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Variation in the Shelf Water Front Position in 1983 from Georges Bank to Cape Romain

by

Reed S. Armstrong

Atlantic Environmental Group, National Marine Fisheries Service
National Oceanic and Atmospheric Administration, U.S. Department of Commerce
South Ferry Road, Narragansett, Rhode Island, USA, 02882

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 imagery such as is available from Advanced Very High Resolution Radiometers (AVHRR) on NOAA satellites. The NOAA National Weather Service and National Environmental Satellite, Data and Information Service (NESDIS) interprets the AVHRR satellite imagery and produces charts (Oceanographic Analysis) which are issued three times a week for the region north of Cape Hatteras and twice a week for the region southward. The charts are constructed from a composite of imagery collected during the day prior to issuance and depict the shelf water front and other oceanic features such as the Gulf Stream and its warm core anticyclonic rings.

The position of the shelf water front off eastern North America was determined from the Oceanographic Analysis charts, following the method described by Gunn (1979). Distances from the coast to the front were measured along twelve bearing lines from Cape Romain, South Carolina to the Gulf of Maine (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 preserve the weekly spacing of frontal observations a single Oceanographic Analysis chart was selected each week as representative of the shelf front location for the week.

During 1983 frontal positions could be ascertained along the bearing lines in about 93% of the weekly observations. Gaps 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 1983 (Fig. 2). Long-term mean positions from June 1973 to December 1977 serve as a base for comparison of 1983 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 Celone (MS 1984).

Casco Bay (120°): The long-term mean positions (1973-1977) remain consistently offshore of the 200-m isobath, but show pronounced seasonal change and large variability in most months. Offshore progression during the winter to a maximum in March is followed by a transition to a more constant, shoreward position during the summer months. Offshore movement with large variability occurs again in the fall, followed by a shift to the most shoreward position and least variable position in December. The December position may not be representative, however, because it is based on only two weekly positions, both from 1975.

In 1983, the position of the shelf water front seemed to be dominated by influences of the circulation associated with the passage of four warm core rings. At the beginning of the year, the front was located about 150 km offshore of the shelf break, in the wake of warm core ring 82-I. From the end of February until mid-April, the front was positioned shoreward of normal in advance of ring 82-J, followed by an abrupt offshore excursion of about 150 km in the wake of ring 82-J. From late May until mid-August, the front was under the influence of ring 83-D. During June, ring 83-D progressed southwestward, away from the region of this bearing line, but in early July, the ring moved back toward the northeast so that the front was again drawn offshore in the ring's wake. By the middle of August, ring 83-D had departed the area, but a large northward meander of the Gulf Stream seemed to interrupt the typical westward flow of slope water so as to keep the shelf water well

offshore of normal, until early September. From early October until the end of the year, the frontal position was under the influence of ring 83-F, first with a shoreward excursion in advance of the ring during October and offshore movement of the front in the wake of the ring during November. For about 70% of the year, the frontal position seemed to be under the influence of rings. With the passage of each ring (82-J, 83-D, 83-F) the front shifted shoreward to about the shelf break, in advance of the ring, and then moved to about 200 km offshore of the shelf break in the wake of the ring. Only from mid-January to late-February and during the latter half of September was the front located near the long-term, monthly mean positions.

Nantucket Island (180°): The long-term monthly mean positions show a regular annual cycle fluctuating offshore and onshore of the 200-m isobath. The maximum distance offshore is in February and the extreme onshore position occurs in September. Variability is less than half the magnitude on Casco Bay (120°), and more uniform, with maxima in the winter and summer.

The front was located near the 200-m isobath for most of 1983. Principal departures of the front from the shelf break occurred during six, brief events of offshore shifts. With the first observation of the front, in mid-January, the front was located about 100 km offshore. In the wake of ring 82-I in early March, the shelf water extended 60 km offshore. In early May, the front shifted to its most offshore position of the year (150 km), following ring 83-E. In early August and again in mid-October, the front moved to about 100 km offshore, in the wake of rings 82-J (August) and 83-D (October). In late December the front again shifted to about 100 km offshore of the shelf break. The seasonal shift in the location of the shelf water front was less distinct in 1983 than appears in the long-term monthly means. Instead of being positioned shoreward of the 200-m isobath during summer and fall, the front remained near the shelf-break in 1983.

Sandy Hook (130°): The long-term mean positions are close to the 200-m isobath from January to June, except for a 25 km offshore excursion in April. In July the front shifts 50 km shoreward and

remains shoreward to a lesser degree for the rest of the year. Variability is generally greater than on the Nantucket (180°) line, although less than on the Casco Bay (120°) line. Maximum variability in winter and summer is a common characteristic of the Sandy Hook (130°) and Nantucket (180°) lines.

In 1983 the front was located near the long-term mean positions until mid-March, when ring 82-I began to enter the area. With the approach of ring 82-I in mid-March, the front moved to about 60 km shoreward of the shelf break. As ring 82-I moved southwestward across and beyond this bearing line during March and April, the front moved steadily toward the offshore direction until late April when it was about 20 km seaward of the shelf break. From the beginning of May until mid-July the front was located near the long-term monthly mean positions. In the wake of rings 83-E in August and 82-J in September, the front shifted to about 100 km offshore of the shelf break. From mid-September through October, the front was near the long-term mean position, but shifted to more than 50 km offshore of the shelf break in November, in the wake of ring 83-D. Through most of December the front was 50 to 90 km seaward of the shelf break, in the absence of a ring.

Albemarle Sound (90°): On this bearing line, near Cape Hatteras, the long-term monthly means show an annual cycle that is almost opposite that found for the bearing lines to the north, and with the least amplitude. The means are shoreward of the 200-m isobath from January through May, offshore from June to September, and inshore again from October through December. Variability is low during January to June, abruptly increases in July, and steadily declines during the rest of the year. Because the Gulf Stream is normally close to the continental shelf in the vicinity of the bearing line, large fluctuations in the position of the shelf front do not normally occur.

Along the Albemarle Sound bearing line in 1983, the shelf water front was near the 1973-1977 mean positions, except from mid-April to mid-May, most of the time from mid-September to mid-October, and in early and late December. During each of these periods, satellite imagery indicated that slope water was absent and shelf water extended offshore to the edge of the Gulf Stream.

Yearly mean: The mean positions of the shelf water front in 1983 followed the general, geographic trend of the 1973-1977 means, but were displaced seaward of the long-term mean positions (Fig.3). Along the three northernmost bearing lines, the front was about 30- to 40-km offshore of the long-term mean positions and about 10- to 20-km offshore of the long-term means for all the other bearing lines.

Variability in the shelf water front positions in 1983 was comparable to the long-term values on all bearing lines, as indicated by the standard deviation (Fig.3).

Discussion: North of Cape Henry the shelf water front is typically positioned in a more offshore location during the first half of the year and in a more shoreward location during most of the latter half of the year. From Cape Romain to Albemarle Sound, the normal annual pattern is about the opposite. In 1983, frontal positions generally followed the seasonal pattern from the Cape Romain area to the Sandy Hook bearing line. From the Montauk Point bearing line eastward, there was no apparent seasonal pattern. For the waters north of the Cape Henry bearing line, most of the departures of the front from the 1973-1977 monthly mean positions corresponded to the passage of five, long-lived warm core rings (rings 82-I, 82-J, 83-D, 83-E and 83-F). South of the Cape Henry area, departures of the front from the long term mean positions seemed to be related to meanders in the Gulf Stream or the absence of slope water along the bearing lines.

References

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- PRICE, C. A., and P. J. CELONE. MS 1984. Anticyclonic warm-core Gulf Stream rings off the northeastern United States during 1983. NAFO SCR Doc. 84/VI/18.

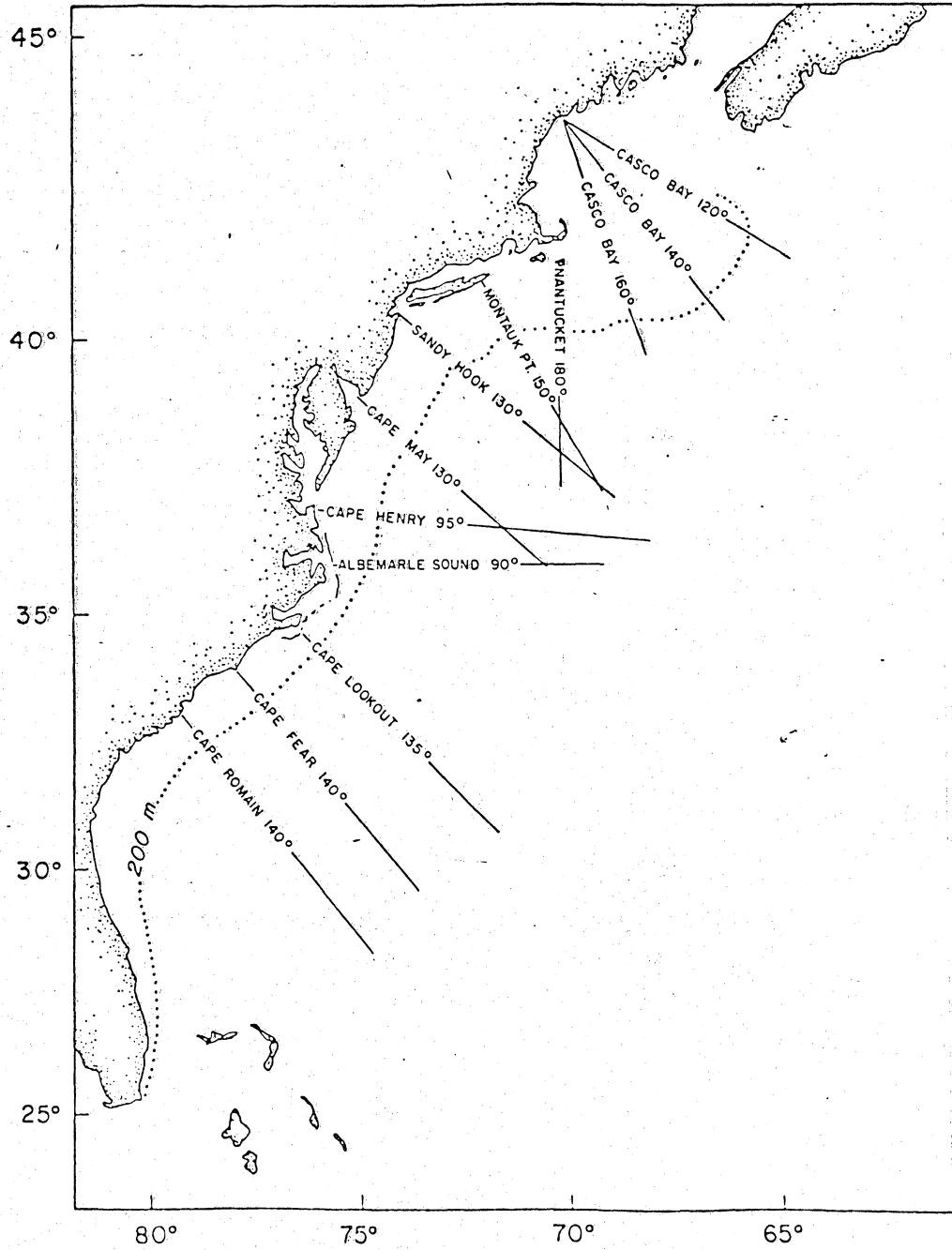


Figure 1. Reference points and bearing lines used to portray variation in position of the shelf water front relative to the 200-m isobath (dotted line). The degrees are azimuths of the lines.

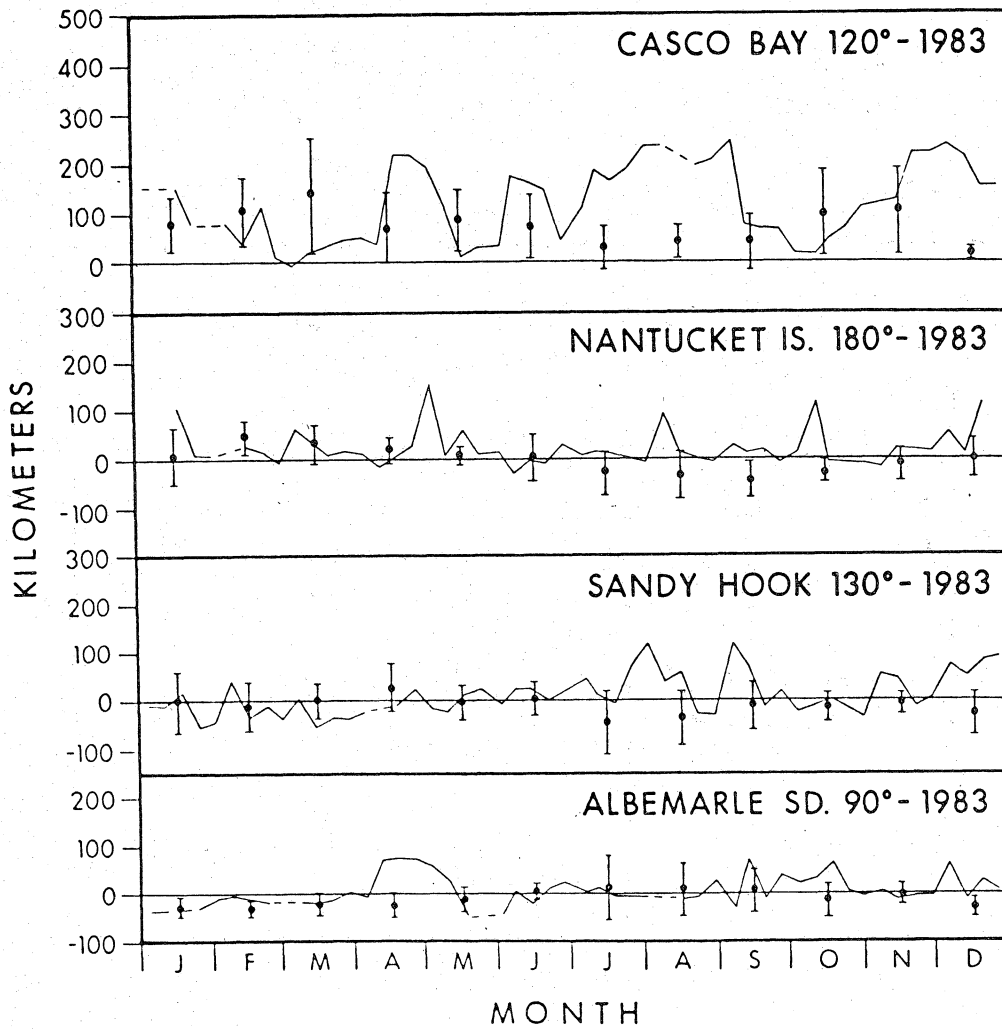


Figure 2. Shelf water frontal positions in 1983 relative to the 200-m isobath (positive is seaward) on selected bearing lines. Dotted lines indicate gaps in the data of two to four weeks. Mean monthly positions of the front are shown as dots with the vertical lines representing ± 1 standard deviation around the means for the base period June 1973 to December 1977.

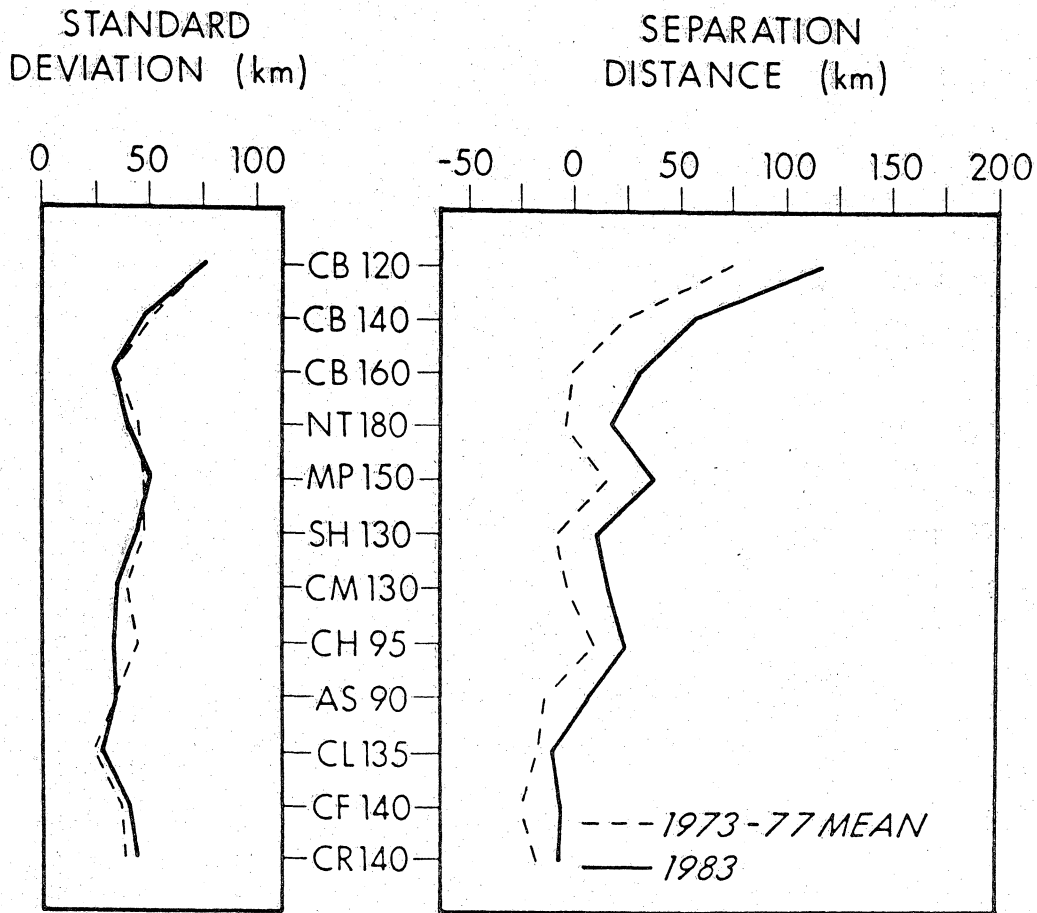


Figure 3. Mean positions of shelf water front, during 1983, relative to the 200-m isobath (positive is seaward) and standard deviations of weekly positions at each bearing line. Long-term means and standard deviations for the June 1973 to December 1977 base period are shown for comparison.