# R.V. FRANKLIN

## NATIONAL FACILITY
## OCEANOGRAPHIC RESEARCH VESSEL

### RESEARCH SUMMARY

### CRUISE FR 13/89

Sailed Hobart 1000hrs 11 November 1989
Called Sydney, Newcastle and Jervis Bay
Arrived Melbourne 2100hrs 7 December 1989
Arrived Hobart 2300hrs 18 December 1989
-oOo-

**Principal Investigator**
Dr George Cresswell - CSIRO Division of Oceanography
**Temperate Eastern Australian Continental Advection Study**

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**Associate Investigators**
Dr Trevor McDougall - CSIRO Division of Oceanography
**Turbulence Measurements in a Warm Core Ring**

Dr John Hunter - CSIRO Division of Oceanography
**Real Time Numerical Modelling of the Continental Shelf**

Dr Peter Nichols - CSIRO Division of Oceanography
Dr John Bavour - University of West Sydney
**Sewage in Sludges, Coastal Waters and Sediments**

Dr Nick Elliott - CSIRO Division of Fisheries
**Stability and Noise Test of Towed AcousticSystem**

3 January 1990

For further information contact

ORV Operations Manager
c/- CSIRO Division of Oceanography
GPO Box 1538, Hobart, Tas. 7001
Telephone (002) 20 6222
Telex AA 57182

AUSTRALIA

R.V. FRANKLIN IS OWNED AND OPERATED BY CSIRO

# RESEARCH VOYAGE FR 13/89 - SUMMARY

**Contents:**



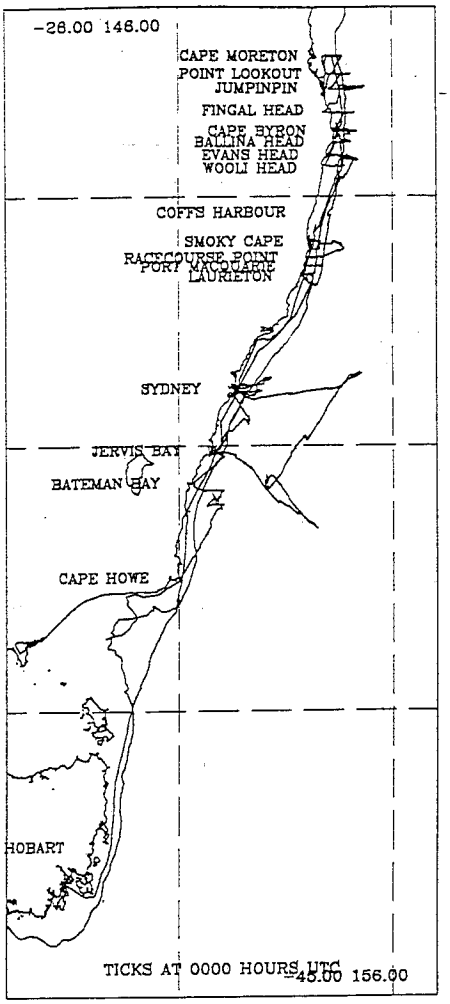


**Figure 1** The ship's track

## ITINERARY

| | | | |
|---|---|---|---|
| A: Dep HOBART | 1000h 11 Nov | Arr SYDNEY | 1500h 14 Nov |
| B: Dep SYDNEY | 1630h 14 Nov | Arr SYDNEY | 2100h 16 Nov |
| C: Dep SYDNEY | 1500h17 Nov | Arr TRIAL BAY | 0630h 20 Nov |
| D: Dep TRIAL BAY | 1100h 20 Nov | Arr NEWCASTLE | 0600h 28 Nov |
| E: Dep NEWCASTLE | 0600h 29 Nov | Arr JERVIS BAY | 0700h 30 Nov |
| F: Dep JERVIS BAY | 0930h 30 Nov | Arr MELBOURNE | 2100h 7 Dec |

## OBJECTIVES

### Temperate Eastern Continental Shelf Advection Study — TECSAS
### G. Cresswell

To use *Franklin* in concert with other methods (satellite and aircraft imagery; moored instruments; satellite-tracked drifters) to examine:

1. The upwellings produced when the East Australian Current (EAC) separates from the central and northern NSW coast near Laurieton and Evans Head.
2. The nature of the continental shelf and slope currents in other areas. These currents are important for effluent disposal, navigation, and fisheries.
3. The effects on the continental shelf waters when an eddy collides with the southern NSW shelf (and the effects produced on that eddy).

In addition, there were several piggyback projects:
**T. McDougall** — A survey of an eddy with *Bunyip*.
**N. Elliott** — Stability and noise tests of a towed acoustic sampling system (TASS).
**J. Hunter** — Running a real time numerical model of currents on the ship's computer.
**P. Nichols** — Chemical sampling in the Sydney region as it pertains to the sewerage outfalls.

## SCIENTIFIC CREW

The following table indicates the 12 available scientific berths and who filled them on the various parts of the voyage.

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | GC | JP | LP | IH | PA | DT | PN | FB | DM | NE | RK | SS |
| B | " | " | QE | AH | " | " | " | JB | MR | CG | JH | DH |
| C | " | " | LP | IH | " | " | CN | PB | PF | AW | " | VL |
| D | " | " | " | " | " | " | " | " | — | — | " | " |
| E | " | ST | " | " | " | " | TM | RS | NT | GG | DS | DM |
| F | " | JP | " | " | " | " | " | " | — | — | — | — |

where the code is:

### CSIRO Division of Oceanography

GC George Cresswell
IH Ian Helmond
PN Peter Nichols
CN Carl Nilsson
TM Trevor McDougall
SS Stuart Swan
RS Richard Schahinger

JP Jan Peterson
PA Phil Adams
FB Fred Boland
JH John Hunter
AW Tony Woods
VL Val Latham

LP Lindsay Pender
DT Dave Terhell
DM Dan McLaughlin
PB Paul Boult
MR Mark Rayner
DH Dan Holdsworth

### CSIRO Division of Fisheries

NE Nick Elliott

RK Rudy Kloser

### Collaborators and observers

JB John Bavor (Uni. West Sydney)
AH SBLT Ann-Louise. Holmes (RAN)
QE Quentin Espey (Sydney Water Bd)
GG Gavin Gilchrist (ABCTV)
DM David Martin (ABCTV)

CG Charles Gray (NSW Fisheries)
PF Peter Fry (ABC Radio Science
ST Lieut Stuart Taylor (RAN)
DS Doug Sleeman (ABCTV)
NT Neil Trenaman.(Lawson and Treloar)

## SHIP'S OFFICERS AND CREW

Captain Neil Cheshire, Chief Engineer Peter Noble, Mate Peter Hinksman[A-D], Mate Phil Rowbottom [E,F], Second Mate Dick Dougal, Second Engineer Ron Parrott, Electrical Engineer Jeff Cullen.
Bosun Norman Marsh, AB Bluey Hughes, AB Kris Hallen, AB John Moore, Greaser Paddy Mclure[A,B], Greaser Simon Bishop[C-F]
Chief Cook Mark Wheeler, Second Cook Paul Gilchrist, Steward Karl King[A,B], Dan Dodd[C,D], Ernie Standen[E,F]

## WORK SUMMARY

- 147 CTD stations and 12 *Seasoar* tows resulting in more than 2 dozen cross-shelf lines on which water property and current profile data were collected concurrently.
- Underway ADCP measurements on the mid-continental shelf from Tasman Island to Moreton Island.
- 70 XBT drops. Where appropriate the essence of these was telexed to the RAN.
- 6 *Bunyip* tows by McDougall.
- 8 satellite-traced drifter releases
- 16 days moored operation by the new ADCP
- *TASS* tests by Elliott, Kloser and Helmond.
- Chemical studies of sewerage plumes and environment by Nichols and Bavor.
- On board running of a real time model of the EAC
- Coordinated study with Ocean Colour Scanner on COSSA aircraft
- Satellite imagery transmitted from Hobart for operational purposes and to aid interpretation of data.

## NARRATIVE

In the following we use eastern summer time (UT+11h). The standard *Seasoar* sections were those that took the ship from inshore across the shelf profiling between the surface and 20m above the bottom and then down the slope with 200m vertical excursions between roughly 150m and 350m. The ship then went along the reciprocal path to profile between the surface and 200m, thereby "painting in" the whole section. The standard *Seasoar* sections were generally done during the GPS "window", which was from about 1300h to 2300h, although it stepped forward about 5 minutes per day. The details of the XBT profiles were regularly forwarded by telex to the RAN at Nowra for their weekly current maps. The satellite images that were transferred to the ship from Hobart via Inmarsat proved extremely valuable in planning and in fitting the ship observations into the larger picture.

The ship sailed in pleasant weather at 1000h on Saturday 11 November. The scientific crew were Cresswell, Peterson, Terhell, Adams, Boland, McLaughlin, Helmond, Pender, Swan, Nichols, Elliott and Kloser. A lifeboat drill was conducted in the Derwent estuary. The underway instrumentation was running as the ship left the estuary and Tasman Island was passed at 1400h; Maria Island at 1600h; Freycinet at 1800h. The sea surface temperature was around 14°C and the currents were small. The ship averaged about 12.5 knots.

On Sunday 12 November, east of Bass Strait, the surface temperature quickly increased to over 18°C when a filament of the EAC was encountered. The Division of Fisheries towed acoustic sonar system, *TASS* , was tested from midmorning to midafternoon by Elliott, Kloser and Helmond. Towing speeds ranged from 5.5 to 8 knots in a short swell of about 1 m with wind less than 10 knots.

The journey to Sydney was continued until the early evening when the *TASS* was given another test. The ship then hove-to for an hour while the engineers tested the ailing bowthruster. The ship then travelled along the midshelf of NSW in calm conditions at 12.5 knots; the current near Gabo was about 1/2 knot to the SW

On Monday 13 November the ship passed inside Montagu Island after first light stemming a 1 knot southward current. XBTs (X1-X5) were dropped between 36°30'S and 34°05'S (Pt Hacking). At noon off Jervis Bay, 35°S, the current was very small. At 1300h a 3°C surface front was crossed and an XBT showed EAC water down to the bottom (126m) with a southward current 2.2 knots that had a noticeable effect on the ship's motion. The course was changed from 030° to 000° to move inshore of the EAC. Off Pt. Kembla the influence of the EAC on the waves was very noticeable, with disturbed bands about 100 m wide. Even in at the 75m contour the current was 1.5 knots.

In the evening off Malabar and Bondi two moorings with sediment traps and Seastars were deployed. The ADCP mooring was also deployed. The current was significant during the mooring operations.

An ADCP/GPS/XBT section (X5-X9) from the moorings along 060° was commenced at 2200h. It became apparent that the filament of the EAC was only on the inner part of the shelf and the course 060° was made good. X9 at the 1500m contour showed a cold T250 of 12.8°C.

At 0100h on Tuesday 14 November when the depth was 1500m two pressure cases were lowered to 1200m as a test for the Antarctic Division. *TASS* was then given further tests until 0700h. Following this the ship travelled to its starting point for the coordinated study

with Stephen Walker and his Ocean Colour Scanner on the COSSA aircraft. This involved underway measurements and going in and out of the sewerage plume at Malabar.

The ship arrived as planned at the Watson's Bay anchorage at 1500h and departed at 1630h. Scientific crew were exchanged: Off were Boland, McLaughlin, Helmond, Pender, Swan, Elliott and Kloser. On were Holmes (RAN), Gray (Fisheries Research Institute, Cronulla), Bavor (Uni of West Sydney), Espey (Sydney Waterboard) and Hunter, Holdsworth and Rayner of CSIRO. Remaining on board were Cresswell, Peterson, Adams, Terhell and Nichols.

The scientific program then came under the direction of Dr. Nichols of CSIRO and is reported fully in a later section of this summary. It involved 26 CTD/rosette casts and bottom grabs along lines across the shelf, with underway measurements being taken of surface characteristics and current profiles. Gray took surface plankton hauls at most stations.

The problems with the bowthruster were considerable by Wednesday 15 November. The weather was particularly good. The CTD cast for the 150 m station showed a thin near-bottom layer of near 15°C. Internal wave slicks about 100m apart were observed on the inner shelf, as were long, 3m wide streaks of trichodesmium, presumably brought by the EAC.

Towards the end of the morning on Thursday 16 November Greaser Mclure collapsed and the ship proceeded the short distance to Watson's Bay where he was taken ashore to go to hospital. He was later discharged but was not classified as fit to return to sea.

The recovery of the two chemistry moorings in the early afternoon went smoothly. This was followed by suspending a Seastar filterer over the side for several hours. The ship then went into Sydney Harbour in the early evening, quite a spectacle in balmy conditions, and docked at Wooloomooloo at 2100h. Greaser Mclure and Steward King had to be replaced; one of the Seamen needed medical attention; part of the scientific party was to be exchanged.

At 1500h on Friday 17 November the ship sailed from Wooloomooloo. The scientific staff leaving the ship were Nichols, Holdsworth, Rayner, Bavor, Gray, Espey, and Holmes, while those joining or rejoining it were Helmond, Pender, Woods, Nilsson, Boult, Latham and Fry (of ABC Radio). Remaining on board were Cresswell, Peterson, Adams, Terhell and Hunter. A lifeboat drill was held at 1600h. At the Harbour mouth there was a trichodesmium plume, birds were feeding and there was very little wind.

The plan had been to do a standard *Seasoar* section to the east, but the instrument had developed many problems that, in the end, took 2 days' hard work by Pender, Helmond and Adams to resolve. The ship travelled northward along the 100m isobath towards Smoky Cape. Enroute the current increased to 1.5 knots and at the Master's suggestion we moved a little inshore

Smoky Cape was reached at 0900h on Saturday 18 November and 6 CTD stations (#27-#32) were done across the shelf from the nearshore to the upper slope along 30°54'S (line 1). The ship then moved southward to the slope station (320m) on the Hat Head line (line 2) (31°05'S). Stations #33-#38 were occupied across the shelf between 1500h and 2000h.

The ship stayed inshore and steamed to the Racecourse line (line 3), 31°14'S, arriving at the first station,#39, at the 35m contour at 2100h. Six stations were done at 2 mile intervals across the shelf. *Seasoar* was launched after the second station but unfortunately it quickly sprang a leak through a new bulkhead connecter and had to be recovered. The Racecourse line was completed with CTD#45 at 0400h Sunday 19 November.

The Pt Macquarie line (line 4) was leapfrogged and the Laurieton line (line 5) , 31°35'S, with stations #46-#51 was run between 0600h & 1100h. From 1230h *Seasoar* was used to do the Pt Macquarie line (line 4) and then the ship returned to the outer end of the Racecourse line to run an ADCP/GPS/XBT section out to the EAC to provide information for John Hunter's model, which was running onboard. The XBTs were X10-X16.
In rainy squally conditions the current climbed to 2.6 knots. The section was stopped at 2115h when the main current jet had been crossed. The plan then to deploy *Seasoar* was foiled by winds of 40 knots with rain. The ship headed for Trial Bay (on the northern side of Smoky Cape), an option to Coffs Harbour for disembarking Woods and Fry in southerly winds.

The ship arrived at Trial Bay at 0630h Monday 20 November. Woods and Fry were put

ashore in the ship's boat. The ship then proceeded along the 100m contour towing *Seasoar* to Cape Byron at the northern end of the next study area which was centred on the Evans Hd upwelling. There was a following sea and swell with wind up to 30 knots.

The *Seasoar* run ended at 0500h Tuesday 21 November off Ballina and gave us the opportunity to get a long section of temperature, salinity and currents. The results (588 *Seasoar* profiles) were similar to those of a coarser CTD section done with *Sprightly* in 1982. Northgoing currents were encountered for a while and then the ship ran into the warm waters of the EAC as it cut across the shelf at up to 2 knots.

The Byron line (line 6), 28°38'S, with CTD stations #52-#57 at 2 mile intervals was commenced at 1300h. Three stations were done and then the *Seasoar* was deployed. Mechanical problems were encountered with the cable fairing. The instrument was recovered for repairs and the line of CTD stations was continued. At and just beyond the shelf edge the surface current was 2 knots, while at 150m it was 2.8 knots. Note that northward currents were encountered at the inshore end of the Byron line.

Off the shelf two zigzag paths with the *Seasoar* were followed southward to the offshore end of the Ballina line (line 7), 28°52'S. CTD stations #58-#65 were occupied at 2 mile intervals along this line from the early hours of Wednesday 22 November, except for a visit by a NSW Fisheries patrol boat commanded by Ron Driver.

At 1230h near the Evans Hd line (line 8) the first of the markers for the two moorings deployed on an earlier voyage was sighted; the other was seen an hour later. A shallow (32m) CTD station, #66, was done in very pleasant conditions and *Seasoar* was deployed midshelf and towed out to sea. The course was a little south of east to avoid the Division's current meter moorings in the area. Several parallel slicks probably associated with internal waves were crossed. Near the shelf edge the ADCP showed a deep slab ~200m thick to be moving at 3 knots. The ship's speed was dropped to 6 knots from 8 so that the *Seasoar* could profile between 140 and 340 m to the eastern turning point and then between the surface and 150m on the return to the 150 m contour. XBTs (X17-X20) were dropped to obtain temperature information below the depth reached by *Seasoar*.

After recovering *Seasoar* at 2200h the ship headed southward along the 200 m contour between the Evans Hd and Wooli Hd lines with a 3 knot lift from 24°C EAC, arriving at 2240h.

CTD stations #67-#75 were occupied at 3 mile intervals along the Wooli Hd line (line 9), 29°21'S, and completed at the inshore end at 0700h Thursday 23 November. The sea was quite smooth as the ship proceeded to the inshore end of the Byron line (line 10), 28°38'S, to release satellite tracked drifters at each of 7 CTD stations, #76-#82, separated by 2 miles across the shelf. The inshore station was at the 54m contour, which was a few metres deeper than the drogue of the drifter.

The final station and drifter release was at the 1100m contour. The sea was smooth on a low swell and the EAC waters were deep blue and transparent. The ship then reversed course to run the ADCP/GPS back along the Byron line (line 11), 28°38'S, finishing at 1600h. A time lapse video made of the current profiles on the VDU screen as the ship crossed the slope and shelf was instructive.

At 1600h the ship turned northward and by 1900h at ~28°10'S (abeam of Mt. Warning) was stemming a 2.2 knot current at the 100m contour.

The ship arrived in good weather at the northernmost line of the voyage, Cape Moreton (line 12), 27°02'S, at 0300h Friday 24 November. Nine CTD stations, #83-#91, were occupied at 2 mile intervals across the shelf to the 600m contour. In fact *shelf* is something of a misnomer: the bottom falls away quite quickly. The 16°-17°C isotherms ran parallel to the sloping bottom right into 90 m.

The ship left the Cape Moreton line at 1000h and angled inward to the inshore end of the Pt Lookout line (line 13), 27°25'S. *Seasoar* was deployed at the 60m contour and used to make a standard section across the shelf, down the slope to several hundred metres and then back along the reciprocal course to collect data in the upper waters. The maximum current was 2.5 knots at the shelf edge.

*Seasoar* was brought back onboard and the ship steamed at 12 knots to the Jumpinpin line (line 14), 27°45'S, arriving at the 50m contour at 1900h. *Seasoar* was deployed in good conditions. The section was continued well beyond the usual to get an understanding of the driving currents in the open ocean. The

*Seasoar* outward line was stopped at 0100h Saturday 25 November and the ship took the reciprocal path back to the shelf, recovering *Seasoar* at 0530h. Several XBTs (X22, X24-X26) were dropped enroute to get temperature information deeper than was available from *Seasoar*.

The ship steamed to the inshore end of the Fingal line (line 15), 28°15'S, arriving at 0800. Five CTD stations, #92-#96, were occupied between the 35m and 80m contours and then *Seasoar* was deployed for measurements above the outer shelf and slope. The turn to the reciprocal path was made at 1400h and the standard section, with a following 0.5 m sea and 10 knot breeze, was completed at 1600h. Two XBTs (X27, X28) were dropped. The surface current above the 150m contour was 2.4 knots; at 100m depth the current was 3 knots.

The ship travelled to the inshore end of the Byron line (line 16), 28°38'S, and occupied 3 CTD stations, #97-#99, at 2 mile intervals between 1800h and 2000h. The innermost station had 18°C water at the bottom (50m). *Seasoar* was deployed and a standard section was run without problems. GPS finished at 2235h and the turn to the reciprocal path was made after that time.

*Seasoar* was recovered by 0150 Sunday 26 November. The ship then proceeded in turn to two of the drifters (the inshore ones) that had become snagged by their drogues at about the 50m contour north of Ballina and north of Evans Hd. The first was recovered shortly after first light; the second at 0815h. There was no damage to either of the drifters or drogues.

CTD stations #100-#109 were then occupied at 2 mile intervals along the Evans Hd line (line 17), 29°08'S, between 0900h and 1500h and revealed the upwelling that had earlier been studied by Rochford. *Seasoar* was deployed after the last CTD station at the 250m contour and was used to profile between 60 and 260m across the EAC Escalating wind speeds to 30 knots by 2000h encouraged us to recover *Seasoar* shortly afterward. The weather stayed bad overnight as the ship headed SSW at 3-4 knots into 30 knot winds and very steep waves from the 2-3 knot current. XBTs (X37-X42) were dropped hourly.

Monday 27 November was rough and uncomfortable until mid afternoon when a turn was made to the inshore end of the Laurieton line (line 18), 31°38'S, CTD stations #110-#116 were occupied every two miles out to just beyond the shelf edge.

The ship docked at Newcastle at 0700h Tuesday 28 November and sailed at 0600h Wednesday 29 November. Remaining on board were Cresswell, Adams, Terhell, Pender and Helmond. Leaving the ship were Peterson, Hunter, Nilsson, Latham and Boult. Joining the ship were McDougall, Schahinger, Trenaman (Lawson and Treloar, Consultants), Taylor (RAN), Gilchrist (ABCTV), Sleeman (ABCTV) and Martin (ABCTV).

The ship proceeded to the mooring site off Bondi arriving at noon. The Lawson and Treloar mooring, which had lost its surface marker, had been given a new marker by divers, who were on a small trawler standing by to assist. The two current meters on the mooring and one of the two anchor clusters were recovered. The second anchor became snagged and had to be cut free.

The CSIRO mooring comprised a new acoustic Doppler current profiler and acoustic release. When it arrived at the surface it was difficult to approach safely with *Franklin* so the divers on the trawler attached a line. (There was a delay caused by a shark). The trawler towed the instruments to the side of *Franklin* where they were recovered with the Hiab crane. The Master of *Franklin* has made some suggestions on improvements of the ADCP/float frame to aid recoveries in the future.

These operations, as well as a CTD station #117 at the 70m contour and the deployment of *Seasoar*, were filmed by the ABCTV crew. Shortly after 1430h the ship was treated to some highly skillful flying by the ABC helicopter as it filmed both *Franklin* and *Seasoar* being towed behind it.

A standard section, line 19, done with *Seasoar* and ADCP/GPS, finished back at the shelf edge at 2230h. The ship turned to run roughly SSW parallel with the shelf edge while *Seasoar* was recovered. This was completed by 0030h Thursday 30 November. The ship then proceeded to Jervis Bay where it anchored at 0700h.

The ship's boat took Gilchrist, Sleeman and Martin of the ABC ashore. Peterson rejoined the ship, coming out from HMAS *Creswell* on the Division of Fisheries vessel, *Catalyst*, which took Taylor and Trenaman ashore. The scientific crew on the ship for the voyage to Melbourne was then Cresswell, Peterson,

Adams, Terhell, McDougall, Pender, Helmond and Schahinger.

Four CTD stations #118-#121 were occupied at 1.5 mile intervals along a N-S line in the Bay. They showed a two-layer system — 19.5°C and 15.5°C — in the 25m deep waters. Subsequent nutrient analyses showed high values near the bottom The low temperature of the bottom layer suggests that a slope water intrusion onto the shelf spread into the Bay. Certainly the waters were quite green after several weeks of looking at the dark blue waters of the EAC.

On leaving Jervis Bay *Seasoar* was launched and run from from 1500h-1800h across the shelf, line 20, and into the 3 knot fast current ring of the warm eddy. *Seasoar* was then recovered so that the system could be reconfigured for *Bunyip* for Dr. McDougall's studies. The ship travelled SE to the eddy centre, as determined from a satellite image transmitted from Hobart. This resulted in an ADCP/GPS/XBT section (X43-X52) to the centre where a satellite-tracked drifter was released at 0200h. The ship continued on without GPS coverage to exit from the eddy on its SE side at 0800h Friday 1 December. The reciprocal course to the NW was taken at 1000h and *Bunyip* (*Seasoar* plus *Microfish*) was launched between 1100h and 1200h. The current reached 3.5 knots as the eddy was reentered from the SE. The conditions were clear skies, 20 knots from the NE, and small but steep seas.

*Bunyip* was recovered and onboard by 2240h. The ship then hove-to until *Bunyip*, after some modifications, was launched again in the early afternoon of Saturday 2 December and a course to the NE at 6-8 knots was followed until *Bunyip* was recovered at midnight in a 3m swell. In rough conditions the ship continued on the same course at 8-10 knots across the radius of the warm eddy, then across a cold eddy, finally entering the EAC and encountering 3.5 knot currents. XBTs (X53-X70) were dropped across the three features. The equal-sized warm and cold eddies could not be distinguished by their surface temperatures — both were 19°-20°C. However the cold eddy was particularly cold at the commonly referred to 250m depth, being as low as 9.3°C. In the warm eddy the 250m temperatures were as high as 18.7°C.

The EAC front, which was crossed at 1030h on Sunday 3 December, was easily distinguishable by eye and radar due to the effect that the current had on wave patterns. The swell coming from the NE — and with the current — steepened when it propagated into the relatively stationary waters of the cold eddy. The ship went 10 miles into the EAC waters and then came back on the reciprocal course, 250°, when GPS came back on to get a good ADCP/GPS current section.

Back into the cold eddy the ship stopped and at 1515h a Niskin bottle was lowered over the bow to obtain a pristine water sample as a baseline for organochlorines for Dr. Fandry. At 1615h more pristine samples were taken with a 1000m CTD/rosette cast, #122.

*Bunyip* had developed problems of communication to and from the ship and so it was decided to use the down time to return to the continental shelf at Sydney. A line of CTDs, #123-#131 was occupied from 1000m-50m off Malabar, line 21, between 0300h and 1000h Monday 4 December.

The ship then returned to the north side of the warm eddy and *Bunyip* was operated between 1400h and 1900h. Problems with it meant that there was time for more continental shelf work and so the ship travelled to the 80m contour at the mouth of Jervis Bay, arriving at midnight, to commence a line of six stations, line 22, CTD #132-#137, at 2 mile intervals across the shelf and down the slope from the 86m-760m contours, finishing at 0530h Tuesday 5 December. Inshore the surface temperature was just under 18°C, indicating upwelling. At the third station the warm eddy edge was encountered, with current speeds increasing to 2.5 knots. At the 2nd deepest station #136 there was a 12.5°C 70m thick bottom mixed layer at 250-300m.

The difficulties continued with *Bunyip*, so the ship went inshore to Bateman's Bay, 35°43'S, in unusually heavy rain to commence another line of CTD stations, line 23, #138-#143 from the 46m- 540m contours. At #138 the surface temperature was 18.2°C and 36m temp 15.3°C. At #139, 104m, the 92m temp was 14.2°C. It is suggested that these temperatures were indicative of upwelling being driven by the close proximity of the eddy. An additional station, #144, was occupied at the 1150m contour to obtain pristine samples for organochlorines for Dr. Fandry.

At 1730h *Bunyip* was deployed and the ship travelled eastward, initially crossing upwelled water (<18°C) that was moving northward and, as we neared the eddy edge, southward to be entrained into it. The current structure showed a depth range of considerable shear

which deepened as the eddy was progressively penetrated. *Bunyip's* microconductivity sensors showed this to be a region of intense vertical mixing. The observations supported our interpretation of an image that had been received from Hobart several days earlier. Several crossings were made in and out of the eddy before *Bunyip* developed problems (another failure of a bulkhead connector) and was recovered between 0150h and 0250h Wednesday 6 December.

The ship then set a course for Melbourne via brief work stops at the Gippsland upwelling (for R. Edwards) and a *Bunyip* test. In the afternoon a line of three CTD stations, line 24, #145-#147, was occupied across the usual position of the upwelling plume as is revealed by satellite imagery. The winds were 25 knots from the east but there was no upwelling. *Bunyip* was successfully tested in the evening.

The ship arrived in Melbourne at 2000h Thursday 7 December. This was a change from Hobart so that it could go into drydock for bowthruster repairs.

## A SELECTION OF THE RESULTS

The highlights of the voyage were the measurements of the effects of the EAC and the warm eddy on the waters of the continental shelf. Subsurface current maxima were a feature of both the shelf edge and open ocean currents. A surprise, even after years of study, was the strength of the current in the warm eddy south of the EAC: the surface expression from the satellite images was anything but dramatic, and yet the current speeds (4 knots) were at least equal to those measured in the EAC (**Figure 2**).

The interplay of strong currents, slope water intrusions and upwellings was documented in particular at Evans Head, south of Cape Byron, and at Jervis Bay. In this section we briefly discuss some of the preliminary data from the Cape Byron and Evans Head lines, since data were collected by the CTD, the ADCP/GPS, satellite-tracked drifters, *Seasoar*, current meter moorings and the NOAA satellite radiometers, although not all data are presented.

The temperature structure from the 7 CTD stations at the drifter release sites that were separated by 2 miles seaward from the 50m contour is shown in **Figure 3**. The warm core of the EAC (>24°C) can be seen to be centred over the shelf edge. Once the drifters had been released the ship turned to follow the reciprocal path with GPS to the west directly across the southgoing current. The ADCP/GPS revealed the current structure shown in **Figure 4**. A subsurface current maximum can be seen and currents of 0.5 $ms^{-1}$ (1 knot) extended in close to the coast. The corresponding surface current vectors for this line and the Jumpinpin and Pt. Lookout lines to the north are shown in **Figure 5**.

The 7 drifters that were released over the 12 mile east-west line on 23 November moved away at speeds ranging from 0.1 to 2.5 knots (note that their drogues were set at 50m), so that in 3 days they were spread over 180 miles, highlighting the problems facing a search and rescue coordinator. **Figure 6** shows the first 9 days of their tracks. The two inshore drifters snagged on the 50 contour and were recovered by the ship. The drifter off Jervis Bay was released near the centre of the warm eddy on 1 December.

The upwelling that was produced south of the Cape Byron separation point of the EAC can be seen in the temperature section at Evans Head on 26 November (**Figure 7**). The upward doming of the temperature structure resulted in cool surface waters in a plume out from the coast that could be discerned in a satellite image at the time. Note that the 4 cross-shelf current meter moorings will give temporal information on the upwellings for the six months from August 1989.

## DIFFICULTIES, NEEDING ATTENTION, SUGGESTIONS

The airconditioning system in the operations room was ineffective and much too noisy.

Conversation in the messroom at mealtimes is near-impossible due to the noise from the televisions.

The handwinch on the davit for the ship's boat was not equal to the task .

New hardhats are needed.

Consideration could be given to acquiring a new photocopier.

Heavy rain on the voyage highlighted the need for a small dismountable canvas hangar for deck work on *Bunyip* and other instruments.

A zoomable VDU display of coastline, bottom topography and ship's position would be something to aim for in the future.

While the XBT display on the VDU is excellent, I feel that the CTD display could be improved and I will discuss this with the Hobart staff.

The ship's inflatable boat was stored on top of the *Seasoar/Bunyip* winch. It collected rainwater which spilled onto workers below in a random and totally frustrating manner. This is hazardous when connecting underwater cables, and an alternative storage site needs to be found for the craft.

A 3-phase power outlet is needed on the port side so that the small moorings winch can be operated without using an extension cord. Again on this voyage, water entered the joint of the extension cord and caused a short.

## PIGGYBACK REPORTS

**Project title:** Stability and noise tests of a towed acoustic sampling system (TASS).

**Personnel:**
Dr. N. **Elliott**, CSIRO Division of Fisheries
Mr. R. **Kloser**, CSIRO Division of Fisheries
Mr. I. **Helmond**, CSIRO Division of Oceanography

**Objectives:** To further examine, and correct, the hydrodynamics of the towed acoustic sampling system; to measure the noise of the system under various conditions, including with and without fairing on the cable; and to test inhouse-built preamplifiers on the system.

**Results:** The towed body was successfully deployed and retrieved on three occasions, with each trial representing different configurations of towing point and trim tab adjustment. During each deployment simultaneous pitch/roll information from the vessel and the towed body was collected under varying conditions of cable length and vessel speed. On the last deployment 50 m of fairing was added to the cable to observe any reduction in cable induced flow noise.

The towed body was successfully deployed, for the first time, to a depth of 1000 m (at 3 knots). This satisfied our final design requirement for obtaining in-situ target strength measurements of deepwater fish at depths down to 1200 m. The towed body was further fine tuned as a stable platform for towing at 200 m depth at 6 knots, our requirement of acoustic surveying.

Simultaneous operation of the pitch/roll sensors on the body and its transducer preamps was not possible on this cruise due to excessive crosstalk in the 7-conductor electromechanical cable. It was necessary to disconnect the preamp circuit and obtain noise measurements without preamplifiers. This reduced the signal to noise performance of the system, but with the very calm conditions experienced it was still possible to detect the variations of flow induced noise. The 50 m of fairing added to the cable proved successful, it appears to reduce the flow induced noise by approximately 10dB. Further tests are required with the preamplifiers to validate this response.

**Special note:** We would like to express our appreciation to the Master and crew of the R V Franklin, Dr Cresswell and all other scientific staff on the cruise for enabling us to perform all our tasks with such success and for making the cruise a very enjoyable experience.

**Project title:** Tracking sewage in sludges, coastal waters and sediments adjacent to Sydney using organic markers.

**Principal Investigators:**
Dr Peter D. **Nichols**
CSIRO Division of Oceanography
Dr H. John **Bavor**
University of Western Sydney

### Itinerary

Sailed Sydney: 1700 Hrs Tuesday 14 November, 1989
Arrived Sydney: 2100 Hrs Thursday 16 November, 1989

### Objectives

Tracking sewage in sludges, coastal waters and sediments adjacent to Sydney using organic markers

1. Determine the physical oceanographic features of near-shore coastal waters

adjacent to Sydney, with particular reference to major sewage outfalls.

2. Collect water column and sediment samples for laboratory determination of organic marker compounds, measurement of other chemical and biological parameters and microbial indicator organisms.
3. Use the chemical, microbiological, physical and other oceanographic data to further understand the distribution, fate and persistence of Sydney's sewage outfall effluent.

## Narrative and Results

### *Part A (Hobart to Sydney, November 11 to 14, Nichols):*

The instrumention for underway measuring of the pH and fluorescence of surface seawaters was set up and calibrated. Plumbing problems with the isolation/flow-through valve to the Turner Fluorometer caused us to modify the inlet tubing to the fluorometer. Garden hose fittings were used in place of the valve.

The pH data was logged and incorporated with temperature and salinity data from the thermosalinograph. Problems were encountered with logging the fluorescence data to the VAX, therefore only a chart printout of surface water fluorescence (Turner units) was obtained for the duration of the Hobart-Sydney and Sydney-Sydney legs. The surface waters pH, salinity and temperature data was transfered to an IBM compatible computer at 24 hour intervals (UTC 0000-2400) for these two legs of the cruise. These data are available in LOTUS spreadsheet format.

Two subsurface chemistry moorings were deployed November 13 at:

(i) 1915 (local), the west end of the Malabar transect (Section C, site 15; see Table for details); mooring #134. The mooring comprised a Seastar acoustic release, one sediment trap (11 m from bottom), one Seastar sampler set up for organics (9 m from bottom) and one Seastar sampler set up for metals (8 m from bottom).

(ii) 2010, the Sydney Water Board ocean reference station site (Section B, site 11, see Table for details); mooring #135. The mooring comprised the same equipment as for mooring #134.

A third mooring, the ADCP mooring, was deployed at the ocean reference sation site.

The deployment of both chemistry moorings was complicated by the strong currents (estimated at 1 to 2 knots) and the need to find exact position. Difficulties were also encountered in setting two of the Seastar sampling devices (Units #10146 and the new deep sampler).

On Tuesday November 14 0830 to 1200 Franklin steamed over the approximate flight track of the COSSA F27 aircraft. The main purpose of this work was to obtain data with the surface waters underway gear, in particular surface fluorescence. These data will provide "ground truthing" for the airbourne colour scanner flown by Dr Stephen Walker (CSIRO, Division of Oceanography Remote Sensing Section). Water samples were collected during these sections for laboratory determination of chlorophyll a. The cruise track during this time was as follows:

0830: Franklin commenced steaming west from the east end of section C (Malabar transect, 33 58.10 S). The surface water fluoresence increased steadily from 0.01 Turner units (approximately 0.01 $\mu$ g/l chlorophyll a) at the start of the section to around 0.9-1.3 Turner units (0.9-1.3 $\mu$ g/l chlorophyll a) at the west end of the section adjacent to the Malabar outfall.

0915: Finished section and steamed north to North Head. The surface water fluorescence decreased to around 0.55 Turner units along this section.

1015: Commenced steaming east from North Head. Fluorescence dropped off steadily again to 0.01 Turner units.

### *Part B (Sydney to Sydney, November 14-16, Nichols, Bavor and associates):*

The acquisition and logging of surface waters underway data continued.

Four chemistry/microbiology sections were undertaken (stations at 0.5,1,2,3,4,5,10,15 nm). A total of 26 stations were occuppied (see accompanying Figure and Table). A complete listing of station locations and samples collected is provided in the accompanying Table. Each station comprised:

1. One CTD dip, collection of water for hydrology, chemistry and microbiology samples. Continous vertical profiles of temperature, salinity, depth (pressure), oxygen, pH and fluorescence were recorded for each station. The turbidity sensor did not show a signal at any station.
2. Sediment collection for chemistry and microbiology using a Smith-MacIntyre grab. The grab was deployed on the hydro-wire.
3. Collection of surface plankton samples for NSW Fisheries. A 500 $\mu$m mesh plankton net was towed for ten minutes at 2 knots.

Strong north to south currents (1-1.5 knots) were encountered during leg B, and at most stations extra time was required to reposition Franklin between the various sample collections. The sewage plumes of the Bondi and Malabar outfalls were visible inshore of the nearshore stations, however the strong prevailing currents directed the plumes south along the coast-line. The nearshore stations were therefore not in the direct path of the visible surface plumes during leg B of FR13/89.

Samples for microbiological analysis were aseptically collected from CTD bottles, in sterile Whirl-Pak bags. Water column samples from surface (2m) and 20m depths were collected. Following collection, the samples were immediately assayed, using membrane filtration techniques.

After filtration, 0.4µm membranes were placed on mFC agar plates and incubated for 24 hours at 44.5°C. Following incubation, the plates were examined for typical dark blue colonies and occasional light blue, mucoid colonies, indicative of faecal coliforms. Colonies were confirmed in the WRL laboratory, upon return to Richmind. Surface, near-shore sampling is currently being carried out to supplement the cruise results.

Sediment samples were aseptically collected from the Smith-MacIntyre grab and refrigerated for 24–48 hours, 4°C, before analysis in the laboratory, following the cruise. Analysis for total aerobic heterotrophic microoganisms were carried out, using a pour-plate technique.

At completion of CTD section D at 1000 (local time) November 16 Franklin steamed to the site of mooring #135 (Sydney Water Board ocean reference station) to commence mooring recovery. A medical emergency occurred during this time and Franklin steamed directly to Watsons Bay in Sydney Harbour. Franklin waited in Watsons Bay to pick up a pilot then proceeded out of Sydney Harbour.

The two chemistry moorings were retrieved during the early afternoon of November 16. Mooring recovery went very smoothly. Mooring #135 (ocean reference station) was retrieved at 1230. The sediment trap contained fine, light-coloured material. The Seastar deployed for metal collection had malfunctioned. Mooring #134 (Malabar section, station #15) was recovered at 1330. The sediment trap contained less material than obtained at the ocean reference station site, and the material was darker in colour and in larger aggregates. The Seastar sampler deployed for collection of organic material had not started.

Franklin steamed to the ocean reference station and a Seastar sampler was deployed by rope for a period of three hours (1500-1800). The Seastar sampler was set up by Dr Espey for collection of particulate and dissolved metal material and was deployed at a depth of 20 m. Care was taken to ensure that Franklin was down current from the sampler during deployment.

The cruise track during the 2 days November 14-16 is summarised as follows:

1. Watsons Bay to west end of Bondi section (A)
2. Section A, west to east, 8 stations occupied
3. Section A, east to west
4. Section B, west to east, 5 stations occupied
5. Section B, east to west
6. Section C, west to east, 8 stations occupied. The 1.0 nautical mile station (#14) was performed before the 0.5 mile station (#15).
7. Section C, east to west
8. Section D, east to west, 5 stations occupied. Stations were undertaken along this section in an east to west direction, rather than west to east as planned, so as to ensure the inshore stations were occupied during daylight hours.
9. Steamed to Watsons Bay to drop off seaman following medical emergency.
10. Steamed to Ocean reference station and recovered mooring #135.

11. Retrieved mooring #134 at Malabar 0.5 nautical mile station.
12. Deployed Seastar sampler by rope at ocean reference station.
13. Steamed to Sydney Harbour and docked at Wooloomooloo at 2100.

It will be some months before all the data and samples collected during the cruise are analysed in detail. Together these data will provide a wealth of information on the complex interactions of the physical, chemical and biological (in particular microbial) systems in coastal water adjacent to Sydney.

**Acknowledgements**

We thank the officers and crew of R.V. Franklin, who with fellow CSIRO scientific personnel and members of collaborating institutions, were essential for the success of the field work; Drs. D. Mackey and E. Butler and J. O'Sullivan for their assistance and advice with the surface waters continuous sensor work.

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**Project Title:** Real Time Numerical Modelling of the Southeast Australian Shelf Region

**Personnel** : Dr. J.R. **Hunter**, CSIRO Division of Oceanography

**Objectives** :
(a) To attempt to model aspects of the circulation in the Southeast Australian shelf region (eg. the effect of the East Australian Current) in real time, on board ship

(b) To investigate the use of a real-time model in aiding the direction of an oceanographic cruise

**Results** :
A two-layer numerical model of the Tasman Sea (stretching from the Australian shelf to New Zealand) was implemented on a 20 km x 20 km grid, prior to the cruise. The model was initialised by a prescribed sea surface and interface topography, which was allowed to relax over a period of three weeks, to predict the evolution of features of the East Australian Current (eg. warm core eddies). The initial sea surface topography was derived from isotherm data at 250 metres depth, supplied by the Naval Weather Centre in the form of contoured charts. The initial interface topography was derived from the sea surface topography and an assumption of geostrophy, zero flow in the lower layer, and an assumed strength for the East Australian Current. All computing tasks (eg. digitisation of the Naval Weather Centre charts, model runs and subsequent graphical display of the results) were carried out on a dedicated Sun 3/50 computer on board the vessel.
Three model runs, each of three-weeks' duration (in "model time") were carried out using different initial conditions and different internal parameterisations. It was clear from these results that a grid size of 20 km x 20 km was inadequate for the resolution of important features of the East Australian Current, especially in areas where it impinged on the continental shelf. A "fine resolution" version, utilising a grid size of 10 km x 10 km, and a reduced areal extent (the western Tasman Sea), was hence implemented on the vessel (Figure 9). This latter model was again used for a further three-week simulation. The results indicated that :

(1) It is possible to run a quite sophisticated hydrodynamic model (ie. a multilayer model with around 11,000 grid points) on board ship

(2) A computer of modest power by today's standards (a Sun 3/50) can cope with all the ancilliary steps in the modelling process from initial digitisation of the input data through to final graphical representation of the results (generally in the form of "movies")

(3) The model predictions indicated a number of features that were observed during the cruise (eg the southward propagation of eddies down the western boundary of the East Australian Current)

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# ORV REPORTS

## Electronics Report — P. Adams

Thermosalinograph
A sticking temperature pen was traced to a faulty pen position pot. This was repaired.

After power up, no paper drive, fault traced to a/c driver transistor. Transistor replaced with equivalent, operating correctly.

EK400 Sounder
Fault developed in displayed bottom echo (appeared to be operating continuously in dynaline mode). Suspect Recorder Amplifier board replaced with spare, no difference. A Recorder Amplifier board was removed from

the Division of Fisheries EK400 (on board for transducer trials) and installed, fixing the initial fault, the digitiser then locked onto 2nd echo. This fault was fixed and the board remained in the set for the rest of the voyage.

The original board and spare had the same faulty component, not carried on board, and not available in Newcastle. Repairs to be carried out in Hobart prior to next voyage.

All boards should be checked in next port period.

Hydrology winch
The payout meter on this failed to operate due to a broken sensor. A new sensor has been ordered and will be installed on receipt.

DELP NEC P7 Printer
TT06: and TT07: had been reversed prior to start of voyage, not sure whether DELP printer was used on previous voyage.

Printed all messages in condensed print and gave multiple carriage returns per single DELP entry. Unable to determine whether hardware/software error, no spares available for printer.

Unit was replaced with spare LA100 from *Bunyip* for entire voyage.

CTD/Rosette Sampler
The trip mechanism of the rosette was dismantled and cleaned. The main ferrel was worn causing occasional misfiring. This was repaired and the unit was reassembled.

Turner Fluorometer
The Turner failed to log onto the network. Fault traced to plug inserted 180° out of position on A/D board of Micro 2.

Operations room overheating
The ops room became too hot for reliable operation of the equipment, due to insufficient suction of the hot air from the racks. The two racks without fans (*Bunyip*) and Micro 1 &3 displays should have them installed and the racks should be sealed off at the fronts and at the bases with air inlets being cut in the pedistals.

Filters should be installed over the inlets. This would also reduce the excessive amounts of dust found on the circuit boards.

The noise level in the operations room is high.

## GLOSSARY

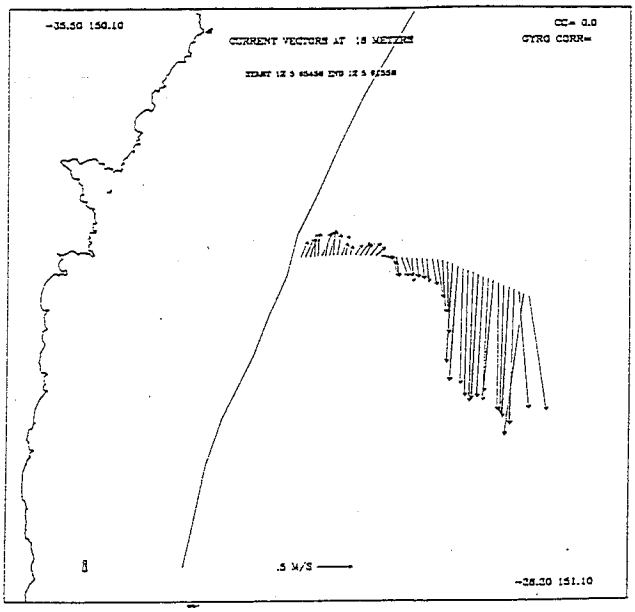
**ADCP** - acoustic Doppler current profiler. Four acoustic beams are projected downward from transducers in the ship's hull. The reflections from biological scatterers and ocean structures are arranged according to depth. The frequencies of the reflected signals give a measure of the current profile down to several hundred metres . Substantial errors are introduced by gyro inaccuracies and the misalignment of the ADCP transducer package in the ship's hull. Recently the Division of Oceanography has acquired an ADCP for operation on a mooring.

**CTD** - a profiling instrument for measuring conductivity, temperature, and pressure (depth) and estimating oxygen content. Salinity can be inferred from the conductivity and temperature measurements. A rosette of 12 water sampling bottles is attached to the CTD; the bottles close sequentially on commands from a shipboard console, thereby providing samples both for CTD sensor calibration and nutrient analysis.

**GPS** - Global Positioning System. A network of satellites and a shipboard receiver capable of fixing the ship's position to several metres. This information is invaluable for determining absolute current profiles from the ADCP and, of course, for any precision navigation. The present network of satellites gives a GPS coverage of about 9 hours per day.

**XBT** — Expendable bathythermograph: a probe that is dropped from a ship and relays temperature information up a hair-thin twin-core cable.

***Bunyip* and *Seasoar*** — *Bunyip* is a streamlined 3m long towed body with sensors for temperature, conductivity, pressure, and microstructure. It is passive and is towed 100m behind the active *Seasoar* which has wings that are controlled by the operator of the shipboard computer. The wings enable it to follow an undulating path with vertical excursions of as much as 200m. It completes one up and down cycle over a depth D each 4D that the ship advances.*Seasoar* is towed with up to 5 km of faired and unfaired cable behind *Franklin*. The wings of *Seasoar* are driven hydraulically by a motor powered by a propeller.
*Seasoar* was used without *Bunyip* for a large part of the voyage. In that mode it carried its own CTD.



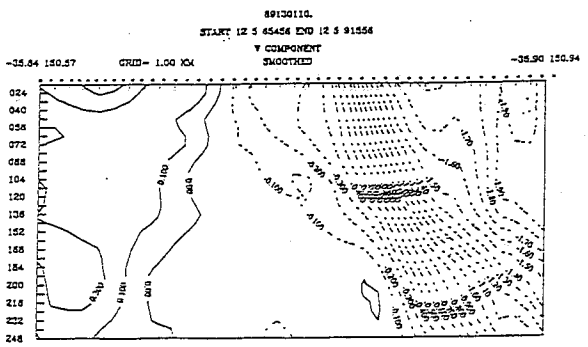




**Figure 2** The ADCP vectors at 16 m and the north-south velocity component section on the line roughly out from Batemans Bay on 5 December (see pages 7 & 8).

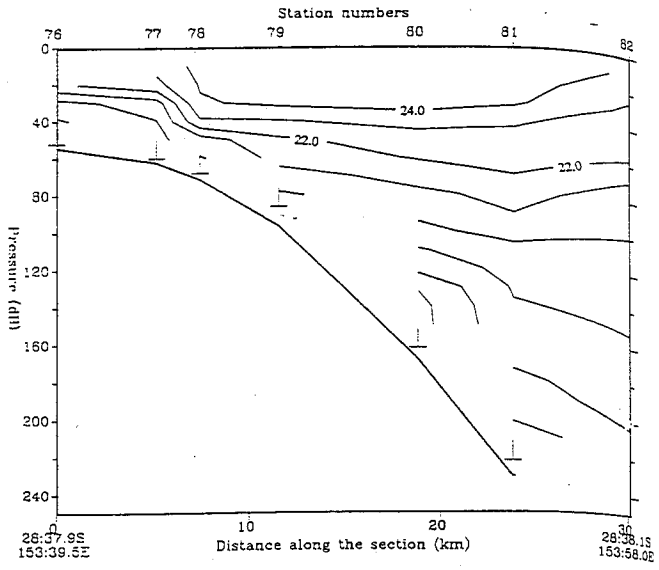



**Figure 3** The temperature section from 7 CTD stations where satellite tracked drifters were released on 23 November out from Cape Byron.

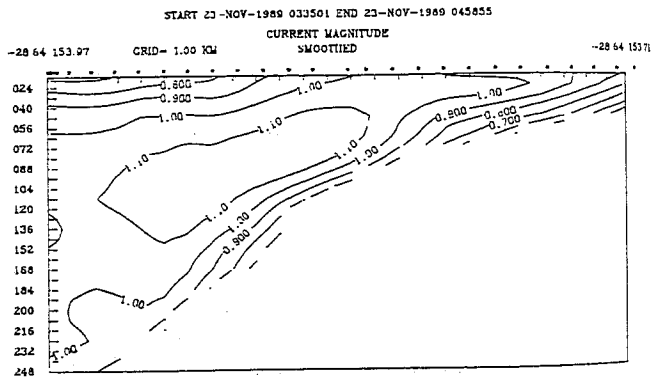



**Figure 4** The ADCP speed section on the return to Cape Byron on 23 November.

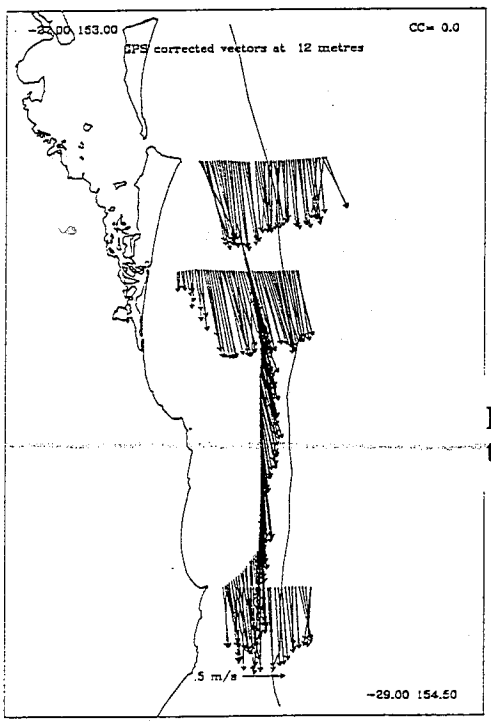



**Figure 5** Near-surface ADCP current vectors at the Pt. Lookout, Jumpinpin, and Cape Byron lines.

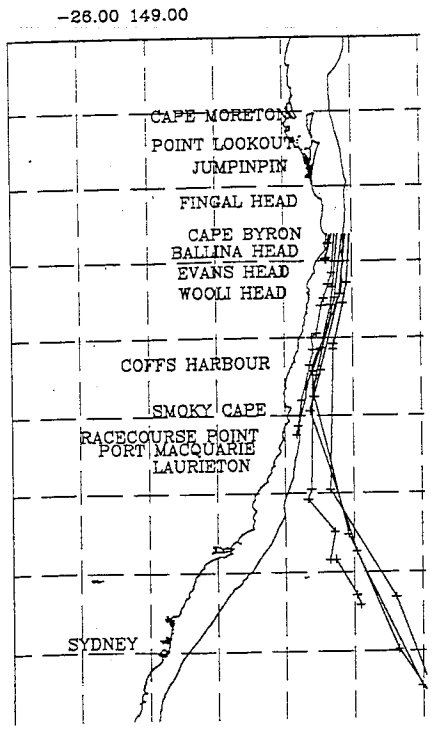
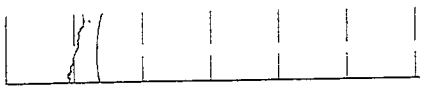



**Figure 6** The tracks of the 7 drifters for the first week..



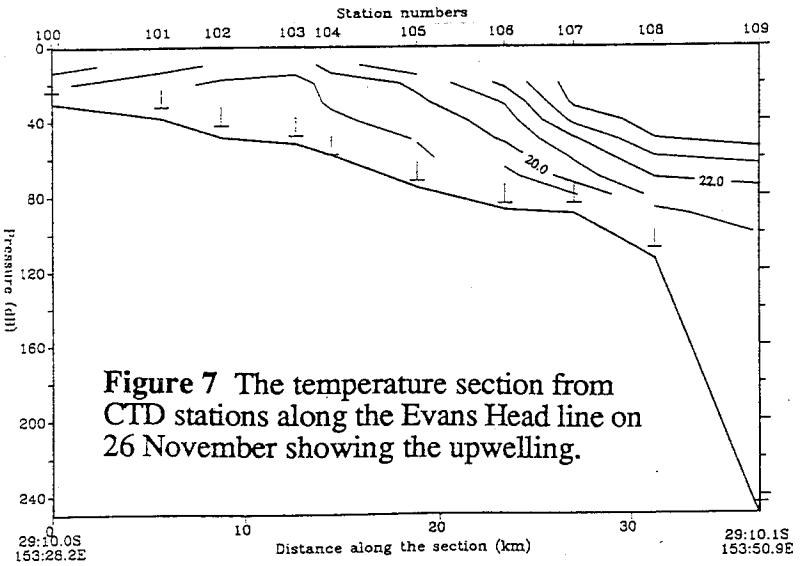



**Figure 7** The temperature section from CTD stations along the Evans Head line on 26 November showing the upwelling.

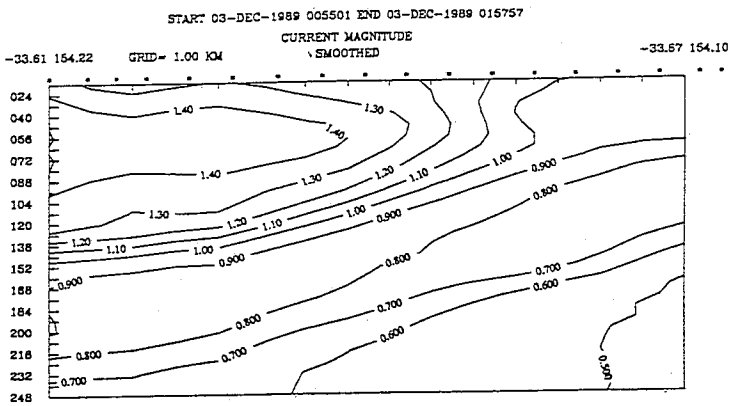



**Figure 8** The ADCP speed section across the EAC in the open ocean on 3 December.

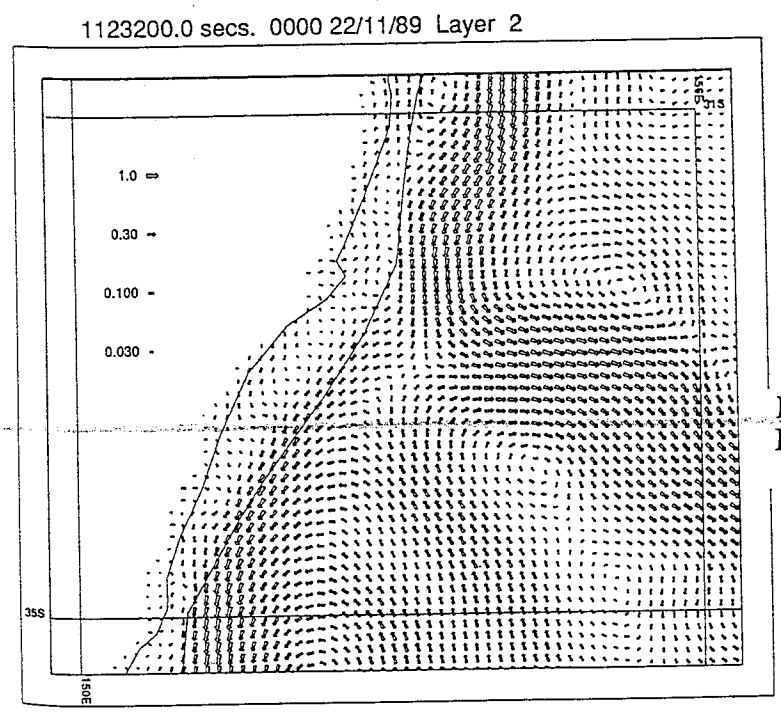



**Figure 9** A sample output from Dr. Hunter's model showing current vectors.