FRANKLIN

National Facility
Oceanographic Research Vessel

Mixing processes in the Subtropical Front.

CRUISE SUMMARY

RV FRANKLIN

FR 02/01

Depart Adelaide 1000hrs, Friday 16 February 2001
Arrive Hobart 1000hrs, Tuesday 6 March 2001

Principal Investigators

Professor Matthias Tomczak
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Scientific Objectives

During research voyage FR02/2001 R/V Franklin will use SeaSoar in a study of small scale mixing processes in the Subtropical Front south of Australia. There are four principal objectives:

1. To determine the relationship between thermohaline structures and density compensation in the Subtropical Front.
2. To determine the influence of density compensation on vertical mixing.
3. To determine the influence of changing surface wind stress on horizontal advection and vertical mixing.
4. To determine the temporal scales of interleaving events in the Subtropical Front.

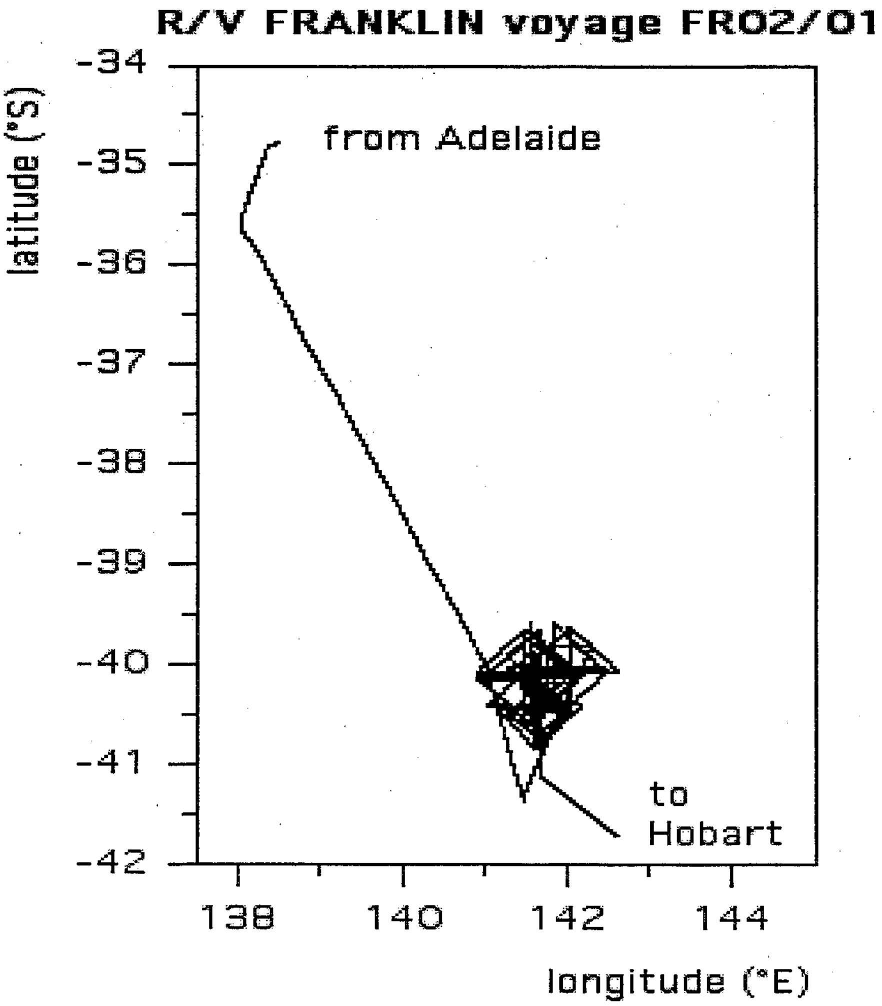
Cruise Objectives

During a summer survey of the Subtropical Front south of Australia (FR02/1998) a rich variety of thermohaline structures were observed below the surface mixed layer. Because of the relatively high degree of horizontal density compensation present in the region, vertically sheared horizontal advection can lead to interleaving of temperature and salinity fields. This process is enhanced by periodic reversals of the local wind stress due to passing low pressure systems. Horizontal temperature gradients in the atmosphere can also perturb the horizontal density compensation and lead to small scale vertical mixing and convection.

The main objective of this cruise is to identify a single thermohaline structure in the Subtropical Front similar to those observed during FR02/98. These structures appear to be due to vertical mixing and horizontal interleaving of water across the front. Once identified, we will study its evolution and reaction to atmospheric forcing by performing repeat surveys of the feature relative to a drifting buoy. The object of this is to study the time evolution of this feature and to identify which specific mechanism is responsible for its formation. The duration of the cruise should be sufficient to observe at least one reversal of the local wind field and we should be able to evaluate the relative importance of these reversals on the observed interleaving.

Cruise Track

The location of the investigation area was determined shortly before the cruise, based on satellite images of the Subtropical Front. An initial survey of the area was performed to determine the precise positioning of a reference buoy, which was then placed in the frontal zone. The ship then performed a series of repeat "butterfly" sections with the drifting buoy at the centre. The resulting cruise track is shown below:



Results

Preliminary analysis indicates nearly complete density compensation over most of the frontal region, the exception being a 10 m wide layer just below the mixed surface layer, which is dominated by large small scale variability, particularly in salinity. Detailed analysis of the data is required to determine to what extent the observed density compensation influences mixing in the frontal zone.

Two atmospheric frontal systems passed through the investigation region during the voyage. This will allow a detailed study of the effects of changing surface wind stress on horizontal advection and vertical mixing.

Small scale structures below the mixed layer became significantly more abundant during the passage of atmospheric fronts but decreased in number in the period between the two fronts, indicating that the ocean reacts quickly to atmospheric conditions at these scales.

Cruise Narrative

Franklin departed from Outer Harbour on Friday 16 February 2001 at 1000hrs as planned and proceeded to a position in the planned working area. The cruise plan had assumed that satellite data obtained over the previous two weeks could guide the ship to a location where an indication of the Subtropical Front could be inferred from the sea surface temperature (SST) distribution. CSIRO Marine Research had set up a web site to support the voyage, which allowed inspection and downloading of satellite SST images. Unfortunately dense cloud cover persisted over the region during the two weeks prior to the voyage, and the available satellite images allowed only a vague identification of a possible front in the vicinity of 141°E, 40°S.

The ship arrived at that location (waypoint P1) on Sunday 18 February 2000 at 0100hrs. After an initial CTD station to 1500 m depth the Seasoar was launched, and the ship commenced a survey of the region, to consist of two traverses in obliquely meridional direction with endpoints at 41°20'S (waypoint P2), 141° 27'E and 39°50'S, 142°18'E (waypoint P3). The Subtropical Front was crossed about half-way between P1 and P2 and three quarter of the way from P2 to P3. It was then decided to place the experiment in the centre of the triangle P1-P2-P3.

Arrangements had been made at Flinders University before the voyage to transmit satellite information to the ship if useful information became available. Dr. Jochen Kaempf identifed a satellite image obtained late on 17 February, which was nearly cloud-free in the area of interest, and transmitted it to the ship just in time before the experiment. The image indicated a surface front where the Seasoar transets had located the Subtropical Front and showed it to be on the eastern edge of a major extrusion of warm water from the continental slope of South Australia which had developed into an anticyclonic swirl. It also suggested that the horizontal gradients in this location were particularly strong.

Supported by this information a decision was made to start the experiment at 40°30'S, 141°40'E. A buoy equipped with a flash light, a radio beacon and a radar reflector, three Seacat CTDs at 20 m, 50 m and 70 m depth and tagged to the 70 m depth level with three sock drogues, was launched as a marker of the front location on 19 February at 1600hrs.

The voyage then proceeded with Seasoar transects centre on the drifting buoy in "butterfly patterns": Two perpendicular transects, which cross each other at the buoy location, are connected on either side by lateral transects. The butterfly layout was a square of 36 nautical miles length with its four corners at the four major points of the compass. After completion of each butterfly pattern the pattern was rotated by 90° to cover the other two sides of the square. At intervals of between 24 and 36 hours the Seasoar was recovered for calibration purposes at one of the corners of the square and a CTD was performed to 1500 m depth before the Seasoar was redeployed.

The flashlight on the buoy stopped working soon after the buoy was deployed, and it became very difficult if not impossible to make visual contact with the buoy at night. The radar reflector gave a strong radar signal in calm seas, when the buoy could be seen in the radar at distances of 3 - 4 miles, but it proved ineffective when the winds became stronger than 15 knots, when it could not be distinguished from the sea clutter. The radio transmitter was the most effective locating device. Its signal could be detected at distances of 10 miles and more, and after some practice we were able to find the buoy's direction easily.

The buoy drifted initially in a direction slightly west of north. Contact with the buoy was lost for nearly two days when an atmospheric front passed over the region during the third day but was established again when seas had calmed down.

The Seasoar performed without any serious problems, and the butterfly pattern could be maintained throughout the experiment. At one stage, when the buoy had moved north by 25 miles, it appeared it was following the surface front, which apparently had moved north from the Subtropical Front, and that the butterfly pattern was barely crossing the Subtropical Front any more. The pattern was therefore shifted south eastward, by shortening its north western side and lengthening the opposite side while keeping the buoy at the intersection of the diagonals. As soon as this was done the buoy started moving eastwards, and the experiment could return to its original pattern.

Based on the planned arrival time in Hobart the experiment could continue until Sunday 4 March 1700hrs. Calm weather conditions during Friday and Saturday and a forecast for not so favourable conditions on Sunday made us decide to retrieve the buoy on Saturday and continue with Seasoar transects into Sunday without a buoy location. When the buoy was retrieved on Saturday 3 March at 1100hrs it was found that the rope had parted just above the metal cross bar that carried the drogues, leading to the loss of the three holey socks, the cross bar and the lowest Seacat immediately above. It appears that the rope was caught by the cross bar during deployment and rapped around its top. Movement of the rope against the cross bar then caused the rope to part.

The experiment contined with another Seasoar butterfly survey centred on the last buoy position. By this time the regional shape and orientation of the Subtropical Front was no longer obvious. A second satellite image received on 25 February had indicated that the warm anticyclonic swirl had lost part of its water to an independent eddy, while to its east cold water had pushed northward and intruded towards the shelf. To place the experiment in the regional context we decided to finish it with a meridional section from 39°40'S to 41°05'S along 141°40'E. This section completed, we retrieved the Seasoar on Sunday 4 March at 2100hrs and set course for Hobart.

The ship arrived at No. 1 Princes Wharf, Hobart on Tuesday 6 March at 1000hrs.

Summary

The voyage was a clear success, despite the loss of the sea anchor and some equipment from the drifting buoy. The Seasoar data set is among the best that have been achieved on R/V *Franklin.* It could not have been obtained without the determined and dedicated service of the CSIRO support staff and the ship's master, officers and crew, whose help is greatly acknowledged.

Personnel

Matthias Tomczak	Chief Scientist, Flinders University
Charles James	Flinders University
Roger Matthews	Flinders University
Aneurin Henry-James	Flinders University
Lindsay Pender	Cruise Manager, CMR Computing
Kevin Miller	CMR Moorings
Gary Critchley	CMR Hydrochemistry
Phil Adams	CMR Electronics
Neil Cheshire	Master
Jürgen Rust	First Mate
John Boyes	Second Mate
John Morton	Chief Engineer
Greg Pearce	First Engineer
Hugh McCormick	Electrical Engineer
Bill Hughes	Bosun
Tony Hearne	Able Seaman
Norm Irvine	Able Seaman
Mal McDougall	Able Seaman
Dan Davies	Greaser
Dave Wilcocks	Chief Steward
Tom Condon	Chief Cook
Mark Wheeler	Second Cook

Matthias Tomczak
Chief Scientist.

Appendices

All systems performed well and to the satisfaction of the scientific party. The Seasoar stood up to the intensive use thanks to care and attention of its operators. It's A-frame, winch, cable and fairing require some maintenance if a similar project is to be undertaken in future.