FRANKLIN

National Facility
Oceanographic Research Vessel

ResearchSummary

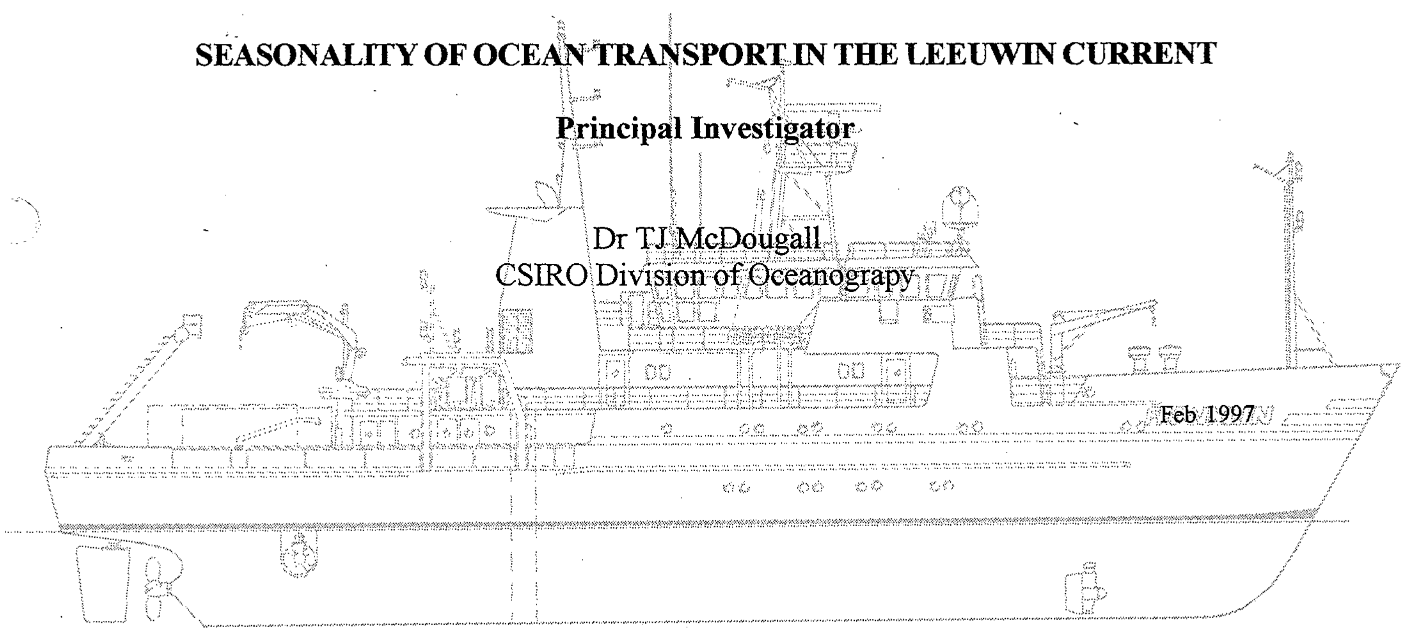
FR08/96

Sail	Fremantle	1000	Thursday	12 September 1996
Arrive	Fremantle	0800	Saturday	28 September 1996

SEASONALITY OF OCEAN TRANSPORT IN THE LEEUWIN CURRENT

Principal Investigator

Dr TJ McDougall
CSIRO Division of Oceanograpy



Feb 1997

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RV Franklin

National Facility
Oceanographic Research Vessel

Research Summary
Cruise Fr08/96

Itinerary

Sail	Fremantle	1000	Thursday	12 September 1996
Arrive	Fremantle	0800	Saturday	28 September 1996

Moored Measurements and CTD sections of the flow of Deep and Bottom Water into the West Australian Basin of the Indian Ocean

Principal Investigator

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Cruise Objectives

(i) To recover moored current meters in the passage between Cape Mentelle and Broken Plateau to measure the flow of Deep and Bottom water into the West Australian Basin.

(ii) To use the moored current-meter data together with several realisations of the hydrography across the section between Cape Mentelle and Broken Ridge to deduce the flow of Bottom, Deep and Intermediate Waters in this region.

(iii) To estimate the vertical diffusivity across the potential temperature surfaces less than 1.1°C in the West Australian Basin using the deduced volume flow rates of Deep and Bottom water across the section from Naturaliste Plateau to Broken ridge.

(iv) By obtaining more reliable estimates of the equatorward flux of deep and bottom water into the West Australian Basin, contribute to the estimate of the poleward heat flux borne by the Indian Ocean.

Personnel

Ship's Crew

Master	Ian Moss
1st Mate	Ian Menzies
2nd Mate	Franky Valeran
Chief Engineer	Michael Culpeper
1st Engineer	David Jonker
Elec. Engineer	Don Roberts
Bosun	Yannick Hansen
AB	Wayne Browning
AB	Peter Genge
AB	Patrick Willis
Greaser	Phil French
Chief Steward	John Tilley
Chief Cook	Gary Hall
2nd Cook	Peter Dux

Scientific Party

Trevor McDougall	CSIRO	Oceanography	Chief Scientist
David Jackett	CSIRO	Oceanography	
Kevin Miller	CSIRO	Oceanography	
Danny McLaughlan	CSIRO	Oceanography	
Beradette Heaney	CSIRO	ORV Computing	
Helen Beggs	CSIRO	ORV Computing	
Phil Adams	CSIRO	ORV Electronics	
Mark Rayner	CSIRO	ORV Hydrology	
Gary Critchley	CSIRO	ORV Hydrology	
Rebecca Deed	CSIRO	ORV Hydrology	

Cruise Narrative

After leaving Fremantle we headed for the easternmost of the ten moorings, M10. Shortly before reaching this position however, the wind increased and the conditions became unworkable. We spent the next three days hove to, making very slow progress to the northwest and enduring a seemingly endless series of lows that kept moving past us.

The first chance we had to recover any moorings was on Monday morning, 16th September and the first mooring we tackled was mooring M8 (see the attached cruise track, Figure 1). Unfortunately this mooring did not talk to us and despite sending the release command on several occasions, nothing appeared on the surface. Later that day we moved eastwards to mooring M9 and recovered it without a hitch.

We moved to the position of mooring M10 but arrived there with just half an hour of daylight remaining and so did not risk a recovery that night. The first CTD was done this evening to a depth of about 3320m and after this, the wind again increased so that we could do no CTDs or mooring recoveries for more than 24 hours.

Mooring M10 was recovered at first light on Wednesday 18th September. On our way westward we tried again to recover mooring M8 but without success. We had no indication that the release on this mooring was alive and its behaviour was consistent with the release being flooded. The second CTD was taken in about 5150m just westward of the unretrievable M8.

Mooring M7 was recovered at first light on Thursday 19th September and after two more CTDs mooring M6 and M5 were recovered during Friday 20th September.

CTD #5 was taken on Friday night, 20th September but this was to be the last of our work for 36 hours. Another CTD was attempted Friday night but was abandoned at a depth of 400m as the bridge could not maintain control of the ship in the high winds.

After hoving to for more than a day, we awoke on Sunday morning 22 September to a sea without whitecaps: this being the first time without whitecaps on the cruise. We took advantage of the favourable weather to recover the remaining four moorings, M4, M3, M2 and M1, during this day, the last one being released at 1715hrs.

We then did some more CTDs along the line of the mooring positions and then moved closer to Fremantle and did some CTDs in the deep Perth basin, with the idea being to characterise the deep water properties in this basin to the north of the line of moorings. After doing five CTDs in this region, the weather again deteriorated and we were forced to abandon the last three stations and steam for Fremantle. On the shelf we cruised around a triangular track for the purpose of calibrating the ADCP alignment.

Summary of work completed

The main achievement of the cruise was the recovery of 9 out of the 10 moorings. The acoustic release on the other mooring did not communicate with the ship, and despite extensive efforts on two separate days to release and search for the mooring, nothing appeared on the surface. This lost mooring (M8) contained one release and three Aanderaa current meters.

The nine moorings that were recovered contained 26 current meters. None of these leaked and all but one of these contained good data:- the remaining one did not record any data. Hence we obtained moored current meter data from 25 current meters out of a total of 29 current meters deployed.

The extensive bad weather on the cruise precluded a complete CTD section across the complete line of the current meter deployments. We did however manage a few CTDs in the Perth Basin to the north of our line of moorings.

The data from the current meters is not yet analysed in detail but it is clear already that there is a general northward flow on the western part of the section and a general southward return flow on the eastern part of the section. It will be a challenge to determine the net inflow into the Perth basin at these depths. Data from two current meters are shown in Figures 2 and 3. Panels (a), (b), (c) and (d) are the speed, direction, velocity in the eastward direction and velocity in the northwards direction respectively, while panels (e) to (h) show the histograms of the corresponding panels on the left. When the rotor of the current meter stalls, the speed has been replaced with the stall speed of 1.1 cm/s in these figures. It is seen that the rotors are stalled for as much as one quarter of the time. The histogram of the directions shows that the flow is roughly to the north at mooring M3 and to the south at mooring M9.

Acknowledgments

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

Franklin cruise 8/96

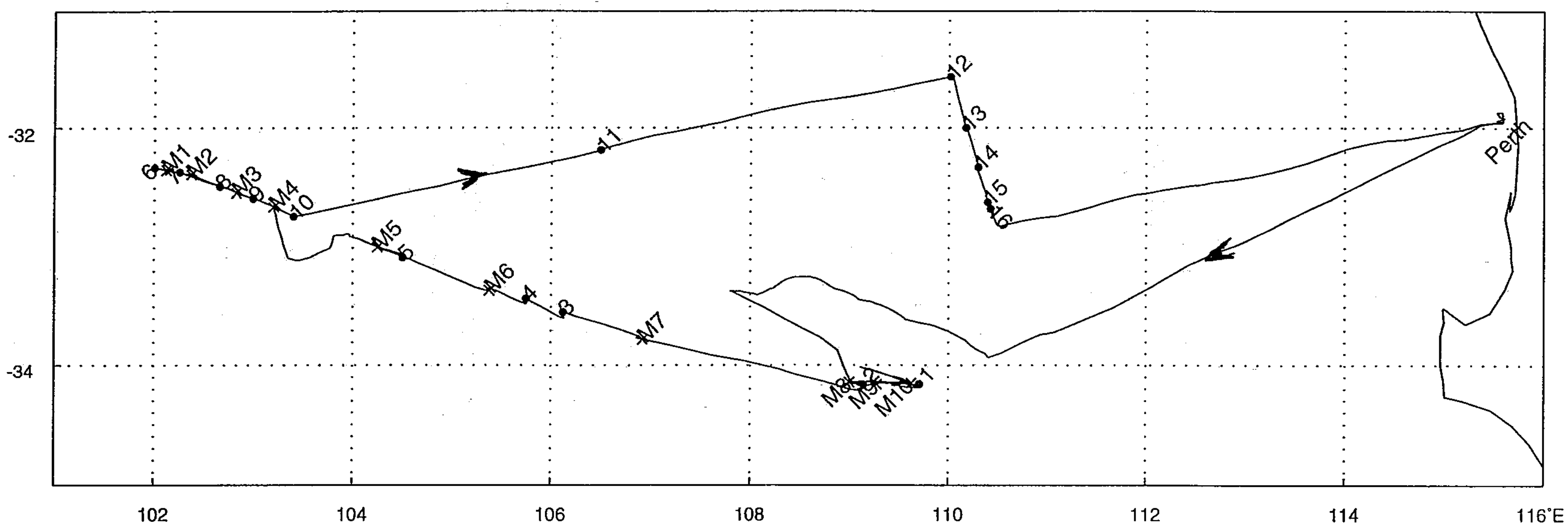

Figure 1.

M3, 4000m

M3 , 4000m

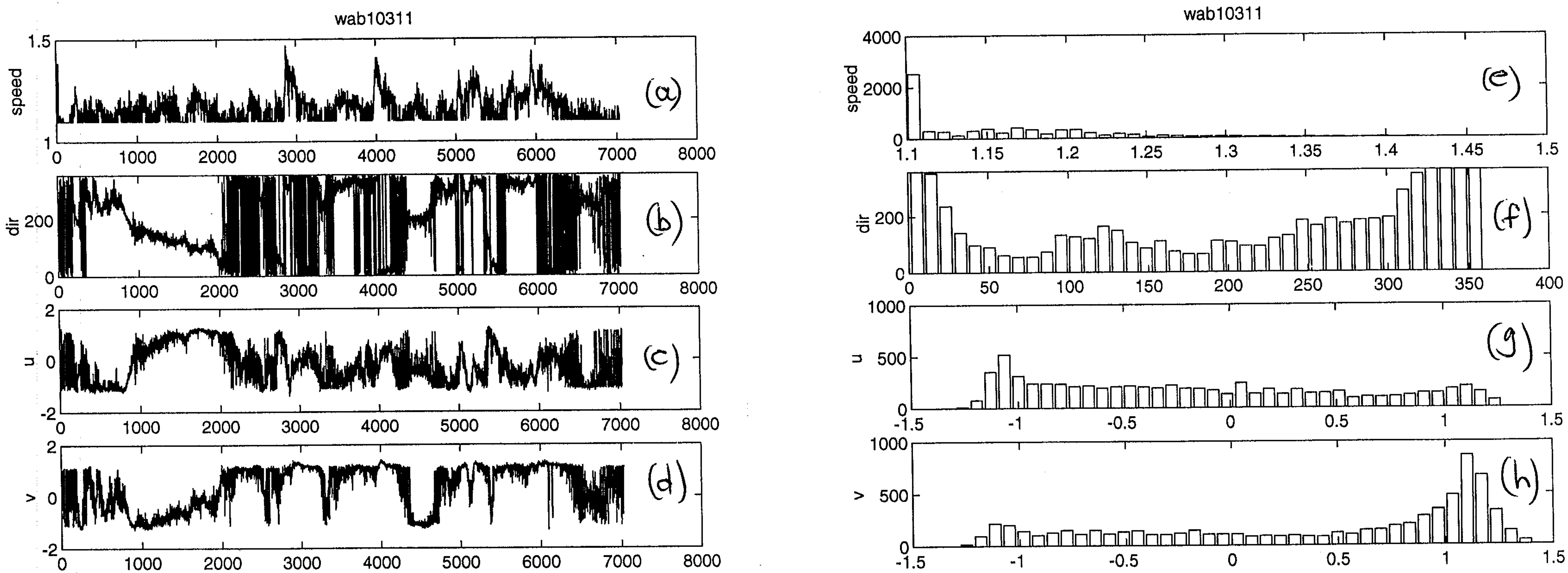

Figure 2

M9, 4000m

M9, 4000m

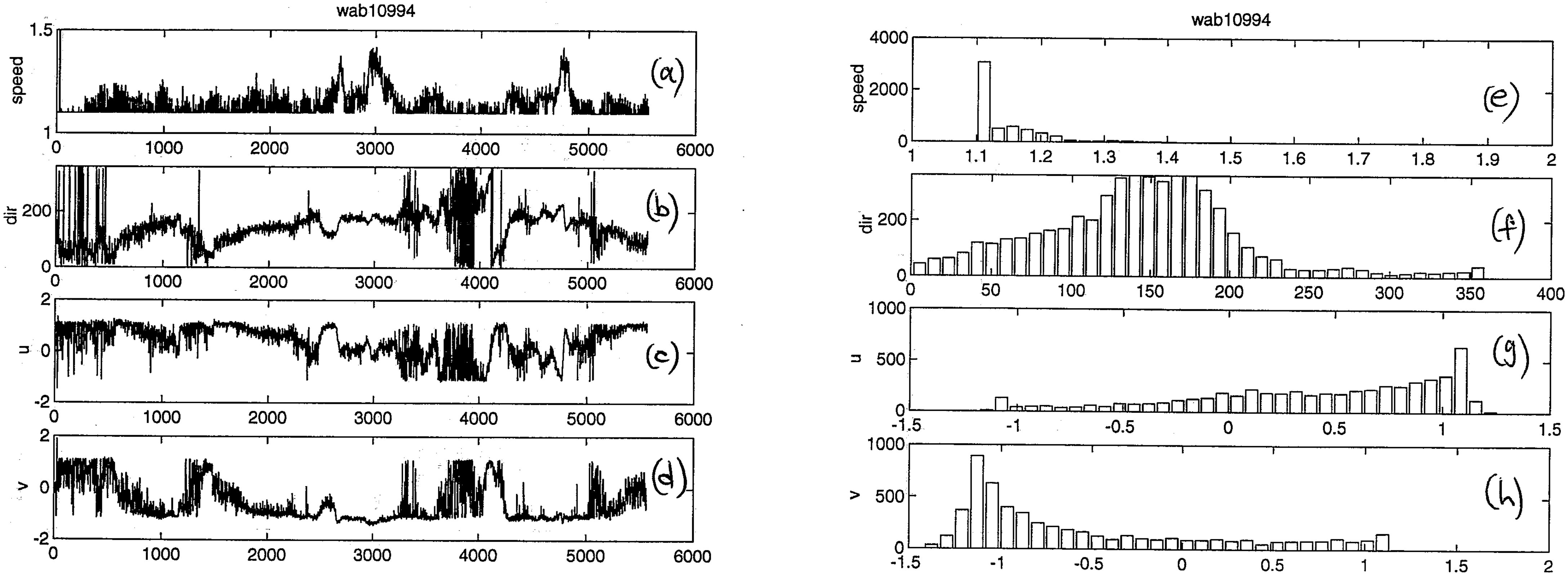

Figure 3

Hydrology Data Processing Notes

Cruise FR 08/96
12 September 1996 to 28 September 1996

Data processing completed by
Rebecca Cowley
17/9/98 to 25/9/98

Principal Investigator Dr. Trevor McDougall, CSIRO Division of Marine Research, Hobart, Tasmania.

General

Following are details of the hydrology processing done for F9608. See Table 1 for specific edits.

Salinity data and most of the oxygen data appears to be of excellent quality, however, most of the nutrient data is of questionable quality due to the lack of quality control procedures included during the voyage. Most of the data has been retained and included in the archived files, but should be used with caution.

No hydro data was collected for cast 17, which was aborted due to bad weather conditions.

Nutrients

As mentioned in the previous section, it is not clear what the quality of the nutrient data is. Stations 3, 4, 5, 8, 10 and 12 show interesting traces at depth for silicate, and to a lesser extent for phosphate. There was no obvious reason to delete this data, so it was retained, and may be real. Gain correction, carryover correction and refractive index corrections were not performed on any of the data. For specific edits to the data, see Table 2.

Salinities

Edits to salinity data are shown in Table 3. There are a few samples where the Hydro salinity differed from the CTD value markedly. Some of these were deleted. Figure 1 shows a plot of CTD salinity - Hydro salinity for the entire voyage.

Temperature

Much thermometer data was deleted due to large discrepancies with the CTD temperature data. Edits are included in Table 4. Thermometer number 12088 (unprotected) appeared to be in error for every cast.

Dissolved Oxygen

The CTD dissolved oxygen results were not calibrated during the CTD processing. There was no CTD downcast data to compare the hydro results to. Hydro dissolved oxygen results were plotted against depth and some data points were deleted due to incorrect data entry on the voyage. Most of the data was acceptable. Edits are listed in Table 5.

Archiving

Data processing was completed on the 25/9/98 and archived on the 25/9/98. Problems were encountered with archiving the data with respect to niskin bottle numbers, as those listed on the CTD sheets are 4 digit numbers. These numbers were shortened by removing the second digit in the number, which in all cases was a one. For example, bottle number 1709 became 709 (signifying a 1.7-litre bottle, number 09).

Table 1. General

Station	RP*	NBN*	Comments	Action
17			No CTD records, station aborted	Delete .DAT file
11			Bottle test cast, depths out of order	Enter correct depths
12			Rosette ramp set incorrectly, samples out of order	Move sample results to suit correct sample depths.
14			Rosette ramp set incorrectly, samples out of order	Move sample results to suit correct sample depths.
101 to 116			Salinity data only, run on YeoKal for an intercomparison	Move .DAT files to a seperate folder.

*RP = Rosette Position, NBN = Niskin bottle number

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Table 2. Nutrients

Station	RP*	NBN*	Comments	Action
10 to 15			DAPA data missing. Re-measure results by hand.	Stations 14 and 15 had silicate and phosphate DAPA data, Nitrate was hand measured
16			Sample order for the run was unable to be determined	No results for this station.
6	2	1701	Bad sample/analysis	Delete results for silicate, nitrate and phosphate
2	2	1701	No sample taken	Delete record of bottle number
2	1	1702	Typo in nitrate result	Correct result entered
13	19	1719	Leaking bottle	Delete all nutrient results
14	16	1716	Possible leaking bottle	Delete all nutrient results
12	1	1702	Leaking bottle	Delete all nutrient results
13	2	1701	Phosphate result questionable	Delete phosphate value
13	7	1707	Phosphate result questionable	Delete phosphate value
13	9	1724	Phosphate result questionable	Delete phosphate value
14	22	1722	Typo in nitrate result	Fix typo
5			Silicate strange trace	Accept results
8			Silicate strange trace	Accept results
10			All nutrients strange trace	Accept results

*RP = Rosette Position, NBN = Niskin bottle number

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Table 3. Salinities

Station	RP*	NBN*	Comments	Action
1	5	1705	CTD - Hydro = -0.706	Mis-fire of rosette, delete result
1	21	1722	CTD - Hydro = -0.012	Accept result, salinity gradient present
2	2	1071	No sample taken	Delete records from bottle log
2	24	1701	CTD - Hydro = 0.010	Bad sample/analysis, delete result
6	12	1712	CTD - Hydro = 0.038	Bad sample/analysis, delete result
6	24	1709	CTD - Hydro = -0.058	Bad sample/analysis, delete result
6	2	1701	CTD - Hydro = 0.009	Bad sample/analysis, delete result
7	18	1718	No sample taken	Delete records from bottle log
10	19	1719	CTD - Hydro = 0.066	Bad sample/analysis, delete result

12	6	1706	CTD - Hydro = -0.019	Bad sample/analysis, delete result
13	19	1719	No sample taken	Delete records from bottle log
14	6	1716	CTD - Hydro = 0.012	Bad sample/analysis, delete result
14	23	1723	CTD - Hydro = -0.018	Bad sample/analysis, delete result
16	14	1714	No sample taken	Delete records from bottle log

*RP = Rosette Position, NBN = Niskin bottle number

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Figure 1. CTD salinity - Hydro salinity

Chart (CTD Salinity - HYDRO Salinity) for f9608

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Table 4. Temperature

Station	RP*	NBN*	Comments	Action
1	2	1701	Thermometer #12088 out of calibration	Delete thermometer results
3	13	1713	No 5min wait for equilibration	Delete thermometer results
3	2	1701	Thermometer #12088 out of calibration	Delete thermometer results
5	2	1701	Thermometer #12088 out of calibration	Delete thermometer results
6	2	1701	Thermometer #12088 out of calibration	Delete thermometer results
7	2	1701	Thermometer #12088 out of calibration	Delete thermometer results
10	24	1709	Incorrect reading	Delete thermometer results
10	2	1701	Thermometer #12088 out of calibration	Delete thermometer results
12	2	1701	Thermometer #12088 out of calibration	Delete thermometer results
13	2	1701	Thermometer #12088 out of calibration	Delete thermometer results
13	2	1701	Thermometer #12088 out of calibration	Delete thermometer results
16	13	1713	Lanyard possibly caught when firing	Delete thermometer results
16	2	1701	Thermometer #12088 out of calibration	Delete thermometer results

*RP = Rosette Position, NBN = Niskin bottle number

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Table 5. Dissolved Oxygen

Station	RP*	NBN*	Comments	Action

2	13	1713	Typo in result	Enter correct result
6	2	1701	Bad sample/analysis	Delete result
8	1	1702	Bad sample/analysis	Delete result
13	19	1719	No sample taken	Delete record in bottle log
16	12	1712	Bad sample/analysis	Delete result

*RP = Rosette Position, NBN = Niskin bottle number

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Created by Rebecca Cowley on 25 September 1998. Informal enquiries and further details may be obtained by contacting:
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RV Franklin ADCP Data Processing Notes
Cruise Fr 08/1996

12-Sep - 27 Sep 1996

Data processing completed on 24 April 2001 by Bernadette Heaney, email: Bernadette.Heaney@marine.csiro.au

Principal Investigator: Dr Trevor McDougall

"Seasonality of ocean transport in the Leeuwin current"

1 Features of this voyage

There was 2% bottom track coverage. The data had not been originally requested - hence the delay in processing. The weather was very rough during most of the voyage and so the range of data is affected.

1.1 Special Processing For This Cruise

3 minute .adp files returned from the voyage were used for data processing. Position dervied velocities were used in preference to direct GPS velocities. Gyro direction was used.

1.2 Profiles integrated

Bottom track corrected, no reference layer averaging in final integration:

fr9608.abt: 23 20 minute profiles

The following two files were first integrated using reference layer averaging over bins 2 to 8, then merged with files which were integrated using no reference layer averaging.

GPS corrected (position-derivedvelocities preferred to direct GPS velocities):

fr9608.agp: 1125 20 minute profiles

fr9608_60.agp: 375 60 minute profiles

Best available correction (Bottom track preferred to position derived velocities, preferred to direct GPS velocities):

fr9608.any: 1125 20 minute profiles

fr9608_60.any: 375 60 minute profiles

Non-integrated profiles (3 minute ensembles):
All possible ensembles with best available correction (bottom track preferred to position-derived GPS velocities, preferred to direct GPS velocities).

e_f9608.any: 7507 3 minute profiles

NB: See ADCP Format Guide for explanation of processed file formats.

2 Data Rejections

Out of a total of 7556 three minute ensembles, 7507 made it through to the processed file stage, with 210169 total good bins.

Bin 1 rejections 957

Number of bins rejected due solely to:

%Good < 30%: 113112

%Good < 50%: where RLA was bad and no acceleration: 3205

%Good < 70%: where RLA was bad and there was acceleration: 227

Vertical Velocity > 0.22 m/s : 163

S.D. of error velocity > 0.13 m/s: 609

dv/dz sites: 5

Number of bins rejected due to multiple tests: 43625

2.1 Calibration

ADCP water profile vectors (measured relative to the ship) are calibrated by being rotated through an angle alpha and multiplied by scaling factor 1 + beta. The rotational calibration primarily corrects for misalignment of the transducer with respect to the ship, of the ship with respect to the gyrocompass (or 3DF GPS), and the error in the gyrocompass (or 3DF GPS). The scaling multiplier primarily corrects biases arising from the profiler itself. Both of these calibrations make a large difference to the resultant currents, particularly because they are both applied to the usually large ship-relative currents. For example, a scaling multiplier of 0.01 applied when the water velocity with respect to the ship is 6m/s alters the measured absolute currents by 6 cm/s.

The following calibrations were chosen for this voyage.

alpha = 1.8111 +/- 0.3 degrees

1 + beta = 1.0014+/- 0.009

3 Errors

The data provided should not be taken as absolutely true and accurate. There are many sources of error, some of which are very hard to quantify. Often the largest error is that of determining the ship's actual velocity.

3.1 Accuracy of water velocity relative to the ship

The theoretical approximate short-term velocity error for our 150 kHz narrow-band ADCP is:

sigma = 1/(pulse length X square root of pings per average)

For a 3 minute ensemble with say 170 pings, using 8m pulse, this gives a theoretical error of 1 cm/s for each value (that is, independently for each bin).

For 20 minute profiles, with say 1150 pings averaged, the error in measuring the velocity of the water relative to the ship is probably reduced to the long term systematic bias. Of this bias, RDI says

> "Internal bias is typically less than 1 cm/s, depending on several factors including temperature, mean current speed, signal/noise ratio, beam geometry errors, etc. It is not yet possible to measure ADCP bias and to calibrate or remove it in post-processing."

In addition, there are the transducer alignment and attitude sensor errors, which mainly cancel out where bottom-track ship velocities are used (see Section 5.3). For GPS ship velocity corrected currents, the transducer alignment and attitude sensor errors probably have a residual effect after calibrating of roughly:

> 0.3 cm/s per m/s of ship speed, due to, say, 0.3 degree uncertainty and variation in alignment angle.
>
> 0.9 cm/s per m/s of ship speed, due to, say, 0.009 uncertainty and variation in scaling factor.

This gives us, say, 0.94 cm/s error per m/s of ship speed, or 5.45 cm/s at 12 knots.

Other sources of bias might be the real-time and post-processing data screening, and depth-dependent bias.

3.2 GPS profiles

In the presence of SA (see sections 1 and 3), errors are larger and even very large errors cannot be removed by dv/dt screening (because this would bias the long term average - there is reason to assume that given a long enough period the accumulated SA error is close to zero).

3.3 Bottom track profiles

Firstly note that errors in current speed arising from transducer alignment and attitude sensor limitations will substantially cancel out. Normally, the accuracy of screened bottom track data appears to be of the same order of accuracy as non-SA GPS, that is, about 2 - 3 cm/s for a 20 minute profile. However, the error in the current direction is at least the error in alpha.