

FRANKLIN

National Facility
Oceanographic Research Vessel

RESEARCH SUMMARY

Cruise FR10/94

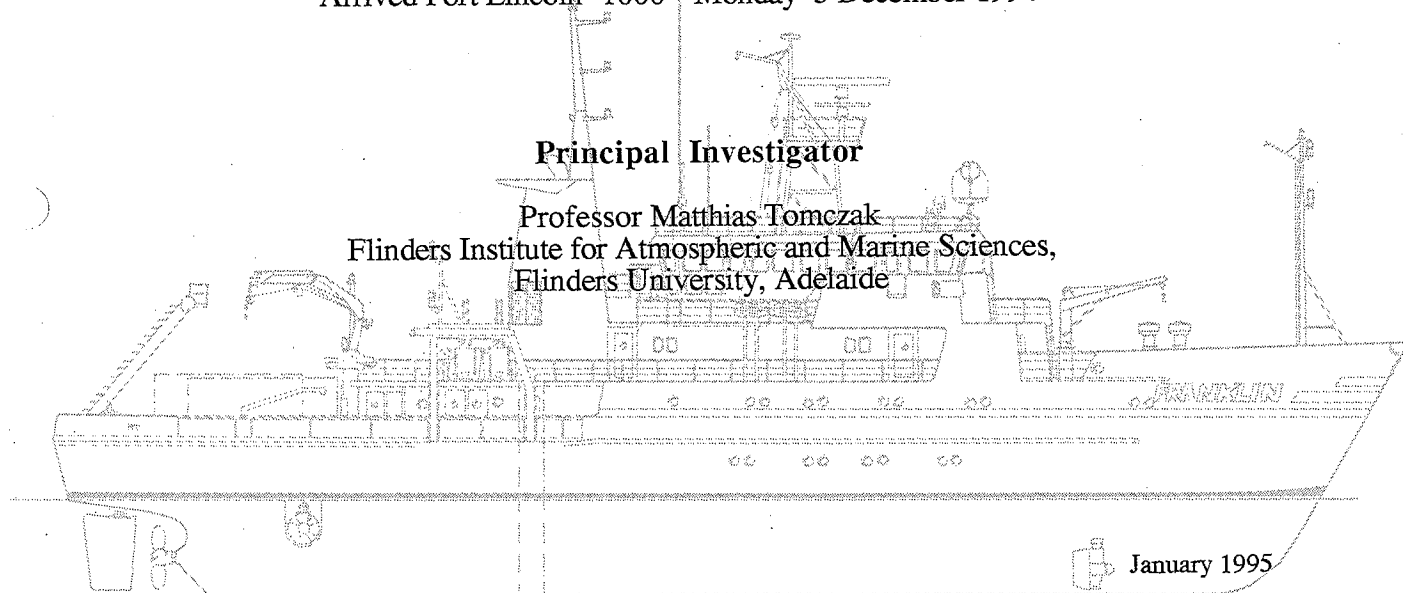
World Ocean Circulation Experiment (WOCE)

HYDROGRAPHIC SECTIONS IN THE SOUTHERN INDIAN OCEAN (GREAT AUSTRALIAN BIGHT)

Sailed Fremantle 0600 Saturday 12 November 1994
Arrived Port Lincoln 1000 Monday 5 December 1994

Principal Investigator

Professor Matthias Tomczak
Flinders Institute for Atmospheric and Marine Sciences,
Flinders University, Adelaide



January 1995

For further information contact:

ORV Operations Manager
CSIRO Division of Oceanography
GPO Box 1538, Hobart, Tasmania 7001

Phone (002) 32 5222
Fax (002) 32 5000
Telex AA 57182



FRANKLIN is owned and operated by CSIRO

RESEARCH SUMMARY

RESEARCH VOYAGE FR10/94

World Ocean Circulation Experiment (WOCE)

HYDROGRAPHIC SECTIONS IN THE SOUTHERN INDIAN OCEAN (GREAT AUSTRALIAN BIGHT)

Sailed Fremantle 0600 Saturday 12 November 1994
Arrived Port Lincoln 1000 Monday 5 December 1994

Principal Investigator

Professor Matthias Tomczak
Flinders Institute for Atmospheric and Marine Sciences,
Flinders University, Adelaide

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

R/V *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.

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.

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 21/11 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 led 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 in 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 thermosalinograph (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 $.25 \text{ m s}^{-1}$ northward and $.35 \text{ m s}^{-1}$ 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 $120^\circ 40' \text{E}$ 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 $120^\circ 40' \text{E}$ (station 32). The strongest indication for northward flow of Bottom Water was seen in a fracture near $123^\circ 40' \text{E}$ (station 37) where water colder than 0.4°C was found below 3800 m; near the bottom the potential temperature fell below 0.3°C . 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 $37^\circ 30' \text{S}$ is surprising, considering that it passes to the south of Tasmania and thus has to shift southward by some 600 km 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 $8 - 9^\circ \text{C}$ range, ie colder than in section 1. In the temperature range $9 - 10^\circ \text{C}$ 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 | |

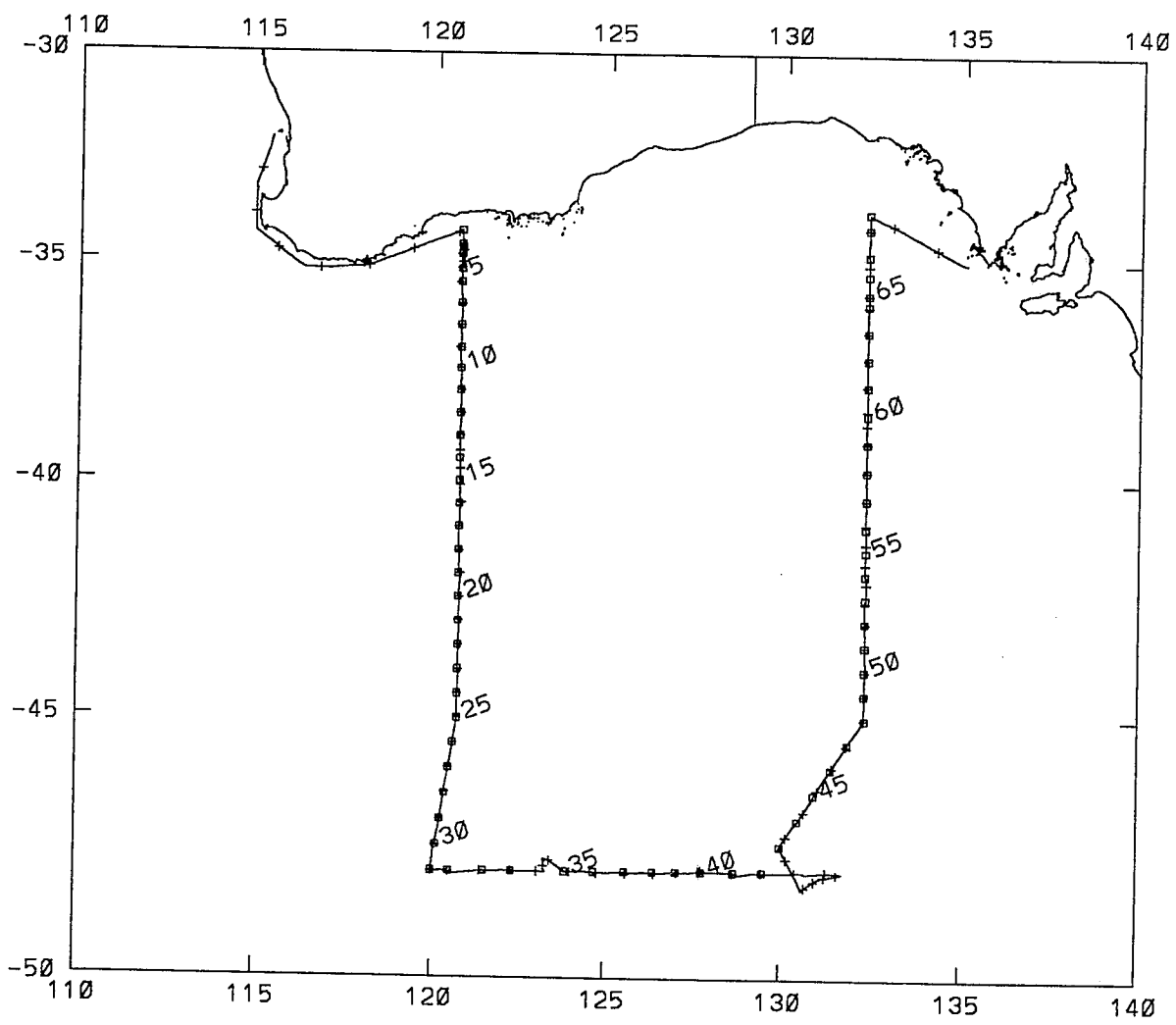


Figure 1. Cruise track and station positions of R/V *Franklin* voyage FR10/94

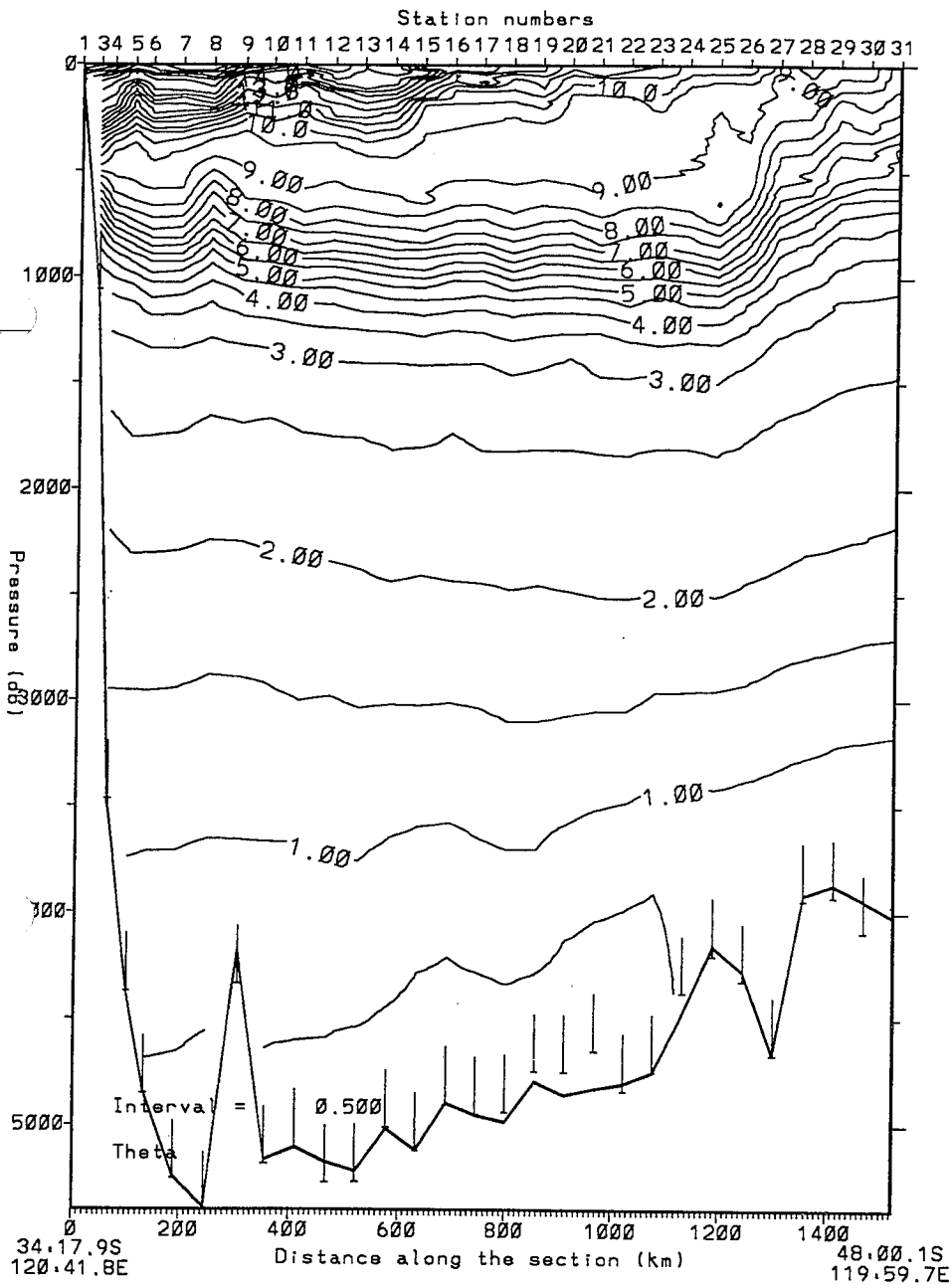


Figure 2. Potential temperature ($^{\circ}\text{C}$) along section 1 (near 120°E).

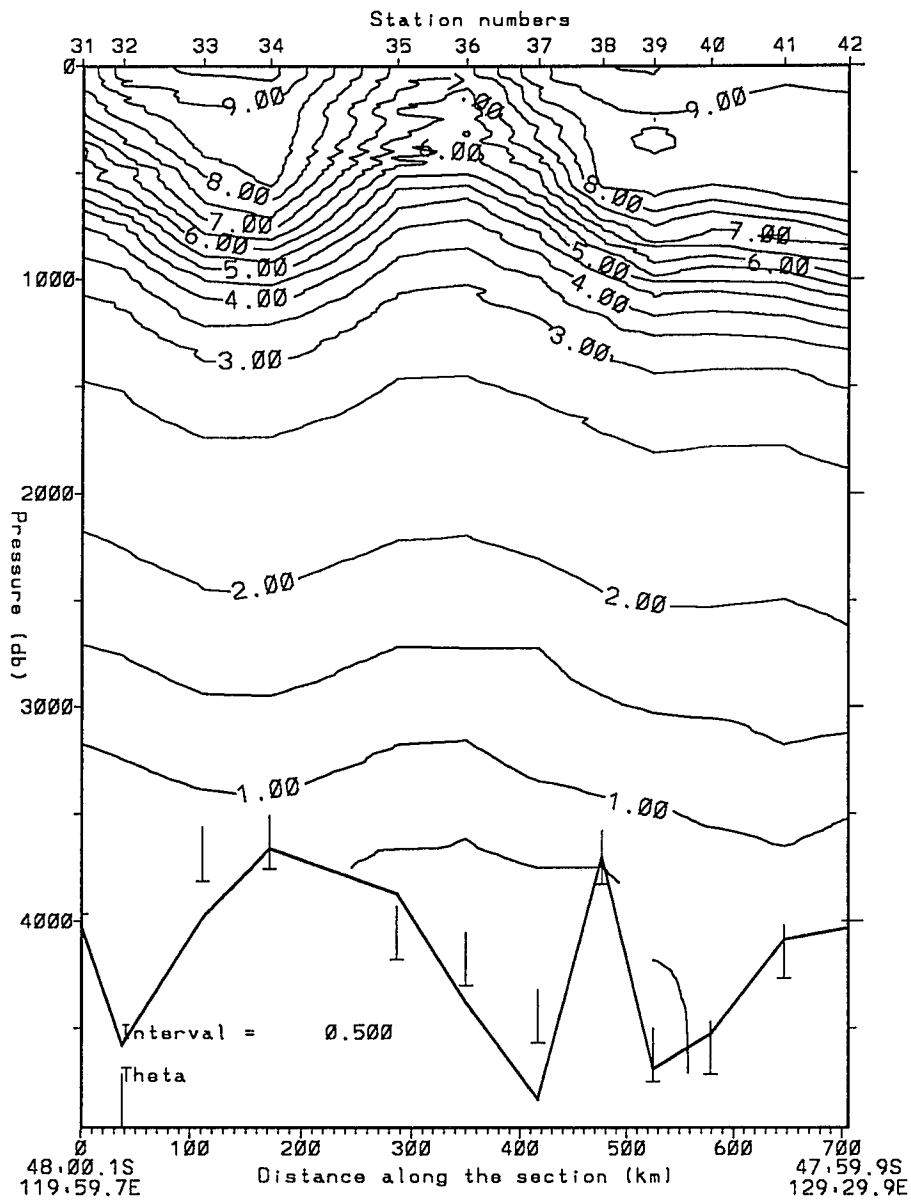


Figure 3. Potential temperature ($^{\circ}\text{C}$) along section 2 (48°S).

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

