SURFACE WATER DRIFT

SOUTH OF CAPE LOOKOUT, NORTH CAROLINA[1]

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Introduction

The patterns of surface water movements directly influence the distribution of many near surface phytoplankton, zooplankton, nutrients and pollutants. The most comprehensive review of information to date on circulation of waters over the continental shelf south of Cape Hatteras (Bumpus, 1973) concluded that this area is a complex and variable system of interacting forces greatly affected by the shifting Florida Current.

The Marine Resources Research Institute (MRRI) of the South Carolina Wildlife and Marine Resources Department has joined with the National Marine Fisheries Service to investigate factors controlling marine fish distributions between Cape Fear, North Carolina and Cape Canaveral, Florida as part of the Marine Resources Monitoring Assessment and Prediction (MARMAP) Program. To accomplish this objective, MRRI has initiated several studies of the physical and chemical oceanographic conditions of this region in conjunction with major studies of ichthyoplankton and groundfish. The objective of this study was to further describe surface water movements south of Cape Lookout, North Carolina.

Methods

Drift bottles containing preaddressed return cards of the type described by Norcross and Stanley (1967) were released at a total of 272 stations (5 bottles per station). Primary releases (213 stations) were made between Cape Lookout, North Carolina and Charleston, South Carolina during four cruises of the R/V Dolphin (September and November 1974, January and April 1975). Stations were located at 18.5 km intervals along 4 to 6 transects parallel to degrees of latitude. Drift bottles were also released at 51 groundfish trawling stations between Cape Fear, North Carolina and Cape Canaveral, Florida during a cruise in September 1975. Bottles were dropped at eight stations on a single north-south transect through Onslow Bay during a cruise of the R/V Palumbo in March 1975 in cooperation with the NMFS's Atlantic Estuarine Fisheries Center, Beaufort, North Carolina.

An attempt was made to limit releases to surface waters inshore of the Florida Current, which was identified by its seasonal temperature and salinity characteristics. However, during the September 1975 cruise, some bottles were released in the Florida Current. Recoveries from most cruises were calculated on the basis of the total number of bottles released during the cruise; recoveries from the September 1975 cruise were calculated on the basis of releases inshore of the Florida Current.

At each station of each cruise, with the exception of the March cruise, a water temperature profile was made with an expendable or mechanical bathythermograph, and surface water temperatures and salinities were taken.

Results

Total card recovery was 13.8% of the number of drift bottles released; the greatest part of the recovery (12.1%) was from bottles released in September, both in 1974 and 1975. The fewest returns were from releases during November 1974.

During September 1974 and 1975 many cards were recovered in northern Florida (Figs. 1 and 2) from bottles released south of Frying Pan Shoals (the submarine projection of Cape Fear). Release sites during 1975 ranged over a greater shelf area and corresponded to recoveries over a large segment of the southeastern coastline (Fig. 2), while a release area north of Charleston in September 1974 resulted in recoveries concentrated only in northern Florida (Fig. 1). In September 1974, there were no returns from bottles released north of Frying Pan Shoals, while in September 1975, two returns were obtained north of the Shoals (Table 1). During September 1975, bottles released north of Frying Pan Shoals generally were recovered northeast of the release point, while those released immediately south of this physiographic feature were recovered to the northwest (Fig. 2).

Return locations from the few bottles released in or at the edge of the Florida Current during September 1975 were variable in direction. From one station approximately 115 km due east of Charleston at the edge of the Florida Current, two bottles were recovered in opposite directions. One bottle was recovered just south

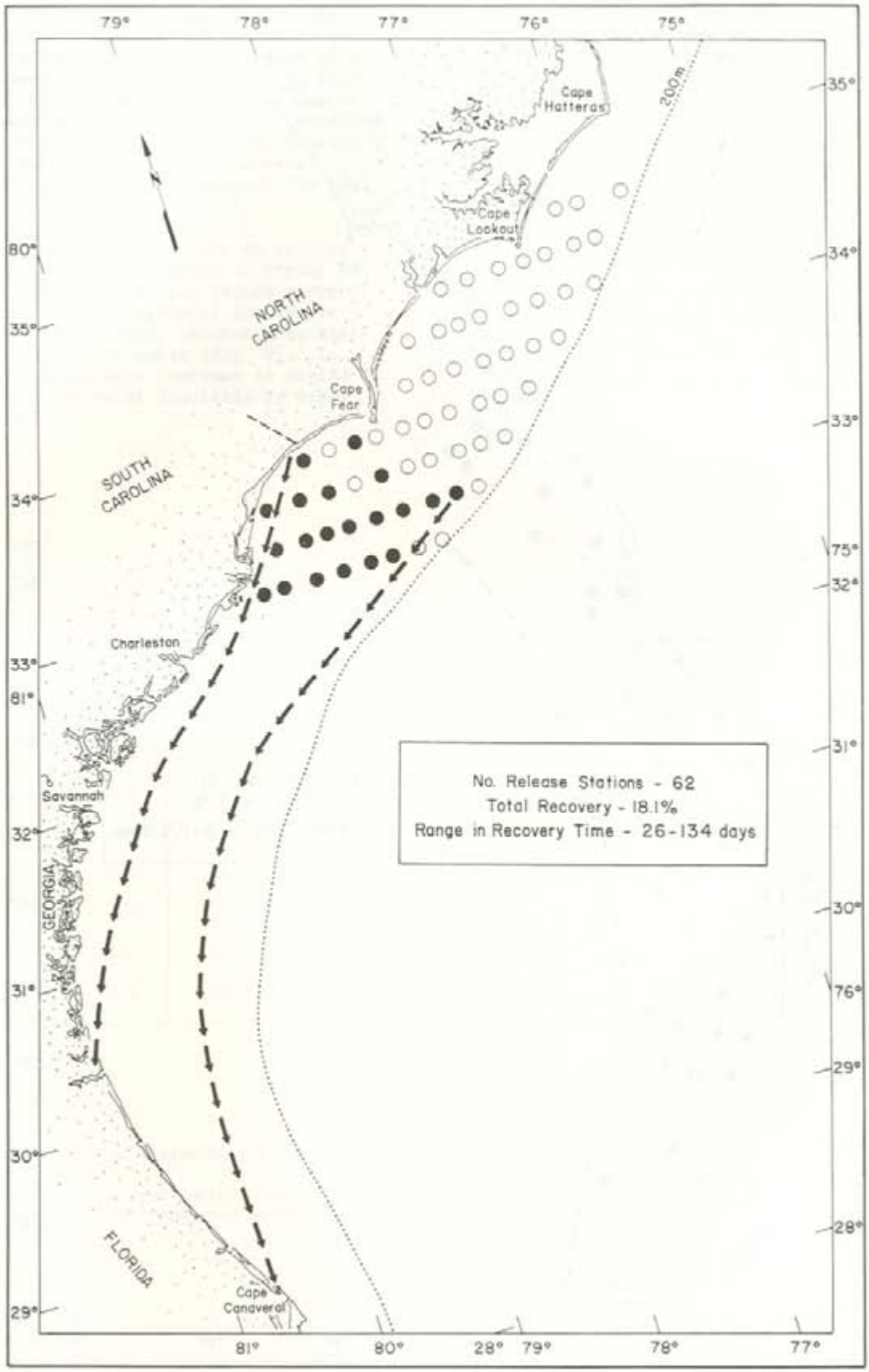

Figure 1. Drift Bottle Cruise September 15-18, 1974. Open circles indicate release stations; solid circles indicate release stations from which bottles were recovered; arrows indicate probable drift direction and area of recovery.

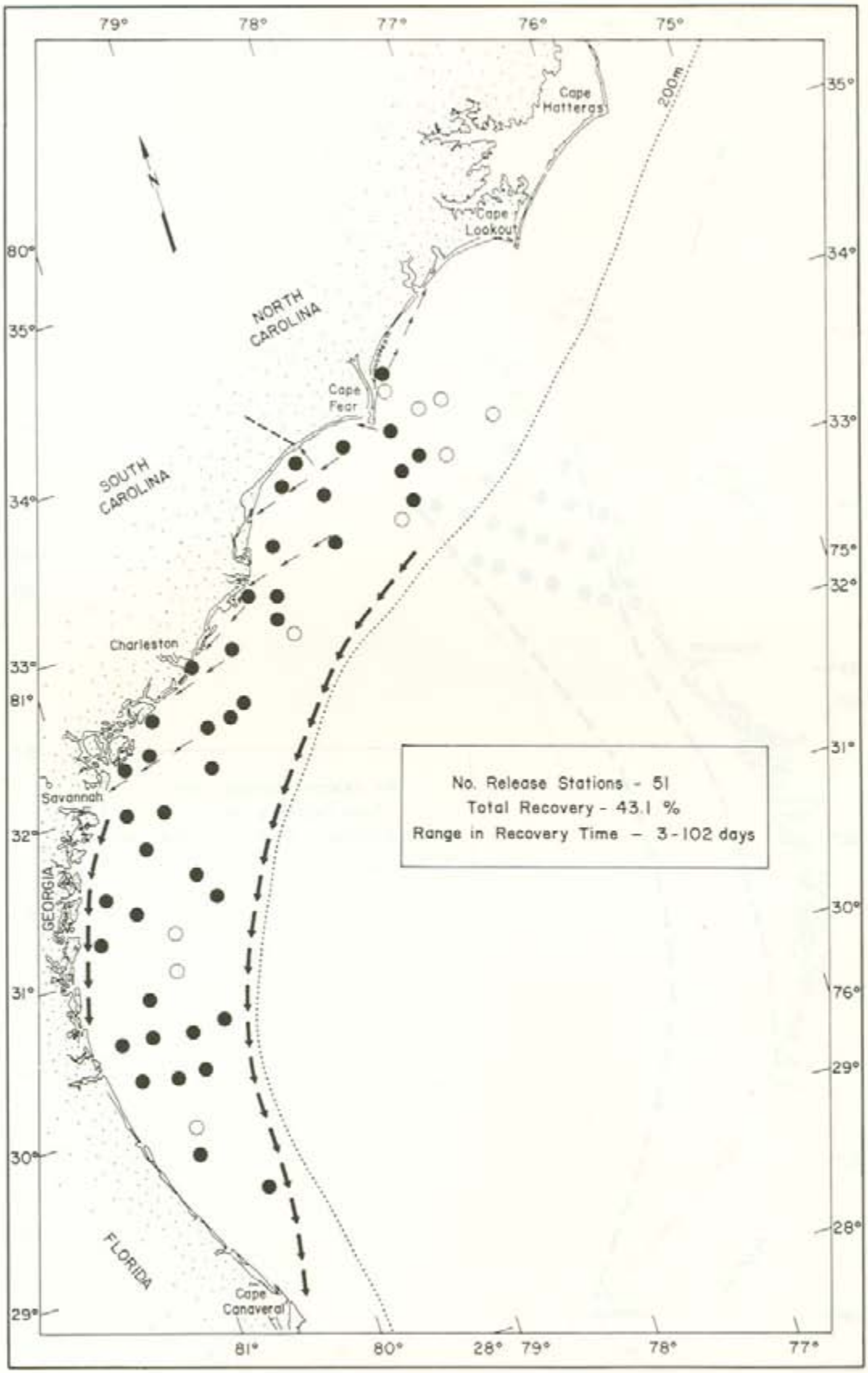

Figure 2. Drift Bottle Cruise August 31 - September 19, 1975. Open circles indicate release stations; solid circles indicate release stations from which bottles were recovered; arrows indicate probable drift direction and area of recovery.

of Cape Hatteras in 23 days and the other just south of Jacksonville in 64 days at approximately equal distances (376-384 km) from the release point. A single recovery from a release about 59 km due east of the above station (completely under the influence of the Florida Current) also was made just north of Cape Canaveral. A nearshore release within the waters of the Florida Current just north of Cape Canaveral resulted in a northward movement (98 km) and recovery of two bottles.

In November, there were no returns from bottles released south of Frying Pan Shoals, and only a single return north of a release position north of the Shoals (Fig. 3). In January, returns were similar to those in November (Fig. 4). In March, releases were confined to Onslow Bay, a body of water insulated by Capes Fear and Lookout, with returns limited to only north of release sites (Fig. 5). In April, card returns from releases north of Frying Pan Shoals were primarily northeast of release positions, while releases south of Frying Pan Shoals were recovered northwest of release positions (Fig. 6).

Current speeds were calculated using the first recovery date from each release station (Table 1). Calculated rates of surface water movement south of Frying Pan Shoals ranged from 1.5 km/day in April to 11.3 km/day in September, while inferred rates north of the Shoals ranged from 2.4 km/day in November to 12.7 km/day in April. Pronounced differences existed in card recoveries (Figs. 1-6) and monthly calculated current speeds (Table 1) for drift bottles released north and south of Frying Pan Shoals.

Table 1. Drift bottle recovery relative to release north or south of Frying Pan Shoals.

	Average Direction From Release		Average Distance From Release (Km)		Average Speed Km/day		Recovery as % of Total Release Each Cruise	
	North	South	North	South	North	South	North	South
September 74	NR	210°	NR	489	NR	11.4	NR	18.1
November 74	063°	NR	100	NR	2.4	NR	0.3	NR
January 75	068°	NR	46	NR	3.1	NR	1.1	NR
March[1] 75	005°	-	14	-	2.9	-	22.5	-
April 75	060°	350°	102	33	12.7	1.5	0.7	3.3
September 75	024°	201°[2]	77	204[2]	3.3	6.6[2]	0.0+	43.1

- = No Releases

NR = No Recoveries

[1] Releases only in Onslow Bay; 8 stations.

[2] Calculation does not include returns from 2 stations directly south of Frying Pan Shoals, bottles of which were recovered northwest of release positions.

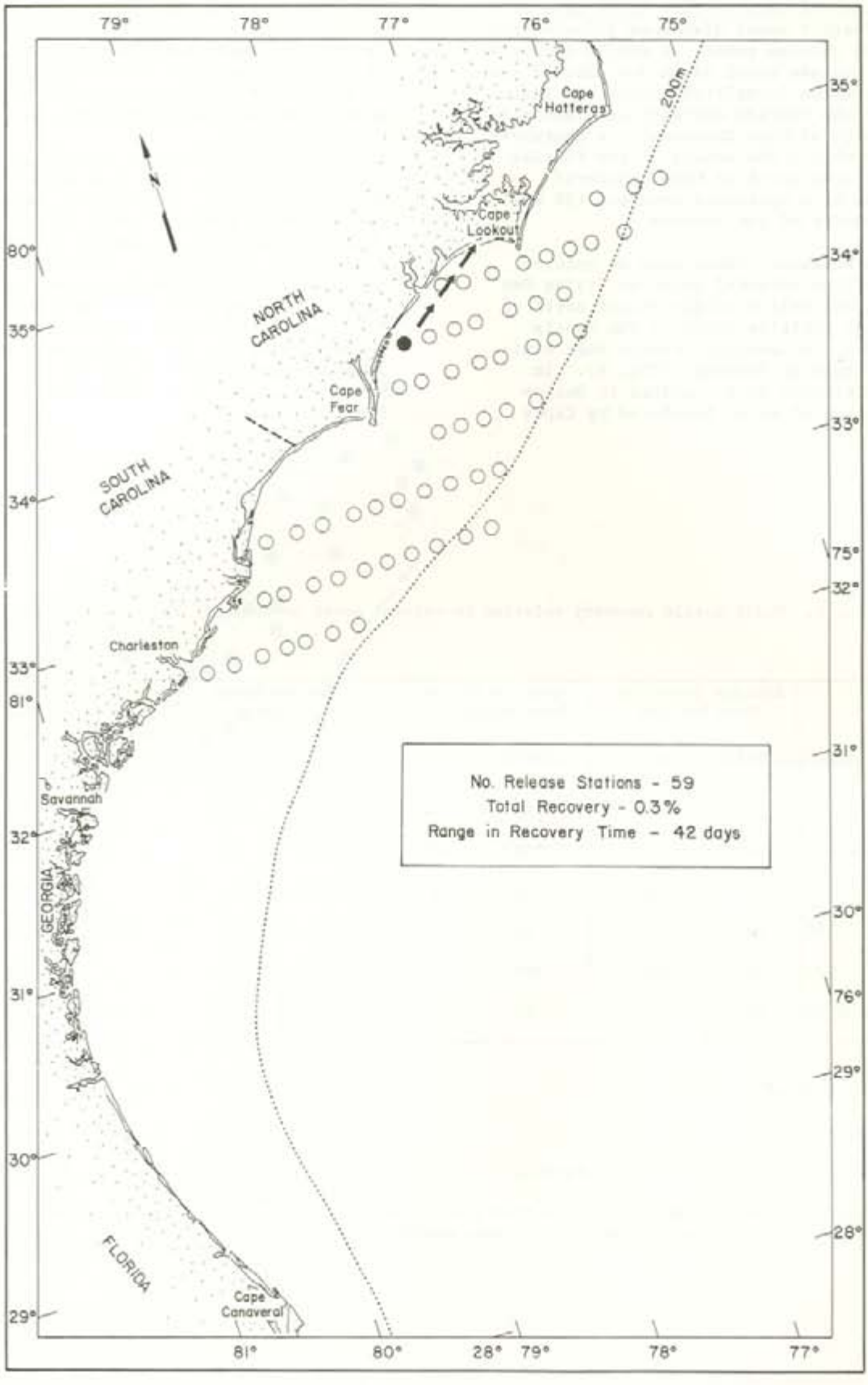

Figure 3. Drift Bottle Cruise November 7-14, 1974. Open circles indicate release stations; solid circles indicate release stations from which bottles were recovered; arrows indicate probable drift direction and area of recovery.

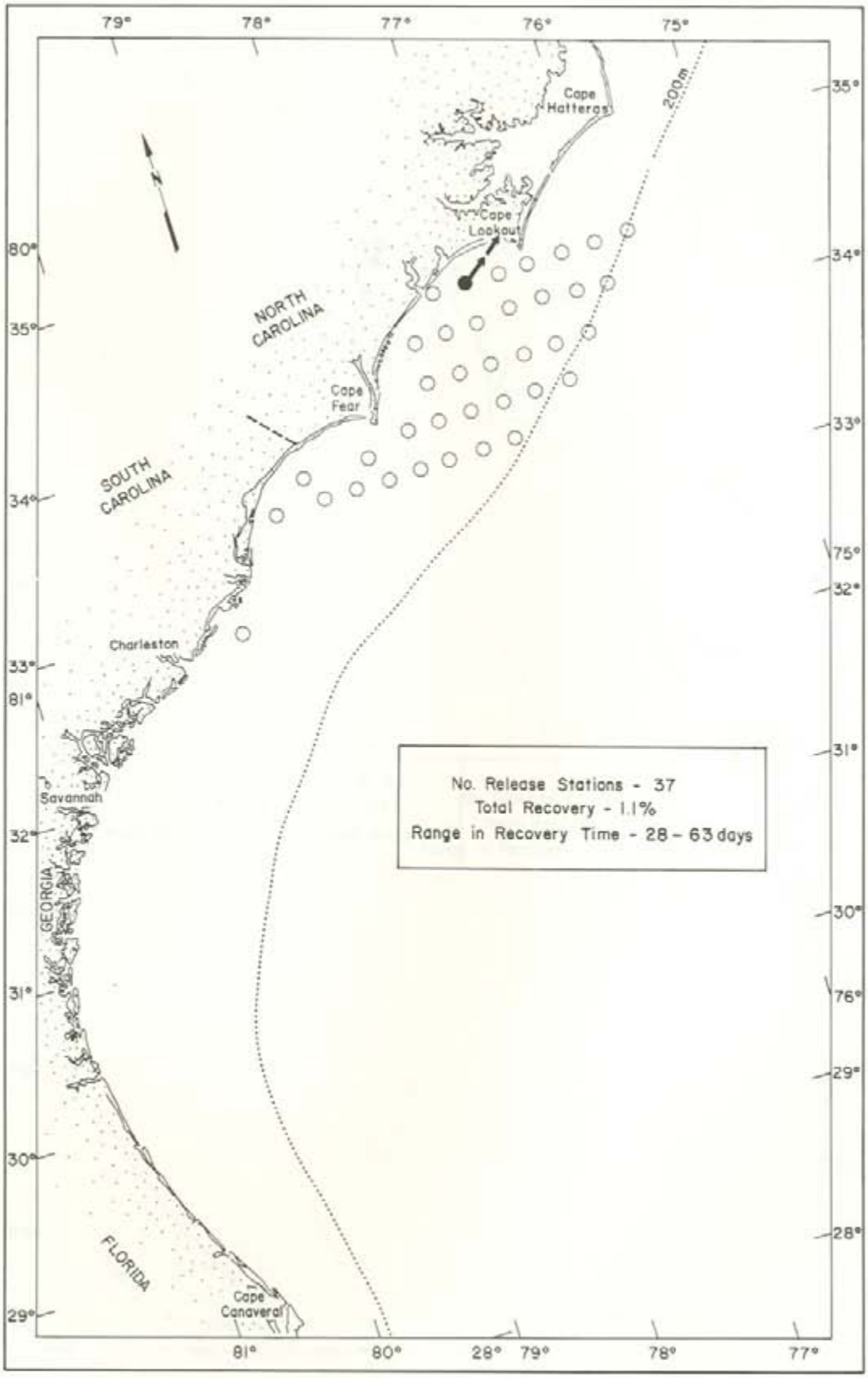

Figure 4. Drift Bottle Cruise January 17-27, 1975. Open circles indicate release stations; solid circles indicate release stations from which bottles were recovered; arrows indicate probable drift direction and area of recovery.

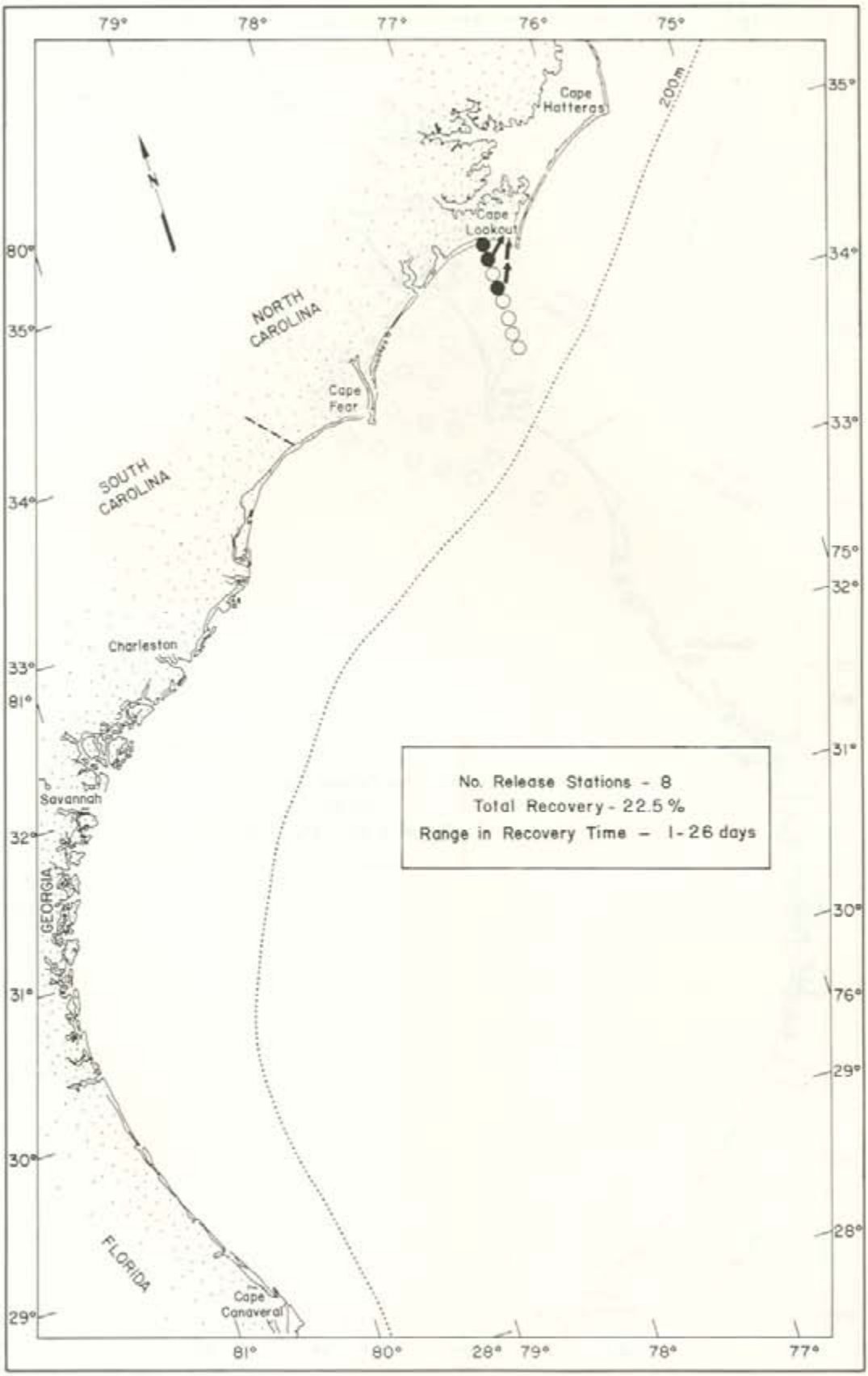

Figure 5. Drift Bottle Cruise March 12-14, 1975. Open circles indicate release stations; solid circles indicate release stations from which bottles were recovered; arrows indicate probable drift direction and area of recovery.

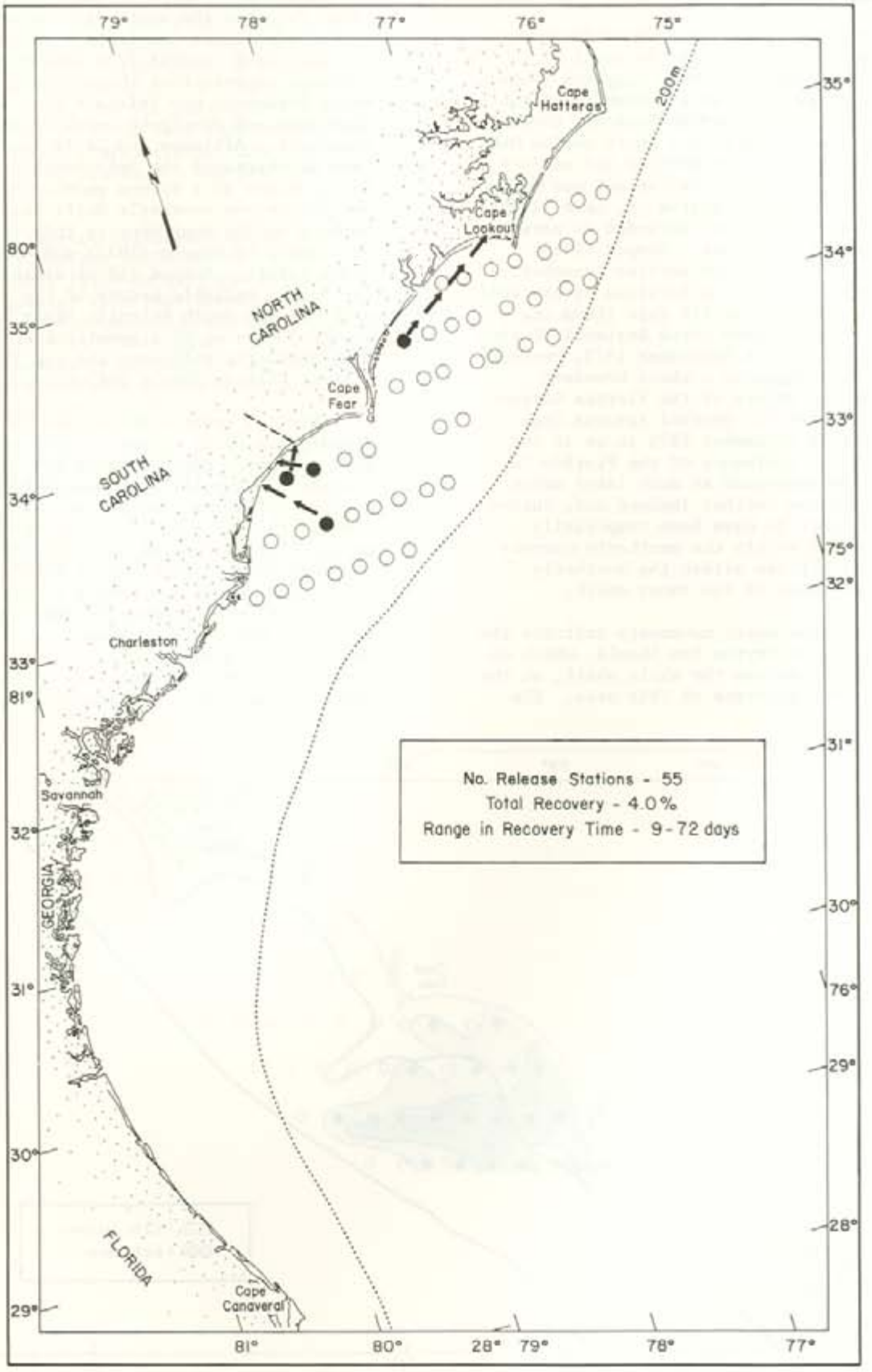

Figure 6. Drift Bottle Cruise April 16-21, 1975. Open circles indicate release stations; solid circles indicate release stations from which bottles were recovered; arrows indicate probable drift direction and area of recovery.

Discussion

The relatively short duration between release and recovery (1-134 days) of bottles during this study suggests transportation by shelf waters inshore of the influence of the Florida Current. Complete lack of returns within a short period indicates entrainment of bottles and surface waters by the northerly current and removal from the nearshore system or, less likely, total loss of bottles stranded in marshlands along the coast. Bumpus (1955) reported returns from bottles transported from waters off North Carolina by the Gulf Stream ranging from 218 days (from the Azores) to 891 days (from England). During all months except September 1975, recovery of bottles suggests a sharp boundary between the waters of the Florida Current and inner shelf. Several returns from releases in September 1975 in or at the edge of the influence of the Florida Current were recovered at much later dates than releases further inshore and, therefore, appear to have been temporarily transported within the northerly current prior to release within the southerly surface system of the inner shelf.

Inferred water movements indicate the importance of Frying Pan Shoals, which extend almost across the whole shelf, on the circulation patterns of this area. The influence of the Shoals area appears especially pronounced during September (Fig. 7), when the southerly counter current dominates the inshore water circulation. Card returns from September releases suggest that the southerly surface water movements may initiate just south of Cape Fear and dissipate north of Cape Canaveral. Atkinson and Jaffe (In Press) have demonstrated the relationship between the presence of a strong geostrophic force and the strong southerly drift observed inshore during September in this study and previously by Bumpus (1955) and Bumpus and Chase (1964). Bumpus (1973) states that the highly variable nature of the surface drift in the South Atlantic Bight is due to the interplay of a geostrophic current with southerly influence and the Florida Current with northerly influence.

Limited returns during November, January and April appear to indicate a weak northerly surface water movement nearshore, especially in Onslow Bay, and suggest entrainment of surface waters over most of the shelf with the northerly-moving Florida Current system. The observed drift directions of bottles released south of the Shoals in April concur with recent findings by Atkinson and Jaffe (In Press) for releases south of Charleston, South Carolina. We found no correlation between estimates of monthly average Ekman transport values (Gunn, 1976

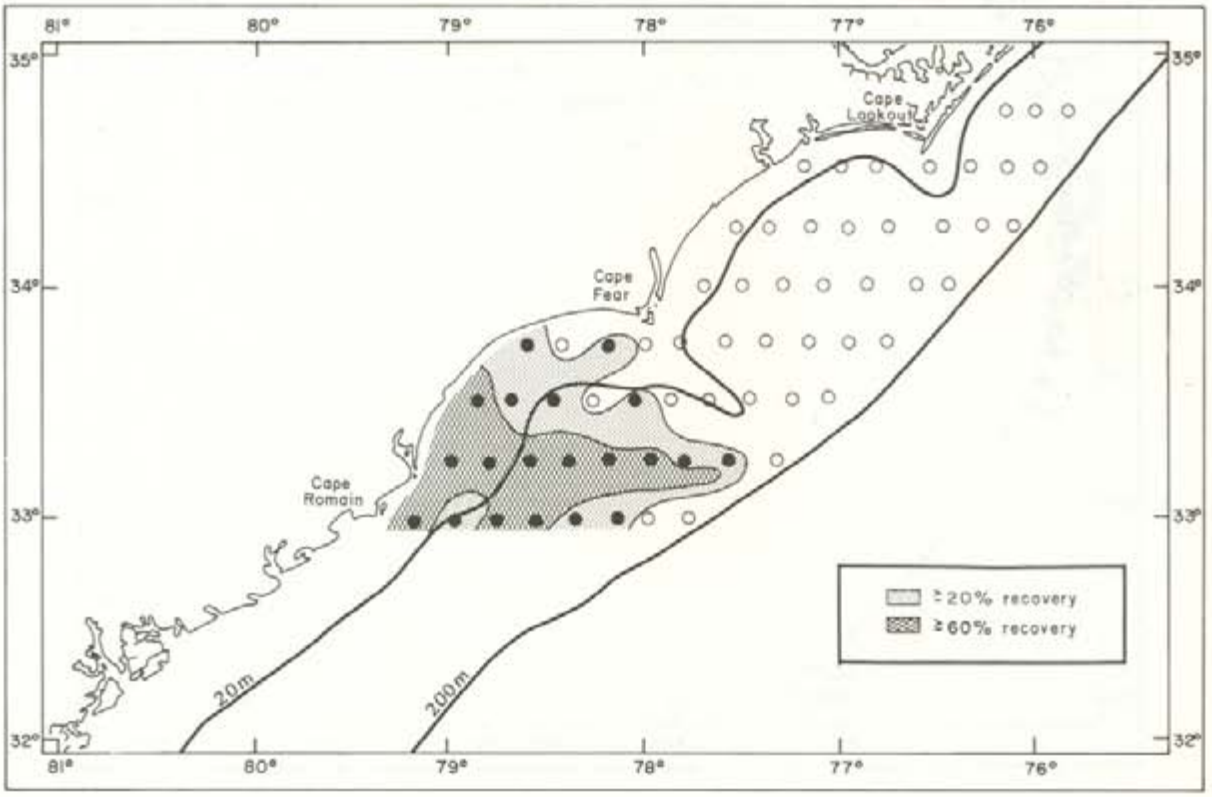

Figure 7. The submerged projection of Cape Fear, indicated by the 20 m isobath contour and the percent of drift bottle recovery from bottles released in September, 1974.

and Ingham, 1976) and the direction of inferred surface water drift. Northerly returns within Onslow Bay could reflect slow northerly movement within nearshore surface waters (Bumpus, 1955; Bumpus and Lauzier, 1965; and Stefansson, Atkinson and Bumpus, 1971) or more rapid transport within the counterclockwise eddy indicated by results of Stefansson and Atkinson (1967).

The average calculated speed for the northerly surface drift in Onslow Bay during April (12.7 km/day) was significantly greater than that previously reported by Bumpus (1973) during this time of year (5.6 to 7.4 km/day). The average current speeds calculated for northerly and southerly drift during other months agree with Bumpus (1973).

Additional surface and midwater current studies are in progress in Onslow Bay by NMFS at Beaufort, North Carolina and south of Charleston by Skidaway Institute of Oceanography and the University of Miami. These should increase our understanding of the circulation patterns over the continental shelf south of Cape Hatteras.

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