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Anticyclonic Warm Core Gulf Stream Rings off the Northeastern United States During 1984

by

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This report summarizes for the eleventh year, 1984, the movements of anticyclonic warm core Gulf Stream rings in the slope water region off the coast of the northeastern United States, primarily from Cape Hatteras, North Carolina, to Georges Bank and south of Nova Scotia. Similar yearly analyses have been prepared for each of the preceeding ten years, by Bisagni (1976) for 1974-75; Mizenko and Chamberlin (1979) for 1976-1977; Celone and Chamberlin (MS 1983) for 1978; Fitzgerald and Chamberlin (1982, 1983, 1984) for 1979-81; Celone and Price (MS 1983) for 1982; and Price and Celone (MS 1984) for 1983.

Information Sources and Analysis Methods

This analysis is based primarily on data collected by the Advanced Very High Resolution Radiometer (AVHRR), a sensor onboard the National Oceanic and Atmospheric Administration (NOAA) series of polar-orbiting satellites, specifically NOAA-6, NOAA-7 and NOAA-8. Six satellite passes covering the study area are potentially available each day, depending on the degree of cloud cover present. Using the processing facilities of the Oceanographic Remote Sensing Laboratory, University of Rhode Island, the high resolution (~1km) digital data is atmospherically and geometrically corrected and enhanced to clearly identify thermal features. Data from the geostationary satellites (GOES) are used in conjunction with the AVHRR data to help differentiate between clouds, fog and sea surface thermal features. Oceanographic Analysis charts, prepared jointly by the NOAA National Weather Service and National Environmental Satellite Data and Information Service (NESDIS), issued three times a week, are also utilized to help interpret

the relative positions of thermal features. Opportunistic shipboard data received from scientists and fishermen are also integrated when available.

A base map showing submarine canyon locations and the zones used in the zonal analysis is provided for reference (Fig. 1). Ring center positions are plotted on the respective trackline charts (Figs 2-8). Formation and destruction locations plus bi-monthly positions are dated. At any time of the year, but especially in summer, rings may not be visible in satellite imagery because of the lack of thermal contrast at the surface. When rings in close proximity to one another are not visible, or hidden by clouds for a number of weeks, there may be uncertainity in distinguishing between the rings when they reappear. In such cases, the simplest interpretation of movements has been accepted.

Surface boundaries of rings are shown for the estimated date of formation and at representative stages in the life of the ring. The location of these boundaries involves errors of unknown magnitude, though every effort has been made to use various enhancement techniques to reduce these errors.

Only rings which occurred west of 60°W longitude during some portion of their lifetime are considered in this analysis. Rings are labelled with the year in which they formed or crossed west of 60°W, and alphabetically in the order of formation.

Ring Histories

A total of ten warm core Gulf Stream rings occurred in the slope water region between Cape Hatteras, North Carolina and 60°W longitude during 1984. Two rings, 83-F and 83-J, were formed in late 1983 and survived into 1984. Eight rings formed during 1984, two of which (84-G and 84-I) persisted into 1985. Estimated formation and destruction dates as well as lifespans for each ring are listed in Table 1.

Ring 83-F (Fig. 2) formed from a large Gulf stream meander about 1 July 1983, centered at 40°48'N 62°06'W. The ring moved northward, maintaining contact with the Gulf Stream throughout July. It then stalled near 41°30'N 62°00'W until early September, when it began slowly moving westward, stalling again in early October. By late November, ring 83-F had approached the eastern edge of Georges Bank (Price and Celone, MS 1984). It travelled southwestward along the continental shelf break throughout January 1984, dissipating

as it travelled. Ring 83-F was resorbed by a tongue or "shingle" of the meandering Gulf Stream near 39°30'N 70°12'W on about 22 February.

Ring 83-J (Fig. 3) detached from a meander on about 1 November 1983, centered near 40°30'N 61°00'W. This ring remained relatively stationary throughout November, being restricted by a Gulf Stream meander to the west, a newly formed ring to the east, and ring 83-I to the north. In late November, the ring to the east was resorbed by the Gulf Stream allowing movement to the northeast, which resulted in the absorption of ring 83-I in early December. Ring 83-J was reduced in surface area following an interaction with the Gulf Stream in late December (Price and Celone, MS 1984). This ring remained in close contact with the Gulf Stream until about 3 February 1984, when it was resorbed by a meander near 40°42'N 61°36'W.

Ring 84-A (Fig. 4) formed on about 5 February from a Gulf Stream meander centered near 40°00'N 64°06'W. This ring was forced to the north by a large Gulf Stream meander in late February, then began moving to the southwest as this meander propagated downstream. Ring 84-A came in contact with the Gulf Stream in late March and was eventually resorbed by a Gulf Stream meander by 5 May near 39°24'N 65°48'W. (This ring was mislabelled 84-B in our weekly analyses from mid-April through May, thus no ring 84-B will be included in this 1984 analysis.)

Ring 84-C (Fig. 5) formed from a very large Gulf Stream meander on about 9 April, centered near 41°12'N 60°12'W. This ring slowly moved west-northwestward until mid-June, when it began interacting with elongated "shingles" of the Gulf Stream. It was resorbed by the Gulf Stream on 25 June near 41°12'N 62°36'W.

Ring 84-D (Fig. 3) formed from a Gulf Stream meander on about 1 June, centered near 39°48'N 65°00'W. The short-lived ring moved northwestward and was absorbed by newly formed ring 84-E on about 9 July near 39°30'N 65°24'W.

Ring 84-E (Fig. 5) was a very large ring at its time of formation, with a surface diameter of at least 250 km. It formed from a Gulf Stream meander on 3 July near 33°48'N 66°36'W. This westward moving ring came in contact with a Gulf Stream meander in late July, greatly reducing the ring's surface area. Ring 84-E moved northwestward, reaching the continental shelf break in early August and continued its propagation along the break in a southwesterly direction. This ring

progressively became weaker and was considered to have dissipated by 15 October near 39°36'N 72°00'W.

Ring 84-F (Fig. 6) formed from the meander which had absorbed ring 84-C. Its formation was on 2 July where it was centered near 40°24'N 63°06'W. Interactions with the meandering Gulf Stream occurred throughout late July. In early August, ring 84-F began moving northwestward, approaching the eastern edge of Georges Bank by mid-September. The ring then travelled southwestward along the continental shelf break and was eventually resorbed by a Gulf Stream meander near 39°36'N 66°06'W by 19 October.

Ring 84-G (Fig. 7) formed from a Gulf Stream meander on 20 August, centered near 40°36'N 60°42'W. This ring began moving to the west, resulting in an interaction with a Gulf Stream meander in mid-September. Ring 84-G continued its movement to the northwest, interacting with meanders in late October, where its surface area was increased, and again in early December. This ring reached the edge of the continental shelf break in early January, centered at 40°30'N 65°00'W on 2 January 1985.

Ring 84-H (Fig. 8) was a very short lived ring, forming from a Gulf Stream meander near 39°42'N 66°00'W on about 10 September. This ring was soon resorbed by a meander by 23 September near 39°54'N 67°18'W.

Ring 84-I (Fig. 8) formed from a Gulf Stream meander on about 12 December, centered near 41°54'N 61°24'W. This ring moved northeastward to the shelf break during December, and was centered near 42°43'N 61°00'W on 2 January 1985.

Zonal Analysis

A generalized summary of the movements of rings during 1984 is presented in Table 2, which shows their mid-month positions with respect to the zones diagrammed in Figure 1. Total zone-month occurrence is 25, next to the lowest number of occurrences observed during the previous ten years. During the years 1974-1983, the total zone-month occurences were 24, 35, 29, 45, 32, 43, 50, 29, 51, and 51 respectively. Two rings, 83-F and 83-J, carried over from 1983 and accounted for 12% of this ring-month total. Two rings occupied the same zone at mid-month only once during 1984.

Zones west of zone 4 were occupied briefly by only two rings. Ring

83-F occupied zone 5 during mid-February, and ring 84-E occupied zone 5 in mid-September and zone 6 in mid-October. No rings were observed in zones 7 or 8 at any time during 1984. This was the first time in the past eleven years that both zones were vacant all year.

Composite Tracklines of Ring Center Positions and Envelope of Surface Boundaries

A composite of tracklines of all ring center positions, and an envelope of ring surface boundaries appear in Figure 9. The envelope was developed from boundary positions digitized from satellite data and from the weekly analysis charts. Seven of the ten rings occurring in 1984 formed very near or east of 64°W. Three of the ten rings never moved west of the 63°W meridian and only two rings (83-F and 84-E) moved west of the 68°W meridian. No rings were observed west of 72°W at any time during 1984.

Number of Rings, Times of Formation, and Longevity

Eight warm core Gulf Stream rings formed during 1984 off the northeast coast of North America. During 1974-1983, ring formation averaged nine per year, ranging from a minimum of five in 1974 to a maximum of eleven in 1979 and 1982. Two rings that formed in 1983 survived into 1984; one of which (83-F) was long-lived (237 days). Of the eight rings that formed in 1984, three had formed by mid-April, one formed during early June, one formed during early July, one formed in mid-August, one formed during mid-September, and one formed during mid-November. Longevity of the rings formed in 1984 ranged from 19 to at least 134 days.

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

RING	DATES[1]	LIFE SPAN (Days)
83-F	(07/01/83) - (02/22/84)	237
83-J	(11/01/83) - (02/03/84)	95
84-A	(02/06/84) - (05/05/84)	90
84-C	(04/09/84)[2]- 06/25/84	78
84-D	(06/01/84) - (07/09/84)	39
84-E	07/03/84 - (10/15/84)	105
84-F	07/02/84 - (10/19/84)	110
84-G	08/20/84 - into 1985	>134
84-H	(09/10/84) - (09/28/84)	19
84-I	(12/12/84) - into 1985	>20

[1]Dates not in parentheses are accurate to within two days. Dates in parentheses could be off by greater than one week.

[2]This ring was not labelled until it completely crossed west of 60°W about 04/30/84.

Table 2. Ring positions at mid-month with respect to zone during 1984.

(Zone boundaries shown in Figure 1.)

Zone	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
1	83-J		84-C	84-C				84-G	84-G			84-I
2					84-C	84-F	84-F			84-G	84-G	84-G
3		84-A	84-A	84-A		84-D			84-F	84-F		
4	83-F					84-E	84-E	84-H				
5		83-F							84-E			
6									84-E			
7												
8												

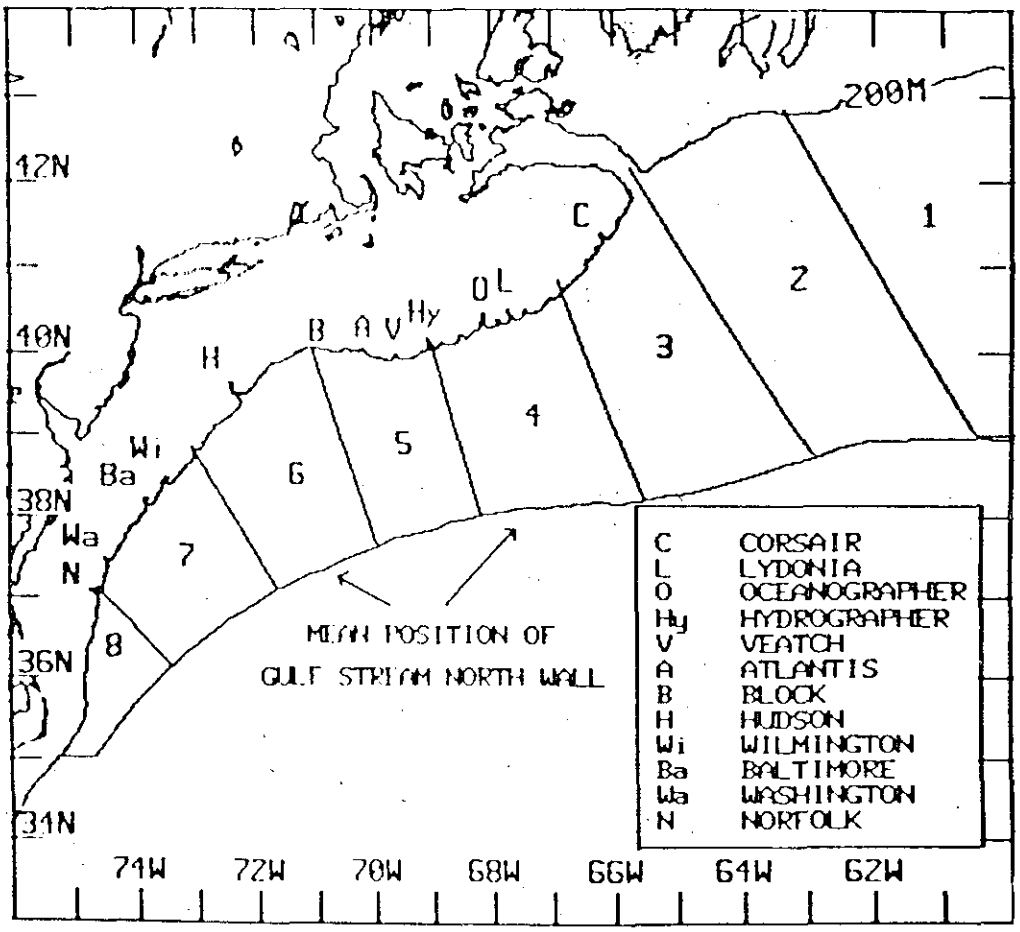

Figure 1. Base map for ring tracklines, showing canyon names and zones used in Table 2.

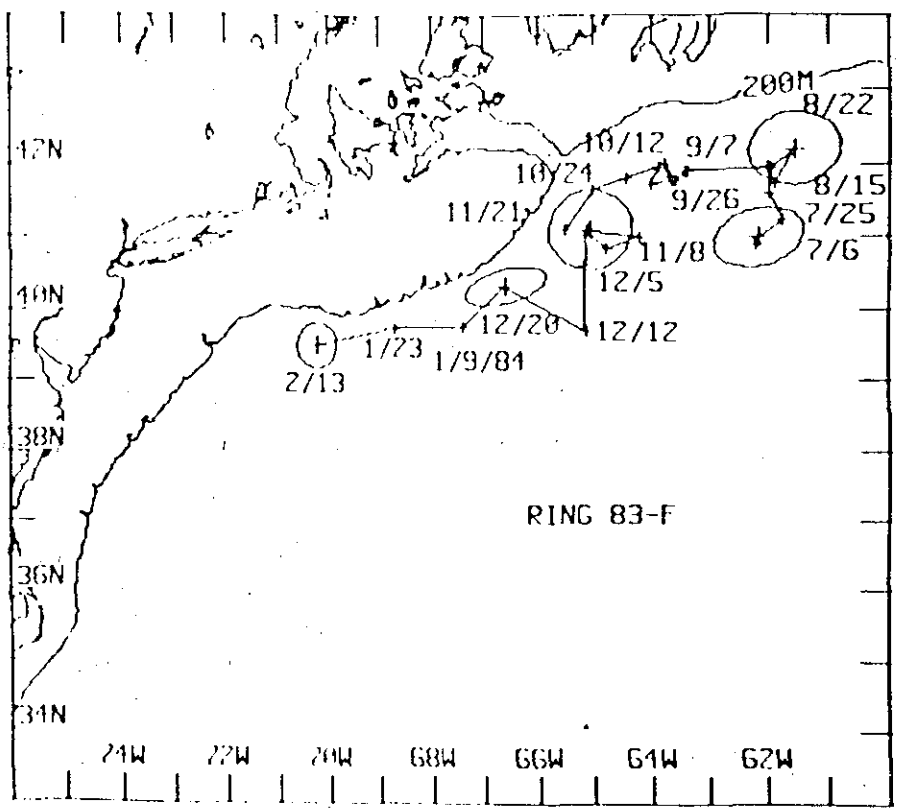

Figure 2. Trackline for ring 83-F

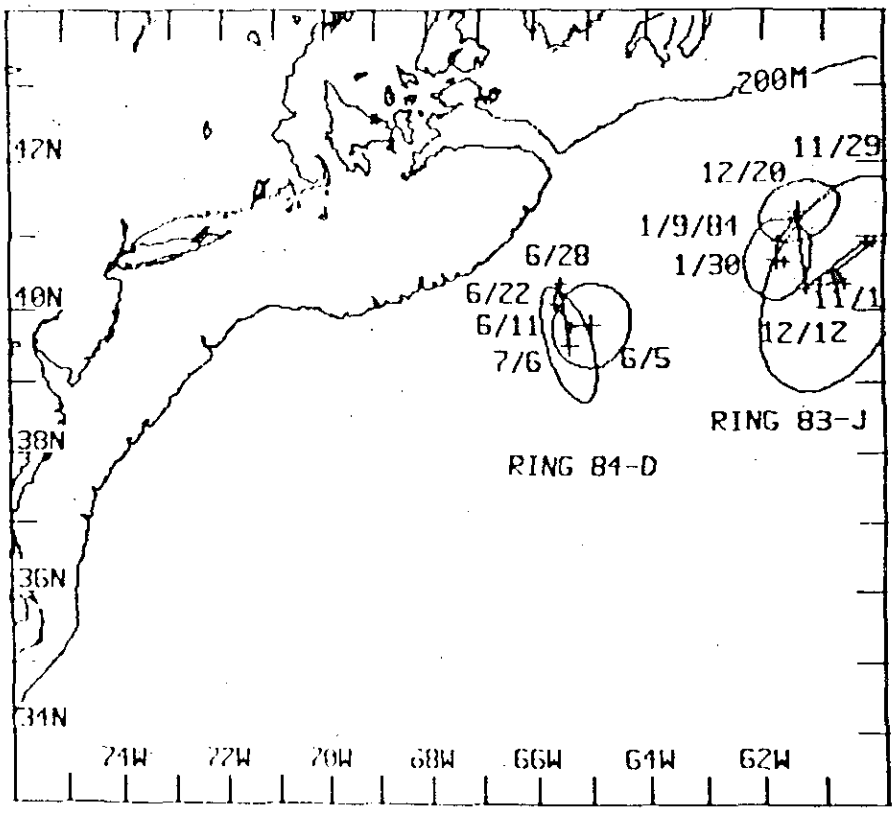

Figure 3. Tracklines for ring 83-J and ring 84-D

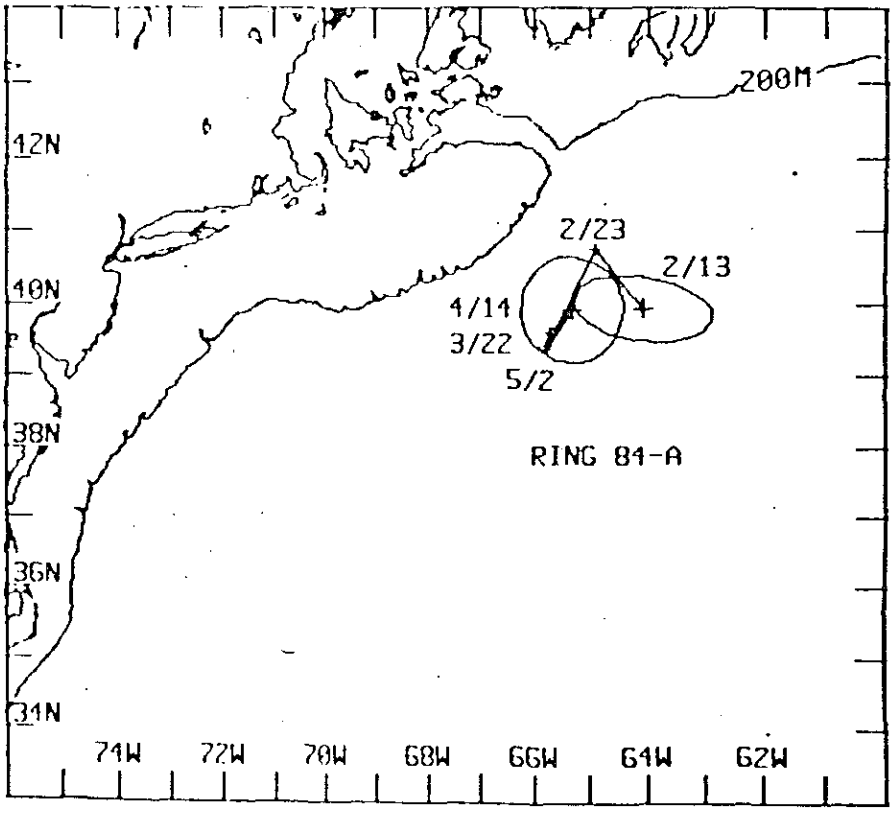

Figure 4. Trackline for ring 84-A

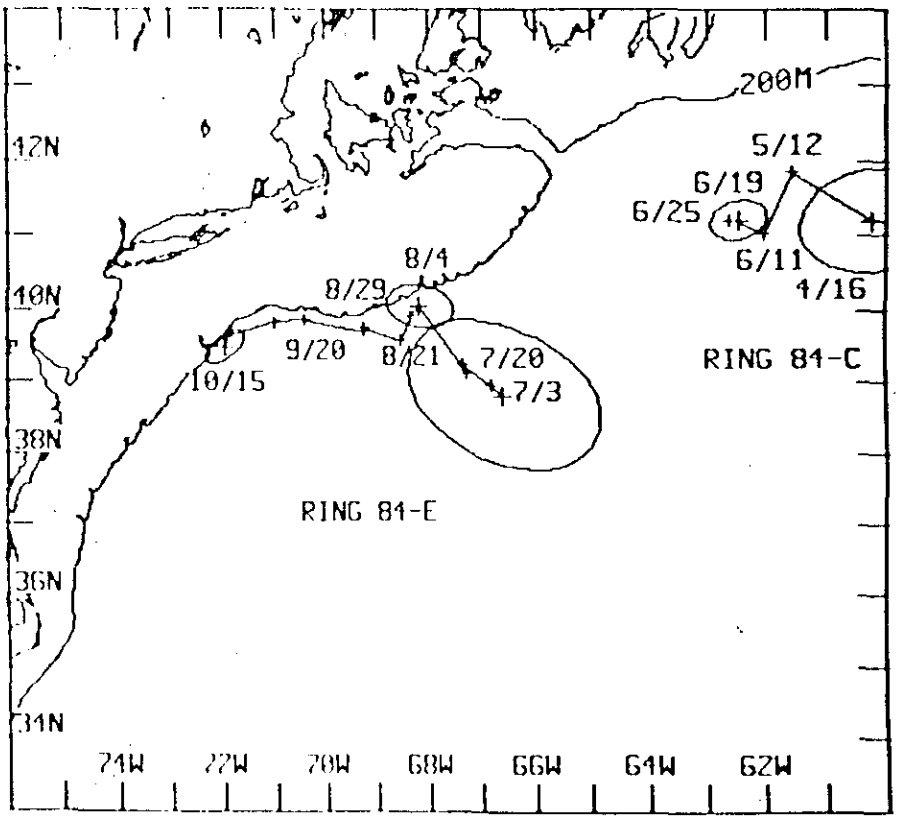

Figure 5. Tracklines for ring 84-C and ring 84-E

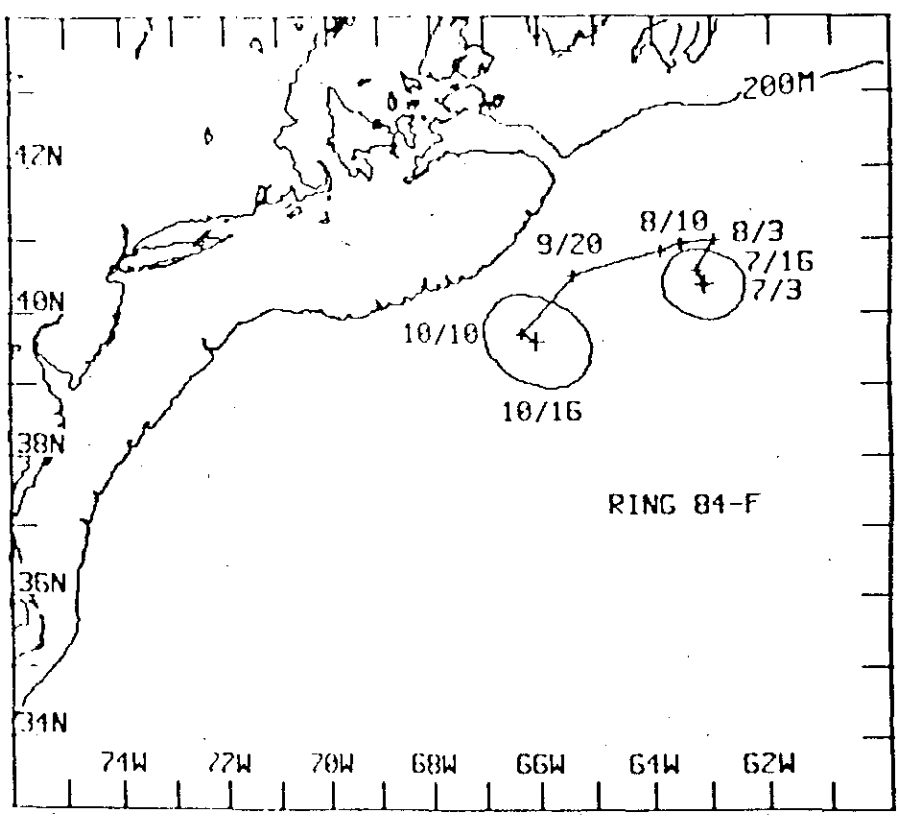

Figure 6. Trackline for ring 84-F

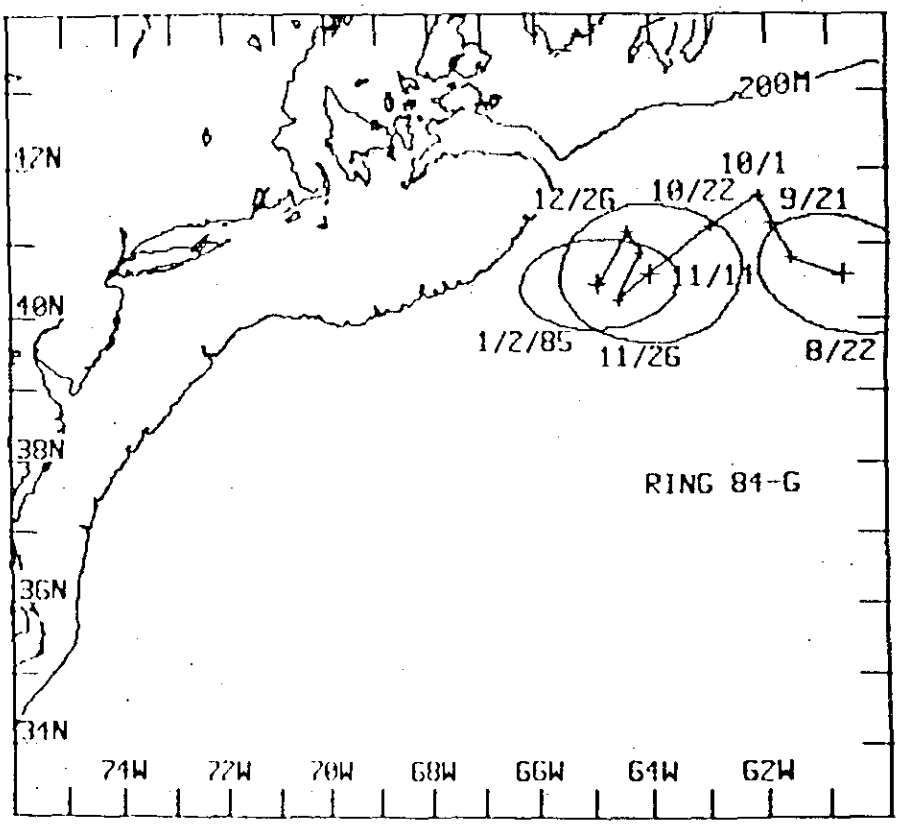

Figure 7. Trackline for ring 84-G

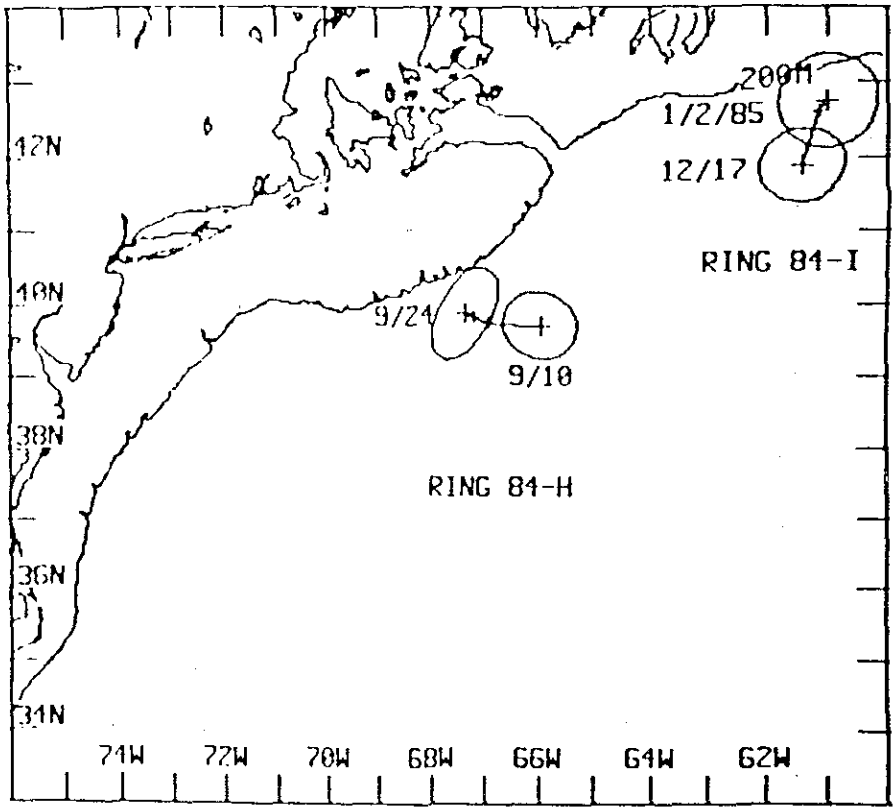

Figure 8. Tracklines for ring 84-H and ring 84-I

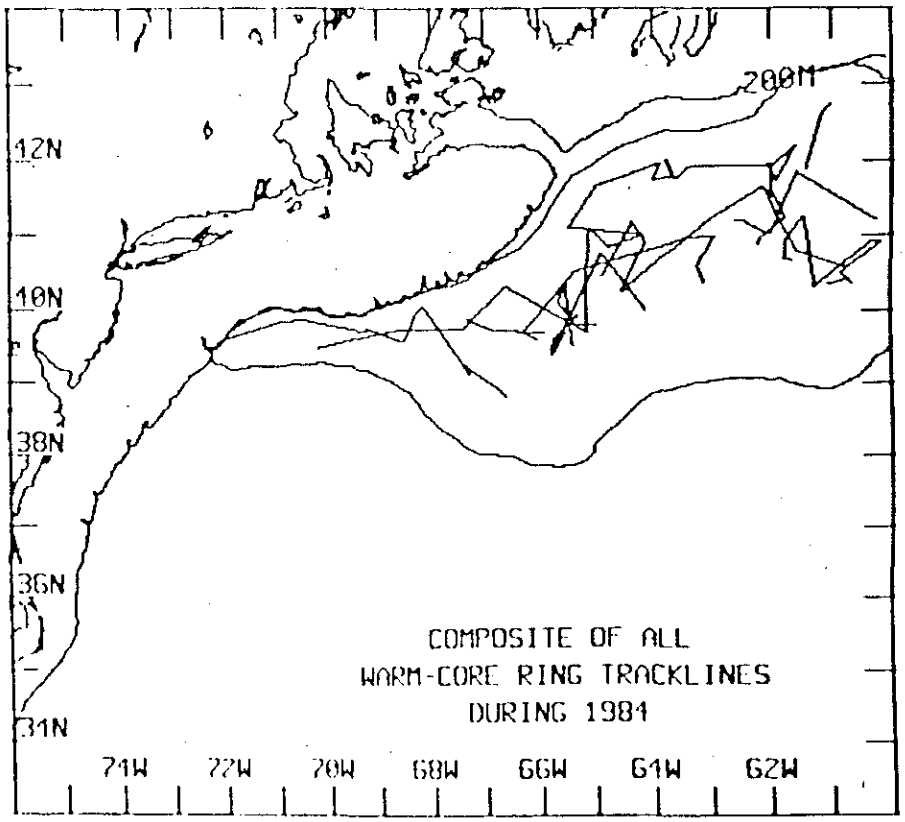

Figure 9. Composite of ring tracklines and envelope of ring surface boundaries.