Northwest Atlantic Fisheries Organization

Serial No. N111

NAFO SCR Doc. 80/VI/65

SCIENTIFIC COUNCIL MEETING - JUNE 1980

Variation in the Shelf Water Front Position in 1979 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) 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 warm-core anticyclonic eddies. The movement of eddies and Gulf Stream meanders in the slope water off the New England and Middle Atlantic coasts often causes brief perturbations in the shelf water frontal position.

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.

Overall, 74% of the weekly determinations of frontal positions could be made along all twelve bearing lines in 1979. Approximately 86% of the missing determinations resulted from cloud interference, and the remainder

resulted from lack of 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 1979 (Fig. 2). Long-term mean positions from June 1973 to December 1977 serve as a base for comparison of 1979 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.

Because of cloud cover few data were available in January and February of 1979. In early March the front was at its most seaward location, well beyond the normal position, but moved shoreward until mid-April and occupied a position more onshore than average. These movements were consistent with the long-term trend, but were exaggerated as the result of Gulf Stream meandering and eddy activity in the region. From mid-April to mid-July the frontal position was variable exhibiting numerous short-term excursions. The formation and movement of an eddy between late May and early July combined with large amplitude Gulf Stream meanders common to this region may have had an influence on the frontal variability. A large excursion in late July was followed by a shoreward progression of the shelf water front. The front remained well shoreward of the 1973-1977 mean position until the end of the year with the exception of two moderate excursions in late November and in December. The large frontal excursion in late July coincided with meandering of the Gulf Stream. The excursions in November and December may have been related to the southwestward progression of two eddies in the slope water.

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.

In early 1979 the front was about 100 km beyond the normal position but progressed steadily shoreward to a position more onshore than average in late August. A large excursion in mid-May persisted for several weeks possibly due to the entrainment of slope water in front of a westward-moving eddy. From late August to the end of December the frontal position was variable. Contrary to the long-term trend the front exhibited a large excursion in September and reached the most offshore position of the year at this time. The front returned to a near normal position by mid-October but was well offshore in early November. Following this excursion a moderate incursion developed in early December, however, the front moved seaward and was in the vicinity of the normal position by the end of the month. The variability displayed by the shelf water front in the latter half of the year was apparently related to the movement of eddies through the area. Cloud cover in January and the lack of thermal contrast in August contributed to the loss of data during these months.

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.

The shelf water front was generally farther offshore than normal during the winter months of 1979. However, a moderate incursion did occur in early February, but was based on only one observation. From mid-March to mid-June the front moved from a position more than 100 km seaward of normal to the proximity of the 1973-1977 mean position. It is noteworthy that during April a lens of mixed shelf/slope water formed along this line, producing two distinct fronts, one bounding shelf water and the other delineating slope water with mixed shelf and slope water between (Fig. 2). However, seasonal warming in May evidently caused the formation of more slope water from this lens and the subsequent shoreward positioning of the front. Between mid-

June and mid-September the front remained seaward of the long-term mean position. Large variations, similar to those on the Nantucket (180°) line prevailed until the end of December. Two large excursions in early November and mid-December were preceded by moderate incursions, apparently as the result of the progression of eddies from the northeast. Once again, few data were obtained in the first two months of the year because of cloud cover and in August because of the lack of thermal contrast.

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.

In general, the shelf water front moved progressively seaward from January through mid-May in 1979. A moderate excursion in late January preceded the offshore march of the front. From mid-May to late September the thermal contrast along the line was not sufficient to discern the shelf water front, however, the boundary between the coastal water and the Gulf Stream north wall was apparent and is denoted by the heavy line (Fig. 2). During this period the minimum offshore departure of the Gulf Stream front occurred in June and the maximum in August. By late September the nearshore surface waters had cooled so that the shelf water front could again be delineated. From mid-September through the end of the year, the front was located near the 1973-1977 mean position. In October and November the shelf water front showed little variability and remained in the proximity of the normal position, but variability increased in December and two moderate incursions were followed by a large excursion at month's end.

Yearly mean: The 1979 mean shelf water positions generally followed the geographical trend of the 1973-1977 mean positions, but with the exceptions of the Albemarle Sound and Cape Romain lines were not displaced as far seaward as the extreme condition observed in 1978 (Fig. 3). In 1979,

the mean frontal positions ranged from about 10 to 40 km seaward of the normal positions and, as in 1978, the front was displaced farther seaward along all bearing lines.

Variability in the position of the shelf water front, depicted by the standard deviation (Fig. 3), indicates that the variability was near normal along the Casco Bay (140°) and Sandy Hook lines and from Albemarle Sound southward. However, the variability along the remaining lines was greater than normal and comparable in magnitude to those observed in 1978.

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 1978 the shelf water front was located further offshore than was the case in the other years of this record (1973-1979). In 1979 the front was typically further offshore than normal, but seemed to be returning to its more usual location. From Cape Henry northward, frontal variability during 1979 was greatest in the spring and fall months. South of Albemarle Sound the front generally followed the annual trend remaining close to the normal position throughout the year. Fitzgerald and Chamberlin (this volume) reported the presence of a large number of eddies off the northeastern United States, commencing in spring and continuing through late fall. This eddy activity may have been an influential factor in causing the shelf water front variability.

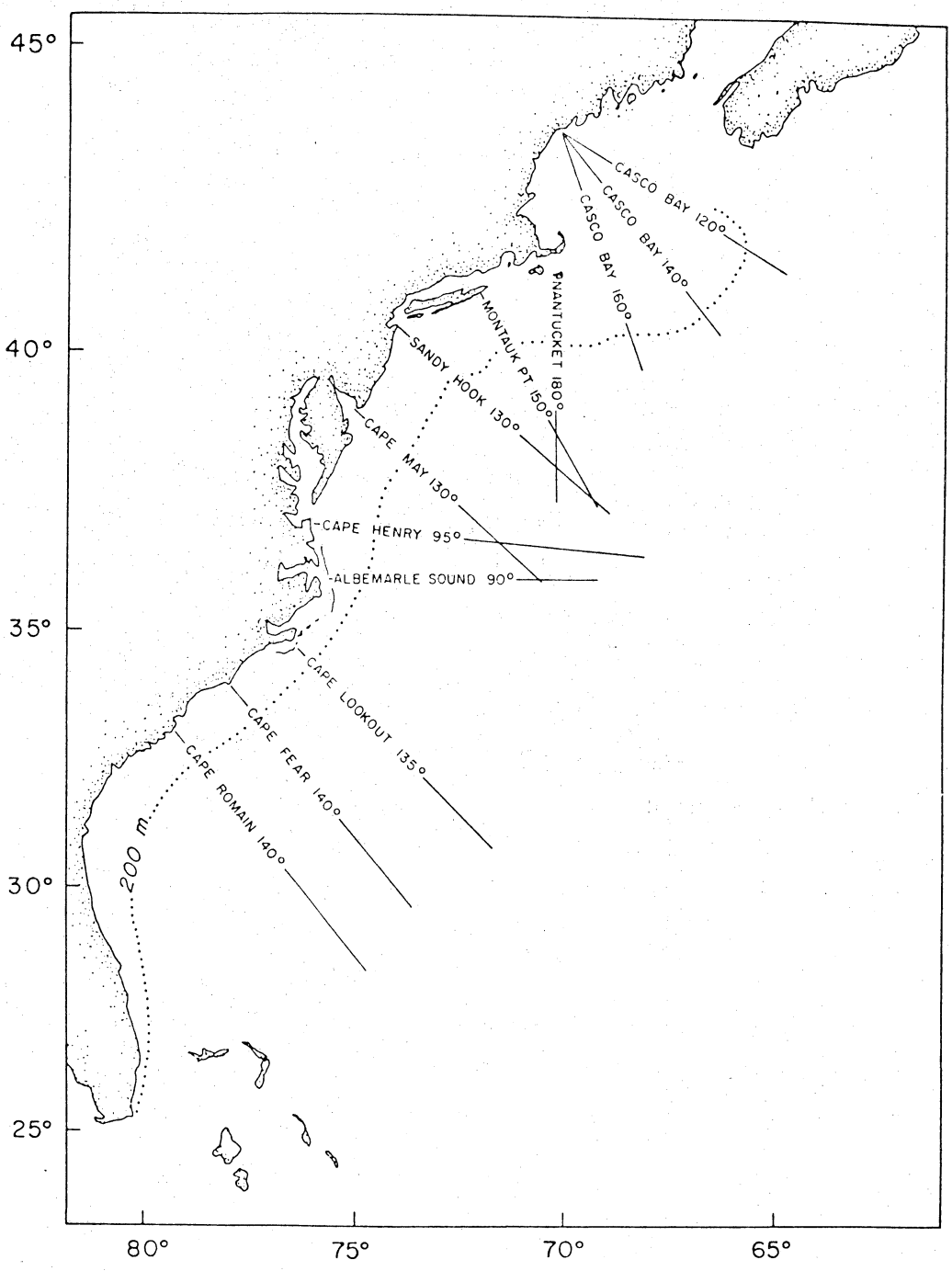

Figure 1. Reference Points and bearing lines used to portray variation in position of the shelf water front relative to the 200 m isobath (dotted line). The degrees are azimuths of the lines.

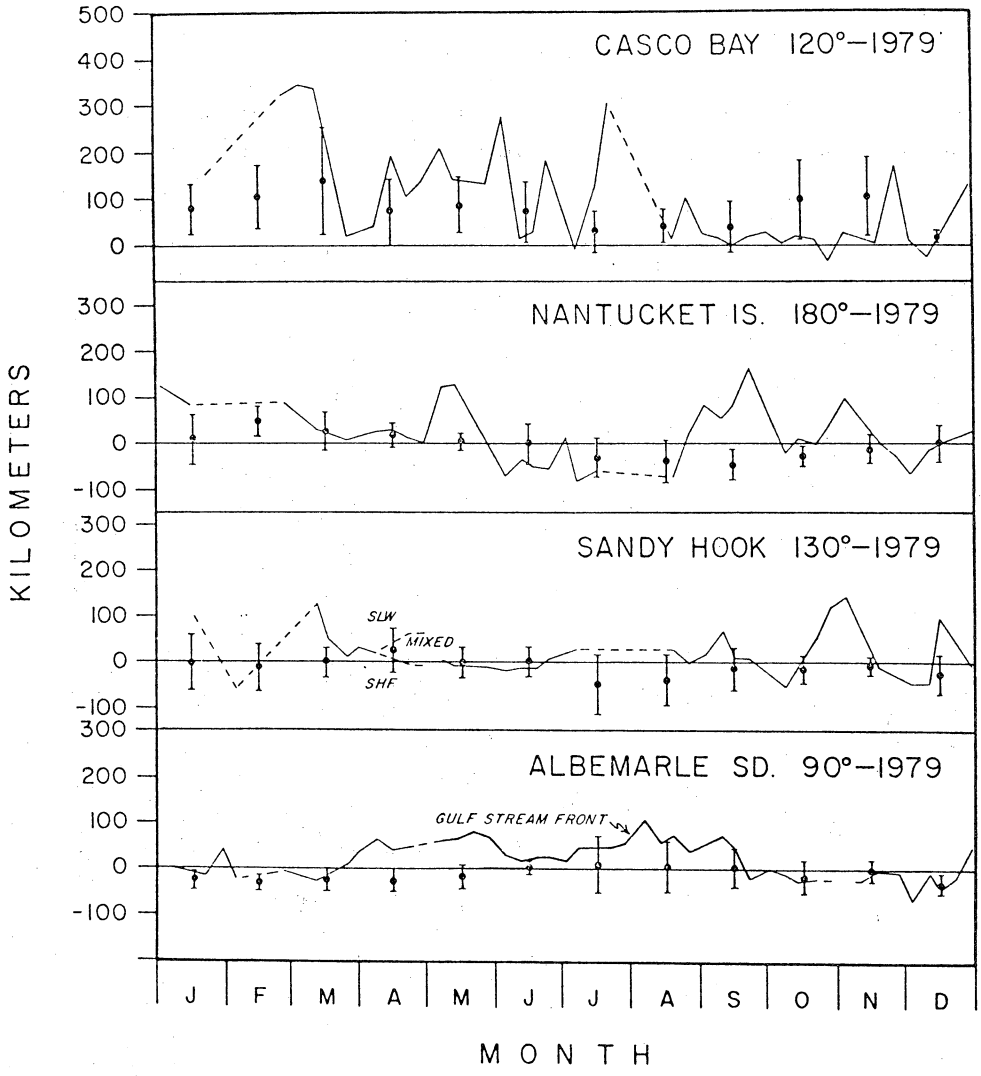

Figure 2. Shelf water frontal positions in 1979 relative to the 200 m isobath (positive is seaward) on selected bearing lines. Dotted lines indicate gaps greater than a month. Mean monthly positions of the front are shown as dots with the vertical lines representing 2 standard deviations around the means for the base period June 1973 to December 1977.

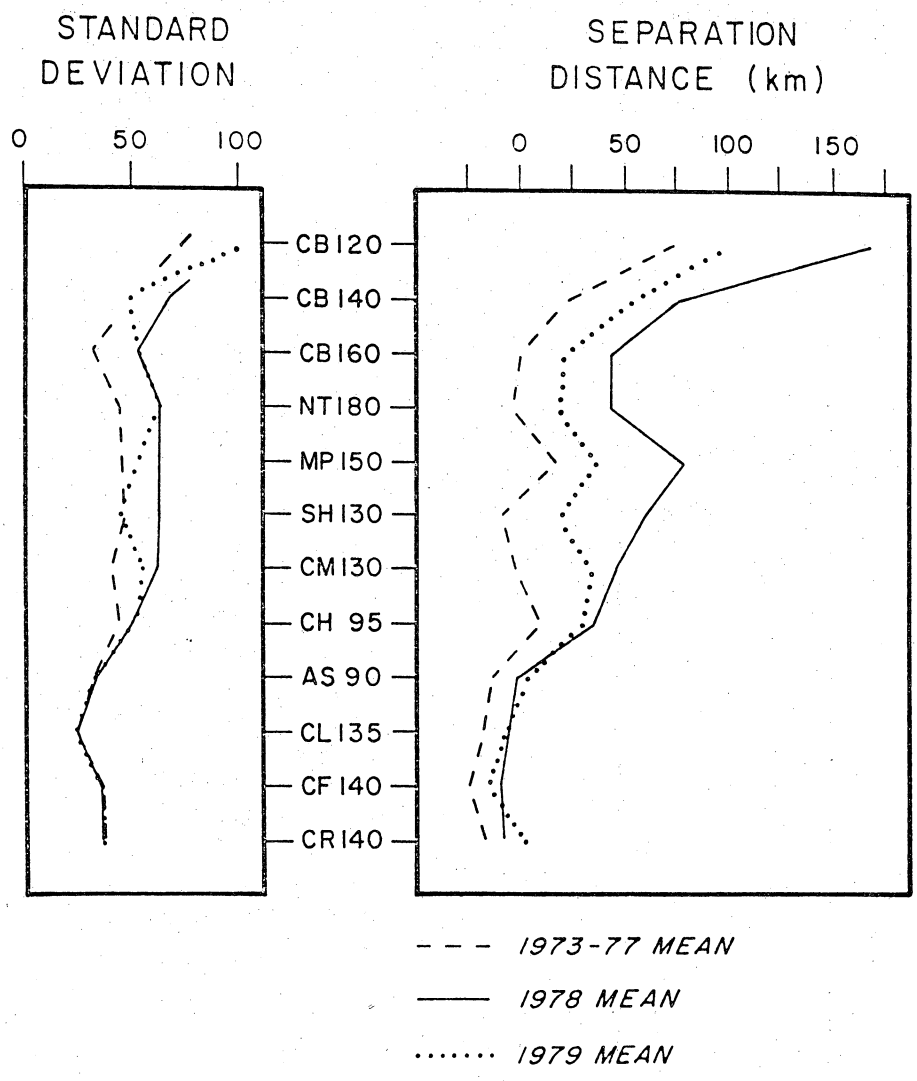

Figure 3. Mean positions of shelf water front, during 1979, relative to the 200 m isobath (positive is seaward) and standard deviations of weekly positions at each bearing line. Long-term means and standard deviations for the June 1973 to December 1977 base period and 1978 are shown for comparison.