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Variation in the Shelf Water Front Position in 1986 from Georges Bank to Cape Hatteras

by

Reed S. Armstrong and Glenn A. Strout

Physical Oceanography Branch, Northeast Fisheries Center, NMFS/NOAA
South Ferry Road, Narragansett, RI 02882, USA

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 from satellite passes over the waters off eastern North America 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 1986, frontal positions could be ascertained along the bearing lines in about 89% 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 1986 (Fig. 2). Long-term mean positions for the ten years, 1974-1983, serve as a base for comparison of 1986 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 Price and Barton (MS 1987).

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.

Throughout most of 1986 along the Casco Bay (120°) bearing line, the shelf water front was located about 100 to 150 km shoreward of the ten-year mean positions, positioned close to the shelf break (200-m isobath). Significant offshore excursions of the front occurred during four periods in the year. From early February until late March, the front was located as much as about 200 km seaward of the shelf break, as warm core ring 86-A gradually moved westward through the slope water near the bearing line. In the wake of warm core ring 86-B in early May, the front briefly shifted to about 150 km offshore of the 200-m isobath. From mid-June until late July, shelf water extended to 100 to 200 km seaward of the shelf break. During this period of the summer, warm core ring 86-C drifted slowly westward in the slope water off eastern Georges Bank, with the bearing line extending across the wake of the ring. In November, following three months of the front remaining close to the 200-m isobath, the shelf water front shifted to about 100 to 150 km seaward of the shelf break. From mid-November until the last observation for the year (in mid-December) the front was near the ten-year mean positions. Extremes of position of the front in 1986 along the bearing line were in mid-February (about 210 km seaward of the

shelf break) and in mid-May, when the front was located about 25 km shoreward of 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.

During most of 1986, the shelf water front was located near the ten-year mean positions and exhibited a general pattern of being positioned more seaward from January through March, shifting shoreward during the spring and remaining shoreward of the shelf break through the summer and until the end of the year. Three warm core rings (86-A, 86-E and 86-F) crossed the Nantucket (180°) bearing line in 1986. In the wake of ring 86-A in late July, the front shifted to about 70 km seaward of the 200-m isobath. In the wake of ring 86-E, in late November, shelf water extended offshore to its most seaward position for the year, with the front positioned about 130 km beyond the shelf break. During December, associated with the passage of ring 86-F, the shelf water front was at its most shoreward positions for the year, with slope water invading about 50 km onto the shelf. About half of the weekly positions in 1986 showed the front located shoreward of 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.

Shelf water front positions in 1986 were near the ten-year monthly mean locations and, instead of following the normal annual cycle, remained close to the 200-m isobath throughout the year. The most significant departures of the front from the shelf break occurred in November with the passage of warm core ring 86-E. With the approach of the ring to the Sandy Hook (130°) bearing line in early November, the

front shifted to about 50 km shoreward of the shelf break and, in the wake of the ring in the latter half of the month, the front moved to as much as 140 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.

In 1986, the front along the Albemarle Sound (90°) bearing line followed the long-term annual cycle, being located more offshore during most of the summer and fall than during the rest of the year. Positions were similar to the ten-year monthly means except during October, when the shelf water front was about 50 km shoreward of the shelf break in advance of the remnants of warm core ring 86-A. At the times of the most offshore positions of the front (about 30 km seaward of the 200-m isobath), in late March, and at times in June and July and in late November, slope water was absent along the bearing line and shelf water extended to the north wall of the Gulf Stream.

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 1986 were shoreward of the long-term means for all bearing lines. Along the Casco Bay (120°) line, the front was about 40 km shoreward of the ten-year annual mean. For the Casco

Bay (140°) through the Montauk Point (150°) lines the front was about 10-20 km shoreward of the long-term means, and for the four southernmost bearing lines, the front was positioned about 5 km shoreward of the 1974-1983 mean locations. Standard deviation values were less than the long-term values for all bearing lines, amounting to about 15 to 20 km less on the Casco Bay (140°) and Casco Bay (160°) lines, and 5 to 10 km less along the other seven lines.

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 1986, 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 was associated with the passage of warm core rings, particularly involving the passage of warm core rings 86-A and 86-E. For the year, frontal positions in 1986 were shoreward of the ten-year means on all bearing lines, averaging about 15 km shoreward of the long-term means. Variability of the frontal positions in 1986 was also 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

- Gunn, J. T. 1979. Variation in the shelf water front from Georges Bank to Cape Romain in 1977. ICES Annales Biol., 34 : 36-39.
- Price, C. A., and K. W. Barton. MS 1987. Anticyclonic warm core Gulf Stream rings off the northeastern United States during 1986. NAFO SCR Doc. 87/14

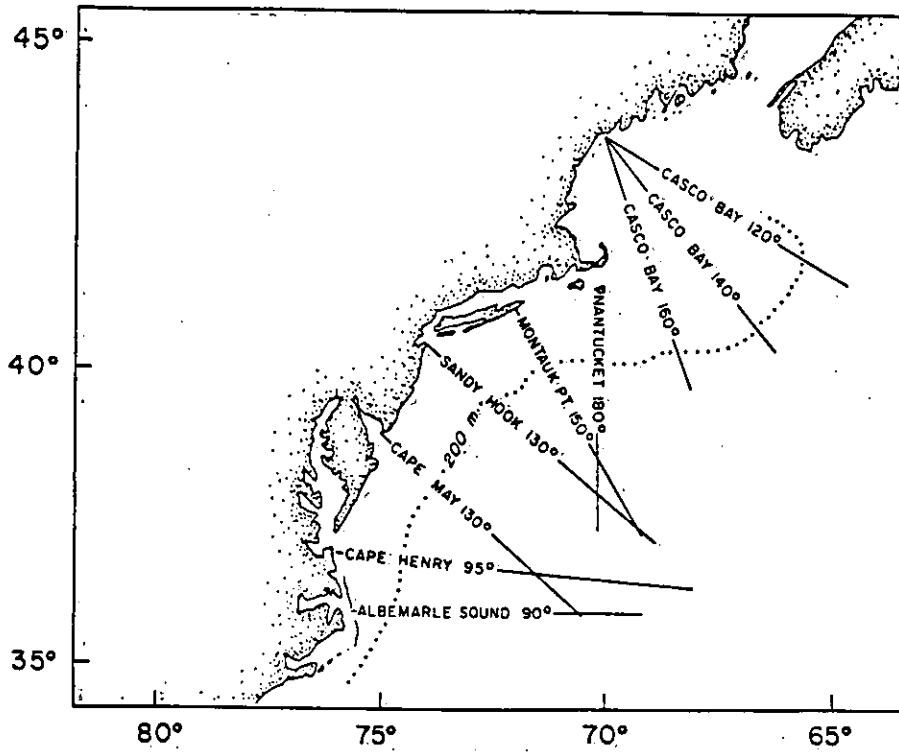


Figure 1. Reference points and bearing lines used to portray variation in position of the shelf water front relative to the 200-m isobath (dotted line). The degrees are azimuths of the lines

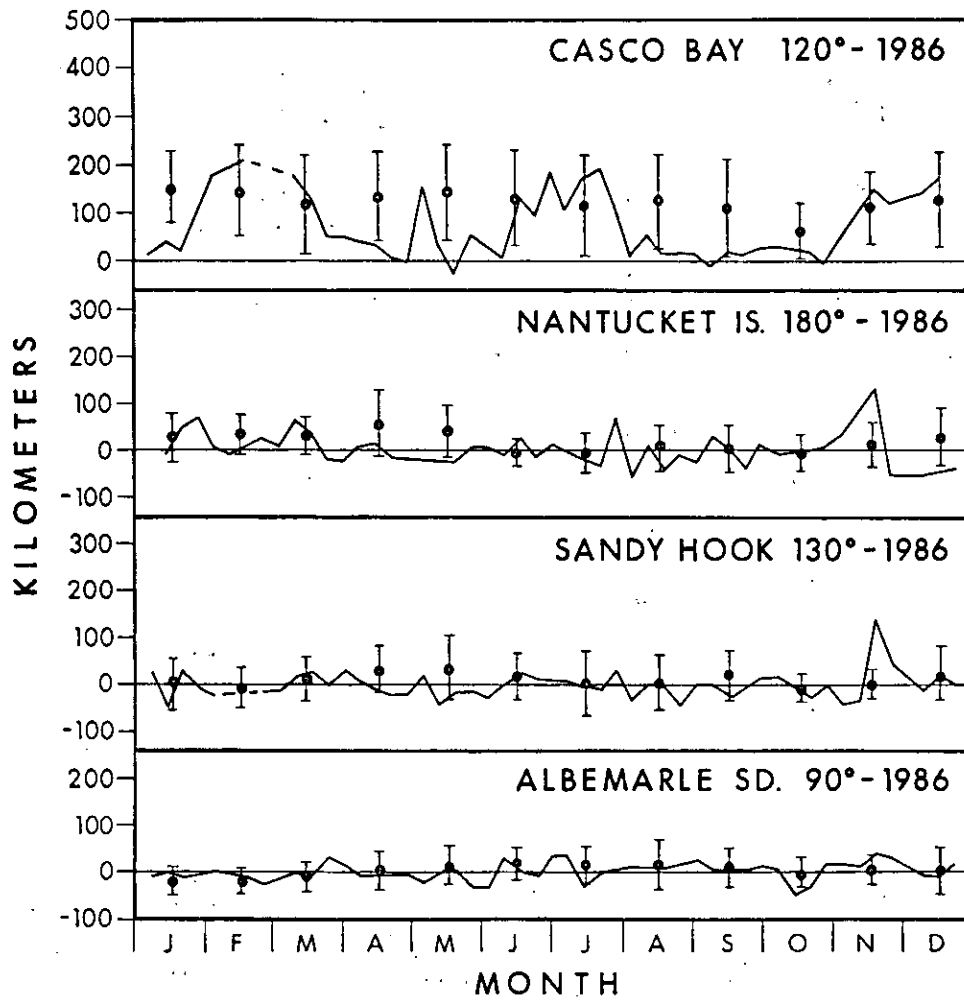


Figure 2. Shelf water frontal positions in 1986 relative to the 200-m isobath (positive is seaward) on selected bearing lines. Dashed lines indicate gaps in the data of two to four weeks. Ten-year (1974-1983) mean monthly positions of the front are shown as dots with the vertical lines representing ± 1 standard deviation around the means.

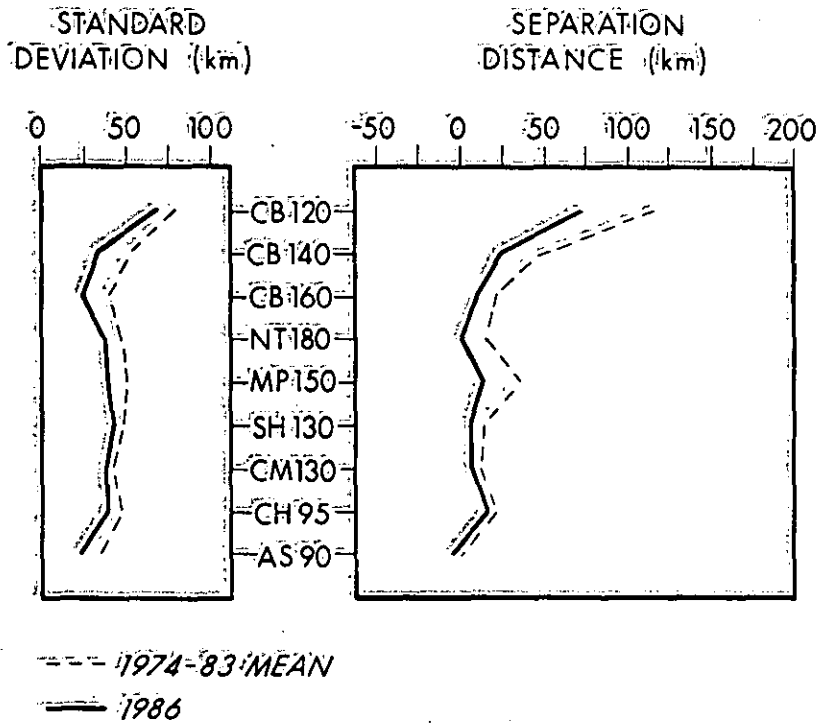


Figure 3. Mean positions of shelf water front, during 1986, relative to the 200-m isobath (positive is seaward) and standard deviations of weekly positions at each bearing time. Long-term means and standard deviations for the 1974-1983 base period are shown for comparison.