Cruise Report

JC 69 "DIMES UK 3"

RRS James Cook, 31 January - 22 March 2012

Contents

1. CRUISE MANAGEMENT

Andrew Watson

1.1 SCIENTIFIC PERSONNEL

These came from University of East Anglia (UEA), Southampton University and National Oceanography Centre (NOCS), Woods Hole Oceanographic Institution (WHOI), Florida State University (FSU), and University of Oxford

JC069 Cruise participants

Scientific Personnel			
Institution	**Last name**	**First names**	**Role**
U. Southampton	NAVEIRA	ALBERTO CARLOS	Co-P Sci,
UEA	WATSON	ANDREW JAMES	Co-P Sci, tracers
FSU	BALWADA	DHRUV	Sound sources, tracers
U. Oxford	BOUMAN	HEATHER ALISON	Trace metal species
U. Southampton	BREARLEY	JAMES ALEXANDER	VMP, Moorings
U. Oxford	BROWNING	THOMAS JOHN	Trace metal species
U. Southampton	COURTOIS	PEGGY	1st Leg
WHOI	DECOTEAU	KENNETH LEE	WHOI VMP
NOCS	KING	BRIAN ANTHONY	CTD, Physics
WHOI	KRISHFIELD	RICHARD ALAN	1st leg HRP
	LIANG	XINFENG	LADCP
UEA	MACKAY	NEILL SUTHERLAND	Tracers
UEA	MESSIAS	MARIE JOSE	Tracers
UEA	MILLS	BENJAMIN JOHN WILLIAM	Tracers
	RAINVILLE	LUC	CTD Physics, 1st, 2nd legs
U. Southampton	SHEEN	KATY LOUISE	NOCS VMP
WHOI	ST LAURENT	LOUIS	WHOI VMP
WHIO	TOOLE	JOHN MERRILL	1st leg HRP
WHOI	WELLWOOD	WARREN DAVID	1st leg HRP
UEA	WOODWARD	STEPHEN COLIN ASHLEY	Tracers
	ZAJACZKOVSKI	URIEL	
	HINOJOSA	GABRIELA	Chilean Observer
NMFSS	PROVOST	PAUL GRAHAM	ST
NMFSS	BENSON	JEFFREY RAY	Tech
NMFSS	BURRIS	JAMES EDWARD	Tech
NMFSS	KNIGHT	GARETH CHARLES	TOM
NMFSS	PHIPPS	RICHARD ANTHONY	Tech
NMFSS	WHITTLE	STEPHEN PAUL	Tech

1.2 Marine Personnel

1	RICHARDSON	WILLIAM	Master
2	WARNER	RICHARD ALAN	C/O
3	HOOD	MICHAEL PATRICK	2/0
4	MORLEY	CATRINA	3/O
5	LUCAS	ROBERT	C/E, 3rd leg
6	McDONALD	BERNARD JOSEPH	C/E, 1st 2nd leg
6	HAGAN	JOHN ANDREW	2/E
7	COLIN	IAN STUART	3/E
8	BRADY	WILLIAM	3/E
9	HAWKSWORTH	DAVID RONALD	ETO
10	McDOUGALL	PAULA ANNE	PCO
11	CRIMMIN	SAMANTHA	Doctor
12	MINNOCK	MICHAEL	CPOS
13	MACLEAN	ANDREW	CPOD
14	PRICE	DAVID ANTHONY	POD
15	CANTLIE	IAN MICHAEL	SG1A
16	SIMS	KENNETH NEIL	SG1A
17	MACKENZIE	WILLIAM	SG1A
18	SMITH	PETER	SG1A
19	SMYTH	JOHN GERARD	ERPO
20	CONTEH	BRIAN	M/Man
21	HAUGHTON	JOHN	H/Chef
22	LINK	WALTER JOHN THOMAS	Chef
23	MINGAY	GRAHAM MALCOLM	Stwd
24	PIPER	CARL	A/Stwd

1.3 DIMES OBJECTIVES

JC 069 was part of the DIMES project, "Diapycnal and Isopycnal Mixing Experiment in the Southern Ocean", which is a joint UK and US project, funded by the National Science Foundation in the US and NERC in the UK. The objective of DIMES is "to test and, if necessary, redefine the present paradigm of Southern Ocean mixing by obtaining the first systematic measurements of mixing processes in two contrasting regimes (the SE Pacific and the SW Atlantic) of the Antarctic Circumpolar Current (ACC)". The methods used are (1) the release of an inert chemical tracer, CF_3SF_5 (tri-fluoromethyl sulphur pentafluoride) in the SE Pacific sector west of Drake Passage and following its dispersion horizontally and laterally as it transits the SE Pacific, Drake passage and the Scotia Sea, (2) The use of fine structure and microstructure measurements from LADCP, CTD and free-falling microstructure probes, (3) the deployment of a substantial array of moorings in the east of Drake Passage to observe the relationship between eddy activity, internal wave activity and vertical and horizontal mixing (4) the release of numerous floats both neutral density type RAFOS floats and surface drifters and (5) interpretation of model data.

The original plan for the DIMES field program is shown in fig 1.3.1, showing the geographic location of the program and the time line of the project.
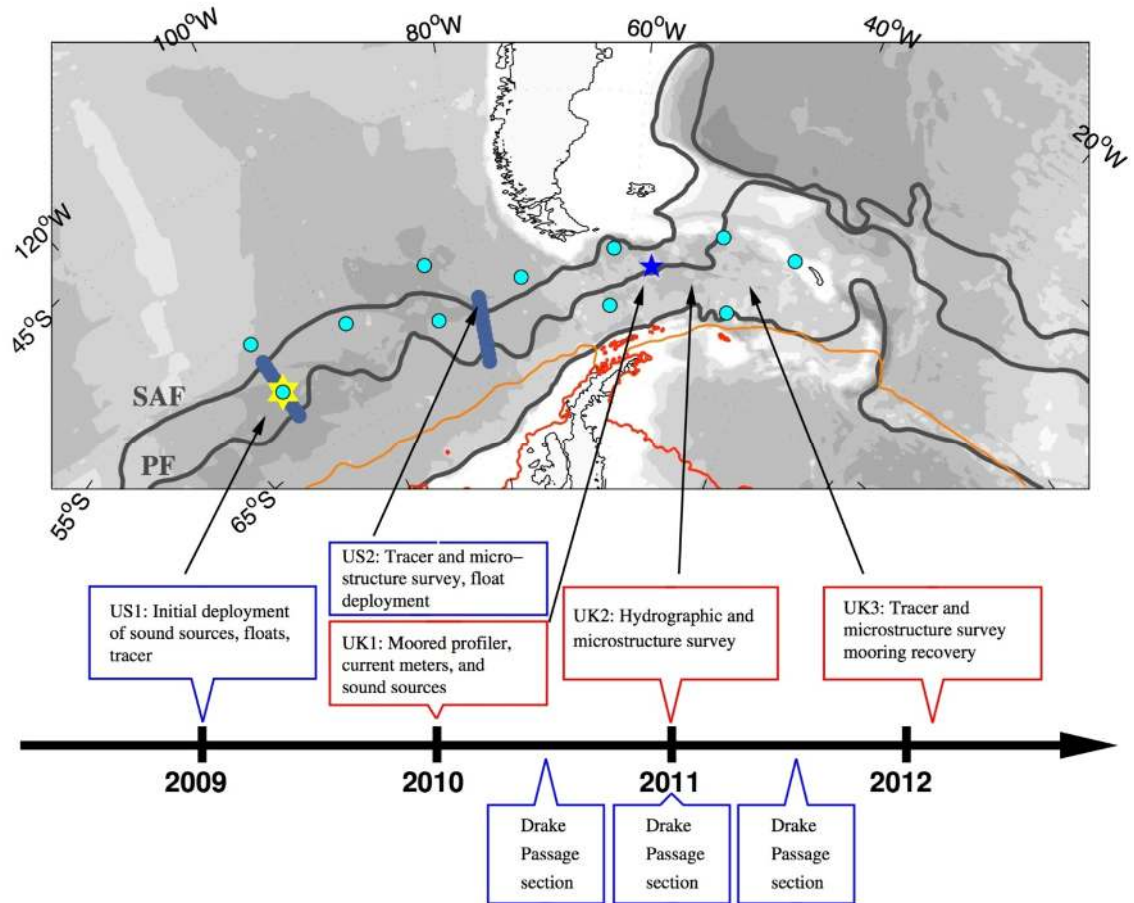
1.4 CRUISE OBJECTIVES

This was cruise "UK 3" of the DIMES project. A tracer and float release were initiated on US1, in February 2009 in the eastern S. Pacific. At the beginning of 2010, cruise UK1 deployed six moorings in an array at 56°S, 57° 50'W, to capture simultaneous data on eddy structure, currents and fine structure, and also sound sources for the positioning of RAFOS style floats. At about the same time, cruise US2 completed a survey of the tracer patch, plus positioning of further floats, in the eastern Pacific sector of the Southern Ocean. This was followed one year later . by UK 2 -- moorings, hydrographic, tracer and microstructure were undertaken by *RRS James Cook* on cruise JC 54 from November 2010-January 2011. Because that cruise was severely impacted by ship-side problems, the work of UK 2 was completed by a second expedition aboard the *James Clark Ross* (UK2.5, JR276) in April 2011. These two cruises together completed 5 sections to the west and east of Drake Passage on which tracer and microstructure measurements were made. A summary of the measurement locations up to the end of 2011 is shown in fig 1.4.1
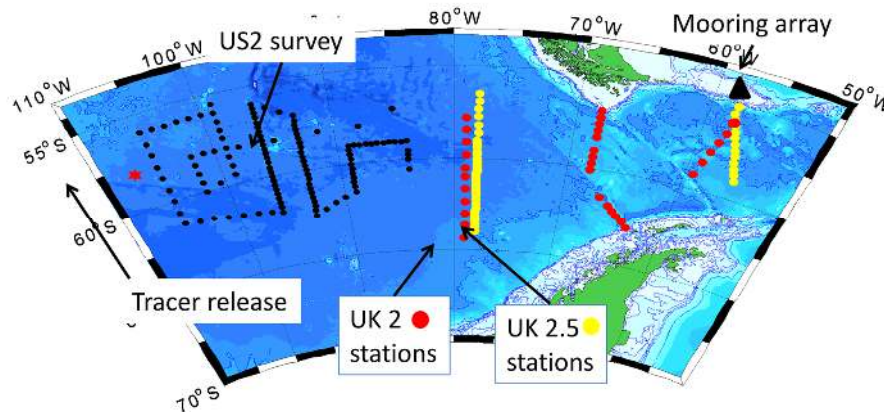
Figure 1.4.1 Summary of DIMES surveys and sections up to end of 2011.

The objectives of JC069 were to conduct further surveys of tracer and microstructure west and east of Drake Passage, as the tracer patch moved through the region. Additionally, it was our aim to survey downstream of Drake Passage, throughout the Scotia Sea and in particular along the North Scotia Ridge, concentrating on the gaps in that ridge through which the Antarctic circumpolar current (ACC) is channelled, in order to determine the influence of the Scotia Sea on horizontal and vertical mixing. we planned to recover the DIMES array and sound source moorings previously deployed, and to release further AARDVARK drifters, which are surface drifters designed to test the the effect of mesoscale dynamics on isopycnal transport.
In summary the principal objectives of JC069 were (see fig 1.4.2 for locations):

(A) Tracer and microstructure section" along the North Scotia Ridge, concentrating on the gaps and passages

(B) Tracer and microstructure section through the centre of the Scotia sea, from SE to NW

(C) Recovery of the DIMES mooring array (red triangles in the figure).

(D) Tracer and microstructure section along SR1, eastern Drake Passage.

(E) Recovery of three FSU sound source moorings (red circles in figure).

(F) Tracer and microstructure section along A21 line, western Drake Passage

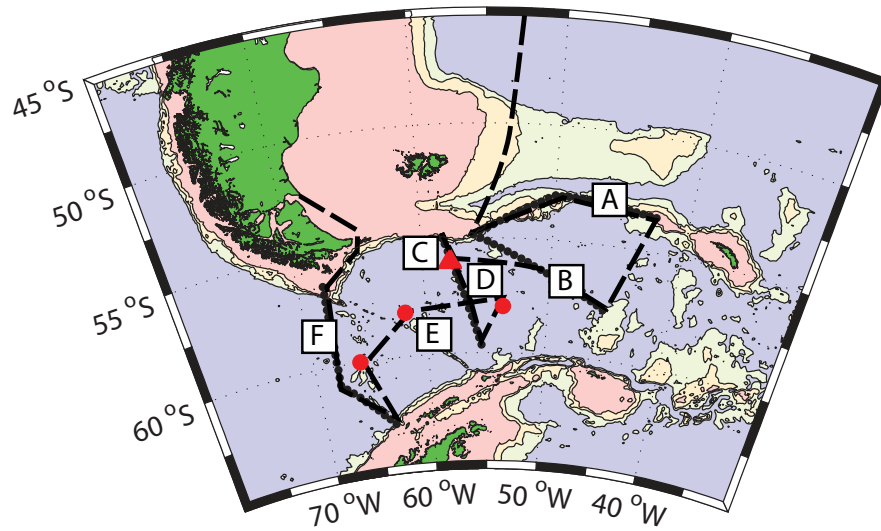(G) Deployment of ~10 Aardvark drifters and several SOLO floats at intervals along the cruise track.

Fig 1.4.2: Planned activities on the cruise Red diamonds are UK moorings, red circles are sound source moorings.

1.5. CRUISE ITINERARY

Date	Time (GMT)	Action
31/01/2012	15:00	Depart Montevideo
03/02/2012	14:30	First deployments
06/02/2012	03:00	Commence work on N. Scotia Ridge
17/02/2012	02:00	Depart for Port Stanley – Medevac
19/022012	23:00	Return from Medevac
20/02/2012	23:00	Depart for Port Stanley, second Medevac
25/02/2012	11:00	Return from Medevac
01/03/2012	18:00	
04/03/2012		Complete work on N. Scotia Ridge
05-06/03/2012		Recovery of UK DIMES mooring array
07/03/2012	06:00	Commence work on SR1 line
11/03/2012	22:00	End work on SR1 line
12-13/03/2012		Recovery sound sources
13/03/2012	22:00	Commence work on A21 line
17/03/2012	02:30	Last completed cast on A21 line

Time and position of the deployments, recoveries and samples taken is given in the event log, see appendix.

1.6 CRUISE TRACK

Figures 1.61 and 1.62 below show the full cruise track and the working region, with station numbers for selected stations
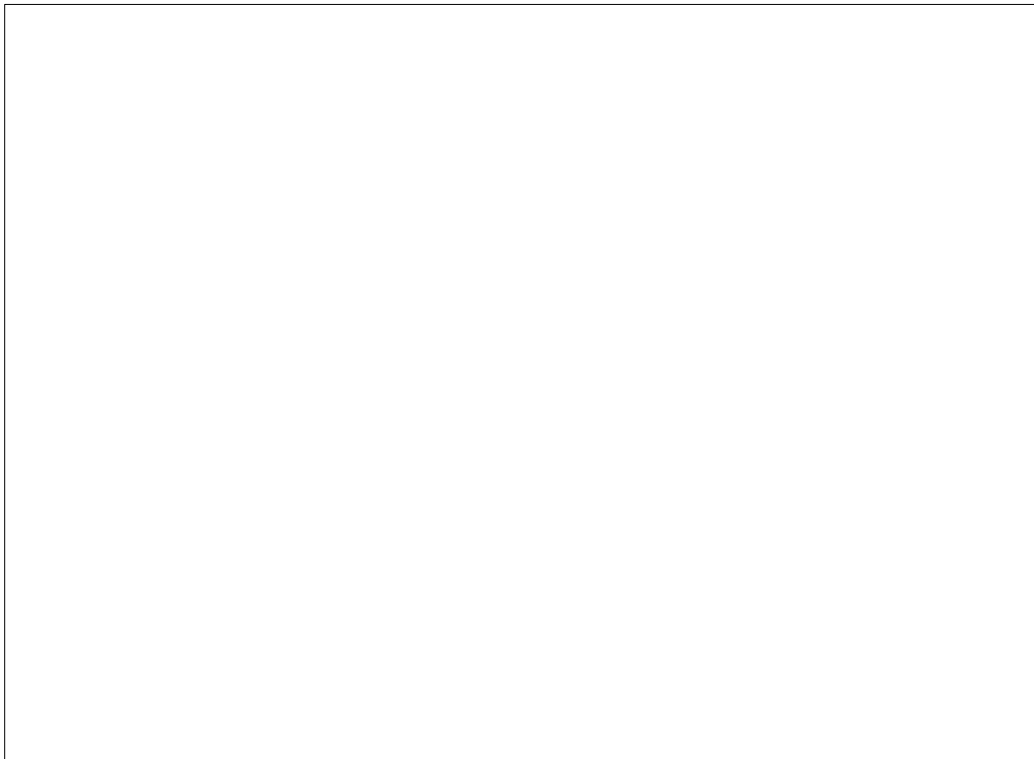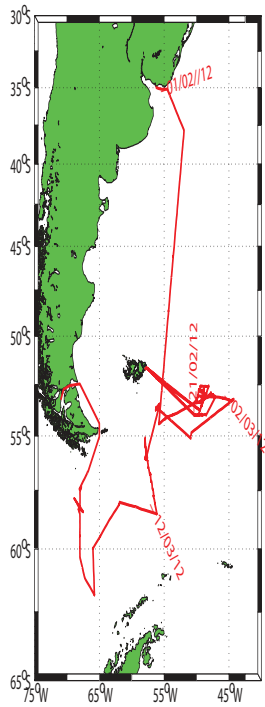
1.7 CRUISE NARRATIVE

31/1/12 1310: sailed from Montevideo.
1615 boat drill and muster
1830 science meeting

01-02 /2/12 steaming south, weather good.

3/2/12 Test station in southern part of Argentine basin. We tested HRP, NOC VMP and WHOI VMP, then CTD cast 001. In all, spent around 7 hours on station from 11am local time to 6pm. We did operations one at a time, rather than trying to get sophisticated about timings at this stage when we are all learning the ropes.
HRP – test dive to 1000 m. Discovered that the ship's echo sounder could not pick up the HRP's 12khz pinger. Problem, since without a pinger we have no knowledge of how the HRP is doing and what depth it is at.
NOC VMP – tethered dive to ~100m.
WHOI VMP: The instrument surfaced prematurely and was apparently run over by the ship. Damage to the instrument but fortunately it did not impact the propeller and the package was recovered in one piece. Damage was not terminal but not trivial either.
Test CTD – good cast, all bottles fired and none leaked.
Deployed trace metal fish before moving off.

4 /2/12 We detected tracer in the first, test station so decide to do a second station in the S. Argentine basin on our way south.

6/2/12: We reached western North Scotia Ridge and began CTD stations at 03:00. Sea state marginal for deployment and CTD winch operated at slow rate. Problems experienced after station 006 with CTD wire retermination necessary.

7/2/12: Continued, slow progress CTD stations; HRP second cast.
8/2/12 First VMP cast: Deteriorating weather led to downtime until evening. CTD stations continued (station 10).
9/2/12 Continued CTD stations (station 12). HRP deployed and either did not resurface or DF radio failed, so no communication. We spent time searching and deployed two drifters to track the surface current: by deploying close together they could also be used for the Aardvark experiment additionally. We continued CTDs, waiting for darkness to resume the search for the HRP and relying on its strobe to improve chances of sighting.

We spent the night looking for the HRP in a pattern extending some 30km to the northeast, guided by the extent of movement of the surface drifters, and relying on the strobe light which should be visible at distance in darkness. No luck however. Search called off at dawn.

10/2/2012: Continued CTD and VMP stations, (stations 13-16)

11/02/2012
Following station 17, in calm weather with good visibility we elected to do one further search for the HRP, and therefore steamed northeast to the best guess of its

present position. Increasing fog began to reduce visibility, to about 100m by mid-day, and the search was abandoned, the prospects of siting the instrument being deemed slight under such conditions. Returned to a working area to the north of Shag Rocks passage, we had a delay due to winch problems. Station 18 begun late evening.

12/02/2012: Continued CTD stations 18-20 in a W-E line north of Shag Rocks passage. Weather shut down operations for ~24 hours following station 20.

13/02/2012: Recommenced work on eastern flank of Drake Passage, float tested WHOI VMP successfully.

14/2/12: As the CTD was being brought inboard and while preparing for a VMP cast, a hydraulic hose burst on the CTD parallelogram, leading to fluid contaminating the sensors of the WHOI VMP. CTD and VMP casts continue.

15/2/12: Good weather including good visibility. We had a wire termination issue: re-terminating and cutting off 200 metres, because of birdsnesting of the wire. Replace CTD vane. Successful test of the US VMP to 1000m and successful NOCS VMP. In the night, finish stations at eastern end of shag rocks, commence steam to southern line.

16/2/12: Bright weather, some swell. Complete steam to southern line, arriving 12:40. Cast completed. US VMP deployed and made successful profile to 4000 m: recovered in good time.

We steamed to the next station: delay due to package wire issue, finding it to have been damaged due to twisting and "birdsnesting", leading to the necessity for a retermination. NOC VMP deployed.

At about midnight we were told that a medical emergency meant we had to go back to Port Stanley. We dropped one SOLO EMfloat and left the working area.

16/02/2012: Uneventful steam back to Port Stanley. We spent about two hours alongside to transfer our medical case to shore. John Toole, Rick Krishfield and Dave Wellwood also left the ship, since the loss of the HRP profiler has left them with little to do on the ship.

19/02/2012 0330: Test station on slope of Northern Malvinas deep: purpose to test the backup CTD wire now being used, and to obtain tracer samples from water that has passed through the NS ridge. Wire worked well. Tracer data similar to station 2.

20:00 arrived back at the work site on line south of Shag Rocks. CTD and VMP station.

20/02/2012: Further CTD and VMP south of the NSR Proceed to further stations and prepare to tow-yo.
The tow-yo proved unworkable at this site because the current was to the southwest. Move 12 nm north to commence again.
20:00 or thereabouts: informed we had to break off and steam back to Stanley for a second medical emergency.

20-21/02/2012 Uneventful steam back to Port Stanley.

23/02/2012 2100 UTC: left Stanley harbour, into moderate seas with swell on beam.

24/02/2012 0630: test station on slope of Falklands Plateau to 1700m, tried to get inshore of the SAF, but not easy to do this and also be in deep enough water to sample tracer.
Steam on to shag rocks passage site
25/02/2012: arrive work site, calm weather. CTD station and WHOI VMP deployment; commence first leg of tow-yo (stations 52-55) from SW to NE, towing up through Shag Rocks passage, and , firing bottles on last of four cycles. Towing beam-on using side thrust, on a NE course. The current ~1 kt to NW and ship heading SE with slow forward motion to offset the current. This works well but only in benign weather conditions with very little swell, since ship is beam on to sea from west. Second VMP near midnight

26/02/2012: continue towyo second leg (56-59) to NE, ending with firing of bottles for tracer analysis and with VMP cast

27, 28/02/2012: Continue toyo third leg (60-62)
Proceeded southwest to do two stations (63,64) and one VMP profile on the northern flank of the western side of Shag Rocks passage, to better capture profiles north of the SAF and where the tracer isopycnal is close to the bottom. We then steamed eastward to continue our survey of the North Scotia Ridge;

29/02/2012-01/03/2012: completed a series of casts (65-70) to east along N. Scotia ridge.. VMPs done on first two casts, after which visibility too restricted.

02/03/2012 : steamed westward; deployed a series of 8 Aardvark floats, four in a single position, at locations advised by JB Sallée as being within filaments and close to hyperbolic points.

03/03/2012: Continued steam to westward, deploying one SOLO float en route, and commenced four stations (72-76) on northern flank of N Scotia ridge, east of Shag rocks, to sample water north of subantarctic front that has passed the ridge.
Fog meant no VMP deployments possible. A problem with the scrolling of the winch meant that the wire had to be paid out with a weight to depth and rewound.

04/03/2012: complete stations north of the ridge, commence steam to south to position of the UK DIMES mooring array.

05/03/2012: arriving in morning, commence recovery of NE mooring, then NW, ?? and M moorings during daylight
VMP followed by a to-yo W-E across the mooring region at night (stations 76-78).

06/03/2012: continued recovery of two remaining moorings. CTD 79 and VMP casts in vicinity of mooring array, then depart for north end of SR1 line.

06-09/03/2012: Worked southward down SR1 line with stations initially closely spaced on the slope of Burdwood Bank, then at ~20 nm intervals, with VMP casts at each

09/03/2012 NOCS VMP – pinger failed on downcast of 87 so no information on its drift or range. Reduced visibility due to mist/fog. DF beacon worked, but rather confusing and weak signal. Search instigated and the VMP was found after ~two hours.

10/03/2012: Following station 89, sea too rough to continue CTD work sometime in night – we wait for it to moderate which we think will happen towards evening.

11/03/2012 recommence SR1 line, VMP and CTD stations. In the afternoon, following the latest weather forecast which suggested that the weather would become unworkable for an extended period next Friday, possibly losing for us the last four days of working time on the cruise, we decided not to pick up the easternmost FSU sound source mooring, in order to save approximately 1.5 days of time and be sure to get at least some working time on the A21 section to the west of Drake Passage.

12/03/2012: SOLO float deployed, sound source mooring 2 recovery. Steam to sound source mooring 1

13/03/2012, recover sound source mooring 1: continue to start of A21 line, station 95. Because of the imminent deterioration in the weather, the southernmost station was skipped and the next one moved north somewhat. CTD casts are only to a point just beyond the tracer depth, in order to work as quickly as possible. No VMPs.

14/03/2012: continue A21 line, stations very widely spaced, cast 96-98

15/03/2012 steam to station 99 and begin deployment of CTD, but too much movement on the ship, with tension in CTD wire regularly falling to zero. CTD cast abandoned, and we wait for better weather

16/03/2012: still waiting on weather. Forecast shows the possibility of some amelioration for a period of order 6 hours towards evening, but thereafter no breadks in the weather until after we will have to break off for port, on 20th March.

17/03/2012: at around 0230 UTC, cast 99 was completed, in marginal conditions. Half the bottles on the rosette were removed before deployment to reduce the drag on the package. The cast was successful, with no damage to the package or wire and a safe deployment and recovery. However, though this would indicate that it is possible to work safely and securely under such conditions, the opinion of the technical staff appears to have been that no further such casts should be attempted because there was too much risk to the equipment.

1703/2012. With no improvement in the weather forecast until after 20th March and the master advising that no further work would be possible, we convened a meeting of the scientific party. We elected to finish working operations and steam to port, two days earlier than originally planned.

2.   UNDERWAY DATA

2.1 Navigation
Brian King

As part of the routine daily processing (Section 6.3.1) eight navigation streams were extracted from TECHSAS into mexec directories, as summarised in the following table:

mexec directory	mexec short name	mexec directory abbreviation	mexec file root
nav/ash	adu5pat	M_ASH	ash
nav/attsea	attsea	M_ATTSEA	attsea
nav/cnav	cnav	M_CNAV	cnav
nav/dps116	dps116	M_DPS116	dps116
nav/gyropmv	gyropmv	M_GYP	gyp
nav/gyros	gyro_s	M_GYS	gys
nav/posmvpos	posmvpos	M_POS	pos
nav/seapath200	seapos	M_SEA200	seapos

Three streams were given intermediate processing before appending into the accumulated cruise file.

Synchro gyro & Ashtech ADU heading: Due to the availability of high-quality real-time heading from the Applanix posmv, the Ashtech ADU was a low-priority navigation stream on this cruise. However, it was maintained in case needed at short notice. Standard processing on previous cruises includes scripts *mgyr_01*, *mash_01* and *mash_02* to clean up any duplicated times in the 5Hz gyro stream, and then an ashtech minus gyro comparison, which cleans up the ashtech data before producing a smoothed ashtech minus gyro time series. This is crucial for shipboard ADCP on *Discovery* , but not used on the *James Cook.*

Figure 2.1.1 shows the 2-minute smoothed ashtech minus gyro time series. This indicated that the gyro was very stable during the cruise, not showing the excursions of several degrees during and after ship manoeuvres commonly seen elsewhere. Two data gaps are obvious, where the Ashtech heading froze. Ashtech positions are available in TECHSAS (mexec short name adupos) but were not read into mexec.

CNAV: The cnav stream in TECHSAS continues to have a known bug, whereby the minutes in the NMEA message sent by the receiver are stored as the decimal part of the degrees. A simple function *cnav_fix* is called from *mcalib* in script *mcnav_01,* and the file name advanced from
cnav_jc069_d070_raw.nc
to
cnav_jc069_d070.nc
Thus the 'standard' file, and the cruise appended file
cnav_jc069_01.nc
have corrected cnav data.

Note that tests in port show that the cnav is clearly the most precise and stable of the navigation sources. However, the need for correction of data taken directly from TECHSAS provided too many possibilities for error to make it wise to use it in 'real time'. Therefore the data were logged and corrected, but not otherwise used. It is

understood that a fix has been developed on *Discovery* which will be installed on *James Cook* soon. This would be most desirable.

posmvpos: posmvpos was used as the master position source; no problems were noted during the cruise. The data stream contains no gaps longer than 5 seconds.

Apart from the synchro gyro, ashtech and cnav, the other data streams were passed through the system and appended with no further editing. Master files such as pos_jc069_01.nc contain the full and final cruise archives for those streams.

Script

m_jc069_daily_processing

called *mday_00* to read in all streams, inserted the required scripts for streams that required intervention, and then *mday_02* to append into an accumulating cruise file. Streams dps116 and seapos were not used during the cruise, but were appended during data tidying at the end of the cruise. As usual the scripts

mday_00_get_all.m

and

mday_02_run_all.m

were edited to select streams available and required on the cruise.

Bestnav: *mbest_all* runs a series of scripts to produce the master bestnav file, bst_jc069_01. This uses posmvpos for position, and merges on heading so that there is a complete file containing position, heading, course and speed made good, and distance run. The data are reduced to a 30-second time base and heading is properly vector averaged. This is the 'definitive' cruise navigation file. The file is found in the nav/posmvpos directory. In order to avoid the problem of housekeeping variables like distrun across daily files, the bestnav processing is rerun from the start of the cruise each time it is required. There is therefore only ever one bst_jc069_01 file.

Attitude and heave: The pitch, roll and heave data are plotted from the 'attsea' stream, ie the seapath attitude stream. Figure 2.1.2 is plotted from the full 1Hz data file attsea_jc069_01.nc. Note heave of order 5m late in the cruise that prevented CTD stations in the last few days.
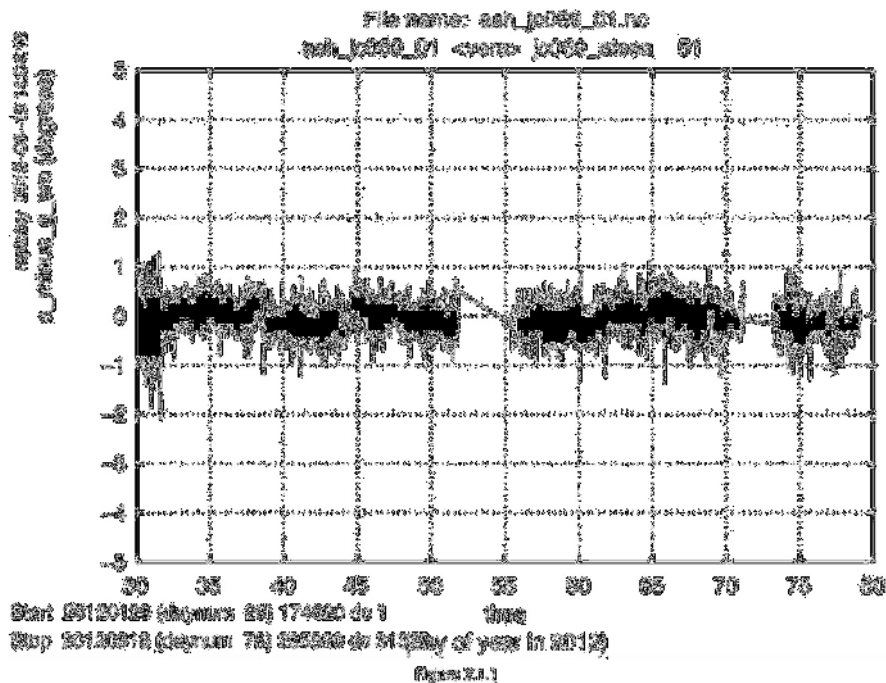
Figure 2.1.1
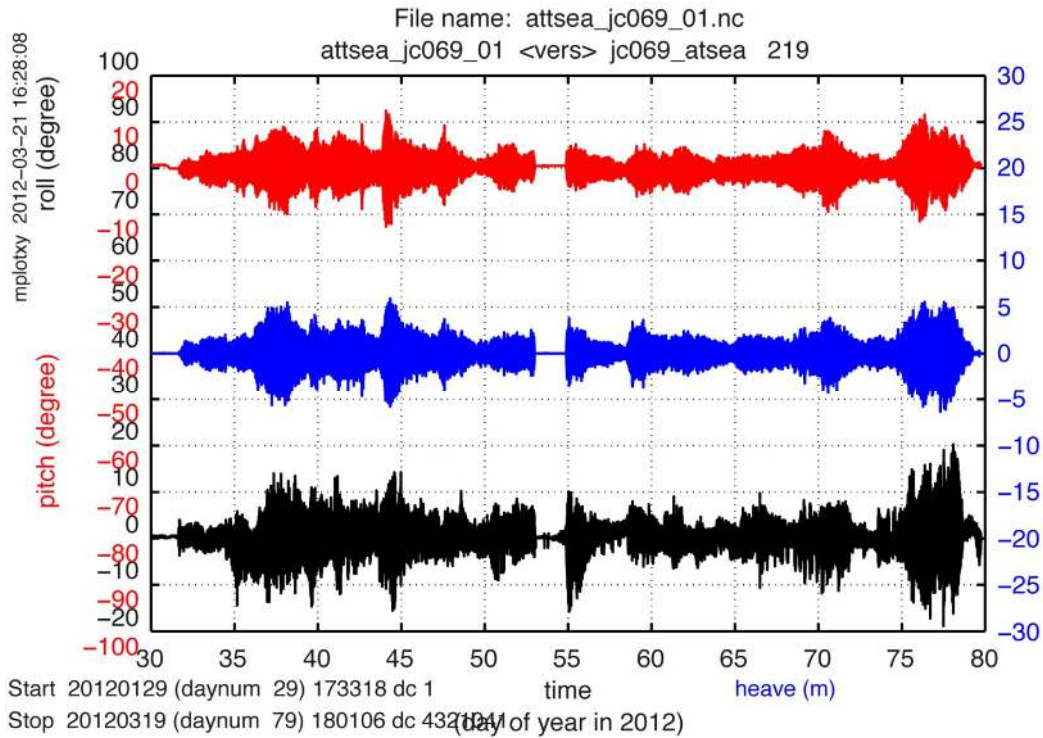
Figure 2.1.2

2.2 Surfmet
Brian King

This surfmet report covers surface meteorology and underway pumped seawater measurements.

The surfmet streams are divided into three TECHSAS streams. In addition, the SeaBird SBE45 thermosalinograph data are also logged in separate data stream

mexec directory	mexec short name	mexec directory abbreviation	mexec file root	variables
met/surfmet	surfmet	M_MET	met	speed direct airtemp humid
met/surflight	surflight	M_MET_LIGHT	met_light	pres ppar spar ptir stir
met/surftsg	surftsg	M_MET_TSG	met_tsg	temp_h temp_m cond fluo trans
tsg	SBE45	M_TSG	tsg	temp_h temp_r cond salin sndspeed

Note the alternative names for sea surface temperature (temp_r and temp_m) as opposed to TSG housing temperature (temp_h).

Note also that wind speed is stored in techsas in m/s, whereas TECHSAS gives the variable units as knots. Therefore script mmet_01 is inserted in the daily processing to correct the units in the met/surfmet/met_jc069_dnnn_raw.nc file.

At the start of the cruise a check was performed to ensure that the salinity calculated from 'surftsg' cond and temp_h matched the salinity found in 'tsg'.

Since the 'surftsg' file also contains the other pumped seawater variables, calibration work was carried out in the 'surftsg' directory. The 'tsg' files are uncalibrated and should not be used.

Note that apart from salinity in the thermosalinograph, all other data have no further calibration applied. For example, no record was made of meteorology sensor numbers, calibrations applied en route to TECHSAS, date of last sensor cal, etc.

Meteorology

Wind variables: Ship speed, position and heading from the bst file (Section 2.1) are merged onto the wind data in the surfmet. The absolute wind speed is calculated and vector averaged in one multi-step script mtruew_01. As with bst processing, this is rerun for the entire cruise each time the data are updated. The output files from this processing are met_jc069_true.nc / met_jc069_trueav.nc

The latter file is reduced to 1-minute averages, with correct vector averaging when required. In order to avoid ambiguity, variable units are explicit in whether wind directions are 'towards' or 'from' the direction in question. The result is a bit cumbersome, but should be unambiguous if the units are read carefully.

Wind over the stern: The standard test of whether the relative wind processing has been done correctly would be to observe no change in the calculated absolute wind when the ship changes direction or speed. This can be misleading, since the anemometer sited on the foremast under-reads speed by a significant margin when the wind is over the stern. Therefore if either the 'before' or 'after' wind direction is over the stern, there can be a significant change in the apparent true wind speed during such manoeuvres.

Wind relative direction near 0/360: The age old problem of wind direction near the 0/360 boundary has reappeared. Or perhaps it never left us. Since the anemometer is set up with 0/360 at the bow, the relative wind is very often around this heading. Even though the anemometer data are recorded at the data rate generated by the sensor (nominal 1 Hz), there is a problem with the raw data. In particular, when the wind is near 0/360, the TECHSAS files will sometimes contain headings in between, eg in the range 150 to 210, reminiscent of when simple numerical averaging of heading was occurring. This is illustrated with data from 32/1602 to 32/1605 (Fig 2.2.1). When these bad headings are used in correct calculation of true wind, bad data are the result. In order to combat this, the sensor was physically rotated 90 degrees to port so that the 0/360 boundary was athwartships, and a 90 degree offset applied to the data. This put relative directions in the range -90 to 270, with zero still over the bow. This would have been perfectly satisfactory, except that the real time surfmet display could not correctly interpret the negative headings, displaying all winds in the port-forward sector as zero relative heading. The data in the TECHSAS files appeared to be fine, but the confusion arising from the displays made this an undesirable state to be in. It was not possible to arrange an update to the surfmet software during the cruise. The sensor was therefore rotated back to its original position. The data with the rotated sensor occur on day numbers 42 to 46. In summary, the wind data are fully processed, but cannot be regarded as perfectly 'clean'.
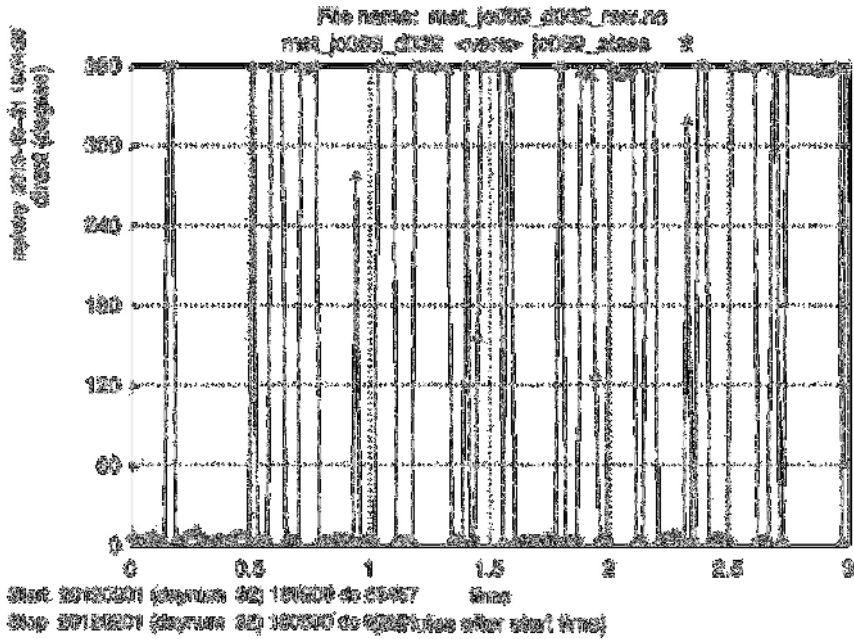
Figure 3.2.1

Irradiance and surface pressure

Downwelling PAR and TIR data are found in the surflight stream, which also contains barometer pressure. These streams were ingested and strored, but no further processing was undertaken. At the end of the cruise, some bad pressure data were noticed on day 030. The raw file was copied to a plain file (no suffix) and the bad data were removed with mplxyed. The appended file was then regenerated. The cruise surface pressure record is displayed in Fig. 3.2.2.

jc069
Bottle minus TSG salinity differences
Individual bottles and smoothed adjustment applied

Figure 2.2.3
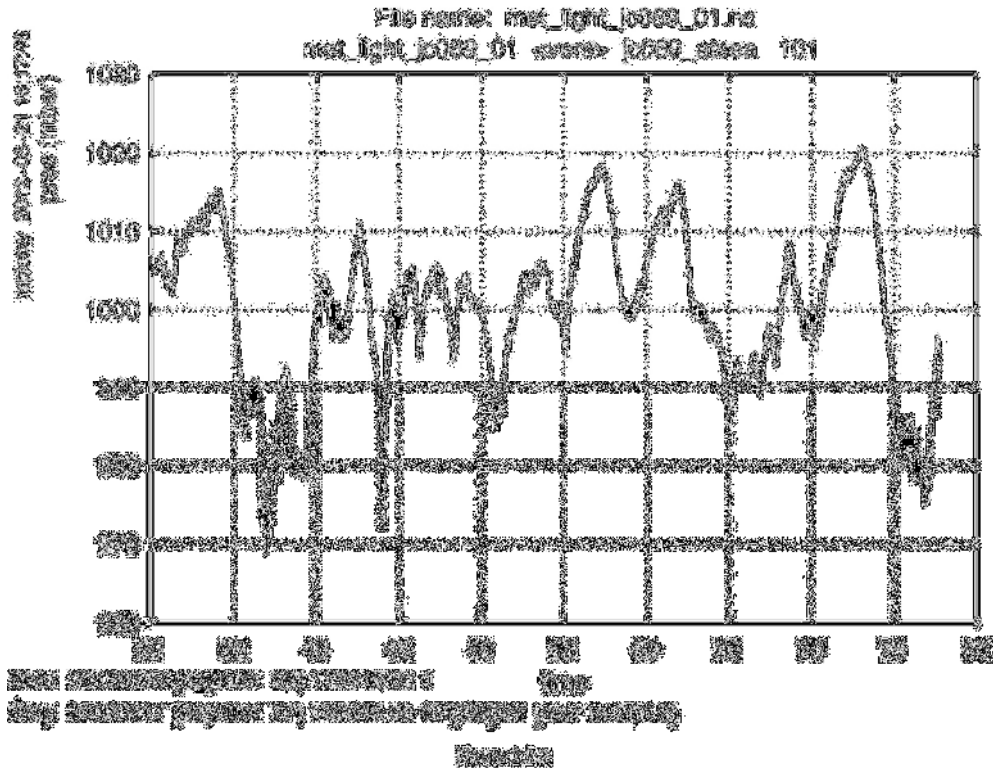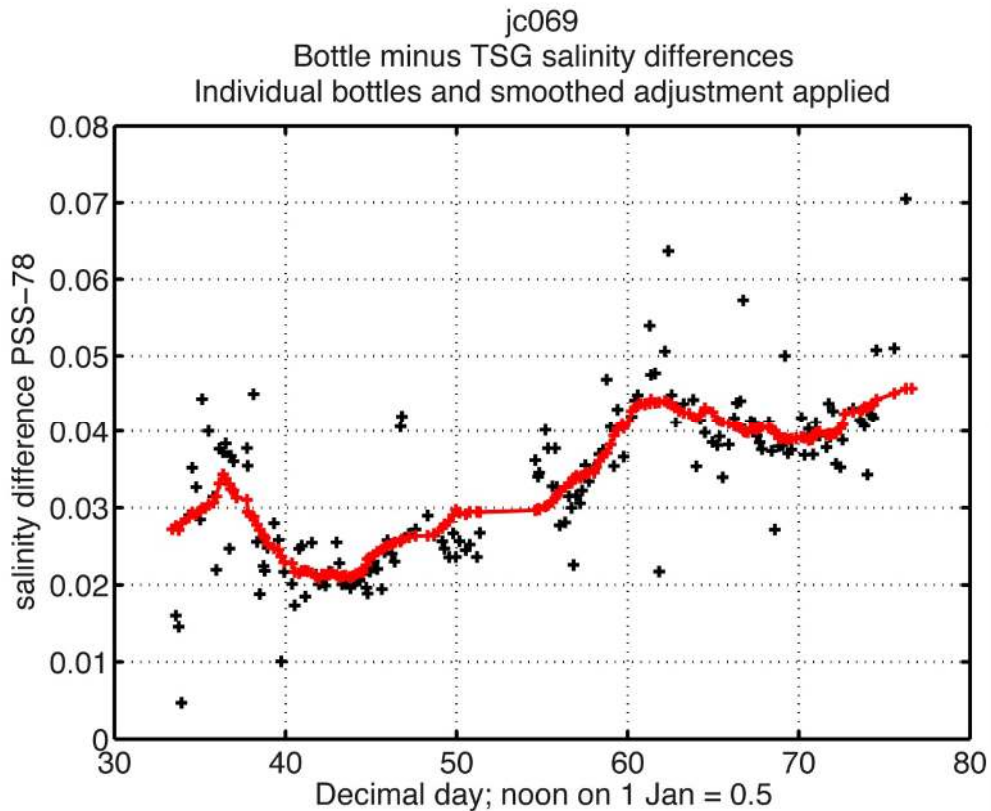
The low pressure in the last week of the cruise was, of course, associated with the bad weather that led to the early end of the cruise.

Underway surface thermosalinograph

As noted above, the calibrated TSG record is in the 'met/surftsg' directory. The 'tsg' directory contains only raw data.

First note that no calibration or data cleaning has been applied to the fluorometer or transmissometer data, except that it has been set to absent where the salinity is absent.

First note the pumps were off and data discarded between the following times, including the two runs into Stanley.

Start	End	Comment
Start of cruise	33/1300	Start of pumped data
39/0800	39/1600	First Stanley call
52/1200	55/1200	Second Stanley call
77/1806	End of cruise	End of surfmet logging

In addition, there were a few periods spotted during data cleaning when the housing temperature rose while the sea temperature remained steady. This was attributed to interruptions in the pumping. Data during these periods were discarded.

It was noted part way through the cruise that there were significant salinity spikes each time there was a strong change in temperature. The characteristic was a negative spike in salinity when temperature was warming. This is characteristic of the conductivity responding slowly. When the temperature in the housing warms, conductivity should increase if salinity is stable. If conductivity increases too slowly,

and remains low, the resulting salinity spikes towards low salinity. This effect seemed to be some sort of extreme cell thermal mass problem. When this was noticed, a first and unsuccessful attempt was made to estimate a time constant to lag the temperature and remove salinity spikes. Instead, spikes were removed by hand using mplxyed. Later in the cruise, the problem became worse, and a more determined effort was made to estimate a lagged temperature and fix the salinity.

After much experimentation, it was decided that a systematic search was required to characterise the history of the problem during the cruise. A lagged temperature was constructed using a one-sided filter. The codes remain somewhat ad hoc, and are not guaranteed to be robust on other cruises. However, the sequence of calculations will be described. Function *mtsg_lagsal* takes time, cond, temp and tlag as arguments. For each time step, lagged temperature is the nanmean of all temperatures within the last tlag seconds. Thus a tlag of 120 corresponds to a lag time of about 60 seconds. This seemed to work better for correcting salinity spikes than $T'(i) = T'(i-1) + T(i)/tau$ approach. *mtsg_lagsal* then calculates salinity from lagged temperature. Further, a smoothed salinity is calculated at each test time as a nanmean of the salinities within 500 seconds either side of that test time. The residual is the standard deviation of the lagged salinity about the smoothed salinity. Thus a small residual is presumed to mean success at removing salinity anomalies on a timescale of minutes, as required. Script *tsglag* was used to search each day of data and each possible value of tlag in the range 0:10:150 seconds. This was computationally slow, but the conclusion of analysis of TSG data up to day 73 was as follows (output in file 'lag_results' in met/surftsg directory):

1) Early in the cruise, the optimum residual for this process was at small or zero tlag.
2) About day 59, the optimum value of tlag was near 60.
3) From day 61, the optimum value of tlag was near 120. Furthermore the visual impression was that the lag temperature process was effective at removing the salinity biases.

Accordingly , it was decided that salinity would be re-calculated from the start of the cruise using tlag = 0 for day numbers up to and including 059, and tlag = 120 for day numbers equal to and greater than 060. Recall that many of the bad data for days up to and after 060 had already been identified and were being removed automatically. Therefore the main requirement was for a procedure that would produce acceptably clean salinity data for the days beyond 060 that had not already been manually cleaned. The full processing sequence was thus

1) *mtsg_apply_ tlag _jc069.m*
     calls   *mtsg_lagsal_jc069.m*
     input: met_tsg_jc069_01.nc
     output: met_tsg_jc069_01_sal_from_tlag.nc
2) *mtsg_medav_clean_cal.m*
     calls   *mtsg_cleanup.m*
     input: met_tsg_jc069_01_sal_from_tlag
     output: met_tsg_jc069_01_medav_clean
     creates 1-minute median bin average of data, then removes known bad data in *mtsg_cleanup*. *mtsg_cleanup* has times of pumps off hardwired in for each cruise. In addition it loads times of bad data from file met/surftsg/bad_time_lims.mat. This file is added to by script *mtsg_findbad*. Between the times identified as bad, all variables are set to nan. This is because this procedure was originally conceived as a means of discarding data when the pumps were off, not merely when salinity had a problem.
3) *mtsg_findbad.m*

allows graphical identification of bad data. Using an interface similar to *mdcs_03g*. See *help mtsg_findbad*.

4) After *mtsg_findbad*, you can loop through steps (2) and (3) as often as required, until a sufficiently clean salinity file is obtained. Limits of bad times are accumulated by successive uses of *mtsg_findbad*, so it is a good idea to back up the bad_time_lims.mat file.

5) mtsg_bottle_compare_jc069.m
      input: met_tsg_jc069_01_medav_clean or
              met_tsg_jc069_01_medav_clean_cal
      output: met_tsg_jc069_01_botcompare.nc

      merges the clean 1-minute data onto bottle samples. The script is set up to make it easy to switch between uncalibrated (variable salin) or calibrated (variable salin_cal) data. Individual bottle residuals are plotted, as well as a smoothed (41-point boxcar filter) of the residuals, which can then be used as a slowly-varying adjustment to the TSG salinity. Figure 2.2.3 shows the resulting comparison for the entire set of 182 surface bottles (taken nominally every four hours; the 10th bottle sample was discarded as being a bad comparison).

6) mtsg_apply_salcal.m
      calls   *mtsg_salcal.m*
      input: met_tsg_jc069_01_medav_clean
      and   met_tsg_jc069_01_botcompare.nc
      output: met_tsg_jc069_01_medav_clean_cal

      smooths the differences in botcompare, interpolates and adds them to the uncalibrated salinity data. Step 5 can be repeated after this step, to check that the residuals are now acceptable. Figure 2.2.4 shows residuals with calibrated data.
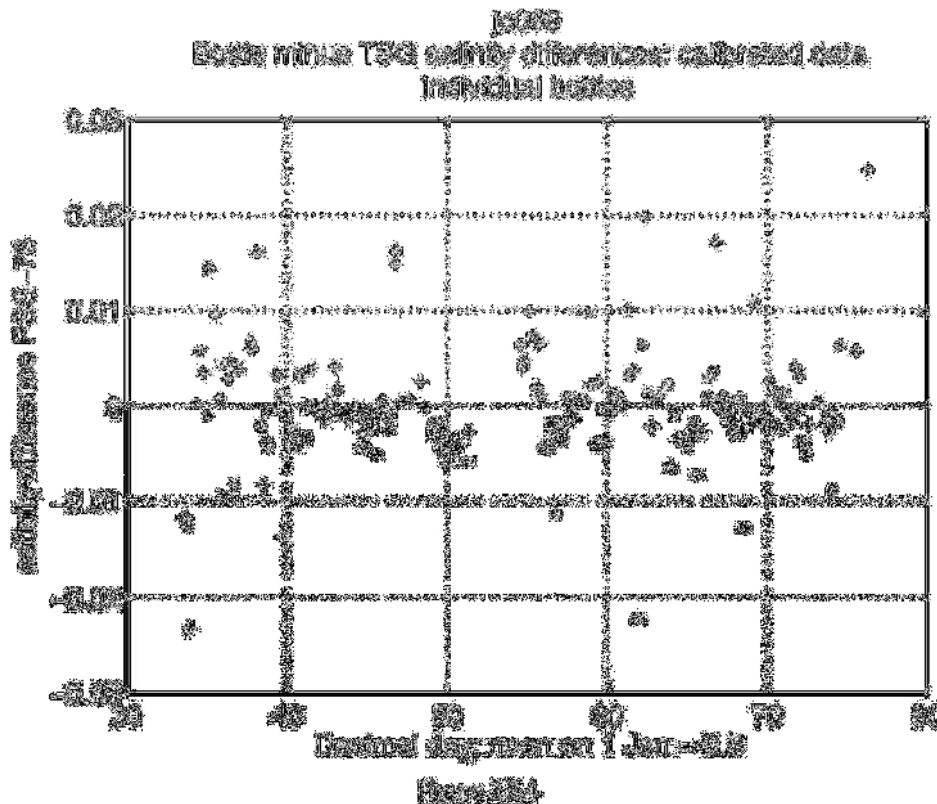
The residuals in Figure 2.2.4 have zero mean and iqr 0.005. Thus while the general quality of the salinity data is of order 0.01 on PSS-78, there may be short periods

where biases remain due to the cell thermal lag being inadequately corrected. The final TSG data are shown in Fig. 2.2.5, with the fluorometer and transmissometer data in Fig. 2.2.6.

Figure 2.2.5

Figure 2.2.6

2.3 Bathymetry
Brian King

Two sources for bathymetry were processed in mexec from TECHSAS files.
EA600: The EA600 was operated throughout the cruise, except when pinging was switched off for VMP tracking and mooring communications. Since the drop keels were raised throughout the cruise, data quality was often poor or non-existent when se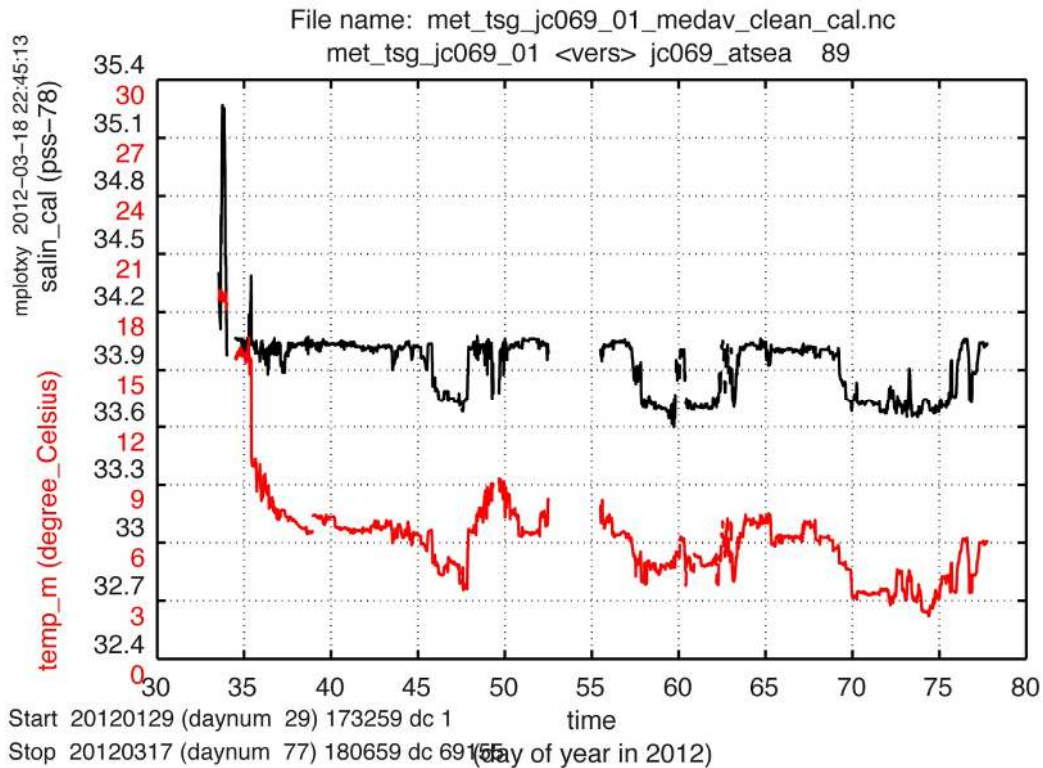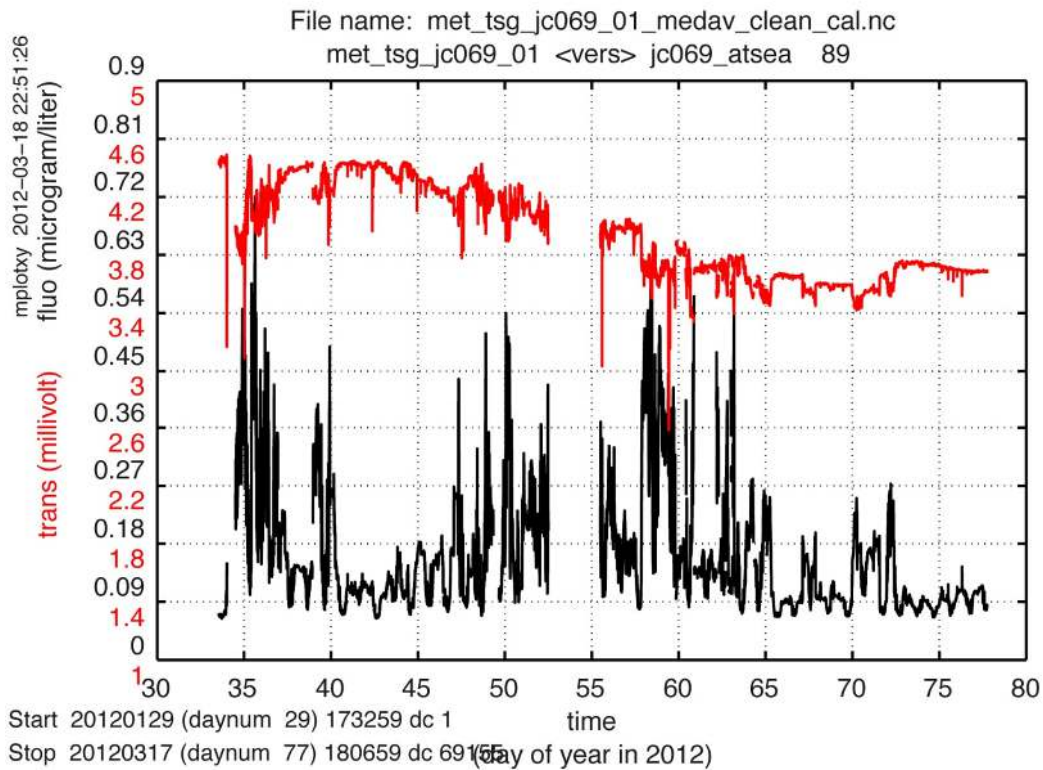a state was unfavourable. Screen dumps in bmp format were captured on the ea600 PC. They were transferred onto the public shared directory in batches, and later copied to mexec directory data/sim/ea600_screendumps, where they were sorted into daily directories. They could in principle be used for checking digitised ea600 depths, however the minimal annotation in the bmp files would make this a difficult task.
Data were read into mexec directory 'sim'. Two processing scripts were used:
msim_01(day):
read raw data for the day (sim_jc069_d070_raw.nc);
pick data in depth range 5 to 10000, to discard zeros;
take median depth in 300 second bins, to discard noise
example output file: sim_jc069_d070_smooth.nc
msim_plot(day):
copy 'smooth' file to 'edited' (sim_jc069_d070_edited.nc) , and enter *mplxyed* for manual removal of bad data.
msim_plot displays an extra window with the full ea600 data, to guide the use of *mplxyed*. A 'quick and dirty edit' was made to the code that plots this window, to add satellite bathymetry, and em120 centre beam depths. The ea600 bmp images were not very helpful for this task on this cruise. Positions for the SS bathymetery were loaded on the fly from 'posmvpos', culled to approximately 5 minute intervals, and depths retrieved using script *pos_to_ssdep*. Em120 data were loaded on the fly from the TECHSAS em120 file, and displayed with depths less than 50m discarded. This script would benefit from an overhaul to make its approach more consistent with other mexec scripts. The 'spare' window is useful for Matlab zooming, as well as for comparing all available estimates of seabed depth.
EA600 data quality: when the ea600 is noisy, it is often very difficult to infer just from the digitised records whether the instrument was finding the bottom or simply returning random noise close to the last known good depth. Accordingly the *mplxyed* editing was done in a fairly harsh manner, preferring to discard data which seemed noisy and for which there was no good evidence that the data were correct. The dataset therefore has many gaps.
EA600 data were acquired from 31/1935 to 77/1205. Approximately 60% of the 5-minute bins during that period have valid depths retained.
After cleaning in *mplxyed*, daily files were appended into a single file
     sim_jc069_01.nc
navigation was added
     sim_jc069_01_nav.nc
and Carter area correction applied using *mcalc*
     sim_jc069_01_nav_cordep.nc
This last file is therefore the master EA600 file, with corrected bottom depths in 5 minute bins.
EM120 centre beam
Em120 centre beam depths were logged in TECHSAS and downloaded in daily files to mexec directory 'em120'. Section 2.4 has some notes on EM120 operation.

Two scripts were written to load and edit EM120 data, based on the scripts for EA600:

mem120_01: (not a function, just a plain script)

read raw data (em120_jc069_d070_raw.nc)

mdatpik for snd > 20

mavmed, median in 300 second bins (em120_jc069_d070_smooth.nc)

copy file to 'edited' (em120_jc069_d070_edited.nc) ready for manual editing

mem120_02: (also a script not a function)

If all the relevant files exist, display the Matlab window with EM120, EA600 and SS bathymetry, then enter *mplxyed* on the edited file. This step can be repeated as often as required. The Matlab plot window displays the data as found in the most recently updated 'edited' file.

Again, in the absence of reliable guides, a cautious approach to accepting data was adopted, and questionable data were discarded rather than retained. Data are retained in the time period 33/1707 to 77/1332, during which 55% of 5-minute bins have retained depths. The daily edited files were appended into the final EM120 file: em120_jc069_01.nc

Comparison of EM120 and EA600

The final EM120 and EA600 depths were compared as follows: the EM120 depths were interpolated using time onto the EA600 timebase using the two final appended files. No interpolation was performed where one or other data stream was absent. The difference is plotted in Fig. 2.3.1. The data are generally unbiased, suggesting both datasets have a reasonable sound speed correction for most of the time period. The median and iqr of the displayed data are 7 and 27 metres respectively. Significantly non-zero values in the figure could arise from bad data retained in one or other file, inappropriate sound speed correction, or in a few cases, measurements in steep topography where the binning process has distorted the result.

Since each data stream has some good measurements where the other absent, the best available estimate of cruise bathymetry requires the two streams to be merged.
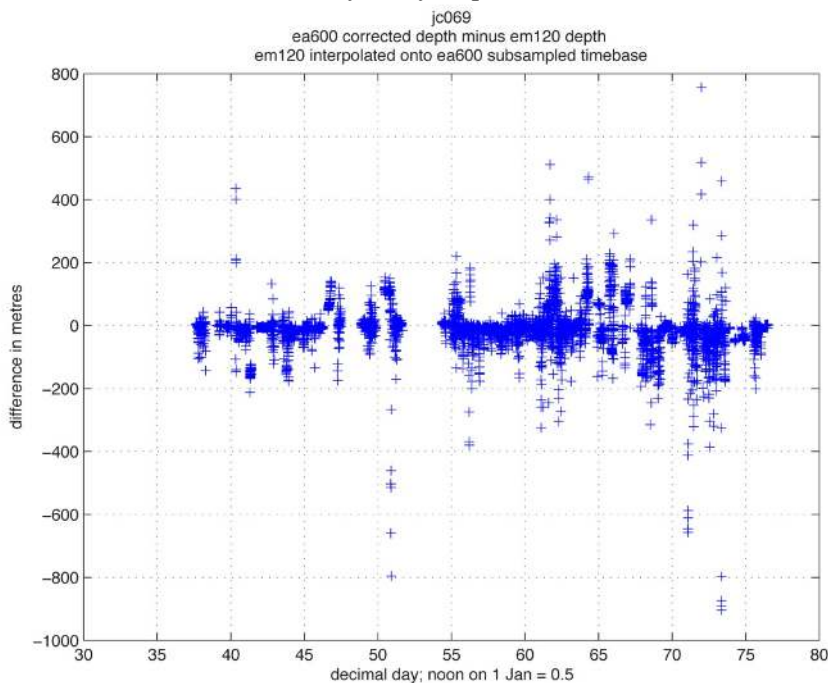

Figure 2.3.1

2.4 EM120 Swath bathymetry
Brian King and Gareth Knigth

The EM120 Swath system was run throughout the cruise, whenever operational requirements permitted its use. Pinging was switched off when other acoustic operations took precedent, in particular acoustic tracking of VMP and communication with moorings. Data were automatically processed in real time and displayed on the Kongsberg monitor, where they could be viewed when required. This was of particular use when searching for nearby shallow depths to limit the programmed depth of VMP dives.

However, these Kongsberg-processed depths are not captured in the data system. Accordingly only the raw data messages are brought ashore, and would need to be post-processed to provide a swath dataset.

Raw data are on the system data archives, of which three are sent ashore. One to BODC, one with A. Watson and one with A Naveira Garabato. The raw data are in directory JC69/Ship_Systems/Acoustics/EM-120/Raw/JC69/2012 and span the time period Feb 02 to Mar 17. Note that due to a glitch in copying, many of the raw files are replicated in directory Acoustics/EM-120/Raw/JC69/JC69/2012

As would be expected, data quality varied between very good, and non-existent, depending on sea state and ship motion.

New sound velocity profiles derived from CTD data were uploaded three times, after stations 001, 016 and 081.

Centre-beam water depth: The centre beam depth is output and logged in TECHSAS. The processing of these data, and comparison with EA600, is described in Section 2.3 'Bathymetry'.

2.5 Underway trace metals, phytoplankton physiology and community structure
Heather Bouman, Thomas Browning.

2.5.1. Fluorometric Chlorophyll-a

2.5.1.1 Objectives

To capture the spatial structure of chlorophyll-a concentration within the surface ocean, measurements of chlorophyll-a were conducted on samples collected from trace-metal FISH, underway non-toxic supply and CTD rosette along the cruise transect. Surface samples collected from the CTD package were used along with samples collected during JC068 (UK-GEOTRACES) to calibrate *in vivo* fluorescence profiles made using an *in situ* fluorometer mounted on the CTD package.

2.5.1.2 Sampling Protocol

Seawater samples were collected in large (9-20 litre) Nalgene carboys. Each carboy was rinsed three times with sample water and then filled. Triplicate samples of 100 ml were filtered through 25 mm GF/F filters. The filters are placed in 10 ml of 90% acetone in 20ml glass scintillation vials and stored overnight at -20°C to allow pigment to extract. A complete list of the samples analysed on JC069 can be found in Table 1.

Date	Station	Lat	Long	Tchl	FRRF	Abs	FluorEx	HPLC	FCM

03/02/2012	FISH TEST	46 07.67'S	53 43.48'W	3X100 ml	Y	100	100	500	Y
03/02/2012	CTD	45 37.715'S	53 36.672'W	3X100 ml	N	100X2	N	480	Y
04/02/2012	FISH	46 50.69'S	53 53.54'W	3X100 ml	Y	100	100	500	Y
04/02/2012	FISH	47 55.620'S	54 09.138'W	3X100 ml	Y	740	620	1000	Y
04/02/2012	CTD_002	48 38.729'S	54 19.430'W	3X100 ml	N	N	N	N	N
04/02/2012	FISH	48 47.90'S	54 20.63'W	3X100 ml	Y	100	100	1000	Y
04/02/2012	FISH	49 18.68'S	54 29.56'W	3X100 ml	Y	200	200	1000	Y
04/02/2012	FISH	49 51.91'S	54 37.53'W	3X100 ml	Y	200	200	1000	Y
05/02/2012	FISH	50 37.99'S	54 48.82'W	3X100 ml	Y	200	200	1000	Y
06/02/2012	CTD_003	54 25.795'S	55 49.363'W	3X100 ml	N	N	N	N	N
06/02/2012	CTD_004	54 23.593'S	55 40.747'W	3X100 ml	N	N	N	N	N
06/02/2012	CTD_005	54 21.58'S	55 33.22'W	3X100 ml	N	N	N	N	N
06/02/2012	CTD_006	54 23.593'S	55 40.747'W	3X100 ml	Y	500	500	1000	Y
05/02/2012	FISH	M	M	3X100 ml	N	N	N	N	N
05/02/2012	FISH	52 06.30'S	55 11.85'W	3X100 ml	Y	1000	1000	1000	Y
05/02/2012	FISH	52 43.21'S	55 21.29'W	3X100 ml	Y	300	300	1000	Y
05/02/2012	FISH	53 40.56'S	55 36.52'W	3X100 ml	Y	200?	200?	1000	Y
06/02/2012	FISH	54 20.04'S	55 27.22'W	3X100 ml	Y	1000	1000	1000	Y
07/02/2012	CTD_007	54 11.086'S	54 51.350'W	3X100 ml	N	N	N	N	N
07/02/2012	FISH	54 04.14'S	54 17.74'W	3X100 ml	Y	1000	1000	1000	Y
07/02/2012	CTD_008	54 05.1845'S	54 26.92'W	3X100 ml	N	N	N	N	N
07/02/2012	CTD_009	53 59.477'S	53 39.042'W	3X100 ml	N	N	N	N	N
08/02/2012	FISH	53 57.26'S	53 22.59'W	3X100 ml	Y	500	500	1000	Y
08/02/2012	FISH	53 51.49'S	52 44.41'W	3X100 ml	Y	1000	1000	1000	Y
08/02/2012	FISH	53 40.81'S	51 45.56'W	3X100 ml	Y	1000	1000	1000	Y
08/02/2012	FISH	53 22.17'S	50 16.76'W	3X100 ml	Y	500	500	1000	Y
08/02/2012	FISH	53 04.97'S	49 46.65'W	3X100 ml	Y	500	500	1000	Y
09/02/2012	FISH	53 22.71'S	49 57.40'W	3X100 ml	Y	500	500	1000	Y
09/02/2012	CTD011	53 23.078'S	50 05.420'W	3X100 ml	N	N	N	N	N
09/02/2012	CTD013	53 23.00'S	49 31.337'W	3X100 ml	Y	500	500	1000	Y
09/02/2012	CTD012	53 23.354'S	49 37.319'W	3X100 ml	Y	500	500	1000	Y
11/02/2012	CTD015	53 21.54'S	49 15.32'W	3X100 ml	Y	1000	590	1000	Y
12/02/2012	CTD018	52 33.823'S	49 25.037'W	3X100 ml	N	N	N	N	N
12/02/2012	CTD019	52 35.19'S	48 43.49'W	3X100 ml	Y	500	500	865	Y
13/02/2012	CTD021	53 11.88'S	48 46.295'W	3X100 ml	Y	500	500	1000	Y
14/02/2012	CTD023	53 08.24'S	48 29.43'W	3X100 ml	Y	500	500	1000	Y
14/02/2012	CTD024	53 11.757'S	48 45.010'W	3X100 ml	Y	500	500	1000	Y
14/02/2012	CTD025	53 07.141'S	48 13.633'W	3X100 ml	Y	500	500	1000	Y
15/02/2012	CTD026	53 02.17'S	48 02.696'W	3X100 ml	Y	500	500	1000	Y
15/02/2012	CTD027	52 55.20'S	47 45.950'W	3X100 ml	Y	500	500	1000	Y
16/02/2012	CTD029	53 00.702'S	47 26.841'W	3X100 ml	Y	500	500	1000	Y
16/02/2012	CTD030	53 05.632'S	47 04.854'W	3X100 ml	Y	500	500	1000	Y
16/02/2012	FISH	53 38.66'S	47 55.28'W	3X100 ml	Y	500	500	1000	Y
16/02/2012	FISH	53 56.14'S	48 24.88'W	3X100 ml	Y	500	500	1000	Y
16/02/2012	FISH	53 58.69'S	48 49.51'W	3X100 ml	Y	500	520	1000	Y
16/02/2012	FISH	53 59.71'S	49 03.55'W	3X100 ml	Y	500	500	1000	Y
17/02/2012	OTW	53 18.07'S	52 35.04'W	3X100 ml	Y	500	500	1000	Y
17/02/2012	OTW	52 56.26'S	53.44.20'W	3X100 ml	Y	500	500	1000	Y
18/02/2012	OTW	51 43.41'S	57 28.54'W	3X100 ml	Y	500	500	1000	Y
18/02/2012	OTW	52 00.48'S	56 36.78'W	3X100 ml	Y	500	500	1000	Y
19/02/2012	FISH	52 52.57'S	53 53.84'W	3X100 ml	Y	500	500	1000	Y
19/02/2012	FISH	53 14.66'S	52 44.81'W	3X100 ml	Y	300	300	1000	Y
19/02/2012	FISH	53 31.99'S	51 50.23'W	3X100 ml	Y	300	300	1000	Y
19/02/2012	FISH	53 52.96'S	50 43.78'W	3X100 ml	Y	200	200	1000	Y
20/02/2012	FISH	53 59.93'S	49 39.01'W	3X100 ml	Y	300	300	1000	Y
20/02/2012	FISH	53 48.44'S	49 31.30'W	3X100 ml	Y	500	500	1000	Y
24/02/2012	FISH	52 41.79'S	54 01.40'W	3X100 ml	Y	500	500	1000	Y

24/02/2012	FISH	52 57.38'S	52 55.94'W	3X100 ml	Y	500	500	1000	Y
24/02/2012	FISH	53 11.00'S	51 57.00'W	3X100 ml	Y	500	500	1000	Y
25/02/2012	FISH	53 24.89'S	50 58.45'W	3X100 ml	Y	200	200	1000	Y
25/02/2012	OTW	53 43.91'S	49 26.05'W	3X100 ml	Y	300	300	1000	Y
26/02/2012	OTW	53 24.04'S	49 08.03'W	3X100 ml	Y	300	300	1000	Y
28/02/2012	FISH	52 46.52'S	49 02.05'W	3X100 ml	Y	500	500	1000	Y
29/02/2012	FISH	52 56.55'S	49 44.38'W	3X100 ml	Y	300	300	1000	Y
29/02/2012	FISH	53 05.16'S	49 18.36'W	3X100 ml	Y	500	500	1000	Y
29/02/2012	FISH	53 06.47'S	47 53.20'W	3X100 ml	Y	500	500	1000	Y
29/02/2012	FISH	53 07.30'S	46 44.20'W	3X100 ml	Y	500	500	1000	Y
01/03/2012	FISH	53 10.62'S	45 48.73'W	3X100 ml	Y	300	300	1000	Y
01/03/2012	FISH	53 14.95'S	44 20.94'W	3X100 ml	Y	500	500	1000	Y
02/03/2012	FISH	53 30.53'S	45 21.41'W	3X100 ml	Y	400	400	1000	Y
02/03/2012	FISH	53 42.23'S	46 07.75'W	3X100 ml	Y	400	400	1000	Y
02/03/2012	FISH	53 54.92'S	47 00.84'W	3X100 ml	Y	500	500	1000	Y
02/03/2012	FISH	54 11.88'S	48 09.19'W	3X100 ml	Y	500	500	1000	Y
02/03/2012	FISH	54 22.70'S	48 52.85'W	3X100 ml	Y	500	500	1000	Y
02/03/2012	FISH	54 33.18 'S	49 36.19'W	3X100 ml	Y	500	500	1000	Y
02/03/2012	FISH	54 44.10'S	50 22.75'W	3X100 ml	Y	500	500	1000	Y
03/03/2012	FISH	55 03.62'S	50 52.40'W	3X100 ml	Y	500	500	1000	Y
03/03/2012	FISH	54 58.44'S	51 22.95'W	3X100 ml	Y	500	500	1000	Y
03/03/2012	FISH	54 49.89'S	51 52.97'W	3X100 ml	Y	500	500	1000	Y
03/03/2012	FISH	54 36.53'S	52 41.06'W	3X100 ml	Y	500	500	1000	Y
03/03/2012	FISH	54 19.97'S	53 41.49'W	3X100 ml	Y	500	500	1000	Y
03/03/2012	FISH	54 05.71'S	54 32.98'W	3X100 ml	Y	500	500	1000	Y
03/03/2012	FISH	53 51.77'S	55 21.80'W	3X100 ml	Y	500	500	1000	Y
03/03/2012	FISH	53 41.16'S	55 01.39'W	3X100 ml	Y	500	500	1000	Y
04/03/2012	FISH	53 32.08'S	55 46.79'W	3X100 ml	Y	500	500	1000	Y
04/03/2012	FISH	53 59.84'S	56 06.24'W	3X100 ml	Y	500	500	1000	Y
04/03/2012	FISH	54 27.06'S	56 28.74'W	3X100 ml	Y	500	500	1000	Y
05/03/2012	FISH	54 54.88'S	56 51.72'W	3X100 ml	Y	500	500	1000	Y
05/03/2012	FISH	55 20.23'S	57 13.58'W	3X100 ml	Y	500	500	1000	Y
05/03/2012	FISH	55 47.83'S	57 34.90'W	3X100 ml	Y	500	500	1000	Y
07/03/2012	FISH	56 00.45'S	57 43.71'W	3X100 ml	Y	500	500	1000	Y
07/03/2012	FISH	55 34.05'S	57 51.19'W	3X100 ml	Y	500	500	1000	Y
07/03/2012	FISH	55 18.65'S	57 57.06'W	3X100 ml	Y	500	500	1000	Y
08/03/2012	FISH	55 38.81'S	57 50.04'W	3X100 ml	Y	500	500	1000	Y
08/03/2012	FISH	55 55.31'S	57 42.59'W	3X100 ml	Y	500	500	1000	Y
08/03/2012	FISH	56 14.75'S	57 31.42'W	3X100 ml	Y	500	500	1500	Y
09/03/2012	FISH	56 32.76'S	57 21.68'W	3X100 ml	Y	500	500	1500	Y
09/03/2012	FISH	56 50.46'S	57 06.00'W	3X100 ml	Y	500	500	1520	Y
09/03/2012	FISH	57 11.08'S	56 53.32'W	3X100 ml	Y	1000	1000	2000	Y
10/03/2012	FISH	57 30.47'S	56 41.48'W	3X100 ml	Y	500	500	1000	Y
11/03/2012	FISH	57 50.83'S	56 33.91'W	3X100 ml	Y	500	500	1000	Y
11/03/2012	FISH	58 10.97's	56 21.28'W	3X100 ml	Y	1000	1000	2000	Y
12/03/2012	FISH	58 27.34'S	56 54.22'W	3X100 ml	Y	500	500	1000	Y
12/03/2012	FISH	58 23.64'S	57 36.03'W	3X100 ml	Y	500	500	1000	Y
12/03/2012	FISH	58 20.48'S	58 13.08'W	3X100 ml	Y	300	300	1000	Y
12/03/2012	FISH	58 15.77'S	58 57.49'W	3X100 ml	Y	1000	1000	1000	Y
12/03/2012	FISH	58 10.33'S	59 59.84'W	3X100 ml	Y	500	500	800	Y
12/03/2012	FISH	58 05.75'S	60 57.04'W	3X100 ml	Y	1000	900	1000	Y
12/03/2012	FISH	58 02.33'S	61 38.95'W	3X100 ml	Y	1000	1000	1600	Y
12/03/2012	FISH	58 26.46'S	62 40.92'W	3X100 ml	Y	1000	1000	2000	Y
13/03/2012	FISH	58 48.65'S	63 31.69'W	3X100 ml	Y	1000	1000	2000	Y
13/03/2012	FISH	59 04.35'S	64 03.42'W	3X100 ml	Y	1000	1000	2000	Y
13/03/2012	FISH	59 23.31'S	64 39.79'W	3X100 ml	Y	1000	1000	2000	Y
13/03/2012	FISH	59 44.72'S	65 28.70'W	3X100 ml	Y	1000	1000	2000	Y
13/03/2012	FISH	59 57.22'S	65 56.46'W	3X100 ml	Y	1000	1000	2000	Y

13/03/2012	FISH	60 31.58'S	65 55.31'W	3X100 ml	Y	1000	1000	2000	Y
13/03/2012	FISH	61 01.06'S	65 51.58'W	3X100 ml	Y	1000	1000	2000	Y
14/03/2012	FISH	61 25.79'S	65 48.69'W	3X100 ml	Y	1000	1000	2000	Y
14/03/2012	FISH	61 44.72'S	65 46.44'W	3X100 ml	Y	1000	1000	2000	Y
14/03/2012	FISH	61 30.80'S	66 29.41'W	3X100 ml	Y	1000	1000	2000	Y
14/03/2012	FISH	61 02.79'S	67 22.38'W	3X100 ml	Y	1000	1000	2000	Y
14/03/2012	FISH	60 37.80'S	67 44.24'W	3X100 ml	Y	1000	1000	2000	Y
14/03/2012	FISH	60 14.22'S	67 59.69'W	3X100 ml	Y	1000	1000	2000	Y
15/03/2012	FISH	59 50.21'S	67 59.98'W	3X100 ml	Y	1000	1000	2000	Y
15/03/2012	FISH	59 25.72'S	67 59.91'W	3X100 ml	Y	1000	1000	2000	Y
15/03/2012	FISH	58 48.30'S	67 59.86'W	3X100 ml	Y	1000	1000	2000	Y

Table 1: List of samples taken for analysis of phytoplankton photophysiology, pigments, flow cytometry and marine optics.

2.5.1.3 Sample Analysis

The samples were analysed onboard using a Trilogy fluorometer (Turner Designs). Prior to the cruise, the fluorometer was pre-calibrated using spinach chlorophyll-a standard (Sigma). The pigment extract is measured both before and after acidification according to be method of Holm-Hansen et al. (1965).

2.5.1.4 Preliminary Results

Chlorophyll-a concentrations showed significant spatial variation over the cruise transect (Fig 1). The highest concentration (3.80 mg m^{-3}) was found north-east of the Falkland Islands on February 4th. The lowest chlorophyll concentration was found on March 14th toward the end of the Albatross line (~61°S). In general, oligotrophic conditions were observed west of 60°W and south of 58.5°S in the Drake Passage region.
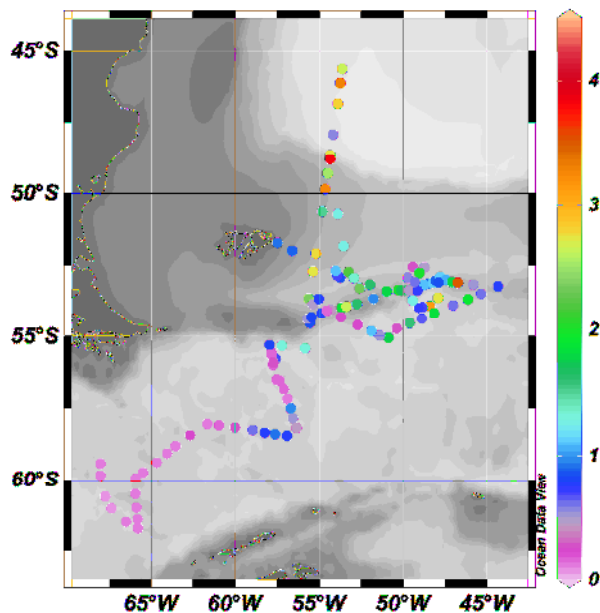

Fig 1. Surface fluorometric chlorophyll values along DIMES cruise transect.

2.5.2. High-performance liquid chromatography analysis of algal pigments

2.5.2.1 Objectives

Phytoplankton pigments can be used as chemotaxonomic markers of key phytoplankton taxonomic groups involved in biogeochemical cycles. These pigments also jointly contribute to the absorptive properties of marine phytoplankton and thus can assist in analysing sources of spectral variation in the shape of the phytoplankton absorption spectra. Thus to examine the spatial distribution of marine phytoplankton groups and their optical properties seawater samples were collected at the sea surface from the trace-metal fish, underway non-toxic supply and CTD rosette.

2.5.2.2 Sampling Protocol

Between 480 ml and 2 litres of seawater was subsampled from large (9-20 litre) Nalgene carboys and filtered through 25 mm GF/F filters. The filters were placed in 2 ml cryovials and flash frozen in liquid nitrogen. Filters were then transferred to a -80°C freezer for long-term storage. A detailed list of samples collected may be found in Table 1.

2.5.2.3 Sample Analysis

Frozen samples will be transported back to the Plymouth Marine Laboratory in a dry shipper and stored at -80°C until analysed. Pigment extracts will be analysed using a reverse-phase HPLC column (Hypersil 3 mm C8 MOS-2) using Thermo-separations and Agilent instruments (Barlow et al., 1997). The instrument is calibrated using pigment standards (DHI Water and Environment, Denmark) on an annual basis.

2.5.3. Light absorption by marine particles

2.5.3.1 Objectives

Samples were collected to examine the absorptive properties of phytoplankton cells. These data will be used to derive information on the absorptive efficiency of the natural phytoplankton assemblage, which in turn will aid in the interpretation of the photochemical signal obtained by Fast Repetition Rate (FRR) Fluorometry. Another motivation is to test and refine algorithms used to detect the concentration of chlorophyll-a and the presence of algal functional types by ocean-colour remote sensing.

2.5.3.2 Sampling Protocol

Surface samples were collected from the FISH, non-toxic supply and CTD rosette. Between 100 ml and 1 litre of seawater was subsampled from large (9-20 litre) Nalgene carboys and filtered through 25 mm GF/F filters. The filters were placed in 2ml cryovials and flash frozen in liquid nitrogen. Care was taken to avoid creases or folds in the filter by rolling the filter with the particle laden side facing inwards. Filters were then transferred to a -80°C freezer for long-term storage. A detailed list of samples collected may be found in Table 1.

2.5.3.3 Sample Analysis

Frozen samples will be transported back to Oxford in a dry shipper and stored at -80°C until analysed. Filters will be scanned using a Shimadzu UV-2550 spectrophotometer equipped with an integrating sphere over the visible range (350-750 nm). Pigment specific absorption coefficients of phytoplankton will be calculated by dividing absorption by chlorophyll-*a* concentration (Turner or HPLC).

2.5.4. Flow cytometric analysis of phytoplankton community structure

2.5.4.1 Objectives

Our aim is to measure the concentration of pico- ($<2\mu$m) and nano- (2-10 μm) phytoplankton cells over the DIMES cruise transect.

2.5.4.2 Sampling Protocol

Seawater samples were collected from the CTD Niskin, non-toxic supply or FISH (rinsing carboy three times with sample water before filling). Samples were then fixed paraformaldehyde as soon as feasible. Duplicate 2 ml cryovials were filled with 1.875 ml of seawater. 0.125 ml of 16% paraformaldehyde (PFA) was pipetted into each vial, yielding a 1% PFA final concentration. The vials were then mixed using a vortex, and let stand at room temperature for not less than 10 minutes (and not more than about 20-30 minutes). The vials were then flash frozen in liquid nitrogen. The vials were then transferred to an ultra-low temperature freezer (-80°C) for long-term storage. A detailed list of samples collected may be found in Table 1.

2.5.4.3 Sample Analysis

The samples will be analysed at the Plymouth Marine Laboratory using a Becton Dickinson FACSortTM flow cytometer equipped with an air-cooled laser providing blue light at 488 nm (Tarran et al. 2006).

2.5.5. Fast Repetition Rate Fluorometry (FRRF)

2.5.5.1 Objectives

The objective was to characterise the along transect surface water phytoplankton photo-physiology with discrete samples using Fast Repetition Rate (FRR) Fluorometry. The sampling strategy was to collect data from ~2m depth samples from the tow fish. Results from this analysis are intended to be interpreted on the basis of macro and micro nutrient availability, light climate, and taxonomic composition (see other relevant sections of cruise report).

2.5.5.2 Sampling Protocol

Samples were collected in 500 mL opaque bottles following 3 rinses with sample water. Samples were then incubated (in opaque bottles – no light) for at least 30 minutes in order for phytoplankton to become dark acclimated. During this period samples were bathed in a continuously flowing water bath of ships underway water to maintain cells at ambient temperature. Samples were collected from the trace-metal FISH, non-toxic supply and CTD niskin (surface bottle ~ 20m depth). Samples were collected in 500 mL opaque bottles following 3 rinses with sample water. Samples were then incubated (in opaque bottles – no light) for at least 30 minutes in order for phytoplankton to become dark acclimated. During this period samples were bathed in a continuously flowing water bath of ships underway water to limit sample temperature change.

2.5.5.3 Sample Analysis

All sample analysis for this measurement was conducted on ship. After 30 minutes of dark incubation (see sampling protocol section), phytoplankton in samples were assumed to be dark acclimated. For each sample bottle: sample bottle was inverted to homogenise sample, sample water was then used to wash a pyrex test tube 3 times before filling with roughly 3 mL of sample. The filled test tube was then wiped with tissue paper before being inserted into the Fast Repletion Rate Fluorometer (FRRF). The FRRF instrument used was a Chelsea Technologies Group Ltd FAST^{act} sample chamber, FAST^{act} base unit, and FAST$^{tracka\ 2}$ sensor. The sensor water jacket was filled with Milli-Q pumped from a beaker stored in the flow through water bath described previously. FRRF measurements were then taken as follows: single acquisitions were taken for all samples to obtain measurements of, among others, F_v/F_m (the maximum photochemical efficiency of Photosystem II (PS II), dimensionless) and σ_{PS2} (the functional absorption cross section of PS II, nm^2). Rapid Light Curves (RLC) were obtained for all samples. The water jacket pump was run between samples for single acquisitions and continuously at a low rate during RLC analysis to maintain sample temperature at that of the ships underway water flow. Blanks were run for most samples using the following procedure: an aliquot of roughly 3 mL of sample was filtered using a 0.2 μm pore size filter and a single acquisition made using the same FRRF settings as the unfiltered sample.

2.5.5.4 Preliminary Results

Refer to Fig. 2 below. F_v/F_m values generally show a shift from high values on the North Scotia Ridge to lower values in the central Scotia Sea and Drake Passage region. This trend is thought to be largely controlled by Fe bioavailability, although species composition and light stress are also thought to exert significant control on observed variability. F_v/F_m variability within a given region is mostly thought to depend on the degree of light stress the phytoplankton are experiencing (i.e. time of day). F_v/F_m values are uncorrected for blank measurements and instrument PMT gain setting. Blank values were often high (reaching>50% of the measurement in low chlorophyll waters) and are therefore thought to have a significant effect on F_v/F_m values when corrected.
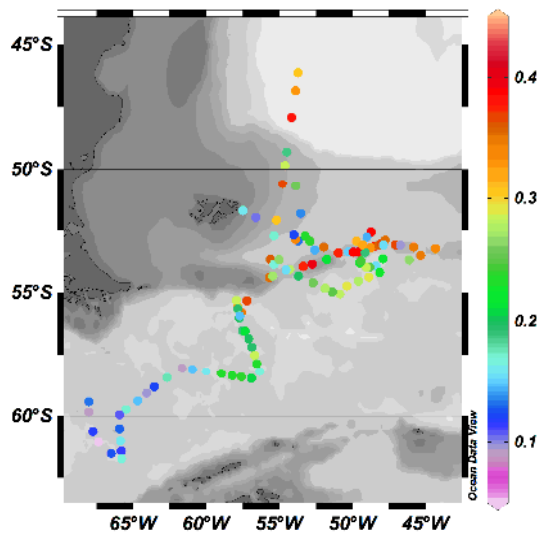

Figure 2: Map of uncorrected F_v/F_m for fish samples in the cruise region.

2.5.6. Fe Incubation Experiments

2.5.6.1 Objectives

The objectives were twofold: 1) to characterise surface Fe limitation of phytoplankton throughout the cruise region, and 2) assess the impact of ash addition on phytoplankton photo-physiology.

2.5.6.2 Sampling Protocol

a) Standard Fe addition experiments

For a standard Fe addition experiment, 9 1L polycarbonate bottle were filled with seawater from the trace metal clean fish. The 1L bottles had previously been rigorously cleaned using soaks in Decon, 3M HCl, 0.5M HCl, with Milli-Q washes in between and were stored in acidified Milli-Q for transport. The bottles were rinsed and filled in a trace metal clean container. The optimum time for filling bottles from the fish was midnight but this varied somewhat depending on the availability of clean fish water at this time (i.e. whether on station or not). The filling time for the 9 1L bottles from the trace metal clean fish was around 10 minutes. Whilst in the clean container, 3 bottles were immediately sub-sampled for chlorophyll concentrations, single acquisitions using the FRRF, and nutrient concentrations (see relevant sections of cruise report for protocols). 3 bottles spiked with $FeCl_3$ in a 10% HCl solution (to produce a final bottle concentration of 2 nM Fe) and 3 control bottles (non Fe spiked) were parafilmed, double bagged and placed in an on-deck incubator which was filled with continuously flowing ships non-toxic flow through water. The incubator was shaded with blue screening to simulate the light field at ~5 m water depth. When on station, the incubator was shielded from deck lighting using an opaque black cover. After 24 hours the 3 Fe spiked and 3 control bottles were removed and sampled for chlorophyll concentrations and single acquisitions from the FRRF. Significant increases in F_v/F_m values of Fe amended bottles were used as a signature for Fe limitation of phytoplankton. When not being used directly for a subsequent experiment, incubation bottles were rinsed and left filled with 100-200 mL 5-10% HCl.

One experiment (IF33) was subsampled for FRRF measurements at 24 hours and then replaced in the incubator for another 24 hours before final FRRF and chlorophyll measurements were made. This was carried out to see if a larger response was seen over 48 hours.

b) Volcanic ash addition experiments

To test the hypothesis that volcanic ash addition to seawater could stimulate phytoplankton though micro nutrient addition, volcanic ash addition experiments were carried out in conjunction with 10 of the above Fe addition incubation experiments. The protocol was exactly the same as for the above Fe addition experiments, yet small quantities of either basaltic (Etna) or rhyolitic (Chaiten) ash were added in the place of $FeCl_3$. Both ash sample types were pristine (collected upon deposition), and were pre-weighed in Oxford and stored in acid cleaned 10 mL vials. When samples for ash

addition experiments were being collected in addition to the regular Fe addition experiments, this increased the bottle filling time to ~15 minutes.

19 fish samples for Fe amended incubation experiments were taken throughout the cruise region, with 10 of these including ash addition experiments (Table 2). In the 10 ash addition experiments 3 to 6 bottles were used for ash additions. This equated to 57 individual ash additions to bottles.

2.5.5.3 Preliminary Results

F_v/F_m values showed significant variability in the response to Fe and ash additions throughout the cruise region. Generally less response was seen in the North Scotia Ridge region, presumably due to sufficient Fe availability from shallow subsurface topography and nearby islands (The Falklands Islands, South Georgia). In the central Scotia Sea and Drake Passage region small increases in Fe amended bottles and larger increases in ash addition bottles were seen. The example in Fig. 3 is the one instance where Fe and ash amendment of samples produced similar F_v/F_m responses, indicating both that phytoplankton were Fe limited in this region and that the ash was supplying sufficient Fe to produce the same magnitude response. F_v/F_m values shown are uncorrected for blank measurements and instrument PMT gain setting. Blank values were often high (reaching>50% of the measurement in low chlorophyll waters) and are therefore thought to have a significant effect on F_v/F_m values when corrected. Chlorophyll concentrations in the control, Fe and ash amended bottles generally varied a small amount from initial concentrations. This was thought to be due to bottle effects e.g. the abundance of zooplankton grazers in Fe amended and control bottles.

Experiment	Start date	Start time (GMT)	End date	End time (GMT)	Ash addition
IF14	04/02/2012	02:40	05/02/2012	01:10	x
IF15	05/02/2012	03:30	06/02/2012	00:45	x
IF16	07/02/2012	21:35	08/02/2012	22:55	x
IF17	09/02/2012	05:00	10/02/2012	05:05	x
IF18	19/02/2012	07:50	20/02/2012	07:00	
IF19	20/02/2012	02:30	21/02/2012	02:30	
IF20	25/02/2012	03:45	26/02/2012	02:30	
IF21	29/02/2012	03:00	01/03/2012	03:30	
IF22	01/03/2012	03:00	02/03/2012	02:30	
IF23	02/03/2012	03:00	03/03/2012	02:30	
IF24	03/03/2012	03:00	04/03/2012	03:00	
IF25	05/03/2012	04:10	06/03/2012	03:00	
IF26	07/03/2012	03:00	08/03/2012	02:30	x
IF27	08/03/2012	04:00	09/03/2012	02:50	
IF28	09/03/2012	05:00	10/03/2012	02:50	
IF29	10/03/2012	05:50	11/03/2012	03:00	x
IF30	11/03/2012	06:00	12/03/2012	03:00	x
IF31	12/03/2012	04:20	13/03/2012	02:30	x
IF32	13/03/2012	04:00	14/03/2012	03:00	x
IF33_24hr	14/03/2012	04:10	15/03/2012	03:00	x
IF33_48hr	15/03/2012	05:10	16/03/2012	03:30	x

Table 2: Table of start/end dates and times for incubation experiments.
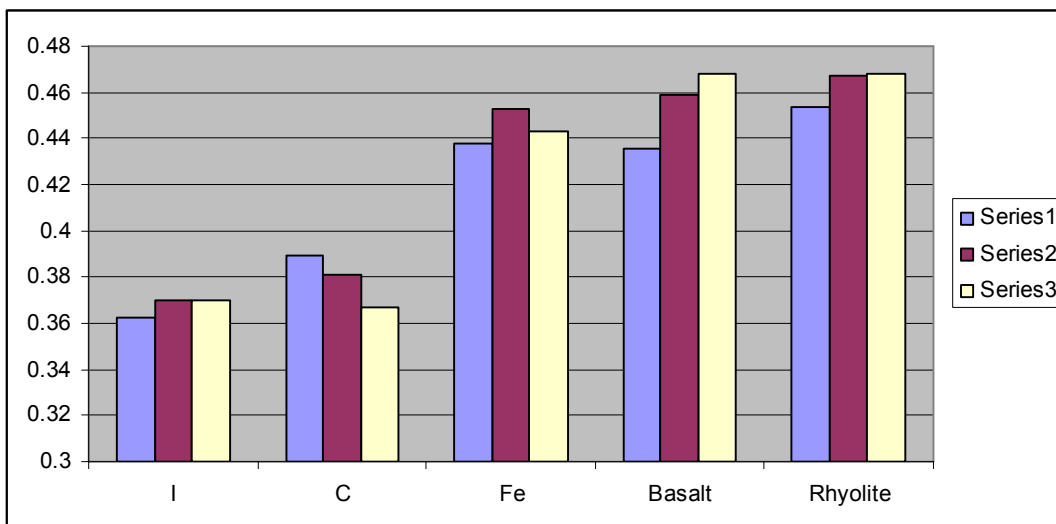
Figure 3: Example F_v/F_m results from a 24 hour Fe and ash addition experiment (IF15). I = Initial, C = Control, Fe = Fe amended to a final Fe concentration of 2 nM, Basalt = basalt ash addition, Rhyolite = rhyolite ash addition. Series number indicates bottle replicate number. In this particular experiment the Fe and ash amended bottles showed a significant F_v/F_m increase in comparison to the control bottles indicating both: 1) Fe limitation and 2) both ash types were supplying sufficient Fe to produce the same response as the Fe spike. F_v/F_m values are uncorrected for blank measurements and instrument PMT gain setting. The mass of ash added in each bottle replicate was as follows: Basalt (Etna): Series 1: 4.4 mg; Series 2: 17.9 mg; Series 3: 196 mg. Rhyolite (Chaiten): Series 1:24.9 mg; Series 2: 246 mg; Series 3: 226 mg.

2.5.7. Trace Metal Clean Fish Sampling

2.5.7.1 Trace Metal Clean Fish Setup

Near-surface seawater (~2 m depth) was pumped into a clean container from a tow-fish using a teflon diaphragm pump connected to a clean air compressor. Fish to container tubing was cleaned with 10% HCl and Milli Q washes at the beginning of the cruise, and at several points during the cruise where any contamination may have been possible (e.g. after the fish was hauled to deck prior to the medical evacuation to the Falkland Islands). The pump was turned off when on station and during pumping of the ships grey water tanks to limit contamination of tubing. When the pump was turned back on after such occasions, 30 minutes of flushing time was given prior to any sampling. There were no major issues with the setup, but several small repairs were carried out during the cruise to maintain the fish pumping clean seawater.

2.5.7.2 Dissolved surface trace metal concentrations (Mn, Fe, Co, Ni, Cu, Zn, Cd and Pb)

The aim was to characterize surface dissolved trace metal concentrations in the cruise region and relate this to the abundance, type and physiological condition of phytoplankton. 95 samples were taken throughout the cruise region (Table 3).

Filtered samples were collected through a Supor Membrane 0.8/0.2 μm Acropak filter (Pall Corperation) into acid cleaned 250 mL Nalgene LDPE bottles. The bottle cleaning protocol involved week long soaks in Decon, 3 M HCl, and 0.5 M HCl with milli Q washes in between. Bottles were stored for transport half filled with 0.024 M HCl. The acropak filter was changed around every 5 days. Samples were then acidified within one day of collection with the addition of 600 μL 10 N quartz distilled HCl under a laminar flow hood. This resulted in a final sample pH of ~1.7. Samples were then stored upright, individually double bagged, in acid cleaned plastic crates.

Upon return to Oxford samples will be analyzed by isotope dilution high resolution magnetic sector inductively coupled mass spectrometry (HR ICP-MS) following pre-concentration with column chemistry and spiking with a multi-element spike, following the method of Milne et al., 2010.

2.5.7.3 Macronutrient Concentrations

The aim was to characterize surface nitrate, phosphate and silicate concentrations in the cruise region and relate this to the abundance, type and physiological condition of phytoplankton. 95 samples were taken throughout the cruise region (Table 3).

Samples were collected from the trace metal clean fish in the clean container into pre-cleaned 60 mL Nalgene HDPE bottles. Vinyl (i.e. non-nitrile) gloves were always used for sample collection. Samples were then immediately frozen and will remain so until measured using a nutrient autoanalyser at Plymouth Marine Laboratory (PML).

2.5.7.4 Dissolved chromium concentrations

18 samples were taken throughout the cruise region on behalf of colleagues in Oxford (Table 3). Unless stated otherwise in Table 3, samples were collected from the trace metal clean fish in the clean container through a 0.8/0.4 μm Acropak filter (Pall Corperation) in 500 mL Nalgene HDPE acid cleaned bottles. Samples were subsequently acidified within one day under a laminar flow bench with 5 mL quartz distilled HCl (10 N), parafilmed, and double bagged. Samples will be measured upon return to Oxford using a Thermo-Finnigan TIMS machine.

2.5.7.4 Dissolved chromium concentrations
Oxygen Isotopes (d18O and dD)

68 samples were taken throughout the cruise region on behalf of colleagues in Oxford (Table 3). Samples were collected from the trace metal clean fish in the clean container into 8 mL glass vials. Samples will be measured upon return to Oxford using Therm Gas Bench attached to a DeltaV IRMS.

Table 3: List of samples taken in the trace metal clean container. IF stands for 'incubation fish'. 0.8/0.2 in the chromium column indicates sample was taken using a 0.8/0.2μm pore size Acropak, with remaining samples filtered using a 0.4 μm pore size Acropak.

Sample	Date	Time start (GMT)	Time finish (GMT)	Trace metals	Nutrients	Cr	O Isotopes	Incubation
D001	03/02/2012	22:02		x	x		x	
D002	04/02/2012	01:43		x	x	x (0.8/0.2)	x	
IF14	04/02/2012	01:43	02:10					x
D003	04/02/2012	07:04		x	x	x (0.8/0.2)	x	
D004	04/02/2012	15:19		x	x	x (0.8/0.2)	x	
D005	04/02/2012	18:27		x	x	x (0.8/0.2)	x	
D006	04/02/2012	21:57		x	x		x	
D007	05/02/2012	00:00		x	x	x (0.8/0.2)	x	
IF15	05/02/2012	02:43	03:00					x
D008	05/02/2012	06:55	07:06	x	x		x	
D009	05/02/2012	11:59	12:06	x	x		x	
D010	05/02/2012	15:56		x	x		x	
D011	05/02/2012	21:43		x	x		x	
D012	06/02/2012	13:01	13:05	x	x		x	
D013	07/02/2012	21:29		x	x		x	
IF16	07/02/2012	21:34	21:55					x
D014	08/02/2012	06:27	06:29	x	x		x	
D015	08/02/2012	08:20	08:23	x	x			
D016	08/02/2012	12:07	12:11	x	x		x	
D017	08/02/2012	14:05	14:07	x	x		x	
D018	08/02/2012	17:21	17:23	x	x		x	
D019	08/02/2012	20:00	20:02	x	x		x	
D020	09/02/2012	04:35	04:36	x	x		x	
IF17	09/02/2012	04:37	04:57					x
D021	16/02/2012	09:38	09:42	x	x			
D022	16/02/2012	14:13	14:15	x	x		x	
D023	16/02/2012	21:02	21:05	x	x		x	
D024	16/02/2012	21:55	21:57	x	x		x	
D025	19/02/2012	07:17	07:19	x	x		x	
IF18	19/02/2012	07:20	07:32					x
D026	19/02/2012	11:24	11:26	x	x		x	
D027	19/02/2012	14:34	14:36	x	x		x	
D028	19/02/2012	18:27	18:29	x	x		x	

D029	20/02/2012	02:08	02:09	x	x		x	
IF19	20/03/2012	02:10	02:24					x
D030	20/03/2012	20:14	20:18	x	x	x	x	
D031	24/03/2012	15:11	15:15	x	x		x	
D032	24/03/2012	19:28	19:31	x	x		x	
D033	24/03/2012	23:24	23:27	x	x		x	
D034	25/03/2012	03:05	03:06	x	x			
IF20	25/03/2012	02:47	03:05					x
D035	28/02/2012	18:15	18:19	x	x	x	x	
D036	29/02/2012	02:20	02:21	x	x			
IF21	29/02/2012	02:22	02:37					x
D037	29/02/2012	09:05	09:08	x	x		x	
D038	29/02/2012	11:03	11:07	x	x		x	
D039	29/02/2012	17:52	17:53	x	x		x	
D040	01/03/2012	01:50		x	x			
IF22	01/03/2012	01:51	02:04					x
D041	01/03/2012	22:04	22:06	x	x		x	
D042	02/03/2012	02:03	02:06	x	x			
IF23	02/03/2012	02:06	02:16					x
D043	02/03/2012	05:06	05:07	x	x		x	
D044	02/03/2012	08:23	08:25	x	x		x	
D045	02/03/2012	12:38	12:40	x	x		x	
D046	02/03/2012	15:29	15:31	x	x		x	
D047	02/03/2012	18:20	18:22	x	x		x	
D048	02/03/2012	21:26	21:27	x	x			
D049	03/03/2012	00:18	00:20	x	x		x	
D050	03/03/2012	02:33	02:35	x	x			
IF24	03/03/2012	02:35	02:50					x
D051	03/03/2012	04:40	04:42	x	x		x	
D052	03/03/2012	08:17	08:19	x	x		x	
D053	03/03/2012	12:21	12:23	x	x		x	
D054	03/03/2012	15:36	15:37	x	x			
D055	03/03/2012	18:38	18:39	x	x		x	
D056	03/03/2012	20:58	20:59	x	x			
D057	04/03/2012	16:08	16:10	x	x		x	

ID	Date	Start	End	C1	C2	C3	C4	C5
D058	04/03/2012	19:07	19:08	x	x			
D059	04/03/2012	22:05	22:08	x	x	x		
D060	05/03/2012	01:05	01:08	x	x		x	
D061	05/03/2012	04:54	04:56	x	x			
IF25	05/03/2012	04:39	04:53					x
D062	05/03/2012	07:11	07:14	x	x		x	
D063	07/03/2012	00:14	00:16	x	x			
D064	07/03/2012	02:53	00:54	x	x			
IF26	07/03/2012	02:27	02:51					x
D065	07/03/2012	19:58	20:00	x	x		x	
D066	08/03/2012	03:35	03:36	x	x			
IF27	08/03/2012	03:38	03:50					x
D067	08/03/2012	14:18	14:20	x	x		x	
D068	08/03/2012	21:23	21:26	x	x	x		
D069	09/03/2012	04:35	04:37	x	x			
IF28	09/03/2012	04:38	04:51					x
D070	09/03/2012	13:53	13:56	x	x		x	
D071	09/03/2012	22:19	22:21	x	x			
D072	10/03/2012	05:26	05:28	x	x			
IF29	10/03/2012	05:29	05:47					x
D073	11/03/2012	05:35	05:39	x	x	x	x	
IF30	11/03/2012	05:04	05:55					x
D074	11/03/2012	13:50	13:51	x	x		x	
D075	12/03/2012	01:23	01:25	x	x		x	
D076	12/03/2012	03:39	03:41	x	x	x		
IF31	12/03/2012	03:43	04:00					x
D077	12/03/2012	08:13	08:16	x	x		x	
D078	12/03/2012	11:38	11:40	x	x	x	x	
D079	12/03/2012	14:12	14:17	x	x	x	x	
D080	12/03/2012	16:29	16:32	x	x	x	x	
D081	12/03/2012	23:37	23:40	x	x	x	x	
D082	13/03/2012	03:04	03:06	x	x			
IF32	13/03/2012	03:08	03:25					x
D083	13/03/2012	08:21	08:23	x	x		x	
D084	13/03/2012	11:50	11:52	x	x		x	

ID	Date							
D085	13/03/2012	13:45	13:47	x	x			
D086	13/03/2012	19:37	19:40	x	x	x	x	
D087	14/03/2012	00:45	00:47	x	x	x		
D088	14/03/2012	02:25	02:26	x	x			
IF33	14/03/2012	02:10	02:24					x
D089	14/03/2012	08:46	08:48	x	x		x	
D090	14/03/2012	15:22	15:25	x	x		x	
D091	14/03/2012	18:07	18:10	x	x	x	x	
D092	14/03/2012	23:07	23:08	x	x			
D093	15/03/2012	23:10	23:13	x	x		x	
D094	15/03/2012	05:06	05:07	x	x			
D095	15/03/2012	12:26	12:29	x	x		x	

2.6 Chernikeef EM-log

The EM log was run throughout the cruise. It was apparent from an early stage that it was displaying readings that were too high (12 knots displayed when 10 knots was more realistic) and that it had an offset near zero (2 knots displayed when speed was near zero). This was addressed during the second Stanley port call. New speed table entries were calculate and entered on 23 Feb at 054/1850.

The initial table entries in the deck unit were obtained from the deck unit using the procedure outlined on page 37 and 38 of the manual. The use of F2 seemed to get the unit into a hung mode. However F3, to display the 'calibration data' (Tables 1 and 2), F4 to enter new calibration data, and F5 to display the LOOKUP table were all useful. The LOOKUP table is the interpolated table that the deck unit makes from the 'calibration data' internally to convert a/d data (sensor measured) to true speed (output). The manual was last seen stored on the shelf of manuals on the starboard side of the plot area in the main lab. F3 was used to establish the 'current' calibration data, as follows: Table 2, in particular, was a bit of a mess. Note speeds are knots times 100, eg 0371 is 3.71 knots.

Table 1		
RPM	s (true)	a (measured)
0037	0371	0092
0060	0590	0150
0085	0788	0212
0110	1066	0274

Table 2		
RPM	s (true)	a (measured)
0013	0108	0019
0020	0155	0032
0027	0207	0046
0037	0371	0092

0047	0411	0093
0060	0590	0150
0084	0795	0180
0110	1011	0274

A new calibration was estimated by comparing chf_emlog data with the forwards resolved component of bin 2 of theOS150 VMADCP. Fig 2.6.1 Shows the initial biased data in blue, a calibration fit to the data, and the calibrated data in black. Figure 2.6.2 shows calibrated data for the very early part of the cruise (up to end of 5 Feb, day 036/235959, showing the reduction in displayed speed has been a bit too severe: the calibrated data now under-reads. Perhaps there is a temperature dependence and the calibration will be in error in warmer water ? Figure 2.6.3 shows 'raw' data after 054/1800: the calibration fit is good and no further adjustments are made.

In order to prepare a revised calibration table, the old LOOKUP table was noted, using F5. The internal Lookup table exists every 2 counts in a/d display, and the table below shows selected entries. At certain key points, the required new true speed was chosen, from the data that made up Fig. 2.6.1. Some extra entries are shown purely for illustration. Thus:

Lookup table		
a/d (transducer)	s (true speed) Before 054/1821	Correct true speed from Fig. 2.6.1 After 054/1821
0000	0000	0000
0010	0048	
0040	0161	0008
0080	0322	
0092	***0371***	0148
0100	0401	0164
0120	0476	
0140	0552	
0150	***0590***	0295
0180	0685	
0200	0749	
0212	***0788***	0628
0274	***1066***	0866
0370	1496	1234

There are several things to note in the lookup table. The numbers in bold, italic, underline correspond to points in calibration Table 1, as they should. It was noted that the raw data in Fig. 2.6.1 could be naturally fitted with a piecewise linear fit with breakpoints at the emlog reported speeds of s = 5.90 and s = 7.88 which occur in Table 1, confirming that those points contained poor calibration data. New 'true speed' values of 2.95 and 6.28 were chosen for the corresponding a/d values, as listed in the right hand column of the displayed Lookup Table. Finally, there did not seem to be a way to enter a 'negative true speed', as might be required when the a/d returns less than 0040. Therefore the Lookup table interpolates to the 0000/0000 point.

A new calibration table was therefore generated as follows, and entered into both Table 1 and Table 2 of the emlog unit:

Revised Tables 1 and 2		
RPM	s (true)	a (measured)
0027	0008	0040
0060	0295	0150
0085	0628	0212
0110	0866	0274
0130	1234	0370

The RPM speeds in this table have no effect on the conversion from sensor a/d to true speed output, but they are needed to construct the table. The new calibration data were entered F4, and the Lookup table examined (F5). The new calibration points appear in the Lookup table exactly as in Revised Tables 1 and 2, with interpolated and extrapolated points as expected. When the sensor a/d reports 0040, the true speed displayed is now 0.08 knots (previously 1.61 knots), reducing to zero at a sensor a/d of zero.

<u>Calculating and applying correction in mexec</u>

emlog_calculate_cal.m

      Load appended vmadcp data (5 minute bins) from os150_jc069_nnx_01; re-calculate relative speed from absolute water velocity and ship speed;

      Load heading data from bst_jc069_01; resolve water-past-ship relative speed to forwards

      Average chf em log data into 5 minute bins

      input: chf_jc069_01.nc

      output: chf_jc069_01_av.nc

      Discard chf time bins in which the standard deviation of the speedfa is greater than 0.5 knots; we want periods of steady speed.

      Interpolate chf speed onto ADCP speed, convert knots to m/s.

      Display comparison between chf and ADCP (converted back to knots !).

      Calculate the calibration line.

There are three different time brackets around line 80 of *emlog_calculate_cal*, used to generate Figs 2.6.1, 2.6.2, 2.6.3, for the 'early','calibration' and 'late' parts of the cruise.

Continuity of calibration: In the calibration period, the data were fitted with a straight line for raw speedfa < 5.90 and for raw speedfa > 7.88. The end points were then joined linearly for raw speedfa in the range 5.90 to 7.88.

emlog_apply_cal.m

      calls *emlog_cal_jc069* in mcalc

            for time earlier than 054/1851, use a lookup table (below) to adjust raw chf data   for time later than 054/1851, no change.

      averages to 5 minute binned data

      input: chf_jc069_01.nc

      output: chf_jc069_01_cal.nc

      outout: chf_jc069_01_cal_av.nc

The adjustment table simply corresponds to the initial and corrected true speeds from the two right hand columns of the Lookup table, extrapolated for all possible input values

Raw chf speedfa	Adjusted chf speedfa
-2.00	-2.3338
5.90	2.9490
7.88	6.2769
20.00	16.6582

Figure 2.6.1

Figure 2.6.2

em log cal jc069
end of cruise no further cal applied
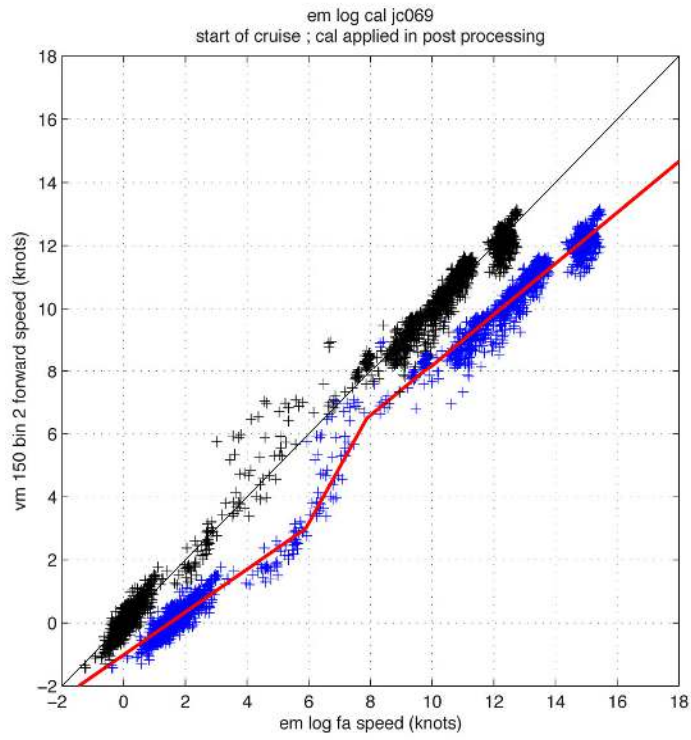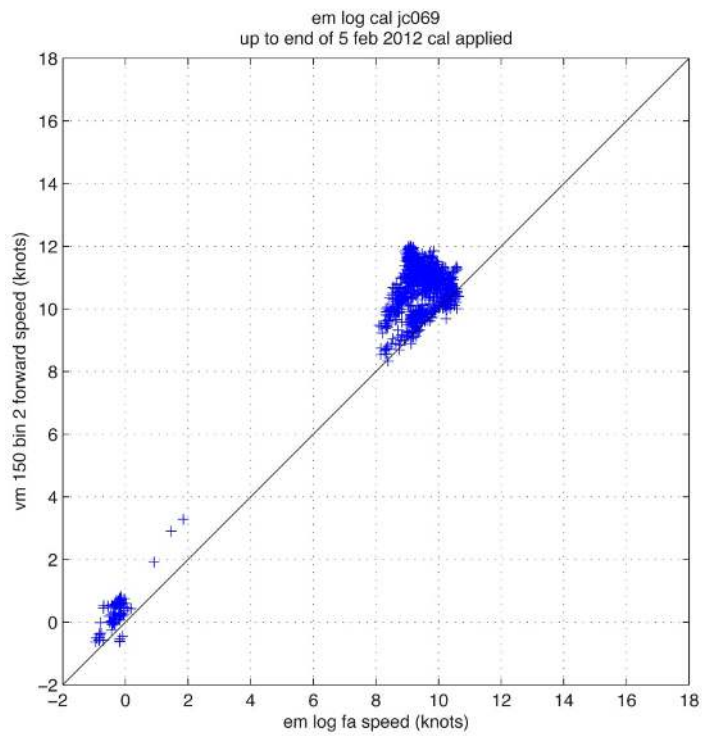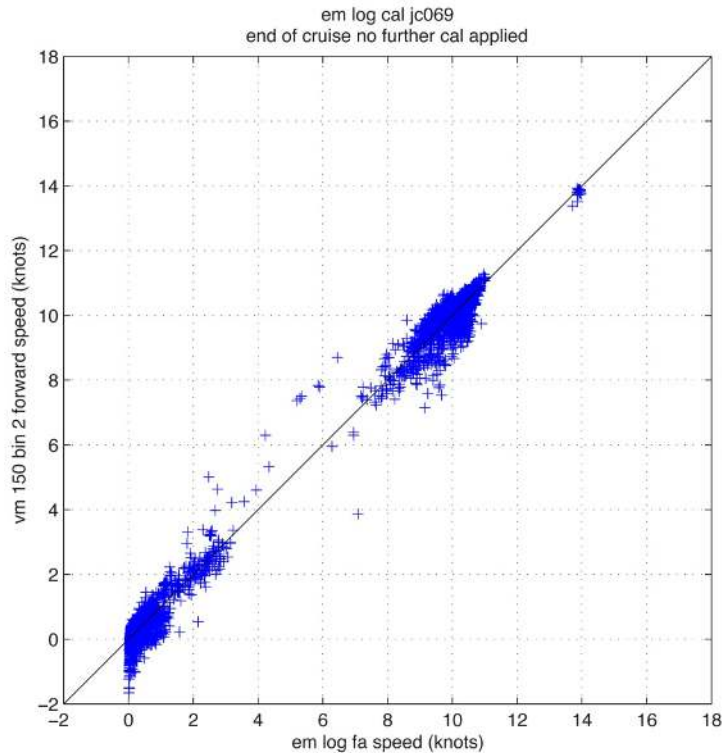
Figure 2.6.3

A copy of this report has been left in the instrument manual.

2.7 Dartcom
Brian King

The Dartcom receiver should be capable of automatically receiving visible and IR weather images form polar orbiting satellites. However a fault somewhere in the system meant that the antenna tended to lock in an unfavourable position and miss all satellite passes.

The orbital predictor worked well, so the solution to the problem was to restart the Antenna Tracking System software shortly prior to a satellite pass. The restart process took 6 minutes, but restarting it, say 7 minutes before a pass commenced was generally effective.

A number of satellite images, mainly from the NOAA 16, 18 and19 satellites were captured in this way.

2.8 Recommendations
Brian King

1) The CNAV logging into TECHSAS should be sorted out as soon as possible.
2) The time lag in the SBE TSG data should be investigated and the situation resolved.

3 DISCRETE SAMPLES

3.1 Bottle salinity
Brian King

Bottle salinity samples were analysed for calibration of CTD and surface thermosalinograph.

Samples were run on one of two autosals in the Controlled Environment lab. The temperature in that lab was monitored as part of the 4-hourly watchkeeping routine, and proved to be very stable during the cruise: much more so than during JC032 for example. The variation was no more than a degree or two from the mean. The autosals were operated at 21°C. The first autosal used, s/n 68426 was not entirely satisfactory. It was very stable while gathering three readings for one sample: frequently no more than 1 count spread in the Guildline display. However, there was a significant drift in the standardisation between the start and end of a run, usually upwards, and sometimes by as much as 10 counts over 2 crates. Accordingly, we swapped to using 65764 for the second part of the cruise, for CTD stations after 039. However, this instrument also showed drift of similar magnitude during a 2-crate run. Since it was no worse than 68426, we stayed on 65764. There was also instability in the sense that the standardisation was not just a simple slow drift over several weeks, as has been seen before. The variations suggested by the running of standards were real, and confirmed by the comparison of bottles with CTD data. The CTD sensors were very stable. When the standards suggest a particular crate should be adjusted up or down relative to its neighbours, this usually brought the bottles into tighter agreement with the CTD.

The reasons for the instruments being less stable than in previous experience were not clear. Temperature in the lab seemed very good and stable. We noted that 65764 has one temperature sensor out of spec. Switching from both sensors to ck1 or ck2 made for a very long delay (minutes) before the heaters started cycling normally. The service sheets showed that at the last service check, one temperature sensor was out of spec, although the 'normal' setting using both sensors was within spec.

In summary, the quality of the bottle data 'good' rather than 'superb', but the stability of the CTD sensors means that enough bottle samples were obtained ot be confident of the final CTD data quality.

Sample data capture: Guildline display values were sampled and logged by software on the attached PC. The use of this software removed possible biases from 6 different analysts. Some notes on a consistent naming convention were used, to make loading of the Excel spreadsheet data into mexec a turnkey operation. Here are the key points:

1) Start a new logging file for each station, rather than each crate (on jc069 we typically took 12 samples per station, so there were 2 stations in a crate). SO there is one excel file per station.

2) The 'root' for the bottle names should be 6 characters and a space, eg 'ctd001 ' or 'tsg001 '. This is the format expected in mexec script *msal_01.m.* Then enter the sample bottle number as normal.

3) When running a standard, ignore the software's standardisation option. Instead run it as a normal sample, with bottle number 9xxx, where xxx is the sequential standard number during the cruise. (00 to 80 on jc069).

The xls file is then edited and saved as a csv file, either
sal_jc069_001.csv, or tsg_jc069_001.csv

The xls file has 9 columns of data, to which a tenth must be added. For CTD crates, this is the sample number for each sample. For station 17, Niskin 6, the sample number is 1706. For standard 9007, the sample number is 999007. Note that 999007 cannot be used as bottle number in the autosal software because it is too large. 9007 cannot be used in mexec, because it would be confused with station 90 sample 07. The mexec script *msal_01* will parse the correct data out of the csv file constructed in this way.

For TSG data, the identifying 'number' for *mtsg_01* in column J is the time of sample: daynumber and hhmmss, eg 70124200 for 1242 and no seconds on day 70.

Offset for each crate: Both *msal_01* and *mtsg_01* request the adjustment to be applied to the data, for the offset between the analysis of standards and the label value. This must be compiled by careful judgement and then applied. On jc069, a handwritten table was maintained of the sequential standards, and which crates were run in between them. This enabled an adjustment to be chosen for each station. The adjustments for each station were assembled in a script *msal_setup_saladj_jc069.m*. This was then used in advance of running *msal_01* in a loop. Whereas on other cruises the assumption has been of steady slow drift, so the offset for each station changes slowly, on this cruise each standard was taken at face value, and crates were adjusted on a case by case basis, usually averaging the standards at the start and end of a crate.

SSW batches. Two batches were used: initially P151 (2*K15 = 1.99994), then an overlap period, then P153 (1.99958). During the overlap period, in which 7 pairs of 151/153 comparisons were run, it was found that adjusting to P151 would have added 5 counts to the Guildline display (0.001 higher salinity) compared with P153. Eg an adjustment of -3 to data for adjusting to P151 or -8 to data for adjusting to P153. Since P153 was the more recently bottled batch, we adjusted all data to P153. Data run early in the cruise using P151 had +5 added to the Guildline adjustment determined from P151.

Thermosalinograph samples

182 samples were analysed for TSG calibration, collected in 8 crates. These were nominally one per 4 hour period, with some omitted when the ship was on station or hove to for weather for extended periods. Data were transferred from the

CTD samples

873 samples were analysed from 74 CTD stations. The residuals with CTD data are discussed in the CTD section of the cruise report.

3.2 Measurements and distribution of the tracer CF3SF5

Marie-Jose Messias*, Ben Mills*, Steve Woodward, Neill Mackay, Andrew Watson* and Dhruv Balwada (*at the University of Exeter since August 2013)

3.2.1 Sample collection and analysis technique

The released tracer, trifluoromethyl sulphur pentafluoride (CF_3SF_5) was measured on board by a purge-and-trap gas chromatographic method. The instrumentation was built and developed at the University of East Anglia based on the Lamont Doherty Earth Observatory (LDEO) design for CFCs measurements [Smethie et

al., 2000]. A total of 1200 seawater samples including ~20% of duplicates were measured.

Water samples were collected from 10 litre bottles as soon as the CTD sampling rosette was on board. The Niskin nitrile 'O' rings were first washed in isopropanol and baked in a vacuum oven for 24 hours to remove susceptible contamination before installation in individual Niskin bottles. The trigger system of the bottles was external. Water samples were collected in 2 liter ground-glass stoppered bottles that were filled from the bottom using Tygon tubing and overflowed 1 time to expel all water exposed to the air. Immediately after sampling, the glass bottles were immersed in a cool box of cold deep seawater in the sampling hangar until the analysis. Ice packs were added as necessary to maintain a temperature below 5°C and prevent degassing.

Sample analysis was performed as soon as possible within 24 hours of the sampling. Samples were introduced to the system by applying nitrogen (N_2) pressure to the top of the sample bottles, forcing the water to flow through and fill a 1736 cm^3 calibrated volume. The measured volumes of seawater were then transferred to a purge and trap system, entering the sparge tower under vacuum. The water was sparged with a N_2 flow at 270ml/mn for 3 minutes and trapped at -110°C on a Unibeads 3S trap (two inches of 1/8inch tubing) immersed in the headspace of liquid nitrogen. The purge and trap system was interfaced to an Agilent 6890N gas chromatograph with electron capture detector (MicroECD at 320°C). The traps were heated to 110° C and injected into the gas chromatographs. The CF_3SF_5 separation was achieved using a 1m Porasil B packed pre-column and a 1.5m carbograph AC main column. A six inches molecular sieve post column was used to remove N_2O. Examples of the resulting chromatograms are displayed figure 1. The three columns were kept in the oven at 75°C. The carrier gas, N_2, was cleaned by a series of purifying traps (VICI nitrogen purifier and oxygen trap). The running time per sample is ~9 minutes.

3.2.2 Calibration, detection limit and precision

The CF_3SF_5 concentrations in air and water were calibrated using external gaseous standards. We use two working standards supplied respectively by NOAA (Brad Hall, March 2010) and WHOI (5B tank from Jim Ledwell, August 2010). The NOAA standard is clean air enriched in CF_3SF_5 inside a 29L Aculife-treated aluminium cylinders. The WHOI standard is nitrogen enriched in CF_3SF_5 inside a 10L steel cylinder. The CF_3SF_5 concentration of the WHOI standard was estimated by gravimetry at WHOI and intercalibrated with Ed Busenberg (Jim Ledwell, pers. communication). The NOAA standard was intercalibrated against the WHOI standard for CF_3SF_5 during the JC054 cruise in January 2010 and then during JC69 in February 2012 with our instrument (Table 3.2.2.1).

CF_3SF_5 concentration in air and seawater samples were determined by fitting their chromatographic peak area to multipoint calibration curves, made by injecting known volumes of gas from the working standard to the analytical system. The routine calibration curves were made by injections of different volumes (0.1, 0.25, 0.3, 0.5, 1, 2ml) of the working standards at least once per day. CF_3SF_5, was found to give a nearly linear response over a large range but was best fitted by a polynomial of order 3 (Figure 3.2.2.1).

The changes in the sensitivity of the system were tracked by injections of a fixed volume of standard gas in between stations and used to adjust the calibration curves respectively. For each sample, the bleed through the ECD sensible to flow and temperature changes was corrected by normalising by the baseline levels. The calibration precision was 1% for the tracer CF_3SF_5 (SF5 , 1ML STD, A=std(JC069_Stds_CFC(:,13)), B=mean(JC069_Stds_CFC(:,13)), C=A/B % percentage of std/mean for 1m standards, A =2.4105e-017 B =2.2098e-015   C = 0.0109).

Blank or 'contamination' are estimated from the analysis of tracer free water and subtracted from the measured concentrations. The blank for CF_3SF_5 was zero. Sparging efficiency was determined by successive resparges of a single sample until no further compound could be detected (Table 3.2.2.2).

	Mixing ratio ppt	Std Dev	calibration
CF_3SF_5	63.9	0.1	Intercalibration with Ledwell 5B tank 7/01/2011 – UK 2
CF_3SF_5	64.3	0.2	Intercalibration with Ledwell 5B tank 7/02/2012 – UK 3
CF_3SF_5	76.6	0.2	Gravimetric value revised by NOAA 1/08/2013 (previous value given in 2010 was 97.4), cylinder not analysed by NOAA for CF_3SF_5

Table 3.2.2.1: Concentrations of the working standard NOAA tank # ALL-072115.

	Mean	SDTVE	N	Area>
CF_3SF_5	96.7	1.2	30	30

Table 3.2.2.2: Sparge efficiency during JC069.
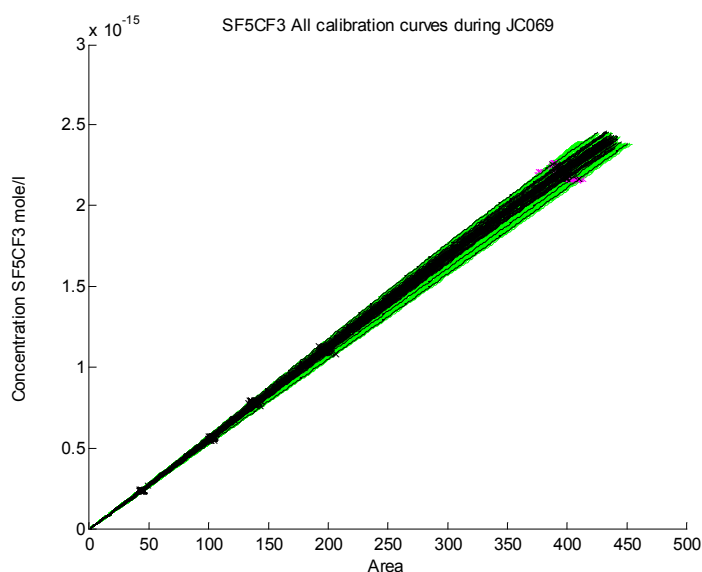
Figure 3.2.2.1:   Calibration curves for SF_5CF_3 during JC069. The measured calibrated curves are in black with the injection points marked by a cross and the extrapolated calibrated curves from the 1 ml standard value are in green.

The reproducibility of the samples was estimated from the analysis of duplicates samples (Figure 3.2.2.2 & Table 3.2.2.3), giving a precision (1 standard deviation) for dissolved SF_5CF_3 measurements of 3.3% or 0.005 femtoM, whichever is greater.
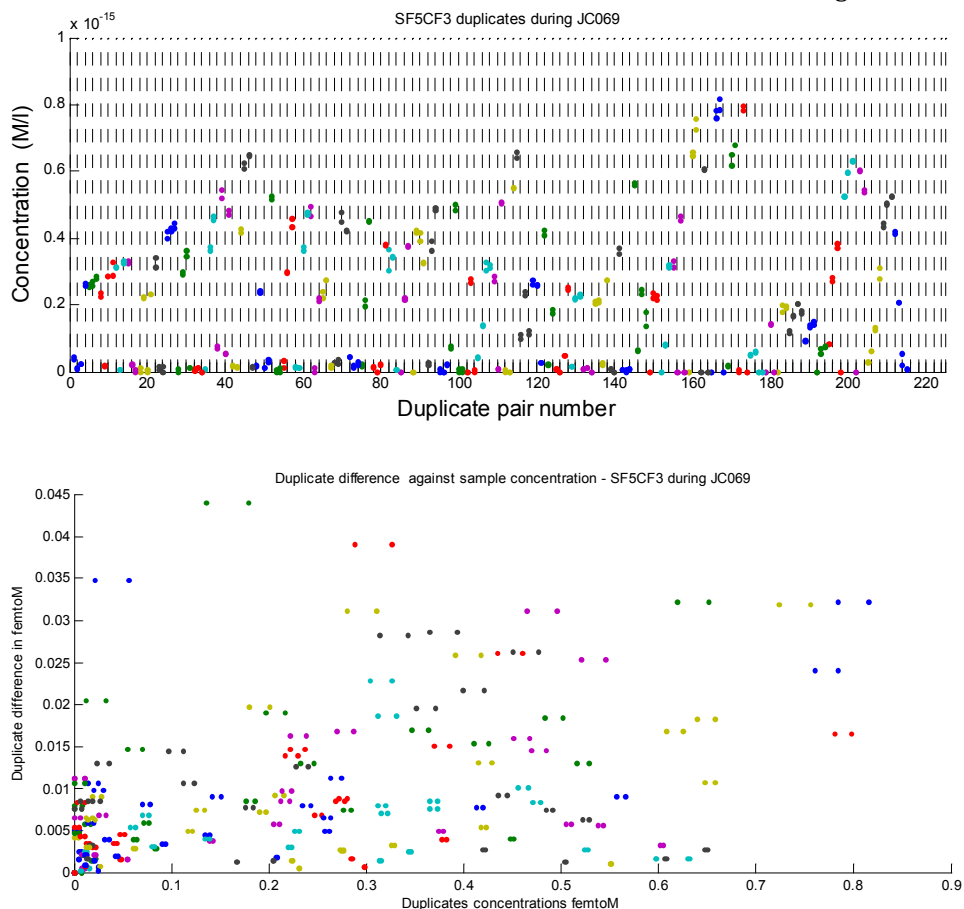
Figure 3.2.2.2 CF_3SF_5 concentrations for each duplicate drawn from same Niskin bottles along the cruise a) Duplicate concentration versus duplicate number b) Difference between duplicates versus duplicate concentration.

	Difference femtoM	Difference %
Mean all samples	0.008	15.29
STD all samples	0.009	26.52
sample concentration	>0.07	>0.07
Mean Concentration difference	0.011	3.60
STD	0.009	3.34
sample concentrations	<0.07	<0.07
Mean Concentration difference	0.004	34.18
STD	0.005	35.34

Table 3.2.2.3. Duplicates results during JC069.
The samples are flagged as 2 for good, 3 for questionable, 4 for bad and 9 for no data.

3.2.3 Preliminary results

The tracer (73 kg) was released in February 2009 (cruise US1) on the 27.9 kg m^{-3} neutral density surface (in UCDW ~1500 m depth) in the Pacific upstream of the Drake Passage at 58°S, 107°W between the SAF and the PF. The aim was to obtain measurements of diapycnal and isopycnal mixing in the Southeast Pacific and the Southwest Atlantic sectors of the Antarctc Circumpolar Current as the tracer spread. Subsequent to the release, several cruises (US2, year 1, UK2 year 1.9, UK2.5 year 2.2, US3 year 2.5) monitored its vertical and horizontal dispersion downstream of the release (note only a fraction of the released amount could be surveyed each time). This cruise, 3.1 years after the release, was the 3rd cruise performed by the UK team using the analysis system described above. The sampling depths of the Niskin bottles were optimised to bracket the tracer density spread range.

Figure 3.2.3.1: Below shows the tracer horizontal spread as amounts of column-integrated tracer concentration measured at each station over the full area surveyed and a zoom over the Shag Rock Passage. Circle diameter is proportional to the tracer concentration (10^{-12} mol m^{-2}), cross station are station without tracer form the release and numbers give stations. GEBCO 2mn topography is in colour.
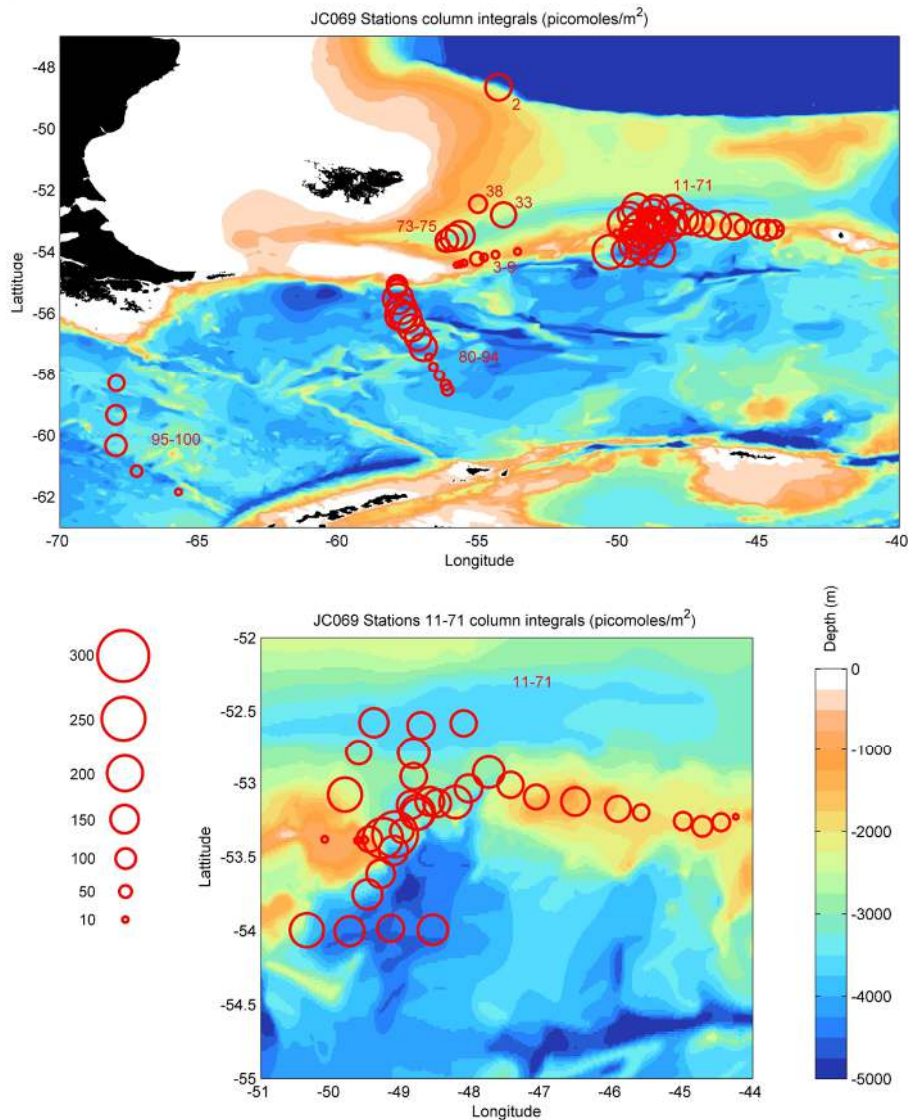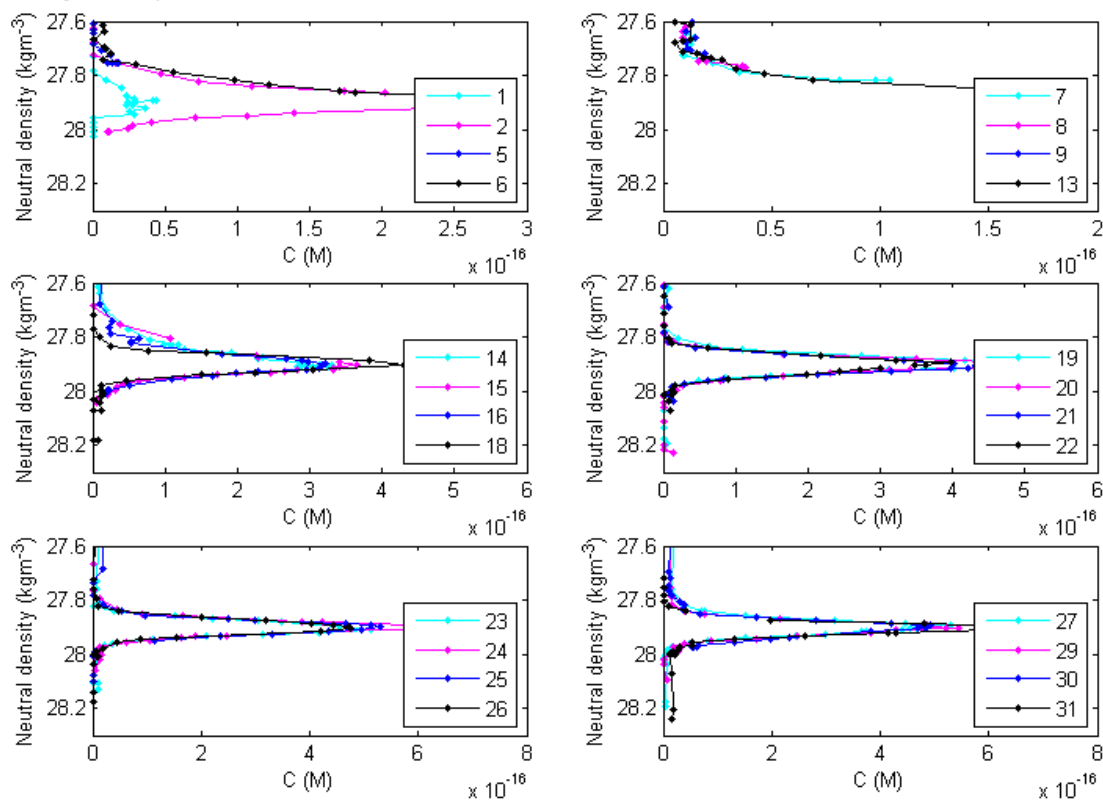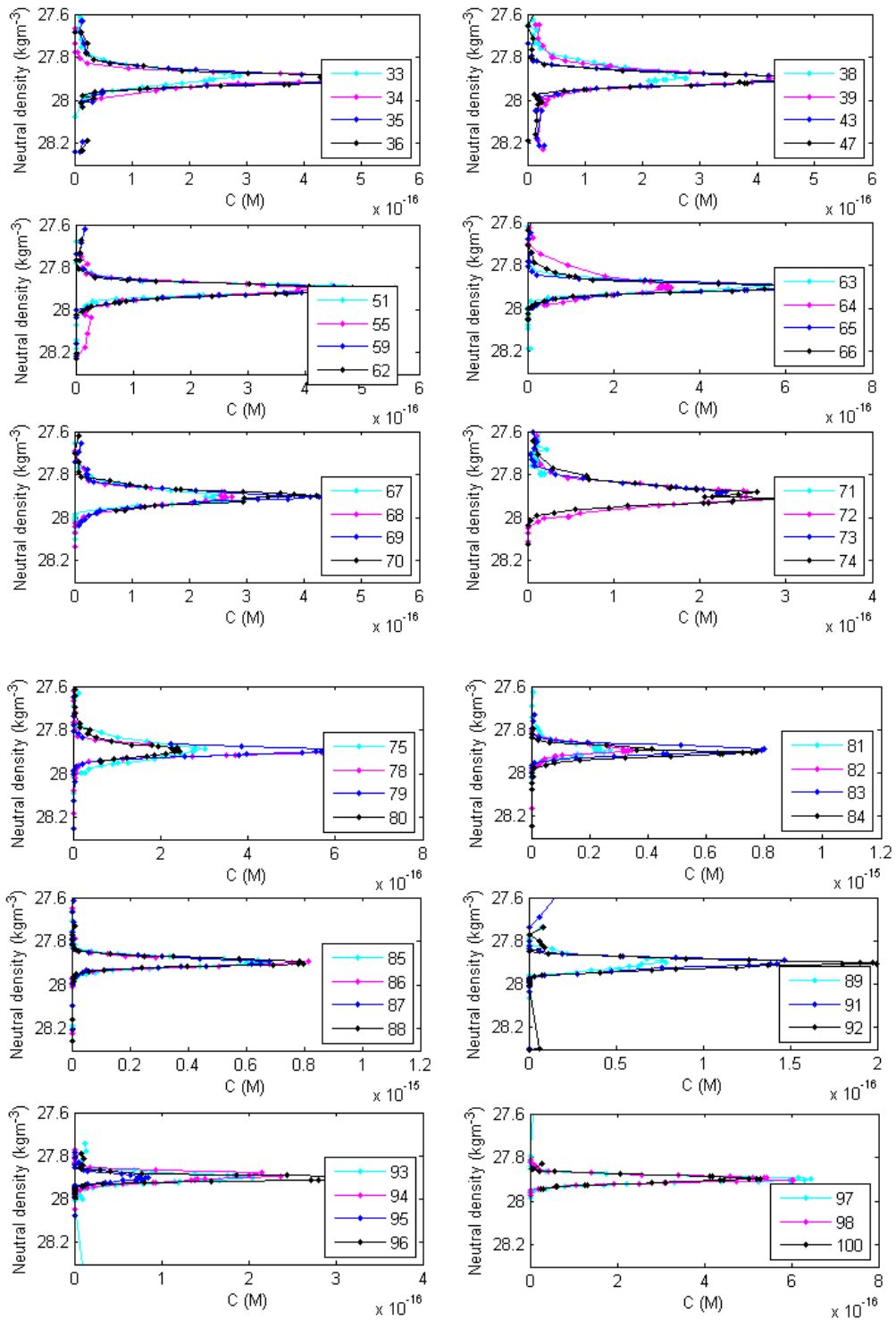
Figure 3.2.3.1 shows the column-integrated tracer concentration distributions along the AAC flow, converging at Drake passage and then veering north.
The high concentrations at the Shag Rock Passage and in the Argentine Basin compared to the section at 68°W suggests that the bulk of the tracer was going through the north Scotia Ridge by the time of the UK3 cruise.

Figure 3.2.3.2.: Below shows tracer vertical spread as width of tracer peak concentration at each station over the full area surveyed and a zoom over the Shag Rock Passage. Circle diameter is proportional to the tracer concentration (10^{-12} mol m−2), cross station are station without tracer form the release and numbers give stations. GEBCO 2mn topography is in colour.
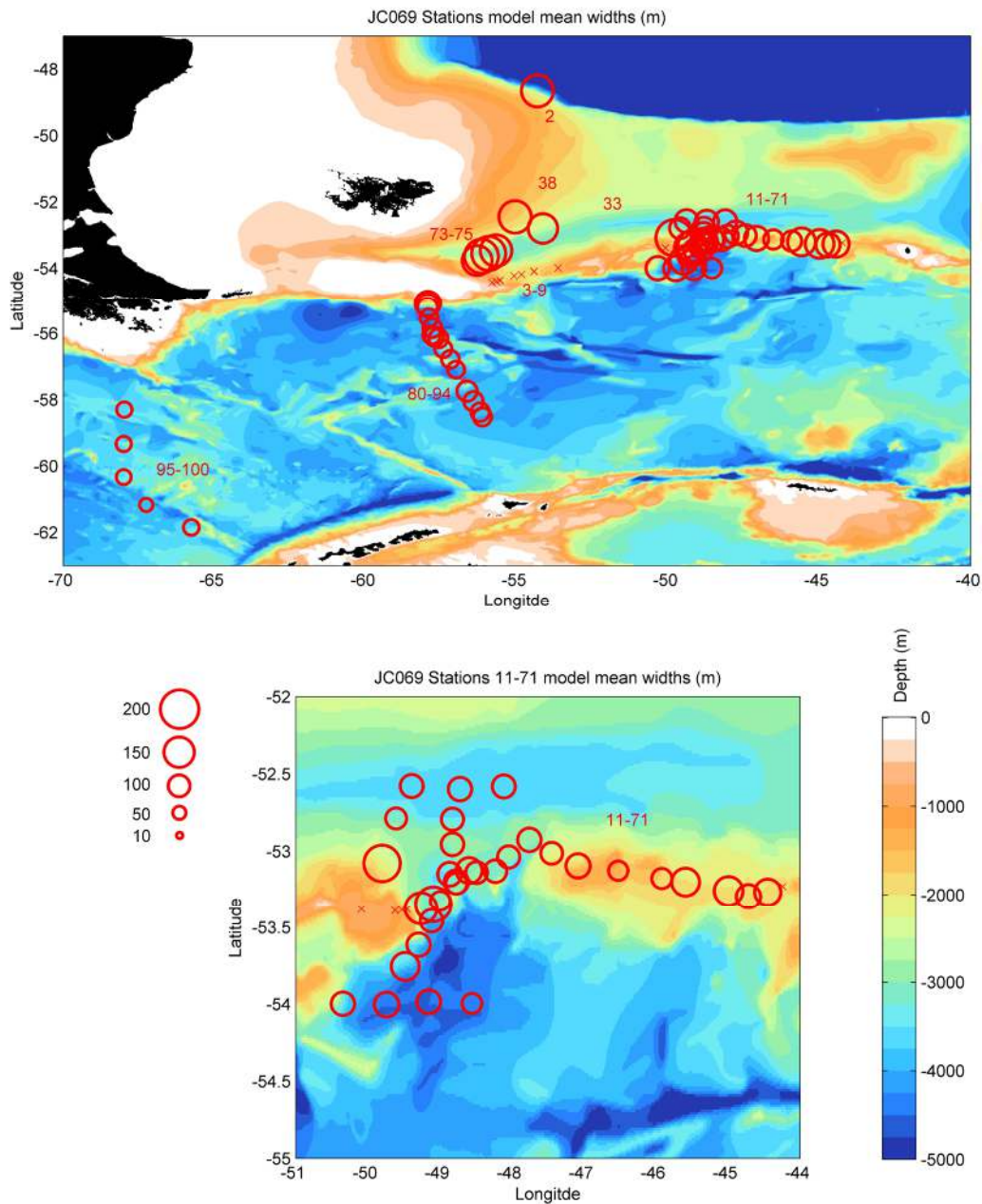
The vertical spread of the tracer illustrated Figure 3.2.3.2 was fairly consistent with the previous cruises results at the SR1 repeat. At Shag Rock Passage and in the Argentinean basin it was larger on the slope along the SAF. The tracer appeared roughly centred on the target density with a near Gaussian peak shape at almost all stations. However, very low concentrations of tracer were found at a lower level at some stations south-east of Shag Rock Passage suggesting downward entrainment may be by turbulent shear flow.

Atmospheric concentrations for CF_3SF_5

CF_3SF_5 in the atmosphere is very low at the sub part per trillion (ppt) level by volume, however it is detectable in cold surface waters. Our air measurements collected via a 100 ml glass syringe at station 7 (7/02/1212, n=9 pairs) are ~0.2 +/- 5 percent ppt. This value is comprised between predicted current levels of CF_3SF_5 of approximately 0.16 (Sturge, personnel communication) and 0.25 +/- 10 percent error ppt (considering an increasing of ~six percent per year based on analyses conducted on Antarctic, Sturges *et al.* 2000, Stay, 2007).

Figure 3.2.3.3: Below shows the tracer data for each station with tracer from the release plotted as a function of neutral density with bottle position and interpolating lines.

References
Smethie, W.M., Schlosser, P., Bönisch, G., Hopkins, T.S., 2000. Renewal and circulation of intermediate waters in the Canadian Basin observed on the SCICEX 96 cruise. Journal of Geophysical Research 105, 1105-1121.
Sturges WT, Wallington TJ, Hurley MD, et al. A potent greenhouse gas identified in the atmosphere: SF5CF3. Science 2000; 289:611-613.
Tsai WT. The prediction of environmental fate for trifluoromethyl sulfur pentafluoride (SF5CF3), A potent greenhouse gas. J Haz Mat 2007; 149: 747-751.

4. DEPLOYED EQUIPMENT

4.1 Vertical Microstructure Probes (VMPs): Operations and Measurements

Jeff Benson, Alex Brearley, Ken Decoteau, Alberto Naveira Garabato, Paul Provost, Katy Sheen, Louis St Laurent

Cruise narrative

The Vertical Microstructure Profiler (VMP-5500, VMP for short thereafter) is a novel scientific instrument manufactured by Rockland Scientific International that measures profiles of temperature, conductivity and velocity microstructure (i.e. on the length scales of the dissipation of turbulent flows, typically a few millimetres to tens of centimetres) throughout the water column. Two VMPs belonging to NOCS and WHOI were used during JC069 / UK DIMES 3 cruise. This represented the third installment of the DIMES microstructure programme (the first set of measurements having been conducted in the US DIMES 2 and UK DIMES 2/2.5 cruises in January – March 2010 and December – April 2010/11, respectively), the central goal of which is to obtain measurements of turbulent kinetic energy dissipation and mixing across a range of topographic and flow regimes in the Southeast Pacific and Southwest Atlantic sectors of the Antarctic Circumpolar Current.

Two unplanned steams back to the Falkland Islands due to medical issues introduced delays to the start of the cruise. In addition, there was several days of weather down time whilst on the North Scotia Ridge section, during which winds reached above 25 knots or thick fog impeded recovery visibility. After the 19th February, conditions improved, and a VMP was deployed with nearly every CTD cast in the remaining North Scotia Ridge stations. All CTDs along the SR1 transect were accompanied with a VMP, other than the very last station which was cut short due to time restraints. Along the Drake Passage line, no VMP deployments were made (out of a total 5 CTD casts). There are some stations in North Scotia Ridge, where problems with the CTD wire meant that only a VMP was cast was conducted or where a complete VMP profile was conducted before the CTD cast was able to begin.

Full-depth CTDs were conducted at VMP stations, which meant that time was not wasted whilst waiting for the instrument to surface and accompanying full-depth LADCP data were collected. The availability of the WHOI track and cradle, relieved

the co-use of the crane for CTD and VMP deployment. It was therefore not necessary to deploy the VMP before the CTD as in previous UK DIMES cruises, introducing much more freedom in choosing the VMP deployment time. As a result, with correct timing, the VMP was not left to floating on the surface whilst waiting to complete the CTD casts. Depending on the depth of the station and VMP fall speed, the VMP was generally deployed between half way and the bottom of the CTD down cast. It was advisable to wait at least 15 minutes after the CTD was in the water to prevent collision with the VMP, allow for estimation of the CTD scroll-out rate and incase of early terminations or wire scrolling trouble. CTD and VMP recovery time differences are presented in table . They generally range from 15 minutes to 2 hours. Longer waits are associated with deeper casts, why (?). Recovery times of the WHOI VMP were slightly longer than the NOCS VMP due to the inability to track the profiler during its dive using the telemetry transponder unit.

The general mode of microstructure operations consisted of the alternate use of the two VMP-5500 instruments, to prevent excessive battery discharge. At the start of the cruise, however, due to repairs being carried out on the WHOI VMP, the NOCS instrument was used for every cast. Shallower dives along the North Scotia Ridge during this period, along with some weather down-time, meant that this was achievable without any time wasted for battery re-charging. Later in the cruise the NOCS VMP was used for roughly every 3 of 5 casts as it was easier to track due to the availability of pressure telemetry information from the Ixsea transponder unit. The faster fall rate of the WHOI VMP, which, during JC054 meant that the instrument was floating at the surface for longer whilst waiting to complete the CTD cast, was not relevant due to the flexibility of deployment time introduced by the track and cradle (more on this below).

Altogether, 47 (including two shallow test casts) VMP and 6 HRP deployments were accomplished. A summary table of operations is included at the end of this section.

NOCS VMP Details
The NOCS VMP had been used successfully on the previous Geo-tracers cruise (JC068) by Kurt Polzin, so was assembled and ready to use. A successful on deck weight release test and tethered check for gross buoyancy were performed at the beginning of the cruise. Untethered operations for the NOCS VMP commenced on 3 February with a 100 m test cast to assess the performance of the weight release mechanism and the various sensors on the instruments. The test was successful, however the drop speed was found to be a little slow at ~0.45 m/s due to the EM current meter and floatation added since DIMES UK 2 and 2.5. It was decided to increase the ballast weights from a total of 11 kg (two NOCS weights) to 14.1 kg (one NOCS and one WHOI weight). This weight balance was used for all remaining casts, giving the NOCS VMP a drop speed of ~ 5.2 m/s.

No NOCS VMP stations were missed because of technical problems with the instrument and no significant technical issues were encountered.

A new GEM current was installed on the NOCS VMP throughout the cruise. During the first station (CTD 10), the current meter worked well, and a sinusoidal response

was seen in both the current components. After the second cast the Ux channel failed due to EL3 hose barb shearing off at base of acrylic block & hose barb elbow shearing off at EL4 port on electrode housing. Also, the connecting tubing was measured & discrepancies found in 3 of 5 lengths, which caused stress at shear points; side-loading and/or twisting of GEM assembly is suspected to be at fault. Both component channels were then bad until CTD station 47, when the Ux channel appeared to record sensible data. This was following a service of the GEM current meter in which the broken fittings and one electrode sensor were replaced.. The GEM seemed to recover a few casts following replacement of the hose barbs, re-cutting of tubing to correct lengths, and the re-potting of agar in EL3. Once stabilised in sterile standard seawater both sensor pairs functioned properly for the last 13 deployments. No attempt has been made to process the data, further than a quick plot of the recorded signals.

Generally, the new weight release mechanism and logic of the NOCS VMP led to a clear improvement in performance with respect to the JC029 / SOFINE cruise, where battery and weight release problems led to multiple bottom crashes. No bottom impacts were registered during this cruise. By alternating the WHOI and NOCS VMPs, or positioning stations accordingly, there was generally no time wasted in recharging the batteries. With a 3 hour charge time, the NOCS VMP battery was able sustain for three successive deep (> 3500 m) casts before a longer battery charge (5 hours) was required. The weight release was typically charged for 30 minutes, or 1 hour after a long profile. A fully charged NOCS battery voltage typically dropped below 9.5 VDC for a 4 hour deployment. The NOCS VMP was charged by a programmable power supply capable of constant voltage or current. To prevent over charging, the power supply was kept below 13.8 V. The NOCS VMP seemed to encounter far fewer problems charging and retaining power than during JC054, even with the new GEM current meter in place which has significant power consumption. Communications with the instrument also seemed far more reliable and speedy than during JC054 (no terminal window hanging was observed).

WHOI VMP and HRP details

Two microstructure sampling instruments from WHOI were deployed during the expedition. The High-Resolution Profiler (HRP) is the WHOI designed system built in 2004. In addition to a standard set of turbulence sensors, the HRP was equipped with a custom WHOI-designed CTD and acoustic velocimeter, in addition to a Sanford geo-electromagnetic current meter. The WHOI Rockland VMPs were built by R. G. Lueck Consulting in 2005. They are essentially identical to the NOC VMP, except one model (unit 008) has not been outfitted with an electromagnetic current meter. All of the Rockland VMPs use an un-pumped Seabird CTD sensor pair (SBE3 and SBE4 cells). The Rockland VMPs are now sold as VMP-6000s by Rockland Scientific. Details of the instrument are described at http://www.rocklandscientific.com.
The HRP was used for the first 4 profiles on the N. Scotia Ridge. On the 4th profile, the HRP appears to have surfaced with a failed RDF beacon. Without the RDF signal, the search for the HRP was entirely visual, and unfortunately, it was never found. As such, there are only 3 HRP profiles, all on the N. Scotia Ridge. The profiles are of good quality, and will be processed in the period following the expedition.

Both of the WHOI Rockland VMPs were prepared for service. Unit 010 had been newly installed with a geo-electromagnetic current meter. However, during the first deployment at the test station in the Argentine Basin, that system was damaged when it unexpectedly dropped weights at 150-m depth, and came up under the ship. The damage to unit 010 was

fortunately limited mostly to some front-end hardware; the seabird sensors and the weight release hardware were lost. While spare hardware was available, given that the system's unexplained weight release, the decision was made to suspend its use. Unit 008 was then brought into service, and served well during the entire expedition. It was used to make 15 profiles (including one test cast) on the N. Scotia Ridge, Shag Rock Passage, and SR1 transect lines. The major consequence of using unit 008 was the lack of a geo-electromagnetic current meter.

Microstructure data from unit 008 were of excellent quality. In general, all profiles had two channels each of microstructure shear and temperature, and a single channel of micro-conductivity. Noise levels for the dissipation estimates are approximately 5×10^{-11} and 1×10^{-12} (in respective units for epsilon and chi). The shear probe on the shear-1 channel served well for the entire project while the probe on the shear-2 channel was changed several times. As such, the best source for epsilon dissipation rates will be the shear-1 channel.

Our CTD conductivity continued to be a problem on this project. The un-pumped SBE4 cell has horrible residence time issues, and makes for a very sluggish and chaotic response of the cell to changes in conductivity. This problem is endemic to all Rockland VMPs. The only solution for this is to pump the cell, which has been traditionally undesirable due to the potential for adding vibrational noise to the instrument. The signal from the un-pumped SBE3 temperature cell is of high-quality, and not a problem.

Our only other common problem appears to be related to a glitch with the pressure sensor. Generally, the pressure signal would spike once on each downcast, and then again on the ascent to the surface (though we do not use up-cast data). The pressure sensor always rebounds, but this takes about 50 seconds. Our analysis code is quite good at fixing the resulting problem with the pressure record, so the issue has been deemed minor. However, we will likely replace the sensor following the program.

In what follows, we present some figures further documenting the WHOI microstructure program.
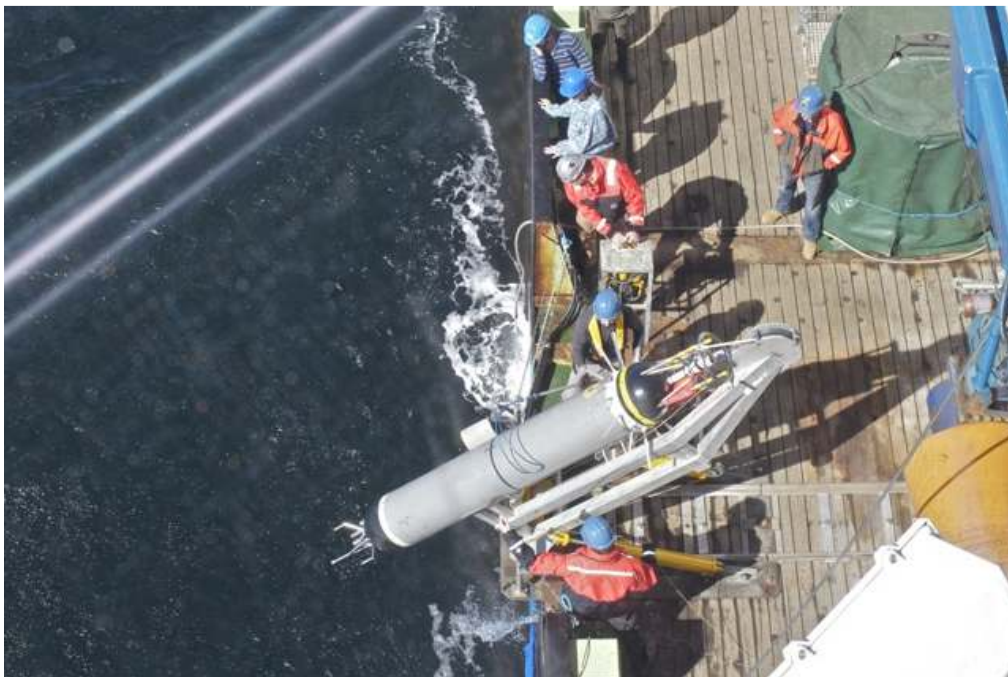
Figure 4.1.1: The WHOI High Resolution Profiler being deployed from the starboard rail. The HRP sled and lifting rig were used by all profilers during the expedition. This proved essential for the simultaneous profiling during CTD casts, as the only other option for deploying and recovering hardware was the parallelagram rig, which was used by the CTD.

Figure 4.1.2:   The WHOI VMP (unit 008) in the JC hangar. The photos show the configuration used during the expedition. The plastic skin, intended for use with the GEMCM, was used as a protective layer. Also, a new white 'dome' attachment was machined by Richie (the JC science bosun). Drag whiskers were modified into a fixed slant-wing geometry, giving the profiler a nice spin. A Xeos Sable Iridium GPS beacon was nested into the 'basket' on the tail section of the profiler.
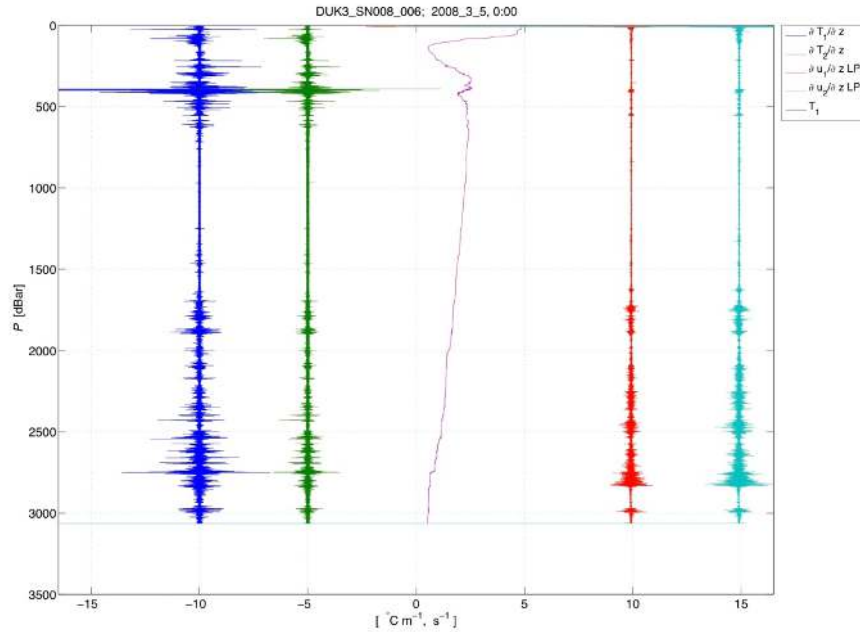
Figure 4.1.3: Raw data signals for microstructure temperature (left) and microstructure shear (right) for unit 008 cast number 6. The temperature profile is also shown (middle). This cast was made in Shag Rock Passage, and reflects some of the strongest turbulence levels observed during the program, with elevated levels from 1700-m depth to the bottom (the profiler ends about 100 m above the seafloor).
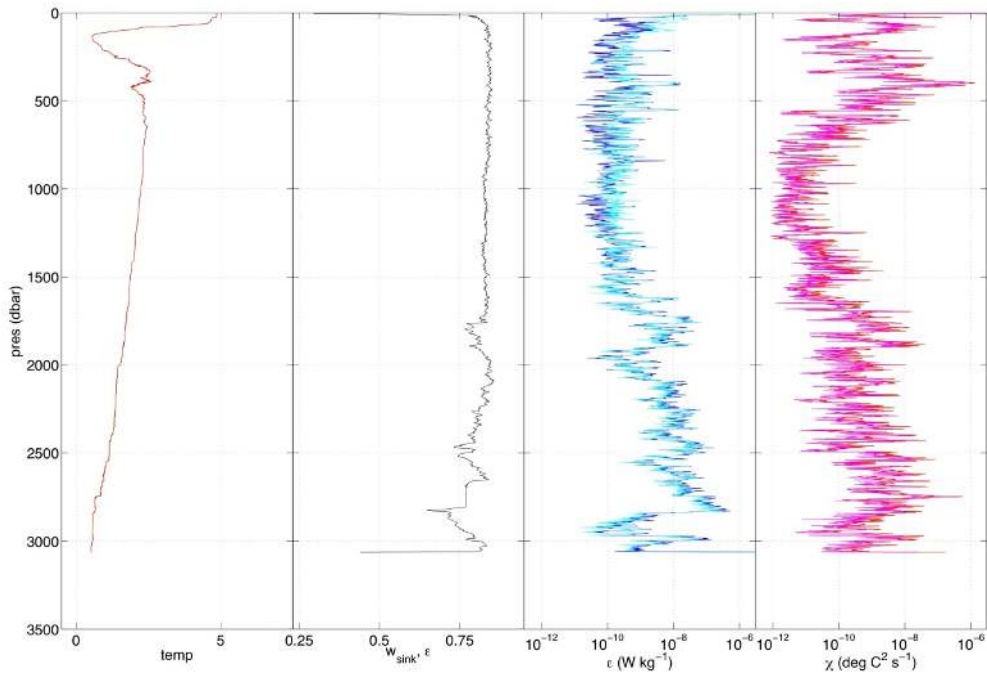

Figure 4.1.4: Processed data for temperature (deg C), profiler fall speed (m/s), epsilon (W/kg), and chi (deg C^2/s) from cast 6. The signals of both probes are shown for epsilon and chi.
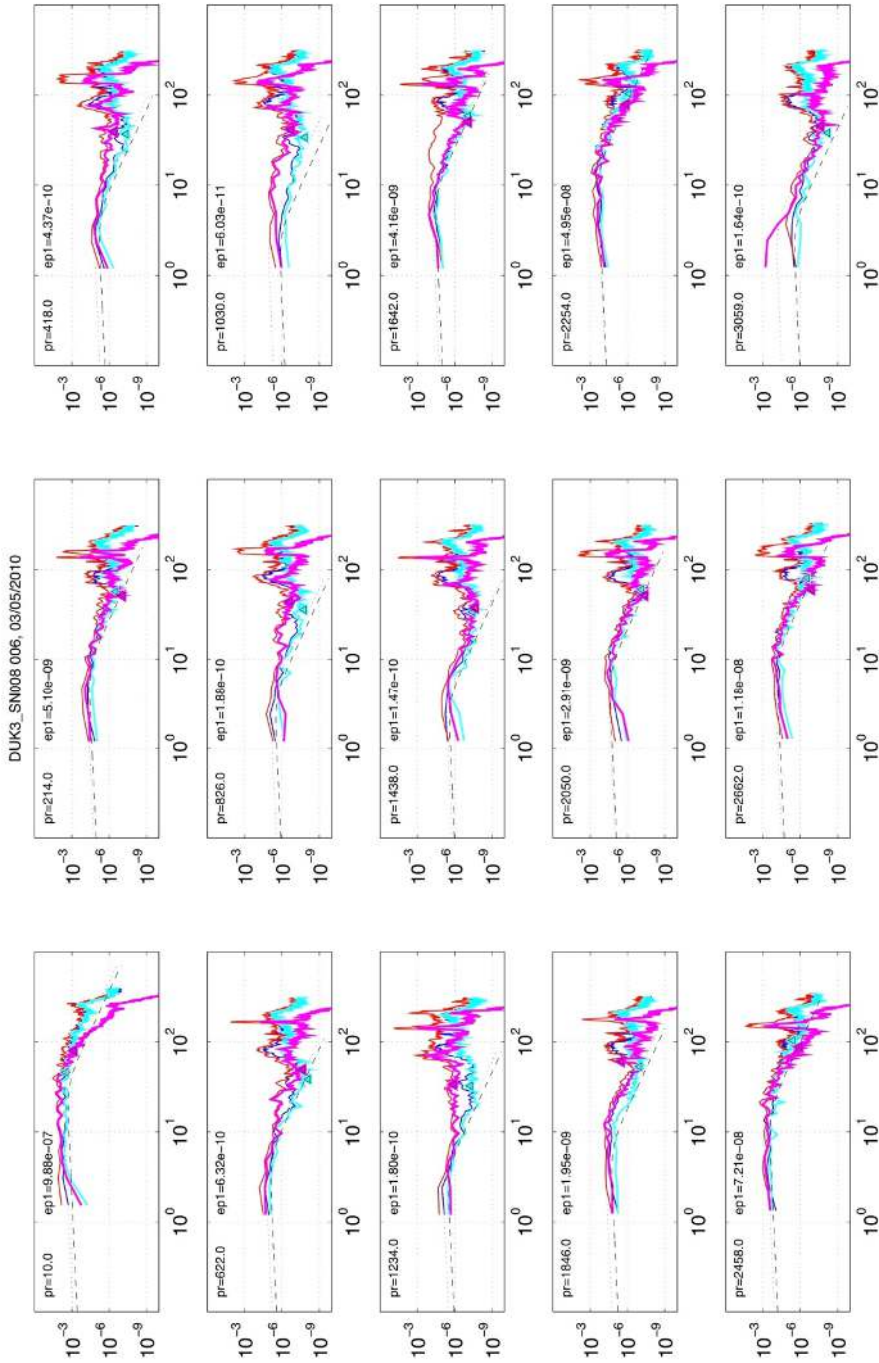
Figure 4.1.5: Example spectra for microstructure shear from cast 6, showing records from 15 selected depth intervals of the profile. Axes are shear variance (s^{-2}/cpm, y-axis) and wavenumber (cpm, x-axis). These show the pre-filtering (thin lines) and post-filtering (thick lines) spectral estimates of two shear probes (blue/cyan = probe 1, red/magenta = probe 2). The upper limit of integration of the filtered spectra was estimated to be the spectral minimum (triangles). The Nasmyth model curves for the reported values of ε are also shown (black broken curves).

Technical remarks on the WHOI and NOCS VMP-5500

Configuration

The WHOI VMP-5500 s/n 008 was deployed with 2 microshear probes, one microtemperature fp07, one microconductivity, a Seabird CTD pair (3F and 4C). Flight data is provided via a pressure transducer mounted in the front bulkhead of the nose cone, a 3-axis ICSensors Accelerometer mounted just opposite the pressure transducer, and a 3-axis magnetometer located center body of the main instrument pressure case.

The NOCS VMP-5500 s/n 016 was deployed with 2 microshear probes, 2 microtemperature probes, one microconductivity probe, one Seabird 3F fast temperature sensor (s/n 4634) and one Seabird 4C conductivity sensor (s/n 3240). Internally there was also a 3-axis accelerometer. The Rockland Geo-ElectroMagnetic Current Meter (s/n 004) was installed for this cruise. Internally there was a 3-axis accelerometer and 3-axis magnetometer electronics board.

WHOI (formerly FSU) VMP
Base Instrument: VMP-5500 SN 008
Microstructure Probes
• 2 shear probes
• 1 microtemperature fp07 thermistor
• 1 microconductivity
Finestructure
• Seabird 3c conductivity cell
• Seabird 4f temperature cell
Flight data streams
• IC sensors 3 axis accelerometer
• Magnetometer
• Pressure sensor
Recovery aids
• Benthos 12kHz pinger. Installed only for initial casts, and when the USBL system was inoperative.
• Sonadyne USBL HB06 transducer for shipboard active tracking.
• Novatech strobe
• Novatech Radio Directional Finder beacon.
• Novatech mounted X-cat Argos beacon. Only fitted for later stations in Drake Passage.

NOCS VMP
Base Instrument: VMP-5500 SN 016
Microstructure Probes
• 2 shear probes
• 2 microtemperature fp07 thermistors
• 1 microconductivity
Finestructure
• Seabird 3c conductivy cell
• Seabird 4f temperature cell
• Rockland Geo-ElectroMagnetic Current Meter
Flight data streams

• IC sensors 3-axis accelerometer
• Magnetometer
• Pressure sensor
Recovery aids
• Ixsea transponder
• Novatech Strobe
• Novatech Radio Directional Finder beacon
• Novatech mounted X-cat Argos beacon.

NOCS Laptop Ethernet Settings
Configure IPv4: Using DHCP with manual address
IP Address: 192.168.2.x where x is any number between 3 and 254
Subnet Mask (if needed): 255.255.0.0

Make sure that the Ethernet is connected before you turn on the VMP (otherwise it goes into dive mode). Once you have issued the 'shutdown now' command you cannot communicate with the instrument again unless it is power cycled (this takes 2 minutes).

VMP Channel Information
"odas4if -f setup.txt –c all –s 1024"
Look out for mean=32768 and st.dev = 0 for channels other than 17,19,255)
The following channel pairs should show similar values: (4,5) (6,7) (8,9) and (10,11)

Recovery Aids (NOCS)
A red hi-vis flag and glow-stick on a mast was used with the following recovery aids:
Seimac Ltd Novatech Model ST-400A Strobe S/N U03-042 Seimac Ltd Novatech Model
RF-700A1 RDF Beacon S/N U03-040 Seimac Ltd Novatech Model AS-900A
Argos Beacon S/N V01-053 ID 74853
Ixsea Model MT861S-R-P1 LBL Acoustic Transponder with Pressure Sensor S/N 314

Deployment and Recovery

General Comments
Thanks to the efforts of the NMF Technicians, WHOI team and the James Cook Deck Crew, deployment and recovery of the VMP went smoothly. In contrast to JC054 and JR276, all deployments and recoveries were made using the specially designed WHOI track, cradle. The track ran from the deck lab, across the starboard deck to the flush hatch, just aft of the CTD parallelogram. Apart from the reduced vessel motion at the midships gantry this location also kept the profiler away from thruster wash and prevented it going out of sight under the stern flare. The VMP was released using a metal pin and rope attached to the VMP cradle handle with a slip knot. It was recovered using a large aluminium pole with large 'clip-stick' snap shackles made fast to the cradle pickup line. A minimum of three people were needed for deployment and recovery operations: one to operate the hydraulics, a second to keep the instrument from bashing the cradle while in it's upright position using a shepherds hook, and a third (on recovery) to release the aluminum pin.

The system was a vast improvement to using the CTD parallelogram. First it allowed freedom to choose when VMP deployment occurred in relation to the CTD cast progress, minimizing time lag between the VMP and CTD recovery and allowing time for swath bathymetry to stabalise for depth determination. Secondly, the cradle system proved an efficient and easy means of getting the VMP on and off deck. In addition, the cradle and track recovery method eliminated the need for somebody to steady the nose whilst the profiler was being picked up and set down on the trolley. The risk of damaging the nose-mounted sensors and putting significant bending load on the main joint between the nose and tail assembly was therefore greatly reduced. The NOCS VMP was stored in the CTD annex and the WHOI VMP was staged from the deck lab. A chain-lift was used to lift the VMPs out of their storage trolleys into the deployment cradles. The trolley allowed the VMP to be easily moved into the CTD annex between casts.

Determining the Instrument's Release Pressure
Successful VMP operation requires determining an accurate depth at which to release the weights. The EM120 and EA600 swath bathymetry was used once the ship was on station. In addition, some existing bathymetry data from JC054 were available for the mooring region, which was a useful complementary source of information. The only difficulty was when ship-board ADCP data indicated that the VMP was projected to drift in a direction not covered by the swath beam. We therefore recommend that a thorough search is done for all available multibeam data prior to future cruises.

Acoustic Telemetry (NOCS VMP)
The VMP was deployed during the down cast of the CTD. During CTD casts the ship normally moves with the currents to maintain the correct angle of the CTD wire; this has the additional benefit of helping keep the distance between ship and VMP small. However, due to vertical shear and temporal changes of the currents, the distance between the ship and the VMP can increase.
Whilst submerged, the NOCS profiler was tracked using an LBL telemetry system consisting of an Ixsea TT801 deck unit s/n 175 (with firmware modification for pressure telemetry). The transponder deck unit was connected to the single element of the EA500 on the starboard drop keel. Data from the deck unit was fed into a Windows XP PC with a serial connection and recorded in NMFD developed "VMP Logger" software. When pinged from the Ixsea transponder the VMP transmitted its pressure, which when combined with the acoustically determined slant range enabled an estimate of the horizontal range using by the VMP Logger software. The 75 kHz VMADCP was used to estimate the VMP drift direction and magnitude. The horizontal range to the VMP was followed closely while the CTD was in the water and if possible the ship was moved in the VMP direction during the CTD profile to try to keep within close range of the VMP.
When the VMP was near the bottom it was 'pinged' more frequently to try and catch the turnaround. Once the CTD was on deck, the bridge was given frequent updates (~10 mins) and the ship position was continually adjusted to keep within ~ 300 - 600 m range of the VMP. During rougher sea conditions, or at long ranges or depths, occasionally contact acoustic contact with the VMP was lost. It was also necessary to turn off the EA120 during VMP tracking, which interfered with the telemetry system. The method proved successful and the VMP normally surfaced within 500 m of the ship and could be easily spotted, especially at night with the strobe beacon. While this

system is useful, caution must be taken when trying to reduce range below 300m. On one occasion the instrument came up within a ship length. The Ixsea system was also useful at alerting users of an early abort of the VMP cast, or a change in its fall or up-cast speed. During a couple of casts the buoyancy on the NOCS VMP slipped, preventing the brushed from folding down, slowing the VMP rise to the surface. Also, at station ??, the weight release occurred 100 dB early due to the dissolution of the magnesium clip. The clip was new, however was thought to be part of a bad batch. The acoustic transponder was checked on deck for battery power and communication before each cast. We recommend this procedure, as the 'on switch' on the instrument is simply a sliding dial and its relatively easy not to locate properly.

Other recovery aids:
The NOCS Argos positions were not required during the cruise to locate the instrument, but continue to form a useful backup of final resort should the instrument be lost.

The VMPs was also fitted with a Novatech RDF beacons. The (WOI installed/?? – ask KEN) on-board RDF system on the RRS James Cook alerted watchers when the VMP had surfaced and its direction (??). A pair of hand held RDF locators (DF500's) were used to help determine the bearing of the VMP when it was not sighted immediately after surfacing. They were often used in locating the WHOI VMP. The RDF units alerted watchers of the surfacing of the VMPs, but were of limited use in providing directional information, with perhaps an accuracy of 45 degrees. Best results were obtained by taken the units out onto the bridge deck.

The Novatech strobes are by far the most immediately useful aids to recovery during hours of darkness. Time was saved by attempting, where possible, to plan for VMP surfacing to occur during the night.

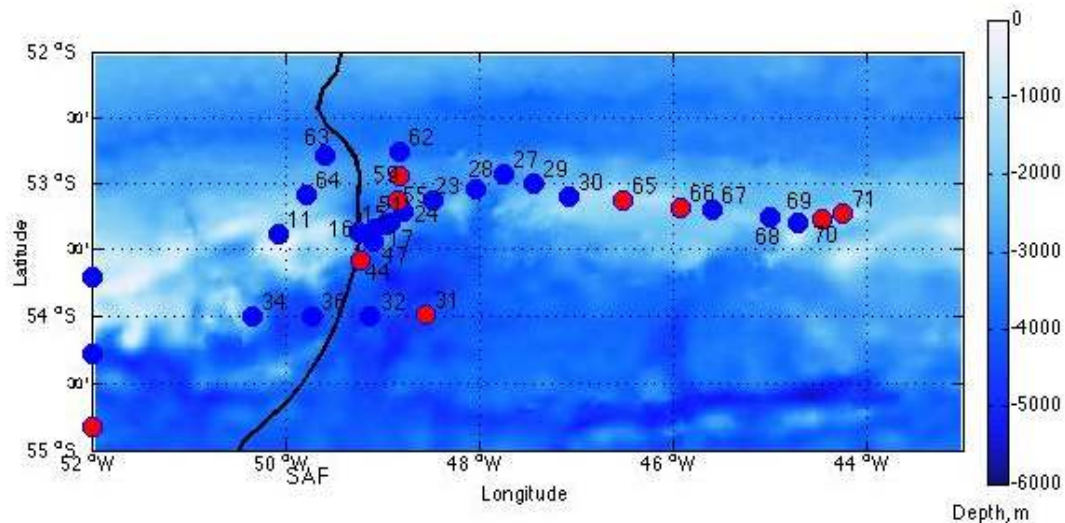**Initial Results for North Scotia Ridge and SR1 section**

Figure 4.1.6: Location map of NOCS (red circles) and WHOI (blue circles) along North Scotia Ridge. Numbers show associated CTD cast number. Black line marks Sub-Antarctic fronts from Orsi.
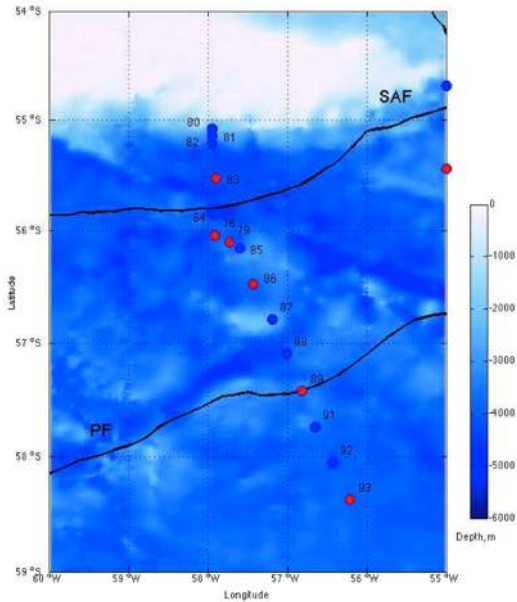
Figure 4.1.7: Location maps of NOCS (red circles) and WHOI (blue circles) along SR1. Numbers show associated CTD cast number. Black lines mark Sub-Antarctic and Polar fronts from Orsi.
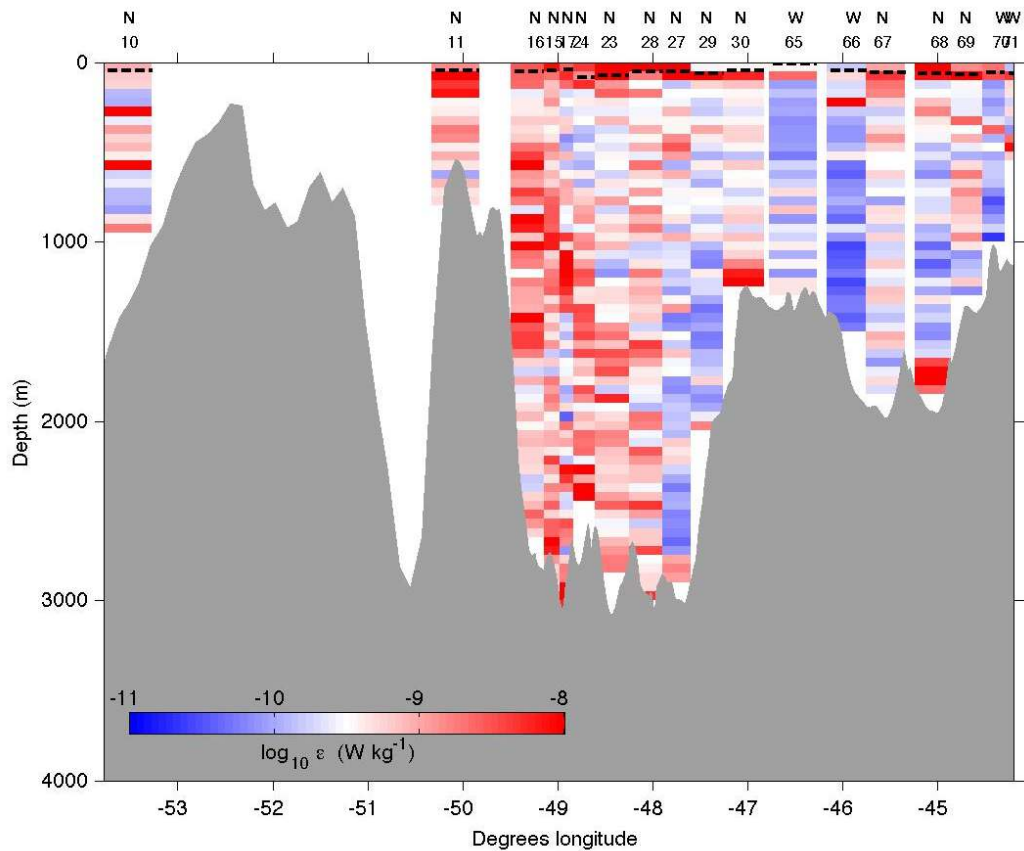

Figure 4.1.8: Vertical section across North Scotia Ridge showing estimated TKE dissipation for VMP casts. Black dashed lines show base of mixed layer, defined by a potential density of 0.03 kg/m^3 below the surface. N and W represent NOCS and WHOI casts, respectively. Numbers along top axis show corresponding CTD station.
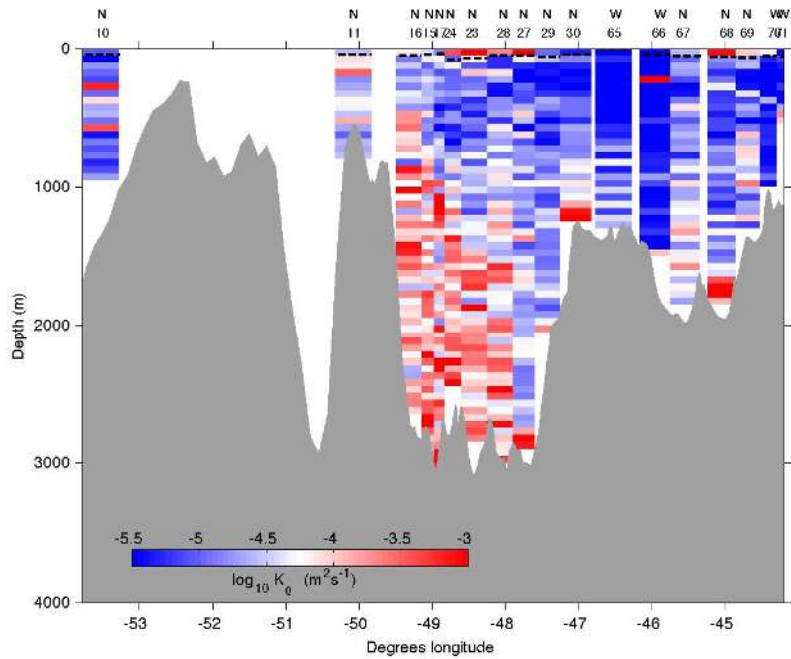
Figure 4.1.9: Diapycnal diffusivity, K_ζ, across North Scotia Ridge section from VMP deployments. Stratification computed from Seabird conductivity and temperature cells. Black dashed lines show base of mixed layer, defined by a potential density of 0.03 kg/m^3 below the surface. N and W represent NOCS and WHOI casts, respectively. Numbers along top axis show corresponding CTD station.

Figure 4.1.10: Vertical section of χ, computed from temperature microstucture across North Scotia Ridge. Black dashed lines show base of mixed layer, defined by a potential density of 0.03 kg/m^3 below the surface. N and W represent NOCS and WHOI casts, respectively. Numbers along top axis show corresponding CTD station.
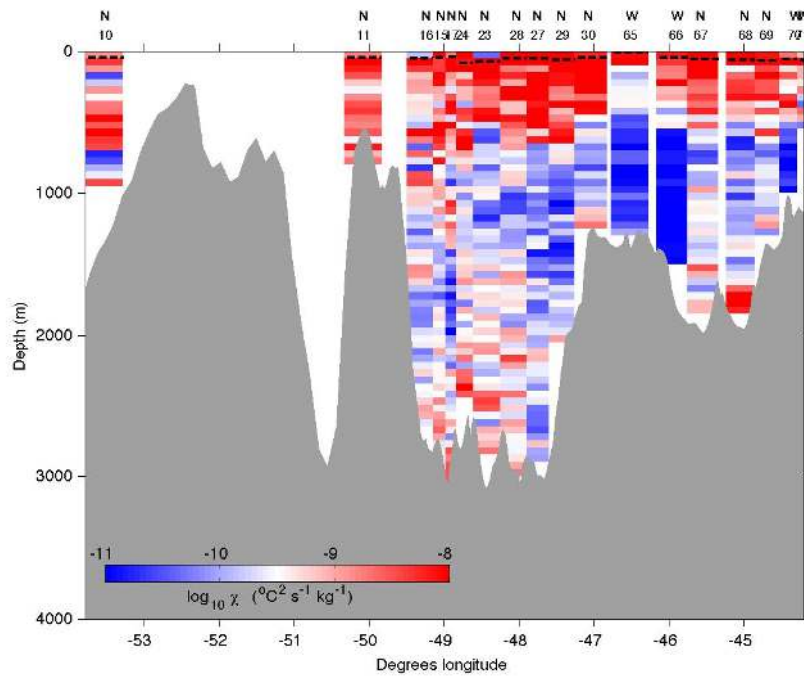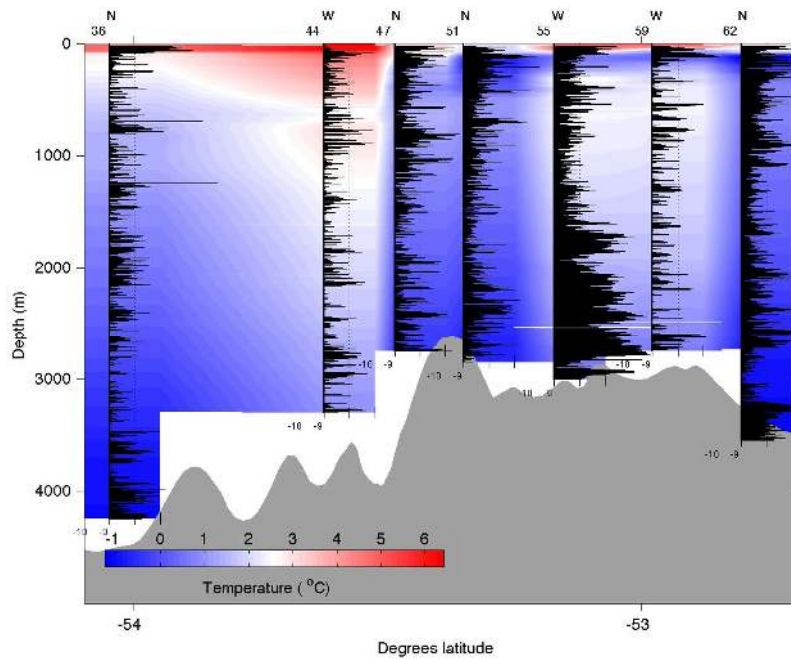
Figure 4.1.11: Dissipation across section towyo line on North Scotia Ridge. Black lines show log plots of estimated TKE dissipation from VMP casts in W/kg. Corresponding CTD station numbers are indicated on top axis. Background colour is temperature from calibrated Seabird temperature cell.
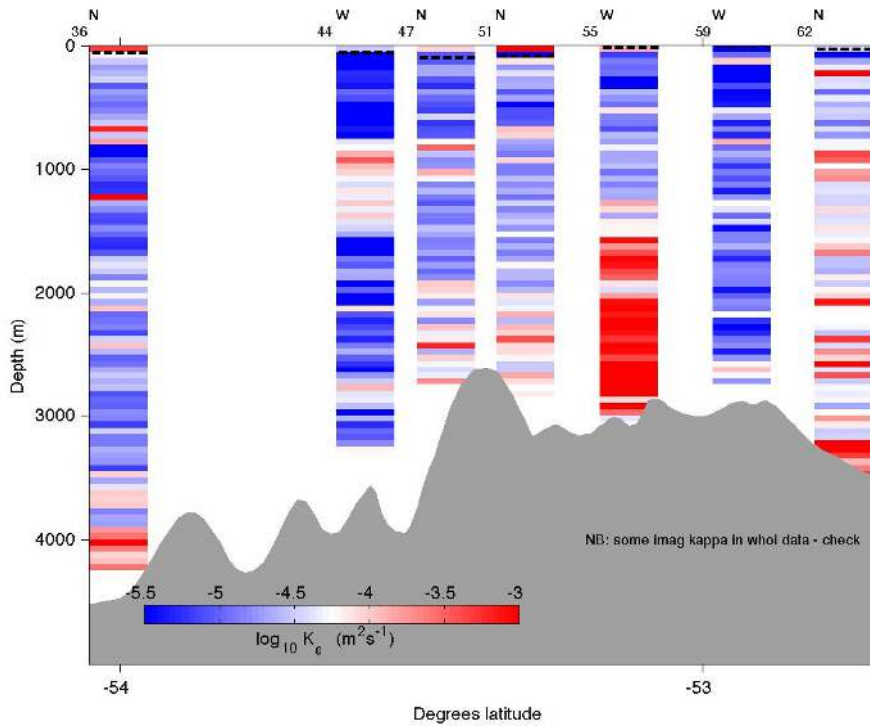

Figure 4.1.12: Diapycnal diffusivity, K_ρ, across TOWYO section from VMP deployments. Stratification computed from Seabird conductivity and temperature cells. Black dashed lines show base of mixed layer, defined by a potential density of 0.03 kg/m^3 below the surface. N and W represent NOCS and WHOI casts, respectively. Numbers along top axis show corresponding CTD station.

Figure 4.1.13: Vertical section of χ, computed from temperature microstucture across TOWYO line. Black dashed lines show base of mixed layer, defined by a potential density of 0.03 kg/m³ below the surface. N and W represent NOCS and WHOI casts, respectively. Numbers along top axis show corresponding CTD station.
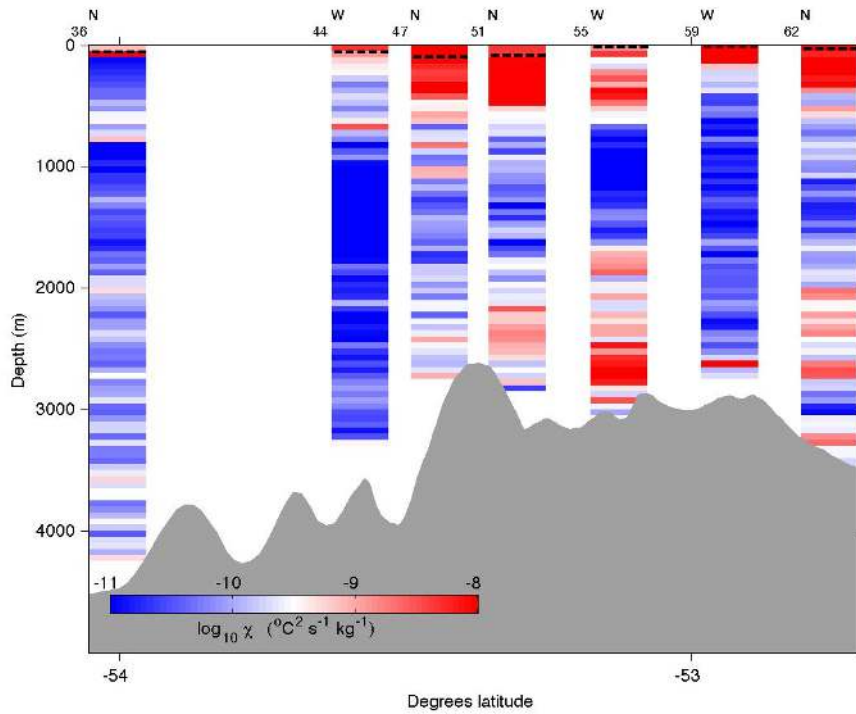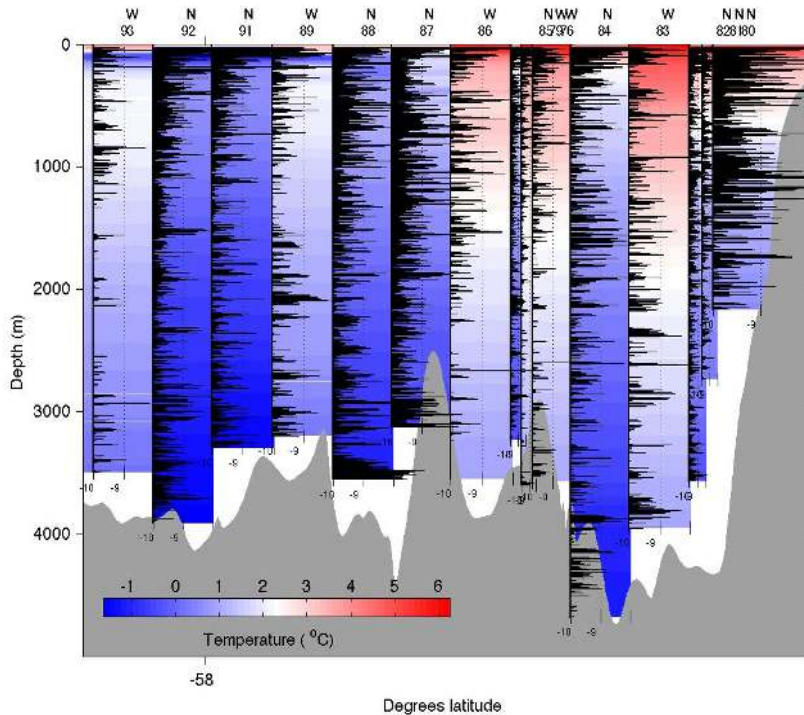

Figure 4.1.14: Dissipation across section SR1. Black lines show log plots of estimated TKE dissipation from VMP casts in W/kg. Corresponding CTD station numbers are indicated on top axis. Background colour is temperature from calibrated Seabird temperature cell. N and W represent NOCS and WHOI casts, respectively. Numbers along top axis show corresponding CTD station.

Figure 4.1.15: Dissipation across section SR1 from VMP deployments. N and W represent NOCS and WHOI casts, respectively. Numbers along top axis show corresponding CTD station.

Figure 4.1.16: Diapycnal diffusivity, K_ζ, across section SR1 from VMP deployments. Stratification computed from Seabird conductivity and temperature cells. Black dashed lines show base of mixed layer, defined by a potential density of 0.03 kg/m^3 below the surface. N and W represent NOCS and WHOI casts, respectively. Numbers along top axis show corresponding CTD station.

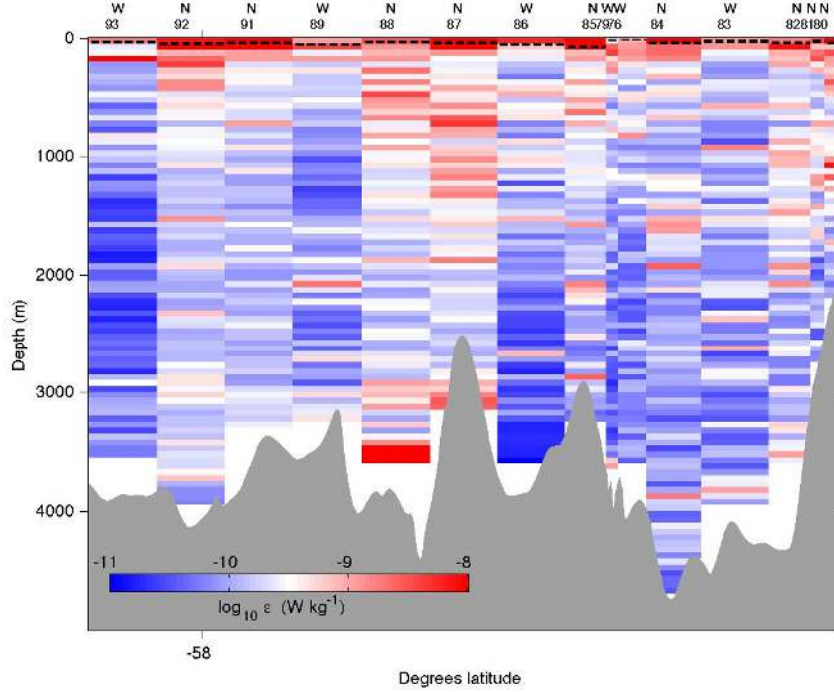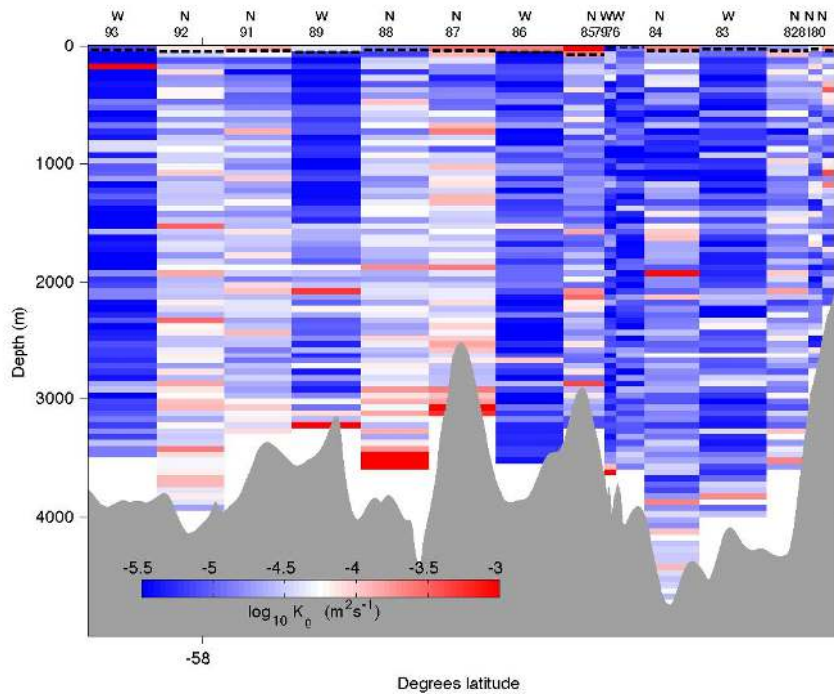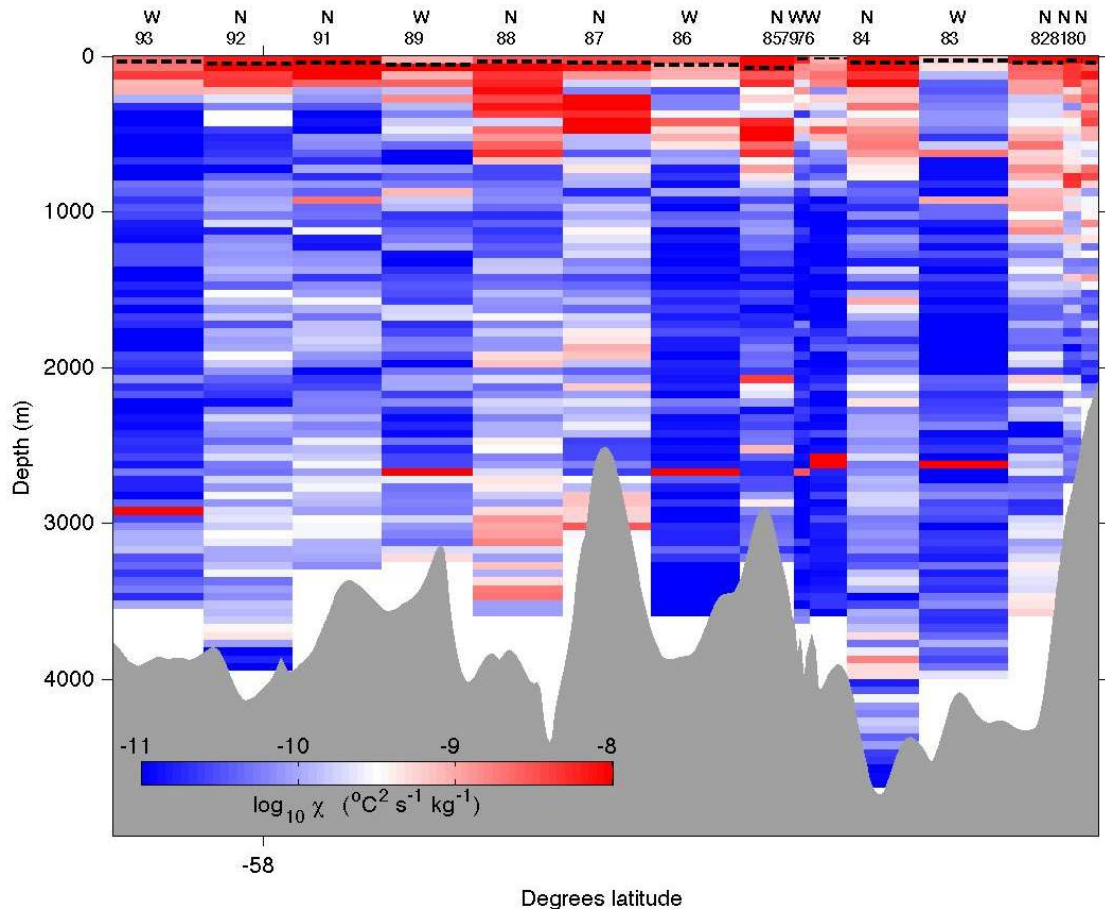**Figure 4.1.17** : Vertical section of χ, computed from temperature microstructure across section SR1.
Black dashed lines show base of mixed layer, defined by a potential density of 0.03 kg/m^3 below the surface.

Comparison of WHOI and NOCS VMP profilers

The average dissipation values across North Scotia Ridge region and section SR1 for WHOI and NOCS casts are plotted in Figures 4.1.18 and 4.1.19, respectively. For both regions, NOCS averaged data appears a little higher than that of the WHOI measurements, however there are regions where WHOI data exceeds that of the NOCS profiles. Differences are likely due to real variations between cast locations. The NOCS chi data however is consistently greater than WHOI chi values, and perhaps slightly high as background levels rarely reach 10^{-11} $^{\circ}$C^2 s^{-1} kg^{-1}. Further investigation is needed to determine whether this is a result of due to differences processing routines (see next section) or the instruments themselves (due to practical difficulties, it was decided not to deploy the two probes together for a direct comparison).

Figure 4.1.18: **Mean dissipation values across North Scotia Ridge for WHOI-processed data**

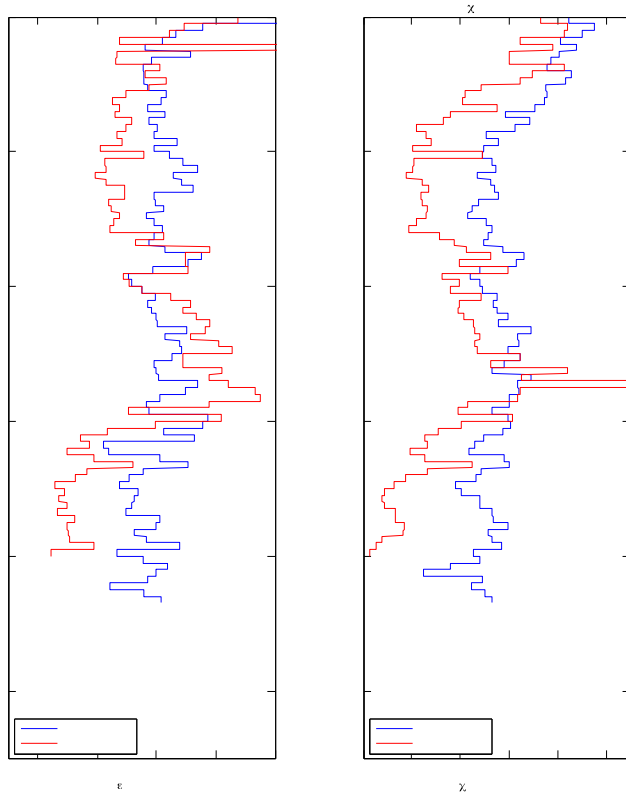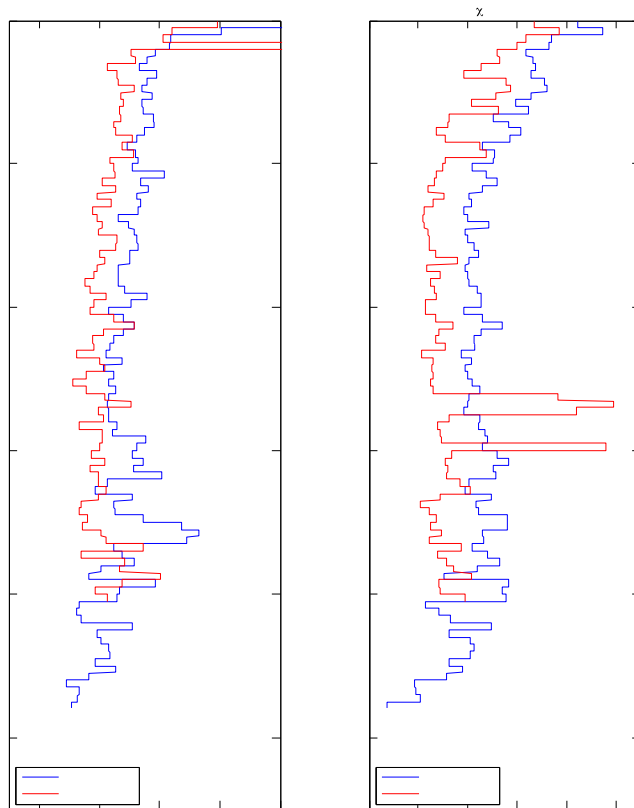**Figure 4.1.19**: **Mean dissipation across SR1 for WHOI processed casts**

Comparison of WHOI and NOCS processing routines

Dissipation and chi values, processed using NOCS and WHOI routines for two example casts (CTD stations 29 and 84) are plotted in Figures 4.1.20 and 21, respectively. The mean, median, upper and lower quartiles over pressure bins of 50 dbar are shown. Dissipation values generally match well, although sometimes lower dissipation values in the NOCS processed data are harsher than those passed through the WHOI processing routines. This trend is particularly apparent in the lower quartile data. Perhaps this is due to slightly harsher smoothing or low-pass filtering in the WHOI routines, as was observed in JC054 data. Dissipation peaks match well. More strikingly, NOCS processed mean chi values are consistently about half an order of magnitude lower than the WHOI values. The discrepancy in mainly manifest in the upper quartile estimates, indicating that it is not a result of different noise levels between the two instruments. Further investigation is needed to determine which processing routine is correct. WHOI chi values are estimated by fitting data to the Batchelor spectrum (written by Loius St Laurent), whereas the NOCS chi values are estimated from code originally written by Kurt Polzin which integrates of the data itself.
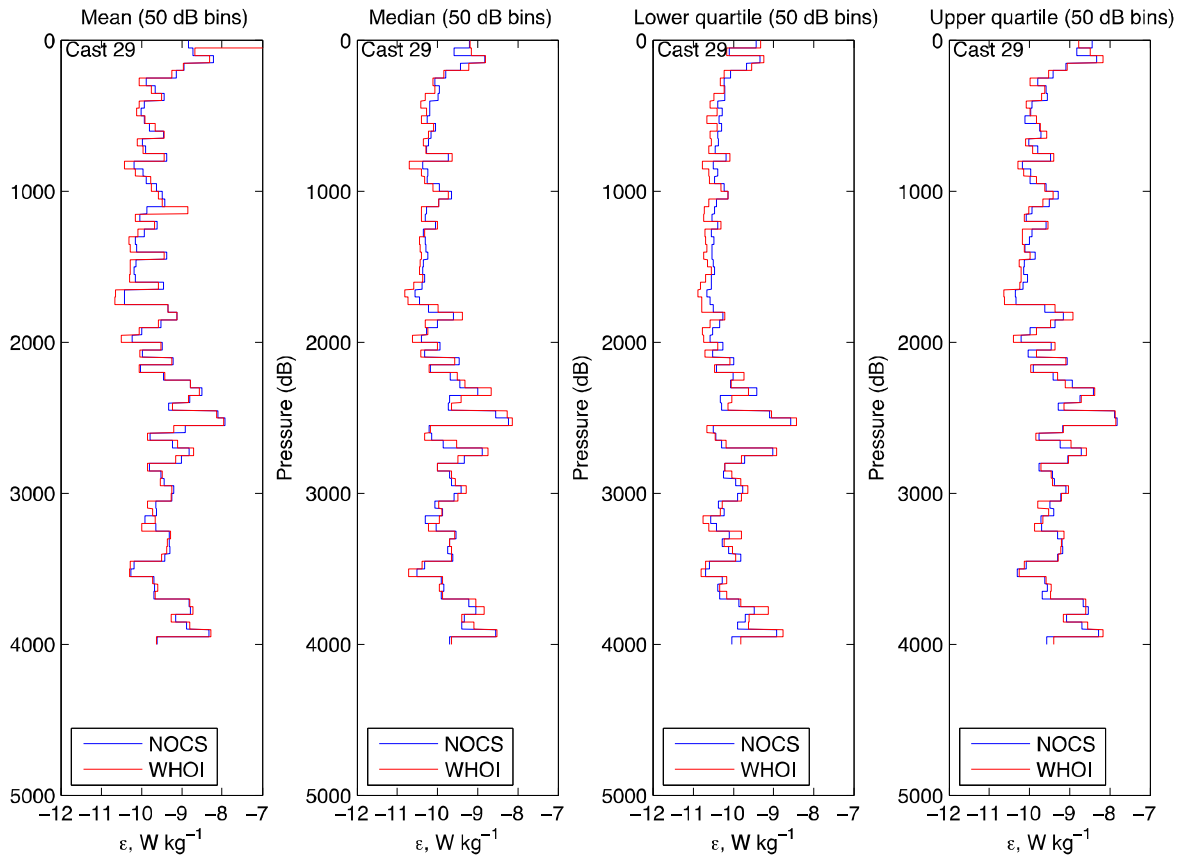
Figure 4.1.20: Comparison of WHOI and NOCS processing of TKE dissipation for two example casts

Figure 4.1.21: **Comparison of WHOI and NOCS processing of chi for two example casts**

Operations Summary

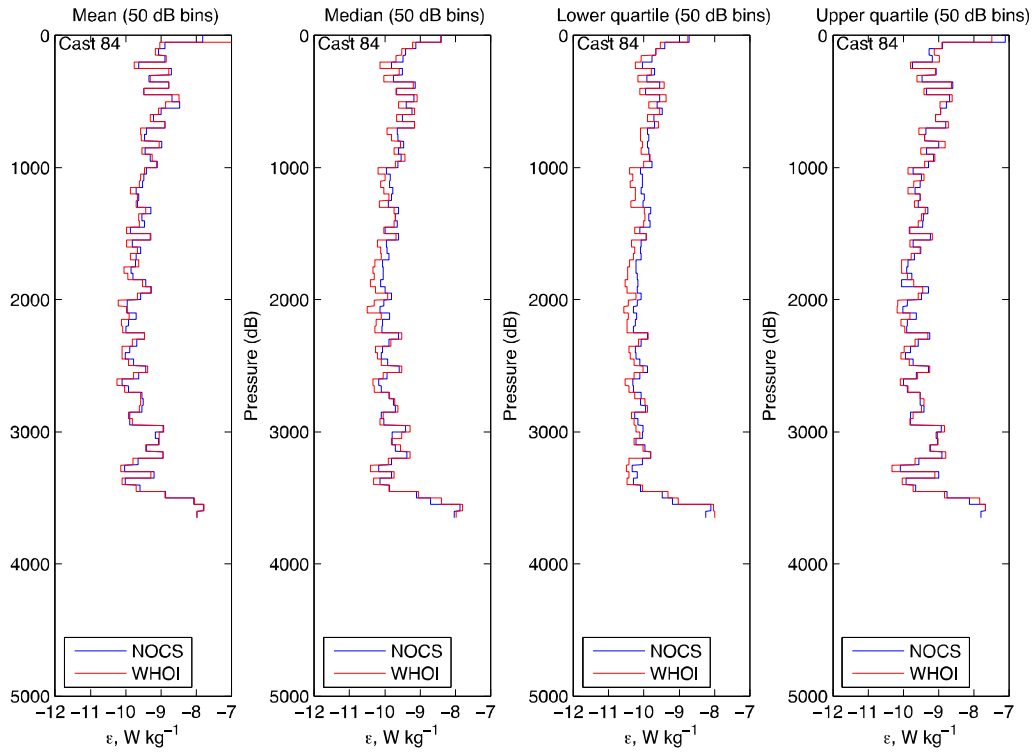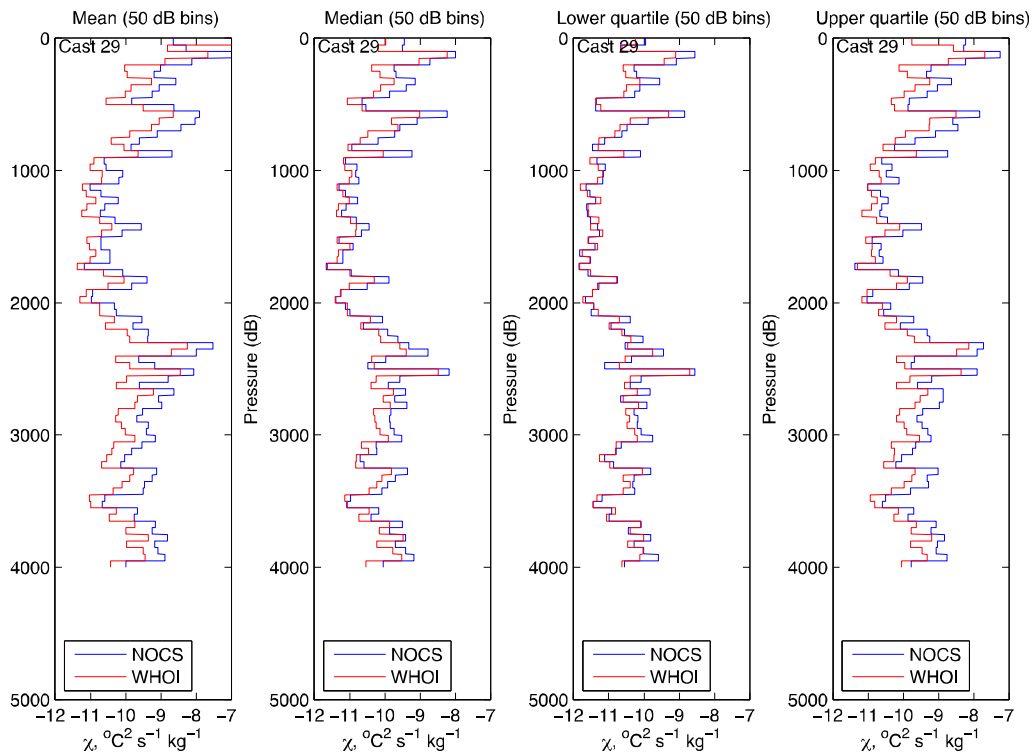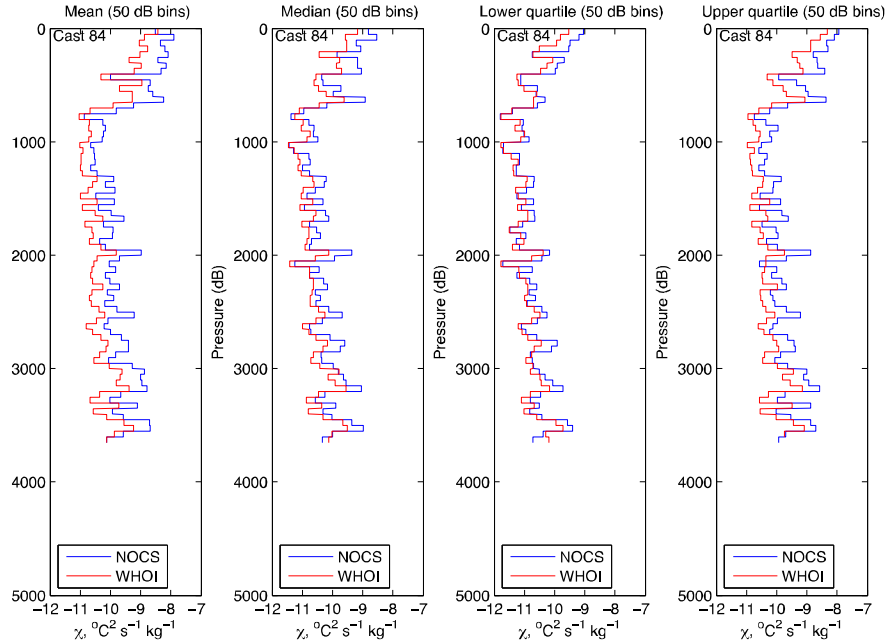| STATION ID	CTD	INSTRUMENT	VMP DIVE NUMBER	J.DAY	HRS (GMT)	MINS	LAT	LON	J.DAY	HRS (GMT)	MINS	LAT	LON	DIVE MAX (dB)	COMMENTS	Sh1	Sh2
					DEPLOYMENT					RECOVERY (ON DECK)						PROBES	
test1	NaN	nocs	1	34	14	42	-45.5833	-53.6	34	14	56	-45.5833	-53.6	122	**	M722	M524
nsr.10	10	nocs	10	39	4	7	-53.9677	-53.5128	39	5	42	-53.974	-53.5316	953		M722	M524
nsr.11	11	nocs	11	40	2	24	-53.3833	-50.0833	40	3	57	-53.3797	-50.0713	804	**	M722	M544
nsr.15	15	nocs	15	41	15	30	-53.341	-49.071	41	18	50	-53.3165	-49.0315	2943	**	M722	M713
nsr.16	16	nocs	16	42	2	44	-53.3595	-49.2553	42	5	45	-53.3279	-49.2329	2689		M722	M713
nsr.17	17	nocs	17	42	9	30	-53.3003	-48.929	42	12	50	-53.2802	-48.8885	3117		M722	M713
nsr.23	23	nocs	23	45	9	18	-53.131	-48.4836	45	12	33	-53.0938	-48.4472	2861		M722	M713
nsr.24	24	nocs	24	45	15	37	-53.2167	-48.7843	45	18	37	-53.1832	-48.7445	2483		M722	M713
nsr.27	27	nocs	27	46	8	0	-52.9282	-47.7494	46	10	56	-52.8976	-47.7688	2931		M722	M713
nsr.28	28	nocs	28	46	13	0	-53.0409	-48.041	46	16	9	-53.0203	-48.0396	3033		M722	M713
nsr.29	29	nocs	29	46	18	51	-53.0007	-47.4368	46	21	6	-53.0038	-47.4423	2075		M722	M713
nsr.30	30	nocs	30	47	5	15	-53.0938	-47.0809	47	6	14	-53.0921	-47.0801	1249		M722	M713
esr.31	31	whoi	2	47	16	32	-53.9933	-48.5544	47	17	40	-53.9939	-48.5531	3978			
esr.32	32	nocs	32	47	22	50	-54	-49.1287	48	3	8	-53.9589	-49.1959	3967	**	M722	M713
esr.34	34	nocs	34	50	21	5	-53.9968	-50.347	50	23	25	-53.9877	-50.3353	2178	**	M722	M713
tyo.36	36	nocs	36	51	12	33	-54.0022	-49.7392	51	16	44	-54.0136	-49.7513	4328		M722	M713
tyo.44	44	nocs	4	57	0	27	-53.5796	-49.2399	57	2	58	-53.5361	-49.2804	3357			
tyo.47	47	nocs	47	57	12	51	-53.4406	-49.0944	57	15	47	-54.3989	-49.1386	2790	**	M722	M713
tyo.51	51	nocs	51	57	23	33	-53.305	-48.9777	58	2	41	-53.277	-49.0178	2893		M722	M713
tyo.55	55	whoi	6	58	12	11	-53.1264	-48.8466	58	14	24	-53.1273	-48.8473	3052			
tyo.59	59	whoi	7	59	0	15	-52.9335	-48.8244	59	2	21	-52.9875	-48.8362	2791			
tyo.62	62	nocs	62	59	11	18	-52.7588	-48.824	59	14	56	-52.7608	-48.846	3609	**	M722	M712
esr.63	63	nocs	63	59	21	28	-52.7877	-49.607	60	0	40	-52.7355	-49.635	3096		M399	M712
esr.64	64	nocs	64	60	4	12	-53.0834	-49.7987	60	6	48	-53.0555	-49.8183	1995		M399	M712
nsr.65	65	whoi	8	60	19	24	-53.1257	-46.525	60	20	23	-53.1218	-46.5246	1270			
nsr.66	66	whoi	9	60	23	43	-53.176	-45.9183	61	0	48	-53.1754	-45.9177	1474			
nsr.67	67	nocs	67	61	3	44	-53.1989	-45.5906	61	5	34	-53.1928	-45.596	1854	**	M399	M712
nsr.68	68	nocs	68	61	9	9	-53.2574	-44.9927	61	11	4	-53.2559	-45.0031	1843		M399	M712
nsr.69	69	nocs	69	61	13	16	-53.2923	-44.7142	61	15	11	-53.2892	-44.7223	1273		M399	M712
nsr.67	70	whoi	12	61	17	14	-53.2658	-44.4491	61	18	5	-53.2263	-44.2452	967			
nsr.71	71	whoi	13	61	20	40	-53.228	-44.243	61	21	8	-53.2263	-44.2452	529			
sr1.76	76	whoi	14	65	22	55	-56.0404	-57.9162	66	2	10	-56.041	-57.915	3640			
sr1.79	79	whoi	16	66	19	34	-56.0974	-57.733	66	22	24	-56.1027	-57.7287	3666			
sr1.80	80	nocs	80	67	6	52	-55.0807	-57.9475	67	9	9	-55.0801	-57.9383	2200	**	M399	M712
sr1.81	81	nocs	81	67	10	21	-55.1401	-57.9482	67	13	8	-55.1367	-57.94	2781	**	M399	M712
sr1.82	82	nocs	82	67	15	11	-55.2092	-57.9533	67	18	50	-55.2005	-57.9642	3635		M399	M712
sr1.83	83	whoi	18	67	23	3	-55.5286	-57.9072	68	2	35	-55.525	-57.8398	4027			
sr1.84	84	nocs	84	68	5	20	-55.8388	-57.9502	68	9	56	-55.8434	-57.7642	4777	**	M399	M712
sr1.85	85	nocs	85	68	17	10	-56.1544	-57.5992	68	20	40	-56.1537	-57.5763	3287	**	M400	M712
sr1.86	86	whoi	19	69	0	34	-56.4755	-57.4332	69	3	14	-56.4717	-57.4337	3614			
sr1.87	87	nocs	87	69	8	1	-56.786	-57.198	69	13	4	-56.761	-57.127	3179	**	M400	M712
sr1.85	88	nocs	88	69	17	23	-57.0957	-57.0107	69	21	17	-57.0873	-56.9555	3618		M400	M712
sr1.89	89	whoi	20	70	1	5	-57.4196	-56.8153	70	3	32	-57.4193	-56.816	3256			
sr1.91	91	nocs	91	71	0	57	-57.7422	-56.6512	71	4	29	-57.7393	-56.6719	3355		M400	M712
sr1.92	92	nocs	92	71	8	27	-58.0499	-56.4381	71	12	32	-58.0508	-56.4295	3984		M400	M712
sr1.93	93	whoi	21	71	17	5	-58.3711	-56.2104	71	19	41	-58.387	-56.2093	3563			
test1	NaN	whoi	1	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	463			

A summary of the deployments is given in Table 1 above, with the probes used for each cast in Table 2.

STATION ID	** REAL TIME COMMENTS
test1	Shallow test cast: found fall speed slightly low (~0.45 m/s)
	Decided to increase ballast weight (14.1 kg)
nsr.11	EM Vx bad
nsr.15	Shear 2 noisy, both EM channels bad
esr.32	Following station, steam to Falklands (medical issue)
esr.34	EM current meter serviced before cast: still both channels bad. Spikes noticed in shear 1 (filtered out ok by processing). Loose connection?
tyo.47	EM Ux spontaneously looks ok again!
tyo.62	Shear 1 lost connection part way down cast (probably reason for earlier spikes). Dried, cleaned and new shear 1 added after cast.
nsr.67	LED light loose. Adjusted before cast, delayed deployment slightly
sr1.80	Both EM channels started to work!
sr1.81	Part way down cast, started recording into new file. Two files (001 and 002) processed and data re-joined with slight blank at jump.
sr1.84	Some water found in shear 1. Cleaned, dried and same probe put back
sr1.85	Buoyancy slipped towards cradel, preventing brushes folding down on upcast. Slow rise speed. Dive ended on time out, not pressure release as magnesium clip dissolved about 100 dB early (part of plastic weight strap missing)
sr1.87	VMP loat for two hours due to failure of xsea beacon (flat batteries)

Table 1: Summary of Unfiltered Operations (HRP stations are not included)

NOCS TEMPERATURE PROBES (FOR ALL CASTS): T1 = T382, T2 = T283

NOCS SHEAR PROBES		
Shear Probe	Sensitiity	Measured
		capacitance (nF)
M722	0.0738	1.065
M524	0.116	1.248
M544	0.1141	1.183
M713	0.0695	1.078
M712	0.0825	1.081
M399	0.1508	nan
M400	0.0699	1.084

Table 2: Summary of microstructure probes used

Recommendations

1. Investigate further the possibility of installing some kind of transmitting GPS device as a further recovery aid. This would assist in speedy recovery of the instrument, especially in adverse, and particularly foggy, weather conditions.
2. HR profiler?
3. Get a track and cradle built for NOCS VMP
4. Investigate different processing methods for chi values.

Stuff to go in cruise report appendix:

NOCS VMP-5500 processing instructions

Summary

If it is the first cast of the cruise, ensure you have the right coefficients for the Seabird variables, pressure variables, accelerometer variables, magnetometer variables and microtemperature variables. For JC069, the processing routines were used as for JC054, with the addition of coding to save the time variable in finally processed files. The codes were also altered such that times and dates for the start and end of data recording, and for the pressure passing the 10 dB on down and up casts were calculated and saved in the final.mat files. It is therefore important to check that the clock is set correctly before each cast. These changes were only implemented after VMP corresponding to CTD station 86.
Note that all data was processed with original matrix and processing codes as used in JC054. (The processing flows used for JR276 were modified due to the absence of the EM current meter. See JR276 cruise report for further details).

First, we need to create a directory structure to deal with the data. Under a parent cruise directory (e.g., 'JC069'), make a 'VMP' directory. Under 'VMP', create a 'raw' data directory, a 'programs' directory, a 'processing' directory, and a 'final' directory.
When you finish a cast, create a subdirectory called 'nnn' below 'raw' and take the raw data file (e.g., 'jc069_nnn_ccc.p', where nnn is the VMP cast number and ccc is a data file number), the cast's log file (e.g., 'jc069_nnn_.txt') and the cast's setup file ('setup.txt') there.
Change to the 'raw/nnn' directory and run 'firstlook_jc069' or equivalent. If this is the first cast of the cruise, you'll need to make sure all the pathnames are correct in 'firstlook_jc069'. This stage will allow you to have a quick look at the (largely uncalibrated) data to check data quality, fall rate, maximum pressure, etc., and will write a file called 'jc069_nnn_ccc_firstlooked' in the 'processing' directory, and create a folder of firstlooked figures called 'processing/nnn/firstlook_figures'. At this stage, back up the raw and processing directories.

Create a 'setup_calibrated.txt' file in the 'raw/nnn' directory, and update calibration coefficients for sh1, sh2, and write down the name of the probes used in the header of the file. If it is the first cast of the cruise, make sure you have the right calibration coefficients for all the accelerometer, T*, pressure, conductivity, Seabird, magnetometer and EM variables.

Check that you are in the 'processing/nnn' directory. Run 'fine_structure_processing_routine'. This creates a 'VMP_CTD.mat' file that contains, amongst other variables, T, C and S data (t_ave, c_ave and s_ave) averaged in a regular 0.5 dbar pressure grid (P_grid) starting at 0.25 dbar. It also creates a folder of finestructure processing figures under 'processing/nnn/finestructure_figures'.

Check that you are in the 'processing/nnn' directory. If this is the first cast in the cruise, check that the right pressure and shear variables differentiator gains are set in 'process_micro_jc069_v2.m'. Then run that script to process the microstructure data. This will produce locally a 'micro_nnn.mat' file containing the processed microstructure data in an approximately 0.5 dbar (1 s) grid, and a

'final_grid_nnn.mat' file under the final directory with processed fine- and microstructure data in a 0.5 dbar grid.

In the end, you'll need to produce a final file with all the processed cruise data by running 'make_cruise_data_set_jc069' in the 'VMP' directory, after entering all the relevant time and location information and selecting which of the microshear or microtemperature channels are of superior quality.

Details

First, an initial check of the data of each cast was performed using the 'firstlook_jc069' matlab routine. This routine reads in the raw data from the cast, converts it to a matlab file and produces a series of diagnostic plots useful for checking the probes and instrument before the next cast. These plots include: the velocity of the profiler with the extracted downcast used for further processing indicated, the battery voltage, the pressure and 'ground', raw data from the microtemperature, microconductivity and shear probes, the profile's acceleration and rotation and the seabird temperature and conductivity.

Secondly, the seabird finestructure data was processed using 'finestructure_processing_routine.m'. The end product is temperature and salinity that are:

1. truncated to include data only below 10 dB;
2. adjusted to account for the spatial displacement between the pressure sensor (at the VMP nose) and the CTD sensors (on the VMP body);
3. despiked;
4. corrected for short-term (sensor response) and long-term (thermal interia) mismatch errors in T and C;
5. corrected to account for the thermal expansion and pressure contraction of the conductivity cell;
6. low-pass filtered to remove high-frequency noise;
7. block-averaged in 0.5 dB pressure bins.

Thirdly, the microstucture data was processed using the routine 'process_micro_jc069_v2.m'. Data is converted to real units and calibrated to the seabird data. The epsilon and chi values are estimated by integrating the power spectra of the shear and the microtemperature gradient, respectively. The data are averaged into regular 0.5 dbar bins. Note that this program used various microstructure parameters, which should be checked before each cruise. The shear probe sensitivities are read from the file 'setup_calibration.txt' which should be updated for each cast.

For a few casts, process_micro routine was modified, such that the pressure value at which to start the extracted downcast was increased (from 7.25 dB). The change was required to account for the different deployment procedures. On this cruise the VMP was released closer to the surface of the water than on JC054, such that the profiler did not reach the previous criteria of a drop speed (W_32) of 0.4 m/s at 5.25 dB.

There is also a diagnostics program which plots computed epsilon and chi values. Measured shear spectra are binned into TKE dissipation rates and compared to the

corresponding Naysmyth spectrum. Calculated microT and microC data are compared with the Batchelor spectra corresponding to the estimated chi values.

Finally, the data was averaged into 1 dbar bins and saved as a matlab structure file using the program 'make_cruise_data_set_jc069.m'. The average results from the two shear or microtemperature probes were used, unless a probe was noisy, in which case the noisy probe data was discarded. Deployment location, time, station number and corresponding CTD cast numbers were added to the dataset. Data was plotted using 'average_ep_plot.m', 'chi_ep_plot_*.m' and 'cross_section_plot_inpstruc*.

NOCS VMP-5500 logsheet

VMP – 5500 Dive LOG

Cruise:	JC054	Station Number:		Year and Day of Year:			

Sensor Information

Fine. Var.	Channel	Used		Micro. Var.	Channel	Used		Probe
GND1	0			Ax	1			
T1	4			Ay	2			
T2	6			Az	3			
P	10			T1_dT1	5			
SBT1E	16			T2_dT2	7			
SBT1O	17			Sh1	8			
SBC1E	18			Sh2	9			
SBC1O	19			P_dP	11			
Mz	32			C_dC	12			
My	33							
Mx	34							
EMvel1	35							
EMvel2	36							
Vbat	37							

Sensor Notes:
Deployment   Name:

Time instrument turned on:		Deployment position:	
Acoustic depth (m):		Bottom press. P_{bot} (db):	
On-deck press. P_{deck} (db):		Assumed overshoot P_{over} (db):	
Safety allowance P_{safe} (db, $\geq$ 50db recommended):		Specified max. press. (db, must not exceed $P_{bot} + P_{deck} - P_{over} - P_{safe}$):	
Estimated dive time (s, at a dive rate of ~0.55 s^{-1}):		Specified max. time (s):	
Available memory		Enough (at ca. 50Mb	

(/root/data):		/1000 m)?:	
Memory cleared?:		If not, most recent data file in memory:	
Main battery voltage (V, should be ≥ 12.8V)		Dive start time i.e. LED flashing (GMT):	
Ship position when VMP released:		Time when VMP released (GMT):	
		Expected surface time (GMT):	

Comments:

Recovery　　　　　　　Name:

Station Number:		DOY / time VMP spotted:	
Range / bearing at which VMP spotted:		Ship position when VMP spotted:	
Date / time VMP on deck:		Recovery position:	
Acoustic depth (m) / corrected bottom pressure:			
Post-dive main battery voltage (V):		Time charging started (GMT):	
Estimated charging end time (GMT):		Time charging ended (GMT):	
Voltage after charging:			
Name of data file:		Size of data file:	
Method of dive end:		Max. pressure of dive:	

Comments:

NOCS VMP-5500 instructions for launch and recovery
Add calcheck and ahcek bridge can here argos and check clock set to correct time

VMP Sequence for Launch
UK DIMES JR276, April 2011

At the Laptop Station At ~30 minutes prior to launch:	On Deck

1. Start a new log sheet in the VMP dive log: enter cruise (JC069), station number, date	\
2. IF the instrument isn't already plugged in and charging, plug the instrument in and connect Ethernet cable: connect one end of the E/CRG charging cable to the instrument and the other end to the charger (~1A, ~13.8 V). connect the charger to the power supply and turn the power supply on plug the Ethernet cable in.	1. Turn on and test the recovery aids: for each: loosen clamps remove instruments for two antennas and strobe light, switch on with obvious on/off switch on shaft for pressure transducer, test by setting to "test" and listen for 2 pings ~6 s apart (6 s indicates good battery charge, less than 6 indicates battery charge is low) then set to F3. OR take into lab and check communicating on F3 replace instrument; keep strobe sticking out tighten clamps test radio by ensuring RAF sees the instrument Check bridge can hear RF beacon
3. Turn the instrument on and start the weight battery charging: connect the on-off switch (plastic plug) on the E/CRG cable. note the time on the log sheet - the instrument needs to be turned on and plugged into computer to allow the weight battery to be charged for at least 20-30 minutes before launch	2. Remove tube protecting the SeaBird conductivity cell
4. Get the laptop talking to the instrument: open terminal window and check location is set to VMP. Type 'telnet 192.168.2.2' log on with login="root" and password=rglr0x (zero not 'o')	3. Remove the tape from the EM current meter ports (5)
5. Make sure there is enough free file space on the instrument for the next profile: type 'df' in the terminal window to get memory available record "Available" memory in the "root/data" directory on the log sheet determine if there is enough memory for the next profile (you require ~ 100 000 kB	4. WHEN the Laptop Station work is done, disconnect the E/CRG cable from the instrument and install the dummy plugs (on both ends) wait 36 s (the weight release mechanism will fire as part of normal procedure)

per 1000 m depth of dive) IF required, make space by deleting all data files (.p) except for the most recent; otherwise note most recent data file (.p) in memory on the log sheet	
6. Check channels and get the pressure on deck from the instrument: - type "odas4ir -f setup.txt –c all –s 1024" in the terminal window. This gives a list of channel numbers and the standard deviation and mean of the measurements over 1024 counts. Check these values look sensible. (Run ./calcheck.sh to record channel data into file). - type 'odas4ir –f setup.txt' in the terminal window. multiple readings of the on-deck pressure will be printed to the screen (should be close to 0) record to nearest first decimal point as "On-deck press P_{deck}" on log sheet exit with CRTL-C	5. Install the weights: check the magnetism of the weights demagnetize if greater than 2G check the state of the magnesium safety clip, replace if necessary and note on log sheet install the weights (2) and check the cable tension
7. Make the specified max. pressure and specified max. time calculations for this dive: when you have arrived on station, make a decision about the water depth and the safety factor for this dive run "calculate_max_press_and_time" in matlab on laptop record "Bottom press P_{bot}", "Assumed overshoot P_{over}", "Safety allowance P_{safe}", "Specified max. press.", "Estimated dive time" and "Specified max. time" from Matlab output on log sheet take a second and make sure it makes sense	6. Turn the instrument ON: turn the instrument on by replacing the dummy plug by the shorting plug watch for the LED on the tip of the probe to start flashing (~ 30s) record the time as the "Dive start time" on the log sheet (i.e. when flashing).
8. Enter this dive's information in the 'setup.txt' file on the instrument: open setup.txt file by typing "edit setup.txt" in terminal window update the prefix field with station number (prefix format='jc29_station#_') enter max_time and max_pressure as calculated above into the appropriate fields	7. Throw it in the water note time and position when VMP is released and estimate expected surface time on log sheet make an offering to the VMP gods

save and exit by hitting "ESC" and hitting enter once to select "Leave Editor" and enter again to select "Save Changes"	
9. Test the setup.txt file: type "odas4ir -f setup.txt" at command line in terminal window check for any error messages if all is well, exit with "CTRL-C"	
10. Turn off the instrument and disconnect from the power supply: type "shutdown now" in the terminal window close the Putty terminal window wait 30 seconds IF the weight release battery has been charging for at least 20 minutes, turn instrument off by disconnecting the white plastic on-off switch turn off the power supply	
11. Test the instrument battery voltage: disconnect the instrument from the power supply using the voltmeter test the instrument battery voltage by measuring the voltage at the connector to the power supply (stick voltage meter probes where wires enter the plastic connector) record the main battery voltage on the log sheet IF voltage >~ 12.8 V OK to deploy; if less charge more (with plastic on-off switch disconnected)	

VMP Sequence for Recovery
V1, UK DIMES2, 2nd December 2010

At the Laptop Station	On Deck
	1. ~ 10 minutes prior to expected surface time: send a look-out with the RAF to the top of the bridge all others to the bridge for look-out

	2. Find it! record date, time, ship position and range and bearing when spotted in the log sheet
	3. Get it on the deck: record the date, time and ship's position in the log sheet
1. Test the instrument battery voltage: connect the E/CRG cable to the instrument using the voltmeter test the instrument battery voltage by measuring the voltage at the instrument's connector to the power supply record the recovery battery voltage on the log sheet	4. Turn the 4 recovery aids off and replace.
2. Plug the instrument in and start it charging: connect the E/CRG charging cable to the power charger and turn on the power supply	5. Replace tube full of millipore water from the wet lab on SeaBird conductivity cell
3. Get the laptop talking to the instrument: IF it is not already connected, connect the ethernet cable on the E/CRG cable to the laptop turn the instrument on by connecting the plastic plug on the E/CRG cable	6. Replace tape over 5 EM current meter probes
4. FTP the data and log file from the instrument to the laptop: cd to /Users/mstar/JR276/VMP/raw create new directory with station number as name cd to the new directory. ftp to the instrument: root@ 192.168.2.2, password rglr0x type prompt type 'mget jr276_station#*' type 'get setup.txt' type 'quit'	7. Rinse with fresh water: be gentle with the flow rate over the shear probes!
5. Once the file transfer is complete, turn off the instrument:	8. Turn the instrument off: remove the shorting plug and connect the

disconnect the white plastic on-off switch on the E/CRG cable so it is in the "off" position leave the instrument plugged in to charge for the next dive note on log sheet when charging started and estimated completion time. Assign someone to turn it off and note who on log sheet.	E/CRG charging cable to the instrument
6. Do a quick look of the data in Matlab on laptop: in station directory on matlab run "firstlook_jr276" inspect output and check for broken microstructure probes – IF microstructure probe needs replacing record on log sheet record max pressure of dive on log sheet (outputted at command line of matlab window) IF a probe needs to be replaced, note failed probe number, cause of failure, new probe number, channel on instrument, and calibration info for new probe if required on the log sheet and VMP probe log book. Update shear probe coefficients in template setup_calibration.txt file (in VMPdata dir). Copy template setup_calibration.txt to station directory (…/raw/station_no)	9. Inspect the magnesium safety pin on the weight release IF needed, replace and record on the log sheet. (Replace about every 2nd time)
7. Record remaining recovery details in the log sheet: record name and size of data files (.p) on log sheet open station .txt file and note method of dive end (pressure release? time release? other?) record on log sheet	
8. Archive: As soon as there is time: backup new station directory (raw data, .mat files and firstlook figs) to jrlb, legdata/work/VMP_raw print output figures from "firstlook_jr276" and put in red VMP binder with log sheet	

4.2 Lowered Acoustic Doppler Current Profiler (LADCP)

Xinfeng Liang

The LADCP system for Cruise JC069 consisted of an ADCP, an external battery, inter- connection cables, a communication/charging cable, a battery charger and a MacBook. LADCP profiles were collected at all CTD stations in order to derive full-depth profiles of ocean velocity, as well as profiles of finescale vertical shear of horizontal velocities. The data are expected to provide background information for studying small-scale process and can be used to evaluate the existing finescale parameterization methods for diapycnal mixing. Preliminary processing was performed immediately following data download using the LDEO LADCP processing software. Both raw and processed data can be found in the final LADCP data set. LADCP operations during JC069 were partially supported by a grand from the US National Science Foundation (OCE-1030309, PI: Andreas Thurnherr).

4.2.1 LADCP System

One Teledyne/RDI Workhorse 300kHz ADCP was mounted on the CTD rosette, pointing downward (downlooker). Although a system consisting of two ADCP headers with one of them pointing upward (uplooker) was preferred to obtain high-quality data, due to the lack of enough backup instruments (the backup instruments for JC069 are only one fully functional and one three-beams working Teledyne/RDI Workhorse 300kHz ADCPs), we chose to use only one as downlooker (s/n: 4275). The LADCP was powered with a standard NOC battery/charger system.

Data acquisition was carried out using the LDEO "acquire" software, version 1.5. The software was installed on a MacBook running MacOSX 10.5. The computer was configured to synchronize the clock automatically. Communications between the acquisition computer and the ADCP took place across a parallel RS-232 connection, via a KeySpan 4-port USB-to-serial adapter. Data backup was done automatically onto an external USB disk. The setting file for the "acquire" software can be found in the Appendix section.

All except the towyo stations were carried out with the instrument configurations supplied with the LDEO data acquisitions software – 25×8m bins, beam coordinates, zero blanking distance, narrow bandwidth, 4.0 ambiguity velocity, 1.3s/1.5s staggered ping rate. This is one of the configurations that were used during the DIMES UK2 cruise (JC054). Different from the regular casts, for the towyo stations, in order to reduce the battery consumption, the staggered ping rate was changed to 1.8s/2.0s. But all the other configurations were the same as regular stations. The associated command files for common and towyo stations can be found in the Appendix section.

4.2.2 Processing Methods

There are currently at least three publicly available software packages that can be used to process LADCP data: 1) One package based on *shear method* and written by

Eric Firing at University of Hawaii; 2) one package based on *inverse method* and maintained by Andreas Thurnherr at LDEO; 3) one also based on *inverse method* and maintained by Gerd Krahman at IfM/Geomar in Kiel. All JC069 LADCP data were processed with the LDEO LADCP processing software, which can be obtained from: http://www.ldeo.columbia.edu/～ant/LADCP. The LADCP processing during this cruise was briefed as follows. For detailed information on the software, refer to "How to Process LADCP Data with the LDEO Software" (A. M. Thurnherr, 2010), which can also be downloaded from the previous link.

4.2.2.1 General Settings

All the processing was carried out on a MacBook, which was also used to communicate with the LADCP as well as to acquire LADCP data. On the MacBook, necessary software including MATLAB, LDEO LADCP Processing Software (Version IX) and a program called "magdec" were installed. Here the program "magdec" was used to calculate the magnetic declination, which is the difference between magnetic and true bearings. Also, a set of perl programs written by Andreas Thurnherr at LDEO were also installed. These perl programs can be used to examine many features of the raw LADCP data and can also be downloaded from http://www.ldeo.columbia.edu/～ant/LADCP

To obtain high-quality full-depth velocity profiles, three auxiliary data are usually needed: 1) the bottom-tracking data, which can provide constrain for the velocity near the seabed; 2) the GPS data, which can provide constrain for the depth-integrated velocity; and 3) shipboard-ADCP (SADCP) data, which can be used to constrain the velocities near the sea surface. In addition to these, another useful auxiliary data are the CTD time-series, which can be used to improve the accuracy of the depth estimation from LADCP data. Since the bottom-track data were included in the raw LADCP data, before processing LADCP data, only CTD time-series, GPS and SADCP data were firstly prepared.

CTD time-series with a temporal resolution of 1s was provided by Dr. Brian King immediately after it was processed, which was usually available just one day after the deployment. For the preliminary processing, the salinity of the CTD data was not calibrated. The data therefore need to be re-processed when all the CTD calibrations are finished. But effects of the calibration are usually not dramatic. The GPS time series with the same temporal resolution of the CTD time-series was collected and merged with the CTD data for each cast, so only one file including both the CTD and GPS time-series was provided for each station during this cruise.

During each CTD/LADCP deployment, SADCP data were collected with two separate systems (150 kHz and 75 kHz). For most stations, only data from the 75kHz system were used for LADCP processing. But for stations 13, 85 and 86, the 75kHz SADCP did not function well, data from the 150kHz were therefore used. Different from the CTD data, each SADCP file provided no temporal information but only profiles of zonal and meridional velocities as well as their standard deviations.

Although the ADCP used as downlooker during this cruise has the RDI LADCP mode (WM15) installed and it reports bottom-tracking data calculated from water-tracking pings, from the experience during cruise JC054 we chose to use the post-processed bottom tracking data to constrain the velocity measurements. Due to the time limit, at some stations the CTD rosette was only deployed to the depth of tracer, therefore no bottom-tracking data were obtained. For those stations, only the GPS and SADCP were used as constrains. The data quality at those stations is therefore expected to be lower.

4.2.2.2 Regular Casts

The regular casts except the towyo stations were processed directly with the LDEO LADCP processing software. Before processing, a cruise-specific directory named "data" was created and the subdirectories were structured as follows:

- LADCP Data Files: raw
- Processed LADCP Files: DL/processed
- Checkpointing Files: checkpoints
- CTD Time-series Files: CTD/1Hz
- SADCP Files: SADCP

In order for processing to work correctly, a MATLAB file named "set_cast_params.m", which contained many cruise-specific parameters, was also generated under the "data" directory. A sample of the "set_cast_params.m" can be found in the Appendix section. For detailed information on meanings of different parameters in the file, refer to "default.m", a file included in the LDEO LADCP processing software package. After creating the directories and "set_cast_params.m", we processed the LADCP data by typing process_cast(nnn) under the data directory in the MATLAB command window, where nnn stands for the station number.

4.2.2.3 Towyo Casts

Since many towyo casts do not start from the ship but certain depths in the water, special procedures are needed to process the towyo casts. During the cruise, only one simply procedure was used and it was described briefly as follows. Several different procedures were kindly suggested by Drs. Andreas Thurnherr and Luc Rainville. Those procedures should be carried out in the future.

1. All processing of towyo casts was carried out in a subdirectory named "towyo" under the main directory "data". Similar structure as the "data" directory was created in "towyo" as well. Also auxiliary data were gathered and stored in proper subdirectories before processing the towyo data.

2. Divide the raw LADCP data to different casts. Based on variations of vertical velocities, temperatures and even tilts, the ensemble numbers of turn points near the surface can be found. With these numbers, the raw LADCP data can be divided into different casts. Now the difference between a towyo cast and regular cast is mainly the start depth.

3. Modify the depth in the CTD time-series file by subtracting the start depth from all depth values. This can make the CTD time-series file look like a normal CTD file, which can be used directly by the LDEO LADCP processing software.

4. Remove the section of SADCP data between the start depth of CTD cast and surface. Then modify the depth of SADCP file in the same way dealing with CTD data.

5. At this stage, all files for processing LADCP data with the LDEO software are available. Then run the LDEO LADCP processing software with the divided LADCP data and the modified CTD and SADCP files.

6. After running the LDEO LADCP software, modify the depths in the output mat files by adding the values that are subtracted in the third step and save the new data with corrected depths.

4.2.3 Problems

The LADCP system performed very well over all during the whole cruise. However, due to the time limit, at several stations no CTD/LADCP but only VMP deployments were carried out and the associated stations numbers were therefore skipped in the data set. In addition to that, few casts only occupied parts of the water columns, full-profilers of velocities are therefore unavailable for those stations. Also, since only one ADCP was used and the ping rate was lowed at towyo stations, the data quality at towyo stations are expected lower than the common stations.

The acquire software was easy to use and worked very well during the whole cruise. The only problem we encountered was at several stations (e.g. station 008) when downloading the LADCP data, warning messages like "Retry 0: Timeout 105" appeared several times. Most times after retrying several times, the data were downloaded successfully. Only once (at Station 008), we had to disconnect the cable and reconnected the MacBook and the instrument, and then the problem was solved.

4.2.4 Preliminary Results

Sample results from section SR1 and towyo stations are presented as follows. Here, the results are mainly presented in three different ways: 1) velocity vectors at certain depth, which show the spatial pattern in the x-y plane; 2) vertical sections of velocities, which reveal the spatial pattern in the x-z or y-z planes; and 3) profiles of zonal and meridional velocities, which show the baroclinic structures as well as the finescale structures much more clearly than the other ways.

4.2.4.1 SR1 Section
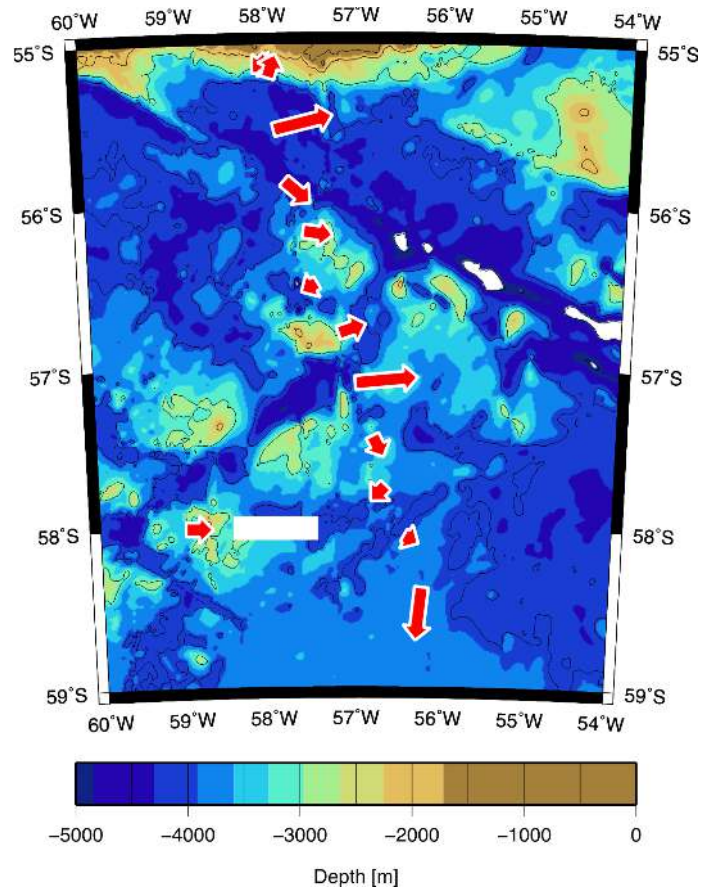
Figure 4.2.4.1.1 Bathymetry and locations of stations along the section SR1. Arrows show the LADCP velocities at the depth of 2000m.
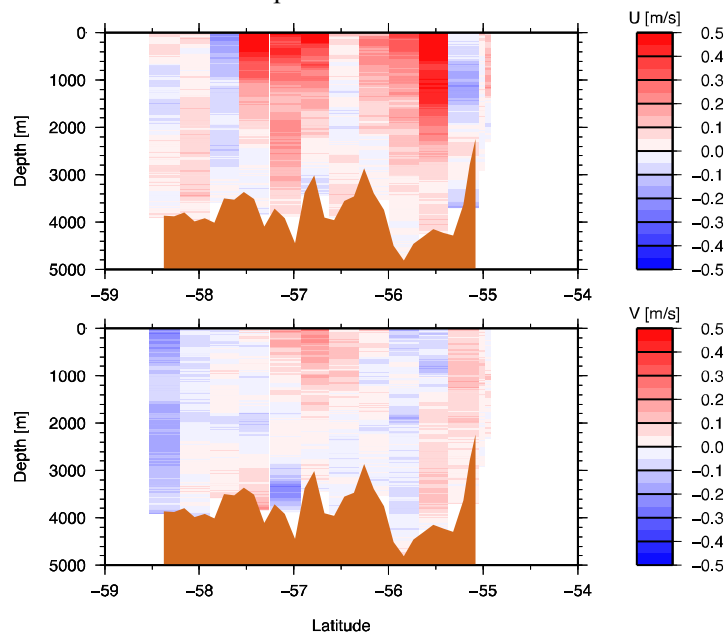
Figure 4.2.4.1.2: Zonal (upper) and meridional (lower) velocities at stations along the section SR1.
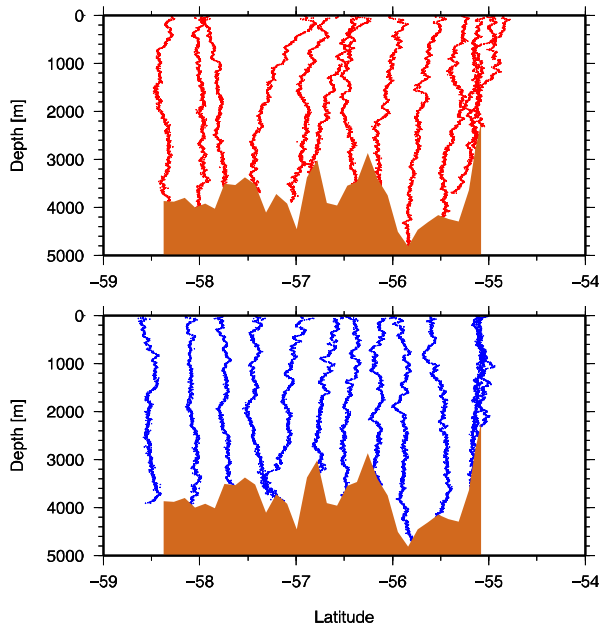
Figure 4.2.4.1.3: Profiles of zonal (upper) and meridional (lower) velocities at stations along the section SR1. This figures reveals many finescale structures above the depth of 2000 m, particular at stations between 57.5S and 55.5S.

4.2.4.2 Towyo Stations

Although the towyo stations received special treatments, the results show consistent features, which suggest the data are at least not bad. One particular interesting feature is the strong shears appearing at the depth of 2000m at stations on the southern end of the towyo section. It looks like an energy beam associated with internal waves. Further examination should be carried out carefully.
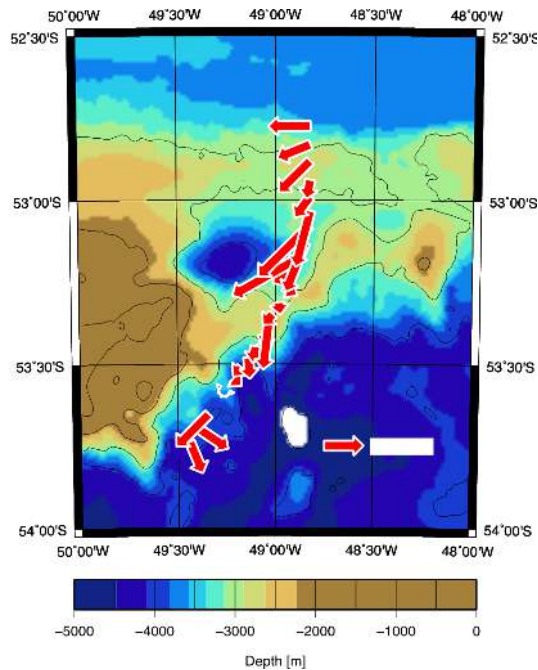
Figure 4.3.4.2.1 Bathymetry and locations of towyo stations near the Shag Rock Ridge. Arrows show the LADCP velocities near the seafloor at towyo stations. The bottom currents in this region during the measurements were mainly flowing southward.
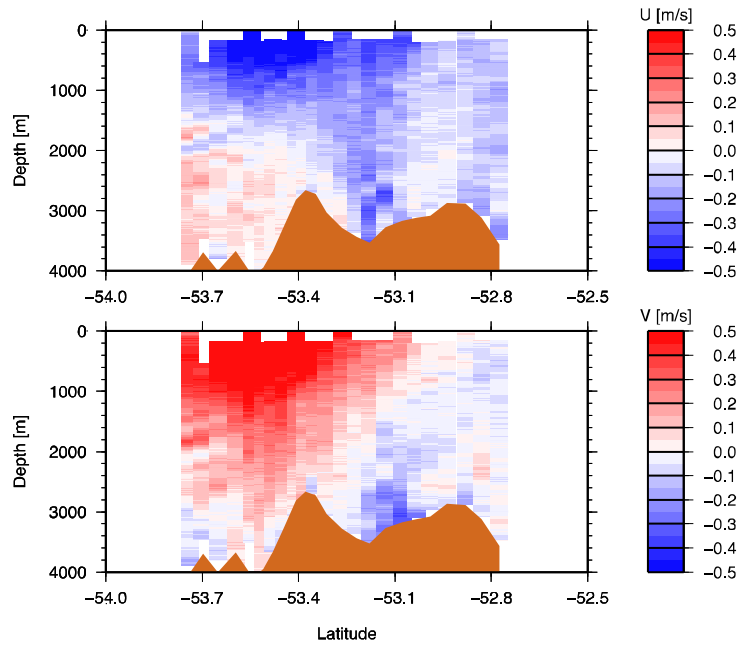
Figure 4.2.4.2.2: Sections of zonal (upper) and meridional (lower) velocities at towyo stations.
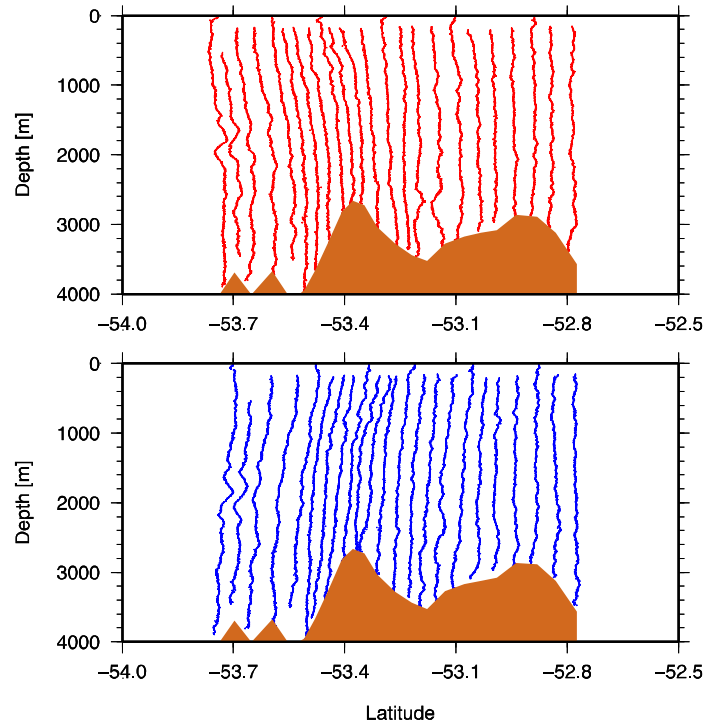
Figure4.2.4.2.3: Profiles of zonal (upper) and meridional (lower) velocities at towyo stations.

Appendixes:

1. ***CRUISE_SETUP.expect***

2. ***MASTER.cmd***

3. ***MASTER_towyo.cmd***

4. ***set_cast_params.m***

1. CRUISE_SETUP.expect

```
#=============================================================
#          C R U I S E _ S E T U P . E X P E C T
#          (c) 2004 A.M. Thurnherr
#          uE-Info: 68 60 NIL 0 0 72 2 2 8 NIL ofnI
#=============================================================


#--------
# HISTORY
#--------

# Mar 10, 2004: - created during NBP0402
# Apr  4, 2004: - final version NBP0402
# Jun 15, 2004: - adapted to BB150/Workhorse setup
# Jun 16, 2004: - ditto
# Jun 19, 2004: - BUG: could not handle multiple BB150 data files
# Jan 19, 2006: - updated documentation
#                    - allowed for empty-string time_server
# Nov  4, 2006: - changed backup dir structure
# Aug 25, 2010: - rename* funs modified to allow them to be used to ensure
#                      that downladed file names have correct case
#                    - renamed from DEFAULTS.expect to CRUISE_SETUP.expect
# Aug 26, 2010: - added ymodem_receive_cmd
#                    - changed default string quotes to {} to prevent Tcl variable
#                      and command substitutions
# Oct 18, 2010: - changed comment for ymodem_receive_cmd to account for the
#                      fact that bbabble now uses the -u option by default
#
# Jan 28, 2012 – Modified for JC069 by Xinfeng Liang.
#

#-----------
# TWEAKABLES
#-----------


# At the beginning of each cast, the clock of the acquisition computer should
# synchronized with the master clock used for timestamping the GPS information.
# The best way to accomplish this is to run a NTP daemon (e.g. ntpd) polling
# an NTP server on the ship.
# If running ntpd is inconvenient or not possible, the follwing variable can
# be set to the name of the NTP server, in which case the time is sync'ed
# at the beginning of each cast with the function set_computer_time (defined
# below).
# If there is no NTP server available, the variable should be set to the
# empty string and the clock must be sync'ed manually.

set time_server      {};

# bbabble needs to know the tty device name(s) of the serial connection(s)
# to the ADCP head(s). If only one head is connected, tty1 is ignored.
# If two heads are connected, the device names are exchangeable, i.e.
# either instrument can be connected to either port.
```

```
set tty0 {/dev/cu.USA49Wfa2P1.1};
set tty1 {/dev/cu.USA49Wfa2P2.2};

# In case of 2 ADCP heads, babble needs to know which is the master and
# which is the slave. This is accomplished by setting the following variables
# to the corresponding instrument serial numbers (PS0 output). By convention,
# the downlooker is the master. If only a single head is connected, both
# variables are ignored.

#set slave_sn 12736;          ### LDEO HP unit; stn 001ff
#set slave_sn  150;  ### LDEO std unit; stn 001-003
set master_sn 4275;### NOC std unit; stn 004-052, 054ff
#set master_sn 13400;          ### NOC titanium unit; stn 053; faulty

# Before deployment, every ADCP head has to be programmed by sending it
# a corresponding command file, defined by the following variables. If only
# a single head is connected, the slave_* variable is ignored.

set master_cmd_file {MASTER.cmd};
set slave_cmd_file  {SLAVE.cmd};

# For convenience, it is best to use the station number to name the ADCP data
# files, and to indicate whether the data file comes from the master or
# slave. The following variables variables define the printf(3) format
# that is used to create the files names from the station number. If only
# a single head is connected, the slave_* variable is ignored.

set slave_deployment_name_fmt        {%03dUL};
set master_deployment_name_fmt       {%03dDL};

# Older RDI instruments (e.g. the BB150) do not allow the data-file name
# to be defined in the instrument, in which case the files have to be
# renamed after downloading. The following variables define the shell
# globbing patterns for the master and slave. For example, the UH BB150
# used during CLIVAR P02 generated files with extension .612; the coresponding
# globbing pattern is {*.612}. If only a single head is connected, the
# slave_* variable is ignored.
# NB: For dual-headed LADCP systems it is important that the globs do not
#     match both master and slave data files. {*.000} therefore will not
#     work for dual-head Workhorse systems.

set master_download_glob    {};
set slave_download_glob              {};

# For consistency it is nicest if low station numbers contain leading
# zeroes. The following variable defines the corresponding printf(3) format.

set stn_format {%03d};

# The following directory is used to store command files, instrument
# configurations and ADCP data. Separate subdirectories (named according to
# stn_format) are used for each cast.

set raw_dir {../data/raw};

# After downloading, the data directory is backed up to the following
# directory. Make sure that it resides on a different disk than raw_dir.
# Empty string disables backup for testing purposes.
# NOTE: RELATIVE PATHNAMES MUST START FROM CAST DIR (NOT ACQUISITION DIR)

set backup_dir {/Volumes/HUBER3/DIMES_UK3/raw};

# By default, bbabble will look for standard UN*X ymodem receive
# programs (rb and lrb) and call the first one it finds with the
# -u option. If neither of the standard programs exist, if neither is in the
# current $PATH, or if non-standard options have to be passed the following
```

```
# variable can be set to a non-empty string, such as {/sw/bin/rb -u}

set ymodem_receive_cmd {}

# bbabble can be made to abort downloading after a preset amount of time,
# defined by the following variable.

set download_timeout 999999;

#----------------------------------------------------------------------
# Semi-Standard Functions
#----------------------------------------------------------------------

# The program for polling an NTP server is different on different
# UN*X systems. Either rdate or ntpdate should be available. Note
# that sudo will propt for the login password of the user running
# the LADCP acquisition, unless it is explicitly set to allow execution
# of the command without a password.

proc set_computer_time {} {                                # set computer clock
        global time_server;
        if {[string length $time_server] == 0} {return}
        exec sudo rdate -s $time_server;
#       exec sudo ntpdate -s $time_server;
}

#----------------------------------------------------------------------

# After the LADCP data files have been downloaded they should be
# checked. A simple yet effective check consists in estimating the
# bottom depth (zmax) and end depth (zend) by time-integrating the
# vertical-velocity measurements. There are two different publicly
# available programs to accomplish this: scanbb from the UH LADCP
# software suite, and mkProfile from the perl-utilities available
# from the LDEO LADCP repository.

proc check_data {file} {                                   # check data file
        exec sh -c "mkProfile -Q $file 2> `basename $file .000`.profinfo";
        exec sh -c "cat `basename $file .000`.profinfo > /dev/tty";
#       exec sh -c "scanbb $file";
#       exec sh -c "sed -n '/^zmax/,/^zend/s/ at.*/m/p' `basename $file .000`.scn > /dev/tty";
}

#----------------------------------------------------------------------

# The following two routines backup the master and slave files from the
# raw directory.

proc backup_master_data {stn} {
        global stn_format master_deployment_name_fmt master_cmd_file backup_dir;
        if {[string length $backup_dir] == 0} {return}

        if {![file isdirectory $backup_dir]} {
                error "$backup_dir does not exist relative to [pwd]";
        }

        set stnstr [format $stn_format $stn];
        set cast_dir [format %s/%s $backup_dir $stnstr];
        if {![file isdirectory $cast_dir]} {exec mkdir $cast_dir};
        exec sh -c "cp [format $master_deployment_name_fmt $stn]* $cast_dir";
        exec sh -c "cp $master_cmd_file* $cast_dir";
        exec sh -c "cp *log $cast_dir";
}

proc backup_slave_data {stn} {                             # copy data to network
        global stn_format slave_deployment_name_fmt slave_cmd_file backup_dir;
        if {[string length $backup_dir] == 0} {return}
```

```
                if {![file isdirectory $backup_dir]} {
                        error "$backup_dir does not exist relative to [pwd]";
                }

                set stnstr [format $stn_format $stn];
                set cast_dir [format %s/%s $backup_dir $stnstr];
                if {![file isdirectory $cast_dir]} {exec mkdir $cast_dir};
                exec sh -c "cp [format $slave_deployment_name_fmt $stn]* $cast_dir";
                exec sh -c "cp $slave_cmd_file* $cast_dir";
                exec sh -c "cp *log $cast_dir";
}

#----------------------------------------------------------------------

# See comments on master_download_glob and slave_download_glob above.

proc rename_master_download_file {target} {              # rename after download
        global master_download_glob;

        if {[string length $master_download_glob] == 0} {return}
        set files [glob -nocomplain $master_download_glob];
        set nfiles [llength $files];
        if {$nfiles == 0} {
                if {![file exists $target]} {
                        error {can't find downloaded master file};
                }
                return;
        }
    if {$nfiles > 1} {
            send_user {WARNING: Multiple files downloaded from master --- rename, backup, check
manually!};
        }
        if {![string equal [lindex $files end] $target]} {
                exec mv [lindex $files end] $target;
        }
}

proc rename_slave_download_file {target} {               # rename after download
        global slave_download_glob;

        if {[string length $slave_download_glob] == 0} {return}
        set files [glob -nocomplain $slave_download_glob];
        set nfiles [llength $files];
        if {$nfiles == 0} {
                if {![file exists $target]} {
                        error {can't find downloaded slave file};
                }
                return;
        }
    if {$nfiles > 1} {
            send_user {WARNING: Multiple files downloaded from slave --- rename, backup, check
manually!};
        }
        if {![string equal [lindex $files end] $target]} {
                exec mv [lindex $files end] $target;
        }
}
```

2. MASTER.cmd

```
;=================================================================
;              M A S T E R . C M D
;              (c) 2004 A.M. Thurnherr
;              uE-Info: 24 51 NIL 0 0 72 2 2 8 NIL ofnI
;=================================================================
;
```

; This is the default master/downlooker command file

; NOTES:
;   - this version requires firmware 16.30 or higher
;   - should contain only commands that change factory defaults
;   - assumes that WM15 is installed (L commands are used)
;   - collect data in beam coordinates
;   - staggered single-ping ensembles every 1.5s/2.0s
;   - narrow bandwidth
;   - 25 8m cells --- reduce after determining the regional instrument

;   -Jan 28, 2012 – Modified for JC069 by Xinfeng Liang.

WM15   ; water mode 15 (LADCP)

TC2   ; ensembles per burst
LP1   ; pings per ensemble
TB 00:00:02.80   ; time per burst
TE 00:00:01.30   ; time per ensemble
TP 00:00.00   ; time between pings

LN25   ; number of depth cells
LS0800   ; bin size [cm]
LF0   ; blank after transmit [cm]

LW1   ; narrow bandwidth LADCP mode
LV400   ; ambiguity velocity [cm/s]

SM1   ; master
SA011   ; send pulse before each ensemble
SB0   ; disable hardware-break detection on Channel B (ICN118)
SW5500   ; wait .5500 s after sending sync pulse
SI0   ; # of ensembles to wait before sending sync pulse

EZ0011101   ; Sensor source:
                              ;   - manual speed of sound (EC)
                              ;   - manual depth of transducer (ED = 0 [dm])
                              ;   - measured heading (EH)
                              ;   - measured pitch (EP)
                              ;   - measured roll (ER)
                              ;   - manual salinity (ES = 35 [psu])
                              ;   - measured temperature (ET)

EX00100   ; coordinate transformation:
                              ;   - radial beam coordinates (2 bits)
                              ;   - use pitch/roll (not used for beam coords?)
                              ;   - no 3-beam solutions
                              ;   - no bin mapping

CF11101   ; Flow control:
                              ;   - automatic ensemble cycling (next ens when ready)
                              ;   - automatic ping cycling (ping when ready)
                              ;   - binary data output
                              ;   - disable serial output
                              ;   - enable data recorder

CK   ; keep params as user defaults (across power failures)
CS   ; start pinging

3. MASTER_towyo.cmd

```
;==============================================================
;           M A S T E R . C M D
;           (c) 2004 A.M. Thurnherr
;           uE-Info: 24 51 NIL 0 0 72 2 2 8 NIL ofnI
```

```
;====================================================================

; This is the default master/downlooker command file

; NOTES:
;    - this version requires firmware 16.30 or higher
;    - should contain only commands that change factory defaults
;    - assumes that WM15 is installed (L commands are used)
;    - collect data in beam coordinates
;    - staggered single-ping ensembles every 1.5s/2.0s
;    - narrow bandwidth
;    - 25 8m cells --- reduce after determining the regional instrument

;   Modified for towyo station by Xinfeng Liang.

WM15                        ; water mode 15 (LADCP)

TC2                         ; ensembles per burst
LP1                         ; pings per ensemble
TB 00:00:03.80              ; time per burst
TE 00:00:01.80              ; time per ensemble
TP 00:00.00                 ; time between pings

LN25                        ; number of depth cells
LS0800                      ; bin size [cm]
LF0                         ; blank after transmit [cm]

LW1                         ; narrow bandwidth LADCP mode
LV400                       ; ambiguity velocity [cm/s]

SM1                         ; master
SA011                       ; send pulse before each ensemble
SB0                         ; disable hardware-break detection on Channel B (ICN118)
SW5500                      ; wait .5500 s after sending sync pulse
SI0                         ; # of ensembles to wait before sending sync pulse

EZ0011101                   ; Sensor source:
                            ;        - manual speed of sound (EC)
                            ;        - manual depth of transducer (ED = 0 [dm])
                            ;        - measured heading (EH)
                            ;        - measured pitch (EP)
                            ;        - measured roll (ER)
                            ;        - manual salinity (ES = 35 [psu])
                            ;        - measured temperature (ET)

EX00100                     ; coordinate transformation:
                            ;        - radial beam coordinates (2 bits)
                            ;        - use pitch/roll (not used for beam coords?)
                            ;        - no 3-beam solutions
                            ;        - no bin mapping

CF11101                     ; Flow control:
                            ;        - automatic ensemble cycling (next ens when ready)
                            ;        - automatic ping cycling (ping when ready)
                            ;        - binary data output
                            ;        - disable serial output
                            ;        - enable data recorder

CK                          ; keep params as user defaults (across power failures)
CS                          ; start pingingset_cast_params.m

%====================================================================
%          S E T _ C A S T _ P A R A M S . M
%          (c) 2006 ladder@
%          uE-Info: 9 22 NIL 0 0 72 0 2 4 NIL ofnI
%====================================================================
```

```
% Jan 28, 2012 – Modified for JC069 by Xinfeng Liang.

processing_version = 3;

if processing_version == 1                              % on cruise
        subdir = 'on_cruise';
elseif processing_version == 2                          % 5m vertical resolution
        subdir = '.';
elseif processing_version == 3                          % 5m rez, DL only
        subdir = 'DL';
elseif processing_version == 4                          % 5m rez, UL, GPS constraint only
        subdir = 'UL_GPS';
elseif processing_version == 5                          % 5m rez, DL, GPS constraint only
        subdir = 'DL_GPS';
end

close all; figure(100);
more off;

f.ladcpdo = sprintf('raw/%03d/%03dDL000.000',stn,stn);
f.ladcpup = sprintf('raw/%03d/%03dUL000.000',stn,stn);

if processing_version == 3 || processing_version == 5        % downlooker only
        f.ladcpup = ' ';
elseif processing_version == 4                                  % uplooker only
        f.ladcpdo = f.ladcpup;
        f.ladcpup = ' ';
end

f.res = sprintf('%s/processed/%03d',subdir,stn);
f.checkpoints = sprintf('checkpoints/%03d',stn);

f.sadcp    = sprintf('SADCP/os75_jc069_ctd_%03d.mat',stn);

% No OS75 SADCP data for station 13
if stn == 13
    f.sadcp= sprintf('SADCP/os150_jc069_ctd_%03d.mat',stn);
end

if stn == 85
    f.sadcp= sprintf('SADCP/os150_jc069_ctd_%03d.mat',stn);
end

if stn == 86
    f.sadcp= sprintf('SADCP/os150_jc069_ctd_%03d.mat',stn);
end


f.ctd = sprintf('CTD/1Hz/ctd_jc069_%03d_1hz_txt',stn);
if exist(f.ctd,'file')
        f.ctd_header_lines    = 0;               % file layout
        f.ctd_fields_per_line         = 6;
        f.ctd_pressure_field= 2;
        f.ctd_temperature_field = 3;
        f.ctd_salinity_field = 4;
        f.ctd_time_field            = 1;
        f.ctd_time_base            = 0;                % elapsed

        f.nav = f.ctd;
        f.nav_header_lines            = f.ctd_header_lines;
        f.nav_fields_per_line         = f.ctd_fields_per_line;
        f.nav_time_field            = f.ctd_time_field;
        f.nav_lat_field             = 5;
        f.nav_lon_field             = 6;
        f.nav_time_base        = f.ctd_time_base;
else
```

```
        f.ctd = ' ';
%       p.drot = 6.3;                                              %%% nominal
end


%=================================================================

p.cruise_id          = 'JC69';
p.whoami= 'X. Liang';
p.name               = sprintf('%s cast #%d (processing version
%d)',p.cruise_id,p.ladcp_station,processing_version);

p.saveplot                        = [1:14];
p.saveplot_png       = [];

p.ladcp_station = stn;

p.btrk_ts = 30;                 % with 10 default, false bottom detected on stn 002
                                        % with 20, false bottom detected on stns 22 & 23

if processing_version ~= 1
        p.avdz = 5;                     % for compatibility with UH & new shearmethod output
        ps.dz = 5;
end

% The following stations had marginal RDI BT data (few seabed points,
% fishy-looking BT profiles in some cases):
%        8, 11, 13, 29, 37, 38, 40, 41, 42, 44
% For consistency, all stations were reprocessed using post-processed
% BT data.

p.btrk_mode = 2;

if processing_version == 4 || processing_version == 5                 % disable BT & SADCP
        ps.botfac = 0;
        ps.sadcpfac = 0;
end

p.edit_mask_dn_bins = [1];
p.edit_mask_up_bins = [1];

p.checkpoints = [1];
```

4.3 Argo floats
Brian King

Breck Owens and Paul Robbins at WHOI provided 9 SOLO floats for deployment for Argo during JC069. The floats were switched on prior to JC068 leaving South Africa, so the only requirement was to deploy them gently into the water. BAK was briefed on deployment procedure by Larry George at the personnel change between JC068 and 069 in Montevideo.

The deployment procedure is very simple. The floats are stored in disposable cardboard crates. The Crates are stropped lengthways, with a release holding the strops at the bottom end. When the release gets wet in the water a starch pellet dissolves and a spring in the release allows the crate to slip away. The top end of the strops are then recovered inboard.

One starch pellet was found to have failed. This float was deployed with rope strops and a pin to release the strops when the weight was taken off the lowering arrangement.

Floats were deployed over the starboard quarter, at slow speed and when leaving a work site. A rope through the four upper strops was taken with one turn around the conveniently located capstan, to allow controlled lowering. The float was arranged athwartships with the top end inboard. For deployment, the float was lifted onto and then outboard of the aft rail, and the weight taken at the top end. A couple of turns of line near the base of the float allowed the float to be lowered to an upright orientation, and this spare line retrieved. The float was then lowered into the sea, following the ship, until its release mechanism operate. The table below gives float deployment details and comments.

	Float serial number	Deployment time day of year month, day HH:MM (UTC)	Lat deg, min Lon deg, min	Comments
1	1110	063 Mar 03 05:10	-54 48.00 -51 59.92	Nearby CTD: None. Transit between sites
2	1113	069 Mar 09 03:36	-56 27.84 -57 25.15	Nearby CTD: 086 (sr1b)
3	1114	071 Mar 11 12:40	-58 03.12 -56 25.96	Nearby CTD: 092 (sr1b)
4	1111	072 Mar 12 08:00	-58 15.90 -58 57.04	Nearby CTD: None Transit between sites
5	????	072 Mar 12 19:25	-58 03.00 -61 50.82	Nearby CTD: None FSU sound source mooring
6	1116	073 Mar 13 16:16	-59 58.92 -65 59.30	Nearby CTD: None FSU sound source mooring
7	1112	074 Mar 14 14:27	-61 09.42 -67 15.52	Nearby CTD: 096 (A21)
8	1120	074 Mar 14 22:21	-60 19.92 -68 00.09	Nearby CTD: 097 (A21)
9	1122	077 Mar 17 14:11	-57 20.96 -67 46.57	Nearby CTD: None (A21) Bad weather prevented CTD

Deployment number 5 was subject to a failure of record keeping. The float number was recorded as 1112, but number 1112 was clearly found still onboard for deployment 7. The number could therefore have been either 1115, or 1121. We presume the position data when the float starts mission telemetry will resolve the uncertainty.

An original plan provided by P Robbins anticipated most float deployments to be coincident with CTDs. The loss of time and reduction in stations meant (a) nearly all the early stations were on the north scotia ridge near shallow topography. (b) an entire section of CTDs was dropped. Therefore floats were deployed in the ratio 5:4 either side of the historical position of the Polar Front. Floats were deployed in international waters except number 9, which was inside the 200 nm Chilean zone. The cruise had sought diplomatic clearance for the deployment of floats. The float was deployed so far north, because the final station, #100, was still only on the northern flanks of the PF, with the latest satellite altimetry confirming the PF to be right at the north end of the section.

Float deployments were notified to P Robbins at WHOI, for notification into the Argo system.

Figure below summarises the float deployment positions, relative to nearby CTDs.

jc069: 31 Jan to 19 Mar 2012
Cruise track
SOLO floats (yellow triangle)
Tracer stations (filled red circle)
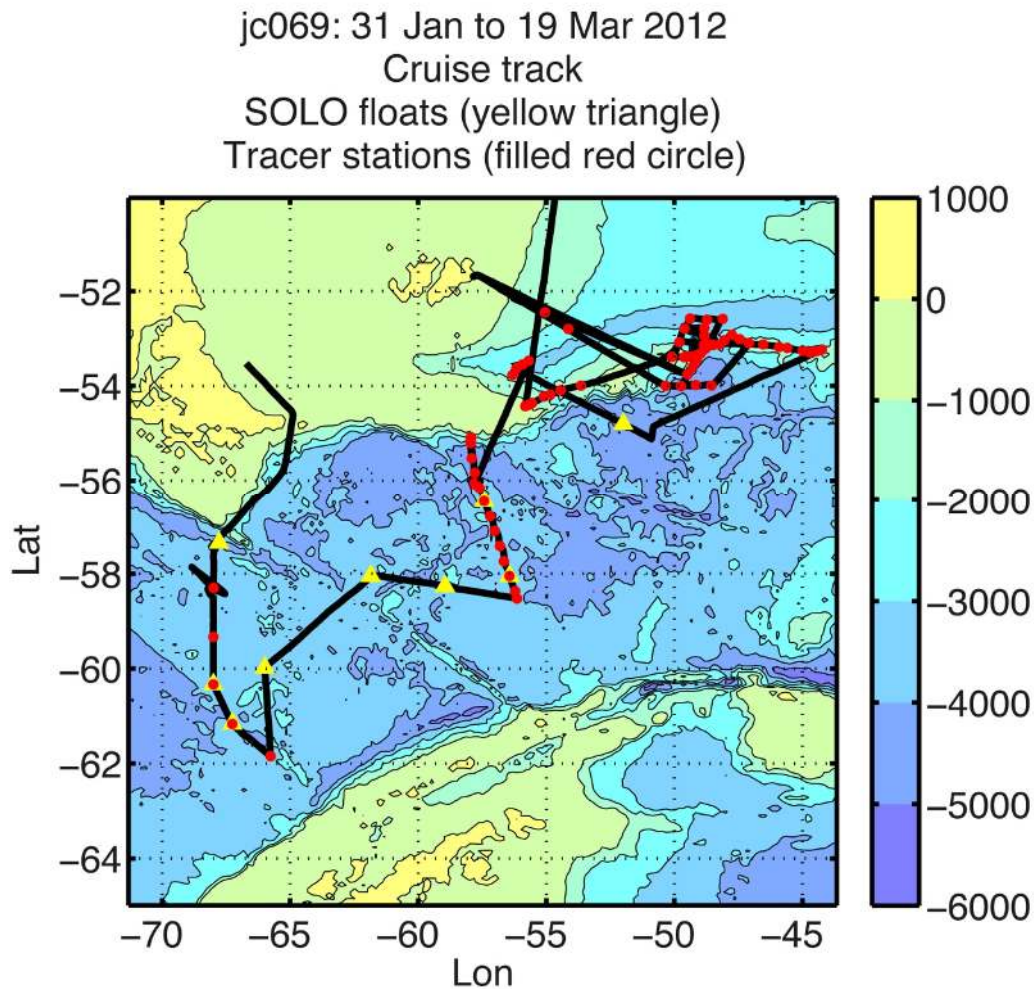
4.4 AARDVARK Drifter Deployments
Alexander Brearley

4.4.1 Overview

Ten surface drifters drogued at 15 m were deployed in targeted locations using satellite altimetry. The main goal of the experiment is to map out unstable manifolds,

where pairs of floats experience a fast exponential separation. This gives us information about mixing, transport and can help to quantify of diffusivities. Float deployment positions were planned by J.B. Sallée and Emily Shuckburgh at the British Antarctic Survey and communicated to Alexander Brearley and Katy Sheen onboard *RRS James Cook*. Float deployment was carried out by Alexander Brearley, Katy Sheen, Paul Provost and Steve Whittle.

4.4.2 Details

Two drifters were deployed in the vicinity of Shag Rocks Passage in an attempt to track the likely trajectory of the missing High-Resolution Profiler. The other eight floats were deployed along a 20 km line on the steam between Shag Rocks Passage and the tracer section on the northern flank of North Scotia Ridge. Deployment positions and float IDs are given in Table 1 below.

Drifter ID	Date (dd/mm/yyyy)	Time	Latitude (deg/decimal minutes)	Longitude (deg/decimal minutes)
012890	09/02/2012	1511	53º 23.37'S	49º 37.34'S
017890	09/02/2012	1529	53º 23.33'S	49º 34.59'S
012900	02/03/2012	2258	54º 50.62'S	50º 48.92'S
113580	02/03/2012	2337	54º 57.34'S	50º 50.61'S
016900	02/03/2012	2345	54º 58.75'S	50º 51.04'S
112580	02/03/2012	2345	54º 58.75'S	50º 51.04'S
114580	02/03/2012	2345	54º 58.75'S	50º 51.04'S
011900	02/03/2012	2345	54º 58.75'S	50º 51.04'S
011890	02/03/2012	2348	54º 59.38'S	50º 51.19'S
015890	03/03/2012	0031	55º 06.76'S	50º 53.27'S

Table 4.4.1: AARDVARK drifter deployment positions and times.

Further technical details of the technologies used by these drifters are given in Sections 6.1 and 6.2 of the JC054 cruise report.

5 MOORINGS

5.1 NOCS DIMES array- UK Moorings
Alexander Brearley, Paul Provost.

5.1.1. Overview

Moorings deployed between 18th and 20th December 2010 on the UK DIMES 2 cruise (JC054) were recovered on 5th and 6th March 2012. Mooring recovery was conducted by the technical team (James Burris, Richie Phipps and Steve Whittle) led by Paul Provost and aided by the CPO(S), Mick Minnock.

5.1.2. Recovery Operations

(a) NE Mooring

The mooring was released at 0901 on 5th March 2012, at 55.9592°S, 57.7541°W, with a subsequent ascent rate of 92 m/min. Table 5.1.1 lists the times and positions of instruments on deck, with operations complete by 1201. All instruments and flotation were recovered successfully.

Instrument and Equipment	Serial Number	Time (UTC) Onboard	Latitude Onboard (°S)	Longitude Onboard (°W)
Benthos		1016	55.9742	57.6938
Seaguard	113	1026	55.9773	57.6883
SBE37 SMP	7292	1027	55.9777	57.6820
Seaguard	116	1035	55.9807	57.6712
SBE37 SMP	7293	1035	55.9807	57.6712
Seaguard	118	1051	55.9872	57.6497
SBE37 SMP	7294	1051	55.9872	57.6497
Nortek	5883	1115	55.9956	57.6238
SBE37 SMP	7295	1115	55.9956	57.6238
Nortek	1420	1145	56.0049	57.5936
SBE37 SMP	8077	1145	56.0049	57.5936
Ixsea	686	1201	56.0101	57.5770

Table 5.1.1: Times and positions of recovery for NE mooring.

(b) SE Mooring

The mooring was released at 1308 on 5th March 2012, at 56.0542ºS, 57.7429ºW, with a subsequent ascent rate of 95 m/min. Table 5.1.2 lists the times and positions of instruments on deck, with operations complete by 1504. All instruments and flotation were recovered successfully.

Instrument and Equipment	Serial Number	Time (UTC) Onboard	Latitude Onboard (°S)	Longitude Onboard (°W)
Benthos		1332	56.0616	57.7145
Seaguard	119	1336	56.0628	57.7112
SBE37 SMP	7296	1336	56.0628	57.7112
Seaguard	120	1343	56.0648	57.7050
SBE37 SMP	7297	1343	56.0648	57.7050
Seaguard	121	1400	56.0701	57.6909
SBE37 SMP	7298	1400	56.0701	57.6909
Seaguard	122	1418	56.0753	57.6764
SBE37 SMP	7299	1418	56.0753	57.6764
Nortek	1404	1446	56.0836	57.6554
SBE37 SMP	8076	1446	56.0836	57.6554
Ixsea	1141	1504	56.0885	57.6426

Table 5.1.2: Times and positions of recovery for SE mooring.

(c) SW Mooring

The mooring was released at 1619 on 5th March 2012, at 56.0566ºS, 57.8979ºW, with a subsequent ascent rate of 111 m/min. Table 5.1.3 lists the times and positions of instruments on deck, with operations complete by 1806. All instruments and flotation were recovered successfully.

Instrument and Equipment	Serial Number	Time (UTC) Onboard	Latitude Onboard (°S)	Longitude Onboard (°W)
Benthos		1644	56.0644	57.8974
Seaguard	123	1647	56.0658	57.8962
SBE37 SMP	7300	1647	56.0658	57.8962
Seaguard	124	1655	56.0699	57.8930
SBE37 SMP	7301	1655	56.0699	57.8930
Seaguard	069	1712	56.0798	57.8862
SBE37 SMP	7302	1712	56.0798	57.8862
Nortek	1415	1728	56.0859	57.8823
SBE37 SMP	8079	1728	56.0859	57.8823
Seaguard	127	1754	56.0929	57.8803
SBE37 SMP	7303	1754	56.0929	57.8803
Ixsea	1142	1806	56.0970	57.8794

Table 5.1.3: Times and positions of recovery for the SW mooring.

(d) M Mooring

The mooring was released at 1907 on 5th March 2012, at 56.0164ºS, 57.7640ºW, with a subsequent ascent rate of 78.5 m/min. Recovery commenced at 1935 and was completed by 2139. Five imploded buoyancy spheres were found immediately above the mooring release, but these do not appear to have significantly affected the uprightness of the mooring. In addition to the UK instruments, a RAFOS sound source supplied by FSU was also included on this mooring. Table 5.1.4 lists the times and positions on deck.

Instrument and Equipment	Serial Number	Time (UTC) Onboard	Latitude Onboard (°S)	Longitude Onboard (°W)
Benthos		1935	56.0273	57.7660
Xenon Flash	W10-027	1935	56.0273	57.7660
ARGOS Sercel	016-110	1935	56.0273	57.7660
RAFOS sound source	56	2006	56.0458	57.7625
Nortek	8059	2025	56.0566	57.7589
SBE37 SMP	8075	2026	56.0572	57.7587
MMP	11974-02	2053	56.0729	57.7539
Nortek	8080	2109	56.0823	57.7523
SBE37 SMP	8076	2109	56.0823	57.7523
MMP + SBE8 (SAMS)	11672-01 (electronics)	2128	56.0928	57.7506

Instrument and Equipment	Serial Number	Time (UTC) Onboard	Latitude Overside (°S)	Longitude Overside (°W)
11794-01 (chassis)				
Ixsea	1137 & 1138	2139	56.0991	57.7051

Table 5.1.4: Times and positions of recovery for the M mooring.

(e) C Mooring

The mooring was released at 0930 on 6th March 2012, at 56.0059°S, 57.8142°W, with a subsequent ascent rate of 85 m/min. Recovery commenced at 0958, with all instruments and flotation successfully recovered by 1212. Table 5.1.5 lists the time and position of instruments on deck. One buoyancy sphere above Nortek 6275 had imploded during the deployment period but did not affect the uprightness of the mooring.

Instrument and Equipment	Serial Number	Time (UTC) Onboard	Latitude Overside (°S)	Longitude Overside (°W)
Xenon Flash	W10-029	0958	56.0194	57.8209
ARGOS Sercel Beacon	016-112	0958	56.0185	57.8182
Nortek	6178	1004	56.0203	57.8168
SBE37 SMP	7304	1004	56.0203	57.8168
Nortek	6181	1019	56.0254	57.8136
SBE37 SMP	7305	1019	56.0254	57.8136
Nortek	6182	1022	56.0265	57.8132
SBE37 SMP	7306	1022	56.0265	57.8132
Nortek	6203	1026	56.0278	57.8128
SBE37 SMP	7307	1026	56.0278	57.8128
Nortek	6212	1042	56.0328	57.8096
SBE37 SMP	7309	1042	56.0328	57.8096
Nortek	6213	1049	56.0350	57.8083
SBE37 SMP	7310	1049	56.0350	57.8083
Nortek	6224	1102	56.0395	57.8049
SBE37 SMP	7311	1102	56.0395	57.8049
Nortek	6225	1109	56.0418	57.8032
SBE37 SMP	7312	1109	56.0418	57.8032
Nortek	6242	1115	56.0439	57.8022
SBE37 SMP	7313	1115	56.0439	57.8022
Nortek	6273	1121	56.0462	57.8014
SBE37 SMP	7314	1121	56.0462	57.8014
Long Ranger ADCP	3301	1141	56.0533	57.7989
Nortek	6275	1159	56.0611	57.7954
SBE37 SMP	7315	1159	56.0611	57.7954
Nortek	6276	1206	56.0626	57.7995
SBE37 SMP	7316	1206	56.0626	57.7995
Ixsea	1134 & 1135	1212	56.0647	57.7936

Table 5.1.5: Times and positions of recovery for the C mooring.

(f) NW Mooring

The mooring was released at 1413 on 6th March 2012, at 55.9761°S, 57.8812°W, with a subsequent ascent rate of 96 m/min. Recovery started at 1441 and was completed by 1613. All instruments and flotation were successfully brought on board, with the times and positions given in Table 5.1.6.

Instrument and Equipment	Serial Number	Time (UTC) Onboard	Latitude Onboard (°S)	Longitude Onboard (°W)
Benthos		1441	55.9703	57.9009
Seaguard	109	1444	55.9714	57.9006
SBE37 SMP	7288	1444	55.9714	57.9006
Seaguard	110	1451	55.9751	57.8993
SBE37 SMP	7289	1451	55.9751	57.8993
Nortek	1430	1510	55.9833	57.8957
SBE37 SMP	7308	1510	55.9833	57.8957
Seaguard	111	1529	55.9918	57.8904
SBE37 SMP	7290	1529	55.9918	57.8904
Seaguard	112	1558	56.0054	57.8841
SBE37 SMP	7291	1558	56.0054	57.8841
Ixsea	1140	1613	56.0122	57.8815

Table 5.1.6: Times and positions of recovery for the NW mooring.

(g) Instrument Failures

All the instruments deployed on UK2 were recovered successfully, with only five incomplete data records. Seaguard 069, deployed at 1293 m on the SW Mooring, collected data only until 17th May 2011, apparently due to a premature battery failure. No reliable conductivity data were collected from Microcat 8075 on the M mooring, due to a failure to remove end caps prior to deployment. MMP 11794-01 gave a full year's CTD and current meter data but failed to profile (it was stuck at the top), whilst MMP 11794-02 profiled and recorded data successfully until 30th December 2011 at 2311 UTC, when the instrument failed due to low battery ("MIN BATTERY" was recorded in 'E' file). Finally, the downward-looking Long Ranger ADCP on the C mooring successfully recorded at least 400 m of velocity data, every 30 minutes, until the battery of the instrument died at 0730 on 25th January 2012, causing a 42-day data gap at the end of the series.

(h) Data Download

After recovery, the raw data files for each instrument were downloaded by Paul Provost, Steve Whittle, James Burris and Alexander Brearley. Data from the SMPs (hereafter referred to as Microcats) were downloaded using Seabird's SeaTerm program, before being extracted in the same package from binary to ascii. Seaguard and Nortek data were downloaded in Seaguard Studio and Aquadopp DW respectively. Data from the MMP profiles were downloaded and unpacked using the McLane software, whilst the Long Ranger data was extracted in WinADCP and

converted to Matlab-readable ascii. Some data file renaming was done prior to caarying out further processing. A list of filenames is given in Table 5.1.7. All data were backed up to the cookfs file server.

Mooring	Instrument Type and Serial No.	Original download file(s)	Other files produced
SE	Seaguard 119	RCM_119_20101812_1200 (directory)	seaguard_119.txt
	Seaguard 120	RCM_120_20101812_1200 (directory)	seaguard_120.txt
	Seaguard 121	RCM_121_20101812_1200 (directory)	seaguard_121.txt
	Seaguard 122	RCM_122_20101812_1200 (directory)	seaguard_122.txt
	Nortek 1404	n140401.dat	n140401.aqd, .hdr, .dia
	SBE37 SMP 7296	SBE37-RS232_03707296_2012_03_10.XML	7296.cap/7296_data.cnv
	SBE37 SMP 7297	SBE37-RS232_03707297_2012_03_10.XML	7297.cap/7297_data.cnv
	SBE37 SMP 7298	SBE37-RS232_03707298_2012_03_10.XML	7298.cap/7298_data.cnv
	SBE37 SMP 7299	SBE37-RS232_03707299_2012_03_10.XML	7299.cap/7299_data.cnv
	SBE37 SMP 8078	SBE37-RS232_03708078_2012_03_10.XML	8078.cap/8078_data.cnv
NE	Seaguard 113	RCM_113_20101812_1200 (directory)	seaguard_113.txt
	Seaguard 116	RCM_116_20101812_1200 (directory)	seaguard_116.txt
	Seaguard 118	RCM_118_20101812_1200 (directory)	seaguard_118.txt
	Nortek 5883	N588302.dat	N588302.aqd, .hdr, .dia
	Nortek 1420	n142001.dat	n142001.aqd, .hdr, .dia
	SBE37 SMP 7292	SBE37-RS232_03707292_2012_03_10.XML	7292.cap/7292_data.cnv
	SBE37 SMP 7293	SBE37-RS232_03707293_2012_03_10.XML	7293.cap/7293_data.cnv
	SBE37 SMP 7294	SBE37-RS232_03707294_2012_03_10.XML	7294.cap/7294_data.cnv
	SBE37 SMP 7295	SBE37-RS232_03707295_2012_03_10.XML	7295.cap/7295_data.cnv
	SBE37 SMP 8077	SBE37-RS232_03708077_2012_03_10.XML	8077.cap/8077_data.cnv
NW	Seaguard 109	RCM_109_20101812_1200 (directory)	seaguard_109.txt
	Seaguard 110	RCM_110_20101812_1200 (directory)	seaguard_110.txt
	Seaguard 111	RCM_111_20101812_1200 (directory)	seaguard_111.txt
	Seaguard 112	RCM_112_20101812_1200 (directory)	seaguard_112.txt
	Nortek 1430	n143001.dat	n143001.aqd, .hdr, .dia
	SBE37 SMP 7288	SBE37-RS232_03707288_2012_03_09. XML	7288.cap/7288_data.cnv
	SBE37 SMP 7289	SBE37-RS232_03707289_2012_03_09. XML	7289.cap/7289_data.cnv
	SBE37 SMP 7308	SBE37-RS232_03707308_2012_03_09. XML	7308.cap/7308_data.cnv
	SBE37 SMP 7290	SBE37-RS232_03707290_2012_03_09. XML	7290.cap/7290_data.cnv
	SBE37 SMP 7291	SBE37-RS232_03707291_2012_03_09. XML	7291.cap/7291_data.cnv
C	Nortek 6178	N617802.dat	N617801.aqd, .hdr, .dia
	Nortek 6181	N618102.dat	N618101.aqd, .hdr, .dia
	Nortek 6182	N618202.dat	N618201.aqd, .hdr, .dia
	Nortek 6203	N620302.dat	N620301.aqd, .hdr, .dia
	Nortek 6212	N621202.dat	N621201.aqd, .hdr, .dia
	Nortek 6213	N621302.dat	N621301.aqd, .hdr, .dia
	Nortek 6224	N622402.dat	N622401.aqd, .hdr, .dia
	Nortek 6225	N622502.dat	N622501.aqd, .hdr, .dia
	Nortek 6242	N624202.dat	N624201.aqd, .hdr, .dia
	Nortek 6273	N627302.dat	N627301.aqd, .hdr, .dia
	Nortek 6275	N627502.dat	N627501.aqd, .hdr, .dia
	Nortek 6276	n627601.dat	n627602.aqd, .hdr, .dia
	LR-ADCP 3301	JC054000.000	3301_data.mat
	SBE37 SMP 7304	SBE37-RS232_03707304_2012_03_09. XML	7304.cap/7304_data.cnv
	SBE37 SMP 7305	SBE37-RS232_03707305_2012_03_09. XML	7305.cap/7305_data.cnv
	SBE37 SMP 7306	SBE37-RS232_03707306_2012_03_09. XML	7306.cap/7306_data.cnv
	SBE37 SMP 7307	SBE37-RS232_03707307_2012_03_09. XML	7307.cap/7307_data.cnv
	SBE37 SMP 7309	SBE37-RS232_03707309_2012_03_09. XML	7309.cap/7309_data.cnv
	SBE37 SMP 7310	SBE37-RS232_03707310_2012_03_09. XML	7310.cap/7310_data.cnv
	SBE37 SMP 7311	SBE37-RS232_03707311_2012_03_09. XML	7311.cap/7311_data.cnv
	SBE37 SMP 7312	SBE37-RS232_03707312_2012_03_09. XML	7312.cap/7312_data.cnv
	SBE37 SMP 7313	SBE37-RS232_03707313_2012_03_09. XML	7313.cap/7313_data.cnv
	SBE37 SMP 7314	SBE37-RS232_03707314_2012_03_09. XML	7314.cap/7314_data.cnv
	SBE37 SMP 7315	SBE37-RS232_03707315_2012_03_09. XML	7315.cap/7315_data.cnv
	SBE37 SMP 7316	SBE37-RS232_03707316_2012_03_09. XML	7316.cap/7316_data.cnv
SW	Seaguard 123	RCM_123_20101812_1200 (directory)	seaguard_123.txt
	Seaguard 124	RCM_124_20101812_1200 (directory)	seaguard_124.txt
	Seaguard 069	RCM_069_20101812_1200 (directory)	seaguard_069.txt
	Seaguard 127	RCM_127_20101812_1200 (directory)	seaguard_127.txt

	Nortek 1415	n141501.dat	n141501.aqd, .hdr, .dia
	SBE37 SMP 7300	SBE37-RS232_03707300_2012_03_10.XML	7300.cap/7300_data.cnv
	SBE37 SMP 7301	SBE37-RS232_03707301_2012_03_10.XML	7301.cap/7301_data.cnv
	SBE37 SMP 7302	SBE37-RS232_03707302_2012_12_09.XML	7302.cap/7302_data.cnv
	SBE37 SMP 8079	SBE37-RS232_03708079_2012_03_10.XML	8079.cap/8079_data.cnv
	SBE37 SMP 7303	SBE37-RS232_03707303_2012_03_10.XML	7303.cap/7303_data.cap
M	Nortek 8059	n805901.dat	n805901.aqd, .hdr, .dia
	Nortek 8080	n808001.dat	n808001.aqd, .hdr, .dia
	SBE37 SMP 8075	SBE37-RS232_03708075_2012_03_10.XML	8075.cap/8075_data.cnv
	SBE37 SMP 8076	SBE37-RS232_03708076_2012_03_09.XML	8076.cap/8076_data.cnv
	MMP 11794-02	11794_02 unpacked (directory)*	11794_02*
	MMP 11794-01	11794_01 unpacked (directory)*	11794_01*

Table 5.1.7: Downloaded data files from each instrument recovered from year 2 of the DIMES mooring array. Other files include capture and cnv files for the SMPs, header and control files for the Norteks and .txt data files for the Seaguards, *The data directories for the MMPs contain A* files containing current meter data, C* files containing CTD data and E* files containing engineering information. Other MMP files include the deploy.txt file, which holds the setup information.

5.1.3. Data Processing

Following data download, stages 1 and 2 of the RAPID mooring data processing were carried out on the Microcats, current meters and Long Ranger ADCP. The aim of stage 1 is to convert the data to the standard rodb format and output in .raw format, whilst in stage 2, the mooring deployment and recovery periods are removed and initial inspection of the data is performed to identify spurious drifts, jumps etc. The output files are given .use extensions.

In addition, the temperature, conductivity and pressure of the 34 Microcats deployed as part of the experiment were calibrated using extended CTD stops on casts 93, 95 and 96 respectively. The offsets were recorded (more details in section 5.1.4) but application of the final calibrations will only be performed after consultation with the RAPID data team in Southampton and similar processing of the data from JC054. These instruments will not be factory-recalibrated prior to deployment on the OSMOSIS experiment in September 2012.

(a) Results from Microcats

The pressure trace from the 34 Microcats confirmed that, as in 2009-2010, every mooring was subject to extensive knockdown during its deployment. However, the use of glass spheres this year prevented any of the moorings collapsing. The maximum knockdown of 830 m occurred in mid-September, coincident with a period of high current speed at all depths (Figure 5.1.1).

Initial observations of the temperature from the Microcats reveal periods of relatively high temperatures in March and July 2011 and notable minima in May and October 2011. The top-to-bottom structure is qualitatively similar for each mooring in the array. Salinity is not obviously related to the temperature, and some of the salinity time series contain isolated spikes (e.g. Figure 5.1.1). Initial plots of temperature, conductivity, pressure and salinity were made and stored as *****raw.ps files in the /noc/users/pstar/cruise/data/moorings/moorings_processing/moor/proc/*xx*_1_201112/ microcat data directory, where *xx* is the mooring name (*cc* for Central, *mm* for Middle, *nw* for Northwest, *sw* for Southwest, *ne* for Northeast and *se* for Southeast).
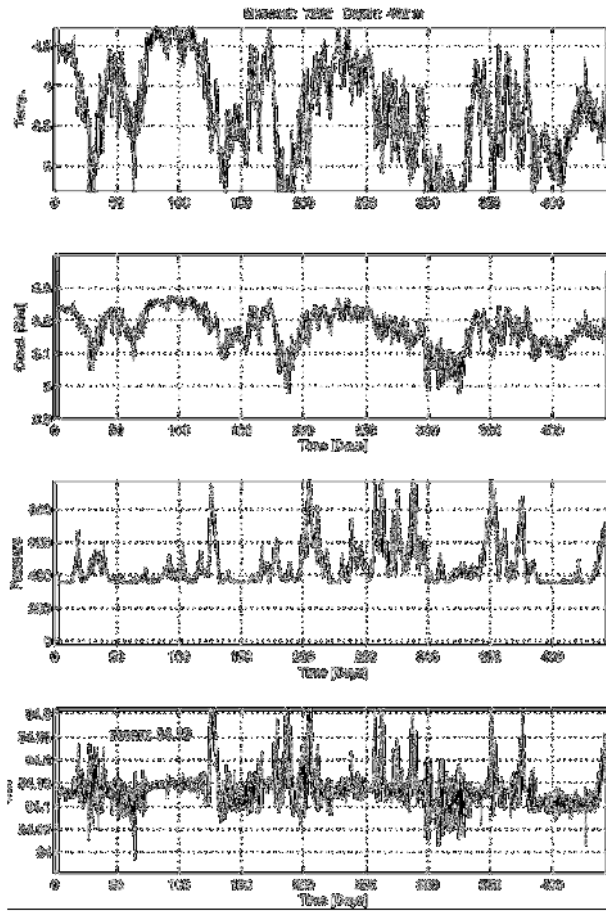
Figure 5.1.1: Temperature, conductivity, pressure and salinity for Microcat 7292 on the NE Mooring. A maximum knockdown of 830 m is found close to Day 280, and a salinity spike is seen near Day 430. Figure of this type were produced for each Microcat (with the extension .raw.ps).

(b) Results from Current Meters

Both Nortek and Seaguard current meters performed well during the experiment with only a single Seaguard failing before the end of the deployment. Initial results show a dominantly east or north-east directed ACC with peak velocities in the top current meters exceeding 60 cm/s. As in 2010, the flow was generally equivalent barotropic in nature, with periods of relatively high flow in July and September 2011 and reduced current speeds in March 2011, October 2011 and January 2012 (Figure 5.1.2). Tilt and pitch measurements were generally less than 20º throughout the deployment, though some of the lower current meters did experience greater angles (up to 45º), especially during the high knockdown event in September (Figure 5.1.2). The resulting time series of current speed does not show any obvious erroneous values, though caution needs to be exercised over velocities derived at such high tilt angles.
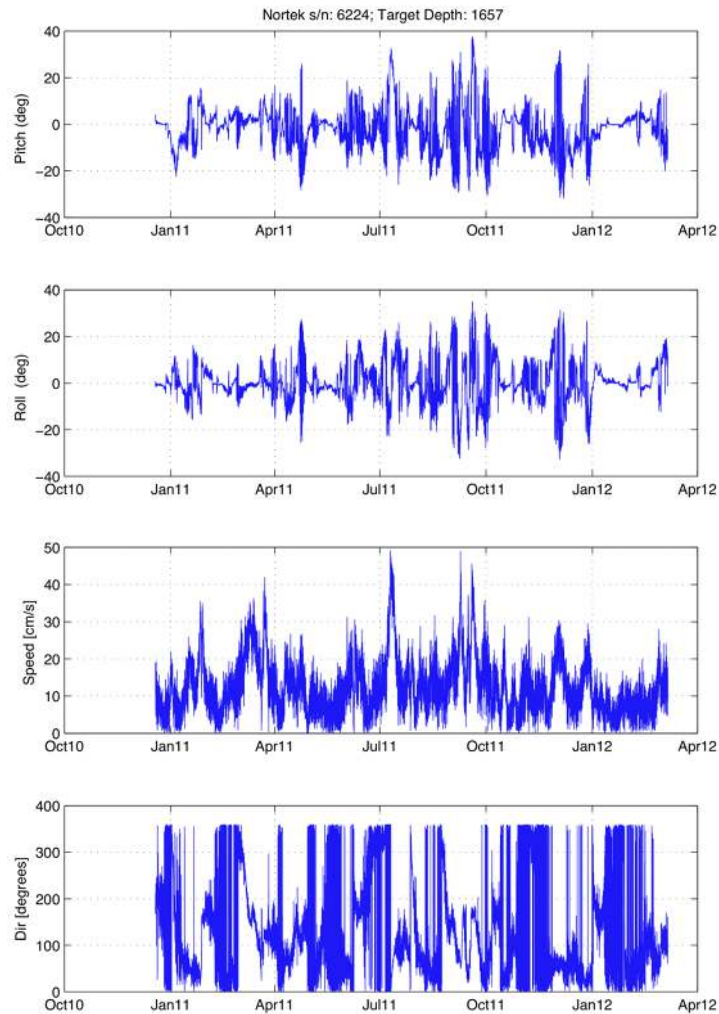
Figure 5.1.2: Pitch, roll, speed and direction from a mid-depth Nortek current meter on the C mooring. Note the high pitch/roll angles at high current speeds.

(c) Results from Long Ranger ADCP

The downward-looking LRADCP, which was programmed to sample every 30 minutes (at 11 pings per ensemble), typically yielded between 300 m and 400 m of good data for 13 months (Figure 5.1.3). The high-speed peak seen in many of the other current meters in July 2011 is clearly evident in the ADCP data. There is some suggestion of a reduction in depth penetration after August 2011, possibly related to diminishing battery power.
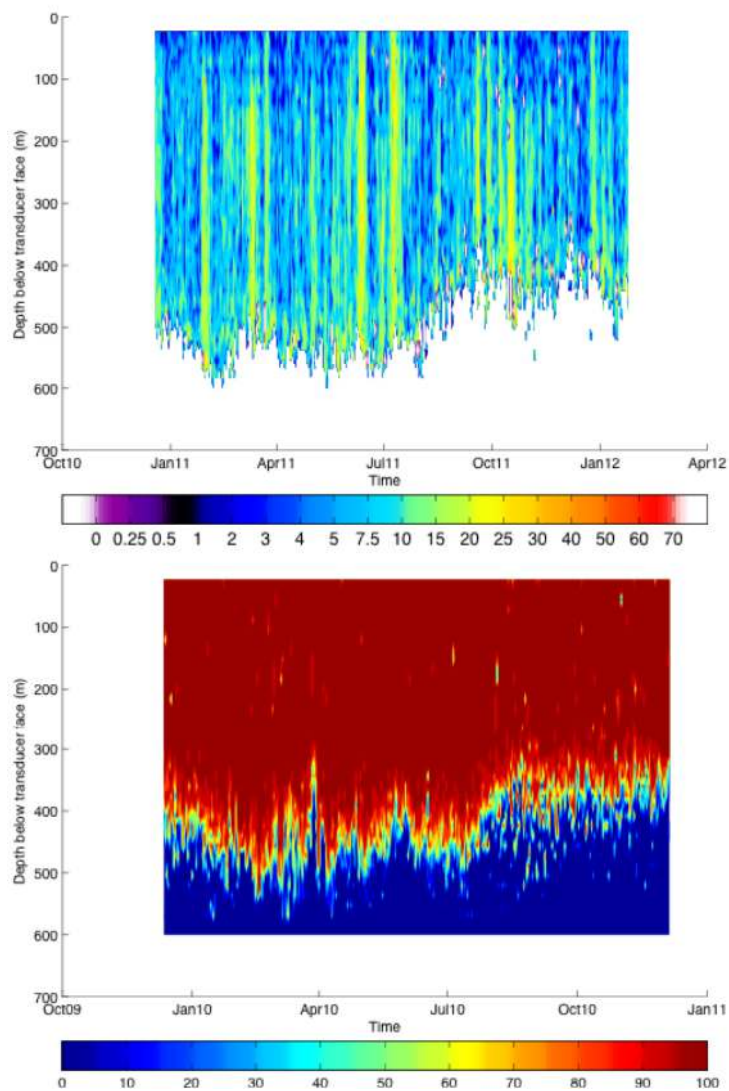
Figure 5.1.3: Speed (cm/s) and percentage good for Long Ranger ADCP on the C mooring.

5.1.4. Microcat Calibration

Three CTD stations were completed, each with six extended 6-minute stops, on which the 34 Microcats were dipped (13 on Cast 93, 12 on Cast 95 and 9 on Cast 96). The positions of the extended stops were designed to encompass the widest conductivity range possible. On cast 93, extended stops were done at 3738 m, 2135 m, 840 m, 237 m, 183 m and 90 m. On cast 95, the stops were at 1497 m, 1303 m, 800 m, 620 m, 86 m and 21 m. On cast 96, they were at 1494 m, 1268 m, 983 m, 628 m, 89 m and 40 m. The Microcats were set to 30 second sampling, with the filenames given in Table 5.1.9.

A script *m_microcat_ctd* was written to determine the size of the pressure, temperature and conductivity offsets for each sensor. This script, found on *nosea1* in the
/noc/users/pstar/cruise/data/moorings/moorings_processing/exec/dimesuk3/stage1/mi

crocat directory, extracts for each of the three casts the times at which the winch was stopped for more than 2 minutes (i.e. the extended stops) and plots up the differences between the CTD and each Microcat at those levels. Pressure, temperature and conductivity are each considered in turn, with a graphical interface allowing the user to select the best value of offset for each variable at each extended CTD stop (Figure 5.1.4).

The best estimates of temperature and conductivity offset for each instrument are given in Table 5.1.8. How best to apply these calibrations to the final mooring data set will be decided once a similar analysis has been performed on the Microcats recovered on JC054, for which the details of the calibration dips are given in the JC054 cruise report.

A feature noticed when doing the calibrations was that whilst temperature and conductivity showed a near constant offset, the pressure offset was larger at higher pressure. Most of the instruments showed a 1-2 dbar offset at 40 dbar, increasing to ~8 dbar at 3800 dbar. We are not clear whether this is a known response of the pressure sensors on the Microcats, or (less likely) a CTD pressure sensor issue. We will consult with Darren Rayner on our return to Southampton about this pressure sensor behaviour and the degree of processing required for final data submission to BODC (e.g. amounts of despiking etc.).

Microcat Serial No.	Dip Cast No.	Cond. Offset (S/m)	Temp Offset (°C)
7290	93	+0.003	+0.002
7291	93	+0.001	+0.001
7295	93	+0.005	+0.002
7299	93	+0.004	+0.001
7303	93	+0.006	+0.001
7313	93	+0.001	+0.002
7314	93	+0.001	+0.002
7315	93	+0.008	+0.002
7316	93	+0.002	+0.002
8076	93	0	+0.002
8077	93	0	+0.001
8078	93	0	+0.001
8079	93	0	+0.002
7289	95	+0.003	+0.001
7292	95	0	+0.001
7293	95	+0.003	+0.001
7297	95	+0.007	+0.002
7298	95	+0.007	+0.002
7300	95	0	+0.001
7301	95	+0.002	+0.001
7304	95	+0.003	+0.001
7307	95	+0.003	0
7308	95	+0.005	0
7312	95	+0.002	+0.001
8075	95	0	+0.001
7288	96	-0.003	+0.001
7294	96	+0.005	+0.001
7296	96	+0.002	+0.001
7302	96	+0.002	+0.002
7305	96	+0.007	+0.001

7306	96	+0.006	+0.001
7309	96	0	0
7310	96	0	0
7311	96	0	0

Table 5.1.8 Best estimate of Microcat offsets from CTD temperature and conductivity.

Instrument Serial Number	CTD cast number where dipped	Downloaded data file	Capture file
7290	93	7290_caldip_2012_03_11.XML	7290_postcd.cap
7291	93	7291_caldip_2012_03_11.XML	7291_postcd.cap
7295	93	7295_caldip_2012_03_11.XML	7295_postcd.cap
7299	93	7299_caldip_2012_03_11.XML	7299_postcd.cap
7303	93	7303_caldip_2012_03_11.XML	7303_postcd.cap
7313	93	7313_caldip_2012_03_11.XML	7313_postcd.cap
7314	93	7314_caldip_2012_03_11.XML	7314_postcd.cap
7315	93	7315_caldip_2012_03_11.XML	7315_postcd.cap
7316	93	7316_caldip_2012_03_11.XML	7316_postcd.cap
8076	93	8076_caldip_2012_03_11.XML	8076_postcd.cap
8077	93	8077_caldip_2012_03_11.XML	8077_postcd.cap
8078	93	8078_caldip_2012_03_11.XML	8078_postcd.cap
8079	93	8079_caldip_2012_03_11.XML	8079_postcd.cap
7289	95	7289_caldip_2012_03_14.XML	7289.cap
7292	95	7292_caldip_2012_03_14.XML	7292.cap
7293	95	7293_caldip_2012_03_14.XML	7293.cap
7297	95	7297_caldip_2012_03_14.XML	7297.cap
7298	95	7298_caldip_2012_03_14.XML	7298.cap
7300	95	7300_caldip_2012_03_14.XML	7300.cap
7301	95	7301_caldip_2012_03_14.XML	7301.cap
7304	95	7304_caldip_2012_03_14.XML	7304.cap
7307	95	7307_caldip_2012_03_14.XML	7307.cap
7308	95	7308_caldip_2012_03_14.XML	7308.cap
7312	95	7312_caldip_2012_03_14.XML	7312.cap
8075	95	8075_caldip_2012_03_14.XML	8075.cap
7288	96	7288_caldip_2012_03_14.XML	7288cd.cap
7294	96	7294_caldip_2012_03_14.XML	7294cd.cap
7296	96	7296_caldip_2012_03_14.XML	7296cd.cap
7302	96	7302_caldip_2012_03_14.XML	7302cd.cap
7305	96	7305_caldip_2012_03_14.XML	7305cd.cap
7306	96	7306_caldip_2012_03_14.XML	7306cd.cap
7309	96	7309_caldip_2012_03_14.XML	7309cd.cap
7310	96	7310_caldip_2012_03_14.XML	7310cd.cap
7311	96	7311_caldip_2012_03_14.XML	7311cd.cap

Table 5.1.9: Original filenames of downloaded cal dip data for each Microcat.
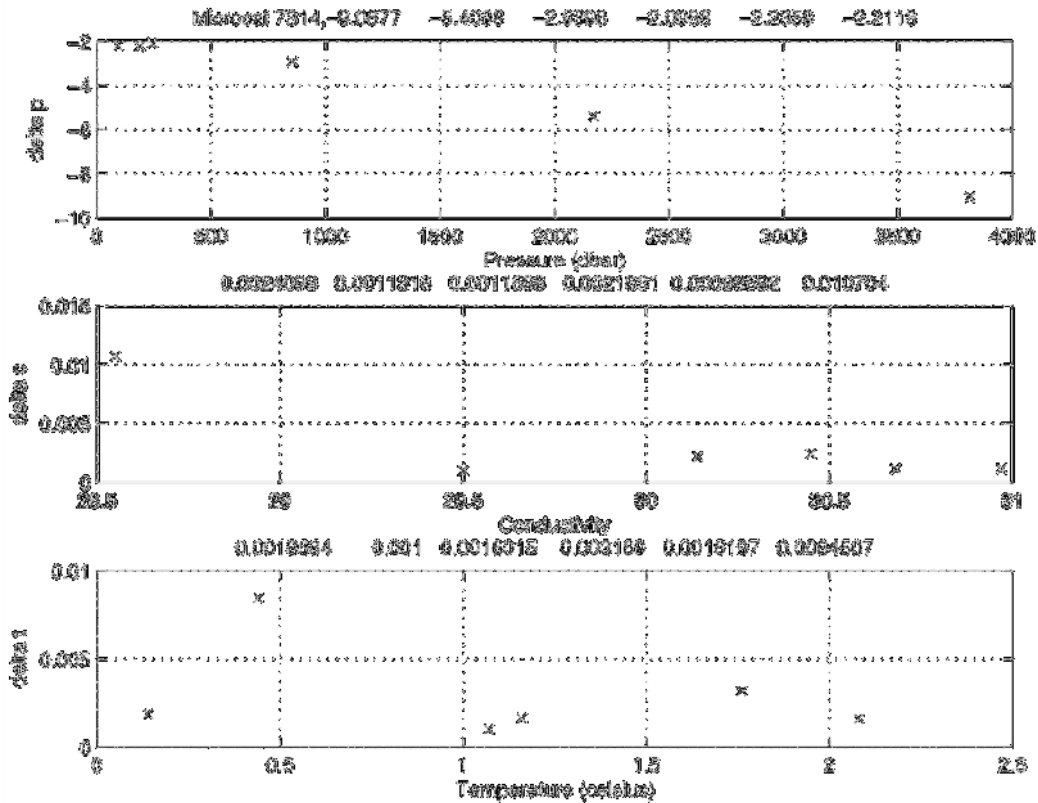
Figure 5.1.4: Example of temperature, pressure and conductivity offsets for Microcat 7314. The individual offset values are plotted and given as text at the top of each plot.

5.2 Florida State University Sound Source Moorings

Alexander Brearley, Paul Provost, Dhruv Balwada.

5.2.1. Overview

Two standalone moorings containing Webb sound sources deployed on the first UK DIMES cruise (JC041) were recovered successfully. In addition, a further sound source on the UK M mooring was also recovered (details in Section 5.1). Owing to time constraints, it was determined that the third sound source mooring (FSU 3) would not be recovered on this cruise.

5.2.2. Recovery Operations

(a) FSU 2

The FSU 2 mooring was released around 1800 on 12th March 2012. Recovery commenced at 1833 and was completed by 1857. Details are given in Table 5.2.1.

Instrument and Equipment	Serial Number	Time (UTC) Onboard	Latitude Onboard (°S)	Longitude Onboard (°W)
Radio	138	1833	58.0252	61.8735
Xenon Flash	143	1833	58.0252	61.8735
ARGOS Sercel	A6031	1833	58.0252	61.8735
RAFOS Sound Source	57	1849	58.0293	61.8570
Edgetech 8242XS Release	32975	1857	58.0309	61.8492

Table 5.2.1: Times and positions of recovery for the FSU 2 mooring.

(b) FSU 1

The FSU 1 mooring was released at 1450 on 13th March 2012. Recovery commenced at 1508 and was completed by 1535. Details are given in Table 5.2.2.

Instrument and Equipment	Serial Number	Time (UTC) Onboard	Latitude Onboard (°S)	Longitude Onboard (°W)
Radio	136	1511	59.9771	65.9899
Xenon Flash	140	1511	59.9771	65.9899
ARGOS Sercel	A5F4F	1511	59.9771	65.9899
RAFOS Sound Source	54	1529	59.9798	65.9892
Edgetech 8242XS Release	32976	1535	59.9807	65.9891

Table 5.2.2: Times and positions of recovery for the FSU 1 mooring.

5.2.3 Post-Recovery Operations

The mooring flotation was stored in cages and will be shipped back to FSU by container from Punta Arenas.

6 CRUISE SERVICES

6.1 Data processing on nosea1
Brian King

Linux workstation nosea1 was carried forward from JC068, and m_setup advanced from jc068 to jc069, in the usual way.
The workstation was used for mexec processing of CTD and underway data; as well as being the platform for codas processing of OS75 and OS150 VMADCP.
A new Matlab license, sent by email from G Jones at NOCS was installed part way through the cruise. The previous license would have expired before the cruise ended.
A number of filesystems were remotely mounted: TECHSAS, mounted on /mnt/techsas, and the two public cookfs partitions. During the cruise TECHSAS data were accessed over the network. At the end of the cruise after TECHSAS logging

stopped, all TECHSAS files were copied onto nosea1 to form part of the cruise mexec archive. The start and end times of techsas streams in that archive is as follows

Start day		End day		TECHSAS stream	mexec short name
29	17:33:07	77	18:16:25	AirSeaII-S84_JC1.AirSeaII	gravity
30	13:21:41	77	03:13:46	CLAM-CLAM_JC1.CLAM	winch
29	17:33:09	77	18:08:17	EA600-EA600_JC1.EA600	ea600m
29	17:33:08	79	18:01:06	EMLog-log_chf_JC1.EMLog	log_chf
29	17:33:16	79	18:01:06	GPPAT-GPPAT_JC1.GPPAT	adu5pat
29	17:33:19	77	18:06:45	Light-JC-SM_JC1.SURFMETv2	surflight
29	17:33:19	77	18:06:45	MET-JC-SM_JC1.SURFMETv2	surfmet
29	17:33:13	79	18:01:06	PASHRPOS-ADUPOS_JC1.PASHR	adupos
29	17:33:14	77	18:16:18	SBE45-SBE45_JC1.TSG	SBE45
29	17:33:19	77	18:06:45	Surf-JC-SM_JC1.SURFMETv2	surftsg
29	17:33:08	79	18:01:06	VDVHW-log_skip_JC1.Log	log_skip
29	17:33:24	79	18:01:06	cnav-CNAV.GPS	cnav
29	17:33:21	79	18:01:06	gyro-GYRO1_JC1.gyr	gyropmv
29	17:33:16	79	18:01:06	gyro-SGYRO_JC1.gyr	gyros_s
29	17:33:06	79	18:01:06	position-Applanix_GPS_JC1.gps	posmvpos
29	17:33:11	79	18:01:06	position-DPS-116_JC1.gps	dps116
29	17:33:21	79	18:01:06	position-Seapath200_JC1.gps	seapos
35	11:42:54	35	14:04:42	position-usbl_JC1.gps	usbpos
29	17:33:06	79	18:01:06	satelliteinfo-Applanix_GPS_JC1.gps	satinfoposmv
29	17:33:24	79	18:01:06	satelliteinfo-CNAV.gps	satinfocnav
29	17:33:11	79	18:01:06	satelliteinfo-DPS-116_JC1.gps	satinfodps
29	17:33:21	79	18:01:06	satelliteinfo-Seapath200_JC1.gps	satinfosea
35	11:42:54	35	14:04:42	satelliteinfo-usbl_JC1.gps	satinfousb
33	16:59:41	77	17:57:49	sb_depth-EM120_JC1.depth	em120
29	17:33:10	79	18:01:06	shipattitude-Aplanix_TSS_JC1.att	posmvtss
29	17:33:18	79	18:01:06	shipattitude-Seapath200AT_JC1.att	attsea
29	17:33:10	79	18:01:06	shipattitude_aux-Aplanix_TSS_JC1.att	attposmv
29	17:33:18	79	18:01:06	shipattitude_aux-Seapath200AT_JC1.att	attseaaux

The mexec short names can be used in mexec to access the TECHSAS streams. The pairings are resolved by script *mtnames*.

Underway navigation was kept running until the end of the cruise. All scientific systems were switched off between 77/1800 and 77/1810, before leaving the Chilean 200 mile zone and entering that of Argentina.

The processing of the main data streams is reported in the relevant sections of underway and CTD data. A directory 'pickup' was created as a useful place for users to collect data that was required for processing elsewhere. eg CTD and VMADCP

data for LADCP processing on a mac laptop; a mat file with appended CTD bottle and tracer data; CTD and VMADCP data for comparison with microstructure; a zipped summary of CTD and tracer data made hourly for easy copying to AJW's laptop.

As usual, a single daily script was run (*m_jc069_daily_processing.m*)to ingest the data for most of the streams processed in daily files: eg navigation, meteorology; ea600 and em120data were handled outside this script because of the extensive manual editing required. These 'daily' datsets can be found in finished appended files, one of the whole cruise, with extension _01, instead of the _dnnn of daily files.

The following files or directories were provided to the Chilean observer, and can be found conveniently collected in directory data/for_observer

README
bst_jc069_01.nc
chf_jc069_01_cal_av.nc
em120_jc069_01.nc
met_jc069_trueav.nc
met_light_jc069_01.nc
met_tsg_jc069_01_medav_clean_cal.nc
os150_jc069nnx_01.nc
os75_jc069nnx_01.nc
sim_jc069_01_nav_cordep.nc
dimes_uk3_ctd_data_for_argo_qc.zip
sam_jc069_all.nc
ladcp

The README file describes the contents of each file. The CTD data were exported to CCHDO format and zipped into one file. 'ladcp' is a directory of mat files. 'sam_jc069_all' is an appended set of bottle samples, including all the tracer data.

Backing up: Four external usb drives were available for backups. jc069_01 to jc069_04, each of capacity 350 Gb. These were mounted 2 at a time, at /mnt/usb_1 and /mnt/usb_2. A crontab entry, adapted from one left in place from jc069 by A Forryan, ran at 0030 each day and backed up cruise/data and cruise/software using rsync -a in the usual scripts, to alternating disks. Because of the way the disks were mounted, the script could not know in advance which disk was mounted on which mount point. Therefore the scripts, one of reach disk were adapted to search for a file 'this_is_jc069_X' and backup to that disk. The disks were rotated through the cruise. As they became full, earlier backups were deleted. By the end of the cruise, a complete backup was 43 Gb. The required entry in crontab was saved in 'exec/crontab_contents_jc069'. crontab jobs are simply scheduled using 'crontab –e' to edit the crontab file. Or 'crontab –l' to list the present jobs. Crontab was used to create the hourly ctd zip for AJW. Four archives were made onto 350Gb usb external hard drives; one went to UEA with A Watson, the others were taken to NOCS. All were checked as readable in B King's mac laptop. Curious faults occurred on jc069_1 and jc069_2. While jc069_2 was plugged into the Mac, an error appeared saying the disk was now read-only and should be reformatted and rewritten. This was done and at the time of typing, jc069_2 is now working normally. Later a similar error occurred on jc069_1. The data seem to be readable, but they were not read off, reformatted and rewritten. Therefore jc069_1 should be considered as a slightly suspect archive. The 4 drives were archived in separate backup jobs, so each has a different time. However, no changes were made on nosea1 between the archives. The times of 'final' archive

files is as follows:

jc069_1: 201203220930xx
jc069_2: 201203221112xx   (also contains an archive of jc068).
jc069_3: 201203221030xx
jc069_4: 201203220230xx

A number of earlier archives from the last few days of the cruise are scattered around the four archive disks.

Accessing raw data acquired outside TECHSAS: Raw CTD and VMADCP data were accessed from the networked ship disks by mounting /mnt/cookfs.

Printing: The cups interface was configured using firefox to set up the main lab laser printer as the default printer (so that lpr, lpq worked without specifying a printer). However, the cupsd server hung or died many times per day. The solution was to log on as root, kill a hung cupsd process if necessary and restart it by typing 'cupsd'.

To configure cupsd in firefox:

http://localhost:632

add printer, device URI:

lpd://192.168.62.53

There was no specific driver available for the HP2605, so instead we chose 'CUPS generic 6'

and then set the page size to A4.

7 ANNEXES

7.1 Incident report High-Resolution Profiler-ii instrument letter
John M. Toole

Incident Report

February 13, 2012
Research Vessel James Cook
Loss of the High-Resolution
Profiler-ii
Cruise JC069 South
Atlantic/Southern Ocean

Instrument Description

The High-Resolution Profiler-ii instrument (HRP) is a cylindrical, ~4-m-long, free-fall (untethered) system designed to sample the vertical variations of the ocean's temperature, salinity and velocity on scales ranging from thousands of meters to approximately 1 cm. It was designed, constructed and assembled at the Woods Hole Oceanographic Institution incorporating sensor subsystems purchased from several commercial companies. Operationally, expendable ballast weights are loaded into the instrument, the microprocessor onboard the HRP is programmed prior to each deployment with the parameters governing the details of the upcoming dive, the main operations program is started, and the device is deployed in the ocean using a custom-built hydraulic lifting rig. With ballast weight installed, the instrument is heavy in water and sinks (in a vertical orientation) at approximately 40 m/min. At the end of the down-going profile, the HRP releases the ballast weights and the instrument rises to the surface at approximately 70 m/min due to its now positive buoyancy. (Release

of one weight is sufficient to surface the HRP, albeit at about half the rise rate.) Ballast release is activated based on a user-programmed release pressure, elapsed time of deployment, or height above bottom (the latter determined by an acoustic altimeter). The weights are held in place by corrodible links that can also cause weight release after sufficient time in sea water (approximately 1 hour). Once at the surface, the top end of the instrument (recovery bail, top end cap) sticks out of the water by about 50 cm. Wave action causes the HRP to pogo at the surface, alternately dipping just below surface and emerging ~1 m with each passing wave. Recovery involves maneuvering the support vessel alongside the HRP, attaching tag lines from the main deck, then hoisting aboard with the lifting rig.

The HRP is equipped with an acoustic pinger, an altimeter, strobe light and radio beacon to monitor each dive and locate the instrument after surfacing[1]. The 12-kHz pinger may be acoustically tracked from the support vessel using standard acoustic release deck equipment and/or the vessel's acoustic echosounding system. The ping rate on descent is 1/minute. A series of 10 pings at 1-s interval are broadcast when the weight releases are activated, whereupon the ping rate for the ascent shifts to 1/15 s. Upon surfacing, the acoustic transducer of the pinger (mounted at the top of the HRP) emerges into air and so can no longer be tracked. At the surface, a radio beacon (operating at VHF channel 19) and strobe light are activated. These are self-contained units with their own battery power. They are switched on before deployment and confirmed to be working before launch. Below the surface, a pressure switch disables these units, saving power until they return to the surface. The radio beacon signal is received aboard the support vessel using a radio receiver mated to a Radio Direction Finder (RDF) that provides bearing to the surfaced instrument. A flag (attached to the top lifting bail of the HRP) and the strobe light aid visual location. This suite of tracking/location components was used successfully on the original High Resolution Profiler (built at WHOI in the mid-1980s) for over 1000 deployments and recoveries. HRP-ii was built as a modern replacement in the first decade of this century and used successfully on two prior major research cruises and at least 3 test cruises together totaling over 100 dives.

1) The HRP radio beacon used on the HRP is the Novatech Model RF700AR; the Novatech Xenon Flasher is model ST400AR. The Novatech product line was acquired by Seimac with Cobham Tracking & Locating, Ltd as serving as distributor. Approximately 1.5 years ago, Cobham sold the Novatech line to MetOcean Data Systems, Ltd. The product manuals for these units cite a battery life of 60 hours in continuous operation for the strobe and 10 days for the radio beacon (at 4°C).

February 9-10 incident
The HRP was being operated from the *Research Vessel James Cook* in support of the joint U.S.-U.K. Diapycnal and Isopycnal Mixing Experiment in the Southern Ocean (DIMES). The HRP deployment apparatus was installed at the starboard rail of the *Cook* (aft of the ship CTD deployment area) with carriage track running into the aft hanger (allowing instrument support activities to occur in a sheltered space). New batteries were installed in both the radio transmitter and strobe light. The cruise was staged out of Montevideo, Uruguay and departed for sea on January 31. A test dive of the HRP to 1000 m was carried out on February 3 without incident. Scientific sampling on the cruise began with a series of stations along the Scotia Ridge between the Falkland Islands and South Georgia Island. HRP dives were done successfully on

February 7 and 8. All systems on the HRP were working normally on these dives, including those associated with deployment/recovery operations: pinger, pressure sensor, altimeter, weight releases, radio beacon and strobe light. Notably, the acoustic altimeter located the bottom on both dives 2 and 3 and initiated the weight release. After these three deployments, the total time accrued on the radio beacon and strobe light batteries is estimated to be less than 5 hours.

On the morning of February 9, the HRP watch consisting of John Toole (WHOI), Ken Decoteau (WHOI) and Luc Rainville (UW/APL) prepared the HRP for deployment at station #4 at 53° 23.37 S, 49° 37.32 W. This took place during ship CTD station #12. Winds were out of the west-northwest at approximately 30 knots with significant seas, swell and white capping but with some moderation forecast for the next few hours. The ship's echosounders indicated the ocean depth was 1015 m (corrected; corresponding derived pressure at the bottom was 1027 dbar). The HRP was programmed to drop weights at a pressure of 975 dbars. The on-board altimeter was programmed to turn on at a pressure of 725 dbars and to release the weights at a height-above-bottom of 50 m. The down-profile time limit was set to 40 minutes. The HRP battery pack voltage was recorded at 27.5 V prior to deployment, easily sufficient for a 1000 m dive.   The on-deck pressure sensor bias was logged at -2.07 dbar.

Following procedures that were successfully demonstrated on HRP dive #2, the Profiler was deployed while the ship CTD was at 500 m depth during haul back. The HRP sensor guards were removed and the light and radio beacon were turned on and verified to be working. Specifically, the pinger was confirmed (by ear) to be pinging at the once per minute rate, the strobe light was flashing once per second, and the radio beacon was transmitting its expected 4-s on, 4-s off signal. (The radio signal was heard both by the receiver/RDF unit installed above the ship's bridge deck and by hand-held radio on deck.) The HRP operations program was initiated with the vehicle in the ship's hanger, and after removing the umbilical cable and fixing the cable plugs, the HRP was rolled in its deployment carriage to the rail. As has been done previously, the HRP on the cradle was raised to ~45-degree angle for ~ 5 minutes to try and facilitate signal lock-on of its on-board GPS receiver, and then at 8:31:30 GMT after receiving permission from the officer on watch, the instrument was lifted to vertical position and lowered into the sea. It quickly sank out of view.

During the descent of the HRP, the once-per-minute acoustic pings were monitored an IXEA TT801 acoustic receiver provided by our U.K. colleagues (same unit used to track their free-fall vehicle). Visual trace of the descent was also documented on the video screen of the vessel-mounted Kongsberg EA600 echosounder in "pinger mode." At 8:54 GMT, the burst of 1-s pings indicating weight release were heard on the IXEA receiver and displayed on the echosounder screen, whereupon the acoustic receiver reported the expected 15-s ping interval of the HRP up profile. One minute later, the ship's CTD system was back on deck and the vessel was free to maneuver. Based on the ship-mounted Acoustic Doppler Current Profiler (ADCP) data that indicated the ocean current at the site was directed to the north-northeast at approximately 25 cm/s, the vessel was repositioned 500 m from the deployment site along course 070° with the expectation that the HRP would surface upwind of the *Cook* by a couple hundred meters.   Due either to the ship maneuvering or general

wave action, no graphical information about the HRP ascent was evident on the EA600 display.

Approximately 15 minutes after the acoustic indication of weight release (roughly 09:09 GMT), ping reception from the IXEA TT801 ceased. This was deemed normal, as this was the anticipated rise time of the HRP to the surface. However, no signal was received by the radio receiver/RDF. Nor was the HRP visually sighted. The ship held station at 53° 23.26 S, 48° 36.91 W for another 30 minutes to allow for the possibility that one of the ballast weights had failed to release and the ascent was slowed, but still no radio signal was heard. Several hands went to the bridge deck to look for the HRP, but they were not successful. Using a handheld VHF radio, normal functionality of the receiver/RDF on the ship was confirmed. No additional acoustic pings were received either. By 1000 GMT it was concluded that the HRP radio may have failed and so after consultation with *Research Vessel Cook's* captain, a visual search grid was initiated sampling north and east of the launch position (as suggested by the ADCP ocean velocity estimates and wind direction. Wind speeds had dropped by this time to 20-25 knots, although seas remained high with many whitecaps. With multiple hands on the bridge scanning all sides, the search continued for several hours but the HRP was not sighted. At 1500 GMT, the cruise chief scientist, Dr. Andrew Watson, recommended that we temporarily suspend the search grid, that we deploy a surface drifter at the launch site, and return after dark in the hope that the strobe light on the HRP could be sighted. The specification for the endurance of the strobe light indicated that it would still be operational through the night. (The surface drifter was aboard for a planned deployment later in the cruise for a shoreside ancillary investigator.) Two surface drifters were deployed at 1511 GMT at 53° 25.37 S, 49° 37.34 W and at 1529 at 53° 25.37 S, 49° 34.39 W respectively.

At 0002 GMT on February 10, the *Research Vessel Cook* returned to the HRP deployment site and began a second visual search grid. Winds had picked up to 30-35 knots from the northwest by this time, with the accompanying waves restricting visibility. Drifter tracks received via satellite and emailed to Dr. Watson guided the search pattern (again to the northeast of the drop site, with the pattern again devised after consultation with the Captain). The ship steamed away from the HRP deployment site on headings between 077° and 060° to a distance of 34 km (dictated by the surface drifter speeds and time since the HRP was launched) with multiple hands on the bridge looking in all directions. At the 34 km range, a search pattern was initiated at right angles to the outbound track. No strobe light was seen. At 0522 GMT on February 10 in increasing daylight, Toole ended the search operations and concluded that HRPii was missing and presumed lost. *Research Vessel Cook* was directed to the next station in the cruise sampling plan and the bridge watchers were dismissed. Up to the point that no radio beacon signal was heard from the HRP at the expected surfacing time, there was no indication that the deployment was anything but routine.

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Postscript: The morning of February 12 dawned clear with little wind or wave (only residual swell). Chief Scientist Watson granted permission for one more search, again guided by the drifters deployed previously. On the way to the search area, fog closed in and by completion of the first leg of the search pattern, visibility dropped to around 100 m. Sighting the HRP in those conditions was deemed highly unlikely, so this third search attempt was abandoned.

7.2 Events log

Time UTC	Day No.	Lat	Lon		CTD/VMP No.	Event
12:00	34	-48.6565	-54.3234		station test	Arrival at test station
12:30	34	-48.6537	-54.3236			HRP deployment delayed due to power supply failure
12:40	34	-48.6521	-54.3236		HRP test	HRP in water (flotation test)
12:44	34	-48.6513	-54.3237			HRP on board (flotation test successful)
13:03	34	-48.6499	-54.3237		HRP 001	HRP in water (1000 m untethered test dive)
13:45	34	-48.6472	-54.3237		HRP 001	HRP on surface
14:01	34	-48.6461	-54.3238		HRP 001	HRP on deck
14:25	34	-48.6424	-54.3209		VMP NOCS test	tethered test of vmp
15:15	34	-48.7743	-54.3391		VMP NOCS test	VMP on deck
15:30	34	-48.817	-54.3477		VMP WHOI test	float test DMP
15:50	34	-48.8743	-54.3631		VMP WHOI 001	deploy DMP
16:35	34	-48.9982	-54.4048		VMP WHOI 001	DMP at surface - under ship!
17:08	34	-49.0856	-54.4346		CTD 001	In water
19:18	34	-49.4263	-54.5176		CTD 001	out water
11:40	35	-52.0208	-55.1732		CTD 002	In water
00:00	35				CTD 002	On deck
						Steaming to North Scotia Ridge Line
03:10	37	-54.1822	-54.8388		CTD 003	in water seastate marginal
04:14	37	-54.1828	-54.8384		CTD 003	On deck
05:21	37	-54.1828	-54.8383		CTD 004	In water
07:37	37	-54.1828	-54.8383		CTD 004	On deck
09:00	37	-54.1828	-54.8383		CTD 005	In water
12:21	37	-54.1841	-54.8496		CTD 005	On deck
14:40	37	-54.1364	-54.6216		CTD 006	In water
17:26	37	-54.1005	-54.4277	6	CTD 006	On deck: wires tangled. Plan to wait at next station until fixed
						Weather delay and working on

						parallellogram
10:10	38	-53.7729	-52.2965	7	CTD 007	In water
13:09 :00	38	-53.6239	-51.4402	7	CTD 007	On deck. Slight problem with wire but ok
16:25	38	-53.4594	-50.5423	8	HRP 002	In water (station at different location to cruise plan, as ship had to stop briefly anyhow)
17:46	38	-53.3412	-50.2034	8	HRP 002	HRP out water
18:00	38	-53.3213	-50.1496	8	CTD 008	In water
20:27	38	-53.1076	-49.8136	8	CTD 008	On deck
00:04	39	-53.3798	-50.0899	9	CTD 009	CTD in water
01:25	39	-53.3842	-50.0902	9	HRP 003	In water (deployed as CTD coming up) ~
01:46	39	-53.3849	-50.0903	9	CTD 009	CTD on deck
02:43	39	-53.3851	-50.0877	9	HRP 003	Recovered
04:07	39	-53.3807	-50.0568	10	NOCS VMP 010	VMP in water (no CTD)
05:38	39	-53.3907	-49.6395	10	NOCS VMP 010	VMP on deck
						NO CTD 010 (left blank as may be filled in with VMP ts data)
						Down time due to bad weather
23:30	39	-53.3872	-49.5608	11	CTD 011	CTD in water
01:31	40	-53.2845	-49.2728	11	CTD 011	Out water
02:24	40	-53.2002	-49.1492		NOCS VMP 011	In water
03:52	40	-53.2458	-48.9979		NOCS VMP 011	On deck
06:49	40	-53.0637	-49.1791	12	CTD 012	In water
08:32	40	-53.2244	-49.2389		HRP 004	Deployed as CTD coming up
08:54	40	-53.2741	-49.2354	12	CTD 012	On deck
					HRP 004	Has not re-surfed/no communication. Spent time searching, deployed two drifters to track. Plan too look again later when dark.
15:11	40	-53.3399	-49.0701		AARDVARK 001	Released: id 012890
15:29	40	-53.3363	-49.0671		AARDVARK 002	Released:id 017890
16:07	40	-53.3294	-49.0602	13	CTD 013	In water
18:11	40	-53.3242	-49.0565	13	CTD 013	On deck (no VMP due to too high winds)
19:21	40	-53.3338	-49.1014	14	CTD 014	In water
22:30	40	-53.38	-49.2663	14	CTD 014	On deck
	40	-53.3866	-49.6269			Steaming back to station 12 to look for HRP
	40	-53.3866	-49.6269			Spent night looking for HRP - no luck!
07:22	41	-53.2991	-48.9286			Search for HRP called off

10:24	41	-53.2918	-48.9166	15	CTD 015	In water
14:33	41	-53.0028	-48.8548	15	CTD 015	On deck
15:30	41	-52.9005	-49.047	15	NOCS VMP 015	Deployed
18:30	41	-52.595	-49.4015	15	NOCS VMP 015	VMP 015 spotted
18:50	41	-52.6057	-49.3486		NOCS VMP 015	VMP 015 on deck
						Load test on CTD wire while VMP in water
22:49	41	-52.5932	-49.3663	15	CTD 016	In water (delay in deploying due to wire problems)
01:55	42	-52.5673	-49.4104	15	CTD 016	On deck
02:44	42	-52.5635	-49.4174		NOCS VMP 016	Deployed
05:45	42	-52.6076	-48.7287		NOCS VMP 016	VMP on deck
09:30	42	-52.5857	-48.7253		NOCS VMP 017	VMP released (no CTD - winch problems)
12:50	42	-52.6038	-48.1026		NOCS VMP 017	VMP on deck
						Steam northwards to look for missing HRP while fixing CTD winch
						Delay in science due to CTD winch problems
23:13	42	-53.1437	-48.7414		CTD 018	In water
02:24	43	-52.9981	-48.8971		CTD 018	On deck
05:55	43	-52.8377	-49.1423		CTD 019	In water
09:26	43	-52.7634	-49.5508		CTD 019	On deck
10:22	43	-52.7657	-49.6764			Attempt at VMP deployment. Did not happen.
13:04	43	-52.8932	-48.965		CTD 020	In water
16:04	43	-53.0731	-48.4838		CTD 020	On deck
						time out due to bad weather
18:55	44	-53.177	-48.7274		VMP-WHOI	Float test - ok
19:23	44	-53.1625	-48.5835		CTD 021	In water
22:38	44	-53.1234	-48.2264		CTD 021	On deck
23:53	44	-53.0895	-48.1566		CTD 022	In water
03:43					CTD 022	On deck
05:39	45	-52.927	-47.7529		CTD 023	In water
09:06	45	-52.914	-47.7618		CTD 023	On deck
09:18	45	-52.9136	-47.7615		NOCS VMP 023	In water
12:33	45	-53.0267	-48.0105		NOCS VMP 023	On deck
15:37	45	-53.0179	-48.0345		NOCS VMP 024	In water
15:51	45	-53.0199	-48.0457		CTD 024	In water

18:02	45	-53.0148	-47.4955		CTD 024	On deck
18:37	45	-53.0069	-47.4369		VMP 024	On deck
21:00	45	-53.0025	-47.4429		CTD 025	In water
23:22	45	-53.0119	-47.4478		CTD 025	On deck
00:38	46	-53.0169	-47.4591		CTD 026	In water
03:14	46	-53.0938	-47.0809		CTD 026	On deck
05:16	46	-53.0913	-47.0785		CTD 027	In water
07:48	46	-53.2444	-47.2976		CTD 027	On deck
08:00	46	-53.2672	-47.3331		NOCS VMP 027	Deployed
10:56	46	-53.584	-47.8404		NOCS VMP 027	On deck
13:00	46	-53.8	-48.1967		NOCS VMP 028	In water
16:09	46	-53.9958	-48.5486		NOCS VMP 028	On deck (no CTD)
18:51	46	-53.9815	-48.5879		NOCS VMP 029	In water
21:06	46	-53.9814	-48.8561		NOCS VMP 029	On deck
21:15	46	-53.9861	-48.8962		VMP-WHOI	In water - 500 m test profile
22:26	46	-54.0003	-49.1287		CTD 029	In water
00:44	47	-53.9855	-49.1528		CTD 029	On deck
02:50	47	-53.97	-49.177		CTD 030	start
04:09	47	-53.9821	-49.4752		CTD 030	end
04:15	47	-53.986	-49.5088		NOCS VMP 030	In water
06:14	47	-53.999	-50.1004		NOCS VMP 030	On deck
15:06	47	-53.2649	-52.6979		CTD 031	start down
16:32	47	-53.1276	-53.1337		WHOI VMP 002	In water
18:28	47	-52.943	-53.7217		CTD 031	On deck
20:06	47	-52.78	-54.184		WHOI VMP 002	On deck
22:50	47	-52.5264	-54.9984		NOCS VMP 032	In water
03:08	47	-53.9599	-49.194		NOCS VMP 032	On deck (no CTD)
05:08	47	-54.0002	-49.7442		APEX float	Deployed
						Steam to Falklands - medical issue
03:48	50	-53.9973	-49.1458		CTD 033	start down
05:59	50	-53.9855	-49.1508		CTD 033	end
20:01	50	-53.8297	-49.5482		CTD 034	In water
21:05	50	-53.7562	-49.5009		NOCS VMP 034	In water
22:19	50	-53.6615	-49.8851		CTD 034	On deck
23:25	50	-53.5713	-50.2422		NOCs VMP 034	On deck

04:24	51	-53.1751	-51.8385		CTD 035	start down
08:24	51	-52.8477	-53.0957		CTD 035	end
10:51	51	-52.6499	-53.8826		CTD 036	start down
12:33	51	-52.5101	-54.4152		NOCS VMP 036	VMP in water
14:20	51	-52.373	-54.9448		CTD 036	on deck
16:44	51	-52.1909	-55.653		NOCS VMP 036	VMP on deck
17:18	51	-52.1436	-55.8226		CTD 037	toyo 1 in water
17:51	51	-52.0981	-55.987		CTD 037	toyo 1 aborted
18:20	51	-52.0571	-56.1301		CTD 037	toyo 1 on deck
						Steam to Falklands - medical issue
09:03	55	-53.761	-49.4747		CTD 038	start down
10:58	55	-53.7509	-49.4842		CTD 038	on deck
08:51	56	-53.4961	-49.1591		CTD 039	start down
09:06	56	-53.4926	-49.1549		WHOI VMP 003	Deployed
12:12	56	-53.4503	-49.1057		CTD 039	On deck
12:24	56	-53.4475	-49.1024		WHOI VMP 003	On deck
						towyo 1
13:54	56	-53.4274	-49.0791		CTD 040	In water
15:21	56	-53.4036	-49.1113		CTD 040	At bottom
16:22	56	-53.422	-49.0817		CTD 040	At top
16:24	56	-53.4219	-49.0816		CTD 041	In water
17:17	56	-53.4121	-49.0696		CTD 041	At bottom
18:18	56	-53.3982	-49.0535		CTD 041	At top
18:20	56	-53.3977	-49.053		CTD 042	In water
19:30	56	-53.376	-49.0335		CTD 042	At bottom
20:41	56	-53.3559	-49.0177		CTD 042	At top
20:44	56	-53.3548	-49.0168		CTD 043	In water
21:59	56	-53.3328	-48.9994		CTD 043	At bottom
23:57	56	-53.2991	-48.9732		CTD 043	On deck
00:27	57	-53.2917	-48.9675		WHOI VMP 004	In water
02:58	57	-53.2794	-49.006		WHOI VMP 004	On deck
						TOWYO
04:12	57	-53.2697	-48.958		CTD 044	In water
05:39	57	-53.2446	-48.9385		CTD 044	At bottom
06:38	57	-53.2242	-48.9226		CTD 044	At top
06:40	57	-53.2234	-48.922		CTD 045	start down
07:52	57	-53.2025	-48.9057		CTD 045	At bottom
08:58	57	-53.1821	-48.8899		CTD 045	At top
09:01	57	-53.1812	-48.8891		CTD 046	start down
10:05	57	-53.1634	-48.8753		CTD 046	At bottom
11:06	57	-53.1453	-48.8612		CTD 046	At top
11:08	57	-53.1445	-48.8606		CTD 047	start down

12:15	57	-53.1261	-48.8463		CTD 047	At bottom
12:51	57	-53.117	-48.8393		NOCS VMP 047	In water
14:07	57	-53.1005	-48.8265		CTD 047	On deck
15:47	57	-53.098	-48.8354		NOCS VMP 047	On deck
						TOWYO
16:34	57	-53.0982	-48.8255		CTD 048	In water
17:39	57	-53.072	-48.8241		CTD 048	At bottom
18:32	57	-53.0571	-48.8241		CTD 048	At top
18:33	57	-53.0566	-48.8241		CDT 049	start down
19:28	57	-53.0366	-48.8241		CTD 049	At bottom
20:17	57	-53.0197	-48.8241		CTD 049	At top
20:19	57	-53.0191	-48.8242		CTD 050	start down
21:08	57	-53.0032	-48.8242		CTD 050	At bottom
21:55	57	-52.9838	-48.8243		CTD 050	At top
21:58	57	-52.9824	-48.8243		CTD 051	start down
22:51	57	-52.9678	-48.8243		CTD 051	at bottom
23:33	57	-52.9509	-48.8243		NOCS VMP 051	deployed
00:35	58	-52.9296	-48.8243		CTD 051	on deck
02:41	58	-52.9341	-48.839		NOCS VMP 051	on deck
						TOWYO
03:21	58	-52.9076	-48.8241		CTD 052	In water
04:35	58	-52.9008	-48.8241		CTD 052	At bottom
05:49	58	-52.87	-48.8241		CTD 052	At top
05:51	58	-52.8693	-48.8241		CTD 053	start down
07:01	58	-52.8497	-48.824		CTD 053	At bottom
08:04	58	-52.8235	-48.824		CTD 053	At top
08:07	58	-52.8225	-48.824		CTD 054	start down
09:15	58	-52.8021	-48.824		CTD 054	At bottom
10:20	58	-52.7751	-48.824		CTD 054	At top
10:23	58	-52.774	-48.824		CTD 055	start down
11:29	58	-52.7561	-48.824		CTD 055	at bottom
12:11	58	-52.7443	-48.824		WHOI VMP 006	in water
14:01	58	-52.7612	-48.8438		CTD 055	On deck
14:24	58	-52.7615	-48.8439		WHOI VMP 006	On deck
						TOWYO
16:23	58	-52.7616	-48.8473		CTD 056	In water
17:37	58	-52.7644	-48.8631		CTD 056	At bottom
18:40	58	-52.7827	-49.1811		CTD 056	At top
18:44	58	-52.7833	-49.2021		CTD 057	start down
19:46	58	-52.7924	-49.5196		CTD 057	At bottom
20:44	58	-52.8011	-49.6013		CTD 057	At top
20:47	58	-52.8003	-49.6016		CTD 058	start down

21:52	58	-52.7818	-49.61		CTD 058	At bottom
22:48	58	-52.7672	-49.6171		CTD 058	At top
22:52	58	-52.7662	-49.6176		CTD 059	start down
23:58	58	-52.752	-49.6241		CTD 059	at bottom
00:15	59	-52.7504	-49.6258		WHOI VMP 007	in water
01:55	59	-52.8936	-49.7165		CTD 055	On deck
02:21	59	-52.9565	-49.7459		WHOI VMP 007	On deck
						TOWYO
04:14	59	-53.0782	-49.8013		CTD 060	In water
05:45	59	-53.0713	-49.8048		CTD 060	At bottom
06:42	59	-53.0579	-49.8153		CTD 060	At top
06:46	59	-53.0565	-49.8177		CTD 061	start down
08:00	59	-53.0668	-49.5589		CTD 061	At bottom
09:00	59	-53.0869	-49.2914		CTD 061	At top
09:01	59	-53.0871	-49.287		CTD 062	start down
10:18	59	-53.0958	-48.9414		CTD 062	at bottom
11:18	59	-53.0966	-48.6585		NOCS VMP 062	Deployed
12:24	59	-53.1008	-48.3443		CTD 062	On deck
14:56	59	-53.1119	-47.6024		NOCS VMP 062	On deck
20:27	59	-53.126	-46.5253		CTD 063	In water
21:28	59	-53.1451	-46.2952		NOCS VMP 063	In water
22:59	59	-53.1739	-45.9138		CTD 063	On deck
00:40	60	-53.1773	-45.9271		NOCS VMP 063	On deck
03:27	60	-53.1988	-45.5883		CTD 064	In water
04:12	60	-53.1996	-45.5946		NOCS VMP 064	In water
05:33	60	-53.1937	-45.5966		CTD 064	On deck
06:48	60	-53.2175	-45.3803		NOCS VMP 064	Ondeck
18:42	60	-53.2531	-44.391		CTD 065	in water
19:24	60	-53.2283	-44.2426		WHOI VMP 008	In water
20:16	60	-53.2283	-44.2426		CTD 065	on deck
20:23	60	-53.2284	-44.2426		WHOI VMP 008	On deck
22:56	60	-53.3139	-44.5769		CTD 066	in water
23:43	60	-53.3654	-44.7797		WHOI VMP 009	In water
00:46	61	-53.4334	-45.0492		CTD 066	on deck
00:48	61	-53.4356	-45.0577		WHOI VMP 009	On decl
02:44	61	-53.556	-45.551		CTD 067	In water

03:44	61	-53.6225	-45.8064		NOCS VMP 067	IN water
04:32	61	-53.675	-46.0088		CTD 067	On deck
05:34	61	-53.7358	-46.2765		NOCS VMP 067	On deck
08:35	61	-53.9415	-47.104		CTD 068	In water
09:09	61	-53.9797	-47.2553		NOCS VMP 068	In water
10:21	61	-54.0532	-47.5773		CTD 068	On deck
11:04	61	-54.1011	-47.7674		NOCS VMP 068	on deck
12:36	61	-54.2037	-48.1738		CTD 069	In water
13:16	61	-54.2493	-48.345		NOCS VMP 069	in water
14:45	61	-54.3397	-48.7242		CTD 069	on deck
15:11	61	-54.3678	-48.8367		NOCS VMP 069	on deck
16:35	61	-54.4501	-49.1937		CTD 070	In water
17:14	61	-54.4885	-49.3514		WHOI VMP 012	In water
17:58	61	-54.5325	-49.5261		CTD 070	On deck
18:05	61	-54.5399	-49.5539		WHOI VMP 012	On deck
19:32	61	-54.629	-49.9067		CTD 071	In water
20:33	61	-54.6887	-50.1684		CTd 071	On deck
20:40	61	-54.6955	-50.1989		WHOI VMP 013	IN water
21:08	61	-54.7223	-50.3252		WHOI VMP 013	On deck
						Steaming to SR1
22:58	62	-53.6343	-56.175		1 aardvark deployed	
23:37	62	-53.6292	-56.1799		1 aardvark deployed	
23:45	62	-53.6279	-56.1811		4 aardvark deployed	
23:48	62	-53.6273	-56.1817		1 aardvark deployed	
00:31	63	-53.6193	-56.1906		1 aardvark deployed	
05:10	63	-53.7597	-56.3151		SOLO deployed	
21:31	63	-54.3743	-56.4194		CTD 072	in water. too foggy for vmp deployment
00:35	64	-54.8523	-56.8073		CTD 072	on deck
	64	-54.7638	-56.734			problem with ctd winch scrolling - realing out the weight to fix
04:00	64	-55.3382	-57.2271		CTD 073	in water
06:02	64	-55.6355	-57.4452		CTD 073	on deck
08:37	64	-55.9592	-57.7541		CTD 074	in water

11:12	64	-55.9945	-57.6272		CTD 074	on deck
12:41	64	-56.0366	-57.6624		CTD 075	in water
15:20	64	-56.0887	-57.663		CTD 075	on deck
09:03	65	-56.0059	-57.8142		NE morring	released
10:16	65	-56.0242	-57.8142		NE mooring	recovery started
12:01	65	-56.0605	-57.7952		NE mooring	recovery ended
13:10	65	-56.0001	-57.8723		SE mooring	released
13:30	65	-55.9599	-57.8987		SE moorin	recovery started
15:10	65	-55.9831	-57.8958		SE mooring	recovery ended
16:20	65	-56.016	-57.8777		SW mooring	released
16:43	65	-56.0564	-57.7925		SW mooring	recovery started
18:06	65	-56.0907	-57.7353		SW mooring	recovery ended
19:06	65	-56.0959	-57.7327		M mooring	released
19:30	65	-56.0972	-57.7319		M mooring	recovery started
21:36	65	-56.1027	-57.7287		M mooring	recovery ended
22:55	65	-56.0972	-57.7337		WHOI VMP 14	in water
02:10	66	-55.6939	-57.822		WHOI VMP 14	On deck
						TOWYO (GRID)
02:32	66	-55.6353	-57.8376		CTD 076	In water
03:53	66	-55.4259	-57.8825		CTD 076	At bottom
04:27	66	-55.3309	-57.9067		CTD 076	At top
04:29	66	-55.3253	-57.9079		CTD 077	start down
05:00	66	-55.2394	-57.9231		CTD 077	At bottom
05:32	66	-55.1469	-57.9308		CTD 077	At top
05:34	66	-55.1426	-57.9312		CTD 078	start down
06:07	66	-55.0806	-57.9477		CTD 078	at bottom
07:55	66	-55.0807	-57.9476		CTD 078	on deck
09:30	66	-55.1108	-57.9415		C mooring	released
09:58	66	-55.1398	-57.948		C mooring	recovery started
12:12	66	-55.14	-57.9496		C mooring	recovery ended
14:13	66	-55.2102	-57.9494		NW mooring	released
14:41	66	-55.2101	-57.9496		NW mooring	recovery started
16:13	66	-55.2076	-57.9593		NW mooring	recovery ended
17:15	66	-55.2058	-57.9669		CTD 079	In water
19:34	66	-55.2524	-57.9572		WHOI VMP 016	In water
21:16	66	-55.5194	-57.9475		CTD 079	On deck
22:24	66	-55.5248	-57.9222		WHOI VMP 016	on deck
21:20	66	-55.5194	-57.9474		CTD 079	surfaced
06:12	67	-55.8407	-57.795		CTD 080	in water
06:52	67	-55.8419	-57.7918		NOCS VMP 080	In water
08:12	67	-55.8445	-57.7854		CTD 080	on deck
09:09	67	-55.8448	-57.7816		NICS VMP 080	On deck

09:57	67	-55.8435	-57.7648		CTD 081	in water
10:21	67	-55.8434	-57.7642		NOCS VMP 081	In water
12:27	67	-55.8441	-57.7481		CTD 081	on deck
13:08	67	-55.8451	-57.7443		NOCS VMP 081	on deck
14:21	67	-55.944	-57.6997		CTD 082	In water
15:11	67	-56.0679	-57.6417		NOCS VMP 082	In water
17:19	67	-56.1546	-57.599		CTD 082	On deck
18:50	67	-56.1556	-57.582		NOCS VMP 082	On deck
21:25	67	-56.2568	-57.5179		CTD 083	in water
23:06	67	-56.4667	-57.4252		WHOI VMP 018	In water
00:57	68	-56.4699	-57.4344		CTD 083	on deck
02:35	68	-56.4767	-57.4446		WHOI VMP 018	On deck
04:53	68	-56.6024	-57.3209		CTD 084	In water
05:20	68	-56.671	-57.2765		NOCS VMP 084	In water
08:17	68	-56.7863	-57.194		ctd 084	On deck
09:56	68	-56.7856	-57.1693		NOCS VMP 084	On deck
10:21	68	-56.7857	-57.1675		wire stream after station 84	end
16:04	68	-57.0948	-57.0249		CTD 085	In water
17:10	68	-57.0954	-57.0122		NOCS VMP 085	In water
18:54	68	-57.0941	-56.9893		CTD 085	On deck
20:40	68	-57.0922	-56.9692		NOCS VMP 085	On deck
22:58	68	-57.2854	-56.8489		CTD 086	In water
00:34	69	-57.4162	-56.8269		WHOI VMP 19	in water
02:52	69	-57.4307	-56.7966		CTD 086	On deck
03:14	69	-57.432	-56.7906		WHOI VMP 19	on deck
03:36	69	-57.4321	-56.7849		solo deployed	solo #2; 1113/104043
06:24	69	-57.6586	-56.6348		CTD 087	In water
08:01	69	-57.7334	-56.6364		NOCS VMP 087	In water
09:12	69	-57.7333	-56.636		CTD 087	On deck
13:04	69	-57.7331	-56.6358		NOCS VMP 087	On deck: VMP lost for 2 hrs as batteries failed in Ixe pinger
15:35	69	-57.733	-56.6356		CTD 088	In water
17:23	69	-57.733	-56.6359		NOCS VMP 088	In water

18:34	69	-57.7331	-56.6357		CTD 088	On deck
21:17	69	-57.733	-56.6357		NOCS VMP 088	On deck
00:04	70	-57.7373	-56.6449		CTD 089	in water
01:06	70	-57.7427	-56.6519		WHOI VMP 20	In water
03:26	70	-57.7464	-56.6711		CTD 089	On deck
03:32	70	-57.7461	-56.6715		WHOI VMP 20	On deck
07:00	70	-58.0485	-56.4398		CTD 090	In water
						Down time after stn 89 due to weather; Stn 90 blank as ctd went in water for 10 mins
22:54	70	-58.5196	-56.191		CTD 091	NOCs VMP 91 in water
00:57	71	-58.4647	-56.7978		NOCS VMP 091	In water
03:01	71	-58.4078	-57.4262		CTD 091	On deck
04:29	71	-58.3668	-57.8954		NOCS VMP 091	On deck
07:24	71	-58.2859	-58.8003		CTD 092	In water
08:27	71	-58.2501	-59.056		NOCS VMP 091	In water
10:50	71	-58.1912	-59.7827		CTd 092	On deck
12:32	71	-58.1522	-60.3224		NOCS VMP 091	On deck
12:40	71	-58.1488	-60.3776		solo deployed	solo #3; 1114/104044
15:12	71	-58.0695	-61.2748		CTD 093	In water
17:05	71	-58.0167	-61.8491		WHOI VMP 21	In water
19:15	71	-58.0405	-61.8451		CTD 093	on deck
19:41	71	-58.0786	-61.8921		WHOI VMP 21	On deck
21:03	71	-58.2409	-62.2095		CTD 094	In water (short station just below tracer depth, no vmp)
22:32	71	-58.3442	-62.4426		CTD 094	On deck
						end of SR1
08:00	72	-59.3432	-64.6033		solo	solo #4; 1111/104041
						decided no time to recover sound source mooring 1
18:33	72	-60.3583	-65.9422		sound source mooring 2	recovery started
18:57	72	-60.4232	-65.9325		sound source mooring 2	recovery ended
19:25	72	-60.5012	-65.9234		SOLO float	
						steaming to mooring site 3
15:08	73	-61.0675	-67.3534		sound source mooring 3	recovery started

15:35	73	-60.9997	-67.4173		sound source mooring 3	recovery ended
15:36	73	-60.9972	-67.4198		SOLO float	
						Steam to Drake Passage line
03:21	74	-59.6498	-67.9993		CTD 095	In water
05:29	74	-59.3628	-67.9989		CTD 095	On deck
11:57	74	-58.8612	-67.9989		CTD 096	In water
14:17	74	-58.5443	-68.0002		CTD 096	On deck
14:28	74	-58.5207	-67.9991		solo float 5	
20:24	74	-58.3284	-67.989		CTD 097	In water
22:08	74	-58.3284	-67.989		CTD 097	On deck
22:22	74	-58.3284	-67.989		solo float 6	
06:19	75	-58.1117	-68.3715		CTD 098	In water
08:09	75	-58.0278	-68.5077		CTD 098	On deck
18:28	75	-58.3874	-67.6055		CTD 099	In water
18:46	75	-58.4172	-67.5409		CTD 099	attampet at ctd cast - brought in early due to weather (large swell)
	75	-58.3234	-67.9986			weather down-time
00:25	77	-56.6878	-66.8188		CTD 100	in water (only 12 bottles to reduce weight)
03:06	77	-56.6878	-66.8188		CTD 100	On deck
14:11	77	-56.6878	-66.8188		SOLO float	
	77	-56.6878	-66.8188			Cruise ended early due to bad weather forcast

NERC Cruise Assessment/ Debrief Agenda Form

This form is an important tool in enabling NERC to monitor the performance of its marine facilities providers, as well as providing useful feedback for improving service provision. Consequently NERC requires all PS's who are programmed in its Marine Facilities Programme (including cruises on barter ships) to complete this form. Please see attached guidance notes for details on how this form should be completed and subsequently handled.

All forms are reviewed by NERC's Marine Facilities Review Group and therefore subsequently become part of the public record. Therefore, please do NOT make reference to individuals by name; any feedback on individuals (both positive and negative) should be sent direct to the head of the appropriate service (Please see guidance notes for contact details).

Ship :	R.R.S. James Cook	Cruise ID:	JC069	Dates:	31 January to 22 March 2012
PS name:	Andrew Watson Alberto Naveira-Garabato	Institute & position:	UEA, Prof U. Soton, Prof	Email:	a.watson@uea.ac.uk, acng@nocs.soton.ac.uk
Work type:	Physical / chemical oceanography		Area of operation:	Drake Passage, Scotia Sea	
Master:	Bill Robinson		Tech Liaison Officer:	Paul Provost	

Please tick the appropriate box and add comments if required

	Exceeded	Met	Below	Greatly Below	Comments Ship's comments in RED	Complaint filed (Y/N)	Internal Use Only: Logged
Supply Agreement Requirements							
Science Objectives Met		X			Tracer and microstructure survey of the Scotia Sea and Drake Passage: Partially met. Recovery of UK DIMES array moorings: fully completed. Recovery of Florida State University sound source moorings: three out of four recovered. Deployment of drifters and floats: fully completed. The reason for the incomplete science objectives was the loss of 8 days of working time due to two medical evacuations in quick succession. A subsidiary reason was the loss of three days science time at the end of the cruise due to bad weather. The original plan had sufficient contingency for bad weather, but this was more than used up by the medevacs. See comments below (AOB).		

Downtime					Downtime		Reason
					Ship	3 h	CLAM failure, CTD wire/sheave issues.

					Equipment	2.5 h	CTD wire re-term. Note 1
					Weather	80 h	Note 2.
					Other	173 h (7d 5h)	Two medical evacuations

Please see separate sheets for comments on medical issues.

1. Additional reterm's carried out during transit periods.

2. In addition to the tabulated weather downtime figure, note that scientific operations were terminated some 50h in advance of the nominal 'cut off' time for this project due to weather conditions.

Pre Cruise

Safety — If Accidents or Near misses have been filed refer to these.	N/A	N/A	N/A	N/A

Accidents
YEAR 07-12	CTD wire jumped sheave.
YEAR 08-12	CTD wire jumped sheave.

Near Miss
NM 02-12	VMP in contact with ship's undersides.

MAIB
Nil

| | | X | Programming & SME | SME, programming and pre-cruise planning support was of the usual high standard |

Pre-Cruise Planning / Supply agreement (X)
The only glitch was the lack of provision of the 3 fully working LADCP units requested. Two were provided instead, due to failure of several units in the previous cruise (JC068). This prevented the use of a dual LADCP system (upward- and downward-looking units) during JC069 -as was intended for collection of velocity data of the desired quality, instead one downlooking LADCP was used throughout the cruise, and the second one was preserved as a spare. This experience calls for the purchase of at least one further LADCP unit by NMF-SS. Reliability and service issues persist with these devices.

Pre Cruise Planning & Communications (X)
See comments below regarding embarkation of equipment suitable for deployment in poor weather.

Mobilisation Support (X)
Excellent support received in Montevideo. Berthing issues in this port are well noted, but on this occasion disruption was minimal.

Communications (X)

Onboard Support

Staff (X)
All the staff, both marine and scientific support, were very competent, well trained and sufficient in number, helpful and friendly. Disagreements were sensibly handled. There is sometimes a disconnect however between the aims of scientists and those of the NMF staff, which is a management issue that needs addressing – see attached sheets

Scientific Facilities (X)
- Functionality
- Performance
- Reliability
- Safety
- Cleanliness of labs

Functionality, performance and reliability. Mostly facilities met, and sometimes exceeded, expectations. There were some important issues concerning the main hydrographic package operations where they were below expectations. See attached sheets
Safety: excellent throughout the cruise
Cleanliness: excellent

Domestic Facilities
  • Hotel facilities
  • Catering service
  • Cleanliness of ship
	X	All good to excellent. Ship very clean, food was generally very good.
		A good performance from the catering department – especially considering the duration of the cruise.

Demobilisation Support Please advise on any issues post completion	X	
Any Other Business		Medical emergencies and NMF policy – see attached sheets Ref. additional detail below. CTD ops. CTD wire 1 was initially our primary in service wire. Repeated torsion issues (kinks upon recovery) resulted in regular reterminations – mechanical and electrical and the need for streaming at regular intervals. This wire eventually became virtually unusable as the outer lay of wires became loosened to a worrying degree. At this stage urgent investigation into the previously abandoned CTD wire 2 began. It is very fortunate that the electrical issues this wire was reported to have could be identified and rectified in this case. If this wire had not been returned to service all further CTD work planned for this cruise would have been jeopardised. CTD wire 1 should be condemned and replaced at the earliest opportunity. General winding speeds have been governed throughout by weather conditions. Marginal Weather. The James Cook is a very capable platform and can maintain station in very poor weather. The motion of the vessel is, however, of prime concern with deploying equipment over the side. All deployments and near surface/splash zone operations were handled extremely skilfully by the teams working on deck. The motion of the package when it is submerged gives cause for concern with regard to snatch loading, (both at the CTD frame and at the Hydroboom head) and the vertical motion encountered by the package. A heave of 4m is in fact – and – 4m, a vertical shift of 8m, without the inclusion of any exaggeration caused by concurrent roll. This motion, combined with the drag acting on the package produces potential for wire damage/fouling at the CTD end. Damaged wires eventually fail. 'Poor weather' alternatives to the large CTD frame carried on this project would ensure that some level of science could be conducted during what is currently, by force, DTWx. Medevacs. Medevacs conducted after advice from the ship's doctor, whose professionalism and thoroughness has been valued enormously. Transits to Stanley conducted at best speed using three generators. Turnaround time at Stanley minimised on both occasions with excellent support from H.O. and the F.I. BAS representative. The replacement of the Ch/Eng. in particular, was achieved with the utmost efficiency and rapidity.

JC069: Water sampling rosette and instrument package operations.

The most important tool for us on this research expedition was the hydrographic winch with the instrument package consisting of CTD, 24 x 10 litre sampling bottles and rosette, lowered ADCP and other associated instruments. Many stations were planned using this gear so it was important, for efficient ship operations, that the package could be let out and hauled back at a good speed. In many respects it worked extremely well: the CTD measurements were of high quality and the sampling bottle system triggered reliably throughout the cruise.

Slow winding: An issue at the beginning of the cruise was the slow winding of the winch and repeated re-terminations, necessitated by the wire becoming damaged due to accumulated twists and torsion in it. This was solved by Paul Provost and his team about 1/3 through the cruise, by switching to the ship's second wire. This entailed however, locating electrical faults at the winch that had caused spiking problems on the signals from this wire on the previous cruise. The wire was subsequently kept in good condition by periodically lowering it to full depth with only a hydrodynamic weight on the end, so allowing any twist that had been built up in the wire to be unwound. We were rather dismayed by the performance of the wire before this fix was made, especially since a similar issue had resulted in a slow winch and low rate of stations on the previous DIMES cruise on the James Cook (JC054) – we brought this issue to the attention of NMF at the time, and in the pre-cruise planning for the present expedition. We were much indebted to the NMF team on board for having been able to fix this problem while at sea.

Working in moderate to heavy swell: The ship was not able to perform hydrographic casts when heave approached 4m, and this – combined with the time earlier lost to medical evacuations – was why several important stations could not be completed. However, such swell conditions are far from unusual in the Southern Ocean. In our case, the weather forecast suggested that there was a period of more than a week in length, when wave conditions would be continually at or above this level in western Drake Passage, at the time that we wished to work there. Towards the end of the cruise, after extensive discussion, a cast in these marginal conditions was made. This was safely and successfully completed, with no evidence of any damage to package or wire, suggesting (to the scientific party at any rate) that it was possible to work securely under those conditions. However, in the event the view was taken that the risk to the equipment was too great, and in the end no further work was done.

If the Cook is to be used for hydrographic science in these relatively unfriendly waters, it would seem that careful thought needs to be given to how best to improve her ability to work in such conditions. This might include the provision of some back-up, simpler gear, that does not rely on the somewhat cumbersome starboard midships arrangement of the present hydrographic winch, and might allow deployment in rougher conditions (an old-fashioned hydro-wire could have deployed equipment in the conditions under which the present vessel cannot work).

The root cause of our difficulty relates to the different priorities that NMF and the scientific party have. NMF staff are understandably very protective of the gear and conservative in their use of it in order to minimize losses and ensure that it is available for future cruises. The scientists see however an unrepeatable opportunity, in which heavy investment has already been made, and feel that the science lost should be weighed against the risk of loss of equipment; if the risk is small enough, it should be accepted, and in the unlucky event of loss after such an assessment has been made, no negative consequences should ensue for NMF or for the scientists and technicians involved.

We suggest an engagement and constructive dialogue between NMF management, NOCS management and scientists, in an effort to better align the scientific priorities with those of the technical service. This might involve for example better provision of backup gear, or insuring some of the gear, so that the risk of loss of equipment can be more realistically weighted against loss of important science objectives.

NMF vessels and medical evacuations

NERC-funded research cruises in remote locations have frequently been disrupted by the necessity for medevacs. The recent history of cruises in the South Atlantic illustrates:

1) the ANDREX I cruise (2007) was aborted due to health problems of a crew member
2) the GEOTRACES expedition (2010) - aborted due to the medevac of a scientist.
3) the present cruise, DIMES UK 3 (2012), suffered two medevacs in quick succession, with loss of science time of 8 days, Three days were lost to evacuate a scientist, and five days for a crew member.

The health requirement for participants in a research cruise on an NMF vessel is to have passed the "ENG-1" medical exam at some time in the previous two years. The ENG-1 ensures only a very basic standard for health, the legal minimum for commercial vessels. These rarely spend weeks in remote locations and usually have smaller numbers of people aboard than a research vessel. When about 50 people (the complement of a research ship) who have been screened only to such a level are at sea for more than a month, the recent experience of NMF suggests that the chances are quite high that a medical evacuation will be required. While such an occurrence is only a minor inconvenience when within short steaming distance of a port, for a research vessel in a remote location the necessary diversion can result in the loss of a good part, perhaps all, of the available science time.

Cruises run by the British Antarctic survey have a much better record with fewer diversions for medical issues than the NMF ships. During the last 7 years, only 5 days have been lost to medevacs on their two ships, according to the operations office at BAS. Before joining a BAS ship, marine staff and scientists are subject to a more stringent medical exam, which, had it been followed by NMF, would certainly have prevented the necessity of the two medevacs experienced on the DIMES cruise.

The impact on NERC's budget and on UK marine science of these repeated medevacs is hard to quantify, but it has been substantial. The ANDREX and GEOTRACES cruises had to be repeated, entailing all the associated direct and indirect expenditure of major seagoing expeditions in remote locations. GEOTRACES and DIMES are multi-national projects with extensive international participation and the damage to NERC's reputation in the international community has to be considered.

In conclusion, present NMF policy makes it likely that such disruptions will continue to occur with high frequency, at considerable financial and reputational cost to NERC. They mean that the NMF operation is not fully fit-for-purpose for remote locations such as the South Atlantic and Southern Ocean. It would be possible to greatly lower the frequency of disruptive medevacs by requiring an additional check on medical fitness for both scientists and marine staff joining research cruises in remote locations.