Coupling between the Canary Current and the upwelling system off northwest Africa

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Deep ocean studies of the Canary Current suggest the existence of an eastern branch of this current which recirculates southward along the African continental slope and platform. During the last three years the Physical Oceanography Group at the Universidad de Las Palmas de Gran Canaria (Canary Islands, Spain) has undertaken several efforts to corroborate the existence of this branch and to investigate its characteristics, in particular its interaction with the upwelling current system off northwest Africa. These studies include XBT measurements, hydrographic cruises, drifters and modeling. Three XBT lines have been maintained with a quarterly periodicity between the Canary Islands and the southern tip of the Iberian Peninsula, and between the Canary Islands, Madeira and the western part of the Iberian Peninsula. These lines, together with standard T-S algorithms developed for the region, allow us to appreciate the clockwise recirculation pattern of the Canary Current and its seasonal variability, and have confirmed the presence of significant onshore flow between the Straits of Gibraltar and Cape Ghir. Two hydrographic cruises between the Iberian Peninsula and the Canary Islands, with special emphasis on the region of the Cape Ghir filament, have been done to investigate how the eastern branch onshore flow recirculates along the African slope and flows back into the deep ocean. The results show the presence of both vertical and horizontal circulation cells at several levels, and confirm the importance of the filament as a mechanism for intermittently returning eastern branch water into the deep ocean. Preliminary numerical studies point at the importance of an adequate representation of this region by showing the potential influence of different boundary conditions on the circulation in the subtropical northeastern Atlantic Ocean. These studies have been carried out through funding from the Spanish government (project Frentes) and the European Union (project Canigo).

COUPLING BETWEEN THE CANARY CURRENT AND THE UPWELLING SYSTEM OFF NORTHWEST AFRICA

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ABSTRACT

During the last three years the Physical Oceanography Group at the Universidad de las Palmas de Gran Canaria (Canary Islands, Spain) has undertaken several efforts to investigate the existence and variability of an eastern branch of the Canary Current, which recirculates southward along the African continental slope and platform. These efforts include the maintenance of periodic XBT lines, hydrographic cruises, launching of drifters, analysis of historical data and modeling. Here we present some of our results, which confirme the presence of significant onshore flow between the Strait of Gibraltar and the Canary Islands.

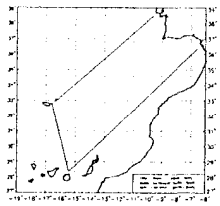
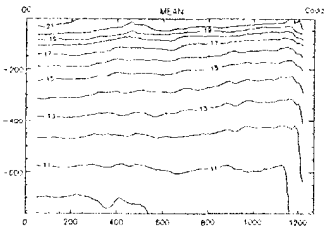
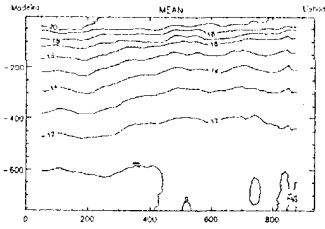


Figure 1. Map of the study area and the approximate XBT sections. Typical distance between stations is 25 nm





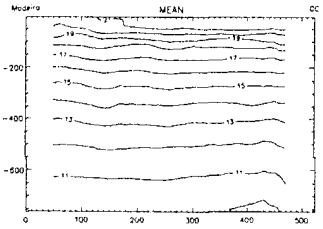


Figure 2. Mean temperature profiles for sections (a) Cádiz Gran Canaria, (b) Lisbon Madeira, and (c) Madeira Gran Canaria. The shallowing of the isotherms with latitude is clear in (a), indicative of the Azores-Canary Current. A substantial shallowing with latitude is also apparent in (b), corresponding to the eastern branch of the Canary Current which flows into the African slope.

Cadiz (Spain) – Gran Canaria (Canary Islands)

Year\Month	1	2	3	4	5	6	7	8	9	10	11	12
1995							X			X	X	
1996			X									X
1997			X				X			X		
1998	X			X		O	O			O		

Lisbon (Portugal) – Funchal (Madeira Islands)

Year\Month	1	2	3	4	5	6	7	8	9	10	11	12
1996												X
1997			X			X				X		
1998	X			X			O			O		

Funchal (Madeira Islands) – Gran Canaria (Canary Islands)

Year\Month	1	2	3	4	5	6	7	8	9	10	11	12
1996												X
1997			X			X				X		
1998	X			X			O			O		

Table 1. Crosses indicate sections done, circles indicate sections planned (lines are as in Figure 1).

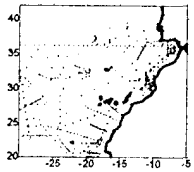


Figure 3. NODC data (CTD stations indicated as dots in this figure), Ifremer data, University of Kiel data, and our own data sets have been used to produce standard T-S diagrams for the region (a total of 779 stations and 73506 data points).

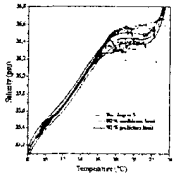
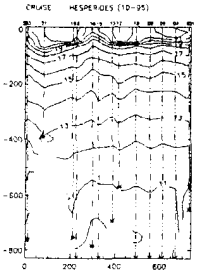


Figura 4

Figure 4. Empirical S(T) relationships are obtained using all available CTD data for regions of 2 x 2 degrees. The figure illustrates the adjustment to the data for box (29-32°N, 9-11°W. R_square= 0.98823, SD= 0.03701), curves corresponding to one standard are also shown.



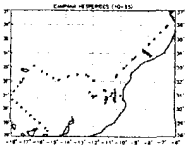


Figure 5. In October 1995 a hydrographic cruise was done over the region with the purpose of examining the recirculation of the Canary Current. The map shows the location of all 71 XBT and 10 CTD stations.

Figure 7. In September-October 1997 a hydrographic cruise was done over the region with the purpose of examining the recirculation of the Canary Current. The map shows the location of all 42 XBT and 24 CTD stations.

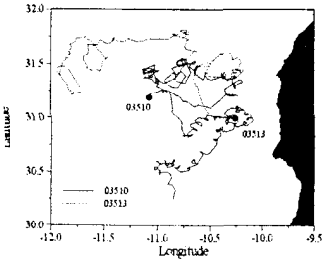


Figure 8. Track of two surface drifting buoys launched in the filament region. A buoy launched in the base of the filament moved offshore with mean speeds of 0.25 m/s over a 11 day period. A second buoy launched at the exterior of the filament ended up flowing south, nearly parallel to the coast, with a mean speed greater than 0.1 m/s over a 17 day period.

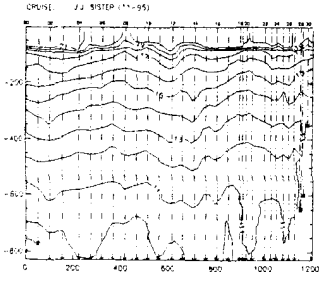


Figure 6. Temperature sections approximately parallel to the African coast between the Iberian Peninsula and the Canary Islands. Part (a) illustrates a temperature section for a line running near the continental slope, while part (b) illustrates a synoptic temperature section for a parallel line (about 70 km offshore). The temperature distributions suggest that the recirculation takes place associated to the coastal upwelling jet, in the relatively narrow band between both lines.

CONCLUSIONS

The analysis of 22 XBT lines and two hydrographic cruises indicates that a significant fraction of the Canary Current circulates southwards along the African coast and through the Canary Archipelago, clearly linked to the coastal upwelling jet. The results confirm the ubiquity of this horizontal recirculation cell, and point at the intimate coupling between the interior and coastal oceans both through this horizontal cell and the vertical upwelling cell. Filaments in the upwelling jet probably act to accommodate the excess inflow, by returning it to the interior ocean. One main conclusion is the very important role played by the coastal upwelling system in controlling a significant fraction of the interior flow. This needs to be taken into consideration for proper modeling of large-scale ocean circulation.

ACKNOWLEDGEMENT

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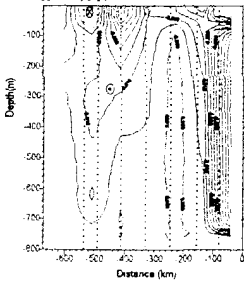

Figure 9. Geostrophic velocity normal to the coast (relative to 760 m) between the Iberian Peninsula and the Canary Islands. Negative values correspond to onshore velocities, integrated transport exceeds 1 Sverdrup into the continental slope.