R.V. FRANKLIN

NATIONAL FACILITY

OCEANOGRAPHIC RESEARCH VESSEL

R.V. FRANKLIN

CRUISE SUMMARY

RESEARCH CRUISE

FR4/88

PRINCIPAL INVESTIGATORS

Eric Lindstrom (CSIRO Division of Oceanography)
Stuart Godfrey (CSIRO Division of Oceanography)
Frank Bradley (CSIRO Division of Environmental Mechanics)
Tony Crawford (University of Tasmania)

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AUSTRALIA

R.V. FRANKLIN IS OWNED AND OPERATED BY CSIRO

CRUISE SUMMARY
FR 4/88

Itinerary

Depart Cairns	1100	23 April 1988
Arrive Madang, PNG	1630	30 April 1988
Depart Madang, PNG	1830	30 April 1988
Arrive Rabaul, PNG	0600	10 May 1988
Depart Rabaul, PNG	1400	11 May 1988
Arrive Townsville	0000	25 May 1988

Scientific Projects and Primary Objectives

1. Equatorial mixed layer and Undercurrent turbulence experiment

-To measure temperature, salinity, and velocity finestructure and microstructure at the bottom of the tropical upper ocean mixed layer and in the Equatorial Undercurrent for determination of turbulent heat diffusion and dissipation of turbulent kinetic energy.

-To examine the structure of water properties and currents adjacent to the northeast coasts of New Ireland, New Guinea, and the southern approaches to New Britain.

2. Heat and Freshwater budget north of Papua New Guinea

-To measure overall mean values of ocean heat storage and radiation balance over a two to four day period in low wind conditions.

3. Petrology-Geochemistry of lavas from seamounts in the New Guinea region

-To collect rock samples by dredging from seamounts east of New Ireland and from the Manus-Williaumez submarine rise in the Bismark Sea.

Principals Investigators

1. Eric Lindstrom and Trevor McDougall (CSIRO Division of Oceanography)
2. Stuart Godfrey (CSIRO Division of Oceanography) and Frank Bradley (CSIRO Division of Environmental Mechanics)
3. A.J. Crawford (University of Tasmania)

Results (Map of cruise track attached as Fig.1)

Success was achieved in measuring temperature and salinity finestructure and conductivity microstructure using Bunyip. Extensive data sets were collected from approximately 20 m depth to 250 m depth, encompassing the bottom of the upper ocean mixed layer and the core of the Equatorial Undercurrent. Failure of shear probes on Bunyip precludes the analysis of velocity microstructure and determination of turbulent kinetic energy dissipation. (Detailed report attached as Appendix 1).

Sections of horizontal velocity were obtained in Vitiaz Strait, Ismrud Strait, St Georges Channel, and off the east coast of New Ireland which revealed strong (50-100 cm/sec) equatorward flowing undercurrent centered at about 200 m depth. Water property information were obtained in conjunction with velocity data along the north east coast of New Guinea and New Ireland. A detailed water property section was obtained across the equator at 149°E. Lower priority work off the south coast of New Britain was not completed. (Preliminary result from all sections illustrated in the Cruise Narrative).

A total of 130 hours of atmospheric turbulence data from which momentum, heat and water vapor fluxes will be calculated were obtained during the cruise. Several days of high resolution radiometer data were collected. (detailed report attached as Appendix 2)

Rocks were successfully dredged from the eastern slopes of the Circular Reef complex on the Manus-Williaumez submarine rise. Seamounts east of New Ireland were not sampled.

Cruise Narrative

Day 1, Saturday, 23 April 1988, Noon position 16°49.65'S 145°53.45'E

Departed Cairns at 1100 after a two hour delay. Delay required in order to get VAX up and running. The engineer from DEC had driven up from Townsville, arriving at 0815. Life boat drill held at 1245. Our next waypoint is Jomard Entrance in the Louisiade Archipelago. Start-up of data logging systems proceeded extremely smoothly. Bunyip team is readying instrument for test deployment. ADCP not yet operational.

Day 2, Sunday, 24 April 1988, Noon position 14°16.34'S 148°42.08'E

Conducted tests of the ships gyro in the early hours of the morning. Did circles to port and starboard at 2 knots and 6 knots comparing the bridge gyro readout to that obtained at the ADCP. Results are the same at each speed. A test CTD station was started at 1000. All bottles fired at salinity minimum (680 m). Still awaiting completion of Bunyip and ADCP. In the afternoon a trial deployment of Bunyip was cancelled because of an open circuit somewhere in the microfish. Upon opening it up no fault was found and the problem disappeared.

Day 3, Monday, 25 April 1988, Noon position 11°39.93'S 151°46.26'E

Proceeding with equipment setup. ADCP transducer deployed in transducer well and system working perfectly. Trial deployment of Bunyip in the afternoon was postponed due to water sensors in the pressure case on the microfish giving a positive alarm. This would appear to be due to the humid conditions, but turned out to be a leak around the connector for the #1 shear probe.

Day 4, Tuesday, 26 April 1988, Noon position 8°26.68'S 151°49.94'E

GPS being up in the morning from about 5 am until noon, we scheduled ADCP alignment tests during this time. We planned reciprocal courses at 0°, 45°, and 90° with ship drift at end of each run. Several problems we encountered with the VAX air-conditioning and temperature alarm system which led to the VAX crashing three times during the morning. It would appear that the air conditioner iced-up due to the high humidity. As we were trying to get the ADCP results in real time the crashing of the VAX killed our file transfers and the exercise was not very successful. The first Bunyip deployment was completed in the afternoon. The deployment and recovery operations went smoothly. Communications from the fish were intermittent and recovery was earlier than intended due to the tripping of the pressure case water detectors. Again, this appeared to be due to condensation. Frank Bradley and Peter Coppin have been gathering some data from their sensors on the meteorological boom. Late in the evening, after the fitting of guy wires, the first outward deployment to its full 10 m extent was successfully completed.

Day 5, Wednesday, 27 April 1988, Noon position 7°40.89'S 148°40.43'E

Heading toward Vitiaz Strait. At 0500 decided to divert from direct course to take a jog in toward the Papua New Guinea coast during GPS coverage. We were looking for any indication of the New Guinea Coastal Undercurrent south of Vitiaz Strait. After completing further gyro tests by circling the ship we believe the difference between the actual gyro reading and that received at the ADCP lies in the CSIRO synchro-digital interface. David Edwards replaced the central interface chip which has resulted in a significant improvement in the characteristics of the signal received at the ADCP. Instead of the previous sin(2 x heading) difference curve between the gyro and ADCP (amplitude of 2-3 degrees!), we now obtain what appears to be a constant offset of between 0.5 and 0.8 degrees (ADCP>gyro). Final confirmation of the offset awaits further tests.

Day 6, Thursday, 28 April 1988, Noon position 5°55.37'S 147°37.40'E

Began a series of transects across Vitiaz Strait at about 0100 today. The transect is from 1.5 nm off Chissi Point on the New Guinea side to 4 nm off Higgins Point on Umboi Island (a distance of 22 nm). The exercise occupied the entire day. We completed four round trips (including one full round trip under GPS). The four round trips we completed at different speeds (8, 12, 10, and 6 kts) in order to provide the maximum amount of calibration information of the ADCP. Results from the transects under GPS which we have processed are illustrated in Fig. 2 below. They show, as hoped, the northwestward flowing New Guinea Coastal Undercurrent (core at about 200 m and speed of 80 cm/s) being the primary circulation feature of the Strait. Near surface flow was very weak (10 cm/s). There was (as during WEPOCS in 1985-86) some indication of a return flow to the southeast on the Umboi Island side of the Strait.

Day 7, Friday, 29 April 1988, Noon position 4°27.74'S 146°59.36'E

Steamed northwest by north into the Bismarck Sea in the morning and deployed the profiling surface drifter just before lunch. Deployed the meteorological boom and began hour long runs at constant heading to collect data near the drifter. Completed 2.5 hours of sampling before sensor failure caused the abandonment of data collection. The drifter was then relocated without any problem and recovered after a deployment time of just under four hours. It had completed one cycle of sampling, thus returning a down and up trace of temperature and salinity to a depth of 160 m. Deployed Bunyip after the evening meal for a couple of hours. It was a fairly successful test some communications difficulty. An amplifier of the shear probe signal failed and had to be replaced. After a late evening recovery we turned southwest for Karkar Island.

Day 8, Saturday, 30 April 1988, Noon position 4°58.58'S 146°01.87'E

During the time when GPS is up in the morning (about 0700-1100 local) we did an ADCP section of Ismrud Strait, between the New Guinea coast and Karkar Island. This Strait, like Vitiaz, should be a conduit for the New Guinea Coastal Undercurrent. Ismrud Strait is 8 nm wide and about 800 m deep. The velocity contours of flow through the strait are shown in Fig. 3. It was interesting that during a period of drift, inshore on the Karkar Island side of the strait, a number of islanders paddled out to Franklin. We wrapped up bread and cookies in plastic and distributed some to the paddlers before departing. Bob Edwards telexed in the morning that Trevor McDougall will not be arriving in Madang at 1700 today as scheduled. He is now to arrive on Sunday evening. I decided that we will still make our scheduled port call at Madang this afternoon at 1600 in order to drop off Jan Peterson. While it might be possible for her to change her schedule of flights back, she is taking back the spare head of the Bunyip microfish for re-machining and return to Rabaul and must get back quickly. As I think it inadvisable to await McDougall's arrival we will proceed with the cruise plan after dropping Jan off and return for McDougall on Monday. Made Madang Harbour pilot at 1600 and dropped anchor at 1640. We cleared customs and sent Jan on her way and weighed anchor at 1840. Course is set for the mouth of the Sepik river where we begin a CTD section northeast toward Manus Island.

Day 9, Sunday, 1 May 1988, Noon position 3°45.86'S 144°33.75'E

After steaming all night we stopped at 0600 so the engineers could track down a power fluctuation problem in the main engines. While this was supposed to take one hour, we did not in fact get underway again until 1130. We then spent the rest of the day completing seven CTD stations in a section out from the PNG coast starting at the mouth of the Sepik river. The last (eighth) CTD station on the section, just southwest of Manus Island, was cancelled due to lack of time. The inshore waters were quite brackish and turbid; salinities as low as 18.0 were observed on the thermosalinigraph. The offshore panorama is quite spectacular with the active volcanos Bam, Blupblup, and Manam all visible.The preliminary results from for the temperature and salinity sections are shown in Fig. 4.

Day 10, Monday, 2 May 1988, Noon position 4°14.01'S 145°45.65'E

The first four hours of the day were spent completing the last two stations on the Sepik River section started on Sunday afternoon. We then had to turn for Madang for the scheduled pickup of T.McDougall. McDougall came aboard at 1700 from the pilot boat outside Madang Harbour. Considering the delays imposed by our return to Madang, I have elected to modify the cruise to plan by dropping the 142°E CTD section. We are now proceeding to 4°S 149°E to spend a day on the "heat flux" experiment of Godfrey, Bradley, and Coppin. We will then do a CTD section up 149°E to 2°N then deploy Bunyip and return long the same route. Set our ETA for Rabaul at 0600 on the 10th and departure for 1400 on the 11th.

Day 11, Tuesday, 3 May 1988, Noon position 4°2.66'S 148°52.95'E

The wind sprung up to 30 knots in the morning before arriving at 4°S 149°E and seas quickly became quite lumpy. Arrived at the nominal site for the "heat flux" experiment at 1300 but postponed it because of the weather. We began a CTD section up 149°E from 4°S to 2°N. Following the first station (CTD#9) we had a complete power failure while leaving station. This was caused by a stuck hydraulic valve causing the propeller to go to maximum pitch and overload. UPS system did not work because voltage was not interrupted. Lost two hours while repairs to the hydraulic system were made. Continued on northward CTD section for the rest of the day - uneventfully.

Day 12, Wednesday, 4 May 1988, Noon position 1°41.46'S 148°57.64'E

A fine day with a light southeast trade and low swell. After clearing the shadow of New Ireland and heading out of the Bismarck Sea we were immediately in the teeth of the South Equatorial Current, which was running due west at 1.0-1.2 m/s north of about 2°30'S. The speed drops to zero at 200 m. Just before lunch we had the microfish over the side for about one half hour to collect some data before final fairing and adjustments are made. The trial was relatively successful although some data dropouts are still occurring. Just as the microfish was to be put over a sailfish of some sort approached the stern. Continued on with CTDs every 30 nm.

Day 13, Thursday, 5 May 1988, Noon Position 1°14.61'N 149°0.02'E

Spent the day completing the 149°E CTD section. We lost some time when the the propeller pitch control stuck. This occurred at the beginning of a CTD station (which was aborted and completed after the pitch hydraulics were repaired). Late in the evening the section was completed and the Bunyip launched without incident. The preliminary temperature and salinity sections from the CTD work along 149°E are shown in Fig. 5. Now begins the long awaited Bunyip sections.

Day 14, Friday, 6 May 1988, Noon Position 0°12.47'N 148°56.06'E

Bunyip brought in after breakfast, just north of the equator. It was a successful deployment in as far as data communications and mechanics went, however, it was found that the microconductivity sensor was not providing real data, the shear probes failed due to water leakage shortly after the deployment, and the CTD type salinity measurements are out of calibration by as much as .5 psu. After recovery we had hoped to redeploy at 1400 so we waited for repairs to be made. When it became apparent that the problems would not be solve as soon as expected, Bunyip work was abandon and we are proceeding to the Bismarck Sea at top speed to find calmer weather for met and profiling drifter observations.

Day 15, Saturday, 7 May 1988, Noon Position 3°14.17'S 148°54.27'E

Just into the day a burning smell was detected in the ops room but its source was never located and no equipment has failed. The morning was spent steaming south for the Bismarck Sea and hopefully calmer conditions. The micrometeorological measurements were started in the afternoon. At 1600 there was a power failure which brought all to a halt. UPS had been switched off due to overheating problems, so all computers went down. The loss of power was caused by a blockage in fuel supply to the main engine. After about an hour power was restored and logging systems restarted. After dinner the profiling drifter was deployed once again. The deployment over the starboard side was not a picture of perfection but eventually the launch was successful. It is to be left in for 24 hours and I set a radius of operations of 20 nm from the buoy during that period. Micromet observations continued all evening in a large box surrounding the profiling drifter.

Day 16, Sunday, 8 May 1988, Noon Position 3°38.35'S 149°14.43'E

Meteorological measurements continued throughout the morning along a track surrounding the deployment site of the profiling drifter. At 1400 these operations were broken off in order to relocate the drifter. At 1500 near the position we expect to find it, we launched the rescue boat to take pictures of the meteorological boom. Frank and Peter were happy with the photo opportunity. The RDF indicated the drifter to the southwest of our position but our drift vectors and ADCP currents during GPS indicated northeastward currents. Winds over the previous 24 hours we mostly north to northeasterly at less than 6 knots. Back tracking along the suspected buoy track (080° at 0.5 knots) to its deployment point we did not find it. RDF always seemed to indicate that it was astern of us! Late in the evening called Bob Edwards in Hobart in hopes of obtaining an Argos position for the drifter. This was provided within the hour and showed the drifter was 25 miles SSW of our current search area at 1830EST. It would have travelled on a course of 163° at 0.7 knots to reach this point. We were proceeding to the Argos position as the day ended.

Day 17, Monday, 9 May 1988, Noon Position 3°59.98'S 150°33.59'E

At 0130 we arrived at the extrapolated position of the drifter based on its set and drift from the deployment site to the 1830 Argos position. The RDF signal was strong but provided no directional information. No light was visible despite the clear windless conditions. After giving up on RDF we tried radar and found a target 0.5 miles on the bow. A weak flashing light was then visually identified and recover operations undertaken. After recovery of the drifter at about 0330 a shallow CTD station was completed. Steaming toward Rabaul along 4°S now with an ETA of 0600 tomorrow. Launched Bunyip for a trial run after breakfast. Following the conclusion of the Bunyip run at 1500 three CTD stations to 1050 m were completed along 4°S.

Day 18, Tuesday, 10 May 1988, Noon Position 4°12.31'S 152°10.17'E

Arrived Simpson Harbour, Rabaul at 0600. We were alongside before 0700 and off the ship by 0800.

Day 19, Wednesday,11 May 1988, Noon Position 4°12.31'S 152°10.17'E

Completed provisioning, water and fuel and departed Rabaul at 1400. Making our way south through St. Georges Channel to Solomon Strait and hence northward along the east coast of New Ireland.

Day 20, Thursday, 12 May 1988, Noon Position 3°34.06'S 152°30.93'E

Arrived off Cape Namarodu, New Ireland at 0600 and began a Doppler profiler section out from the coast to about 20 miles offshore. Returned on a reciprocal course to 1.5 nm offshore of the Cape where we did CTD#28. Continued offshore doing CTD stations. Finally completed station #34 at 3°S 153°E just before midnight. The alongshore component of current obtained from the Doppler profiler is shown in Fig. 6. It shows a northwestward undercurrent in excess of 50 cm/s centered at 200 m depth.

Day 21, Friday, 13 May 1988, Noon Position 1°37.19'S 152°52.44'E

Began a Bunyip deployment shortly after midnight. However the deployment was aborted soon after launch when it was found that there was no wing control on the main fish. After recovery at 0330 we continued steaming north at full speed enroute to Lyra Reef dredging site. In the early morning hours Lindsay Pender was unable to fault Bunyip so another trial was scheduled for after breakfast. This did not eventuate because further examination revealed that the termination between microfish and mainfish was faulty. The weather being perfect for micrometeorological work (no wind and sunny), it was agreed to proceed with slow steaming toward the equator with the meteorological boom fully deployed. Repair work on Bunyip was completed during the day and it should be ready for deployment at the equator tomorrow. Winds are less than 6 knots from the NNE and the NE swell is very low.

Day 22, Saturday, 14 May 1988, Noon Position 0°18.81'N 152°57.71'E

Reached the equator at 0700 and concluded micrometeorological operations. At 0800 we stopped for CTD #35 to 500 m depth followed immediately by Bunyip deployment. This went smoothly and we turned north intending to keep it in the water for the rest of the day. During the mornings GPS coverage we covered the area from about 0°20'S to 0°20'N and obtained a nice suite of Equatorial Undercurrent profiles (Fig. 7). They show the 40-60 cm/s westward South Equatorial Current at the surface and 60-80 cm/s eastward Equatorial Undercurrent core at 160 m depth. At about 1500 the cable slip detector on Bunyip triggered and the mainfish was brought aboard for a checkup. The cable slip detector was replaced and the mainfish redeployed. Bunyip appeared to be obtaining good data during the day's run. At midnight recovery operations commenced. When brought aboard it was found that one section of about 9 m of fairing was missing and one shear probe was dangling loose from the microfish.

Day 23, Sunday, 15 May 1988, Noon Position 0°3.75'S 152°54.33'E

The Bunyip recovery concluded about 0100 at 1°35'N along 153°E. As soon as all the gear was aboard we did CTD #36 to 500 m depth then turned south heading for the equator once again. There was a group of fishing boats about at 1°20'N and the sea surface temperature is 1°C lower than at the equator. The mixed layer is 90 m deep compared to practically nil at the equator. Stopped at 0900 for a pre-Bunyip CTD to 500 m. Upon completion it was raining and Bunyip deployment was delayed for about an hour (much to the dismay of the chief scientist). Further delay occurred because of the need to replace fairing lost in the previous deployment. There was three knots (1.5 m/s) shear between the surface and 150 m so Bunyip hung way off to port as we steamed south. Around sunset the cable slip detector again raised the alarm and recovery operations began. It was found that the slip detector had malfunctioned. Once again the shear probes failed to operate. Finished the day steaming back to the equator at 152°E.

Day 24, Monday, 16 May 1988, Noon Position 0°1.74'N 151°13.19'E

Arrived on the equator at 152°E at 0240 and slowed to 4 knots to begin a long transect west along the equator to 147°E. Stopped for CTD #39 to 500 m at 0900 and then continued west awaiting the deployment of Bunyip. The mainfish finally made it into the water at 1130. Both fish were brought in again at 1530 to take off string mounted on the connecting cable to reduce vibration. It appeared to be causing to much drag - leaving the microfish in the wake of the mainfish. Redeployment was completed at 1710. Just before midnight another recovery operation was mounted to bring aboard the mainfish only. Its hydraulics had failed and the entire hydraulic unit was replaced. Repair work continued well past midnight. While the plan to obtain 24 continuous hours of data along this equatorial transect is being thwarted by gear failure, the measurements appear to be of higher quality than previous runs. One shear probe has collected data and the noise level on microconductivity measurements has reduced by a factor of ten.

Day 25, Tuesday, 17 May 1988, Noon Position 0°2.87'N 148°20.62E

Bunyiped along the equator all day. Hydraulic failure of the previous day was fixed and the mainfish was back in the water at 0300. We are changing ship speed every 10 minutes in order to get the full dynamic flight range out of the mainfish in this three knot shear. The flight path is 30-200 m return trip every 20 minutes at an average speed over ground of 7 knots. Bunyip recovery began as the day ended.

Day 26, Wednesday,18 May 1988, Noon Position 0°59.77'S 147°25.91'S

Following the recovery of Bunyip at 0130 we steamed back about 18 nm to 147E on the equator to do a survey of the bottom topography for future use in the joint Australian-United States mooring project on this site. It was planned to do some Doppler profiler calibration tests at this site as well but the swell and wind combined to provide less than ideal conditions for profiling. Turned southeast to return to the Bismarck Sea via the east side of Manus Island. Cruising for the remainder of the day while dismantling Bunyip gear and rigging for dredging.

Day 27, Thursday, 19 May 1988, Noon Position 3°24.11'S 148°18.38'E

Steaming south through the Bismarck Sea toward a nominal dredging site east of Sherburne Reef. Our arrival on the site at 0300 coincided (by plan) with GPS coverage and we began a survey of the bottom in the area. Found a nice slope from 800-1600 m depth over a distance of about 1 nm at 3°24'S 148°20'E. At 0530 the survey was completed to my satisfaction and we started working on the previously postponed ADCP trials. Did an octagon-shaped track at 6 knots with 20 minutes on each side. It did not go as smoothly as hoped because I was unable to get the profiler to log raw data without crashing and GPS was not well behaved. Started dredging operation at 0840. Laid out 2100 m of cable and pulled it in as we sat over the top of the slope. It came up at 1130 with a bucket full of rocks. Having been successful we retired from dredging and set course for St. Georges Channel at slow speed to accommodate micrometeorological experiments.

Day 28, Friday, 20 May 1988, Noon Position 3°50.00'S 150°50.83'E

Steaming slowly across the Bismarck Sea (4, 6, and 8 knots) with the met boom fully deployed. It is a perfect day for these observations - calm and sunny. At 1030 (while underway) a fire drill was conducted. All went well with the "rescue" of Stuart Godfrey from the GP lab by Dave Terhell and Lindsay Pender in SCBA gear. The chief engineer desires time to work on pitch control during this good weather. We finally reached the solution of continuing met observations until 2000 (in order to complete a full 24 hour cycle). Thus at 2000 began 5.5 hours of drifting and variable speed as the pitch control was "tuned." Work finished just in time to make our appointment with GPS and an ADCP survey of St. Georges Channel.

Day 29, Saturday, 21 May 1988, Noon Position 4°12.00'S 152°33.44'E

Reached Cape Tawui on the Crater Peninsula of New Britain at 0300 about 10 minutes after GPS came up. Setting speed at 10 knots we began completing transects (of 23 nm) across St. George's Channel between Cape Tawui and Palabong, New Ireland. We reached Palabong at 0530 for sunrise over the steep New Ireland jungle and completed our next turn at Cape Tawui at 0815. On the way back to Palabong we spotted a pod of pilot whales feeding off the north shore of Duke of York Island and a large basking shark patrolling off the New Ireland shore. At 1055 we completed the transect and turned south down St. Georges Channel for the run to Townsville. Our passage will be via Jomard Entrance and Grafton Passage. Began an XBT section at this point which will continue to Grafton Passage. It is a beautiful windless day in the Channel, which appears to have a wealth of fish and bird life. Preliminary results for along-channel currents from St Georges Channel are shown in Fig. 8.

Day 30, Sunday, 22 May 1988, Noon Position 9°4.03'S 152°10.62'S

Steaming across the Solomon Sea toward home today. Cleaning up and sorting things out are the words for the day. XBTs every four hours until noon when the intensity is increased to once per hour going through the Louisiade Archipelago. Finished the day at Jomard Entrance.

Day 31, Monday, 23 May 1988, Noon Position 12°55.49'S 150°21.09'E

Into the Coral Sea and we are happy to find it quite calm. Only a 12-15 knot southeast trade on the beam. Cruise summaries are being written and XBTs continuing. Launches of XBTs at thirty minute intervals from Jomard Entrance to 12°S and at three hour intervals from 12°S to 14°S.

Day 32, Tuesday, 24 May 1988, Noon Position 16°13.06'S 146°42.46'E

XBT section continues with launches every two hours from 14°S to 16°S and every thirty minutes from 16°S to Grafton Passage. Reached Grafton Passage at 1500 (results of section shown below) and stopped for two hours fishing. Several Coral trout were caught and one small (10kg) "Hump-headed Maori Wrasse." Underway to Townsville at 1700. Appointment with pilot moved up from 0900 to 0800 on Wednesday.

Day 33, Wednesday, 25 May 1988, Noon Position - Townsville

Completing final shutdown of instruments and backup of data files in the early hours of the morning. So ends FR 4/88 - a good cruise all in all.

Summary

FR4/88 was very successful considering the impromptu changes in the original cruise plan which had to be accommodated because of disrupted travel schedules, equipment failure, and weather conditions .General circulation studies using current and water property profiling went really well. Particularly exciting are the results of current profiling in Vitiaz Strait, St Georges Channel and off New Ireland. While Bunyip operations were marred by equipment malfunctions, useful microconductivity measurements were obtained and will lead to estimates of turbulent fluxes of heat and freshwater. Measurements of turbulent fluxes above the sea surface from the meteorological boom went extremely well but useful simultaneous measurements of oceanic heat content were logistically difficult.

Scientific personnel

Name	Institution	Comments
Eric Lindstrom (Chief scientist)	CSIRO DO	
Trevor McDougall	CSIRO DO	Madang to Townsville
Stuart Godfrey	CSIRO DO	
Stuart Swan	CSIRO DO	
Alex Papij	CSIRO DO	Cairns to Rabaul
Lindsay Pender	CSIRO DO	
Ian Helmond	CSIRO DO	
Jeff Butt	CSIRO DO	
Janice Peterson	CSIRO ORV	Cairns to Madang
David Terhell	CSIRO ORV	
David Edwards	CSIRO ORV	
Frank Bradley	CSIRO EM	
Peter Coppin	CSIRO EM	

Eric J. Lindstrom
Chief Scientist

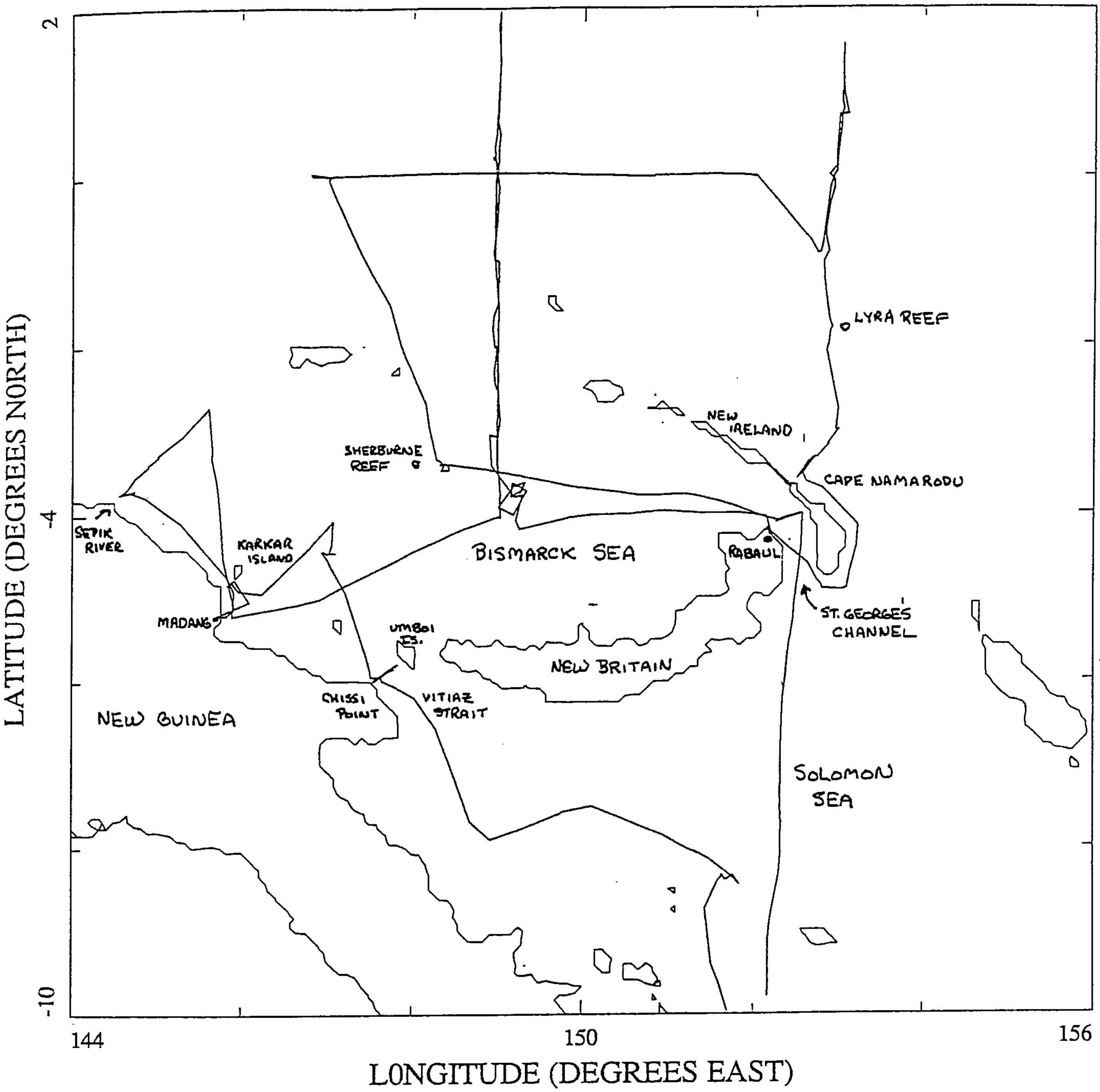


Fig. 1 **Cruise track for FR4/88 (otherwise known as WEPOCS 3). Coral Sea transects to and from Australia are not shown**

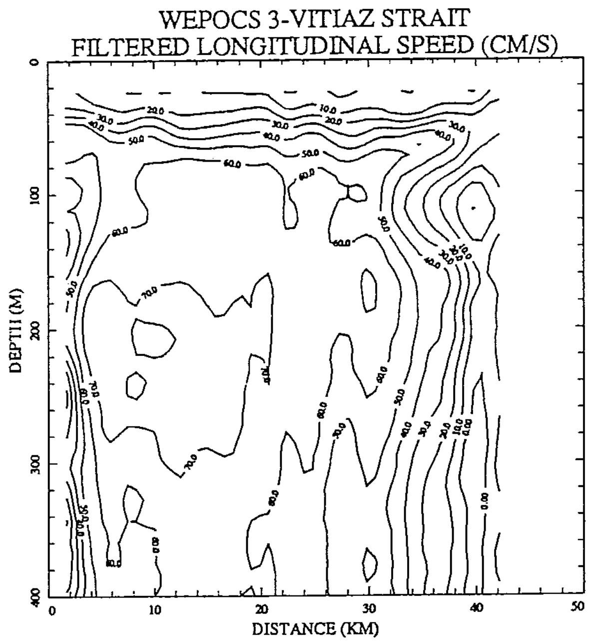


Fig. 2 Contours of along-channel speed across Vitiaz Strait (between Chissi Point, New Guinea on the left and Higgins Point, Umboi Island on the right). Positive values (in cm/sec) indicate flow from the Solomon Sea into the Bismarck Sea

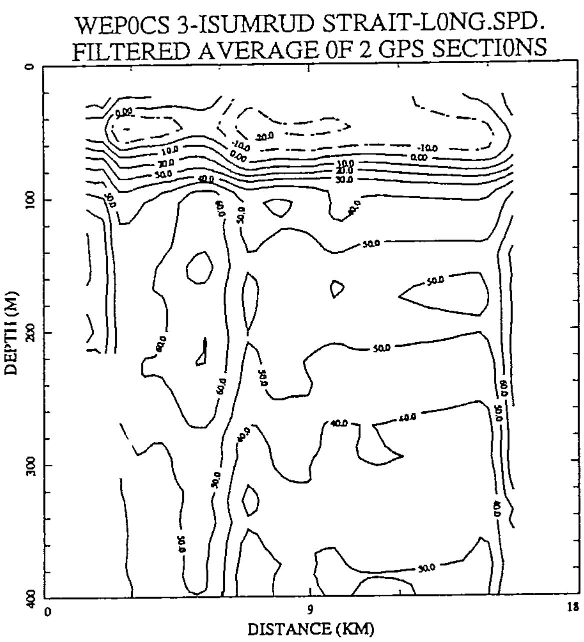
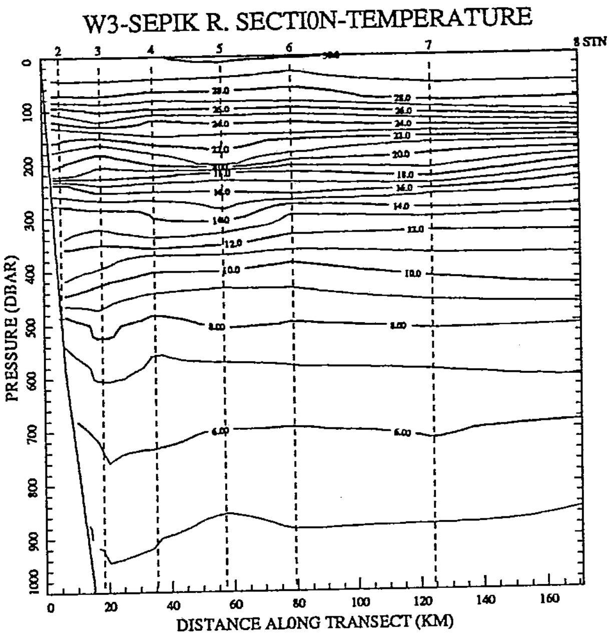


Fig 3 Contours of along-channel speed across Ismrud Strait (between New Guinea on the left and Karkar Island on the right). Positive values (in cm/sec) indicate flow toward the northwest.

Fig. 4 Contours of temperature and salinity along a section from the Sepik river mouth (New Guinea) to southwest of Manus Island. Dashed vertical lines indicate location of profiles



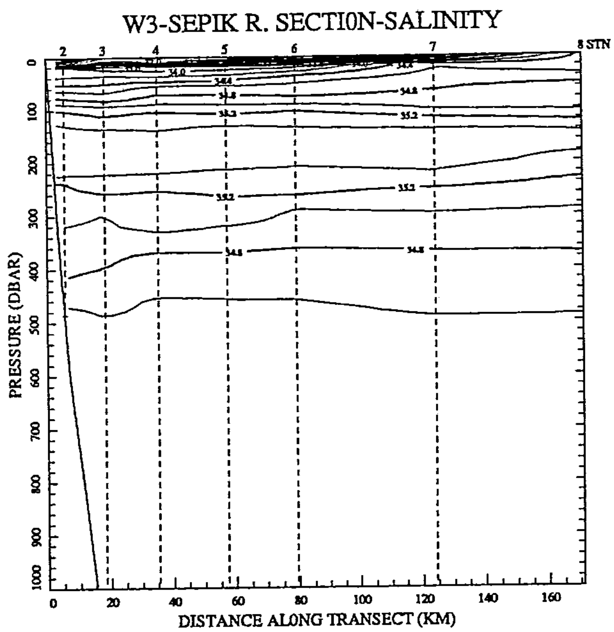
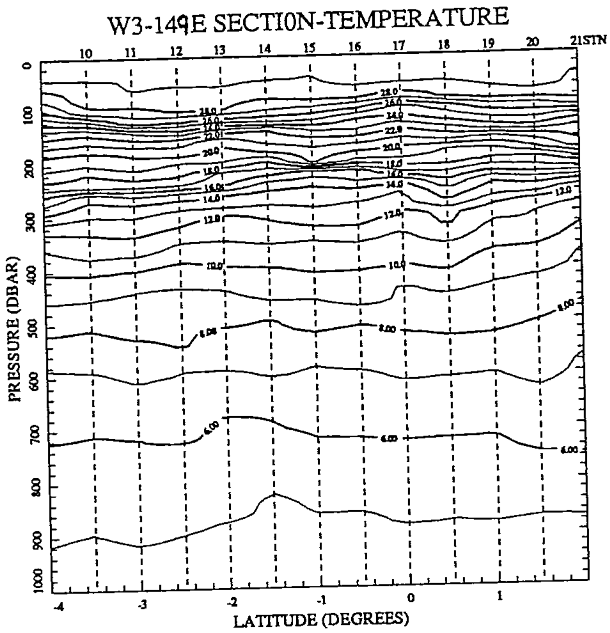


Fig 5 **Contours of temperature and salinity along a section from 4°S to 2°N along 149°E. Dashed vertical lines indicate location of profiles**



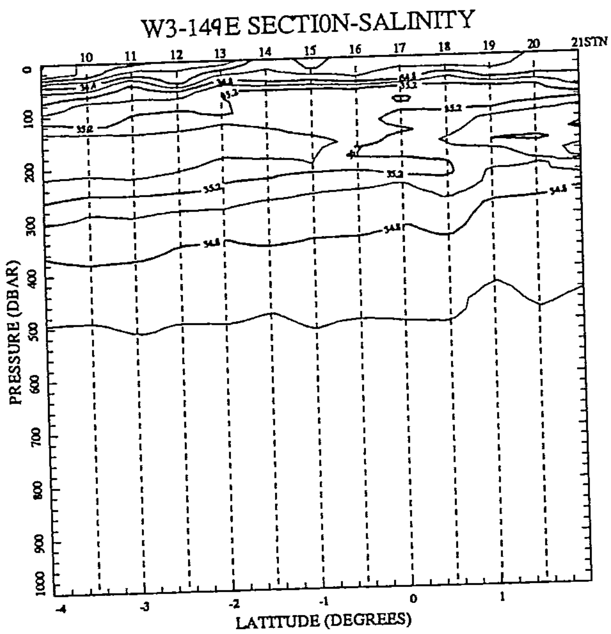


Fig. 6 **Contours of along-shore speed in a section offshore from Cape Namarodu on the east coast of New Ireland. Positive values (in cm/sec) indicate flow toward the northwest**

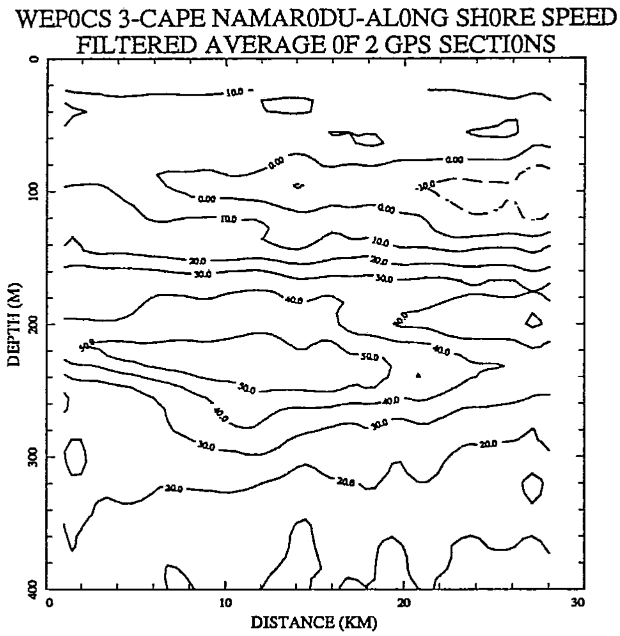
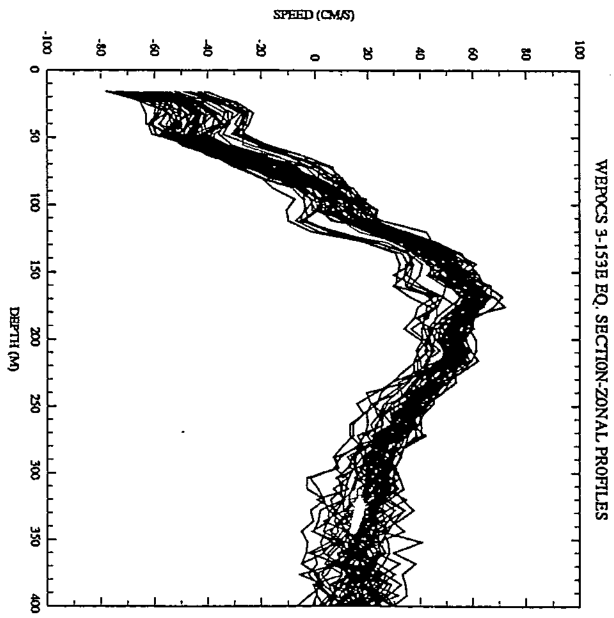
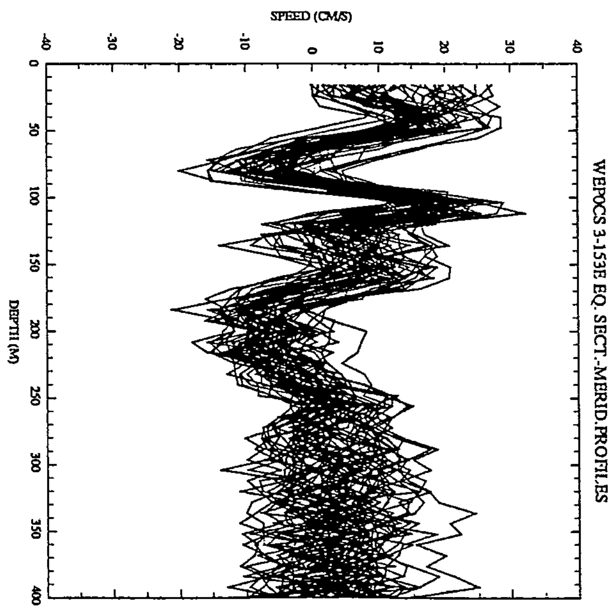


Fig 7 Profiles of zonal (east-west) and meridional (north-south) velocity within 20 nautical miles of the equator at 153°E. Note that scale for meridional speed is expanded.





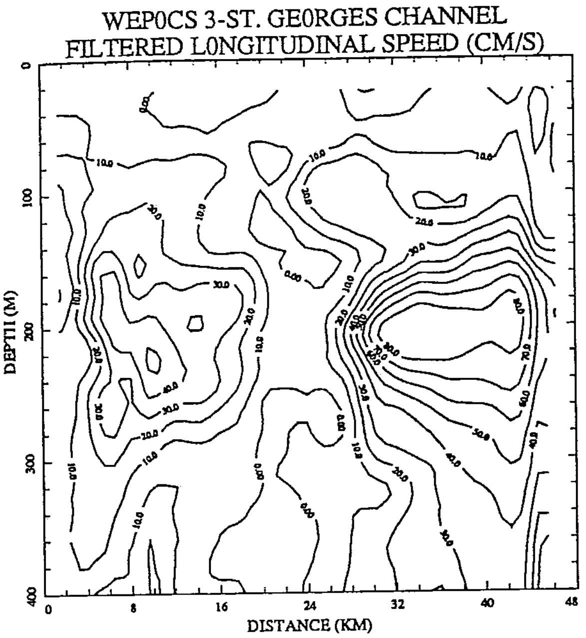


Fig. 8 Contours of along-channel speed across St Georges' Channel (between Cape Tawui, New Britain and Palabong, New Ireland). Positive values (in cm/sec) indicate flow from the Solomon Sea into the Bismarck Sea

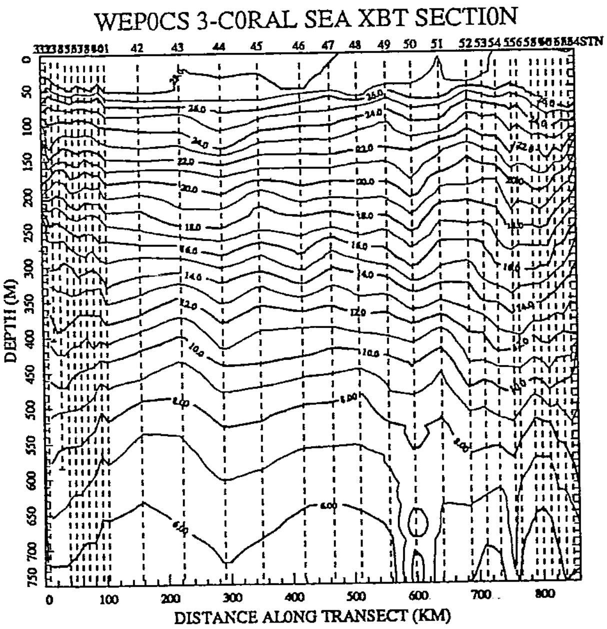


Fig 9 Contours of temperature obtained from expendable bathythermograph (XBT) profiles between Jomard Entrance in the Louisiade Archipelago and Grafton Passage (off Cairns). Dashed vertical lines indicate location of profiles

Appendix 1

Report on 'Bunyip' the towed microstructure vehicle

Bunyip was deployed, with the Division of Oceanography's microfish, seven times during the cruise and collected its first turbulence data with the micro-conductivity probe. The first few deployments were beset by technical problems, but the last four deployments yielded 63 hours of successful CTD and turbulence data in a triangular flight-path between 33 m and 200 m depth. The following is a short summary of each deployment. At the end of the report is a list of Bunyip hardware casualties from this cruise.

Tow (1). 26 April, 1400-1600 EST. The communications up the tow cable was very intermittent on this tow (subsequently found to be due to a faulty underwater connector). During the tow, the line driver chips of two RS232 connections in the operations room blew up. When this fault was rectified, the microfish was giving a warning that it had water inside, whereupon recovery commenced. The leak had occurred around the screw threads of the nose-cone where the turbulence sensors attach to the microfish. The anodizing there had come away from the aluminium. This was not a very encouraging first tow.

Tow (2) . 29 April, 1900-2200EST. This was a short deployment to test whether the makeshift repair to the nose-cone would be water-tight and that the modifications that had been made to the communications would improve their reliability. There were no more problems with water leakage on this cruise, but the communication problems were not completely cured. After this tow the cause of our communications problems was isolated as an intermittently faulty electrical connection in the main coaxial cable near the underwater connector between the two fish at the mainfish end. At the same time we found an open circuit in the underwater connector that feeds power to the Seabird CTD pumps.

Tow (3). 2000, 5 May- 0830, 6 May, from 2N to 0 degrees 15'N along 149E. This tow encountered the intense interleaving between water masses of southern and northern origins. The noise level of the shear probes due to mechanical vibrations is about 10^{-8} W/kg, too high by at least an order of magnitude. The microconductivity signals will prove more useful, although on this tow, the very high temperatures in the equatorial regions caused this sensor to go off-scale in the upper part of the water column. After tow (3) the gain of this circuit was reduced and the sensor recalibrated.

Tow (4). 9 May, 0930-1400 EST. This was a short deployment to ensure that microconductivity was working properly, to test its noise level and to gain confidence that it was indeed measuring the dissipation of thermal variance. The noise level was a little less than 10^{-9} K^2s^{-1}, which is adequate for studies of equatorial turbulence. This tow included runs at different speeds as well as at a series of fixed depths. After tow (4), was the port call at Rabaul. The following deployment was aborted as soon as it had begun because the cable was open-circuited again at the same connector as in tow (2). This time the connector had to be replaced with a spare.

Tow (5). 14 May, 0900-2320 EST, from the equator to 1.5N along 153E. This tow was the first long tow of scientific interest where all the sensors (except the shear probes) were operational. The ship speed was 8 knots and the depth range was varied from 80 m to 280 m for the first few hours and then from 33 m to 200 m thereafter. In the middle of this tow, the "cable-slip detector" sounded. This detector indicates that the main tow cable is slipping through the first termination at the mainfish (Seasoar). In fact the cable did not slip at all during the cruise, but the detector sounded three times, and safety dictated that we retrieve the mainfish each time. The sensor was redesigned twice during the cruise, and a more robust model needs to be made based on a Bowden cable. On this tow, the cable slip incident caused a delay of 3.5 hours.

Tow (6). 15 May, 1130 -1940 EST, from the equator to 1.0S along 152 50'E. This tow was very similar to tow (5). The cable slip detector sensor lasted until 1940 hrs (EST), and we decided to end the tow then.

Tow (7). 1130, 16 May - 2230 17 May, from 151E to 147E along the equator. In an effort to reduce the turbulence shed by the interconnecting cable, we began this tow with a helical strake of string wound onto the bottom half of this cable. However this increased the drag of the cable to such an extent that the microfish was often sampling in the wake of the mainfish. After several hours, the system was retrieved and the strake removed. During the whole of this long tow, the ship speed was cycled between 5 and 8 knots, in order to counteract the 3 knot shear between the surface and the centre of the equatorial undercurrent. When Bunyip was in the upper half of its sawtooth depth pattern, the ship did 8 knots, while at the larger sampling depths, we did 5 knots. The flight path was slowed so that the vertical velocity of Bunyip was 0.3 m/s over a 180m depth range, giving a 20 minute cycle time, in harmony with our instructions to the bridge to change speed every ten minutes. At 2300 on 16 May, a fault developed in the hydraulic control valve that controls the mainfish wing position. The mainfish was recovered and the complete spare hydraulic unit that was built in Tasmania was installed. This whole operation took four hours.

List of Bunyip hardware casualities

1. The CPU board of the Bunyip 11/73 computer. (ORV spare CPU was used).

2. The line drivers on two RS232 boards, one in the 11/73, the other in the FORCE VME deck unit. (Both chips were replaced at sea).

3. An underwater cable connection which failed (this was resoldered and cold-moulded).

4. Two different underwater connectors that failed very near the connector (these were replaced with spares at sea. We will attempt to get them replaced free of charge from the supplier).

5. The hard disc of the NEC APC III computer developed a "disc seek error". The computer was replaced with a spare.

6. An NEC APC III keyboard was repaired at sea.

7. An anodized nose-cone leaked salt water into the microfish. It was pressed back in service with the help of liberal amounts of RTV.

8. We lost several metres of Fathom fairing. It is clear that we must design our own stoppers for this fairing.

9. The Zippertube fairing proved difficult to keep on the cable, however a suitable attachment technique was devised for the last few deployments.

This was the first scientific cruise on which turbulence data was successfully collected. It is obvious from this cruise that we must do much more to reduce the vibrations of the microfish. It was hoped that we would have been able to do FFTs in real time on this cruise, but this software was not completed in time. The 11/73 computer was too busy to collect all the unprocessed data, and all it was able to do was to store one block of raw microconductivity data in five. We do have the variance of all channels continuously. It is clear that the 11/73 will not be able to keep up with the data flow in the future and will have to be replaced with a faster computer.

There were a surprising number of problems caused by bad connectors on this cruise. This was not expected based on our previous experience with the system.

We also towed two dissolved oxygen sensors this cruise. One was a slow membrane-type cell made by Titron and the other was a fast response cell manufactured in Perth. Both sensors appear to be working as expected, however complete analysis has yet to be done.

We expect to be able to obtain good estimates of the turbulent fluxes of heat and freshwater in the equatorial region from 33 m to 200 m with reasonable coverage of different times of day.

Appendix 2

Report on Micrometeorology program

Met Boom

A major innovation of this cruise was the installation of a boom extending 10 m forward of the ship's prow, on which to mount micrometeorological equipment clear of disturbance caused by the bulk of the ship. Designed by Ian Helmond, without the benefit of the presence of the ship itself, this facility must be rated a great success. Possible improvements for the future are few and minor. It is able to be deployed and retracted quickly by only three persons, rather than the concentration of labour which we had feared would be necessary. The addition of a small boat winch would reduce the requirement to two persons.

The boom consists of a horizontal section supporting a seven meter long vertical mast which supports gradient and turbulence measuring instruments, in a similar fashion to the mounting employed in land based studies of heat and moisture fluxes. There are two main differences: a) some disturbance of the air-flow ahead of the ship is inevitable - the boom would need to extend several ship cross sections ahead to avoid this; b) "false"wind due to the ship motion and changing attitude must be removed from the signals. The former will be estimated from wind tunnel studies of flow around a model of the ship; strategies to measure and eliminate the latter have been a constant topic of analysis and debate throughout the cruise.

Ship's Motion Sensors

In principle, the motion of the end of the boom can be determined by measuring the three translational and three rotational components, for example, by integrating the outputs from six appropriately located accelerometers. High quality, expensive instruments are called for, so we settled for only three orthogonally mounted accelerometers at the end of the boom, combined with a pair of cheaper tilt sensors mounted in the gravimeter room to measure the ship's pitch and roll. This was not entirely satisfactory, the tilt sensors being out of phase with the accelerations, the resulting integrations having drifts which showed the ship rising several meters out of the water! Short period motions seemed to be properly resolved, so that a high-pass filter in the analysis procedure produced entirely reasonable turbulence signals. Also much of the data was obtained under flat sea conditions where the ship motion and consequent corrections are small. However, more thought must be given to the problem of measuring ship motion and to determining a fixed frame of reference for the analysis of turbulence data.

Turbulence Sensors

A three component sonic anemometer and Lyman- α fast humidity sensor were mounted facing forward at boom level. The Lyman- α is a UV absorption instrument, whose response falls logarithmically with increasing absolute humidity. At the very high humidities encountered on this cruise, it is necessary to increase the source current up to 5 times our usual value. Neither the Lyman- α nor the sonic appeared to suffer from the salt spray contamination that we had expected, although the fine wire temperature sensor was washed frequently in distilled water as a precaution. The only real problem with these instruments was electromagnetic interference from some of the ship's equipment, notably the radio-telephone. (although not the 3 cm radar). Vibration from the ship's engine, which was at times severe was another problem, partially overcome by foam mounting the Lyman-

Gradient Equipment

Psychrometers and small cup anemometers were mounted at three heights on the vertical mast. Some problems were encountered early on with wet bulbs drying out, but after this was cured they were being recorded almost continuously throughout the cruise. Calibrated to ±0.01°C the difference between 3 m and 7 m was usually only a few tenths of a degree. Again salt contamination did not seem a problem, although with such small gradients wicks were washed frequently as a precaution. Our major problems in fact have been cable failures, possibly due to an unforgiving marine environment. A pair of high resolution thermometers, also calibrated to ±0.01°C for the measurement of near sea-surface temperature failed because we had not accounted for the forces on the cable as the unit was dragged through the water.

Radiation

Several radiation sensors were set up to determine the radiation balance at the ocean surface. Short- and long-wave downward were measured using the Eppley solarimeter and Pyrgeometer belonging to Manuel Nunez, mounted on the ship's main mast; SST using an infra-red radiometer mounted on the monkey island (developed by Ian Barton) and a net radiometer mounted at boom level, forward of the vertical mast. A very common and useful instrument in studies of radiation balance, the net radiometer cannot usually be used for ship-board work. In our case, we reasoned that the boom was far enough out from the ship to avoid error, and, mounted symetrically with respect to the vertical mast, the radiometer would be no less favourably exposed than when similarly mounted on land. The radiometer was of a type which uses rigid domes so that gas flow ventilation is not required. Our results lead us to believe that our net radiometer measurements are reliable. The Barton radiometer is a very sophisticated instrument which obtains its high resolution by continuously going through a calibration/reading/zero cycle.

Unfortunately the shutter mechanism which controls the cycle failed early in the cruise and went undetected for some time. However, we were able to rectify the problem, and we obtained several days of excellent SST data. Attempts were made to co-ordinate our measuring periods with the collection of NOAA 9 and NOAA 10 AVHRR data by James Cook University. Unfortunately, it is likely most satellite passes will be unsuccessful because of the extensive cloudiness of the region.

CO_2 Exchange

There has developed in the past two or three years a controversy regarding the rate of carbon dioxide transfer between the sea and atmosphere, principally as determined by isotopic and eddy-correlation methods. We attempted to estimate CO_2 fluxes in two ways; by comparing absolute CO_2 concentrations in the air and in the sea water; and by measuring the vertical gradient in the concentration in the air. Airlines were brought from the top and bottom of the vertical mast to two gas analysers; an older ADC analyser which is notoriously sensitive to vibration and a new generation BINOS which has overcome this problem. The ADC was used for absolute CO_2 measurement, by successively passing through its cell dry nitrogen (for zero), calibrating air of known CO_2 content, air from the top of the mast and air in equilibrium with a sample of sea water taken from over the side and shaken vigorously in a closed flask. This process was only possible under rather special conditions - the ship steaming at 4-6 kts with no swell so that the ADC was steady, the water sample from undisturbed water and the air sample unpolluted by the ship. Nevertheless sufficient measurements were made throughout the cruise to enable a systematic pattern to emerge. In the confined waters of the Bismark Sea, the air is consistently 10 to 30 ppm above the sea concentration; implying CO_2 transfer into the ocean. In the Pacific around the equator the sea is a few ppm greater than the air, implying transfer out of the ocean. In the outflow from the Sepik river, which was full of organic matter, the ocean concentration increased from around 330 ppm to 500 ppm. The BINOS proved a disappointment and no gradient measurements were possible. Certainly we were working at maximum sensitivity (with an air sea concentration difference of 100 ppm we expect a gradient of perhaps 0.05 ppm) but the BINOS seems extremely sensitive to the low frequency rolling and pitching motion of the ship. This will prove to be a disappointment to many who had anticipated that it could be used in such unstable environments as shipboard

Data

Signals from the sensors were recorded on "slow" or "fast" loggers depending on the frequency of the signal. The turbulence sensors and those signals required to correct them for ships motion are recorded via a PDP 11/23 onto 9-track VAX-compatible tape. We have a total of 130 hours of turbulence data (from which the momentum, heat and water vapour fluxes are calculated) taken under a variety of conditions. During two 30 hour periods dedicated to the micrometeorological program May 7-8 and MAY 19-20 conditions were almost ideal for our purpose, with light winds and smooth seas. Instruments were working well for most of the time, and we anticipate a good data set from these periods to address the question of low-wind transfer coefficients. Turbulence data was also recorded at other times during the cruise when conditions were favourable, e.g. during Bunyip tows."Slow" sensors are the psychrometers, cup anemometers and radiation instruments, which were logged into a Datataker and unloaded onto a PC disc each day. The Barton requires special handling because of its 6-minute cycle and was therefore logged onto a separate Datataker. The PC files have been analysed daily using Lotus 123 and graphs produced of the time sequence of the various physical quantities. We were thus able to keep track of instrument performance. With such a large number of sensors deployed we were fortunate that no fatal breakdowns occurred. Results It would be premature to draw firm conclusions on the basis of our initial scrutiny of the data. The turbulence data require complete analysis and the development of a database. Most instruments require re-calibration after a month at sea, particularly the psychrometers in view of the incredibly small gradients of temperature and humidity that we are trying to measure. This is also true of the radiation instruments which are being used to establish the residual heat flux into the ocean by difference. In this context the Barton radiometer, after its repair, will enable a comparison between the "true" SST and the readings of the ship's thermosalinograph, currently used to estimate the outgoing long-wave component. First indications are that the difference is no more than a few tenths of a degree. The carbon dioxide results, referred to above, suggest that the very large fluxes obtained by eddy-correlation methods are unlikely.

E.F. Bradley, P.A. Coppin and J.S. Godfrey.

Appendix 3

ELECTRONICS REPORT FR 4/88

CTD Profiler

CTD unit 1 was used for the first cast of the cruise. No problems were experienced. Following receipt of a telex from Hobart suggesting that this unit may have an intermittent fault, the underwater unit was changed to CTD unit 2. This performed flawlessly, apart from one occasion when biological material (sea-snot) fouled the sensor head. This was removed and the sensor head cleaned. At the start of another deployment, the sea-cable fouled the rosette assembly, breaking the rubber strap used to close a niskin. This niskin was replaced and the cast continued.

XBT Profiler

A number of problems were experienced with faulty XBT probes. Some of these may have been due to contact between the wire and the ships side. After two bad probes in sequence, the test canister was used to verify the performance of the hardware.

ADCP Profiler

On a number of occasions continual BIT failures occurred. These appear to be due to a software malfunction, as they disappeared when the ADCP deck box power was cycled and the ADCP program restarted. Early in the cruise, the SYNCRO to DIGITAL Encoder chip in the gyrocompass interface was replaced. This appeared to remove the sin(20) error curve and replace it with a linear offset.

Met Station

On a couple of occasions (once immediately after a power failure) MET data was not received by the MET logging program. After resetting the RIMCO hardware and the MET logging program, data was restored.

GO Block

No problems were experienced with this unit.

Inmarsat System

No problems were experienced with this unit.

GPS Locator

This unit required resetting twice during the cruise. It is important that the reference position be set correctly each day prior to the GPS window. I suggest that this be done automatically every hour, using SATNAV derived positions. The reference height (currently set at 20 meters) which is used during the 3 satellite mode, has an effect on the final calculated position fix. (see attached printout). I recommend that either the true reference height with respect to the WGS 84 geoid (calculated from previous fix information) or the last, averaged 4 satellite mode derived height be used. It would also be useful if all normal default parameters were set remotely.

Thermosalinograph

On a couple of occasions, the chart recorder pens jammed at the edge of the paper, during the scale indication process. No other problems occurred.

Vax Temperature Alarm System

An additional overtemperature alarm system was implemented using the new prototype MET STATION. Two sensors were fitted, one at the main air outlet of the air conditioner and one at the main air outlet of the VAX. A command program was written by L. Pender to monitor these sensors and to alert all users of impending VAX shutdown. Three conditions are detected:-

1. Failure of the alarm system.
2. Failure of the airconditioner.
3. Overheating of the VAX.

The DEC supplied alarm is now set at 35 DegC, so the overtemperature alarm is set at 33 DegC. The exhaust cowls on the VAX were modified by the Chief Engineer to ensure that deg. C of the warm exhaust air cannot occur. In the final system, I recommend that the Ops Room airconditioner be monitored, as well as the exhaust temperature of each Micro PDP11. Two channels could also be used to monitor the UPS supply voltage and frequency.

Compaq Computer

The keyboard on this failed partway through the cruise, with symptoms of a phantom typist. When tried towards the end of the cruise, no problems could be detected. The unit will be returned to Hobart for service.

Pitch and Roll Sensors

The Sperry sensors were mounted in the rack in the Gravimeter Room. Two accelerometers (Bunyip spares) were also mounted from the rack. The prototype MET STATION was modified to allow 4 channels of analog data to be collected at a 16Hz rate. The Chief Engineer mounted a stabilizing bracket to the top of the rack to prevent excessive movement of the rack in heavy seas. Four 5 minute sets of data (pitch, roll, yaw and noise) were recorded during the passage across the Coral Sea to Townsville.

EK400 Sounder

This unit performed OK, except that difficulty was experienced in maintaining electronic bottom lock in deep water (greater than 2000 meters).

UPS System

The Electrical Engineer has been requested to separate the existing single circuit which currently supplies the new Ops Room Annex and the Electronics Lab into two separate circuits. The UPS System was not used for the majority of the cruise, due to reliability problems. These should be fixed as a matter of urgency. It may be necessary to call in the manufacturer to service the system.

New Met Station

Several design deficiencies in the prototype were discovered while using the unit during the cruise. These will be rectified in the final production units. Several units will be built, one for the VAX alarm system, one for the Met Station, and one for the pitch and roll sensors.

TOGA Buoy

The TOGA buoy was deployed twice. On the first deployment, problems were experienced with the wire spooling, so the wire length was halved, and an additional 2Kg of lead was added to the SDL to increase the wire tension from 1KG to 3Kg. More satisfactory performance was obtained on the second deployment. It seems, however, that a spooling system needs to be implemented to prevent cable jams. Difficulty was experienced in locating the buoy after the second deployment. The radio buoy proved to be useless, and the flashing light was too dim to see at any distance. The buoy was finally located using radar. This would have been easier if a proper radar reflector had been fitted. I recommend that the ORV purchase an RDF beacon, a waterproof strobe light and a radar reflector for use in these situations, if so required in the future.

David Edwards
25 May 1988