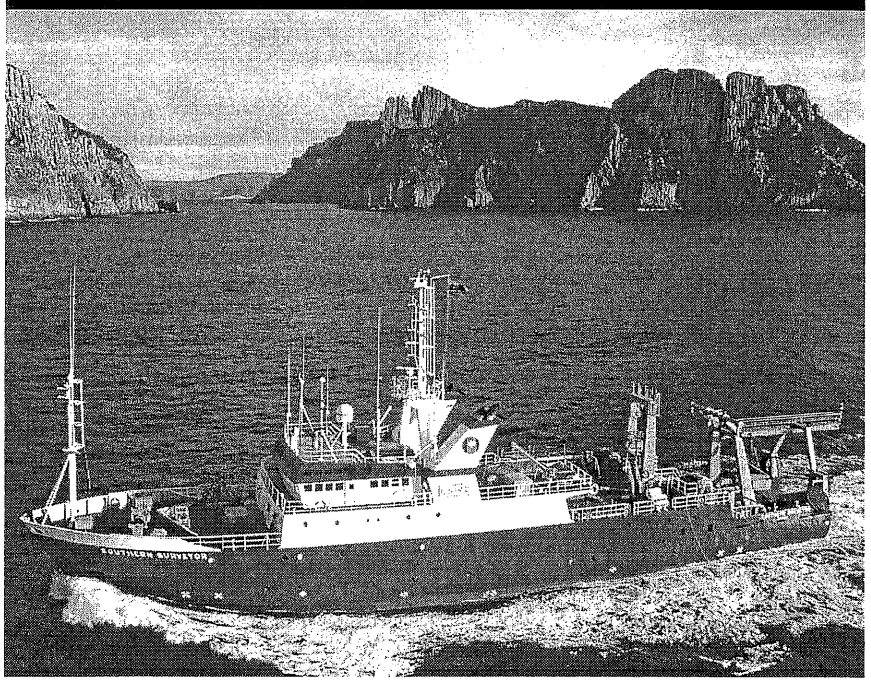
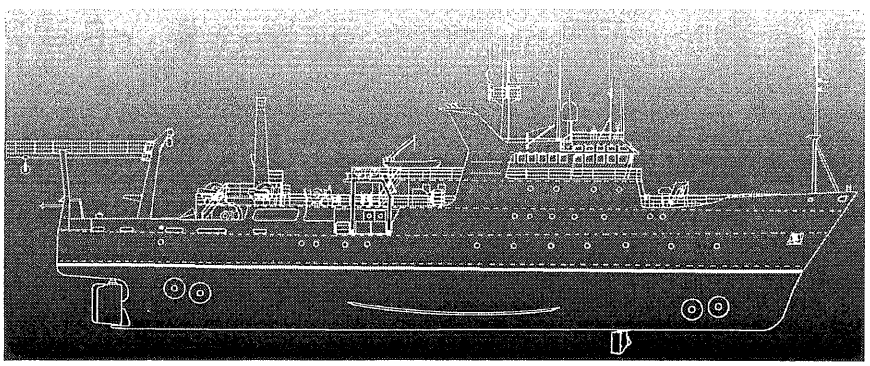
RV *Southern Surveyor*

CRUISE SUMMARY
SS 02/98





TITLE

Subantarctic Front Meander Survey.

ITINERARY

Depart: Hobart 1000 Tuesday, March 10, 1998
Arrive: Hobart 2000 Monday, March 30 , 1998

PRINCIPAL INVESTIGATOR

Dr Steve Rintoul (Chief Scientist)
CSIRO Marine Research
GPO Box 1538, Hobart, Tasmania 7001

RESEARCH BACKGROUND

The Subantarctic Front (SAF) is found near 50°S south of Tasmania. The SAF is the main core of the Antarctic Circumpolar Current in this sector of the Southern Ocean. The front extends throughout the water column and marks the boundary between relatively warm, salty water to the north and cool, fresh water to the south.

The SAF south of Tasmania is characterized by numerous meanders, which sometimes pinch off to form both warm- and cold-core rings. The meanders are sites of enhanced vertical velocities and cross-frontal exchange. The goal of SS 02/98 is to estimate the vertical and cross-front exchange by carrying out an intensive survey of a meander of the SAF.

Southern Surveyor cruise SS02/98 is part of a two-ship expedition to study the SAF and the waters to either side of the front. *Aurora Australis* will carry out a north-south transect along 141°30'E, including four time series stations where the ship will remain on site for five days. *Aurora Australis* will also recover four sediment trap moorings. The focus of the work on *Aurora Australis* is on uptake and export of carbon and on processes controlling biological productivity.

CRUISE TRACK

The area of operation was Southern Ocean (48° S to 52° S, 138° E to 144° E) (see Figure 1).

CRUISE OBJECTIVES

1. To map the distribution of temperature, salinity, oxygen, nutrients and velocity at the Subantarctic Front, with a cross-front resolution of 12 nm or better, and an along-front resolution of 18 nm or better.

2. To use the detailed spatial maps to determine how cross-front exchange and vertical velocities are related to meanders of the Subantarctic Front.

3. To recover two magnetometer moorings for Dr Ted Lilley.

RESULTS

The maps of velocity and other properties show that we succeeded in following a sinusoidal meander of the Subantarctic Front. The richness of structure revealed by these maps in both the along-front and cross-front directions will take a while to digest, but a few highlights are summarized here.

Satellite sea surface height measurements suggest that the meander was largely stationary during the period of the survey, although the meander steepened slowly during the five weeks between late February and the end of March.

The horizontal gradients across the front are much tighter at the crest and trough of the meander than they are between them. Current velocities show a similar pattern: a strong, narrow jet at the crest and trough, and a broader, weaker flow between the crest and trough.

The "front" consists of up to three filaments, which are more obvious in maps of density at 500 m than in the velocity field. Between the crest and troughs the filaments separate, broadening the front; at the crest and trough the filaments merge.

Cross-front gradients of properties along isopycnals vary dramatically along the meander. The very weak isopycnal gradients of temperature and salinity along much of the meander suggest that mixing along density surfaces is very strong. This observation supports the notion that sub-surface mixing plays an important role in the formation of Antarctic Intermediate Water, by carrying cool, fresh, high oxygen water across the front from south to north. In regions where isopycnal gradients are large, this appears to be due to advection of anomalous water masses from the north and south impinging on the front. The strongest anomaly is the result of a warm, salty water mass on the northern side of the front on the eastern end of the survey: here the temperature and salinity characteristics are very similar to profiles from the southern Tasman Sea.

The cross-frontal mixing is the result of very active interleaving observed on all crossings of the front. The maximum fluorescence values were observed in the core of the front. Below the maximum fluorescence, the vertical gradient of both fluorescence and density were very sharp across the base of the mixed layer. North and south of the core of the front, the density and fluorescence gradients at the base of the mixed layer were more gradual. A subsurface fluorescence maximum was sometimes observed north and south of the front, while the high values in the core of the front were uniform throughout the mixed layer.

SUMMARY OF MEASUREMENTS MADE

- 101 CTD stations to 1500 m depth, providing profiles of temp, salinity, oxygen and fluorescence
- approximately 1200 water samples analysed for nitrate, phosphate, silica, oxygen and salinity
- samples were filtered for pigments to calibrate the CTD fluorometer at eight sites, at 5 depths
- test of 12 TSK XCTD probes, deployed while on station for comparison to CTD trace
- continuous underway measurements of velocity (ADCP), sea surface temperature and salinity.

CRUISE NARRATIVE

After leaving Hobart, Southern Surveyor sailed for the first of two magnetometer moorings at 50° 30.73'S, 143° 49.2'E. On March 11 we stopped for two test casts, tripping 12 Niskin bottles in the salinity minimum on each cast to check for leaking bottles.

We enjoyed beautiful weather for the steam to the mooring site and the good weather continued long enough to get both moorings safely on board with a minimum of fuss.

Satellite images of sea surface temperature and sea surface height showed the meandering Subantarctic Front to the north of the mooring site. We began the CTD/ADCP survey from the site of the second mooring at 51° 45.1'S, 143° 16.8'E, running north along 143°17'E. Soon the weather began to deteriorate, and we hove to to sit out a gale with average winds over 60 knots and gusts over 70 knots. Scientists and crew got a quick refresher course in what it means to tie down gear securely.

When weather permitted, we resumed the survey, working north and west following the meandering front. The satellite altimeter maps sent by email to the ship proved to give a good indication of the location and orientation of the front. The new acoustic Doppler current profiler (ADCP) also performed very well and was a big help in determining where we should carry out the transects in order to maintain the required cross-front and along-front resolution (see Figure 2). In the end, we had relatively little trouble following the front.

We completed a total of 101 CTD stations, including 11 complete crossings of the front. The wavelength of the meander was approximately 420 km, and the survey covered about 3/4 of a complete wavelength. This will allow us to determine how the cross-front exchange and vertical velocity vary as the flow enters and leaves both a trough and a crest of a meander. The combined ADCP and CTD survey carried out on SS02/98 provides the most comprehensive description yet obtained of the anatomy of this major ocean front.

We maintained daily radio contact with *Aurora Australis* throughout the cruise. Results from each vessel assisted the other in planning its field work. In particular, the map of the front carried out by *Southern Surveyor* was used by scientists on the *Aurora Australis* to determine the best place to carry out their biogeochemical investigations of the front.

With the exception of a few days of relatively calm weather during the second week, the wind was usually strong (over 30 knots) and the seas usually rough. Sixty out of the 101 stations were carried out in gale conditions (Beaufort scale Force 6 and above). The ship, gear and people performed extremely well under difficult conditions. As a result, all objectives of the field work were achieved.

Shortly after completing the final CTD station, two icebergs were sighted off the port bow at 50°20'S, 139°27'E. We took this as a sign that our southern ocean adventures had come to an end, and set course for Hobart.

SUMMARY

The success of this cruise depended on a large number of people, both on the ship and at the Marine Labs. The work at sea was hard and uncomfortable; the work on land was complex and had a very tight time constraint. My thanks to all of the following without whose efforts we could not have done the work: Helen Beggs, Pamela Brodie, Kim Finney, Bob Beattie, Neil White, Lindsay Macdonald, Matt Sherlock, Jeff Cordell, Phil Adams, Kylie Brown, Erik Madsen, Dave Edwards, Alex Papij, Ian Helmond, Rudy Kloser, Clive Liron, Harry Higgins, Dave Vaudrey, Kim Badcock, Peter Campbell, Andrew Forbes

PERSONNEL

Steve Rintoul	CMR	Chief Scientist, CTD watch
Serguei Sokolov	CMR	CTD
Ted Lilley	ANU	CTD, moorings
Matt Fitzpatrick	CMR Volunteer Fellow	CTD
Helen Beggs	CMR	ADCP, computing, CTD
Lindsay Macdonald	CMR	Electronics, CTD
Val Latham	CMR	Hydrochemistry
Gary Critchley	CMR	Hydrochemistry
Mark Rayner	CMR	Hydrochemistry
Peter Dunbar		Master
Roger Pepper		1st Mate
John Boyes		2nd Mate
Ian Murray		Chief Engineeer Officer
Evan Peters		1st Engineer Officer
John Hinchliffe		Electrical Engineer
Malcolm Mcdougall		Bosun
Alan Brownlie		A.B.
Norman Irvine		A.B.
Drew Meincke		A.B.
Graham Mcdougall		A.B.
Tony Hearne		A.B.
Dieter Kurz		A.B.
Howard Davies		Greaser
Anthony Gleeson		Chief Cook
Wayne Hatton		2nd Cook
Gene Innes		Chief Steward

Steve Rintoul, Chief Scientist.

Figure 1 Map of the cruise track during the meander survey. Eleven short sections were carried out across a meander of the Subantarctic Front, with the location of the sections guided by satellite images of sea surface temperature and sea surface height.

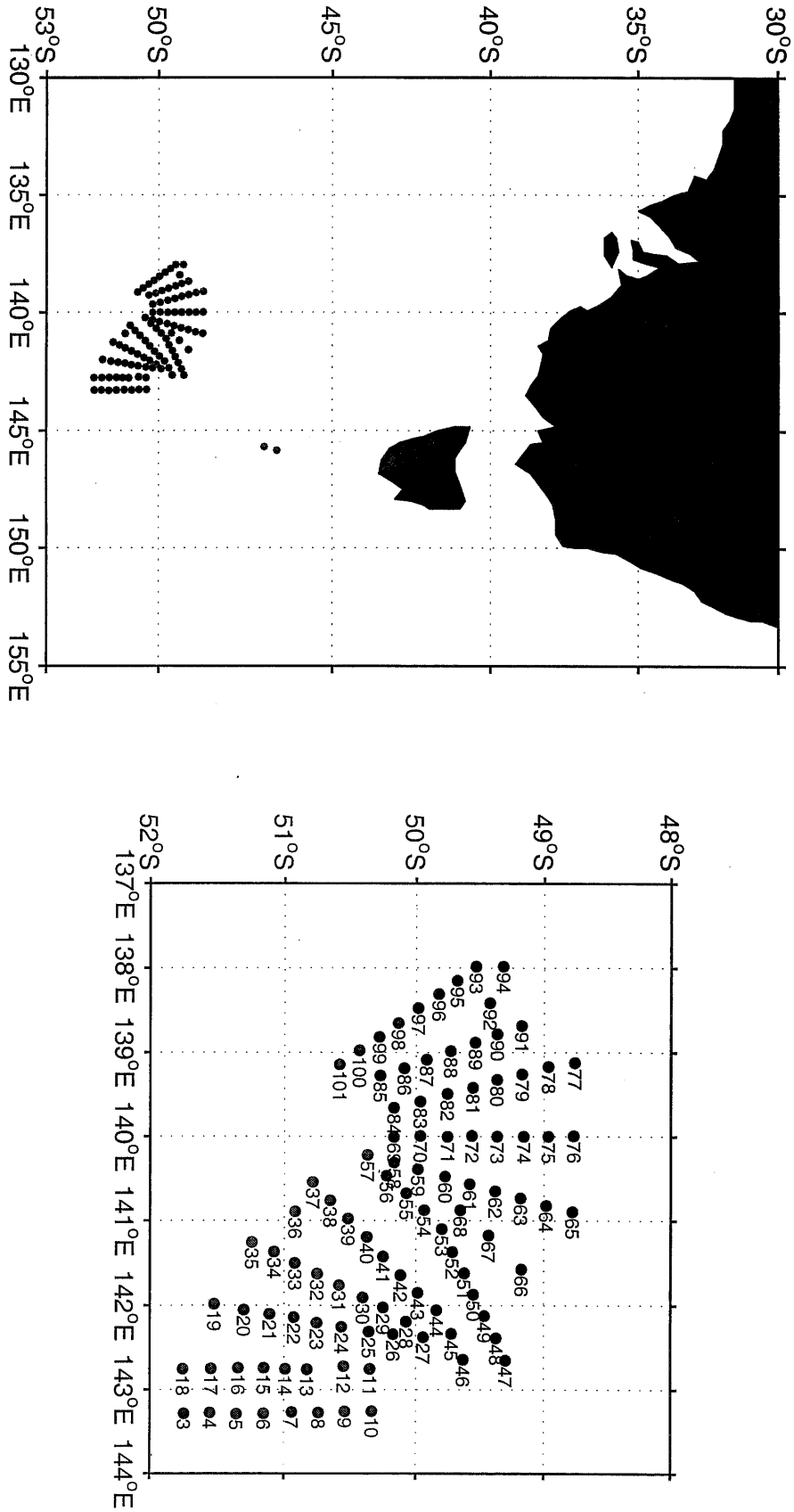


Figure 2 The potential density at 500 m depth is shown by the contour lines. Velocity at 150 m as measured by the new acoustic Doppler current profiler (ADCP) mounted in the hull of the Southern Surveyor is shown by the arrows. Note that the flow tends to converge on entering the trough and the crest of the meander, and to become broader between the trough and crest.