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Variation in the Shelf Water Front Position in 1987
from Georges Bank to Cape Hatteras

by

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Abstract

Examination of variations during 1987 in the offshore boundary of shelf water off the northeastern United States coast continued for the fourteenth 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. Results of the weekly positions through the year are presented for four of the bearing lines and compared to the ten-year (1974-1983) monthly mean positions. Also described are the annual mean positions and variability for 1987, which are compared to the ten-year averaged results.

In 1987, 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 as the ten-year mean values, but variability during 1987 was less.

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. The 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 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 bound 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 each week as representative of the shelf front location for the week. During 1987, frontal positions could be ascertained along the bearing lines in about 88% 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 1987 (Fig. 2). Long-term mean positions for the ten years, 1974-1983, serve as a base for comparison of 1987 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 Barton and Sano (MS 1988).

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 1987 at the Casco Bay (120°) bearing line, the shelf water front was observed primarily seaward of the shelf break. On five occasions, associated with warm core rings, the front extended significantly seaward. During mid-February, in the wake of warm core ring 86-H, the front was approximately 145 km southeast of the shelf break. As warm core ring 87-C moved westward past the bearing line at the end of April, the front was located as much as 149 km seaward of the shelf break. After ring 87-D passed at the beginning of June, shortly behind ring 87-C, the location of the front reached its seaward extreme during 1987 of approximately 280 km offshore of the 200-m isobath. It remained well offshore throughout July but in August started returning toward the shelf break. After passage of two closely associated rings, 87-F and 87-G, in September, the front remained relatively close to the shelf break until the last observation in early December. The shoreward extreme occurred in early November, when the front was located at the shelf break.

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.

Shelf water front positions remained within 50 km of the 200-m isobath throughout 1987, except during three episodes which were associated with the passage of warm core rings. In March, while ring 86-I was centered on the bearing line, the front was at its shoreward extreme position for the year, about 60 km shoreward of the shelf break. During October, in the wake of ring 87-C, the front shifted to 120 km offshore of the shelf break. Following ring 87-C, in late

October, ring 87-F moved slowly across the bearing line and shelf water extended to its most offshore location for the year, when the front was 135 km seaward of the 200-m isobath. Ring 87-F remained close to the Nantucket bearing line until its demise at the end of November. This may account for the continued seaward location of the front through early December.

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.

In 1987, the shelf water front was located near the ten-year monthly mean positions and close to, but predominately seaward of the 200-m isobath. The most shoreward position of the front for the year occurred in March, when slope water extended to about 50 km shoreward of the 200-m isobath. At the end of May, in the wake of ring 86-I the front was at its most seaward position for the year with shelf water extending to about 150 km seaward of the shelf break. The front shifted almost 100 km seaward in late June with further interaction with ring 86-I and in August, in the wake of rings 87-C and 87-E. In late November and again in late December, the front was located almost 100 km offshore of the 200-m isobath.

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.

During 1987, the front along the Albemarle Sound bearing line remained close to the ten-year mean values. The front remained

primarily shoreward of the 200-m isobath into March. It then oscillated about the shelf break until August. The first significant departure from the shelf break occurred in August with the arrival of ring 86-I, the only ring to make it to this bearing line in 1987. Subsequently, the front was positioned mostly seaward of the 200-m isobath.

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.

In 1987, the annual mean positions closely resembled the ten-year mean values. The distance to the front, always seaward of the 200-m isobath, generally decreased from Casco Bay (120°) to Albemarle Sound (90°). The standard deviation values were less than the long-term mean values for all bearing lines. From Casco Bay to Montauk Point, the 1987 standard deviation values were no more than 10 km below the long-term means, but south of Montauk Point were about 15 to 20 km less than the ten-year mean values.

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 1987, frontal positions generally followed the long-term mean seasonal pattern, although any seasonal cycle seemed to be overshadowed by shorter period fluctuations. Typically, the largest variability in the positions of the shelf water front occurred near warm core rings, particularly involving the passage of warm core rings 86-I, 87-C and 87-F. For the

year, frontal positions in 1987 were about the same as the ten-year means on all bearing lines, with the maximum difference of 23 km on Casco Bay (120°) line. Variability of the frontal positions in 1987 was less than the long-term means on all bearing lines, with standard deviation estimates of variability amounting to about 25% less than the ten-year mean values.

References

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Barton K. W., and M. H. Sano. MS 1988. Anticyclonic warm core Gulf Stream rings off the northeastern United States during 1986. NAFO SCR Doc.

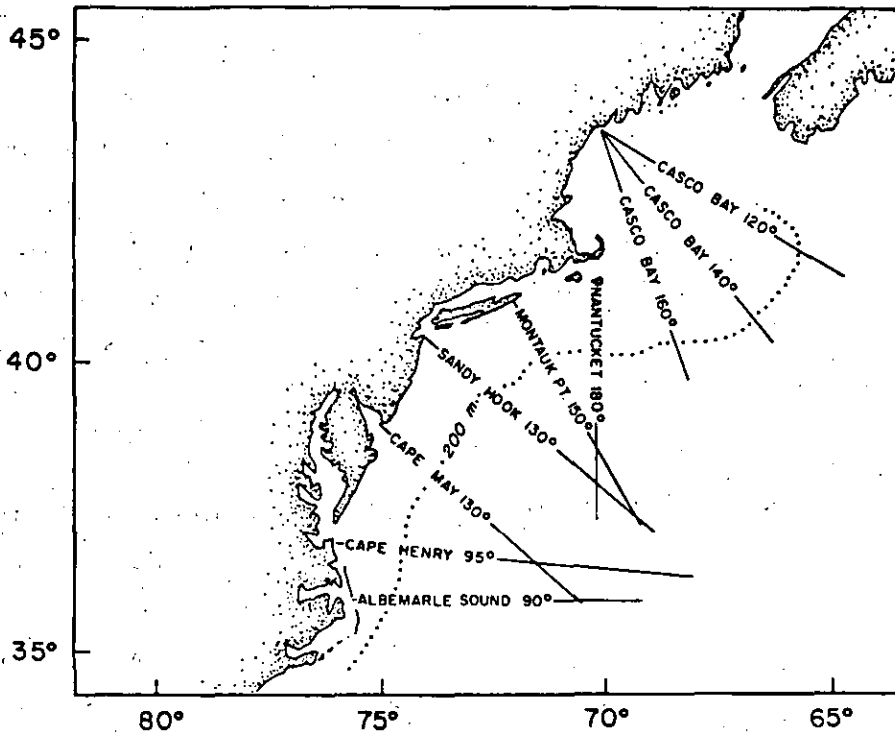


Figure 1. Reference points and bearing lines used to portray variation in position of the shelf water front relative to the 200-m isobath (dotted line). The degrees are azimuths of the lines.

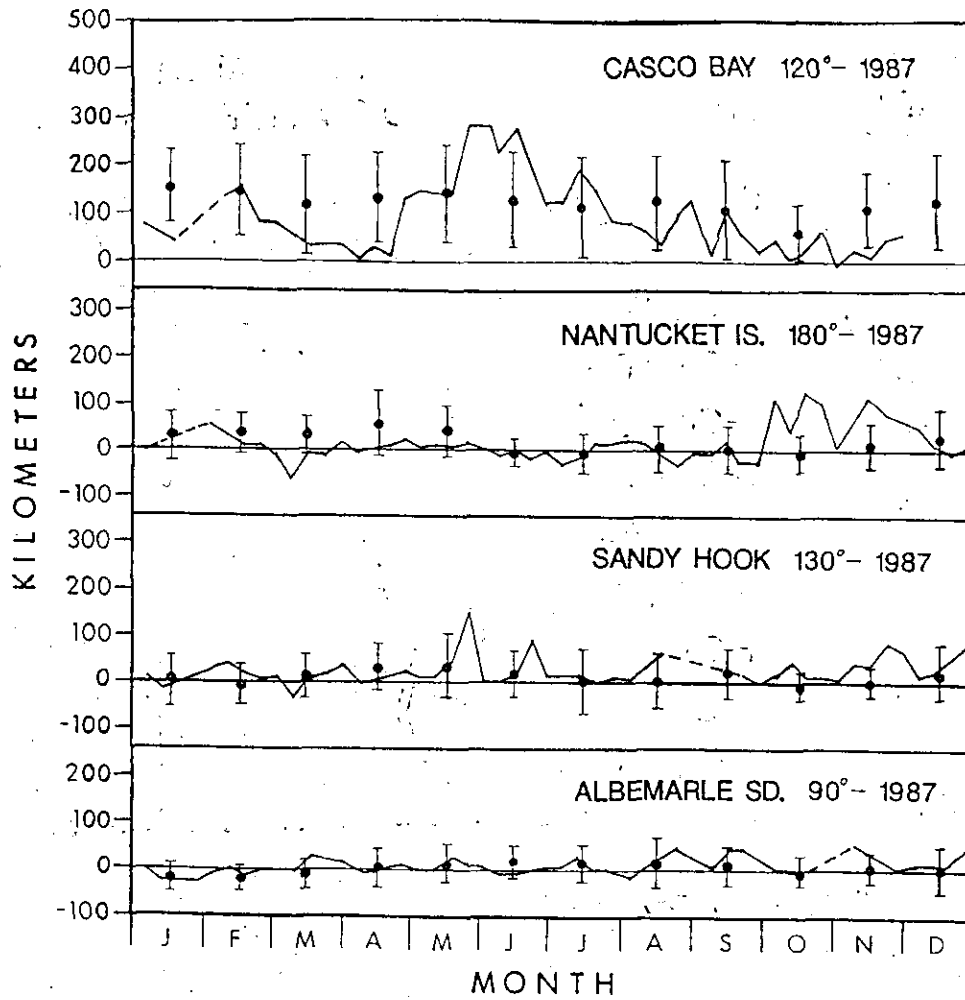


Figure 2. Shelf water frontal positions in 1987 relative to the 200-m isobath (positive is seaward) on selected bearing lines. If data was missed for more than four weeks the interval was left blank. Dashed lines indicate gaps in the data of two to four weeks, while the adjacent points were connected for a missed week. Ten-year (1974-1983) mean monthly positions of the front are shown as dots with the vertical lines representing ± 1 standard deviation.

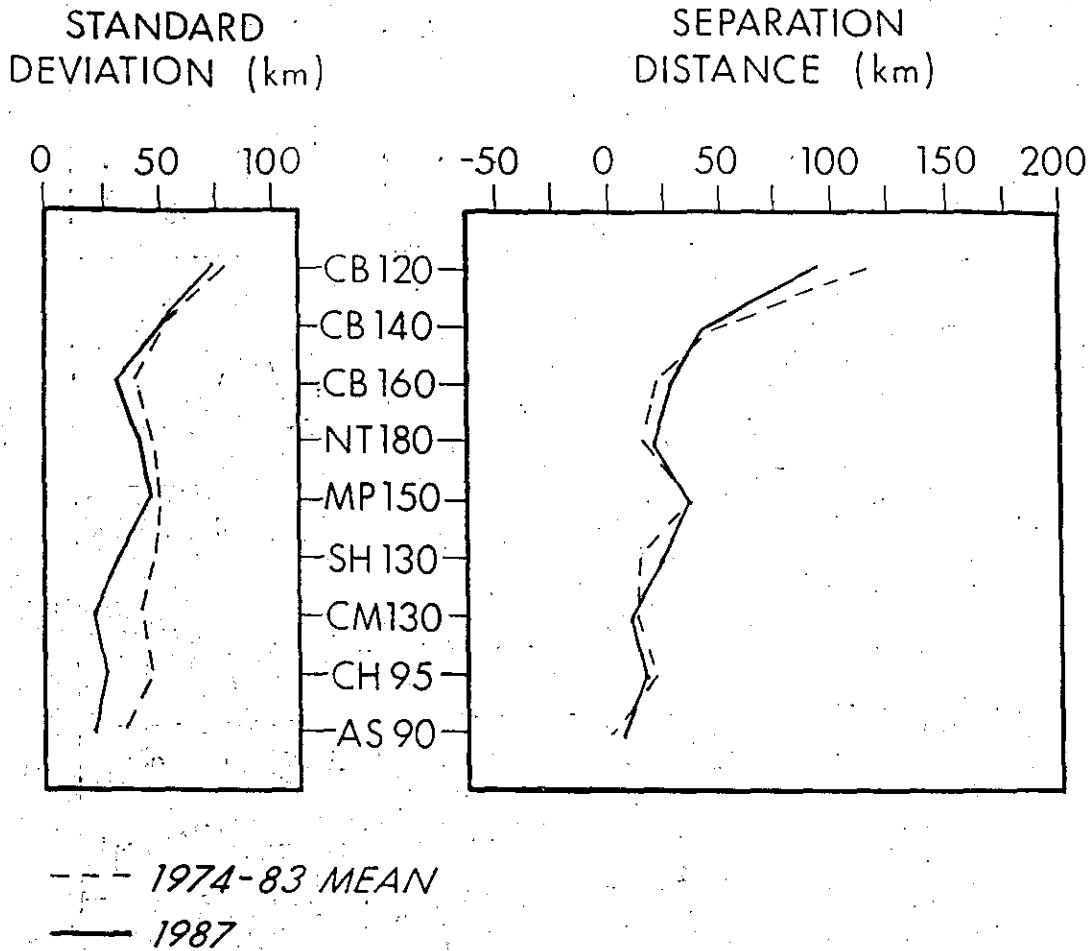


Figure 3. Mean positions of shelf water front, during 1987, relative to the 200-m isobath (positive is seaward) and standard deviations of weekly positions at each bearing line. Long-term means and standard deviations for the 1974-1983 base period are shown for comparison.