The North Atlantic shelfbreak current: an advective link for climate variability.

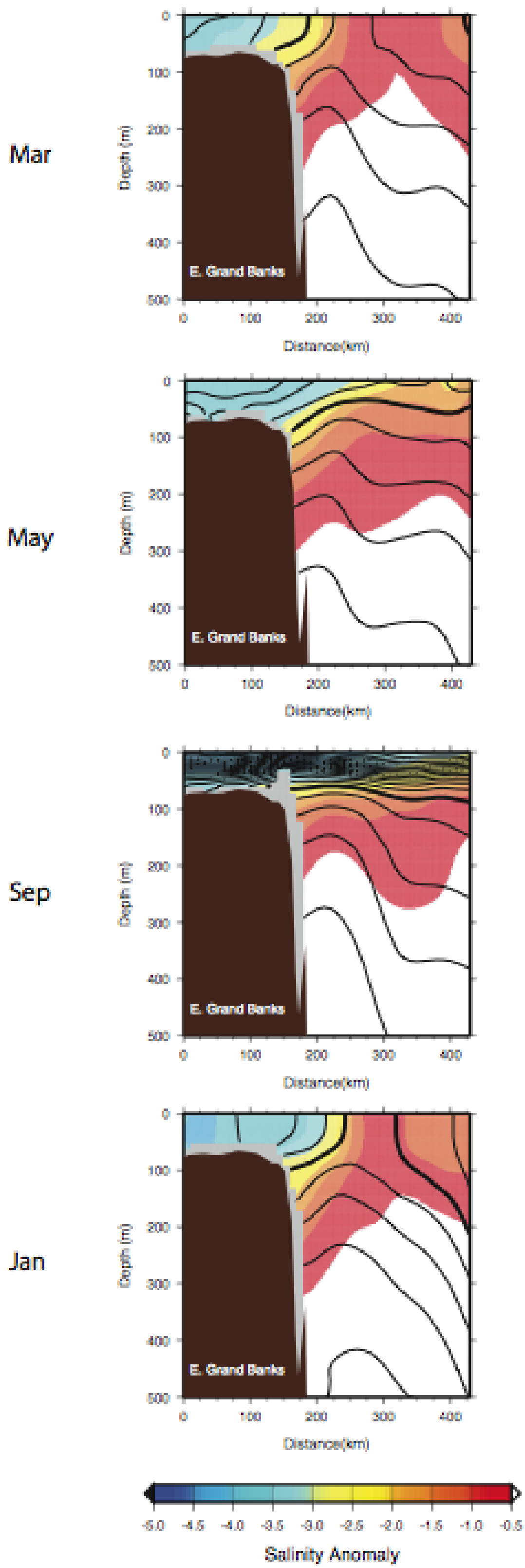
Paula S. Fratantoni
Principal Investigator

FINAL REPORT

The coastal circulation in the western North Atlantic is dominated by a buoyancy-driven current that follows the continental shelf edge, transporting relatively fresh subpolar and Arctic-origin water equatorward. Along its extensive path, the current transports high-latitude climate-driven variability equatorward, although it is not clear exactly how these signals are communicated to the interior of the Atlantic where they might have an impact on the larger climate system. Coastal ecosystems are sensitive to where and how much freshwater leaves the boundary as it is advected by the shelfbreak current and it has been conjectured that the anomalous penetration of low salinity waters into the interior can modulate the thermohaline overturning circulation. Recent studies suggest that there are select geographical regions along the path of the current where mass and freshwater are lost, however little direct evidence of these pathways exist. The Grand Banks of Newfoundland appears to be one such location. Here large changes in topography alter the cross-shelf distribution of temperature and salinity, and appear to force a large portion of the current onto the upper slope. Particularly large transport losses follow, presumably when a portion of the current retroflects offshore, transporting a significant (yet unknown) fraction of the coldest, freshest arctic-origin water into the interior.

In this study, 100 years of historical hydrographic data have been used to construct a seasonal climatology of the freshwater pathways along and across the shelf/slope boundary, paying particular attention to the current branching that occurs at the Tail of the Grand Banks of Newfoundland. One of the major findings of this work is that advective processes do not dominate the seasonal patterns of freshening observed along the boundary. Since a significant portion of the shelfbreak current retroflects offshore at the Tail of the Grand Banks of Newfoundland, one might expect to observe the seasonal pulse of fresh water, originating from melting ice and increased river runoff, propagating along this pathway. Instead, the seasonal fresh water boundary expands offshore and contracts back toward shore through a mixture of advective and diffusive processes (see Figure). In addition, seasonal heating and cooling at the sea surface alters the density distribution across the shelf/slope region, further constraining these lateral processes.

In the future, I hope to use this climatology to trace the evolution of anomalous freshwater pulses through the system, enhancing our ability to predict the impact of climate-driven variability far from its source. Findings from this study were presented at the Ocean Sciences Meeting in Orlando, Florida in February, 2008, and a manuscript is currently in preparation. In addition, the results from this work have helped to motivate the proposal of a field program that will be submitted to the National Science Foundation in August, 2008, to examine the interplay between the retroflecting shelfbreak current and branching Gulf Stream, and the deep western boundary current, as they navigate the topography at the Tail of the Grand Banks (with co-principal investigators Michael McCartney, WHOI, and Kathleen Donahue, URI).



Shown left: vertical sections of salinity anomaly (color) and density (contours) extracted from the 100-year monthly average climatology along a single cross-shelf section crossing the eastern flank of the Grand Banks of Newfoundland. The salinity anomaly is calculated relative to a time-independent standard T-S curve (relative to density) from observations in the Sargasso Sea. The blue shades represent the freshest water and the heavy black contour is the 26.80 isopycnal, roughly defining the base of the shelf-water layer.

The seasonal flux of freshwater onto the shelf from spring maximum river outflow and ice melt (1) builds on the shelf in the spring, isolated by the outcropped isopycnals, (2) diffuses offshore and mixes with the North Atlantic Current after the seasonal pycnocline is reestablished, and (3) is ultimately swept downstream by the NAC and/or progressively eroded by the cooling and salinification of surface water during winter convection.