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Variation in the Shelf Water Front Position in 1984 From Georges Bank to Cape Romain

by

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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 1984 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 1984 (Fig. 2). Long-term mean positions for the ten years, 1974-1983, serve as a base for comparison of 1984 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 (MS 1985).

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 1984, the passage of five warm core rings seemed to dominate the position of the shelf water front. From mid-November, 1983 through January, 1984 the front was offshore of its mean position in the wake of ring 83-F. With the approach of ring 84-A in mid-February, the front again shifted offshore and, by the end of February, the front was at the most seaward position for the year (almost 400km seaward of the 200-m isobath). From mid-March until mid-April the front was shoreward of the ten-year mean position under the influence of ring 84-A, and the front abruptly shifted offshore in late April in the wake of the ring. Ring 84-D approached the bearing line in early June, with the front shifting shoreward and, in the wake of the ring during late June, the front moved to more than 250km offshore of the 200-m isobath. With the formation of ring 84-F in early July along this bearing line, the shelf water front shifted shoreward to near the 200-m isobath. The front was under the influence of ring 84-F until early October, remaining shoreward of normal through mid-September, followed by an offshore excursion of almost 200km in the wake of the ring. From mid-November until the end

of the year, the shelf water front was shoreward of normal with the approach of ring 84-G. Only for about 25% of the year was the frontal position not under the influence of warm core rings. During these periods (in early February, during May into early June, in early July, and from mid-October through early November) the front was generally either near the ten-year mean positions, or shoreward of the mean positions.

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.

The shelf water front remained near the ten-year mean positions in 1984 except during late March until May, when the front was shoreward of normal. Only the weak remnants of two warm core rings reached this bearing line in 1984 (ring 83-F during early February and ring 84-E from late August through September). Neither ring seemed to have much influence on the psoition of the front. Extreme positions of the front, relative to the 200-m isobath, were in late October (46km shoreward) and at the end of the year (93km seaward).

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.

At the beginning of the year in 1984, the front was positioned about 50km offshore of the 200-m isobath, as the result of an offshore excursion that had begun in December, 1983. From February through mid-July, the shelf water front remained near the 200-m isobath, exhibiting only minor fluctuations in position. In mid-July, and lasting until the end of the month, shelf water extended well offshore, to more than 150km

offshore of the shelf break at the end of July. During that time, the western edge of warm core ring 84-E was located about 250km east of the bearing line, but was large enough to extend almost all the way from the Gulf Stream to the southern side of Georges Bank. The presence of this ring may have interrupted the normal southwestward flow of the slope water into the waters off the mid-Atlantic Bight, and led to the offshore excursion of the shelf water. During the latter half of July shelf water extended to about 100km offshore of the 200-m isobath along all bearing lines from Montauk Point (150°) line to the Cape Henry (95°) line. From early August until the last week of December, the front was generally positioned shoreward of normal and inshore of the 200-m isobath. At the end of the year the front was located about 40km offshore of the shelf break. No warm core rings were present along the bearing line in 1984.

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 20km 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 1984, the front was near the ten-year mean psoitions for most of the year, particularly from January through July. Offshore excursions of shelf water to more than 50km seaward of the 200-m isobath occurred during four episodes, in early August, early September, late October and late November, when slope water was absent along the bearing line and shelf water extended to the edge of the Gulf Stream. In mid-December, the shelf water front was located about 50km shoreward of the shelf break. At that time, the Gulf Stream was shoreward of normal along the bearing line, with the shoreward side of the Stream only about 10km offshore of the 200-m isobath.

Yearly mean: The ten-year, annual mean positions of the shelf water front along the twelve bearing lines (Fig. 3) indicate that the front is

typically about 115km seaward of the 200-km 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 and, for the three bearing lines south of Cape Hatteras, the front is typically about 10-15km shoreward of the shelf break. 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 Cape Lookout 135° line.

The annual mean positions in 1984 closely followed the long-term means, except that the front was displaced shoreward of normal on the Sandy Hook 130° line, by about 15km, and by 10-15km along the three bearing lines south of Cape Hatteras.

Discussion: Based on the ten-year means (1974-1983), north and east of Cape Henry, the shelf water front is typically positioned in a more offshore location during the spring and in a more shoreward location during late summer and early fall. From Cape Romain to Cape Henry, the front is located more offshore during summer and is more shoreward during winter. In 1984, frontal positions generally followed the long-term annual cycle from the Casco Bay (160°) line to Albemarle Sound. Along the two easternmost bearing lines off eastern Georges Bank, the location of the front seemed to be dominated by the effects from five warm core rings. No seasonal pattern was evident for the frontal position along the three bearing lines south of Cape Hatteras, from Cape Lookout to Cape Romain.

References

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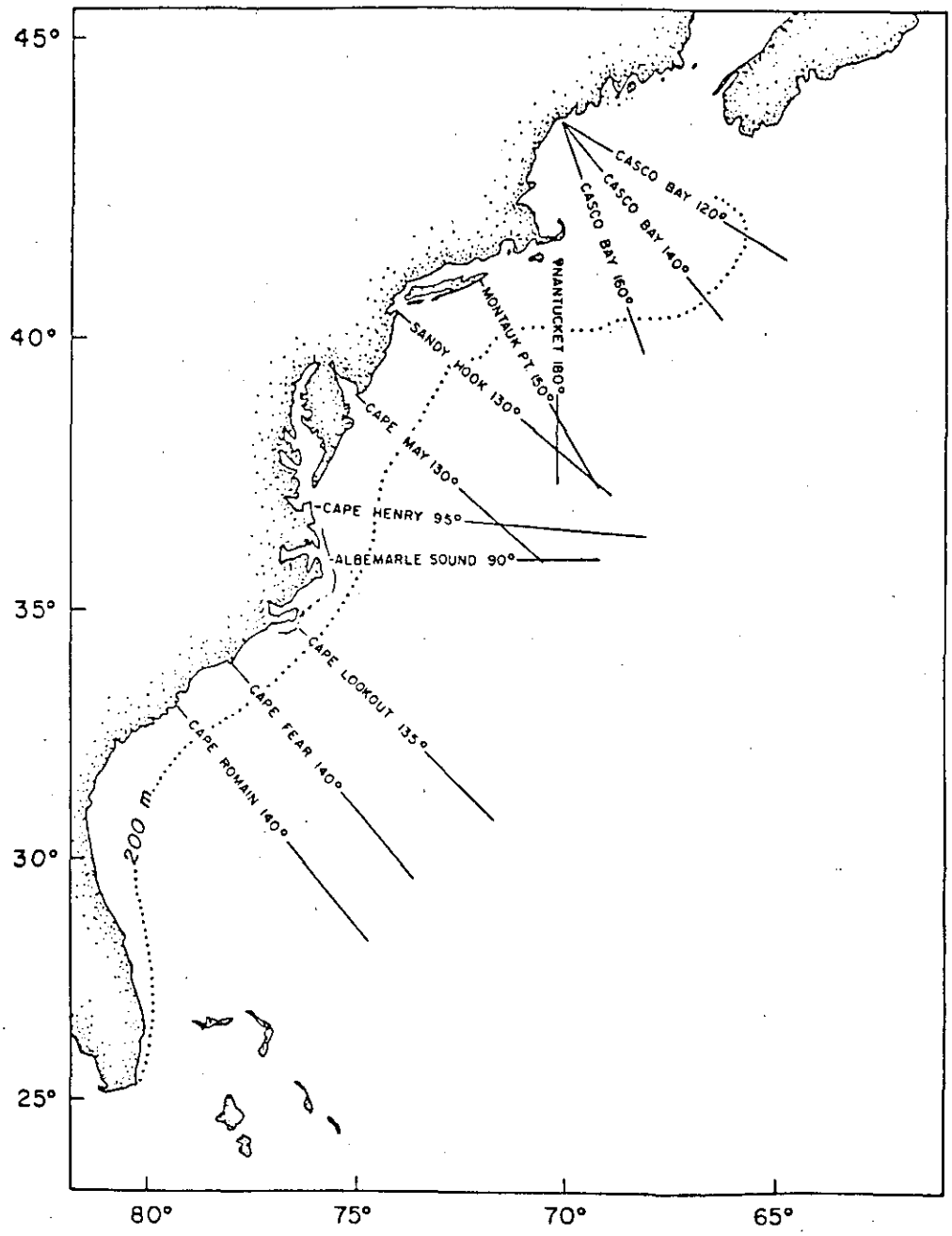

Figure 1. Reference points and bearing lines used to portray variation in position of the shelf water front relative to the 200-m isobath (dotted line). The degrees are azimuths of the lines

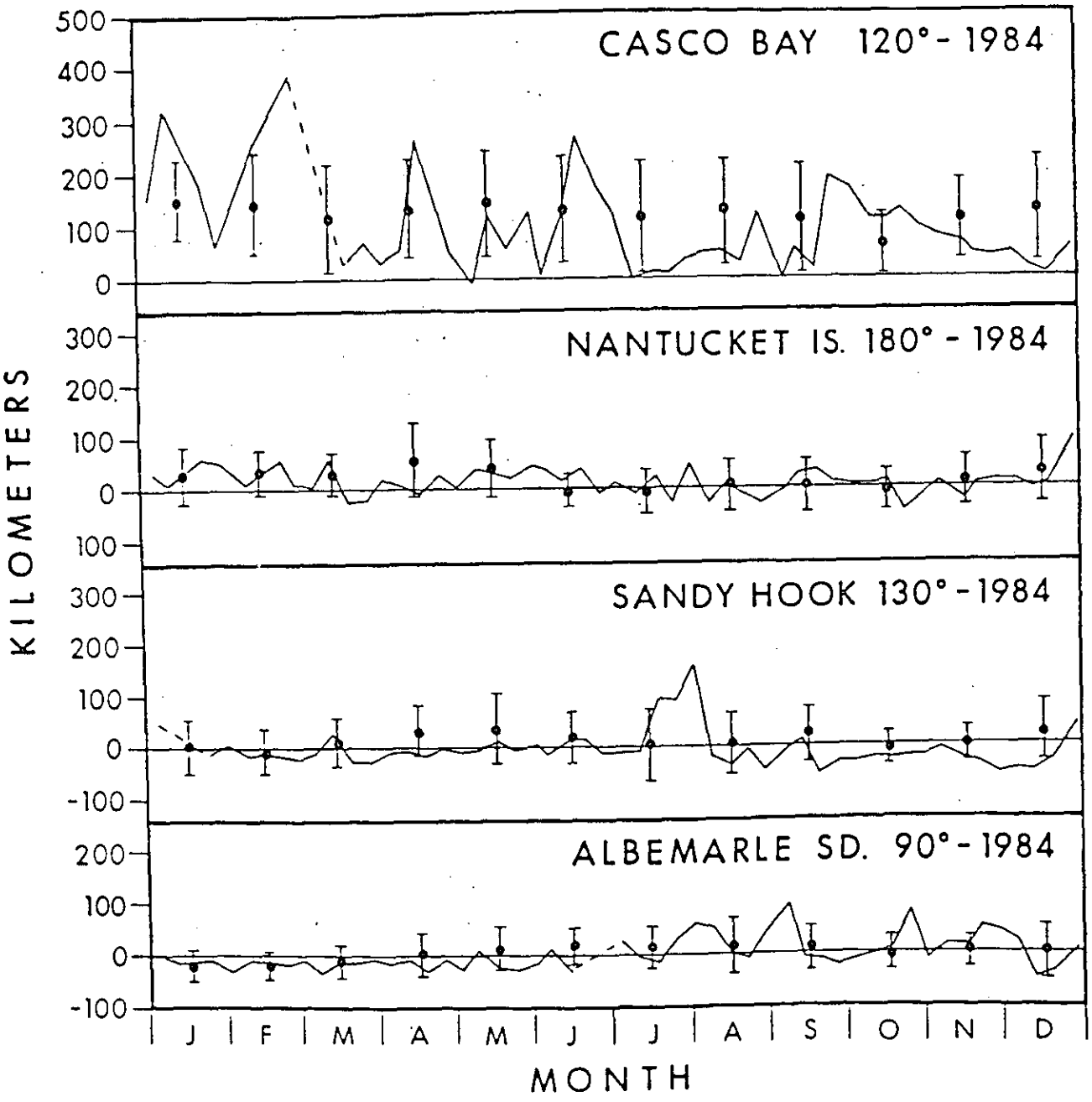

Figure 2. Shelf water frontal positions in 1984 relative to the 200-m isobath (positive is seaward) on selected bearing lines. Dashed lines indicate gaps in the data of two to four weeks. Ten-year (1974-1983) mean monthly positions of the front are shown as dots with the vertical lines representing ±1 standard deviation around the means.

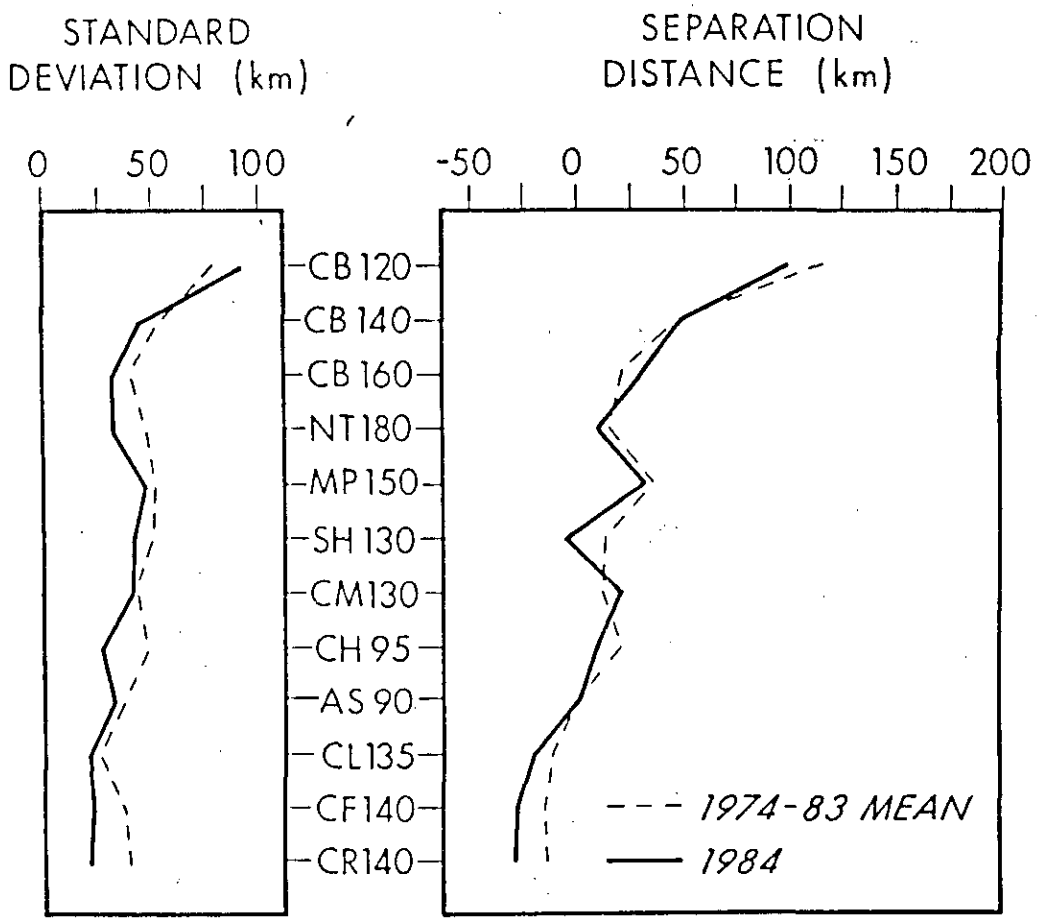

Figure 3. Mean positions of shelf water front, during 1984, relative to the 200-m isobath (positive is seaward) and standard deviations of weekly positions at each bearing line. Long-term means and standard deviations for the 1974-1983 base period are shown for comparison.