Hydrographic Report
Billy Baa

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1 Executive Summary

This report has been prepared by Scottish Sea Farms Ltd. (SSF) to meet the data collection and reporting requirements of the Scottish Environment Protection Agency (SEPA) [2] for the purpose of assessing an application to install equipment for a marine salmon farm at a site currently named Billy Baa, as well as for assessing the environmental impact of waste and medicine treatments at said proposed site through modelling. The report describes the hydrographic survey conducted to collect modelling input data for the proposed Billy Baa site, a summary of which is provided in Table 1.1 below.

Table 1.1: Summary of survey and site information.

Site Details	
Name	Billy Baa
Location	Scalloway Islands / Weisdale Voe, Shetland
Development	**Proposed**
Average depth	44.95 m
Hydrographic Summary	
Survey Date	31/08/2022 - 21/12/2022
ADCP Location	**Lat/Long (WGS 84)** 60.19471°N -1.35298°W **OS Grid Ref** 435975E 1145730N
Equipment type	Teledyne Sentinel Workhorse ADCP (600kHz)

2 Introduction

This report details the hydrographic survey conducted by SSF for the purpose of collecting environmental data for NewDEPOMOD, dispersion, and hydrodynamic models to assess an application for a marine fish farm site at Billy Baa. The report describes the collection of data using an Acoustic Doppler Current Profiler (ADCP) at the proposed location of the site, located to the north east of the Billy Baa and island of Fore Holm and to the east of Fora Ness on the west coast of the Shetland Mainland (Figure 2.1). The average water depth around the proposed development is 44.95m. Data collection during this survey follows the procedures recommended in current SEPA guidance [1] [2] [3].

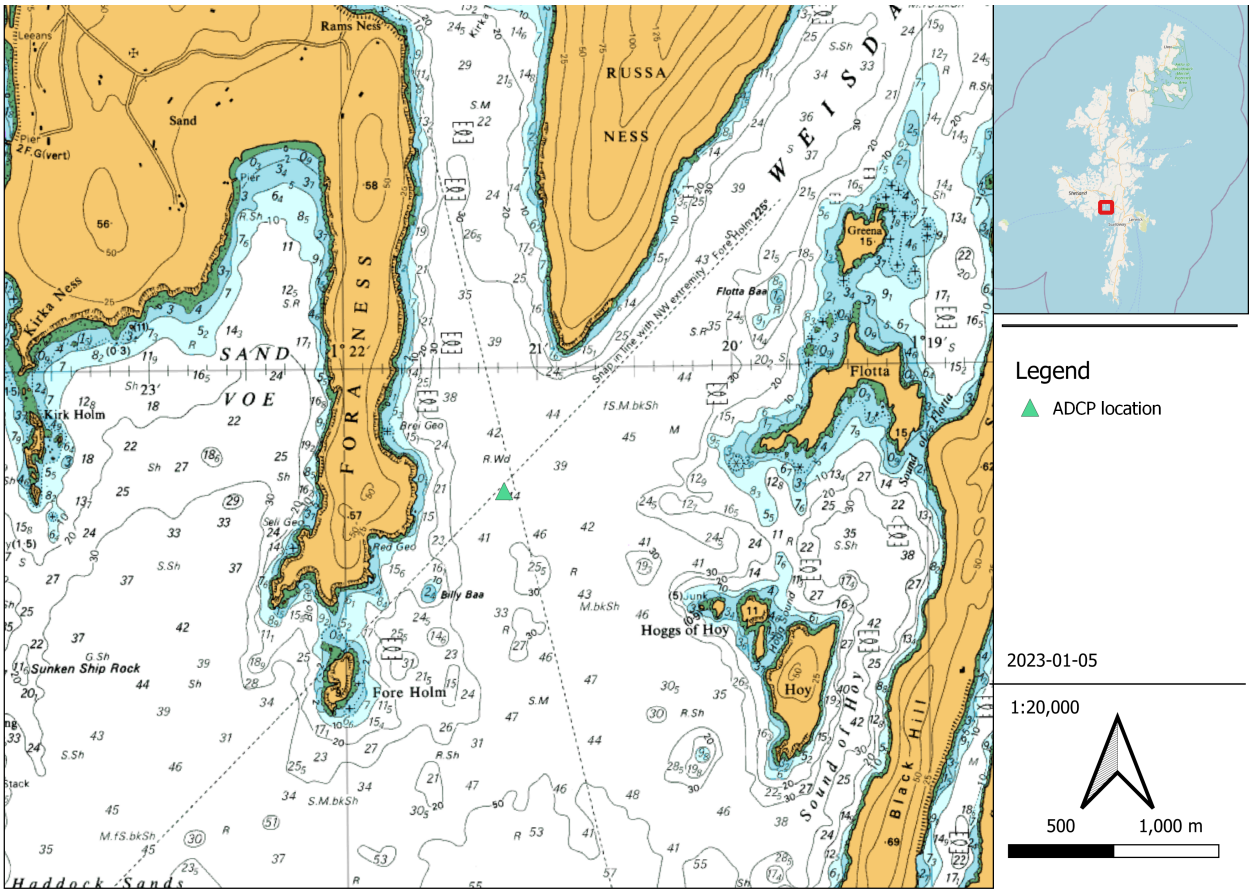

Figure 2.1: Location of survey area and ADCP deployment.

3 Methodology

3.1 Data Acquisition Positioning

A handheld GPS (Garmin GPSmap 76), set to WGS84, was used to obtain position fixes during the survey. The accuracy of the GPS unit was confirmed using the integrated GPS on board the workboat vessel used in the survey.

3.2 Water depth

The on-board echo sounder system (Garmin GPS Map XSV) was utilised to determine depth.

3.3 Wind conditions

Meteorological data was not collected during this hydrographic survey as it took place over a longer period than 90 days.

3.4 Current Profiler

3.4.1 Configuration parameters

Table 3.1 summarises the configuration settings used during the survey. To comply with SEPA guidelines the profiler must be configured to specify a precision within 10% of the mean current speed, a precision of 0.5cm/s was obtained in this instance.

Table 3.1: Summary of ADCP settings used during deployment.

Parameter	**Setting**	**Unit**
Profile interval	3600	s
Number of Bins	33	-
Bin size	1.8	m
Blanking distance	1.06	m
Depth range	60.46	m

3.4.2 Mooring system

The profiler was connected to a frame with chain leading away from it. This chain was attached to an anchor and rope leading to a surface buoy. This system ensures the surface rope does not interfere with the data obtained from the profiler. Figure 3.1 illustrates an example of the mooring system used during the survey.

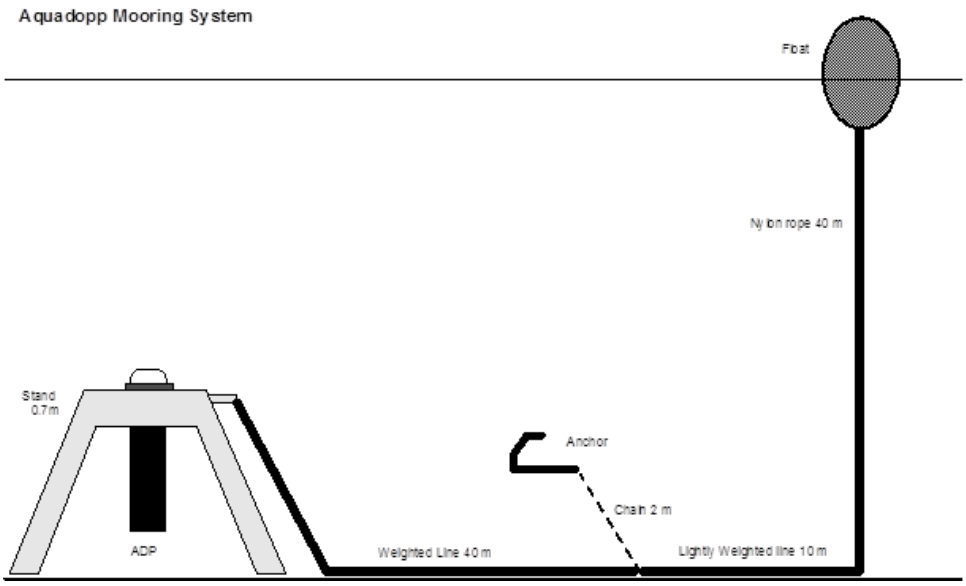

Figure 3.1: Example ADCP mooring system used during deployment.

3.4.3 Current Profiler Specifications

Table 3.2 provides a summary of the profiler sensor specifications.

Table 3.2: ADCP sensor specifications.

	Accuracy	**Resolution**	**Range**
Velocity	0.3 cm/s	0.1 cm/s	5 m/s
Pressure	1.5 dB	User configurable	80 dB
Tilt/roll	0.5°	0.01°	15°
Temperature	0.4°C	0.01°C	-5° to 45°C

3.4.4 Data processing and analysis

The data were retrieved from the profiler and three bins were identified to represent the near bed, the cage bottom and the sub-surface. The following relationship was used to determine the height of the bin centres from the seabed

$$\text{Bin height above bed} = ht + BD + (nBS)$$

Where ht is the height of the ADCP transducer above the bed (0.626 m), BD is the ADCP blanking distance (1.06 m), n is the bin number and BS is the bin size (1.8 m).

Near-bottom currents were recorded as close to the seabed as was practicable. A depth corresponding to the cage-bottom was chosen to represent the cage-bottom currents, and the sub-surface depth was normally retrieved from a depth approximately five metres below the mean depth during the deployment period. However, when operating the ADCP near to surface layers, special consideration must be given when analysing the resulting data. Sidelobe interference may affect the last 10% of the water column current profile. The extent to which the sidelobe interference will affect the current measurements is a function of the surface conditions, the scattering return signal strength from the water and the acoustic properties of

the transducers. Therefore, the sub-surface data was retrieved from a depth sufficient that the data was not affected by sidelobe interference or wave breaking. Depths extracted from the current profiler data records are calculated from the centre point of each bin, considering the height of the ADCP from the seabed (0.626 m) and the blanking distance (1.06m).

The time-series data were extracted from the raw data file (BBA22.000), using RD Instrument's Velocity software, to generate ASCII text files of sensor and derived parameters.

The magnetic direction data were corrected using data derived from the magnetic declination obtained from the British Geological Survey website and from grid convergence as calculated by the code in the OS corrections tool, as implemented in SEPA's data analysis tool; values obtained are presented in table 3.3, below.

Table 3.3: Coordinates and magnetic heading corrections.

Date	Lat	Long	NGR_X	NGR_Y	mag. dec	grid conv.	GMA
31/08/2022	60.19438°N	1.35303°W	435975	1145730	-0.9	0.56	-1.46
Notes: positions recorded to WGS84, and converted to OSGB36 magnetic declination from BGS Geomagnetism website [4] grid convergence from OS corrections tool grid magnetic angle = magnetic declination – grid convergence							

3.5 Tidal Correction for Bathymetric Data

Tide times were obtained from software Admiralty TotalTide for the Scalloway Tidal Station.

4 Quality Checks

4.1 Positioning Data

The accuracy of the handheld GPS was checked against the boats GPS.

4.2 Bathymetric Data

Depth soundings and depth recordings from the ADCP were assessed against charts and UKHO bathymetry data for accuracy.

4.3 ADCP current data

Initial data integrity checks were made looking at heading, pitch, roll, depth and anomalous current magnitude spikes, within the Velocity software. Further checks were made of data consistency after conversion from binary to ASCII data in Microsoft Excel, and then through importing the data into SEPA's analysis tool (HGdata_analysis_v7.xls; v7.11). Final checks of the data were undertaken by SEPA before this report was written.

5 Results

5.1 Bathymetric Data

Depth soundings were obtained from UKHO bathymetry data, to confirm chart accuracy (Figure 5.1) and compare against depth sounder readings and the depth recordings from the ADCP.

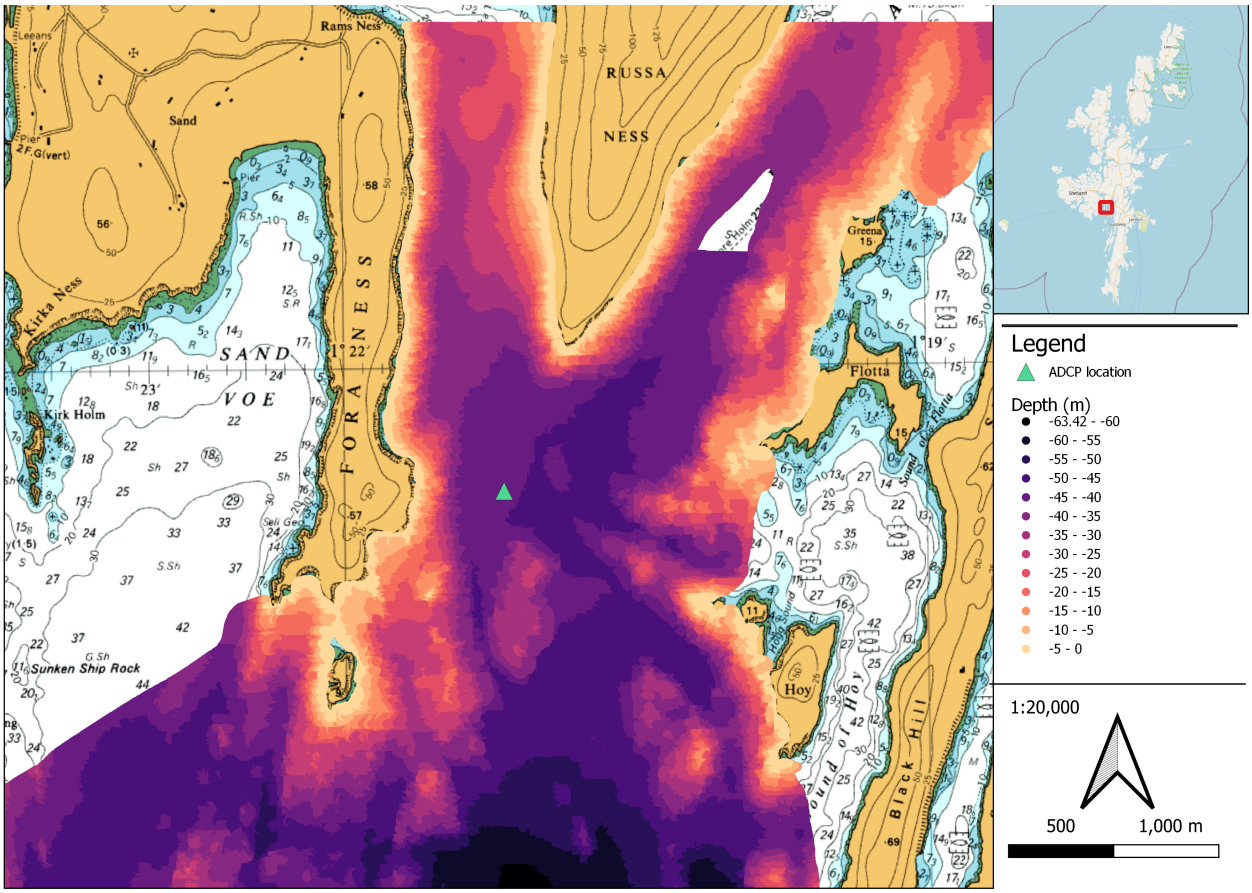

Figure 5.1: UKHO bathymetry at Billy Baa.

5.2 Meteorological data

Meteorological data was not collected during this hydrographic survey as it took place over a longer period than 90 days.

5.3 Current data

Data were obtained from all sensors (speed, direction, pressure, temperature, heading, pitch and roll) for a 112-day period between 31/08/2022 to 21/12/2022.

The signal strength data indicates that no objects such as creels and mooring lines interfered with profiler recording.

The pitch and roll data shows that the profiler was upright and within the manufacturer's recommendation of a maximum range of 20° (Figure 5.2)

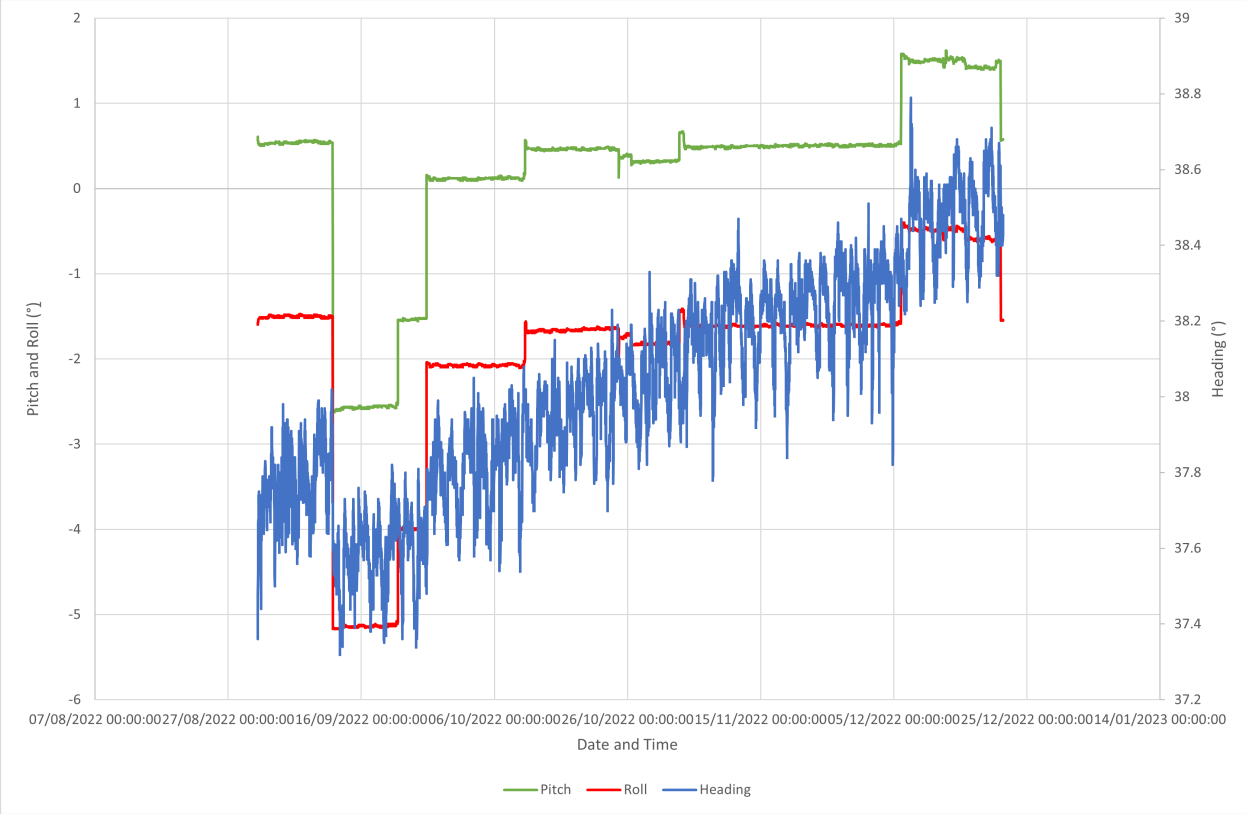

Figure 5.2: Pitch, Roll and Heading data for duration of ADCP deployment.

Table 5.1 summarises the statistics obtained through the SEPA HG analysis v7 Excel templates (Appendix 1).

Table 5.1: Summary statistics for ADCP deployment.

Bin height	Sub-surface Bin 21 (38.86 m from sensor)	Cage-bottom Bin 16 (29.86 m from sensor)	Near-bed Bin 1 (2.86 m from sensor)
Mean Speed (m s-1)	0.050	0.034	0.038
Mean Speed Ranked %	57	58	60
3 cm s-1 Ranked %	30	52	49
4.5 cm s-1 Ranked %	50	75	68
9.5 cm s-1 Ranked %	92	99	96
Residual Direction (°Grid)	203	215	030
Residual Speed (m s-1)	0.021	0.007	0.010
Longitudinal Residual (m s-1)	0.021	0.007	0.010
Lateral Residual (m s-1)	0.001	0.003	0.003
Longitudinal Amplitude (m s-1)	0.061	0.033	0.056
Lateral Amplitude (m s-1)	0.046	0.044	0.029
Ellipse Major Axis (°Grid)	200	195	015
Amplitude Anisotropy	1.34	1.34	1.93

6 Discussion

UKHO Bathymetric data confirmed Admiralty Charts are accurate in the area. Data was combined and interpolated onto a regular 25m, 2km x 2km grid for use in NewDEPOMOD.

The near-bed data has a more distinct tidal component than the cage-bottom and sub-surface data. The mean current speeds suggest that current speed through the water column from near bed to cage bottom is fairly consistent, with greater current speeds found at the sub-surface bin. Tide in the area doesn't appears to be particularly dominated by one direction, though is most prevalent in a NE or SW direction as shown by the cumulative velocity vector plot (Figure 6.1), which would appear to make sense following the Sandsound and Weisdale Voes to the North and North East of the site, as the tide would be channeled in and out of these through it's spring and neap cycles. The eastern component of the near bed current direction might also be due to the effect of the bathymetry of the area, which slopes downwards in this direction.

At the near-bed cell, 96% data were below the SEPA resuspension threshold of 9.5 cm s-1. This suggests that very little solid waste from the site will be transported away from its initial deposition position; what movement there may be is likely to be to the northeast, as evidenced in the cumulative vector plot (Figure 6.1).

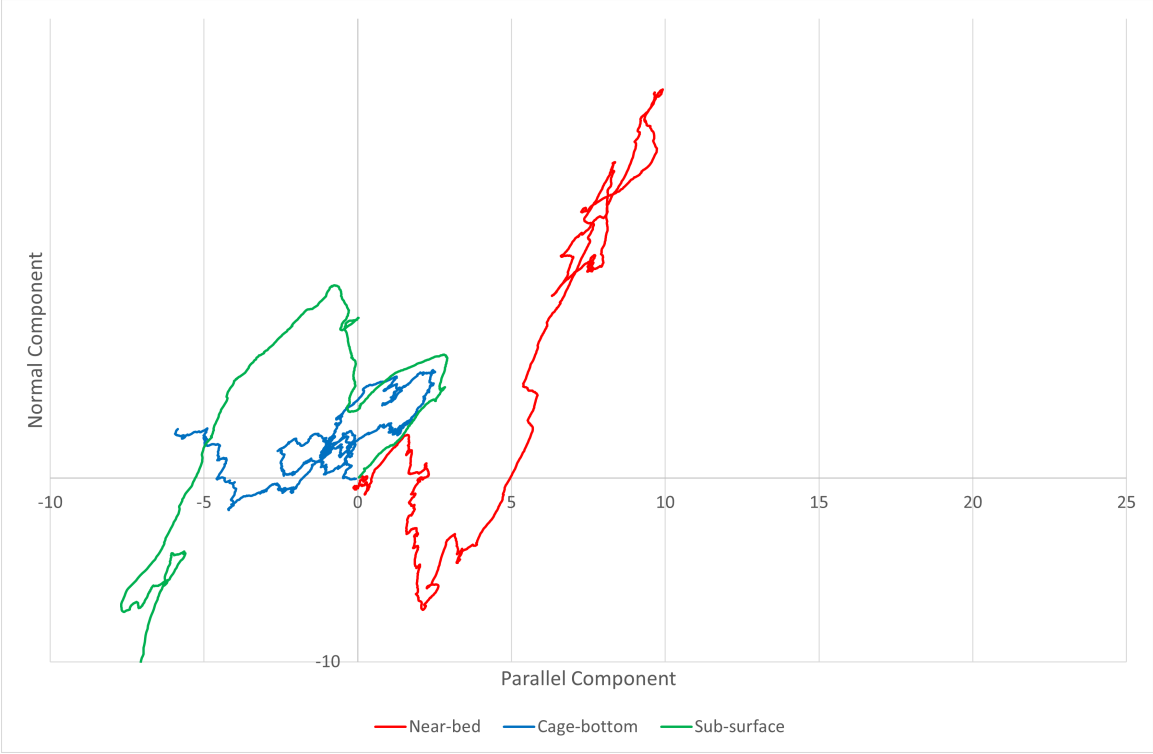

Figure 6.1: Cumulative vector plot of current velocity for all relevant bins.

7 Conclusion

Examination of the collected current data suggests that the data is of sufficient accuracy and quality to be used as a measure of flow conditions around the Billy Baa site and subsequent use for NewDEPOMOD and marine modelling purposes.

References

[1] SEPA. *Aquaculture Modelling: Regulatory Modelling Guidance for the Aquaculture Sector*. Tech. rep. 2019.

[2] SEPA. *Aquaculture Modelling: Regulatory Modelling Process and Reporting Guidance for the Aquaculture Sector Scope of Report*. Tech. rep. 2019.

[3] SEPA. "NewDEPOMOD Interim Guidance - 220427". In: (2022).

[4] *World Magnetic Model Calculator*. URL: https://geomag.bgs.ac.uk/data_service/models_compass/wmm_calc.html.

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Revision No.	1.1

8 Appendices

8.1 Appendix 1 - SEPA HG Analysis v7

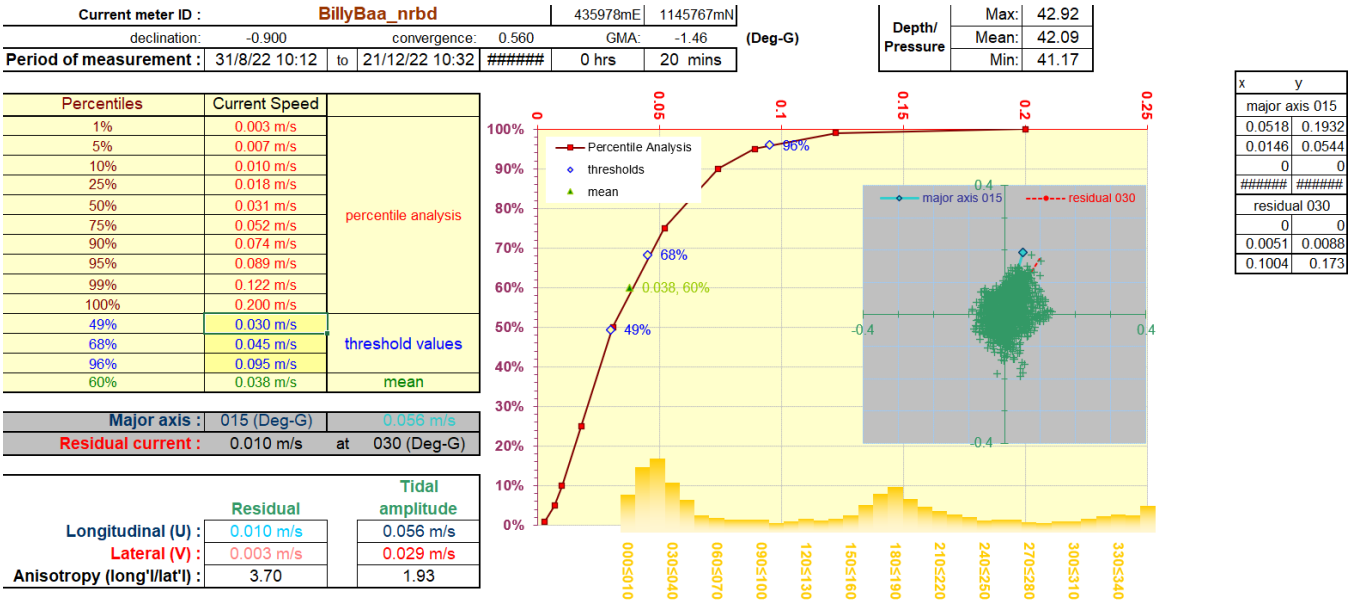


Figure 8.1: Near-bed HG analysis at Billy Baa.

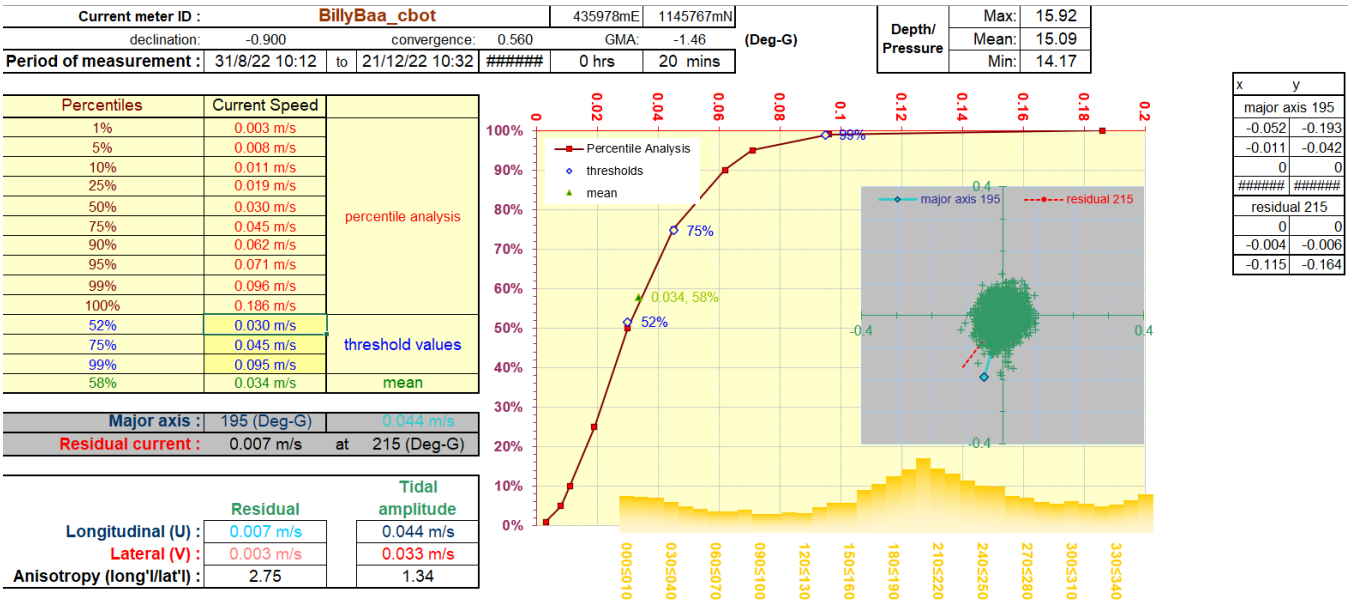


Figure 8.2: Cage-bottom HG analysis at Billy Baa.

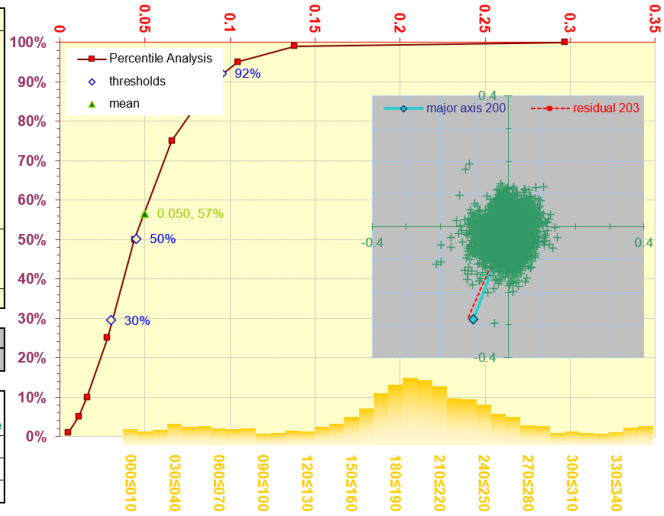
Current meter ID :	subsurface_subs			435978mE	1145767mN
declination:	-0.900	convergence:	0.560	GMA:	-1.46 (Deg-G)
Period of measurement :	31/8/22 10:12	to	21/12/22 10:32	#######	0 hrs 20 mins

Depth/ Pressure		
	Max:	6.92
	Mean:	6.09
	Min:	5.17

Percentiles	Current Speed	
1%	0.005 m/s	percentile analysis
5%	0.011 m/s	
10%	0.016 m/s	
25%	0.028 m/s	
50%	0.044 m/s	
75%	0.066 m/s	
90%	0.090 m/s	
95%	0.105 m/s	
99%	0.138 m/s	
100%	0.297 m/s	
30%	0.030 m/s	threshold values
50%	0.045 m/s	
92%	0.095 m/s	
57%	0.050 m/s	mean

Major axis :	200 (Deg-G)		0.061 m/s
Residual current :	0.021 m/s	at	203 (Deg-G)

	Residual	Tidal amplitude
Longitudinal (U) :	0.021 m/s	0.061 m/s
Lateral (V) :	0.001 m/s	0.046 m/s
Anisotropy (long'l/lat'l) :	17.92	1.34



x	y
major axis 200	
-0.103	-0.282
-0.021	-0.057
0	0
#######	#######
residual 203	
0	0
-0.008	-0.02
-0.118	-0.276

Figure 8.3: Sub-surface HG analysis at Billy Baa.

8.2 Appendix 2 - Definitions and terminology

Averaging interval – the period, in seconds, over which the NDP averages data before computing a mean velocity profile.

Profile interval – the time between sequential profiles, in seconds. This is given as the time from the start of one profile to the start of the next profile, and must be greater than or equal to the averaging interval (or averaging interval will take precedence).

Temperature mode – Temperature mode refers to the source of temperature data used for sound speed calculations. USER indicates that the value input in the set-up parameters should be used; MEASURED indicates that the value reported by the NDP temperature sensor should be used. The temperature sensor used by the NDP is considered to be sufficiently reliable and accurate for sound speed calculations, thus MEASURED is the more common choice. Note that sound speed is recorded with each profile.

Number of Bins – number of bins to collect per profile. The maximum number of bins with accurate velocity data will vary with system frequency, bin size, and deployment conditions. Bin size (m) – vertical length of each bin.

Blanking distance (m) – the vertical distance from the ADP transducers to the start of the first bin. There is a minimum value required for each frequency to avoid interference in the first bin.

Co-ordinate system – this determines in what coordinate system the velocity profile data will be stored. BEAM gives velocity data as along beam velocities. XYZ gives velocity data in a Cartesian coordinate system relative to ADP orientation. ENU (for East-North-Up) reports data in an instrument independent Earth coordinate system.

Velocity precision – this is a theoretical estimate of the accuracy of current speed measurements based upon the acoustic frequency of the ADP, bin size and averaging interval.

Dyer (1979) Equation - The Dyer Equation is used to find the bed shear velocity and can be used to calculate the current velocity at any depth (z).

$$U* = KU(z)Ln(z/z0)$$

Where U* = is the bed shear velocity, K= 0.4 the von Karman Constant z0= 2x10-4, m = bottom roughness length z= sampling depth and U(z)= current speed at depth z