FISHNISH B, SOUND OF MULL

MODELLING DATA COLLECTION REPORT

Report To	Scottish Environment Protection Agency
Deployment ID	FishB20180126T122904 & FishB 20220722T111507
Status	V1
Date	06/02/2023

Scottish Sea Farms Ltd
South Shian
Benderloch
Argyll & Bute
[redacted]

1. Site Description

Hydrographic surveys were carried out at the SSF marine cage fish farm (MCFF) Fishnish B. Current speed and direction, depth and meteorological data were collected as part of this survey for use with SEPA's particle tracking model NewDEPOMOD to assess this site's suitability for future development.

The survey area is located to the east of Fishnish Bay, Sound of Mull adjacent to the existing SSF Fishnish B site. The site is sheltered from most southerly directions winds with the greatest exposure to the wind from the northwest.

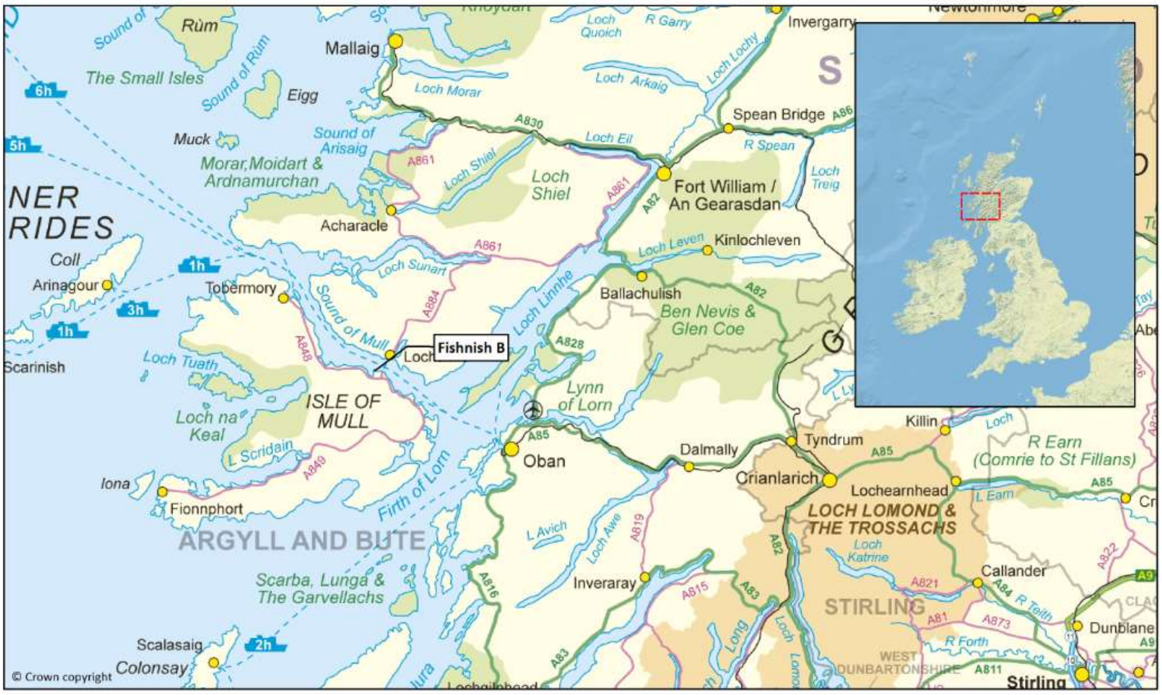


Figure 1: Survey location

2. Scope

SSF Hydrographic surveys were carried out at this location in January 2018 & July 2022. These surveys are presented in this report along with the summary statistics.

3. Methods

a. Instrument deployment

In each survey an Acoustic Doppler Current Profiler (ADCP) was deployed at the survey location. Specifically, a Teledyne Sentinel v50 mounted in a fiberglass Seaspider frame was deployed in a u-shaped mooring with ground rope running to weights attached to surface buoys. The current meters were deployed within 150 m the site centre.

- 2018 - 56 31.119 N 05 48.976 W (165343, 742817) 26/01/2018 to 29/03/2018
- 2022 - 56 31.146 N 05 49.046 W (165275, 742871) 22/07/2022 to 28/09/2022

Position fixes were obtained using a Garmin GPSmap 76S in WGS84. The GPS position accuracy was compared against a known location and checked for consistency at the end of the survey.

Current flow and direction were recorded at throughout the water column using 1 m bins with an averaging period of 20 minutes.

Deployment configuration:

Table 1: ADCP configuration for Fishnish B 2018 & 2022 hydrographic surveys

Survey	2018	2022
Frequency	492 kHz	492 kHz
Pings/Ens	400	350
Ensemble Interval (s)	1200	1200
1st Bin Range (m)	2.21	2.23
Bin Size (m)	1	1

b. Data processing

All datasets are first opened in the Teledyne's data processing software package Velocity where they are given an initial inspection (e.g. orientation, pitch, roll, heading) to check that the meter has remained undisturbed and there are no obvious breaks in the data. Any side lobe interference is removed. If a dataset passes this first check the valid cells are exported in ASCII format and then examined in detail using Teledyne's *QA/QC Parameter for Acoustic Doppler Current Profilers* application. Appropriate depth cells representing the bed, cage bottom and surface currents were determined as outlined in SEPA's Regulatory Modelling Guidance for the Aquaculture Sector (July 2019, v1.1) and these data analysed using the SEPA tool *HGdata_analysis_v7.11.xls.* All bearings were corrected from magnetic north to grid north using the appropriate Grid Magnetic Angle using declinations obtained for the survey position and date from the IGRF 2020 Model provided online by NOAA, and from a grid convergence angle calculated from the deployment National Grid Reference by the HGdata_analysis spreadsheet.

4. Flow data

a. Deployment position

Deployment positions are given in Table 2 and Figure 3 below. The ADCPs were within 150 m of the existing site centre and within 100 m of the nearest cage. Recorded depths were corrected to chart datum using predicted tidal heights from Craignure obtained from Admiralty TotalTide (ATT).

Table 2: Recorded location and depth of Fishnish B 2018 and 2022 current meter deployments

Date & time (UT)	Latitude	Longitude	Easting	Northing	Depth (mCD)
26/01/2018 13:29:09	56° 31.119 N	05° 48.976 W	165343	742817	28.56
22/07/2022 14:20:00	56° 31.146 N	05° 49.046 W	165275.4	742871.2	30.27

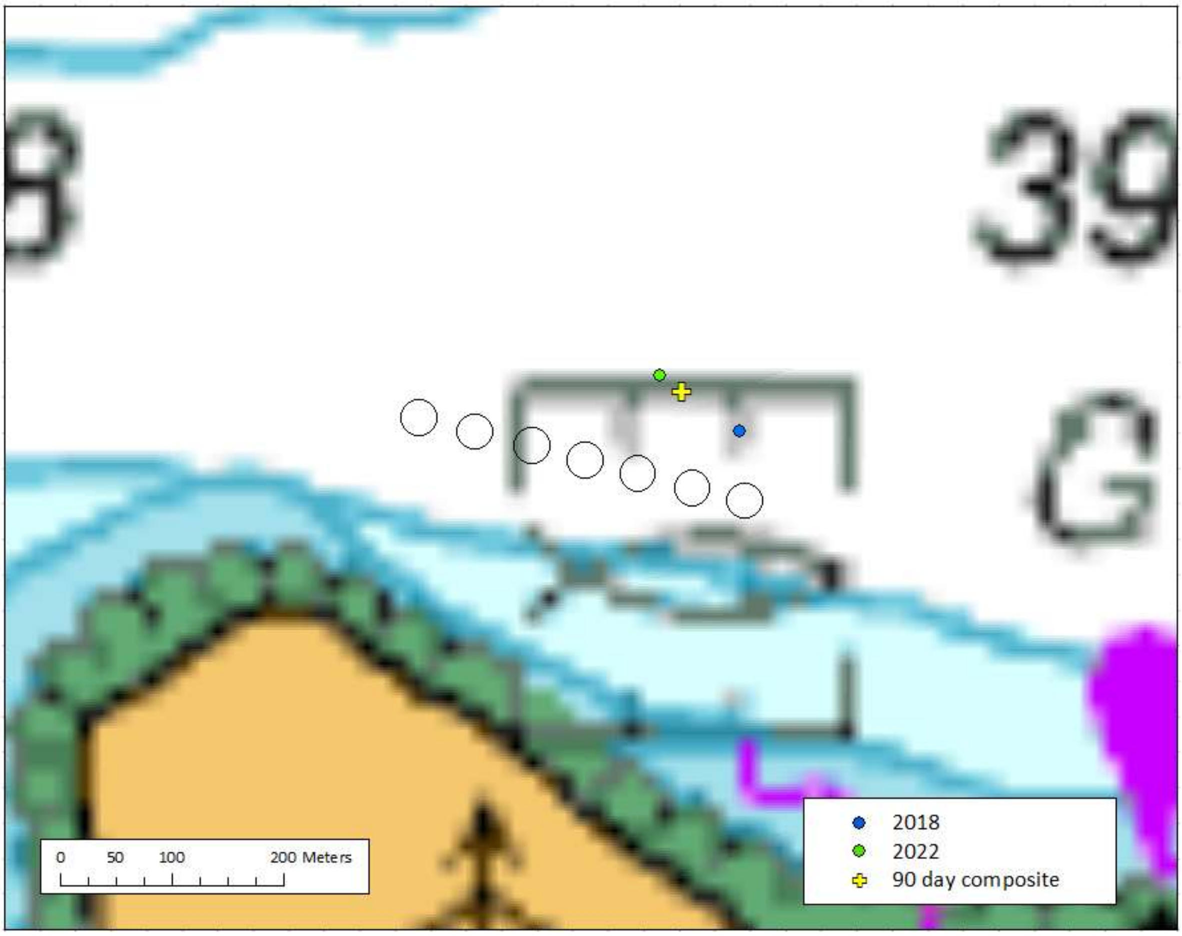


Figure 2: Recorded location of Fishnish B 2018 & 2022 current meter deployments and the 90-day composite position used for NewDepomod modelling

b. Description

i. Quality

2018

Valid ensembles were collected during this deployment for the period 26/01/2018 13:29:09 – 29/03/2018 10:49:09 giving 61.9 days of data with valid bins 1 - 27. Small amount of rocking in the pitch and roll during the deployment however this was well within the tolerance of the ADCP while there is some minor drift in the heading this was insignificant over the length of the survey with an overall change 2.53 degrees. This could be attributed to the meter settling. Plots of heading, pitch, roll and sensor depth are presented at Appendix B.

The recorded pressure was compared with the estimated tidal heights for Craignure. Both range and timing are relatively consistent with those predicted. The pressure record indicates that the mean depth during the deployment, including the height of the frame, was 31.12 m and the sensor depth at deployment was 28.56 mCD.

The standard deviation (SD) for each ensemble at each cell is calculated according to:

$$cell\ SD = \frac{single\ ping\ SD}{\sqrt{\frac{(PG1 + PG4)}{100} * no.of\ pings}}$$

Where the single ping SD is specific to the Sentinel v50 for a cell size of 1.0 m (0.0736 m s^{-1}), PG1 (percent good 1) and PG4 are the percentages of 3 and 4 beam solutions respectively (i.e. valid pings) and the number of pings is that per ensemble programmed for the deployment (400).

The mean SD for bins 1 to 27 is 0.0037 m $s^{-1}$and is therefore well within the SEPA guideline threshold for horizontal precision of exceeding 10% of the mean velocity recorded (0.2337 m s^{-1}, cells 1-27).

In bins 21 – 27 there is an occasional missing record, this may have been caused by water clarity or may be an indication of a rope or other obstruction causing occasional interference. There is minimal impact on the bins selected for modelling and repairs have been carried out at the following locations:

Bin 22

- 14/02/2018 02:29:09
- 21/02/2018 04:29:09
- 09/03/2018 18:29:09
- 10/03/2018 08:49:09 - 10/03/2018 09:29:09
- 12/03/2018 09:49:09 - 12/03/2018 10:29:09
- 13/03/2018 11:49:09 - 13/03/2018 12:09:09
- 28/03/2018 00:29:09

Repairs were made by taking the average of the good cells either side of the cells requiring repair. This was also verified by checking for agreement with surrounding bins and corresponding tidal phase within the record. A total of 12 cells were repaired.

2022

Valid ensembles were collected during this deployment for the period 22/07/2022 14:20– 28/09/2022 09:00 giving 67.8 days of data with valid bins 1-26. Plots of heading, pitch, roll and sensor depth are presented at Appendix C.

The recorded pressure was compared with the estimated tidal heights for Craignure. Both range and timing are consistent with those predicted. The pressure record indicates that the mean depth during the deployment, including the height of the frame, was 29.77 m and the sensor depth at deployment was 30.27 mCD.

The standard deviation (SD) for each ensemble at each cell is again calculated according to:

$$cell\ SD = \frac{single\ ping\ SD}{\sqrt{\frac{(PG1 + PG4)}{100} * no.of\ pings}}$$

Where the single ping SD is specific to the Sentinel v50 for a cell size of 1.0 m (0.0736 m s^{-1}), PG1 (percent good 1) and PG4 are the percentages of 3 and 4 beam solutions respectively (i.e. valid pings) and the number of pings is that per ensemble programmed for the deployment (350).

The mean SD for bins 1 to 26 is 0.0039 m $s^{-1}$and is therefore well within the SEPA guideline threshold for horizontal precision of exceeding 10% of the mean velocity recorded (0.2551 m s^{-1}, cells 1-26).

ii. Depth cell selection

Bins 1, 17, 22 (2018) and 1, 17, 24 (2018) were selected to represent near-bed, pen-bottom and sub-surface conditions respectively, detailed in Table 3. The near-bed cell is at a depth within 3 m above the seabed. The pen-bottom cell was selected from a depth corresponding to the bottom of the pens at the mean depth observed during the deployment period. The sub-surface cell was selected from a depth to be within 5 m of the lowest observed tide during the deployment, while being below potential effects from wave breaking or side-lobe interference.

Table 3: Depth cell selection

Number	m from seabed
2018	
1	2.8
17	18.8
22	23.8
2022	
1	2.8
17	18.8
24	25.8

iii. Analysis

The summary statistics for the datasets are given in Tables 4 & 5 below.

2018

Table 4: Fishnish B (FishB20180126T122904) hydrographic summary statistics.

	Near-bed	Pen-bottom	Sub-surface
Mean velocity (m s^{-1})	0.175	0.252	0.255
Min velocity (m s^{-1})	0.003	0.001	0.002
Max velocity (m s^{-1})	0.564	0.698	0.794
Ranked percentage 0.095 m s^{-1}	24 %	14 %	14 %
Major axis (°G)	110	280	280
Amplitude anisotropy	3.22	1.46	5.73
Residual velocity (m s^{-1})	0.03	0.03	0.04
Residual direction (°G)	105	218	248
Parallel Residual (m s^{-1})	0.033	0.012	0.032
Normal Residual (m s^{-1})	-0.003	-0.022	-0.020
Parallel tidal amplitude (m s^{-1})	0.269	0.402	0.407
Normal tidal amplitude (m s^{-1})	0.084	0.066	0.071
	Min	**Max**	**Range**
Depth (m)	28.57	33.11	4.54

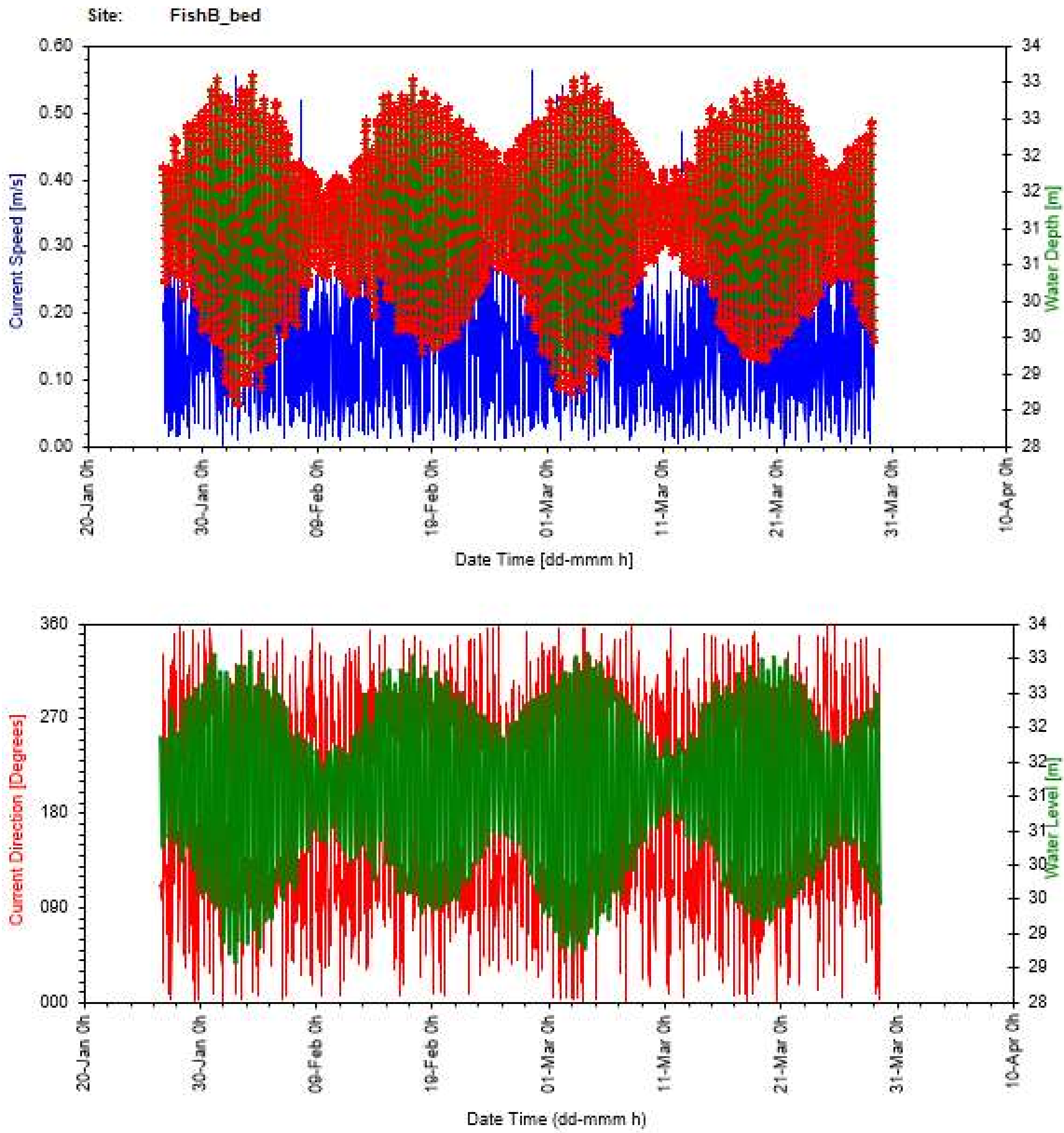


Figure 3: Near-bed time series plots for current speed and direction against water level

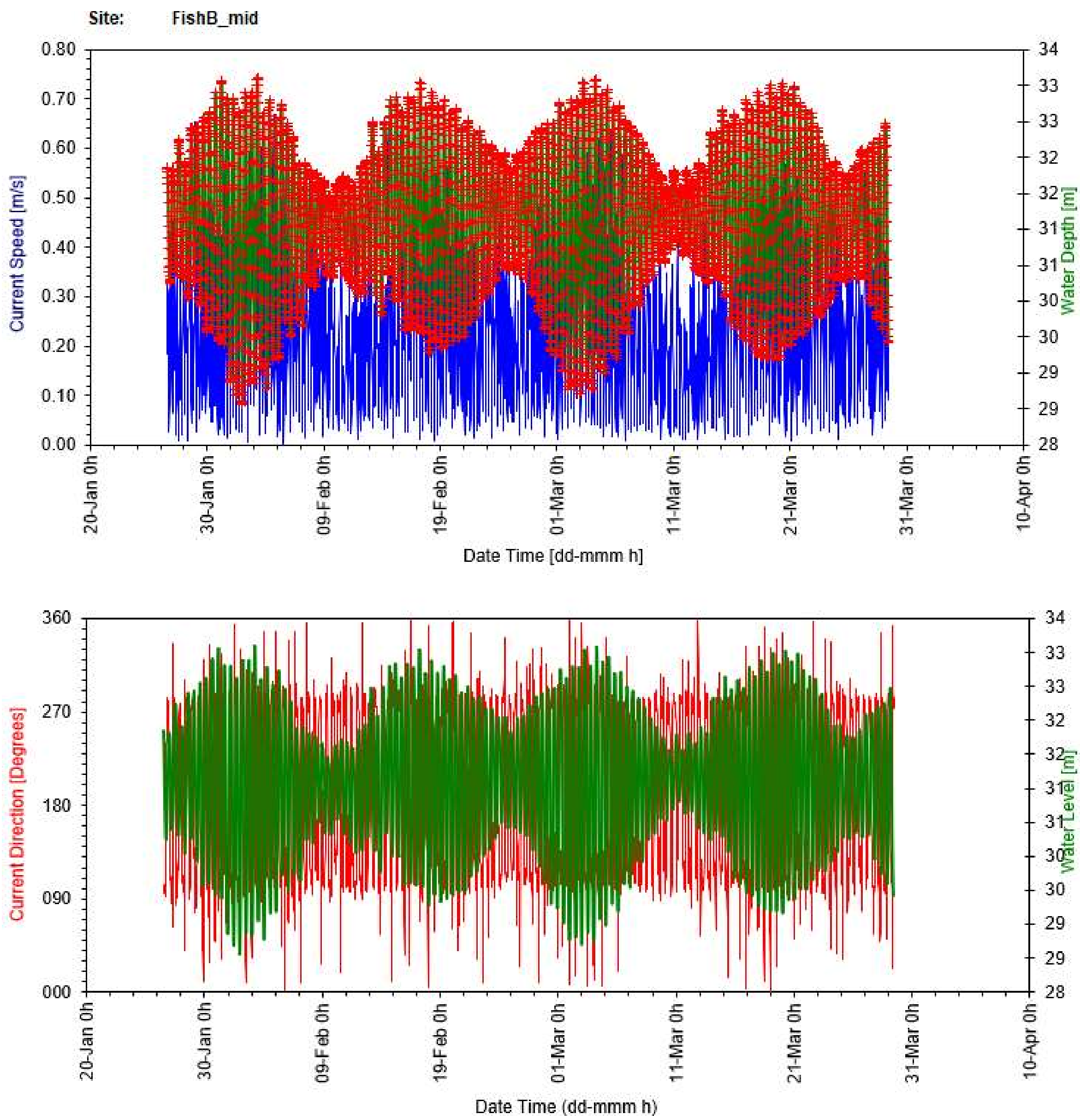
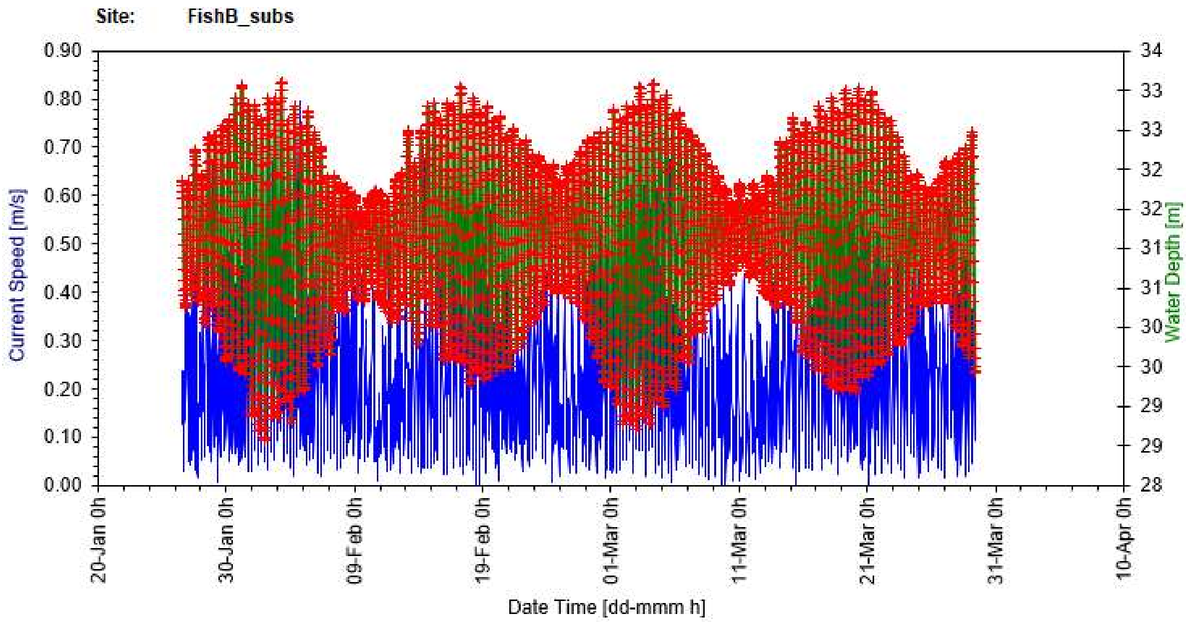


Figure 4: Cage bottom time series plots for current speed and direction against water level



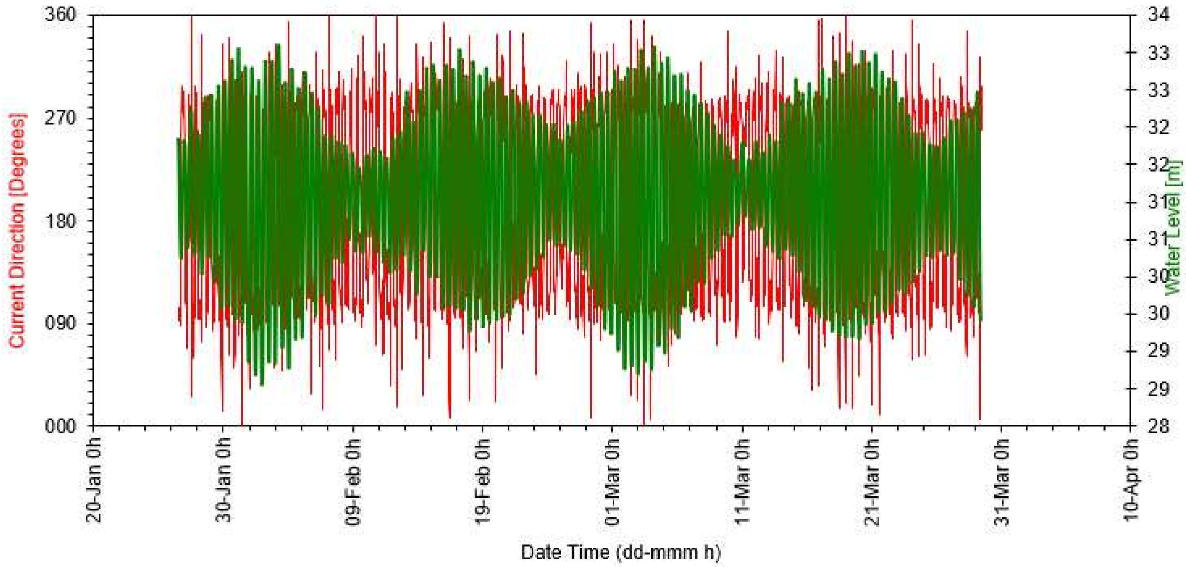


Figure 5: Subsurface time series plots for current speed and direction against water level

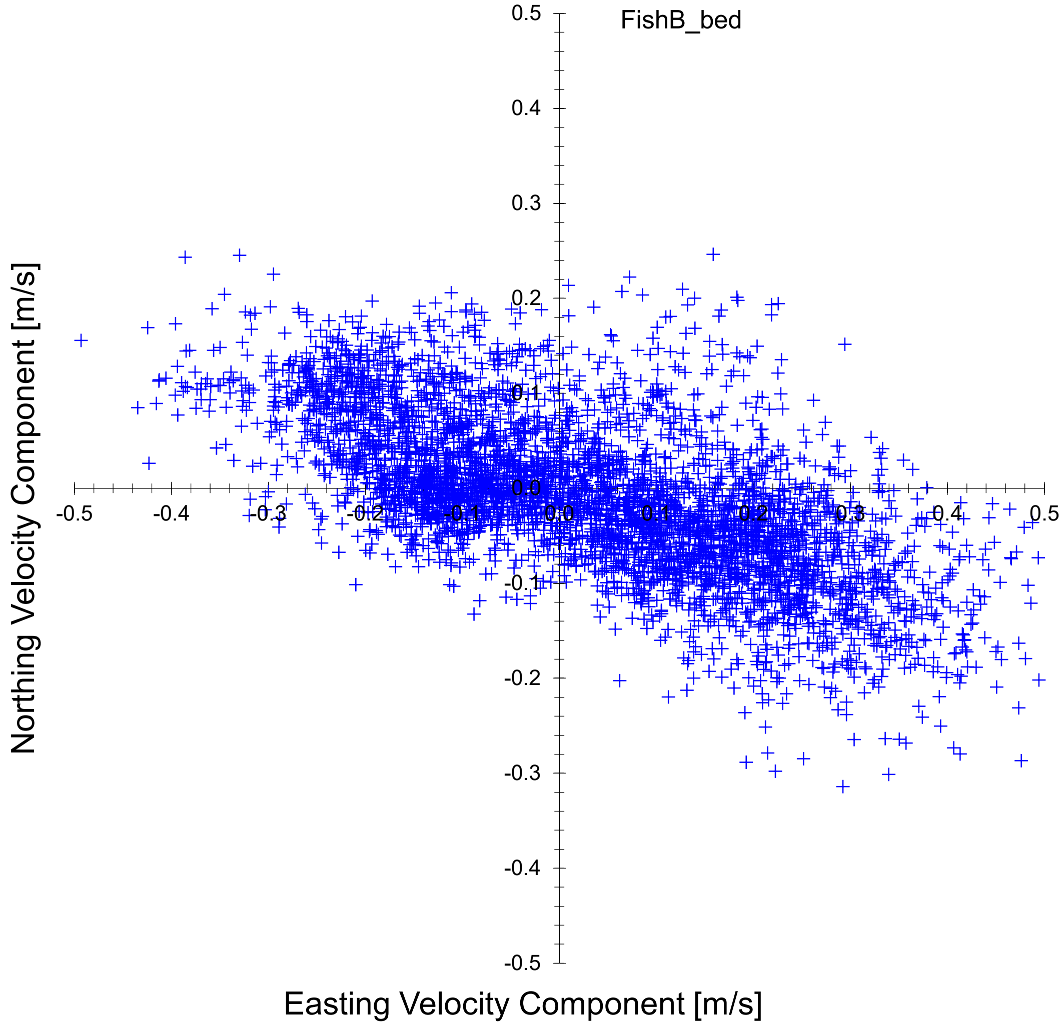


Figure 6: Near-bed scatter plot of easting and northing velocity components

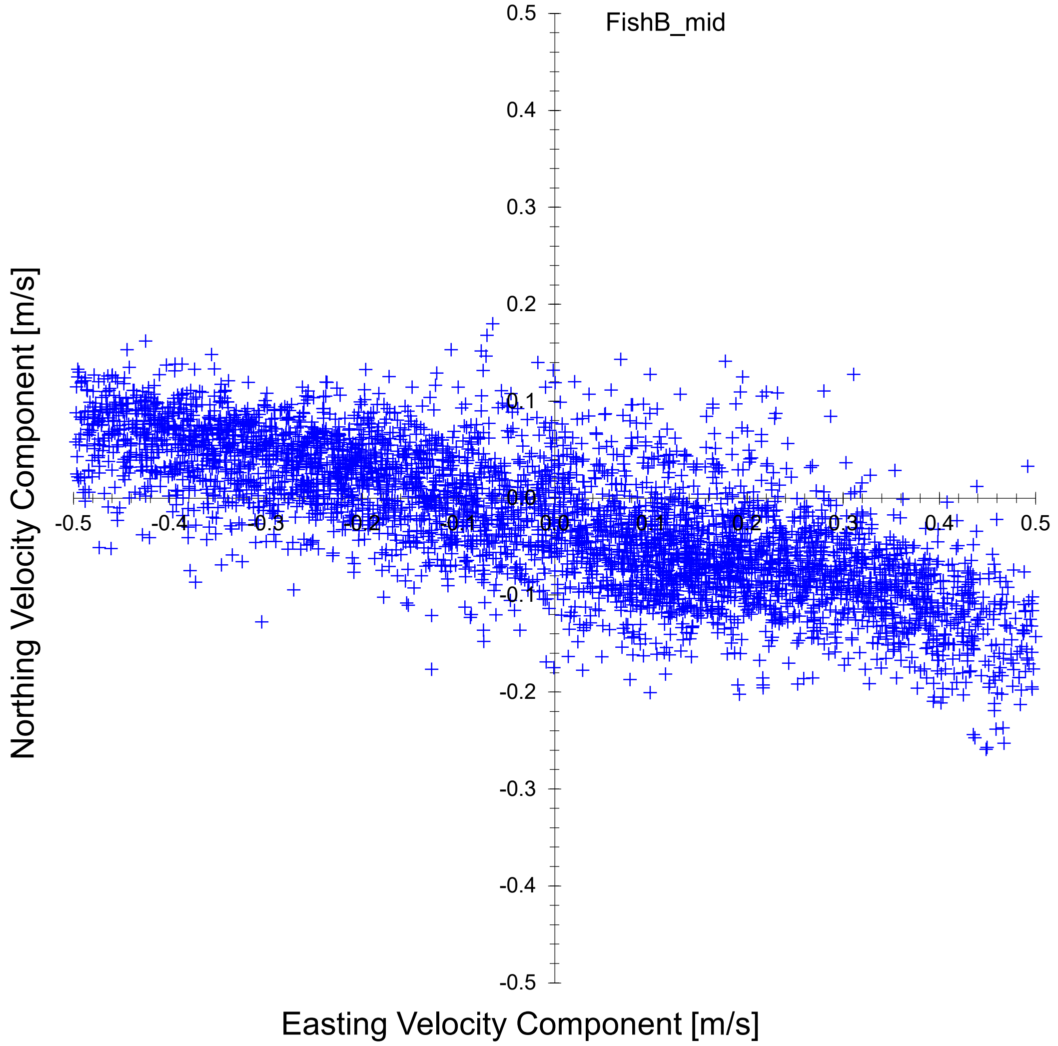


Figure 7: Cage bottom scatter plot of easting and northing velocity components

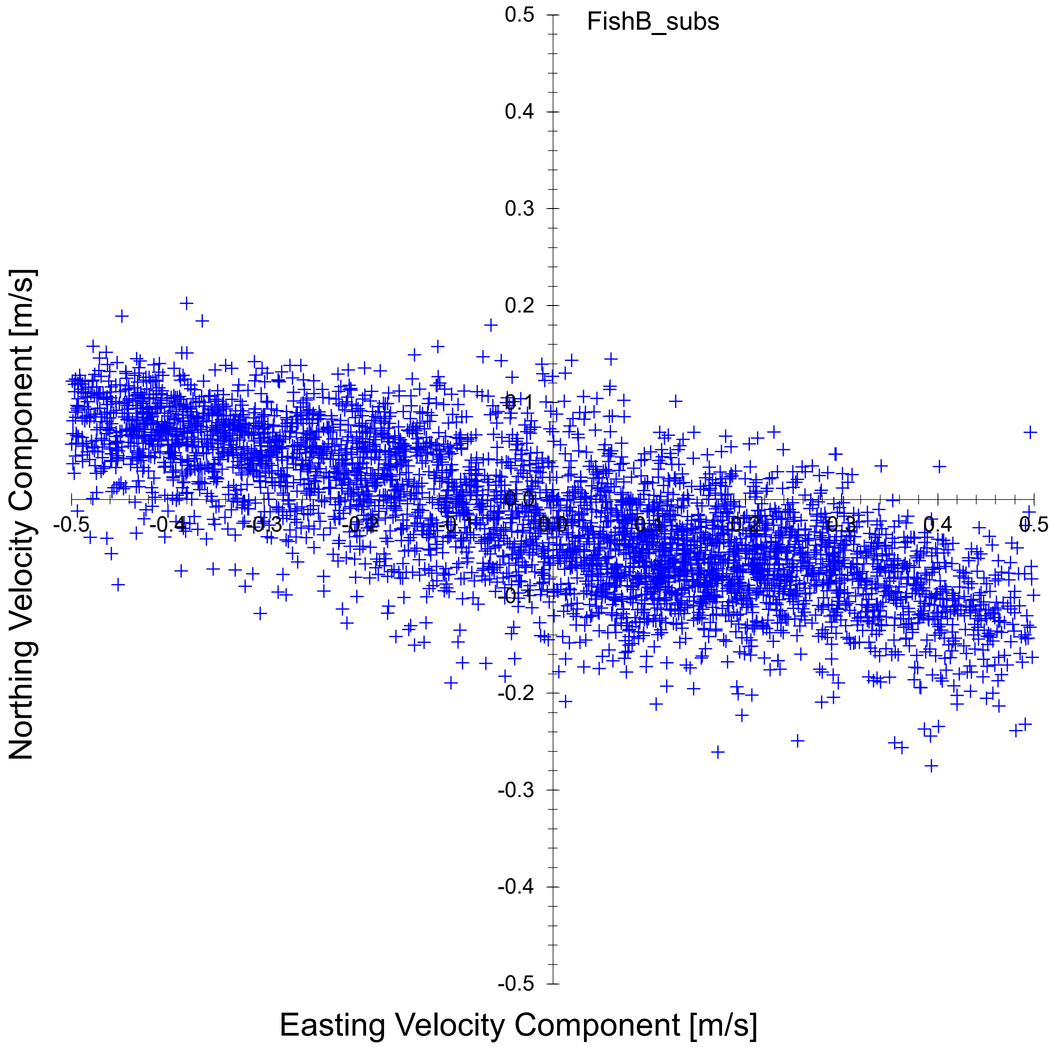


Figure 8: Subsurface scatter plot of easting and northing velocity components

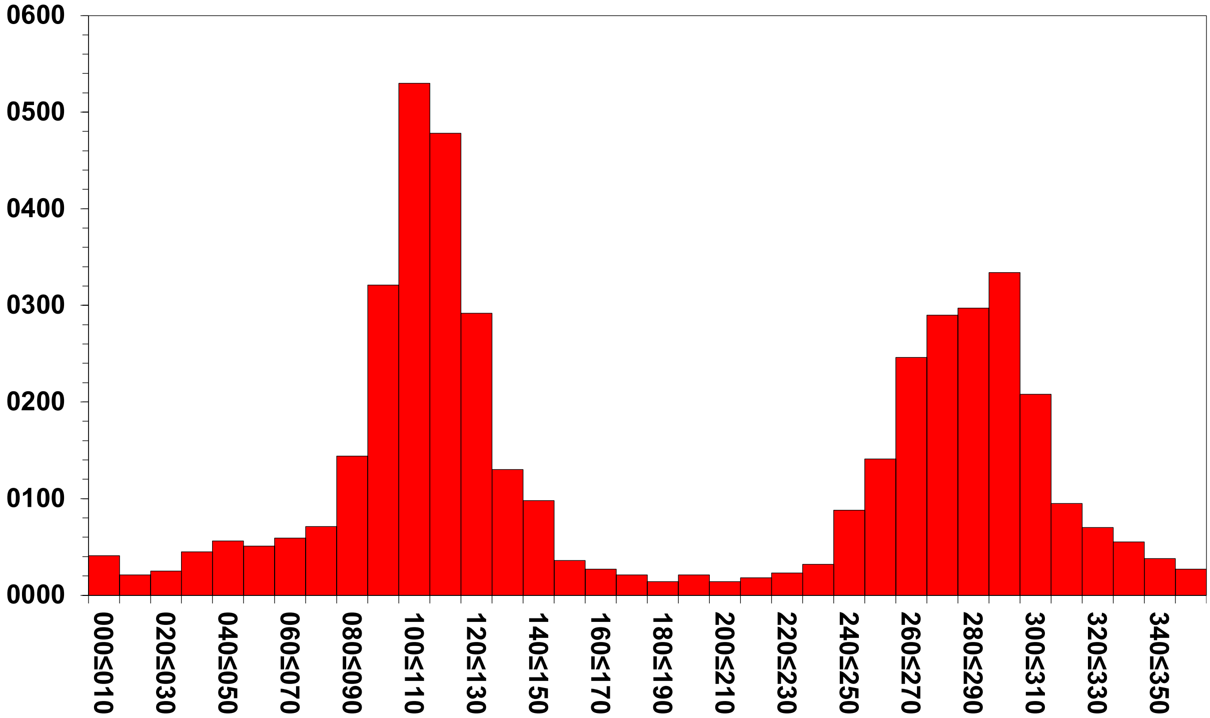


Figure 9: Near-bed current direction frequency plot.

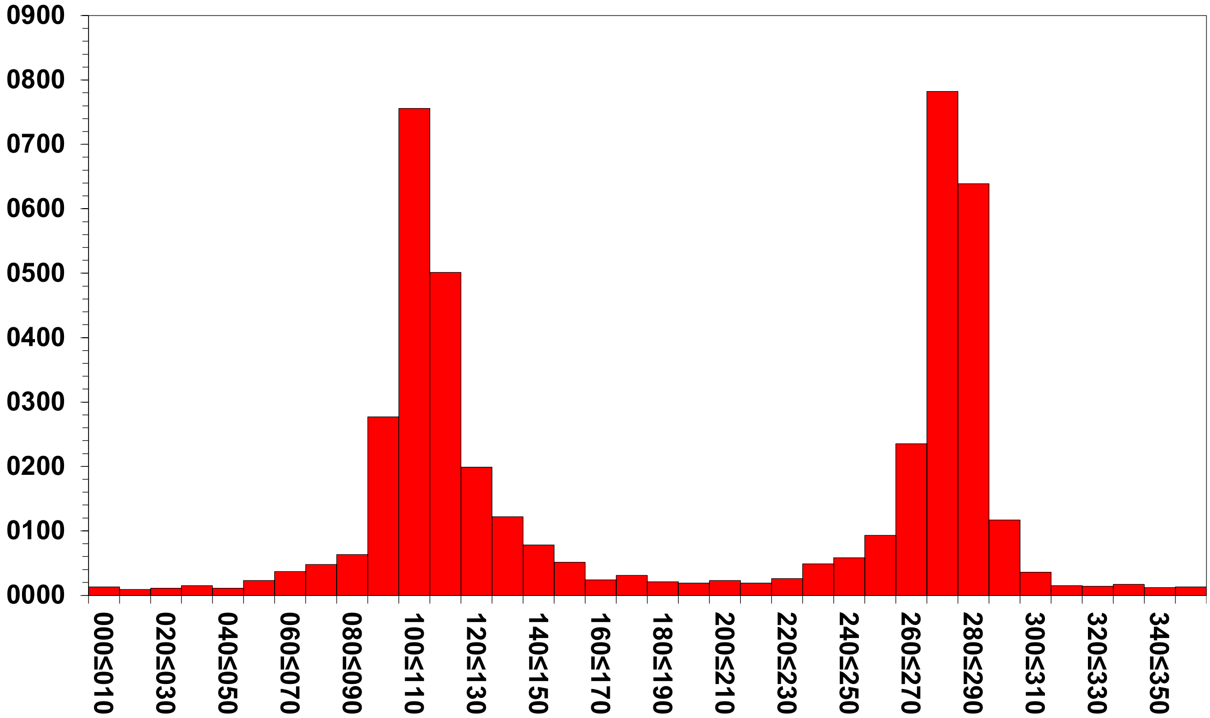


Figure 10: Cage bottom current direction frequency plot.

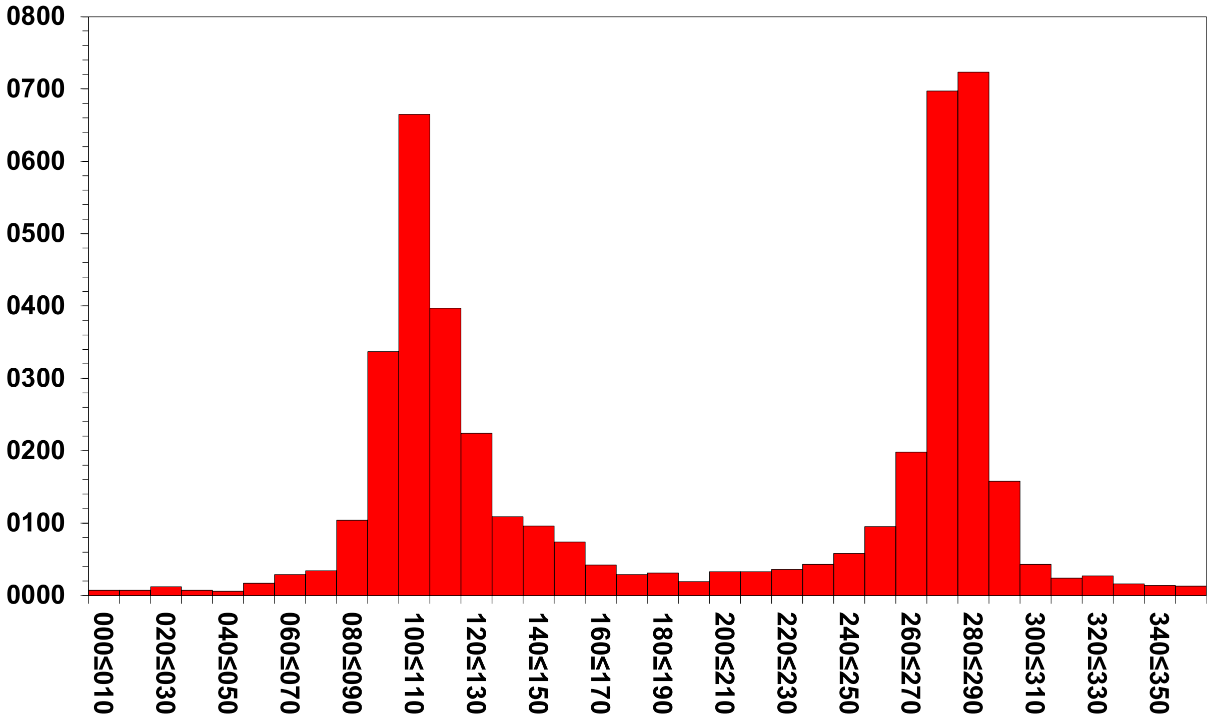


Figure 11: Subsurface current direction frequency plot.

2022

Table 5: Fishnish B (FishB 20220722T111507) hydrographic summary statistics.

	Near-bed	Cage bottom	Sub-surface
Mean velocity (m s^{-1})	0.207	0.266	0.256
Min velocity (m s^{-1})	0.004	0.001	0.001
Max velocity (m s^{-1})	0.634	0.663	0.730
Ranked percentage 0.095 m s^{-1}	21 %	14 %	15 %
Major axis (°G)	105	275	275
Amplitude anisotropy	4.43	6.41	5.40
Residual velocity (m s^{-1})	0.04	0.01	0.04
Residual direction (°G)	084	351	287
Parallel Residual (m s^{-1})	0.039	0.001	0.038
Normal Residual (m s^{-1})	-0.015	0.005	0.008
Parallel tidal amplitude (m s^{-1})	0.323	0.423	0.407
Normal tidal amplitude (m s^{-1})	0.073	0.066	0.075
	Min	**Max**	**Range**
Depth (m)	30.51	35.01	4.5

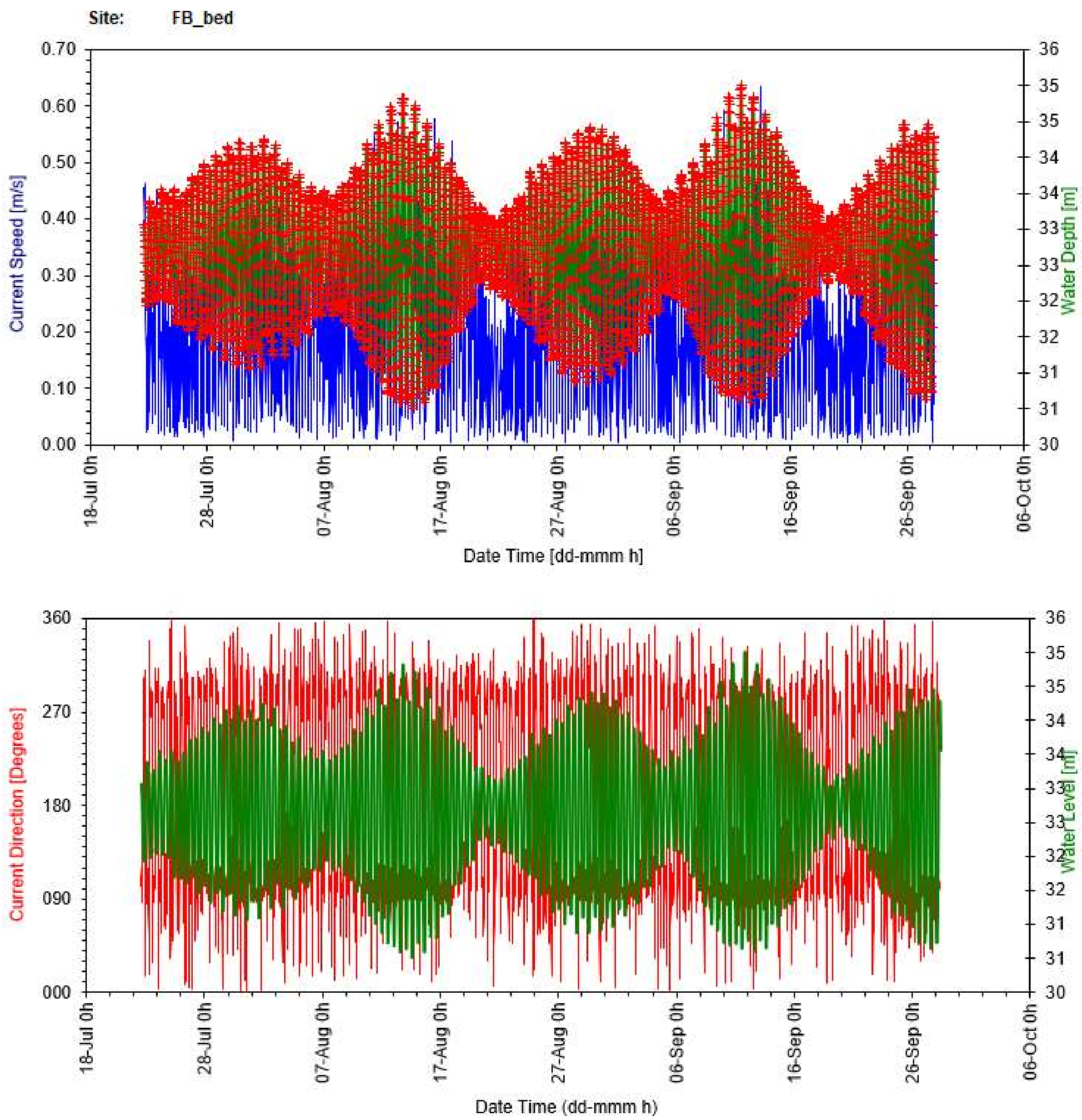


Figure 12: Near-bed time series plots for current speed and direction against water level

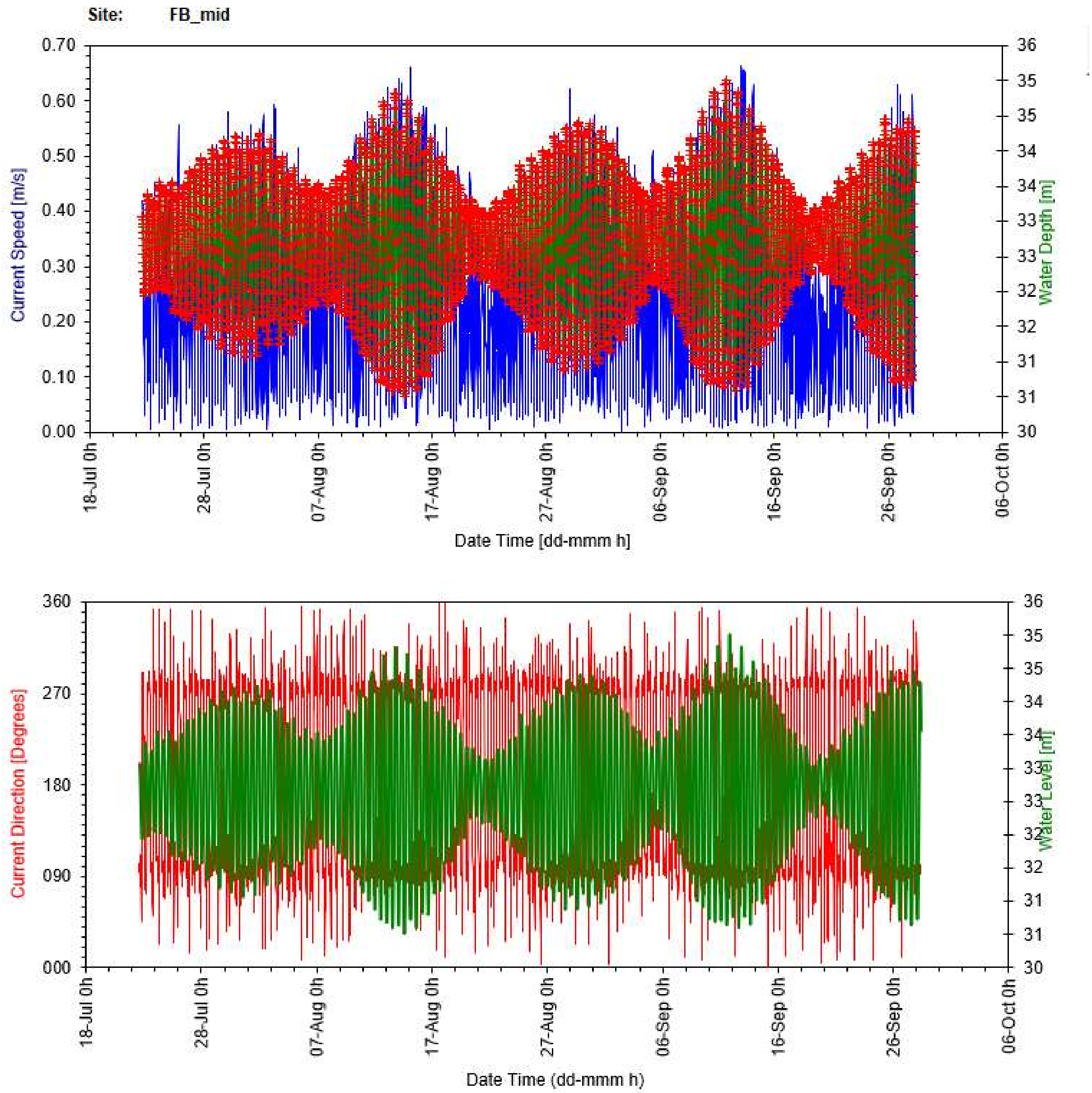


Figure 13: Cage bottom time series plots for current speed and direction against water level

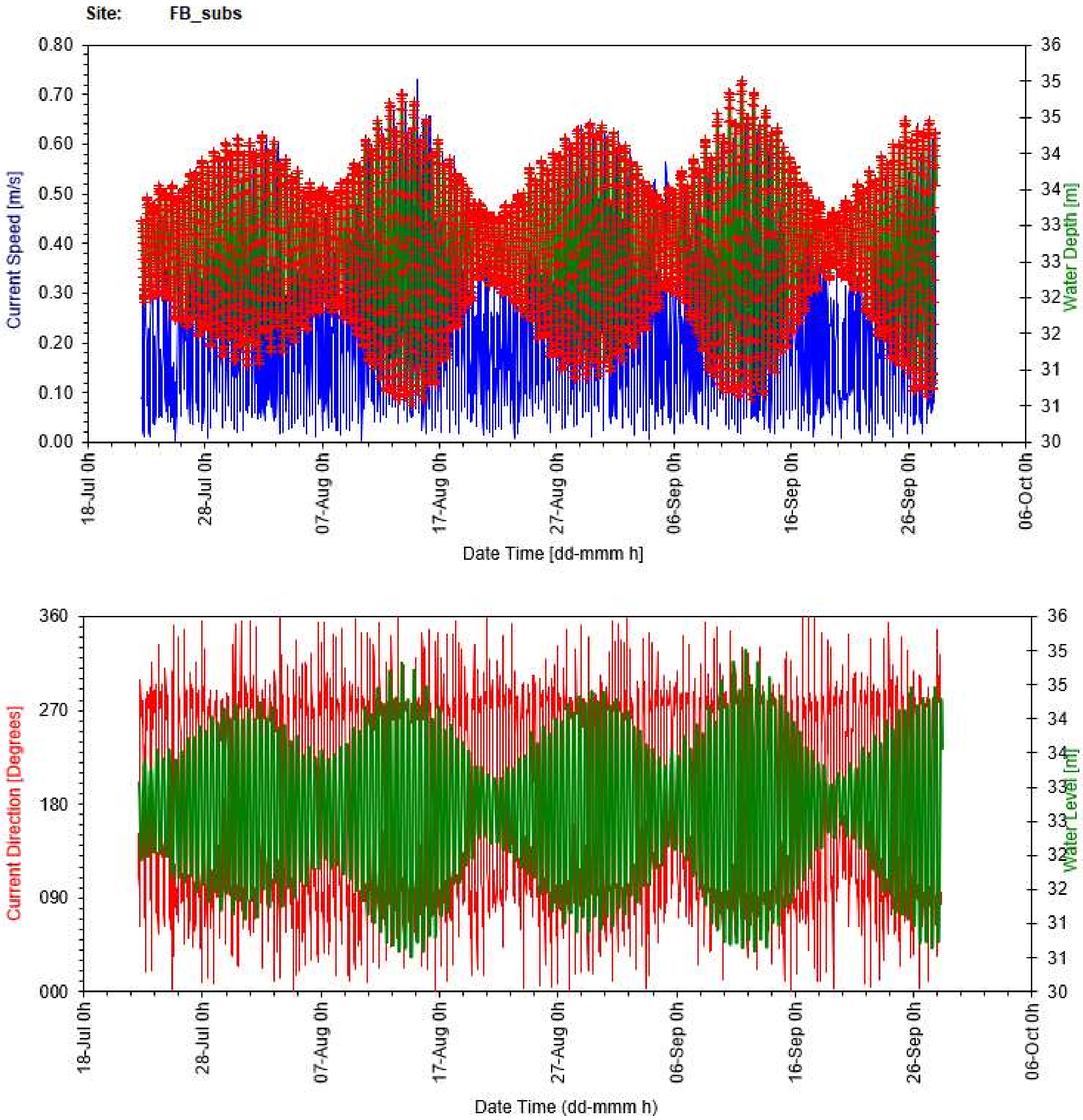


Figure 14: Subsurface time series plots for current speed and direction against water level

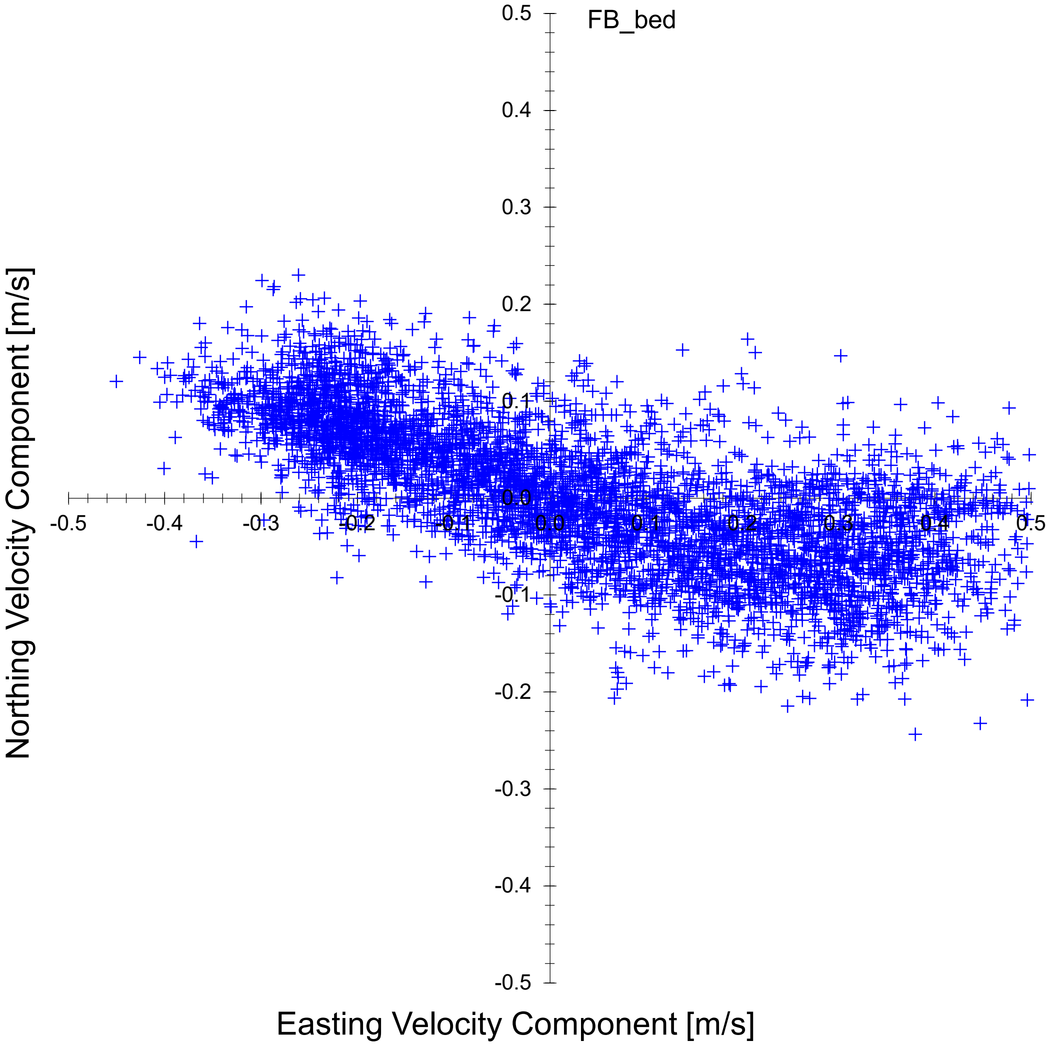


Figure 15: Near-bed scatter plot of easting and northing velocity components

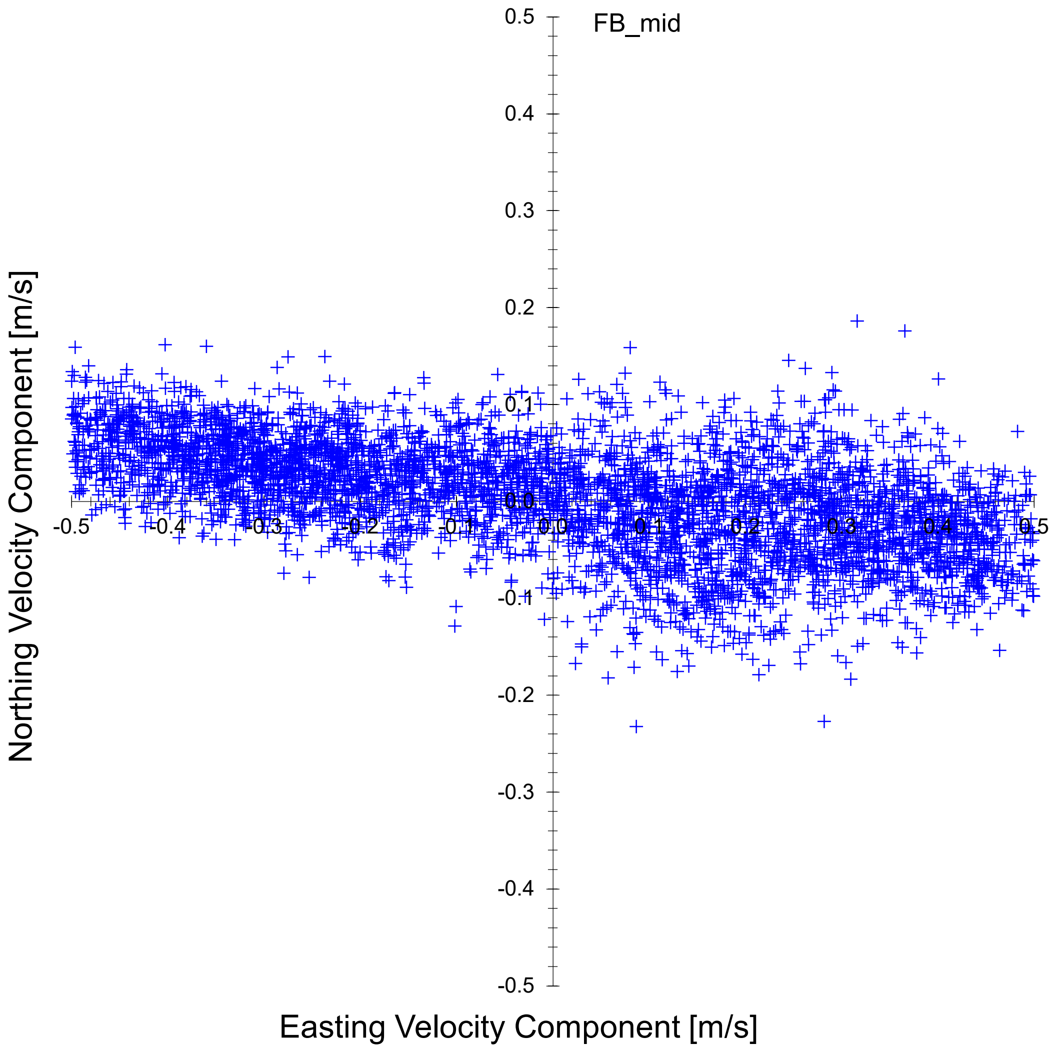


Figure 16: Cage bottom scatter plot of easting and northing velocity components

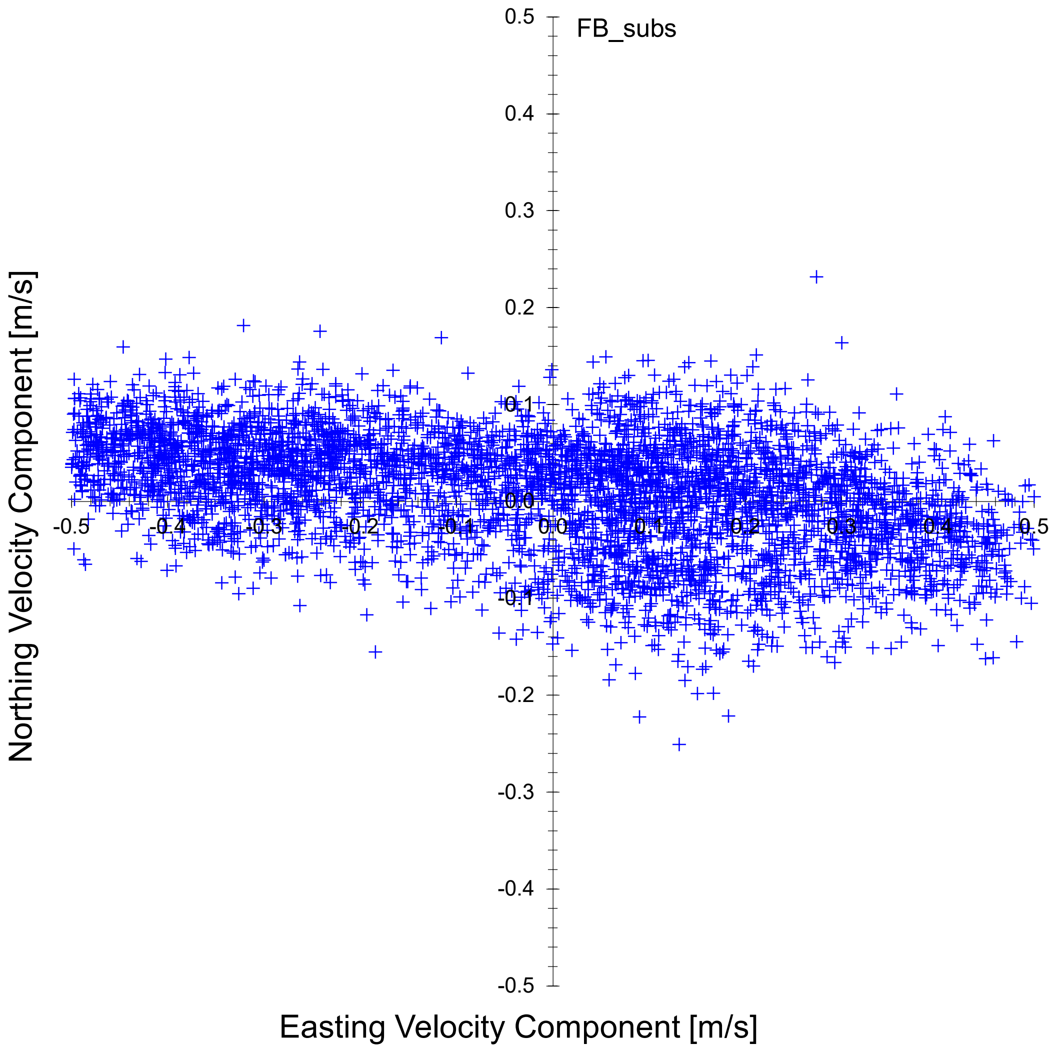


Figure 17: Subsurface scatter plot of easting and northing velocity components

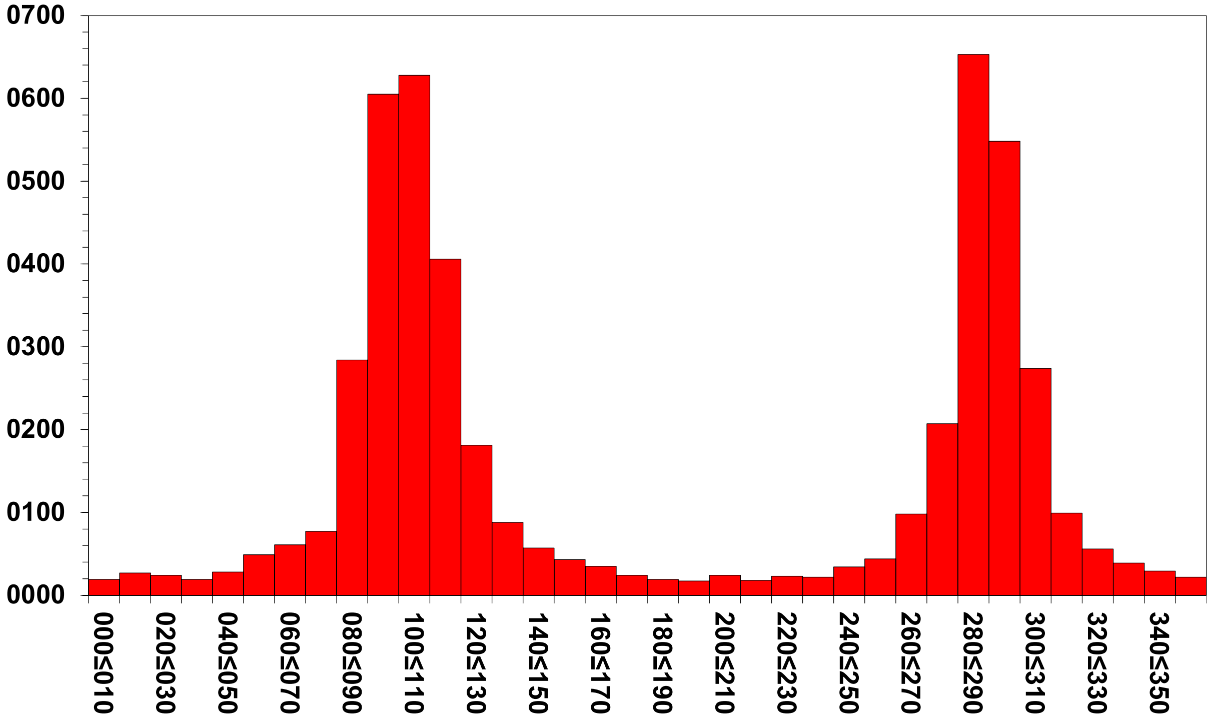


Figure 18: Near-bed current direction frequency plot.

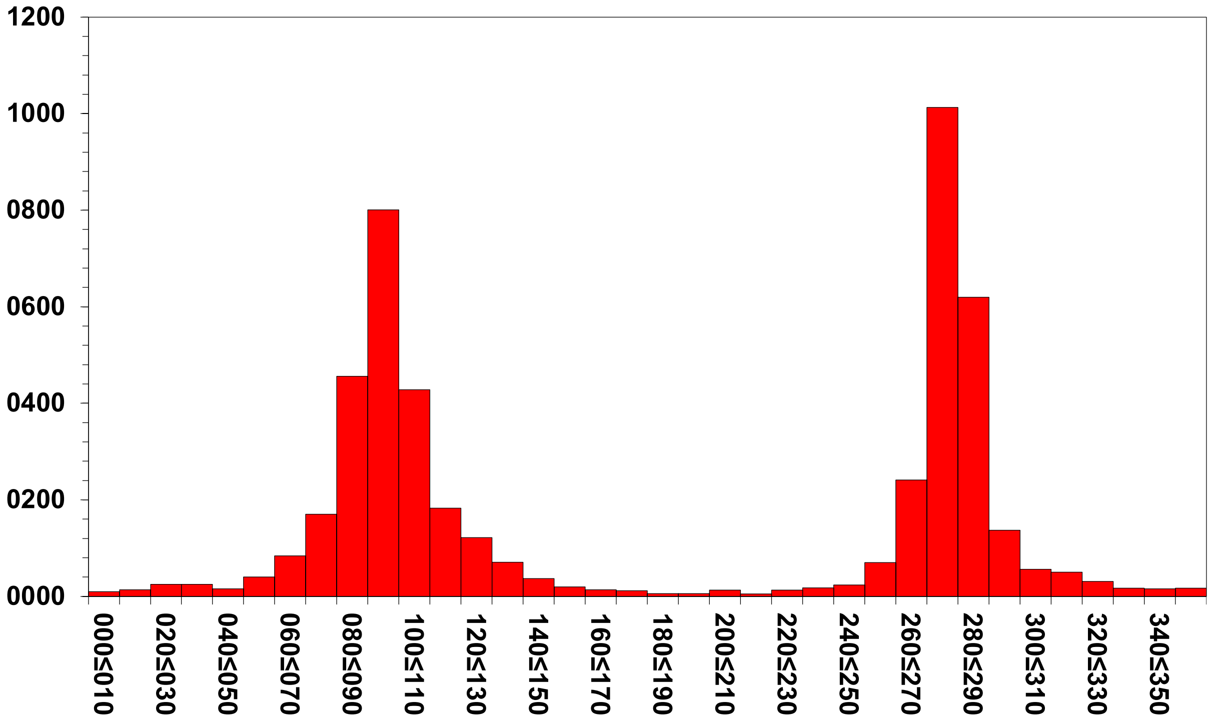


Figure 19: Cage bottom current direction frequency plot.

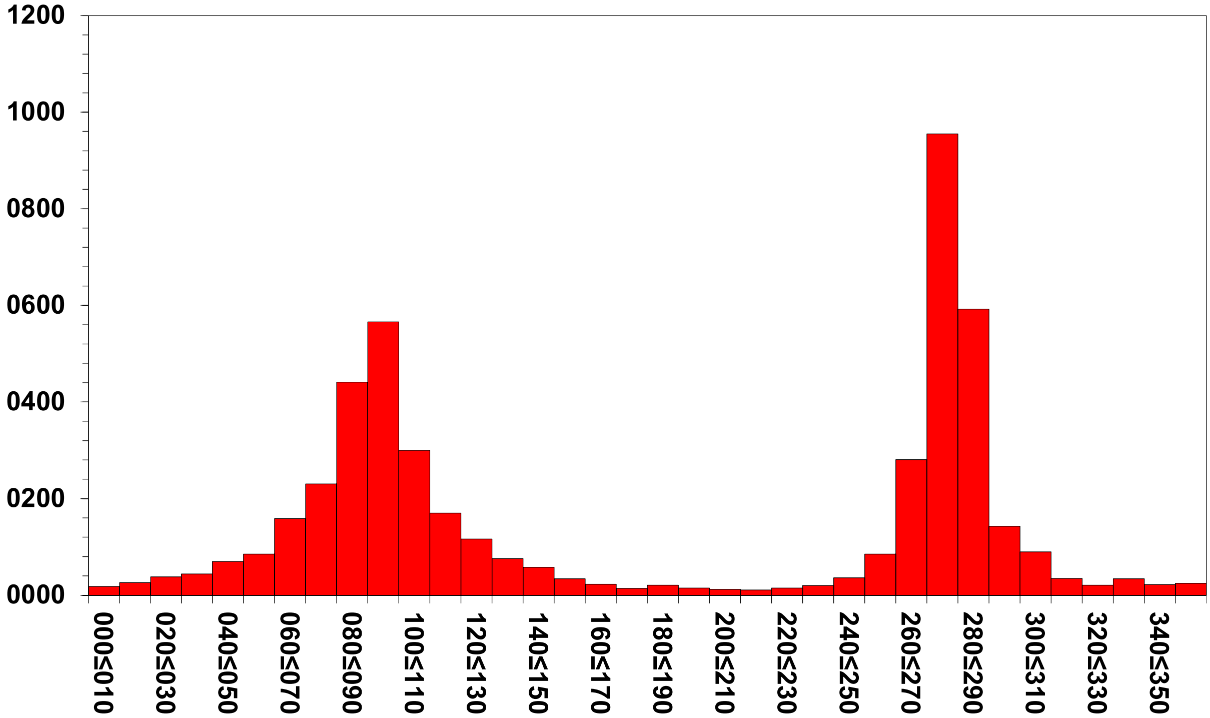


Figure 20: Subsurface current direction frequency plot.

v. 90-day composite

Subsets of the above datasets were used to create a 90 day long composite of the 2 surveys to be used within NewDepomod for modelling with SEPA's Standard Default Approach. The start and end points of each section are detailed in Table 7 below.

Table 6: Subsets used to create 90-day composite.

Identifier	part	start	Tide height (m)	Tide timing	end	Tide height (m)	Tide timing
FishB 20220722T111507	1	22/07/2022 14:20	2.8	1.33 hrs after HW	25/09/2022 11:40	0.7	LW
FishB20180126T122904	2	16/02/2018 00:29:09	0.9	0.15 hrs after LW	29/03/2018 10:49:09	0.7	0.18 hrs before LW

Table 7: 90-day composite summary statistics

	Near-bed	Pen-bottom	Sub-surface
Mean velocity (m s^{-1})	0.198	0.260	0.253
Min velocity (m s^{-1})	0.004	0.001	0.001
Max velocity (m s^{-1})	0.634	0.698	0.73
Ranked percentage 0.095 m s^{-1}	22 %	14 %	16 %
Major axis (°G)	105	280	280
Amplitude anisotropy	3.98	5.88	4.97
Residual velocity (m s^{-1})	0.04	0.01	0.04
Residual direction (°G)	089	257	276
Parallel Residual (m s^{-1})	0.038	0.008	0.044
Normal Residual (m s^{-1})	-0.010	-0.004	-0.003
Parallel tidal amplitude (m s^{-1})	0.308	0.413	0.400
Normal tidal amplitude (m s^{-1})	0.077	0.070	0.081
	Min	**Max**	**Range**
Normalised Depth (m)	-2.40	2.33	4.73

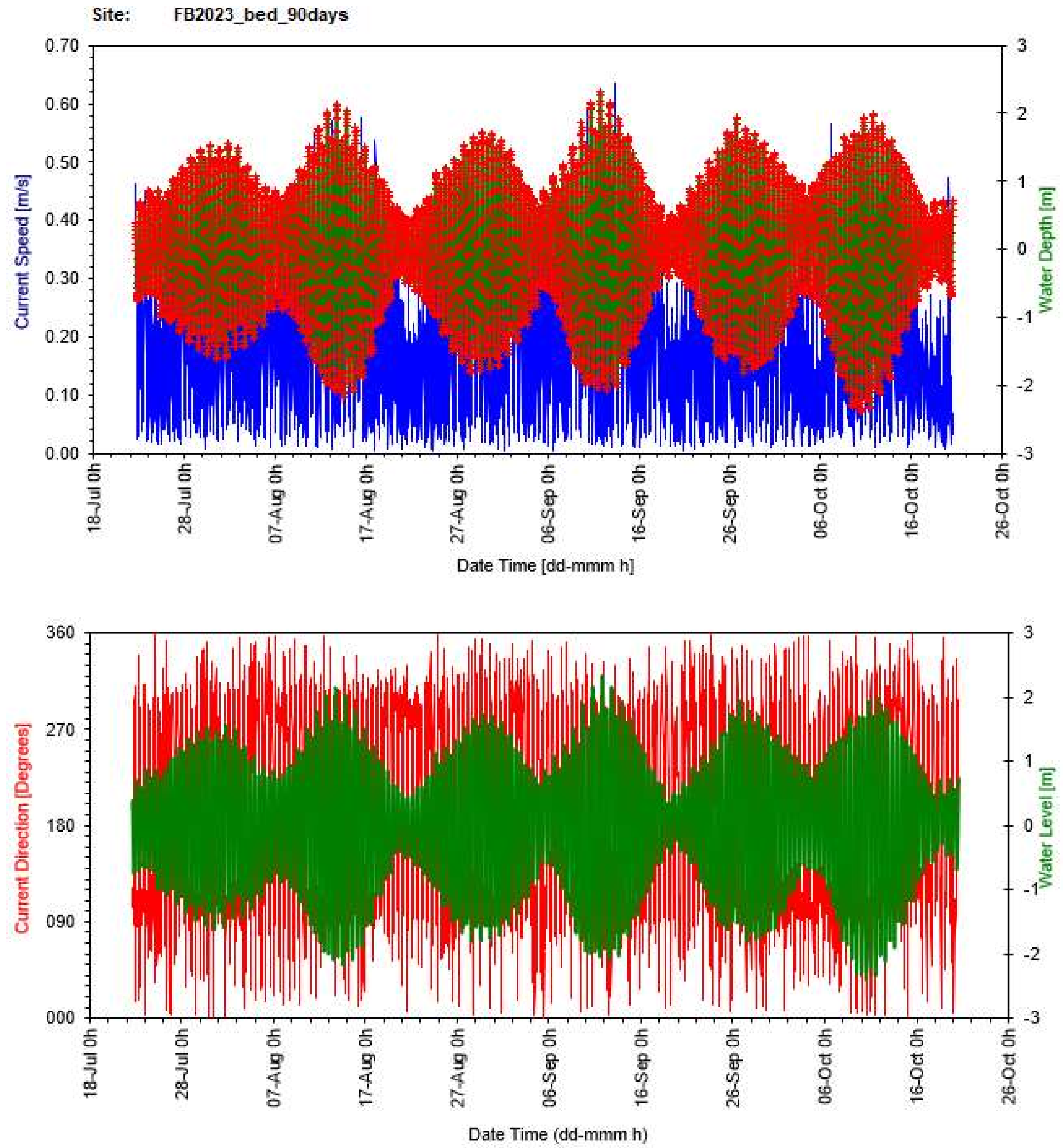


Figure 21: Bed time series plots for current speed and direction against water level

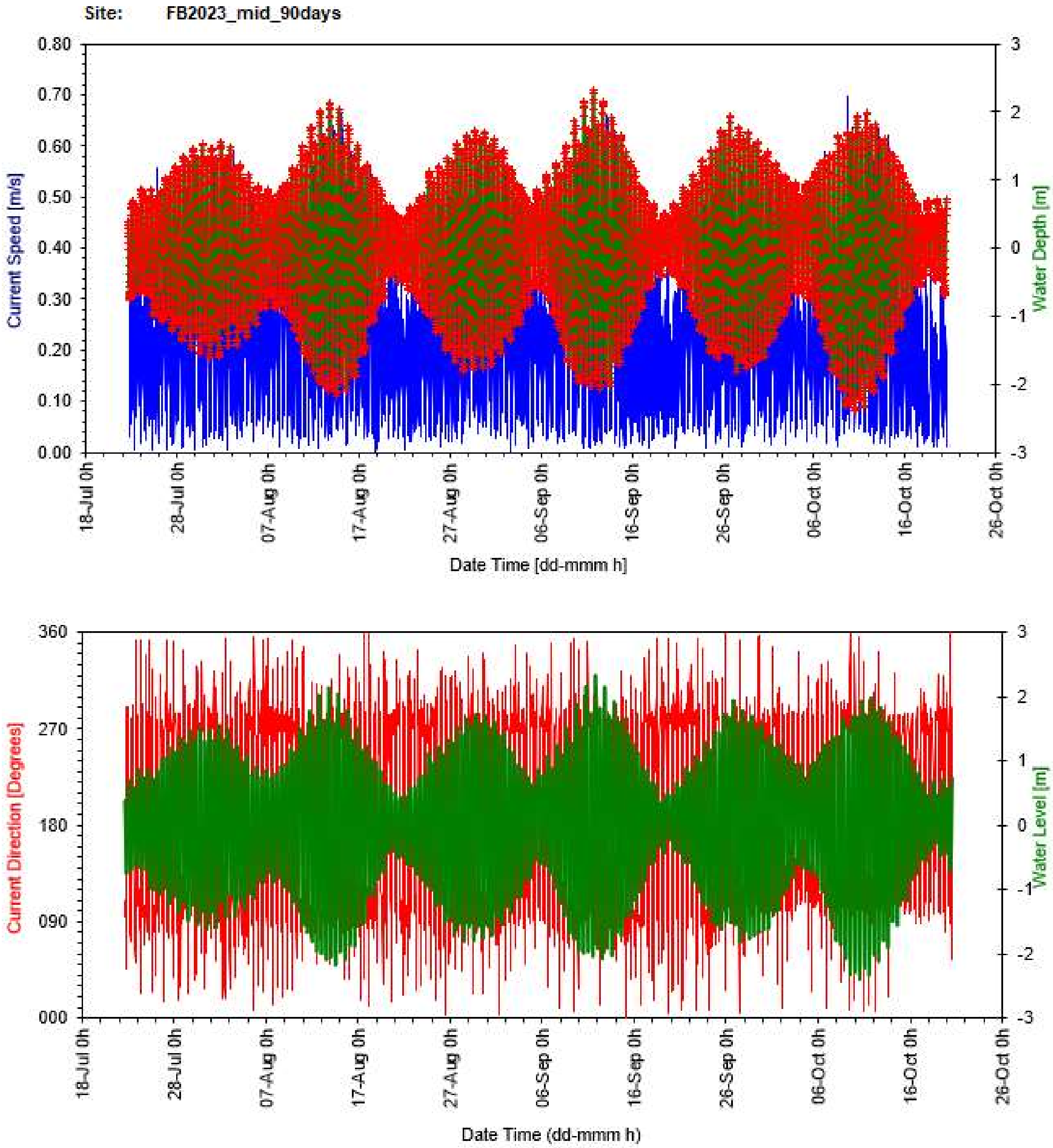


Figure 22: Mid time series plots for current speed and direction against water level

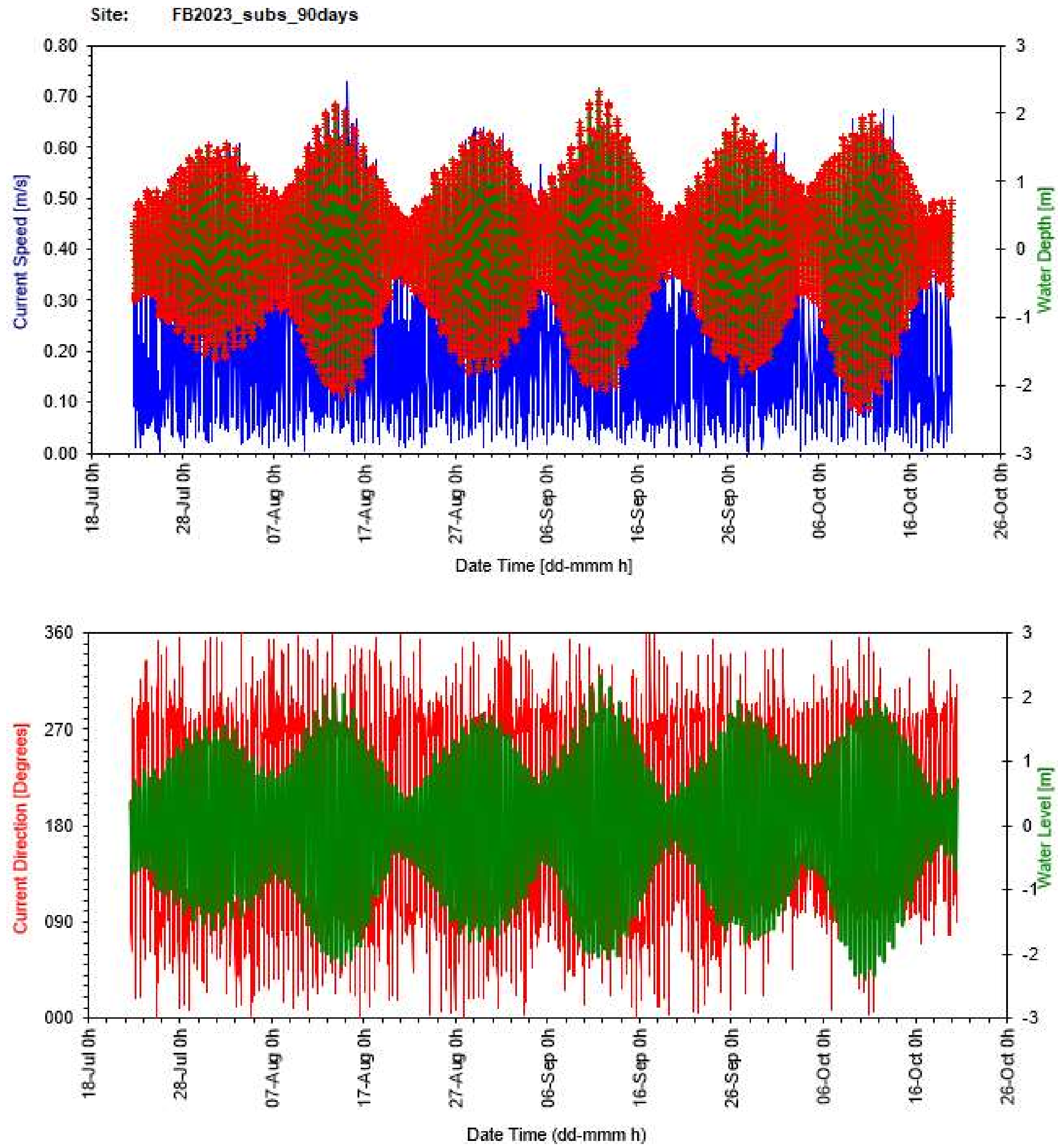


Figure 23: Subsurface time series plots for current speed and direction against water level

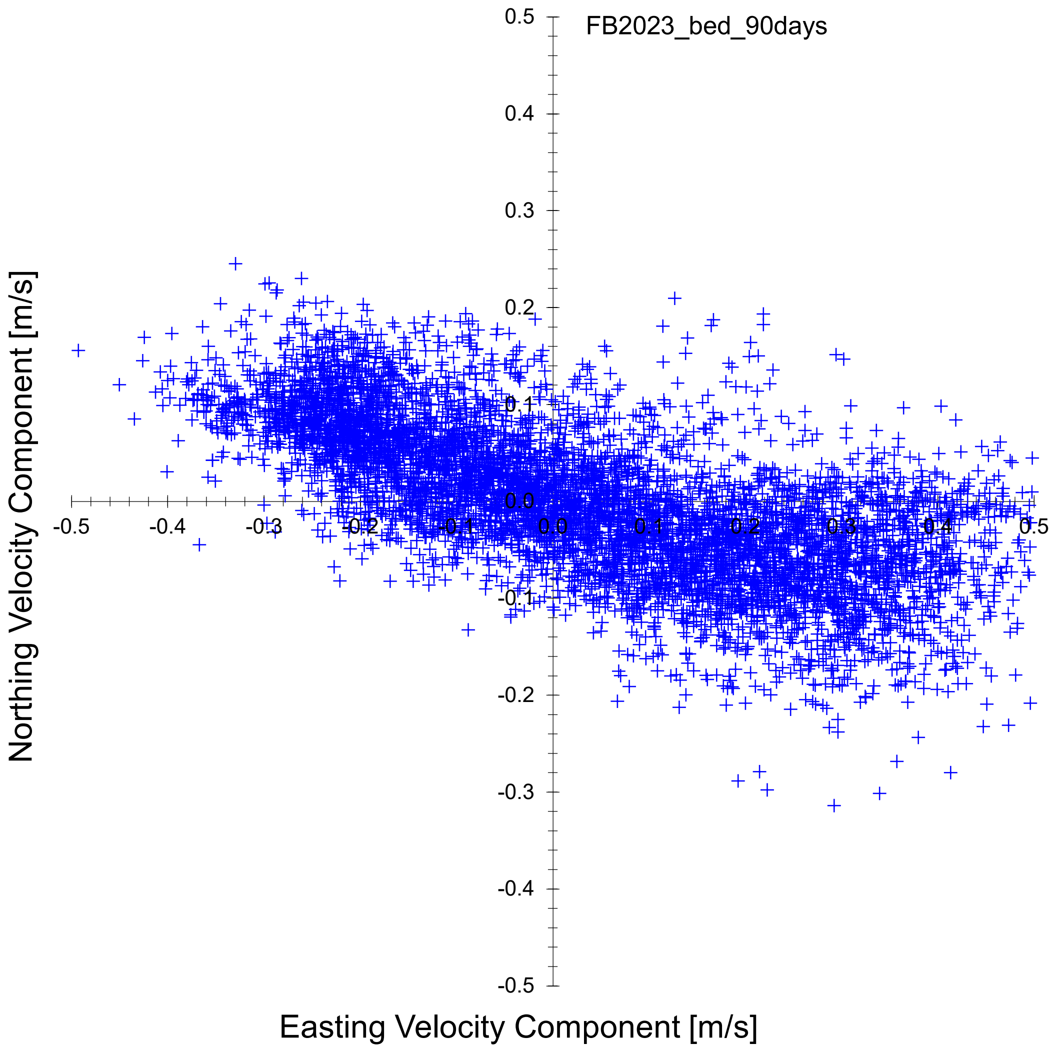


Figure 24: Bed scatter plot of easting and northing velocity components

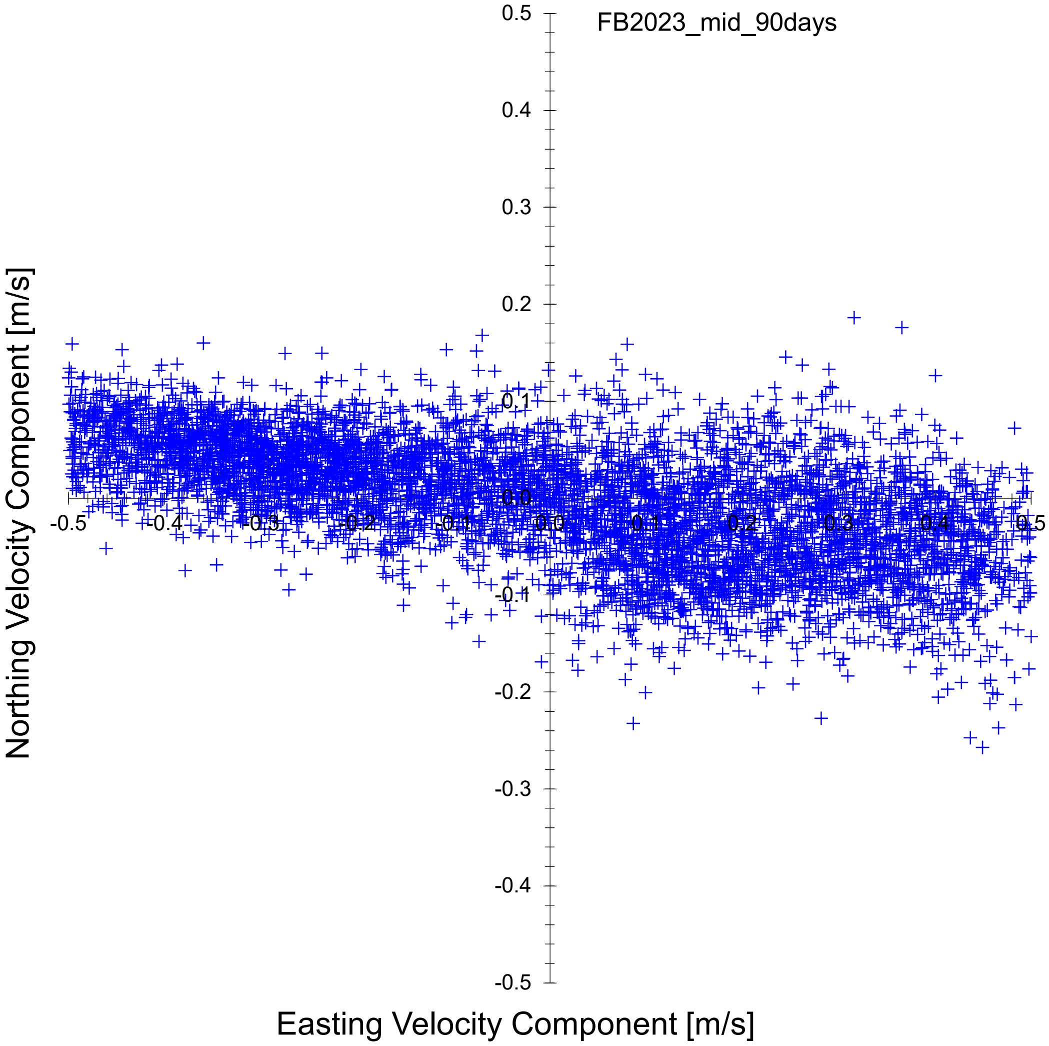


Figure 25: Mid scatter plot of easting and northing velocity components

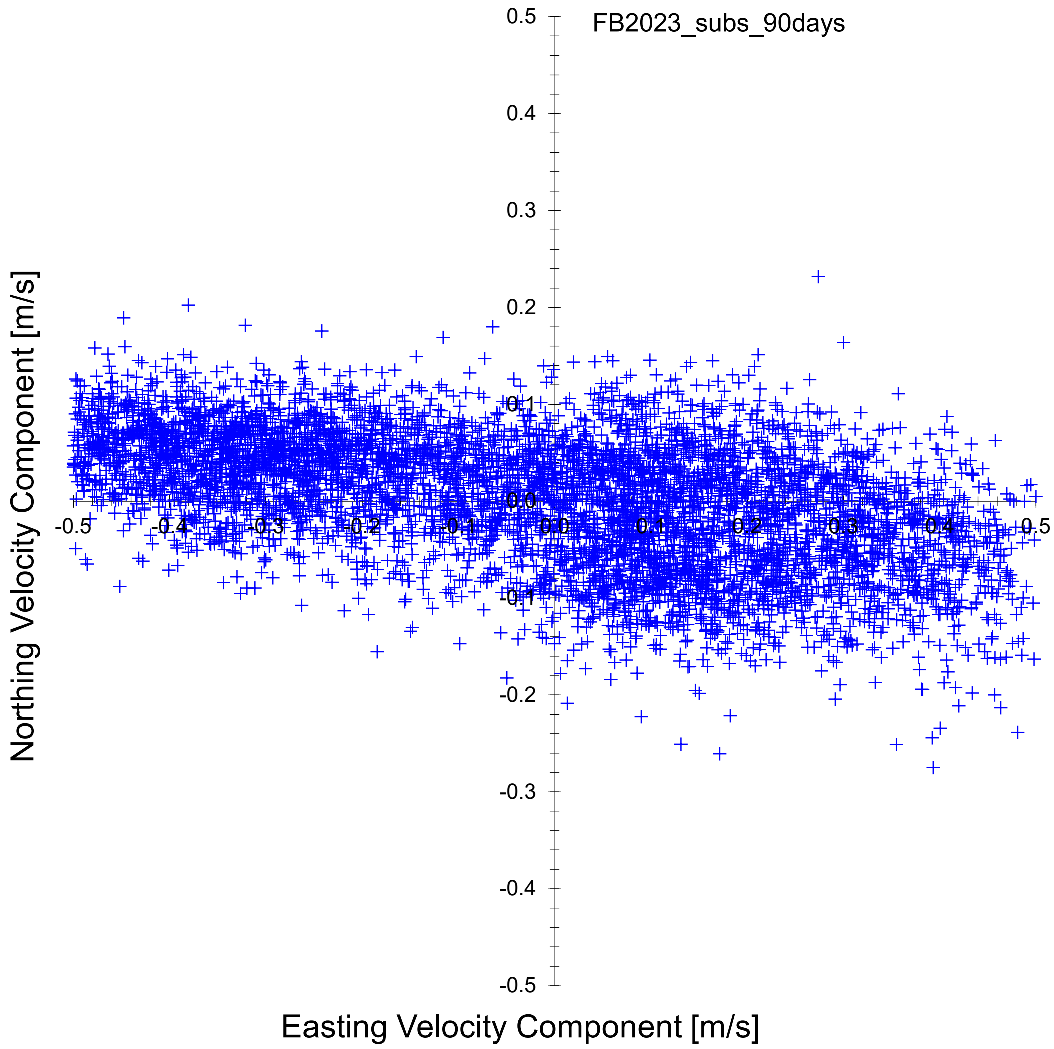


Figure 26: Subsurface scatter plot of easting and northing velocity components

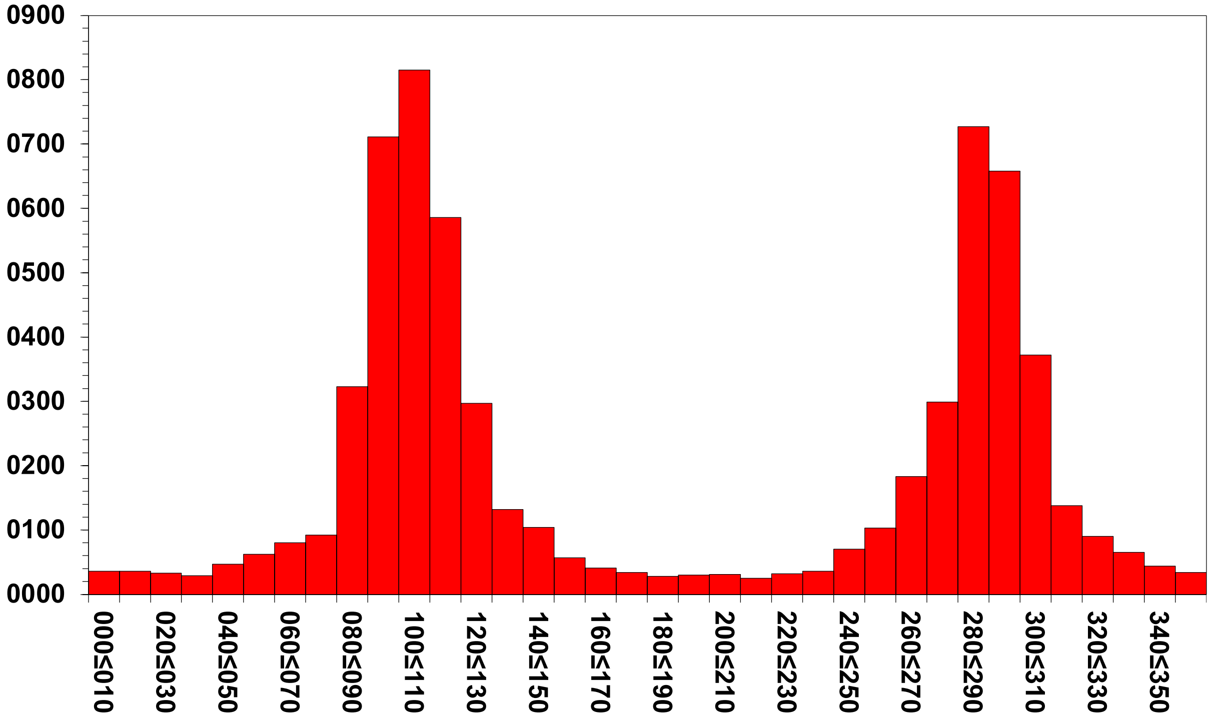


Figure 27: Bed current direction frequency plot.

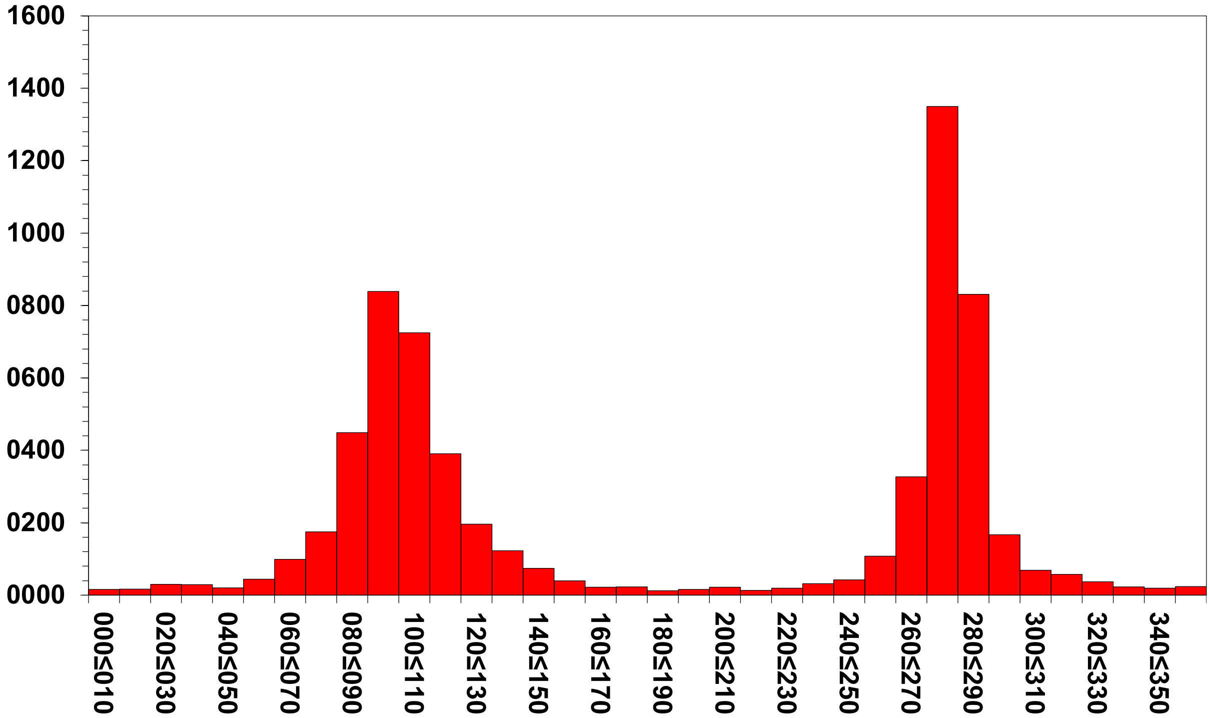


Figure 28: Mid current direction frequency plot.

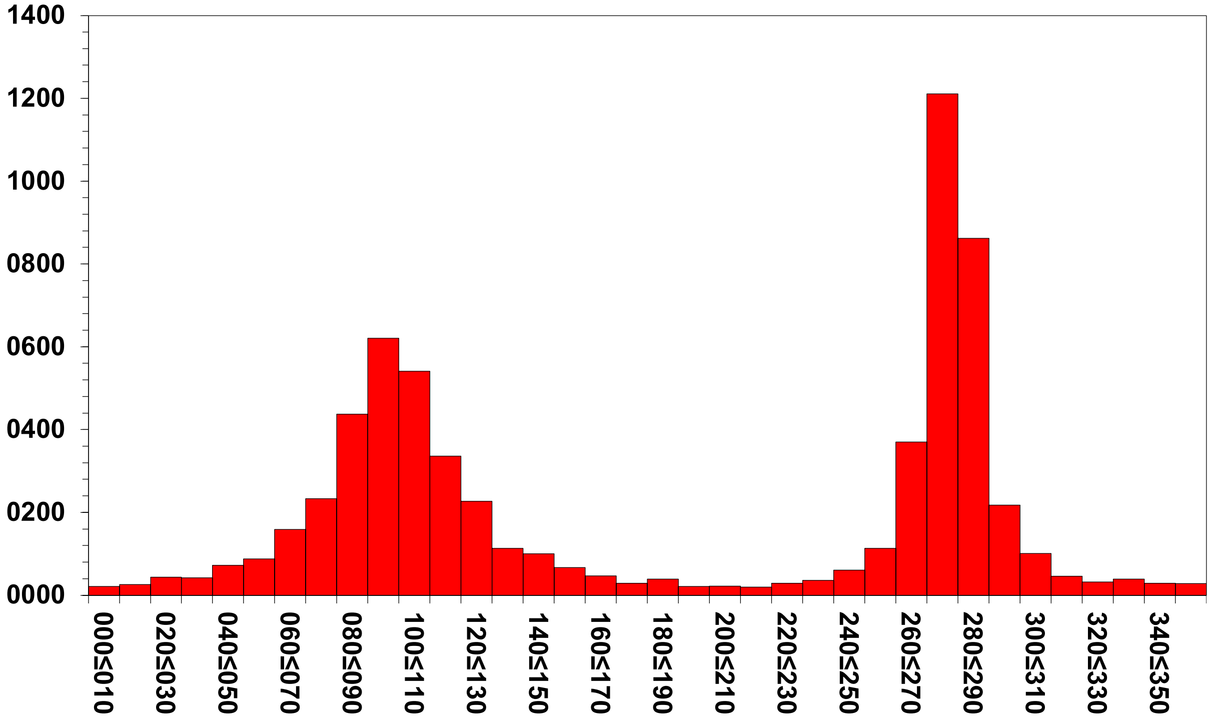


Figure 29: Subsurface current direction frequency plot.

3. Equipment set-up parameters and specifications

Table 8: ADCP configuration for Fishnish B 2018 and 2022 deployments

Date	2018	2022
Instrument	Teledyne Sentinel v50	Teledyne Sentinel v50
Serial number	sv114	sv114
Deployment name	FishB20180126T122904	FishB 20220722T111507
First viable ensemble (no.)	26/01/2018 13:29:09 (4)	22/07/2022 14:20 (10)
Last viable ensemble (no.)	29/03/2018 10:49:09 (4460)	28/09/2022 09:00 (4890)
Frequency	492 kHz	492 kHz
Cell size (m)	1.0	1.0
Blanking distance (m)	1.0	1.0
No. of cells	44	49
First cell range (m)	2.21	2.23
Ensemble interval (s)	1200	1200
Number of pings	400	350
Ping interval (s)	2.00	2.00
Bandwidth (%)	25	25
Theoretical standard deviation (m s^{-1})	0.0037	0.0039

Depth Cell Size[1]	Depth Cell Size[1]	V20 (1000 kHz) Range (m)[2,3] Wide/Narrow	V20 (1000 kHz) Std Dev (cm/s)[3,4] Wide/Narrow	V50 (500 kHz) Range (m)[2,3] Wide/Narrow	V50 (500 kHz) Std Dev (cm/s)[3,4] Wide/Narrow	V100 (300 kHz) Range (m)[2,3] Wide/Narrow	V100 (300 kHz) Std Dev (cm/s)[3,4] Wide/Narrow
	0.25 m	18.0/22.6	19.2/36.5				
	0.3 m	19.3/24.0	11.1/20.8				
	0.5 m	20.2/24.9	7.1/13.4	44.1/57.6	19.2/36.5		
	1.0 m	22.1/26.9	3.6/6.7	50.5/64.6	7.1/13.5	94.5/120.6	10.9/20.6
	2.0 m	24.5/29.4	1.7/3.2	56.0/70.6	3.6/6.7	103.5/130.4	5.5/10.3
	4.0 m	26.9/32.0	0.8/1.6	63.1/78.2	1.7/3.2	114.6/142.3	2.7/5.2
	6.0 m			67.4/82.8	1.1/2.1	121.7/151.5	1.8/3.3

Self-Contained (SC) Communications and Recording	Wireless/Ethernet Internal memory	802.11 b/g/n / TCPIP One 16 GB Micro SD Card included
Real-Time (RT) Communications	Serial/Ethernet	RS232 and RS422 / TCPIP (setup) UDP (output)
Profile Parameters	Velocity accuracy Velocity resolution Velocity range Ping rate	V20/V50: 0.3% of the water velocity relative to the ADCP ± 0.3 cm/s V100: 0.5% of the water velocity relative to the ADCP ± 0.5 cm/s 0.1 cm/s ± 5m/s (default); ± 20m/s (maximum) Up to 4 Hz (SC); Up to 16 Hz (RT)
Echo Intensity Profile	Vertical resolution Dynamic range Precision	Depth cell size 80 dB ±1.5 dB
Transducer and Hardware	Beam angle Configuration Depth rating Materials	25° 4-beam, convex; 5th beam vertical 200 m Transducer, housing, and end cap: plastic Connector: metal shell
Standard Sensors	Temperature (mounted on transducer) Compass (magneto-inductive sensor) Tilt (MEMS accelerometers) Pressure sensor (mounted on transducer) Recorder	Range -5° to 45°C, precision ± 0.4°C, resolution 0.1° Accuracy 2° RMS, resolution 0.1°, max. dip angle 85° Pitch range ± 90°, roll range ± 180°, accuracy 2° RMS, precision 0.05° RMS, resolution 0.1° Range 300m, accuracy 0.1% FS 16GB Micro SD Card

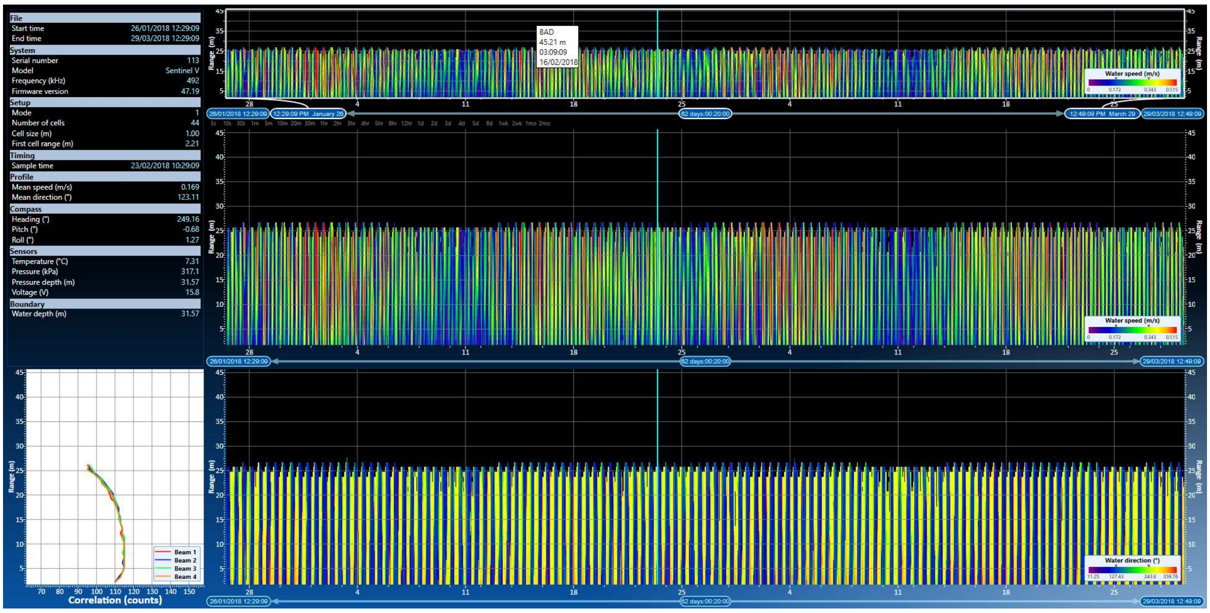
Figure 30: Teledyne RDI Sentinel V50 technical specifications

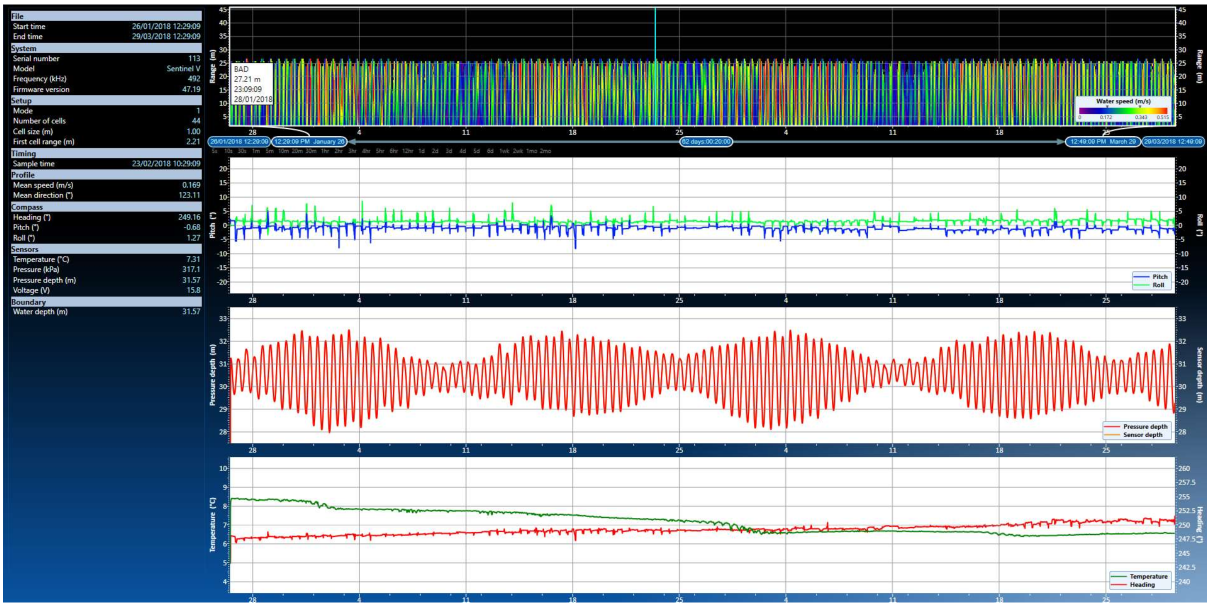
4. List of data files

Raw current meter data, ASCII format, exported from FishB20180126T122904.pd0 FishB 20220722T111507.pd0	*FishB20180126T122904.averaged.txt* *FishB 20220722T111507.averaged.txt*
Processed HG data	*FB2023_bed_90days_hgdata_analysis_v7.xls* *FB2023_mid_90days_hgdata_analysis_v7.xls* *FB2023_subs_90days_hgdata_analysis_v7.xls* HG Analysis files for 2018 and 2022 full datasets have also been included.

5. Appendices

Appendix A 2018 dataset - Screenshots of *FishB20180126T122904.pdv* from Teledyne's *Velocity* data processing software (entire dataset).





Appendix B 2022 dataset - Screenshots of *FishB 20220722T111507.pdv* from Teledyne's *Velocity* data processing software (entire dataset).