RESEARCH SUMMARY

Cruise FR 8/95

Repeat Hydrographic Sections between Australia and Indonesia

1.0 Scientific Objectives

- To observe the seasonal variation of the Indonesian through flow and the associated changes in hydrographic structure and regional currents
- To assess the representativeness of the once-off, basin-wide WOCE hydrographic survey in relation to annual and inter-annual variations.
- To assess the consistency of estimates of the volume transport of the currents and the distribution of chemical tracers using inverse methods.

Principal Investigators.
Dr. S. Wijffels, Dr. G. Meyers, Dr. G. Cresswell, Dr. S. Godfrey
CSIRO Division of Oceanography, Hobart

Dr. Bambung Herunadi and Muhummad Ilyas
BPPT, Jakarta

Prof. M. Tomczak
Flinders Institute for Atmospheric and Marine Sciences, Adelaide

2.0 Cruise Narrative

All times are Australian Western Standard Time.

13.9.95 Franklin departs Fremantle at 1000. At this time we have no word from the Indonesian Government whether Franklin will be allowed to work in Indonesia's Exclusive Economic Zone (EEZ). However, provision has been made to pick up an Indonesian security officer from Christmas Island around September 28 should permission be granted.

Problems arose getting the ADCP up and running, and so we turned north on the shelf to stay inshore of the Leeuwin Current. Once the ADCP was logging satisfactorily we headed northwest to cross the shelf and slope, commencing an ADCP and XBT survey of the Leeuwin Current, similar to the survey done in

April on FR3/95. XBTs were dropped on the hour every hour as we made our way north to the site of the first test cast off the Abrolhos Islands.

14.9.95 A test cast was done off the Abrolhos in about 1500m of water with the newly-collared small diameter 3L CSIRO Niskins. Gary Meyers (Chief Scientist) had received news that his mother was gravely ill and decided he must leave the ship in Geraldton. We arrive off the Geraldton breakwater at 1600. Gary departed Franklin on the pilot boat. Wijffels takes role as chief scientist with Bob Beattie agreeing to act as cruise manager. We head offshore again, commencing XBTs in 50m of water near the shelf break.

15.9.95 Results of our first test cast look bad but are ambiguous, as the salinity minimum appeared to have a lot of fine structure. A second test cast was made. Both crew and ORV staff were not happy to see the large rosette (fits 5L Niskins bottles) put into action, considering it to be cumbersome and possibly dangerous in rough weather. During the night the ORV staff worked on repairing the 3L bottles. The Niskins were pressurized with compressed air and then submerged in water in the wet lab's sink (Helmond's idea). Many and various problems were found: loose rubbers, leaks at the glue joints in the end caps, leaking spigots and leaking glue joints at the new collars. Results suggest little testing was carried out on these Niskins before they were sent out to the ship. XBT survey continues.

16.9.95 We started again with a revamped set of bottles approaching the first cast in the Shark Bay section (station #3). All the bottles were fired at the same depth to check performance. Spikes in CTD data noted and solved when Dave Edwards checked the winch slip rings. Bottle results of station 3 are good (standard deviation of bottle-CTD salts = +/- 0.002psu excluding four obvious leakers). I decide to stay with small rosette, using 5L bottles to replace leakers where necessary and with Helmond fixing bottle problems as we go e.g. gluing joints, replacing end caps etc. Niskin Bottle Log started (attached). The log is based on reports by the CTD watches of visibly leaking bottles, as well as on daily inspection of the salinity residuals (CTD - bottle salts) produced by the hydrology personnel.

17.9.95 Working inshore on Shark Bay section, weeding leakers (via Niskin Log) off the rosette and replacing them with 5L bottles used on FR3/95. Conductivity cell calibration seems stable.

18.9.95 Bottle results are still not good. Ian Helmond continues to fix 3L bottles as we go.

We receive our first message concerning clearance to enter Indonesian EEZ: Bambung Herunadi of BPPT suggests that the Indonesian Institute of Science (LIPI) will not be able to vet our cruise in time. M. Ilyas of BPPT who is aboard, sends a fax to his superior, Dr. Indroyono, requesting information on the status of Franklin.

19.9.95 CSIRO 3L bottles continue to give bad results - more and more 5L bottles are put onto small rosette.

20.9.95 Message forwarded by Dave Vaudrey from Australian Embassy in Indonesia: a positive result for Franklin's clearance anticipated.

23.9.95 Finished station 42, the last of WOCE station before starting 3 days of SEASOR work in the water mass front near 15°S. SEASOR work begins with Karstenson and Carvalos at the reigns.

Several problems had arisen with the CTD:

1. Dissolved oxygen noted to be bad on station 41, and found to be bad DO temperature which had given out on the upcast of 40. Decided to do station 42 with the bad probe and then carry out surgery on the CTD while SEASOR work was underway. Anticipate that DO temperature from previous casts might be substituted for corrupted casts or proxy DO temperature derived from the *in situ* temperature.

2. 3L bottle performance continues to degrade with use and we have reached point where there will be no more space for 5L replacements. Decide to switch to large rosette and 5L Niskin set.

24.9.95 Second day of SEASOR survey steaming south along the WOCE line. All seems to be running well, after some initial adjustments.

During SEASOR work, ships crew use the crane to lower the large rosette down to the main deck. CTD 8 was opened up and DO temperature probe replaced. CTD 8 was set up in the large rosette. Of the 3L bottles, 5 seemed to perform well and these were moved to the large rosette. The rosette was then filled with 5L bottles from the hold (a mix of GO and CSIRO made Niskins).

Optimistic fax from Dave Vaudrey arrives regarding clearance. Worked up a cruise plan complying with BPPT's suggested way-points along the coast of Java, and fax it back to Dave.

25.9.95 Begin series of shallow casts every 8nm returning northwards along the WOCE line, resampling the region surveyed by SEASOR. On the first of these the dissolved oxygen was still bad. This turned out to be an error in the calibration file - easily solved, though not easily spotted. Cast restarted.

Halfway back where the WOCE line was interrupted, a second 13 hour SEASOR survey was done perpendicular to the WOCE track. Resumed shallow CTDs at 8nm spacing heading north along the WOCE line.

26.9.95 Resumed WOCE section with station 59. Worked our way northwards to Christmas Island without event. We encountered very strong westward currents north of 13°S. Large rosette has not been a problem from the safety or handling aspect.

28.9.95 Off Christmas Island. Used up about 4 hours prior to meeting pilot with some SEASOR development tests. Spent day at Christmas Island - welcome respite. Let off FIAMS personnel (Carvalos and Karstenson) and Mark Raymer, while welcomed aboard Lidia Pigot and Bob Griffiths. At 1700 we drop the mooring and head north to the next WOCE station.

Still no news yet on clearance from Indonesia. The possibility still exists of getting clearance while we are within range of Christmas Island.

30.9.95 At northern most limit of Australian EEZ around Christmas Island. No news from Indonesia. Started work on a line that with take us east to Ashmore Reef south of Timor. Data from 5L Niskins is showing excellent results. A few random leakers, but overall much better. We have done several 6000db (CTD limit) casts at edge of the Java Trench during which the wire tension went to over 50% of cable breaking strength. No problems were encountered. Weather has been calm.

1.10.95 Station work continues eastward with little event.

4.10.95 Today is the deadline for the option of steaming back to Christmas Island to collect an Indonesian Security officer. Dave Vaudrey rang to say that there was still no answer from Indonesia. He suggested one last attempt to get permission through Minister Habibi, and reported that Division of Oceanography was prepared to grant the needed extra day of ship time should permission come tomorrow. We continue to work eastwards.

5.10.95 No word from Hobart or Jakarta.

6.10.95 Dave Vaudrey rang to say that they have had no success in extracting an answer from Jakarta. We decide that it is too late to press further. The South Java Current escapes sampling again!

9.10.95 Station 104: climbing broad shelf-slope towards Ashmore Reef. Schools of tuna around us.

10.10.95 Finished first occupation of Ashmore Shelf section. Steam out to 2000m along line to start section occupation, aiming for 18 hour time difference between occupations to realize opposite phases of the semi-diurnal tide. Full moon a few days ago.

11.10.95 Second occupation of Ashmore section completed. Finished last CTD station (#120) in ~150m of water 3nm off the reef. Deployed SEASOAR in late afternoon for testing new large wing panels. SEASOAR towed along WOCE line as CTD data suggest several strong salt fingering layers in the thermocline near Ashmore.

12.10.95 SEASOAR work continues through early morning. We then began our transit to Darwin. SEASOAR was again deployed for a few hours in shallow water for testing the bottom avoidance system.

14.10.95 Arrive in Darwin at 0800.

3.0 Results

A second occupation of the WOCE IR6 hydrographic section between Western Australia and the southern boundary of the Indonesian territorial waters (roughly 9^{o} N) has been completed. Due with-holding of permission by Indonesia to enter their territorial waters, the section could not be extended up to the coast of Java as originally planned. The section was closed off instead at Ashmore Reef on the Australian continental shelf south of Timor. A total of 120 hydrographic stations were made (Figure 1), all of which were to full depth except for the 12 casts associated with the 3 days of SEASOAR work by FIAMS. Two occupations of the shelf and slope were made at each end point.

In contrast to the conditions observed in April, we encountered much stronger currents at the northern end of the section in the South Equatorial Current (Figure 2). Preliminary transport calculations show that relative to 2000db, the SEC is transporting roughly 65Sv between 14 and 9°S (Figure 3). Some of this water is presumably supplied by both the Throughflow and the South Java Current. Relative to 2000db, the net transport into the region enclosed by the section is

around only 2Sv. The repeat shelf occupation 18hours apart off Ashmore Reef shows considerable internal tides: over 50m in main thermocline.

A second opportunistic XBT/ADCP survey of the Leeuwin Current was also completed. Comparison with satellite images taken a few days before the cruise revealed good qualitative agreement between the ADCP vectors and the positions of strong meanders of the current. This data, along with the survey done in April, give two synoptic current and temperature field in the Leeuwin Current which will be used to examine whether the several offshore meanders of the current core coincide with a loss of heat by the boundary flow.

4.0 Recommendations/Comments

- The 3L Niskins were problematic once again, which was a disappointment. I recommend that if wire tensions permit, the large 24 bottle rosette using the 5L bottles be accepted and maintained as the working 24 bottle system aboard Franklin. Based on data taken during this cruise, we should soon have an answer on whether the large rosette is safe to use in heavy seas (a major concern of the ship's crew). If not, the 3L bottles should be either replaced or given a thorough going over. The 3L set should then be given both laboratory testing and at sea tests e.g. the 3L bottles could be used on a few casts at the beginning of a cruise to check their performance. Until they perform well the large rosette and 5L bottles need to be maintained as the working system.
- The state of the Niskins should be tracked and repairs should be made as necessary. A Niskin bottle log should also be kept, saving us wasted effort and bad data: on both this cruise and FR9503, we spent the first two weeks sorting through the bottles before we had a reliable set of 24. It would have helped knowing in advance which were known leakers.
- During this cruise, the hydrology personnel produced plots of CTD - bottle salt residuals on a daily basis which was immensely useful for tracking both the bottle performance and the health of the conductivity probe. With the appropriate software in place, this important task could be made routine and easy for the hydrology staff.
- A second temperature channel would be a nice redundancy to have and would mean we could do away with those thermometers.
- Having MATLAB available was a tremendous help.
- The SEASOR appeared to work very well.
- I'm looking forward to having e-mail fully operational on the ship.

5.0 Personnel

Scientific Personnel

Susan Wijffels	CSIRO DO	Chief Scientist
Bob Beattie	CSIRO ORV	Cruise Manager

Dave Edwards	CSIRO ORV
Lindsay Pender	CSIRO ORV
Ian Helmond	CSIRO ORV
Bob Griffiths	CSIRO ORV
Val Latham	CSIRO ORV
Alison Featherstone	CSIRO ORV
Lydia Pigot	CSIRO DO
Muhummad Ilyas	BPPT, Jakarta, Indonesia
Johannes Karstenson	Flinders University of South Australia
Oldemar Carvalos, Jr.	Flinders University of South Australia

Ship's Company

Neil Cheshire (Master)	Dick Dougal	Ian Menzies
Michael Culpeper	Lindsay Cale	Don Roberts
Gary Hall	Peter Day	John Tilley
Jannik Hanson	Norm Marsh	SaiWo Wang
Wayne Browning	Sam McCafferty	

6.0 Acknowledgements

Thanks go firstly to the crew of Franklin for their cheerful and patient approach to this rather tedious work. Many thanks also to Dave Vaudrey from CSIRO and Mr. Don Scott-Kemis of the Australian Embassy in Jakarta for all their efforts in trying to gain security clearance from the Indonesian government for Franklin. Thanks also go to Dr. Basri Gani and Bambung Herunadi from BPPT, Jakarta who also made efforts to find out the fate of our clearance application. Lastly many thanks to the folks who collected the data and who can now sample Niskin bottles in their sleep.

SeaSoar Section in the Hydrographic Front at 15°S in the Indian Ocean

Prof. M. Tomczak, Oldemar Carvalos, Johannes Karstenson
Flinders Institute for Atmospheric and Marine Sciences, Adelaide

The purpose of the FIAMS SEASOAR experiment was a high resolution transect through the front between the throughflow water from the Indonesian Seas and the Indian Central water. This data set should allow the deduction of typical water mass interleaving and intrusion scales. The experiment was separated into three steps:

- Making a SEASOAR section across the front.
- CTD/rosette samples at this section.
- The CTD/rosette sampling was interrupted for an extra SEASOAR section, perpendicular to the track.

1.0 Narrative

The FIAMS experiment was mainly located along the WOCE track. We started FIAMS SEASOAR work on the 23.9. 1995 at 16.00 local time for 26.5 hours and got data covering 5 WOCE stations (120 nm). The CSIRO SEASOAR technical team (L. Pender and I. Helmond) work over 30 hours without sleep for this !!!!! The vertical resolution was in the range of 150 - 450 dbar. On the 24.9.1995 at 21.00 we started with 16 stations CTD/rosette sampling with a 15 m vertical resolution and 8 nm horizontal resolution. The section started with problems with the oxygen sensor and it was replaced after station 43. The rosette had 24 Niskin bottles, we took 24 nutrient samples, 6 oxygen and 6 salinity samples at each station. At station 51 the CTD station work stopped for a second SEASOAR section perpendicular to the WOCE track. This was done at a location where a main frontal feature was deduced by the shipboard analyses of the first SEASOAR section to get a three dimensional view of the front. The conductivity sensors of the SEASOAR show different values at this section. By doing the calibration after the measurement we couldn't find evidence for this difference.

2.0 Results

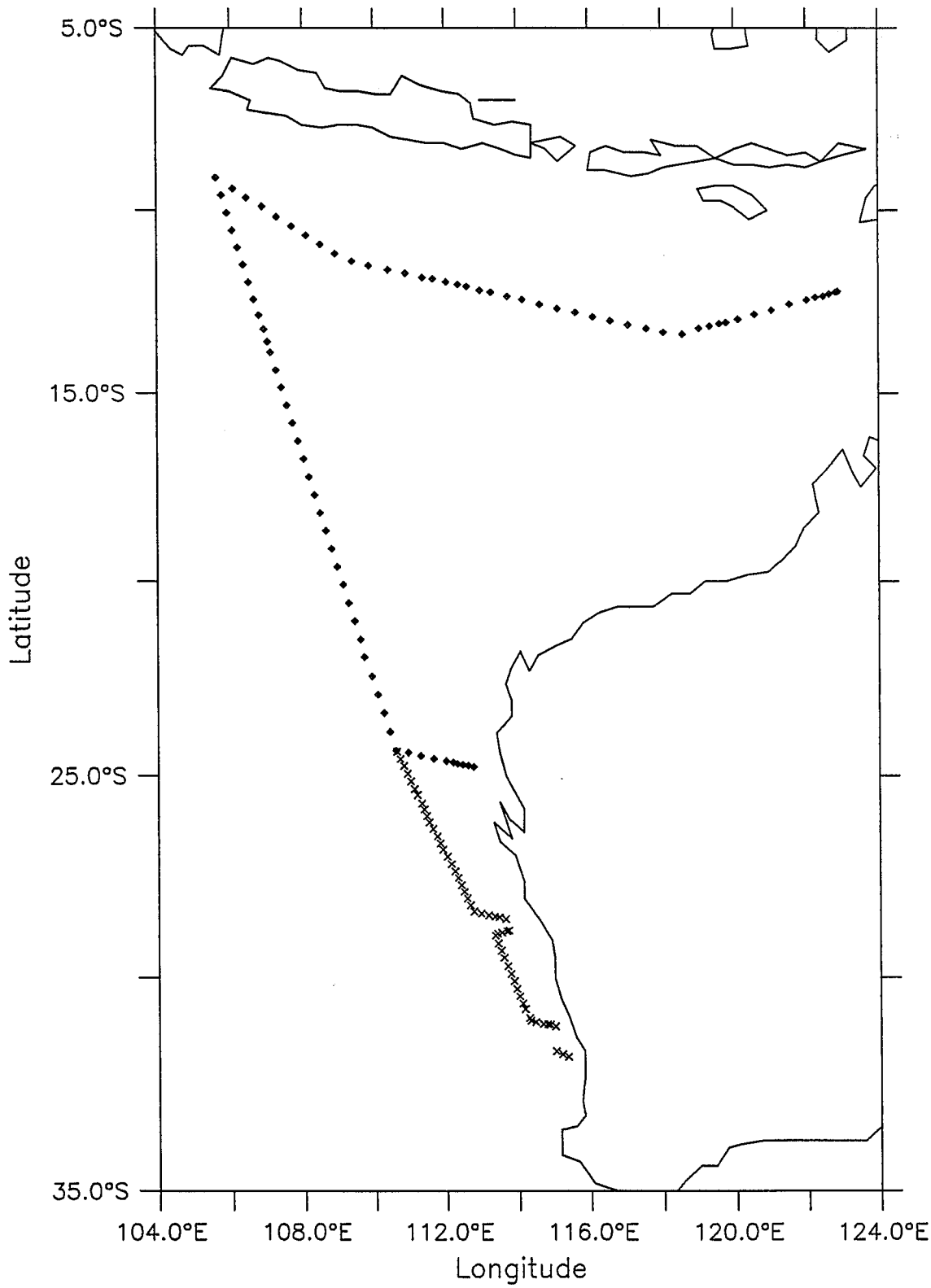
The T/S diagram of the first SEASOAR section shows that the mixing zone between the two water masses is well resolved. There is evidence for preferred

mixing paths at the front which is expressed in bands of T/S values perpendicular to the isopycnal and regions were no T/S value is found.

Calculations of the stability ratio for the data shows two zones with evidence for diapycnal mixing separated by a band between 300 and 350 m with less activity.

3.0 Acknowledgements

Thanks to the people from CSIRO and the crew of the RV FRANKLIN for their patience and help.



x - XBT
◆ - CTD

Figure 1

Corrected Currents [ny] at 15m

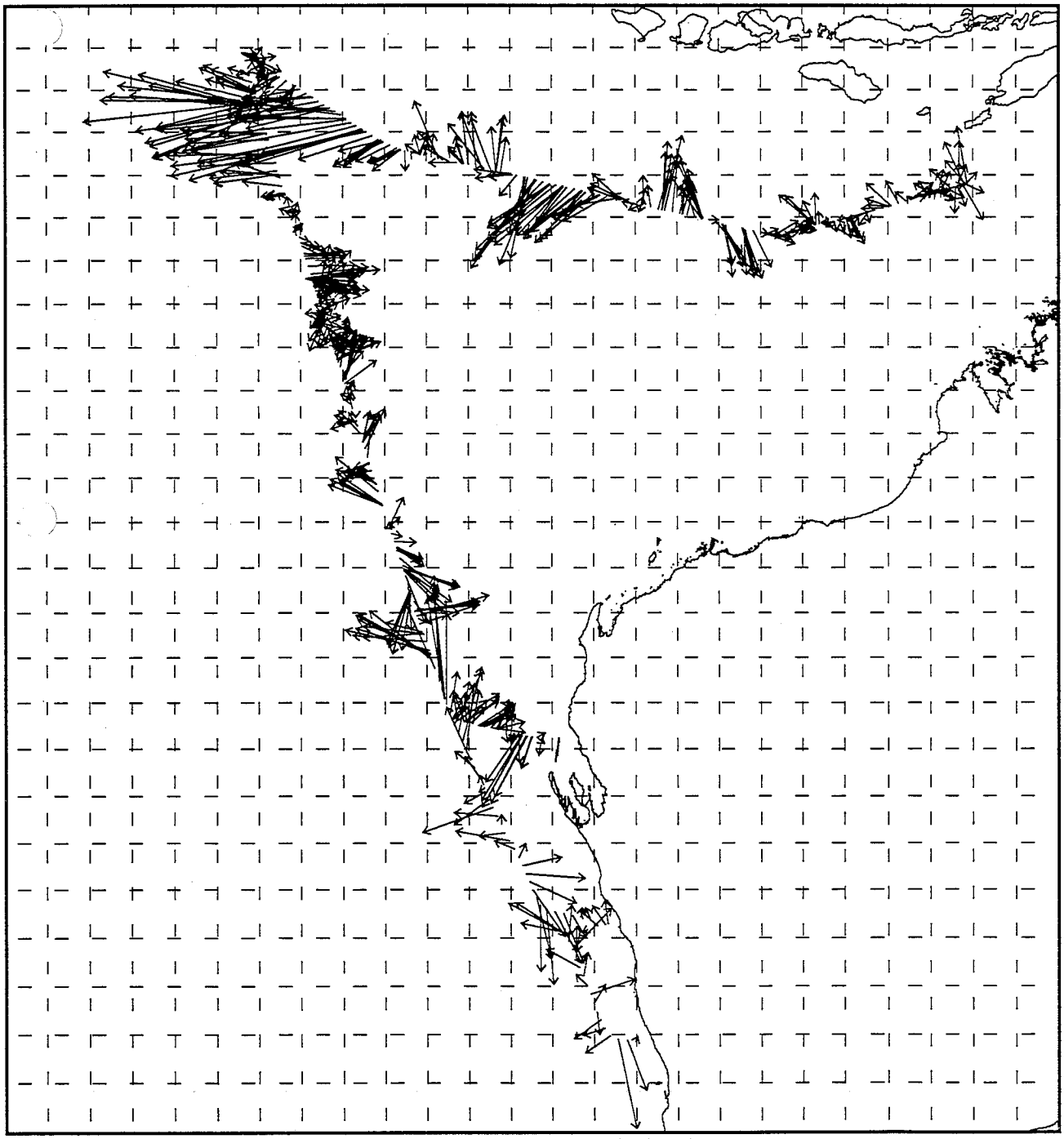


Figure 2

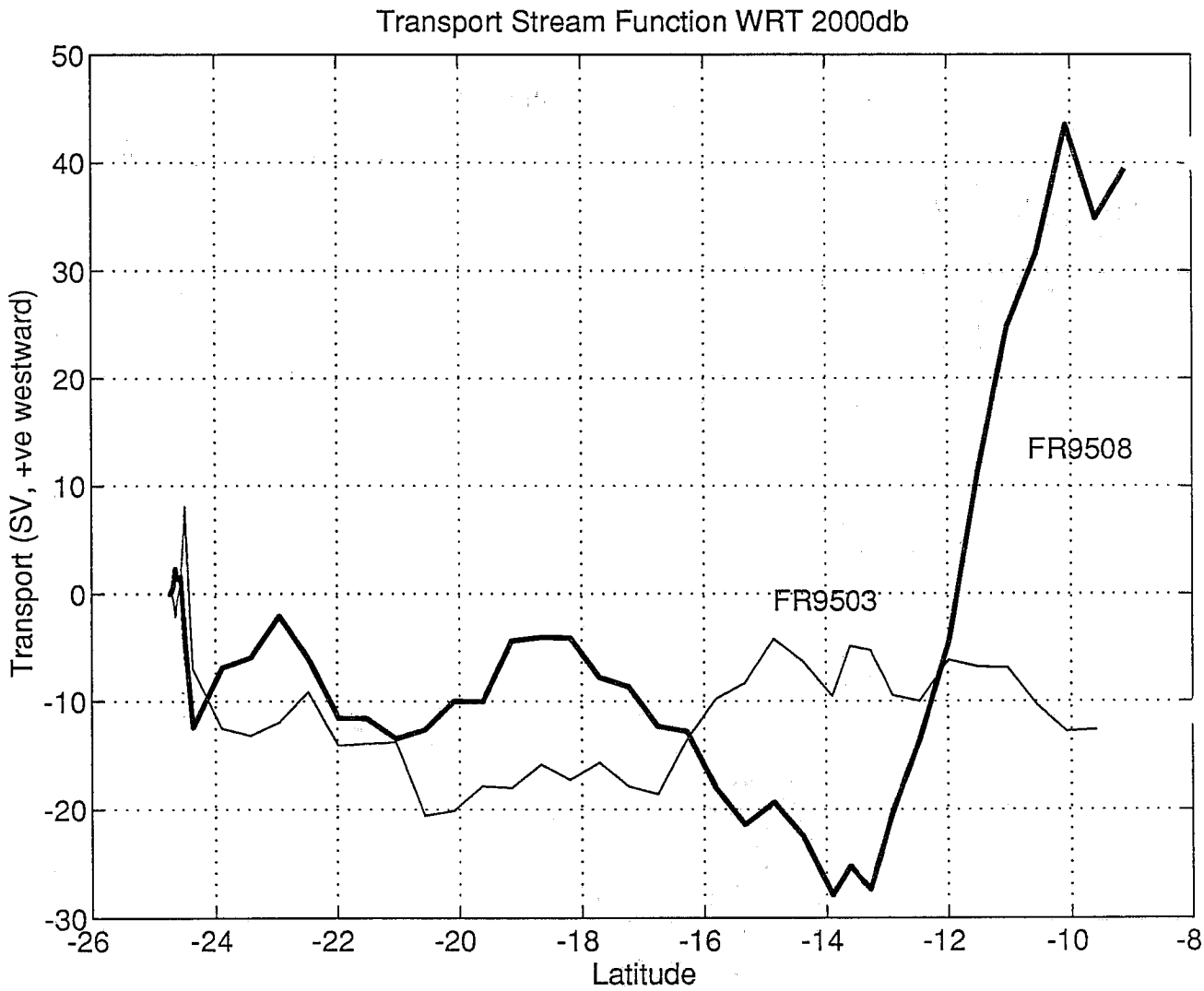
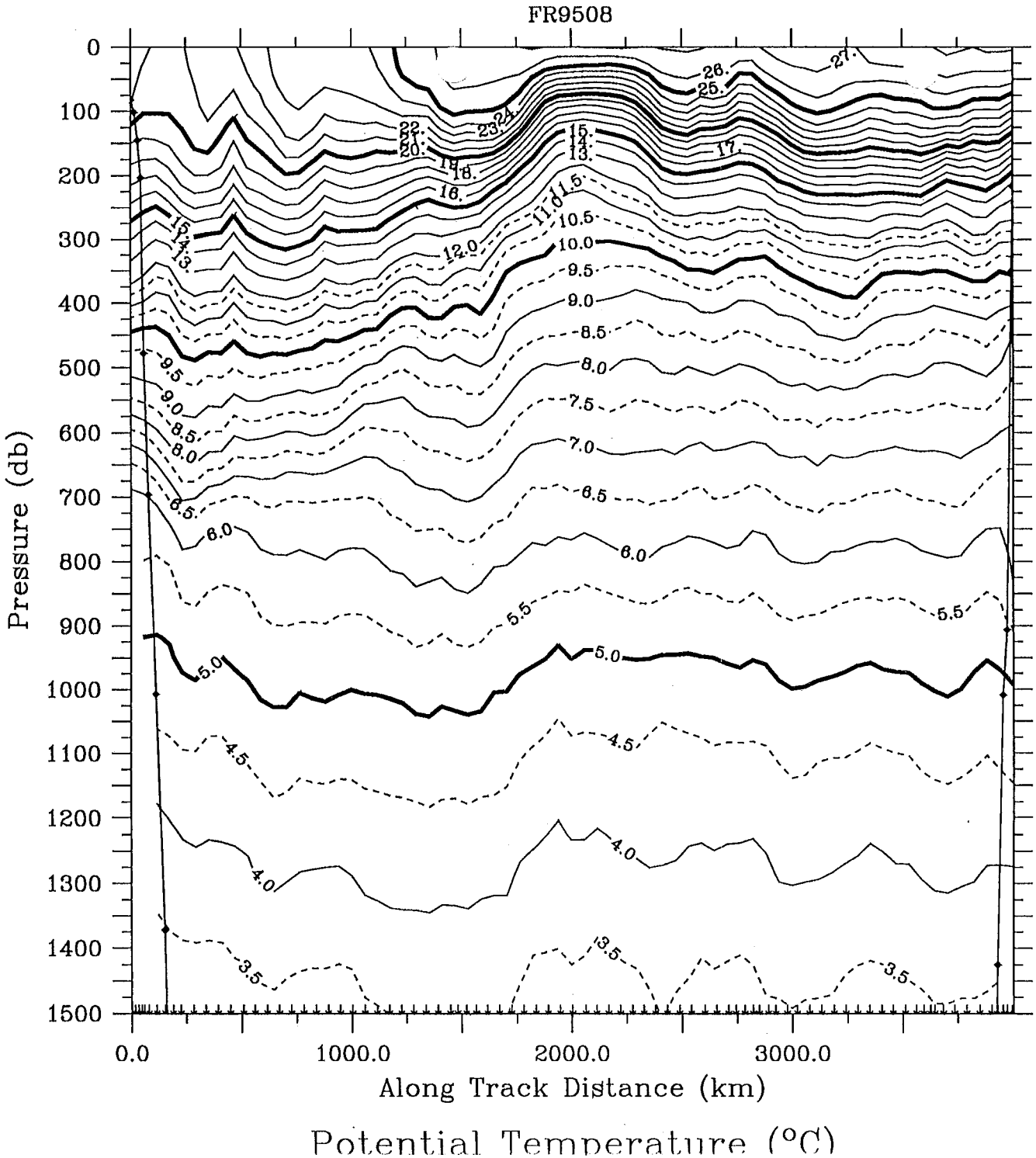

Transport Stream Function WRT 2000db
Transport (SV, +ve westward)
Latitude
FR9508
FR9503
50
40
30
20
10
0
-10
-20
-30
-26
-24
-22
-20
-18
-16
-14
-12
-10
-8

Figure 3


FR9508
Pressure (db)
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
0.0
1000.0
2000.0
3000.0
Along Track Distance (km)
Potential Temperature (°C)