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Variation in the Shelf Water Front Position in 1978 from Georges Bank to Cape Romain

by

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The Shelf Water Front off the northeastern U.S. separates cooler, less saline shelf water from warmer, more saline slope waters that lie offshore. The surface position of the Shelf Water Front can usually be determined from thermal infrared imagery such as is available from Very High Resolution Radiometers (VHRR) in NOAA satellites. The NOAA National Environmental Satellite Service (NESS) interprets the VHRR satellite imagery and produces a weekly chart (Satellite Observed Gulf Stream Analysis), using the best image or a composite of several images.

The charts show the position of the Shelf Water Front and other oceanic features such as Gulf Stream position and Gulf Stream anticyclonic warm core eddies. The eddies, which move generally west and southwest in the slope water region off the New England and Middle Atlantic coasts, as well as Gulf Stream meanders in this region, sometimes cause short term fluctuations in the shelf water frontal position.

The Shelf Water Front locations were taken from the Gulf Stream Analysis, 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). Since the front is typically located near the shelf break, these distances were converted to departures of the front from the 200-m isobath along each bearing line.

Overall, 75% of the weekly determinations of frontal positions could be made along all twelve bearing lines in 1978. Approximately 80% of the missing determinations resulted from cloud interference and the remainder resulted from lack of contrast in the satellite imagery.

FRONTAL VARIATION ALONG SELECTED BEARING LINES

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 1978 (fig. 2). Long-term mean positions from June 1973 to December 1977 serve as a base for comparison of 1978 values.

Casco Bay (120°): The long-term mean positions (1973-77) 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 and least variable position of all in December. The December mean position may not be representative, however, because it is based on only 2 weekly positions, both from 1975.

Data were not available during January and February 1978, because of cloud cover. In early March, the front was more onshore than average, but moved offshore as the month progressed, and from April through June was much farther seaward than average. Two large excursions in May and June may have been related to the development of large amplitude meanders in the Gulf Stream off Georges Bank during this time. In early July the front moved shoreward, but remained seaward of the 1973-77 mean position until mid-October. This shoreward movement at least partly related to the presence of eddies. A large offshore excursion in September possibly related to offshore meandering of the Gulf Stream and the absence of eddies. From late October through December, the front was generally shoreward of the mean position, with the exception of a brief excursion in December. This excursion and a prior incursion paralleled meanderings of the Gulf Stream and the progression of an eddy.

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 inshore in September. Variability was less than half the magnitude on Casco Bay (120°), and more uniform, with maxima in the winter and summer.

The position of the front in early 1978 was close to the 1973-77 mean, but progressed offshore far beyond the normal position through April. The front returned to near the mean position by June and remained close to it through December, although mostly on the offshore side. Westward moving eddies in the area may have kept the front in the proximity of the 1973-77 mean position during the latter half of the year. Frontal incursions in July and October coincided with the presence of eddies.

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 to 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 the winter and summer is a common characteristic of the Sandy Hook (130°) and Nantucket (180°) lines.

In 1978 data were not available along this bearing line in January and August, because of cloud cover. During most of February, the front was close to the 1973-77 mean position, because of the presence of an eddy on the line, but exhibited a large offshore excursion late in the month after the eddy moved to the south and was destroyed by a large Gulf Stream meander. In mid-March, the front briefly approached the 1973-77 mean position as slope water moved onto the line during passage of a Gulf Stream meander, but after that moved far seaward of the mean position from late March through July. A brief oscillation in the frontal position was indicated in July. From September till December the Shelf Water Front was close to the mean position. A small incursion in November was followed by a large excursion in December. The incursion and the following excursion from the 200-m isobath were evidently related to the approach of an eddy and its subsequent rapid passage to the southwest.

Albemarle Sound (90°): On this bearing line, near Cape Hatteras, the long-term monthly means show an annual cycle that is rather opposite to what has been found for the bearing lines to the north, and has 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, increases greatly in July, and diminishes gradually during the rest of the year. Because the Gulf Stream is normally close to the continental slope in the vicinity of this bearing line, large fluctuations in the position of the shelf front do not normally occur.

Throughout 1978, the position of the front remained close to the 1973-77 mean position as compared to positions on the other lines. However, the front was displaced distinctly seaward of the mean positions from March through July. No eddies occurred in the vicinity of the bearing line. In late October and early November, however, a remnant of warm water from a disrupted Gulf Stream eddy caused a small incursion of the front from the 200-m isobath. Data were not available for August and early September, because of cloud cover.

YEARLY MEAN

In general, the 1978 mean shelf water positions followed the geographical trend of the 1973-77 mean positions, but were displaced farther seaward than average along all bearing lines, and much farther along the lines north of Cape Henry (fig. 3). The 1978 mean frontal positions ranged from 10 to 100 km seaward of the 1973-77 mean positions. The actual extent of the frontal displacement during 1978 is subdued in the annual mean because the seaward displacement on most of the lines occurred principally in the spring and summer months and recurred at the end of the year.

Variability of the frontal position in 1978, as measured by the standard deviation, was greater than during the base period from the Cape Henry line northward. However, the variability was no different from that of the base period from the Albemarle Sound line southward.

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. During 1978, the frontal position generally followed this annual cycle. However, for the waters north of Cape Henry, it was distinctly further offshore than normal, from March through June. Except for brief periods, the front was near normal position for most of the remainder of the year. Chamberlin (1978) has considered that this extensive offshore excursion of the front during the spring and summer of 1978 may have resulted from increased advection of shelf water from the east. Another contributing factor in the offshore excursion of shelf water may have been the total absence of Gulf Stream warm core eddies off the northeastern United States during March and early April, and absence off the Middle Atlantic coast from March to July, as reported by Celone and Chamberlin (Ms).

REFERENCES

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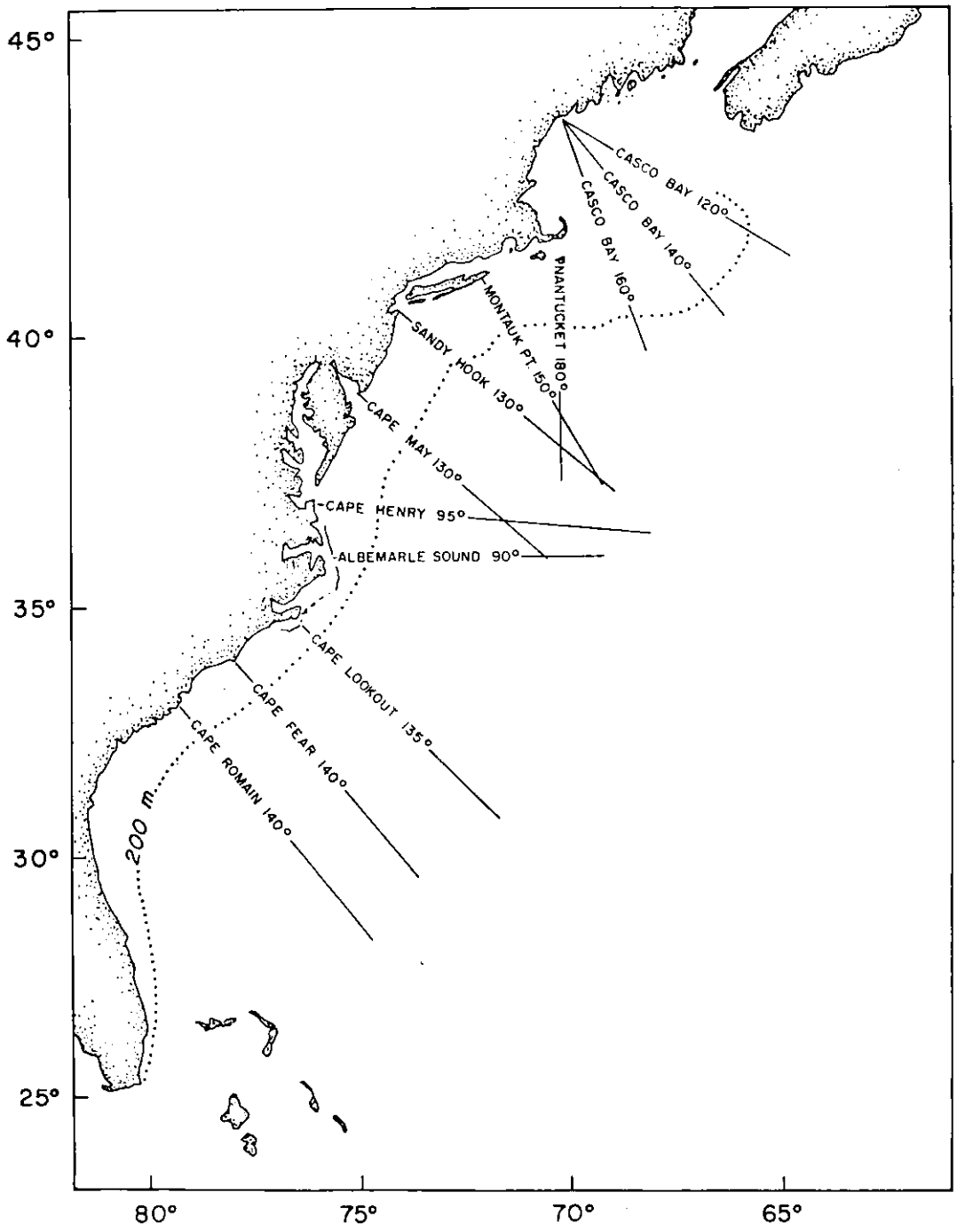

Fig. 1. Reference points and bearing lines used to portray variation in position of the Shelf Water Front relative to the 200-m isobath (dotted line). The degrees are azimuths of the lines.

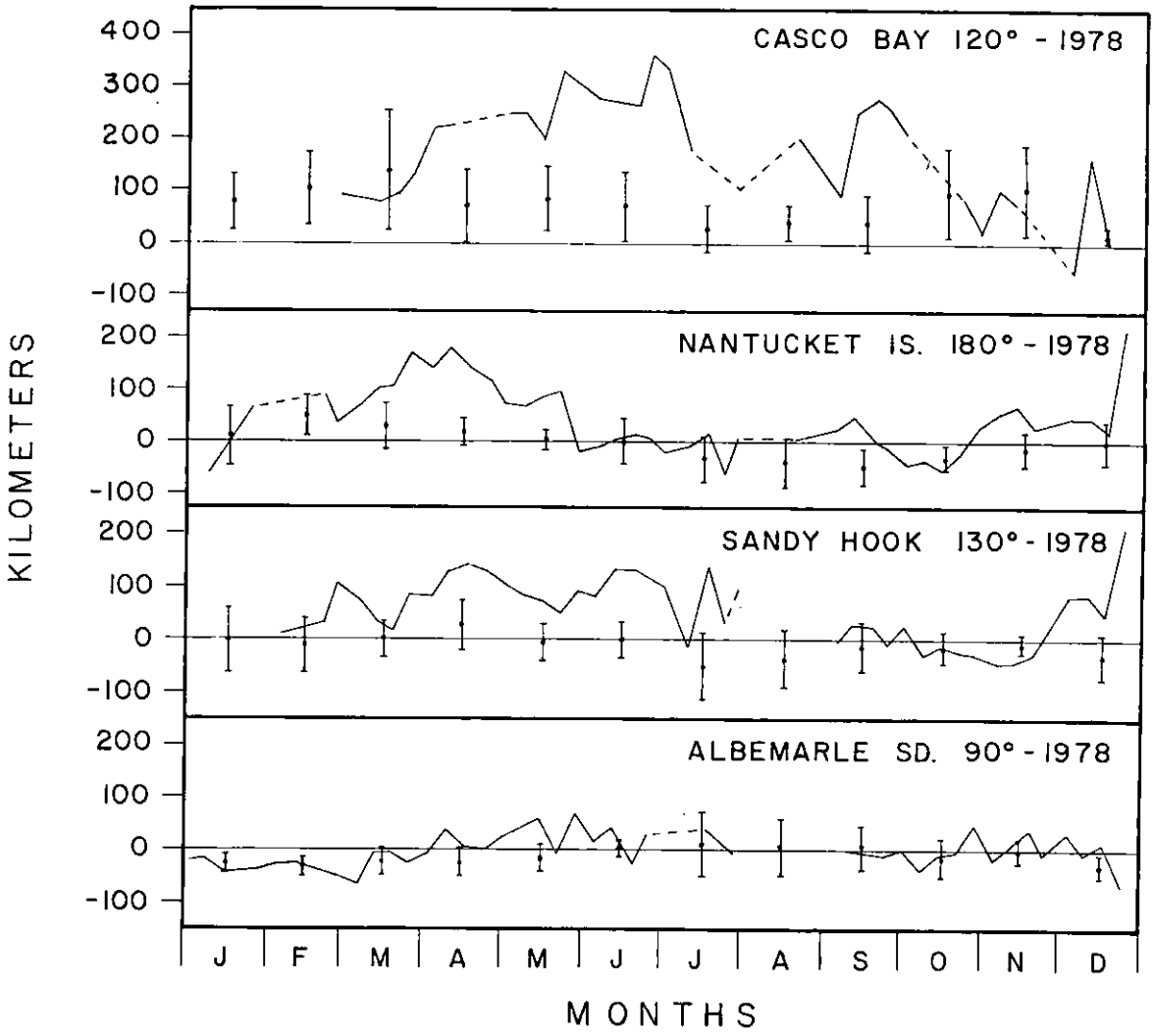

Fig. 2. Shelf water frontal positions in 1978 relative to the 200-m isobath (positive is seaward) on selected bearing lines. Dotted lines indicate gaps in the data of 2 to 4 weeks. Breaks in lines indicate gaps greater than a month. Mean monthly positions of the front are shown as dots with the vertical lines representing 2 standard deviations around the means for the base period June 1973 to December 1977.

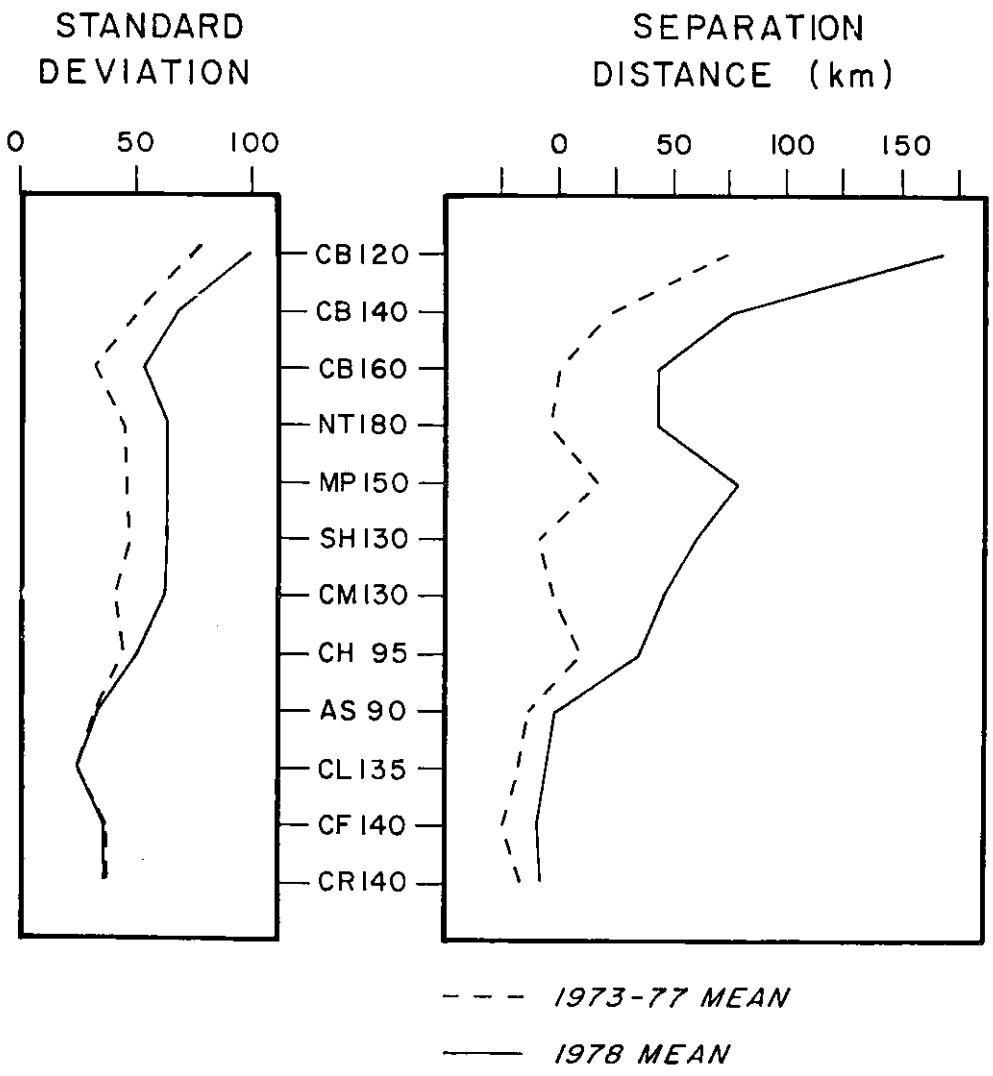

Fig. 3. Mean position of Shelf Water Front, during 1978, relative to the 200-m isobath (positive is seaward) and standard deviations of weekly positions at each bearing line. Long-term means and standard deviations for the June 1973 to December 1977 base period are shown for comparison.