RESEARCH SUMMARY

Cruise FR 10/93

Sailed Sydney 1700 Saturday 18 December 1993

Arrived Hobart 1230 Wednesday 22 December 1993

TRIALS OF MODIFIED SEASOAR AND BUNYIP MICROSTRUCTURE TOWED BODYS

Principal Investigators
Dr. L.F. Pender, Mr. I. Helmond and Dr. T.J. McDougall
CSIRO Division of Oceanography

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TOPEX-POSEIDON ALTIMETER VERIFICATION

Principal Investigators
Mr. R. Bailey
CSIRO Division of Oceanography

Dr. R. Coleman
University of Tasmania

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Research Summary

RV FRANKLIN

FR 10/93

Itinerary

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Dr. L.F. Pender, Mr. I. Helmond, Dr. T.J. McDougall and Mr. R. Bailey
CSIRO Division of Oceanography
GPO Box 1538
Hobart
Tas. 7001, Australia
Phone (002) 325222

Dr. R. Coleman
University of Tasmania
Antarctic CRC
Churchill ave.
Sandy Bay, Tas.
Phone (002) 202108

Personnel

Dr. L.F. Pender, CSIRO Division of Oceanography (Cruise Leader)
Dr. T.J. McDougall, CSIRO Division of Oceanography
Mr. I. Helmond, CSIRO Division of Oceanography
Mr. P. Adams, CSIRO Division of Oceanography
Mr. L. Carter, CSIRO Division of Oceanography
Ms. C. Page, CSIRO Division of Oceanography
Mr. R. Plaschke, CSIRO Division of Oceanography
Mr. D Vaudrey, CSIRO Division of Oceanography
Mr J. Reeve, Antarctic Division
Mr I. Knott, University of Tasmania

1. Cruise Objectives

During this cruise, trials of the modified ORV SeaSoar (Mainfish) were to be undertaken to determine the performance characteristics of the modifications. The modifications involved larger wings, and a redesigned roll stabiliser using ailerons on the SeaSoar tail plane. The prime motivations for undertaking these modifications were to increase the depth range, and to possibly enable the replacement of the hydraulic wing drive system with an electric drive. It is hoped that an electric drive will decrease maintenance time of the SeaSoar and increase reliability. The objectives of the Mainfish trials were to determine the:

- depth range at different tow speeds and varying tow cable lengths.
- vehicle roll stability.
- wing torque - needed for the design of an electric drive.
- cable tension under the various tow conditions.

Further trials of the Bunyip Microstructure vehicle (Microfish) were also to be undertaken. The objectives of the Microfish trials were to:

- determine the origin of the correlation between vehicle vibration and slow (~5sec) vehicle attitude changes.
- attempt to minimise the vehicle attitude changes to minimise vibrations.
- test a new shear probe sensor mount, designed to increase resonant frequencies beyond the maximum frequency of microstructure signals.
- test a Seabird TC duct on the Microfish CTD. The TC duct is ducting which ensures that the temperature and conductivity cells are sampling the same water.

This cruise was the first time the Bunyip system has been used with the new ORV computing system, and thus also presented an ideal opportunity to test new software and to test the new cable interface constructed by DO electronics.

As a Piggy-Back project, XBT, XCTD, CTD, ADCP and thermosalinograph measurements were to be made within 5km of two ground tracks of the TOPEX-POSEIDON satellite. The objectives of this project were to:

- make direct comparisons of sea surface heights and velocities to enable verification of the accuracy of the satellite's altimeter.
- calculate independent estimates of the geoid structure along altimeter ground tracks by providing a calibration for inverse model methods, thereby aiming to improve the accuracy of the altimeter in the region.
- evaluate the latest model of the XCTD.

Where possible, XBT, ADCP and SeaSoar CTD sections were to be made on the shelf and out beyond the shelf break to add to the historic records of the southern end of the EAC and Tasmanian's east coast.

2. Cruise Narrative

Sydney to Waypoint B

The cruise was shortened by 33hrs from the original time allocation due to Bow Thruster problems preceding FR 9/93. After leaving Sydney at the new departure time, we sailed directly to the entrance of Jervis Bay. There we completed a CTD station and collected water samples for later examination at the CSIRO Marine Labs (data collected in relation th the paper, S.I. Blackburn and G. Cresswell, *A Coccolithophorid Bloom in Jervis Bay, Australia,* Aust. J. Mar. Freshwater Res., 1993, **44**, 253-60). The Jervis Bay CTD was completed by 0100 19 Dec., at which time we sailed to waypoint B (see cruise track).

TOPEX-POSEIDON Altimeter Experiment - Waypoints B to E

Legs BC and CE were designed to lie within 5km of the satellite ground track for a descending and ascending orbit respectively. Waypoint B was reached at 0200 19 Dec. when we dropping the first XBT for the TOPEX-POSEIDON altimeter experiment. XBTs were dropped approximately every hour while we were sailing, until we reached waypoint E. The first CTD station (CTD #2) for the altimeter experiment was completed on the 2000m contour at 0700. As with all other CTDs, an XCTD was dropped when the CTD had been lowered to 200m. Further CTD stations were undertaken at C (CTD #3, starting at 1430, 19 dec.), D (CTD #4, 2230), at the 4000m contour (CTD #5, 1530, 20 dec.) and the 2000m contour (CTD #6, 0200, 21 Dec.). The last CTD cast was undertaken using the Antarctic Division's CTD. The cruise track was interrupted 3 times to do Bunyip Mainfish trials. Waypoint E was reached at 0830 21 Dec.

Bunyip Trials

There was a total of six Bunyip deployments made, the last two being with the complete Microfish system. See the attached table of Bunyip deployments for a description of each deployment.

A further CTD using the Antarctic Division's CTD was done at 2300 21 Dec. before the last Microfish deployment. Following this Microfish deployment, we sailed to Hobart, being along side at 1230 22 Dec.

Due to the limited time available, planned CTD sections at the southern end of the EAC and off Eastern Tasmania were not attempted.

The weather conditions throughout the cruise were very good, with moderate sea conditions being the worst experienced. This lasted for a period of appoximately 12 hours during the early morning of 22 Dec.

3. Preliminary Results

Mainfish Trials

Ian Helmond

Three modifications to SeaSoar were tested as planned. These were:
1. New tailplane with aileron stabiliser.
2. Removal of towing bridle stops to allow +/- 90° movement.
3. Larger wings.

The new tailplane was fitted and SeaSoar deployed at 0900 20 Dec. The adjustable weight on the stabiliser system was not fitted so as to test the system at minimum sensitivity. The fish flew with reasonable roll stability but was perhaps a bit "tender". SeaSoar was recovered and the weight added at maximum radius to test at maximum sensitivity. Roll stability was good and did not appear to have excessive sensitivity. For the next deployment the towing bridle stops were removed. These stops are a requirement of the original stabiliser arrangement and limit the angle of rotation of the towing bridle from 0 to 90°. This restricted movement applies a negative pitching moment reducing the upper end of the depth range. Roll stability was still good for this deployment and an improvement in depth range was realised. At a tow speed of 4m/s the fish could reach the surface with a cable length of 620m and dive to 300m. This compares with a depth of 250m using 350m of cable when the stops are in place.

The larger wings were fitted and the fish put out on 200m of cable at 1250 20 Dec. The new wings made the depth control of the fish VERY sensitive; such that the coefficients in the flight control algorithm (integer numbers) could not be reduced sufficiently. There were bad instability problems apparently caused by large pitch variations causing stall and then roll. With 800m of cable out at 4m/s the fish reached the surface with a wing angle of attack of -11° and reached a depth of 400m with 15°. Due to the instabilities, we decided not to test with longer cable lengths. The achieved depth performance agrees well with theory (-11° gives a theoretical depth of -30m and 15° gives 420m) so it is expected the planned 500m depth would be achieved with 1200m of cable provided the instability problem can be solved. Although closer analysis of the data is required it would appear that the causes for this pitch instability were:

1. Excessive mechanical sensitivity of the wing rotation arrangement.
2. Inappropriate flight control algorithm at the time.
3. Erratic behaviour of the hydraulic servo valve causing uncontrolled wing rotation.
4. Higher aspect ratio wings more inclined to stall with excessive pitch angles.

The first three points are easy to address, particularly if an electric drive is used to replace the hydraulic unit. The solution to the last point could be either to reduce the aspect ratio or perhaps to increase the effect of the tail plane to reduce pitch. More consideration of this problem is required.

Strain gauges were fitted to the push-rod that rotates the wings in order to determine the torque required to rotate them during actual flight. These data are needed to design an electric drive unit to replace the existing hydraulic unit. The torque required for the new wings is approximately 20% that of the old wings, with most of that torque being due to the weight of the wings rather than due to hydrodynamic forces. This result confirms the suitability of an electric drive unit with perhaps an arrangement to balance the weight of the wing.

Microfish Trials

These trials were hampered by three problems, namely, a water leak from the new sensor mount into the Microfish pressure case, the inability of the new deck unit to keep up with the Microfish data rate (see electronics report) and insufficient time to reconfigure the Mainfish back to a more stable configuration. Despite these problems, useful and adequate data was collected to fulfil most of our objectives.

The coupling between vehicle vibrations and attitude seem to be largely removed by using a universal joint in the Microfish tow staff. The original tow staff was constrained to move in the vertical plane only, and it was felt that this arrangement forced vehicle roll into yaw, leaving the vehicle unaligned with the flow direction and subsequently increasing vibration. The universal joint removes this coupling between roll and yaw. Within time intervals of 10s, rotation rate sensors indicate that the vehicle is rotating by less than a degree in the yaw and pitch directions when towed at constant depth. Under the same conditions the vehicle rolls by less than 4°. For comparison with past results, it would have been useful to look at the rotation rate sensors in conjunction with the original tow staff, however time didn't permit this.

From the short times series we were able to collect (typically 2min. at a time), the variation in vehicle vibration spectral power over 5s intervals, is typically 1/20th that observed prior to using the universal joint. However, the minimum spectral power (minima of the variations) is approximately the same in both configurations, i.e. ~ 10^{-8} W/kg.

The new shear probe mount resulted in reduced spectral power due to resonances, however, a strong peak at 450Hz remains. This peak was also present when using the previous mount, and is presumably not due to the mount itself.

There was insufficient time to test the Seabird TC duct.

TOPEX-POSEIDON Altimeter Experiment

Rick Bailey

A total of 39 T-7 XBTs (760m) and 7 XCTDs (1000m) were launched during the cruise. XBTs were launched every hour in an effort to resolve the eddy field. Four CTD stations (top to bottom) were undertaken in depths greater than 2000 metres in order to evaluate reference levels to be used in the calculation of sea surface heights and geostrophic velocities from the XBT data. The CTD stations were also used to evaluate the accuracy of the XCTD.

Most of the XBTs performed adequately. The cruise track crossed the southern end of the EAC and a larger eddy off the VIC/NSW border. A marked improvement was shown in the reliability of the XCTD compared to earlier tests. Changes to the software and hardware for the XCTD appear to have generally eliminated earlier severe interference problems. Small amplitude noise, however, is still evident at depths greater than 900m, indicating the latest attempts to correct problems with the filtering routines will require further work. The actual accuracy of the XCTD will be evaluated when the CTD data is processed. Previous tests showed the XCTD did not match up to manufacturer specifications.

4. Antarctic Division Cruise Report

Jon Reeve

This is the voyage report for FR10/93 for the tests run by Jon Reeve (from Antarctic Division) and Ian Knot (from University of Tasmania.)

Aims

Our aims for this voyage were :
1. To test the operation of our CTD (recently repaired.)
2. To test the operation of our Rosette (new and untried.).
3. To test the operation of a new rate of descent meter (new and untried.)
4. To observe operations and equipment on RV Franklin.

The first three pieces of equipment are required for use on RSV Aurora Australis Voyage 7 93/94.

What we did

Initially the rosette module had it's connector replaced (it was damaged in shipping), a new non interrupt electronic unit installed, and was installed in the CSIRO spare rosette. The CTD data format was found to be incompatible with the CSIRO deck unit set up and the rosette did not work.

The CTD was disassembled and the data inverted to match CSIRO format, and the electronics replaced with an older unit (which had given trouble before). The systems were tested on deck and worked. The system was the deployed to a depth of 3200 m. This showed that the rosette did not work properly at depth and that the oxygen current and oxygen sensors did not work.

The rosette mechanical systems were cleaned, the oil thinned, and the electronics unit swapped back to the "new" unit after a wrong component was found on it and replaced. A second CTD dip was done to 2500 m and the rosette system worked.

The rate of descent meter was tested and worked, although the output is noisier than ideal.

Summary

This voyage has been very useful in identifying and repairing faults in the systems tested. A fault has been identified in the CTD which can now be worked on in the laboratory, the rosette has been made operational, and rate of descent meter operation confirmed.

I would like to thank CSIRO for the opportunity to participate in this voyage, and the crew and scientific personnel on board for their help and assistance.

Acknowledgements

The entire RV Franklin crew is thanked for their excellent support and co-operation.

Table of SeaSoar & Bunyip Deployments, Fr10/93, page 1

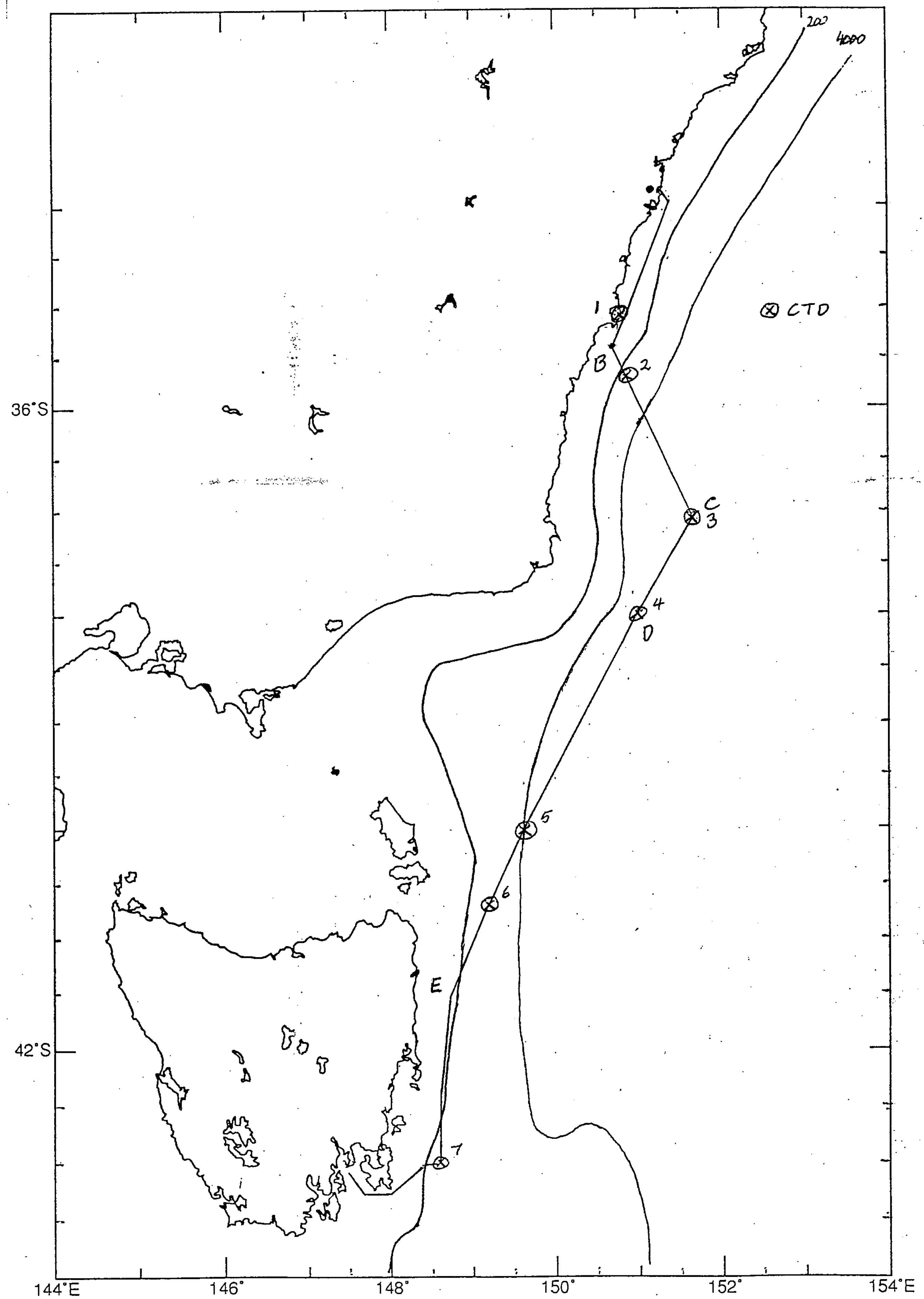
#	Time In	Position In	Time Out	Position Out	Sensors	Comments
1	*Sun 19 Dec* *2200 UTC* —— Mon 20 Dec 0900 LT	39° 11.0′S 150° 14.8′E			SeaSoar only	Test deployment with the new tailplane and ailerons. On a sawtooth from 0 to 60m the roll got up to 23° and a negative roll on the up parts of the sawtooth. This was without the weight on the rod part of the aileron mechanism. Finished File 01 and brought it in to add the weight to the aileron mechanism. Deployed again at 0949 LT and File 02 begun. In the middle of File 02, we aborted and repowered it in order to try and get the strain gauges to wake up and be recorded. This procedure seemed to work as the hex data was there after the restart. The added weight definitely reduced the roll during sawtooth profiles at 8 knots. started File 03 at 1004 LT. At full wings down (-23°) the roll was very good. Files 01–03 incl.
2	*Mon 20 Dec* *0150 UTC* —— Mon 20 Dec 1250 LT	39° 44.0′S 149° 50.0′E	*Mon 20 Dec* *0515 UTC* —— Mon 20 Dec 1615 LT	40° 05.0′S 149° 36.0′E	SeaSoar only	This deployment had the stops on the tow bridle removed. Some of the fibreglass of the front housing was removed so that the tow staff would not jam. Still using the old small wings and the new tailplane assembly. It seems to be able to lift more cable at 8 knots. We had problems with the ship log during this tow and it is clear that we towed at 12 knots for half of the time. The roll behaved well until the end and then it listed to one side badly and intermittently. This was due to the bevel gear slipping on the vertical shaft of the new tailplane assembly. Files 04–05 incl.
3	*Mon 20 Dec* *0934 UTC* —— Mon 20 Dec 2034 LT	40° 14.1′S 149° 29.7′E	*Mon 20 Dec* *1243 UTC* —— Mon 20 Dec 2343 LT	40° 32.6′S 149° 16.5′E	SeaSoar only	This deployment had the new large wings, with the new tailplane and without the tow-bridle stops. Had stability problems. On recovery, the ailerons were again loose on the vertical shaft. However, it seemed that the stalls occurred on high wing angles and without an initiating large roll. Files 06–10 incl.

Key
LT = Local Time which is Hobart Summer Time.

Table of SeaSoar & Bunyip Deployments, Fr10/93 (Continued), page 2

#	Time In	Position In	Time Out	Position Out	Sensors	Comments
4	*Tues 21 Dec 0228 UTC* —— Tues 21 Dec 1328 LT	42° 35.2′S 148° 33.7′E	*Tues 21 Dec 0310 UTC* —— Tues 21 Dec 1410 LT		SeaSoar only	This deployment had the new large wings, with the new tailplane and without the tow-bridle stops. The plates at the ends of the large wings had been removed prior to this deployment, and the vertical shaft has been drilled so that it won't slip again. Also have the sliding weight on the stabiliser in the full inboard. (Note that it is clear that the axes of the vertical tailplane should not be vertical because this makes for a bi-stable control in a dive.) With 200m of cable out the system was stable at 6 knots. Then we went for 8 knots at 1355LT. It seemed to behave itself. Files 11–11 incl.
5	*Tues 21 Dec 0549 UTC* —— Tues 21 Dec 1649 LT	42° 54.0′S 148° 28.9′E			SeaSoar and microfish with 2 DSP, no µCond	Water Level Detect showed up on deployment Opened file 12 and recorded data from 1656LT for just a couple of minutes. Data drop out after about 5 minutes. Brought it back on board. Files 12–12 incl.
6	*Tues 21 Dec 1617 UTC* —— Wed 22 Dec 0317 LT	43° 01.1′S 148° 32.2′E			SeaSoar and microfish with 2 DSP, no µCond	Cable out is 200m. 2nd shear probes off and the accelerometers are off too. We had slippage on the winch twice and reduced speed so that we could abort to get the data. Had water-level detect at 0325LT. Start File 14 at 0328LT after a restart. Had to restart again. Had to keep the SeaSoar at the surface while we tried to get the system started at 5 knots and then get the speed up and get the data rate up. That is, we are nursing several system deficiencies at once. File 15 started at 0335LT. Decide to let the thing bounce along the surface while we get some data because on File 15 we got a huge tension and the wire paid off the winch brake. It takes several tries to get the system restarted. File 15 continued, at 0342LT logged all the sensors for a while until LT. Water Level detect is not coming up now. The Mainfish wings are now much worse in its control than on the previous deployment. From 0350LT we tried to get it deeper, starting at File 17. Starting from 16° wing angle, we reduced the wing angle 2° at a time until it dived below the surface. Accelerometers are on during this time. The ship speed was 8.5knots during this procedure. Needed a wing angle of 4° to get it below the surface. At 0355LT it had levelled out at 55m and collected data on the long shear robe and the accelerometer, in File 17. Stopped this high data rate at 0358LT when some data was lost and brought it to the surface gently by controlling the wing angle very slowly. Why does it take so many tries to get the system started? Lindsay thinks that we should only be powering off Stuart's box once. Start File 18 at 0408LT. Then we decided to get flat out data (on File 18) while the Mainfish is at the surface and the ship speed is 6 knots. The Microfish is at 24m at this speed. Data steam lost at 0408LT. Files 13–18 incl.

Key
DSP = Dual Shear Probe. µCond = Microconductivity Probe.
LT = Local Time which is Hobart Summer Time.



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