Plymouth Marine Laboratory
Cruise Report

RRS CHARLES DARWIN
Cruise 97

12 October 1995 - 06 November 1995

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1. PERSONNEL

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Morse, J.T.	3rd Officer
Baker, J.G.	Radio Officer
Holt, J.M.	Chief Engineer
Dean, S.F.	2nd Engineer
Bell, S.J.	3rd Engineer
Lutey, W.D.	Electrical Engineer
Trevaskis, M.	CPO(D)
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Dickinson, R.	Seaman
Luckhurst, K.R.	Seaman
Dean, P.H.	Seaman
Allam, J.P.	Catering Manager
Perry, C.K.	Chef
Smith, L.V.	Mess Steward
Shields, S.	Steward
Mingay, G.M.	Steward
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2. SUMMARY: SCIENTIFIC OBJECTIVES

1. To recover OMEX current meter moorings.

2. To measure the geostrophic transport of the Azores current.

3. To deploy Argos Buoys and ALACE floats.

4. To relate biological and physical parameters to the measured physical structures in the Canary - Azores region.

5. To deploy moored current meters at the Great Meteor Tablemount and in the Azores Current.

3. NARRATIVE

The *RRS Charles Darwin* arrived at the Port of Ponta Delgada on the early morning of Tuesday 10th October 1995 after a 10 day Portuguese chartered cruise from Ponta Delgada - Ponta Delgada. By noon, the CD97 scientific party were on board, and with the hired help of a dozen or so stevedores from the Port of Ponta Delgada, two container loads of equipment from PML and one from RVS, were unloaded onto the afterdeck during that afternoon. With the following day to set up and secure the equipment, the *RRS Charles Darwin* sailed from Ponta Delgada at 0814 on Thursday 12 October 1995 in good weather, but a large swell. The pilot disembarked at 0818/285 and the vessel was underway at 0830. The 10khz PES Fish was quickly deployed at 0850/285 (37°40.8'N, 25°39.7'W) along with the commencement of the computer logging of all navigation (GPS and DGPS), ADCP and surface properties (all times now in GMT/Julian Day).

A south-westerly course was set and at 1000/285, we began 20 minute zigzag legs on courses of 270°T and 180°T, to enable the calibration of the ships hull mounted ADCP (shown on the track plot, fig 3.1, also see section 9). The calibration was completed by 1450/285, and was immediately followed by the launch of XBT 003 (the previous two were system tests). The *RRS Charles Darwin* then altered course to 248°T and launched XBT 004 on route to the first CTD station at 2013/285 in position 36°59.9'N 27°00.0'W. CTD 01 was deployed to 2013m and was the first of a transect of 9 CTD's (CTD's 01-09, shown on the CTD track plot, fig 3.2), deployed at every degree of latitude along 189°T, as part of the survey across the Azores Sub-Tropical Front (here after refered to as leg 1). The course on this first leg was identical to a previous survey during the cruise CD66 (see PML Cruise Report 66), and was primarily an attempt to investigate the temporal changes in position and physical structure of the Azores front.

Each CTD was to a depth of approximately 2000m with the exception of CTD 02 (3577m). CTD 02 was deployed at 0420/286, and upon recovery, also saw the commencement of the daily early morning primary production sampling from the CTD upcasts, within the euphotic zone. With the subsequent deployments of XBT's 007-008, CTD 03 was deployed at 1411/286 in position 35° 00.0'N 27°35.0'W, to 2013m, after which the course was altered slightly to 193°T. The vessel arrived on station for CTD 04 at 2137/286 in position 33°59.9'N 27°52.5'W, with XBT's 009-010 deployed enroute. Upon recovery of CTD 04 we commenced three successive deployments of the WP/2 Nets (#s 01,02,03) at 2324/286 in position 33°59.5'N 27°51.8'W. Steaming was then resumed with XBT's 012-013 (11 failed) deployed enroute to CTD 05 which was deployed at 0633/287 in position 32°59.5'N 28°09.6'W, with primary production samples also being taken. Our course was then altered from the CD66 track to 012°T, to return to the centre of the Azores front for the deployment of two Argos Buoys

(No. 20815 at 1148/287 in position 33°29.7'N 28°01.5'W, and No. 3344 at 1203/287 in position 33°29.5'N 28°01.6'W). CTD 06 was then deployed alongside the Argos Buoy deployments, along with WP/2 Net #s 04, 05, 06. At 1601/287 all was secure and a course of 195°T was set to resume leg 1 across the Azores front. A violent storm meant that the vessel was hove to for 20 minutes at 2030, after which the course was resumed along with the deployments of XBT's 014-015.

At 0226/288 however, a radar contact was made with no visible light, and the *RRS Charles Darwin* altered course to investigate (Navtex had reported an overdue yacht named 'Mugwump', call sign MDUD6). The radar contact was identified as a Dhan Buoy at 0326/288 and our scientific course was resumed, arriving at CTD 07 at 0427/288 in position 32°00.0'N 28°26.6'W. Upon recovery, it appeared that the firing of the Nisskin bottles had developed a fault, and a short cast CTD (08) was deployed to 110m at 0611 to enable chemical and biological water samples to be taken. Upon recovery of CTD 08, WP/2 Net #s 07, 08, 09 commenced deployment at 0657/288. Leg 1 was completed with XBT's 016-017, and the deployment of CTD 09 at 1420/288 in position 31°00.0'N 28°43.4'W, and WP/2 Net #s 10, 11, 12.

With all decks secure a course of 170°T was set to begin a survey of the Great Meteor Tablemount (GMT), albeit not as intensively as that performed during the CD66 Cruise. With the launch of a further two XBT's, CTD 10 at 2012/288 in position 30°30.0'N 28°35.0'W to 2009m, and WP/2 net #s 13-15, we arrived at the center of the GMT at 0217/289. Three CTD casts (10-12, to depths of 307m, 120m and 120m respectively), and eight WP/2 Nets (#16-23) at 30°00.0N and approx. 28°27.0W were taken. Argos Drogue Buoy 3345 was deployed at 0735/289 in position 29°59.9'N 28°27.2'W, followed by Current Meter Mooring 157, laid in 303m water on the GMT, with the subsurface float 200m below the surface.

The survey of the GMT was complete at 0910/289 and a course of 270°T was set to steam due west along 30°N (here after refered to as Leg 2). Leg 2 was primarily a 48 hour steaming leg to enable a further survey through the Azores Front approximately five degrees west of Leg 1. Six CTD's (CTD's 14-19) were deployed on route, with 11 intermittent XBT deployments (XBT's 20-30 shown on the XBT track plot, fig 3.3) and 12 WP/2 Nets (#s 24-35), culminating with CTD 19 at 0145/291 in position 29°59.8'N 33°45.3'W (deployed to 2031m).

Before proceeding with a second survey across the Azores Front with a course of 013°T, it was decided to recover Argos Buoy 5030 deployed in January 1994 at 2112/008 during cruise CD83 (see PML Cruise Report 83). Argos Buoy 5030 was originally deployed near the shelf edge west of Lisbon in position 38°25.5'N 09°57.4"W. A course of 261°T was set and we began homing in on the Buoy at 0736/291. Argos Buoy 5030 was grappled at 1014/291 and recovered at 1018/291 in position 29°4.8'N 34°32.3'W. With XBT's 30-32 deployed either side of the

Argos Buoy recovery, the *RRS Charles Darwin* steamed to 30°00.1'N 34°45.1'W for CTD 20, deployed to 2010m at 1310/291. This was principally an extension to the CTD-XBT survey for Leg 2. A course of 048°T was then set to reunite us with the second proposed transect across the Azores Front along 013°T from CTD 19. With two more XBT launches, a rendezvous with the third transect (Leg 3) was at 0017/292 in position 31°00.0'N 33°28.3'W. CTD 20 was deployed along with WP/2 Net #s 36-38 while in position.

Leg 3 was once again a CTD-XBT survey across the sub-tropical front comprising CTD's (19, 21-26), XBT's (035-044), and WP/2 Nets (#s 39-44) along 013°T, culminating with CTD 26 at 0043/294 in position 35°20.1'N 32°14.0'W (to 2012m). During Leg 3, and after steaming through what was initially thought to be the center of the subtropical front, a reverse course of 193°T was set at 1237/292 in position 32°22.7'N 33°04.9'W for a succession of lagrangian drifter deployments. Following the recovery of CTD 23 at 1800/292 in position 31°29.9'N 33°18.2'W, a course of 360°T was set for the short steam to the first Argos Buoy deployment site. Argos Drogued Buoy 25977 was deployed at 2154/292 in position 31°39.6'N 33°16.5'W, followed shortly by ALACE Float 50-I at 2204/292 in position 31°39.4'N 33°16.2'W, and lastly Argos Drogued Buoy 25685 at 2242/294 in position 31°38.7'N 33°154'W.

Following the completion of Leg 3, the sub-tropical front was clearly identified at the northern extreme of the transect. It therefore became apparent that the CTD, XBT and ADCP survey had revealed a large cold core structure through the center of the transect, with physical and dynamical characteristics consistent with a large meander or eddy, associated with the sub-tropical front.

Following the recovery of CTD 26 at 0157/295 at the northern extreme of Leg 3, a course of 212°T was set to steam to a position due west of the cold core structure. XBT's 045-053 were deployed enroute, arriving on station for CTD 27 at 2041/294 in position 32°35.0'N 34°18.4'W (deployed to 2550m).

Due to the time constraints of the cruise, and the necessity for the *RRS Charles Darwin* to steam towards the Iberian shelf for the recovery of OMEX current meter moorings deployed during the CD83 cruise, little time now remained for a scientific survey of the sub-tropical cold core feature. Following CTD 27 a rapid zigzag, west-east CTD-XBT survey through the center of the structure was performed, initially due south (course set at 180°T at 2228/294) but essentially eastward, in preparation for the steam towards the Iberian shelf (once permission for the recovery of the OMEX moorings had been authorised by the Portuguese authorities). This incorporated CTD's (27-31), XBT's (54-68) and WP/2 Nets (#s 45-50), culminating with CTD 31 at 0855/296 in position 31°40.1'N 31°59.8'W. All deep CTD's are now to 2500m except for CTD 29 (deployed to 3012m, near the center of the physical structure). Upon recovery of CTD 29, the first of three Argos Drogued Buoys were deployed at 1552/295 (No.

5032 in position 32°19.8N 33°19.9W) with Nos. 25687 & 25684 deployed nearby at 1651/295 and 1809/295 respectively.

At 1614/296, a fax was received from RVSOPS of a fax from FCO, with written notification that Portugal had refused permission for the extension on the clearance for the *RRS Charles Darwin* to recover the OMEX moorings. In light of this information from RVSOPS, the time remaining before the steam home to Southampton was utilised by conducting a more detailed survey of the subtropical frontal feature.

Following the recovery of CTD 31 at 0855/296 in position 31°40.1'N 31°59.8'W, a course of 310°T was set to conduct a SE-NW XBT survey through the core of the feature, incorporating XBT's 069-082. During this survey the new RVS SeaSoar cable was streamed out at 1331/296, and then recovered at 1558/296 in preparation for a SeaSoar deployment. At position 32°50.5'N 34°03.6'W, CTD 32 was deployed to 2474m at 0617/297, along with WP/2 Net #s 51-53. After the launch of a further two XBT's along this section, a course of 128°T was set to return to near the center of the feature. A succession of ALACE floats and Argos Drogued Buoys were then deployed prior to the deployment of CTD 33 at 2146/297 in position 32°25.6'N 33°20.6'W (deployed to 3516m). These consisted of three ALACE floats (No. 48-I deployed 1826/297, No. 51-I deployed 1930/297, & No. 49-I deployed 2122/297) and three Argos Drogued Buoys (No. 25686 deployed 1901/297, No. 25682 deployed 2112/297 & No. 25683 deployed 2118/297).

After the recovery of CTD 33 and the deployment of WP/2 Net #s 54-56, the first deployment of SeaSoar commenced at 0223/298 in position 32°19.0'N 33°11.8'W. SeaSoar was clearly malfunctioning once fully deployed and recovery commenced one hour after deployment. At 0510/298, an intensive CTD-XBT survey was conducted along 056°T, beginning with XBT 085 in position 32°25.0'N 33°01.3'W, and ending with CTD 40, deployed to 2022m at 0509/299 in position 33°29.5'N 31°07.5'W. This survey (CTD's 34-40 & XBT's 85-91) endeavoured to confirm whether the feature was a meander of the subtropical front, or a large subtropical eddy.

The *RRS Charles Darwin* then sailed due west at 0641/299, launching XBT's 092-093 on route to CTD 41, deployed to 2510m at 33°30.2'N, 30°00.0'W. An intensive XBT survey followed while steaming along a course of 239°T, incorporating XBT's 094-106.

At 1504/299 a message from RVSOPS arrived, regarding a fax received by the British Embassy, Lisbon, from the Ministry of Foreign Affairs, Lisbon, confirming that no extension to the clearance for CD97 was possible, owing to the impossibility of giving an answer in reasonable time.

Following the recovery of CTD 42 (to 200m) at 0339/300 in position 32°29.7'N, 32°00.9'W, SeaSoar was re-deployed on a course due west along 32°32.4'N at 1232/300. SeaSoar successfully conducted a transect across the sub-tropical feature, with XBT's 107-117 launched enroute (4 XBT failures including XBT 114 which was logged). The SeaSoar survey was completed at 0040/301, with SeaSoar on board at 0124 in position 32°33.4'N, 35°31.6'W. A deep CTD (43 to 3634m) was deployed at the western extreme of the transect at 0300/301 along with WP/2 Net #s 60-62.

The feature being surveyed was now clearly identified as a sub-tropical eddy. In anticipation of its propagation in a westerly direction, a long term current meter mooring (No. 155) was deployed in 3880m water at 1114/301 in position 32°31.2'N, 35°29.1'W. With a course then set at 090°T, CTD 44 was then deployed to 3527m on route to position 32°30.0'N, 33°59.7'W, chosen as the site for further ALACE float and Argos Drogued Buoy deployments. At 0147/302, Argos Drogued Buoy No. 3899 was deployed, followed swiftly by Argos Drogued Buoy No.5031 at 0204/302 and ALACE Float No.52-I at 0208/302.

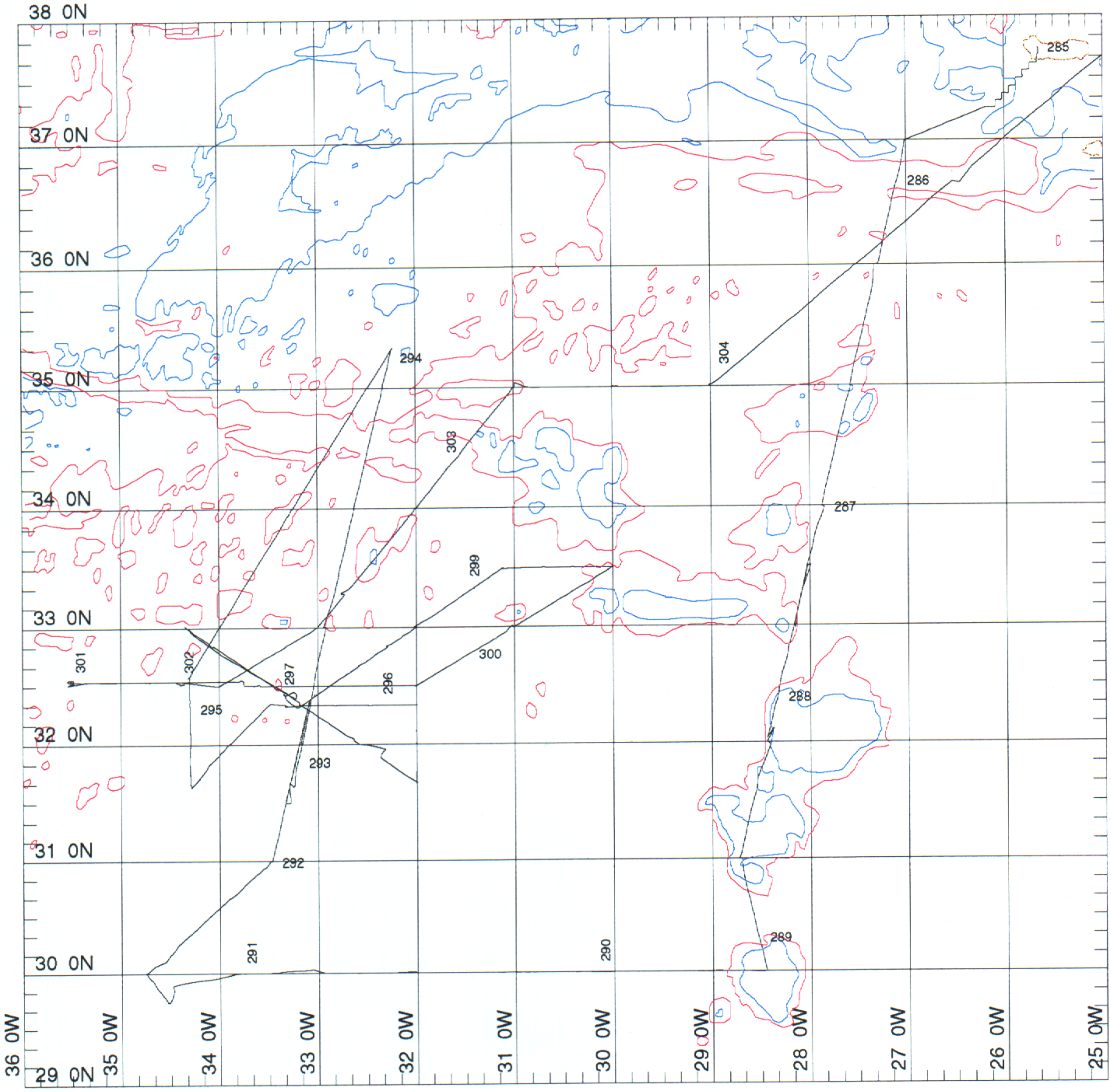
A course of 060°T was now set at full speed to make one last survey of the transport across the subtropical front. XBT's 119-125 were deployed enroute to CTD 46 (to 3479m) at 1713/302 in position 33°59.9'N, 32°00.0'W. After the recovery of CTD 46, SeaSoar's final deployment of the CD97 Cruise was underway at 1954/302, steaming due NE from 34°N 32°W to 35°N 31°W. Enroute, a further 8 XBT launches failed due to interference with the SeaSoar faired cable. The SeaSoar recovery was marked by the deployment of CTD 47 (to 2998m) at 0718/303. Finally, with a course set due east along 35°N, CTD's 48 & 49 were deployed to 3000m at 1406/303 & 2104/303 respectively, along each subsequent degree of longitude. CTD 49 in position 35°00.3'N 29°00.1'W, marked the final CTD deployment of the CD97 Cruise, and at 2258/303 a course of 050°T was set to embark on our steam home to the Southampton Oceanography Center. The PES Fish was immediately recovered, and all science was effectively postponed while the vessel steamed through the Portuguese waters off the Azores. At this time Hurricane Tanya had been reported near 36.2°N, 45.7°W at 1200/304, moving eastnortheast at 23 knots. Tropical storm force winds and seas of 12ft or higher were forecast. Over the following 48hrs the sea state deteriorated rapidly, and although it was not necessary to hove too, we were imperilled by what was thankfully only the trailing edge of Hurricane Tanya.

A slight deviation to this schedule was conducted at 1201/305 when we altered course to 042°T, and made haste towards the OMEX Current Meter Mooring 150, identified on the Celtic Shelf. Mooring 150 had been deployed on 3rd September 1995 on the Goban Spur, and was last reported adrift in position 49°42.0'N, 09°21.0'W (see the complete CD97 Cruise Track, fig 3.4). XBT's 141-157 were deployed on route, and the Argos Beacon on Mooring 150 was first located at 1716/308 in position 49°47.9'N, 09°36.9'W. The Buoy was sighted, in darkness, at 1843/308 and the subsurface sphere and 1 current meter were recovered at 1858/308 in position 49°54.5'N, 09°39.7'W. Argos Drogued Buoys 3349 & 3350 were deployed alongside the recovery position at 1909/308 & 1912/308 respectively, and a final course of 097°T was then set for the homeward passage. XBT's 158-160 were deployed on route whilst still in stratified shelf waters' and were the last scientific deployments of the cruise.

The RRS Charles Darwin finally moored in Empress Dock, Southampton, at midday on Monday 6th November, Julian day 310.

Paul Chatwin UOP / PML

Fig 3.1   CD97 Trackplot work area



MERCATOR PROJECTION

SCALE 1 TO 5000000 (NATURAL SCALE AT LAT. 35)

INTERNATIONAL SPHEROID PROJECTED AT LATITUDE 35

GRID NO. 1

Fig 3.2 CD97 Trackplot work area CTD Stations

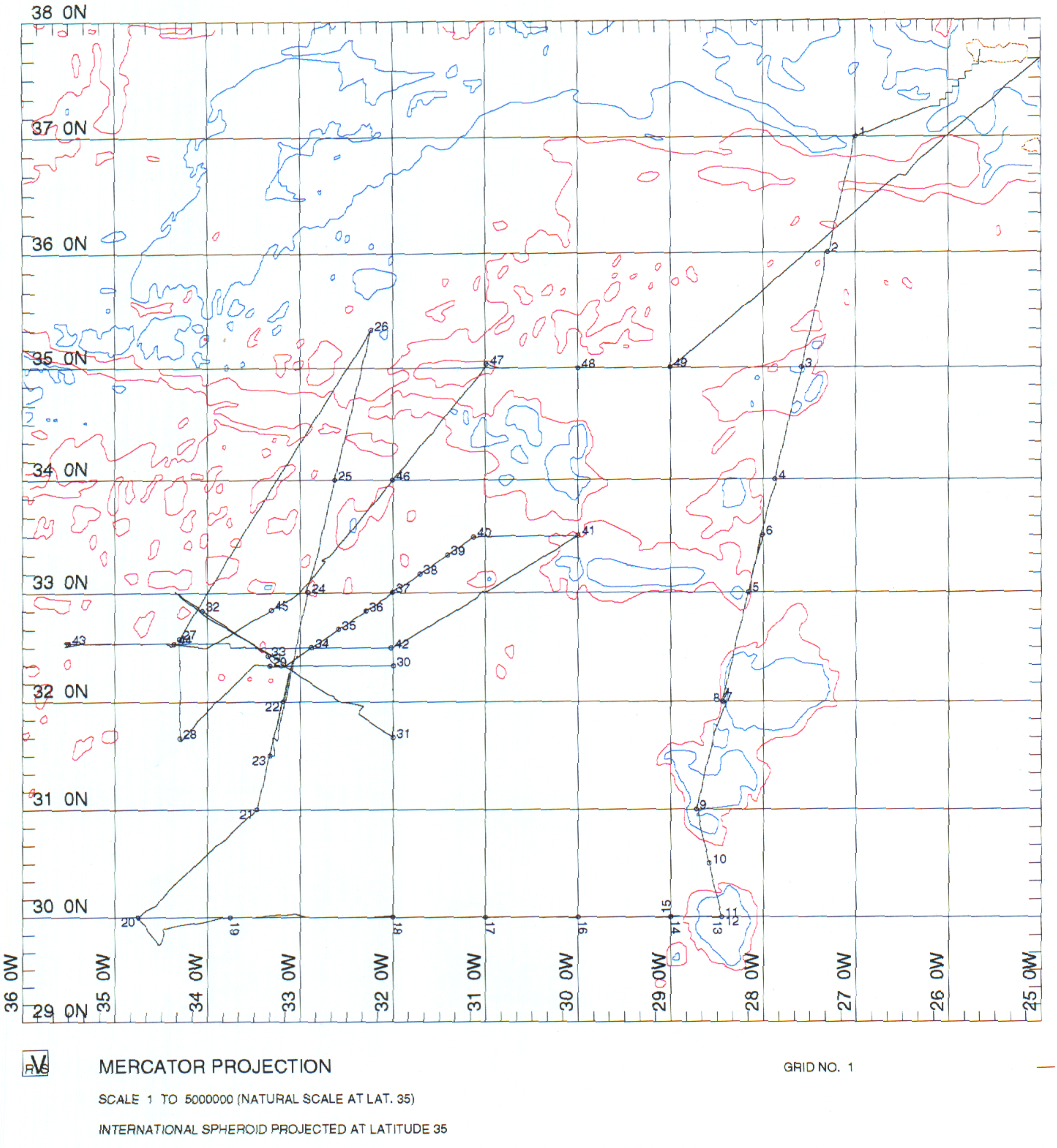
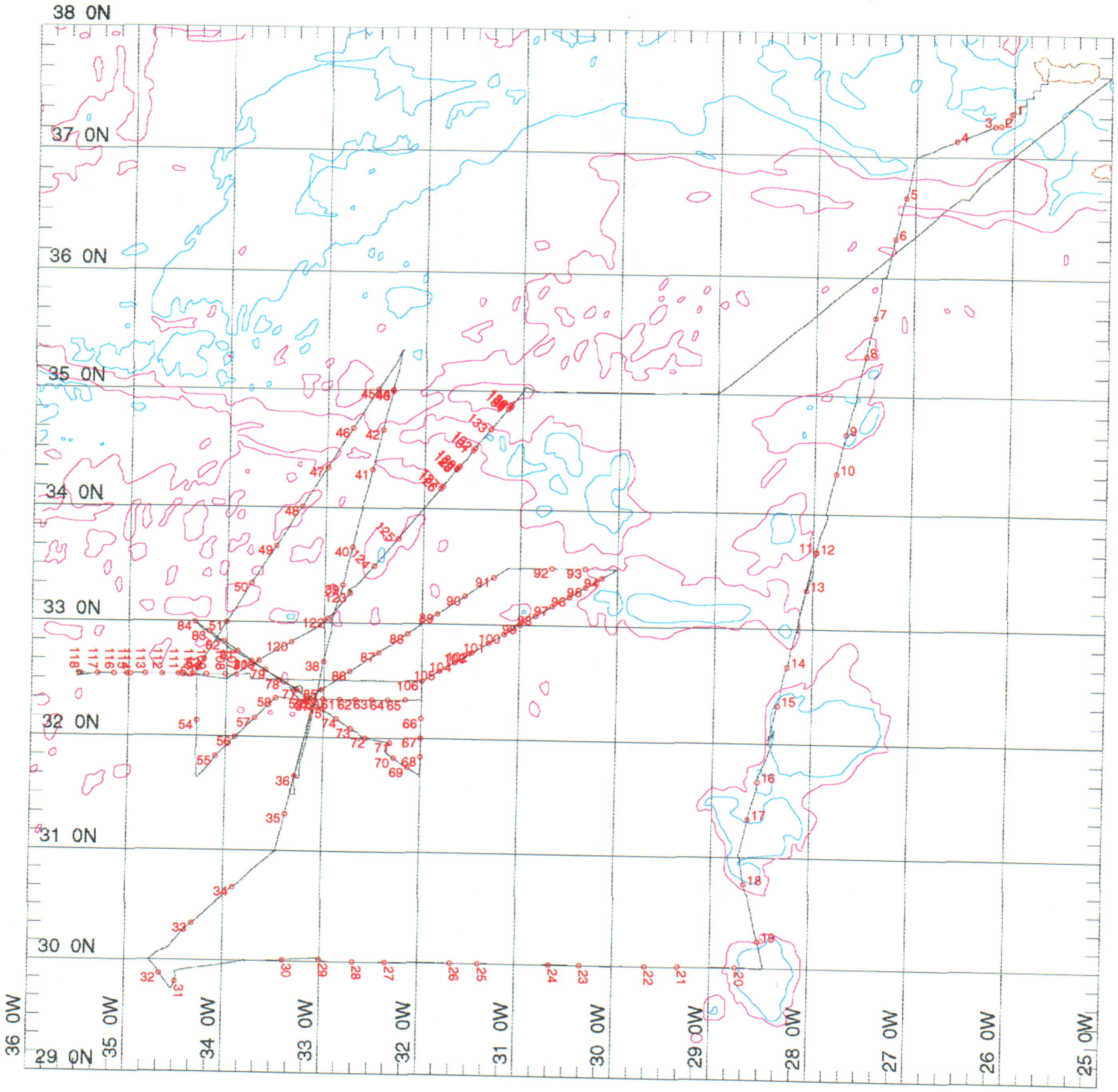


Fig 3.3 CD97 Trackplot work area XBT Stations



MERCATOR PROJECTION

SCALE 1 TO 5000000 (NATURAL SCALE AT LAT. 35)

INTERNATIONAL SPHEROID PROJECTED AT LATITUDE 35

GRID NO. 1

CD97 trackplot work area XBT stations

Scaled to fit

4. COMPUTER REPORT

The computing was provided by the RVS ABC system. Data was logged from the fitted ships equipment in real time. The parameters logged included navigation from the Trimble GPS, ships speed and heading, bathymetry, surface sampling of temperature, salinity, the CTD and Seasoar. The total amount of data collected was approximately 540 Mbytes.

Seasoar was logged in real time but found to contain gaps due to rejection by the pressure spike checking routine. The data was recovered from the CTD PC and shifted in time to match the profile that was collected in real time.

The data was processed using Pstar and the RVS software suites on three Sun workstations. A further PC was provided for wordprocessing and spreadsheet applications. In total 427 Mbytes of processed data was produced.

Routine plots of cruise tracks were plotted using a Mercator projection. On some of the plots were marked the positions of all the XBT probes that were launched together with the positions of all the CTD stations. Plots of the CTD casts of 200m, 500m and full depth were made.

Contour plots were made of the surface parameters of temperature, salinity and density. Other contour plots of isotherms were made by combining the CTD and XBT data. Contours of constant salinity against depth were made from the CTD data.

This was a fascinating final cruise and it was very refreshing to see such attention to data quality.

Andy Lord RVS

5. ARGOS BUOY REPORT

During *RRS Charles Darwin* Cruise 97, 15 Argos satellite tracked drifting buoys and 5 ALACE floats were deployed (Tables 5.1 & 5.3). All of the buoys operate on the standard Argos transmit frequency of 401.650 Mhz +/- 4khz.

5.1 Argos satellite tracked drifting buoy deployments

The drogues used during this cruise were all manufatured 'In House' at PML from polyethylene netting. All Talurit splices used in the PVC covered stainless steel strops were made of copper to reduce corrosion. Much attention was also paid to all joints to ensure there was no undue freedom of movement which might cause excessive ware to components. All shackles were given extra security by having lock pins inserted and hammering over all pin ends.

All buoys were deployed using the same method in that the buoy was streamed first from aft with the ship just moving ahead. Once the drogue tether was fully paid out and the slack taken up the drogue was carefully paid out using a retaining line to ensure no fouling of the drogue either on it's own components or the ship. Once paid out the ship stood by to observe the drogue sink and to acquire calibration data.

In addition to the 15 Argos satellite tracked drifting buoy deployments, there was also a recovery of Argos Buoy 5030, prior to the commencement of the second survey across the Azores Front (Leg 3). The Metocean buoy was originally deployed near the shelf edge west of Lisbon in position 38°25.5'N 09°57.4"W deployed in January 1995 during cruise CD83 (see PML Cruise Report 83). Argos Buoy 5030 was grappled at 1014/291 and recovered at 1018/291 in position 29°4.8'N 34°32.3'W.

5.2 ALACE float deployments

Five Autonomous Lagrangian Circulation Explorer (ALACE) floats were purchased from the Webb Research Corporation, Massachusetts for deployment during CD97. The ALACE floats were shipped directly to the R.R.S. Darwin in Ponta Delgado. ALACE is a subsurface float which cycles vertically from a depth where it is neutrally buoyant to the surface where it is located by System Argos Satellites. Information which is also relayed from the ALACE includes pressure and temperature averaged over both the first half and second half of the drifting cycle, pressure whilst at the surface during the previous dive and voltage information. No profiling information is relayed. The ALACE float is programmed to periodically change their volume by pumping hydraulic fluid from an internal reservoir into an external bladder, thus changing their density. The floats are designed to have a maximum depth capability of 2000m and an endurance of up to five years with lithium batteries. The battery life is dependent on the frequency of dive cycles within the mission program, Table 4.2a summarises the mission programs of the ALACE floats.

The Lithium battery packs were transported separately by an employee of WBR to the ship. The battery packs for each instrument were installed aboard prior to sailing. The program mission of each instrument was checked and the instruments were sealed up and evacuated. This was all performed by the WBR employee who then returned home.

During the cruise all the ALACE floats were tested as per the manual. The test is started by means of a magnetic switch. On activation the motor should switch on for one second, this is followed by a signal detected by the ARGOS beeper, ten seconds later ten more signal may be detected five seconds apart.Shortly after this, the pump is activated and the external bladder begins to fill, the bladder pushes out an end cap which protects the bladder during transit. The test takes 100 minutes, the bladder will then empty 342 minutes later. All five ALACE floats failed this test first time round and according to the manual should have been stored away for return to the manufacturer. Subsequent resets on all the instruments were however successful, though not all the instruments responded exactly as described in the manual. All instruments did complete the full test cycle and were then prepared for launch.This is done by attaching the launch collar supplied with each instrument. Launching is achieved by lowering the ALACE using a tape which runs through a hole in the collar into the water. Care must be taken to ensure the float stays clear of the hull, 51-I did however take a slight knock during deployment. The details of each launch are summarised in Table 4.2b. Only ALACE s/n 50-I was deployed in floating mode, this float would have begun to sink at 02:18Z 20/10/95. With all the other floats great care was taken to ensure that no air bubbles were trapped in the lower end cap during launch, all these floats were seen to sink shortly after deployment.

Table 5.2 ALACE float characteristics.

WRC s/n	DECIMAL ARGOS ID	HEX ARGOS ID	BALLAST DEPTH (dB)	MISSION (days)	SURFACE (hours)
48-I	25972	95D09	200	20	12
49-I	25973	95D5A	700	40	16
50-I	25974	95DAF	200	20	12
51-I	25975	95DFC	400	15	12
52-I	25976	95E28	700	40	16

Table 5.3 ALACE float deployments.

WRC s/n	RESET		DEPLOYMENT		POSITION
	DATE	TIME	DATE	TIME	
48-I	22/10/95	1506Z	24/10/95	1826Z	N32° 25.62' W33° 13.18'
49-I	22/10/95	1558Z	24/10/95	2122Z	N32° 25.30' W33° 20.24'
50-I	19/10/95	1856Z	19/10/95	2204Z	N31° 39.39' W33° 16.24'
51-I	22/10/95	1357Z	24/10/95	1930Z	N32° 26.92' W33° 14.38'
52-I	25/10/95	1621Z	29/10/95	0208Z	N32° 30.21' W33° 59.63'

Since the cruise, all ALACE floats have transmitted data in accordance with their mission programs.

Colin Griffiths PML

6. MOORINGS REPORT

Mooring operations carried out during the cruise were as follows;

6.1 Mooring 157

Deployed 16th October 1995 Day 289 The mooring was designed onboard using available instrumentation and hardware. The design and materials are adequate for a two year deployment .

The design uses all chain interconnecting the current meter and acoustic releases with each package separated such that neither will interfere with the performance of the other . The use of chain to connect the current meter to the buoyancy sphere is such that if the mooring is trawled, there is an improved prospect that the current meter will remain secured to the buoyancy with a possible recovery of the current meter .

The current meter is an Aanderaa RCM 8 type recording temperature, current speed and direction at a 120 minute sample interval .

The releases are IOSDL CR200 type prepared as spare units for use in 1995 and have a two year endurance .Each unit fires a single pyro on a common release mechanism . Testing was carried out in March 1995 and bench tests made during this cruise .

Deployment

Deployment was buoy first with the anchor freefall when the mooring was adequately stretched out . Depth was monitored on the shipboard EA500 sounder . The buoy was observed visually to submerge .

ACM 9909 RCM 8 type RVS fitted with Titanium spindle . First data 2200 GMT 13th October 1995 day 286 . 120 min sample . Full function tests carried out onboard .

CR200	2400	314-322hz	335-344hz	0.94 sec
	2385	315-322hz	337-344hz	1.04 sec

Mooring 157 Deployed 16th October 1995 Day 289
Great Meteor Tablemount

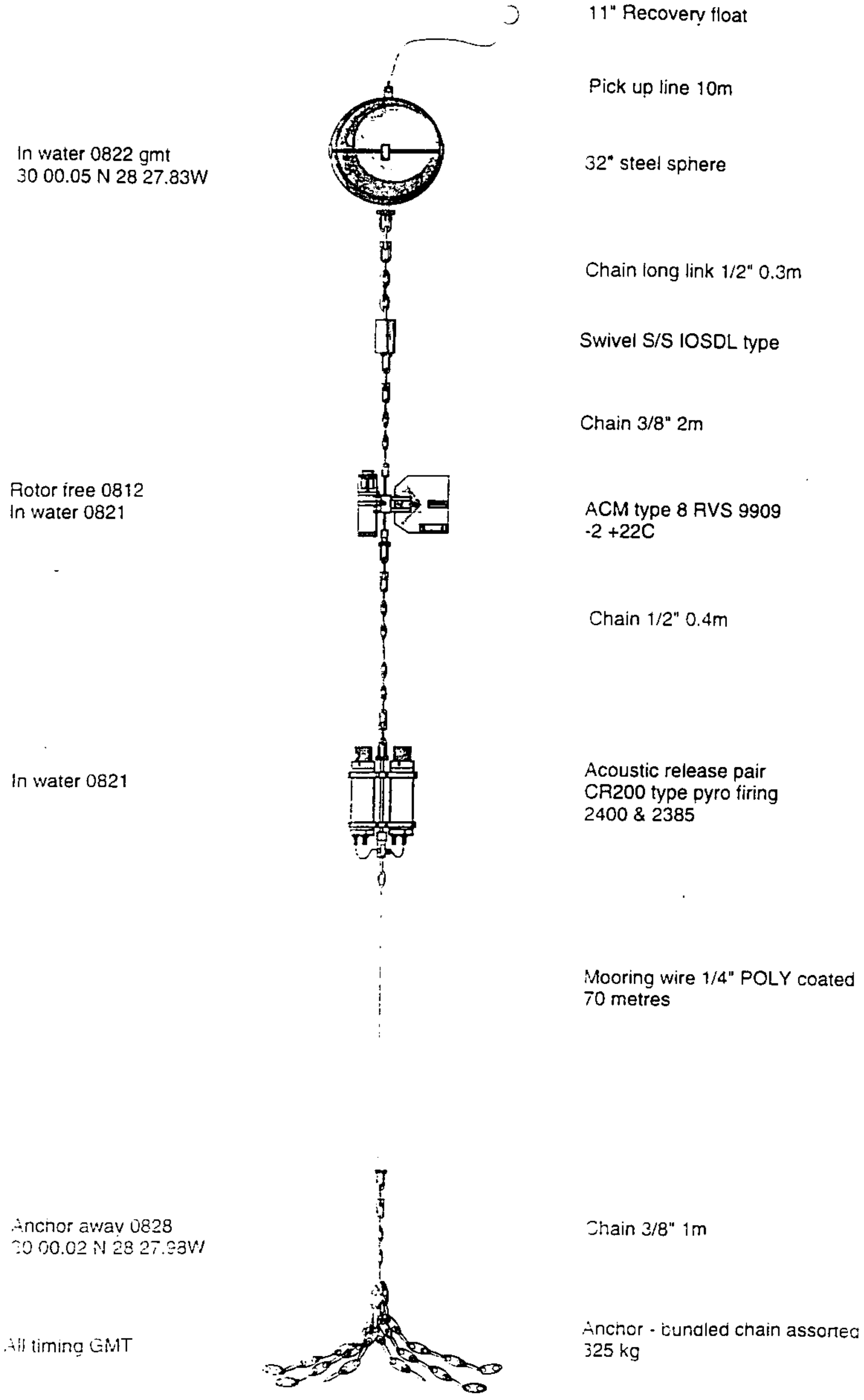


Fig 6.1 Mooring rig 157

6.2 Mooring 155

Deployed 28th October 1995 Day 301

The mooring was designed at IOSDL (now SOC) using hardware from RVS ,PML and IOSDL. The mooring to be deployed for up to two years duration in water depths from 4500 metres to 3000 metres and requiring the minimum of onboard preparation.

The design is derived from moorings deployed in SWINDEX experiment 1993-1995 and utilises materials pre-stretched and measured on that deployment. No time is thus lost to onboard measuring. The mooring is adequate for open oceanic current regimes to 75 cm/sec in the upper 1000 metres with minimised knockdown.

The scientific criteria and geographical location changed on the cruise and the mooring revised to reposition the instrumentation.

The current meters are a mix of Aanderaa RCM 8 and 5 type recording temperature, current speed and direction at all depths and pressure/depth at the top meter. Sampling at 120 minute for the RCM8 and 180 minute for the RCM5. The units were prepared and calibrated at IOSDL and RVS.

The temperature profile recorder is fitted to a 400 metre thermistor string which is attached using PVC tape at 0.5 metre intervals for the top 200 metres and 1 metre intervals for the lower 200 metres. The recorder was prepared at RVS with temperature range checks carried out, no calibration was available as the thermistor string was delivered at a late date. A CTD close by should verify the calibration.

The acoustic release is a MORS RT661 fitted with a mechanical release mechanism using a side slung through load bar. Prepared at RVS for two year deployment and fitted with an RVS custom release link manufactured from stainless steel.

Deployment

Prior to deployment a topographic survey was carried using the shipborne EA500 echosounder on a 1.5 mile box. This indicated the proposed mooring position centrally located in the box was in fact an abyssal hill with many side echoes. To the south east corner of the box a relatively flat area was determined which was then adopted as a revised position. The ship steamed off 2 miles to the south west, hove to and commenced final deployment preparations. When all was prepared the ship increased speed to 0.5 knots to deploy the buoy and instrumentation on a heading into wind towards the proposed mooring position. Ships speed was then increased to 1 knot as the mooring streamed astern. Deployment was buoy first with the anchor freefall when the mooring was adequately stretched out. Depth was observed on the shipboard EA500 sounder with close monitoring as the mooring was fully streamed. Some towing was required to tension the mooring and adjust depth.

The RT661 was monitored on the EA500 using the pinger mode to observe mooring descent. Signals became poor as the mooring approached the bottom due to the ship moving slowly off site. When the signals became difficult to distinguish from background noise the ship was turned back onto the anchor release position. Pinger signals were detected easily on the anchor release position and a good bottom echo established confirming that the mooring was upright and the release at the correct height off bottom. The pinger was then turned off and the mooring left on site.

ACM 11214 RCM 8 type PML fitted with Titanium spindle. First data 1200 GMT 19th October 1995 day 292. 120 min sample. Full function tests carried out onboard.

ACM 11215 RCM 8 type PML fitted with Titanium spindle. First data 1200 GMT 1 9th October 1995 day 292. 120 min sample. Full function tests carried out onboard.

ACM 7948 RCM 5 type IOSDL fitted with Titanium spindle First data 1500 GMT 19th October 1995 day 292. 180 min sample. Full function tests carried out onboard.

TL 1260 & TP2362 400 metres
Aanderaa logger RVS set to 7.36 to 21.25 C range First data 0900 GMT 27th October 1995 day 300. 180 min sample. Plugged in 0838+20s 28th October 1995 day 301.

RT661 184 Side hook type-full transponder function and 10khz precision pinger.

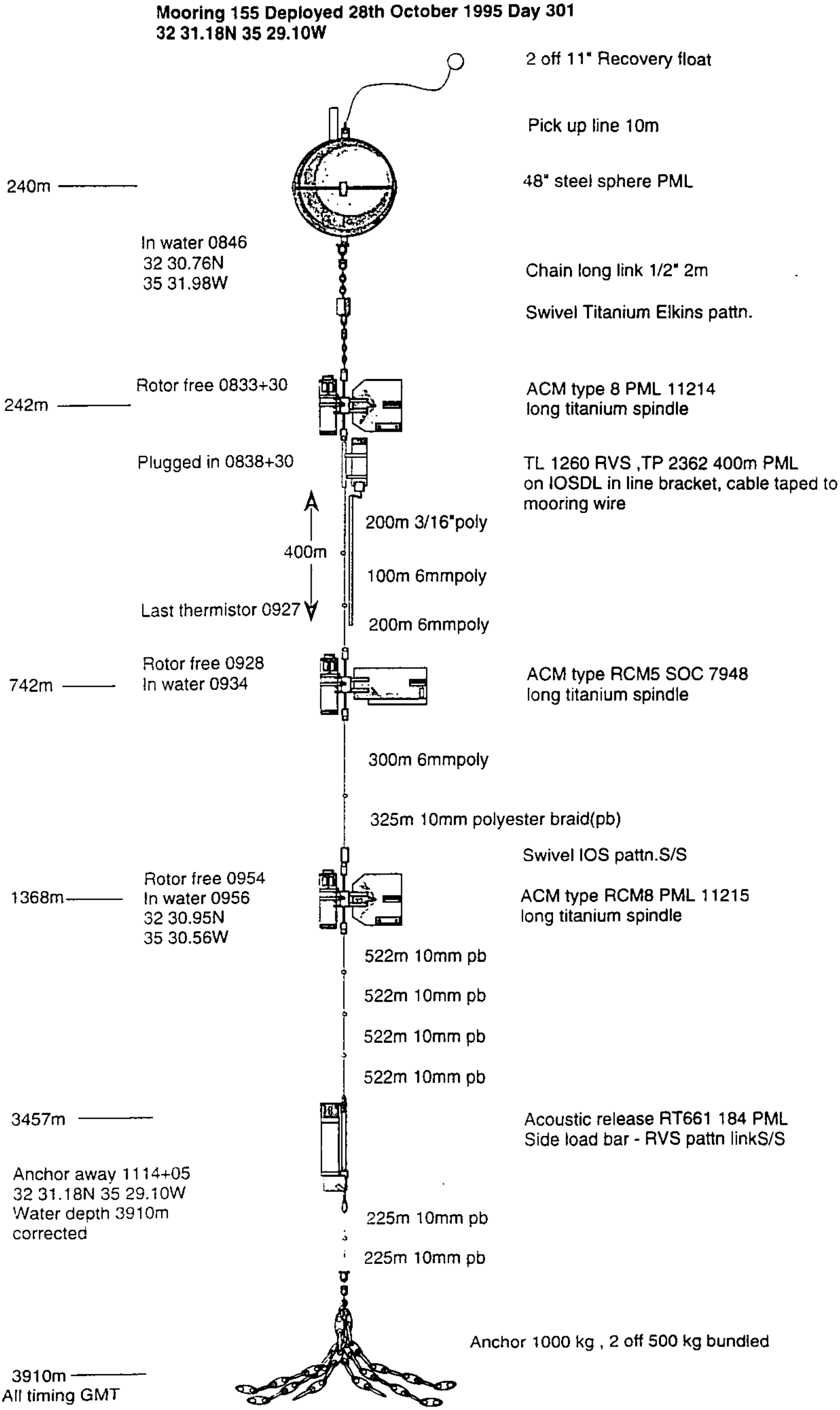


Fig 6.2 Mooring rig 155

6.3 Mooring 156

Deployed 28th October 1995 Day 301 Design, preparation and revision of design as mooring 155. The current meters are a mix of Aanderaa RCM 8 and 5 type, recording temperature, current speed and direction at all depths and pressure/depth at the top meter. Sampling at 120 minute for the RCM8 and 180 minute for the RCM5. The units were prepared and calibrated at IOSDL and RVS.

The acoustic releases are a MORS RT661 and an IOS CR200 each fitted to a common titanium release bar and set to each fire a pyro release on a common mechanical release mechanism. The units were prepared at sea Discovery March 1995 for a two year deployment and subsequently bench tested on this cruise.

Deployment

Prior to deployment the site had been visited and a simple topographic survey made on the run to the site. This indicated the proposed mooring position was relatively flat. The deployment start point was 2 miles to the south west, with the vessel hove to for final deployment preparations. When all was prepared the ship increased speed to 0.5 knots to deploy the buoy and instrumentation on a heading into wind towards the proposed mooring position. Ships speed was then increased to 1.5 knots as the mooring streamed astern. Deployment was buoy first with the anchor freefall when the mooring was adequately stretched out. Depth was observed on the shipboard EA500 sounder with close monitoring as the mooring was fully streamed. With the mooring streamed depth was correct and the anchor was immediately released. The RT661 was monitored on the EA500 using the pinger mode to observe mooring descent. Signals were monitored to anchor bottoming out and a good bottom echo established confirming that the mooring was upright and the release at the correct height off bottom. The pinger has a skew in its repetition rate which is indicated as a slant on the EA500 display. The pinger was then turned off and the mooring left on site.

ACM 9911 RCM 8 type PML fitted with Titanium spindle. First data 1600 GMT 1 7th October 1995 day 290. 120 min sample. Full function tests carried out onboard.

ACM 6225 RCM 5 type IOSDL fitted with Titanium spindle. First data 1800 GMT 17th October 1995 day 290. 180 min sample. Full function tests carried out onboard.

ACM 4738 RCM 5 type IOSDL fitted with Titanium spindle. First data 1800 GMT 1 7th October 1995 day 290. 180 min sample. Full function tests carried out onboard.

RT661 58 Pyro firing - full transponder function and 1O khz precision pinger.

CR200 2106 Pyro firing - Command and release 10 khz precision pinger; 31 8-325hz 333-344hz 1.04sec.

Mooring 156 Deployed 28th October 1995 Day 301
32 31.00N 34 23.96W

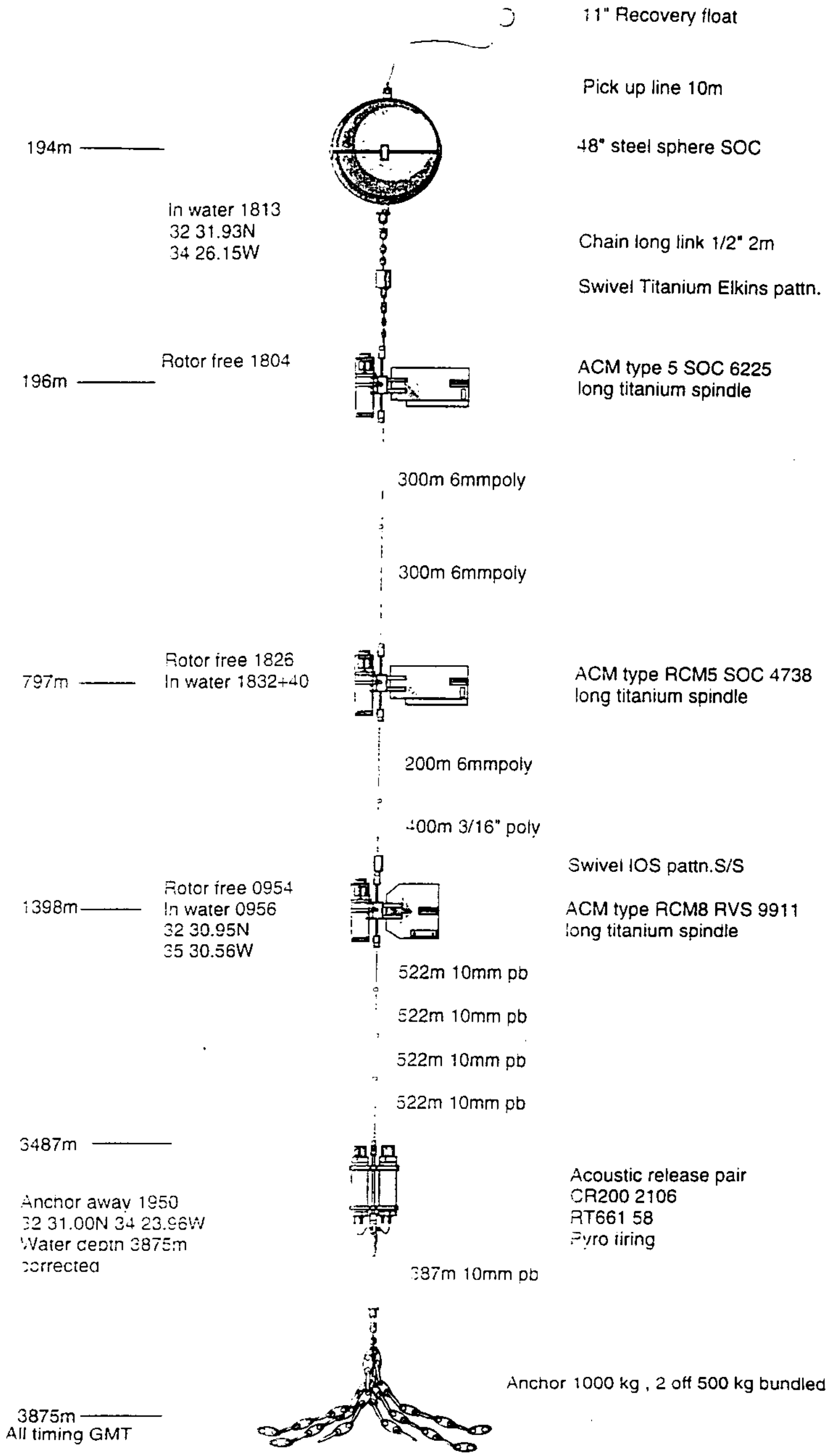


Fig 6.3 Mooring rig 156

6.4 Mooring 150

Mooring 150 deployed 3rd September 1995 on the Goban Spur as part of the OMEX exercise set off the ARGOS alarm system earlier in the cruise. This indicated that the mooring had prematurely surfaced and being equipped with an ARGOS submersible beacon was in a relatively upright position and drifting. Routine monitoring of buoy position was obtained through SOC and an onboard positional plot maintained.

The Charles Darwin proceeded towards the last fix position where on arrival 4th November 1995 (Day 309) at 1720h a poor signal was determined. This signal was at the limit of detection and the ID no. could not be determined. The ship then proceeded on a course extrapolated from previous good fixes and the signal strength was seen to improve such that the GON10 DF set could be locked on to the ID 24574 of the beacon. Darkness fell and vision was restricted to less than 100 metres from the ship. The vessels course was adjusted from bearings obtained from the GON10 and signal strength related to previous observations made on the cruise to estimate range. At 1835 h the buoy was observed to pass close alongside the vessel on the port side by GON10 observations. The vessel was manoeuvred back along the track and the buoy sighted very close alongside. The buoy was kept in sight visually and by careful manoeuvring was brought alongside the starboard main deck where the stray line could be grappled at 1856h. The buoy was then passed astern and hauled aboard by the double barrel mooring winch at 1858h. The buoy was swung onboard and one current meter was hand hauled aboard with a very short mooring wire attached.

The recovered equipment was examined and from the evidence of damage it was determined that the mooring had been "trawled", severing the mooring line just below the top current meter. The current meter spindle was bent and the gimbal assembly destroyed.

The current meter was uncased in the lab and last data time obtained. A data dump revealed that the mooring had been dragged down below the pressure sensor range at approximately 1000h 20th October 1995 for two hours at speeds in excess of 2 knots and then popped up and drifted on the surface.

Further data analysis is to be carried out at PML.

The benefits of ARGOS submersible beacons are well illustrated with this exercise, enabling data and equipment to be recovered. Also for future exercises in OMEX plans can revised in the knowledge of this occurrence. Again chaining the upper current meter to the submersible buoy probably contributed greatly to the recovery of the current meter.

4th November 1995

1720h			Manoeuvring on ARGOS signal
1843h	49^{0}54.50N	09^{0}39.65W	Buoy sighted
1856h	49^{0}54.53N	09^{0}36.69W	Buoy alongside
1858h	49^{0}54.5 N	09^{0}39.70W	Buoy inboard

6.5 Mooring Acoustics

The Simrad EA500 was used to monitor all mooring acoustic units with either IOSDL deck unit on the single element commanding the CR200 sea units or the MORS TT200 (PML) unit being used to command the MORS sea units .

Representative settings used to display the MORS units were;

1.	Operation menu	Ping mode 2 seconds
		Ping interval O
		Noise margin 20db
2	.Display menu	Colour set light
		Echogram speed 1:1
		Echogram 1
	Echogram 1 menu	Range 1000 metres
		Range upper O
		Auto range off
		TVG off
		Colour gain 100 db
3.	Bottom detect menu	min depth O
		max depth O
4.	Transceiver	Passive for no transmission
		Active for depth sounding

For water depths to 3900 metres the pinger signal could be identified clearly. The MORS TT200(PML) was quite difficult to use given the noise conditions prevailing. Ranges were erratic and no positive comment can be made. The overside transducer was used from midships on the starboard side using the full extent of the overside cable.

Commands always got through to the sea unit 184 as seen from the pinger response as displayed on the EA500. Similarly unit 58 could be commanded but as the reply frequency was 8 khz no replies can be detected by the PML deck unit.

On deployment with unit 184 towing astern at 400 metres range and near horizontal pointing away from the ship. The unit could be switched easily from the overside transducer trailing over the stern of the ship. Further development is required to provide an overside towed fish which is lightweight and can be towed at 4 knots plus. This will give greater flexibility in deployment and when relocating moorings for recovery.

All the MORS RT units and deck units now being operated by SOC should be standardised to give better utilisation of the systems.

GONIO Antenna fitting to Darwin

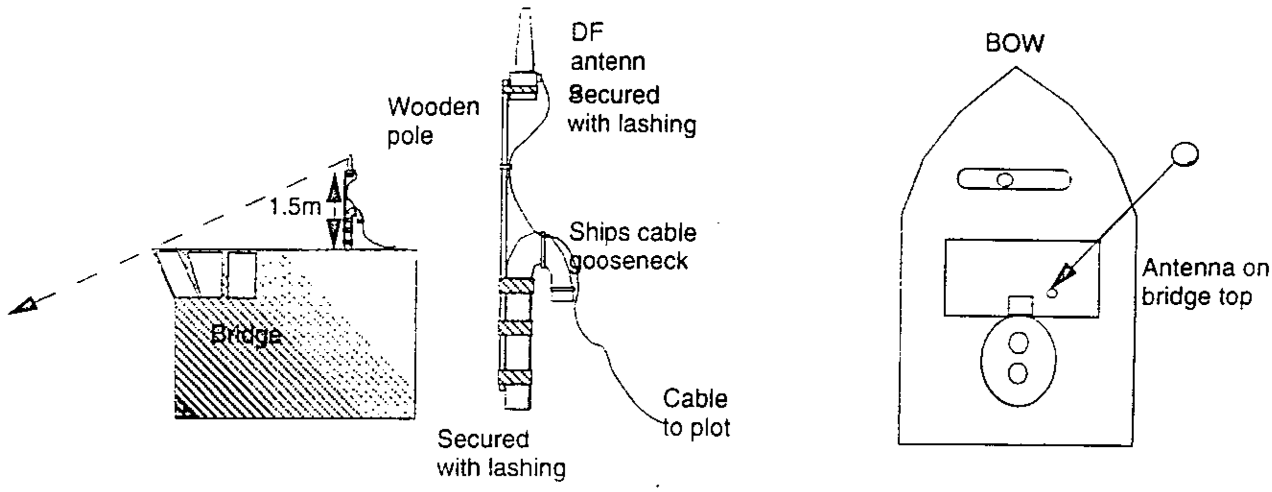


Fig 6.4 GONIO Antenna fitting to Darwin

Buoy type	Range (nm)	Signal strength Digital Display
Moonraker & IDB	12	22
	8	40
	4	50
	2	70
	1	78
MetOcean	12	Not detected
	10	15 Noisy ID.
	8	25
	4	42
	1	68
Mooring 150	3	35 with errors
SIS beacon	1	74
	Alongside	95

Mooring 150 was a drifting mooring and the signal strengths observed are approximations from observed values worked backwards along the shipstrack. The beacon was observed to be moving through an arc of 45 degrees as the buoy moved over the swell, thus causing poor onboard reception as the beacon antenna could be masked by the swell and buoy structure.

6.6 IESM GON10 400 Direction Finder Operations for relocation of ARGOS buoys.

The GON10 400 was used to relocate drifting buoys and check onboard and in water operation of buoys. The unit can detect and recognise the Identification number and sensor data transmitting within the range of the DF antenna. The DF also searches for any or specific ARGOS PTT s as defined by the ID number within its reception area, giving a relative bearing of the PTT to the ship.

The antenna was located on the bridge top secured on a 1.5 metre pole. The DF relative bearing was zeroed in Ponta Delgada by using a transmitting Moonraker buoy positioned approximately 200 metres ahead of the ships bow on the quayside. This was then rechecked and re-zeroed at sea on the firs buoy deployment. The buoy was deployed and then positioned ahead of the vessel to zero the unit. Unfortunately the unit was zeroed when the buoy was 40 degrees off the bow and no further opportunity was available to repeat the exercise. However the 40 degree correction was successfully applied throughout the cruise and presented no problem.

Signal strengths and detection ranges were determined for various buoy deployments relating buoy deployment position to the ships GPS as the vessel steamed away. This was particularly useful when relocating buoys as signal strengths and relative accuracy of the DF bearing could be related to observations for this installation.

Ian Waddington, SOC
Robin Pingree, PML

7. CTD DEPLOYMENTS AND CALIBRATION

The deep CTD used was a Neil Brown mark III. A total of 49 stations were occupied, to a typical depth of 2000m, but some were deeper (to 3500m), and some much shallower (order 200m) for biological sampling purposes. The in situ sampling rate was 8 Hz, but this was averaged to 1 Hz by the level ABC system, which also performed removal of outlying data points. Some processing and presentation was undertaken on the RVS files on the level C computer, but this was mostly done with the PSTAR system after using the programme "datapup" to transfer the data. The PSTAR processing followed the procedures from previous cruises, utilising macros for data calibration, editing and presentation.

An initial calibration for the CTD sensors was provided by RVS and used by the PSTAR routine ctdcal, and hysteresis in the pressure sensor was corrected for. The CTD temperatures agreed to within typically 2-3 millidegrees with two reversing thermometers, but was believed to be both more stable, and possibly more accurate. As a result, no correction was applied to the CTD temperatures. The CTD salinities were compared with values derived from bottle samples mid-way through the cruise, and it was found necessary to add an offset of +0.0277 to increase the CTD values. The mean deviation from the bottle samples was then about +/- 0.002. We also note that the bottles taken during the latter part of the cruise showed a small drift in the CTD salinities, but so far this has not been included in the processing.

CTD oxygen values were also compared with bottle-derived values using the Winkler method, and the resulting final calibration was determined as

oxygen(cal) = 0.19238 + 2.30476*oxygen(CTD) ml/l.

Transmission and fluorescence were left converted from raw counts into volts.

Adrian New, SOC
Bablu Sinha, PML

8. EXPENDABLE BATHYTHERMOGRAPHS

A total of 160 expendable bathythermographs (XBTs) were used extensively throughout the cruise to determine water column temperature profiles and to locate features of interest such as eddies, main current meanders, temperature inversions, intrusions at frontal zones and within the subsurface layer. They were used more intensively to map the three dimensional structure of subtropical front eddies and meanders in combination with CTD stations and acoustic doppler current measurements. A listing of the stations is given in Scientific Appendix 14.2. Of the 14 complete failures, most were due to the XBT wire being blown by following winds back onto the ship and thus shorting the connection. A simple launch tube reaching closer to the water would remedy this and also make the operation safer for launcher operator on deck.

Of the 160 XBTs used, most were of type T5 with a maximum design depth of 2000m, but also some of the shallower T7 were deployed. The controlling and recording system and many of the XBTs were provided by the MOD Hydrographic Office. The system used was the Sippican SA810 launcher and Bathy Systems 'SEAS' software. This included the facility to provide immediate temperature depth profile plots, with expanded plots of areas of interests, and listing of isotherm depths. Also included was a facility for transmitting the data in near real time via the GOES satellite system but for the duration of the cruise the transmitter was not working.

There was no direct connection to the ship computer network, so the data was transferred by disk and converted to RVS data files. The actual time of launch and thus the true position and water depth, were entered into the data files as the original data headers were recorded some minutes before launch. Top and bottom data transients and other erroneous data were flagged using the graphical editor programme. One feature of concern was the presence on all traces of large unreal displacement to low temperatures on entering the water, following by an apparent exponential recovery to reasonable values in the top 60m or so of the surface mixed layer. The reason for this is unknown but a defect in the data acquisition hardware is suspected. Another annoying feature of the software was the maximum depth of 1833m allowed for T5 probes, thus losing 10% of the depth capability.

The accuracy of the XBT measurements was analysed by comparing with the CTD measurements, which we took to represent the truth. A typical comparison of the profiles of temperature obtained from XBT and CTD measurements are shown in figs 8.1(a-d). There is clearly an unreal displacement to low temperatures within the surface mixed layer (fig 8.1a), followed by a consistent positive offset in the XBT profile when compared to that of the CTD below the mixed layer. Estimates of the differences between isotherm depth locations determined from XBT and CTD measurements were evaluated (fig 8.2a), along with temperature differences between XBT and CTD measurements at fixed depth levels (fig 8.2b). Finally, the main statistics (means, standard deviations) for these XBT-CTD differences throughout the cruise duration were calculatedand are presented in Appendices 14.3 & 14.4.

Note that generally, XBT measured isotherm locations are deeper than CTD ones, and such differences increase with depth from about 5-10m within upper mixed layer and seasonal thermocline, to near 50-60m below the active layer (fig 8.2a). Thus water temperature measured at fixed depths by the XBTs are higher compared to the CTD measurements, but these temperature differences decrease with depth in an exponential fashion from 0.7-0.8 C in seasonal thermocline to 0.3-0.2 C in deep layers. These correction factors were taken into account with the subsequent post-processing of the XBT profiles.

Finally, XBT data collected during the cruise were combined with CTD data to provide contour maps of the depth of isotherm surfaces. The RVS data files were also converted to PSTAR data files both with and without the corrections. Temperature depth profile plots were produced.

Leonid Nechvolodov, SOI

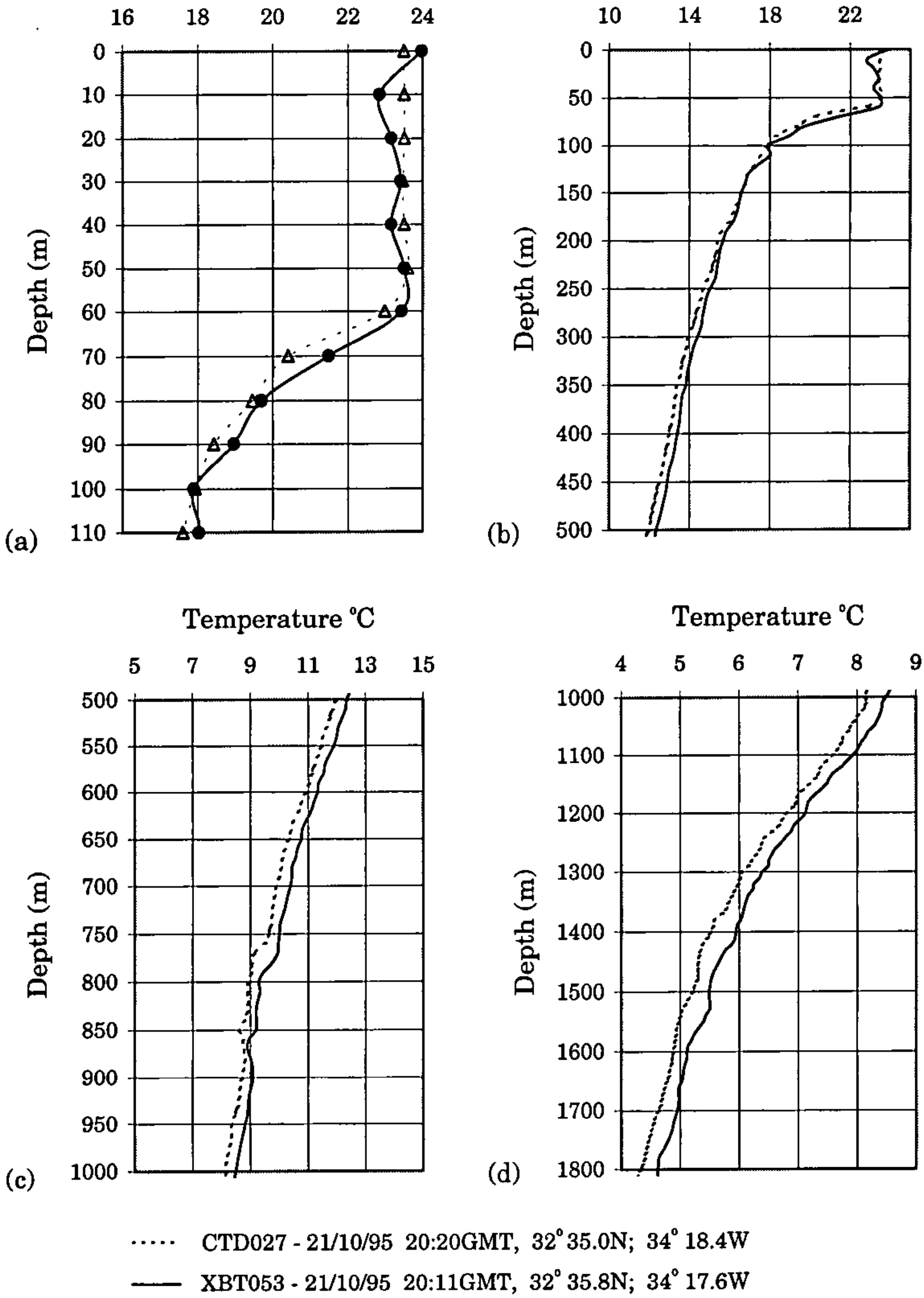


Fig 8.1 XBT vs. CTD vertical profiles of temperature

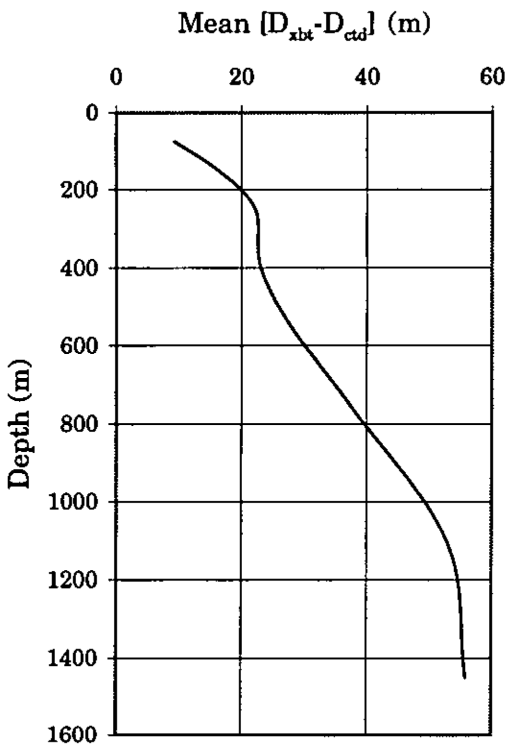


Fig 8.2a Differences in depth of selected isotherms determined from both XBT and CTD profiles.

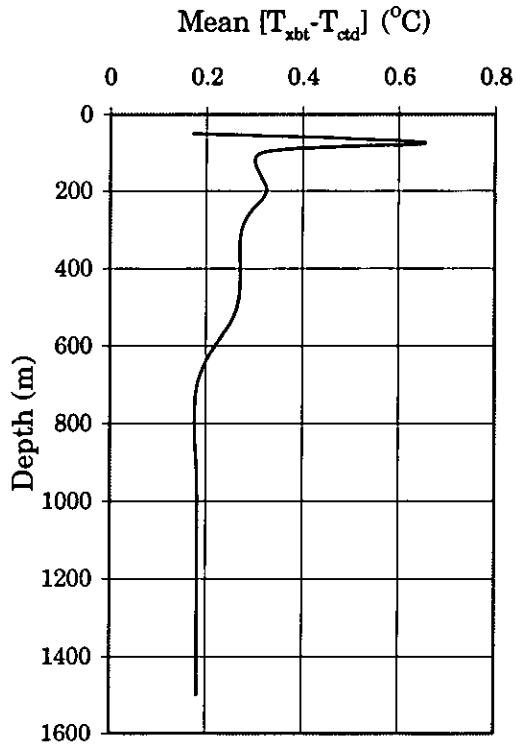


Fig 8.2b Temperature differences between XBT and CTD profiles.

9. ACOUSTIC DOPPLER CURRENT PROFILER

The ship-mounted ADCP (153 kHz, RDI transducer serial number 302) was used successfully throughout the cruise and recorded data continuously. Two configurations were set up for use, cdocean (50*8m bins, no bottom tracking) and cdshelf (50*8m bins, with bottom tracking). Ensembles were averaged over 2.5 minutes by the pc and logged directly by the ABC computer system. This worked well apart from a single loss of about 7.5 hours of data (day 293/1330-2100 hours) due to a problem with the pc after a clock reset (see below), which also meant that data was also not logged by the pc itself. Bottom tracking was set to be possible in water in up to 700m water depth by inserting FB00003 for parameter 2 in the DC menu, even though most of the cruise was in deep water. Other menu changes from standard were DM = No, AP = Yes, BK = 4m and OD = 13m (5m transducer depth and 8m bin length). The transducer heads were concave, with a mounting angle of 30 degrees, and the speed of sound was assumed to be 1500 m/s throughout by the ADCP software.

Software was version 2.48 and firmware version 17.07, and good underway data was typically achieved to about 150-200m in moderate seas, with around 140 pings per ensemble (for cdocean). This low depth penetration probably resulted from typical ship's speeds of around 11 kt, which were necessary in order to complete the cruise objectives. On station, on the other hand, good data was typically recorded to about 300m depth. The ADCP clock ran fast by order 20 seconds per day, and this was reset once per day. A linear clock drift was applied in the processing of the data in the PSTAR system. The drift rate was taken as 2.26x10-4 for the large part of the cruise, until day 304, after which a rate of 2.072x10-4 was used. Other notable problems were that the pc would often not restart the ADCP programme on the command "adcp" from the "ADCP248" directory after a clock reset, necessitating a complete reboot with "Control/Alt/Delete", and also that even after restarting the ADCP pinging there was no guarantee that this would be logged by the ABC system (and also possibly by the pc itself). After one loss of data (see above), a warning device was installed on the computer in the main lab. This prevented further data loss.

An initial zig-zag calibration was undertaken on leaving Ponta Delgada by running to the southwest, but this was contaminated by internal tidal motions. A further calibration was made suspect by the presence of inertial motions following a rapid change in the wind direction. Finally, a good calibration was obtained by steaming backwards and forwards over the same piece of water before and after a CTD station, on two separate occasions, and averaging the result. This gave A = 1.0188 and Ø = 4.0712 (the value for Ø being consistent with noting that the ship's heading as read into the ADCP programme was about 4 degrees lower than showing on the repeater gyro in the scientific plot room, for some unknown reason). This calibration appeared to give good absolute velocities both underway and on station, after merging the adcp data with gps position fixing (with a 2-minute running mean applied with the routine pfiltr) to calculate the ship's speed over the ground. All ADCP data processing was performed with the PSTAR system, using unix scripts developed on previous cruises. Some improvements (described in the log sheets) were made to these scripts on this cruise, to more accurately align the centre of ensembles with the appropriate gps fixes. (Note that the routine posspd takes two consecutive positions and places the resulting speed at the second time.) Data was averaged into 10-minute ensembles and routinely contoured in 12-hour sections. Absolute current vectors were drawn on charts of the ships track by further averaging with the routine padpav, using an interval of 30 minutes and a search radius of 45 minutes.

Finally, we remark that the data quality deteriorated markedly on the northeasterly leg from the Azores to the Goban Spur, with good data to only 50-100m. The onset of this poorer data quality may have been associated with the passage of hurricane Tanya (although some distance away) on day 306, which resulted in some strong winds and a heavy following sea. However, the data quality did not seem to improve after the passage of the storm, nor after air was bled from the transducers. This problem affected only the last few days of the cruise, however, on the homeward passage, and the quality of the absolute currents inferred from the ADCP over the main part of the cruise (in the area of principal scientific interest) was pleasing.

Bablu Sinha, PML
Adrian New, SOC.

10. SEASOAR DEPLOYMENT AND CALIBRATION

The SeaSoar used had been newly purchased by RVS, and had not been previously deployed. After streaming the (new) faired cable, an initial deployment was made, but there were problems apparently with the hydraulic unit, and the SeaSoar would not fly properly. This was subsequently corrected for, and there were two successful deployments, of the order of 12 hours each, in which the SeaSoar typically cycled to about 400m depth every 12 minutes or so. After discussions with the RVS computer technicians, the data was captured at the full rate of 8Hz to allow future studies of small-scale variability. Again, this data was transferred to the PSTAR system for processing and calibration.

As for the deep CTD, the initial calibration was supplied by RVS. During the cruise, further calibration was attempted by two methods. Firstly, we compared the SeaSoar readings from the last/first SeaSoar profile (between the surface and about 400m, with no averaging) with CTD stations immediately after/before the SeaSoar runs (CTD numbers 043, 046 and 047). This comparison was done on isopycnal surfaces (rather than on levels) to reduce the errors from isopycnal "heaving". Secondly, surface comparisons were made with the ship's thermosalinograph (TSG, which had been calibrated) and with surface bottle samples. For temperature,the isopycnal comparison showed quite a large scatter, but comparisons with the TSG showed differences of about 2 millidegrees. As for the deep CTD, no correction was therefore applied to the SeaSoar temperatures. For salinity, the isopycnal comparison implied an offset of +0.0290 should be added to the SeaSoar values. Comparisons with the bottles indicated an offset of +0.0195, and with the TSG, an offset of +0.0165. Consequently, a weighted mean of +0.0210 was applied to increase the SeaSoar values.

Finally, for oxygen, the only calibration available was that from the isopycnal comparison, and this was applied to the SeaSoar values as

oxygen(cal)= 0.0806 + 2.520*oxygen(SeaSoar) ml/l.

Adrian New, SOC
Bablu Sinha, PML

11. MEASUREMENT OF SURFACE PROPERTIES

11.1 Instrumentation

During the cruise period continuous on-line monitoring of surface (4m) properties was carried out for temperature, salinity, in vivo chlorophyll fluorescence, transmission and inorganic nutrients. The seawater supply was fed from the ship's non toxic supply pumped from an intake at a depth of 4m. Data was logged either on the Darwin's level A interface computer, PC's or on chart recorders.

11.2 Temperature and Salinity

Measurements of surface (4m) temperature and salinity were carried out using:

(a) The RVS Falmouth Scientific Instruments thermosalinograph (TSG) mounted in the wet lab and fed from the ship's non toxic supply via a header/debubbling tank. The output was graphically displayed on a PC in the main lab with data logged onto the level A computing system.
(b) The PML Bisset Berman TSD system mounted in a deck box, with the frequency outputs logged as voltages on the Siemens chart recorder in the main laboratory.

Calibration of individual salinity sensors was carried out by comparison with 4 hourly discrete salinity samples taken from the TSG seawater outlet. A number of the surface samples were also utilised in calibrations for the salinity sensor on Seasoar.

Calibration of temperature sensors was effected by comparison with CTD temperature values at 4m depth on CTD profiles.

11.3 Transmission

Transmission measurements were carried out with duplicate 25cm Seatech transmissometers mounted in deck boxes fed with seawater from the non toxic seawater supply. Transmissometer lenses were cleaned every seven days. Data was logged onto a Siemens chart recorder for the PML system and the ships level A computing system for the RVS transmissometer.

11.4 In Vivo Chlorophyll Fluorescence

Measurements of in vivo Chlorophyll fluorescence were carried out with duplicate Chelsea Instruments Aquatracka II fluorometers mounted in deck boxes fed from the ship's non toxic seawater supply. Discrete calibration samples were taken from the non toxic supply at regular intervals to compare fluorescence output with measured chlorophyll 'a' values. Data was logged onto the Siemens chart recorder for the PML system and the ships level A computing system for the RVS fluorometer.

11.5 Inorganic Nutrients

The Autoanalyser system in all respects was identical to that used on Darwin cruises 66 and 83 and Discovery cruise 198. The instrument was run on-line with water being fed from the ship's non toxic supply system via a 12mm tygon loop. Water was pumped into the autoanalyser train via a 3mm pvc inlet connected to a three way valve so that analysis could be switched from on-line mode to discrete sampling. No inline filter was incorporated into the system for removal of particulates. Discrete samples, taken from CTD profiles were run for 5 minutes interspersed with a I minute wash giving a total analysis time of 6 minutes per sample. Samples greater than 10µm/l were diluted 1:1 with low nutrient seawater. The chemical methods used were the well tested wet chemical methods which have been developed and used at PML for many years. Calibrations were carried out on each batch of samples with standards of 2.5µm/l, 5.0µm/l, 7.5µm/l and 10.0 µm/l. Data was logged onto chart recorders only. Calculation of data was by application of peak height analysis.

Bob Head, PML

12. CHEMICAL AND BIOLOGICAL SAMPLING

12.1 Underway Sampling

12.1.1 Chlorophyll 'a'

Surface 4m discrete samples (see appendix 14.5) were taken at 2 hourly intervals from the ship's non toxic supply for chlorophyll 'a' estimates. 100ml aliquots were filtered onto 25mm GF/F microfibre filters and after extraction into 90% Acetone, fluorometric determinations before and after addition of acid were made on a Turner 111 fluorometer. The fluorometer was calibrated pre and post cruise with known dilution's of a chlorophyll 'a' standard in 90% Acetone (~$1mgL^{-1}$). Discrete samples were also taken from the majority of CTD profiles within the top mixed layer with special reference to the chlorophyll fluorescence/oxygen maxima. (80 - 120m)

12.1.2 Quantitative Phytoplankton Sampling

Duplicate samples were taken at discrete depths from CTD profiles in addition to standard 4 hourly samples taken from the surface (4m) non toxic seawater system and fixed in both Lugols iodine and buffered formaldehyde for post cruise Phytoplankton species identification and enumeration (see appendix 14.6).

12.1.3 Particulate Carbon/Nitogen (PCN) Sampling

Surface 4m samples were taken for PCN by filtration of 250ml aliquots onto precombusted GF/F microfibre filters. A number of samples were also taken from CTD profiles in conjunction with Chl 'a' and lugols/formalin Phytoplankton sampling (see appendix 14.7).

12.1.4 Particle Sizing

A Coulter Multisizer particle size analyser was used to determine size distribution, volume and concentration of natural particulates. A 100µm orifice tube was utilised to count particles in the range 2 - 20µm ESD. (equivalent spherical diameter, see appendix 14.8).

12.1.5 Provisional Results

Surface Chlorophyll levels were extremely low with measured Chl 'a' values being typically less than 0.1ug l^{-1}. Acid ratios were ~1.4 - 1.6 (pure chlorophyll ~ 2.05. Size fractionated data collected during cruises CD66/92 and CD83/94 indicate that within the working area surrounding the Azores Subtropical Front (ASTF), > 90% of the photosynthetic Phytoplankton are associated with the <2µm size fraction. The measured values may well be underestimated as the literature seems to indicate that GAF/F filters (pore size ~0.7µm) may only retain 75 - 95% of the total Chl 'a' from samples containing plankton in that size range. Similarly nutrient values were minimal with nitrate levels of < 0.1µm and silicate levels of < 0.5µm observed. No increased response in Chl 'a', transmission or inorganic nutrients was observed in the legs crossing the ASTF.

CTD profiles exhibited a deep weak Chlorophyll fluorescence maxima at 100 - 120m with the oxygen maxima occurring at a depth usually 20 - 30m shallower. Maximum measured chlorophyll 'a' values on each profile coincided with the oxygen maximum rather than the fluorescence maximum. Across the thermocline measured acid ratios decreased with depth, thereby indicating less active Phytoplankton either due to senescence or decreasing light levels. The nutricline was always observed at depths of 175-250m.

Bob Head, PML

12.2 Zooplankton sampling

There are few studies comparing communities of zooplankton over seamounts with those off of seamounts and results appear contradictory. Where an increase in zooplankton abundance has been detected it has been related to possible increases in primary productivity due to current - topography interactions which cause local upwelling. But more usually a decreased abundance of zooplankton or a difference in the composition of the zooplankton community has been detected and this has been related to the absence of diurnally migrating plankton over seamounts and to increased predation of zooplankton in the vicinity of seamounts by predators resident on the seamount or seamount flanks. CD 97 provided opportunities to sample and compare the zooplankton communities both on and off seamounts in the vicinity of the subtropical front south of the Azores. This cruise also provided the opportunity to sample and compare the shallow water zooplankton community both within and outside a large eddy which has originated along the subtropical front.

Methods.

Samples were collected using a WP2 plankton net with a mesh size of 200μm. Samples were taken from 100m depth and the net was hauled at a speed of 15 m/min. Samples were immediately fixed in 4% formalin and stored in labelled plastic jars. Three replicates were collected at each site and treated individually. Times and positions were recorded at each sampling site and these were used to locate surface temperatures, salinity and fluorimetry. Since samples coincided with CTDs temperature, salinity and oxygen concentration at 50m and 100m were also recorded for each sample.

Samples will be sorted and identified in Plymouth where statistical analysis will also be carried out to identify any correlations between zooplankton sample composition and the physical characteristics measured. It is expected that there will be a difference in day vs night samples due to the presence/ absence of diurnal migrators. A record of movement of scattering layers was made during sampling to identify when diurnally migrating plankton were moving towards and away from the sea surface. This was carried out using a SIMRAD EA500 echo sounder with a 12 MHZ transducer at 100-110DB.

A list of the WP2 sampling stations are given in Appendix 14.10, giving date (Julian days), time at which each sample began, number of the CTD station and latitude and longitude according to BESTNAV GPS positioning, except for samples at CTD station 43 which are GPS TRIM.

Alex Rogers, PML

12.3 Vertical profiling with CTD samples

12.3.1 Dissolved oxygen concentration

The oxygen sensor on the CTD was calibrated using a winkler titration with automatic end point determination on an SIS Dissolved Oxygen Analyser (Dosimat 665). Samples were collected in numbered stoppered glass bottles for which individual volumes had been previously calculated. Each bottle was filled directly from CTD bottles at least three times - care being taken not to admit any air bubbles to the sample water prior to fixation of oxygen. To each sample 1ml of $MnSO_4$ (50% w/v) and 1ml of NaOH (8N)/NaI (4M) was added and the bottles stoppered, without admitting air bubbles, and shaken up to produce a precipitate of manganous hydroxide. This precipitate was allowed to settle and then the bottles were shaken up and allowed to settle a second time. Samples were then acidified by adding 1ml of 10N H_2SO_4. This causes manganous hydroxide to dissolve and react with iodide to form a soluble triiodide complex which is chemically equivalent to the oxygen that originally entered the reaction. The amount iodine was then determined by titration in the SIS Oxygen Analyser with 2N sodium thiosulphate and from this the concentration of oxygen in the original sample was calculated according to WOCE standard procedures. Two replicates were carried out for each CTD bottle sample and reagent blanks were determined by titrating 1 ml of 0.01N KIO_3 in distilled water.

A calibration graph was constructed of oxygen concentrations calculated from titration vs values for dissolved oxygen from the CTD sensor.

Dissolved oxygen concentrations (ml/l), calculated for various depths from CTD stations 4-25, are shown in Appendix 14.9 and were used in the calibration of the CTD oxygen sensor.

Alex Rogers, PML

12.3.2 Size fractionated primary production

Samples for simulated *in situ* incubations were taken from the CTD rosette from casts prior to dawn to minimise the risk of light shock to the phytoplankton. All samples were handled using clean techniques according to the JGOFS, level 1 protocols. Whenever possible 10 depths were sampled, with the depths being selected after examination of the vertical structure of chlorophyll fluorescence, temperature and oxygen concentration. Sampling depths were chosen to correspond to the light intensities available in the on deck incubator. A full list of CTD's sampled and depths selected is presented in table 1.

Four replicate bottles from each depth were inocculated with 10 microcuries of 14C-Sodium bicarbonate solution before being placed in the on-deck incubator for 24 hours at the % transmission which corresponded most closely to that likely to be experienced at the depth sampled. One of the four replicates from each depth was incubated in a black tube to act as a dark control. The light spectra in each of the on-deck tubes was modified using a combination of coloured and neutral density filters to simulate the *in situ* spectra in oligotrophic waters. Tubes were cooled with surface seawater from the non-toxic supply. The incubators were covered at night to prevent illumination of the samples from the ships deck lights. At dawn, the following day, sample bottles were removed from the incubator and transferred, in the dark, to the laboratory for filtration.

Samples were filtered sequentially through 20, 2.0 and 0.2 micron polycarbonate filters, which correspond to the micro, nano and picoplanktonic size classes of phytoplankton, dried by dessication for 24 hours and subsequently counted in an LKB Spectral liquid scintillation counter. Counting efficiency was determined by the external standard, channels ratio method. 12 incubations were succesfully completed involving a total of 1426 samples.

The biomass of phytoplankton will be determined by 2 methods: A large volume sample from each of the CTD bottles sampled (table 1) was filtered through a 47mm GFF filter for spectrophotometric analysis of chlorophyll a concentration. A replicate 100 ml sample was also taken from each CTD bottle and filtered through 20, 2.0 and 0.2 micron polycarbonate filters for fluorometric analysis to determine the size fractionated distribution of chlorophyll. A total of 118 samples were collected for spectrophotometric analysis and 354 for fluorometric analysis.

A preliminary examination of the primary production data show the phytoplankton to be dominated by the picoplanktonic size fraction, with between 75-90% of the productivity occuring in this size class. Daily production rates were low, generally being at or below 250 mg C m^{-2} d^{-1}.

Heterotrophic bacteria

The numbers and productivity of heterotrophic bacteria have been determined for every sample taken for primary productivity incubations. This will enable the proportion of primary production, measured in the picoplanktonic size fraction, and potentially due to the uptake of 14C labelled DOC by bacteria, to be determined. This is of particular importance in waters dominated by picoplankton as bacteria will also be retained on 0.2 micron filters. Bacterial abundance has been determined for all samples listed in table 1 using epifluorescence and the nucleic acid stain diamidino phenylindole (DAPI). All samples were examined and counted on board before being frozen and stored for the subsequent, laboratory determination of bacterial sizes,biovolume and hence carbon content. A total of 118 samples were counted.

Rates of heterotrophic activity have been measured using 2 complementary techniques: The uptake of tritiated, methyl thymidine, which is incorporated into bacterial nucleic acids and the uptake of tritiated L-leucine, which is incorporated into protein. The former relates directly to rates of bacterial division and the latter to growth. Four replicate samples and one glutaraldehyde-fixed control were incubated from each of the CTD bottles sampled. The use of a specially designed incubation system, with surface seawater from the non-toxic supply at one end and a cooler and circulator at the other enables the thermal structure of the upper water column to be simulated in the laboratory, giving up to 24 different temperatures. All bacterial samples were incubated within 0.2^{o}C of in situ temperatures. Previous work in the N. Atlantic and Indian Ocean has demonstrated that bacterial production is more closely linked to temperature than to bacterial numbers.

Samples were innoculated with 5nM thymidine or 10nM leucine and incubated for 1 hour. The incubations were terminated by the addition of ice-cold trichloroacetic acid at a final concentration of 5%. The addition of TCA precipitates the bacterial nucleic acids or proteins , which can then be filtered onto 0.2 micron polycarbonate filters. These are then rinsed with 5% TCA and dried by dessication overnight before being counted in the liquid scintillation counter. The rates of uptake of tritiated leucine can be affected by isotopic dilution if the extracellular concentration of unlabelled leucine is high. This is unlikely to be the case in oligotrophic waters, but a number of kinetic experiments were completed to ensure that an addition of 10nM was sufficient to saturate the bacterial demand for leucine. A total of 26 incubations were completed involving a total of 1255 samples.

Table 1. Primary production and bacterial production samples.

Date	CTD	Depths (metres)									
13-Oct-95	2	1	11	20	30	37	49	56	65	71	85
14-Oct-95	5	1	13	24	35	43	58	66	76	83	100
15-Oct-95	7	1	13	24	35	43	58	66	76	83	100
16-Oct-95	12	1	13	24	35	43	58	66	76	93	100
17-Oct-95	17	1	19	34	49	60	81	92	106	116	140
18-Oct-95	19	1	19	34	49	60	81	92	106	116	140
20-Oct-95	24	1	13	24	35	43	58	66	76	83	100
22-Oct-95	28	1	13	24	35	43	58	66	76	83	100
24-Oct-95	32	1	13	24	35	43	58		76	83	100
26-Oct-95	40	1	13	24	35	43	58	66	79	83	100
28-Oct-95	43	1	13	24	35	43	58	66	76	83	100
29-Oct-95	45	1	12	22	32	39	52	59	68	75	90

Alan Pomroy, PML

12.3.3 Phytoplankton biomass distribution

Objectives

It is important to know the relationship between velocity of the currents, possible upwelling - downwelling, and biological production.

It would be interesting to know which is the physiological state and growth capacity of the phytoplankton in the chlorophyll and oxygen maximum in all different hydrographic features possible.

1.- At the Greater Meteor Seamount area (29° 59.96 N 28° 26.92W) 4 CTD profiles were carried out (CTD10, 12, 13 & 14) at the plateau, the slope and away from the seamountain.

The chlorophyll and the primary production samples were size fractionated (0.2, 2.0 & 20 µm) to investigate the phytoplankton biomass distribution in the euphotic zone.

The primary production samples were inoculated with 14C and incubated during 24 hours at their lights of origin. The filters are frozen because It wouldn't be possible to bring the equipment necessary to do the fractionated into the main final products of the photosynthetic metabolism (carbohydrates, proteins, lipids and low molecular weight metabolites). This part of the analysis it will be undertaken in Oviedo following a procedure modified by from Li et al . (1980) and Lohrenz & Taylor (1987).

2.- At the large, circulating, hydrographic feature of primary interest, five CTD's (24, 28, 29, 30, 32, 42, 43,45) were carried out in the centre and in the peripheral waters. The methods were the same as at the GMT. Cold core rings have interesting potential to stimulate the biological production. The objectives were to study the phytoplankton biomass in the chlorophyll maximum and oxygen maximum (always is upper than the chlorophyll maximum). It is important to study the taxonomy because it is possible that transport of distinct phyto and zooplankton species may occur in this feature.

The samples from the CTD's 28 of the chlorophyll maximum were incubated during 24 hours at different levels of irradiance, to have an idea about physiological adjustment s during acclimation to new irradiance.

3.- The rest of the CTD's were taken to complement the information from the size fractionated of primary production of Alan Pomroy. A full listing of the samples taken are given in Appendix 14.9.

Methods (JGOFS Protocols- June 1994)

Shipboards sampling:

A set of 5-6 depths bracketing the entire euphotic zone (light levels include 95-1 %) were sampled. In addition, dark controls were taken from the depth of the oxygen maxima. I have selected the depths based on the chlorophyll and oxygen profile .

Whenever possible the samples were taken before dawn. However a number of CTD's where sampled during day-light hours, when interesting hydrographic features were present (GMT etc...).

Natalia Gonzalez, UO

13. UNDULATING OCEANOGRAPHIC RECORDER (UOR)

Due to the lack of availability of the PML UOR's, the DRA kindly offered the loan of one of their 'Aquashuttles' for the CD97 Cruise. The Aquashuttle had been in storage at the suppliers, Chelsea Instruments Ltd, for the previous two years, and was due to be upgraded. The Aquapack facilidated CTD and fluorescence measurements, but there were no light sensors. With a maximum undulating depth of 80m with a 8mm steel cable, at a maximum steaming speed of 11knts, the 'Aquashuttle' was hoped to be used opportunistically whilst steaming along each leg.

Due to time constraints prior to the final depature date for the RVS container, it was not possible to fully test the 'Aquashuttle' before going to sea. During the CD97 Cruise, it became clear that there existed a communications breakdown between the Aquapack and the Servo mechanism. Although the CTD was operating properly this meant that there was no control of the undulating pattern, or any idea of its present settings. In light of this restriction, and with the facility to deploy SeaSoar, there were no subsequent deployments of the 'Aquashuttle'.

The time that Simon and Alan (RVS - technical support) set aside to help me to try to resolve the communications fault was greatly appreciated.

Paul Chatwin, UOP / PML

SCIENTIFIC APPENDICES

14.1 CTD Station listing

CTD	Date (yy/mm/dd)	Time (hhmmss)	Lat (°N)	Lon (°W)	Depth (m)	Max Press (db)
ctd 001	95/10/12	201336	37.00	26.99	2536	2031
ctd 002	95/10/13	042119	35.99	27.29	3619	3563
ctd 003	95/10/13	140950	35.00	27.58	2338	2029
ctd 004	95/10/13	213721	33.99	27.86	3807	2027
ctd 005	95/10/14	063316	32.99	28.15	3182	2032
ctd 006	95/10/14	125752	33.50	28.01	4291	2023
ctd 007	95/10/15	042734	31.99	28.44	1963	1930
ctd 008	95/10/15	061115	31.99	28.43	1915	112
ctd 009	95/10/15	142101	30.99	28.72	2023	2076
ctd 010	95/10/15	201258	30.49	28.58	4221	2028
ctd 011	95/10/16	021600	29.99	28.44	311	308
ctd 012	95/10/16	041201	30.00	28.44	312	122
ctd 013	95/10/16	055500	30.00	28.44	312	121
ctd 014	95/10/16	122137	29.99	28.99	3384	2028
ctd 015	95/10/16	151615	29.99	29.00	3448	261
ctd 016	95/10/16	211455	29.99	29.99	4510	2024
ctd 017	95/10/17	051046	29.99	31.00	4831	2024
ctd 018	95/10/17	130413	29.99	32.00	4221	2026
ctd 019	95/10/18	014421	29.99	33.74	4663	2026
ctd 020	95/10/18	131030	30.00	34.75	4534	2024
ctd 021	95/10/19	001744	30.99	33.48	4573	2024
ctd 022	95/10/19	085400	31.99	33.18	4032	2027
ctd 023	95/10/19	180030	31.50	33.33	3556	2020
ctd 024	95/10/20	063249	33.00	32.91	3254	2026
ctd 025	95/10/20	141500	34.00	32.62	3481	2025
ctd 026	95/10/21	004250	35.33	32.23	2392	2029
ctd 027	95/10/21	204108	32.58	34.30	3619	2527
ctd 028	95/10/22	034431	31.66	34.29	4325	2482
ctd 029	95/10/22	130339	32.33	33.33	3903	3048
ctd 030	95/10/23	013310	32.33	32.08	3823	2552
ctd 031	95/10/23	085631	31.66	31.98	3909	2491
ctd 032	95/10/24	061750	32.84	34.06	3832	2497
ctd 033	95/10/24	214710	32.42	33.34	3828	3561
ctd 034	95/10/25	061520	32.50	32.87	3930	2032
ctd 035	95/10/25	093221	32.67	32.58	3740	2032
ctd 036	95/10/25	124731	32.83	32.29	3674	2028
ctd 037	95/10/25	160526	33.01	32.00	3732	2536
ctd 038	95/10/25	195241	33.16	31.70	3592	2531

CTD	Date (yy/mm/dd)	Time (hhmmss)	Lat (°N)	Lon (°W)	Depth (m)	Max Press (db)
ctd 039	95/10/25	233900	33.33	31.40	3341	3394
ctd 040	95/10/26	051230	33.49	31.12	3204	2028
ctd 041	95/10/26	121200	33.50	30.00	3044	2535
ctd 042	95/10/27	034053	32.49	32.01	4106	207
ctd 043	95/10/28	030015	32.53	35.50	3560	3676
ctd 044	95/10/28	211500	32.53	34.36	3843	3556
ctd 045	95/10/29	063133	32.84	33.31	3550	302
ctd 046	95/10/29	171309	33.99	31.99	3491	3501
ctd 047	95/10/30	071808	35.03	30.98	2703	3017
ctd 048	95/10/30	140753	34.99	29.99	3149	3052
ctd 049	95/10/30	210706	35.00	28.99	3642	3052

14.2 XBT Station listing

XBT	Date (yy/mm/dd)	Time (hhmmss)	Lat (°N)	Lon (°W)	Depth (m)	Max Press (db)
xbt 003	95/10/12	150500	37.25	26.19	2168	1833
xbt 004	95/10/12	173900	37.13	26.59	2688	1775
xbt 005	95/10/13	000200	36.65	27.10	3651	1833
xbt 006	95/10/13	020900	36.32	27.20	3120	1833
xbt 007	95/10/13	094800	35.65	27.39	3444	1833
xbt 008	95/10/13	115200	35.32	27.49	3245	1833
xbt 009	95/10/13	173200	34.65	27.68	1680	1833
xbt 010	95/10/13	192900	34.34	27.77	3816	1833
xbt 012	95/10/14	022300	33.66	27.97	3928	1833
xbt 013	95/10/14	041800	33.34	28.06	4139	1833
xbt 014	95/10/14	220400	32.66	28.25	3320	1833
xbt 015	95/10/15	002200	32.32	28.34	1349	1833
xbt 016	95/10/15	095000	31.65	28.54	1876	1833
xbt 017	95/10/15	115400	31.33	28.63	1432	1734
xbt 018	95/10/15	182200	30.74	28.65	2830	1833
xbt 019	95/10/16	002300	30.23	28.51	2110	1833
xbt 020	95/10/16	104500	29.99	28.74	1650	1833
xbt 021	95/10/16	172500	30.00	29.33	4165	1833
xbt 022	95/10/16	191600	29.99	29.66	4351	1833
xbt 023	95/10/17	011700	29.99	30.34	4630	1833
xbt 024	95/10/17	030500	30.00	30.66	4666	1833
xbt 025	95/10/17	093200	30.00	31.38	4758	1833

XBT	Date (yy/mm/dd)	Time (hhmmss)	Lat (°N)	Lon (°W)	Depth (m)	Max Press (db)
xbt 026	95/10/17	105900	30.00	31.66	4814	1833
xbt 027	95/10/17	165700	30.00	32.33	4320	1833
xbt 028	95/10/17	184200	30.00	32.67	3878	1833
xbt 029	95/10/17	202700	30.00	32.99	4934	1833
xbt 030	95/10/17	222500	30.00	33.37	4550	1833
xbt 031	95/10/18	082700	29.80	34.48	4810	1833
xbt 032	95/10/18	114900	29.87	34.64	4950	1833
xbt 033	95/10/18	175600	30.33	34.32	4888	1833
xbt 034	95/10/18	210400	30.66	33.90	4882	1833
xbt 035	95/10/19	043300	31.33	33.37	3530	1833
xbt 036	95/10/19	063200	31.66	33.28	4400	1833
xbt 037	95/10/19	121000	32.32	33.09	3858	1699
xbt 038	95/10/20	042800	32.66	33.00	3717	1833
xbt 039	95/10/20	100800	33.33	32.81	3304	1833
xbt 040	95/10/20	120400	33.66	32.72	3231	1833
xbt 041	95/10/20	182200	34.33	32.52	3190	1833
xbt 042	95/10/20	202400	34.66	32.42	3505	1833
xbt 044	95/10/20	223000	32.56	34.30	2685	1833
xbt 045	95/10/21	041000	34.99	32.48	2747	1833
xbt 046	95/10/21	062500	34.66	32.74	3578	1833
xbt 047	95/10/21	084300	34.33	32.99	3364	1833
xbt 048	95/10/21	105600	34.00	33.24	3273	1833
xbt 049	95/10/21	131300	33.66	33.50	3339	1833
xbt 050	95/10/21	152000	33.33	33.75	3499	1833
xbt 051	95/10/21	173300	32.99	34.00	2476	1833
xbt 052	95/10/21	193700	32.67	34.23	3501	1833
xbt 053	95/10/21	201100	32.60	34.29	3257	1833
xbt 054	95/10/22	005300	32.12	34.29	4019	1833
xbt 055	95/10/22	074900	31.82	34.10	3879	1833
xbt 056	95/10/22	091400	31.99	33.90	4167	1833
xbt 057	95/10/22	103800	32.16	33.70	4060	1833
xbt 058	95/10/22	120600	32.34	33.49	3780	1833
xbt 059	95/10/22	192200	32.33	33.16	3728	1833
xbt 060	95/10/22	201400	32.33	33.00	3703	1833
xbt 061	95/10/22	210600	32.33	32.83	3852	1833
xbt 062	95/10/22	215700	32.33	32.66	4217	1833
xbt 063	95/10/22	224800	32.33	32.50	4188	1833
xbt 064	95/10/22	234000	32.33	32.34	4109	1833
xbt 065	95/10/23	003500	32.33	32.16	4102	1833
xbt 066	95/10/23	052200	32.17	32.00	-	1833
xbt 067	95/10/23	062700	31.99	32.00	4334	1833
xbt 068	95/10/23	072900	31.83	31.99	4165	1833
xbt 069	95/10/23	113400	31.75	32.14	4279	1833

XBT	Date (yy/mm/dd)	Time (hhmmss)	Lat (°N)	Lon (°W)	Depth (m)	Max Press (db)
xbt 070	95/10/23	123900	31.83	32.28	4076	1833
xbt 071	95/10/23	155900	31.96	32.32	3704	1833
xbt 072	95/10/23	172500	32.00	32.58	4318	1833
xbt 073	95/10/23	185100	32.08	32.72	4504	1833
xbt 074	95/10/23	195900	32.16	32.87	3784	1833
xbt 075	95/10/23	211000	32.25	33.02	3900	1833
xbt 076	95/10/23	223000	32.33	33.17	3585	1833
xbt 077	95/10/23	235200	32.41	33.28	3830	1833
xbt 078	95/10/24	011700	32.49	33.45	3545	1833
xbt 079	95/10/24	023300	32.58	33.60	3427	1833
xbt 080	95/10/24	033800	32.66	33.75	3812	1833
xbt 081	95/10/24	044000	32.74	33.89	3842	1833
xbt 082	95/10/24	054200	32.83	34.04	3840	1833
xbt 083	95/10/24	094800	32.91	34.18	3577	1833
xbt 084	95/10/24	104800	32.99	34.32	3443	1833
xbt 085	95/10/25	050700	32.41	33.02	3739	1833
xbt 086	95/10/25	082700	32.58	32.73	3726	1833
xbt 087	95/10/25	113600	32.74	32.43	3706	1833
xbt 088	95/10/25	145600	32.91	32.14	3738	1833
xbt 089	95/10/25	185100	33.08	31.84	3700	1833
xbt 090	95/10/25	223200	33.24	31.56	3219	1833
xbt 091	95/10/26	024800	33.41	31.26	3350	1833
xbt 092	95/10/26	085000	33.50	30.66	3418	1833
xbt 093	95/10/26	102800	33.49	30.33	3242	1833
xbt 094	95/10/26	152100	33.41	30.16	2472	1833
xbt 095	95/10/26	162500	33.33	30.33	3290	1833
xbt 096	95/10/26	172600	33.25	30.50	2750	1833
xbt 097	95/10/26	182900	33.16	30.66	3367	1833
xbt 098	95/10/26	192900	33.08	30.83	3537	1833
xbt 099	95/10/26	202600	33.00	30.99	3622	1833
xbt 100	95/10/26	220400	32.91	31.16	3621	1833
xbt 101	95/10/26	230300	32.83	31.33	3700	1833
xbt 103	95/10/27	002200	32.74	31.51	3733	1833
xbt 104	95/10/27	011800	32.66	31.66	3863	1833
xbt 105	95/10/27	021500	32.58	31.83	3604	1833
xbt 106	95/10/27	031700	32.49	32.00	4197	1833
xbt 107	95/10/27	141000	32.53	33.91	3381	1758
xbt 108	95/10/27	145400	32.53	34.01	3426	1664
xbt 109	95/10/27	160700	32.53	34.21	3622	1693
xbt 110	95/10/27	165700	32.53	34.34	3837	1534
xbt 111	95/10/27	175800	32.54	34.50	3885	1792
xbt 112	95/10/27	190400	32.54	34.67	3878	1792
xbt 113	95/10/27	201500	32.54	34.85	3815	1833

XBT	Date (yy/mm/dd)	Time (hhmmss)	Lat (°N)	Lon (°W)	Depth (m)	Max Press (db)
xbt 114	95/10/27	211600	32.54	35.00	3717	567
xbt 115	95/10/27	212900	32.54	35.06	3717	1734
xbt 116	95/10/27	222000	32.54	35.15	3594	1833
xbt 117	95/10/27	232800	32.54	35.33	3482	1787
xbt 118	95/10/28	004000	32.54	35.51	3597	1833
xbt 119	95/10/29	041100	32.66	33.66	3815	1833
xbt 120	95/10/29	060700	32.82	33.33	3483	1833
xbt 122	95/10/29	091900	33.04	32.96	3708	1833
xbt 123	95/10/29	110200	33.26	32.74	3495	1833
xbt 124	95/10/29	131700	33.50	32.49	3413	1833
xbt 125	95/10/29	150800	33.74	32.24	3293	1833
xbt 126	95/10/29	214800	34.18	31.82	3449	908
xbt 127	95/10/29	220400	34.19	31.80	3449	1833
xbt 128	95/10/29	233500	34.33	31.66	3262	463
xbt 129	95/10/29	234100	34.34	31.66	3262	270
xbt 130	95/10/29	235400	34.37	31.62	3262	250
xbt 131	95/10/30	012000	34.51	31.48	3360	290
xbt 132	95/10/30	013400	34.53	31.46	3360	1763
xbt 133	95/10/30	030500	34.68	31.31	3120	1676
xbt 134	95/10/30	044500	34.85	31.14	3120	977
xbt 135	95/10/30	045600	34.86	31.13	3120	541
xbt 136	95/10/30	050300	34.89	31.10	3120	844
xbt 137	95/10/30	104500	35.00	30.66	3128	1833
xbt 138	95/10/30	121700	35.00	30.33	3492	1833
xbt 139	95/10/30	173100	35.00	29.66	3500	1833
xbt 140	95/10/30	190900	35.00	29.33	3443	1833
xbt 141	95/11/03	150300	46.04	14.27	4735	1323
xbt 142	95/11/03	170400	46.33	13.93	4792	1299
xbt 143	95/11/03	190700	46.61	13.59	4644	1354
xbt 144	95/11/03	210000	46.88	13.28	4433	1323
xbt 145	95/11/03	225800	47.15	12.93	4464	1336
xbt 146	95/11/04	010100	47.44	12.57	4091	1311
xbt 147	95/11/04	030300	47.73	12.21	4084	1390
xbt 148	95/11/04	050400	48.02	11.86	3625	1250
xbt 149	95/11/04	070600	48.31	11.51	3740	1348
xbt 150	95/11/04	085900	48.57	11.16	2428	1354
xbt 151	95/11/04	110400	48.89	10.77	480	-
xbt 152	95/11/04	125900	49.17	10.40	142	-
xbt 153	95/11/04	135700	49.32	10.20	155	-
xbt 154	95/11/04	150100	49.48	10.01	156	-
xbt 155	95/11/04	155800	49.62	9.833	155	-
xbt 156	95/11/04	170500	49.77	9.644	154	-
xbt 157	95/11/04	171500	49.79	9.615	154	-

XBT	Date (yy/mm/dd)	Time (hhmmss)	Lat (°N)	Lon (°W)	Depth (m)	Max Press (db)
xbt 158	95/11/04	210300	49.87	9.249	138	-
xbt 159	95/11/04	225700	49.84	8.817	136	-
xbt 160	95/11/05	105700	49.65	6.502	106	-

14.3 XBT-CTD temperature differences

CTD No.	Temperature differences (°C) between comparable XBT & CTD proflies at selected depths (m)								
	50m	75m	100m	200m	300m	500m	700m	1000m	1500m
1	0	0	-0.3	0	0.3	0	0	-0.1	-0.1
2	1.1	0.5	0.4	0.3	0.2	0.1	0.2	-0.2	0.1
3	-0.6	0	0	0.8	0.5	-0.2	0	0.3	-0.1
4	-0.2	-1	-1.2	0.1	0.1	-0.2	-0.1	-0.1	0.1
6	0.8	1.3	-0.5	0.1	-0.8	-0.4	0	-0.1	0.1
5	0.5	1.5	0.2	0.3	0	0.3	0.2	0.3	0.2
7	0.6	2	1	0.6	0.4	0.4	0.3	0.5	0.3
9	1.6	2.1	0.7	0.5	0.4	0.6	-0.2	0.2	0.5
16	0.2	0.7	-0.5	0	-0.3	-0.3	0.2	-0.1	0.2
17	-0.9	0.5	0.5	0.5	0.6	0.5	0.4	0.3	0.3
18	-0.7	0.1	0.2	0.7	1.1	0.7	0.4	0.2	0.2
19	-0.1	0.1	0.3	0.4	0.3	0.6	0.4	0.3	0.2
20	-0.2	0	-0.1	0.2	0.2	0.7	0.5	0.4	0.2
23	0.1	0.5	0.6	0.3	0.3	0.2	0	0.1	0.2
22	0.2	1	0.8	0.5	0.5	0.5	0.1	0.3	0.1
24	0.3	1.4	0.3	0.4	0.3	0.1	0.4	0.3	0.1
25	0	0.6	0.7	0.3	0.1	0.2	0.3	-0.2	0.2
27	-0.1	0.8	0.2	0.2	0.4	-0.3	0.1	0.1	0.3
29	2	1.4	0.7	0	0.2	0.3	0.3	0.3	0.2
32	0.4	0	0.3	0.3	0.8	0.4	0	0.5	0.2
33	-0.1	0	0	0.2	0	0.1	0	0	0.2
34	0	2.5	0.6	0.5	0.1	0.2	0.1	0.1	0
35	0.1	1.2	0.7	0.7	0.8	1	0.8	0.7	0.5
36	0.1	0.3	1.8	0.8	0.5	0.7	0	0.1	0.3
37	0	2	0.6	0.3	0.1	0.1	0.2	0.3	0.1
38	-0.1	0	1.3	0.5	0.1	0.3	0.3	0.1	0
39	-0.2	-0.5	-0.3	-0.4	0.2	0.1	-0.2	0.1	0.2
40	0	-0.7	-0.2	0	0.3	0.7	0.4	0.4	0.3
Mean	0.17	0.65	0.31	0.32	0.27	0.26	0.18	0.18	0.18
St. Dev	0.61	0.88	0.60	0.27	0.35	0.35	0.22	0.22	0.14

14.4 XBT-CTD differences in isotherm depth locations

CTD No.	Differences in depth (m) of selected isotherms (°C) from comparable XBT & CTD proflies							
	20°	18°	16°	14°	12°	10°	8°	6°
1	-15	-20	-25	-30	0	30	-60	-45
2	20	15	25	25	25	30	-75	75
3	5	0	35	60	0	10	10	-10
4	-25	0	35	5	0	30	30	0
6	10	0	-30	-35	5	25	5	0
5	15	30	25	20	35	40	0	30
7	30	65	25	35	50	50	100	60
9	20	60	25	35	25	0	40	45
16	20	15	25	10	5	5	30	30
17	5	25	40	50	40	50	60	70
18	5	25	65	60	60	60	65	100
19	20	35	15	25	25	45	75	100
20	-5	15	-5	0	35	55	75	120
23	-5	25	140	100	50	100	90	125
22	5	-60	-70	-50	-50	-75	140	60
24	20	25	40	35	110	80	175	180
25	20	20	15	0	15	40	40	65
27	5	15	5	30	30	75	45	80
29	20	15	0	20	25	30	75	75
32	5	10	25	30	25	25	35	40
33	5	20	15	30	10	-25	60	65
34	0	0	15	30	30	20	30	60
35	15	5	35	35	90	125	140	50
36	20	20	40	40	25	80	50	30
37	20	30	40	20	30	30	20	30
38	15	25	20	15	15	30	35	30
39	0	20	15	5	10	15	65	35
40	10	20	30	45	60	60	125	65
MEAN	9.285714	16.25	22.14286	23.03571	27.85714	37.14286	52.85714	55.89286
STDEV	12.22583	22.63335	34.86558	30.07211	30.04406	38.25907	54.59325	45.11413

14.5 List of Samples for Discrete Chlorophyll 'a'

Date (ddmmyy)	Time (hhmm)	Julian Day	Lat (°N)	Lon (°W)	CTD #	Depth (m)
12/10/95	2115	285	37 00.0	26.59.9	CD97/001	4
						50
						84
						125
						200
13/10/95	2300	286	34 00.0	27 52.5	CD97/004	4
						50
						75
						100
						300
14/10/95	0500	287	33 13.5	28 06.0	surface	4
	0800		32 59.9	28 09.7	CD97/005	4
						35
						66
						100
	1415		33 29.3	28 01.7	CD97/006	4
						40
						75
						100
						150
15/10/95	0520	288	32 00.0	28 26.5	CD97/007	4
						24
						58
						76
						100
						110
	0900		31 47.8	28 29.4	surface	4
	1100		31 29.2	28 35.2	surface	4
	1300		31 08.8	28 40.5	surface	4
	1530		31 00.0	23 43.4	CD97/009	4
						75
						100
						200
	1700		30 59.1	28 42.0	surface	4

Date (ddmmyy)	Time (hhmm)	Julian Day	Lat (°N)	Lon (°W)	CTD #	Depth (m)
	1900		30 39.4	28 37.5	surface	4
	2130		30 30.0	28 35.1	CD97/010	4
						13
						23
						41
						95
						200
16/10/95	0100	289	30 07.7	28 29.0	surface	4
	0315		30 00.2	28 27.0	surface	4
	0500		30 00.0	28 27.0	CD97/012	4
						35
						43
	0500		30 00.0	28 27.0	CD97/012	66
						93
						120
	0700		29 59.9	28 27.0	surface	4
	1300		30 00.0	29 00.0	surface	4
	1355		29 59.9	28 59.9	CD97/014	4
						13
						24
						43
						65
						100
						550
	1700		30 00.0	29 15.7	surface	4
	1900		30 00.0	29 37.5	surface	4
	2220		30 00.0	30 00.0	CD97/016	4
						80
						400
17/10/95	0100	290	30 00.0	30 17.3	surface	4
	0330		30 00.1	30 40.2	surface	4
	0514		29 59.9	31 00.0	CD97/017	4
						49
						92
						106
						116
						140
	0700		29 59.8	31 00.2	surface	4
	0900		30 00.1	31 17.5	surface	4
	1115		30 00.1	31 42.4	surface	4

Date (ddmmyy)	Time (hhmm)	Julian Day	Lat (°N)	Lon (°W)	CTD #	Depth (m)
	1300		30 00.0	32 00.1	surface	4
	1415		30 00.0	30 00.1	CD97/018	4
						90
						120
						200
	1500		30 00.2	32 00.6	surface	4
	1700		30 00.0	32 20.1	surface	4
	1900		30 00.0	32 42.1	surface	4
	2100		30 00.0	33 05.2	surface	4
	2300		29 59.9	33 29.1	surface	4
18/10/95	0100	291	30 00.0	33 45.0	surface	4
	0300		29 59.8	33 46.0	surface	4
	0315		30 00.0	33 44.9	CD97/019	4
						49
						92
						116
						140
	0500		29 58.4	33 56.6	surface	4
	0700		29 55.1	34 21.2	surface	4
	1100		29 46.9	34 33.6	surface	4
	1300		29 59.8	34 44.9	surface	4
	1500		30 01.6	34 43.0	surface	4
	1700		30 05.9	34 25.7	surface	4
	1900		30 25.8	34 11.9	surface	4
	2130		30 42.0	33 50.7	surface	4
19/10/95	0100	292	30 59.8	33 28.2	surface	4
	0300		31 04.2	33 27.0	surface	4
	0200		31 00.0	33 28.2	CD97/021	5
						66
						300
	0500		31 23.9	33 21.6	surface	4
	0900		31 59.9	33 11.1	surface	4
	1000		31 59.9	33 11.1	CD97/022	4
						72
						97
						250
	1300		32 18.8	33 06.1	surface	4
	1500		31 58.0	33 12.0	surface	4
	1700		31 39.4	33 17.3	surface	4
	1930		31 30.0	33 19.9	CD97/023	4

Date (ddmmyy)	Time (hhmm)	Julian Day	Lat (°N)	Lon (°W)	CTD #	Depth (m)
						75
						100
						200
	2315		31 42.6	33 14.2	surface	4
20/10/95	0100	293	32 02.0	33 09.2	surface	4
	0300		32 24.1	33 03.9	surface	4
	0500		32 49.9	32 57.8	surface	4
	0735		33 00.0	32 55.0	CD97/024	13
						35
						66
						76
						83
						100
	0903		33 09.0	32 58.8	surface	4
	1500		34 00.0	32 38.0	surface	4
	1515		34 00.0	32 37.5	CD97/025	4
						75
						100
						200
	1700		34 05.8	32 36.0	surface	4
	2100		34 44.7	32 24.2	surface	4
	2300		35 04.7	32 18.7	surface	4
21/10/95	0100	294	35 20.0	32 18.8	surface	4
	0500		34 53.3	32 34.7	surface	4
	0700		34 35.8	32 47.8	surface	4
	0852		34 19.4	33 12.7	surface	4
	1100		34 00.0	33 15.0	surface	4
	1300		33 42.0	33 28.6	surface	4
	1500		33 23.2	33 42.6	surface	4
	1700		33 05.0	33 56.3	surface	4
	1900		32 46.7	34 09.8	surface	4
	2230		32 35.0	34 18.4	CD97/027	4
						60
						80
						100
						250
22/10/95	0107	295	32 06.2	34 17.9	surface	4
	0352		31 39.8	34 18.0	surface	4
	0500		31 39.3	34 17.5	CD97/028	4

Date (ddmmyy)	Time (hhmm)	Julian Day	Lat (°N)	Lon (°W)	CTD #	Depth (m)
						13
						58
						100
	0900		32 00.9	33 53.1	surface	4
	1100		32 11.7	33 39.8	surface	4
	1300		32 20.0	33 19.9	CD97/029	4
						33
						64
						77
	1500		32 20.0	33 18.8	surface	4
	1700		32 19.4	33 19.6	surface	4
	1900		32 19.7	33 15.2	surface	4
	2100		32 20.0	32 51.1	surface	4
	2300		32 20.0	32 20.0	surface	4
23/10/95	0100	296	32 20.0	32 05.0	surface	4
	3330		32 20.1	31 59.87	CD97/030	4
						33
						79
						90
						152
	1030		31 40.0	32 00.0	CD97/031	4
						103
	1330		31 53.1	32 21.9	surface	4
	1500		31 56.4	32 20.0	surface	4
	1700		31 59.0	32 28.3	surface	4
	1900		32 05.9	32 45.5	surface	4
	2100		32 14.3	33 02.3	surface	4
	2300		32 21.4	33 11.4	surface	4
24/10/95	0100	297	32 28.6	33 25.1	surface	4
	0300		32 36.9	33 39.7	surface	4
	0500		32 46.5	32 56.3	surface	4
	0800		32 506	34 03.5	CD97/032	4
						35
						58
						76
						83
						100
	0900		32 50.5	34 05.4	surface	4
	1130		32 58.0	34 17.4	surface	4
	1303		32 47.2	34 00.3	surface	4

Date (ddmmyy)	Time (hhmm)	Julian Day	Lat (°N)	Lon (°W)	CTD #	Depth (m)
	1500		32 36.1	33 38.9	surface	4
	1700		32 24.9	33 16.7	surface	4
	1900		32 25.8	33 13.3	surface	4
25/10/95	0010	298	32 25.3	33 20.1	CD97/033	4
						40
						80
						101
						125
						149
	0100		32 25.8	33 20.1	surface	4
	0300		32 20.8	33 08.7	surface	4
	0515		32 24.1	33 02.0	surface	4
	0700		32 30.0	32 52.8	surface	4
	1044		32 40.1	32 35.4	surface	4
	1300		32 50.2	32 17.8	surface	4
	1510		32 55.7	32 07.8	surface	4
	1700		32 59.9	32 00.6	surface	4
	1900		33 06.2	31 48.9	surface	4
	1925		33 09.8	31 42.5	CD97/038	4
						100
26/10/95	0100	299	33 19.7	31 24.3	surface	4
	0200		33 20.4	31 23.4	CD97/039	4
						60
						80
						100
	0301		33 25.6	31 14.4	surface	4
	0500		33 29.6	31 07.4	surface	4
	0700		33 29.6	31 03.9	surface	4
	0715		33 29.6	31 03.4	CD97/040	5
						58
						83
						101
	0854		33 30.1	30 40.2	surface	4
	1058		33 30.1	29 59.5	surface	4
	1300		33 30.3	29 59.5	surface	4
	1353		33 30.3	29 59.5	CD97/041	4
						76
						83
						100
	1500		33 27.0	30 05.9	surface	4

Date (ddmmyy)	Time (hhmm)	Julian Day	Lat (°N)	Lon (°W)	CTD #	Depth (m)
	1700		33 17.3	30 25.3	surface	4
	1900		33 07.5	30 45.1	surface	4
	2100		33 00.2	31 01.8	surface	4
	2300		32 50.6	31 18.7	surface	4
27/10/95	0100	300	32 41.6	31 36.6	surface	4
	0300		32 31.1	31 56.4	surface	4
	0408		32 29.8	32 00.4	CD97/042	4
						60
						100
	0500		32 30.0	32 09.5	surface	4
	0700		32 30.0	32 36.8	surface	4
	1100		32 30.1	32 27.8	surface	4
	1502		32 33.4	34 02.3	surface	4
	1705		32 32.4	34 22.1	surface	4
28/10/95	0300	301	32 32.2	35 30.0	surface	4
	0500		32 31.9	35 29.7	surface	4
	0700		32 31.4	35 29.7	surface	4
	0715		32 31.4	35 29.7	CD97/043	4
						83
						100
	2320		32 32.4	34 21.5	CD97/044	4
						69
						85
						101
						110
						129
						160
						225
29/10/95	0645	302	32 50.6	33 18.8	CD97/045	1
						52
						75
						90
31/10/95	0100	304	35 11.9	28 42.1	surface	4
	0258		35 24.8	28 23.4	surface	4
	0500		35 37.7	28 03.8	surface	4
	0700		35 51.0	27 44.9	surface	4
	0900		36 03.9	27 24.9	surface	4
	1100		36 16.5	27 06.7	surface	4

Date (ddmmyy)	Time (hhmm)	Julian Day	Lat (°N)	Lon (°W)	CTD #	Depth (m)
	1258		36 29.4	26 48.1	surface	4
	1500		36 39.5	26 28.4	surface	4
	1700		36 53.0	26 10.9	surface	4
	1915		37 08.8	25 47.9	surface	4
	2100		37 20.8	25 29.1	surface	4
	2300		37 35.0	25 08.3	surface	4
01/11/95	0100	305	37 47.6	24 47.3	surface	4
	0310		38 03.7	24 22.9	surface	4
	0500		38 16.5	24 04.1	surface	4
	0700		38 30.4	23 43.4	surface	4
	0900		38 44.2	23 23.1	surface	4
	1100		38 58.6	22 59.8	surface	4
	1300		39 13.6	22 39.9	surface	4
	1530		39 39.4	22 15.6	surface	4
	1700		39 46.5	22 00.8	surface	4
	1900		40 03.0	21 41.0	surface	4
	2100		40 20.1	21 21.6	surface	4
	2305		40 37.9	21 00.7	surface	4
02/11/95	0100	306	40 52.4	20 42.8	surface	4
	0330		41.13.0	20 18.0	surface	4
	0600		41 33.4	19 53.7	surface	4
	0800		41 49.9	19 33.5	surface	4
	1000		41 06.3	19 13.3	surface	4
	1200		42 22.7	18 53.8	surface	4
	1300		42 31.2	18 43.6	surface	4
	1500		42 45.3	18 21.8	surface	4
	1800		43 12.0	17 52.4	surface	4
	2000		43 29.0	17 33.0	surface	4
	2200		43 44.8	17 11.9	surface	4
03/11/95	0000	307	43 59.4	16 53.4	surface	4
	0100		44 07.4	16 44.1	surface	4
	0300		44 22.9	16 23.8	surface	4
	0500		44 38.8	16 03.8	surface	4
	0700		44 54.8	15 43.8	surface	4
	1100		45 28.0	15 01.3	surface	4
	1200		45 36.9	14 51.3	surface	4
	1400		45 53.7	14 27.9	surface	4
	1500		46 02.0	14 17.5	surface	4
	1600		46 10.5	14 07.3	surface	4

Date (ddmmyy)	Time (hhmm)	Julian Day	Lat (°N)	Lon (°W)	CTD #	Depth (m)
	1700		46 18.8	13 57.7	surface	4
	1800		46 27.2	13 47.4	surface	4
	1900		46 35.6	13 37.5	surface	4
	2000		46 44.2	13 28.8	surface	4
	2115		46 53.9	13 15.6	surface	4
	2200		47 00.5	13 06.6	surface	4
	2300		47 08.7	12 56.8	surface	4
04/11/95	0000	308	47 17.7	12 46.4	surface	4
	0100		47 26.5	12 35.4	surface	4
	0200		47 34.4	12 24.9	surface	4
	0300		47 41.1	12 14.0	surface	4
	0400		47 51.4	12 03.2	surface	4
	0500		48 00.5	11 52.8	surface	4
	0600		48 09.7	11 42.3	surface	4
	0700		48 17.8	11 32.1	surface	4
	0800		48 26.1	11 20.8	surface	4
	0900		48 34.5	11 10.0	surface	4
	1000		48 43.7	10 58.4	surface	4
	1100		48 52.5	10 47.6	surface	4
	1200		49 01.4	10 36.3	surface	4
	1300		49 10.5	10 24.7	surface	4
	1415		49 22.3	10 09.5	surface	4
	1500		49 28.3	10 01.5	surface	4
	1530		49 32.9	09 55.5	surface	4
	1600		49 37.1	09 50.2	surface	4
	1700		49 45.4	09 39.6	surface	4
	1730		49 50.0	09 35.6	surface	4
	2000		49 51.3	09 02.7	surface	4
	2100		49 52.3	09 16.4	surface	4
	2200		49 51.3	09 02.7	surface	4
	2305		49 50.5	08 50.1	surface	4
05/11/95	0000	309	49 49.4	08 36.9	surface	4
	0100		49 48.4	08 25.9	surface	4
	0200		49 47.3	08 14.0	surface	4
	0300		49 46.4	08 01.0	surface	4
	0400		49 45.1	07 47.6	surface	4
	0500		49 43.8	07 32.6	surface	4
	0600		49 42.6	07 19.9	surface	4
	0700		49 41.8	07 08.3	surface	4
	0800		49 41.1	06 58.1	surface	4

Date (ddmmyy)	Time (hhmm)	Julian Day	Lat (°N)	Lon (°W)	CTD #	Depth (m)
	0900		49 40.1	06 47.2	surface	4
	1000		49 39.5	06 38.3	surface	4
	1110		49 39.1	06 29.3	surface	4
	1200		49 39.2	06 21.3	surface	4
	1300		49 39.1	06 12.5	surface	4
	1400		49 40.7	06 01.5	surface	4
	1500		49 41.3	05 50.7	surface	4
	1600		49 43.9	05 37.5	surface	4
	1700		49 46.4	05 24.8	surface	4
	1800		49 47.8	05 11.2	surface	4

14.6 List of Preserved Phytoplankton Samples in Lugol's Iodine and Formaldehyde

Sample#	Date	Time (hhmm)	Lat (°N)	Lon (°W)	Depth (m)	L/F
1	15-Oct	0900	31 47.8	28 29.4	4	yes
2		1300	31 08.8	38 40.8	4	yes
3		1700	30 59.1	28 42.0	4	yes
4		2130	30 30.0	28 35.1	4 (CTD10)	yes
5					95 (CTD10)	yes
6	16-Oct	0100	30 07.7	28 29.0	4	yes
7		0500	30 00.0	28 27.0	4	yes
8		1700	30 00.0	29 15.3	4	yes
9		2200	30 00.0	30 00.1	4	yes
10		1300	30 00.0	29 00.1	4	yes
11	17-Oct	0100	30 00.0	30 17.3	4	yes
12		0514	29 59.9	31 00.0	4	yes
13		0900	30 00.1	31 17.5	4	yes
14		1300	30 00.0	32 00.1	4	yes
15		1700	30 00.0	32 20.1	4	yes
16		2100	30 00.0	33 05.2	4	yes
17	18-Oct	0100	30 00.0	33 45.0	4	yes
18		0500	29 58.4	33 56.6	4	yes

Sample#	Date	Time (hhmm)	Lat (°N)	Lon (°W)	Depth (m)	L/F
19		1100	29 46.9	34 33.6	4	yes
20		1300	29 59.8	34 44.9	4	yes
21		1700	30 05.9	34 25.7	4	yes
22		2130	30 42.0	33 50.7	4	yes
23	19-Oct	0100	30 59.8	33 28.2	4	yes
24		0500	31 23.9	33 21.6	4	yes
25		0900	31 59.9	33 11.1	4	yes
26		1300	32 18.8	33 06.1	4	yes
27		1700	31 39.4	33 17.3	4	yes
28		2315	31 42.7	33 14.2	4	yes
29	20-Oct	0100	32 02.0	33 09.2	4	yes
30		0500	32 49.9	32 57.8	4	yes
31		0903	33 09.0	32 52.8	4	yes
32		1700	34 05.8	32 36.0	4	yes
33		2100	34 44.7	32 24.7	4	yes
34	21-Oct	0100	35 20.0	32 13.8	4	yes
35		0500	34 53.3	32 34.7	4	yes
36		0852	34 19.4	33 12.7	4	yes
37		1300	33 42.0	33 28.7	4	yes
38		1700	33 05.0	33 56.3	4	yes
39	22-Oct	0107	31 39.8	34 18.0	4	yes
40		0500	31 29.3	34 17.5	4	yes
41		0900	32 00.9	33 53.1	4	yes
42		1300	32 20.0	33 19.9	4	yes
43		1700	32 19.4	33 19.6	4	yes
44		2100	32 20.0	32 51.1	4	yes
45	23-Oct	0100	32 20.0	32 05.0	4	yes
46		1030	31 40.0	32 00.0	4 (CTD031)	yes
47		1330	31 53.1	32 21.9	4	yes
48		1700	31 59.0	32 28.3	4	yes
49		2100	32 14.3	33 02.3	4	yes
50	24-Oct	0100	32 28.6	33 25.1	4	yes
51		0900	32 50.5	34 05.0	4	yes
52		1303	32 47.2	34 00.3	4	yes
53		1700	32 24.9	33 16.7	4	yes

Sample#	Date	Time (hhmm)	Lat (°N)	Lon (°W)	Depth (m)	L/F
54	25-Oct	0100	32 25.8	33 20.1	4	yes
55		0515	32 24.1	33 02.0	4	yes
56		1044	32 40.1	32 35.4	4	yes
57		1300	32 50.2	32 17.8	4	yes
58		1700	32 59.9	32 00.6	4	yes
59		1925	33 09.8	31 42.5	4 (CTD38)	yes
60					100	yes
61	26-Oct	0100	33 19.7	31 24.3	4	yes
62		0500	33 29.6	31 07.4	4	yes
63		0854	33 30.1	30 40.2	4	yes
64		1300	31 30.3	29 59.5	4	yes
65		1700	33 17.3	30 25.3	4	yes
66		2100	33 00.2	31 01.1	4	yes
67	27-Oct	0100	32 41.6	31 36.6	4	yes
68		0500	32 30.0	32 09.5	4	yes
69		1705	32 32.4	34 02.3	4	yes
70	28-Oct	0500	32 31.9	35 29.7	4	yes
71		2320	32 32.4	34 21.5	5	yes
72					85	yes
73					101	yes

14.7 List of samples for particulate carbon/nitrogen analyses.

Sample#	Date	Time (hhmm)	Lat (°N)	Lon (°W)	Depth (m)	Vol filt (L)
1	15-Oct	0900	31 47.8	28 29.4	4	0.25
2		1300	31 08.8	38 40.8	4	0.25
3		1700	30 59.1	28 42.0	4	0.25
4	16-Oct	0100	30 07.7	28 29.0	4	0.25
5		0500	30 00.0	28 27.0	4	0.25
6		1700	30 00.0	29 15.3	4	0.25
7		2200	30 00.0	30 00.1	4	0.25
8		1300	30 00.0	29 00.1	4	0.25

Sample#	Date	Time (hhmm)	Lat (°N)	Lon (°W)	Depth (m)	Vol filt (L)
9	17-Oct	0100	30 00.0	30 17.3	4	0.25
10		0514	29 59.9	31 00.0	4	0.25
11		0900	30 00.1	31 17.5	4	0.25
12		1300	30 00.0	32 00.1	4	0.25
13		1700	30 00.0	32 20.1	4	0.25
14		2100	30 00.0	33 05.2	4	0.25
15	18-Oct	0100	30 00.0	33 45.0	4	0.25
16		0500	29 58.4	33 56.6	4	0.25
17		1100	29 46.9	34 33.6	4	0.25
18		1300	29 59.8	34 44.9	4	0.25
19		1700	30 05.9	34 25.7	4	0.25
20		2130	30 42.0	33 50.7	4	0.25
21	19-Oct	0100	30 59.8	33 28.2	4	0.25
22		0500	31 23.9	33 21.6	4	0.25
23		0900	31 59.9	33 11.1	4	0.25
24		1300	32 18.8	33 06.1	4	0.25
25		1700	31 39.4	33 17.3	4	0.25
26		2315	31 42.7	33 14.2	4	0.25
27	20-Oct	0100	32 02.0	33 09.2	4	0.25
28		0500	32 49.9	32 57.8	4	0.25
29		0903	33 09.0	32 52.8	4	0.25
30		1700	34 05.8	32 36.0	4	0.25
31		2100	34 44.7	32 24.7	4	0.25
32	21-Oct	0100	35 20.0	32 13.8	4	0.25
33		0500	34 53.3	32 34.7	4	0.25
34		0852	34 19.4	33 12.7	4	0.25
35		1300	33 42.0	33 28.7	4	0.25
36		1700	33 05.0	33 56.3	4	0.25
37	22-Oct	0107	32 06.2	34 17.9	4	0.25
38		0500	31 29.3	34 17.5	4	0.25
39		0900	32 00.9	33 53.1	4	0.25
40		1300	32 20.0	33 19.9	4	0.25
41		1700	32 19.4	33 19.6	4	0.25
42		2100	32 20.0	32 51.1	4	0.25
43	23-Oct	0100	32 20.0	32 05.0	4	0.25

Sample#	Date	Time (hhmm)	Lat (°N)	Lon (°W)	Depth (m)	Vol filt (L)
44		1030	31 40.0	32 00.0	4	0.25
45		1330	31 53.1	32 21.9	4	0.25
46		1700	31 59.0	32 28.3	4	0.25
47		2100	32 14.3	33 02.3	4	0.25
48	24-Oct	0100	32 28.6	33 25.1	4	0.25
49		0500	32 46.5	33 56.3	4	0.25
50		0900	32 50.5	34 05.0	4	0.25
51		1303	32 47.2	34 00.3	4	0.25
52		1700	32 24.9	33 16.7	4	0.25
53	25-Oct	0100	32 25.8	33 20.1	4	0.25
54		0515	32 24.1	33 02.1	4	0.25
55		1044	32 40.1	32 35.4	4	0.25
56		1300	32 50.2	32 17.8	4	0.25
57		1700	32 59.9	32 00.6	4	0.25
58		1925	33 09.8	31 42.5	4 (CTD038)	0.25
59					100	0.25
60	26-Oct	0100	33 19.7	31 24.3	4	0.25
61		0500	33 29.6	31 07.4	4	0.25
62		0854	33 30.1	30 40.2	4	0.25
63		1300	33 30.3	29 59.5	4	0.25
64		1700	33 17.3	30 25.3	4	0.25
65		2100	33 00.2	31 01.1	4	0.25
66	27-Oct	0100	32 41.6	31 36.6	4	0.25
67		0500	32 30.0	32 09.5	4	0.25
68		1705	32 32.4	34 22.1	4	0.25
69	28-Oct	0500	32 31.9	35 29.7	4	0.25

14.8 List of samples for multisizer counts

Date	Time (hhmm)	Lat (°N)	Lon (°W)	CTD #	Depth (m)
24-Oct	800	32 50.6	34 03.5	32	4
					83
					100
24-Oct	1130	32 58.0	34 17.4	-	4
24-Oct	1700	32 24.9	33 16.7	-	4
25-Oct	1700	33 00.0	32 00.6	-	4
25-Oct	1925	33 09.8	31 42.5	38	4
					100
26-Oct	730	33 19.9	31 24.6	39	4
					60
					80
					100
26-Oct	1353	32 30.2	30 00.0	41	6
					76
					83
					100
27-Oct	400	32 29.8	32 00.9	42	6
					60
					100
28-Oct	400	32 32.3	35 29.4	43	1
					83
					100

14.9 Dissolved oxygen samples

CTD #	Depth (m)	Oxygen conc' (ml/l)
CTD 4	2000	6.115
CTD 4	2000	5.958
CTD 4	1500	5.494
CTD 4	1500	5.471
CTD 4	750	4.291
CTD 4	750	4.231
CTD 4	300	4.662
CTD 4	300	4.631
CTD 4	75	5.341
CTD 4	75	5.347
CTD 4	4	4.942
CTD 4	4	4.981
CTD 5	2000	5.867
CTD 5	2000	5.965
CTD 5	1000	4.408
CTD 5	1000	4.602
CTD 5	83	5.156
CTD 5	83	5.134
CTD 5	4	4.927
CTD 5	4	4.896
CTD 6	2000	5.854
CTD 6	2000	5.850
CTD 6	1300	4.929
CTD 6	1300	4.918
CTD 6	800	4.420
CTD 6	800	4.428
CTD 6	400	4.603
CTD 6	400	4.594
CTD 6	150	4.655
CTD 6	150	4.598
CTD 6	103	5.021
CTD 6	103	5.007
CTD 6	44	4.902
CTD 6	44	4.891
CTD 7	1908	5.776
CTD 7	1908	5.751
CTD 7	76	5.425
CTD 7	76	5.360
CTD 7	4	4.888
CTD 7	4	4.877

CTD #	Depth (m)	Oxygen conc' (ml/l)
CTD 9	2050	5.673
CTD 9	2050	5.745
CTD 9	1500	5.313
CTD 9	1500	5.286
CTD 9	1200	4.701
CTD 9	1200	4.739
CTD 9	800	4.025
CTD 9	800	4.039
CTD 9	400	4.577
CTD 9	400	4.698
CTD 9	75	5.335
CTD 9	75	5.402
CTD 9	4	4.849
CTD 9	4	4.824
CTD 10	2000	5.763
CTD 10	2000	5.743
CTD 10	1200	4.568
CTD 10	1200	4.565
CTD 10	850	3.958
CTD 10	850	4.010
CTD 10	400	4.530
CTD 10	400	4.567
CTD 10	95	5.272
CTD 10	95	5.270
CTD 10	4	4.741
CTD 10	4	4.773
CTD 11	306	4.638
CTD 11	306	4.691
CTD 11	58	5.030
CTD 11	58	5.017
CTD 11	4	4.819
CTD 11	4	4.792
CTD 14	2000	5.678
CTD 14	2000	5.665
CTD 14	1500	5.561
CTD 14	1500	5.552
CTD 14	950	4.199
CTD 14	950	4.166
CTD 14	820	4.097
CTD 14	820	4.103
CTD 14	65	5.432
CTD 14	65	5.639
CTD 16	2000	5.079

CTD #	Depth (m)	Oxygen conc' (ml/l)
CTD 16	2000	5.278
CTD 16	1500	5.444
CTD 16	1500	5.544
CTD 16	750	4.314
CTD 16	750	4.384
CTD 16	400	4.558
CTD 16	400	4.592
CTD 16	80	5.447
CTD 16	80	4.930
CTD 16	4	5.677
CTD 16	4	4.880
CTD 17	2000	5.857
CTD 17	820	3.947
CTD 17	92	5.281
CTD 17	4	4.856
CTD 18	2000	5.724
CTD 18	2000	5.714
CTD 18	1600	5.321
CTD 18	1600	5.386
CTD 18	900	3.945
CTD 18	900	3.964
CTD 18	600	4.638
CTD 18	600	4.493
CTD 18	120	4.960
CTD 18	120	5.096
CTD 18	4	4.901
CTD 18	4	4.864
CTD 19	2000	5.657
CTD 19	2000	5.664
CTD 19	850	4.001
CTD 19	850	3.994
CTD 19	81	5.518
CTD 19	81	5.498
CTD 19	4	4.749
CTD 19	4	4.759
CTD 20	2000	5.593
CTD 20	2000	5.599
CTD 20	920	3.983
CTD 20	920	3.961
CTD 20	400	4.535
CTD 20	400	4.527
CTD 20	75	5.328
CTD 20	75	5.337

CTD #	Depth (m)	Oxygen conc' (ml/l)
CTD 20	4	4.857
CTD 20	4	4.818
CTD 21	2000	5.783
CTD 21	2000	5.762
CTD 21	910	4.168
CTD 21	910	4.259
CTD 21	300	4.700
CTD 21	300	4.703
CTD 21	66	5.538
CTD 21	66	5.829
CTD 21	4	5.222
CTD 21	4	4.720
CTD 22	2000	5.510
CTD 22	2000	5.887
CTD 22	675	4.319
CTD 22	675	4.310
CTD 22	72	4.988
CTD 22	72	5.012
CTD 22	4	5.637
CTD 22	66	5.670
CTD 23	2000	5.990
CTD 23	2000	5.723
CTD 23	800	4.278
CTD 23	800	4.464
CTD 23	600	4.635
CTD 23	600	4.690
CTD 23	75	4.938
CTD 23	75	5.295
CTD 23	4	4.910
CTD 23	4	4.938
CTD 24	2000	5.869
CTD 24	2000	5.889
CTD 24	1000	4.609
CTD 24	1000	4.570
CTD 24	83	5.580
CTD 24	83	5.505
CTD 24	66	5.166
CTD 24	66	5.206
CTD 24	13	4.905
CTD 24	13	4.908
CTD 25	2000	5.799
CTD 25	950	4.583
CTD 25	950	4.303

CTD #	Depth (m)	Oxygen conc' (ml/l)
CTD 25	200	4.694
CTD 25	200	4.767
CTD 25	75	5.139
CTD 25	75	5.226
CTD 25	4	5.036
CTD 25	4	4.903

14.10 WP2 plankton net samples

Julian day	Time (hh.mm)	CTD #	Lat (°N)	Lon (°W)
286	23.40	4	33 59.32	27 51.66
286	23.50	4	33 59.28	27 51.60
287	00.10	4	33 59.11	27 51.39
287	15.00	6	33 30.21	28 00.59
287	15.15	6	33 30.24	28 00.40
287	15.34	6	33 30.40	28 00.14
288	07.00	7	31 59.25	28 25.64
288	07.20	7	31 59.04	28 25.16
288	07.34	7	31 58.82	28 24.87
288	16.00	9	31 00.08	28 42.67
288	16.12	9	31 00.07	28 42.54
288	16.25	9	31 00.01	28 42.36
288	22.00	10	30 29.20	28 34.74
288	22.20	10	30 28.94	28 34.72
288	22.35	10	30 28.76	28 34.73
289	03.05	11	30 00.23	28 26.99
289	03.25	11	30 00.17	28 26.97
289	03.50	11	30 00.13	28 26.99
289	05.00	11	30 00.10	28 26.72
289	05.30	11	30 00.07	28 26.75
289	06.20	11	30 00.02	28 26.72
289	06.40	11	30 00.01	28 26.84
289	07.07	11	29 59.88	28 26.96
289	14.10	14	30 00.05	29 00.13
289	14.26	14	29 59.99	29 00.07
289	14.44	14	29 59.92	29 00.13
289	22.40	16	30 00.05	30 00.15
289	22.57	16	29 59.91	30 00.18
289	23.15	16	29 59.76	30 00.32
290	14.30	18	30 00.05	32 00.40

Julian day	Time (hh.mm)	CTD #	Lat (°N)	Lon (°W)
290	14.47	18	30 00.09	32 00.49
290	15.01	18	30 00.15	32 00.59
291	01.00	19	29 59.95	33 44.93
291	01.15	19	29 59.97	33 45.04
291	01.30	19	29 59.91	33 45.15
292	01.45	21	30 59.61	33 28.09
292	02.07	21	30 59.57	33 28.01
292	02.15	21	30 59.58	33 28.02
292	19.37	23	31 29.99	33 18.22
292	19.57	23	31 30.00	33 17.71
292	20.08	23	31 29.97	33 17.43
293	15.40	25	33 59.99	32 37.57
293	15.55	25	34 00.08	32 37.64
293	16.10	25	34 00.22	32 37.69
295	05.35	28	31 38.98	34 17.32
295	05.50	28	31 38.74	34 17.25
295	06.03	28	31 38.54	34 17.29
296	03.30	30	32 20.24	32 00.02
296	03.46	30	32 20.19	31 59.98
296	04.06	30	32 20.22	31 59.95
297	08.16	32	32 50.38	34 04.50
297	08.30	32	32 50.32	34 04.70
297	08.45	32	32 50.23	34 04.87
298	00.30	33	32 25.96	33 20.60
298	00.48	33	32 25.86	33 20.54
298	01.05	33	32 25.77	33 20.56
299	04.03	40	33 29.84	31 06.82
299	04.17	40	33 29.79	31 06.88
299	04.35	40	33 29.68	31 07.13
301	02.10	43	32 32.30	35 29.83
301	02.27	43	32 32.25	35 29.88
301	02.43	43	32 32.22	35 29.99

14.11 Samples for primary production incubations (C-14)

Date (dd/mm/yy)	Time (hh:mm)	Lat (°N)	Long (°W)	CTD #	Depth (m)	Irrad (%)	Replicates
15/10/95	04:30	31 51 86	28 26 35	8	4	97	3
					13	55	3
					24	32.6	3
					43	13.8	3
					100	1	3
					83	dark	2
15/10/95	20:30	30 29 95	28 35 08	10	4	97	3
					13	55	3
					24	32.6	3
					43	13.8	3
					95	1	3
16/10/95	04:30	29 59 96	28 26 92	12	4	97	3
					13	55	3
					24	32.6	3
					43	13.8	3
					93	1	3
16/10/95	06:00	30 00 05	28 26 84	13	4	97	3
					13	55	3
					24	32.6	3
					43	13.8	3
					100	1	3
16/10/95	14:00	30 0 06	29 00 16	14	NTW	97	3
					13	55	3
					24	32.6	3
					43	13.8	3
					100	1	3
17/10/95	06:30	29 59 92	30 59	17	4	97	3
					19	55	3
					34	32.6	3
					60	13.8	3
					140	1	3
18/10/95	04:00	29 59 77	33 45 67	19	4	97	3
					19	55	3

Date (dd/mm/yy)	Time (hh:mm)	Lat (°N)	Long (°W)	CTD #	Depth (m)	Irrad (%)	Replicates
					34	32.6	3
					60	13.8	3
					96	1	3
20/10/95	08:11	33 0.00	32.54.87	24	4	97	3
					13	55	3
					24	32.6	3
					43	13.8	3
					66	4.6	3
					66	dark	2
					100	1	3
17/10/95	07:00	31.38.29	34.17.27	28	NTW	97	3
					13	55	3
					24	32.6	3
					43	13.8	3
					83	2.1	3
					100	97	3
new experiment					100	55	3
					100	2.1	3
					100	1	3
22/10/95	13:04	32.20.24	33.20.45	29	4	97	3
					10	55	3
					18	32.6	3
					32	13.8	3
					62	4.6	3
					75	1	3
23/10/95	01:00	32.2	32	30	NTW	97	3
					11	55	3
					19	32.6	3
					34	13.8	3
					80	2.1	3
					90	1	3
24/10/95	06:11	32.50.33	34.04.35	32	4	97	3
					13	55	3
					24	32.6	3
					83	2.1	3
					100	1	3

Date (dd/mm/yy)	Time (hh:mm)	Lat (°N)	Long (°W)	CTD #	Depth (m)	Irrad (%)	Replicates
26/10/95	06:29	33.29.54	31.07.52	40	4	97	3
					13	55	3
					24	32.6	3
					76	4.6	3
					83	2.1	3
					100	1	3
27/10/95	04:00	32.29.89	32.0.80	42	4	97	3
					13	55	3
					24	32.6	3
					59	6.9	3
					59	dark	2
					100	1	3
28/10/45	05:00	32.31.84	35.29.67	43	6	97	3
					14	55	3
					25	32.6	3
					76	4.6	3
					83	2.1	3
					83	dark	2
					100	1	3
29/10/95	06:30	32.50.6	33.18.82	45	5	97	3
					12	55	3
					22	32.6	3
					39	4.6	3
					75	2.1	3
					75	dark	2
					90	1	3