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Variation in the Shelf Water Front Position  
in 1988 from Georges Bank to Cape Hatteras

by

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Abstract

Based on weekly measurements of the surface position of the shelf water front along nine bearing lines between eastern Georges Bank and Cape Hatteras, variations during 1988 in the offshore boundary of shelf water off the northeastern United States coast were examined for the fifteenth year. Frontal positions are derived from analyses of sea surface temperature patterns from satellite infrared data. Results of the weekly positions through the year 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 1988, which are compared to the ten-year averaged results.

In 1988, frontal positions generally followed the ten-year mean seasonal patterns, but seasonal cycles seemed to be overshadowed by the shorter period and larger-magnitude variations associated with the passage of warm core rings. Average positions for the year were about the same, or offshore of the ten-year mean values, and variability during 1988 was similar, or less, than the ten-year means over most of the area.

### Introduction

The shelf water front along eastern North America is delineated by the narrow gradient zone between cooler, less saline shelf water and warmer, more saline slope water that lies offshore. The surface position of the shelf water front can usually be determined from thermal infrared data available from Advanced Very High Resolution Radiometers (AVHRR) on NOAA polar-orbiting satellites. 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 at the University of Rhode Island. Oceanographic Analysis charts which display oceanic features and are prepared by the NOAA National Weather Service, Ocean Services Unit, from interpretation 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 found close to the shelf break, consequently the distances along each bearing line were reduced to give departures of the front from the 200-m isobath (the shelf break). To maintain the weekly schedule of frontal observations that has been compiled since 1974, a single position for the front along each bearing line was selected weekly as representative of the shelf front location for the week. During 1988, frontal positions could be ascertained along our bearing lines in about 97% 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 ( $120^{\circ}$ ), Nantucket Island ( $180^{\circ}$ ), Sandy Hook ( $130^{\circ}$ ), and Albemarle Sound ( $90^{\circ}$ ) have been selected to show the fluctuations of the frontal

position during 1988 (Fig. 2). Long-term mean positions for the ten years, 1974-1983, serve as a base for comparison with 1988 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 Fairfield and Sano (MS 1989).

### 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 1988, the shelf water front was generally shoreward of the ten-year monthly mean positions, but seaward of the shelf break. During January, in the wake of warm core ring 87-I, the front moved seaward of the shelf break approximately 200 km. In early February the front moved shoreward to near the shelf break. From mid-March through June, influenced by the development and interaction of five rings (88-A,B,D,E, and G) in the slope waters near the bearing line, the front fluctuated between the shelf break and about 200 km seaward of the shelf break. The front moved to its most shoreward position of the year (about 10 km shoreward of the 200-m isobath) as ring 88-H approached the bearing line, in mid-August. Behind ring 88-H the front moved offshore and, at the beginning of September, reached its extreme seaward position for the year (217 km seaward of the shelf break). During September, the front shifted shoreward, close to the ten-year mean position, and remained near the long-term monthly mean positions for the remainder of the year, during which time no rings were close enough to significantly affect the front.

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 the magnitude on Casco Bay (120°), with the largest variability in April.

Frontal positions during 1988 tended to follow the pattern of the ten-year mean seasonal cycle. From the beginning of the year through March, the front was located at its most seaward distances during the year, approximately 100 km off the shelf. In April and May, the front was near the shelf break and close to the long-term, monthly mean positions. With the approach of ring 88-C in June, the front migrated to 78 km shoreward of the 200-m isobath, its shoreward extreme for the year. Following ring 88-C, the front extended briefly beyond the shelf break until ring 88-E approached the bearing line in early July. The front remained about 50 km shoreward of the shelf break through August as ring 88-E persisted close to the bearing line. In September, the front moved to near the shelf break in the wake of ring 88-E. In October and November, with the passage of ring 88-H, the front first shifted to about 50 km shoreward of the shelf break and, in the wake of the ring, to about 100 km seaward of the shelf break. In late December, with the approach of ring 88-K, the front moved shoreward, close to the 200-m isobath.

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 1988, the shelf water front was located predominately seaward of the 200-m isobath and close to the ten-year monthly

mean positions. In March, an offshore excursion developed near a large northward meander of the Gulf Stream, with shelf water extending to 160 km seaward of the shelf break and almost to the western boundary of the meander. The extreme displacements from the 200-m isobath for the year were associated with the passage of ring 88-C. Ahead of the ring in August, the front was 66 km shoreward of the shelf break and, behind the ring, in September, the front shifted to 200 km seaward of the shelf break. With the passage of ring 88-H in December, the front remained close to the shelf break.

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 15-20km 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.

Along the Albemarle Sound bearing line in 1988, the front remained close to the ten-year mean values, oscillating about the shelf break for the entire year. From late June through early September the front was primarily shoreward of the 200-m isobath, with the most significant departure of 57 km shoreward of the shelf break occurring in late August. No rings traveled this far south in 1988.

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 115km 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 15-20km 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.

The annual mean positions for 1988 were seaward of the 200-m isobath on all bearing lines, except at Albermarle Sound, where the front was shoreward of the shelf break. Positions of the front for the year were similiar to, or offshore of, the ten-year means except at Casco Bay 120° and from Cape Henry southward. Standard deviation values were about the same, or less, than the long-term means except on the Casco Bay 140° line, where the 1988 value was greater.

#### 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 1988, frontal positions generally followed a seasonal pattern of being more offshore during winter and spring and shoreward during summer into early fall for the bearing lines from Nantucket 180° to Albermarle Sound 90°, without any clear seasonal tendency on the bearing lines along Georges Bank. Generally, the largest variability in positions of the front was associated with warm core rings, particularly involving the passage of rings 88-C, E, and H. Annual mean positions of the front were about the same as, or offshore of, ten-year means and variability through the year was similar, or less, than the ten-year means over most of the area.

References

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Fairfield C. P., and M. H. Sano. MS 1989. Anticyclonic warm core Gulf Stream rings off the northeastern United States during 1988. NAFO SCR Doc.

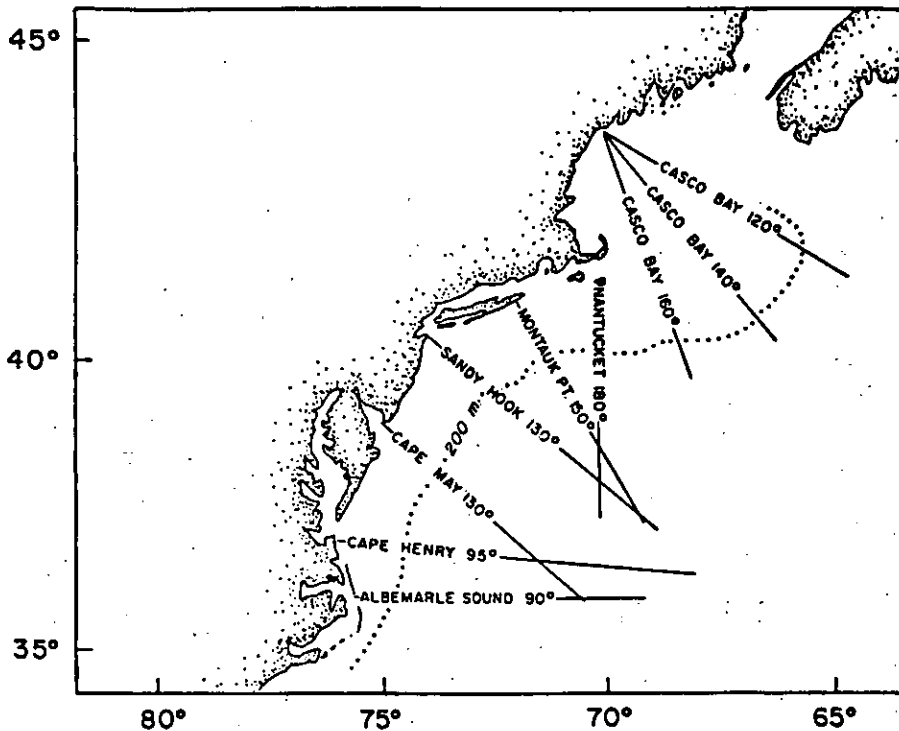


Figure 1. Reference points and bearing lines used to portray variation in position of the shelf water front relative to the 200-m isobath (dotted line). The degrees are azimuths of the lines.

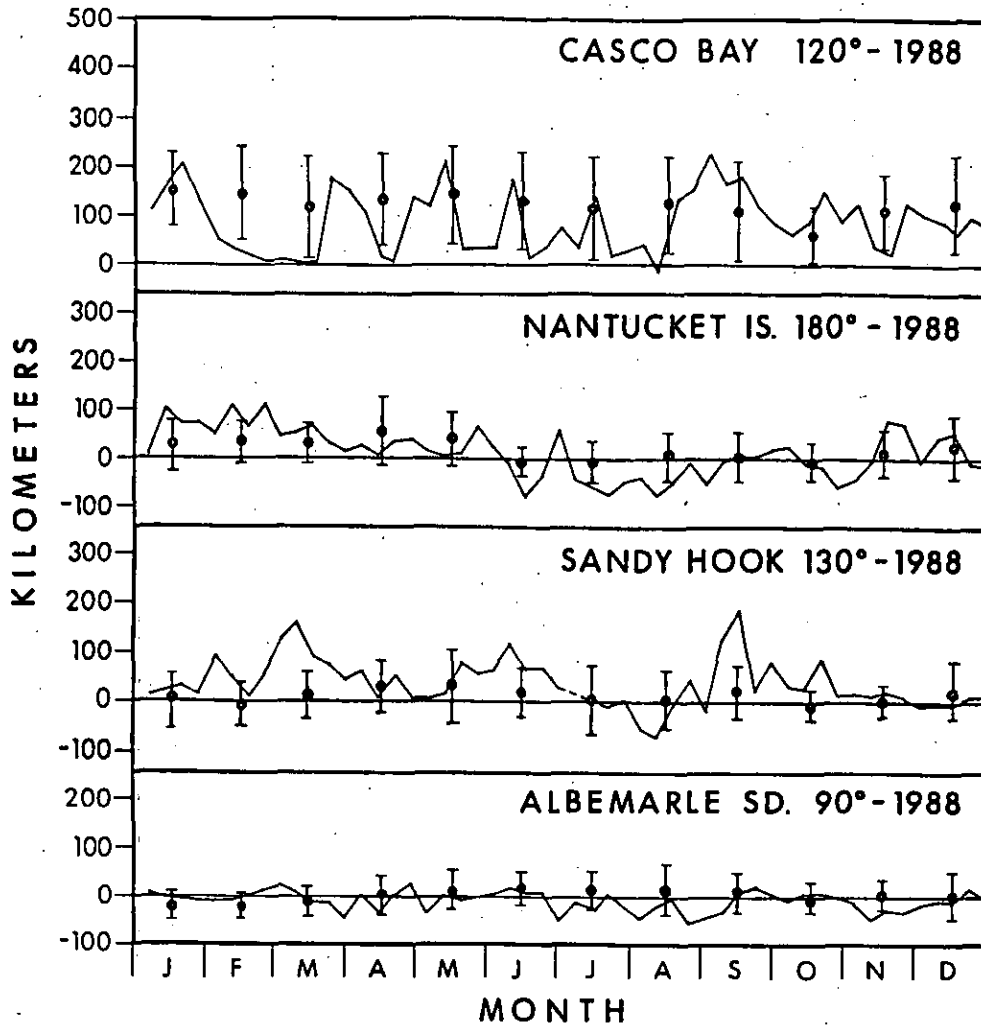


Figure 2. Shelf water frontal positions in 1988 relative to the 200-m isobath (positive is seaward) on selected bearing lines. Dashed lines indicate points were connected for a missed week. Ten-year (1974-1983) mean monthly positions of the front are shown as dots with the vertical lines representing  $\pm 1$  standard deviation.



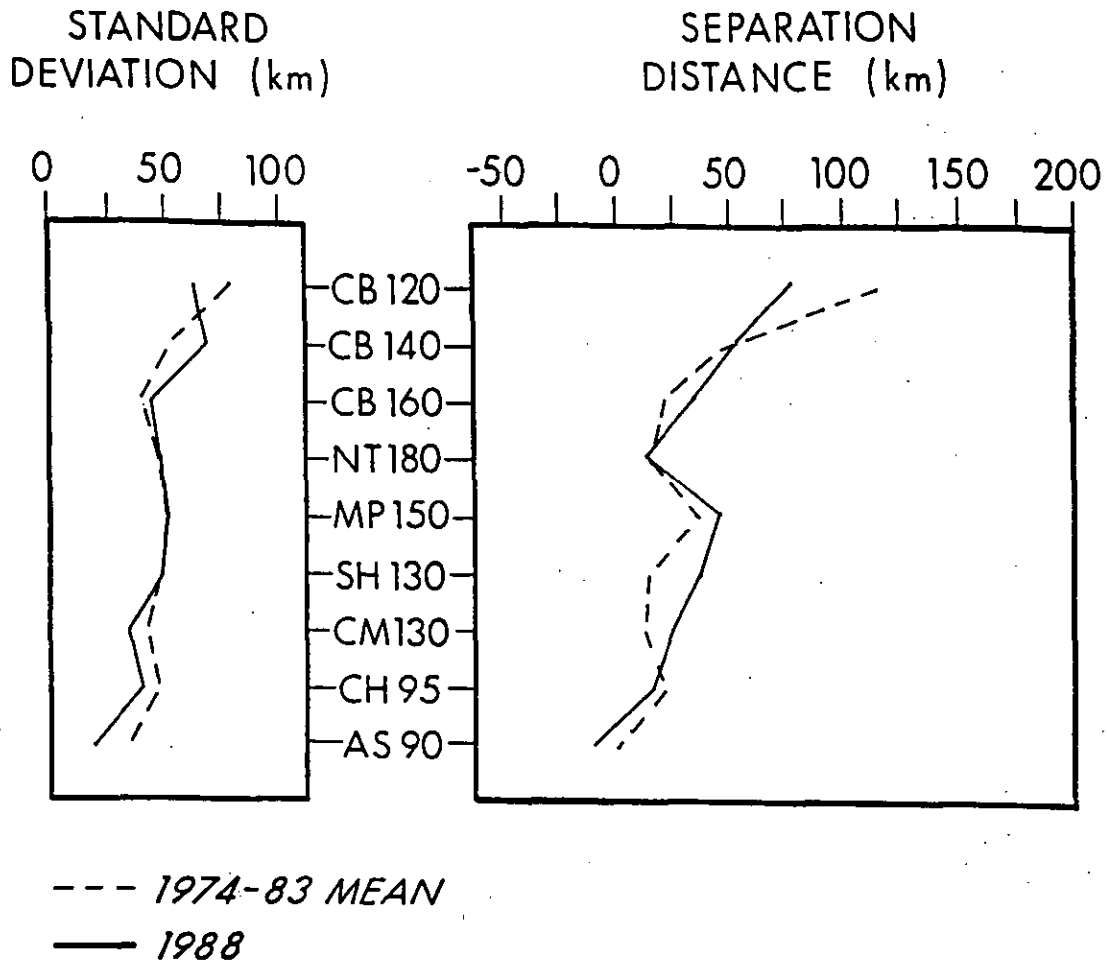


Figure 3. Mean positions of shelf water front, during 1988, relative to the 200-m isobath (positive is seaward) and standard deviations of weekly positions at each bearing line. Long term means and standard deviations for the 1974-1983 base period are shown for comparison.