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RRS CHARLES DARWIN
CRUISE 34A

15 AUG – 30 SEP 1988

THE NEAR SURFACE PHYSICAL OCEANOGRAPHY AND METEOROLOGY OF THE WESTERN EQUATORIAL PACIFIC

CRUISE REPORT NO. 207
1989

Natural Environment Research Council

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OCEANOGRAPHIC SCIENCES
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The near surface physical oceanography and meteorology of the western equatorial Pacific

Principal Scientist

D.J. Webb

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ABSTRACT

Studies of the near surface oceanography and meteorology were carried out in the Western Equatorial Pacific between The Philippines and 160°E, and between 7°N and 3°S.

The primary instruments used were:

1. A SeaSoar instrumented with a CTD to give a temperature and salinity section of the top 250 m of the ocean.

2. An Acoustic Doppler Current Profiler to give the velocity structure of the top 350 m of the ocean.

3. The IOSDL Meteorological Instrument Package, measuring air temperature, humidity and velocity, downward long and short wave radiation and the sea surface temperature.

Precision echo sounder and gravimeter observations were also made.

The region surveyed may be involved in triggering El Niño events. The survey was therefore designed to look for structure which may be involved in generating these events.

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Smithers, John	(IOSDL)	Applied Physics	(Legs 1 and 2)

SHIP'S PERSONNEL

Maw, Peter H.P.	Master	(Legs 1 and 2)
Richardson, Brian M.	Chief Officer	(Legs 1 and 2)
Chamberlain, Roger J.	2nd Officer	(Legs 1 and 2)
Beal, Shaun B.	3rd Officer	(Legs 1 and 2)
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Lutey, William D.	Electrical Officer	(Leg 1)
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plus twelve crew.

ITINERARY

RRS Charles Darwin sailed from Auckland, New Zealand on August 15th 1988 on passage for Cairns, Australia where it arrived on August 23rd. Leaving Cairns on the 24th the ship proceeded via Torres Strait and the Halmahera Sea into the Western Pacific, arriving off the island of Mindanao in the Philippines on the 2nd September. The main survey was then carried out in the region between the Philippines and 160E, and between 7N and 3S. The survey finished on the 24th September just south of the equator on 160E, the ship finally arriving at Suva, Fiji on the 30th September.

SCIENTIFIC OBJECTIVES AND TASKS

The objective of the cruise was to study the physical oceanography of the surface layers of the western Pacific and their interaction with the atmosphere. In particular it was hoped to obtain information on how El Niño events may be triggered in the region.

Leg One

During the initial passage leg the SeaSoar and its equipment were installed and tests carried out on the performance of the new fairing and cable.

Leg Two

A large scale survey was carried out of the Western Pacific using the following primary instruments:

1. A SeaSoar instrumented with a CTD to give temperature and salinity sections of the top few hundred metres of the ocean.
2. The Acoustic Doppler Current Profiler (ADCP) to give the velocity structure of the top few hundred metres.
3. The IOSDL Meteorological Instrument package measuring air temperature, humidity and velocity, downward long and short wave radiation and sea surface temperature.

Use was made of the ships navigation equipment to transform the ADCP measurements into absolute velocities. Gravity measurements were made during the cruise to aid in interpreting satellite altimeter measurements of the region and precision echo sounder measurements were made for charting purposes.

The track covered during the survey is shown in Figure 1. The area covered by the survey was limited by failures with the SeaSoar system (parts of the survey were cut short and we originally intended to go to 9N), but within these limits cruise 34A was very successful in providing new and important information on the near surface physical oceanography and meteorology of the region.

NARRATIVE

Leg One

RRS Charles Darwin sailed from Auckland at 2315 on day 227, 1989 (1115 local time on August 15th). After rounding the North Cape course was set for the Capricorn Channel at the southern end of the Australian Barrier Reef. During the passage seas were low and the ship often made in excess of 13 knots.

The ship's satellite navigation and EM log were run continuously during the leg. GPS navigation was available for four to eight hours each night but the quality of the fixes varied. The ADCP started logging data at 0255Z on day 228 a few hours after leaving Auckland and continued until the Australian continental shelf was reached at 1310 on day 233. Precision echo sounder data was collected from 0416 on day 230 until 1230 on day 233.

Between 1350 and 1750 on day 231, while GPS was active, the ship carried out a series of ziz-zags about its main course in order to calibrate the ADCP (Pollard and Read, 1989), the E-M Log and the Doppler Log. The ship first steered for twenty minutes in a straight line 45 degrees to one side of the mean track and then did the same at 45 degrees on the other side of the mean track. This was repeated three times at ten knots and then three times at eight knots.

During day 230 the new SeaSoar cable was stretched by running it out behind the ship. This was followed by detailed tests of the full SeaSoar system during days 231 and 232. These showed that the maximum depth that could be reached with the SeaSoar was only just over 300m, that the fairing tended to break up at speed and that the SeaSoar was unable to dive after reaching the surface. Further details of the tests are given in the reports of scientific work. Following this a number of modifications were made to the SeaSoar. RRS Charles Darwin arrived in Cairns at 2048 on day 235 (0648 local time on the 23rd August). Supplies were replenished and the remainder of the research party joined the ship.

Leg Two

RRS Charles Darwin sailed from Cairns at 0800 on day 237 (1800 local time on the 24th August). It proceeded to the first part of the work area, off Mindanao in the Philippines via Torres Strait and the Halmahera sea. Torres Strait was passed at 0000 on day 239 and the straight between the Halmahera Sea and the Pacific Ocean at 0200 on day 243.

Between 1100 and 1640 on day 239, a second calibration of the E-M log and ADCP was carried out - this time in the shallow seas of the Arafura Sea using the bottom tracking mode of the ADCP.

The meteorological package started recording data at 0352 on day 247 and the ADCP at 1030 on day 239. The Thermosalinograph, Gravimeter and Precision Echo sounder which require more attention were started recording when the scientific watch system started at 0600 on day 241. This was just after the RRS Charles Darwin crossed the continental shelf edge of the Arafura Sea.

Between 2100 on day 242 and 0100 on day 243 the ship passed through a region of strong large scale internal waves. The first observed took the form of a long line of disturbed water running at right angles to the coast of a small island. Those observed later appeared to be propagating southward away from the strait between the Halmahera Sea and the Western Pacific. Water depths were in excess of 1000m and the waves seemed to be similar to those observed off the continental shelf in the Bay of Biscay. No waves were observed north of the strait.

As further tests on the SeaSoar could not be carried out in Indonesian waters a detour was made into Palau waters. The tests were started at 2230 on day 243 and continued until 0620 on day 244. They again showed that the fish would not dive at its operating speed. Because of the continuing problems with the SeaSoar it was decided at this stage to limit the study region to 7N.

Philippine waters were reached on day 245. A CTD and water bottle dip was carried out to calibrate the shallow CTD used in the SeaSoar. During the first dip the bottle release mechanism malfunctioned. The station was repeated but for the second dip the triggering mechanism was accidently set up 180 degrees out of phase. The deep and shallow thermometers were therefore triggered in the wrong order.

The second SeaSoar was now deployed and at 8 knots was found to cycle correctly between the surface and 310m. Tests at a higher speed were tried but tensions went right up and eventually speed was reduced to 7 knots for the night. The Philippine coast was approached at 0100 on day 246 and RRS Charles Darwin then turned eastward along 7N to start the main survey.

During this period the ship passed through the strong western boundary current off Mindanao. Winds were light and continued so throughout the first half of the main survey. Sea surface temperatures were 30 degrees Celsius and above. The highest temperature of 34.5 degrees was measured on day 252.

During the morning of day 246 the SeaSoar was recovered and showed extensive but easily repairable damage to the fairing and evidence of wire bird-caging near the top end. It was thought at the time that the damage resulted from the excessive strains on the wire during the tests at 9 knots so for the rest of the cruise this wire was kept on the drum. However when bird-caging was again observed late in the cruise, it was due to the twisting caused by the damaged fairing and the cable was seen to recover when the cable was paid out again.

As the survey progressed, the SeaSoar suffered from a large number of faults which necessitated the recovery of the fish and construction of new terminations. The faults included damage due to the uncontrollable initial dive of the fish, damage to the fairing and failure of the CTD temperature sensor. Further details are given below and in Appendix I. Repairs often took four hours or more and as the delays could not be afforded unless the area was of particular interest, the ship usually continued at full speed along its track, taking CTD's to 300m every 30 minutes of latitude or longitude.

Initially during these periods, XBT's were also taken between each CTD but it soon became apparent that the deck unit was malfunctioning and eventually it failed completely.

The track covered by the survey is shown in Figure 1. At 1800 on day 248 the ship passed through a large region with scattered trunks of mangrove trees. The E-M log sensor was detached at 0910 and the boom holding it badly bent. The PES cable fairing was also damaged. As night was approaching and the extent of the flotsam was unknown, both the SeaSoar and the PES were retrieved for redeployment the following morning.

Because of the extent of the damage, replacement of the E-M log was both a lengthy and difficult operation. Eventually the work was completed successfully and the new unit started operating at 1028 on day 252. Calibration of the new unit was postponed until the end of the cruise.

During the following eastward and northward legs of the cruise the ship crossed strong frontal regions between the relatively salty waters of the South Equatorial current and the fresher waters to the north.

At 2200 on day 253 the CTD temperature signal started to behave erratically. This was not detected for a few hours but eventually the unit was recovered and the sensor, which was found to be corroded, replaced.

The ship then carried out a long southward section crossing the north equatorial counter current, the equatorial current and undercurrent and the New Guinea coastal currents. Strong frontal structures were seen in the temperature and salinity fields.

The New-Guinea coast was reached at 2200 on day 257 and the east-west section from this point showed a near surface water mass with a strong eastward component. Because of the delays that had occurred during the survey, the section on 3S was curtailed after leaving the coastal current system. The north-south section on 150E was also curtailed at 3N. In practice the SeaSoar had to be recovered at 2N after heavier seas than usual had damaged the fairing and the remainder of the section surveyed using CTD dips. Following this all fairing was removed from the top 50m of cable (i.e. that most affected by the surface wave field).

The final north-south section on 160E started at 2200 on day 264 and ended just south of the equator at 1445 on day 267. The ADCP, precision echo sounder and gravimeter measurements continued until 0600 on day 270 and the meteorological measurements until 0207 on day 271.

During the run in to Suva, the ship was slowed by steep head seas. The calibration of the E-M log was therefor not possible and instead was carried out by R. Searle at the end of cruise 35. The RRS Charles Darwin docked in Suva, Fiji, at 2230 on day 273 (1030 local time on the 30th of September), ten thousand miles and 46 days after leaving Auckland.

REPORTS OF THE SCIENTIFIC PROGRAM

SeaSoar and CTD systems

Day 230 (17.8.88)

In preparation for full SeaSoar deployment, it was first necessary to deploy the full 600 metres of new cable and fairing over the stern of the ship to tension the cable which had been previously laid onto the winch drum by hand. This was achieved by attaching a pair of 'bomb' weights, fixed to a steel bar, to the end of the cable and then paying it out and retrieving it over the SeaSoar towing sheave.

It was found necessary to bring the sheave inboard during deployment and recovery, to allow the fairing to be guided over it by hand. With the cable fully deployed and towed at 10 knots, it streamed behind the ship with no noticeable yaw to either side. After half an hour the ship slowed to four knots for recovery. Recovery was fairly easily although slow. Five of the fairing sections were found to have come apart.

The grooved strip on the winch drum designed to lay the cable in, was found to be too narrow. This caused some difficulty laying the cable onto the drum without catching it in the fairing of a previous turn. A turn had to be jumped every 5 or 6 to alleviate this problem.

During the cruise small leaks of hydraulic oil were experienced from the SeaSoar drum unit - partly due to the higher pressures used on RRS Charles Darwin. Accurate control of the drum speed was difficult, especially when starting, because the leaks and the stiffness and small size of the hydraulic controls. Some delays were experienced in getting power to the aft A frame, possibly due to a sticking valve.

Day 231 (18.8.88)

The first deployment of the SeaSoar was carried out to perform a number of tests on the system and to assess the performance of the new fairing. For the first of these tests, the maximum allowable down wing angle was limited to 5 degrees. This was achieved by appropriately adjusting the yoke assembly connecting the SeaSoar hydraulics to the wings. Once fully deployed with the cable strain measuring system in place, the ship's speed was then altered in 2 knot increments.

The wings were held in the maximum down position for these tests. Sufficient time was allowed at each speed for the depth of the SeaSoar to stabilize.

Ship's speed, cable tension and achieved depth were noted, the results, for a 5 degree wing angle, being as follows:

Time	Speed kts	Tension kgs	Wire Angle	Pressure dBars
0453	6.20	420	24	265.3
0512	8.25	760	18	241.7
0539	9.95	1160	17	239.1

On completion of the fixed depth tows, we tried to fly the SeaSoar in its yoyo mode. This was soon aborted as it proved virtually impossible to make the SeaSoar dive. It was thought that the SeaSoar flew tail down to such an extent, that the wing angle relative to the water was too small to achieve a dive.

Day 232 (19.8.88)

The maximum down wing angle was set to 10 degrees for the second series of fixed depth tows and the SeaSoar deployed.

Time	Speed kts	Tension kgs	Wire Angle	Pressure dBars
0047	5.93	720	28	326.7
0115	7.70	1100		321.0 **
0416	7.90	1060	23	308.0
0459	8.80	1300	23	313.0

Note: **

The pressure sensor failed at this point so the SeaSoar was recovered for repair. A wire had become detached from the pressure sensor in the CTD. The SeaSoar was redeployed for completion of the tests.

An attempt was then made to fly the SeaSoar again. Once again it was reluctant to dive, sinking very slowly to about 33 metres or so. It would then dive very quickly with high cable tensions. It was felt that the 10 metres of cable left unfaired at the SeaSoar may have contributed to this performance. On recovery some of the shortcomings of the new fairing were found. The fairing is formed by a moulding of aerodynamic cross-section which folds around the cable. A further moulding slides onto the rear edge holding the front section together and completing the aerodynamic shape. Each complete section is held together by a flat dumbbell shaped joining link having a hole in each end. Pins moulded into the inside of each side of the front sections locate in the joining link holes. A number of sections are joined together to form a 2 metre length. A special section at the top of each length is held by an aluminium stop swaged onto the cable. These stops hold each length in its proper position.

During the tow the adjacent sections had moved laterally to each other in turbulent water. This caused the sections to open out slightly, Allowing the joining links to pull out of its pins. Adjacent section could not then line up in the flow due to this misplaced joining link. In some cases whole lengths would be affected in this way, with the sections displaced around the whole of the cable to form a 'hedgehog' like appearance. Most of the displaced sections were in the top 200 metres of cable i.e. the cable within the wave field. There were also a number at the lower end close to the SeaSoar. However, due to the flexibility of the sections it was fairly easy to repair the damage as the cable was hauled in slowly. Some fairing was removed from the inboard end of the cable, for attachment to the SeaSoar end on the next deployment.

Day 237 (24.8.88)

During the port call at Cairns, a known 500 kg weight was hired in order to calibrate the strain gauge used for monitoring cable tension. With 500 kgs, the load registered by the strain gauge was 600 kgs. The strain gauge readout was adjusted to make it read correctly. All previous loads noted in this report should be multiplied by 0.833 to obtain a true reading.

Day 244 (30.8.88)

A pair of marine ply aerofoil sections manufactured by D Grohmann during the passage leg to Cairns were fitted to the lower rear tail. The SeaSoar was deployed and the fixed depth tows with a 10 degree maximum wing down angle repeated. The results were as follows,

Time	Speed kts	Tension kgs	Wire Angle	Pressure dBars
243/2332	5.95	712	26	320.4
243/2355	7.9	1120	23	308.8
244/0015	9.1	1260	18	285.2

Once again the SeaSoar repeatedly held on the surface and only when the ship's speed was dropped to 6 knots, could any reasonable response be obtained. On recovery the SeaSoar was closely examined for any clue as to the reason for its poor performance It was found that the towing bridle was extremely stiff and that the wings required a high pressure from the hydraulics unit to move them. The SeaSoar nose cone also contained a hole normally occupied by an additional instrument. This allowed a flow of water under pressure into the SeaSoar which may have affected its performance.

Day 245 (1.9.88)

The CTD was first transferred from the SeaSoar to a vertical CTD frame for the purpose of a calibration dip to 600 metres. Two casts were performed (CTD casts 1,2) but owing to failures in the Rosette sampler answering mechanism on the first cast and to incorrect setting up on the second, only a limited number of calibration samples were obtained.

For the deep CTD casts a new collapsible frame was used made of scaffolding poles. The frame performed well although its drag appears to be large and there was some corrosion. It was also difficult to support the SeaSoar CTD in a vertical position, an arrangement made necessary because of the orientation of the sensors.

The CTD and Hydraulics unit were then transferred to a second SeaSoar vehicle with unmodified nose cone. The towing bridle and wings moved more easily on this vehicle. The ply wing sections were also transferred, and a 'bomb' weight mounted in the vehicle as far forward as possible and beneath the CTD.

At 0900 on day 245 the second SeaSoar was deployed. Control was much improved and the vehicle now turned well at the surface. It was noted on recovery, that as the ship's speed was raised from 2 to 4 kts, the tail of the vehicle now lifted nicely in the water. The CTD on this deployment was noisy causing some erratic response during a dive. At one stage the SeaSoar dived with peak load of 2000 kgs at 9 kts. This seemed to clear the noise problem from then on. Peak tensions were reaching 2000 kgs so the towing speed was reduced to 8 kts and eventually 7 kts.

Day 246 (2.9.88)

Recovery of the SeaSoar started at 2300 on day 245. The fairing had badly hedgehogged, neighbouring links of fairing often jammed at 120 degrees to each other. Near the top of the cable it had also bird-caged, the outer strands becoming separated from the inner ones. The bird-caging is most likely due to the hedgehogging which jams the fairing hard against the cable. The resultant 'propeller' formed rotates the outer armouring on the cable, causing it to loosen on the inboard end. Because of the bird-caging and the high tensions, the top section of the cable was kept on the drum for the rest of the cruise.

The corresponding tightening of the cable at the SeaSoar end may also responsible for some of the kinking there which was found during later recoveries. The cable was cleaned up and the SeaSoar redeployed. The fairing added earlier on the last 10m of wire near the fish was removed as it might have been affecting the dive of the fish.

At this stage of the cruise the performance of the fish was reasonable except for an instability as it dived from the surface. The initial dive to 50m was uncontrollable, at which stage the fish oscillated waiting for the control signal to catch up. Thereafter it dived slowly to 200m. The climb rate was about 1.2m per second with a gradual decrease near the surface. When the climb rate was reduced the fish became sluggish and did not dive again correctly from the surface.

After a few hours there was a failure in one of the cable conducting wires causing loss of control. The SeaSoar was recovered to affect a repair, coming onboard at 1110 on day 246 . The cable had at some stage caught around the wing and had damaged the wing end plate. The pressure signal also indicated that the fish had been tumbling and rolling. The wire near the fish was also badly kinked. Damage to the fairing this time was only minor. The damaged cable was cut and the terminations remade.

Day 247 (3.9.88)

The SeaSoar was deployed at 1530 on day 246 (run 8) but within 4 hours had failed again this time with loss of CTD signal. The cable was once again kinked at the SeaSoar. The cable was cut and reterminated. The maximum wing down angle was reset to 7.5 degrees and the 'bomb' weight removed from inside the vehicle in an attempt to reduce the initial dive of the fish. During the first redeployment(run 9) the 'bomb' weight under the vehicle was found to have a badly bent fin and so was replaced.

The next deployment (run 10) was at 0120 on day 247.

Day 248 (4.9.88)

The cable tension increased gradually during the day so at 0750 the SeaSoar was recovered to repair the damaged sections of fairing and then immediately redeployed(run 11).

During the early evening we steamed through an area containing floating debris, much of which was in the form of large logs. The ship's EM log was removed by this debris so it was decided that the SeaSoar should be recovered to prevent damage to the vehicle during the hours of darkness.

The CTD was transferred to the vertical frame and a cast carried out every 30 miles to provide data continuity between the SeaSoar recovery and its next deployment. This amounted to 4 casts to 300m (casts 3-6) the first three without water sample bottles or reversing thermometers. For the last cast a new oxygen sensor was installed in the CTD and calibrated against water bottles.

Day 249 (5.9.88)

The CTD was refitted in the SeaSoar and redeployed (Run 12 248/2225 248/2237). However there was water in the electrical connections which had to be remade.

While repairs were effected, a calibration CTD station (No 7) was carried out to 300 with water bottle samples for temperature, salinity and oxygen at 50m intervals.

The next deployment was at 0254 on day 249 (run 13).

Day 250 (6.9.88)

Overnight the CTD data became noisy, indicating an intermittent failure in one of the conducting wires. The SeaSoar was recovered at 2309 on day 249 but no obvious fault was found. A coaxial cable junction in the control box may be responsible.

The SeaSoar was redeployed at 0030 on day 250 (run 14). The pressure signal gave one spike during the first dive but thereafter was smooth.

Soon after, fishing floats were observed ahead. The SeaSoar was therefor brought to the surface until they had passed.

The response of the SeaSoar to the command signal had been reasonably good, but there was a problem at the start of each dive. The lag between the command signal and the SeaSoar depth was excessive when trying to dive from the surface causing high cable tensions and a tendency for the vehicle to overshoot its predetermined position. This produced oscillations in the down path of the vehicle with some high tension peaks. These were eventually reduced by adjusting the depth and command circuits of the SeaSoar deck control unit.

Day 251 to day 253 (7 to 9.9.88)

SeaSoar continued operating successfully during this period.

Day 254 (10.9.88)

During the morning jumps were discovered in the CTD data. At 0200 run 14 was terminated and the SeaSoar recovered. The problem initially appeared to be a fouling of the conductivity cell but on close examination turned out to be an 0.8 degree offset together with noise in the CTD platinum resistance thermometer. On inspection it was found that the cable was kinked near the SeaSoar and that there had been corrosion taking place at the base of the platinum resistance thermometer.

There was an electrical resistance of approximately 100 kohms between the platinum element and the external pressure housing of the thermometer. This was replaced with a new one and a matching Vishay resistor mounted in the sensor head assembly. It was not possible to set the thermometer up to read correctly as facilities for accurate calibration were not available. A vertical cast (CTD 8) was made with reversing thermometers to provide a working calibration. The top bottle failed to fire.

The CTD was replaced in the SeaSoar fish and this was redeployed at 0800 day 254 (run 15). Immediately noise spikes were found when the wire was under tension, implying that both the wires used to power the CTD were going open circuit. The SeaSoar was retrieved and the cable reterminated.

Day 255 (11.9.88)

The SeaSoar was redeployed at the start of run 16 at 1430 on day 254. As at other times during the cruise, during deployment the ship had to turn in order to prevent the cable fouling the Gloria davit.

Day 256 to day 258 (12-14.9.88)

The survey continued uninterrupted.

Day 259 (15.9.88)

The SeaSoar was recovered at 0900 to allow a passage at full speed to be made, to make up time lost. The top 200 metres of fairing had 'hedgehogged' but was in fairly good condition from there on.

Day 260 (16.9.88)

Deployed SeaSoar at 0930 day 260 (run 17).

Day 261 (17.9.88)

There were strong current shears during the afternoon while crossing the equatorial undercurrent and the SeaSoar was unable to get below 180m. Eventually the cable tensions increased and so the SeaSoar was recovered (0915 day 261). The top quarter of the fairing was badly damaged.

In order to make up for the loss in time due to towing at 7.5 knots the ship's speed had been increased to 8 knots. There was also increased surface wave action. The cable was somewhat kinked at the bottom end due to the outer armouring of the cable tightening up. The recovery speed was also increased to 4 knots at this stage to alleviate the problem of the vehicle spinning in the water due to the turning moments applied to the cable by way of the damaged fairing.

The SeaSoar was redeployed at 1016 on day 261 (run 18) roughly at the point that recovery started. It was noted that the loosening and tightening of the cable outer was releaved on deployment.

Day 262 (18.9.88)

Seas increased overnight and in the morning the SeaSoar cable was observed to be slowly twisting (bird-caging) near the drum. The SeaSoar response to the command signal also became poor, indicating a failure in the hydraulics unit. SeaSoar was recovered at 2350 on day 261. There was a large amount of fairing in need of repair even though the ship's speed had been kept to 7.5 kts.

The CTD was transferred to the hydrographic frame and the section was completed with two CTDs to 600m (stations 9 and 10).

Day 263 (19.9.88)

On close inspection of the cable, a bad kink was found hidden beneath the cowtail that leads the cable onto the SeaSoar towing point. Although the cable had not failed it was decided to reterminate it anyway. The hydraulic unit was replaced with a spare. The maximum wing down angle was increased to 10 degrees, hopefully to increase the depth range obtainable.

Two calibration casts were made at 155E 5N. The first (cast 11) was to 600 metres using the SeaSoar CTD. The second (cast 12) was made with the deep CTD to 3500 metres.

During the second cast the multisampler failed to send an answering signal of bottle closure on two occasions. On recovery one bottle was found to have misfired. 1.1 litre sample bottles were used for this intercalibration dip.

Day 265 (21.9.88)

SeaSoar deployed at 2100 on day 264 (run 19). Because of the increased seas, on this deployment the top 50m of cable, the part most affected by the waves, had the fairing removed. At 0120 on day 265 spikes were observed in the CTD pressure signal.

Day 266 (22.9.88)

At 1430 on day 265 the SeaSoar was recovered because of further noise on the CTD signal which indicated that the cable conductor was failing. The fairing was found to be in reasonable condition and there was no evidence of bird-caging.

The cable was reterminated and the SeaSoar redeployed at 1730 on day 265 (run 20).

Day 267 (23.9.88)

SeaSoar in continuous operation. It was recovered for the last time at 1445 on day 267 just south of the Equator.

JS, DG

Acoustic Doppler Current Profiler

The ADCP was operated using the parameter file from RRS Charles Darwin cruise 32. On the run from Auckland to Cairns it gave good signal returns at all times despite the ship travelling at speeds in excess of 13 knots.

Similarly during the initial passage of leg 2 and during the survey up to day 259 it performed well.

However during the short passage leg which started on day 259, the instrument stopped giving good returns. On investigation, using the diagnostic software, it was found that there were errors on all 4 beams. It was then decided to use the direct command menu to set up the test conditions described in the manual. None of these tests showed an obvious fault, but it was discovered that bending the transducer cable at the plug on the back of the instrument could bring the profiles back.

Although failure within this cable this may be one of the reasons for the lack of good returns, it was found that sometimes moving the cable made no difference at all. Alternative possibilities are first that there was a very low bio-mass in the water column so the strength of the returned signal was low compared with the ambient noise due to ship motion, or secondly that there was a reduction in the performance of the discriminating circuits compared with the earlier passage legs.

During the rest of the cruise good returns where achieved when the ship was stopped or towing the SeaSoar and poor returns when the ship was on passage.

Meteorological Instruments

Whilst in Auckland two new mountings were fabricated to the Forward Mast for the radiometer sensors, one at the top of the mast ladder portside and the second at the top of the central mast. Gymbal units were fitted to the two new mountings and the original mounting on the starboard side the ready for the sensor deployment.

On day 236 the radiometers, wind speed and direction, and psychrometer were fitted to the forward mast whilst the vessel was in port in Cairns together with the MultiMet logging equipment in the Plot. On day 238 the wheelhouse sensor suite was connected and monitoring of all sensors by MetMan commenced, data output via a Level C, which added calibration coefficients, was commenced on the Level B. Data recording to MultiMet tape was commenced on day 247 at 03.53 and terminated on day 271 at 02.07. MultiMet logged continuously throughout the cruise collecting and processing data producing '1' minute means of all variables.

Of the fourteen sensors whose output was recorded, only two that of the Sea Surface Temperature (SST) and the Wind Direction on the forward mast experienced any operational difficulty. The SST sensor was deployed on day 241 and towed at 12 knots until day 245 producing good data which indicated that the calibration of the thermosalinograph was 0.3 degrees high. Due to failure in securing the sensor the cable parted at the connector and the sensor was lost. A second sensor of an inferior mechanical design was fitted, which produced calibrated data until day 259 at 12.00, this failure was due to an ingress of water shortly after the ship commenced a passage leg at 12 knots. The third sensor was then deployed only whilst the ship was steaming at about 8 knots until the end of cruise data collection on day 271, remaining in calibration throughout deployment. On day 267 a reed switch in the Forward Mast Wind Direction sensor ceased functioning and the data was invalid, however if necessary this could be corrected by further processing with respect to the wheelhouse direction sensor.

Differences in temperatures measured by the two psychrometer units could not be investigated as the weather conditions at the end of the cruise precluded the climbing of the Forward Mast, these differences will be examined when the units are re-calibrated.

Both of the Level A units work without problems allowing the ships gyro to be interfaced to MultiMet and the data output of MultiMet to the calibrated and logged by the Level B system.

KB

Navigation

GPS and MX1117

The GPS equipment performed well and good coverage was obtained for about six hours each day except for a period during the middle part of the cruise when the satellite code was changed. Best results were obtained when using groups of three well positioned satellites and assuming that the height of the receiver was fixed. A accurate clock was carried to extend the period of good fixes but because of the grouping of the satellite orbits, the period with two good satellites visible was very short.

The older Magnavox MX1107 Satnav system performed consistently well throughout the cruise.

E-M log

The electro-magnetic log operated successfully until damaged by drifting debris on day 248. Attempts were made to bring the log inboard but the spar section was badly bent and jammed when only partly retracted. This burnt out the electrical motor for the hydraulics, the overload cell having failed to work. The spar was eventually retracted by hand after some difficult moments working in cramped conditions. The unit was then dismantled and the E-M spar removed, the original transducer head having been lost during the collision.

As there was no spare transducer cable on board a new one was fabricated. Using this and a new spar and transducer head, the log was assembled. It started operating again on day 251.

While installing the new log in the hull unit, the limit switches for the spar and the sea valve were found to be faulty. The spar limit switches were cleaned and adjusted so they worked correctly. The valve switches were unrepairable at sea and were eventually replaced in Fiji.

HE, CR

Compass

During the zig-zag runs used to calibrate the E-M log and the ADCP, a significant oscillation of the gyro compass showed up relative to the GPS measurements. The angular movement of the compass zero direction was of the order of one or two degrees. Similar observations were made on cruise 32 by Pollard. They are important in that they can introduce systematic errors into the absolute velocities calculated from ADCP data.

Doppler log

An attempt was made to use the doppler log after the E-M log failed. However no sensible readings could be obtained. The most likely explanation for the failure is that the returning sonar signal was corrupted by the ADCP which operates at a similar frequency.

Thermosalinograph

The 6620 thermosalinograph, supplied by RVS, was used primarily to keep a constant check on the salinity calibration of the CTD mounted on the SeaSoar. It was also used to monitor the near surface water masses and to intercompare the sea surface temperatures measured by the meteorological SST instrument and the SeaSoar CTD.

The instrument measures the temperature and salinity of the ships non-toxic water supply, which according to the ship plans is taken from a stainless steel pipe extending below the ship's hull near the hydrographic winch to a depth of 5m below the water-line.

The instrument performed well throughout the cruise. The main problem experienced arose from interruptions in the non-toxic supply. These occurred early in the cruise and were due to corrosion in the stainless steel pipes. There were also some leaks from plastic pipes in the system. Care was also needed to ensure a constant bubble free flow. This meant altering the flow gauge with the changes in water pressure.

DP

Salinometer

Salinity Sample Analysis

641 salinity samples were analysed on the Guildline Autosal salinometer. Of these 80 were drawn from 12 CTD casts and 561 were underway samples taken hourly from the thermosalinograph outlet.

The salinity data showed that the thermosalinograph had a good linear response, but had a different offset for the different salinity ranges. The calibrations to be applied to the thermosalinograph data are:

Thermosalinograph salinity range 32.5 - 34.5:

$$S = 1.0699\, S' - 2.6415$$

Thermosalinograph salinity range 34.0 - 36.0:

$$S = 0.9850\, S' + 0.2941$$

S' is the salinity measured by the thermosalinograph and S the corrected salinity.

The hourly underway samples and the thermosalinograph data are used to check and correct the SeaSoar CTD salinity calibration. Partly because of the problem encountered with the SeaSoar temperature probe, no corrections were applied to the data while at sea. Final corrections to salinity await an accurate calibration of the new SeaSoar temperature sensor.

JR

Oxygen Measurements

The CTD oxygen sensor

An oxygen sensor was added to the SeaSoar CTD during cruise 34A as an aid to tracing the sources of the different water types in the region. The sensor use is know to have a 300s time constant which arises from its thermal inertia. This showed up clearly as an hysteresis during deep CTD casts.

However the data generated while it was in the SeaSoar vehicle and undulating in the strong near surface thermal gradients, showed that there was an additional effect present with a 50 second time constant.

Attempts were made to calibrate the sensor and to allow for the different time constants but the sensor slowly became less sensitive and so was replaced by a new one just prior to CTD 6 on day 248. The new sensor also showed both the short term (50s) and long term (300s) hysteresis.

The sensors also exhibited non-linear behaviour. During the SeaSoar downcasts the signal was irregular but with similar features showing up at the same depth on neighbouring downcasts. During the upcasts the response was much smoother, the signal only being affected by the longer term hysteresis effects. The non-linear behaviour may have been produced by dmaage to the sensor, the initial sensor first showing non-linear behaviour after CTD 2 and the second one after CTD 8.

Oxygen Analysis

A total of 25 oxygen samples taken from four of the shallow CTD stations were analysed by Winkler's Titration procedure. However because of the unexplained hysteresis affecting the CTD oxygen sensors, no attempt has been made yet to determine a correct calibration to use with the SeaSoar data.

SF, BAK, JR

XBT

Seven XBT's were used early in the cruise. The surface temperatures reported were above 35 degrees but initially the system was continued in use between CTD stations, as the problem may just have been a fixed offset due to the surface unit. However on day 248 the analogue to digital converter in the surface unit failed and could not be repaired.

Because it is unlikely that in the process of failing the offset of the surface unit remained constant, the XBT data has been discarded.

Precision Echo Sounder

The PES ran continuously and successfully throughout the cruise. Both the hull and fish transducers were used and gave good returns.

Gravimeter

The gravimeter operated almost continually and with only minor failures between day 241 and day 270. Calibrations were carried out on shore in Cairns before the cruise and again in Fiji at the end.

PDP-11 Data Processing

During the cruise data from the main instrument systems was transferred to a PDP-11 for analysis and archiving on the p-star system. This computer was also used to log data from the ADCP, the SeaSoar and the CTD, the raw data being stored in two hour files.

Data from the ship GPS system, the MX1107 satellite receiver, the Meteorological system one minute averages and the thermosalinograph ten second averages were first collected by the level A-B-C system and then transferred by tape to the PDP-11

Ship positions at one minute intervals from the 'bestnav' suite of programs and electromagnetic log data, at one minute intervals, from the 'relmov' package were also transferred.

At the end of the cruise the depth data from the PES, tabulated at six minute intervals, was transferred together with a file of smoothed navigation for use with gravimeter data. Also, as some of the culled MX1107 data may not have been transferred, the entire file of unedited fixes was transferred.

The two hour files of raw SeaSoar and CTD data were first calibrated, edited and plotted and then combined into twelve hour files. The SeaSoar files were merged with the navigation data and were then gridded ready for contouring variables as a function of distance run and pressure. For gridding the data, averaging was carried out using bins with a 4 km horizontal spacing and an 8m vertical spacing.

The ADCP data was also appended into 12 hour files for calibrating, averaging (over 4 km) and contouring. During the first part of the cruise this data was combined with the navigation data to give absolute water velocities which was then plotted. After losing the E-M log this was no longer possible.

The thermosalinograph data was averaged over two minute periods for archiving and plotting. The Meteorological data was plotted in 24 hour sections.

During the cruise the Level B computer broke down for a short time on day 258. The thermosalinograph and meteorological data from this period were lost but may be recovered from the original records. The Level A computer which acted as an interface between the PDP-11 and the CTD broke down for several hours on day 255.

The PDP 11/34 worked well throughout the cruise with a few minor problems. These usually arose because the system was overstretched by the data processing load. The most major breakdown occurred on day 266 when the drive belt on one of the disk drives broke. When necessary CTD and SeaSoar data could be recovered from either Level C or digidata tapes. The ADCP data was backed up to floppy disks and the meteorological data was also stored in magnetic cassettes.

SA, SF, BK, JR

A-B-C data processing

Equipment used

Level As: E-M LOG, GYRO, MULTIMET, MUL_GYRO, GRAVITY, GPS, MX1107, SEASOAR, CTD.

Level B

Level C

Problems Encountered

During the period that the E-M log was damaged and out of action, the Doppler Log could not be used for navigation because it used the same frequencies as the ADCP. As an interim measure, to provide data for track charts and the plotting of data, velocities were taken every ten minutes from the MX1107 printout and entered into the level A-B-C system using the 'antcal' program. 'Interpolt' was used to fill in any gaps.

The navigation file obtained using this data with 'bestnav' was good enough for most purposes but was not accurate enough for combining with the ADCP data to give absolute current velocities.

Calcomp: As occurred during the previous SeaSoar cruise, the PDP Calcomp broke down after only a few days. The computer room Calcomp therefor had to be shared between the level C and PDP-11 systems.

Tape drives: There were problems with the tape drives on the Level C and Level B systems during the cruise.

Marinet: There were many suggestions as to why the Marinet system on this ship did not work but it was finally tied down to two separate problems, the first being a faulty PC and the second problems with the PABX attached to the Satcom.

Data Transfer: Data transfer between the Level C and the PDP was made using magnetic tapes. Although this meant a lot of work on both sides it caused no real problems.

Multimet: The gyro averaging level A that was developed on cruise CD32 was used and worked successfully throughout the cruise. The level A developed to log the MultiMet itself worked well during the cruise except for a single crash which was not detected by the watch keepers.

CTD Level A: The CTD Level A caused no problems and worked well at 8 Khz but seemed to lose an unexceptable amount of data at 16 Khz. The Level B itself worked well throughout the cruise and the only real problem was a failure of the tape drive which caused a slight loss of data.

AB, DL

Ship facilities

Overall the ship was in a good state of repair and was an excellent platform to work from.

ACKNOWLEDGEMENTS

I would like to thank the master, officers and crew of the RRS Charles Darwin, the RVS staff and my colleagues from IOSDL for their support and hard work during a long cruise. The data collected is in many ways unique and is already giving new insights into a region of ocean which has an important effect on the world climate. Their efforts have thus been particularly worthwhile.

I would also like to especially thank Dr B. King for his collaboration in planning the cruise and his help in preparing this report.

REFERENCES

POLLARD, R.T. & READ, J.F. 1989 A method for calibrating shipmounted acoustic doppler profilers and the limitations of gyro compasses.
Journal of Atmospheric and Oceanic Technology (in press).

POLLARD, R.T., READ, J.F., SMITHERS, J. & STIRLING, M.W. 1987 SeaSoar sections from the Antarctic Circumpolar Current at 52E, 32E to the Subtropical Front at 37S, 52E.
Institute of Oceanographic Sciences Deacon Laboratory, Report, No. 244, 55pp.

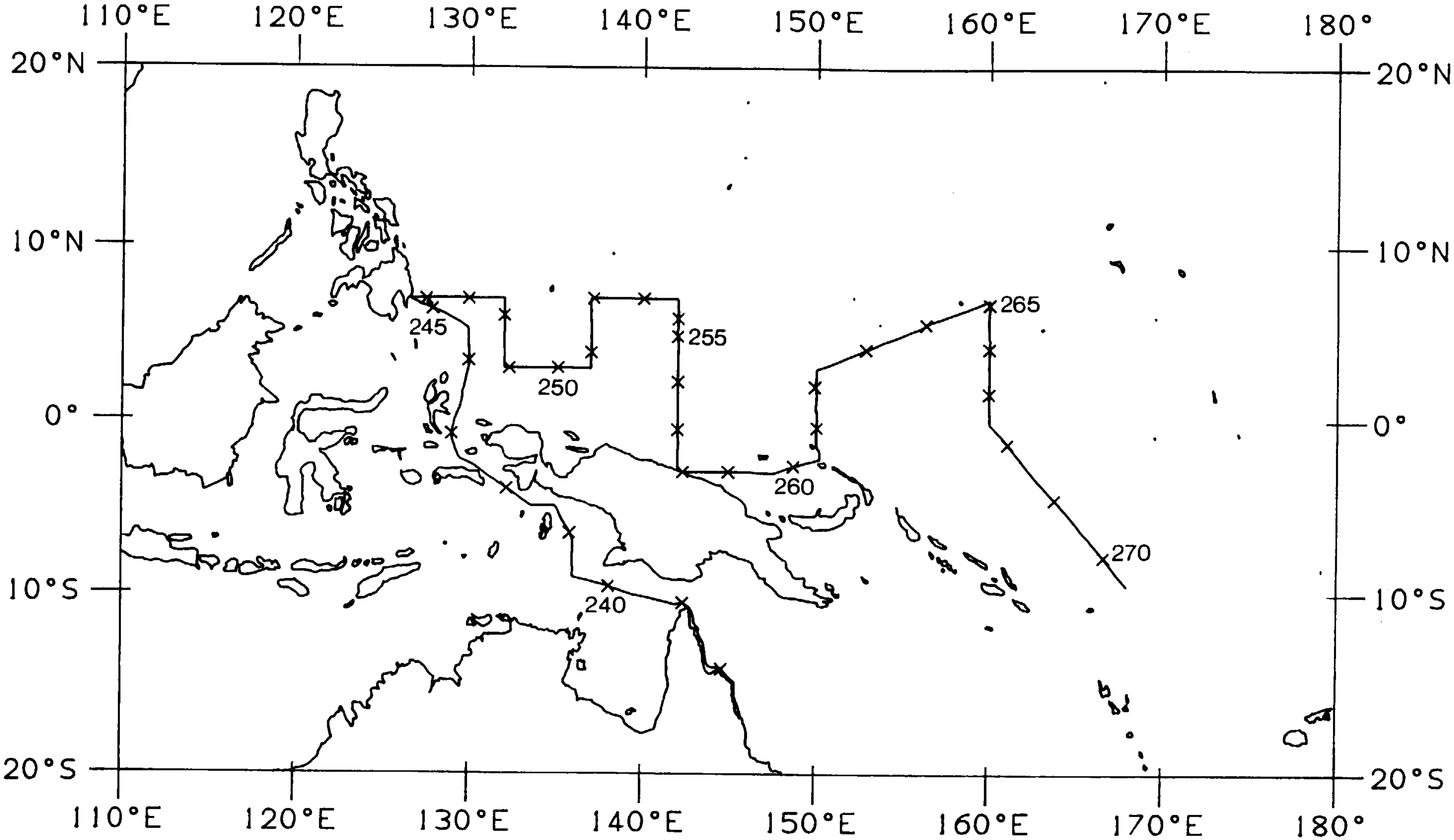

Figure 1 Track of the <u>RRS Charles Darwin</u> during Cruise 34A/88 (15 August - 24 September 1988). The crosses show the ship's position at 0000Z on the days indicated.

TABLE 1

SeaSoar runs

	Start	End	Comments
1	230/0114	230/0320	Trial 1.
2	231/0408	231/0747	Trial 2.
3	232/0038	232/0244	Trial 3.
4	232/0422	232/0740	Continuation of 3.
5	243/2230	244/0620	Trial 4. Start of main survey.
6	245/0900	246/0140	Large cable tensions.
7	246/0300	246/1110	Failure of cable control wires. Damaged wing.
8	246/1529	246/1831	Failure of signal wires, kinked cable.
9	247/0000	247/0015	Aborted deployment.
10	247/0120	247/0750	Large cable tensions.
11	247/0758	247/1039	Risk of damage from flotsam.
12	248/2225	248/2237	Aborted deployment, water in electrical connections.
13	249/0254	249/2309	Noisy signals.
14	250/0030	254/0258	Thermistor corroded.
15	254/0803	254/1121	Wires open circuit.
16	254/1445	259/0941	Recovered for passage leg.
17	260/0917	261/0913	Large cable tensions.
18	261/1016	261/2348	Wire bird-caging, also SeaSoar response poor.
19	264/2200	265/1520	Failure of cable conductor.
20	265/1743	267/1445	End of main survey.

TABLE 2

CTD stations

	Start	End	Depth	Position and Comments
1	245/0320	245/0504	600m	127 16'E 6 36'N Calibration station. Bottle failure.
2	245/0527	245/0711	600m	127 16'E 6 36'N Calibration station.
3	248/1212	248/1239	300m	131 59'E 4 28'N
4	248/1500	248/1518	300m	132 01'E 4 00'N
5	248/1744	248/1807	300m	132 00'E 3 30'N
6	248/2048	248/2119	300m	132 00'E 3 01'N Oxygen calibration.
7	249/0105	249/0200	300m	132 30'E 3 00'N Calibration station.
8	254/0627	254/0727	600m	142 00'E 6 07'N Calibration station for new thermistor.
9	262/0309	262/0340	600m	150 00'E 2 30'N
10	262/0640	262/0706	600m	150 00'E 2 58'N
11	263/1224	263/1321	600m	155 01'E 5 00'N Calibration station.
12	263/1342	263/1620	3000m	155 01'E 5 00'N Calibration station.

TABLE 3

ADCP data

Time	Comments
229/0255	Logging starts at record 1. Parameter file CD34A.CNF Calibration run 231/1350-1750.
233/1312	Logging ends at record 2552.
239/1030	Logging starts. Calibration run 239/1100-1640 using parameter file CD34AC.CNF
270/0600	Logging ends.

TABLE 4

Gaps in ADCP data archived to PDP-11

Start	Stop	Duration	Comments
239/1014	239/1044	0:30	Reset ADCP for calibration run.
244/1047	222/1142	0:55	Not noted.
247/0756	247/0911	1:15	Not noted.
248/0944	248/1029	0:45	Not noted.
254/0721	254/0759	0:38	Not noted.
255/0112	255/0128	0:16	ADCP Deck unit crash.
259/0855	260/0614	21:19	ADCP off on passage.
262/0003	262/0946	9:43	ADCP off on passage.
262/1839	262/1927	0:48	ADCP deck unit crash.
262/2257	264/2207	47:10	ADCP off on passage.
265/1812	265/1900	0:48	PDP-11 down.
268/0513	268/0533	0:20	PDP-11 down.
269/2056	269/2301		Poor data (discarded).
270/0602			Logging ends.

TABLE 5

Meteorological Instruments

Time	Comments
247/0353	Data recording started.
245	Loss of first SST sensor.
259/1200	Failure of second SST sensor.
267	Partial failure of forward wind direction sensor.
271/0207	Data recording ends.

TABLE 6

PES chart rolls

Roll	Start	End	Comments
1	230/0416	231/0218	
2	231/0224	233/1230	Data loss 232/1224-232/2200. Cross shelf 233/0600.
3	241/0600	243/0242	Cross shelf edge.
4	243/0250	245/0100	
5	245/0140	247/0600	
6	247/0620	249/1400	CTD.
7	249/1406	251/0536	
8	251/1024	253/2030	
9	253/2047	255/1948	
10	255/1958	258/08068	
11	258/0815	260/1500	
12	260/1505	263/0236	
13	263/0348	265/1200	CTD34A/012 263/1200.
14	265/1206	266/0942	
15	266/0948	267/2100	
16	267/2106	270/0600	

TABLE 7

Thermosalinograph chart rolls

Roll	Start	End	Comments
1	239/0606	246/0402	
	239/1463		End of ADCP calibration expt - stop soon after.
	241/1135		Restart thermosalinograph after pipe repairs.
	243/0302		Internal waves east of Halmehera.
	244/1459	244/1526	Thermosalinograph switched off.
2	246/0521	254/1203	
	247/1230		Cell test after long period of constant salinities.
	248/0853		Restart cell.
3	254/1304	262/1805	
	262/2100	270/0600	

TABLE 8

Gravity chart rolls

Roll	Start	End	Comments
1	241/0715	243/1715	
	241/0915		Noise in record.
	241/1700		Intermittent noise on green channel.
	241/2320	242/0020	Mending chart recorder.
2	243/1724	247/0850	
	245/0400		Gravity pen sticking
	247/0700		Change +-15volt deregulator - AD920.
3	247/0900	250/1316	
	248/0200		Red pen changed from av beam to cross coupling.
4	250/1328	253/0610	
5	253/1118	256/1620	
6	256/1630	259/2218	
	257/1646	259/1652	Test with spring tension total correction off.
7	259/2300	262/2044	
	260/1600	261/0500	Intermittent noise on green channel.
8	262/2110	265/1810	
9	265/1816	269/0011	
10	269/0148	270/0603	End recording.