CRUISE REPORT
CHALLENGER 121/LOIS-SES 3
AUGUST/SEPTEMBER 1995

by

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and

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UNIT FOR COASTAL AND ESTUARINE STUDIES
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CRUISE REPORT
CHALLENGER 121/SES3A & 3C

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Challenger 121/95 (SES 3)
Cruise Report

Aims and objectives
This cruise was the second of six cruises under the LOIS Shelf Edge Study (SES) aimed at defining the nature of the processes occurring at the shelf edge, their seasonal variability and their impact on the fluxes of nutrients and carbon across the shelf and into the seabed sediments through the shelf.

The cruise was divided into three legs with the first and third being principally directed to the deployment and recovery of an extensive mooring array and the acquisition of sediment cores from selected sites in the SES area. The second leg had a series of objectives concerned with measuring the water column structure and velocity field in the shelf edge regime. To complement the timeseries data from the moored array of current meters and thermistor chains, the cruise plan called for measurements by shipboard adcp and CTD together to help identify the motions associated with internal tides and waves. These motions, which are generated at the shelf edge, may contribute to turbulent mixing and dissipation and the distribution of the latter was to be investigated with the aid of the FLY free-fall turbulence probe which was to be investigated. More wide-ranging spatial measurements were required to demonstrate the continuity of the slope current and to investigate its cross slope structure.

While this cruise was principally concerned with the physics of the shelf edge system, the programme was also designed to obtain an extensive set of measurements of chlorophyll a, primary production and nutrient concentrations in parallel with physical observations. A further goal was to acquire surficial sediment material from a number of sites down the slope.

Narrative

LegA (10-18/8/95)

The status of the array at the beginning of this leg was largely known prior to the cruise thanks to previous recoveries and reports from DML during Ch120. From the original deployment in May only a few moorings remained unaccounted for, the rest having been recovered or reported missing. The exceptions were the sub-surface moorings at S300 and N300, the sediment trap mooring at N1500, a bottom mounted ADCP and three bottom pressure recorders. Of these, the key central mooring S300 was recovered intact along with the ADCPs and two of the three pressure recorders. The third pressure recorder and the sediment trap mooring were verified in position by acoustic ranging and were left for recovery in leg C or later.

An acoustic search in the vicinity of the N140 position gave a positive response for acoustic release (no. 257) which was part of a U mooring originally deployed at the S140 position. A well defined position was established by triangulation on the release. A plan to drag at this location on the last morning of the leg was thwarted by failure of the main winch just as dragging was about to start.

The initially sparse array was increased to provide the full planned coverage on the S line with most of the instruments set on rapid sampling for the forthcoming programme of internal wave observations in leg B. The Toroid surface moorings at S140, S200 and S300 were all recovered and the instruments serviced and the moorings deployed along with a replacement for the missing Toroid at S700. The Stable rig was deployed in a line along a contour at the S200 position along with a U mooring an ADCP and the toroid. A similar along-contour line with markers at each end was adopted at S140 where the Aries mooring was incorporated into the line. ADCPs were also deployed at S400 and S140E.

Constraints of time and equipment meant that on the N line we were able only to replace the missing N300 mooring, verify the presence of N1500 and service the pressure recoder at N140.

In all, we completed a total of 8 recoveries and deployed a total of 20 individual mooring elements in the seven daylight working days available to us. This was made possible by generally reasonable weather and intensive efforts by all concerned. The wind was mostly around force 5 with occasional periods of beaufort 6 although a heavy swell contrived to make conditions less than ideal for mooring operations.

While almost all daylight hours were given over to mooring work, night were dedicated to coring for sediments or CTD profiles on the S and N lines. After initial repair due to a sheared leg incurred during the previous cruise, the SMBA Multiple Corer was successfully deployed at stations S700, R1000 and N1500. Nine cores (approximately 30 cm in length) were recovered at each of these sites: three each for ^{13}C, ^{210}Pb and meiofauna. Following centimetric slicing, the former two were frozen whilst the later was preserved in 8% borax buffered formalin. Each of the coring sites was surveyed by bed hop camera along with The Sholkovitch corer was deployed at sites S700 and R1000 but despite repeated attempts (varying descent velocity, altering cocking mechanism etc.), no sediment was recovered and no further coring was undertaken. It is thought that the cocking mechanism should only be overlapped half way otherwise it is unlikely it will trip on withdrawal from the sea bed.

We also completed CTD and associated sampling on both the S and N lines with a total of 30 profiles. Samples were taken for the calibration of the recording chlorophyll and nutrient sensors as well as for the ship's flow sensor systems. Nitrate analysers (NAS2) and fluorometers were recovered from S200 and S140 Toroids having been deployed on 24th and 25th July during Challenger 120. They were re-deployed on the same moorings after data was successfully recovered from both instruments. In addition two other fluorometers were deployed at the surface and at 40m depth on the S700 toroidal mooring.

Leg C

The main priorities on this leg was to recover the fast sampling instruments moorings deployed on leg A and to redeploy a reduced array for the period until SES4 in November. As in leg A, the mooring activities during daylight hours were complemented by Coring and CTD survey work at night.

The weather was not especially favourable but it was never severe enough to seriously impede operations, with winds in the range Beaufort 4-6 and a moderate swell at times. We were, therefore, able to make good progress with the mooring operations. The S140 U mooring had already been retrieved at the end of leg B while the S200 U mooring had been reported as missing along with the toroids at the S300 and S700 sites. We recovered the two remaining fast sampling moorings (at S300 & N300) and all the four ADCP systems installed on leg A along with the ARIES mooring at S140. Replacement moorings, with instruments on low rate sampling, were deployed at S140 and S300. Together with the mooring installed at S700 during leg A, these moorings were intended to form the basis of a reduced array for the autumn period. Two ADCPs were deployed one at S400 and the other at S140 where the Met buoy, deployed on leg A, was supplemented by a replacement waverider buoy. An optimum alignment was achieved at S140 with the U mooring and the Met buoy at the ends of aline along the 140m contour.

We were also successful in recovering and redeploying the deep sediment trap mooring at N1500. Some difficulty was experienced in locating the mooring because it surfaced almost a mile from the ship due to a previous position being logged in the vessels's navigation system. The problem was compounded by the poor performance of the RVS acoustic ranging system which failed to give consistent ranges.

Nitrate analysers and Fluorometers, deployed on leg A, were recovered from the S140 and S200 surface packages along with a Fluorometer from S700. Data was successfully recovered from all these instruments although there are unresolved questions about the performance of the nitrate analysers when sampling at the low frequency rate used in these deployments. One fluorometer was re-deployed at the surface at S140.

All the above operations were completed by the morning of 6/9 when it was planned to deploy a replacement marker at S700 prior to recovering Stable and attempting the retrieval of several missing items by dragging. On arriving at the S700 site, however, we found the main buoyancy at the surface with the mooring adrift. The whole string, except for the bottom two current meters and the release, was recovered but damage to the wires precluded re-deployment. Contact was established with the release on the bottom and efforts made to fire the release. We were,however, uncertain about whether the instruments had come to the surface and, again, the lack of ranging facilities on the acoustics increased our difficulties. A protracted visual search, without the help of a pinger (which could not be switched into continuous mode) revealed a number of free floating red buoyancy units from the mooring. In total, these accounted for 60% of the remaining back-up buoyancy suggesting that the release and attached instruments were still on the seabed.

During the search a group of 8 yellow buoyancy units were located with a short length of "cropped-off" blue wire attached. These were not part of the S700 mooring but had been used on the recently deployed S300 unit. The bad news was confirmed when a signal was received on board ship from the Argos beacon at 2100 on 6/9. By next morning, no alarm had been received from Argos but persistent telephone enquiry produced a position close to which the subsurface buoy was eventually located. Two current meters and two thermistor chain systems were recovered though one of the chains was badly damaged by trawl wire scuffing.

By contrast the night time coring work was straightforward and uneventful. A series of multicore camples were obtained from two sites (S700 and R1000). A satisfactory

70 cm long core was also obtained from the R1000 site using the Sholkovitz corer. The CTD programme was also successful in covering all four lines in the SES box. Parallel measurement from the Dutch vessel *Tydeman* will provide valuable supplementation of this data set with results from the M and T lines as well as the main SES box.

Biological Instruments (by I. Ezzi)

Nitrate Analysers

Nitrate analysers were recovered from S140 and S200 surface packages having been deployed on Leg A. Data were recovered from both instruements.

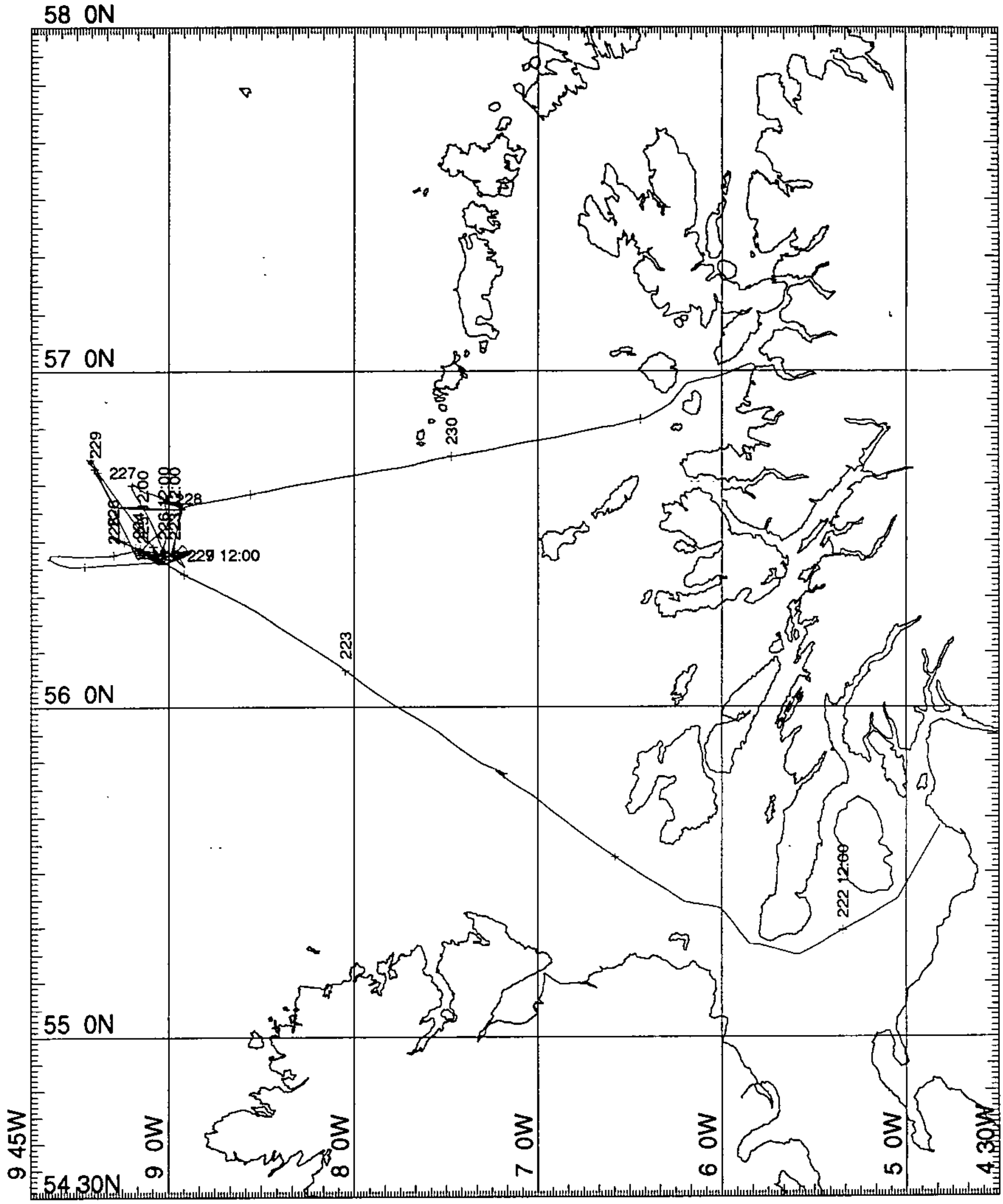
Flurometers

Fluorometers were recovered from S140 and S200 surface packages and from S700 40 m, all of which had been deployed during Leg A. Data were recovered from all instruments. One fluorometer was re-deployed at S140 surface.

Fluorometer calibration

Water samples were taken for chlorophyll determination for calibration of the underway/deck-tank fluorometer and CTD fluormeter.

APPENDIX A
SES 3A AND 3C CRUISE TRACKS AND MOORING POSITIONS



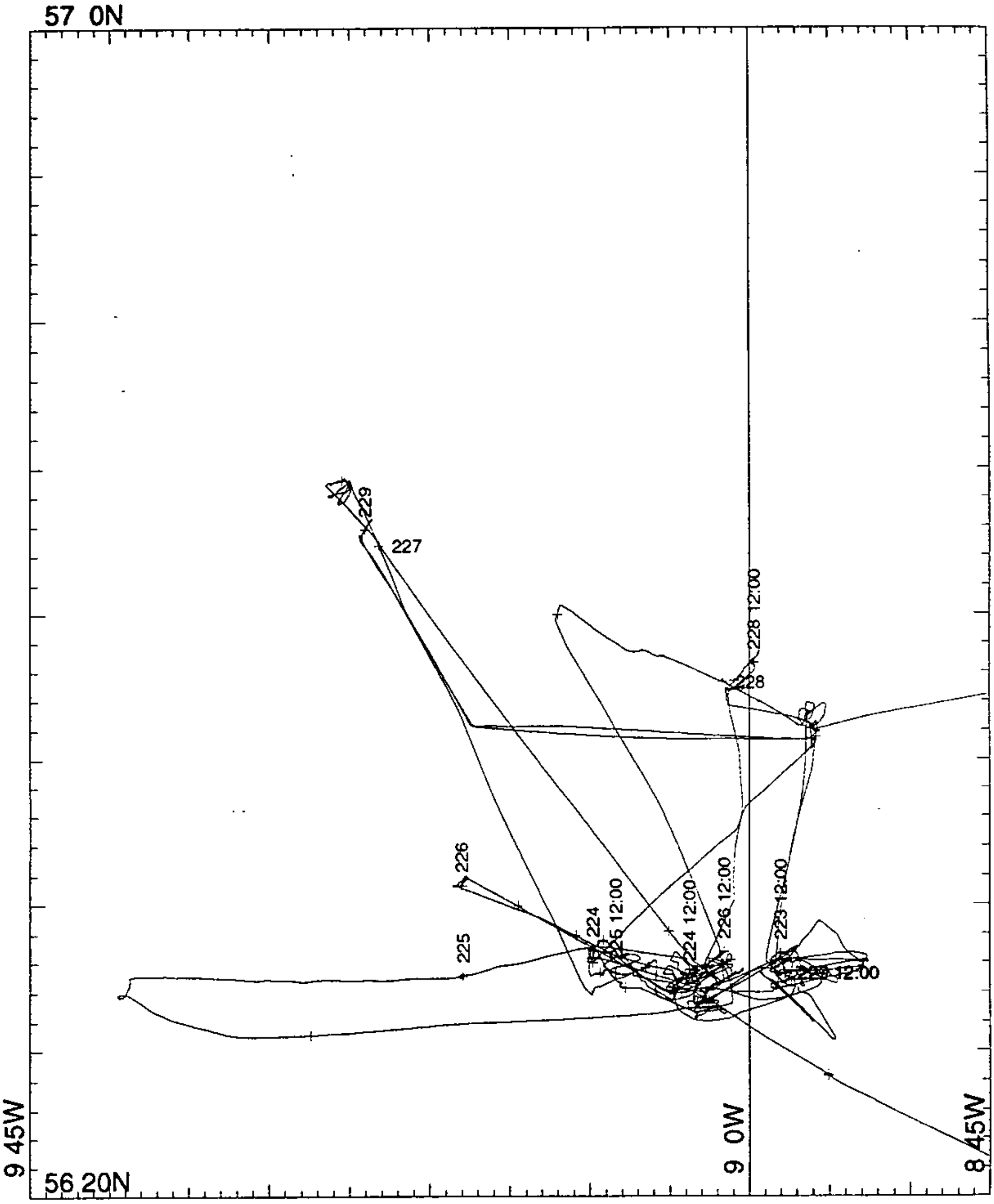
MERCATOR PROJECTION

GRID NO. 1

SCALE 1 TO 3500000 (NATURAL SCALE AT LAT. 0)

INTERNATIONAL SPHEROID PROJECTED AT LATITUDE 0

Challenger 121A Cruise Track



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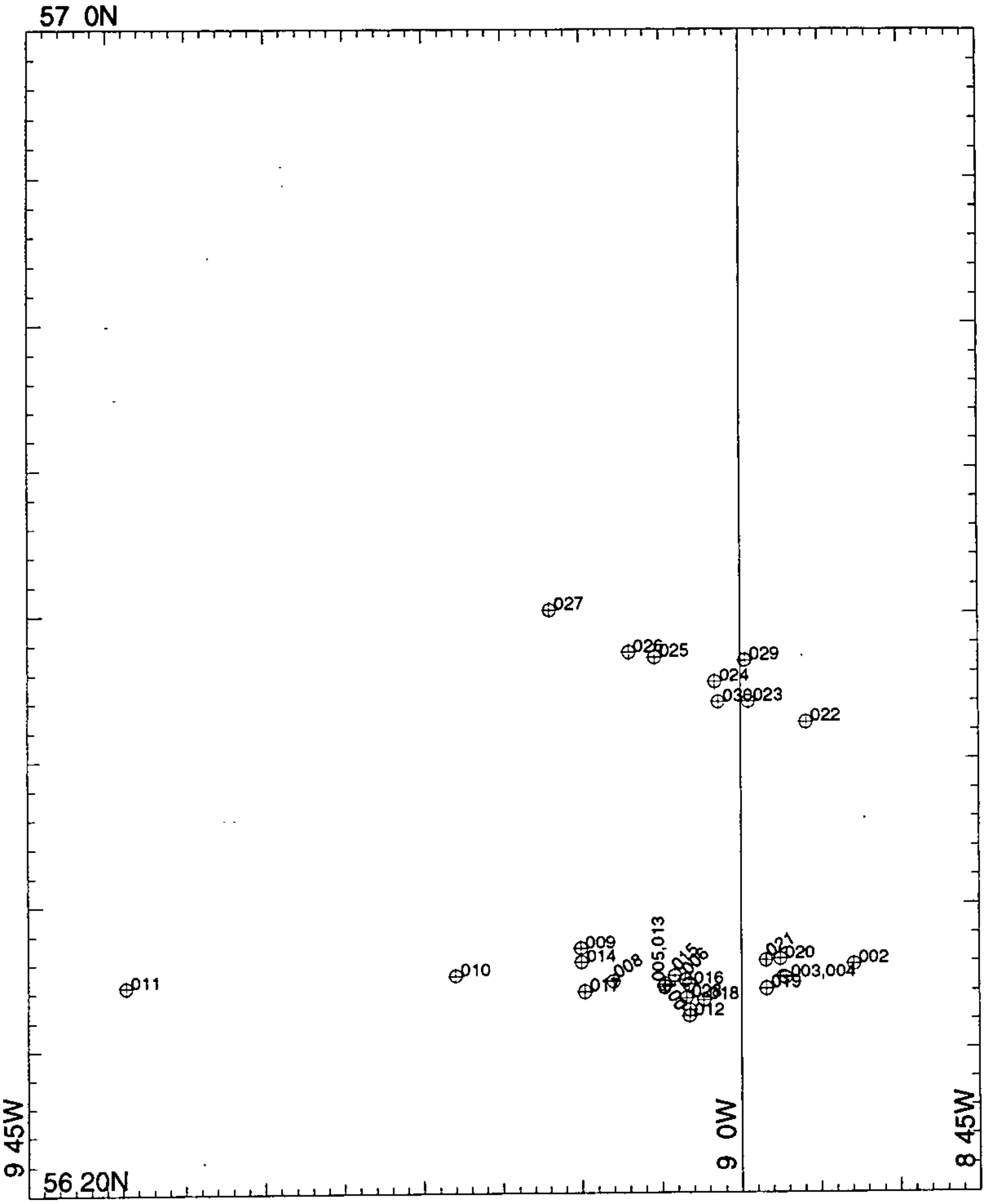
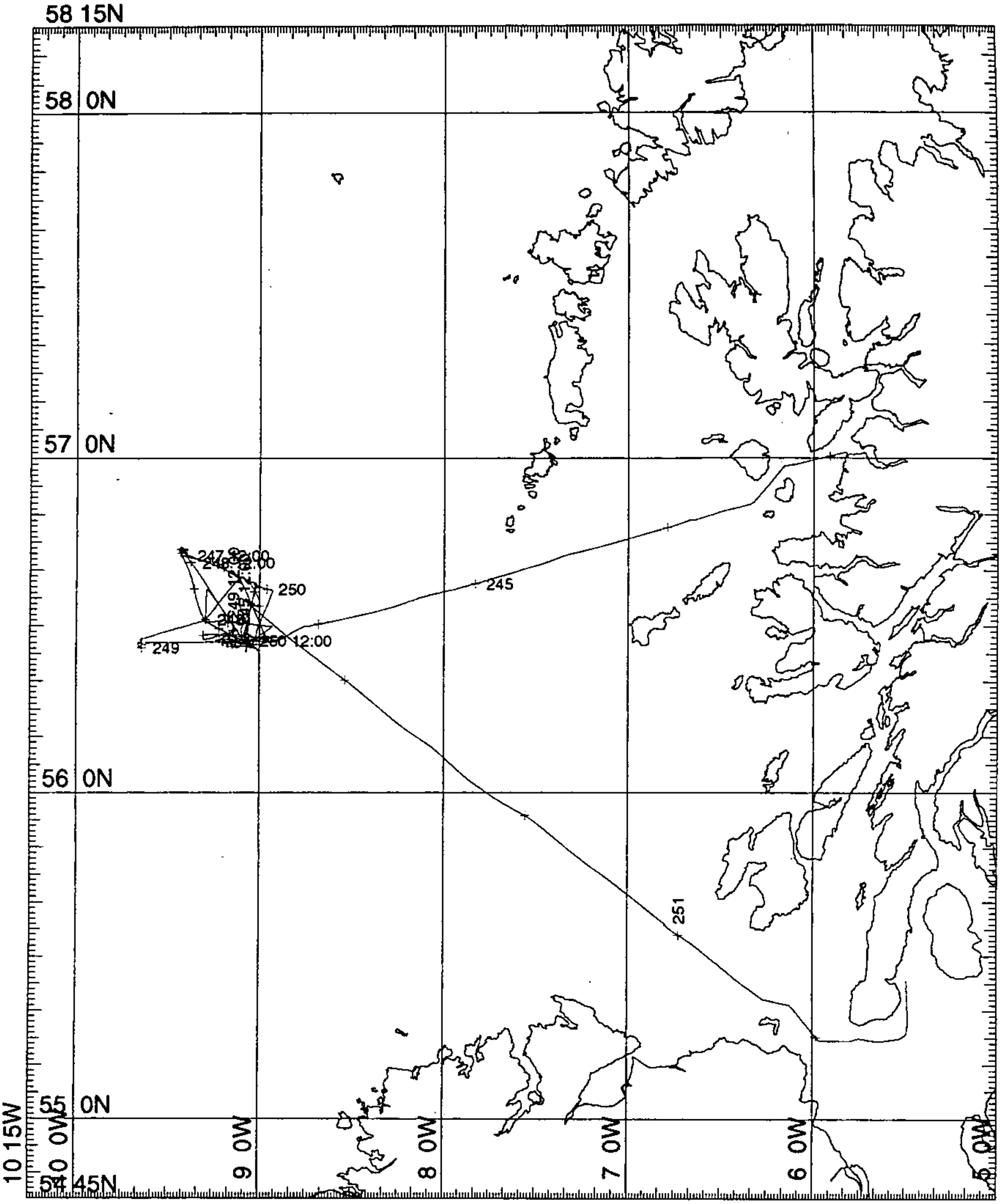
Challenger 121A Cruise Track



Challenger 121A CTD Stations (N-S lines)



MERCATOR PROJECTION

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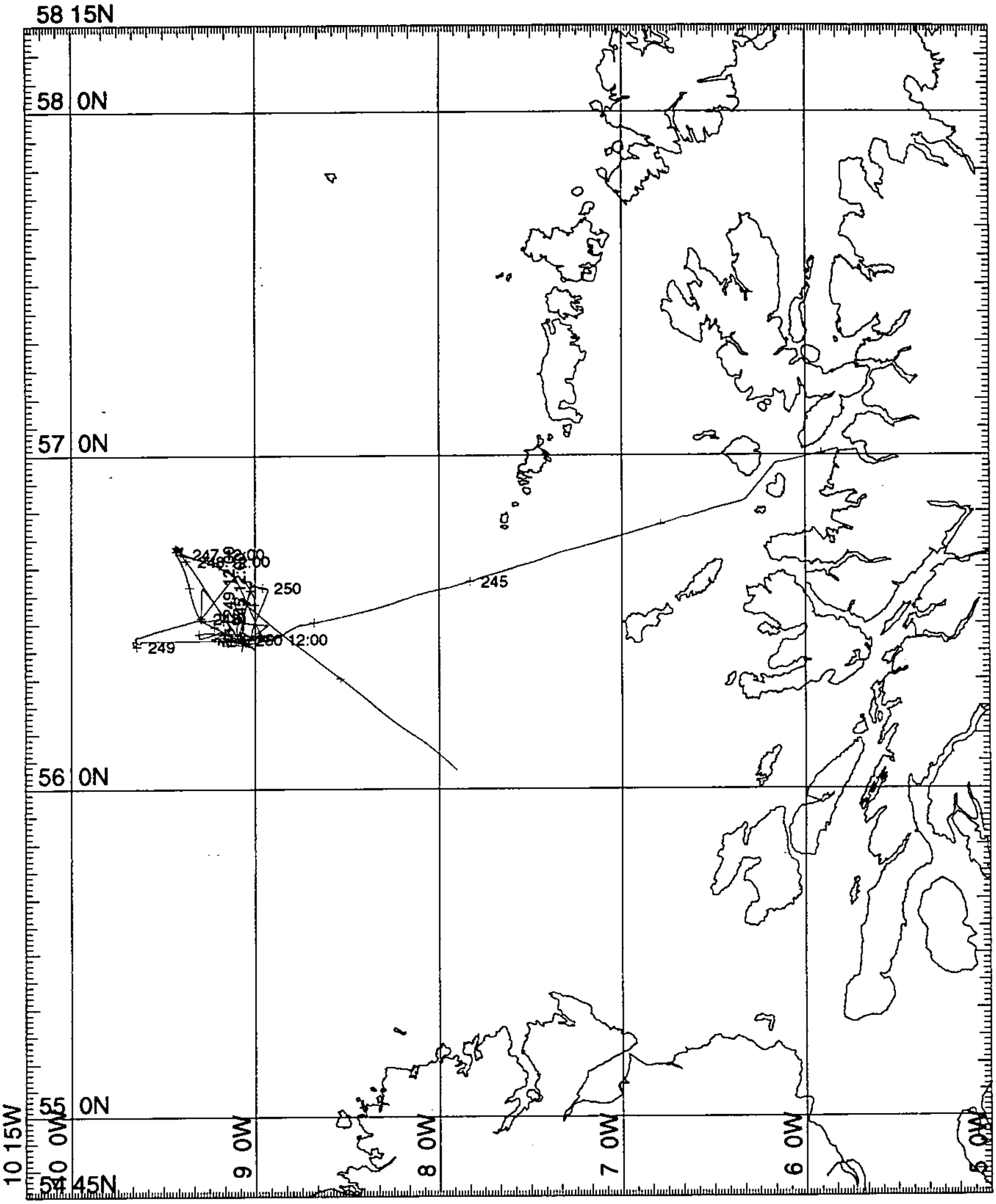
INTERNATIONAL SPHEROID PROJECTED AT LATITUDE 0

Challenger 121C Cruise Track



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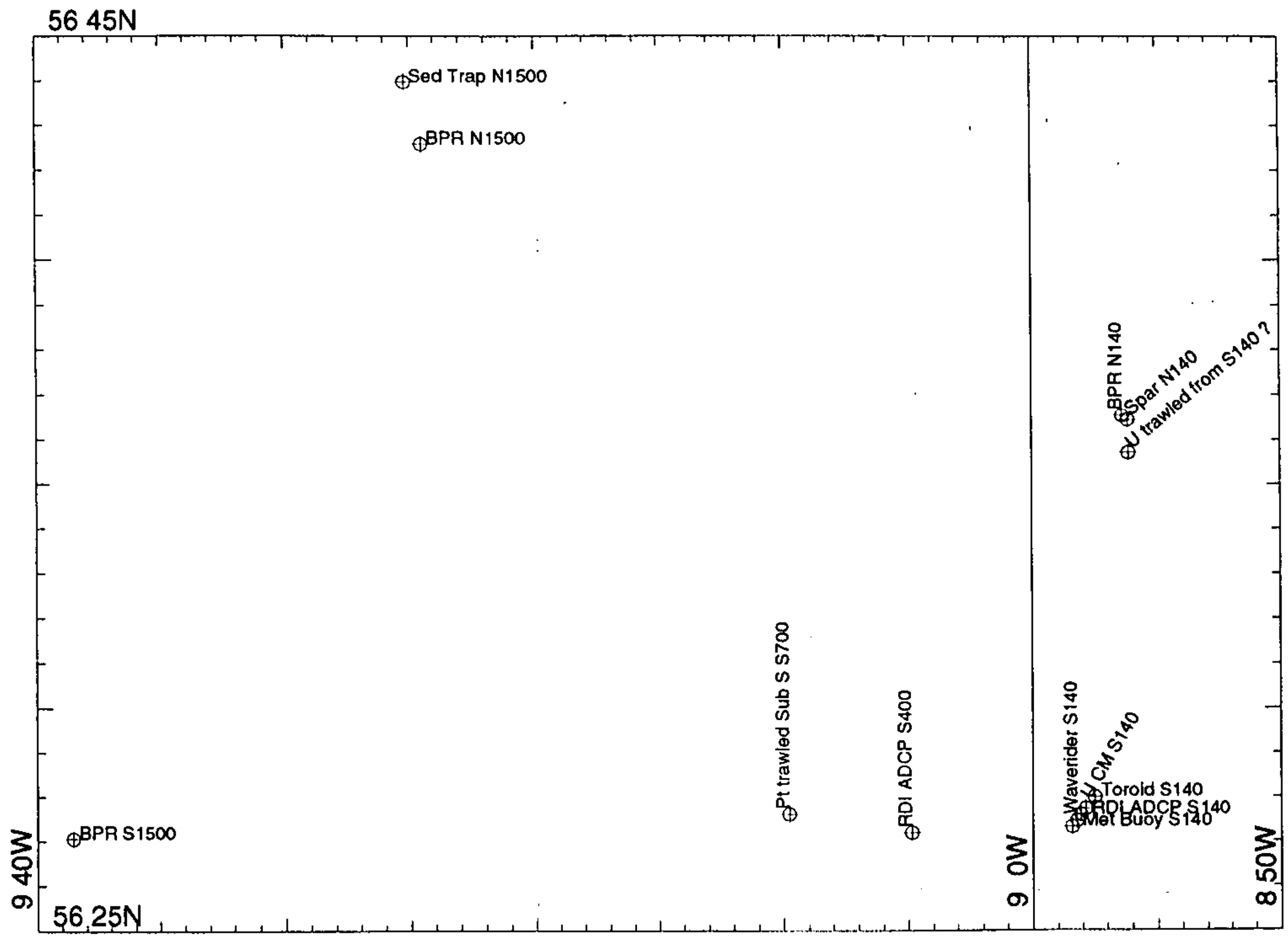
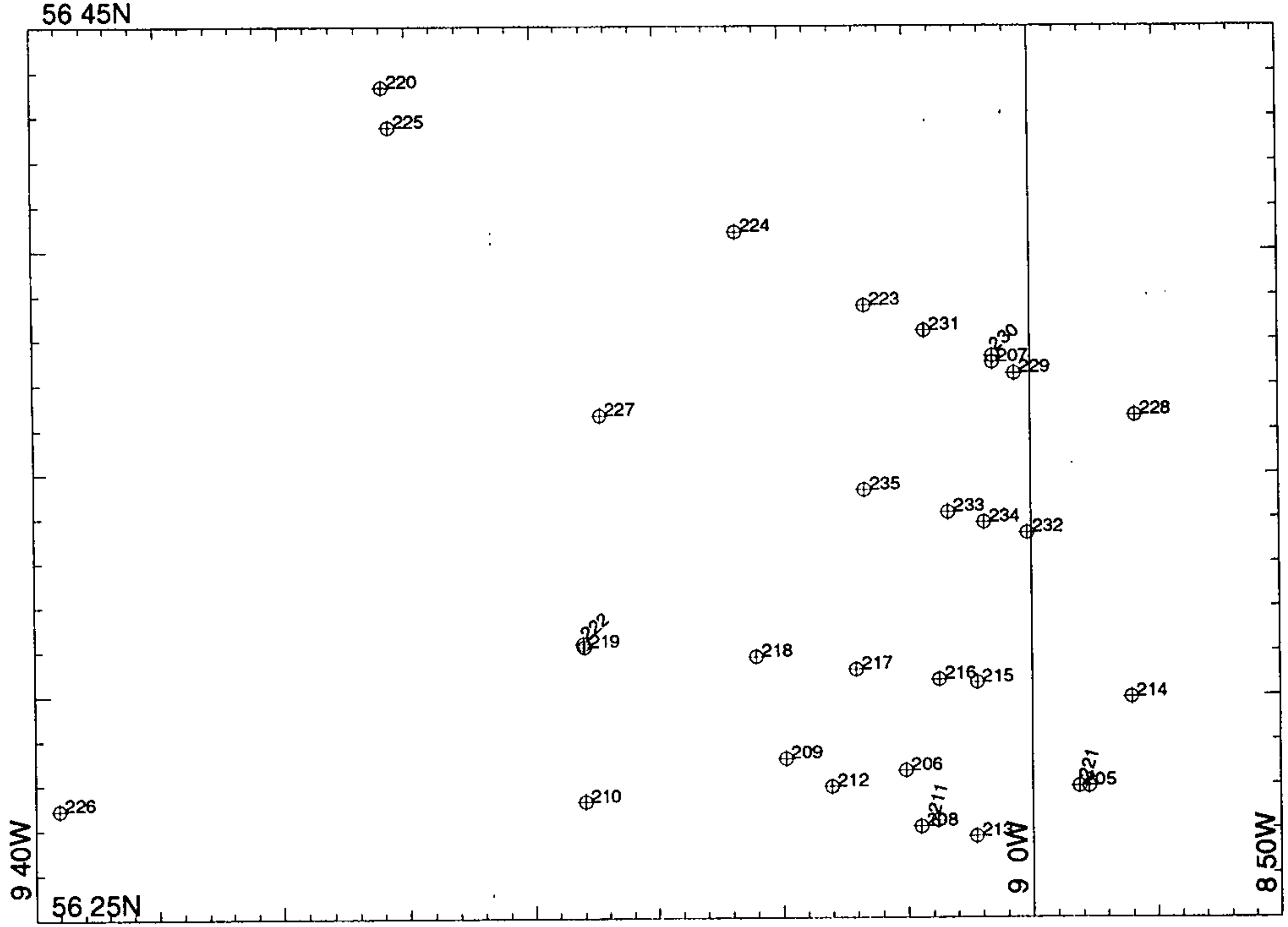
Challenger 121C Cruise Track



Challenger 121C Moorings final Array



Challenger 121C CTD Stations

APPENDIX B
SES3A AND 3C MOORING, INSTRUMENT AND CTD SHEETS

Cruise CH121 Leg A					MOORINGS DEPLOYMENTS/RECOVERIES
Date/Time	Site	Lat (deg N)	Lon (deg W)	Wdepth	Type
DEPLOYMENTS					
11/08/95 05:36	S200	56 26.73	09 02.92	197	STABLE
11/08/95 08:12	S200	56 26.67	09 03.09	202	RDI ADCP
11/08/95 09:17	S140E	56 28.02	08 52.87	146	ADCP (experimental)
11/08/95 13:51	S140	56 27.45	08 58.09	146	ARIES 2
11/08/95 19:23	S140	56 27.69	08 57.77	150	'U' SHAPE CURRENT METER MOORING
12/08/95 08:40	S400	56 27.18	09 04.84	397	RVS ADCP
13/08/95 06:51	S200	56 26.35	09 03.08	194	'U' SHAPE CURRENT METER MOORING
13/08/95 16:21	S700	56 27.61	09 09.75	702	STET MOORING
14/08/95 14:02	S300	56 27.48	09 03.79	300	SUB-SURFACE CURRENT METER MOORING
14/08/95 17:19	S300	56 27.26	09 03.86	300	TOROID MOORING
14/08/95 21:11	S700	56 27.19	09 09.48	700	TOROID MOORING
15/08/95 15:48	S400	56 27.04	09 04.85	398	S4 BOTTOM CURRENT METER MOORING
15/08/95 18:11	S140E	56 28.06	08 52.84	148	ADCP (experimental)
15/08/95 19:33	S140	56 27.99	08 57.70	146	TOROID MOORING
16/08/95 08:30	S200	56 26.86	09 02.86	193	TOROID MOORING
16/08/95 16:07	N300	56 37.55	09 01.11	297	SUB-SURFACE CURRENT METER MOORING
16/08/95 17:06	N300	56 37.37	09 01.38	295	SPAR MARKING BUOY
17/08/95 11:30	S140	56 27.32	08 58.40	146	MET BUOY
17/08/95 12:06	S140	56 27.63	08 58.00	147	RDI ADCP
17/08/95 13:53	N140	56 36.53	08 56.33	135	BOTTOM PRESSURE RECORDER
17/08/95 17:57	N140	56 36.59	08 56.15		SPAR MARKER BUOY
RECOVERIES					
12/08/95 09:45	S300	56 27.56	09 03.64	290	SUB-SURFACE CURRENT METER MOORING
13/08/95 18:09	S300	56 27.30	09 03.80	285	TOROID MOORING
15/08/95 08:55	S200	56 26.96	09 02.75	189	TOROID MOORING
15/08/95 10:54	S140	56 28.13	08 57.42	147	TOROID MOORING
15/08/95 12:14	S140	56 27.56	08 58.19	140	RDI ADCP
15/08/95 13:20	S140E	56 27.80	08 53.20	140	ADCP (experimental)
16/08/95 18:16	N140	56 36.56	08 56.16	134	BOTTOM PRESSURE RECORDER
17/08/95 08:57	S140	56 27.33	08 58.34	146	MET BUOY
17/08/95 14:45	N140	56 36.40	08 56.20	146	SPAR MARKER BUOY

Cruise CH121 Leg A					MOORINGS DEPLOYMENTS/RECOVERIES
Date/Time	Site	Lat (deg N)	Lon (deg W)	Wdepth	Type
DEPLOYMENTS					
17/08/95 13:53	N140	56 36.53	08 56.33	135	BOTTOM PRESSURE RECORDER
16/08/95 16:07	N300	56 37.55	09 01.11	297	SUB-SURFACE CURRENT METER MOORING
16/08/95 17:06	N300	56 37.37	09 01.38	295	SPAR MARKING BUOY
11/08/95 09:17	S140E	56 28.02	08 52.87	146	ADCP (experimental)
11/08/95 13:51	S140	56 27.45	08 58.09	146	ARIES 2
11/08/95 19:23	S140	56 27.69	08 57.77	150	'U' SHAPE CURRENT METER MOORING
15/08/95 19:33	S140	56 27.99	08 57.70	146	TOROID MOORING
17/08/95 11:30	S140	56 27.32	08 58.40	146	MET BUOY
17/08/95 12:06	S140	56 27.63	08 58.00	147	RDI ADCP
15/08/95 18:11	S140E	56 28.06	08 52.84	148	ADCP (experimental)
11/08/95 05:36	S200	56 26.73	09 02.92	197	STABLE
11/08/95 08:11	S200	56 26.67	09 03.09	202	RDI ADCP
13/08/95 06:51	S200	56 26.35	09 03.08	194	'U' SHAPE CURRENT METER MOORING
16/08/95 08:30	S200	56 26.86	09 02.86	193	TOROID MOORING
14/08/95 14:02	S300	56 27.48	09 03.79	300	SUB-SURFACE CURRENT METER MOORING
14/08/95 17:19	S300	56 27.26	09 03.86	300	TOROID MOORING
12/08/95 08:40	S400	56 27.18	09 04.84	397	RVS ADCP
15/08/95 15:48	S400	56 27.04	09 04.85	398	S4 BOTTOM CURRENT METER MOORING
13/08/95 16:21	S700	56 27.61	09 09.75	702	SUB-SURFACE CURRENT METER MOORING
14/08/95 21:11	S700	56 27.19	09 09.48	700	TOROID MOORING
RECOVERIES					
16/08/95 18:16	N140	56 36.56	08 56.16	134	BOTTOM PRESSURE RECORDER
15/08/95 10:54	S140	56 28.13	08 57.42	147	TOROID MOORING
15/08/95 12:14	S140	56 27.56	08 58.19	140	RDI ADCP
17/08/95 08:57	S140	56 27.32	08 58.10	146	MET BUOY
15/08/95 13:20	S140E	56 27.80	08 53.20	140	ADCP (experimental)
15/08/95 08:55	S200	56 26.96	09 02.75	189	TOROID MOORING
12/08/95 09:41	S300	56 27.64	09 03.64	290	SUB-SURFACE CURRENT METER MOORING
13/08/95 18:09	S300	56 27.30	09 03.80	285	TOROID MOORING

	Cruise CH121 Leg A CTD Casts					
Cast	**Start Date/Time**	**End Date/Time**	**Site**	**Lat (deg N)**	**Lon (deg W)**	**Wdepth**
CTD1	11/08/95 06:15	11/08/95 06.30	S200	56 26.70	09 02.80	191
CTD2	11/08/95 09:33	11/08/95 09.51	S140E	56 27.91	08 52.91	146
CTD3	11/08/95 14:20	11/08/95 14.35	S140	56 27.38	08 56.87	145
CTD4	11/08/95 19:45	11/08/95 20.01	S140	56 27.47	08 57.23	147
CTD5	12/08/95 08:48	12/08/95 09.19	S400	56 27.10	09 04.86	403
CTD6	12/08/95 14:18	12/08/95 14.38	S300	56 27.48	09 03.64	281
CTD7	12/08/95 18.13	12/08/95 18.39	S200	56 26.33	09 03.22	201
CTD7A	12/08/95 18.41	12/08/95 18.53	S200	56 26.30	09 03.20	200
CTD8	12/08/95 20.15	12/08/95 20.59	S600	56 27.32	09 08.01	600
CTD9	12/08/95 21.18	12/08/95 22.08	S700	56 28.43	09 09.92	699
CTD10	12/08/95 23.03	13/08/9500.10	S1000	56 27.54	09 18.13	1000
CTD11	13/08/95 01.43	13/08/95 03.10	S1500	56 27.54	09 38.72	1511
CTD12	13/08/95 07.03	13/08/95 07.26	S200	56 26.33	09 03.20	200
CTD13	13/08/95 09.57	13/08/95 10.12	S400	56 27.19	09 04.79	400
CTD14	13/08/95 16.51	13/08/95 17.26	S700	56 28.01.	09 10.00	718
CTD15	14/08/95 14.20	14/08/95 14.48	S300	56 27.52	09 04.17	343
CTD16	14/08/95 17.41	14/08/95 18.02	S300	56 27.18	09 03.30	235
CTD17	14/08/95 21.32	14/08/95 21.52	S700	56 27.02	09 09.84	731
CTD18	15/08/95 10.00	15/08/95 10.18	S200	56 26.71	09 02.30	170
CTD19	15/08/95 14.17	15/08/95 14.32	S140	56 27.08	08 58.37	145
CTD20	15/08/95 17.17	15/08/95 17.43	S140	56 28.12	08 57.53	145
CTD21	15/08/95 19.52	15/08/95 20.21	S140	56 27.96	08 58.62	148
CTD22	15/08/95 21.24	15/08/95 21.40	N140	56 36.30	08 55.83	140
CTD23	15/08/95 23.01	15/08/95 23.17	N200	56 37.04	08 59.52	166
CTD24	15/08/95 23.56	16/08/95 00.25	N300	56 37.64	09 01.65	337
CTD25	16/08/95 01.02	16/08/95 01.41	N600	56 38.51	09 05.27	615
CTD26	16/08/95 01.57	16/08/95 02.47	N700	56 38.74	09 06.65	693
CTD27	16/08/95 03.15	16/08/95 04.02	N1000	56 40.31	09 11.75	1011
CTD28	16/08/95 08.41	16/08/95 09.05	S200	56 26.81	09 03.44	239
CTD29	16/08/95 12.03	16/08/95 12.37	N300	56 38.37	08 59.70	280
CTD30	16/08/95 17.20	16/08/95 17.44	N300	56 37.02	09 01.41	305

CH121C Moorings							DAN 19950910
Stn	**Buoy Type**	**Event type**	**Date & Time**	**Latitude**	**Longitude**	**Depth**	**Comments**
S140	U	deploy	19950902 0848Z	56 27.83N	008 57.67W	147.4	CTD205; clump 2 56 27.72N 008 57.86W
S300	pop up	recover	19950902 1006Z	56 27.62N	009 03.62W	296	CTD206
N300	spar marker	recover	19950902 1348Z	56 37.31N	009 01.22W	284	
N300	pop up	recover	19950902 1440Z	56 37.45N	009 01.48W	315	CTD207
S400	pop up	recover	19950902 1740Z	56 27.05N	009 04.87W	400.6	CTD208
S300	pop up	deploy	19950903 1100Z	56 27.53N	009 03.73W	304	CTD211
S300	spar marker	deploy	19950903 1240Z	56 27.30N	009 03.88W		
S600	drogue	deploy	19950903 1320Z	56 27.76N	009 07.93W	597	CTD212
S140	toroid	recover	19950903 1515Z	56 27.97N	008 57.63W	146	
S140E	p/u ADCP	recover	19950903 1625Z	56 28.00N	008 52.85W	146	R. Palin experimental
S200	p/u ADCP	recover	19950903 1805Z	56 26.73N	009 03.07W	200	CTD213
N1500	p/u sed trap	recover	19950904 1100Z	56 43.62N	009 24.22W	1495	
S140	toroid	deploy	19950904 1611Z	56 27.99N	008 57.49W	146	CTD221
S140	p/u ADCP	recover	19950904 1730Z	56 27.62N	008 58.02W	146	
S140	p/u ADCP	deploy	19950904 1825Z	56 27.82N	008 59.99W	146	log pos'n 56 27.59N 008 58.05W
N1500	p/u sed trap	deploy	19950905 1136Z	56 43.54N	009 25.31W	1530	CTD225
S400	p/u ADCP	recover	19950905 1350Z	56 27.26N	009 04.45W	393	ref: LS01
S140	toroid ARIES	recover	19950905 1500Z	56 27.58N	008 58.02W	149	
S140	waverider	deploy	19950905 1823Z	56 27.47N	008 58.23W	145	
S400	p/u ADCP	deploy	19959906 0735Z	56 27.19N	009 04.84W	400	ref: LS02
S200	toroid	recover	19950906 0809Z	56 26.90N	009 02.65W	182	
S700	pop up	recover	19950906 1040Z	56 28.43N	009 09.94W	699	cut below 400m TC
S200	p/u STABLE	recover	19950906 1821Z	56 26.78N	009 03.14W	208	
S300	pop up	recover	19950907 0918Z	56 25.60N	009 00.44W	147	cut below 2nd TC; spar also recovered
Notes:	There are some slight discrepancies with the bridge log positions. These have all been examined and the						
	and the most accurate position (in DANs opinion) used in the above table.						
	The S140 Met. buoy was not serviced (Argos id: 245967?)						

CH121C Instrumentation								
Station	**Rig**	**Instrument**	**Serial No.**	**Date & Time**		**Sample**	**Owner**	**Comments**
				Started/Finished	**In/Out Water**	**Interval**		
S140 (deploy)	U	Argos	31 10-11:11443					
		RCM	11608	19950901 1730Z	19950902 0807Z	30 min	UCNW	
		TC logger	1142	19950901 1730Z	19950902 0807Z	30 min	DRA	
		TC (76m)	1185				DRA	
		RCM	11818	19950901 2000Z	19950902 0825Z	30 min		
		SeaTech	638					CTD 204
		Release	222					
S300 (recover)	pop up	S4	5111117	19950903 080730Z	19950902 1030Z	15 min	RVS	
		RCM	8240	19950902 1403Z	19950902 1034Z	5 min		
		TC logger	1453	19950902 121512Z	19950902 1034Z	10 min		
		TC 50m	2336					
		RCM	8249	19950902 1310Z	19950902 1047Z	5 min		tangled in cable
		TC logger	1451	19950902 1326Z	19950902 1047Z	10 min		
		TC 50m	2337					
		RCM	11822	19950902 1650Z	19950902 1120Z	5 min		lemo connector leaked
		SeaTech	631					
		TC logger	1461	19950902 1215Z	19950902 1120Z	10 min		
		TC 100m	2338					
		RCM	11049	19950902 1428Z	19950902 1143Z	5 min		
		TC (Sea Data)	8	19950904 082215Z	19950902 1143Z	7.5 min	DRA	
		RCM	11820	19950902 1600Z	19950902 1155Z			flooded
		SeaTech	641					
		Oceano release	261					
N300 (recover)	pop up	RCM	9603	19950903 120525Z	19950902 1503Z	5 min		
		TC logger	1141	19950903 1110Z	19950902 1503Z	10 min	DRA	
		TC (100m)	1688					
		RCM	9450	19950903 114530Z	19950902 1520Z	5 min	DRA	
		TC logger	1443	19950902 183029 Z	19950902 1520Z	10 min		
		TC 100m	1690					
		RCM	11814	19950903 1305Z	19950902 1545Z	10 min		
		SeaTech	556					connector leaked

S400 (recover)	pop up	RCM	9540	19950903 124018Z	19950902 1753Z	5 min				
S300 (deploy)	pop up	Argos	94				DML	id 24027		
		RCM	8249	19950902 1330Z	19950903 0930Z	30 min.				
		TC logger	1443	19950903 0800Z		30 min				
		TC 100m	1690							
		RCM	11049	19950902 1500Z	19950903 0950Z	30 min				
		TC logger	1461	19950902 1300Z		30 min				
		TC 100m	2338							
		RCM	11822	19950903 0830Z	19950903 1029	30 min				
		SeaTech	641							
		MORS release	261							
S140 (recover)	toroid	Argos	3604							
		nitrate analyser	1754		19950903 1515Z	60 min	DML			
		fluorometer	11		19950903 1515Z	60 min	DML			
		Transmissometer	TRB2-1761	19950903 1557Z			POL			
		TC logger	1457	19950903 120650Z			POL			
		TC chain (40m)	2331				POL			
S140E (recover)	pop up	ADCP	experimental		19950903 1639Z		POL			
S200 (recover)	pop up	ADCP RDI	BBCS-150 1148		19950903 1820Z	5 min	POL			
N1500 (recover)	pop up	Parflux sed traps	10452-1		19950904 1100Z	7 day	RVS/UWB			
		Mark 7G-2	10452-2		19950904 1120Z	7 day	RVS/UWB			
		RCM	11045	19950904 1201:35Z	19950904 1120Z	30 min		balance weight wrong		
		SeaTech	555					faulty		
S140 (deploy)	toroid	Fluorometer		19950904 1700Z	19950904 1611Z	60 min	DML			
S140 (recover)	pop up	ADCP RDI	BBCS-150 1149		19950904 1730Z		RVS			
		WLR	1042	19950905 0713Z	19950904 1730Z	15 min	POL			
S140 (deploy)	pop up	ADCP RDI	BBCS-150 1148		19950904 1825Z	10 min	POL			
		WLR	444	19950904 140041Z	19950904 1825Z	15 min	POL			

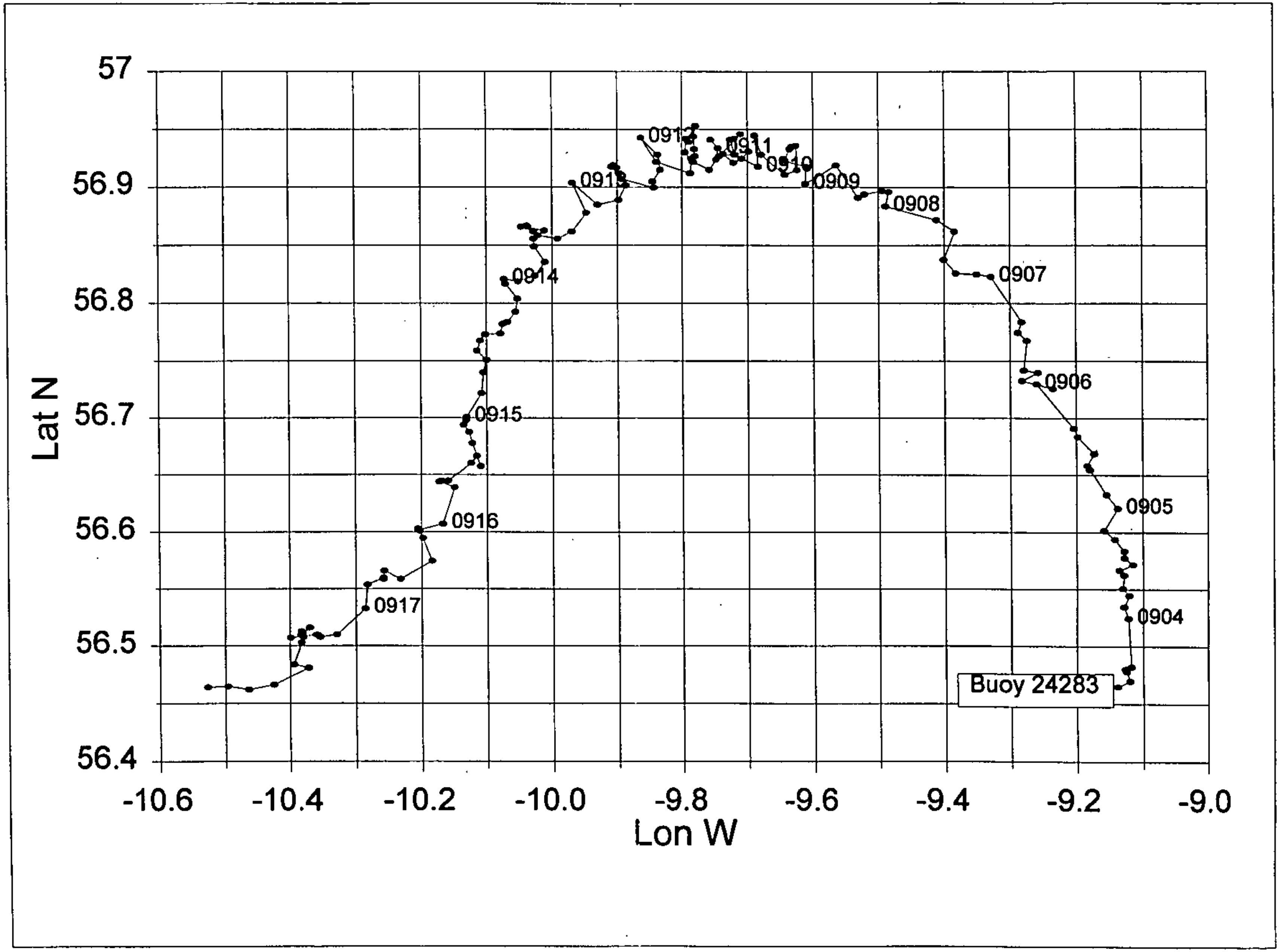
N1500 (deploy)	pop up	Argos			19950905 1136Z		RVS/UWB			
		Parflux sed traps	10452-1	19950910 1200Z	19950905 1136Z	7 day	RVS/UWB	last sample on 19960204		
		Mark 7G-21	10452-2	19950910 1200Z	19950905 1136Z	7day	RVS/UWB	last sample on 19960204		
S400 (recover)	pop up	ADCP RDI	NBSC-300 597		19950905 1408Z	5 min	RVS			
S140 (recover)	toroid	ARIES	II		19950905 1500Z	2h/12h	USO			
S140 (deploy)	waverider	Datawell	none		19950905 1823Z		POL			
		Argos	3704?		19950905 1823Z		POL			
		Synergetics 14A	2390A861		19950905 1823Z		POL	satellite arial		
S400 (deploy)	pop up	ADCP RDI	NBSC-300 597	19950906 0700Z	19950906 0735Z		RVS			
		Oceano release	255							
S200 (recover)	toroid	Fluorometer	112/2530/013		19950906 0809Z	30 min	DML			
		Nitrate Analyser	1750		19950906 0809Z	60 min	DML			
		Transmissometer	TRB2-1762	19950906 1726Z	19950906 0809Z	1 min	POL			
		Light meter	CS-22		19950906 0809Z		UWB			
		TC logger	852	19950906 090426Z	19950906 0809Z	10 min	POL			
		TC chain (40m)	1611				POL			
S700 (recover)	pop up	Argos	S/N 53 id:24329		19950906 1035Z					
		S4	5111119		19950906 1035Z					
		Fluorometer	2530/012		19950906 1040Z					
		RCM	6749	19950906 144116Z	19950906 1040Z	30 min				
		TC logger	1460	19950906 160320Z	19950906 1040Z	60 min				
		TC chain (50 m)	2334							
		RCM	3308	19950906 144116Z	19950906 1054Z					
		TC logger	1455	19950906161525Z	19950906 1054Z	60 min				
		TC chain (100m)	2339							
		RCM	11817	19950906 154028Z	19950906 1118Z	30 min				
		SeaTech	637							
		TC logger	1444	19950906 160327Z	19950906 1118Z	60 min				
		TC chain (400m)	1763					damaged		
		CUT - instruments below lost								

S200 (recover)	pop up	STABLE	misc.		19950906 1821Z					
S300 (recover)	pop up	Argos	id 24027		19950907 0917Z					
		RCM	8249	19950907 110010Z	19950907 0924Z	30 min				
		TC logger	1443	19950907 113018Z	19950907 0924Z	60 min				
		TC chain (100m)	2338					destroyed		
		RCM	11049	19950907 1107Z		30 min		damaged		
		TC logger	1461	19950907 113009Z		60 min				
		TC chain (100m)	1690					destroyed		
		CUT - instruments below lost								

CH121C CTD CASTS		EG+G Mk IIIB instrument no. IMCT1117					
Cast	**Date&time**	**Station**	**Latitude**	**Longitude**	**Depth**	**Comments**	
204	19950901 1859Z		56 49.11N	006 39.77W	169	SeaTek S/N 638 calibration	
205	19950902 0858Z	S140 (deploy)	56.464N	8.969W	148		
206	19950902 1211Z	S300 (recover)	56.470N	9.084N	440		
207	19950902 1410Z	N300 (recover)	56.624N	9.025W	314		
208	19950902 1722Z	S400 (recover)	56 20.07N	009 04.46W	350		
209	19950902 1954Z		56 28.48N	009 09.74W	687	delayed - water for corer	
210	19950903 0250Z		56 27.63N	009 18.92W	996		
211	19950903 0726Z	S300 (deploy)	56.451N	9.065W	290		
212	19950903 1328Z	Drogue (deploy)	56.465N	9.133W	606		
213	19950903 1924Z		56.446N	9.036W	170		
214	19950903 20.38		56 29.94N	008 55.98W	141		
215	19950903 2135Z		56 30.30N	009 02.24W	195		
216	19950903 2213Z		56 30.33	009 03.66W	312		
217	19950903 2308Z		56 30.49N	009 04.12W	508		
218	19950904 0004Z	R700	56 30.76N	009 10.89W	715		
219	19950904 0117Z	R1000	56 30.97N	009 17.85W	1009		
220	19950904 0728Z	N1500	56.729N	9.431W	1544		
221	19950904 1535Z		56 27.95N	008 57.72W	140		
222	19950904 2039Z	R1000	56 31.11N	009 18.08W	1012		
223	19950905 0213Z	N700	56 38.66N	009 06.66W	685		
224	19950905 0317Z	N1000	56 40.32N	009 11.61W	1011		
225	19950905 0833	N1500	56 42.72N	009 25.72W	1475		
226	19950906 0109Z	S1500	56 27.51N	009 38.98W	1520		
227	19950906 0506Z	P1000	56 36.08N	009 17.34W	999		
228	19950906 2334Z	N140	56 36.30N	008 55.79W	134		
229	19950907 0013Z	N200	56 37.21N	009 00.58W	218		
230	19950907 0215Z	N300	56 37.58N	009 01.57W	325		
231	19950907 0250Z	N500	56 38.06N	009 04.34W	510		

CH121C CTD CASTS		EG+G Mk IIIB instrument no. IMCT1117					
Cast	**Date&time**	**Station**	**Latitude**	**Longitude**	**Depth**	**Comments**	
232	19950907 0400Z	P150	56 33.62N	009 00.17W	157	P140?	
233	19950907 0433Z	P300	56 34.14N	009 03.78W	303		
234	19950907 0511Z	P200	56 33.85N	009 01.95W	206		
235	19950907 1304Z	P500	56 34.55N	009 06.70W	500		

APPENDIX C
DRIFTER TRACK
(D MELDRUM)



57
56.9
56.8
56.7
56.6
56.5
56.4
Lat N
-10.6
-10.4
-10.2
-10.0
-9.8
-9.6
-9.4
-9.2
-9.0
Lon W
0912
0911
0910
0909
0908
0913
0914
0907
0906
0915
0916
0905
0917
0904
Buoy 24283

CRUISE REPORT
CHALLENGER 121/SES 3B
18TH AUGUST TO 1ST SEPTEMBER 1995
MALLAIG - MALLAIG

by

T J SHERWIN
Chief Scientist

PROJECT: UCES 121
UCES REPORT: U95-7 SEPTEMBER 1995

UNIT FOR COASTAL AND ESTUARINE STUDIES
UNIVERSITY OF WALES, BANGOR
MARINE SCIENCE LABORATORIES
MENAI BRIDGE
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1. INTRODUCTION AND OBJECTIVES

The SES 3B cruise was a two week process study within the four week *RRS Challenger* cruise 121. The weeks either side of SES 3B, which involved supporting mooring deployments, are described elsewhere. The work was mainly conducted at the shelf break, west of Tiree, although it also involved an excursion along the break from 55° N to 58° N.

As part of the LOIS/SES community project, the cruise had these specific scientific objectives:

i) to make measurements of internal waves, to support the moored instruments, at neap and spring tides. This involved deploying and recovering a lightweight moored buoy with attached thermistor chain and current meter at specific sites; imaging the surface signature of the waves from ship's radar and photographs; where appropriate, yo-yoing a CTD and profiling the currents with the ship's ADCP near the internal wave buoy.

ii) to make dissipation and turbulence measurements near the head of the shelf using a profiling dissipation sensor, the FLY probe.

iii) to make observations of the slope current between 58° N and 54.5° N using a combination of CTD dips, XBT casts and the ship's ADCP.

iv) to repeat the intensive study of biological parameters in the SES box (between 56° 44' N and 56° 47.6' N) made during SES 2 in May 1995.

In addition there were two other objectives

v) to support and protect (as far as possible) the moored instruments. This objective was implicit, given the importance of the instruments to the process study, but circumstances forced it to take greater prominence than had been originally intended.

vi) to conduct a collaborative exercise with the *Colonel Templar* which was working for DRA in the same region.

This report contains a description of the activities of the ship, and summarizes the initial impressions of the scientists involved whose names are given in Table 1.

2. CRUISE DIARY

A brief summary of the chronology of the cruise activities is given in Table 2. A summary of the cruise track and CTD stations are given in Figs 1 to 3 and CTD, bottle and FLY probe details are contained in Tables 3 to 10. Note that all times in the diary are in BST.

Friday 18 Aug (Day 1) - CTD casts 31 to 32

Challenger left Mallaig at 1600 h in calm hot weather. Overnight a CTD transect was worked westward from Tiree to the shelf break along an extension of the S line, latitude 56° 27' N, at 15' intervals. The purpose of this line was to help get the cruise under way and to provide background information on the structure of the shelf physics in support of SES.

Saturday 19 Aug (Day 2) - CTD casts 33 to 86

The weather was very calm all day and the inshore extension of the S line was completed at 0700 h. The ship then moved to a position about 1 mile south of S140 and deployed the lightweight internal wave mooring at Sta FS1, and at 1000 h a programme of yo-yoing the CTD at 15 minute intervals was started to examine the evolution of the vertical structure of the water column over a tidal cycle. Occasional bottle casts were conducted to calibrate oxygen and determine nutrient concentrations. Internal wave packets were encountered at 1400 h and between 1900 and 2100 h.

During this time the FLY profiler was being prepared for use. However, a problem was encountered with the motor for the winch which had to be replaced with a spare and this involved machining a new plate. Also the nutrient analyser did not work initally, although this problem was fixed by the start of the following day.

Sunday 20 Aug (Day 3) - CTD casts 87 to 119

The weather remained calm during the main part of the day, but wind speeds started to increase in the evening. The yo-yo station was continued overnight, and was interrupted to deploy an *in situ* primary productivity experiment attached to the internal waves mooring. The experiment started later than intended (at 0545 h) because of the presence of an internal wave train at dawn (0500 h) which made it difficult to choose the right depths for the incubation samples. The yo-yo station was abandoned at 0850 h when it was noticed on the ship's radar that the toriod at S300 had disappeared after it had been passed by the French fishing vessel, *Izoard.* When questioned, the skipper denied all knowledge of it and so the toriod was replaced with a spar buoy to protect the subsurface mooring. At 1500 h a fine resolution CTD transect was commenced over the shelf break along the S line with a spatial interval of 0.6' longitude from a depth of 140 m out to 500 m (the FRS line). Nutrient samples were taken near the sea bed and at 10 m intervals across the thermocline. Standard S line stations were then occupied between S500 and S1100. The fine resolution line had been commenced in the expectation that the FLY probe would be ready at about 1800 h. In the event it was not available until the next day. At 2100 h the line was interrupted for an hour whilst the productivity experiment was successfully recovered from the internal wave buoy.

Monday 21 Aug (Day 4) - CTD casts 120 to 127

The fine resolution line continued overnight, and was extended with a few conventional S line stations between S500 and S1100. During this time the wind freshened to about force 5 from the SW. FLY probe profiles started mid-morning with a series of runs into the wind, at about 1 hourly intervals, along 220 deg between S140 and FS1. There was a problem with the line puller which was only circumvented by hand feeding the line from the winch. This seemed to work fairly satisfactorily. At about 2000 h a train of internal waves were observed propagating onto the shelf under the ship and the line was extended in order to conduct a full investigation of turbulence and mixing by the waves. Profiling continued for the rest of the day.

Tuesday 22 Aug (Day 5) - CTD casts 128 to 131

At midnight a new profiling section was started, running westwards from about 150 m over the shelf break to a depth of between 250 and 320 m with each line lasting about 2 h in duration. (By now the wind had dropped to about Force 2). Profiling ended at about 1230 h, and was followed by a test of the line puller, which appeared to function satisfactorily. Overall, the survey appeared to show little turbulence above the shelf break, but increased turbulence below about 100 m in the deeper water. This enhancement coincided with an almost uniform vertical temperature profile.

After the profiling had ended, an oxygen profile was taken near S200 and the internal wave mooring was then recovered. Although the S4 current meter had performed satisfactorily until about 2030 h on Monday, the tape in the thermistor chain logger had fouled and no data were recovered. The ship then proceeded northwards to latitude 58° N to start the slope current survey, stopping to make nutrient measurements in the SES box at R300 and N700.

Wednesday 23 Aug (Day 6) - CTD casts 132 to 144

The slope current experiment (nicknamed the Mexican Wave by the bridge) started at Sta. SC1 at 0240 h. For the first 24 h it consisted of a series of relatively sparse CTD profiles along a zig-zag over the slope which were supplemented by a much higher density of XBT casts. Under a misunderstanding the PSO removed most of the CTD bottles from the rosette sampler, but this decision was recinded once it was realised that the biologists were interested in these nutrient data. In the evening one of the CTD bottles started leaking, which meant that we then had only eleven servicable bottles on board. Three legs of the Mexican wave were completed by 0140 h when the SES box was started at Sta. N1500. The wind began picking up in the evening.

Thursday 24 Aug (Day 7) - CTD casts 145 to 156

This day was marked by strong SW to W winds (force 6 to 7) which gradually built up a swell. Although conditions were a little difficult, the rate of progress was satisfactory and the N line of the SES box was completed by 1800 h. However, after this conditions were too rough for the CTD and the ship hove to for 24 h. At 1840 h the radar serving the WAVEX imaging software broke down irretrivably - this meant that it would not be possible to record the internal waves surface signature during the spring tide observation programme.

Friday 25 Aug (Day 8) - CTD casts 157 to 161

Overnight winds were westerly force 7, gusting force 8, and *Challenger* remained hoved to most of the day while swell was high. After due consultation, it was decided to abandon lines P and R because of the time lost. The S line was started at 1800 h, but at 2040 h a cross swell forced a further delay of about three hours. In all over 24 h were lost to bad weather at this time.

Saturday 26 Aug (Day 9) - CTD casts 162 to 175

Two more hours were lost in the morning whilst a kink was removed from the CTD wire which was then reterminated. The S line was eventually completed by 1530 h by which time it had taken two and a half days to complete just lines N and S. Primary productivity measurements along the S line were particularily badly represented since most of the stations there were conducted at night. The Mexican wave restarted to the south of the SES box at Sta. SC14 at 1700 h.

Sunday 27 Aug (Day 10) - CTD casts 176 to 180

The slope current experiment was continued as far as Sta. SC24 at 55° 25' N in 250 m at midday. After that the northerly swell generated by a force 5 to 6 wind was too great for the CTD and the rest of the day was spent deploying XBTs in the vicinity of the shelf edge as the ship worked its way back to the SES box.

Monday 28 Aug (Day 11) - CTD casts 181 to 184

After conducting a CTD cast at S700 for a primary productivity measurement, it was noticed that further moorings had disappeared. In all, the toroid at S700 and the new spar buoy S300 and the U mooring at S200 were missing, although the single point moorings at the two deeper sites were still there. Earlier, the surface marker at N700 had failed to appear on the radar. The internal wave mooring was re-deployed at Sta. FS1 and at 1120 h a dissipation line was started running westward over the shelf break, with occasional CTD casts at about S300. During a break of about four hours to fix a fault in the FLY probe, the opportunity was taken to conduct a CTD at S500 in further support of primary productivity. The dissipation line was subsequently worked during the night, although individual sections sometimes took over four hours to complete, as the ship worked against an (apparently) strong eastward current. This current seemed to be uniform through the water current and have a speed of about 1 knot.

Tuesday 29 Aug (Day 12) - CTD casts 185 to 190

We continued FLY profiling over the shelf break until 1300 h. The work then changed to performing six profiles northward from S200 along the 200 m contour, before returning to the start of the line to do a CTD cast. Nutrient samples were taken at the same time. In general there was very low turbidity in the water column and the pronounced nepheloid layers observed in May were not present. By now the wind had moderated significantly, and there was an increase in fluoresence in the surface mixed layer (about 20 m deep) compared with values a few days earlier. At 2000 h *Challenger* was joined by the *Colonel Templar* (working for DRA) which proceeded to run a transect along the 200 m contour for about 4 miles to the north and south of S200 towing a 160 m thermistor chain.

Wednesday 30 Aug (Day 13) - CTD casts 191 to 199

The calm weather persisted and dissipation measurements continued along the 200 m contour until 1300 h, when the position was changed to the 140 m contour. Initally we searched a little to the east of S140 in the hope that we might encounter a wave train that had just passed through but, being out of luck, we quickly returned to the line between S140 and the internal wave mooring, originally worked on neap tides. In the shallower water it was possible to conduct 10 profiles per line with CTD casts again about every two hours at S140. Throughout the rest of the day there was very little evidence of internal wave activity on the shelf. At 1930 h *Challenger* was visited by Dr John Scott from the *Colonel Templar* who brought with him plots from his thermistor chain data. These revealed a big variation in the depth of the isotherms over a tidal cycle at the top of the slope, as the thermocline dropped from about 20 m depth on the flood to sometimes as much as 80 m on the ebb.

Thursday 31 Aug (Day 14) - CTD casts 200 to 203

Profiling along the 140 m contour continued during the night. At about 0400 h a train of internal waves were observed on the ship's radar passing under the ship. Profiling stopped at 1200 h when the internal wave mooring and the U-mooring at S140 were recovered. This time data from both the thermistor chain and the S4 appeared to be good. During the last two hours that the ship was in the area an unsuccessful attempt was made to grapple for the U-mooring lost at S200 earlier on in the cruise. *Challenger* returned for Mallaig at 1800 h, reaching there the following morning.

3. SCIENTIFIC ACHIEVEMENTS

A full assessment of the scientific achievements of the cruise will only become apparent once the data have been analysed in conjunction with the mooring and other data. An initial assessment by the scientists involved is given below and summarized here.

Quite large internal solitary waves (with a vertical excursion of up to 25 m) were observed at both spring and neap tides, and despite several equipment failures and the fact that we had to curtail our neap tide observations, we expect to be able to learn much about their nature. The dissipation measurements revealed that turbulence near the shelf break is generally much smaller and variable than in shelf seas, and is not limited to boundary mixing.

The slope current was quite clearly present in the CTD sections and at the top of the slope there was a correlation between the salinity maximum and oxygen minimum, although further investigation is required since the latter seemed to be beneath the former. In general this region also showed lower transmission values.

Biological activity appears to have been fairly low at the beginning of the cruise, with low respiration rates, a nutrient depleted surface layer, and a chlorophyll maximum in the thermocline which was sometimes related to a salinity minimum. After a near gale in the middle of the cruise there appears to have been an increase in respiration in surface waters which was accompanied by an increase in surface nutrients and chlorophyll. The impression at the time was that we had witnessed a late summer event linked to the breakdown of the thermocline.

3.1 Oceanographic overview

The first transect, which was across the shelf set, the eastern context of the shelf break region. The Scottish coastal current, which flows around Tiree, extended to about 7° 48' W. To the west, seabed salinities were of order 35.3, but of note was a salinity <u>minimum</u> of about 35.1 at about 25m depth near the shelf break. This minimum continued to be seen in the S line salinity profiles near the shelf break before the mid-cruise gale. The thermocline near the shelf break was well established at about 25 m, although it was more diffuse in the coastal current. Fluorescence peaked beneath the mixed layer and in general transmissometer levels where smallest in mid water (about 4.3).

Three sections were worked over the shelf break, on part of the S line and the N line before the gale and on the S line after the gale (Figs 4 to 6). The slope current shows clearly as a salinity maximum at a depth of between 200 and 400 m. On the N line there appear to be two separate peaks at 200 m and 400 m respectively. There also appears to be an oxygen minimum at the lower of these two depths which possibly correlates with a minimum in transmission levels at that depth. The mixed layer and thermocline of the surface waters overlies a region of fairly uniform density down to 1000 m, although both temperature and salinity are layered at these depths. The ocean bed has fresher, (< 35.0), colder (< 5 °C) water than that higher up. On the S line the isopycnal surfaces sloped down towards the shelf break, apparently in response to the slope current. This was not apparent on the N line and it will be interesting to find out whether this difference is due to the internal tide or a transient eddy, for example, or is a more permanent feature of the region. The deep waters of the Rockall Trough revealed low fluorescence values beneath the higher values of the upper 60 - 70 m.

The AVHRR images mailed to Challenger during the cruise were of value, but only for the negative reason that they failed to reveal a surface signature of the slope current. One image from 18 August at 0335 GMT shows the boundary of the cool Scottish coastal current quite clearly, but north of Donegal and western Ireland the isotherms run approximately north east, from 18° C west of Ireland to about 15° C off the Hebrides, and do not appear to interact with the shelf break.

3.2 Shelf break current experiment (The Mexican Wave) (by A. Souza)

The transect ADCP software problem from the first leg, was fixed by the time we started the experiment. A 5 minute sampling interval strategy was adopted and the reference velocity was alternate from bottom tracking to navigation as we left the shelf.

The Hydrographic survey covered six lines plus the N and S line from the SES box. Each line consisted of 5 CTD casts plus a series of XBTs, with an additional XBT line along the 700m isobath. A total of 24 CTD casts and a 104 XBTs were made for this purpose. It appears from preliminary plots, made onboard, that the strategy has been successful in detecting the temperature signal of the shelf break current.

3.3 Internal wave measurements (by M.E. Inall)

Objectives of physical programme

The main objective of the physical aspect of the cruise was to measure the internal wave field near the shelf break on short time scales O(minutes), during both spring and neap tides. To achieve this fast sampling rates were set on the S line moorings. A light weight mooring with a near surface current meter (5 m) and a 76 m long thermistor chain was deployed for two periods of 3 days duration. An X-band radar image capture system was also employed on the ship. The current meter and thermistor chain sampled every 2 minutes. A radar image was captured every 15 minutes. The ship's hull mounted ADCP, a good instrument for observing internal waves, was set to record with an emsemble average of 2.5 minutes and a bin depth of 8 m. Complementary observations of turbulent dissipation are described elsewhere in this report.

Observations and initial analysis

Data from the S line moorings have not yet been retreived. Data from the light weight mooring have been recovered. The thermistor logger failed on the first deployment. Radar images were captured during the neap tide deployment, but not during the spring tide deployment due to radar faliure. The ADCP functioned continuously during both experiments.

Much high frequency internal wave activity associated with the internal tide was observed at S140. Thermocline excursions of up to 25 m were observed between CTD upcasts and downcasts. Surface slicks were observed visually and by radar with length scales O(200 m), propagating onshore at approximately 50 cm s^{-1}. The slicks appear to be the surface signature of solitary internal waves. The packets of the solitary internal waves at S140 appear phase locked with the barotropic tide. The timing of the waves seems to fit with the conceptual model of an internal lee wave formed by the ebb tide propagating onshore as the ebb tide decreases. Figure 7 shows U and V from 5 m on the light weight mooring during neap tides. What appear to be solitary internal waves can be seen as the sharp peaks in U and V, suggesting the waves to be propagating in a south easterly direction. It is interesting to note that the solitary internal wave signature in the 5 m current meter record appears no stronger at spring tides than at neap tides.

3.4 Measurement of turbulent energy dissipation (by T.P. Rippeth)

The instrument we employed to make measurements of turbulence dissipation was the Osborne-Crawford free fall probe (FLY). The method for measurement of dissipation is to allow the probe to fall freely (although it remains loosely connected to the ship via a Kevlar cable) at it's terminal fall speed (about 80 cm s^{-1}). Two sensors, which measure along sensor pressure differences 268 times per second, are mounted at the front of the probe and the measurements they make are converted to velocity shears on scales down to 1.5 cm. As yet this technology does not exist in Europe and so it was therefore necessary to hire in a FLY probe and the technical support of Chris MacKay (Sy-Tech Research). It took several days to get the system up and running because of quite a serious problem - the electric motor to be used to drive the hydraulics was found to have been damaged in transit. Luckily a spare had been brought, which although not specifically designed to fit the available mounting, was modified by Dave Boon and served well throughout the cruise. This prevented use of the FLY during the first few days of the cruise. The need to allow the probe to fall freely means that it is usually necessary to use a line puller fitted to the back of the ship to pull the line out of the winch and fire it over the back. For the neaps measurement set the line puller was not functioning properly and therefore could not be used. It is clear that during this set of measurements the cable became taught at times. As yet it is not possible to estimate how much of the data were corrupted in this way. The line puller was in operation by the second set of FLY measurements so this is not a problem in the second data set. A serious problem (the FLY power pack burning out!) occurred at the beginning of the springs observation programme. At this time there was a strong feeling that was it as far as the fly measurements went. However this did not deter Chris MacKay who succeeded in getting the system up and running within about 4 hours. We then went on to use the FLY more or less continuously for the following 3 days!

The measurements were made in two blocks, a day of measurements at the beginning of the cruise (around neap tides) and 3 days of measurement at the end of the cruise (spring tides). Because of the way the instrument is deployed it is necessary that the ship move forward at approx. 1 knot relative to the water. During the cruise we adopted two strategies for data collection. (1) To steam off shelf, from water depth 140m to 300m (the maximum operating depth of the FLY) continuously profiling, and to steam along the shelf (following either the 140m or 200m contour), for approx. 2 hours, continuously profiling. In each case series of data lasted between 12.5 and 25 hours and were complimented by the shipborne ADCP and 2 hourly CTD dips. At neaps we profiled off shelf and along the 140m contour and at springs, off shelf, 140m contour and 200m contour. In all 388 profiles of turbulent dissipation were made constituting some 160 Mbytes of data! Examination of data and turbulent energy spectra are encouraging in that the data show a wide range of dissipation and the spectra fit the Kolmogorov spectral shape. Interesting results that have already become apparent are that at times there is high energy dissipation in the pcynocline (possibly related to internal waves), the formation of a bottom boundary during the tidal cycle is apparent and it is possible that some of the dissipation levels measured are below those measurable by the probe.

3.5 Chlorophyll Distributions (by K. Jones)

Vertical profiles of chlorophyll fluorescence were obtained on every CTD deployment. Near-surface chlorophyll distributions were monitored continuously in the non-toxic seawater supply to a rapidly flushing deck tank during the cruise. A short interruption in logging the deck-tank fluorometer ocurred early in the cruise due to a computer system fault, but otherwise all instrumentation performed satisfactorily. Water samples were taken from 2 or 3 depths within the upper 60m on each CTD dip and at intervals (6-10 samples per day) from the deck tank and filtered for determination of chlorophyll to calibrate the fluorometers. Samples were stored frozen and will be analysed after the cruise at DML.

Preliminary examination of CTD fluorescence profiles indicate that a mid-water chlorophyll maximum occurred early in the cruise at about 20-30m. Occasionally this maximum corresponded with a salinity minimum region, the source of which is yet to be determined. Highest fluorescence values were observed seaward of the shelf break in the region of the 700m contour. Stormy weather during the mid-cruise period appeared to redistribute the chlorophyll maximum more evenly through the surface layer and may have stimulated some additional phytoplankton growth.

Observations of fluorescence distributions during yo-yo casts at the shelf break suggest that alteration in the fluorecence distribution with depth may have followed thermocline displacement due to passage of internal waves.

Preserved Phytoplankton Samples

Phytoplankton samples were taken from within the upper 100m at selected stations within the SES area (see Table 9) and additionally from water used for experimental process measurements.

Dissolved Organic Carbon, Nitrogen and Phosphorus
Water samples were collected from standard depths at selected stations within the SES box. Samples were filtered immediately after collection and stored for later analysis ashore. DOC/DON measurements will be carried out at PML and DOP/DON measurements at DML.

Dissolved iodine concentrations and iodine reduction potential
Evidence exists that iodine in seawater may be reduced either to iodide or organic iodine by dissolved organic compounds such as the extracellular products of algal cells. The reduction potential may be determined by measuring the conversion to iodide of a known quantity of iodine, added to the sample. This measured potential might therefore provide, indirectly, information about dissolved organic carbon distributions.

Water samples were collected during the cruise to determine the iodine reduction potential in a range of hydrographic regimes (shelf, shelf break and oceanic) and, in particular, determine the correlation between these measurements and phytoplankton and dissolved organics distributions also determined during this cruise. Samples were taken to determine vertical profiles of iodine reduction potential at selected stations within the SES box and inner shelf region. Samples will be analysed at Oxford Brookes University.

3.6 Nutrient determinations (by B.E. Grantham)

Nutrient measurements were carried out on samples from 94 stations from the shelf and shelf edge area. The main transects surveyed were the N and S lines of the SES box and a zig-zag traverse along the Shelf Edge. Two time series were carried out at stations S200 and S140. Analyses were made for ammonium, phosphate, silicate and nitrate plus nitrite.

A cursory look at the results indicated a surface layer 15 - 20m deep depleted of nutrients with a marked nutricline from 30 to 60 metres below which, with the exception of ammonium, concentrations increased more slowly with depth. Ammonium concentrations were low at all depths but at some stations there was evidence of an ammonium maximum around 30 to 60 metres indicative of strong biological activity at the depth of the nutricline.

There was no opportunity on this cruise to sample the water below 1500m because of a depth restriction on the CTD. This was most unfortunate as an important aspect of this work is the estimation of the transfer of nutrients from the deep waters onto the shelf. For this, measurements are required on a seasonal basis of the nutrient concentrations at depths down to 2300 m. The lack of data from this cruise has thus created a break in the seasonal time series started in May on cruise CD93.

During the cruise inter-calibration samples were run as part of the LOIS Chemical Harmonisation programme.

The Milli-Q deionised water supply worked well but there was considerable concern over the amount of ships water it was taking. The problem lies with the reverse osmosis (RO) unit which takes water directly from the ship's supply, purifies it and stores it in a tank. The cut-off valve which controlled the water input only worked intermittently and as a result there were many occasions when the water supply continued to run even when the tank was full or the RO unit had stopped because of low inlet pressure.

3.7 Primary production and size-fractionated Chlorophyll (by L.C. Gilpin)

The object of this work was to determine the species composition, size distribution and photosynthetic characteristics of the phytoplankton assemblages located throughout the LOIS SES working area during the period of the cruise; assumed to represent late summer conditions. Stations were sampled across the survey area to provide spatial coverage of the on shelf, shelf break and oceanic regions.

The photosynthetic characteristics of the planktonic assemblages were determined from a photosynthesis versus irradiance (P:I) curve produced following sample inoculation with ^{14}C sodium bicarbonate and incubation in a range of irradiances (1.5 - 1500 $\mu E\ m^{-2}\ s^{-1}$) using a photosynthetron. Following the incubation, any remaining ^{14}C was displaced using acidification and agitation and incorporation of ^{14}C in the particulate component will be measured using a scintillation counter back in the lab. Two time series P:I studies were carried out; a 20 litre sample was incubated on deck and subsamples collected for P:I, chlorophyll concentration, plankton taxonomy and nutrient concentration measurements.

Primary production in the euphotic zone was determined at two stations using 24hr incubations. Water samples were collected from a predawn CTD cast at 10 depths selected to represent 97, 55, 33, 20, 14, 7, 5, 3, 2 and 1% surface incident irradiance. Triplicate 60 ml samples and one dark bottle from each depth were inoculated with ^{14}C bicarbonate in subdued light and suspended in the water column at the depth from which they were collected, using an *in situ* production rig deployed at dawn and retrieved at dusk. The bottles were stored in the dark for the remainder of the incubation period. This procedure was carried out at station FS1. Incubations were also carried out in an on deck incubator used to simulate the *in situ* light level and spectral quality at each of the sample depths. Following incubation, samples were fractionated under minimal vacuum using 18, 2 and 0.2 µm polycarbonate membrane filters and the particulate incorporation of labelled bicarbonate in each size-fraction will be measured using a scintillation counter. The resulting profiles of carbon uptake per day will be used to determine depth integrated primary production over the euphotic zone at each station.

Size-fractionated chlorophyll measurements were made for each water sample collected during the cruise. Samples were size-fractionated using 18, 2 and 0.2 µm membrane filters and the chlorophyll concentration determined fluorometrically following acetone extraction.

Duplicate plankton samples from each station were preserved in 50ml amber bottles using Lugols iodine and Glutaraldehyde solutions.

3.8 Calibration of oxygen sensor and water column respiration measurements
(by H. Wilson)

The objectives of this cruise were two fold:
1. To calibrate the CTD-mounted dissolved oxygen polarographic sensor.
2. To estimate microplankton respiration in the water column.

Calibration of the oxygen sensor
The oxygen sensor which had previously been calibrated in May during the SES 2 cruise (CD93A and B) was not connected to the tone-fire system on the CTD. As a consequence, the system had to be interrupted prior to firing rosette bottles. This interruption depolarizes the oxygen sensor membrane, which needs approximately 15 minutes to re-polarize. This caused a considerable amount of histeresis, and presented some problems for calibration, as well as some doubts in the reliability of the data obtained. The problem was partly overcome by combining downcast and upcast data. Water density (as sigma-t) from the upcast at points where bottles were fired and

samples taken for micro-Winkler titrations were used as a marker to track down the same water packet during the downcast. Once this had been done, values for oxygen sensor current and oxygen sensor temperature were used from the downcast data. This was relatively successful for depths greater than 200 m (Fig. 8). Large errors appeared for water depths less than 200 m, most likely due to the great spiking in salinity values around the thermocline. It will thus be assumed that the calibration from > 200 m can be applied to more shallow waters.

It is also stressed that for the oxygen sensor to produce 'sensible' results for surface waters, the sensor must be flushed by taking the CTD to approximately 50m, taken back up to just below the surface before being cast in the usual manner. This is not satisfactory and will need further investigation.

Estimation of respiration rates in the water column

Estimates of microplankton (organisms <200μm) and bacterial respiration were obtained with 24 hour dark incubations at *in situ* temperature. They were almost undetectable at the beginning of the cruise, but following 2 days of strong wind, the thermocline was less marked and there was some small breakdown in stratification, possibly entraining nutrients in the surface water. An increase in surface water fluorescence up to the surface was seemingly accompanied by an increase in respiration rates at the stations sampled following this change (see Table 11).

3.9 Characterisation and fluxes of suspended particulate matter (SPM)

(by S.E. Jones)

The primary task for the cruise involved collection and filtering of water samples for calibration of the CTD-mounted optical beam transmissometer in terms of total SPM concentration. Rosette water bottle samples of between 4.0 and 9.0 l were filtered through washed and pre-weighed Whatman GF/C filters, which were then rinsed in 50 ml distilled water and air-dried before freezing. A total of 101 samples were filtered during the cruise, from a range of locations and at various depths. For a given suspended particle composition there is a linear relationship between optical beam attenuation and SPM concentration. As part of the post-cruise analysis the effect of depth/time varying composition (e.g. due to phytoplankton) on the calibration will be investigated. The calibration constants will also be applied to the moored transmissometers.

A secondary objective was to determine the distribution of suspended particle equivalent spherical diameter (ESD) at various depths and locations within the SES study area. ESD is an important control of settling rate and surface area, and its determination allows characterisation of sub-populations of particles from different sources. A Galai C1S100 particle analyser was used to measure the size distribution of samples freshly withdrawn from the Rosette water bottle sampler. This instrument determines ESD from the time of interception of an oscillating laser beam with individual suspended particles. It also features a videomicroscope which allows visual monitoring of the particles under analysis (and later image analysis for 2-D size and shape characterisation). Unfortunately problems developed with the instrument which prevented analysis for several days during the cruise. At other times sampling was possible but measurement was restricted to a size range of 2-600 microns (the 0.5-150 micron alternative would have been more appropriate). A total of 22 samples were successfully analysed during the cruise, from surface and midwater chlorophyll maxima, and from close to the sea-bed. Two video tapes were also recorded.

Preliminary findings

From both the raw CTD profiles and inspection of filters, it was clear that SPM concentrations were very low throughout the cruise at all depths. While a distinct nepheloid layer was observed near the bed at some of the deeper sites, it was much less pronounced or extensive than had been observed in May. At and just below the surface mixed layer, concentrations were increased due to phytoplankton, and transmissometer records closely matched those of the fluorometer.

Particle ESD was generally very small (concentrated in the 2-50 micron range), both near the bed and in the upper part of the water column. Much larger particles were observed in May during and after the spring diatom bloom. Again in contrast to the May observations, there was no evidence of flocculation in the nepheloid layers. At the start of the cruise the 2-5 micron fraction appeared to be dominant in the mid-water chlorophyll maximum. By the end of the cruise, after a period of wind-mixing and subsequent increased primary production in the mixed surface layer, the dominant size fraction had increased to 5-10 microns. This indicates a change in population from microflagellates to dinoflagellates, and is supported by direct videomicroscope observations.

Issues

Even if the instrument had worked throughout the cruise, it would not have been possible to maintain a 24 hour sampling programme of particle size determination.

This was because of heavy commitment of almost all personnel to support the intensive physical sampling programme (CTD/XBT and FLY profiling) and routine calibration sampling (nutrients, chlorophyll, SPM concentration). This problem also prevented any determinations of particle settling rate (each of which requires 10 hours of sampling and filtering), which were initially planned, and which were performed successfully during the May cruise on Darwin. During May there were two SPM personnel aboard, but most importantly the CTD was operated and deployed solely by RVS staff, freeing up scientific personnel (who were only required to perform one routine watch per day). Given that we have *Challenger* for the remainder of the SES cruises, the implications of limitation of personnel dedicated to biological and SPM sampling should be considered carefully.

4. FAILURES AND DELAYS

By and large it was a successful cruise. The programme was not over-ambitious in the sense that had everything happened without incident then it would have been completed. However, and inevitably, there were failures and delays due to bad weather, and each part of the programme suffered as a result. Delays in getting the FLY probe working resulted in only half the planned dissipation measurements being made on neap tides, although they were supplemented with the CTD yo-yo station. Bad weather and time lost in support of the moorings cost about a day and a half, which was mainly lost by the SES box and slope current measurements. The spring tide dissipation and internal wave work at the end of the cruise had to be cut short to permit the recovery of the U-mooring at S140 to help leg C.

The biggest disappointment was probably in the loss of so much moored equipment - five surface markers in all seemed to have disappeared, although the proportion of instruments surviving seems to have been greater since some sub-surface moorings had survived. Also the CTD was unable to profile to the required 2300 m and a failure in the tone fire system made it difficult to calibrate the oxygen sensor. The breakdown of the auxiliary radar affected the digital capture of internal wave images during spring tides.

5. PSO'S PERSPECTIVE

SES 3B was a multi-disciplinary cruise with an emphasis on physical process studies. Inevitably such a cruise has to be tightly programmed, and one of the main tasks of the PSO is to try and ensure an equitable share of time and resources to all participants. In so doing he must be aware of the overall objectives of LOIS/SES and the specific objectives of the cruise. I ask forbearance of any group which may feel that, despite my best efforts, I failed them.

Following the procedure adopted during SES 2, an *ad hoc* group was formed which met every evening at 5 p.m. to discuss the day's events and plan for the next 24 h. The group comprised watch leaders and representatives of the different interests on the cruise; TS (PSO, internal waves), KJ (biology), SJ (suspended matter), AS (slope current) and TR (dissipation probe). Captain Robin Plumley was a useful addition. The group provided a valuable forum and ensured that as many scientists as possible could participate in, and keep up to date with, the ship's plans. As a physicist I found it particularly valuable to have Ken Jones on board to represent the biological interest.

From the point of view of the wider organisation, it would have helped had there been a stronger biological presence at the pre-planning meetings and had there been a clear directive from the SES committee of the relative priorities of the different activities, particularly between the biological and physical components. (The existing document is of a general nature rather than being cruise specific). This would have helped in responding to any surprises that individuals, equipment or the weather sprung on us during the cruise, as indeed happened.

6. Acknowledgements

Robin Plumley and the crew of *Challenger* gave us excellent assistance during the cruise. Dave Boon, Gareth Knight and Robin Powell were also invaluable for their general technical support, and I should also like to thank John Hughes from BODC who, by being official bookkeeper, took one of the chores of a PSO on his shoulders. *Challenger* is a fairly small vessel for this kind of work, but she coped well, although the biologists in particular could have done with an extra pair of hands. Finally, I would like to thank the rest of the scientific team for providing me with relatively few problems during the cruise.

Table 1

List of participants

University of Wales, Bangor

Name	Activity	Watch
Dave Boon	Dissipation winch, moorings, instrumentation	0400 - 0800 h
Harikrishnan	Slope current	0800 - 1200 h
Mark Inall	Internal waves	0000 - 0400 h
Sarah Jones	SPM calibration	0800 - 1200 h
Tom Rippeth	Dissipation probe data processing	0400 - 0800 h
Toby Sherwin	PSO, internal waves	0800 - 1200 h
Alex Souza	Slope current, SPM calibration	0000 - 0400 h
Hilary Wilson	Oxygen calibration	0400 - 0800 h

Dunstaffnage Marine Laboratory:

Brian Grantham	Nutrients	n/a
Ken Jones	Biology overview	0000 - 0400 h

Queens University, Belfast:

Linda Gilpin	Primary productivity	n/a

RVS Barry:

Gareth Knight	Computer support	n/a
Robin Powell	Instrumentation	0000 - 0400 h

BODC:

John Hughes	Data archive	0400 - 0800 h

Sy-Tech Res., B.C., Canada:

Chris MacKay	Dissipation probe	0800 - 1200 h

Table 2

Timetable of events, agreed by Captain and PSO

Date	Time (BST)	Event
18/08/85	1600	Clear of Fish Quay, Mallaig, no pilot taken.
	1612	Clear of approach channel.
	2230	Commence CTD line W of Tiree.
19/08/95	0703	Complete CTD line.
	0849-0900	Internal wave buoy deployed for tidal cycle work, neaps.
	0953	Commence 30 h yo-yo CTD deployments.
20/08/95	0640-0648	Deploy productivity rig on internal wave buoy.
	0850	Cease yo-yo CTD's.
	0850-1423	Investigating loss of S300 toroid mooring.
	1423-1451	Deploy marker spar buoy at S300.
		Position: 56° 27.3' N, 9° 03°.89' W, depth 300 m.
	1501-2044	FRS CTD section.
	2120-2129	Productivity rig recovered.
	2205-	
21/08/95	0048	Complete FRS CTD section.
	0124-0733	S Line CTD section.
	0855-	
22/08/95	1257	FLY dissipation probe in vicinity of FS1 and S140.
	1307-1328	CTD at FS1.
	1501	Internal wave buoy recovered.
	1551-1626	CTD at R300.
	1726-1814	CTD at N700. Proceed to start of slope current study.
23/08/95	0246	Commence northern section slope current study, CTD & XBT stations.
24/08/95	0137	Complete northern section slope current study.
	0304	Commence SES box fast sampling survey.
	1824	Vessel hove to due to rough sea and heavy swell conditions.
25/08/95	1806	Resume science.
	2042-2342	Postpone CTD deployments due to cross swell conditions.
26/08/95	1520	Complete SES box stations.
	1700	Resume slope current study stations.
27/08/95	1223	Cease CTD's due to swell conditions. Continue XBT's only.
	1511	Proceed towards S700.
28/08/95	0710-0831	CTD at S700.
	0845-0953	Check moorings at S700, S300, S200 & S140.
	1033	Deploy internal wave buoy at FS1.
	1118	Commence FLY probe profiling with CTD casts, springs.
31/08/95	1155	FLY Probe recovered.
	1323-1330	Recover internal wave buoy.
	1413-1517	Recover U-shaped mooring at S140.
	1700-1806	Attempt dragging U-mooring at S200.
	1812	Removal of boxes from scientific hold and proceed to Mallaig.

Table 3
Shelf CTD line (Tiree to S140)

START DATE & TIME		BODC ID	LAT (degN)	LON (degE)	WATER DEPTH m	SITE NAME
18/08/95 21:35	CTD	CP31	56.4508	-7.3365	85.5	S1
18/08/95 22:50	CTD	CP32	56.4529	-7.5035	134.5	S2
19/08/95 00:14	CTD	CP33	56.4520	-7.7458	155.8	S3
19/08/95 01:33	CTD	CP34	56.4499	-7.9995	169.5	S4
19/08/95 02:55	CTD	CP35	56.4504	-8.2504	156.0	S5
19/08/95 04:21	CTD	CP36	56.4487	-8.5000	143.7	S6
19/08/95 05:45	CTD	CP37	56.4501	-8.7502	144.7	S7

Table 4
Summary of sampling stations at yoyo site FS1

START DATE & TIME		BODC ID	LAT (degN)	LON (degE)	WATER DEPTH m	No. Bots
19/08/95 08:55	CTD	CP38	56.4358	-8.9736	145.2	6
19/08/95 11:36	CTD	CP46	56.4356	-8.9719	145.9	6
19/08/95 13:30	CTD	CP51	56.4359	-8.9694	144.0	6
19/08/95 15:33	CTD	CP57	56.4344	-8.9698	144.7	2
19/08/95 17:27	CTD	CP63	56.4329	-8.9699	145.2	4
19/08/95 19:30	CTD	CP73	56.4325	-8.9740	145.0	4
19/08/95 23:16	CTD	CP85	56.4356	-8.9774	146.2	6
20/08/95 01:15	CTD	CP92	56.4371	-8.9721	145.3	6
20/08/95 03:30	CTD	CP100	56.4355	-8.9698	144.7	7
20/08/95 04:33	CTD	CP103	56.4344	-8.9681	143.9	7
20/08/95 05:00	CTD	CP104	56.4340	-8.9682	143.7	4
20/08/95 06:30	CTD	CP107	56.4331	-8.9681	144.1	3

Table 5
Fine Resolution S-line stations

START DATE & TIME		BODC ID	LAT (degN)	LON (degE)	WATER DEPTH m	SITE NAME
20/08/95 15:27	CTD	CP112	56.4669	-9.0093	154.8	FRS1
20/08/95 16:29	CTD	CP113	56.4668	-9.0196	159.2	FRS2
20/08/95 17:29	CTD	CP114	56.4669	-9.0303	169.2	FRS3
20/08/95 18:19	CTD	CP115	56.4669	-9.0401	192.0	FRS4
20/08/95 19:16	CTD	CP116	56.4668	-9.0503	233.2	FRS5
20/08/95 21:05	CTD	CP117	56.4668	-9.0602	297.7	FRS6
20/08/95 22:02	CTD	CP118	56.4672	-9.0700	365.8	FRS7
20/08/95 23:05	CTD	CP119	56.4668	-9.0797	430.6	FRS8
21/08/95 00:24	CTD	CP120	56.4670	-9.0929	461.9	S500
21/08/95 02:00	CTD	CP121	56.4670	-9.1574	673.3	S700
21/08/95 03:33	CTD	CP122	56.4655	-9.2138	828.6	S850
21/08/95 05:00	CTD	CP124	56.4650	-9.2911	982.4	S1000

Table 6
Slope Current ('Mexican Wave') survey

START DATE & TIME		BODC ID	LAT (degN)	LON (degE)	WATER DEPTH m	SITE NAME
23/08/95 01:40	CTD	CP132	57.9998	-8.9973	170.5	SC1
23/08/95 02:44	XBT	XBT1	57.9716	-9.0950	181.5	
23/08/95 03:25	CTD	CP133	57.9422	-9.1994	199.4	SC2
23/08/95 04:45	XBT	XBT2	57.9085	-9.3018	225.6	
23/08/95 05:25	CTD	CP134	57.8839	-9.3973	267.8	SC3
23/08/95 07:12	CTD	CP135	57.8186	-9.6025	485.4	SC4
23/08/95 08:19	XBT	XBT11	57.7987	-9.6604	609.7	
23/08/95 08:24	XBT	XBT12	57.7936	-9.6753	711.6	
23/08/95 08:34	XBT	XBT13	57.7836	-9.7042	811.1	
23/08/95 08:41	XBT	XBT14	57.7761	-9.7253	890.5	
23/08/95 08:47	XBT	XBT15	57.7702	-9.7428	980.5	
23/08/95 08:52	XBT	XBT16	57.7652	-9.7573	1111.6	
23/08/95 09:13	CTD	CP136	57.7506	-9.8132	1281.7	SC5
23/08/95 11:05	XBT	XBT17	57.7137	-9.7542	1076.1	
23/08/95 11:10	XBT	XBT18	57.7022	-9.7418	1002.4	
23/08/95 11:20	XBT	XBT19	57.6793	-9.7141	899.1	
23/08/95 11:37	CTD	CP137	57.6520	-9.6793	807.0	SC6
23/08/95 12:46	XBT	XBT20	57.6245	-9.6389	704.3	
23/08/95 13:20	XBT	XBT21	57.5544	-9.5545	508.8	
23/08/95 13:30	CTD	CP138	57.5515	-9.5513	504.1	SC7
23/08/95 14:28	XBT	XBT22	57.5134	-9.5024	408.7	
23/08/95 14:44	XBT	XBT23	57.4782	-9.4630	345.4	
23/08/95 15:02	XBT	XBT24	57.4438	-9.4250	288.9	
23/08/95 15:07	CTD	CP139	57.4434	-9.4238	286.0	SC8
23/08/95 15:49	XBT	XBT25	57.4138	-9.3746	230.2	
23/08/95 16:07	XBT	XBT26	57.3719	-9.3249	201.2	
23/08/95 16:28	CTD	CP140	57.3333	-9.2969	190.9	SC9
23/08/95 16:58	XBT	XBT27	57.3099	-9.3068	204.4	
23/08/95 17:04	XBT	XBT28	57.2968	-9.3163	220.8	
23/08/95 17:12	XBT	XBT29	57.2789	-9.3319	259.8	
23/08/95 17:19	XBT	XBT30	57.2631	-9.3469	311.6	
23/08/95 17:30	XBT	XBT31	57.2376	-9.3663	413.5	
23/08/95 17:43	CTD	CP141	57.2210	-9.3817	544.2	SC10
23/08/95 18:30	XBT	XBT32	57.1841	-9.4038	776.8	
23/08/95 18:35	XBT	XBT33	57.1733	-9.4169	954.1	
23/08/95 19:13	CTD	CP142	57.1040	-9.4839	1692.2	SC11
23/08/95 19:58	XBT	XBT34	57.1044	-9.4854	1694.2	
23/08/95 21:16	CTD	CP143	56.9833	-9.5725	1843.7	SC12
23/08/95 23:21	CTD	CP144	56.8641	-9.6667	1835.6	SC13
24/08/95 07:11	XBT	XBT35	56.6829	-9.2329	1098.3	
24/08/95 13:14	XBT	XBT36	56.6274	-9.0458	391.3	
26/08/95 16:00	CTD	CP170	56.2590	-9.4516	1257.6	SC14
26/08/95 17:32	XBT	XBT37	56.2018	-9.3498	944.4	
26/08/95 17:49	XBT	XBT38	56.1639	-9.3068	859.7	
26/08/95 17:56	CTD	CP171	56.1659	-9.3001	835.7	SC15
26/08/95 19:00	XBT	XBT39	56.1369	-9.2433	517.0	
26/08/95 19:04	XBT	XBT40	56.1280	-9.2309	395.8	

Table 6 (cont)

START DATE & TIME			BODC ID	LAT (degN)	LON (degE)	WATER DEPTH m	SITE NAME
26/08/95	19:13	XBT	XBT41	56.1079	-9.2035	228.4	
26/08/95	19:38	CTD	CP172	56.0692	-9.1508	198.7	SC16
26/08/95	20:21	XBT	XBT42	56.0368	-9.0919	164.1	
26/08/95	20:36	XBT	XBT43	56.0077	-9.0432	154.1	
26/08/95	20:57	CTD	CP173	55.9798	-8.9894	144.6	SC17
26/08/95	21:36	XBT	XBT44	55.9495	-8.9368	138.4	
26/08/95	21:53	XBT	XBT45	55.9155	-8.8846	135.4	
26/08/95	22:14	CTD	CP174	55.8865	-8.8371	132.6	SC18
26/08/95	23:18	XBT	XBT46	55.8652	-8.9255	134.0	
26/08/95	23:38	XBT	XBT47	55.8446	-8.9973	138.9	
26/08/95	23:54	CTD	CP175	55.8367	-9.0387	141.9	SC19
27/08/95	00:41	XBT	XBT48	55.8240	-9.0860	146.6	
27/08/95	01:03	XBT	XBT49	55.8060	-9.1431	154.7	
27/08/95	01:29	XBT	XBT50	55.7880	-9.2090	127.9	
27/08/95	01:49	CTD	CP176	55.7832	-9.2485	138.9	SC20
27/08/95	02:33	XBT	XBT51	55.7750	-9.2832	163.7	
27/08/95	02:37	XBT	XBT52	55.7728	-9.2935	174.6	
27/08/95	02:48	XBT	XBT53	55.7667	-9.3206	243.7	
27/08/95	02:54	XBT	XBT54	55.7637	-9.3354	315.2	
27/08/95	02:59	XBT	XBT55	55.7618	-9.3484	373.2	
27/08/95	03:03	XBT	XBT56	55.7604	-9.3592	428.8	
27/08/95	03:08	XBT	XBT57	55.7588	-9.3715	518.1	
27/08/95	03:15	XBT	XBT58	55.7563	-9.3894	581.0	
27/08/95	03:36	XBT	XBT59	55.7479	-9.4409	686.9	
27/08/95	03:50	CTD	CP177	55.7476	-9.4648	808.2	SC21
27/08/95	05:09	XBT	XBT60	55.7328	-9.5123	966.0	
27/08/95	05:22	XBT	XBT61	55.7204	-9.5511	1088.9	
27/08/95	06:04	CTD	CP178	55.6814	-9.6689	1605.0	SC22
27/08/95	08:13	CTD	CP179	55.5494	-9.6993	1172.7	SC23
27/08/95	09:56	XBT	XBT62	55.5297	-9.7014	1084.9	
27/08/95	10:05	XBT	XBT63	55.5061	-9.7016	977.7	
27/08/95	10:10	XBT	XBT64	55.4930	-9.7034	732.6	
27/08/95	10:15	XBT	XBT65	55.4802	-9.7053	483.5	
27/08/95	10:19	XBT	XBT66	55.4726	-9.7071	416.1	
27/08/95	10:29	XBT	XBT67	55.4565	-9.7095	331.0	
27/08/95	10:42	XBT	XBT68	55.4343	-9.7128	266.0	
27/08/95	10:57	CTD	CP180	55.4170	-9.7236	241.2	SC24
27/08/95	12:00	XBT	XBT69	55.4037	-9.7327	226.3	
27/08/95	12:10	XBT	XBT70	55.3770	-9.7337	201.1	
27/08/95	12:20	XBT	XBT71	55.3483	-9.7352	186.0	
27/08/95	12:59	XBT	XBT72	55.2896	-9.7556	166.8	
27/08/95	13:10	XBT	XBT73	55.2758	-9.7597	156.2	
27/08/95	13:21	XBT	XBT74	55.2552	-9.7593	139.3	
27/08/95	13:37	XBT	XBT75	55.2267	-9.7602	122.2	
27/08/95	13:57	XBT	XBT76	55.1932	-9.7675	117.0	
27/08/95	14:13	XBT	XBT77	55.1695	-9.7716	121.0	
27/08/95	14:37	XBT	XBT78	55.1868	-9.7924	122.5	
27/08/95	15:01	XBT	XBT79	55.2024	-9.8110	129.5	

Table 6 (cont)

START DATE & TIME		BODC ID	LAT (degN)	LON (degE)	WATER DEPTH m	SITE NAME
27/08/95 15:17	XBT	XBT80	55.2137	-9.8241	141.8	
27/08/95 15:30	XBT	XBT81	55.2229	-9.8346	153.2	
27/08/95 15:57	XBT	XBT82	55.2408	-9.8528	170.9	
27/08/95 17:26	XBT	XBT83	55.3301	-9.8336	222.0	
27/08/95 17:58	XBT	XBT84	55.3946	-9.7764	248.7	
27/08/95 18:28	XBT	XBT85	55.3817	-9.6830	189.8	
27/08/95 19:02	XBT	XBT86	55.4459	-9.6084	228.8	
27/08/95 19:32	XBT	XBT87	55.4972	-9.5342	272.0	
27/08/95 20:01	XBT	XBT88	55.5487	-9.5011	321.5	
27/08/95 20:30	XBT	XBT89	55.6008	-9.4684	394.7	
27/08/95 21:01	XBT	XBT90	55.6559	-9.4369	520.6	
27/08/95 21:11	XBT	XBT91	55.6740	-9.4271	544.9	
27/08/95 22:18	XBT	XBT92	55.7936	-9.3747	580.5	
27/08/95 22:31	XBT	XBT93	55.8144	-9.3696	545.6	
27/08/95 22:59	XBT	XBT94	55.8589	-9.3555	605.7	
27/08/95 23:21	XBT	XBT95	55.8942	-9.3430	649.9	
27/08/95 23:43	XBT	XBT96	55.9300	-9.3287	653.6	
27/08/95 23:57	XBT	XBT97	55.9530	-9.3192	635.9	
28/08/95 00:10	XBT	XBT98	55.9744	-9.3113	640.1	
28/08/95 00:38	XBT	XBT99	56.0185	-9.2963	681.9	
28/08/95 01:00	XBT	XBT100	56.0533	-9.2876	680.3	
28/08/95 01:20	XBT	XBT101	56.0825	-9.2790	686.5	
28/08/95 01:42	XBT	XBT102	56.1145	-9.2683	637.4	
28/08/95 02:02	XBT	XBT103	56.1443	-9.2571	631.6	
28/08/95 02:20	XBT	XBT104	56.1718	-9.2466	613.2	
28/08/95 02:40	XBT	XBT105	56.2031	-9.2370	652.1	
28/08/95 02:56	XBT	XBT106	56.2269	-9.2294	658.9	
28/08/95 03:30	XBT	XBT107	56.2769	-9.2143	599.9	
28/08/95 03:58	XBT	XBT108	56.3194	-9.2004	741.2	
28/08/95 04:28	XBT	XBT109	56.3651	-9.1851	679.7	
28/08/95 04:58	XBT	XBT110	56.4108	-9.1739	767.9	
28/08/95 05:29	XBT	XBT111	56.4436	-9.1705	736.7	

Table 7
SES core survey lines (S&N)

START DATE & TIME		BODC ID	LAT (degN)	LON (degE)	WATER DEPTH m	SITE NAME
24/08/95 02:05	CTD	CP145	56.7347	-9.4014	1508.5	N1500
24/08/95 03:55	CTD	CP146	56.7335	-9.3983	1501.2	N1500
24/08/95 04:58	CTD	CP147	56.7004	-9.3210	1287.0	N1300
24/08/95 06:34	CTD	CP148	56.7003	-9.3270	1296.0	N1300
24/08/95 07:36	CTD	CP149	56.6698	-9.1909	982.2	N1000
24/08/95 09:02	CTD	CP150	56.6554	-9.1476	820.1	N850
24/08/95 10:48	CTD	CP151	56.6439	-9.1124	693.5	N700
24/08/95 12:09	CTD	CP152	56.6324	-9.0713	490.5	N500
24/08/95 13:30	CTD	CP153	56.6257	-9.0266	322.1	N300
24/08/95 14:41	CTD	CP154	56.6186	-9.0083	209.7	N200
24/08/95 15:53	CTD	CP155	56.6142	-8.9843	154.0	N150
24/08/95 16:45	CTD	CP156	56.6044	-8.9309	137.1	N140
25/08/95 17:06	CTD	CP157	56.4490	-8.9755	147.5	S140
25/08/95 17:59	CTD	CP158	56.4600	-9.0266	165.2	S160
25/08/95 18:52	CTD	CP159	56.4585	-9.0464	206.1	S200
25/08/95 22:25	CTD	CP160	56.4620	-9.0627	302.2	S300
25/08/95 23:39	CTD	CP161	56.4595	-9.1021	502.6	S500
26/08/95 01:08	CTD	CP162	56.4617	-9.1334	601.3	S600
26/08/95 02:25	CTD	CP163	56.4655	-9.1572	675.3	S700
26/08/95 04:00	CTD	CP164	56.4600	-9.2130	816.8	S850
26/08/95 05:36	CTD	CP165	56.4602	-9.2988	994.7	S1000
26/08/95 09:16	CTD	CP166	56.4573	-9.4013	1142.0	S1150
26/08/95 10:50	CTD	CP167	56.4581	-9.5212	1300.7	S1300
26/08/95 12:32	CTD	CP168	56.4569	-9.6618	1523.0	S1500
26/08/95 14:06	CTD	CP169	56.4602	-9.6508	1515.7	S1500

Table 8
CTD stations conducted at the end of FLY probe lines

START DATE & TIME	BODC ID		LAT (degN)	LON (degE)	WATER DEPTH m	SITE NAME
FLY run along the 140 m contour (neaps):						
21/08/95 14:59	CTD	CP126	56.4552	-8.9535	146.3	
21/08/95 20:43	CTD	CP127	56.4130	-9.0196	148.7	
FLY run over the shelf edge (neaps):						
22/08/95 05:04	CTD	CP128	56.4333	-9.0737	276.3	
22/08/95 12:01	CTD	CP129	56.4353	-9.0605	220.5	
FLY run over the shelf edge (springs):						
28/08/95 13:01	CTD	CP182	56.4348	-9.0868	372.7	
28/08/95 23:16	CTD	CP184	56.4313	-9.1004	446.0	
29/08/95 02:09	CTD	CP185	56.4359	-9.0944	424.4	
29/08/95 04:16	CTD	CP186	56.4373	-9.0761	324.2	S300
FLY run along the 200 m contour (springs):						
29/08/95 12:07	CTD	CP187	56.4572	-9.0501	217.8	S200
29/08/95 19:24	CTD	CP188	56.4598	-9.0449	201.0	S200
29/08/95 22:22	CTD	CP189	56.4600	-9.0432	194.5	S200
30/08/95 00:16	CTD	CP190	56.4587	-9.0439	194.8	S200
30/08/95 02:54	CTD	CP191	56.4601	-9.0497	221.9	S200
30/08/95 05:18	CTD	CP192	56.4610	-9.0448	203.4	S200
30/08/95 07:42	CTD	CP193	56.4605	-9.0434	197.1	S200
30/08/95 09:46	CTD	CP194	56.4601	-9.0442	199.3	S200
30/08/95 12:00	CTD	CP195	56.4595	-9.0433	193.2	S200
30/08/95 14:06	CTD	CP196	56.4578	-9.0433	190.5	S200
FLY run along the 140 m contour (springs):						
30/08/95 17:20	CTD	CP197	56.4484	-8.9732	145.7	S140
to						
31/08/95 09:41	CTD	CP203	56.4501	-8.9731		S140

Table 9
Summary of chemical and biological sampling at selected CTD stations

START DATE & TIME			BODC ID	LAT degN	LON degE	WATER DEPTH m	SITE NAME	IRP	DOC DON	DON DOP	PHY	POC PON	PPD	OXY RES	P:I
18/08/95	21:35	CTD	CP31	56.4508	-7.3365	85.5	S1	*							
19/08/95	00:14	CTD	CP33	56.4520	-7.7458	155.8	S3	*							
19/08/95	13:30	CTD	CP51	56.4359	-8.9694	144.0	FS1								*
19/08/95	15:33	CTD	CP57	56.4344	-8.9698	144.7	FS1							*	
20/08/95	04:33	CTD	CP103	56.4344	-8.9681	143.9	FS1						*		
20/08/95	05:00	CTD	CP104	56.4340	-8.9682	143.7	FS1						*		
20/08/95	14:02	CTD	CP111	56.4515	-9.0629	276.1	S300	*	*						
22/08/95	14:48	CTD	CP130	56.5066	-9.0597	303.0	R300							*	*
22/08/95	16:27	CTD	CP131	56.6445	-9.1115	693.6	N700		*						*
23/08/95	13:30	CTD	CP138	57.5515	-9.5513	504.1	SC7								
24/08/95	02:05	CTD	CP145	56.7347	-9.4014	1508.5	N1500		*	*	*	*			
24/08/95	03:55	CTD	CP146	56.7335	-9.3983	1501.2	N1500							*	
24/08/95	04:58	CTD	CP147	56.7004	-9.3210	1287.0	N1300							*	
24/08/95	07:36	CTD	CP149	56.6698	-9.1909	982.2	N1000								*
25/08/95	17:06	CTD	CP157	56.4490	-8.9755	147.5	S140								*
25/08/95	17:59	CTD	CP158	56.4600	-9.0266	165.2	S160	*	*	*		*			
25/08/95	22:25	CTD	CP160	56.4620	-9.0627	302.2	S300	*	*	*	*				
25/08/95	23:39	CTD	CP161	56.4595	-9.1021	502.6	S500	*	*						
26/08/95	02:25	CTD	CP163	56.4655	-9.1572	675.3	S700	*	*	*					
26/08/95	05:36	CTD	CP165	56.4602	-9.2988	994.7	S1000	*	*	*					
26/08/95	09:16	CTD	CP166	56.4573	-9.4013	1142.0	S1150								*
26/08/95	10:50	CTD	CP167	56.4581	-9.5212	1300.7	S1300								*
26/08/95	12:32	CTD	CP168	56.4569	-9.6618	1523.0	S1500							*	
26/08/95	14:06	CTD	CP169	56.4602	-9.6508	1515.7	S1500								*
27/08/95	08:13	CTD	CP179	55.5494	-9.6993	1172.7	SC23								*

Table 9 (cont)

START DATE & TIME		BODC ID	LAT degN	LON degE	WATER DEPTH m	SITE NAME	IRP	DOC DON	DON DOP	PHY	POC PON	PPD	OXY RES	P:I
28/08/95 06:12	CTD	CP181	56.4660	-9.1630	697.8	S700							*	*
28/08/95 13:01	CTD	CP182	56.4348	-9.0868	372.7									*
28/08/95 15:10	CTD	CP183	56.4608	-9.0932	477.7	S500								*
29/08/95 04:16	CTD	CP186	56.4373	-9.0761	324.2	S300						*		
29/08/95 12:07	CTD	CP187	56.4572	-9.0501	217.8	S200								*
30/08/95 09:46	CTD	CP194	56.4601	-9.0442	199.3	S200							*	*
30/08/95 12:00	CTD	CP195	56.4595	-9.0433	193.2	S200	*	*						
31/08/95 07:17	CTD	CP202	56.4504	-8.9740	147.1	S140								*

IRP : Iodine reduction potential
DOC/DON : Dissolved Organic Carbon/Nitrogen (for PML)
DON/DOP : Dissolved Organic Nitrogen/Phosphorus (for DML)
PHY : Phytoplankton determinations
POC/PON : Particulate Organic Carbon/Nitrogen
PPD : Primary Production
OXYRES : Oxygen respiration
P:I : Photosynthesis versus Irradiance

Table 10
Summary of FLY probe deployments

START DATE & TIME		BODC ID	LAT (degN)	LON (degE)	COMMENTS
21/08/95 09:15	FLY	FLY001	56.4572	-8.9513	4 drops
21/08/95 10:21	FLY	FLY002	56.4556	-8.9559	10 drops
21/08/95 11:56	FLY	FLY003	56.4565	-8.9553	10 drops (2-11 to 3-09)
21/08/95 13:29	FLY	FLY004	56.4551	-8.9555	10 drops (4-10 missing)
21/08/95 15:35	FLY	FLY005	56.4571	-8.9553	13 drops
21/08/95 17:12	FLY	FLY006	56.4555	-8.9558	11 drops
21/08/95 18:49	FLY	FLY007	56.4388	-8.9804	15 drops (7-05 missing)
21/08/95 21:49	FLY	FLY008	56.4535	-8.9615	10 drops
21/08/95 23:14	FLY	FLY009	56.4345	-9.0045	20 drops
22/08/95 02:40	FLY	FLY010	56.4335	-9.0326	14 drops
22/08/95 06:36	FLY	FLY011	56.4330	-9.0341	13 drops
22/08/95 09:06	FLY	FLY012	56.4333	-9.0343	13 drops
22/08/95 11:27	FLY	FLY013	56.4358	-9.0753	2 drops
28/08/95 10:20	FLY	FLY015	56.4335	-9.0004	16 drops
28/08/95 19:02	FLY	FLY016	56.4330	-9.0139	24 drops
29/08/95 00:22	FLY	FLY017	56.4332	-9.0284	9 drops
29/08/95 03:23	FLY	FLY017B	56.4337	-9.0625	3 drops (17-10 to 17-12)
29/08/95 05:08	FLY	FLY018	56.4327	-9.0271	21 drops
29/08/95 09:43	FLY	FLY019	56.4324	-9.0494	9 drops
29/08/95 13:03	FLY	FLY020	56.4612	-9.0462	5 drops
29/08/95 14:30	FLY	FLY021	56.4738	-9.0411	2 drops
29/08/95 15:22	FLY	FLY022	56.4617	-9.0442	6 drops
29/08/95 17:34	FLY	FLY023	56.4620	-9.0428	6 drops
29/08/95 20:46	FLY	FLY024	56.4612	-9.0434	6 drops
29/08/95 22:46	FLY	FLY025	56.4596	-9.0432	6 drops
30/08/95 01:00	FLY	FLY026	56.4605	-9.0457	6 drops
30/08/95 03:35	FLY	FLY026B	56.4604	-9.0455	6 drops
30/08/95 05:58	FLY	FLY027	56.4616	-9.0432	5 drops
30/08/95 08:11	FLY	FLY028	56.4611	-9.0446	6 drops
30/08/95 10:17	FLY	FLY029	56.4605	-9.045	6 drops
30/08/95 12:32	FLY	FLY030	56.4607	-9.044	6 drops
30/08/95 15:17	FLY	FLY031	56.4478	-8.9352	9 drops
30/08/95 17:50	FLY	FLY032	56.4491	-8.9741	10 drops
30/08/95 20:26	FLY	FLY033	56.4494	-8.9741	10 drops
30/08/95 22:33	FLY	FLY034	56.4500	-8.9751	10 drops
31/08/95 00:12	FLY	FLY035	56.4494	-8.9759	10 drops
31/08/95 02:31	FLY	FLY036	56.4488	-8.9752	10 drops
31/08/95 04:59	FLY	FLY037	56.4498	-8.9732	10 drops
31/08/95 07:48	FLY	FLY038	56.4497	-8.9749	10 drops
31/08/95 10:05	FLY	FLY039	56.4498	-8.9739	6 drops

Table 11
Respiration Summary SES3

SUMMARY OF RESPIRATION MEASUREMENTS - SES 3 CH121B

Date	Station	Cast	Depth (m)	Microplankton respiration (µM/d)	SE	Bacterial respiration (µM/d)	SE
19/8/95	S140	57	30	0.369	0.533	0.132	0.106
			100	ND		ND	
22/8/95	R300	130	70	ND		0.658	0.451
			30	ND		1.14	0.989
24/8/95	N1500	146	40	ND		0.911	0.278
24/8/95	N1300	147	1270	ND		0.463	0.543
26/8/95	S1500	168	1529	ND		ND	
			30	0.343	0.166	0.772	0.104
28/8/95	S700	181	60	1.344	0.865	0.522	0.232
			30	0.29	0.183	ND	
30/8/95	S200	194	5	1.359	0.205	1.216	0.602

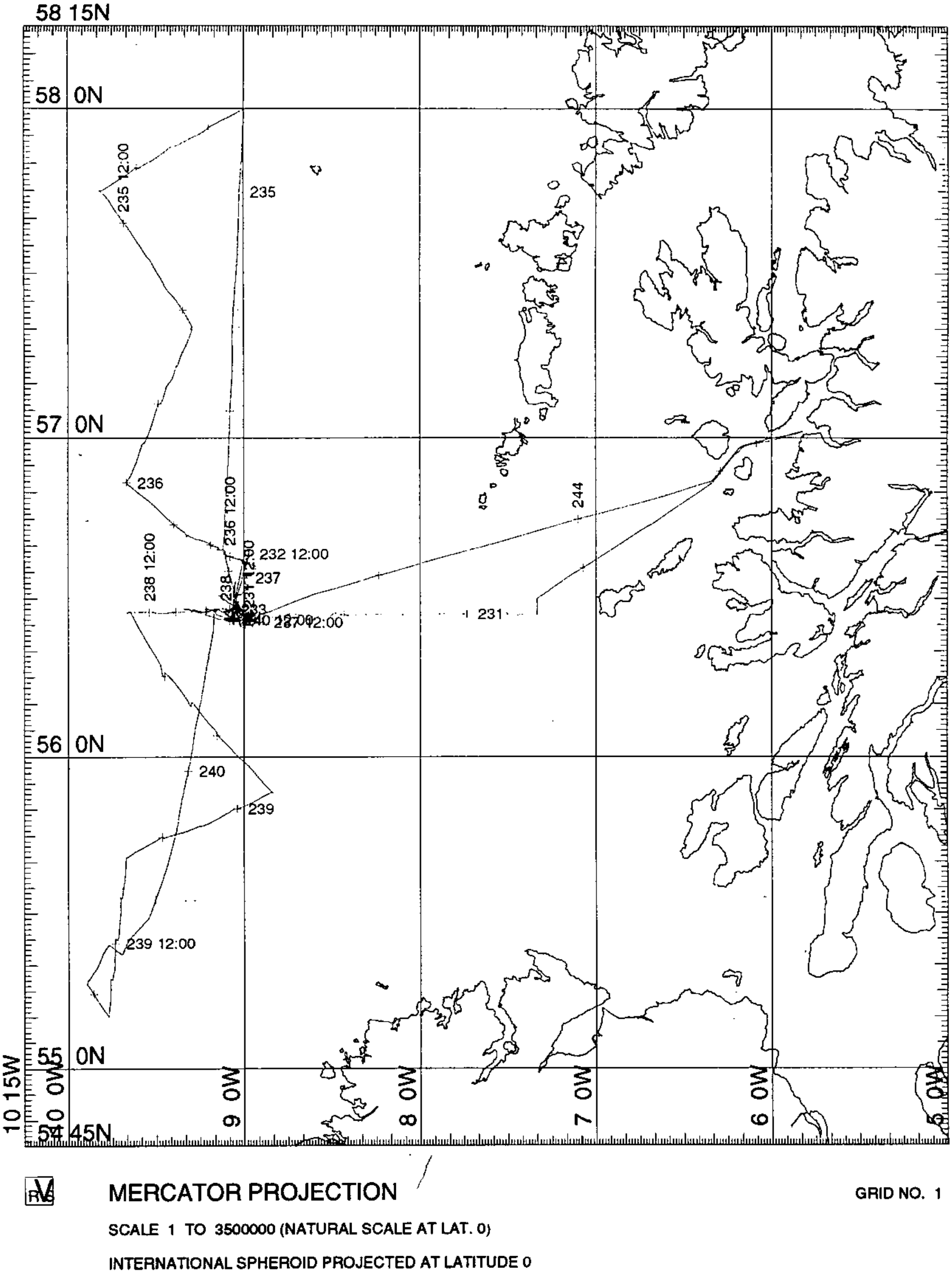

Figure 1. Cruise Track.

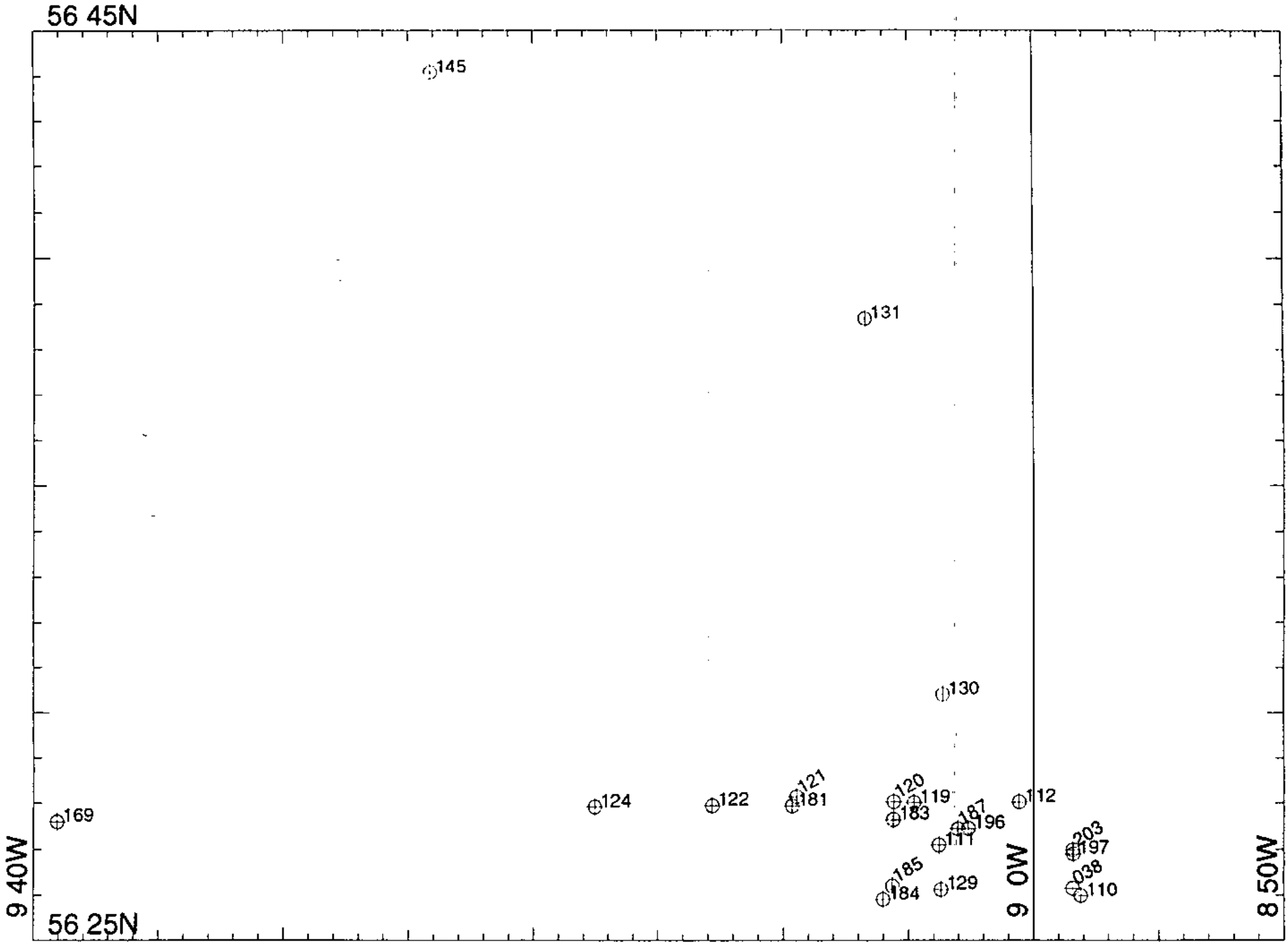

Figure 2. CTD station positions near the SES box.

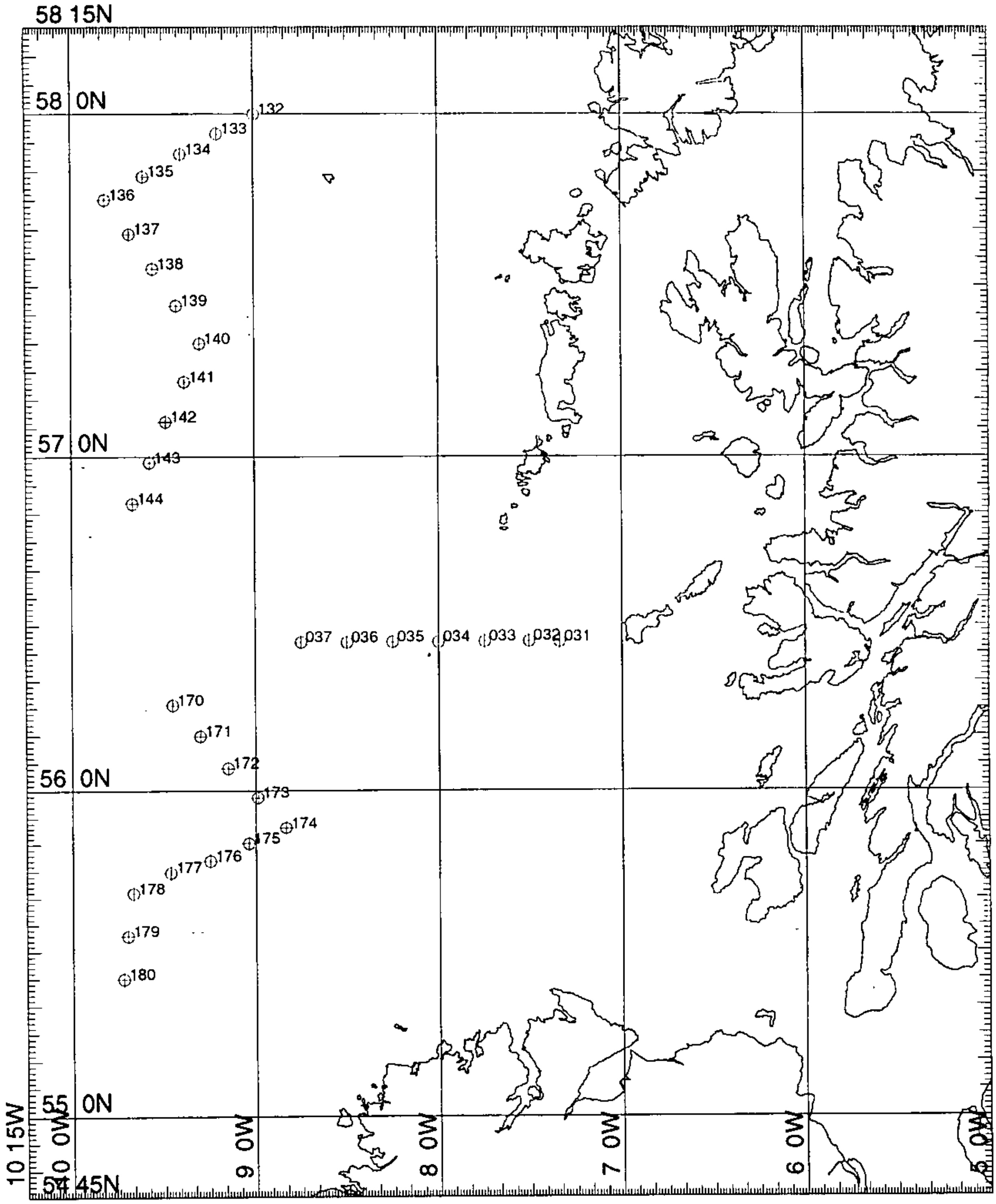

Figure 3. CTD station positions outside the SES box.

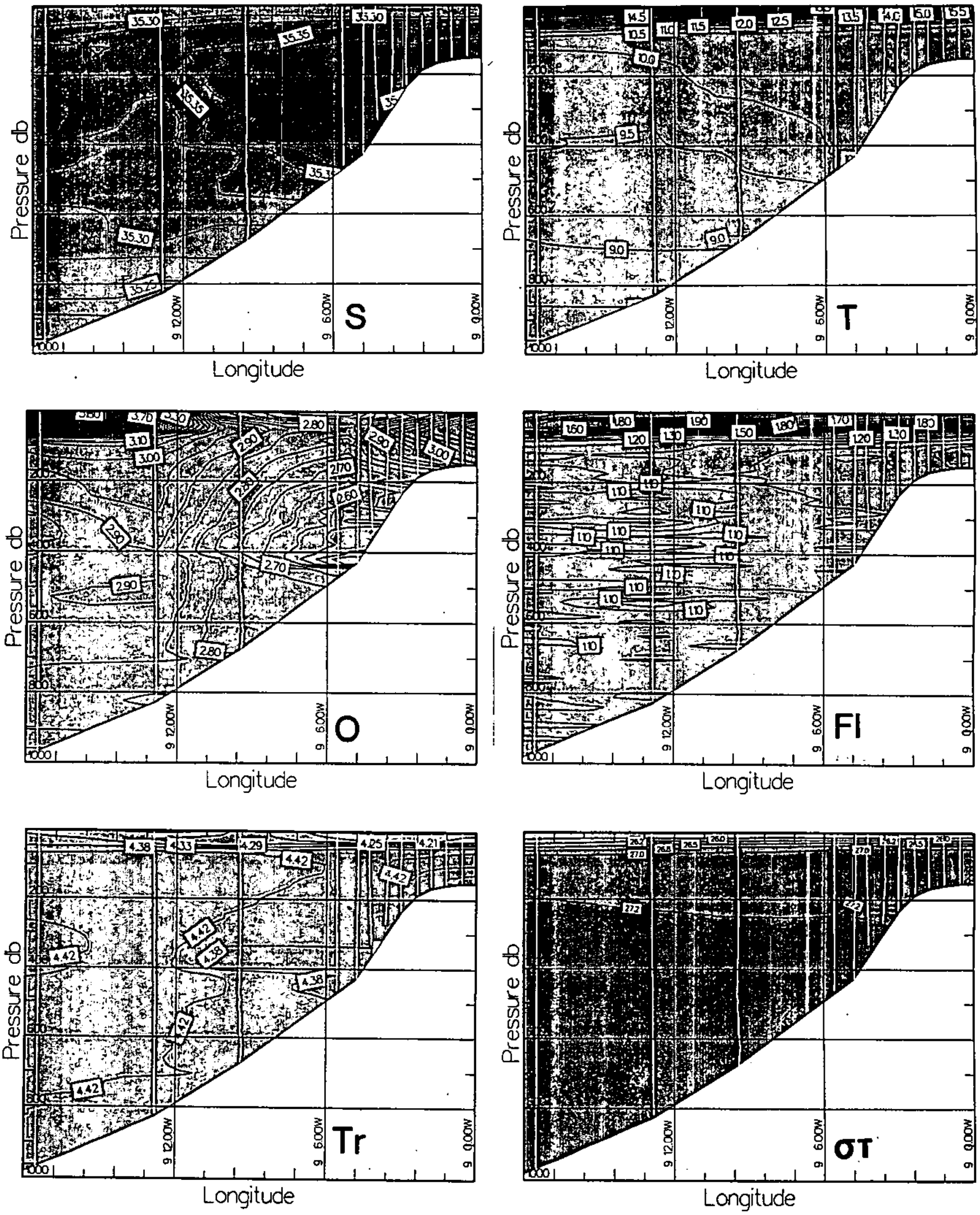

Figure 4. Sections of salinity (S), Temperature (T), Oxygen (O), Fluorescence (FL), Transmission (Tr) and Density Anomaly (σt). All values are nominal. S line 20th August.

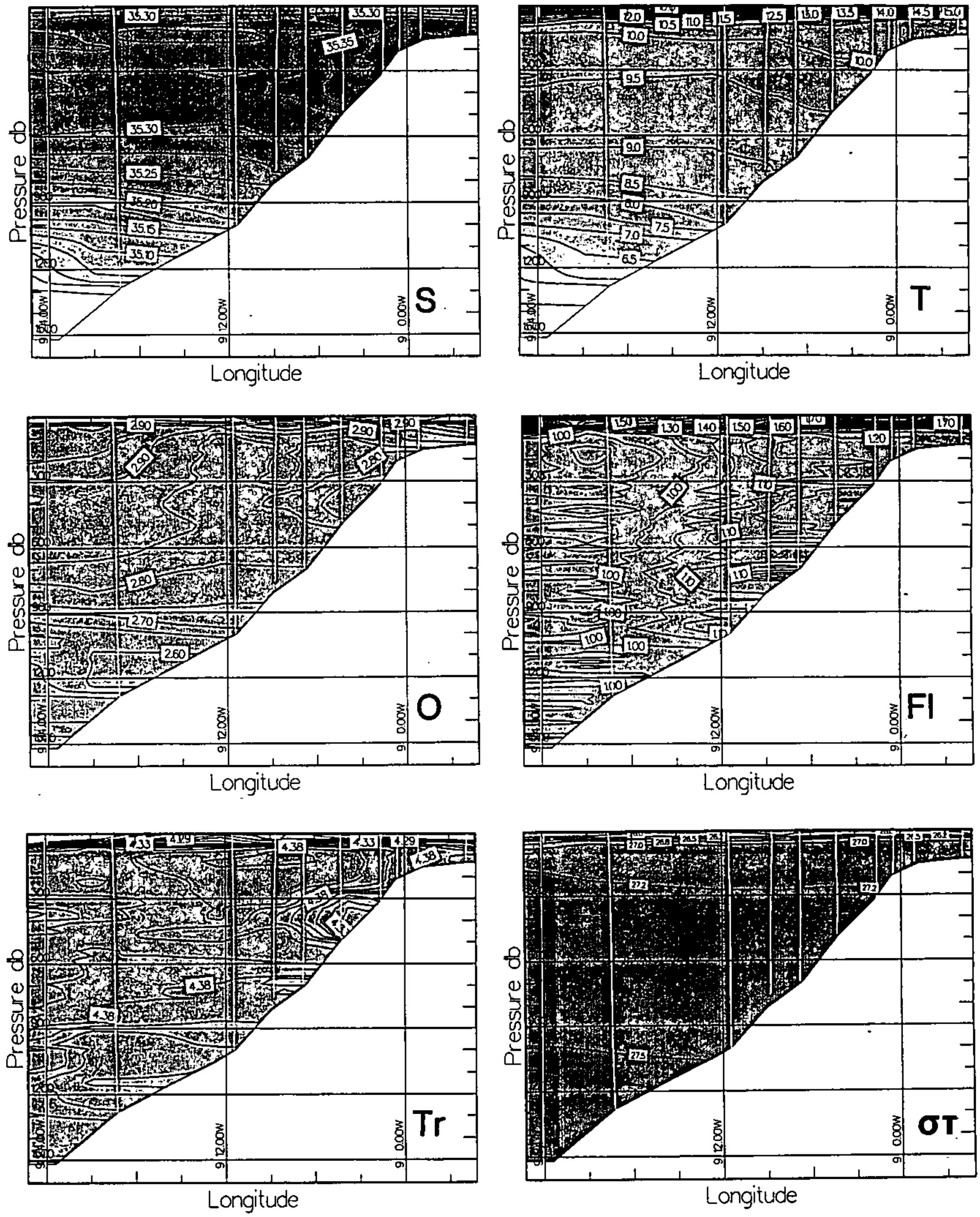

Figure 5. Sections of salinity (S), Temperature (T), Oxygen (O), Fluorescence (FL), Transmission (Tr) and Density Anomaly (σt). All values are nominal. N line 24th August.

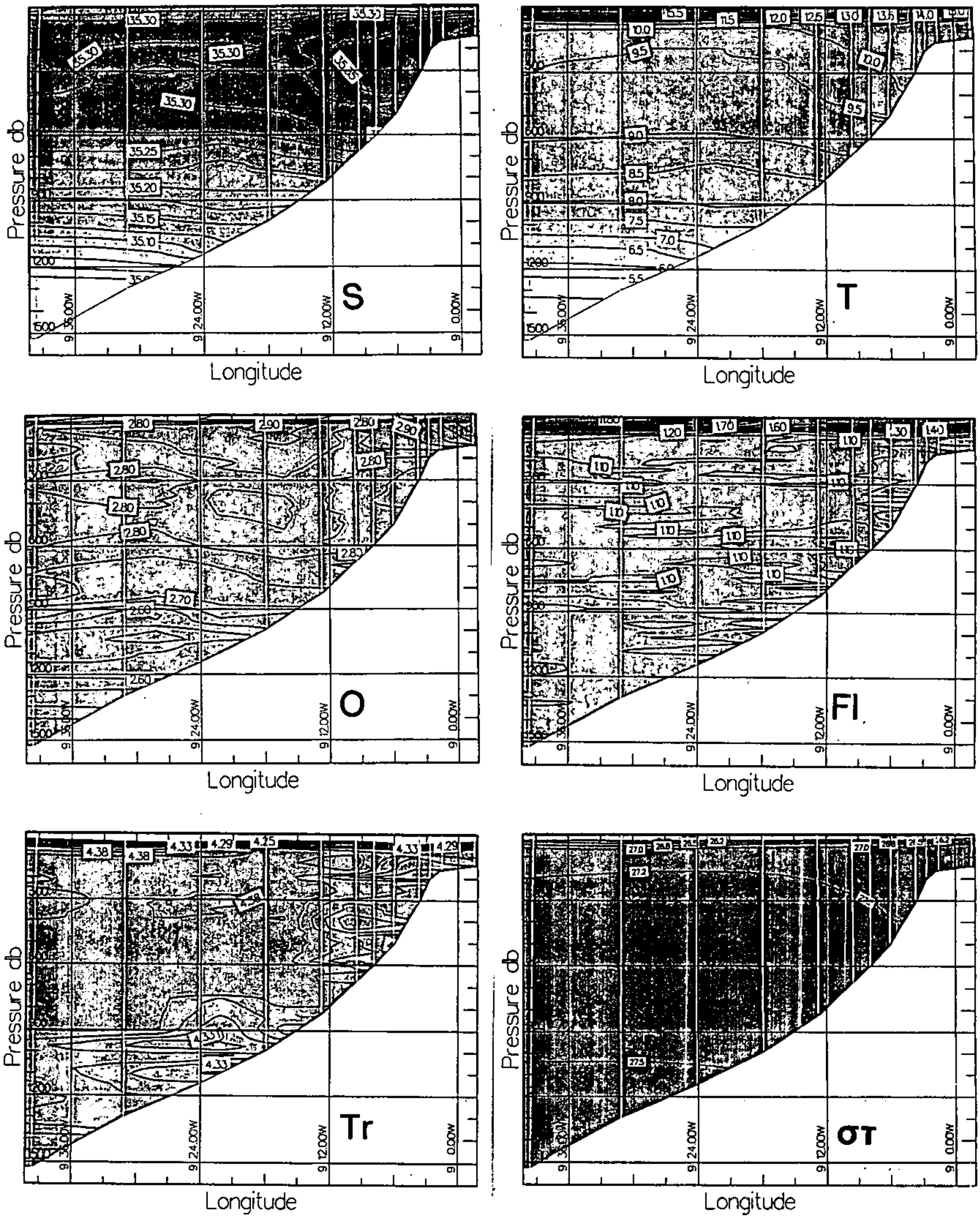

Figure 6. Sections of salinity (S), Temperature (T), Oxygen (O), Fluorescence (FL), Transmission (Tr) and Density Anomaly (σt). All values are nominal. S line 25th August and 26th August.

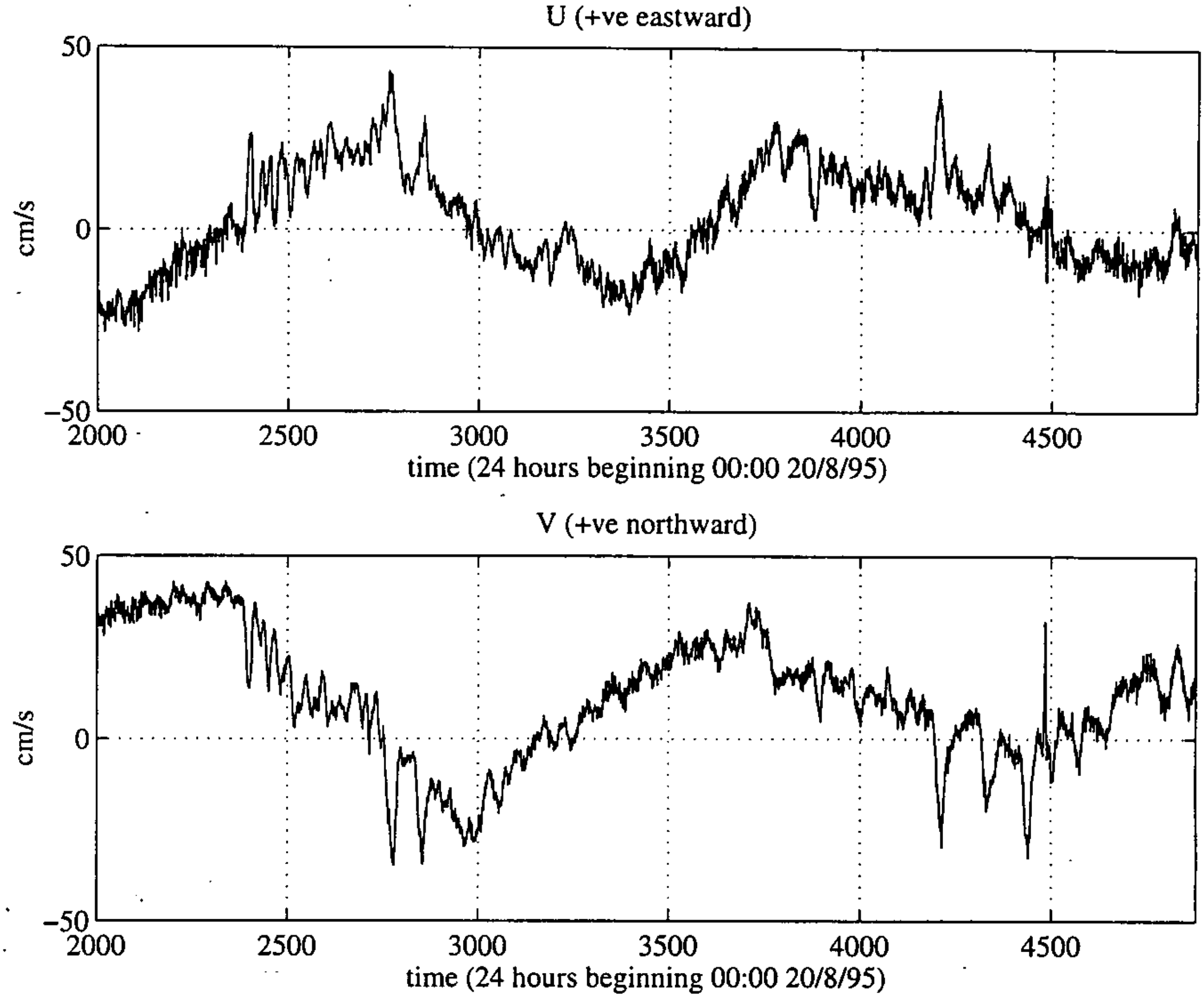

Figure 7. Currents observed by the S4 on the internal wave mooring during neap tides.

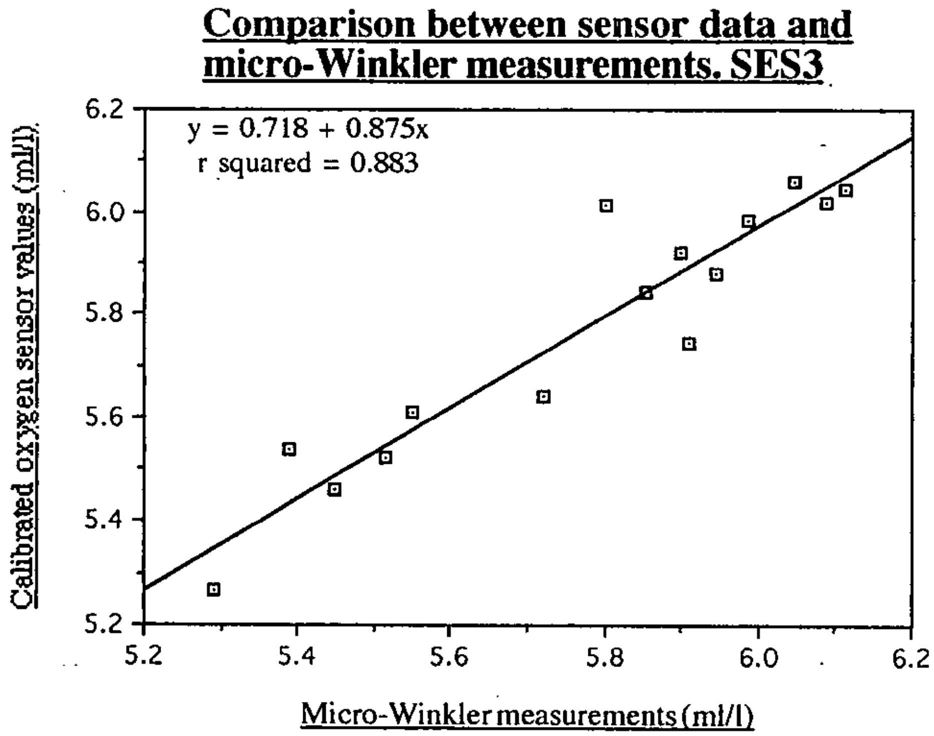

Figure 8. Comparison between sensor data and micro-Winkler measurements. SES3.