FRANKLIN

National Facility
Oceanographic Research Vessel

RESEARCH SUMMARY

FR 08/94

Sailed Fremantle	1230 Tuesday	23 August 1994
Arrived Colombo	1100 Thursday	14 September 1994

OCEAN TRANSPORT IN THE LEEUWIN CURRENT AND IN THE EQUATORIAL INDIAN OCEAN

Principal Investigators

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Dr A White
Flinders Institute for Atmospheric and Marine Sciences

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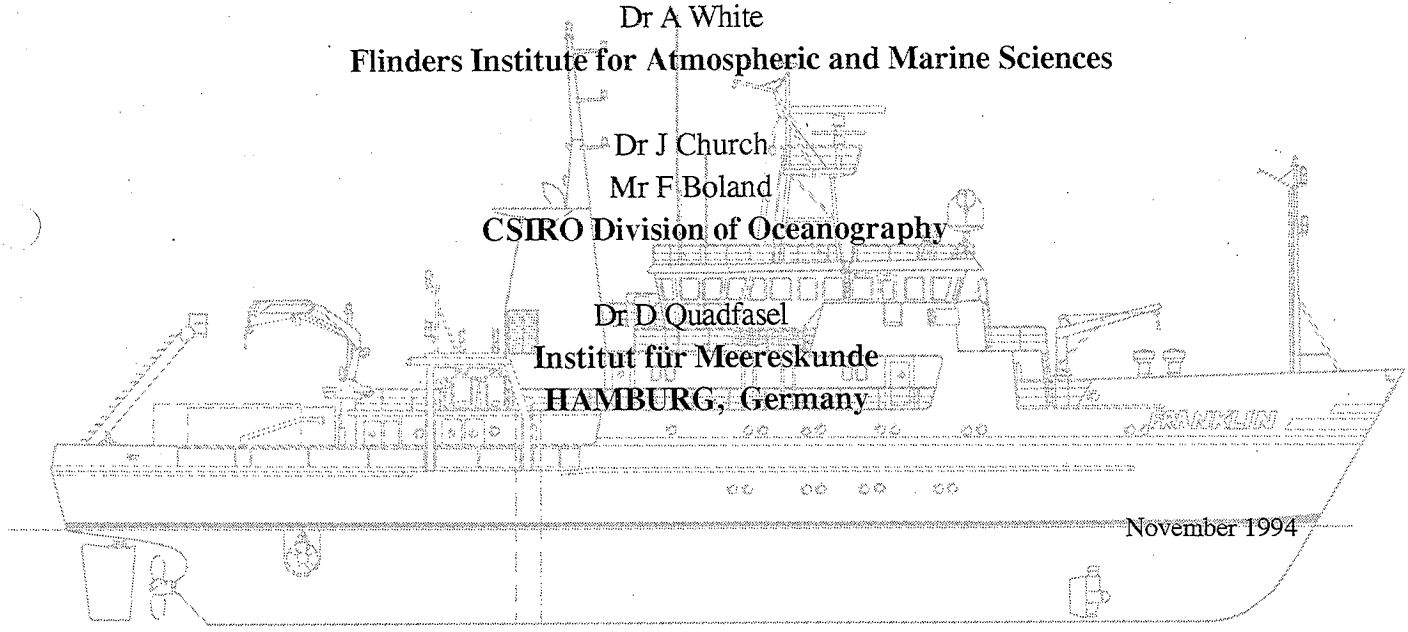

November 1994

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AUSTRALIA

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Itinerary

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Principal Investigators

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Scientific Programme

To determine the seasonal variability of the Leeuwin Current near 20°S and thus the variability in southward oceanic heat flux near north-western Australia, by measuring the current's transport and water mass characteristics using current meters (an Australian contribution to WOCE).

To measure the transport in the equatorial current system at 80°E using current meters.

To determine the depth averaged water velocity in the Leeuwin Current near 20°S by measuring the magnetic and electric field fluctuations associated with it, using ocean floor magnetometers and electrometers.

R/V Franklin voyage FR08/94

CRUISE SUMMARY

Narrative

The ship was informed of an accident in the familiy of the electicial engineer that required a change to the crew list at short notice. The new engineer could not arrive in Perth before Tuesday morning. As a result, our departure was delayed from 23/8/94 0800 h to 1230 h. We then set course north towards the location of WOCE mooring line ICM6, initially keeping on the shelf but in the evening seeking the shelf edge to locate the Leeuwin Current and ascertain its strength.

A test station in the Leeuwin Current was scheduled for 24/8/94 1300 h just north west of the Abrolhos Islands in 600 m of water. Two ADCPs were tested, and a magnetometer from the Australian National University was used on the hydrowire to produce a profile of the current. The CTD was tested in 1250 m of water, with all 24 bottles triggered at the depth of the salinity minimum near 900 m.

Two whales, probably sei whales, were sighted off Shark Bay. More whales were seen along the Australian coast during the following days.

The first mooring (A) was deployed on Friday 26/8/94 at 0700 h, followed by moorings B - D during the same day. The training ship *Leeuwin II* passed within less than a mile on her way from Darwin to Fremantle while we were deploying mooring B. She could be seen for the rest of the day, becalmed and waiting for wind while we had perfect conditions for our mooring deployments.

Mooring D was deployed by 16.00 h, leaving enough time to deploy one of the two magnetometers from Flinders University (Dr. A. White) during daylight.

A CTD section along the line of moorings was done during the night., while the second magnetometer was prepared for deployment. It was deployed later that evening. The CTD section continued during the night. We arrived at the position for mooring E in the early morning hours of Saturday 27/8/94. The remainder of the CTD section was then completed in between the deployment of moorings E and F.

After completion of the CTD section the ship proceeded to 14°S, 80° 30'E, the southern end of our working area in the equatorial current system and more than six sailing days away. Along the track is a region with depths around 6500 m near 17°50'S, 101°50'E where we planned to spool the CTD wire off the drum and wind in on properly again. This position was reached after more than two days sailing on Tuesday 30/8/94 at 06.00h.

Having successfully completed the CTD wire spooling we set course in the afternoon to 14°S, 80°30'E, the southern end of the planned meridional CTD section and a distance of 5 days sailing. We arrived just before Sunday 04/9/94 and began a section of CTD stations every 30 miles with simulataneous Pegasus stations every 120 miles. Pegasus drops were determined by the locations of the transponders, which were placed along 80° 30'E in 1991 and 1993 and located at 14°S with 2 degree spacing to 5° 47'N. Pegasus drop depth was 2000 m initially and to the bottom from 4°S northward. CTD station depth was 1000 m; CTD stations coinciding with Pegasus drops were to 2000 m. The northernmost Pegasus transponders were known not to work any more, so the northernmost Pegasus station was scheduled for 5°N.

Recovery of the moorings along 80° 30'E began on the morning of Friday 09/9/94. Winds were very light, about 5 - 8 knots, currents were northward,with some light easterly swell. A turtle was seen inspecting Pegasus at close range as it came up just before the first mooring recovery. The releases of the first mooring refused to respond to interrogation but released the mooring anyway, and recovery was no problem. This pattern continued with the other moorings.

Several small buoys were sighted on arrival at the 2°N mooring site before the mooring was released. They were part of some long line gear entangled with the mooring.

All moorings came up at the first attempt to release them, and recovery posed no problems. The extra day scheduled for unforeseen difficulties was therefore not needed, and R/V *Franklin* arrived in Colombo 20 hours ahead of schedule on Wednesday 14/9 at 11.00 h.

General comments

It took some experience to set Pegasus up properly. The station at 14°S reached some 1750 m drop depth. No data were recorded at the 12°S station. Only one transponder responded at the 10°S station. The instrument worked well at all following stations.

The CTD wire was again badly layered after the first station. It is now clear that the drum is too wide for the spooling gear to work properly. An attempt to rectify this by adding a layer of plywood on both sides was unsuccessful, apparently because the plywood did not match the wire thickness. This ruled out deep stations for this cruise and has to be rectified before cruise FR10/94 in November.

A power failure on the afternoon of Monday 13/9 caused a shut down of all computers. All systems were initialized again. The ADCP could not be started again. Efforts to locate the fault were unsuccessful.

The data processing and display set-up is a big improvement over the pre-Unix days. A few additions would make it even more useful for data analysis and monitoring cruise progress. I offer some suggestions in the appendix.

The ADCP processing and display programmes available on the system differed from those described in the cruise utilities manual. The assistence of the cruise manager was required to use them.

As a regular user of R/V *Fraklin* I have become used to the excellent support from the crew and from the National Facility support staff; but this should not mean that it should go unnoted. The cooperation from the master, officers and engineers, the outstanding seamanship of the deck crew, the excellent food were again a big help for achieving the aims of the cruise, as was the dedicated technical and computing support from the CSIRO.

Summary

depart Fremantle	23/8/94	12.30 h
CTD and ADCP test, magnetic profile near Abrolhos Is.	24/8/94	13.00 h
arrive western end of ICM6 line	25/8/94	20.00 h
finish CTD stations on ICM6 line, eastern end	26/8/94	07.00 h
deploy moorings A - D	26/8/94	
deploy moorings E - F	27/8/94	
arrive at 17° 49.15'S, 101° 51.15'E for CTD wire spooling	30/8/94	06.00 h
arrive at 14°S, 80°30'E, start of CTD/Pegasus section	03/9/94	23.30 h
arrive at first 80° mooring location (00° 45'S, 80° 30' E)	09/9/94	04.00 h
complete last mooring recovery	13/9/94	09.00 h
complete last CTD station	14/9/94	01.00 h
arrive Colombo	14/9/94	11.00 h

Number of moorings deployed (ICM6)	6
Number of moorings recoverd along 80° 30'E	6
Number of CTD stations	59
number of Pegasus stations	13

Note: All times are local times: Western Australian (UTC + 8h) from 23/8 to 29/8 24.00 h, Western Australian - 1 hour (UTC + 7 h) from 30/8 00.00 h to 2/9 24.00 h, Western Australian - 2 hours (UTC + 6 h) from 3/9 00.00 h to 11/9 24.00 h, Sri Lanka time (UTC + 5h 30min) from 12/9 00.00 h to arrival in Colombo.

Cruise participants

Crew

Ian Sneddon	Master
Dick Dougal	Chief Officer
Ian Menzies	Second Mate
Max Cameron	Chief Engineer
Don Roberts	Second Engineer
Lazlo Polgardi	Electrical Engineer
Jannik Hansen	Bosun
Bluey Hughes	AB
Norman Marsh	AB
Ron Carr	AB
Phillip French	Greaser
Reg Percell	Chief Steward
Gary Hall	Chief Cook
Nat Dall	Second Cook

Scientific party

Matthias Tomczak	FIAMS	Chief Scientist
Anthony White	FIAMS	Geophysics
Gert Johannson	FIAMS	Mooring technician
David Vaudrey	CSIRO	Cruise manager
Phil Adams	CSIRO	Electronics technician
Bob Griffiths	CSIRO	Hydrology technician
Fred Boland	CSIRO	Group leader, ICM6 moorings
Kevin Miller	CSIRO	Mooring technician
Danny MacLaughlan	CSIRO	Mooring technician
Detlef Quadfasel	IFM Hamburg	Group leader, 80°E moorings
Jörg Reppin	IFM Kiel	Scientist
Uwe Papenburg	IFM Kiel	Mooring technician

Preliminary results

The CTD section (see attached figures) showed a distinct frontal boundary between Indian Central Water and Australasian Mediterranean Water in the south, followed by much interleaving in the 150 - 500 m depth range and a more gradual transition towards the low oxygen Indian Central Water of the northern hemisphere. The layering and interleaving was clearly seen in the nutrients which, sampled at 25 - 50 m depth interval, allowed delineation of most intrusions. The data set obtained during the cruise offers the best nutrient resolution of upper ocean water masses in the equatorial Indian Ocean available to the present day. It will be used for a detailed water mass analysis based on the optimum multiparameter method.

The ADCP records from the 80°E moorings show a remarkably strong eastward current in the 50 - 150 m depth range on the equator. It has the appearance of the equatorial undercurrent usually observed during the Northeast Monsoon season (December - April). As the cruise is in the Southwest Monsoon season, currents at the surface are also eastward, so the undercurrent is seen as a subsurface current maximum. It can be clearly identified in the temperature section by the fanning out of the isotherms in the thermocline at the equator (1550 km from the beginning of the section) and in the salinity by a high salinity core at the depth of the current maximum. The ADCP records from the mooring show that the undercurrent was absent during the Southwest Monsoon season of 1993; currents at the equator during August 1994 are completely different from the situation found in August 1993.

Appendix: Some comments on R/V *Franklin*'s scientific research facilities

1. CTD profiles and property-property plots.

It should be possible to analyze successive profiles, TS-diagrams etc. by comparing them one by one, for example by highlighting selected profiles in a plot that contains many profiles or by shifting successive profiles in the plot. Station profiles should allow display of only part of the total station depth. They should at least use total cast depth, not actual bottom depth, for the vertical axis dimension. The present setup does not include nutrients sections. Analysis of nutrient sections in parallel with CTD sections is a logical tool of regional oceanography.

The bench mark for this type of analysis is OceanAtlas on Macintosh, which allows synchronized displays and detailed analysis of sections, property-property diagrams and profiles, including extraction (enlargement) of parts of the diagrams. OceanAtlas is installed in the SE30 in the general laboratory but of limited use since it requires a colour monitor to be fully effective and it requires a data link with the CTD hydrodata files.

My suggestion is to purchase a basic colour Mac and install it in the computer room and to write software to provide the CTD and hydrology data in a form that they can be used by OceanAtlas. The cost involved is less than $4,000 plus the time to write and test the software. The software task is relatively trivial. FIAMS has experience with OceanAtlas and can assist if required.

2. CTD sections

The existing cruise utility for sections is well thought out and user friendly but based on contouring routines that do not use the full potential of NCAR Graphics on colour terminals. Interpretation of sections could be much easier, particularly in cases such as oxygen and salinity where inversions, local minima and maxima are common, if the sections were rendered in colour. I see two alternatives:

Option A: NCAR Graphics has powerful colour facilities. It should be possible to upgrade the utility programme to the use of colour. The drawback is that NCAR Graphics requires extensive programming before it does a neat job. This option is therefore only feasible if the programming support is available.

Option B: Several software companies offer excellent and extremely user friendly software for colour image presentation. FIAMS has experience with Transform from Spyglass. It comes at an attractive price (US$1200 or less) and allows the user to display sections and change them interactively with virtually no learning time. Colleagues who know Matlab and tried Transform at FIAMS say that Transform beats Matlab hands down when it comes to ease of use and data display. In addition to the display of data provided by the ship's systems, Transform also allows on-line data manipulation (such as calculation of density from T and S, calculation of heat content of a water column etc.); the user can write Fortran or C code directly and interactively see the result. Transform reads data in virtually any format and requires nearly no new data manipulation software before it can be used. It took me only three hours to find out how to transfer the nutrient data to the Mac SE30 and produce the enclosed contoured sections on the minuscule black and white screen. The same product on the large colour Unix terminals would have been an excellent analysis tool.

I suggest that R/V *Franklin* purchase a single user Unix license of Transform from Spyglass to complement the existing cruise utilities. This option requires an outlay of up to US$1200 plus about 3 hours of programming to interface the data files with Transform. FIAMS can again assist with the programming requirements.

Transform is also available for Macintosh. I installed it on the SE30, where it produced the enclosed printer output but refused to save files and crashed frequently. The reason is that Transform is designed for colour Macs, and using it on the SE30 stretches that computer's capabilities. If my suggestion to install a colour Mac is accepted, FIAMS can offer a trial period for Transform by supplying the Macintosh version for a limited time without licence. (The Unix version is licenced to specific sites and not transferable.) If after six months or so the ship's users support the availability of Transform on the FIAMS copy should then be replaced by a licenced copy.

3. GEBCO topography

The GEBCO charts are now available on CD-ROM. The CD-ROM contains the data files for depth and data coverage (survey tracks) and for topographic features and comes with display software. The displays give colour coded depth contours and on demand an overlay of the survey tracks on which the information is based. They give the most accurate bottom topography and allow the user to judge the reliability of the depth contours by checking the survey track density. This makes GEBCO superior to the presently used ETOPO5 data set, which gives interpolated depth at 5' intervals without information on reliability.

I suggest that GEBCO on CD-ROM be made available for R/V *Franklin*. Since the software is for PCs this requires purchase and installation of a PC with CR-ROM reader. The price of the GEBCO CD-ROM is about $500.

Some savings may be possible if the installation of OceanAtlas and GEBCO are combined. My understanding is that there is a PC equivalent for OceanAtlas called Atlast, written by and available from Peter Rhines of the University of Washington. FIAMS does not have experience with Atlast.

4. The library

The *Franklin* library is badly stocked and of very limited use for scientific work. The ship's cruises are getting longer on average and opportunities to do work on board would exist if a basic collection of reference books were available. A decision should be made whether to provide the library with a basic collection of research books or abandon the concept of a scientific library and make its use as just another recreation room official.

The random collection of old journal issues should go back to a library on land. If journals are to be kept on the ship a system should be considered were the latest issues of selected journals could be on loan for 3 - 6 months before they are returned to land.

A welcome addition to the library would be a set of *Nature* or *Science*. These journals do not have to be up to date. The CSIRO Marine Laboratories library could send 3-5 months old issues to the ship and exchange them regularly. This would require a system that guarantees proper handling of the journals on board, which could be organized without any doubt.

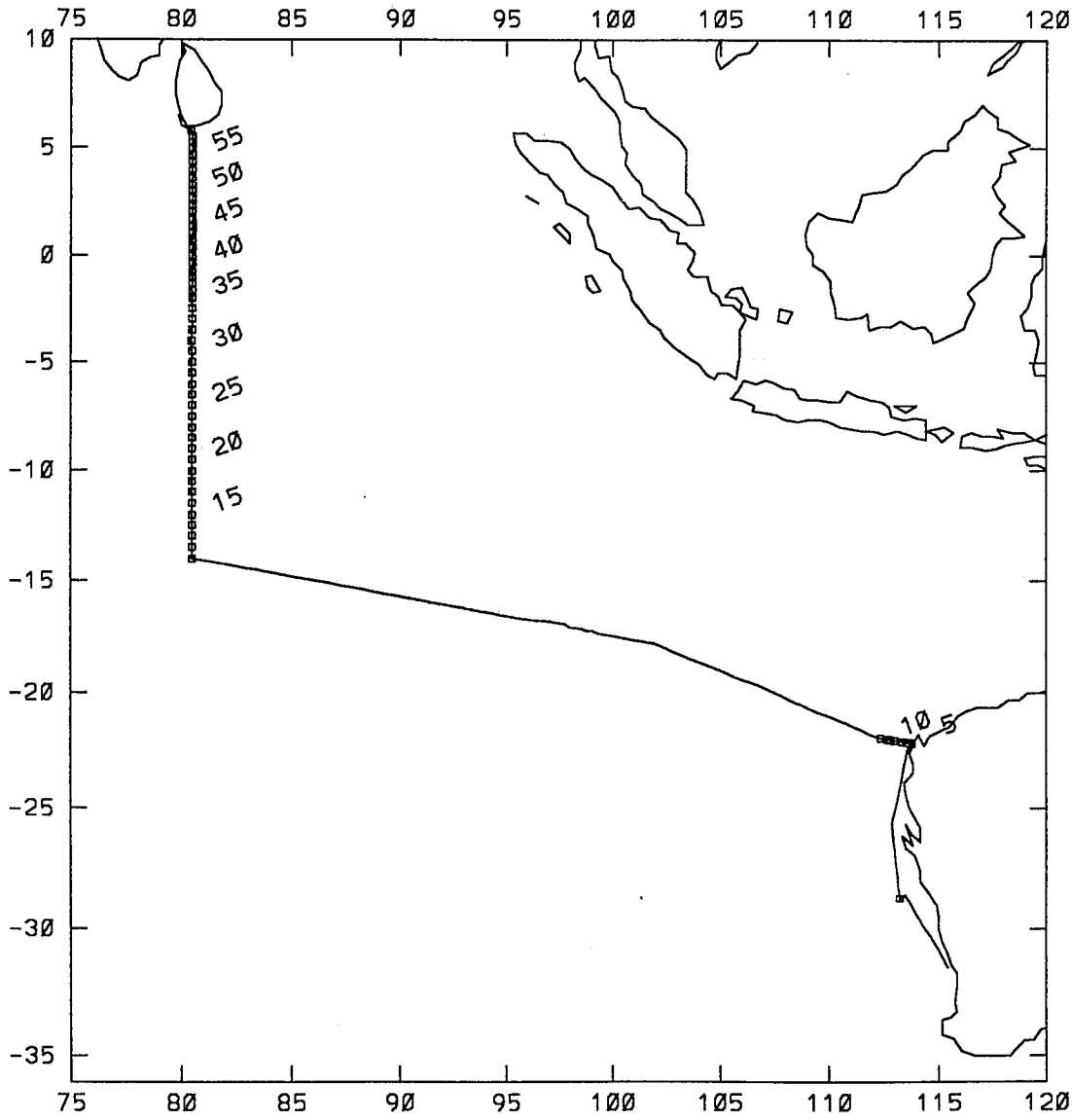

Figure 1 Cruise track FR08/94. Squares indicate CTD stations; every fifth station is numbered.

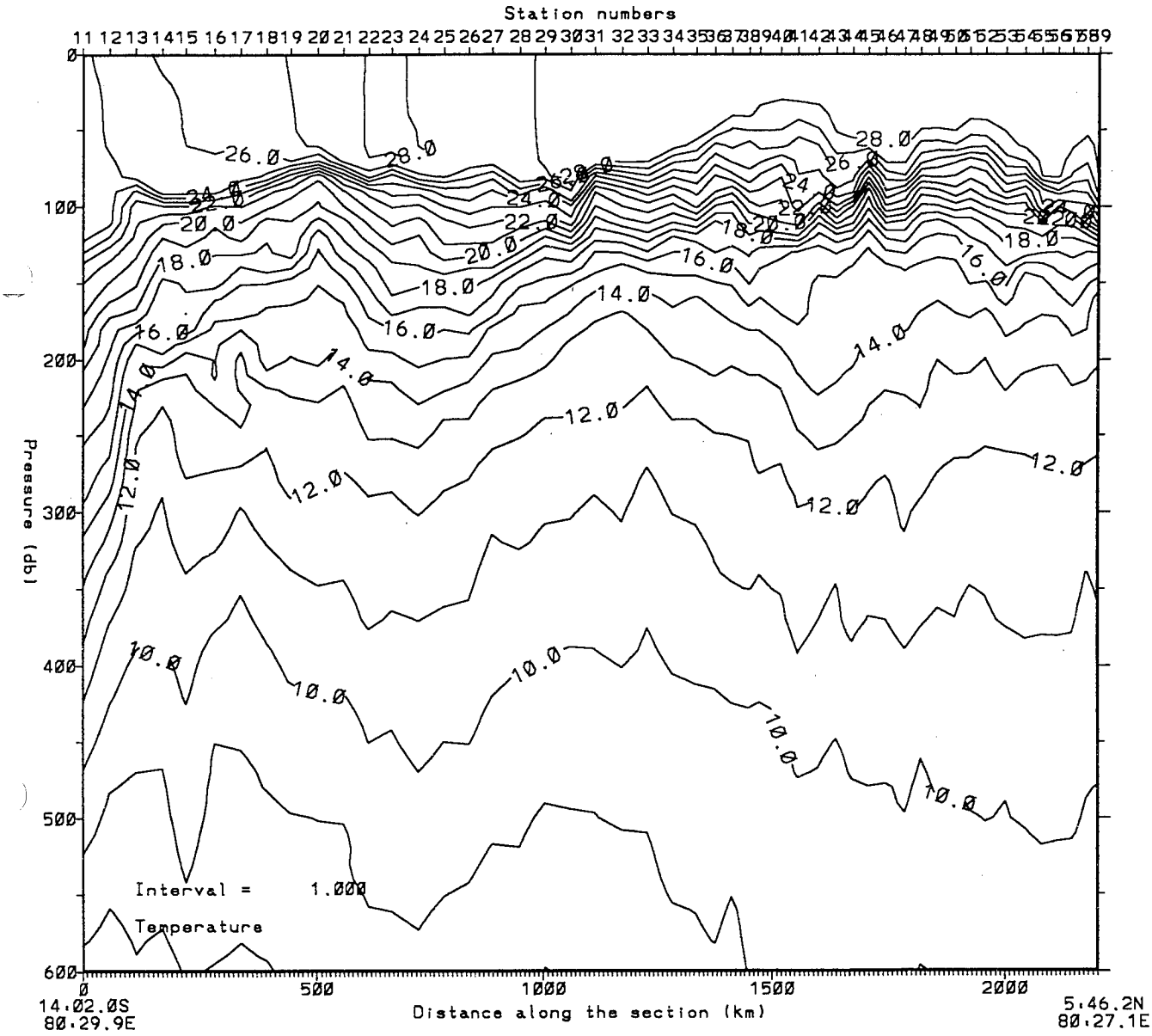

Figure 2 Temperature section for the upper 600 m along 80° 30'E

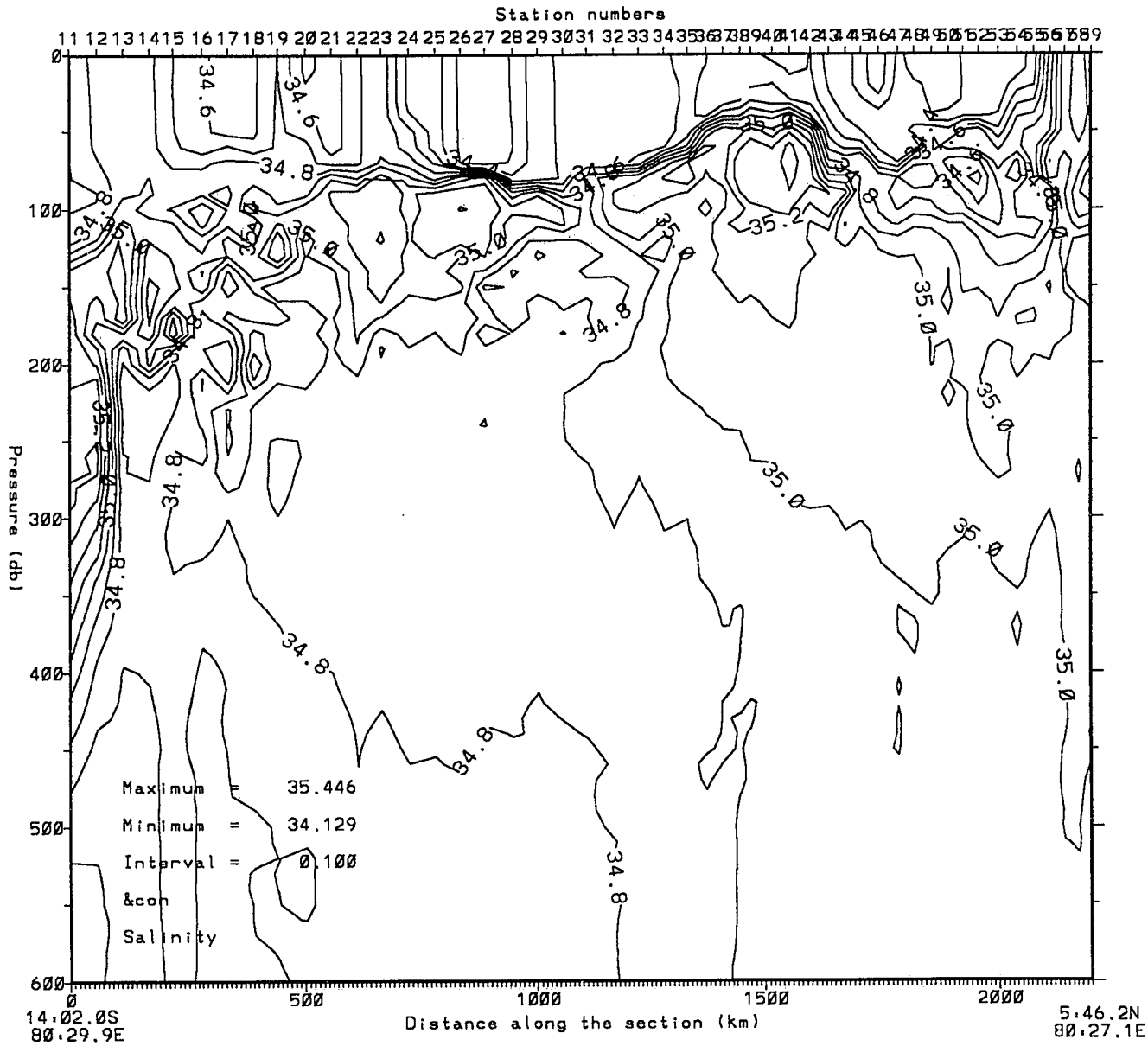

Figure 3 Salinity section for the upper 600 m along 80° 30'E

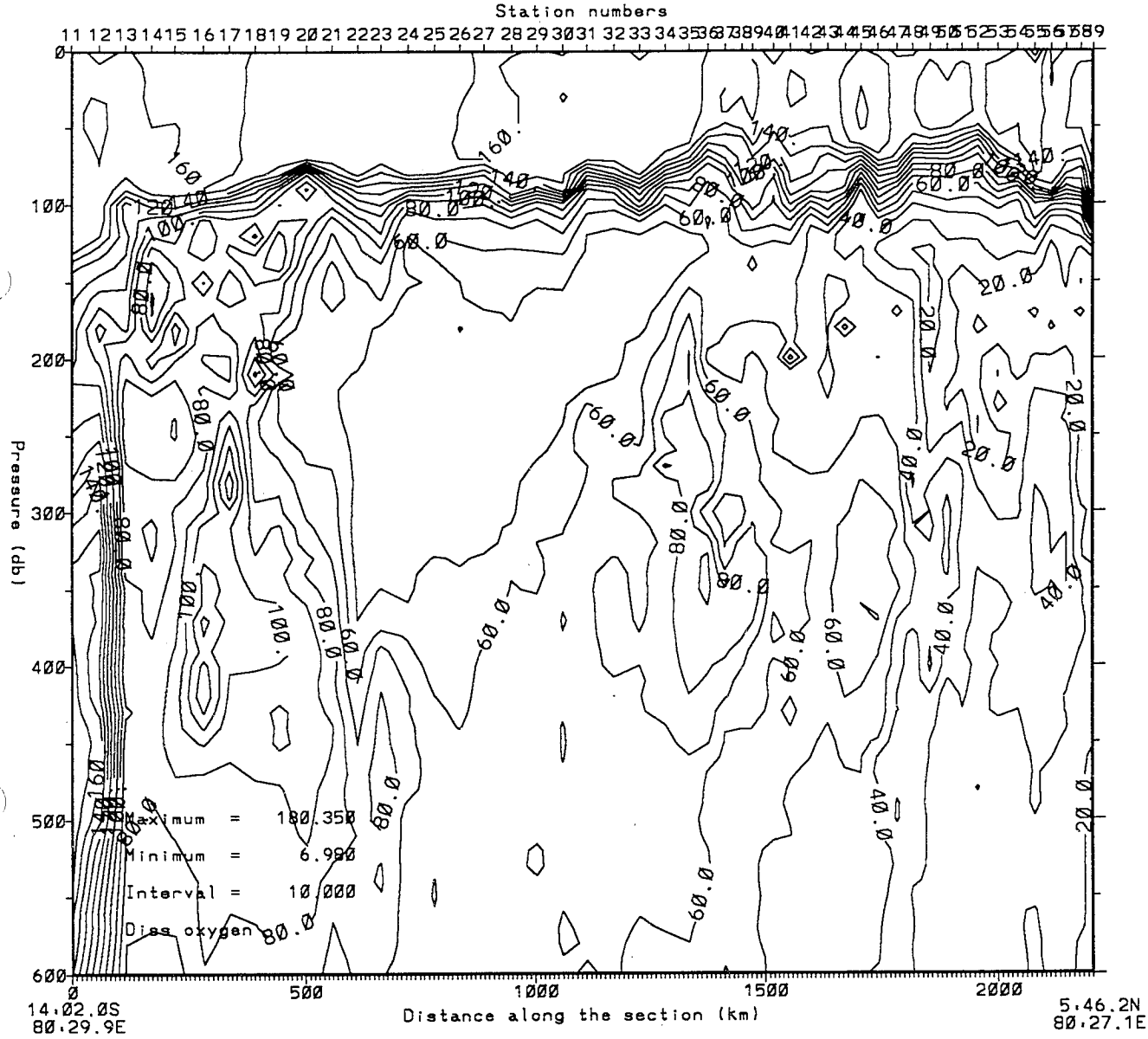

Figure 4 Oxygen section for the upper 600 m along 80° 30'E

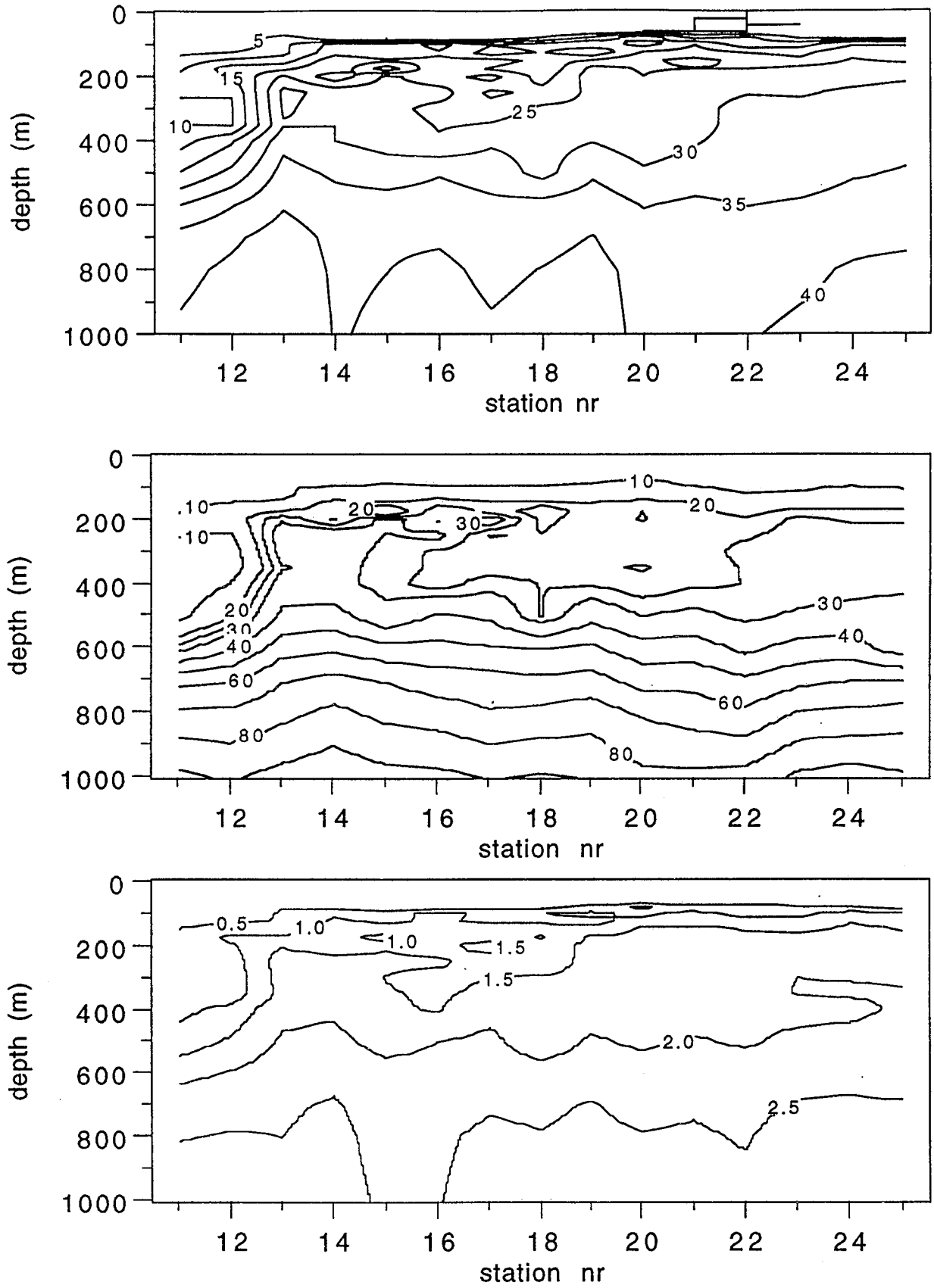

Figure 5 Sections of phosphate (bottom), nitrate (centre) and silicate (top) for the southern part of the CTD section along 80° 30'E

nitrate_md_x vs. (row, col)