4 Satellite Images, Surface T, S, F and CTD Sections

4.2 Stanley to Montevideo

The confluence of the Brazil and Falkland Currents is recognised as one of the most dynamic features of the global ocean. The location and movement of the water masses involved, the Falkland Current, the Brazil Current and a coastal current, are important factors in the determination of the areas of high phytoplankton production. The study of the confluence is particularly suited to the use of remotely sensed imagery, because of the complex mesoscale activity and variability of the region. Imagery that can be used to resolve the eddy structure of the region includes AVHRR (Sea Surface Temperature) and TOPEX-POSEIDON (Sea Surface Height Anomalies). *In situ* measurements add detail and vertical structure to the dataset.

4.2.1 Cruise track

The JCR sailed from Stanley on 24 April 1999 (Sday 114) and made a course for the waypoint 46°30 S, 53°W, from where it followed the 53°W meridian to 38°S, then the ship took a direct route to Montevideo. The ship docked in Montevideo on 29 April. Figure 3 shows the cruise track and the location of station on leg I.

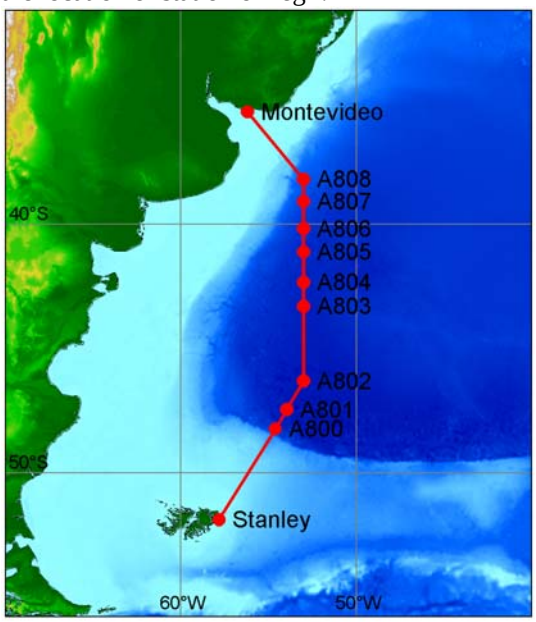

Figure 3. Leg1 Stanley to Montevideo

4.2.2 Current systems

The surface waters of the S. W. Atlantic are dominated by the presence of the two major currents - the Falkland (Malvinas) Current and the Brazil Current. The Brazil Current originates as a branch of the South Equatorial Current and runs poleward nearly parallel to the shelf break. Due to its tropical origin, it is warm, saline and relatively oligotrophic (Bisbal, 1995). Olson *et al* (1988) describe how the southern limit of the warm water associated with the Brazil Current fluctuates between 38-46°S, accompanied by the intermittent formation of warm-core anti-cyclonic eddies. Garzoli and Giulivi (1994) described the encounter between the warm southward flowing Brazil Current and the cold northwards flow of the Falkland Current, at approximately 38°S causing a strong thermohaline front. The cool, nutrient-rich Falkland Current branches off the Antarctic Circumpolar Current (ACC), and flows northward along the continental slope (Provost *et al*, 1996). Glorioso and Flather (1995) described how it flowed round both sides of the Falkland Islands before turning northwards as a single flow approximately 100 km wide. The Falkland Current is the dominant circulation feature along the Falkland Shelf Break. Goni *et al*, (1996) and Garzoli *et al*, (1992) observed sub-Antarctic waters from the Falkland Current to flow along the shelf as far north as 32°S before returning south as the Falkland Return Current (Gordon, 1989) and flowing offshore at the confluence zone. Stevenson (1997) found surface water temperatures in the northerly coastal current, between 24-33°S, to be several degrees lower than the Brazil Current, consisting of a mixture of cool water from the Falkland Current and warm water being recirculated from the Brazil Current.

Ciotti *et al* (1995) define the water masses in terms of the temperature and salinity characteristics of water sampled in October 1987 and September 1988. Brazil Current waters have a temperature greater than 20.0°C and salinity greater than 36.0; Falkland Current waters have a large temperature range between 4.0 - 15.0°C, but a narrow salinity signal between 33.7 – 34.1. Due to the large gap between the salinity ranges specified for the Brazil and Falkland Currents, it is expected that a large proportion of the water sampled will have mixed characteristics. Provost *et al* (1996) observed high temperatures (≥19.0°C) over the continental slope, very high temperatures (≥24.0°C) in the River Plate Estuary. Salinity values given for the outer limit of the River Plate estuary vary from 33.0 (Framian & Brown, 1996) to 30.0 (Guerrero *et al*, 1997).

4.2.3 AVHRR imagery

Figure. 4 shows an AVHRR daily composite SST of the area between 25-55°S, 40-70°W on 13 May 1999 taken from the Rosentiel School of Marine and Atmospheric Sciences web page. (http://www.rsmas.miami.edu/environment/imagery/) with

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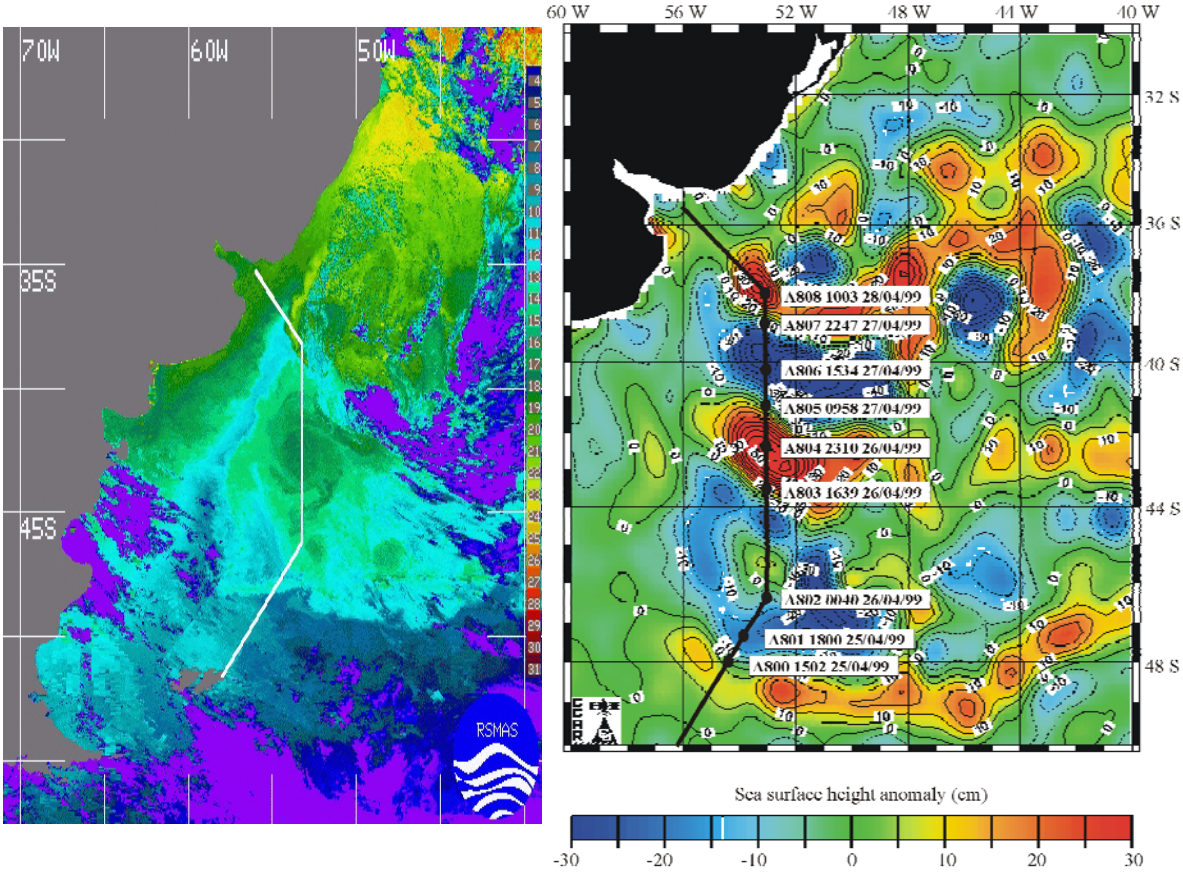

Figures 4 and 5. Satellite Imagery of the Brazil and Falkland Current Confluence, with AMT-8 cruise track overlaid. On the left is an AVHRR image for 13 April 1999, on the right a TOPEX analysis for the period 14- 24 April 1999 with the date, time and location of the CTD casts.

the AMT-8 cruise track overlaid. The Falkland Current is seen as a band of cold water, between 4-8°C (blue), flowing along the shelf break from 50°S to 37°S, while the warmer waters of the Brazil Current flow south to the east of this. The waters of the Brazil Current reach temperatures of around 21°C (green) in the region between 30-40°S, with eddies and filaments south of this, concentrated in the area where the two Currents meet between 38-46°S. Eddies with a warm surface signal shed by the main Brazil Current, can be seen in the imagery, reaching as far south as 48°S.

4.2.4 Altimeter Data

The Colorado Centre for Astrophysics Research process TOPEX datasets the results are available via their website (http://www-ccar.colorado.edu/~realtime/global_historical_ssh). The maps show sea-surface height anomalies (SSHA) produced from TOPEX and ERS-2 altimeter data. Lillbridge *et al* (1997) describe how the data from the Geophysical Data Records from the satellites are referenced to the Ohio State University Mean Sea Surface 1995. Figure 5 shows the TOPEX analysis of the region 40-55°S, 40-70°W, on 24 April 1999 with the AMT cruise track superimposed, with the location and dates of the CTD casts

The eddy activity in the confluence is very clearly defined in the TOPEX image as areas of pole and dipole anomalies. The TOPEX image shows the eddy structure of the confluence with much greater definition than the AVHRR image where the edges of eddies are less well defined due to mixing across the temperature gradient. Robinson (1984) stated that eddies may exist below the sea surface without having a thermal surface signature

The imagery shows cyclonic eddies as positive SSH anomalies and anticyclonic eddies as negative anomalies. Grundlingh (1995) states that there is good agreement between the topographic and infrared portrayals of rings, but the altimetry can also depict features that are invisible in the infrared imagery, either due to obscuration by cloud or from having lost their surface signature through air-sea interaction.

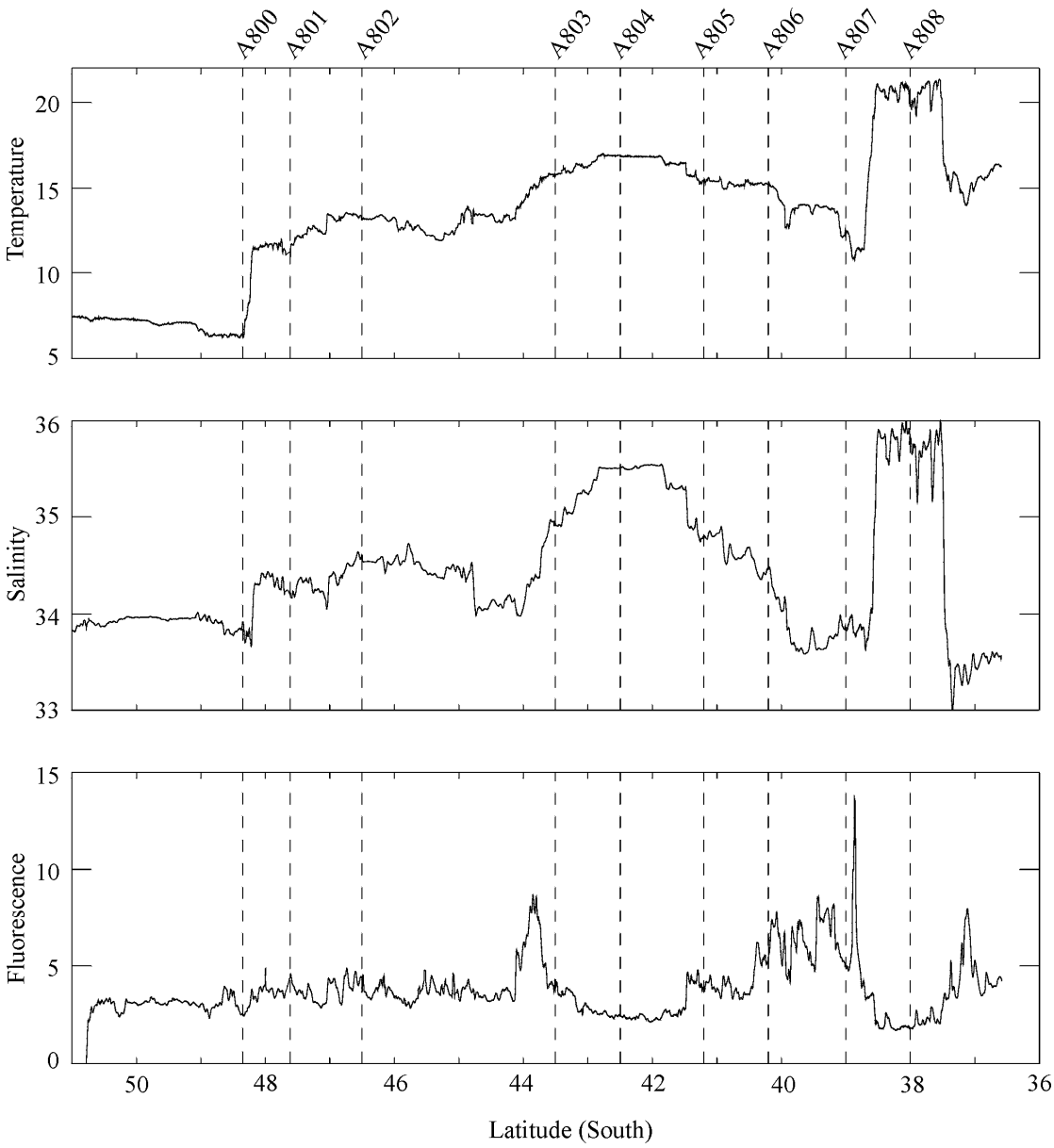

Figure 6. Surface temperature, salinity and fluorescence for leg I plotted against latitude, with the location of the stations overlaid.

4.2.5 In Situ Surface Measurements

The near-surface (7m) measurements of temperature (T), salinity (S) and raw fluorescence (F) voltage between Stanley and Montevideo are shown in Figure 6. The data shows the track crossing the shelf break, and encountering the Sub Antarctic Front (SAF) at circa 48.4°S. The T-S values indicate the region between 48 and 45°S contains a mixture of the warm brazil current and the colder fresher Falkland Current water. The low S and high F seen at 44°S, is probably caused by a dipole originating from the Falkland Current which is rotating around the warm core eddy. The T-S relationship of the warm core eddy identifies it as originating from the Brazil Current. It is centred at approx. 42°S it is distinctly evident in both the AVHRR and TOPEX images. At circa 38.6°S there is an intense front (SAF) between the northern extent of the Falklands Current. (noted by low S, low T and high F), and the southern edge of the Brazil Current (high T, high S, low F).).

At 37.5°S the outflow from the River Plate is sampled (low S, high F, relatively high T).

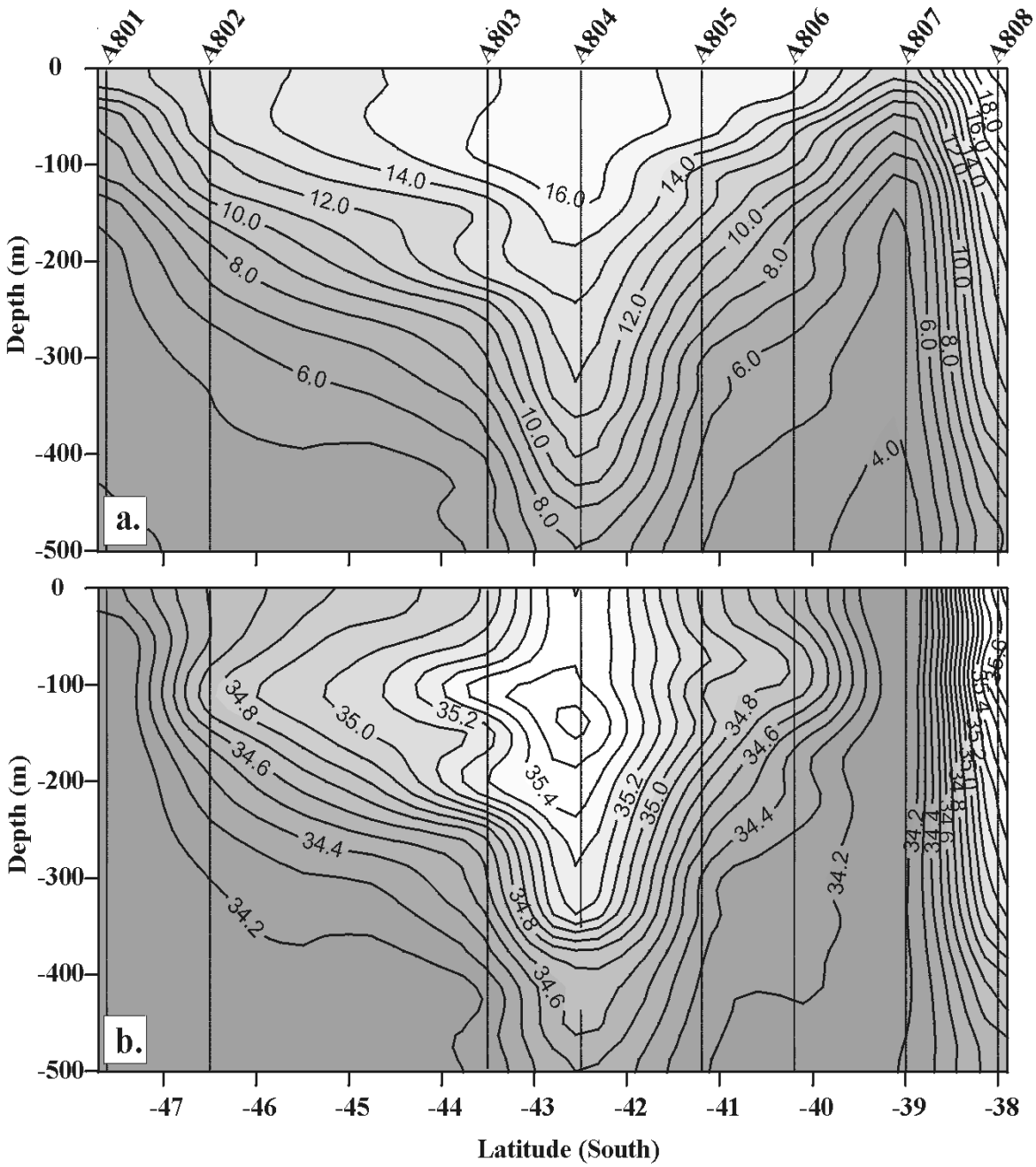

Figure 7. CTD sections for temperature (a) and salinity (b) for leg I, plotted against latitude, with the location of the stations overlaid.

4.2.6 In-situ CTD sections.

The measurements of T and S obtained from the CTD casts are shown as contoured section in Figure 7. The dominant physical feature is the warm core eddy system originating from the Brazil current centred at 42.5°S. The eddy has a core of the high S, and T between 100 and 200m and extends to depths below 500m. Mixing between the colder less saline water of the Falkland Currents have dynamically altered the T and S fields both vertically and horizontally, influenced the surface waters between 40 and 46°S.

The northern extent of the Falkland Current (39°S) is seen immediately to the north of the warm core eddy. Clearly visible in the AVHRR as a band of cold water which circulates eastward and becomes entrapped within the confluence. The intense front between the Falkland Current and Brazil Current (38°S) shows a front of 8°C within 50 km and is seen at all depths to 500m.