Northwest Atlantic Fisheries Organization

Serial No. N660

NAFO SCR Doc. 83/VI/12

SCIENTIFIC COUNCIL MEETING - JUNE 1983

Variation in the Shelf Water Front Position in 1982 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 Very High Resolution Radiometers (VHRR) on NOAA satellites. The NOAA National Earth Satellite Service (NESS) interprets the VHRR 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 1982 frontal positions could be ascertained along the bearing lines in 90% 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 Is-

land (180°), Sandy Hook (130°), and Albemarle Sound (90°) have been selected to show the fluctuations of the frontal position during 1982 (Fig. 2). Long-term mean positions from June 1973 to December 1977 serve as a base for comparison of 1982 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 Celone and Price (MS 1983).

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 1982, the shelf water front was located well offshore of the long-term mean positions for most of the year, and any seasonal pattern was obscured by the offshore excursions of shelf water. The position of the front seemed to be strongly influenced by the presence of three warm core rings. Of particular significance was ring 81-G which formed late in 1981 and followed an oscillating course through the slope water east and southeast of Georges Bank until about mid-September. Corresponding to the offshore directed flow in the wake of this ring, shelf water was drawn offshore at the beginning of the year and during May and again from mid-June until mid-September. During each of these episodes, the front was located more than 200 km seaward of the 200-m isobath. In advance of ring 81-G, in late March and late May through early June, the front shifted shoreward. In the wake of ring 82-A, which formed in January, the front shifted more than 300 km seaward of the 200-m isobath. As the ring progressed westward during February and March, the front gradually shifted shoreward toward the long-term mean position. In advance of the third ring affecting the front along this bearing line (ring 82-I), the front moved shoreward in November and then was drawn offshore in the ring's wake during December. Only during October did the front

seem not to be under the influence of a ring; and during that month was located near the long-term mean 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 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 long-term mean positions in 1982, except for three periods of offshore excursions. All of these exceptions resulted from entrainment of shelf water, with offshore movement of the front, in the wake of three warm core rings that moved through the area. With the passage of the first ring (82-B), the front shifted offshore about 200 km during April into May. In August, the second ring (82-D_1) caused entrainment to draw shelf water about 100 km seaward of the 200-m isobath; and in October, the third ring (82-G) moved relatively fast past the area and caused a brief offshore excursion of shelf water with the front being moved seaward a maximum of about 50 km from the 200-m isobath. The seasonal shift in the frontal position was less distinct in 1982 than appears in the long-term monthly means. Instead of being located shoreward of the 200-m isobath during summer and fall, the front remained near the shelf-break in 1982.

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.

During 1982 the front was located near the 200-m isobath and closely followed the long-term mean positions, except during four episodes of offshore displacements when the front was about, or more than, 100 km seaward of the 200-m isobath. Three of these episodes were associated with entrainment of shelf water in the wake of warm core rings (ring 81-F in March, ring 82-B in May to mid-June, and ring 82-D_1 from mid-August to mid-September).

The offshore excursion of the front in July could not be related to any dynamic condition apparent in the satellite imagery, but appeared as a lobe of shelf water extending offshore which slowly shifted southwestward, persisted for about a month, and covered an area of about 6500 km^2.

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.

During those months of 1982 when the shelf water front was discernible, it remained close to the 1973-1977 mean positions, except from mid-February through March, when imagery indicated that slope water was almost absent along the bearing line and shelf water nearly extended to the north wall of the Gulf Stream. Most of the fluctuations which occur in the frontal position seem to be in response to short-term, wave-like pulses in the Gulf Stream and involve complex interactions between the Gulf Stream and adjacent waters. For periods from July through September, the front could not be detected because of insufficient thermal contrast in the surface water. But during that time, the boundary between nearshore waters and the Gulf Stream north wall was discernible, and its position is shown by the heavy line in Figure 2 and labeled as the Gulf Stream Front.

Yearly mean: The mean positions of the shelf water front followed the general, geographic trend of the 1973-1977 means, but were displaced seaward of the long-term mean positions on all bearing lines except the southern-most line, off Cape Romain (Fig. 3). The 1982 mean frontal positions were typically 25 to 35 km seaward of the 1973-1977 means, with an extreme of 100 km seaward along the Casco Bay 120° bearing line.

Variability in the shelf water front positions was comparable to the long-term means 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 1982, frontal positions generally followed the seasonal pattern west of the Nantucket Island bearing line; but to the east, off Georges Bank, any seasonal pattern was overshadowed by offshore excursions of shelf water. Most of the departures from the 1973-1977 monthly mean positions corresponded to the passage of warm-core rings in the slope water.

References

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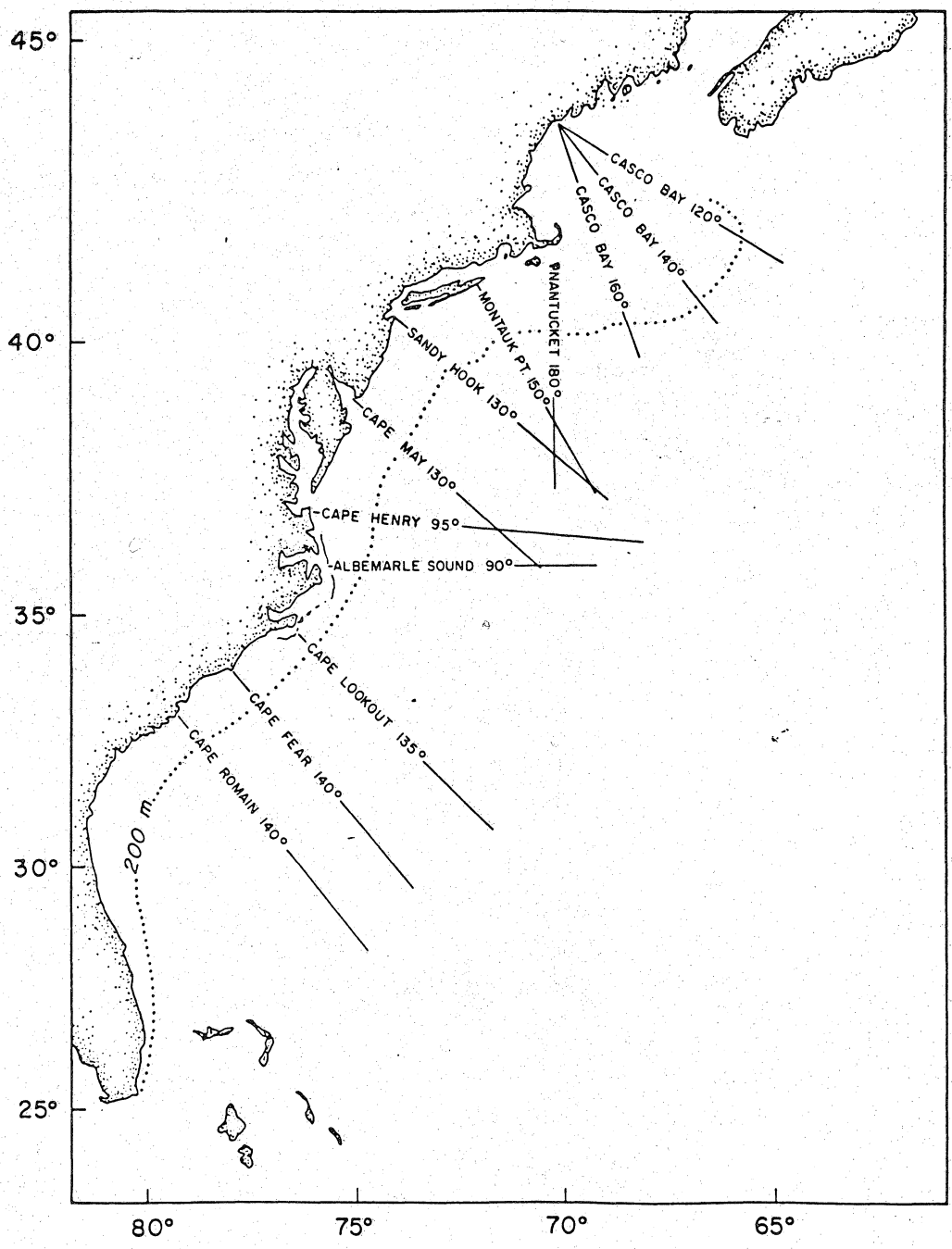

Figure 1. Reference points and bearing lines used to portray variation in position of the shelf water front relative to the 200-m isobath (dotted line). The degrees are azimuths of the lines.

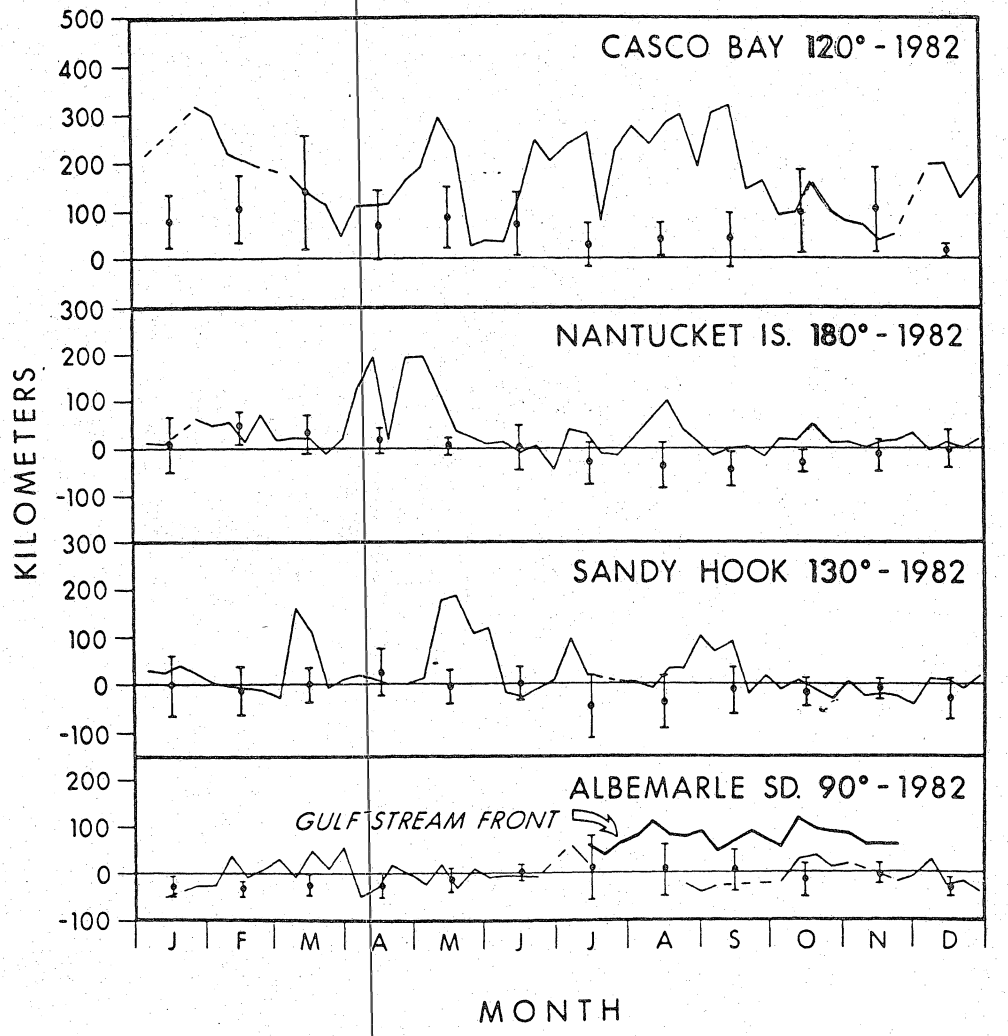

Figure 2. Shelf water frontal positions in 1982 relative to the 200-m isobath (positive is seaward) on selected bearing lines. Dotted lines indicate gaps in the data of two to four weeks and breaks in lines indicate gaps greater than a month. Mean monthly positions of the front are shown as dots with the vertical lines representing ±1 standard deviation around the means for the base period June 1973 to December 1977.

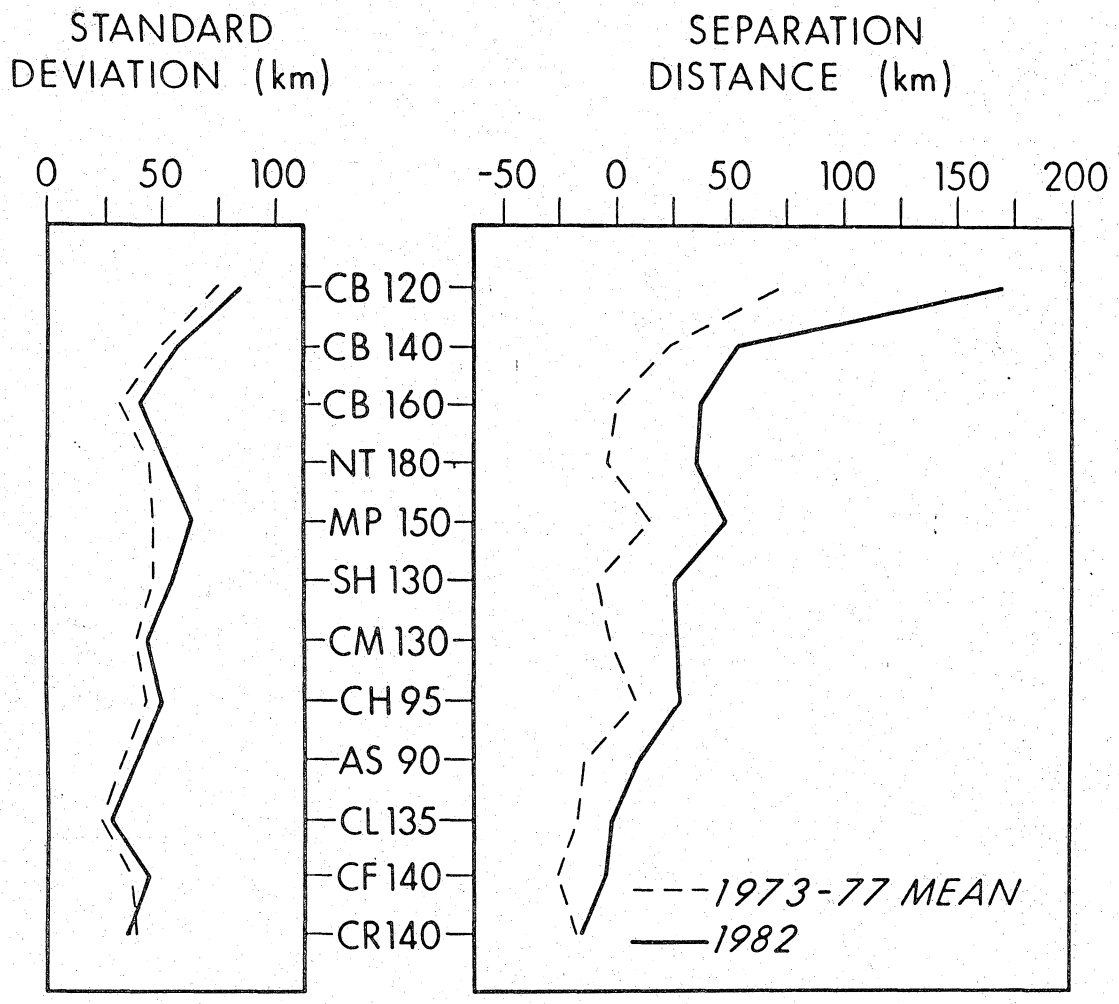

Figure 3. Mean positions of shelf water front, during 1982, relative to the 200-m isobath (positive is seaward) and standard deviations of weekly positions at each bearing line. Long-term means and standard deviations for the June 1973 to December 1977 base period are shown for comparison.