FRANKLIN

National Facility
Oceanographic Research Vessel

RESEARCH SUMMARY
FR 06/96

Sail :	Dampier	1000	Saturday	1 June1996
Arrive :	Fremantle	0800	Tuesday	11 June1996

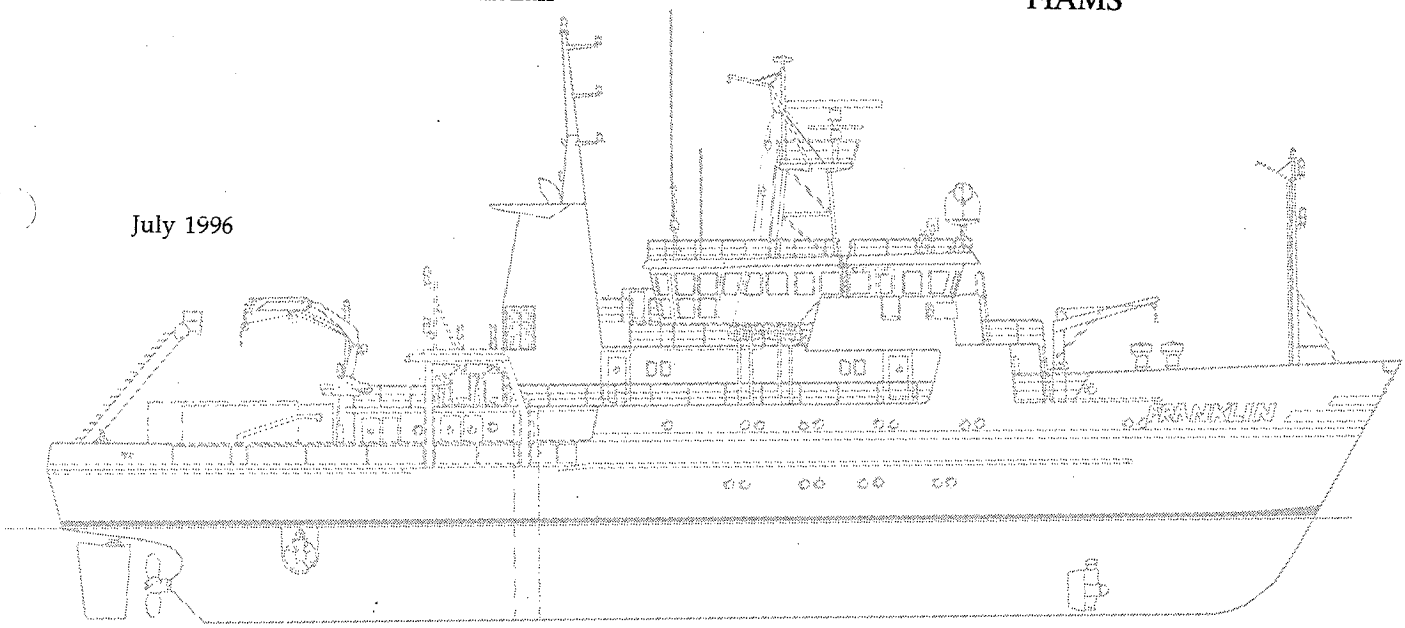
OCEAN TRANSPORT OF THE LEEUWIN CURRENT.

Principal Investigators

Dr John Church — CSIRO Division of Oceanography
Dr Susan Wijffels — CSIRO Division of Oceanography

Prof Matthias Tomczak — FIAMS

July 1996



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AUSTRALIA

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Research Summary

FR9606

OCEAN TRANSPORT OF THE LEEUWIN CURRENT

Principle Investigators:

John Church and Susan Wijffels, CSIRO Division of Oceanography

Matt Tomczak, Flinders Institude of Atmospheric and Marine Sciences (FIAMS)

Itinerary:

Sailed Dampier 1000 Saturday 1 June 1996

Arrived Fremantle 0800 Tuesday 11 June 1996

Aim:

To determine the seasonal variability of the Leeuwin Current near 20°S using current meters and thus the meridional transport of heat associated with the current (an Australian contribution to WOCE).

Cruise Narrative

June 1, 1996: Franklin left Dampier at 1000 and steamed for 24hrs to the site of the first test station in 1500m of water between moorings 4 and 5.

June 2, 1996: Carried out the test station as planned, and Mark Rayner trained the watches in water sampling. After completion of the test station we steamed in along the mooring line to the shallowest mooring (#1). Mooring work began at 1200 WST. Both moorings 1 and 2 (two shallowest moorings) were recovered without incident, though the second half of the retrieval of mooring 2 was in the midst of a very strong front consisting of 50kn gusts and heavy rain. We spent an hour hove to before proceeding inshore along the line to the first CTD station. Occupation of the CTD line began at 1830 with station 2. During the night stations 2 - 6 were completed (out to 1300m). With no time left for another deep cast, an ADCP transect into to the coast and out again along the line was done, and had us over mooring 3 by dawn.

June 3 1996: Recovery of mooring 3 went smoothly ending at 0920. After steaming to their locations, attempts to communicate with both moorings 4 and 5 proved futile. We then steamed on to mooring 6 and made contact (1715). Three hours were spent steaming in a grid over mooring 6 trying to use the echo sounder to 'see' the mooring. By tuning the echo sounder in this way we had hoped to use this technique to locate the unresponsive moorings #4 and 5. We triangulated on mooring 6 using the transponder, and again steamed over its exact location. We still couldn't pick up the mooring on the echo sounder despite the fact that we knew it was there. Hence, we decided that using the echo-sounder to 'search' for the missing moorings would be a waste of time. As it was dusk we headed offshore to deep water complete the first occupation of the CTD line (stations 7 and 8).

June 4 1996: We were on site at mooring 6 in the morning. The mooring crew successfully released and recovered mooring 6. We then steamed west to the site of mooring 5 and, after another unsuccessful attempt to get the acoustic release to work, began trawling. About 3000m of wire was spooled out with a dead weight and grapple hooks on the end. Trawling went on all day until on our last pass the Master spotted the surface float on the starboard side. Upon recovery we found the mooring had been severed just below the first Anderra current meter. Being near dusk we headed inshore to start the second reoccupation of the CTD line. CTD stations 9-13 were completed.

June 5 1996: Arrived at the site of mooring 4 at dawn. Attempts to communicate with the acoustic release were unsuccessful once again. Trawling for the mooring began around 0800 and continued all day with no success. On hauling up the trawl wire at the end of the day, the tension indicated that we had the mooring and anchor hooked. We got it up to 60m from the surface (though there was no sign of the top float or any of the glass balls). Tension then dropped suddenly indicating that the mooring had got free. A single glass float appeared at the surface that had been stripped off the mooring. The position at which the mooring dropped was noted. Headed offshore to do CTD 14.

June 6 1996: Spent the day trawling for mooring 4. No success. At dusk we steamed offshore to complete CTD 15 and steamed in to be over mooring 4 at dawn.

June 7 1996: Spend the day trawling for mooring 4 again. On first pass, hooked the mooring again on bringing in trawl wire. The end of the cable came within a few hundred meters of the surface and tension dropped indicating mooring had fallen off again. Two yellow floats came up. On recovery we found an Anderra attached. From the serial number we discovered that the mooring was severed just above the acoustic release. We then spent the rest of the day on a downwind search for the rest of the mooring, as we assumed that the top must have sheared off and that we had somehow failed to see it (despite excellent visibility for most of the time we had trawled). This was unsuc-

cessful. The fact that we didn't see the upper part of the mooring the first time we lifted the anchor off the sea floor suggests that the upper part had parted some time before. At dusk we started an ADCP survey along the line into the coast and back out to mooring 5.

June 8 1996: Returned to mooring 5 to see if we could trawl up the remaining part of the mooring. We did two trawl passes over the mooring with no luck. At 1000 we headed south on our transit back to Fremantle, dropping XBT's every 2 hours in a survey of the offshore edge of the Leeuwin Current.

June 11, 1996: The ADCP/XBT survey of the Leeuwin was completed at 0300, with probes dropped on specified isobaths as we crossed the shelf bread at right angles on our way into Fremantle. We arrived in Fremantle at 0730, having had a very fast passage down the coast with unusually weak winds and calm seas.

Results

The primary aim of the cruise was to recover the ICM6 Mooring array. We were only partially successful in achieving this aim due to the failure of the two acoustic releases on Moorings 4 and 5. Two CTD sections were obtained along the mooring line (stations 2-8 and 9-15), as well as 4 full ADCP runs along the line. Both the CTD and ADCP data will be of great use in filling in the gap left in the data set by the mooring failures. The initial intention was to occupy two stations further offshore of the moorings (repeating the stations taken during the I3 WOCE transindian section). However due to their distance offshore (a 6 hour steam) and the need to spend the daylight hours trying to recover the recalcitrant moorings by trawling, these stations were not occupied. However the area was covered by hydrographic work during the previous cruise (FR9605) so this loss is not so problematic.

CHANGES IN THE LEEUWIN CURRENT OVER 10 DAYS:

The ADCP surveys taken during the CTD occupations and taken between mooring recoveries gives some insight into the structure of the Leeuwin Current and how rapidly it can change in one week. The 15m ADCP data are shown for the entire voyage in Figure 1. It shows the Leeuwin as a 50km wide southward jet with variable though predominantly northward currents offshore. The variability in the current structure is best seen by the series of cross-sections taken during the CTD sections and ADCP surveys (Figure 2). At the start of the week (June 2, Figure 2a) the Leeuwin penetrates to the bottom on the shelf and reaches speeds of 70cm/s in its core over the shelf break. Both below and offshore of the Leeuwin the flow is consistently to the north reaching 40cm/s in a strong core

on the shelf slope below and offshore of the Leeuwin's core. Though the Leeuwin's undercurrent remains at this strength for the period of the cruise the Leeuwin itself diminishes in both speed and size contracting vertically and horizontally (Figure 2d), probably more than halving its transport by the end of the week. The geostrophic velocity field calculated from the CTD data show a similar change. These changes do not seem related to local winds as they were fairly steady in speed and direction (~20kn from the south east) for most of the cruise. The current meter data from the ICM6 mooring array should shed light on these rapid changes in the current strength and size.

XBT/ADCP SURVEY OF THE LEEUWIN'S OFFSHORE JETS AND MEANDERS

The XBT and ADCP data collected on the southward transit to Fremantle reveal the meandering nature of the Leeuwin Current. Strong southward velocities measured during the transit (Figure 3a) shows that despite being in 600m of water, the ship spent much of its time near the current. Interestingly, the strong subsurface equatorward flows seen off the North West Cape exist along most of the coast. As hoped, several strong meanders were crossed further south. Mixed layer temperatures dropped off as expected from around 26°C off the North West Cape to 22°C off Fremantle. The role the eddies play in cooling the current will be examined using this data and the two similar surveys completed in 1994.

Suggestions and Comments:

All the gear ran very well on this cruise, with the new Niskin bottles appearing to work well (from the test cast results and subsequent salt residuals). As far as I could see no Niskin Bottle Log had been kept up on the last cruise. Even though the bottles appear to work well I still strongly suggest that a Niskin bottle log be maintained as a matter of course for all CTD cruises (and the original or a copy left on the ship), so that as they age their performance is monitored.

The mooring operations ran very efficiently, safely and smoothly. The cause of the release failure of moorings 4 and 5 is unknown, though it is noted that these had the same kind of release and batteries (and different from the other successfully recovered moorings), suggesting a systematic problem. More though might be given to having some redundancy in the release mechanism especially when expensive items such as ADCPs are attached.

Acknowledgements:

Great thanks go out again to the ship's company for a pleasant and successful cruise. In particular, thanks to those on the bridge who suffered most from the tedious job of trawling for the moorings,

and keeping a sharp lookout for any results of it.

Scientific Personnel:

Susan Wijffels	Chief Scientist, CSIRO DO
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Anna Lebedev	FIAMS
Michael Schodlok	FIAMS
Marion Tait	FIAMS
Craig McCaulay	CSIRO DO Communications
Dave Edwards	ORV
Bernadette Heaney	ORV
Mark Rayner	ORV
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Ships Company

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Ian Moss
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Don Roberts
John Tilley
Lindsay Ballinger
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Jannick Hansen
Wayne Browning
Sam McCafferty
Norm Marsh
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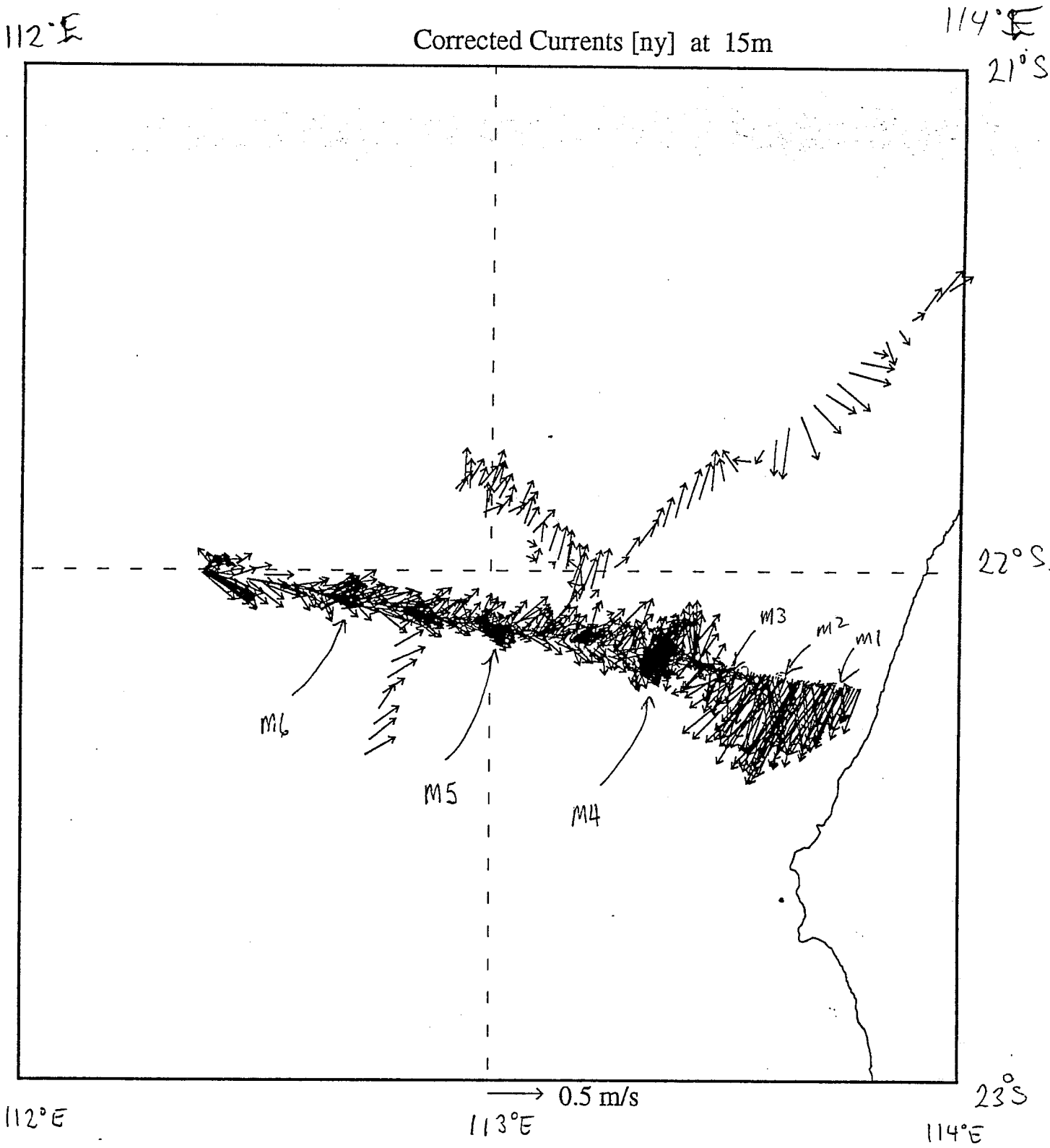
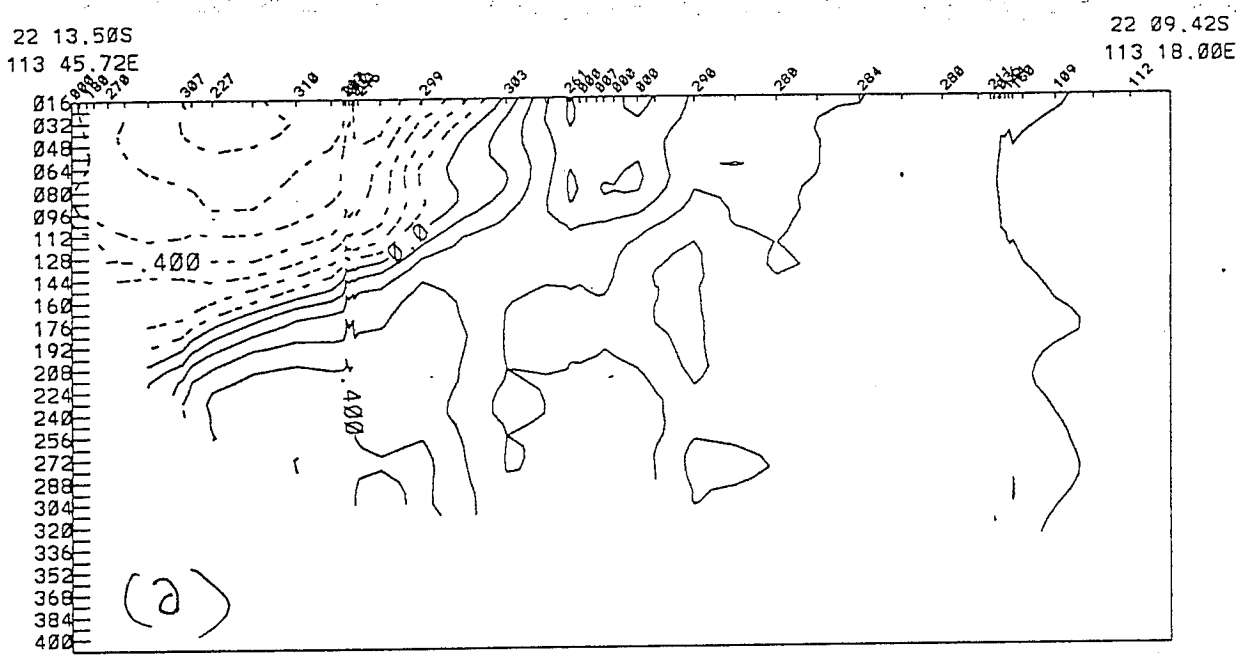

112°E
Corrected Currents [ny] at 15m
114°E
21°S
22°S
23°S
M1
M2
M3
M4
M5
M6
0.5 m/s
112°E
113°E
114°E

FIGURE 1.

From 02-JUN-1996 10:00:00 to 02-JUN-1996 19:20:00

FR9606 CTD OCCUPATION 1: STNS 2-6

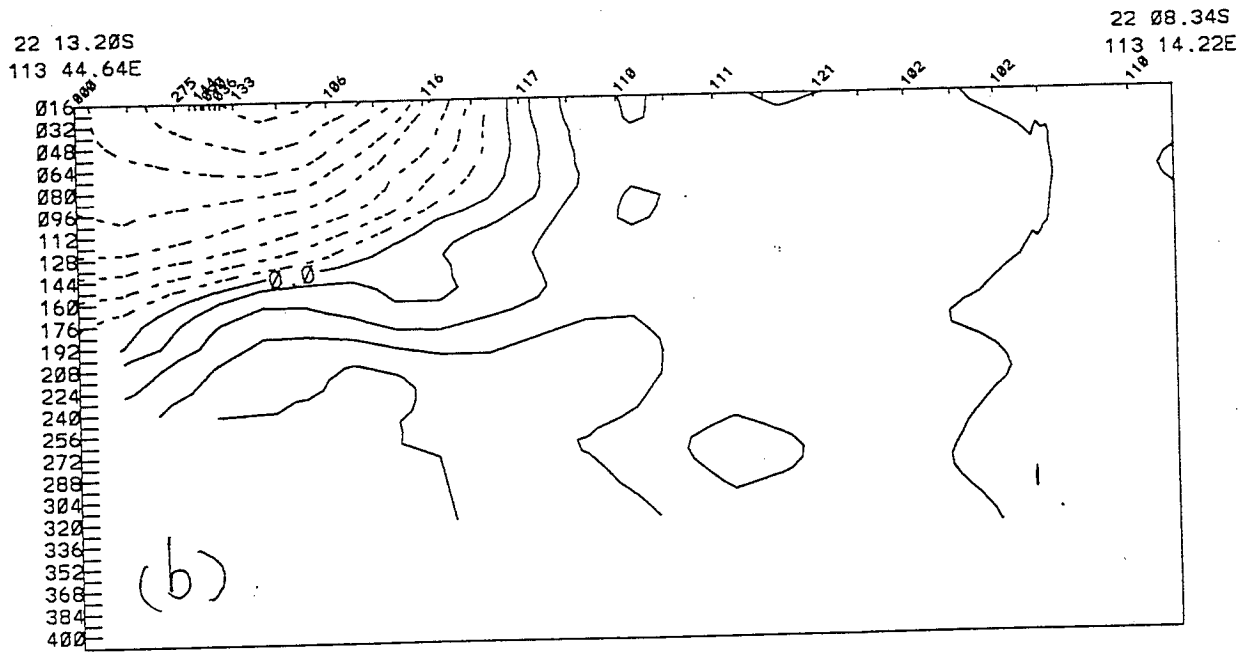
Across component (Dashed = in to page)
Smoothed



From 02-JUN-1996 17:00:00 to 02-JUN-1996 22:00:00

FR9606 : ACDP Survey after CTD station 6

Across component (Dashed = in to page)
Smoothed



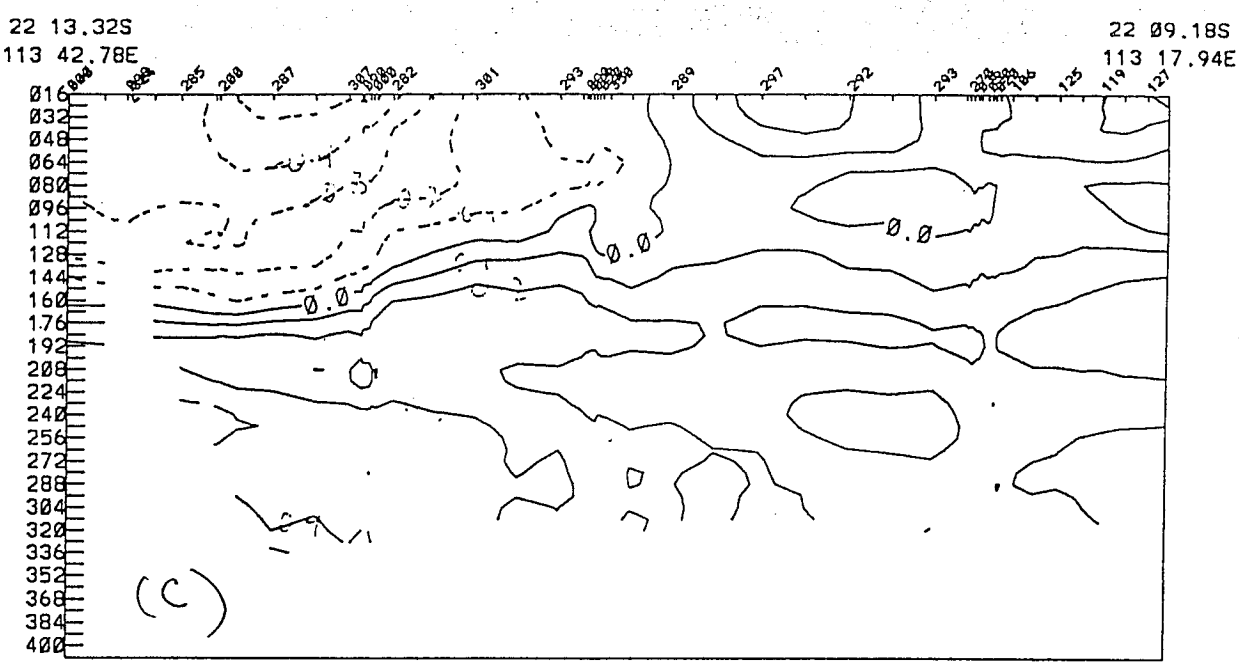
CONTOUR FROM -2.0000 TO 1.9000 CONTOUR INTERVAL OF 0.10000 PT(3,3)= 0.13978

FIGURE 2.

From 04-JUN-1996 13:30:00 to 04-JUN-1996 23:20:00

FR9606

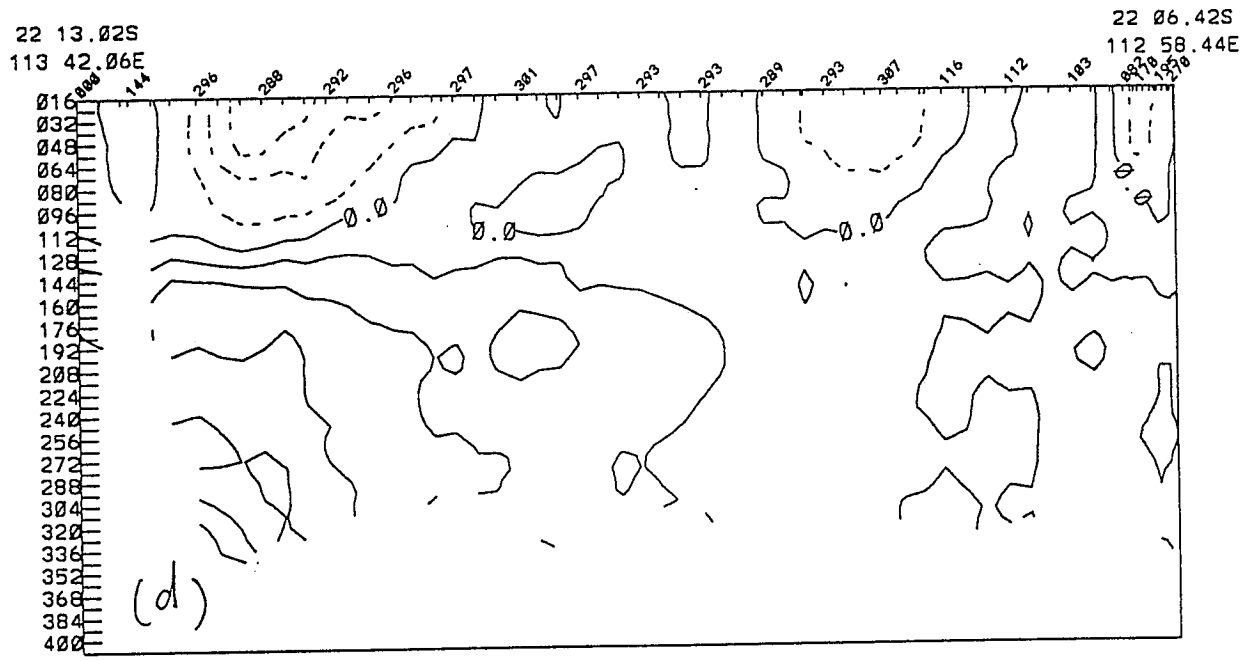
Across component (Dashed = in to page)
Smoothed



From 07-JUN-1996 13:10:00 to 07-JUN-1996 23:20:00

FR9606

Across component (Dashed = in to page)
Smoothed



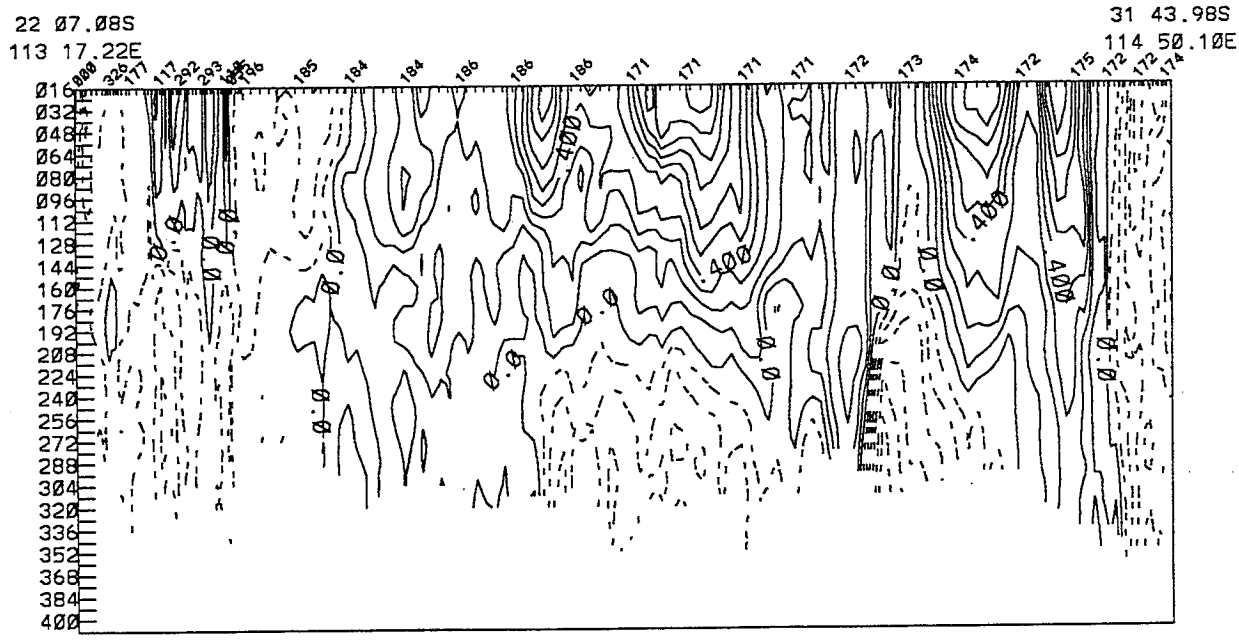
CONTOUR FROM -2.0000 TO 1.9000 CONTOUR INTERVAL OF 0.10000 PT(3,3)= 0.18091E-01

FIGURE 2 (cont.)

From 07-JUN-1996 03:00:00 to 10-JUN-1996 10:00:00

OFFSHORE EDGE OF LEEUWIN CURRENT

Along component (Dashed = flow to left)
Smoothed



CONTOUR FROM -2.0000 TO 1.9000 CONTOUR INTERVAL OF 0.10000 PT(3,3)= -0.31848

FIGURE 3(a)

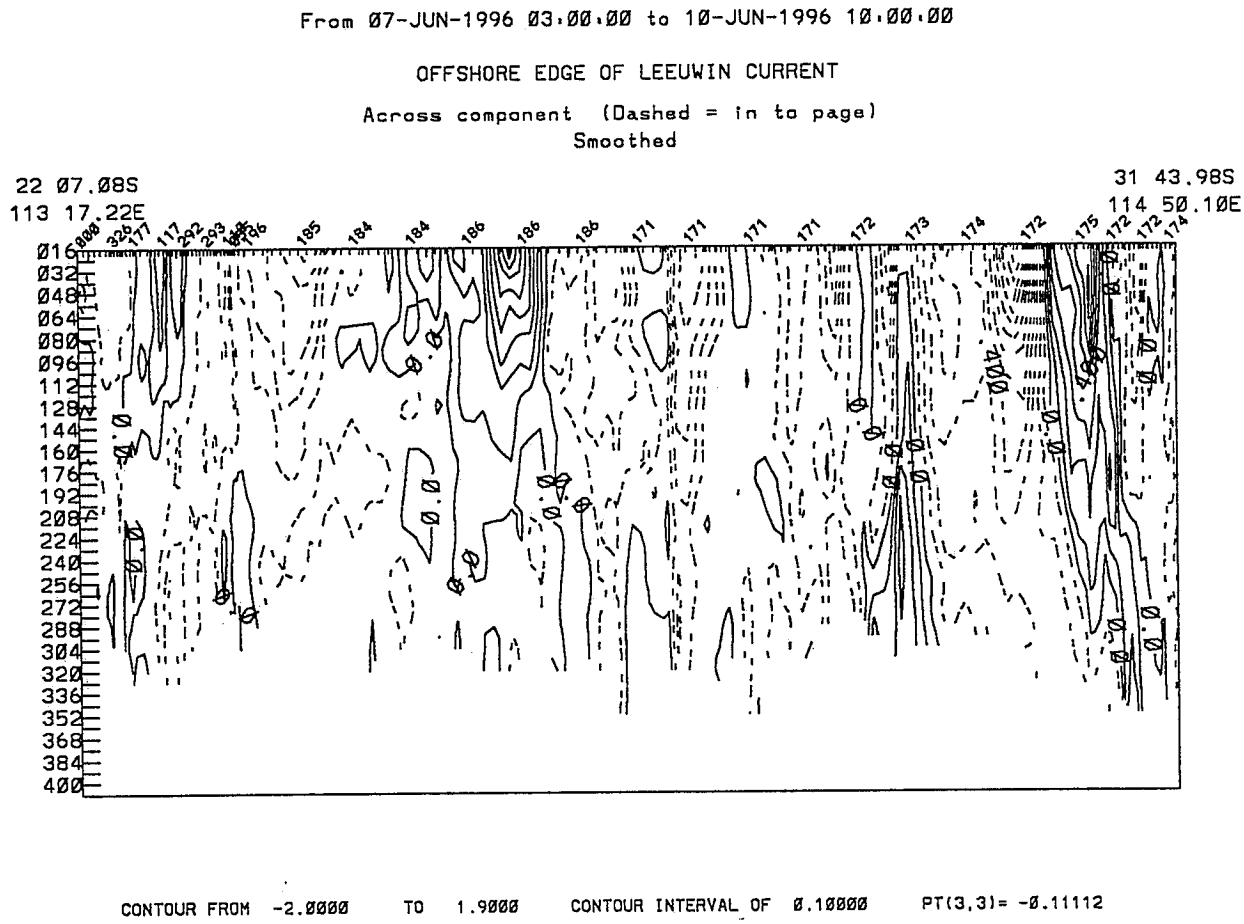

From 07-JUN-1996 03:00:00 to 10-JUN-1996 10:00:00
OFFSHORE EDGE OF LEEUWIN CURRENT
Across component (Dashed = in to page)
Smoothed
22 07.08S
113 17.22E
31 43.98S
114 50.10E
016
032
048
064
080
096
112
128
144
160
176
192
208
224
240
256
272
288
304
320
336
352
368
384
400
CONTOUR FROM -2.0000 TO 1.9000 CONTOUR INTERVAL OF 0.10000 PT(3,3)= -0.11112

FIGURE 3(b)

MOORING POSITIONS OFF WEST COAST W.A.

ICM6:

MOORING 1: 22 13.17 S 113 43.96 E
MOORING 2: 22 12.59 S 113 39.74 E
MOORING 3: 22 11.47 S 113 31.52 E
MOORING 4: 22 09.99 S 113 21.09 E
MOORING 5: 22 06.22 S 112 59.17 E
MOORING 6: 22 03.29 S 112 39.02 E

CTD STATION LISTING

1	22 07.59S	113 05.84E	0038Z	02-Jun-96
2	22 13.54S	113 45.34E	1018Z	02-Jun-96
3	22 13.03S	113 41.63E	1112Z	02-Jun-96
4	22 12.09S	113 35.66E	1237Z	02-Jun-96
5	22 10.77S	113 26.30E	1438Z	02-Jun-96
6	22 08.28S	113 10.21E	1733Z	02-Jun-96
7	22 04.81S	112 49.06E	1458Z	03-Jun-96
8	21 59.98S	112 23.00E	1924Z	03-Jun-96
9	22 13.58S	113 45.56E	1354Z	04-Jun-96
10	22 12.95S	113 41.63E	1502Z	04-Jun-96
11	22 12.24S	113 35.87E	1619Z	04-Jun-96
12	22 10.81S	113 26.50E	1811Z	04-Jun-96
13	22 08.14S	113 10.14E	2053Z	04-Jun-96
14	22 05.18S	112 49.18E	1428Z	05-Jun-96
15	22 00.30S	112 22.93E	1453Z	06-Jun-96

CTD Processing Notes

Marie Robert
Data Processing completed 29 November 1996

FR 6/96, 1 June 1996 - 11 June 1996

Ocean Transport of the Leeuwin Current.

Principal Investigators
Dr John Church
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Dr Susan Wijffels
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Prof Matthias Tomczak
Flinders Institute of Atmospheric and Marine Sciences (FIAMS)

The cruise departed from Dampier and ended in Fremantle. After leaving Dampier, the boat steamed for 24 hrs to the site of the first test station in 1500 m of water between moorings 4 and 5. A CTD test station was done there. During the night of June 2 CTD stations 2 - 6 were completed (out to 1300 m). As it was dusk on June 3 the CTD stations 7 and 8 were done. CTD stations 9 to 13 were completed on the evening of June 4. CTD station 14 was done during the evening of June 5, whereas CTD station 15 was completed during the evening of the next day. The CTD stations were done as 2 sections along the mooring line (stations 2-8 and 9-15)

Voyage Objective

To determine the seasonal variability of the Leeuwin Current near 20S using current meters, and thus the meridional transport of heat associated with the current (an Australian contribution to WOCE).

CTD Unit

CTD unit 8 was used for all CTD stations. A 24 bottle rosette was used.

Pressure calibration

CTD Unit 8 has a Titanium Pressure Gauge and a Stainless Steel Gauge. The data from the Titanium Pressure Gauge were used. Constants from the laboratory calibration done on 16 August 1995 were inserted in the subroutine, and a new offset term was calculated for each station from the pressure of the first ‘in water’ data records.

Temperature calibration

Temperature calibration constants from the laboratory calibration done on 24 August 1995 were used. The mean offset of the temperature residuals (difference between CTD temperature and reversing thermometer readings) is 0.0098 C (dtplot). There is a general offset of -0.02 C between the thermometer readings and the CTD temperature.

Conductivity calibration

Conductivity (salinity) calibration was done over the cruise as 3 groups, stations 1-2, 3-8, 9-15. 161 out of 221 bottle values were used for calibration. The standard deviation of the conductivity after calibration is 0.0021 psu (calplot). The standard deviation of the salinity residuals is also 0.0021 psu (dsalplot).

Additional Channels

There was a column of fluorometer data in the *.cro files, but no mention of the fluorometer was made in the CTD Log Sheets or in the cruise report. Also, some members of the cruise could not remember using the fluorometer. So no additional channel has been included for fluorometer data.

Table 1: Too many bottles in cal001015.dat w.r.t. CTD log sheets

Station no.	Pressure dB	Reason	Comment
4	4	Misfire in .cro file	Delete 3rd bottle at 4 dB in calib.dat
6	395	Spike in pressure	Delete records #2886 to #2899
12	797	Spike in pressure	Delete records #1871 to #1873
14	394	Spike in pressure	Delete records #4103 to #4106
15	94	Spike in pressure	Delete records #3731, #3732
15	495	Spike in pressure	Delete records #4865 to #4867
15	1390	Spike in pressure	Delete records #6209, #6210

Table 2: Bottle samples rejected in conductivity calibration

Station no.	Bottles	Comments
10	14	Obviously bad
11	14	Obviously bad

Table 3: Thermometers readings that have been deleted

Station no.	Bottle no.	Pressure dB	CTD temp.	Bottle temp.
4	23	4.2	26.237	24.240
13	1	1254.9	4.269	4.322

Table 4: Bottles rejected by program new_cal

Station no.	Bottle no.	Pressure (dB)
4	21, 14	198.9, 697.9
5	13, 12, 17, 15, 14	147.0, 196.9, 297.7, 897.6, 1095.3
6	3	1319.3
7	23, 23, 12	3.2, 196.2, 593.6
8	5, 12	195.6, 1392.5
9	14	75.0
10	9	49.6
11	9, 12	247.0, 697.6
12	24	494.6
13	17	395.0
14	2, 22	195.9, 792.3
15	11, 4	94.6, 793.9

Table 5: Density inversions

Station no.	Pressure	Density difference	
2	14 dB	22.909, 22.935 = 0.025	Delete records 6200 to 6255
3	4 dB	22.864, 22.878 = 0.014	Delete records 1850 to 1880, 1922 to 1937, 2050 to 2090, 2219 to 2221
4	4 dB	23.002, 23.005 = 0.003	Nothing done
15	974 dB	31.762, 31.776 = 0.013	Delete records 28060 to 28180
15	976 dB	31.738, 31.762 = 0.024	