Hydrographic Report
Easter Score Holms

April 8, 2021

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1 Executive Summary

This report has been prepared by Grieg Seafood Shetland Ltd. (Grieg) to meet the data collection and reporting requirements of the Scottish Environment Protection Agency (SEPA) [1] for the purpose of assessing an application to install equipment, increase production and for consent to use adequate sea lice treatments on the marine salmon farm named Easter Score Holm. The report describes the hydrographic survey conducted to collect modelling input data for proposed changes to the Easter Score Holm site, a summary of which is provided in Table 1.1 below.

Table 1.1: Summary of survey and site information.

Site Details	
Name	Easter Score Holm
CAR Licence No.	CAR/L/1004217
Location	Scalloway Islands, Shetland
Development	**Active**
Average depth	50 m
Hydrographic Summary	
Survey Date	18/12/2020 - 22/03/2021
ADCP Location	**Lat/Long (WGS 84)** 60.17327°N -1.36318°W **OS Grid Ref** 435435E 1143374N
Equipment type	Teledyne Sentinel Workhorse ADCP (300kHz)

2 Introduction

This report details the hydrographic survey conducted by Grieg for the purpose of collecting environmental data for NewDEPOMOD, dispersion, and hydrodynamic models to assess an application to alter the marine fish farm site at Easter Score Holm. The report describes the collection of Acoustic Doppler Current Profiler (ADCP) and bathymetric data in the eastern vicinity of Score Holms, west of Strom Ness in Shetland (Figure 2.1). The data collection procedure from this survey follows the Regulatory Modelling Guidance for the Aquaculture Sector Version 1.1 (SEPA, July 2019) [1].

2.1 Site Description

The Easter Score Holms aquaculture site is situated to the east of the Score Holms islands and west of North Havra and Strom Ness, in the Scalloway area to the west of the Shetland central mainland (Figure 2.1). The proposed development lies over the existing Easter Score Holm site, extending further south of the site. The average water depth around the proposed development is 50m (Figure 2.2).

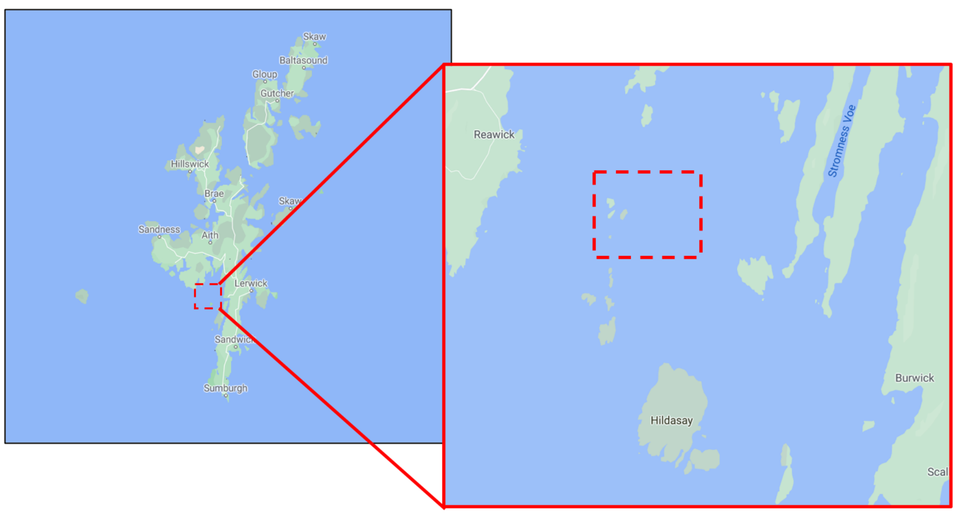

Figure 2.1: Location of Easter Score Holms Site.

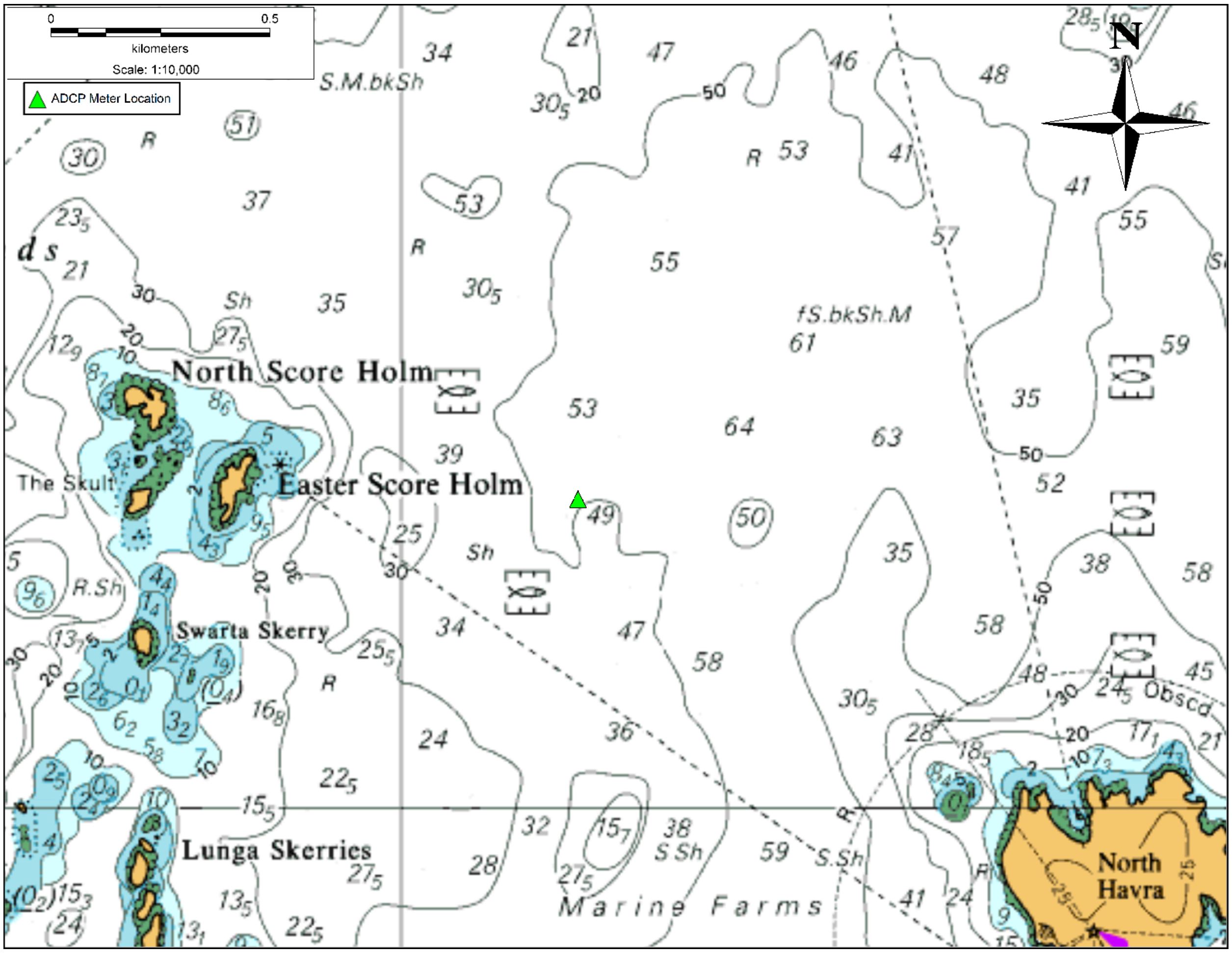

Figure 2.2: Location of ADCP.

3 Materials

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. An Olex system also installed onboard was used to convert the echo soundings to point data and correct these readings for chart datum and allow the data to be exported in xyz format.

3.3 Wind conditions

Meteorological data was not recorded during this hydrographic survey as it lasted longer 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	38	-
Bin size	1.8	m
Blanking distance	2.05	m
Depth range	70	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.

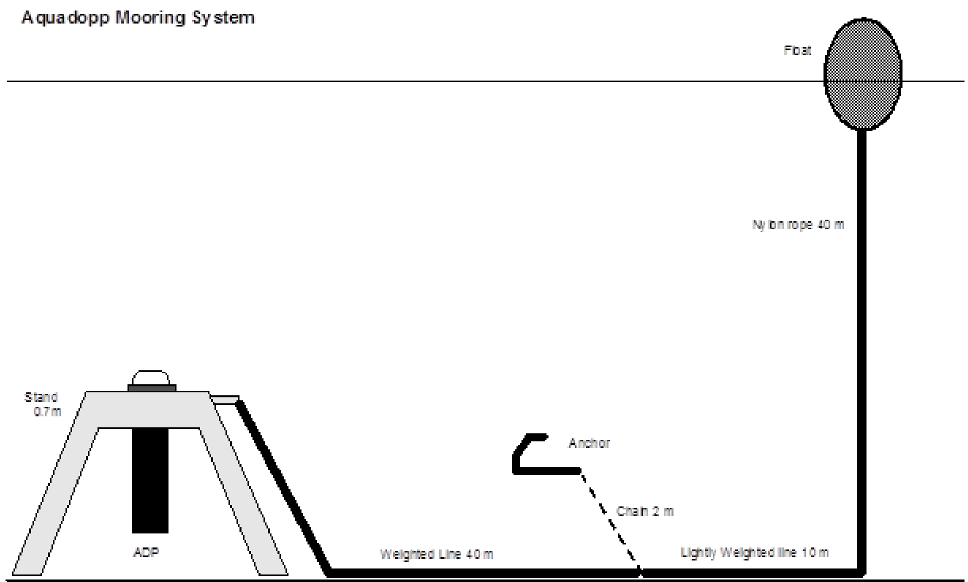

Figure 3.1: Example ADCP mooring system used during deployment.

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	0.5 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 (2.05 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 (2.05m).

The time-series data were extracted from the raw data file (T008_ScoreHolms_181220.000), using Teledyne's WinADCP 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
18/12/2020	60.17327	-1.36318	435435	1143374	-1.311	0.55	-1.90

Notes:
positions recorded to WGS84, and converted to OSGB36
magnetic declination from BGS Geomagnetism website [2]
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 Scalloway 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 sounding were taken and checked against charts for accuracy.

4.3 ADCP current data

Initial data integrity checks were made looking at heading, pitch, roll, depth and anomalous current magnitude spikes. Further checks were made of data consistency after conversion from binary to ASCII data and import 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 during a survey conducted on 15/02/2020, to confirm chart accuracy. Details of depth soundings are included in Appendix 1. Bathymetry data were loaded into Matlab and interpolated onto a regular grid with 25m spacing (Figure 5.1).

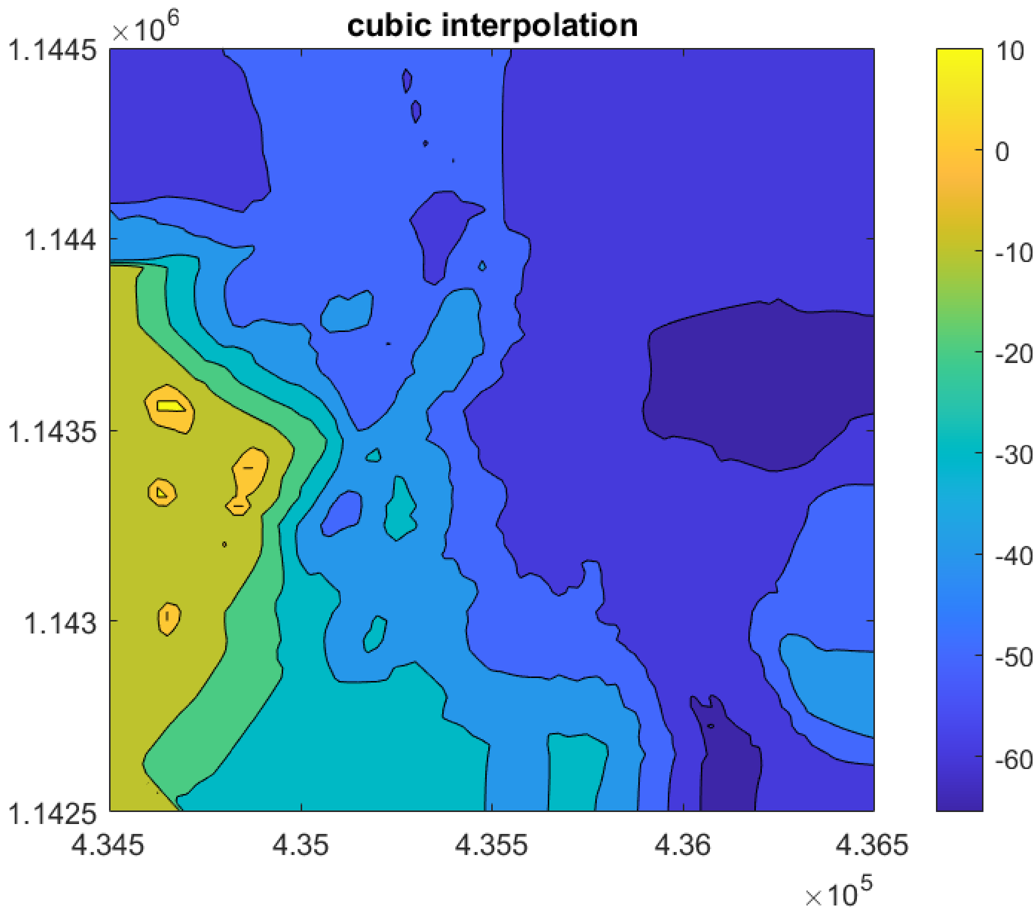

Figure 5.1: Easter Score Holms interpolated bathymetry.

5.2 Meteorological data

Meteorological data was not collected during this hydrographic survey as it lasted longer than 90 days.

5.3 Current data

Data were obtained from all sensors (speed, direction, pressure, temperature, heading, pitch and roll) for a 95-day period between 18/12/2020 to 22/03/2020.

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)

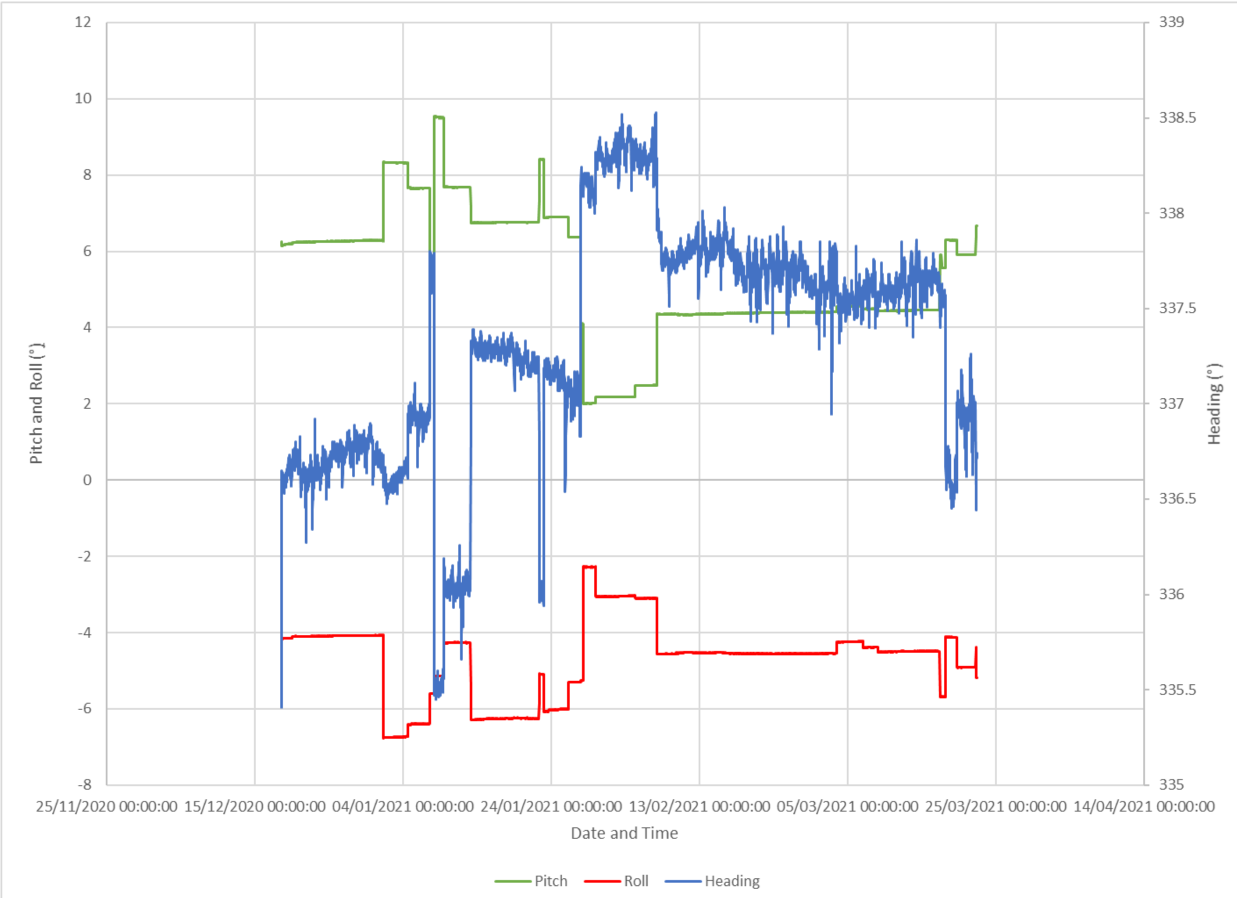

Figure 5.2: Pitch, Roll and Heading data for duration of ADCP deployment.

Table 5.1 summarises the statistics obtained through the SEPA HG analysis v7 Excel templates (Appendix 2).

Table 5.1: Summary statistics for ADCP deployment.

Bin height	Sub-surface Bin 26 (39.85 m from sensor)	Cage-bottom Bin (25.45 m from sensor)	Near-bed Bin 1 (3.85 m from sensor)
Mean Speed (m s-1)	0.080	0.033	0.033
Mean Speed Ranked %	61	57	58
3 cm s-1 Ranked %	18	53	53
4.5 cm s-1 Ranked %	31	77	75
9.5 cm s-1 Ranked %	70	99	99
Residual Direction (°Grid)	042	332	176
Residual Speed (m s-1)	0.013	0.009	0.003
Longitudinal Residual (m s-1)	0.013	0.008	0.002
Lateral Residual (m s-1)	0.004	-0.004	0.002
Longitudinal Amplitude (m s-1)	0.114	0.040	0.042
Lateral Amplitude (m s-1)	0.081	0.035	0.035
Ellipse Major Axis (°Grid)	025	360	135
Amplitude Anisotropy	1.41	1.12	1.2

6 Discussion

Bathymetric data taken during the depth survey in February 2021 confirmed Admiralty Charts are accurate in the area. Data were combined and interpolated onto a regular 25m, 2km x 2km grid for use in NewDEPOMOD.

The sub-surface and cage-bottom data have a less distinct tidal component than the near-bed data. This is commonly found as these data are more subject to the effects of wind stress; this is evidenced by the increased residual speed both laterally and longitudinally compared to cage bottom and near bed cells and by the more meandering cumulative velocity vector. Despite this, tide in the area appears to be dominantly N-NE as shown by the cumulative velocity vector plot (Figure 6.1 and the tidal ellipse major axes)

The tidal ellipse major axes determined from the current direction records is consistent with flows predominantly running parallel to the shape of the coastline and the general bathymetry of the area.

At the near-bed cell, 99% 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).

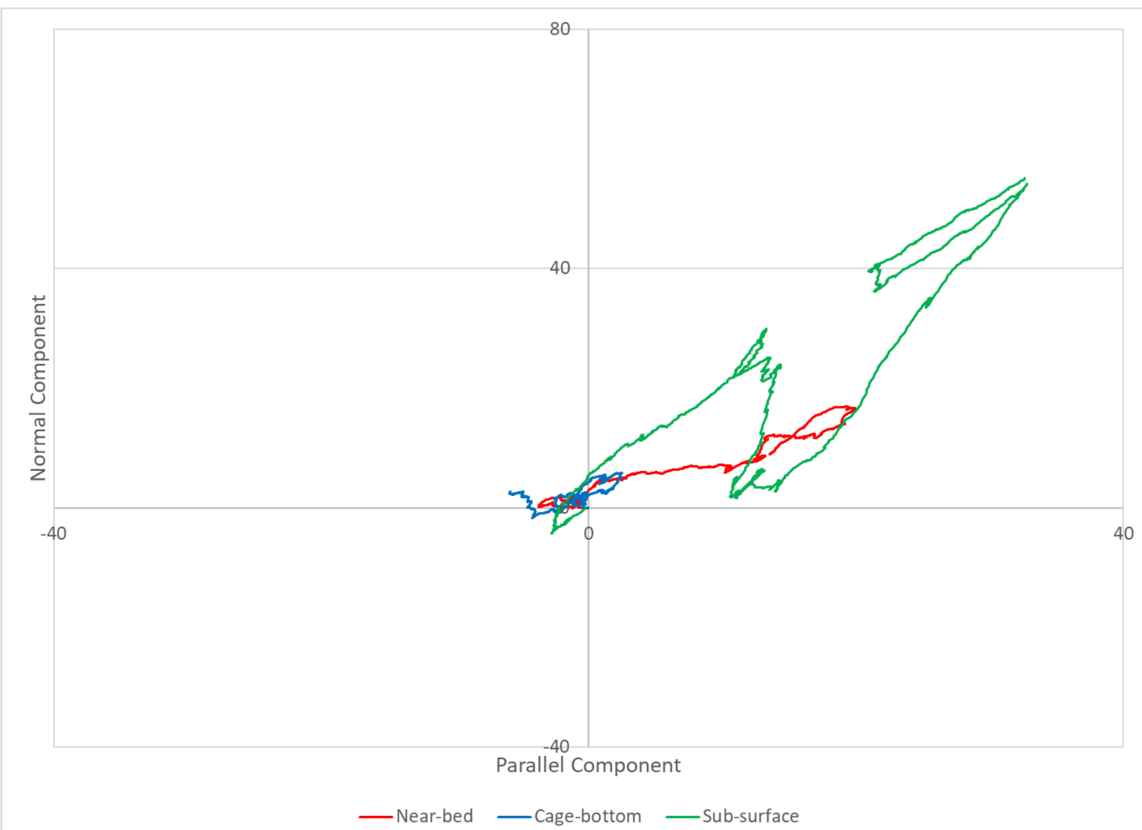

Figure 6.1: Cumulative vector plot of current velocity for all relevant bins.

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 Easter Score Holm site and subsequent use for NewDEPO-MOD and marine modelling purposes.

References

[1] *AQUACULTURE MODELLING Regulatory Modelling Process and Reporting Guidance for the Aquaculture Sector Scope of Report*. Tech. rep. 2019.

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

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Date	April 8, 2021
Revision No.	Draft 0.1

8 Appendices

8.1 Appendix 1 - Depth survey February 2021

Table 8.1: Maximum and minimum x and y extents of the bathymetry data used.

xmax	xmin	ymax	ymin
436370	435494	1144154	1142613

Tidal corrections of bathymetry were performed using an Olex system installed on the vessel used in the survey.

8.2 Appendix 2 - SEPA HG Analysis v7

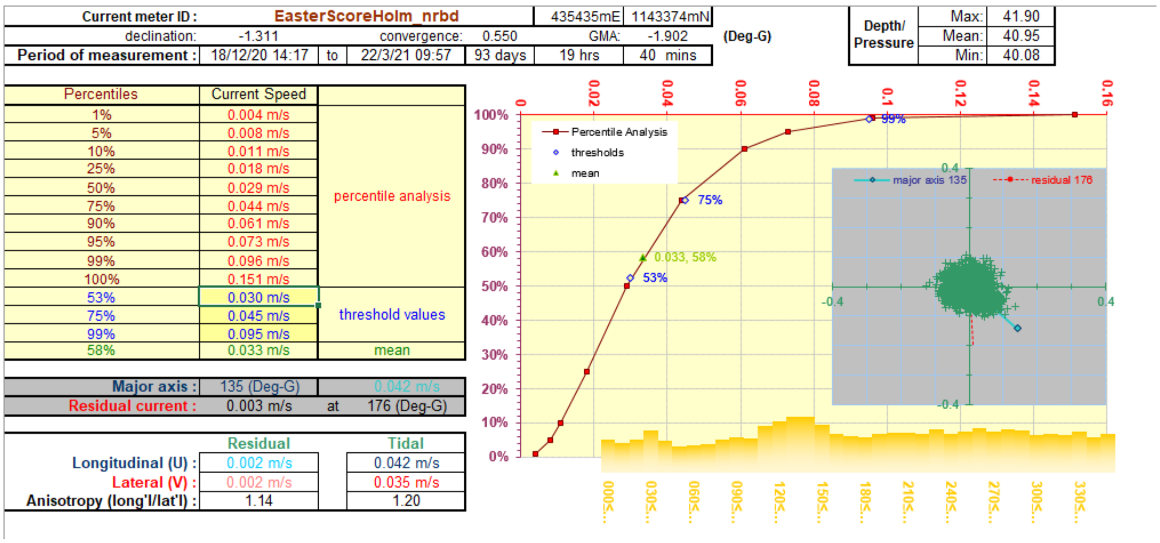

Figure 8.1: Near-bed HG analysis at Easter Score Holms.

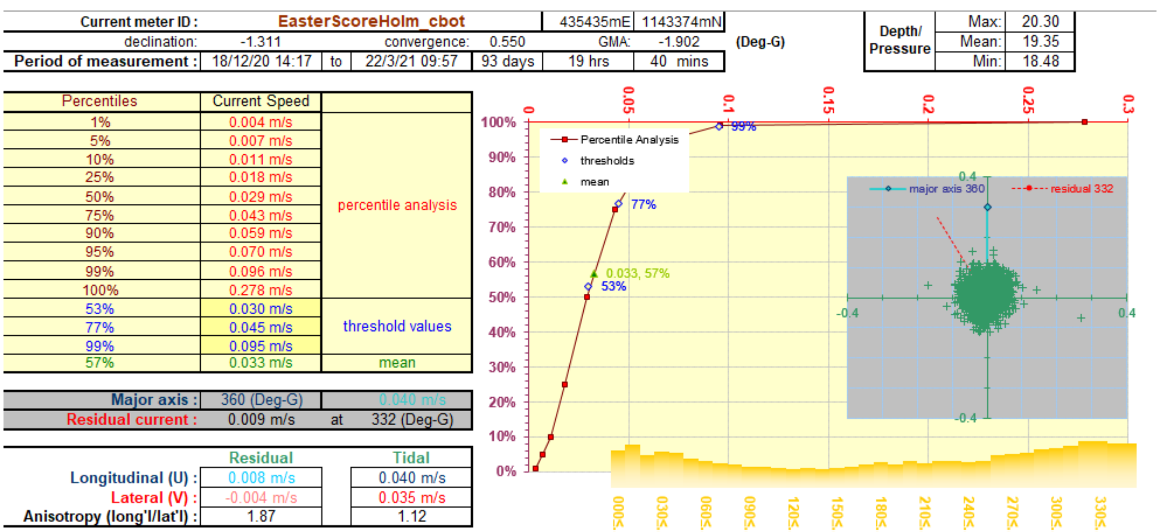

Figure 8.2: Cage-bottom HG analysis at Easter Score Holms.

Current meter ID :	EasterScoreHolm_subs				435435mE	1143374mN			
declination:	-1.311		convergence:	0.550	GMA:	-1.902	(Deg-G)		
Period of measurement :	18/12/20 14:17	to	22/3/21 09:57	93 days	19 hrs	40 mins			

Depth/ Pressure		
	Max:	5.90
	Mean:	4.95
	Min:	4.08

Percentiles	Current Speed	
1%	0.006 m/s	percentile analysis
5%	0.015 m/s	
10%	0.022 m/s	
25%	0.039 m/s	
50%	0.066 m/s	
75%	0.105 m/s	
90%	0.153 m/s	
95%	0.194 m/s	
99%	0.292 m/s	
100%	0.565 m/s	
18%	0.030 m/s	threshold values
31%	0.045 m/s	
70%	0.095 m/s	
61%	0.080 m/s	mean

Major axis :	025 (Deg-G)		0.114 m/s
Residual current :	0.013 m/s	at	042 (Deg-G)

	Residual	Tidal
Longitudinal (U) :	0.013 m/s	0.114 m/s
Lateral (V) :	0.004 m/s	0.081 m/s
Anisotropy (long'l/lat'l) :	3.28	1.41

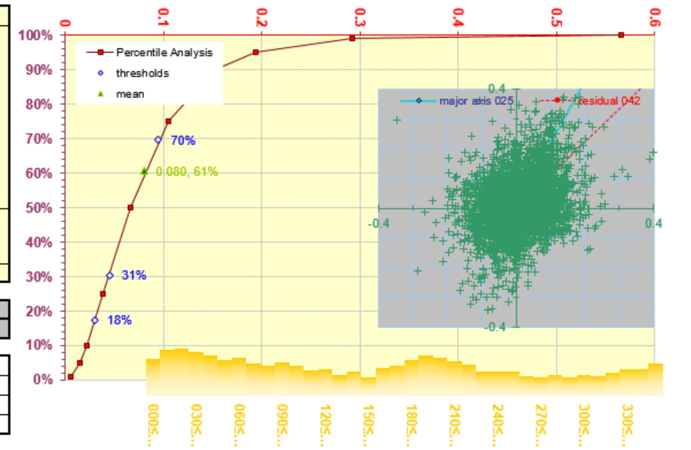

Figure 8.3: Sub-surface HG analysis at Easter Score Holms.

8.3 Appendix 3 - 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