Oceanic forcing of the dynamics at the continental margin west of Ireland and the effect on zooplankton distributions

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Introduction

Historical records from the Continuous Plankton Recorder survey in the Northeast Atlantic span from the 1960s to the present day. The Continuous Plankton Recorder is towed behind ships of opportunity (usually merchant vessels) and the samples are analysed and collated by the Sir Alister Hardy Foundation of Ocean Science in Plymouth, UK.

This study has analysed these data for trends in zooplankton abundance and examined the effects of the regional oceanographic forcings upon significant keystone species. The hydrographic conditions to the west of Ireland have been studied, in particular the North Atlantic Current (NAC) and the Shelf Edge Current and the seasonal and interannual variations in their flows. These flows are strongly correlated with the North Atlantic Oscillation (NAO) and efforts are made to elucidate these links through direct measurements of the currentfield. A number of direct and indirect measurements were used to observe these variations: Sea Surface Height from satellite altimetry; direct current meter measurements; remote sensed sea surface temperature and wind stress curl data to measure the effect of the NAO on the NAC through variations in storminess.

Through the direct measurement of these oceanographic variables and the abundances of key indicator species and assemblages, this study aims to show the effect of climate change upon the zooplankton to the west of Ireland, an area of great importance, both for oceanography with a branch of the thermohaline circulation passing through the region and for fisheries with a number of large, economically important nurseries in the area.

The Continuous Plankton Recorder

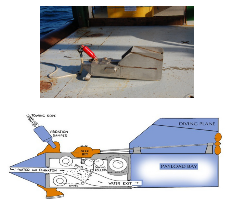

Figure 1 The CPR and its internal mechanism As the CPR is towed behind the vessel, water is filtered through a ~270μm mesh which is continuously wound on by means of rollers attached to an impeller. The sandwich of mesh is wound into a storage tank and fixed with borax-buffered formaldehyde.

Area of Interest

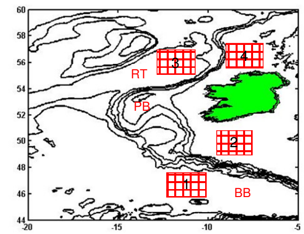

Figure 2 Study Area Red hatched boxes show areas over which sea level anomalies were averaged. PB = Porcupine Bank, RT = Rockall Trough, BB = Bay of Biscay

Results

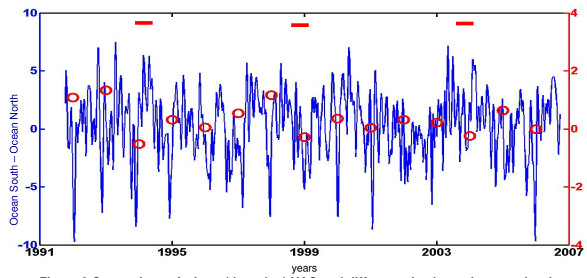

Figure 3 Comparison of winter (dec – jan) NAO and difference in along-slope sea level change (Biscay – Rockall) The blue line shows the difference in sea level anomalies along the slope in two regions north (i.e. 3 in figure 2) and south (i.e. 1 in figure 2) of the Porcupine Bank. Sea level anomalies were obtained from Topex/Poseidon and ERS-1 altimetry data. The red circles show the mean winter (dec – mar) NAO index. The red dashes indicate times of low NAO values

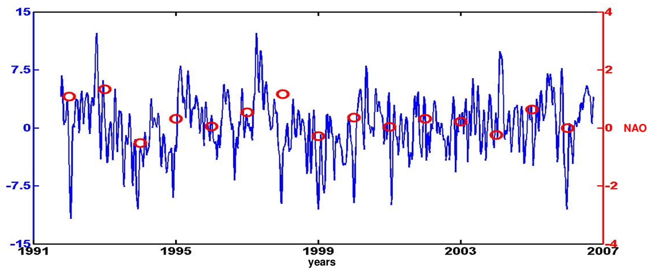

Figure 4 Comparison of winter (dec-mar) NAO and difference in cross-slope sea level change (Biscay – Rockall) The blue line show the difference in the change in sea level anomalies from a seven year mean across the slope in two regions, north and south of Ireland(i.e. (2-1)-(4-3) in figure 2). Sea level anomalies were obtained from Topex/Poseidon and ERS-1 altimetry data. The red circles show the mean winter (dec – mar) NAO index.

Meridional sea level anomaly values (figure 3) show a response to NAO forcings. Low NAO winters are often followed by a spike in alongslope differences. A low NAO value corresponds with a flatter shelf margin, with subsequent spreading of warm Biscay water northwards into the Rockall Trough system (Garcia Soto *et al,* 2002).

More positive values of the difference between the cross-shelf sea level changes to the north (i.e. between areas 3 and 4 in figure 2) and south (i.e. between areas 1 and 2) of the Porcupine Bank (figure 4) imply stronger shelf edge current flows south of Porcupine Bank, more negative values show weaker SEC flow south of Porcupine Bank. This signifies a stronger North Atlantic Current influence on the water in the Rockall Trough, which matches well with the NAO values seen (Reid et al., 2001).

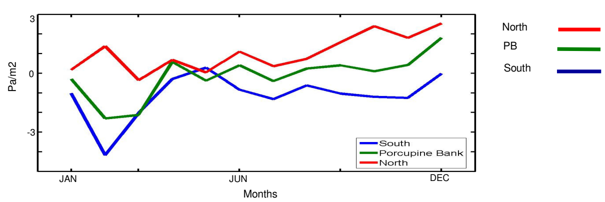

Figure 5 Monthly Mean Wind Stress Curl north of Porcupine Bank, at PB and south of PB 1995 – 2002 Values of monthly mean wind stress curl display increasing force over the latter part of the year.

Figure 5 shows monthly wind stress values along the continental margin. The WSC north of the PB promotes increased SEC transport in the area later in the year while the values to the south respond to the SOMA response early in the year. Barotropic response to this forcing leads to increased alongslope transport later in the year, consistent with increases in NAO values during the winter months. This finding is consistent with results along the margin (e.g. Orvik & Skagseth, 2003).

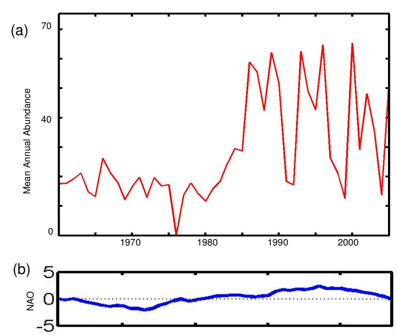

Figure 6 (a) Annual mean abundance of *Metridia lucens* in Biscay Area (b) smoothed (15 yr filter) winter NAO index Historical CPR data reveals trends in zooplankton abundance which can be correlated with hydrographic conditions. Study of the linkages between these variables proves more challenging.

Figure 6(a) shows the mean annual abundance of *Metridia lucens*, a temperate oceanic species of zooplankton in an area to the west of the Porcupine Bank (PB in figure 2). The winter NAO index shows a good positive relationship with the mean abundance of *M. lucens*. This may be due to a higher NAO index related to an expansion of the Atlantic subpolar gyre. This expansion causes the intrusion of more saline, oceanic water into the Rockall Trough, carrying with it more oceanic species (Bersch, 1999,Hatún et al, 2003). CPR data obtained from SAHFOS historical database.

Conclusions

- It is evident the NAO influences the hydrographic conditions to the west of Ireland through development and variability of wind stress curl fields and large scale sea level changes.
- Zooplankton species abundances and overall abundances relate directly to winter NAO variations due to the effect of the winter NAO on hydrographic conditions for the important spring zooplankton spawning and phytoplanton growth period.
- Overall, zooplankton abundances show sensitive adjustment to ambient hydrographic conditions and, as such, their value as an indicator of rapid environmental change, especially in the hydrographically complex and important study region, are increased.

Further Work

- Investigation and quantification of the linkages between large scale environmental forcings and local scale effects
- Further analysis of zooplankton data, in particular its relationship with environmental temporal and spatial variability

References

Bersch,M., J. Meincke and A. Sy, Interannual thermohaline changes in the northern North Atlantic 1991–1996, *Deep-Sea Research Part II* 46 (1999), pp. 55–75.

Garcia-Soto, C.; Pingree, R.; Valdés, L. Navidad development in the southern Bay of Biscay: Climate change and swoddy structure from remote sensing and in situ measurements. *J. Geophys. Res-Oceans 107(C8)* (2002).

Hátún, H., N. B. Sandø, H. Drange, B. Hansen, and H. Valdimarsson, Influence of the Atlantic Subpolar Gyre on the Thermohaline Circulation. *Science*, 309, (2005) 1841-1844.

Orvik, K. A. and Ø. Skagseth, The impact of the wind stress curl in the North Atlantic on the Atlantic inflow to the Norwegian Sea toward the Arctic. *GEOPHYSICAL RESEARCH LETTERS*, 30. (2003)

Reid, P.C., N. P. Holliday, T. J. Smyth. Pulses in the eastern margin current and warmer water off the north west European shelf linked to North Sea ecosystem changes, *Mar Ecol Prog Ser* 215 (2001), pp. 283–287

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