Institute of
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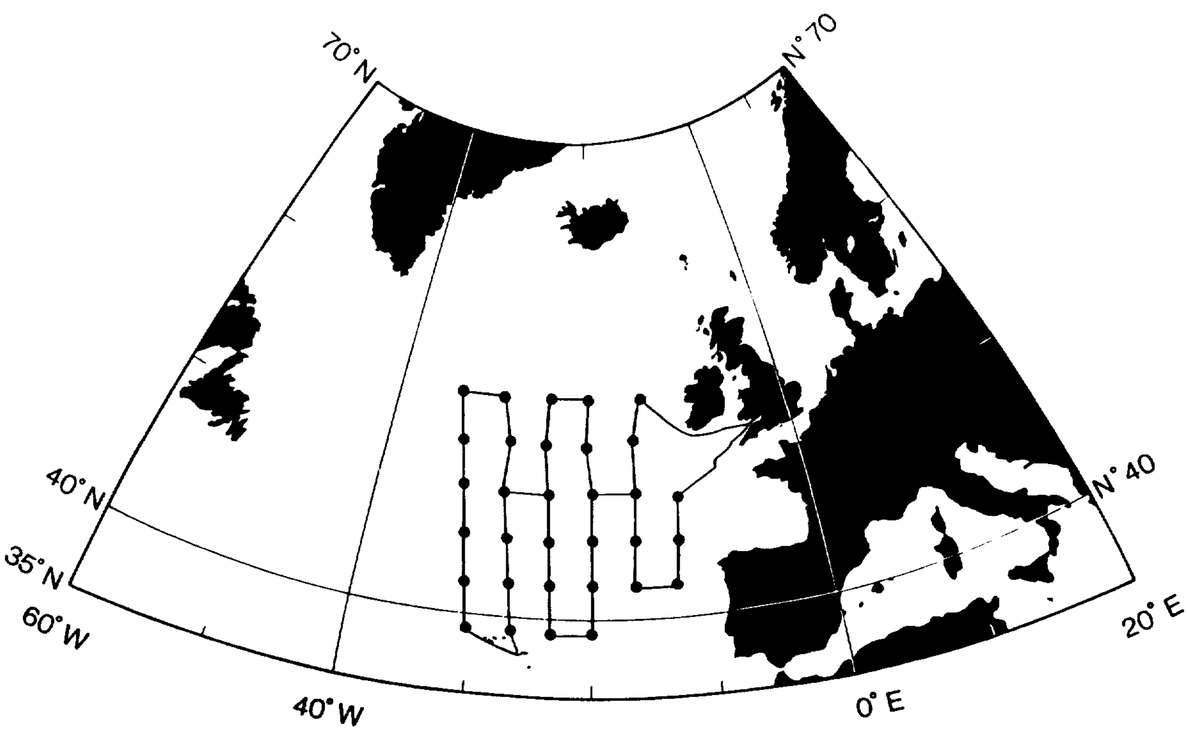
RRS Charles Darwin Cruises 58 & 59

25 Apr-16 May; 18 May-10 Jun 1991

VIVALDI '91

Cruise Report No 228 1991



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INSTITUTE OF OCEANOGRAPHIC SCIENCES

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CRUISE REPORT NO. 228

RRS CHARLES DARWIN CRUISES 58 & 59
25 APR-16 MAY; 18 MAY-10 JUN 1991

VIVALDI '91

Principal Scientists
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1991

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\BSTRACT

RRS *Charles Darwin* Cruises 58 and 59, in April to June 1991 - Vivaldi '91, were a major UK contribution to the World Ocean Circulation Experiment. Vivaldi was conceived as a series of seasonal surveys of the NE Atlantic. The Vivaldi '91 trial combined the high spatial resolution of SeaSoar surveys with deep CTD stations spaced every 3 degrees of latitude on tracks 300 km apart. These primary measurements were complemented by a shipboard acoustic Doppler current profiler, chlorofluorocarbon tracer chemistry, oxygen, nutrient and chlorophyll measurements, and mean surface meteorology.

The aims of Vivaldi are to:

- calculate seasonal upper ocean heat and fresh water budgets
- map isopycnic potential vorticity variations from the sub-tropical gyre to the subpolar gyre
- map interannual changes in the properties of water masses formed by deep convection
- calculate statistics of upper ocean parameters and air sea fluxes
- investigate the role of eddies

KEYWORDS

ACOUSTIC DOPPLER CURRENT PROFILER(ADCP)
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"CHARLES DARWIN" - cruise(1991)(59)
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CTD OBSERVATIONS
NUTRIENTS
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SEASOAR
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VIVALDI 91
WOCE

ISSUING ORGANISATION

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CONTENTS   Page

SCIENTIFIC PERSONNEL CRUISE 58

POLLARD, Raymond T. (Principal Scientist)	JRC
ALDERSON, Steven G.	JRC
ANDERSON, Tom R.	JRC
BENEY, Martin	RVS
CUNNINGHAM, Stuart A.	JRC
GRIFFITHS, Gwyn	JRC, Project Manager
GRIFFITHS, Mike J.	JRC
GROHMANN, Dave	IOSDL
GWILLIAM, T.J. Pat	IOSDL
HAINE, Tom W.	Southampton University/PML
HOLLEY, Sue E.	JRC
KEENE, Steve B.	IOSDL
LANCASTER, Peter F.	Southampton University
PAYLOR, Rodger	JRC
PHIPPS, Richard A.	RVS
RIOS, Aida	CSIC, Vigo, Spain
SMITH, Paul K.	IOSDL
WHITE, Gary R.	RVS

SCIENTIFIC PERSONNEL CRUISE 59

LEACH, Harry (Principal Scientist)	Liverpool University
BONNER, Robin N.	JRC
BOWERMAN, Sarah J.	Liverpool University
CUMMING, Tony R.	RVS
CUNNINGHAM, Stuart A.	JRC
DONLON, Craig J.	Southampton University
GRIFFITHS, Gwyn	JRC, Project Manager
GRIFFITHS, Mike J.	JRC
HEMMINGS, John C.P.	JRC
HOLLEY, Sue E.	JRC
LOWRY, Roy K.	BODC
PEARCE, Rod	RVS
PHIPPS, Richard A.	RVS
PRESTON, Martin R.	Liverpool University
SMITH, Paul K.	IOSDL
SMITHERS, John	IOSDL
STIRLING, Moragh W.	IOSDL

SHIP'S PERSONNEL

MACDERMOTT, P.J.	Master	Cruise 58
HARDING, M.A.	Master	Cruise 59
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CLARKE, J. L.	Second Officer	Cruise 59
MORSE, J.T.	Extra Second Officer	
DONALDSON, B.	Radio Officer	
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ROWLANDS, D.C.	Chief Engineer	Cruise 59
MOSS, S.A.	Second Engineer	
MCDONALD, B.J.	Third Engineer	Cruise 58
LOVELL, V.E.D.	Third Engineer	Cruise 59
PARKER, P.G.	Electrical Engineer	
TREVASKIS, M.	CPO(D)	
CAREW, J.	Seaman	
COOK, S.C.	Seaman	
CRABB, A.E.	Seaman	
SCRIVEN, A.G.	Seaman	
PRIDDLE, N.J.	Seaman	
HUBBARD, C.	CPO(C)	
BISHOP, P.J.	Cook	
STEPHEN, R.M.	Second Steward	
CROSS, M.J.	Steward	
HILLBERG, J.C .	Steward	
BRENNENSTUHL, M.J.	Motorman	

NARRATIVE

As a major contribution to the UK WOCE effort Vivaldi was conceived as a series of seasonal surveys covering the NE Atlantic. In order to obtain both spatial coverage and high resolution a plan was developed in which nearly north-south SeaSoar sections, spaced 300km apart relative to longitude 20°W as origin, would be complemented by deep CTD stations every 3 degrees of latitude.

Vivaldi'91, Charles Darwin Cruises 58 and 59 together, represents the first attempt to carry out a systematic survey as suggested by the Vivaldi concept. It was decided to carry out the survey given the time and season available in two parts, first a southeastern part from Barry to Ponta Delgada (Cruise 58) and then a western and northern part (Cruise 59) from Ponta Delgada back to Barry. The position of the deep CTD stations was in theory defined by the formula enunciated above. However because some of the theoretical positions were in untypically shallow water it was decided to move these into adjacent deeper water so that the deep water would also be sampled. (Tables 1 & 2).

Cruise 58

Sailing from Barry was delayed by over 12 hours because of an RVS management ban on weekend working. *RRS Charles Darwin* passed through the lock at 0600Z/25 April (all times will be expressed in GMT) and set course for the first station position. The ADCP was calibrated from 0230-0600/26 April by a series of 90^{o} course changes at 20 minute intervals with the ADCP in bottom track mode on the continental shelf. A trial CTD cast at 1030 revealed a number of problems, most serious of which was that the lanyards supplied with the new 10 litre water bottles were the wrong length. A second trial cast was therefore undertaken at 1400. The casts were numbered CTD11v01 and 11v02. The first '1' signifies the year 1991 and the second '1' signifies the first Vivaldi cruise in that year. Thus the second leg (Cruise 59) will have numbers in the series CTD12....

After each of the CTD stations, a zoological net was cast on the starboard side using a small kevlar winch and with the block held on the crane. Minor problems were corrected after the first cast and the procedure was followed after every CTD cast throughout the cruise. Later in the day (1836/26 April) the SeaSoar was deployed for a two-hour trial run, using the RVS-supplied block.

Vivaldi leg B

The first fulldepth CTD (11v03) in the Vivaldi series was begun at 0252/27 April at position B48. The numbering scheme signifies a cast on line B at 48°N. Five sections were to be occupied on

Cruise 58. The sections were nearly north-south runs, parallel in the sense of being 300 km apart, with the third leg along 20°W exactly north-south. Each leg was identified by a letter of the alphabet (see Fig. 1), with the first leg being leg B. CTD positions were nominally at 3° intervals of latitude, at 39°, 42°, 45° and 48°N. The exact positions were adjusted usually by no more than a few miles to maximise the water depth available and avoid known seamounts. The first cast was moved more than a few miles from its nominal position at 48°N however, to 47.5°N, to reach deep water well south of the Celtic Shelf edge.

After the CTD cast, the SeaSoar was deployed for the passage from B48 - B45 (SS11001). The block was changed to the IOS supplied U-shaped sheave so that (a) a length of chain could be removed, (b) the RVS block could be built up on its cheeks to ensure that the wire could not jam down the sides of the cheeks. The SeaSoar run was historic, with the SeaSoar profiling for the first time to 500m. It ended at 0222/28 April when course was altered downwind to recover SeaSoar. With the IOS block outboard, quite a few individual fairings snapped.

During deployment of the CTD (CTD11v04, B45) the roller fitted to the A-frame was not freed from its stowed position. It sprang free suddenly, which jarred the CTD and led to poor quality data on casts 11004 and 5. After changing the stern block back to the RVS one, the SeaSoar was deployed from 1829 for run B45-B42 (SS11002). Good speeds were attained, the SeaSoar preferring speeds of 8.5 - 9 knots to provide the lift needed to raise the extra weight of cable. This compensated for the time on station, which was rather longer than had been allowed.

After CTD11v05 (B42) it had been intended to continue south to 39°N, but with time lost before sailing, a slight underestimate of the mean time between stations, and the need to allow at least a day for bad weather, it was reluctantly decided that stations B39 and A39 would have to be abandoned for this Vivaldi trial. The SeaSoar was therefore deployed to run west towards A42, but had to be recovered after little over an hour because of electronics failure. The problem was quickly shown to be leakage in a blanking plug, but it was decided not to redeploy the SeaSoar, but to steam on to the next station. It was a blow to have to lose this 42°N section, which would have repeated a section occupied in the two previous years. However, in the context of Vivaldi it was the right decision, as it enabled the CTD to be fully checked out during the passage run. It had given very noisy data on cast CTD11v05. Although no fault was found, a board must have been shaken loose when the frame was jarred, as the noise disappeared after disassembly and reassembly.

Vivaldi leg A

Stations A42, A45 and A48 (CTD11v06-8) were occupied between 30 April and 2 May, with SeaSoar runs (SS11003-5) inbetween. During this period problems in both CTD and SeaSoar systems were gradually traced and corrected, but the consequent strain, particularly on the senior electronics engineer (Pat Gwilliam), was high.

During SS11003 (A42-A45) the SeaSoar was recovered because of a noisy signal, traced to a noisy fluorometer lead. The ship steamed on during repair (1337-1448/30 April). After deployment for run A45-A48 the SeaSoar would not respond to command and leaky hydraulics were suspected. Recovery went badly steaming into a fresh wind. Several lengths of fairing were stripped off at either the stern block or the roller at the lead onto the winch. The former was caused by swinging of the stern sheave, which was reduced by welding a bar across it to give greater control. The latter was caused by the metal stoppers on the cable catching on the edge of the roller when the cable lead was at angle. This happened when the wire was fully out as the winch was mounted somewhat to port of the centre line of the ship. On recovery at A48 brooms were used to turn the fairing upwards as it led onto the blocks. The A-frame was held inboard so that the stern block could be reached. A great reduction in fairing damage was noted. Once inboard, it was found that the bottom tail-plane was missing and the impeller blades bent. The loss was most probably due to fatigue, and explained the rather poor maximum depths attained during the preceding run.

Vivaldi leg Z - 20°W

Leg Z was completed between 3 May and 6 May from 48°N to 39°N. CTD casts were CTD11v09-11v12, and SeaSoar runs SS11006-8. Weather was good throughout. Because 20°W was the 'master' section, some extra time was allowed to run up to each CTD position before recovering SeaSoar and to position the ship prior to deployment so that the SeaSoar would be deployed and profiling by the time the CTD position was reached again. This added about 30 minutes to manoevering time at each station.

During leg A, careful examination of salinities, oxygens and nutrients from the 101 24 bottle multisampler had led to the definite conclusion that the bottles were not firing consistently at the depths at which they were triggered according to the deck unit. Salinities provided the most accurate evidence, so from CTD11v10 (Z45) onwards salinities were drawn from every bottle (previously samples had been drawn from alternate bottles for CTD calibration). This proved that two bottles were firing at some depths and none at others. After CTD11v11 the multisampler was stripped down, minor seawater damage repaired, and the firing pin position retarded. Double firing was still apparent. After CTD11v12, the multisampler was again stripped down and the firing pin advanced carefully to the midpoint between firing positions. Thereafter, near-perfect firing was achieved for the rest of the cruise. The conclusion is that, on a 24 bottle multisampler, with only 15°

between firing positions, setup is critical, given that there is some play in the pin turning mechanism.

At the end of SeaSoar run SS11007 (45°-42°N) there was some swell and the nose of the SeaSoar slammed into the stern in the final moments during recovery. The fibreglass nose was squashed and the bolts holding the weight sheared off, but no further damage was apparent. Recovery at Z39 at the end of the next run was much easier running with the wind but kept a little on the quarter to reduce pitching. Ideally, both deployment and recovery should be made running with the wind and the ship speed should be quite high, 4 quickly increasing to 7-8 knots on deployment and 6 knots dropping at a late stage to 4 knots on recovery. For run SS11009 (Z39-Y39), the course was westward running into wind. Considerable pitching made deployment difficult when the faired cable went slack and threatened to foul the safety rails. During run SS11009 trials with varying cable lengths were done which confirmed previous calculations. A sea anchor was also tested for drag efficiency.

Vivaldi leg Y

The fourth leg was occupied from 7 May to 11 May, with CTD casts 11v13-16 at Y39, Y42, Y45 and Y48. The SeaSoar runs inbetween were numbered SS11010-12. With so little time lost to bad weather, it was possible to continue the manoevering described above to avoid any gaps in SeaSoar data just before and after each CTD cast.

Before recovery at position Y42 a metal guide (ploughshare) was fitted to the travelling arm of the SeaSoar winch which laid the fairing correctly so that it could not foul the next turn. In addition to being safer and reducing by one the number of people needed during recovery, the guide saves time, avoiding the two or three occasions on each recovery when wire has to be paid out to clear fouled turns.

With so little bad weather, it was possible to make time for the main trawling warp, damaged on a previous cruise, to be ditched after CTD11v16 (Y48). This took 5.5 hours (0533-1105/11 May), including the time needed to draw all samples from the multisampler, strip and stow the bottles and cover the multisampler to avoid damage or grease contamination during the wire cutting operation using the starboard A-frame.

Vivaldi leg X

After the main warp had been ditched, the SeaSoar was deployed (1105-1131/11 May) to run west from Y48 to X48. During this run, the wind increased to force 6 overnight. By 1000/12 May it was decided that it would be impossible to hold station for the next CTD cast at X48, so there was no point in risking damage to the SeaSoar by recovering it in marginal conditions. The wind was southwest, putting it on the port side during the westward run, but the starboard side after turning south. The multisampler was therefore made more secure, the bottles removed and all gear stowed or lashed before the course change at 1122/12 May.

The weather had eased considerably by the time SeaSoar was recovered at X45 (0947/13 May) for CTD11v17. The SeaSoar runs from X48 to X39 (SS11014-16) were without incident apart from the poorer minimum depths attainable while the ship speed was reduced to 6-7 knots during the bad weather. The final CTD casts CTD (11v17-19) went smoothly, except that the fluorometer fouled at the start of CTD11v19 during the first minutes of the cast. The CTD was brought to the surface, during which time the fouling cleared, and the cast restarted.

After all bottles had been sampled after the final cast, a zigzag ADCP calibration run was completed from 1740-2042/15 May, before course was set for Ponta Delgada. *RRS Charles Darwin* berthed at 0915 on Thursday 16 May at the end of a very satisfactory Vivaldi trial cruise.

Cruise 59

The second leg of Vivaldi '91, Charles Darwin Cruise 59, began in Ponta Delgada, Azores, on Saturday 18 May 1991 when the ship set sail at 1000. We steamed directly to the first station, W39, where at 1110 on the 19th, after the first CTD and net station (CTD12v01), we began SeaSoaring northwards along Section W. Station W51 (CTD12v05) on 23 May seemed to be positioned directly on the Polar Front, which marks the boundary between the Subtropical and Subpolar Gyres. A peregrine falcon and several housemartins were observed here. At 2131 on 24 May we reached the northern end of Section W at Station W54 (CTD12v06). From there we steamed east to Station X54 and then south to X48. During the section east the SeaSoar conductivity cell 1 finally failed completely explaining the increasingly problematical salinities of the last day or so. At the recovery of the SeaSoar at Station Y48 on 29 May the towing cable was caught in the side of the block and needed reterminating. From there we steamed north again. At Station Y51 (30 May) the very first test of the IOSDL EG & G MkV CTD was made in a double station (CTD12v011 12) in 4002m of water. From Station Y54 (31 May) we steamed east to Z54 (1 June) and then south along Section Z (20°W). Stations Z51 (CTD12v15 16) and Z48 (CTD12v17 18) were also double stations with both CTDs. At Station Z51 many pilot whales and dolphins were observed close to the ship. On the 4th at Station Z48 the bench in the wet laboratory flooded due to surplus water from the non-toxic supply not draining away and damaged the through-flow fluorometer so that it had to be replaced by an older model. On leaving Station A48 (5 June) as the SeaSoar was being deployed in heavy seas the towing cable became jammed in the side of the block and needed reterminating.

Then we were able to tow off northwards. On the 6th June at Station A51 (CTD12v20) bad weather developed while the CTD cast was in progress. As a result the ship remained hove to until 0400 7 June after which SeaSoaring was resumed and Section A continued northwards. The last station (A54, CTD12v21) was finished by 0530 8 June, after which we set sail for Barry.

Final remarks

For the first time the IOSDL SeaSoar CTD was equipped with two conductivity cells to help with the problem of correcting the salinity when the conductivity cell fouls. Although this modification helped to some extent it did not solve the problem, which was particularly acute in frontal regions with high TS-variability.

At all CTD stations hauls were made with plankton nets from 100m depth and at most stations on Leg 2 from 300m - 450m as well.

During Leg 2 an air sampler mounted forward was used when the wind direction and speed were appropriate to collect aerosols.

The Level C Computer System provided by RVS in which two whole SUN workstations were available for the needs of scientific data processing and analysis proved to be very effective in coping with demand. The only minor drawback was the lack of cross-accessablity of the disk drives.

Excellent technical support was provided by the RVS personnel on board who worked with enthusiasm beyond the call of duty to help make the cruise a success. Likewise the excellent catering on board lead to many mealtimes being a considerable crisis of conscience.

Finally our thanks are due to the Masters, Officers and Ratings during both Legs of the Cruise for their support and assistance in every way.

SEASOAR

Engineering

Apart from maintaining the data gathering equipment for the scientists, Cruise 58 was highlighted for the CTD/SeaSoar engineers with the successful commissioning of the new SeaSoar winch.

SeaSoar Winch

The winch was the culmination of hydrodynamic measurements taken on previous cruises and the scientific request for routine surface to 450 metres SeaSoar profiling.

There were several differences between the old and new winches but the main difference was the increase in faired cable length from 600 metres to 750 metres. Results of tests carried out during the cruise of cable length against maximum depth accurately followed the depth prediction curves provided from previous studies. With the full 750 metres deployed, SeaSoar depths of 500 metres plus have routinely been obtained in the cycling mode.

Cable strains, now directly measured at the winch, are of the same order as those experienced with the 600 metre cable on the old system, ranging from 2 kN at the surface to 15 kN at maximum depth.

The backup electrical recovery system, used in the event of a hydraulic failure, was satisfactorily tested, with the rate of hauling found to be approximately 0.25 metres per second.

On the handling side, the deployment and recovery was much improved over the old system although some problems still exist. The big advantage was the reduction in manpower necessary for deployment and recovery, particularly near rotating equipment. On earlier recoveries there was still a need for manual alignment of the fairing onto the drum, however, with the addition of a "ploughshare" arrangement to the winch block, constructed by Richard Phipps, the RVS engineer, this task was made unneccesary.

On initial deployments, fairing breakage was relatively high when the cable entered the stern and winch blocks at such an angle that the load was transferred from the cable onto the fairing. By the innovative use of bristle brooms, the fairing was presented to the blocks at the correct attitude, either cable onto the block, or the fairing horizontal. This resulted in the reduction of breakages. A modification to the blocks may need to be carried out in the future, but it is doubtful whether it will be as simple, or the results as good as, the broom method. Other modifications to be carried out on the winch include the alteration to the block cable entry to allow for larger fleeting angles and the incorporation of the hydraulic operating handle at a lower level.

On recovery of at the end of Run 11, the heaving of the ship resulted in the nose of the SeaSoar vehicle striking the stern of the ship and damaging the fibre glass. In anticipation of this problem a sea anchor arrangement was brought along and although satisfactorily calibrated was not used.

Much experience was gained in SeaSoar deployment and recovery, with 19 of each during the cruise (Table 3). With a winch powerful and controllable enough to operate with considerable strain on the cable, it is best to do most operations at 6-8 knots. Because the ship is controllable at those speeds when running with the wind, deployment and recovery are best done that way to reduce pitching. Deploy the SeaSoar at 4 knots, pay out 20-30m of cable, then stop the winch while the A-frame is brought inboard and the ship speed is brought up to over 6 knots, 7-8 is acceptable. Given that the payout speed of the winch is about 1 m s^{-1}, or 2 knots, the high ship speed is necessary for the SeaSoar to remain controllable during the deployment. It can thus be kept at the surface, reducing the angle the cable makes as it passes over the stern sheave. Ship speed can be slightly slower during recovery, as the haul rate of the winch adds to the ship speed. At least 6 knots should still be maintained, else the SeaSoar starts to sink whenever hauling is stopped for whatever reason (typically to cut a damaged piece of fairing). The ship speed should be gradually reduced once only 200m of cable are outboard, the speed of 2-4 knots during the final moments being a compromise between minimising pitching (higher speed preferred) and allowing the SeaSoar to sink so that it does not swing forward and hit the ship at the last moment. Some thought should still be given to improving final recovery. The sea-anchor was not used because of fears that it would snag on the fairing instead of sliding down to the SeaSoar when it was attached.

On Cruise 59 the only problem was the failure of the wire out counter after Run 29. The only additional comment to add to those of Cruise 58 would be the fitting of a steel mesh guard around the three exposed sides of the winch to provide protection from the rotating drum.

SeaSoar vehicle

The intention for this cruise was to study the handling characteristics with the longer cable so no modifications were incorporated into the vehicle apart from mounting the irradiance sensor on the leading edge of the fin.

We found that the major influence of the longer cable was the need to reduce the up and down cycling rates to maintain synchronisation between SeaSoar and the command signal. Initially, the vehicle followed the command signal poorly and it was thought that the servo system drive current amplifier had too low a gain, but this was traced to a fault in the electronics.

Apart from the damage to the fibre glass, the vehicle sustained damage on two further occasions. The first was during run 2 when a cable loop bent a wing end plate. The second occurrence was during run 8 when half of the lower tailplane section fractured and broke away. In so doing the impeller was damaged and the remaining section of tailplane was torn off. The damaged wing was replaced with the spare wing and the impeller repaired and modified to extend the diameter from 270mm to 356mm. Although difficult to assess in operation, there were indications of improved vehicle performance near the surface, however, measurements would have to be made to substantiate this.

Cruise 59

Twenty further SeaSoar runs were completed during Cruise 59 (Table 4). Each began with a deep vertical CTD cast, to cross-calibrate the SeaSoar CTD sensors. A final CTD cast was made at the end of the series.

During the first three runs (Runs 20-22, Table 4), hydraulic control and hence vehicle flight path were rather poor. Hydraulic unit 02, still in use from Cruise 58, was changed for unit 03 after the first two runs. Control was still poor so this was subsequently replaced by unit 02 which had been overhauled by R.Bonner.

Servicing of these units revealed that unit 02 had developed a sea water leak and that the reservoir bellows had come off its fitting. Unit 03 had a pinhole puncture in the reservoir bellows which caused it to lose oil under pressure. This resulted in oil starvation and cavitation in the hydraulic circuit and poor vehicle performance.

With the refurbished hydraulic unit 02, control was much improved giving a slightly faster cycle time, with better turning performance at the surface. A subsequent gain from this improvement was the reduced rate of change of cable strain, with no termination failures during runs. However, the tow-cable was reterminated at the end of Run 30, and at the start of run Run 38, when severe pitching of the ship's stern in heavy seas caused the cable to jump from the towing sheave and jam between its roller and side cheek.

The Par lightmeter lead was replaced for run Run 27 as it had become damaged.

During run Run 30 the calibration of conductivity cell 1 jumped to a higher value and became noisier with continuous drifting. Normal biological fouling causes the calibration to jump to a lower value so it was decided to replace the cell with a new one for Run 31.

Apart from the faulty cell the SeaSoar CTD performed faultlessly. During Run 35 hydraulic control became intermittent. The vehicle was recovered and the electrical connections to the hydraulic unit replaced, curing the fault.

Launch and recovery operations generally went very smoothly with the exception of a few cases in heavy seas. Using techniques developed on Cruise 58, loss of fairing was kept to a minimum. However, the maximum depth obtainable during the later runs was reduced, probably due to higher cable drag caused through the cumulative fairing loss.

SeaSoar Sensors

The following instruments were incorporated into the vehicle:

Chelsea Instruments Fluorometer

This is the original IOSDL unit, recently returned from Chelsea Instruments after upgrading and calibration.

Chelsea Instruments Irradiance Sensor

This is a new instrument manufactured by Chelsea Instruments under licence from the PML. Although the data has yet to be fully analysed it would appear to be working satisfactorily.

Neil Brown (EG & G) CTD

This is the usual Neil Brown CTD used previously with the SeaSoar but with the addition of the irradience meter interface card and a second conductivity cell. The purpose of the extra conductivity cell was to reduce the loss of data due to cell contamination, and, by comparison, a figure for long term cell stability could be produced. In practise, the dual cell system exceeded expectations and will probably become an established feature of the SeaSoar system.

SeaSoar/CTD shipboard equipment

The new 1401/PS2 deck system has performed without fault with both the CTD vertical cast and SeaSoar systems.

A program developed by Martin Beney (RVS computer engineer) to display the CTD real time data in hex and decimal on a PS/2 has been particularly useful in monitoring the dual conductivity cells and other parameters.

For this cruise the old 6 pen ink chart recorder was replaced with a 4 channel thermal printer and real time monitor. This instrument has been a great success in monitoring and recording the command, pressure and cable strain signals.

TJPG, JS, RNB, DG, SBK

SeaSoar Data Processing

SeaSoar data was processed using a set of standard command files of PEXEC programs. These were modified from their form for previous cruises to allow both the addition of a par meter and the second conductivity cell. Raw data was initially logged by the RVS ABC system, and then copied into PSTAR format every four hours. After simple editing for spikes it was then calibrated and plotted.

By examining the difference between the salinities calculated from the two conductivities, fouling events could clearly be identified on a time series plot. Where appropriate, sections of data were swapped from one salinity variable to the other to remove offsets. Differences between the two salinities down to ~0.005 could be identified within each four hour section. Any further inconsistencies and offsets during each SeaSoar tow were corrected by comparing the T/S relationships from the SeaSoar with the shallow part of that from the CTD station at each end.

After this editing, the four hour files were appended together into a single section between each CTD station. These were then merged with navigation and gridded into 12km intervals and 8m depth bins on pressure, density and temperature surfaces. Each section was then plotted against latitude or longitude on a standard scale.

After leaving Ponta Delgada at the start of Cruise 59, it was noticed that the salinity difference between the two conductivity cells was drifting. Initially it was thought that the cells had been adversely affected by heat during the port call as the SeaSoar remained exposed on deck for 48hrs. Later it became clear as the level of the primary conductivity cell jumped erratically between recovery and deployment of the SeaSoar that the cell electrodes were breaking down. Consequently the conductivity cell was replaced by a new one. Unfortunately no calibration was available for this cell and we opted to apply the calibration of the secondary cell. The old secondary cell was then promoted to be the primary with the new nominally calibrated cell becoming the secondary.

A problem was encountered in the data from the par meter. The level A program did not inspect the sign bit for this variable, so that the raw voltage was fully rectified. It had the effect of introducing a sub-surface maximum in the calibrated irradiance. This was rather laboriously corrected using an interactive graphics program, and the data recalibrated. On Cruise 59 a more efficient way of correcting the data was devised whereby R Pearce of RVS used their advanced graphical capabilities to derectify the data which were then merged with the appropriate SeaSoar file and calibrated.

RTP, SAC, MJG, PFL, SGA, RKL,CJD, SJB

DEEP CTD AND MULTISAMPLER

Equipment:

*....Neil Brown CTD Mk III b

*....Chelsea Instruments Fluorometer

*....Sea Tech 100cm transmissometer

*....10khz acoustic pinger

*....General Oceanics 10 litre, 24 bottle rosette system

Initial minor problems with leads were soon sorted out. After a severe cable drop (see narrative), data noise suggested a loose printed circuit board or connection in the CTD. After inspection and repair of a suspect cable all was well.

The multisampler was a problem from the start. The lanyards supplied with the bottles were not of the correct length and had to be shortened. The bottle firing code signals were not providing sensible information. Analysis of the water samples indicated that the unit was tripping two bottles at a time. After a complete strip down, inspection showed that sea water had penetrated into the stepper motor housing and corroded the odd/even switch assembly from which the bottle firing codes are derived. The unit was cleaned and reassembled but the double bottle firing persisted. After several adjustments, the cam plate was realigned and the unit worked satisfactorily from CTD11013.

An SIS digital reversing thermometer broke, near the glass-metal seal, for no apparent reason, although the thermometers were a very tight fit in the new thermometer frames.

Cruise 59

Deep vertical casts, 21 in total, were made throughout the cruise every 3° of latitude. The equipment used was the same as for Cruise 58 except for three double casts where the new Neil Brown MkV CTD was deployed. The MkIIIb CTD performed without fault throughout the cruise. The fluorometer failed to work during cast CTD12v13, due to a faulty connection. The CTD pinger failed during two casts from low battery voltage.

The multisampler gave the same problems experienced on Cruise 58, but the misfires and double fires were generally confined to the first two bottles. A second reversing thermometer failed in the same way as that on Cruise 58. The thermometer frames were subsequently bored out to provide a better fit and no further problems were encountered. Due to the heavier swells experienced on this cruise, the high drag to weight ratio of the instrument package caused a number of cable failures . Although the sea-cable did not go open circuit, it became stretched and "bird-caged" under snatch loads. This is a problem that will need resolving before future cruises.

The MkV CTD worked without fault although its performance has not yet been examined in detail. The conductivity cell data was clearly reading much too low, but the reason has not been identified. Data from this instrument could not be logged directly by the RVS level A, so was copied from the CTD/PS2 to floppy discs and then transferred to the Sun system.

Although the CTD/PS2 system had worked without fault, it crashed on two occasions at the start of the upcast on the MKV stations.

TJPG, JS, DG, RNB, SK

TD Data Processing

CTD data were copied from the RVS ABC system onto the Sun darwin3 into PSTAR format. They were then processed in a standard manner by a series of command files containing PEXEC program calls. Information such as the station position and water depth, was entered into the PSTAR file header at the first stage. Next the data were calibrated. This included recently adopted corrections for pressure hysteresis, and the calculation of potential transmittance from the transmissometer data. Plots were then made of temperature, salinity, etc against pressure and temperature against salinity, for the full cast as well as for deep and shallow data. Any spikes in the data were then removed at this stage.

At the beginning of the cruise the whole of the cast was read into one file and then later split into an up and a down cast, to allow the final calibration from bottle data. This proved to be unsatisfactory since information from the downcast could be useful on the upcast in determining depths for firing spare bottles. Consequently, the command files were altered to allow the down cast to be dealt with separately once the CTD had reached its maximum depth.

RTP, SAC, MJG, SGA, RKL, SJB

CTD MkV Processing

Data for the MkV were taken from the CTD IBM PS2 and transferred to RVS' level C on a floppy disk. The raw data were read into RVS format by combining software written prior to the cruise by IOS and existing RVS utilities, then transferred to PSTAR using datapup as usual. No times were logged with the data so 'pseudo' times from previous CTD casts were merged with the RVS data to provide a timestamp. Once into PSTAR format, the cast was calibrated using the manufacturer's figures - only the pressure sensor temperature was not implemented fully due to lack of information about the form of calibration. No account was taken for hysteresis affects on pressure, again due to lack of data.

RP, MJG

CTD calibration

Each of the Mk IIIb CTD casts was accompanied by salinometer determinations of bottle samples from 24 or 12 depths. Oxygen calibration data were available at 24 depths for all casts except 12v11, 12v15 and 12v20 for which no oxygens were available.

Comparison of the salinometer values with the CTD data showed a systematic increase in the absolute difference with decreasing pressure for the up cast. This indicates either a pressure or temperature related effect which has not been taken into account by the calibration software and the phenomena deserves further investigation.

The calibration strategy used on board was to average the differences from all bottles fired below 1200 m. The resulting calibrations showed the instrument to have been stable to within 0.005 until cast 12v20 where the difference jumped to almost 0.01. The instrument appeared particularly stable between casts 12v04 and 12v19 inclusive.

RKL

THERMOSALINOGRAPH

The temperature and salinity of non-toxic supply of sea-water was measured by the Seabird thermosalinograph every 30 seconds. This was then calibrated to give the actual temperature and salinity in 24 hour sections corresponding to the period of the SeaSoar passages. Graphs of the two variables were produced to give surface data for the whole cruise.

To calibrate the thermosalinograph, the data were merged with the corrected surface data from the SeaSoar passages; (the SeaSoar reaching the surface approximately every 20-25 minutes for about 5 minutes). Salinity plots showed that the thermosalinograph gave values 0.03 with a standard deviation of 0.02 above the SeaSoar results, which was fairly consistent throughout cruise 58. The correlation of temperature between the two data sets was extremely close, within error bands of 0.01°C to a standard deviation of 0.009, except where the temperature changed very rapidly, e.g. crossing a front.

The data from the Seabird thermosalinograph having been verified to a high degree against the SeaSoar data can be used to produce a map of sea surface temperature across the cruise area.

PL

On Cruise 59 a slightly different approach was taken to handling the Seabird data set. The primary objective was to close the salinity calibration loop: non-toxic bottle salinities to Seabird to SeaSoar to CTD to CTD bottle salinities.

For each thermosalinograph leg between CTD stations approximately 20 salinity determinations were available. Contemporaneous, discrete, despiked thermosalinograph salinities were extracted, the mean differences obtained and the resulting calibration applied. The calibrated data were then merged with surface values from the appropriate SeaSoar leg and mean temperature and salinity differences obtained. The former was used as a temperature calibration for the thermosalinograph temperature channel whilst the latter represents the offset in the salinity calibration loop closure.

Two overall conclusions may be drawn from the results. First the Seabird thermosalinograph performed extremely well returning uncalibrated results for both temperature and salinity consistently within 0.02 and often much better. This was achieved despite the reduced precision resulting from the configuration of its connection to the ABC system.

Secondly, the salinity loop closure was shown to be an excellent quality control tool providing both a valuable internal consistency check on the SeaSoar salinity data and a useful aid in locating processing errors.

RL

SHIPBOARD ACOUSTIC DOPPLER CURRENT PROFILER

The RD Instruments 150kHz ADCP was in operation throughout the cruise. Neither the instrument or the IBM data acquisition system (DAS) gave any hardware problems. The DAS software had been upgraded to version 2.48 at Barry prior to the cruise. A new version of the firmware (version 17.07) was also installed, together with the associated hardware modifications. The firmware revision incorporates improvements to the water and bottom tracking. After these upgrades a bug soon became apparent - the DAS ReInitialize command would only work if the deck unit was switched on then off again. Whilst in port, the ADCP transducer unit was removed, inspected for corrosion and marine growth, then replaced. There was very minor barnacle damage to the front faces of the transducers, but they had not penetrated the thin urethane coating.

Whilst alongside, the ADCP heading was checked against the master gyro compass and the Magnavox satellite receiver. The ADCP indicated 0.1° low. The ADCP temperature sensor was also checked against the bridge hull temperature readout on the bridge - the ADCP showing 0.2° low.

The zig zag course technique was used to calibrate the ADCP whilst steaming at 8 knots on the continental shelf on passage to the first station. With the GPS position accuracy estimated at 7 metres rms, each leg of the zig zag was 20 minutes. The scaling factor (A) was 0.9956 with a standard deviation of .0030, a standard error of the mean of 0.0014. The alignment angle error (phi) was -0.68° with a standard deviation of 0.69°, a standard error of the mean of 0.31°. The deck officers maintained a log of gyro errors using star bearings, Table 5.

On leaving the shelf, the configuration was changed from 50 by 4 metre cells with bottom tracking to 64 by 8 metre cells with water tracking only. The ensemble average period was set to two minutes. No other changes were made to the configuration during the cruise. As the ADCP temperature sensor was functioning correctly, the auto scaling mode was selected for sound velocity correction.

A second calibration was made in deep water on passage to Ponta Delgada. The scaling factor was 0.9958 with a standard deviation of 0.0081, a standard error of the mean of 0.0036. The alignment angle was -1.2° with a standard deviation of 0.55°, a standard error of the mean of 0.25°.

The instrument performed very well, the only evidence for spurious shears in rough weather was when the ship was steaming into a 40kt wind, with 5 metre waves, when the near surface currents showed a ~20 cm/s under-reading in the direction of the ship's heading. Under such circumstances, the range decreased markedly, and the minimum AGC count increased substantially, indicating a high ambient noise level

The majority of the data processing for the ADCP was done using PSTAR command files. The ADCP data set was processed as two series: 'on station' covering periods of minimal ship speed whilst on CTD and net stations, and 'underway' covering SeaSoar runs and all associated course changes and manoeuvres. The first three processing stages were identical to previous cruises, the plotting options were enhanced to make full use of the Sun-Mac ethernet and the laser printer was used for all final ADCP plots. Final plots were also stored in Postscript format on disk in an attempt to speed up the production of data report figures.

A new interactive graphical editing program was developed to operate on the vector format plots of ADCP data used for quality control. Overplotting GPS and ADCP velocities allowed navigation fix errors to be identified. The high quality and almost 100% coverage of GPS made the determination of absolute currents much easier than on previous cruises, whilst also allowing a higher accuracy.

Obtainable ranges varied from in excess of 400 metres down to 100 metres, primarily related to the amount of scattering organisms present in the water column. The greatest ranges were achieved where the spring bloom was in progress - the lowest ranges were seen further south, where the bloom had ended, as shown by the chlorophyll measurements and zooplankton net hauls. The ADCP backscatter strength estimates clearly showed diurnal migration, and enhanced scattering near fronts and eddies.

Colour contoured cross track velocities were plotted for the periods of the SeaSoar runs, with the same averaging scheme - 12 km averages, 4 km apart. The correlation between the ADCP currents and the density structure was striking. In general, the currents showed little shear, the features extending to beyond the depth range of the instrument.

Whilst on station the ADCP velocity measurements showed lower scatter than whilst underway. During some stations, depending on wire angle, there was interference from the CTD wire. The errors were not always easily seen on the velocities, but could be seen using a pseudo-vector plot of the error and vertical velocities.

GG, SGA

EMLOG CALIBRATION

The two component em log was calibrated using the data obtained during the zig zags performed for ADCP calibrations. Whereas this method is much more efficient in terms of ship time over the traditional 'measured mile' or acoustic ranging methods, it does have limitations in that the same calibration is assumed for the fore/aft and port/starboard components, it also assumes that there is no zero offset. The errors introduced by these assumptions are minimised (for SeaSoar surveys) by performing the calibration at the operational speed.

For the first calibration, eight points were obtained for the amplitude scaling factor and the pointing angle error. The mean scaling factor was 0.9805 with a standard deviation of 0.0049, giving a standard error of the mean of 0.0035. The mean pointing angle was -0.26° with a standard deviation of 0.69°, giving a standard error of the mean of 0.49°. These calibration factors were applied to a reworked RVS relmov file to obtain surface currents. The original file was not altered to avoid any problems with changing the distance run used for SeaSoar and ADCP processing.

For the second calibration on the passage to Ponta Delgada the mean scaling factor was 0.9752 with a standard deviation of 0.011, giving a standard error of the mean of .0055. The mean pointing angle was -0.18° with a standard deviation of 0.68°, a standard error of the mean of 0.34°. For Cruise 59 a mean calibration was used, A=0.9778 and phi=-0.22°.

GG, MJG, SAC

NUTRIENTS

Discrete samples were taken from the non-toxic supply every 30 minutes during the cruise and, together with duplicate samples from each of the individual Niskin bottles fired during the CTD casts, analysed for concentration of silicate, phosphate and nitrate.

The analysis was performed simultaneously using an Alpkem continuous flow analyser. Due to previous instability in the duplication of silicate measurement, the channel had been recently modified to include temperature stabilisation which greatly improved the performance of the analysis and only minor operational problems were experienced. The nitrate chemistry worked particularly well, the open tube cadmium reactor maintained full reduction without reactivation during the entire cruise. Several problems were experienced with the phosphate analysis. Baseline shifts associated with complex coating of the flowcell and cartridge tubing sometimes made calibration difficult, and some analyses had to be repeated. However, on the whole, replacement of all PVC tubing on the cartridge led to problems of this nature being reduced to a minimum.

Despite the problems associated with the phosphate line, the results obtained showed a notable improvement. The standard deviation for duplication was 0.07µmol/l for silicate, 0.06 for nitrate,and 0.01 for phosphate. This equates to 0.3%,0.45% and 0.8% full scale reproducibility respectively for each of the analyses.

On Cruise 59 discrete samples were taken from the non-toxic supply every 30 minutes and stored in the refrigerator prior to analysis. Duplicate samples were taken from each of the individual Niskin bottles fired during the CTD casts- on the occasions when two CTD casts were performed, using each of the Mk III and Mk V CTD units, nutrient samples were drawn from the second cast only (first cast only sampled on 2 June).

Problems were encountered with the nitrate chemistry with a loss of sensitivity which necessitated an increase in gain on the sample channel. Baseline drifts on the phosphate line continued but were largely controlled by prolonged wash through and frequent replacement of the PVC tubing on the cartridge. The silicate chemistry continued to work well.

The reproducibility was on the whole poorer than on Cruise 58. The standard deviation for duplication was 0.05µmol/l for silicate, 0.18 for nitrate, and 0.02 for phosphate. This equates to 0.19%,1.46 % and 1.49% reproducibility full scale respectively for each of the analyses. This may have been due to deterioration of the light source which completely failed on 4 June. Attempts were made to improvise a light source but failed to reestablish a gate cycle. The analysis of nutrients from station 12017 onwards and surface samples after 2 June was not carried out onboard. Sample collection was continued for future analysis, despite studies of sample storage (carried out both on board and in an earlier study) which suggest poor reproducibilities resulting from the freezing of nutrient samples.

RP, SEH, MRP

OXYGEN DETERMINATIONS

During the cruise discrete samples for dissolved oxygen analysis were taken in duplicate from the 24 Niskin bottles fired on each CTD cast. Samples were pickled on deck immediately after drawing and before capping.

The methodology adhered closely to the Carpenter modification of the Winkler technique, and the analyses were performed using an automated photometric endpoint detection system consisting of a solid state light source and photodiode detector peaked to the iodine signal, a Metrohm dossimat, and a PC and software supplied by Sensoren Instrumente Systeme.

Since the equation used in the software and the suggested blanking procedure were not consistent with Carpenter's original method, all titre volumes were substituted into the equation specified by the WOCE operations and methods manual. Blanking was performed using pure water and not seawater to avoid differences due to depth and position. A buoyancy factor was applied to the weight of the potassium iodate standard, since the normality of Carpenter's original standard was 0.025% higher than the nominal value.

The equipment worked well throughout the cruise, and the reproducibility of the oxygen measurements (two times the standard deviation) was calculated to be 0.0065 ml/l. This equates to 0.1% of the highest oxygen concentration encountered.

RP, SEH

On three occasions during cruise 59 two CTD casts were performed at a location using each of the Mk III and Mk V CTDs. On these occasions oxygen samples were drawn from the second cast only.

The oxygen measuring system generally performed well and once accustomed to the exacting requirements of the system good reproducibilities were normally obtained between duplicates. However, about two thirds of the way through the cruise a problem of erratic reproducibility became apparent. As a relatively inexperienced operator (MRP) it was difficult to show that it was a machine trouble rather than handling errors. Eventually however the problem exceeded even the most pessimistic assessments of operator error and it was necessary to consider a machine problem as the most likely cause. It could also be seen by eye that the titrator was (in some cases wildly) missing the correct end point. In the absence of any guidance it was fortunate that John Smithers recognised the symptoms as similar to something that he had experienced with this system before. Adjustment of both the light and dark current settings immediately restored the reproducibility. A further readjustment was required a few days later, after which the system then behaved perfectly.

The difficulty seems to be that there are threshold settings above or below which the titrator does not accurately detect the end point. These values appear to be below about 8 (dark current) or below 30000 or above about 31600 light current. The existence of this upper threshold was unexpected and should perhaps be further investigated in the laboratory.

A further aspect that I believe should be investigated in the laboratory is the accuracy of the reagent dispensers. Rather rough and ready observations using measuring cylinders suggested that the Anachem dispensers were providing more that the set amounts; possibly as much as 10%. This will not affect the precision of the analyses provided the amount dispensed is constant, but will influence the accuracy. I have also to say that I was also not particularly impressed with the Labindustries Micropipettor which I found extrordinarily difficult to fill without the inclusion of air bubbles. I would strongly suggest that all the dispensors are subjected to a proper gravimetric calibration so that any inaccuracies/inconsistencies can be appreciated.

On one occasion (CTD12v19), rough weather prevented immediate analysis of the samples and they had to be stored overnight under water and in the dark until conditions improved. Although not easy to assess, it does not appear that any serious discrepancies arose from this enforced storage. As a further development it would be worth building secure racks for the reagent dispensor bottles for use both on deck and in the laboratory so that analyses can be performed safely under adverse conditions.

The overall mean difference between duplicates was 0.010ml/l which was somewhat poorer than had been obtained on Cruise 58 and was due to the combination of operator and instrument problems outlined above. Despite the problems encountered and described above there is no doubt that the available system is capable of producing very high quality data and will form a very sound basis for oxygen probe calibrations and more fundamental studies.

As a postcript, there appears that there may be discrepancies between the equations actually used for calculating the oxygen concentrations on the first and second legs. Without hardcopy or computer storage of the calculations used on the first leg, it was not possible to be sure of this and the data need to be carefully checked on return to the laboratory and before it is irretrievably entered into calibration data files.

MRP

CHLOROFLUOROCARBONS

Cruise 58

Water trapped in Niskin bottles was sampled for the determination of dissolved Chlorofluorocarbon gas concentration. The technique, used for the first time on this cruise, allows analysis of three CFC compounds : CFC-11, CFC-12 & CFC-113. A routine was established rapidly with 14 Niskin bottles being sampled by ground glass syringes (with about 200ml used per bottle;

the CFC sample was always the first to be taken). A unique instrument, developed at the PML, employing high resolution capillary Gas Chromatography and Electron Capture Detection was used to remove dissolved gases from the seawater sample, separate these species, and measure their concentrations. A standard gas containing known mixing ratios of each compound of interest was used to calibrate the ECD. Samples of marine air were also regularly taken and analysed.

Making measurements of volatile gases dissolved in seawater at concentrations of 1-2 picomoles per litre, with a desired precision of less than 1% is never easy. The main danger is contamination of pieces of the sampling apparatus; the Niskin bottles and the syringes. These items were intensively prepared before the ship sailed, and for the first few casts no problems were encountered with contaminated samples (although the instrument typically requires 7 days to settle down after transportation; and this cruise was no exception). Occasional problems with CFC-11 were noticed from that time on. Initially, they were eliminated by a programme of syringe treatment every third cast. However, for the last five days of cruise 58 the CFC-11 problem spread to nearly every sample analysed. After treating both the syringes and the exposed parts of the Niskin bottles, the problem was eliminated for the last CTD station. Nevertheless, during these contaminated casts, CFC-12 & CFC-113 remained free of polluting sources, and replicate observations frequently showed better than 1% reproducibility. Another problem involved variability in standard injections and reduced CFC-113 peaks. This was resolved eventually, and it is believed that casts previous to this can be straightforwardly corrected. This cruise also revealed several invaluable lessons about measuring CFCs aboard Charles Darwin, about the nature of likely contamination and appropriate remedies.

Cruise 59

The same techniques used for dissolved CFC determinations on Cruise 58 were continued for Cruise 59. Every cast was sampled apart from station 12020.

The problem encountered with CFC-11 contamination on the first cruise recurred in the same way shortly after sailing from Ponta Delgada. The intensive treatment of Niskin taps, syringes, syringe taps and syringe container allowed the problem to be moderated, although rarely with 100% success, and for short periods of a couple of days only. It was evident that there is a potent CFC-11 source on board, and this was located eventually as the air conditioning plant room just forward of the amidships winch. The door to this space was opened and closed at irregular intervals by ship's engineers. With this puzzle resolved, the quality of CFC-11 observations improved consistently, although some Niskin bottles appeared to be permanently contaminated and occasional wildly stray measurements persisted.

In general, the quality of measurements improved during the second cruise as the Gas Chromatograph became increasingly free of trace contaminants. Several causes of variability in the analytical technique were identified and eliminated. In particular the precision of replicate standard runs was increased and a consistent method for sampling marine air was developed allowing considerably better results to be achieved. A series of standard gas mixtures were analysed in order to recalibrate the standard cylinder used routinely.

TWH

MEASUREMENTS OF THE CARBONIC SYSTEM

The knowledge of carbon dioxide interchange between the air and the ocean, as well as its distribution in the sea, is of special interest in order to improve the understanding of increasing carbon dioxide in the atmosphere and its climate effects.

The responsibility of the Spanish team on Cruise 58 was to carry out measurements of pH and alkalinity.

In addition to the CTD cast samples at all levels, surface samples were taken each half hour to determine pH, in order to calculate the pCO_2 of the surface seawater over a wide area.

A Metrohm 654 was used to determine pH with a ROSS combination glass electrode (Orion 810400). The calibrations were conducted with 7.413 NBS buffers taking Nernstian slope. The temperature was measured at the same time with a Pt-100 resistance thermometer which allows the correction of the pH according to temperature. All pH values are refered to 15°C.

A pH meter (Metrohm E-510) with a separate glass electrode (Metrohm 6.0102.000) and a reference electrode (ground glass sleeve junction, Metrohm 6.0726.100) connected to an automatic burette (Metrohm E-415) and an impulsomat (Metrohm E-473) was used to measure the alkalinity by carrying out potentiometric titrations with HCl to a final pH of 4.44. This method of determining alkalinity has a precison of 0.1%. The electrodes were standardized using 7.413 NBS buffer taking Nernstian slope and checking this with a 4.008 NBS buffer. Total inorganic carbon and pCO_2 were calculated using the equations of the carbonic system with published carbonic constants.

AFR

SALINITY

The measurement of salinity samples, taken from the CTD casts and surface sampling was carried out using two Guildline Autosals type 8400 (old) and 8400A (new). Initially, 12 duplicate samples were taken on the CTD casts. These proved very consistent even between salinometers, so that later, only one sample was taken from each of the 24 bottles. The salinities were also used to help determine bottle firing depths. Surface salinity samples were taken every hour when underway for SeaSoar and thermosalinograph calibration.

The two Autosals were located in a controlled temperature laboratory set to 20°C. The 8400 soon developed a leak in the viewing window and a repair was attempted, but after refilling it still leaked. A second attempt was made while underway, and this proved successful. This Autosal gave good results initially, but later the values became very unstable, the flow rate was reduced slightly and the discharge tube repositioned. Although the readings were then more stable, the problem returned later. It was thought that mains-borne interference may have been the cause, so an Uninterruptible Power Supply with internal filters was used. This seemed to work at first, but as the interference was very irregular, the power supply made no difference. As the machine was used, the readings became more stable, and usually only affected the first few readings or none at all, but the instability never completely disappeared. Overall this Autosal produced good, accurate and repeatable results. The new Autosal 8400A gave stable readings, but there were problems with small air bubbles getting trapped on the electrodes. Also, at one place in the cell, the water frequently stopped and only passed with difficulty. Perhaps the cell was a little greasy. Finally, a large air bubble was trapped around the lower current electrode (i.e. third from left). The cell was removed from the tank and the air vent tube was blocked with water droplets. To clear the fault would involve the cell assembly to be completely stripped down. As the old Autosal was working well this was not attempted.

On Cruise 59 the old Autosal proved very reliable and the Standard Sea Water calibrations were generally within 1ppm between the start and end of a set of 24 samples. Towards the end of the cruise a bubble would sometimes form around the second electrode, but was always easy to clear.

PKS

BIOLOGICAL SAMPLING

Chlorophyll

Three fluorometers were used for monitoring purposes on the cruise: SeaSoar (z/t profiles), CTD (depth profiles) and wet lab (surface chlorophyll). Each produces a logged voltage based on the fluorescence of chlorophyll passing through the instrument. By taking appropriate water samples, extracting chlorophyll in acetone and passing the solution through a fluorometer calibrated against standards (positioned in main lab), the necessary calibration for each instrument can be derived.

Chlorophyll samples were taken approximately hourly from the non-toxic supply in the wet lab. When possible, these were timed to coincide with water passed through by the SeaSoar when it was at the surface (calculated as a function of ship speed, cable length, SeaSoar cycle time and the time it takes water to be pumped to the wet lab). The measured chlorophyll content of these samples was then used to calibrate the SeaSoar and wet lab fluorometers. Samples taken from CTD bottles (17-24) on cruise 58 were used for the CTD calibration (19 - 24 on cruise 59)

A master calibration file was maintained storing the following data for each wet lab sample: time, extracted chlorophyll measurement, fluorescence logged by wet lab and SeaSoar fluorometers, and PAR measured by both SeaSoar and mast radiometers. Surface fluorescence and PAR at the calibration points were taken from one minute averages of 10 second data. SeaSoar data was averaged over the top 10m at the relevant turning points. From the data, the following models were fitted for each instrument:

SeaSoar:	chl = exp(1.3774V) - 1.2278
CTD:	chl = exp(1.0366V+0.2580) - 1.9557
wet lab:	chl = 2.978V - 0.32

where chl is chlorophyll-a (mg m^{-3}), and V is logged voltage (volts,or arbitrary units in the case of the wet lab fluorometer). All these calibrations used samples taken under dark conditions only to reduce any effects of fluorescence quenching. They serve as nominal calibrations for each instrument. It had been hoped to additionally provide more detailed forms of these calibrations, allowing for regional and light induced changes in fluorescence yield, but time did not permit.

The two mast radiometers used to measure surface PAR and the SeaSoar radiometer were 2 pi PAR meters with the following calibrations supplied by the PML.

$$PAR = \exp(a+bV),$$

where PAR is in μWcm^{-2}, V is output voltage in mV, and a and b are as follows for each instrument.

	serial no.	a	b
port radiometer	4	7.2376	-0.005139
stbd radiometer	9	6.7874	-0.005052
SeaSoar radiometer	20	6.9495	-0.004975

The mast radiometers were connected in the opposite sense to which they were originally calibrated and so b was negated when applying the calibrations. They were not fitted with cosine collectors so, although they were calibrated using an irradiance source, they were measuring incident radiation over a hemispherical surface and not downwelling irradiance. The data is considered suitable for use in calibrating surface fluorescence but care should be taken in any comparison with other data sets where downwelling irradiance was recorded. The port radiometer only was used to generate surface PAR data for the calibration data set as the starboard radiometer failed early in the cruise.

Unfortunately, the calibration of the main lab fluorometer.was somewhat suspect: the machine itself may have been misbehaving, or the standards used to calibrate it may have been inadequate. During the first part of Cruise 58, 10ml of extracted solution was used in the cuvette; it was discovered that 20ml was more appropriate and the fluorometer was recalibrated midway through the cruise. As a backup, therefore, towards the end of Cruise 58 numerous filtered samples were kept frozen in millipore petrislides for analysis back on land. A shortage of acetone also meant that samples had to be frozen towards the end of Cruise 58.

At the start of leg Cruise 59 the main lab fluorometer was calibrated while in port using the new standards brought out from the UK. Differences between the Cruise 59 calibration and the final calibration from Cruise 58 using the stored standard were insignificant and easily attributed to differences in the standard as supplied by Sigma who only guarantee the accuracy to 5%. The calibration of the main lab fluorometer gave values of Fd = 0.05 and Fb/Fa of 2.101. Equivalent values from Cruise 58, using the stored chlorophyll standard, were Fd = 0.0497 and Fb/Fa of 2.1! Thus there was no need to modify data from Cruise 58 which had been calculated using the final calibration.

The new values for Fd and Fb.Fa were incorporated into a file, sssurfcal59, to enable a calibration exercise to be run until the PSTAR processing was up and running. Using only the dark values, and calibrating on a daily basis, the fluorescence yield was shown to remain fairly constant until we crossed the Polar front when it changed by a factor of around 3. During station 12017 on 4 June, the sink in the wet lab became blocked and caused serious flooding over the bench. This resulted in the wet lab fluorometer being flooded and we had to replace it with a spare, a Turner 111. This was set up with the flow-through door and connected into the level A computer logger. Surface chlorophyll a values reached a peak at about 10.6 mg/m-3 on 24 May (which we found hard to believe until we ran that evening's plankton net which was like pea soup)! Sub-surface values were even higher. The peak in chlorophyll was very dramatic, from <1 to over 10 mg/m^{-3} in a very sharp peak. This peak coincided with crossing the Polar front. There was little detectable signal from the fronts crossed previously on leg W. From the ADCP data, an increase in biomass apparently occured at the previous front but it is probable that the strong diurnal signal from vertically migrating zooplankton confused the picture.

The shortage of acetone led us to decide that we would concentrate on SeaSoar calibrations and freeze CTD samples for later analysis at the laboratory. However, an extra 7 litres of acetone were obtained from Sue Holley and it was decided to analyse some of the CTD samples for two reasons;

1) to provide near real time information on subsurface chlorophyll levels (since the existing calibration was suspect) and to compare these values with the calculated SeaSoar chlorophyll, and

2) to provide information on any changes occuring due to storage. In addition, several samples were filtered and frozen for High Pressure Liquid Chromatography analysis giving us further information on storage and on the accuracy and precision of the measurement of chlorophyll by fluorescence.

Bacterial Sampling

The objectives of the bacterial sampling programme were:

1) to follow surface changes in bacterial abundance and relate those changes to changes in the hydrography of the region and to surface chlorophyll values

2) to test the effect of storage in different bottles and the efficiency of using sonication to recover cells from the bottle walls.

On Cruise 58 a total of 25 bacteria samples were collected, all on the 20°W transect.

During Cruise 59 samples were taken hourly during the crossing of the Polar front, during the 20°W section and during the 15°W section. Those taken on the 20°W section will give information on interannual variability of bacterial abundance since a similar section was sampled during the 1989 BOFS programme.

Preserved Samples

Lugol's samples were taken, for phytoplankton identification, from the bottle nearest the surface, on every CTD station except 11v01, 11v02,11v03, 11v04, 11v16 and 12v10. Stations 12v12, 12v16, 12v17 were duplicate stations to test the Mk V CTD and were not sampled. The dominant species of phytoplankton will affect the fluorescence yield of the fluorometers. An additional sample was collected and stored in glutaraldehyde (1%) and formalin (5%) on 30 May, after station 12v11, to check for coccolithophores. The sea was very milky which is often an indicator for high concentrations of coccolithophores due to their reflective coccoliths. Coccoliths are constructed of calcium carbonate and dissolve in the acidic Lugol's solution.

Zooplankton samples:

A zooplankton net (55cm diameter) was successfully dropped to 100m immediately after the CTD was brought back on board at each station. Samples were emptied into jars with 10% formalin, for identification and counting back on land. A wide variety of catches was obtained, ranging from very large numbers of copepods early in the cruise (during the phytoplankton bloom), to a dominance of salps and an almost complete absence of copepods during the post-bloom phase.

On Cruise 59 In order to provide more points to compare with the ADCP data, an additional net was taken from deeper levels, usually 300m with two to 450m, during the daytime casts. The ADCP showed a deeper layer of acoustic scatterers during the day. The differences between the two hauls were seldom as pronounced as the AL CP trace would suggest. One possible explanation for this is that crustacea, which may be the dominant scatterers, are able to avoid the net. However, on station 12015, the 300m catch filled three jars with Jellyfish! On that day several pods of pilot whales stayed close to the ship. At the start of the second leg there was a problem with the nets, as, during the Cruise 58 the ship had been positioned beam onto the wind out of caution to prevent the net getting caught round the propeller. This resulted in very high wire angles and so probably hauls of less than 100m. On Cruise 59 we managed to persuade the deck officers to try keeping the ship hove to on the bow thruster. This worked really well in the conditions we had and wire angles after our first cast were very good.

TRA, MWS, JCPH

SURFACE METEOROLOGY

The equipment for surface meteorology equipment consisted of three systems: Multimet for mean meteorology, a fast sampling system for wind stress measurement and the shipborne wave recorder.

The Multimet system had the following sensors connected to it:

	Sensor	**Location**
1	Short Wave Radiation	Fore mast, port side
2	Psychrometer	Fore mast, port side
3	Propeller & Vane Wind Velocity	Fore mast, port side
4	Psychrometer (with radiation shield)	Fore mast, port side
5	Long Wave Radiation	Fore mast, top
6	Short Wave Radiation	Fore mast, stb side

7	Psychrometer	Bridge top, port side
8	Psychrometer	Bridge top. stb side
9	Wind Direction	Main mast, top
10	Wind Speed	Main mast, top

The raw data from the Multimet system are stored internally on EPROM and sent to a BBC Master computer for conversion to physical units and for graphical and tabular display. The raw data were also sent to the RVS ABC system for further processing. Plots of the calibrated data were produced daily for all of the sensors.

The position of the two psychrometers on the fore mast obscured the foremast light, and so they were lowered by 0.30m. The Multimet system stopped logging data to the internal EPROMs when the first board was full. When the SETUP program was run, the configuration was found to be set to one board, when reset to three boards the logging restarted. On some days there was a pronounced difference between the two short wave radiation sensors, perhaps due to one being in shadow.

During Cruise 59 the Long Wave Solarimeter signal became very noisy, either due to a sensor or amplifier fault. Further investigation of the fault was not possible due to heavy weather making the foremast inaccessible.

The fast sampling system consisted of a 3-axis sonic wind speed sensor on the fore mast port side and an NEC portable computer. The horizontal wind speed is spectrally analysed and the results stored on the internal hard disc. The internal clock gained some 12 minutes during Cruise 58, and the hard disk failed towards the end of Cruise 59.

The shipborne wave recorder derives values for significant wave height when the ship is on station. It consists of sensors mounted in the engine room and an NEC portable computer performing spectral analysis and smoothing with the results stored on the internal hard disc. The system worked well, though a display or printout of the wave measurements would have been useful.

PKS

NAVIGATION

Because of the high quality GPS data available almost continuously throughout the cruise, navigation data processing was based entirely on this satellite system. The RVS program 'bestnav' was run continuously to combine GPS, EM log and gyro data to give positional information once every 30 seconds. This data was then copied regularly into PSTAR format and appended to a master navigation file for use in other processing. Each portion was also smoothed using a 'top hat' filter of 15 minutes duration and appended to another file of smoothed navigation. The latter was used in the ADCP processing to calculate absolute velocities.

One problem encountered in the running of bestnav was that when the Sun darwin1 was rebooted the program reset the distance run variable to zero. The simplest way to get around this was to rerun the program from the start of the RVS navigation files.

GPS

Whilst the ship was at port for the days prior to the cruise, GPS position data was recorded at RVS in order to estimate the accuracy of the fixes, the procedure was repeated whilst at Ponta Delgada. As the system has not yet been declared operational, the position accuracy for commercial users is controlled by the US Department of Defense through Selective Availability (SA) and AntiSpoofing (AS). However, these methods of degrading the position fixes were apparently not implemented over the period of the cruise. The standard deviation of 1515 fixes whilst at Barry was 7 metres in both latitude and longitude, while for 1048 fixes in the Azores, the standard deviation averaged 6 metres.

Estimating accuracy at sea

Directly estimating the accuracy of GPS whilst at sea is difficult. However, an upper bound to the error can be obtained by examining the absolute currents from the ADCP whilst on station. The absolute currents are obtained using the velocity over the ground of the ship from GPS positions and the velocity of the water relative to the ship from the ADCP. If we assume that the observed current fluctuations can be ascribed to GPS position error alone, then an upper bound to the error can be estimated. For example, on station CTD11v07, the standard deviation of 15 minute averaged currents was 4 cm/s. The mean ship drift over the station was 2.7km in 3.75 hours or 20 cm/s, a displacement of 180 metres in 15 minutes. Applying the (4 /1.414) cm/s variation to each track endpoint, the maximum position error is:

$$((4/1.414)/20)*180 = 25 \text{ metres.}$$

Availability

Over the period 26 April to 8 June, there were only 65 gaps of greater than 5 minutes in the GPS coverage. Of these, only 23 were greater than 10 minutes, the maximum gap being 23 minutes. These gaps do not include periods when only two space vehicles were in sight, with the third reference supplied by the rubidium clock. However, periods of only two space vehicles amounted to only 10%.

GG, SGA

COMPUTING

The upgrade to the Charles Darwin computing system was completed prior to this cruise. In line with the other ships in the NERC fleet, the previous three Sun3 workstations have now been replaced with Sun4's, with a consequential increase in processor power of about three. As a result, the layout of the system has changed such that one workstation is now capable of supporting the RVS processing suite leaving the other two available for ship users.

As Discovery is currently out of commission, some of her computing system was also installed, boosting the complement of computing equipment for the cruise to 4 Sun4 workstations, around 2 Gigabytes of disk space, 2 screen dump plotters, 1 drum plotter, 1 flat-bed plotter, 3 printers, 6 tape backup devices and an IBM PC. The Ethernet linking the workstations was extended to include the 4 Apple Mackintosh's and 1 Postscript laser printer brought on board for the cruise. These were capable of accessing all the data on the network.

During the cruise, data were collected from the following instruments; Emlog, Gyro, Transit Satnav, GPS, Multimet, ADCP, SeaSoar and CTD, 2 PAR lightmeters, Seabird Thermosalinograph, Turner Fluorometer and Echo sounder.

The RVS workstation was run with its own operating system. Access to its data and programs by the other workstations was on a read-only basis. The only processing required was for navigation as the rest was done using PEXEC; however, during the time SeaSoar was deployed, the data were processed and a bandplot displayed in the main lab. The GPS produced virtually 24 hour coverage with a positional output every minute. The final navigation data were interpolated to 30 seconds using corrected dead-reckoning. The other 3 workstations were configured such that one of them (a server - darwin2) supported the other two (as clients - darwin3 and 4). Each client had its own local data disk to reduce the amount of data being transferred across the Ethernet. Parts of the RVS disks were mounted across the network to give the users access to the data. This was the first time this setup had been fully tested and it seemed to overcome many of the problems encountered during previous cruises.

Tasks were divided between the two ship user workstations - the first was used primarily for retrieving and processing data from the RVS level C. Once worked up to a satisfactory level data were copied to the second workstation where plotting and further processing was carried out. To keep Ethernet traffic to a minimum the two stations were not cross mounted, which meant that data from one machine could not be viewed from the other - they had to be copied across. Keeping track of current versions proved tricky towards the end of the cruise. It would be a useful test to try cross mounting both stations to see how much this affects the Ethernet traffic, and improves the data handling.

MB, RP, MJG, SGA, SAC

ATMOSPHERIC SAMPLING

Two atmospheric sampling systems were installed on the small deck forward of the PSO's cabin for use on Cruise 59. These consisted of a high volume filtration/semi-volatiles sampler and a six stage cascade impactor unit both made by Anderson Sierra Instruments and enclosed in a water resistant wooden box which could be sealed when adverse conditions were encountered.

The units were operated when stable winds from ahead of the sampling position were present. Unfortunately for a significant part of Cruise 59, particularly the first half, the wind was from astern thus reducing sampling time. Nevertheless some 150-200 hours of sampling time was obtained resulting in a useful set of samples. This will be carried back to Liverpool University for analysis for hydrocarbons and PAH, using GC and GC-MS techniques.

At an early stage in the cruise an event occured which caused some contamination of the units. This was due to the high volume pumping system being turned on whilst the box was closed. Investigations showed that a timing switch, previously removed, had been reinstalled during the pre-cruise assembly operations. Removal of the switch and thorough cleaning of the unit has, it is hoped, restored the proper situation. However, the truth of this will not be known until the samples are analysed.

MRP

MACSAT

After the initial setting-up of the Macsat system, great difficulties were encountered in receiving clear signals from passing polar orbiting satellites. A fault finding search led to the re-positioning of the VHF antenna, as the signal was being masked by the ships own large VHF transmitting aerial.

Once the antenna had been re-sited, the quality of images vastly improved. The signal strength received from the satellite was typically less than 0.5 on the Macsat receiver scale (until ~15°W when the signal strength increased to +1.2.). This poor signal resulted in signal drop outs and broken images. Very few NOAA 11 or 9 images were received and the majority of the data were from the Russian Meteor series of satellites. Images from NOAA 10 were obtained successfully.

However, owing to blanket cloud covering most of the cruise track, few useful infra-red images to give a false colour representation of sea-surface-temperature were obtained. The visible portion of all NOAA satellite images was also much improved, though the infra-red view retained a low contrast (images of a clear Mediterranean really cheered us up). The further west and south the cruise went, the worse the image reception from the NOAA family of satellites became, possibly due to further interference problems. The Soviet Meteor satellites although of good quality were variable in their output, being either visible or infra-red, and even upside-down with no land in view! Positional registration of images was very approximate (~100 km) relying on the satellite orbit characteristics predicted by Macsat.

The images that were found to be of interest were further processed on the RVS Sun darwin2 using the ALV image processing software. This was superior to the Macsat processing tools, giving a better picture and better control of the image processing routines. All good images were processed and the raw signal saved and kept on audio cassette, so that the other half of NOAA images could be re-captured.

PFL, CJD

RVS ENGINEERING

The Simrad echo sounder performed well throughout, for both underway surveying and the CTD stations. The Simrad being more sensitive than the PES Mk IIIB and the ability to expand the range is a great benefit when tracking the CTD pinger near the sea bed. During Cruise 59 some time was spent displaying the top 1000m with a gain of 30logR to study the plankton scattering layer, this proved to be very interesting and also confirmed the need for a higher frequency channel (38-49kHz). This channel would be used for both high resolution continental shelf surveys and for studying in greater detail the scattering layer.

The ADCP transducer housing requires a permanent method of bleeding the air from the transducer without having to dismantle the ship to get at the housing.

The CTD winch ran trouble free after initially overhauling the braking system as a linkage had seized. The wire had to be reterminated several times; usually due to the wire going slack and suddenly going tight again. This was caused by the large surface area of the CTD package and a comparatively low weight in water; with a bad roll, it would still do this at 300 metres. The wire was also becoming damaged where it went round the small diameter roller on the outboard side of the spooling gear during deployment.

The SeaSoar winch was modified to enable the cable to be spooled onto the drum without continuous manual adjustment of the parked fairing. A crossbar was fabricated and fitted to the aft block containing a wide-throated sheave and tied off via pulleys to the main "A" frame base. This prevented the block from damaging the faired cable through the cable twisting when the SeaSoar was being deployed or recovered.

The inside edges of the RW3 plankton net winch drum flanges need a radius machined or ground on them to prevent the sharp edge abrading the line.

We had a surprise wave find it's way into the air gun workshop on one occasion; it then became apparent that the drainage pipe down to the scuppers is too small to cope with this kind of drama.

RP, ARC, GRW

TABLE 1

CTD stations Cruise 58

Vivaldi reference	Station	Start date	Start time	Down time	End time	Latitude	Longitude	Depth of cast (dbar)
	CTD11v01	26/4/91	1047	1109	1123	48 37.1'N	09 21.7'W	140
	CTD11v02	26/4/91	1415	1437	1452	48 28.0'N	09 46.8'W	192
B48	CTD11v03	27/4/91	0314	0516	0712	47 30.0'N	11 59.6'W	4686
B45	CTD11v04	28/4/91	0410	0524	0704	44 53.4'N	12 16.8'W	2790
B42	CTD11v05	29/4/91	0636	0847	1112	42 00.0'N	12 44.9'W	5090
A42	CTD11v06	30/4/91	0306	0516	0734	41 58.5'N	16 22.1'W	5024
A45	CTD11v07	1/5/91	0655	0842	1044	44 59.2'N	16 11.3'W	4365
A48	CTD11v08	2/5/91	0847	1047	1317	48 01.4'N	15 59.1'W	4820
Z48	CTD11v09	3/5/91	0927	1058	1247	48 00.5'N	19 59.8'W	4384
Z45	CTD11v10	4/5/91	1320	1451	1631	44 59.7'N	20 00.5'W	4374
Z42	CTD11v11	5/5/91	1617	1709	1815	42 01.4'N	19 56.2'W	2841
Z39	CTD11v12	6/5/91	1853	2018	2212	39 00.2'N	19 57.4'W	4677
Y39	CTD11v13	7/5/91	1925	2036	2205	38 59.1'N	23 28.2'W	3909
Y42	CTD11v14	8/5/91	2125	2231	2357	42 01.1'N	23 37.7'W	3650
Y45	CTD11v15	10/5/91	0039	0140	0250	44 59.7'N	23 48.4'W	3217
Y48	CTD11v16	11/5/91	0231	0345	0519	48 00.2'N	24 01.8'W	4040
X45	CTD11v17	13/5/91	1115	1157	1300	45 05.6'N	27 38.1'W	2461
X42	CTD11v18	14/5/91	1331	1424	1536	41 59.1'N	27 06.0'W	2937
X39	CTD11v19	15/5/91	1413	1454	1549	39 10.2'N	26 43.3'W	2370

TABLE 2

CTD stations Cruise 59

Vivaldi reference	Station	Start date	Start time	Down time	End time	Latitude	Longitude	Depth of cast (dbar)
W39	CTD12v01	19/5/91	0833	0915	1006	39 00.7'N	30 25.8'W	1789
W42	CTD12v02	20/5/91	0750	0830	0932	41 59.9'N	30 52.4'W	2219
W45	CTD12v03	21/5/91	1211	1311	1423	45 00.3'N	31 27.4'W	3185
W48	CTD12v04	22/5/91	1346	1501	1647	48 01.1'N	32 06.0'W	4061
W51	CTD12v05	23/5/91	1641	1807	2001	50 44.4'N	32 50.3'W	4161
W54	CTD12v06	24/5/91	2256	2350	0101	53 59.4'N	33 45.0'W	2556
X54	CTD12v07	25/5/91	2147	2248	0006	53 59.6'N	29 11.3'W	3043
X51	CTD12v08	27/5/91	0125	0238	0416	51 05.4'N	28 07.0'W	3694
X48	CTD12v09	28/5/91	0544	0652	0811	48 00.2'N	28 31.1'W	3070
Y48	CTD12v10	29/5/91	0725	0843	1029	48 00.0'N	24 02.6'W	4065
Y51	CTD12v11*	30/5/91	1103	1222	1359	50 59.5'N	24 37.2'W	4014
Y51	CTD12v12	30/5/91	1537	1657	1838	50 59.5'N	24 38.3'W	3956
Y54	CTD12v13	31/5/91	1738	1840	1959	54 00.0'N	24 34.9'W	3350
Z54	CTD12v14	01/6/91	1514	1605	1707	53 59.9'N	20 19.6'W	2667
Z51	CTD12v15	02/6/91	1700	1830	2014	51 00.3'N	20 38.7'W	4469
Z51	CTD12v16*	02/6/91	2128	2252	0050	51 02.8'N	20 39.1'W	4442
Z48	CTD12v17*	04/9/91	0146	0306	0502	48 00.3'N	19 59.4'W	4432
Z48	CTD12v18	04/9/91	0551	0714	0909	48 01.9'N	19 55.7'W	4420
A48	CTD12v19	05/6/91	0807	0943	1154	47 59.9'N	15 56.93'W	4913
A51	CTD12v20	06/6/91	1516	1644	1849	51 00.42'N	15 59.73'W	4450
A54	CTD12v21	08/6/91	0255	0351	0505	53 59.70'N	14 59.78'W	2864

* denotes station using EG & G MKV CTD

TABLE 3

SeaSoar runs Darwin Cruise 58

Vivaldi reference	Run	Deployment or recovery date	time	Computer run	Comments
	1	26/4/91	1836	none	Trial run. Data not processed
			2118		
B48 -	2	27/4/91	0812	SS11001	IOS block used, resulted in slow recovery
B45		28/4/91	0335		and fairing loss. Wing edge bent
B45 -	3		0829	SS11002	RVS block used
B42		29/4/91	0615		
B42 -	4		1146	none	Transmissometer blanking plug leakage
			1406		Data not processed
A42 -	5	30/4/91	0750	SS11003	
			1337		Noisy data, traced to faulty fluorometer lead
	6		1448	SS11003	Steamed on during repair then redeployed
A45		01/5/91	0646	(cont)	Hard to control block rotation
A45 -	7		1114		Would not fly, leaky hydraulics suspected
			1300		Much fairing loss during recovery, see text
	8		1517	SS11004	block now has bar for rotational control
A48		02/5/91	0814		Brooms nearly eliminated fairing loss
					Bottom tail plane missing and impellor bent
A48 -	9		1340	SS11005	
Z48		03/5/91	0901		
Z48 -	10		1319	SS11006	
Z45		04/5/91	1239		
Z45 -	11		1710	SS11007	
Z42		05/5/91	1530		Nose squashed on stern, weight bolts sheared
Z42 -	12		1915	SS11008	
Z39		06/5/91	1822		
Z39 -	13		2234	SS11009	Heavy pitching, difficult launch
Y39		07/5/91	1856		1324-1513 trials on passage
Y39 -	14		2231	SS11010	
Y42		08/5/91	2030		Ploughshare now lays fairing on drum
Y42 -	15	09/5/91	0020	SS11011	
Y45		10/5/91	0031		
Y45 -	16		0332	SS11012	
Y48		11/5/91	0203		
Y48 -	17		1105	SS11013	
X48		12/5/91	1122		CTD not possible so SeaSoar not recovered,
X48 -			1130	SS11014	alter course from 270 to 171 and continue
X45		13/5/91	1021		Wing edge plate bent again
X45 -	18		1349	SS11015	
X42		14/5/91	1256		
X42 -	19		1600	SS11016	
X39		15/5/91	1327		

TABLE 4

SeaSoar runs Darwin Cruise 59.

VIVALDI reference	Run	Deployment or recovery date	time	Computer run	**Comments**
W39 -		19/5/91	1115	SS12001	Control poor.
W42	20	20/5/91	0720		
W42 -			1030	SS12002	Loss of control.
	21		2024		
		20/5/91	2145	SS12002	Control poor.
W45	22	21/5/91	1118	(cont)	
W45 -			1539	SS12003	Control good.
W48	23	22/5/91	1307		
W48 -			1809	SS12004	Loss of control.
	24		1930		
		23/5/91	1947	SS12004	Loss of control.
W51	25		1615	(cont)	
W51 -			2108	SS12005	Control good.
W54	26	24/5/91	2215		
W54 -		25/5/91	0145	SS12006	New Par lead.
X54	27		2116		
X54 -		26/5/91	0209	SS12007	,,
X51	28	27/5/91	0049		
X51 -			0445	SS12008	W/O counter u/s.
X48	29	28/5/91	0530		
X48 -			0900	SS12009	Cond1 failing.
Y48	30	29/5/91	0643		
Y48-			1138	SS12010	New cell & term'n
Y51	31	30/5/91	1027		
Y51 -			1908	SS12011	Control good.
Y54	32	31/5/91	1648		
Y54 -			2130	SS12012	,,
Z54	33	01/6/91	1438		
Z54 -			1823	SS12013	,,
Z51	34	02/6/91	1644		
Z51 -		03/6/31	0209	SS12014	Loss of control.
	35		0454		
		03/6/91	0630	SS12014	New valve leads.
Z48	36	04/6/91	0122	(cont)	
Z48 -			1036	SS12015	Control good.
A48	37	05/6/91	0708		
A48 -			1500	SS12016	New term'n.
A51	38	06/6/91	1445		
A51 -		07/6/91	0500	SS12017	Control good.
A54	39	08/6/91	0229		

TABLE 5

Gyro Checks by star sights

Date	time	error port	error starboard
26/4/91	03:47	1	
29/4/91	21:00		-1
30/4/91	01:00	2	
30/4/91	05:13	2	
1/5/91	21:20	2	
2/5/91	01:24	2.5	
2/5/91	04:12		1
2/5/91	00:00	1.75	
3/5/91	00:00		1
3/5/91	04:11	-1	
7/5/91	00:00		2
8/5/91	01:51	2	
8/5/91	05:34	0.5	
9/5/91	04:14		-1.5
10/5/91	20:56	2.5	
12/5/91	04:09		-0.5
14/5/91	22:19		0.75
15/5/91	01:09		0.5
15/5/91	02:39	2	
15/5/91	04:16		0.5
15/5/91	20:50		0.75
20/5/91	01:04	1.5	
20/5/91	22:24	2.5	
21/5/91	00:16	2	
21/5/91	21:30	1.5	
22/5/91	00:37	2	
22/5/91	04:14		-2
23/5/91	03:14	2	
23/5/91	22:00	2	
24/5/91	00:19	2	
24/5/91	04:15		0
25/5/91	01:44	2	
25/5/91	22:05		1.25
27/5/91	02:17		1
30/5/91	21:41	2.75	
31/5/91	00:38	0.5	
31/5/91	04:42	2.5	
2/6/91	01:24	1	
2/6/91	04:14		0.5
5/6/91	01:49		1
5/6/91	05:14	1.5	
6/6/91	02:47		1
6/6/91	05:02		-1
7/6/91	02:08		1.5
	Mean Error	1.72	0.36
	Standard Deviation	0.81	1.07

Figure 1 RRS Charles Darwin Cruises 58 & 59, 25 Apr-16 May; 18 May 10 Jun 1991.
Track chart and CTD locations, Vivaldi '91.