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Variation in the Shelf Water Front Position in 1989 from Georges Bank to Cape Hatteras

by

Glenn A. Strout

Physical Oceanography Br., Northeast Fisheries Center
NMFS/NOAA, 28 Tarzwell Dr., Narragansett, RI 02992

Abstract

Examination of variations during 1989 in the offshore boundary of shelf water off the northeastern United States coast continued for the sixteenth year, based on weekly measurements of the surface position of the shelf water front along nine bearing lines between eastern Georges Bank and Cape Hatteras. The frontal positions are derived from analyses of sea surface temperature patterns from satellite infrared data. Summaries of the weekly positions are presented for four of the bearing lines and compared to ten-year (1974-1983) monthly mean positions. Also described are the annual mean positions and variability for 1989, which are compared to the ten-year averaged results.

During 1989, frontal position patterns were similar to the long-term mean patterns, but seemed to be punctuated by short-term, large-magnitude variations associated with the passage of warm core rings. Average positions for the year were closely associated with the ten-year mean values, and variability during 1989 was about the same, or greater than the ten-year means.

Introduction

The shelf water front along eastern North America is delineated by the narrow gradient zone between cooler, less saline shelf water and the warmer, more saline slope water that lies offshore. The surface position of the shelf water front can usually be determined from thermal infrared data such as is available from Advanced Very High Resolution Radiometers (AVHRR)

on NOAA polar-orbiting satellites. For this study digital data with approximately one kilometer resolution were collected from satellite passes over the waters off eastern North America and were atmospherically and geometrically corrected and enhanced to identify ocean surface thermal features, using the facilities of the Oceanographic Remote Sensing Laboratory, University of Rhode Island. Oceanographic Analysis charts, prepared by the NOAA National Ocean Service from interpretations of satellite data, were also used in locating the shelf water front, following the method described by Gunn (1979).

Methods

Distances from the coast to the front were measured along nine bearing lines from Cape Hatteras to eastern Georges Bank (Fig. 1). In general, the front is bound to the shelf break, consequently the distances along bearing lines were reduced to give departures of the front from the 200-m isobath (the shelf break). A single position of the front along each bearing line was selected each week as representative of the shelf front location for the week. During 1989, frontal positions could be ascertained along the bearing lines in about 82% of the weekly observations. Omissions occurred because of cloud cover or because of the lack of thermal contrast in the satellite imagery.

Four representative bearing lines: Casco Bay (120°), Nantucket Island (180°), Sandy Hook (130°), and Albemarle Sound (90°) have been selected to show the fluctuations of the frontal position during 1989 (Fig. 2). Long-term mean positions for the ten years, 1974-1983, serve as a base for comparison with 1989 values. Major displacements in the front often correspond to the passage of anticyclonic warm core rings. Names and paths of rings used in this report are from the analyses of Sano and Wood (MS 1990).

Results

Casco Bay (120°): The ten-year mean positions (1974-1983) remain consistently offshore of the 200-m isobath, and show large

variability in most months. A seasonal pattern in the frontal position is not apparent, although the front tends to be more offshore during the winter and spring months and shoreward in the fall. The most offshore location occurs in January and most shoreward position in October. The January and October mean positions also exhibit the least variability.

In 1989, the shelf water front was located near the ten-year mean positions with several notable exceptions. From January to mid-February, as warm core ring 88-L crossed the bearing line close to the shelf, the frontal position was near the 200-m isobath. This was approximately 100 km shoreward of the ten-year mean positions for the same period. Afterward, the front remained near the average position until June when it fluctuated sharply, first shoreward (to its yearly minimum about 50 km shoreward of the 200-m isobath) then seaward to more than 300 km offshore of the 200-m isobath. Associated with this sharp change was the development of warm core ring 89-B along the bearing line. The front reached its seaward maximum for the year (more than 350 km seaward of the 200-m isobath) in the wake of warm core ring 89-E in mid-August. In September, the front was near the ten-year mean position, but from October to mid-December the front was about 100 km shoreward of average, and was about 25 km shoreward of the 200-m isobath from mid-October through early November.

Nantucket Island (180°): The long-term mean positions exhibit a distinct annual cycle, with the front located near the 200-m isobath from June through November, and offshore of the shelf break for the other half of the year. The front is at the most offshore position in April and the extreme onshore position occurs in October. Variability is about half as large as on Casco Bay (120°), with the largest variability in April.

Frontal positions in 1989 were generally near the shelf break. Early in the year, behind ring 88-K, the front was located seaward of the ten-year mean positions. It then remained near the 200-m isobath, shoreward of the ten-year averages from late February through May. In June the front shifted offshore to its

yearly seaward maximum (approximately 230 km beyond the shelf break) following the passage of ring 88-L. The front was near average in position, and generally seaward of the 200-m isobath from late June until mid-August. Except for one week in September the front was shoreward of the shelf break into November, about the same period that it took warm core ring 89-G to move across the bearing line. The front reached its yearly shoreward extreme, about 80 km shoreward of the shelf break, during this period. The last recorded frontal positions, from the end of October to the end of December, were near the ten-year average.

Sandy Hook (130°): The 1974-1983 monthly mean positions indicate that the shelf water front remains near the 200-m isobath from July through March and is more offshore during April through June. The most shoreward positions are in October and February, and the most offshore location of the front is in May. Variability is of similar magnitude to that of the Nantucket Island (180°) line, with maximum variability in May and July and minimum values in October and November.

During 1989, the frontal positions were generally near the average positions. The front was at the yearly minimum in the middle of January, approximately 50 km shoreward of the shelf break. In February the front moved seaward to about 75 km seaward of the shelf break, though no rings or meanders were present along the bearing line at that time. The front remained close to the 200-m isobath from March until July, when it shifted seaward to its yearly maximum, roughly 200 km from the shelf break. This corresponded with the reabsorbtion of warm core ring 88-L near the bearing line. The remainder of the year was characterized by normal conditions.

Albemarle Sound (90°): On this bearing line, near Cape Hatteras, the long-term monthly mean positions of the shelf water front show a regular annual cycle fluctuating offshore and onshore of the 200-m isobath. From January to March the front is located about 20 km shoreward of the shelf break, during April the front shifts offshore until it is about 15-20 km seaward of the shelf

break for May through September. In October through December, the front shifts shoreward and it is located near the shelf break. Maximum variability for the ten-year record occurs in August and the minimum is in February.

Frontal positions in 1989 tended to follow the ten-year mean annual cycle, but with distinct seaward departures in March, June, August and September, associated with the absence of slope water along the bearing line. During these periods when slope water was absent, shelf water extended to the edge of the Gulf Stream. The front was at its most shoreward position of the year (75 km shoreward of the shelf break) in early August, and was at its seaward extreme (about 100 km offshore of the shelf break) in late August.

Yearly mean: The ten-year, annual mean positions of the shelf water front along the nine bearing lines (Fig. 3) indicate that the front is typically about 115 km seaward of the 200-m isobath on the eastern-most line (Casco Bay 120°). The separation of the front from the shelf break steadily decreases until the Nantucket (180°) line. From there southward to the Cape Henry (95°) line, the front is generally about 15-20 km offshore of the shelf break. Along the Albemarle Sound (90°) line, the front is located over the 200-m isobath. Variability in the frontal position from the ten-year record, as indicated by the standard deviation (Fig. 3) shows maximum variation at the Casco Bay (120°) line and minimum variability along the Albemarle Sound (90°) line.

Mean positions in 1989, except for Albemarle Sound, were seaward of the 200-m isobath. The yearly means tended to follow the pattern of the ten-year mean positions with two exceptions: Casco Bay (160°) was about 30 km seaward of its average position and Cape Henry (95°) was about 20 km shoreward of its mean position. Standard deviations for 1989 were greater than the standard deviations for the long-term means of all positions from the Montauk Point (150°) line and eastward, and on the Albemarle Sound (90°) bearing line. Those from Sandy Hook (130°) to Cape Henry (95°) were silimilar to the long-term standard deviations.

Conclusions

Based on the ten-year monthly means (1974-1983), along the bearing lines from eastern Georges Bank to the Sandy Hook (130°) line, the front tends to be more offshore during spring and shoreward during fall. From the Cape May (130°) line to Cape Hatteras, the front's position is typically further offshore in summer and shoreward in winter.

In 1989, frontal positions were similar to the pattern of the long-term means from the Nantucket (180°) to Albelmarle Sound (90°) bearing lines with no clear pattern along Casco Bay (120°). However, the front did not appear to be as far offshore during the winter and spring months as the long-term seasonal averages for the southern bearing lines. The largest variability in the positions was associated with absence of slope water at times along the Albemarle Sound (90°) line, and with the passage of warm core rings 88-K, 88-L, 89-B, 89-E, and 89-G on the other bearing lines. Annual mean positions for the front were approximately the same along most of the bearing lines, although the positions east of Sandy Hook exhibited greater variability than the ten-year averages.

References

Gunn, J. T. 1979. Variation in the shelf water front from Georges Bank to Cape Romain in 1977. ICES Annales Biol., 34 : 36-39.

Sano, M. H. and G. Wood MS 1990. Anticyclonic warm core Gulf Stream rings off the northeastern United States during 1989. NAFO SCR Doc.

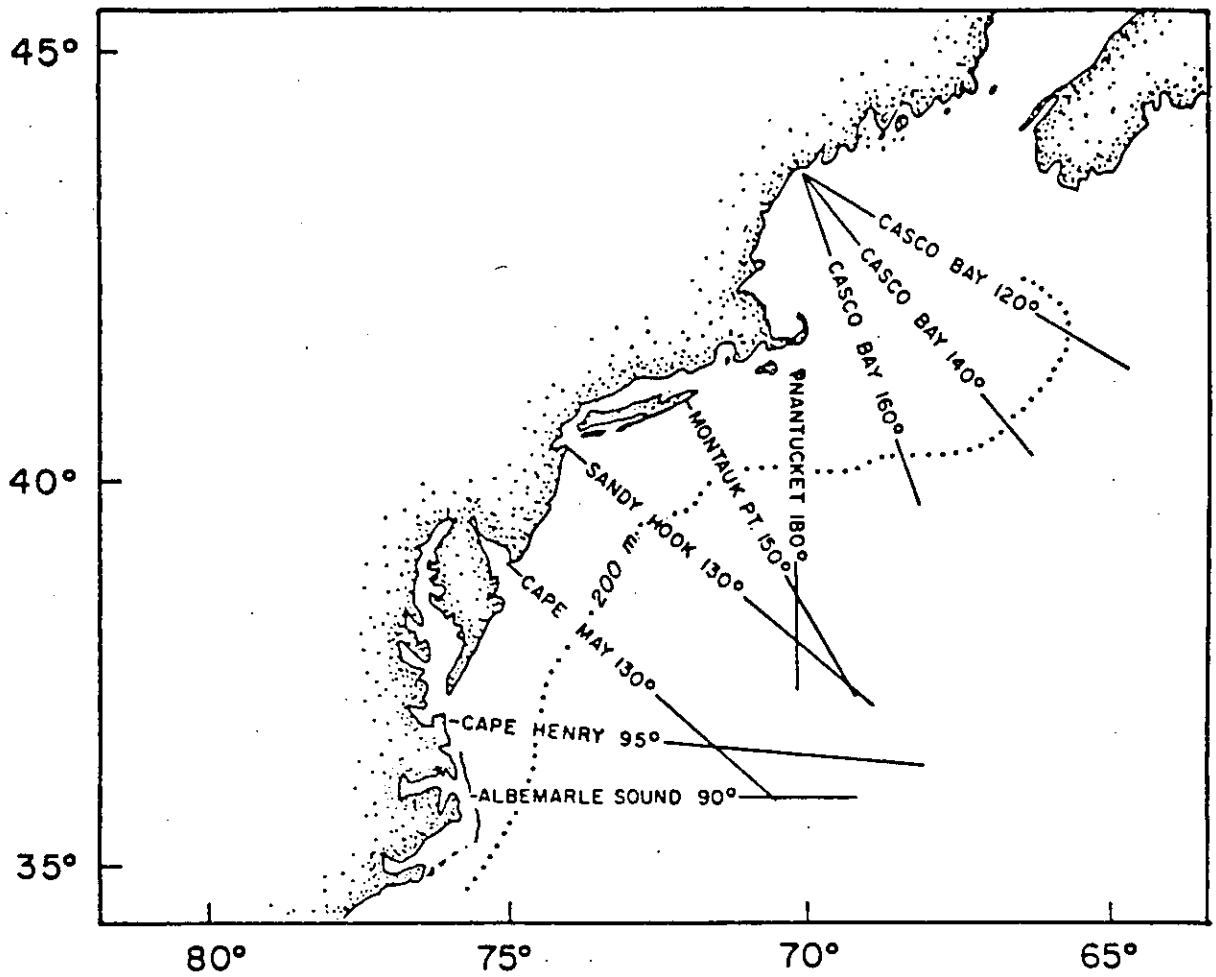

FIgure 1. Reference points and bearing lines used to portray variation in position of the shelf water front relative to the 200-m isobath (dotted line). The degrees are azimuths of the lines.

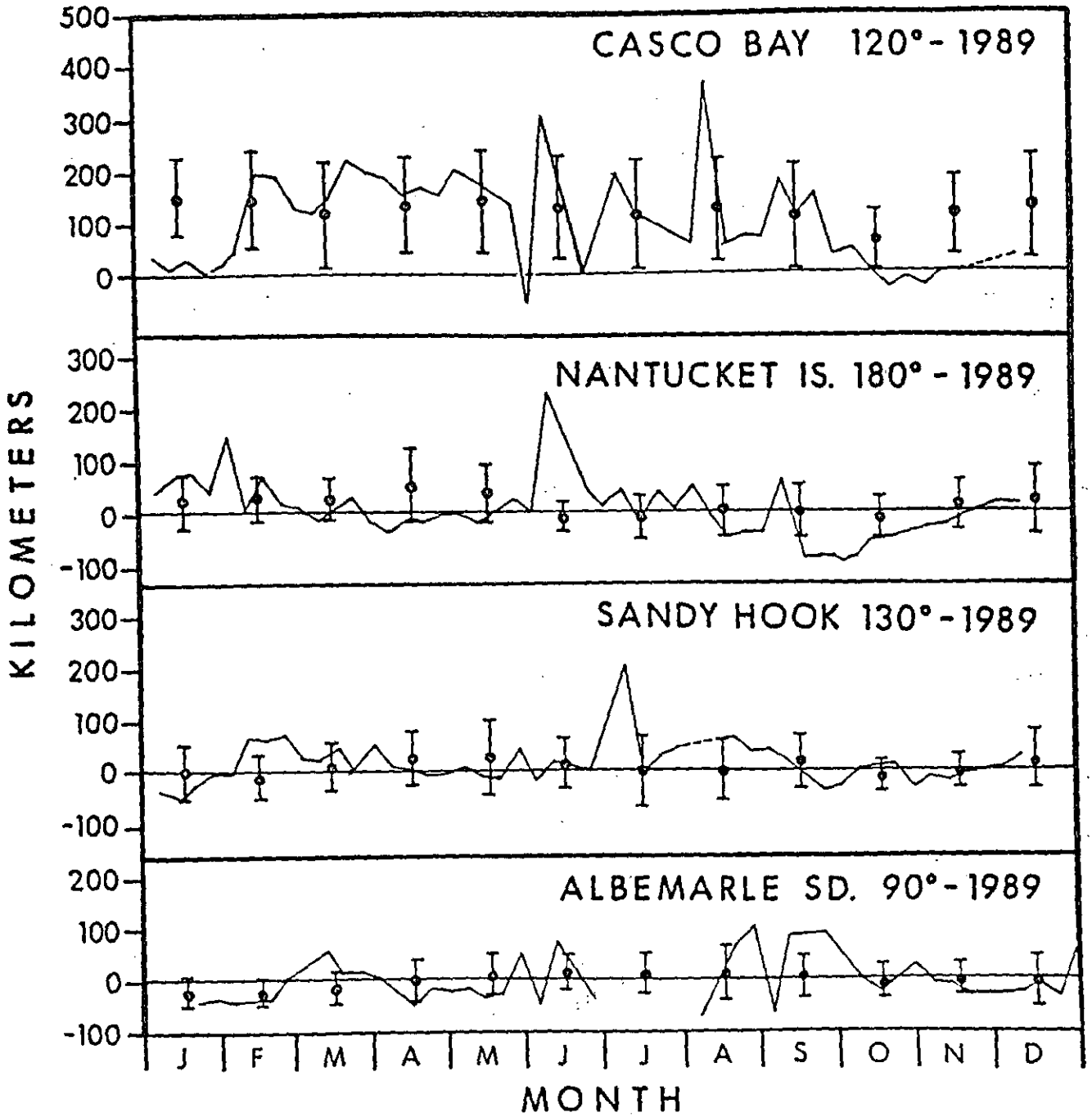

Figure 2. Shelf water frontal positions in 1989 relative to the 200-m isobath (positive is seaward) on selected bearing lines. For missing data, a solid line connects adjacent points for a missed week, a dashed line for two consecutive weeks, and no line for more than two consecutive weeks. Ten-year (1974-1983) mean monthly positions of the front are shown as dots with the vertical lines representing ±1 standard deviation.

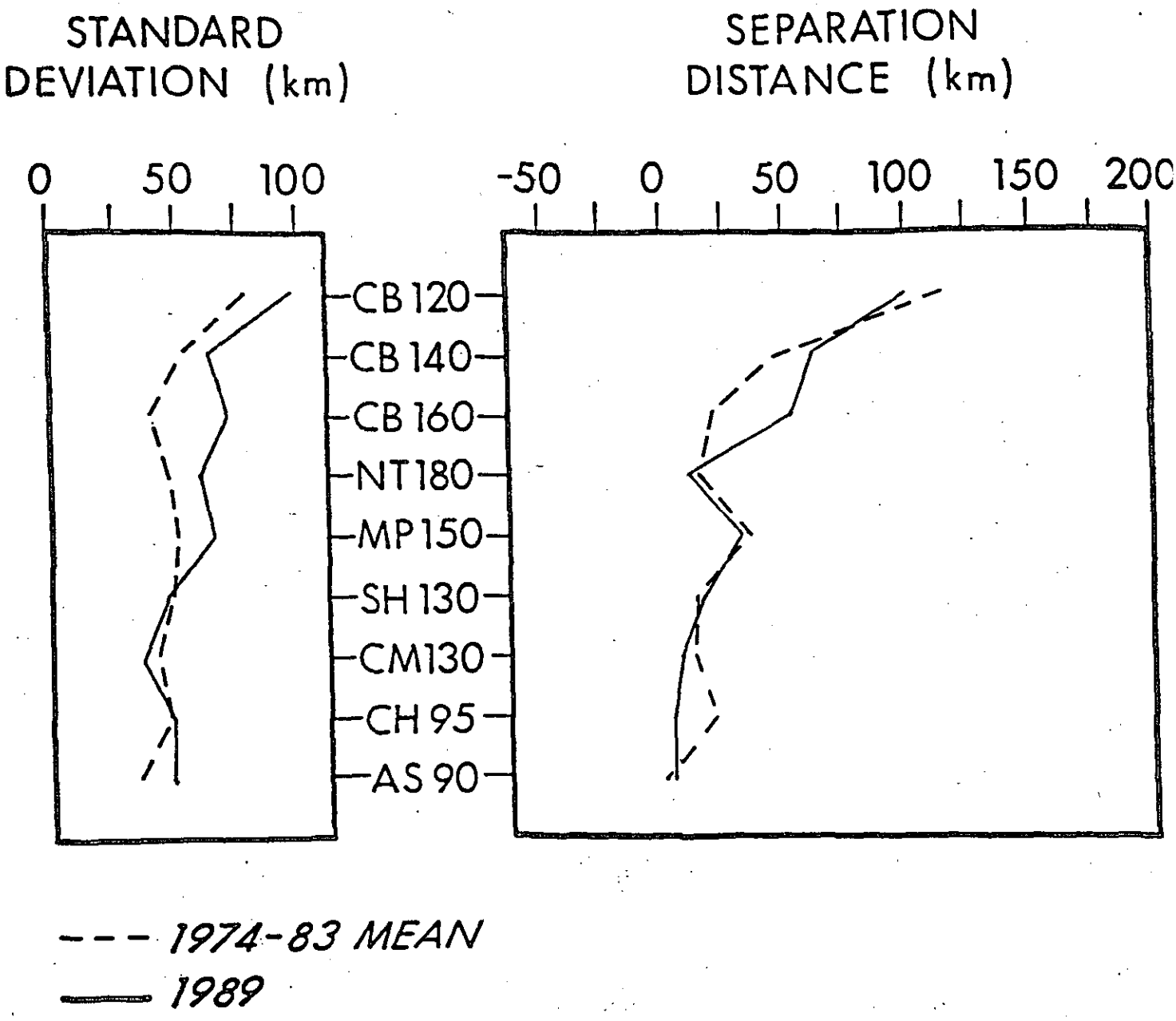

Figure 3. Mean position of shelf water front, during 1989, relative to the 200-m isobath (positive is seaward) and standard deviations of weekly positions at each bearing line. Long term means and standard deviations for the 1974-1983 base period are shown for comparison.