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Short note

Continuous Plankton Records: a possible reversal in the downward trend in the abundance of the plankton of the North Sea and the Northeast Atlantic

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The data from the Continuous Plankton Recorder survey of the Northeast Atlantic and the North Sea (Glover, 1967) have indicated that, over the last three decades or so, there has been a clear systematic pattern in the year-to-year changes in the abundance of the plankton in the form of a quasi-linear downward trend. The trend occurs over a wide area including the whole of the North Sea, the Atlantic shelf of the U.K., and the open ocean from Iceland to the Bay of Biscay. It is shown by 14 out of 24 species of phytoplankton and 16 out of 24 species of zooplankton (Colebrook, 1982). The extent of the trend varies from area to area and from species to species. The most pronounced decline in abundance is shown by the copepod *Pseudocalanus*

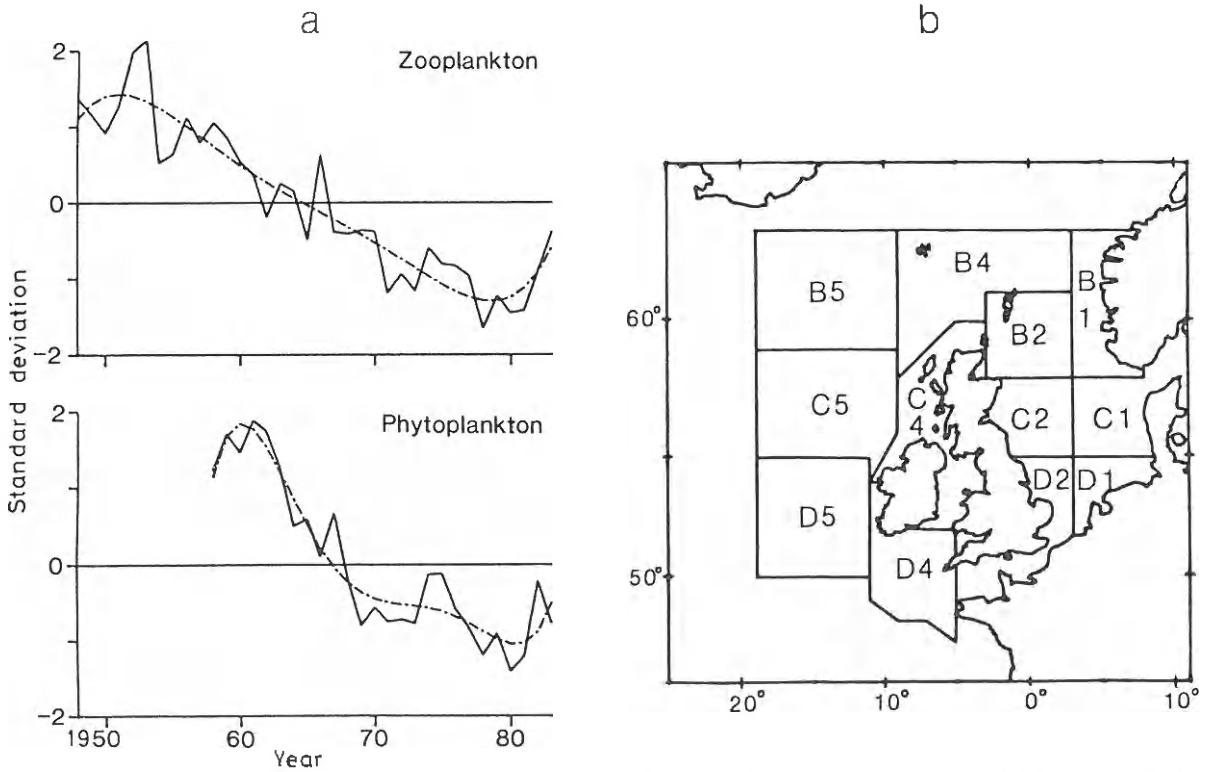

Figure 1. The graphs in a are the first principal components for zooplankton and phytoplankton of the annual fluctuations in the abundance, for the period 1948 to 1983, in each of the 12 areas shown in the chart, b. Not all the species occur in all the areas and the zooplankton component is based on 24 species and 247 series while the phytoplankton component is based on 24 species and 263 series. Superimposed on the graphs are fitted fifth-order polynomial curves (dashed lines). The graphs are scaled to zero mean and unit variance.

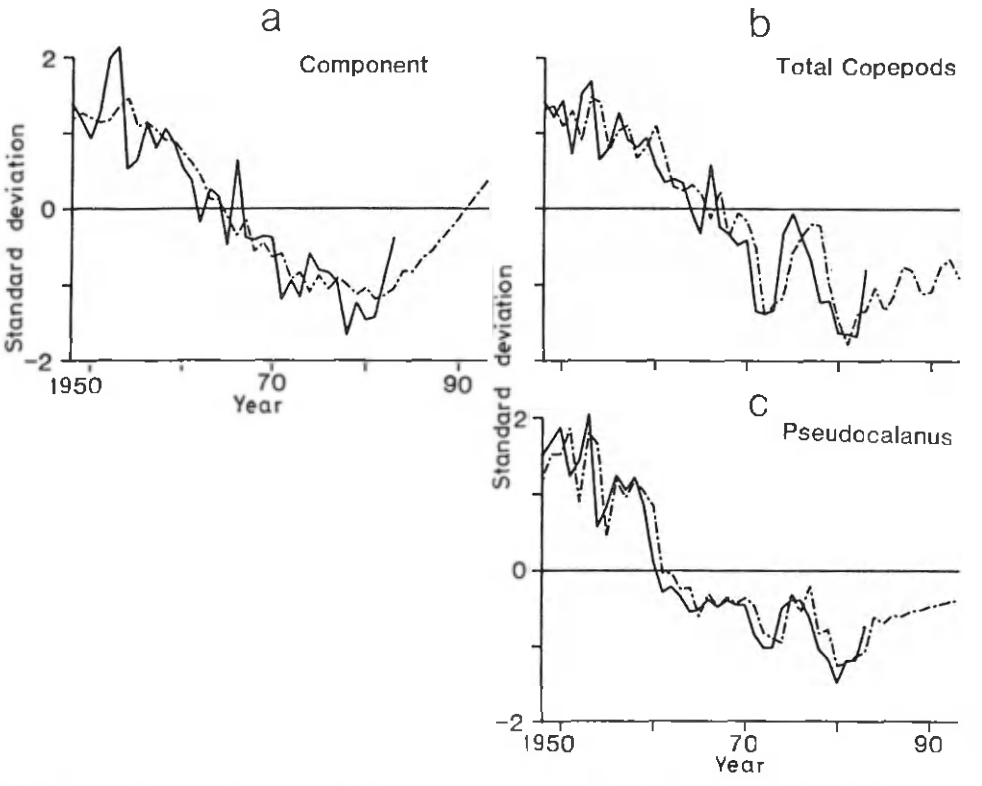

Figure 2. Graphs of first principal components with superimposed (dashed lines) ARMA models, including predicted values up to 1993. Graph a shows the overall zooplankton component also plotted in Figure 1. Graphs b and c are equivalent plots of the first principal components of the annual fluctuations in the abundance of total copepods and *Pseudocalanus elongatus* based on data for all the 12 areas in the chart in Figure 1. All the graphs are scaled to zero mean and unit variance.

elongatus in the North Sea where its numbers are down to only about 15 % of those of 30 years ago. Most of the other species show reductions of between a quarter to a half over the same period.

The data for 1983 have recently been added to the time series and, with these data, there is perhaps an indication of the beginnings of a reversal of the downward trend. For the first time there are signs of a consistent increase in abundance, from about 1980 onwards, affecting most of the areas and most of the species that had previously shown declining numbers. Figure 1 shows graphs of the first principal components, for zooplankton and phytoplankton, of the annual fluctuations in abundance of 48 species in 12 areas (chart in Fig. 1 b). Superimposed on the components in Figure 1 are fitted fifth-order polynomial curves. Both show an upward curl for the last few years. In the mid-1960s, there were also some indications of a reversal of the trend, as can be seen in the graph for zooplankton in Figure 1 a. On that occasion, however, the change tended to be limited to the open ocean areas and to fewer species; in the event, the downward trend continued for at least a further decade.

In Figure 2a the graph shows again the zooplankton component with a fitted (dashed line) autoregressive, moving average (ARMA) model, including predicted values up to 1993. This technique has not been applied before to the data from the Continuous Plankton Recorder survey and, by accepted standards, a series of 36 points is rather short for fitting ARMA models. However, models containing three autoregressive and two moving average elements were fitted successfully to principal components derived from the data for zooplankton for each of the 12 areas shown in Figure 1 in addition to the overall first component; data for *Pseudocalanus* and total copepods are also shown separately in Figure 2. The precise predicted values should not be taken too seriously. They do show, however, that given the structure of the time series of observations so far, as reflected in the fitted ARMA models, the numbers can be expected to increase over the next few years, indicating a possible reversal of the downward trend. It is obvious, however, that several more years of data will be needed to confirm this: the intention of this note is simply to draw attention, at an early stage, to the possibility that the 35-year long decline in the abundance of the plankton of the Northeast Atlantic and the North Sea may be coming to an end.

A recent study (Colebrook, in press) has suggested that the downward trend in the plankton has its origins

in some influence, as yet unidentified, on the overwintering stocks. Our knowledge of the biology of overwintering of plankton is scanty and the fact that so far the signal has been a more or less straight line has not helped in the identification of possible forcing factors. A reversal of the trend can only simplify this task.

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