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Sea-surface Temperatures Along the Continental Shelf from Cape Hatteras to Hamilton Bank

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Abstract

The monthly pattern of sea-surface temperatures along the continental shelf from Cape Hatteras to southern Labrador for the 1971-83 period is described. Monthly anomalies of above or below "normal" temperatures often extend over a large area and may persist for several months. Also, there is some indication that temperature anomalies in the region from the Gulf of Maine northward is out of phase with those to the south.

Introduction

The water temperature at a given coastal site is the result of both local processes (heat exchange across the sea surface and mixing) and advection which operate on a range of geographic scales. For a given month (or even a year), temperature anomalies between sampling sites, which are only a few tens of kilometers apart, may be of different magnitude and sign (Akenhead *et al.*, 1981). However, the mean anomalies generally become comparable when they are averaged over several years. Despite the relatively high variability in small-scale processes, there is increasing evidence that large-scale processes are operating over distances of perhaps several thousand kilometers that can produce coherent temperature shifts (Trites, 1982; Trites and Drinkwater, 1984; Loucks and Trites, MS 1984).

The large data base of sea-surface temperatures, derived principally from weather messages radioed from merchant ships to the U.S. Fleet Numerical Oceanography Center (FNOC), Monterey, California, is routinely analyzed by month and 1° quadrangles for the Northwest Atlantic (e.g. see McLain and Ingham, MS 1984). Such analyses show areas and times when major anomalies are present. However, the small-scale spatial and temporal variability, combined with limited data for single 1° quadrangles, often makes it difficult to identify large-scale shifts and differences. To examine the hypothesis that major variation in shelf-water temperatures are coherent over areas much larger than 1° quadrangles and that the waters of neighboring areas along the continental shelf are generally linked advectively, the sea-surface temperatures were grouped into a set of contiguous areas for a strip of the continental shelf off northeastern United States and eastern Canada (Fig. 1).

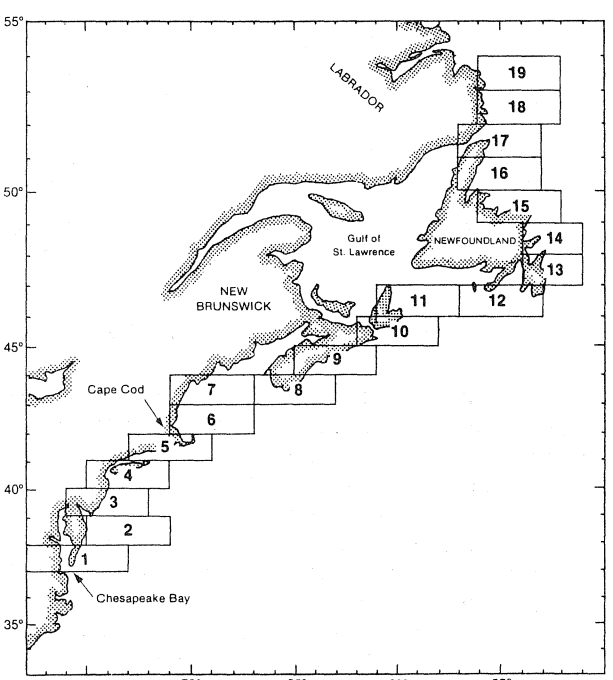

Fig. 1. Locations of 19 areas in the Northwest Atlantic (Chesapeake Bay to southern Labrador) for which sea-surface temperature data were grouped for analysis.

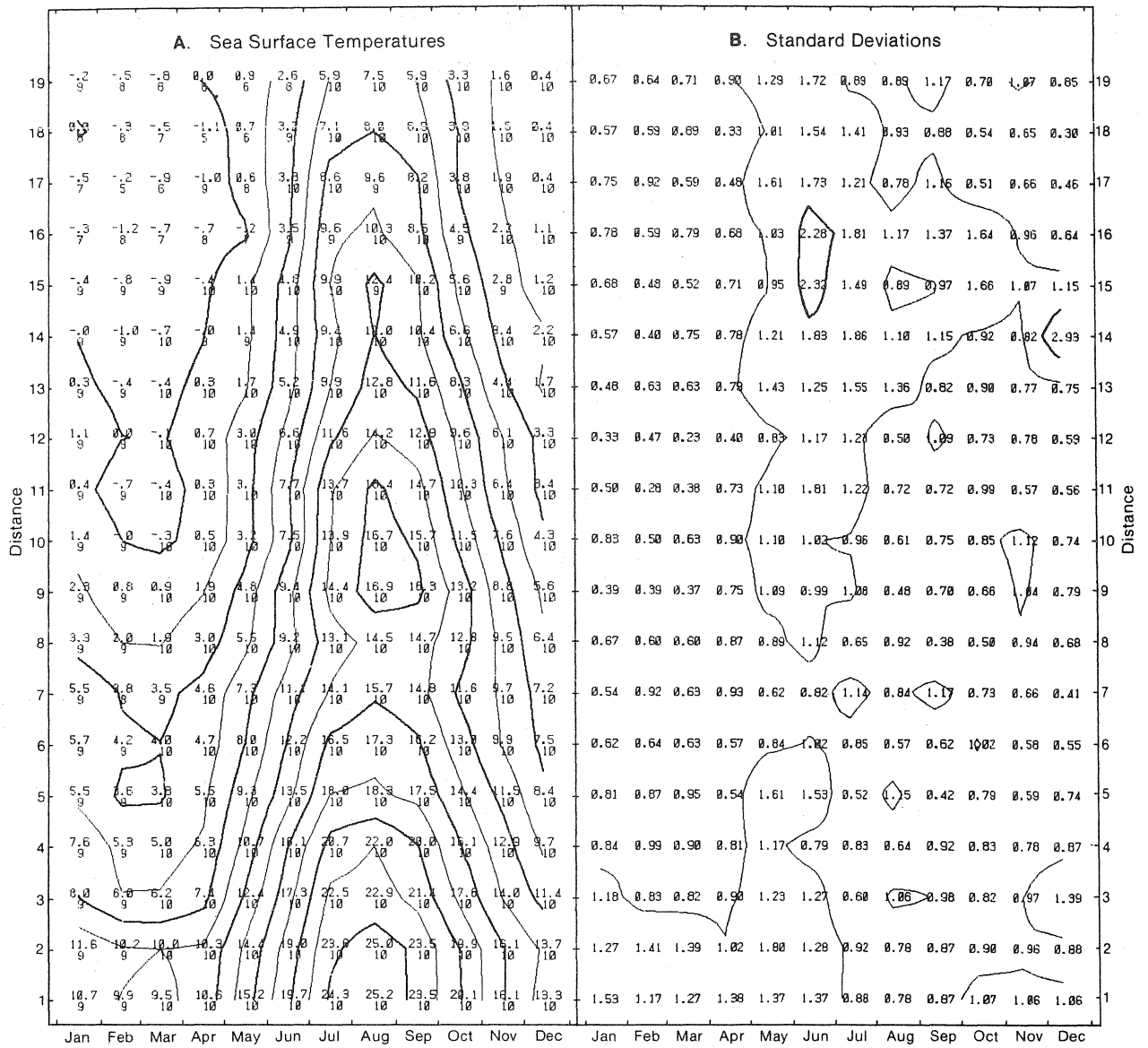

Fig. 2. Contoured plots of (**A**) average monthly sea-surface temperatures (° C) and (**B**) their standard deviations, in the 1971-80 base period for the 19 coastal areas illustrated in Fig. 1. (Number of years of available data is given below each temperature value.)

Data Grouping and Analysis

The continental shelf region from Chesapeake Bay to southern Labrador was divided into 19 areas, each consisting of at least three (usually four) 1° quadrangles contiguous with each other in an east-west direction (Fig. 1). All sea-surface temperature data for the period from March 1971 to December 1983 were used in the analysis. Monthly averages were computed for each area. In accordance with the NAFO recommendation (NAFO, 1983), data for the 10-year base period (March 1971-December 1980) were used to establish the average monthly temperatures ("normals") and their standard deviations.

Results and Discussion

The space-time plot of the average monthly temperatures for the 1971-80 base period (Fig. 2A) displays the general cycle of heating and cooling for the entire region. The plot of the corresponding deviations (Fig. 2B) shows the maxima generally in the May-June period throughout the region with the largest values off northeastern Newfoundland (areas 15 and 16). The smallest seasonal variation in the standard deviations is the Gulf of Maine and may be related to the greater tidal mixing there than in other areas. Spatially, it is not immediately obvious why the standard deviations should be highest in the more northerly

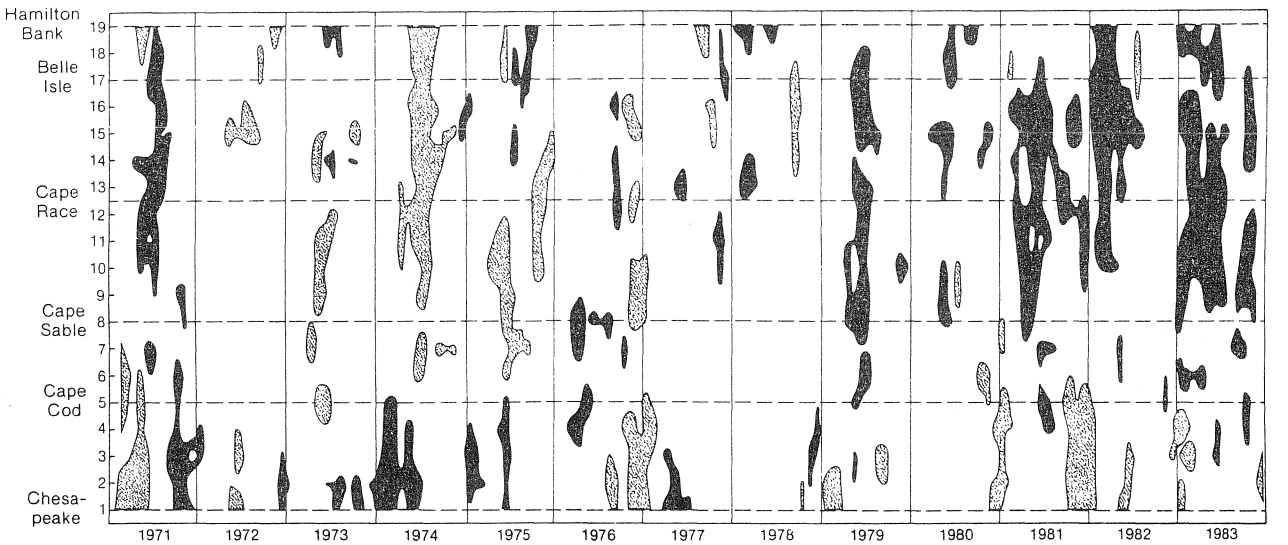

Fig. 3. Contoured plot of monthly sea-surface temperature anomalies (relative to the 1971-80 base period) by area for the 1971-83 period. (Only anomalies exceeding 1° C (dark) and less than -1° C (light) which extended in space through at least two neighboring areas or in time for at least two consecutive months have been contoured.)

areas. Temporally, it is reasonable to expect that variability will be highest during the heating season due to the stratifying effect on the water column. For example, under light wind conditions and a clear sky in June or July, sea-surface temperatures may temporarily increase by a much as 1° to 2° C from one day to the next.

In order to simplify the presentation of monthly sea-surface temperature anomalies for 1971-83, relative to the 1971-80 base period, only anomalies with values less than -1° C and in excess of 1° C and which occurred in at least two adjacent time or space steps were contoured (Fig. 3). The anomalies tend to be coherent over large space scales and often for several months at a time. In 1971, temperatures in a large area from southern Labrador to the northeastern Scotian Shelf were higher than normal (by about one standard deviation) during late spring and early summer. Temperatures were near-normal during most of 1972 and 1973, but, in 1974, the entire region from Hamilton Bank to the Gulf of Maine had below-normal temperatures in late spring and early summer, with July temperatures being nearly 3° C below normal in areas 11-16 (Laurentian Channel to northeastern Newfoundland). Temperatures in the region south of Cape Cod (area 5) were above normal during January-June 1974 and near-normal for the remainder of the year. The general pattern of cold in the north and warm in the south continued in 1975. Except for below-normal conditions in the winter of 1976/77, particularly in the Cape Cod-Chesapeake Bay areas, 1976-78 appeared to be near-normal transition years. The trend to above-normal temperature in the spring and summer months in the north appeared to be well-established in 1979, and this pattern continued in 1980-83, with anomalies exceeding 3° C in some months and areas.

Evidence of large-scale events, with a time scale of several years and with opposite phase to the north and south of the Gulf of Maine-Georges Bank region (areas 6 and 7), as noted previously by Trites and Drinkwater (1984), is apparent in the temperature-anomaly pattern of Fig. 3. Work has recently commenced, with the use of empirical orthogonal functions (EOF), to study the major features of the sea-surface temperature patterns and their relationship to large-scale meteorological variations (Loucks and Trites, MS 1984).

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