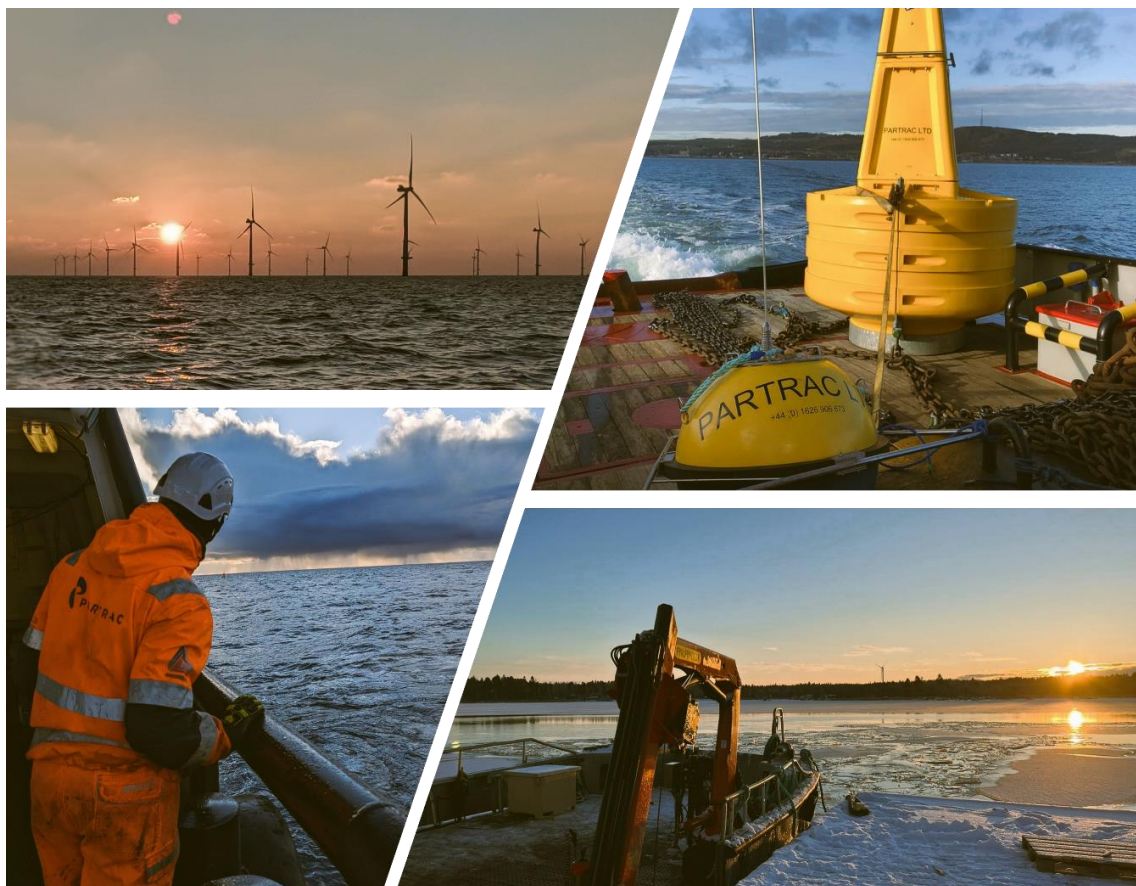




Port of Dundee ADCP Monitoring Campaign

Port of Dundee | Final Data Report

M5179 V1 | 11 April 2025



FORTH PORTS

Document Control

Document information

Project Title	Port of Dundee ADCP Monitoring Campaign
Partrac Project No.	M5179
Issue Number	V1
Issue Status	Issued

Revision History

Issue	Date	Status	Comments on Content	Prepared By	Checked By	Approved By
V1	11/04/2025	ISSUED	Original Document	JL	KH	KRR

Document Distribution

Recipient	Distribution Method		
	Paper	PDF	Online
Port of Dundee – Pauline Marshall		X	

Holders of controlled copies will automatically be provided with subsequent approved versions of this document when they become available.

This document contains proprietary information which is disclosed for the purposes of evaluation only. Any reproduction or usage (in whole or in part) by any person other than our Client, or Parties authorised by our Client, is strictly prohibited.

This document has been prepared in accordance with the terms of a contract between Partrac and our Client. No further or other warranty, express or implied, is made as to the accuracy, quality or veracity of any part of the document and Partrac assumes no liability or duty of care to any third Party in respect of, or arising out of, this document.

This document is the copyright of Partrac Ltd; Copyright © Partrac Ltd 2025.

Executive Summary

On 23rd January 2025 Partrac deployed two seabed frames, each with a Nortek AWAC current profiler and an Aquatec *AQUAlogger* pressure/temperature/turbidity sensor, within the River Tay, for the Port of Dundee measurement campaign. The instruments were recovered on the 25th February 2025.

This document describes the collected hydrodynamic and turbidity data from the moorings. The data return statistics are shown in Table A.

Table A: Data return statistics

Site	Reporting Start Time	Reporting End Time	Expected Samples	Received Samples	Recovery (%)	Passed QC	Passed QC (%)
AWAC Site 1	2025-01-23 10:10	2025-02-25 07:40	9475	9475	100	9475	100
AWAC Site 2	2025-01-23 09:05	2025-02-25 08:35	9499	9499	100	9499	100
Aqualogger Site 1 Turbidity	2025-01-23 10:10	2025-02-25 07:40e	9475	9474	99.99	9474	99.99
Aqualogger Site 1 Pressure	2025-01-23 10:10	2025-02-25 07:40	9475	9474	99.99	9474	99.99
Aqualogger Site 1 Temperature	2025-01-23 10:10	2025-02-25 07:40	9475	9474	99.99	9474	99.99
Aqualogger Site 2 Turbidity	2025-01-23 09:05	2025-02-25 08:35	9499	9498	99.99	9498	99.99
Aqualogger Site 2 Pressure	2025-01-23 09:05	2025-02-25 08:35	9499	9498	99.99	9498	99.99
Aqualogger Site 2 Temperature	2025-01-23 09:05	2025-02-25 08:35	9499	9498	99.99	9498	99.99

Table of Contents

DOCUMENT CONTROL.....	I
EXECUTIVE SUMMARY.....	II
ABBREVIATIONS.....	IV
1. INTRODUCTION	1
1.1 Site Locations.....	1
2. QUALITY CONTROL AND DATA PROCESSING	4
2.1 Current Data Analysis.....	4
2.2 Aqualogger Data Analysis.....	4
2.3 Suspended Solids Concentration (SSC).....	5
3. RESULTS.....	8
3.1 Data Return Overview.....	8
3.2 Current Data.....	10
3.3 Turbidity Data.....	24
3.4 Summary of Results.....	30
3.5 Provision of Data Files.....	30

Figures

Figure 1: Site positions.....	1
Figure 2: Site 1 SSC analysis.....	6
Figure 3: Site 2 SSC analysis.....	7
Figure 4: Site 1 estimated total water column depth at AWAC.....	11
Figure 4: Site 1 AWAC temperature.....	11
Figure 5: Site 1 AWAC heading.....	12
Figure 6: Site 1 AWAC pitch and roll.....	12
Figure 7: Site 1 AWAC depth-mean velocity magnitude.....	13
Figure 8: Site 1 AWAC depth-mean velocity direction.....	13
Figure 9: Site 1 AWAC velocity magnitude – all bins.....	14
Figure 10: Site 1 AWAC velocity direction – all bins.....	14
Figure 11: Site 1 AWAC depth-mean velocity polar scatter plot.....	15
Figure 12: Site 1 AWAC depth mean velocity rose.....	16
Figure 14: Site 2 estimated total water column depth at AWAC.....	18

Figure 14: Site 2 AWAC temperature.....	18
Figure 14: Site 2 AWAC heading.....	19
Figure 15: Site 2 AWAC pitch and roll.....	19
Figure 16: Site 2 AWAC depth-mean velocity magnitude.	20
Figure 17: Site 2 AWAC depth-mean velocity direction.....	20
Figure 18: Site 2 AWAC velocity magnitude – all bins.	21
Figure 19: Site 2 AWAC velocity direction – all bins.....	21
Figure 20: Site 2 AWAC depth-mean velocity scatter plot.....	22
Figure 21: Site 2 AWAC depth-mean velocity rose.....	23
Figure 22: Site 1 Aqualogger pressure.....	25
Figure 23: Site 1 Aqualogger temperature.	25
Figure 24: Site 1 Aqualogger turbidity.....	26
Figure 25: Site 1 Aqualogger derived suspended solids concentration.	26
Figure 26: Site 2 Aqualogger pressure.....	28
Figure 27: Site 2 Aqualogger temperature.	28
Figure 28: Site 2 Aqualogger turbidity.....	29
Figure 29: Site 2 Aqualogger derived suspended solids concentration.	29

Tables

Table 1: As-laid deployment positions.....	2
Table 2: Instrument details.....	3
Table 3: Current data quality control checks. Data flagged if beyond maximum rate of change or interval.....	4
Table 4: Pressure, Temperature and Turbidity timeseries data quality control thresholds	5
Table 5: Data return statistics	8
Table 6: Summary parameter statistics	9

Abbreviations

AWAC	Acoustic Wave and Current Profiler
FTU	Formazine Turbidity Unit
MSL	Mean Sea Level
NWSS	Northumbrian Water Scientific Services
SSC	Suspended Solids Concentration
TSS	Total Suspended Sediment
WGS 84	World Geodetic System 1984 (Lat° Long°)

1. INTRODUCTION

Partrac were contracted by Forth Ports to collect current and turbidity measurements in the River Tay, for a period of 30 days at two locations. The data will be used to inform hydrodynamic modelling studies.

The scope of work includes simultaneous data collection at two project sites on two seabed frames. The instrument payload on the frames comprises of:

- 2 x Nortek AWAC 1MHz current velocity profilers.
- 2 x Aquatec Aqualogger 310TYPT2 turbidity sensors.
- 2 x Sediment Traps.

Water samples were also collected at both sites to allow for turbidity to Total Suspended Sediment (TSS) concentration conversions to be made.

This report details the data collected by the AWAC and Aqualogger instruments at both sites.

1.1 Site Locations

The deployment sites are shown in Figure 1 and as-laid positions are shown in Table 1.

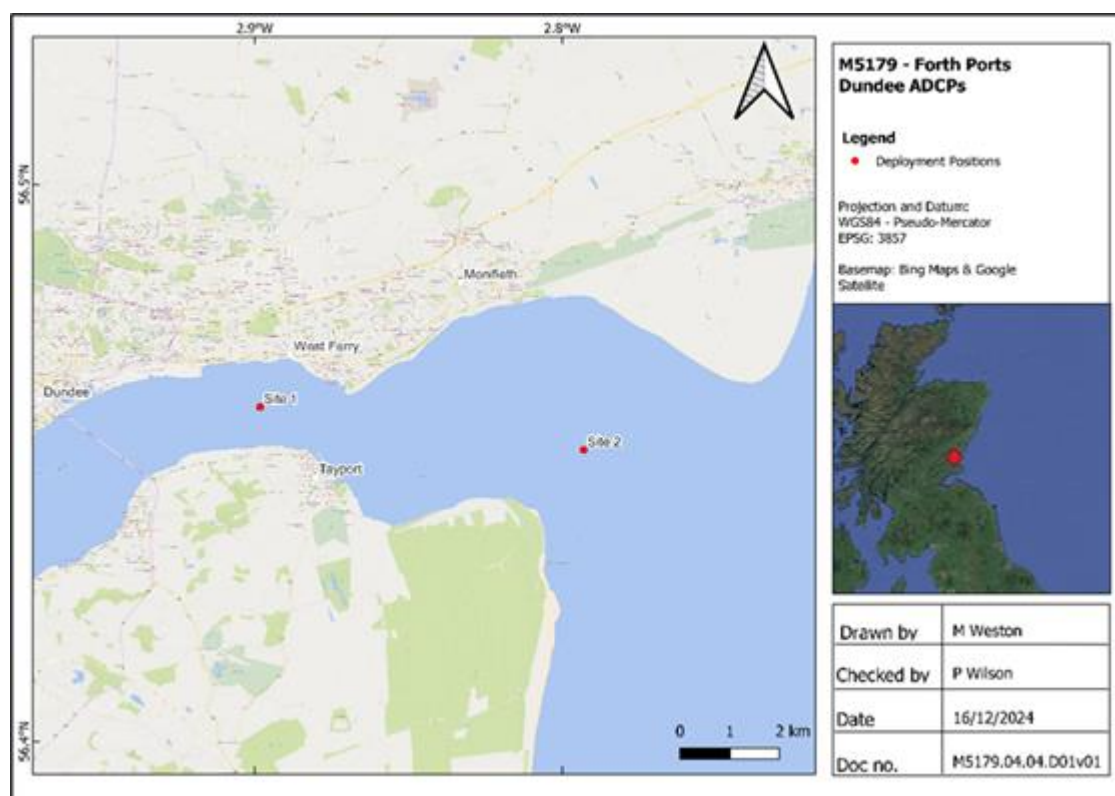


Figure 1: Site positions.

Table 1: As-laid deployment positions

Site ID	Equipment Type	Deployment Location (WGS84 DD)		Deployment Location (WGS84 DDM)		Depth (CD m)
		Latitude (N)	Longitude (W)	Latitude	Longitude	
Site 1	ADCP Frame	56.46010	2.89847	56° 27.606'N	2° 53.908'W	10
	Ground weight	56.46012	2.89708	56° 27.607'N	2° 53.825'W	
Site 2	ADCP Frame	56.45253	2.79242	56° 27.152'N	2° 47.545'W	5
	Ground weight	56.45316	2.79282	56° 27.190'N	2° 47.569'W	

Details of the instruments on each mooring are provided in Table 2.

Table 2: Instrument details

Instrument	Site	Instrument Height ASB (m)	Blanking Distance (m)	Centre of 1st Bin ASB (m)	Bin Size (m)	Range (m)	Sampling Regime
Nortek AWAC 1MHZ WPR 2689 WAV 7183	Site 1	0.53	0.40	0.90	0.50	20.4	2 minute profile sampled every 5 minutes
Aquatec Aqualogger 310TYPT2 2554-240	Site 1	0.27	-	-	-	-	30 second burst sampled every 5 minutes
Nortek AWAC 1MHZ WPR 2774 WAV 7229	Site 2	0.53	0.4	0.90	0.50	20.40	2 minute profile sampled every 5 minutes
Aquatec Aqualogger 310TYPT2 2554-241	Site 2	0.27	-	-	-	-	30 second burst sampled every 5 minutes

2. QUALITY CONTROL AND DATA PROCESSING

2.1 Current Data Analysis

Current and ancillary data from the Nortek AWAC sensors is firstly exported to an ASCII format using the Nortek utility *Storm64*.

Partrac has developed a bespoke system for processing ocean current data. A rate of change criterion is applied to detect and flag outliers. This is determined on a per site basis as tidal current features are highly variable with respect to location. Partrac's MATLAB® routines import all data and apply the data parameters to identify (flag) any large changes in flow parameters. These data are investigated further to determine if data are anomalous (outliers) and therefore to be removed from the dataset. Table 3 summarises the flag criteria.

Table 3: Current data quality control checks. Data flagged if beyond maximum rate of change or interval.

Parameter	Units	Maximum rate of change per interval	Interval (minutes)
Current speed	m s ⁻¹	0.5	5

Statistics are derived from data that have passed quality control. These are minimum, maximum, mean and standard deviation.

2.2 Aqualogger Data Analysis

Data from the Aqualogger sensors were initially downloaded and processed using the Aquatec utility *AQUAtalk*. After a general inspection the data were then exported for further processing in *MATLAB*.

The pressure data are corrected by subtracting the atmospheric pressure recorded immediately prior to deployment.

Data processing then follows an in-house quality control method. Our bespoke MATLAB routines import all data and identifies and removes any data out of the predetermined ranges (see Table 4). The process then identifies (flags) any large changes in parameter values that occur between sample records (see also Table 4), for inspection and possible removal. The data that are recorded adjacent to the flagged data are inspected and may also be removed if warranted.

The data was then averaged to determine mean values for each 30 second burst.

Table 4: Pressure, Temperature and Turbidity timeseries data quality control thresholds

Parameter	Units	Range		Rate
		Minimum	Maximum	Maximum Rate of Change per Sample
Pressure (Site 1)	Bar	0	2	0.01
Pressure (Site 2)	Bar	0	2	0.05
Turbidity	NTU	0	10000	10
Temperature	°C	0	10	0.4

Statistics are derived from burst averaged data that have passed quality control. These are minimum, maximum, mean and standard deviation.

2.3 Suspended Solids Concentration (SSC)

A sequence of 15 suspended solids water samples, at different concentrations, were analysed for each site to determine the relationship between turbidity and SSC (in mg l^{-1}), using sediment collected from the bed at each site. The samples at each concentration were measured using the same Aqualogger instrument used for the deployment, then bottled and sent to Northumbrian Water Scientific Services (NWSS) labs for SSC analysis. At Site 1 14 samples were acceptable for use, and at Site 2 11 samples were acceptable for use. The findings are presented for Site 1 in Figure 2 and Site 2 in Figure 3.

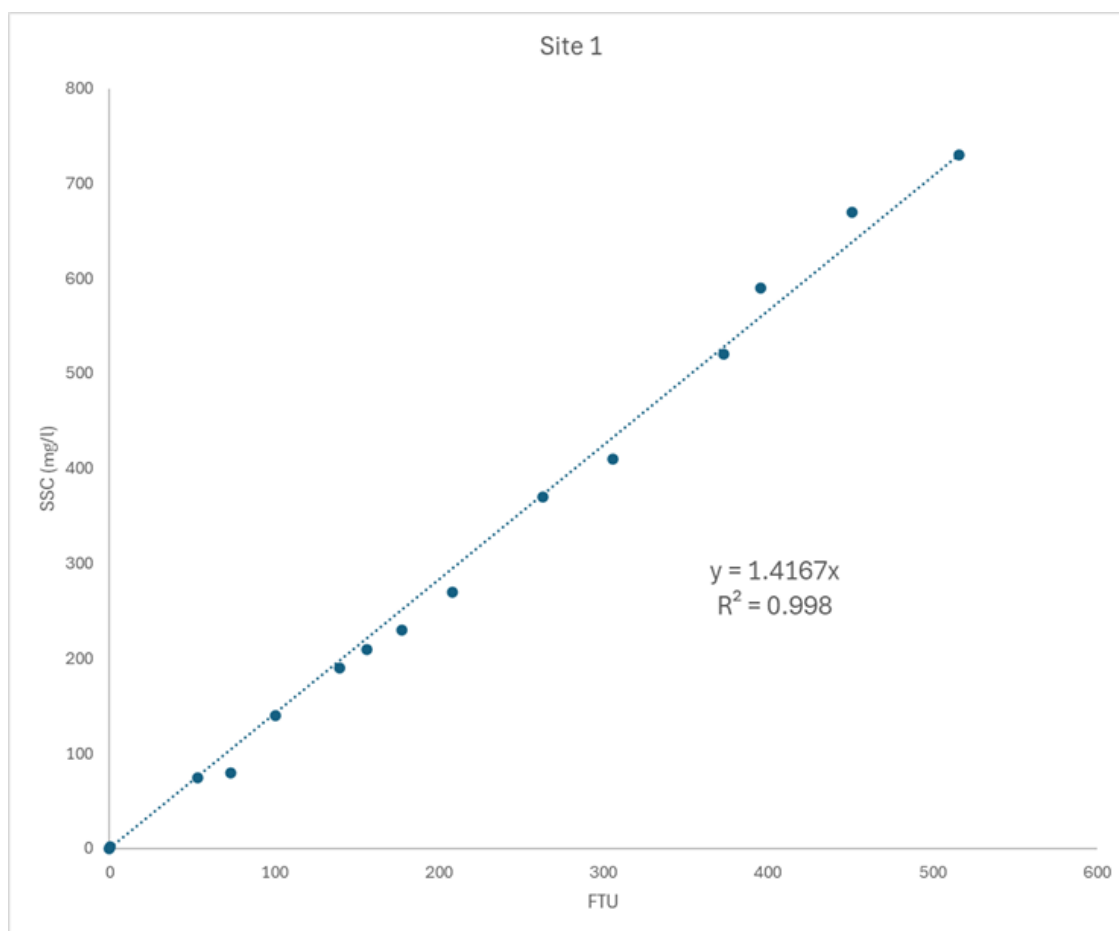


Figure 2: Site 1 SSC analysis.

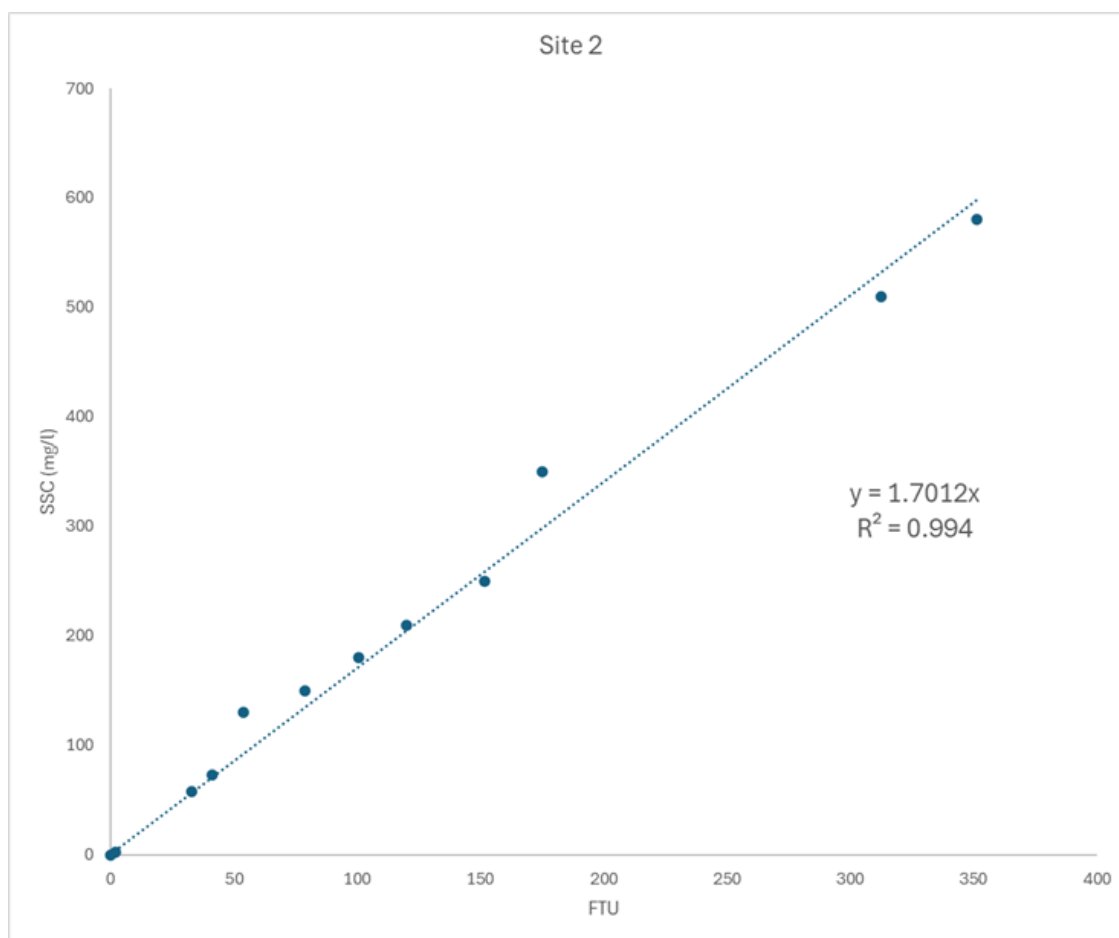


Figure 3: Site 2 SSC analysis.

The identified relationships were then applied to the turbidity time series for each site to estimate respective time series of suspended solids concentration.

3. RESULTS

3.1 Data Return Overview

Table 5 below presents the data return statistics for the two sites, and the summary parameter statistics are presented in Table 6 below.

Table 5: Data return statistics

Site	Reporting Start Time	Reporting End Time	Expected Samples	Received Samples	Recovery (%)	Passed QC	Passed QC (%)
AWAC Site 1	2025-01-23 10:10	2025-02-25 07:40	9475	9475	100	9475	100
AWAC Site 2	2025-01-23 09:05	2025-02-25 08:35	9499	9499	100	9499	100
Aqualogger Site 1 Turbidity	2025-01-23 10:10	2025-02-25 07:40	9475	9474	99.99	9474	99.99
Aqualogger Site 1 Pressure	2025-01-23 10:10	2025-02-25 07:40	9475	9474	99.99	9474	99.99
Aqualogger Site 1 Temperature	2025-01-23 10:10	2025-02-25 07:40	9475	9474	99.99	9474	99.99
Aqualogger Site 2 Turbidity	2025-01-23 09:05	2025-02-25 08:35	9499	9498	99.99	9498	99.99
Aqualogger Site 2 Pressure	2025-01-23 09:05	2025-02-25 08:35	9499	9498	99.99	9498	99.99
Aqualogger Site 2 Temperature	2025-01-23 09:05	2025-02-25 08:35	9499	9498	99.99	9498	99.99

Table 6: Summary parameter statistics

Parameter	Minimum	Mean	Maximum	Standard Deviation
AWAC Site 1				
Current Magnitude (All Bins) (ms ⁻¹)	0.00	0.72	2.00	0.38
Depth mean Current Magnitude (ms ⁻¹)	0.00	0.70	1.43	0.34
AWAC Site 2				
Current Magnitude (All Bins) (ms ⁻¹)	0.00	0.74	2.05	0.43
Depth mean Current Magnitude (ms ⁻¹)	0.00	0.75	1.86	0.42
Aqualogger Site 1				
Turbidity (FTU)	2	20	389	18
Pressure(Bar)	1.01	1.29	1.54	0.12
Temperature (°C)	4.22	5.46	6.55	0.53
SSC (mg.l ⁻¹)	3	28	551	5.89
Aqualogger Site 2				
Turbidity (FTU)	2	15	199	13
Pressure(Bar)	0.65	0.92	1.17	0.12
Temperature (°C)	4.55	5.78	6.86	0.49
SSC (gm.l ⁻¹)	3	26	339	23

3.2 Current Data

3.2.1 Site 1 AWAC

Current data collected by the AWAC at Site 1 are presented in Figure 4 to Figure 13 as follows:

- Time series plot of total water column depth, estimated from the AWAC pressure record.
- Time series plots of temperature, heading, orientation, depth mean horizontal velocity magnitude and direction.
- Heat maps of current horizontal velocity magnitude and direction.
- Polar scatter plot of depth-mean current and direction.
- Rose plot of depth-mean current.

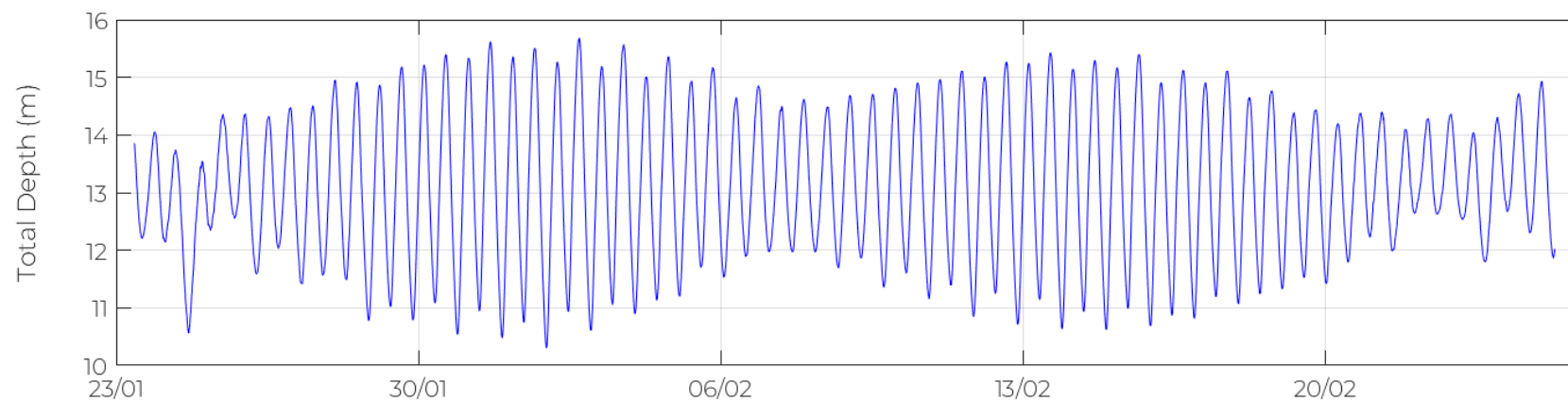


Figure 4: Site 1 estimated total water column depth at AWAC.

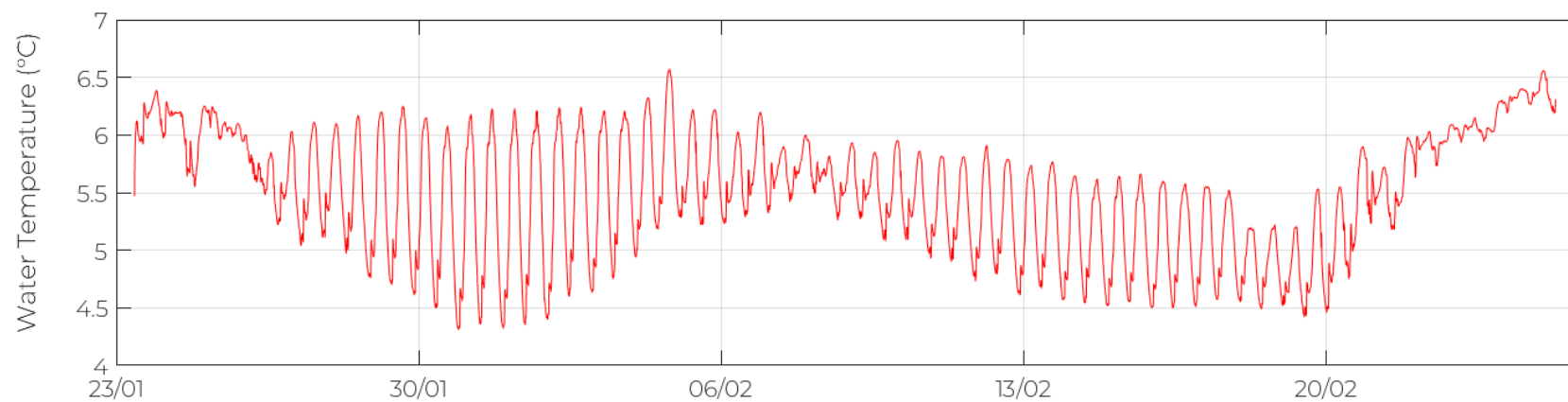


Figure 5: Site 1 AWAC temperature.

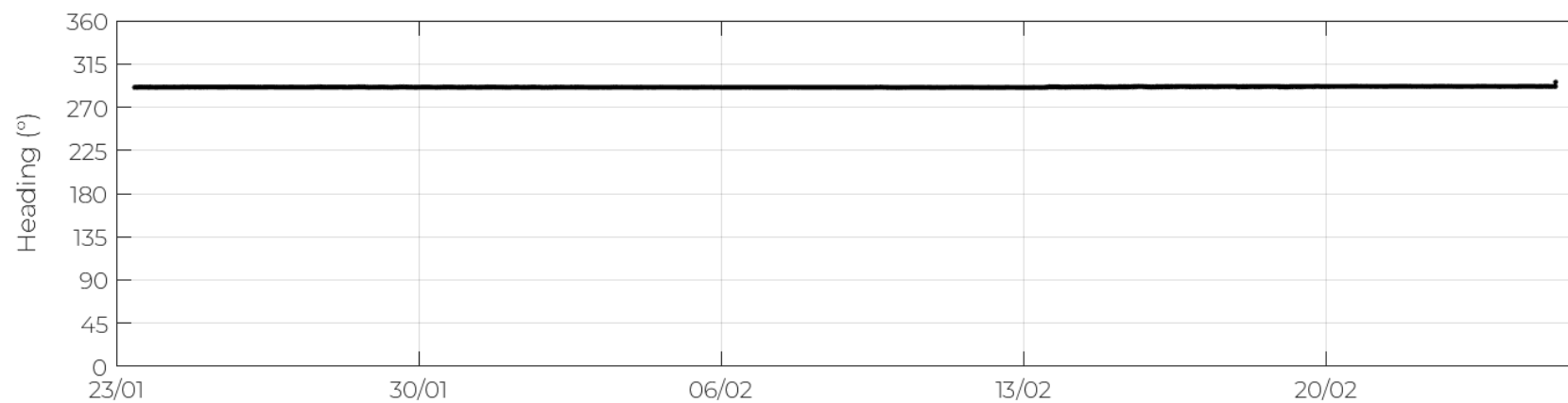


Figure 6: Site 1 AWAC heading.

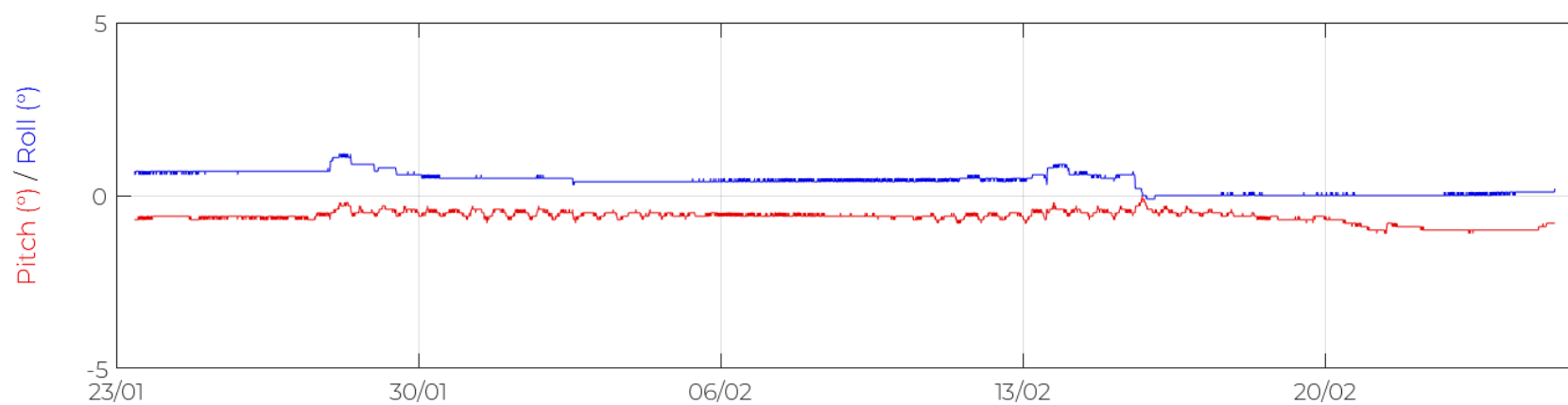


Figure 7: Site 1 AWAC pitch and roll.

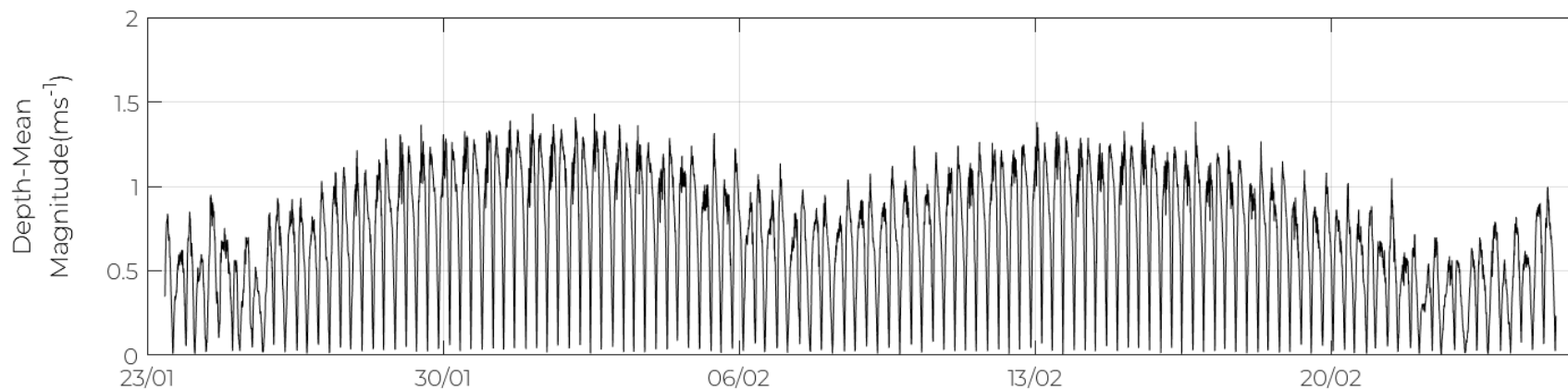


Figure 8: Site 1 AWAC depth-mean velocity magnitude.

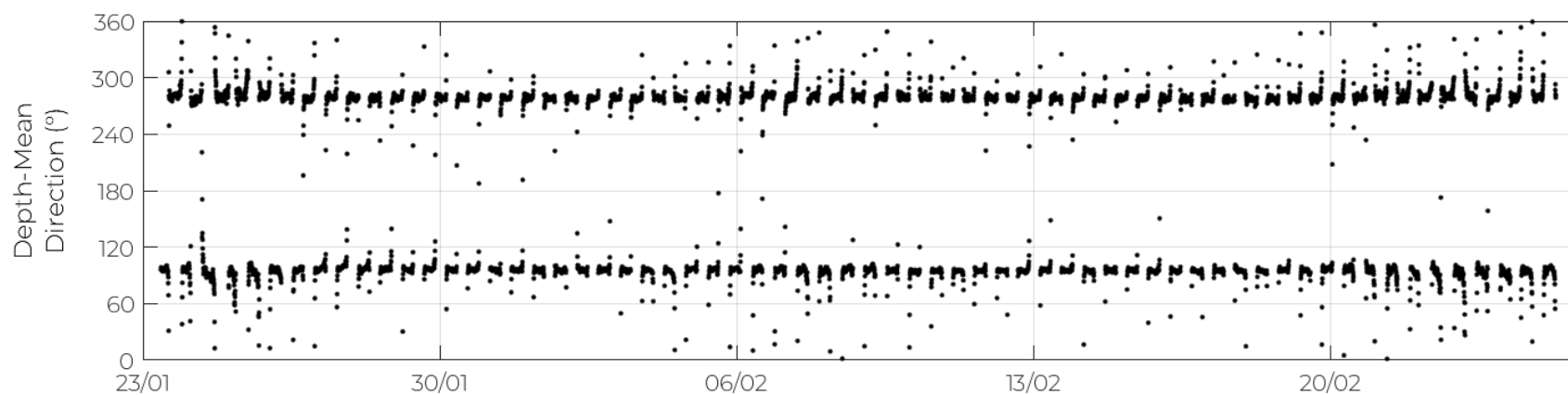


Figure 9: Site 1 AWAC depth-mean velocity direction.

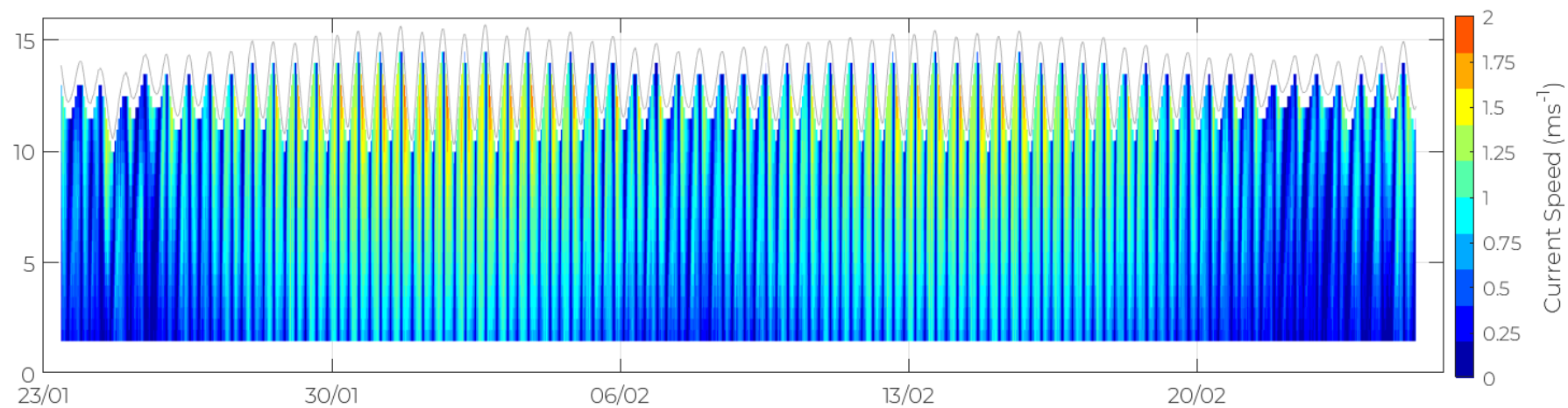


Figure 10: Site 1 AWAC velocity magnitude – all bins.

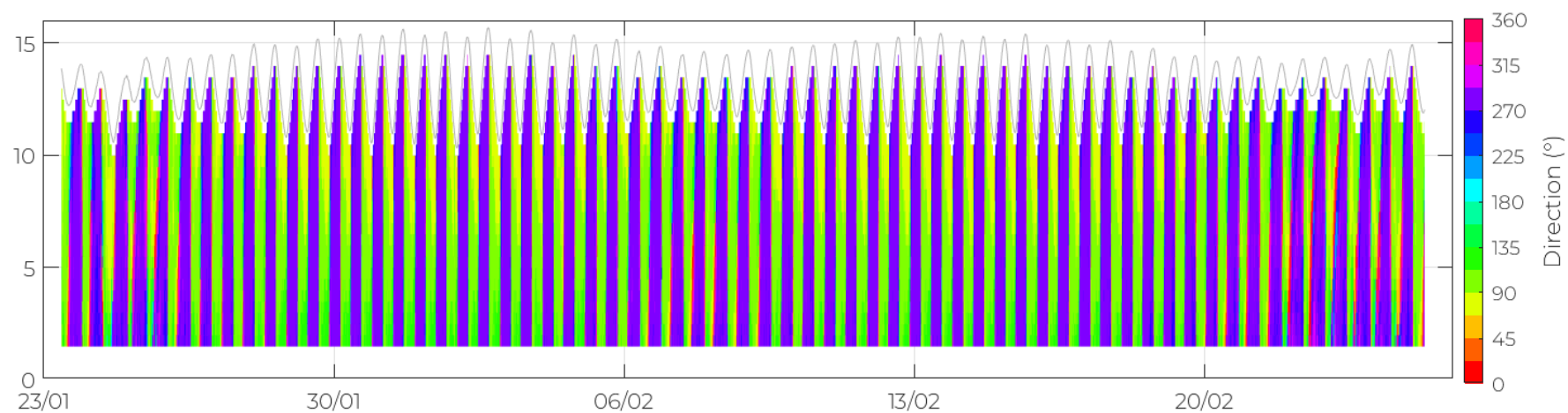


Figure 11: Site 1 AWAC velocity direction – all bins.

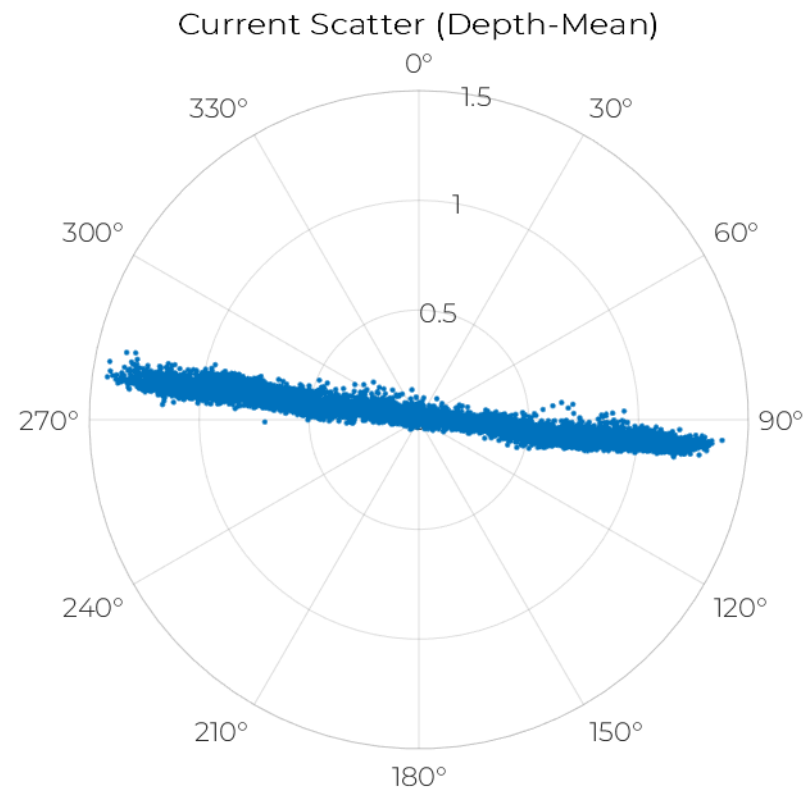


Figure 12: Site 1 AWAC depth-mean velocity polar scatter plot.

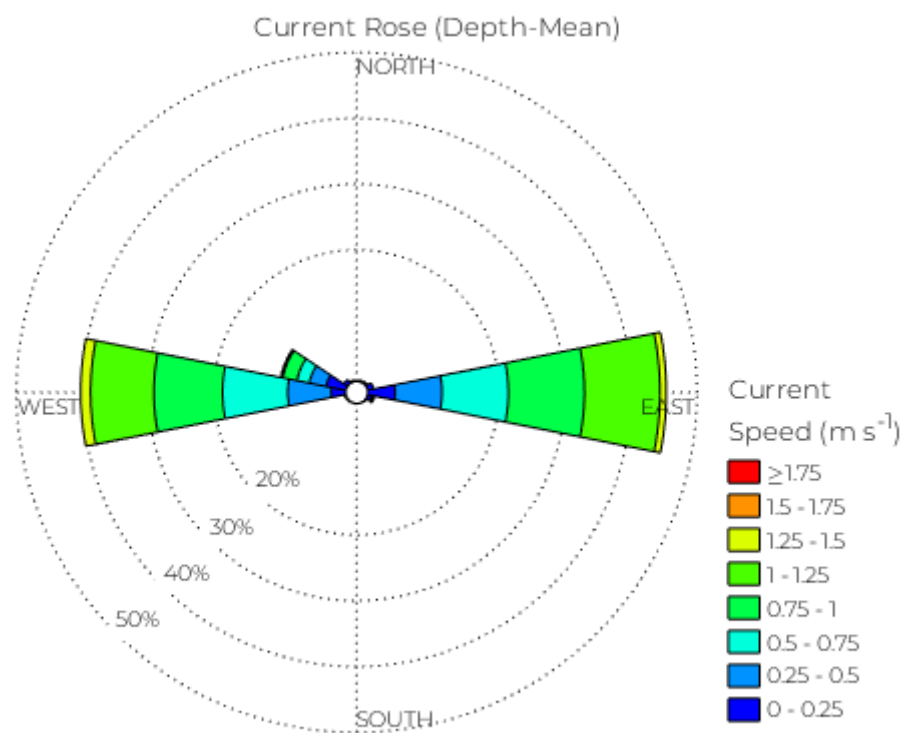


Figure 13: Site 1 AWAC depth mean velocity rose.

3.2.2 Site 2 AWAC

Current data collected by the AWAC at Site 2 are presented in Figure 14 to Figure 23 as follows:

- Time series plot of total water column depth, estimated from the AWAC pressure record.
- Time series plots of temperature, heading, orientation, depth mean horizontal velocity magnitude and direction.
- Heat maps of current horizontal velocity magnitude and direction.
- Polar scatter plot of depth-mean current and direction.
- Rose plot of depth-mean current.

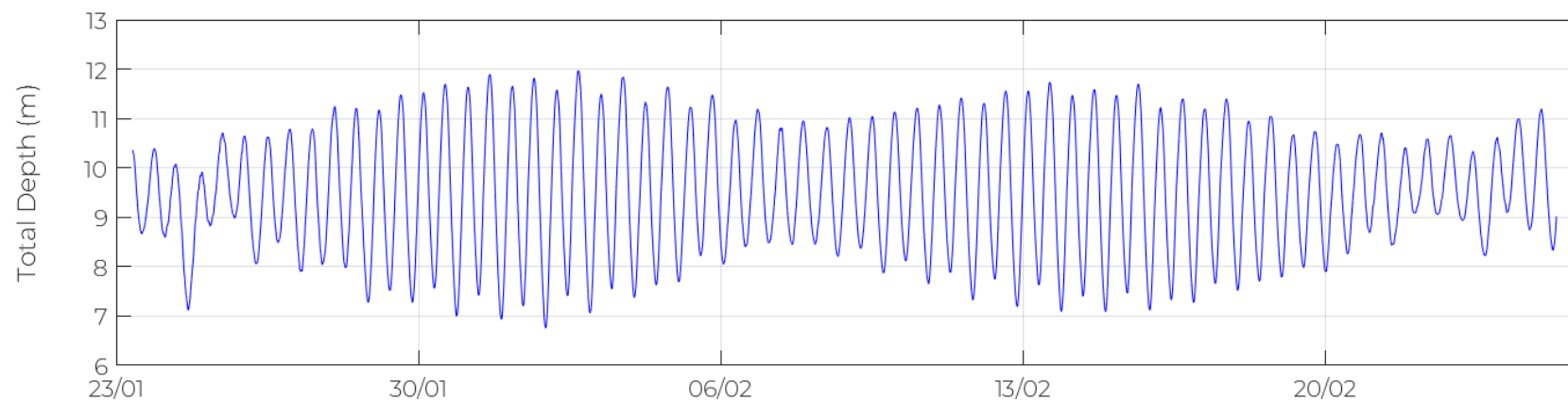


Figure 14: Site 2 estimated total water column depth at AWAC.

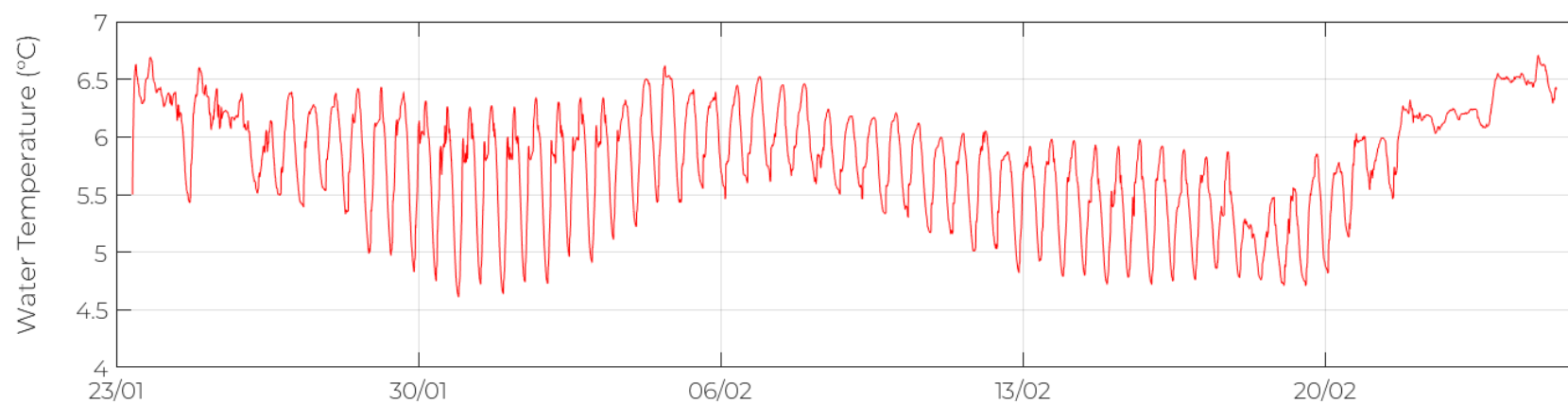


Figure 15: Site 2 AWAC temperature.

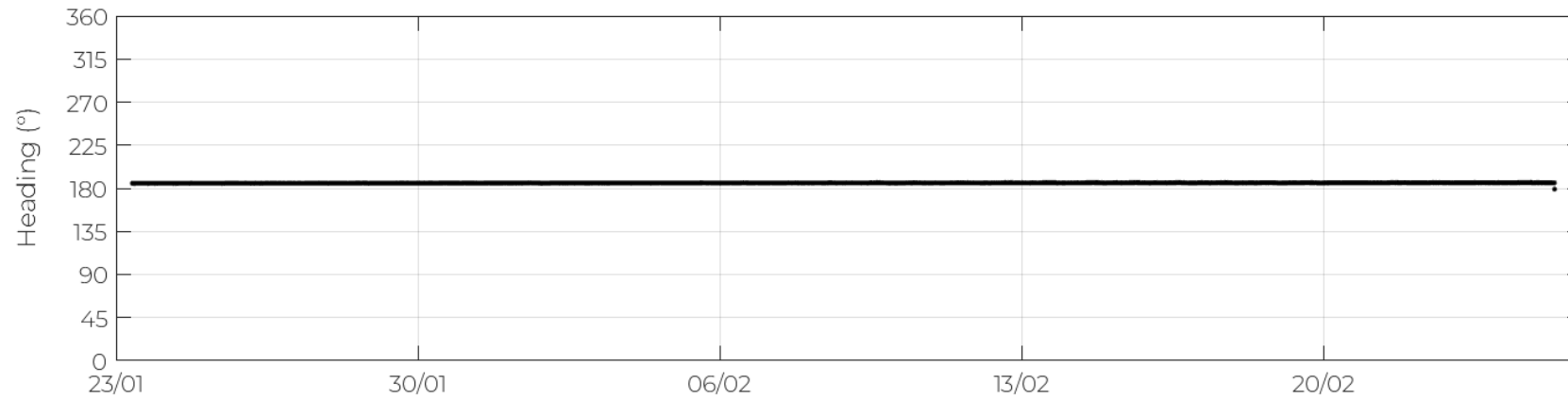


Figure 16: Site 2 AWAC heading.

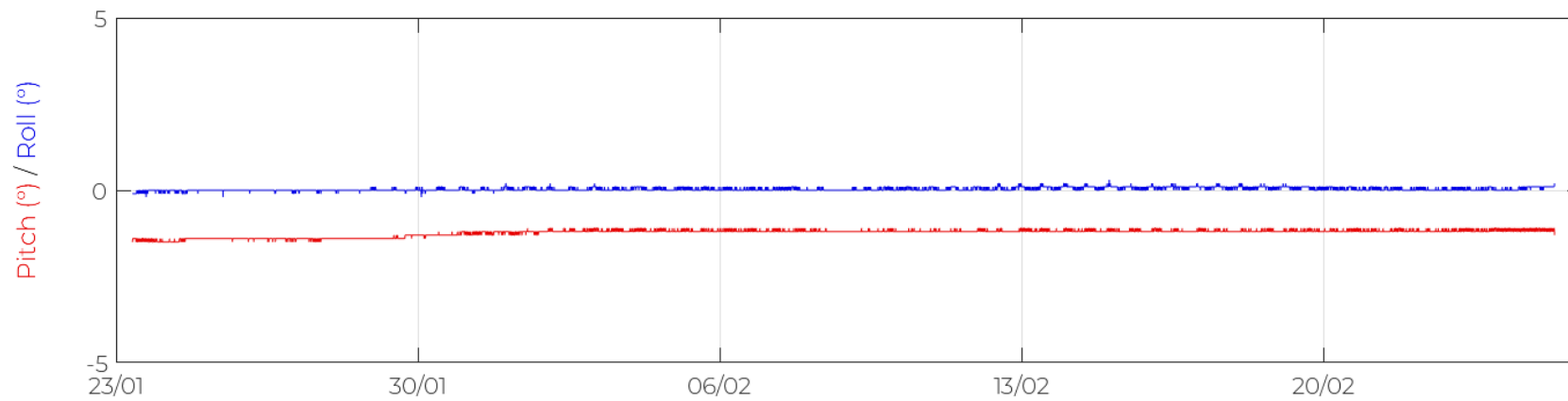


Figure 17: Site 2 AWAC pitch and roll.

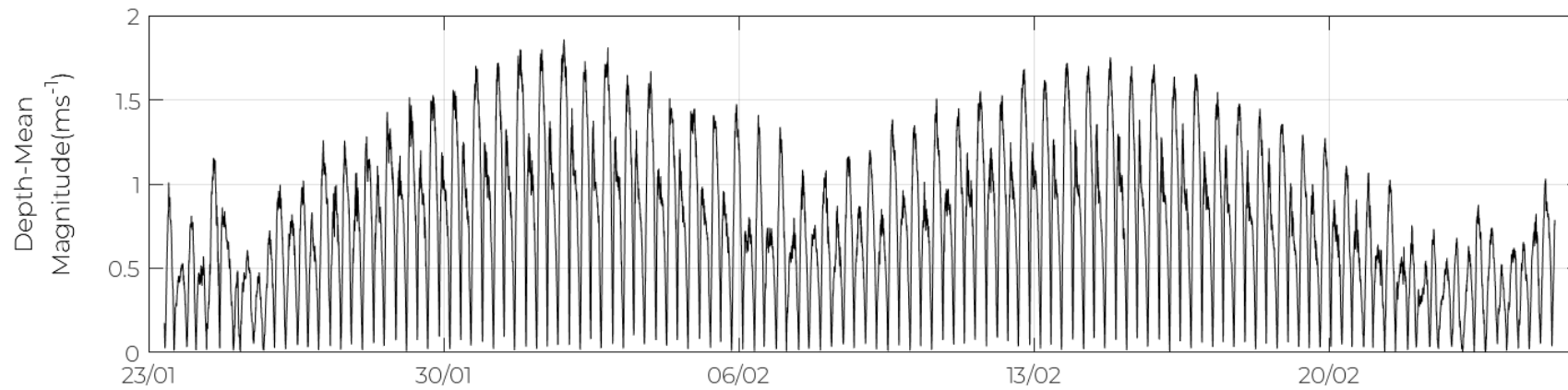


Figure 18: Site 2 AWAC depth-mean velocity magnitude.

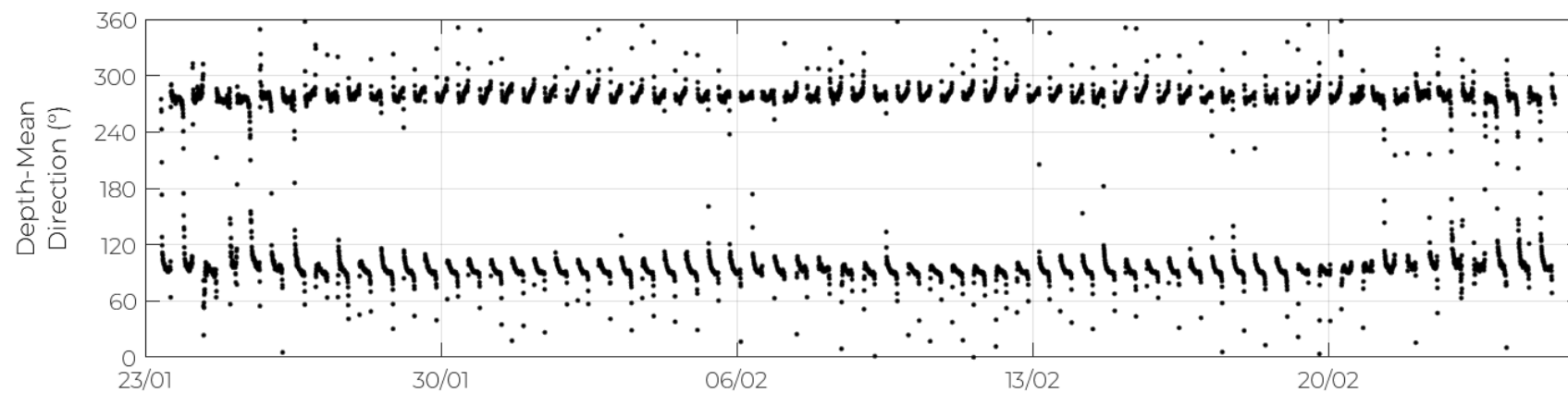


Figure 19: Site 2 AWAC depth-mean velocity direction.

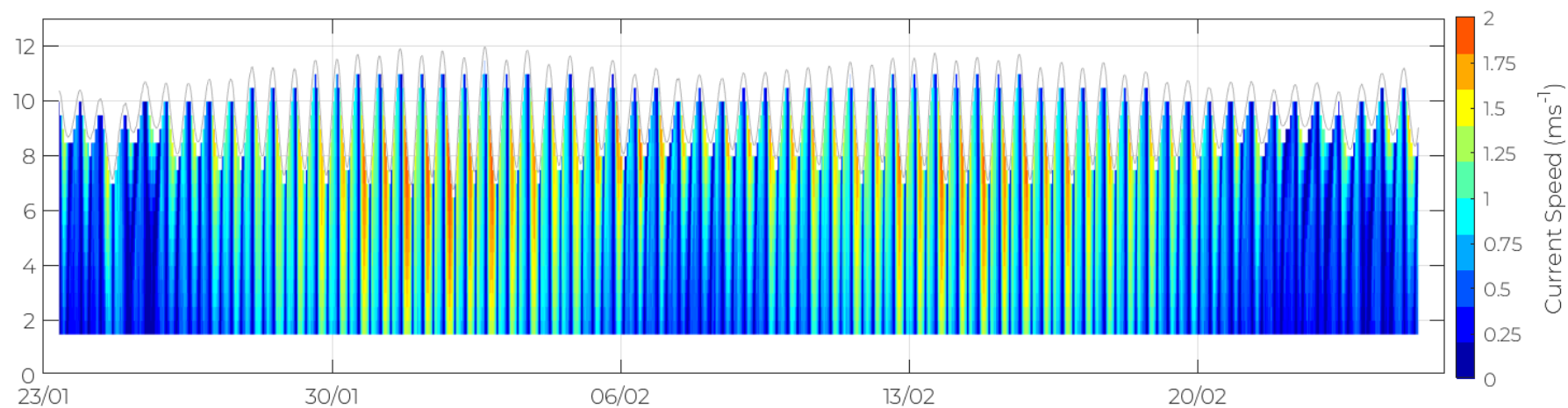


Figure 20: Site 2 AWAC velocity magnitude – all bins.

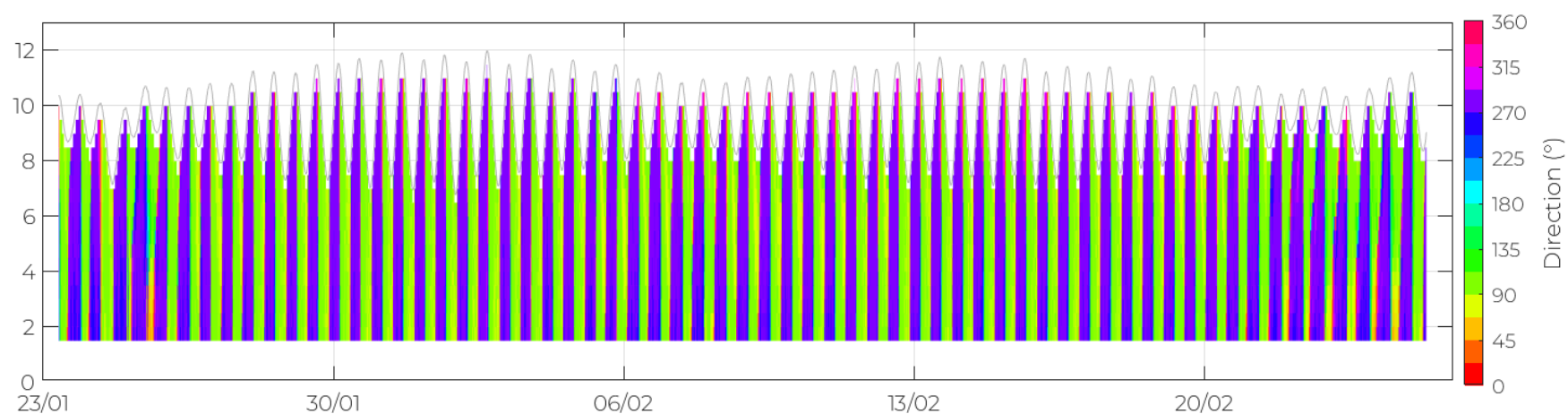


Figure 21: Site 2 AWAC velocity direction – all bins.

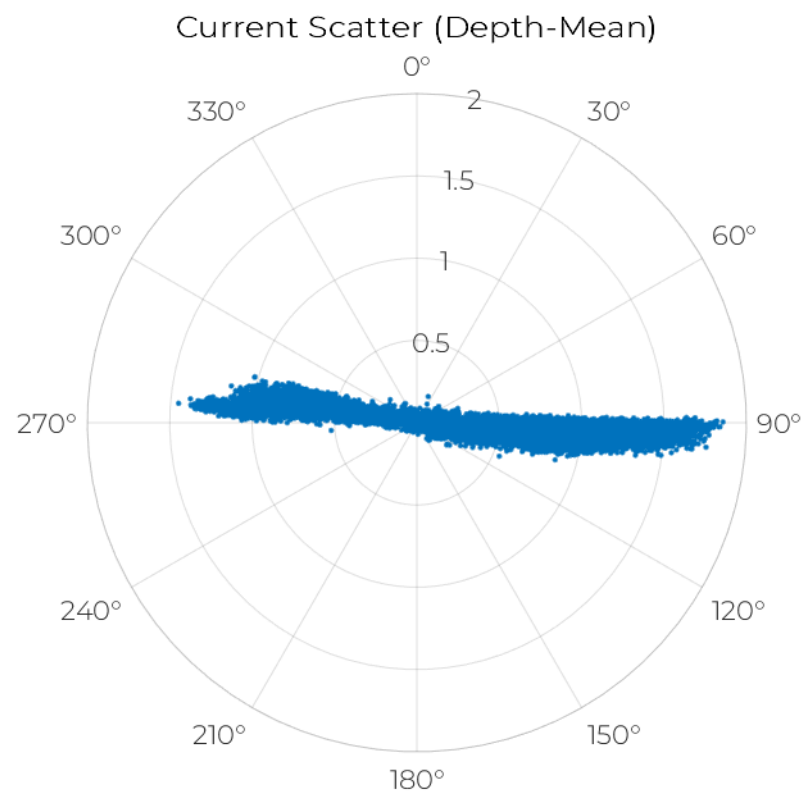


Figure 22: Site 2 AWAC depth-mean velocity scatter plot.

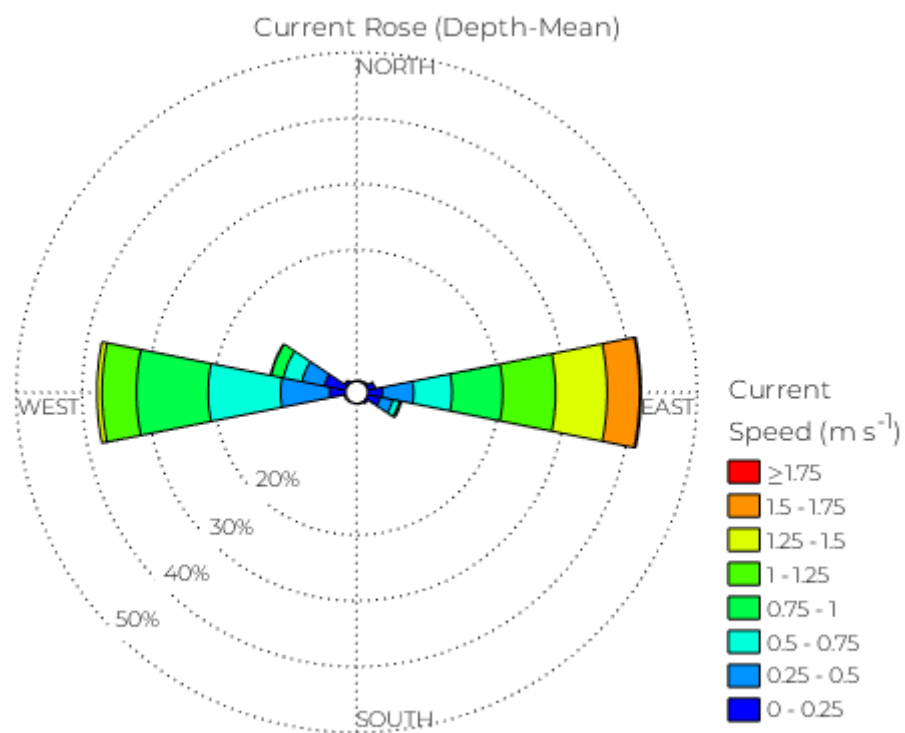


Figure 23: Site 2 AWAC depth-mean velocity rose.

3.3 Turbidity Data

3.3.1 Site 1 Aqualogger

Burst-mean data collected by the Aqualogger at Site 1 are presented in Figure 24 to Figure 27 as follows:

- Time series plots of pressure, temperature.
- Time series (log-scale) plot of turbidity.
- Time series (log-scale) plot of derived suspended solids concentration.

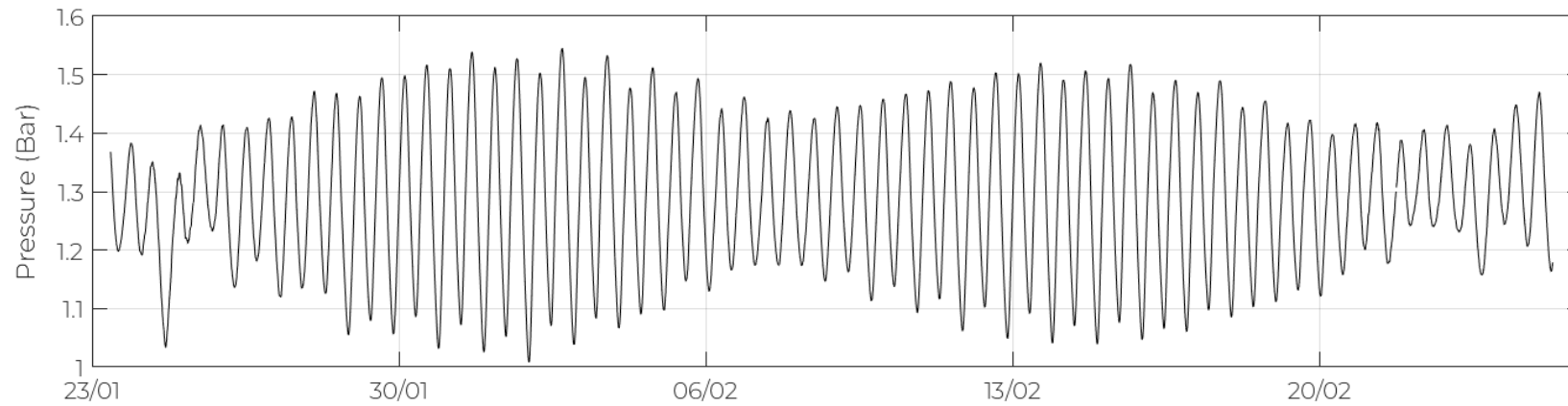


Figure 24: Site 1 Aqualogger pressure.

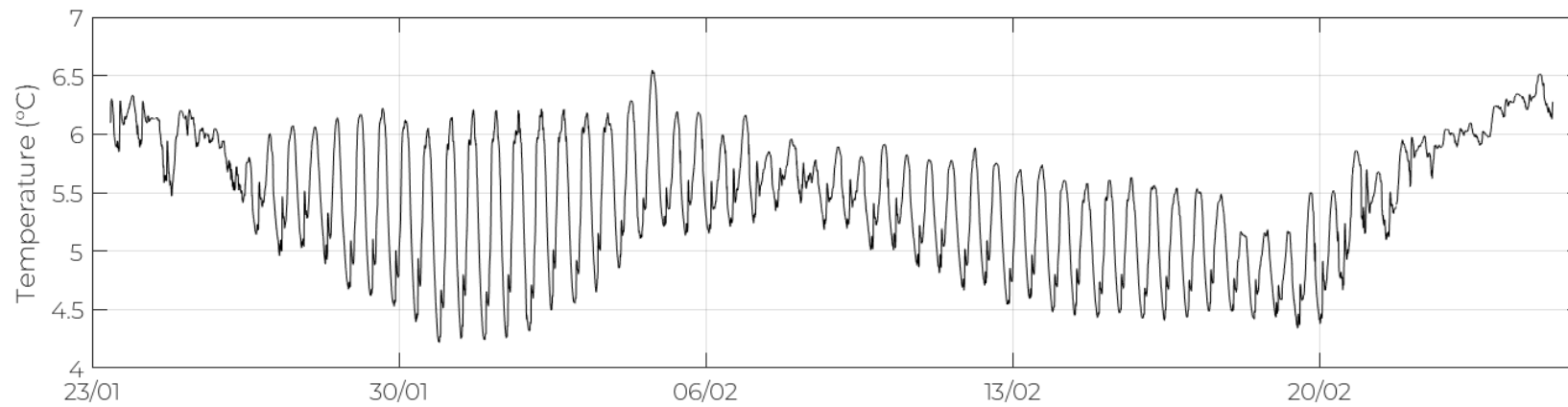


Figure 25: Site 1 Aqualogger temperature.

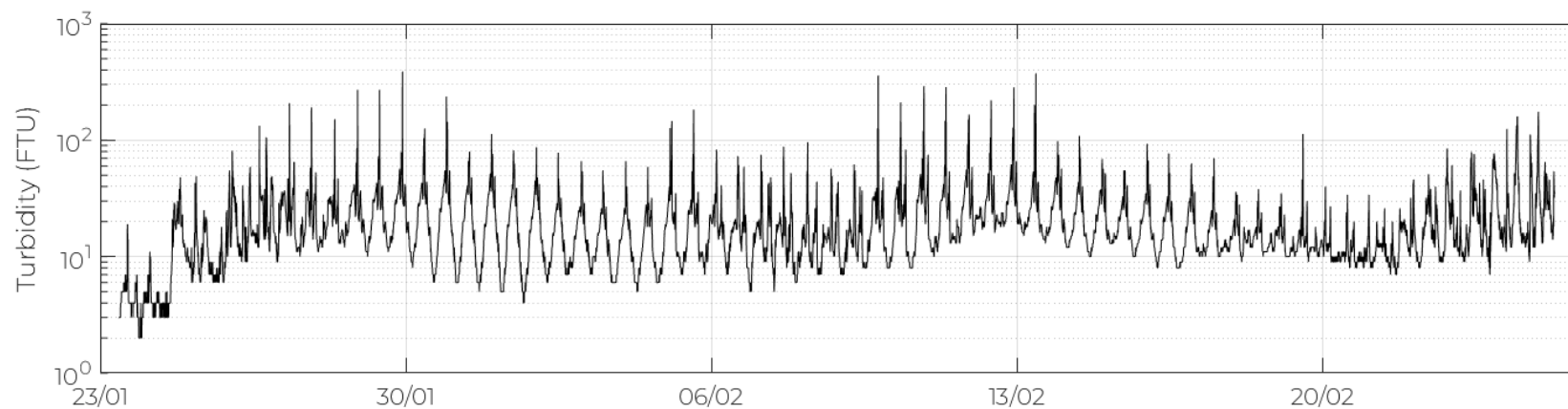


Figure 26: Site 1 Aqualogger turbidity.

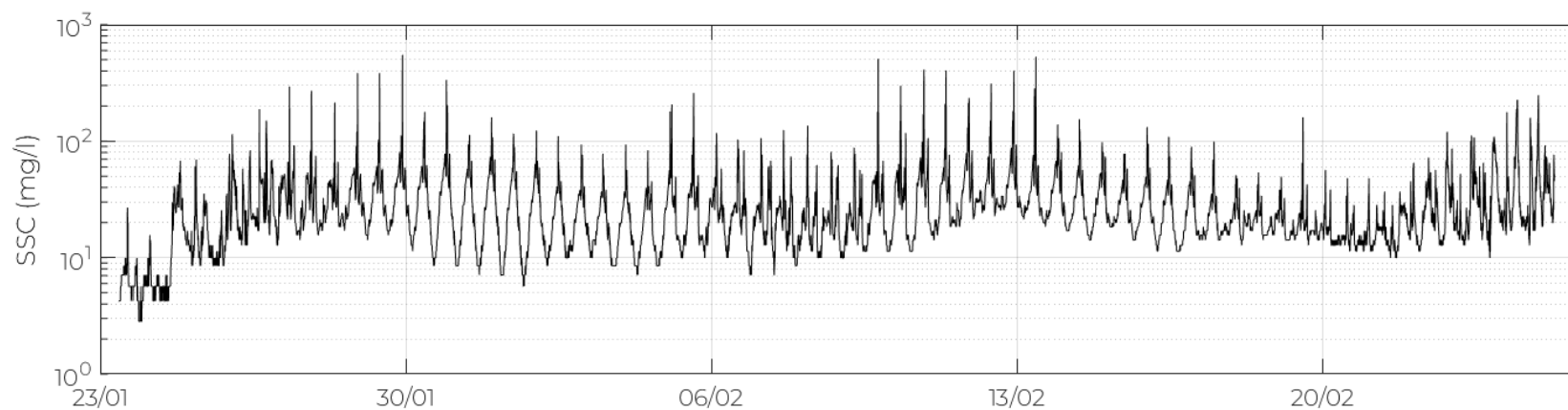


Figure 27: Site 1 Aqualogger derived suspended solids concentration.

3.3.2 Site 2 Aqualogger

Burst-mean data collected by the Aqualogger at Site 2 are presented in Figure 28 to Figure 31 as follows:

- Time series plots of pressure, temperature.
- Time-series (log-scale) plot of turbidity.
- Time-series (log-scale) plot Of derived suspended solids concentration.

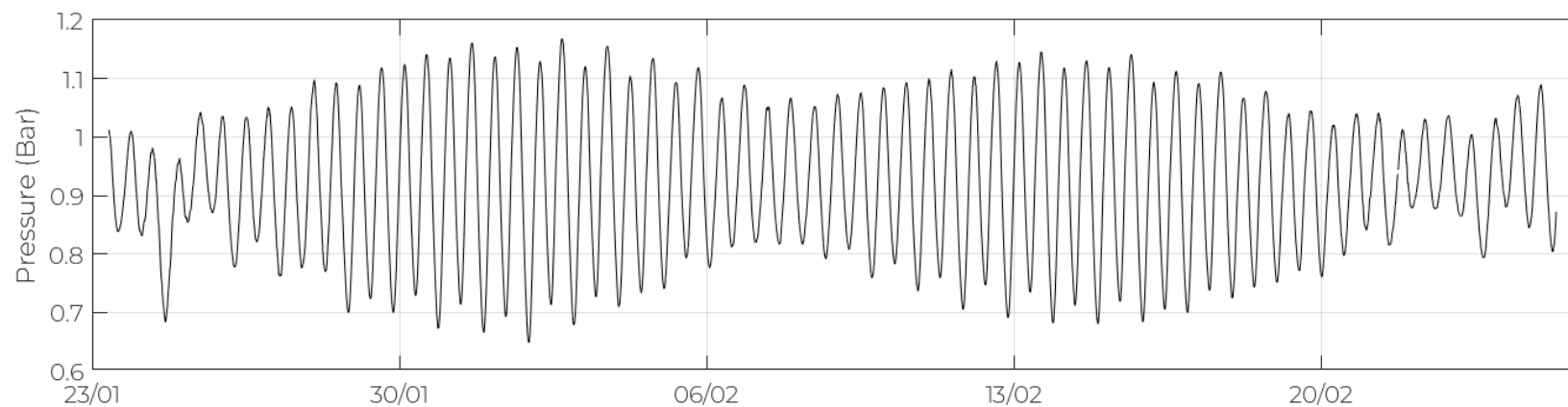


Figure 28: Site 2 Aqualogger pressure.

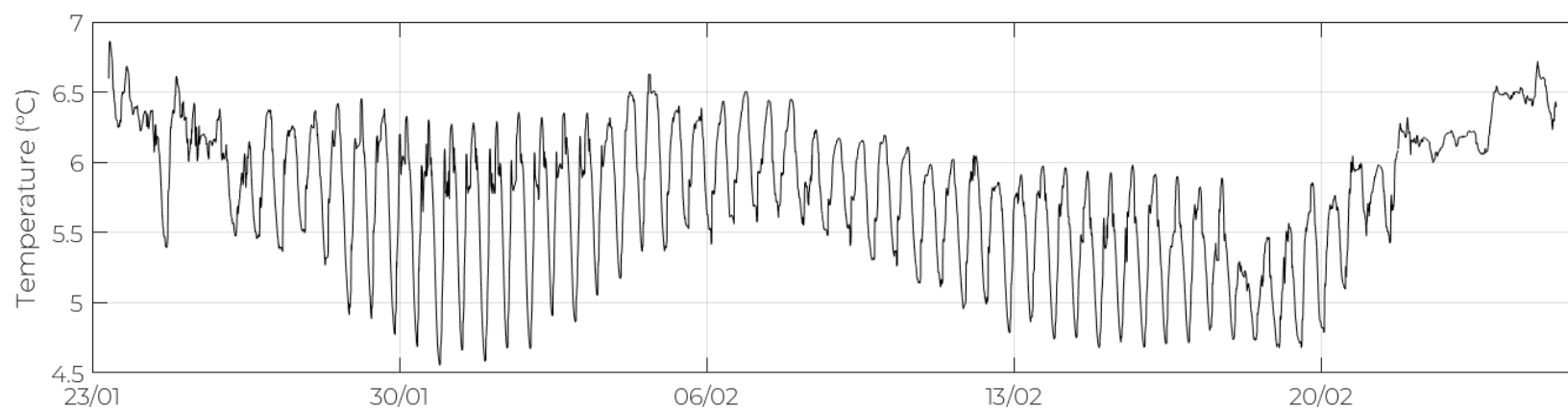


Figure 29: Site 2 Aqualogger temperature.

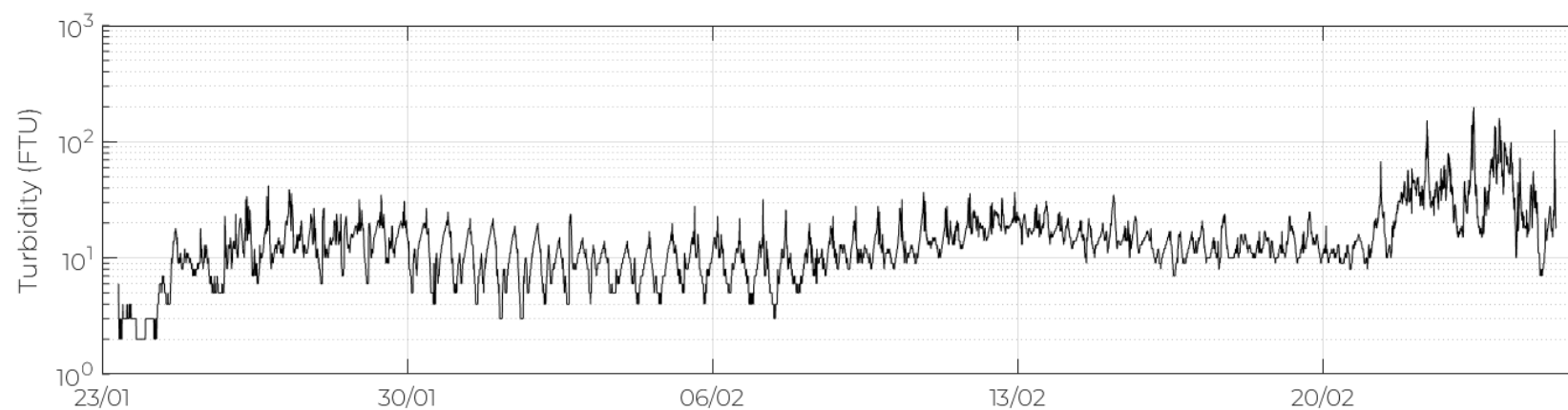


Figure 30: Site 2 Aqualogger turbidity.

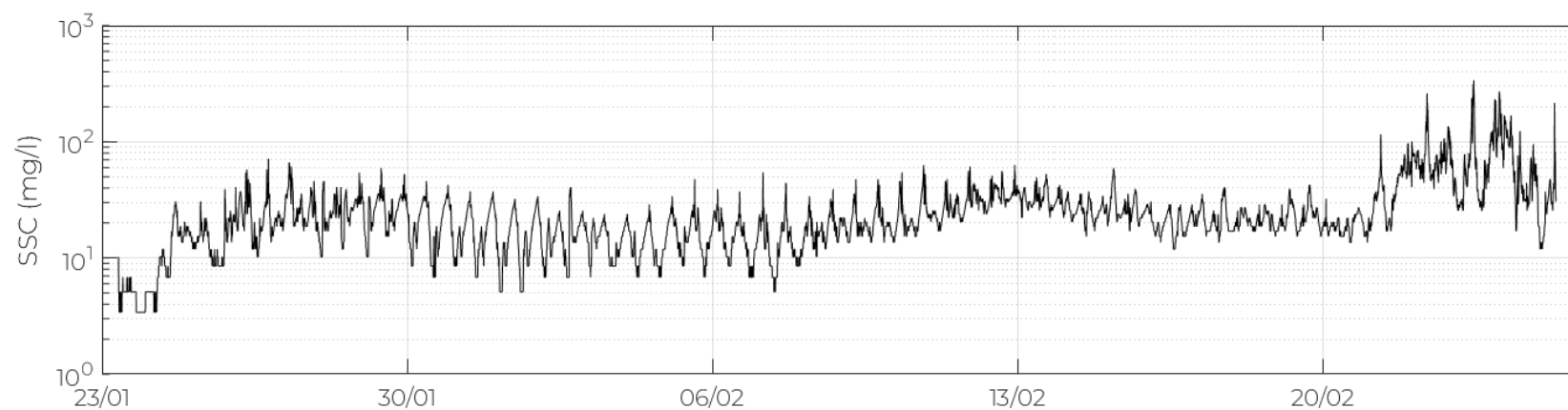


Figure 31: Site 2 Aqualogger derived suspended solids concentration.

3.4 Summary of Results

At Site 1, the fastest observed depth-mean current was 1.43 ms^{-1} , and the fastest observed current from all bins was 2.00 ms^{-1} . The temperature ranged between 4.22 and $6.55 \text{ }^{\circ}\text{C}$. The highest observed turbidity was 389 FTU and the highest observed suspended solids concentration was 551 mg l^{-1} .

At Site 2 the fastest observed depth-mean current was 1.86 ms^{-1} , and the fastest observed current from all bins was 2.05 ms^{-1} . The temperature ranged between 4.55 and $6.86 \text{ }^{\circ}\text{C}$. The highest observed turbidity was 199 FTU and the highest observed suspended solids concentration was 339 mg l^{-1} .

3.5 Provision of Data Files

- Raw data files downloaded from the deployed instruments.
- Quality controlled data files; and
- Data description files providing metadata and details of software packages for analysing non-ASCII format file.