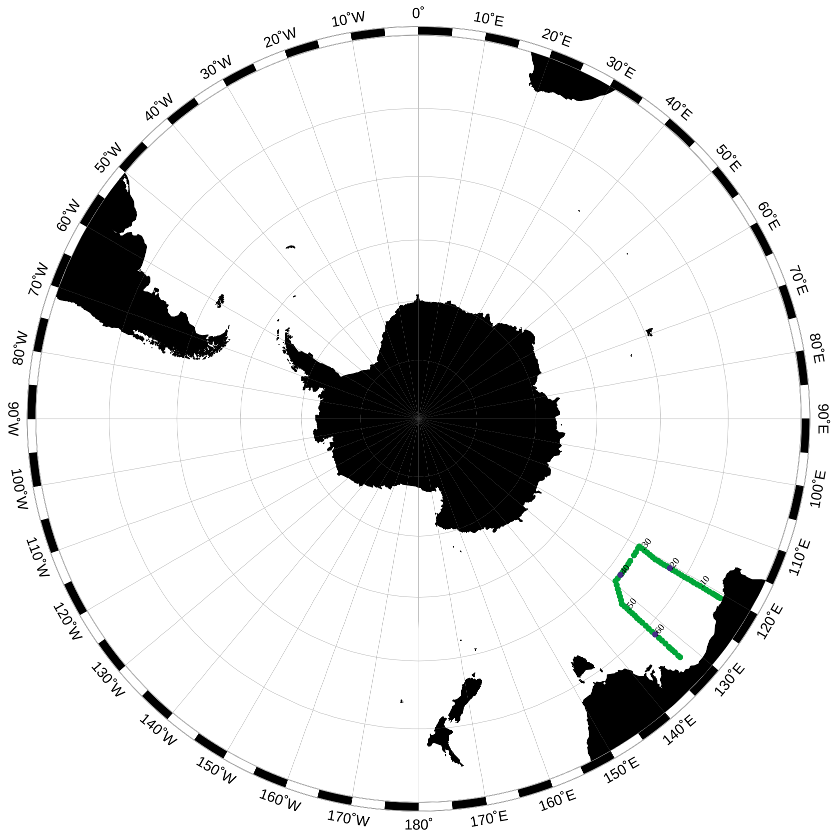
A. Cruise Narrative: **S05** (GREAT AUSTRALIAN BIGHT)



A.1. Highlights

WHP Cruise Summary Information

WOCE line designation	**S05**
Expedition designation (ExpoCode)	**09FA1094**
Chief scientist / affiliation	**Matthias Tomczak / FIAMS ***
Ship	RV Franklin
Cruise dates	1994 NOV.12 to 1994.DEC.05
Ports of call	Fremantle - Port Lincoln
Number of stations	69
Geographic boundaries	33° 51.32' S 119° 59.6' E 132° 20.18' E 48° 3.9' S
Floats and drifters deployed	0
Moorings deployed or recovered	0

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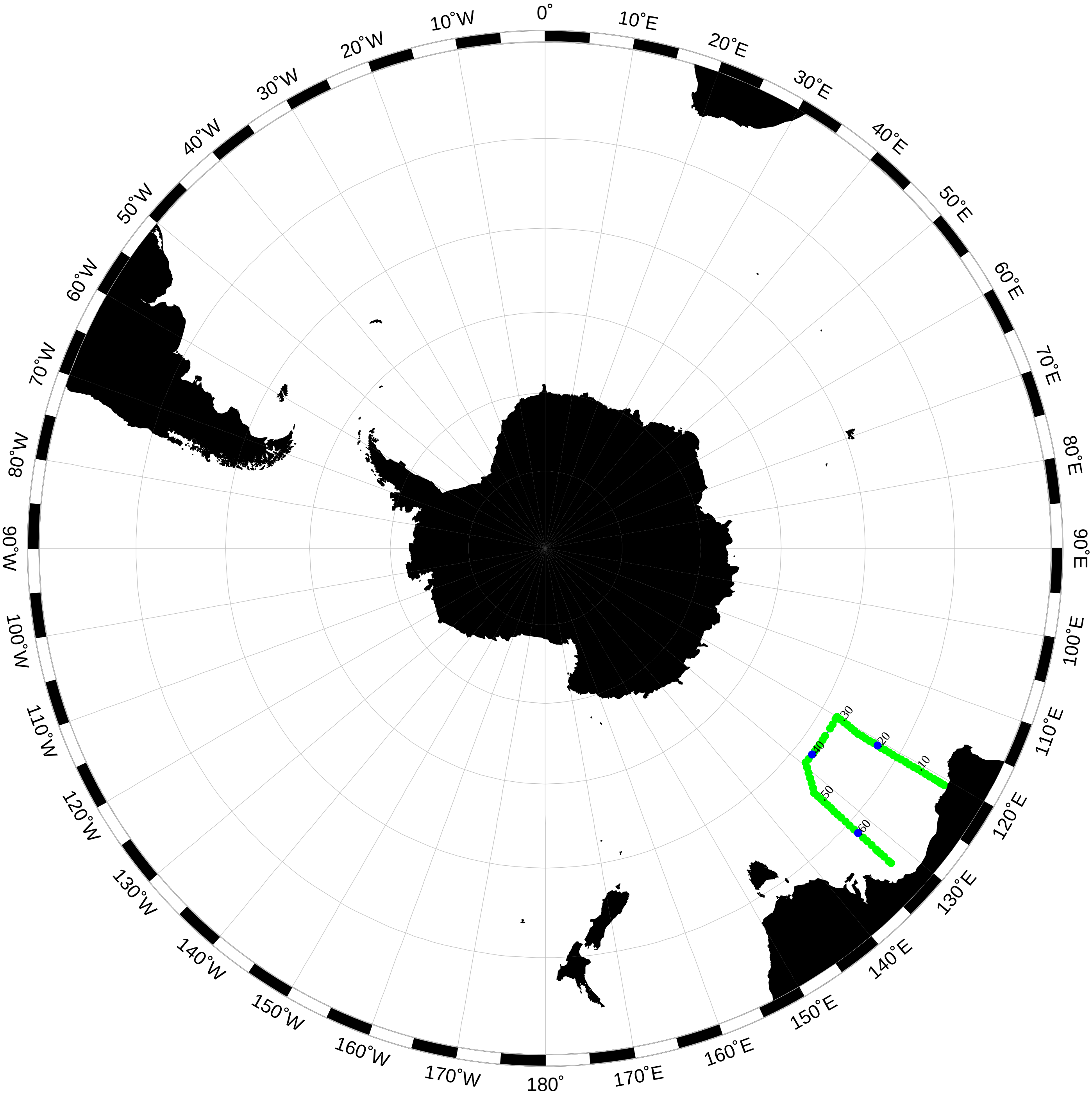
WHP Cruise and Data Information

Instructions: Click on any item to locate primary reference(s) or use navigation tools above.

Cruise Summary Information	**Hydrographic Measurements**
Description of scientific program	CTD measurements
Geographic boundaries of the survey	
Cruise track (WHPO) (FIAMS)	
Description of stations	
Description of parameters sampled	
Principal Investigators for all measurements	
Cruise Participants	
Problems and goals not achieved	
Other incidents of note	
Underway Data Information	**DQE Reports**
Navigation	
Acoustic Doppler Current Profiler (ADCP)	
Methodology and Calibrations	**References** **Acknowledgments**
Pressure calibration	ADCP
Temperature calibration	
Conductivity calibrations	**Data Processing Notes**

Station locations for S05



Produced from .sum file by WHPO-SIO

A.2. RESEARCH SUMMARY

Abstract :

This dataset contains the processed Hydrology (HYD) data collected on Franklin voyage FR 10/94. The voyage took place in the Great Australian Bight and the Southern Ocean during 12 November - 5 December 1994. This dataset has been processed and is archived within the CSIRO Marine Research Data Centre in Hobart. Additional information regarding this dataset is contained in the cruise report for this voyage and/or the data processing report (as available). Franklin on-voyage hydrology data are typically obtained from water samples collected in Niskin bottles at various depths during each CTD cast. Parameters measured normally comprise temperature, salinity, dissolved oxygen, phosphate, nitrate, silicate and nitrite.

Scientific Programme

To determine the movement of Antarctic Intermediate Water and Indian Central Water in the Great Australian Bight and possible exchange between the Pacific and Indian Oceans in the depth range of these water masses.

To investigate the flow of Antarctic Bottom Water through the Australian-Antarctic Discordance.

Cruise objectives

To complete three sections extending meridionally to 48°S along 120°42'E, zonally along 48°S to 132°E and meridionally along 132°E to form a closed box with the Australian south coast, with CTD/Rosette coverage from the surface to the bottom.

Narrative

RV Franklin left Victoria Quay, Fremantle, as planned at 6 a.m. on Saturday 12 November 1994. A summer high pressure system was moving into the Bight from the west, so winds were moderate, reducing to nearly calm conditions over the next few days. The vessel therefore made good speed, and we arrived at the first station at 2 a.m. on Monday 14/11. A pod of humpback whales was spotted on the way.

Problems and goals not achieved:
Most of Monday was spent running out the wire on the drum and spool it back on under tension. A first attempt at a location with 3000 m depth had to be abandoned because the wire rubbed on the A-frame when trailed behind the ship. The wire was then run out in 4000 m of water, with an angle of 45 - 50° pointing away from the ship. When it was brought up it became evident that a substantial length at the end was badly damaged and

had to be taken off the drum. This left about 5650 m of usable CTD wire, just enough to extend nearly all stations to the ocean floor as planned, missing the bottom by about 100 m at two stations.

A bottle test station on which all bottles were triggered in the salinity minimum at about 900 m depth to check for possible leaks was completed on late Monday. The first section (along 120°42'E) was started in good weather.

A weak front passed the region during Wednesday 16/11, followed by a large high pressure system. Progress with the section was therefore excellent over the next couple of days. The weather held out until Sunday 20/11, with winds of 10 - 20 knots from the southeast gradually turning southwesterly. By that time we had reached 47°S and passed the Subantarctic Front.

Other incidents of note:

The best aspect of the Southern Ocean is without doubt its wildlife. The ship is always accompanied by birds of all kind, from the size of a swallow to albatrosses nearly the size of a pelican. Seals pop up at CTD stations to check on our work, and on Sunday the ship was circled at close range by a pod of about 30 pilot whales. At the Subantarctic Front the water was full of long narrow creatures that looked like sea snakes but were fragile like salps. Patches of kelp were seen drifting by just to the north of the front. Squid, garfish and on one occasion a shark were also seen. The tropics are barren in comparison; during the voyage to Colombo earlier this year there were days when not a single bird could be seen.

Winds on Monday 2 1 /11 were westerly at 25 - 35 knots, causing the ship to roll heavily on its way to the last two stations of section 1. The section was completed without loss of a single station in the early hours of Tuesday 22/11.

Section 2 was dominated by a low pressure system that remained nearly stationary for several days. To everyone's surprise winds were strong northerlies, making the ship's eastward course much more awkward than anticipated. One CTD station had to be cancelled during the passage of a front which saw the thermometer drop to below 2°C. This was followed by fair weather in the centre of the low, where the barometer dropped to below 972 hPa. Station work proceeded well during this period, until increasing swell forced cancellation of a station despite moderate winds.

The pressure system eventually began moving east on Thursday 24/11, causing the wind to increase and turn to westerly. This lead to further cancellations. The night of Friday 25/11 and all of Saturday 26/11 was spent waiting for the winds and the swell to abate. The decision was then taken to terminate section 2 at 129°30'E and begin section 3 along a course of 35°, to meet the original track near 45°S.

Section 3 was begun on Sunday 27/11 and proceeded well in fair weather. To make up for lost time stations in the central part (the South Australian Basin) were spaced out from 30 to 37.5 mile distance. Work on the section continued in constantly improving weather conditions. The last station was completed on the early hours of Sunday 4/12. The passage to Port Lincoln was made in brilliant sunshine and calm seas. The ship arrived in Port Lincoln on the morning of Monday 5/12 as planned.

69 CTD stations were completed. The willing and expert assistance of the ship's officers and crew and of the CSIRO-ORV personnel made this cruise a great success.

Cruise track

The final cruise track with all station positions is shown in Figure 1.

Results

As an example of the data set, Figure 2 shows the meridional section of potential temperature along 120°E (section 1). The Subtropical Front (STF) was crossed between 39°30'S and 40°S (stations 14 and 15). As usual, the front is better seen in the salinity, and its narrowness is better appreciated from the continuous record of sea surface temperature and salinity obtained from the thermosalinogaph (not shown).

The Subantarctic Front (SAAF) was crossed between 45°S and 46°S (stations 25 - 27), though its surface expression was only reached towards the southern end of the section. Its position was evident from the geostrophic current, which showed a broad band of strong eastward currents between 45°S and 47°30'S reaching to 1000 m depth and below, with maximum velocities reaching 0.25 m s-1 at the surface associated with the front. In comparison, the geostrophic current associated with the Subtropical Front was weak, just exceeding 0.05 m s -1 and counteracted by westward flow on its southern side. Another region of deep reaching strong currents was seen close to the continental slope (stations 3 - 8). This is a region of intense eddy activity associated with current shear between the eastward flowing Leeuwin Current and the offshore circulation.

The permanent thermocline was dominated by a large volume of Subantarctic Mode Water with a temperature of 9 - 10°C. Water with these properties was found at the surface in a small region north of the Subantarctic Front.

Antarctic Intermediate Water was seen as a salinity minimum near the 1000 m level. The gradual erosion of the salinity minimum towards the north was interrupted by lenses of low salinity, suggesting that the AAIW circulation may not be uniform in space and time. This was supported by the patchy oxygen distribution at AAIW level.

Deep Water was seen near 2500 m in the south as a salinity maximum with highest salinity in the south, gradually decaying and sinking to 3000 m in the north. Its salinity and oxygen distribution both evolved slowly from south to north, so movement at Deep Water level is likely to be more uniform in space and time.

The presence of Bottom Water below 4500 m was indicated by potential temperatures below 0.5°C, about 0.2°C warmer than potential temperatures found in the Australian Antarctic Discordance on section 2.

Figure 3 shows the zonal section of potential temperature along 48°S (section 2). The SAAF was close to this latitude and appeared to oscillate between a more northward and more southward location. The crossings of the front dominated the section; contours were lifted upward as the front moved south and downward as it moved north. The frontal movement was seen in the geostrophic current, which showed current reversals through nearly the entire water column. Maximum surface velocities of .25 m s -1 northward and .35 m s -1 southward were in good agreement with the ship's acoustic Doppler current profiler (ADCP) which recorded currents up to 1.5 m s -1 to the north-east (60°) and about 1 m s-1 to the south-east (130°).

The GEBCO topography (Figure 4) identifies several fractures in the South Indian Ridge near 120°40'E and 128°E. None of these is shown as allowing passage of water below the 4000 m level. Section 2 is to the north of the sills and therefore shows depths greater than the sill depths, but it should capture all Bottom Water flowing across the sills. Figure 3 shows that no Bottom Water got through the major fracture near 120°40'E (station 32). The strongest indication for northward flow of Bottom Water was seen in a fracture near 123°40'E (station 37) where water colder than 0.4°C was found below 3800 m; near the bottom the potential temperature fell below OYC. Water with similar potential temperature was also seen to come from a fracture near 127°E (station 39), but in an apparently smaller amount.

The Subantarctic Front was to the south of section 2 when section 3 was commenced, so section 3 did not show a crossing of the SAAF. The Subtropical Front was crossed between 37°S and 38°S (stations 61 and 62), although surface water with properties derived from the frontal zone was seen as far south as 43°S (station 52). The location of the STF as far north as 37°30'S is surprising, considering that it passes to the south of Tasmania and thus has to shift southward by some 600 kin over a zonal distance of only 1100 km and that over the 900 km between sections 1 and 2 it shifted northward by some 200 km.

Subantarctic Mode Water was seen with a substantial volume in the 8 - 9°C range, ie colder than in section 1. In the temperature range 9 - 10°C it had much more surface contact than in section 1.

The distributions of Deep Water and Bottom Water resembled those seen in section 1 closely. Bottom Water temperatures were again about 0.2°C higher than those found near the Discordance in section 2.

Personnel

Ship's crew		
Ian Sneddon	Master	
Richard Dougal	Mate	
Ian Menzies	Second Mate	
Maxwell Cameron	Chief Engineer	
Lindsay Cale	Second Engineer	
Donald Roberts	Electrical Engineer	
Jannick Hansen	Bosun	
Ronald Carr	AB	
Ron Kelleher	AB	
John McNabe	AB	
Phillip French	Greaser	
Reg Purcell	Chief Steward	
Gary Hall	Chief Cook	
Melvin Dall	Second Cook	

Scientific party		
Matthias Tomczak	FIAMS	Chief Scientist
Colin Andrew	FIAMS	
Jarrad Exelby	FIAMS	
Michael Herzfeld	FIAMS	
Michael Schodlok	FIAMS	
Peter Strutton	FIAMS	
Neil White	CSIRO-ORV	Cruise Manager
Erik Madsen	CSIRO-ORV	
Ron Plaschke	CSIRO-ORV	
Mark Rayner	CSIRO-ORV	
Dave Terhell	CSIRO-ORV	

CTD Processing Notes Fr 10/94
(Neil White)

This cruise is part of the Australian contribution to WOCE and consisted of three deep sections in the southern Indian Ocean.

The cruise was carried out with CTD underwater unit number 2. There are 69 stations numbered 1-69.

The data is of reasonably good quality, but problems with salinometers and sample bottles have caused the salinity data to be less good than it ought to have been.

Of the three Yeokal salinometers on board (including one which had just returned from service) not one was properly functional. The most usable of the three salinometers had a broken thermistor, so sample temperatures had to be taken manually using a DSRT! While this apparently gave good results, there were a number of stations for which the salinities appeared to be anomalous - the salinities for a complete station would be different from the adjacent (and very nearly equivalent) stations. Uncalibrated CTD data for these groups of stations suggested that there were no changes in water properties, so data from stations 8, 21, 35, 43, 61 and 65 were rejected altogether.

The sampling bottles used were designed and constructed by CSIRO. They were first trialled in mid-1993 and some of the major problems fixed, but there are still problems. One bottle in particular produced clearly anomalous readings for about 40% of its samples! All data for the two worst bottles were rejected, but it is clear from the CTD calibration process that there were still a large number of bad samples.

These two factors combined to produce a salinity calibration that is not as good as I would like.

There are a small gaps in a few stations. Some of these were introduced when salinity spikes causing density inversions in the 2 decibar averages were removed. There are four gaps of 2 decibars or so, however, which have no plausible explanation other than loss of data for a second or so when the data was logged. This is being investigated. These gaps occur in regions of low gradients, so should not cause any problems. The largest gap of 10 decibars occurs near the bottom of station 50 where some sediment or other matter fouled the conductivity cell.

Pressure calibration

Constants from the last laboratory calibration were used but a new offset term was calculated for each station from the pressure of the first Ôin waterÕ data records. These offsets range from 4.1 to 5.8 decibars.

Temperature calibration

Temperature calibration constants from the last laboratory calibration were used.

Conductivity calibration

Many groupings were tried and a large number of samples had to be thrown out because of the salinometer and sample bottle problems. The best calibration seems to come from using the groups: 1-9, 10-23, 24-46, 47-48, 49-62, 63-69.

The standard deviation of the salinity residuals is .0036 psu.

Notes on ADCP data for Fr 10/94

1. Features of this voyage

GPS "SA" degradation (see section 2) was in force during this voyage, and GPS coverage was almost 100%. A RACAL Differential GPS system was being used on a trial basis. It provided data approximately 60% of the time, and this data was much more accurate than non-differential GPS. It was often virtually free of "SA" effects. Obviously, where possible the Differential GPS has been used in the final product.

There was no discernable heading dependant gyro error. However, there was an apparent variation in the alignment error throughout the voyage which may have arisen from a corresponding error in the gyro data. A time-varying correction has been applied, ranging from +0.2° to -0.6°.

Anomalies were detected at times which were characterised by a change in the current pro-file shape when the ship's velocity changed. These occurred in varying degrees and were associated with poor conditions, especially large following seas. Such events may have occurred before, but have never been detected. The only hypothesis for these events is that an acoustic interference is set up which biases the frequency shift toward lower values. As it appears to decay with depth, one would suppose it involves a passive use of the ping itself. The two most extreme cases were cut out of the dataset. Also, to reduce the likelihood of more subtle events corrupting the dataset, screening was tightened (especially RMS error velocity and percent-good).

1.1 Profiles integrated

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

- 172 20 minute profiles (11% of voyage covered).
- GPS corrected
- RACAL differential GPS profiles are identified by a 'cnav' value of " R". Ashtech non-differ-ential GPS used is denoted by 'cnav' values of "P" and "D". See Data Format Guide for details.
- 1529 20 minute profiles, of which 1039 were used solely Differential GPS (95% of voyage covered). Use the non-differential with care, if at all, for period when SA was active.
- 510 60 minute profiles, of which 346 used solely Differential GPS (95% coverage).

2. GPS data degraded by SA (Selective Availability)

The US Department of Defence, who operates the GPS satellites, has introduced deliberate complex errors into GPS data. It is generally considered that these errors cannot be removed without extra equipment and post processing (and even then cannot be achieved with deep ocean work.)

The characteristics of SA errors are probably changed from time to time, however they usu-ally seem to be across quite a wide time spectrum. Of most concern for ADCP data are the errors of order 50 cm/s over 5 to 10 minute periods. There also appears to be a smaller and lower frequency component, the worst case so far observed had a residual error of 6 cm/s after averaging an hour's data.

The implications for ADCP data are:

- Individual GPS corrected ensembles (3 minute or less) often have errors of around .5 m/s.
- The existence of such errors prohibits the use of some quality control measures, espe-cially of course dv/dt.
- 20 minute integrated profiles will usually have little extra error, maybe 1 or 2 cm/s. How-ever, at times low frequency components of SA may cause larger errors, up to 10 or 20 cm/s.
- 60 minute profiles will rarely have more than 1 or 2 cm/s extra error.
- Incomplete 20 minute profiles (low 'icover' percentage) are less reliable because they are probably incomplete due to a break in GPS coverage, and data adjacent gaps is usually of poorer quality. Also, the SA errors are less likely to have been removed by averaging.
- Bottom track, Transit and shear data are, of course, unaffected by this. When using GPS to get ship's position, these errors are negligible (200m or 300m at most).

3. Calculating the Bin Depth

The depth to the centre of bin j, in metres, is approximately:

depth(j) = draught + (plen + blen)/2 + delay + blen*(j-1) + blen/10

where:

draught - 4 m
blen - bin length
plen - pulse length
delay - delay after transmit (also known as DTFB - Depth To First Bin).

The depth bins are generated by the instrument using the assumption of a sound speed of 1475 m/s. The above approximation can therefore be refined by correcting for the approximate real sound speed, that is, by multiplying the above-derived depth by (estimated_real_sound_speed) / 1475. This sound speed estimate would be made by estimating the mean temperature, salinity and depth for the main study area.

4. Calibration

ADCP water profile vectors are calibrated by being rotated through an angle a and multiplied by scaling factor 1+b. The rotational calibration primarily corrects for misalignment of the transducer with respect to the ship, of the ship with respect to the gyro compass, and the error in the gyro compass. 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 .01 applied when the water velocity with respect to the ship is 6 m/s alters the measured absolute currents by 6 cm/s. Calibration is particularly difficult when the coefficients change with time, as appears to be the case on this voyage.

Results for this voyage:

1 + beta ~= 1.0135

Overall mean a ~ -0.2. However, time varying a effectively applied as a gyro cor-rection, ranging from -0.6 to +0.2.

5. Data Quality

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.

Accuracy of water velocity relative to the ship

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

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

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, independantly 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

> "Bias is typically of the order of 0.5 - 1.0 cm/s. This bias depends on a variety of factors including temperature, mean current speed, signal/noise ratio, beam geometry errors, etc. It is not yet possi-ble to measure ADCP bias and to calibrate or remove it in post-processing."

As well as that, there are the transducer alignment and gyro-compass errors, which probably have a residual effect after calibrating of roughly:

0.4 cm/s per m/s of ship speed, due to say 0.4 uncertainty in alignment angle
0.3 cm/s per m/s of ship speed, due to say 0.003 uncertainty in scaling factor

This gives us say 0.5 cm/s error per m/s of ship speed, or 3 cm/s at 12 knots.

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

GPS profiles

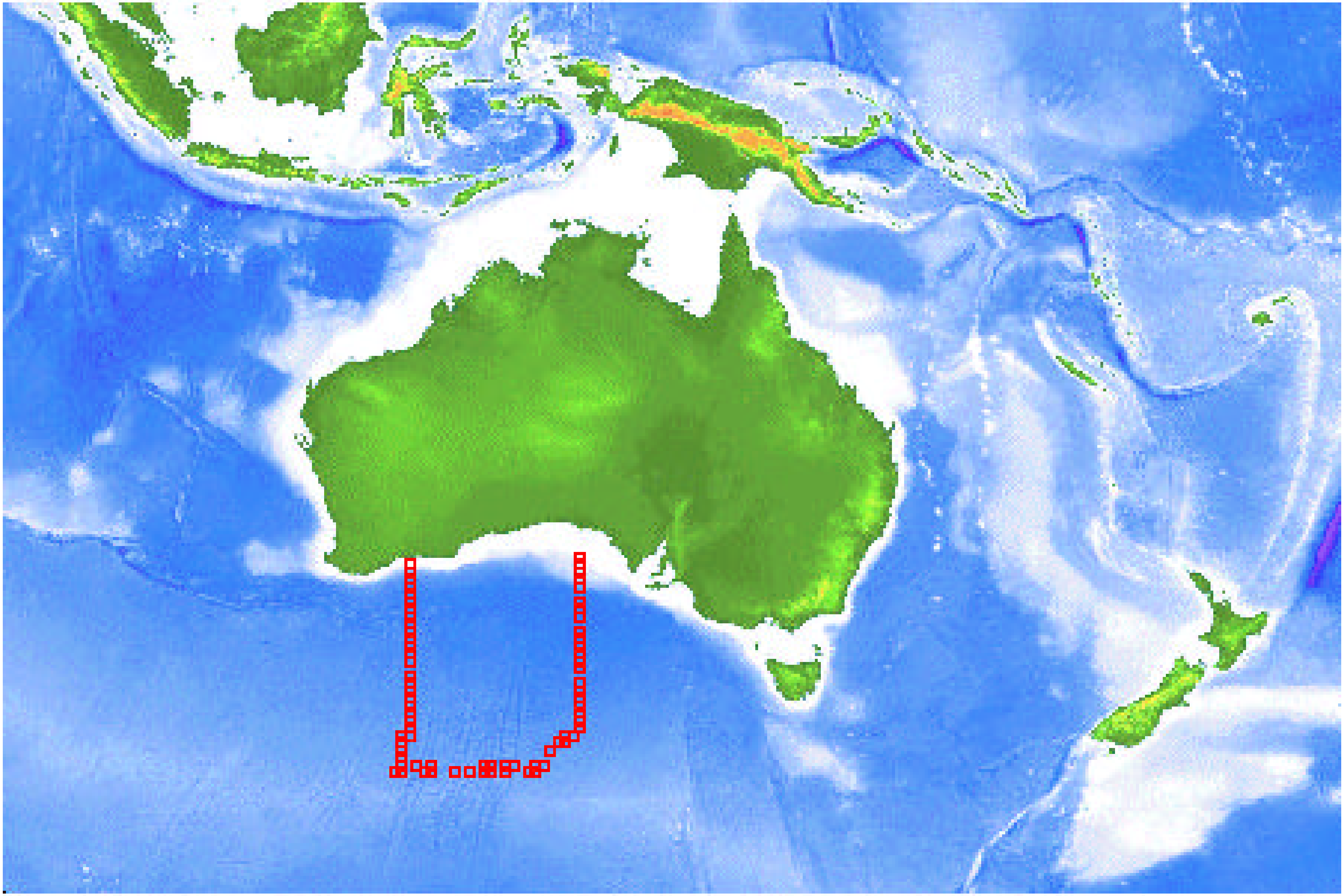
In the presence of SA, errors are larger and even very large errors cannot be removed by dv/dt screening (because this would bias the long term average - there is reason to assume that given a long enough period the SA error is close to zero).

Bottom track profiles

Firstly note that errors arising from transducer alignment and gyro 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 -3cm/s for a 20 minute profile.

References : Franklin National Facility (1994). Research Summary, Cruise FR 10/94. Miscellaneous Publication. CSIRO Division of Oceanography [for] Franklin National Facility, 8 pp.

Franklin November, 1994 Station Locations



Produced by CSIRO Division of Marine Research

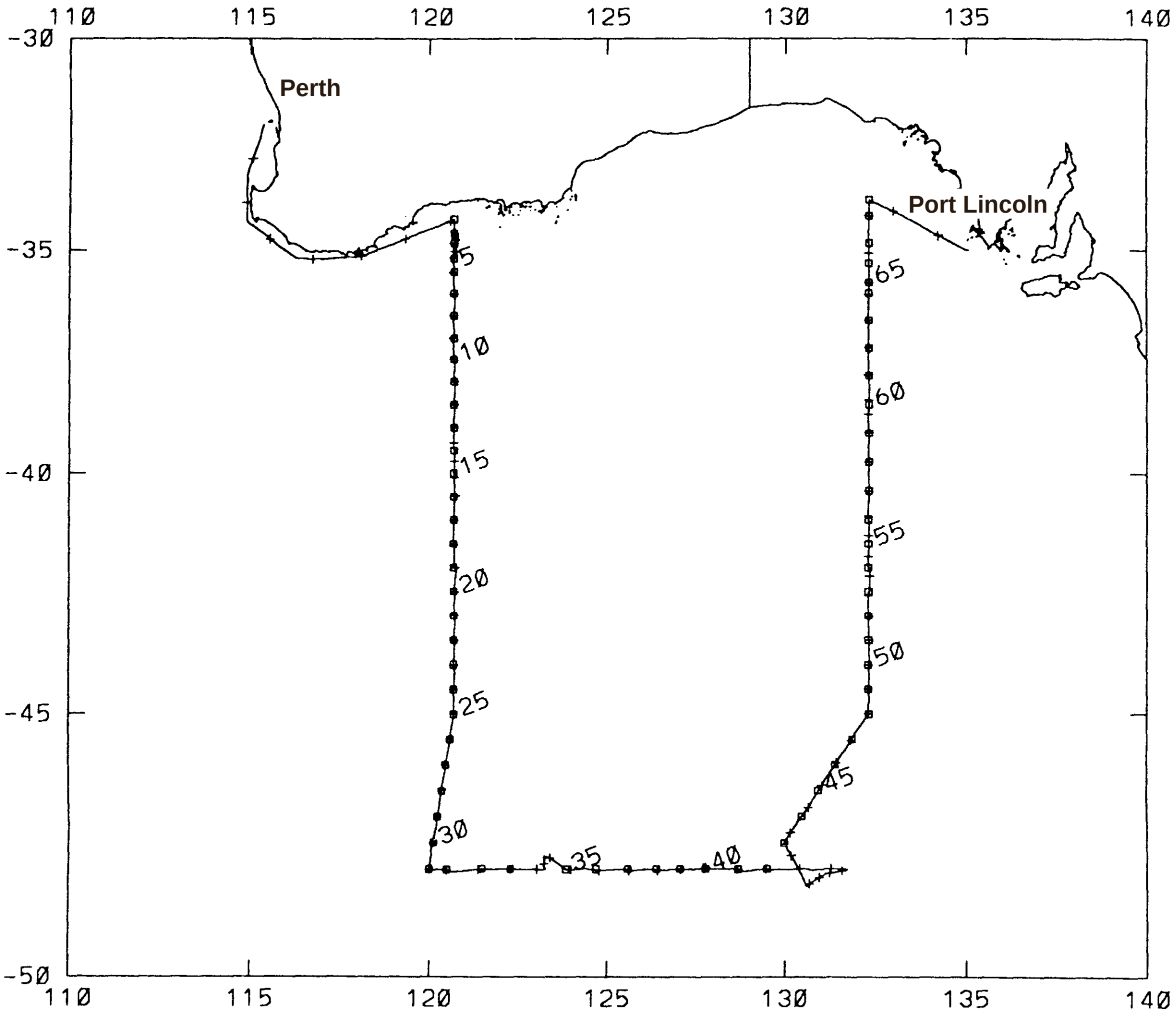


Figure 1: Cruise track and station positions of R/V Franklin voyage FR1O/94

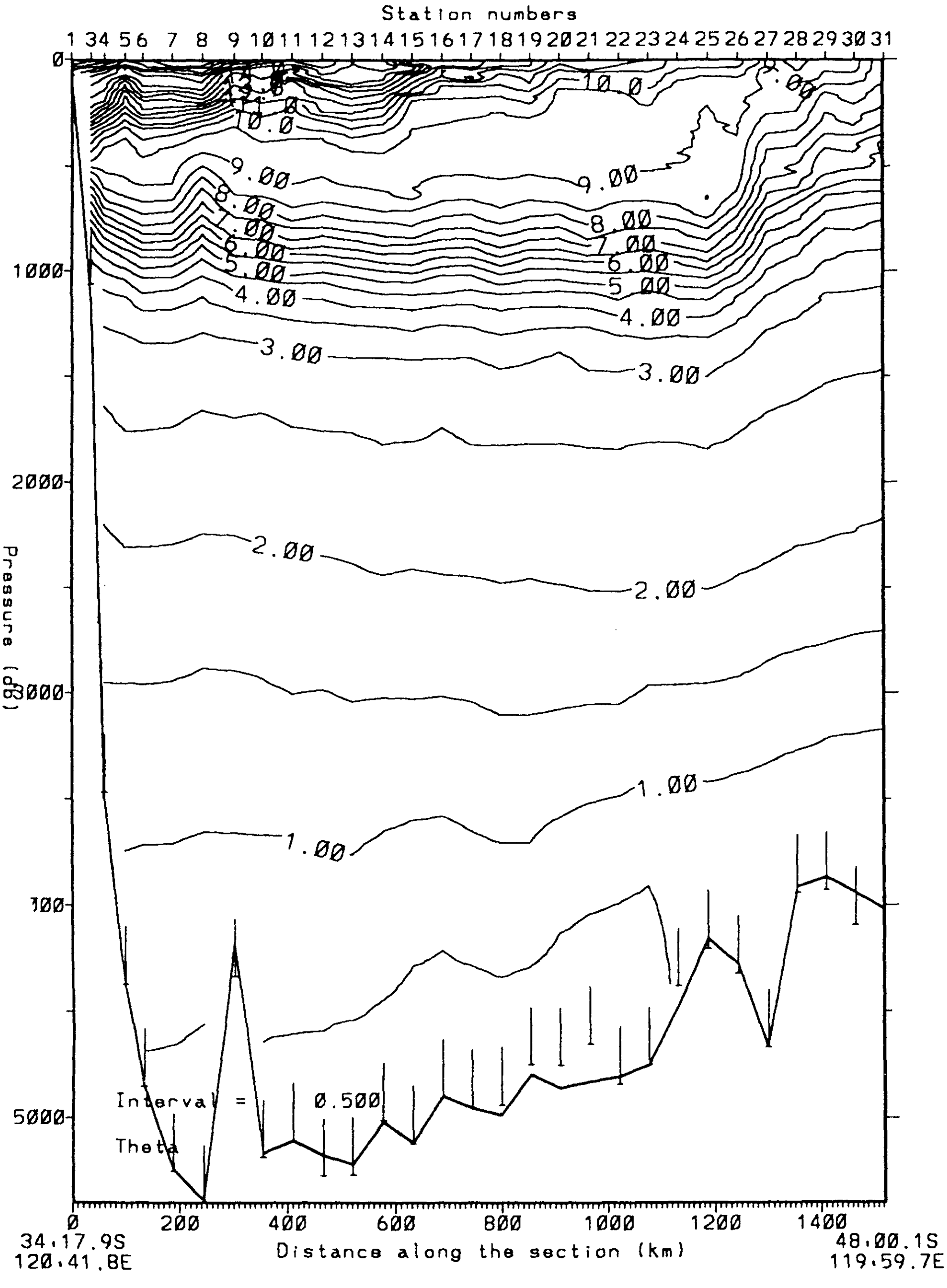


Figure 2: Potential temperature (°C) along section 1 (near 120°E).

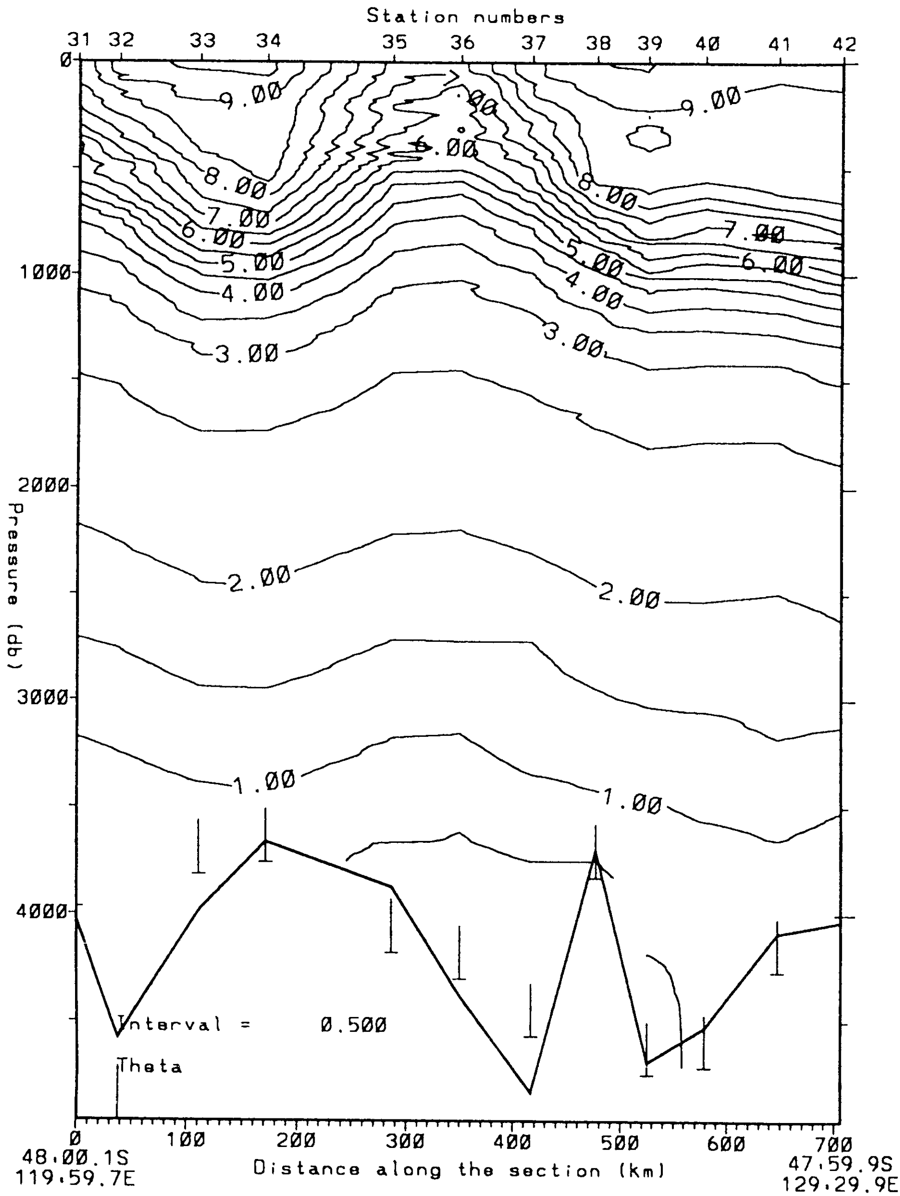


Figure 3: Potential temperature (°C) along section 2 (48°S).

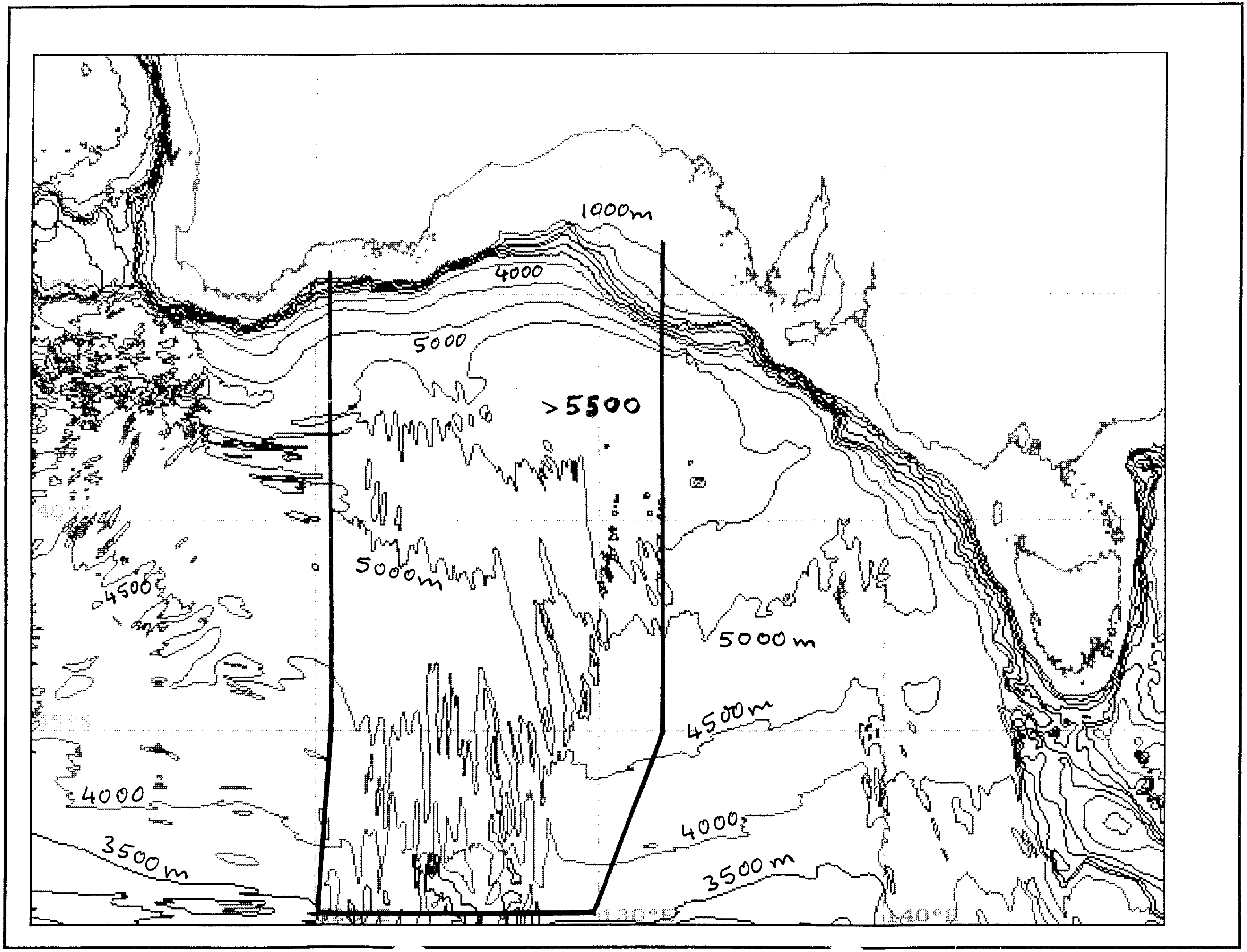


Figure 4: The GEBCO topography with the approximate cruise track.

WHPO Data Processing Notes

Date	Contact	Data Type	Data Status Summary
05/21/97	Lebedeva	CTD	Data Update; Unit Conversions Provided

1. WOCE section name.
   These sections were added to the WOCE section network on the initiative of M. Tomczak. They form a closed box from the Australian south coast along 120E to 48S, then along 48S to 132E, then along 132E to the Australian south coast. At the moment, these sections have no WOCE name/number, but I submitted the data files toWOCE as WOCE section I11 on the suggestion of Dr. Tomczak.
2. Unit conversion.
   Nitrate, silicate, phosphate, nitrite and bottle oxygen data have been converted from UMOL/L to UMOL/KG using the density calculated from P=0, T=17 C (lab temperature, according to Dave Terhell (CSIRO)) and bottle salinity. If salinity was missing for a particular bottle, the interpolated salinity was used for density calculations.

   CTD dissolved oxygen data have been converted from UMOL/L to UMOL/KG using the density calculated from in-situ P,T and S.

   To convert the data expressed in micromole/liter units to micromole/kilogram units I divided the former data by the density as expressed in kilograms/liter (same as gm/cm3).
3. Additional parameters in the __.CTD files.
   SDTEMP - Standard deviation of good temperature samples in the interval
   SDCOND - Standard deviation of good conductivity samples in the interval

Date	Contact	Data Type	Data Status Summary
08/25/97	Tomczak	CTD/BTL	Submitted for DQE
06/01/99	Tomczak	CTD/BTL	Website Updated; Data Public

Please remove the encryption from the data set obtained by R/V Franklin during cruise FR10/94.

Date	Contact	Data Type	Data Status Summary
02/29/00	Bartolacci	CTD/BTL/SUM	Website Updated; Expocode changed

I have changed all occurrances of expodec 09FR10/94 in all a05 files (except doc) to 09FA1094 and updated all tables.

Date	Contact	Data Type	Data Status Summary
06/21/01	Uribe	CTD/BTL	Website Updated with New Exchange File

Updated CTD and bottle exchange files were put online.

Date	Contact	Data Type	Data Status Summary
08/21/01	Uribe	Line designation changed from I11 to S05	

Exchange File Updated:
It was determined by Jerry and Danie that the sumfile should be modified from i11 to s05 to fit format in bottle and ctd files. Bottle was re-run through exchange, new file is online.

Date	Contact	Data Type	Data Status Summary
12/26/01	Uribe	CTD	Exchange File Generated, OnLine

CTD has been converted to exchange using the new code and put online.

Date	Contact	Data Type	Data Status Summary
01/03/02	Hajrasuliha	CTD	Internal "DQE" completed

generated *check.txt file.

12/17/02	Kappa	DOC	Cruise Report Updated/OnLine

Added:

Cruise Summary Information
- Abstract
- Geographic Boundaries
- Cruise Narrative
- Scientific Program
- Cruise Objective
- Results
- Scientific Party and Ship Crew lists

ADCP Information
- References

WHPO Data Processing Notes

PDF file with all the above plus:
- Cruise Track and various figures
- Map of Station Locations
- Internal (PDF) links