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Variation in the Shelf Water Front Position in 1980 from Georges Bank to Cape Romain

by

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The shelf water front along eastern North America is delineated by the zone between cooler, less saline shelf water and the 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) on NOAA satellites. Prior to June 1980 the NOAA National Environmental Satellite Service (NESS) interpreted the VHRR satellite imagery and produced a weekly chart (Satellite Observed Gulf Stream Analysis), using the best image or a composite of several images. Commencing with June a new chart (Oceanographic Analysis) was issued three times a week covering the region north of Cape Hatteras and twice a week for the region southward. The charts were constructed from a composite of imagery collected during the day prior to issuance and, as with the former charts, depicted the shelf water front and other oceanic features such as Gulf Stream position and warm core anticyclonic eddies.

To determine the position of the shelf water front along eastern North America, 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. 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.

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During 1980 frontal positions could be ascertained along the bearing lines for 76% 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 1980 (Fig. 2). Long-term mean positions from June 1973 to December 1977 serve as a base for comparison of 1980 values.

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 January and early February 1980 few data were available because of cloud cover. The formation of an eddy in late 1979 and its subsequent passage by early March coincide with the shoreward position of the front in February and its seaward progression until late March. In early April the front returned to a position more shoreward than average as the result of large-scale Gulf Stream meandering and eddy formation.

A moderate excursion persisted until mid-May and by early June the front was found near the 200 m isobath. The pattern of meandering and eddy formation continued throughout the summer months and combined with seasonal warming to locate the front at its most seaward position in late August. The front exhibited decreasing activity through late October when it was located about 80 km shoreward of the mean position. Cloud cover in November and December prevented frontal determinations until late December when the front was found well offshore of its normal position.

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

During January and early February 1980 cloud cover interfered with frontal determinations; however, one observation in January showed the front near its normal position. From mid-February to late September the front was generally seaward of the 200 m isobath. During this period the front showed little variability reaching its most offshore position, about 50 km, in April. Eddy activity was high throughout these months and an eddy largely accounted for the small incursion in early June. Contrary to the long-term trend the front remained seaward of the 200 m isobath during the summer months. By mid-October the front had reached its most shoreward location of -60 km. A Gulf Stream meander of more than 100 km initiated this incursion which persisted until the meander moved downstream. The front showed little variability in November and December while remaining close to the long-term mean position.

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.

Along this line in 1980 the front was again obscured by clouds in January and early February. A small excursion in late February, following the passage of an eddy, preceded a long period of low variability. From March to early August the front remained close to the 200 m isobath occasionally in opposition to the long-term mean. By mid-August the front had migrated well offshore and reached its most seaward location, approximately 145 km, by late September. This large excursion occurred when the Gulf Stream was particularly convoluted. Between October and the year's end there was an absence of eddies in the region and the front generally shifted seaward through a series of undulations.

Albemarle Sound (90°): On this bearing line, near Cape Hatteras, the long-term monthly means show an annual cycle that is almost opposite what

has been 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 slope in the vicinity of this bearing line, large fluctuations in the position of the shelf front do not normally occur.

The shelf water front generally remained close to the 1973-1977 mean position from January through mid-April, 1980 when a moderate excursion occurred. Because of insufficient thermal contrast the shelf water front could not be detected from late April to mid-September. However, the boundary between nearshore water and the Gulf Stream north wall was discernible and is denoted by the heavy line (Fig. 2). The Gulf Stream front reached its most seaward location in late May and began a steady shoreward march in late June until it reached its most onshore location in mid-July. Intermittent observations of the shelf water front obtained in September and October showed it more onshore than average. The advection and entrainment of shelf water near Cape Hatteras prevented shelf front determinations until late November. At this time the front was more seaward than average and remained so through late December.

Yearly mean: The 1980 mean shelf water positions closely followed the geographical trend of the 1973-1977 mean positions (Fig. 3). Frontal locations in 1980 resembled those observed in 1979, but were not displaced as far seaward along the Cape May and Cape Henry lines. The front was displaced farther seaward than normal along all bearing lines, ranging from 5 to 40 km beyond the 1973-1977 mean.

The shelf front positions along the Casco Bay lines and from Cape Henry southward showed normal to above normal variability as illustrated by the standard deviation (Fig. 3). In contrast, from Nantucket to Cape May the variability was below normal. Frontal variability, with two exceptions, was much less than that observed in 1979 from Albemarle Sound northward, but is comparable in magnitude with 1979 south of Albemarle Sound.

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.

The location of the shelf water front, along all lines, was relatively close to the long-term mean position during the first six months of the year. This was also a period of low variability. During the last six months of the year the front showed greater variability and was more seaward than normal along the lines north of Cape Henry. Short term perturbations of the shelf water front seem to be related to periods of eddy activity as reported by Fitzgerald and Chamberlin (MS 1981). Furthermore, large-scale Gulf Stream meanders often contributed to frontal displacements this year. It is noteworthy that, as in 1979, the front remained seaward of the long-term position. Ingham (MS 1981) reports sea-surface temperature anomalies comparable to 1979 possibly maintaining this general seaward departure of the front.

REFERENCES

Fitzgerald, J. L., and J. L. Chamberlin. MS 1981. Anticyclonic warm core Gulf Stream rings off the northeastern United States during 1980. NAFO SCR Doc. 81/IX/90, Serial No. N388.

Ingham, M. C., and D. R. McLain. MS 1981. Sea-surface temperatures in the Northwestern Atlantic Atlantic in 1980. NAFO SCR Doc. 81/IX/94, Serial No. N392.

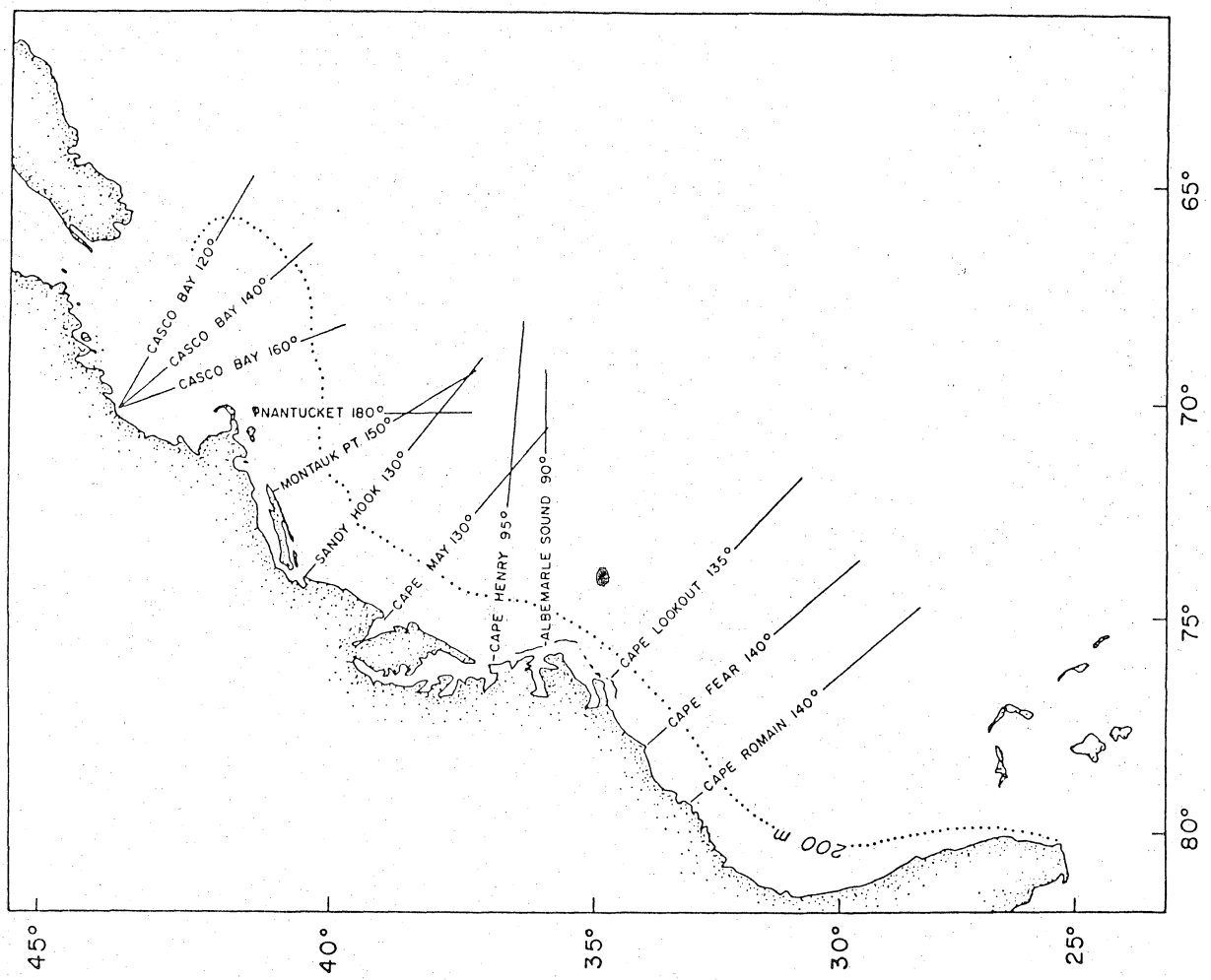

Figure 1. Reference Points and bearing lines used to portray variation in position of the shelf water front relative to the 200 m isobath (dotted line). The degrees are azimuths of the lines.

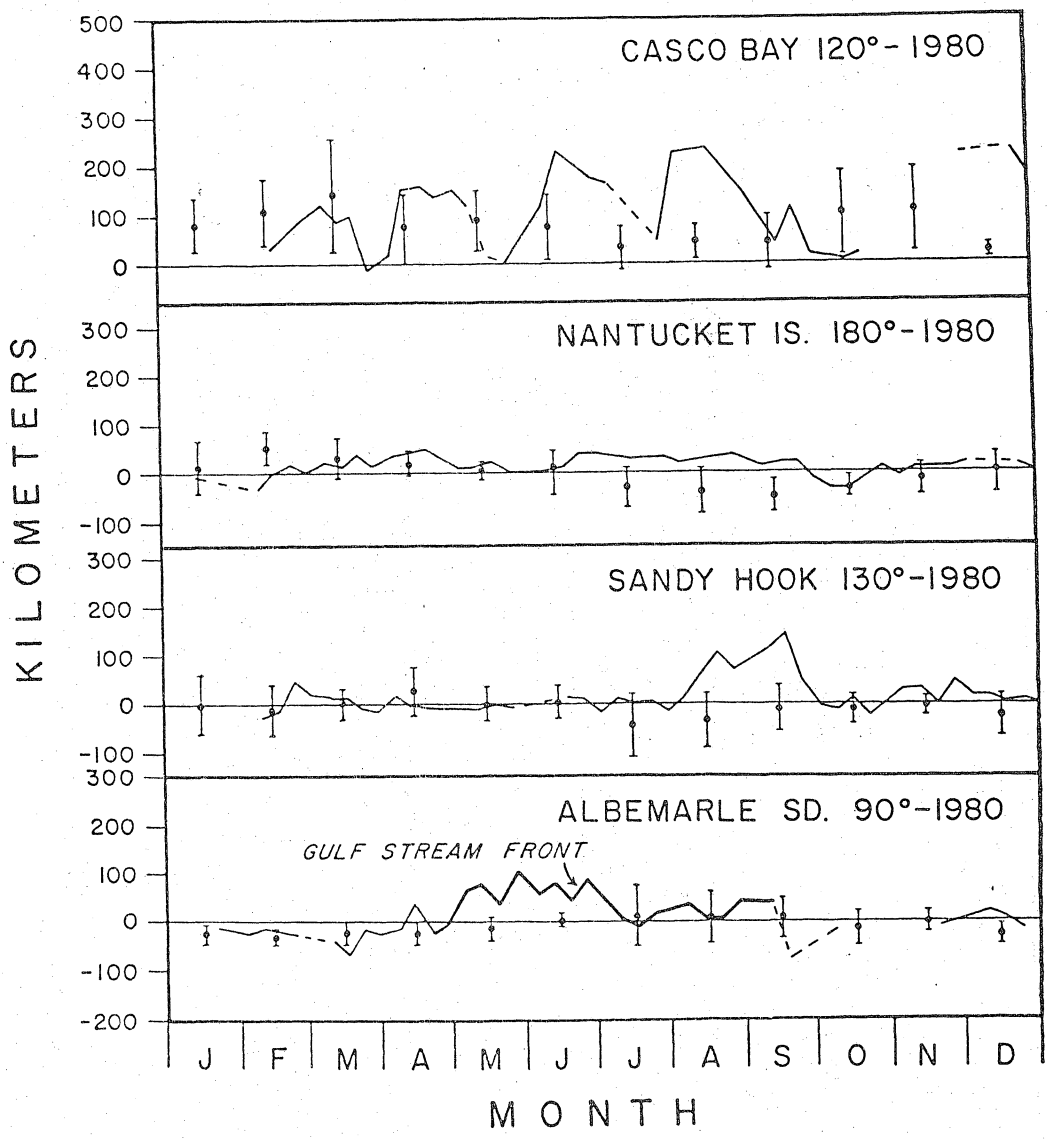

Figure 2. Shelf water frontal positions in 1980 relative to the 200 m isobath (positive is seaward) on selected bearing lines. Dotted lines indicate gaps greater than a month. Mean monthly positions of the front are shown as dots with the vertical lines representing 2 standard deviations around the means for the base period June 1973 to December 1977.

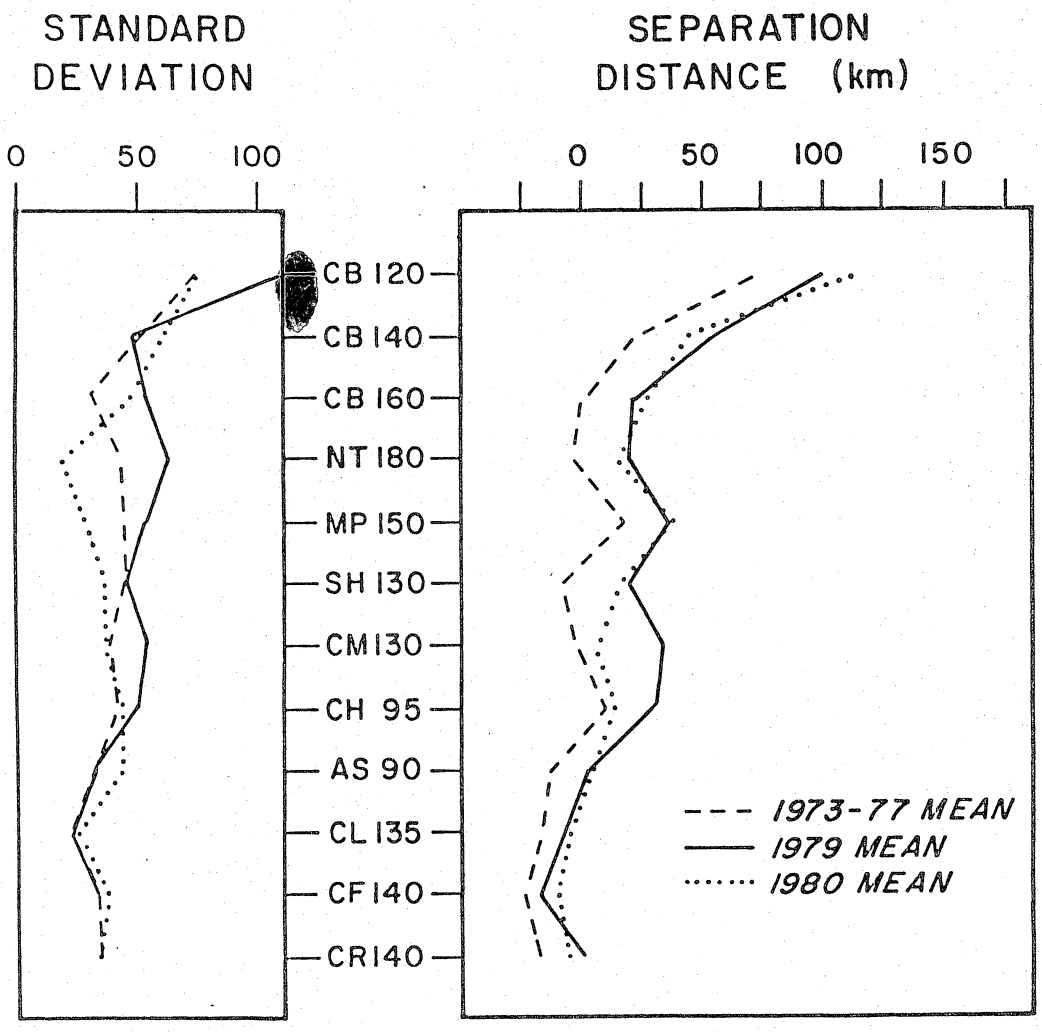

Figure 3. Mean positions of shelf water front, during 1980, relative to the 200 m isobath (positive is seaward) and standard deviations of weekly positions at each bearing line. Long-term means and standard deviations for the June 1973 to December 1977 base period and 1978 are shown for comparison.