Boundary Current System at 52°W in the North Atlantic

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In this work we compare two Deep Western Boundary Current (DWBC) sections in the North Atlantic to investigate the continuity of the current between the subpolar and subtropical domains. The upstream section is a composite of 10 springtime occupations of the WOCE A20 hydrographic line, crossing the Labrador Sea at nominally 56°N, occupied over the years 1990-7. Absolute geostrophic velocities have been computed by referencing the mean thermal field using PACE float data, followed by a simple inverse calculation across the Labrador basin. The downstream section is the northern end of the WOCE A20 hydrographic/ADCP section occupied in summer, 1997, nominally along 52°W; for this section, geostrophic velocities were referenced using ADCP data, and then a mass and silicate conserving inverse was used to make additional adjustments. Both sections conserve overall mass. Their locations are shown in Figure 1, and velocity/potential density sections in Figures 2 and 3.

The comparison of these two sections was motivated by the observation that the net theoretical transport calculated for the northern boundary current system at 52°W was nearly identical to the comparable transport of the western boundary current system in the Labrador Sea, but for 20 times larger magnitude. However, it has long been observed how much of the equatorward flow in the latter is able to round the Grand Banks, where the Labrador Current is in particular, it is believed to intertropical north and eastward as it encounters the North Atlantic Current. To investigate this question, we divided the water column into 10 potential density classes (Table 1), and computed transport for these classes at the two locations. For the Labrador Sea (LS), the flow was integrated from the seaward (western) boundary in the northwest of the study region (Figure 2) to zero for the net equatorward transport only. For the Grand Banks section (GB), all water flow between stations 1 and 18 was considered. Note that the seaward flow between stations 11 and 15 in Figure 3 is the overflow water at the northern end of the Gulf Stream, and therefore not part of the DWBC system (McKelvie, 1962; Isachsen and Hall, 1983).

Figure 1: Composite of 10 springtime occupations of the WOCE A20 hydrographic line, crossing the Labrador Sea at nominally 56°N, occupied over the years 1990-7. Absolute geostrophic velocities have been computed by referencing the mean thermal field using PACE float data, followed by a simple inverse calculation across the Labrador basin. The downstream section is the northern end of the WOCE A20 hydrographic/ADCP section occupied in summer, 1997, nominally along 52°W; for this section, geostrophic velocities were referenced using ADCP data, and then a mass and silicate conserving inverse was used to make additional adjustments. Both sections conserve overall mass. Their locations are shown in Figure 1, and velocity/potential density sections in Figures 2 and 3.

The transport by density class for the two locations is shown in Table 1 and Figure 4. The results are striking, including the lightest density layer (which barely exists in the LS section), transport in the other 4 lightest density classes (which lie above ~1500 m) decreases by about 20%, with a similar trend in the 2 to 3 lightest classes (which lie above ~1000 m). For the Grand Banks section (GB), the deep transport in the other 4 lightest density classes (which lie above ~1500 m) decreases by about 40%.

Table 1: Layer Transports

<table>
<thead>
<tr>
<th>Layer</th>
<th>Boundary transport (Sv)</th>
<th>Cumulative transport (Sv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LS</td>
<td></td>
<td></td>
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<tr>
<td>GB</td>
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Finally, we compare the properties for the abyssal layer 10 (Figure 7). Although the bottom depth is greater at the GB section, deeper water exists in the LS. Note that the deeper water in the GB section is colder and fresher than water of similar density in the LS. This is opposite from the expected trend, suggesting that the abyssal GB water did not originate in the DWBC upstream. This is consistent with the transport results: the GB equatorward transport below 19°C (where the GB and LS density curves diverge) is 5-6 times, similar to the difference between the net transport for layer 10 at the two locations (4.5S). Pickart and his group (1996) used potential vorticity arguments to demonstrate that, indeed, the deeper part of the GBW should be blocked by the Southeastern Newfoundland Rise. Thus, the additional deep transport at 52°W must come from one of two sources: 1) it is due to the presence of the Northern Hemisphere (NH) Core Ring water, or the GBR (Hogg et al., 1996; or 2) it is water that diverges from the Antarctic Bottom Water. The latter would be consistent with the low salinity, as suggested by McCarthy (1996). Strongly enhanced silicate values below 2C (Figure 8) suggest that the latter is, indeed, the source of the additional transport.

Figure 7: Temperature and salinity for layer 10 at the LS and GB sections.

Figure 8: Silicate concentration at 2°C for layers 10, 9, and 8 at the LS and GB sections.

Figure 9: Transports for layers 10, 9, and 8 at the LS and GB sections.