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CRUISE REPORT No. 60

RRS *DISCOVERY* CRUISES 285/286
3 NOV – 10 DEC 2004
13 DEC 2004 – 21 JAN 2005

CROZet circulation, iron fertilization and
EXport production experiment (CROZEX)

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ABSTRACT

CROZEX (CROZet circulation, iron fertilization and EXport production experiment) is a complex, multidisciplinary project to examine the causes and consequences of the annual bloom that forms north of the Crozet Plateau in the southwest Indian Ocean sector of the Southern Ocean. The CROZEX cruises took place between 3 Nov 2004 and 21 Jan 2005. Much of the cruise was planned around a series of Major Stations every two or three days at each of which a series of CTD casts was made to sample physical parameters, currents, nutrients, phytoplankton, iron and phytoplankton productivity, ^{234}Th and SAPS. Other work at each Major Station included zooplankton nets, radium samples, Pelagra deployment and occasionally other sampling such as LHPR tows, neodynium, mooring deployment, coring, Argo float deployment and water collection for bioassay experiments. Five moorings were deployed, one of which was recovered at the end of the cruise. The other four, with 6 sediment traps in total were deployed for a year. In between Major Stations there were some additional sCTD casts to fill in hydrographic details and SeaSoar tows. Underway measurements included thermosalinograph and fluorimeter, hull-mounted ADCP, surface nutrients, iron from a special TMS (trace metal) fish, CO_2, analytical flow cytometry, aerosols and rain.

KEYWORDS

acronym, circulation, Crozet Plateau, CROZEX, cruise 285 2004, cruise 286 2004-05, *Discovery*, export production, natural iron fertilization, phytoplankton productivity, Southern Ocean

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RRS Discovery cruises 285 and 286 – CROZEX

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3/O	Kieron Hales	
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1. Overview

CROZEX (CROZet circulation, iron fertilization and Export production experiment) is a complex, multidisciplinary project to examine the causes and consequences of the annual bloom that forms north of the Crozet Plateau in the southwest Indian Ocean sector of the Southern Ocean. The field phase, described here, consisted of a pair of cruises, D285 and D286, funded by SOC Core ship time for the George Deacon Divisions's (GDD) Core Strategic Project BICEP (Biophysical Interactions and Controls on Export Production). An extra 6 days (identified as D287) spread between the two cruises were funded as part of "benthic Crozet", a NERC responsive mode project led by Prof George Wolff of Liverpool University, for which the main cruise will be D300 in December 2005. The contents list testifies to the breadth of work undertaken, which tested the capacity of RRS Discovery to the limit. Nevertheless, the cruises overall were highly successful.

1.1 Objective

The overall objective of the project is

To examine, from surface to sediment, the structure, causes and consequences of a naturally occurring phytoplankton bloom in the Southern Ocean

Detailed objectives for different parts of the project will be given in the appropriate section.

1.2 Cruise overview — Raymond Pollard

RRS Discovery cruise 285 departed from Cape Town, South Africa on 3 Nov 2004, docking at Port Elizabeth 37 days later on 10 Dec. Leg 2, cruise 286, departed on 13 Dec and docked at Durban 39 days later on 21 Jan 2005.

Details of day by day operations are given in the cruise diary (1.4), supported by track plots (Fig 1.1), station maps (Fig. 1.2) and weekly time series plots of meteorological parameters, annotated ship heading and speed, water depth and near surface chlorophyll (Figs 1.3.1-10). A Julian day v. date lookup table is provided (Table 1.1) but participants are encouraged to use date rather than day-of-year in plots and references. Satellite images (1.3) were of considerable value in planning operations and in interpreting results, so a series of composites is presented in Fig. 1.4.

Stations were all numbered using the Discovery station numbers, initiated on the original Discovery cruises and now in the 15 thousands, which on our cruise ranged from 15486 to 15634. Each CTD cast was given a new station number, but associated nets, SAPS deployments, etc usually took the same station number as the associated CTD cast. Pelagra, SeaSoar and coring were also given station numbers, though all cores in a sequence were sub-numbered within a single station number. A complete list of CTD casts is given in Table 1.2. A useful aid through the cruise was the complete list of stations, which was updated regularly by watchkeepers and later typed in by the BODC representatives. These tables are included, unedited, as Tables 1.3 and 1.4.

Much of the cruise was planned around a series of Major Stations (labelled in red in Table 1.2) every two or three days. At each Major Station (M1 to M10 in Fig. 1.2) a series of CTD casts was made, typically a full depth CTD with the stainless steel rosette (sCTD) to sample physical parameters, currents (LADCP) and nutrients through the whole water column and phytoplankton down to 500m; a cast with the titanium rosette (tCTD or

TiCTD) (not always to full depth) for iron and phytoplankton productivity sampling; a second sCTD cast for ^{234}Th sampling and a SAPS deployment. The order of casts depended on time of day to ensure that samples for on-deck incubations were drawn in darkness or low light conditions. Other work at each Major Station included zooplankton nets, radium samples, Pelagra deployment and occasionally other sampling such as LHPR tows, neodynium, mooring deployment, coring, Argo float deployment and water collection for bioassay experiments. In between Major Stations there were some additional sCTD casts to fill in hydrographic details and SeaSoar tows. Underway measurements included thermosalinograph and fluorimeter, hull-mounted ADCP, surface nutrients, iron from a special TMS (trace metal) fish, CO_2, analytical flow cytometry, aerosols and rain.

After a 6-day passage at the start of D285, only one sCTD of a planned line from J to M3 (Fig. 1.2) was worked before bad weather stopped all work for over a day. M1 was worked on the way to M3, where a mooring was set (recovered at the end of D286). A planned 3.5-day SeaSoar survey extended to 5 days because of bad weather and M3 was reoccupied. Over the next 6 days Discovery ran south via M2 to M6, including a site survey and a few megacores at M6 followed by a dog-leg SeaSoar run back to M3. In a major change of plan, it was decided not to work east to M5, but to survey the bloom area to the northwest of M3. Major Stations M7, M8E, M8W and M9 were occupied in that order over the next 9 days, with SeaSoar runs in between to allow two 41 hour Pelagra deployments. A line of 4 sCTD stations was occupied at the start of the 5 day passage to Port Elizabeth.

On D286, SeaSoar was deployed about 4 days after leaving PE in order to survey across the SubAntarctic Front (SAF) that bounds the bloom area. Major Station M9 was repeated and a line of CTDs worked to M10, where the first sediment trap mooring was deployed. Before re-occupying M3, ten days into the cruise, an aborted attempt was made to land on Ile de la Possession, but several stations were worked in and near the Baie Americaine. Discovery spent the next 7 days (including passage) working at the easternmost site, M5, including mooring deployment and coring, with a SeaSoar run out to M5 and CTDs back to M3. The next 8-day excursion (including time lost to weather) was south to M6, the "control" benthic site, again including mooring deployment and coring, with the final mooring deployed at M2 on the way back to the islands. After a sampling party had gone ashore at Port Alfred on 8 Jan, a Major Station was occupied three times over the next 5 days in an intense new bloom in a cyclonic eddy north of the islands and close to M3, with spatial surveys in between and recovery of the M3 mooring. The final SeaSoar survey was on passage to the final Major Station, a repeat of M10, where a few cores were taken. The final passage to Durban took 5 days.

1.3 Satellite images

Satellite images (2.5) show that the bloom began (Fig. 1.4a) and peaked (Fig. 1.4b) before the start of the cruise, and gradually decayed during D285 (Figs 1.4c, d, e). At the start of D286, a "new" bloom was beginning (Fig. 1.4f), clearly tied to the bathymetry of the Crozet Plateau and Islands. The 10 Jan 2005 image (Fig. 1.4g) shows a small cyclonic eddy close to M3, which was occupied with a Major Station three times on 8, 10 and 12 Jan. The final image on 27 Jan (Fig. 1.4h) shows that the bloom continued for at least a month.

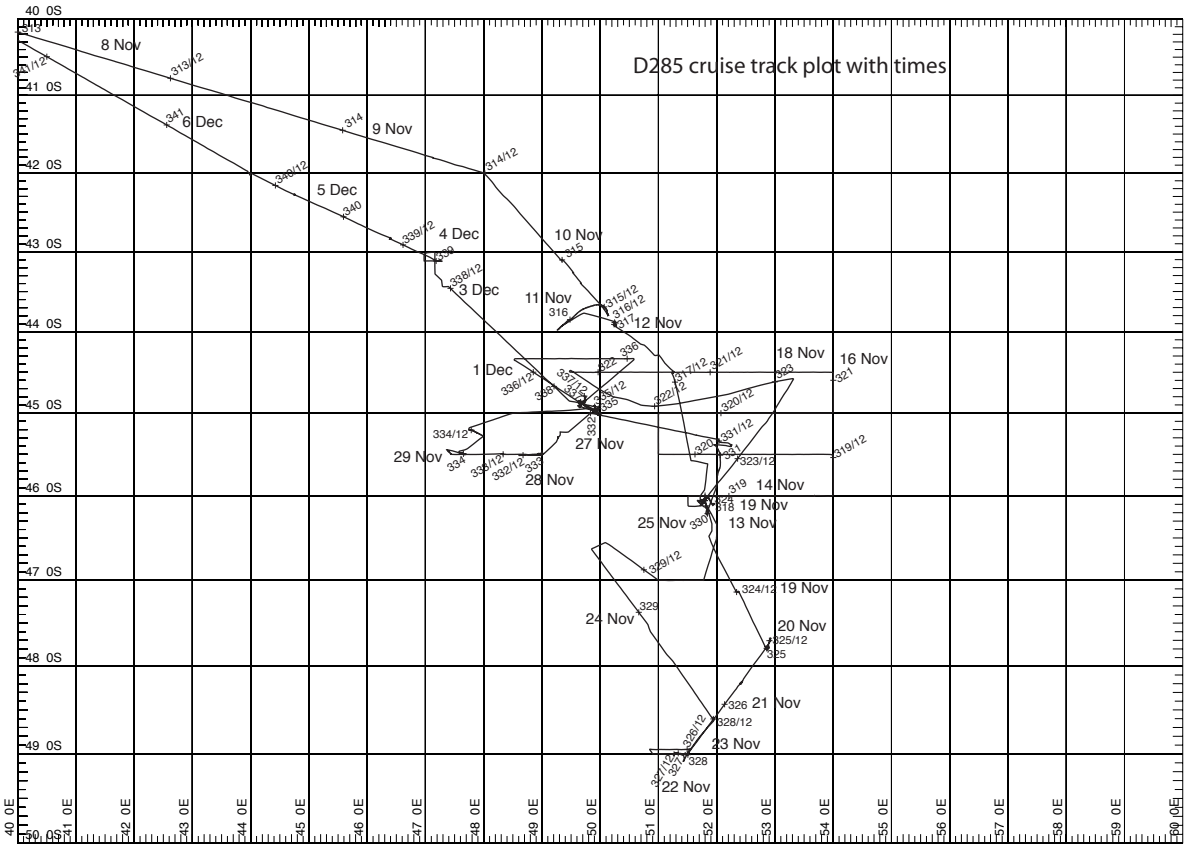


Fig. 1.1a Track plot for Discovery Cruise 285 - Crozet

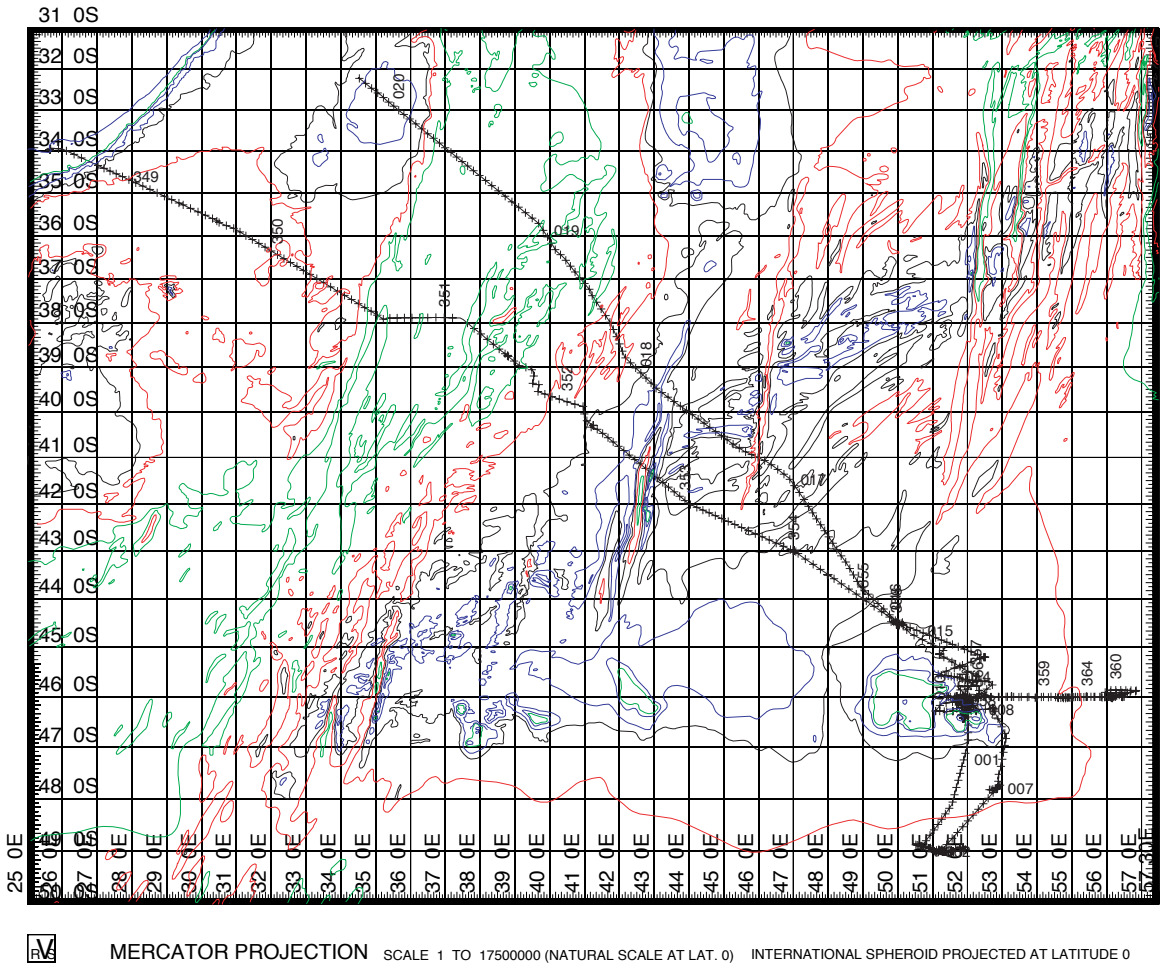


Fig. 1.1b Track plot for Discovery Cruise 286 - Crozet

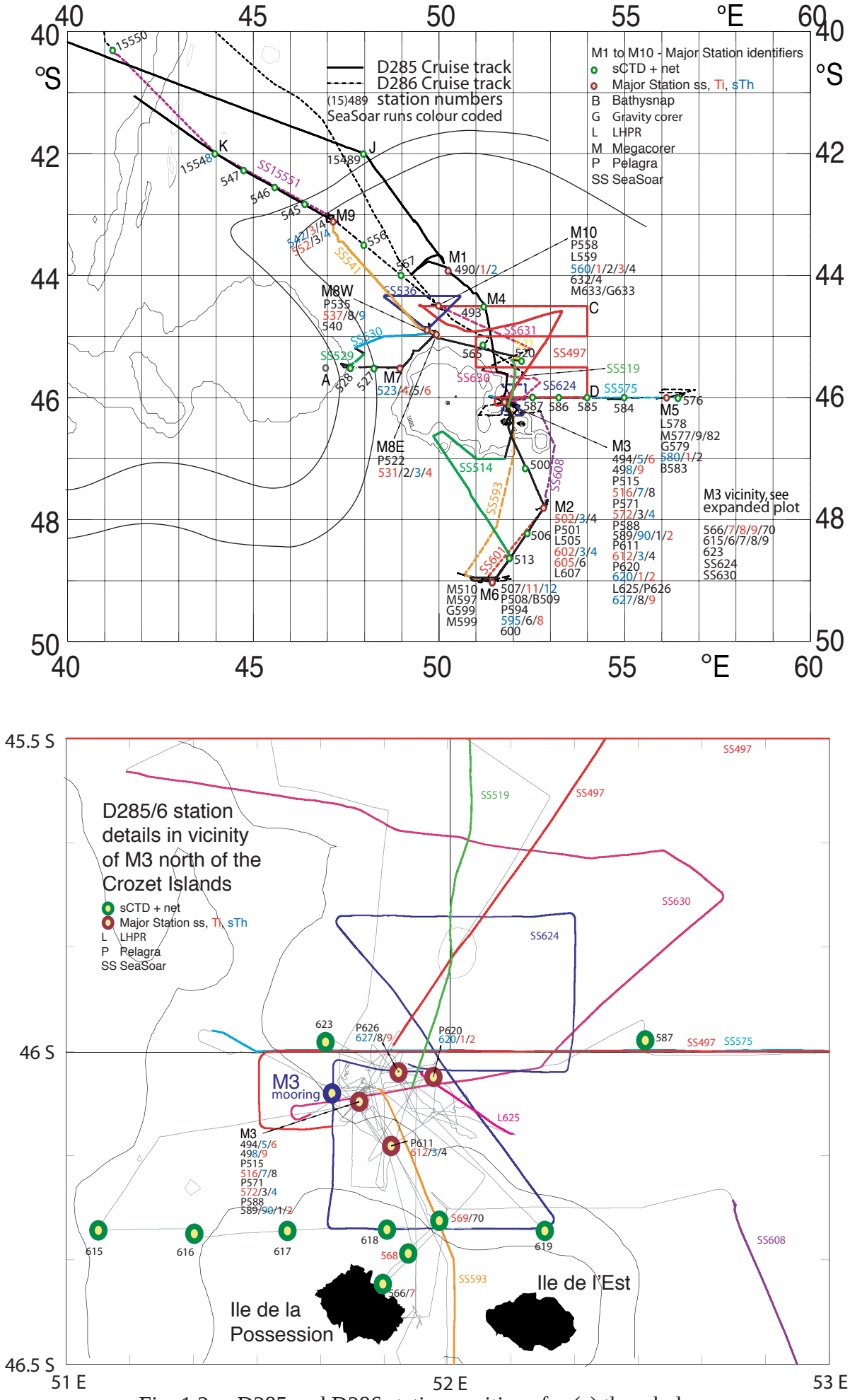


Fig. 1.2 D285 and D286 station positions for (a) the whole survey area (b) details in the vicinity of M3

Table 1.1 - Julian day (2004) to date lookup table

Jday	date	Jday	date	Jday	date
303	29 Oct	332	27 Nov	361	26 Dec
304	30 Oct	333	28 Nov	362	27 Dec
305	31 Oct	334	29 Nov	363	28 Dec
306	1 Nov	335	30 Nov	364	29 Dec
307	2 Nov	336	1 Dec	365	30 Dec
308	3 Nov	337	2 Dec	366	31 Dec
309	4 Nov	338	3 Dec	367	1 Jan
310	5 Nov	339	4 Dec	368	2 Jan
311	6 Nov	340	5 Dec	369	3 Jan
312	7 Nov	341	6 Dec	370	4 Jan
313	8 Nov	342	7 Dec	371	5 Jan
314	9 Nov	343	8 Dec	372	6 Jan
315	10 Nov	344	9 Dec	373	7 Jan
316	11 Nov	345	10 Dec	374	8 Jan
317	12 Nov	346	11 Dec	375	9 Jan
318	13 Nov	347	12 Dec	376	10 Jan
319	14 Nov	348	13 Dec	377	11 Jan
320	15 Nov	349	14 Dec	378	12 Jan
321	16 Nov	350	15 Dec	379	13 Jan
322	17 Nov	351	16 Dec	380	14 Jan
323	18 Nov	352	17 Dec	381	15 Jan
324	19 Nov	353	18 Dec	382	16 Jan
325	20 Nov	354	19 Dec	383	17 Jan
326	21 Nov	355	20 Dec	384	18 Jan
327	22 Nov	356	21 Dec	385	19 Jan
328	23 Nov	357	22 Dec	386	20 Jan
329	24 Nov	358	23 Dec	387	21 Jan
330	25 Nov	359	24 Dec		
331	26 Nov	360	25 Dec		

Table 1.2 CTD stations

Major Stations in red

ctds station	ID	type*		day doy	date	time GMT	latitude dec deg N	longitude dec deg E	lat deg S	lat min	lon deg	lon min	PES m	max pres	altr m	comments
		s stainless CTD cast														
bold		**s stainless deep cast**														
italics		*t titanium cast*														
bold italics		***sTh Thorium cast***														
15486		t	be	310	5/11/04	755	-37.05363	26.89170	37	3.22	26	53.50	2979			
			bo	310	5/11/04	814	-37.05117	26.89329	37	3.07	26	53.60	??	1011		trial to 1000m
			en	310	5/11/04	841	-37.04715	26.89787	37	2.83	26	53.87	2897			
15487		s	be	310	5/11/04	1131	-37.13036	27.19161	37	7.82	27	11.50	3222			
			bo	310	5/11/04	1154	-37.12221	27.19390	37	7.33	27	11.63	3224	1000		trial to 1000m
			en	310	5/11/04	1227	-37.11845	27.19408	37	7.11	27	11.64	3220			
15489	J	s	be	314	9/11/04	1106	-42.00553	48.01119	42	0.33	48	0.67	3294			
			bo	**314**	**9/11/04**	**1209**	**-42.00200**	**48.02094**	**42**	**0.12**	**48**	**1.26**	**3264**	**3286**	**17**	
			en	314	9/11/04	1354	-41.99815	48.01771	41	59.89	48	1.06	??			time from ctd start+time in water
15490	**M1**	s	be	316	11/11/04	1036	-43.87797	50.24623	43	52.68	50	14.77	3108			
			bo	**316**	**11/11/04**	**1137**	**-43.88370**	**50.24646**	**43**	**53.02**	**50**	**14.79**	**3109**	**3118**	**0**	**touched bottom**
			en	316	11/11/04	1310	-43.89188	50.25054	43	53.51	50	15.03	??			time from ctd start+time in water
15491	**M1**	t	be	316	11/11/04	1411	-43.89823	50.25842	43	53.89	50	15.51	3104			
			bo	*316*	*11/11/04*	*1733*	*-43.92049*	*50.26742*	*43*	*55.23*	*50*	*16.05*	*3106*	*3118*	*0*	*altimeter uncertain - touchdown?*
			en	316	11/11/04	1914	-43.92515	50.26108	43	55.51	50	15.66	3107			scrolling gear failure at 800m
15492	**M1**	sTh	be	316	11/11/04	1953	-43.92616	50.25964	43	55.57	50	15.58	3107			
			bo	***316***	***11/11/04***	***2018***	***-43.92688***	***50.25728***	***43***	***55.61***	***50***	***15.44***	***3106***	***1017***		
			en	316	11/11/04	2104	-43.92514	50.24976	43	55.51	50	14.99	3103			
15493	M4	s	be	317	12/11/04	653	-44.50003	51.25354	44	30.00	51	15.21	3263			
			bo	**317**	**12/11/04**	**752**	**-44.49690**	**51.25691**	**44**	**29.81**	**51**	**15.41**	**3222**	**3269**	**15**	**failed at 100m on up**
			en	317	12/11/04	933	-44.50297	51.24803	44	30.18	51	14.88	??			time from ctd start+time in water
15494	**M3**	s	be	318	13/11/04	28	-46.05642	51.78834	46	3.39	51	47.30	2377			
			bo	**318**	**13/11/04**	**116**	**-46.05766**	**51.78060**	**46**	**3.46**	**51**	**46.84**	**2398**	**2402**	**14**	**pre mooring**
			en	318	13/11/04	228	-46.06278	51.77306	46	3.77	51	46.38	2339			
15495	**M3**	sTh	be	318	13/11/04	955	-46.05668	51.79179	46	3.40	51	47.51	2355			
			bo	***318***	***13/11/04***	***1019***	***-46.05698***	***51.79213***	***46***	***3.42***	***51***	***47.53***	***2353***	***1011***		***added par***
			en	318	13/11/04	1104	-46.05499	51.79068	46	3.30	51	47.44	2369			
15496	**M3**	t	be	318	13/11/04	1507	-46.05942	51.79007	46	3.57	51	47.40	2355			
			bo	*318*	*13/11/04*	*1551*	*-46.06809*	*51.78529*	*46*	*4.09*	*51*	*47.12*	*2304*	*2287*	*~25*	
			en	318	13/11/04	1706	-46.07652	51.78405	46	4.59	51	47.04	2289			
15498	**M3**	***sTh***	be	323	18/11/04	1739	-46.05319	51.79430	46	3.19	51	47.66	2368			***also Thorium cast***
			bo	**323**	**18/11/04**	**1830**	**-46.04243**	**51.80026**	**46**	**2.55**	**51**	**48.02**	**2437**	**2396**	**15**	
			en	323	18/11/04	1937	-46.03221	51.81001	46	1.93	51	48.60	2515			
15499	**M3**	t	be	323	18/11/04	2103	-46.02751	51.80976	46	1.65	51	48.59	2552			
			bo	*323*	*18/11/04*	*2112*	*-46.02559*	*51.81050*	*46*	*1.54*	*51*	*48.63*	*2563*	*305*		
			en	323	18/11/04	2141	-46.02139	51.80606	46	1.28	51	48.36	2547			
15500		s	be	324	19/11/04	1153	-47.13679	52.33839	47	8.21	52	20.30	3436			
			bo	**324**	**19/11/04**	**1254**	**-47.13850**	**52.35403**	**47**	**40.62**	**52**	**55.66**	**3422**	**3428**	**20**	**N of M2**
			en	324	19/11/04	1428	-47.13500	52.37243	46	22.47	53	2.27	3444			altimeter uncertain
15502	**M2**	t	be	324	19/11/04	2021	-47.79924	52.85540	46	42.49	53	0.58	3857			
			bo	*324*	*19/11/04*	*2140*	*-47.79537*	*52.86216*	*46*	*47.27*	*53*	*0.17*	*NA*	*3870*	*NA*	
			en	325	20/11/04	8	-47.79309	52.85485	46	55.97	52	59.44	3857			
15503	**M2**	sTh	be	325	20/11/04	122	-47.79482	52.85587	47	0.11	52	59.09	3857			
			bo	***325***	***20/11/04***	***133***	***-47.79552***	***52.85540***	***47***	***0.81***	***52***	***59.03***	***3857***	***507***		
			en	325	20/11/04	159	-47.79663	52.85384	47	2.74	52	58.87	3857			
15504	**M2**	s	be	325	20/11/04	542	-47.76572	52.88210	47	15.11	52	57.82	3856			
			bo	**325**	**20/11/04**	**654**	**-47.77291**	**52.88365**	**47**	**19.61**	**52**	**57.44**	**3859**	**3879**	**12**	
			en	325	20/11/04	915	-47.78290	52.89307	47	27.95	52	56.73	3847			
15506		s	be	325	20/11/04	1718	-48.19607	52.40869	48	11.76	52	24.52	3872			
			bo	**325**	**20/11/04**	**1828**	**-48.19150**	**52.41306**	**48**	**11.49**	**52**	**24.78**	**3869**	**3896**	**10**	**S of M2**
			en	325	20/11/04	2032	-48.18507	52.42438	48	11.10	52	25.46	3861			
15507	**M6**	s	be	326	21/11/04	1530	-49.00442	51.49066	49	0.27	51	29.44	4199			
			bo	**326**	**21/11/04**	**1647**	**-49.00333**	**51.49086**	**49**	**0.20**	**51**	**29.45**	**4206**	**4246**	**15**	**altimeter approximate**
			en	326	21/11/04	1848	-49.00235	51.47790	49	0.14	51	28.67	4202			
15511	**M6**	t	be	327	22/11/04	2205	-49.00079	51.49824	49	0.05	51	29.89	4227			
			bo	*327*	*22/11/04*	*2327*	*-49.00557*	*51.50046*	*49*	*0.33*	*51*	*30.03*		*4275*	*3*	*T2 failed on down*
			en	328	23/11/04	138	-49.01080	51.49200	49	0.65	51	29.52	4220			
15512	**M6**	sTh	be	328	23/11/04	252	-49.01502	51.47633	49	0.90	51	28.58	4226			
			bo	***328***	***23/11/04***	***314***	***-49.01547***	***51.47307***	***49***	***0.93***	***51***	***28.38***	***4222***	***1014***		
			en	328	23/11/04	352	-49.01627	51.47536	49	0.98	51	28.52	??			time from ctd start+time in water
15513		s	be	328	23/11/04	753	-48.59949	51.95161	48	35.97	51	57.10	??			
			bo	**328**	**23/11/04**	**906**	**-48.59614**	**51.94782**	**48**	**35.77**	**51**	**56.87**	**3962**	**3986**	**15**	**N 0f M6**
			en	328	23/11/04	1137	-48.60148	51.94330	48	36.09	51	56.60	3973			altimeter approximate
15516	**M3**	t	be	330	25/11/04	42	-46.05881	51.79332	46	3.53	51	47.60	2350			
			bo	*330*	*25/11/04*	*54*	*-46.05961*	*51.79093*	*46*	*3.58*	*51*	*47.46*	*2353*	*507*		
			en	330	25/11/04	116	-46.06175	51.78563	46	3.71	51	47.14	2346			
15517	**M3**	sTh	be	330	25/11/04	215	-46.06868	51.77442	46	4.12	51	46.47	2344			
			bo	***330***	***25/11/04***	***223***	***-46.07007***	***51.77153***	***46***	***4.20***	***51***	***46.29***	***2331***	***309***		
			en	330	25/11/04	252	-46.07499	51.76243	46	4.50	51	45.75	2284			
15518	**M3**	s	be	330	25/11/04	625	-46.06952	51.77662	46	4.17	51	46.60	2350			
			bo	**330**	**25/11/04**	**713**	**-46.07895**	**51.76161**	**46**	**4.74**	**51**	**45.70**	**2278**	**2308**	**15**	**restart CTD at bottom**
			en	330	25/11/04	900	-46.09805	51.73410	46	5.88	51	44.05	??			altimeter approximate
15520		s	be	331	26/11/04	535	-45.39915	52.24220	45	23.95	52	14.53	3116			
			bo	**331**	**26/11/04**	**633**	**-45.39553**	**52.24041**	**45**	**23.73**	**52**	**14.42**	**3117**	**3118**	**15**	
			en	331	26/11/04	821	-45.39091	52.24922	45	23.45	52	14.95	3120			
15523	**M7**	sTh	be	332	27/11/04	1450	-45.50314	48.98932	45	30.19	48	59.36	2748			
			bo	***332***	***27/11/04***	***1500***	***-45.50486***	***48.98661***	***45***	***30.29***	***48***	***59.20***	***2749***	***304***		
			en	332	27/11/04	1527	-45.50767	48.98400	45	30.46	48	59.04	2749			
15524	**M7**	t	be	332	27/11/04	1839	-45.49943	49.00242	45	29.97	49	0.15	2747			
			bo	*332*	*27/11/04*	*1849*	*-45.49893*	*49.00171*	*45*	*29.94*	*49*	*0.10*	*2747*	*508*		
			en	332	27/11/04	1927	-45.49705	49.00281	45	29.82	49	0.17	2747			
15525	**M7**	s	be	332	27/11/04	2237	-45.48504	48.99591	45	29.10	48	59.75	2752			
			bo	**332**	**27/11/04**	**2331**	**-45.48650**	**48.99757**	**45**	**29.19**	**48**	**59.85**	**??**	**2747**		
			en	333	28/11/04	103	-45.48915	48.98316	45	29.35	48	58.99	??			
15526	**M7**	t	be	333	28/11/04	234	-45.49018	48.95978	45	29.41	48	57.59	2755			
			bo	*333*	*28/11/04*	*326*	*-45.49089*	*48.94548*	*45*	*29.45*	*48*	*56.73*	*2758*	*2743*	*15*	*estimate altimeter*
			en	333	28/11/04	503	-45.50035	48.93090	45	30.02	48	55.85	2760			
15527		s	be	333	28/11/04	1003	-45.49971	48.33358	45	29.98	48	20.01	2898			
			bo	**333**	**28/11/04**	**1102**	**-45.49853**	**48.33416**	**45**	**29.91**	**48**	**20.05**	**2898**	**2908**	**0**	**hit bottom?**

			en	333	28/11/04	1252	-45.50001	48.32829	45	30.00	48	19.70	2905					
15528		s	be	334	29/11/04	41	-45.49133	47.64150	45	29.48	47	38.49	2435					
			bo	**334**	**29/11/04**	**126**	**-45.48963**	**47.63362**	**45**	**29.38**	**47**	**38.02**	**2410**	**2419**	**10**		**10-15 altimeter**
			en	334	29/11/04	241	-45.48477	47.63071	45	29.09	47	37.84	2394					
15531	**M8E**	t	be	334	29/11/04	2354	-44.92030	49.90447	44	55.22	49	54.27	2750					
			bo	*334*	*29/11/04*	*2359*	*-44.92019*	*49.90487*	*44*	*55.21*	*49*	*54.29*	*2750*	*n/a*				
			en	335	30/11/04	13	-44.91779	49.90411	44	55.07	49	54.25	??					
15532	**M8E**	s	be	335	30/11/04	40	-44.91612	49.90391	44	54.97	49	54.23	2752					
			bo	**335**	**30/11/04**	**132**	**-44.91659**	**49.90688**	**44**	**55.00**	**49**	**54.41**	**2752**	**2747**	**14**			
			en	335	30/11/04	249	-44.91238	49.90820	44	54.74	49	54.49	2754					
15533	**M8E**	sTh	be	335	30/11/04	539	-44.95826	49.94000	44	57.50	49	56.40	2712					
			bo	***335***	***30/11/04***	***601***	***-44.95355***	***49.94103***	***44***	***57.21***	***49***	***56.46***	***2715***	***1014***			***1000m***	
			en	335	30/11/04	643	-44.95416	49.94818	44	57.25	49	56.89	??				time from start +ctd time	
15534	**M8E**	t	be	335	30/11/04	1005	-44.94729	49.96007	44	56.84	49	57.60	2723					
			bo	*335*	*30/11/04*	*1047*	*-44.94709*	*49.96695*	*44*	*56.83*	*49*	*58.02*	*2724*	*1004*				
			en	335	30/11/04	1156	-44.94579	49.96894	44	56.75	49	58.14	2728					
15537	**M8W**	t	be	336	1/12/04	2233	-44.87014	49.65785	44	52.21	49	39.47	2818					
			bo	*336*	*1/12/04*	*2324*	*-44.86585*	*49.66330*	*44*	*51.95*	*49*	*39.80*	*2808*	*2811*	*7.7*			
			en	337	2/12/04	43	-44.85744	49.65953	44	51.45	49	39.57	??					
15538	**M8W**	s	be	337	2/12/04	120	-44.85551	49.65783	44	51.33	49	39.47	2818					
			bo	**337**	**2/12/04**	**215**	**-44.85659**	**49.65218**	**44**	**51.40**	**49**	**39.13**	**2816**	**2801**	**25**		**altimeter uncertain**	
			en	337	2/12/04	340	-44.85666	49.64303	44	51.40	49	38.58	2817					
15539	**M8W**	sTh	be	337	2/12/04	614	-44.87125	49.64893	44	52.28	49	38.94	2808					
			bo	***337***	***2/12/04***	***627***	***-44.87236***	***49.64711***	***44***	***52.34***	***49***	***38.83***	***2805***	***505***			***500m***	
			en	337	2/12/04	705	-44.87030	49.64731	44	52.22	49	38.84	2808				time from start+ctd time	
15540	M8W	s	be	337	2/12/04	1605	-44.90975	49.63175	44	54.59	49	37.90	2779					
			bo	**337**	**2/12/04**	**1617**	**-44.91140**	**49.62931**	**44**	**54.68**	**49**	**37.76**	**2778**	**404**			**for SeaSoar calibration**	
			en	337	2/12/04	1649	-44.91444	49.62176	44	54.87	49	37.31	2776					
15542	**M9**	sTh	be	338	3/12/04	2036	-43.11771	47.18484	43	7.06	47	11.09	2911					
			bo	***338***	***3/12/04***	***2053***	***-43.11760***	***47.18493***	***43***	***7.06***	***47***	***11.10***	***2911***	***507***				
			en	338	3/12/04	2135	-43.11676	47.18552	43	7.01	47	11.13	2917					
15543	**M9**	t	be	338	3/12/04	2245	-43.11720	47.18450	43	7.03	47	11.07	2912					
			bo	*338*	*3/12/04*	*2341*	*-43.11740*	*47.18411*	*43*	*7.04*	*47*	*11.05*	*2912*	*2918*	*11*			
			en	339	4/12/04	113	-43.12147	47.18059	43	7.29	47	10.84	2900					
15544	**M9**	s	be	339	4/12/04	453	-43.11719	47.18383	43	7.03	47	11.03	2913					
			bo	**339**	**4/12/04**	**546**	**-43.11593**	**47.18615**	**43**	**6.96**	**47**	**11.17**	**2918**	**2916**	**15**		**approximate altimeter**	
			en	339	4/12/04	738	-43.11653	47.18400	43	6.99	47	11.04	2914					
15545		s	be	339	4/12/04	1332	-42.83607	46.38926	42	50.16	46	23.36	3269					
			bo	**339**	**4/12/04**	**1432**	**-42.83344**	**46.39160**	**42**	**50.01**	**46**	**23.50**	**3247**	**3257**	**11**			
			en	339	4/12/04	1604	-42.83344	46.39871	42	50.01	46	23.92	3222					
15546			be	339	4/12/04	2138	-42.56021	45.59336	42	33.61	45	35.60	3385					
			bo	**339**	**4/12/04**	**2241**	**-42.55980**	**45.59644**	**42**	**33.59**	**45**	**35.79**	**3370**	**3399**				
			en	340	5/12/04	26	-42.55576	45.59531	42	33.35	45	35.72	3380					
15547			be	340	5/12/04	605	-42.27947	44.74844	42	16.77	44	44.91	3349					
			bo	**340**	**5/12/04**	**711**	**-42.27615**	**44.75162**	**42**	**16.57**	**44**	**45.10**	**3381**	**3421**	**20**		**altimeter approximate**	
			en	340	5/12/04	915	-42.27749	44.75238	42	16.65	44	45.14	??					
15548	K	sTh	be	340	5/12/04	1412	-42.00298	43.99468	42	0.18	43	59.68	3134					***also thorium cast***
			bo	**340**	**5/12/04**	**1432**	**-42.00822**	**43.99335**	**42**	**0.49**	**43**	**59.60**	**3175**	**1008**				
			en	340	5/12/04	1518	-42.01628	43.99008	42	0.98	43	59.40	3200					
15549		s	be	351	16/12/04	1028	-38.74784	38.78815	38	44.87	38	47.29	5474				test to 200m	
			bo	351	16/12/04	1033	-38.74662	38.78830	38	44.80	38	47.30	5474	205				
			en	351	16/12/04	1108	-38.73685	38.79127	38	44.21	38	47.48	5474					
15550		s	be	352	17/12/04	515	-40.29562	41.24607	40	17.74	41	14.76	2874				calibration cast start of SeaSoar	
			bo	352	17/12/04	529	-40.29531	41.24745	40	17.72	41	14.85	2872	509				
			en	352	17/12/04	556	-40.29811	41.24620	40	17.89	41	14.77	2863					
15552	**M9**	t	be	353	18/12/04	1808	-42.99798	47.00177	42	59.88	47	0.11	3245					
			bo	*353*	*18/12/04*	*1908*	*-42.99845*	*47.00386*	*42*	*59.91*	*47*	*0.23*	*3242*	*3248*	*10*			
			en	353	18/12/04	2041	-42.99478	47.01842	42	59.69	47	1.11	na					
15553	**M9**	s	be	354	19/12/04	314	-43.00175	46.99978	43	0.10	46	59.99	3233					
			bo	**354**	**19/12/04**	**412**	**-43.00291**	**47.00285**	**43**	**0.17**	**47**	**0.17**	**3228**	**3242**				
			en	354	19/12/04	551	-43.00195	47.00273	43	0.12	47	0.16	3233					
15554	**M9**	sTh	be	354	19/12/04	847	-42.99700	47.02032	42	59.82	47	1.22	3204					
			bo	***354***	***19/12/04***	***859***	***-42.99510***	***47.02378***	***42***	***59.71***	***47***	***1.43***	***na***	***507***				
			en	354	19/12/04	939	-42.99510	47.02865	42	59.71	47	1.72	na					
15555		s	be	354	19/12/04	1515	-43.49971	47.99924	43	29.98	47	59.95	2463	-			aborted at 1535 for par removal	
15556		s	be	354	19/12/04	1544	-43.49874	47.99946	43	29.92	47	59.97	2464					
			bo	**354**	**19/12/04**	**1632**	**-43.49914**	**47.99899**	**43**	**29.95**	**47**	**59.94**	**2451**	**2442**	**14**			
			en	354	19/12/04	1755	-43.50154	47.99132	43	30.09	47	59.48	2460					
15557		s	be	355	20/12/04	19	-44.00028	49.00187	44	0.02	49	0.11	2891					
			bo	**355**	**20/12/04**	**112**	**-43.99919**	**49.00103**	**43**	**59.95**	**49**	**0.06**	**2892**	**2893**				
			en	355	20/12/04	240	-44.00223	48.99945	44	0.13	48	59.97	2895					
15560	**M10**	sTh	be	355	20/12/04	1521	-44.51835	49.99419	44	31.10	49	59.65	2956					
			bo	***355***	***20/12/04***	***1533***	***-44.51829***	***49.99248***	***44***	***31.10***	***49***	***59.55***	***2956***	***507***				
			en	355	20/12/04	1609	-44.51871	49.98894	44	31.12	49	59.34	na					
15561	**M10**	t	be	355	20/12/04	1848	-44.52419	49.96866	44	31.45	49	58.12	2945					
			bo	*355*	*20/12/04*	*1859*	*-44.52436*	*49.96880*	*44*	*31.46*	*49*	*58.13*	*2948*	*508*				
			en	355	20/12/04	1933	-44.52628	49.96353	44	31.58	49	57.81	2945					
15562	**M10**	s	be	355	20/12/04	2001	-44.52843	49.95948	44	31.71	49	57.57	2944					
			bo	**355**	**20/12/04**	**2058**	**-44.52786**	**49.96032**	**44**	**31.67**	**49**	**57.62**	**2944**	**2943**				
			en	355	20/12/04	2228	-44.52841	49.96093	44	31.70	49	57.66	2944					
15563	**M10**	t	be	355	20/12/04	2327	-44.52740	49.96212	44	31.64	49	57.73	2945					
			bo	*356*	*21/12/04*	*20*	*-44.52528*	*49.96059*	*44*	*31.52*	*49*	*57.64*	*2946*	*2943*				
			en	356	21/12/04	139	-44.52226	49.96102	44	31.34	49	57.66	2948					
15564	**M10**	s	be	356	21/12/04	245	-44.51784	49.96608	44	31.07	49	57.96	2950					
			bo	**356**	**21/12/04**	**340**	**-44.51310**	**49.96920**	**44**	**30.79**	**49**	**58.15**	**2955**	**2953**			**all water for radium / neodynium**	
			en	356	21/12/04	448	-44.50957	49.96962	44	30.57	49	58.18	2952					
15565		s	be	356	21/12/04	1600	-45.13632	51.19208	45	8.18	51	11.52	3066					
			bo	**356**	**21/12/04**	**1658**	**-45.13870**	**51.19627**	**45**	**8.32**	**51**	**11.78**	**3060**	**3062**	**10**			
			en	356	21/12/04	1824	-45.13634	51.19668	45	8.18	51	11.80	3063					
15566	**BA**	s	be	357	22/12/04	740	-46.37047	51.82960	46	22.23	51	49.78	99				aborted at bottom because ship	
			bo	**357**	**22/12/04**	**749**	**-46.37013**	**51.82767**	**46**	**22.21**	**51**	**49.66**	**na**	**89**			**drifting, so few bottles fired**	
			en	357	22/12/04	757	-46.36930	51.82922	46	22.16	51	49.75	105				radium samples collected	
15567	**BA**	t	be	357	22/12/04	959	-46.36865	51.82688	46	22.12	51	49.61	95					
			bo	*357*	*22/12/04*	*1002*	*-46.36854*	*51.82754*	*46*	*22.11*	*51*	*49.65*	*103*	*83*				
			en	357	22/12/04	1015	-46.36791	51.82967	46	22.07	51	49.78	105					
15568		t	be	357	22/12/04	1303	-46.32223	51.89694	46	19.33	51	53.82	405					
			bo	*357*	*22/12/04*	*1314*	*-46.32332*	*51.89459*	*46*	*19.40*	*51*	*53.68*	*395*	*379*				
			en	357	22/12/04	1338	-46.32481	51.88826	46	19.49	51	53.30	420					
15569		t	be	357	22/12/04	1514	-46.27009	51.97679	46	16.21	51	58.61	1557					
			bo	*357*	*22/12/04*	*1549*	*-46.26997*	*51.97083*	*46*	*16.20*	*51*	*58.25*	*1565*	*1491*				

			en	357	22/12/04	1637	-46.26914	51.96399	46	16.15	51	57.84	1300						
15570		s	be	357	22/12/04	1710	-46.26677	51.96055	46	16.01	51	57.63	1284						
			bo	**357**	**22/12/04**	**1742**	**-46.26472**	**51.95772**	**46**	**15.88**	**51**	**57.46**	**1354**	**1387**	**10**				
			en	357	22/12/04	1836	-46.26340	51.95475	46	15.80	51	57.29	1425						
15572	**M3**	t	be	357	22/12/04	2127	-46.06290	51.78260	46	3.77	51	46.96	2385						
			bo	*357*	*22/12/04*	*2138*	*-46.06223*	*51.78169*	*46*	*3.73*	*51*	*46.90*	*2375*	*508*					
			en	357	22/12/04	2216	-46.06425	51.77791	46	3.86	51	46.67	2354						
15573	**M3**	s	be	357	22/12/04	2239	-46.06579	51.77614	46	3.95	51	46.57	2351						
			bo	**357**	**22/12/04**	**2322**	**-46.06834**	**51.77819**	**46**	**4.10**	**51**	**46.69**	**2363**	**2348**					
			en	358	23/12/04	39	-46.07176	51.77847	46	4.31	51	46.71	2345						
15574	**M3**	sTh	be	358	23/12/04	344	-46.08085	51.78279	46	4.85	51	46.97	2263						
			bo	***358***	***23/12/04***	***354***	***-46.08142***	***51.78237***	***46***	***4.89***	***51***	***46.94***	***2256***	***409***					
			en	358	23/12/04	423	-46.08388	51.78502	46	5.03	51	47.10	2267						
15576		s	be	359	24/12/04	1252	-45.98752	56.42929	45	59.25	56	25.76	4238						
			bo	**359**	**24/12/04**	**1421**	**-45.99679**	**56.43891**	**45**	**59.81**	**56**	**26.33**	**4250**	**4278**					
			en	359	24/12/04	1602	-46.00431	56.45611	46	0.26	56	27.37	4254						
15580	**M5**	sTh	be	362	27/12/04	1458	-45.99661	56.15275	45	59.80	56	9.16	4272						
			bo	***362***	***27/12/04***	***1510***	***-45.99740***	***56.15210***	***45***	***59.84***	***56***	***9.13***	***4271***	***508***					
			en	362	27/12/04	1539	-45.99949	56.15202	45	59.97	56	9.12	4269						
15581	**M5**	t	be	362	27/12/04	1852	-46.00104	56.15407	46	0.06	56	9.24	4268						
			bo	*362*	*27/12/04*	*2010*	*-46.00057*	*56.15122*	*46*	*0.03*	*56*	*9.07*	*4268*	*4304*	*10*				
			en	362	27/12/04	2211	-46.00196	56.15052	46	0.12	56	9.03	4267						
15582	**M5**	s	be	362	27/12/04	2256	-46.00245	56.15153	46	0.15	56	9.09	4267						
			bo	**363**	**28/12/04**	**10**	**-46.00005**	**56.15157**	**46**	**0.00**	**56**	**9.09**	**4269**	**4310**					
			en	363	28/12/04	202	-45.99897	56.14809	45	59.94	56	8.89	4269						
15584		s	be	364	29/12/04	1903	-45.99950	55.01140	45	59.97	55	0.68	3955						
			bo	**364**	**29/12/04**	**2014**	**-45.99770**	**55.01050**	**45**	**59.86**	**55**	**0.63**	**3957**	**3990**					
			en	364	29/12/04	2209	-45.99847	55.00369	45	59.91	55	0.22	3949						
15585		s	be	365	30/12/04	510	-46.00043	54.00148	46	0.03	54	0.09	3462						
			bo	**365**	**30/12/04**	**613**	**-46.00461**	**54.00371**	**46**	**0.28**	**54**	**0.22**	**3433**	**3475**					
			en	365	30/12/04	738	-46.01109	53.99814	46	0.67	53	59.89	3456						
15586		s	be	365	30/12/04	1214	-45.99852	53.26045	45	59.91	53	15.63	3458						
			bo	**365**	**30/12/04**	**1316**	**-45.99915**	**53.26655**	**45**	**59.95**	**53**	**15.99**	**3456**	**3462**					
			en	365	30/12/04	1441	-45.99651	53.26953	45	59.79	53	16.17	3454						
15587		s	be	365	30/12/04	1912	-45.99879	52.52650	45	59.93	52	31.59	3119						
			bo	**365**	**30/12/04**	**2011**	**-45.99112**	**52.52283**	**45**	**59.47**	**52**	**31.37**	**3163**	**3146**					
			en	365	30/12/04	2136	-45.97872	52.51634	45	58.72	52	30.98	3184						
15589	**M3**	s	be	366	31/12/04	404	-46.06451	51.78105	46	3.87	51	46.86	2356						
			bo	**366**	**31/12/04**	**448**	**-46.06441**	**51.78068**	**46**	**3.86**	**51**	**46.84**	**2358**	**2365**					
			en	366	31/12/04	555	-46.06546	51.77471	46	3.93	51	46.48	2343						
15590	**M3**	sTh	be	366	31/12/04	710	-46.06343	51.77814	46	3.81	51	46.69	2365						
			bo	***366***	***31/12/04***	***723***	***-46.06256***	***51.77720***	***46***	***3.75***	***51***	***46.63***	***2359***	***509***					
			en	366	31/12/04	748	-46.06193	51.77686	46	3.72	51	46.61	2358						
15591	**M3**	s	be	366	31/12/04	1128	-46.04512	51.77813	46	2.71	51	46.69	2409						
			bo	**366**	**31/12/04**	**1211**	**-46.04319**	**51.77791**	**46**	**2.59**	**51**	**46.67**	**2411**	**2397**	**10**				
			en	366	31/12/04	1258	-46.04878	51.77563	46	2.93	51	46.54	na						
15592	**M3**	t	be	366	31/12/04	1411	-46.05161	51.77661	46	3.10	51	46.60	2406						
			bo	*366*	*31/12/04*	*1417*	*-46.05134*	*51.77591*	*46*	*3.08*	*51*	*46.55*	*2404*	*204*					
			en	366	31/12/04	1436	-46.04928	51.77393	46	2.96	51	46.44	2402						
15595	**M6**	sTh	be	3	3/1/05	1816	-48.99862	51.54057	48	59.92	51	32.43	4207						
			bo	***3***	***3/1/05***	***1828***	***-48.99897***	***51.53799***	***48***	***59.94***	***51***	***32.28***	***4214***	***510***					
			en	3	3/1/05	1853	-48.99909	51.53798	48	59.95	51	32.28	na						
15596	**M6**	s	be	3	3/1/05	2210	-49.00020	51.53423	49	0.01	51	32.05	4215						
			bo	**3**	**3/1/05**	**2324**	**-48.99956**	**51.53338**	**48**	**59.97**	**51**	**32.00**	**4214**	**4249**					
			en	3	4/1/05	100	-49.07550	51.68815	49	4.53	51	41.29	4213						
15598	**M6**	t	be	4	4/1/05	1855	-48.99964	51.53791	48	59.98	51	32.27	4214						
			bo	*4*	*4/1/05*	*2011*	*-49.00158*	*51.53467*	*49*	*0.09*	*51*	*32.08*	*4214*	*4253*					
			en	4	4/1/05	2146	-49.00038	51.53375	49	0.02	51	32.02	4214						
15600	**M6**	s	be	5	5/1/05	2303	-48.99720	51.34048	48	59.83	51	20.43	4222						
			bo	5	5/1/05	2312	-48.99718	51.33912	48	59.83	51	20.35	4225	403.8		water for experiments			
			en	5	5/1/05	2329	-48.99713	51.33730	48	59.83	51	20.24	4223						
15602	**M2**	t	be	6	6/1/05	1621	-47.79787	52.85606	47	47.87	52	51.36	3858						
			bo	*6*	*6/1/05*	*1627*	*-47.79815*	*52.85535*	*47*	*47.89*	*52*	*51.32*	*3057*	*205*					
			en	6	6/1/05	1641	-47.79857	52.85403	47	47.91	52	51.24	na						
15603	**M2**	sTh	be	6	6/1/05	1701	-47.79917	52.85209	47	47.95	52	51.13		3 misfires, redo					
			bo	6	6/1/05	1712	-47.79919	52.85154	47	47.95	52	51.09		506					
			en	6	6/1/05	1738	-47.79990	52.84954	47	47.99	52	50.97							
15604	**M2**	sTh	be	6	6/1/05	1804	-47.80026	52.84835	47	48.02	52	50.90	3858						
			bo	***6***	***6/1/05***	***1809***	***-47.80029***	***52.84838***	***47***	***48.02***	***52***	***50.90***	***3858***	***205***					
			en	6	6/1/05	1823	-47.80039	52.84811	47	48.02	52	50.89	na						
15605	**M2**	t	be	6	6/1/05	2109	-47.80076	52.85049	47	48.05	52	51.03	3857						
			bo	*6*	*6/1/05*	*2217*	*-47.80111*	*52.84952*	*47*	*48.07*	*52*	*50.97*	*3857*	*3883*					
			en	6	6/1/05	2340	-47.80152	52.84844	47	48.09	52	50.91	3857						
15606	**M2**	s	be	7	7/1/05	43	-47.80214	52.85087	47	48.13	52	51.05	3856						
			bo	**7**	**7/1/05**	**152**	**-47.80385**	**52.84979**	**47**	**48.23**	**52**	**50.99**	**3852**	**3879**					
			en	7	7/1/05	323	-47.80895	52.84782	47	48.54	52	50.87	3853						
15612	**aM3**	t	be	8	8/1/05	2250	-46.14772	51.85818	46	8.86	51	51.49	1999						
			bo	*8*	*8/1/05*	*2302*	*-46.14647*	*51.85978*	*46*	*8.79*	*51*	*51.59*	*2039*	*507*					
			en	8	8/1/05	2331	-46.14501	51.85822	46	8.70	51	51.49	1974						
15613	**aM3**	sTh	be	8	8/1/05	2357	-46.14371	51.85809	46	8.62	51	51.49	2029						
			bo	***9***	***9/1/05***	***12***	***-46.14298***	***51.85775***	***46***	***8.58***	***51***	***51.47***	***2031***	***507***					
			en	9	9/1/05	43	-46.14131	51.85367	46	8.48	51	51.22	1817						
15614	**aM3**	s	be	9	9/1/05	446	-46.15461	51.85443	46	9.28	51	51.27	1975						
			bo	**9**	**9/1/05**	**522**	**-46.15475**	**51.85215**	**46**	**9.28**	**51**	**51.13**	**1969**	**1982**					
			en	9	9/1/05	629	-46.16132	51.84533	46	9.68	51	50.72	1927						
15615		s	be	9	9/1/05	2215	-46.28319	51.08446	46	16.99	51	5.07	1264						
			bo	**9**	**9/1/05**	**2226**	**-46.28323**	**51.08436**	**46**	**16.99**	**51**	**5.06**	**1264**	**507**		**not deep**		
			en	9	9/1/05	2303	-46.28377	51.08434	46	17.03	51	5.06	1253						
15616		s	be	10	10/1/05	44	-46.28773	51.33500	46	17.26	51	20.10	1155						
			bo	**10**	**10/1/05**	**57**	**-46.29182**	**51.33359**	**46**	**17.51**	**51**	**20.02**	**1092**	**505**		**not deep**		
			en	10	10/1/05	134	-46.29978	51.32779	46	17.99	51	19.67	1141						
15617		s	be	10	10/1/05	257	-46.28545	51.57752	46	17.13	51	34.65	718						
			bo	**10**	**10/1/05**	**310**	**-46.28629**	**51.58034**	**46**	**17.18**	**51**	**34.82**	**718**	**505**		**not deep**		
			en	10	10/1/05	349	-46.28682	51.57622	46	17.21	51	34.57	682						
15618		s	be	10	10/1/05	511	-46.28550	51.83866	46	17.13	51	50.32	1081						
			bo	**10**	**10/1/05**	**522**	**-46.28509**	**51.84014**	**46**	**17.11**	**51**	**50.41**	**1102**	**508**		**not deep**		
			en	10	10/1/05	543	-46.28319	51.84057	46	16.99	51	50.43	1111						
15619		s	be	10	10/1/05	744	-46.28505	52.25486	46	17.10	52	15.29	1521						
			bo	**10**	**10/1/05**	**755**	**-46.28425**	**52.25631**	**46**	**17.06**	**52**	**15.38**	**1524**	**507**		**not deep**		
			en	10	10/1/05	831	-46.28409	52.25150	46	17.05	52	15.09	na						

15620	***bM3***	sTh	be	10	10/1/05	1633	-46.03230	51.86957	46	1.94	51	52.17	2320				
			bo	***10***	***10/1/05***	***1645***	***-46.03230***	***51.87041***	***46***	***1.94***	***51***	***52.22***	***2320***	***509***		***no deep ss cast taken***
			en	10	10/1/05	1728	-46.03316	51.87081	46	1.99	51	52.25	na				
15621	***bM3***	t	be	10	10/1/05	1816	-46.03252	51.86615	46	1.95	51	51.97	2320				
			bo	*10*	*10/1/05*	*1827*	*-46.03267*	*51.86606*	*46*	*1.96*	*51*	*51.96*	*2440*	*508*			
			en	10	10/1/05	1848	-46.03325	51.86531	46	1.99	51	51.92	2335				
15622	***bM3***	t	be	10	10/1/05	2224	-46.03347	51.86723	46	2.01	51	52.03	2306				
			bo	*10*	*10/1/05*	*2308*	*-46.03412*	*51.86656*	*46*	*2.05*	*51*	*51.99*	*2300*	*2322*			
			en	11	11/1/05	5	-46.03366	51.86811	46	2.02	51	52.09	2313				
15623	cM3	s	be	11	11/1/05	706	-45.99120	51.67599	45	59.47	51	40.56	2497				
			bo	**11**	**11/1/05**	**719**	**-45.99009**	**51.67869**	**45**	**59.41**	**51**	**40.72**	**2506**	**507**		**not deep**	
			en	11	11/1/05	744	-45.98778	51.67911	45	59.27	51	40.75	2515				
15627	***dM3***	sTh	be	12	12/1/05	1900	-46.04172	51.96239	46	2.50	51	57.74	2520				
			bo	***12***	***12/1/05***	***1914***	***-46.04223***	***51.96235***	***46***	***2.53***	***51***	***57.74***	***2529***	***508***			
			en	12	12/1/05	1945	-46.04268	51.95929	46	2.56	51	57.56	2545				
15628	***dM3***	s	be	12	12/1/05	2250	-46.04096	51.96064	46	2.46	51	57.64	2542				
			bo	**12**	**12/1/05**	**2343**	**-46.04089**	**51.96060**	**46**	**2.45**	**51**	**57.64**	**2514**	**2529**			
			en	13	13/1/05	52	-46.04265	51.95761	46	2.56	51	57.46	2532				
15629	***dM3***	t	be	13	13/1/05	121	-46.04511	51.95849	46	2.71	51	57.51	2382				
			bo	*13*	*13/1/05*	*134*	*-46.04566*	*51.95920*	*46*	*2.74*	*51*	*57.55*	*2382*	*504*			
			en	13	13/1/05	203	-46.04797	51.95825	46	2.88	51	57.50	2352				
15632	***M10***	sTh	be	15	15/1/05	425	-44.50190	49.98677	44	30.11	49	59.21	2965				
			bo	***15***	***15/1/05***	***446***	***-44.50151***	***49.98558***	***44***	***30.09***	***49***	***59.13***	***2965***	***1013***		***not deep***	
			en	15	15/1/05	525	-44.50269	49.98596	44	30.16	49	59.16	2964				
15634	***M10***	s	be	15	15/1/05	2059	-44.52447	49.99822	44	31.47	49	59.89	2955				
			bo	**15**	**15/1/05**	**2150**	**-44.52456**	**49.99827**	**44**	**31.47**	**49**	**59.90**	**2972**	**2947**			
			en	15	15/1/05	2252	-44.52490	49.99964	44	31.49	49	59.98	na				

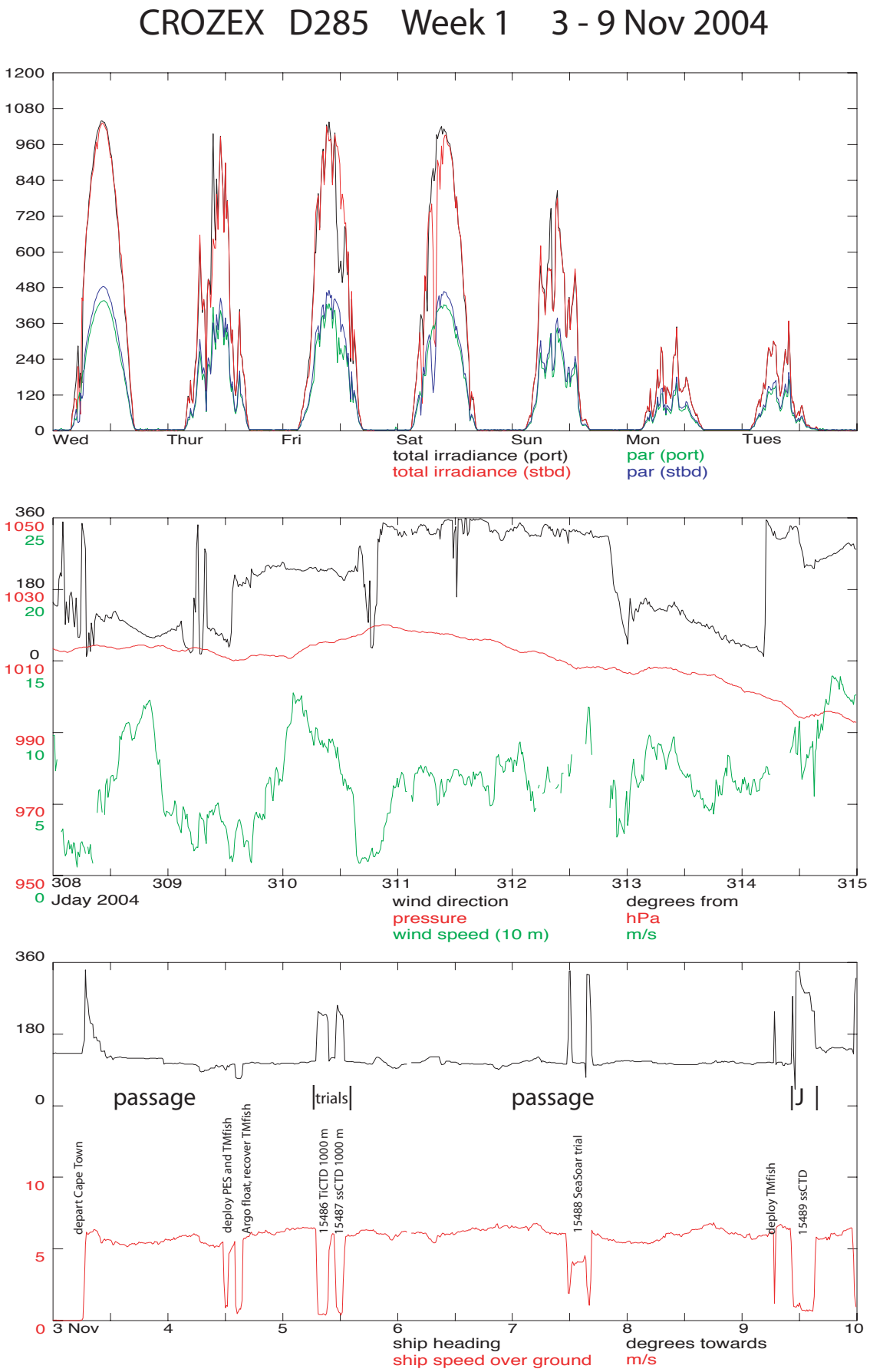


Fig. 1.3.1a - D285 week 1 3-9 Nov wind, irradiance, pressure, ship speed and direction

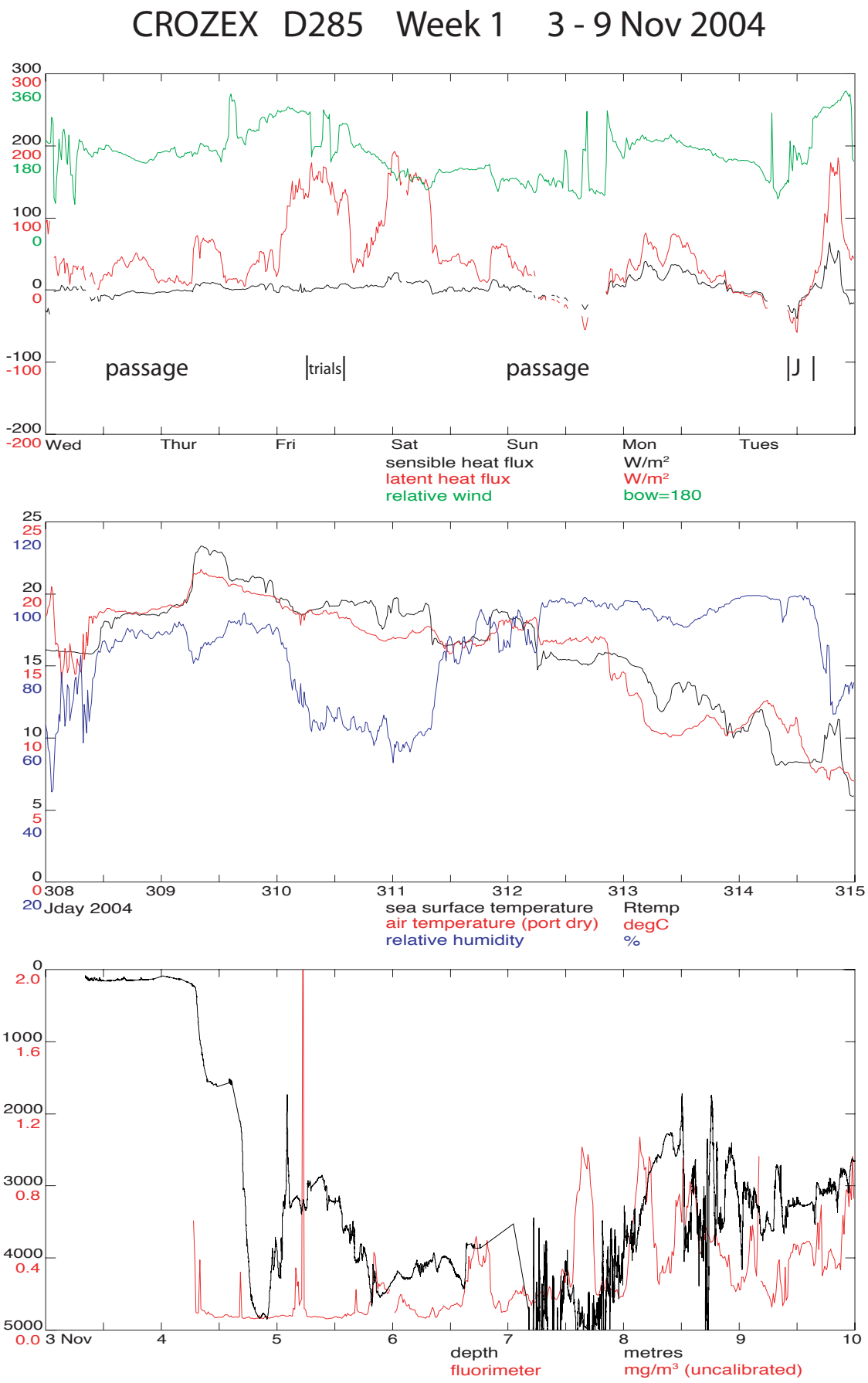


Fig. 1.3.1b - D285 week 1 3-9 Nov heat flux, SST, humidity, depth, surface chlorophyll

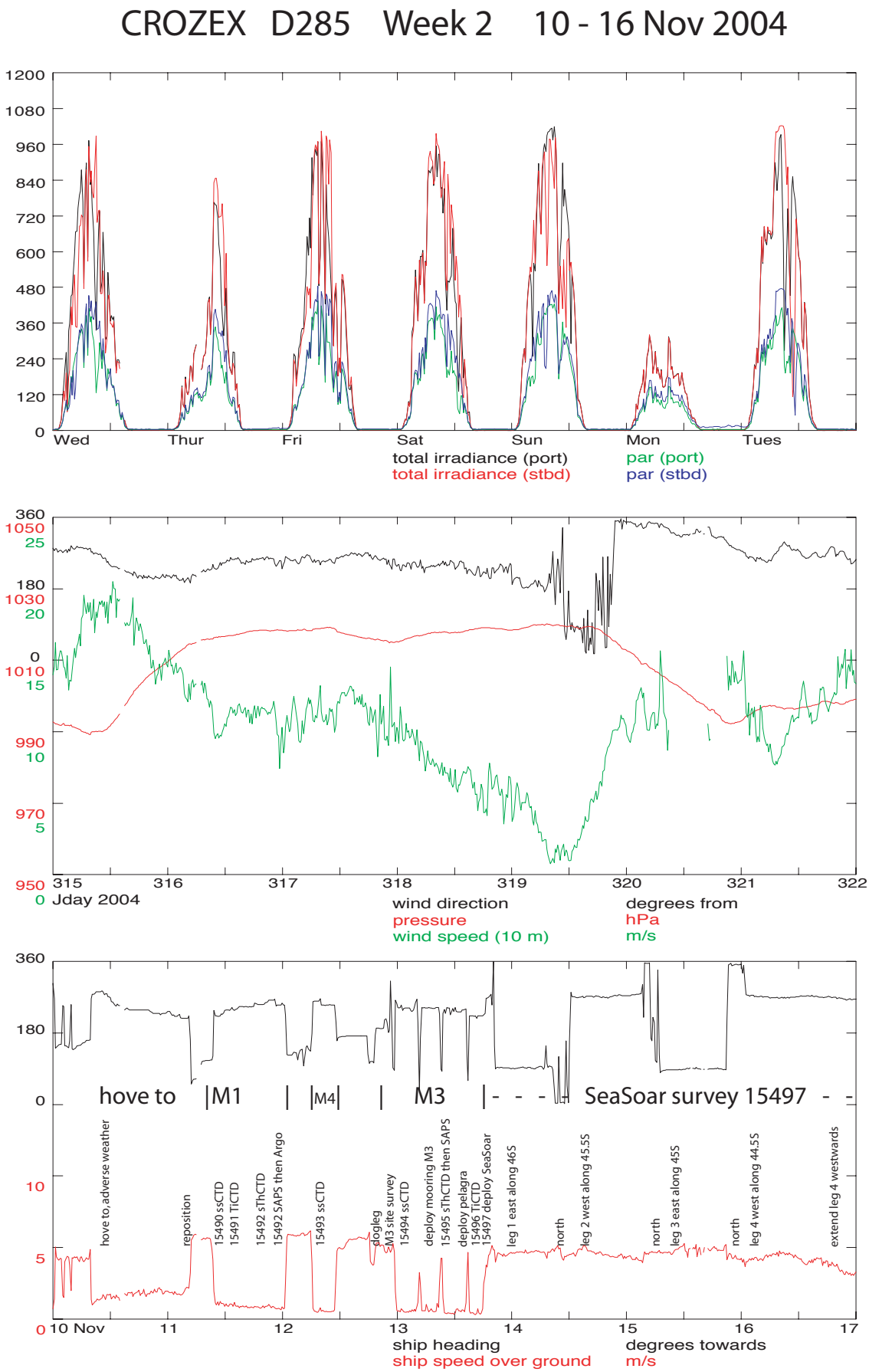


Fig. 1.3.2a - D285 week 2 10-16 Nov wind, irradiance, pressure, ship speed, direction

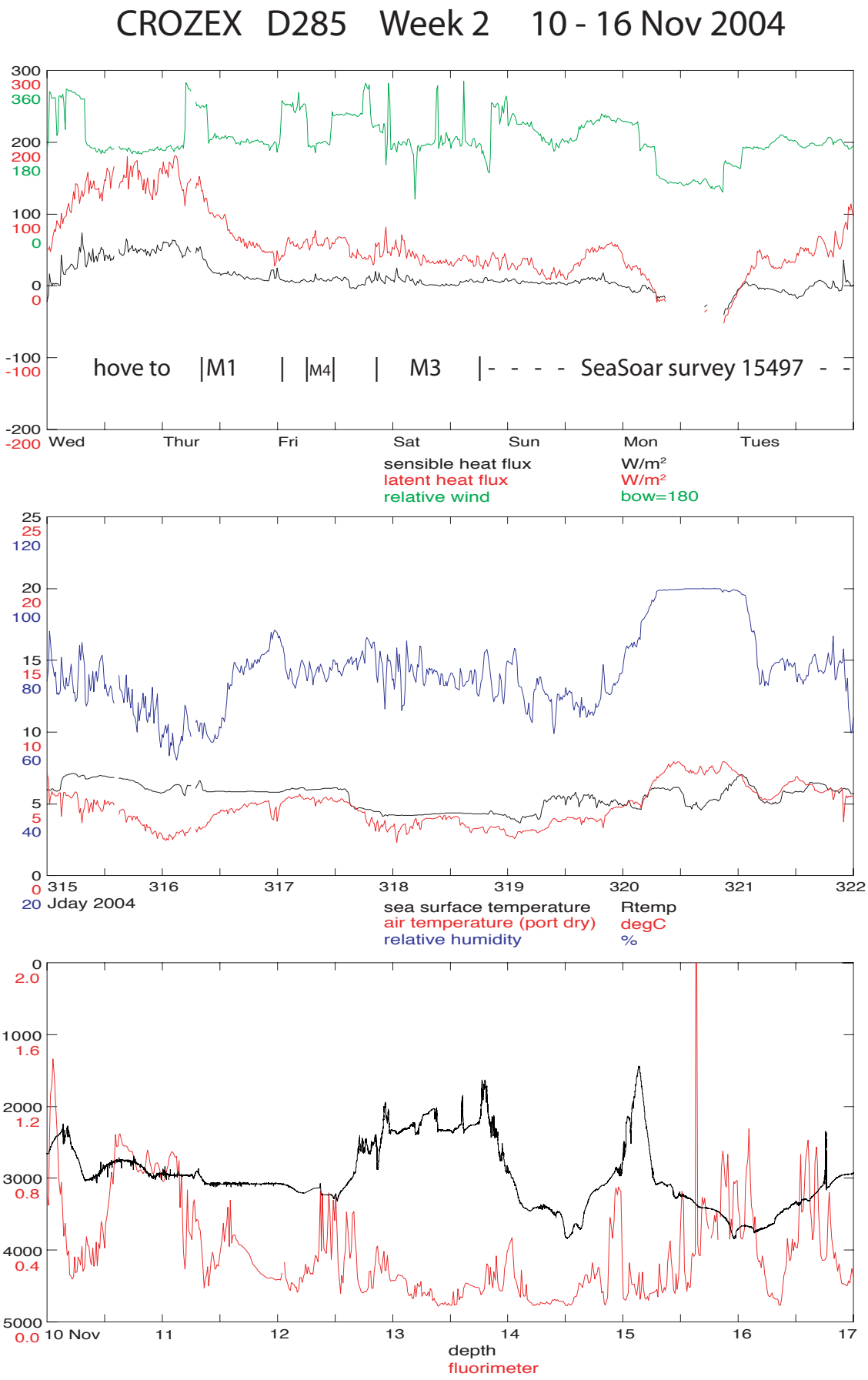


Fig. 1.3.2b - D285 week 2 10-16 Nov heat flux, SST, humidity, depth, surface chlorophyll

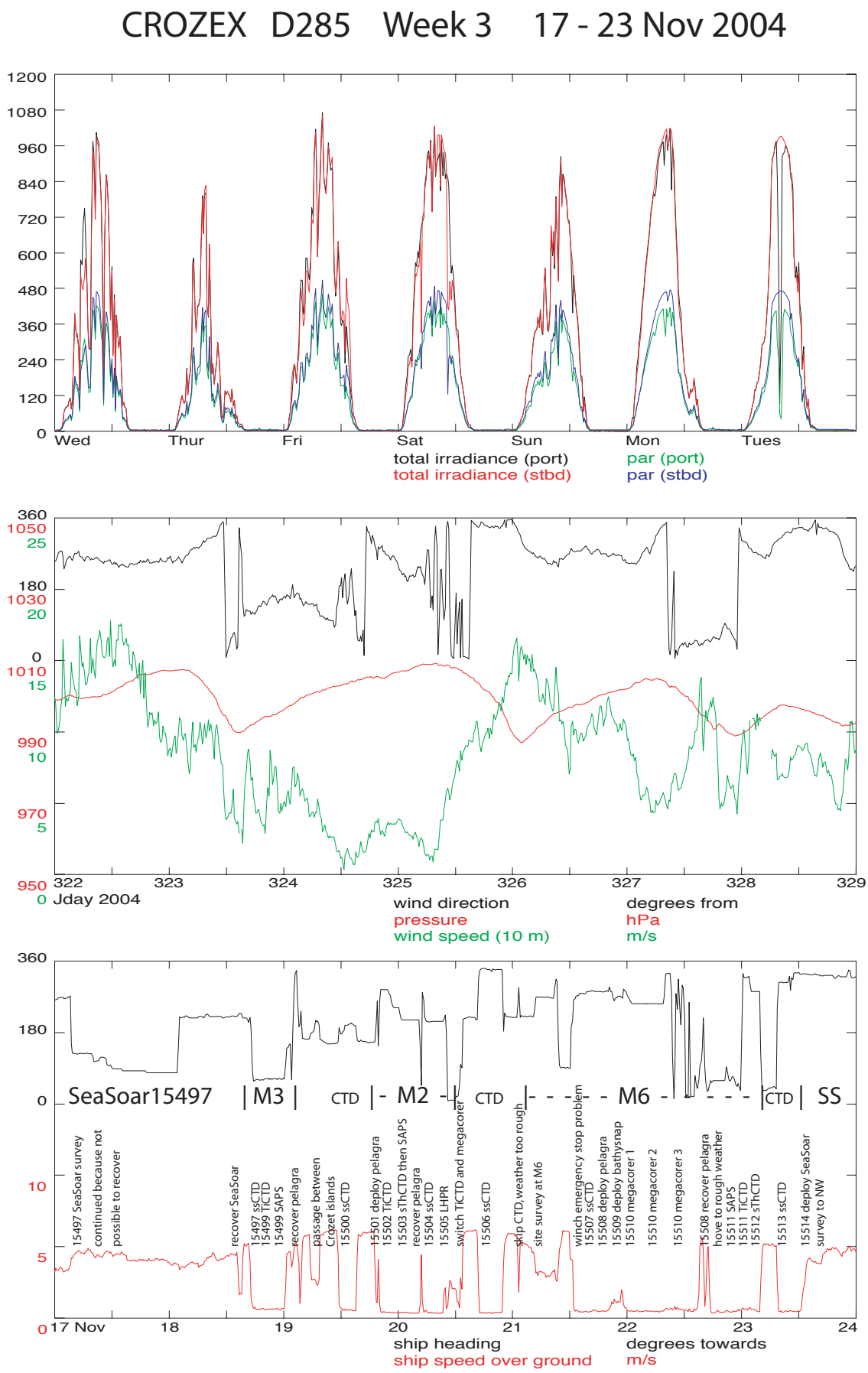


Fig. 1.3.3a - D285 week 3 17-23 Nov wind, irradiance, pressure, ship speed, direction

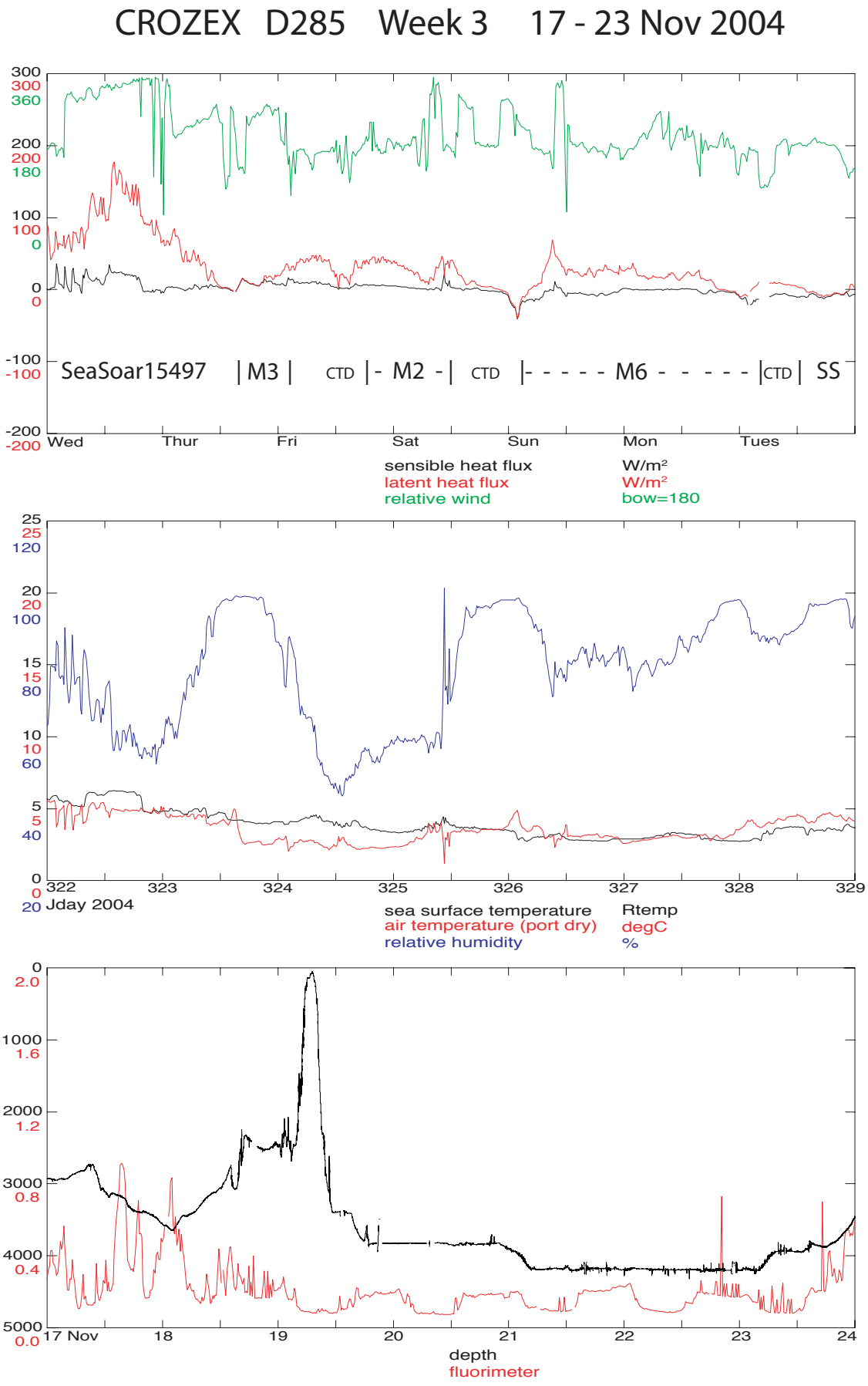


Fig. 1.3.3b - D285 week 3 17-23 Nov heat flux, SST, humidity, depth, surface chlorophyll

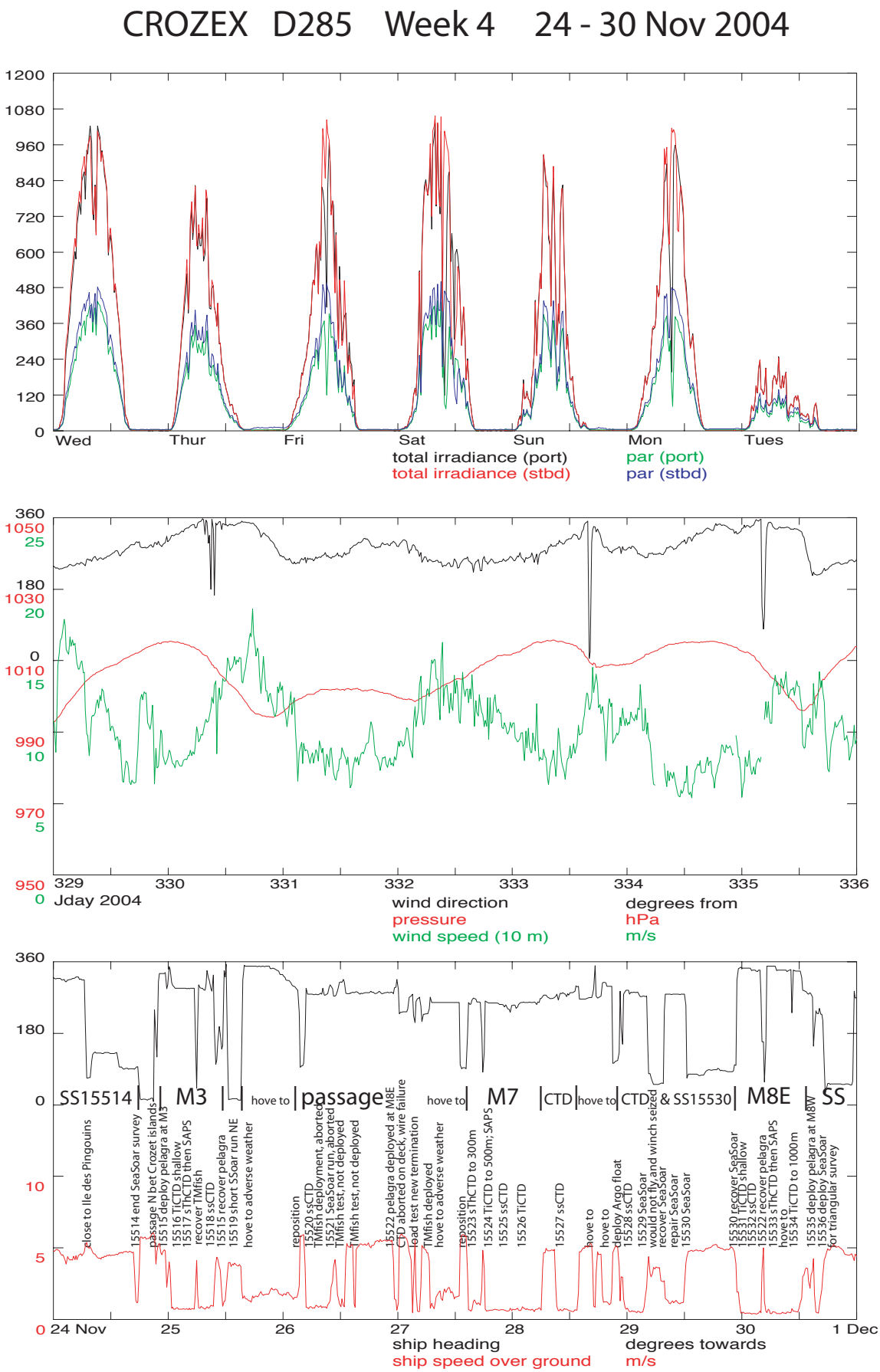


Fig. 1.3.4a - D285 week 4 24-30 Nov wind, irradiance, pressure, ship speed, direction

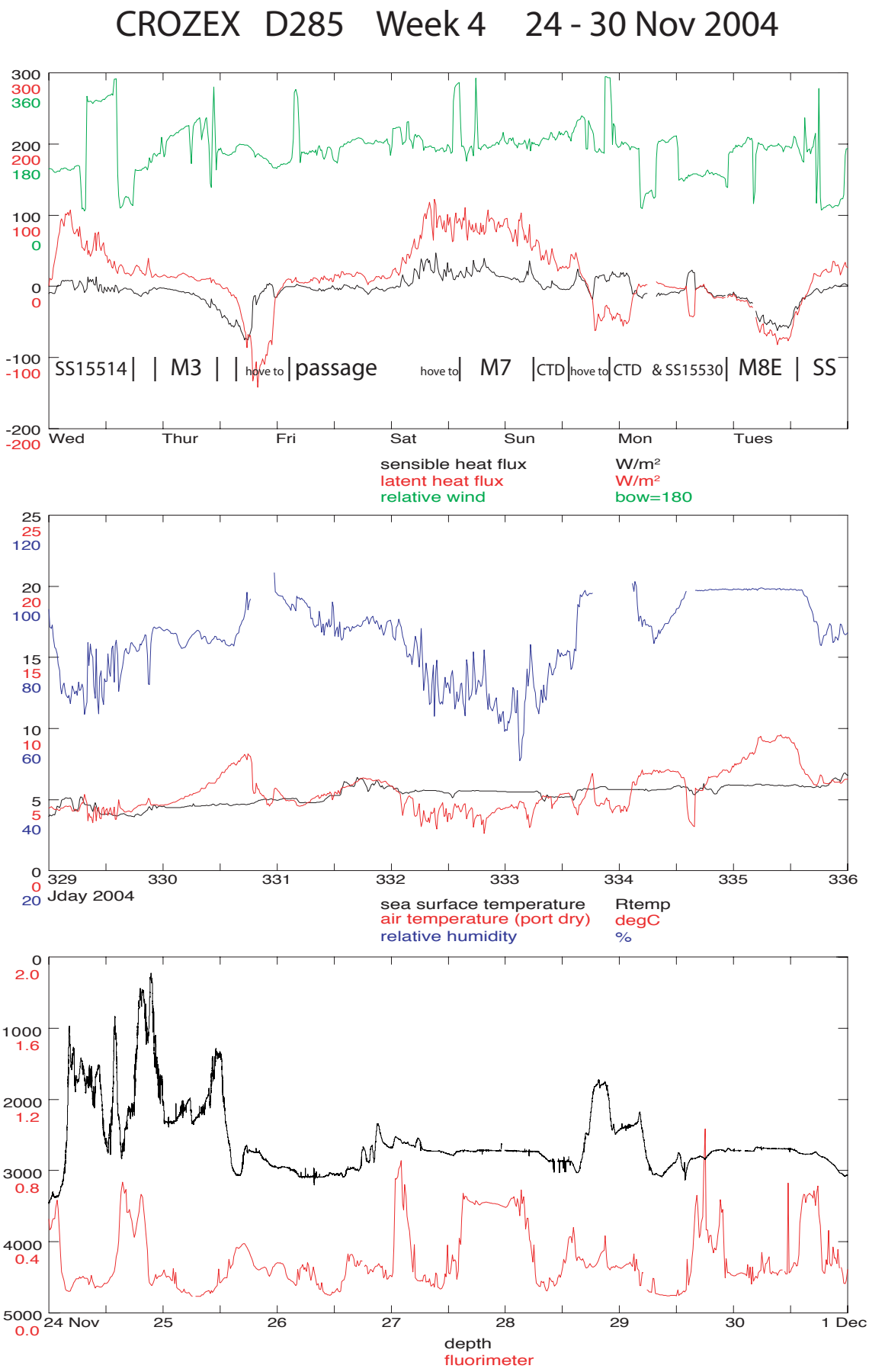


Fig. 1.3.4b - D285 week 4 24-30 Nov heat flux, SST, humidity, depth, surface chlorophyll

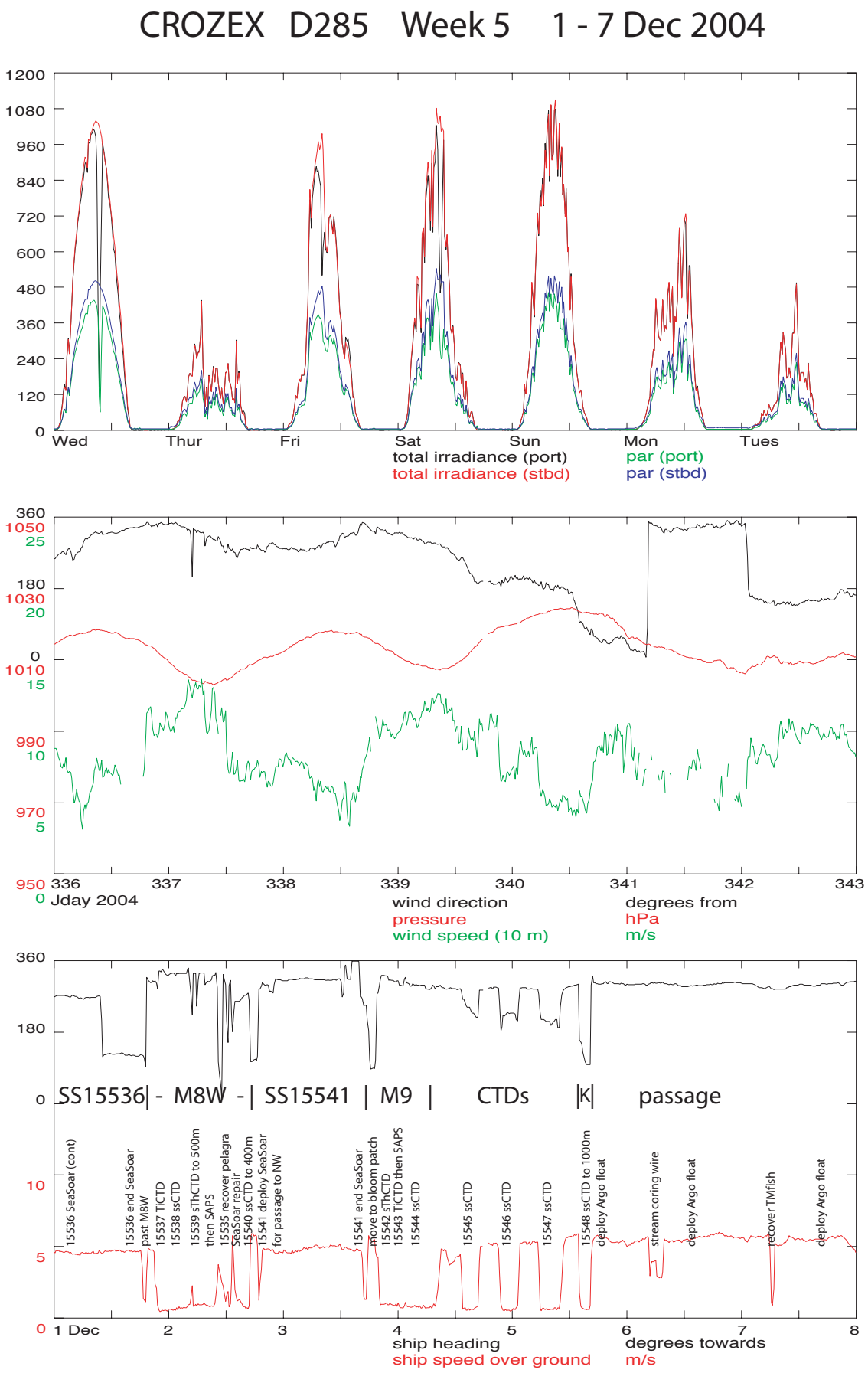


Fig. 1.3.5a - D285 week 5 1-7 Dec wind, irradiance, pressure, ship speed, direction

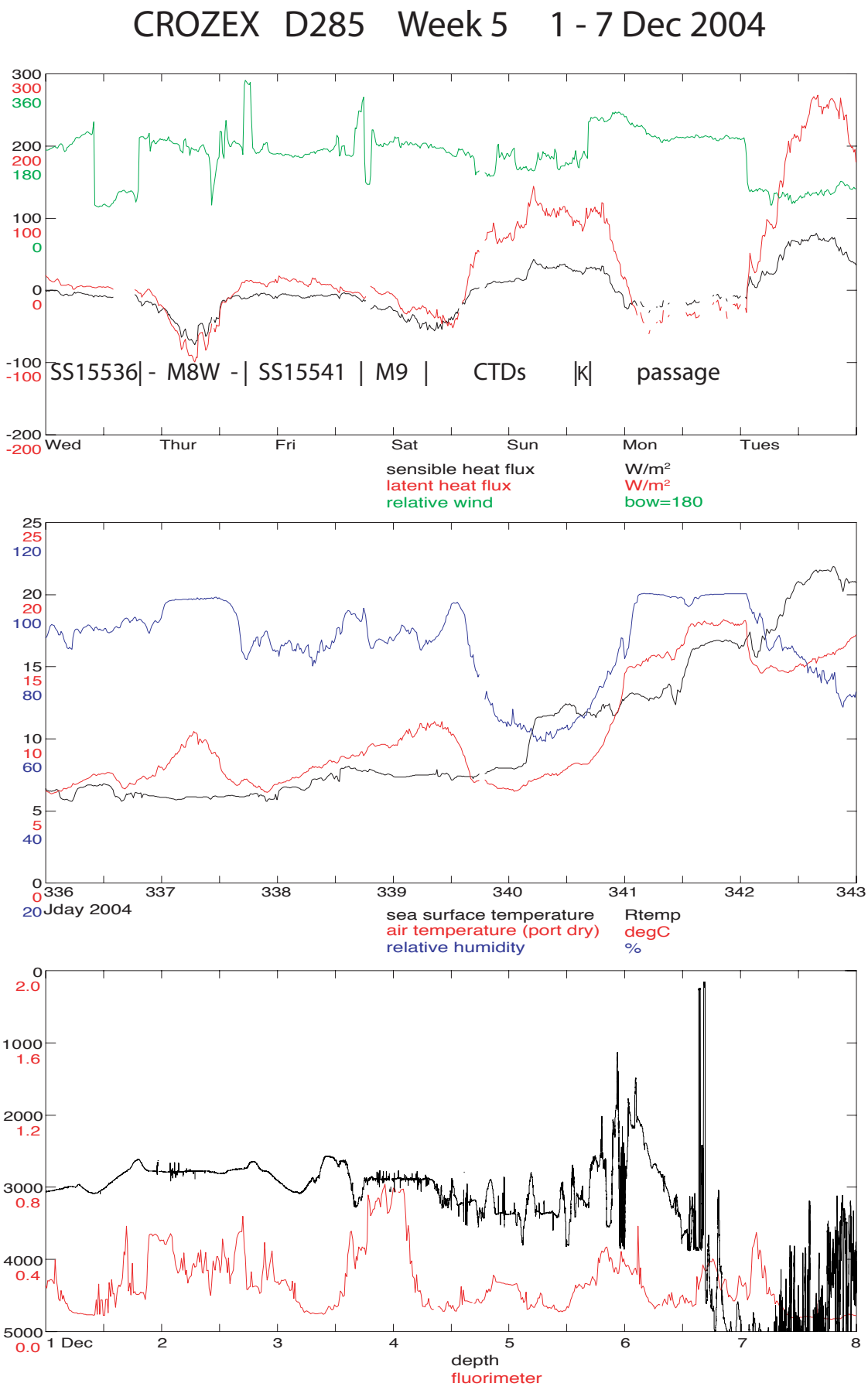


Fig. 1.3.5b - D285 week 5 1-7 Dec heat flux, SST, humidity, depth, surface chlorophyll

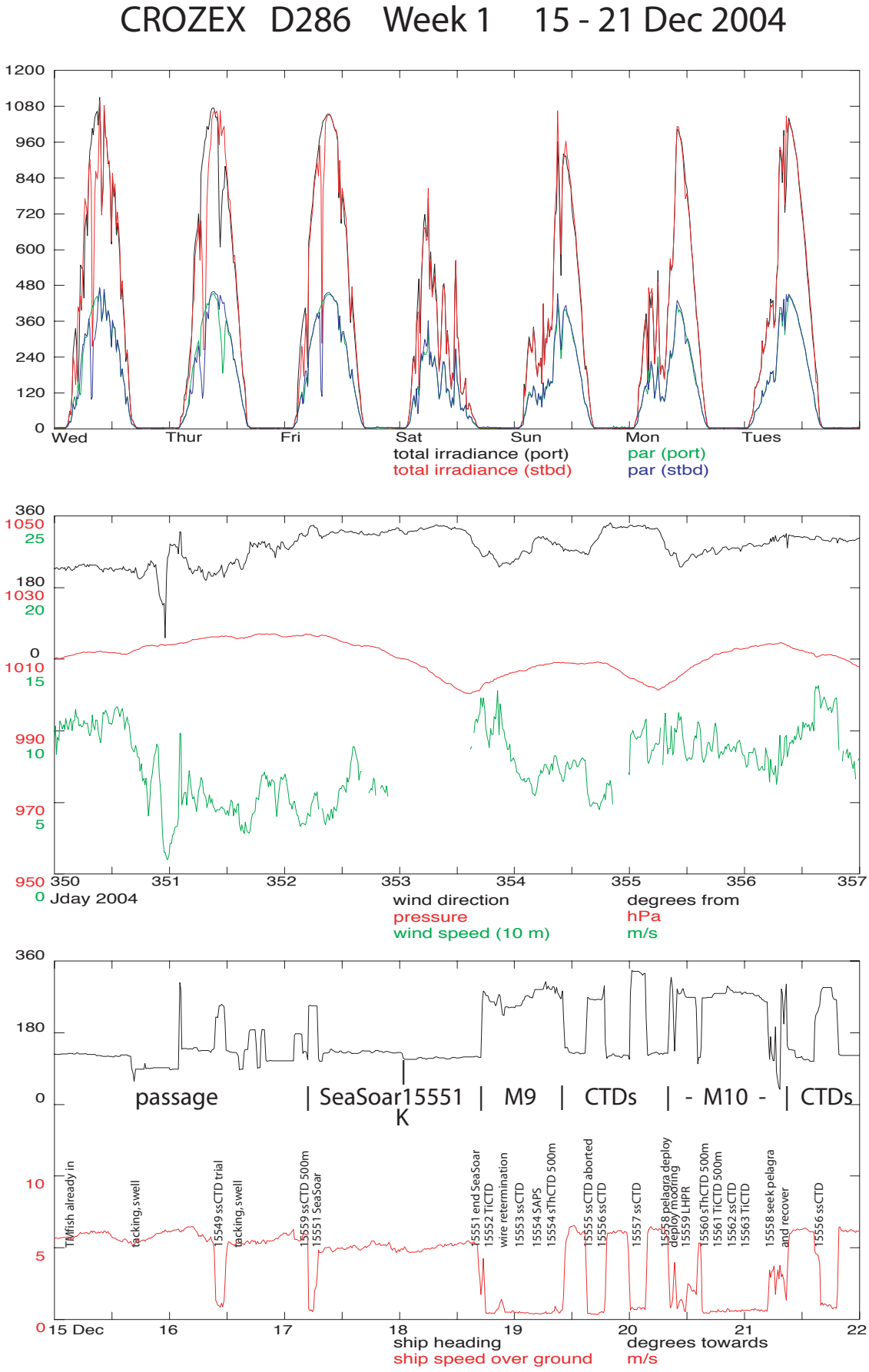


Fig. 1.3.6a - D286 week 1 15-21 Dec wind, irradiance, pressure, ship speed, direction

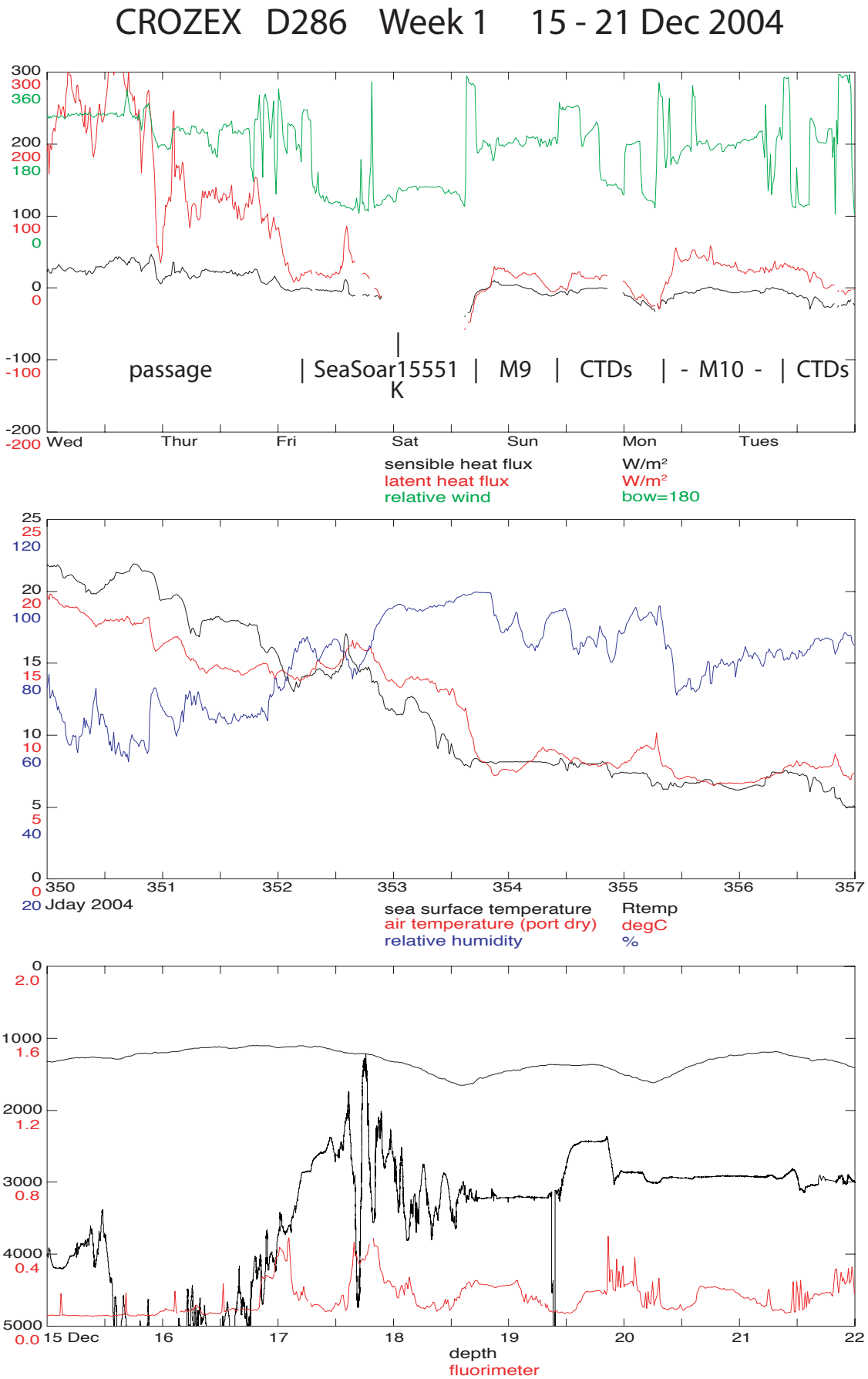


Fig. 1.3.6b - D286 week 1 15-21 Dec heat flux, SST, humidity, depth, surface chlorophyll

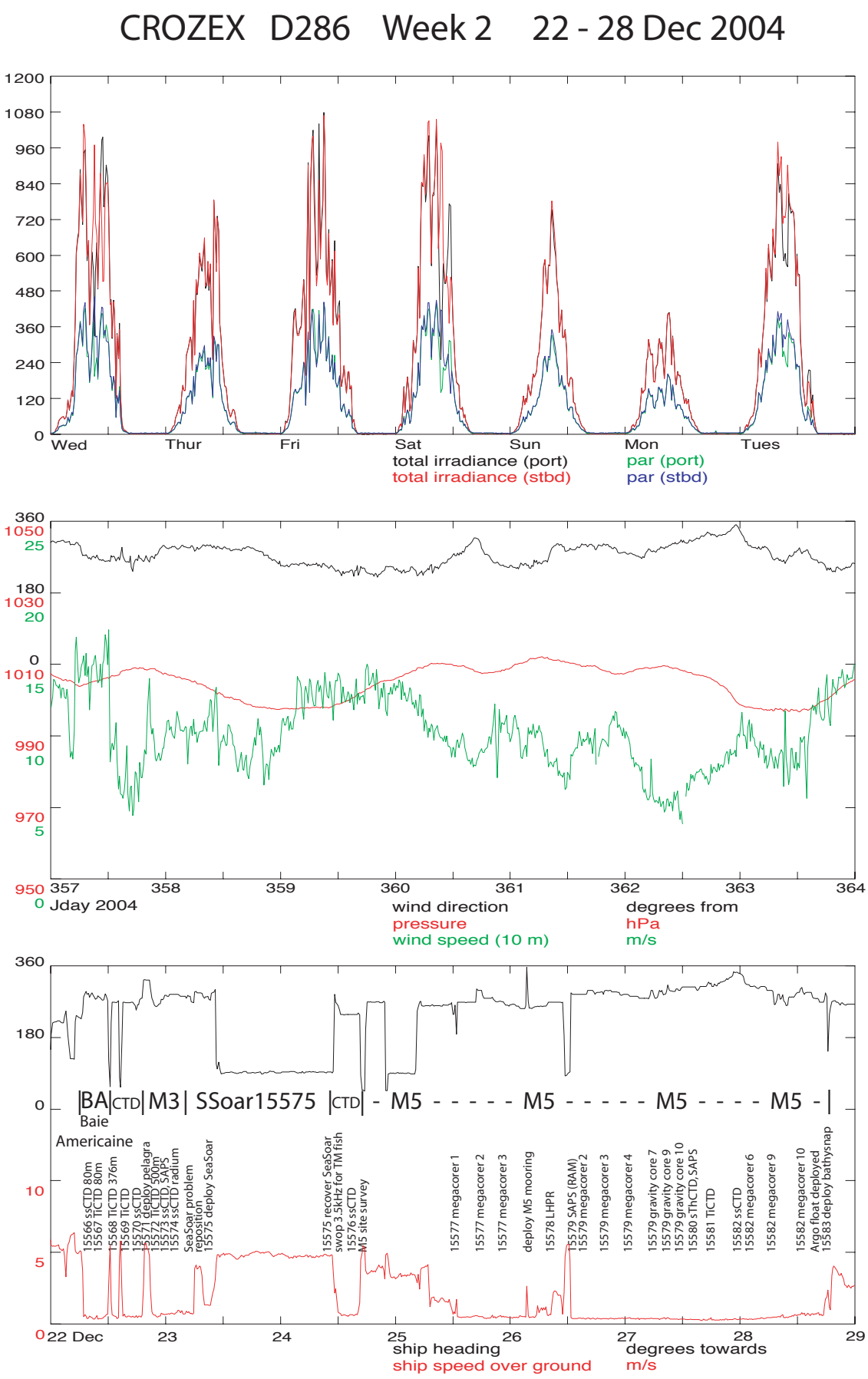


Fig. 1.3.7a - D286 week 2 22-28 Dec wind, irradiance, pressure, ship speed, direction

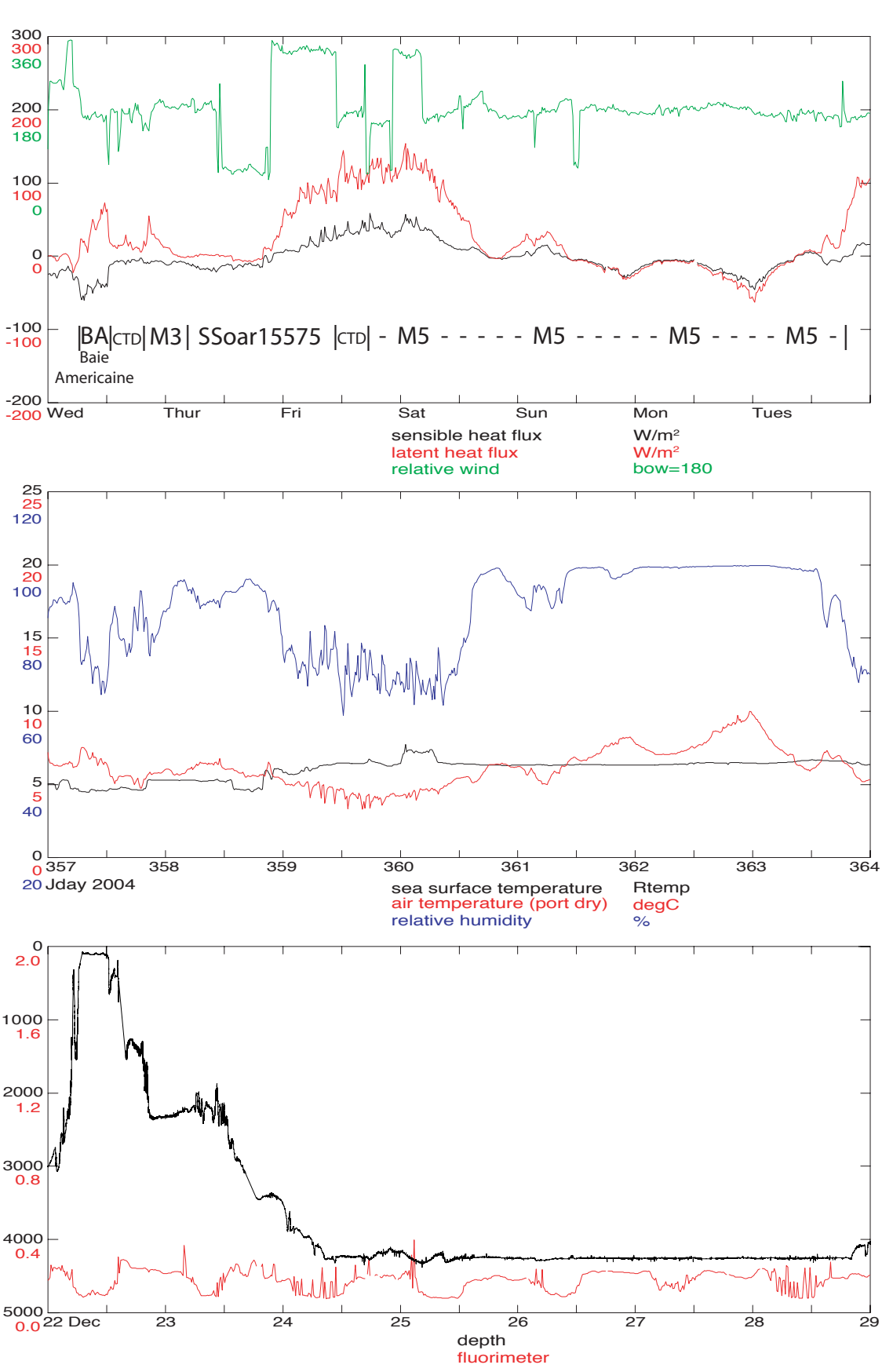


Fig. 1.3.7b - D286 week 2 22-28 Dec heat flux, SST, humidity, depth, surface chlorophyll

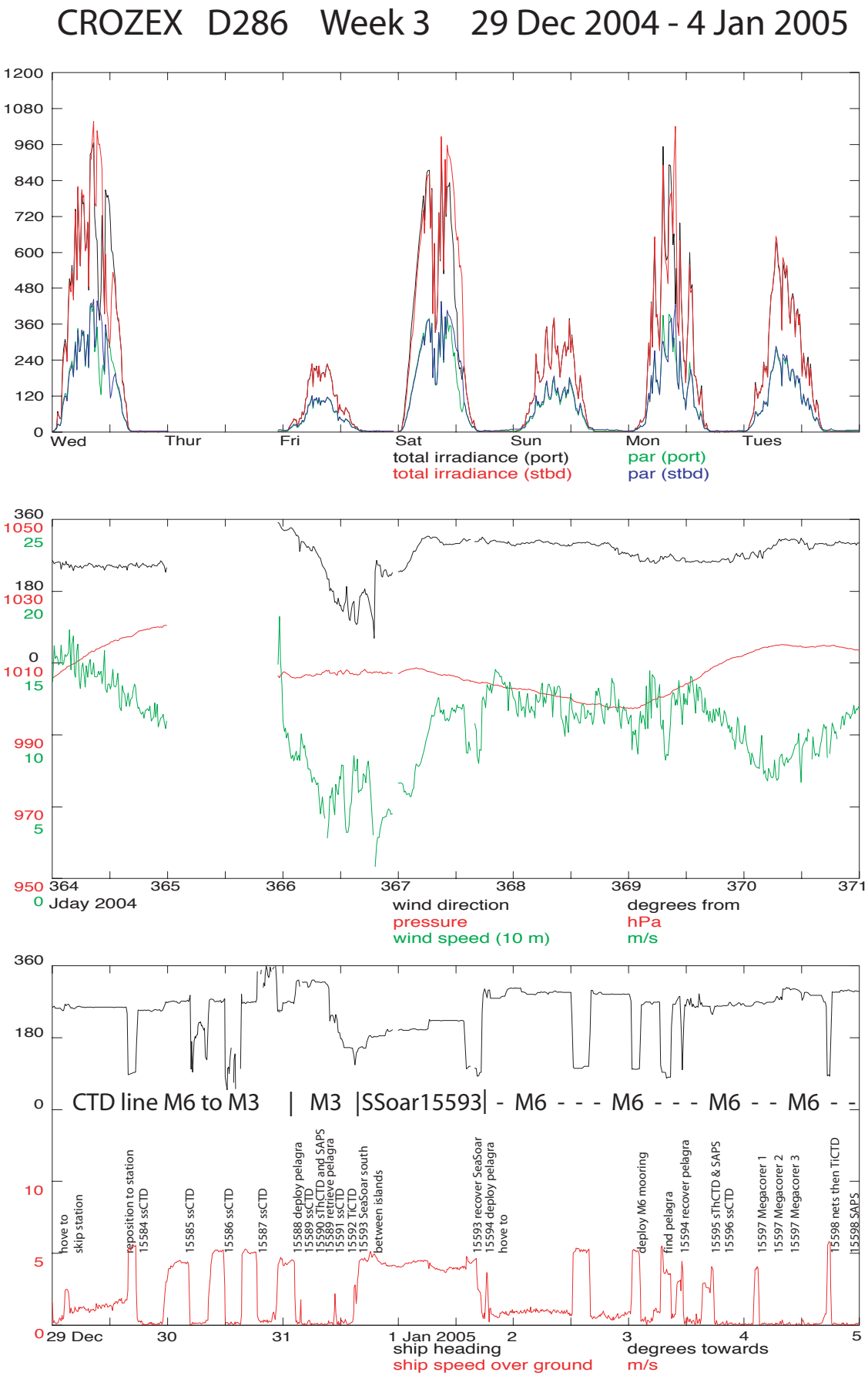


Fig. 1.3.8a - D286 week 3 29 Dec - 4 Jan wind, irradiance, pressure, ship speed, direction

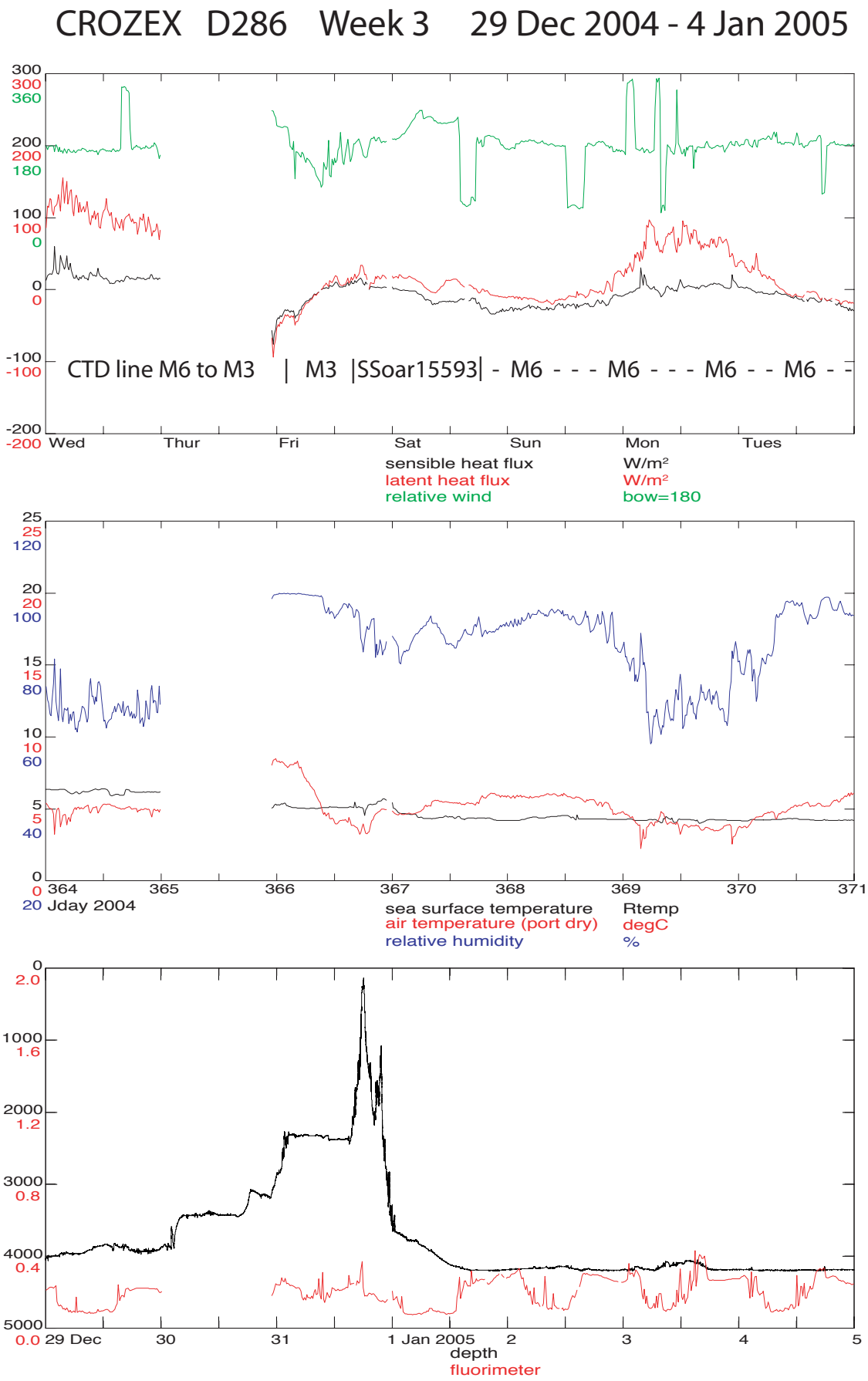


Fig. 1.3.8b - D286 week 3 29 Dec - 4 Jan heat flux, SST, humidity, depth, chlorophyll

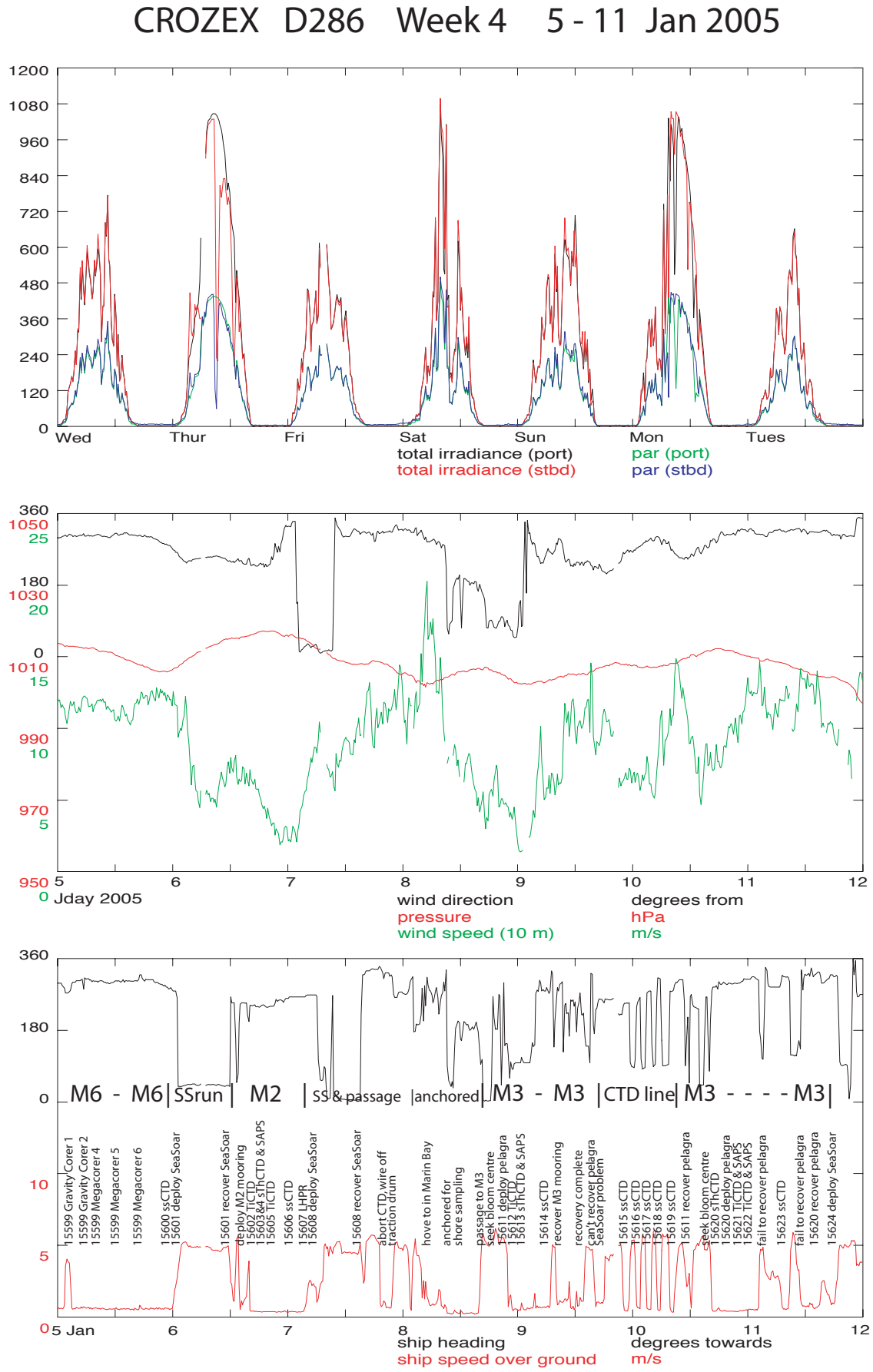


Fig. 1.3.9a - D286 week 4 5-11 Jan wind, irradiance, pressure, ship speed, direction

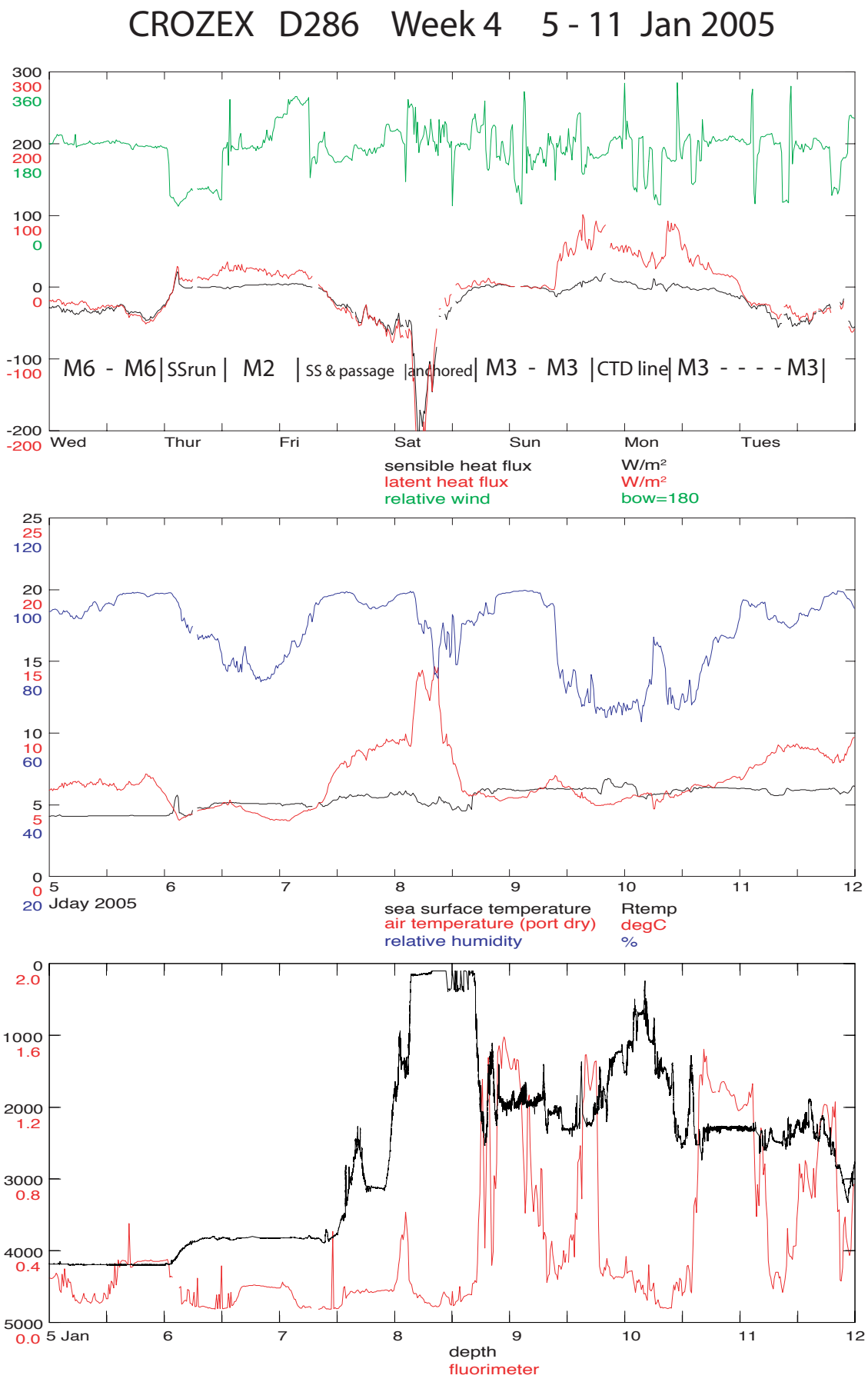


Fig. 1.3.9b - D286 week 4 5-11 Jan heat flux, SST, humidity, depth, surface chlorophyll

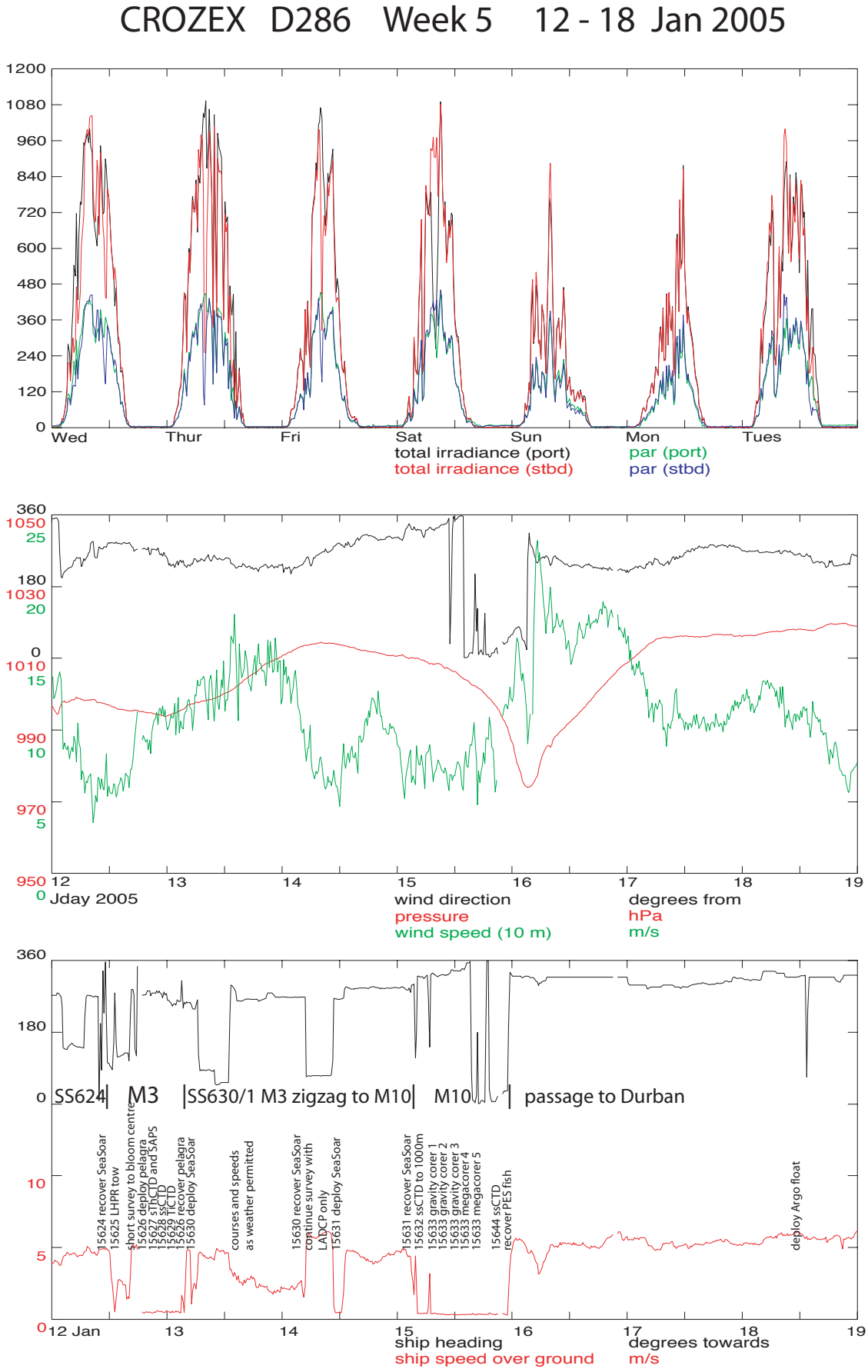


Fig. 1.3.10a - D286 week 5 12-18 Jan wind, irradiance, pressure, ship speed, direction

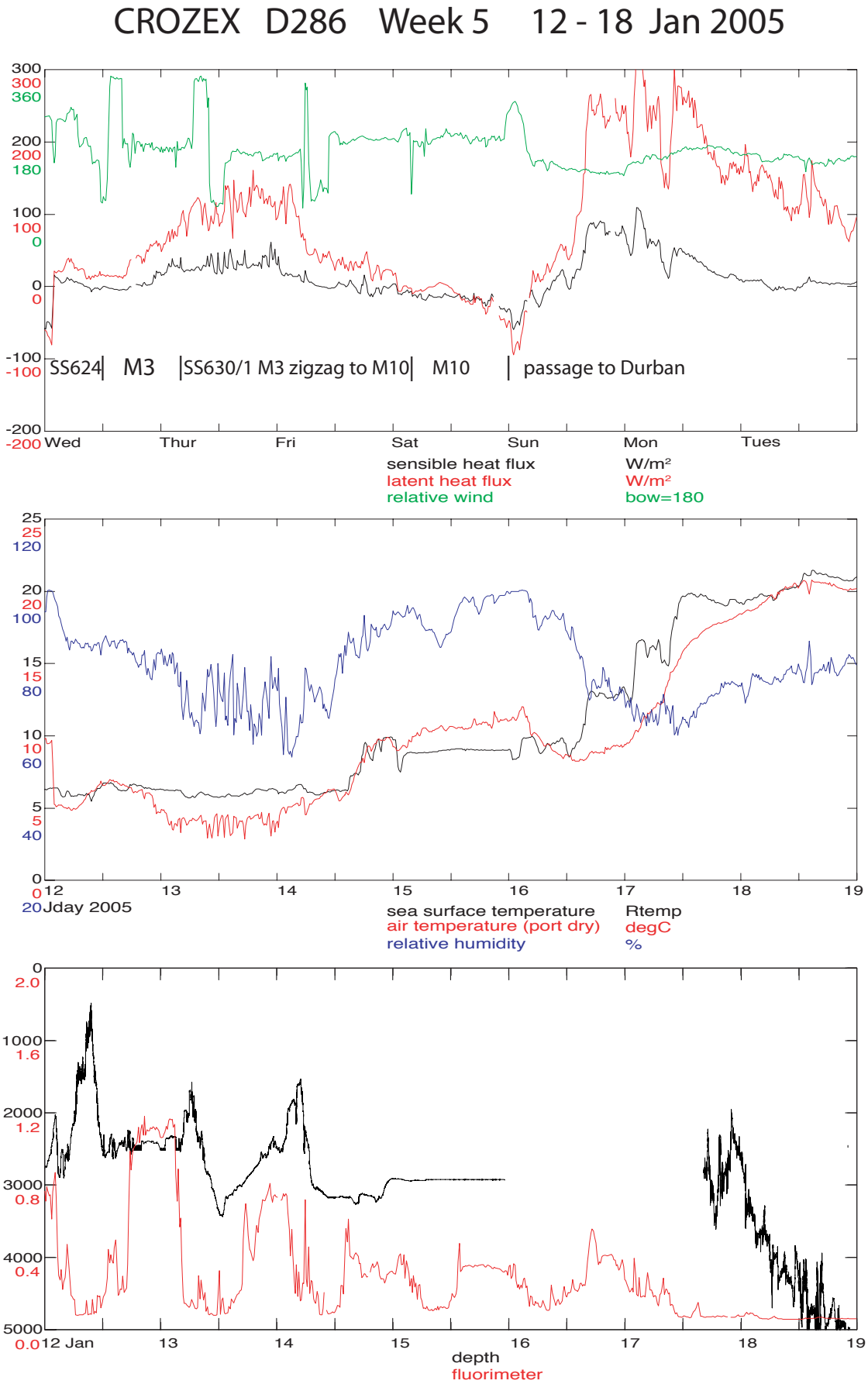


Fig. 1.3.10b - D286 week 5 12-18 Jan heat flux, SST, humidity, depth, surface chlorophyll

Tab le 1.3 **Complete station list for D285**

maintained by Claudia Castellani

Station Name	Day	Date	Station No	Deployed Instrument	Cruise Start time GMT	Di285/286 stop time GMT	Comments
	309	4/11/04		Argo floats	15:30		Provor float
	310	5/11/04	15486	T CTD	7:50	8:42	24 bottles OK
	310	5/11/04	15486 #2	net 200 um	9:22	9:52	x 1 net trial no sample
	310	5/11/04	15487	S CTD	11:25	12:27	trial cast
	312	7/11/04	15488	Sea Soar	12:00	15:19	trial tow OPC U/S ??
J	314	9/11/04	15489	S CTD	11:01	13:54	Station J bottom 12:05
	314	9/11/04	15489 #2	net 200 um	14:14	14:50	to 150 m abundance fixed
	314	9/11/04	15489 #3	net 63 um	14:39	14:56	to 150 m abundance fixed
	314	9/11/04	15489 #4	Martek float	14:56		
M4-1	316	11/11/04	15490	S CTD	10:33	13:10	at bottom ~ 11:38
	316	11/11/04	15490 #2	net 200 um	13:30	13:38	
	316	11/11/04	15490 #3	net 63 um	13:41	13:48	Kevlar cable problem net aborted
	316	11/11/04	15491	T CTD	14:08	19:16	Whinch problem See CTD log
	316	11/11/04	15492	S CTD	19:47	21:07	Thorium cast
	316	11/11/04	15492 #2	SAPS	22:20		
	316	11/11/04	15492 #3	float	0:40		leaving station
	317	12/11/04	15493	S CTD	7:00	9:48	CTD failed at ~90 m
	317	12/11/04	15493 #2	net 63 um	9:30		abundance fixed
	317	12/11/04	15493#3	net 200 um			abundance fixed
	317	12/11/04	15493#4	net 200 um	10:16		gut fluorescence
M3	318	13/11/04	15494	S CTD	0:26	2:30	
	318	13/11/04	15494 #2	net 63 um	2:40	2:52	abundance fixed
	318	13/11/04	15494 #3	net 200 um	3:00	3:13	abundance fixed
	318	13/11/04	15494 #4	net 200 um	3:15	3:25	gut fluorescence
	318	13/11/04		mooring		8:16	
	318	13/11/04	15495	S CTD	9:55	11:06	
	318	13/11/04	15495 #2	SAPS	11:32	13:43	
	318	13/11/04	15495 #3	net 63 um	13:48	13:59	bongo net abundance fixed
	318	13/11/04	15495 #4	net 200 um	14:02	14:13	abundance fixed
	318	13/11/04	15495 #5	Argo float		14:18	
	318	13/11/04	15495 #6	Pelagra		14:31	Deployed ??
	318	13/11/04	15496	T CTD	15:02	17:06	
	318	13/11/04	15497	Seasoar	17:40		start survey
M3	323	18/11/04	15497	Seasoar		15:11	end of survey
	323	18/11/04	15498	S CTD	17:35		
	323	18/11/04	15498 #2	net 63 um	19:43	20:10	to 200 m abundance
	323	18/11/04	15498 #3	net 200 um	20:16	20:29	to 100 m abundance
	323	18/11/04	15498 #4	net 200 um	20:35	20:47	gut fluorescence
	323	18/11/04	15499	T CTD	20:58	21:44	
	323	18/11/04	15499 #2	SAPS	22:07	23:45	
M2	324	19/11/04	15499 #3	net 200 um	0:01	0:12	Iron experiment 100 m
	324	19/11/04	15500	S CTD	11:48	14:35	
	324	19/11/04	15500 #2	net 200 um	14:32	14:58	200 m abundance
	324	19/11/04	15500 #3	net 63 um	15:04	15:15	100 m abundance (bongo)
	324	19/11/04	15501	Pelagra	19:35		Deployed ??
	324	19/11/04	15502	T CTD	20:18		
	325	20/11/04	15502 #2	net 63 um	0:19	0:28	
	325	20/11/04	15502 #3	net 200 um	0:33	0:43	
	325	20/11/04	15502 #4	net 200 um	0:45	0:55	
	325	20/11/04	15503	S CTD	1:20	2:00	Thorium cast
	325	20/11/04	15503 #2	SAPS	2:19		
	325	20/11/04	15501	Pelagra	5:20		on board
	325	20/11/04	15504	S CTD	5:40	9:17	in water
	325	20/11/04	15505	LHPR	10:18	12:22	
	325	20/11/04	15506	S CTD	17:15		
	325	20/11/04	15506 #2	net 63 um	21:00	21:08	100 m abundance (single net)
	325	20/11/04	15506 #3	net 200 um	21:10	21:18	100 m abundance (single net)

	325	20/11/04	15506 #4	net 200 um	21:20	21:30	gut fluorescence
M6	326	21/11/04	15507	S CTD	15:26	18:49	
	326	21/11/04	15507 #2	net 63 um	19:20	19:30	100 m abundance (single net)
	326	21/11/04	15507 #3	net 200 um	19:31	19:40	100 m abundance (single net)
	326	21/11/04	15507 #4	net 200 um	19:41	19:50	gut fluorescence
	326	21/11/04	15508	Pelagra			deployed
	326	21/11/04	15509	Roughsnap			
	326	21/11/04	15510	Megacorer	23:50	4:20	
	327	22/11/04	15510 #2	Megacorer	5:00	9:15	
	327	22/11/04	15510 #3	Megacorer	9:55	14:16	
	327	22/11/04	15508	Pelagra		16:30	recovered
	327	22/11/04	15511 #1	SAPS	19:25		Saps to 175 m
	327	22/11/04	15511 #2	T CTD	22:03	1:41	
	328	23/11/04	15511 #3	net 63 um	2:10	2:20	Feeding exp
	328	23/11/04	15511 #4	net 200 um	2:23	2:32	Fe experiment
	328	23/11/04	15512	S CTD	2:50	4:00	Thorium cast
	328	23/11/04	15513	S CTD	7:52	11:39	bottles #18 & #17 leaking. Collision with other
							CTD on deck while recovering
	328	23/11/04	15513 #2	net 63 um	11:50	12:00	abundance fixed
	328	23/11/04	15513 #3	net 200 um	12:10	12:21	abundance fixed
	328	23/11/04	15513 #4	net 200 um	12:22	12:23	gut fluorescence
	328	23/11/04	15514	Seasor	12:50		M2 at 22:56
	329	24/11/04	15515	Pelagra	23:40		deployed
M3	330	25/11/04	15516	T CTD	0:39	1:20	
	330	25/11/04	15516 #2	net 63 um	1:26	1:36	abundance fixed
	330	25/11/04	15516 #3	net 200 um	1:38	1:48	abundance fixed
	330	25/11/04	15516 #4	net 200 um	1:49	1:58	gut fluorescence
	330	25/11/04	15517	S CTD	2:12	3:00	Thorium cast
	330	25/11/04	15517 #2	SAPS	3:13	5:35	
	330	25/11/04	15518	S CTD	6:20	9:03	Bottom bottle #1 & #2 did not fire
	330	25/11/04	15518 #2	net 63 um	9:09	9:20	Feeding exp
	330	25/11/04	15518 #3	net 200 um	9:21	9:32	Fe experiment
	330	25/11/04	15519	Seasor	12:00	20:00	
	331	26/11/04	15520	S CTD			
	331	26/11/04	15520 #2	net 200 um	8:30	8:40	abundance fixed
	331	26/11/04	15520 #3	net 200 um	8:42	9:00	gut fluorescence
	331	26/11/04	15520 #4	net 63 um	9:05	9:20	bongo net abundance
	331	26/11/04	15521	Seasoar	9:49	12:00	network cable failure, hard disk file system fail
	331	26/11/04	15522	Pelagra	23:19	23:20	recovered????
M7	332	27/11/04	15523	S CTD	14:07	15:31	Thorium cast to 300 m
	332	27/11/04	15524	T CTD	18:34	19:35	
	332	27/11/04	15524 #2	SAPS	19:53	22:07	
	332	27/11/04	15525	S CTD	22:34	1:00	
	333	28/11/04	15525 #2	net 63 um	1:12	1:22	abundance fixed
	333	28/11/04	15525 #3	net 200 um	1:25	1:35	abundance fixed wire problem gut fluor net aborted
	333	28/11/04	15526	T CTD	2:31	5:04	
	333	28/11/04	15526 #2	net 63 um	5:20	5:30	abundance fixed
	333	28/11/04	15526 #3	net 200 um	5:30	5:40	abundance fixed
	333	28/11/04	15526 #4	net 200 um	5:40	5:50	gut fluorescence
	333	28/11/04	15527	S CTD	9:58	13:00	
	333	28/11/04	15527 #2	net 63 um	13:05	13:15	abundance fixed
	333	28/11/04	15527 #3	net 200 um	13:18	13:28	abundance fixed
	333	28/11/04	15527 #4	net 200 um	13:29	13:39	gut fluorescence
	333	28/11/04	15528 #2	Argo float		22:52	Provor
	334	29/11/04	15528	S CTD	0:38	2:42	
	334	29/11/04	15528 #3	net 63 um	2:50	3:00	abundance fixed
	334	29/11/04	15528 #4	net 200 um	3:04	3:14	abundance fixed
	334	29/11/04	15528 #5	net 200 um	3:15	3:25	gut fluorescence
	334	29/11/04	15529	Seasoar	3:50		Connector pin failure Penguin. No hydraulic control
	334	29/11/04	15530	Seasoar	12:00	23:30	
M8E	334/5	29/11/04	15531	T CTD	23:51	0:18	to 150 m bottles fired from 55 m
	335	30/11/04	15532	S CTD	0:37	2:50	full depth
	335	30/11/04	15532 #2	net 63 um	2:57		abundance fixed
	335	30/11/04	15532 #3	net 200 um	3:09		abundance fixed flow-meter 75390-78141
	335	30/11/04	15532 #4	net 200 um	3:24		gut fluorescence
	335	30/11/04	15533	S CTD	5:36		Thorium
	335	30/11/04	15533 #2	SAPS	7:05		
	335	30/11/04	15534 #3	net 200 um	9:28		
	335	30/11/04	15534	T CTD	10:05		CTD to 1000 m?
	335	30/11/04	15535	Pelagra	16:00		Deployed on board 2/12/04 (337) 12:58
	335	30/11/04	15536	Seasoar	7:00	19:20	

M8W	336	01_2/12/20	15537	T CTD	22:30	0:45	
	337	2/12/04	15538	S CTD	1:16		
	337	2/12/04	15538 #2	net 63 um	5:08		abundance fixed
	337	2/12/04	15538 #3	net 200 um	5:21		abundance fixed flow-meter 80288-83755
	337	2/12/04	15538 #4	net 200 um	5:32		gut fluorescence
	337	2/12/04	15539	S CTD	6:14		Thorium CTD
	337	2/12/04	15539 #2	SAPS	7:20		
	337	2/12/04	15535	Pelagra		12:58	Recovered 2/12/04 at 12:58 (see above)
	337	2/12/04	15540	S CTD	16:03	16:57	
	337	2/12/04	15541	Seasoar	18:59	17:20	
M9	338	3/12/02	15542	S CTD	20:34	21:42	Thorium CTD to 500 m
	338	3/12/02	15542 #2	net 200 um	21:54	22:04	Iron experiment 100 m
	338	3/12/02	15543	T CTD	22:40	1:19	
	339	4/12/04	15543 #2	SAPS	1:30	3:45	
	339	4/12/04	15543 #3	net 63 um	3:52	4:02	abundance fixed
	339	4/12/04	15543 #4	net 200 um	4:05	4:17	abundance fixed flow-meter: 91861-93070
	339	4/12/04	15543 #5	net 200 um	4:19	4:29	gut fluorescence
	339	4/12/04	15544	S CTD	4:50	7:46	full depth
	339	4/12/04	15545	S CTD	13:30	16:00	full depth
	339	4/12/04	15545 #2	net 63 um	16:11		abundance fixed
	339	4/12/04	15545 #3	net 200 um	16:27		abundance fixed flow-meter 93406-94531
	339	4/12/04	15545 #4	net 200 um	16:38	16:50	gut fluorescence
	339	4/12/04	15546	S CTD	21:36		to 3300 m
	340	5/12/04	15546 # 2	net 63 um	0:36		abundance fixed
	340	5/12/04	15546 # 3	net 200 um	0:51		abundance fixed flow-meter 95465-98136
	340	5/12/04	15546 # 4	net 200 um	1:05		gut fluorescence

Table 1.4 Complete station list for D286

maintained by Alex Gardiner

					time	time	
	CROZEX				**begins**	**ends**	
JDAY	**date**	**site**	**Station**	**Instrument**	**(GMT)**	**(GMT)**	**Comments**
351	16-Dec		15549	NET	9:30	10:15	Trials
351	16-Dec		#2	CTD	11:00		Trials
352	17-Dec		15550	CTD	5:10	6:00	CTD shallow to calibrate seasoar
353	18-Dec		15551	seasoar		17:00	tow from ~K to M9
353	18-Dec	M9	15552	TiCTD	18:05	20:42	
353	18-Dec			SSCTD			CTD cable jumped tension drums
							Re-termination 22:15
353	18-Dec		#2	200um	23:23	23:32	200um net, 0-100m fixed
353	18-Dec		#3	200um	23:35	23:42	200um, gut fluoresence
353	18-Dec		#4	63um	23:49	23:56	63um, 0-100m fixed
354	19-Dec		15553	SSCTD	3:10	5:50	full depth
354	19-Dec		15554	SAPS	6:11	8:11	
354	19-Dec		#2	SSThCTD	8:43	9:40	
354	19-Dec		#3	net	9:55	10:07	
354	19-Dec		15555	CTD	15:15	15:35	forgot to remove PAR sensor
354	19-Dec		15556	CTD	15:42	18:00	
354	19-Dec		#2	63um	18:18	18:28	63um net
354	19-Dec		#3	200um	18:31	18:37	200um net
354	19-Dec		#4	200um	18:39	18:47	200um net
355	20-Dec		15557	SCTD	0:16	2:43	
355	20-Dec		#2	63um	2:52	3:01	0-100m
355	20-Dec		#3	200um	3:05	3:14	0-100m, 125306 127229
355	20-Dec		#4	200um	3:16		0-100m
355	20-Dec		15558	Pelagra	8:35	8:40	ends on 21/12/04
355	20-Dec	M10		Sediment trap	na	10:59	M10 mooring
355	20-Dec		15559	LHPR	11:49	13:54	
355	20-Dec		15560	ThCTD	15:18	16:10	
355	20-Dec		#2	SAPS	16:25	18:30	2h deployment 110m
355	20-Dec		15561	TiCTD	18:45	19:36	200m
355	20-Dec		15562	SCTD	19:55	22:37	
355	20-Dec		#2	200um	22:40	22:50	
355	20-Dec		15563	TiCTD	23:24	1:44	full depth
356	21-Dec		#2	63um	1:52	2:02	
356	21-Dec		#3	200um	2:05	2:15	
356	21-Dec		#4	200um	2:18	2:28	
356	21-Dec		15564	CTD	2:41	4:52	radium & neodinium full depth
356	21-Dec		15565	SS CTD	15:56	18:26	full depth
356	21-Dec		#2	63 um	na	19:20	abandoned - wind too strong
357	22-Dec	Baie	15566	SS CTD	7:30	na	~100m
357	22-Dec	Americaine	15567	Ti CTD	9:53	na	
357	22-Dec		#2	200 um	na	na	fixed ~80m

357	22-Dec		#3	200 um	10:48	na	gut fluor ~80m
357	22-Dec		#4	63 um	11:00	na	fixed ~80m
357	22-Dec		15568	Ti CTD	12:55	13:42	500m
357	22-Dec		#2	200 um	13:48	13:57	0-100m 138379
357	22-Dec		#3	200 um	14:00	14:09	141230 144316
357	22-Dec		15569	Ti CTD	15:10	16:40	full depth
357	22-Dec		15570	SS CTD	17:05	18:35	full depth
357	22-Dec		#2	63 um	na	na	
357	22-Dec		#3	200 um	na	na	
357	22-Dec		#4	200 um	na	19:25	
357	22-Dec	M3	15571	Pelagra	21:00	na	
357	22-Dec	M3	15572	Ti CTD	21:25	22:17	500m
358	23-Dec	M3	15573	SS CTD	22:36	0:45	full depth
358	23-Dec		#2	SAPS	1:05	3:15	180m
358	23-Dec		15574	ThCTD	3:41	4:25	
358	23-Dec		#2	63 um	4:34	4:40	0-100m
358	23-Dec		#3	200 um	4:43	4:50	
358	23-Dec		#4	200 um	4:52	4:58	
358	23-Dec		#5	200 um	4:59	5:07	
358	23-Dec		15575	seasoar	9:35	11:50	ends on 24/12/04
359	24-Dec		15576	SSCTD	12:48	16:05	full depth
360	25-Dec		15577	Mega	12:59	17:20	no mud - redeploy
360	25-Dec		#2	Mega	17:28	21:55	
360	25-Dec		#3	Mega	22:06	2:46	mud!
361	26-Dec			Mooring	5:50	7:38	check posns
361	26-Dec		15578	LHPR	8:38	10:56	
361	26-Dec		15579	SAPS	12:49	14:25	
361	26-Dec		#2	Mega	14:52	19:07	
361	26-Dec	M5	#3	Mega	19:20	23:45	3 cores
362	27-Dec	M5	#4	Mega	0:07	4:25	4 cores
362	27-Dec	M5	#5	200 um	4:46	4:51	
362	27-Dec	M5	#6	200 um	4:53	5:00	
362	27-Dec	M5	#7	gravity core	6:02	8:10	short core retrieved
362	27-Dec	M5	#8	net	8:37	8:47	
362	27-Dec	M5	#9	gravity core	8:54	10:54	
362	27-Dec	M5	#10	gravity core	11:30	13:37	
362	27-Dec	M5	#11	200 um	14:01	14:09	162380 164205
362	27-Dec	M5	#12	200 um	14:10	14:18	
362	27-Dec	M5	15580	ThCTD	14:55	15:47	500m
362	27-Dec	M5	#2	SAPS	16:03	18:05	1.5hr pump 125m
362	27-Dec	M5	#3	NET	na	na	
362	27-Dec	M5	15581	TiCTD	18:45	22:17	
362	27-Dec	M5	#2	NET	22:23	22:30	fixed 170847 173470
362	27-Dec	M5	#3	NET	22:31	22:39	
362	27-Dec	M5	15582	SSCTD	22:53	2:04	
363	28-Dec	M5	#2	63 um	2:14	2:22	
363	28-Dec	M5	#3	200 um	2:26	2:34	
363	28-Dec	M5	#4	200 um	2:36	2:44	
363	28-Dec	M5	#5	200 um	2:47	2:55	
363	28-Dec	M5	#6	Mega	3:25	7:55	
363	28-Dec	M5	#7	200 um	8:16	8:24	0-100m fixed 183825 186431
363	28-Dec	M5	#8	200 um	8:25	8:34	gut fluor
363	28-Dec	M5	#9	Mega	8:40	13:00	
363	28-Dec	M5	#10	Mega	13:25	17:25	
363	28-Dec			ARGO	17:38	na	Argo float
363	28-Dec		15583	B/SNAP	18:54	na	
364	29-Dec		15584	SSCTD	19:00	na	
364	29-Dec		#2	63um	na	na	net
364	29-Dec		#3	200um	na	na	net

364	29-Dec		#4	200um	na	23:05	gut fluor
365	30-Dec		15585	SSCTD	5:08	7:40	full depth
365	30-Dec		#2	63um	na	na	fixed
365	30-Dec		#3	200um	na	na	fixed
365	30-Dec		#4	200um	na	na	gut fluor
365	30-Dec		15586	SSCTD	12:10	na	
365	30-Dec		#2	63um	14:51	15:00	fixed
365	30-Dec		#3	200um	15:03	15:11	fixed
365	30-Dec		#4	200um	15:13	15:21	gut fluor
365	30-Dec		15587	SSCTD	19:10	21:40	
366	31-Dec	M3	15588	Pelagra	3:34	perhaps	
366	31-Dec		15589	SSCTD	4:01	6:00	full depth
366	31-Dec		#2	63um	na	na	0-100m fixed
366	31-Dec		#3	200um	na	na	fixed
366	31-Dec		#4	200um	na	na	gut fluor
366	31-Dec		15590	ThCTD	7:10	7:52	
366	31-Dec	M3	#2	SAPS	8:30	10:55	
366	31-Dec	M3	15591	SSCTD	11:27	13:00	
366	31-Dec		#2	200um	13:09	na	iron
366	31-Dec		#3	200um	13:21	13:30	iron
366	31-Dec		15592	TiCTD	14:10	14:40	200m
366	31-Dec	M3	15593	seasoar	15:20	17:00	run S between islands ends 1/1/05
366	31-Dec		15594	Pelagra	18:03	3/1/05	
3	3-Jan	M6	na	mooring	4:40	6:16	
3	3-Jan		15595	ThCTD	18:13	na	restart programme
3	3-Jan		#2	SAPS	19:26	21:26	
3	3-Jan	M6	15596	SSCTD	22:08	1:03	full depth
4	4-Jan		#2	63um	1:14	1:24	fix 0-100m
4	4-Jan		#3	200um	1:26	1:34	fix 0-100m
4	4-Jan		#4	200um	1:36	1:44	gut fluor 0-100m
4	4-Jan	M6	15597	Mega	3:20	7:30	1 core
4	4-Jan		#2	Mega	7:50	12:00	1 really good core
4	4-Jan		#3	Mega	12:10	16:20	1 really long core
4	4-Jan	M6	15598	200um	18:10	18:18	
4	4-Jan		#2	200um	18:20	18:30	
4	4-Jan		#3	TiCTD	18:52	21:52	
4	4-Jan		#4	net	21:58	22:08	
4	4-Jan		#5	net	22:09	22:18	
4	4-Jan		#6	SAPS	23:10	0:40	
5	5-Jan		15599	gravity core	3:01	5:28	
5	5-Jan		#2	gravity core	5:36	na	
5	5-Jan		#3	net	8:52	9:00	
5	5-Jan		#4	Mega	9:15	13:30	4 good cores
5	5-Jan		#5	Mega	13:45	17:57	did not trip
5	5-Jan		#6	Mega	18:05	22:23	no cores
5	5-Jan		15600	SSCTD	23:00	23:34	400m bottles 1-23 odd numbers
							only for Ross Holland
6	6-Jan		15601	seasoar	0:10	12:27	
6	6-Jan	M2	mooring	Mooring	15:30	na	
6	6-Jan		15602	TiCTD	16:18	16:45	200m
6	6-Jan		15603	ThCTD	16:59	17:40	500m, 3 misfires, redo
6	6-Jan		15604	ThCTD	18:01	18:22	
6	6-Jan		#2	SAPS	18:40	20:50	
6	6-Jan		15605	TiCTD	21:07	23:43	full depth
6	6-Jan		#2	net	na	na	
6	6-Jan		#3	net	na	na	
6	6-Jan		#4	net	na	na	
6	6-Jan		#5	net	na	na	
7	7-Jan		15606	SSCTD	0:41	3:25	

7	7-Jan		15607	LHPR	3:59	6:06	start paying out 04:03
7	7-Jan		15608	seasoar	7:20	15:55	
7	7-Jan	M3	15609	200um	21:28	21:38	0-100m fixed
7	7-Jan	M3	#2	200um	21:38	21:48	0-100m gut fluor
8	8-Jan	M3	15610	200um	1:36	1:44	0-100m fixed
8	8-Jan	M3	#2	200um	1:45	1:54	0-100m gut fluor
8	8-Jan	M3	15611	Pelagra	22:12	12:15	ends 10/1/05
8	8-Jan	M3	15612	TiCTD	22:48	23:35	500m
8	8-Jan	M3	15613	ThCTD	23:57	0:45	500m Thorium
9	9-Jan	M3	#2	SAPS	1:45	na	
9	9-Jan	M3	#3	63um	3:37	na	
9	9-Jan	M3	#4	200um	3:49	na	
9	9-Jan	M3	#5	200um	4:00	na	
9	9-Jan	M3	#6	200um	4:10	na	
9	9-Jan	M3	15614	SSCTD	4:43	6:37	full depth
9	9-Jan	M3	mooring	recovery	na	na	recovery
9	9-Jan		15615	SSCTD	22:12	23:05	500m
10	10-Jan		15616	SSCTD	0:44	1:38	500m
10	10-Jan		15617	SSCTD	2:55	3:53	500m
10	10-Jan		15618	SSCTD	5:09	5:46	
10	10-Jan		15619	SSCTD	7:42	8:33	
10	10-Jan		15620	ThCTD	16:31	17:31	
10	10-Jan		#2	Pelagra	na	15:00	ends 12/1/05
10	10-Jan		15621	TiCTD	18:13	18:52	
10	10-Jan		#2	SAPS	19:10	21:10	
10	10-Jan		#3	63um	21:30	na	0-100m fixed
10	10-Jan		#4	200um	21:41	na	0-100m fixed
10	10-Jan		#5	200um	21:50	na	0-100, gut fluor
10	10-Jan		#6	200um	22:02	22:12	Sophie Fe
10	10-Jan		15622	TiCTD	22:20	0:07	
11	11-Jan		#2	SAPS	0:30	2:05	Mills saps 30m GFF + nucleo
11	11-Jan		15623	SSCTD	7:07	7:48	
11	11-Jan		#2	63um	8:02	na	0-100m fixed
11	11-Jan		#3	200um	8:12	na	0-100m fixed
11	11-Jan		#4	200um	8:22	na	0-100m gut fluor
12	12-Jan		15624	seasoar	na	12:47	
12	12-Jan		15625	LHPR	13:30	15:38	
12	12-Jan		15626	Pelagra	18:20	3:25	ends 14/1/05
12	12-Jan		15627	ThCTD	19:00	19:45	
12	12-Jan		#2	SAPS	20:10	22:21	to 80m
12	12-Jan		15628	SSCTD	22:47	2:55	
13	13-Jan		15629	TiCTD	1:18	na	
13	13-Jan		#2	63um	2:16	na	
13	13-Jan		#3	200um	2:28	na	fixed gut fluror
13	13-Jan		#4	200um	2:38	na	iron
13	13-Jan		#5	200um	2:48	na	
13	13-Jan		15630	seasoar	5:30	4:38	ends 14/1/05
14	14-Jan		15631	seasoar	12:45	3:31	
15	15-Jan		15632	SSCTD	4:22	na	
15	15-Jan		#2	200um	5:34	5:42	
15	15-Jan		15633	gravity core	6:58	na	2m barrel
15	15-Jan		#2	gravity core	9:02	10:45	2m barrel
15	15-Jan		#3	gravity core	11:08	na	2m barrel
15	15-Jan		#4	Mega	13:40	na	
15	15-Jan		#5	Mega	16:56	na	
15	15-Jan		15634	SSCTD	20:58	22:56	full depth

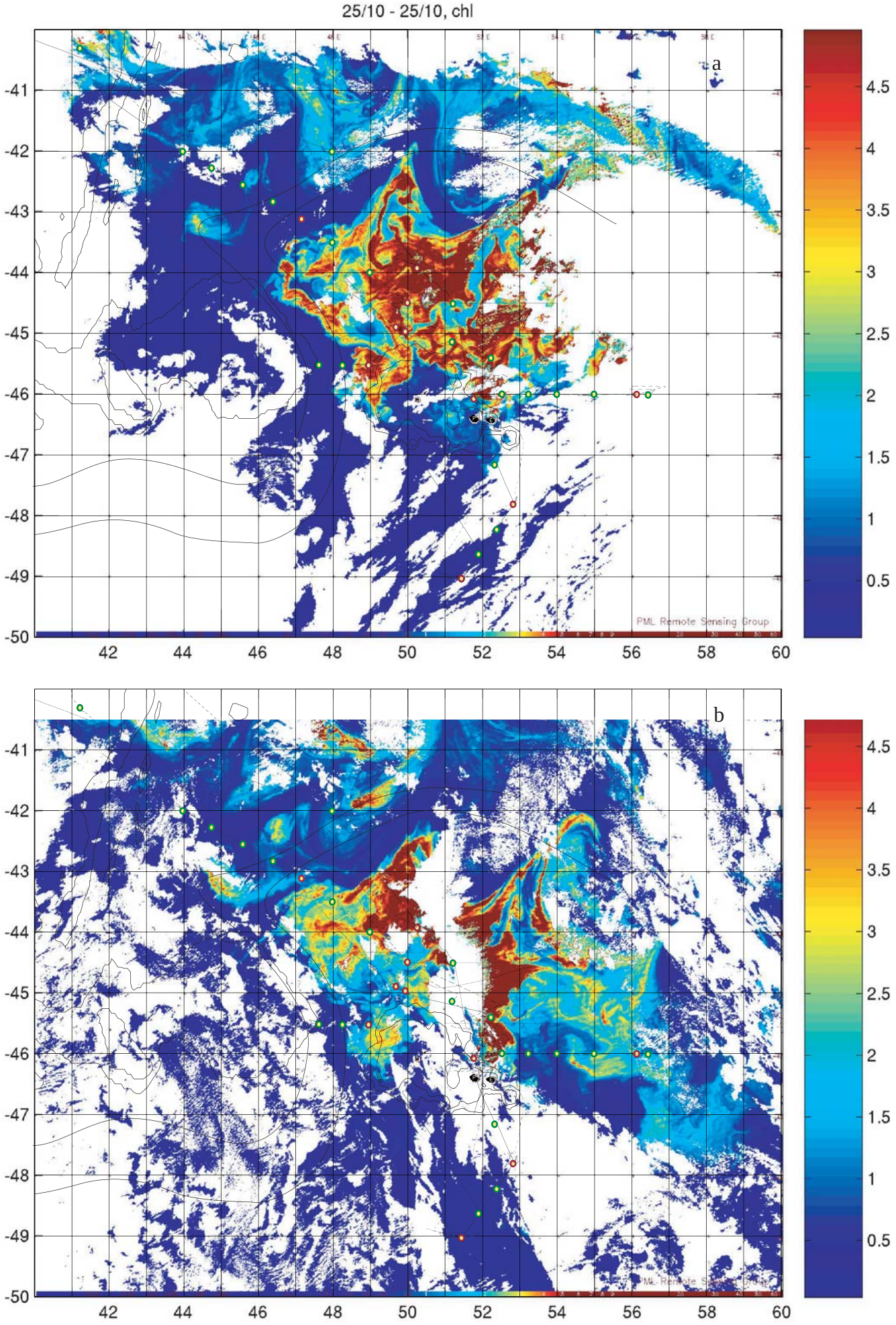


Fig. 1.4 Modis chlorophyll images for (a) 25 Oct 2004, (b) 31 Oct – 3 Nov

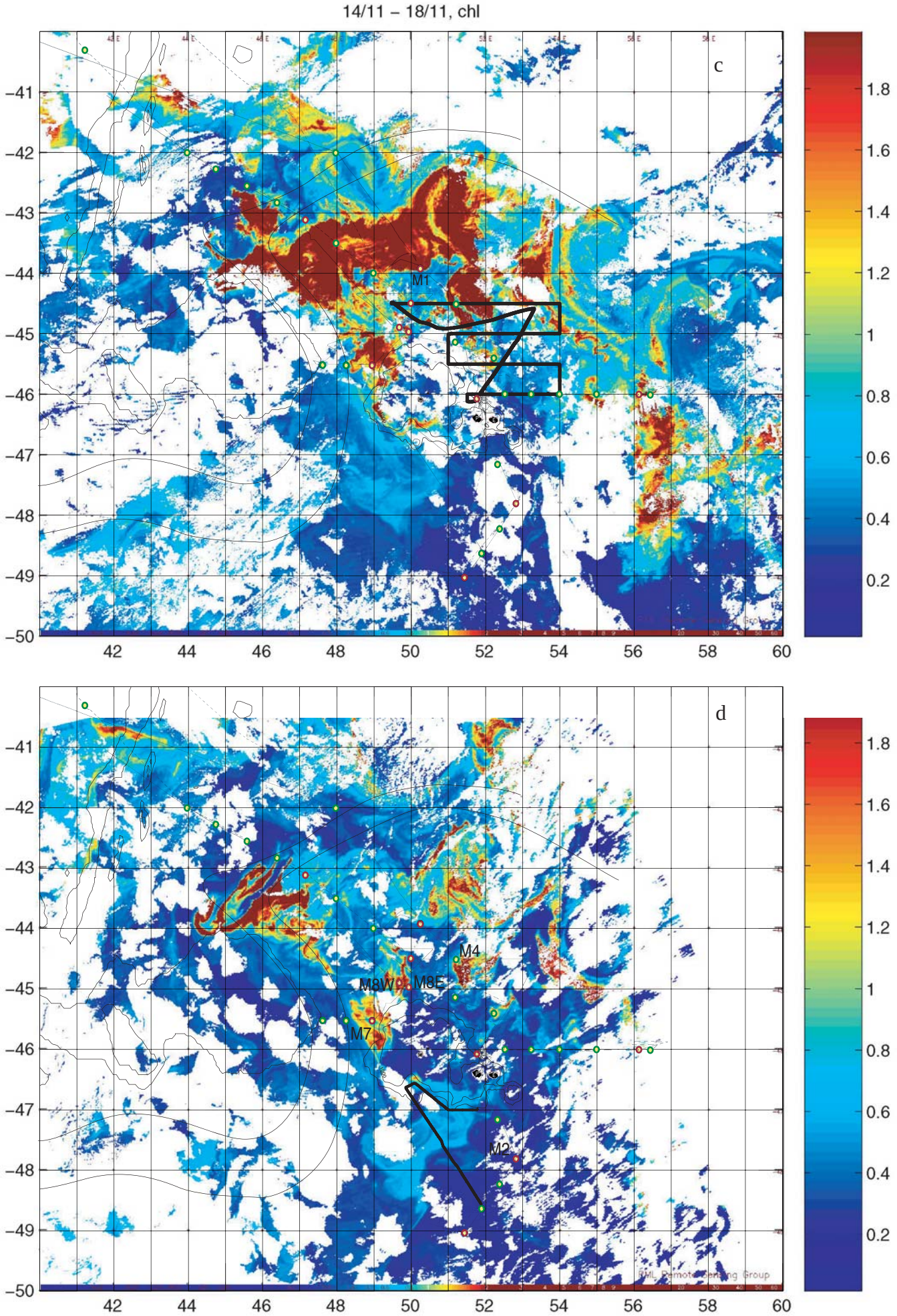


Fig. 1.4 Modis chlorophyll images for (c) 14-18 Nov, (d) 24 Nov2004

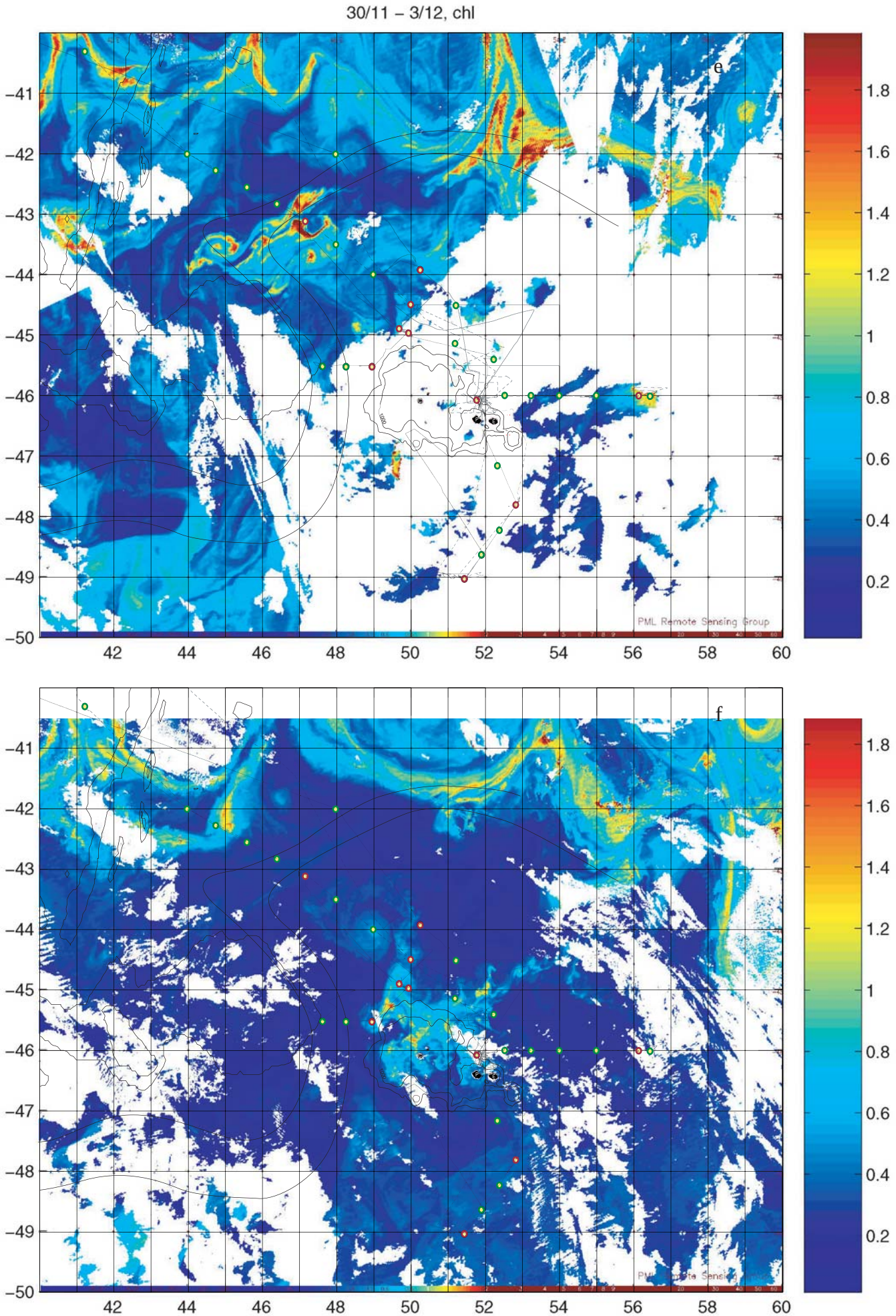


Fig. 1.4 Modis chlorophyll images for (e) 30 Nov – 3 Dec, (f) 19-22 Dec 2005

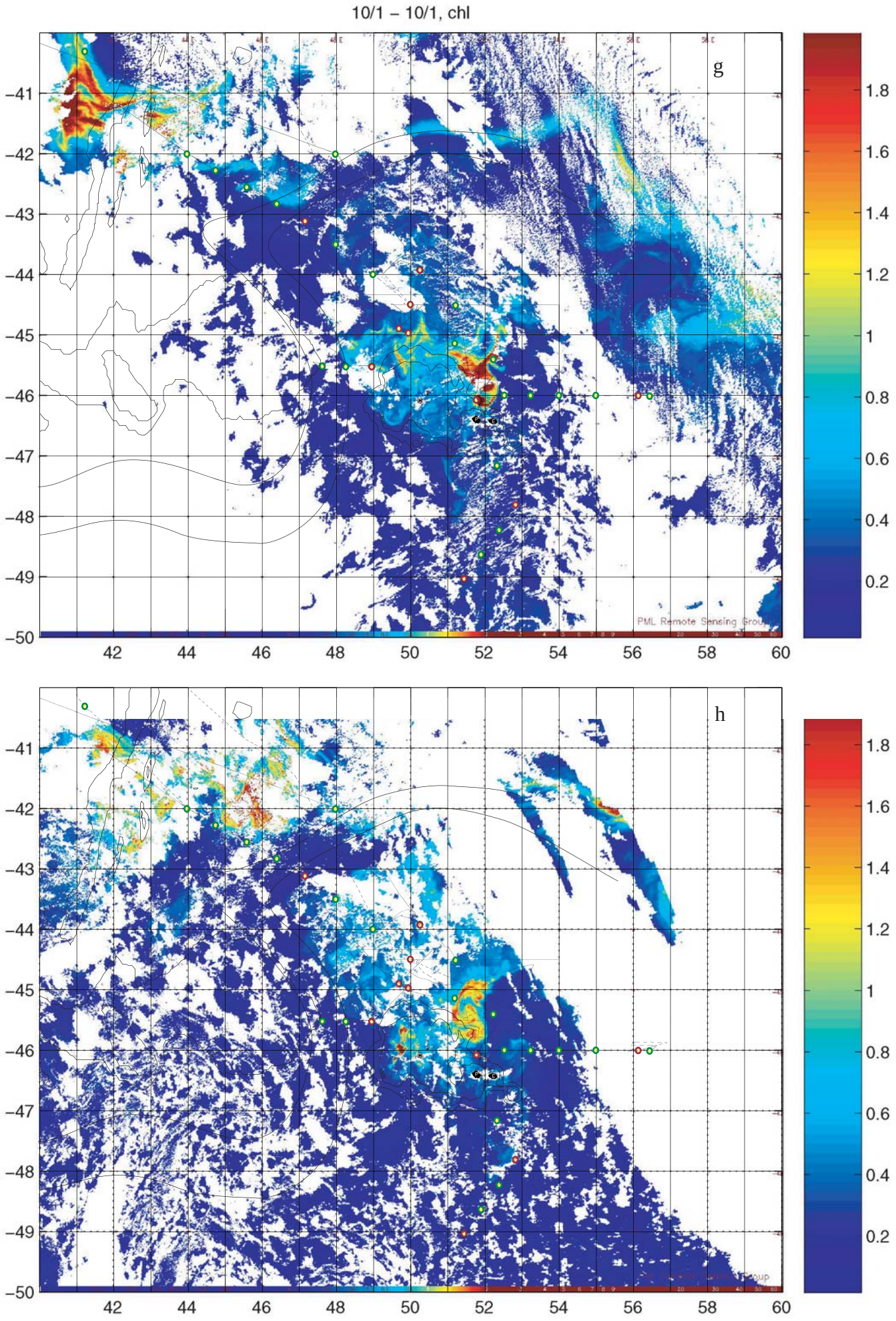


Fig. 1.4 Modis chlorophyll images for (g) 10 Jan 2005, (h) 27 Jan 2005

1.4 Cruise diary for RRS Discovery Cruises 285 and 286

29 Oct 2004 (Fri) 303

Demobilization of D284 took all morning. Rearrangement of after deck took the afternoon. No unloading of D285 equipment from the hold was possible. Reports indicate the all the sediment traps being air-freighted via Germany are stuck there and may not arrive until 5 Oct. The small rexroth winch on the side of the gantry has been replaced by a smaller one, apparently by marine side. This may not hold enough Kevlar for satisfactory zooplankton nets. Has there been lack of coordination between RSU and UKORS?

30 Oct 2004 (Sat) 304

Leaving crew paid off so slow start. But all gear out of the hold by noon

31 Oct 2004 (Sun) 305

1 Nov 2004 (Mon) 306

2 Nov 2004 (Tues) 307

Brisk southeaster all day. Moved at 1000 to bunker berth in the Duncan Dock as planned, but there was a queue until 1500 before bunkering started, and it then proceeded much more slowly than expected, so was not completed until 2200? Sailing deferred until 0800 because of weather, lateness and long hours worked.

3 Nov 2004 (Wed) 308

0800 cast off from bunker berth. Near flat calm as we left harbour, on passage all day.

4 Nov 2004 (Thur) 309

1136-1411 streamed the trace metal fish for trials. Fairing adjusted on deployment. A line was attached to the tail and adjusted such that it was taut when stationary to prevent the fish rotating. On passage the line streamed aft to about halfway down the length of the after deck, and the drag turned the tail of the fish inwards so that the fish streamed well out from the ship, a desirable side effect.

At 1730Z (all times GMT hereafter) a Provor Argo float was deployed. (This float reported successfully at 0300 on 8 Nov as programmed)

5 Nov 2004 (Fri) 310

Clocks were advanced one hour to GMT+3.

0715-0905 the vessel was hove to for trial tCTD (Discovery station 15486) cast and net deployment. Here tCTD is the abbreviation for the Titanium rosette and CTD from trace metal work. This distinguishes it from the stainless steel rosette with CTD and LADCP, which we shall refer to as sCTD. The tCTD was lowered to 1000 m. After continuing passage, the vessel hove to again 1112-1253 for a trial sCTD (15487) cast to 1000 m.

6 Nov 2004 (Sat) 311

On passage all day.

7 Nov 2004 (Sun) 312

Clocks were advanced one hour to GMT+4. Once plans for safe deployment and recovery of the SeaSoar were in place and the SeaSoar winch had been load tested, a SeaSoar trial was undertaken in relatively calm conditions. From 1139 to 1201 SeaSoar was deployed (15488) for a trial run, using the starboard crane aft to hold the shieve during deployment. Profiling was gradually adjusted and a depth of 300 m was reached with a reasonable sawtooth pattern at 8 and later 9 kts before the SeaSoar was retrieved 1519-1615

8 Nov 2004 (Mon) 313

On passage all day.

9 Nov 2004 (Tues) 314

The trace metal fish was deployed at 0648. At 1056 station J (42°S, 48°E) was reached and the first station sCTD15489 was worked to 3031m. This position was known to be in the Agulhas Return Current just NW of a tongue of blue, probably HNLC, water seen on satellite images up to 3 Nov. The intention was to work a line of CTDs down to M4, the primary site in the oldest bloom area. The sCTD was recovered at 1757 and followed by a 2 nets. A Provor Argo float was deployed before leaving J. The next station was intended to be in the HNLC tongue, but the combination of low temperature and low chlorophyll (being watched on the underway data stream) proved elusive, and the vessel hove to at 2334 in much colder water, probably already in the bloom regime.

10 Nov 2004 (Wed) 315

However, the weather had deteriorated, and the vessel could not hold station for a CTD. After discussion it was decided to continue on towards M4, as the vessel was running easily with the wind and swell behind. Underway observations were to be taken. By 0806 however it was no longer possible to maintain course SE and the vessel hove to.

11 Nov 2004 (Thur) 316

After creeping west until 0445, the vessel turned to run back east, easing the course round to a little south of east until heaving to at the next CTD station, one to the north of M4 on the original plan (M4-1). By 1032 it was possible to begin sCTD15490, after 26 hours lost to weather. The cast, to 3085 m, ended at 1312, and was followed by one net, the second having to be abandoned when it was seen that the outer sheath of the Kevlar had parted. At the same time, the decision was being made to make the position a Major Station, i.e. one at which both sCTD casts (normal and for 234Th) and a tCTD cast (for iron and productivity), plus nets and SAPS would be taken. The was because there was still a large swell, and station keeping might not be possible in the dark by the time the intended position for the Major Station M4 was reached. Work at M4-1 continued overnight. The tCTD15491 station lasted from 1408 to 1916 (2316 local), halted for 2 h 20 m at 841 m because the scrolling gear on the winch drum failed, a known problem although it had only been renewed in late October. That cast was followed immediately by sCTD15492 to 1000 m for 234Th, with 12? bottles fired at 1000 m to collect water for radium. Meanwhile, the auxiliary winch on the gantry had been stripped of Kevlar and new rope wound on for the zooplankton nets. However, this fouled and the net had to be aborted. The drum specification has been changed and the auxiliary winch will no longer

hold enough Kevlar for net deployments to 200 m. The station ended with a SAPS deployment, hanging two SAPS (one for C/Fe, the second for C/234Th) on the end of the CTD cable.

12 Nov 2004 (Fri) 317

An Argo Provor float was deployed as we left station M4-1. The next station, M4, is planned to be the site for a moored sediment trap. The station position was moved 15' east to 44°30'S, 51°15'E to avoid a seamount. However, only a normal sCTD15493 plus 3 nets was worked from 0620-1103 so that a tCTD could be done at M3 the following day. The CTD signal failed at about 100m on the upcast, so that the near surface bottles could not be fired. In order to reach M3 at a suitable time it had already been decided to skip the CTD casts planned between M4 and M3. In fact, the cause of CTD failure was the cable termination, which was remade during passage and load tested during a temporary course alteration.

13 Nov 2004 (Sat) 318

On arrival at M3 we ran south along a ridge on which the mooring might be set. The ridge had been chosen from a detailed French chart and a swathe bathymetry survey, and the latter proved accurate to pinpoint the ridge crest, as verified by a second pass from west to east. Station sCTD15494 was worked in deeper water just east of the mooring position, followed by three nets. Mooring preparation and deployment lasted from 0230Z (0630 local) until 0815, after which sCTD14595 for 234Th was done to 1000m (PAR sensor was refitted for this cast), followed by SAPS at 225 m, 2 nets, deployment of an Argo (Webb) float and deployment of Pelagra, the drifting sediment trap. Finally, to finish after dark, tCTD15496 was completed at 1708. At the end of the work at M3, SeaSoar (15497) was deployed running SW into wind on the south side of the mooring M3, and was towed west a short way then north on the west side of the mooring, finally turning onto the first track of the main SeaSoar survey, running east along 46°S towards 54°E.

14 Nov 2004 (Sun) 319

From 0707 until 0723 inadvertent power cycling of the autopilot (while investigating a short-circuit) resulted in loss of gyro input and the vessel steamed a full circle. The ship turned north at 0840, then west at 1207 along 59°30'S for the second SeaSoar leg from 54°·E to 51°E.

15 Nov 2004 (Mon) 320

Leg 2 was completed at 0317, and leg 3 eastwards along 45°S started at 0653. During Monday a major activity was preparation of talks to introduce results to date in the evening. This was the third such meeting, and proved most useful for discussion of future plans in the light of progress. Participants involved in the tCTD casts on 11 and 13 Nov had expressed a wish for a three day break to catch up before the next major station, and the meeting agreed to continue the SeaSoar survey with all four tracks, which should be completed in time to do station work overnight on 16 Nov. Leg 3 was completed at 2053 when the northward turn commenced.

16 Nov 2004 (Tues) 321

Leg 4 along 44°30'S began at 0050 and was intended to end at 51°E at 1700. But by then it was clear that a CTD cast would be impossible with strong winds from the west and building swell. It was therefore decided to continue westwards until 49°30'E then turn to the SE back towards M3.

17 Nov 2004 (Wed) 322

The turn was successfully accomplished at 0317 after discussion about the safety of SeaSoar. With a large swell, the normal rate of turn of 10° per minute would be untenable, keeping the ship beam on to the swell for too long. Therefore, the SeaSoar was held at 70 m to stream out aft and the difficult 90° of the turn was done rapidly, then allowing the SeaSoar cable to recover from "abeam" to aft before completing the turn. The turn was 225° to starboard to protect gear on the starboard deck from the weather. The plan to head for M3 was also frustrated, as the wind and swell were shifting round to the SW and the most south-easterly course that could be safely maintained was in fact 085°. Thus perforce we resurveyed the survey area running more or less east along 44°50'S. By the evening the wind and swell were so large that we could neither turn to the SW back towards M3 nor turn into wind to recover SeaSoar, so the eastward passage was continued overnight.

18 Nov 2004 (Thur) 323

By 0155 the turn became possible and course was set 212°T towards the last reported position of Pelagra near M3. In the late afternoon SeaSoar was recovered (1427-1512Z) in preparation for a repeat Major Station at M3 overnight. However, the work had to be cut down to enable Pelagra recovery in the morning. M3 was reached at 1728 and sCTD15498 (full depth, sampled for ^{234}Th), 3 nets, TiCTD15499 (300 m only), SAPS (205 m) and a final net were completed in quick succession between 1734 and 0016/19th.

19 Nov 2004 (Fri) 324

Pelagra was located and recovered between 0023 and 0333. From satellite fixes received via SOC, it had drifted quite close inshore to the north of Possession Island. In fact it had been over ballasted, so had dropped a weight and come immediately back to the surface after nearly equilibrating at 400 m depth. In good conditions Discovery then proceeded slowly south through the passage between Possession and East Islands, carefully checking depths, but navigating using the Swathe bathymetry map supplied by Dr G Ruzie. Surface water samples for iron and radium were collected during this passage and there were excellent views of the French base on Possession Island.

The next objective was to work south via M2 to M6, the supposed HNLC control sites. M2 was relocated substantially east of its planned (47.5°S 50.8°E) position to 47.8°S, 52.85°E, based on satellite images which showed an eddy of not-very-low chlorophyll affecting the planned site, and the "bluest" water at the new site. It proved to be HNMediumC in fact, which was a surprise. Two sCTDs were planned on passage to M2, but only the first, sCTD15500 (1139-1430) during which there was a emergency drill, followed by nets, could be occupied in order to complete the productivity cast at M2 before dawn on Saturday.

As a test of ballasting, pelagra15501 was deployed for a short 7 hour cycle 2 miles before heaving to for Major Station M2.

20 Nov 2004 (Sat) 325

The TiCTD15502 (3800 m) was occupied first, ending at 0006, followed by 3 nets, sCTD15503 (500m for 234Th) and SAPS, ending at 0430. As Pelagra was by then visible on the surface, it was recovered at 0520 before again heaving to for sCTD15504 (3800 m). Given the calm conditions, the first Longhurst Hardy Plankton Recorder (LHPR) tow was successfully undertaken from 1001-1225. Finally an Argo Provor float was deployed thus completing work at M2 by 1233. The TiCTD and megacorer were swapped over while the weather permitted. By a lucky chance, the circular base of the megacorer frame was exactly the same diameter as that of the TiCTD rosette rig, so the megacorer could be safely placed onto the rail track. Course was then set towards the southernmost site M6, with 2 sCTD casts planned en route. The first, sCTD15506 (3825 m) and nets was completed (1658-2150).

21 Nov 2004 (Sun) 326

However, after heaving to for the second sCTD, conditions were marginally too rough to occupy a long station, so it was decided to continue on and complete the site survey for megacorer work instead. Running west from M6 (49°S, 51°30'E), along the 4200 m contour, there was a 20 mile stretch of relatively flat terrain (we ran west to 50°54'E) after a mound a few miles west of M6. It was therefore decided to set the moorings at the nominated M6, east of the mound, to be clear of the trawling ground to the west. The site survey was therefore completed with a reverse leg eastwards along 48°57'S three miles north of the first survey line. By the time the vessel returned to M6, conditions had abated, so a CTD cast was possible. However, once on station, over two hours was lost while a fault on the emergency stop panel was traced and temporarily fixed. From 1526-1850, sCTD15507 (4170 m) was occupied, followed by nets. Pelagra15508 was deployed for another overnight period at 2006 and bathysnap (15509) was deployed at 2035. During passage back to west of the mound, water was drawn for a second iron addition experiment. Megacoring began at 2320.

22 Nov 2004 (Mon) 327

Through much of the day, three megacore deployments (15510) were made, taking 4 hr 8 min, 4 hr 51 min, and 5 hr 3 min respectively, including turnaround time. By the time the third megacore was inboard, 1422Z, personnel needed a break, so coring was ended. The success rate had improved with each core, with 5 reasonable barrels retrieved on the third cast. In addition, the wind was increasing, so the megacorer and TiCTD were swapped over while conditions permitted. The plan was to complete the M6 station some miles to the east with the usual Major Station. On passage back to it, it was worthwhile searching for Pelagra, and, with the aid of a recent satellite fix from a special email transfer, Pelagra was spotted close to 2000 local time just before the light faded. It was retrieved by 1625 and the vessel was hove to on station at 1718.

A rapidly dropping barometer and squally showers delayed the start of the M6 station work, but the front went through quickly, and a shallow SAPS deployment to 175 m ran from 1925 to 2139. By then the wind had dropped, so the full depth TiCTD15511 (4200 m) was occupied starting at 2203.

23 Nov 2004 (Tues) 328

The TiCTD was followed by two nets, and work at M6 ended at 0400 after the sCTD15512 thorium cast. The next task was to occupy the final sCTD15513 + nets along the M2 to M6 line, which it had not been possible to work on 21 Nov. After completing this station at 1231, the SeaSoar (15514) was deployed for a short survey south of the islands while on passage back to M3.

24 Nov 2004 (Wed) 329

The survey ran as close as possible to the Ile des Pingouins to seek the apparent source of the bloom just south of there as seen in satellite images, then southeast and east along the south side of the Crozet Plateau. Underway sampling was enhanced to 15 minute intervals for part of this run. Unfortunately, the trace metal fish was out of action (pump stuck) for the crucial part of the run. SeaSoar was recovered at 1740 before a night time passage between the main islands back to M3.

25 Nov 2004 (Thur) 330

Shortly before arrival at M3, Pelagra was launched (15515), and at M3 a Major Station was worked, albeit with some shallow casts. TiCTD15516 (0039-0117) was followed by 3 nets, sCTD15517 (0211-0254) to 300 m for 234Th and SAPS (0315-0534). The trace metal fish was recovered at 0534 to be checked over, and because of suspect iron values. It was found that the connection between the nose water intake and the flexible tubing that carries water up to deck had sheared off. While the sCTD was rerigged, Discovery repositioned to the nominal M3 CTD position and sCTD15518 (0618-0903) was followed by two nets (0909-0930). The CTD had to be restarted near the bottom of the cast (2350 m), when the bottles refused to fire. Restarting cleared the fault. After completing work at M3, course was set to retrieve Pelagra, which was inboard at 1126.

It had been decided that priority must be given to surveying to the north of the Crozet main plateau whence the bloom appeared to originate, so a line of CTDs was planned. A short SeaSoar run (15519) was started on passage to the first CTD position, and successfully proved that the “shallow” OPC was working satisfactorily once SeaSoar was in the water. However, worsening weather terminated the run, and SeaSoar was recovered by 1554 and the vessel hove to.

26 Nov 2004 (Fri) 331

After nearly 12 hours hove to, it was possible to run back to the CTD position and sCTD15520 was occupied 0529 to 0824, followed by nets. The trace metal fish had been out of action for some time, but an attempt to deploy it after the CTD was aborted when the tubing kinked. To gain time, it was decided to skip two CTD stations and SeaSoar to the next Major Station position. SeaSoar was deployed at 0951 but recovered again shortly afterwards (completed by 1153) when the penguin computer crashed. On passage to the next position the trace metal fish was tested a couple of times.

Just short of the station position, Pelagra (15522) was deployed (later designated M8E) for two days. However, the CTD cast had to be aborted before it went into the water when the wire twisted.

27 Nov 2004 (Sat) 332

Since retermination and load testing would take 4-5 hours, it was decided to press on towards 45°30'S 49°E, the original site chosen for a major station M7, shown by satellite images to be in a bloom. By the time the wire was reterminated and position M7 reached, the weather had deteriorated, and the vessel hove to at 0648. At 1300 the vessel repositioned and sCTD15523 for 234Thorium was occupied to 300 m from 1448 to 1530. However, conditions remained marginal, and it was decided not to attempt another cast until they eased. After again repositioning, work restarted at 1835 with a shallow TiCTD15524 down to 500 m primarily to collect water for primary productivity experiments. A SAPS deployment to 150m was then possible, and was followed by full depth (2710 m) sCTD15525.

28 Nov 2004 (Sun) 333

The sCTD was recovered at 0105 and was followed by two nets, a full depth TiCTD 15526, and a further three nets, ending work at M7 at 0612.

The intention was then to complete a line of 4 CTDs west along 45°30'S from 49°E to 47°E, of which sCTD15525 at M7 was. This line would cross the major northward branch of the ACC which bounds the survey region. The second CTD, sCTD15527 to 2854 m followed by 3 nets was worked from 0919 to 1353. However, on arrival at the next CTD position at 1658, the weather had deteriorated and gear could not be deployed. The initial decision was to skip that station and continue to the westernmost station (at position A, 45°30'S, 47°E), but it was shortly realized that A was in only 1600 m of water, and it was more important to obtain an LADCP profile in the deep channel. So the vessel returned to 45°30'S, 47°40'E to await weather abatement. An Argo float was deployed at this position at 2252.

29 Nov 2004 (Mon) 334

By daylight the wind had dropped sufficiently for the station to become workable, and sCTD15528 was begun at 0038, after time lost to weather of 7 h 40 m. The CTD and subsequent nets were completed at 0328. The intention was to SeaSoar back to Pelagra position M8E in time for a Major Station overnight and SeaSoar (15529) was deployed by 0408. Two problems then arose. First, the SeaSoar winch scroll bar ceased traversing just at the last 50 m of wire was paid out. The SeaSoar was stopped off as usual and could have been operated perfectly normally while the winch was fixed had it not been that the SeaSoar refused to respond to commands to profile as soon as the ship speed was increased. Slow passage had to be maintained with the SeaSoar vehicle more or less at constant depth while the winch was fixed. The scroll bar had seized on the shaft that supports it, as a result of a bit of shotblast grit that had scored the shaft and eventually seized. The shaft had to be knocked out, surfaces sanded and cleaned, and the winch was reassembled by 0738. SeaSoar was recovered and the vessel hove to while the fault was traced to a broken connector pin. This was replaced by 1144. Meanwhile, the pole sampler had been prepared to collect an uncontaminated water sample for iron analysis, so this was collected just before the SeaSoar was relaunched. In fact, the sample was found on analysis to be contaminated, probably because the ship had been hove to on one spot for a while. The SeaSoar run 15530 was finally begun at 1210 (downtime 8 h), and recovery commenced at 2304 at M8E.

30 Nov 2004 (Tues) 335

The Major station M8E (44°55'E, 49°54'E)began with a shallow TiCTD15531 to 150 m for productivity and shallow iron measurements, followed by full depth sCTD15532 (2710 m) then 3 nets. The fog lifted a little at 0800 local time so Pelagra was found and recovered in the space of 1 h 20 m. A crane hose broke just after Pelagra was stowed, spraying hydraulic oil over the crane operator, the after deck and incubation rig. The weather was deteriorating, so the remaining work was done at the Pelagra recovery site (44°57'S, 49°57.7'E) rather than repositioning the ship about 3 n.m. back to the earlier site. A 1000 m sCTD15533 cast for Thorium was followed by SAPS and a single net. Work was then suspended for a short while when a violent rain squall came through, but the final TiCTD15534 was deployed at 1003. However, it had to be limited to 1000m, and was inboard by 1158.

The future work plan had meanwhile been discussed in detail. It had been decided not to return to the planned bloom site M4, as that was now believed to be at a cusp of a wave in the Agulhas Return Current. Rather, the emerging circulation pattern suggested that the present site was the most likely origin of iron-rich water with non-zero silicate signal. However, M8E had turned out to be in HNLC water just east of a northward extending tongue of relatively high bloom. Therefore, the vessel proceeded west for about 10 n.m. while the front went through, to look for the high chlorophyll patch. This was found, and pelagra redeployed at M8W (44°53.2'E, 49°40.9'E) at 1600. Conditions had by then eased, so SeaSoar was deployed at 1615 for a day-long tow round a triangular track designed to span the tongue of high chlorophyll and the relatively HNLC water on either side of the tongue. The first 050°T leg was completed at 2316.

1 Dec 2004 (Wed) 336

,The second leg ran west along 44°20'S starting at 50°34'E. The third and final leg 123°T was begun at 1006 from position 44°20'S, 48°32'E. After running past M8W and into the HNLC water a few miles to the east, SeaSoar was recovered by 1905 and the Major Station at M8W begun at 2230, after careful positioning to the centre of the bloom based on underway fluorimeter data.

2 Dec 2004 (Thur) 337

TiCTD15537 to the bottom (2770 m) was completed at 0045, and followed by sCTD15538 also to the bottom (2758 m). After repositioning to the centre of the bloom, 4 nets were worked, then sCTD15539 to 500 m for Thorium, followed by SAPS until 0932. Pelagra was then located and recovered by 1258. It was clear that M8E and M8W had been in strongly contrasting sites, with massive export at M8W. Consideration was given to repeating M8W, but time constraints made it necessary to begin working westwards. SeaSoar deployment began at 1341 but was aborted when it was found that the conductivity sensor was u/s. The Chelsea minipack CTD had been changed after the previous run because of drift in the temperature sensor, but the only option was to swap back in the drifting minipack.

By 1600 the SeaSoar was again ready to deploy, but it was decided to do a final shallow CTD at M8W partly to see if the bloom had changed, partly for SeaSoar calibration. After sCTD15540 to 400 m, the vessel repositioned 16 n.m. to the east in order to survey

one final time the transition between M8E and M8W and also pass the recent CTD position with SeaSoar fully profiling. SeaSoar 15541 was begun at 1924.

3 Dec 2004 (Fri) 338

SeaSoar was towed on course 311°T but changed to 352°T at 2300 when analysis of a recent satellite image showed that the bloom at the western end of the overall Crozet bloom area had shifted significantly in the past few days. During emergency drill in the afternoon the course was temporarily changed to west then north, but by 1359 it was clear that the bloom had shifted again, probably to the north. Course was altered to north then west and SeaSoar was recovered at 1646 when the bloom centre had been passed.

The vessel was then repositioned to the centre of the high bloom area and the final Major Station, M9, was begun at 2035 with sCTD15542 to 500 m for thorium, followed by a single net for gut fluorescence, then TiCTD15543 to 2870 m.

4 Dec 2004 (Sat) 339

Work at M9 continued with SAPS, , three nets and finally sCTD15544, finishing at 0745.

When Discovery first arrived in the bloom area on 10 Nov, severe weather had made a good CTD section from J to M4 impossible, so a full depth CTD section across the bloom boundary on passage home was planned. Four stations at 40 n.m. intervals were to be worked along the line from M9 to 42°S 44°E, each consisting of a CTD and nets. On passage, engine revs were restricted because of overheating. The first two stations were sCTD15545 and sCTD15546, the latter completed at 0116/5th.

5 Dec 2004 (Sun) 340

The final two stations, sCTD15547 and sCTD15548 were worked, though the latter had to be abbreviated at 1000 m. This was because the time of departure from the last station had been brought forward by 3.5 hours because of the engine problems. Bottles fired at 1000 m were used for Thorium calibration. An Argo float was deployed at the last station before course was set for Port Elizabeth.

6 Dec 2004 (Mon) 341

During the morning the core wire was streamed in order to relay it correctly on the drum. An Argo float was deployed at 1325.

7 Dec 2004 (Tues) 342

Clocks were retarded by an hour. The trace metal and PES fish were recovered at 0615. An Argo float was deployed at 1645.

8 Dec 2004 (Wed) 343

A new SeaSoar cable was streamed and wound on to the winch. A final scientific discussion was held in the evening in the saloon.

9 Dec 2004 (Thur) 344

An Argo float was deployed at 0718.

10 Dec 2004 (Fri) 345

The vessel docked at Port Elizabeth at 0800 (10 a.m. local) after a comfortable passage from the Crozet Islands. Work commenced on loading a container to send home with surplus equipment and on loading equipment including 6 McLane sediment traps.

11 Dec 2004 (Sat) 346

Mobilization continued including the satisfactory testing of all 6 traps. Many personnel went on safari and saw leopards, giraffe, rhino, lions and assorted antelope as well as embarking on a river cruise.

12 Dec 2004 (Sun) 347

Mobilization continued including a trial deployment of the Gravity Corer. A wooden infill for the CTD railway track, considered a prerequisite for gravity coring was made and agreed by all to be a useful safety feature.

13 Dec 2004 (Mon) 348

Bunkers were taken 8 a.m. – 2 p.m. after moving to an iron ore loading berth. The hold was opened and scientific equipment retrieved. The hangar was tidied and everything lashed down. Discovery sailed at 2:30 p.m. following a scare with the VMADCP. The VMACDP computer was subsequently stopped to allow installation of new software. This resulted in the motherboard blowing of the PC which displayed the results. This was fixed by the use of another motherboard. A short transect of radium samples across the African shelf was taken.

14 Dec 2004 (Tues) 349

On passage. The new ADCP software was installed on new computer and the ADCP connected to it, the result was that no communication with the instrument was possible. Reconnection of the old machine produced the same result. The instrument was thus unusable. Minor faults with sediment oxygen probe fixed. A meeting to discuss coring was held. The penguin system on SeaSoar was assembled and a new termination performed. The decision to shift sediment trap mooring from M10 to M4 was made in light of bathymetry at M10 and ADCP indications of strong currents in that region. A SeaSoar/ CTD approach path to the mooring site was devised. The PES and TM fishes were deployed and the CTD cable reterminated. A meeting with the captain and senior officers to run through the science programme was held. A science meeting was held which included a presentation by Mike Lucas on D285 results and a presentation by Sanders on the shore based modelling efforts.

15 Dec 2004 (Wed) 350

On passage. The iron analyser was replumbed and the ropes for the first mooring wound onto the storage drum. Bottles for the sediment traps were engraved and formalin prepared. Further efforts to communicate with the ADCP were unsuccessful. The SeaSoar penguin system was tested and a processing pathway for seabird CTD initialized.

16 Dec 2004 (Thur) 351

On passage, VMADCP communications achieved, SeaSoar, Net and CTD trials were undertaken.

17 Dec 2004 (Fri) 352

SeaSoar was deployed at 0900Z for a run repeating the final CTD section of the previous cruise.

18 Dec 2004 (Sat) 353

We arrived at our first biological station at M9, a repeat of the last process station carried out on the last leg. SeaSoar was hauled at 8.30 pm and the Titanium CTD deployed. As it was being recovered the wire jumped and required retermination.

19 Dec 2004 (Sun) 354

Nets were hauled and at 0815 the stainless CTD was deployed followed by SAPS. These were followed by a stainless CTD for Thorium. When this was recovered the first biological station of D286 had been occupied. Course was set for the next CTD station on the transect from the edge of the work area to M3 via the next biological station and first mooring deployment at M10. This was occupied without incident at 1908, followed by nets.

20 Dec 2004 (Mon) 355

The next CTD station was reached at 0402. The Stainless CTD was deployed and nets taken, course was made for the next CTD station at M10. This was occupied at noon when Pelagra was launched. A bottom survey was commenced to find a suitable spot for the mooring. Deployment commenced at 1400 and was fully deployed by 1459 and then the LHPR deployed. The biological station at M10 commenced at 1906 with a stainless CTD to 500m for thorium followed by SAPS and a 200m Titanium cast.

21 Dec 2004 (Tues) 356

The M10 process station continued with a SS CTD, a full depth Titanium cast and finally a stainless cast for neodymium and radium. The hunt for Pelagra was successfully concluded at 1237 and course set towards the next station at 1309. Course was slightly modified to ease motion and a CTD station occupied at 2100. Nets were aborted thereafter due to weather.

22 Dec 2004 (Wed) 357

The intended Pelagra deployment at M3 was abandoned and the vessel approached Baie Americaine on Isle de la Possession with the intention of landing a shore party to collect water samples. This would have followed 75 years after her predecessor Discovery I had anchored there in 1929. Strong katabatic winds meant that landing was unfeasible however nets were taken and the opportunity was taken to work a mixed transect of titanium and stainless steel CTDs at three sites going away from the island to investigate whether substantial amounts of dissolved iron are advected offshore from its putative source region.

23 Dec 2004 (Thur) 358

Discovery arrived at M3 at 0100 to begin the biological station. This commenced with a Pelagra deployment followed by a Titanium CTD to 500m, a stainless CTD, SAPS, a thorium CTD and then nets. SeaSoar was then deployed for a run W to M5. Following some technical problems the vehicle was in the water by 1336 and course made towards M5. Pelagra was not recovered, probably due to a faulty timer preventing the unit from surfacing.

24 Dec 2004 (Fri) 359

Discovery was on passage to M5 with SeaSoar in the water until 15:50 when recovery was completed. This was followed by a full depth SSCTD. Following that a 3.5 KHz survey to find suitable sites for coring, trawling and mooring deployment was started. A Christmas Eve carol concert was enjoyed by all present.

25 Dec 2004 (Sat) 360

The site survey continued through Christmas dinner which was enlivened by a message purportedly from "her Majesty the Queen". At 1600 megacoring commenced. This continued for 15 hours overnight.

26 Dec 2004 (Sun) 361

At 0950 the mooring deployment began with the weight being released at 1138. The LHPR was then deployed and recovered at 1454. Vessel repositioning followed and SAPS were taken for paleo crozex with coring being resumed again at 1852.

27 Dec 2004 (Mon) 362

Coring continued until 0823. Nets were then deployed and the megacorer and gravity corers exchanged. Three gravity corer deployments separated by nets were undertaken followed by the swapping of the Titanium CTD frame for the gravity corer. This allowed the overnight biological station to commence at 1855 with a Thorium CTD. SAPS were then deployed, then nets and finally the Titanium CTD.

28 Dec 2004 (Tues) 363

At 0218 the Titanium CTD landed on deck. Nets followed and the stainless steel CTD was then deployed. More nets ensued and the titanium CTD and the megacorer were swapped by 0715. Three megacorer deployments followed with intervening nets. At 2139 work at station M5 finished and a float and bathysnap were deployed before Discovery headed W back to M3 with the intention of working a CTD section en route.

29 Dec 2004 (Wed) 364

The first CTD station was reached at 0401. Severe winds prevented deployment of the CTD package so Discovery proceeded to the next CTD station. Severe weather prevented any work so Discovery crept west into the weather for the remainder of the day. At 1945 the ship was turned and returned to 55E where the CTD was deployed at 2300.

30 Dec 2004 (Thur) 365

The CTD was recovered at 0211 and nets collected. Discovery then steamed W towards the next station arriving at 0840. The opportunity was taken to swap the Titanium CTD for the megacorer in daylight and the CTD deployed at 0906. Upon recovery net samples

were taken and the vessel proceeded to the next station, arriving at 1600. The Stainless steel CTD was deployed immediately and recovered at 1844. Nets were then taken and the next station reached at 2245. The stainless steel CTD was then deployed.

31 Dec 2004 (Fri) 366

The stainless steel CTD was recovered at 0138 and course towards M3 set. Pelagra was deployed there at 0733 and the final stainless CTD of the transect deployed at 0802. Recovery at 958 was followed by nets, a thorium CTD and SAPS. Pelagra was then recovered by 1516. A stainless steel CTD profile was then undertaken to collect water for radium analyses and nets undertaken. The final part of the M3 biological station was a titanium CTD deployed at 1809, with recovery at 1840. SeaSoar was then deployed at 1918 for a run south to M6 between the islands. The passage through the islands passed without incident and the New Year was celebrated in traditional style in the Discovery bar.

1 Jan 2005 (Sat) 367/1

Discovery was on passage to site M6 with SeaSoar deployed. A large iceberg was seen. Heavy weather required the course to be modified and M6 was reached at 2028. SeaSoar was then recovered and crane operations to switch the megacorer for the titanium CTD undertaken. Pelagra was deployed. Severe weather prevented further operations.

2 Jan 2005 (Sun) 368/2

Discovery was hove to all day in heavy weather.

3 Jan 2005 (Mon) 369/3

The mooring was set at 1016 and the hunt for Pelagra started. Two attempts later the instrument was on deck by 1903 and at 2150 Discovery was hove to on station for biological work at M6. This began with a Thorium CTD followed by SAPS, a stainless steel CTD and nets.

4 Jan 2005 (Tues) 370/4

The megacorer and the titanium CTD were swapped and megacoring commenced at 0720. Three deployments later nets were hauled, the megacorer and titanium CTD were swapped and a titanium CTD was undertaken.

5 Jan 2005 (Wed) 371/5

Nets were followed by SAPS and then the gravity corer was swapped for the titanium CTD. Gravity coring commenced at 0700 and two cores were taken before at 1222 the megacorer was reinstated for the gravity corer. Nets followed and then the megacorer was deployed three times.

6 Jan 2005 (Thur) 372/6

The final megacorer deployment ended at 0219. After a brief inspection of the weather the SS CTD was deployed. Work at M6 ended with the launch of SeaSoar for a run northeast to M2 at 0414. SeaSoar was recovered at 1628 and the last mooring was then deployed with the weight being released at 1931. The M2 biological station began with a Titanium CTD.

7 Jan 2005 (Fri) 373/7

The titanium CTD was followed with SAPS, nets, a stainless CTD and then the LHPR. SeaSoar was deployed at 1040 for a run east of the islands. Fog reduced visibility at 1505 and speed was reduced given the earlier observation of a large iceberg between the islands and M6. SeaSoar malfunctioned at 1909 and it was hauled shortly after with the intention of replacing the SeaSoar survey with a CTD section. At the first CTD station, reached at 2326 the CTD winch failed on deployment.

8 Jan 2005 (Sat) 374/8

Nets were taken and the vessel proceeded to another net station at 0529. Discovery then steamed south down the passage between the islands to Port Alfred with the intention of landing a shore sampling party. High winds impeded anchoring; the opportunity was taken to load test the new termination. Working on the principle that high winds inshore were likely be replicated offshore and thus that conditions were likely to become workable faster in Canal des Orques than offshore the decision was made to stay hove to and await an improvement in the weather. At 1253 the weather moderated and Discovery anchored in Crique du Navire, 76 years after her predecessor Discovery I had anchored in Baie Americaine in 1929. The shore party were landed at 1343 and the remainder of the ships company then availed themselves of the opportunity to inspect the numerous King penguins and Elephant seals at close quarters from the ship's boat. The shore party was recovered at 1945 and Discovery then steamed north towards M3 to sample an intense phytoplankton bloom which had developed there. A short survey ensued before the biological station to find the bloom centre.

9 Jan 2005 (Sun) 375/9

At 0212 Pelagra was released and the biological station began with a titanium CTD followed by SAPS, Nets and a stainless steel CTD. These events concluded at 1031 and Discovery headed for the mooring deployed on D285 at M3. The acoustic release was fired at 12:06 and the buoyancy package sighted at 1211. Recovery was complex due to the mooring line breaking but all components were on board by 1750. In the process of recovery the Trace Metal fish had fouled the PES fish and the former was recovered for repairs. Pelagra was briefly sought but the attempt was truncated by a SeaSoar deployment intended to survey the region N of the Islands, commencing at 21:00. SeaSoar failed on launch and instead a line of CTDs north of the islands was embarked on.

10 Jan 2005 (Mon) 376/10

A line of CTDs across the N flank of the plateau was worked; Discovery reached the vicinity of the M3 bloom at 14:01. Pelagra was recovered by 1615 and a short survey of the M3 bloom undertaken before the Biological station which began at 2024. Initially a Thorium CTD was deployed followed by Pelagra and then a titanium CTD and nets.

11 Jan 2005 (Tues) 377/11

A further titanium CTD deployment was followed by SAPS and then the search for pelagra began. Severe weather prevented visual identification and Discovery steamed west to undertake a CTD station to 500m and deploy nets. The weather having improved the search for Pelagra resumed and visual identification was established at 1436. Two

attempts were required before the instrument was on board at 19:01. SeaSoar was deployed at 2215 and a survey of the region around the bloom commenced.

12 Jan 2005 (Wed) 378/12

The SeaSoar survey continued in beautiful sunshine withy lovely views of both islands and of a large group of pilot whales. SeaSoar was recovered at the M3 bloom at 1617 and a LHPR tow commenced. This finished at 1939 and a short survey of the bloom area to pick the site of maximum plankton biomass was undertaken in preparation for the overnight biological station. This commenced with a Pelagra deployment, a Thorium CTD and SAPS.

13 Jan (Thur) 379/13

SAPS were deployed to just below the chlorophyll maximum to collect samples coincident with the thorium cast. A Stainless Steel CTD station was performed followed by a Titanium CTD and four zooplankton nets. Pelagra was recovered and the final biological station was thus concluded. The vessel repositioned for a SeaSoar survey of the northern part of the bloom and SeaSoar was deployed around 10:00. After initial problems with Penguin satisfactory communications were achieved and the vehicle flew well overnight, albeit in heavy seas.

14 Jan 2005 (Fri) 380/14

At 03:00 SeaSoar stopped communicating with its control unit in the main lab. Heavy weather precluded immediate recovery however by 0800 the weather had moderated sufficiently to recover the instrument. This was done without incident and fault finding commenced whilst the ship steamed on to the furthest west position and hove to awaiting a repaired termination. The repair was effected by 1700 and the SeaSoar tow towards M10 resumed. The rest of the day passed without incident.

15 Jan 2005 (Sat) 381/15

The SeaSoar tow finished at 0800 at M10 and the ship relocated to the haul point to undertake a CTD to 1000 m. Crane operations to swap the gravity corer and the Titanium CTD were undertaken before gravity coring commenced. Three cores were recovered. The first slumped badly on recovery, the second was very short however the third deployment retrieved a 1.5 m core overlain by clear water. Coring then switched to the megacorer once crane operations to swap the corers had taken place and a first deployment yielded two perfect and one disturbed cores.

16 Jan 2005 (Sun) 382/16

The megacorer came inboard after its second deployment with the main shackle and swivel caught underneath the coring unit and the cores exposed. Strops were placed around the frame and the load transferred to the CTD wire and the corer lowered to the deck. The single long core collected was disturbed but archived. Damage to the megacorer prevented further deployments so a final CTD cast to the bottom was undertaken. Discovery then began the long passage Northwest to Durban in heavy weather.

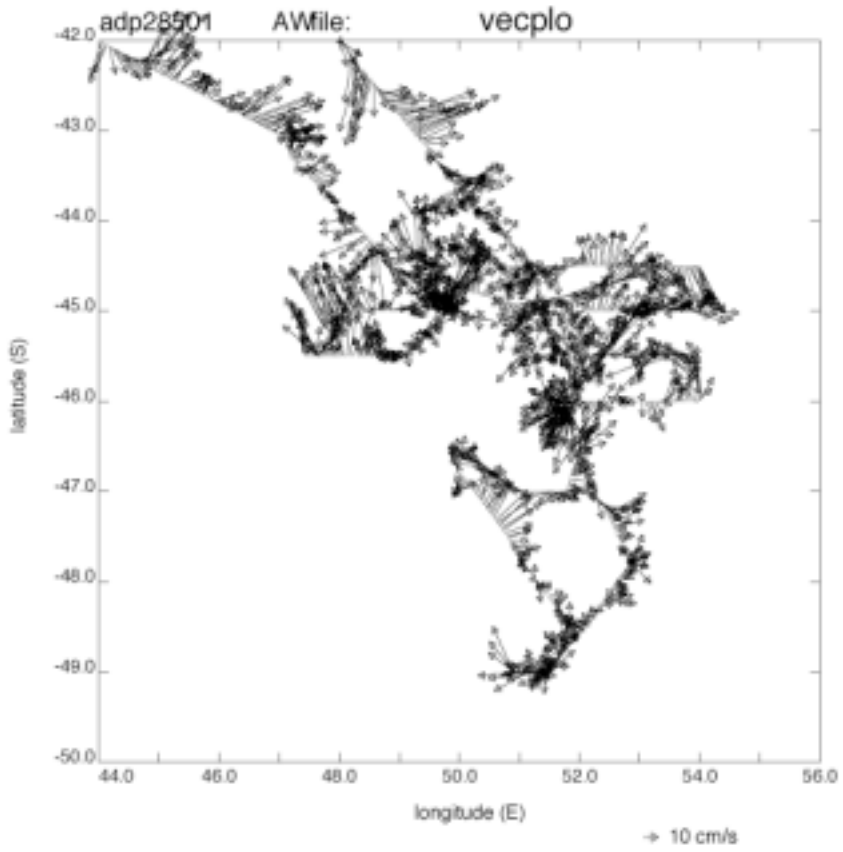
2. Underway measurements

2.1 Navigation and VM-ADCP John Allen, Hugh Venables and Robin Pascal

Since the FISHES cruise (D253) in May/June 2001, two RDI Vessel-Mounted Acoustic Doppler Current Profilers (VM-ADCPs) have been in operation on RRS *Discovery*; the narrowband 150kHz VM-ADCP and a 75 kHz Phased Array instrument (Ocean Surveyor). The vast majority of this report duplicates that of Penny Holliday and Helen Johnson for D253.

The 150 kHz ADCP is mounted in the hull 1.75 m to port of the keel, 33 m aft of the bow at the waterline and at an approximate depth of 5 m. The 75 kHz ADCP is also mounted in the hull, but in a second well 4.15 m forward and 2.5 m to starboard of the 150 kHz well.

This section describes the operation and data processing paths for both ADCPs. The navigation data processing is described first since it is key to the accuracy of the ADCP current data.



An expedient trick to create a vector plot for a complex multidisciplinary cruise like D285, is to append all 24 hour files together, re-grid to 4 km distrun interval along track using padpav and then select a single depth using pcopyg. To a considerable extent this quickly avoids the messy separation of "on-station" data particularly where stations may involve many different deployments and recoveries, some of them non-stationary! In this example (Fig. 2.1), vectors for D285 are plotted for a depth of 103 m for the 150 KHz ADCP data.

Fig. 2.1 150 kHz ADCP vectors for Di285 at a depth of 103m

Navigation

The ship's best determined position was calculated by the RVS process "bestnav" (10 second averaging period). The main data source for D285 was the GPS Trimble 4000 system. This had been determined to be the most accurate system on a number of preceding cruises, and D285 was no exception. An examination of positional accuracy, whilst tied up alongside Duncan Dock at the beginning of the cruise, showed that the corrected GPS 4000 system provided slightly higher

positional accuracy than the Ashtech G12 system, and both were significantly better than the Glonass system. As with preceding cruises, this accuracy was ~1.0-1.5 m for the GPS4000 system and ~ 2.0 m for the G12 system.

Both of these systems had sufficient precision to enable a calculation of ship's velocities to better than 1 cms^{-1}, and therefore below the instrumental limits of the RDI ADCP systems.

If there were gaps in the GPS4000 data, the bestnav process used other inputs as necessary. These were turned to in the strict preference order, Ashtech G12, GPS Ashtech 3D, GPS Glonass (which uses a combination of Russian and American satellite networks). Or, as a last resort, if no GPS was available the Chernikeef electo-magnetic log velocity data and gyro heading would be used to dead-reckon the ship's position.

Data were transferred daily from the RVS Level C bestnav stream to the pstar absolute navigation file, abnv2851. The G12, gps-4000, and gyro (gyronmea) data streams were also transferred daily. Transfer of the gps_glos stream was stopped early on in the cruise as there was no clear purpose in its continued recording.

Scripts:

navexec0: transferred data from the RVS bestnav stream to pstar, calculated the ships velocity, appended onto the absolute (master) navigation file and calculated the distance run from the start of the master file. Output: abnv2851.

gyroexec0: transferred data from the RVS gyronmea stream to pstar, a nominal edit was made for directions between 0-360° before the file was appended to a master file.

gp4exec0: transferred data from the RVS gps_4000 stream to pstar, edited out pdop (position dilution of precision) greater than 5 and appended the new 24 hour file to a master file.

glosexec0: this was identical to gp4exec0 but transferred the RVS gps_glos data stream to pstar.

gpsexec0: this was identical to gp4exec0 but transferred the RVS gps_g12 data stream to pstar.

Heading

The ships attitude was determined every second with the ultra short baseline 3D GPS Ashtech ADU2 navigation system. Four antenna, two on the boat deck, two on the bridge top, measured the phase difference between incoming satellite signals from which the ship's heading, pitch and roll were determined. Configuration settings from previous calibrations (Trials cruise in April 2001) were used throughout the cruise, these were:

Adjusted Relative Antenna Positions (m), which require no pitch or roll offset angle.

	X(R)	Y(F)	Z(U)
1-2 Vector	0.000	6.492	0.167
1-3 Vector	-10.162	0.135	-4.337
1-4 Vector	-10.113	6.431	-4.193

The Ashtech data were used to calibrate the gyro heading information as follows:

ashexec0: transferred data from the RVS gps_ash stream to pstar.

ashexec1: merged the ashtech data from ashexec0 with the gyro data from gyroexec0 and calculated the difference in headings (hdg and gyroHdg); ashtech-gyro (a-ghdg).

ashexec2: edited the data from ashexec1 using the following criteria:

heading 0 < hdg < 360 (degrees)

pitch -5 < pitch < 5 (degrees)

roll -7 < roll < 7 (degrees)

attitude flag -0.5 < attf < 0.5

measurement RMS error 0.00001 < mrms < 0.01

baseline RMS error 0.00001 < brms < 0.1

ashtech-gyro heading -7 < a-ghdg < 7 (degrees)

The heading difference (a-ghdg) was then filtered with a running mean based on 5 data cycles and a maximum difference between median and data of 1 degree. The data were then averaged to 2 minutes and further edited for

-2 < pitch <2

0 < mrms < 0.004

The 2 minute averages were merged with the gyro data files to obtain spot gyro values. The ships velocity was calculated from position and time, and converted to speed and direction. The resulting a-ghdg should be a smoothly varying trace that can be merged with ADCP data to correct the gyro heading. Diagnostic plots were produced to check this. During ship manoeuvres, bad weather or around data gaps, there were spikes which were edited out manually (plxyed).

Ashtech 3D GPS coverage was generally good. Dropouts only occurred early on in the cruise; and on only one occasion was it necessary to reset the Ashtech Unit in the Comms Room. Gaps over 1 minute in the data stream are listed below.

time gap : 04 307 10:30:32 to 04 307 10:33:00 (2.5 mins)

time gap : 04 311 11:02:31 to 04 311 12:37:34 (95.0 mins)

time gap : 04 311 12:41:42 to 04 311 13:35:40 (54.0 mins)

time gap : 04 311 13:37:47 to 04 311 14:05:51 (28.1 mins)

time gap : 04 311 14:09:39 to 04 311 15:31:26 (81.8 mins)

time gap : 04 311 15:33:17 to 04 311 15:37:45 (4.5 mins)

time gap : 04 311 16:13:05 to 04 311 16:27:37 (14.5 mins)

time gap : 04 312 06:25:16 to 04 312 08:39:37 (2.2 hrs)

time gap : 04 312 08:50:13 to 04 312 08:51:34 (81 s)

time gap : 04 312 11:53:46 to 04 312 16:00:53 (4.1 hrs)

time gap : 04 351 07:26:51 to 04 351 07:27:59 (68 s)

time gap : 04 351 07:28:00 to 04 351 07:29:12 (72 s)

time gap : 05 014 17:22:44 to 05 014 17:25:19 (2.6 mins)

RDI 150 kHz ADCP

The 150kHz RDI ADCP was logged using RDI Data Acquisition Software (DAS) version 2.48 with profiler firmware 17.20. The instrument was configured to sample over 120 second intervals with 96 bins of 4 m thickness, pulse length 4 m and a blank beyond transmit of 4m. The high vertical resolution was chosen to support the remote detection of zooplankton patchiness. Early in the cruise the ADCP was switched to bottom and water track mode over shallow ground to enable calibration. After closely inspecting the data from the two ADCPs without configuring them to synchronise their pings over the ensemble period, it was decided to leave them in this mode as little evidence of interference could be seen. To synchronise the instruments, the 150 kHz instrument has to be set as the "master" and the 75 as the "slave", as recommended by RDI and discussed by Penny Holliday in the D253 cruise report. The result is that each ADCP has only 40 water track pings in the 2 minute period. With no obvious evidence of interference this seemed an unacceptable compromise. Spot gyro heading data were fed into the transducer deck unit where they were incorporated into the individual ping profiles to correct the velocities to earth co-ordinates before being reduced to a 2 minute ensemble.

Following advice from RDI, the 150 KHz ADCP on RRS *Discovery* had been refitted in dry dock, several years ago, to a heading offset of ~45°. This offset was accounted for in the DAS software configuration on D285. On some previous cruises the ADCP PC clock had been synchronised with the ship's master clock, so removing the tedious need for logging the drift of the PC clock and correcting for it in the processing (old adpexec1). Sadly this was not available on D285 and adpexec1 was resurrected.

The ADCP data were logged continually by the level C computer. From there they were transferred once a day to the Pstar data structure and processed using standard processing scripts in Pstar; which are presented below.

Data processing:

adpexec0: transferred data from the RVS level C "adcp" data stream to pstar. The data were split into two; "gridded" depth dependent data were placed into "adp" files while "non-gridded" depth independent data were placed into "bot" files. Velocities were scaled to cm/s and amplitude by 0.42 to db. Nominal edits were made on all the velocity data to remove both bad data and to change the DAS defined absent data value to the pstar value. The depth of each bin was determined from the user supplied information. Output files: adp285##, bot285##

adpexec1: Clock correction applied to both, gridded and non-gridded files. The PC clock was found to have a steady drift, ~ 2 seconds per day, so time checks were made every 24 hours and these offset values were used in adpexec1 to create a clock correction file for calibrating adcp time. Output files: adp285##.corr, bot285##.corr

adpexec2: this merged the adcp data (both files) with the ashtech a-ghdg created by ashexec2. The adcp velocities were converted to speed and direction so that the heading correction could be applied and then returned to east and north. Note the renaming and ordering of variables. Output files: adp285##.true, bot285##.true.

adpexec3: applied the misalignment angle, ø, and scaling factor, A, to both adcp files. The adcp data were edited to delete all velocities where the percent good variable was 25% or

less. Again, variables were renamed and re-ordered to preserve the original raw data. Output Files: adp258##.cal, bot258##.cal.

adpexec4: merged the adcp data (both files) with the bestnav navigation file (abnv2581) created by navexec0. Ship's velocity was calculated from spot positions taken from the abnv2851 file and applied to the adcp velocities: the bestnav averaging is now only 10 seconds, and therefore there is no requirement to take spot values from the raw 1 second GPS4000 dataset which still has the rare spike. The end product is the absolute velocity of the water. The time base of the ADCP profiles was then shifted to the centre of the 2 minute ensemble by subtracting 60 seconds and new positions were taken from abnv2851. Output Files: adp285##.abs, bot285##.abs.

A calibration of the 150 kHz ADCP was achieved using bottom tracking data available from our departure across the Agulhas Bank. Using long, straight, steady speed sections of standard two minute ensemble profiles we obtained a calibration of

$\tan\phi = -0.0039\ (\pm s.d. = 0.0080), \therefore \phi = -0.22°$ and $A = 1.0034\ (\pm s.d. = 0.0064)$.

Ocean Surveyor 75 kHz ADCP

D253 was the first scientific cruise on which the new RDI Ocean Surveyor 75 kHz Phased Array ADCP was used and thus a new processing path was written. No significant changes were made to this path on D285. The instrument was configured to sample over 120 second intervals with 60 bins of 16m depth, pulse length 16m and a blank beyond transmit of 8m. The instrument is a narrow band phased array ADCP with 76.8 kHz frequency and a 30° beam angle. The PC was running RDI software VmDAS v1.3. Gyro heading, and GPS Ashtech heading, location and time were fed as NMEA messages into the software which was configured to use the Gyro heading for co-ordinate transformation. The software logs the PC clock time, stamps the data (start of each ensemble) with that time, and records the offset of the PC clock from GPS time. This offset was applied to the data in the processing path before merging with navigation. The ADCP was fitted in the forward well as previously noted. It was known to have a heading alignment offset of 60°, this offset was not accounted for in the RDI software configuration. Bottom tracking was switched on early in the cruise and at the end of the first leg for calibration purposes.

The 2 minute averaged data were written to the PC hard disk in files with a .STA extension, eg D285005_000000.STA, D285006_00000.STA etc. Sequentially numbered files were created whenever data logging was stopped and re-started. The software was set to close the file once it reached 100MB in size, though on D285 files were closed after ~24 hours, so they never became that large. All files were transferred to the unix directory /data61/os75 and most were later archived in /data62/D285/os75/raw; .ENX files contain the raw ping by ping profiles ready for averaging and were archived in case they could be useful for looking at deep acoustic backscatter signals. Broadly speaking the new processing path followed the steps outlined for the 150 kHz ADCP. In the following script description, "##" indicates the daily file number.

In parallel with the 150 KHz ADCP, a calibration of the 75 kHz ADCP was achieved using bottom tracking data available from our departure across the Agulhas Bank. Using long, straight, steady speed sections of standard two minute ensemble profiles (.STA files) we obtained a calibration of

$\tan\phi = -1.7508\ (\pm s.d. = 0.0244), \therefore \phi = -60.26°$ and $A = 1.0018\ (\pm s.d. = 0.0060)$.

surexec0: data read into pstar format from RDI binary file (psurvey, new program written on D253 by S. Alderson). Water track velocities were written into "sur" file, bottom track into "sbt" files if in bottom track mode. Velocities were scaled to cm/s and amplitude by 0.45 to db. The time variable was corrected to GPS time by combining the PC clock time and the PC-GPS offset. The depth of each bin was determined from the user supplied information. Output Files: sur285##.raw, sbt285##.raw.

surexec1: data edited according to status flags (flag of 1 indicated bad data). Velocity data replaced with absent data if variable "2+bmbad" was greater than 25% (% of pings where >1 beam bad therefore no velocity computed). Time of ensemble moved to the end of the ensemble period(120 secs added with pcalib). Output files: sur285##, sbt285##.

surexec2: this merged the adcp data (both files) with the ashtech a-ghdg created by ashexec2. The adcp velocities were converted to speed and direction so that the heading correction could be applied and then returned to east and north. Note the renaming and ordering of variables. Output files: sur285##.true, sbt285##.true.

surexec3: applied the misalignment angle, ø, and scaling factor, A, to both files. Variables were renamed and re-ordered to preserve the original raw data. Output Files: sur285##.cal, sbt285##.cal.

surexec4: merged the adcp data (both files) with the bestnav navigation file (abnv2581) created by navexec0. Ship's velocity was calculated from spot positions taken from the abnv2851 file and applied to the adcp velocities: the bestnav averaging is now only 10 seconds, and therefore there is no requirement to take spot values from the raw 1 second GPS4000 dataset which still has the rare spike. The end product is the absolute velocity of the water. The time base of the ADCP profiles was then shifted to the centre of the 2 minute ensemble by subtracting 60 seconds and new positions were taken from abnv2581. Output Files: sur285##.abs, sbt285##.abs.

It is still noticeable that the 75 kHz depth penetration during steaming suffered very readily with the onset of anything other than calm conditions. It was postulated on D253 that the forward well is more prone to contamination by bubbles than the aft well, and if the 75 kHz ADCP is to become the standard ADCP for Discovery it may be appropriate to move the 75 kHz to the aft well, we continue to agree.

2.2 AutoFlux – the autonomous air-sea interaction system Robin Pascal

2.2.1. Introduction

AutoFlux is an autonomous, stand-alone system which obtains direct, near real-time (2 hr) measurements of the air-sea turbulent fluxes of momentum and sensible and latent heat in addition to various mean meteorological parameters. The main aims of the present deployment were to test the new Licor sensor to determine its suitability for making direct measurements of the air-sea CO_2 flux. The AutoFlux system was mobilized at SOC in September 2004 prior to the start of cruise D284 and left to run autonomously until the beginning of D285. OED staff then joined the ship to service the sensors and develop the system during D285. Previously, the system obtained flux measurements using the inertial dissipation (ID) method that relies on good sensor response at frequencies up to 10 Hz. The ID method has the advantage that the flux results a) are insensitive to the motion of the ship and b) can be corrected for the effects of the presence of the ship distorting the air flow to the sensors. Momentum and latent heat flux measurements have been successfully made using this method for a number of years. Sensible heat and CO_2 flux measurements are made more difficult by the lack of sensors with the required high frequency response. For these fluxes the eddy correlation (EC) method provides an alternative. This method requires good sensor response up to only about 2 to 3 Hz, but is a) very sensitive to ship motion and b) can not be corrected for the effect of air flow distortion. Once EC fluxes are obtained they can be corrected for flow distortion effects by comparison with the ID fluxes where available. Since the scalar fluxes (sensible and latent heat and CO_2) are all affected by flow distortion in the same fashion, only one ID scalar flux is required. If the new CO_2 sensor performs adequately at low frequencies, direct measurements of the air-sea CO_2 flux will thus be obtained. In collaboration with the UEA carbon team, any successful CO_2 flux measurements will be used to improve the parameterization of the CO_2 transfer velocity.

The development work on this cruise entailed improving the stability of the software to achieve better results when the system is in stand alone mode. Throughout the cruise near real time flux data and mean met parameters were emailed back to SOC via an Orbcomm Satellite communicator. Data was then daily published on the SOC web site and used in computer modeling, results of which were then sent to the ship.

This report describes the AutoFlux instrumentation (Section 2.2.2). A brief discussion of the performance of the mean meteorological sensors is given in Section 2.2.3, where comparisons are made between the ship's instruments with those of AutoFlux where possible. As part of a separate project, visual observations of the cloud cover were made by the ship's officers (Section 2.2.3). Initial flux results are described in Section 2.2.4. Appendix A lists significant events such as periods when data logging was stopped, and Appendix B contains figures showing time series of the mean meteorological and flux data. All times refer to GMT.

More information on air-sea fluxes and the AutoFlux project in particular can be found under http://www.soc.soton.ac.uk/JRD/MET/AUTOFLUX

2.2.2. Instrumentation

The SOC Meteorology Team instrumented the Discovery with a variety of meteorological sensors. The mean meteorological sensors (Table 2.1) measured air temperature and humidity, pressure and incoming longwave (4-50 micron) radiation. The surface fluxes of momentum, heat, moisture and CO2 were obtained using the fast-response instruments in Table 2.2. The HS and R3 sonic anemometers provided mean wind speed and direction data in addition to the momentum and sensible heat flux estimates.

To obtain EC fluxes, ship motion data from the MotionPak system has to be synchronized with those from the other fast response sensors. In order to achieve this the MotionPak output was logged via the analogue input channel of the HS anemometer. In addition, a timer circuit was added in to the HS sonic interface unit. This circuit generated a square wave sync signal which was input to the analogue channels of the Licor and R3, and to the PRT input to the HS. Once allowance was made for the 0.185 second delay in the H_2O and CO_2 output from the Licor, this enabled synchronization of all fast response data. Unfortunately On day 265 the analogue input to the R3 sonic failed, so from that time on the R3 was unsynchronized

Navigation data were logged in real time at 2 second intervals, using the ship's data stream rather than the separate AutoFlux GPS and compass. These data are used to convert the relative (measured) wind speed and direction to true wind speed and direction. The ship's mean meteorological data were also logged in real time at 2 second intervals. The details of the ship's meteorological instruments are given in Table 2.3.

All data were acquired continuously, using a 58 minute sampling period every hour (the remaining 2 minutes being used for initial data processing), and logged on "nimbus", a SunBlade 100 workstation. Processing of all data and calculation of the ID fluxes was performed automatically on "nimbus" during the following hour. Program monitoring software monitored all acquisition and processing programs and automatically restarted those that crashed (2.2 Appendix A). A time sync program was used to keep the workstation time synchronised with the GPS time stamp contained in the navigation data. Both "nimbus" and all the AutoFlux sensors were powered via a UPS. Any further data processing required was performed on a second SunBlade 100 ("cirrus").

All of the instruments were mounted on the ship's foremast (Figure 2.2) in order to obtain the best exposure. The psychrometers and the fast response sensors were located on the foremast platform and the radiation sensors were mounted on a platform installed at the top of the foremast extension. The heights of the instruments above the foremast platform were: HS sonic anemometer, 2.11 m; R3 sonic anemometer 2.86 m; psychrometers 1.85 m; Licor H2O/CO2 sensor 1.21 m.

Sensor	Channel variable na	Addres	Serial No	Calibration Y = C0 C1*X + C2*X^2 + C *X^3	Sensor positi	Parameter (accuracy)
Psychrometer	1 pds1	$ARD	HS1031 D	C0 –1.028209 C1 3.956719E-2 C2 3.04469E-7 C3 8.247377E-10	Port side of foremast platfo	Wet and dry b air temperatur and humidit (0.05°C)
Psychrometer	2 pws1	$BRD	HS1031 WET	C0 –1.242953 C1 4.008864-2 C2 –4.480979-7 C3 1.200651-10		
Psychrometer	3 pdp2	$CRD	IO2002 DRY	C0 –10.40584 C1 3.832149E-2 C2 2.019618-6 C3 5.050707E-11	Port side of foremast platfo	Wet and dry b air temperatur and humidit (0.05°C)
Psychrometer	4 pw2	$DRD	IO2002 W	C0 -10.41061 C1 3.938167-2 C2 7.661895-7 C3 5.436118E-10		
Epply LW dor temp.	6 Td1	$4RD	31170	C1 1	Top of forema platform, por position	Incoming longwave radiation (10 W/m2)
Body temp.	7 Ts1	$KRD	31170	C1 1		
Thermopile	8 E1	$LRD	31170	C1 1		
Epply LW dor temp	9 Td2	$MRD	31172	C1 1	Top of forema platform, stbdposition	Incoming longwave radiation (10 W/m2)
Body temp	10 Ts2	$NRD	31172	C1 1		
Thermopile	11 E2	$ORD	31172	C1 1		

Table 2.1 The mean meteorological sensors. From left to right the columns show; sensor type, channel number, rhopoint address, serial number of instrument, calibration applied, position on ship and the parameter measured.

Sensor	Program	Location	Data Rate (H	derived flux / parame
Gill HS Research Ultrasonic Anemometer serial no. 000027	gillhsd	stbd side of forem platform	20 Hz	momentum and hea
Licor-7500 CO2 / H2O sensor serial 75H0614	licor3	90 cm directly bene HS	20 Hz	H2O and CO2
Gill R3 Research Ultrasonic Anemometer serial no. 000227	gillr3d	94 cm to port of H	20 / 100 H	momentum and hea
MotionPak ship motion sensor seri no. 0682	via gillhsc	114 cm directly aft HS	20 Hz	EC motion correctic

Table 2.2 The fast response sensors.

Name	Sensor	Type	Serial no.	Sensitivity	Surfmet Cal
STIR	Kipp & Zonen CM6 (335 – 2200 nm)	Pyranometer	994132	11.43 μV /W/m2	8.688097E4
PTIR	Kipp & Zonen CM6 (335 – 2200 nm)	Pyranometer	973135	11.84μV/W/m2	9.737098E4
SPAR	ELE DRP-5 (0.35 to 0.7 μm)	PAR	30470	7.18μV/W/m2	1.5432099E5
PPAR	?	PAR?	unknown		1.17785E5
Pressure	Vaisala PTB100A	Barometric	S361 0008	800–1060 mbar	
wind speed	Vaisala WAA151	Anemometer	P50421	0.4-75 m/s	
Wind Dir	Vaisala WAV151	Wind Vane	S21208	-360 deg	
Air temp	Vaisala HMP44L	Temp	U 185 001	-20-60 degC	
humidity	Vaisala HMP44L	Humidity	U 185 001	0-100%	

Table 2.3 The ship's meteorological sensors, all logged by Vaisala QLI50 (R381005)

Note Correct Cal for SPAR should have been 1.39275E5.

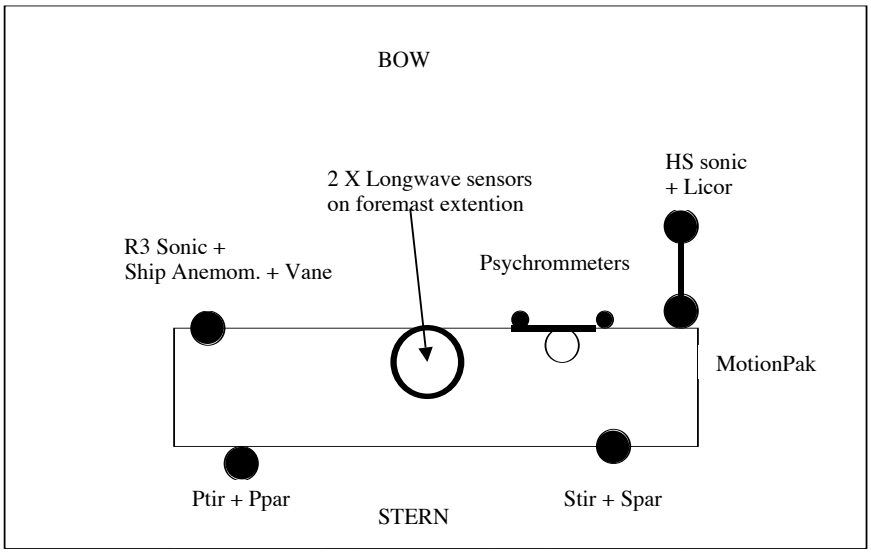


Fig. 2.2 Schematic plan view of the foremast platform, showing the positions of the sensors.

2.2.3. Mean meteorological parameters.

Air temperature and humidity

Two wet- and dry-bulb psychrometers were installed on the foremast at SOC for the start of D284. During D285 it was noticed that the dry bulb of psychrometer PDP2 (IO2002) was consistently reading higher than psychrometer PDS1 (HS1031). To ascertain which psychrometer was incorrect PDP2 (HS1031) was replaced on day 325 (10:00hrs) with sensor HS1026. During the calibration up date of this sensor it was noticed that IO2002 calibration was entered incorrectly and that an offset of -0.40584 deg was missing. With this corrected both psychrometers then agreed well. This did not cause any problems since the automatic processing chooses the lowest of the two dry bulb temperatures. Between Days 330 – 335 and 337 – 341 PDP2 (hs1026) became very noisy in damp conditions and was removed from the automatic processing. Allowing for the offset in PDP2, 1 minute averaged data from the two psychrometers showed that the mean difference between the dry bulb temperatures was only 0.007º (standard deviation of 0.12º): the large standard deviation is due to occasional drips from the wet bulbs falling on the dry bulbs. The difference between the wet bulb temperatures was only 0.02º (s.d. 0.073) well within the sensor specification. A comparison between the ship's air temperature sensor and the best psychrometer data showed that the former is biased slightly high by 0.022º (s.d. 0.11º).

Relative humidity was calculated from the psychrometer data and compared to the ship's humidity sensor. The ship's sensor read slightly lower by 0.24% (s.d 3.5%).

Wind speed and direction.

There were three anemometers mounted on the foremast platform (Fig. 2.2). On the port side were the ship's propeller anemometer and vane plus a fast response R3 Solent sonic anemometer. On the starboard side was the main AutoFlux fast response HS Solent sonic anemometer and MotionPak. Both fast response sensors measured all three components of wind speed and both are calibrated on a regular basis. The HS anemometer was the best exposed and will be used as the reference instrument in the following comparison. The measured wind speeds (uncorrected for ship speed) from each anemometer are compared to those from the HS in Fig. 2.3, which shows the wind speed difference (measured - HS measured) against relative wind direction for each anemometer. A wind blowing directly on to the bows is at a relative wind direction of 180 degrees. For a bow on wind, the R3 sonic and the ship anemometer read high by about 5%. Some of the biases will be due to flow distortion. Accurate flow distortion corrections have yet to be determined for the precise anemometer locations, but previous work (Yelland et al. 2002) has shown that the bias at the R3 and HS anemometer sites should be between -1 and +2%.. Since the HS and R3 sonics were located on the opposite side of the foremast extension to each other, roughly 50% of the trend in wind speed error seen in the latter is actually due to the variation in flow distortion with wind direction at the HS anemometer site. The large dips in the speed ratios at 90 and 270 degrees are due to the HS and R3 anemometers being in the wake of the foremast extension for winds from the port and starboard beams respectively. Fig. 2.4 shows the difference in relative wind direction as measured by each anemometer compared to that from the HS. It has been noted before (Yelland and Pascal., 2004) that the ship anemometer is mis-aligned by about 10 deg. From the bow-on winds the ships anemometer shows an error of 17 deg implying that the HS maybe mis-aligned by about 7 deg. This would also make the HS and R3 come to close agreement as they differ by about 10 deg.

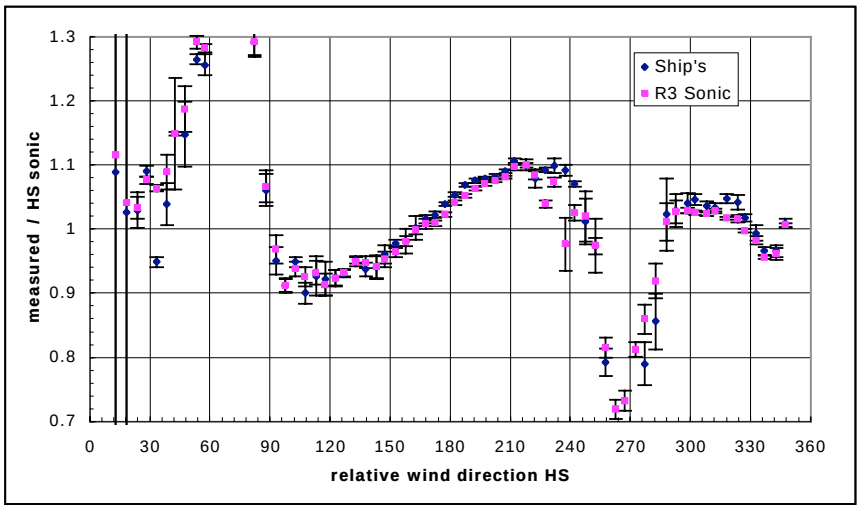


Figure 2.3. Measured wind speed / wind speed from the HS sonic for the R3 sonic and the ship's anemometer each binned against relative wind direction. A relative wind direction of 180 degrees indicates a flow directly on to the bow of the ship.

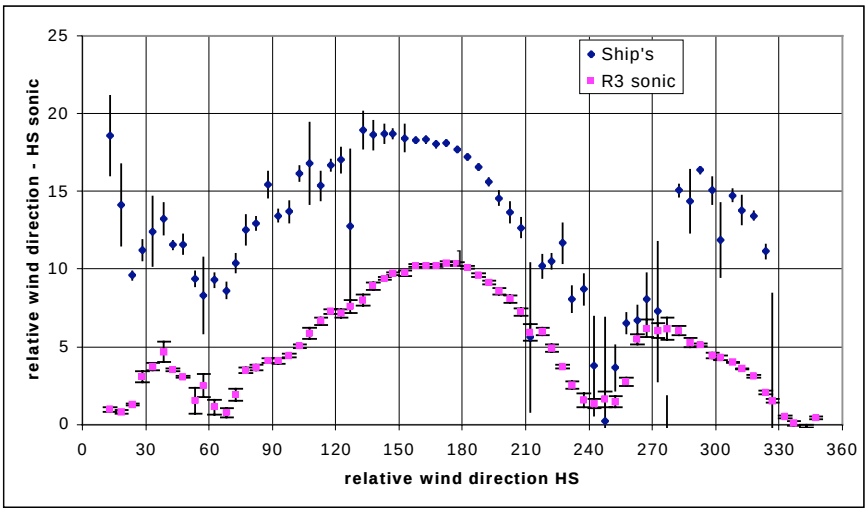


Fig. 2.4 As Fig. 2.3 but showing the difference (measured - HS) in the relative wind direction from the two anemometers.

TIR and PAR sensors.

The ship carried two total irradiance sensors, one (Ptir) on the port side of the foremast platform and the other (Stir) on the starboard. These measure downwelling radiation in the wavelength ranges given in Table 2.3. Both tir sensors functioned well throughout with a mean difference of less than 1 Watt (s.d. 16.4).

Mounted alongside each TIR sensor is a "PAR" (photosynthetically active radiation) sensor. Early examination of the data from these revealed that the starboard par sensor (Spar) produced significantly high values than the port sensor (Ppar). Later investigation of the sensors showed that the port sensor (Ppar) had no serial number, and the starboard sensor (Spar) serial no. 30470 had the wrong calibration applied. Correcting Spar to the right value then gave a mean difference of –0.4W (s.d. 1.6) showing that the sensors now agreed and that Ppar probably has the correct calibration applied..

Long wave radiation.

As part of the AutoFlux instrumentation, two Epply pyrgeometers were installed on top of the foremast extension. These sensor measure incoming long wave (LW) radiation. Following standard procedure (Pascal and Josey., 2000), three outputs from each sensor were recorded and a correction made for short-wave leakage. The Ptir data were used for this purpose. From 15 minute averages of the resulting LW data, the mean difference between the two sensors was 3.9(s.d. 2.9) W/m^2, with sensor 31170 reading relatively high. Although this is close to the expected accuracy of the sensors it appears that one sensors calibration has drifted. Applying the fit in Fig. 2.5 to LW31172 the mean difference drops to 0.002(s.d. 2.05) W/m^2.

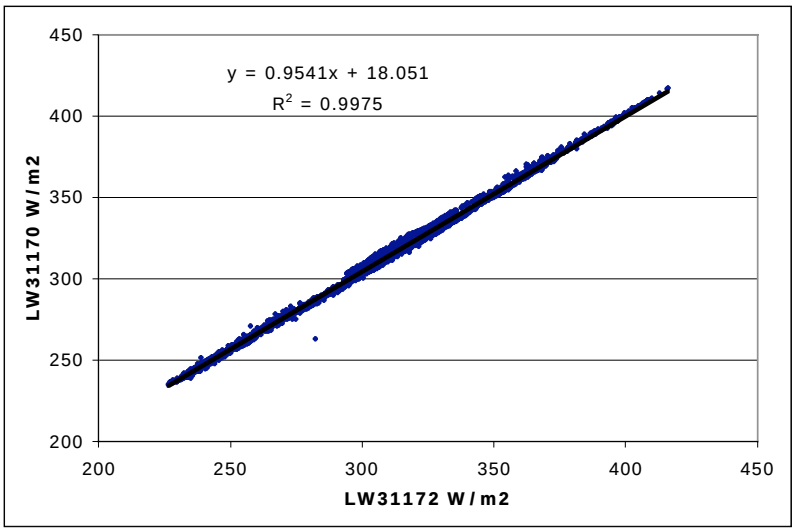


Fig. 2.5 LW31170 plotted against LW31172

Visual cloud observations.

During D284 and D285, visual cloud observations were made by the bridge officers as often as possible. These observations will be used to parameterise the downwelling longwave radiation in terms of cloud cover and type. The parameterisation will allow calculation of the LW radiation to be made from the visual observations routinely obtained by the 7000-strong Voluntary Observing Ship fleet, thus ultimately improving the accuracy of weather forecast models.

Sea surface temperature.

Sea surface temperature (SST) data from the thermosalinograph (TSG) were logged on the AutoFlux acquisition workstation as part of the "surfmet" data stream. Daily pstar files are produced as part of the normal AutoFlux processing and these were moved over to discovery2 at the end of the cruise.

Ship borne wave recorder.

The SBWR which had been faulty was fixed prior to D284 and the system was started for D284 and continued to operate thoughout D285 without problems. An attempt to install a network card in to the SBWR PC failed , so that data had to be downloaded periodically by floppy disc.

2.2.4 Initial flux results.

Inertial dissipation (ID) flux measurements.

The **ID momentum flux** obtained from the HS sonic anemometer is shown in Fig. 2.6 where the drag (transfer) coefficient is shown against the true wind speed corrected to a height of 10 m and neutral atmospheric stability. The drag coefficient is defined as (10^3 * momentum flux / wind speed ^{2})

Although flow distortion corrections have not yet been determined for the exact HS anemometer position, it has been shown that the vertical displacement of the flow varies little with anemometer position or relative wind direction (Yelland et al. 2002). In contrast, the mean bias in the measured wind speed is sensitive to both these factors. A 5% bias in the drag coefficient could be explained by a bias in the measured wind speed of only 1 to 2%, possibly due to a combination of calibration error and/or the effect of flow distortion on the mean wind speed. All the anemometers will be re-calibrated after the cruise, and accurate flow distortion corrections applied.

Fig. 2.7 shows the **ID latent heat flux** obtained from the Licor H_2O data. In general the results are in agreement with data from previous experiments, but some high values are evident. During the cruise it was noted that the licor sensor was sensitive to both rain and fog and during periods where these occur, high values of the latent heat flux can be produced.

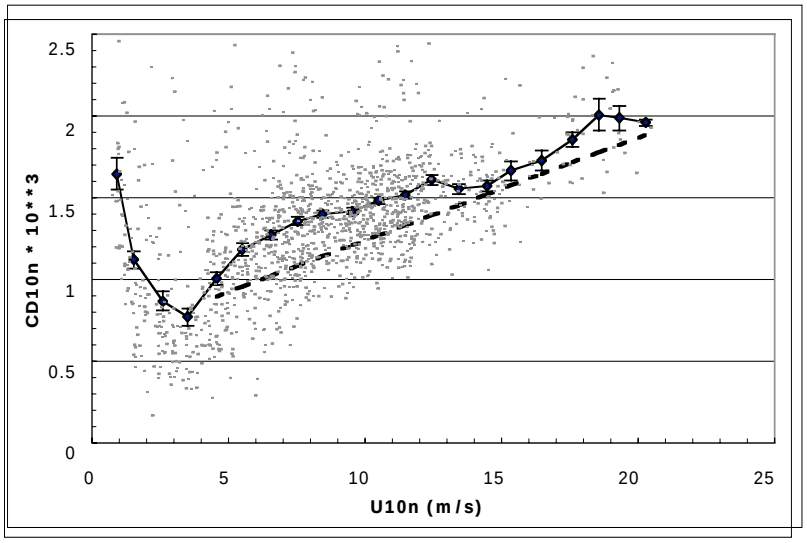


Fig. 2.6 Fifteen minute averaged values of the measured ID drag coefficient (dots), plus the mean results (solid line) binned against the 10 m neutral wind speed. The Smith 80 relationship is shown by the dashed line.

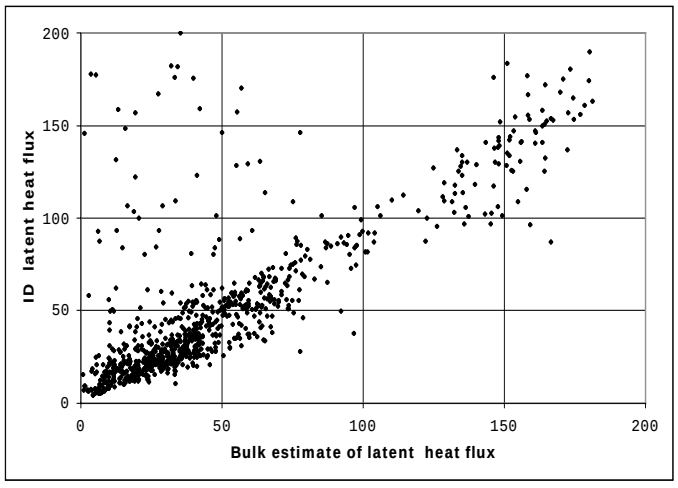


Fig.2.7 Direct measurements of the kinematic latent heat flux from the ID method (dots) shown against a flux estimated from a bulk formula for bow on winds

2.2.5 Additional Data Processing

The AutoFlux final data file and Underway (TSG) datafile were further processed and combined to produce a single weekly 15 minute averaged data file, from which weekly plots and ascii data files were produced for other cruise participants.

The AutoFlux system automatically logs a number of data streams such as mean met, winds, navigation from the GPS4000 and the underway TSG data. These data are stored in daily files which have been converted into PSTAR files. Further processing for the AutoFLux Fluxes then merges the variables needed to complete the flux processing in to one final merged file. Filename of the form mergeD285.ddd.

To produce the Met and Underway plots for the cruise report it necessary to merged the Tsg data in to this file as well. The mergeD285.ddd file also includes many variables not required for general Met and Underway parameters so while merging the TSG on it is also advisable to copy only the required variables across to the new file. This file can then be used to generate ascii data for those who are not familar with PSTAR.

The variable list from Autoflux merged file:

No: 1, 21, 23, 25, 27, 29, 31, 35, 37, 39, 41, 43, 44, 50, 51, 52, 85, 87, 90, 91, 112.

Var: jday, reldd, spdENV, press.M, Ptir.M, Stir.M, LW3117.M, pdUSE.M, pwUSE.M, cog.M, sog.M, latUSE.M, lonUSE.M,

heading, TRUspd, TRUdd, sst, U10BSL, SENBSL, LATBSL, RH.

Variable list from TSG:

No: 1, 2, 3, 4, 5, 6, 11, 12, 13, 14, 15, 16, 17, 22, 23, 24.

Var: jday, Htemp, Rtemp, Cond, Flour, Trans, Press, Ppar, Spar, Speed, Dir, Airtemp, Hum, Ptir, Stir, Salinity.

Note AutoFlux merged file variables: sst, press.M, Ptir, Stir are the same data as TSG Rtemp, Press, Ptir, Stir.

AutoFlux Variables:

jday = Julian Day in fraction of a day.

reldd = relative wind direction as measured by the HS Sonic Anemometer located Starboard side opn the Foremast BOW=180.

spdENV = relative wind speed as measure by theh Sonic HS.

press.M = Atmosphereic Air Pressure with no height correction. (inlet on foremast at 18m height).

Ptir.M = Calibrated port side Total Iradiance (Kipp & Zonen CM6B) taken from tsg data.

Stir.M = CAlibarted stbd side Total Iradiance (Kipp & Zonen CM6B) taken from tsg data.

LW3117.M = Calibrated Longwave data measured using a Eppley Pyronometer on top of the foremast .

pdUSE.M = Psychrometer Dry bulb temperature (with simple quality control bewteen two psychrometers on fore mast).

pwUSE.M = Psychrometer Wet bulb temperature (with simple quality control bewteen two psychrometers on fore mast).

cog.M = Course over ground from GPS 4000.

sog.M = Speed over ground from GPS 4000 m/s.

latUSE.M = latitude from GPS 4000.

lonUSE.M = longitude from GPS 4000.

heading = Ship gyro heading.

TRUspd = True speed of Sonic HS as measured on the STBD side of foremast.

TRUdd = True Direction of Sonic HS as measured on the STBD side of foremast.

sst = TSG Rtemp which is sea surface temperature at about 5m depth.

U10BSL = True windspeed normalized to 10m height and netural conditions.

SENBSL = Sensible heat flux derived from bulk measurements.

LATBSL = Latent heat flux derived from bulk measurements.

TSG Variables:

jday = Julian Day in fraction of a day.

Htemp = Housing temperature ie Non toxic water temperature at tsg location in water bottle annex.

Rtemp = Non Toxic water temperature at inlet at approx 5m depth.

Cond = Conductivity measured by tsg from non toxic in water bottle annex.

Flour = Fluorometer data from tsg from non toxic in water bottle annex.

Trans = Transmissometer data from tsg from non toxic in bottle annex.

Press = Atmosphereic Air Pressure with no height correction. (inlet on foremast at 18m height). Vaisala PTB100A

Ppar = Port Par Sensor (350 - 700 nm) on Foremast

Spar = Starboard Par Sensor (350 - 700 nm) on Foremast

Speed = Vaisala WAA151 cup anemometer port side of Foremast

Dir = Vaisala WAV151 Vane port side of Foremast

Ptir = Calibrated port side Total Iradiance Kipp & Zonen CM6B (335 - 2200nm).

Stir = CAlibarted stbd side Total Iradiance Kipp & Zonen CM6B (335 - 2200nm).

Salinity = calculated from Conducivity and H temperature.

Airtemp = Temperature from Vaisala HMP44L air temp and humidity sensor on foremast

Hum = Humidity from Vaisala HMP44L air temp and humidity sensor on foremast

2.2 References

Yelland, M. J. and R. W. Pascal, 2004: RRS Discovery D279, ROPEX, 4th April – 10 May 2004. Southampton Oceanography Centre, Cruise Report.

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2.2 Appendix A. List of significant events.

Day 265: 4 days after sailing from SOC the analogue input to the R3 sonic failed stopping the R3 synchronization.

Day 307: Licor program modified, Cleaned Licor, LW and TIR sensors.

Day 309: TSG started 0700 gmt.

Day 315: nimbus hung and had to be rebooted and fsck run manually.

Day 316: R3 sonic stops working.

Day 319: 10:00 gmt Cleaned Licor, LW and TIR sensors. Found loose wire on R3 on foremast, 10:30 gmt R3 working again but no sync.

Day 325: 10:00 Cleaned Licor, LW and TIR sensors. Replaced psychrometer HS1031 with HS1026, corrected error in psy IO2002 dry bulb cal causing a positive offset of +0.40584.

Day 328: Progmon program modified to clear launch no. at midday.

Day 329: Progmon modified so that disk stats sent by Orbcomm.

Day 331: Progmon modified so that disk stats sent only once per hour.

Day 332: Progmon crashed, had to put 10 sec delay back in.

Day 334: Psy dry bulb PDS1 (HS1026) started to be very noisy when damp. Changed scrp.amet so only PDP2 dry bulb used in AutoFlux processing.

Day 338: Orbcomm stopped working.

Day 340: Modified "amet.edit.windows" so longwave does not go out of range.

Modified daily.scrp so that tsg daily file and merg daily file automatically copied to cirrus for further processing. Modified 'cvibat' on nimbus so cirrus mounted to /mnt on bootup.

Day 344: 11:30 gmt Change Psy HS1026 back to HS1031, Cleaned Licor, LW and TIR sensors. 13:00 gmt. Changed scrp.amet so both dry bulbs used.

2.3 Aerosols and rainfall

D285 **Hélène Planquette**

The atmosphere can represent an important role in material transport from land to sea and may represent an external source of trace elements, such as Fe. The aim of the study is to quantify any Fe input from the atmosphere around the Crozet Plateau.

Aerosol Collection

Aerosol collection requires a 72h period of sampling. As many rain events occurred during this cruise, it was therefore almost impossible to collect aerosol samples around the Crozet region. Aerosol samples for Fe analysis are collected with a high volume (1 m^3. min^{-1}) air sampler (Graseby-Anderson) as the ship's course coincided with the prevailing wind direction, so that exhaust from the ship's stack was not blown over the collector during this period.

The filters used for aerosol collection have been acid-washed.

A filter blank will be determined on an unexposed acid-washed filter that had been loaded into a sampling cassette and left for ~ 24h, with no air drawn through it.

After aerosol collection, the filters were stored in double plastic bags, in a –20°C freezer. They will be analysed probably at UEA, with the collaboration of Dr Alex Baker. The soluble Fe will be extracted with ammonium acetate buffer as a model for Fe release from aerosol in rainwater. Then, Fe will be determined by Graphite Furnace Atomic Absorption Spectrometry (GFAAS).

Rain collection

Atmospheric iron concentrations will be investigated in rain samples collected at different periods (see Table 1) with a 30 cm diameter funnel attached to a sample bottle, which was located on the monkey island. The polypropylene funnel (30 cm diameter) and acid-washed (with nitric acid) low-density polyethylene bottles were both acid-washed prior to use.

The samples were stored in a freezer at –20 C.

The iron and other metals of interest will be determined by GFAAS.

Table 2.4 Rain Samples.

Event	Sample	Start Date	Time (GMT)	End Date	Time (GMT)	Comments
1	R1 D285	8-nov-04	09H13	08-nov-04	09H13	Blank, 125 mL
2	R2 D285	8-nov-04	09H13	08-nov-04	15H05	50 mL,
3	R3 D285	8-nov-04	15H05	08-nov-04	20H15	60 mL,
4	R4 #1 D 285	9-nov-04	20H15	09-nov-04	13H30	500 mL, split in two bottles
	R4 #2 D 285	9-nov-04	20H15	09-nov-04	13H30	because overfilled
5	R5 #1 D285	18-nov-04	09H32	18-nov-04	15H26	500 mL split in two bottles
5	R5 #2 D285	18-nov-04	09H32	18-nov-04	15H26	
6	R6 D285	22-nov-04	18H30	22-nov-04	22H25	250 mL
8	R7 D285	30-nov-04	06H20	30-nov-04	10H00	50 mL
9	R8 D285	30-nov-04	10H00	30-nov-04	16H00	40 mL
10	R9 D285	02-déc-04	08h03	03-déc-04	15h20	40 mL

Objective

The amount of mineral aerosol particles has doubled as a result of human activity (Tegan et al., 1996 in Harrison, 2000). It is thought that the resultant increases in dust delivered to oceans via atmospheric deposition could increase CO_2 uptake by the oceans (Harrison, 2000). Takeda (1998) supports this hypothesis by concluding that changes in iron inputs from atmospheric dust to the ocean were responsible for changes in primary production and thus the drawdown of atmospheric CO_2 during the last glaciation.

These findings highlight the importance of quantifying the atmospheric deposition fluxes of minerals such as silica and iron, which are believed to play important roles in the oceanic cycling of carbon. In the context of this research, objectives included investigating atmospheric inputs of iron and silica to the ocean in the vicinity of the Crozet Plateau in order to quantify this pathway as an external source of minerals to the water column.

Method

A high volume (1 m^3 min^{-1}) air sampler (Graseby-Anderson) was used for obtaining trace metal (1st leg only) and major ion aerosol samples over the duration of the cruise. A rainfall collector was used to collect rainfall over the 1st leg of the cruise only (see above).

The aerosol collector acts as a vacuum with a pre-calibrated air-flow rate and monitored sampling time. Filters were placed in the upper compartment of the collector approximately every 3 days (Fig. 2.8) during the 1st leg and every 2 days during the 2nd leg of the cruise. Upon removal, filters were stored in sealed double plastic bags and frozen (-20 ^oC) for transport back to the UK for analysis (UEA).

It is thought that the potential for data from the filters will be hindered by the difficulties encountered in retrieving good quality filters. This was due both to the fact that it proved difficult to obtain filters over the course of the 2/3 day sample period that had not been marred by the occurrence of rainfall, high winds closing the collector lid, or by an alteration in the ship's course that meant fumes became part of the head wind during sampling.

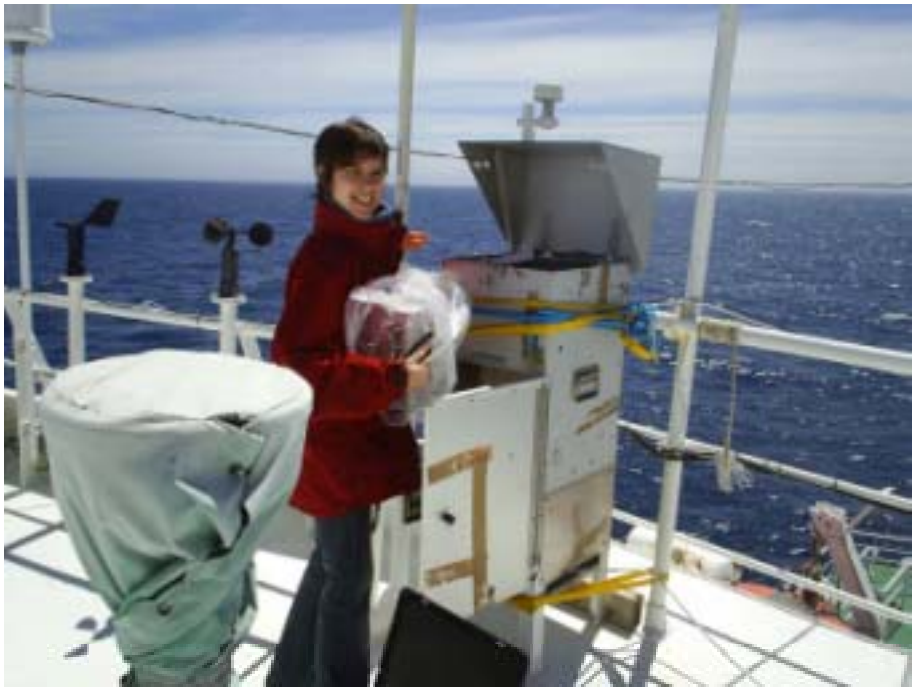

Fig. 2.8 Aerosol filter changing

References

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2.4 Underway Fast Repetition Rate fluorometry (FRRf)

Underway FRRf on D285 **Mark Moore**

A Chelsea Scientific instruments FAST*tracka*™ Fast Repetition Rate fluorometer (FRRf) (Kolber et al. 1998) was connected to the ships non-toxic supply within the bottle annex in order to monitor the physiological state of photosystem II (PSII) within the surface phytoplankton population throughout the study area. Saturation of variable chlorophyll fluorescence was performed using 100 flashlets of 1.1μs duration with a 2.3μs repetition rate. Subsequent relaxation of fluorescence was monitored using flashlets provided at 98.8μs spacing, giving a total relaxation protocol length of around 2ms. Such a protocol should allow adequate resolution of Q_a relaxation kinetics (Kolber et al. 1998).

The data were stored internally on the instrument and downloaded at between 2 and 7 day intervals throughout the D285. Instrument optics were cleaned whilst the download operation was being carried out. Some fouling of the optical surfaces was apparent after the longest sample collection periods and it is recommended that downloading of files and cleaning of optical surfaces be performed more regularly during Leg 2. A total of 9 files were collected (Table 2.5). Data were then analysed using custom software in a Matlab™ environment. Only limited initial checks on data quality were performed during the cruise. However data appeared to be a similar quality to previous deployments of the instrument in this mode. An exception was found for file 'uw4' where data quality appeared particularly poor. The cause of this problem is unknown at the current time and will require further investigation.

Much of the signal was dominated by marked diel variability in the parameters that can be measured by an FRRf deployed in this mode (F_v'/F_m' and σ_{PSII}'), limiting the interpretation of special variability within physiological parameters to night-time data.

Table 2.5 Underway FRRf files collected during D285

	UW1	UW2	UW3	UW4	UW5	UW6	UW7	UW8	UW9
Start time	14:45 3 Nov 2004	13:01 4 Nov 2004	13:19 7 Nov 2004	12:12 9 Nov 2004	12:05 11 Nov 2004	12:37 13 Nov 2004	12:30 18 Nov 2004	14:39 24 Nov 2004	16:18 2 Dec 2004
End time	12:21 5 Nov 2004	12:45 7 Nov 2004	11:40 9 Nov 2004	12:15 11 Nov 2004	11:49 13 Nov 2004	11:46 18 Nov 2004	14:00 24 Nov 2004	15:35 2 Dec 2004	07:08 8 Dec 2004

Underway FRRf on D286 **Anna Hickman**

Underway FRRf measurements were collected following methods of CROZEX Leg 1, and are as follows:

A Chelsea Scientific instruments FAST*tracka*™ Fast Repetition Rate fluorometer (FRRf) (Kolber et al. 1998) was connected to the ships non-toxic supply within the bottle annex in order to monitor the physiological state of photosystem II (PSII) within the surface phytoplankton population throughout the study area. Saturation of variable chlorophyll fluorescence was performed using 100 flashlets of 1.1μs duration with a 2.3μs repetition rate. Subsequent relaxation of fluorescence was monitored using flashlets provided at 98.8μs spacing, giving a total relaxation protocol length of around 2ms. Such a protocol should allow adequate resolution of Q_a relaxation kinetics (Kolber et al. 1998).

The data were stored internally on the instrument and downloaded at between 1 and 5 day intervals throughout the D286. Instrument optics were flushed and cleaned whilst the download operation was being carried out. A total of 10 files were collected (Table ?). Only limited initial checks on data quality were performed during the cruise.

The underway instrument was swapped after completion of UW14 with the instrument used on SeaSoar. Some data were lost at the end of files UW17 and UW18 possibly due to a damaged flashcard limiting storage capacity of the second instrument. However, this problem will require further investigation.

Table 2.6 Underway FRRf files collected during D286

	UW10	UW11	UW12	UW13	UW14	UW15	UW16	UW17	UW18	UW19
Start time	19:20 JD 348	14:55 JD 349	13:56 JD 350	10:03 JD 353	13:54 JD 356	15:30 JD 358	13:17 JD 361	12:11 JD 365	12:42 JD 040	13:06 JD 090
End time	14:40 JD 349	13:22 JD 350	09:46 JD 353	13:35 JD 356	08:30 JD 358	12:50 JD 361	11:46 JD 365	12:10 JD 040	12.30 JD 090	13:20 JD 010

2.5 Satellite images

Hugh Venables, Katya Popova

Concurrent Modis Chlorophyll and SST images were processed at Plymouth and placed on their website as png images, generally within 6 hours of the satellite pass. These were then downloaded by Katya Popova and the relevant images e-mailed to the PSO's account (due to size restrictions on personal accounts). Each image was 50-400K depending on coverage. The files were copied to /data61/sat and then to /data61/hjv/psat/chl (or /sst) with the filenames changed to ddmmi.png where dd is day of month, mm is month and i is image number (there could be up to 3 images per day). The matlab script psat2boat, in /data61/hjv/matlab, could then be run to create composite images. Time periods for the composites can be selected by entering day of month and month for start and end or jday for September-December. Images were then saved in data61/hjv/matlab as jpg or eps format to be imported into illustrator or printed. eps gives greater resolution so is preferable if software is available to view it. Plotting images to the screen was time consuming (1011x1424 pixels) and so psat2boatquick can be used to quickly plot successive days images subsampled to every 10 data point in latitude and longitude to allow coverage to be assessed so that a sensible series of composites could be created.

The composites were created by averaging all available data for each position, using a counting array to record how many previous images had provided data for each position, so each image was given equal weight in the composite.

3. SeaSoar

3.1 Penguin — Paul Duncan

3.1.1 Introduction

The Penguin system (originally developed at SOC by Nick Crisp and Vic Cornell) comprises two Linux computer systems, one at the surface, and one residing in the SeaSoar towed vehicle. The system in the vehicle logs data from several instruments to its hard disk, and sends pressure across its network connection (provided by a pair of ADSL modems) to the surface system (known as Emperor) which sends the pressure data to the flight control system. As well as this, the Emperor system regularly transfers data from the Penguin (underwater) system.

The underwater units previously used on UKORS supported cruises were prototypes, with two veroboard circuit boards (one for the power supply, and one for the interface board). Prior to this cruise, Seamap were contracted to develop the prototype Penguin system into a more supportable "production" system. Improvements to the system included:

- Improved robustness of power supply design
- Fuses on the sea power input
- Fuses on the low power +/-15V and 5V outputs
- Provision for control over individual instrument power
- Provision for voltage monitoring of the low voltage supplies
- Better shock mounting of the hard disk

Fig. 3.1 Prototype (left) and production (right) Penguin units

3.1.2 Problems

The majority of problems seem to have been related to instruments, such as the OPC's reluctance to reliably provide data when the vehicle was on deck (we suspect some kind of earthing problem) and problems with some sensors on both Chelsea Minipack units.

The OPC problem was solved by making sure we only switched it on once it was in water (see "Software" below). Even then, it sometimes still did not log properly immediately, and had to be shutdown for thirty seconds – this would not have been possible with the prototype system.

The Minipack problem is being addressed by loading SeaSoar with an additional payload – a Seabird MicroCAT 37SI. This device gives out temperature and conductivity, and so the Minipack will now mainly be used for pressure and fluorescence.

Apart from Instrument failures there have been occasional problems with the ADSL link which meant that pressure data were no longer available for the flight control system. Normally we have simply power-cycled the top-end ADSL modem. But during one such suspected case of ADSL link failure, this did not help. After a while an attempt was made to re-boot the Penguin system by power-cycling it from the surface, but only the ADSL modem in the SeaSoar was contactable. So another attempt was made to re-boot it – probably too soon, whilst it was still doing file system checking. This required the removal of the hard disk and manual file system checking on another Linux system. During investigation, Gareth Knight discovered that the cable connecting the ADSL modem to the TP-400 computer in Penguin had a break in it close to one of the RJ-45 connectors. This cable was then re-terminated by Gareth and has worked ever since. Since then, a communications monitoring system that had been disabled whilst Penguin was in the lab at SOC, has been re-enabled. This monitors the link between Emperor and Penguin. If the link appears to have gone down, the Penguin-end modem is re-booted. If this fails to bring the link up, the Penguin system shuts itself down properly, thus preserving the integrity of its file systems.

After the problem with the internal Penguin network cable had been rectified, the vehicle went in the water for another tow, only to find that now we had no control over the vehicle's flight control. The vehicle was recovered after several attempts to control it.

Investigations by Dave Teare and Gareth Knight revealed a broken pin on the main sea-cable connection to Penguin. The bulkhead connector was replaced, and the flight controls tested on deck. The vehicle was then put back in the water to complete another tow.

3.1.3 Software

The Penguin system, as shipped to the ship, only carried software to switch all of the instruments on, or all of the instruments off. To solve the OPC problem, detailed above, the "mp_on" program that switched all instruments on, was modified, and the modified program, called "poweron" could be used to turn power on to one or more instruments, by specifying the port numbers of the instruments to be powered.

The original near-real-time graphics on Penguin used the Gnuplot program, with several scripts. This worked, but it was unable to produce an output similar to the Level C program "bandplot" which used to be used in the days of the Neil Brown CTD, logging through the ABC system. To deal with this, a new program called "dapsband" was written. This shows the SeaSoar pressure trace, but changes the colour of the trace to show changes in value of the particular channel being monitored. Currently, only data from the Chelsea Minipack can be viewed.

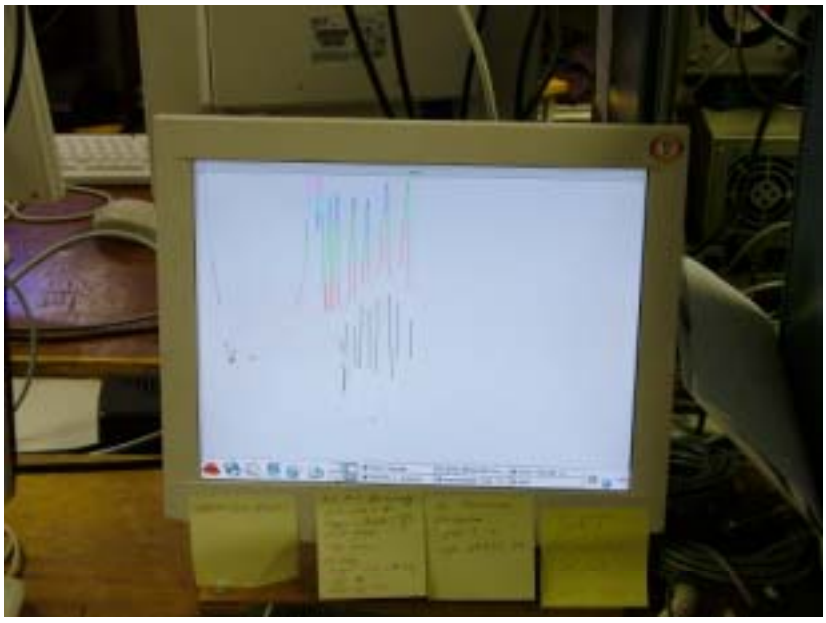

Fig. 3.2 An early version of "dapsband" showing the first part of a tow

Because of the problems with the Chelsea Minipack, the DAPS system needed a new module to log data from the Seabird MicroCAT 37SI. This was achieved with guidance from Nick Crisp (the author of DAPS) over the E-mail system. The new module was tested on the Emperor system, with the instrument directly connected to its only serial port (usually used for sending pressure data to the SeaSoar flight control system). The new software has now been loaded on the Penguin system, but will not be tested in the water until the next leg – Discovery 286.

3.1.4 Deployments

The SeaSoar was deployed 17 times in all, including trials. These are summarized in Table 3.1

Table 3.1 SeaSoar deployments

Cruise 285

station number	start date	start time GMT	stop date	stop time GMT	duration	distance run (km) start	distance run (km) end	length of run (km)	notes
15488	7/11/04	1142	7/11/04	1610	4 h 28 m				trial only, data not processed
15497	13/11/04	1733	18/11/04	1510	4 d 21 h 37 m	3727	5448	1721	4-leg survey NE of M3, extended by severe weather
15514	23/11/04	1248	24/11/04	1738	1 d 04 h 50 m	6239	6672	433	survey south of Crozet past Ile des Pingoiuns
15519	25/11/04	1137	25/11/04	1608	4 h 31 m	6728	6872	144	trial of shallow OPC, early recovery forced by weather
15521	26/11/04	951	26/11/04	1144	1 h 53 m	6961	6978	17	no control, aborted?
15529	29/11/04	347	29/11/04	836	4 h 49 m	7516	7565	49	no control, recovery not possible until winch fixed
15530	29/11/04	1124	29/11/04	2328	12 h 04 m	7576	7762	186	straight run NW of Crozet Plateau
15536	30/11/04	1637	1/12/04	1928	1 d 02 h 53 m	7817	8227	410	triangular run north of M8
15541	2/12/04	1851	3/12/04	1718	22 h 27 m	8347	8699	352	run to NW M8 to M9
				Total	**9 d 7 h 32 m**			**3312**	

Cruise 286

15551	17/12/04	600	18/12/04	1707	1 d 11 h 07 m	1664	2249	585	run into area through K to M9
15575	23/12/04	956	24/12/04	1159	1 d 02 h 03 m	3133	3544	411	W to E transect M3 to M5
15593	31/12/04	1500	1/1/05	1714	1 d 02 h 14 m	4325	4719	394	N to S transect M3 to M6
15601	5/1/05	2346	6/1/05	1236	12 h 50 m	5103	5291	188	NE transect M6 to M2
15608	7/1/05	636	7/1/05	1424	7 h 48 m	5344	5462	118	N run from M2 aborted early
15624	11/1/05	1758	12/1/05	1248	18 h 50 m	6232	6513	281	box round M3 bloom
15630	13/1/05	615	13/1/05	2232	16 h 17 m	6605	6789	184	zigzag run M3 to M10, slow speeds only, aborted
15631	14/1/05	1242	15/1/05	334	14 h 52 m	6951	7170	219	NW transect ending at M10
				Total	**6 d 14 h 1 m**			**2380**	

3.2 CTD minipack processing and calibration — John Allen

Data

The 'C21' SeaSoar system (Allen et al., 2002), used for the first time on D253 (May/June 2001), carries a Chelsea Instruments Minipack CTDF (Conductivity, Temperature, Depth and Fluorescence) instrument which is considerably more compact than the Neil Brown CTD instrument that had traditionally been carried in SeaSoar. The two MiniPack CTDs taken on D285/6 suffered major problems that are discussed later in this section.

During SeaSoar deployments data were recovered, in real time, from the PENGUIN data handling system on SeaSoar by ftp to create identical data files on the EMPEROR Linux PC in the main lab: this is discussed in detail in the preceding technical support section. Thus data were logged in three files, one containing the CTDF measurements, and two other files for the FRRF and OPC data. The FRRF and OPC data are dealt with elsewhere in this report.

All of the variables output by the MiniPack CTDF were calibrated using pre-set calibrations stored in the instrument firmware. The sensors sampled at 16 Hz, but the output variables were one second averages. The variables output were:

Conductivity ($mScm^{-1}$)

Temperature (°C)

Pressure (dbar)

ΔT ($°Cs^{-1}$), temperature change over the one second averaging period.

Chlorophyll (mgm^{-3})

Each of these were output at one second intervals and a time/date stamp was added by the DAPS handling software on PENGUIN. The time rate of change of temperature, ΔT ($°Cs^{-1}$) was the difference between the first and the last sample in the one second average of temperature. Firmware calibration coefficients for the two CTDs were as follows:

Minipack serial no. 210012, calibration date 30/01/04,

$$press. = \left(-1.85335 \times 10^{-9} \times bits^2\right) + \left(9.46170 \times 10^{-3} \times bits\right) - 10.2313$$

$$temp. = \left(5.15065 \times 10^{-11} \times bits^2\right) + \left(5.99447 \times 10^{-4} \times bits\right) - 3.5094$$

$$cond. = \left(-7.16162 \times 10^{-11} \times bits^2\right) + \left(1.11034 \times 10^{-3} \times bits\right) - 0.9619$$

$$chl.conc. = \left(0.00208 \times bits\right) - 3.694.$$

Minipack serial no. 210035, calibration date 10/12/04,

$$press. = \left(-1.43239 \times 10^{-9} \times bits^2\right) + \left(9.41950 \times 10^{-3} \times bits\right) - 9.4446$$

$$temp. = \left(5.48513 \times 10^{-11} \times bits^2\right) + \left(6.02014 \times 10^{-4} \times bits\right) - 2.9999$$

$$cond. = \left(-1.02301 \times 10^{-10} \times bits^2\right) + \left(1.12546 \times 10^{-3} \times bits\right) - 0.9859$$

$$chl.conc. = \left(0.00211 \times bits\right) - 3.902.$$

Minipack 210012 was used throughout both D285 and D286 but suffered severe temperature calibration drifting from the middle of the second major tow SS15514. This is clearly apparent below (Fig. 3.3), plotted against the thermosalinograph remote housing temperature. However, at the time, without a CTD deployment at the end of this tow, and with the close proximity of the Crozet Islands, the resulting low salinities seemed plausible. After the third major tow, stn. 15530, the severity of this temperature drift became clearly apparent, now ~0.3 degrees high and getting rapidly worse. From profile to profile the T/S relationship was tight, and the drift was not easily discernable from a single plotpr page (less than 1 mm over the entire page, 10 groups of four profiles at 20 mm offset spacing). After swapping for Minipack 210035, it was found that its conductivity cell did not work and so we were forced to swap 210012 back into the vehicle despite the temperature drift. Following 210012's replacement in the SeaSoar vehicle, during the last major tow, stn. 15041, the drift appeared to have ceased and perhaps even begun to reverse, however the offset was now in the region of 0.4-0.5 °C. Significant effort would be required to recover these data to anything like a reasonable standard. A 'final' calibration was obtained for the D285 data before the end of D286 and is discussed later.

With no prospect of a replacement CTDF for D286, work began to fit a SeaBird MicroCat CT sensor on SeaSoar. This then used TTY2 serial port on PENGUIN and was expected to provide reliable temperature. In addition, the temperature sensor from 210035 was swapped into 210012 during passage at the end of D285, with the hope that this would at least provide stability, accepting of course that we would not have a

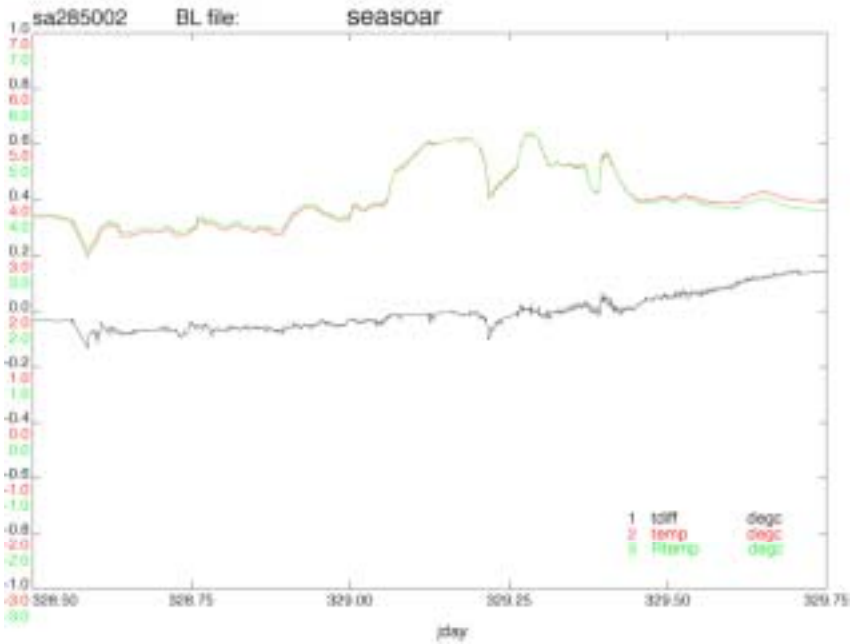

Fig. 3.3 Comparison of minipack (temp) and thermosalinograph (Rtemp) temperatures

relevant calibration. For the first SeaSoar deployment on D286, SS15551, The MicroCat was fitted inside the SeaSoar body with a neoprene tube fitted to take water from the nose of SeaSoar to the instrument. The MicroCat has a free flow conductivity sensor arrangement into which the right diameter hose could easily be fitted, however I had not realised at this stage that the temperature sensor was external to this! It was not possible

therefore, to calculate sensible salinity values from this setup. Therefore for the subsequent tows, SS15575 and SS15593, the Microcat was fitted external to the SeaSoar body, on the upper tail plane close to the fin, where there was no requirement for any ducted water supply. The MicroCat was not designed for use on this sort of platform; it had a maximum rate of sampling of just under 1 Hz and it was not possible to synchronise temperature and conductivity measurements sufficiently to produce sensible T/S profiles. The MicroCat instrument was eventually fitted to a mooring as originally planned, and thus the remaining SeaSoar tows, SS15601, SS15608, SS15624, SS15630 and SS15631, were carried out with only the MiniPack CTD sensors. Two new cshell scripts were created, ***mcexec0*** and ***mcexec1***, from those used for processing MiniPack data and discussed later in this section. The principal difference was an additional call to *pcalib* to obtain conductivity in mmho/cm from ***mcexec0***, and additional calls to *pmerge* and *pcalc* to obtain pressure data from the MiniPack files and to calculate/apply a lag temperature, respectively, from ***mcexec1***. The temperature data from the MicroCat were useful in guiding our initial calibration of the MiniPack data during D286, however, it is unlikely that a similar instrument will be used on the SeaSoar vehicle again and thus further detailed discussions are not required here.

Processing Steps

The following processing route was followed every 12 hours during SeaSoar tows:

The DAPS data file on EMPEROR was stopped and a new one started every 12 hours, at which time the PENGUIN clock was checked for large drifts and later clock correction if required. The PENGUIN clock was found to gain, but even after nearly six days continuous logging, the PENGUIN clock only gained ~ 40 seconds and thus no offsets were applied to the datasets. The PENGUIN clock was reset at the beginning of each SeaSoar deployment. The latest 12 hour DAPS data files were copied from the EMPEROR PC to the shipboard SUN UNIX system over the ship's ethernet.

pgexec0

Read the raw DAPS data into PSTAR format and added information to the PSTAR header. In addition time in seconds was calculated from the Jday variable used by DAPS. Note that it was necessary to use the *-square* command line option for the pexec program *pxtime*. Unless this option was specified *pxtime* rounded the time to the nearest second occasionally giving rise to two records having the same time.

pgexec1

With the Minipack set to output variables in physical units it is not necessary to use the pexec program *ctdcal*, and so this script was written to replace ssexec1 by D. Smeed during D253. We may review this for temperature during D286, following the drifting temperature problem with MiniPack 210012 during D285. The main steps are

a) *pcalc* to apply temperature lag correction

b) *pintrp* to interpolate pressure across gaps in the data. Typically less than 0.3% of the data had to be interpolated

c) *peos83* to calculate salinity and density.

Pedita was then used to remove the worst surface salinity spiking and rare fluorometer spikes. Further editing for spikes, and salinity offsets due to high vehicle dive rates was carried out by inspection with *plpred*.

Subsequently, 12 hour files were merged to produce a single file for each survey, which was then merged with the navigation data. The data were interpolated to a 4 km by 8 dbar regular grid using *pgridp*.

Temperature Correction

It is necessary to make a correction for the small delay in the response of the CTD temperature sensor for two reasons: First, to obtain a more accurate determination of temperature for points in space and time; second, and more importantly, to obtain the correct temperature corresponding to conductivity measurements, so that an accurate calculation of salinity can be made.

Surprisingly, according to the Minipack users manual, the time response of the temperature and conductivity cells should have been the same. However, a lag in temperature was apparent in the data in two ways. There was a difference between up and down profiles of temperature (and hence salinity) because the time rate of change of temperature has opposite signs on the up and down casts. The second manifestation was the "spiking" of salinity as the sensors traversed maxima in the gradients of temperature and salinity. The rate of ascent and descent of SeaSoar was greater (typically up to 3-4 ms^{-1} at the beginning of descent and ascent) than that of a lowered CTD package, thus the effects of the temperature lag were more pronounced. Thus, the following correction was applied to the temperature during ***pgexec1*** before evaluating the salinity

$$T_{corr} = T_{raw} + \tau.\Delta T$$

where ΔT is defined above and τ is constant.

The best value of τ was chosen so as to minimise the difference between up and down casts and noise in the salinity profile. Initially the best value was found to be $\tau = 1.3$ second (stns. 15497-15536), but this noticeably changed after replacement of the Minipack 210012 in the SeaSoar vehicle for SS15541 to $\tau = 1.15$ second. This agreed with the large lag needed on D253, but it was still somewhat concerning and needs to be discussed further with Chelsea instruments.

Following the exchange of temperature sensors between D285 and D286, it was clear that the lag correction required was greatly reduced. At the beginning of D286 (SS15551), the best value was found to be $\tau = 0.3$, and therefore similar to the expected time response of the temperature sensor, 0.3 seconds. However this did not remain stable for the rest of the cruise: $\tau = 0.35$ was found to be a better value for SS15575, returning to $\tau = 0.3$ for stns. 15593-15630. During the final SeaSoar tow, SS15631, the required temperature lag correction changed from $\tau = 0.24$ at the beginning of the tow to $\tau = 0.27$ at the end.

Calibration

Our primary tool for the calibration of the Minipack CTD data was and is the underway thermosalinograph (TSG) connected to the ship's non-toxic supply. With such a poor absolute reference to temperature from the Minipack CTD we were very lucky to find that the TSG was generally stable, well behaved and easy to calibrate during D285 and

D286. In the following sections I will therefore deal with the TSG calibration first, moving on to the final calibration of D285 SeaSoar temperature and salinity and finishing with the initial temperature calibrations applied to the D286 SeaSoar data. In this final section I hope also to have provided some pointers for further calibration of the D286 data which should be significantly easier than the procedure that was necessary for the D285 data.

TSG calibration

TSG remote temperature, 'Rtemp' measured at the ship's non-toxic intake, was calibrated to CTD temperature data (discussed elsewhere) from ~ 4 metres water depth during both up and down casts. For both D285 and D286 only a constant offset was required to calibrate the TSG remote temperature to an accuracy of ~ 0.02, excluding occasional apparently random outliers.

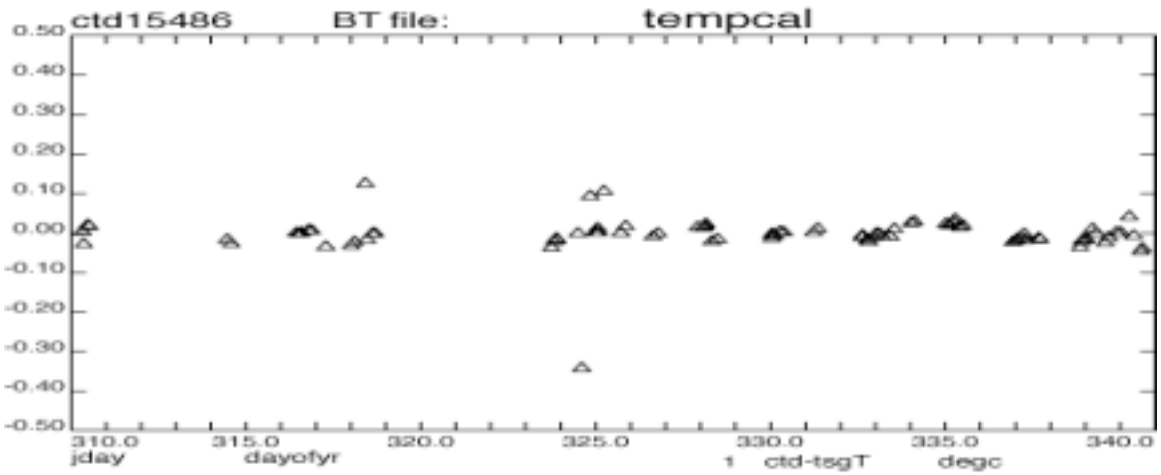

Fig. 3.4 Comparison of corrected TSG temperature with CTD temperature for D285, where corrected TSGtemp = Rtemp – 0.065

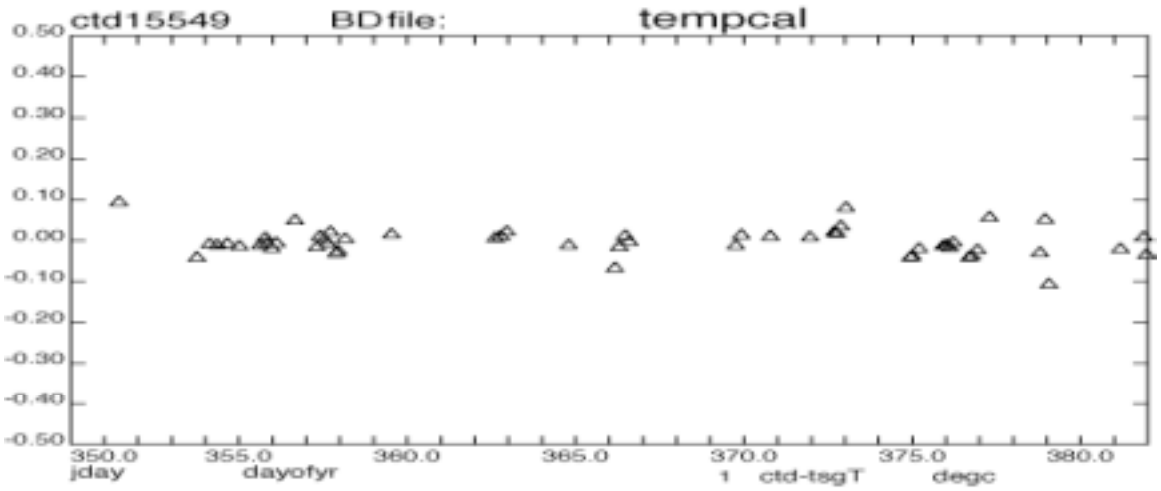

Fig. 3.5 Comparison of corrected TSG temperature with CTD temperature for D286, where corrected TSGtemp = Rtemp – 0.050

For D285, calibrated TSG temperature (TSGtemp) was determined as

$$TSGtemp = Rtemp - 0.065$$

For D286, calibrated TSG temperature (TSGtemp) was determined as

$$TSGtemp = Rtemp - 0.050$$

TSG salinity was then calibrated to underway bottle samples determined using the Guildline Autosal and discussed elsewhere in this report. During both D286 and D285 the TSG salinity offset was found to have a significant but linear temperature dependence. This was calibrated out as follows, using *pcalc*.

For D285, calibrated TSG salinity (TSGsalin) was determined as

$$TSGsalin = Salinity - 0.1314 - (0.0012 * TSGtemp)$$

For D286, calibrated TSG salinity (TSGsalin) was determined as

$$TSGsalin = Salinity - 0.1180 - (0.0024 * TSGtemp)$$

however, in this case there was also a noticeable linear temporal drift of 0.01 in magnitude towards the end of the survey (beginning at jday 375) which was calibrated out using *tabcal*.

D285 SeaSoar Minipack 'final' calibrations

Comparison with the calibrated thermosalinograph data was made throughout by selecting SeaSoar Minipack data on a depth range of 3-6 metres using *datpik*.

SS15497

Against TSGsalinity, the SeaSoar salinity was 0.02 high and for this tow there appeared to be no significant problem with temperature. Following calibration of salinity as

$$salin = salin - 0.02,$$

a reasonable match with ctd15496 was possible but a similar match with ctd15498 was not achieved, possibly because of poor co-location with the end of the SeaSoar tow.

I am happy with this calibration to an accuracy of ~0.02 in both salinity and temperature, with the following caveats. Firstly, during daylight hours of jday 219 there was no correlation between minipack and TSG data. It is possible that this results from a transient surface skin heating phenomenon known as the 'afternoon effect' but it looks more serious and I can find no clear explanation. Secondly, the Minipack temperature appeared high by 0.02 over the TSG until it jumped to being ~0.015 low at midnight on jday 320. No temperature calibration has been made for this as the point of transition did not correlate with salinity; which, and finally, was high by 0.02 until a period of bad weather over midnight jday 321 where SeaSoar failed to reach the surface due to reduced ship speed. After this point the salinity appears to have drifted to a zero offset before returning to a 0.02 offset by the end of the deployment.

SS15514

Against the calibrated TSGtemp, the SeaSoar temperature began to drift noticeably from the beginning of this deployment. Furthermore, the rate of drift appeared to increase with time. Initially it looked as though three linear drift gradients might best characterise the

offset. However in echo of the problems encountered with Stn. 15497, it seemed impossible to reconcile intercept points that explained both salinity and temperature offsets. In the end a second order polynomial fit was derived using MS Excel, fitting to jday (normalised to the start of the deployment - 329) at 6 decimal place resolution. Thus temperature was calibrated as

$$temp = temp - 0.0163 - (0.1177 \times jday*) - \left(0.1946 \times (jday*)^2\right)$$

where

$$jday* = jday - 329.$$

Referenced to the thermosalinograph, this left a residual offset in salinity of ~ 0.007 low within an accuracy of 0.025 (estimated). Comparison with previous ctd casts indicated a residual offset of 0.004 low but with respect to the noise level there was little point in calibrating any further. I am happy with the calibration to ~ 0.03 in temperature and salinity.

SS15519

This was a very short deployment and for much of the time SeaSoar failed to reach the surface - experimenting with flight parameters as this was the first time the deep OPC (much heavier, although smaller, 6000 m rated pressure case) had been carried on SeaSoar. Comparison with the calibrated TSGtemp allowed us to apply a constant offset of

$$temp = temp - 0.235.$$

The recalculated salinity showed a possible residual offset against TSGsalin but considerable less than 0.01 high. I was not able to make any sensible T/S match with ctds; but this is probably accounted for by deployment/recovery distances and rapid spatial changes in water mass characteristics. I am happy with the calibration to ~ 0.03 in both temperature and salinity.

SS15530

Continued temperature drift by comparison with the calibrated TSGtemp allowed us to apply a drifting temperature calibration as follows

$$temp = temp - 0.16 - (0.22 \times jday*)$$

where

$$jday* = jday - 334.$$

The recalculated salinity showed an additional moderate temporal drift. And a good match to to ctd 15528 (some distance before) and ctds 15531/2/4 gave significant robustness to the identification of this drift. Thus I further calibrated salinity as follows

$$salin = salin + 0.012 - (0.077 \times jday*)$$

where again

$$jday* = jday - 334.$$

I am satisfied with temperature to an accuracy of ~ 0.02. Given temperature, however, I would consider salinity to be within 0.01; what a shame about the caveat!

SS15536

Continued temperature drift by comparison with the calibrated TSGtemp allowed us to apply a drifting temperature calibration as follows

$$temp = temp - 0.299 - (0.1353 \times jday^*)$$

where

$$jday^* = jday - 335.5 .$$

The recalculated salinity showed a moderately good fit to zero residual offset at an accuracy level of 0.02. Comparison to ctds was interesting. A clear match could be obtained between the beginning of the survey and ctd15537/ctd15538, and a clear match could be obtained between the end of the survey and ctd15534. This is best explained by the triangular nature of the survey N.E from M8 E/W and returning in a S.E. direction to and through M8 E/W. The match at the beginning of the tow indicated that the Minipack salinity was still 0.02 high - which agreed with the moderate fit to the TSGsalin. At the end of the survey the ctd match indicated that the Minipack was 0.005 high, whereas the TSGsalin also indicated 0.02. So why not calibrate further ? Well the fit to TSGsalin indicated the Minipack to be low by as much as 0.02 for much of the middle part of the survey. Additionally a good T/S comparison was made between SeaSoar stn. 15536 and stn. 15497, which overlapped in space twice, with no offset following calibration of the latter. Thus I am happy with leaving the calibration there as within ~ 0.02 in salinity and temperature.

SS15541

Temperature appeared to stop drifting (well that's good, it was getting a little warm - not tropical but warm nonetheless !). Comparison with the calibrated TSGtemp and ctds 15540/2/3/4 allowed us to apply a constant offset temperature calibration as follows

$$temp = temp - 0.46 .$$

The recalculated salinity left a moderate drift from 0.00 to 0.02 low by comparison with TSGsalin. However, comparison with the ctds gave no compelling evidence to believe this, if anything such a comparison indicated a zero offset. I am therefore happy with the calibration to ~ 0.02 in both temperature and salinity.

D286 SeaSoar Minipack initial 'calibrations'

With the SeaBird Microcat data for the first three deployments of SeaSoar we were at least able to compare temperature sensors. The temperature sensor on Minipack 210012 was now that from Minipack 210035, however, the calibration coefficients built into firmware remained. Therefore we effectively had an uncalibrated or mis-calibrated sensor. I expect that a quadratic fit to temperature is still required, and a re-calibration from CTG, post D288, will help particularly if we work with CTG towards a good output. However two things were obvious. Firstly, that visual comparison with the SeaBird Microcat temperature profiles (at expanded temperature scale - ~0.01 resolution) indicated very little temperature dependence. Secondly that comparison with the uncalibrated thermosalinograph remote temperature indicated significant drifts and jumps in the Microcat temperature data at the 0.01 - 0.03 level. This, as will now be discussed is at

least similar to that shown in the Minipack data after a constant offset is taken into account. Early comparison between the uncalibrated thermosalinograph temperature and the 3-6 metre SeaSoar Minipack data indicated a large but reasonably constant offset around 0.7 degC high.

SS15551

Comparison of Minipack and Microcat temperature pressure profiles indicated a constant temperature offset even at a vastly expanded temperature scale of 1 degC per 2 cm x-axis unit. Therefore a constant calibration was applied such that

$$temp = temp + 0.70 .$$

Re-calculation of salinity and comparison with ctd T/S profiles at the beginning and end of the deployment indicated a residual offset of 0.015 in salinity but no attempt was made to calibrate for this.

SS15575

In 3-6 metre data, what initially looked like a temperature dependant Minipack temperature offset to the Microcat temperature data was not applied. This was because such an offset was not clearly apparent in depth profile comparisons. And, furthermore, the Microcat temperature displayed time drifts (at the 0.02 degC level) and jumps (at the 0.01 degC level) when compared with the 'uncalibrated' TSG data which were not apparent in a similar comparison between the Minipack and the TSG. Therefore I chose to apply a best fit constant calibration of

$$temp = temp + 0.67$$

Re-calculation of salinity and comparison with ctd15576 indicated a residual offset of 0.010 in salinity but no attempt was made to calibrate for this.

SS15593

Once again, considerable relative drifting and jumping between near surface temperature values from the Minipack and the Microcat were not borne out in depth profile comparisons. Indeed such comparisons indicated little or no pressure or temperature related offset and therefore I chose, once again, to apply a best fit constant calibration of

$$temp = temp + 0.67$$

This appeared to be safe to an accuracy of ~ 0.02 but little better. A more complicated time dependent offset was hinted at by comparison with the 'uncalibrated' TSGtemp but this will have to wait until after the cruise.

A comparison of conductivity/depth profiles hinted at the Minipack high by 0.01 over the Microcat, but constant throughout the survey. After temperature calibration and re-calculation of salinity, a good match comparison with ctd15592 indicated a residual high offset of just 0.0025 in salinity. Interestingly the early Microcat temperature profiles showed a significant offset to this ctd, confirming that the large, rapidly drifting, offset in temperature at the beginning of this deployment was probably due to the Microcat and not the Minipack.

SS15601

The SeaBird Microcat was removed for the mooring at M2 prior to this deployment. Matching with the preceding ctd profiles at M6 and subsequent profiles at M2, indicated that the Minipack temperature was low by between 0.60 and 0.68, and clearly hinting at a lower offset that had been applied to the previous SeaSoar deployments. I chose to apply a best fit constant calibration of

$$temp = temp + 0.65 .$$

SS15608

The initial calibration is based on a comparison with preceding ctds at M2 and the end of SeaSoar deployment stn. 15601. The ctds indicated that the Minipack temperature was low by between 0.60 and 0.64, and the comparison with SeaSoar stn. 15601 indicated that the Minipack temperature was low by between 0.63 and 0.68. I chose to continue to apply a best fit constant calibration of

$$temp = temp + 0.65 .$$

SS15624

This was a mesoscale survey that began and ended at M3. The initial calibration is based on a comparison with preceding and subsequent ctds at M3. No really good match was found despite the transect through M3 during the survey, however the comparisons indicated that the Minipack was low by between 0.64 and 0.71. I therefore chose to revert to the best fit constant calibration of

$$temp = temp + 0.67 .$$

Following re-calculation of salinity a better T/S fit to the ctd profiles was possible and this indicated that the Minipack temperature was still low by between 0.03 and 0.08.

SS15630

This deployment began at M3 and was to survey a number of east-west legs whilst progressing generally northwards towards M10. Bad weather less than 12 hours after deployment forced the ship to slow to below 4 knots and significantly restricted the vertical flight profile SeaSoar. Eventually, a termination failure forced vehicle recovery at the earliest opportunity, which was not until the next morning. Comparison with ctds 15627/8/9 at M3 indicated a temperature offset of between 0.71 and 0.74, but with a particularly good match to 0.74. I therefore chose a best fit constant calibration of

$$temp = temp + 0.74 .$$

However, following re-calculation of salinity a better T/S fit to the ctd profiles was possible and this indicated that the Minipack temperature was now high by ~ 0.05 and that residual salinity was high by ~ 0.03.

SS15631

This deployment completed the run to M10. Comparison with ctd 15632 at M10 provided a good match to an offset of 0.81. I therefore chose a best fit constant calibration of

$$temp = temp + 0.81.$$

Summary

As found on D253, a great advantage of the inductive conductivity cell used in the CTG Minipack is that the occurrence of spikes and offsets due to biological fouling is virtually nil. Thus it was entirely feasible for all the SeaSoar processing to be undertaken by just one scientist.

However, the stability of the instrument's temperature sensor is clearly a worrying problem. Such a wild drift in temperature seriously threatens our ability to recover some of the data, and must raise doubts over the long term suitability of the Minipack instrument for the SeaSoar vehicle. In 2001, this instrument was one of the first of the modern miniaturised CTD instruments on the market, however, there now exists considerable choice in the market place including instruments from SeaBird, the company that currently holds the standard in lowered CTD accuracy. However it is noted that the tight replication between T/S profiles that are achieved, once a suitable temperature correction is determined, might be hard to beat.

Allen, J., J. Dunning, V. Cornell, M. Moore and N. Crisp 2002. Operational Oceanography using the 'new' SeaSoar ocean undulator. *Sea Technology*, **43**(4), 35-40.

3.3 OPC processing — Raymond Pollard

An Optical Plankton Counter was mounted on the SeaSoar on all deployments, summarized in Table 3.1. The raw data consist of millions of data cycles, one for each particle that passes through the OPC giving a count which converts to Equivalent Spherical Diameter (ESD). Extra data cycles every half second give time stamp and attenuance readings. Processing is greatly simplified using Penguin. Penguin provides its own time stamp for every data cycle, so the OPC's own time stamp can be discarded. Thus the raw data are in ascii. A simple grep (see exec opc1) extracts only the ESD count data cycles, with jday and count. These are read into pstar using pascin, jday is converted to time in seconds, merged on time with pressure (from the SeaSoar full resolution file) and distrun (from the SeaSoar ss file or the navigation file), then binned and gridded using gropc4. We chose 8m bins in the vertical (6,398,8) for uniformity with SeaSoar CTD data, 4 km bins in the horizontal, and size classes defined by class count boundaries 5,17,63,230,874,1651/ which provide ESD boundaries at 0.25, 0.5, 1, 2, 4 and 8 mm (to convert to copepod length multiply by about 2-2.5). The only wrinkle to the processing occurred at New Year, as Penguin gives only jday, not year. Thus the file had to be split at the year boundary, and the start date in the header (YYMMDD) set to 040101 or 050101 as appropriate.

The OPC failed about halfway through two 15536, during the triangular run from M8E to M8W. It was fixed prior to the next run 15541.

3.4 Fast Repetition Rate fluorometer on SeaSoar — Mark Moore

A Chelsea Scientific instruments FAST*tracka*™ FRRf was flown on the SeaSoar instrument package. Data collection from this instrument was handled using the PENGUIN control and data acquisition system as performed previously on D253 (FISHES) and JR98. Instrument setup was identical to that used during D253. Saturation of variable chlorophyll fluorescence was performed using 100 flashlets of 1.1µs duration with a 2.3µs repetition rate, no relaxation protocol was employed as it is suspected that accurate estimates of downstream electron transport cannot be obtained *in situ* due to the speed of the instrument through the water. The instrument gain setting was fixed at the lowest value.

Processing of the data was performed in Matlab™ using custom codes written during D253 and D285. ASCII data files were transferred to the directory /data61/frrf/seasoar then processed using the routine: SSFRRFproc executed as a function:

SSFRRFproc('filename.extension')

Outputs from this routine were then merged with the depth record from the minipack using the routine: Merge_minipack_frrf, which requires editing each time to change the minipack and FRRf files loaded and merged.

Future re-processing using an updated physiological model is likely to be necessary, however initial quality checks indicated no significant problems with the deployment

strategy other than those inherent to the current generation of the FRRf instrument and well documented elsewhere (e.g. Laney, 2003; Moore et al. 2004).

Data were processed from all tows where significant periods of flight were obtained with SeaSoar (Table 3.2)

Table 3.2 SeaSoar FRRf files

Deployment	15497	15514	15519	15530	15536	15541
FRRf file nos.	1,2,3,4,5a,5b,6, 7,8,9,10,11a,11b	1,2,3	1	1	1,2,3,4	1,2,3

Initial results from the first extensive SeaSoar survey are presented in Fig. 3.6. Variability in PSII physiology in terms of both F_q'/F_m' and σ_{PSII}' was apparent throughout the survey region and was associated with gradients in water masses and bloom distribution. Interpretation of the variability in PSII physiology will require appreciation of the effects of nutrient stress, light and species composition. As is frequently the case, quantitative assessment of any of these individual factors is likely to be difficult using the mapped FRRf data alone, due to the complex interactions occurring between them.

Data from D286 will be processed by Mark Moore at NOC on return from sea.

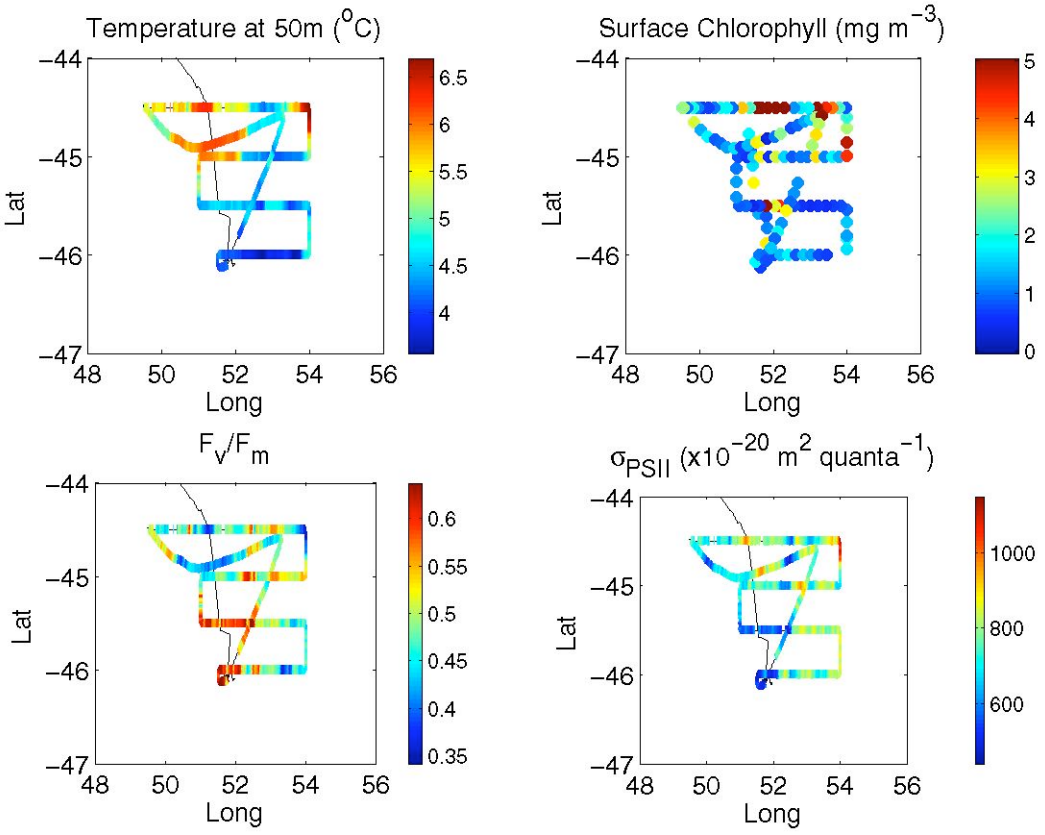

Fig.3.6 Initial map of FRRf data from SS15497. Temperature and PSII characteristics are mapped at 50m depth. Underway surface chlorophyll concentration is also provided for comparison.

CTD Stations

4.1 CTD and rosette technical report

Dave Teare

Two CTDs systems were used during the cruise. One of standard stainless steel construction, with aluminium, titanium and plastic instrument housings, used for physics and biology sampling. The second, of titanium and plastic construction, used for iron sampling. The instrument suits were basically very similar, consisting of Seabird 9+ CTDs with dual C/T sensors and oxygen. Auxiliary sensors were Chelsea Instruments transmissometer and fluorometer and Seatech light backscatter sensor.

Additional instruments on the stainless steel unit included an RDI 300kHz workhorse lowered ADCP, for all casts, and the occasional fitting of a PML par light sensor. Also the secondary T/C sensors and an experimental oxygen sensor were fitted to the stabilising vane, to remove the effects of water entrainment within the CTD package. The occasional sock and polystyrene cup were fitted for deep water compressibility tests.

In general both systems worked well, with two notable exceptions. Both altimeters were poor at bottom detection, this is an ongoing problem which sometimes results in a little sediment sampling(!), due to low power out, bottom type and package orientation. The old IOS 10kHz pinger is fitted as standard back up to cater for this.

The second problem was with the stainless system fluorometer, which had a persistent depth related noise problem around 80 to 200 metres. Sensor, cable and data channel changes failed to cure the fault. There appeared to be no correlation between this and other instrument operation. This problem was still unresolved at the end of D285.

The LADCP worked without problem, except for one instance when it ‘hung up’ after a cast. This was simply cured by disconnecting power for a short period.

Table 4.1a CTD sensors and serial numbers at start of D285

	Titanium	Stainless steel
Primary temp	4381	4105
Primary cond	2851	2571
Pressure	90074	83008
Secondary temp	4380	4151
Secondary cond	2858	2580
Oxygen (SBE 43	0363	0621
Altimeter (Benthos-916)	1037	1040
Fluorometer (Chelsea mk3)	163	160
Transmissometer (Alpha traka)	161047	161048
Light back scatter	338	346
P.A.R (PML)	not fitted	RVS01
R.D.I.(WH300 in lowered mode)	not fitted	4726

Table 4.1b Sensor and configuration changes during D285

Titanium	No changes.
Stainless	The transmissometer was changed prior to 15489s
	The fluorometer was changed prior to 15523s
	The P.A.R. was changed prior to 15523s
	The fluorometer channel was changed prior to 15540s.

All calibrations, sensor numbers and CTD configurations are held in the Seabird ******.CON files associated with each cast.

CTD technical update for D286 **Jon Short**

For the second leg of the Crozex cruises (D286) the only change to either frame was the substitution of the LSS with a WetLabs BBRTD s/n 167. The fluorometer problem was investigated but again no cause was found, however it was discovered that the altimeter connector had leaked due to being badly fitted onto the CTD breakout box. This connector, along with the BBRTD connector which had also leaked, was replaced at the end of the cruise.

4.2 Salinometry

John Allen, Paul Duncan, Alan Hughes, Dougal Mountifield, Hugh Venables

A Guildline Autosal salinometer (model 8400B, serial no. 65764) was installed in the stable laboratory. This salinometer had been serviced by OSIL just before the AMT cruise, D284. The stable laboratory rather than the constant temperature (CT) laboratory, was used because the latter was required for biological incubation experiments at temperatures below the operating range of the salinometer. The chemistry laboratory was also fully occupied with carbon chemistry apparatus. Not having access to controlled environmental conditions is a problem for salinometry. According to the manual, the 8400B can operate successfully at lab temperatures between 4°C below and 2°C above the bath temperature, the preferred temperature being in the middle of this range. The bath temperature was set at 21°C for the majority of this cruise, however, salinity crates processed at the beginning and end of the cruise were an exception, where rising temperature in the CT lab forced the selection of a bath temperature of 24°C. A

thermometer was used to measure the temperature of the stable lab., which varied slowly between 18.5 and 22°C throughout the cruise.

This was the first cruise during which we used OSIL's Autosal software, SoftSal, throughout. On a multidisciplinary cruise like D285, this expedites the entry of determined salinities into excel spreadsheets for merging with instrument data files. The software and the Autosal worked well and the stability of measurements, determined by monitoring the standard deviation of salinity measurements, was good. With few exceptions, the bottle samples were determined to a precision greater than 0.001. S.D. is plotted against sample number in Fig. 4.1, for the underway bottle samples; interestingly the precision seems to improve with time. There are a couple of points worth noting about using this software however; firstly the software encourages the operator to re-trim the salinometer after each standardisation to standard seawater. This is almost certainly because, and the second point to note is, the measured salinity standard is not recorded in the output file, so no post measurement offset can be made. OSIL's latest software (advertised in the standard seawater boxes), looks as though it overcomes this limitation, furthermore it is designed to be directly compatible with spreadsheet software like MS Excel.

Salinity values were copied in to an Excel spreadsheet, then transferred to the Unix system in the form of a tab-delimited ASCII file. Data from the ASCII files were incorporated into the sam files using the Pstar script `passam`.

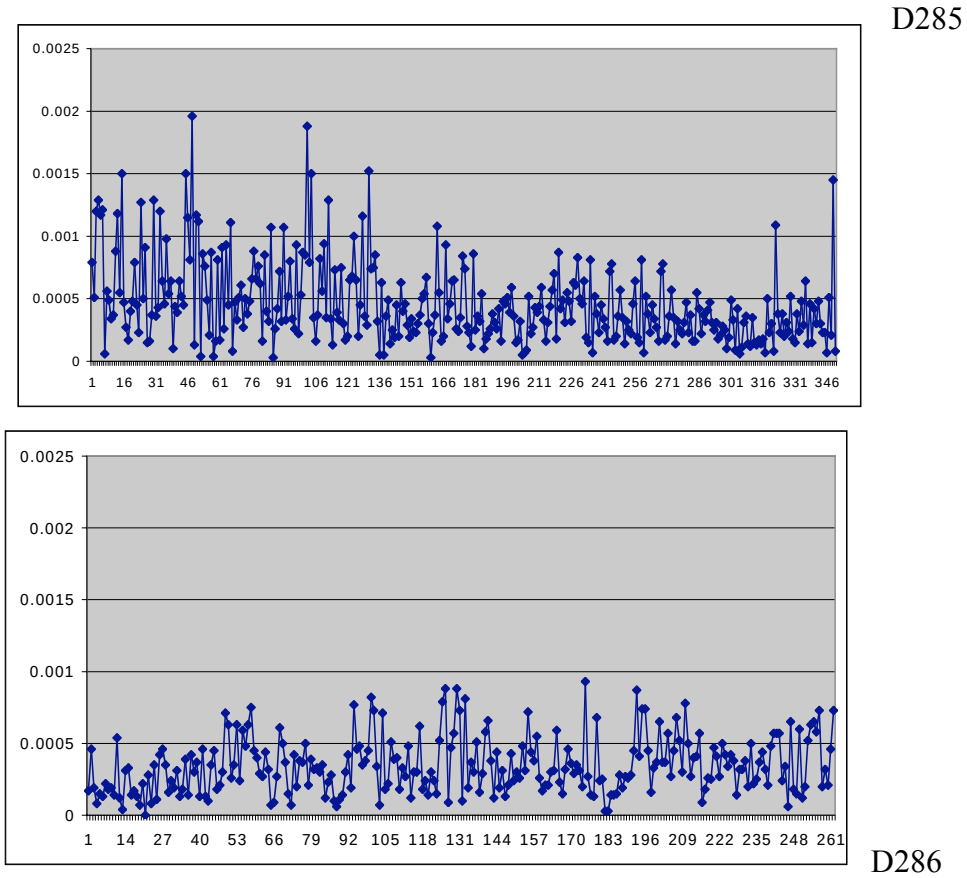

Fig. 4.1 Standard deviation plotted against bottle number, i.e. as a function of time

4.3 Oxygen sampling — Mark Stinchcombe, Richard Sanders

Leg 1 D285

Dissolved oxygen samples were drawn from Niskin bottles on each stainless CTD cast, bar those taken for thorium samples, and analysed using the Winkler whole bottle titration method. One duplicate sample was drawn on each cast from a randomly selected Niskin bottle after all other samples had been taken.

Samples were drawn through short pieces of silicone tubing into clear, pre-calibrated (approximately 100ml) wide-necked glass bottles. The temperature of each sample was taken using a handheld temperature probe immediately prior to fixing on deck with 1ml manganous chloride and 1ml sodium hydroxide. These chemicals were dispensed using Anachem dispensers, which were periodically rinsed throughout the cruise. The temperature at fixing of each of the samples was later used to calculate any temperature dependent changes in the volume of the sample bottles. After fixing, the lid of the sample bottles was inserted, taking care to ensure that no air bubbles were introduced, and the bottles shaken thoroughly. The samples were then taken to the CT (controlled temperature) laboratory, whereupon they were shaken once more, and then stored for later analysis. All reagents were prepared after Dickson (1994).

Analysis of the samples started at a minimum of one hour after the collection of the samples. The SIS Winkler whole bottle titration method with spectrophotometric end-point was used for analysis. Immediately prior to titration, each sample was acidified with 1ml of sulphuric acid (using an Anachem dispenser) in order to dissolve the precipitate and stirred with a magnetic stir bar.

The user variable parameters in the SIS supplied software, (parameters screen in the options menu), were determined by trial and error at the start of the cruise and applied throughout. The following values were used: Stepsize 10, Wait time, 10, Fast delay, 3, Slow delay 3, Fast factor 0.5. This parameter set resulted in titration times of less than four minutes.

One batches of sodium thiosulphate solution ($25gL^{-1}$) was made up at the start of the cruise. As the thiosulphate solution is unstable, it was standardised by titrating it against 5ml of certified standard 0.01N solution of potassium iodate. This was done every 5-7 days; the volume of thiosulphate required to titrate 5ml of this standard was then used in calculations of oxygen concentration in an MS Excel spreadsheet following the equations of Dickson (1994). Figure 1 shows the volume of thiosulphate required to titrate the reference iodate solution on each day a calibration was performed. The reagent blank was evaluated at the start of the cruise and was found to be 1.0×10^{-3} ml. This value was applied to all calculations undertaken.

The duplicate samples drawn at each station were compared and the percentage difference between them is also shown in figure 1, for a sample size of 22 pairs of duplicates. The mean percentage difference between duplicate samples is 0.2% and imporoved with time consistent with more esperienced operators. Precision is weakly correlated with Niskin

number with low Niskin numbers having the poorest precision. This is consistent with ingassing of oxygen into undersaturated samples on deck once the niskin tap was undone.

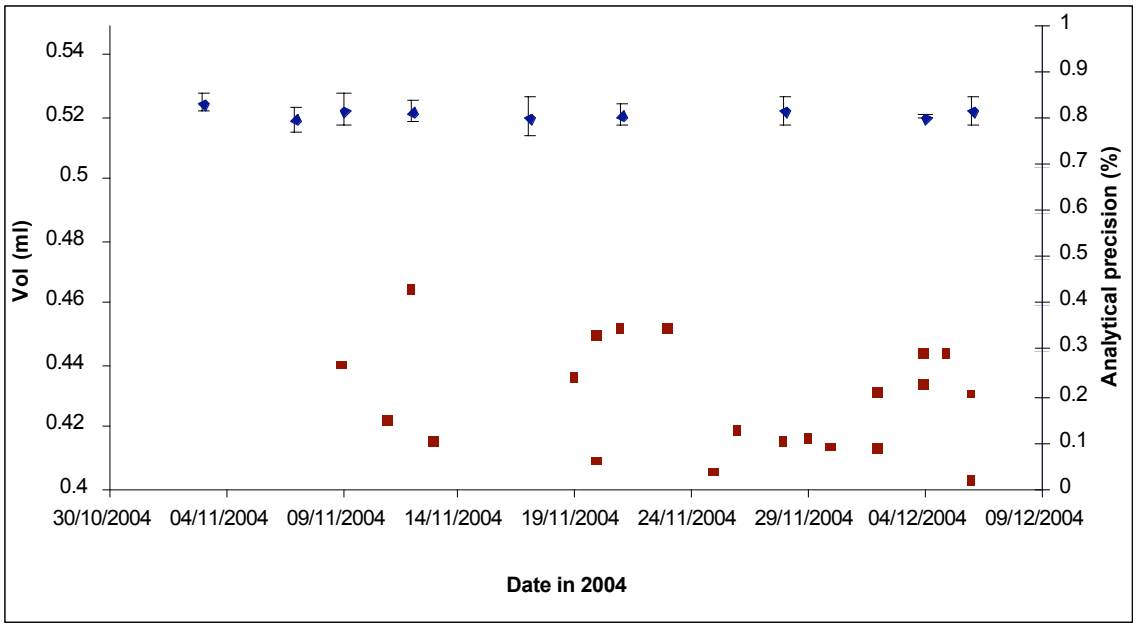

Fig. 4.2. Volume of sodium thiosulphate used to titrate 5mls of certified standard of potassium iodate over the duration of the cruise (blue diamonds), error bars are the standard deviation of five replicate samples. Also shown is the time course of analytical precision evaluated from the duplicate samples (brown squares).

Leg 2 D286

A new batch of thiosulphate was prepared in Port Elizabeth. This was standardised on three occasions during the cruise. The individual volumes, together with the mean, standard deviation and relative standard deviation, of thiosulphate required to titrate 5ml of 0.01N KIO3 on each of the determinations is shown below. The replication was good and the thiosulphate did not appear to degrade with time.

Date	Thiovol1	Thiovol2	Thiovol3	Thiovol4	Thiovol5	Mean thiovol	Stdev thiovol	RSD
	ml	ml	ml	ml	ml	ml	ml	%
20/12/20(	0.4613	0.468	0.4679	0.4665	0.4677	0.4663	0.0028	0.6108
31/12/20(	0.4626	0.4637	0.4632	0.4652	0.4629	0.4635	0.0010	0.2208
16/1/200!	0.4592	0.4656	0.4649	0.4669	0.4677	0.4649	0.0033	0.7200

Duplicates

One bottle per cast was duplicated. The results of the analyses of these duplicates are shown below. The mean difference between duplicates was 1.3 umol/l which equates to 0.5% of the mean oxygen concentration in the duplicate bottles analysed.

Cast	Niskin	Conc 1	Conc 2	Difference	Difference/ Mean
		umol/l	umol/l	umol/l	%
15549	23	250.4	250.3	0.08	0.03
15553	12	296.2	294.5	1.73	0.59
15556	1	212.2	213.4	1.17	0.55
15557	9	194.5	194.0	0.53	0.27
15562	7	187.6	186.1	1.56	0.83
15565	23	318.4	316.9	1.42	0.45
15570	3	270.7	271.5	0.71	0.26
15573	13	222.3	222.3	0.06	0.03
15582	14	236.6	235.2	1.43	0.61
15584	14	265.3	263.7	1.58	0.60
15585	21	292.9	288.4	4.48	1.54
15586	14	305.4	305.5	0.1	0.03
15587	6	201.6	201.3	0.28	0.14
15596	14	227.1	228.1	0.99	0.44
15606	10	179.9	179.6	0.24	0.13
15614	2	201.5	199.4	2.05	1.02
15620	8	292.5	293.1	0.65	0.22
15623	4	286.9	287.4	0.51	0.18
15628	20	307.8	313.6	5.8	1.87
15632	15	301.4	300.7	0.74	0.25
Mean				1.3	0.50

4.4 CTD calibration — Raymond Pollard

Salinity calibration for stainless CTD

Four separate conductivity cells potentially needed calibration, two each on the titanium and stainless CTDs. Salinities were mostly within a few ppm of salinometer derived values so calibrations were applied only to salinity, not conductivity. On most stainless CTD casts four to eight calibration samples were drawn, trying to use depths where vertical salinity gradients were weak. Comparisons of bottle values (botsal) with sensor 1 (sal1 - mounted on the tail) and sensor 2 (sal2 - mounted within the frame) suggested that sal1 should be reduced by 0.002. After this correction, salinity differences are shown in Table 4.2

Table 4.2 Salinity calibration statistics

Difference	no. in sample	outliers omitted	mean	standard deviation
botsal - sal1	184	24	0.0009	0.0022
botsal - sal2	177	31	0.0001	0.0018
sal1 - sal2	633	5	-0.0004	0.0014

Note that the standard deviation of within-cast scatter for sal1-sal2 is less than for botsal-sal1 or botsal-sal2, suggesting that the bottle samples have wider scatter than the instruments, probably because of sampling errors. Fig. 4.3a shows the offsets after correction against pressure for the primary salinity sensor. There is a suggestion that the offset should by further corrected by 0.001 at the surface down to –0.001 at 4000m. However, the scatter in Fig. 4.3b against cast convinced us not to do this. The large positive offsets at the end are the result of a poor calibration for one box of samples, because of rising temperature in the salinometer room. Also there are few sample values deeper than 3500 dbar.

The cast to cast offsets in sal1-sal2 (Fig. 4.3c) are caused by changes in the secondary sensor sal2. As this in mounted within the frame, it is subject to offsets resulting from water trapped by the frame, so is not used except as backup, and so has not been calibrated. However, after the first few casts, sal1-sal2 remains close to zero for nearly all casts and depths, confirming that no calibration beyond the –0.002 offset in sal1 is justified. Overall, we estimate that the 0.002 standard deviation given in the table is an upper limit to the accuracy of sal1, much of this being errors in the bottle values.

Salinity calibration for titanium CTD

To minimize potential iron contamination, no salinity samples were drawn from the titanium CTD. However, TiCTD casts were almost always associated with ssCTD casts close by in space and time at the major iron and productivity stations. We therefore attempted cross-calibration by comparing adjacent casts. The casts were merged on pressure, or potential temperature. Density cannot be used, as any error in salinity will affect density. Potential temperature proved the more useful parameter on which to merge, as internal waves can offset profiles at all depths. Above 2200 dbar, the difference in the primary salinity sensors was not stable at the 0.001 level, varying by typically ±0.002 as the pressure difference varied. Below 2200 dbar however, there was less than 0.001 variation with depth, and comparative values are given in Table 4.3

By eye, we conclude that the titanium CTD primary salinity is correct at the 0.001 level. Plots of the primary-secondary salinities indicated that sal1-sal2 had similar standard deviation to the ssCTD (Table 4.2) and a mean of 0.006. Thus sal2 is too low by 0.006. This correction was not made.

Table 4.3 Cross calibration of titanium to stainless rosette salinities and oxygens

SsCTD	TiCTD	ss-tiSal for p > 2200 dbar		ss-tiOxy for p > 2200 dbar		
		mean	std devn	mean	std devn	correction
15490	15491	-0.0007	0.0005	23.6	0.3	+24
15494	15496	~-0.0005		~23.5		+24
15500	15499	max press 305 dbar				+24
15504	15502	-0.0003	0.0004	23.7	0.3	+24
15507	15511	0.0001	0.0019	28.2	0.9	+28
15518	15516	max press 507 dbar				+30
15525	15524	max press 500 dbar				+30
15525	15526	-0.0004	0.0010	29.9	0.4	+30
15532	15534	max press 1000 dbar				+30
15538	15537	0.0005	0.0003	30.1	0.2	+30
15544	15543	0.0000	0.0004	28.0	0.3	+28

Oxygen calibration for stainless CTD

On the ssCTD oxygen samples were drawn for calibration at most depths. After chemical analysis, the bottle oxygen values were converted from μMol/l to μMol/kg using the fixing temperature. Fig. 4.4a shows the scatter plot of (bottle oxygen – CTD oxygen) plotted against CTD oxygen. The mean and standard deviation of bot-CTDoxy for all values in the range –5 to 20 μMol/kg was 5.9 ± 2.9 μMol/kg. Linear regression suggested a correction to the CTD oxygen values oxygen (corrected) = 1.7 + 1.01626 * oxygen μMol/kg and this has been made in Fig. 4.4b. This reduced mean, but the standard deviation only marginally, to 0.2 ± 2.6 μMol/kg. On reexamination, the slope has probably been overestimated because of the high outliers at high oxygen values, and post-cruise recalibration could slightly improve the calibration. Similarly, plotting the corrected oxygen differences against station number (Fig. 4.4c) indicates station to station changes of order ± 2 μMol/kg. Nevertheless, overall the CTD oxygens are remarkably good, with errors of order 2 in 200, or 1%.

Oxygen calibration for titanium CTD

Even more than for salinity, drawing oxygen samples from the titanium rosette would pose a serious contamination risk to the iron sampling, so cross calibration was attempted as for salinity as summarized in Table 4.3. No variation of oxygen calibration with depth could be determined because of variations of up to 5 μMol/kg with pressure difference and pressure for pressures less than 2200 dbar, though there was some evidence for such drift. Below 2200 dbar, Table 4.3 shows differences ranging from 23.6 to 30.1 μMol/kg, although the cast to cast differences in the stainless CTD values (corrected as above) may contribute. The offset corrections shown in the last column of Table 4.3 have been made to all data files for each cast.

Fluorimeter calibration

None was done during the cruise.

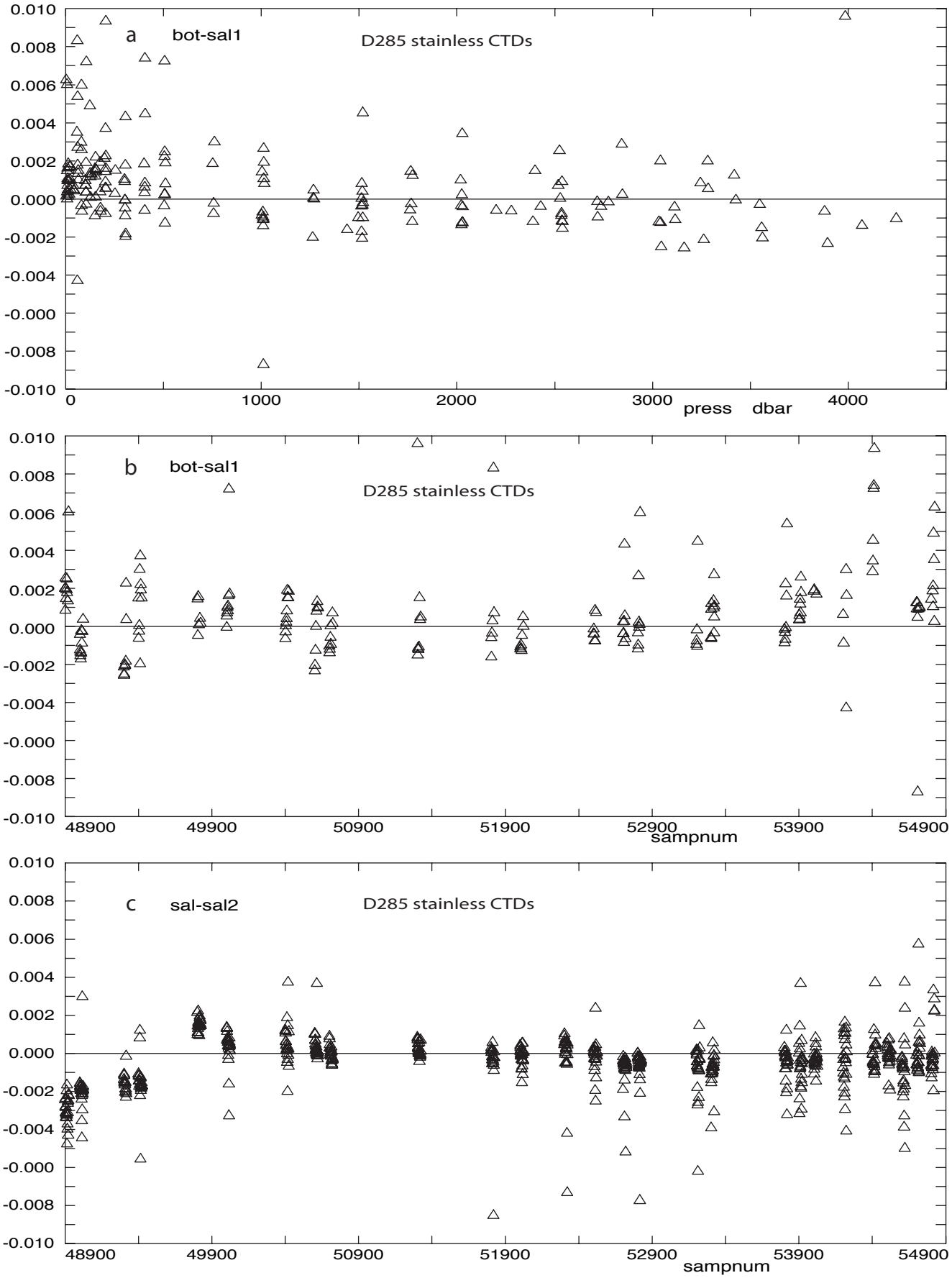

Fig. 4.3 Salinity calibration for D285. Sal1 has been corrected by -0.002. Plots of (bottle - salinity) errors against (a) pressure (b) cast & bottle number. (c) Primary salinity - secondary salinity

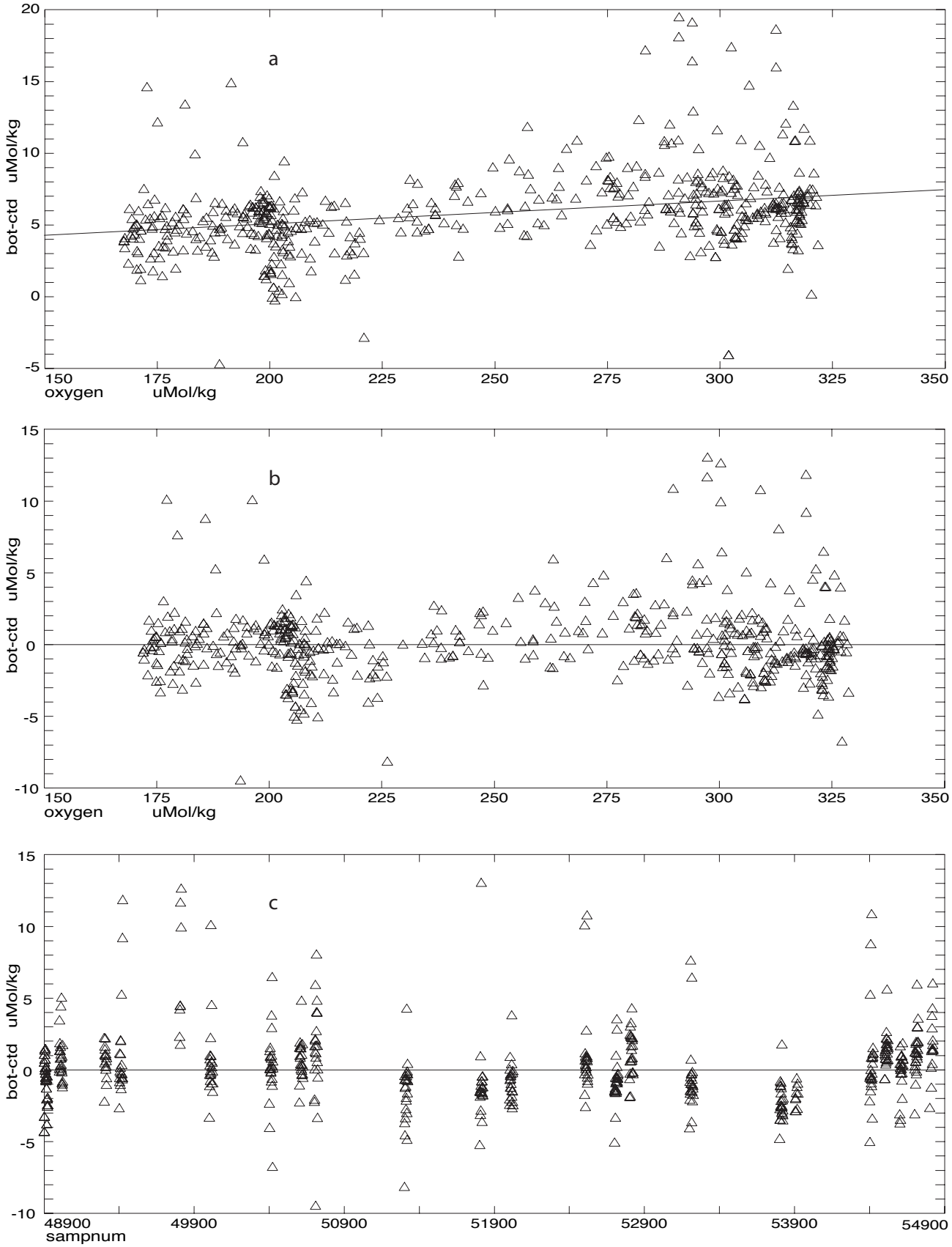

Fig. 4.4 Bottle - sensor oxygen (a) against pressure, and after recalibration (b) against pressure and (c) against station and sample number

4.5 Lowered ADCP processing on D285/6 Hugh Venables, Raymond Pollard

The 150 kHz LADCP mounted on the stainless steel rosette was used on every stainless cast except for a few shallow ones. Data were copied over to ladcp/raw and then renamed using the directory structure given at the end of this section. The Visbeck processing scripts were used, with modifications developed on Marine Productivity cruises and updated a little. The major improvement was to use the ship-mounted ADCP to constrain the Visbeck fit at the surface. Ascii files were created from the CTD data, the navigation stream and the ocean surveyor ADCP for the duration of the cast. donavpro was used when the navigation stream had already been processed, donavraw only being used if not as it was much slower. dosurasc created ascii. A master matlab script was left in ladcp/m and this was edited to create the first script ladnnnnn.m (where nnnnn is the 5 digit station number) but then these were recursively copied, renamed and edited in the matlab editor, using the find and replace function to change the cast numbers quickly. The data were copied to the appropriate directory: withSADCP or withoutSADCP.

On some casts the script getdephti.m fails, on the second loop, to find the bottom despite the first loop successfully identifying a bottom close to that expected from the CTD altimeter or PES depth. In order to make it create a bottom track in these cases the script was modified and renamed getdepthioneloop.m and this was called by laproconeloop.m and the ladnnnnn.m was modified to call this rather than laproc.m.

Removal of prompt for type

Due to the need to reprocess all the casts to obtain data without SADCP and the fact that only one instrument (300kHz) was used the prompt for the type of instrument was commented out of the matlab script and set automatically to 'w'. This allowed many casts to be run in one batch by listing the names of each script in an m-file and running that. This saved a lot of time and so it may be worth having different scripts for different instruments if more than one is being used.

With and without SADCP constraint comparison

compare.m and compare2.m were written to calculate the average difference between results with and without SADCP data used as a constraint to the inversion. compare2.m averages over the full depth of all casts whereas compare.m allows the depth limits of the comparison to be entered and only casts with data spanning the limits are included. Comparisons are shown in Table 4.4

It is noticeable from Table 4.4 that there is a greater difference in the surface 500m on deep casts, lasting over 2 hours. This is presumably due to variations in the surface layer being averaged out in the SADCP data. Using this as a constraint to the inversion is therefore acting more to average out short timescale motions than to correct for measurement error in the LADCP instrument as differences are <1cm/s for shallow casts but up to 6cm/s for deep casts. If it is to be used to correct for instrument error then the particular data from the Ocean Surveyor relating to the down and up cast should be

extracted and used separately and if the average is wanted then the Ocean Surveyor data should be averaged over as long as we were on station.

Quiver plots of average velocities

vect.m plots the average velocity of each cast, between specified depth limits, as a quiver plot, with an arrow added for scale. vectbott.m does the same but from the bottom up to a specified height above the bottom.

Directory structure

data61/ladcp/m: Location of all matlab scripts and pstar scripts to process ctd, navigation and SADCP data and the place where data and graphs were originally saved to.

data61/ladcp/m/withsadcp: Results with Ocean Surveyor data used as a constraint.

data61/ladcp/m/withoutsadcp: Results without Ocean Surveyor data.

data61/ladcp/raw: Location of raw data ftp'ed from LADCP PC. Files renamed from nnnnn000.000 to wnnnnn.000 so they are found by matlab script.

data61/ladcp/nav: Location of ascii navigation files, put there when donavpro or donavraw run.

data61/ladcp/ctd: Location of ascii CTD data, put there when doctdasc run.

data61/ladcp/sur: Location of ascii Ocean Surveyor data, put there when dosurasc run.

data61/ladcp/sur/surhidden: Location of SADCP data once it had been used to allow a second run without it being found by the matlab scripts.

Table 4.4 Comparison of LADCP constrained or not by SADCP

Station	Mean u-diff m/sec	Mean v-diff m/s	Rms u-diff m/s	Rms v-diff m/s	Depth m
489	-0.04601	-0.056153	0.048354	0.057601	3240
490	0.016798	-0.0020986	0.016806	0.0022218	3040
493	0.014744	0.028365	0.018467	0.03279	3220
494	0.008035	0.010836	0.013346	0.011357	2360
498	0.0083331	0.0024161	0.0085226	0.0027196	2360
500	0.0027083	-0.026737	0.019006	0.028045	3380
503	-0.0023377	0.0038598	0.0050074	0.0090234	620
504	-0.066379	0.0095316	0.068241	0.01982	3800
506	-0.01704	-0.019918	0.01927	0.02055	3820
507	0.025132	-0.044196	0.02609	0.04461	4160
513	-0.048534	0.025932	0.053316	0.029198	3900
518	-0.045146	-0.02945	0.049535	0.031831	2320
520	0.0015517	-0.014756	0.013558	0.014941	3060
525	0.017032	0.0083151	0.025939	0.038555	2700
527	-0.0056505	0.0094165	0.0083995	0.018366	2840
528	-0.024785	0.01346	0.028165	0.024017	2380
532	-0.029669	-0.020344	0.031132	0.021216	2700
538	0.0092896	-0.00072883	0.018002	0.0041178	2760
544	0.024282	0.041572	0.025921	0.047231	2860
545	0.0078837	0.0079863	0.025574	0.009082	3200
546	0.01438	-0.023579	0.015259	0.024909	3320
547	0.0090641	-0.034144	0.013359	0.034391	3360
548	-0.0025192	-0.013027	0.0051041	0.023907	1120
553	-0.0053963	-0.0028393	0.0094812	0.0083803	3180
556	0.024539	0.017408	0.024936	0.01771	2400
557	0.0066127	0.0047727	0.018448	0.0093782	2840
562	0.022068	-0.0096349	0.024894	0.012379	2880
565	0.054073	-0.007025	0.067679	0.01809	3000
570	0.012975	-0.0013584	0.013727	0.032267	1360
573	-0.023786	0.0047494	0.026633	0.011991	2300
576	0.029492	0.0043079	0.033484	0.0093514	4200
582	0.031504	0.022133	0.031882	0.02263	4220
584	0.041362	0.017889	0.042647	0.017968	3900
585	0.038492	-0.032528	0.052427	0.051568	3400
586	-0.0019285	-0.026317	0.023439	0.029029	3400
587	-0.0033965	-0.025975	0.012864	0.031789	3080
589	0.004105	-0.025372	0.038145	0.037567	2320
591	-0.00095017	-0.011989	0.023939	0.024952	2360
596	0.001072	0.0018169	0.0056814	0.0044126	4160
606	0.009165	0.0087418	0.010485	0.010973	3800
613	-0.0093752	0.00077912	0.028746	0.014294	640
614	0.015231	-0.015705	0.020107	0.02127	1940
615	-0.00028097	-0.0054296	0.0074293	0.012132	660
616	-0.0047603	-0.011508	0.010168	0.030932	640
617	-0.0060876	-0.0074906	0.019464	0.029261	660
618	-0.0020752	-0.022079	0.0080517	0.02681	660
619	0.002356	-0.0010907	0.0053923	0.014627	660
620	0.0019775	-0.0028693	0.0076059	0.0088354	660
623	-0.0064355	-0.0056127	0.016837	0.018297	660
628	0.011343	0.010148	0.013903	0.016157	2480
Aves:	0.0022612	-0.0049104	0.023097	0.021871	

4.6 Biogenic Silica (BSi) **Megan French**

Objective

The primary objective of the analysis undertaken in this work was to obtain concentration profiles for Biogenic Silica (i.e. SiO_2, opal) through the upper water column (to 500 m).

The relevance of determining Biogenic Silica (BSi) profiles is that it provides insight into the occurrence of silicon dependant marine organisms such as diatoms, silicoflagellates, and radiolarians. In the interests of this study BSi concentration data potentially offers key information since it provides a means of distinguishing between different phytoplankton assemblages. Almost all the BSi produced in the oceans is precipitated by planktonic organisms in the surface layers and the global production of BSi is dominated by diatoms (Nelson et al., 1995). The existence of diatom communities is controlled by the availability and distribution of silicic acid ($Si(OH)_4$) (Yool and Tyrrell, 2003), which is up taken by diatoms and subsequently used to construct their cell walls (i.e. BSi). $Si(OH)_4$ is not passed up the food chain to any degree, and its regeneration is not by organic degradation but by dissolution of opaline SiO_2 (Broecker and Peng, 1982, in Dugdale et al., 1995).

Method

BSi concentration profiles were determined for stainless steel CTD sampling stations over Legs 1 and 2 of the cruise (refer to Tables 4.5 and 4.6). 500 ml samples of seawater were taken from each Niskin bottle for depths 5 - 500 m. Water samples were then filtered through 0.4 m GF/F polycarbonate filters, with additional size fractionated filtrations (20 m and 2 m) made at 2 selected depths for each station. Filters were placed into 20 ml plastic vials and frozen whilst awaiting analysis.

In order to determine the concentration of BSi accumulated on each sample filter, it was first necessary to dry filters (in uncapped vials) for a 12 h period at 60°C. Once dried, 4 ml 0.2 mol L^{-1} sodium hydroxide was added to each filter/vial. It was necessary to ensure that filters were fully submerged before vial caps were replaced and samples heated for 2 h at 90°C in order to digest the BSi. Samples were subsequently allowed to cool before being neutralised with 10 ml 0.1 mol L^{-1} hydrochloric acid. Blank samples were prepared accordingly. Each sample was vigorously shaken and approximately 5 ml was transferred to a plastic analysis cup which was immediately placed in the auto analyser (Skalar San-plus Segmented Flow Analyser) in order to determine the silicate concentration (from calibration samples prepared and analysed prior to each set of station samples).

Full details of the technique, chemistry and equipment specifics involved in the determination of silicate are outlined in Skalar Seawater Analysis Handbook (1994). Briefly, the technique is based on the ammonium molybdate method, whereby dissolved silicate reacts with ammonium molybdate under acidic conditions to form silicomolybdic acid of which there are α and β isomers. Reagent ratios and pH are optimised to favour the formation of β isomers, which is then reduced by ascorbic acid. Absorbance is measured at 810 nm.

Table 4.5 Station numbers sampled for BSi from D285 with respective maximum [BSi] and corresponding depth

Station	JDay	Latitude	Longitude	$[BSi]_{max}$	$[BSi]_{max}$ Dep
		S	E	uM L^{-1}	m
489	314	42 00.35	48 00.68	0.90	10
490	316	43 52.68	50 14.77	3.25	80
493	317	44 30.00	51 15.20	3.83	5
494	318	46 03.23	51 47.17	4.25	150
498	323	46 03.15	51 47.41	2.63	20
504	325	47 45.96	52 52.90	1.86	100
506	325	48 11.50	52 24.30	2.08	40
507	326	49 00.26	51 29.42	1.67	40
513	328	48 35.96	51 57.09	1.28	10
518	330	46 04.09	51 46.64	3.65	80
520	331	45 23.96	52 14.94	5.88	20
525	332	45 29.75	48 59.76	3.26	80
527	333	45 29.96	48 20.00	4.90	60
528	334	45 29.48	47 38.48	1.95	5
532	335	44 54.96	49 54.24	1.42	40
538	337	44 51.39	49 39.13	3.97	100
544	339	43 06.58	47 11.11	1.36	60

Summary of provisional findings

Depth profiles of [BSi] were obtained for each of the stations listed in Tables 4.5 and 4.6. Details of the maximum [BSi] and corresponding depth are also provided in these tables for each station. Overall the data obtained appears to be of good quality, with profiles demonstrating general decreasing trends of BSi with depth. Figures 4.5 and 4.6 present a compilation of station profiles for D285 and D286 respectively. The most pronounced profiles, with highest surface (upper 100 m) occurring at stations 494, 520 and 527 during D285 and stations 573 (M3), 596, 606 and 614 during D286. The data also indicates that during D285 a higher fraction of surface BSi was being exported to a greater depth (i.e. up to ~200 m) in comparison to that on D286 (Figures 4.5 and 4.6).

Table 4.6 Station numbers sampled for BSi from D286 with respective maximum [BSi] and corresponding depth

Station	JDay	Latitude	Longitude	$[BSi]_{max}$	$[BSi]_{max}$ Depth
		S	E	uM L^{-1}	m
553 M9	354	43 00.00	47 00.00	1.36	200
556	354	43 29.90	47 39.90	0.72	200
557	355	43 59.95	49 00.00	0.51	150
562	355	44 31.67	49 57.60	3.20	20
565	356	45 08.30	51 11.73	2.31	5
573	357	46 04.60	51 46.40	4.28	10
582 M5	363	46 00.00	56 09.00	0.66	150
584	364	45 59.57	55 00.41	0.75	20
585	365	46 00.00	54 00.00	1.18	80
586	365	45 59.91	53 15.61	2.24	100
587	365	45 59.93	52 31.58	1.90	100
589 M3	366	46 03.86	51 46.86	1.38	80
596	003	49 00.00	51 32.00	4.22	80
606	007	47 48.13	52 51.04	5.04	80
614	009	46 09.27	51 51.25	4.64	20
620	010	46 01.93	51 32.17	3.44	20
623	011	45 59.47	51 40.60	1.89	20
628	012	46 02.45	51 57.62	3.92	10

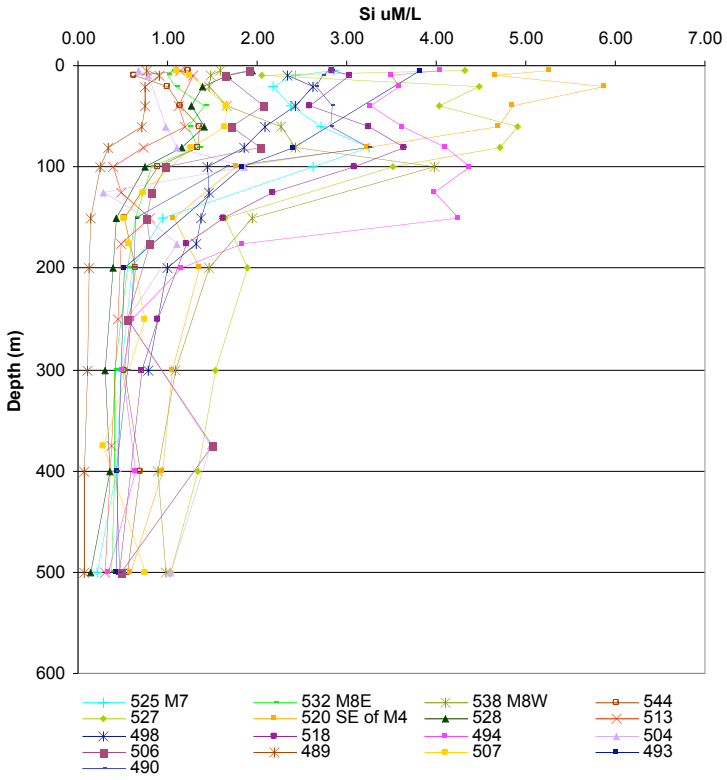

Fig. 4.5 Biogenic Silica profile for stations during leg 1

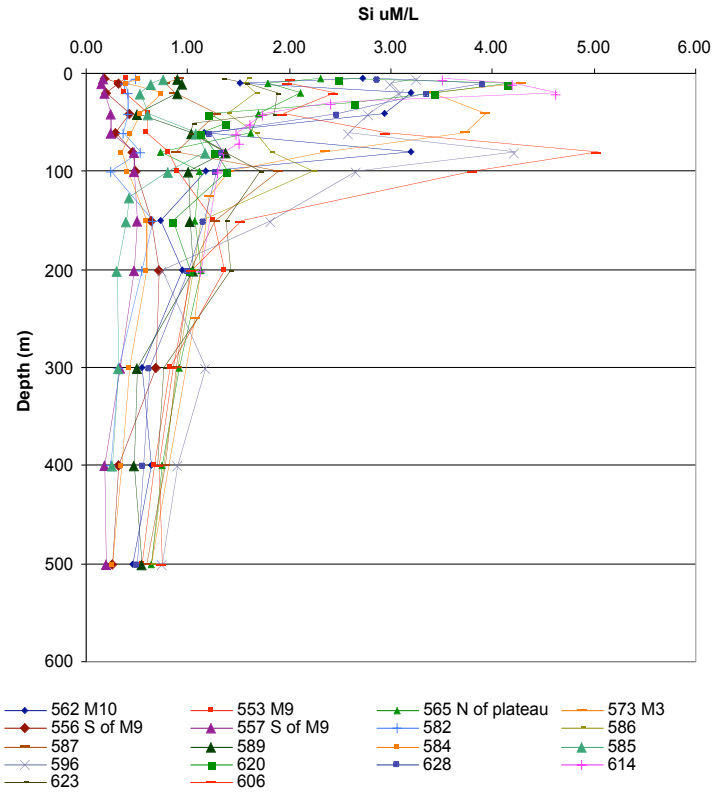

Fig. 4.6 Biogenic Silica profile for stations during leg 2

Table 4.5 highlights data showing that the highest and lowest BSi_{max} concentrations found during D285 were 5.88 µM L^{-1} (station 520 at a depth of 20 m) and 0.9 µM L^{-1} (station 489 at a depth of 10 m) respectively. During D286 (Table 4.6), the highest and lowest BSi_{max} concentrations were 5.04 µM L^{-1} (station 606 at a depth of 80 m) and 0.51 µM L^{-1} (station 557 at a depth of 150 m) respectively. During D285, 64.7 % of the BSi_{max} concentrations occurred at depths ≤ 60 m, whereas this decreased to 44.5 % during D286. Interestingly, 63.6 % of the maximums occurring at ≤ 60 m were <2.3 _M L^{-1} during D285 whereas during D286, 75 % of the maximums occurring at ≤ 60 m were >2.3 µM L^{-1}. This information is illustrated graphically in Figs 4.7 and 4.8.

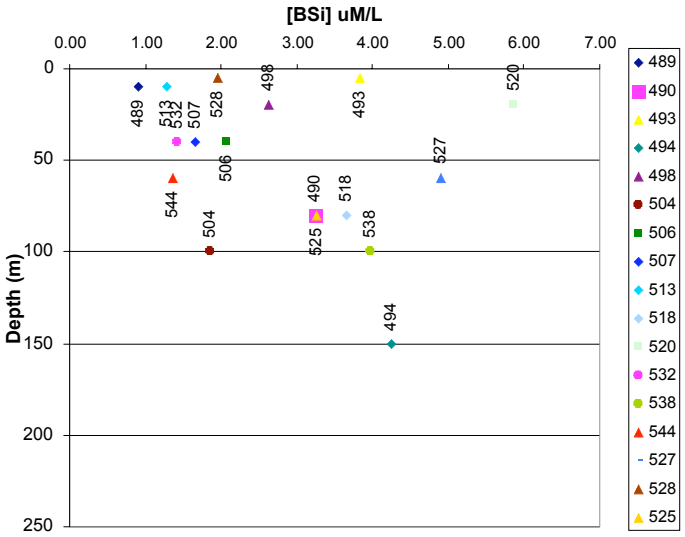

Fig. 4.7 Maximum Biogenic Silica values for each Station on D285

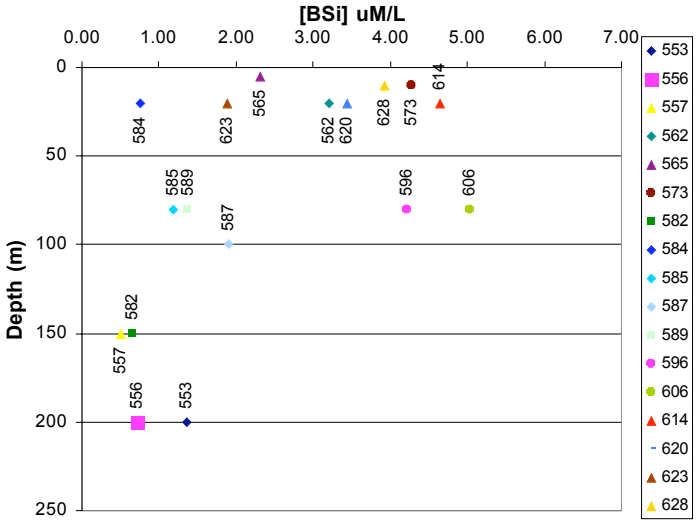

Fig. 4.8 Maximum Biogenic Silica values for each Station on D286

4.7 Rare Earth Element Studies in the Crozet Region

Main objectives of study

- To investigate the Rare Earth Element (REE) and Nd isotope signatures of water masses encountered along the Crozet plateau.
- To examine water mass paths and to investigate the extent of seawater – margin interactions.

This work is lead by Dr. Valerie Chavagnac at SOC in collaboration with Dr. Catherine Jeandel at LEGOS, Toulouse, France.

Water samples:

Seawater samples were collected during D285 and D286 for REE studies. The samples were collected from the TiCTD and from the Stainless CTD. For REE studies 1 litre of unfiltered seawater and 1 litre of filtered seawater (0.4 μm) were collected from the TiCTD casts at M5, M6, M9 and M10 (Table 4.7). For the Nd isotope studies 20L samples were taken directly from the Stainless steel CTD. These were drawn into 25 litre carbuoys. The samples were unfiltered and un-acidified; they were wrapped in black plastic bags to block out the light. Samples were collected at M5, M6 and M10.

Table 4.7 REE sampling during D286

Station number	Station Name	Depth of cast (m)	Sampling Depths (m) for REE	Sampling Depths (m) for Nd isotope
15552	M9	3200	25;200;500;1000;1500; 2000;2500;3000;3200	
15563	M10	2897	15;125;200;500;1000; 1500;2000;2500;2897	
15581	M5	4220	100;500;1000;1250;1750; 2500;4000;4220	
15564	M10	2908		500;1000;1500;2000;2500;2908
15582	M5	4226		500;1000;1250;1750;2500;4000

Sediment samples:

Due to the poor performance of the megacorer (see separate section) limited sediment samples were available for this study. Two cores were taken at M6 and stored cold. Transportation problems may lead to these cores being transported back frozen to SOC. Sub-cores were taken at M5 and frozen. No cores were obtained at M10.

All analysis for these studies will be undertaken by Dr. Valerie Chavagnac back at SOC.

4.8 Discrete FRRf measurements on CTD *Anna Hickman*

A bench top FRRf instrument was used to obtain photosynthetic parameters from water samples from the titanium CTD (ti). Initial data processing was carried out in Matlab™ and will be completed after the cruise. Sampling was carried out on six occasions, as shown in Table (?) below. Samples depths were chosen to match other biological measurements taken, as outlined elsewhere in this report.

Table 4.8 Discrete FRRf measurements made during D286.

	D01	D02	D03	D04	D05	D06
Sampling location	**M9**	**M3**	**M5**	**M10**	**M3**	**M3**
Ti CTD number	15552	15572	15581	15598	15621	15629
	JD 354	JD 357	JD 362	JD 050	JD 010	JD 013
Sample Depths (m)	5,10,15,25,	5,10,15,25,	5,10,20,40,	5,10,20,40,	5,8,12,20,	5,8,12,20,
	35,55	35,55	60,80	60,80	30,41	35,55

4.9 Dissolved oxygen microelectrode sensor — Robin Pascal

1. Introduction

A new dissolved oxygen sensor is being developed within OED. The sensor is based on a platinum microdisc (25 μm diameter) working electrode and a copper counter electrode. The advantage of this type of sensor compared to those commercially available is that it has the potential to have a very fast response time (fractions of a second) and should not suffer from hysteresis due to temperature and pressure effects.

To avoid signal fluctuations caused by water flow across the head, the electrode sits within a chamber through which water is pumped periodically. Oxygen measurements are made while there is no flow. Since the last trial of the sensor the electronics have been completely re designed and modifications made to the flow head arrangement. In addition a new pump was installed reducing the sensors current drain significantly, allowing the sensor to be powered directly from the CTD rather than using a battery pack. Earlier deployments had shown that the electrode potentials, which need to be setup precisely to measure oxygen, were being significantly shifted by the various metals on the CTD frame. It is hoped that the new electronics, designed so that it is completely isolated from the CTD and with digitally controlled timings and both analogue and RS232 connection, would demonstrate stable potentials when deployed.

2. CTD deployments

The sensor was installed on to the fin of the CTD frame at the start of the cruise. Initially results were not good and the sensor was unable to detect oxygen at all. The potentials were altered a number of times but without improvement. Eventually it was found that a low pass filter in the new electronics was causing problem. With the filter removed results were immediately better and the best results obtained when the potentials were returned to the design values, clearly demonstrating that the new sensor electronics isolation worked very well. In addition the sensor showed no shift in values when the CTD was stationary, as had been seen before, indicating that the new flow head arrangement was an improvement. One unexplained problem was that the sensor produced lower than expected oxygen values and that they increased with time during each cast, causing the up and down profiles to separate. The sensor was re configured from Cast 15528 to a 1.25 sec sampling rate with a cleaning cycle of 30 secs.

Appendix A. List of significant events.

Day 318: Oxygen sensor fixed to CTD Vane and connected directly to CTD including power for pump. Potentials set to Vmeas=-0.5v, Vclean=0.75v
Day 320: Oxygen sensor potentials set to Vmeas=-0.35v, Vclean=1.1v
Day 326: : Oxygen sensor potentials set to Vmeas=-0.434v, Vclean=1.004v
Day 330: : Oxygen sensor potentials set to Vmeas=-0.493v, Vclean=0.769v
Day 331: Flow chamber made bigger to ensure electrode not covered.
Day 334: Changed sampling rate to 1.25 seconds with a 30 sec cleaning pulse cycle.
Day 335: First CTD with new setting 15528
Day 336: Oxygen sensor deployed pointing downwards for casts 15538,15539
Day 337: Back in original position parallel to flow.
Day 339: Put 200micron gauze across input for cast 15546.
Day 340: Gauze off.

5. Inorganic nutrients

Richard Sanders

Preamble

Analysis for nitrate + nitrite (hereinafter nitrate), phosphate and silicate was undertaken on a skalar sanplus autoanalyser following methods described by Kirkwood (1994) with the exception that the pump rates through the phosphate line are increased by a factor of 1.5 which improves reproducibilty and peak shape. Samples were drawn from niskin bottles into 25ml sterilin coulter counter vials and kept refrigerated at 4 C until analysis which commenced within 24 hours. Stations were run in batches of 1-3 with most runs containing 1 or 2 stations. Overall 40 runs were undertaken. An artificial seawater matrix (ASW) of 40 g/l sodium chloride was used as the intersample wash and standard matrix. The nutrient free status of this solution was checked by running Ocean Scientific International (OSI) nutrient free seawater on every run. A single set of mixed standards were made up at the start of the cruise and used throughout the cruise. These were made by diluting 5 mM solutions made from weighed dried salts in 1 l of ASW into plastic 1l volumetric flasks that had been cleaned. Three low silicate standards were also used after several initial run without them. It proved difficult to detect the peak heights for the surface silicate values using the deep water standards. This was in an effort to minimise the run to run variability in concentrations observed on previous cruises. OSI nutrient standard solutions were used sporadically during the cruise to monitor the degradation of these standards. Data was transferred to another computer initially using a floppy disk and then by means of a memory stick. The floppy disk transfer route was unreliable and resulted in a delay between sample analysis and data work up of 8-10 stations. Data processing was undertaken using Skalar proprietary software. Generally this was straightforward. The wash time and sample time were 75 seconds, the lines were washed daily with 0.25M NaOH (P) and 10% Decon (N, Si). Time series of baseline, bulk standard concentration, instrument sensitivity, calibration curve correlation coefficient, nitrate reduction efficiency and duplicate difference were compiled and updated on a daily basis.

Performance of the analyser:

1) During one run the water bath failed. The problem was discovered and the waterbath was sent to the technicians to be fixed. They were able to fix it and the waterbath was back up and running before the end of the run. This resulted in one station that had to be re-run, but overall no samples were lost because of it's malfunction.

2) The first nitrite standard that was made up seemed to produce reduction efficiencies from the cadmium column of only 60%. This was more than likely an error in the dilution of the nitrite standard than with the column itself as all standards made up after the first one show column efficiencies approaching 100%. On the 30th of November, at the end of a run, the column was broken. This required the column to be replaced. The new column was fitted and the auto-analyser was left to run with reagents to flush through the nitrate

line. The nitrate baseline took a long time to settle down again, almost 12 hours. When it eventually did settle down samples could be analysed as normal and no samples were lost because of this process. There was no change in the column efficiency either between the two columns.

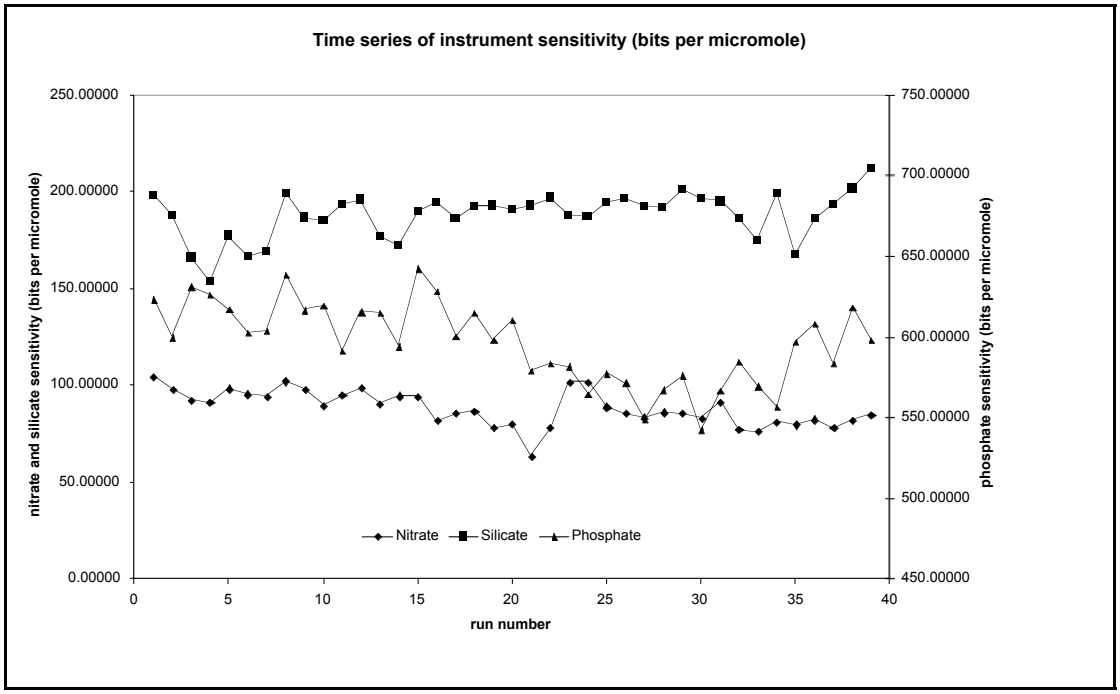

Fig. 5.1 Time series of instrument sensitivity (bits per micromole)

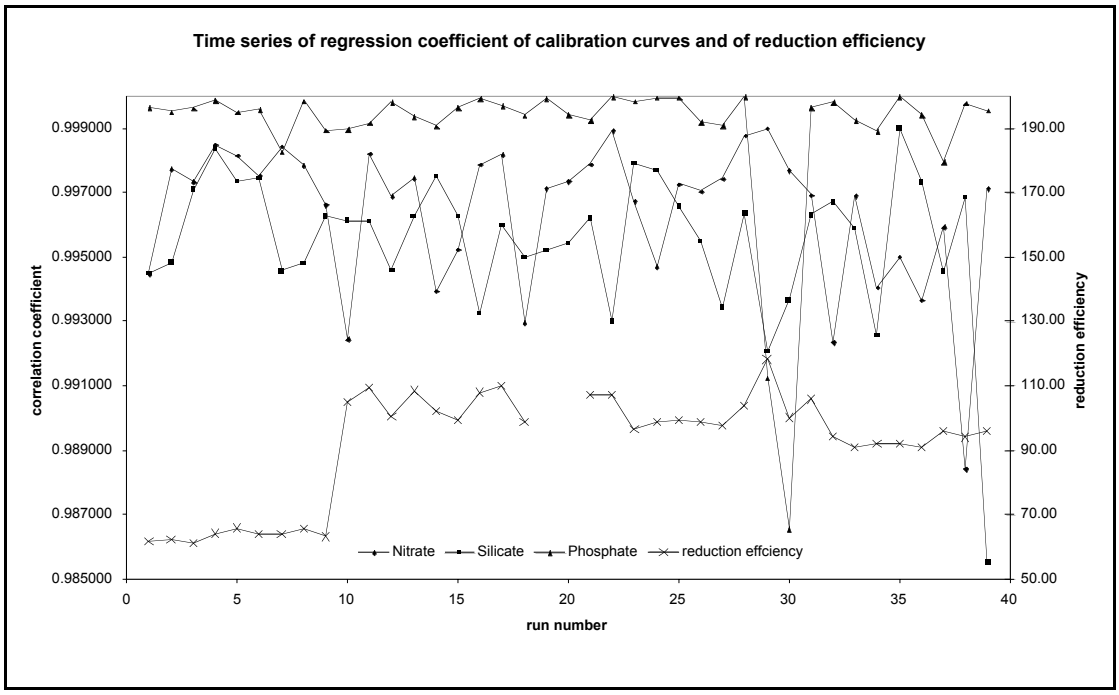

Fig. 5.2 Time series of regression coefficient of calibration curves and of reduction efficiency

Analyser performance

The performance of the autoanalyser is monitored via the following parameters: baseline value, calibration curve slope, regression coefficient of the calibration curve, nitrate reduction efficiency. Time series of these parameters are shown in Figures 5.1-5.5.

The instrument sensitivity for nitrate and silicate varied by only 10%, though a few runs did vary by up to 40%. Phosphate sensitivity behaved much more reproducibly with these parameters varying by about 10% over the 5 week period of observations.

For nitrate and silicate, a 2nd order bent calibration curve was fitted to the standards. A linear regression was fitted to the phosphate standards. The quality of the calibration curves was generally good with 95% having regression coefficients of better than 0.993 for silicate and nitrate, and 95% having regression coefficients of better than 0.999 for phosphate. The reduction efficiency of the cadmium column was 60% during the early part of the cruise due to an error in diluting the nitrite standard. This increased to approximately 100% after run 9 at which point we changed the nitrite standard. Then the efficiency increased to approximately 100%. The change of the column on the 30th November had no discernable effect on the reduction efficiency.

The baseline value of the instrument barely changed through the cruise.

Data quality

Precision of measurements: The short term precision of the measurements was evaluated by running one duplicate sample per station. Figure shows time series of the ratio between the duplicates for silicate, nitrate and phosphate. The mean ratios for Si, N and P were 1.00, 1.00 and 1.00.

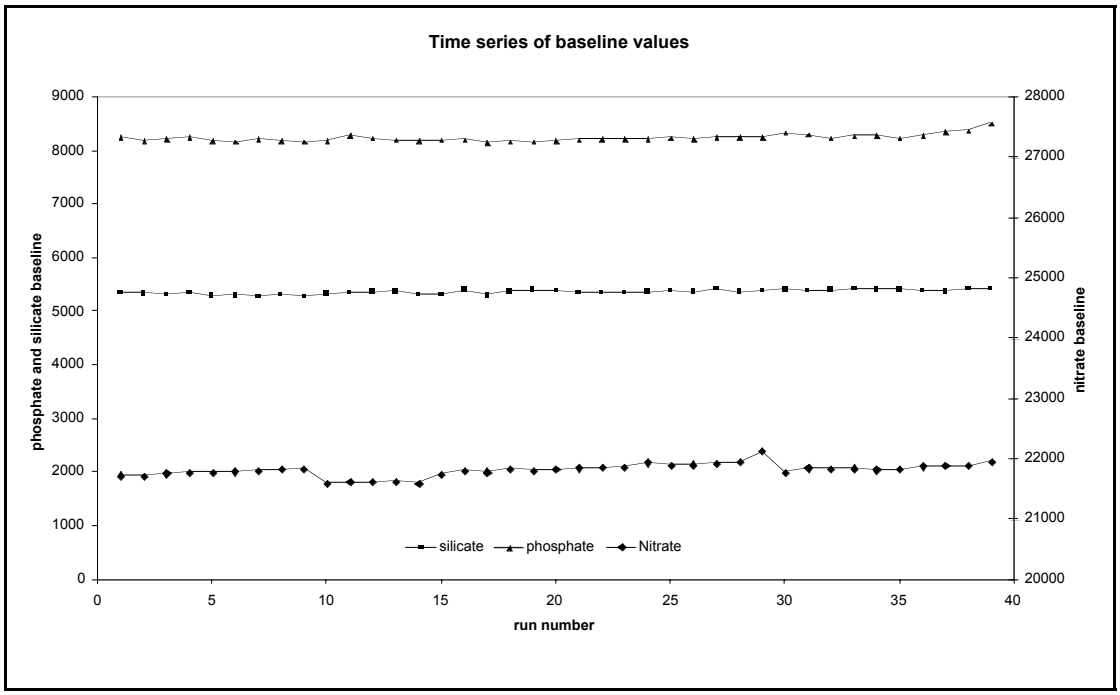

Fig. 5.3 Time series of baseline values

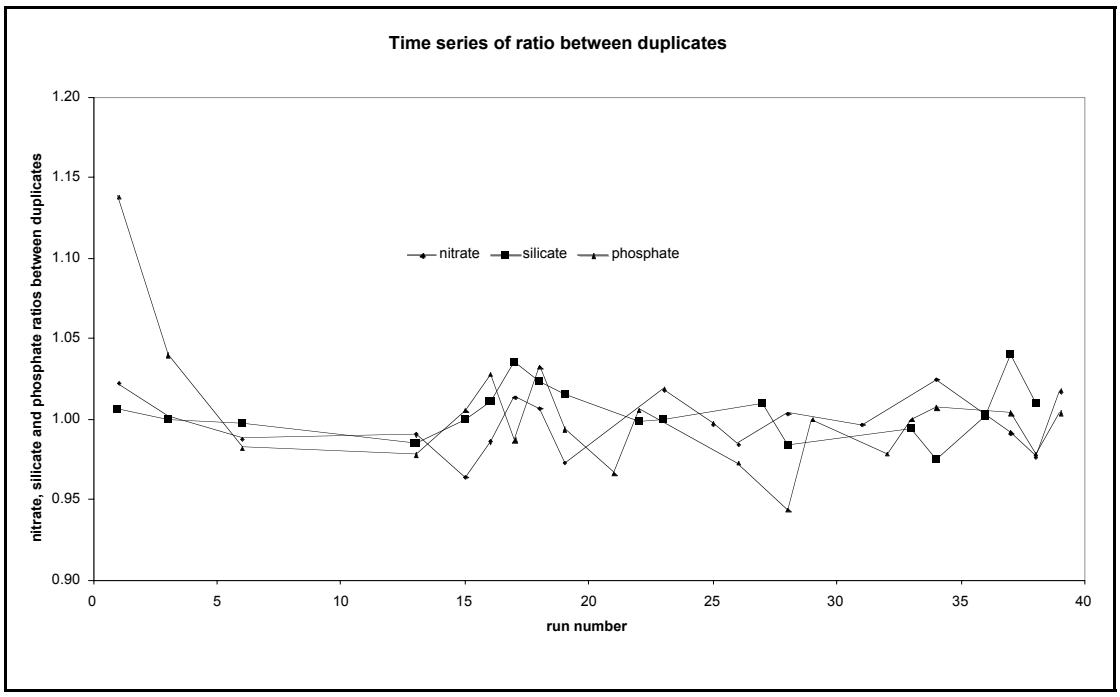

Fig. 5.4 Time series of ratio between duplicates

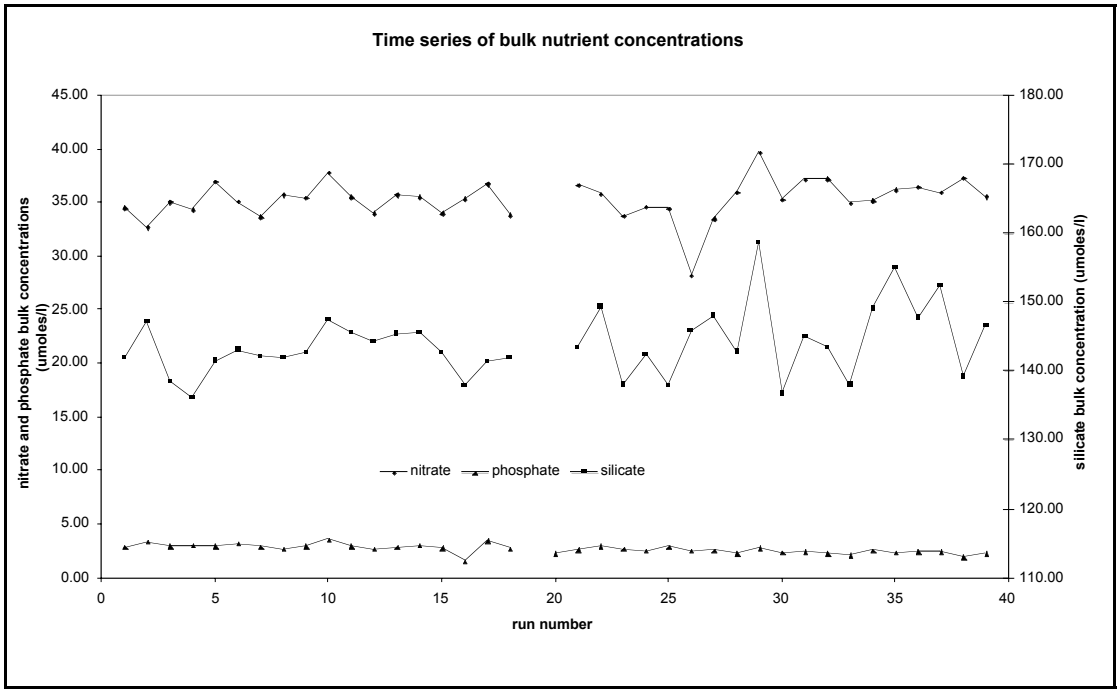

Fig. 5.5 Time series of bulk nutrient concentrations

Internal consistency of measurements: This was evaluated by using a deep water sample taken on station 1. This was run on every station. The concentrations of nitrate, phosphate and silicate in this sample over time are shown in Figure. Despite some variability, especially in the silicate lines, there was no overall degradation of the bulk

samples and the data points are normalised about the mean values which are for N, 35.29 umoles, Si, 144.00 umoles and for P, 2.70 umoles.

Samples taken

Samples were taken for analysis from the three types of CTD cast undertaken and the non-toxic water supply. All samples were run within 24 hour of being collected and were kept at 4oC in a fridge. There were approximately 400 samples taken from the non-toxic supply with a sample being taken at least once an hour, though sometimes more regularly if we were passing by an interesting feature or water mass.

All three different CTD casts (standard, thorium and iron casts) were samples from. From the 24 standard casts, approximately 550 samples were taken. They were taken from each bottle, even if several bottles were fired at the same depth. From the 10 thorium casts, there were approximately 90-100 samples were taken. 9 or 10 samples were taken from each of the thorium casts and these represented the 9 or 10 depths at which the bottles were fired. Depths weren't repeated from this cast although the final cast did have three replicas from 125m. There were also 12 iron casts using the titanium CTD. From these 12 casts there were approximately 200 samples. One sample was taken from each bottle depth and the depths were not repeated if more than one bottle was fired at the same depth. The only times samples weren't taken from any CTD bottle was when the bottle had been leaking as it hadn't shut properly. The only exceptions to this were thorium casts 15512 and 15523 when no nutrients were taken. The reason for this is unclear, but maybe a lack of communication.

6. Inorganic carbon cycling in the Crozet area

6.1 Leg 1 D285 Dorothee Bakker, Maria Nielsdóttir

Rationale

Iron supply and air-sea exchange of carbon dioxide (CO_2) are closely linked in the Southern Ocean. The current understanding is that low iron concentrations limit algal growth in HNLC waters. Seasonal algal blooms downstream of islands and in frontal jets reduce the CO_2 concentration in the mixed layer (Bakker et al., 1997). The overall primary productivity in the Southern Ocean may be higher than satellite observations suggest (Schlitzer, 2002). It is not clear where this 'extra' production occurs: HNLC waters might be less widespread or more productive than the satellite observations indicate. Or, algal growth in iron-replete waters has been under-estimated.

The Southern Ocean is an important area for ventilation of the deep ocean and for uptake of anthropogenic CO_2. Deep water comes to the surface and exchanges heat, CO_2, and other gases with the atmosphere before descending again. Estimates of net oceanic CO_2 uptake south of 50°S for ~1995 range from 0.1-0.5 Pg C yr^{-1} (Pg = 10^{15} g) (Rayner et al., 1999; Takahashi et al., 2002), 6-29% of the net global oceanic uptake of the greenhouse gas (Prentice et al., 2001). Most of the anthropogenic CO_2 taken up by the Southern Ocean is transported north along equal density surfaces (Caldeira and Duffy, 2000), presumably in Antarctic Intermediate Water and Subantarctic Mode Water (Sloyan and Rintoul, 2001). A reduction of the vertical mixing and upwelling in the Southern Ocean would probably increase the atmospheric CO_2 level (Sarmiento et al., 1998; Matear and Hirst, 1999). Such circulation changes could also reduce the supply of iron from shallow topography to surface waters, which would further limit algal growth and would equally increase the atmospheric CO_2 level. Global warming might provoke such changes in the circulation of the Southern Ocean (Sarmiento et al., 1998).

Objectives

- Assess the importance of natural iron fertilisation from shallow topography for the marine CO_2 sink near the Crozet Plateau.
- Quantification of a carbon budget for the Crozet blooms.
- Comparison of the effects of natural and anthropogenic iron fertilisation on oceanic CO_2 uptake.
- Determine potential applications of satellite observations for quantifying oceanic CO_2 uptake.

With the additional objectives:

- Assessment of CO_2 air-sea transfer between the Crozet Plateau and South Africa.
- Better quantification of the air-sea gas transfer velocity.

Methods

Underway parameters: oxygen and pCO_2

The seawater supply –The ship's seawater supply provided large volumes of water for underway sampling. The seawater temperature was measured at the water intake at 6.5 m depth in the ship's bow. A centrifugal pump transported the water to the laboratories. The water was fed through a debubbler. The salinity of the water was measured. In the chemistry laboratory the seawater passed an oxygen sensor, a strainer with a bypass, and finally the equilibrator for pCO_2 analysis. The bypass was used for discrete sampling of oxygen, dissolved inorganic carbon (DIC), and alkalinity.

The partial pressure of CO_2 in surface water and marine air - Continuous measurements of pCO_2 in surface water and marine air were made throughout the cruise with the underway CO_2 system designed by Ute Schuster (UEA) (CAVASSOO, 2004). Marine air was collected through tubing from the foremast. Seawater from the ship's surface water supply was introduced at a rate of 3 l min^{-1} into a fast response equilibrator with a showerhead (Bakker et al., 2001). A Pt100 probe accurately determined the water temperature in the equilibrator. A vent kept the headspace of the equilibrator at atmospheric pressure. Every minute the CO_2 content and the moisture content of the headspace were determined by an infrared LI-COR 6262 analyser. The analysis of the CO_2 content in the headspace was interrupted for that of the CO_2 content in marine air (20 minutes per 6 hours) and in two CO_2 standards (30 minutes per six hours each). Samples from the equilibrator headspace and marine air were partly dried to 10°C below the ambient temperature in an electric cool-box. The standards of 266.6 (later 267.7) and 481.0 µmol CO_2 mol^{-1} (σ of 0.5 µmol mol^{-1}) had been calibrated against certified NOAA standards. The analyses were carried out for a flow speed of 100 ml min^{-1} through the LI-COR at a slight overpressure. A final analysis for each parameter was made at atmospheric pressure with no flow. The flow and overpressure did not have a discernable effect on the CO_2 and moisture measurements, once the pressure had been corrected for. The correction by Takahashi et al. (1993) was used to correct for warming of the seawater between the ship's water intake and the equilibrator. Here warming of the seawater was taken as 0.4°C. The pCO_2 measurements were time stamped by GPS. The time delay between sampling and analysis will be taken as 4 minutes for pCO_2 in air and surface water. The precision and accuracy of the pCO_2 data was approximately 1.0 µatm, as determined in previous cruises (Bakker et al., 2001).

The final pCO_2, DIC, alkalinity, and O_2 data will be stored with other cruise data at the British Oceanographic Data Centre (http://www.bodc.ac.uk/). Initially the data will be accessible to cruise participants only. The data will become publicly accessible once the results have been published. Surface water pCO_2 data will also be submitted to the international, publicly accessible surface water pCO_2 database at the U.S. Carbon Dioxide Information Analysis Center (http://cdiac.esd.ornl.gov/oceans/).

The oxygen concentration of surface water – The oxygen (O_2) concentration and water temperature were measured with an optode, model 3930 from Aanderaa (Figure 6.1a). The oxygen measurement is based on dynamic luminescence quenching of luminophore molecules (platinum porphyrine) embedded in a sensing foil, which is exposed to the surrounding water (Aanderaa, 2003). A light emitting diode (LED) and a photo-diode are

placed on the instrument side of the foil. Absorption of a photon from the blue-green photo-diode excites the luminophore molecules in the foil. If a luminophore molecule does not collide with another molecule, it will return to its initial state by emitting a photon. The photo-diode detects the quantity of this fluorescent light. However, if a luminophore molecule collides with an O_2 molecule, it transfers its excitation energy to the oxygen molecule. The intensity of fluorescent light thus decreases with the oxygen concentration.

The instrument is in a cylindrical titanium housing with a length of 160 mm and a diameter of 40 mm. A purpose built titanium housing positioned the optode in the seawater flow (Fig. 6.1b). The optical window of the optode was in the wider part of the housing and in the centre of the flow. The external housing was positioned vertically, as in Fig. 6.1b. The optical window of the optode was put in the direction of the flow, in order to minimize any effects from air bubbles. The temperature sensor just entered the wider part of the external housing. A 10 pin cable with a small split cable fitting connected the optode to the temperature and oxygen channels on the datalogger, model 3660 from Aanderaa. The data from the optode were logged on the datalogger and passed on every minute to the laptop of the online pCO_2 system.

The optode has a measuring range of 0-500 μM for oxygen, with a resolution better than 1 μM and an accuracy better than 8 μM or 5%, whichever is greater (Aanderaa, 2003). The optode is valid for a salinity range of 33-37. Software in the data logger calculates the oxygen concentration (μM) from the raw data and the calibration coefficients of the oxygen sensor. The oxygen optode has its own internal thermometer for the calculation of the oxygen concentration in addition to the external temperature sensor.

The optode provided oxygen concentrations in freshwater, which were corrected to a constant salinity of 33.8, while assuming warming of 0.4°C between the seawater inlet and the optode (Aanderaa, 2003). Preliminary values for the oxygen saturation in seawater were calculated using the equations by Garcia and Gordon (1992). The oxygen data will be recalculated for the correct seawater temperature and salinity and will be checked against oxygen concentrations determined by the Winkler method in surface samples from the CTD (Richard Sanders and colleagues) and the ship's seawater supply.

The temperature range for the external temperature sensor is –7.5 to +41°C with an accuracy of ±0.1°C and a resolution of 0.05°C. The temperature readings of the optode showed an offset of several degrees Celsius relative to the temperature in the equilibrator. Earlier study of this problem (Nielsdóttir, 2004) suggests that the temperature sensor is outside the main flow of the water. These temperature data will not be discussed further.

Vertical profiles of DIC and alkalinity

CTD sampling – Samples for the analysis of DIC and alkalinity were collected in 500 ml glass bottles from the 20 l Niskin bottles on the CTD rosette. The 25 standard CTD casts were sampled, as well as 5 thorium casts (15495, 15498, 15539, 15540, 15548). The standard CTD casts were sampled to the bottom, except at station 15489 (J). Typical sampling depths were 10 m, 20 m, 40 m, 60 m, 80 m, 100 m, 150 m, 200 m, 300 m, 400 m, 500 m, 750 m, 1000 m, 1500 m, 2000 m, 2500 m, 3000 m, 3500, bottom – 10 m, while leaving out depths, if the water column was shallower. Thus, approximately 400 CTD samples were analysed for DIC and alkalinity. Samples were also taken from the

ship's surface water supply to increase spatial coverage: 297 samples for DIC and 199 for alkalinity.

Generally samples were analysed within 24 hours of collection. If this could not be achieved due to instrument failure (DIC) or close station spacing, the samples were fixed by adding 100 µl of a saturated mercury chloride solution for each 500 ml sample. Fixed samples were stored in the dark in a cold room (5°C). All samples were analysed within 6 days of collection.

Dissolved inorganic carbon – Samples were kept cold before measurement in a seawater flow. The DIC concentration was determined by coulometric analysis after the method of Johnson et al. (1987). At least three replicate analyses were made on each sample bottle, until two replicates were within 1 µmol kg^{-1} (100 counts) for a blank below 0.3 µmol kg^{-1} min^{-1} (30 counts min^{-1}). The system had a small carry over effect, such that the first replicate of a sample was discarded, if a strong DIC change occurred between samples and between samples and standards. The instrument was kept running, except when the cell was changed, as this gave the best results. Generally all samples from one cast and sometimes a few samples of another cast were run per cell. The starting up time for a new cell varied from 2 to 8 hours, before the blanks came down sufficiently. The temperature of the samples during analysis was determined with an accurate Pt100 sensor.

At least one standard of certified reference material from batches 65 and 66 (DOE, 1994) was used per coulometric cell and per cast. The specifications of batch 65 were:

salinity	33.049
DIC	1993.68 µmol kg^{-1} ± 0.32 µmol kg^{-1}
total alkalinity	2206.00 µmol kg^{-1} ± 0.68 µmol kg^{-1}
phosphate	0.40 µmol kg^{-1}
silicate	1.0 µmol kg^{-1}
nitrite	0.03 µmol kg^{-1}
nitrate	0.14 µmol kg^{-1}.

Batch 66 awaits certification.

From 26-28 November the instrument blank stayed above 30 counts per minute, just as a new nitrogen cylinder of a 4.6 quality was started. During trouble shooting many components of the system were replaced: new coulometer chemicals, fresh soda lime from a new pot, a new 4.5 quality nitrogen gas cylinder, a clean extractor for the extractor unit, and a new lamp for the coulometer. Exclusion of the extractor unit from the system showed that the blank problem originated from the carrier gas, the soda lime, the coulometer, or the cell. The carrier gas and ineffective soda lime were the most likely source of the blank problem. The blanks came down after the trouble-shooting.

Organic particles and possibly dissolved organic matter affected the analysis of some samples from the upper 1000 m. We estimate a precision and an accuracy better than 2.7 µmol kg^{-1} after Bakker et al. (2001). The data await processing and careful analysis.

Alkalinity – The alkalinity measurements were made by potentiometric titration with a VINDTA instrument (#4, version 3C) developed by Ludger Mintrop (2004). The acid consumption up to the second endpoint is equal to titration alkalinity. The system uses a Metrohm Titrino 719S, an ORION-Ross pH electrode and a Metrohm reference electrode. The burette, the pipette (volume 99 ml), and the analysis cell have a water jacket around them.

Samples were kept at room temperature (~18°C) before measurement. The water jackets and two samples, one awaiting analysis and the other being analysed, were kept at a constant temperature of 24.5°C by a recirculation water bath. The temperature was checked regularly by a calibrated mercury thermometer. The titrant (0.1M hydrochloric acid, HCl) was made by dilution of 50 ml of 1 M HCl with 450 ml of MilliQ. Three different batches of titrant were used.

Two or three replicates were run on each sample bottle, until the difference between two replicates was less than 1 μmol kg^{-1}. The first measurement after restarting the system, a pause in the analysis, or after topping up the electrodes was generally slightly off and was discarded. The instrument was occasionally affected by a carry over effect if there were large differences in alkalinity between successive samples or between samples and the seawater standards. At least one standard of batches 65 or 66 was run per CTD cast, generally after they had been used for DIC analysis. Occasionally a new standard was opened for alkalinity. The alkalinity data need correction for seawater density and nutrient concentrations. The data await careful analysis.

Results

The data shown here are preliminary. The mixing ratio of CO_2 in dry air varied between 374.5 and 378.5 μmol mol^{-1} throughout the cruise. The range of the values may decrease once the values affected by the ship's exhaust gases have been removed. Atmospheric pCO_2 ranged from 365 to 379 μatm. This variation resulted from changes in atmospheric pressure between 985 and 1025 mbar.

Surface water pCO_2 varied from 290 to 400 μatm in the Crozet area (Fig. 6.2). Large areas, in particular to the north of the Crozet plateau, were sinks for atmospheric CO_2. Areas with strong algal blooms had low pCO_2 and high oxygen saturation (Fig. 6.2). Such areas were encountered at M4 (15493), during the first SeaSoar survey (SS15519), and at M9 (15544). These areas of high biological activity are also evident from other surface water parameters, such as chlorophyll, Fv/Fm (Mark Moore, personal communication) and satellite images of ocean colour (Hugh Venebles and Raymond Pollard, personal communication).

Small to moderate sources for atmospheric CO_2 were found south of the plateau, in the Canal des Orgues between the Ile de la Posession and Ile de l'Est, and at station M3. The highest values were found at station M3 (15494/495/498/518), in the Canal des Orgues, at the 3000 m contour south of the straits, and at station M2 (15504). The supersaturation of pCO_2 may reflect seasonal warming of the water in areas with low marine productivity. The highest values may also reflect some input from deeper water rich in CO_2, especially as most of these sites, except for M2 are in locations where the topography of the plateau might affect the movement of the water.

Future work

• *The importance of natural iron fertilisation from shallow topography for the marine CO_2 sink near the Crozet Plateau* - Comparison of surface water pCO_2 and O_2 with other underway parameters, such as the concentrations of nutrients, chlorophyll, and iron, as well as with satellite observations of ocean colour and sea surface temperature will illustrate the spatial and temporal evolution of the Crozet blooms. The vertical profiles of DIC and alkalinity may allow testing whether any deeper water has reached the surface at the stations close to the plateau. Combination of the CO_2 data with the iron data (Peter Statham, Florence Nadelec, Hélène Planquette) will provide information on the factors controlling the oceanic CO_2 sink and whether natural iron fertilisation from shallow topography plays an important role.

This objective will also include study of CO_2 data previously collected in the Crozet area by OISO (Océan Indien Service d'Observation) scientists. This work will be carried out in collaboration with Nicolas Metzl and Alain Poisson (Laboratoire de Biogéochimie et Chimie Marines, Université Jussieu, Paris). The OISO program continues a valuable time series (since 1984) of surface water CO_2 measurements in the Indian sector of the Southern Ocean. It is jointly funded by INSU (Institut National des Sciences de l'Univers), IPEV (Institut Polaire Français Paul Emile Victor) and IPSL (Institut Pierre Simon Laplace).

• *A carbon budget for the Crozet blooms* - The vertical profiles of DIC will allow calculation of the deficit in dissolved inorganic carbon in the mixed layer. The organic and inorganic carbon stocks and rates of change in the stocks will be combined into a comprehensive carbon budget for the blooms in collaboration with other cruise participants.

• *Effects of natural and anthropogenic iron fertilisation on oceanic CO_2 uptake* – Comparison of changes in fCO_2 and DIC in the Crozet blooms to results from algal blooms near the Polar Front, in SOIREE, and in EisenEx (Bakker et al., 1997, 2001, 2005) will allow testing whether natural and anthropogenic iron fertilisation affect CO_2 air-sea exchange and carbon cycling in similar ways.

• *Potential applications of satellite observations for quantifying oceanic CO_2 uptake* - The research will investigate potential uses of satellite information for quantifying CO_2 air-sea transfer, following an approach similar to Boutin et al. (1999). We will also compare how oceanic CO_2 uptake and carbon export compare with satellite based estimates of primary productivity and with Schlitzer's POC export (2002) for this region. This research is closely related to CASIX (Centre for Observation of Air-Sea Interactions and Fluxes; http://www.pml.ac.uk/casix/).

• *CO_2 air-sea transfer between the Crozet plateau and South Africa* - Surface water fCO_2 measurements will be made during the repeat transects between the Crozet Plateau and South Africa. The data will provide insight into the variation of CO_2 air-sea exchange between the plateau and South Africa from November to January.

• *Quantification of the air-sea gas transfer velocity* - The CO_2 air-sea flux will be calculated from the CO_2 air-sea concentration difference and wind speed. These indirect CO_2 air-sea fluxes will be compared to CO_2 fluxes, which have been measured by the eddy correlation method throughout the cruise (Robin Pascal, Margaret Yelland). The comparison will hopefully allow independent quantification of the gas transfer velocity for various wind speed regimes during the cruise. The oxygen excess (Richard Sanders)

and CO_2 deficit in surface waters will be compared in order to assess if it is possible to calculate an average gas transfer velocity for the period preceding the measurements.

This future work will be carried out in close collaboration with other cruise participants, who are not always mentioned individually in the above text. The collaborative effort will hopefully be reflected in several multi-author research articles. In some cases other participants may lead the research.

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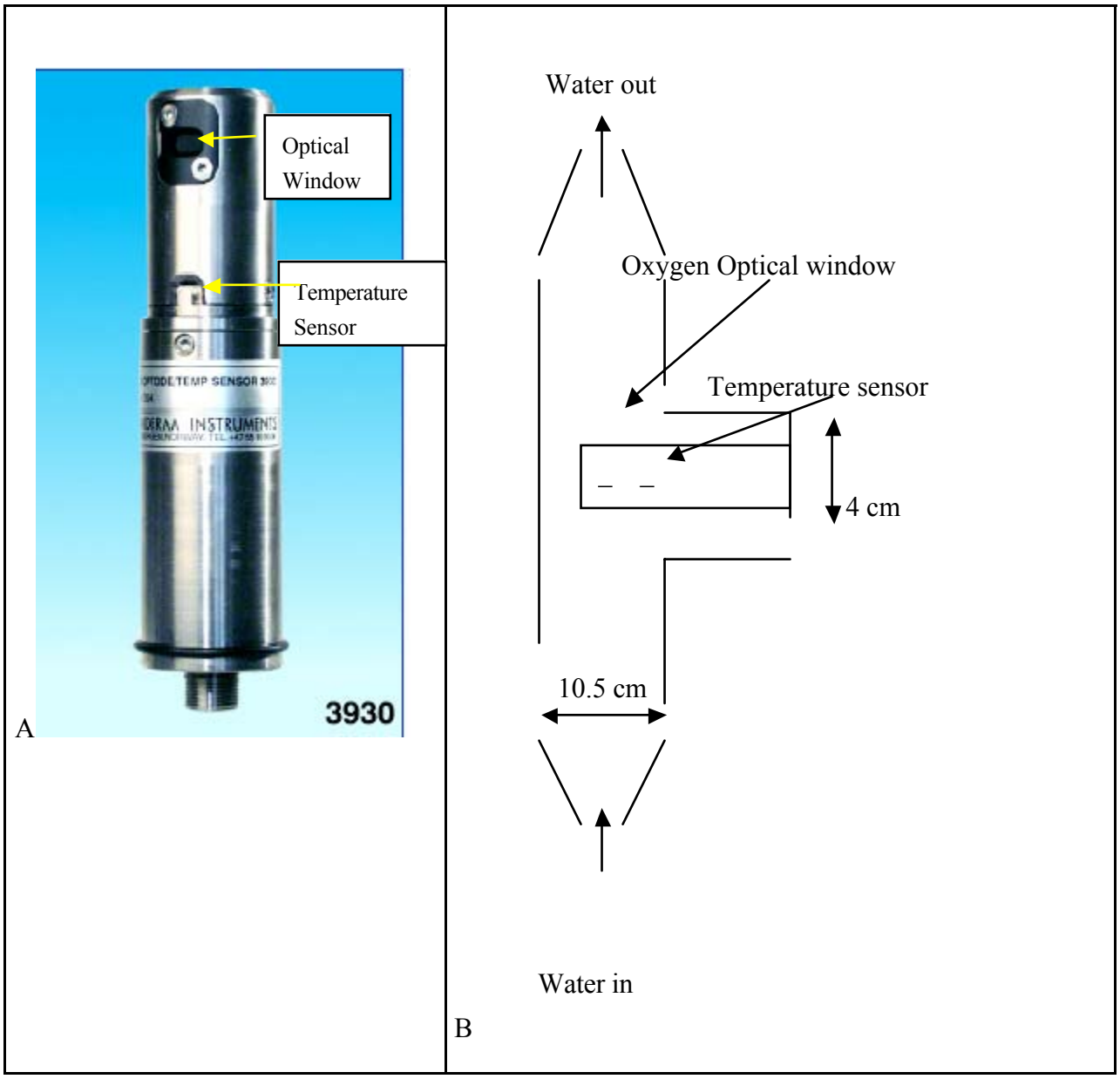

Fig. 6.1 (a) The optode 3930 (Aanderaa, 2003) and (b) the purpose built housing for the optode (Nielsdóttir, 2004)

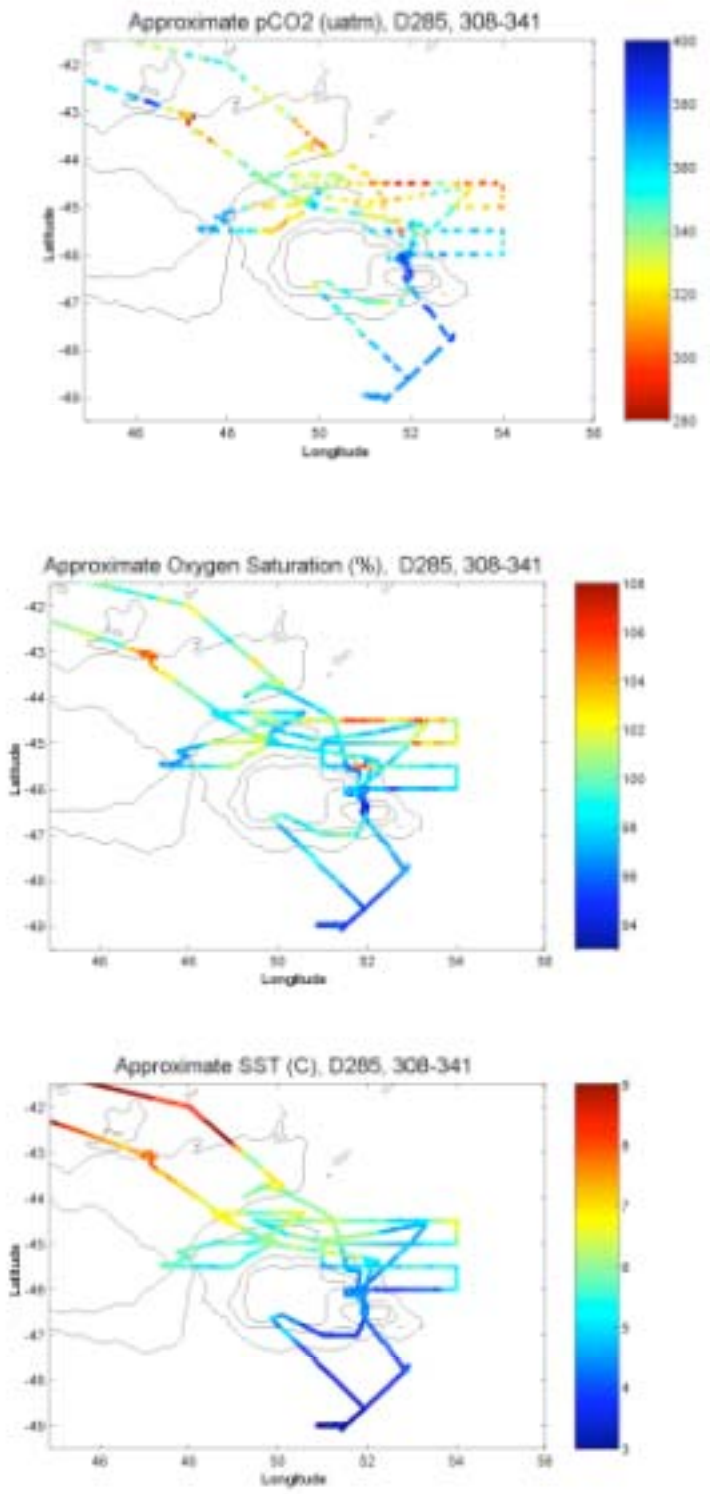

Fig. 6.2 The spatial distribution of (a) surface water pCO_2 (µatm), (b) the percentage oxygen saturation, and (c) the approximate sea surface temperature (°C) for the Crozet area. The colour scale of surface water pCO_2 has been reversed, such that high oxygen saturation and low pCO_2 both show as a red colour. Depth contours of 1000 m, 2000 m, and 3000 m are shown (ETOPO 5, 1988). A better topography is now available for the area (Smith and Sandwell, 1997). The approximate sea surface temperature was calculated by subtraction of 0.4°C from the temperature in the equilibrator.

6.2 Leg 2 D286

Methods

Underway parameters: oxygen and pCO_2

The partial pressure of CO_2 (pCO_2) in surface water and marine air, and the oxygen concentration of surface water were determined in a similar manner to the first leg. A bad electronical connection resulted in a valve failure on the online pCO_2 instrument on 19 December 2004. Support from Dougal Mountiford and Jeff Bicknell (UKORS) kept the downtime of the instrument to a minimum (2-3 hours). A roll of the ship sent the online pCO_2 instrument flying on 16 January 2005. Fortunately the instrument seems to have suffered only minor damage. In future the instrument needs better securing. Preliminary pCO_2 and oxygen data are available for the cruise until 14 January.

Vertical profiles of DIC and alkalinity

Samples for the analysis of dissolved inorganic carbon (DIC) and alkalinity were taken from the CTD at 25 stations. Typical sampling depths were: 10, 20, 40, 60, 80, 100, 150, 200, 300, 400, and 500 m. Repeat stations were carried out at M9 (leg 1+2), M10 (leg 2), M2 (leg 1+2), M3 (leg 1+2), M6 (leg 1+2), and the bloom site near M3 (leg 2). The CTD section between M3 and M5 was sampled. In total 261 CTD samples were analysed for DIC and alkalinity. All samples were analysed within 8 days of collection.

The analysis of DIC and alkalinity was carried out in a similar fashion to the previous leg (D285). Certified Reference Material (batch 66) was used to calibrate the DIC and alkalinity data. At least three replicate analyses were made on each DIC sample, until two replicates were within 1 µmol carbon kg^{-1} (100 counts) for a blank below 0.3 µmol carbon kg^{-1} min^{-1} (30 counts min^{-1}). The analysis of DIC suffered from similar problems as during the previous leg with a high initial instrument blank for new coulometer cells. The blank problem may have originated from a variable quality of the MilliQ water, which was used for cell cleaning. The DIC data have an estimated precision and an accuracy better than 2.7 µmol kg^{-1} after Bakker et al. (2001). Two or three replicates were run on each alkalinity sample, until the difference between two replicates was less than 1 µmol kg^{-1}. Processing of the DIC and alkalinity data is in progress.

Results

Surface water pCO_2 values ranged from 340 to 370 µatm to the north, east, and south of the plateau with occasionally higher values of 380 µatm (Fig. 6.3). Atmospheric pCO_2 was close to 373 µatm (+/-5 µatm). This made the Crozet area a significant sink for atmospheric CO_2.

In comparison with leg 1 (D285) the signature of strong algal blooms north of the plateau had disappeared in surface pCO_2 and O_2 by late December (Fig. 6.3). The bloom north of Ile de la Posession and Ile de l'Est (46°09'S 51°51'E) in early January was a notable exception to this. In this bloom pCO_2 was as low 300 µatm, while the oxygen saturation was up to 108% (Figs 6.4 and 6.5).

South of the plateau surface water pCO_2 had decreased by about 15 µatm between late November (D285) and the first days of January. This pCO_2 decrease occurred despite warming of the surface water by about 1°C. This suggests that biological carbon uptake promoted a pCO_2 reduction of 30 µatm.

Relatively high surface water pCO_2 values of 380 µatm were encountered on the Crozet plateau at depths shallower than a 1000 m, for example in the Baie aux Americains (Ile de la Posession) on 22 December 2004, and in the Baie du Marin (Ile de la Posession) on 8 January 2005. Such relatively high pCO_2 values were also encountered over the plateau during D285 and during certain French Minerve and OISO cruises (data by Alain Poisson and Nicolas Metzl, LOCEAN, Paris). A pCO_2 maximum, an oxygen minimum, and a minimum of sea surface temperature (SST) coincided with a shallowing of the isotherms by 50 m at the shallowest point (~ 150 m deep) of the Canal des Orques, the Strait between Ile de la Posession and Ile de l'Est, in the SeaSoar survey on 31 December 2004. A pCO_2 maximum, an oxygen minimum and a distinct SST minimum also occurred at 46°17'S 51°42'E, immediately north of Ile de la Posession on 10 and 12 January 2005. It will be interesting whether the parallel SeaSoar survey on 12 January showed a shallowing of the isotherms. The results of the first SeaSoar survey suggest that vertical advection may explain some of the relatively high surface pCO_2 values over the plateau.

A salinity minimum (fresh by 0.03 units) was apparent between 51°47'E and 51°58'E in the CTD section along 46°17'S, just east of the aforementioned pCO_2 maximum. Surface water pCO_2 of ~355 µatm was relatively low in the salinity minimum, while the oxygen saturation was relatively high. Further study is necessary to assess how surface water pCO_2 varied with salinity in the vicinity of the islands.

Conclusion

The Crozex cruises (D285, D286) have provided a wealth of data on the evolution of the carbonate system from spring to summer in the Crozet area. The importance of iron fertilisation from the Crozet plateau for algal growth and marine carbon cycling will be assessed from the iron, radium, chlorophyll, pCO_2, and O_2 data. Careful study of the inorganic carbon results from both legs will highlight the processes controlling surface pCO_2 and the vertical distribution of DIC and alkalinity in the area, notably biological processes (algal carbon uptake, remineralisation, carbon export), seasonal warming, vertical advection, air-sea gas transfer, and possibly freshwater input. Changes in the vertical profiles of DIC and alkalinity at repeat CTD stations will allow quantification of net community production. Combination of the surface data with satellite observations of ocean colour and sea surface temperature will place the shipboard pCO_2 data in a wider context and may possibly allow the extrapolation of the surface water pCO_2 data for well mapped areas (eg. SeaSoar surveys), by a method such as co-Kriging. This work will be pursued in the context of the NERC CASIX and BICEP programs, in collaboration with researchers of the French OISO program.

Acknowledgements - The captain and crew of RRS Discovery enthusiastically supported the multidisciplinary CROZEX project. Ute Schuster, Gareth Lee, Andrew Hind, Andrew MacDonald, Stewart Rix, Dave Blomfield, Nick Griffin, Kim Wright, Alan Goillau, and Neil Loveday (UEA) contributed in many ways to the recent refurbishment of the instruments and cruise preparations. The JIF LGMAC grant (NER/H/S/1999/00176) has allowed the essential refurbishment of our existing instrumentation (underway pCO2, discrete DIC) and the acquisition of the alkalinity instrument, while the EU CAVASSOO project (EVK2-CT-2000-00088) allowed Ute Schuster to develop and extensively test the new UEA underway pCO2 instrument. The EU project ORFOIS (EVK-CT-2001-00100), the NERC CASIX project (F14/G6/115), and the BICEP (Biophysical Interactions and Controls on Export Production) program, a

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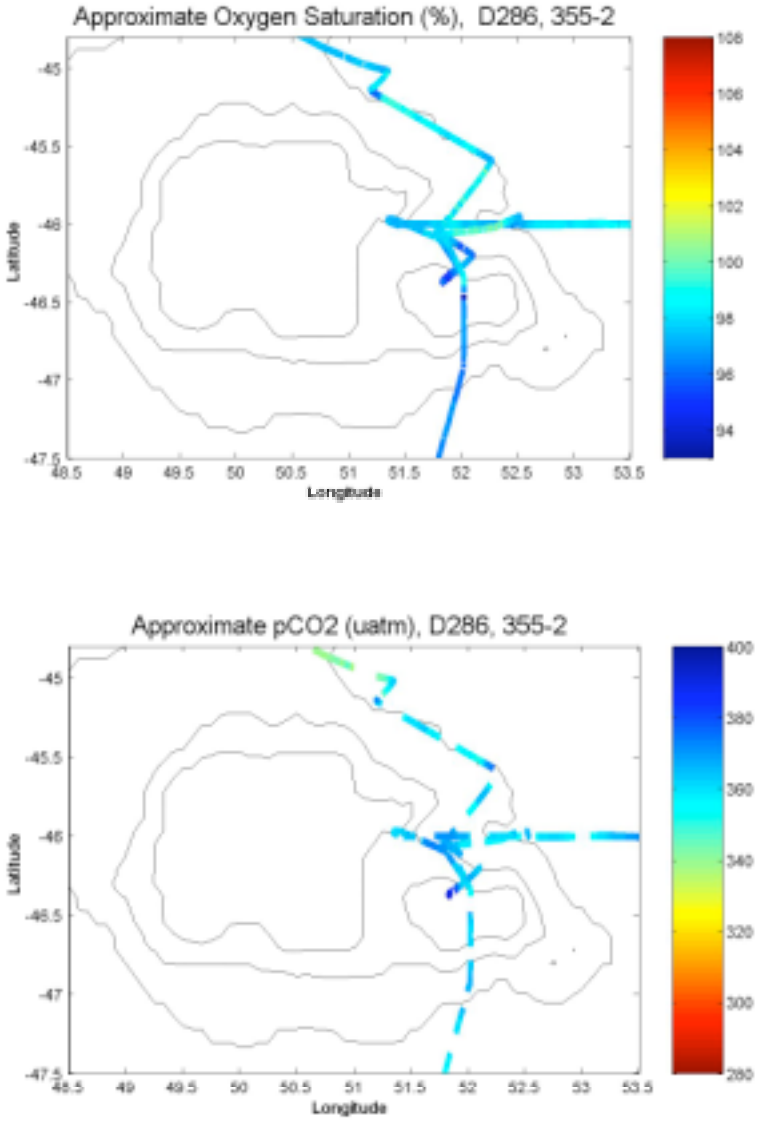


Fig. 6.3 The spatial distribution of surface pCO_2 and O_2 in the vicinity of the Crozet plateau from 21 December 2004 to 2 January 2005. The colour scale of surface water pCO_2 has been reversed, such that high oxygen saturation and low pCO_2 both have a red colour. Depth contours of 1000 m, 2000 m, and 3000 m are shown (ETOPO 5, 1988). A better topography is now available for the area (Smith and Sandwell, 1997).

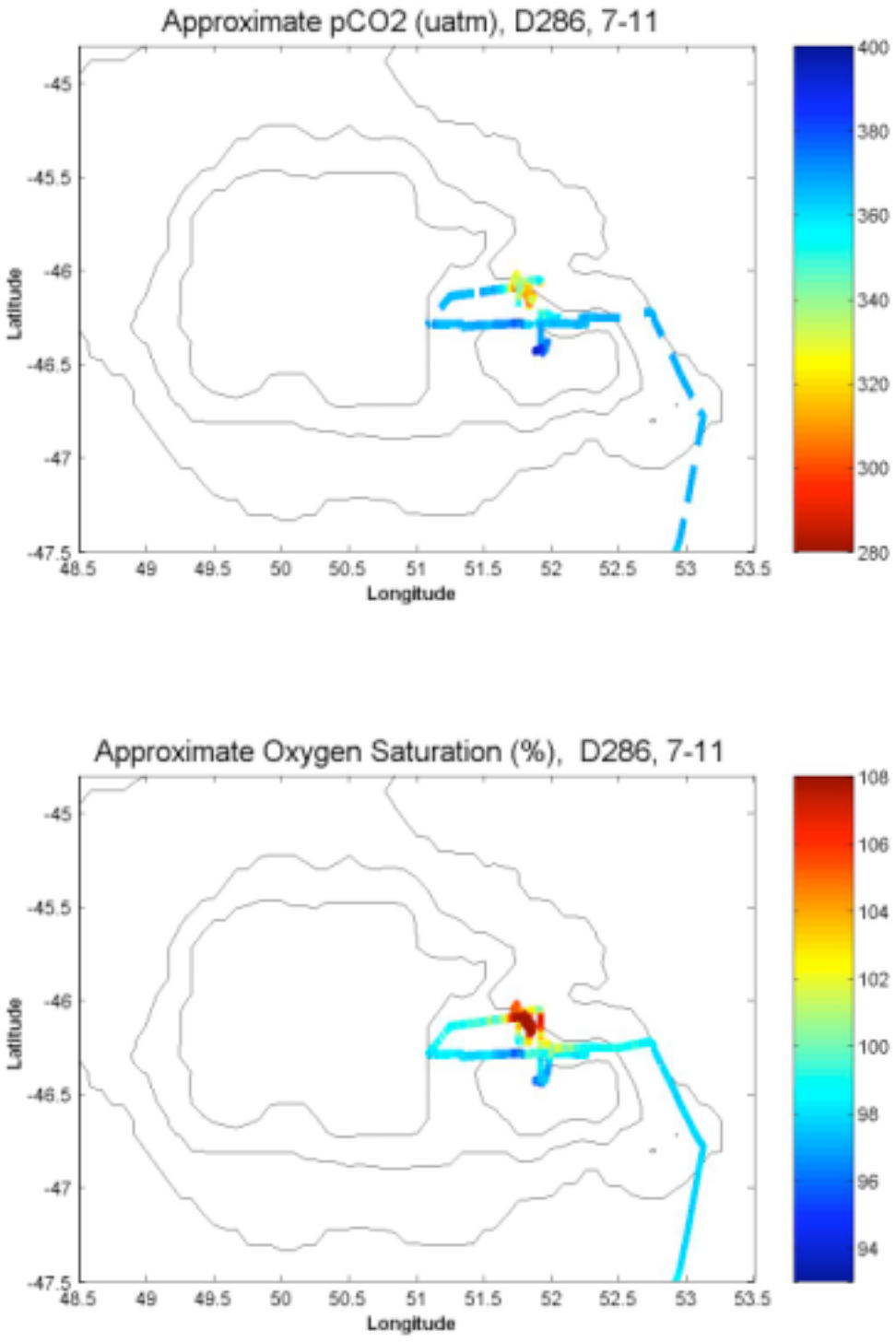


Fig. 6.4 The spatial distribution of surface pCO_2 and O_2 in the vicinity of the Crozet plateau from 7 to 11 January 2005. Depth contours are shown at 1000 m intervals (ETOPO 5, 1988).

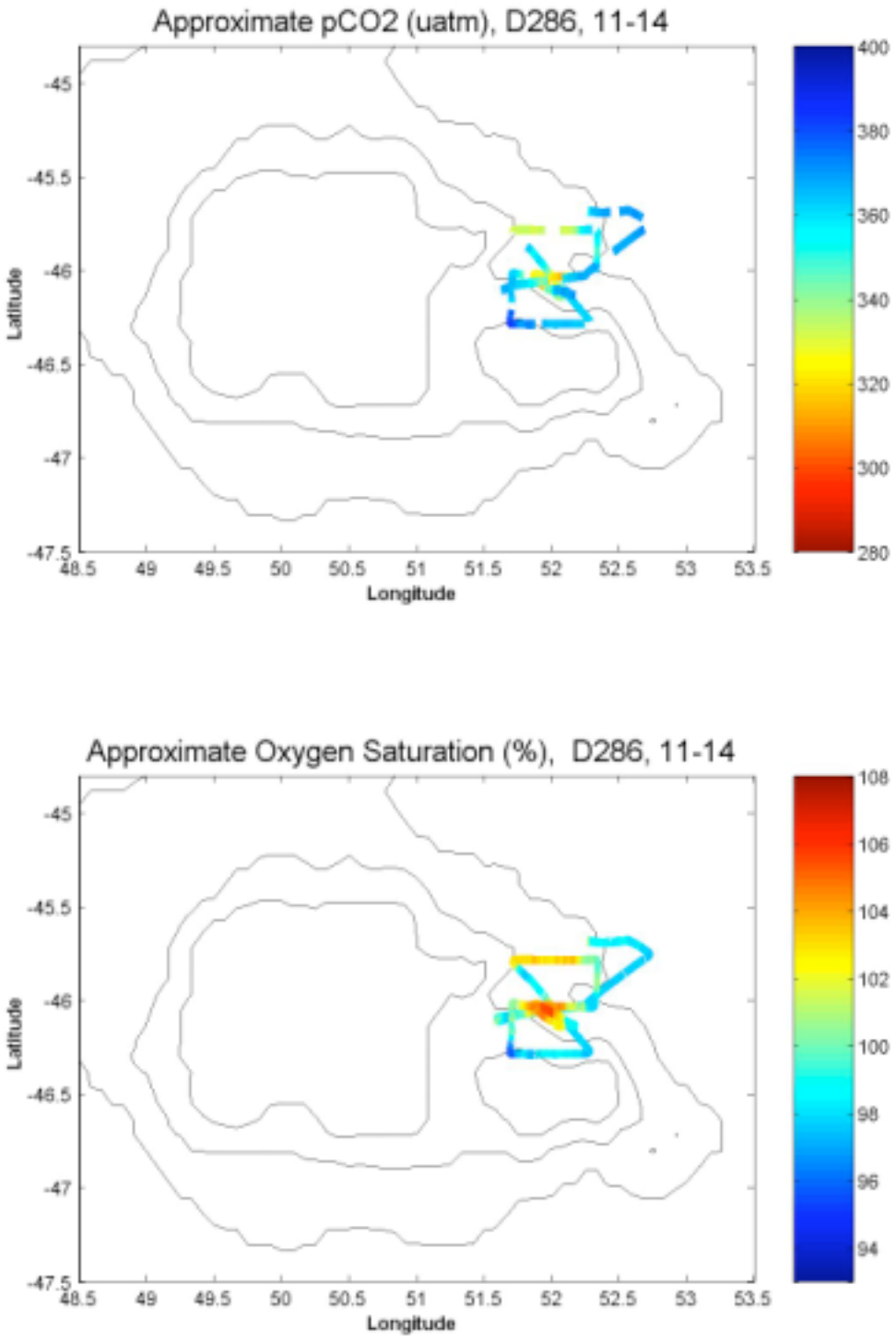
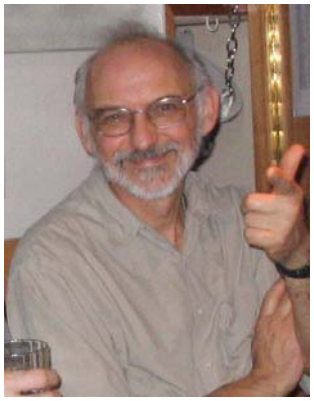


Fig. 6.5 The spatial distribution of surface pCO_2 and O_2 in the vicinity of the Crozet plateau from 11 to 14 January 2005. Depth contours of 1000 m, 2000 m, and 3000 m are shown (ETOPO 5, 1988).

7. Iron Studies in the Crozet Region

Peter Statham, Gary Fones, Florence Nédelec, Hélène Planquette, Ian Salter



7.1 Dissolved iron

Main objectives

- To map changes in total dissolved Fe around the Crozet islands in relation to other key parameters including macronutrients, chlorophyll and phytoplankton species, in order to better understand the role of Fe in initiating and maintaining the bloom.
- To determine the vertical distribution of Fe at key stations around the islands in order to identify possible sources of upwelling Fe and the iron content of water masses.

The sampling objectives were to collect surface samples using the trace metal clean fish system and to collect samples from the vertical water column using the modified OTE bottles on the Titanium CTD-rosette system (UKORS).

Analytical Equipment

The Fe analyser system

The system is based on pre-concentration of Fe (III) and (II) from seawater onto an 8-hydroxyquinoline column, which is then subsequently eluted and mixed with a buffered luminol stream in the presence of hydrogen peroxide. The chemistry is carried out in a continuous flow system. The reaction leads to the production of light in the blue part of the spectrum, which is measured by a highly sensitive photo-multiplier tube [PMT], and the light emitted is directly related to the Fe in the original sample. Control of the flow system and data collection is done through a LabView programme, and NI DAQ and control cards.

The system had performed well at SOC immediately before D285 in analysing samples collected on recent cruises. However on D285 there was in initial major problem on the ship when on leaving Cape Town it was found impossible for the LabView programme to read the data stream from the PMT correctly and a variable high voltage was noted. A variety of time consuming tests were performed and even a chart recorder was rigged up to the system to monitor data. A solution was found by Robin Pascal, who re-grounded the channel 8 to another ground in the break out box. When this was done the system recognised the output from the instrument and the system worked as in the shore laboratory.

By the end of D285 another major problem occurred: The instrument showed poor sensitivity and there appeared to be random contamination of some samples. Despite new luminol solution

and replacement of most other solutions, no clear improvement was observed and the sensitivity remained poor. On the return to Crozet during D286, part of the system was rebuilt (new column, tubes, acid wash, fresh peroxide, heater temperature checking) to try to rectify the instruments problems. Several samples collected during the first leg were then analysed but they all still showed a high degree of contamination. To overcome this problem, an acid wash of the entire system was performed and a new batch of reagents was prepared.

Several vertical profiles (#15568, #15569 & #15572) were analysed during D286 but these results must be viewed with caution considering the number of problems encountered. They will be re-analysed back at SOC to ascertain any variations in concentration. A major problem observed later on was an inconsistent response of the analyser. For example, when the same solution was re-analysed, the peak heights differed and each time, the calibration failed. Thus, despite all the work done on the instrument, no improvement was observed and causes of the problems remain unclear. Work back at SOC post-cruise will involve re-evaluation of this system in comparison with an Fe analyser system recently set up at SOC by Dr Eric Achterberg.

Electrochemistry equipment

This system is used for on-board measurements of Fe-organic complexation. This data can be used with total Fe data to model the ligand concentrations, the different class of ligand (L1, L2), the conditional stability constants of these different ligand classes, and Fe(III)_ (soluble inorganic Fe(III) hydrolysis species). The instrumentation used consists of a PAR303A hanging mercury drop electrode connected to an Ecochemie 303 Interface and an Ecochemie μAutolab 3 voltammeter, the system was run using GPES software. During D286 major problems were encountered with the system. No signal was achieved due to a break in the mercury contact somewhere in the valve body or capillary. Despite numerous changes of capillary and cleaning of the valve body no signal was detected. The two 303A stands used had previously been serviced by Ametek before being packed for Crozex. Ametek will be contacted upon return to SOC to ascertain the reasons for the equipment not working in order to rectify them for analysis of samples returned to SOC. See section on Fe speciation studies for samples collected and future work.

Sampling Rationale

Underway TMS

During D285 a total of 210 surface samples were collected during the cruise. Water was pumped up from the clean fish (Fig. 7.1) at a depth of ~6m and into the clean container where it was withdrawn at the manifold either un-filtered or through a 0.2 μm filter cartridge.

Fig. 7.1 Underway Trace Metal Sampling (TMS) fish

Underway surface samples were collected during D285 (Fig. 7.2) on Crozex in order to provide a broad range of samples across the region of interest. Some problems were encountered:

The measured high Fe on passing between La Possession and Ile de l'Est, may be correct but could also be due to the potential contamination source noted by Mike Lucas. On this section samples

were collected with both fire hose (for Radium) and underway fish. When the fire hose was on, excess water for the pump is directed through hawsers at the bow of ship, and this iron laden water is discharged into the water surrounding the ship. There is clear potential for some of this water to be collected by the Fe fish. During earlier underway sampling at full speed, contamination was not overtly evident, but passage between the islands was at half speed. It was

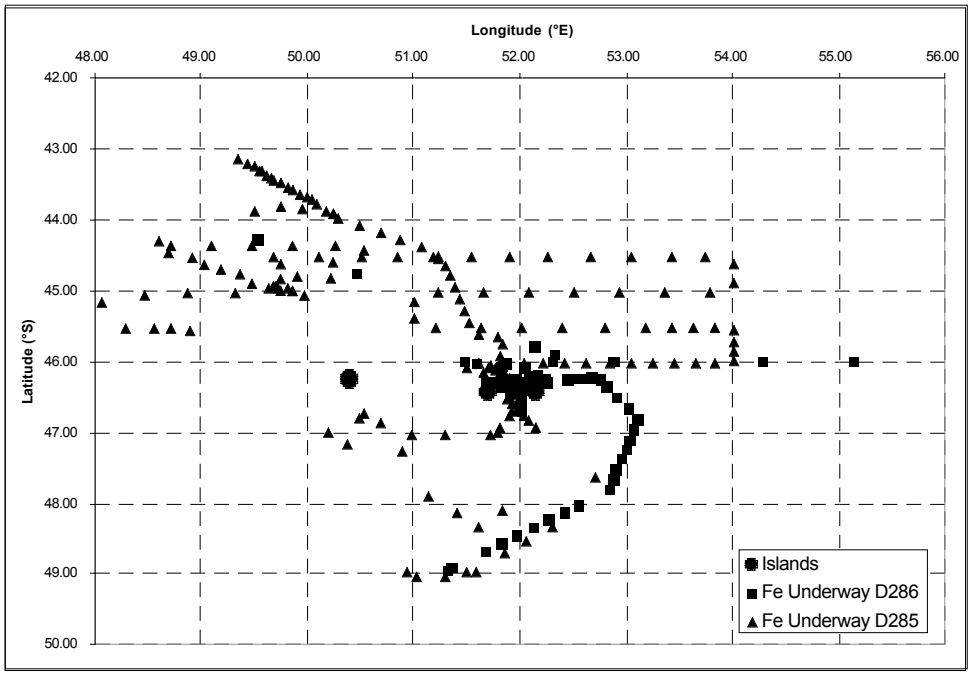


Fig. 7.2 Underway samples collected during Crozex cruises using the TMS Fish

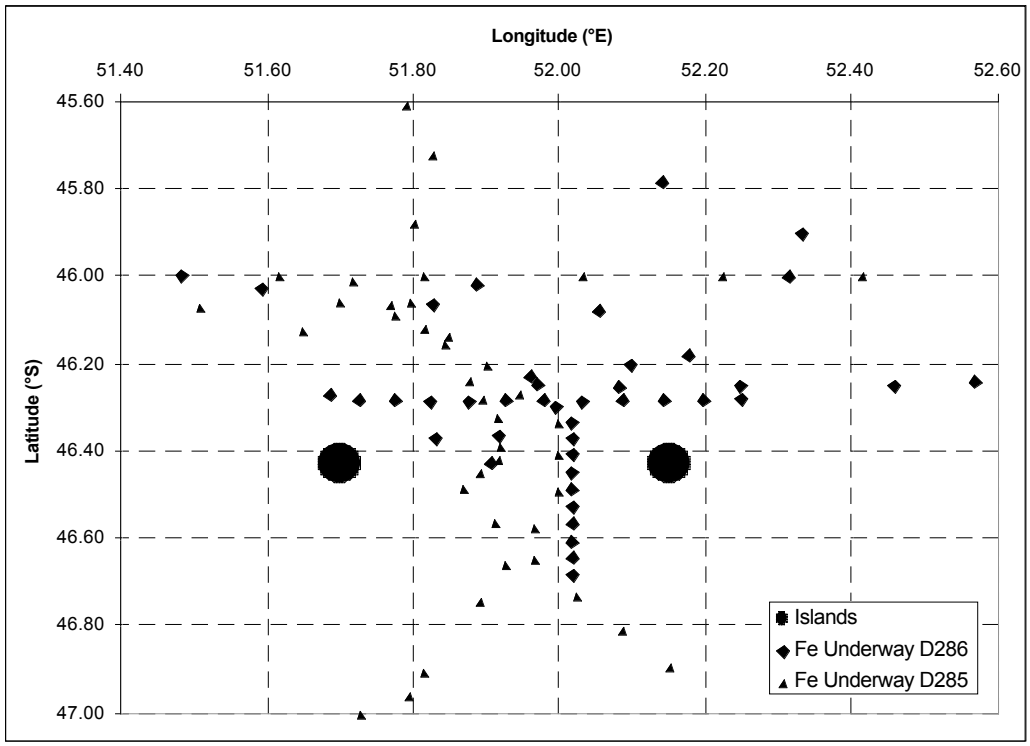


Fig. 7.3 Underway samples collected during Crozex cruises using the TMS Fish close to the Islands (Ile de La Possession and Ile de l'Est)

intended to resample on heading north between the islands later but at this time it seems the fish samples was also contaminated/non operational.

South of the islands in "HNLC" expected waters, a contamination problem was identified by the analyser (see below). It took about 3 days to resolve this problem and by this time the ship was back to the north of islands, and so there is limited data to south.

During D286 a total of 75 surface samples (Fig. 7.2) were collected during the cruise in order to improve the range of samples across the region, and to fill the gaps due to a lack of samples or contamination during D285. During D285, the samples collected on the passage between Ile de La Possession and Ile de l'Est and south of the islands shown to be contaminated. Therefore, a particular effort during D286 was made to get good samples at these locations (Fig. 7.3). Some further problems were encountered with the fish (pump). For details, see later report on that instrument.

Titanium CTD rosette system

During D285 a total of 11 Ti CTD stations were occupied (Table 7.1) and samples for dissolved iron collected. These samples were filtered through acid washed 0.2 µm polycarbonate filters housed in Teflon filtration units. Samples were collected in 1 litre and 0.5 litre trace metal cleaned LDPE bottles. Initially the samples were acidified with HCl (1ml per 1L – 6M). Analyses showed that this may have been a large contribution to the contamination. This corresponds to a total of 214 individual samples collected, and includes samples for other studies on Rare Earth Elements – REE (Section 4.7). Analysed vertical profiles follow the trends reported in the literature, although perhaps a little higher than given in some recent information, this may be however due to the problems encountered with the Fe analyser. In addition to giving Fe values for information on deep water sources, the surface data will provide information on water column Fe inventories.

Table 7.1 Titanium CTD stations occupied during D285

(Samples from stations in blue were measured on board ship. Samples in red are contaminated)

Station #	Name	Depth of cast (m)
15486	Test station	1000
15491	M1	~3100
15496	M3	2330
15502	M2	3842
15511	M6	4217
15516	M3	500
15524	M7	500
15526	M7	2722
15534	M8E	1000
15537	M8W	2770
15543	M9	2870

During D286 a total of 13 Ti CTD stations were occupied during the cruise. Samples were collected for dissolved iron (0.2 μm), Fe speciation studies and rare earth element studies. This corresponds to a total of 179 individual samples collected for dissolved iron, and includes 55 samples for speciation work (see later section). 26 samples were collected for rare earth elements (see separate section). Vertical profiles could not be analysed properly because of the failure of the analyser. All these samples were stored carefully in clean acid washed LDPE (dissolved iron) and Teflon (speciation work) bottles for analysis back to SOC. Samples for dissolved iron analysis are usually acidified prior to storage and measurements to avoid any reactions due to the biology. However, none of the samples were acidified due to too many problems of contamination by the acid itself during D285. A decision was therefore made to ship all the samples back to SOC so that they can be analysed there using several methods in order to establish accurate Fe concentrations. Dissolved iron will be analysed at SOC using the Fe analyser system of Eric Achterberg, multi-collector isotope dilution inductively coupled plasma mass spectrometry after $Mg(OH)_2$ coprecipitation and using cathodic stripping voltammetry after microwave digestion. This will enable accurate measurements to be made free of contamination worries and also it will give the opportunity to undertake a laboratory inter-comparison of Fe analytical techniques.

Table 7.2 Titanium CTD stations occupied during D286

(BUS refers to the stations done in Baie Americaine, Ile de la Possession)

Station #	Station Name	Depth of cast (m)	Sampling depths (m)
15552	M9	3200	5;15;35;75;125;200;500;1000;1500;2000; 2500;3200
15563	M10	2897	5;15;35;75;125;200;500;1000;1500;2000; 2500;2897
15567	BUS	80	5;25;50;80
15568	BUS	376	5;25;50;100;200;300;376
15569	BUS	1470	5;25;50;100;300;750;1000;1250;1470
15572	BUS	175	5;25;35;75;175
15581	M5	4220	5;40;60;100;170;300;500;1000;1250; 2500;3000;4000;4220
15592	M3	200	5;25;55;100;200
15598	M6	4168	5;10;20;40;60;80;100;160;225;400;750; 1000;1500;2000;3000;4000;4168
15605	M2	3810	10;50;100;160;300;500;750;1000;1500; 2000;3000;3500;3810
15612	M3	500	10;60;100;160;500
15622	M3	2288	5;20;80;150;300;500;750;1000;1250; 1500;2000;2288
15629	M3	500	5;8;12;20;35;55;80;100;150;300;500

Sample collected with the Pole Sampler

During D285, in order to check the surface water concentration data obtained by the fish system, a separate sample was collected using a clean bottle on the end of a pole on 29 November 2004. The concept is that the pole can be deployed away from the ship and thus the sample can be collected in un-contaminated water. However when analyzed both the fish sample taken at the same time and the pole sample appeared to be contaminated, suggesting a halo of iron contamination had developed around the vessel whilst on station. Some earlier data had also suggested the ship as a contamination source on station.

Fe Speciation Studies

Background – Although abundant in the earth's crust iron (Fe) is relatively insoluble in oxygenated sea water resulting in concentrations that are known to limit phytoplankton growth and nitrogen fixation rates over large areas of the ocean. The physicochemical speciation of Fe in seawater determines its bioavailability and the primary productivity of the phytoplankton thereby directly linking the biogeochemistry of iron and carbon (C) in the sea. Our knowledge of Fe speciation in seawater, however, is severely limited due to a lack of measurements of Fe concentrations and its degree of organic complexation in seawater. The few existing electrochemical measurements of Fe speciation demonstrate that greater than 99% of the operationally defined "dissolved" Fe that passes through a 0.4 micron filter is strongly bound to organic ligands of presumed biological origin. These ligands were thought to be of low molecular weight, slow to adsorb onto particulate surfaces and have long oceanic residence times. However, recent studies using microfiltration and low level Fe analysis by HR-ICP-MS indicate that soluble (<0.02 microns molecular diameter) Fe and organic ligand concentrations are much lower than previously determined in the "dissolved" (<0.4 micron) fraction. A significant fraction of "dissolved" Fe and Fe binding ligands may actually exist in the colloidal size range. These results suggest that "dissolved" Fe may be less bioavailable to phytoplankton than was previously thought and that colloidal aggregation may be an important Fe removal process in the ocean.

This program of research aims to investigate the distribution and importance of the soluble and dissolved Fe(III) fraction in the water column and close to the sediments of the Crozet Island region. Knowledge of the size distribution of Fe species and the strength of its organic complexes is of paramount importance in oceanography in order to incorporate Fe into biogeochemical models of the oceanic C cycle. One of the major goals is to elucidate the size fraction and binding strength of these exuded ligands which can further our knowledge as to the bioavailabilty of Fe in HNLC zones.

Methodology – Seawater was collected using the TiCTD at stations and depths of major interest (Table 7.3). After filtration through the 0.2 micron filters and collection in Teflon bottles the water was further filtered through Whatman Anodisc 0.02 micron filters using a dedicated separate Teflon filtration unit (Fig. 8). The 0.02 micron fraction was stored n 250 ml LDPE bottles for further analysis at SOC. Due to the unavailability of the CSV equipment, 19 0.2 micron fractions in Teflon bottles were frozen for subsequent analysis at SOC. Previous studies have shown that immediate freezing of the samples retains the integrity of the sample for future speciation studies.Analysis will be undertaken at SOC using the technique of CLE-ACSV

Fig. 7.4 Teflon filtration rig

(Competitive ligand exchange – adsorptive cathodic stripping voltammetry) with the added ligand TAC. Complexing capacity titrations will be undertaken on the samples to determine the Fe-TAC response over a series of increasing Fe concentrations (0.2 to 5 nM) . Total dissolved Fe in the two fractions will be measured in the laboratory at Southampton Oceanography Centre. The seawater will be subjected to UV irradiation and analysed using CSV with DHN as the added ligand. Total Fe values will also be determined using high-resolution isotope dilution inductively coupled plasma mass spectrometry after $Mg(OH)_2$ coprecipitation. After the total values have been measured the numbers combined with the complexing capacity titrations can then be used to yield the ligand concentrations, the different class of ligand, the conditional stability constants of these different ligand classes, and Fe(III)_ (soluble inorganic Fe(III) hydrolysis species).

Table 7.3 Titanium CTD stations sampled for Fe speciation studies during D286

(Frozen Teflon samples in bold, 0.02 μm samples in italics)

Station #	Station Name	Depth of cast (m)	Sampling depths (m)
15563	M10	2897	*5;15;35;75;125;200;500;1000;1500; 2000;2500;2897*
15581	M5	4220	*5;40;100;170;500;1000;1250;2500;4000;42*
15598	M6	4168	**5; 10; 20; 60;100;400;1000;2000;3000; 4000;4168**
15605	M2	3810	*10;50;100;160;500;1000;2000;3000;3500;3 0*
15622	M3	2288	***5;20;80;150;500;1000;1500;2288***

7.2 Particulate iron

Pelagra Sediment Trap Samples

An important component of the surface water mass balance of Fe is its removal through association with particles that are transported into deeper waters. A direct way to measure this flux is with sediment traps. Each Lagrangian trap can be programmed to stay at a set depth in the water column for a set period of time, and each of the 4 X 0.1 meter squared cones should in theory collect similar material. One trap cup for each deployment was designated for Fe work and did not contain any preservative. During D285 there were 6 deployments. PE1 was lost, and for PE6 no material was collected because the closing mechanism did not work correctly. For PE6, a large deposition event was intercepted. As the Fe cup was found to be empty, a sub-sample of the 2% formalin preserved sample together with a sub-sample of the formalin solution used in the trap cup, was taken and frozen for later analysis at SOC

During D286 there were 6 deployments, but only 3 were kept for iron work.

Particles and overlying solution in the cups were separated onboard the ship by filtration through pre-weighed filters (20 mL on ashed GF/F filters and 500 mL on 0.2 μm Nucleopore membrane filters). Iron in both particles and dissolved phase will be determined back at SOC. Measurement of Fe in both phases is necessary as some loss of Fe into the dissolved phase may occur during deployment. One problem noted with the trap samples was the frequent collection of paint particles with the biogenic material present. This was partly relieved by shrouding the hook

weight on the crane used during deployment and retrieval, which appeared to be an important source of these red paint particles. Black paint from the trap lifting frame was also removed at the beginning of D286 by Ian Salter. See Pelagra section for more information on the deployments.

Integrated Fe fluxes from the upper ocean using Stand Alone Pump System (SAPS)

The aim was to collect particles sinking from the biologically productive mixed layer of the water column in order to measure C and Fe export from the upper ocean. When combined with ^{234}Th:C ratio(see section in the report on ^{234}Th), an integrated flux of Fe from the upper ocean can be calculated. The depth at which the SAPS were deployed was determined on a case-by-case basis. Parameters we used to determine this depth were water temperature, fluorescence and transmission. We aimed to place the SAPS at a depth that would collect the sinking particles that were falling out of the biologically productive surface layers of the water column. Therefore, SAPS were deployed below the thermal mixed layer, ie below the chlorophyll maximum and below the point of increasing transmission corresponding to decreasing chlorophyll concentrations. We then gave ourselves around 20m margin of error below these features.

In total, 20 deployments were made at deployment depths ranging from 70 to 225m (see Tables 7.4 and 7.5). SAPS were set to pump for 90 minutes except at one station where the biomass had a high concentration and a 60 minute pump time was chosen (D285, station 15499#2) and typically filtered ~2000 litres.

Table 7.4 sampling details for SAPS during D285

Station #	Station name	Depth (m)	Volume filtered (L)
15492#2	M4-1	200	1863.9
15495#2	M3	225	1933
15499#2	M3	155	1501.8
15503#2	M2	150	2017.3
15511#1	M6	200	2052.8
15517#2	M3	200	1989.7
15524#1	M7	150	1939.6
15533#1	M8E	200	1972
15539#2	M8W	150	1842.1
15543#2	M9	120	1719.1

The filter put in the SAPS was a 52 μm nylon mesh monofilament screen chosen because particles above this size are considered to be the sinking and therefore exporting carbon. Each filter was acid washed and pre-weighted at the University of Cape Town (UCT) just before leaving on cruise D285. Immediately after recovery of the SAPS pumps, excess water in the housing was drawn off under vacuum in a flow laminar hood. The swimmers (i.e copepods, jellyfish etc) were removed and placed in vials, then the filter was immediately put in a freezer at –20°C, together with the sample of swimmers.

Table 7.5 sampling details for SAPS during D286

Station #	Station name	Depth (m)	Volume filtered (L)
15554	M9	120	1861
15560	M10	110	1817
15573/2	M3	180	1945
15580	M5	125	1001
15591	M3	100	1909
15595	M6	120	1878
15604	M2	160	1653
15613	M3	80	1492
15620	M3	80	1493
15628	M3	80	2031

Fe and C measurements on the particulate material will be carried out at SOC, and then combined with ^{234}Th:C data from samples in exactly the same way. The intention is to extend the range of elements from Fe alone and to look at series of other important elements, such as P.

As anticipated, there was a significant variability in the amount of material collected, reflecting the variable biomass at each station sampled.

To avoid any contamination while SAPS was on deck, a plastic bag was wrapped around the SAPS until deployment, and replaced immediately after recovery.

The Fe SAPS was placed above the Th SAPS to avoid contamination from the latter. A weight was placed under the two SAPS to maintain them as vertical as possible in the water column.

7.3 Shore Sampling

The major hypothesis of the Crozex programme is that phytoplankton productivity in the seas surrounding Crozet is enhanced because of natural Fe fertilisation of surface waters. Following this, a key point to ask is to identify the source of Fe. Two possibilities exist which are not mutually exclusive. One is that as deep water rises towards the surface as it flows northwards over the Crozet plateau, it brings Fe-enriched water to the surface. The other is that freshwater run-off from the islands introduces Fe and perhaps silicate and other nutrients into the near-shore surface waters. During D286, a sampling expedition was undertaken the Ile de la Possession on the 8th of January. This was to collect sediment and water samples both in fresh water areas and coastal input areas. See separate section for details and also radium section.

7.4 Report on facilities and equipment used in Fe work

Clean container laboratory

Overall the container lab worked well, and provided a high quality environment for the taxing trace metal work being undertaken in CROZEX. One problem noted was with the water sample bottle rack in the entrance area where the coating on the frame had begun to flake away and the iron

corrosion exposed become a significant contamination concern. Richie Phipps provided a bolt on plastic inset to isolate the bottles from the corrosion just at the end of D285.

Underway clean Fish sampling system

At the end of the cruise prior to D285, the fish system was in a bad state of repair. The bottom cover and weight had be lost, the original LDPE tubing had been replaced by reinforced PVC tubing taped to the exterior of the faring, and the intake tube had been broken. Richie Phipps undertook a major rebuild and rethink of the operation of the fish system. The bottom weight was replaced and a spare bottom cover fitted. A new length of LDPE tube was fitted, and crucially a line was fitted to the end of the fish and secured on the aft port quarter to prevent the fish rotating (which had apparently caused much of the damage to the original system) when on station. These modifications proved very successful and the fish proved to tow well at about 2 m depth and at about 8 m from the midships of the vessel. During D285, a series of mechanical problems were encountered with the fish operation, and then overcome:

1) The bolts holding on the end housing of the pneumatically operated pump loosened, allowing air leakage and stopping of the pump. Careful tightening solved this problem (caution needed as both parts of pump are plastic).
2) The independent compressed air supply for the fish pump failed. This turned out to be an overheating problem related to the level of the lubrication oil being too low. Once replaced, the compressor started again and once settled down performed satisfactorily.
3) The fish stopped pumping and as the compressed air supply was working the pump itself was stripped down. The problem was tracked to a stuck ball valve at the inboard side of the pump. The pump was reassembled and then functioned correctly.
4) A major problem arose when south o f the Crozet islands when the underway samples began to give very high values. The problem was identified as being two breaks in the tube system. The tube at the junction with the fish had sheared off and further up the faring the tube had parted in a second position where one of the faring location clamps had worn through the tubing. The fish faring and tubing had to be completely removed and refitted, right back to the winch. Initially there was a problem with getting the fish to self prime at this point.

However the problem was tracked to a split tube that was allowing air into the system. On refitting the tubing, the fish system worked correctly. A minor problem occurred when a length of tubing behind the Forecastle level container rubbed on a box and eventually wore through, leading to a substantial leak. This leaking section was cut out, the tube rejoined and the length of tubing running aft re-secured. A similar problem arose with the tubing on the after deck adjacent to the clean container (6 Dec 2004), where the pulsing action of the pump led to rubbing of a length of tube against the deck and eventually the wall of the tube was completely worn through and leaked. During D286, only one major mechanical problem was encountered with the fish operation. The fish stopped pumping on the night of the 11th of January. The fish was then brought back on the ship. The problem was identified as being one break in the tube system close to the fish itself. The tubing had to be completely removed and refitted. Once the tubing had been refitted, the fish system worked correctly. Overall the fish system worked well considering the frequently rough weather encountered, in providing a pulsed stream of clean water at a flow rate of about 5L/min. The efforts of the UKORS staff (Richie Phipps –D285; Ian Waddington, Emma Northrop and Alan Davies – D286) in keeping this system operational, are much appreciated.

8. Radium studies in the Crozet region

Paul Morris, Peter Statham, Ian Slater, Gary Fones

Background

In order to estimate the time since water bodies were last in contact with bottom sediments (T_w), and thus proposed benthic Fe source, we will use an approach based on the ratio of ^{223}Ra/^{228}Ra at the Crozet shelf relative to that found in a given water parcel:

$$\left[\frac{^{223}Ra}{ex^{228}Ra}\right]_{obs} = \left[\frac{^{223}Ra}{ex^{228}Ra}\right]_{i} e^{-\lambda_{223}T_w}$$

where $\left[^{223}Ra/ex^{228}Ra\right]_i$ is the activity ratio at the coastline and $\left[^{223}Ra/ex^{228}Ra\right]_{obs}$ is the activity ratio in the samples. This method is based on the decay rate of ^{223}Ra relative to ^{228}Ra, which corrects for mixing effects. Since the open ocean contains measurable activities of ^{228}Ra (but relatively little ^{223}Ra), we normalize ^{223}Ra to ex^{228}Ra which is simply the observed activity minus the oceanic end-member. Therefore measurements of natural series Radium isotopes will give information on time since water was in contact with Ra source (sediments, ground-waters, run off), and if all necessary isotopes measured also an estimate of dilution. The work is being done in collaboration with Dr Matt Charette at WHOI.

Main objectives of study

- To study Fe surface distributions in relation to radium, with Ra acting as a proxy of water that has been in contact with sediments or other Ra sources
- In a vertical profile to use Ra data as indicator of upwelled benthic waters (in contact with sediments) and to measure Fe in relation to this Ra
- To provide information on the physical turbulence and upwelling in the vertical profile

Sampling Rationale

Surface underway - Surface water Ra samples (~150-400 L) for Ra samples were originally collected using the ship's fire hose system, this approach worked well until the water tanks were switched and contamination was found in the samples. Sampling was then switched to the ships non-toxic supply (after Ra 68 onwards) and filtered through a 10 μm and 1 μm pre-filter. 200 litre barrels were filled for sampling (Fig. 1); two barrels were used when the sample was anticipated to be low in Ra. The water was also sub-sampled for ancillary measurements (i.e. salinity, nutrients). The water was then passed through MnO_2-impregnated fibres to collect the Ra isotopes. During D285, 72 surface radium samples (plus one sample for Actinium) were collected, while on D286, 38 surface samples were collected including a transect from Port Elizabeth to out past the shelf. The sampling track can be seen in Fig. 8.1, with the triangles representing D285 samples and the diamonds D286.

Specific targets for D285 were horizontal transects across clear gradients in biological activity and water types. In particular from J to M3, from M3 to M5, at M6 (as typical HNLC water with minimal Ra activity anticipated) and along the Sea-Soar transect to the north of the Crozet

plateau. Surface sampling for D286 concentrated on repeating samples to the south of the islands around M6, presumed to be HNLC and out east towards the sediment sampling site at M5. Further emphasis was placed on surface sampling a transect through the islands.

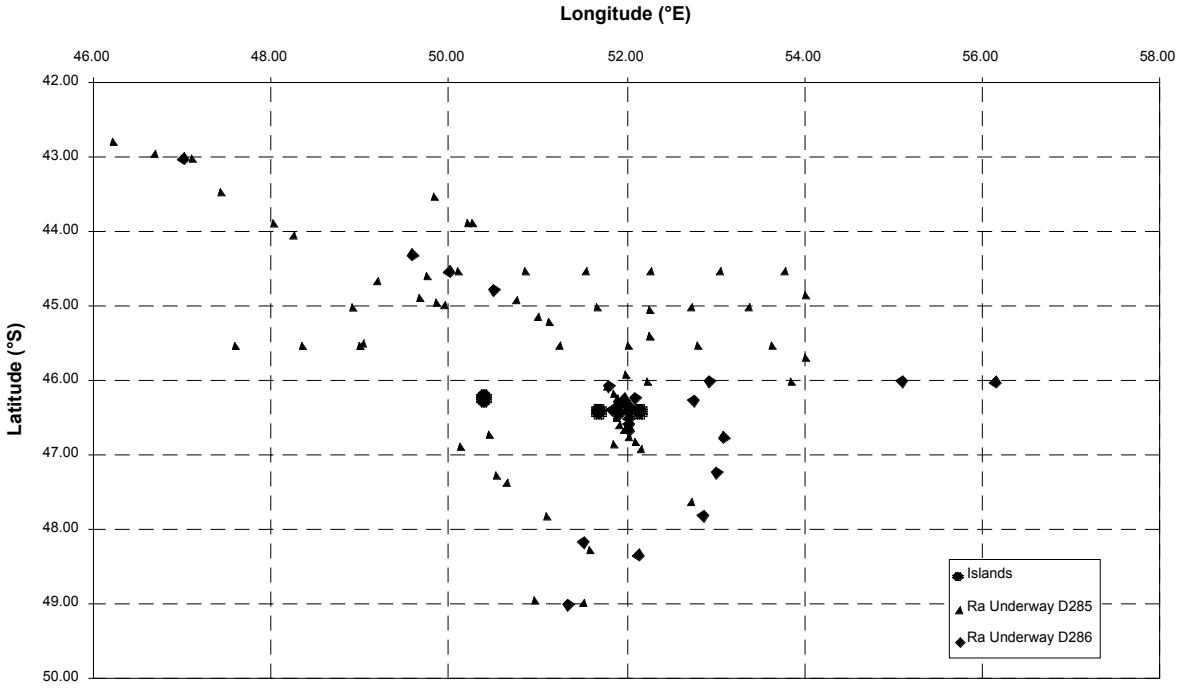


Fig. 8.1 Radium underway sampling track

Table 8.1 M3 sampling for Radium samples – 9 depths in total

Sample ID	Julian day	Date	Lat	Long	Depth (m
Ra 57	330	25/11/2004	46.073	51.766	50
Ra 134	12	12/01/2005	46.042	51.961	100
Ra 31	323	18/11/2004	46.024	51.809	150
Ra 106	358	23/12/2005	46.082	51.783	300
Ra 111	366	31/12/2005	46.062	51.777	500
Ra 9	318	13/11/2004	46.057	51.792	900
Ra 113	366	31/12/2005	46.046	51.774	1687
Ra 112	366	31/12/2005	46.045	51.775	1877
Ra 105	357	22/12/2005	46.069	51.777	1930

CTD Samples – Samples for Radium analysis were also collected opportunistically from the ThCTD casts. Major scientific rationale was to build up a profile at M3 with repeat visits over the two cruises. CTD samples were also taken at other stations at various depths to determine benthic input, the emphasis was on collecting samples at 150m. In total 21 CTD radium samples

were taken, 9 from D285 and 12 from D286. The repeat station of M3 was sampled in total 9 times to compare with the mesh bags on the M3 mooring. Table 8.1 gives the sample data for CTD radium samples for the M3 repeat station. Table 8.2 gives the data for the other CTD samples.

Sampling of the CTD involved the firing of up to 15 Niskin bottles (20 L) on the stainless steel CTD at the depth of interest. On recovery the Niskins were emptied into 25 litre carbuoys and carried round to the radium barrels and emptied. Normal Ra procedures were then undertaken including the sub-sampling of salts and nutrients along with the filtering of the sample through the MnO_2-impregnated fibres.

Table 8.2 CTD sampling for Radium samples – 12 Samples in total

Sample ID	Julian day	Date	Station ID	Lat	Long	Depth (m)
Ra 101	357	07:51:00	15566	46.370	51.827	85
Ra 46	325	20/11/2004	15503	47.796	52.855	150
Ra 65	332	27/11/2004	15523	45.506	48.986	150
Ra 69	335	30/11/2004	15533	44.950	49.961	150
Ra 78	338	03/12/2004	15542	43.117	47.185	150
Ra104	357	22/12/2004	15570	46.263	51.957	150
Ra109	362	27/12/2004	15580	45.998	56.151	150
Ra 96	355	20/12/2004	M10	44.518	49.991	150
Ra 93	354	19/12/2004	M9	42.994	47.026	150
Ra 97	356	21/12/2004	M10	44.510	49.967	900
Ra 8	316	11/11/2004	M4-1	43.927	50.257	1000
Ra 49	328	23/11/2004	M6	49.016	51.473	1000

Table 8.3 M3 physical mooring depths for Ra mesh bags sampling – 11 depths in total

Ra Array Bag No.	Depth	Date In	Time In	Date Out	Time Out
1	50	13/11/04	05.50	09/01/05	8.55
2	100	13/11/04	05.55	09/01/05	9.00
3	150	13/11/04	06.00	09/01/05	9.05
4	200	13/11/04	06.05	09/01/05	9.10
5	300	13/11/04	06.10	09/01/05	9.15
6, 7	500	13/11/04	06.40	09/01/05	13.00
8	904	13/11/04	06.55	09/01/05	13.00
9	1307	13/11/04	07.10	09/01/05	13.20
10	1687	13/11/04	07.25	09/01/05	13.35
11	1877	13/11/04	07.35	09/01/05	13.45
12	1930	13/11/04	07.45	09/01/05	13.45

M3 Mooring – Mesh bags containing MnO_2-impregnated fibres were attached at different depths on the physical instrument mooring at M3 which was deployed during D285. The mooring was deployed on November 13th 2004 (JDay 318) and recovered on January 9th 2005 (JDay 9). The isotope ratio information obtained should give data on age of water since in contact with sediments.

Crozet Island sampling – Three samples were also taken during a field expedition to sample on the Crozex Islands. Sampling took place on Ile de la Possession on January 8th 2005. Samples were taken at a fresh water source (Fig. 3), in the surf zone and a few hundred meters offshore from a RIB, as well as a sample taken on board using the non-toxic. The fresh water sample was filtered at the sampling site at the Baie du Sphynx (Fig. 4). This transect will hopefully give a better indication of Ra input and dilution and thus potential Fe input from Crozet to surrounding waters.

Fig. 8.2 Field sampling for Radium

Fig. 8.3 Field filtration for Radium

Table 8.4 Sampling locations for Crozet Island Ra sampling

Sample ID	Date	Julian Day	Location	Lat	Long
Ra 131	08/01/05	8	Baie du Sphynx	46.414	51.866
Ra 132	08/01/05	8	Port Alfred	46.426	51.862
Ra 134	08/01/05	8	Mid-way	46.427	51.868
Ra 130	08/01/05	8	Discovery	46.425	51.906

Radium analysis

On-board ship – Because of the short half lives of Ra 223 and Ra 224 (^{224}Ra–$t_{1/2}$ = 3.66 days, and ^{223}Ra–$t_{1/2}$ = 11.4 days), it is essential to measure their activity on the ship. Four delayed coincidence alpha counting systems (Fig. 8.4) were provided by WHOI, for determination of gaseous Rn daughters of the Ra isotopes of interest, this allowed location of radium gradients in near real-time and subsequent adjustment of the sampling plan. Samples were rinsed four times with Ra-free Q-water and then dried using compressed air. The detectors were run for three hours or until the Radon^{219} counts reached 100. After two weeks the samples were then run for a second time for quantifying the supported activities of ^{223}Ra and ^{224}Ra from their parent radio-nuclides ^{227}Th and ^{228}Th.

At WHOI – In collaboration with Dr Matt Charette at Woods Hole Oceanographic Institution, USA, Radium isotopes will be counted non-destructively using gamma spectrometers and alpha scintillation techniques at WHOI during the summer of 2005. Samples that have not all ready been counted a second time will be analysed at WHOI for ^{223}Ra and ^{224}Ra, The Mn-fibres will then be ashed and ^{226}Ra and ^{228}Ra (^{226}Ra–$t_{1/2}$ = 1600 years, ^{228}Ra–$t_{1/2}$ = 5.75 years) counted on a well-type germanium gamma spectrometer.

Fig. 8.4 Delayed Incidence Counters on board

Data quality and provisional results

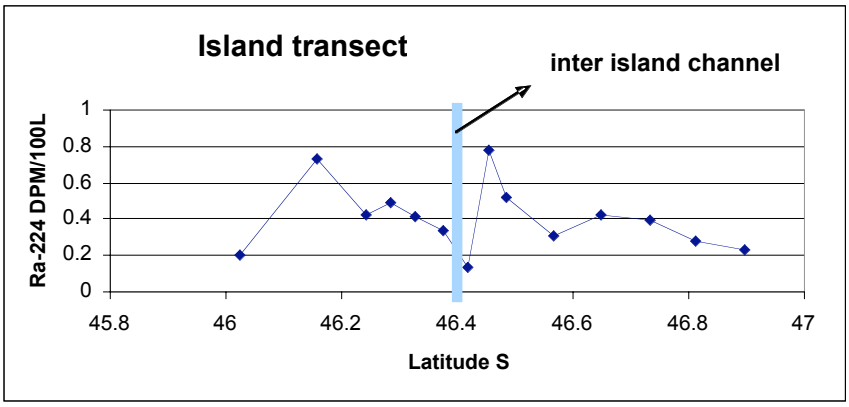


Fig8.5 Ra-224 activity along the N-S transect between the main Crozet islands

Data quality – Problems were encountered with the ships fire hose system and certain samples were contaminated. These were mainly to the south of the islands during D285, after switching to the ships non-toxic supply no further contamination was noted. These samples will be checked and rejected for the final work undertaken at WHOI. All samples from D285 were measured twice on board ship along with all the samples from D286 being measured once. The priority is for the equipment and samples to be air freighted back to WHOI so the second counts can be undertaken on the remaining D286 samples. Subsequently samples will be prioritized for the ^{226}Ra and ^{228}Ra analysis at WHOI.

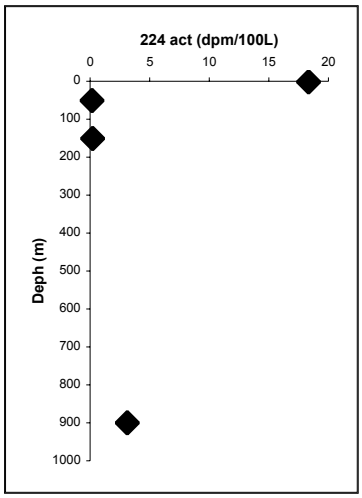


Fig. 8.6 Provisional 224 act plot for M3

Provisional results – Age models require a good end-member, source 224/223 ratio, and as this had not been determined at the end of leg 1, corrected Ra-224 counts are plotted in Fig. 8.5 showing data on the transect between the main islands on the Crozet plateau (Ile de la Possession and Ile de l'Est).

Higher activities are evident around the islands but a clear trend is not evident with distance inferring multiple sources and complex mixing in this zone. A provisional data plot for CTD radium samples from M3 indicate a high surface Radium224 signal potentially meaning a relatively new source of water recently in contact with sediment or rock. Interestingly at 900m there is also a signal indicating a potential benthic or deep source of radium.

9. ^{234}Thorium and Stand Alone Pumps (SAPS)

9.1 ^{234}Th on D285 — Paul Morris

Objective: To measure total (dissolved and particulate) thorium-234 as a proxy measurement of carbon export.

All major process stations were sampled: 15492 (M1), 15495 (M3), 15498 (M3), 15503 (M2), 15512 (M6), 15517 (M3), 15523 (M7), 15533 (M8E), 15539 (M8W), 15542 (M9). Also sampled the shake down station 15487 and station 15548.

Sample volume 10 litres.

Profiles from all major stations had 10 sampling depths with higher resolution in the top 200m and lower resolution down to ~500m.

When the thorium cast was considered to be significantly separated in time or space (or both) from the standard sCTD samples were also collected for POC/N and chlorophyll.

Salts also taken from Niskins allocated for thorium so that a value for uranium concentration can be derived.

A double precipitation was carried out on samples collected from station 15542 to estimate the extraction efficiency. This entails collecting the filtrate from the first precipitation and re-precipitating the filtrate to see if anymore ^{234}Th can be extracted.

Samples from station 15548 were all collected from 1000m to estimate the precision on the method.

Volume of seawater filtered: 1240 litres (1.24 metric tons)

Problems/Suggestions/Comments

When initially decanting concentrated ammonia in the fume hood it quickly became apparent that the filters in the fume hood were not suitable for ammonia. Stunk out the labs!! Risk assessment amended to dispense ammonia in a well ventilated space eg in the hanger. Solution: have filters that are capable of handling ammonia.

Originally we tried to collect the ^{234}Th samples from the main core sCTD at the shake down station (15492) but the water budget proved too tight, therefore it was decided to have a separate thorium cast. Only way to combine the thorium and sCTD casts would be to either have larger Niskins (if they do them) or sample fewer depths.

Having an extra cast for thorium allowed other parameters to gain opportunistic volumes of water, namely radium, which required high volumes of deep water. See radium cruise report for further details.

Claudia also took some samples from 20-40m. CO_2 samples taken at station 15495 and O_2 and CO_2 on station 15539.

Two ^{234}Th samples only totalled 5 litres in volume due to leaking Niskins.

Filtration procedure is very time consuming because only one sample can be filtered at a time, ~8h to filter 10 samples. The method could very easily be scaled up to process multiple samples at once.

9.2 ^{234}Th on D286 — Sandy Thomalla

Objective: to measure Carbon and Nitrogen export from ^{234}Thorium and ^{238}U disequilibria

Biological activity in surface waters drives the oceanic particle cycle, which in turn controls the scavenging of trace metals and sedimentation to the sea floor. Carbon fixation and carbon export is central to understanding oceanic productivity, and its long-term effect on atmospheric CO_2 concentration. The particle-reactive radioisotope ^{234}Th (half life 24.1 days) is often in disequilibrium with its parent nuclide ^{238}U in surface ocean waters. This occurs because ^{234}Th but not ^{238}U partitions strongly onto particle surfaces and its removal on the sinking flux of material leads to radioactive disequilibrium. Consequently ^{234}Th/^{238}U disequilibrium is potentially a powerful tool to study the downward flux of carbon in the ocean via sinking particles.

Knowledge of the integrated disequilibrium in the water column combined with a steady-state assumption and with the decay constant of ^{234}Th yields an estimate for the flux of ^{234}Th from the surface ocean caused by settling particles. To calculate the POC flux from the surface ocean, the ratio of POC to ^{234}Th on sinking particles is multiplied by the estimated ^{234}Th flux.

Methods

Samples for thorium analysis were collected from the stainless steel CTD at various stations (see Table1 for station positions). Ten litre water samples were collected from ten depths to 500m. The sampling distribution is concentrated in the surface 300m where a significant export of thorium on settling particles is expected to result in radioactive disequilibrium between thorium and uranium. The samples collected at 500m represent radioactive equilibrium between ^{234}Th and ^{238}U.

Total uranium is calculated from salinity and does not have to be measured independently.

Total ^{234}Th is measured by adding potassium permanganate ($KMnO_6$), manganese dichloride ($MnCl_2$), and concentrated ammonia (NH_3) to the 10 litre water sample. Dissolved and particulate ^{234}Th is precipitated from the water as MnO_2 precipitate within 8 hours. This precipitate is filtered onto 142mm 0.8µm polycarbonate filters which are then folded in a reproducible way, wrapped in mylar foil and counted directly in a beta counter. Appropriate corrections are made for self-absorption of radiation due to the filter and for detector efficiencies <100%, and corrections for ^{234}Th decay and ^{234}Th in growth from ^{238}U decay since sampling.

The extraction efficiency of the precipitate as well as the precision and reproducibility of the method were tested at station 15632 where nine of the Niskin bottles allocated to thorium were fired at 1000m. Accuracy may be assessed by comparing the determined activity of total ^{234}Th with the ^{238}U activity at 1000m. Following the filtration of the precipitate, the filtered sea water is collected and the precipitation process is repeated to test whether all the thorium was removed from the sample by the first precipitate and hence determine the extraction efficiency of the precipitate.

At each of the thorium depths samples for particulate organic carbon (POC) and particulate organic nitrogen (PON) were filtered onto ashed GFF filters. Filters are stored frozen at -20°C for future analysis at the Southampton Oceanography Centre. These samples were collected in particular to determine how the ratio of total POC and PON to ^{234}Th changed through the water column.

The large particulate thorium fraction >50µm was sampled by deploying in-situ Stand Alone Pumps (SAP) at the bottom of the export layer. A 293mm 50µm nylon mesh was inserted into the filter holder of the SAP which was set to pump for 90 minutes. Once the SAP pumps are back on board the 60µm mesh is removed and rinsed with 1 litre of filtered thorium free sea water. The SAP sample is then split using a Fulsam sample splitter. 6/8^{ths} of the sample is filtered onto 142mm 0.8µm polycarbonate filter for ^{234}Thorium. 1/16th of the sample is filtered onto a pre weighed GFF filter for POC and PON analysis. 1/16th is filtered onto a 20um polycarbonate filter for Biogenic Silica. 1/6th is stored in Lugols and Formalin for microscopy. 3x 5ml of 1/16th is filtered for Chlorophyll and the remainder of the 1/16th split is filtered for HPLC pigment analysis.

Table 9.1 Thorium station positions on D286

Station Number	Station Identifier	Date	Latitude	Longitude	SAPS Number	SAPS Depth
15554	M9	19/12/04	42^0 59.80' S	47^0 01.26 E	11	120m
15560	M10	20/12/04	44^0 31.09' S	49^0 59.51' E	12	110m
15574	M3	23/12/04	46^0 04.84' S	51^0 46.96' E	13	180m
15580	M5	27/12/04	45^0 59.88' S	56^0 09.10' E	15	125m
15590	M3	31/12/04	46^0 03.74' S	51^0 46.63' E	16	100m
15595	M6	03/01/05	48^0 59.93' S	51^0 32.27' E	17	120m
15603	M2	06/01/05	47^0 47.57' S	52^0 51.05' E	19	160m
15613	M3	09/01/05	46^0 08.33' S	51^0 51.25' E	20	80m
15620	M3	10/01/05	46^0 01.56' S	51^0 52.11' E	21	80m
15627	M3	12/01/05	46^0 02.31' S	51^0 57.44' E	23	80m
15632	M10	15/01/05	44^0 30.09' S	49^0 59.07' E	-	-

9.3 SAPS (Stand Alone Pump System) Hélène Planquette, Paul Morris

Objective: to collect the particles that are sinking from the biologically productive mixed layer of the water column, in order to measure C and Fe export from the upper ocean.

The depth the SAPS were deployed at was determined on a case by case basis. Parameters we used to determine this depth were water temperature, fluorescence and transmission. We aimed to put the SAPS at a depth that would collect the sinking particles that were falling out of the biologically productive surface layers of the water column. So the SAPS were deployed below the thermal mixed layer, below the bulk of the chlorophyll and below where the transmission starts to increase, and gave ourselves about a 20m margin of error below these features.

Approximate depth of deployment ranged from 150-225m. (Tables 9.2 and 9.3)

SAPS were set to pump for 90 mins and typically filtered ~2000 litres, except at one station where the biomass had a high concentration and a 60 minute pump time was chosen.

10 deployments in total.

Total approximate volume of water filtered was 20,000 litres per SAPS

^{234}Thorium

Aim: In order to convert a ^{234}Th number into a carbon number, and hence the downward flux of carbon, it is necessary to measure the particulate carbon to particulate thorium ratio – C:Th. This is the prime purpose of the thorium SAPS.

Each time a thorium profile was taken, the SAPS were deployed

The filter we put in the SAPS was 52μm nylon monofilament screen. 52μm was chosen because particles above this size are considered to be the sinking (and therefore exporting) particles.

Particles collected were split for ^{234}Th, POC/N, biogenic silica and chlorophyll.

Problems/suggestions

Frequently saw flecks of yellow paint in the sample, from the yellow painted shackles. Solution: stripped paint off shackles but ultimately use stainless shackles.

^{234}Th SAPS 2 – frit and mesh not loaded in the correct orientation into the filter housing. Therefore the sample volume will not be reliable, but a sample was still taken. Suggested action: request a split from the iron SAPS for POC/N analysis and then back calculate a volume filtered for the thorium SAPS.

Iron

Aim: is to collect particles at the base of the mixed layer in order to measure Fe and C export then combine with Th:C (see above) to get an integrated flux of Fe from the upper ocean.

The filter we put in the SAPS was also a 52_m nylon mesh. Each of them has been pre-acid washed and pre-weighted at the University of Cape Town just before leaving on the cruise.

Immediately after collection, the excess of water in the housing was drawn off under vacuum in a flow laminar hood. The swimmers (copepods, jellyfish…) were taken out and placed in vials, then the filter was immediately put in a freezer at –20°C, together with the swimmers sample.

Fe and C measurements will be done at SOC, and then combined with Th:C data from samples in exactly the same way. The intention is to extend the range of elements from Fe alone and to look at series of other important elements, like P.

As anticipated, there were significant variations in amount of material collected reflecting the ambient biomass at each station sampled.

Table 9.2 SAPS deployments on D285

					234-Thorium	Iron
Station #	Station name	Day	Depth(m)	Pumping Time (hrs)	Volume Filtered (L)	Volume Filtered (L)
15492	M1	09/11/200	200	1H30min	1980.1	1863.9
15495	M3	13/11/200	225	1H30 min	2048.6	1933.8
15498	M3	18/11/200	200	1H	1494.2	1501.8
15503	M2	19/11/200	150	1H30 min	2085.1	2016.8
15512	M6	22/11/200	175	1H30 min	2117.5	2052.8
15517	M3	25/11/200	200	1H30 min	2094.5	1989.7
15523	M7	27/11/200	150	1H30 min	2039.8	1939.6
15533	M8E	30/11/200	150	1H30 min	2059.6	1972
15539	M8W	02/12/200	150	1H30 min	2006.9	1842.1
15542	M9	09/11/200	120	1H30 min	2015.4	1719.1

Table 9.3 SAPS deployments on D286

					234-Thorium	Iron
Station #	Station name	Day	Depth(m)	Pumping Time (hrs)	Volume Filtered (L)	Volume Filtered (L)
15554	M9	19/12/2004	120	1H30 min	2071.8	1851.5
15560	M10	20/12/2004	110	1H30 min	2016.0	1817.0
15573	M3	23/12/2004	180	1H30 min	2068.0	1845.0
15580	M5	27/12/2004	125	1H30 min	1310.0	1001.0
15590	M3	31/12/2004	100	1H30 min	1859.0	1909.0
15595	M6	03/01/2005	120	1H30 min	1802.0	1878.0
15604	M2	06/01/2005	160	1H30 min	1933.0	1653.0
15613	M3	09/01/2005	80	1H30 min	1627.5	1492.0
15621	M3	10/01/2005	80	1H30 min	1571.2	1492.3
15627	M3	12/01/2005	80	1H30 min	1758.9	2031.3

Problems/suggestions

To avoid any contamination while SAPS was on deck, a plastic bag was wrapped around the SAPS until deployment, and replaced immediately after recovery.

The Fe SAPS was placed above the Th SAPS to avoid contamination.

A weight was placed under the two SAPS to maintain them as vertical as possible in the water column.

9.4 SAPS for 'Proxy Calibration' Study — Hélène Planquette

SAPS were also used to collect particulate material from the upper water column for Dr. Rachel Mills (NOC) and Dr. Richard Pancost (University of Bristol) as a part of their proxy calibration study. The aim was therefore to collect particles at the depth of the chlorophyll maximum. The depth at which the SAPS were deployed was determined on a case-by-case basis. Parameters we used to determine this depth were water temperature, fluorescence and transmission. In total, 3 deployments were made during D286 at deployment depths ranging from 70 to 225m (see Table 9.4). SAPS were set to pump for 60 minutes and typically filtered ~500 litres.

Table 9.4 SAPS for proxy calibration, blue (Pancost), yellow (Mills)

Station #	Date (Julian day)	Name	Depth (m)	Volume filtered (L)
	361	M5	70	531
15579	361	M5	70	535
	4	M6	70	440
15598	4	M6	70	673
	11	M3	20	333
15620	11	M3	20	725

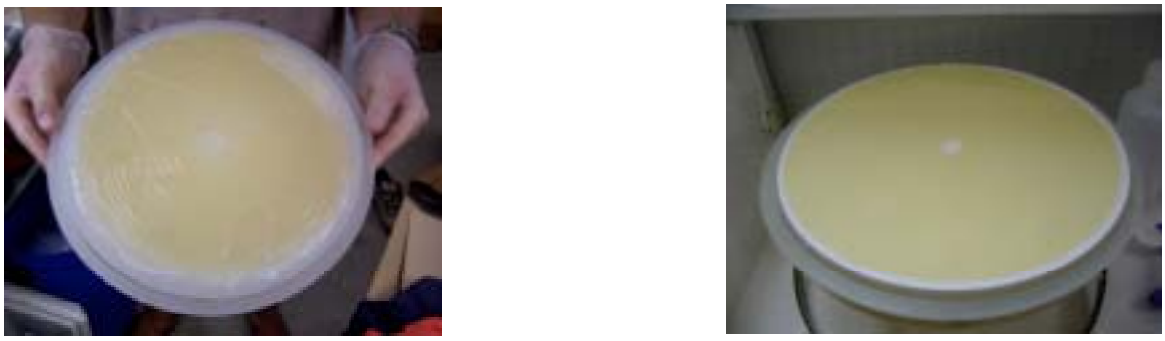


Fig. 9.1 SAPS filters from M3 15620 left: Nucleopore filter, right: GF/F filter

The SAPS filter for Pancost consisted of two 293 μm diameter ashed GF/F filters, foiled in pairs. Two stacked GF/F filters were used to give greater structural strength to the filters and represent a nominal pore-size of 0.7 μm. They were placed carefully with tweezers rinsed in methanol. SAPS filters for Mills were 1 μm Nucleopore filters, placed in the SAPS filter holder under a laminar flow hood. Immediately after recovery of the SAPS pumps, excess water in the housing was drawn off under vacuum in laminar a flow hood. The filters for Mills were immediately rinsed with MQ water to remove the sea-salts. Filters were stored in a –20°C freezer. They will be air-freighted back to University of Bristol and SOC.

As anticipated, there was a significant variability in the amount of material collected, reflecting the variable biomass at each station sampled.

The Nucleopore filters proved to be very difficult to handle, especially in a laminar flow hood, and were often found dislodged after filtration. It is recommended that during any future deployments the Nucleopore filters are supported on a matrix such as Nitex screen.

10. Microbial abundance and dynamics

Mike Zubkov, Ross Holland

Aim: To compare abundance and organic nutrient uptake by dominant microbial groups in planktonic communities around the Crozet Islands.

Objectives

1) To determine the vertical distribution, abundance and flow cytometrically resolved community structure of nano- (2 – 20 μm) and pico- (0.2 – 2 μm) plankton in the top 200 m using flow cytometry;

2) To estimate the microbial turnover rates of common dissolved organic nutrients, to assess microbial competition and to relate the latter with community composition.

3) To collect samples for analyses of bacterioplankton community composition using molecular approach including fluorescence in situ hybridisation.

4) Underway sampling from the uncontaminated seawater supply: a) To assess microbial spatial variability at ten km scale; b) To test the capability of the CytoSense flow cytometer for automated underway analysis and to determine the distribution, abundance and community structure of phytoplankton (approx. 3 – 200 μm) in surface waters;

Phytoplankton concentration in the studied area varied between 2 to 10×10^3 cells ml^{-1} in surface waters, and bacterioplankton concentration varied about 20 fold, from $<100\times10^3$ cells ml^{-1} at 200m depth to 2×10^9 cells ml^{-1} in the surface waters (see Appendix at the end for examples of vertical distribution). Also a wide range of rates of microbial activity was observed. Flow sorting and scintillation counting were done on board the ship but the detailed analysis of the data will be done back in the UK. The molecular analysis will be also done after the cruise. When completed the data set will allow estimation of the rates of microbial nutrient uptake as well as linkage between microbial function, composition and hydrological structure of the water column.

Methods

Seawater samples were collected and analysed for determination of microbial concentration, biomass and composition. Fresh seawater samples were collected in acid washed 50 mL polypropylene tubes from a CTD system containing 24 x 20 L Niskin bottles. Samples were stored in a refrigerator and microorganisms were preserved with paraformaldehyde (1% final concentration) within 1-2 hours of collection. Phytoplankton samples were analysed unstained and bacterioplankton samples were stained with SYBR Green I nucleic acid dye. The bacterial samples were then left in the dark at 35°C for at least 1 hour before enumeration of bacterioplankton by a flow cytometer (FACSort BD). Table 10.1 summarises the CTD casts sampled and analysed during cruise D285. Samples

were also collected for later molecular identification of microorganisms. To correlate with high-resolution underway analyses samples were collected from the Ti-CTD casts at 5 m depth to determine microbial nutrient uptake and turnover rates by incubating samples with isotopically labelled precursor molecules: ^{3}H-leucine, ^{35}S-methionine, ^{3}H-glucose (Table 10.2).

Underway samples (Table 10.3) for analysis by FACSort were drawn and preserved with 1% paraformaldehyde automatically from the ships underway supply system by a Tecan Miniprep 60 robot. Samples for analysis by Cytosense flow cytometer were taken automatically by the instrument from the ships underway supply system.

10.1 CTD Sampling

A list of CTD's sampled is provided below for cruises D285 and D286 in tabular form, along with total numbers of bacterioplankton and phytoplankton cells recorded. Data for total numbers of individuals within different populations have also been recorded. After station 15496, it was decided that samples should not be taken from depths greater than 200m, owing to low phytoplankton and bacterioplankton abundance at greater depths. Alterations in bottle firing sequence however denoted that some stations had to be sampled to a depth of 250m, in order to obtain data for depths greater than 175m. No data were recorded for Bacterioplankton at station 15496 due to an error in the preservation / SYBR Green staining procedure. Samples were not analysed from Niskin bottles 17 and 18 (150 and 125 m) at station 15513 as the bottles misfired. Niskin bottles 17 at station 15553, 20 at station 15584 and 20 at station 15587 were not sampled, as they were observed to be leaking.

10.2 Underway sampling

Underway Sampling on D285

FACSort underway sampling began before Station J, at 14:30 on day 314 (09/11/04). Continuous Cytosense sampling began at Station J, at 11:15 on day 316 (11/11/04). Underway samples were drawn continuously throughout the survey and the results of sampling were related to ships navigational data in order to compare large-scale variation in community structure whilst steaming, to small-scale variation whilst on station. Variations in sampling frequency, with reasons for alteration are outlined below.

As Cytosense sampling is automated and not labour intensive, regular sampling is possible. Cytosense sampling frequency was altered from 15 minutes to 10 minutes at 18:00 on day 321. The decision was made in order to increase the resolution of the survey to coincide with the SeaSoar survey. Such frequent sampling had not been undertaken previously owing to concerns about the stability of the laser under conditions of such regular use. As the instrument suffered no ill effects during increased sampling, at the end of the first Sea Soar survey it was decided not to revert to the original 15 minute sampling interval.

The FACSort autoloader equipment was not used during D285 or D286 in order to allow a greater volume of water to be analysed per phytoplankton sample, facilitated by an external syringe pump. As the manual analysis of FACSort samples is more labour intensive than Cytosense, an initial half hourly sampling frequency was selected for this instrument. A change in frequency to hourly sampling at 05:00 on day 317 occurred in

order to accommodate time for shipboard data analysis. Sampling was again increased to half hourly intervals, at the expense of data analysis time throughout the period of the first Sea Soar survey, commencing at 18:30 on day 320, and returning to hourly sampling at 18:00 on day 325. The final half hourly sampling period (19:30, day 335 until 19:00 day 336,) was undertaken during a sea soar survey, and was possible owing to a decrease in CTD sampling.

Underway Sampling on D286

Hourly sampling for FACSort analysis (Table 10.4) began before Station J, at 09:00 on day 349 (2004) and was continued throughout the cruise. Sampling was discontinued after leaving the area of study on day 016 (2005) due to a recurrent sampling error caused by stormy seas.

Cytosense sampling at 10 minute intervals began at 07:30 on day 349 (2004), and continued until 07:30 on day 018 (2005).

Table 10.4 Underway sampling (D285)

	FACSort	Cytosense
JULIAN DAY	Sampling Interva	Sampling Interva
314	30 minutes	
315	_	
316	_	15 minutes
317	60 minutes	_
318	_	_
319	_	_
320	30 minutes	_
321	_	10 minutes
322	_	_
323	_	_
324	_	_
325	60 minutes	_
326	_	_
327	_	_
328	_	_
329	_	_
330	_	_
331	_	_
332	_	_
333	_	_
334	_	_
335	30 minutes	_
336	60 minutes	_
337	_	_
338	_	_
339	_	_
340		

Table 10.1 CTD casts sampled for determination of microbial concentrations (D285)

Station number	Sample number	Location	Depth, m	Bacterioplankton, cells ml^{-1}	Phytoplankton, cells ml^{-1}
15496	49610	M3	175	-	1263.5
15496	49611	M3	150	-	1253.9
15496	49612	M3	100	-	3585.4
15496	49613	M3	63	-	3101.5
15496	49615	M3	42	-	3889.3
15496	49617	M3	27	-	3996.2
15496	49619	M3	15	-	3080.1
15496	49621	M3	10	-	3859.0
15500	50015		200	322421.9	817.2
15500	50016		150	390015.8	1349.0
15500	50017		100	650081.1	8301.5
15500	50018		80	711117.5	8973.4
15500	50019		60	707967.9	9337.8
15500	50020		40	701561.7	9869.6
15500	50021		20	725162.7	9866.6
15500	50022		10	685432.7	9418.2
15500	50023		5	664125.0	9797.3
15504	50415	M2	250	174159.6	151.2
15504	50417	M2	150	269463.2	338.5
15504	50418	M2	125	309019.4	585.6
15504	50419	M2	100	524356.2	4287.6
15504	50420	M2	80	586166.5	6538.6
15504	50421	M2	60	548153.6	7551.3
15504	50423	M2	10	485080.3	7108.8
15504	50424	M2	5	471555.9	6110.8
15506	50615		250	206309.7	76.0
15506	50616		175	290862.5	442.5
15506	50617		150	381075.0	1016.4
15506	50618		125	504856.2	2611.0
15506	50619		100	567639.6	4463.8
15506	50620		80	604824.8	6400.7
15506	50621		60	593926.7	10243.5
15506	50622		40	573268.5	10209.6
15506	50623		10	515849.9	7996.1
15507	50715	M6	250	338130.6	3212.9
15507	50716	M6	175	266545.5	630.6
15507	50717	M6	150	332052.9	1200.8
15507	50718	M6	125	423793.4	3770.5
15507	50719	M6	100	460979.5	6037.1
15507	50720	M6	80	448410.1	6979.7
15507	50721	M6	60	454198.1	7824.2
15507	50722	M6	40	444712.7	7723.9
15507	50723	M6	10	453311.3	7836.8
15507	50724	M6	5	429412.2	8069.9
15513	51315		250	202217.1	31.7
15513	51316		175	250051.8	147.5
15513	51319		100	514558.9	1290.8
15513	51320		80	703077.9	6728.2
15513	51321		60	734112.0	9736.8
15513	51322		40	693734.5	10438.2
15513	51323		10	679751.6	10341.6
15513	51324		5	689808.6	10034.8
15518	51814	M3	175	415742.9	841.6
15518	51815	M3	150	465082.6	1034.1
15518	51816	M3	125	609469.7	1579.9
15518	51817	M3	100	806595.3	3134.7
15518	51818	M3	80	783775.3	3676.8
15518	51819	M3	60	869325.9	7706.2
15518	51820	M3	40	958844.0	13072.1
15518	51822	M3	20	861064.9	12937.2
15518	51823	M3	10	905178.4	13550.8
15518	51824	M3	5	862545.5	13053.7
15520	52014		200	133859.5	-
15520	52015		150	274151.5	392.4
15520	52016		100	311132.6	183.7
15520	52017		80	513702.6	455.8
15520	52018		60	939997.3	5981.0
15520	52019		40	1069343.6	10877.8
15520	52021		20	1043742.5	11057.1
15520	52022		10	1067890.0	10245.7
15520	52023		5	1084795.7	8167.2
15525	52513		200	229002.7	132.8
15525	52514		175	223623.6	126.1
15525	52515		150	221577.1	159.3
15525	52516		125	282176.8	165.2
15525	52517		100	306762.6	242.7
15525	52518		80	390308.2	465.4
15525	52519		60	886959.8	1058.4
15525	52520		40	984991.9	4367.2
15525	52522		20	1003248.5	3530.1
15525	52523		10	1017862.0	3949.7
15525	52524		5	1010067.2	4165.9
15527	52713		200	238569.5	218.3
15527	52714		175	239174.0	255.2
15527	52715		150	276214.2	216.1
15527	52716		125	300107.4	238.2
15527	52717		100	403577.9	579.7
15527	52718		80	703867.9	1504.7
15527	52719		60	757836.9	2730.5
15527	52720		40	838048.8	9126.1
15527	52722		20	833545.9	10306.9
15527	52723		10	805022.3	9479.4
15527	52724		5	907870.2	9385.7
15528	528013		200	194140.9	103.3

15528	528014		175	203425.0	125.4
15528	528015		150	199341.5	184.4
15528	528016		125	239333.8	354.8
15528	528017		100	444496.9	1419.1
15528	528018		80	517133.6	3437.9
15528	528019		60	537803.8	7740.9
15528	528020		40	513439.0	9212.4
15528	528022		20	529401.0	9199.1
15528	528023		10	500341.2	9365.8
15528	528024		5	550373.6	9348.1
15532	532013	M8E	200	272612.8	90.7
15532	532014	M8E	175	267731.6	115.8
15532	532015	M8E	150	317977.6	180.7
15532	532016	M8E	125	398742.2	384.3
15532	532017	M8E	100	445880.1	648.3
15532	532018	M8E	80	908040.4	9960.3
15532	532019	M8E	60	1303883.7	13131.9
15532	532020	M8E	40	1091786.3	15135.9
15532	532022	M8E	20	1002901.3	19192.6
15532	532023	M8E	10	935027.9	20568.9
15532	532024	M8E	5	907804.5	20854.3
15539	53903	M8W	200	250263.615	199.1465603
15539	53905	M8W	175	320236.686	196.1962409
15539	53907	M8W	150	380371.429	242.6637717
15539	53910	M8W	125	440864.458	469.8383664
15539	53912	M8W	100	642734.043	598.9148407
15539	53913	M8W	80	656034.173	943.3646321
15539	53915	M8W	60	968269.494	2400.084842
15539	53917	M8W	40	930684.34	2286.497545
15539	53920	M8W	20	798626.374	6144.040176
15539	53922	M8W	10	790073.703	4640.114856
15540	54003	M8W	200	297493.348	387.9670027
15540	54005	M8W	175	306407.388	268.4790665
15540	54007	M8W	150	336406.883	380.5912042
15540	54009	M8W	125	451605.456	678.5734648
15540	54011	M8W	100	532140.575	814.2881578
15540	54013	M8W	80	677824.17	1005.32134
15540	54015	M8W	60	896258.152	2400.084842
15540	54017	M8W	40	787162.442	3554.397312
15540	54020	M8W	20	781771.654	3294.769204
15540	54022	M8W	10	815338.583	4151.836993
15544	54413	M9	200	212699.443	267.7414867
15544	54414	M9	175	479114.286	3578.737447
15544	54415	M9	150	216193.439	469.1007866
15544	54416	M9	125	263454.545	673.4104059
15544	54417	M9	100	330008.451	1862.389129
15544	54418	M9	80	479941.292	2593.330763
15544	54419	M9	60	768498.516	8476.267672
15544	54420	M9	40	560503.125	9379.802992
15544	54422	M9	20	577814.371	6506.191884
15544	54423	M9	10	490977.509	3628.155297
15544	54424	M9	5	542333.966	6938.413678
15546	54616		200	181704	276.5924449
15546	54617		150	202428.872	342.2370518
15546	54618		100	336504.215	1006.796499
15546	54619		80	415206.677	1500.237421
15546	54620		60	443282.881	1817.396758
15546	54621		40	680643.402	6461.937093
15546	54622		20	711309.524	3515.30558
15546	54623		10	570949.926	4835.573517
15546	54624		5	609635.711	5187.399107
15547	54714		200	213548.896	275.1172852
15547	54715		150	257746.154	411.569558
15547	54716		100	454521.531	1545.967372
15547	54717		80	707735.849	3689.374425
15547	54718		60	957418.033	7544.704317
15547	54719		40	1279959.48	14632.84671
15547	54721		20	1286971.9	16175.12618
15547	54722		10	1283424.34	15854.27894
15547	54723		5	1332864.16	15085.72073

Table 10.2 CTD casts sampled for determination of microbial concentrations (D286)

Station number	Sample number	Location	Depth, m	Bacterioplankton cells ml^{-1}	Phytoplankton cells ml^{-1}
15553	55314	M9	200	303180.3797	350
15553	55315	M9	175	333712.6246	202
15553	55316	M9	150	409409.7421	300
15553	55318	M9	100	515811.8406	1568
15553	55319	M9	80	604910.1628	5721
15553	55320	M9	60	651024.5902	10804
15553	55321	M9	40	468089.3884	16244
15553	55322	M9	20	634266.6667	12453
15553	55323	M9	10	738499.7196	11329
15553	55324	M9	5	757395.8333	11126
15556	55612		200	219603.9067	359
15556	55613		150	311295.2799	791
15556	55614		100	364903.0234	761
15556	55615		80	496508.8235	6243
15556	55616		60	733258.2322	29453
15556	55617		40	958015.2225	27127
15556	55618		20	1008264.868	29946
15556	55621		10	998963.3081	30080
15556	55623		5	987460.733	30177
15557	55714		200	256447.5874	401
15557	55715		175	307675.0142	349
15557	55716		150	362430.4009	316

15557	55718		100	476592.0398	903
15557	55719		80	548361.2233	2000
15557	55720		60	766061.7978	14347
15557	55721		40	943485.0993	31059
15557	55722		20	981378.0207	32070
15557	55723		10	973566.3717	31630
15557	55724		5	917551.0204	30720
15562	56214	M10	200	210498.3389	220
15562	56215	M10	175	250332.9298	258
15562	56216	M10	150	293606.5574	285
15562	56217	M10	125	366017.2911	457
15562	56218	M10	100	436115.6304	936
15562	56219	M10	80	483840.4133	1375
15562	56220	M10	60	560745.0524	8612
15562	56221	M10	40	860150.289	18453
15562	56222	M10	20	909050.2793	15168
15562	56223	M10	10	891000	15218
15562	56224	M10	5	809240.7199	14648
15565	56514		200	206324.2009	124
15565	56515		150	252901.3255	205
15565	56516		125	298903.7571	328
15565	56517		100	353191.0995	494
15565	56518		80	427679.4616	447
15565	56519		60	586793.9481	9193
15565	56520		40	574156.9027	2878
15565	56521		20	730178.8413	23211
15565	56523		10	723863.7532	23331
15565	56524		5	769766.9492	23346
15566	56610		85	28517	3908
15566	56611		75	23367	5762
15570	57008		200	276802.0441	641
15570	57009		150	503558.5831	903
15570	57019		100	493370.0138	3082
15570	57020		80	700203.8627	5445
15570	57021		60	693619.8738	6994
15570	57022		40	632756.0473	6096
15570	57023		20	619927.4611	6206
15570	57024		10	608351.735	5921
15573	57317	M3	250	228840	164
15573	57318	M3	125	470511.9543	414
15573	57319	M3	100	565301.8868	1026
15573	57320	M3	80	696503.3872	2919
15573	57321	M3	60	925895.5614	6770
15573	57322	M3	40	1381483.771	30017
15573	57323	M3	20	1362712.902	30102
15573	57324	M3	10	1301276.488	30918
15576	57616		200	157287.2076	265
15576	57617		150	228840	583
15576	57618		100	470511.9543	561
15576	57619		80	565301.8868	4605
15576	57620		60	696503.3872	21724
15576	57621		40	925895.5614	20008
15576	57622		20	1381483.771	22088
15576	57623		10	1362712.902	22186
15576	57624		5	1301276.488	22258
15582	58216	M5	200	158329.1833	110
15582	58217	M5	150	222732.2134	221
15582	58218	M5	100	411097.0677	3294
15582	58219	M5	80	368183.8454	13500
15582	58220	M5	60	482338.0567	15167
15582	58221	M5	40	467212.8784	17416
15582	58222	M5	20	492835.277	22601
15582	58223	M5	10	498591.8675	22337
15582	58224	M5	5	555494.5055	23018
15584	58415		200	152876.8963	215
15584	58416		150	189695.1626	199
15584	58417		125	280827.8633	474
15584	58418		100	338736.9036	1578
15584	58419		80	500518.5615	9308
15584	58421		40	464627.1641	18870
15584	58422		20	460901.5002	19001
15584	58423		10	452342.9251	19229
15584	58424		5	496074.104	18652
15585	58515		200	156409.0279	19102
15585	58516		150	195581.7139	14830
15585	58517		125	229077.1043	34214
15585	58518		100	384376.4495	361085
15585	58519		80	462463.8408	574301
15585	58520		60	494944.9359	701189
15585	58521		40	481425.1247	596918
15585	58522		20	488347.6155	531042
15585	58523		10	491196.2839	424893
15585	58524		5	502340.7516	434796
15586	58615		200	104343.5157	104
15586	58616		150	114547.2742	136
15586	58617		125	398108.6517	947
15586	58618		100	304112.0008	1643
15586	58619		80	326274.3196	4948
15586	58620		60	309804.3535	7800
15586	58621		40	241988.5865	6601
15586	58622		20	233829.7296	6935
15586	58623		10	207224.9402	6265
15586	58624		5	230615.9699	6282
15587	58715		200	101742.3021	326
15587	58716		150	152986.111	292
15587	58717		125	245097.5692	652
15587	58718		100	256274.7739	1013
15587	58719		80	264686.9471	2519

15587	58721		40	306142.9061	4158
15587	58722		20	316634.8141	4662
15587	58723		10	282215.5552	4157
15587	58724		5	278935.5597	3899
15589	58913	M3	200	149014.1603	442
15589	58914	M3	150	191026.2097	912
15589	58915	M3	125	212282.4095	1483
15589	58916	M3	100	244689.3224	4145
15589	58917	M3	80	281575.4127	5926
15589	58918	M3	60	298014.9503	7433
15589	58920	M3	40	287209.9525	7497
15589	58921	M3	20	268788.3293	7205
15589	58922	M3	10	268429.7621	7141
15589	58924	M3	5	248671.1179	7447
15596	59616	M6	200	309603.253	111
15596	59617	M6	150	189456.7789	162
15596	59618	M6	100	438621.0851	984
15596	59619	M6	80	576502.5673	1827
15596	59620	M6	60	511321.0753	5894
15596	59621	M6	40	526448.4955	5755
15596	59622	M6	20	525612.027	5537
15596	59623	M6	10	529247.7445	6825
15596	59624	M6	5	514644.3124	6061
15600	60001	M6	40	608957.0174	8048
15600	60003	M6	40	580988.9394	8579
15600	60005	M6	40	585454.5818	8845
15600	60007	M6	40	572608.2454	8063
15600	60009	M6	40	589426.0569	8280
15600	60011	M6	40	520998.752	6644
15600	60013	M6	40	586575.008	7906
15600	60015	M6	40	615492.5037	8898
15600	60017	M6	40	618054.8828	7361
15600	60019	M6	40	613641.5933	10047
15600	60021	M6	40	543808.3496	18668
15600	60023	M6	40	580921.2316	8720
15606	60615	M2	200	146204.1152	86
15606	60616	M2	150	203275.2881	327
15606	60617	M2	125	319191.8149	693
15606	60618	M2	100	460344.654	1710
15606	60619	M2	80	582554.7977	3144
15606	60620	M2	60	602837.8819	10259
15606	60621	M2	40	466222.1806	9210
15606	60622	M2	20	490558.9195	9726
15606	60623	M2	10	429511.0905	8951
15606	60624	M2	5	413978.6699	8345
15614	61411		200	138229.5767	284
15614	61412		150	126556.9984	706
15614	61413		125	160024.8337	696
15614	61414		100	184350.0753	1353
15614	61415		80	249259.3742	2653
15614	61416		70	325011.8506	3108
15614	61417		60	272521.6361	3727
15614	61418		50	300197.1041	5819
15614	61419		40	304985.1509	6400
15614	61420		30	323715.2918	11396
15614	61421		20	420242.8395	28123
15614	61423		10	469962.8015	28651
15614	61424		5	475327.9529	29636
15620	62006		200	212144.511	963
15620	62008		150	244335.2086	665
15620	62011		100	294660.9932	683
15620	62013		80	335390.4966	1245
15620	62015		60	383198.9085	1598
15620	62016		50	423818.3949	2052
15620	62018		40	464690.7676	2856
15620	62021		20	639834.1801	14312
15620	62023		10	776934.2022	14955
15623	62305		200	235415.1783	621
15623	62306		200	248251.0107	594
15623	62307		150	282872.4447	882
15623	62308		125	306083.4859	1644
15623	62309		100	391160.1868	1198
15623	62310		100	398006.1751	1220
15623	62311		80	435399.0748	3125
15623	62312		80	436729.0046	3346
15623	62313		60	452626.9723	9990
15623	62314		60	496505.6876	11247
15623	62315		50	415782.0492	20473
15623	62316		50	421805.2635	20653
15623	62317		40	399762.4001	23631
15623	62318		40	419643.0893	23001
15623	62319		20	399732.2	22538
15623	62320		20	409047.5532	23072
15623	62321		10	376594.7396	24020
15623	62322		10	369754.9893	24028
15623	62323		5	399606.1104	21677
15623	62324		5	392038.1816	23955
15628	62815		200	175113.8502	240
15628	62816		150	232516.3028	319
15628	62817		125	247649.8784	401
15628	62818		100	337004.5212	527
15628	62819		80	318960.5823	786
15628	62820		60	419707.6935	1449
15628	62821		40	589355.3759	6053
15628	62822		20	751350.2507	14867
15628	62823		10	674827.8026	15307
15628	62824		5	697764.8101	16140
15632	63215		200	137348.7825	108

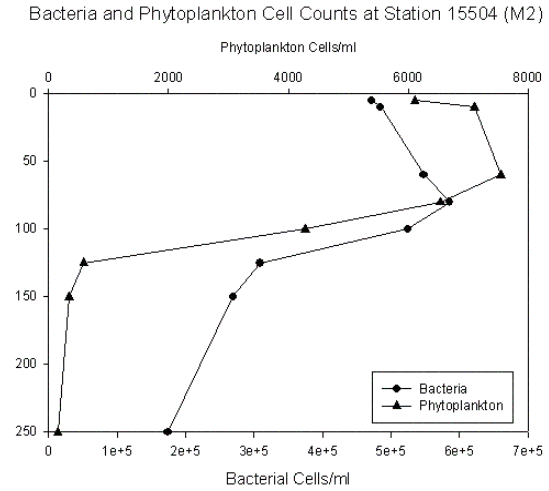
15632	63216		150	155119.6896	163
15632	63217		125	166874.9645	257
15632	63218		100	214516.4907	651
15632	63219		80	201091.58	1079
15632	63220		60	268095.9711	2462
15632	63221		40	418552.2164	5370
15632	63222		20	345175.8866	19199
15632	63223		10	352913.2299	19187
15632	63224		5	447270.0641	20005

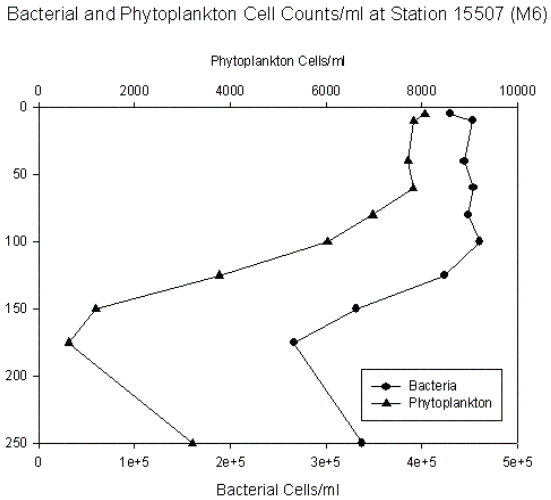
Table 10.3 CTD casts sampled for nutrient dynamic experiments

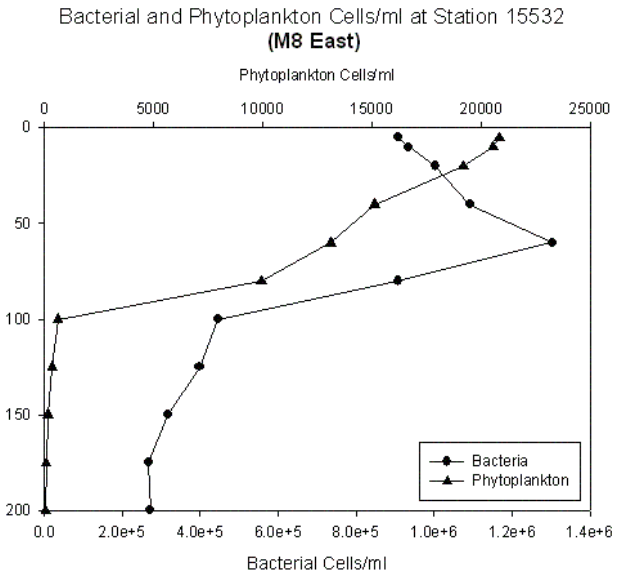
Date	CTD	Lat, °S	Long, °E
11-Nov	15491	43.92	50.23
13-Nov	15496	46.07	51.79
18-Nov	15499	46.03	51.81
19-Nov	15502	47.80	52.86
23-Nov	15511	49.00	51.50
24-Nov	15516	46.06	51.79
27-Nov	15524	45.49	49.00
30-Nov	15531	44.92	49.90
2-Dec	15537	44.87	49.66
4-Dec	15543	43.12	47.18

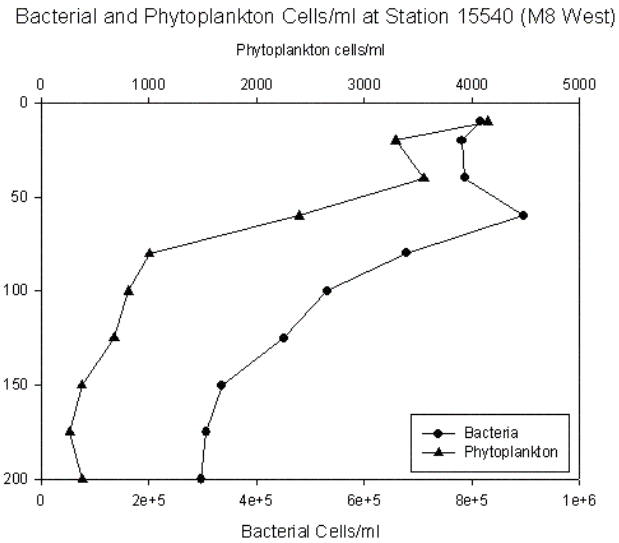
Appendix:

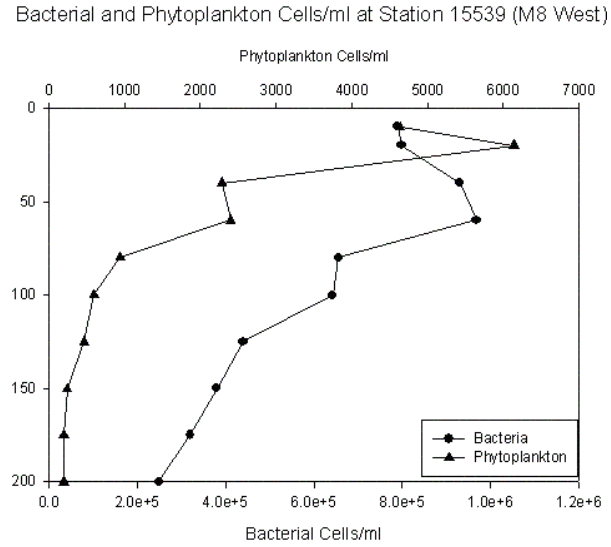
Plots of Raw CTD FC Data for Major Stations Sampled

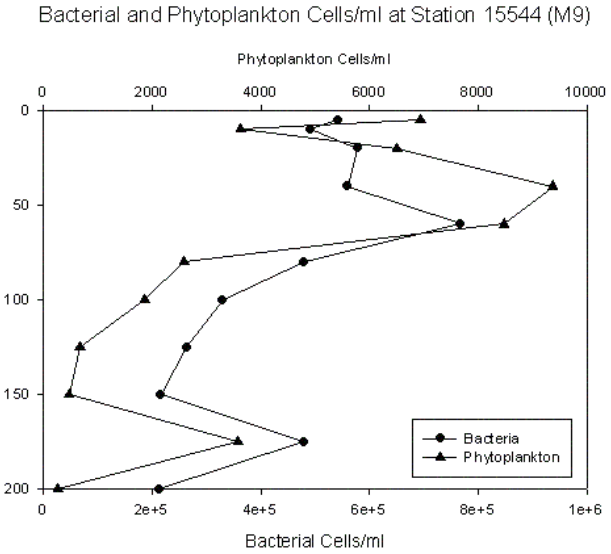





Bacterial and Phytoplankton Cells/ml at Station 15532
(M8 East)
Phytoplankton Cells/ml
0
5000
10000
15000
20000
25000
0
50
100
150
200
0.0
2.0e+5
4.0e+5
6.0e+5
8.0e+5
1.0e+6
1.2e+6
1.4e+6
Bacterial Cells/ml
Bacteria
Phytoplankton


Bacterial and Phytoplankton Cells/ml at Station 15540 (M8 West)
Phytoplankton cells/ml
0
1000
2000
3000
4000
5000
0
50
100
150
200
0
2e+5
4e+5
6e+5
8e+5
1e+6
Bacterial Cells/ml
Bacteria
Phytoplankton


Bacterial and Phytoplankton Cells/ml at Station 15539 (M8 West)
Phytoplankton Cells/ml
0
1000
2000
3000
4000
5000
6000
7000
0
50
100
150
200
0.0
2.0e+5
4.0e+5
6.0e+5
8.0e+5
1.0e+6
1.2e+6
Bacterial Cells/ml
Bacteria
Phytoplankton


Bacterial and Phytoplankton Cells/ml at Station 15544 (M9)
Phytoplankton Cells/ml
0
2000
4000
6000
8000
10000
0
50
100
150
200
0
2e+5
4e+5
6e+5
8e+5
1e+6
Bacterial Cells/ml
Bacteria
Phytoplankton

11. Pelagra

Richard Sanders, Ben Boorman

Pelagra is a neutrally buoyant sediment trap designed and manufactured at the NOCS which, it is hoped, will collect samples of settling marine snow representative of those falling from the upper ocean without the bias associated with conventional upper ocean traps caused by turbulence, shear and swimmers. The general principle of operation is that the float should become neutrally buoyant at some depth and then spend its deployment period drifting around the upper ocean subject to internal wave and current activity collecting material. It consists of an Argo float with modified software around which are clamped four steep fibreglass collecting funnels and 6 semicircular buoyancy hoops. Beneath the float sits a timer activated release which drops a weight to enable surfacing and trap closure, this weight activates at 450m in case of severe overballasting. Above the float sits a titanium lifting frame. At some predetermined time a timer activated dropweight falls off which results in the traps shutting and the float surfacing. At this point it begins to signal its position to the SOC via the Argo network, these signals can be detected on board using a Gonio receiver which allows the range and bearing from the ship to be determined. The vehicle is visually located via large orange flags strapped to the lifting framework. Its deployment is complex, requiring the setting up of a separate pressure logger, the float itself, an associated CTD cast for ballasting, the timer release system and the preparation of preservative solutions. Its usage on this cruise represents the first time that multiple long deployments have been possible on a single cruise and also the first time that a surface pressure activated dropweight has been used. Six deployments were undertaken, detailed below in Table 11.1.

Table 11.1 Pelagra deployments on D285

Deployment	Site	Station	Date in Nov	Target depth (m)	Latitude	Longitude	Duration (hours)
1	M3	15495,6	13	200	46 04.8	51 44.61	78
2	M2	15501	19	100	47 46.4	52 49.7	7
3	M6	15508	21	100	48 59.9	51 28.558	9
4	M3	15515	24	150	46 07.3	51 49.72	8
5	M8W	15522	26	200	45 00.2	49 31.18	41
6	M8E	15535	30	200	44 53.2	49 40.9	41

Deployment 1 was conducted at M3 using our then best understanding of how its buoyancy responded to pressure and temperature. It resulted in a substantial overshoot however the float became stable at depth immediately prior to the emergency pressure release firing. This period of stability allowed us to recalculate the ballast required to reach a particular depth on subsequent deployments. Deployments 2, 3 and 4 were short and conducted at M2, M6 and M3 with shallow target depths. They resulted in modest catches of material. Deployments 5 and 6 were conducted for longer (41hr) and deeper (250m) at M8E and M8W and resulted in substantial catches of material. A crude chlorophyll based estimate of export efficiency (export/production) at 250m at M8W is about 10%, consistent with other observations.

12. Phytoplankton measurements

12.1 Phytoplankton Community Structure, Productivity and New & Regenerated Production

Mike Lucas, Sophie Seeyave

12.1.1 Overview

We had planned to make primary production (PP) measurements every two days, resulting in 12 PP stations on each leg of the cruise. However, we managed 10 PP stations on each of the D285 and D286 legs; losing two on each leg either to poor weather or to alternate activities. Size-fractionated (total, >20µm, >2µm) primary productivity (^{14}C) plus "new" and "regenerated" production (^{15}N-NO_3, ^{15}N-NH_4, ^{15}N-urea) simulated *in situ* incubations were undertaken at six light depths (97, 55, 33, 14, 4.5, 1%) on seawater samples collected in an Fe free manner from night-time Ti-CTD casts between 11th Nov and 3rd December 2004 (D285) and between 18th December and 13th January (D286). For the second leg, we introduced an additional 10µm size-fraction for chlorophyll analyses and for the ^{15}N size-fractionated uptake experiments, but not for the PP work.

Seawater was collected directly into 3 x 2L Fe clean Nalgene polycarbonate bottles that were then transferred in dark cool boxes to the laminar flow hood in the RN container. Here the water was split into sub-samples required for ^{14}C and ^{15}N uptake and NH_4 regeneration experiments as well as water for nutrient and size-fractionated chl-a measurements. Incubations were run for a 24 hour period in Perspex incubation tubes cooled with surface seawater and covered with neutral density (Lee: Misty Blue [061] & Neutral Density Grey [210 ND]) filters to re-construct water column light attenuation spectrally corrected to remove red light.

Wherever possible, all incubation bottles were placed in the incubators before dawn. In addition, some Ti-CTD water samples ("surface" & "deep") were used to construct ^{14}C P vs E curves that were size-fractionated on some occasions.

Additionally, a water sample (~20L) was collected from the underway Fe-fish (~10m) on approaching the Ti-CTD (PP) station for size-fractionated (total, <20µm,

Fig. 12.1 Incubator tubes set up on a steel frame so that waves would not wash them overboard! The RN container is behind and the SeaSoar winch is on the right.

<2µm) ^{15}N uptake experiments (NO_3, NH_4, urea). However, from 27 Nov. onwards (Stn. 15524), water was collected from the Ti-CTD because of Fe contamination problems with the Fe fish.

Size-fractionated chl-a measurements (total, >20µm, >2µm) and nutrient determinations (NO_3, Si, PO_4, NH_4 & urea) were also made from the Ti-CTD PP water samples as well as from the Fe fish water samples when this was used.

The PP Station Logs are shown in Tables 12.1 and 12.2. A summary of the PP experiments performed is given in Tables 12.3 and 12.4.

12.1.2 Primary Productivity (^{14}C)

12.1.2.1 Size-fractionated on-deck incubations

Water for the ^{14}C incubation experiments was withdrawn from the "NO_3" labelled 2L polycarbonate Fe clean bottle into which water from the Ti-CTD had been decanted directly (and prior to ^{15}N spiking). For each light depth, 4 seawater samples (3 replicates at each depth and 1 dark bottle) in 60ml acid-rinsed polycarbonate bottles were inoculated with ~10 µCi $NaOH^{14}CO_3$ (100µl stock solution) in the laminar flow hood. The same procedure was carried out for size-fractionated primary productivity. These bottles were placed in the on-deck incubators together with the ^{15}N experiment bottles for a 24 hour period before recovering the incubations. Five total activity standards were made up in 7ml polycarbonate vials by adding 10ml Packard "Carbosorb" (CO_2 trapping agent) to 100µl ^{14}C working stock then dispensing 100µl of this solution into the pony vials before adding 5ml Packard "Permafluor" scintillation cocktail. At the end of the experiment, samples were filtered under vacuum onto 25mm diameter, 0.2µm (Whatman), 2µm and 20µm (Osmonics) polycarbonate filters.

Filters were rinsed with filtered seawater and 0.5% HCL solution made up in artificial seawater before being acid-fumed under a fume hood for several hours to expel any unfixed inorganic ^{14}C. The filters were then placed in 7ml polyethylene Pony vials and 5ml Packard "Hi-Safe 3" scintillation cocktail was added before samples were counted on-board on a Tri-Carb 3100 TR liquid scintillation counter.

Fig. 12.2 Two x 12 port filtration rigs for ^{14}C filtering in the RN container

12.1.2.2 P vs E experiments

PvsE incubations were carried out at 8 out of the 11 PP stations on leg 1 and at 9 of the 10 PP stations on leg 2 (see Tables 12.3 & 12.4 for details on depth and size fractions). For these, water was collected into separate 2L polycarbonate bottles (generally 2 x 2L bottles at each depth [surface and 4.5% light depth]) and transferred into 15 light and 3 dark 60mL polycarbonate bottles, under the laminar flow hood, and spiked with 10µCi ^{14}C stock. These were then placed in racks in the PvsE incubators, where they were subjected to a light gradient (~3-900 µE m^{-2} s^{-1}) for 2h. The incubator channels were chilled by a flow of surface water from the non-toxic supply; in addition, glass water jackets with circulating surface water were placed in between the light sources (halogen lamps) and the incubators, in order to reduce the heat emitted by the lamps. Blue

filters (Lee "misty blue" [061]) were placed on the perspex front-ends of the incubators to screen out light from the red end of the spectrum. Filters (neutral density grey [0.3 ND]) were also placed before and after the 14th bottle in the sequence, to achieve a near-zero irradiance at the far end of the channel. At the end of the incubation, the same filtering protocol was followed as for the primary production samples.

12.1.2.3 P vs E experiments in association with Fe enrichment experiments

To test the theory of Fe limited growth rates by phytoplankton, a total of eight of 5-6 day bottle incubations (+ Fe additions) were carried out in "high light" and "low light" deck incubators. At time zero and at the end of the experiment, P vs E incubations (and FRRf measurements) were carried out to test phytoplankton physiological responses to light with and without Fe supplements. The P vs E protocols for these experiments were identical to those described above. For each experiment, there were four treatments and therefore 4 x end of experiment P vs E curves; viz. one each for high light control (HLC), high light + Fe (HLFe), low light control (LLC) and low light + Fe (LLFe). In addition to the Pvs E curves, chl-a determinations and HPLC, POC and Lugol's samples were taken from each treatment bottle. The FRRf experiments are described elsewhere in cruise reports by M. Moore and A. Hickman.

12.1.3 New and regenerated production (^{15}N)

12.1.3.1 Standard ^{15}N Uptakes

Three water sub-samples were taken for analyses of "new" and "regenerated" production; one each for NO3, NH4 and urea uptake. Approx. 1L samples (but ~2 L for NH4) decanted directly from the Ti-CTD into 3 x acid rinsed Fe clean 2.0L polycarbonate bottles for each light depth were inoculated (in the RN container Laminar Flow Hood) with 200µl stock solutions of $K^{15}NO_3$ (1µmol / 100µl) and $^{15}NH_4Cl$ (0.1µmol / 100µl) and 100µl of $CO(^{15}NH_2)_2$ (0.1µmol / 100µl) respectively. The volume of ^{15}N spike in each case was adjusted to approximately 10% of the ambient nutrient concentration – typically ~ 20µmol NO3 and <1µmol for NH4 and urea respectively. To avoid the risk of Fe contamination, the initial incubation volumes were not measured out, as is usual. Instead, the incubation volume was measured at the end of the experiment. However, immediately after spiking the NH4 incubation bottle (~2L), exactly 1.0 L was withdrawn into a separate 2.0L polycarbonate bottle to measure time zero (To) ammonium concentrations (see ammonium regeneration, below). The remaining unknown volume (but ~1L) was used for the NH4 uptake incubation.

At the end of the incubation period (+24hrs), all ^{15}N incubations were terminated by filtering the incubation volumes (measured at this point) onto 25 mm ashed GF/F filters. After filtration, the filters were stored at –20 ˚C to await analysis by stable isotope mass spectrometry back at SOC. To monitor changes to the chl-a and nutrient concentrations during the incubation, post-incubation samples were recovered from each light depth and treatment for chl-a and nutrient (NO_3, Si, P, NH_4 and urea) measurements. All urea samples were frozen at –20°C in ~80ml acid-cleaned glass bottles for later analysis at the University of Cape Town.

12.1.3.2 Ammonium regeneration

Isotopic dilution (^{15}N-NH_4 by excreted ^{14}N-NH_4) ammonium regeneration experiments were conducted simultaneously with the ammonium uptake experiments. This is essential to correct the NH_4 uptakes for NH_4 re-cycling in the incubation bottles. 1L recovered from each of the 6 depths (time zero) NH_4 uptake incubation bottles (above) was immediately filtered through a 25mm

(ashed) Whatman GF/F filter to collect 900ml filtrate for transfer into 6 x 1.0L glass Schotte bottles. Exactly 600µl NH_4Cl solution (10µmol / ml) was added to each bottle as a "carrier" prior to freezing the samples at –20°C. This sample provides the time zero NH_4 regeneration concentration (Ro). The GF/F filter (PN) from this sample was retained for HPLC analyses. (See below). At the end of the 24 hr incubation period, a further 900ml of filtrate was recovered from the NH_4 uptake filtration to measure ^{15}N isotopic dilution by excreted NH_4, Carrier (600µl) was added as before and the sample (Rt) was also frozen as before. Back in Cape Town, the aqueous NH_4 will be recovered onto GF/F filters by diffusion and the isotopic composition measured by mass spectrometry back at SOC to provide a measure of NH_4 regeneration.

12.1.3.3 Size-fractionated ^{15}N uptakes

Water from the Fe-fish @ ~10m, or later (after Nov. 27th) from the Ti-CTD (usually ~25m)), was decanted directly into 3 x 6.0L volume Perspex bottles for size-fractionated NO_3, NH_4 and urea uptake experiments. Spikes (15N) to ~5-6 L water were added at the same concentrations as for the standard un-fractionated incubations and the incubation bottles were incubated in the 55% light tube for 24 hours. At the end of the experiment, each bottle treatment was fractionated into "total" (i.e. un-fractionated), < 20µm (plankton mesh screened) and < 2µm (membrane filters) sub-samples of approx. 1-2 L depending on the chl-a concentration and filtered onto 25mm ashed Whatman GF/F filters. As before, these filters were frozen at –20°C for later mass spectrometry analyses at SOC.

12.1.4 Chlorophyll, nutrients and preserved phytoplankton samples

12.1.4.1 Chlorophyll

Approximately 1L of sample water at each depth was withdrawn from the "urea" labelled Fe clean 2.0L polycarbonate (^{15}N) incubation bottle into separate 1 L polycarbonate bottles to make immediate measurements of size-fractionated chl-a (total, >20µm, >2µm). Between 100-200ml sample was filtered separately onto a GF/F (total) and onto 20µm & 2µm filters respectively. On the second cruise (D286), an additional 10µm fraction was included for chl-a analyses. The filters were placed in 20ml glass scintillation vials and 10mls 90% HPLC grade Acetone was added for pigment extraction over 24 hours in a fridge. Pigment was measured fluorometrically on a Turner fluorometer following the Welschmeyer protocol. The Fluorometer was calibrated with a chl-a standard (Sigma) read on a Spectrophotometer.

12.1.4.2 Nutrients

Approx 20mls of the water sample from each depth (above) was placed in diluvials for immediate analysis of NO3, Si & PO4 on a Skalar autoanalyser on-board. Ammonium measurements were made on fresh samples (To) and at T24 from the incubation bottles using a modified (Probyn) Indo-Phenol Blue protocol (Grasshof) for small 5ml samples. The developed colour (after 8 hours) was measured on a Unicam Spectrophotometer at 630nm and NH4 concentrations were calculated from a calibration curve constructed from NH_4Cl "carrier" solution (10µmol / ml) additions to artificial sea-water. Urea samples at T_0 and at T_{24} were collected and frozen for later analysis as described above.

12.1.4.3 HPLC

Apart from HPLC samples taken from the Ti-CTD "associated" stainless steel CTD casts, the GF/F filter sample (usually 1.0L) from the time-zero filtration of the ammonium regeneration bottle at each of the six light depths was frozen at –80°C for later HPLC analysis.

12.1.4.4 Lugols and Formalin preserved phytoplankton & microzooplankton samples

There was insufficient water from the Ti-CTD casts to preserve phytoplankton samples for later taxonomy. However, for each stainless steel CTD sampled, preserved Lugol's and Formalin samples were typically taken at 10m, at the chl-a max (40-80m) and sometimes within the thermocline (~100-125m). For each, 200mls of sample was preserved in a brown glass medicine bottle containing 4mls Lugols Iodine, and in a separate bottle, 4mls buffered Formalin to yield a final concentration of 2% for each.

12.1.5 Progress & Plans for Analysing Frozen or Preserved Samples

Phytoplankton (^{14}C) Production

All samples have been successfully counted at sea using the on-board scintillation counter. Simulated *in situ* productivity rates have been calculated and P vs E curves and parameters have been calculated also. Integrated water column production rates have been calculated but these calculations will require some revision based on accurately determined light depths from the limited PAR profiles taken on daylight Thorium CTD casts and also from the PAR sensor on SeaSoar. Given that the ^{14}C results are at an advanced stage of analysis, a manuscript can be prepared for publication as soon as some preliminary analysis of phytoplankton community structure (HPLC & taxonomy) has been done, as well as a hydrographic and ocean colour (satellite imagery) framework to place the results in context.

New (^{15}N) Production

Although the incubations have been successfully completed, the frozen (@ -20°C) filter samples (840; including regeneration samples, below) need to be dried, punched & pelleted before the samples can be run on the Mass Spec back at SOC. Some sample preparation has been carried out at sea. The remaining ^{15}N sample preparation will be carried out at the University of Cape Town (UCT) prior to transporting the dried and pelleted samples back to SOC for running on the Mass Spec. To calculate ^{15}N uptake rates, we need to know ambient nutrient concentrations of nitrate, ammonium and urea. Both the nitrate and ammonium values have been measured at sea but the frozen urea samples (~180) will need to be measured back at the University of Cape Town.

Ammonium Regeneration (Ro + Rt)

Approximately 240 Schotte Bottles (1.0L) containing 900mls of frozen filtrate from which the regenerated ammonium will be transported to Cape Town (UCT) so that regenerated ammonium can be recovered by diffusion. The process is simple but time-consuming. After each bottle has been thawed, a teaspoon of MgO is added to the bottle which raises the Ph to ~9. This drives the ammonium into the head-space of the bottle and the ammonium is recovered as ammonium chloride on an HCL acidified 25mm Whatman GFF filter placed in the bottle cap. Diffusion recovery of the ammonium takes approx. 3 weeks at ambient room temperature. Once this has been completed, the filters are dried, punched and pelleted as before prior to running the samples on the Mass Spec. Assuming the ammonium recovery procedure is completed within February, the regeneration samples will be ready for the Mass Spec in March.

Chlorophyll

All samples – some 2500! - have been measured on the Turner fluorometer and calculated. On the first leg, all the PP stations were fractionated for the six light depths into total, >20µm & >2µm fractions. However, on the second leg, we included a >10µm fraction to asses the contribution of

small diatoms, if any, in the absence of the large colonies of the prymnesiophyte flagellate, *Phaeocystis* sp. that characterised the high chlorophyll stations during Leg 1. Repeat visits to station M3 at the end of Leg 2 were rewarded with this policy where total chl-a concentrations reached ~6mg m^{-3} in a shallow (<40m) surface layer, dominated by small diatoms mostly (~60%) in the 10-20µm fraction.

HPLC

At each PP station for both legs of the cruse, HPLC samples are available for each of the six light depths. They were frozen at –80°C and will be shipped in a dry (liquid N) shipper to UCT. One option is to analyse the HPLC samples (~ 120 samples) in Cape Town, or to ship them back to SOC to run on the SOC HPLC instrument. The problem with the latter option is that there is currently only one HPLC instrument in operation at SOC that is fully committed to AMT samples. Permission to use the AMT instrument is required.

SeaSoar and Underway (NT supply) FRRf (see Report by Moore & Hickman)

Although the experimental FRRf work on the Fe incubation experiments is of paramount importance, there are useful analyses and results to be obtained from the SeaSoar and underway NT FRRf measurements; particularly in terms of 3-D mapping of phytoplankton distribution and physiological "fitness".

Preserved Phytoplankton and Micro-zooplankton samples (Formalin & Lugols)

There are approximately 140 phytoplankton samples preserved in Lugols, and approx. 100 samples preserved in buffered Formalin. In addition there are approx. 100 samples preserved in Formalin for micro-zooplankton enumeration. These samples have been carefully numbered and crated for transport back to SOC. It is not yet clear who will undertake the phytoplankton counting; this task alone requires approximately 3-6 months to complete, including the calculation of bio-volume and cellular carbon for the different taxa.

Nutrients

All the nutrients required for the ^{15}N uptake and ammonium regeneration calculations have been analysed on-board, with the exception of the frozen urea samples. These will be analysed at UCT (see earlier commentary).

POC, PIC & BSi

These primary "state variables" were obtained from the stainless steel CTD casts and are linked at the PP stations with the appropriate TI CTD. For each CTD deployment, 12 standard depths to 500m were sampled. At two depths within the euphotic layer (surface & chl-a max.), the state variables (except for PIC) were size-fractionated into total, 20 & 2µm fractions, with a 10µm fraction being added on the second leg. Commentary on the chl-a samples has already been provided above so will be ignored here.

The POC samples (~800) were frozen on-board at –20°C and will be transported back to UCT to be acid-fumed (to remove PIC), dried and pelleted in preparation for running on a CHN analyser. Most of the POC samples originated from the "standard" stainless steel CTD casts but on the second leg in particular, Thorium CTD casts generated their own chl-a and POC samples. There is some doubt about running the POC samples at SOC because the SOC instrument is set up to run geochemistry (rock) samples so the precision for low value phytoplankton POC samples is

poor. The PML instrument is probably the more appropriate instrument to run the samples on. Once again, Ms Seeyave emerges as the most likely person to process the POC samples.

The PIC samples (~600) have been stored semi-dried at room temperature in 20ml plastic scintillation vials and can be readily transported back to SOC for analysis. Calcite needs to be extracted by acidification and the samples run on the IPC Atomic Emission Spectrometer (AES) at SOC. Who will do this is unclear, but the PIC sample analysis is a low priority.

The BSi samples (~700) have been digested and run on-board ship by Ms Megan French (UEA). The results look extremely interesting indeed and one obvious question is whether we can match inorganic silicate draw-down with BSi production. Although preliminary analyses have therefore been completed, further interpretation remains to be done

12.1.6 Conclusion & Highlights

The phytoplankton research undertaken during CROZEX has gone exceptionally smoothly and results we have to date are exciting. All phytoplankton communities demonstrate varying degrees of Fe stress and Si limitation with N being abundant everywhere. Photo-physiological responses to Fe and light are complex and require careful interpretation and indeed we don't yet have a clear idea of the processes at work. Productivity rates varied from as low as 100mg m-2 d-1 (M2) to as high as 3000 mg m-2 d-1 in the diatom-dominated communities we encountered at M3 late in the second leg of the cruise. *Phaeocystis* were prolific almost everywhere on the first leg of the cruise wherever chlorophyll concentrations exceeded ~ 1mg m-3. They were insensitive to Si limitation but were also clearly limited by Fe availability which appears to be a strong determinant of colony size. At M8W & M8E we were fortunate enough to be able to relate primary production to "export" captured by "Pelagra". Other measurements of export are yet to be determined from the f-ratio and from ^{234}Thorium measurements, although early evidence indicates a good positive correlation between chlorophyll concentration and ^{234}Th activity, suggesting higher export associated with high chlorophyll concentrations.

Table 12.1 Log of Primary Production Ti-CTD casts on D285

Ti-CTD Dat (GMT)	Time CTD in water (GMT)	Time CTD inboard (GMT)	JD (GMT)	Stat	Loc
11-Nov	1410	1916	316	15491	M1
13-Nov	1502	1706	318	15496	M3
18-Nov	2058	2144	323	15499	M3
19-Nov	2121	0009	324	15502	M2
22-Nov	2203	0141	327	15511	M6
25-Nov	0039	0120	330	15516	M3
27-Nov	1834	1926	332	15524	M7
29-Nov	2351	0018	334	15531	M8 E
01-Dec	2230	0050	336	15537	M8 W
03-Dec	2240	0119	338	15543	M9

Table 12.2 Log of Primary Production Ti-CTD casts on D286

Ti-CTD Dat (GMT)	Time CTD in water (GMT)	Time CTD inboard (GMT)	JD (GMT)	Stat	Loc
18-Dec	1805	2100	353	15552	M9
20-Dec	1846	1935	355	15561	M10
22-Dec	2125	2217	357	15572	M3
27-Dec	1845	2217	362	15581	M5
31-Dec	1410	1438	366	15592	M3
04-Jan	1852	2152	004	15598	M6
06-Jan	1617	1845	006	15602	M2
08-Jan	2248	2335	008	15612	M3
10-Jan	1813	1853	010	15621	M3
13-Jan	0118	0204	013	15629	M3

Table 12.3 Log of Primary Production, P.vs.E & ^{15}N stations, 1st Leg (D285)

CTD Date (GMT)	JD	CTD	Stat	Primary production		P vs E		^{15}N			
				Depth	Size fraction	Depth	Size fraction	Depth	NO3, NH4, urea	NH4 regen	Size fraction
11-Nov	316	15491	M1	5	T, >2µm, >20µm	5	T, >20µm	5	T		
				10	T, >2µm, >20µm			10	T		
				20	T, >2µm, >20µm			20	T		
				40	T, >2µm >20µm			40	T		
				60	T, >2µm, >20µm	60	T, >20µm	60	T		
				70	T, >2µm, >20µm			70	T		
13-Nov	318	15496	M3	5	T, >2µm, >20µm	5	T	5	T	Ro, Rt	
				10	T, >2µm, >20µm			10	T	Ro, Rt	T, <2µm, <20µm
				15	T, >2µm, >20µm			15	T	Ro, Rt	
				27	T, >2µm, >20µm			27	T	Ro, Rt	
				42	T, >2µm, >20µm	42	T	42	T	Ro, Rt	
				63	T, >2µm, >20µm			63	T	Ro, Rt	
18-Nov	323	15499	M3	5	T						
				5	T						
				10	T						
				15	T						
				40	T						
				60	T						
19-Nov	324	15502	M2	5	T, >2µm, >20µm	5	T, >2µm, >20µm	5	T	Ro, Rt	
				10	T, >2µm, >20µm			10	T	Ro, Rt	T, <2µm, <20µm
				20	T, >2µm, >20µm			20	T	Ro, Rt	

				40	T, >2µm, >20µm			40	T	Ro, Rt	
				60	T, >2µm, >20µm			60	T	Ro, Rt	
				80	T, >2µm, >20µm			80	T	Ro, Rt	
22-Nov	327	15511	M6	5	T, >2µm, >20µm	5	T	5	T	Ro, Rt	
				10	T, >2µm, >20µm			10	T	Ro, Rt	T, <2µm, <20µm
				20	T, >2µm, >20µm			20	T	Ro, Rt	
				40	T, >2µm, >20µm			40	T	Ro, Rt	
				60	T, >2µm, >20µm	60	T	60	T	Ro, Rt	
				80	T, >2µm, >20µm			80	T	Ro, Rt	
25-Nov	330	15516	M3	5	T, >2µm, >20µm	5	T	5	T	Ro, Rt	
				10	T, >2µm, >20µm			10	T	Ro, Rt	
				20	T, >2µm, >20µm			20	T	Ro, Rt	
				40	T, >2µm, >20µm			40	T	Ro, Rt	
				60	T, >2µm, >20µm	60	T	60	T	Ro, Rt	
				80	T, >2µm, >20µm			80	T	Ro, Rt	
27-Nov	332	15524	M7	5	T, >2µm, >20µm	5	T	5	T	Ro, Rt	
				10	T, >2µm, >20µm			10	T	Ro, Rt	T, <2µm, <20µm
				15	T, >2µm, >20µm			15	T	Ro, Rt	
				25	T, >2µm, >20µm			25	T	Ro, Rt	
				35	T, >2µm, >20µm	35	T	35	T	Ro, Rt	
				55	T, >2µm, >20µm			55	T	Ro, Rt	
29-Nov	334	15531	M8 E	5	T, >2µm, >20µm	5	T	5	T	Ro, Rt	
				10	T, >2µm, >20µm			10	T	Ro, Rt	T, <2µm, <20µm
				15	T, >2µm, >20µm			15	T	Ro, Rt	
				25	T, >2µm, >20µm			25	T	Ro, Rt	
				35	T, >2µm, >20µm			35	T	Ro, Rt	
				55	T, >2µm, >20µm			55	T	Ro, Rt	

01-Dec	336	15537	M8 W	5	T, >2µm, >20µm			5	T	Ro, Rt	
				10	T, >2µm, >20µm			10	T	Ro, Rt	T, <2µm, <20µm
				15	T, >2µm, >20µm			15	T	Ro, Rt	
				25	T, >2µm, >20µm			25	T	Ro, Rt	
				35	T, >2µm, >20µm			35	T	Ro, Rt	
				55	T, >2µm, >20µm			55	T	Ro, Rt	
03-Dec	338	15543	M9	5	T			5	T	Ro, Rt	
				10	T			10	T	Ro, Rt	
				15	T			15	T	Ro, Rt	
				25	T			25	T	Ro, Rt	
				35	T			35	T	Ro, Rt	
				55	T			55	T	Ro, Rt	

Table 12.4 Log of Primary Production, P.vs.E & ^{15}N stations on D286

CTD Date (GMT)	**JD**	**CTD**	**Stat**	**Primary production**		**P vs E**		**^{15}N**			
				Depth	Size fraction	Depth	Size fraction	Depth	NO3, NH4, urea	NH4 regen	Size fraction
18-Dec	353	15552	M9	5	T, >2µm, >20µr	5	T	5	T	Ro, Rt	
				10	T, >2µm, >20µr			10	T	Ro, Rt	T, <2µm <20µm
				15	T, >2µm, >20µr			15	T	Ro, Rt	
				25	T, >2µm, >20µr			25	T	Ro, Rt	
				35	T, >2µm, >20µr	35	T	35	T	Ro, Rt	
				55	T, >2µm, >20µr			55	T	Ro, Rt	
20-Dec	355	15561	M10	5	T, >2µm, >20µr	5	T	5	T	Ro, Rt	
				10	T, >2µm, >20µr			10	T	Ro, Rt	
				15	T, >2µm, >20µr			15	T	Ro, Rt	

				25	T, >2µm, >20µr	25	T	27	T	Ro, Rt	
				35	T, >2µm, >20µr			42	T	Ro, Rt	
				55	T, >2µm, >20µr			63	T	Ro, Rt	
23-Dec	357	15572	**M3**	5	T, >2µm, >20µr	5	T	5	T	Ro, Rt	
				10	T, >2µm, >20µr			10	T	Ro, Rt	T,<20µm <10µm, <2µm
				15	T, >2µm, >20µr			15	T	Ro, Rt	
				25	T, >2µm, >20µr						
				35	T, >2µm, >20µr	35	T				
				55	T, >2µm, >20µr						
27-Dec	362	15581	M5	5	T, >2µm, >20µr	5	T	5	T	Ro, Rt	
				10	T, >2µm, >20µr			10	T	Ro, Rt	T,<20µm <10µm, <2µm
				20	T, >2µm, >20µr			20	T	Ro, Rt	
				40	T, >2µm, >20µr			40	T	Ro, Rt	
				60	T, >2µm, >20µr	60	T	60	T	Ro, Rt	
				80	T, >2µm, >20µr			80	T	Ro, Rt	
31-Dec	366	15592	M3	5	T, >2µm, >20µr			5	T	Ro, Rt	
				10	T, >2µm, >20µr			10	T	Ro, Rt	T,<20µm <10µm, <2µm
				15	T, >2µm, >20µr			15	T	Ro, Rt	
				25	T, >2µm, >20µr			25	T	Ro, Rt	
				35	T, >2µm, >20µr	35	T	35	T	Ro, Rt	
				55	T, >2µm, >20µr			55	T	Ro, Rt	
4-Jan	005	15598	**M6**	5	T, >2µm, >20µr	5	T	5	T	Ro, Rt	
				10	T, >2µm, >20µr			10	T	Ro, Rt	T,<20µm <10µm,

											<2µm
				20	T, >2µm, >20µr			20	T	Ro, Rt	
				40	T, >2µm, >20µr			40	T	Ro, Rt	
				60	T, >2µm, >20µr	60	T	60	T	Ro, Rt	
				80	T, >2µm, >20µr			80	T	Ro, Rt	
06-Jan	006	15602	M2	5	T, >2µm, >20µr	5	T	5	T	Ro, Rt	
				10	T, >2µm, >20µr			10	T	Ro, Rt	T,<20µm <10µm, <2µm
				20	T, >2µm, >20µr			20	T	Ro, Rt	
				40	T, >2µm, >20µr			40	T	Ro, Rt	
				60	T, >2µm, >20µr	60	T	60	T	Ro, Rt	
				80	T, >2µm, >20µr			80	T	Ro, Rt	
9-Jan	009	15612	M3	5	T, >2µm, >20µr	5	T	5	T	Ro, Rt	
				10	T, >2µm, >20µr			10	T	Ro, Rt	T,<20µm <10µm, <2µm
				20	T, >2µm, >20µr			20	T	Ro, Rt	
				30	T, >2µm, >20µr			30	T	Ro, Rt	
				40	T, >2µm, >20µr			40	T	Ro, Rt	
				60	T, >2µm, >20µr			60	T	Ro, Rt	
10-Jan	010	15621	**M3**	5	T, >2µm, >20µr	5	T	5	T	Ro, Rt	
				8	T, >2µm, >20µr			8	T	Ro, Rt	T,<20µm <10µm, <2µm
				12	T, >2µm, >20µr			12	T	Ro, Rt	
				20	T, >2µm, >20µr	20	T	20	T	Ro, Rt	
				30	T, >2µm, >20µr			30	T	Ro, Rt	
				45	T, >2µm, >20µr			45	T	Ro, Rt	
13-Jan	013	15629	**M3**	5	T			5	T	Ro, Rt	
				8	T			8	T	Ro, Rt	T,<20µm

											<10µm, <2µm
				12	T			12	T	Ro, Rt	
				20	T			20	T	Ro, Rt	
				35	T			35	T	Ro, Rt	
				55	T			55	T	Ro, Rt	

Note: Station locations in bold (eg **M3**) denote stations where discrete FRRf measurements were made on the bottle water samples. At station 15629, there was insufficient ^{14}C spike remaining to do size-fractionated experiments or P vs E curves.

Table 12.5 Summary of Fe addition experiments

(PvsE incubations were carried out at the start and finish of each experiment).

	Date Start	Date Finish	Location	Depth
LEG 1				
Expt 1	11/11/04	16/11/04	M1	5m
Expt 2	22/11/04	26/11/04	M6	5m
Expt 3	26/11/04	30/11/04	M3	5m
Expt 4	30/11/04	04/12/04	M8E	5m
LEG 2				
Expt 5	20/12/04	26/12/04	M10	25m
Expt 6	31/12/04	05/01/05	M3	35m
Expt 7	06/01/05	12/01/05	M2	60m
Expt 8	10/01/05	15/01/05	M3	20m

12.2 Nutrient addition bioassay experiments

D285 **Mark Moore, Mike Lucas, Sophie Seeyave**

Nutrient addition bioassay experiments were performed using a highly replicated design to investigate the inter-dependence of iron and light availability on phytoplankton physiology, growth and nutrient drawdown. Original plans to incorporate silicate additions as a further factor were abandoned due to the increased logistical problems and time constraints involved in performing experiments of twice the size. Given the successful completion of a number of experiments during Crozex Leg 1 (D285) it is hoped that some work on silicate limitation may be possible during Leg 2 (D286).

As with all work involving manipulation of iron availability for phytoplankton populations, strict controls were required to avoid contamination of incubation containers and sampled water. Incubations were performed in 2 l polycarbonate bottles which had passed through a rigorous cleaning process involving a Decon wash and soaking in 50% HCl for 1 week, followed by rinsing then storage with acidified Milli-Q prior to sailing.

The original intention was to collect incubation water from the underway Fe fish, however this strategy presented a number of problems. Firstly it was thought that collection whilst on station might result in contamination from the ship, conversely underway collection can potentially result in variability within the sample bottles due to patchiness along track. Finally a broken hose within the fish body during sampling for the second experiment resulted in serious contamination and hence a failure to collect any usable data. This contamination may have also resulted in a noisy fourth and final experiment where replication was poor. Due to constraints on sampling time before leaving the study area, this experiment was performed in the bottles contaminated during Expt. 2, the other bottles being used in Expt. 3. It was subsequently concluded that these bottles were probably not cleaned adequately between experiments. A more rigorous cleaning procedure between experiments will thus be adopted on the second leg. Additionally, sampling from the titanium CTD (Ti) rig is considered to be the only reliable method of collecting uncontaminated water and is recommended during Leg 2.

The experimental design involved the incubation of 20 bottles in 4 sets of 5 replicates, one set each for high light (control and +Fe) and low light (control and +Fe). Two of the five replicate bottles were sub-sampled approximately every 2 days. The remaining three replicates remained sealed until the 5-6th day as a check that sub-sampling had not contaminated the time-series measurements. Such a strategy also provides more robust statistics and a large volume of water for an additional suite of final measurements.

Sampling of the time-series was routinely performed for chlorophyll, ambient macronutrients (N, P and Si) and PSII characteristics as measured by FRRf. Additional sampling at the beginning and end time points consisted of ^{14}C P vs E determinations, POC/PON and preservation of samples in lugols iodine for phytoplankton counts. In order to assess contamination, samples were also collected for analysis of total dissolvable iron (TDFe) at the end of the experiments.

Table 12.6 Sampling methods, locations, times and initial conditions for bioassay experiments

	Expt. 1	Expt. 2	Expt. 3	Expt. 4
Sampling location	**M1**	**M6**	**M3**	**M8E**
Sampling method	Fe Fish	Fe Fish	Ti CTD, Station 15516, Depth, 20m	Ti CTD, Station 15531 Depth, 25m
Bottle set	1	2	1	2
Start point	1435 GMT, JD 316	2100 GMT, JD 326	0230 GMT, JD 330	0220 GMT, JD335
End point	1630 GMT, JD 321	1700 GMT, JD 331	1630 GMT, JD 335	1645 GMT, JD 339
Initial chlorophyll concentration	1.83 ± 0.05	0.59 ± 0.05	0.63 ± 0.02	0.80 ± 0.04
Initial Nitrate concentration	18.49 ± 0.17	22.95 ± 0.15	23.46 ± 0.13	23.10 ± 0.42
Initial Silicate concentration	1.23 ± 0.23	17.64 ± 0.52	8.84 ± 0.21	2.52 ± 0.09
Comments	Replication good, clear +Fe response	Experiment contaminated due to problems with Fe Fish	Replication good, clear +Fe response	Poor replication, some indication of +Fe response, suspect contamination of bottle remains after Expt. 2!

A total of four experiments lasting 5-6 days each were carried out during Leg 1. Of these experiments, 2 produced good quality data. A complete list of experiments along with sampling locations and initial conditions is provided in Table 12.6.

Despite the contamination problems that resulted in only half the experiments providing robust repeatable data, overall results were satisfactory, with some potentially novel outcomes. Relatively few experiments on the combined effects of iron and light availability have been performed in the field (Boyd et al. 1999, Maldonado et al. 1999). Additionally it is not known of any previous work including extensive measurements of PSII characteristics within such a framework. Preliminary results from experiment 1 are presented in Fig. 12.3. This experiment was of further interest as the incubation water was sampled within a relatively large bloom of a colonial *Pheocystis* spp.

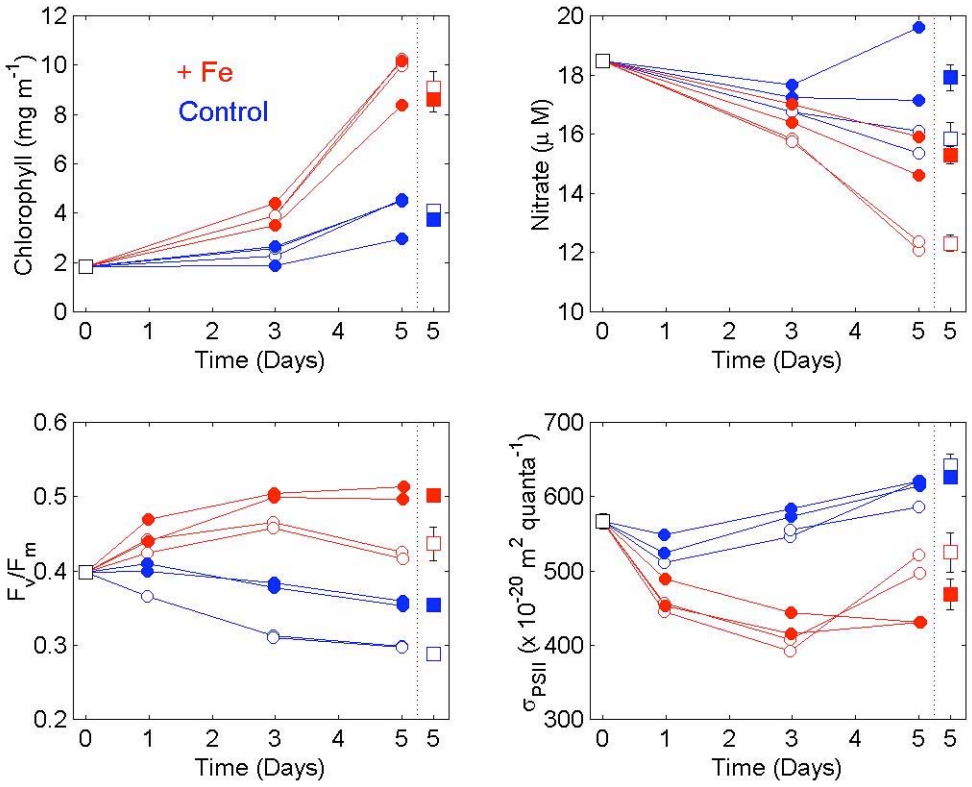


Fig. 12.3 Results from nutrient addition bioassay experiment '1'. A clear response to iron addition is observed. Distinct responses in nutrient drawdown and PSII characteristics (F_v/F_m and σ_{PSII}) to both iron availability and light level were also observed.

D286 **Anna Hickman, Mike Lucas, Sophie Seeyave**

Nutrient addition bioassay experiments were performed following the protocols designed and conducted by Mark Moore on Leg 1.

A highly replicated design was used to investigate the inter-dependence of iron and light availability on phytoplankton physiology, growth and nutrient drawdown. Original plans to incorporate silicate additions as a further factor were abandoned on Leg 1 due to the increased logistical problems and time constraints involved in performing experiments of twice the size.

As with all work involving manipulation of iron availability for phytoplankton populations, strict controls were required to avoid contamination of incubation containers and sampled water. Incubations were performed in 2 l polycarbonate bottles which had passed through a rigorous cleaning process prior to Leg 1 (involving a Decon wash and soaking in 50% HCl for 1 week, followed by rinsing then storage with acidified Milli-Q prior to sailing). On both the return and outward passages between Leg 1 and Leg 2 bottles were rinsed with 10% HCl, rinsed and subsequently stored with acidified Milli-Q. Between experiments all bottles were cleaned with 10% HCl and rinsed with milli-Q. All samples were collected from the titanium CTD (ti) rig.

The experimental design involved the incubation of 20 bottles in 4 sets of 5 replicates, one set each for high light (control and +Fe) and low light (control and +Fe). Two of the five replicate bottles were sub-sampled approximately every 2 days. The remaining three replicates remained sealed until the 5-6th day as a check that sub-sampling had not contaminated the time-series measurements. Such a strategy also provides more robust statistics and a large volume of water for an additional suite of final measurements.

Table 12.7 Sampling for bioassay experiments on D286

	Expt. 5	**Expt. 6**	**Expt. 7**	**Expt. 8**
Sampling location	**M10**	**M3**	**M2**	**M3**
Sampling method	Ti CTD Station 15561 Depth, 25m	Ti CTD Station 15592 Depth, 25m	Ti CTD, Station 15602 Depth, 40m	Ti CTD, Station 15621 Depth, 20m
Bottle set	1	1	1	2
Start point	1845 GMT, JD 355	1400 GMT, JD 366	1600 GMT, JD 006	1800 GMT, JD 010
End point	1700 GMT, JD 361	1700 GMT, JD 005	1700 GMT, JD 012	1630 GMT, JD 015
Initial chlorophyll concentration	0.79 ± 0.05	0.78 ± 0.01	0.36 ± 0.02	4.84 ± 0.07
Initial Nitrate concentration	20.78 ± 0.10	22.87 ± 0.14	21.47 ± 0.02	18.40 ± 0.07
Initial Silicate concentration	1.11 ± 0.01	2.89 ± 0.02	2.02 ± 0.01	0.12 ± 0.02
Comments	Replication good, clear but minimal +Fe response	Replication poor, minimal +Fe response	Replication good, minimal +Fe response	Replication good, clear +Fe response in early stages.

Sampling of the time-series was routinely performed for chlorophyll, ambient macronutrients (N, P and Si) and PSII characteristics as measured by FRRf. Additional sampling at the beginning and end time points consisted of ^{14}C P vs E determinations, POC/PON and preservation of samples in lugols iodine for phytoplankton counts. Samples were also filtered for dissolved iron measurements at the beginning and end of the experiments.

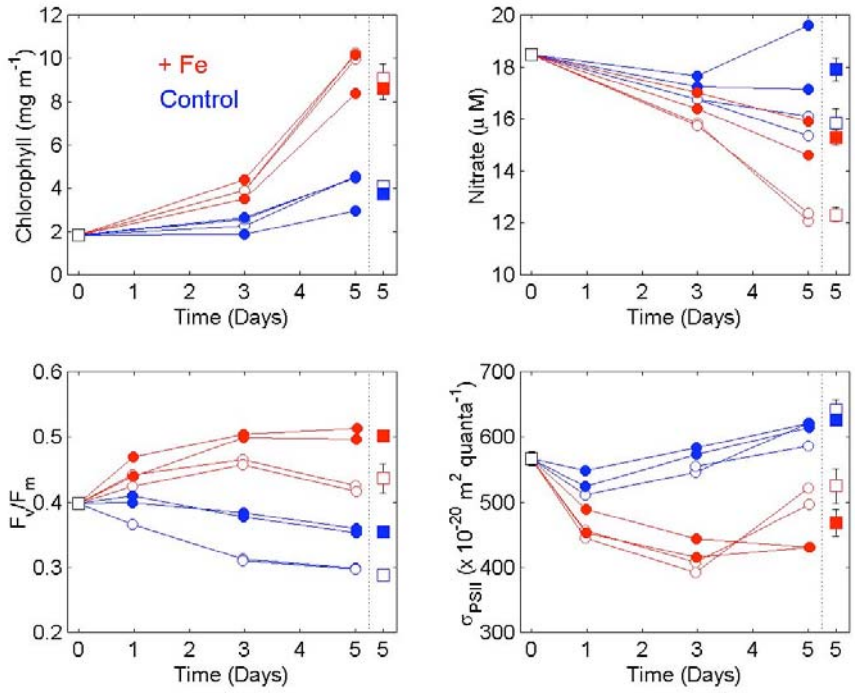


Fig. 12.4 Results from nutrient addition bioassay experiment '5'. A clear iron response is observed, although there is minimal difference between incubations of high and low light levels.

A total of four experiments lasting 5-6 days each were carried out during Leg 2. A complete list of experiments along with sampling locations and initial conditions is provided in Table 12.7. Preliminary results from all experiments are promising, showing no sign of contamination of samples. Preliminary results from Experiment 5 are shown in Fig. 12.4.

References:

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Moore, C.M., Lucas, M.I., Sanders, S., and Davidson, R., (2004) Basin-scale variability of phytoplankton bio-optical characteristics in relation to bloom state and community structure in the Northeast Atlantic. *Deep-Sea Res. I, In press*

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12.3 Phytoplankton sampling from stainless CTDs

Robert Williamson, Mike Lucas, Mark Moore

Without exception, all stainless steel CTD deployments in our survey area were successfully sampled for the core state variables of POC/N, HPLC, Chl-a, BSi, PIC & preserved plankton. In addition, a number of the stainless steel ^{234}Th CTD casts were sampled for chl-a and POC/N when requested by the Paul Morris. The six light depths sampled from the Ti-CTD at Primary Production stations were sampled for size-fractionated chl-a (total, >20µm, >2µm) determinations. Typically, POC/N, HPLC, Chl-a, BSi and PIC samples were collected from 12 standard depths to 500m. Size-fractionated samples (total, >20µm, >2µm) were also routinely collected from two depths, normally at 10m and the chl-a max. (range: 40-80m). Preserved samples for phytoplankton (200mls Lugol's & 200mls Buffered Formalin) and for micro-zooplankton (200mls Buffered Formalin) were also routinely collected at the size-fractionated depths on the stainless steel CTD's. Stainless steel CTD's associated with the major T-CTD primary production stations are coupled with the appropriate Ti-CTD in the Log (see attached Table.).

Sample Collection

Approximately 10L of water was collected from the stainless steel CTD in a light-shaded 10L plastic container for each appropriate depth. These samples were the last to be decanted from the CTD and were used to obtain all the above-mentioned variables. The container was agitated before being sub-sampled each time for the variables sampled.

POC/N

Samples were filtered onto pre-ashed 25mm GF/F filters by low vacuum (300-400hPa) filtration. The volumes used for filtration were dependent on the amount of phytoplankton present at each station. Stations with high concentrations, especially of *Phaeocystis*, required lower volumes in order to prevent the filters from clogging. Typical volumes filtered were 1000ml for the upper mixed layer and 2000ml below. Where filters became clogged the remaining unfiltered volume was measured and subtracted from the initial sample volume to obtain a net sample volume filtered. Filters were placed in labelled petri-dishes and stored at -20°C. These samples will be analysed back at SOC.

Size fractionated POC/N

For each specified depth, 2L was filtered through a 20µm mesh sieve. 1L of the <20µm particle water was collected onto an ashed GF/F to obtain a <20µm fraction. The remaining 1L was filtered through a 2µm polycarbonate membrane filter and the collected water was then filtered onto an ashed GF/F to obtain a <2µm fraction. Samples were stored as above.

HPLC

Filtered samples for HPLC were collected onto regular GF/F filters from 1000ml volumes except where phytoplankton biomass was high enough to clog the filter. In such cases filtered volumes were calculated as for POC/N. HPLC was only collected up to station 15504 from the stainless steel CTD's. However, all of the primary production sample stations (15491, 15496, 15499, 15502, 15511, 15516, 15524, 15531, 15537 & 15543) had water collected at 6 depths per station for HPLC (or pigments) as part of the 15N experimental protocol. HPLC filter samples were stored on-board at –80°C and will be analysed back at SOC.

Chl-a

More than 1200 samples were filtered (by RW & MIL) and read by Mark Moore on the Turner fluorometer. He asks that this stupendous effort of his is duly recognised! (Beers?) The volumes sampled were again dependent on phytoplankton concentrations but were predominantly 200ml or 100ml in higher chl-a water. Samples were collected onto 25mm GF/F filters under low vacuum filtration. Each filtered sample was placed in a 20ml glass scintillation vial with 10ml of 90% acetone added. Vials were stored in a fridge for 24 hours before fluorometric analysis of the extracted pigment was made.

Size fractionated Chl-a

200ml was initially filtered onto 2, 10 and 20µm polycarbonate membrane filters but later the >10µm fraction was deemed unnecessary. Samples were stored and measured as above.

BSi

These samples were obtained by filtering between 250-1000ml onto 37mm 0.4µm polycarbonate membranes. Volumes filtered depended greatly on planktonic concentrations at each station. Clogging occurred frequently and net volumes were calculated as for POC/N. Collected samples were placed in 20ml plastic scintillation vials and stored at -20°C on board. It is our intention on the 2nd Leg of Crozex to analyse the BSi samples on-board (Megan French).

Size fractionated BSi

Volumes associated with total BSi were filtered onto 20µm polycarbonate membranes and stored as above. A very few <2µm samples were taken at the start of the cruise.

PIC

Filtration methods were the same as for BSi except that a small un-measured volume of Potassium Tetraborate (buffer) was used to rinse the 0.4µm membrane after the seawater sample had been filtered. The filtered sample was stored in 20ml plastic scintillation vials and stored at ambient temperatures on board.

Size fractionated PIC

Fractions of >20µm and >2µm were derived from filtering samples onto 20 and 2µm membrane filters. Again, Potassium Tetraborate was used to rinse the membrane and the sample was stored as above.

13. Mesozooplankton measurements

13.1 Mesozooplankton abundance, gut fluorescence, feeding and iron content

Sophie Fielding, Claudia Castellani, Alan Hughes, Tania Smith

Mesozooplankton analysis overview and objectives

The objective of the mesozooplankton group was to study the population structure of mesozooplankton in high chlorophyll and HNLC waters, its feeding rates, herbivorous grazing rates and iron content. There were three specific aims.

1) To estimate the contribution of zooplankton to the vertical carbon flux in the study area through grazing on the phytoplankton standing stock.

2) To estimate the potential impact of *Oithona* on retarding vertical carbon flux (through feeding on faecal pellets) and its role within the microbial food web (through selective predation on microzooplankton).

3) To investigate whether mesozooplankton promote the recycling of iron in HNLC regions and iron export on the Crozet Plateau

Vertical net sampling

Mesozooplankton samples were collected at each CTD station (Table 13.1) to examine the species, stage and size structure of the zooplankton community, and to provide undamaged animals for gut fluorescence measurements, feeding experiments and iron content.

The zooplankton standing stock was sampled using a 63 μm mesh size net (single or bongo) and a single WP-2 200 μm mesh sized net towed vertically from between 200 and 100 m depth to the surface (Table 13.1). During cruise D285 the nets were deployed from the CTD winch gantry, initially off a Kevlar rope on an auxiliary gantry winch. Initial aims were to deploy nets to a depth of 200 m, but it was immediately obvious that we could not fit that much rope on to the new winch. Various trials were undertaken during the cruise to extend the sampling depth to 200 m, but after several efforts it was decided to limit the vertical extent to "semi-reliable" 100 m depth to maintain consistency during the cruise. In addition, there were spooling problems associated with the winch that caused three ropes to part during net deployments (see comments on table). The rope was finally replaced by a plastic-coated wire that, although suffering from similar jamming problems, was patched with PVC tape.

During cruise D286 the nets were deployed from a polyfil rope using an auxiliary winch mounted on the starboard deck. The rope was fed from the winch through a snatch block attached to the starboard gantry. To prevent slack in the wire a heavier weight was used attached to the net. All deployments were successful and only the one piece of rope was required.

Mesozooplankton species abundance and size fractionation

The zooplankton samples for abundance and speciation were immediately concentrated by sieving through an appropriate filter and fixed in 4 % buffered formaldehyde. Zooplankton species, stage and size structure will be examined on return to the laboratory.

Gut fluorescence

A separate WP-2 200 μm net was undertaken at each CTD station to provide live animals for gut fluorescence analysis. The net sample was diluted into a 10 l bucket with surface water from the non-toxic supply, gently mixed and aliquots of approximately 500 ml were immediately filtered on a 125 μm mesh and frozen at -20˚ C. Each sample was then defrosted in low light and four zooplankton size fractions (large (>3.5 mm), medium (2.6 – 3.5 mm), small (1.2 – 2.5 mm) and very small (<1.2 mm)) were picked and placed into 6 to 10 ml of acetone (varied during the cruise because of chemical quantity constraints) for chlorophyll extraction. Between 10 and 50 individual zooplankton were placed in each vial of acetone, depending on size class. The vials were then placed in the -20˚ C freezer, and left to extract for between 20 and 24 hours. The chlorophyll concentrations were determined fluorometrically in the same way as for filtered chlorophyll samples (see primary productivity and chlorophyll section of this cruise report). Preliminary results from D285 showed that the gut chlorophyll concentrations per animal were relatively constant for the smallest size classes (<1.2 and 1.2 – 2.5 mm), whilst the larger size classes were more variable. During D286 gut fluorescence values were far lower than D285 in all size classes except at diatom blooming station M3. In addition it was often difficult to find copepods that fitted within the large and medium size range.

Oithona similis feeding experiment

We have carried out 8 experiments (see Table 13.1) on the feeding *Oithona similis*. Zooplankton was collected using a 63 μm net and the catch diluted in a 10 l bucket with water from the non-toxic supply. Feeding rates on the different nano and microplanktonic groups were estimated by incubating 10 to 15 *O. similis* adult females, in 200 ml glass amber bottles filled with water from the Chl *a* maximum. Three replicates and three control bottles were incubated on a plankton wheel (1 rpm) for 24 h in the dark at the mixed layer temperature. An additional bottle was filled and immediately fixed to estimate the nano and microplankton concentrations at the start of the experiment. At the end of the experiment lugol's iodine was added to the bottles to obtain a final concentration of 2 % (Nielsen & Kiørboe 1994). The samples will be analysed back in the laboratory.

Iron content analysis

Water was drawn either from the iron fish (coming onto station) or from the titanium CTD at the chlorophyll maxima. Replicates of between 1 and 4 litres was filtered onto pre-weighed 0.4 and 10 μm acid-cleaned polycarbonate filters for analysis of particulate iron concentration on return to the laboratory. These filters were fast-frozen and stored in the -20˚ C freezer. These measurements will be used in concert with C:N and biogenic Si measurements taken by the primary productivity group.

At each of the "iron" stations a net sample was taken to catch live animals using, where possible due to wind constraints, a plastic net. Between 3 and 80 zooplankton (typically *Rhincalanus gigas*, *Calanus* sp., amphipods and euphausiids) were incubated in 0.4 μm filtered seawater for 6-12 hours. These zooplankton were fast-frozen and stored in the -20˚ C freezer for analysis of iron and carbon content on return to the laboratory. The incubation water was then filtered onto a pre-weighed acid-cleaned 2 μm filter to collect any faecal material (and the filter frozen). However, only once did there appear to be faecal material retained on the filter. All volume filtered and zooplankton picked are given in the Table 13.2.

Table 13.1 Mesozooplankton stations

Station	Depth (m)	Abundance		Gut fluor	Feeding	Iron	Comments
		63 μm	200 μm				
D285							
15498	150	√	√				
15490	150	√*	√				*Kevlar rope parted
15493	100	√	√	√			
15494	100	√	√	√			
15495	100				√	√*	*plastic net
15498	100	√*	√	√			*To 200 m depth, rope parted
15499	100					√*	*plastic net
15500	100	√	√*				*To 200 m depth, rope parted
15502	100	√	√	√			
15506	100	√	√	√*			*wrong mesh used
15507	100	√	√	√			
15511	100				√	√*	*plastic net
15513	100	√	√	√			
15516	100	√	√	√			Very windy
15518	100				√	√*	*metal net due to wind
15520	100	√	√	√			
15525	100	√	√	√*			*aborted due to cable split
15526	80			√	√	√*	*metal net due to wind
15527	100	√	√	√			
15528	100	√	√	√			
15532	100	√	√	√			
15534	100					√*	*metal net due to wind
15538	100	√	√	√		√*	*metal net due to wind
15542	100					√*	*metal net due to wind
15543	100	√	√	√			
15545	100	√	√	√			
15546	100	√	√	√			
15547	100	√	√	√			
15548	100	√	√	√			
D286							
15552	100	√	√	√			New winch system
15554	100					√	Metal net due to winch
15556	100	√	√	√			

15557	100	√	√	√			
15562	100					√	Metal net due to winch
15563	100	√	√	√			
15565	100						Abandoned due to wind
15567	100	√	√	√			Very windy
15568	100		√	√			Baie Americane
15570	100	√	√	√			
15574	100	√	√	√		√	Metal net due to winch
15579	100		√	√√√			4 gut fluor samples
15580	100		√	√			
15581	100		√	√			
15582	100	√	√√	√√		√	#2#3 delayed freezing for 4 hours. Metal net due to winch
15584	100	√	√	√			
15585	100	√	√	√			
15586	100	√	√	√			
15589	100	√	√	√			
15596	100	√	√	√			
15598	100		√√	√√			
15599	100					√	Metal net due to winch
15605	100	√	√	√		√	Metal net due to winch
15609	100		√	√			
15610	100		√	√			
15613	100	√	√	√		√	Metal net due to winch
15621	100	√	√	√		√	Metal net due to winch
15623	100	√	√	√			
15629	100	√	√	√		√	Metal net due to winch
15632	100						Net for additional samples

Table 13.2 Mesozooplankton sampling for iron content

Station	Uway/CD	10 µm filters	0.4 µm filters	Zooplankton picke	Fecal material	Comments
D285						
15491	Uway	2 l C50 20.27 2 l C43 20.89	1 l A92 16.13 1 l A80 15.80	Nets aborted	X	Polysulphone rig
15495	Uway	4 l C36 20.34 4 l C42 15.65	2.5 l A94 16.27 2.5 l A91 15.94 2.5 l A95 15.65	B44 33.47 B46 33.43 B50 33.10 B15 32.73 3 x 10 R.g*	X	Teflon rig Polysulphone used
15499	40 m	3 l C25 20.44 3 l C30 20.37	3 l A79 15.73 3 l A88 15.83	2 x 8 R.g 1 x 7 R.g 1 x 9 R.g 1 euphausiid	X	Teflon rig Polysulphone used
15511	Uway	4 l C31 20.53 2 l C41 20.74	4 l A78 15.67 2 l A73 16.10	18 R.g 20 R.g 15 R.g 6 R.g 2 amphipods	X	Si/C/N taken 1.5 l in 10 µm 2 x 1 l in 0.4 µm 2 x 1 l GF/F 1 l <10µm GF/F
15518	80 m	4 l C24 20.66 4 l C29 20.49	3 l A77 16.36 3 l A61 16.09	22 R.g 27 R.g 2 euphausiid	B91 32.2 From 33 R.g	Potential contamination fron polysulphone rig identified
15526	35 m	2.5 l C28 20.29 2.5 l C44 20.42	1.5 l A65 15.86 1.5 l A87 15.73 1 l A62 16.19	22 R.g 5 R.g	B94 33.1	Fibres removed fro 2 µm filter
15534	25 m	4 l C49 19.40 3 l C20 21.03*	2 l A52 15.88 2 l A63 15.87	8 R.g		* prob. filtering not many R.g
15538	35 m	2 l C26 20.56 2 l C38 20.48	1.5 l A82 16.07 1.5 l A74 16.49	2 euphausiid 2 amphipod 10 R.g, 18 R.g, 6 R 17 R.g	B97 33.0	17 copepods incubated (no fecal material)
15542	55 m	2 l C16 20.87 2 l C17 19.60	0.5 l A81 15.66 0.5 l A84 16.12*	3 R.g 7 Cal	X	* dropped pot. contamination

			0.5 l A76 15.80			
D286						
15552	15 m	3 l C21 20.07 3 l C45 20.25	2 l A51 15.54 2 l A96 15.94	2 x 3 x 15 CV Cal	X	
15561	35 m	3 l C48 20.55 3 l C33 20.43	2 l A72 16.16 2 l A98 16.33	2 x 5 amphipods 2 x 15 Cal	18 Cal B42 33.0 11 Cal B48 32.5	
15572	25 m	3 l C22 19.82 3 l C6 20.16	2 l A90 16.12 2 l A81 16.37	3 x Cal, 5 R.g (Fe) 3 x Cal, 5 R.g (C:N)	X	
15581	40 m	2 l C34 20.71 2 l C37 20.38	2 l A99 16.26 2 l A85 15.81	3 x 10 Cal (Fe) 3 x 5 Cal (C:N)	X	
15592	25 m	3.5 l C8 20.11 3.5 l C11 20.50	2 l A69 15.58 2.5 l A68 16.25	3 x 10 Cal, 10 R.g (3 x 5 Cal, 8 R.g (C:	X	
15598	40 m	3 l C19 20.34 3 l C12 20.04	2.5 l A56 15.40 2.5 l A55 15.73	3 x 10 Cal, 3 x 10 R (Fe) 3 x 5 Cal, 5 x 5 R.g (C:N)	X	
15602	40 m	3 l C1 20.67 3 l C2 18.89	2.5 l A70 16.01 2.5 l A54 15.72	2 x 10 + 8 Cal, 3 x R.g (Fe) 3`x 5 Cal, 3 x 5 R.g (C:N)	X	
15613	20 m	1 l C9 20.89 1 l C5 19.97 1 l C4 20.44	1.5 l A59 16.318 1.5 l A60 15.85	3 x 10 Cal, 3 x 10 R (Fe) 3 x 5 Cal. 3 x 5 R.g (C:N)	X	Smoke (from AC unit) contanimatio possible
15621	12 m	1 l C10 20.33 1 l C40 20.85	1.5 l A64 15.46 1 l A57 15.45	3 x 10 Cal, 3 x 10 R (Fe) 3 x 5 Cal, 3 x 5 R.g (C:N)	X	
15629	20 m	1.5 l C35 20.46 1.5 l C13 20.84	1.5 l A49 15.66 1.5 l A53 15.59	3 x 10 Cal, 3 x 10 R (Fe) 3 x 5 Cal, 3 x 5 R.g (C:N)	X	

*R.g = *Rhincalanus gigas*

*Cal = *Calanus* species

13.2 Longhurst Hardy Plankton Recorder (LHPR) Tow Sophie Fielding

The LHPR is a vehicle designed to be towed in a single V-shaped profile through the upper 400 m of the water column. It has a large aluminium frame, with a polypropylene tail fin, which houses a conical net. A nose cone at the front of the frame channels water through the 333 μm conical net to a cod-end. The cod-end contains two spools of gauze which wind round a take-up spool every two minutes (set on the instrument), sandwiching a sample of zooplankton between them, thus allowing semi-discrete samples. Attached to the frame, one each side, are two cylinders containing a rechargeable battery pack and the electronics for driving the cod-end, monitoring the sensors (in our case these were a Seabird conductivity meter, temperature probe, depth sensor and flowmeter) and communicating with the surface. To assist the sampler to dive a 45 kg depressor weight is attached to the underside front and a drogue streams from the back of the frame to assist stability and maintain a horizontal aspect.

During D285 only one LHPR tow was achieved due to weather constraints, whilst during D286 four deployments were achieved (Table 13.3). The deployment of the LHPR was from the main A frame, over the stern of *Discovery*, using the main trawl wire. As the trawl wire has no conducting core the LHPR was run in internal logging mode. The maximum duration of the LHPR tow in this mode is 180 minutes (the data holding capacity of the sensor cylinder before overwriting), including deployment and recovery: to err on the side of caution the tow was limited to a maximum of 150 minutes. This deployment was the first time I had used the LHPR on the trawl wire and the first time it has been deployed since the ship became responsible for driving the winches. As a result a 10 minute delay before the first wind-on of the gauze was added for the first haul to allow time for deployment and the wire-out was limited to 900 m to ensure the LHPR did not travel too deep in the water. The LHPR was held just below the surface for 10 minutes to allow the gauze to wind-on before the wire was payed out at ~15 m/minute until the frame became steady in the water, where wire-out speed was increased to 30 m/minute. The LHPR was held at the bottom of its tow (900 m wire out on the first deployment and 1200 m on subsequent deployments) for 6 minutes before hauling in at 30 m/minute. The ships speed was 4.5 knots during paying out and decreased to 3.5 knots during hauling in. The subsequent four tows were deployed with a five minute wind-on delay.

Upon retrieval, the cod-end was removed from the frame. The third spool, holding the sandwiched zooplankton, was placed in a bucket containing 4% formaldehyde and then both net and cod-end were washed and reset in preparation for the next tow.

Table 13.3 LHPR tows

Station No.	Date/Jday	Time deployed GMT	Time recovered GMT	Depth M
15505	20/11/04 325	10:18	12:22	290.8
15559	20/12/04 355	11:47	13:54	375.6
15578	26/12/04 361	08:38	10:56	379.9
15607	07/01/05 007	03:54	06:07	346.5
15625	12/01/05 012	13:30	15:38	327.4

14. Benthic studies

14.1 Megacoring — Alan Hughes, Ben Boorman

D285

Three Megacore deployments were carried out at Station M6 (15510#1, 15510#2, and 15510#3) on 22/11/2004 (Julian Day 327). The Megacorer was deployed with eight core tubes on each deployment, and recovered three, four and five cores on subsequent deployments. The cores ranged in depth from 9 to 22 cm, with the average depth approximately 14 cm. The shallow depth of some cores necessitated that were removed from the corer using the "open top method". The cores contained light brown calcareous oozes; the colour was consistent throughout the cores, with no obvious redox potential discontinuity layers. All cores contained small patches of black sediment at various depths, suggesting the presence of anoxic microenvironments. Several cores contained lateral macrofaunal burrows to 10 cm sediment depth. Preliminary microscopic examination of the sediments revealed the presence of large numbers of planktonic foraminiferal tests in the sedments.

Table 14.1 Details of Megacorer deployments on D285

Sample	Water Depth (m)	Number of cores recovered	Comments
15510#1	4201	3	One core sectioned to 10 cm for meiofauna.
			The other two cores were too disturbed to be used.
15510#2	4217	4	One core sectioned to 10 cm for meiofauna.
			One core sectioned to 10 cm for lipid analysis.
			One core sectioned to 5 cm for particle size analysis.
			Surface sample taken for cyst analysis.
			One core to be used by Dr. Peter Statham (SOC) for iron flux experiments
15510#3	4220	5	One core sectioned to 10 cm, and one to 5 cm, for meiofauna.
			One core sectioned to 10 cm for lipid analysis.
			One core to be used by Dr. Peter Statham (SOC) for iron flux experiments.
			One core was too disturbed to be used.

In total, seventeen Megacorer deployments were carried out during the cruise: nine at Station M5, six at Station M6, and two at station M10. These are in addition to the three deployments carried out at M6 during D285. The cores were used for a variety of purposes, outlined below.

The overall poor performance of the Megacorer was disappointing. This may be attributed to a combination of the sediments in the area, together with problems with the Megacorer itself.

D286 M5

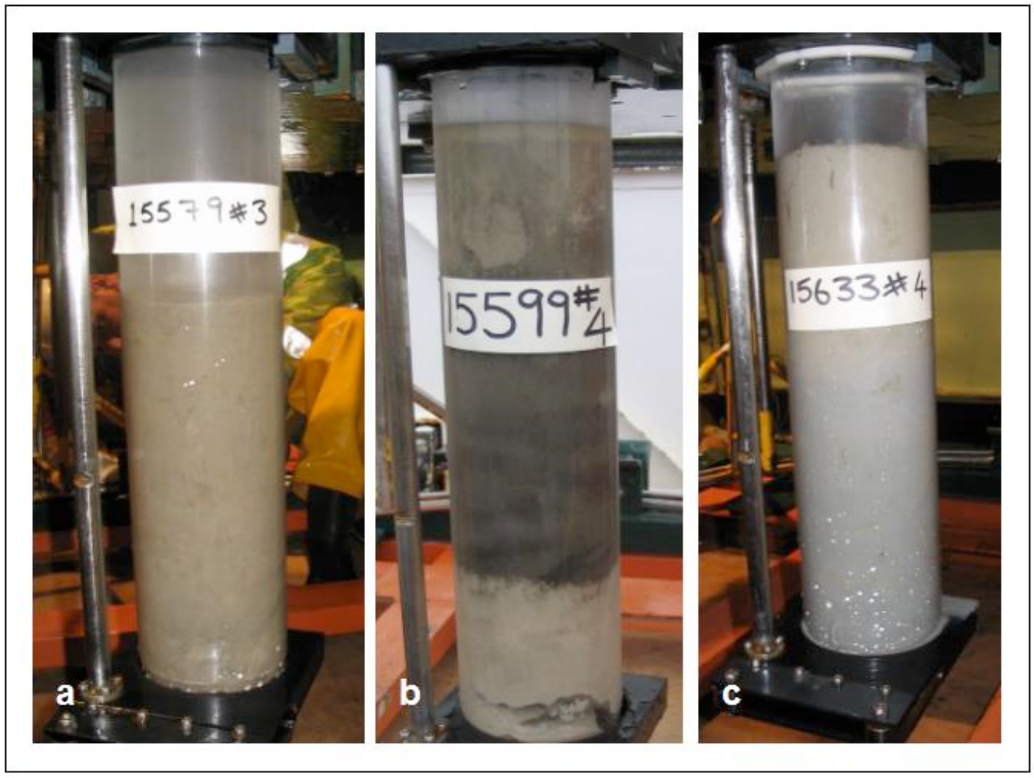


Fig. 14.1 Photographs of representative cores from a) Site M5 (15579#3), b) Site M6 (15599#4), and c) Site M10 (15633#4). The core tubes have a 10 cm diameter.

The cores ranged in depth from 12.5 to 34.5 cm, with the average depth approximately 23 cm. The cores contained light brown calcareous oozes; the colour was consistent throughout the cores, with no obvious redox potential discontinuity layers (Figure 1a).

D286 M6

The seven good cores obtained at M6 varied from 14 to 57 cm deep, with the average depth 42 cm (Figure 1b). All of the cores contained a soft, very pale brown surface layer about 1 cm thick. The sediments got steadily darker with depth, with a series of darker layers, gradually turning black at around 30 cm, although the exact depth varied between cores. In all the deeper cores, there was a "white band" (3 – 9 cm deep) at 35 to 50 cm sediment depth.

D286 M10

The four good cores obtained at M10 varied from 36.5 to 39 cm sediment depth. All cores contained homogeneous grey mud (Figure 1c).

Table 14.2 Details of the Megacorer deployments at M5, and the fate of the cores obtained. From deployment 15577#3 onwards, the Megacorer was deployed with eight multicorer weights attached to corer head.

Sample	Date	Water Depth (m)	Number of cores recove	Comments
15577#1	25/12/2004	4269	0/8	
15577#2	25/12/2004	4269	0/6	
15577#3	25/12/2004	4269	3/4	All cores too disturbed to be used.
15579#2	26/12/2004	4269	3/4*	One core sectioned to 10 cm for meiofaunal studies.
				One core was lost while removing it from the Megacorer.
				One core was too disturbed to be used.
15579#3	26/12/2004	4269	3/4*	One core sectioned to 10 cm for meiofaunal studies.
				One core sectioned to 10 cm for lipid analysis.
				One core was used for pore water studies.
15579#4	27/12/2004	4268	4/4*	One core sectioned to 10 cm for meiofaunal studies.
				One core sectioned to 10 cm for lipid analysis.
				One core was used for pore water studies.
				One core was sectioned for biomarkers.
15582#6	28/12/2004	4270	4/4*	One core was sub-sampled for pigment analyses and a syrin sub-sample taken for meiofauna.
				One core sectioned to 10 cm for lipid analysis.
				One core sectioned to 20 cm for thorium profiles.
				One core was used for gel probe studies.
15582#9	28/12/2004	4269	4/4*	One core was sub-sampled for pigment analyses and a syrin sub-sample taken for meiofauna.
				One core was used for gel probe studies.
				One core subsampled with syringe subcores for thorium profiles.
				One core frozen whole.
15582#10	28/12/2004	4267	0/4*	

Table 14.3 Details of the Megacorer deployments at M6, and the fate of the cores obtained. The Megacorer was deployed with extra weights attached to the head in all deployments.

Sample	Date	Water Depth (m)	Number of cores recove	Comments
15597#1	04/01/2005	4221	1/4	One core was sub-sampled for pigment analyses and a syringe sub-sample taken for meiofauna.
15597#2	04/01/2005	4222	1/4	One core was used for pore water studies.
15597#3	04/01/2005	4218	1/4	This core was frozen whole.
15599#4	05/01/2005	4221	4/4	One core was sub-sampled for pigment analyses and a syringe sub-sample taken for meiofauna. One core sectioned to 3 cm for lipid analysis. One core was used for pore water studies. One core was used for gel probe studies, then syringe sub-samples were taken for Thorium studies.
15599#5	05/01/05	4224	0/4	The corer heads failed to fire.
15599#6	05/01/05	4223	0/4	The corer heads failed to fire.

Table 14.4 Details of the Megacorer deployments at M10, and the fate of the cores obtained.

Sample	Date	Water Depth (m)	Number of cores recove	Comments
15633#4	15/01/2005	2955	3/4	One core sectioned to 20 cm for thorium profiles. One core was used for pore water analyses. One core was used for gel probe studies.
15633#5	15/01/2005	2935	3/4	One core was sectioned to 6 cm for pigment analyses. The other two cores were too disturbed to be used.

Analysis of the Cores

Meiofaunal Studies – Alan Hughes

Cores were sectioned to 10 cm sediment depth, and fixed in buffered 4% formalin. On return to the laboratory, these samples will be wet-sorted for benthic foraminifera, including soft shelled and agglutinated taxa, as well as metazoan meiofauna. Syringe sub-cores (2.9 cm internal diameter) were also taken from four cores. These were sectioned in 1 cm layers (0-5 cm), and fixed in buffered 4% formalin. The samples will be used in the study of live (= rose Bengal stained) and dead calcareous foraminiferal assemblages.

Frozen Cores – Alan Hughes

Entire cores were frozen from both M5 and M6. These will be used for geological analyses.

Thorium Profiles – Ian Salter

One core was sectioned to 20 cm and frozen. All remaining cores were sub-sampled with syringe cores to 5 cm and sectioned at 1 cm intervals. I attempted to use syringe cores for Thorium analysis but there was too much material for the filter. On return to the laboratory, cores will be analysed for major biogenic components.

Pigment Analyses – Tania Smith

The surface layers of the cores (5mm) were taken and frozen immediately at -80 ^{o}C. HPLC analysis for pigments will be carried out at SOC. These samples will give preliminary results ahead of the benthic CROZEX cruise in December 2005. The objective of my work is to look at the essential compounds available to deep-sea megafauna and how this may effect the community structure and biodiversity. During the Benthic CROZEX cruise Dec 2005 I will trawl for megafauna and compare what the megafauna are consuming with what is available to them, as well as comparing the two contrasting sites, M5 and M6.

Lipid Analyses – for George Wolff (University of Liverpool)

Cores were sectioned to 10 cm sediment depth, and frozen at –80 ^{o}C. On return to the laboratory these samples will be used to compare the biochemical and isotopic composition of carotenoids, steroids and other lipids in sediments at the two stations.

Gell Probe – Gary Fones

See section 14.6 on sediment geochemistry.

Pore Water Analyses – Sarah Taylor

See section 14.6 on sediment geochemistry.

14.2 Gravity coring — Ian Waddington, Richard Sanders

Gravity cores were collected on D286 for Rachel Mills (SOES) for her "PaleoCROZEX" contribution to CROZEX. PaleoCROZEX aims to evaluate a range of proxies for upper ocean processes including carbon export with the ultimate aim of reconstructing water column productivity above the crozet plateau back to the last glacial maximum and use the spatial variability in iron supply and productivity across the Crozet plateau as an analogue for the transition between high and low productivity observed elsewhere in the Southern Ocean. It requires the collection of mega and gravity sediment cores, saps samples and sediment trap material from a range of sites across the plateau.

Eight gravity cores were recovered for use in PaleoCROZEX. The technical details of the acquisition are given below and the Table 14.5 summarises the samples obtained. Three were from M5, the longest was 1m and had a layer of granular black material at the core base. Two were from M6, the longest was 1.2m and had extensive white bands in it. Three were from M10, the longest was 1.5m and had no slumping or fracturing. A dark band was apparent at the base of the core but no other features were noted. The cores were stored at 4°C in a vertical position until the surface water had evaporated. At that point they were cut off close to the core top and recapped for transport back to the UK in a chilled environment.

Table 14.5 Gravity cores recovered

Core ID	Site	Lat	Long	Date	Length	Comments
CROZ1	M5	46°S	56°09'E	27/12/04	30cm	
CROZ2	M5	46°	56°09'	27/12/04	1m	Black stuff in base of core retained cutter
CROZ3	M5	46°	56°09'	27/12/04	70cm	
CROZ4	M6	49°	51°20'	5/1/05	80cm	
CROZ5	M6	49°	51°20'	5/1/05	1.2m	White bands
CROZ6	M10	44°31.5'	50°	15/1/05	Ca 150cm	Slumped extensively in liner
CROZ7	M10	44°31.5'	50°	15/1/05	Ca 50cm	Very short and water logged
CROZ8	M10	44°31.5'	50°	15/1/05	Ca 150cm	No slumping or fracturing

Coring technicalities

The Gravity corer was test assembled and a system of deployment and recovery tested in Port Elizabeth whilst the ship was alongside after D285. A chain lifting strop was made up from mooring components to lift the corer horizontally when moving deck position. Planking was laid within the rail track used for CTD deployment to provide a flat surface and reduce the possibility of tripping over the track. A new wooden coring head cradle and core barrel stands were manufactured at sea, by Ben Boorman. Coring parts were all serviced onboard with the catchers being re-fashioned and the cutter heads being cleaned and machined.

On the 27th December the series of gravity coring operations commenced using procedures as practised in Port Elizabeth, no changes were required to the methods of handling. Details of the 8 gravity cores obtained at 3 stations follow.

Methods

The method developed in Port Elizabeth was to use the auxiliary winch in conjunction with the main coring warp to lift the corer complete with 2 metre barrel horizontally from its stand over the starboard bulwark. The auxiliary winch then paid out to deploy the corer to the vertical position on the main coring warp. The auxiliary winch wire was then disconnected and the corer lowered to the sea surface at which point the metering was zeroed. The coring winch was then deployed to attach a 1 second repetition 10 kHz beacon. Deployment commenced with pay out at 90 metres a minute and was adjusted through the deployment. Details of each deployment follow.

Station number 15579 # 7 commenced at 0600 gmt with the corer being lowered into the water using the midships system and coring warp .

Time gmt	Depth metres	Winch speed metres/min	Wire out metres	Pinger metres	Load tonne
0602	4271	90	825	50m	
0624	4270	100	1550		
0630	4270	110	1991		
0655	4269	Stopped	4150	514	
0706	4269	50	4616	50	3.5
0707	4269	20		20	
0709		Stopped			
0710	4269	Hauling 20			4.0
0715		Hauling 50		77	
0717	4269	Hauling 90		115	

Corer recovered inboard at 0810 gmt

Station 15579 # 9

Time gmt	Depth metres	Winch speed metres/min	Wire out metres	Pinger metres	Load tonne
0854	4268	in water	0	100m	
0900	4268	110			
0953	4268	70	4647	50	
0954	4268	50	4699	10	
0955		20			
0958	4268	Hauling 20			3-3
1005	4268	Hauling 50	4636		4.4
1007	4268	Hauling 50			4.0
1008	4268	Hauling 90	4533		4.0

Corer recovered inboard at 1054 gmt

Station 15579 # 10

Time gmt	Depth metres	Winch speed metres/min	Wire out metres	Pinger metres	Load tonne
1130	4267	0	0	100	
1140	4267	110	1303		
1215	4268	110	4261		3.5
1220	4268	30	4766		3.3
1221	4268	Stopped		10	
1223	4268	Haul 20			3.5
1233	4268	Haul 90		165	
1234	4268	Haul 90		225	4.0
1309	4269	Haul 90	2030		2.1

Corer recovered inboard at 1337 gmt

05/01/05 Station 15599 #1

Time gmt	Depth metres	Winch speed metres/min	Wire out metres	Pinger metres	Load tonne
0301	4220	0	0		0.7
0306		0	100	100	
0309	4222	90			
0323	4222	110	1541		0..9
0403		90	4500	260	3.8
0404	4222	20	4649	100	3.1
0409		Haul 20	4722	10	3.1
0418		Haul 50			4.0
0419	4222	Haul 50	4553	50	4.1
0420		Haul 90	4527		3.9

Core recovered

05/01/05 Station 15599 #2

Time gmt	Depth metres	Winch speed metres/min	Wire out metres	Pinger metres	Load tonne
0540	4210	0	0		0.7
0543		110	300		
0632		60		100	
0635	4210	20	4680	65	3.7
0637		0 stop on bed	4724	15	3.4
0642	4210	Haul 20	4724	15	3.4
0649		Haul 20	4612		4.1
0651		Haul 90	4544		4.1

As ship maintained position when corer on seabed , the corer was left on bed from 0637 gmt to 0642 gmt several and pinger height observed as near constant at 15m off
Core recovered

15 / 01/05 Station 15633#1

Time gmt	Depth metres	Winch speed metres/min	Wire out metres	Pinger metres	Load tonne
0658	2955	0	0		0.7
0727		110	2000		1.8
0742		50	3124	136	2.7
0746		20	3222	80	2.3
0751	2955	0	3300	20	2.4
0754		Haul 20	3210		2.8
0757		Haul 90	3189		2.9

Core recovered - upper soft core slumped along liner tube .

Station 15633#2

Time gmt	Depth metres	Winch speed metres/min	Wire out metres	Pinger metres	Load tonne
0902	2955	0	0		0.7
0940	2955	110	2958	100	2.8
0942		50	3180		
0944		20	3223		2.3
0948		0	3290	28	
0950		Haul 20	3290		2.3
0955		Haul 20	3211		2.8
0956		Haul 90	3170		
0959		Haul 90	3000		2.8

Core recovered - liner removed whilst corer held at angle at bulwark.

Station 15633#3

Time gmt	Depth metres	Winch speed metres/min	Wire out metres	Pinger metres	Load tonne
1109	2955	0	0		
1114		110			
1137		110	2090		1.9
1152		50			2.8
1154		20	3240	80	2.3
1158	2955	0	3300	20	2.3
1201		20	3293		2.8
1209	2955	90	3185		2.8

Core recovered - liner removed in hangar - vertically .

14.3 Bathysnap deployments — Ben Boorman

D285

This gear is a time-lapse camera mooring consisting of an Oceancam 6000s camera and flash, fibreglass mounting frame, release unit and associated weight and buoyancy package. Two of these moorings were planned to be deployed, one each at the two benthic study areas of M5 and M6.

Prior to deployment two release units were wire tested satisfactorily and both cameras were checked. Unfortunately one camera was found to be faulty. After many e-mail consultations with SOC and much cursing a loose grub screw allowing the feed spool to slip was discovered and rectified. However the problems did not end. The camera then locked up, continuing to try to take photos even without power! Eventually the problem cleared and the camera appeared to function normally on the bench.

At the time of the planned first deployment at M5 the camera that had been causing problems was plugged into the flash and did nothing. Even a faulty camera should indicate that it is not functioning correctly. This camera will be returned to the UK for further investigation and a replacement has been requested for Port Elizabeth for deployment on the following cruise. The second camera was fitted to the frame and was successfully deployed. It will take pictures every eight hours for a year and be recovered around Christmas 2005.

Station number	15509 M5
Position	48º 59.81'S 51º 28.67'E
Depth	4202m (uncorrected)
Release unit	Mors S/N 283

D286

Following problems with one camera on D285 a spare unit was flown out to Port Elizabeth for deployment at M6. Unfortunately this unit had recently undergone repairs and had not been pressure tested, nor were any of the working components compatible with any of those from the broken unit. To avoid pressure testing at sea the camera housing from the broken unit was modified to take the new camera. This also obviated the need to splice a new wiring harness.

After some teething troubles a working system was established on the bench with scrap film. However, during loading of the new film the problematic latches again sprang off and consequently the clutches took a lot of rejigging to get the camera to operate successfully. Eventually a working system was established and left running on deck for several days prior to deployment. It will take pictures every eight hours for a year and be recovered around Christmas 2005.

Station number	15583 M6
Position	46º 00.59'S 56º 07.37'E
Depth	4264m (uncorrected)
Release unit	Mors S/N 386

14.4 Sediment chemistry sampling on D286 Sarah Taylor, Gary Fones

The objectives of the sediment geochemistry program were two fold, firstly to calibrate core top proxies for productivity (Opal/calcite/C_{org} accumulation and preservation, authigenic U, Biogenic Ba, 231Pa/230Th) and nutrient utilisation (_^{15}N, _^{30}Si, _^{13}C, Cd/Ca) and to quantify changes through the LGM - recent. All these proxies are affected by sediment focussing, diagenesis, dissolution, dissolution and changing water mass characteristics. Secondly to elucidate trace metal gradients within the sediments using pore waters and gel probes. The cores collected represent a range of productivity and sedimentation regimes which can be coupled to work on the overlying water column.

Table 14.6 Cores for sediment chemistry

Station	Site	Latitude	Longitude	Depth (m)	Date	Time at seafloor (GMT)	# cores
15579#	M5	45°59.97'S	56°08.95'E	4269	26/12/04	21:39	1
C1 - sectioned anaerobically and porewaters extracted for trace metal (SOC) and nutrient (onboard) analysis. Porewaters and solid residue stored at 4°C.							
15579#	M5	45°59.99'S	56°08.93'E	4268	27/12/04	02:14	2
C2 - sectioned for geochemical analysis and stored at 4°C C3 - sectioned for biomarker analysis and stored frozen at -20°C (R. Pancost)							
15582#	M5	45°59.91'S	56°08.94'E	4270	28/12/04	05:41	2
D1 - sampled with DET/DGT probes. Top 5cm subsequently sampled for particle size analysis (A. Hughes)							
15582#	M5	46°00.00'S	56°09.07'E	4269	28/12/04	10:45	2
D2 sampled with DET/DGT probes. Subsequently sampled with 50ml syringe subcores which were then stored frozen at -20°C							
15597#	M6	48°59.98'S	51°20.03'E	4222	04/01/05	10:00	1
C4 - sectioned anaerobically and porewaters extracted for trace metal (SOC) and nutrient (onboard) analysis. Porewaters and solid residue stored at 4°C. Solid sampl stored frozen at -20°C							
15599#	M6	49°00.01'S	51°20.00'E	4268	05/01/05	11:26	2
C5 - sectioned for geochemical and biomarker analysis D3 - sampled with DET/DGT probes and subsequently with 50ml syringe cores which were then frozen (2 – I. Salter, 1- G. Fones)							
15633#	M10	44°31.45S	49°59.86E	3227	15/01/05	15:07	2
C6 - sectioned anaerobically and porewaters extracted for trace metal (SOC) and nutrient (onboard) analysis D4 – Sampled with DET/DGT probes and subsequently with 50ml syringe subcore which were then frozen.							

Samples were obtained from the megacorer deployments carried out by Alan Hughes and Ben Boorman (section 14.1). Cores from site M5 contained light brown calcareous oozes, with no obvious redox boundaries. Cores from M6 contained a soft brown surface layer, darkening to black layer at 15-25cm depth suggesting an anoxic environment, overlying a distinct colour change to a light band 2-9cm thick. This layer contained small stones and grains of a volcanic material. Cores from M10 contained light brown shading to light grey sediment. See Fig. 14.1 for photographs of representative cores.

Porewater analysis

Sediment samples for pore water analysis were extruded in a glovebag in which a nitrogen atmosphere has been established and transferred to 125ml centrifuge bottles. The centrifuge bottles were capped in the glovebag, then removed and centrifuged at 3000rpm and 4°C for 30 minutes. The bottles were reopened under a nitrogen atmosphere and the separated porewaters were filtered through 0.45, 0.2 and a 1ml sub-sample through 0.02, filters into 15ml bottles for trace metal analysis (acidified) and vials for nutrients (unmodified). Nitrate, silicate and phosphate were measured on board.

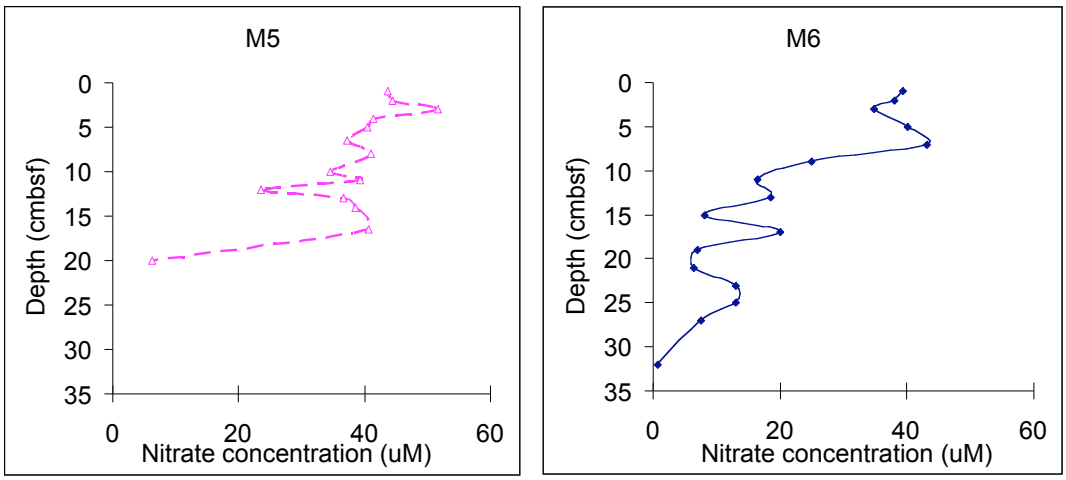


Fig. 14.2 Nitrate profiles obtained for sites M5 and M6

Trace metal geochemistry

Diffusive gradient in thin-films (DET) and diffusive gradients in thin-film (DGT) gel probes were deployed in collected cores (Table 2). These will be used to measure Fe and Mn pore water concentrations (DET) and trace metal gradients (DGT). Collected pore waters will also be analysed for a suite of trace metals including Fe in two fractions (dissolved and soluble) to determine Fe speciation through the core.

Table 14.7 DGT and DET core deployment times

Deployment	Site	Core #	Gel Probes	Date/Time In	Date/Time Out
15582#6	M5	D1	1 x DET & 1 x DG	28/12/04 16.30 GMT	30/12/04 11.20 GMT
15582#9	M5	D2	1 x DET & 1 x DG	28/12/04 16.30 GMT	30/12/04 11.20 GMT
15599#4	M6	D3	1 x DET, 1 x DGT and 1 x μDGT	06/01/05 08.00 GMT	07/01/05 16.15 GMT
15633#4	M10	D4	1 x DET, 1 x DGT and 1 x μDGT	16/01/05 13.00 GMT	18/01/05 05.15 GMT

15. Moorings and sediment traps

15.1 Mooring deployment — Ian Waddington

Five mooring deployments were planned for D285. However due to unforseen delays in airfreight, the new Sediment traps were not delivered to CapeTown for ship sailing. Thus the four sediment trap moorings were postponed to D286.

Preparation of all the mooring equipment onboard was carried out for all the moorings throughout D285. All instruments and acoustic releases were tested and in the case of the instruments all run in barrels of seawater on the aft deck to ensure correct operation and logging. Thus minimal preparation was required on D286.

Mooring operations are summarized here. Full details are given in the deployment and recovery logs that are appended. Current meters, CTDs and sediment traps are summarized in Table 15.1.

Table 15.1 Major mooring instrumentation

Mooring ID	M2	M3	M5	M6	M10
latitude	47°45.6'S	46°03.468'S	46°00.00'S	49°00.03'S	44°29.954'S
longitude	52°52.4'E	51°43.568'E	56°05.00'E	51°30.59'E	49°59.923'E
deployed	6-Jan-2005	13-Nov-2004	26-Dec-2004	3-Jan-2005	20-Dec-2004
recovered		9-Jan-2005			
CTD		SBE 50m			
CTD		SBE 150m			
CTD		SBE 200m			
CTD		SBE 300m			
upward looking ADCP		ADCP 500m			
Current meter		RCM8 503m			
Current meter + CTD		Sontek+SBE 904m			
Parflux sediment trap	1973m		2001m	2007m	2000m
Current meter	RCM11 1975m		RCM11 2003m	RCM11 2010m	RCM8 2004m
Current meter		RCM11 1307m			
Current meter + CTD		Sontek+SBE 1940m			
Bottom (corr m)		2040m			
Parflux sediment trap			3195m	3183m	
Current meter			RCM11 3199m	RCM8 3186m	
Current meter + CTD	Sontek+SBE 3725m				
Bottom (corr m)	3826m				2935m
Current meter			Nortek 4142m	RCM11 4086m	
Bottom (corr m)			4247m	4191m	

Mooring M3

Mooring M3 was provided as an outline mooring with final design and hydrodynamics being completed onboard prior to deployment. The mooring comprises an ADCP and current meter mooring with distributed buoyancy and steel wire . Onto the top of this mooring is an additional CTD mooring comprising Seabird SBE37 SMP units clamped to a parallel fibre kevlar line. Simple steel support buoyancy supports this section and minimum depth of sphere and upper sensor aimed at 50 metres depth . All mooring lines were measured when winding onto the dbc system prior to deployment. At suitable depths Thorium sampling bags were added from 50 metres depth to 1930 metres depth.

Deployment was carried out on the 13th November 2004 commencing at 0550 gmt. Buoy first, anchor freefall last. Machinery used being UKORS dbc and reeler system , ships aft crane.

Deployment was relatively simple and completed to freefall the anchor. The ARGOS SMM beacon was monitored using the RDF receiver to ensure that the top buoy fully submerged.

The sediment traps for delayed moorings arrived at Port Elizabeth and immediate checking of electronics and the fitting batteries commenced at the end of D285. All the traps passed tests successfully.

The sediment trap moorings have Sediment traps, current meters, acoustic releases and glass support buoyancy. The mooring lines are all 10 or 12mm polyester braided line. Designed for buoy first anchor last freefall deployment.

Current meters are Sontek Argonaut, Nortek Aquadopp, Aanderaa RCM 11, 7 and 8.

Acoustic releases are Ixsea AR861 B2S .

Mooring M10

Mooring M10 comprises a single sediment trap with current meter supported by glass spheres.

Final design and mooring line adjustment carried out just prior to deployment.

The mooring was deployed on 20th December 2004 , buoy first ,anchor freefall last. Towing onto site and depth during final pay out phase.

Mooring M5

Mooring M5 comprises two sediment traps with accompanying current meters and a single current meter 100 metres above seabed.

The mooring was deployed on 26th December 2004.

Mooring M6

Mooring M6 comprises two sediment traps with accompanying current metres and a single current meter 100 metres above seabed.

The mooring was deployed on 3rd January 2005

Mooring M2

Mooring M2 comprises a single sediment trap and accompanying current meter with a current meter 100 metres above the seabed.

Mooring M3

Mooring recovery

Recovery of mooring M3 was carried out on the 9th January 2005. On the approach to the mooring the acoustic release was interrogated at a slant range of 8.5 km using the ships PES fish on single element with a TT801 deck unit interfaced. Ranges were observed as the ship closed the mooring position and using the diagnostics command the mooring was determined to be upright.

At 0806 gmt the release command sequence was transmitted and the mooring observed to be rising by using transponder ranging.

Visual watch from the bridge was maintained and at 0811 gmt the top yellow buoy was sighted followed shortly afterwards by the ADCP buoy. Further acoustic ranging indicating the glass support buoyancy rising more slowly.

The mooring top buoy was grappled alongside at 0850 gmt and recovery commenced aft using DBC and crane.

At 0926 when lifting the ADCP buoy inboard the kevlar line and steel wire were tangled about the buoy. During lift operations the kevlar line was severely damaged by the mooring wire and parted allowing the adcp buoy to drop back into the water. Two attempts were made to re-attach to the ADCP buoy but with the seastate increasing and the mooring buoys all on the surface and lying across the wind and swell, recovery was postponed for a period. The ship stood by the buoys and when a suitable opportunity arose the ADCP buoy was hooked amidships using the Hook on a pole, Ben Boorman effecting hooking on.

The rig was then recovered, wire was tangled at Sontek 319 and RCM 11 426, this was cleared on deck and all equipment recovered onboard by 1350 gmt.

Data Downloading

All instruments were downloaded onboard and preliminary plots made. The data recovered indicating correct operation of all of the instruments. RCM 11047 had some water ingress, but had run a complete data record . The cause of this water ingress will require further investigation, it is thought possible that the water may have entered during the recovery operation when the current meter took severe impact with the ADCP buoy as it fell back into the sea. Also the main battery terminals had jumped off indicating that the impact was quite severe.

Initial data indicates that the mooring has performed well and that the depths of the instruments are within design parameters.

15.2 Sediment traps — Ian Salter

The export of biogenic material from the euphotic zone to the ocean interior is of great biogeochemical interest, the oxidation of organic matter occurs mainly in the ocean interior through the action of heterotrophic microbes, which enriches the ocean interior with inorganic carbon. Because the ocean interior is not in contact with the atmosphere it can be considered as decoupled from the atmosphere, and the enrichment of this region of the water column with inorganic carbon effectively removes carbon dioxide from the atmosphere. Also organic matter that originates from the surface ocean and descends through the water column is required to maintain deep-water pelagic and benthic ecosystems. The main approach used for measuring export production is in the form of free-floating particle interceptor traps (PITS). Sediment traps passively collect particles settling through the water column. They are usually deployed at different depths in anchored, vertical arrays and are designed to collect sinking material over time intervals ranging from a few days to more than a year. This allows temporal trends in export production at a specified depth to be recorded throughout an entire sampling year.

Deployment Locations

In total six sediment traps were deployed at four sites in the study area, the locations were selected based on numerous factors. One sediment trap was moored at M10 and also one at M2, the rationale for these positions is based on composite satellite images of the Crozet Islands and the surrounding area. These images show M10 to experience elevated surface chlorophyll levels compared to M2, which is considered to be an oligotrophic HNLC region. It has been hypothesised that the differences in productivity between these two sites is governed by an input of Fe from the Crozet plateau, which is a limiting micronutrient for phytoplankton populations in this area. M5 and M6 locations were decided on similar grounds, with M6 representing the oligotrophic control area. When selecting M5 and M6 we had the additional constraints that required the two sites to have similar water depths and flat bathymetries to facilitate benthic studies. M5 and M6 have two sediment traps connected to each vertical mooring array, the positions and depths of all six sediment traps are summarised in Table 15.1 and Figure15.1.

Deployment Schedules

The sediment traps deployed can accommodate 21 sample cups which are attached to a rotating plate, the trap can be programmed in a way which allows you to specify the amount of time each sample cup spends underneath the collecting funnel. The sample cups are filled with a preservative solution prior to deployment, which allows the particulate material to be stored for the length of deployment without degrading. During periods where we expect a relatively low flux, for example during the winter, the intervals between samples are quite large. However during periods of enhanced particle flux then the intervals are shortened to increase the sampling resolution, and facilitate a more accurate record of the temporal evolution of the overlying phytoplankton bloom. Tables 1-6 are summaries of the deployment schedule for each of the sediment traps.

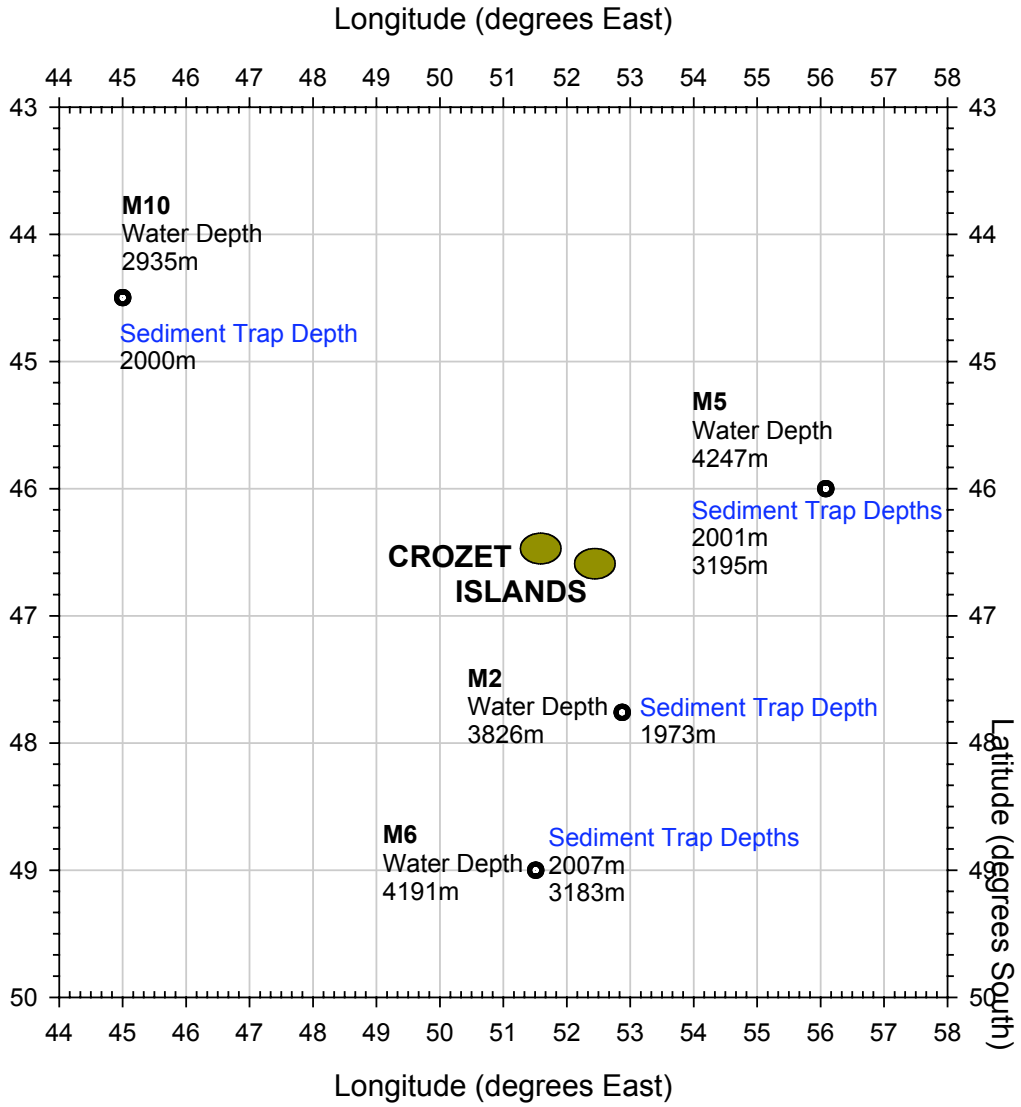


Fig. 15.1 Map showing the positions of the sediment trap moorings in relation to the Crozet Islands

Table 15.2 M2 (1973m) Parflux sediment trap Schedule

Sample code	Open Date	Open day	Julian Day	Interval
	at 1200h	2004	Mid-day	Days
XXXVII-A-1	01/08/05	8.5	194.5	8
XXXVII-A-2	01/16/05	16.5	22.5	14
XXXVII-A-3	01/30/05	30.5	36.5	14
XXXVII-A-4	02/13/05	44.5	54	21
XXXVII-A-5	03/06/05	65.5	78.5	28
XXXVII-A-6	04/03/05	93.5	106.5	28
XXXVII-A-7	05/01/05	121.5	134.5	28
XXXVII-A-8	05/29/05	149.5	162.5	28

XXXVII-A-9	06/26/05	177.5	190.5	28
XXXVII-A-10	07/24/05	205.5	218.5	28
XXXVII-A-11	08/21/05	233.5	243	21
XXXVII-A-12	09/11/05	254.5	264	21
XXXVII-A-13	10/02/05	275.5	281.5	14
XXXVII-A-14	10/16/05	289.5	295.5	14
XXXVII-A-15	10/30/05	303.5	309.5	14
XXXVII-A-16	11/13/05	317.5	323.5	14
XXXVII-A-17	11/27/05	331.5	337.5	14
XXXVII-A-18	12/11/05	345.5	348	7
XXXVII-A-19	12/18/05	352.5	355	7
XXXVII-A-20	12/25/05	359.5	362	7
XXXVII-A-21	01/01/06	366.5	372.5	14

Table 15.3 M10 (2000m) Parflux sediment trap Schedule

Sample code	**Open Date**	**Open day**	**Julian Day**	**Interval**
	at 1200h	**2004**	**Mid-day**	**Days**
XXXVI-A-1	12/21/2004	356.5	361.5	12
XXXVI-A-2	1/2/2005	2.5	8.5	14
XXXVI-A-3	1/16/2005	16.5	22.5	14
XXXVI-A-4	1/30/2005	30.5	40	21
XXXVI-A-5	2/20/2005	51.5	64.5	28
XXXVI-A-6	3/20/2005	79.5	92.5	28
XXXVI-A-7	4/17/2005	107.5	120.5	28
XXXVI-A-8	5/15/2005	135.5	148.5	28
XXXVI-A-9	6/12/2005	163.5	176.5	28
XXXVI-A-10	7/10/2005	191.5	204.5	28
XXXVI-A-11	8/7/2005	219.5	232.5	28
XXXVI-A-12	9/4/2005	247.5	260.5	28
XXXVI-A-13	10/2/2005	275.5	281.5	14
XXXVI-A-14	10/16/2005	289.5	295.5	14
XXXVI-A-15	10/30/2005	303.5	309.5	14
XXXVI-A-16	11/13/2005	317.5	323.5	14
XXXVI-A-17	11/27/2005	331.5	337.5	14
XXXVI-A-18	12/11/2005	345.5	348	7
XXXVI-A-19	12/18/2005	352.5	355	7
XXXVI-A-20	12/25/2005	359.5	362	7
XXXVI-A-21	1/1/2006	366.5	372.5	14

Table 15.4 M5 (2001m) Parflux sediment trap Schedule

Sample code	Open Date	Open day	Julian Day	Interval
	at 1200h	2004	Mid-day	Days
XXXVIII-A-1	12/28/04	363.5	2.5	12
XXXVIII-A-2	01/09/05	9.5	15.5	14
XXXVIII-A-3	01/23/05	23.5	29.5	14
XXXVIII-A-4	02/06/05	37.5	47	21
XXXVIII-A-5	02/27/05	58.5	71.5	28
XXXVIII-A-6	03/27/05	86.5	99.5	28
XXXVIII-A-7	04/24/05	114.5	127.5	28
XXXVIII-A-8	05/22/05	142.5	155.5	28
XXXVIII-A-9	06/19/05	170.5	183.5	28
XXXVIII-A-10	07/17/05	198.5	211.5	28
XXXVIII-A-11	08/14/05	226.5	236	21
XXXVIII-A-12	09/04/05	247.5	257	21
XXXVIII-A-13	09/25/05	268.5	278	21
XXXVIII-A-14	10/16/05	289.5	295.5	14
XXXVIII-A-15	10/30/05	303.5	309.5	14
XXXVIII-A-16	11/13/05	317.5	323.5	14
XXXVIII-A-17	11/27/05	331.5	337.5	14
XXXVIII-A-18	12/11/05	345.5	348	7
XXXVIII-A-19	12/18/05	352.5	355	7
XXXVIII-A-20	12/25/05	359.5	362	7
XXXVIII-A-21	01/01/06	366.5	372.5	14

Table 15.5 M5 (3195m) Parflux sediment trap Schedule

Sample code	Open Date	Open day	Julian Day	Interval
	at 1200h	2004	Mid-day	Days
XXXVIII-B-1	12/28/04	363.5	2.5	12
XXXVIII-B-2	01/09/05	9.5	15.5	14
XXXVIII-B-3	01/23/05	23.5	29.5	14
XXXVIII-B-4	02/06/05	37.5	47	21
XXXVIII-B-5	02/27/05	58.5	71.5	28
XXXVIII-B-6	03/27/05	86.5	99.5	28
XXXVIII-B-7	04/24/05	114.5	127.5	28
XXXVIII-B-8	05/22/05	142.5	155.5	28
XXXVIII-B-9	06/19/05	170.5	183.5	28
XXXVIII-B-10	07/17/05	198.5	211.5	28
XXXVIII-B-11	08/14/05	226.5	236	21

XXXVIII-B-12	09/04/05	247.5	257	21
XXXVIII-B-13	09/25/05	268.5	278	21
XXXVIII-B-14	10/16/05	289.5	295.5	14
XXXVIII-B-15	10/30/05	303.5	309.5	14
XXXVIII-B-16	11/13/05	317.5	323.5	14
XXXVIII-B-17	11/27/05	331.5	337.5	14
XXXVIII-B-18	12/11/05	345.5	348	7
XXXVIII-B-19	12/18/05	352.5	355	7
XXXVIII-B-20	12/25/05	359.5	362	7
XXXVIII-B-21	01/01/06	366.5	372.5	14

Table 15.6 M6 (2007m) Parflux sediment trap Schedule

Sample code	Open Date	Open day	Julian Day	Interval
	at 1200h	2004	Mid-day	Days
XXXIX-A-1	01/05/05	5.5	10	11
XXXIX-A-2	01/16/05	16.5	22.5	14
XXXIX-A-3	01/30/05	30.5	36.5	14
XXXIX-A-4	02/13/05	44.5	54	21
XXXIX-A-5	03/06/05	65.5	78.5	28
XXXIX-A-6	04/03/05	93.5	106.5	28
XXXIX-A-7	05/01/05	121.5	134.5	28
XXXIX-A-8	05/29/05	149.5	162.5	28
XXXIX-A-9	06/26/05	177.5	190.5	28
XXXIX-A-10	07/24/05	205.5	218.5	28
XXXIX-A-11	08/21/05	233.5	243	21
XXXIX-A-12	09/11/05	254.5	264	21
XXXIX-A-13	10/02/05	275.5	281.5	14
XXXIX-A-14	10/16/05	289.5	295.5	14
XXXIX-A-15	10/30/05	303.5	309.5	14
XXXIX-A-16	11/13/05	317.5	323.5	14
XXXIX-A-17	11/27/05	331.5	337.5	14
XXXIX-A-18	12/11/05	345.5	348	7
XXXIX-A-19	12/18/05	352.5	355	7
XXXIX-A-20	12/25/05	359.5	362	7
XXXIX-A-21	01/01/06	366.5	372.5	14

Table 15.7 M6 (3183m) Parflux sediment trap Schedule

Sample code	Open Date	Open day	Julian Day	Interval
XXXIX-B-1	at 1200h	2004	Mid-day	Days
XXXIX-B-2	01/05/05	5.5	10	11
XXXIX-B-3	01/16/05	16.5	22.5	14
XXXIX-B-4	01/30/05	30.5	36.5	14
XXXIX-B-5	02/13/05	44.5	54	21
XXXIX-B-6	03/06/05	65.5	78.5	28
XXXIX-B-7	04/03/05	93.5	106.5	28
XXXIX-B-8	05/01/05	121.5	134.5	28
XXXIX-B-9	05/29/05	149.5	162.5	28
XXXIX-B-10	06/26/05	177.5	190.5	28
XXXIX-B-11	07/24/05	205.5	218.5	28
XXXIX-B-12	08/21/05	233.5	243	21
XXXIX-B-13	09/11/05	254.5	264	21
XXXIX-B-14	10/02/05	275.5	281.5	14
XXXIX-B-15	10/16/05	289.5	295.5	14
XXXIX-B-16	10/30/05	303.5	309.5	14
XXXIX-B-17	11/13/05	317.5	323.5	14
XXXIX-B-18	11/27/05	331.5	337.5	14
XXXIX-B-19	12/11/05	345.5	348	7
XXXIX-B-20	12/18/05	352.5	355	7
XXXIX-B-21	12/25/05	359.5	362	7

Ocean Engineering Division
UKORS

Mooring Operational Sheet

PROJECT : CROZEX

UKORS Mooring No: 2004/38 **Mooring Name :M2**

DEPLOYMENT **RECOVERY**

CRUISE **:D286** :
DEPLOYMENT SHIP**:DISCOVERY** :
LATITUDE **: 47 45.6S** :
LONGTITUDE **: 52 52.4E** :
DATE/TIME **:6th Jan 2005 :**
Methods DEPLOYMENT BUOY FIRST , ANCHOR FREEFALL AFT

Mooring diagram

EQUIPMENT	Ser.no/Length	Time in	Time out	Comments
17 inch Glass sphere		1412		
PICK UP LINE 24MM	15M			White line
10 x 17 inch glass spheres				Benthos
Swivel stainless steel		1415		Van der Weyden
15m Polyester line 10mm	15m			
Parflux trap ML11804 -05				21 bottle
chain 1/2"	0.25m			Trap and Rcm recovered and redeployed
Recording current meter 423 type RCM11		1440		see notes below
Polyester line 10mm	50m			
Polyester line 10mm	200m			
Polyester line 10mm	450m			
Polyester line 10mm	450m			
Polyester line 10mm	450m			
AR 861 # 265				fitted new design release link
Polyester line 90m 10mm	90m			Gleistein white Tasmania
Chain 1/2" galv long link	8m			
Chain 5/8" grade 30 stnd link	1m			
Railway wheel anchor	550kg	1531		2 x Railway wheels welded straps
Anchor released using knife				Freefall anchor

Acoustic Release Observations

AR 861 SER.NO. 265

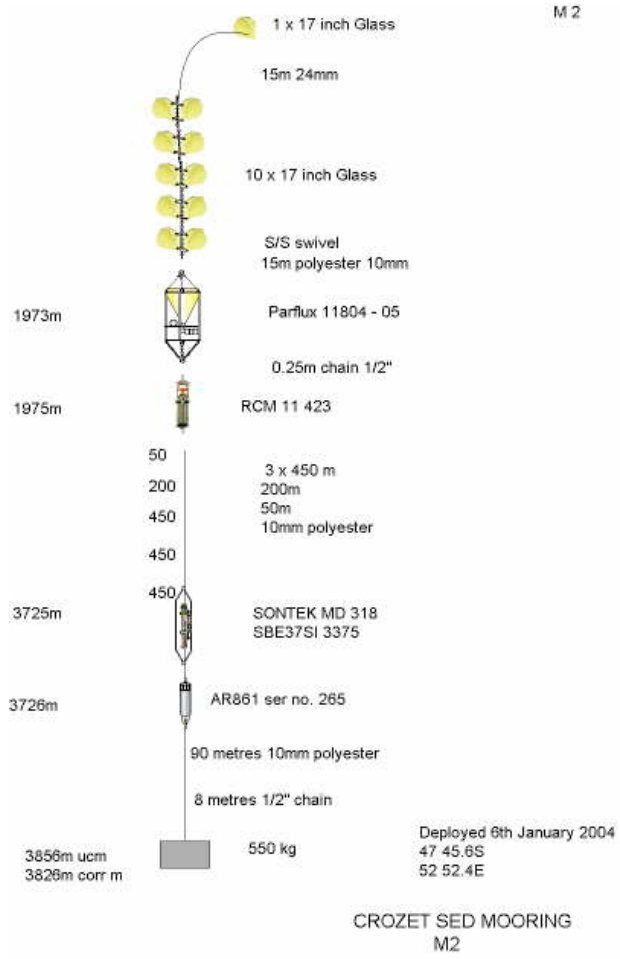
CAF	14B6	REL	CAF 1455	REL + PING	CAF 1456
PINGER	CAF 1447	PING OFF	CAF 1448	Diagnostic	CAF CAF

ARGOS Beacon Observations
NONE - NO beacon fitted

Other Comments

A Parflux trap 1/2 bush was found on deck shortly after deploying the trap , the mooring had to be retrieved for 250 metres to determine if the trap was missing a bush. On recovery to deck a 1/2 bush was found to be missing from one of the wire bridle attachment points . This was replaced and launch continued .

WATER DEPTH OBSERVED5 3856M CORRECTION BY CARTER TABLES 3826M
DEPLOYED BUOY FIRST USING DBC AND CRANE- Anchor freefall sharp knife by Emma
UKORS MOORING 204/34
UKORS PERSONNEL WADDINGTON / NORTHROP/SHORT - GDD FIELDING/BOORMAN



D318 ARGONAUT MD DEPLOYMENT - using "VIEW ARGONAUT"

LOG FILE

Argonaut-MD
SonTek/YSI, Inc.
Copyright 1996-2003

Hardware Configuration

System Type ---------- MD
Sensor serial # ---------- D318
Sensor frequency - (kHz) ------- 1500
Number of beams ---------- 3
Beam Geometry ---------- 3_BEAMS
Vertical Beam ---------- NO
Slant angle - (deg) ---------- 45.0
System Orientation ---------- UP
Compass installed ---------- YES
Recorder installed ---------- YES
Temperature sensor ---------- YES
Pressure sensor ---------- YES
PressOffset - (dbar) ---------- -145.943810
PressScale -- (dbar/count) ---- 0.112611
PressScale_2 - (pdbar/count^2) - 0
Ctd sensor ---------- YES
Ext. Press. sensor ---------- NONE
YSI sensor ---------- NO
Waves Option ---------- NO
Internal SDI-12 Option --------- NO
Internal Flow Computations ----- NO
Analog Output Option ---------- NO
Multi-cell Profiling Option ---- NO
>show system

System Parameters

CPU Ver ---------- ARG 20.0
BoardRev ---------- REV F
Date ---------- 2005/01/05
Time ---------- 20:47:25
AutoSleep ---------- YES
VoltageProtecttion - YES
OutMode ---------- AUTO
OutFormat ---------- METRIC
Recorder ---------- ON
RecMode ---------- NORMAL
ModemMode ---------- NO

Setup Parameters

Temp ---------- 20.00 deg C
Sal ---------- 34.50 ppt
TempMode ------- MEASURED
Sound Speed ---- 1520.9 m/s
AvgInterval ---- 30 s
SampleInterval - 1200 s
CoordSystem ---- ENU
>show deploy

DEPLOYMENT PARAMETERS

Deployment ------ 318M2
StartDate ------- 2005/01/05
StartTime ------- 21:00:00
AvgInterval ----- 30 s
SampleInterval -- 1200 s
BurstMode ------- DISABLED
BurstInterval --- 1200 s
SamplesPerBurst - 1
Comments:
Mooring M2 CROZEX
>show other
MISCELLANEOUS PARAMETERS

AdcmConf
CompassOffset 0
PowerSaveMode 1
SeabirdOutputDelay 25000
StoreRawVelocity 0
PingDelay 0
Transformation Matrix: 0.942 -0.472 -0.472
0.000 -0.816 0.816
0.472 0.472 0.472
AdcmOper
NpingsPerBeam 1
ModemMode 0
NominalNoise 23 24 24
SampleRecordMode 0
UseCompassFlux 0
MaxLevelPressDiff 0.3 m
LevelOffset 0 mm
StoreNoiseData 1
StoreDiagnosticData 0

UserSetup
PulseLength 100 cm
PingInterval 0.0 s
Coh. Pulse Lag 0.00 m
>dir
No deployments found.
0 bytes used in 0 deployments. 4194304 bytes free.
>sensor cont
Temp = 20.92 Pressure = 0.00 Battery = 10.0
Temp = 20.92 Pressure = 0.00 Battery = 10.0
Temp = 20.92 Pressure = 0.00 Battery = 10.0
Temp = 20.92 Pressure = 0.00 Battery = 10.0
Temp = 20.94 Pressure = 0.00 Battery = 10.0
Temp = 20.94 Pressure = 0.00 Battery = 10.0
Temp = 20.94 Pressure = 0.00 Battery = 10.0
Temp = 20.94 Pressure = 0.00 Battery = 10.0
Temp = 20.94 Pressure = 0.00 Battery = 10.0
Temp = 20.97 Pressure = 0.00 Battery = 10.0
Temp = 20.94 Pressure = 0.00 Battery = 10.0
Temp = 20.94 Pressure = 0.00 Battery = 10.0>
compass cont
Heading=110.1 Pitch= -3.5 Roll= 4.2
Heading=109.8 Pitch= -3.8 Roll= 3.9
Heading=109.6 Pitch= -3.8 Roll= 3.6
Heading=110.1 Pitch= -3.7 Roll= 3.5
Heading=110.4 Pitch= -3.6 Roll= 3.4
Heading=110.5 Pitch= -3.5 Roll= 3.3
Heading=110.4 Pitch= -3.5 Roll= 3.2

>deploy

Initializing CTD. Please wait...
Checking Setup Parameters...
4194304 free bytes left in recorder.
Free space is sufficient for 1004.38 days of operation.
Data collection will start on: 2005/01/05 at 21:00:00
In 0 days, 0 hours, 12 minutes and 18 seconds from now.

Data will be recorded to file 318M2001.
OK

DATA OUTPUT recorded on LOG file

2005 01 05 21 00 00 -8.1 4.7 -8.8 20.6 17.3 12.7 26 28 29 100 106.3 -3.6 3.2 2.8 1.4 1.0 20.97 0.000 0.000 9.8 1.5 4.0 24 28 29 21.4097 0.00009 0.000 0.0104
2005 01 05 21 20 00 -57.9 7.0 6.6 21.8 19.2 15.4 26 28 29 100 106.8 -3.6 3.2 2.7 1.3 1.3 21.00 0.000 0.000 9.8 1.5 4.0 25 27 29 21.3803 0.00007 0.000 0.0104
2005 01 05 21 40 00 -47.5 -6.1 -43.0 20.1 17.9 14.0 26 28 29 100 113.4 -2.8 3.6 2.7 1.8 1.1 20.96 -0.225 0.000 9.8 1.5 4.0 25 27 29 20.6005 0.00009 0.000 0.0102
Instrument disconnected and blank plug fitted .
Images taken of final instrument mechanical configuration in ET Workshop.

Cruise Number D286 RCM 11 M2 423

Mooring number 2004/38 Date **6th Jan 2005**

Mooring Location M2 Lat **47 45.6S** Long **52 52.4E**

Instrument Depth

Deployment Time 1440 gmt

Channels	Data
1	*Reference 138*
2	*Speed*
3	*Direction*
4	*Temperature*
5	*Conductivity*
6	*Pressure*
7	
8	
9	*Tilt*

Recording Interval minutes	30
Number of Channels	9
Off/On/Burst	On
Temperature Range	Low
Conductivity Measurement range	20-40 mS/cm
Ensemble number	300

Note conductivity range changed onboard 15 dec04

DSU Checks

Clock Check	GMT	X	DSU Serial Number	14387
	Local		DSU clock set	Yes
			DSU Check	Passed

Time on 14-00 15th December 2004 Sampling 30 minutes
Time Off at start up 15 words
CASED UP 16TH DEC

Ocean Engineering Division
UKORS

Mooring Operational Sheet

PROJECT : CROZEX

UKORS Mooring No: 2004/34 Mooring Name :M3

	DEPLOYMENT	RECOVERY
CRUISE	:D285	:D286
DEPLOYMENT SHIP	:DISCOVERY	:DISCOVERY
LATITUDE	: 46 03.468S	:Final lift - 46 02.4S
LONGTITUDE	: 51 43.568E	:51 43.1E
DATE/TIME	:13th Nov 2004 Day 318: 9th January 2005 Day 09	

Methods DEPLOYMENT BUOY FIRST , ANCHOR FREEFALL AFT

Mooring diagram

EQUIPMENT	Ser.no/Length	Time in	Time out	Comments
28 STEEL SPHERE		0550	0850	Released 0811 - Grappled 0850
PICK UP LINE 20MM	15M			
ARGOS BEACON SMM	24329			SER. NO. 053 ID 24329
CERAMIC SWIVEL				PROTOTYPE
0.5M _" CHAIN				
PARAFIL 8.5MM	450M			RETERM ONBOARD
SBE37SMP	3479	0550		DEPTH 50M BAG1
SBE37SMP	3485	0600		DEPTH 100M BAG 2
SBE37SMP	3480	0605		DEPTH 150M BAG 3
SBE37SMP	3487	0610		DEPTH 200M BAG 4
SBE37SMP	3482	0640		DEPTH 300M BAG 5
FLOTECH45 + LRADCP		0640	0926	DEPTH 500M BAG 6 AND 7
O.5M CHAIN			1251	On recovery tangled at ADCP and parted
CERAMIC SWIVEL				Grappled after several attempts
ACM RCM7	11047	0640		Grapple 46 01.5S 51 44.2E
WIRE 3/16 JKT	400M			
SONTEK MD SBE37SI	SK319 SB 3361	0655		DEPTH 904M BAG 8
WIRE 3/16 JKT	400M			
GLASS 17 4 OFF				
RCM 11	426	0725		DEPTH 1307M BAG 9
WIRE 3/16 JKT	190M 190M 190M			DEPTH 1687M BAG 10
POLYESTER 1OMM	50M			DEPTH 1877M BAG 11
GLASS 17 4 OFF				
CHAIN 3/8 3M				
SONTEK MD SBE37S1	320 3376			DEPTH 1930M BAG 12
AR861 SER NO 318	318		1350	Inboard 46 02.4S 51 43.1E
POLYESTER 10MM	90M			
CHAIN 3/8	5M			
ANCHOR WHEELS	850KG			

Acoustic Release Observations

AR 861 SER.NO. 318

CAF	14CE	REL	CAF 1455	REL + PING	CAF 1456
PINGER	CAF 1447	PING OFF	CAF 1448	Diagnostic	CAF CAF

Mooring detected at 8km range whilst steming towards mooring at 10 kts. PES single element and TT801 used throughout . Reliable ranges at 3.5 km . Transmission of first release made when ship hove to 1/2 mile downwind , good range and release noted . Observe rise of release using transpond modes .

ARGOS Beacon Observations

Beeper for several hours in lab AND OBSERVED DURING DEPLOY ON GONIO
OBSERVED UNTIL TOP BUOY SUBMERGED

ARGOS detected on surfacing using GONIO on bridge.
Subsequent to recovery ARGOS alerts received at SOC.

Other Comments

WATER DEPTH OBSERVED 2070 M CORRECTION BY CARTER TABLES 2040M
MOORING LENGTH 1990M – DEPLOYED BUOY FIRST USING DBC AND CRANE
UKORS MOORING 2004/34
UKORS PERSONNEL WADDINGTON / KEEN / PHIPPS RECOVERY PERSONNEL - WADDINGTON / SHORT / NORTHROP GDD BOORMAN

9th January 2005

On recovery the mooring was hauled onboard and all SBE37 SI units removed from wire along with Thorium sample bags . At the ADCP buoy the Parafil was tangled with the mooring wire and on lifting the Parafil was chafed through and the buoy dropped back into the water .
Two attempts were made to re-attach to the ADCP buoy but with the seastate increasing and the mooring buoys all on the surface and lying across the swell recovery was postponed for a period . The ship stood by the buoys and when a suitable opportunity arose the ADCP buoy was hooked amidships using the Hook on a pole , Ben Boorman effecting hooking on .
The rig was then recovered , wire was tangled at Sontek 319 and RCM 11 426 , this was cleared on deck and all equipment recovered onboard by 1350 gmt.

Instrumentation Summary

SEABIRD SBE 37SMP

ser no.	depth	Start date	time	Sample	End date	Scans
3479	50m	12-Nov-04	12:00:00	120 sec	NONE	39070
3485	100m	12-Nov-04	12:00:00	120 sec	NONE	39033
3480	150m	12-Nov-04	12:00:00	120 sec	NONE	38998
3487	200m	12-Nov-04	12:00:00	120 sec	NONE	39866
3482	300m	12-Nov-04	12:00:00	120 sec	NONE	39120

No last data recorded as all memory full - Last data 5th January 2005
Download 11th Jan 2005

AANDERAA RCM 8

ser no.	depth	Start date	time	Sample	End date	Scans
11047	500m	12-Nov-04	16:00:00	600 sec	NONE	8365

No last data as instrument slight flood on recovery last recorded data
09/01/2005 09:18 Download 11th Jan 2005

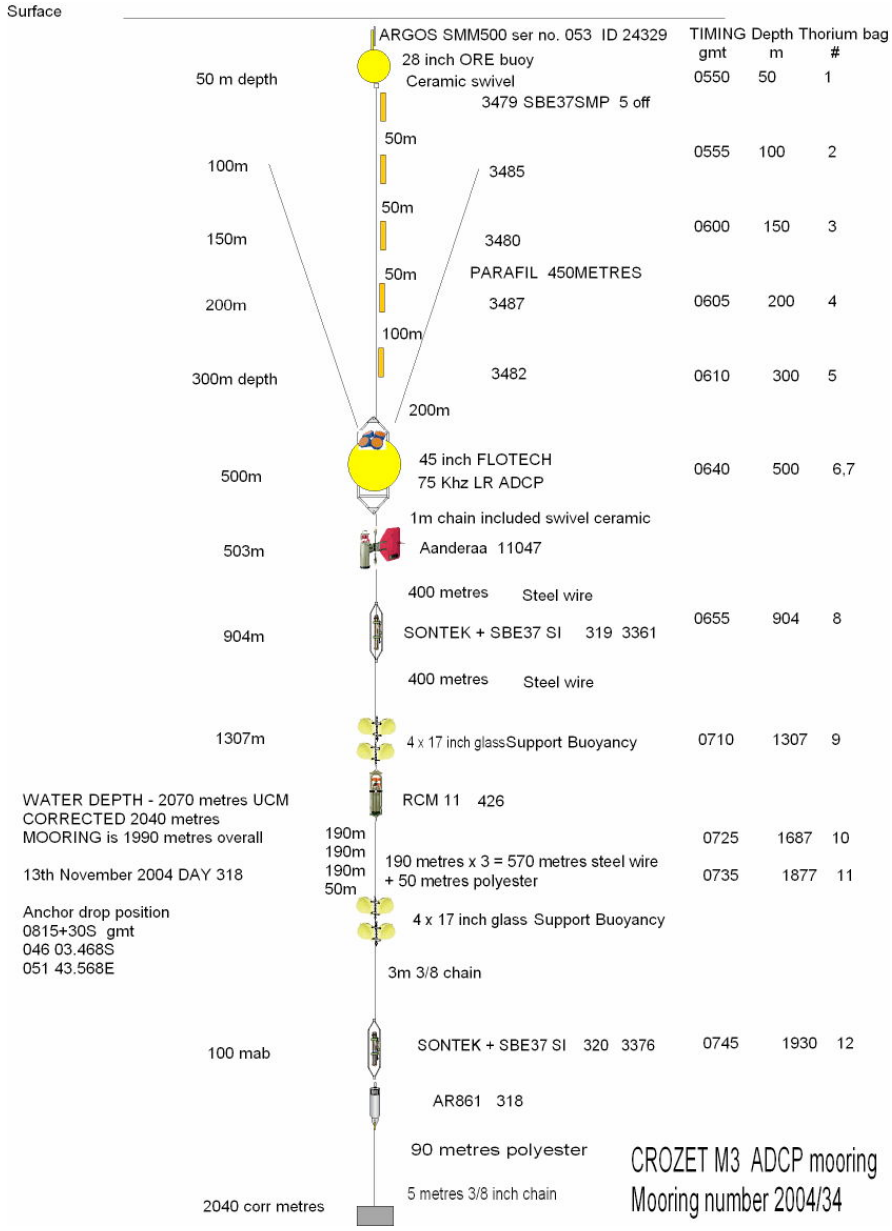
AANDERAA RCM11

ser no.	depth	Start date	time	Sample	End date	Scans
426	1300m	12-Nov-04	16:00:00	300 sec	11-Jan-05	17293

Last data 11th Jan 2005 12:00:02

SONTEK ARGONAUT MD and SBE37SI

ser no.	depth	Start date	time	Sample	End date	Scans
319	904m	12-Nov-04	18:00:00	300 sec	09-Jan-05	16581
sbe 3361				Last data 9th Jan 2005 07:40:00		
320	1940m	12-Nov-04	18:45:00	300 sec	09-Jan-05	17172
sbe 3376				Last data 11th Jan 2005 09:40:00		



Hardware Configuration **SONTEK**

System Type ---------- MD
Sensor serial # ---------- D320 WITH SBE37SI 3361
Sensor frequency - (kHz) ------- 1500
Number of beams ---------- 3
Beam Geometry ---------- 3_BEAMS
Vertical Beam ---------- NO
Slant angle - (deg) ---------- 45.0
System Orientation ---------- UP
Compass installed ---------- YES
Recorder installed ---------- YES
Temperature sensor ---------- YES
Pressure sensor ---------- YES
PressOffset - (dbar) ---------- -145.952740
PressScale -- (dbar/count) ---- 0.112618
PressScale_2 - (pdbar/count^2) - 0
Ctd sensor ---------- YES
Ext. Press. sensor ---------- NONE
YSI sensor ---------- NO
Waves Option ---------- NO
Internal SDI-12 Option --------- NO
Internal Flow Computations ----- NO
Analog Output Option ---------- NO
Multi-cell Profiling Option ---- NO
>s setup

Setup Parameters

Temp ---------- 20.00 deg C
Sal ---------- 34.50 ppt
TempMode ------- MEASURED
Sound Speed ---- 1520.9 m/s
AvgInterval ---- 60 s
SampleInterval - 300 s
CoordSystem ---- ENU
>s deploy

Wake up initialization. Please wait...

>format
FORMAT command erases everything on the memory card. You
may want to download any useful files before destroying them.
Proceed with FORMAT? (YES or NO): yes

The flash memory will require 20 to 60 seconds to erase.
Please wait...

Time (seconds): 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41

OK
>sd 04/11/12
OK
>st 18:45:00
OK
>savesetup
OK
>s deploy

DEPLOYMENT PARAMETERS

Deployment ------ M3320
StartDate ------- 2004/11/12
StartTime ------- 18:45:00
AvgInterval ----- 60 s
SampleInterval -- 300 s
BurstMode ------- DISABLED
BurstInterval --- 80 s
SamplesPerBurst - 4
Comments:
>deployment M3320
OK
>deploy

Subsequent to recovery data download was commenced as M3320001

File ---------- M3320001.arg
File Size (bytes) --------- 979222
Number of Samples --------- 17172
Time of first sample ------ 12/11/2004 18:45:00
Time of last sample ------ 11/01/2005 09:40:00

Data checking carried out and configuration and sample data downloaded.

Config Data.

```
ArgonautDP Hardware Configuration
---------------------------------
ArgType ------------------ MD
SerialNumber -------------- D320
Frequency ------- (kHz) --- 1500
Nbeams -------------------- 3
BeamGeometry -------------- 3_BEAMS
VerticalBeam -------------- NO
SlantAngle ------ (deg) --- 45.0
CPUSoftwareVerNum --------- 20.0
DSPSoftwareVerNum --------- 1.0
BoardRev ------------------ F
SensorOrientation---------- UP
CompassInstalled ---------- YES
RecorderInstalled --------- YES
TempInstalled ------------- YES
PressInstalled ------------ YES
CtdSensorInstalled -------- YES
YsiSensorInstalled -------- NO
Ext Press Sensor ---------- NONE
TempOffset (deg C) -------- 0.00
TempScale  (deg C/deg C) -- 1.0000
PressOffset (dbar) -------- -145.952740
PressScale  (dbar/count) -- 0.112618
PressScale_2 (pdbar/c^2) -- 0.000000
Transformation Matrix -----    0.942  -0.472  -0.472
                               0.000  -0.816   0.816
                               0.472   0.472   0.472

Argonaut User Setup
---------------------
DefaultTemp ----- (deg C) -- 20.00
DefaultSal ------ (ppt) ---- 34.50
TempMode ------------------ MEASURED
```

```
DefaultSoundSpeed (m/s) ---- 1520.90
CellBegin ------- (m) ------ 1.50
CellEnd --------- (m) ------ 3.00
ProfilingMode -------------- NO
DynBoundaryAdj ------------- NO
WaveSpectra ---------------- NO
WaterDepth ------ (m) ------ 0.00
AvgInterval ----- (s) ------ 60
SampleInterval -- (s) ------ 300
YsiBufferSize --- (bytes) -- 0
BurstMode ------------------ DISABLED
BurstInterval --- (s) ------ 80
SamplesPerBurst ------------ 4
CoordSystem ---------------- ENU
AutoSleep ------------------ ON
OutMode -------------------- AUTO
OutFormat ------------------ METRIC
DataFormat ----------------- LONG FORMAT
RecorderEnabled ------------ ENABLED
RecorderMode --------------- NORMAL
DeploymentName ------------- M3320
DeploymentStart Date/Time -- 12/11/2004 18:45:00
Comments:



--------------------------------------------------
Argonaut ASCII data file Long format is as follows:
--------------------------------------------------
Column  1- 6: Year Month Day Hour Minute Second;
Column  7- 9: WaterVel1/X/E WaterVel2/Y/N WaterVel3/Z/U (cm/s)
Column 10-12: VelStDev1/X/E VelStDev2/Y/N VelStDev3/Z/U (cm/s)
Column 13-15: SNR1          SNR2          SNR3          (dB);
Column 16-18: SignalAmp1    SignalAmp2    SignalAmp3    (counts);
Column 19-21: Noise1        Noise2        Noise3        (counts);
Column    22: percent good pings
Column 23-25: Heading Pitch Roll (deg);
Column 26-28: Standard deviation of the Heading Pitch Roll (deg);
Column 29-30: Mean Tempr (degC) MeanPress (dBar);
Column    31: StDevPress (dBar);
Column    32: Power level (battery voltage) (Volts);
Column 33-34: CellBegin CellEnd (m);
Column    35: Speed (cm/s);
Column    36: Direction (deg);
Column    37: CTD - Temperature (deg C);
Column    38: CTD - Conductivity (mS);
Column    39: CTD - Pressure (dbar);
Column    40: CTD - Salinity (ppt);


-----------------------------------
Flow data file format is as follows:
-----------------------------------
Column  1- 6: Year Month Day Hour Minute Second;
Column     7: Depth (m)
Column     8: Area (m2)
Column     9: Vx (m/s);
Column    10: V Mean (m/s);
Column    11: Flow (m3/s);
```

Argonaut-MD
SonTek/YSI, Inc.
Copyright 1996-2003

Wake up initialization. Please wait...

>Show conf

Hardware Configuration

System Type ---------- MD
Sensor serial # ---------- D319 WITH SBE37SI 3376
Sensor frequency - (kHz) ------- 1500
Number of beams ---------- 3
Beam Geometry ---------- 3_BEAMS
Vertical Beam ---------- NO
Slant angle - (deg) ---------- 45.0
System Orientation ---------- UP
Compass installed ---------- YES
Recorder installed ---------- YES
Temperature sensor ---------- YES
Pressure sensor ---------- YES
PressOffset - (dbar) ---------- -145.836810
PressScale -- (dbar/count) ---- 0.112528
PressScale_2 - (pdbar/count^2) - 0
Ctd sensor ---------- YES
Ext. Press. sensor ---------- NONE
YSI sensor ---------- NO
Waves Option ---------- NO
Internal SDI-12 Option --------- NO
Internal Flow Computations ----- NO
Analog Output Option ---------- NO
Multi-cell Profiling Option ---- NO
>Show System

System Parameters

CPU Ver ---------- ARG 20.0
BoardRev ---------- REV F
Date ---------- 2004/11/12
Time ---------- 17:02:31
AutoSleep ---------- YES
VoltageProtecttion - YES
OutMode ---------- AUTO
OutFormat ---------- METRIC
Recorder ---------- ON
RecMode ---------- NORMAL
ModemMode ---------- NO

><BREAK>

Argonaut-MD
SonTek/YSI, Inc.
Copyright 1996-2003

Wake up initialization. Please wait...

>ai 60
OK
>si 300
OK

>ctd

Initializing CTD. Please wait...
Temp = 22.1658 Cond = 0.00002 Press = 0.000 Sal = 0.0109
>format
FORMAT command erases everything on the memory card. You
may want to download any useful files before destroying them.
Proceed with FORMAT? (YES or NO): yes

The flash memory will require 20 to 60 seconds to erase.
Please wait...

Time (seconds): 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50

OK
>deployment M3319
OK
>sd 04/11/12
OK
>st 18:00:00
OK
>savesetup
OK
>s conf

Hardware Configuration

System Type ---------- MD
Sensor serial # ---------- D319
Sensor frequency - (kHz) ------- 1500
Number of beams ---------- 3
Beam Geometry ---------- 3_BEAMS
Vertical Beam ---------- NO
Slant angle - (deg) ---------- 45.0
System Orientation ---------- UP
Compass installed ---------- YES
Recorder installed ---------- YES
Temperature sensor ---------- YES
Pressure sensor ---------- YES
PressOffset - (dbar) ---------- -145.836810
PressScale -- (dbar/count) ---- 0.112528
PressScale_2 - (pdbar/count^2) - 0
Ctd sensor ---------- YES
Ext. Press. sensor ---------- NONE
YSI sensor ---------- NO
Waves Option ---------- NO
Internal SDI-12 Option --------- NO
Internal Flow Computations ----- NO
Analog Output Option ---------- NO
Multi-cell Profiling Option ---- NO
>s setup

Setup Parameters

Temp ---------- 20.00 deg C
Sal ---------- 34.50 ppt
TempMode ------- MEASURED
Sound Speed ---- 1520.9 m/s
AvgInterval ---- 60 s
SampleInterval - 300 s
CoordSystem ---- ENU
>s deploy

DEPLOYMENT PARAMETERS

Deployment ------ M3319
StartDate ------- 2004/11/12
StartTime ------- 18:00:00
AvgInterval ----- 60 s
SampleInterval -- 300 s
BurstMode ------- DISABLED
BurstInterval --- 1200 s
SamplesPerBurst - 1
Comments:

>deploy

Initializing CTD. Please wait...
Checking Setup Parameters...

4194304 free bytes left in recorder.
Free space is sufficient for 251.10 days of operation.

Data collection will start on: 2004/11/12 at 18:00:00
In 0 days, 0 hours, 15 minutes and 43 seconds from now.

Data will be recorded to file M3319001.
OK
2004 11 12 18 00 00 64.6 103.9 -92.6 9.4 12.9 8.2 25 25 26 100 1.1 -3.6 -1.6 7.1 2.1 0.7 21.62
0.112 0.000 10.0 1.5 4.0 25 23 24 22.0375 0.00003 0.000 0.0108
2004 11 12 18 05 00 53.8 69.7 -121.4 9.0 13.2 10.0 25 25 26 100 7.1 -3.2 -1.6 16.5 4.7 1.1 21.63
0.112 0.000 10.0 1.5 4.0 24 24 24 21.9983 0.00003 0.000 0.0108
2004 11 12 18 10 00 33.1 85.9 -129.1 11.1 15.5 7.6 25 25 26 100 7.4 -2.8 -1.6 17.6 4.2 1.4 21.63
0.225 0.000 10.0 1.5 4.0 24 24 25 21.9769 0.00003 0.000 0.0108
2004 11 12 18 15 00 87.7 98.2 -116.7 9.4 13.3 7.7 25 25 26 100 9.0 -3.6 -1.6 11.6 2.3 0.7 21.64
0.112 0.000 10.0 1.5 4.0 25 24 24 21.9615 0.00003 0.000 0.0107

Subsequent to recovery data download was commenced as

M3319001

Data checking carried out and configuration and sample data downloaded.

Config Data.

File ---------- M3319001.arg
File Size (bytes) --------- 945570
Number of Samples --------- 16581
Time of first sample ------ 12/11/2004 18:00:00
Time of last sample ------ 09/01/2005 07:40:00

```
ArgonautDP Hardware Configuration
---------------------------------
ArgType ------------------- MD
SerialNumber -------------- D319
Frequency ------- (kHz) --- 1500
Nbeams -------------------- 3
BeamGeometry -------------- 3_BEAMS
VerticalBeam -------------- NO
SlantAngle ------ (deg) --- 45.0
CPUSoftwareVerNum --------- 20.0
```

```
DSPSoftwareVerNum --------- 1.0
BoardRev ------------------ F
SensorOrientation---------- UP
CompassInstalled ---------- YES
RecorderInstalled --------- YES
TempInstalled ------------- YES
PressInstalled ------------ YES
CtdSensorInstalled -------- YES
YsiSensorInstalled -------- NO
Ext Press Sensor ---------- NONE
TempOffset (deg C) -------- 0.00
TempScale  (deg C/deg C) -- 1.0000
PressOffset (dbar) -------- -145.836810
PressScale  (dbar/count) -- 0.112528
PressScale_2 (pdbar/c^2) -- 0.000000
Transformation Matrix -----    0.942  -0.472  -0.472
                               0.000  -0.816   0.816
                               0.472   0.472   0.472

Argonaut User Setup
--------------------
DefaultTemp ----- (deg C) -- 20.00
DefaultSal ------ (ppt) ---- 34.50
TempMode ------------------- MEASURED
DefaultSoundSpeed (m/s) ---- 1520.90
CellBegin ------- (m) ------ 1.50
CellEnd --------- (m) ------ 3.00
ProfilingMode -------------- NO
DynBoundaryAdj ------------- NO
WaveSpectra ---------------- NO
WaterDepth ------ (m) ------ 0.00
AvgInterval ----- (s) ------ 60
SampleInterval -- (s) ------ 300
YsiBufferSize --- (bytes) -- 0
BurstMode ------------------ DISABLED
BurstInterval --- (s) ------ 1200
SamplesPerBurst ------------ 1
CoordSystem ---------------- ENU
AutoSleep ------------------ ON
OutMode -------------------- AUTO
OutFormat ------------------ METRIC
DataFormat ----------------- LONG FORMAT
RecorderEnabled ------------ ENABLED
RecorderMode --------------- NORMAL
DeploymentName ------------- M3319
DeploymentStart Date/Time -- 12/11/2004 18:00:00
Comments:



--------------------------------------------------
Argonaut ASCII data file Long format is as follows:
--------------------------------------------------
Column  1- 6: Year Month Day Hour Minute Second;
Column  7- 9: WaterVel1/X/E WaterVel2/Y/N WaterVel3/Z/U (cm/s)
Column 10-12: VelStDev1/X/E VelStDev2/Y/N VelStDev3/Z/U (cm/s)
Column 13-15: SNR1          SNR2          SNR3          (dB);
Column 16-18: SignalAmp1    SignalAmp2    SignalAmp3    (counts);
Column 19-21: Noise1        Noise2        Noise3        (counts);
Column    22: percent good pings
Column 23-25: Heading Pitch Roll (deg);
Column 26-28: Standard deviation of the Heading Pitch Roll (deg);
Column 29-30: Mean Tempr (degC) MeanPress (dBar);
Column    31: StDevPress (dBar);
Column    32: Power level (battery voltage) (Volts);
Column 33-34: CellBegin CellEnd (m);
Column    35: Speed (cm/s);
Column    36: Direction (deg);
Column    37: CTD - Temperature (deg C);
Column    38: CTD - Conductivity (mS);
Column    39: CTD - Pressure (dbar);
Column    40: CTD - Salinity (ppt);


-----------------------------------
Flow data file format is as follows:
-----------------------------------
Column  1- 6: Year Month Day Hour Minute Second;
Column     7: Depth (m)
Column     8: Area (m2)
Column     9: Vx (m/s);
Column    10: V Mean (m/s);
Column    11: Flow (m3/s);
```

Cruise Number

Mooring number 2004/34 (M3) **Date** **12-Nov-04**

Mooring Location **Lat** **Long**

Instrument Depth

Deployment Time

Channels	Data
1	*Reference 433*
2	*Speed*
3	*Direction*
4	*Temperature*
5	*Conductivity*
6	*Pressure*
7	
8	
9	*Tilt*

Recording Interval minutes	5
Number of Channels	9
Off/On/Burst	On
Temperature Range	Low
Conductivity Measurement range	0-70 mS/cm
Ensemble number	300

Clock Check	GMT	X
	Local	

Time on 1600 **Last Data time** 1200+02
Date 12/11/2004 **Date** 11/01/2005
Day Number 317 **Day number** 5

Instrument serial number

Sensors	Type	Serial number	Range
Doppler Current sensor	*3820*	*487*	
Temperature sensor	*3621*	*1757*	
Conductivity Cell	*3919A*	*145*	
Pressure sensor	*3815E*	*986*	0-60 Mpa

Visual and Mechanical Checks

1. Epoxy coating intact
2. No corrosion, O-ring groove pressure case
3. No corrosion, other parts
4. Zinc anode installed
5. Pressure sensor oil filled

Performance test

to be conducted twice with resistance loop set to 100 then 1000 ohms

70 Ohms

channel no	Reading	Cal. Cross check
1	**433**	
2	*114*	
3	*550*	
4	*940*	
5	**902**	
6	**32**	
7	*1023*	
8	*1023*	
9	**63**	

150 Ohms

channel no	Reading	Cal. Cross check
1	**433**	
2	*36*	
3	*664*	
4	*949*	
5	**421**	
6	**32**	
7	1023	
8	1023	
9	**50**	

RCM 11 SER NO 426

Cruise Number

Date

Instrument Serial Number 426

DSU serial number		14389
DSU check (Pass/Fail)		Pass
Clock Check	GMT	X
	Local	

Mooring number

Mooring Location Lat Long

Instrument Depth m

Time/Day on 12:00 309
Time/Day off 6:38 311

Channels	Data
1	*Reference 433*
2	*Speed*
3	*Direction*
4	*Temperature*
5	*Conductivity*
6	
7	
8	
9	*Tilt*

Recording Interval minutes	5
Number of Channels	9
Off/On/Burst	On
Temperature Range	Low
Conductivity Measurement range	24-38mS
Ensemble number	300

Cruise Number

RCM 11047

Mooring number 2004/34 Date

Mooring Location M3 Lat Long

Instrument Depth

Deployment Time

Channels	Data
1	*Reference 407*
2	*Temperature*
3	*Conductivity*
4	*Expanded Temp*
5	*Compass*
6	*Rotor*
7	
8	
9	

Recording Interval minutes	10
Number of Channels	6
Off/On/Burst	On
Temperature Range	Low & -1 to + 3.5
Conductivity Measurement range	26 - 33 mS/cm
Ensemble number	n/a

Clock Check		
	GMT	X
	Local	

Time on **1600** **No last data**
Date **12/11/2004** **Instrument with**
Day Number **317** **slight flood**

Data downloaded OK

Instrument serial number 11047

Sensors	Type	Serial number	Range
Current Sensor	*Rotor*	*n/a*	
Temperature sensor	*Thermistor*	*n/a*	-2 to 22' Low
Conductivity Cell	*2994*	*1776*	26 to 33 mS/cm
Pressure sensor	*nil*	*n/a*	

Visual and Mechanical Checks

Epoxy
1. coating intact
   No corrosion, O-ring groove pressure
2. case
3. No corrosion, other parts
4. Zinc anode installed
5. Pressure sensor oil filled

Performance test

to be conducted twice with resistance loop set to 100 then 1000 ohms

70 Ohms

channel no	Reading	Cal. Cross check
1	407	
2	1023	
3	1023	
4	1023	
5	227	
6	0	
7		
8		

150 Ohms

channel no	Reading	Cal. Cross check
1	407	
2	1023	
3	0	
4	1023	
5	224	
6	4	
7		
8		

Seabird SBE37 SMP

The Seabird SBE37SMP is a ctd logger with in situ pump.

Five loggers were set up as an example Serial number 3479 is shown below , each logger had the same set up and start times .

The memory was filled in each instance with full memory useage . The last recorded data occurred on January 5th 2005 .

*** Sea-Bird Data File:**

*** FileName = C:\D285_286 at sea\DATA\SBE 37SMP DATA\3479 rec.asc**

*** Software Version 1.43**

*** Temperature SN = 3479**

*** Conductivity SN = 3479**

*** System UpLoad Time = Jan 10 2005 18:20:46**

**** CROZEX SBE37SMP 3479 MOORING M3**

*** ds**

*** SBE37-SM V 2.5 SERIAL NO. 3479 05 Jan 2005 18:21:28**

*** not logging: received stop command**

*** sample interval = 120 seconds**

*** samplenumber = 39071, free = 151579**

*** do not transmit real-time data**

*** do not output salinity with each sample**

*** do not output sound velocity with each sample**

*** store time with each sample**

*** number of samples to average = 4**

*** serial sync mode disabled**

*** wait time after serial sync sampling = 30 seconds**

*** temperature = 20.93 deg C**

*** S>**

*** SBE37-SM V 2.5 3479**

*** temperature: 21-mar-04**

*** TA0 = -4.861541e-05**

*** TA1 = 2.793682e-04**

*** TA2 = -2.551370e-06**

*** TA3 = 1.604335e-07**

*** conductivity: 21-mar-04**

*** G = -1.030313e+00**

*** H = 1.290820e-01**

*** I = -1.815412e-04**

*** J = 3.256667e-05**

*** CPCOR = -9.570000e-08**

*** CTCOR = 3.250000e-06**

*** WBOTC = -5.862654e-06**

*** pressure S/N 5343, range = 10153 psia: 17-mar-04**

*** PA0 = -2.112261e+00**

*** PA1 = 4.844724e-01**

*** PA2 = -4.705214e-07**

*** PTCA0 = 9.459992e+00**

*** PTCA1 = -1.266239e-01**

*** PTCA2 = -2.368840e-03**

*** PTCSB0 = 2.488163e+01**

*** PTCSB1 = -1.075000e-03**

*** PTCSB2 = 0.000000e+00**

*** POFFSET = 0.000000e+00**

*** rtc: 21-mar-04**

*** RTCA0 = 9.999823e-01**

*** RTCA1 = 1.623128e-06**

*** RTCA2 = -2.916830e-08**

*** S>**

END

RDI LONG RANGER 75

>>>>>>>>>>Function Starting 11/09/04 07:53:41 >>>>>>>>>>>>>>>>>

CR1
PARAMETERS SET TO FACTORY DEFAULTS
CF11101
CQ255
EA00000
EB00000
ED00000
ES35
EX11111
EZ1111111
TE00:15:00
TF04/11/09,12:00:00
TP:45.00
WB0
WD111100000
WF0704
WN037
WP00020
WS1600
WV170
CK
Parameters saved as USER defaults
The command CS is not allowed in this command file It has been ignored
The following commands are generatd in this program
CF?
CF=11101----------Flow Ctrl (EnsCyc:Png:Binry:Ser:Rec
CF11101
RN CROZ_
Cs

RDI LONG RANGER 75

LR ADCP – TEST AND SET UP

EXPERT PLAN 1

CR1
CQ255
CF11101
EA0
EB2100
ED6000
ES35
EX11111
EZ1111111
WA50
WB1
WD111100000
WF704
WN37
WP20
WS1600
WV175
TE00:15.00.00
TP:45.00

Instrument = Workhorse Log Ranger
Frequency = 76800
Water Profile = yes
Bottom track = no
High Res Modes = no
High ping rate = no
Shallow bottom mode = no
Wave Gauge = no
Lowered adcp =no
Bean angle = 20
Temperature = 5
Deployment hours = 2400:00
Battery packs = 4
Automatic TP = YES
Memory size MB = 48
Saved Screen = 3

Consequences generated by PLAN ADCP version 2.02

First cell range 24.33m
Last cell range 600.33m
Max range 644.46m
Standard deviation 1.36cm/s
Ensemble size 888 bytes
Storage required 8.13 MB
Power usage 1585.83 Wh

Warnings and Cautions

There are no warnings or cautions present

Ocean Engineering Division
UKORS

Mooring Operational Sheet

PROJECT : CROZEX

UKORS Mooring No: 2004/36 **Mooring Name :M5**

DEPLOYMENT **RECOVERY**

CRUISE **:D286** :
DEPLOYMENT SHIP**:DISCOVERY** :
LATITUDE **: 46 00.00S** :
LONGTITUDE **: 56 05.00E** :
DATE/TIME **:26th Dec 2004** :
Methods DEPLOYMENT BUOY FIRST , ANCHOR FREEFALL AFT

Mooring diagram

EQUIPMENT	Ser.no/Length	Time in	Time out	Comments
17 inch Glass sphere		0550		44 30.87S 50 02.48E o/c 290
PICK UP LINE 20MM	15M			Blue line
8 x 17 inch glass spheres		0552		Benthos
Swivel stainless steel				Van der Weyden
15m Polyester line 10mm	15m			
Parflux trap ML11804 -04		0557		21 bottle 44 30.8S 50 02.39E o/c 286
chain 1/2"	1m			
Recording current meter 386 type RCM 11		0557		RCM8 with long spindle
Polyester line 10mm	nom 450m			Gleistein white
Polyester line 10mm	nom 450m			Gleistein white
8 x 17 inch glass spheres				
Polyester line 20m 12mm	20m			Liros red/white
Parflux trap ML11804-06				
Chain 1/2" galv long link	1m			
Recording current meter 427 type RCM 11				
Polyester line 10mm	nom 450m			Gleistein white
Polyester line 10mm	nom 450m			Gleistein white
Recording current meter NORTEK + FSI 37SI				
Chain 1/2" galv long link	1m			
Stainless steel swivel				Van der Weyden
AR861 283				
Polyester line 10mm	95m			
Chain 1/2" galv long link	8m			
Railway wheel anchor	770 kg			welded wheels
Anchor cut away on drop line				Chopped away with " big sharp knife " by Soph

Acoustic Release Observations
Free fall

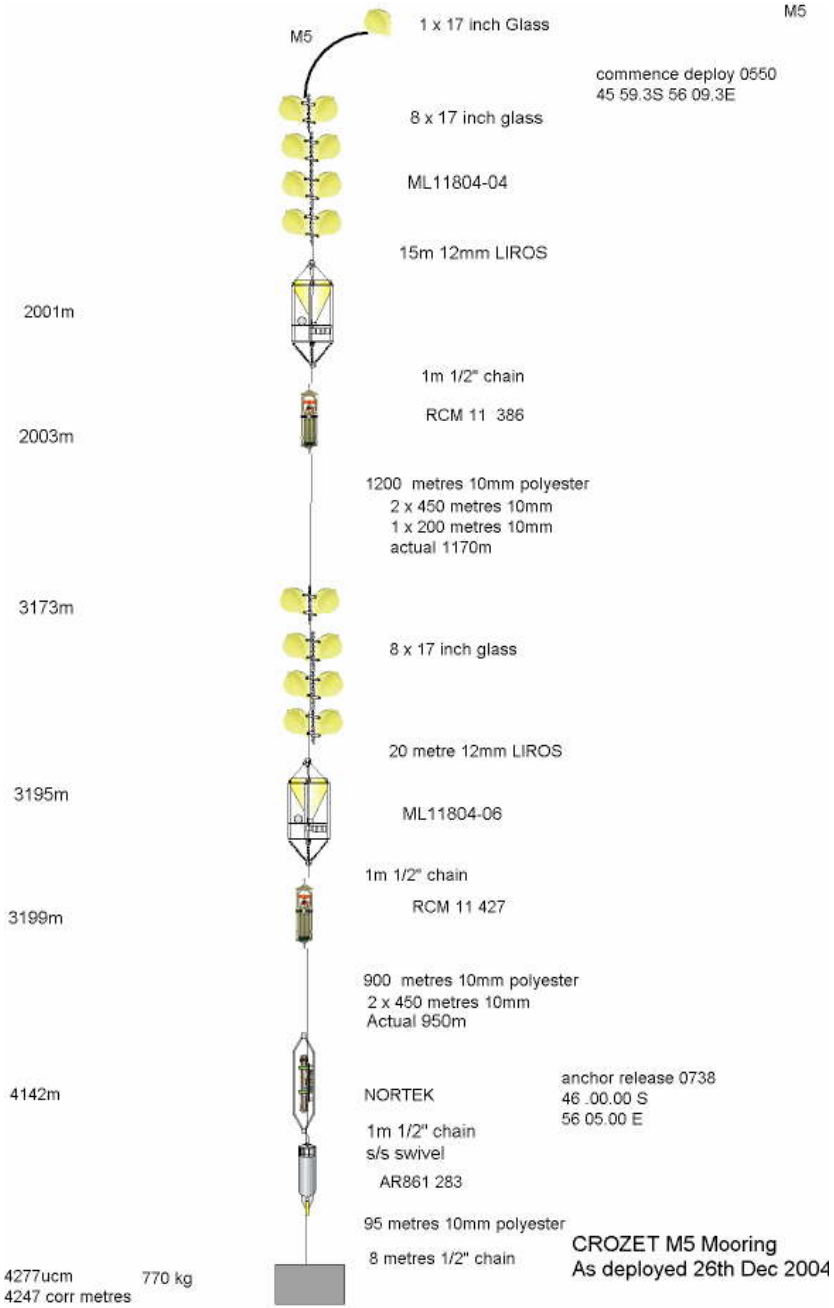
AR 861 SER.NO. 283

CAF	14BB	REL	CAF 1455	REL + PING	CAF 1456
PINGER	CAF 1447	PING OFF	CAF 1448	Diagnostic	CAF CAF

ARGOS Beacon Observations
NONE - NO beacon fitted

Other Comments

WATER DEPTH OBSERVED 4277 M CORRECTION BY CARTER TABLES 4247M
MOORING LENGTH M – DEPLOYED BUOY FIRST USING DBC AND CRANE
UKORS MOORING 2004/34
UKORS PERSONNEL WADDINGTON / NORTHROP - GDD FIELDING "SOPH"



RCM 11 SERIAL NUMBER 386

Cruise Number	286	M5	386

Mooring number 2004/36 Date **26TH DEC 04**

Mooring Location Lat **46 00.000S** Long **56 05.00E**

Instrument Depth

Deployment Time

Channels	Data
1	*Reference 461*
2	*Speed*
3	*Direction*
4	*Temperature*
5	*Conductivity*
6	*Pressure*
7	
8	
9	*Tilt*

Recording Interval minutes	*5*
Number of Channels	*9*
Off/On/Burst	*On*
Temperature Range	*Low*
Conductivity Measurement range	*20-40mS/cm*
Ensemble number	*300*

Note conductivity range changed at sea

DSU Checks

Clock Check			DSU Serial Number	**14380**
	GMT	X	DSU clock set	**Yes**
	Local		DSU Check	**Passed**

Time on 14-00 16th Dec 2004 15 words Sample rate 30 min

Time off 14-30 24 words

Data Recovery

Number of 10-bit words

Data File Name

Time difference (GMT-DSU)

Erased after download

RCM 11 SERIAL NUMBER 427

Cruise Number	D286	M5	427
			M5

Mooring number — Date

Mooring Location — Lat **46 00.00S** — Long **56 05.00E**

Instrument Depth

Deployment Time

Channels	Data
1	*Reference 461*
2	*Speed*
3	*Direction*
4	*Temperature*
5	*Conductivity*
6	*Pressure*
7	
8	
9	*Tilt*

Recording Interval minutes	*5*
Number of Channels	*9*
Off/On/Burst	*On*
Temperature Range	*Low*
Conductivity Measurement range	*20-40 Ms/sec*
Ensemble number	*300*

DSU Checks

Clock Check	GMT	X	DSU Serial Number	**14390**	
	Local		DSU clock set	**Yes**	
			DSU Check	**Passed**	
Time on	17-00		16th December 2004	30 min	15 words
Time off			17th Dec 2004 0338	210 words	
			Cased up 17th Dec		

Data Recovery

Number of 10-bit words

Data File Name

Time difference (GMT-DSU)

Erased after download

NORTEK for MOORING M5 CROZEX Discovery 286

FINAL DEPLOYMENT

==========

Deployment : moorM5
Current time : 19/12/2004 12:57:41
Start at : 19/12/2004 13:00:00
Comment:
Discovery D286 CROZEX Mooring M5

Measurement interval (s) : 900
Average interval (s) : 30
Blanking distance (m) : 0.37
Diagnostics interval(min) : 720
Diagnostics samples : 20
Measurement load (%) : 9
Power level : HIGH
Compass upd. rate (s) : 2
Coordinate System : ENU
Speed of sound (m/s) : 1525
Salinity (ppt) : N/A
File wrapping : OFF

Assumed duration (days) : 400.0
Battery utilization (%) : 181.0
Battery level (V) : 13.6
Recorder size (MB) : 9
Recorder free space (MB) : 9.000
Memory required (MB) : 2.2
Vertical vel. prec (cm/s) : 2.2
Horizon. vel. prec (cm/s) : 1.5

Aquadopp Version 1.25
Copyright (C) 1997-2003 Nortek AS

NOTE BATTERY USEAGE BASED ON 1 PACK - FITTED 2 PACKS
BATTERY UTILISATION IS 181%/2 = 90.5% IN A 400 DAY PERIOD

DIAGNOSTICS INITIALISED FOR DEPLOYMENT PERIOD AT 720 MIN PERIOD - EA. 12 HOURS DIAGNOSTICS AT 0100 AND 1300H

TIME CHECK 24th December using Radio receiver
Received signal at : -
1530 +00 GMT 30 SEC OF PULSES AT 1 SEC INTERVALS .
1545 +00 GMT ..
1600 +00 gmt ..
1745 +00 GMT ..
1415 +00 gmt 25 - Dec - 2004
0645 +00 GMT 26 - Dec - 2004 checked in hangar prior to deploy .
TIME CHECKED USING SHIPS TIMING - ALL gmt

Ocean Engineering Division
UKORS

Mooring Operational Sheet

PROJECT : CROZEX
UKORS Mooring No: 2004/37 Mooring Name :M6

DEPLOYMENT		RECOVERY
CRUISE	:D286	:
DEPLOYMENT SHIP	:DISCOVERY	:
LATITUDE	: 49 00.03S	:
LONGTITUDE	: 51 30.59E	:
DATE/TIME	:3rd JAN 2005	:

Methods DEPLOYMENT BUOY FIRST , ANCHOR FREEFALL AFT

Mooring diagram

EQUIPMENT	Ser.no/Length	Time in	Time out	Comments
17 inch Glass sphere		0448		44 30.87S 50 02.48E o/c 290
PICK UP LINE 20MM	15M			Blue line
8 x 17 inch glass spheres		0449		Benthos
Swivel stainless steel				Van der Weyden
15m Polyester line 10mm	15m			
Parflux trap ML11804 -02		0454		21 bottle 44 30.8S 50 02.39E o/c 286
chain 1/2"	1m			
Recording current meter 425 type RCM 11		0455		RCM8 with long spindle
Polyester line 10mm	nom 450m			Gleistein white
Polyester line 10mm	nom 450m			Gleistein white
8 x 17 inch glass spheres				
Polyester line 20m 12mm	20m			Liros red/white
Parflux trap ML11804-07				
Chain 1/2" galv long link	1m			
Recording current meter 12363 type RCM 8				
Polyester line 10mm	nom 450m			Gleistein white
Polyester line 10mm	nom 450m			Gleistein white
Recording current meter 421 type RCM11				
Chain 1/2" galv long link	1m			
Stainless steel swivel				Van der Weyden
AR861 282				
Polyester line 10mm	95m			
Chain 1/2" galv long link	8m			
Railway wheel anchor	770 kg			welded wheels
Anchor cut away on drop line		0616		Chopped away with " big sharp knife " by Ian

Acoustic Release Observations
Free fall

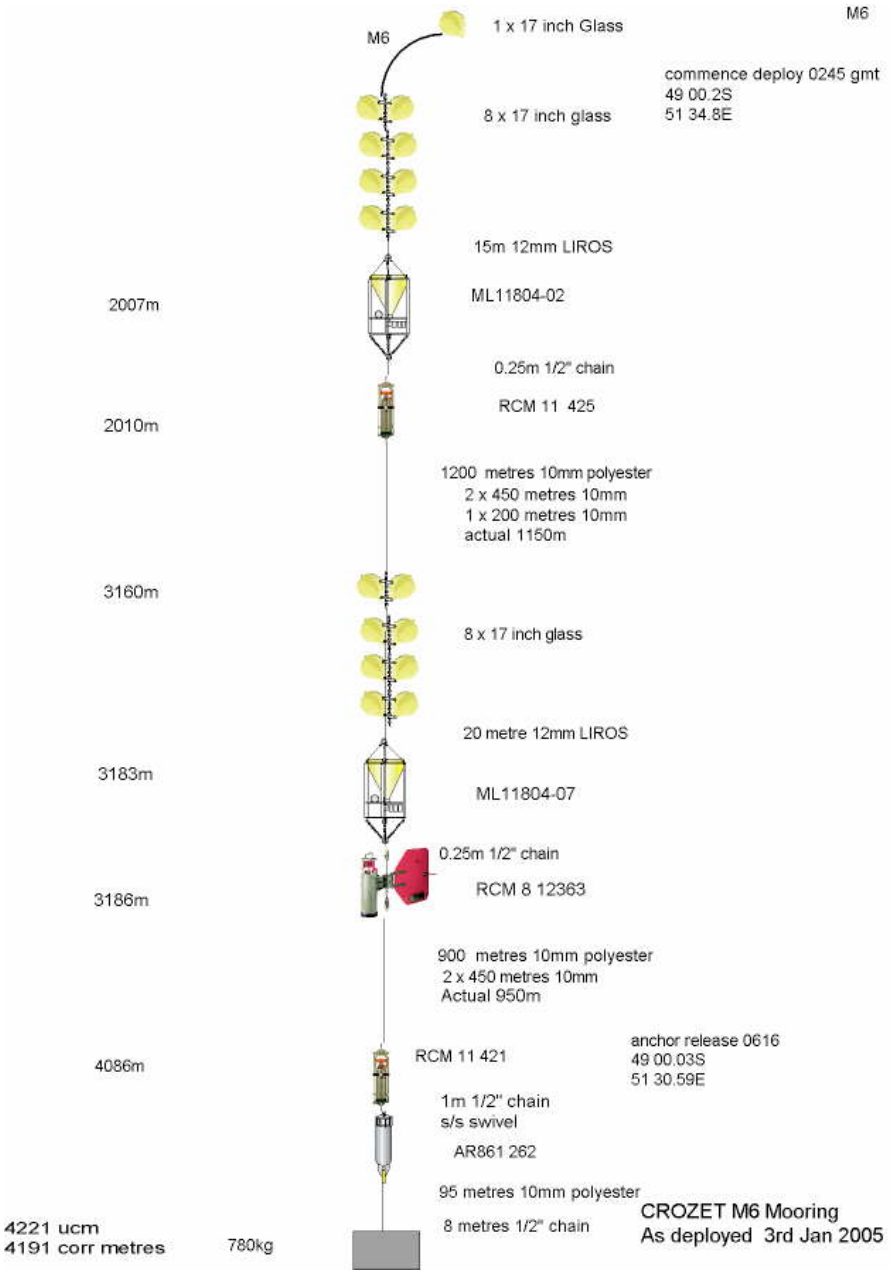
AR 861 SER.NO. 262

CAF	14B3	REL	CAF 1455	REL + PING	CAF 1456
PINGER	CAF 1447	PING OFF	CAF 1448	Diagnostic	CAF CAF

ARGOS Beacon Observations
NONE - NO beacon fitted

Other Comments

WATER DEPTH OBSERVED 4221 M CORRECTION BY CARTER TABLES 4191M
MOORING LENGTH M – DEPLOYED BUOY FIRST USING DBC AND CRANE
UKORS MOORING 2004/34
UKORS PERSONNEL WADDINGTON / NORTHROP/DAVIES/MOUNTIFIELD - GDD FIELDING "SOPH"



RCM 11 SERIAL NUMBER 425

Cruise Number D286 425

Mooring number 2004/37 Date **3rd Jan 2005**

Mooring Location Lat **49 00.03S** Long **51 30.59E**

Instrument Depth

Deployment Time 0616 gmt

Channels	Data
1	*Reference 461*
2	*Speed*
3	*Direction*
4	*Temperature*
5	*Conductivity*
6	*Pressure*
7	
8	
9	*Tilt*

Recording Interval minutes	30
Number of Channels	9
Off/On/Burst	On
Temperature Range	Low
Conductivity Measurement range	20-40mS/cm
Ensemble number	300
Conductivity range change	
minor repaint on 3820 sensor	

DSU Checks

Clock Check	GMT	X	DSU Serial Number	**14388**
	Local		DSU clock set	**Yes**
			DSU Check	**Passed**
Time on	05-00		17th December 2004	30 min	15 words
Time off			Cased up 18th Dec 04	0810h	507 words

Data Recovery

Number of 10-bit words

Data File Name

Time difference (GMT-DSU)

Erased after download

Cruise Number	D286		421
			M6
Mooring number	2004/37	Date	**3rd Jan 2005**
Mooring Location	Lat **49 00.03S**	Long	**51 30.59E**
Instrument Depth			
Deployment Time	0616		

Channels	Data
1	*Reference 461*
2	*Speed*
3	*Direction*
4	*Temperature*
5	*Conductivity*
6	*Pressure*
7	
8	
9	*Tilt*

Recording Interval minutes	5
Number of Channels	9
Off/On/Burst	On
Temperature Range	Low
Conductivity Measurement range	20-40mS/cm
Ensemble number	300
Range change cond cell at sea	

DSU Checks

Clock Check			DSU Serial Number	**14386**
	GMT	X	DSU clock set	**Yes**
	Local		DSU Check	**Passed**

Time on	12-00	18th December 2004	30 min	15 words
Time off		19th December 2004	0532h	336 words
		cased up 19th		

Data Recovery

Number of 10-bit words
Data File Name
Time difference (GMT-DSU)
Erased after download

Cruise Number		M6	12363
Mooring number	2004/37	Date	**3rd Jan 2005**
Mooring Location	M6 Lat **49 00.03S**	Long	**51 30.59E**
Instrument Depth			
Deployment Time	0616 gmt		

Channels	Data
1	*Reference*
2	*Temperature*
3	*Conductivity*
4	*Expanded Temp*
5	*Compass*
6	*Rotor*
7	
8	
9	

Recording Interval minutes	60
Number of Channels	6
Off/On/Burst	On
Temperature Range	Low (ch 2) -1 - 3 deg C (ch. 4)
Conductivity Measurement range	26 - 33 mS/cm
Ensemble number	Vector Averaged

DSU Checks

Clock Check			DSU Serial Number	7166
	GMT	X	DSU clock set	Yes
	Local		DSU Check	Passed
			Cased up 16-Dec-04	

Time on	08-00	15-Dec-04	12 words
Time Off			

Data Recovery

Number of 10-bit words
Data File Name
Time difference (GMT-DSU)
Erased after download

Ocean Engineering Division
UKORS

Mooring Operational Sheet

PROJECT : CROZEX

UKORS Mooring No: 2004/35 **Mooring Name :M10**

DEPLOYMENT **RECOVERY**

CRUISE **:D286** :
DEPLOYMENT SHIP **:DISCOVERY** :
LATITUDE **: 44 29.954S** :
LONGTITUDE **: 49 59.923E** :
DATE/TIME **:20th Dec 2004** :
Methods DEPLOYMENT BUOY FIRST , ANCHOR FREEFALL AFT

Mooring diagram

EQUIPMENT	Ser.no/Length	Time in	Time out	Comments
17 inch Glass sphere		1000		44 30.87S 50 02.48E o/c 290
PICK UP LINE 20MM	15M			Blue line
10 x 17 inch glass spheres		1002		Benthos
Swivel stainless steel				Van der Weyden
15m Polyester line 10mm	15m			
Parflux trap ML11804 -03		1006		21 bottle 44 30.8S 50 02.39E o/c 286
chain 1/2"	1m			
Recording current meter 12356 type ACM 8		1006		RCM8 with long spindle
Polyester line 12mm	401m			Liros red/white
Polyester line 12mm	402m	1020		Liros red/white
AR 861 # 319		1034		fitted new design release link
Polyester line 30m 12mm	30m			Liros red/white
Polyester line 90m 10mm	90m			Gleistein white Tasmania
Chain 1/2" galv long link	8m			
Chain 5/8" grade 30 stnd link	1m			
Railway wheel anchor	560kg			2 x Railway wheels welded straps
Anchor released using BOSS				Freefall anchor
				44 49.954S 49 59.923E o/c 292 speed 1.76kt

Acoustic Release Observations

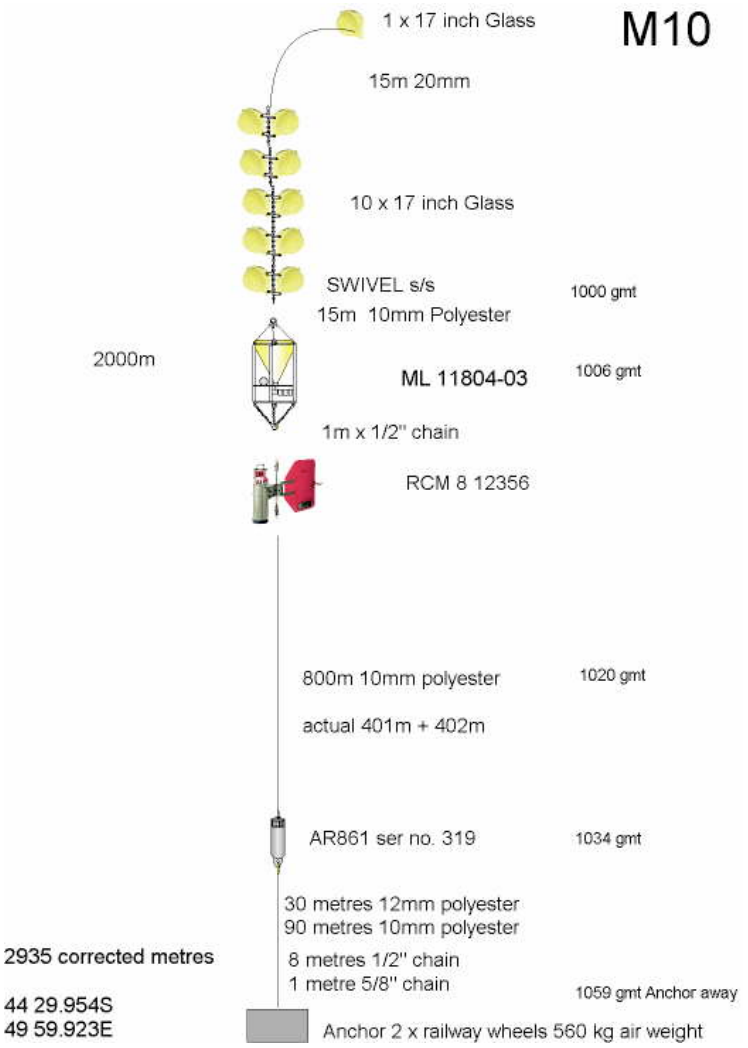
AR 861 SER.NO. 319

CAF	14CF	REL	CAF 1455	REL + PING	CAF 1456
PINGER	CAF 1447	PING OFF	CAF 1448	Diagnostic	CAF CAF

ARGOS Beacon Observations
NONE - NO beacon fitted

Other Comments

WATER DEPTH OBSERVED 2965 M CORRECTION BY CARTER TABLES 2935M
MOORING LENGTH M – DEPLOYED BUOY FIRST USING DBC AND CRANE
UKORS MOORING 2004/34
UKORS PERSONNEL WADDINGTON / NORTHROP/SHORT - GDD BOORMAN



Cruise Number	D286	Mooring M10	12356

Mooring number	2004/35			Date	**20th December 04**
Mooring Location		Lat	**44 29.954S**	Long	**49 59.923E**
Instrument Depth			2000 metres		
Deployment Time			1020 gmt 20th dec 04		

RCM 8 type

Channels	Data
1	*Reference*
2	*Temperature*
3	*Conductivity*
4	*Expanded Temp*
5	*Compass*
6	*Rotor*

Recording Interval minutes	60
Number of Channels	6
Off/On/Burst	On
Temperature Range	2 - 6 deg C
Conductivity Measurement range	26 - 35 mS/cm
rotor	Vector Average

DSU Checks

Clock Check	GMT	X	DSU Serial Number	3993
	Local		DSU clock set	Yes
			DSU Check	Passed
			CASED UP 16-Dec-04	

Time on	**23-00**	**14-Dec-04**	**12 data words**
Time Off			

16. ARGO ProfilingFloats

John Allen, Paul Duncan, Alan Hughes and Hugh Venables

Four Webb Corporation APEX and six Martek PROVOR profiling ARGO floats were deployed during Crozex I, D285 with a further 2 Apex and 2 PROVOR deployed on D286. The floats were "park and profile"; that is to say that they would float at a set park pressure (1000 dbar for the APEX floats and 2000 dbar for the PROVOR floats), then surface if a PROVOR float or sink to the maximum profile pressure (2000 dbar) before surfacing if an APEX float. All the floats had been programmed to resurface every 10 days, although we set the PROVOR floats to make their first profile after just two days. Time at the surface was set to 6 hours to minimise transportation by surface currents, but to allow time for full data transmission by Argos satellite communication.

All deployments were carried out from the port corner of the stern of the ship. Initially they were lowered gently into the water as the ship steamed into the wind at 1 knot. However, after problems nearly entangling a rope with both the damper ring and sensors on a PROVOR float, we began deploying them whilst getting underway, or underway, by launching them from a cardboard launching tube (PROVOR, provided by Martek) or launching the lighter APEX floats clear of the ship by hand, as vertically as possible, into the water.

The floats were tested and launch details recorded as instructed in a comprehensive “manual” compiled by Brian King immediately prior to D285.

Float launches are shown in Table 16.1.

Table 16.1 Details of ARGO float deployments

Launch time Jday/hhmm	Float No./ A P E X (A) PROVOR(P)	Argos ID	Latitude	Longitude
309/1530	02-F2-09/(P)	60C2700	36° 11.66’ S	23° 22.37’ E
314/1456	02-F2-06/(P)	57A0800	42° 00.10’ S	48° 01.42’ E
317/0040	03-F3-01/(P)	5D81600	43° 54.50’ S	50° 13.75’ E
318/1418	1816/(A)	713746A	46° 04.00’ S	51° 44.00’ E
325/1233	03-F3-03/(P)	5DBC200	47° 40.85’ S	52° 55.21’ E
333/2252	03-F3-04/(P)	643DB00	45° 29.40’ S	47° 38.33’ E
340/1618	1817/(A)	7137479	42° 01.50’ S	43° 59.19’ E
341/1324	1812/(A)	7137426	40° 22.61’ S	40° 13.72’ E
342/1644	03-F3-06	6B8C700	38° 06.47’ S	35° 05.75’ E
344/0518	1813/(A)	7137435	35° 12.63’ S	28° 48.11’ E
363/1738	03-F3-05	6603B00	46° 00.93’ S	56° 08.92’ E
018/1238	1814	713744C	37° 26.04’ S	41° 15.76’E
019/0547	1815	713745F	35° 05.78’ S	38° 45.62’ E
020/0653	03-F3-02	5D84500	32° 13.57’ S	34° 30.64’ E

17. Shore sampling on Ile de La Possession, Crozet, 8 January 2005

Gary Fones, Mike Lucas, Paul Morris, Hélène Planquette, Hugh Venables

Background

The major hypothesis of the Crozex programme is that phytoplankton productivity in the seas surrounding Crozet is enhanced because of natural Fe fertilisation of surface waters. One of the major objectives of the Crozex programme was to identify any shallow benthic source of iron and elucidate the pathways of vertical and horizontal dispersion of this iron to surface waters around Crozet. The hypothesis is that these sources of Fe could be rain run off from the islands, upwelling or from sediments. Therefore one of the strategies is to locate the source of Fe close to /at island. A key component of this work is the tracing of water masses that we anticipate will contain elevated Fe back to a sediment source. Two possibilities exist which are not mutually exclusive. One is that as deep water rises towards the surface as it flows northwards over the Crozet plateau, it brings Fe-enriched water to the surface. The other is that freshwater run-off following weathering from the islands introduces Fe and perhaps silicate and other nutrients into the near-shore surface waters.

To test these possibilities, a small team of scientists (Fig. 17.1) were brought ashore at Port Alfred to sample a small stream system located in the Crique du Sphinx for nutrients, Fe, radium and other biogenic parameters about 2 miles north east of the main base.

Fig.17.1 The Crozet sampling Team… From left to right: Hugh Venables, Hélène Planquette, Bart Van de Vijver, Mike Lucas, Paul Morris & Gary Fones. Thierry Deles took the picture.

Fig. 17.2 Crique du Sphinx

After we arrived in Baie de La Grande Manchotière (Port Alfred), Thierry Deles, Chef de District des Iles Crozet, and Bart Van de Vijver, a Belgian scientist welcomed us among a large King Penguin colony. They then guided us to the sampling site, La Crique du Sphinx (Fig. 17.2), located 2 miles north east to Port Alfred. After an hour walking in the hills, we arrived at the Crique du Sphinx.

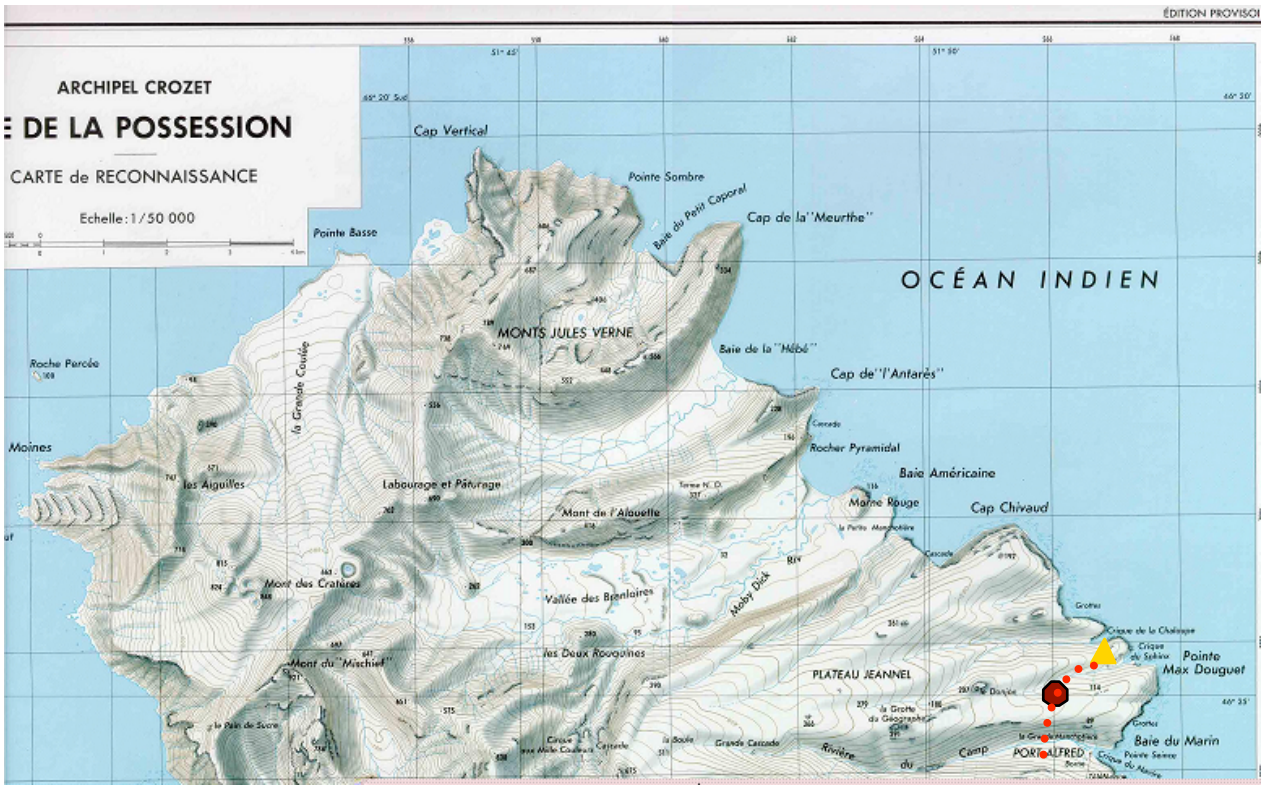


Fig. 17.3 Map of Ile de La Possession, given by Thierry Deles.
▲ Crique du Sphinx : 46.414°S 51.866°E
● Rock sampling: 46.413°S 51.864°E
····· Our route

Table 17.1 Summary of the sampling in Crique du Sphinx.

Site	1. Surf-zone	2. Waterfall	3. Top seal	4. Freshwater
Position		46.413°S 51.866°E		
Dissolved Fe	500 mL LDPE	500 mL LDPE		500 mL LDPE
Fe Speciation		500 mL Teflon		500 mL Teflon
Fe sediments				3 core syringes
Ra		40 L		
REE	1 L			1 L
Mixing Expts	500 mL			500 mL
Nutrients	□	□	□	□
Salinity	□	□	□	□
Chl-a (Total)	119	120	121	122
Chl-a (<20 µm)	123	124	125	126
HPLC	250 mL	250 mL	250 mL	250 mL
POC/N	310 mL	310 mL	470 mL	595 mL
Lugols	123	124	125	126
Formalin	160	161	162	163

Sampling strategy

We decided to set up four sampling sites between the surf-zone and a point about 400m upstream beyond the highest excursions of the elephant seal or penguin populations.

Various samples were taken to better understand the islands geochemistry and biology. With one of the major objectives being Fe, clean samples were taken at the four sites (Fig. 17.4c), this will enable an Fe gradient entering the surrounding waters to give an estimate of the importance of island run-off on the Crozet region Fe budget. Core syringe sediment samples were taken by Bart Van de Vijver (Fig. 17.4d), these will be used to undertake re-suspension and Fe release experiments at SOC. A sample was also taken for Radium, this fresh water sample was filtered at the sampling site at the Crique du Sphinx (Fig. 17.4b).

After collecting the water samples (Table 17.1), we trudged wearily (and sadly) back to the La Grande Manchotière carrying our heavy but precious water in 10L carboys, 2L polycarbonate bottles and in small 500 mL sample bottles. On the way back to the La Grande Manchotière, rock samples were collected for Dr. Rachel Mills to determine Fe content and weathering on the Plateau Jeannel (Fig. 17.5).

Fig. 17.5 Plateau Jeannel

Fig. 17.4 (below) Crique du Sphinx

Fig. 17.4a) Chlorophyll: surf zone and freshwater site

Fig. 17.4 b) Radium: waterfall and filtration


Fig. 17.4c) Iron


Fig. 17.4d) Sediments

Shore to ship transect

Just before leaving the island, two sediment cores were taken and a radium sample (40L), which was then filtered on the ship. After saying goodbye to our hosts, we left the island (sadly, again…) and another radium sample was taken as well as an iron and a neodymium sample, half way between the shore and the ship (Table 2).

Table 17.2 Summarises the samples, sample number and volumes taken or filtered during the transect.

Site	Position	Fe		Ra	Nd + REE	Nuts. & Salini
		Dissolved Fe	Speciation			
1.Surf-zone	46.426°S 51.862°E	500mL LDPE		40L		□
2.Half-way	46.427°S 51.868°E	500mL LDPE	500mL Teflon	40L	1L	□

This transect will hopefully give a better indication of Ra input and dilution and thus potential Fe input from Crozet to surrounding waters.

Analyses

Nutrients and Chlorophyll

Nutrients and chlorophyll analyses have been completed on board. HPLC samples have been frozen at –80°C and will be transported first to Cape Town (c/o Mike Lucas) and then to SOC for later analysis. POC/N samples have been frozen at –20°C and they will

be transported to Cape Town (c/o Mike Lucas) where they will be oven dried and pelleted in readiness for analysis on a CHN analyser back at SOC. Lugols and Formalin samples of preserved phytoplankton and micro-zooplankton will be shipped back to SOC for later enumeration of cells.

Preliminary Results

Crique Du Sphinx					
Site	NO_3	Si	PO_4	Total Chl	<20µm C
1.Surf-zone	17.63	31.21	1.96	1.44	0.73
2.Waterfall	0.49	119.92	0.13	0.90	0.53
3.Top seal	0.13	121.71	0.07	0.37	0.18
4.Freshwater	0.18	123.26	0.05	0.17	0.15
Shore to ship transect					
Site	NO_3	Si	PO_4	Salinity	
5.Surf-zone	19,31	32,83	4,7	27	
6. Half way	26,34	17,08	2,22	32	

Interpretation of Results

For all the parameters, there was an increasing concentration gradient from the upper freshwater stream down towards the surf-zone. The chlorophyll concentrations within the upper stream region were very low, ranging from ~0.1µg l-1 at the upper site but increasing to ~1.0 µg l-1 in the surf-zone. However, the GF/F filters were very coloured (for POC & for chlorophyll) and on that basis, much higher chl-a values were expected than the one obtained. This observation strongly suggests that much of the material observed on the filters was either lithogenic, or more likely, biogenic and consisting of detrital material originating from the surrounding bogs. Clearly too, elephant seal activity and the presence of King & Gentoo Penguin colonies lower down towards the shore were increasing the detrital input to the stream. It was noticeable too that the filters from the surf-zone were heavily loaded with particulate material. Much of this will originate from the fragmentation of kelp (*Durvillaea spp., Macrocystis spp*.) in the heavy shore break surf-zone. Research at Marion Island ~200nm to the west of Crozet has shown that *Macrocystis* grows at ~ 4cm per day and that kelp-bed productivity makes a substantial contribution to overall near-shore productivity. [see Attwood CG., Lucas MI., et. al., (1991) Production and standing stocks of the kelp *Macrocystis laevis* (Hay) at the Prince Edward Islands, sub-Antarctic. *Polar Biol.* **11**: 129-133]

Therefore, POC/N analyses should confirm that there is a high load of detrital particulate material. It will be important however to subject the filters with fuming HCL to remove any inorganic lithogenic carbon sources.

Conversations between Mike Lucas and Dr. Bart Van de Vijver on the walk to the sampling site were most revealing. His research on Crozet is to identify and assess the importance of freshwater diatoms on the Islands. Apparently all the diatoms are benthic, not pelagic, and that there are a number of different taxa represented, including some endemic species. Surprisingly, the pH of the water is close to 7 rather than acidic as expected. He also has nutrient data that demonstrate that nitrate concentrations in the freshwater reaches of all the streams are close to zero or undetectable. In conclusion, they agreed to stay in touch and to exchange research findings as he clearly has a lot of information of value to us.

Radium and Iron

Radium is acting as a proxy of water that has been in contact with sediments or other Ra sources. The two samples taken on the shore to ship transect were filtered back on board Discovery and analysed. (See Ra section)

The island clearly has a high content of iron, there are some hydrothermal sources and there are lots of indications of the presence of iron everywhere (Fig. 17.6). We have stored the samples in a freezer and they will be analysed back to SOC, as well as the sediments cores.

Fig. 17.6 Evidence of the presence of iron in Crique du Sphinx-"rusty rocks"

Future Requirements

To translate the nutrient, Fe, Ra and other parameter concentrations into input rates to the near-shore marine environment, we will clearly need to have some knowledge of seasonal flow rates over an annual cycle. The most likely way of getting this information is through our French colleagues on Crozet, in particular Dr. Bart Van den Vijver and Thierry Deles.

Acknowledgements

We would like to thank Thierry and Bart for their help in the sampling and their kindness. We had a fantastic day…