CLIMATIC-BIOTIC INTERACTIONS IN THE CENTRAL-WEST NORTH SEA ZOOPLANKTON COMMUNITY

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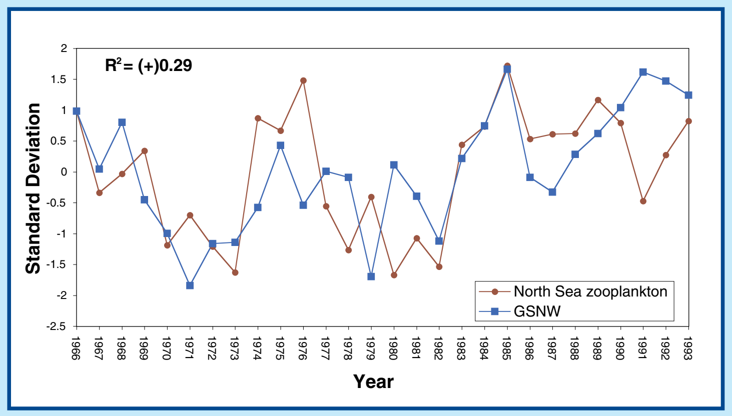
Background

The importance of zooplankton as secondary producers in the marine ecosystem, and thus their potential influence on fish stocks, has been the primary reason why researchers have attempted to determine how their long term dynamics are influenced by climatic and/or interspecific factors.

Most studies on the long term dynamics of zooplankton populations have focussed on zooplankton "birth" rates, and how increased temperatures or food supply produce increased population growth and abundances (Ohman and Wood, 1995). However, despite the wealth of evidence that "death" rates may influence zooplankton populations (e.g. Steele and Henderson, 1992), relatively few studies appear to have addressed how changes in mortality or predation rates influence long term zooplankton trends.

Here, we summarise the long term relationships between a zooplankton community in the central-west North Sea and a climatic indicator (the Gulf Stream North Wall), focussing upon the influence of a predator in modifying the signal of climate which is observed in the grazer fraction of the zooplankton community.

Across most of the North Sea positive relationships have been found to exist between long term zooplankton trends and the Gulf Stream North Wall (GSNW) (Taylor *et al.*, 1992). The GSNW is a climatic indicator of weather across the North Atlantic and in western Europe (Taylor, 1996). Northerly or positive positions of the GSNW are known to be associated with warmer temperatures across Europe (Topliss, 1997). Therefore, the positive relationship between the GSNW and zooplankton is what we would expect - higher temperatures (a northerly GSNW) result in increased zooplankton abundances.



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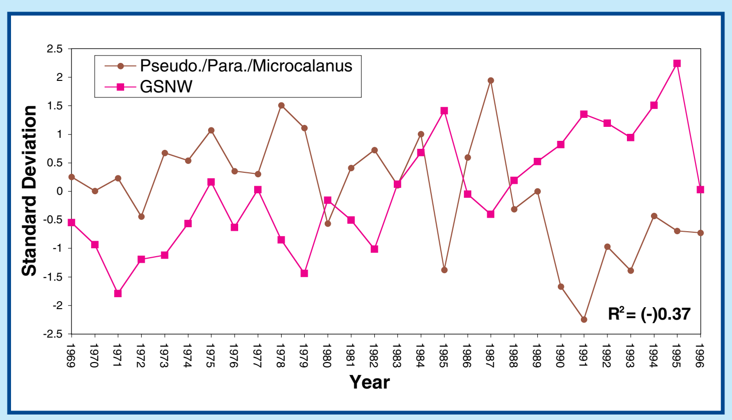
However, in the central-west North Sea, unexpected negative relationships were detected between the GSNW and zooplankton trends in this region (Frid and Huliselan, 1996). Here, northerly positions of the GSNW were associated with reduced zooplankton abundances, suggesting that cooler temperatures resulted in increased zooplankton production!! These relationships were particularly noticeable with the most abundant taxonomic unit - the Pseudocalanus/Paracalanus/Microcalanus group.



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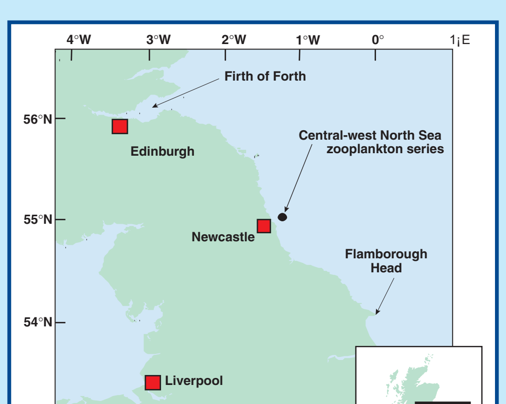
Methods

Monthly zooplankton sampling by the Dove Marine Laboratory began in January 1969 at a station approximately 5.5 nautical miles from the coast in the central-west North Sea, using vertical hauls from 50m to the surface using a 200µm meshed WP2 net (see Evans and Edwards, 1993 for rationale).

To determine whether predation was involved in producing the observed relationship between the main grazer group (Pseudo./Para./Microcalanus) and the GSNW, this study focussed on the month to month and interannual relationships of the grazers and the dominant predator, the chaetognath Sagitta elegans.



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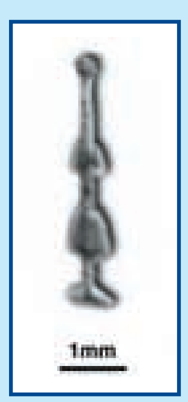

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Results

- During high grazer abundance years, the rate of grazer population growth during the spring (March-April) was higher compared to the growth rate during low abundance years.
- During these low grazer abundance years with lower growth rates, spring predator abundances were relatively high.

Thus, higher predator abundances during these spring months appear to be able to restrict the population growth of the grazer community. Conversely, during years with a lower spring predator abundance, the population growth rate of the grazer community is unrestricted and thus greater.

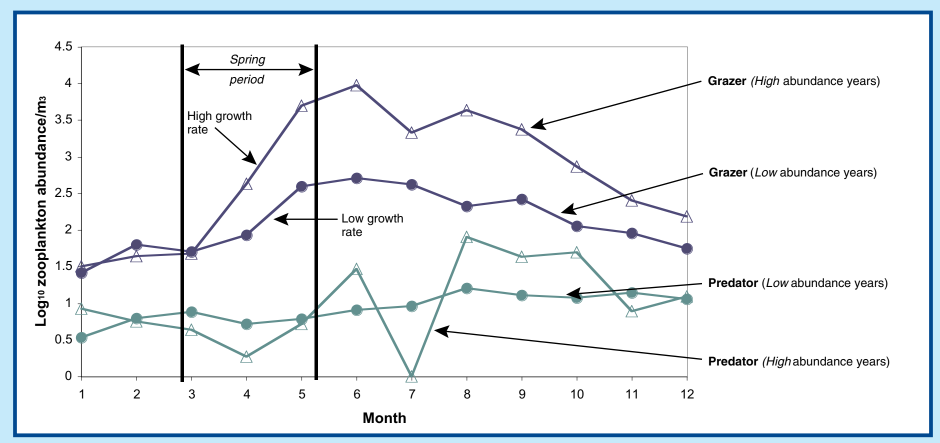
Therefore, during a particular year, overall grazer productivity is inversely related to the spring abundance of predators. This inverse relationship can be clearly observed over the 1969 to 1996 period.

But what has predation got to do with producing the unexpected negative relationship between the GSNW and the Central-West North Sea zooplankton community?

It has been suggested that the occurrence of spawning of Sagitta is linked to the spring bloom and increases in prey-density (Feigenbaum and Maris, 1984).

In turn, the timing of the spring bloom is linked to the existence of suitable weather conditions which allow stratification (Dickson *et al.*, 1988).

As such, it is unsurprising that more northerly positions of the GSNW, which would be expected to promote the spring bloom, were found to be positively related to higher spring predator abundances.



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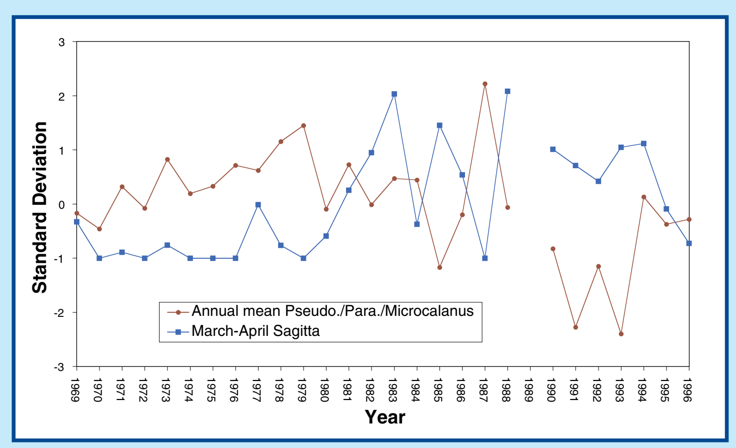

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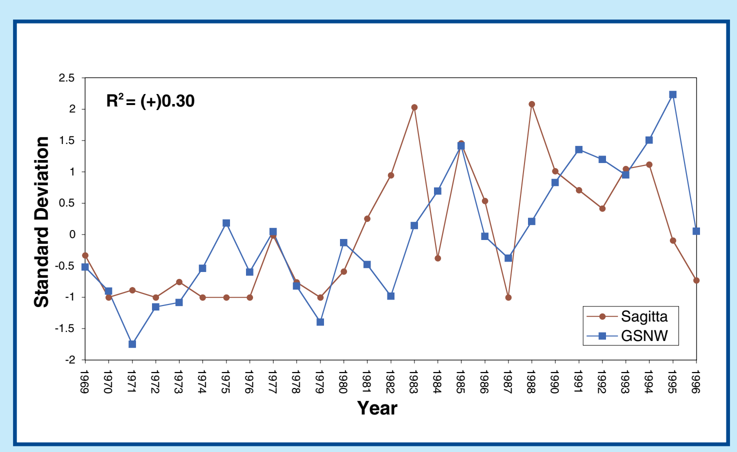

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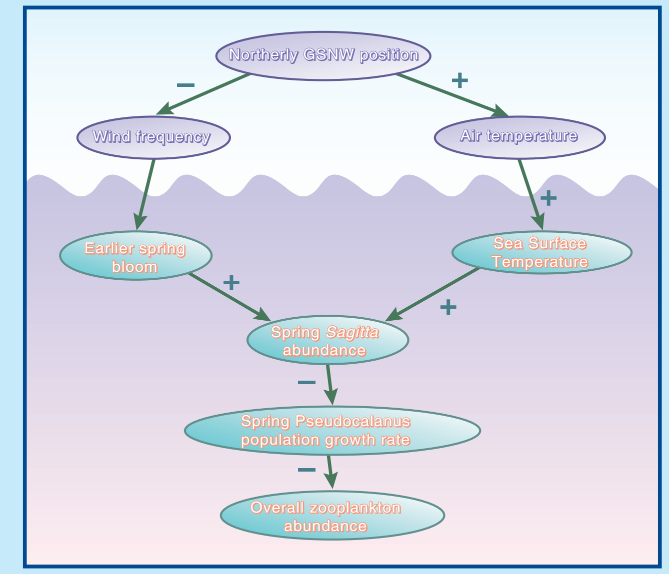
The hypothesis:

The unexpected negative relationship between the grazer population and the GSNW is due to suitable weather conditions which induce a spring bloom and lead to an increased abundance of Sagitta. This increased Sagitta population is then able to reduce the growth rate of the Pseudo./Para./ Microcalanus population during the spring, and effectively mediates an inverted climatic signal (the GSNW) onto the zooplankton population.



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Conclusions

- Most North Sea zooplankton series show a positive relationship to the position of the Gulf Stream North Wall (GSNW).
- The central-west North Sea zooplankton series unexpectedly shows a negative relationship to the GSNW.
- Spring abundances of the predator Sagitta bear a positive relationship to the GSNW
- The negative relationship between the GSNW and the central-west North Sea zooplankton series is due to predation upon the grazer community by Sagitta during the period of their main population growth (March-April).
- Thus, presence of Sagitta - which is positively related to climate, effectively inverts the signal of climate observed in the grazer fraction of the zooplankton community.

"Take home message"

When attempting to relate long term trends to environmental variables, biotic factors such as predation are rarely considered to be important, but as observed here, such biotic factors may be crucial in controlling the long term trends observed.

References

Dickson, R.R., Kelly, P.M., Colebrook, J.M., Wooster, W.S., and Cushing, D.H., 1988. North winds and production in the eastern North Atlantic. Journal of Plankton Research, 10(1):151-169.

Evans, F., and Edwards, A., 1993. Changes in the zooplankton community off the coast of Northumberland between 1969 and 1988, with notes on changes in the phytoplankton and the benthos. Journal of Experimental Marine Biology and Ecology, 172(11-29):11-31.

Feigenbaum, D., and Maris, R., 1984. Feeding in the chaetognatha. Oceanography and Marine Biology Annual Review, 22:343-392.

Frid, C., AND Huliselan, N., 1996. Far-field control of long-term changes in Northumberland (NW North Sea) coastal zooplankton. ICES Journal of Marine Science, 53:972-977.

Ohman, M., and Wood, S., 1995. The inevitability of mortality. ICES Journal of Marine Science, 52:517-522.

Steele, J.H., and Henderson, E.W., 1992. The role of predation in plankton models. Journal of Plankton Research, 14(1):157-172.

Taylor, A.H., Colebrook, J.M., Stephens, J.A., and Baker, N.G., 1992. Latitudinal displacements of the Gulf Stream and the abundance of plankton in the north-east Atlantic. Journal of the Marine Biological Association of the UK, 72:919-921.

Taylor, A.H., 1996. North-south shifts of the Gulf Stream: Ocean-atmosphere interactions in the North Atlantic. International Journal of Climatology, 16:559-583.

Topliss, B., 1997. Climate links across the North Atlantic. Ocean Challenge, 7(3):40-46.

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