Rockall Trough Hydrographic Time Series

The Extended Ellett Line

Recent reduction in temperature and compensation of density in the upper Rockall Trough, Northeast Atlantic

John Allen, Jane Read, Toby Sherwin*, Colin Griffiths*, Raymond Pollard, David Ellett*
Lead Author: jta@noc.ac.uk , Corresponding author: jfr@noc.ac.uk
National Oceanography Centre, Southampton, UK : *Scottish Association for Marine Science, Oban, Scotland, UK

Introduction

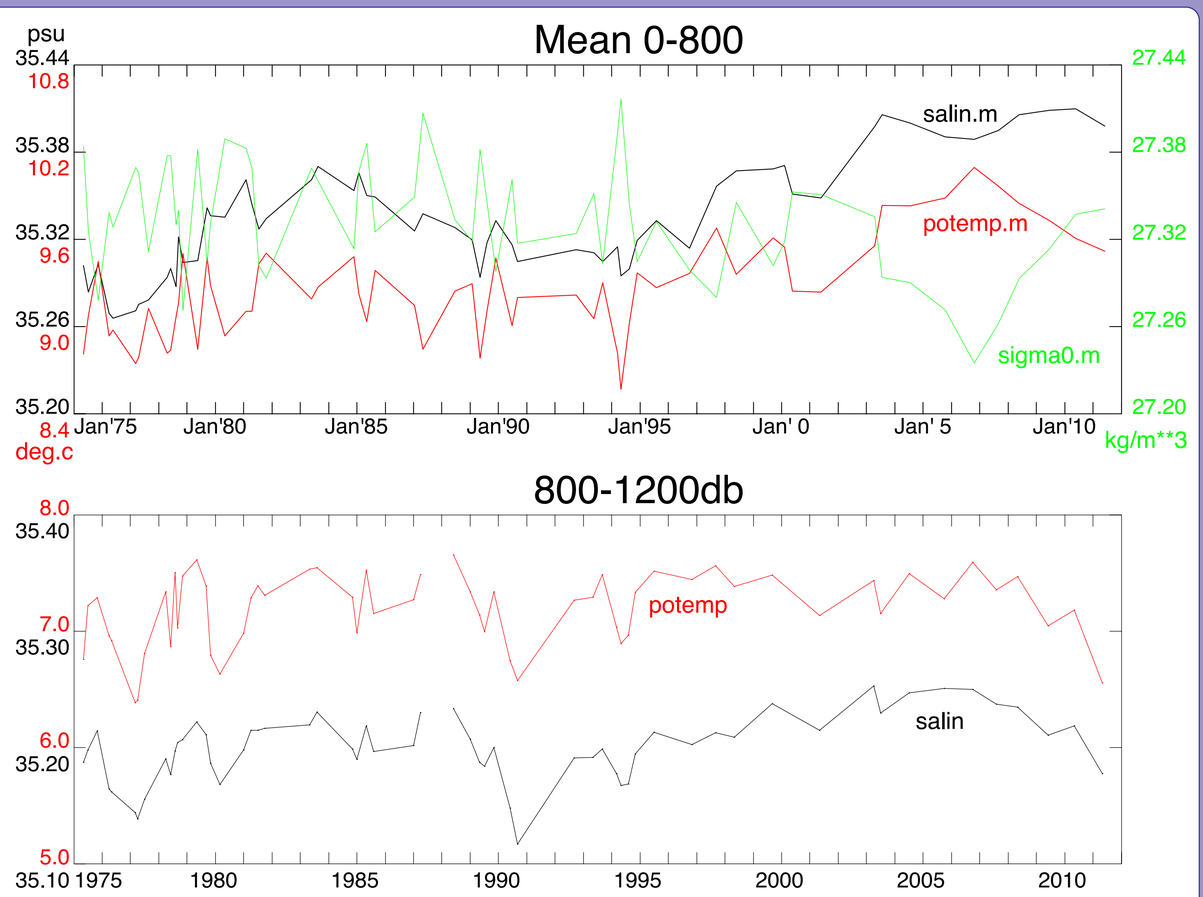
The Extended Ellett Line is a full depth hydrographic section between Scotland, Rockall, 60°N 20°W and Iceland. Here we consider just the Ellett Line (red line on map, right) between Scotland and Rockall, which has been occupied every year since 1975.

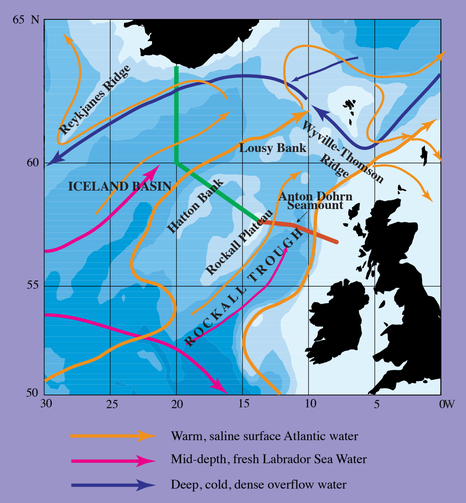
Changes in the Upper Ocean

Mean properties of the upper 800 m of the water column over 37 (upper right) years show variability but generally increased from a low in the mid 1970's, the time of the great salinity anomaly (Dickson et al, 1988), to the mid 2000's. The last decade of this period saw a change in the circulation of the gyre (Hakkinen & Rhines, 2005; Hatun et al, 2005), which allowed more warm, saline water from the south to enter the Rockall Trough. The spread of warm water northward through the Nordic Seas to the Arctic was documented by Holliday et al, 2008.

Since 2006 there has been a small but steady decrease in temperature., about 0.5°C, suggesting that the long-term increase in temperature has reversed over the last 5 years. Salinity since 2004 is unchanged. It is possible that the changes result from aliasing of the seasonal signal.

However, the mean properties of the permanent pycnocline (800-1200m, lower right) show a much greater decrease in temperature, ~1.0°C and a decrease in salinity, ~0.07. This depth is well below the influence of seasonal signals from which we can infer that this is likely to be an advective change, rather than a change in air-sea fluxes.



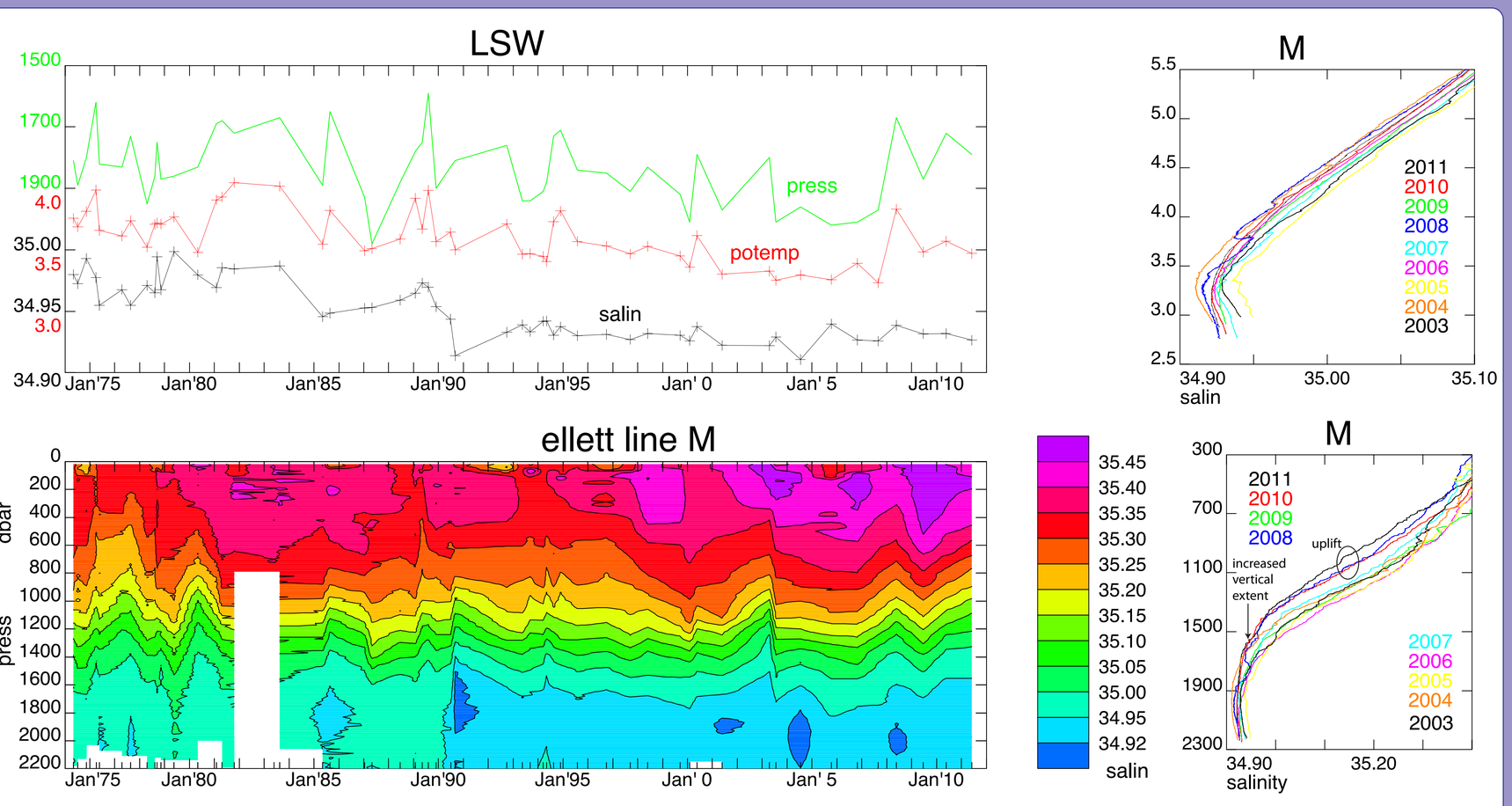


Changes in Labrador Sea Water (LSW)

The time series of LSW properties at the potential vorticity minimum (upper right) is quite different to the overlying water. It reflects changes taking place elsewhere in the gyre, thus the step change in 1990-1991 probably reflects the renewal of deep convection that took place in the Labrador Sea in the late 1980's (Yashaev et al 2007).

More recently 2006 saw an increase in salinity while temperature increased in 2008. These changes are slight (t/s plot far right) and the more striking difference is the increase in thickness of the layer of LSW (profiles far right). In 2010-2011, LSW extended 200-300m higher in the water column than previously. Profiles also showed an uplift in the pycnocline explaining the decrease in temperature in the 800-1200m mean.

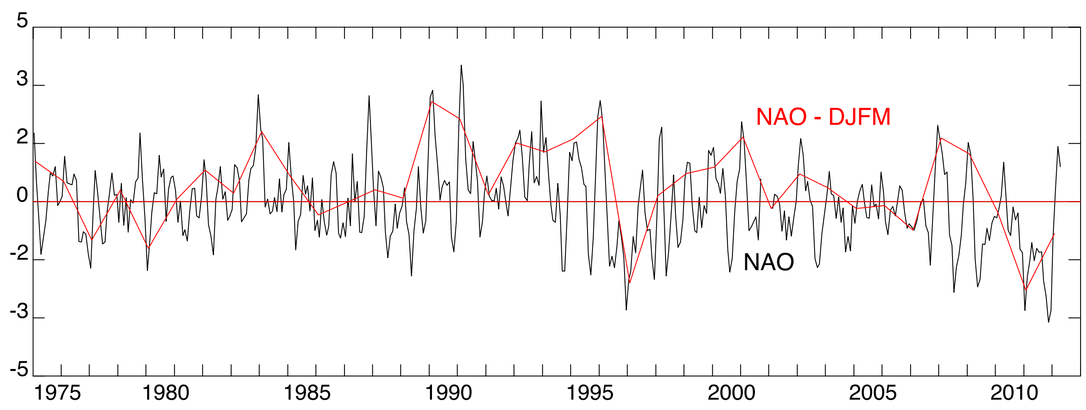
Station M, the deepest station of the section, shows how the changes in the different layers link together. Salinity illustrates LSW better than temperature. The decrease in temperature of the upper layer occurs at the same time as recent shallowing of the salinity contours.



Changes in circulation

The NAO index represents the normalised sea-level pressure difference between Iceland and the Azores and is the leading mode of atmospheric variability over the N Atlantic (Hurrell, 1995). A high NAO represents strong westerly winds and well-defined subpolar gyre and is associated with deep convection. The NAO peaked in the early 1990's and has since decreased, leading to weaker zonal winds, a contraction of the gyre and a westward shift in the subpolar front. During this period, the Rockall Trough became increasingly warm and salty.

Over the last few years the NAO has become increasingly negative with the winter of 2009/10 experiencing the most negative NAO index recorded. Since this is a continuation of the process that has led to warming and increased salinity, it might be expected that the Rockall Trough should continue to warm and salinify. However, there appears to be some other process at work, which we are seeking to identify.



Conclusions

The recent decrease in temperature of the upper 800m results from thinning of the layer of upper water, rather than a change in the properties of the water mass (ENAW). At the same time there has been a thickening of the LSW layer, leading to an uplift in isolines and apparent cooling. Further work will investigate the causes of these changes.

References

Dickson, R.R., Meincke, J., Malmberg, S.-A., Lee, A.J., 1988. The 'Great Salinity Anomaly' in the northern North Atlantic 1968-1982, Progress in Oceanography, 20, 103-151, doi:10.1016/0079-6611(88)90049-3

Häkkinen, S., Rhines, P.B., 2004. Decline of subpolar North Atlantic circulation during the 1990s. Science, 304, 555-559

Hatun, H., Sando, A.B., Drange, H., Hansen, B., Valdimarsson, H., 2005. Influence of the Atlantic subpolar gyre on the thermohaline circulation. Science, 309. 1841-1844.

Holliday, N.P., S. L. Hughes, S. Bacon, A. Beszczynska-Moeller, B. Hansen, A. Lavin, H. Loeng, K. A. Mork, S. Osterhus, T. Sherwin, W. Walczowski, 2008. Reversal of the 1960s - 1990s Freshening Trend in the northeast North Atlantic and Nordic Seas. Geophysical Research Letters, 35, L03614, DOI:10.1029/2007GL032675

Hurrell, J.W., 1995. Decadal trends in the North Atlantic Oscillation: regional temperatures and precipitation. Science, 269, 676-679

Yashayaev, I., van Aken, H.M., Holliday, N.P., Bersch, M., 2007. Transformation of the Labrador Sea Water in the subpolar North Atlantic. Geophysical Research Letters, 34, L22605, doi:10.1029/2007GL031812. 8(11)