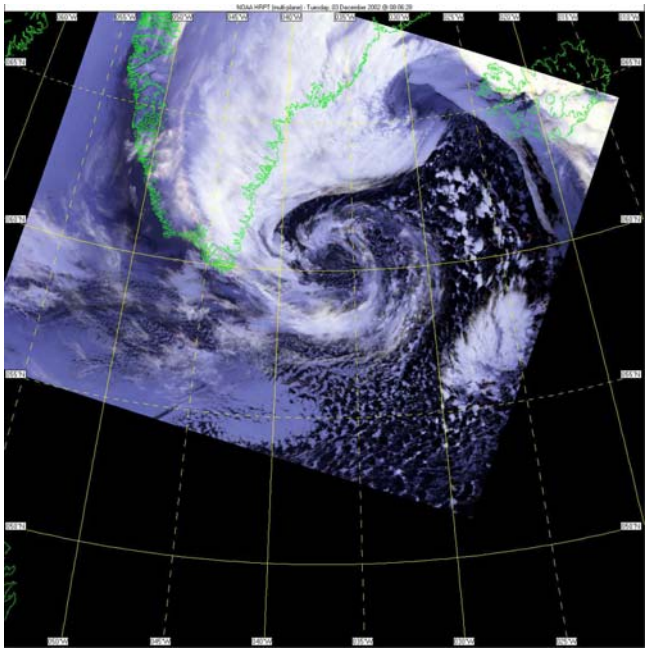
RRS Discovery Cruise 267

Biophysical studies of zooplankton dynamics in the northern North Atlantic: 2nd winter cruise, 6 Nov – 19 Dec 2002

MARINE PRODUCTIVITY CRUISE REPORT NO. 4



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Document Data Sheet

AUTHORS

J T ALLEN, S J HAY and Marine Productivity researchers, with editorial assistance by P Williamson and G Moncoiffe

TITLE

RRS Discovery cruise 267. Biophysical studies of zooplankton dynamics in the northern North Atlantic: 2nd winter cruise, 6 Nov- 19 Dec 2002.

REFERENCE

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ABSTRACT

Discovery 267 was the last of four multi-institute and multidisciplinary research cruises supported by the NERC Marine Productivity thematic programme within the wider context of the international Global Ocean Ecosystem Dynamics project (GLOBEC). It provided information on biological and physical conditions during early winter in the northern Irminger Basin, along the Reykjanes Ridge, parts of the Iceland Basin, and at the northern and southern ends of the Rockall Trough. As in other cruises, scientific effort was directed at: mapping physico-chemical features in terms of water mass distribution, velocity field and mixed layer properties; nutrient analyses; FRRF and ^{14}C primary production measurements; collection of water samples for additional analyses of micro-plankton; determination of 3D abundances of the copepod *Calanus finmarchicus*, other mesozooplankton, and their main invertebrate predators; experimental studies of egg production and feeding for *Calanus* and *Oithona* spp; genetic analysis of *Calanus* populations, and zooplankton collection for further taxonomic, physiological and biochemical studies.

Weather conditions were generally unfavourable (~9 days downtime due to poor weather), limiting coverage for the ocean areas of interest. Nevertheless, much was achieved, including 17 CTD profiles, 12 ARIES tows, 12 Dual Methot net tows, 12 Ocean Sampler tows, 18 sets of vertical net hauls, 19 FRRF underway datasets, 1 MetO buoy deployment, 9 lowered EK500 deployments and 24 EK500 tows. Provisional data from ARIES and other sources indicated that *Calanus* abundances were similar to the previous year's results (D258), primarily located at 1000-1500m in the Irminger Basin.

KEYWORDS

ADCP SYSTEMS, ARIES SYSTEM, CALANUS FINMARCHICUS, COPEPOD, CTD OBSERVATIONS, DISSOLVED OXYGEN, DUAL METHOT NET, EGG PRODUCTION, EUPHAUSIID, FRRF SYSTEM, GLOBEC, ICELAND BASIN, IRMINGER BASIN, MARINE PRODUCTIVITY THEMATIC, MICROPLANKTON, NORTHERN NORTH ATLANTIC, NAUPLII, NUTRIENTS, OCEAN SAMPLER, OITHONA, OPTICAL PLANKTON COUNTER, PHYTOPLANKTON, PRIMARY PRODUCTION, REYKJANES RIDGE, RRS DISCOVERY, SALINITY, SCIENTIFIC ECHOSOUNDER, SEA SURFACE TEMPERATURE, ZOOPLANKTON.

ISSUING ORGANISATION

Natural Environment Research Council, Swindon SN2 1EU, UK

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Scientific personnel

ALDERSON, Steven	Legs 1 and 2	SOC-JRD
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ANDERSON, Cairistiona	Legs 1 and 2	St. Andrews
BROWN, Louise	Leg 1	SOC-GDD
CASTELLANI, Claudia	Leg 1	SOC-GDD
COMBEN, Dan	Leg 2	SOC-OED
COOK, Kathryn	Legs 1 and 2	FRS-Aberdeen
DIDCOCK, Carol	Leg 1	St. Andrews
DRIFF, Karina	Leg 1	FRS-Aberdeen
DUNCAN, Paul	Legs 1 and 2	SOC-OED
FIELDING, Sophie	Legs 1 and 2	SOC-GDD
HAY, Steve	Leg 1	FRS-Aberdeen
HENSON, Stephanie	Legs 1 and 2	SOC-SOES
HOUGHTON, Robert	Legs 1 and 2	QUB-Belfast
HUNTER, Jim	Legs 1 and 2	FRS-Aberdeen
JOHNSON, Martin	Legs 1 and 2	UEA
LUCAS, Mike	Leg 1	SOC-GDD
McDERMOTT, Tommy	Leg 2	QUB-Belfast
MUSTARD, Alex	Leg 2	SOC-GDD
PAINTER, Stuart	Leg 1	SOC-SOES
RASMUSSEN, Jens	Legs 1 and 2	FRS-Aberdeen
RIXEN, Michel	Leg 2	SOC-GDD
ROBERTS, Emily	Legs 1 and 2	UW-Swansea
ROURKE, Liz	Legs 1 and 2	SOC-OED
SANDERS, Richard	Leg 2	SOC-GDD
SAUNDERS, Ryan	Legs 1 and 2	St. Andrews
SHERRING, Alan	Leg 1	SOC-OED
SHORT, John (Technical Liason)	Legs 1 and 2	SOC-OED
TEARE, Dave	Legs 1 and 2	SOC-OED
WHITTLE, Steve	Legs 1 and 2	SOC-OED
WONG, Grace	Legs 1 and 2	UW-Bangor
YOUNG, Darren	Legs 1 and 2	SOC-OED

FRS, Fisheries Research Services; QUB, Queen's University Belfast; SOC**,** Southampton Oceanography Centre (GDD, George Deacon Division; JRD, James Rennell Division; OED, Ocean Engineering Division; SOES, School of Ocean and Earth Sciences); UEA, University of East Anglia; UW**,** University of Wales.

Ship's personnel

WARNER, Richard	Master
NODEN, Derek	Chief Officer
COPE, Andy	2nd Officer
REYNOLDS, Peter	EX. 2nd Officer
ADAMS, Andy	Chief Engineer
McDONALD, Bernie	2nd Engineer
CONNOR, Keith	3rd Engineer
COLLARD, Glynn	3rd Engineer
GOVIER, Gerry	Electrical Technical Officer
DRAYTON, Michael	CPO(D)
BENNET, Peter	PO(D)
BUFFERY, Dave	SG.1.A.
COOPER, Gerry	SG.1.A.
DICKINSON, Bob	SG.1.A.
DOLLERY, Perry	SG.1.A.
MOORE, Mark	SG.1.A.
MACLEAN, Andy	SG.1.A.
MacDIARMID, Donald	Motorman 1.A.
CURTIS, Keith	S.C.M.
COOPER, Sandy	Chef
EATON, Mark	Asst. Chef
MINGAY, Graham	Steward
HAILES, Keiran	D/Cadet

Acknowledgements

Winter experiments at these latitudes are not expected to be easy, but *RRS Discovery* cruise 267 certainly had more than its fair share of bad luck. However, the overwhelming success of D267 to make the most efficient use of the scientific time available was principally due to the outstanding teamwork achieved by the Master, officers, crew, engineers and scientists involved in the cruise. Their enthusiasm, patience and professionalism enabled me to remain focussed on the job in hand - many thanks.

This cruise was made possible by the support services provided by the NERC Research Ships Unit, SOC Ocean Engineering Division (UK Ocean Research Services), SOC George Deacon Division, and the Fisheries Research Services Marine Laboratory, Aberdeen. Funding was primarily provided through research grants awarded by the NERC Marine Productivity thematic programme. The key role of the programme Steering Committee in developing the scientific framework is gratefully acknowledged as too is their maintained enthusiasm over email during the tougher times of the cruise.

John Allen

1. Introduction

RRS Discovery Cruise 267 was the fourth and final cruise supported by the NERC Marine Productivity (MarProd) thematic programme. The vessel sailed from Fairlie quay, Fairlie on the morning of 6 November 2002 (Wednesday) and returned to Empress Dock, Southampton in the evening of 18 December 2002 (Thursday), a total time at sea of 43 days. There was a mid-cruise port call at Reykjavik, Iceland from 25-27 November that included scientific discussions at the Marine Research Institute.

2. Objectives

The overall goal of the Marine Productivity programme is "to develop coupled modelling and observation systems for the pelagic ecosystem, with emphasis on physical factors affecting zooplankton dynamics". The target zooplankton species for programme fieldwork was the copepod *Calanus finmarchicus*. This species was chosen principally because it is the dominant species in the northern N Atlantic, it is a major food supply for fish larvae, and its abundance is known to vary with changing climatic conditions over the North Atlantic. Understanding the controls on *Calanus finmarchicus* is key to understanding the impact of changes of climate on the marine ecosystem.

The specific objectives of the fourth and final MarProd cruise are similar to those of the earlier cruises (D258, 262 and 264), namely:

- To map the physical features of the survey region (Irminger Sea and parts of the Iceland Basin) in terms of water mass distribution, velocity field and mixed layer properties
- Collect water samples for plant pigment and microscopic analyses, to estimate the biomass of different taxonomic/functional groups of microplankton
- Measure high resolution profiles of inorganic nutrient concentrations
- Determine the 3D abundance of mesoplankton of main interest (*Calanus finmarchicus*, also *Oithona* spp.), and their planktivorous predators (primarily euphusid spp), obtaining material for further taxonomic, physiological and biochemical studies.

In addition, because this was the second winter cruise a number of other studies previously only undertaken on the spring and summer cruises were undertaken to determine the closure winter baseline conditions. These studies covered:

- *Oithona* feeding experiments
- *Oithona* and *Calanus* egg production
- C/N and stable isotope ratios
- Primary productivity incubations
- Underway continuous sampling by, and station deployment of, a Fast Repetition Rate Fluorometer (FRRF), for comparison with primary production experiments.

The broad scope of the dataset compiled by the MarProd series of cruises to the Irminger Sea will facilitate comparison with historic datasets (e.g. NORWESTLANT, 1963 and the Continuous Plankton Recorder surveys), the EU supported zooplankton programmes TASC and ICOS, and other national and international studies. The MarProd programme provides the main UK contribution to the Global Ocean Ecosystem Dynamics project (GLOBEC), co-sponsored by IGBP, SCOR and IOC.

3. Overview

It was well understood by the MarProd Steering Committee that the second winter cruise, like its predecessor (D258) carried a high probability of significant downtime due to weather. However, given the lack of winter zooplankton data for both the northern and southern lines across the Irminger Basin and our opportunity to repeat stations along the central line, it was considered that the cruise would be worthwhile even if only a small number of stations could be worked. The split of time between major activities (Table 1 below) was based on statistics kept by the 2nd officer. These statistics are not kept in exactly the same way by different deck officers so care must be taken in the comparison between different cruises. However, they do show that there was around 43% downtime in leg 1, and 35% in leg 2.

Despite this, 12 ARIES tows, 12 Dual Methot net tows and also 12 Ocean Sampler tows were carried out. There were 17 lowered CTD stations, 9 of them followed by lowered EK500 scientific echosounder (LEK) deployments. Note also that around 20% of the time was passage. The passage time was actually longer than that, because some was also entered as downtime due to bad weather. Thus there is a considerable penalty in working in the Irminger Sea (or even the western Iceland Basin) when the passage is from the UK. The total figures for downtime are a minimum: for more detailed information, see Cruise Narrative (Section 4). Time hove to is time lost and therefore, given the wide selection of possible sampling sites following the three previous cruises, the most efficient use of time was made by reading the 72 hr forecasts and avoiding bad weather where possible. However, this does mean that scientific stations of secondary importance, not part of the original plan for this cruise, were occupied for most of the second leg.

Table 1: Time distribution between scientific and non-scientific activities during D267

	Science	**Passage**	**Weather downtime**	**Medical downtime**	**Marine equipment failure**	**Equipment loss**
Leg 1 **hr**	188.2	92.7	60.5	56.3	84.4	0
(%)	(39%)	(19%)	(13%)	(12%)	(18%)	
Leg 2 **hr**	222.2	116.0	154.6	0	0	25.3
(%)	(43%)	(22%)	(30%)			(5%)

A detailed cruise diary is given in Section 4, the original map of 'stations to choose from' is shown in Fig 1, and a complete list of sites and stations occupied is given in the following tabular summary. The original cruise plan concentrated on the three lines across the Irminger Basin that had been surveyed on the previous MarProd cruises, D258, 262 and 264. It soon became clear that these lines could not be achieved in their entirety. As on the first winter cruise, weather windows were often only a day or so long, but unlike D258, the second leg of the cruise was completed re-fashioned due to a series of very large and deep depressions that wiped out any chance of working anywhere near the Irminger Basin. In the end, the northern line was completed during the first leg of the cruise and the eastern half of a repeat occupation of the central line was worked during the first few days of the second leg. After this we were forced over as far as the eastern Iceland Basin and we would not get further than 22° W again before having to set course for Southampton.

Note that time records for D267 relate to GMT throughout the cruise. Whilst dates in the text of this cruise report are mostly given as calendar days, Julian days are also used for data-logging purposes (where 6 Nov and 18 Dec, the cruise start/end dates, are JD 310 and JD 352 respectively).

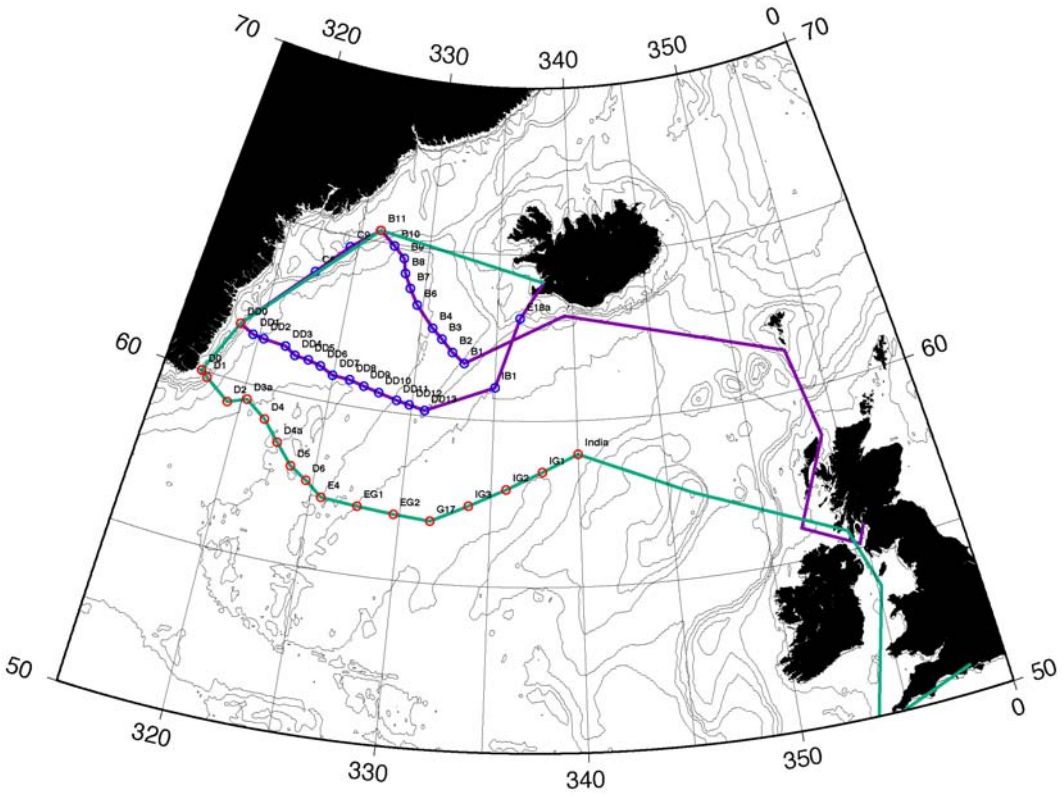

Fig. 1: Original cruise plan, providing 'stations to choose from'.

Table 2. Summary of stations occupied

Site	Station No.	Instrument	START				END				Comments
			Date DD/MM/YY	Time (GMT) HH:MM	Latitude deg N	Longitude deg W	Date DD/MM/YY	Time (GMT) HH:MM	Latitude deg N	Longitude deg W	
Trials	15067	CTD									
Trials	15068	CTD									
	15069	TEK	14/11/02	16:15	64 06.62	22 50.55	15/11/02	10:30	61 41.79	26 57.87	Removed between 18:45-19:38 to check pitch sensors
B1	15070	Secchi Disc	15/11/02	10:50	61 40.55	27 00.11	15/11/02	10:55	61 40.59	27 00.02	FRRF not working so Secchi replaced
B1	15071	CTD	15/11/02	11:19	61 40.65	27 00.10	15/11/02	12:28	61 40.46	27 00.40	
B1	15072	Vertical nets	15/11/02	12:35	61 40.47	27 00.47	15/11/02	13:45	61 40.21	27 02.37	
B1	15073	LEK	15/11/02	15:03	61 40.08	27 02.99	15/11/02	16:02	61 40.23	27 02.30	
B1	15074	TEK	15/11/02	16:15	61 40.39	27 02.62	16/11/02	03:53	62 21.22	28 31.79	
B1	15075/6/7	OS	15/11/02	16:29	61 40.59	27 03.28	15/11/02	17:33	61 42.76	27 07.97	Nets didn't fire
B1	15078	DM	15/11/02	18:30	61 43.66	27 10.40	15/11/02	20:28	61 47.11	27 18.56	
B1	15079/80/81	ARIES	15/11/02	21:10	61 47.73	27 20.27	15/11/02	23:35	61 52.19	27 30.29	
B3	15082	CTD	16/11/02	04:06	62 21.02	28 31.85	16/11/02	06:02	62 21.37	28 30.30	
B3	15083	Vertical nets	16/11/02	06:30	62 21.51	28 29.67	16/11/02	07:10	62 22.06	28 29.10	1x Bongo 63μ 1 x zooplankton 1 x Calanus
B4	15085	CTD	16/11/02	10:40	62 37.50	29 09.53	16/11/02	12:00	62 36.97	29 09.12	No bottles fired above 10m
B4	15086	Vertical nets	16/11/02	12:10	62 36.85	29 09.14	16/11/02	13:00	62 36.44	29 09.25	2x Bongo 63μ 1x 200μ 1x Calanus net

Site	Station No.	Instrument	START				END				Comments
			Date DD/MM/YY	Time (GMT) HH:MM	Latitude deg N	Longitude deg W	Date DD/MM/YY	Time (GMT) HH:MM	Latitude deg N	Longitude deg W	
B4	15087	TEK	16/11/02	13:10	62 36.33	29 08.90	16/11/02	20:10	62 20.55	29 06.26	
B4	15088/89/90	OS	16/11/02	13:35	62 36.01	29 08.11	16/11/02	14:40	62 33.66	29 07.03	
B4	15091/2/3	ARIES	16/11/02	15:28	62 32.47	29 08.85	16/11/02	19:47	62 21.10	29 06.51	
B4	15094	TEK	18/11/02	19:50	63 06.48	27 41.06	19/11/02	09:30	63 16.34	30 23.75	EK60 data 22:00-23:53
B6	15095	CTD	19/11/02	09:52	63 16.80	30 23.81	19/11/02	12:10	63 17.23	30 24.54	
B6	15096	Secchi	19/11/02	11:21	63 17.21	30 24.44	19/11/02	11:26	63 17.14	30 24.44	
B6	15097	FRRF	19/11/02	12:40	63 17.47	30 23.76	19/11/02	12:55	63 17.60	30 23.37	
B6	15098	Vertical nets	19/11/02	13:00	63 17.67	30 23.37	19/11/02	13:54	63 17.93	30 22.25	
B6	15099	TEK	19/11/02	14:08	63 18.02	30 21.78	19/11/02	19:20	63 57.63	31 11.83	EK out of water 15:45-16:29
B8	15100	CTD	19/11/02	19:26	63 57.58	31 11.77	19/11/02	21:54	63 57.32	31 11.06	
B8	15101	TEK	19/11/02	22:04	63 57.49	31 11.11	20/11/02	10:06	64 23.53	31 46.62	
B8	15102/3/4	OS	19/11/02	23:00	63 58.75	31 13.03	20/11/02	00:17	64 01.50	31 16.62	
B8	15105	DM	20/11/02	01:18	64 03.74	31 39.61	20/11/02	03:23	64 07.60	31 25.31	
B8	15106/7/8	ARIES	20/11/02	04:29	64 09.41	31 27.99	20/11/02	09:45	64 22.99	31 46.53	
B8	15109	CTD	20/11/02	10:20	64 23.61	31 47.65	20/11/02	10:50	64 23.65	31 47.55	Shallow cast
B8	15110	Vertical nets	20/11/02	10:55	64 34.64	31 47.58	20/11/02	11:40	64 23.97	31 47.87	2x Bongo 63μ 1x 200μ 1x Calanus
B8	15111	FRRF	20/11/02	11:43	64 34.98	31 47.93	20/11/02	11:57	64 24.00	31 48.24	
B8	15112	TEK	20/11/02	12:03	64 24.06	31 48.43	20/11/02	16:18	64 56.46	32 30.83	Good data 13:00-15:00
B10	15113	CTD	20/11/02	16:26	64 56.61	32 30.93	20/11/02	18:26	64 56.66	32 33.32	
B10	15114	Vertical nets	20/11/02	18:34	64 56.65	32 33.68	20/11/02	18:55	64 56.76	32 33.95	1x Bongo 63μ 1x Calanus
B10	15115	Met Buoy	20/11/02	19:05	64 56.74	32 34.06					
B10	15116	TEK	20/11/02	19:21	64 56.95	32 33.86	21/11/02	05:52	65 15.45	33 17.84	
B11	15117/8/9	OS	21/11/02	01:01	65 11.29	33 22.68	21/11/02	05:36	65 14.88	33 22.69	
B11	15120	DM	21/11/02	03:48	65 10.81	33 22.99	21/11/02	05:36	65 14.93	33 17.63	
B11	15121	CTD	21/11/02	06:18	65 15.52	33 17.95	21/11/02	07:30	65 15.62	33 18.27	
B11	15122	Vertical nets	21/11/02	07:50	65 15.72	33 18.55	21/11/02	08:40	65 15.77	33 18.78	2x Calanus nets 1x 200μ net 2x 63μ Bongo nets
B11	15123	FRRF	21/11/02	08:45	65 15.73	33 18.79	21/11/02	08:55	65 15.66	33 19.00	
	15124	TEK	21/11/02	08:57	65 15.39	33 19.04	22/11/02	11:38	60 48.73	35 02.09	
DD7	15125	FRRF	22/11/02	11:45	60 48.78	35 02.07	22/11/02	11:57	60 48.73	35 02.09	
DD7	15126	CTD	22/11/02	12:15	60 48.67	35 02.24	22/11/02	15:46	60 49.32	35 02.64	Bad recovery, winch not hauling, DB hurt
DD7	15127	Vertical nets	22/11/02	15:56	60 49.14	35 02.34	22/11/02	16:30	60 49.32	35 02.64	2x 63μ Bongo nets 1x 200μ net
E18b	15128/29/30	OS	25/11/02	01:22	63 37.91	24 58.52	25/11/02	02:45	63 39.94	24 49.05	
E18b	15131	DM	25/11/02	03:32	63 40.69	24 46.66	25/11/02	04:34	63 41.90	24 41.45	
E18b	15132/3/4	ARIES	25/11/02	05:15	63 40.64	24 46.83	25/11/02	06:15	63 41.98	24 41.36	
E18b	15136	Vertical nets	25/11/02	07:45	63 42.96	24 40.41	25/11/02	08:15	63 43.29	24 40.37	
E18b	15137	TEK	25/11/02	08:27	63 43.42	24 40.35	25/11/02	13:16	64 06.20	22 53.06	
	15138	TEK	27/11/02	19:16	64 05.31	22 59.70	28/11/02	22:03	63 41.02	23 40.97	
DD13	15139	CTD	28/11/02	22:20	60 09.56	29 12.13	28/11/02	23:50	60 08.64	29 10.87	

Site	Station No.	Instrument	START				END				Comments
			Date DD/MM/YY	Time (GMT) HH:MM	Latitude deg N	Longitude deg W	Date DD/MM/YY	Time (GMT) HH:MM	Latitude deg N	Longitude deg W	
DD13	15140	TEK	29/11/02	00:03	60 08.59	29 11.41	29/11/02	08:12	60 10.13	29 38.87	
DD13	15141/2/3	OS	29/11/02	00:07	60 08.61	29 11.41	29/11/02	01:40	60 09.69	29 17.72	
DD13	15144	DM	29/11/02	02:30	60 10.10	29 19.99	29/11/02	04:27	60 10.99	29 29.57	
DD13	15145/6/7	ARIES	29/11/02	05:17	60 10.31	29 30.07	29/11/02	07:57	60 10.31	29 39.11	
DD13	15148	Vertical nets	29/11/02	08:25	60 10.13	29 38.75	29/11/02	08:59	60 10.18	29 38.03	
DD13	15149	LEK	29/11/02	09:08	60 10.15	29 37.83	29/11/02	10:15	60 10.08	29 36.24	
DD13	15150	TEK	29/11/02	10:32	60 09.81	29 36.19	29/11/02	15:10	60 21.50	30 55.24	
DD11	15151	CTD	29/11/02	21:40	60 22.49	30 56.47	29/11/02	23:33	60 23.36	30 55.59	
DD11	15152	TEK	29/11/02	23:54	60 23.20	30 55.98	30/11/02	04:25	60 32.17	32 03.67	
DD10	15153	CTD	30/11/02	04:42	60 32.14	32 03.71	30/11/02	07:07	60 31.91	32 03.53	
DD10	15154	Vertical nets	30/11/02	07:27	60 31.67	32 03.56	30/11/02	07:39	60 31.70	32 03.42	Net lost on recovery
DD10	15155	LEK	30/11/02	08:05	60 31.39	32 03.98	30/11/02	09:15	60 31.41	32 02.99	
DD10	15156	TEK	30/11/02	09:40	60 31.31	32 02.85	30/11/02	13:29	60 27.88	32 28.16	
DD10	15157/8/9	OS	30/11/02	10:08	60 31.06	32 04.18	30/11/02	12:00	60 30.63	32 12.07	
DD9	15160	DM	1/12/02	04:16	60 38.81	33 04.03	1/12/02	06:18	60 42.64	33 08.01	
DD9	15161/2/3	ARIES	1/12/02	07:45	60 41.99	33 08.59	1/12/02	13:15	60 26.54	33 16.18	
DD9	15164	Vertical nets	1/12/02	13:35	60 26.31	33 15.76	1/12/02	14:10	60 25.89	33 15.10	
DD9	15165	TEK	1/12/02	14:33	60 25.55	33 14.69	2/12/02	14:43	63 24.04	29 08.24	EK60 data 19:00-21:00
B4	15166/7/8	ARIES	2/12/02	10:25	62 33.01	29 09.67	2/12/02	14:25	64 24.10	29 07.75	
B4	15169	LEK	2/12/02	14:58	62 24.23	29 08.95	2/12/02	15:54	64 24.69	29 09.31	
B4	15170	TEK	2/12/02	16:07	62 24.78	29 09.78	2/12/02	17:11	62 18.27	29 10.69	
RD	15171	CTD	7/12/02	07:47	59 23.83	11 07.80	7/12/02	10:40	59 24.34	11 07.98	
RD	15172	Vertical nets	7/12/02	10:50	59 24.46	11 08.14	7/12/02	11:17	59 24.49	11 07.69	Only 2 out of 3 nets deployed, due to weather
RD	15173	LEK	7/12/02	11:27	59 24.54	11 07.67	7/12/02	12:32	59 24.63	11 07.10	
RD	15174	TEK	7/12/02	18:05	59 22.40	11 16.50	8/12/02	21:05	57 00.13	08 59.66	EK60 data 14:40-16:10
RD	15175/6/7	OS	7/12/02	18:53	59 22.77	11 09.93	7/12/02	20:05	59 20.70	11 16.16	
RD	15178	DM	7/12/02	20:20	59 20.74	11 16.91	7/12/02	22:35	59 19.89	11 25.72	
RD	15179/80/81	ARIES	7/12/02	23:01	59 20.01	11 26.92	8/12/02	02:42	59 17.90	11 41.62	
ADR	15182	CTD	8/12/02	21:15	57 00.16	08 59.52	8/12/02	22:00	57 00.21	08 58.97	
ADR	15183	Vertical nets	8/12/02	22:05	57 00.22	08 58.94	8/12/02	22:25	57 00.30	08 58.77	
ADR	15184	LEK	8/12/02	22:35	57 00.30	08 58.60	8/12/02	23:56	57 01.03	08 58.24	Calibration data
ADR	15185	TEK	9/12/02	00:12	57 01.21	08 58.87	9/12/02	08:42	57 13.71	10 02.76	
ADR	15186/7/8	OS	9/12/02	00:18	57 01.46	08 59.56	9/12/02	01:11	57 03.18	09 04.21	
ADR	15189	DM	9/12/02	02:25	57 08.87	09 19.00	9/12/02	03:30	57 10.60	09 22.78	
ADR	15190/1/2	ARIES	9/12/02	04:24	57 11.08	09 23.55	9/12/02	07:05	57 11.99	09 34.95	Raised from 10m to the surface to turn Seabird on
ADN	15193	CTD	9/12/02	09:08	57 13.56	10 02.99					CTD lost
	15196	TEK	10/12/02	19:15	56 15.78	11 06.34	11/12/02	09:25	53 59.94	13 30.26	
FF2	15197	CTD	11/12/02	19:54	53 59.63	16 00.38	11/12/02	22:49	54 01.28	16 00.94	
FF2	15198	Vertical nets	11/12/02	22:54	54 01.34	16 01.00	11/12/02	23:30	54 01.75	16 01.50	
ADN	15194	Vertical nets	9/12/02	09:55	57 13.39	10 03.25	9/12/02	10:30	57 13.57	10 03.18	
FF2	15199	LEK	11/12/02	23:53	54 01.87	16 01.84	12/12/02	01:25	54 02.45	16 02.02	Calibration sphere at surface and 450m

Site	Station No.	Instrument	START				END				Comments
			Date DD/MM/YY	Time (GMT) HH:MM	Latitude deg N	Longitude deg W	Date DD/MM/YY	Time (GMT) HH:MM	Latitude deg N	Longitude deg W	
FF2	15200	TEK	12/12/02	01:32	54 02.56	16 02.16	12/12/02	16:17	53 59.96	18 00.12	
FF2	15201/2/3	OS	12/12/02	01:45	54 02.67	16 02.30	12/12/02	03:15	54 02.71	16 10.23	
FF2	15204	DM	12/12/02	04:03	54 02.59	16 13.14	12/12/02	05:59	54 01.92	16 22.08	
FF2	15205/6/7	ARIES	12/12/02	06:46	54 01.66	16 25.56	12/12/02	12:35	54 00.54	16 57.00	
FF3	15208	CTD	12/12/02	16:25	53 59.87	17 59.99	12/12/02	19:02	53 59.69	17 59.19	
FF3	15209	Vertical nets	12/12/02	19:09	53 59.73	17 59.15	12/12/02	19:42	53 59.79	17 58.90	
FF3	15210	LEK	12/12/02	19:53	53 59.83	17 58.84	12/12/02	21:19	53 59.63	17 58.48	
FF3	15211	TEK	12/12/02	21:31	53 59.49	17 58.02	13/12/02	13:50	53 59.79	20 29.83	
FF3	15212/3/4	OS	12/12/02	21:40	53 59.33	17 57.63	12/12/02	23:00	53 59.60	18 04.11	
FF3	15215	DM	12/12/02	23:29	53 59.80	18 05.25	13/12/02	01:22	53 59.95	18 12.22	
FF3	15216/7/8	ARIES	13/12/02	02:00	54 00.11	18 14.40	13/12/02	08:25	54 00.26	18 51.39	
FF4	15219	CTD	13/12/02	14:07	53 59.69	20 29.51	13/12/02	16:53	53 59.33	20 27.57	
FF4	15220	Vertical nets	13/12/02	16:59	53 59.30	20 27.50	13/12/02	17:20	53 59.20	20 27.19	
FF4	15221	LEK	13/12/02	17:41	53 59.08	20 26.74	13/12/02	18:36	53 58.75	20 26.11	
FF4	15222	TEK	13/12/02	18:44	53 58.70	20 26.41	14/12/02	11:53	53 51.71	21 44.80	
FF4	15223/4/5	OS	13/12/02	19:02	53 58.71	20 26.84	13/12/02	20:16	53 58.86	20 32.25	
FF4	15226	DM	13/12/02	20:49	53 59.10	20 33.36	13/12/02	22:30	53 59.63	20 38.50	
FF4	15227/8/9	ARIES	13/12/02	22:55	53 59.82	20 39.94	14/12/02	05:24	54 00.22	21 13.07	
FF5	15230	DM	14/12/02	08:30	53 59.74	21 59.56	14/1/202	09:45	53 57.34	21 58.11	

4. Narrative: PSO's Diary

6 November (Day 310)

Discovery slipped from Fairlie pier on time at ~09:00. During the morning engine control system trials were carried out with a visiting engineer on board. Originally the visiting engineer was due to leave by boat transfer off Ayr at ~13:00, but a poor sea state forced changes to this plan. By 13:30 we were hove to in Kilchatten Bay, Bute, waiting for a boat to come from Greenock bringing engine room spares. The boat did not arrive until ~17:00 whereupon the visiting engineer left us and the engine room spares were taken on board.

Discovery anchored in Brodick Bay, Arran, at ~18:15 for overnight acoustic instrument calibrations. A CTD cast began this station (No. **15067**), but was abandoned at 15 m following a Seabird CTD error warning indicating data transmission problems. However, enough sound velocity information was gathered to proceed with the acoustic calibrations; which involves the positioning of small spheres of known target strength below the acoustic transducers. The towed EK500/60 system (TEK) was in the water gathering calibration data by 20:00 hrs and this would carry on all night. At 19:20 we held a brief introductory scientific meeting attended by most of the scientific and technical staff.

7 November (Day 311)

Heavy squalls caused *Discovery* to drag anchor at ~00:30, so the calibration exercise was stopped, the anchor and the TEK were recovered immediately at which point *Discovery* hove to. Enough data had been gathered to consider the TEK calibrations as completed: but we would wait until morning to consider calibration of the lowered EK500 system (LEK).

At 08:30 *Discovery* moved to a more northerly position in the bay and dropped anchor again. By 10:00 hrs it was clear on deck that there were communication problems with the LEK and

so the calibration was abandoned. The communications problems with the CTD persisted and were indicating a need for re-termination. Thus at 13:00 *Discovery* weighed anchor and steamed out of Brodick Bay, heading for Stornoway; where the master had secured further anchorage with clearance from the Harbour Master.

8 November (Day 312)

A rough night spent beam on to a heavy swell cut the rate of progress. However a much reduced sea state by morning brought *Discovery* back up to full speed for the passage north through the Minches.

Discovery anchored off Stornoway in the shelter of the Eye Peninsula at 17:55. CTD winch operation failed, producing a terrible hammering noise heard throughout the ship, and thus the CTD was abandoned in favour of the LEK calibration deployment (No. **15068**). The non-toxic supply was turned on so that a guide value for in-situ sound speed could be obtained. Unfortunately the LEK refused to communicate over the wireless ethernet despite having worked on deck earlier in the day and the calibration was temporarily abandoned. By this time the CTD winch was ready to try again, and this time two CTD dips were succesfully made to over 30 m. However both altimeters were failing to work properly and the CTD deck unit alarm had become a permanent feature - much head scratching would still be required. Attention then returned to the LEK for the latter half of the evening, eventually abandoning further attempts at carrying out an acoustic calibration by 11:30; the ethernet communication with the PC laptop proving to be too unreliable.

9 November (Day 313)

With everything squared away on deck, *Discovery* weighed anchor at 01:10 and we began our long steam towards station B1. The weather forecasts were favourable for the next 48 hr for our planned direct course. By 09:00 *Discovery* was being blown along nicely at over 11 knots, although we were rather beam on to a small remnant swell. The swell built during the day but our speed made good remained high, 12 knots or more. By 21:00 the weather analyses were somewhat different from the original forecasts but none suggested any obvious deviation to our set course.

10 November (Day 314)

03:30, the weather continues to deteriorate as we get closer to the storm, although the storm itself is probably weakening. The barometer continues to drop like a stone and the wind speed is now 25 knots steady, gusting 40 knots. Forecast for maximum gale force 9, but with the wind directly behind, *Discovery* is still making good speed.

At 08:30 *Discovery* was forced to heave to in big lumpy seas; ~ 11 m peak wave height (> 6 m mean) and 35 knot mean wind speed. By 11:45 however, the wind speed had dropped a little and we were able to continue albeit in a more westerly rather than WNW direction.

11 November (Day 315)

At 04:15, *Discovery* was without a working radar. One radar had stopped working the day before, but the second radar failing was a serious blow to our ability to continue and would certainly stop us getting anywhere near ice off the Greenland coast. At 07:25 *Discovery* hove to due to deteriorating weather, 35-50 knot winds and a heavy swell (~14 m peak wave).

The master and ETO spent much of the morning investigating options with RVSOPS and following advice from the radar service company, with a view to possible quick fixes. However, it rapidly became clear that we would have to make an early run into Reykjavik to get expert radar engineering support. By 12:00 the wind had lifted sufficiently to allow us to make a little headway northwards rather than remain hove to, and so we began our steam to Reykjavik. By late evening the weather was improving and we were able to increase speed from 4 to 6 knots.

12 November (Day 316)
For a brief period in the early hours of the morning *Discovery* was back up to full speed, but running into a heavy swell closer to Iceland forced us to change to a westerly course by ~10:00.

The news regarding spares for the radar has been rather depressing. Some arriving Wednesday pm others a day later, and more importantly, still no confirmation when the specialist engineer will get to Reykjavik. Nonetheless we make the best of it, trying hard to work a shelf station into the transit to Reykjavik. This will depend on timing; wind and sea state are beginning to drop and we do not wish to enter Reykjavik at night. *Discovery* no longer has exposed bridge wings, and sightings through the bridge windows are far from ideal for collision avoidance in a confined space.

At ~19:30, *Discovery* was able to turn northwards again towards Reykjavik. However, remnant swell and still 30 knot winds forced *Discovery* down to 7.5-8 knots. Thus our hopes of fitting in a shelf edge science station on the way in were dashed; we would need all the time we had to get in to Reykjavik by early afternoon tomorrow at this pace.

13 November (Day 317)
At 13:45 *Discovery* tied up alongside in Reykjavik. The radar spares had arrived and were arriving a day earlier than expected in both cases and the specialist engineers were an hour away, things were looking up at last. Shore leave was granted initially until 19:00 hrs.

Early in the afternoon it was discovered that *Discovery* had lost an emergency distress aerial. Although RVSOPS had insisted that it was safe and legal to sail without it, the senior engineers and ETO were reasonably concerned. This put the Master in an uncomfortable position. Having determined that the radars would take several more hours of work and testing (some spares were still due to arrive), and that a new aerial could be fitted before 12:00 tomorrow, I took the decision that we would not leave Reykjavik until 13:00 tomorrow.

14 November (Day 318)
As things turned out, following the overnight tests, a further part had to be fitted to one of the radar systems in the morning and thus the fitting of the new radio aerial did not delay our departure. *Discovery* slipped from Reykjavik at 13:30 and headed for station B1. The weather forecast was good, clear skies and crisp air temperatures, a fine winter's day. The PES fish was deployed at 16:10 and the TEK (stn. **15069**) deployed at 16:15. At 18:45, the TEK was recovered as it was clear that it was not 'flying' at the right attitude. By 19:45 the TEK had been redeployed and was flying well.

15 November (Day 319)
The TEK was recovered and station B1 began at 10:30. The FRRF failed to communicate with the laptop and could not be setup so it was replaced by a Secchi disc deployment (**15070**): communication was re-established later but no explanation for, or solution to, the problem was discovered. After an inauspicious start, a full depth CTD (**15071**) followed by four vertical net hauls (**15072**) were completed successfully. The deployment of the LEK (**15073**) was delayed until ~15:00 (approx 1 hr) because the deployment wire had to be re-spooled onto the deck winch drum to pay out from the bottom of the drum rather than the top; otherwise the angle of the wire to the CTD gantry block did not match up with the position of the scrolling gear guide rollers. After re-deployment of the TEK (**15074**), the three net systems, Ocean Sampler (OS) (**15075/6/7**), Dual Methot (DM) (**15078**) and ARIES (**15079/80/81**) were towed sequentially in that order in the general NW direction of the B line. The first two net systems were not wholly successful due to the failure of net opening and closing mechanisms. ARIES was considerably more successful, although a slightly out

of adjustment bottle firing mechanism left only a down cast of ~20 bottles for nutrient sampling.
Discovery departed station B1 and headed for station B3 at 23:48. We had already chosen to drop station B2 as the ARIES deployment, which includes a SeaBird CTD, was due to be completed less than 10 nm from the nominal position of station B2.

16 November (Day 320)
Station B3 began at 03:45, a full depth CTD (**15082**) and three vertical net hauls (**15083**) were carried out, however, an instrument warning from the LEK stopped its deployment. Thus the TEK was re-deployed (**15084**) at 07:20 and *Discovery* began the steam to B4.

On station B4 with the TEK in board by 10:00. A full depth CTD (**15085**) and vertical net hauls (**15086**) were carried out by 13:00. The CTD data stream and bottle firing failed before reaching the 10 m bottle stop on the upcast. During the CTD deployment the wind speed began rising rapidly and latest forecasts indicated bad weather, 9 gusting 10, setting in fast. This was not a complete surprise as we had been watching the development of a tight cyclonic weather system south of Cape Farewell for 48 hours. As a resulted it was decided to make B4 a fully instrumented sampling station if possible.

The TEK was in the water (**15087**) by 13:10 and the OS was deployed at 13:35 (**15088/9/90**). With the weather deteriorating rapidly (30 knot winds), the net systems were towed south in the direction of station DD13. This was a desperate bid to avoid being hove to for longer than necessary, as the forecast isobars indicated that line DD would offer the first chance of working again after B4.

The OS was in-board by 14:35 and ARIES was deployed at 15:25 (**15091/2/3**). The ARIES tow was not completed until 19:45, by which time the wind was gusting 50-55 knots for prolonged periods. During recovery the front section of the ARIES frame was significantly bent on impact with the stern of the ship. Initial inspection indicated that no damage had been done to the instruments or net systems on the frame, but the sampler drive shaft would require closer inspection. The DM net deployment had been cancelled somewhat earlier as a result of the deteriorating weather, and despite our best endeavours *Discovery* was hove to by 20:40.

17 November (Day 321)
Still hove to with wind speeds of 60knots, gusting 70 knots, at times overnight. By first light the winds had dropped following the passage of the cold front. This brought brighter skies, even clear in places but the sea was still rough (~14 m waves).

At 16:00 we reassessed the situation and tried other headings. Although the wind had continued to drop somewhat, the sea was still rough and confused. On even the most comfortable headings *Discovery* would still take the occasional roll of well over 30º; up to 43º degrees had been reliably recorded (ashtech and inclinometer) during the previous night.

Reviewing the situation at 22:15, the sea had remained consistently rough and confused for the past six hours. Further scrutiny of weather forecasts and route planning charts failed to provide any better solution than to remain hove to where we were (just south of B2) overnight. The storm appeared to be turning back south, but there was little certainty here and our present position maintained flexibility with regard to heading south to DD13 or north west to B6 as soon as things eased.

18 November (Day 322)
At 10:30, a little after first light, it was finally decision time although the sea state was still rough and some courses too uncomfortable. With the depression filling over the centre of our survey region and a good forecast developing from the north of the Irminger Sea, B6 was the most obvious destination but we would have to tack to get there; current ETA 10:30

tomorrow. The TEK was deployed at 19:15 (**15094**). Furious cutting and welding were taking place in the Hanger as repairs were made to the nose frame of the damaged ARIES.

19 November (Day 323)

Discovery was on station B6 and the TEK inboard by 09:30. A full depth CTD (**15095**) was completed and back on deck by 12:10. During the CTD cast, a Secchi disc was deployed (**15096**) to determine light depths for the upper water bottle stops. There was insufficient ambient light before the CTD deployment to obtain light depths from an FRRF cast with PAR sensor. However the FRRF was deployed (**15097**), to ~ 100 m, after the CTD recovery for comparison with the primary productivity incubations that will be carried out on the water bottle samples from the CTD. A series of vertical net hauls (**15098**) were completed by 13:54. Following deployment of the TEK (**15099**), *Discovery* began steaming towards B8 by 14:15.

15 n miles short of B8, *Discovery* was stopped, the TEK was brought inboard and a full depth CTD cast (**15100**) was begun at 19:25. We had to find time savings, and with the acoustic ScanMar tow fish being re-terminated we were not able to deploy the towed net systems yet. However, making an early CTD station gave us time to complete the termination and still tow the net systems towards and through B8, therefore using the passage time most effectively with the spacing of the stations along track. The CTD was recovered and the TEK deployed (**15101**) at 22:04. The ScanMar tow fish termination took longer than expected and the OS was not deployed (**15102/3/4**) until 23:05.

20 November (Day 324)

At 00:17 the OS was recovered. Continuing our tow direction towards B8 the DM net was deployed at 01:24 (**15105**) and recovered a couple of hours later at 03:18. ARIES was in the water by 04:30 (**15106/7/8**) and a fully successful tow was completed with its recovery at 09:50. Station B8 was completed with a shallow water collecting CTD (**15109**), vertical net hauls (**15110**) and an FRRF cast (**15111**). By just after mid-day, the TEK had been re-deployed (**15112**) and *Discovery* began steaming for station B10. The timing here was critical as we had already reached the edge of iceberg warning territory and therefore our steaming speed after dark would be reduced to 5 knots. However, we had just enough time to reach B10 in the light and thus at 10 knots.

Discovery reached station at 16:15 and the TEK was recovered by 16:20. A full depth CTD station (**15113**) was completed by 18:27 and vertical net hauls (**15114**) began at 18:35. The UK Meteorological Office's Met. Buoy, serial number 21628, was turned on at 18:45:00 by removing the magnetic strip attached to the side of it. Following the recovery of the nets at 18:57, the Met. Buoy was deployed (**15115**) by the Boatswain at 19:06 at position 64° 56.73'N, 32° 34.09'W. The sea was quite choppy as a result of high wind speeds during the afternoon and thus *Discovery* remained hove to on station until sampling of the CTD rossette was complete. But by 19:35 the TEK had been deployed (**15116**) and *Discovery* had begun a 5 knot steam to B11. The high winds were due to a small scale depression that had built up in our immediate vicinity over the past 12 hours.

21 November (Day 325)

By 00:30 *Discovery* hove to early, 15 nm short of the original B11 (which resided on a 176 m bank), but also ~5 n miles short of an amended position, chosen the previous day, which lay on the 500 m isobath. We were suffering strong northerly winds, force 6.5 steady gusting to 7, and the net systems would therefore need to be towed in an upslope direction. The OS was deployed at 01:00 (**15117/8/9**): following a rough recovery at 02:37 in marginal weather conditions it was decided that there would be no ARIES deployment at this station. After back-tracking south, *Discovery* was turned north again and the DM net system was deployed at 03:44 (**15120**).

Following recovery of the DM net at 05:34, the TEK was brought inboard and a full depth CTD cast (**15121**) was carried out: the CTD cast was completed and back on deck at 07:29. Vertical net hauls (**15122**) and an FRRF deployment (**15123**) were completed by 08:55; at which point, the completion of the northern survey line, the TEK was re-deployed (**15124**) and *Discovery* began a long steam southwards to station DD7. It would not be possible in the time available to attempt the whole of the central survey line, but if we could achieve the eastern end of this line then there would be an opportunity to complete the line westwards at the beginning of the second leg of the cruise.

22 November (Day 326)

Arriving on station DD7, the TEK was inboard by 11:37. Work began immediately on changing the TEK tow cable in the hope of improving data quality. An FRRF cast (**15125**) was made between 11:44 and 11:56. A badly timed roll, in response to a significant remnant swell, caused the FRRF to strike the side of the ship just as it left the surface on recovery. After close examination it appears that only superficial damage was sustained; a mark on one corner of the titanium photo-receiver head and a broken plastic elbow to the dark chamber.

A full depth CTD cast (**15126**) began at 12:09. During recovery, the winch system was troublesome; it proved difficult to initiate haul after stopping for bottle firing. The CTD was eventually recovered at 15:42: sadly, SG.1A Dave Buffery was injured in the process. The ship was rolling in a moderate remnant swell, and on first attempt the CTD frame missed the claws on the trackway landing plate. This is not an uncommon problem, and is normally easily rectified by hauling in 30 cm or so on the winch and under the restraint of the deck crew a second attempt is generally successful. However, on this occasion, the winch cobra began to slip as it had on the bottle stops and thus it was not hauling in any wire. During attempts to keep restraint on the CTD, Dave Buffery lost his footing and slipped feet first into the trackway landing plate in the path of the swinging CTD frame. To their credit, Dave was pulled clear by SG.1A Mark Moore and Claudia Castellani very quickly, before the CTD swung back and thus Dave was not crushed in any way by the CTD frame. During this time the winch operator was working hard with the winch controls to gain traction on the cobra wheels; in the end to no avail, the CTD was eventually lifted by extending the gantry outrigger block and recovered onto its landing frame. However, Dave Buffery had clearly injured himself falling. Vertical net hauls (**15127**) began at 15:56. However over the next half hour or so, Dave's condition worsened rapidly with considerable pain and apparent difficulty breathing. I therefore cancelled all science at 16:30 and requested the safe stowage of all scientific equipment in preparation for a likely emergency medical evacuation.

The PES and ScanMar tow fish were brought inboard by 17:21 and *Discovery* set course for Reykjavik. By now Dave had been given a shot of morphine, but it was clear that he was still having trouble breathing even though the pain had been relieved. Constant monitoring had begun and radio medical advice was being followed. By 19:00 Dave was considerably more comfortable. The science party began a one hour watch system through the night to keep him comfortable and monitored; blood pressure, pulse and breathing rates every 30 minutes. Later in the evening Dave had clearly stabilised and although uncomfortable was out of immediate danger: Iceland Coastguard helicopter rescue plans were stood down as in these circumstances it was safer to head in to Reykjavik.

23 November (Day 327)

The hourly watches continued and Dave remained uncomfortable but stable. He was rather sick of watching videos, but it was too uncomfortable for him to lie down and so sleep was not easy. *Discovery* continued steaming to Reykjavik, but her speed was reduced by a head-on swell direction. By evening *Discovery* was able to increase speed again. At 20:00 hrs I held a safety meeting in the library to construct an addendum to the risk assessment for CTD

deck operations: this was generally felt necessary to continue CTD operations for the remainder of the cruise in the light of the recent accident.

The PSO, TLO, Master, Chief Engineer and Boatswain agreed to the implementation of the addendum and it is incorporated here as a permanent reference:

Addendum to the risk assessment for CTD operations - specifically for *Discovery 267*, following accident report 22 November and a meeting held at 20:00 hr on 23 November 2002

Present at the meeting: J. Allen (PSO), J. Short (TLO), A. Adams (Chief Eng.), P. Duncan, D. Teare, A. Sherring, S. Whittle and D. Young.

Discovery's hydrographic winch system is due to be replaced at refit following D267 and thus this is expected to be a temporary addendum to be reviewed after refit. However, we would expect most of the precautionary measures outlined below to be pertinent for consideration with any winch installation.

1 Over the next 36 hours we will carry out a series of CTD winch trials, starting with a static deck lift of the CTD frame and ending up with a full deployment at shelf station E18a (~ 500 m). The purpose of these trials is to make a repeat of the wire haul problems encountered on the 22/11/02 as unlikely as possible.

For the remainder of cruise D267:

2 At the beginning of deployment and during recovery, slip ropes are to be thrown round CTD frame tubulars on each side of the frame by the two members of the deck crew handling the CTD recovery; such that close restraint of the CTD is avoided until it is necessary to locate the frame in the landing claws. Restraint of the CTD is then obtained by working the two ropes in tension against each other. Thus if a member of the deck crew lose their footing they are a sufficient distance from the CTD frame to fall clear of the immediate path of the CTD frame.

3 The winch operators are to work out a system of recovery such that control of the CTD height off the deck may be obtained by the gantry extension block as a failsafe backup to winch haul failure.

4 Immediately prior to CTD recovery both the CTD technician and the watch leader must be in the possession of radios. The watch leader is to be in full safety gear and on deck watching the proceedings and acting as a communication go-between as required - critically they are not to be involved in the CTD recovery.

5 We request that the bridge officers apply 'WOCE style' rough weather recovery vessel positioning where necessary. I.e. where there is a significant swell in a different direction to the wind, then the vessel is turned head to swell for deployment and recovery and turned in the usual head to wind direction (or just off) during the main period of the CTD cast. The winch operators are to allow the bridge time to turn the ship and only to proceed with each stage of CTD deployment when the bridge has confirmed the correct heading. This procedure is to minimise the effect of ship's roll on the behaviour of the CTD frame when out of the water.

J. Allen (PSO) J. Short (TLO)
R. Warner (Master) A. Adams (Chief Eng.)
M. Drayton (Boatswain)

<u>24 November (Day 328)</u>

The Pilot was on board by 11:00 and *Discovery* was alongside in Reykjavik at 11:40. No shore leave was granted except to Dave Buffery and Mark Moore to attend a hospital examination, and Kieran Hailes to accompany them. Iceland shelf station E18a was re-positioned (63° 37.5' N, 25° 00' W) and renamed E18b to enable us to plan a 24 hr working schedule before returning to Reykjavik at 16:00 on the 25th. To make the most sensible use of scientific time, we had brought the mid-cruise port call forward by 24 hr, following the

requirement to make an emergency medical evacuation. We would now plan to leave Reykjavik for Leg 2 of the cruise at 09:00 hrs on Wednesday, 27 November.

The hospital reported that Dave Buffery had suffered a punctured lung but no indication of cracked ribs and that Mark Moore had been nursing asthma, bronchitis and pleurisy, so both were payed off in Reykjavik. This left us with a complete deck crew watch missing, and the problem was being addressed back at RVSOPS.

Discovery slipped from Reykjavik at 16:50 heading for station E18b.

25 November (Day 329)

Discovery was on station by 00:45 and the PES and ScanMar fish were deployed by 01:05. Using a 12 n mile run of bottom depth >400 m that we had just steamed over, the OS (**15128/9/30**) and the DM net (**15131**) were deployed and recovered by 04:35. During the swap over to ARIES *Discovery* recovered some of the 12 n mile line by steaming back in a south west direction before turning and deploying ARIES (**15132/3/4**) at 05:15. ARIES was recovered at 06:15 and a full depth CTD cast (~415 m) was begun (**15135**) at 06:39. During the cast, a number of tweaks were made to increase winch back tension and its performance was significantly improved. The additional safety measures were put in place during recovery, but in such calm conditions it was difficult to assess their effectiveness. The CTD was back on deck by 07:35 and vertical net hauls (**15136**) began at 07:38. Four nets were deployed and recovered by 08:28, at which point the PES and ScanMar fish were brought inboard and the TEK (**15137**) was deployed for the steam to Reykjavik.

The Reykjavik pilot was taken on board at ~15:40 and *Discovery* was alongside at 16:40. Leg 1 had ended.

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27 November (Day 331)

Andy Maclean had flown out to join us in Reykjavik and replace Dave Buffery. *Discovery* was delayed in port, requiring further emergency radio and radar repairs. However, at 16:10 *Discovery* slipped out of Reykjavik harbour and set course for DD13. The PES and ScanMar fish were deployed by 19:10 and the TEK was in the water (**15138**) by 19:20. The weather forecast indicated a major depression filling rapidly, but leaving doubts as to the likely sea state at DD13 when we get there. The longer term forecast showed another depression building off Cape Farewell, however we can but try!

28 November (Day 332)

A muster and boat drill was held at 10:30. The weather was considerably more pleasant and the sea state lighter than we had expected.

By 22:06 the TEK had been recovered and *Discovery* had hove to on station DD13. The wind and sea state were only 5-6 but the light swell was fairly confused, and some time was spent playing with the ship's heading to find a direction that reduced rolling to a minimum. A full depth CTD cast (**15139**) began at 22:20 and the CTD was recovered at 23:50.

29 November (Day 333)

The TEK was deployed (**15140**) by 00:05 as we prepared to begin the three towed net systems, to be towed westerly along the DD line towards DD11. Station DD12 had already been dropped from our plans in favour of DD11 since it was expected that the ARIES net system which carries a SeaBird CTD would be recovered only 10 n miles or so from DD12. The OS was deployed (**15141/2/3**) at 00:25. On recovery, the trawl winch tripped out just before the OS left the water surface, but after resetting the power-pack the recovery was completed at 01:36. The DM net was deployed (**15144**) at 02:26 and recovered by 04:30. ARIES was deployed (**15145/6/7**) at 05:17. By 07:30, the wind and sea state were around force 6 but the wind speed appeared to be increasing and therefore *Discovery* changed course

in preparation for the ARIES recovery. A well controlled recovery of ARIES was carried out at 07:58, by which time we had travelled ~14 n miles towards DD11, some 5 n miles less than expected. With the TEK recovered at 08:12, vertical net hauls (**15148**) began at 08:24 and were completed by 09:00. The LEK had been put back together during the early hours of the morning and was deployed (**15149**) between 09:19 and 10:16. Station DD13 was complete, the TEK was deployed (**15150**) by 10:33 and *Discovery* began steaming towards DD11.

On reaching DD11 at ~14:30, *Discovery* immediately hove to and science was stopped. A steady force 9 gale was blowing and the sea was already quite rough with 6 m waves. The sea continued to get quite lumpy during the afternoon but during the evening the wind speed dropped off as fast as it had begun. Conditions were workable by 21:00 and after repositioning on station DD11, a full depth CTD cast was deployed (**15151**) at 21:40. The wind speed was now being monitored every 15 minutes by the watch, the sudden calm conditions indicated the passing of a front and we were now near the eye of the depression, therefore we feared the winds could pick up again very quickly if the other side of the depression approached us before it began to fill. The CTD was recovered at 23:25, and sampling was carried out whilst hove to. The TEK was deployed (**15152**) by 00:00.

30 November (Day 334)

Discovery remained hove to until the CTD bottles had been emptied and fully cocked for the next deployment, but by 00:30 *Discovery* was underway heading for DD10.

The TEK was recovered at 04:25 and *Discovery* was hove to on station by 04:30. A big swell made conditions marginal but after assessing the ship's motion, a full depth CTD cast (**15153**) was begun at 04:40. The CTD was recovered at 07:08 and vertical net hauls (**15154**) began at 07:27. Sadly the kevlar line, being used to deploy the nets from the aft Rexroth winch, parted just above the big net on recovery and thus net hauls were stopped at 07:37. Since the loss of the EK500 during D253 in June 2001, questions have been raised about the stability of kevlar for sea water deployments: however, this kevlar failure was closely examined and found to be a termination rather than cable failure, thus a new and stronger termination was made. Kathryn Cook and Alex Mustard constructed a spare net using a second frame hoop during the morning.

The LEK was deployed (**15155**) at 08:15 and recovered an hour later at 09:20. The TEK was re-deployed (**15156**) at 09:41 and after finding a suitable course in the rather lumpy conditions, the OS was deployed (**15157/8/9**) at 10:26. By the time the OS was recovered at 11:50, it was clear that the swell had grown (7 m mean and 11 m peak). It would prevent us from towing in the direction of DD9 and deploying ARIES altogether. In addition daylight was scientifically the wrong period to deploy the DM net system. Thus *Discovery* began to tack towards DD9 ready for deployment of the DM net and ARIES when possible.

By 14:30 the swell, now peaking at 13 m as reported by the watch leader, was creating too much roll to hold any direction other than 210° into swell or 030° with the swell. Clearly the latter direction would not help our scientific objectives but with a good forecast over the next 48 hours a direction of 210° would take us to D6 or E4 at the eastern end of the southern transect. Thus *Discovery* set course for as fast a steam as possible (~6 knots to begin with) towards stations D6 and E4.

At 21:20 we were forced to re-assess our situation with regard to the weather. The pleasant 72, then 48 and finally 24 hour forecasts for Sunday had been superseded by an analysis for 18:00 on 30 November and a new 72 hr forecast. The analysis showed a much deeper low (972 mb) south east of Cape Farewell than originally forecast (984 mb). This accounted for the rather heavy seas that we had experienced. Furthermore the analysis indicated air pressure at our location 984 mb which we were able to confirm. The new 72 hr forecast was

alarming; it indicated a new low off Cape Farewell deepening to 952 mb and isobars packed close enough to estimate hurricane force winds. *Discovery* was currently heading straight for it. The Master and I agreed that it was prudent to head back NNE overnight.

1 December (Day 335)
Following a good 24 hr forecast for 18:00 today, the barograph rising and sea state falling by 00:00, the Master and I deliberated over the balance between the arrival time of the deep depression in the 72 hr forecast and the time taken to run to Reykjavik if necessary. As a result, *Discovery* changed course to ~NNW at 00:45, heading for station DD9.

Discovery was on station at DD9 by 03:45. The DM net was deployed (**15160**) at 04:17 and recovered at 06:18. After careful examination of the somewhat marginal conditions, ARIES was deployed (**15161/2/3**) at 07:46 and expertly recovered at 13:06. The TEK was recovered and vertical net hauls (**15164**) began at 13:42. With the vertical nets completed by 14:25, the TEK was redeployed (**15165**) at 14:32 and *Discovery* set course for a re-occupation of station B4. The 48 hour forecast for midnight Monday confirmed the previous 72 hour forecast for 12:00 Tuesday and thus it was still prudent to head north closer to shelter if that becomes necessary. The previous ARIES deployment at B4 had been largely unsuccessful with a failure of both its net sampler and OPC data recorder.

2 December (Day 336)
'Detonation' warnings for a large area around our northern line were received the previous evening. They applied from midnight tonight for 48 hr. The warnings were to do with US activity and several lines of enquiry were followed asking for more information but none was forthcoming.

After manoeuvring to repeat the original ARIES tow at B4 as closely as possible, ARIES was deployed (**15166/7/8**) at 10:25 and recovered at 14:21. The TEK was brought inboard at 14:45 and the LEK deployed (**15169**) at 14:54. After recovery of the LEK, the TEK was re-deployed (**15170**) at 16:07 and *Discovery* set course due south overnight. Our overall objective now was station E4 at the eastern end of the southern line; but we would try to approach from east and south of the path forecast for the depression now some 280 nm just west of south of Cape Farewell and of 963 mb depth.

The TEK was recovered at 17:11 due to a loose cable tie on the deployment boom. Deteriorating weather persuaded us to keep the TEK inboard overnight.

3 December (Day 337)
By 15:00 *Discovery* was still making 3 knots in an overall southward direction. The wind speed was a steady force 10, gusting 11, and the occasional packet of very big swell waves had peak amplitude up to 20 m in a background mean of 11 m. The winds were beginning to turn from southerlies into westerlies as the depression moved north of us to the west (Fig. 2).

It was depressing but necessary to realise that, as far as the science programme was concerned, it was now unlikely that much, if any, further work could be achieved in the Irminger Basin although we had not given up hope of a day or so. However it was now sensible to consider any useful work significantly east of our present position (~61°N, 29°W): station India came to mind.

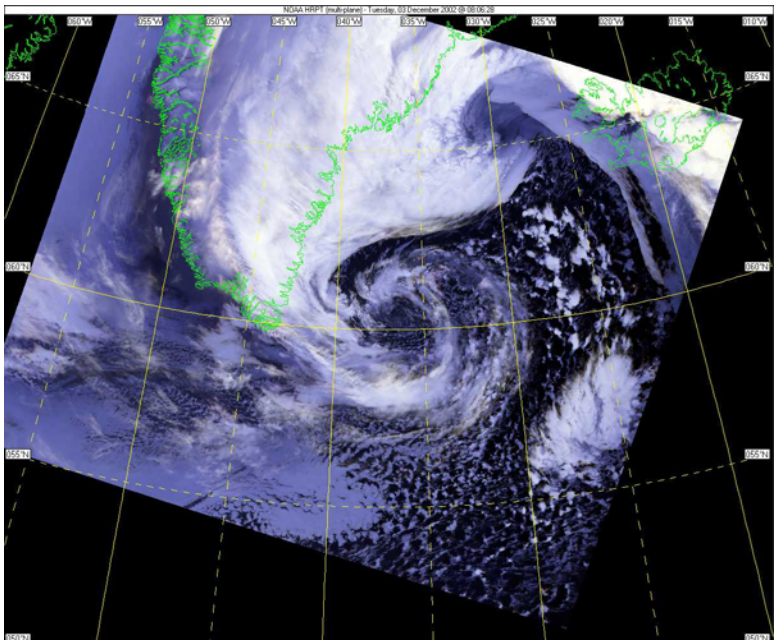


Fig 2. Satellite visible image of cloud cover at 08:06 on 3 December 2002. We received two more weather forecasts which showed a second, larger and as deep depression following the same course as the one we were currently negotiating. This provided a potential for hazardous conditions over the next 48-72 hr (Fig. 3) where an already confused and lumpy sea would be forced again by a strong cyclonic wind field. It was now imperative that we find a way to travel east as well as south over the next 24 hr to avoid severe sea conditions.

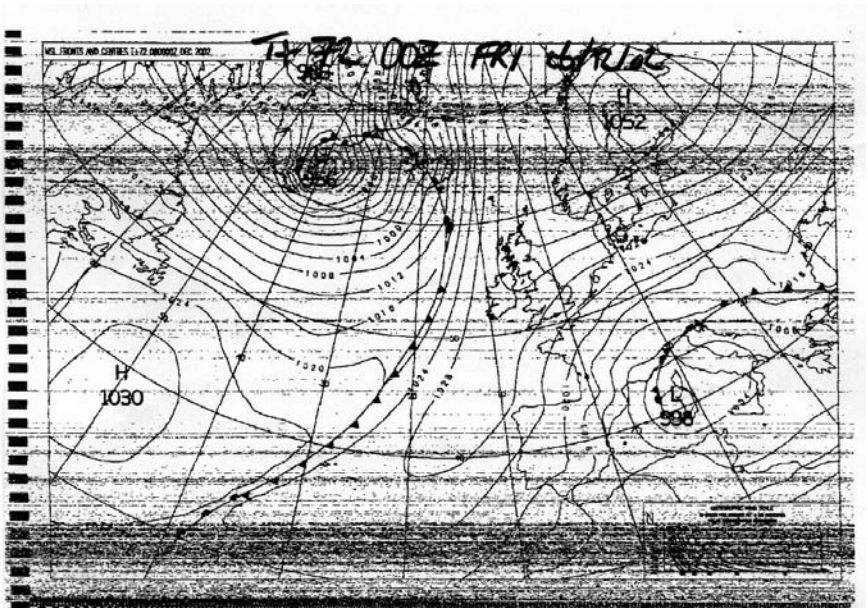


Fig 3. 72 hr forecast for 00:00 hr on 6 December 2002.

At 20:45 *Discovery* made a turn to head east. Although conditions were not ideal for turning about, the new forecast for 12:00 on 5 December showed that the new depression was expected to be deeper (949 mb) than previously forecast and was not satisfied with the Irminger basin, it would have a significant influence on most of the Iceland Basin too (Fig. 4). *Discovery* was able to make a good 10 knots in front of the swell although it was not a particularly comfortable passage.

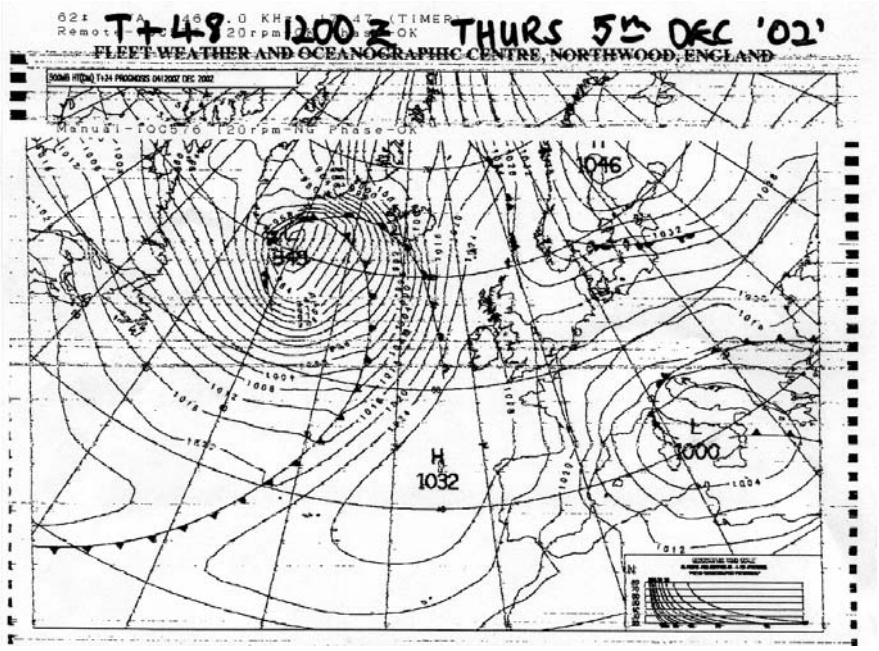


Fig 4. 48 hr forecast for 12:00 on 5 December 2002.

4 December (Day 338)

Still heading east, by 14:30 *Discovery's* position was ~60°10'N, 22°53'W. A 24 hr forecast for 06:00 tomorrow still indicated a strong cyclonic wind field stretching as far east as 16°W. The depression was forecast to fill over 6-7 December with a new third depression forming off Newfoundland by 06:00 on 7 December. The peak wave height was now down to 9-10 m in a background mean of 6-7 m.

Following input invited from the MarProd PIs, it was apparent that insufficient was known about the winter distribution of *Calanus finmarchicus* over much of the central and southern Iceland Basin or indeed the central and southern Rockall Trough. Therefore hanging around for a window in the weather, to return to the Irminger Basin for a couple of days or so before turning homeward bound, would not be the most efficient use of ship time.

Thus, on reaching 59°45'N, 15°W tomorrow (around mid-day) we would follow one of two new plans. If the weather allows, we would carry out a full station there and make a series of stations south west across the central Iceland Basin, including a repeat of last winter's G17, before turning south east for stations in what can be described as the Hatton-Rockall Bight (~53°N, 23°W) and the mouth of the Rockall Trough. If, on the other hand, the current 24 hr forecast for 12:00 tomorrow turns out to be an unpleasant reality, we would then experience gale force southerlies. Under those circumstances we would try to steam on south eastwards to work a line of stations south through the Rockall Trough before turning north west to work stations in the Hatton Rockall Bight, Maury Channel and hopefully G17 prior to turning home.

5 December (Day 339)

By 08:00 *Discovery* was already experiencing 45 knot south easterly winds. The latest forecast indicated that even the north west coast of Scotland would feel some effects of this depression, the eye of which was still forecast to run north up the Irminger Sea.

Two hours later, the winds were more southerly but still a steady 45 knots. It was clear that a series of stations south through the Rockall Trough was our only option for achieving any work in the near future. Thus *Discovery* continued to head further east for a new position, 59°23'N, 11°8'W, approximately 12 n miles north of a > 2000 m trough south east of

Rosemary Bank which, for want of a better description, we would call Rosemary Deep (RD). During the day *Discovery* just managed to keep up with the development of the fringes of the storm heading as fast as she could east.

6 December (Day 340)

By 03:20 *Discovery* was forced to heave to, just 4 hr or so from station. 40 knot winds had been maintained and the fetch had forced a large sea (8 m peaks in a 6 m background mean) from both the south and the west. The air pressure had still been rising steadily past 1022 mb. Even though the latest surface analysis indicated a low pressure anomaly of 945 mb at its centre, it was incredible to think that this wind field had its storm centre some 800 nm away (Fig 5).

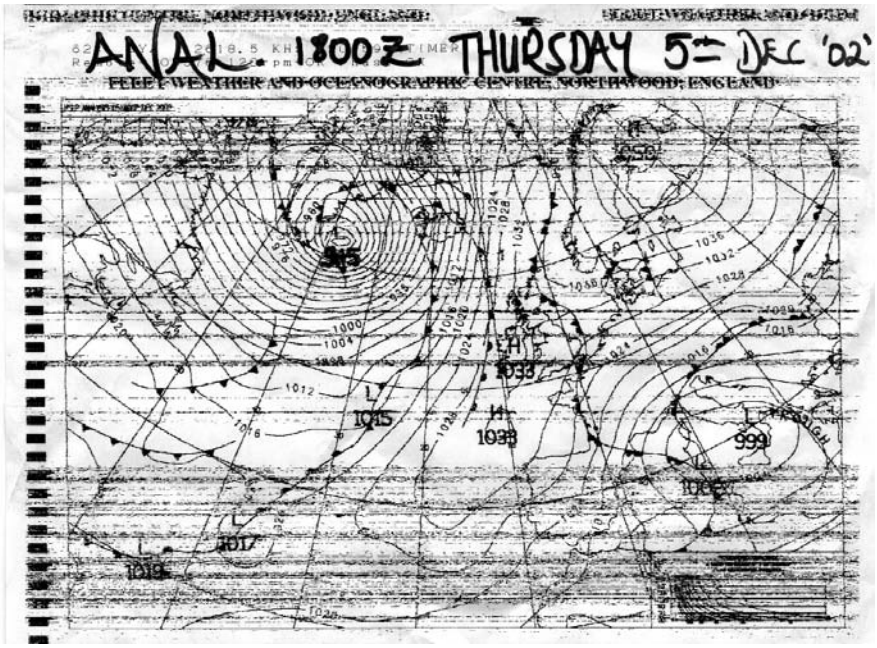


Fig 5. Surface pressure analysis for 18:00 on 5 December 2002.

At 10:05, *Discovery* was still hove to. Although the sea-state remained confused, it seemed to be improving and the wind speed had begun to drop off (30-35 knots). Preparations were made for getting underway again.

However, at 17:00 it was clear that the conditions were still unworkable. With better weather forecasts for the next 24 hr we would review this decision every 4 hr.

At 21:00 hrs, conditions remained unworkable, 30-35 knot winds had been maintained and *Discovery* was still rolling heavily (8 m peak swell in a 6 m background mean). The pressure had begun to level out around 1026 mb so hopes were high for 01:00.

7 December (Day 341)

At 01:00 the weather was improving, but slowly. There were two distinct swells with mean wave height >5 m. The wind speed was now 25 knots but gusting significantly harder at times.

At 07:20 the decision was made that conditions had improved enough to begin the station. In a maintained background swell of still >5 m we would employ a head to swell deployment and recovery procedure with *Discovery* then brought to wind (still 20-25 knots) in the conventional fashion during the descent and ascent of vertical casts. At 07:48 a full depth CTD cast began (**15171**) and was recovered at 10:38. Two vertical net deployments (**15172**) were then completed by 11:19. A LEK deployment (**15173**) began at 11:31 and was

completed at 12:30 when a series of alarmingly heavy cross swell waves caused the cessation of science on safety grounds.

By 16:30 the sea state was judged to be workable again and the TEK was hurriedly prepared for a dual role as an alternative ScanMar platform for the determination of the depth of the towed net systems. The ScanMar fish had been recovered earlier only to find that its tow cable had nearly severed just above the potted termination, and the fish was thus unserviceable for the rest of the cruise. By 18:00 the TEK had been deployed (**15174**). The winches then failed to power up and took some persuasion from the technicians. But by 18:55 the OS had been deployed (**15175/6/7**) and was recovered at 20:07. The DM net system was deployed (**15178**) at 20:46 and recovered at 22:33. Apparently the biology here was strikingly different to the Irminger Basin. ARIES was deployed (**15179/80/81**) at 23:17.

Having lost >30 hr trying to work station RD, the sampling plan conceived just 72 hr earlier began to look rather weak. We could no longer work the stations westward towards G17 before needing to steam back to Southampton. That left just three more stations south through the Rockall Trough some 120-180 n miles apart. Scientifically this looked difficult to justify as an efficient use of ship time. However, it would be possible to work a series of stations along the nearby 'Ellett line' and extend this out to station India. A series of eight stations were envisaged and would provide a coherent and reasonably spaced sampling line. Thus positions were given to the Bridge, maintaining original Ellett line stations where possible.

8 December (Day 342)

ARIES was recovered at 02:38 and by 03:00 *Discovery* had set course for station ADR near the eastern end of the Ellett line.

During the day it was discovered that Perry Dollery had hurt himself falling against a sink two days earlier. Following diagnosis by satellite phone to RN hospital Haslar, Perry was taken off duty with suspected cracked ribs. This reduced our deck crew to 5 and therefore threatened our 24 hr working capability.

At 20:46 *Discovery* hove to on station ADR. The CTD wire promptly threw itself off a sheave on tension take up, but this was expertly rethreaded in about ten minutes. The TEK was recovered at 21:04 and the CTD was deployed (**15182**) at 21:13. The CTD was recovered at 21:48, the data stream had been lost at 46 m on the upcast and a sea cable failure was suspected as a number of kinks had been noticed in the wire whilst on deck. Vertical net deployments (**15183**) began at 21:53 and were finished by 22:25. The LEK was deployed (**15184**) at 23:00 with calibrated targets hung beneath to provide a partial calibration. Recovery of the LEK was completed at 23:58.

9 December (Day 343)

The TEK was re-deployed (**15185**) at 00:17 and *Discovery* began to steam slowly in the overall direction of station ADN for the towed net deployments. The OS was deployed (**15186/7/8**) at 00:33 and recovered at 01:09. The DM net system was deployed (**15189**) into wind (prolonged gusts of 25-30 knots) at 02:39 and recovered in a similar fashion by 03:40. Finally ARIES was deployed (**15190/1/2**) at 04:24 and recovered at 07:06. *Discovery* then set course for station ADN.

Discovery hove to on station ADN at 08:37 and the TEK was recovered. The new CTD termination was load tested to ~1.8 tonne at 08:51. At 09:08 the CTD was deployed for a full depth cast (**15193**). At 09:20 the CTD came off the wire and was lost. This happened at a depth of 4 metres on the initial descent, after the usual soaking at 10 m, with a tension of less than 0.4 tonne on the wire. The water depth was ~2100 metres and position 57°13.5006'N, 10°02.9616'W. It was clear from examination of the cable that the termination rather than the wire had failed; i.e. it appeared that the wire had pulled through the three cable clamps

and around the tear drop. This had happened just 29 min after a load test which had been watched particularly closely by our newly recruited mechanical technician Dan Comben; Dan recalled seeing absolutely no slip in the termination during load test.

Vertical net deployments (**15194**) began at 09:56 and were completed by 10:30. By this time, the TLO and I had been in voice communication with Colin Day at SOC. Colin had requested that we spend 24 hr dragging for the lost CTD. The pro's and con's were as follows:

- The NMEP (National Marine Equipment Pool) was already stretched for equipment for its cruise commitments for the next two years.
- Between £200-300k worth of instrumentation was carried on the lost CTD.
- The pinger (altimeter) on the CTD frame was still working and this gave reason to suppose that other instruments might be salvageable.
- Time spent dragging would not further damage the core MarProd scientific aims of this cruise as these had already been cut short by bad weather.
- The manner in which the termination failed was alarming and it would be desirable to see what if anything had failed mechanically.
- Although the current scientific plan was outside the Irminger Basin, it was still of relevance to the MarProd objectives; time lost from this would significantly affect what could be achieved before steaming to Southampton.
- Although our navigation systems allow us to be very accurate with the position of *Discovery* when we lost the CTD, we would still be looking for a very small object in a water depth of 2100 m.

On balance I decided to allocate the 24 hr requested to search for the lost CTD.

By 14:30, everything had been prepared for dragging. A gifford (selection of grappling hooks and chain) was attached to a mass of old anchor chain by 12 m of chain. This was then attached to 250 m of trawl wire on a deck winch. After paying this out, the trawl wire was attached to the trawl warp through a 5 tonne rated weak link. A pinger was finally attached to the trawl warp 100 m above the weak link.

Discovery began deploying the dragging gear (**15195**) at 14:48. The deck officers would attempt to follow a number of trawl patterns including contracting boxes /circles and star lines. However, an increasing swell and steady force 6-7 winds made *Discovery* hard to handle at the low speeds required. The wind and swell remained a problem all day and most of the night, but with careful and consistent hard work at the helm, *Discovery's* deck officers went on to make a large number of passes within and over an area of 500 m diameter around the position at which the CTD was lost. By continuous examination of the echo intensity of the signal from the pinger on the CTD frame we were able to ascertain that the CTD rested on the sea floor within ~ 50 m of this position.

<u>10 December (Day 344)</u>

By 09:00, 24 hr after losing the CTD, I called a halt to dragging procedures. *Discovery* had made many passes dragging the area of sea floor occupied by the CTD, and it was now time to continue science particularly as wind and sea state had dropped off considerably. However, it would take some time to prepare the spare CTD and the cable haulers on the main trawl winch needed some attention. Furthermore, I had received emails from MarProd PIs, Mike Heath and Raymond Pollard, the previous morning requesting that *Discovery* carried out a line at 54° N rather than the Ellett line. Thus, after consulting scientists on board, I changed our plans again and gave the Bridge four new stations, FF1-4, forming a

line westwards along 54° N as far as 20°30'W. Effectively we would thus begin steaming closer to home whilst making necessary equipment preparations.

At 10:46 the grappling gifford was recovered and by 12:50 *Discovery* had set course for station FF1. Following the inexplicable circumstances for the loss of the CTD I discussed safety issues with watch leaders and instrumentation technicians. It was quickly determined that this method of termination was well 'tried and tested' and in general usage within this scientific discipline, there was a long and safe history of its usage. Having failed to retrieve the CTD we could only speculate on the possible causes for termination failure. Thus we reviewed the addendum to the risk assessment for CTD deployments previously written on this cruise and published earlier in this diary. We concluded that Paragraph 2 of the addendum provides the best possible safety measure for the unlikely event that a termination failure should happen again, i.e. that slip ropes are used to control the CTD such that no one is close to the CTD until it is just above the claws of the landing frame.

The TEK was redeployed (**15196**) at 19:15.

11 December (Day 345)

The TEK was recovered and *Discovery* was on station FF1 by 09:25. It then occurred to us that no permission had been sought for MarProd work in Irish waters. We were well inside 200 nm from the Irish coast and therefore station FF1 was immediately abandoned and station FF2 was moved to 54°N, 16°W. At 09:49 *Discovery* set course for station FF2.

After lunch the new CTD termination was load tested in the usual manner, pulling against strops attached to four deck eyes. The termination was then closely inspected as usual for any slippage in the clamps or slackness of the tear drop.

Discovery hove to on station FF2 at 17:26. At 17:53, ~ 1 tonne of scrap chain was deployed on the CTD termination and three descents were made to a depth of 500m. On recovery at 19:14, the termination was checked and replaced on the CTD frame. The CTD was then deployed for a full depth cast (**15197**) at 19:53. After the CTD was recovered at 22:48, vertical net hauls (**15198**) began at 22:56 and were finished by 23:30. The LEK was deployed with calibration spheres (**15199**) at 23:53.

12 December (Day 346)

With the LEK recovered by 01:20, the TEK was re-deployed (**15200**) at 01:31 to begin the horizontal net system tows towards station FF3. The OS was deployed (**15201/2/3**) at 01:56 and recovered by 03:15. The DM net system was deployed (**15204**) at 03:59 and recovered by 06:02. ARIES was deployed (**15205/6/7**) at 06:44. By 12:30 ARIES had been recovered and *Discovery* set course for station FF3 at 12:49.

Discovery arrived on station FF3 and the TEK was recovered by 16:20. At 16:25 a full depth CTD cast (**15208**) was begun. The CTD was recovered by 19:00 and vertical net hauls began (**15209**) at 19:09. After completion of the net hauls at 19:42, the LEK was deployed (**15210**) at 19:54. Following recovery of the LEK, the TEK was re-deployed (**15211**) and an OS tow (**15212/3/4**) began at 21:46 in the direction of station FF4. The OS was recovered at 22:56 and the DM net system was deployed (**15215**) by 23:35.

13 December (Day 347)

The DM net system was recovered at 01:20 and an ARIES deployment (**15216/7/8**) began at 01:54. ARIES was recovered at 08:12 and, with everything secured, *Discovery* set course for station FF4.

Discovery was hove to on station FF4 by 13:45. Brilliant sunshine all morning with light broken cloud cover had cheered everyone up. The TEK was recovered and a full depth CTD cast (**15219**) began at 14:00. At 16:15 the ship's complement took part in a safety muster

exercise and boat drill, after which the CTD was recovered at 16:50. Vertical net hauls (**15220**) began at 16:59 and were completed by 17:29. The LEK was deployed (**15221**) and recovered by 18:36. After re-deploying the TEK (**15222**) at 18:44, the OS was deployed (**15223/4/5**) at 19:00 to begin the net system tows in the direction of FF5. The OS was recovered at 20:13 and the DM net system deployed (**15226**) at 20:50. By 22:30 the DM had been recovered and ARIES was deployed (**15227/8/9**) at 23:11.

14 December (Day 348)

ARIES was recovered at 05:24 and *Discovery* set course for FF5 at 05:36. *Discovery* was on station at FF5 by 08:00. The DM net system was deployed (**15230**) at 08:26 and towed in a south south eastward direction. Although a bright sunny day, a steady wind force 7 and already marginal seas raised a serious question mark over the planned ARIES deployment. The DM was recovered at 09:56 and the sea state and vessel motion were watched closely whilst the ARIES system was prepared. The water depth was over 3500 metres and the ARIES tow would therefore take over 7 hr. Our best weather forecast indicated that we could expect force 7 winds to be maintained until late in the evening. In a slowly deteriorating sea state we were therefore forced to abandon the ARIES tow.

The next available time slot for deploying our second and last Meteorological Buoy was not until 11:45, therefore all was secured for steaming. *Discovery* set course east south east, but was unable to achieve more than 7.5 knots into wind speeds of 25-30 knots and peak swell waves of 6 m against a background mean of 4 m.

At 11:42 *Discovery* slowed to 1.5 knots and Met. Buoy serial no. 21556 was deployed (**15231**) at 11:46 in position 53°51.8'N, 21°44.9'W. The TEK was recovered at 11:54 and the PES fish at 12:00. *Discovery* set course for Southampton. By 12:30, *Discovery* was able to make around 8-8.5 knots, but sadly still too slow to allow us to make a detour via the Porcupine Abyssal Plain (PAP) site and look for the errant ANIMATE mooring that we had been informed about over the last 72 hr or so - all very frustrating.

By 15:00 I was still having doubts about my decision; *Discovery* was up to 10 knots. However, if we took the detour via the PAP site (and risked losing all our contingency for the steam home), the timing was such that we would have to search for the errant mooring at night with only an Argos location - since apparently no beacon lights or radar reflectors were fitted to the flotation buoys. As if to appease my mind, by early evening (~ 20:00) *Discovery* was forced back to 9 knots by moderately lumpy seas similar to those in the late morning.

15 December (Day 349)

By 10:30, *Discovery* was still being forced back to ~ 9 knots steaming into a modest swell and 25-30 knot winds.

16 December (Day 350)

By 08:30 *Discovery* was up 10.5 knots in a light sea, but with gale 8 warnings for the Sole region later it was still possible that we would need our time contingency and thus it was important to press on with the journey home as fast as possible.

J. Allen

5. Technical Support

5.1 Mechanical report - *Darren Young, Steve Whittle, Alan Sherring and Dan Comben*

UKORS ship-fitted mechanical equipment

Starboard Gantry (Used)
Was equipment left in good working order: Yes *Faults rectified in use:* None
Reportable faults: None

Stern Gantry (Used)
Was equipment left in good working order: Yes *Faults rectified in use*: None
Reportable faults: None

Amidships Scientific power pack (Used)
Was equipment left in good working order: Yes *Faults rectified in use*: None
Reportable faults: None

Aft Scientific Power packs (Used)
Was equipment left in good working order: Yes *Faults rectified in use*: None
Reportable faults: None

P.E.S. Winch, Davit & Power Pack (Used)
Was equipment left in good working order: Yes *Faults rectified in use:* None
Reportable faults: None

300KW Power Pack, 20T and 10T Cobra Unit (Used)
Was equipment left in good working order: Yes
Faults rectified in use: Refitted repaired inboard cobra sheave and motor on 10 T system. (Fault encountered on D266). Replaced split brake spring plate on outboard cobra motor of 20T system.
Reportable faults: None

10T Storage System, including 37KW Power Pack, Inboard Compensator & Diverter Sheaves (Used)
Was equipment left in good working order: Yes/No *Faults rectified in use*: None
Reportable faults: Several intermittent faults occurred during the cruise. One of the faults occurred during starting of the power pack. When the power pack was turned from cable loading to Auto the current on motor two would shoot up to over 44 amps and a very load (almost deafening) thumping noise could be heard. This fault was extremely difficult to rectify because the power pack had to be turned back to the loading position immediately to stop the thumping.

The other problem we encountered was that on several occasions during recovery of several CTD's the winch would not haul in. The only way we found to overcome this fault was to go down to the winch room and shut down the 10T power pack and then restart everything again.

We spent much time during the early part of the cruise trying to rectify these faults and on several occasions thought that we had, only to find several days later the fault had returned. These faults are still on the 10T system, but since the winches are being replaced, there is no need to spend any more time and effort trying to solve these.

20T Storage System, including 37KW Power Pack, Inboard Compensator & Diverter Sheaves (Used)
Was equipment left in good working order: Yes *Faults rectified in use:* None
Reportable faults: During several recovery exercises (hauling in) the winch would be hauling in at 30m/m then the back tension would shoot up and the cobra would stop turning. On investigation all the motors on the 20T power pack had tripped out and could not be restarted without powering down the entire control cabinet. On other occasions only the two main motors would have tripped out.

This fault is still in the system - but the winches are being replaced

10T & 20T Cable Haulers/Power Pack (Used)

Was equipment left in good working order: Yes
Faults rectified in use: The 20T cable haulers would spin on the cable and not grip it, making paying

out slack wire extremely difficult. New cable hauler wheels were fitted but still made no improvement. All new wheels were removed and 2mm machined off each wheels diameter. Fault rectified.
Reportable faults: None

10T Outboard Hanger Deck Diverter Sheaves (Used)
Was equipment left in good working order: Yes *Faults rectified in use*: None
Reportable faults: None

20T System Hanger Deck Diverter Sheaves and Roller Assembly (Used)
Was equipment left in good working order: Yes *Faults rectified in use*: None
Reportable faults: None

30Tm Crane, Port Aft & Power Pack (Used)
Was equipment left in good working order: No *Faults rectified in use:* -
Reportable faults: The crane could not be certificated after a load test because the crane would not jib out to full extension. The crane would jib out with no problems until it reached the last extension jib when it would slow and stop before reaching the end of travel

30Tm Crane, Aft Stbd & Power Pack (Used)
Was equipment left in good working order: Yes/No *Faults rectified in use*: None
Reportable faults: The crane could not lift the proof load used to certificate the crane to its SWL. The crane was given a test certificate, but at a down-rated SWL. The crane needs to be load-tested back in Southampton. Possibly the main relief pressure needs to be adjusted to do the proof load on the crane and than re-adjusted to the SWL pressure.

Non-Toxic Water System (Used)
Was equipment left in good working order: Yes *Faults rectified in use:* None.
Reportable faults: None.

Workshop (Used)
Was equipment left in good working order: Yes *Faults rectified in use*: None.
Reportable faults: None.

Winch Control Cab (Used)
Was equipment left in good working order: Yes *Faults rectified in use:* None
Reportable faults: None

Clam System (Used)
Was equipment left in good working order: Yes *Faults rectified in use:* None
Reportable faults: None

Seismic Compressors (Not Used)
Was equipment left in good working order: Yes *Faults rectified in use:* N/A
Reportable faults: N/A

Spares / consumables used and required for subsequent cruises (Used)
List below as required: 10 bags of rags; hacksaws; 18 inch shifters; general purpose grease

Additional comments/recommendations
See fault on 10T level wind. This fault needs to be looked at as soon as possible before all the electrics rot away due to the water that has been in the control box.

UKORS portable equipment report

5T Lebus G.P. Winch Ser No 5T-LEB01
Was the cruise completed with the equipment in good working order: Yes
Faults rectified in use: None *Reportable faults*: None

5T Lebus G.P. Winch Ser No 5T-LEB02
Was the cruise completed with the equipment in good working order: Yes
Faults rectified in use: None *Reportable faults:* None

Radionuclide container lab

Was the cruise completed with the equipment in good working order: Yes
Faults rectified in use: None *Reportable faults*: None

10T Level wind

Was the cruise completed with the equipment in good working order: No
Reportable faults: Several times during the cruise the electrical controls of the winch failed

Flake Ice maker F-120B

Was the cruise completed with the equipment in good working order: Yes
Faults rectified in use: None *Reportable faults:* None

Echo Sounder Davit Port 03

Was the cruise completed with the equipment in good working order: Yes
Faults rectified in use: None *Reportable faults:* None.

2T Danfoss winch

Was the cruise completed with the equipment in good working order: Yes
Faults rectified in use: None *Reportable faults:* None

5.2 Instrumentation - *Jon Short, Dave Teare and Paul Duncan*

CTD

A total of 21 CTD cast were performed, two of which were test casts. Until the loss of the CTD on station 15193 the instrument had performed reasonably well. The only problem being the Altimeter, which failed to work correctly until the CTD was closer than 10m to the seabed. Approach and separation from the seabed were monitored using the 10 KHz pinger. After the loss of the main CTD the spare system was built up and used on the last three casts. The main CTD system had twenty four 10 litre bottles, and comprised the following instruments: primary and secondary temperature and conductivity sensors, an oxygen sensor, fluorometer, transmissometer, light backscatter and altimeter. Also attached to the frame were two ADCPs operating at 600 and 300 KHz.

The spare CTD system had twenty 10 litre bottles and comprised primary temperature and conductivity sensors, oxygen sensor, fluorometer and altimeter.

SurfMet

The SurfMet was run for the whole cruise. The starboard total irradiance (STIR) failed after ~5 days. This was not replaced due to lack of spares. The flow through fluorometer failed on day 322 and was replaced. All other sensors appeared to be working correctly.

Echo Sounder

The EA 500 was used throughout the cruise, on both the hull and fish transducers. The 10 kHz mode was used exclusively as the 12 kHz failed approximately 15 minutes after being switched on. The 12 kHz system had failed on the previous MarProd cruise so it seems likely that the initial problem is still present.

Salinometer

This was used throughout the cruise without problem after an intial airlock had been removed.

VM-ADCP

Both vessel-mounted RDI ADCPs, the 150 kHz and the 75 kHz Ocean Surveyor, were used during D267. The problems encountered with the control PC for the 150 kHz unit during the previous MarProd cruise (D264) had been rectified during the previous *Discovery* cruise (D266) and this performed well for the duration of the cruise; however the percentage good

data appeared to indicate air trapped in the ADCP housing. This is cleared using a normally open valve to bleed of the trapped air. It appears that the pipe running to this valve may have been clogged but this cleared itself after approximately 24 hours.

The Ocean Surveyor (75 KHz ADCP) performed well for the duration of the cruise.

Shipborne Wave Recorder

The control PC for the SBWR was replaced at the beginning of the cruise. Following this, the system performed well for the duration of the cruise.

5.3 General data logging and IT support - *Liz Rourke*

Data logging

Data was logged using the ISG ABC System. The Level A system collects data from individual pieces of scientific equipment. Level B collects each of the Level A SMP messages and writes them to a disk, monitoring the frequency of the messages and warns the operator when messages fail to appear. Level C parses these messages into data streams.

The following general data were collected on D267:

Chernikeef Log	LOG_CHF	MkII Level A
Ships Gyro	GYRONMEA	MkII Level A
Trimble GPS	GPS_4000	MkII Level A
Ashtec ADU	GPS_ASH	MkII Level A
Ashtec Glonass GPS	GPS_GLOS	MkII Level A
Echo-Sounder	EA500D1	MkII Level A
	EA500D2	MkII Level A
G12	GPS_G12	MkII Level A
Winch	WINCH	SEG PC
ADCP	Level C direct log	ADCP PC
Surface Logger	SURFMET	SIG PC

Hardware

At the start of the cruise there was no Level A system available for logging the EA500D2. A spare Level A was reconfigured to accept messages from the EA500D2. The GPS_ASH Level A was also showing problems but this was replaced with a spare Level A.

On day 313 the Ashtec was not recording pitch and roll data. This was found to be caused by a salt encrusted inline amplifier on the Port Forward Antenna. On day 314, when we were in Reykjavik, the amplifier was replaced and pitch and roll data reinstated. Ashtec Evaluate soft-ware is currently installed on a PC in the main lab and allows the user to look at the current working of the Ashtec. The Ashtec had to be reconnected (in the comms room) to the PC running Ashtec Evaluate, before being used to assess the working state of the Ashtec receiver.

Several times during the cruise, the Level A stopped receiving data from the Ashtec despite the receiver still being operational. This was solved by power cycling the receiver. After the first failure the power supply was rewired. Since the Ashtec is used to provide heading data for ADCP data processing, a list of time gaps in the data greater than five minutes in the Level C data file is given below:

Ashtec time gaps > 5 min (year, day, hour, min, sec):

02 310 10:36:41 to 02 310 10:49:02
02 313 22:17:27 to 02 313 22:35:49
02 313 22:48:59 to 02 313 22:57:49
02 313 22:59:46 to 02 314 13:42:55
02 314 18:31:54 to 02 314 18:49:49

02 314 19:59:29 to 02 314 20:23:54
02 314 22:13:59 to 02 314 22:45:24
02 315 00:14:05 to 02 315 08:59:50
02 320 18:01:31 to 02 320 18:31:54
02 322 18:34:07 to 02 322 18:58:24
02 325 02:07:27 to 02 325 02:14:49
02 333 15:39:38 to 02 333 16:12:16
02 333 16:33:09 to 02 333 16:55:25
02 333 17:11:11 to 02 333 17:16:26
02 333 17:43:37 to 02 333 18:13:19
02 339 13:52:20 to 02 339 14:22:19
02 344 20:24:33 to 02 344 20:45:24
02 346 01:27:44 to 02 346 01:34:41

The GPS_G12 power supply failed at several points during the cruise. This was thought to be overheating since the power supply had been replaced at the start of D264. Due to this *bestnav* was run using data from the GPS_4000 receiver. Since the former receives differential gps from the GPS_G12, time gaps greater than 5 minutes are listed below.

GPS_G12 time gaps > 5 min (year, day, hour, min, sec):

02 322 15:03:30 to 02 322 15:23:22
02 323 11:38:35 to 02 323 11:53:46
02 323 14:22:55 to 02 323 14:31:22
02 331 10:37:34 to 02 331 10:45:23
02 333 15:39:34 to 02 333 16:01:16
02 333 16:04:48 to 02 333 16:17:41
02 333 16:33:34 to 02 333 16:54:15
02 333 17:05:59 to 02 333 17:15:31
02 346 01:27:36 to 02 346 01:34:33

The Level B system was shutdown on day 333 to replace the Level B tape drives with one from the spare Level B system on board. Since the vessel was hove to at the time, there was no loss of significant data. As a result of having only one Level B tape running for backup, data from the Level C files were then backed-up twice a day. There were two Level B crashes during the cruise.

Email system

The mail system performed well on the cruise. Restrictions on mail size sent from the Principal Scientist's account were lifted. A new webmail system, SquirrelMail, running under Slackware 8.1 [Linux] was installed on the old Novell server and run successfully throughout the cruise.

Networking

Several PC's and laptops were networked during the cruise. After the mains power was switched off by the ship's engineers whilst finding an earth fault, the coax network was no longer working. The problem was solved by resetting the terminal box in EL4 in the main lab.

Printers

The hp2000c printer suffered the same problems experienced on D264. This caused no significant problems since two other colour printers were available.

Data Processing

The Level C plotting suite was used to produce annotated cruise track incorporating the GEBCO depth contours. True wind data was produced using 'windcalc' and protsg was run

continuously throughout the cruise. Depth data was merged from the EA500D1 and EA500D2 files and then edited before running prodep. Daily checks using the 'rvsedit' program were performed on the gps_g12 and gps_4000 data.

The Generic Mapping Tools [GMT] software was used to plot station positions. The main pages for the suite of utility programs were available on Discovery's web site [http://discovery2/Documentation/gmt_man.html].

DartCom Satellite System

The Dartcom satellite image acquisition system was used extensively during the cruise to track storms travelling across the North Atlantic (Fig. 2). Most of these images [HRPT] were acquired from NOAA satellites. The images were sub-sampled using the three thermal channels due to the lack of daylight in the working area.

6. Scientific Investigations

6.1 Lowered CTD sampling, processing and calibrations - *Steven Alderson*

Introduction

On D267 CTDs were mainly 'full profile' stations to full depth. As on the previous MarProd cruises, bottles were fired at a standard set of depths from the bottom to the surface. Data from CTD stations were processed in the standard manner described below.

Sampling Protocol

Water samples were taken from every cast for analysis and calibration purposes. Samples were taken in the following order; oxygen, ammonium (where required), nutrients, salinities, then chlorophyll and stable isotope samples. On the first half of the cruise, oxygen samples were taken from approximately half the bottles from the bottom to the surface, excluding the 5m bottles (with a duplicate from bottle number 2). On the second half oxygen samples were taken at all depths. Samples for nutrient analysis were taken from every depth. In addition nutrient samples were drawn from all bottles shallower than 1000m which were then frozen for total nutrient analysis ashore. Sufficient salinity samples were taken for calibration purposes (typically 5-8 samples spanning the cast, with one duplicate at the bottom).

The standard bottle firing depths (wire-out, m) for full profile CTDs were as follows, with near-surface bottles sampled at depths related to the remaining percentage of light energy:

> 5m (x2); 50% LD; 25% LD; 10% LD; 5% LD; 1% LD; 0.1% LD; 100m; 125m; 150m; 200m; 300m; 400m; 600m; 800m; 1000m; 1250m; 1500m; 1750m; 2000m; 2500m; bottom.

Processing

The processing of the SeaBird CTD data followed the paths established during the first MarProd cruise D258 (Pollard & Hay, 2002). The reader is referred to that document for full details, but a broad outline is given here. Note that 5-digit Discovery station numbers were used throughout the cruise.

Raw binary data were logged to the Seabird deck unit, copied to zip disk and then transferred to a user PC for processing by SeaBird software. It was discovered part way through the cruise that the deck unit does some data pre-processing before this transfer. Specifically, an alignment shift is made on each of the two conductivity cells of 0.073 seconds. Inspection of the AlignCTD command files used on earlier MarProd cruises indicated that an inappropriate further shift of 0.073 seconds may have been applied to the second conductivity cell in step v) below. This is dependent on the particular deck unit used and must be checked. Inspection of conductivity data processed with and without an extra 0.073 seconds in cond2 alignment shows significant differences in noise level.

SeaBird Software (SeaSoft) Processing

The following processing steps were performed on the binary 24 Hz data. Input file is ctd15nnn.dat in directory "C:\D267ctd", output file is ctd15nnn.dat in subdirectory "C:\D267ctd\Processed".

i) datcnv Convert raw data, copies selected variables (only measured variables, not derived). Processing file: DatCnv267.psu.

ii) rossum Averages the SeaBird .ros file into one value per bottle. Processing file: RosSum267.psu.

iii) celltm Corrects the conductivity for the thermal mass of the cell. Processing file: CellTM267.psu.

iv) wildedit Edits spikes in the 24 Hz data in preparation for averaging (using D258 values) Processing file: WildEdit267.psu.

v) align Advances the oxygen variable to match timing of other variable (D258 values) Processing file: AlignCTD267.psu.

vi) trans Converts the data to ascii. Processing file: Trans267.psu.
All processing files (.psu) were simply copies of those used on cruise D264. Output ascii files are ctd15nnn.cnv an ctd15nnn.btl. These were then transferred to the unix directory by FTP where further processing was done using PEXEC programs.

Pexec Processing

i) ctd0 Translates the 24 Hz SeaBird ctd14nnn.cnv file into pstar format. Requires the latitude and longitude of the bottom of the cast. These are manually entered from details on the cast logsheet, but are automatically checked and corrected later. Output ctd15nnn.24hz

ii) ctd1 Performs further editing of the 24 Hz file: averages into 1 Hz data, calculates derived variables salinity, potential temperature and density. Output ctd15nnn.1hz

iii) ctd2 Requires data cycle numbers of the first good in-water data (lowest pressure after soaking), the bottom of the downcast (maximum pressure) and the last in-water data (all obtained manually by listing ctd15nnn.1hz using program mlist). Extracts data from the 1 Hz file to produce the entire in-water 1 Hz cast (ctd15nnn.ctu) and the downcast profile averaged to 2dbar intervals (ctd15nnn.2db).

iv) ctd3du Produces standard profile and temperature-salinity plots for deep and shallow stations including both the up and down casts.

v) sam0 Converts the ascii .btl file into a pstar file that contains the CTD variables from the bottle firing times. Output fir15nnn.

vi) sam1 Converts the firing file into a master sample file, into which bottle oxygen, nutrient, salinity and chlorophyll data will be pasted. The script adds space for each expected sample variable. It is controlled by a simple text file called sam.names containing variable names, units and missing data values. Output sam15nnn.

vii) passam Pastes ascii sample (oxygen, nutrient, salinity or chlorophyll) data into the master sample file. Requires tab-delimited text file with sample numbers that match those already in the sam15nnn file (convention for sample number is nnn01 to nnn024). Any extra variables in the input text files that are not in sam.names (and therefore do not appear in the sam file) are ignored by this script.

viii) makeresid Calculates the bottle conductivity (using bottle salinity and CTD pressure and temperature). Calculates the difference between bottle and CTD oxygens, bottle chlorophyll and CTD fluorescence, bottle salinity and CTD salinity, and bottle conductivity and CTD conductivity. Can be run with some bottle data absent, re-run as necessary. Output file res15nnn.

ix) ctdtimes.exec Extracts times from the CTD files corresponding to the start, bottom and end of the cast. Used for extracting on-station ADCP data and for adding the correct position and water depth information to the CTD and sample files' headers. Output tim15nnn.

x) ctd4 Checks the true position and water depth from the master navigation and master bathymetry files. Allows user to correct the information in all CTD and sample files.
A helper script was created on D267 to perform most of the above steps for sample data.

xi) dosam This script performs the sam1 step then adds all available sample data with passam and performs a final makeresid. In particular, after pasting in the bottle oxygen data, this script re-calculates the bottle oxygen in units umol/kg for direct comparison with CTD oxygens (new variable botoxyk in sam15nnn). If the oxygen sample data is not available it creates a dummy botoxyk value to allow makeresid to still work.

Calibrations: stations 15071 to 15171

These stations were performed with the same system as other MarProd cruises employing dual conductivity and temperature sensors. The secondary sensor suite was mounted on a bracket to the side of the frame to reduce the affect of flow distortion by the frame (see the D264 report for more details). After the loss of this CTD package (see Narrative), the spare package was employed which only has a single suite. This necessitated a different calibration and also some modification of the processing.

Salinity

The bottle salinity samples are used to derive a final calibration of the two conductivity sensors. The sensors were calibrated by SeaBird prior to the cruise and manufacturer's specifications indicate that they should not drift by more than 0.001 in salinity over 6 months. The calibration is based on the assumption that the bottle samples measure the absolute salinity (to within 0.0001); see section on Salinometry. The procedure recalculates the bottle conductivity (using CTD temperature and pressure) and compares that to the measured CTD conductivity. The bottle conductivity (botcond) and the differences (botc-ctd, botc-ct2) are calculated in makeresid. The conductivity difference between botcond and cond is shown in Fig 6 below.

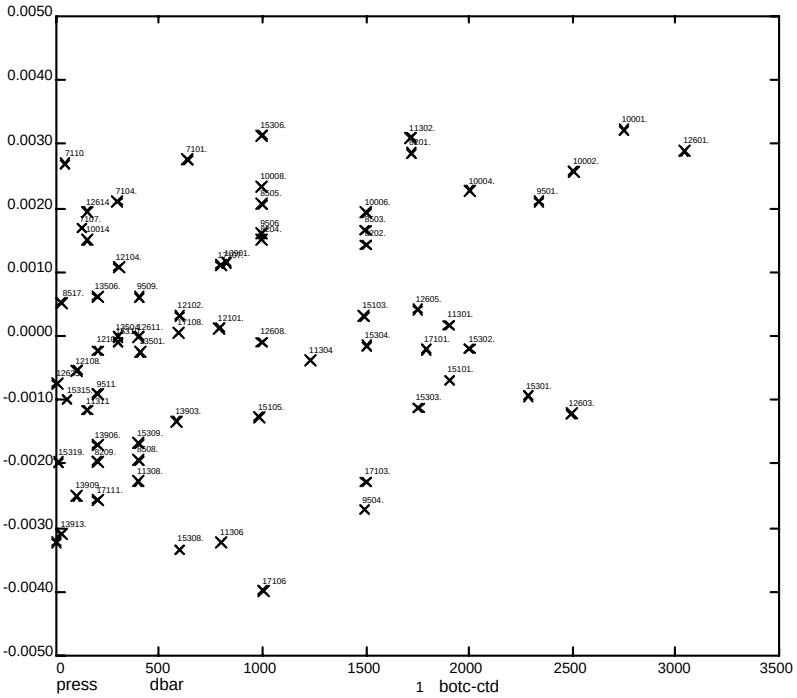


Fig 6. Conductivity difference between botcond and cond.

The conductivity difference between botcond and cond2 is shown in Fig 7. Numbers correspond to the sample number (in the range nnn01-nnn24). Both residuals appear to be bimodal and split between casts 15100 and 15109.

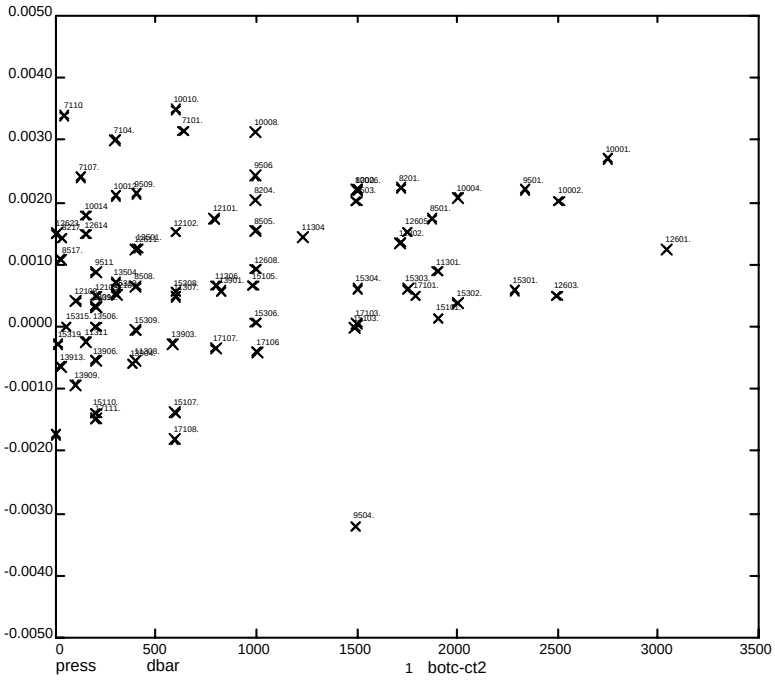
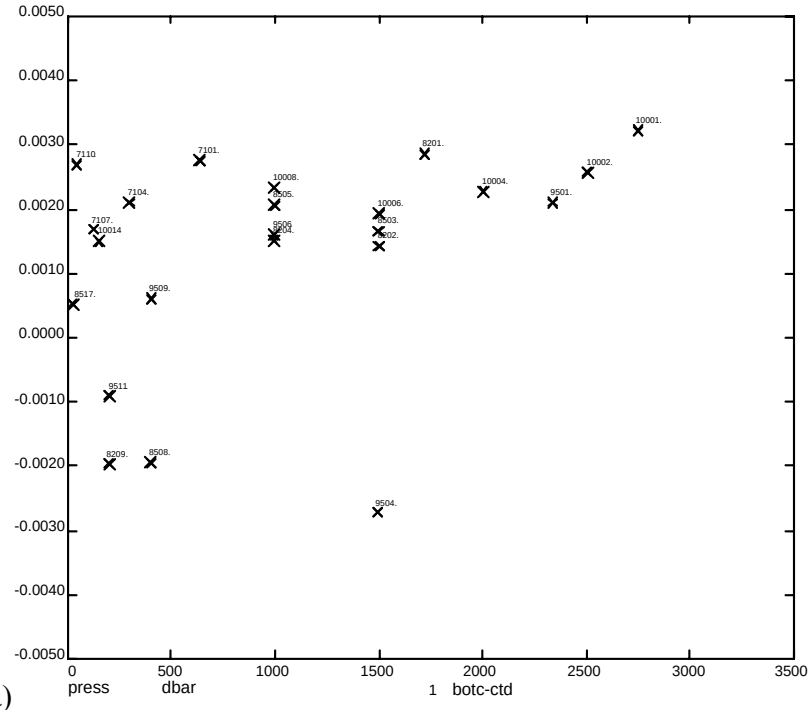
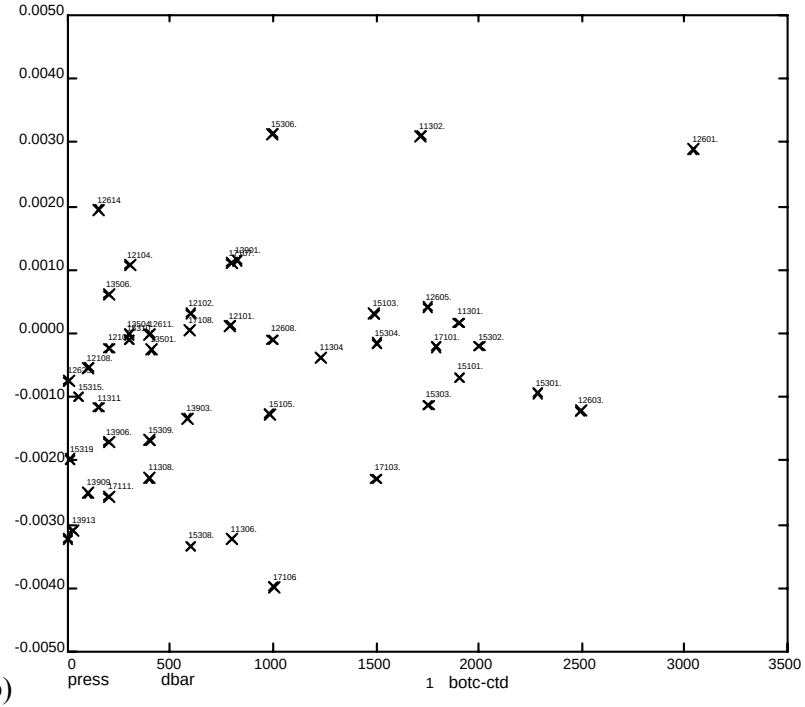


Fig 7. Conductivity difference between botcond and cond2.

Figs 8a and 8b show points before 15109 and points after 15100 separately for the primary cell (cond). Figs 9a and 9b show the same but for the secondary cell (cond2).

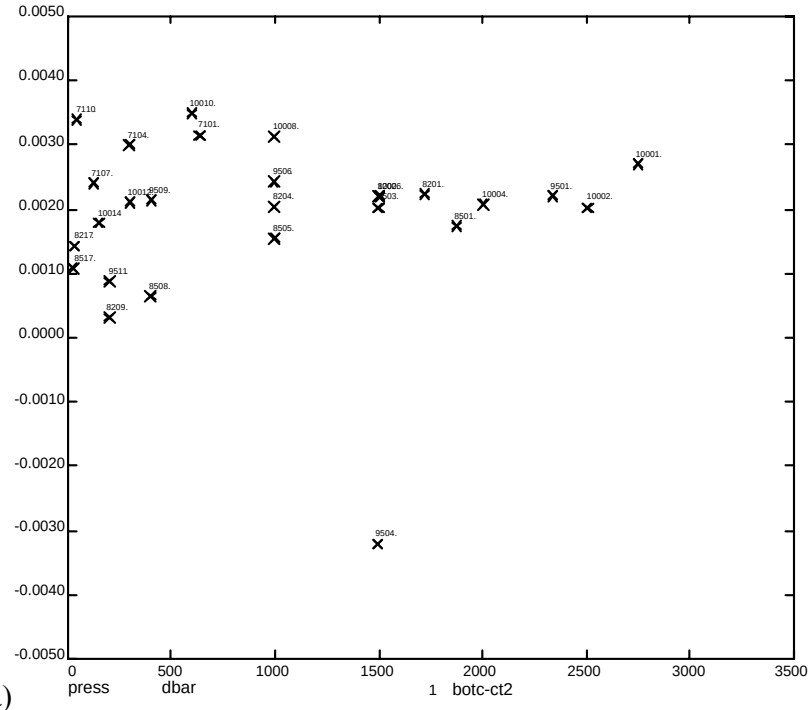


(Fig 8a)

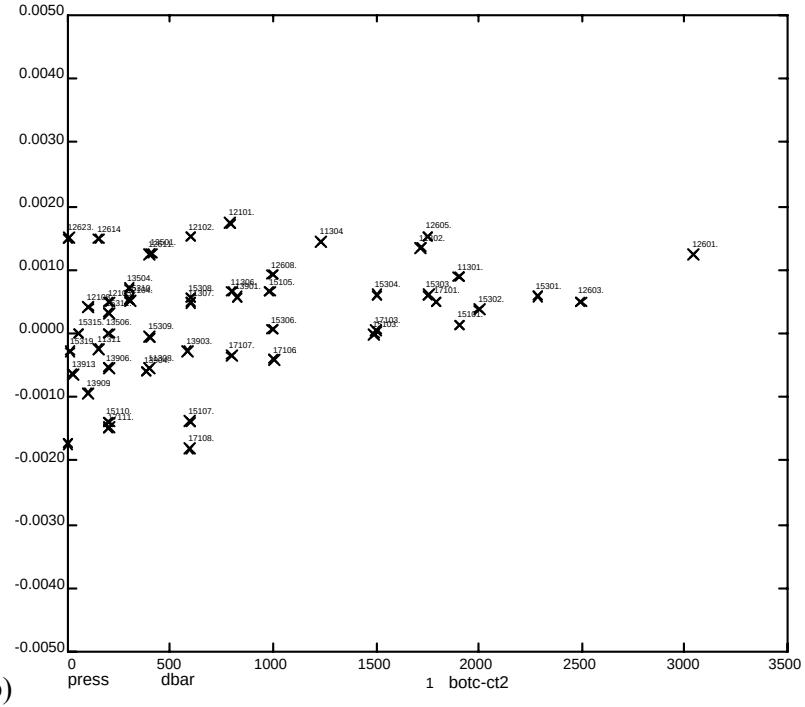


(Fig 8b)

Fig 8. Conductivity residuals for the primary sensor for a) stations 15071-15100 and b) stations 15109-15171.



(Fig 9a)



(Fig 9b)

Fig 9. Conductivity residuals for the secondary sensor for a) stations 15071-15100 and b) stations 15109-15171.

Table 3 presents the statistics derived from these four plots. Somewhat surprisingly, the calibrations can be approximately summarised as:

cond(cal) = 0.002 + cond(raw) for stations 15071-15100
and cond(cal) = cond(raw) for stations 15109-15171

Table 3. Statistics of conductivity calibration for the primary and secondary cells divided into two groups of casts.

cell	stations	mean	Standard deviation	Number in sample after exclusions	Excluding
primary	15071 - 15100	0.00196	0.00071	19	08209 08508 09504 09511
secondary	15071 -15100	0.00209	0.00081	26	09504
primary	15109 -15171	- 0.00065	0.00119	40	11302 11306 11307 12601 15110 15306
secondary	15109 -15171	0.00025	0.00088	51	15312

Salinity was recalculated using pressure and temperature (sensor 2). After calibration the salinity residuals for sensor 2 had a mean difference of -0.0002 (σ = 0.0015, n=79), including outliers. The residuals are shown in Fig 10. The secondary sensor data is to be used as the definitive data from this package.

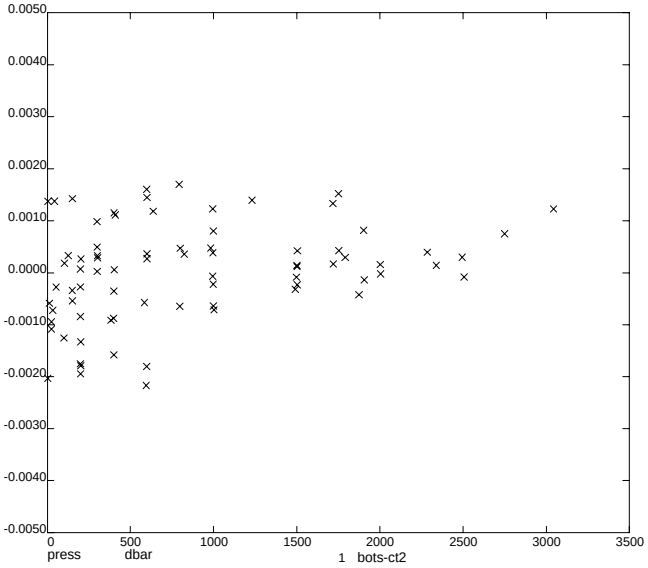


Fig 10. Final calibrated salinity residuals for the secondary sensor for stations 15071-15171.

Oxygen

The SeaBird CTD is calibrated by comparison with bottle oxygen measurements. These sample oxygen values are measured in µmol/l, and are converted into µmol/Kg, the WOCE standard, using the equation:

$$O_2(\mu mol/kg) = O_2(\mu mol/litre)/(1 + 0.001\sigma_0)$$

where σ_0 is the density of the oxygen samples at the time at which the samples is fixed. It is calculated using the temperature of the samples at the time of fixation, and the salinity of the sample (the pressure is set to zero as the samples are fixed on deck, i.e. at sea level). This oxygen value is known as botoxyk in the following calculations.

Fig 11 shows a scatter plot of botoxyk from the bottles versus oxygen values extracted from the cast data at the time of the bottle firing (sam0). Although there is some scatter a straight line fit was judged adequate. This produces a regression line of the form:

botoxyk = a + (b * oxygen)

where a = -7.155 (standard error 2.511), b = +1.063 (s.e. 0.0765) and $r^2 = 0.80$, excluding 10001, 11301 and 11302.

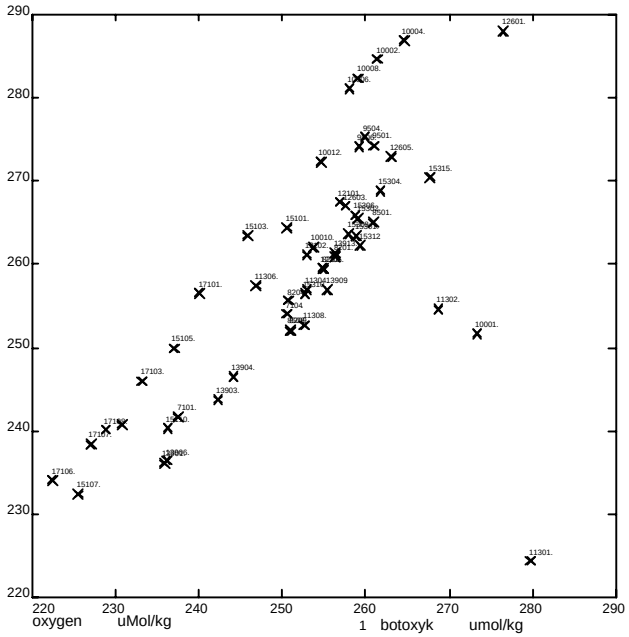


Fig 11. Oxygen from sample analysis versus CTD oxygen for stations 15071-15171.

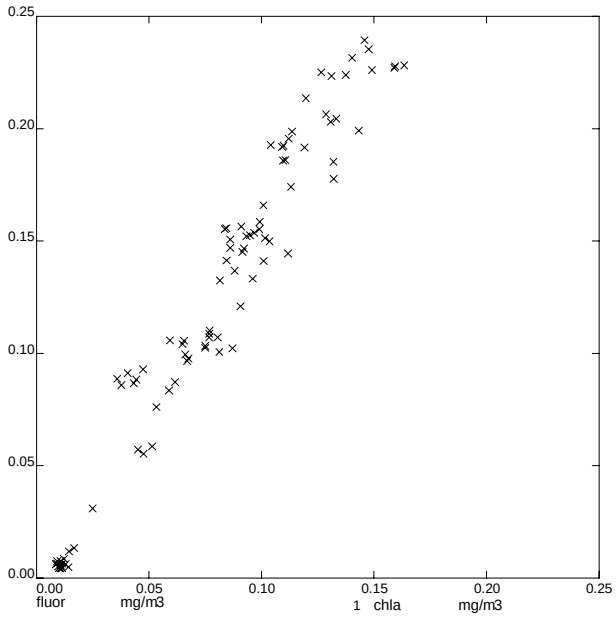


Fig 12. Chlorophyll from sample analysis versus CTD fluorescence derived value for stations 15071-15171.

Chlorophyll

The SeaBird processing converts a fluorometer value in volts to nominal 'fluor' in mg m^{-3}. Chlorophyll-*a* results from the laboratory analysis of samples from the bottles were used to calibrate the SeaBird fluorometer. The differing physiology, environment, health and abundances within the cruise region mean that a complicated calibration is inappropriate at this stage. Consequently a simple linear regression was employed as for oxygen:

$$chla = a + (b * fluor)$$

where a = -0.0046 (0.0036), b = +1.6029 (0.0395) and r^2 = 0.95, using all points (see Fig 12). The resulting mean calibrated residual is 0.000 with standard deviation 0.016 from 90 samples.

Applying the calibrations

Calibrations were applied to the ctd15nnn.1hz and sam15nnn files using the script calctd (this is the same as the script ctdcal referred to in previous cruise reports, but renamed to avoid a name conflict). This must have embedded into it the pairs of calibration coefficients for the fluorescence, oxygen and both conductivity sensors (eight numbers in total). It must be run twice: first with the values relevant to stations 15071-15100, second with values for stations 15109-15171. After calctd had been run, ctd2 was re-run to create calibrated ctd15nnn.ctu and ctd15nnn.2db files, and makeresid to calculate the new residual file. The ctd15nnn.24hz files were therefore the only uncalibrated raw files.

Calibrations: Stations 15197-15219

Use of a single suite CTD required the modification of some of the routines above. In particular all calculations involving temp2 and cond2 had to be removed from scripts ctd0, ctd1, sam1, makeresid, dosam and calctd. Note that it is not possible to simply create dummy variables temp2 and cond2 in ctd0b and continue through the existing processing path (ctd1, etc) because sam1 uses the variable names in the ctd 1hz file to interpret the SeaBird .btl file. New scripts were created called ctd0b, ctd1b, sam1b, makeresid1b, dosamb and calctdb.

Salinity

A calibration was required for the final three CTD's. Bottle and CTD conductivity differences are plotted in Fig 13. This produces a mean conductivity difference of 0.00234 with standard deviation 0.00056 for 30 samples (excluding samples 21907, 21911, 20806 and 20813). This correction has been applied to stations 15197, 15208 and 15219. The resulting salinity residual is -0.0032 psu with standard deviation 0.0011 for 34 samples including outliers.

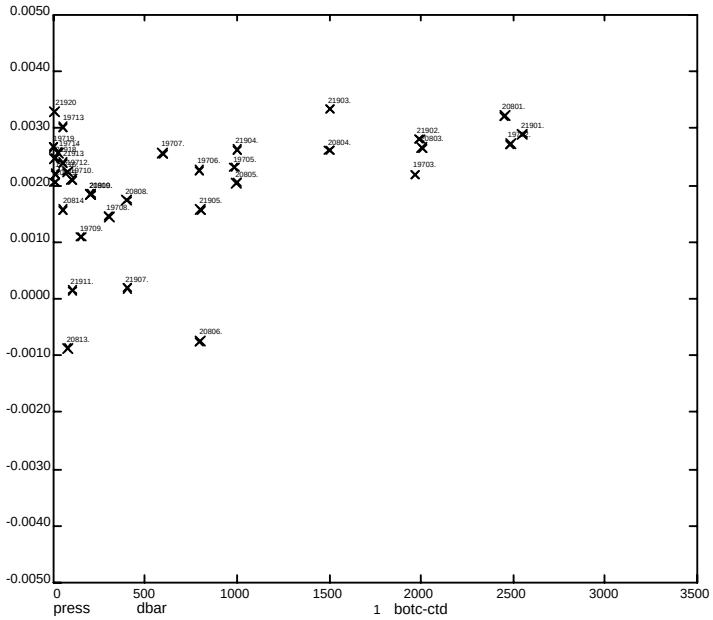


Fig 13. Residual conductivity for stations 15197, 15208 and 15219.

Oxygen and chlorophyll

No oxygen or chlorophyll calibration data were calculated before the end of the cruise.

6.2 ARIES CTD sampling, processing and calibrations - *Steven Alderson*

Introduction

The ARIES platform includes a SeaBird 911 CTD and a rosette of 59 bottles of 300ml volume. After each cast the CTD data and ARIES firing files were transferred by zip disk and FTP to unix directories and processed in the pstar format.

Sampling protocol

The water bottles were fired at the same time as the nets, with some proportion (around half) fired on the downcast, and the rest on the upcast. The water was sampled by means of a tube that opened the bottle valve when clicked onto each tap. Because of the small volume water bottles, only very small samples of water can be taken. Consequently only chlorophyll and nutrient samples were taken from these bottles.

Processing

Broadly speaking the pstar processing path followed that of the lowered CTDs:

i) asam0. Creates the ari15nnn file and fir15nnn file. List ari15nnn to find lat and lon at maximum pressure

ii) ctd0. Creates the ctd15nnn.1hz file

iii) actd1. Edits the original file and calculates some derived variable. Output ctd15nnn.1hz.

iv) actd2. Creates ctd15nnn.ctu and ctd15nnn.2db

v) actd3du. Creates standard profile and temperature-salinity plots.

vi) asam1. Creates the sample file sam15nnn including the CTD data from firing time. Excludes bottles fired on deck for shallow casts.

vii) apassam. Pastes sample data into the sam15nnn file.

viii) amakeresid. Creates residual file (res15nnn).

Calibrations

Salinity

Calibration of the ARIES salinity data was made by visual comparison of T/S profiles from the ARIES data and those from the calibrated SeaBird lowered CTD. Unfortunately because of the relatively small number of stations only two pairs of profiles have been identified as calibration candidates. These are 15100 and 15085 (lowered), and 15091 and 15106 (ARIES). Relevant parts of these profiles are plotted together in Fig 14**.** Estimates of salinity difference at the bottom of the profiles suggest values of 0.002 and 0.003 psu. This is consistent with a similar correction made to ARIES data on D264, which is encouraging given the stability of SeaBird CTDs. Consequently 0.0025 psu has been added to all ARIES salinities 1hz files, and later CTD and sample files recreated using actd2. This is a first effort at calibration; further study of the T/S relation in this region from the earlier cruises should be made to confirm this correction.

Fluorescence

No fluorescence calibration was applied during the cruise.

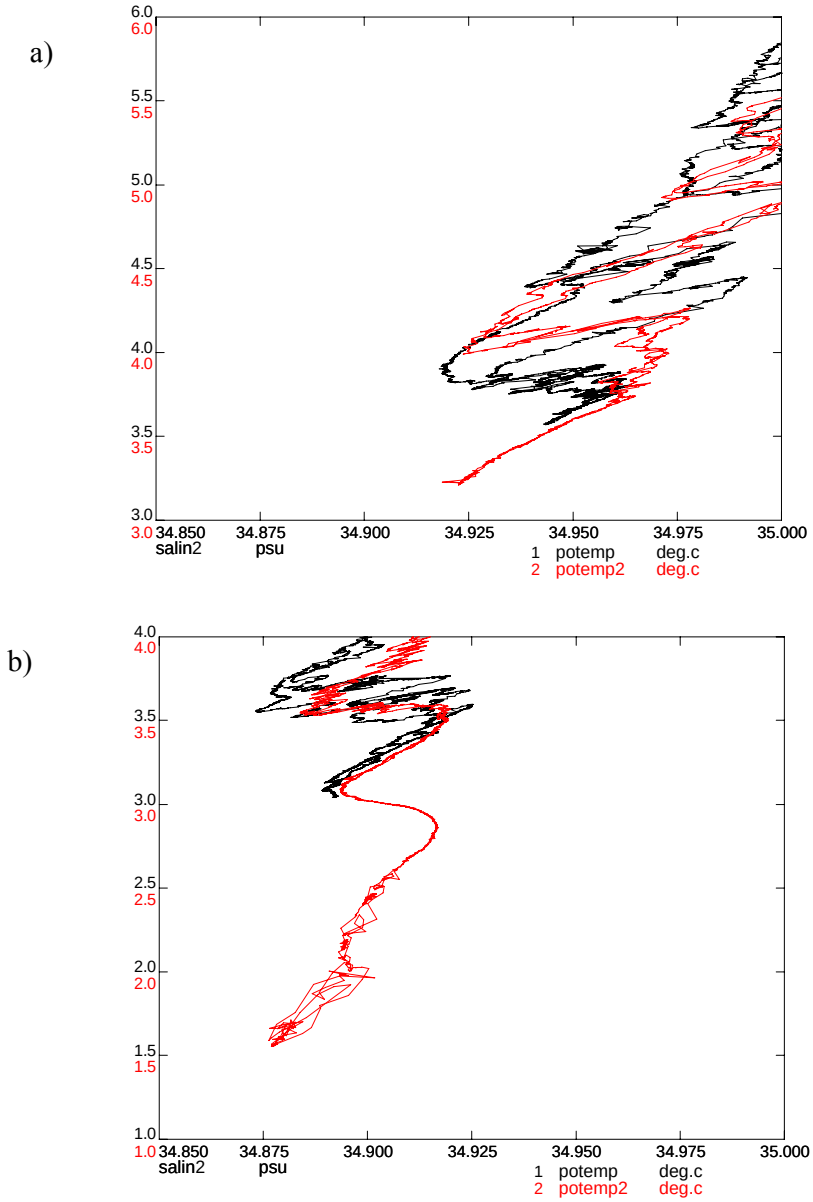


Fig 14. Small scale comparison of the T/S relation for the ARIES and lowered CTD SeaBird sensors for (a) stations 15091 (ARIES in black) and 15085 (lowered in red), and (b) stations 15106 (ARIES in black) and 15100 (lowered in red).

6.3 Salinity bottle samples - *Sophie Fielding, Steven Alderson and Stephanie Henson*

A Guildline Autosal Salinometer (model 8400B, serial no. 65764) was installed in the chemistry laboratory. It had been serviced by OSI Ltd prior to the cruise. The chemlab, 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 salinometers. 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 (set at 24°C for this cruise, apart from one salinity crate where the temperature in the CT lab dropped to 21°C for 24 hr), the preferred temperature being in the middle of this range.
Unlike previous MarProd cruises, the more modern model 8400B salinometer remained remarkably stable throughout the cruise, such that it almost made the black art of salinometry

a pleasure. It is highly recommended that wherever possible future cruises use the modern 8400B model.

A thermometer was used to measure the temperature of the chemlab, which varied between 21° - 25°C throughout the cruise. Efforts to maintain the chemlab at an appropriate temperature were hampered by temperature fluctuations associated with variations in the state of air conditioning or the number of doors to the outside which were open. Please refer to the first MarProd Cruise Report (D258) for possible temperature associated problems.

Good quality salinity measurements were obtained. The average double conductivity ratio of the Standard SeaWater was 1.99942 with a standard deviation 0.00002. A difference of 0.00006 corresponds to a salinity change of ~ 0.0001, the precision claimed for the instrument. The duplicates of the deepest bottle collected on every CTD cast varied by an average of 0.0002 in salinity (Fig 15). These results confirm that our sampling techniques were adequate.

Salinity values were obtained from the double conductivity ration measurements in the usual way, using an Excel spreadsheet, then transferred to the Unix system in the form of a tab-delimited ASCII file containing the four columns *statnum*, *sampnum*, *botsal* and *botsalf* – following the simplified method of the first MarProd cruise (D258). Data from the ASCII files were incorporated into the sam files using the Pstar script *passam*.

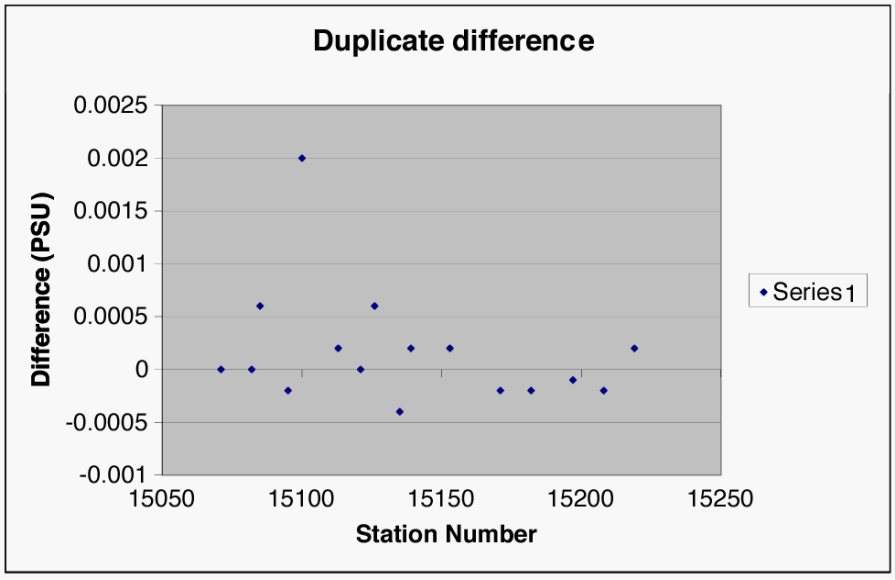


Fig 15. Duplicate sampling differences of the deepest bottle collected on every CTD cast.

6.4 Thermosalinograph and SurfMet data - *Stephanie Henson*

Instruments

Underway surface meteorology and thermosalinograph (TSG) measurements were made by the RVS/UKORS Surfmet system throughout D267. The instruments used, together with their
serial numbers and manufacturer, are listed in Table 4 below.

Table 4. Sensors for Surfmet and thermosalinograph.

Instrument	Manufacturer	Serial Number
OTM (temperature) Housing	FSI	1374
OTM (temperature) Remote	FSI	1360
Fluorometer	Wetlabs	248/117
Transmissometer	SeaTech	T1005
Barometric Pressure	Vaisala	S361008
Temperature/ Humidity	Vaisala	1850014
PAR (DRP-5) (port)	Didcot/ELE	32057
PAR (DRP-5) (starboard)	Didcot/ELE	32058
TIR (Pyranometer) (port)	Kipp & Zonen	994132
TIR (Pyranometer) (starboard)	Kipp & Zonen	994135
OCM (Conductivity)	FSI	1376
Sensor collector (QL150)	Vaisala	R381005
Anemometer	Vaisala	P50421
Wind Vane	Vaisala	R07101

Processing

Processing of the underway data was undertaken daily after 16:00 hrs GMT. The PSTAR scripts used are described below.

i) smtexec0: used to read the data stream SURFMET on the RVS level C in to PSTAR format using datapup. The resultant file was smt267**.raw.

ii) smtexec1a: ensured absent Surfmet data values were set to –999. The script also calculated TSG salinity using housing temperature, conductivity and a zero pressure value.

Bestnav positions from abnv267* were then merged into the output file smt267** and averaged into a 2 minute file, smt267**.av.

The light sensors recorded data on the Level B system to 4 decimal places (measured in mV), with a resolution of 10 Wm^{-2}. The conversion factors below were applied to the light sensors:

Photosynthetically available radiation (PAR), Port/Starboard:

$$Ppar\left(W/m^{-2}\right) = 1.1779x10^{4}\,Ppar_{(raw)}$$

$$Spar\left(W/m^{-2}\right) = 1.5432x10^{4}\,Spar_{(raw)}$$

Total incident radiation (TIR), Port/Starboard:

$$Ptir\left(W/m^{-2}\right) = 0.9709x10^{5}\,Ptir_{(raw)}$$

$$Stir\left(W/m^{-2}\right) = 0.9634\,x10^{5}Stir_{(raw)}$$

iii) smtexec1b. The 2 min average smt267*.av files are merged with the master Ashtech file to add gyroHdg and a-ghdg variables and calculate true heading, resulting in file smt267**.hdg

iv) smtexec2. This script computes vessel speed and subtracts it from relative winds to obtain true wind speed and direction, producing file smt267**.met.

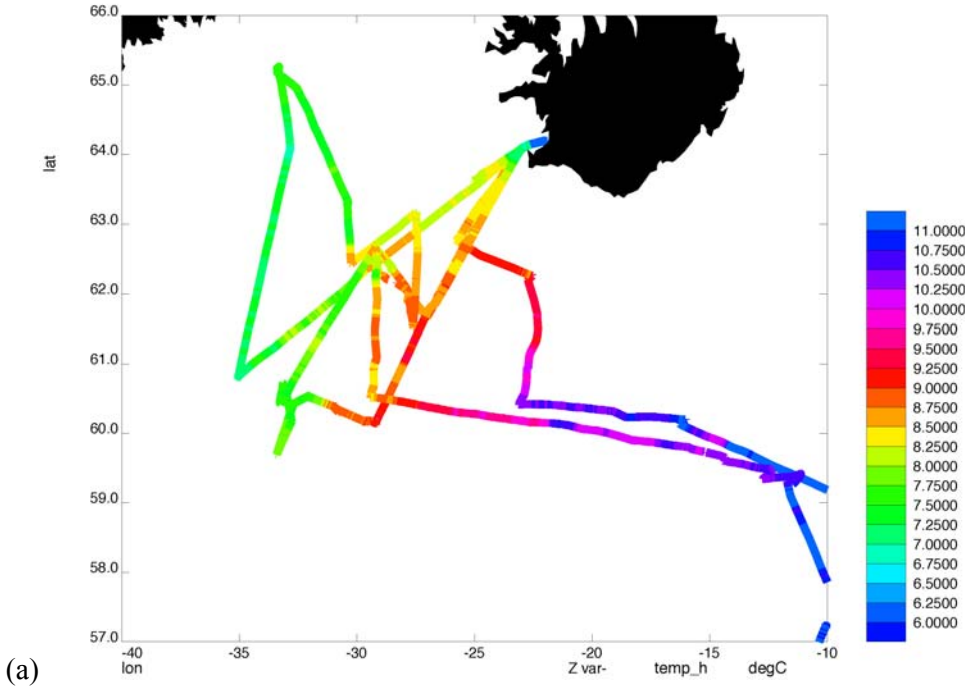
The .av files were appended to each other to create a single large data file, smt267, which was used to calibrate salinity.

Salinity calibration

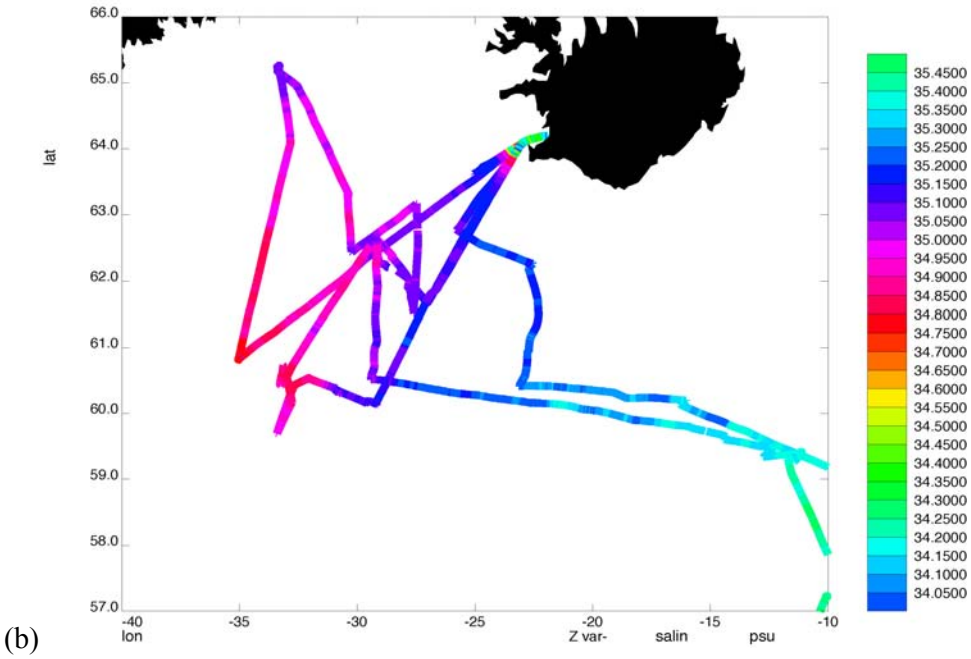
Samples for salinity analysis were collected approximately every 4 hr from the non-toxic supply, either from the TSG sample tap, or as it left the FRRF if water pressure was low. The routine *tpsel* was used to extract TSG salinity values corresponding to the times of the discrete underway samples. An offset between the raw and calibrated data was found and salinity was recalculated:

$$Sal(cal) = Sal(raw) - 0.1034$$

with a standard deviation of 0.0368.



(a)



(b)

Fig 16. Thermosalinograph derived sea surface temperature (a) and salinity (b).

Chlorophyll, fluorescence and calibration

Samples for chlorophyll analysis were also collected approximately every 4 hours and compared to the underway fluorescence. Prior to JD 322 the WetLabs fluorometer (serial number 248) was used to collect underway fluorescence data, but these data were found to vary erratically, reaching values as high as 4mV. These data were discarded and subsequently the WetLabs fluorometer (serial number 117) was used to collect the underway samples. No statistically significant correlation could be found between the TSG fluorescence data and underway chlorophyll samples.

Underway nutrient and ammonia samples were also collected and are reported on elsewhere. Collection of underway data ceased at 16:00 hrs on JD 350.

6.5 Precision Echosounder (PES) data - *Stephanie Henson*

A combination of two precision echosounders were used to record bottom depth throughout *Discovery* 267. The main instrument was the 10/12 kHz Simrad EA500 Hydrographic echosounder mounted on a fish on the port side, and the secondary instrument was the hull mounted 12 kHz transducer. The data from both instruments were recorded as separate Level A/B data streams, ea500d1 for the hull and ea500d2 for the fish. These were merged (by Liz Rourke) into a single 'rawdep' file. Note that the simexec0 script was changed to use the rawdep, rather than prodep data streams. For most of the cruise data were of reasonable quality, although some data gaps of up to 30 minutes occurred.

The Pstar processing steps were as follows:

Simexec0 - transferred data from the rawdep stream to Pstar. Output: sim267** and sim267**.cal.

Simexec1- merged sim267**.cal with navigation and vessel speed data from the bestnav file and averaged to 5 minute intervals. Output: sim267**.nav and sim267**.5min.

Simexec2 - append daily files to master files (dep267*.nav and dep267*.5min) and remove on-station data using criteria of speeds less than 2 knots (dep267*.track).

6.6 Vessel Mounted ADCP (VM-ADCP); navigation, heading and gyro
Sophie Fielding and Michel Rixen

Introduction

Two RDI Vessel Mounted Acoustic Doppler Current Profilers (VM-ADCPs) were operated on D267; the 150kHz VM-ADCP and the 75 kHz Phased Array instrument (Ocean Surveyor) that had been fitted immediately prior to FISHES (D253 - May/June 2001). This report follows the same format as that by John Allen *et al* from the first MarProd cruise D258, but does not cover in detail aspects which are unchanged from that cruise. This section summarises the operation and data processing paths for navigation data and for both ADCPs.

Navigation

Ship's position can be obtained from one of several gps receivers, namely gps_g12, gps_4000, gps_glos and gps_ash, using the names of the RVS data streams. The primary source input to bestnav was gps-4000, the data stream with 10 second position values throughout the cruise.

Data were transferred daily from the RVS Level C bestnav stream to the pstar absolute navigation file, abnv2671 The G12, gps-4000, gps_glos, gps_ash and gyro (gyronmea) data streams were also transferred daily. Processing paths were exactly as for D258, so are not reproduced here. The only amendment was the creation of a gps4000 master file.

A new script ‘createall’ in the gps4000 directory was used to append all gps4000 files into a single file, in order to allow an automatic calibration of both 75Khz and 150Khz data and an automatic processing of VM 75Khz data.

150 kHz ADCP

The 150kHz RDI ADCP was logged using IBM Data Acquisition Software (DAS) version 2.48 with profiler software 17.20. The instrument was configured as for D258, to sample over 120 second intervals using 100 bins of 4 m thickness, pulse length 4 m and a blank beyond transmit of 4m: the higher vertical resolution would better support the remote detection of zooplankton patchiness. Bottom track mode was used when working or transitting shallow water (at the start, on passage for the medivac and port calls to and from Reykjavik), but water track was the normal mode for the majority of the cruise. The two vessel mounted ADCPs were configured to synchronise their pings over the ensemble period, with the 150 as the ‘master’ and the 75 as the ‘slave’ as recommended by RDI. This resulted in ~50 pings per ensemble in water track mode (but only 24 pings per ensemble for the Surveyor).

The 150 kHz RDI ADCP data was 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 in previous MarProd cruise reports (see D258, Appendix A2.2).

75Khz ADCP

The RDI Ocean Surveyor 75 kHz Phased Array ADCP was configured to sample ensembles 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 logging PC ran the RDI VmDAS v1.2.012 and WinADCP v1.1.0 software. 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 is applied to the data in the processing path before merging with navigation. The rotational offset of 60° of the ADCP installation was accounted for in the RDI software.

The 2 minute ensemble data were written to the PC hard disk in files with a .LTA extension, eg DD262001_000000.LTA, DD262002_00000.LTA. Sequentially numbered files were created whenever data logging was stopped and re-started. The software will close the file once is reaches 48MB in size (a user-specified size), though during the cruise, new files were opened every 24 hours. The .LTA and .ENX files were transferred to a networked Mac for ftp’ing to the unix directory /data62/D267/surveyor; .ENX files contain the raw ping by ping profiles ready for averaging and were recorded in case they could be useful for looking at deep acoustic backscatter signals.

The 75Khz were processed automatically using the script ‘surexecall’ in the ‘shipexec’ directory. That new script needs the appended gps4000 file and the ashtec file, then runs sequentially surexec0-4. Before running surexec-3, it asks for the Phi and A calibration parameters. Before entering these values, one may run the ‘surexeccalib’ script (see below), that computes these data almost automatically.

The usual match between the LTA files and the sur* and sbt* files is given below:

Sur/sbt	ADCP file name
aa	D267004_000000
ab	D267005_000000
ac	D267006_000000
ad	D267007_000000

ae	D267008_000000
af	D267009_000000
ag	D267010_000000
ah	D267011_000000
ai	D267012_000000
aj	D267013_000000
ak	D267024_000000
al	D267025_000000
am	D267026_000000
an	D267027_000000
ao	D267028_000000
ap	D267029_000000
aq	D267030_000000
ar	D267031_000000
as	D267032_000000
at	D267033_000000
au	D267034_000000
av	D267035_000000
aw	D267036_000000
ax	D267037_000000

Calibration

The calibrations of the 75Khz and 150Khz VM ADCP were achieved automatically using limited high quality bottom tracking data available.

150 Khz ADCP calibration
The script adcpexeccalib in the 'shipexec' directory looks for long straight runs in given increasing angle limits. A first long sequence was found for an anglular width of 1.5° in file bot26704.true.dpk.2.list for time steps 424 to 533, corresponding to the period 2002 11 09 06:06:46 to 2002 11 09 13:202:47 with values of Phi = 4.0177 and A = 1.0048. For angular widths of 2° and 2.5° these values were respectively Phi = 3.873 and 3.9875, and A = 1.0036 and 1.0015. Subsequently, mean values of Phi = 3.9594 ±0.0763 and A = 1.0033 ±0.0017 were chosen for the calibration.

75Khz ADCP calibration
The script surexeccalib in the 'shipexec' directory looks for long straight runs in given increasing angle limits. A first long sequence was found for an angular width of 1.5° in file sbt267ab.true for time steps 1966 to 2080, corresponding to the period 2002 11 09 06:33:13 to 2002 11 09 12:27:15 with values of Phi = 1.3928 and A = 1.0841. For angular 2° and 2.5° these values were respectively Phi = 1.268 and 1.3736, and A = 1.268 and 1.3736. Mean values of Phi = 1.3448 ± 0.0672 and A = 1.0562 ±0.0248 were chosen for the calibration.

6.7 Lowered ADCP (LADCP) - *Sophie Fielding and Michel Rixen*

Overview

Two LADCPs were fitted to the CTD rosette frame on D267, RDI 300 kHz (Serial No. 1857) and RDI 600 kHz (Serial No. 1935) workhorse ADCPs. The 600 kHz had been used on all MarProd cruises, and was principally intended for mean volume backscatter (MVBS) measurements to full ocean depth, to establish whether acoustic measurements of the over-wintering *Calanus* layer are feasible. A 300 kHz ADCP has been used on the spring (D262), summer (D264) and this winter cruise (D267).

The LADCPs were used on all full depth CTD casts and were not switched on for the one shallow 'chlorophyll max' cast, whose primary purpose was to obtain water for on-board experiments. Both LADCPs were downward looking and set up in the master (300 kHz) and slave (600 kHz) mode common to all MarProd cruises. The raw data files and log files were FTP-transferred from the dedicated LADCP pc in the deck lab to the shipboard system and processed using the Visbeck software. The first CTD cast was made with the previous

summer cruise setup (8 m bin depths for both ADCPs), and was altered on advice from RDI on the second and subsequent casts so that the 300 kHz used 8 m bins whilst the 600 kHz had 4 m bin depths.

Unfortunately we did not carry spare LADCPs, hence when they were lost with the CTD this concluded LADCP observations.

Backscatter was logged and calculated from both LADCPs for all profiles using the software developed by Nick Crisp and Sophie Fielding. Previous cruise profiles plotted utilized the 2, 4, 6 and 8th bin depths, exhibiting range correction problems. On this cruise the backscatter data from the first four bins (1, 2, 3 and 4) were presented and the 2alphar (range) correction applied (having not been used in the previous cruises).

The use of bins closer to the tranducers resulted in fewer range correction problems and it is suspected that the range correction problem observed in previous cruises may be a function of noise level reference chosen (see equations for calculating MVBS in the previous winter MarProd cruise report, D258) especially since there was less range correction error in the 300 kHz data than in the 600 kHz data (possibly as a result of number of targets).

The 600 kHz acoustic backscatter data were typically dominated by two strong discrete scattering layers in the surface 400 m of the water column and a suggestion of a scattering layer at depth (Fig 17**,** Station 15095). The 300 kHz acoustic backscatter profiles frequently contained more detailed scattering layers at depths similar to the 600 kHz and elsewhere (Fig 18**,** Station 15095).

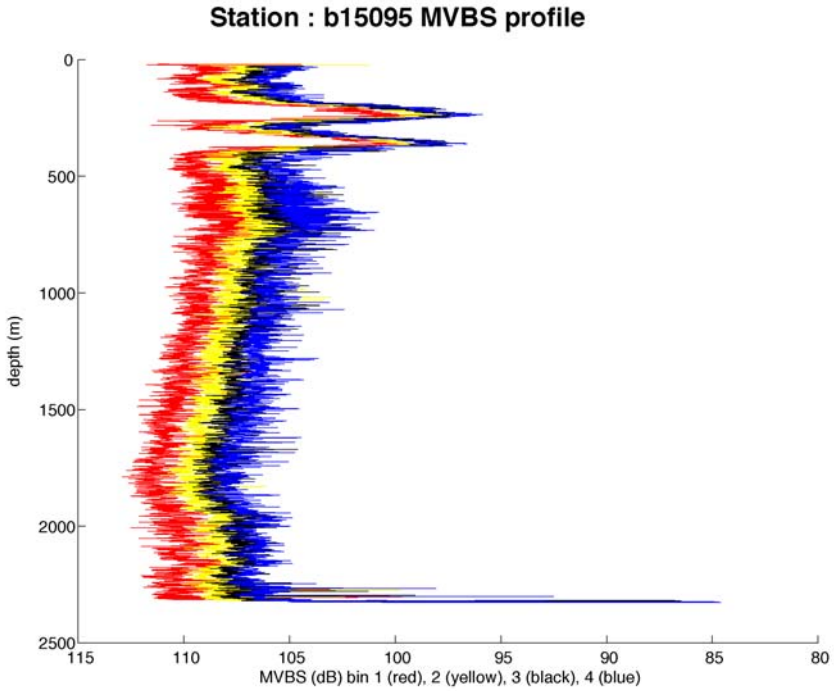


Fig 17. Typical 600 kHz acoustic backscatter data (station 15095).

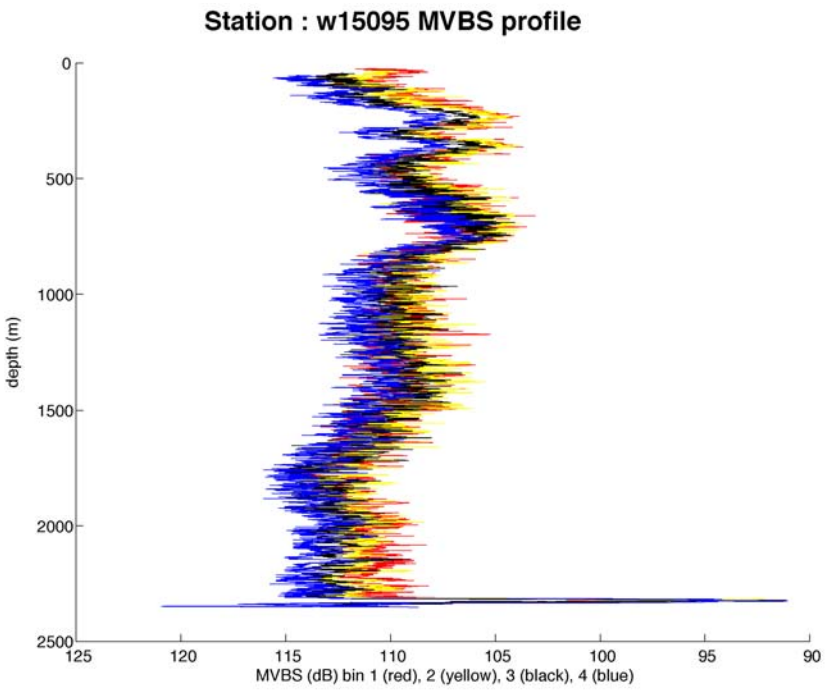


Fig 18. Typical 300 kHz acoustic backscatter data (station 15095).

Directory structure

The directory structure, software and processing path used on D267 echoed that modified by RTP on cruise D264, permitting post-processing of the previous cruise data. The MarProd cruise D264 report contains detailed descriptions of the software. As with D264, on D267 only the Visbeck method to calculate water velocities was used as it a) incorporates the Firing technique as the "Shear method"; b) it allows access to echo amplitude information needed to calculate backscatter; and c) it has the ability to use enhanced echo amplitudes to determine bottom echos, and hence determine absolute bottom velocities. The directory structures consisted of the following directories:

Top level - ladcp
Second level - 150 kHz 300 kHz 600 kHz m ctd nav logs pro ppro
Third level - for each frequency: raw, and for pro: res

CTD and navigation data required to span a deployment are common to any ladcps used and were stored in the second level directories CTD and nav. When using matlab it is convenient to have all the m scripts in one directory. Therefore the m directory was also placed at the second level, and results were initially written into the m directory.

Each cast generated figures, text and matlab files from each of the two ladcps. These were transferred into a third level cast directory ladcp/pro/res with the exception of the master matlab file that was placed in the second level directory ladcp/pro. Each frequency results was then identified by a different letter ('d' for 150 kHz, 'w' for 300 kHz and 'b' for 600 kHz).

Processing path

Given two downward looking ladcps on the CTD frame, one is defined as master and the other slave (see D262 MarProd spring cruise report). On D267, as with previous cruises, the 300 Hz was master and the 600 kHz slave. From the ladcp logging pc, ftp the four files:

AAAAAm.000 (the master) to /data62/ladcp/300kHz/raw
AAAAAs.000 (the slave) to /data62/ladcp/600kHz/raw

where AAAAA is the Discovery station number. These files were renamed to the conventions adopted from D262 and D264: 'd' for 150 kHz, 'w' for 300 kHz and 'b' for 600 kHz.

mv AAAAAm.000 wAAAAA.000
mv AAAAAs.000 bAAAAA.000
cd ladcp/m
vi ladmaster.m in the ladcp/m directory, pasting in the station number wherever it occurs, the start and stop times and positions, max wire out and altimeter height off bottom.

Save the edited file as ladAAAAA.m. This script is now the same for both frequencies.

doctdasc – enter station number for CTD cast
donavpro – enter station number for CTD cast and gps4000 nav file number (Note on cruise D267, to save space, a master nav file of gps4000 data was not created and this script was modified to take a daily gps4000 file).

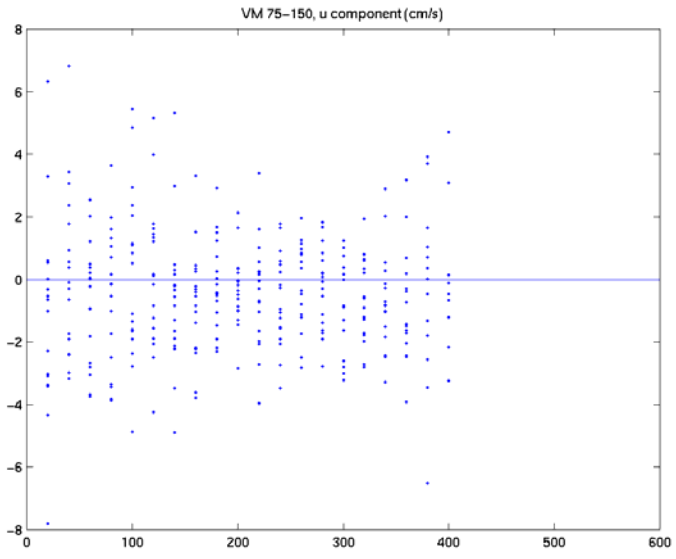
Still in the ladcp/m directory:

matlab
ladAAAAA – where AAAAA stands for the discovery station number. When prompted type in the identifying letter for the frequency to be processed (d, w or b). Exit matlab.
ladexec0 – copies the cast specific files and plots from ladcp/m directory to ladcp/pro for the master .mat files and ladcp/pro/res for the postscipt files.

Comparison of on station LADCP and VM-ADCP derived water velocities

The on-station data tends to be the best quality VM-ADCP data, penetrating deepest into the water column. The on-station data for the CTD stations were selected and averaged into u and v profiles for each ADCP. The data were merged together and the differences in u and v calculated (75 kHz minus 150 kHz). As usual, the results were very encouraging (Fig 19), suggesting the ADCPs agreed within the expected noise level of the instruments:

U (east) Mean = -0.4594 (cm/s), Std = 2.0008 (cm/s) (n = 867)
V (north) Mean = -0.1783 (cm/s), Std = 2.2123 (cm/s) (n = 867)



(Fig 19a)

b)

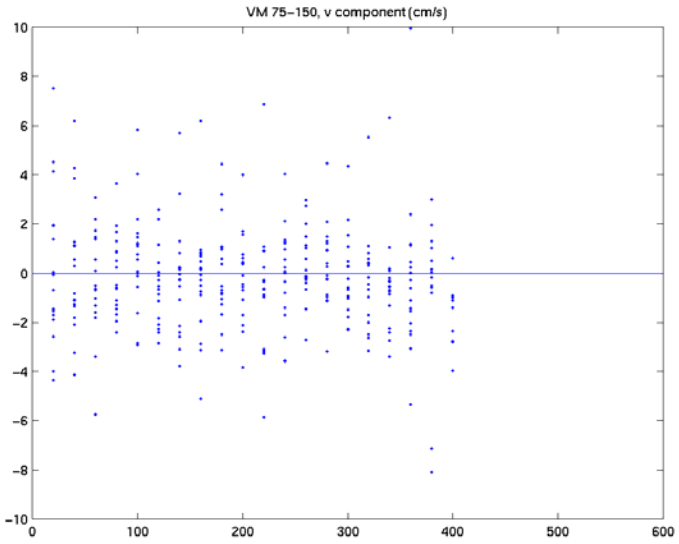


Fig 19. On station velocity profile difference between the two VM-ADCPs (75Khz-150Khz); a) East component, b) North component.

Table 5. Mean difference, maximum absolute difference and standard deviation between the LADCP 300Khz, the VM75Khz and the VM 150Khz for E and N components respectively; all values in cm/s.

	75-150 Mean		Max		Std	
	U	V	U	V	U	V
Stations						
15071	0.67672	0.58379	5.3114	2.1122	1.9743	0.85593
15082	-0.63813	0.83913	3.9812	3.2117	1.6105	1.5239
15085	0.27085	0.9043	1.6382	3.2246	0.70388	1.012
15095	1.6301	-1.7982	5.452	3.596	2.4073	1.3618
15100	-0.20643	0.27306	2.3702	1.5352	0.95379	0.92481
15121	0.50101	-0.53469	2.013	3.092	0.89805	1.6686
15126	0.35235	-0.78778	1.604	2.6379	0.68796	0.81553
15135	-1.6088	-1.9513	3.4921	5.8506	1.0673	1.9456
15139	-2.0598	4.6033	3.4866	9.9406	1.1571	2.1377
15151	-1.7861	-1.5772	3.9092	3.5696	1.1293	1.1986
15171	0.41913	-0.71416	3.9128	2.3599	1.6286	0.97326
	75-300 Mean		Max		Std	
	U	V	U	V	U	V
15071	-2.2749	3.5534	13.9309	7.0961	3.877	1.948
15082	-2.1406	1.243	4.6103	4.0252	1.3461	1.8845
15085	-2.2685	-3.8584	4.3842	8.0389	0.85744	1.7913
15095	-3.8672	-1.7496	11.9831	6.4958	3.0098	3.626
15100	-4.3317	-4.6666	6.608	7.3692	1.3711	1.4557
15121	-2.6248	-1.9608	6.5801	3.9943	1.8753	1.4041
15126	-0.49053	0.50102	2.0906	2.3269	0.904	1.4022
15135	-4.355	0.042937	7.6934	3.9556	2.5661	2.3294
15139	-3.5513	5.7954	5.8905	9.352	1.1819	2.9468
15151	-7.0708	1.8321	10.6352	5.2274	1.2043	1.435
15171	-0.51396	2.6495	1.876	5.0394	0.91597	1.4615
	150-300 Mean		Max		Std	
	U	V	U	V	U	V
15071	-2.9516	2.9696	10.1905	5.638	3.0117	1.6823
15082	-1.5024	0.40384	3.6796	2.5975	1.1924	1.3779
15085	-2.5394	-4.7627	4.5513	8.2681	0.8436	1.8033
15095	-5.4973	0.048624	9.6823	8.3224	2.0539	3.5244
15100	-4.1253	-4.9396	5.6802	7.1453	0.88461	1.1445
15121	-3.1258	-1.4261	7.7934	3.5315	1.7686	1.3791
15126	-0.84288	1.2888	3.1381	3.123	0.9073	1.6582
15135	-2.7461	1.9942	4.6602	5.988	2.08	3.3904
15139	-1.4916	1.1921	2.682	3.5746	0.88099	1.9763
15151	-5.2847	3.4093	7.4835	5.8578	1.1872	0.98918

A comparison of individual profiles is illustrated in Fig 20 and Fig 21 for stations 15121 and 15151 respectively.

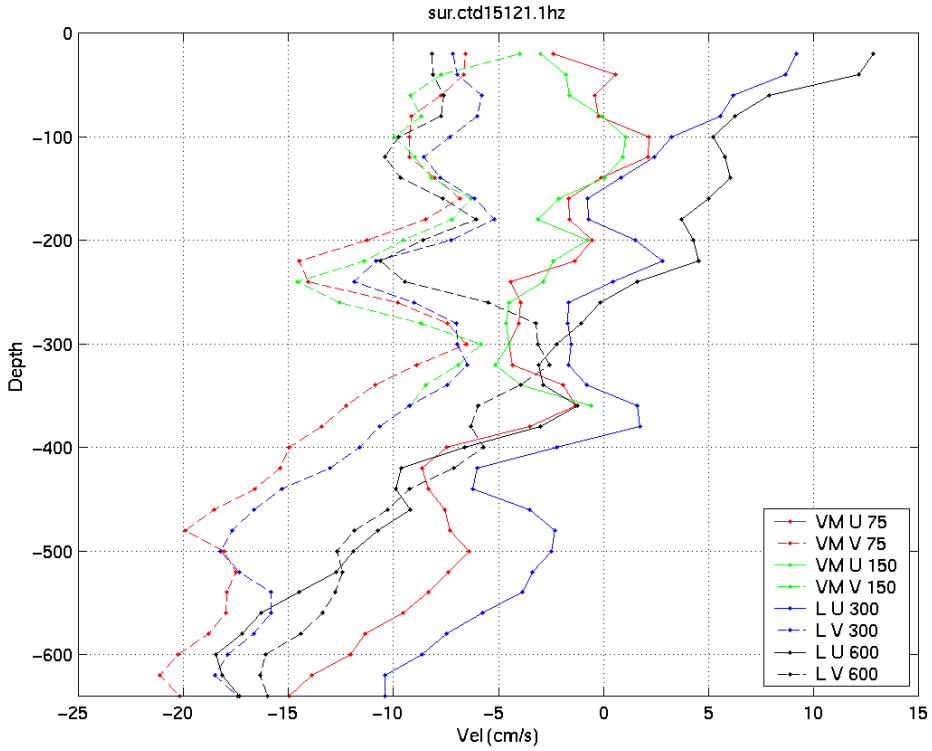


Fig 20. A comparison of individual velocity profiles for station 15121.

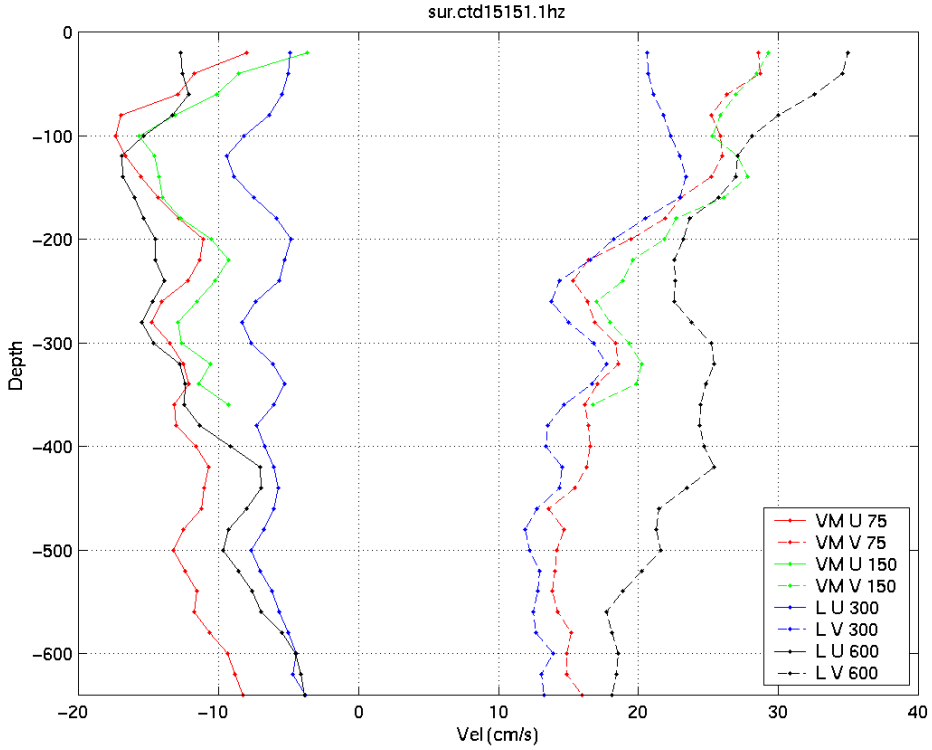


Fig 21. A comparison of individual velocity profiles for station 15151.

6.8 Lowered EK500 scientific echosounder (LEK)

Cairistiona Anderson, Carol Didcock and Ryan Saunders

The lowered EK500 scientific echosounder package (LEK) comprises a drop frame housing the 'Behemoth' (an EK500 echosounder with a logging/control notebook PC), a battery pack, three transducers operating at 38kHz, 120 kHz and 200 kHz, and a Scanmar transmitter. It is deployed on station to collect good resolution higher frequency echosounder data from depths > 500 m. During the cruise, data were collected to allow the equipment to be calibrated so the correct integrator and target strength gain values could be applied during post-processing.

Deployment diary

The LEK data collected are indicated in Table 6 below. The LEK was first successfully deployed at station B1 (Discovery station 15073). When an attempt was made to deploy it at the next full station (B3) the power monitoring system indicated a problem. On opening the Behemoth's housing it was found that ~ 1 cm of water had entered during the previous deployment. This appeared due to the presence of a piece of fine copper wire lying across the path of the O ring which had allowed water to penetrate the casing at high pressures, but had not caused a problem during the various calibration attempts.

Further investigations concluded that no permanent damage had been done to any of the components and the Behemoth was reassembled immediately after the mid-cruise port call in Reykjavik. No other problems were experienced with the LEK itself and it was deployed successfully at DD13 and all further full stations. As initial attempts to collect calibration data in the normal way were not successful, the calibration sphere was deployed under the frame during two deployments where the collection of data for scientific analysis was a lower priority (15184 at ADR and 15199 at FF2).

Table 6. The MarProd stations at which LEK data were collected, with Discovery station numbers and depths of each deployment.

Station Name	Discovery No.	Deployment Depth(s)	Notes
B1	15073	400 m	Data time stamp wrong
DD13	15149	400 m	
DD10	15155	450 m	Cable marked at 450 m and 495 m
B4	15169	450 m	Data time stamp wrong
RD	15173	450 m	
ADR	15184	Surface	Calibration data with sphere
FF2	15199	Surface, 450 m	Calibration data with sphere
FF3	15210	400 m, 495 m	30 min data at each depth
FF4	15221	495 m	

Deployment technique

The deployment technique developed on the preceding MarProd cruises (D262 and D264) was followed for all deployments and again worked well. The extended CTD trackway, with the second flat bed trolley located at the far end, was used to store the LEK between deployments. The trolley had previously been modified with the addition of corner brackets, which held the bottom of the LEK frame securely and prevented it sliding in rough weather. The LEK was deployed from the centre of the track way using a wire run from a 5 tonne Lebus winch, sited further aft on the starboard deck, through the main block on the CTD gantry. The angle of the wire was controlled using a scrolling device situated 1m forward of the winch and immediately aft of the metal deck plate covering the pipe work crossing the deck. The mains supply for the Behemoth and the chargers for the battery pack were sited in

the water bottle annexe, behind the roller door, with the cables run under the door through a foam strip located on top of the sill. The cables were kept outside the door at all times to allow the shutter to be sealed, and when not in use were blanked off and secured to the handrail on the side of the hanger. Although the mains supply was kept in a lidded plastic box, it got wet during a period of heavy seas breaking on the starboard side of the ship, and an alternative housing should be considered in future.

The aerial for the remote control PC was located above the main entrance off the starboard deck using an aerial bracket fitted to the inboard stanchion, and the Behemoth's operation was controlled remotely from the PC located in the main laboratory whilst the aerial worked. After it developed a fault, either the laptop PC was taken out on deck or communications were established from within the hanger through the glass panels in the starboard door.

To simplify the deployments, the winch wire was marked at 400 m, 450 m and 495 m so that the Scanmar system was not needed for deployments to those depth. When the Scanmar system was used, the signal was received via the Scanmar towfish and the 'bird cage' hydrophone was not used. Again, it should be noted that at least four people are required to complete launch and recovery operations safely, as two people are required to assist the frame in and out, whilst another two people are required to drive the winch and gantry respectively. Beyond this, no problems were experienced and no further modifications to either the LEK or the deployment strategy appear necessary.

6.9 Towed EK500 scientific echosounder (TEK)

Cairistiona Anderson, Carol Didcock and Ryan Saunders

The towed EK500 echo sounder package (TEK) comprises a towed body containing three transducers, operating at 38 kHz, 120 kHz and 200 kHz, which are normally connected directly to an EK500 echosounder, which in turn is connected to a desktop logging PC. The 38 kHz transducer may alternatively be connected directly to an EK60 echosounder that logs the data internally. The standard EK500 system is deployed whenever the ship is underway, to collect broad-scale survey data in the top 1000 m of the water column, both in conjunction with the various towed nets and on the transects between the stations. The towed body is deployed on the starboard side of the ship, aft of the winch cabin, using a lifting wire, and is towed from a boom deployed forward of the CTD gantry. The boom must be stowed inboard during each CTD deployment, so the towed body must be recovered before each CTD station and re-deployed afterwards. As with the LEK, data were collected at the beginning of the cruise to allow the calibration of both the EK500 and EK60 echosounders so that the correct integrator and target strength gain values could be applied during post processing.

Deployment diary

The TEK data collected are indicated in Table 7 below. Few problems were found in the use and deployment of the TEK towed body, and the standard deployment strategy worked well (see below). The TEK was consistently deployed when the ship was steaming, except when bad weather or other exceptional circumstances precluded its use. However, before the first port call (during tow 15099) concerns were raised about the levels of noise seen in the data collected at all three frequencies. This problem appeared to be related to the speed of the ship, and possibly with the towed body flying closer to the hull with increases in speed. It was initially counteracted by reducing the ship's speed for periods during the steam between the stations (tows 15112 and 15124). However, the noise rapidly became worse and the towing cable package was changed to correct the problem before tow 15137. Unfortunately, the second package made up with a Scanmar hydrophone cable was faulty and the third package, without the Scanmar cable, had to be used. This did not present a problem until the Scanmar PES fish became unusable (before tow 15174) and a hydrophone cable had to be attached to the outside of the towing cable package in a similar manner to that used on D258. This did not appear to affect the quality of the acoustic data

collected in any way and the TEK was successfully deployed for the rest of the cruise. 38 kHz data were collected using the EK60 during four of the longer tows (15069, 15094, 15165 and 15174). This was primarily to test the new equipment, although the data are appropriate for scientific analysis. No data from the 120 kHz or 200 kHz were logged during periods where the EK60 was used, so they are not appropriate for multi-frequency analysis.

Table 7. Discovery stations for TEK deployments, with the MarProd stations between which the data were collected and the times over which they collected with the EK60 echosounder.

Discovery No.	Start station	End station	EK60 data	Notes
15069	---	B1	21:44 – 22:55	Removed from water to check set-up, 18:45 - 19:38
15074	B1	B3	--	
15084	B3	B4	---	
15087	B4	---	---	Stopped due to weather
15094	---	B6	22:00 – 23:53	
15099	B6	B8	---	Very high noise levels in data, removed from water for flight adjustments 15:45 - 16:29
15101	B8	B8	---	
15112	B8	B10	---	Good data 13:00 - 15:00
15116	B10	B11	---	Slow due to ice
15124	B11	DD7	---	Right speed 10:15 - 14:15, 02:00 - 04:00
15137	E18b	(Reykjavik)	---	New towing cable package used
15138	(Reykjavik)	DD13	---	
15140	DD13	DD13	---	
15150	DD13	---	---	Stopped due to weather
15152	DD11	DD10	---	
15156	DD10	DD9	---	
15165	DD9	B4	19:00 – 21:05	
15170	B4	---	---	Stopped due to weather
15174	RD	ADR	14:40 - 16:10	Scanmar cable added before start of tow
15185	ADR	ADN	---	
15196	ADN	(FF1)	---	
15200	FF2	FF3	---	
15211	FF3	FF4	---	
15222	FF4	FF5	---	

Deployment technique

The deployment technique developed on D262 was employed during this cruise, with the extended Schat davit being used to swing the towed body over the side, and the 2 tonne Lebus winch working the lifting wire. The winch was located 2 m inboard of the mooring bollards on the starboard side of the after deck, with the davit 3 m further aft and 1 m closer to the bulwark. The lifting wire (~ 75 m long) was run from the winch, via a block attached to the foot of the davit, through another block at the end of the davit and down to the towed body. During deployments, three people assisted the towing cable over the rail, whilst a fourth (holding the radio) held the aft end of the cable and assisted a deck rating in moving the towed body safely off the deck and over the bulwark. A second deck rating worked the davit and the mechanical technician drove the winch.

This procedure was reversed during recovery, with a minimum of two people required to recover the towing cable package from the water. This arrangement proved very robust, with both deployment and retrieval easily accomplished in all the weather conditions experienced. The only cause for concern was that the towed body might damage the hydraulics on the outboard side of the winch, but this can be overcome by lashing a board in place to protect

them. Although, the towed body was still secured to the mooring bollards between deployments, none of the problems seen on D258 were experienced even though similar weather conditions were present at times and this still seems the simplest and most effective method for storing the towed body.

6.10 FRS towed zooplankton net systems - *Jens Rasmussen, Ryan Saunders, Kathryn Cook, Steve Hay, Robert Houghton, Alex Mustard and Emily Roberts*

Zooplankton sampling

During D267 we collected plankton and associated specimen samples using the ARIES (AR), Dual Methot (DM), and Ocean Sampler (OS), at stations identified in Tables 2 and 8 (below). ARIES and Ocean Sampler also collect water samples, for which all or subsets have been analysed for nutrients and/or chlorophyll. The two samplers are, in addition, equipped with two pup nets each providing depth integrated samples. On a few occasions where the net-mechanisms on AR or OS have failed or concentrations of key species has been very low, the pup nets have been utilised for picking out specimen samples for biochemical analyses.

During D267 we carried out a total of 36 tows, 12 of each sampler type. All net systems performed well during the sometimes rough conditions in which they were deployed and recovered. The assistance of UKORS technical staff winch operators, deck crew and ship's officers during the gear deployment and recovery were very much appreciated, in particular Jon 'NBN' Short working with Jim Hunter throughout the full procedure of each tow.

The methods of deployment were as previously described in the D258 cruise report, as were the procedures for sample handling, specimen sorting/selection, and sample preservation. During one particular incident where the frame of the ARIES sampler got damaged during recovery the speedy repair and welding carried out by Jim Hunter, Alan Sherring, Steve Whittle, and Darren Young were very much appreciated, as we were able to continue the sampling scheme without interruption. During the first two ARIES deployments the Optical Plankton Counter malfunctioned, but after Jim Hunter inspected and reassembled the unit, it performed without interruption for the rest of the cruise.

Samples for biochemical analysis were taken from ARIES, and Dual Methot nets. On station B11, poor weather caused the ARIES tow to be cancelled, so material was picked from Ocean Sampler instead. Specimen extraction from net-samples was carried out as described below.

The complete results of the plankton sampling await further work onshore. Some indication of the presence of the key species *Calanus finmarchicus* can be derived from Optical Plankton Counters (OPC), deployed on ARIES and Ocean Sampler; however, the OPC results are compromised by the presence particles in the water, which register in the same size categories as *Calanus.* In addition, a high presence of *Pleuromamma* sp. of almost identical sizes as *Calanus* C5 was noted at stations FF2, and FF3. Therefore these data need to be viewed cautiously, pending further detailed analysis and comparison with net catches. Fig 22 summarises the preliminary OPC results for *Calanus* stages C4-C5, expressed as *Calanus* per m^2 during the MarProd winter cruises (D258 and D267). Additional data from *FRV Scotia* have been included, since they were obtained with identical equipment and during the same periods (December 2001/2002) as the MarProd cruises.

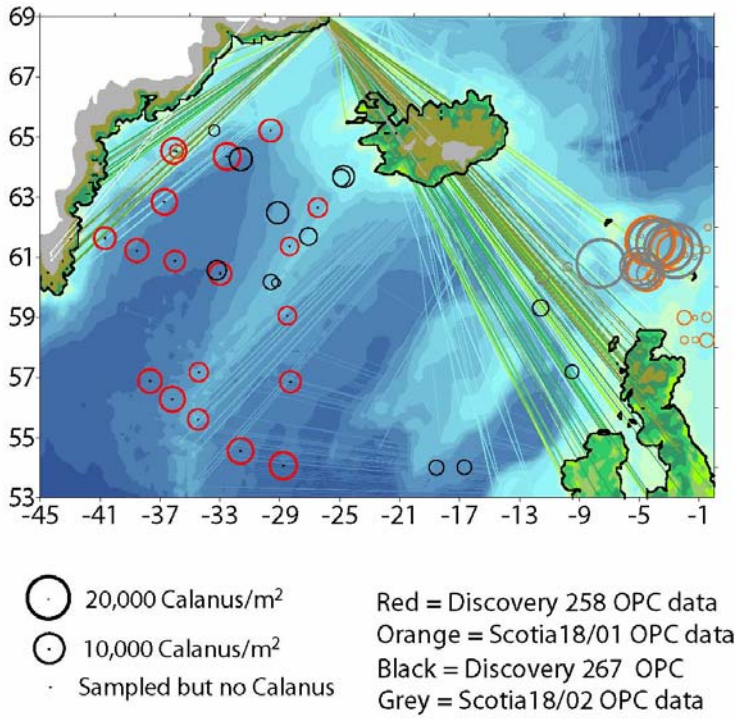


Fig 22. Winter concentrations of *Calanus* based on OPC results for D258 and D267, and *RV Scotia* cruises 18/01 and 18/02. FF4 is not included on this plot.

Although we met severe difficulties in obtaining data from the Irminger Basin due to poor weather conditions, the data that were obtained provide some comparison in winter abundance of the key species for this project. C*alanus* abundance proved to be similar to the previous year's results at stations B4, and DD13, where they were primarily located at depths of 1000-1500 m. A similar situation occurred at station B8. Immediately prior to our exchange of scientific personnel, we sampled a shallow coastal station (E18B) where *Calanus* was abundant in similar concentrations to the three stations already mentioned. However, the highest concentrations were found in nets very close to the bottom at a depth of ~500m. At the same time, the Dual Methot net contained many chaetognaths at a similar depth.

Due to the severe weather situation on the second leg of D267 we found ourselves sampling outside the Irminger Basin. The first two stations outside the Irminger Basin (RD and ADR) proved quite different in species composition to those seen in Dual Methot and ARIES samples in the Irminger Basin. On these two stations the abundance of *Calanus* was so low that the specimen extraction for biochemical analysis had to be restricted to a bare minimum to ensure sufficient material for all types of analysis.

On stations FF2, FF3 and FF4 a gradual increase in of *Calanus* concentrations were found as we moved further west. In addition, the species composition in the Dual Methot net became more similar to that seen in the Irminger Basin, but with very high numbers of *Parathemisto* sp. (most likely *Parathemisto gaudichaudi*). We found an increasing abundance of *Thysanoessa logincaudata* on the FF line, but no *Meganyctiphanes norvegica*.

In conclusion, D267 was somewhat limited in providing repetition of previous stations in the Irminger Basin, but has supplemented the MarProd project with additional data of the species composition in the vicinity of the Iceland and Irminger Basins which will hopefully prove useful in the further analysis of species productivity and dynamics.

Table 8. Biological material preserved for further analysis from Dual Methot net (DM), ARIES net (AR), ARIES pup net (AP), Ocean Sampler net (OS) and Ocean Sampler pup net (OP).

Discovery station no.	Sampler	Haul	Species	No of sets removed	Set size	Preservation
15078	DM	1078001	Euchaeta C6F	1	8	Frozen - C:N
	DM	1078001	Meg F	1	3	Ethanol - GENETICS1
	DM	1078001	Meg M	3	3	Cryo - LIPIDS
	DM	1078001	Meg F	1	3	Cryo - LIPIDS
	DM	1078001	Meg M	1	2	Frozen - C:N
	DM	1078001	Meg F	1	6	Frozen - C:N
	DM	1078001	T long F	2	3	Cryo - LIPIDS
	DM	1078001	T long M	1	3	Cryo - LIPIDS
	DM	1078001	T long F	1	3	Ethanol - GENETICS1
	DM	1078001	T long M	1	4	Frozen - C:N
	DM	1078001	Meg M	2	3	Ethanol - GENETICS1
	DM	1078001	Benthosema	1	2	Frozen - C:N
	DM	1078001	T long M	2	3	Ethanol - GENETICS1
	DM	1078001	Eukrohnia hamata	1	3	Frozen - C:N
	DM	1078001	Long thin fish	1	1	Frozen - C:N
	DM	1078001	Parathemisto gaudichaudii	1	4	Frozen - C:N
	DM	1078001	Red decapod	1	1	Frozen - C:N
	DM	1078001	Red mysid	1	1	Frozen - C:N
	DM	1078001	Pseudosagitta maxima	1	3	Frozen - C:N
	DM	1078001	Periphylla	1	1	Frozen - C:N
	DM	1078001	Siphonophore	1	2	Frozen - C:N
	DM	1078001	Spiratella retroversa	1	10	Frozen - C:N
	DM	1078001	Calanus hyperboreus	1	7	Frozen - C:N
	DM	1078001	Aglantha digitalis	1	4	Formalin
	DM	1078001	Eukrohnia hamata	1	10	Ethanol - Alba Lucia
	DM	1078001	Pseudosagitta maxima	1	5	Ethanol - Alba Lucia
	DM	1078001	Caecosagitta macrocephala	1	5	Ethanol - Alba Lucia
	DM	1078001	T long F	1	5	Frozen - C:N
15079	AR	1079034	Calanus C5	2	10	Cryo - LIPIDS
	AR	1079034	Calanus C5	2	10	Frozen - C:N
	AR	1079034	Calanus C5	1	50	Ethanol - GENETICS2
	AR	1079044	Calanus C5	4	10	Cryo - LIPIDS
	AR	1079044	Calanus C5	2	20	Cryo - ENZYMES
	AR	1079044	Calanus C5	3	10	Ethanol - GENETICS1
	AR	1079044	Calanus C5	2	10	Frozen - C:N
15093	AP	1093001	Pseudosagitta maxima	1	2	Frozen - C:N
	AP	1093001	Euchaeta C5	1	3	Frozen - C:N
	AP	1093001	Long thin fish	1	1	Frozen - C:N
	AP	1093001	Calanus C5	1	50	Ethanol - GENETICS2
	AP	1093001	Thysanoessa longicaudata	1	3	Frozen - C:N
	AP	1093001	Red decapod	1	1	Frozen - C:N
	AP	1093001	Sergestid	1	1	Frozen - C:N
	AP	1093001	Calanus C5	4	10	Cryo - LIPIDS
	AP	1093001	Euchaeta C6	1	3	Frozen - C:N
	AP	1093001	Calanus C5	2	20	Cryo - ENZYMES
	AP	1093001	Calanus C5	3	10	Frozen - C:N
	AP	1093001	Benthosema	1	1	Frozen - C:N
	AP	1093001	Eukrohnia hamata	1	3	Frozen - C:N
	AP	1093001	Siphonophore	1	1	Frozen - C:N
	AP	1093001	Calanus C5	3	10	Ethanol - GENETICS1

	AP	1093001	Spiratella	1	45	Frozen - C:N
15105	DM	1105001	Benthosema	1	1	Frozen - C:N
	DM	1105001	Euchaeta C6F	1	8	Frozen - C:N
	DM	1105001	Eukrohnia hamata	1	3	Frozen - C:N
	DM	1105001	Parathemisto gaudichaudii	1	3	Frozen - C:N
	DM	1105001	Red decapod	1	1	Frozen - C:N
	DM	1105001	Red mysid	1	1	Frozen - C:N
	DM	1105001	Sergestid	1	1	Frozen - C:N
	DM	1105001	Calanus hyperboreus	1	1	Frozen - C:N
	DM	1105001	Aglantha digitalis	1	3	Frozen - C:N
	DM	1105001	Meg saM	2	3	Cryo - LIPIDS
	DM	1105001	Pseudosagitta maxima	1	3	Frozen - C:N
	DM	1105001	T long F	1	10	Frozen - C:N
	DM	1105001	T long M	1	10	Frozen - C:N
	DM	1105001	T long F	2	3	Ethanol - GENETICS1
	DM	1105001	T long M	1	3	Ethanol - GENETICS1
	DM	1105001	T long F	1	3	Cryo - LIPIDS
	DM	1105001	T long M	2	3	Cryo - LIPIDS
	DM	1105001	Meg saM	1	2	Frozen - C:N
	DM	1105001	Meg saF	1	3	Cryo - LIPIDS
	DM	1105001	Pasiphaea	1	1	Frozen - C:N
	DM	1105001	Meg saF	1	7	Frozen - C:N
	DM	1105001	Meg saM	2	3	Ethanol - GENETICS1
	DM	1105001	Meg saF	1	3	Ethanol - GENETICS1
	DM	1105002	Long thin fish	1	1	Frozen - C:N
	DM	1105002	Meg saF	1	3	Cryo - LIPIDS
	DM	1105002	Meg saM	2	3	Ethanol - GENETICS1
	DM	1105002	Meg saF	1	2	Frozen - C:N
	DM	1105002	Meg saM	1	2	Frozen - C:N
	DM	1105002	Caecosagitta macrocephala	1	1	Ethanol - Other
	DM	1105002	Sagitta sp#2	1	1	Ethanol - Other
	DM	1105002	Eukrohnia hamata	1	10	Ethanol - Other
	DM	1105002	Benthosema	1	1	Frozen - C:N
	DM	1105002	Meg saM	1	3	Cryo - LIPIDS
	DM	1105002	Eukrohnia hamata	1	4	Frozen - C:N
	DM	1105002	Pseudosagitta maxima	1	4	Ethanol - Other
	DM	1105002	Parathemisto gaudichaudii	1	3	Frozen - C:N
	DM	1105002	Red decapod	1	1	Frozen - C:N
	DM	1105002	Red mysid	1	1	Frozen - C:N
	DM	1105002	Pseudosagitta maxima	1	3	Frozen - C:N
	DM	1105002	Siphonophore	1	1	Frozen - C:N
	DM	1105002	Calanus hyperboreus	1	3	Frozen - C:N
	DM	1105002	Sergestid	1	1	Frozen - C:N
	DM	1105002	Euchaeta C6F	1	8	Frozen - C:N
	DM	1105002	Sagitta sp#1	1	3	Ethanol - Other
15106	AR	1106042	Calanus C5	4	10	Cryo - LIPIDS
	AR	1106042	Calanus C6F	1	4	Frozen - C:N
	AR	1106042	Calanus C5	2	10	Frozen - C:N
	AR	1106042	Calanus C5	1	50	Ethanol - GENETICS2
	AR	1106042	Calanus C4	1	10	Ethanol - GENETICS1
	AR	1106042	Calanus C5	2	20	Cryo - ENZYMES
	AR	1106042	Calanus C5	2	10	Ethanol - GENETICS1
	AR	1106056	Calanus C6F	1	4	Frozen - C:N
	AR	1106056	Calanus C5	2	10	Frozen - C:N
	AR	1106056	Calanus C5	1	50	Ethanol - GENETICS2
	AR	1106056	Calanus C4	1	10	Ethanol - GENETICS1

	AR	1106056	Calanus C5	2	10	Ethanol - GENETICS1
	AR	1106056	Calanus C5	2	20	Cryo - ENZYMES
	AR	1106056	Calanus C5	4	10	Cryo - LIPIDS
15117	OS	1117001	Calanus C5	2	10	Cryo - LIPIDS
	OS	1117001	Metridia longa	1	10	Cryo - LIPIDS
	OS	1117001	Calanus C5	2	10	Ethanol - GENETICS1
	OS	1117001	Calanus C5	1	20	Cryo - ENZYMES
15118	OP	1118001	Euchaeta	1	3	Frozen - C:N
	OP	1118001	Spiratella	1	32	Frozen - C:N
	OP	1118001	Metridia longa	2	5	Frozen - C:N
	OP	1118001	Calanus C5	2	10	Frozen - C:N
	OP	1118001	Parathemisto	1	3	Frozen - C:N
	OP	1118001	Pseudosagitta maxima	1	1	Frozen - C:N
	OP	1118001	Calanus hyperboreus	1	3	Frozen - C:N
	OP	1118001	Pleurobrachia	1	5	Frozen - C:N
15119	OP	1119001	Calanus C5	3	10	Ethanol - GENETICS1
	OP	1119001	Calanus C5	1	20	Cryo - ENZYMES
	OP	1119001	Calanus C5	4	10	Cryo - LIPIDS
	OP	1119001	Calanus C6F	1	5	Ethanol - GENETICS1
15120	DM	1120001	T long F	1	3	Ethanol - GENETICS1
	DM	1120001	Sergestid	1	1	Frozen - C:N
	DM	1120001	Parathemisto gaudichaudii	1	6	Frozen - C:N
	DM	1120001	Eukrohnia hamata	1	3	Frozen - C:N
	DM	1120001	Euchaeta C6F	1	8	Frozen - C:N
	DM	1120001	Calanus hyperboreus	1	8	Frozen - C:N
	DM	1120001	Benthosema	1	1	Frozen - C:N
	DM	1120001	T inermis sa	1	3	Ethanol - GENETICS1
	DM	1120001	T long M	1	5	Frozen - C:N
	DM	1120001	T long M	2	3	Ethanol - GENETICS1
	DM	1120001	T long M	2	3	Cryo - LIPIDS
	DM	1120001	Meg F	1	3	Cryo - LIPIDS
	DM	1120001	T long F	1	3	Cryo - LIPIDS
	DM	1120001	Meg saM	3	1	Ethanol - GENETICS1
	DM	1120001	Meg saM	1	3	Cryo - LIPIDS
	DM	1120001	Meg saF	1	1	Frozen - C:N
	DM	1120001	Meg saF	1	3	Cryo - LIPIDS
	DM	1120001	Meg M	1	2	Frozen - C:N
	DM	1120001	Meg M	3	1	Ethanol - GENETICS1
	DM	1120001	Meg F	3	1	Ethanol - GENETICS1
	DM	1120001	Pseudosagitta maxima	1	3	Frozen - C:N
	DM	1120001	T long F	1	4	Frozen - C:N
	DM	1120001	Meg saM	1	2	Frozen - C:N
	DM	1120002	Aglantha digitalis	1	3	Frozen - C:N
	DM	1120002	Pseudosagitta maxima	1	3	Ethanol - Alba Lucia
	DM	1120002	Red decapod	1	1	Frozen - C:N
	DM	1120002	Benthosema	1	1	Frozen - C:N
	DM	1120002	Siphonophore	1	1	Frozen - C:N
	DM	1120002	Eukrohnia hamata	1	3	Frozen - C:N
	DM	1120002	Pseudosagitta maxima	1	3	Frozen - C:N
	DM	1120002	Long thin fish	1	1	Frozen - C:N
	DM	1120002	Red mysid	1	1	Frozen - C:N
	DM	1120002	Pasiphaea	1	1	Frozen - C:N
	DM	1120002	Parathemisto gaudichaudii	1	4	Frozen - C:N
	DM	1120002	Euchaeta C6F	1	6	Frozen - C:N
	DM	1120002	Calanus hyperboreus	1	6	Frozen - C:N
	DM	1120002	Ostracod	1	5	Frozen - C:N

15131	DM	1131001	T inermis sa	1	4	Frozen - C:N
	DM	1131001	Meg saF	1	7	Frozen - C:N
	DM	1131001	Maurolicus muelleri	1	1	Frozen - C:N
	DM	1131001	Meg J	1	8	Frozen - C:N
	DM	1131001	Meg M	1	5	Frozen - C:N
	DM	1131001	Meg F	1	5	Frozen - C:N
	DM	1131001	Meg saF	1	3	Ethanol - GENETICS1
	DM	1131001	Meg saM	2	3	Ethanol - GENETICS1
	DM	1131001	Meg saF	2	3	Cryo - LIPIDS
	DM	1131001	T inermis sa	3	3	Ethanol - GENETICS1
	DM	1131001	T inermis sa	3	3	Cryo - LIPIDS
	DM	1131001	Meg saM	1	3	Cryo - LIPIDS
	DM	1131002	Calanus hyperboreus	1	2	Frozen - C:N
	DM	1131002	Mysid sp	1	1	Frozen - C:N
	DM	1131002	Caecosagitta macrocephala	1	1	Ethanol - Alba Lucia
	DM	1131002	Eukrohnia hamata	1	10	Ethanol - Other
	DM	1131002	Sagitta sp#1	1	1	Ethanol - Other
	DM	1131002	Pseudosagitta maxima	1	3	Ethanol - Other
	DM	1131002	Euchaeta C6M	1	6	Frozen - C:N
	DM	1131002	Parathemisto gaudichaudii	1	3	Frozen - C:N
	DM	1131002	Aglantha digitalis	1	2	Frozen - C:N
	DM	1131002	Sergestid	1	1	Frozen - C:N
	DM	1131002	Eukrohnia hamata	1	8	Frozen - C:N
	DM	1131002	Beroe	1	1	Frozen - C:N
	DM	1131002	Hyperia	1	1	Frozen - C:N
	DM	1131002	Pseudosagitta maxima	1	3	Frozen - C:N
	DM	1131002	Euchaeta C6F	1	8	Frozen - C:N
15132	AR	1132021	Calanus C5	2	10	Ethanol - GENETICS1
	AR	1132021	Calanus C5	1	50	Ethanol - GENETICS2
	AR	1132024	Calanus C4	1	10	Ethanol - GENETICS1
	AR	1132024	Calanus C5	4	10	Cryo - LIPIDS
	AR	1132024	Calanus C5	2	10	Ethanol - GENETICS1
	AR	1132024	Calanus C5	2	5	Frozen - C:N
	AR	1132024	Pseudocalanus	1	20	Frozen - C:N
	AR	1132024	Calanus C5	2	20	Cryo - ENZYMES
15144	DM	1144001	Euchaeta C6F	1	10	Frozen - C:N
	DM	1144001	Benthosema	1	1	Frozen - C:N
	DM	1144001	Euchaeta C6F	1	20	Cryo - ENZYMES
	DM	1144001	T long F	1	6	Frozen - C:N
	DM	1144001	Parathemisto gaudichaudii	1	4	Frozen - C:N
	DM	1144001	Red mysid	1	1	Frozen - C:N
	DM	1144001	Sergestid	1	1	Frozen - C:N
	DM	1144001	Pasiphaea	1	1	Frozen - C:N
	DM	1144001	Hatchet fish (Argyropelecus)	1	1	Frozen - C:N
	DM	1144001	Meg saF	1	2	Frozen - C:N
	DM	1144001	T long M	1	6	Frozen - C:N
	DM	1144001	Scyphozoa medusae	1	1	Frozen - C:N
	DM	1144001	E krohn F	2	3	Cryo - LIPIDS
	DM	1144001	T long M	1	3	Ethanol - GENETICS1
	DM	1144001	Meg saM	1	3	Ethanol - GENETICS1
	DM	1144001	Meg saF	2	3	Ethanol - GENETICS1
	DM	1144001	Meg saF	1	3	Cryo - LIPIDS
	DM	1144001	Meg saM	2	3	Cryo - LIPIDS
	DM	1144001	E krohn M	1	3	Cryo - LIPIDS
	DM	1144001	E krohn M	1	3	Ethanol - GENETICS1
	DM	1144001	E krohn F	2	3	Ethanol - GENETICS1

	DM	1144001	E krohn M	1	3	Frozen - C:N
	DM	1144001	E krohn F	2	3	Frozen - C:N
	DM	1144001	T long M	2	3	Cryo - LIPIDS
	DM	1144001	T long F	1	3	Cryo - LIPIDS
	DM	1144001	T long F	2	3	Ethanol - GENETICS1
	DM	1144001	Meg F	1	2	Frozen - C:N
	DM	1144002	Eukrohnia hamata	1	3	Frozen - C:N
	DM	1144002	Sergestid	1	2	Frozen - C:N
	DM	1144002	Pseudosagitta maxima	1	3	Frozen - C:N
	DM	1144002	Periphylla	1	1	Frozen - C:N
	DM	1144002	Siphonophore	1	3	Frozen - C:N
	DM	1144002	Long thin fish	1	2	Frozen - C:N
	DM	1144002	Euchaeta C6F	1	8	Frozen - C:N
	DM	1144002	Calanus hyperboreus	1	3	Frozen - C:N
	DM	1144002	Benthosema	1	2	Frozen - C:N
	DM	1144002	Aglantha digitalis	1	3	Frozen - C:N
	DM	1144002	Euchaeta C6F	1	20	Cryo - ENZYMES
	DM	1144002	Pseudosagitta maxima	1	5	Ethanol - Other
	DM	1144002	Eukrohnia hamata	1	5	Ethanol - Other
	DM	1144002	Red mysid	1	2	Frozen - C:N
15145	AR	1145034	Calanus C5	2	10	Ethanol - GENETICS1
	AR	1145037	Calanus C5	3	10	Cryo - LIPIDS
	AR	1145037	Calanus C5	1	50	Ethanol - GENETICS2
	AR	1145037	Calanus C5	1	10	Ethanol - GENETICS1
	AR	1145037	Calanus C5	2	10	Frozen - C:N
	AR	1145037	Euchaeta	2	5	Cryo - LIPIDS
	AR	1145037	Calanus C5	2	20	Cryo - ENZYMES
15160	DM	1160001	Eukrohnia hamata	1	5	Ethanol - Alba Lucia
	DM	1160001	T long F	1	3	Frozen - C:N
	DM	1160001	Meg M	1	3	Frozen - C:N
	DM	1160001	Red mysid	1	1	Frozen - C:N
	DM	1160001	Red decapod	1	1	Frozen - C:N
	DM	1160001	Sergestid	1	2	Frozen - C:N
	DM	1160001	Parathemisto gaudichaudii	1	6	Frozen - C:N
	DM	1160001	Euchaeta C6F	1	20	Cryo - ENZYMES
	DM	1160001	E krohn F	2	3	Frozen - C:N
	DM	1160001	T long F	1	3	Ethanol - GENETICS1
	DM	1160001	E krohn M	1	3	Frozen - C:N
	DM	1160001	T long M	1	3	Frozen - C:N
	DM	1160001	E krohn M	2	3	Cryo - LIPIDS
	DM	1160001	E krohn F	2	3	Ethanol - GENETICS1
	DM	1160001	E krohn F	1	3	Cryo - LIPIDS
	DM	1160001	E krohn M	1	3	Ethanol - GENETICS1
	DM	1160001	Meg F	3	3	Cryo - LIPIDS
	DM	1160001	T long M	2	3	Cryo - LIPIDS
	DM	1160001	Megalops M	1	3	Frozen - C:N
	DM	1160001	Megalops F	1	3	Frozen - C:N
	DM	1160001	Meg F	2	3	Ethanol - GENETICS1
	DM	1160001	T long F	1	3	Cryo - LIPIDS
	DM	1160001	Benthosema	1	1	Frozen - C:N
	DM	1160001	T long M	2	3	Ethanol - GENETICS1
	DM	1160001	Meg M	1	3	Ethanol - GENETICS1
	DM	1160002	Red decapod	1	1	Frozen - C:N
	DM	1160002	Pseudosagitta maxima	1	5	Ethanol - Alba Lucia
	DM	1160002	Euchaeta C6F	1	20	Cryo - ENZYMES
	DM	1160002	Euchaeta C6F	2	5	Cryo - LIPIDS

	DM	1160002	Benthosema	1	2	Frozen - C:N
	DM	1160002	Long thin fish	1	2	Frozen - C:N
	DM	1160002	Siphonophore	1	3	Frozen - C:N
	DM	1160002	Sergestid	1	2	Frozen - C:N
	DM	1160002	Eukrohnia hamata	1	3	Frozen - C:N
	DM	1160002	Pseudosagitta maxima	1	3	Frozen - C:N
	DM	1160002	Euchaeta C6F	1	9	Frozen - C:N
	DM	1160002	Red mysid	1	2	Frozen - C:N
15161	AR	1161035	Calanus C5	2	20	Cryo - ENZYMES
	AR	1161035	Calanus C5	3	10	Cryo - LIPIDS
	AR	1161035	Calanus C4	1	10	Ethanol - GENETICS1
	AR	1161035	Calanus C5	3	10	Ethanol - GENETICS1
	AR	1161035	Calanus C6F	1	7	Frozen - C:N
	AR	1161035	Calanus C5	2	10	Frozen - C:N
15166	AR	1166047	Calanus C5	1	20	Cryo - ENZYMES
	AR	1166047	Calanus C5	2	10	Ethanol - GENETICS1
	AR	1166047	Calanus C5	1	10	Cryo - LIPIDS
	AR	1166049	Calanus C5	1	50	Ethanol - GENETICS2
	AR	1166050	Calanus C5	1	20	Cryo - ENZYMES
	AR	1166050	Calanus C5	1	10	Ethanol - GENETICS1
	AR	1166050	Calanus C5	2	10	Frozen - C:N
	AR	1166050	Calanus C5	2	10	Cryo - LIPIDS
15178	DM	1178001	Fish sp?	1	1	Frozen - C:N
	DM	1178001	Siphonophore	1	3	Frozen - C:N
	DM	1178002	Meg M	1	3	Frozen - C:N
	DM	1178002	Hatchet fish (Argyropelecus)	1	1	Frozen - C:N
	DM	1178002	Long thin fish	1	1	Frozen - C:N
	DM	1178002	Red mysid	1	1	Frozen - C:N
	DM	1178002	Benthosema	1	1	Frozen - C:N
	DM	1178002	Tomopteris	1	2	Frozen - C:N
15181	AP	1181001	Calanus C5	3	10	Cryo - LIPIDS
	AP	1181001	Calanus C5	2	10	Ethanol - GENETICS1
	AP	1181001	Calanus C5	1	20	Cryo - ENZYMES
	AP	1181001	Calanus C5	2	10	Frozen - C:N
15189	DM	1189001	Meg M	1	3	Frozen - C:N
	DM	1189001	Megalops J	1	3	Frozen - C:N
	DM	1189001	Unknown Jellyfishes	1	1	Frozen - C:N
	DM	1189001	Beroe	1	2	Frozen - C:N
	DM	1189001	Unknown Jellyfishes	1	1	Frozen - C:N
	DM	1189001	Unknown Jellyfishes	1	1	Frozen - C:N
	DM	1189001	Hyperia	1	2	Frozen - C:N
	DM	1189001	Hatchet fish (Argyropelecus)	1	1	Frozen - C:N
	DM	1189001	Sergestid	1	1	Frozen - C:N
	DM	1189001	Siphonophore	1	4	Frozen - C:N
15192	AP	1192001	Calanus C5	2	10	Cryo - LIPIDS
	AP	1192001	Calanus C5	2	10	Ethanol - GENETICS1
15204	DM	1204001	T long NS	3	3	Frozen - C:N
	DM	1204001	Red decapod	1	1	Frozen - C:N
	DM	1204001	E krohn F	1	3	Frozen - C:N
	DM	1204001	Red mysid	1	2	Frozen - C:N
	DM	1204001	Euchaeta C6F	1	8	Frozen - C:N
	DM	1204001	Sergestid	1	3	Frozen - C:N
	DM	1204001	Euchaeta C6F	1	20	Cryo - ENZYMES
	DM	1204001	T long NS	3	3	Ethanol - GENETICS1
	DM	1204001	T long NS	3	3	Cryo - LIPIDS
	DM	1204001	E krohn M	1	3	Frozen - C:N

	DM	1204001	E krohn F	2	3	Ethanol - GENETICS1
	DM	1204001	E krohn M	1	3	Cryo - LIPIDS
	DM	1204001	E krohn F	2	3	Cryo - LIPIDS
	DM	1204001	Parathemisto gaudichaudii	1	6	Frozen - C:N
	DM	1204001	E krohn M	1	3	Ethanol - GENETICS1
	DM	1204002	Benthosema	1	2	Frozen - C:N
	DM	1204002	Calanus hyperboreus	1	8	Frozen - C:N
	DM	1204002	Scyphozoa medusae	1	2	Frozen - C:N
	DM	1204002	Red decapod	1	2	Frozen - C:N
	DM	1204002	Long thin fish	1	2	Frozen - C:N
	DM	1204002	Euchaeta C6F	1	8	Frozen - C:N
	DM	1204002	Euchaeta C6F	2	5	Cryo - LIPIDS
	DM	1204002	Red mysid	1	3	Frozen - C:N
	DM	1204002	Euchaeta C6F	1	20	Cryo - ENZYMES
15205	AR	1205058	Calanus C5	3	10	Cryo - LIPIDS
	AR	1205058	Calanus C5	2	10	Ethanol - GENETICS1
	AR	1205058	Calanus C5	1	20	Cryo - ENZYMES
	AR	1205058	Calanus C5	2	10	Frozen - C:N
	AR	1205058	Pleuromamma	2	5	Frozen - C:N
15215	DM	1215001	Parathemisto gaudichaudii	1	8	Frozen - C:N
	DM	1215001	Sergestid	1	3	Frozen - C:N
	DM	1215002	Sagitta sp#1	1	10	Ethanol - Alba Lucia
	DM	1215002	Euchaeta C6F	2	5	Cryo - LIPIDS
	DM	1215002	T long F	1	3	Cryo - LIPIDS
	DM	1215002	T long F	2	3	Ethanol - GENETICS1
	DM	1215002	T long M	1	3	Ethanol - GENETICS1
	DM	1215002	T long F	2	3	Frozen - C:N
	DM	1215002	T long M	1	4	Frozen - C:N
	DM	1215002	Megalops F	1	3	Frozen - C:N
	DM	1215002	Euchaeta C6F	2	20	Cryo - ENZYMES
	DM	1215002	T long M	2	3	Cryo - LIPIDS
15216	AR	1216059	Calanus C5	1	20	Cryo - ENZYMES
	AR	1216059	Calanus C5	2	10	Ethanol - GENETICS1
	AR	1216059	Calanus C5	2	10	Frozen - C:N
	AR	1216059	Calanus C5	3	10	Cryo - LIPIDS
15226	DM	1226001	E krohn F	1	2	Frozen - C:N
	DM	1226001	Parathemisto gaudichaudii	1	8	Frozen - C:N
	DM	1226001	Megalops J	1	2	Frozen - C:N
	DM	1226001	Stylocheiron max	1	2	Frozen - C:N
	DM	1226001	Meg J	1	2	Frozen - C:N
	DM	1226001	T long NS	3	3	Frozen - C:N
	DM	1226001	T long NS	3	3	Cryo - LIPIDS
	DM	1226001	Sergestid	1	3	Frozen - C:N
	DM	1226001	E krohn M	1	4	Frozen - C:N
	DM	1226001	E krohn F	1	3	Ethanol - GENETICS1
	DM	1226001	E krohn M	2	3	Ethanol - GENETICS1
	DM	1226001	E krohn F	1	3	Cryo - LIPIDS
	DM	1226001	T long NS	3	3	Ethanol - GENETICS1
	DM	1226001	E krohn M	2	3	Cryo - LIPIDS
	DM	1226002	Long thin fish	1	4	Frozen - C:N
	DM	1226002	Benthosema	1	2	Frozen - C:N
	DM	1226002	Sagitta sp#1	1	5	Ethanol - Other
	DM	1226002	Euchaeta C6F	2	5	Cryo - LIPIDS
	DM	1226002	Euchaeta C6F	2	20	Cryo - ENZYMES
	DM	1226002	Parathemisto gaudichaudii	1	4	Frozen - C:N
	DM	1226002	Red mysid	1	3	Frozen - C:N

	DM	1226002	Scyphozoa medusae	1	1	Frozen - C:N
	DM	1226002	Euchaeta C6F	1	8	Frozen - C:N
	DM	1226002	Scyphozoa medusae	1	1	Frozen - C:N
	DM	1226002	Unknown Jellyfishes	1	2	Frozen - C:N
	DM	1226002	Siphonophore	1	1	Frozen - C:N
	DM	1226002	Sagitta sp#1	1	4	Frozen - C:N
	DM	1226002	Red decapod	1	2	Frozen - C:N
15227	AR	1227029	Calanus C5	1	20	Formalin
	AR	1227029	Calanus C5	2	10	Cryo - LIPIDS
	AR	1227029	Calanus C5	2	10	Ethanol - GENETICS1
	AR	1227029	Calanus C5	2	10	Frozen - C:N
	AR	1227029	Calanus C5	1	20	Cryo - ENZYMES
15230	DM	1230001	Hatchet fish (Argyropelecus)	1	2	Frozen - C:N
	DM	1230001	Sagitta sp#1	1	8	Frozen - C:N
	DM	1230001	Siphonophore	1	1	Frozen - C:N
	DM	1230001	Scyphozoa medusae	1	1	Frozen - C:N
	DM	1230001	Unknown Jellyfishes	1	3	Frozen - C:N
	DM	1230001	Parathemisto gaudichaudii	1	8	Frozen - C:N
	DM	1230001	T long NS	3	3	Cryo - LIPIDS
	DM	1230001	T long NS	3	3	Frozen - C:N
	DM	1230001	Meg M	1	3	Frozen - C:N
	DM	1230001	Stylocheiron max	1	2	Frozen - C:N
	DM	1230001	T long NS	3	3	Ethanol - GENETICS1
	DM	1230001	Euchaeta C6F	2	5	Cryo - LIPIDS
	DM	1230001	Euchaeta C6F	1	8	Frozen - C:N
	DM	1230001	Sergestid	1	2	Frozen - C:N
	DM	1230001	Long thin fish	1	2	Frozen - C:N
	DM	1230001	Red mysid	1	2	Frozen - C:N
	DM	1230001	Red decapod	1	1	Frozen - C:N
	DM	1230001	Calanus hyperboreus	1	4	Frozen - C:N
	DM	1230001	Megalops J	1	2	Frozen - C:N

Biological sorting

As noted abocve, zooplankton and associated specimen samples were collected with the Autosampling Recording Instrumented Environmental Sampler (ARIES), Dual Methot (DM) and Ocean Sampler (OS) to provide data on zooplankton populations and distribution, on food chain interactions and on environmental conditions. Deck work and sorting procedures were essentially as described in the report for the winter cruise D258.

Species selected for further analysis are identified in Table 8 (above) according to the protocols summarised below. Those to be analysed for lipids/ hormones/enzymes, were transferred into plain cryovials and stored in liquid nitrogen; those for genetics, into sealed cryovials with pure 100% ethanol; and those for CN/isotope ratios into glass screw top vials that were then placed in the –20ºC freezer. A typical number of sets of individuals, dependent on abundance, is given in parenthesis. Where possible, sets of specimens were picked from both surface and deeper nets for comparisons. From ARIES samples, 1990 *Calanus* were picked out; from Dual Methot hauls, euphausiids and other material were picked. As follows:

i) from ARIES nets for lipids, hormones, enzymes, genetics and CN/Isotope ratios:

Copepoda **Calanus* (3 – 6 sets x 10) [* MarProd target species]
Plus occasionally specimen sets of other species for the CN/Isotope ratios studies.

ii) from Dual Methot net for lipids, genetics and CN/Isotope ratios:

Euphausiidae	**Meganctiphanes norvegica* (3 sets x 5) **Thysanoessa longicaudata* (3 sets x 5) *Thysanoessa inermis* (3 sets x 5)

iii) for CHN/Isotope ratios, a standard species set where found, with occasional additions:

Copepoda	*Calanus hyperboreus* adults or late copepodids(6) *Euchaeta spp.* females (6)
Decapoda & Mysidaceae	Common species, incl. Sergestiid shrimps and other deep water spp.
Chaetognatha	*Sagitta maxima* (6); *Eukronia hamata*(6)
Amphipoda	*Parathemisto spp.*(3)
Fish	Specimens of representative deep water species
Jellyfish	Representative species, including *Periphylla, Atolla, Aglantha* and some siphonophores
Other species	As encountered (Table 9, below)

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Table 9. A preliminary list of 'other species' in the Dual Methot catches

Euphausiacea *Meganyctiphanes norvegica* *Thysanoessa inermis* *Thysanoessa longicaudata* *Thysanopoda acutifrons* *Nematobrachion boopis* *Stylochieron maximum* **Decapoda** Red deep sea decapod spp Red decapod-slim sp Decapod larvae *Pasiphaea* *Sergestes sp* **Mysidacea** **Amphipoda** *Parathemisto sp.* *Parathemisto gracilipes* *Parathemisto gaudichaudi* *Hyperia galba* **Copepoda** *Euchaeta norvegica* *Calanus hyperboreus* Caligid copepod (on sandeels)	**Ctenophora** Ctenophore bits *Beroe cucumis* *Beroe ovata* *Pleurobrachia* *?Mnemiopsis?* **Ceriantheria** *Arachnactes* sp **Hydromedusa** *Laodicea undulata* **Trachymedusa** *Aglantha digitalis* **Siphonophora** agalmid siphonophore *Agalma elegans* *agalmid cormidium* dyphid siphonophore *Lensia sp* **Scyphozoa** red *scyphomedusa sp* *Periphylla* *Atolla*	**Pteropoda** *Limacina helicoides* *Spiratella limacina* *Euclio spp* *Clione limacine* **Chaetognatha** *Eukrohnia hamata* *Sagitta maxima* **Thalliacea** Salpa fusiformis **Acantharia** **Cephalopoda** **Polychaeta** *Aphrodites sp?* *Tomopteris septentrionalis* orange polychaete **Pisces** Myctophid type fish hatchet fish long-thin deepwater fish sandeel larvae

6.11 Recruitment and mortality of *Calanus* eggs and nauplii - *Kathryn Cook*

Background

The aims of this project are to explore the demography, mortality and factors controlling the survival of *Calanus finmarchicus* and *C. helgolandicus*. During the D267 cruise our efforts were primarily focussed on whether there was any winter *C. finmarchicus* egg production and, if so, the hatching success of these eggs.

Individual female egg production rates

At most full stations (as listed in Table 10) we collected live female *C. finmarchicus* using vertical hauls of a 1 m ring net from 120 to 0 metres. Animals were rapidly sorted and, where possible, up to 12 female *C. finmarchicus* were incubated over 24 hours in individual containers in the dark. These containers, which are designed to reduce egg canabalism, have meshed bottoms that allow eggs to settle through but exclude the females. Water collected

from 10m and screened through a 95 μm mesh to remove eggs and nauplii was used as the incubation medium. The egg production containers were placed in a flow through tank using the non-toxic sea water supply to maintain the incubation at sea surface temperature. After 24 hr eggs were drained off, enumerated, and the individual females preserved for subsequent gonad staging. After 96 hr the number of nauplii that had hatched were counted. Rates of female egg production and hatching success data from our experiments at each station sampled are presented in Table 10.

Once the animals for egg production experiments had been extracted from the net samples, the remainder was preserved to allow subsequent taxonomic analysis for comparison with NORWESTLANT data.

Table 10. Sites/stations sampled for individual *C. finmarchicus* female egg production rates and hatching success. AP = live ARIES pup net.

Site	Discovery station no.	Date	Average incubation temp ^{o}C	No. of females incubated	Eggs f.d^{-1}	% Hatch 96 hr
B1	15072	15/11/02	8.10	9	0.00	
B4	15086	16/11/02	8.10	11	1.05	73.68%
B6	15098	19/11/02	6.95	7	1.27	60.00%
B8	15110	20/11/02	6.80	10	3.29	52.50%
B10	15114	20/11/02	6.70	12	0.00	
B11	15122	21/11/02	7.45	5	0.00	
E18b AP	15133	25/11/02	8.20	5	0.00	
E18b	15136	25/11/02		0		
DD13	15148	29/11/02		0		
DD9	15164	01/12/02	7.35	12	8.10	65.74%
RD	15172	07/12/02		0		
ADR	15183	08/12/02		0		
ADN	15194	09/12/02		0		
FF2	15198	11/12/02	11.15	4	0.00	
FF3	15209	12/12/02		0		
FF4	15220	13/12/02		0		

The abundance of female *C. finmarchicus* in the surface waters was very low at all stations. At site E18b, although there were no female *C. finmarchicus* found in the 1 m ring net sample, animals were extracted from the live ARIES pup net. There are no results from site DD10 (station 15154) as the net was lost on recovery.

6.12 Vertical net sampling: *Oithona* standing stock and production

Claudia Castellani, Karina Driff, Alexander Mustard, Kathryn Cook, Emily Roberts

The *Oithona* standing stock was sampled at the main and intermediary stations using a 63 μm mesh size Bongo net (9 samples) and a single WP-2 200 μm mesh sized net (8 samples) hauled vertically from a 120 m depth. Exceptions were stations RD (15172), where the 63 μm was not deployed because of the large swell, and DD10 (15154), where neither net was deployed following the loss of the large ring net used for capturing *Calanus* for egg production studies. The samples were immediately concentrated by sieving through an appropriate filter and fixed in 4% buffered formaldehyde. The *Oithona* in the samples will be enumerated, sized and staged in the laboratory. Abundance data for *Oithona* will be converted to biomass by means of the length-weight regression reported by Sabatini & Kiorboe (1994; *J. Plank. Res.* 16: 1329-51).

The water column was fully mixed from the surface down to the first 100 m. Within the depth sampled, *Oithona sp.* was the dominant plankton species at all the stations (B transect and DD7, see Table 11). *Oithona sp.* abundance appeared intermediary between that measured in spring and summer with all the stages, particularly nauplii, being well represented. *Calanus* abundance was very low compared to the spring and summer with only very sparse nauplii, late copepodites CV and females found particularly at the off-shore stations.

The limited number of stations and area sampled does not allow at this stage to define different feeding environments. Yet, net samples indicated that the microplankton concentration was overall low with the dinoflagellates (and possibly flagellates) being the best represented group, whereas diatoms were rarely present.

The predominance of *Oithona* in all the samples may be the result of the reproductive and feeding ability of this species at food concentrations that may be limiting for other copepods groups. In this respect, it is interesting to note that even at this time of the year *Oithona* sp. were reproducing well, both in the central part of the basin and on the coast, as indicated by the large number of nauplii and egg sacs found in the catches and the eggs produced during onboard experiments. Preliminary observations indicate that the number of eggs per sac was not different from that measured in spring and summer although the number of actively reproducing females was lower and the time taken to lay an egg sac longer (at temperatures comparable to that in spring, i.e. 7°C).

With regards of the distribution of the different *Oithona* species in the Irminger Sea we found that *O. spinirostris* and *O. nana* were more commonly found in the shelf area whereas *O. similis* dominated in the oceanic regions. The second most abundant species was *Pseudocalanus/Paracalanus sp.* Other species found were, *Euchaeta sp.* (copepodites), *Calanus hyperboreus, Microsetella sp*. and *Metridia sp*. It is noteworthy that the DD7 station had higher plankton diversity being characterised by the presence of *Euchaeta sp.*, *Sagitta sp.* and jelly-fish, which were virtually absent at the stations on the B transect. The samples from the FF transect, in addition to *Oithona* spp. and *Pseudocalanus/Paracalanus*, also contained notable numbers of *Pleuromamma* sp. and biomass of *Parathemisto* sp. amphipods.

Oithona sp. egg production rate (EPR)

Egg production experiments were conducted at a number of stations depending on the availability of copepods. A total of 6 experiments were conducted. Females were gently sampled using a 63 μm net with a small mouth diameter and a large cod end and the catch diluted in a large bucket with water from the non-toxic supply. After collection, 15 - 20 females were individually incubated in 70 ml culture flasks on a plankton wheel at an average temperature of 7 ± 0.5 °C, using seawater collected with a CTD usually at 10 m depth. The egg production was monitored daily over 2-4 days. At the end of the incubations, the eggs produced were counted, sized and the female cephalotorax length measured for conversion to biomass by means of the length-weight regression (Sabatini & Kiorboe, 1994).

The egg production obtained from the incubation experiment will be compared with egg production estimates obtained with the egg-ratio method counting the egg sacs and the number of females extracted from the preserved samples. The *Oithona*'s population specific egg production (SEP, day^{-1}) will be calculated from the egg to female ratio (E/F), temperature dependent hatching rate (HR, d^{-1}) and carbon content of the eggs and female from:

$$SEP = (E/F)*HR*(egg\text{-}C/Female\text{-}C)$$

One long-term egg production experiments was also conducted to estimate the inter-clutch duration (i.e. the time elapsing between the production of two successive egg sacs) in oceanic conditions. Sixteen *Oithona sp.* were incubated as described above and their egg production

monitored under low power microscope every day or every 8 hr during one spawning cycle. The water in the culture flask was changed every two days.

Oithona sp. grazing experiments

We carried out 7 experiments (Table 11) on the feeding behaviour of *Oithona sp.* with ~ 49 samples to be counted back in the lab. In general we found apparently uniform feeding conditions with very low microplankton available. Diatoms were rarely encountered in the central basin whereas a modest number of *Rhyzosolenia sp.* were found at the coastal station in Greenland (B11). Dinoflagellates seemed by far the best represented microplankton obsesrved in net samples.

Table 11. Summary of *Oithona* sampling and experiments carried out during the cruise

Station	Leg	Net 63µm	Net 200µm	*Oithona feeding*	*Oithona* EPR	*C/N*
ADN	2	√	√			
ADR	2	√	√			
B1	1	√	√	√	√	√
B3	1	√	√	√	√	√
B4	1	√	√		√	
B6	1	√	√	√	√	√
B8	1	√	√	√	√	√
B10	1	√				
B11	1	√	√	√	√	√
DD7	1	√	√	√	√	√
DD9	2	√	√			
DD10	2					
DD13	2	√	√			
E18b	1	√	√	√		√
FF1	2	√	√			
FF2	2	√	√			
FF2	2	√	√			
RD	2		√			

C/N and stable isotope ratios

Duplicate samples of 100 *Oithona similis* females were collected at 7 stations for C/N and natural abundance isotope ratios (NAIR) analysis. Whereas the C/N analysis will provide information on the average biomass of the female the stable isotope ratio will give indications on the trophic activity (Montoya *et al*., 1992; *Deep-Sea Res., A -Oceanog. Res.*, 39: 363-92).
The NAIR results together with the feeding experiments will provide information on the food source that allows *Oithona* to maintain its production in winter conditions.

6.13 Microplankton CN and stable isotope study - *Emily Roberts*

Total particulate CN samples

Sea water was collected from Niskin bottles fired at three different depths at each site sampled. The three depths were either surface, 10% and 0.1% light depth or surface, 25m and 100m (depending on whether primary production measurements were being made at the station, Table 12). For each sample, 5 litres of water were filtered through a 25 mm pre-ashed GF/C filter. Filters were placed in 1.5 ml microcentrifuge tubes and then frozen (-20°C). Samples will be freeze dried and analysed for total particulate CN and stable isotope ratio (^{13}C:^{12}C and ^{15}N:^{14}N) back in the Swansea laboratory using a Europa 20:20.

Due to the low concentration of particulate material in the water column, size fractionated samples were not taken.

Table 12. Sites and depths at which filtered particulate CN samples were taken.

	surface, 10% and 0.1% light depth	surface, 25m and 100m	Non toxic replicates
Site	B3, B6, B8, B10, B11, DD7	B1, B4, DD10, DD13, E18B, RD, ADR, FF2, FF3, FF4	FF5

6.14 FRRF (Fast Repetition Rate Fluorometer) data - *Sophie Fielding & Stuart Painter*

The FRRF is an active fluorescence instrument, which can be used to make rapid, non-destructive, and in-situ measurements of phytoplankton physiology (Kolber *et al*., 1998). One instrument was kept permanently attached to the ship's non-toxic supply in order to provide a continuous record of changes in near surface phytoplankton physiology and provide a comparison and data verification with other instruments deployed *in situ*. Power was provided to the instrument using a standard Chelsea Instrument deck box.

Data were recorded internally and downloaded at typically two-day intervals to a PC laptop via a RS232 communications cable that ran from the bottle annexe into the main lab. During the second leg of D267 it was noticed that downloading of the FRRF data whilst the towed EK500 was in the water caused noise interference on the 120 kHz acoustic data channel. This resulted in attempts to download data from the FRRF when the EK500 was onboard, resulting in variable durations of subsequent FRRF files. The optical chamber was cleaned every few days using a soft white tissue.

The files collected are given below (Table 13), using the following instrument settings:

```
***Boot protocol = 1***
6. 65535        Acquisitions
7. 16           Flash sequences per acquisition
8. 100          Saturation flashes per sequence
9. 4            Saturation flash duration (in instrument units)
A. 0            Saturation interflash delay (in instrument units)
B. ENABLED      Relaxation flashes
C. 20           Relaxation flashes per sequence
D. 4            Relaxation flash duration (in instrument units)
E. 61           Relaxation interflash delay (in instrument units)
F. 10000        ms Sleeptime between acquisition pairs
G. 16           PMT Gain in Autoranging Mode
H. ENABLED      Analog output
I. ENABLED      Desktop (verbose) Mode
J. INACTIVE     Light Chamber (A)
K. ACTIVE       Dark Chamber (B)
L. ENABLED      Logging mode to internal flashcard
M. 77           Upper limit autoranging threshold value
N. 23           Lower limit autoranging threshold value
```

Table 13. FRRF files

Jday/Time		File name	Time drift	Comments
Start	End		FRRF fast	
313 – 13:13	314 – 19:03	D26701	0	10s flashes
314 – 20:34	316 – 22:02	D26702	2	30 sec flashes
316 – 22:29	317 – 12:28	D26703	2	Lens cleaned
318 – 16:01	318 – 18:45	D26704	2	File stopped collecting
319 – 00:20	320 – 17:25	D26705	4	Water not turned on till 04:00
320 – 18:55	322 – 20:33	D26706	4	Lens cleaned. Format flashcard
322 – 21:21	324 – 09:50	D26707	4	-----
324 – 09:52	324 – 10:54	D26708	4	Format flashcard
325 – 20:34	327 – 19:44	D26709	6	Lens cleaned
327 – 20:28	328 – 16:25	D26710	6	In port at end of file
328 – 17:38	----	D26711	7	-------
331 – 19:19	334 – 04:18	D26712	8	Format flashcard
334 – 06:26	336 – 18:26	D26713	9	Lens cleaned. Format flashcard. Problems downloading
336 – 20:24	338 – 13:06	D26714	10	---------
338 – 13:47	339 – 13:00	D26715	--	Power turned off ~339 13:00. Format flashcard
340 – 10:33	344 – 14:00	D26716	11	Interference downloading. Format flashcard
344 – 19:05	346 – 16:51	D26717	14	----------
346 – 18:06	348 – 21:29	D26718	14	Lens cleaned. Format flashcard
348 – 22:26	350 – 19:00	D26719	14	---------

6.15 Phytoplankton biomass, community structure and productivity

Mike Lucas, Stuart Painter and Sau Yu Grace Wong

The primary aim of this study was to measure phytoplankton community structure, biomass and primary production in winter within the Irminger Basin and on the eastern continental slope of Greenland. Very little information is available for winter primary production measurements in this region. The assumption has always been that winter phytoplankton production is light rather than nutrient limited within a deeply mixed water column. The implications of probably reduced production rates by a community dominated by small cells and a low biomass (<0.5µg chl*a* l^{-1}) for over-wintering zooplankton populations are uncertain.

Concurrent measurements of phytoplankton production based on ^{14}C fixation and on FRRF measurements provided rates of primary production as well as an index of their physiological status based on FRRF derived P vs E parameters. Carbon fixation experiments covering the euphotic layer to the 1% light depth used water obtained from the CTD bottle rosette. Water column FRRF parameters were derived from profiling the instrument to 150 m. Continuous underway surface (~5 m) values of FRRF were obtained from the non-toxic sea-water supply. Community structure was determined from preserved phytoplankton samples while biomass was derived from chl.*a* measurements and HPLC analyses of total pigment. Both the latter allowed for calibration of underway FRRF and profiled FRRF and CTD fluorescence measurements.

Sites and stations where these studies were carried out are given in Table 14; additional information on specific aspects is given below.

Table 14. Stations where phytoplankton measurements were made.

Date & J Day	Discovery station no. (site)	Latitude (N)	Longitude (W)	Prod.	Chl./counts
15.11 / 319	15071 (B1)	61°40.07	27°00.00	3	3
16.11 / 320	15082 (B3)	62°21.00	28°31.72	3	3
16.11 / 320	15085 (B4)	62°37.94	29°09.62		3
19.11 / 323	15095 (B6)	63°17.12	30°24.17	3	3
19.11 / 323	15100 (B8)*****	63°57.66	31°11.86		3
20.11 / 324	15109 (B8)*****	64°23.61	31°47.65	3	3
20.11 / 324	15113 (B10)	64°56.61	32°30.95		3
21.11 / 325	15121 (B11)	65°15.50	33°17.90	3	3
22.11 / 326	15126 (DD7)	60°48.73	35°02.07	3	3
25.11 / 329	15135 (E18a)	63°42.23	24°40.90		3
28.11 / 332	15132				3
29.11 / 333	15151				3
30.11 / 334	15153				3
7.12 / 341	15171				3
8.12 / 342	15132				3
11.12 / 345	15208				3
12.12 / 347	15219				3
13.12 / 348	15231				3

Note: i) FRRF was deployed for each station where productivity was measured with the exception of at station B1 as the battery was flat and needed recharging; ii) The CTD cast for station B8 was split into a'physics' deep cast (D15100***)** at 9.45pm on the evening of 19 Nov and a shallow (200m) 'biology' cast (D15109*****) at ~ 10.50am on the morning of 20 Nov 2002.

CTD station sampling. When a CTD profile was completed, it was sampled at light depths of 97%, 50%, 21%, 10%, 4.5%, 1 % and 0.1% of surface PAR as determined from prior deployment of the FRRF. The 0.1% light depth was typically around 90-100m. Two additional depths of 150m and 200m were sampled for chlorophyll a and pigments.

Underwater irradiance and PAR. The underwater light field and percent light depths for sampling were measured and calculated (as a ratio) from the 2π light sensor deployed with the Chelsea Instruments FRRF and the ship-based 2π PAR sensor.

Pigments: chlorophyll-a. For each CTD station, duplicate total and size-fractionated chlorophyll-a measurements were taken. For the total chlorophyll, samples were taken by filtering 500 ml of seawater from each depth on to Whatman 25 mm GF/F filters.

Duplicate size-fractionated chlorophyll measurements were taken for surface, 10% and 0.1% light at each CTD station. Chlorophyll measurements were obtained for >20 μm, 20-10 μm, 10-5 μm and 5-0.2 μm fractions. For the >20 μm fraction, 500 ml seawater was filtered onto a Whatman 20 μm (25 mm) membrane filter. The filtrate was passed through a 10 μm plankton mesh and backwashed onto a GF/F filter to give the 20-10 μm fraction. For the 10-5 μm fraction, a 200 ml sample was screened through a 10 μm plankton mesh and particulates retained on a Whatman 5 μm (25 mm) membrane filter. From the filtrate, 50 ml was filtered onto a Whatman 0.2 μm (25 mm) membrane filter to provide the 5-0.2 μm chl-*a* fraction. Chlorophyll was extracted over 24 hr in 90% acetone in a dark fridge. Extracted pigments were read on a Turner T70 Fluorometer following the Welschmeyer (1994) protocol.

HPLC. For each of the 7 light depths as well as from 150 m and 200 m, duplicate 1.0 litre volumes were filtered onto two 25 mm Whatman GF/F filters and stored in the –70°C freezer.

Preserved samples. Phytoplankton samples (100 ml) were preserved in Lugols (1.0 ml / 100 ml sample) and separately, in Formalin (2 ml / 100 ml sample), for 3 depths (surface, 10% and 0.1% light) at each CTD station. Samples for ciliate counts were preserved (10 ml Lugols /100 ml sample) at every depth to 200 m. Picoplankton (< ~2 μm) samples were also preserved (1.8 ml sample + 50 μl filtered formalin) for each depth to 200 m.

Non-toxic seawater supply. Duplicate samples (2 x 500 ml) from the non-toxic seawater supply (~ 5 m) were filtered (as above) for total chl-*a* every 4 hours.

Ocean Sampler. The towed Ocean Sampler carries with it seven small bottles (< 500 ml capacity) for water sampling. When deployed (see elsewhere), total chlorophyll (2 x 100 ml samples) and preserved samples for ciliates were recovered as described above.

Productivity measurements. Rate measurements were based on simulated in situ (on-deck) ^{14}C radio-isotope tracer incubation experiments for each of the 6 light depths sampled. The on-deck incubation tubes, cooled with running surface seawater, were screened with neutral density filters to mimic the underwater light field.

The protocol used was as follows. For each depth, a set of three 80 ml polycarbonate 'light bottles' and one 'dark bottle' were filled with seawater and innoculated with 200 μl of 10 μCi/100 μl buffered $NaH^{14}CO_3$ working stock; ie. 20 μCi per incubation bottle. As the day length was short (~ 6 hr or less) and the chlorophyll biomass was low (~ 0.2-0.3 μg l^{-1}), the ^{14}C activity was double that used during the summer MarProd cruise (10 μCi). The 'spiked' bottles were placed in the on-deck incubators for 24 hours. At the end of this period, the bottles were filtered onto 25 mm (0.2 μm) polycarbonate Nucleopore filters to retain the phytoplankton. All filters were then fumed with 10% HCl overnight to remove unfixed inorganic ^{14}C. The filters were then placed in 7 ml plastic pony vials (Packard) and 5 ml Packard 'Hisafe 3' scintillation cocktail was added.

The precise activity of the ^{14}C spikes was determined from standards. Precisely 100 μl of the working stock was added to 10 ml 'Carbasorb' and from this, 5 replicates of 100 μl were placed in 7 ml pony vials to which 5 ml Packard 'Supermix' scintillation cocktail was added. It was hoped that samples could have been counted (DPM) on a liquid scintillation counter on-board ship. However, an instrument was not available for the cruise. Counts and subsequent calculation of productivity rates will therefore only be available once the samples have been returned to Southampton.

6.16 Nutrient data: nitrate, nitrite, silicate, phosphate

Leg 1 *- Louise Brown*

Methods

Concentrations of the dissolved inorganic nutrients nitrate and nitrite (henceforth referred to as nitrate), orthophosphate, and silicate were measured on unfiltered water samples on a Skalar SanPlus segmented flow autoa alyser, located in the forward port side corner of the deck lab. The analytical methods were based on those of Kirkwood (1983), but incorporated some modifications to the phosphate flow rates introduced on the first MarProd cruise, D258 (Pollard *et al.*, 2002), to improve peak shape. Phosphate reagent flow rates were 0.16 ml/min and sample flow rate was 1.4 ml/min. Sample and wash times were each 90 sec throughout the first leg. Throughout each sample run, wash and drift standards were run every 10-15 standards to enable baseline and drift corrections to be made to the data.

Samples for shipboard inorganic nutrient analysis were collected from Niskin bottles on all full-depth casts from CTD and ARIES sample collection systems. Samples from CTD casts were collected from every depth sampled. Samples from ARIES were collected to provide a full upcast or full downcast profile, depending on the water depth sampled. Due to inclement weather, ARIES was not deployed at station B11 – samples were taken from the seven-bottle Ocean Sampler rosette instead (station 15117). Additional underway samples were taken every 4 hr from the ship's non-toxic seawater supply. A total of 211 CTD/ARIES samples and 54 underway samples were analysed. All samples were collected in brand new 40 ml diluvials and immediately refrigerated at 4°C until analysis. All samples were analysed within 24 hr from the time of sampling. Samples for total nitrate analysis were also collected at all stations. Water was drawn directly from all CTD bottles above 1000 m depth into 60 ml sterile screw top containers and immediately frozen for analysis on return to shore.

Nutrient concentrations were calculated using calibrations curves obtained from dilutions of the same working standards used on all previous MarProd cruises. The performance of the analyser was monitored throughout the cruise by the gradient of the calibration curves from the in-house standards, measurement of the deep ocean bulk seawater sample collected on D262, and analysis of Ocean Scientific International inorganic nutrient standards. Duplicates of 2-3 samples per station, and most underway samples, were also measured to check for consistency throughout the run. After completing each run, data was processed using Skalar Flow Access v.1.4 software and saved in both Flow Access runfile and Unicode text format. The analyser was cleaned daily, and between runs, by rinsing with 10% Decon solution, followed by deionised water. The polythene tubing connecting reagents to the analyser was cleaned weekly by removing from the reagent bottles and rinsing with Decon/deionised water.

Operations

The autoanalyser was completely re-tubed at the beginning of the cruise and a new cadmium column fitted. Due to the deterioration of the performance of the analyser towards the end of D264, it was thought prudent to also install new photometer bulbs. New reagents were prepared for all methods at the beginning of the cruise. The silicate reagents were sufficient to last the entire first leg, and the nitrate reagents from the beginning of the cruise until 21 November. However, whilst the phosphate reagents should have been adequate to for the first leg, it was noticed that the stability of the background and the quality of the peak shape deteriorated significantly after a few days. The system was cleaned thoroughly, including the reagent bottles, and new reagents prepared. This rectified the problem in the short term, but a similar degradation of peak quality occurred within 3-4 days of the new reagents being introduced.

Performance of the analyser

Baselines and calibration. The calibration constants determined for each run using the nutrient standard solutions are shown as a time series in Fig 23. With the exception of run 6, nitrate remained fairly stable during leg 1 (261 ± 7.3 DU, excluding this run). The phosphate calibration constant was noticeably higher in the first four runs (817 ± 7.3), then decreased to a stable level for the remainder of the leg (776 ± 6.1). In comparison, the silicate calibration was fairly variable throughout the cruise (181 ± 15.8). The goodness of fit of the calibration for all methods was >0.999 for all runs after run 2 (Fig 23); this is a significant improvement over D264 for the nitrate method. The baselines for all methods were stable throughout this leg, with percentage standard deviation from mean values of 1.2, 0.3 and 1.3 for nitrate, phosphate and silicate respectively (Fig 24).

Standards and duplicates. Three samples of deep ocean (>1500 m) bulk seawater collected on D262 were measured on each run to determine day-to-day variations in autoanalyser

precision (Fig 25). The mean values for leg 1 were 7.08 ± 0.11 µmol/l for nitrate, 0.55 ± 0.02 µmol/l for phosphate, and 10.63 ± 0.08 µmol/l for silicate. The measured concentration of nitrate clearly decreased over the leg, and the values recorded also represent a significant decrease from the initial values recorded on D262 for nitrate and phosphate, most likely due to biological utilisation of the nutrients.

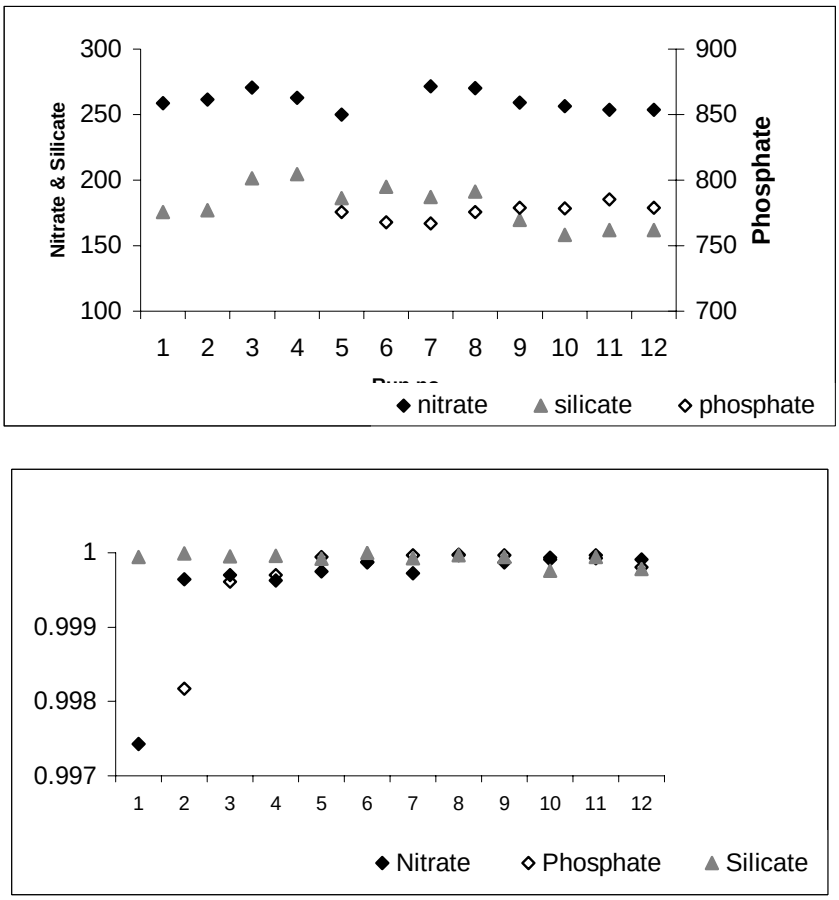

Fig 23. Upper graph, calibration constants, determined using the nutrient standard solutions, shown as a time series; lower graph, the goodness of fit for the calibrations.

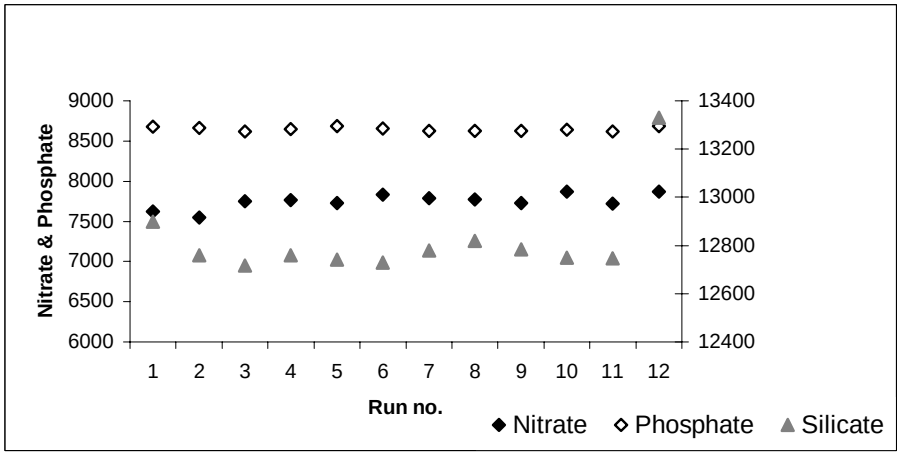

Fig 24. The baselines for nitrate, phosphate and silicate.

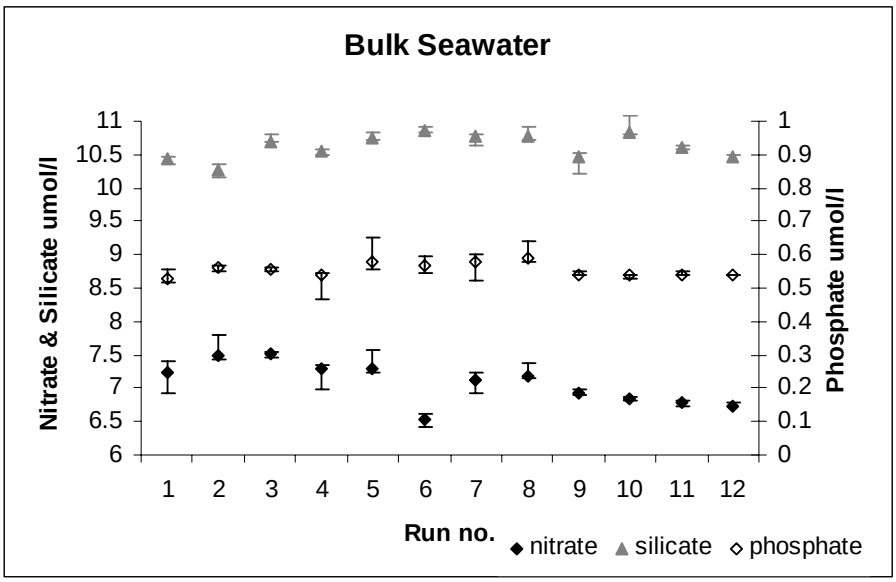

Fig 25. Day-to-day variations in autoanalyser precision.

Three to five samples of Low Nutrient Seawater and nutrient standards (Ocean Scientific International) were run at the beginning and end of the first leg. For the nutrient standards, values of 8.49 ± 0.1 and 8.46 ± 0.02 µmol/l were obtained for nitrate, 0.90 ± 0.005 and 0.93 ± 0.005 µmol/l for phosphate, and 10.20 ± 0.07 and 10.47 ± 0.04 µmol/l for silicate. Low nutrient seawater samples ranged from –0.07 to 0.14 for nitrate, -0.01 to 0.02 for phosphate, and 0.50 to 0.87 for silicate.

Three samples per CTD or ARIES cast, and at least three underway samples were measured in duplicate on each cast. Absolute (mean of value 1 – value 2, expressed as a positive number) and true (actual mean of value 1 – value 2) differences were calculated for each run of samples (Fig 26). No systematic change in absolute difference for any of the chemistries was observed throughout leg 1. The mean first leg absolute differences were 0.14 µmol/l for nitrate, 0.01 µmol/l for phosphate, and 0.10 for silicate; comparable with values obtained on previous MarProd cruises. There is some suggestion of a tendency for the second nitrate measurement to be greater than the first (i.e. negative true difference) but this is not consistent throughout the cruise, so it may be an artefact of the low number of sample runs included in the analysis.

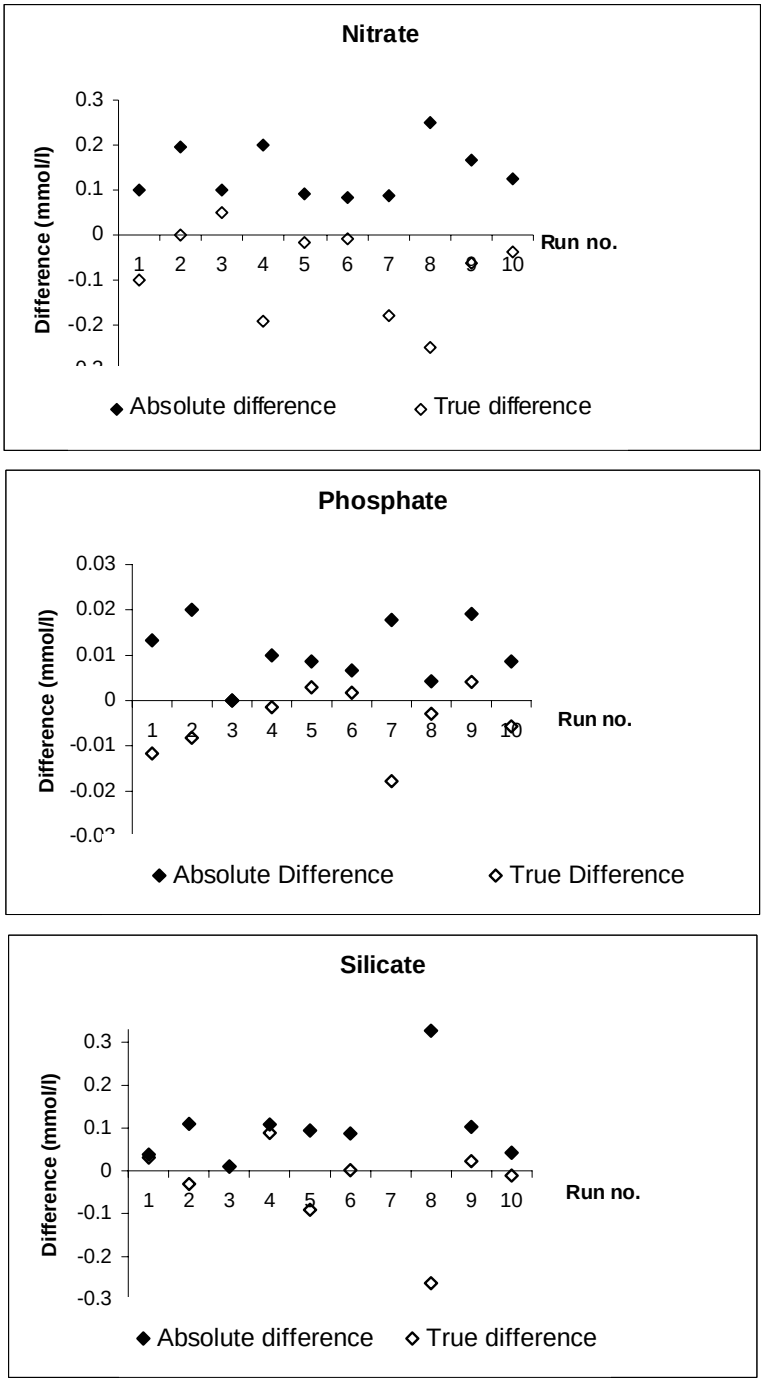

Fig 26. Absolute and true differences calculated for each run of samples.

Addendum for Leg 2 *- Richard Sanders*

Closely similar analytical methods were followed for Leg 2 as Leg 1, with the following notes. The cadmium column was removed at the start of the leg and the valve that isolates it from the rest of the chemistry manifold removed. This was in an effort to improve the precision measured earlier. A new column was fitted and instead of glass wool being used to prevent cadmium granules entering the reaction column, two thin pieces of 1mm piping were inserted into the column. The theory here is that the glass wool gets plugged up with small

granules of cadmium and eventually the column blocks. Narrow diameter tubing allows small pieces of Cd to eneter the flow cell and exit in the waste stream. Cadmium column efficiency was monitored using a nutrient standard. The mean column efficiency was 90 ± 4%.

The performance of the phosphate line was less than optimal throughout the second leg for two reasons. Firstly the standard curve did not obviously intersect with zero on a regular basis. This can be explained by phosphate contamination in the artificial seawater used to make up the standards, however this material is also used to make up the intersample wash. Contamination in the bulk reservoir used to contain the intersample wash was investigated , this was confirmed by analysing two samples of Ocean Scientific International Low Nutrient seawater on each run ensuring that these samples were only placed in the carousel immediately prior to sampling to avoid atmospheric contamination.

In contrast, samples of the standard and wash artificial seawater which were analysed as unknowns and sat on the carousel for up to an hour before being drawn into the instrument frequently gave large signals (order 0.03 μM). It is therefore likely that samples in the cups on the carousel receive contamination from the lab atmosphere. This was addressed by trying to only load a maximum of 20 samples onto the carousel. Running the analyser in a proper chemistry laboratory away from open doors and other scientists processing biological samples must be considered. Obviously erroneous peaks were edited out and rerun where practicable.

In practical terms the problem was addressed by exporting the data to Excel and calculating a calibration curve from the corrected peak heights, not forcing this through the origin. This cannot be done in the Skalar software which offers two calibration options. The first is a linear fit forced through the baseline which is inappropriate here given the contamination in the standards. The second is a first order fit not forced through the baseline. However, this automatically subtracts the offset from the peak height before calculating a result. In the assumption that the samples on the carousel were non-contaminated this was also considered inappropriate. Instead the slope of the Excel-generated curve was applied to the raw peak heights relative to the baseheights generated by flow access to evaluate concentration. This method gave results consistent with the Leg 1 data, the flow access generated values were generally around 0.05 μM higher or lower than the Excel generated values depending on the Skalar calibration method used. The assumption that samples were not contaminated on the carousel is probably inaccurate given that it appears likely that the standards and wash samples were contaminated, but there is no obvious way to correct for this in a rigorous way.

Secondly, the baseline and peaks were extremely noisy, particularly when samples and standards were introduced to the analyser. The line was dismantled and soaked in Decon on 4 December to try and eliminate this problem but it remained throughout Leg 2. In addition, new phosphate reagents were prepared on 7 and 10 December following the example set by Louise Brown on Leg 1. I am accustomed to washing the phosphate line with dilute NaOH to try and eliminate this problem; however, on this cruise I only used Decon. In addition a de-bubbler line was removed from the phosphate manifold to try to calm the flow within the line. Overall more rigorous cleaning with a more aggressive agent and a more frequent preparation of reagents (daily) in small volumes need to be applied. It is our intention to switch to an alternative phosphate method in the near future on both the SOC Skalar autoanalysers. I also note that Louise was conducting shorter runs and this needs to be considered - although it is not always practical.

Performance of the analyser

Baselines and calibration. The calibration constants determined for each run using the nutrient standard solutions are shown as a time series in Fig 27.

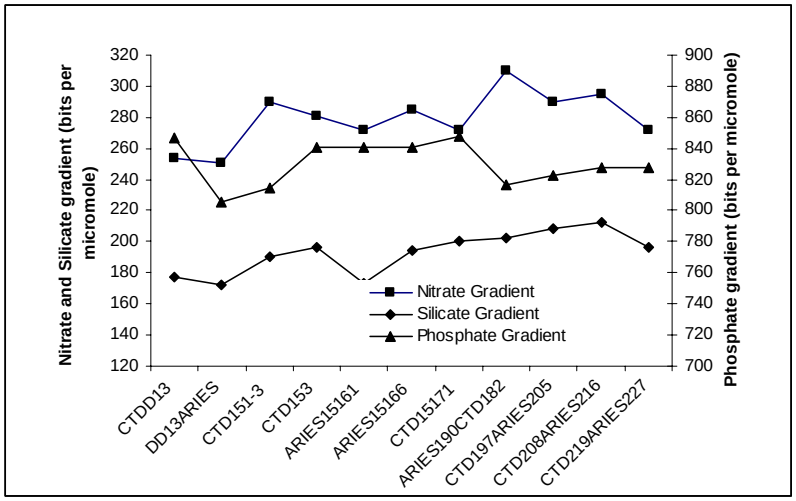

Fig 27. Time series of instrument calibration constants during Leg 2.

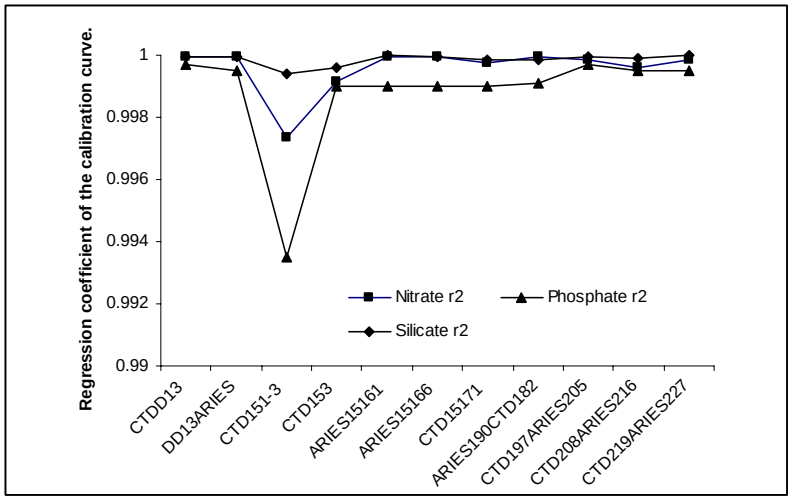

Fig 28. Time series of regression values for calibration curves.

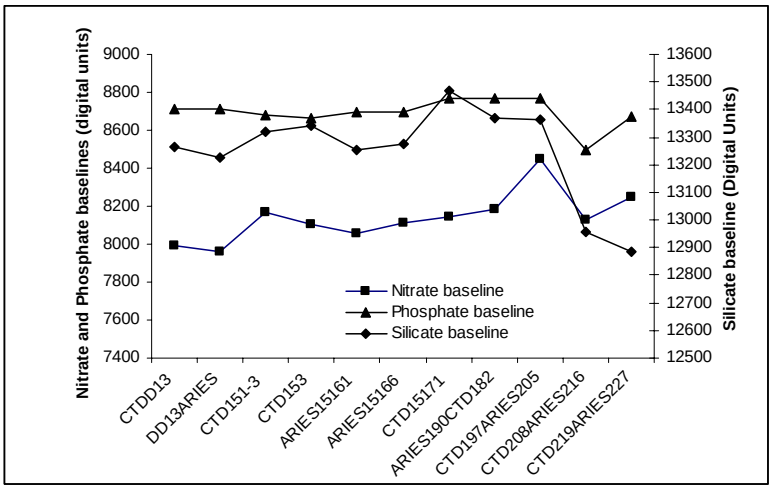

Fig 29. Time series of instrument baseline values during Leg 2.

With the exception of run 8, nitrate remained fairly stable during Leg 2 (276 ± 15 Digital Units, excluding this run). The phosphate calibration constant was fairly stable over Leg 2 (830 ± 14 DU), as was the silicate calibration (192 ± 13 DU).

The goodness of fit of the calibration for all methods was >0.999 for all runs except run 3 (Fig 28); this is a significant improvement over D264 for the nitrate method.

The baselines for all methods were stable throughout this leg, with percent standard deviation from mean values of 1.6, 0.6 and 1.3 for nitrate, phosphate and silicate respectively (Fig 29).

Standards and duplicates. Two samples of Low Nutrient Seawater were run on each run. The results were used to zero the phosphate baseline. Ocean Scientific nutrient standards were run on 17 December to calibrate the remaining master nutrient standards which have been used for the whole MarProd programme of cruises. The results from these analyses are too late to be included here.

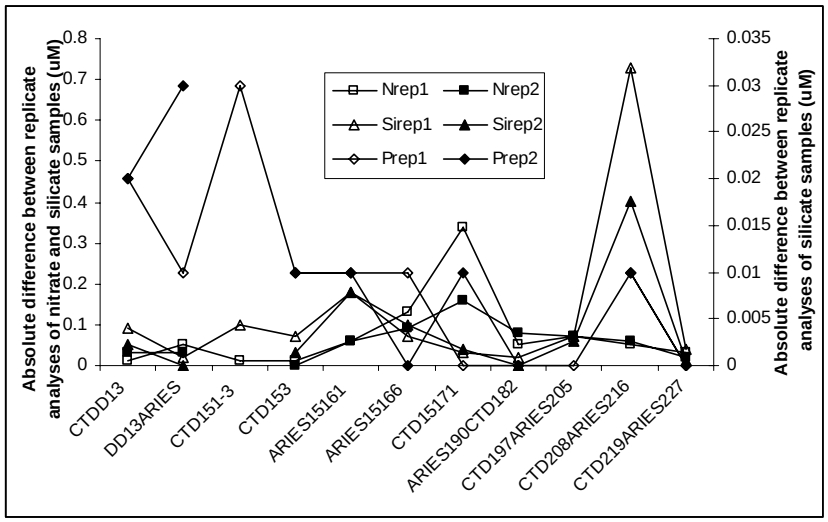

Fig 30. Time series of absolute differences between duplicate measurements.

Two samples per analytical run were duplicated. The limited number of runs means that I have not attempted a carryover analysis such as that conducted on CD139 which conclusively showed a minor carryover problem for silicate or the one attempted eralier in this report for Leg 1 with inconclusive results. Fig 30 shows the time series of the absolute differences between replicate samples for each of the three nutrients analysed. It is noticeable that the phosphate error declined significantly over the course of the cruise, reflecting the work carried out on the manifold and that the highest nitrate and silicate errors were observed at the end of the cruise. This coincided with the sampling of very high silicate (>30µM) bottom waters of Antarctic origin recirculating round the Rockall Hatton plateau.

The mean second (first) leg absolute differences were 0.07 (0.14) µmol/l for nitrate, 0.01 (0.01) µmol/l for phosphate, and 0.1 (0.1) for silicate; comparable with values obtained on previous MarProd cruises. Thus the work carried out on the nitrate line probably had some effect.

Comparison between Leg 1 and Leg 2 data

This was undertaken by evaluating the N/P ratio of the whole Leg 2 dataset (~ 400 paired measurements) and comparing it to the N/P ratio of the CTD dataset from Leg 1 (~150 paired measurements). The results, shown in Fig 31 suggest that the two datasets compare well. There is more scatter in the Leg 2 datset reflecting the larger number of datapoints used in the analysis.

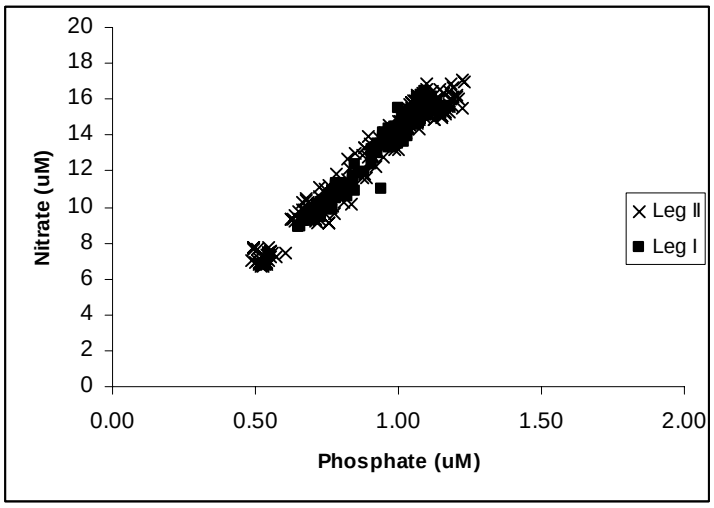

Fig 31. N/P ratio of the datsets from the two legs of the cruise.

6.17 Dissolved oxygen concentration

Louise Brown, Richard Sanders, Liz Rourke and Sophie Fielding

Dissolved Oxygen (DO) samples were taken from 6-8 Niskin bottles fired at all CTD stations. The oxygen samples were the first to be collected from the CTD rosette as soon as was practicable after the CTD had been secured to the deck. Samples were collected using Tygon tubing into pre-calibrated glass DO bottles with ground glass tops, which were rinsed three times before being filled with the sample. Dissolved oxygen was then fixed immediately by addition of 1 ml manganous chloride and 1 ml alkaline iodide from Anachem dispensers, then the bottles sealed and shaken. A second DO bottle was rinsed and filled with sample from the same Niskin and the temperature of the water measured using a hand held electronic thermometer. The samples were stored underwater until analysis.

After storage for 1-8 hr, samples were acidified using 2.5 ml 5M H_2SO_4 and immediately titrated with sodium thiosulphate of nominal concentration 0.1 M. The titration was carried out using the SIS dissolved oxygen kit with photometric endpoint detection and a PC equipped with DOA software. This system was located on an island bench adjacent to the nutrient autoanalyser kit in the deck lab.

The normality of the thiosulphate solution was checked prior to each set of analyses by determining the quantity of thiosulphate required to titrate triplicate samples of 10 ml of an in-house known concentration (~ 0.01 M) potassium iodate standard. The mean value obtained for concentration of the thiosulphate was 0.0978 ± 0.002 M. Oxygen concentration, in µmol/l was then determined using an Excel spreadsheet containing the equations of Dickson (1994). One replicate sample, usually from the deepest station, was measured for each cast. At two stations, 15100 and 15113, the replicates varied by >30 %. At least one of these may be due to a leaking Niskin bottle. Excluding these two stations, the mean difference between Leg 1 replicates was 0.58 µmol/l.

Problems obtaining a low, repeatable reagent blank for oxygen analyses were encountered throughout Leg 1. Steps taken to rectify this included cleaning the reagent dispensers, replacing reagents, increasing the speed of the magnetic stirrer and the volume of water in the bottle, and changing the quantity of KIO3 used in determining the blank from 1 ml to 5 ml. These modifications stabilised the blank somewhat, but it remained high compared to the values obtained on D262 and D264 (on the order of 0.02 compared to 0.002 ml). Applying a blank correction increased the DO values by about 5 µmol/l. It is anticipated the reagents

will be subject to testing on different DO equipment on return to SOC to resolve this problem.

Addendum for Leg 2

The same analytical methods were used as on Leg 1. The instrument was calbrated using OSI potassium iodate each time samples were run. At least one sample per cast was duplicated. The mean difference between duplicates was 1 μmol/l. Following the loss of the CTD all bottles were sampled on casts conducted using the new package to maximise the number of samples that could be used to calibrate the electrode on the limited number of casts remaining.

6.18 Seawater ammonium and atmospheric ammonia measurement – *Martin Johnson*

In order to calculate transfer of ammonia gas across the air-sea interface, atmospheric ammonia concentrations and seawater total ammonium concentrations were measured. Atmospheric ammonia samples were collected using in-line acid coated paper filters and ammonium assay was conducted using the OPA fluorimetry method outlined by Holmes *et al* (1999). This work was funded by the NERC thematic research programme, Global Nitrogen Enrichment and, as such, all data will be made available through the NERC data centre at CEH Monks Wood, Cambridgeshire.

Atmospheric ammonia

Normally the filter pack equipment used to collect ammonia samples is placed on the monkey island or the boat deck on a ship, to maximise the periods when air unaffected by the ship is available for sampling. For safety and logistical reasons, neither of these options was suitable for this winter cruise and so the equipment was set up on the boat deck level on the port side, behind the bridge. Sampling could then only be conducted when the wind direction was in an approximately 100º arc – from just to the port side of dead ahead to just aft of directly on to the port side. Samples were not run during rain events or in bad weather because of the interference of rain / sea spray and also, in the latter case, for safety reasons. Samples needed to be run for a minimum of 15 hr to obtain a significant signal; so only during long steams was it viable to deploy samples. The combination of these requirements and the long periods of bad weather during which it was impossible to work resulted in only two high quality ammonia samples being taken (Table 15). As there are no previous winter measurements of atmospheric ammonia in remote Northern seas, let alone the Irminger basin, these two measurements are of considerable value.
Filter pack samples are run by pulling air through three in-line acid-coated paper filters, which trap ammonia gas from the atmosphere. A 1 μm PTFE filter is placed in front of the paper filters to trap particulate (aerosol) ammonium. Greater than 90 % of the ammonia is trapped by the first acid coated filters, the second and third filters acting as back-ups. These filter packs are deployed in tandem in order replicate the measurement. A third filter pack is deployed without air flow, to act as a blank for aerosol ammonium and gaseous ammonia.

Table 15. Summary of successful atmospheric ammonia measurements.

	FP2		FP3	
	Start	**Finish**	**Start**	**Finish**
Latitude	61.668	62.562	65.117	61.297
Longitude	-27.044	-29.117	-33.215	-34.733
Date / time	15/11 15:36	16/11 14:30	21/11 11:05	22/11 08:30

Seawater ammonium concentrations

Seawater ammonium analysis was conducted using a Jasco FP750 spectrofluorometer. This is a lab instrument not really designed for use at sea. On previous cruises it has behaved well and provided extremely high quality data. However, it did not take kindly to the continual movement of the ship, and provided spurious results on rough days. The general stability of the instrument seems to have been affected as well – the high variability in repeated measurements of the same samples / blanks led to a detection limit of 10 to 20 nM rather than the usual 5 nM. This was problematic as many of the samples run were of 20 nM concentration or less. It is recommended that future marine measurements of ammonium using this technique are run on a simpler and more robust fluorometer, such as a Turner designs 10AU with the necessary filters and lamp.

Samples were taken from the non-toxic supply and also from Niskin bottles on CTD casts. Table 16 lists CTD stations and underway samples taken. The same method was used to analyse the atmospheric ammonia and ammonium samples. Calibrations were made using standard additions of a 50 µM ammonium chloride stock standard solution. Each set of samples was calibrated individually.

Table 16. List of ammonia data from CDT stations and underway samples.

CTD stations sampled	Date / Time of underway samples
15082	09/11/2002 16:25
15095	15/11/2002 15:45
15121	16/11/2002 14:16
15139	21/11/2002 17:16
15171	22/11/2002 09:20
15182	02/12/2002 09:10
15197	02/12/2002 12:56
	02/12/2002 21:07

6.19 Genetic structure of *Calanus finmarchicus* populations – *Bob Houghton*

The objective was to sample winter populations of *Calanus finmarchicus* at six stations in and around the Irminger Basin (C6, DD9, D0/D1, EG2, IG1/India and E18a/b) as part of a wider study considering the effects of current systems in the North Atlantic and Norwegian Sea on the genetic structure of *C. finmarchicus* populations. Where possible, samples were to be depth specific and composed of between 50 and 100 animals.

In the event, primarily as a result of bad weather, samples were obtained from only two of the six targeted stations (DD9 and E18b), neither being depth specific. However, a further seven samples – 4 depth specific – were obtained from other stations during the cruise which will be useful to the study in respect of the general ecological and physiological aspects of *C. finmarchicus* and in developing primers for microsatellite analysis. Two samples were obtained for Dual Methot tows, while the remainder came from ARIES 4 deployments.

Although this may not appear to be a significant return from 6 weeks at sea, it should be considered in the light of the difficulties encountered in getting on station – and, when that was achieved, the relative scarcity of *C. finmarchicus.*

6.20 Cetacean surveys – *Bob Houghton*

During the cruise a number of cetacean surveys were carried out. These were done as an additional activity, on an *ad hoc* basis, following the guidelines for ship-based observations issued by the cetacean monitoring unit at Seawatch Foundation. Six watches, varying in

duration from 30 to 100 minutes, were undertaken between 14 November and 2 December giving a total observation time of 260 minutes.

Cetaceans were encountered during 50% of the watches and on 5 other occasions outside of the surveys. Two species were observed during the surveys – White-beaked dolphins (*Lagenorhynchus albirostris*) and Minke whale (*Balaenoptera acutorostrata*). Both of these species were sighted outside watches along with additional sightings of Harbour Porpoise (*Phocoena phocoena*) once, Short-beaked or Long-beaked common dolphins (*Delphinus delphis* or *D. capensis*) once and one very large Mysticete, possibly a Blue whale (*Balaenoptera musculus*) but more likely a Fin whale (*Balaenoptera physalus*).

For a number of reasons, mainly relating to the sea state, cetacean watching at sea is notoriously difficult and often highly selective. Positive ID to species level is often impossible – for example, even though the Common dolphins mentioned above were bow-riding and close observation for 10 minutes or more, positive discrimination between short-beaked and long beaked varieties will have to wait until the photographic records are to hand and even then may not prove definitive. That said, for all the frustrations and the sporadic nature of sightings, scientifically conducted surveys, particularly at sea, remain an important source of information for cetacean researchers and hopefully can be continued on future cruises. There are few things on board that generate as much interest and excitement among both crew and scientists as the sighting of a whale or dolphin and I for one shall long remember looking down over the side being blasted by an icy wind, trying to get a steady view and a good photograph of the dolphins riding the bow wave while the ship bowled along, rising and falling in the North Atlantic swell – quite an experience!