VOYAGE SUMMARY SS09/2003

Title
Continental shelf processes between Cape Leeuwin and the Abrolhos islands during the summer.

Itinerary
Departed: Fremantle 1000 hrs, Friday 24 October 2003
Arrived: Fremantle 0800 hrs, Sunday 9 November 2003

Principal Investigator
Professor Charitha Pattiaratchi
Centre for Water Research, The University of Western Australia
35 Stirling Highway, CRAWLEY WA 6009, Australia
Phone: (08) 6488 3179, Fax: (08) 6488 1015
e-mail: pattiara@cwr.uwa.edu.au

Scientific Objectives
The main objective of the voyage was to identify the physical and biological processes of the Capes Current, which flows along the south-west Australian continental shelf during the summer; and its extension to the region to the north of Rottnest Island terminating at the Abrolhos islands. Specific objectives were to:

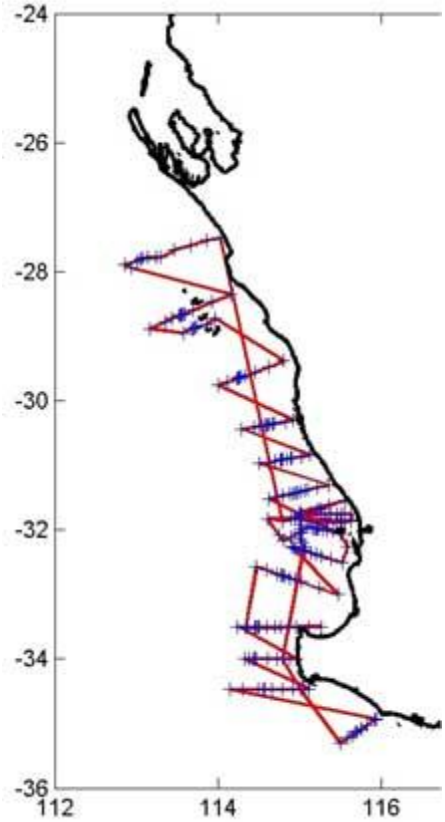
1. define the effects of topographic features on the Capes Current;
2. investigate the role of the onshore geostrophic flow from the West Australian Current to the Leeuwin Current;
3. investigate the subsurface chlorophyll maximum (SCM) to determine if there is a consistent SCM on the shelf and under the Leeuwin Current, and the spatial extent of this feature between Abrolhos Islands and Cape Leeuwin; and
4. assess onshore-offshore and alongshore patterns in the: abundance, diversity and species composition of the zooplankton community.

Voyage Objectives
The voyage objectives were: To conduct 14 cross-shelf transects (Figure 1) (see Attached), with one transect (G) repeated. For each transect, 10-15 CTD stations will be occupied depending on the shelf width. Transects will extend from the coast (~30 m isobath) to the 1000 m contour. In addition to the standard CTD and fluorescence, nutrient data will also be collected. On alternate transects, oblique zooplankton tows will be taken to a maximum depth of 150 m at the 30, 50, 100, 200 and 1000 m stations. Micro-zooplankton samples will be obtained from the Niskins at the near-surface and chlorophyll maximum at these stations. The measurement of currents (from the shipborne ADCP) and water properties (temperature, salinity, fluorescence) will enable the mapping of the structure of the continental current systems and the Leeuwin Current.

Process studies (using ADCP measurements and high-resolution CTD stations) will be undertaken at two sites: (a) Abrolhos Islands and (b) Rottnest Canyon to examine the fine-scale features of the effect of topography on the currents.

Voyage Track

Figure 1 – Cruise track and locations of CTD stations



Results

This voyage was one of the first to undertake detailed physical and biological measurements on the continental shelf/slope between the Abrolhos Islands and Cape Leeuwin during the summer months. Preliminary analysis of the data indicate that we will be able to address all of the scientific objectives as detailed below.

1. Define the effects of topographic features on the Capes Current

There are several topographic features, which may influence the Capes Current. These include: the Abrolhos Islands; Rottnest Island and Cape Naturaliste; together with the variation in the width of the continental shelf and changes in the slope of the continental slope.

Physical and biological data collected during the study will provide a very good understanding of how these features influence both physical and biological processes within the study region. For example, data collected during the voyage indicated lower temperatures and higher fluorescence to the north of Rottnest Island due to the island wake effect. Similarly, the two-step structure of the continental shelf (shelf breaks at 50m and 150m) indicated strong upwelling and associated higher fluorescence values at the 50m contour in the region between Cape Naturaliste and Cape Leeuwin, the generating region of the Capes Current.

2. Investigate the role of the onshore geostrophic flow from the West Australian Current to the Leeuwin Current

The Leeuwin Current is driven by an alongshore geopotential gradient coupled with an eastward geostrophic flow from the central Indian Ocean. Using the CTD data collected during Franklin voyage FR10/2000, we estimated that the geostrophic inflow, between North-west Cape and the Abrolhos Islands, relative to the 300db level across the 1000m and 500 m isobaths, to be 4Sv and 2Sv, respectively accounting for up to 40% of the total flow of the Leeuwin Current in this region. The data collected during the present study will enable us to undertake a similar estimate for the southern region from the Abrolhos Islands to Cape Leeuwin.

3. Investigate the subsurface chlorophyll maximum (SCM) to determine if there is a consistent SCM on the shelf and under the Leeuwin Current, and the spatial extent of this feature between Abrolhos Islands and Cape Leeuwin

One of the major findings of this voyage is that we will be able to demonstrate that there is a consistent subsurface chlorophyll maximum (at depths of 70-100 m) on the shelf and beneath the Leeuwin Current. Typical examples of the SCM are shown on Figure 2 (transect A) and Figure 3 (Rottnest Canyon transect) (see Attached). Every transect (A to N) showed the existence of this feature. In general, the fluorescence within the SCM was a factor of 3-4 higher than at the surface.

4. Assess onshore-offshore and alongshore patterns in the: abundance, diversity and species composition of the zooplankton community

This voyage, along with FR10/2000, are the first to examine the broad-scale distribution of zooplankton along the west coast of Australia. Samples were collected on these voyages from Northwest Cape to Cape Leeuwin from the coastal environment (30-50 m depth), across the shelf, and out to depths of 1000 m. The data should enable us to examine latitudinal and onshore-offshore gradients in the plankton community and relationships between plankton community structure and dominant ocean features, such as the Leeuwin, Capes and Ningaloo Currents.

Cruise Narrative

General and Physical Oceanography

The ship departed on schedule at 1000 hrs on Friday 24 October. All underway measurements: standard meteorological; thermosalinograph (including fluorometer); shipboard ADCP and Echo-sounder were enabled when the ship departed and worked without any problems throughout the voyage. We were using the Seabird CTD, that in addition to the standard CTD sensors, included dissolved oxygen, fluorometer and PAR meter. A 24 10L niskin bottle rosette was used for water samples.

At each transect, CTD stations were located at the following depth contours: 30m, 50m, 100m, 150m, 200m, 250m, 300m, 500m and 1000m. Additional stations were completed depending on the width of the continental shelf and at deeper depths (2000m, 3000m) depending on the length of transect. A total of 211 CTD profiles were completed.

After completing transect G (SRFME transect), we steamed to the start of transect A and completed 11 stations. Transect A was the southernmost transect undertaken during Franklin voyage FR10/2000. After completing transect B, an additional transect (Pelsaet) around the Abrolhos Islands was completed before completing transects C to F. At the completion of transect F, a transect along Rottnest canyon (Figure 1) (see Attached) was completed together with two additional shore-normal transects to the north of Rottnest Island. Transects H and M were then completed and, as we were ahead of time, an additional transect N at Point D'Entrecasteaux along the Leeuwin Canyon was completed.

After completing transect N, a cross-canyon (north-south) transect of Rottnest Canyon was completed before repeating the first transect (G, SRFME transect) and two additional transects to the north of Rottnest Island before returning to Fremantle. We docked at 0800 on Sunday 9 November 2003.

For the duration of the voyage there were no major equipment or weather problems.

Primary Productivity
Phytoplankton investigations were undertaken by Luke Twomey, Florence Verspect and Vanessa Pez, all from the Centre for Water Research, University of Western Australia. In general, at each of the CTD transects, primary production (using ^{14}C technique) and nitrogen uptake measurements were undertaken at the 'shoreline' station (the station closest to the shore), 300m contour station and at the 1000m contour.

Zooplankton
Tony Koslow, CMR was responsible for zooplankton sampling. Replicate zooplankton samples were obtained on Transect G at the beginning and end of the voyage, providing data on temporal change along a transect north of Perth. This transect has been sampled on a monthly and quarterly basis since February 2002 as part of Dr Koslow's CSIRO/SRFME project. Depths sampled on this transect were 17, 40, 100, 300 and 1000 m, the depths covered by the SRFME time series.

Other transects covered on the voyage were A, C, E, H, K, and M. Additional zooplankton tows were obtained in the vicinity of the Abrolhos Is (inshore) and around the Rottnest Canyon (Transect I) to examine the influence of these features on the zooplankton. Standard sampling depths on these transects were 30, 100, 300 and 1000 m. Tows were carried out with a bongo net (60 cm mouth diameter) with 100 µm and 355 µm meshes, to sample both the smaller mesozooplankton dominant in these oligotrophic waters, as well as the larger forms, including the ichthyoplankton.
A small aliquot from the 100 µm samples was preserved in liquid N_2 to trial a biochemical assay for secondary productivity. Half of one of the coarse-mesh zooplankton samples was preserved in ethanol to enable analysis of larval fish otoliths and examination of the genetic structure of certain copepods as part of the US-funded project ZooGene. Water samples from the surface and chlorophyll maximum layers were also collected at these stations to assess phytoplankton and microzooplankton species composition.

Summary
This voyage was one of the first to examine in detail the physical and biological oceanography along the west coast of Western Australia, and was very successful in meeting its scientific objectives. During the voyage we had no problems with instrumentation (except when a crack in the CTD rossette lifting cradle was identified and repaired). The weather was reasonable and although we experienced high winds and swell conditions no time was lost due to weather conditions. This enabled additional transects to be undertaken. All of these factors and the excellent support and cooperation of the ship's crew and CSIRO personnel (both on board and in Hobart) combined to produce a very successful and happy voyage.

Scientific Crew

Charitha Pattiaratchi	CWR/UWA	Chief Scientist/Physical Oceanography
Luke Twomey	CWR/UWA	Phytoplankton, nutrients
Joanne O'Callaghan	CWR/UWA	Physical Oceanography, student
Susan Rennie	CWR/UWA	Physical Oceanography, student
Florence Verspect	CWR/UWA	Phytoplankton, nutrients, student
Will Schroeder	Uni of Alabama	Physical Oceanography
Venessa Pez	CWR/UWA	Phytoplankton, nutrients, student
Tony Koslow	CMR	Zooplankton
Bob Beattie	CMR	Voyage Manager, Computing
Lindsay MacDonald	CMR	Electronics
Kate Berry	CMR	Hydrochemistry
Rebecca Cowley	CMR	Hydrochemistry

Ships' Crew

Ian Taylor	Master
Arthur Staron	1st Officer
John Boyes	2nd Officer
John Morton	Chief Engineer
Dave Jonker	1st Engineer
John Hinchliffe	Second Engineer
Phillip French	IR/Greaser
Mal McDougall	Bosun
Tony Hearne	IR
Manfred Germann	IR
Graham McDougall,	IR
David Willcox	Chief Steward
Peter Williams	Chief Cook
Andy Goss	2nd Cook

Acknowledgements
The scientific party would like to acknowledge the professional expertise of Captain Ian Taylor, and all officers and crew of RVSouthern Surveyor, and thank them for their friendly help at all times. The CSIRO personnel (Voyage Manager, Bob Beattie, electronics specialist, Lindsay MacDonald and the hydrochemists Rebecca Cowley and Kate Berry) were thoroughly competent and co-operative. Their continual cheerfulness and skill in all situations enabled non-stop data gathering and a very high data return. Compliments are also due to the Cooks, Peter Williams and Andy Goss for their excellent and varied menus throughout the voyage.

Charitha Pattiaratchi
Chief Scientist

Figure 2 – Cross-section transect of fluorescence at Transect A showing the consistent deep chlorophyll maximum and upwelling on the continental shelf.

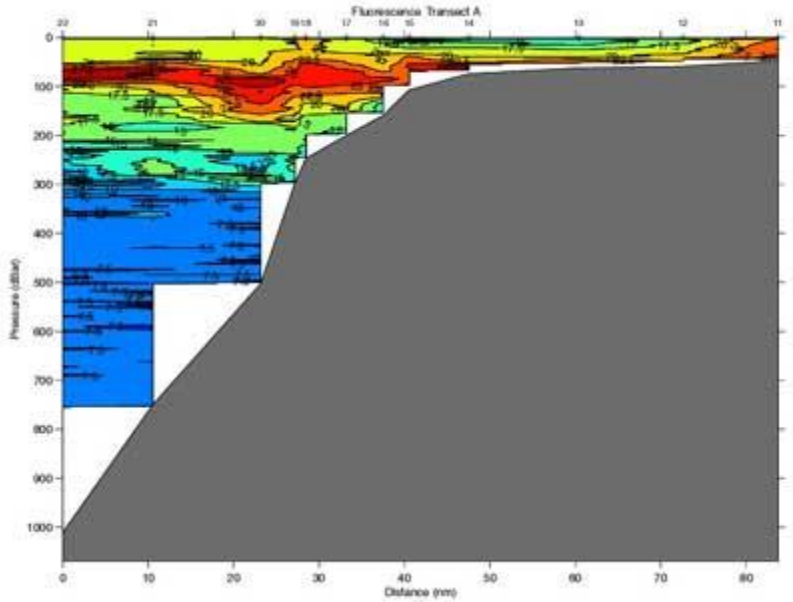


Figure 3 – Cross-section transect of fluorescence at along Rottnest Island showing the consistent deep chlorophyll maximum and upwelling at the Canyon Head.