

How the Capes current ends: an investigation of a west Australian coastal current using an autonomous ocean glider

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SUMMARY

The Capes Current was first defined by Pearce and Pattiaratchi [8] as a cooler inner-shelf current, originating from the region between capes Leeuwin and Naturaliste (i.e. 34°S). Forced by a southerly wind stress in summer, the Capes Current carries higher productivity upwelled water equatorward along the south western Australian coast, reaching as far as the Abrolhos Islands (28°S). The present study presents an exploration of the final legs of the Capes Current with the use of an autonomous ocean glider. Between 22nd December 2009 and 17th January 2010, a SLOCUM glider was deployed at the furthest northerly extent of the Capes Current, carrying a suite of hull-mounted probes which recorded high resolution measurements of temperature, salinity, dissolved oxygen, chlorophyll-a fluorescence, coloured dissolved organic matter and turbidity. The glider dived to maximum depths of 196 m and moved at an average horizontal velocity of 0.25 – 0.40 ms⁻¹, navigating through a series of pre-programmed waypoints to complete one along-shore and five cross-shore transect lines. The field data revealed that at the latitude of 27.7°S, the Capes Current finally descended onto the continental shelf as a dense cascade of relatively cooler (22°C) higher salinity (35.6) water, with relatively high levels of chlorophyll-a (0.5 mg/m³) and low dissolved oxygen content (4.75ml/L). The Capes Current water was absent north of the cascade; subsequently, it had likely been swept southward in the prevailing poleward boundary current (Leeuwin Current).

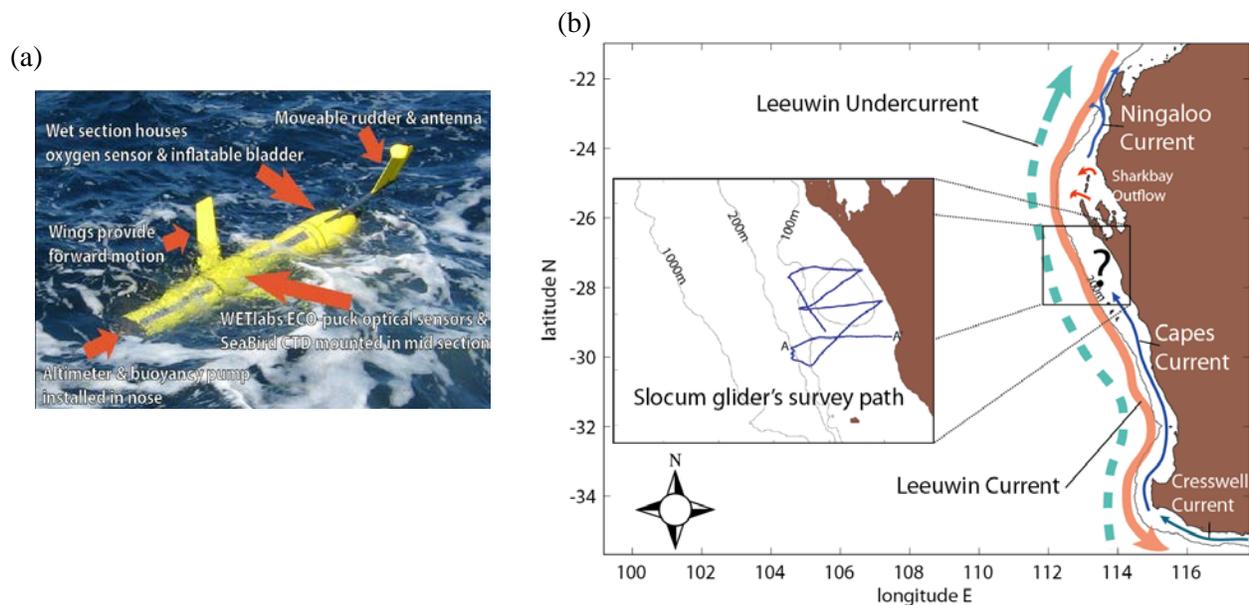


Figure 1: (a) Slocum glider in recovery position at the water surface, with indications of positions of its functional parts. (b) Schematic diagram of the main surface and subsurface currents along the west Australian coast. Inset: Mission path of Slocum glider SL130 during 22 December 2009 – 17 January 2010.

1. INTRODUCTION

The ocean circulation off the western coast of Australia is dominated by the Leeuwin Current system, which comprises the Leeuwin Current (LC), Leeuwin Undercurrent (LU) and wind-driven shelf currents (Fig. 1b) [16][9]. The LC dominates the dynamics over the outer shelf [11]. It is driven by a strong alongshore potential gradient which overwhelms the opposing equatorward wind stress [12][13][3][14][1][6]. Anomalous to the equatorward eastern boundary currents that occur in ocean basins everywhere else in the world, the LC flows poleward, carrying warm, lower salinity, nutrient-depleted tropical water [10][11] which gradually cools and gains salt content as it progresses poleward, due to a geostrophic inflow of offshore water [16]. The LC's structure is a shallow (< 300m-deep), narrow (< 100km-wide) band which slows, shallows and broadens with increasing shelf is widths (e.g. near Shark Bay) and accelerates, deepens and narrows again as the shelf narrows (e.g. south of Shark Bay) [16].

Landward of the LC, cool, equatorward currents occupy the inner and mid shelf regions during the austral summer when prevailing southerly wind stress overcomes the along-shore pressure gradient [2]. Pearce and Pattiaratchi [8] first defined such a current flowing along the south-west Australian coast, naming it 'Capes Current' after its area of origination (between Capes Leeuwin and Naturaliste) (Fig. 2). Although a portion of the CC can be from the south coast, the dominant supply of the CC is from local coastal upwelling of water from the bottom of the LC (~100m depth) at the Capes region [2][8][5]. The CC is well established from November to March when regional winds are prevalently southerly due to strong sea breezes [7][9]. The CC is then driven equatorward along the south-west coast, extending to the Abrolhos Islands (28°S) [16].

Field study has shown that the CC does not continue past Sharkbay (25°) [16]. Rather, it is the Ningaloo Current that flows northward along the Ningaloo coast, carrying locally upwelled water as well as LC water re-circulated in a recurring eddy caused by a combination of southerly wind stress, alongshore

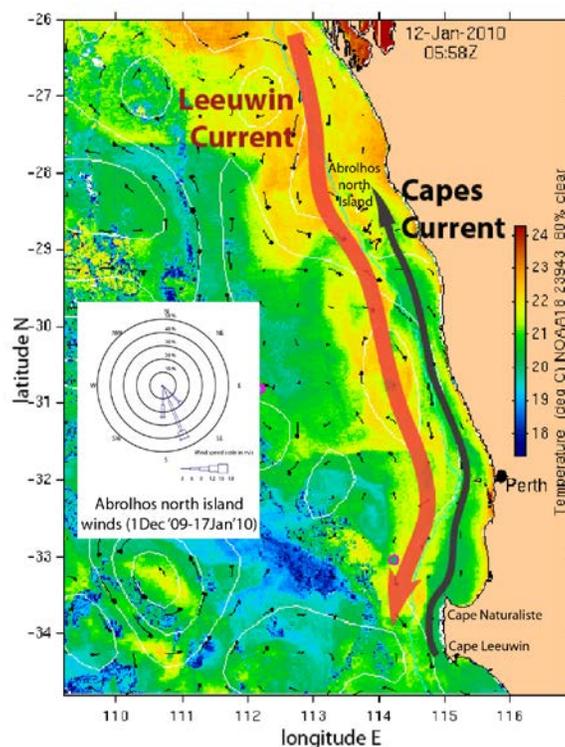


Figure 2: NOAA_AVHRR satellite image of sea-surface temperature off Western Australia in January 2010 shows the warm Leeuwin Current at the 200m shelf break and the cooler Capes Current along the coasts. Inset: Wind data from Abrolhos North Island meteorological station (1 December 2009 – 17 January 2010).

geopotential gradient and an abrupt transition in bathymetry at 22.8°S [15]. The NC is cooler than offshore waters and has a temperature-salinity signature similar to that of LC. It has been found to have high nutrient concentrations, phytoplankton biomass and regional primary production rates [5]. The present study aims to provide an understanding regarding the ending of the CC (Fig. 1b).

2. METHODS

This investigation deployed Slocum glider unit SL130 (Fig. 1a) from 22 December 2009 to 22 January 2010. The 1.8m-long glider is a new kind of autonomous unmanned vehicle (AUV) which derives forward propulsion with buoyancy changes (via inflatable bladders) and a pair of wings, and steers by a tail rudder and moveable internal battery packs. Slocum unit SL130 dived to depths of up to 196m. It moved forward (at horizontal speeds of 0.25-0.40 ms⁻¹) in a saw-tooth gliding trajectory, from one pre-programmed waypoint to the next, completing one long-shore and five cross-shore transects in the coastal water north of the Abrolhos Islands (Fig. 1b). Scientific sensors mounted in the vehicle's hull included a Seabird-CTD (measuring temperature, conductivity and depth), WETLabs BBFL2SLO optical sensor (measuring Chlorophyll-a fluorescence and 660nm Backscatter) and an Aanderaa Oxygen optode (measuring dissolved oxygen concentration).

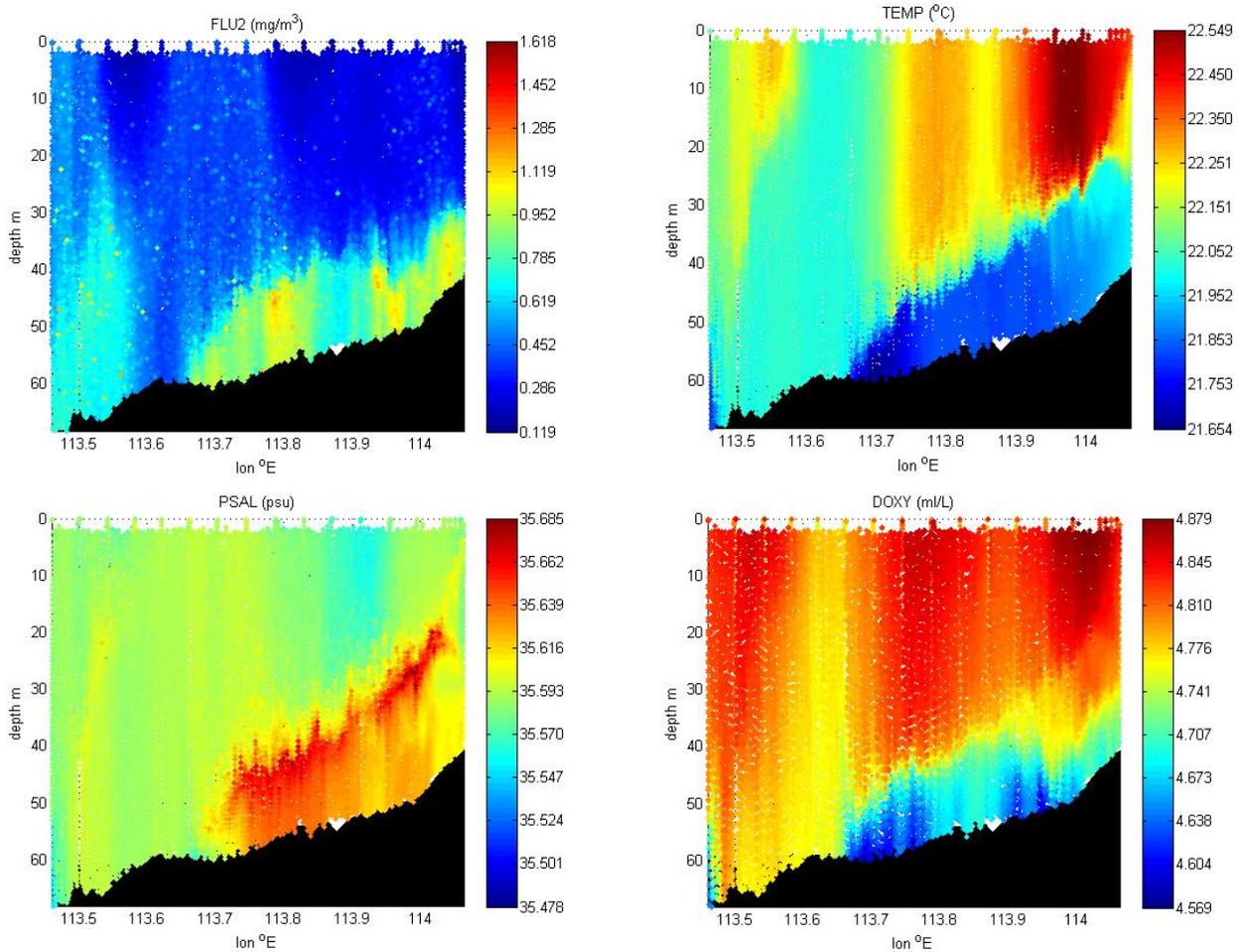


Figure 3: Water property patterns observed at the coastal end of transect A-A': (Clockwise from top left) Chlorophyll-a fluorescence, temperature, dissolved oxygen concentration, salinity (sharp salinity spiking at the boundary of the cascading body is most likely an aberration caused by unresolved thermal instrumental lag issues).

3. RESULTS AND DISCUSSION

For the duration of the field study and the three weeks leading up to it, local winds were persistently strong and south-south-easterly (Fig. 2 inset). A band of cooler (20-22°C) coastal water seen in satellite imagery of sea-surface temperature (SST) revealed that the Capes Current extended from Cape Leeuwin to the Abrolhos Islands (28°S), likely due to the prevailing southerly winds. At its furthest northerly extent, the Capes Current abutted against the warmer (22-23°C) surface waters of the Leeuwin Current, which had widened to occupy the width of the shelf at that location (Fig. 2). There was no indication from the SST image what subsequently occurred to the CC; it did not appear to have turned offshore on the surface. However, subsurface data from the ocean glider field survey revealed that at the landward end of transect A-A' (Fig. 1b inset), cooler (< 22°C) water cascaded from the coast down the slope of the seabed (Fig. 3). The descending water displayed qualities of higher chlorophyll fluorescence (> 0.5 mg/m³), lower dissolved oxygen content (< 4.75ml/L) and higher salt content (> 35.6); this pattern is as expected of CC, which comprises previously upwelled water of such a nature.

North of transect A-A' there was an absence of any dense water cascade. It is hypothesised when the CC water had cascaded westward across the shelf, it was subsequently taken poleward in the Leeuwin Current there, thus bringing its 770km equatorward journey to an end.

4. References

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