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Anticyclonic Warm Core Gulf Stream Rings off the Northeastern United States During 1981

by

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This report summarizes for an eighth year, 1981, the movements of anticyclonic, warm core, Gulf Stream rings (eddies) in the slope water region off the New England and Mid-Atlantic coasts. Similar yearly analyses have been reported by Bisagni (1976) for 1974-75, Mizenko and Chamberlin (1979a, 1979b) for 1976 and 1977, Celone Chamberlin (1980) for 1978, and Fitzgerald and Chamberlin (1980, 1981) for 1979 and 1980.

Information Sources and Analysis Methods

The analysis is based primarily on the ring positions shown in the Oceanographic Analysis charts prepared by the NOAA National Weather Service and National Earth Satellite Service each Monday, Wednesday, and Friday. In addition, AVHRR infrared Satellite imagery from NOAA polar-orbiting satellites was received twice daily. Up to four infrared images per day were also received through much of the year from NOAA geostationary environmental satellites. The imagery was used to produce a single warm core ring analysis for each week, by modifying the above-mentioned frontal analysis charts. In weeks for which there was no clear satellite imagery, ring positions were interpolated and then adjusted in the end-of-year analysis.

Ring center positions, estimated by eye, are plotted and dated on the trackline charts. When ring positions were clearly seen in imagery as a result of (1) thermal contrast with surrounding slope water or (2) encircling bands of entrained colder shelf water or warmer Gulf Stream water, the center positions were plotted as closed circles (●) and dated with the day of observation. Less certain ring positions, estimated from

unclear imagery or questionable entrainment features, were plotted as triangles (Δ) and dated with the last day of the weekly compilation chart. Center positions estimated entirely by interpolation are plotted as open circles (o) and dated the same way as for the less certain positions.

Surface boundaries of rings are shown for the estimated date of ring formation and at representative stages in the life of the ring. These boundaries, interpreted directly from the satellite imagery and encompassing any entrainment features around the ring, involve unknown degrees of error. Surface thermal expressions of rings often have a distorted pattern, and shipboard observations have shown that the surface pattern may coincide imperfectly in both location and size with the boundary of the ring below the surface.

Only rings which occurred entirely west of 60°W during some portion of their lifetimes are considered in this analysis. Rings are labeled with the year when they formed, and alphabetically in the order of their formation.

Ring Histories

A total of nine warm core, Gulf Stream rings occurred off the northeastern United States during 1981. Two of them (80-F and 80-G) were formed during the last half of 1980 and survived into 1981. Of the eight rings that formed during 1981, two still existed at the end of the year. Table 1 lists estimated dates of ring formation and destruction, as well as their longevity in days.

Ring 80-F (Fig. 1) formed on 1 August at 40.2°N, 61.9°W about 250 km south of Western Bank on the Scotian Shelf as reported by Fitzgerald and Chamberlin (1981). It was centered south of Georges Bank at 39.8°N, 66.9°W on 5 January 1981. During 1981, the ring traveled southeast near the continental slope at a fairly uniform rate until resorbed by the Gulf Stream northeast of Cape Hatteras about 16 July 1981.

Ring 80-G (Fig. 2) formed south of Georges Bank (39.2°N, 68.6°W) on 11 October 1980 and was centered south of Cape Cod in January 1981 (Fitzgerald and Chamberlin (1981). After moving westward past 71°W longitude in late January, 80-G "stalled" for 2 months. In late March, the ring moved away from the outer continental shelf and traveled southwest through the slopewater. The ring was resorbed

east of the Delmarva Peninsula, near 37.9°N, 72.9°W about 19 Apr 1981.

Ring 80-H formed about 14 November 1980, centered at 39.0°N, 65.9°W and was reported to have carried over into 1981 (Fitzgerald and Chamberlin, 1981). The ring did not appear in satellite imagery after 28 December 1980, therefore, we now conclude that the ring was resorbed in early January 1981.

Fing 81-A (Fig. 3) formed about 19 January 1981 near 39.4°N, 63.7°W, south of the Scotian Shelf. The ring was pushed north by a large Gulf Stream meander in late January and resorbed by this same meander about 9 February 1981.

Ring 81-B (Fig. 4) formed about 9 March 1982 from the meander which resorbed 81-A. Following formation near 40.2°N, 62.2°W, south of the Scotian Shelf, the ring moved steadily west. During the third week of April a northward-tending Gulf Stream meander to the southwest of Ring 81-B commenced erosion of the ring. Continued growth of the meander and destruction of the ring was followed by disruption of the meander itself, by 23 April and then coalescence of meander and ring remnants to form ring 81-C by about 29 April.

Ring 81-C (Fig. 5) formed about 29 April, as described in the previous paragraph. The ring was initially centered near 39.1°N, 65.7°W, southeast of Georges Bank, and was of unusually large size (its greater diameter was >330 km from east to west and was double the lesser diameter from north to south). A Gulf Stream meander in late May partially resorbed the ring, reducing its initial large diameter. Ring 81-C subsequently moved west and southwest near the continental slope and was resorbed by the Gulf Stream on 9 November 1981, east of the mouth of the Chesapeake Bay (37.1°N, 74.2°W).

Ring 81-D (Fig. 6) originated from a Gulf Stream meander about 11 May 1981 near 40.1°N, 59.7°W, about 580 km south of Emerald Bank. After moving west, the ring apparently was pushed east by a large Gulf Stream meander. It was resorbed by this meander about 12 July 1981 near 40.0°N, 60.3°W, only about 60 km west of where it was formed.

Ring 81-E (Fig. 7) formed near 39.3°N, 62.5°W from a large Gulf Stream meander, on about 16 July 1981. By early November the ring was located about 150 km southeast of Georges Bank at 39.5°N, 66.1°W. The

ring became trapped between two large Gulf Stream meanders and was destroyed by 16 November. Satellite imagery was unusually poor during November and December as a result of cloud cover. Therefore, we are not certain of the actual fate of 81-E and the subsequent formation dates of 81-F and 81-G.

NOTE: Ring 81-E was mislabeled as 81-D in the weekly analysis charts prepared by this office during July-November 1981. The extensive warm core ring investigation aboard the RVs Endeavor, Knorr, Oceanus, and Albatross IV, during September and October 1980, was in the ring labeled 81-E in the present report.

Ring 81-F (Fig. 8) first appeared clearly in satellite imagery on 28 November 1981 near 38.8°N, 66.9°W, south of Georges Bank. We are uncertain, but estimate that it formed about 28 November 1981 from an extensive Gulf Stream meander located near 66.0°W. This ring moved rather rapidly west during December to near 39.3°N, 70.0°W, south of Georges Bank on 3 January 1982.

Ring 81-G (Fig. 9) apparently formed about 7 December 1981 from a large Gulf Stream meander centered 39.8°N, 62.5°W. On 4 January 1982 the ring was centered south of Emerald Bank at 40.2°N, 62.4°W.

Zonal Analysis

A generalized summary of the movements of rings relative to one another, during 1981, is presented in Table 2, which shows their mid-month positions with respect to the zones diagrammed in Figure 10. Total zone-month occurrence in this table is 29, one of the smallest totals in eight years of analysis (24, 35, 29, 45, 32, 43 and 50, respectively for the years 1974-1980). The hiatuses in the diagram on either side of the 81-B and 81-C sequence are, in part, a function of the large size of these rings. The rings were large enough to occupy zones adjacent to the one in which they were centered at any given time during their early months of occurrence. A large percentage (38%) of the 1981 ring-month totals were from persistent 1980 rings. This percentage is identical to the percentage of ring carry-over which occurred between 1979 and 1980 (Fitzgerald and Chamberlin, 1980, 1981). Composite Track Lines of Ring Center Positions and Envelope of Surface Boundaries.

Composite Track Lines of Ring Center Positions and Envelope of Surface Boundaries

A composite of tracklines of ring center positions, derived from Figures 1-9, and an envelope of ring surface boundaries appear in Figure 11. The envelope was composited from surface boundaries in weekly modified frontal analysis charts. The tracklines show that rings occurred either to the east or to the west of 66°W longitude during 1981. None which formed completely east of 66°W ever moved west of that median, concordantly, of course, all the rings that occurred west of 66°W formed west of 66°W. This "barrier" coincides with the New England Sea Mounts. Such a barrier, however, has been characteristic in regard to the region of the 60°W meridian, as illustrated by Ring 81-D (Fig. 6). Of the 65 rings which occurred off the northeast coast during 1974-1981, only 2 of those which formed east of 60°W entirely crossed the meridian.

Number of Rings, Times of Formation, and Longevity

During 1981, seven warm core Gulf Stream rings formed off the northeast coast of North America. In the previous seven years, ring production has usually been higher: 4, 8, 7, 9, 9, 11, and 8, respectively from 1974-1980 (Fitzgerald and Chamberlin, 1981). Two rings survived into 1982; they were long lived. Five of the seven 1981 rings formed before the end of July; the other two did not form until after mid-November and carried into 1982. Ring longevity of 1981 rings varied from 21 to 195 days.

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Table 1. Ring Formation, Destruction Dates, and Life Spans

Ring	Dates *	Life Span (Days)
80-F	8/1/80 - 7/16/81	352
80-G	10/11/80 - 4/19/81	190
81-A	1/19/81 - 2/9/81	21
81-B	(3/9/81)-(4/23/81)	45
81-C	(4/29/81)- 11/91/81	195
81-D	(5/11/81)- 7/12/81	62
81-E	7/16/81 - (11/9/81)	116
81-F	(11/28/81) - into 82	>33
81-G	(12/7/81)- into 82	>24

* Dates in parentheses could be off by greater than one week. Dates not in parentheses are accurate to within one week, and generally to within several days.

Table 2. Ring Positions at mid-month with respect to zone during 1981 (locations of zones in Figure 10)

	J	F	M	A	M	J	J	A	S	O	N	D
1.					81-D		81-D					
2.			81-B			81-D	81-E	81-E	81-E			81-G
3.	81-A			81-B						81-E		
4.	80-F				81-C	81-C						
5.	80-G	80-F	80-F				81-C	81-C				81-F
6.		80-G	80-G	80-F	80-F				81-C			
7.				80-G		80-F				81-C		
8.							80-F					

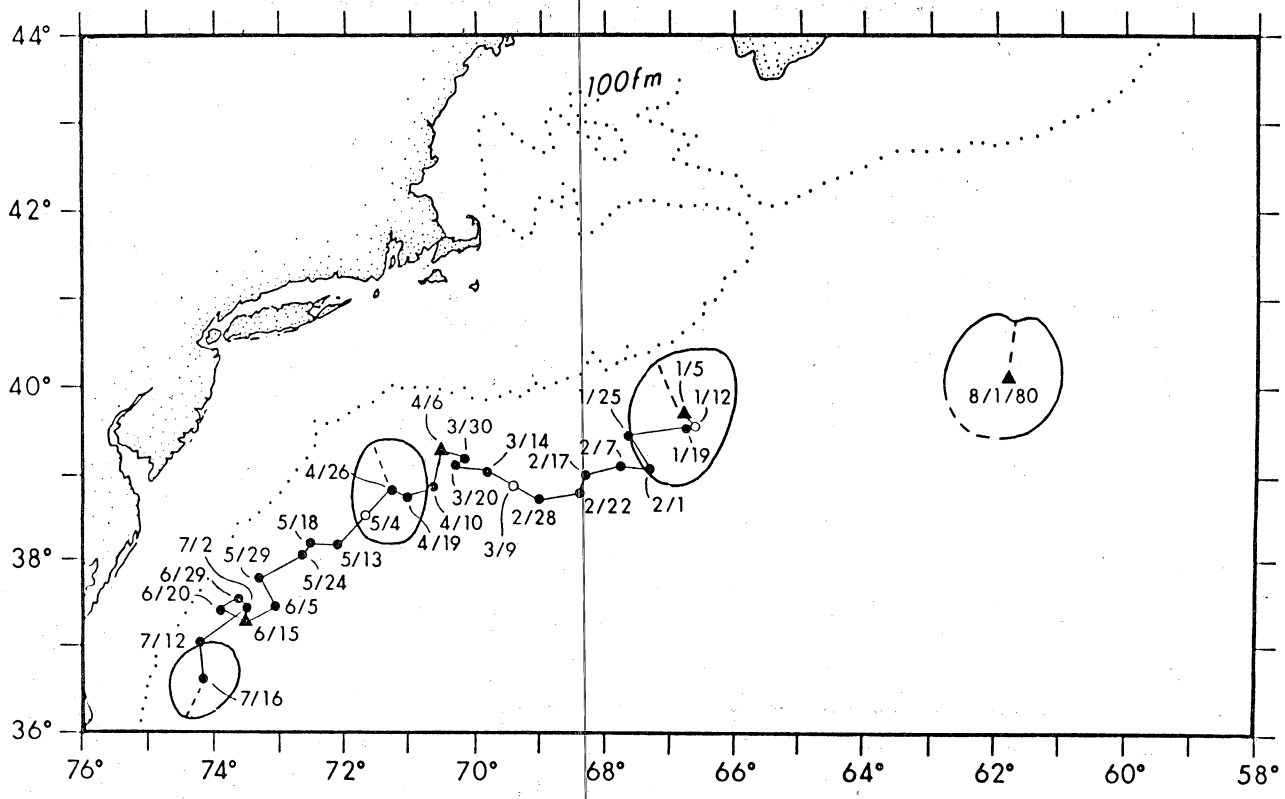

Figure 1. Trackline for Ring 80-F.

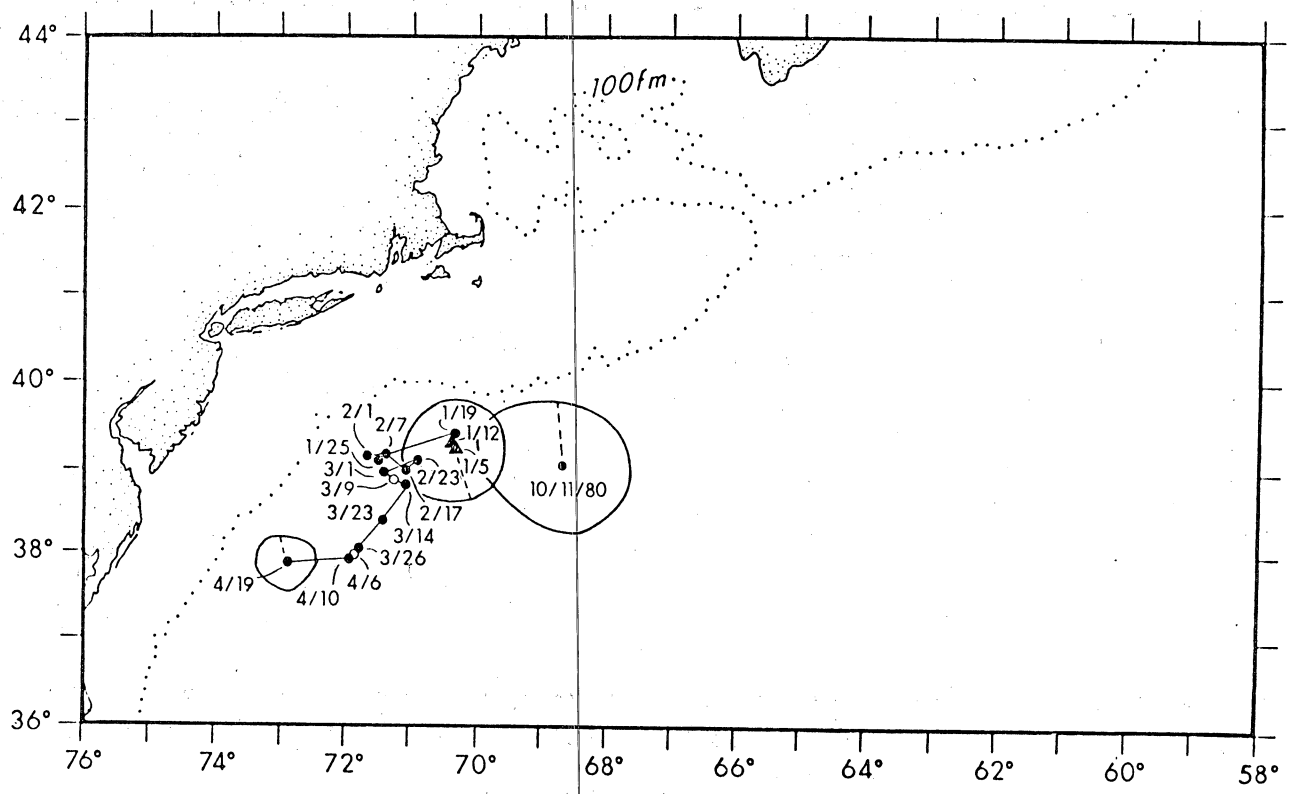

Figure 2. Trackline for Ring 80-G.

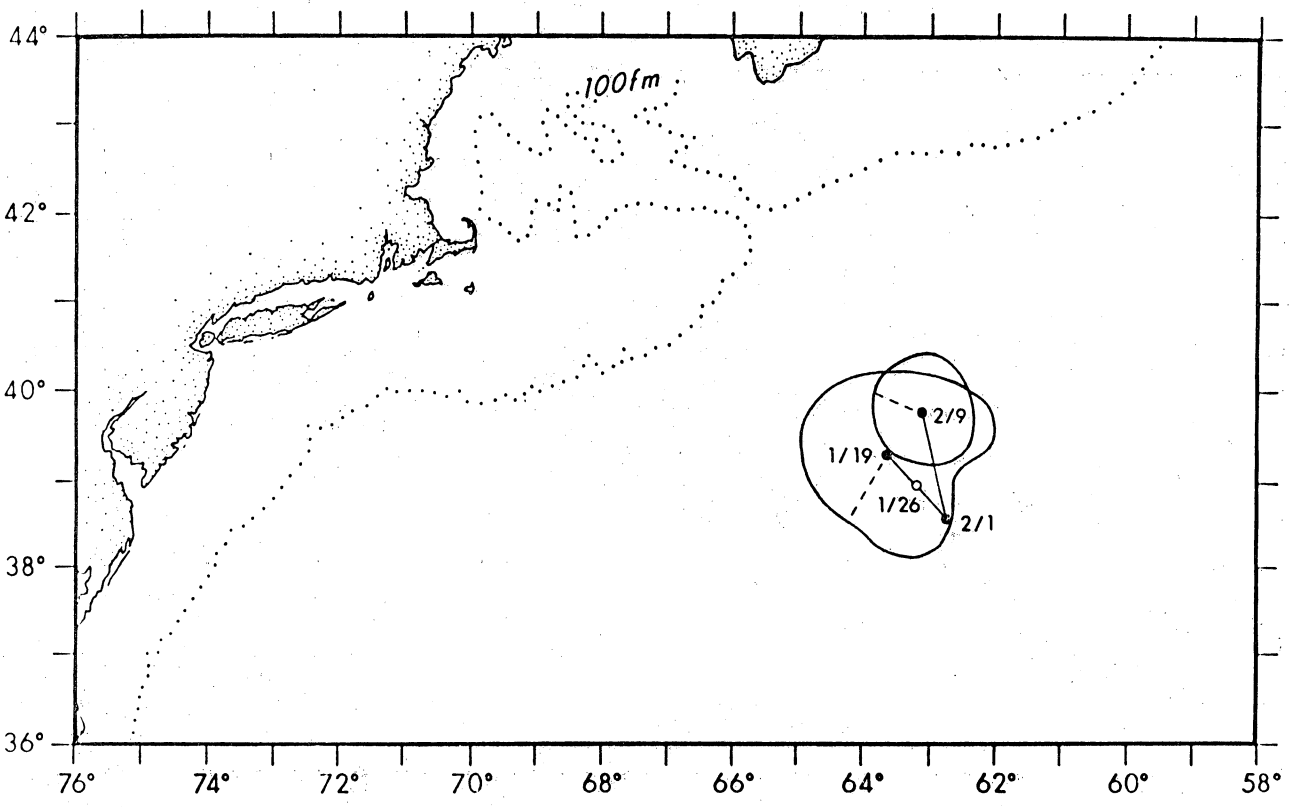

Figure 3. Trackline for Ring 81-A.

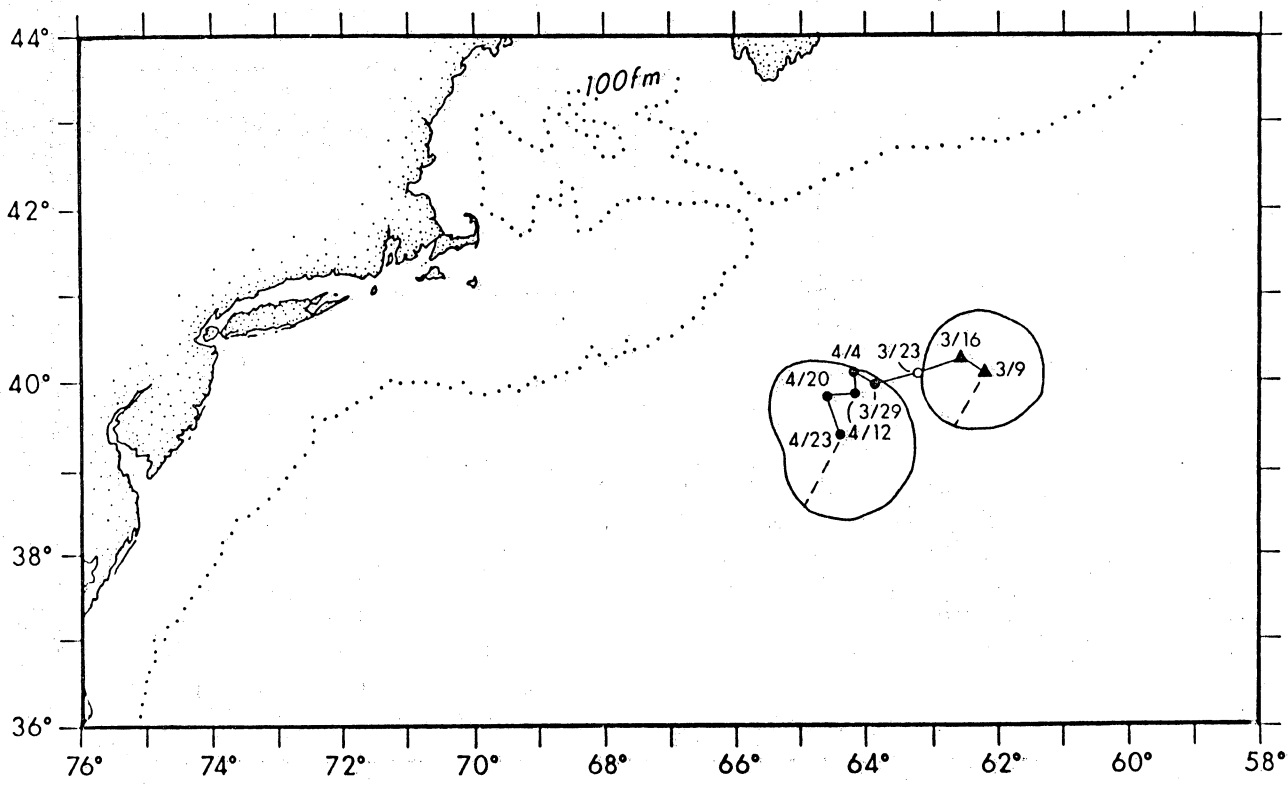

Figure 4. Trackline for Ring 81-B.

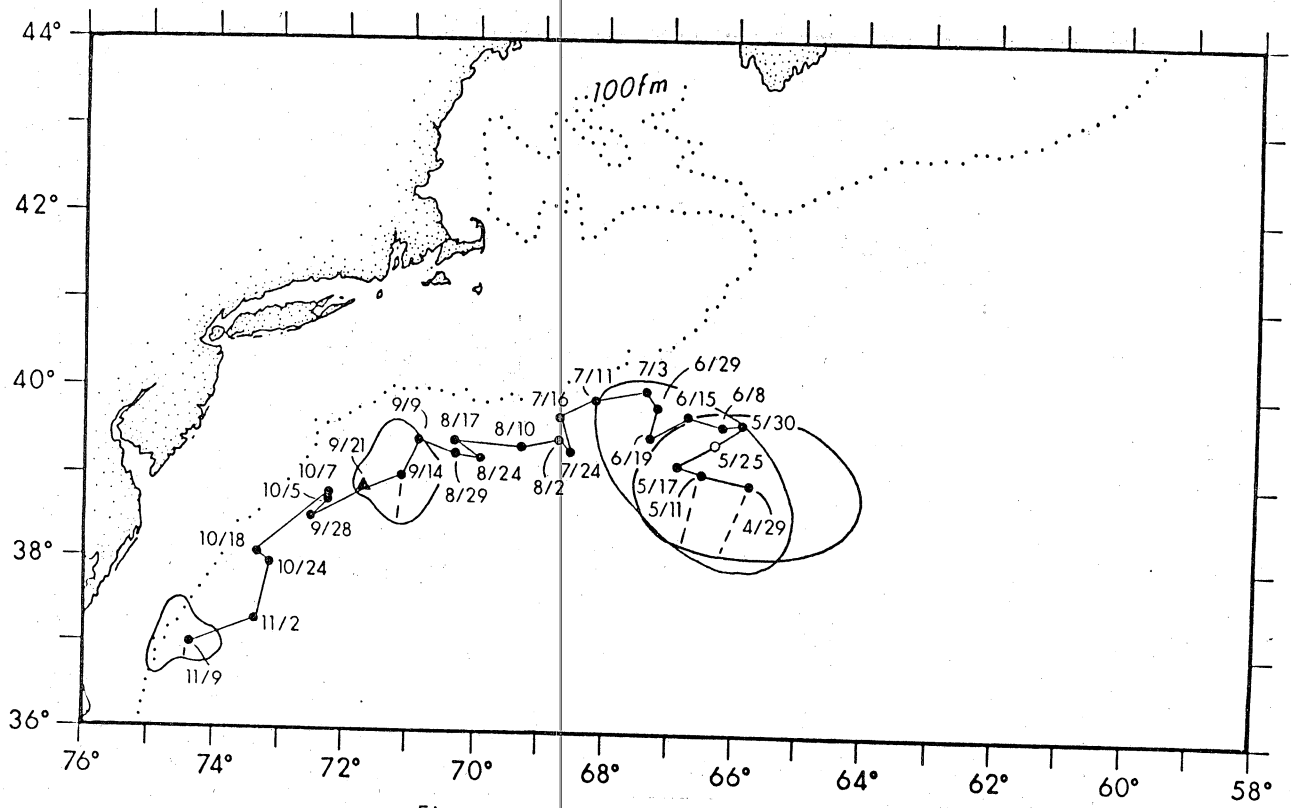

Figure 5. Trackline for Ring 81-C.

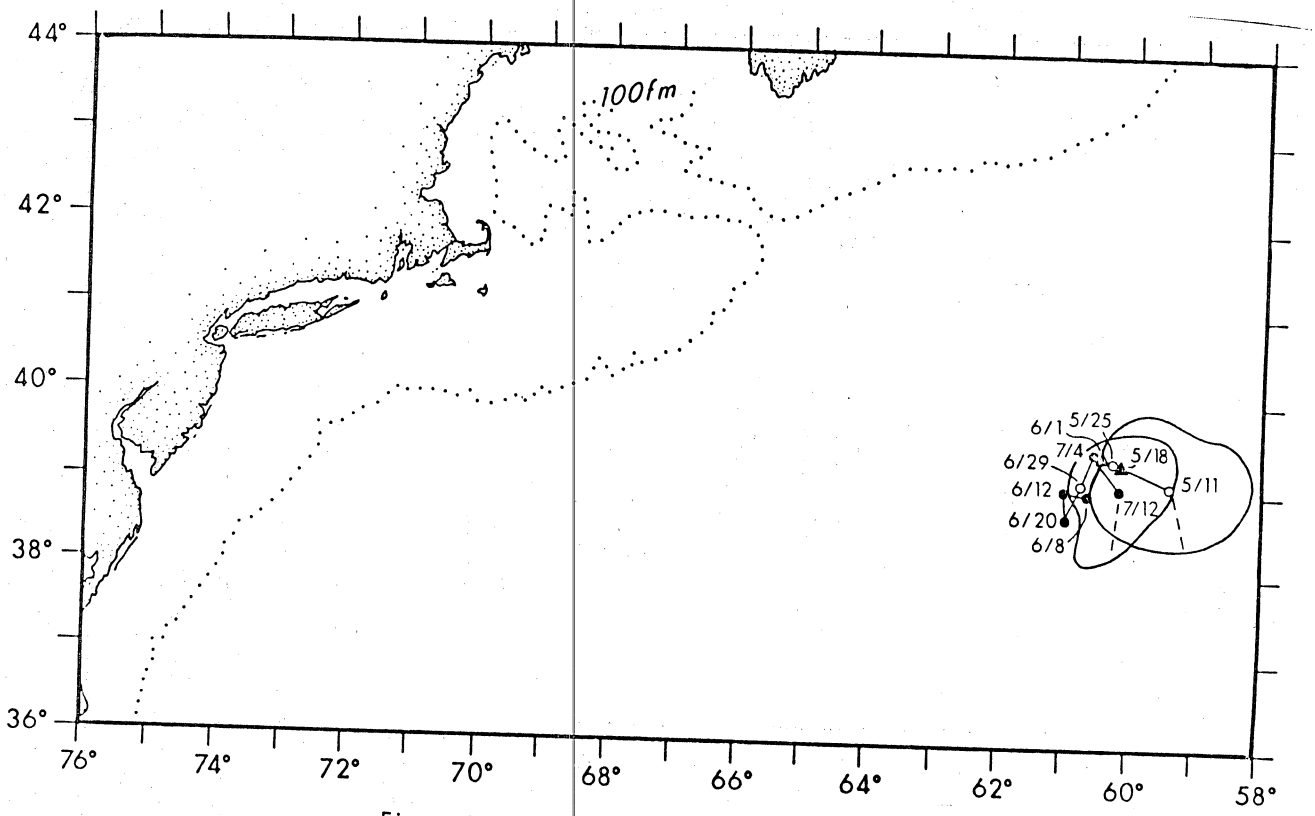

Figure 6. Trackline for Ring 81-D.

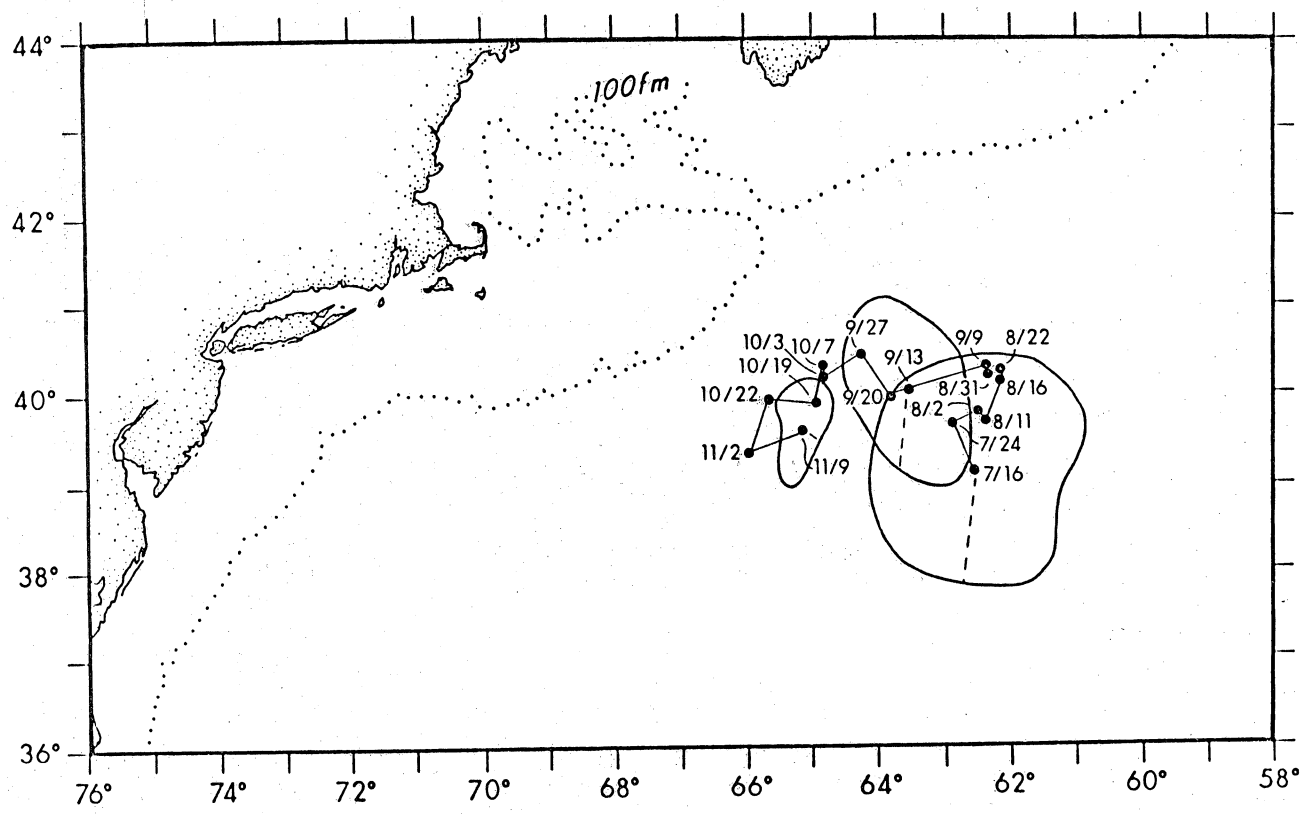

Figure 7. Trackline for Ring 81-E.

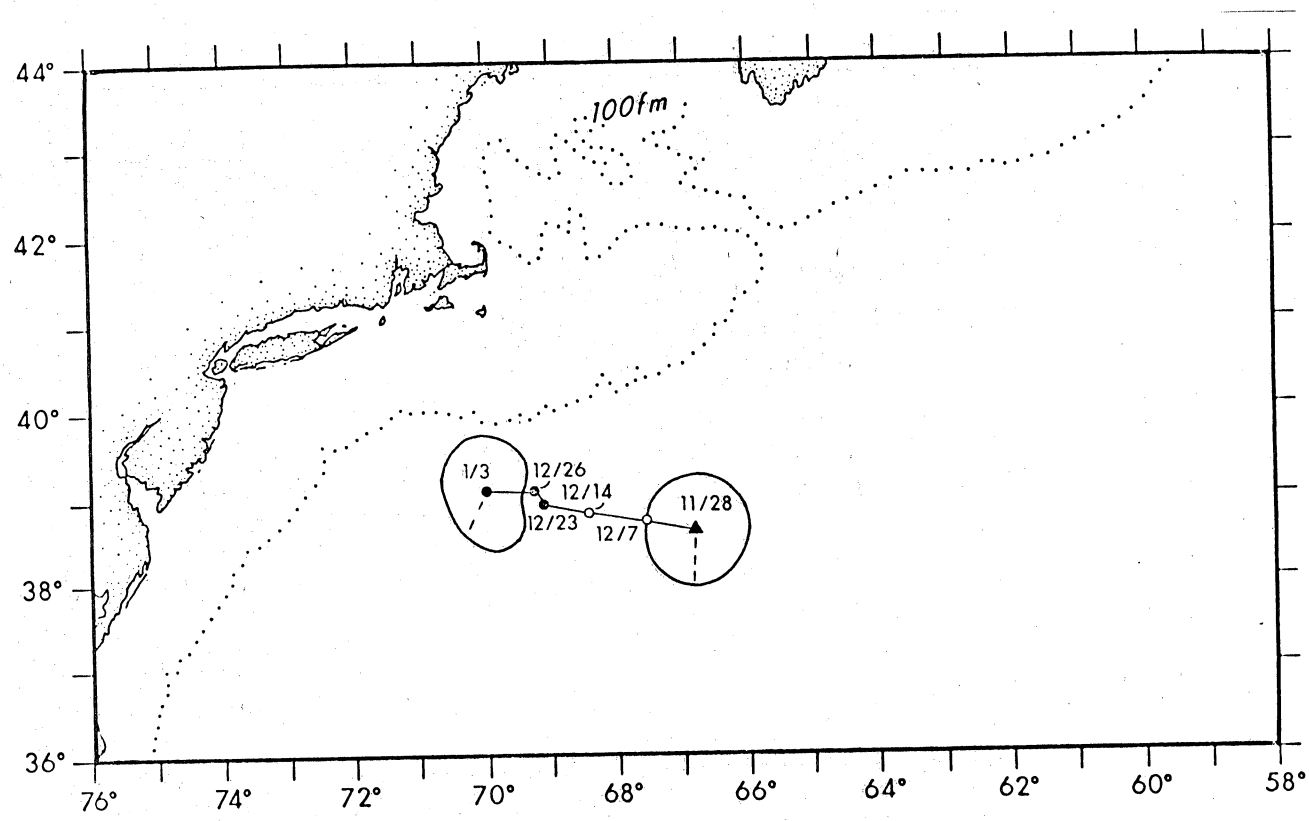

Figure 8. Trackline for Ring 81-F.

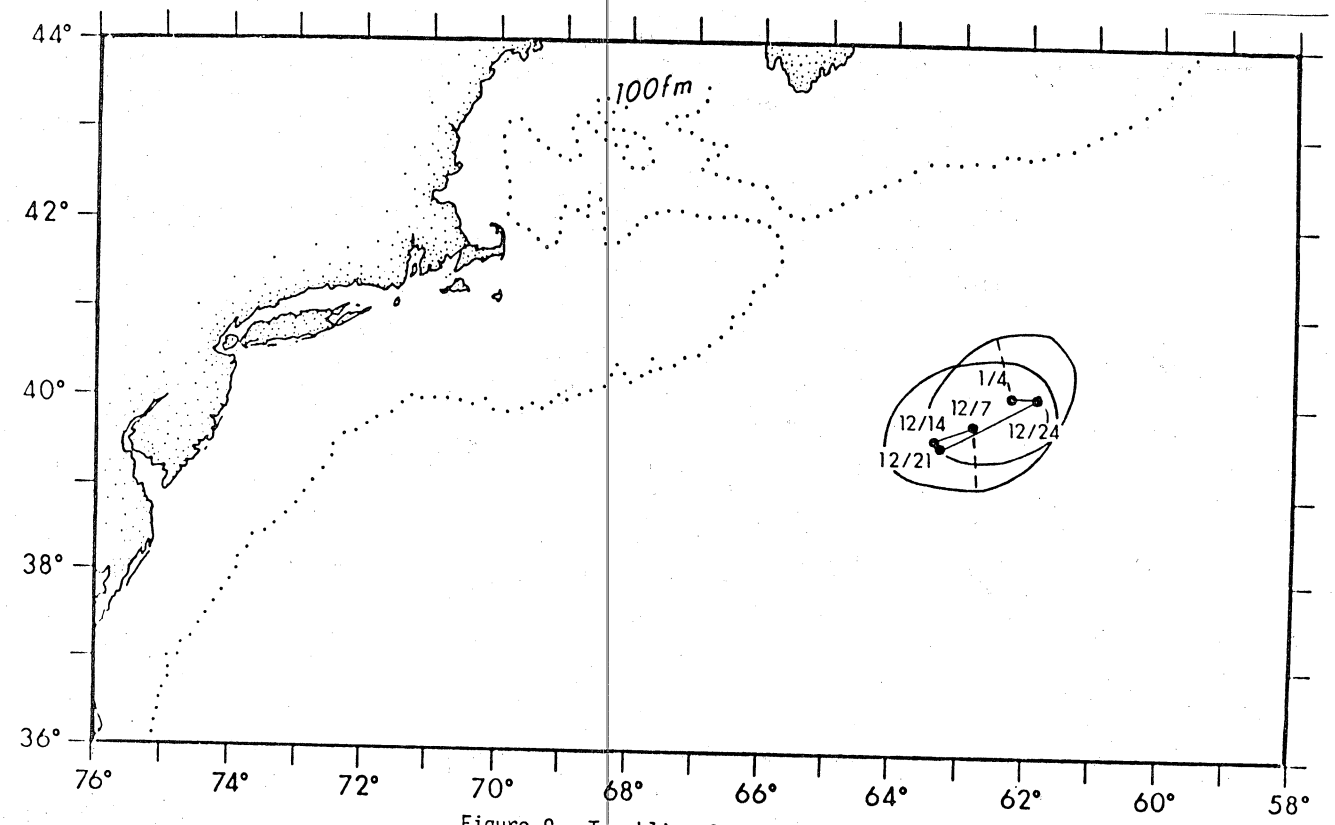

Figure 9. Trackline for Ring 81-G.

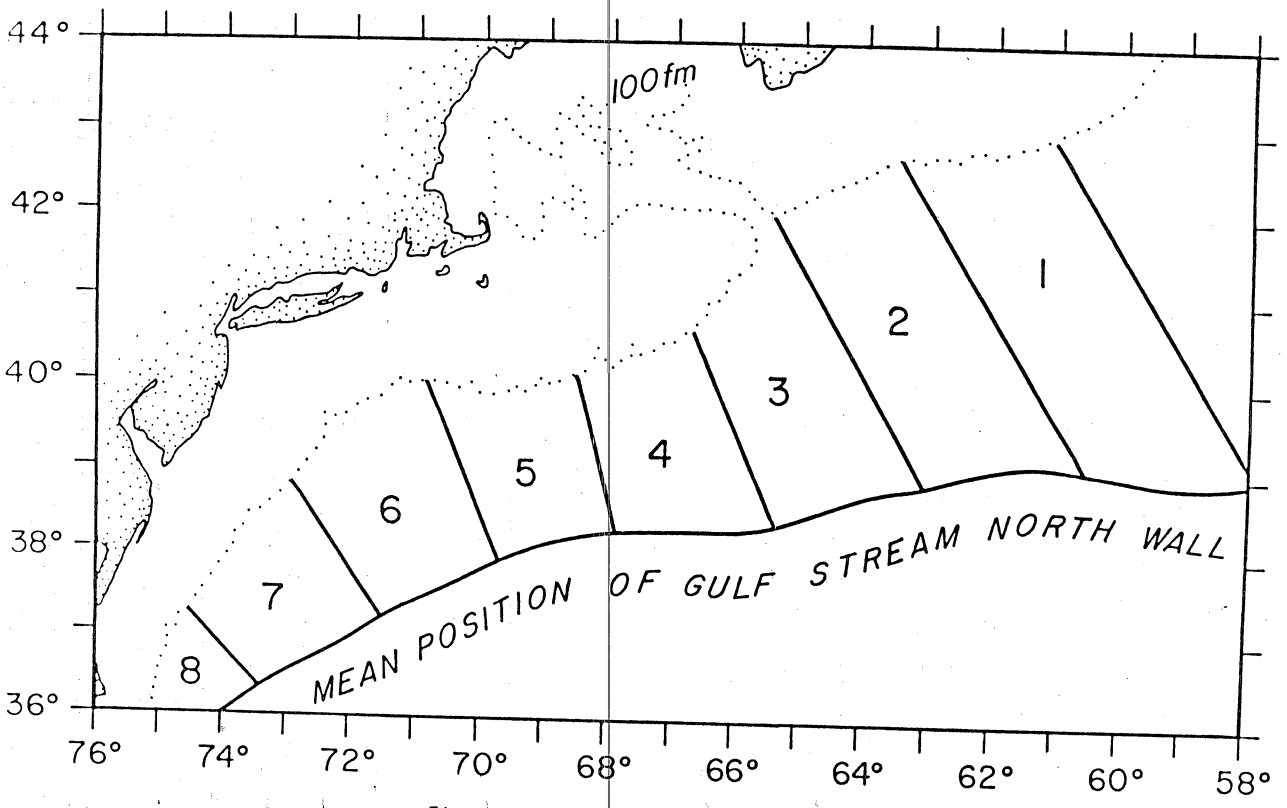

Figure 10. Zones used for Table 2.

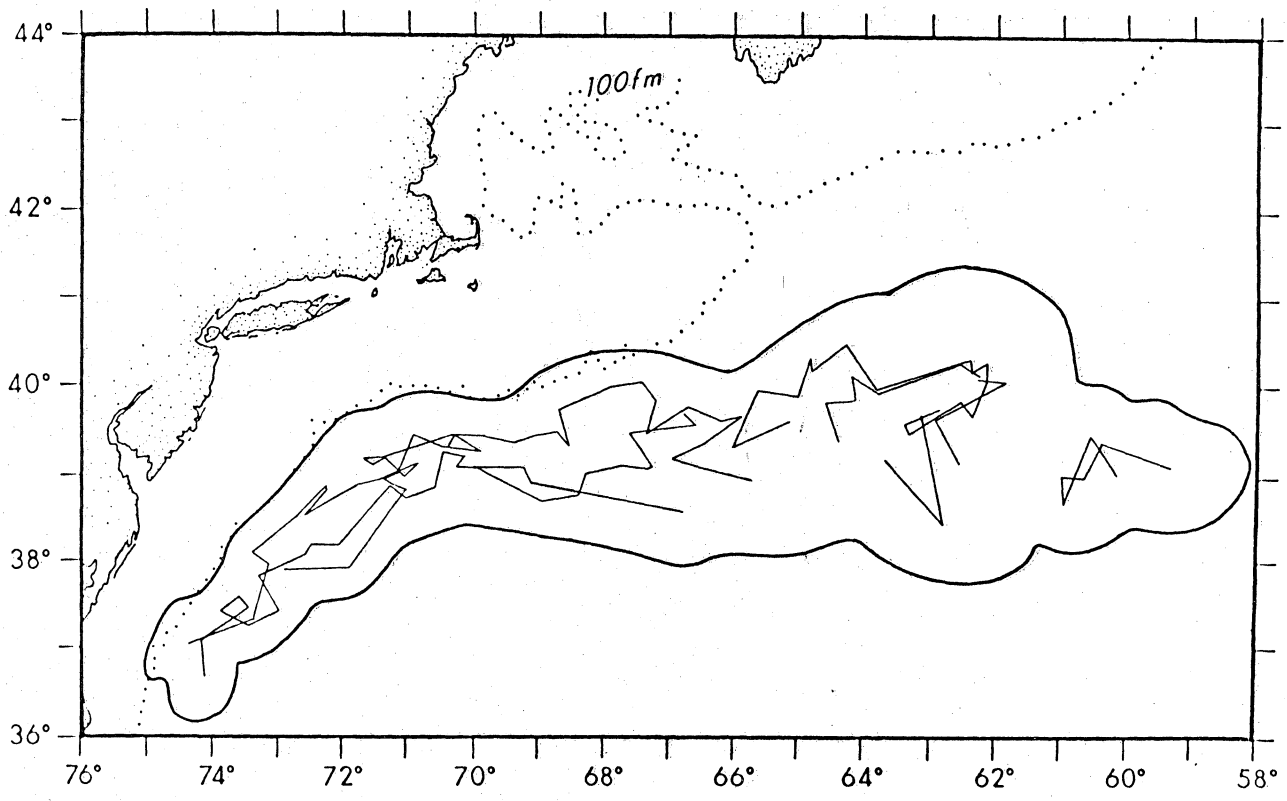

Figure 11. Composite of ring tracklines and envelope of ring surface boundaries.