ICES Journal of Marine Science, 53, 1113–1119. 1996

Variation in the abundance of southern fish species in the southern North Sea in relation to hydrography and wind

A. Corten and G. van de Kamp

Corten, A., and van de Kamp, G. 1996. Variation in the abundance of southern fish species in the southern North Sea in relation to hydrography and wind. – ICES Journal of Marine Science, 53: 1113–1119.

Is the increased abundance of southern fish species in the southern North Sea during recent years a signal of a long-term trend, or can it be explained by random variability? Time-series data on the abundance of 12 southern fish species were derived from the 1st quarter International Bottom Trawling Surveys 1970–1994. Two periods of increased abundance were identified, one in the mid-1970s and one around 1990. Both periods coincided with positive anomalies of winter temperature and salinity. These anomalies in turn are correlated with the southerly wind component over The Netherlands, suggesting increased inflow of Atlantic Water through the Strait of Dover. The conclusion is that the increased abundance does not reflect a long-term trend, but is the effect of temporary increases in southerly winds over the southern North Sea, resulting in increased transport of southern fish species into the North Sea, and favourable temperature conditions during winter.

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Key words: hydrography, North Sea, southern fish, wind.

A. Corten and G. van de Kamp, Netherlands Institute for Fisheries Research (RIVO), PO Box 68, 1970 AB IJmuiden, The Netherlands.

Introduction

The southern North Sea is a transition area between the relatively warm and saline water of the English Channel and colder and less saline waters of the central North Sea. This transitional hydrographic character is reflected in the faunal composition, which contains both boreal and Lusitanian elements. Results from bottom-trawl surveys in the southern North Sea, reported in this note, indicate increased numbers of southern fish species in the late 1980s and early 1990s. This raised the question whether the higher abundance of these species was related to changes in hydrography, and, if so, whether these changes were signals of a long-term trend.

The temporary occurrence of southern fish species is not a new phenomenon in the area. Aurich (1953) and Postuma (1978) described episodes of increased abundance of anchovy (*Engraulis encrasicolus*) and pilchard (*Sardina pilchardus*) during the period 1948–1952 and 1958–1960. Aurich (1953) postulated that the increase reflected enhanced seasonal migration from the English Channel into the North Sea caused by climatic warming.

This note describes changes in abundance of southern fish species in the southern North Sea during 1970–1994. These changes are compared with hydrographic time-series data to see whether these can explain the observed ecological changes.

Abundance of southern fish species

Data on the abundance of southern fish species were derived from the International Bottom Trawl Survey (IBTS) programme. These surveys monitor abundance of both commercial and non-commercial fish species and have been conducted annually in February since 1965. Typical southern fish species were identified on the basis of data on winter and summer distribution (1985–1987), presented in the *Atlas of North Sea Fishes* (Knijn *et al.*, 1993). Fish species were classified as "southern" if they satisfied one or both of the following criteria: (1) abundance during summer higher than during winter, indicating seasonal migration from the English Channel into the southern North Sea; and (2) distribution restricted to the southern North Sea, indicating a preference for relatively high temperatures.

Southern fish species thus identified were: *Sardina pilchardus*, *Trachurus trachurus*, *Mullus surmuletus*, *Echiichthys vipera*, *Scomber scombrus*, *Trigla lucerna*, *Engraulis encrasicolus*, *Trisopterus luscus*, *Trisopterus minutus*, *Zeus faber*, *Dicentrarchus labrax*, and *Spondyliosoma cantharus*. Catch data referring to roundfish sampling in areas 5 and 6 were extracted from the IBTS database. These subareas cover the entire southern North Sea (cf. Fig. 1).

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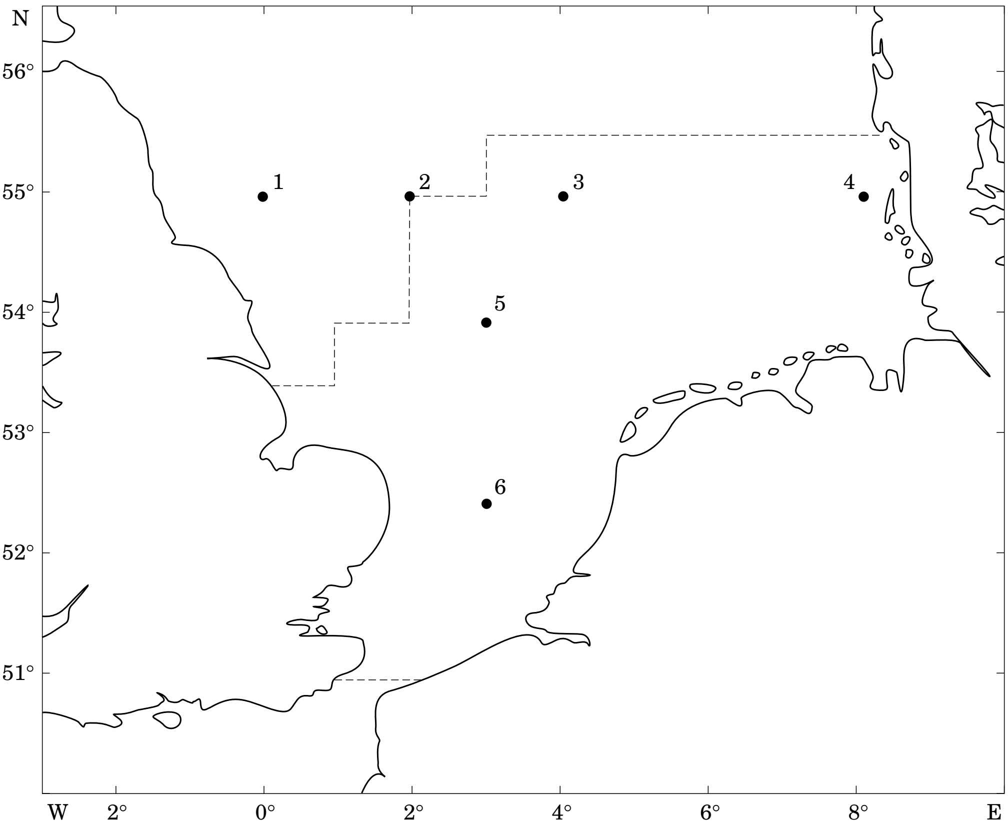

Figure 1. Area (corresponding to ICES Roundfish Areas 5 and 6) for which bottom trawl catches were included in the analysis and ICES standard hydrographic positions.

Histograms of the average catch rates of individual species during winter (Fig. 2) indicate similarities in the patterns observed over the entire time series, although there are pronounced differences between species. Most species were relatively abundant in the mid-1970s, in the early 1990s, or during both periods. In-between, there has been a long episode of relatively low abundance of all species (Fig. 3).

Temperature and salinity

Hydrographic data have been routinely collected during the annual IBTS cruises in February in conjunction with each trawl station. Each year, the ICES Hydrographic Service prepared maps of temperature and salinity as observed during the survey. In order to compare hydrographic conditions between years, reference points have been defined for which temperature and salinity are estimated by spatial interpolation from the distribution charts. Six of these (Fig. 1) were considered appropriate for describing the hydrographic conditions in the southern North Sea.

Temperature anomalies for February were calculated for each position, and these were then averaged to provide an annual index for the southern North Sea (Fig. 4). Two periods of elevated temperatures emerge: 1973–1975 and 1988–1994. The highest positive anomalies were found in 1990, followed by a decline in later years. In-between, there has been a long period of negative anomalies, with minima in 1979 and 1986.

Salinity data were processed in the same way as temperature data. The picture obtained for the average annual salinity anomalies (Fig. 5) strongly resembles the temperature graph. Positive anomalies were found in 1972–1975 and 1989–1993, whereas salinity, with a few exceptions, was below average in the intervening period.

The close relationship between salinity and temperature in the southern North Sea suggests that both parameters reflect the inflow of relatively warm and saline Atlantic Water through the Straits of Dover (Fig. 6). Thus, the hydrographic data indicate that the Atlantic inflow during winter has been relatively strong in 1972–1976 and 1989–1993.

Temperature and salinity are of course influenced by other factors as well. Salinity may be affected by evaporation, precipitation, and river run-off, and temperature will be influenced by heat exchange with the

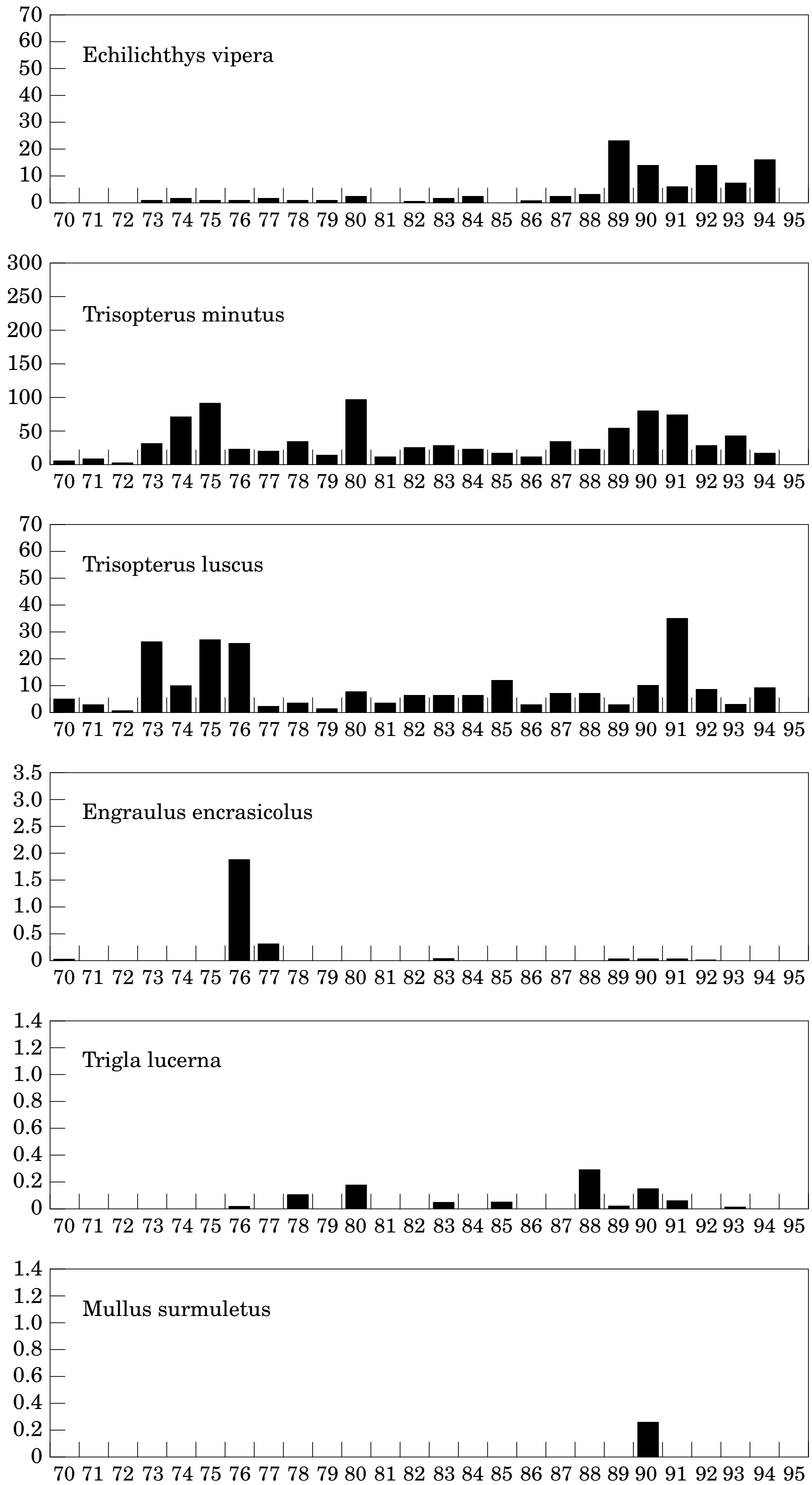

Figure 2. Average abundance of 12 southern fish species (numbers per hour fishing) in the southern North Sea during the first quarter IBTS.

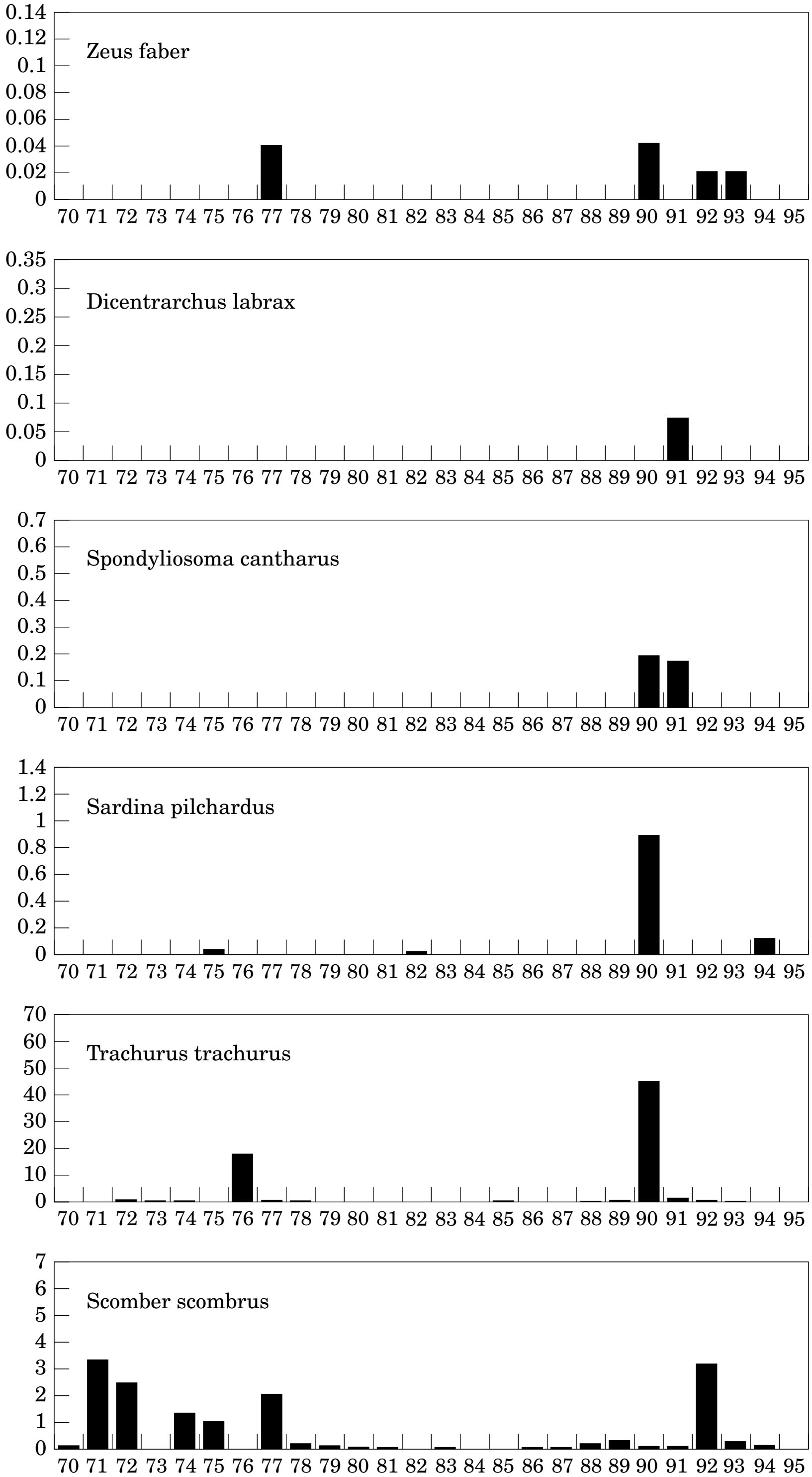

Figure 2. *Continued.*

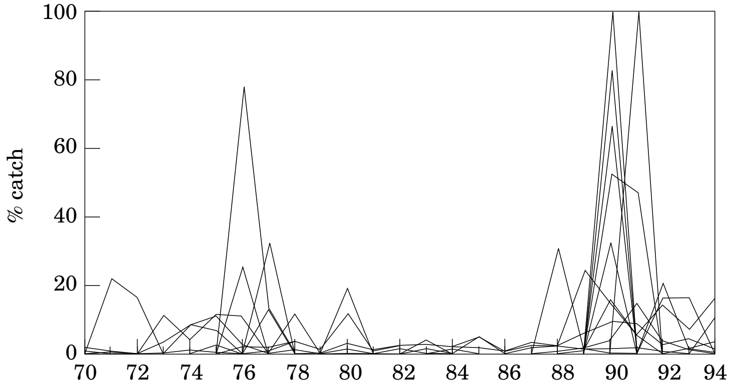

Figure 3. Indices of annual abundance of 13 southern fish species, expressed as the percentage contribution of the catch rate of each species in each year to the total sum of catch rates over all years.

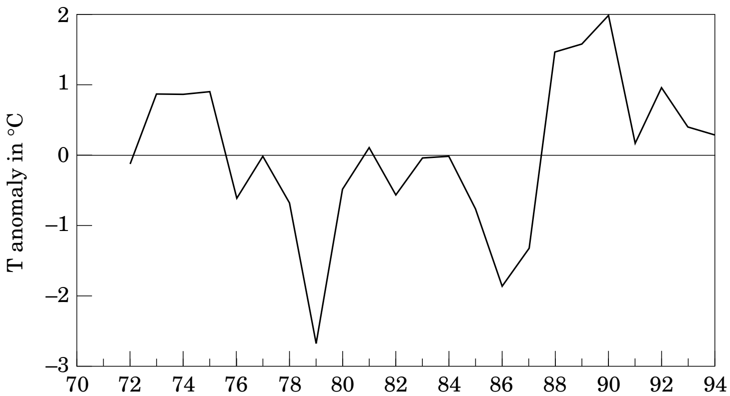

Figure 4. Average temperature anomalies in February for ICES Stations 1–6.

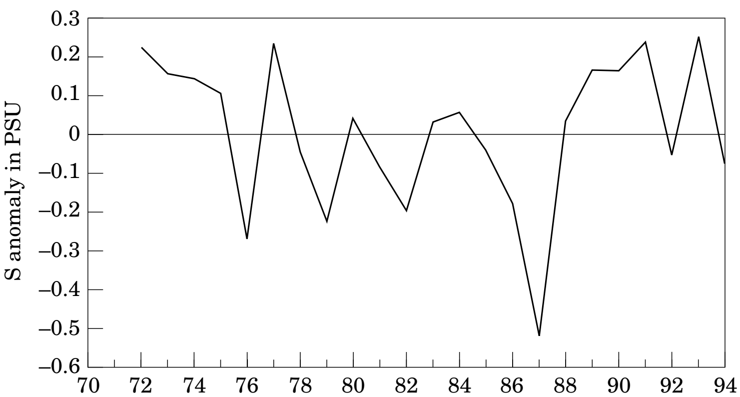

Figure 5. Average salinity anomalies in February for ICES Stations 1–6.

atmosphere. These factors may to some extent mask the effects of the Atlantic inflow.

Wind

The Atlantic inflow is driven partly by tidal forces and partly by windstress. Tidal forces will average out over one lunar cycle, which leaves windstress as the main cause of long-term variability. Salomon and Bretton (1993) showed that the rate of inflow through the Straits of Dover is mainly a function of the north/south component of the wind: southerly winds result in a maximum inflow and northern winds have the opposite effect.

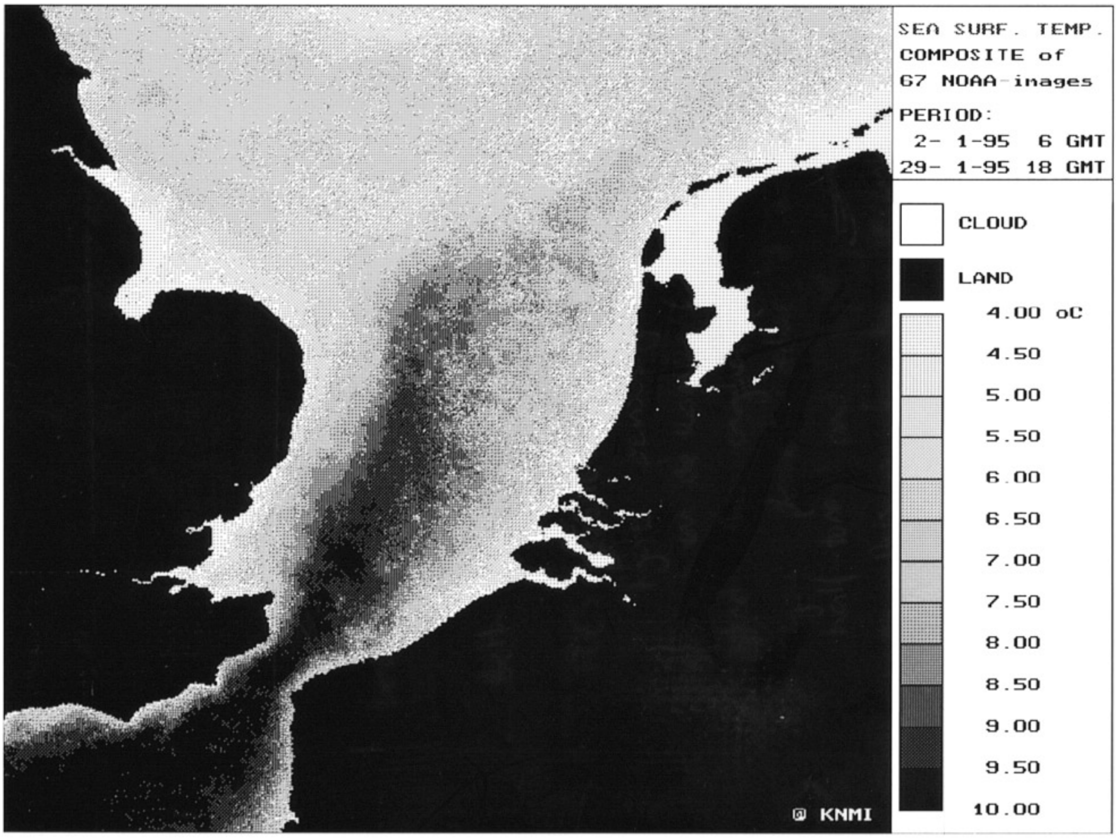

Figure 6. Infrared satellite photograph showing inflow of warm Atlantic Water into the southern North Sea in January 1995. Courtesy of Royal Netherlands Meteorological Institute (KNMI).

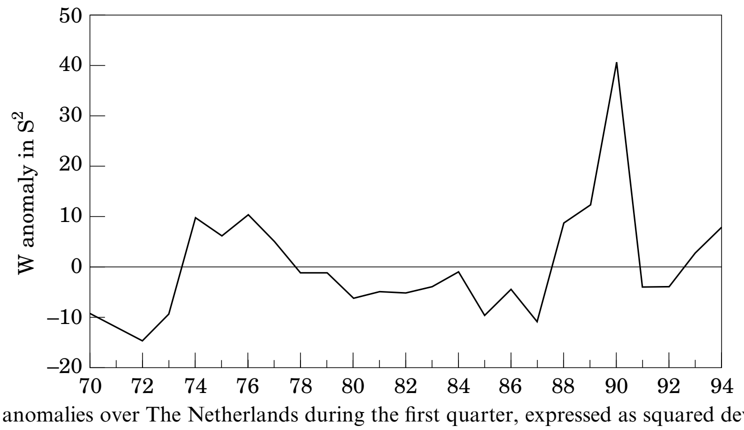

Figure 7. Average wind anomalies over The Netherlands during the first quarter, expressed as squared deviations of the southerly wind component.

In order to study wind-induced variations in Atlantic inflow, data on monthly wind speed over The Netherlands were analysed. The mean wind vector in each month was decomposed into a north/south and an east/west component, and the south component was squared to obtain an index of wind-induced inflow through the Straits of Dover. This simplified procedure ignores the effect of short-term variations in windstress, and assumes that wind conditions over The Netherlands are representative for those over the Channel area and southern North Sea. Moreover, effects of westerly winds on Atlantic inflow are ignored. Nevertheless, we expect that major trends in windspeed responsible for large-scale variations in water transport would be detected by this analysis.

Anomalies of southerly windstress during the 1st quarter were calculated by first taking the average of monthly values (January–March) of the squared southerly component of the wind (m/s), and then calculating the deviation from the mean over the period 1970–1994. Two periods of positive anomalies were identified (Fig. 7): one in 1974–1977 and a second one in 1988–1990. Apparently, years with strong southerly winds during winter roughly coincide with years of increased temperature and salinity.

Conclusions

The analysis of IBTS data and hydrographic data for the southern North Sea shows a relationship between abundance of southern fish species during the first quarter and temperature, salinity, and southerly winds during the same time of year. Therefore, abundance of southern fish species is likely to be affected by wind-induced variations in the inflow of Atlantic Water. An increased inflow during winter may benefit these species in a number of ways. Resident populations of southern species may sustain less mortality at a time when water temperatures reach their minimum. Migratory species may leave the North Sea later in the season, or even overwinter. Also, spawning success may be greater during prolonged periods of increased Atlantic inflow. Finally, vagrant species should have a greater chance of being transported by chance into the area.

Over the period 1970–1994, there have been two distinct periods of increased abundance of southern species during winter, separated by a long period of reduced abundance. Although the existence of a long-term climatic trend over the entire period cannot be ruled out on the basis of the present observations, such a trend is in any case masked by the observed medium-term variability.

Acknowledgements

Hydrographic data were kindly provided by the ICES Hydrographic Service for the years 1972–1994.

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