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CURRENT METER MEASUREMENTS EAST OF SHETLAND OCTOBER 2004-OCTOBER 2005: MONITORING OCEANIC EXCHANGES WITH THE NORTH SEA – DATA REPORT.

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EXECUTIVE SUMMARY

- This report is a record of measurements undertaken during 2004 as part of ROAME AE1190, Oceanic transport around Scotland.

- Two current meter moorings were successfully deployed on the east coast of Shetland, between October 2004 and October 2005. A third mooring was deployed to the north-west of Shetland but unfortunately the mooring was disturbed and no data were recovered

- In addition, hydrographic measurements were made in the vicinity of the moorings along three standard sections on the east coast of Shetland during research cruises in October 2004, May 2005 and October 2005.

- The data have undergone preliminary processing/quality control and are presented here. All data have been archived in preparation for further analysis.

1 INTRODUCTION

The North Sea ecosystem is open to the North Atlantic at its northern boundary, where the continental shelf falls away into the deeper waters of the North Atlantic and the Faroe Shetland Channel (Figure 1). Conditions within the North Sea are strongly influenced by the inflow of saline Atlantic water. This cross shelf exchange of water varies greatly from year to year and also shows a degree of seasonal variability. Understanding the driving forces of these exchange events is important as the waters of the North Atlantic have a strong influence on the North Sea ecosystem.

The Faroe-Shetland Channel is known to be a region of intense mesoscale activity. The slope current that carries warm and salty Atlantic water through the Faroe Shetland Channel and into the Nordic Seas, does not flow in a laminar fashion but breaks into a series of meanders, filaments and eddies. The exchange of water between the deeper areas of the continental slope and the North Sea is also thought to be influenced by this mesoscale activity.

The objective of this research was to make initial measurements of currents flowing. around Shetland, which could then be used to determine how these vary in relation to currents in the Faroe-Shetland Channel as well as meteorological forcing. This work forms part of Task 3, Oceanic and North Sea exchange of ROAME AE1190, Oceanic transport around Scotland. This report describes the data collected for this task during three cruises between October 2004 and October 2005. Cruise reports are included in Appendix C of this report. Current Meters were deployed on moorings around Shetland and hydrographic data were gathered at stations in the northern North Sea (Figure 2).

2 DATA COLLECTION

Current Meter Moorings

Two instrumented moorings were deployed at positions near the inner and outer edges of the Pobie Bank 4nm and 18nm to the east of Fetlar, Shetland. A third was deployed 8nm miles north of mainland Shetland. The details of the mooring deployments are presented in Table 1.

The moorings, 707,708 and 709, were laid in October 2004 on cruise 1404S. The two on the Pobie Bank were recovered and replaced in May 2005, as 712 and 713, during cruise 0705S and were recovered again in October 2005 on cruise 0405S. The third, 709, was found to have been disturbed by a vessel and although no data were recovered one of the instruments was eventually returned to FRS.

The moorings were designed as single string or “I” moorings. A single string mooring is a simple vertical arrangement of floats and instruments connected by steel wire or rope and held down on the seabed by a weight (Figure 3). A crucial component is the acoustic release which is fitted just above the weight but below all the recoverable parts (instruments, floats and ropes). The acoustic release is a mechanical link which can be broken by remote control, sending a unique code down through the water using a hydrophone suspended from a nearby vessel. The entire mooring, minus the sacrificial weight, then floats to the surface using its own buoyancy and all of it is recovered over the stern of the vessel. The key feature of this design is that the entire mooring is sub-surface i.e. no part of the mooring is visible on the surface. The main advantage of this design is the protection from rough seas and accidental interference from surface shipping. The disadvantage is that the mooring is unmarked and can present a hazard to vessels that are working in the sub-surface zone, such as fishing vessels or submarines. Moorings require consent from the Scottish Executive Transport Division under the Coast Protection Act 1949 (Section 34) and this was obtained for each of the moorings. Further precautions are also taken by issuing a ‘Notice to Mariners’ via Kingfisher Fortnightly Bulletins and by informing the Hydrographer of the Navy directly.

The two current meters on each mooring were intended to measure water currents near the seabed and near the surface. The design “heights” chosen were 10 metres above the seabed and nominally 30 metres below the surface. The actual depth or “height” of the top of the mooring was designed as a compromise between the objective of measuring near surface water flow while avoiding the worst effects of wave action and avoiding contact with surface vessels.

The positions chosen for deployment were determined after consultation with Shetland fishing skippers, whose local knowledge was sought in identifying areas that were least likely to be fished during the proposed deployment period. One such area was a small unproductive patch within an otherwise fair fishing ground. The second was an area with two or more large, broken-up shipwrecks and the third was very close to a sunken fishing vessel which was marked on the Admiralty chart.

The instruments used were Aanderaa RCM7 current meters, recording water speed and direction. Water temperature and conductivity, for calculation of salinity, was also recorded. One reading was taken every 30 minutes over the year long deployment.
Aanderaa current meters have a mechanical rotor and although reliable are subject to biofouling. After deployment on the Pobie Bank, through the summer of 2005, the rotating parts of the instruments at 30m were found to be fouled with filamentous algae.

The upper instrument on mooring 709 (West Shetland) was sent back to FRS in December 2004 after being recovered from an array of gear being towed by the seismic survey vessel “Western Regent”. The survey dates and areas of seismic vessels are publicised in advance in the Kingfisher Fortnightly Bulletin along with the length and operating depth of their towed gear. Typically this gear is up to several kilometres long and is less than 10m below the surface but on this occasion the vessel was sheltering from gale force winds some 60 km west of the survey area, while still towing gear. In poor weather and while the vessel makes turns the gear is liable to sink below the optimum depth. Course data obtained from the seismic crew onboard the “Western Regent” has allowed the departure course of the mooring to be plotted. It is estimated the lost portion of this mooring will be contactable until the acoustic release batteries fail in 2009 and further attempts will be made to recover it.

Hydrographic Data

During the cruises hydrographic data were collected using a Seabird 911+ CTD along standard sections in the northern North Sea. These sections have been occupied in the past, either as part of the continuous monitoring programme in Scottish waters (JONSIS Line) or as part of previous research projects (East Shetland and East Coast Sections, Turrell *et. al.* 1996.).

The sections were occupied as much as possible within the limitations of the existing cruise schedule and the weather. As such, not all stations and/or sections were occupied on each cruise. A summary of the CTD stations occupied during each cruise is presented in Table 2. At each station temperature and salinity data were collected.

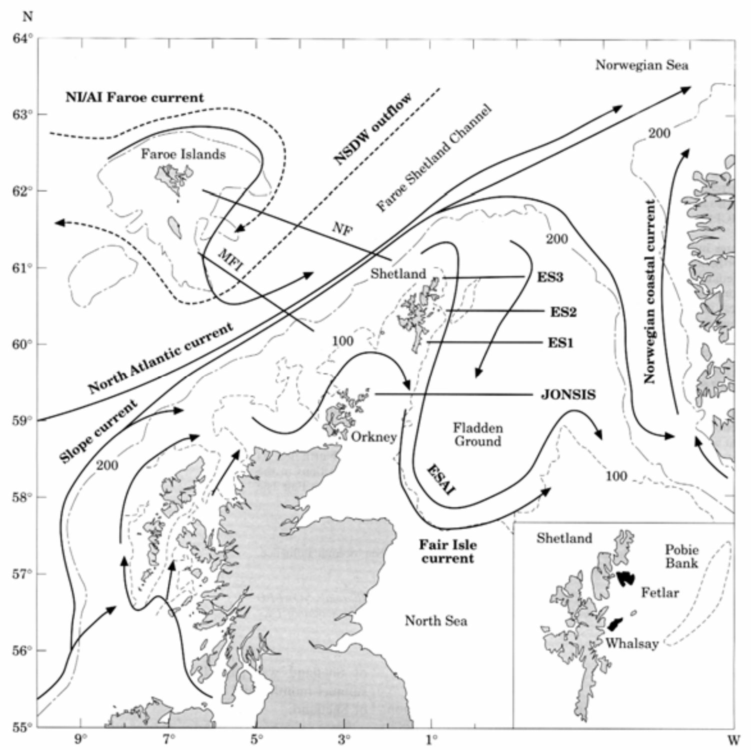

Figure 1 Map (taken from Turrell et. al. 1996) showing the key features of the circulation around Scotland. The East Shetland Atlantic Inflow (ESAI) is shown

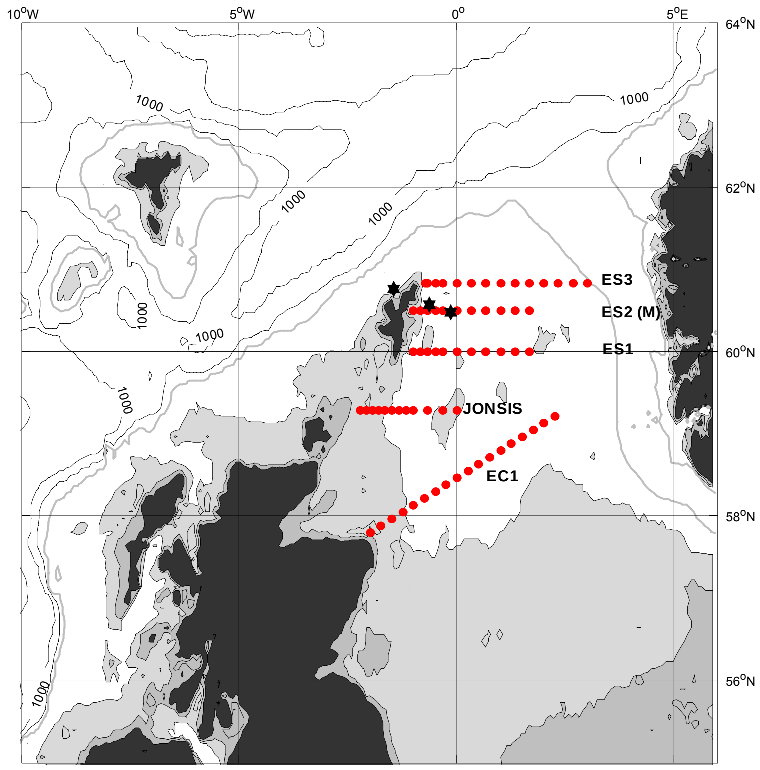

Figure 2 Map showing the bathymetry of the seas around Scotland. Dark Grey shading <50m, Light Grey Shading 50-100m. 250m contour is marked in grey. Other contours are 500m, 1000m, 2000m and 3000m. The position of current meter moorings (*) and hydrographic sections undertaken during cruises between October 2004 and October 2005 (•) are shown.

TABLE 1

Summary of Mooring Deployments

Mooring	Name	Position	Deployment Date	Recovery Date	Sounding	Upper Instrument Depth	Lower Instrument Depth
707	East Shetland Inner	60° 34.44'N 000° 37.90'W	06/10/2004	10/05/2005	144	49	134
708	East Shetland Outer	60° 28.54'N 000° 07.71W	07/10/2004	10/05/2005	116	36	106
709	West Shetland	60° 45.83'N 001° 27.12W	07/10/2004	LOST	128	33	118
712	East Shetland Inner	60° 34.50'N 000° 38.08'W	10/05/2005	01/05/2005	146	51	136
713	East Shetland Outer	60° 28.63'N 000° 07.75'W	10/05/2005	01/05/2005	117	37	107
	West Shetland						

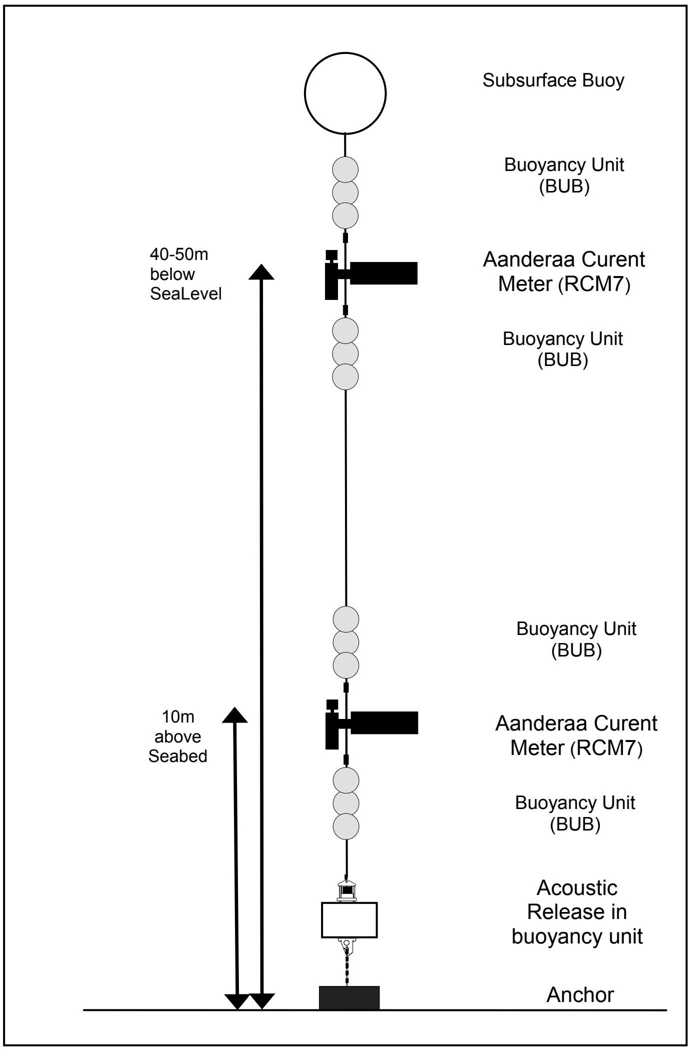

Figure 3 Typical Mooring Diagram

TABLE 2

Summary of Hydrographic measurements, numbers in column 7-9 are FRS hydrographic station numbers.

East of Shetland Line 1

Ind	Name	Latitude	Longitude	Depth (m)	Dist (km)	SC200414	SC200507	SC200514
1	ES1_1	60° 00.00' N	01° 00.00' W	110			198	
2	ES1_2	60° 00.00' N	00° 50.00' W	130	9.1		199	
3	ES1_3	60° 00.00' N	00° 40.00' W	125	9.1		200	
4	ES1_4	60° 00.00' N	00° 30.00' W	125	9.1		201	
5	ES1_5	60° 00.00' N	00° 20.00' W	150	9.1		202	
6	ES1_6	60° 00.00' N	00° 00.00' E	150	18.3		203	
7	ES1_7	60° 00.00' N	00° 20.00' E	130	18.3		204	
8	ES1_8	60° 00.00' N	00° 40.00' E	125	18.3		205	
9	ES1_9	60° 00.00' N	01° 00.00' E	125	18.3		206	
10	ES1_10	60° 00.00' N	01° 20.00' E	120	18.3		207	
11	ES1_11	60° 00.00' N	01° 40.00' E	120	18.3		208	

East of Shetland Line 2 (Modified to Mooring Position)

Ind	Name	Latitude	Longitude	Depth (m)	Dist (km)	SC200414	SC200507	SC200514
1	ES2(M)_0	60° 30.00'N	01° 00.00'W	121		458	162	388
2	ES2(M)_1	60° 30.00'N	00° 50.00'W	100	9.1	457	161	387
2	ES2(M)_2	60° 30.00'N	00° 40.00'W	95	9.1	456	160	386
3	ES2(M)_3	60° 30.00'N	00° 30.00'W	100	9.1	455	159	385
4	ES2(M)_4	60° 30.00'N	00° 20.00'W	100	9.1	454	158	384
5	ES2(M)_5	60° 30.00'N	00° 00.00'E	130	9.1	453	157	383
6	ES2(M)_6	60° 30.00'N	00° 20.00'E	150	18.3	452	156	382
7	ES2(M)_7	60° 30.00'N	00° 40.00'E	140	18.3		155	381
8	ES2(M)_8	60° 30.00'N	01° 00.00'E	160	18.3		154	380
9	ES2(M)_9	60° 30.00'N	01° 20.00'E	140	18.3		153	
10	ES2(M)_10	60° 30.00'N	01° 40.00'E	125	18.3		152	

East of Shetland Line 3

Ind	Name	Latitude	Longitude	Depth (m)	Dist (km)	SC200414	SC200507	SC200514
1	ES3_1	60° 50.00' N	00° 44.00' W	75			218 (163)	
2	ES3_2	60° 50.00' N	00° 40.00' W	95	3.6		217 (164)	
3	ES3_3	60° 50.00' N	00° 30.00' W	110	9		216 (165)	
4	ES3_4	60° 50.00' N	00° 20.00' W	140	18		215 (166)	
5	ES3_5	60° 50.00' N	00° 00.00' E	160	18		214 (167)	
6	ES3_6	60° 50.00' N	00° 20.00' E	140	18		213	
7	ES3_7	60° 50.00' N	00° 40.00' E	150	18		212	
8	ES3_8	60° 50.00' N	01° 00.00' E	155	18		211	
9	ES3_9	60° 50.00' N	01° 20.00' E	145	18		210	
10	ES3_10	60° 50.00' N	01° 40.00' E	130	18		209	
11	ES3_11	60° 50.00' N	02° 00.00' E	125	18			
12	ES3_12	60° 50.00' N	02° 20.00' E	120	18			
13	ES3-13	60° 50.00' N	02° 40.00' E	190	18			
14	ES3_14	60° 50.00' N	03° 00.00' E	250	18			

TABLE 2 (continued)

Summary of Hydrographic measurements, numbers in column 7-9 are FRS hydrographic station numbers.

JONSIS Line

Ind	Name	Latitude	Longitude	Depth (m)	Dist (km)	SC200414	SC200507	SC200514
1	JO 1	59° 17.00' N	02° 14.00' W	75		451	151	375
2	JO 1A	59° 17.00' N	02° 5.00' W	90	8.5	450	150	376
3	JO 2	59° 17.00' N	01° 56.00' W	100	8.5	449	149	377
4	JO 3	59° 17.00' N	01° 48.00' W	80	7.6	448	148	378
5	JO 4	59° 17.00' N	01° 40.00' W	90	7.6	447	147	379
6	JO 5	59° 17.00' N	01° 30.00' W	95	9.5	446	146	
7	JO 6	59° 17.00' N	01° 20.00' W	110	9.5	445	145	
8	JO 6A	59° 17.00' N	01° 10.00' W	120	9.5	444	144	
9	JO 7	59° 17.00' N	01° 0.00' W	125	9.5	443	143	
10	JO 8	59° 17.00' N	00° 40.00' W	120	18.9	442	142	
11	JO 9	59° 17.00' N	00° 20.00' W	140	18.9	441	141	
12	JO10	59° 17.00' N	00° 0.00' W	135	18.9	440	140	

East Coast Line

Ind	Name	Latitude	Longitude	Depth (m)	Dist (km)	SC200414	SC200507	SC200514
1	EC18	59° 13.00' N	02° 15.00' E	220				
2	EC17	59° 8.00' N	02° 00.00' E	75	17			
3	EC16	59° 3.00' N	01° 45.00' E	95	17			
4	EC15	58° 58.00' N	01° 30.00' E	125	17			
5	EC14	58° 53.00' N	01° 15.00' E	120	17.1			
6	EC13	58° 48.00' N	01° 00.00' E	120	17.1	439		
7	EC12	58° 43.00' N	00° 45.00' E	140	17.1	438		
8	EC11	58° 38.00' N	00° 30.00' E	140	17.1	437		
9	EC10	58° 33.00' N	00° 15.00' E	150	17.2	436		
10	EC9	58° 28.00' N	00° 00.00' W	140	17.2	435		
11	EC8	58° 23.00' N	00° 15.00' W	130	17.2	434		
12	EC7	58° 18.00' N	00° 30.00' W	120	17.3	433		
13	EC6	58° 13.00' N	00° 45.00' W	105	17.3	432		
14	EC5	58° 08.00' N	01° 00.00' W	115	17.3	431		
15	EC4	58° 03.00' N	01° 15.00' W	110	17.3	430		
16	EC3	57° 58.00' N	01° 30.00' W	95	17.4	429		
17	EC2	57° 53.00' N	01° 45.00' W	75	17.4	428		
18	EC1	57° 48.00' N	02° 00.00' W	185	17.4	427		

3 DATA ANALYIS

Current Meter Moorings

Current meter records have undergone preliminary data analysis, converting the data from raw engineering units into actual data parameters and applying instrument derived calibration coefficients. Timeseries plots of all parameters recorded by each current meter are presented in figures A1-A8 in Appendix A.

Although all current meters logged data continuously throughout the deployments, there was some loss of data from the lower current meter on the East Shetland Outer mooring during the first (Figure A4) and second deployments (Figure A8), most likely caused by the algal growth that was reported when the instruments were recovered. Data from these periods were flagged as erroneous.

Once the data had been quality controlled, data files from each deployment were merged together to create a single year long timeseries. Figure 4 shows the current speed data from this timeseries.

Residual current speeds were calculated filtering the data and removing the tidally generated components of the current. Residual current data can then be examined to investigate the effects of non-tidal forcing on the current flow.

All current meter data are archived in the FRS data archives and will be submitted to both the BODC and ICES data centres

Hydrographic Data

The CTD data were processed using standard Seabird processing and FRS quality control and calibration procedures.

CTD data from each section have been contoured and plotted to show temperature, salinity and density, as show in Figure B1-B9, Appendix B.

All CTD data are archived in the FRS data archives and will be submitted to both the BODC and ICES data centres

4 RESULTS

A preliminary investigation of the data shows that there were a number of strong flow events recorded by all current meters during the measurement period. These can be seen in the current speed plots (Figure 4) but are more clearly identified when looking at residual current speeds (current speed after tidal variability is removed) in Figure 5.

Residual currents speeds were generally fairly low, with average speeds of between 4-8 cm/s. However on occasion, strong current events were observed. Most notable is the peak current speed of around 20 cm/s observed during January 2005, an event which was recorded at both moorings (Figure 5 and Table 3). The cause of these events will be investigated further. It is also apparent from these figures that the residual current speed in the lower current meter on the East Shetland Outer mooring appears to have a different pattern from that of the upper current meter.

As expected, the residual current flow is oriented closely to the bathymetry with the majority of the flow toward the south-south-east, this can be seen clearly in the occurrence plots (Figure 6-9) and the joint occurrence/exceedence tables in Appendix A.

The current meters also record temperature and salinity, which can be used to infer the hydrographic variability during the period of deployment. Unfortunately the conductivity sensors fitted to the Aanderaa current meters are extremely prone to fouling and as a result the data must be used with great caution.

The timeseries of temperature data from the mooring clearly shows that during the initial deployment the water column was well mixed. However during May/June, stratification begins to occur and temperatures in the upper layers become much warmer than those below (Figure 10).

Due to the problems associated with the current data, it is not possible to merge it into a single timeseries. The salinity data might however be used to identify periods of strong variability even when the absolute accuracy of the sensors is unreliable.

5 CONCLUSIONS

These data provide us with much needed timeseries of the currents flowing in the East Shetland Atlantic Inflow. Further analysis and investigation of these data will be useful in future studies to investigate the influence of mesoscale activity on cross shelf exchange and other research of the variability of inflows to the North Sea.

6 REFERENCES

Turrell, W.R, Slesser, G., Payne, R., Adams, R.D. and Gillibrand, P.A. 1996 Hydrography of the East Shetland Basin in relation to decadal North Sea variability. ICES Journal of Marine Science 53: 899-916.

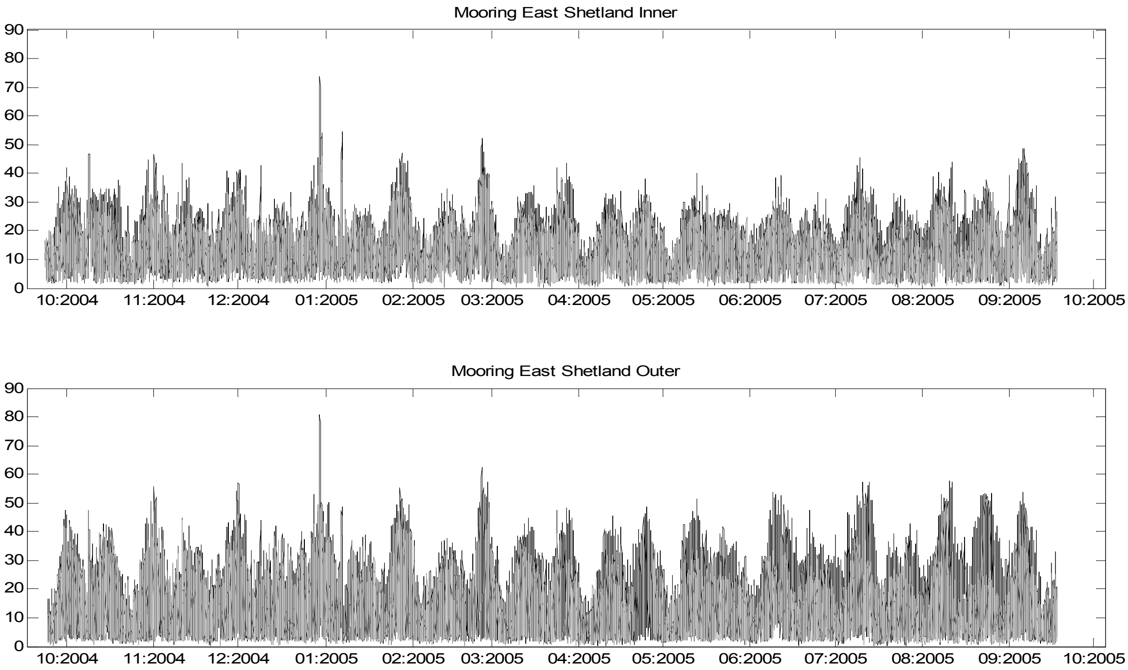

Figure 4 Current Speed (cm/sec) from Inner Mooring (upper panel) and Outer Mooring (lower panel). In each pane data from the upper mooring is shown in black and the lower mooring is shown in dark grey. X-axis shows month:year.

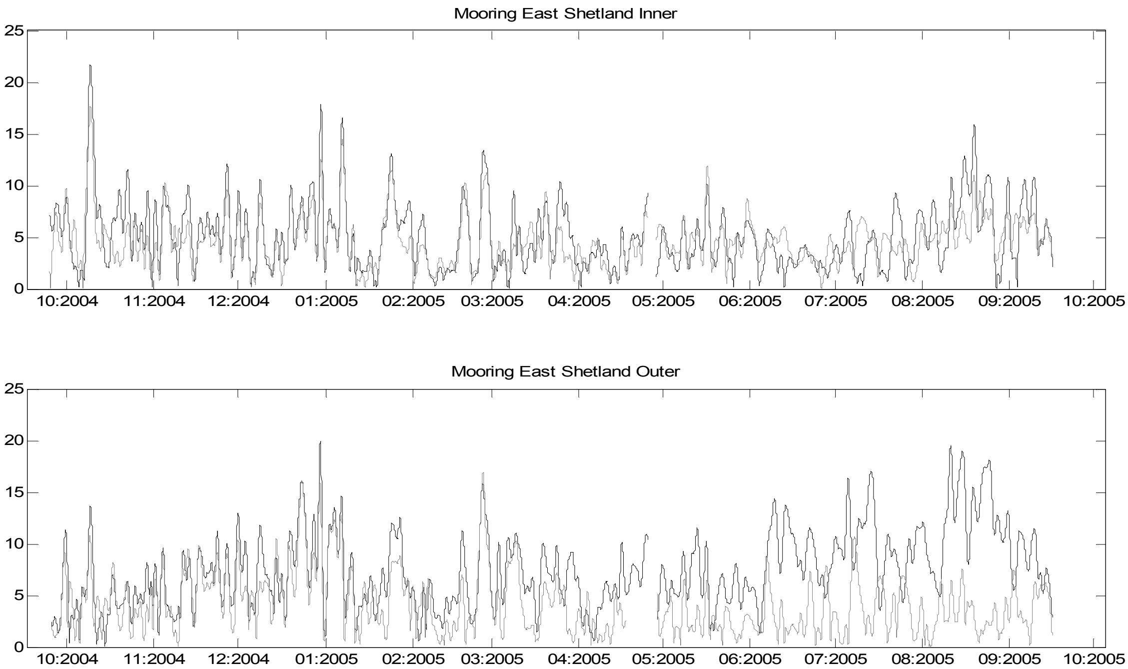

Figure 5 Residual Current Speed (cm/sec) from Inner Mooring (upper panel) and Outer Mooring (lower panel). In each pane data from the upper mooring is shown in black and the lower mooring is shown in dark grey. X-axis shows month:year.

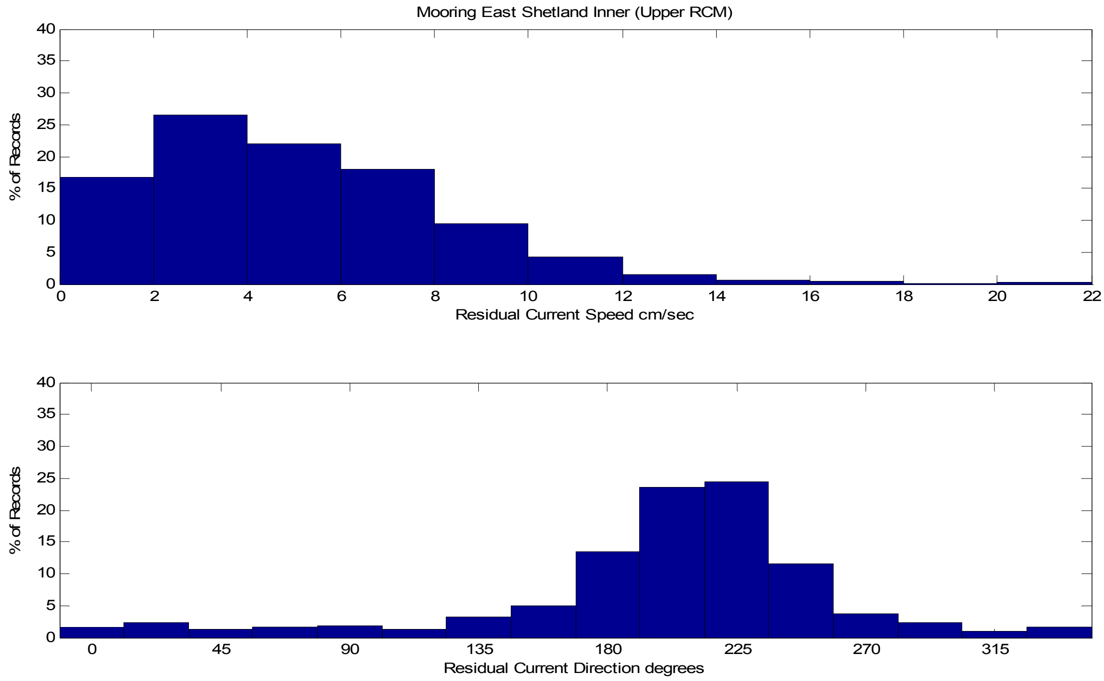

Figure 6 Occurrence plots of residual current speed and direction from the upper RCM on the East Shetland Inner Mooring.

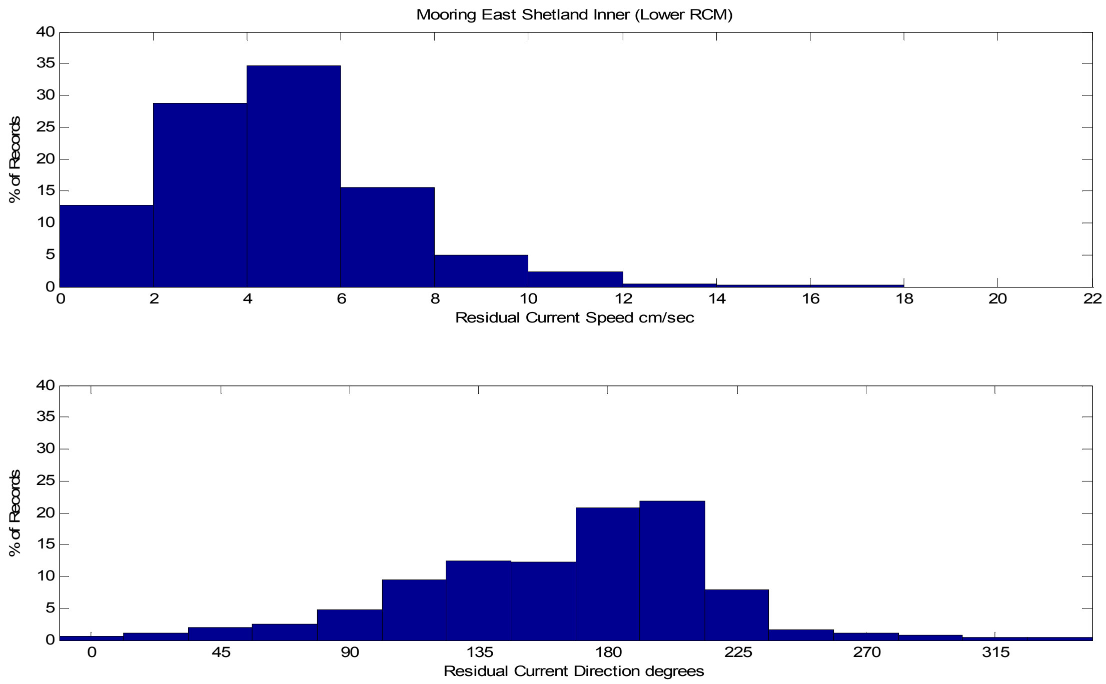

Figure 7 Occurrence plots of residual current speed and direction from the lower RCM on the East Shetland Inner Mooring.

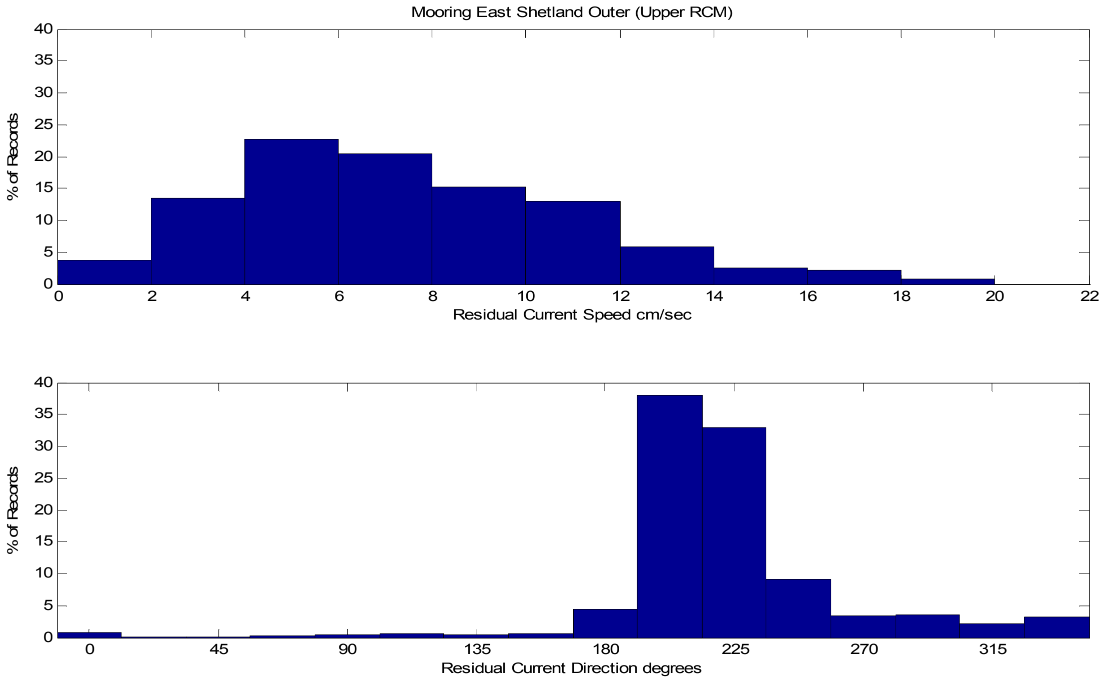

Figure 8 Occurrence plots of residual current speed and direction from the upper RCM on the East Shetland Outer Mooring.

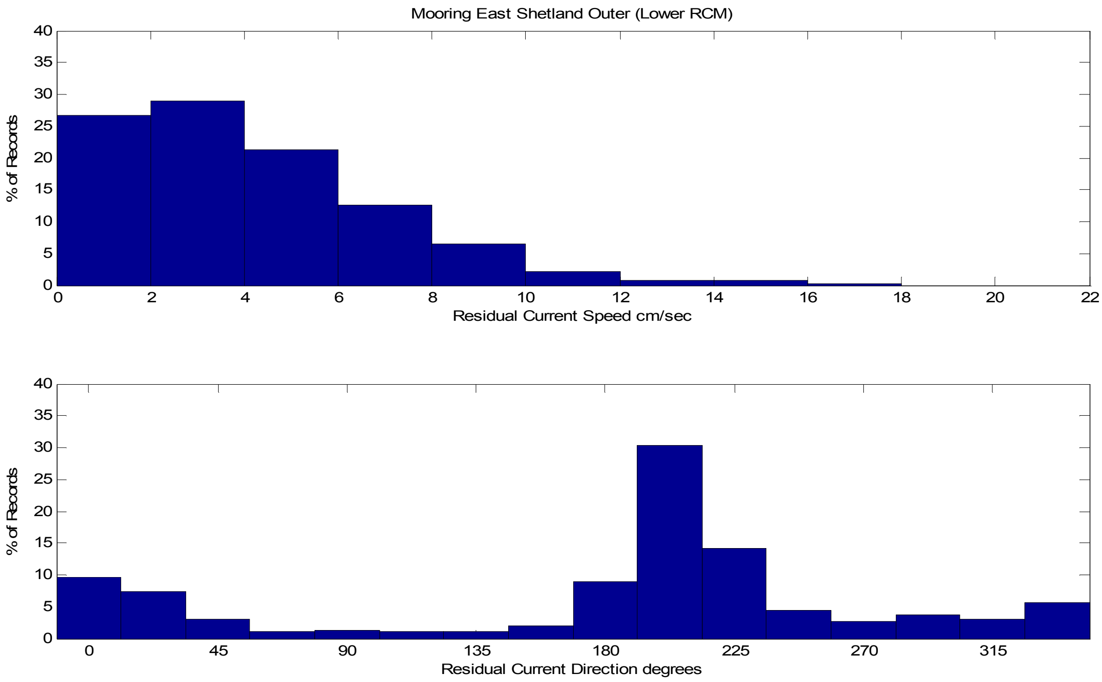

Figure 9 Occurrence plots of residual current speed and direction from the lower RCM on the East Shetland Outer Mooring.

TABLE 3

Statistics of residual current speed for upper and lower current meters on each mooring.

Mooring	Depth (metres)	Maximum Speed (cm/s)	Mean Speed (cm/s)	St Dev Speed (cm/s)	Stability	Number of Hourly Samples
East Shetland Inner	**50**	21.70	5.10	3.20	79.71	8489
	135	17.71	4.61	2.44	74.45	8489
East Shetland Outer	**36.5**	19.96	7.47	3.71	89.34	8472
	106.5	16.87	4.16	2.89	48.77	8285

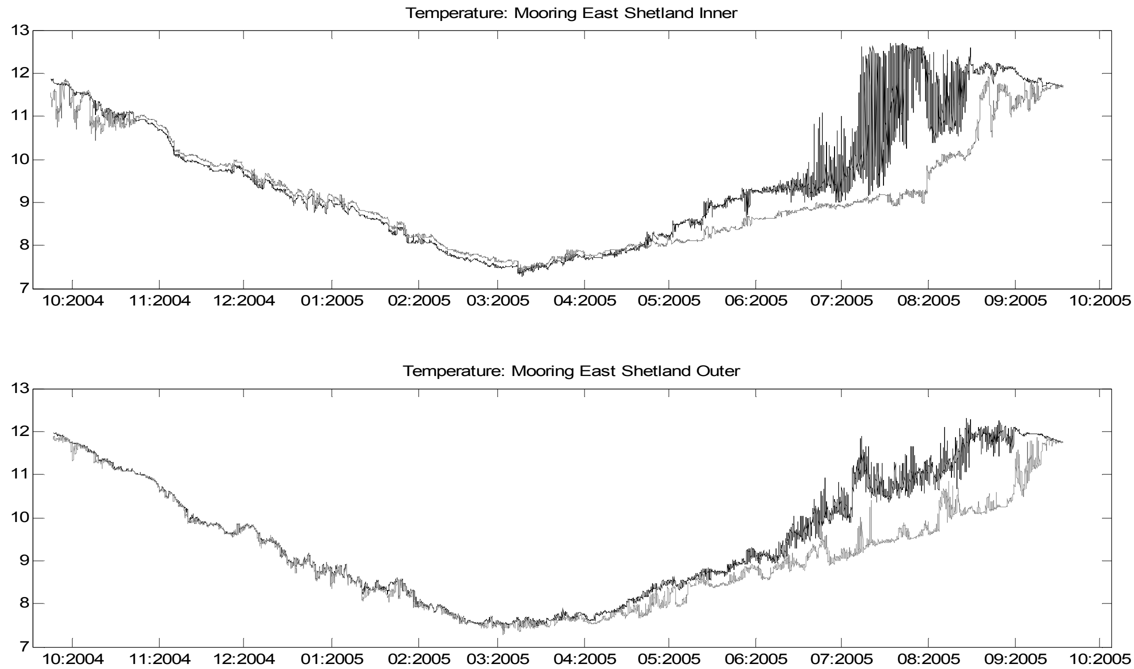

Figure 10 Sea temperature (°C) from Inner Mooring (upper panel) and Outer Mooring (lower panel). In each panel data from the upper mooring is shown in black and the lower mooring is shown in dark grey. X-axis shows month:year.

APPENDIX A: CURRENT METER DATA

TABLE A1

Occurrence/Exceedence of Current Speed for Mooring East Shetland Inner, Upper Current Meter

		>=	348.75	11.25	33.75	56.25	78.75	101.25	123.75	146.25	168.75	191.25	213.75	236.25	258.75	281.25	303.75	326.25	**0**
		<	11.25	33.75	56.25	78.75	101.25	123.75	146.25	168.75	191.25	213.75	236.25	258.75	281.25	303.75	326.25	348.75	**360**
		mid	0	22.5	45	67.5	90	112.5	135	157.5	180	202.5	225	247.5	270	292.5	315	337.5	**All**
>=	**<**	**mid**	**N**	**NNE**	**NE**	**ENE**	**E**	**ESE**	**SE**	**SSE**	**S**	**SSE**	**SE**	**WSE**	**W**	**WNW**	**NW**	**NNW**	
0	2	**1**	**74** *146* **(51)** *(100)*	**83** *193* **(43)** *(100)*	**71** *108* **(66)** *(100)*	**48** *133* **(36)** *(100)*	**71** *157* **(45)** *(100)*	**62** *112* **(55)** *(100)*	**85** *276* **(31)** *(100)*	**93** *424* **(22)** *(100)*	**75** *1149* **(7)** *(100)*	**135** *1997* **(7)** *(100)*	**168** *2071* **(8)** *(100)*	**154** *987* **(16)** *(100)*	**78** *313* **(25)** *(100)*	**84** *197* **(43)** *(100)*	**52** *86* **(60)** *(100)*	**87** *140* **(62)** *(100)*	**1420** *8489* **(17)** *(100)*
2	4	**3**	**66** *72* **(45)** *(49)*	**95** *110* **(49)** *(57)*	**37** *37* **(34)** *(34)*	**37** *85* **(28)** *(64)*	**51** *86* **(32)** *(55)*	**41** *50* **(37)** *(45)*	**123** *191* **(45)** *(69)*	**145** *331* **(34)** *(78)*	**194** *1074* **(17)** *(93)*	**396** *1862* **(20)** *(93)*	**491** *1903* **(24)** *(92)*	**261** *833* **(26)** *(84)*	**117** *235* **(37)** *(75)*	**109** *113* **(55)** *(57)*	**34** *34* **(40)** *(40)*	**53** *53* **(38)** *(38)*	**2250** *7069* **(27)** *(83)*
4	6	**5**	**6** *6* **(4)** *(4)*	**15** *15* **(8)** *(8)*	**0** *0* **(0)** *(0)*	**14** *48* **(11)** *(36)*	**7** *35* **(4)** *(22)*	**9** *9* **(8)** *(8)*	**64** *68* **(23)** *(25)*	**121** *186* **(29)** *(44)*	**373** *880* **(32)** *(77)*	**546** *1466* **(27)** *(73)*	**416** *1412* **(20)** *(68)*	**220** *572* **(22)** *(58)*	**77** *118* **(25)** *(38)*	**4** *4* **(2)** *(2)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**1872** *4819* **(22)** *(57)*
6	8	**7**	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**33** *34* **(25)** *(26)*	**9** *28* **(6)** *(18)*	**0** *0* **(0)** *(0)*	**4** *4* **(1)** *(1)*	**43** *65* **(10)** *(15)*	**386** *507* **(34)** *(44)*	**398** *920* **(20)** *(46)*	**421** *996* **(20)** *(48)*	**193** *352* **(20)** *(36)*	**41** *41* **(13)** *(13)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**1528** *2947* **(18)** *(35)*
8	10	**9**	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**1** *1* **(1)** *(1)*	**19** *19* **(12)** *(12)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**22** *22* **(5)** *(5)*	**90** *121* **(8)** *(11)*	**282** *522* **(14)** *(26)*	**260** *575* **(13)** *(28)*	**136** *159* **(14)** *(16)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**810** *1419* **(10)** *(17)*
10	12	**11**	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**27** *31* **(2)** *(3)*	**170** *240* **(9)** *(12)*	**148** *315* **(7)** *(15)*	**18** *23* **(2)** *(2)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**363** *609* **(4)** *(7)*
12	14	**13**	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**3** *4* **(0)** *(0)*	**30** *70* **(2)** *(4)*	**89** *167* **(4)** *(8)*	**3** *5* **(0)** *(1)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**125** *246* **(1)** *(3)*
14	16	**15**	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**1** *1* **(0)** *(0)*	**16** *40* **(1)** *(2)*	**34** *78* **(2)** *(4)*	**2** *2* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**53** *121* **(1)** *(1)*
16	18	**17**	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**24** *24* **(1)** *(1)*	**11** *44* **(1)** *(2)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**35** *68* **(0)** *(1)*
18	20	**19**	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**13** *33* **(1)** *(2)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**13** *33* **(0)** *(0)*
20	22	**21**	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**20** *20* **(1)** *(1)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**20** *20* **(0)** *(0)*
0	22	**All**	**146 (1.7)**	**193 (2.3)**	**108 (1.3)**	**133 (1.6)**	**157 (1.8)**	**112 (1.3)**	**276 (3.3)**	**424 (5.0)**	**1149 (13.5)**	**1997 (23.5)**	**2071 (24.4)**	**987 (11.6)**	**313 (3.7)**	**197 (2.3)**	**86 (1.0)**	**140 (1.6)**	**8489**

Tables show number of records in which there is **occurrence** within the speed bands (bold) and *exceedence* of minimum speed threshold (italics) within each directional sector. Figures in brackets express the same data as a percentage of the total number of records.

TABLE A2

Occurrence/Exceedence of Current Speed for Mooring East Shetland Inner, Lower Current Meter

		>=	348.75		11.25		33.75		56.25		78.75		101.25		123.75		146.25		168.75		191.25		213.75		236.25		258.75		281.25		303.75		326.25		**0**	
		<	11.25		33.75		56.25		78.75		101.25		123.75		146.25		168.75		191.25		213.75		236.25		258.75		281.25		303.75		326.25		348.75		**360**	
		mid	0		22.5		45		67.5		90		112.5		135		157.5		180		202.5		225		247.5		270		292.5		315		337.5		**All**	
>=	<	mid	**N**		**NNE**		**NE**		**ENE**		**E**		**ESE**		**SE**		**SSE**		**S**		**SSE**		**SE**		**WSE**		**W**		**WNW**		**NW**		**NNW**			
0	2	**1**	**28**	*54*	**72**	*101*	**66**	*169*	**53**	*209*	**117**	*406*	**107**	*799*	**85**	*1062*	**103**	*1038*	**158**	*1766*	**88**	*1852*	**62**	*676*	**25**	*134*	**45**	*94*	**44**	*68*	**21**	*30*	**18**	*31*	**1092**	*8489*
			(52)	*(100)*	**(71)**	*(100)*	**(39)**	*(100)*	**(25)**	*(100)*	**(29)**	*(100)*	**(13)**	*(100)*	**(8)**	*(100)*	**(10)**	*(100)*	**(9)**	*(100)*	**(5)**	*(100)*	**(9)**	*(100)*	**(19)**	*(100)*	**(48)**	*(100)*	**(65)**	*(100)*	**(70)**	*(100)*	**(58)**	*(100)*	**(13)**	*(100)*
2	4	**3**	**15**	*26*	**11**	*29*	**77**	*103*	**120**	*156*	**100**	*289*	**231**	*692*	**352**	*977*	**339**	*935*	**529**	*1608*	**426**	*1764*	**127**	*614*	**36**	*109*	**39**	*49*	**24**	*24*	**9**	*9*	**13**	*13*	**2448**	*7397*
			(28)	*(48)*	**(11)**	*(29)*	**(46)**	*(61)*	**(57)**	*(75)*	**(25)**	*(71)*	**(29)**	*(87)*	**(33)**	*(92)*	**(33)**	*(90)*	**(30)**	*(91)*	**(23)**	*(95)*	**(19)**	*(91)*	**(27)**	*(81)*	**(41)**	*(52)*	**(35)**	*(35)*	**(30)**	*(30)*	**(42)**	*(42)*	**(29)**	*(87)*
4	6	**5**	**10**	*11*	**10**	*18*	**26**	*26*	**36**	*36*	**141**	*189*	**344**	*461*	**494**	*625*	**399**	*596*	**701**	*1079*	**506**	*1338*	**218**	*487*	**45**	*73*	**10**	*10*	**0**	*0*	**0**	*0*	**0**	*0*	**2940**	*4949*
			(19)	*(20)*	**(10)**	*(18)*	**(15)**	*(15)*	**(17)**	*(17)*	**(35)**	*(47)*	**(43)**	*(58)*	**(47)**	*(59)*	**(38)**	*(57)*	**(40)**	*(61)*	**(27)**	*(72)*	**(32)**	*(72)*	**(34)**	*(54)*	**(11)**	*(11)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(35)**	*(58)*
6	8	**7**	**1**	*1*	**8**	*8*	**0**	*0*	**0**	*0*	**48**	*48*	**117**	*117*	**126**	*131*	**155**	*197*	**332**	*378*	**431**	*832*	**92**	*269*	**5**	*28*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**1315**	*2009*
			(2)	*(2)*	**(8)**	*(8)*	**(0)**	*(0)*	**(0)**	*(0)*	**(12)**	*(12)*	**(15)**	*(15)*	**(12)**	*(12)*	**(15)**	*(19)*	**(19)**	*(21)*	**(23)**	*(45)*	**(14)**	*(40)*	**(4)**	*(21)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(15)**	*(24)*
8	10	**9**	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**5**	*5*	**41**	*42*	**24**	*46*	**214**	*401*	**115**	*177*	**15**	*23*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**414**	*694*
			(0)	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(4)**	*(4)*	**(1)**	*(3)*	**(12)**	*(22)*	**(17)**	*(26)*	**(11)**	*(17)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(5)**	*(8)*
10	12	**11**	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**1**	*1*	**12**	*22*	**121**	*187*	**53**	*62*	**8**	*8*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**195**	*280*
			(0)	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(1)**	*(1)*	**(7)**	*(10)*	**(8)**	*(9)*	**(6)**	*(6)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(2)**	*(3)*
12	14	**13**	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**9**	*10*	**23**	*66*	**6**	*9*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**38**	*85*
			(0)	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(1)**	*(1)*	**(1)**	*(4)*	**(1)**	*(1)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(1)*
14	16	**15**	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**1**	*1*	**20**	*43*	**3**	*3*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**24**	*47*
			(0)	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(1)**	*(2)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(1)*
16	18	**17**	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**23**	*23*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**23**	*23*
			(0)	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(1)**	*(1)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*
18	20	**19**	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*
			(0)	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*
20	22	**21**	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*
			(0)	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*	**(0)**	*(0)*
0	22	**All**	**54**		**101**		**169**		**209**		**406**		**799**		**1062**		**1038**		**1766**		**1852**		**676**		**134**		**94**		**68**		**30**		**31**		**8489**	
			(0.6)		**(1.2)**		**(2.0)**		**(2.5)**		**(4.8)**		**(9.4)**		**(12.5)**		**(12.2)**		**(20.8)**		**(21.8)**		**(8.0)**		**(1.6)**		**(1.1)**		**(0.8)**		**(0.4)**		**(0.4)**			

Tables show number of records in which there is **occurrence** within the speed bands (bold) and *exceedence* of minimum speed threshold (italics) within each directional sector. Figures in brackets express the same data as a percentage of the total number of records.

TABLE A3

Occurrence/Exceedence of Current Speed for Mooring East Shetland Outer, Upper Current Meter.

>=	<	mid	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSE	SE	WSE	W	WNW	NW	NNW	All
		>=	348.75	11.25	33.75	56.25	78.75	101.25	123.75	146.25	168.75	191.25	213.75	236.25	258.75	281.25	303.75	326.25	**0**
		<	11.25	33.75	56.25	78.75	101.25	123.75	146.25	168.75	191.25	213.75	236.25	258.75	281.25	303.75	326.25	348.75	**360**
		mid	0	22.5	45	67.5	90	112.5	135	157.5	180	202.5	225	247.5	270	292.5	315	337.5	**All**
0	2	**1**	**16** *66* **(24)** *(100)*	**4** *9* **(44)** *(100)*	**4** *8* **(50)** *(100)*	**14** *20* **(70)** *(100)*	**17** *32* **(53)** *(100)*	**11** *57* **(19)** *(100)*	**24** *38* **(63)** *(100)*	**22** *46* **(48)** *(100)*	**12** *378* **(3)** *(100)*	**36** *3212* **(1)** *(100)*	**26** *2792* **(1)** *(100)*	**21** *770* **(3)** *(100)*	**39** *290* **(13)** *(100)*	**18** *302* **(6)** *(100)*	**27** *185* **(15)** *(100)*	**29** *267* **(11)** *(100)*	**320** *8472* **(4)** *(100)*
2	4	**3**	**21** *50* **(32)** *(76)*	**5** *5* **(56)** *(56)*	**4** *4* **(50)** *(50)*	**6** *6* **(30)** *(30)*	**15** *15* **(47)** *(47)*	**38** *46* **(67)** *(81)*	**6** *14* **(16)** *(37)*	**15** *24* **(33)** *(52)*	**49** *366* **(13)** *(97)*	**87** *3176* **(3)** *(99)*	**198** *2766* **(7)** *(99)*	**203** *749* **(26)** *(97)*	**126** *251* **(43)** *(87)*	**175** *284* **(58)** *(94)*	**104** *158* **(56)** *(85)*	**91** *238* **(34)** *(89)*	**1143** *8152* **(13)** *(96)*
4	6	**5**	**9** *29* **(14)** *(44)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**8** *8* **(14)** *(14)*	**8** *8* **(21)** *(21)*	**9** *9* **(20)** *(20)*	**26** *317* **(7)** *(84)*	**378** *3089* **(12)** *(96)*	**729** *2568* **(26)** *(92)*	**403** *546* **(52)** *(71)*	**108** *125* **(37)** *(43)*	**109** *109* **(36)** *(36)*	**45** *54* **(24)** *(29)*	**95** *147* **(36)** *(55)*	**1927** *7009* **(23)** *(83)*
6	8	**7**	**3** *20* **(5)** *(30)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**44** *291* **(12)** *(77)*	**712** *2711* **(22)** *(84)*	**779** *1839* **(28)** *(66)*	**120** *143* **(16)** *(19)*	**17** *17* **(6)** *(6)*	**0** *0* **(0)** *(0)*	**9** *9* **(5)** *(5)*	**46** *52* **(17)** *(19)*	**1730** *5082* **(20)** *(60)*
8	10	**9**	**17** *17* **(26)** *(26)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**45** *247* **(12)** *(65)*	**656** *1999* **(20)** *(62)*	**546** *1060* **(20)** *(38)*	**23** *23* **(3)** *(3)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**6** *6* **(2)** *(2)*	**1293** *3352* **(15)** *(40)*
10	12	**11**	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**101** *202* **(27)** *(53)*	**730** *1343* **(23)** *(42)*	**270** *514* **(10)** *(18)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**1101** *2059* **(13)** *(24)*
12	14	**13**	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**63** *101* **(17)** *(27)*	**293** *613* **(9)** *(19)*	**140** *244* **(5)** *(9)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**496** *958* **(6)** *(11)*
14	16	**15**	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**20** *38* **(5)** *(10)*	**158** *320* **(5)** *(10)*	**31** *104* **(1)** *(4)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**209** *462* **(2)** *(5)*
16	18	**17**	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**18** *18* **(5)** *(5)*	**123** *162* **(4)** *(5)*	**41** *73* **(1)** *(3)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**182** *253* **(2)** *(3)*
18	20	**19**	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**39** *39* **(1)** *(1)*	**32** *32* **(1)** *(1)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**71** *71* **(1)** *(1)*
20	22	**21**	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*
0	22	**All**	**66 (0.8)**	**9 (0.1)**	**8 (0.1)**	**20 (0.2)**	**32 (0.4)**	**57 (0.7)**	**38 (0.4)**	**46 (0.5)**	**378 (4.5)**	**3212 (37.9)**	**2792 (33.0)**	**770 (9.1)**	**290 (3.4)**	**302 (3.6)**	**185 (2.2)**	**267 (3.2)**	**8472**

Tables show number of records in which there is **occurrence** within the speed bands (bold) and *exceedence* of minimum speed threshold (italics) within each directional sector. Figures in brackets express the same data as a percentage of the total number of records.

TABLE A4

Occurrence/Exceedence of Current Speed for Mooring East Shetland Outer, Lower Current Meter.

		>=	348.75	11.25	33.75	56.25	78.75	101.25	123.75	146.25	168.75	191.25	213.75	236.25	258.75	281.25	303.75	326.25	**0**
		<	11.25	33.75	56.25	78.75	101.25	123.75	146.25	168.75	191.25	213.75	236.25	258.75	281.25	303.75	326.25	348.75	**360**
		mid	0	22.5	45	67.5	90	112.5	135	157.5	180	202.5	225	247.5	270	292.5	315	337.5	**All**
>=	<	mid	**N**	**NNE**	**NE**	**ENE**	**E**	**ESE**	**SE**	**SSE**	**S**	**SSE**	**SE**	**WSE**	**W**	**WNW**	**NW**	**NNW**	
0	2	**1**	**100** *793* **(13)** *(100)*	**91** *615* **(15)** *(100)*	**88** *251* **(35)** *(100)*	**45** *100* **(45)** *(100)*	**93** *107* **(87)** *(100)*	**83** *87* **(95)** *(100)*	**94** *100* **(94)** *(100)*	**89** *171* **(52)** *(100)*	**146** *746* **(20)** *(100)*	**270** *2521* **(11)** *(100)*	**280** *1172* **(24)** *(100)*	**150** *366* **(41)** *(100)*	**109** *228* **(48)** *(100)*	**197** *309* **(64)** *(100)*	**156** *251* **(62)** *(100)*	**224** *468* **(48)** *(100)*	**2215** *8285* **(27)** *(100)*
2	4	**3**	**294** *693* **(37)** *(87)*	**210** *524* **(34)** *(85)*	**76** *163* **(30)** *(65)*	**55** *55* **(55)** *(55)*	**14** *14* **(13)** *(13)*	**4** *4* **(5)** *(5)*	**6** *6* **(6)** *(6)*	**63** *82* **(37)** *(48)*	**258** *600* **(35)** *(80)*	**426** *2251* **(17)** *(89)*	**349** *892* **(30)** *(76)*	**161** *216* **(44)** *(59)*	**104** *119* **(46)** *(52)*	**112** *112* **(36)** *(36)*	**95** *95* **(38)** *(38)*	**171** *244* **(37)** *(52)*	**2398** *6070* **(29)** *(73)*
4	6	**5**	**266** *399* **(34)** *(50)*	**148** *314* **(24)** *(51)*	**56** *87* **(22)** *(35)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**19** *19* **(11)** *(11)*	**187** *342* **(25)** *(46)*	**663** *1825* **(26)** *(72)*	**289** *543* **(25)** *(46)*	**42** *55* **(11)** *(15)*	**15** *15* **(7)** *(7)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**73** *73* **(16)** *(16)*	**1758** *3672* **(21)** *(44)*
6	8	**7**	**119** *133* **(15)** *(17)*	**134** *166* **(22)** *(27)*	**31** *31* **(12)** *(12)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**98** *155* **(13)** *(21)*	**530** *1162* **(21)** *(46)*	**118** *254* **(10)** *(22)*	**12** *13* **(3)** *(4)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**1042** *1914* **(13)** *(23)*
8	10	**9**	**13** *14* **(2)** *(2)*	**12** *32* **(2)** *(5)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**43** *57* **(6)** *(8)*	**391** *632* **(16)** *(25)*	**75** *136* **(6)** *(12)*	**1** *1* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**535** *872* **(6)** *(11)*
10	12	**11**	**1** *1* **(0)** *(0)*	**20** *20* **(3)** *(3)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**14** *14* **(2)** *(2)*	**119** *241* **(5)** *(10)*	**31** *61* **(3)** *(5)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**185** *337* **(2)** *(4)*
12	14	**13**	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**51** *122* **(2)** *(5)*	**15** *30* **(1)** *(3)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**66** *152* **(1)** *(2)*
14	16	**15**	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**47** *71* **(2)** *(3)*	**15** *15* **(1)** *(1)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**62** *86* **(1)** *(1)*
16	18	**17**	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**24** *24* **(1)** *(1)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**24** *24* **(0)** *(0)*
18	20	**19**	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*
20	22	**21**	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*	**0** *0* **(0)** *(0)*
0	22	**All**	**793** **(9.6)**	**615** **(7.4)**	**251** **(3.0)**	**100** **(1.2)**	**107** **(1.3)**	**87** **(1.1)**	**100** **(1.2)**	**171** **(2.1)**	**746** **(9.0)**	**2521** **(30.4)**	**1172** **(14.1)**	**366** **(4.4)**	**228** **(2.8)**	**309** **(3.7)**	**251** **(3.0)**	**468** **(5.6)**	**8285**

Tables show number of records in which there is **occurrence** within the speed bands (bold) and *exceedence* of minimum speed threshold (italics) within each directional sector. Figures in brackets express the same data as a percentage of the total number of records.

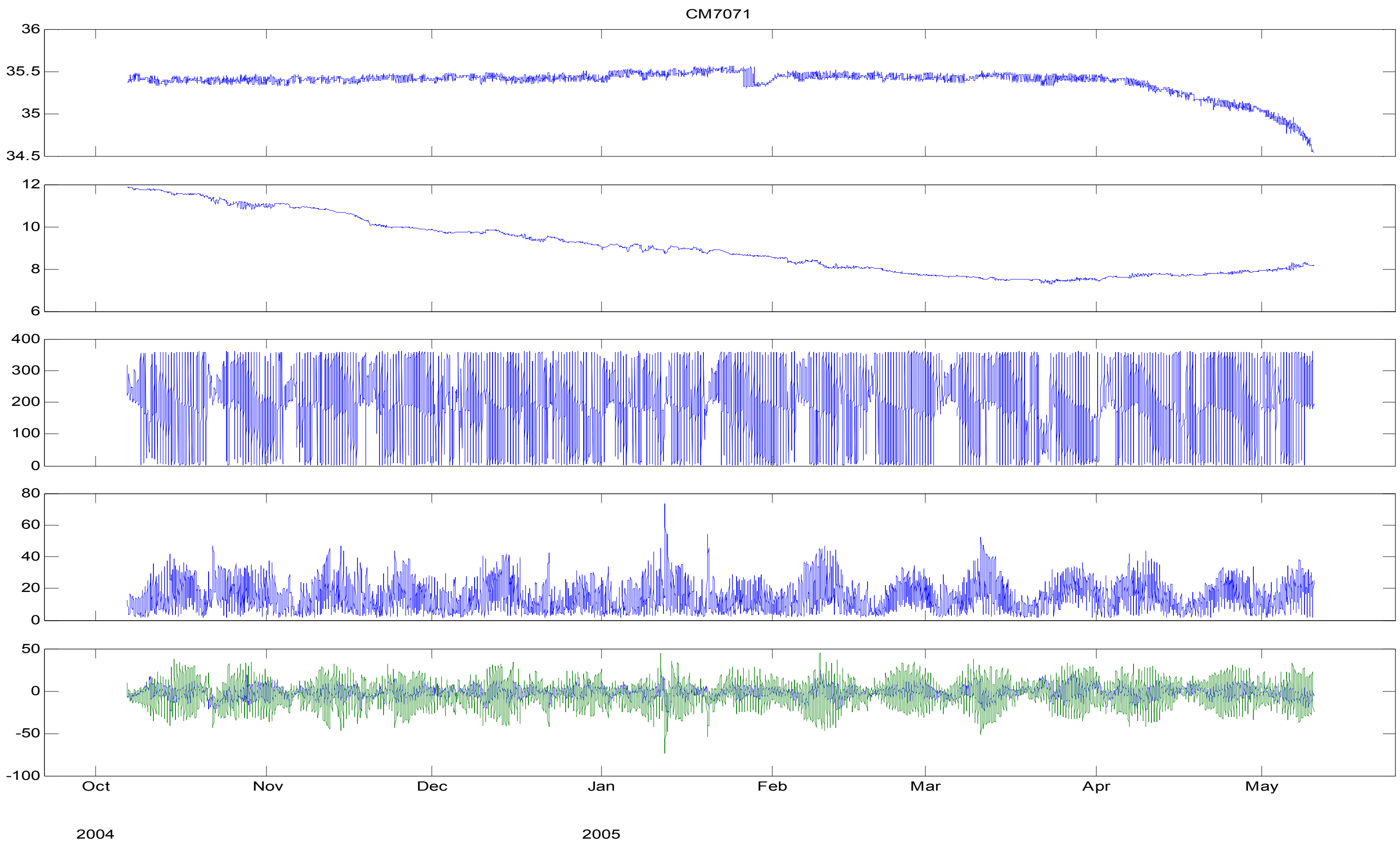

FIGURE A1 Salinity, Temperature, Current Direction, Current Speed and U and V components of velocity. of Current Speed for Mooring East Shetland Inner, Upper Current Meter, October 2004 – May 2005

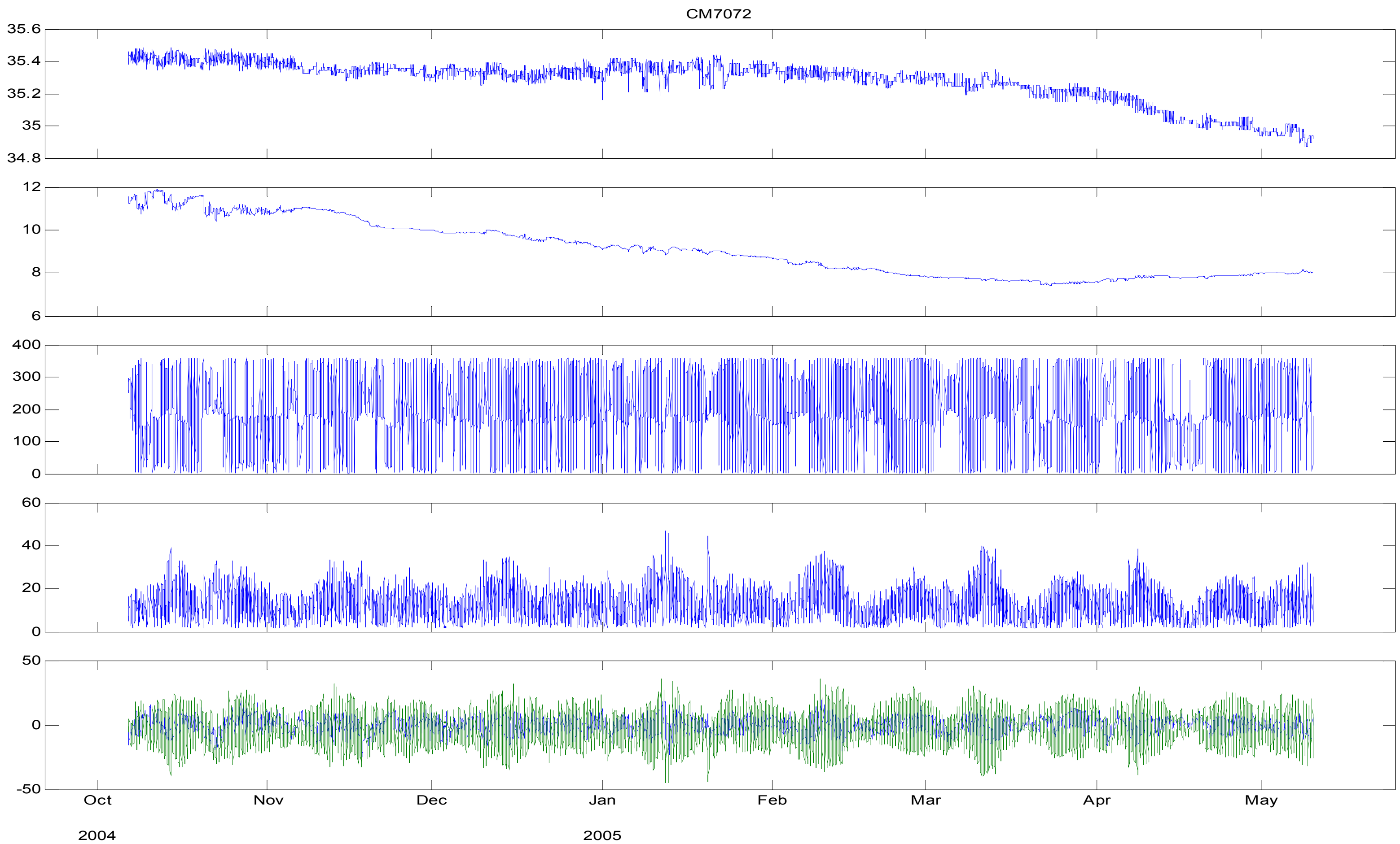

FIGURE A2 Salinity, Temperature, Current Direction, Current Speed and U and V components of velocity. of Current Speed for Mooring East Shetland Inner, Lower Current Meter, October 2004 – May 2005

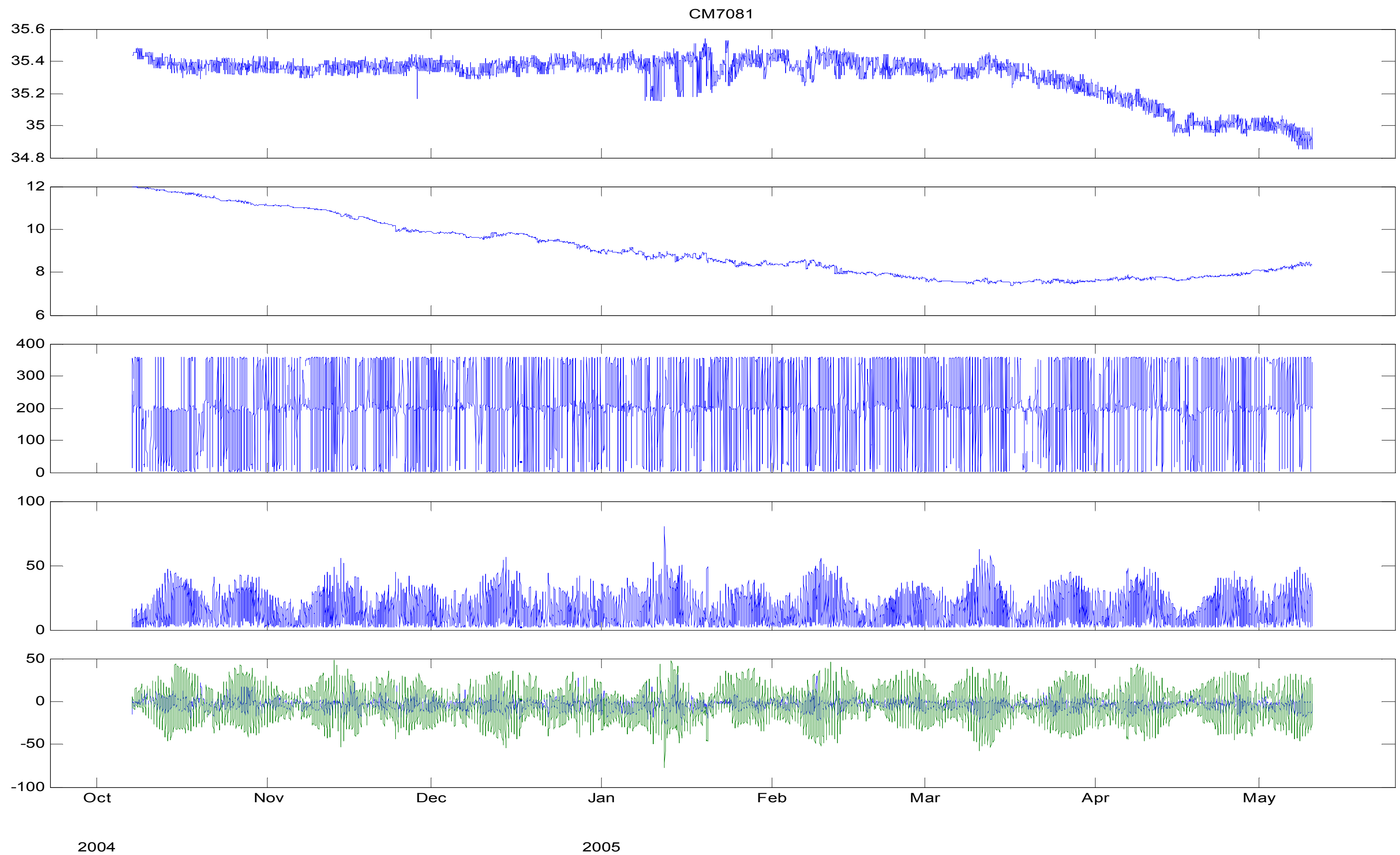

FIGURE A3 Salinity, Temperature, Current Direction, Current Speed and U and V components of velocity. of Current Speed for Mooring East Shetland Outer, Upper Current Meter, October 2004 – May 2005

FIGURE A4 Salinity, Temperature, Current Direction, Current Speed and U and V components of velocity. of Current Speed for Mooring East Shetland Outer, Lower Current Meter, October 2004 – May 2005

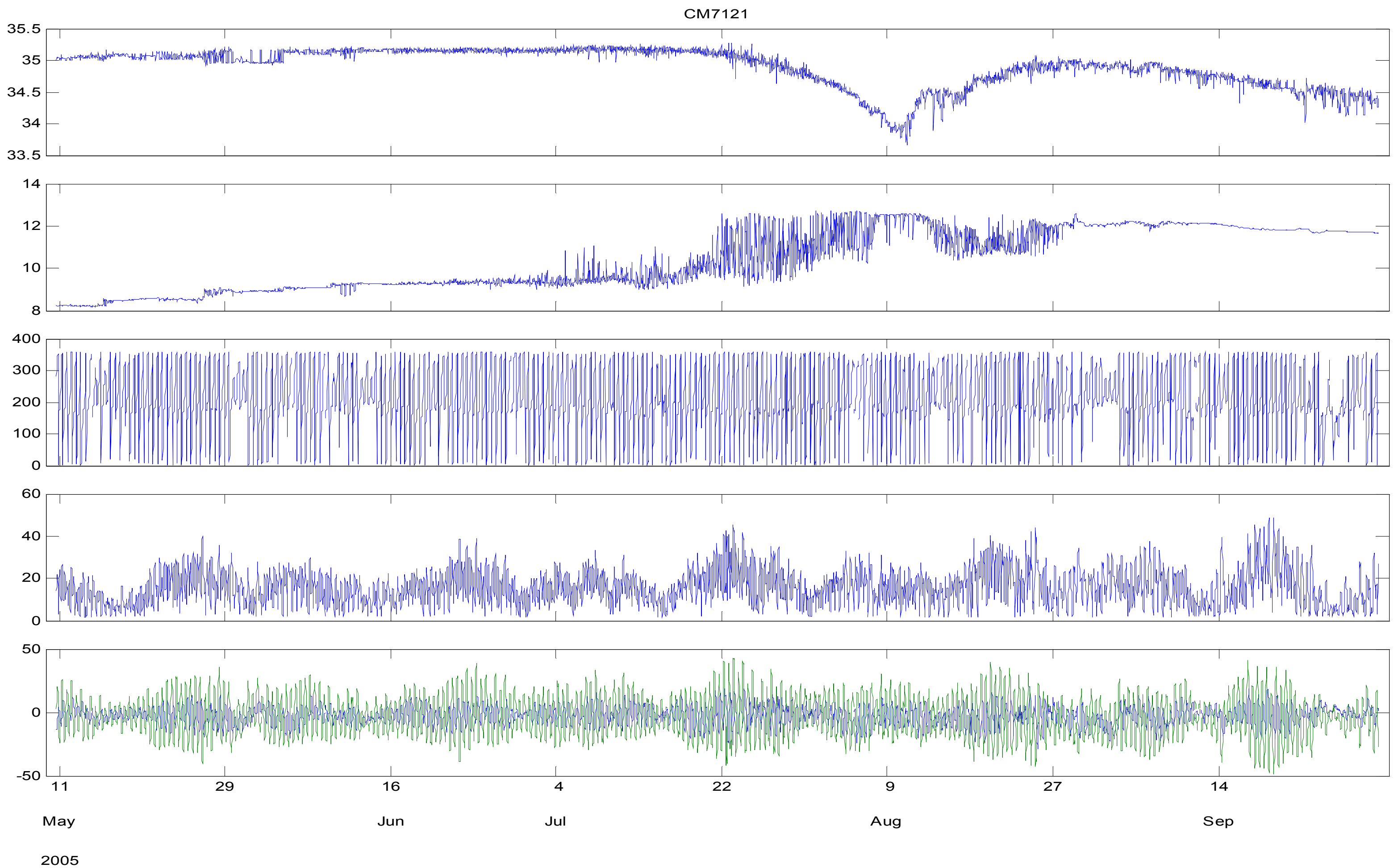

FIGURE A5 Salinity, Temperature, Current Direction, Current Speed and U and V components of velocity. of Current Speed for Mooring East Shetland Inner, Upper Current Meter, May 2005 – October 2005

FIGURE A6 Salinity, Temperature, Current Direction, Current Speed and U and V components of velocity. of Current Speed for Mooring East Shetland Inner, Lower Current Meter, May 2005 – October 2005

FIGURE A7 Salinity, Temperature, Current Direction, Current Speed and U and V components of velocity. of Current Speed for Mooring East Shetland Outer, Upper Current Meter, May 2005 – October 2005

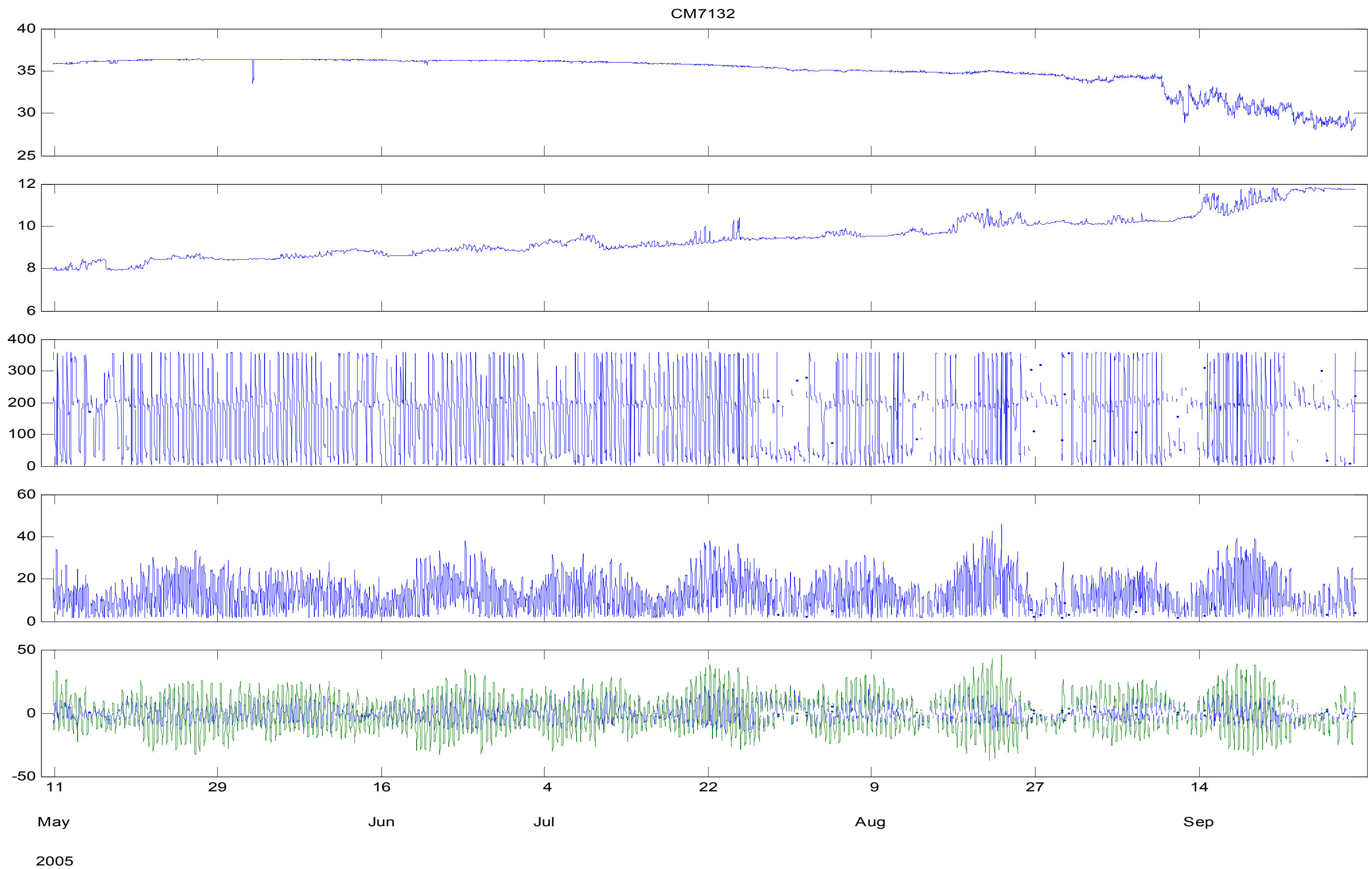

FIGURE A8 Salinity, Temperature, Current Direction, Current Speed and U and V components of velocity. of Current Speed for Mooring East Shetland Outer, Lower Current Meter, May 2005 – October 2005

APPENDIX B: CTD SECTIONS

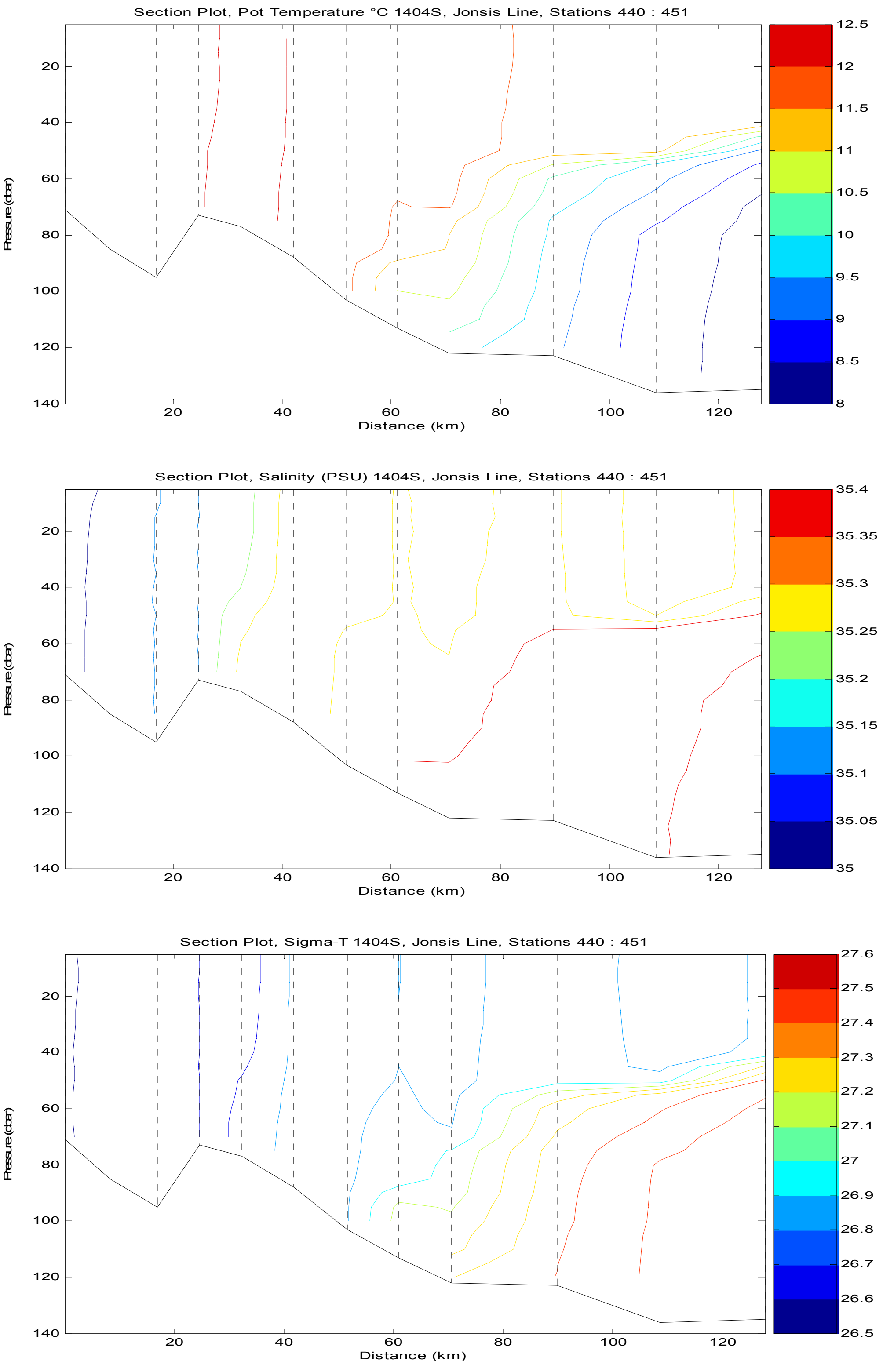

FIGURE B1 Temperature, Salinity and Density Sections, Jonsis Line, October 2004

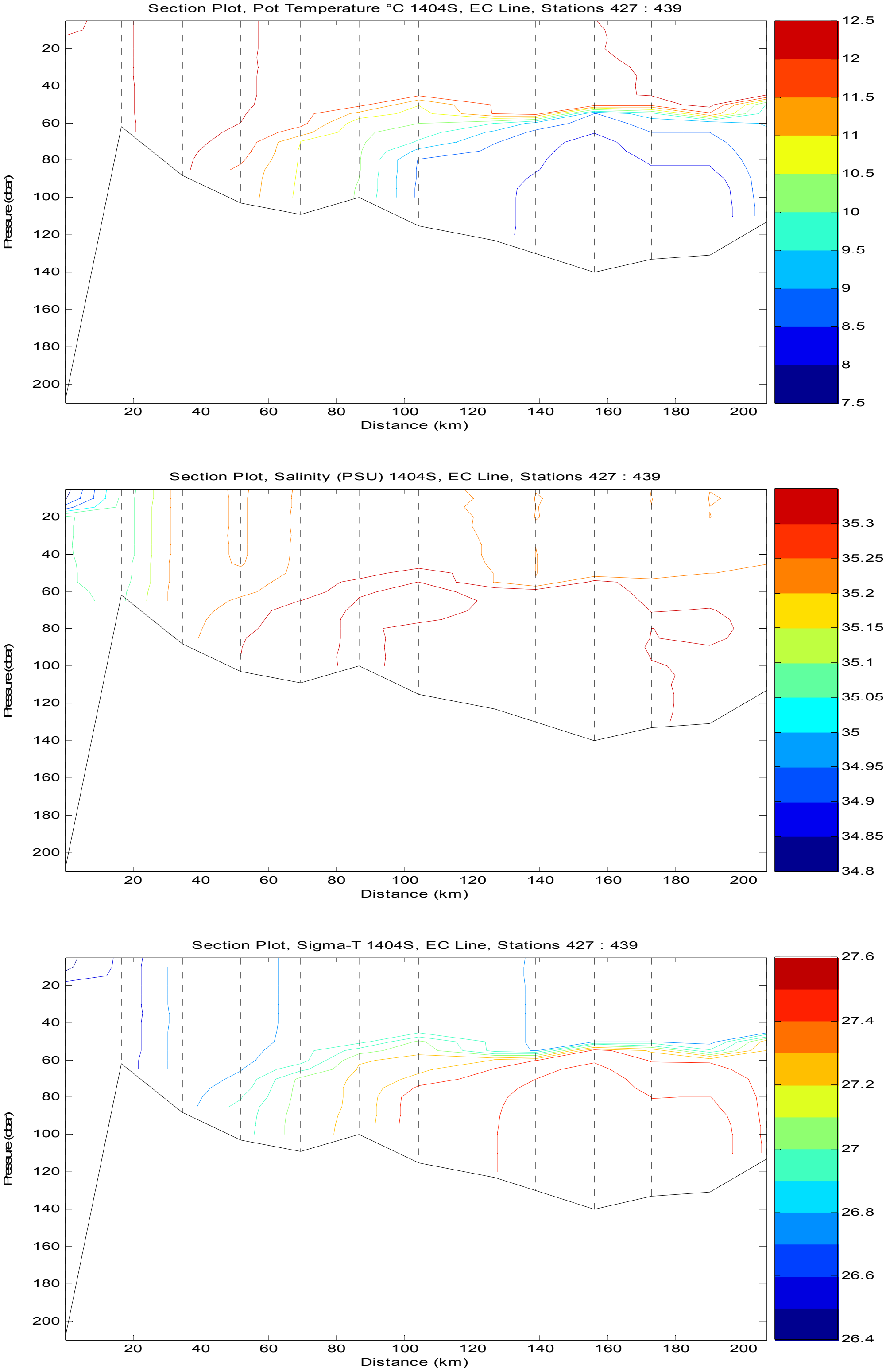

FIGURE B2 Temperature, Salinity and Density Sections, East Coast Line, October 2004

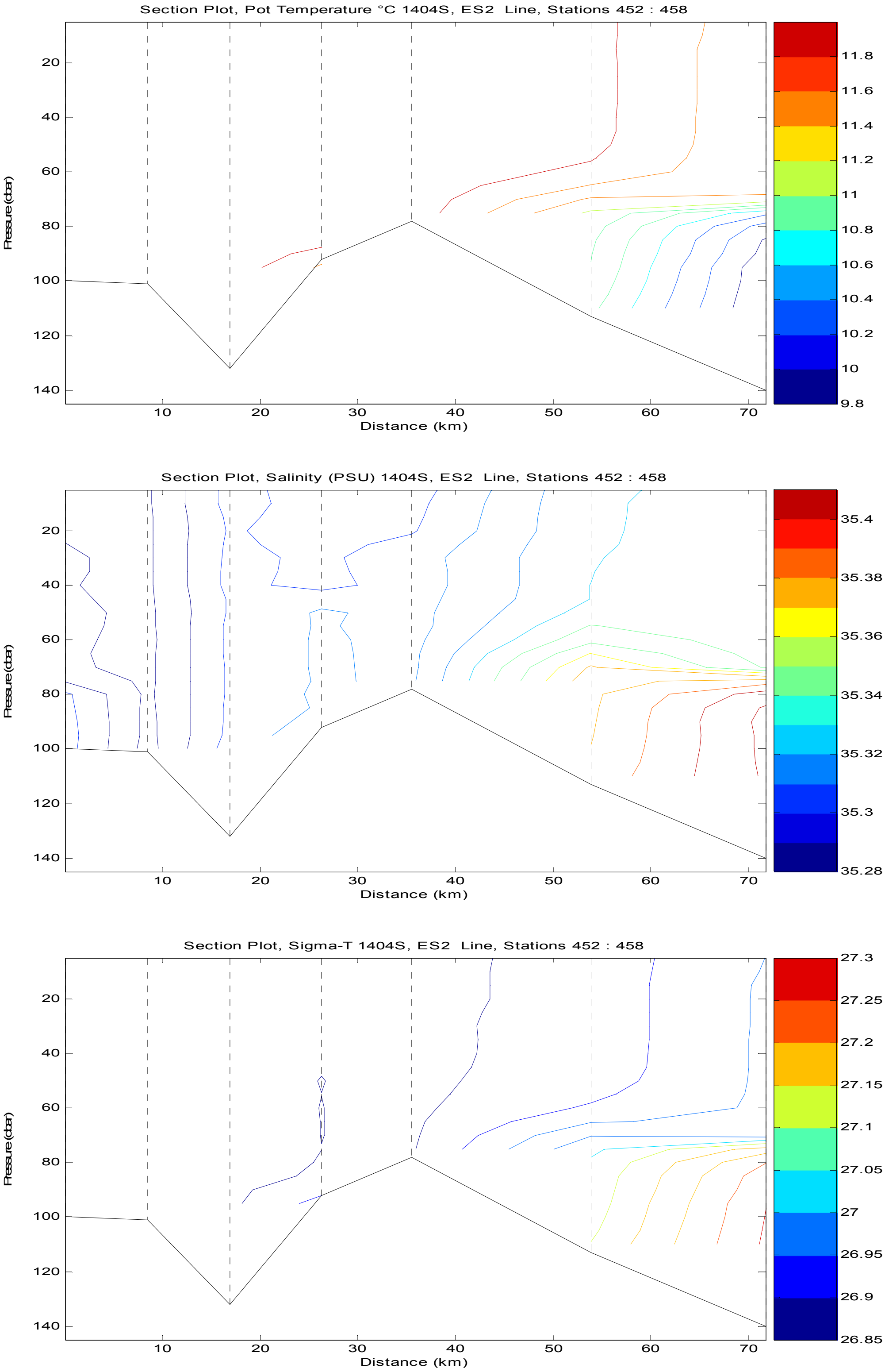

FIGURE B3 Temperature, Salinity and Density Sections, East Shetland 2, October 2004

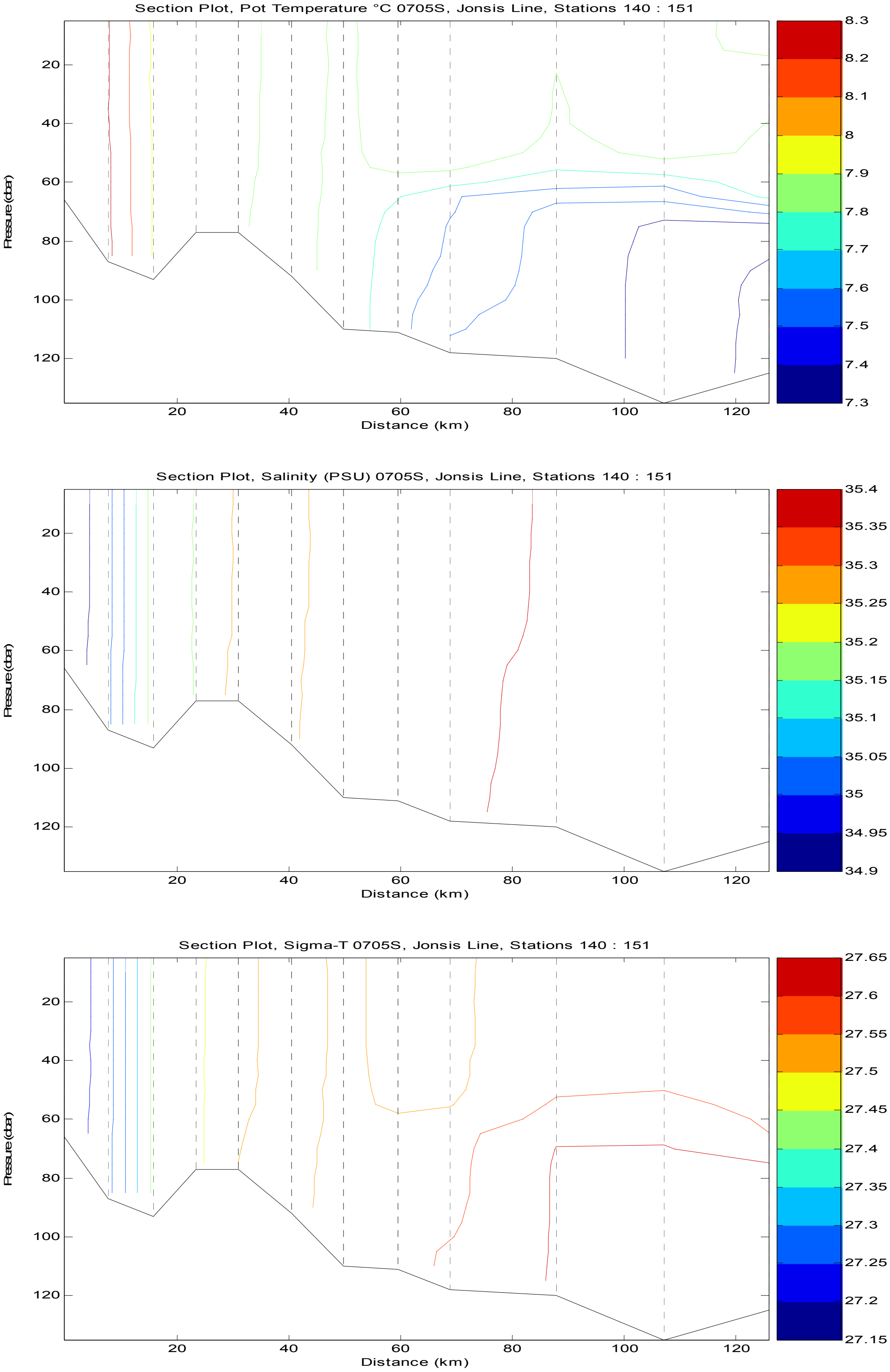

FIGURE B4 Temperature, Salinity and Density Sections, Jonsis Line, May 2005

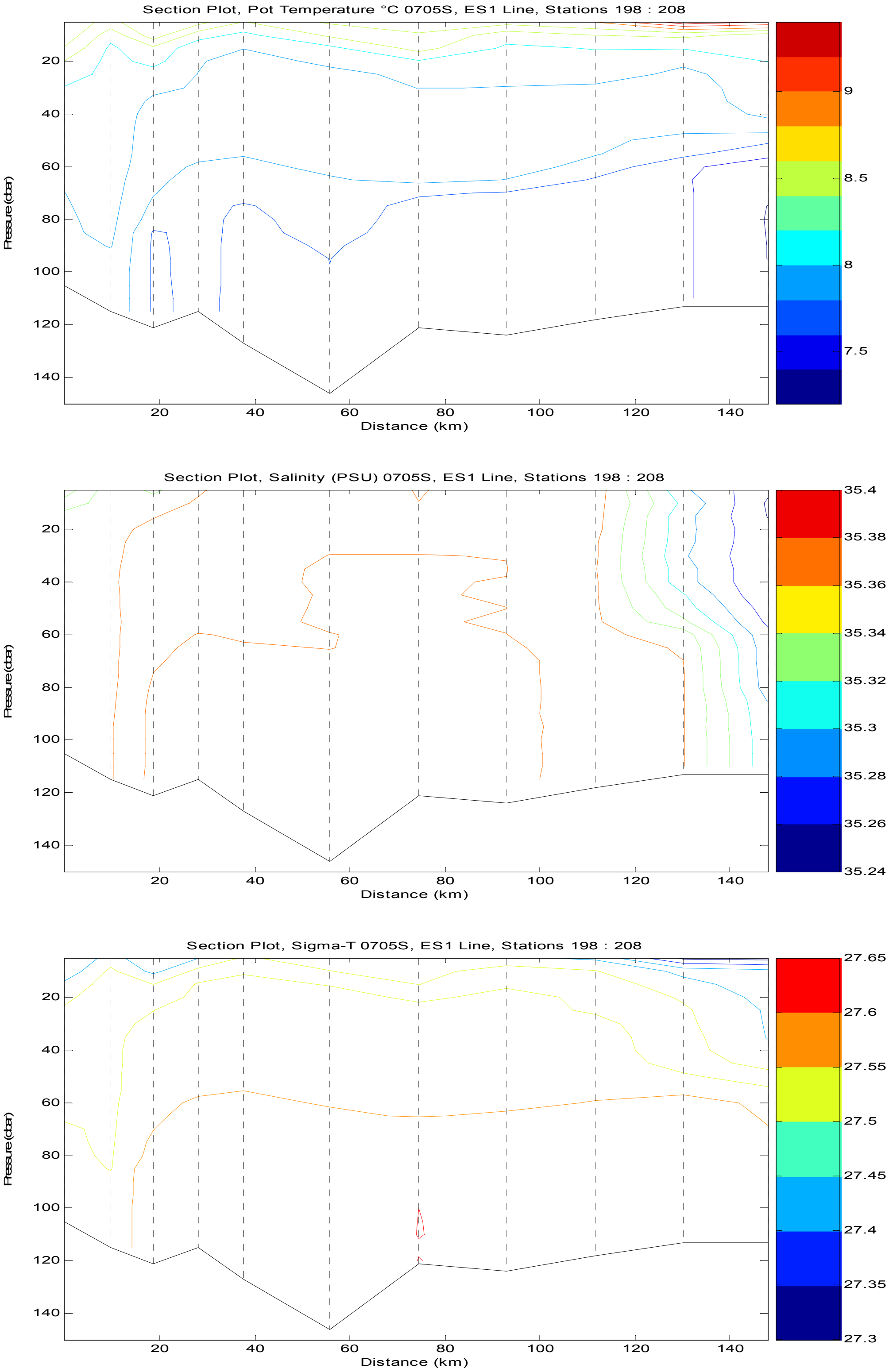

FIGURE B5 Temperature, Salinity and Density Sections, East Shetland 1, May 2005

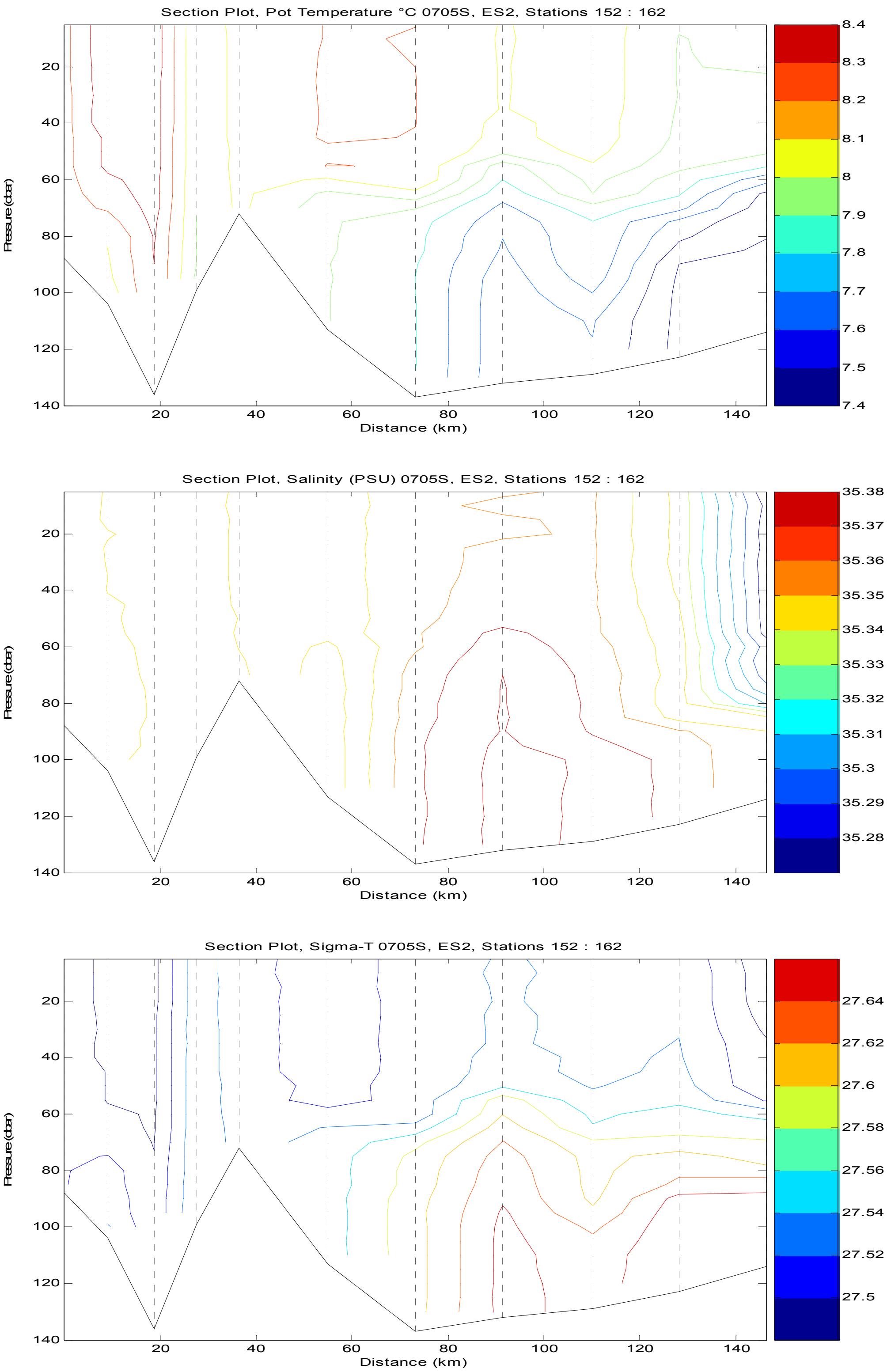

FIGURE B6 Temperature, Salinity and Density Sections, East Shetland 2, May 2005

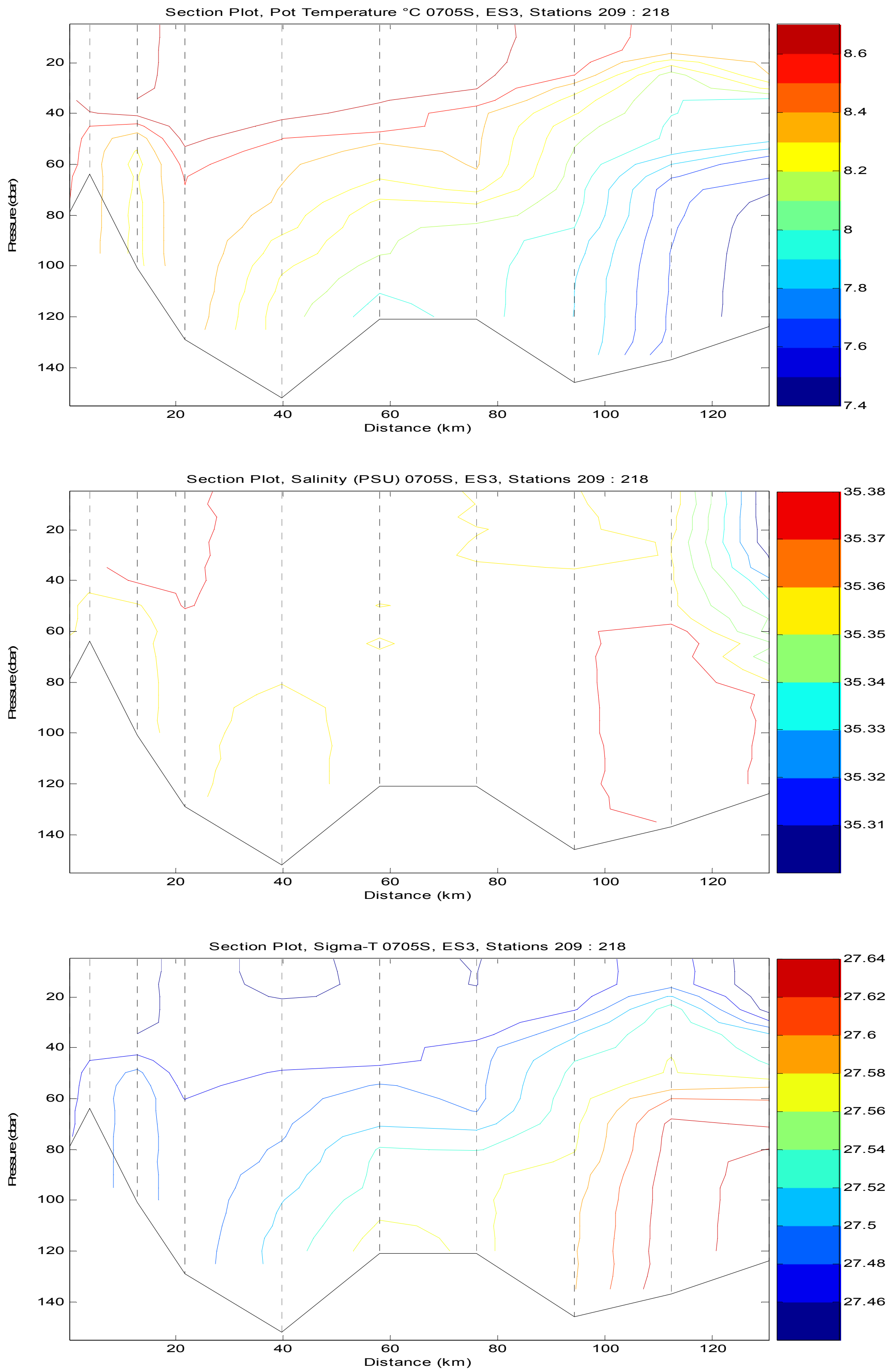

FIGURE B7 Temperature, Salinity and Density Sections, East Shetland 3, May 2005

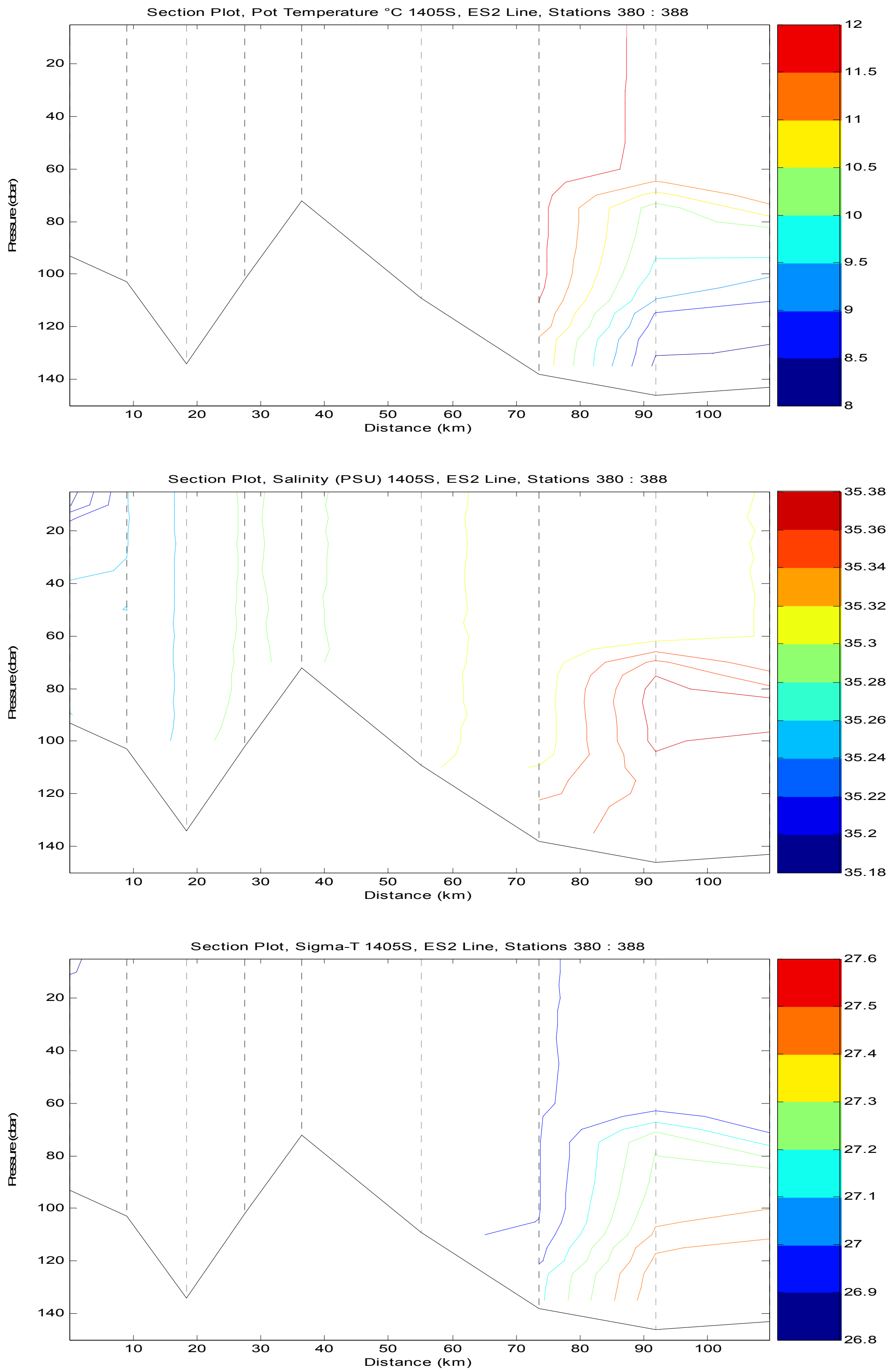

FIGURE B8 Temperature, Salinity and Density Sections, East Shetland 2, October 2005

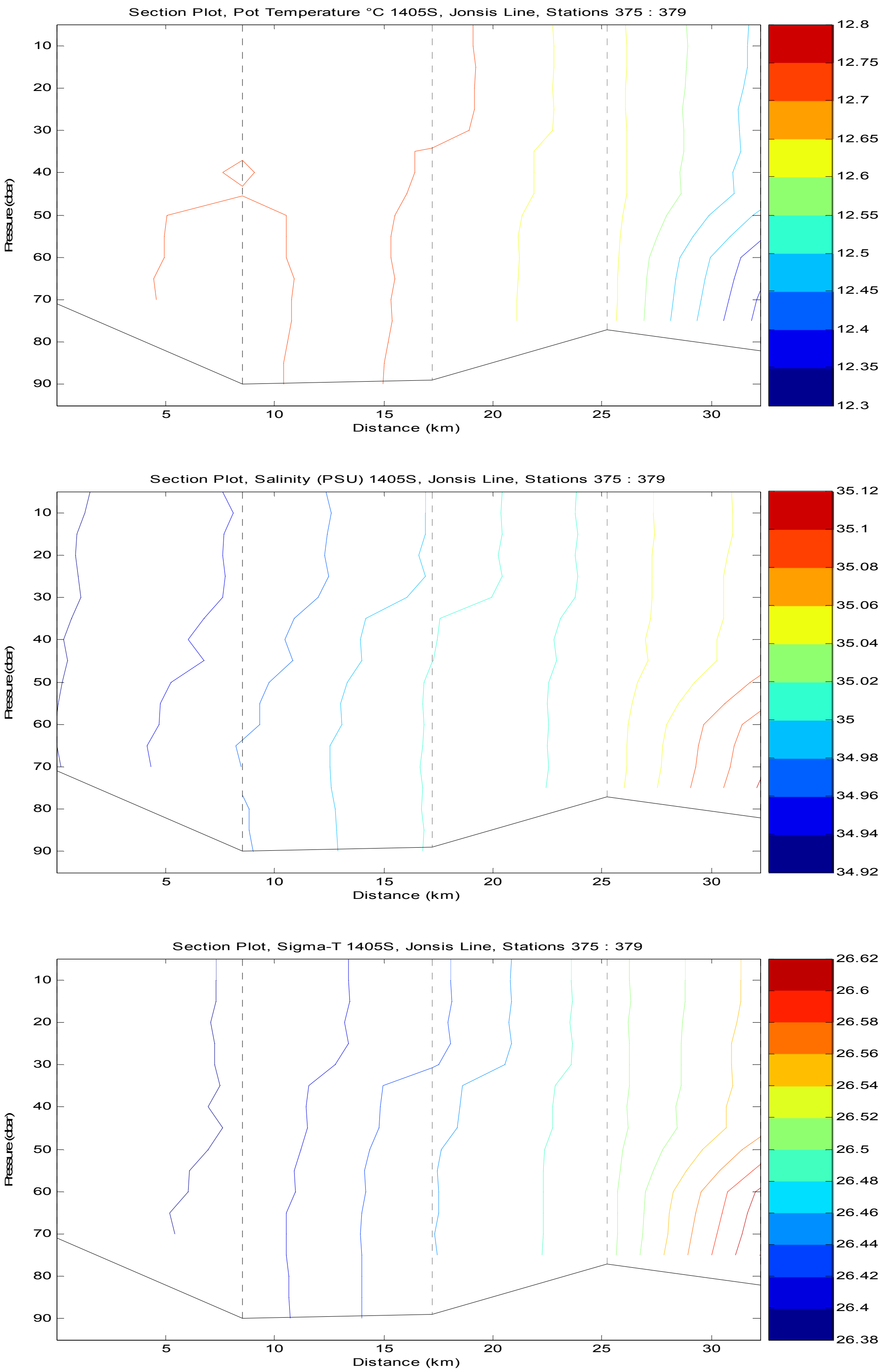

FIGURE B9 Temperature, Salinity and Density Sections, Jonsis Line, October 2005

APPENDIX C: CRUISE REPORTS

Report - FRV Scotia, Cruise 1404S

R1/12, Not to be cited without prior reference to the FRS Marine Laboratory, Aberdeen

REPORT

4–18 October 2004

Loading: Aberdeen
Unloading: Aberdeen

Personnel

G Slesser	In charge
S Hughes	
J Beaton	
D Lichtman	
M Rose	
C Shepherd	Hydrographic Office
E Koutsoubos	University of Oulu
S Mendes	University of Aberdeen
C Emblng	University of St Andrews

Gear
SeaBird CTDs, ADCPs, SonoBuoys, Acoustic releases

Objectives

1. To perform a hydrographic survey along the JONSIS standard section in the northern North Sea.

2. To perform hydrographic surveys along the standard Faroe Shetland Channel sections.

3. To service two ADCP moorings in the Faroe-Shetland Channel.

4. To recover two current meter moorings south of the Wyville-Thomson Ridge.

5. To deploy a current meter mooring west of the Shetland Islands.

6. To deploy two current meter moorings east of the Shetland Islands.

7. To carry out coastal hydrographic surveys.

8. To perform ad-hoc towed array acoustic recordings for cetaceans and deployment of sonobuoys for Aberdeen University Zoology Department.

Out-Turn Days per Project: 10 days: Ae11r0, 5 days: Ae1190

Narrative

Scotia sailed from Aberdeen at 1200 (all times are GMT) on Monday 4 October for the first of two E Scotland CTD hydrographic sections. Sampling commenced at the first station of these sections at 1347. The last station on the second section was completed at 1733 on Tuesday 6 October (Stns 420-439). *Scotia* then proceeded to the start of the JONSIS standard section. CTD measurements and water sampling commenced at 1935 on Tuesday 5 October and was completed at 0735 on Wednesday 6 October (Stns 440-451).

Passage was then made to the proposed position for deployment of the outermost East of Shetland current meter mooring (Fig. 1). This mooring (60º28.54'N 000º07.71'W) was deployed at 1730 and followed by a line of CTD stations through this mooring position (Stns 452-458). On completion the second East of Shetland current meter mooring (60º34.44'N 000º37.90'W) was laid at 0758 on Thursday 7 October. Passage was then made to the proposed West of Shetland current meter mooring position (Fig. 1) and this mooring (60º45.83'N 001º27.12'W) was laid at 1313 on Thursday 7 October. This was followed by working a line of stations (Stns 459-463) through this current meter mooring position.

Scotia then proceeded to the start of the Nolso - Flugga section for further CTD measurements and water sampling. Work started at 2139 on Thursday 7 October. A break of four hours was required during this section to make repairs to the CTD caused by a faulty cable. This section was completed at 0618 on Saturday 9 October (Stns 464-479). Ships passage was then made to the start of the Fair Isle - Munken section where CTD stations commenced at 1121. The section was completed at 0816 on Saturday 10 October (Stns 480-493) and passage was made to the NWOCE mooring position NWSE (60º16.87'N 004º19.51'W).

ADCP mooring NWSE was recovered at 1128 on Saturday 10 October followed by the recovery of ADCP mooring NWSD (60º26.93'N 004º22.13'W) at 1326. *Scotia* then made to the Wyville-Thomson Ridge area to survey a series of CTD sections (Stns 494-533). This work commenced at 0219 on Sunday 11 October and was completed at 0651 on Wednesday 13 October. Two brief breaks were taken during the working of these sections to stop at the two current meter moorings deployed during *Scotia* Cruise 8 of this year. This allowed scientific staff to interrogate these moorings by hydrophone and verify that they were still on position.

Following the completion of these CTD sections *Scotia* proceeded to the position of the NWOCE mooring NWSD. This mooring (60º27.02'N 04º22.54'W) was successfully deployed at 1538 on Wednesday 13 October. This was followed by the deployment of the NWOCE mooring NWSE (60º16.61'N 04º20.02'W) at 1747.

Scotia then proceeded to the Butt of Lewis to start coastal CTD section work. This work commenced at 0530 on Thursday 14 October and continued throughout the next three days. During this time 50 CTD stations (Stns 534-583) were completed.

In the early hours of Sunday 17 October *Scotia* proceeded to Aberdeen, where she berthed at 0530 on Monday 18 October.

Results

The weather conditions throughout the trip were reasonably good throughout the cruise and no ship time was lost.

1. The JONSIS standard section in the northern North Sea was surveyed.
2. The two standard Faroe Shetland Channel sections were surveyed.

3. The two Nordic WOCE ADCP moorings NWSD and NWSE were recovered successfully. Due to a malfunction on the NWSD ADCP no data were recovered. The data from the NWSE ADCP was successfully down loaded. The NWSD malfunction

was identified and repaired. The Two ADCPs were re-deployed. The recovered ADCP data will be processed in the laboratory by in-house software.

4. The two current meter moorings south of the Wyville-Thomson Ridge were not recovered as these are now to be recovered later in the year. However CTD hydrographic sections were worked in the vicinity of the current meter moorings to provide background data for the later analysis of the current meter data when recovered.

5. The current meter mooring for this objective was successfully deployed.

6. The two current meter moorings for this objective were successfully deployed.

7. Coastal CTD sections were carried out East of Scotland, West of the Hebrides and in the South Minch area.

8. Passive acoustic surveys for cetaceans were carried out in the Faroe-Shetland Channel from *Scotia* between the period 4-18 October 2004. Surveys were conducted using a towed hydrophone array (0.2-150 kHz). The hydrophone array was towed between standard hydrographic stations along Fair Isle-Munken and Nolso-Flugga standard hydrographic sections as well as in the area of the Wyville-Thomson Ridge, West Hebrides, the Minch and the North Sea, where travel times between stations exceeded 30 minutes. On several occasions the *Scotia* steaming speed between hydrographic stations was reduced to allow enough time to tow the hydrophone. Towed array surveys were also carried out during transits between mooring deployment and recovery sites. Around 140 hours of acoustic monitoring effort were carried out which corresponds to around 2550 km. Two-minute listening stations were carried out every 15 minutes. In total, 477 listening stations were made. Sperm whales were detected in 3.5% of all stations (Fig. 2) and dolphin species were detected in 27.5% of all stations (Fig. 3). There were also 2 sightings, one of a group of unidentified baleen whales (probably fin whales) and the other a group of common dolphins. Recordings were automatically made for 30 seconds every 2 minutes together with long continuous recordings carried out when in the presence of whales or dolphins either vocalizing close to the vessel or emitting unusual sounds.

Low-frequency, one-hour recordings (0.0001-0.2 kHz) were made using sonobuoys deployed at hydrographic stations separated by 30 kilometers or in water depths greater than 300 m. 27 sonobuoys were deployed. Post processing of these recordings will be carried out by René Swift in order to detect vocalizations of baleen whales.

It is planned that the towed hydrophone array data will be analysed by Sónia Mendes (Aberdeen University), and Clare Embling (Sea Mammal Research Unit) independently as part of their PhD research projects.

Throughout the cruise, sea surface temperature, salinity and fluorescence recordings were made using a Sea-Bird SBE21 Thermosalinograph and Sea Point Fluorometer. Surface samples were taken throughout the cruise to calibrate these data. The fluorometer data continues to show the same problem that has persisted over the past few months. This is the "ramping" up of the fluorometer data as the cruise continues. Further discussions with the Engineering Services Group are continuing to resolve this problem. Detailed results of the hydrographic and ADCP data collected during the cruise will be made available as these data are worked up and interpreted in the laboratory.

G Slesser
25 October 2004

FRS Scotia Cruise 8 2004

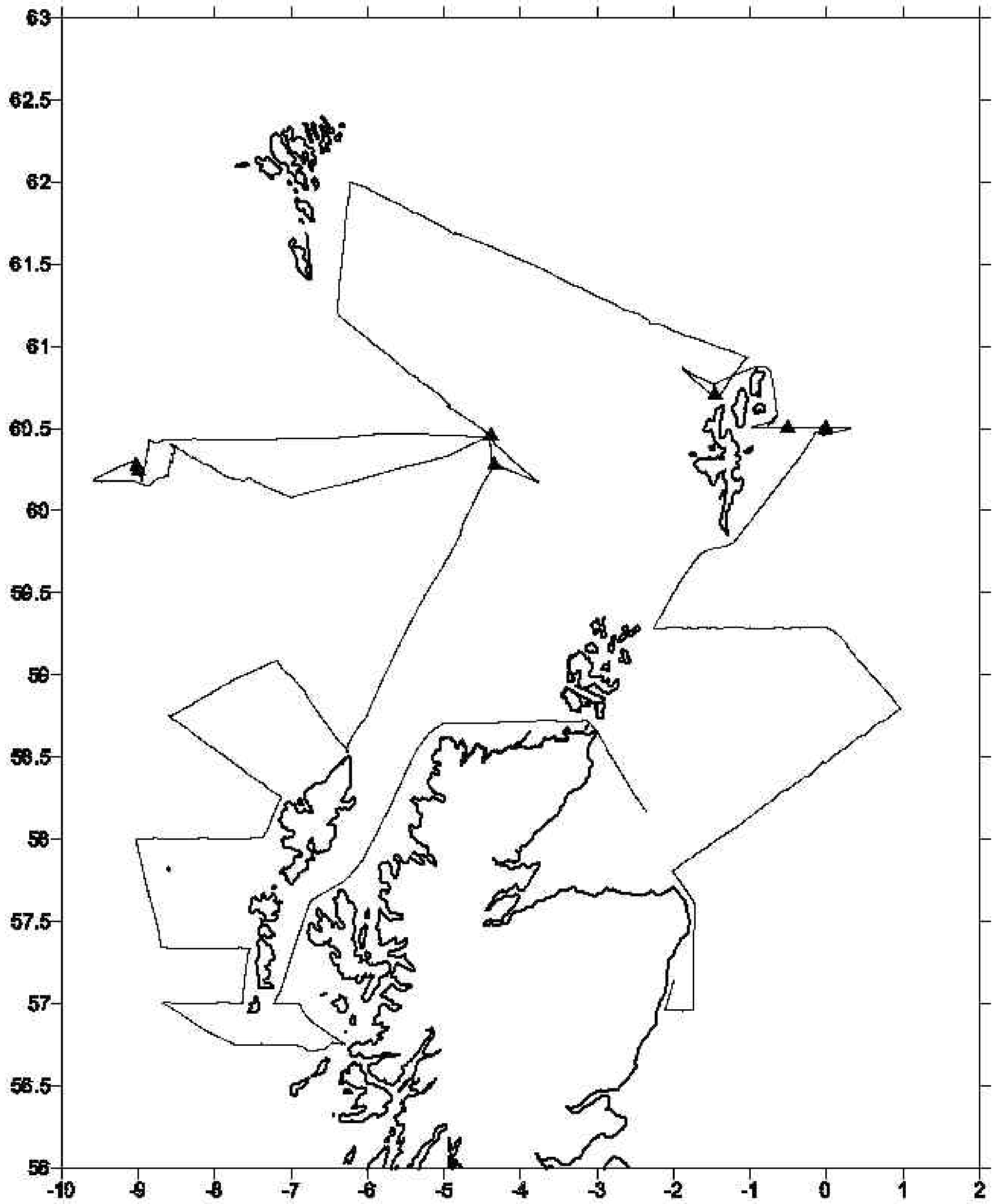

Figure 1. Cruise Track and Mooring Positions

Report - FRV Scotia, Cruise 0705S Part I

R1/12, Not to be cited without prior reference to FRS Marine Laboratory, Aberdeen

REPORT

7–27 May 2005

Loading: Aberdeen
Unloading: Aberdeen

Personnel

G Slesser	In Charge	
J Beaton		
N Collie	7-18 May	
M Rose	7-18 May	
T Amundrud	7-18 May	
A Gallego	7-18 May	
J P Lacaze	7-18 May	
J MacLean	19-27 May	
G MacDonald	19-27 May	
R Shelton		Atlantic Salmon Trust
J Holst	19-27 May	Institute for Marine Research, Bergen
T Gridley		University of Aberdeen
C Embling		University of St Andrews

Gear
SeaBird CTDs, ADCPs, SonoBuoys, Acoustic releases

Objectives

1. To perform hydrographic surveys along the JONSIS standard section in the northern North Sea.

2. To perform hydrographic surveys along the standard Faroe Shetland Channel sections.

3. To service two ADCP moorings in the Faroe Shetland Channel.

4. To recover two current meter moorings and re-deploy these moorings east of the Shetland Islands.

5. To recover a current meter mooring west of the Shetland Islands.

6. To carry out coastal hydrographic surveys.

7. To investigate post-smolt migration pathways along the shelf edge.

8. To perform ad-hoc CTD surveys in order to describe the environment within which post-smolts are found.

9. To undertake a pilot study for the use of synthetic adsorbents in order to assess the concentration of free marine biotoxins and other compounds in the environment.
10. To collect 20 carboys of low nutrient seawater for QUASIMEME.

11. To perform ad-hoc towed array acoustic recordings for cetaceans and deployment of sonobuoys.

Out-Turn Days per Project: 16 days: AE11r0, 5 days: AE1190

Narrative

Scotia sailed from Aberdeen at 1200 (all times are GMT) on Saturday 7 May for the start of the JONSIS standard section. CTD measurements and water sampling commenced at 0252 on Sunday 8 May. A short break was made prior to JONSIS station “1a” to make a temporary replacement of a leaking hydraulic fluid pipe on the CTD crane. The line was completed at 1521 on Sunday 8 May. (Stns 140-151).

Passage was made to the start of the East of Shetland Line 2 and CTD sampling commenced at 0008 on Monday 9 May. This sampling continued till 1009 when the *Scotia* broke off sampling operations to make passage for Lerwick to procure a hydraulic pipe to replace the temporary hydraulic pipe on the CTD crane. Passage was then made to complete the remaining part of the East of Shetland Line 2. This line was completed at 1806 on Monday 9 May. (Stns 152-162). *Scotia* then made way to the start of the East of Shetland Line 3. This line was worked until 0431 on Tuesday 10 May (Stns 163-167). At this time *Scotia* made passage to the East of Shetland 2 mooring (60°28.54’N 000°07.71’W) position.

On transmission of the release command to the acoustic release at the East of Shetland 2 mooring position, the acoustic release would not come free from the mooring anchor. After attempting to free the mooring using a bottom creeper the mooring was brought to the surface on the second attempt using the recovery trawl. After the necessary maintenance the mooring was re-deployed (60°28.63’N 000°07.75’W) at 1525 on Tuesday 10 May. Passage was then made to the East of Shetland 1 mooring (60°34.44’N 000°37.90’W) where a successful recovery of this mooring was made. This mooring was re-deployed (60°34.50’N 000°38.08’W) at 1916 on the same day. This was followed by overnight passage to the West of Shetland mooring position (60°45.83’N 001°27.12’W). At the beginning of this year a current meter from this mooring was returned to FRS by personnel of a seismic vessel. This vessel had towed over the mooring position. After several attempts of trying to interrogate the acoustic release of this mooring the conclusion was drawn that it was no longer on position. A grid was drawn up in an attempt to locate the remaining part of the mooring. After several hours of trying to locate the mooring it was decided to give up and *Scotia* made passage to the start of the Nolso-Flugga line for CTD measurements and water sampling. Work commenced at 1733 on Wednesday 11 May.

This section was completed at 2049 on Thursday 12 May (Stns 168-183). Ships passage was then made to the start of the Fair Isle - Munken section where CTD stations commenced at 0118 on Friday 13 May. The section was completed at 2116 on Friday 13 May (Stns 184-197) and passage was made to the NWOCE mooring position NWSE (60°16.61’N 004°20.02’W). ADCP mooring NWSE (60°16.61’N 004°20.02’W) was recovered at 0540 on Saturday14 May followed by the recovery of ADCP mooring NWSD (60°27.02’N 004°22.54’W) at 0810. Following maintenance work on mooring NWSD, the NWSD mooring (60°26.99’N 04°22.48’W) was successfully deployed at 1315. This was followed by the deployment of the NWOCE mooring NWSE (60°16.58’N 04°19.89’W) at 1743.
Scotia then proceeded to east of Sumburgh Head to start CTD section work at east and north of the Shetland Islands and this continued until the half landing at Lerwick on Wednesday 18 May. During this time five CTD sections were surveyed (Stns 198-243). In Lerwick a change in scientific personnel took place. On Wednesday evening presentations were given by Dr Turrell and Dr Holst to North Atlantic Fisheries College staff and students followed by a guided tour of the *Scotia*.

Scotia departed from Lerwick at 1300 on Thursday 19 May for west of Shetland where initial deployment trials of the salmon trawl took place. Thereafter passage was made to the Minch where calm waters provided the ideal location for preliminary trials of the gear. The gear comprised a 60 m (wide) x 10 m (deep) open ended trawl net, modified by attaching a metal frame holding a CCTV camera inside the net. A cable link from the camera fed to a transmitting aerial aboard a small catamaran which was towed further behind the net. Transmissions from the catamaran were received from a ship mounted aerial thus providing live CCTV footage of fish passage through the trawl net. Over the next three days trials continued until the rigging/deployment of the net and transmission of signals was deemed to have been successfully achieved. On the evening of Sunday 22 May passage was made to the shelf edge west of the Butt of Lewis, a known feature associated with post-smolts, where 4 transects were conducted over the following three days.

On completion of these transects *Scotia* returned to Aberdeen, where she berthed at 1900 on Thursday 26 May.

Results
The weather conditions throughout the trip were reasonably good throughout the cruise and no ship time was lost.

1. The JONSIS standard section in the northern North Sea was surveyed.

2. The two standard Faroe Shetland Channel sections were surveyed.

3. The two Nordic WOCE ADCP moorings NWSD and NWSE were recovered successfully and data downloaded. The 75 KHz Broadband ADCP recovered at NWSD was replaced by a Workhorse ADCP and the NWSE Workhorse ADCP re-deployed. The recovered ADCP data will be processed in the laboratory by in-house software.

4. The current meter moorings for this objective were successfully recovered, the current meters replaced and the moorings re-deployed.

5. The remaining part of the mooring west of the Shetland Islands was not recovered. A further attempt to recover the mooring maybe made during early October. This mooring was towed over during late December 2004 and the top current meter returned to FRS during January 2005.

6. North and east Shetland CTD sections were surveyed.

7/8. Post-smolt distribution and towed CTD data were collected. The successful use of the open ended trawl will make future post-smolt surveys more cost effective, non-destructive to the fish it encounters and will allow a more precise relation between post-smolt distribution and hydrographic variables to be determined.

9. Twenty carboys were filled with low nutrient seawater for QUASIMEME at 59°17.09'N 000°00.41'W.

10. 41 samples were taken as part of a pilot study in order to assess the concentration of free marine bio-toxins and other compounds in the environment. Eight of these were duplicates for quality control purposes.

11. Passive acoustic surveys for cetaceans were carried out in the Faroe-Shetland Channel from the *FRV Scotia* between 7 and 27 May 2005. Surveys were conducted using a towed hydrophone array (0.2-150 kHz). The hydrophone array was towed between standard hydrographic stations along Fair Isle-Munken and Nolso-Flugga standard hydrographic lines as well as in the North Sea, where travel time between stations exceeded 30 minutes. Towed array surveys were also carried out during transits between moorings deployment and recovery sites and between the salmon smolt trawls on the second half of the trip in the North Minch and shelf-edge waters. During the salmon smolt trawls, the keel-mounted hydrophone was monitored continuously; however this hydrophone was a lot less efficient, only detecting the loudest dolphin whistles and no sperm whale clicks. Around 170 hours of acoustic monitoring effort were carried out which corresponds to around 3,000 km. Two-minute listening stations were carried out each 15 minutes. In total, 674 listening stations were made. Sperm whales were detected in 3.9% of all stations (Fig. 1) and

dolphin species were detected in 11.9% of all stations (Fig. 2). There were also two sightings, one of a group of pilot whales and unidentified dolphin species and another of a group of unidentified dolphin species. Recordings were automatically made for 30 seconds every two minutes together with long continuous recordings carried out when in the presence of whales or dolphins either vocalizing close to the vessel or emitting unusual sounds. The high frequency hum that was present during last year's cruises is no longer present.

Low frequency recordings (0.0001-0.2 kHz) were made using sonobuoys deployed at hydrographic stations in water depths greater than 300 m. Eleven sonobuoys were deployed. Post processing of these recordings will be carried out by René Swift in order to detect vocalizations of baleen whales.It is planned that the towed hydrophone array data will be analysed by Sónia Mendes (Aberdeen University), and Clare Embling (Sea Mammal Research Unit) independently as part of their PhD research projects.

Throughout the cruise, sea surface temperature, salinity and fluorescence recordings were made using a Sea-Bird SBE21 Thermosalinograph and Sea Point Fluorometer. Surface samples were taken throughout the cruise to calibrate these data. Detailed results of the hydrographic data collected during the cruise will be made available as these data are worked up and interpreted in the laboratory. Calibrations were carried out on *Scotia* for both the thermosalinograph and CTD instrumentation.

Prior to the start of the cruise a faulty time was shown on the Zendiq display screens. The fault appeared to be coming from the NR230 (GPS). The AWE PC clock was altered to display the correct time on the display screens. After the first station on the JONSIS line the position displayed by Zendiq was also faulty. Again this information originated from the NR230. The NR230 was switched off and on again by the ETO and the Zendiq system rebooted this corrected the faulty display position, however, the time displayed was again incorrect. As above the, time on the display was altered by changing the AWE PC system clock.

G Slesser, 22 June 2005

Report - FRV Scotia, Cruise 1405S

R1/12, *Not to be cited without prior reference to the FRS Marine Laboratory, Aberdeen*

REPORT

26 September – 10 October 2005

Loading: Aberdeen
Unloading: Aberdeen

Personnel

G Slesser	In charge	
J Beaton		
D Lichtman		
N Collie		
M Rose		
L Stobo		
J P Lacaze		
T Gridley		University of Aberdeen
C Booth		University of St. Andrews

Gear

SeaBird CTDs, ADCPs, SonoBuoys, Acoustic releases.

Objectives

1. To perform hydrographic surveys along the JONSIS standard section in the northern North Sea.

2. To perform hydrographic surveys along the standard Faroe Shetland Channel sections.

3. To service two ADCP moorings in the Faroe Shetland Channel.

4. To recover two current meter moorings east of the Shetland Islands.

5. To carry out CTD hydrographic surveys in the Wyville-Thomson Ridge and Rosemary Bank areas.

6. To recover a current meter mooring from Anton Dohrn Sea Mount.

7. To perform ad-hoc towed array acoustic recordings for cetaceans and deployment of sonobuoys.

Out-Turn Days per Project: 11 days: Ae11r0, 4 days: Ae1190.

Narrative

Scotia sailed from Aberdeen at 1000 hours (all times are GMT) on Monday 26 September for the start of the long term monitoring (LTM) JONSIS CTD/water line. En route a trial CTD deployment was carried out. On completion of this trial deteriorating weather conditions prevented passage to the first JONSIS line station and the *Scotia* remained in the Moray Firth overnight. The following morning *Scotia* proceeded to the start of the JONSIS line. Sampling commenced at 1556 hours on Tuesday 27 September. By time of the completion of the JONSIS 2 station at 1757 hours the weather conditions had deteriorated again and shelter was sought off the Orkney Islands. Slightly better conditions on Wednesday 28 September allowed work to recommence at 0825 hours. Two stations, JONSIS 3 and 4 were worked before weather conditions again called a halt to the sampling work at 1015 hours.

Due to the continuing bad weather conditions *Scotia* left the JONSIS line at 0630 hours on Thursday 29 September and made passage to the CTD line bisecting two FRS current mooring positions east of the Shetland Islands. Working this line commenced at 1730 hours on Thursday 29 September and was completed by 0230 hours on Friday 30 September. Once again due to the deteriorating weather conditions it was only able to confirm that both current meter moorings were on position by interrogating the acoustic release at each mooring position. Shelter was sought by *Scotia* off Fetlar. With improved weather conditions the following morning both current meter moorings were recovered at 0730 and 1005 hours on Saturday 1 October.

Scotia then made passage to the start of the LTM Nolso-Flugga CTD/water sampling line where two stations were completed before work again was brought to a halt by gale force weather conditions. Work recommenced at 0600 hours on Sunday 2 October. Slow progress was made along this LTM sampling line before it was finally completed at 1612 hours on Monday 3 October. Passage was then made to the start of the LTM Fair Isle - Munken CTD/water sampling line. En route, *Scotia* received a message that the Chief Engineers wife had been injured in a car accident. *Scotia* broke its passage to call in to Torshavn to allow the Chief Engineer to fly home. Once the Chief Engineer had departed *Scotia* set sail from Torshavn at 0700 hours on Tuesday 4 October for the start of the Fair Isle – Munken line. The line was worked till station 3a when *Scotia* broke off to recover the NWOCE ADCP moorings.

ADCP mooring NWSE (60 16.58'N 004 22.48'W) was recovered at 0755 hours on Wednesday 5 October followed by the recovery of ADCP mooring NWSD (60 26.99'N 004 22.48'W) at 0950 hours The remaining stations on the Fair Isle – Munken line were then worked and completed at 1404 hours. Scotia then made passage to the Anton Dohrn seamount to recover a current meter mooring deployed on the previous Scotia cruise. En route to the seamount the ADCP data was downloaded, batteries replaced and set up for redeployment.

The following morning, Thursday 6 October, an updated weather forecast for the following day showed that despite the forecast issued the previous day gale force 8 and 9 conditions were forecast for the seamount area. It was decided to abandon the recovery of this mooring and make a return passage to the NWOCE ADCP mooring position for deployment of the ADCP instruments the following morning. Information was made available to us that the *Charles Darwin* would be working the Anton Dohrn Seamount area sometime over the period 6-28 October. Contact was made with the *Charles Darwin* to ask whether she would be willing to recover the mooring during its cruise. Chief scientist, Dr Toby Sherwin, indicated that he would be happy to make an attempt to recover the mooring.
On the morning of Friday 7 October mooring NWSD (60 27.09'N 04 22.62'W) was successfully deployed at 0813 hours and mooring NWSE (60 16.91'N 04 19.25'W) at 1032 hours. Passage was then made to the start of the JONSIS line. En route deteriorating weather conditions prevented work starting on the line and Scotia sheltered overnight off the Orkney Islands awaiting better conditions. However, given the forecast received later for the next 48 hours, it was decided to abandon working the JONSIS line. On Saturday 8 October time was spent carrying out a trial run of the ships ADCP into the Moray Firth followed by an ADCP survey over Moray Firth dump sites. Finally, on Sunday 9 October testing, running and drawing up a set of step by step instructions of the Windows version of the Sea-Bird 911 CTD software was carried out before returning to Aberdeen. The *Scotia* berthed at 2100 hours that evening.

Results

The weather conditions throughout the cruise were characterised by gales, resulting in considerable loss of time and the inability to undertake some of the objectives.

1. Only stations 1, 1a, 2, 3 and 4 of the JONSIS LTM line in the northern North Sea were surveyed.

2. Both the standard Faroe - Shetland Channel sections were surveyed.

3. The two Nordic WOCE ADCP moorings NWSD and NWSE were recovered successfully; data downloaded and re-deployed. The recovered ADCP data will be processed in the laboratory by in-house software.

4. The East of Shetland current meter moorings for this objective were successfully recovered and the data downloaded. The current meter data will be processed on return to the laboratory.

5. Due to the intermittent gale-force weather conditions throughout the cruise no work was carried out in the Wyville-Thomson Ridge and Rosemary Bank area as other objectives had a higher priority.

6. Again due to the weather conditions throughout the cruise the Anton Dohrn Seamount mooring was not recovered. As mentioned in the narrative it is hoped that this mooring will be recovered by the *Charles Darwin* some time over the next three weeks.

7. Passive acoustic surveys for cetaceans were carried out in the Faroe-Shetland Channel from the FRV *Scotia* between the 26 September and 10 October 2005. The surveys

were conducted using a towed hydrophone array (0.2-150kHz). The hydrophone array was towed between standard hydrographic stations along the Fair Isle-Munken, Nolso-Flugga and East of Shetland standard hydrographic lines as well as in the North Sea, where travel time between stations exceeded 30 minutes. Towed array surveys were also carried out during transits between mooring retrieval and deployment and also whilst under passage.

Approximately 159 hours of acoustic monitoring effort were carried out; covering 2193.7 km. Two-minute listening stations were conducted every 15 minutes. In total, 434 listening stations were made. Sperm whales were detected in 2.3% of all stations (Fig. 1) and dolphin species were detected in 11.3% of all stations (Fig. 2). Recordings were automatically made for 30 seconds every 2 minutes together with long continuous recordings carried out in the presence of vocalizing whales or dolphins. There were also 5 sightings made by crew members on the bridge, though species identification was not possible.
The towed hydrophone array data will be analysed by Sónia Mendes (University of Aberdeen) and Clare Embling (Sea Mammal Research Unit, University of St. Andrews) independently as part of their PhD research projects.

Low frequency recordings (0.0001-0.2 kHz) were made using sonobuoys deployed at hydrographic stations. Twenty seven sonobuoys were deployed throughout the cruise. Post processing of these recordings will be carried out by René Swift in order to detect vocalisations of baleen whales.

Throughout the cruise, sea surface temperature, salinity and fluorescence recordings were made using a Sea-Bird SBE21 Thermosalinograph and Sea Point Fluorometer. Surface samples were taken throughout the cruise to calibrate these data. Clogging up of the pipe work of the thermosalinograph system throughout the cruise by mussels finding their way into the intake pipe has resulted in some of these data to be deemed unsafe. A decision on these data to be deleted from this data set will be taken in post processing at the laboratory.

Detailed results of the hydrographic data collected during the cruise will be made available as these data are worked up and interpreted in the laboratory. Calibrations samples were taken for both the thermosalinograph and CTD instruments. Due to the problems highlighted above no calibration was determined for the thermosalinograph. A conductivity calibration was determined for CTD and is shown in Figure 3.

No depths were displayed on the Zendiq display screens throughout the cruise. Checks carried out by the ships electrical officer and laboratory engineer showed that depth readings were being received from the EA500 by the communications serial cable to the point of connecting to the Zendiq DAS PC. It is thought that there maybe a fault in the multi port serial card on DAS1. On 1 October the date on the Zendiq displays was found not to have updated from the 30 September. The date was updated by altering the AWE PC clock to the correct date. This problem will also be investigated on return to Aberdeen.

G Slesser
17 October 2005