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Sea-surface Temperature Anomalies off the Northeastern U.S.A. During 1981-86

by

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Abstract

Monthly mean sea surface temperatures for 65 1° x 1° rectangular areas along the northeast coast of the U. S. were analyzed by a statistical clustering method, and the 65 areas were grouped into 5 "climatic regions". Averages, by region, for the 6-year period 1981-1986 were compared to 30-year averages for 1951-1980, and trends were computed from the resulting anomalies. Statistically significant positive trends for the 1980's were found in 4 of the 5 regions. Absence of trend in the 5th region (Gulf of Maine) was associated with a virtual absence of negative anomalies in the 1980's and a 6-year average anomaly of +0.92°C.

Introduction

Measurements of water temperature at or near the sea surface have been widely used by fishery biologists in studies of the distribution and abundance of commercial fish species. In recent years, the commercial fishing industry has adopted the practice of monitoring sea surface temperature as a means for locating the best fishing areas and for improving catch rates. If the condition of commercial fish stocks in the 1980's has been affected by changes in climatic patterns, what is the nature of these climatic changes as expressed in the patterns of sea surface temperature? Certainly, changes in fish distribution or abundance may be related to shifts or trends in climatic patterns and more directly related to changes occurring in the ocean

Data Sources and Methods

The National Climatic Data Center (NCDC)/NOAA regularly collects weather and oceanographic information from ships at sea and fixed weather buoys. Compilations of these data are made available to the public by the NCDC. The

data are catalogued by 1° latitude X 1° longitude areas by month, and include information on routinely observed parameters such as sea surface temperatures, winds, wave height and cloud cover. In addition to the collected values, continuously updated summaries of long-term monthly means, standard deviations and short-term departures from the mean are available for each parameter in the data base. A summary of these data was recently acquired which includes calculated monthly means and anomalies for 65 1° X 1° areas along the northeast coast of the U. S., extending from Cape Hatteras, NC to Cape Sable, Nova Scotia (Figure 1), and covering the time period 1946-1986. Monthly mean values for sea surface temperature, from January 1951 to December 1980 were extracted from the larger NCDC data set, so that a "30-year mean" could be computed for each month, for each 1° X 1° area.

Due to the size of the 30-year data set (over 23,000 values), a statistical clustering technique (Ward's minimum variance method, SAS Inst., 1985) was applied to the 30-year monthly mean values in an effort to combine the 65 areas into fewer, more manageable regions based on similarity of annual temperature cycles and temperature ranges. The new groupings could then be considered "climatic regions" with respect to their sea surface temperature patterns. The inflection point of the "pseudo-t^2" statistic, a common diagnostic in cluster anlysis, was used to help determine the most significant "climatic regions" resulting from the clustering treatment. In this case, the pseudo-t^2 statistic was asymptotic as the eighth cluster was formed. Based on what is known about surface temperature cycles in this area, it was decided that the first five cluster generations provided an adequate distinction between regions. The five clustered climatic regions (see Figure 1) were labelled: Sargasso Sea Region (SSR); Gulf Stream Region (GSR); Southern Bight Region (SBR); Southern New England (SNE) and Gulf of Maine (GOM). Within the climatic regions, the 30-year values for each month, for each 1° area were averaged to produce the 30-year monthly means, and the mean annual sea surface temperature cycle (Figure 2).

For the sea surface temperature data of the 1981-1986 period, individual monthly values were assigned to the previously determined clustered regions and regional monthly means were calculated in the same manner as above. Subtracting the 30-year monthly mean temperature from each regional monthly value for the 1980's produced an estimate of the departure (monthly anomaly) from the expected sea surface temperature in each climatic region. A 6-year trend for each region was obtained by regressing the time-ordered monthly

anomalies on the months (1 through 72) in the period. Hypothesis tests of whether the slopes of regional trends were significantly different from zero (Neter et al., 1983), were controlled at the .05 level.

Finally, estimates of the average yearly anomaly and 6-year anomaly in the 1980's were calculated.

Results

A plot of mean annual sea surface temperature cycles (Figure 2), based on the cluster analysis and the 1951-1980 monthly means, indicates clearly that all five regions follow nearly identical cycles, but are separate and distinct by way of the ranges and magnitudes of sea surface temperature throughout the year. It can also be noted that the timing of regional minima and maxima occur at about the same time.

Plots of monthly anomalies (Figure 3) indicate a distinctly greater frequency of higher-than-normal temperatures (positive anomalies) in the 1980's, in all except the Sargasso Sea Region, where the average anomaly for the six years was slightly negative (see Table 1). Calculated trends for the regional anomaly patterns (Table 1.), yielded positive slope values which were statistically significant in all regions except the Gulf of Maine. In this latter region, the lack of trend was due to the fact that only four of the seventy-two months exhibited lower than normal temperatures, though the possibility remains that what is seen here is part of a slowly rising trend which began before 1980. This idea is supported by reports on Gulf of Maine temperatures for the previous decade (Mountain, 1982; Trites, 1982).

It should also be noted that the positive trends in two of the shelf water and the Gulf Stream regions (SNE, SBR and GSR) are driven principally by the occurrence of two consecutive cool years early in the 6-year period (1981-1982) and three consecutive warm years (1984-1986) during the latter part of the period, though between regions, there is a difference in timing of the transition from very cool to very warm conditins of about one year.

Comparison of the Southern Bight Region (SBR) and Gulf Stream Region (GSR) shows very similar anomaly patterns, suggesting a strong influence on the southern shelf waters by the higher energy Gulf Stream system. The Southern New England (SNE) anomaly field is also similar in pattern to the GSR and SBR patterns, though the magnitudes of anomalies are reduced from those co-occurring in the southern regions. A very distinct pattern is seen in the Gulf of Maine (GUM) anomaly field which indicates persistence of warmer than normal conditions throughout the 6-year period.

References

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Table 1. Annual and six year averages of sea surface temperature anomalies (°C) and slopes of computed anomaly trends for 1981-1986 for the climatic regions in Figure 1.

Year	SSR	GSR	SBR	SNE	GOM
1981	−0.30	−0.39	−0.20	−0.61	0.63
1982	−0.39	−0.74	0.01	−0.31	0.58
1983	−0.27	0.11	0.46	0.68	1.53
1984	−0.08	0.84	0.65	1.14	1.06
1985	0.22	1.82	1.60	1.00	0.81
1986	0.46	0.96	1.05	0.39	0.92
6-Year Anom.	−0.06	0.43	0.60	0.38	0.92
°C/Yr. Trend	0.168	0.408	0.276	0.252	0.048

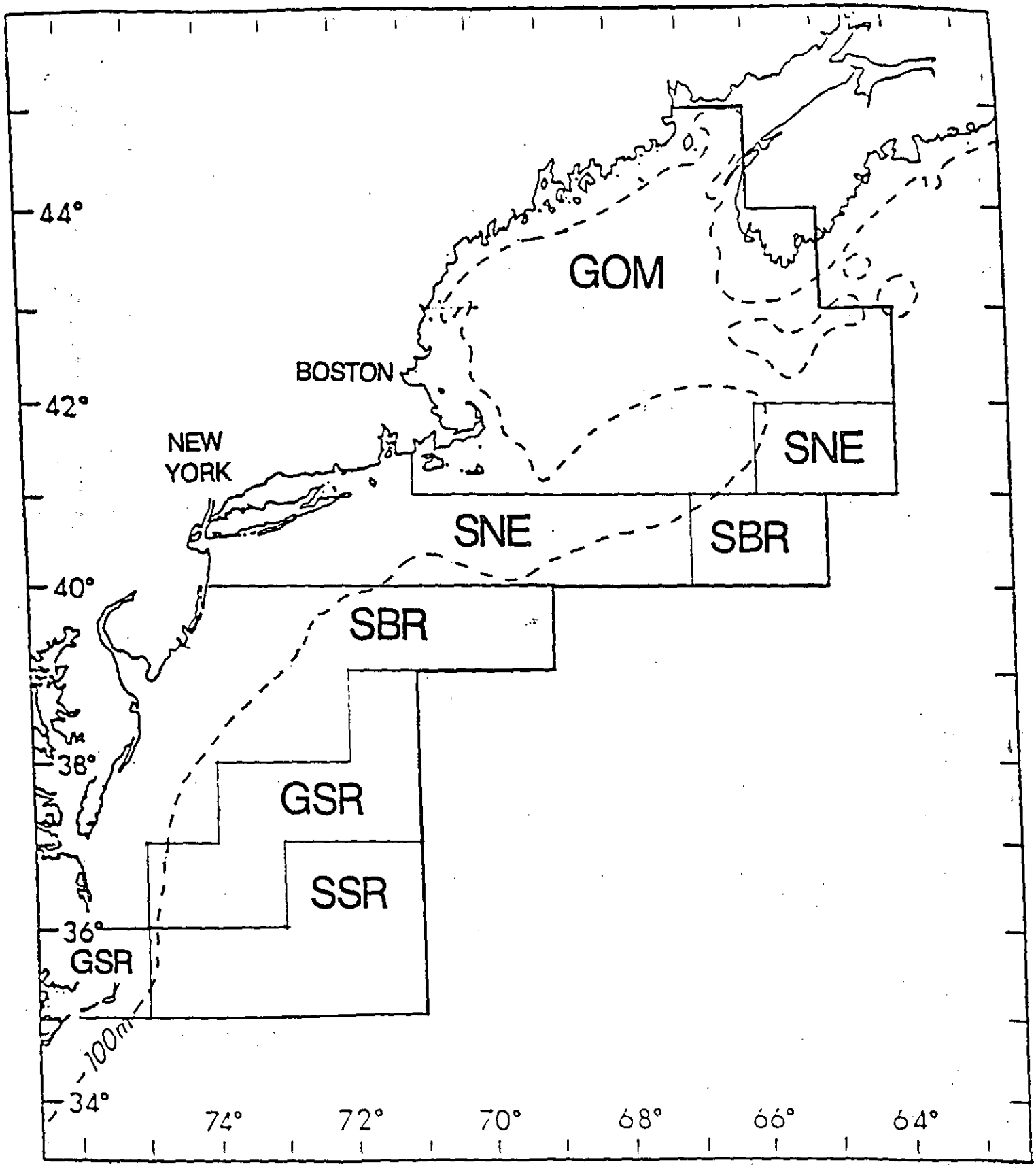

Figure 1. Area chart showing the seaward boundary (bold line) of the 1° latitude X 1° longitude squares for which sea surface temperature monthly means were analyzed, and the divisions into climatic regions by Ward's minimum variance method. Legend: **GOM**, Gulf of Maine; **SNE**, Southern New England; **SBR**, Southern Bight Region; **GSR**, Gulf Stream Region; **SSR**, Sargasso Sea Region.

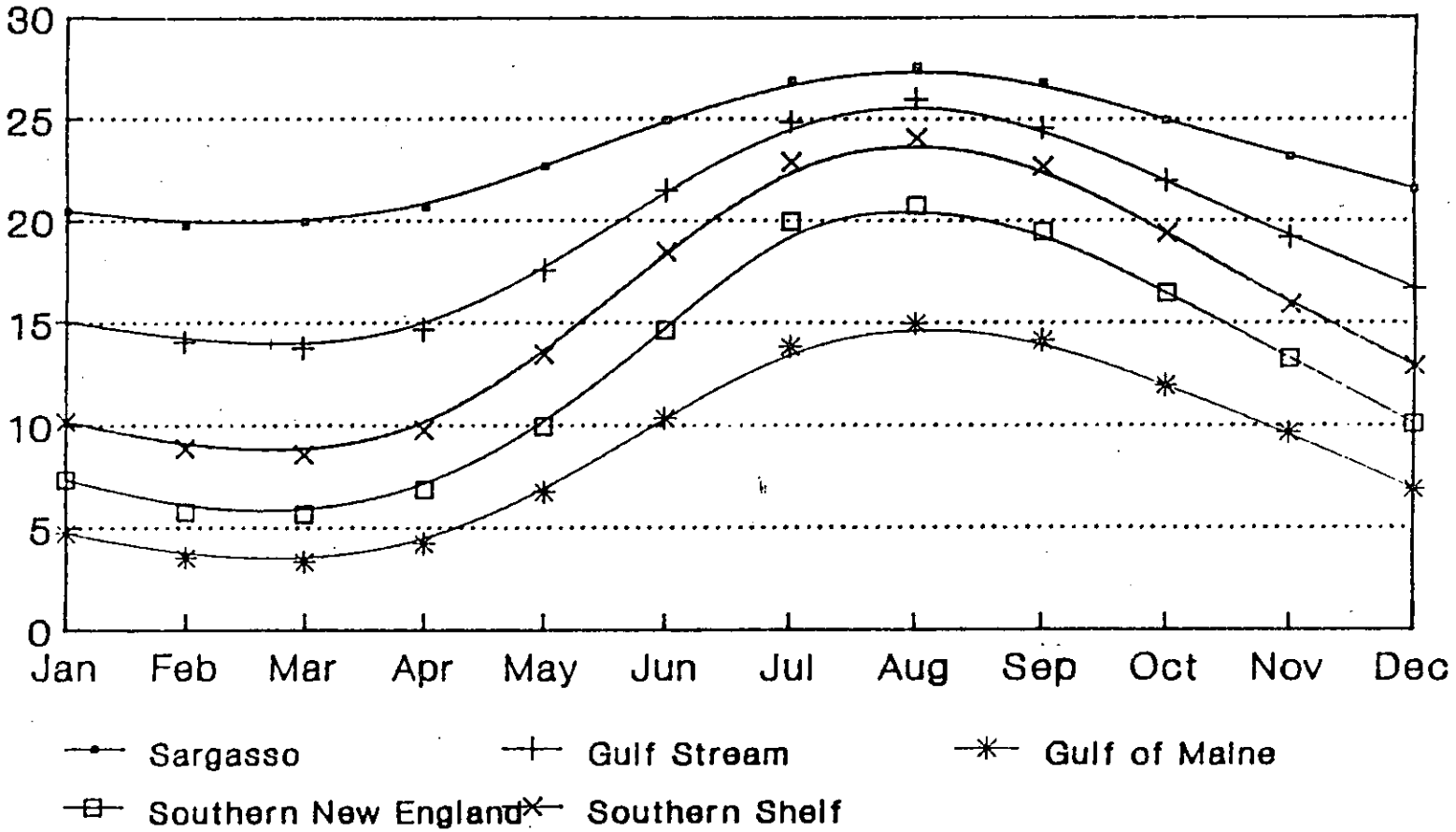

Figure 2. Mean annual sea surface temperature cycles, based on averages for each month over the period 1951-1980, and computed for each of the clustered climatic regions indicated in Figure 1.

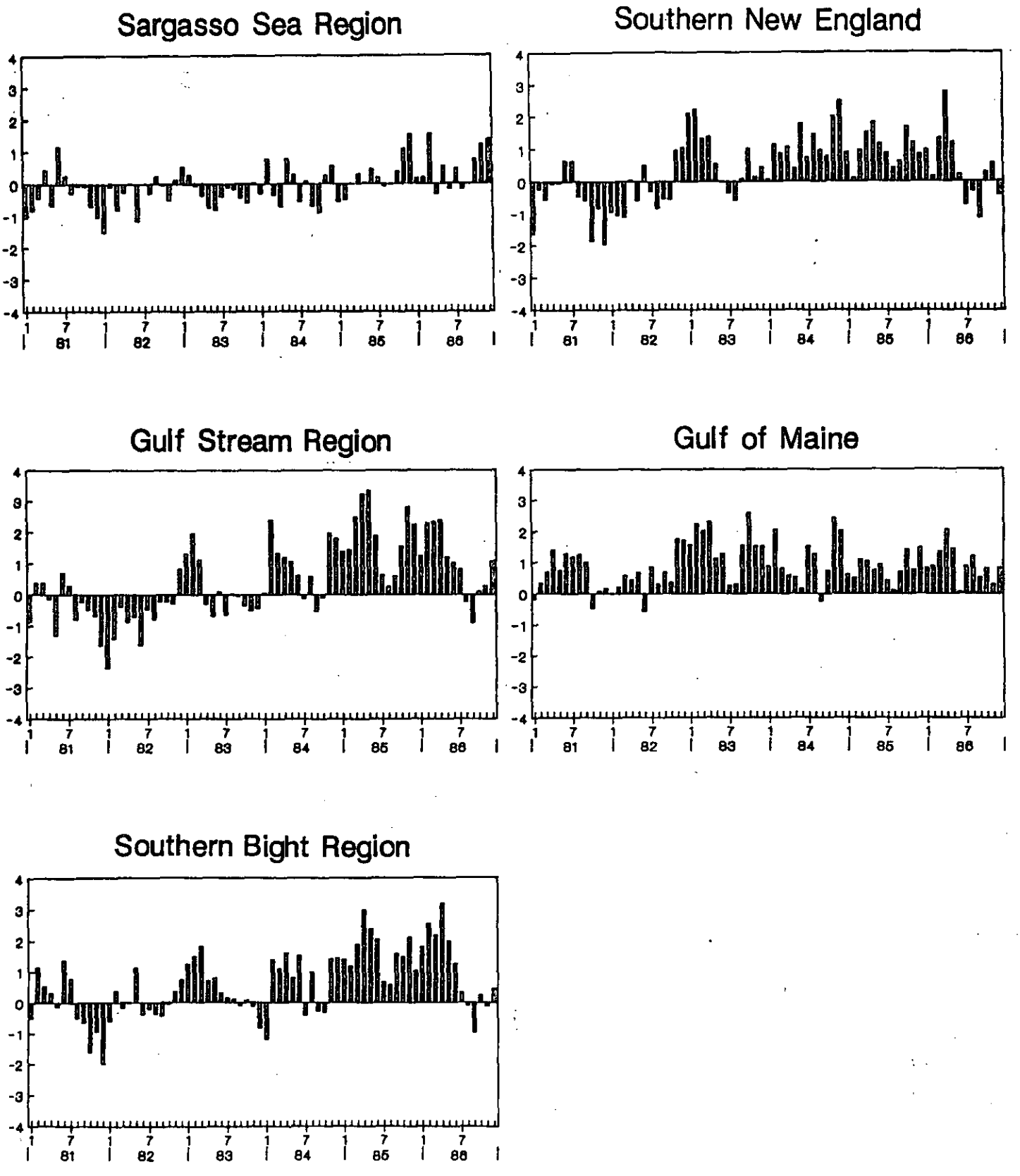

Figure 3. Monthly anomalies (°C) of sea surface temperature for 1981-1986, for each clustered climatic region. Anomalies are calculated as departures from 30-year (1951-1980) monthly means, with positive values warmer than the 30-year means.