 to < 0.09 μm . The test result reported is percentage volume based and is expressed in terms of equivalent spheres, and is an average of one set of triplicate measurements.

4.3.4.5 ABS

The acoustic return values from each of the beams on the AWAC were first averaged to produce one acoustic return value per profile bin, per timestamp. These raw values were converted to normalised decibels (n dB), to remove the effect of signal attenuation through the water column. This was achieved using the method described in Lohrmann (2001).

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 Acoustic Backscatter (ABS) data could be converted into estimated concentration values (in mg/l). Both linear and exponential regression lines were applied to the scatter of results. Poor correlation was found using a linear regression so an exponential relationship was chosen. Fugro 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 values from the site-specific calibration were added to Fugro’s previous acoustic backscatter calibrations appropriate to the frequency of the AWAC.

Data were calibrated using the equation stated in Figure 4.2.

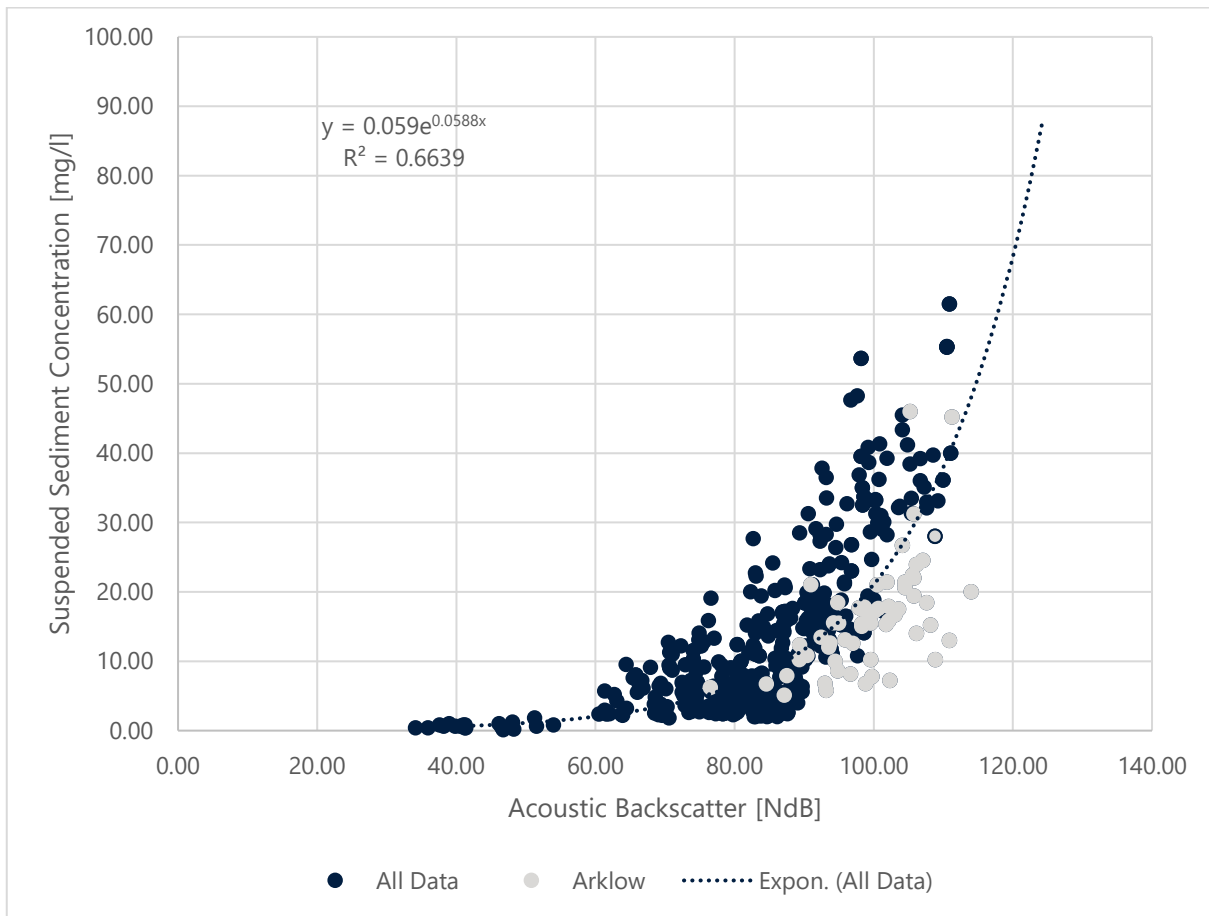


Figure 4.2: ABS exponential regression with project water samples and Fugro database

4.3.4.6 OBS

The raw Aqualogger data files include 1 Hz data taken every 10 minutes. The sample number taken per burst was determined by the power requirements for the instruments. 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.

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 TSS analysis from the water samples. A regression was compiled, whereby the water sample concentrations (in mg/l) were plotted against the corresponding turbidity values (in FTU) from the instrument. A linear best-fit line was applied to the scatter of values. A satisfactory calibration could not be established purely with the results of the local water samples. Therefore, the values from the site-specific calibration were added to Fugro’s previous Aqualogger optical backscatter calibrations.

The calibration of the OBS data were completed by applying the regression stated in Figure 4.3.

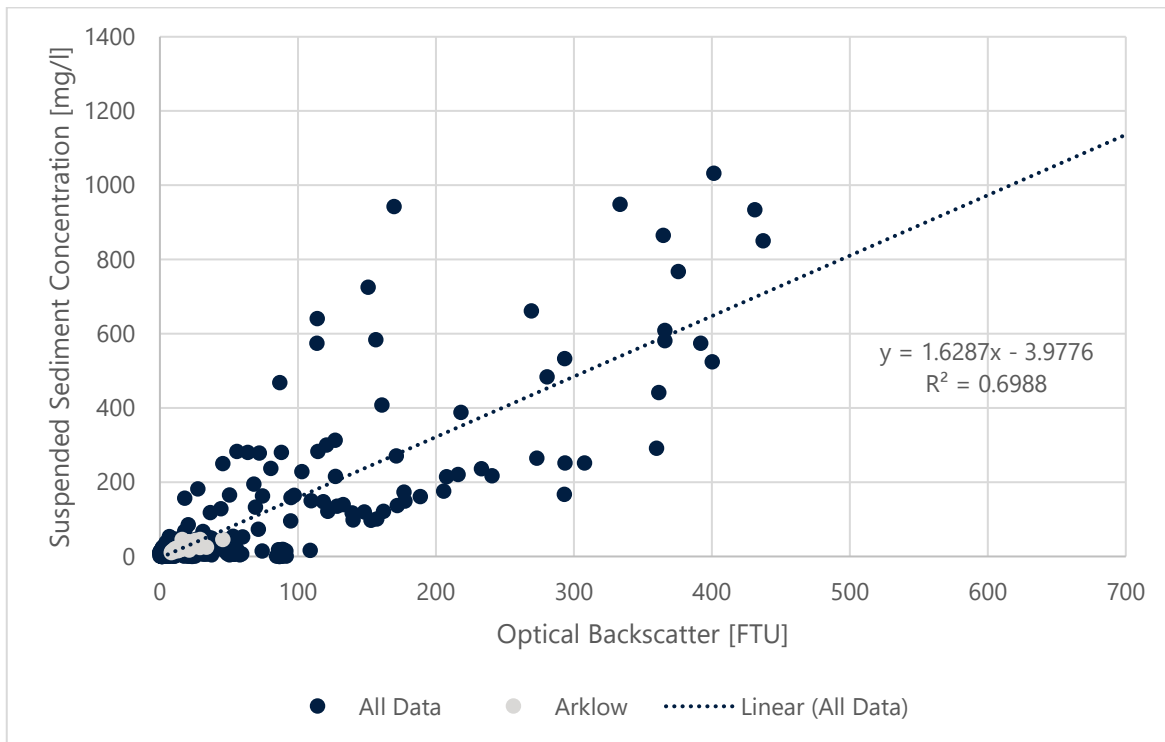


Figure 4.3: OBS regression with project water samples and Fugro database

Unfortunately, the OBS data contain a high level of noise, regardless of the regression, so the reliability of these data were questioned. Fugro used the data from the ABS calibration to perform QC on the resulting OBS data. The files provided should be used with caution and thus the threshold system used by Fugro, which flags the values and the result of the QC test, have been provided to the client for their review.

The threshold system devised was based on three times the maximum ABS turbidity value from bin 1. These are detailed in Table 4.3, where the values differed per Location. The resulting file has a numbered system which shows the reason as to why the data were accepted or rejected based on a flagging system of 0-5 as follows:

0. Value passed the QC test
1. Value was less than the minimum threshold
2. Value was more than the maximum threshold
3. Exceeded repetition threshold
4. Exceeded variance threshold
5. The value was missing in the file analysed

Table 4.3: Thresholds for QC of OBS values

Location	Threshold [mg/l]
A	240
B1	240
C	195
D1	210
E	270

4.3.5 Water Temperature Data

Temperature data were gathered from a range of instruments and collected at the sea surface and seabed.

The sea surface water temperature data were collected using a Starmon mini attached to the underside of the SMB. These instruments were set up to record every minute, but a rolling average was applied in post processing to provide an average value per 10 minutes.

The AWAC, Aqualogger and SeaGuard/Seabird all collected a single point measurement at 10-minute intervals. This was imported and no further averaging was conducted.

4.3.6 Conductivity Data

Conductivity data were captured by the Seabird. A single point measurement was taken every 10 minutes. The data were imported and no further averaging was applied to these files.

5. Health and Safety

5.1 HSE

Fugro 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 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 resources to safely complete the work scope. 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 within suitable weather conditions;
- Contact was maintained with other vessels working in the area to ensure no equipment would interfere with other surveys or operations taking place.

Fugro 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 Fugro personnel and made available to all members of the vessel crew.

5.1.1 HSE Procedure During Operations

Prior to fieldwork commencement, a kick-off meeting was held for all Fugro and vessel personnel undertaking offshore works. A specific Arklow Project site induction was delivered by the Fugro Survey Supervisor at the start of the deployment campaign and repeated when new crew members or new vessels began work on the project.

In addition, a pre-work safety briefing was held on the vessel with all crew members. The briefing was carried out by the Survey Supervisor to discuss the intended activities and their health, safety and risk considerations. All attendees of this briefing were recorded on the Survey Safety Briefing sheet included in the project HSE documentation.

Prior to sailing, Fugro personnel were given a vessel induction by the Vessel Master that identified the location of emergency and survival equipment, and procedures to be followed in the event of emergency.

In March 2020 a project specific risk assessment was introduced solely to cover the COVID-19 pandemic. This was adhered to by all personnel for the remainder of the campaign. This included both Irish and UK guidelines as well as the Fugro-wide measures for fieldwork during the pandemic.

5.1.2 Hazard Observations

During Deployment 1 two Safe Acts were entered into Fugro Impact, Fugro's QHSSE Reporting & Recording software solution, during initial deployment operations.

The first Safe Act (entry number 211428 in IMPACT) was raised for working in hours of darkness on the deployment vessel. A Dynamic Risk Assessment was carried out with Fugro surveyors and vessel crew to assess levels of fatigue and introduce measures to ascertain safety was maintained (lanyards worn for the aft deck crew etc.)

The second Safe Act (entry number 212053 in IMPACT) was raised for calling off deployment of Locations C, D and E due to deteriorating weather conditions. The weather was making it unsafe for crew on the deck of the vessel and preventing any lifting operations. The client was notified, and deployment was re-attempted in the following days.

Two Equipment Investigation Reports (EIR) were submitted to SSE. These were as follows:

- i. Document number 181399_EIR_001 for the adrift SMB and subsequent irretrievable seabed frame at Location D;
- ii. Document number 181399_EIR_002 for the irretrievable seabed frame at Location B due to a broken groundline.

6. Data Files and Visualisations

6.1 Data Files

A list of supplied data files is included in Table 6.1 alongside an explanation of the data file columns, as repeated in the metadata at the start of each file.

Table 6.1: Data file nomenclature

Data File Name	Data Type	Columns
M181399_AWAC_LX*_D1-D3_Turbidity.csv	Turbidity Data	Turbidity Y ⁺ [mg/l]
M181399_AWAC_LX*_D1-D3_Current Profile.csv	Current Data	Velocity Y ⁺ [m/s], Direction Y ⁺ [°T], Easting Vector Y ⁺ [m/s], Northing Vector Y ⁺ [m/s], Vertical Vector Y ⁺ [m/s]
M181399_AWAC_LX*_D1-D3_Currents_DA_RP.csv	Current Data	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], Number of good bins [count], 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]
M181399_AWAC_LX*_D1-D3_Currents_MD_RP.csv	Current Data	Mid-Depth Velocity [m/s], Mid-Depth Direction [°T], Mid-Depth Easting Vector [m/s], Mid-Depth Northing Vector [m/s], Mid-Depth 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]
M181399_AWAC_LX*_D1-D3_Currents_NB_RP.csv	Current Data	Near-Bed Velocity [m/s], Near-Bed Direction [°T], Near-Bed Easting Vector [m/s], Near-Bed Northing Vector [m/s], Near-Bed 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]
M181399_AWAC_LX*_D1-D3_Currents_NS_RP.csv	Current Data	Near-Surface Velocity [m/s], Near-Surface Direction [°T], Near-Surface Easting Vector [m/s], Near-Surface Northing Vector [m/s],

Data File Name	Data Type	Columns
		Near-Surface 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]
M181399_AWAC_LA_D1-D3_Current Profile_Velocity Percentiles.csv	Current Data	Data Type, Maximum, Minimum, Mean, Standard Deviation, Skewness, Kurtosis, Null Records, Good Records, 1%, 2%, 3%, 4%, 5%, 6%, 7%, 8%, 9%, 10%, 11%, 12%, 13%, 14%, 15%, 16%, 17%, 18%, 19%, 20%, 21%, 22%, 23%, 24%, 25%, 26%, 27%, 28%, 29%, 30%, 31%, 32%, 33%, 34%, 35%, 36%, 37%, 38%, 39%, 40%, 41%, 42%, 43%, 44%, 45%, 46%, 47%, 48%, 49%, 50%, 51%, 52%, 53%, 54%, 55%, 56%, 57%, 58%, 59%, 60%, 61%, 62%, 63%, 64%, 65%, 66%, 67%, 68%, 69%, 70%, 71%, 72%, 73%, 74%, 75%, 76%, 77%, 78%, 79%, 80%, 81%, 82%, 83%, 84%, 85%, 86%, 87%, 88%, 89%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, 99.1%, 99.2%, 99.3%, 99.4%, 99.5%, 99.6%, 99.7%, 99.8%, 99.9%, 99.91%, 99.92%, 99.93%, 99.94%, 99.95%, 99.96%, 99.97%, 99.98%, 99.99%, 99.995%, 99.999%
M181399_AWAC_LX*_D1-D3_Temperature.csv	Environmental Data	Seabed Water Temperature [°C]
M181399_AWAC_LX*_D1-D3_Water Level_LAT_RP.csv	Water Level Data	Depth [m], Height to LAT [m], Residual Height [m], Predicted Height [m]
M181399_AWAC_LX*_D1-D3_Waves.csv	Wave Data	Significant Wave Height Spectral [m], Significant Wave Height Deterministic [m], Maximum Wave Height [m], Peak Wave Period Tp [s], Zero Up Crossing Period Tz [s], Mean Period Tm02 [s], Period of the Maximum Wave Tmax [s], Peak Coming Direction [°T], Spreading Angle [°], Mean Coming Direction [°T]
M181399_AWAC_LX*_D1-D3_Waves_2D_Spectra_Time_series.csv	Wave Data	Period Z [‡] [s], Energy Z [‡] [m ² S], Coming Direction Z [‡] [°T], Spreading Angle Z [‡] [°]
M181399_AWAC_LX*_D1-D3_Waves_Energy_Direction_Time_Series.csv	Wave Data	Energy from U [#] °T [m ² /°]

Data File Name	Data Type	Columns
Surface_DSP_Spectra_for_WaveFile_AST_YYYY-MM-DD_HH-mm.csv	Wave Data	Harmonic Number, Harmonic Period, Directions [°T], Energy [m ² S/°T]
Surface_Spectra_for_WaveFile_AST_YYYY-MM-DD_HH-mm.csv	Wave Data	Harmonic Number, Harmonic Period, Depth Harmonic at Surface, Surface East, Surface North, Depth Auto-spectra, East Auto-spectra, North Auto-spectra, E-N Cross-spectra, E-D Cross-spectra, N-D Cross-spectra, Wave Length, Wave Speed, Coming Direction, Spreading, Wave Spreading Factor
M181399_AQL_LX*_D1-D3_Turbidity_Flagged.csv	Environmental Data	Turbidity [mg/l], QC results for Turbidity
M181399_Aqualogger_LX*_D1-D3_Temperature.csv	Environmental Data	Seabed Water Temperature [°C]
M181399_ASG_SBE_LX*_D1-D3_Conductivity.csv	Environmental Data	Conductivity [mS/cm]
M181399_ASG_SBE_LX*_D1-D3_Temperature.csv	Environmental Data	Seabed Water Temperature [°C]
M181399_Starmon_LX*_D1-D3_Temperature.csv	Environmental Data	Surface Water Temperature [°C]
M181399_CTD_LX*_D1-D3_V^W+.csv	Environmental Data	Depth [m], Temperature [°C], Conductivity [mS/cm], Salinity [ppt], Density [kg/m ³], Turbidity 1 [NTU], Turbidity 2 [NTU]
<p>Notes</p> <p>* = X denotes the Location ID; either A, B, B1, C, D, D1 or E</p> <p>† = Y denotes the bin number from 1 to 50; bin numbers increment from the seabed to surface</p> <p>‡ = Z denotes the band from 1 to 48</p> <p># = U denotes the degree from 0 to 359</p> <p>^ = V denotes the depth of the cast; either bottom, middle or top cast</p> <p>+ = W denotes the incrementing cast number</p> <p>Where an instrument only collected data for a certain deployment, this has been captured in the data file name.</p>		

6.2 Visualisations

The visualisations for the final reporting are included in Appendix A through to Appendix F. The visualisation locations within the appendices are detailed in Table 6.2.

Table 6.2: Visualisation Requirement and Appendix Location

Visualisation Requirement	Data Type	Location and Number
Time series of observed water level	Water Level Data	Location A – Appendix A Sub number 1-1 Location B1 – Appendix B Sub number 1-1 Location C – Appendix C Sub number 1-1

Visualisation Requirement	Data Type	Location and Number
		Location D1 – Appendix D1 Sub number 1-1 Location E – Appendix E Sub number 1-1
Tidal height harmonic analysis report	Water Level Data	Location A – Appendix A Sub number 1-2 Location B1 – Appendix B Sub number 1-2 Location C – Appendix C Sub number 1-2 Location D1 – Appendix D1 Sub number 1-2 Location E – Appendix E Sub number 1-2
Time series of observed current velocities and directions	Current Data	Location A – Appendix A Sub number 2-1 Location B1 – Appendix B Sub number 2-1 Location C – Appendix C Sub number 2-1 Location D1 – Appendix D1 Sub number 2-1 Location E – Appendix E Sub number 2-1
Time series of depth-average current speed and current direction	Current Data	Location A – Appendix A Sub number 2-2 Location B1 – Appendix B Sub number 2-2 Location C – Appendix C Sub number 2-2 Location D1 – Appendix D1 Sub number 2-2 Location E – Appendix E Sub number 2-2
Current speed harmonic analysis report	Current Data	Location A – Appendix A Sub number 2-3 Location B1 – Appendix B Sub number 2-3 Location C – Appendix C Sub number 2-3 Location D1 – Appendix D1 Sub number 2-3 Location E – Appendix E Sub number 2-3
Polar scatter plot of current velocity	Current Data	Location A – Appendix A Sub number 2-4 Location B1 – Appendix B Sub number 2-4 Location C – Appendix C Sub number 2-4 Location D1 – Appendix D1 Sub number 2-4 Location E – Appendix E Sub number 2-4
Table of joint occurrence of current speed versus direction	Current Data	Location A – Appendix A Sub number 2-5 Location B1 – Appendix B Sub number 2-5 Location C – Appendix C Sub number 2-5 Location D1 – Appendix D1 Sub number 2-5 Location E – Appendix E Sub number 2-5
Depth average elliptical harmonics	Current Data	Location A – Appendix A Sub number 2-6 Location B1 – Appendix B Sub number 2-6 Location C – Appendix C Sub number 2-6 Location D1 – Appendix D1 Sub number 2-6 Location E – Appendix E Sub number 2-6
Near-surface time series of depth-average current speed and current direction	Current Data	Location A – Appendix A Sub number 2-7 Location B1 – Appendix B Sub number 2-7 Location C – Appendix C Sub number 2-7 Location D1 – Appendix D1 Sub number 2-7 Location E – Appendix E Sub number 2-7

Visualisation Requirement	Data Type	Location and Number
Near-surface current speed harmonic analysis report	Current Data	Location A – Appendix A Sub number 2-8 Location B1 – Appendix B Sub number 2-8 Location C – Appendix C Sub number 2-8 Location D1 – Appendix D1 Sub number 2-8 Location E – Appendix E Sub number 2-8
Near-surface polar scatter plot of current velocity	Current Data	Location A – Appendix A Sub number 2-9 Location B1 – Appendix B Sub number 2-9 Location C – Appendix C Sub number 2-9 Location D1 – Appendix D1 Sub number 2-9 Location E – Appendix E Sub number 2-9
Near-surface table of joint occurrence of current speed versus direction	Current Data	Location A – Appendix A Sub number 2-10 Location B1 – Appendix B Sub number 2-10 Location C – Appendix C Sub number 2-10 Location D1 – Appendix D1 Sub number 2-10 Location E – Appendix E Sub number 2-10
Near-surface elliptical harmonics	Current Data	Location A – Appendix A Sub number 2-11 Location B1 – Appendix B Sub number 2-11 Location C – Appendix C Sub number 2-11 Location D1 – Appendix D1 Sub number 2-11 Location E – Appendix E Sub number 2-11
Mid-depth time series of depth-average current speed and current direction	Current Data	Location A – Appendix A Sub number 2-12 Location B1 – Appendix B Sub number 2-12 Location C – Appendix C Sub number 2-12 Location D1 – Appendix D1 Sub number 2-12 Location E – Appendix E Sub number 2-12
Mid-depth current speed harmonic analysis report	Current Data	Location A – Appendix A Sub number 2-13 Location B1 – Appendix B Sub number 2-13 Location C – Appendix C Sub number 2-13 Location D1 – Appendix D1 Sub number 2-13 Location E – Appendix E Sub number 2-13
Mid-depth polar scatter plot of current velocity	Current Data	Location A – Appendix A Sub number 2-14 Location B1 – Appendix B Sub number 2-14 Location C – Appendix C Sub number 2-14 Location D1 – Appendix D1 Sub number 2-14 Location E – Appendix E Sub number 2-14
Mid-depth table of joint occurrence of current speed versus direction	Current Data	Location A – Appendix A Sub number 2-15 Location B1 – Appendix B Sub number 2-15 Location C – Appendix C Sub number 2-15 Location D1 – Appendix D1 Sub number 2-15 Location E – Appendix E Sub number 2-15
Mid-depth elliptical harmonics	Current Data	Location A – Appendix A Sub number 2-16 Location B1 – Appendix B Sub number 2-16 Location C – Appendix C Sub number 2-16

Visualisation Requirement	Data Type	Location and Number
		Location D1 – Appendix D1 Sub number 2-16 Location E – Appendix E Sub number 2-16
Near-bed time series of depth-average current speed and current direction	Current Data	Location A – Appendix A Sub number 2-17 Location B1 – Appendix B Sub number 2-17 Location C – Appendix C Sub number 2-17 Location D1 – Appendix D1 Sub number 2-17 Location E – Appendix E Sub number 2-17
Near-bed current speed harmonic analysis report	Current Data	Location A – Appendix A Sub number 2-18 Location B1 – Appendix B Sub number 2-18 Location C – Appendix C Sub number 2-18 Location D1 – Appendix D1 Sub number 2-18 Location E – Appendix E Sub number 2-18
Near-bed polar scatter plot of current velocity	Current Data	Location A – Appendix A Sub number 2-19 Location B1 – Appendix B Sub number 2-19 Location C – Appendix C Sub number 2-19 Location D1 – Appendix D1 Sub number 2-19 Location E – Appendix E Sub number 2-19
Near-bed table of joint occurrence of current speed versus direction	Current Data	Location A – Appendix A Sub number 2-20 Location B1 – Appendix B Sub number 2-20 Location C – Appendix C Sub number 2-20 Location D1 – Appendix D1 Sub number 2-20 Location E – Appendix E Sub number 2-20
Near-bed elliptical harmonics	Current Data	Location A – Appendix A Sub number 2-21 Location B1 – Appendix B Sub number 2-21 Location C – Appendix C Sub number 2-21 Location D1 – Appendix D1 Sub number 2-21 Location E – Appendix E Sub number 2-21
Time series of significant wave height spectral (H_s), maximum wave height (H_{max}), peak wave period (T_p), zero up crossing wave period (T_z), peak coming direction, mean coming direction, spreading angle	Wave Data	Location A – Appendix A Sub number 3-1 Location B1 – Appendix B Sub number 3-1 Location C – Appendix C Sub number 3-1 Location D1 – Appendix D1 Sub number 3-1 Location E – Appendix E Sub number 3-1
Table of joint occurrence of significant wave height (H_s) versus mean wave direction	Wave Data	Location A – Appendix A Sub number 3-2 Location B1 – Appendix B Sub number 3-2 Location C – Appendix C Sub number 3-2 Location D1 – Appendix D1 Sub number 3-2 Location E – Appendix E Sub number 3-2
Table of joint occurrence of significant wave height (H_s) versus peak wave period (T_p)	Wave Data	Location A – Appendix A Sub number 3-3 Location B1 – Appendix B Sub number 3-3 Location C – Appendix C Sub number 3-3 Location D1 – Appendix D1 Sub number 3-3

Visualisation Requirement	Data Type	Location and Number
		Location E – Appendix E Sub number 3-3
Table of spreading angle versus mean coming direction	Wave Data	Location A – Appendix A Sub number 3-4 Location B1 – Appendix B Sub number 3-4 Location C – Appendix C Sub number 3-4 Location D1 – Appendix D1 Sub number 3-4 Location E – Appendix E Sub number 3-4
Wave height and period scatter plot (regression)	Wave Data	Location A – Appendix A Sub number 3-5 Location B1 – Appendix B Sub number 3-5 Location C – Appendix C Sub number 3-5 Location D1 – Appendix D1 Sub number 3-5 Location E – Appendix E Sub number 3-5
Time series of sea temperature	Environmental Data	Location A – Appendix A Sub number 4-1 Location B1 – Appendix B Sub number 4-1 Location C – Appendix C Sub number 4-1 Location D1 – Appendix D1 Sub number 4-1 Location E – Appendix E Sub number 4-1
CTD profiles	Environmental Data	Location A – Appendix A Sub number 5-1 Location B1 – Appendix B Sub number 5-1 Location C – Appendix C Sub number 5-1 Location D1 – Appendix D1 Sub number 5-1 Location E – Appendix E Sub number 5-1
Conductivity time series	Environmental Data	Location A – Appendix E Sub number 6-1 Location E – Appendix E Sub number 6-1
Turbidity (OBS) time series	Environmental Data	Location A – Appendix A Sub number 7-1 Location B1 – Appendix B Sub number 7-1 Location C – Appendix C Sub number 7-1 Location D1 – Appendix D1 Sub number 7-1 Location E – Appendix E Sub number 7-1
Turbidity (ABS) time series	Environmental Data	Location A – Appendix A Sub number 7-2 Location B1 – Appendix B Sub number 7-2 Location C – Appendix C Sub number 7-2 Location D1 – Appendix D1 Sub number 7-2 Location E – Appendix E Sub number 7-2
Suspended solids results	Sediment Data	Appendix F
Particle Size Distribution presentations	Sediment Data	Appendix F

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