FRANKLIN

National Facility
Oceanographic Research Vessel

RESEARCH SUMMARY

Cruise FR 3/91

Sailed Hobart 1045 hrs Wednesday 6 March 1991
Arrived Hobart 0700 hr Wednesday 27 March 1991

TURBULENCE MEASUREMENTS AND TURBULENT SCALING IN THE ANTARCTIC CIRCUMPOLAR CURRENT

Principal Investigators

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5 May 1991

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R.V. Franklin
National Facility
Oceanographic Research Vessel

Research Summary
Cruise FR03/91

Itinerary

Sailed	Hobart	1045	Wed 6 March 1991
Arrived	Hobart	0700	Wed 27 March 1991

Principal Investigators

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Cruise Objectives

Turbulence Measurements and Turbulent Scaling in the Antarctic Circumpolar Current

This cruise was designed to collect the first microstructure measurements from the Southern Ocean in the Antarctic Circumpolar Current and to compare these with the internal wave activity. Bunyip was deployed as often as logistically possible and in between Bunyip tows, expendable current profilers (XCPs) were dropped and CTD stations occupied:- all subject to the prevailing conditions.

Personnel

Ship's Crew

Master	Neil Cheshire
Mate	Dick Dougal
2nd Mate	Mike McAuley
Chief Engineer	Peter Noble
2nd Engineer	Ron Parrott
Elec. Engineer	Jeff Cullen
Bosun	Jannik Hansen
AB	Blue Hughes
AB	Kris Hallen
AB	Wayne Browning
Greaser	Jeff Snell
Chief Steward	Steve Corridon
Chief Cook	Gary Hall
2nd Cook	Bob Clayton

Scientific Party

Trevor McDougall	CSIRO Division of Oceanography (Chief Scientist]
Lindsay Pender	CSIRO Division of Oceanography (Cruise Manager)
Ian Helmond	CSIRO Division of Oceanography
Stuart Swan	CSIRO Division of Oceanography
Leigh Carter	CSIRO Division of Oceanography
Phil Adams	CSIRO Division of Oceanography (& ORV)
Bob Griffiths	CSIRO Division of Fisheries Research
Paul Boult	CSIRO Division of Oceanography
Nathan Bindoff	CSIRO Division of Oceanography
John Hunter	CSIRO Division of Oceanography
Mark Hindell	Royal Australian Ornithological Union
Earl Krause	University of Washington, Seattle, USA

Cruise Narrative

We were a few hours late leaving port due to having to wait for some gear to clear customs in Hobart, and also a minor problem with the ship. After leaving port we steamed for Maatsuyker Island to recover a buoy for Andrew Forbes. We arrived at the site at 1930 and looked in good conditions for 30 minutes. There was no sign of the buoy.

We then set course for 52°S 152°E and steamed for two days to arrive at this position. On the way we conducted one trial CTD station and a short XBT section from 51°S to 52°S. At 52°S the surface temperature was about 7°C and we were obviously not far from the Antarctic Convergence. Here we did a set of a CTD (#002), an XCP (eXpendable Current Profiler, #3301) and another CTD (#003) followed by the first deployment of Bunyip. Unfortunately this Bunyip tow lasted only 20 minutes before water was detected inside the microfish pressure vessel and the tow was abandoned. The leak had come from one of the seven sensor connectors, and Ian reassembled these with RTV in the O-ring grooves.

By midday Saturday 9th March we had steamed back to our original location of 52°S 152°E where we repeated the CTD, XCP, CTD routine (#005, #3303, #006, respectively), and in the early evening, deployed Bunyip for the second time. To our disbelief, the microfish pressure vessel had drank a few tablespoons of water when it was first powered up after deployment. This turned out to be due to a slightly loose bulk-head connector which did not place sufficient pre-compression on its O-ring. After correcting this fault and doing one more CTD (#007), Bunyip was redeployed (tow 3, see the attached tables of the tows for this cruise), and we towed for 11 hours without incident. We put out a total of 3250 m of cable (2850 of unfaired cable) and achieved a tow depth of 600 m at 8 knots. There was considerable turbulence on this tow and even the new, and as yet rather noisy, fast thermistor sensor (FP071) showed some patches of high temperature gradient variance, χ, that coincided with the high patches of conductivity gradient variance.

After tow 3 we did another CTD, XCP, CTD sequence (#008, #3304, #009, respectively) and deployed Bunyip for the fourth time, still towing to the south. The pre-Bunyip CTD cast (#009) showed that there was almost no vertical gradient of potential temperature below about 350 m, so this tow was relatively shallow, with the microfish ranging between 120 m and 330 m. The S-θ structure of these Bunyip profiles was very interesting and showed much intrusive activity between contrasting water masses, with the cooler and less saline water being to the north. The isopycnals sloped down to the south and the ADCP-derived velocity swung around as we travelled south, all pointing to the fact that we were in an eddy. The mixing activity was quite low all along this tow. At 0527 local time on Monday the 11th March we turned to the east, along 55°S and continued tow 3 for six more hours without escaping the clutches of this eddy. Upon recovering Bunyip, we made good some further distance to the east so as to be clear of the eddy.

The next CTD, XCP, CTD sequence (#010, #3305, #011, respectively) took place at about 55°S, 154° 48'E, followed by the fifth Bunyip deployment, towing to the north for 17 hours at a series of different depth ranges down to a maximum depth of 720m. The turbulent activity was now largest near the surface and decreased with depth. Near the end of the tow, μCond1 speared a fish of some kind and its data is useless. There was feverish thermoclinic structure on this tow at all depths. Interfacial temperature contrasts of in excess of 1°C were not uncommon. This looked like double-diffusively driven intrusions.

Then followed CTD, XCP, CTD (#012, #3306, #013) at about 53°S, 155° 30'E, then the sixth Bunyip deployment, towing to the north for 8.5 hours and then to the southwest for a further 9 hours. These tows were at a series of different depth ranges down to a maximum depth of 720m. The only significant turbulent activity was found at about 450 m. Interleaving activity between contrasting water masses was again very prevalent.

Just before the recovery of Bunyip tow #6 the wind picked up, gusting to 40 knots, and we did no work for the afternoon of Wednesday 13 March. Early the next morning we managed four CTDs (#014-#017) and two XCPs (#3307 and #3308) but the wind again increased from the west before turning to come more from the north. During this blow we decided to gain some northings and did so at a rate of about 1.5 knots. A group of about 50 pilot whales joined us for a while, letting Franklin take the lead, with a group of 25 to each of the port and starboard quarters.

We started work again at 1030hrs on the 15th, doing CTD stations #018 and #019 with XCP #3309 in between. Then we towed Bunyip eastward for 18 hours along 52°S, reaching a depth of 800m with 3500m of cable out at 6 knots. There was a curious lack of lateral interleaving between 250m and 350m and the density ratio, R_ρ, was quite low in this depth range. This was observed for two lots of two hours, separated by 10 hours. At the end of this tow we did two CTDs (#s 020 and 021) separated by an XCP (#3310), then started heading west so that we could later tow with the waves, towards the east. This westward steam took 48 hours during which we twice had winds of 80-85 knots for more than an hour. The second time the wind shifted from northwest to south west in the space of a few minutes, creating a very nervous time on the bridge. The skipper was on watch and managed to keep the ship pointing into the changing wind, but not without drama. All hands were woken and we spent an hour from midnight Monday morning dressed in warm clothes and wandering around the ship carrying our survival suits.

At 1400 Monday 18th March we did a CTD (#022) and an XCP (#3311) at 52° 30'S, 152° 00'E intending to start a time-series of CTDs and XCPs for an inertial period, but the first CTD showed that we were a little south of the main ACC axis, so we steamed a degree further north where we did seven CTDs (#023-#029) and seven XCPs (#3312-18) spaced 2 hours 33 minutes apart (one sixth of the inertial period). The aim of this time series is to determine what fraction of the vertical shear signal is caused by internal waves of near-inertial frequency, and to find out if these waves are propagating vertically upwards or downwards. Then we deployed Bunyip for a 12-hour eastward tow that was ended by the detection of water in the pressure vessel. There followed CTD, XCP, CTD (#030, #3319, #031) at about 51° 30'S, 156° 05'E.

Wednesday evening 20th March saw the 9th tow begin southwards from 50° 33'S, 154° 01'E. This tow lasted only ten hours because of the unsolved water leak. At the end of this tow we used our last XCP. Thursday evening saw a repeat of Wednesday's pattern with the microfish pressure vessel still proving to be leaky. This tow was on the heading 335° beginning at 51° 43'S 153° 55'E and ending at about 50° 26'S 153° 23'E. Around midnight we were treated to a fantastic auroral display with bright streaks of red, white and hints of green that shafted their way from one horizon to directly overhead and then to the other horizon.

Bunyip tow #11, to the southwest, began on Friday afternoon 22 March and went until midnight, again foreshortened by the water leak. There was some weak contrasts in water masses at the 200-400m level that did not show much intrusive activity. Given the prevelence of such intrusions when the contrast between the water masses is large, perhaps this means that double-diffusion was not strong enough to drive the intrusions against other competing mecanisms when the water-mass contrast is weak.

Bunyip tow #12, to NNW, began early Saturday morning and ended at midday. In the 200-400m region the isopycnals sloped significantly, the surface current was 0.7 m s^{-1} to the west, and there was intense turbulent activity there. When the isopycnals flattened out later in the tow, the turbulent activity subsided. At the end of this tow three water leaks were spotted on the outside of the carbon-fibre pressure vessel. These were presumed to have caused all our leak problems in the past few days. At the end of this tow we did a CTD to the bottom at about 4100 m. Bunyip deployment #13 was made steaming in a direction towards Hobart, and to our surprise, the pressure vessel continued to leak. Perhaps it was residual water that was being squeezed out under pressure. This tow lasted nine hours and ended before breakfast on Sunday 24th March, followed by a CTD to the bottom at 3000 m. Tow #14 lasted for 18 hours and was also made in the direction of Hobart and again water accumulated inside the pressure vessel.

Summary of work completed

Overall we did 14 Bunyip tows, 50 CTD casts, and 21 XCP drops. Bunyip spent 160 hrs (6.5 days) in the water with little biological contamination of the turbulence sensors, giving 10^6 m of turbulence data. We lost no more than three days to bad weather which was more favorable than our expectations. Most of the expendable current profilers seemed to work, and together with the turbulence data, we should be able to avhieve the cruise objectives of deducing the strength of vertical mixing processes in this region.

Attachments

Computing Report

Electronics Report

Table of Bunyip deployments #1 - #14 (4 pages).

Cruise Track

An example of intrusive activity on a S-θ diagram.

Acknowledgements

The entire FRANKLIN crew is thanked for their excellent support and cooperation throughout the cruise.

Computing Report - Lindsay Pender

The three week cruise went without any major incidents of note. Worthy of comment however are the following:

1. The EPROM from micro2 had to be replaced with that from micro5 which was under test, inorder to keep correct time.

2. There is some evidence that the calender clock is running slow when the power is off.

3. At 03:50 on 22-mar-91, micro1 was totally dead with no diagnostic messages. It could not be restarted from the console. When powered off and on again there were no more problems and the micro continued without fault for the rest of the cruise.

4. More magtape write rings need to be kept on board to enable a reasonable number of scratch tapes to be initialized in advance. I suggest at least 10.

5. VAX Exabyte MUA0: produced a fatal drive error when initializing a tape using EXA_INIT. This problem was solved by doing a power down/up sequence on the Exabyte units. The same problem reappeared when initializing tapes for the second part of this cruise (EZ).

6. The Bunyip data aquisition system on a Sun 3/160 is working very well, and apart from a couple of fine tuning problems, can be considered complete.

FRANKLIN CRUISE REPORT FR03-91
PHILLIP ADAMS
DATE:31-03-91.

CTD

The oxygen sensor failed.No spares available.

MET STATION

The met station temperature has an +0.4 degC error at 8 degC.There is a-10hPA offset on the pressure sensor.

THERMOSALINOGRAPH

Prior to the cruise the shutout valve was removed from the line to the TSG header tank.This was in response to an occasional problem with temperature drift during CTD stations.The problem did not occur during the cruise.

MICRO 2

Micro 2 would not maintain correct time.The xtal oscillator board was replaced(the spare was found to be faulty,and was repaired),swapped roms from micro 5 error 61 appeared,cleaned contacts on wiring loom,unit functioned correctly.The roms from micro 2 are now in micro 5 and correctly set up.

TRIMBLE NAVTRAC GPS

The GPS display and keyboard locked up while attempting to enter waypoints,two vertical lines appearing on the screen.The waypoint memory was corrupted.Now when entering waypoint,1 part of the screen(top right)disappears.The unit is under warranty and should be returned for inspection.

TRICYCLE

The tricycle fell off the wire damaging one wheel and preventing it from rotating,it also caused a large offset to appear in the output.This was removed by adjustment.Later in the cruise the output became very noisy and the unit had to be removed,a faulty regulator was replaced.The unit should be repaired and recalibrated prior to the next cruise.

CABLE METERING SYSTEM

The metering system worked well giving accurate displays of strain and velocity however there was a large cableout offset at the end of each cast.The magnetic ring was spaced out from the wheel fixing the problem.

The display was difficult to read at times,and the numbers were too small for the winch operators to read easily in certain conditions.A larger display should be installed prior to the installation of the new CTD system.

The maximum tension indicated at 4400meters was .7 - 1.1 tonnes this was achieved in flat seas with minimal ship movement.

The unit was calibrated during the cruise for both cable out and velocity,the final config values were

Cableout(CGAIN)=0.15733
Velocity(VGAIN)=104.5146
Tension(TGAIN) Not changed

BUNYIP WINCH

The slipring assembly became intermittent and required servicing. The unit was disassembled,cleaned and refilled with clean mercury.It gave no further problems during the cruise.

BUNYIP MAINFISH

Large amounts of data was being lost making the system inoperable.The mainfish cable interface board was swapped with the microfish(including the external inductor),fixing the problem.Unable to fit the large inductor into the mainfish,two smaller inductors were connected in series on the existing board which was taped to the power supply module.

MISCELLANEOUS

The ship's sullage tank overflowed into the GP lab via the sinks.The LA 100 printer paper suffered minor water damage and the Microscope case and power supply got wet.Both were cleaned and dried out.A bracket to store the case above the floor will be drawn up and given to the workshop to manufacture during the next shore period.

MAINTENANCE WORK PRIOR TO NEXT CRUISE

1 Repair and calibrate Tricycle.
2 Calibrate Met station pressure and temperature.
3 Install new display on bridge for cable metering system.
4 Install mounting bracket for GO block in hold.
5 Finnish installation of shelving in laundry store.
6 Install new ctd system if operational.
7 Remove CTD units and check all underwater connectors.
8 Check spare CTD boards.
9 Install cable metering system on hydro winch.
10 Make storage box for tricycle.
11 Work shop to make 5 each resealable storage boxes for data and audio tapes.
12 Spare parts storage boxes.

Table of Bunyip Deployments, Fr03/91

#	Time In	Position In	Time Out	Position Out	Sensors	Comments
1	*Fri 08 Mar 1640 UTC* —— Sat 09 Mar 0340 LT	52° 16.3′S 152° 09.5′E	*Fri 08 Mar 1700 UTC* —— Sat 09 Mar 0400 LT		µCond1 Clay µCond2 FP071 FP072	Pre-Bunyip CTD cast was CTD #003. Pre-Bunyip XCP was #3301. The thermosalinograph showed T=7.02°C and S=33.94 psu on deployment. This tow lasted only 20 minutes when water was detected in the microfish. We could not determine which of the seven probes had leaked, Ian filled each O-ring seal with RTV and we let it cure before the next tow. File fr0391001 only.
2					µCond1 Clay µCond2 FP071 FP072	Pre-Bunyip CTD cast was CTD #006. Pre-Bunyip XCP was #3303 (#3302 was a dud). Water level detect circuitry activated as soon as Bunyip was powered up. This was due to a loose bulk-head connector. No file was archived on this deployment.
3	*Sat 09 Mar 1520 UTC* —— Sun 10 Mar 0220 LT	52° 13.3′S 152° 09.0′E	*Sun 10 Mar 0420 UTC* —— Sun 10 Mar 1520 LT	53° 46.0′S 152° 35.0′E	µCond1 Clay µCond2 FP071 FP072	Pre-Bunyip CTD cast was CTD #007. There was no pre-Bunyip XCP for this tow. The thermosalinograph showed T=8.16°C and S=34.06 psu on deployment. OxyTE was sanded prior to this deployment, and the Titron sensor was also checked. Towing to the south. Surface current is 0.5 m s^{-1} to the west. The flight path was perturbed by excessive cable tension with 3250 m of cable out at 8 knots and almost no ship heave. We were reaching 600 m. µCond1, µCond2 and FP071 all saw quite a bit of turbulence, even though the vertical temperature gradient was weak. The noise level of the new FP071 sensor is about two orders of magnitude worse that µCond1. Files fr0391002 – fr0391005.
4	*Sun 10 Mar 0935 UTC* —— Sun 10 Mar 2035 LT	53° 51.0′S 152° 34.0′E	*Mon 11 Mar 0056 UTC* —— Mon 11 Mar 1156 LT	54° 58.6′S 154° 00.3′E	µCond1 Clay µCond2 FP071 FP072	Pre-Bunyip CTD cast was CTD #009. Pre-Bunyip XCP was #3304. The thermosalinograph showed T=5.56°C and S=33.74 psu on deployment. Towing to the south. Neither OxyTE nor the Titron sensors were checked prior to this tow. This tow was in the depth range 120 m to 330 m as there was almost no θ_z deeper than 330 m. There were very interesting θ-S curves on this deployment. We towed south through a cold, less saline intrusion that emanated from the north, getting warmer and more saline as the tow wore on to the south. Also, the isopycnals dipped down in the tow direction, indicating that we were in an eddy. At 0527 LT Mon 11 Mar, (1827 UTC Sun 10 Mar) we changed direction to the east as we had hit the well-known wall at 55°S. The ensuing 6 hours of the tow continued to show that we were still in the eddy, so after having retrieved Bunyip we opted for steaming to the East to get out of the eddy's clutches. Turbulence-wise, this tow was not very active, compared with tow 3. From looking at the past CTD casts, it is clear that there was a reasonable θ_z at the more northern latitudes of tow 3. Files fr0391006 – fr0391011.

Key

Acc = Accelerometer Shear Probe. OSP = Osborn Shear Probe. DSP = Dual Shear Probe. µCond = Microconductivity Probe. Clay = Clayton's Shear Probe. Titron = Titron oxygen sensor. OxyTE = Three-electrode Oxygen sensor. FP07 = Fast Response Thermistor.

Table of Bunyip Deployments, Fr03/91 (Continued)

#	Time In	Position In	Time Out	Position Out	Sensors	Comments
5	*Mon 11 Mar 0933 UTC* —— Mon 11 Mar 2033 LT	55° 01.8′S 154° 47.7′E	*Tues 12 Mar 0245 UTC* —— Tues 12 Mar 1345 LT	53° 10.7′S 155° 13.2′E	µCond1 Clay µCond2 FP071 FP072	Pre-Bunyip CTD cast was CTD #011. Pre-Bunyip XCP was #3305. Towing to the north. OxyTE was sanded prior to this deployment, and the Titron sensor was also checked. We did 100 minutes of towing at a series of depths, (120-330m) during 2040-2230hrs, (290-450m) during 2255-0104hrs, (420-600m) during 0130-0305hrs, (600-720m; {7 knots up, 4 knots down}) during 0315-0538hrs, (370-550m) during 0538-0710hrs, (270-430m) during 0745-1010hrs, and (120-330m) during 1010-1130. There was more turbulent activity on the shallower parts of this tow and less on the deeper parts. The isopycnals sloped up towards the surface along (most of?) this northward tow, suggesting that we were again in an eddy. There was huge double-diffusive intrusive activity on this tow, in all parts of the upper 700m of the water column. Many sharp interfaces had more than 1°C across them. From 2223hrs LT µCond2 caught some fish or other, until about 2356hrs. At 0925 LT µCond1 (the usually good one) caught a fish and it remained there until just before recovery at 1345 LT. µCond2 also caught something in the last hour or so. Post-Bunyip CTD was CTD#012. Files fr0391012 – fr0391018.
6	*Tues 12 Mar 0745 UTC* —— Tues 12 Mar 1845 LT	53° 13.7′S 155° 24.5′E	*Wed 13 Mar 0125 UTC* —— Wed 13 Mar 1225 LT	53° 10.2′S 154° 35.0′E	µCond1 Clay µCond2 FP071 FP072	Pre-Bunyip CTD cast was CTD #013. Pre-Bunyip XCP was #3306. Towing to the north initially. OxyTE was sanded prior to this deployment, and the Titron sensor was also checked. We did 100 minutes of towing at a series of depths, (120-330m) during 1855-2057hrs, (290-450m) during 2110-2300hrs, (420-600m) during 2320-2356hrs, a constant (µfish) depth of 453±2m (mainfish at 430m) during 2357-0028hrs, more of (420-600m) during 0028-0120hrs, (600-720m) during 0120-0315hrs, (450-580m) during 0315-0600hrs, a supposed problem with the block during 0600-0720hrs, (270-430m) during 0720-0915hrs, (120-330m) during 0943-1100hrs, and (20-230m) during 1140-1225hrs. This tow showed plenty of lateral intrusions, just as the past tows. The first time we hit a depth of about 453m the turbulence was quite intense and this lasted for a while during the constant-depth tow. From 0315 the heading was changed from north to SW as the wind was getting up a little. At depths of less than 470m there was very very little turbulence on this tow. We appeared not to have speared any fish on this tow. Files fr0391019 – fr0391027.
7	*Fri 15 Mar 0420 UTC* —— Fri 15 Mar 1520 LT	52° 00.3′S 152° 29.0′E	*Fri 15 Mar 2045 UTC* —— Sat 16 Mar 0745 LT	52° 01.6′S 156° 05.7′E	µCond1 Clay µCond2 FP071 FP072	Pre-Bunyip CTD cast was CTD #019. Pre-Bunyip XCP was #3309. Towing to the East. OxyTE was dead last tow and is not being replaced. The Titron sensor was checked prior to deployment. The thermosalinograph showed T=7.43°C and S=33.90 psu on deployment. We did approximately 100 minutes of towing at a series of depths, (50-230m) during 1530-1650hrs, (200-400m) during 1700-1835hrs, (330-550m) during 1845-2010hrs, (550-750m) during 2043-2330?hrs, (470-600m) during 2352-0010hrs, (350-550m) during 0010-0208hrs, (200-400m) during 0250-0452hrs, (40-220m) during 0530-0745hrs. This tow also showed plenty of lateral intrusions, but not in the depth range 225m-350m; rather here there was a single S-θ curve that also had a very low R_ρ. This was observed both on the way down and on the way up, many hours later. The deep parts of this deployment showed very very little turbulent activity. Some reasonable mixing activity in the 350m-550m depth range at times. µCond2 caught a fish from 1944-1959hrs and from 2129-2209hrs. µCond1 caught a fish during 0540-0620hrs. The CTD at the end of this tow confirmed that we had been in the central region of thermal wind, at least at the tow's end. Files fr0391028 – fr0391035.

Key

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Table of Bunyip Deployments, Fr03/91 (Continued)

#	Time In	Position In	Time Out	Position Out	Sensors	Comments
8	*Tues 19 Mar 0545 UTC* ——— Tues 19 Mar 1645 LT	51° 31.0′S 152° 07.0′E	*Tues 19 Mar 1800 UTC* ——— Wed 20 Mar 0500 LT	51° 30.0′S 156° 06.0′E	µCond1 Clay µCond2 FP071 FP072	Pre-Bunyip CTD cast was CTD #029. Pre-Bunyip XCP was #3318. Towing to the East. The Titron sensor was checked prior to deployment. The thermosalinograph showed T=7.20°C and S=33.87 psu on deployment. We did approximately 100 minutes of towing at a series of depths, (50-230m) during 1710-1900hrs, (200-400m) during 1920-2130hrs, (330-550m) during 2145-2340hrs, (480-680m) during 2352-0234hrs, (750-830m, @ 6 knots, 3444m of cable out) during 0239-0500hrs. Then we had a water detect alarm and recovered the vehicles. This tow showed plenty of lateral intrusions. The deep parts of this deployment showed very very little turbulent activity. Post-Bunyip CTD was CTD#030. Post-Bunyip XCP was #3319. Files fr0391036 – fr0391043.
9	*Wed 20 Mar 1100 UTC* ——— Wed 20 Mar 2200 LT	50° 32.9′S 154° 01.2′E	*Wed 20 Mar 2130 UTC* ——— Thur 20 Mar 0830 LT	51° 54.3′S 153° 47.5′E	µCond1 Clay µCond2 FP071 FP072	Pre-Bunyip CTD cast was CTD #033. Pre-Bunyip XCP was #3320. Towing just west of south. The Titron sensor was checked prior to deployment, and a new membrane installed. The thermosalinograph showed T=9.33°C and S=34.35 psu on deployment. We did approximately 100 minutes of towing at a series of depths, (50-230m) during 2208-2356hrs, very little tutrbulence initially but more later on, mixed layer was 130m deep, (200-400m) during 0010-0210hrs, very low activity, (330-550m) during 0228-0415hrs, not much turbulence, (480-680m) during 0436-0615hrs, (550-800m @ 6 knots down, 8 knots up, 3500m of cable out) during 0636-0728hrs. At 0730hrs we had a water detect alarm and recovered the vehicles. Post-Bunyip CTD was CTD#034. Post-Bunyip XCP was #3321. This was the last XCP for the cruise. Files fr0391044 – fr0391048.
10	*Thur 21 Mar 0553 UTC* ——— Thur 21 Mar 1653 LT	51° 43.0′S 153° 55.0′E	*Thur 21 Mar ~1900 UTC* ——— Fri 22 Mar ~0600 LT	50° 26.0′S 153° 23.0′E	µCond1 Clay µCond2 FP071 FP072	Pre-Bunyip CTD cast was CTD #035. Towing just west of north (335° heading). The Titron sensor was not checked prior to deployment. We noted a large difference between Cond1 and Cond2 of 0.66, with Cond2 being larger. This difference persisted for the whole tow, and was almost certainly due to the connectors to the sensors being reversed, as this was consistent with a test on deck. We did approximately 100 minutes of towing at a series of depths, (50-230m) during 1702-1845hrs, quite energetic at 150m, (200-400m) during 1900-2055hrs, very low activity, (330-550m) during 2105-2320hrs, some intense turbulence even visible on FP071, (480-680m) during 2330-0154hrs, (550-800m @ 6 knots, 3500m of cable out) during 0154-0317hrs, moderate intensity. µCond1 caught something at 0317hrs. At 0317hrs we had a water detect alarm and recovered the vehicles. Post-Bunyip CTD was CTD#036. Files fr0391049 – fr0391053.
11	*Fri 22 Mar 0410 UTC* ——— Fri 22 Mar 1510 LT	50° 09.1′S 153° 13.6′E	*Fri 22 Mar 1353 UTC* ——— Sat 23 Mar 0053 LT	50° 45.3′S 152° 02.5′E	µCond1 Clay µCond2 FP071 FP072	Pre-Bunyip CTD cast was CTD #037. At the beginning we towed just west of north (335° heading). At 1630 we turned to head Southwest. The Titron sensor was checked prior to deployment. We did approximately 100 minutes of towing at a series of depths, (50-230m) during 1515-1604hrs, quite energetic at this depth, but not as energetic as further south, (200-400m) during 1624-1938hrs, some intense patches, (330-550m) during 1952-2332hrs, some intense turbulence here. µCond1 caught things for 5 minutes several times on this tow. In the 200-400m depth range there was little change in water masses, but there was a detectable signature. The lack of identifiable intrusions in this data suggest that double-diffusively driven intrusions are only effective when the driving epineutral potential temperature contrast is sufficiently large. At 2332hrs we had a water detect alarm and recovered the vehicles. Post-Bunyip CTD was CTD#038, which went to the bottom at about 4100 m. Files fr0391054 – fr0391057.

Key

Acc = Accelerometer Shear Probe. OSP = Osborn Shear Probe. DSP = Dual Shear Probe. µCond = Microconductivity Probe. Clay = Clayton's Shear Probe. Titron = Titron oxygen sensor. OxyTE = Three-electrode Oxygen sensor. FP07 = Fast Response Thermistor.

Table of Bunyip Deployments, Fr03/91 (Continued)

#	Time In	Position In	Time Out	Position Out	Sensors	Comments
12	*Fri 22 Mar* *1850 UTC* ——— Sat 23 Mar 0550 LT	50° 45.0′S 152° 04.0′E	*Sat 23 Mar* *0116 UTC* ——— Sat 23 Mar 1216 LT	49° 59.0′S 151° 35.0′E	µCond1 Clay µCond2 FP071 FP072	Pre-Bunyip CTD was CTD#038, which went to the bottom at about 4100 m. Towing toward Hobart on 330° heading. The Titron sensor was not checked prior to deployment. We towed at a series of depths, (50-230m) during 0603-0741hrs, most intense activity for days, (200-400m) during 0757-1120hrs. At 0930 we were in the middle of a broad region of thermal wind, with the surface ADCP velocity being 0.7 m s^{-1} to the west, and there was intense turbulence. When we moved out of this shear region, the turbulence dropped. At 1120 we had a water detect alarm and began to recover the vehicles. On deck we noticed three leaks of water comming out of the pressure vessel, so we think we have found the cause of our water leaks. Post-Bunyip CTD was CTD#039. Files fr0391058 – fr0391060.
13	*Sat 23 Mar* *1024 UTC* ——— Sat 23 Mar 2124 LT	49° 42.0′S 151° 34.0′E	*Sat 23 Mar* *1918 UTC* ——— Sun 24 Mar 0618 LT	48° 36.3′S 150° 58.5′E	µCond1 Clay µCond2 FP071 FP072	There was no Pre-Bunyip CTD. Towing toward Hobart on 330° heading. The Titron sensor was checked prior to deployment, and the membrane replaced. We towed at a series of depths, (50-230m) during 2133-0006hrs, not much turbulence here, (180-400m) during 0030-0327hrs, (370-560) during 0327-0558hrs. µCond2 had an unusually high noise base for all of this deployment. At 1120 we had a water detect alarm and began to recover the vehicles, this despite having patched up three holes with epoxy before this deployment. Post-Bunyip CTD was CTD#040, which went to the bottom at 3000 m. Files fr0391061 – fr0391064.
14	*Sun 24 Mar* *0340 UTC* ——— Sun 24 Mar 1440 LT	48° 04.3′S 150° 48.8′E	*Sun 24 Mar* *2200 UTC* ——— Mon 25 Mar 0900 LT	45° 59.0′S 149° 29.0′E	µCond1 Clay µCond2 FP071 FP072	There was no Pre-Bunyip CTD. Towing toward Hobart on 330° heading. The Titron sensor was not checked prior to deployment. The thermosalinograph showed T=9.45°C and S=34.26psu on deployment. We towed at a series of depths, (50-210m) during 1440-1620hrs, (180-400m) during 1635-1900hrs, (370-560) during 1915-2243hrs, (450-640m) during 2257-0152hrs, (370-550m) during 0222-0347hrs, (200-400m) during 0421-0608hrs, (50-210m) during 0652-0830hrs, constant depth of 15m during 0830-0850hrs. Extremely active turbulence in the shallow 50-200m range, both at the beginning of the tow and particularly at the end of the tow. Moderate activity in the 200-400m range. While we had no water alarm on this tow, we did have a diaper in the pressure vessel and it did get wet. Post-Bunyip CTD was CTD#041, which went to the bottom at 4260m. Files fr0391065 – fr0391070.

Key

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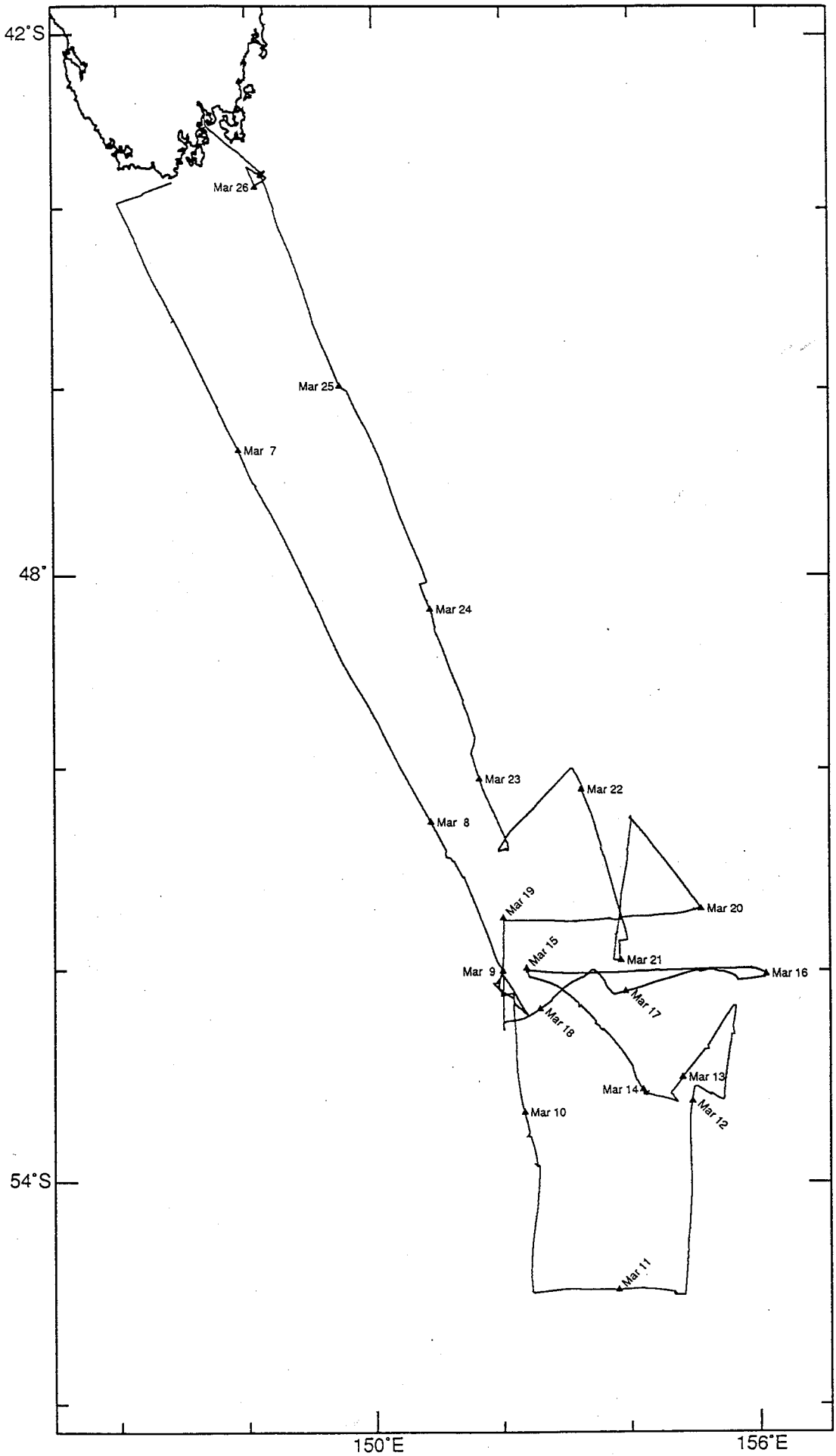
42°S
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Mar 20
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Mar 14
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Mar 10
Mar 11

Lat 51 31.05S Long 152 40.16 to 152 44.95E