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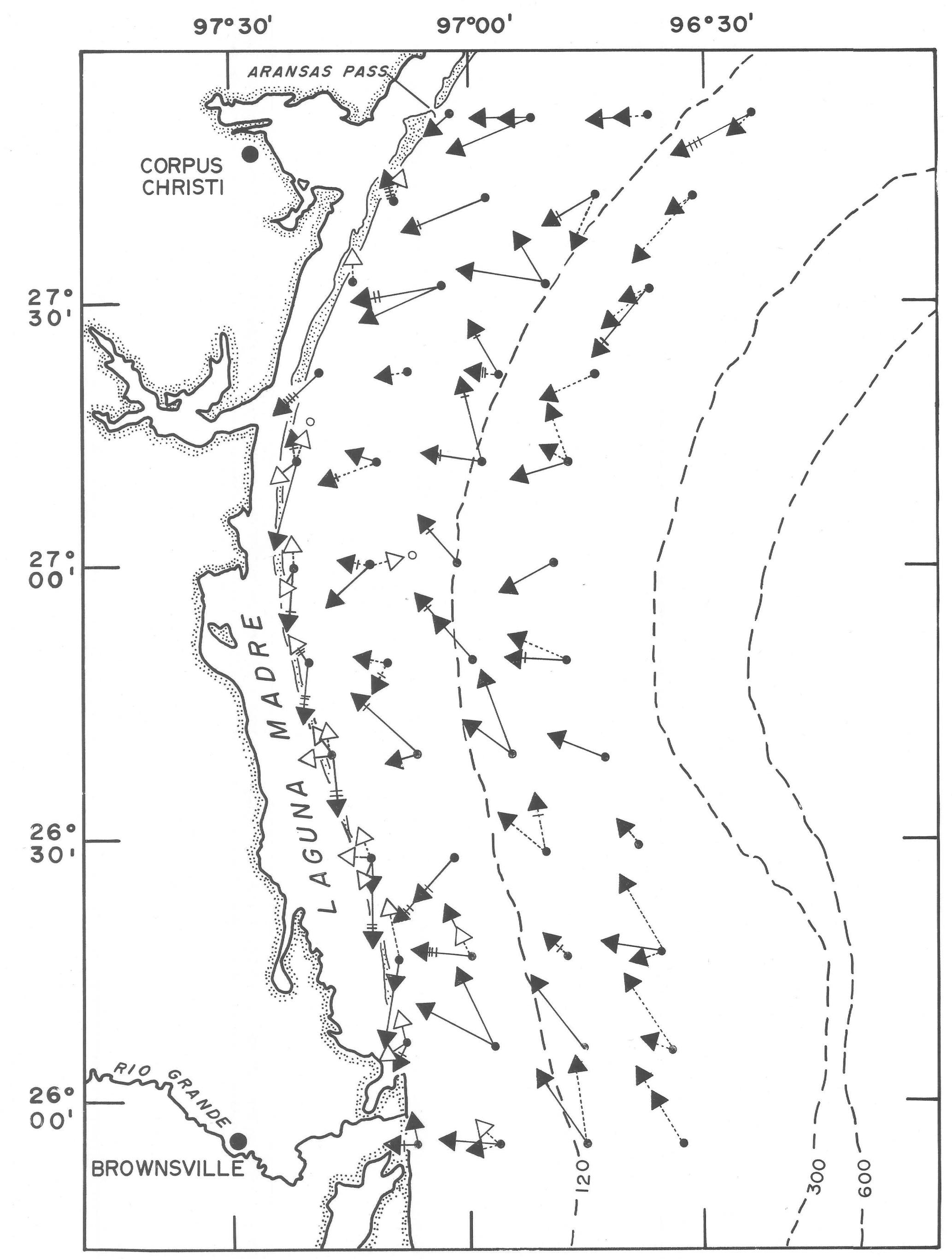
MISCELLANEOUS FIELD STUDIES
MAP MF-623
(SHEET 2 OF 2)



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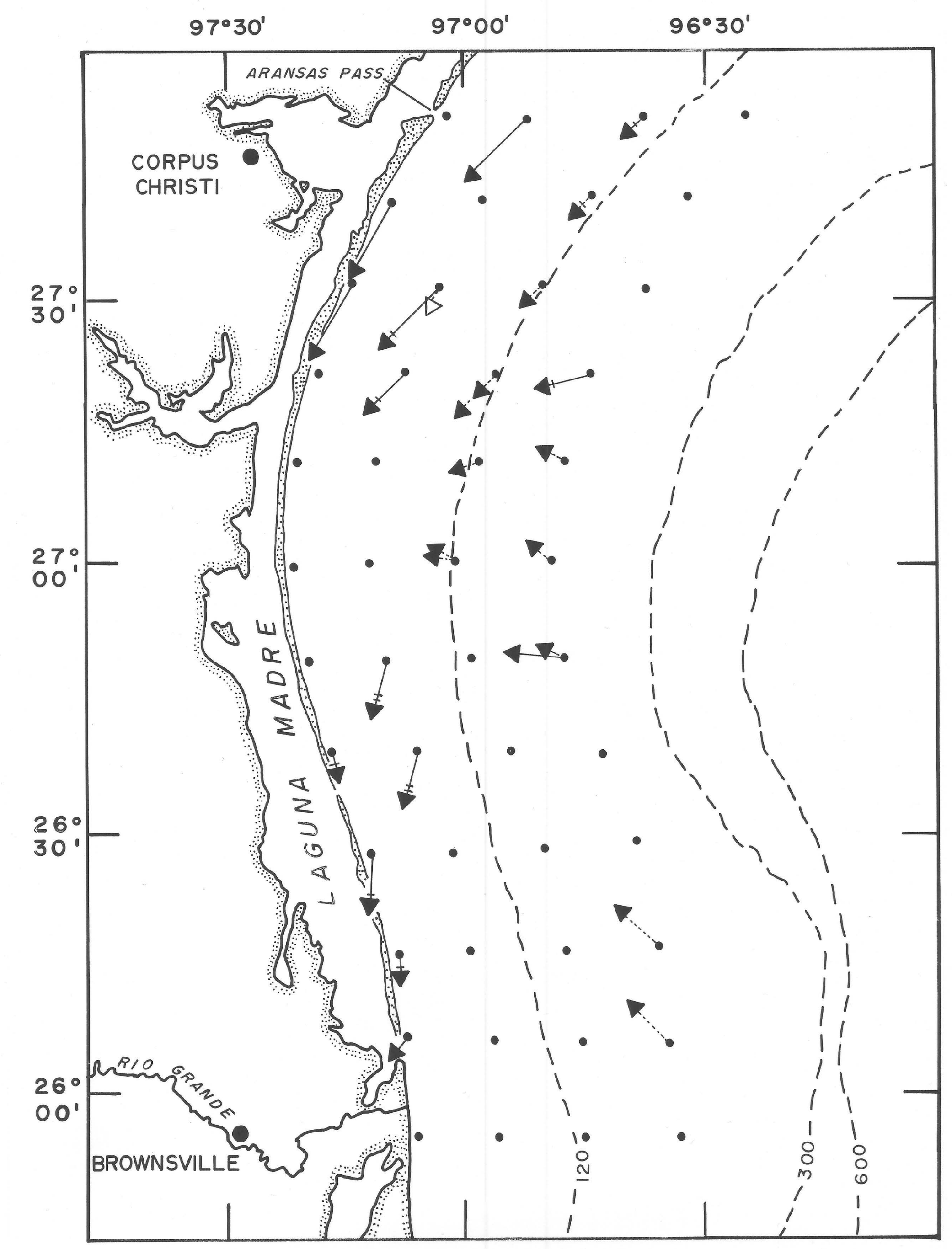

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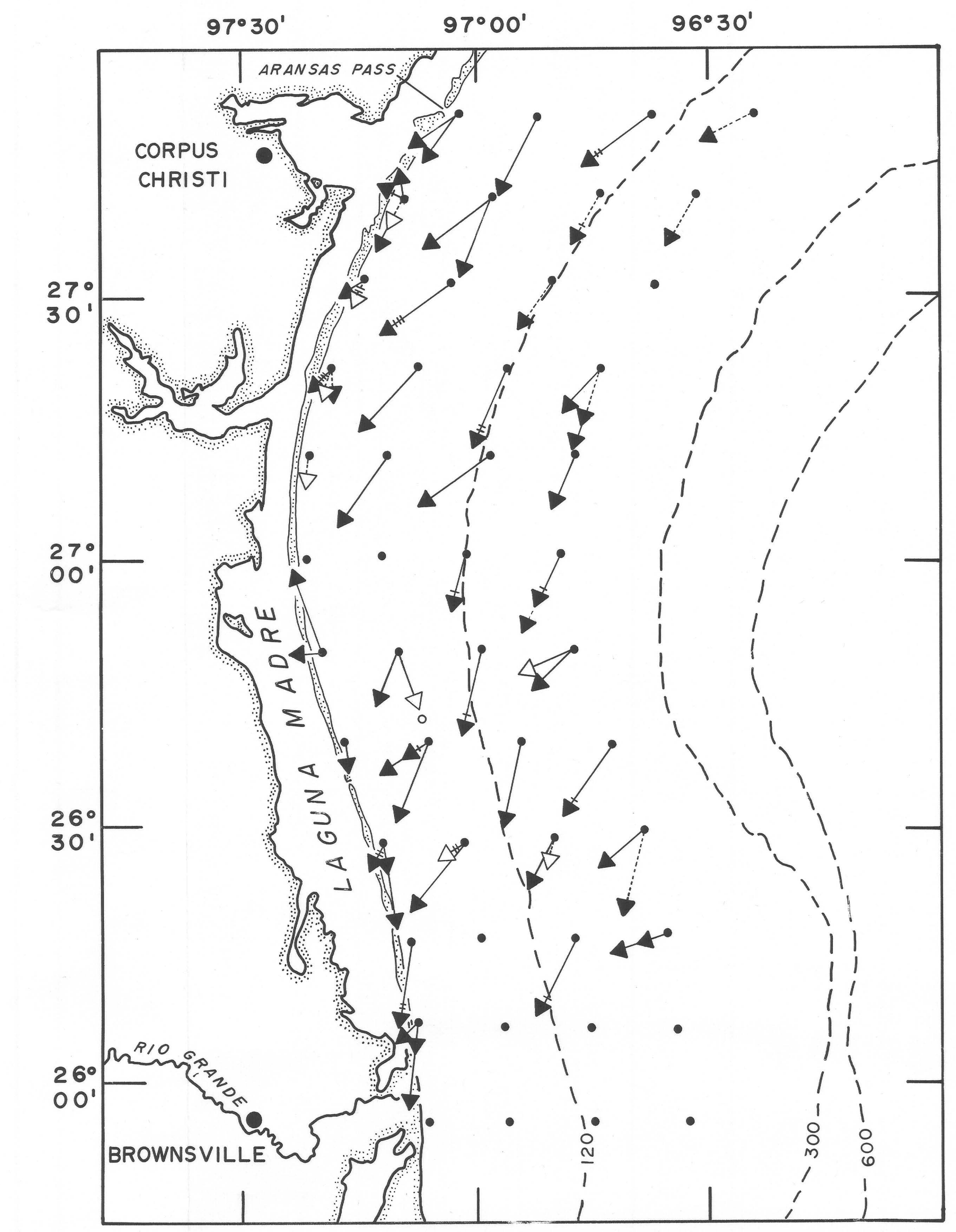

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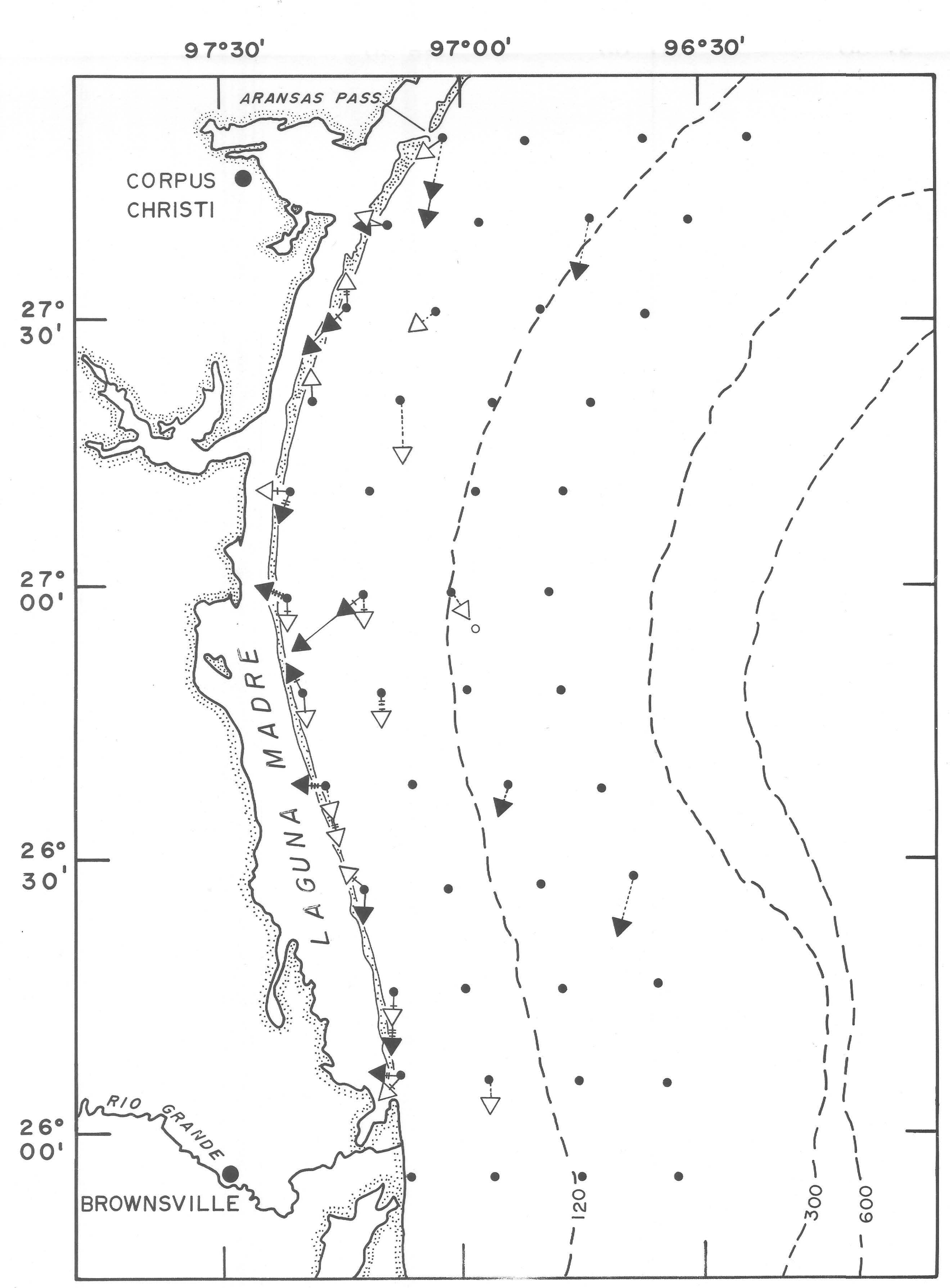

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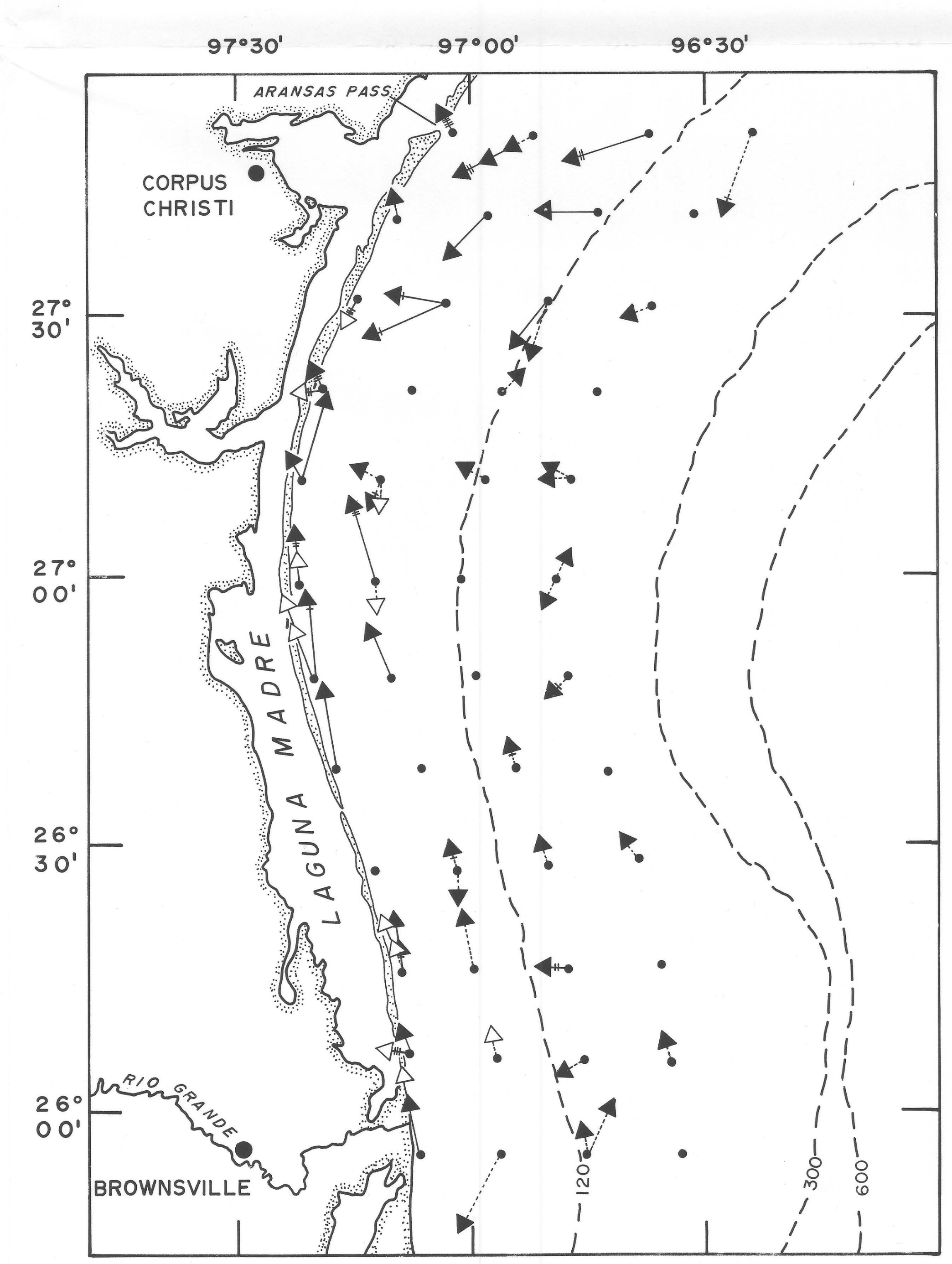

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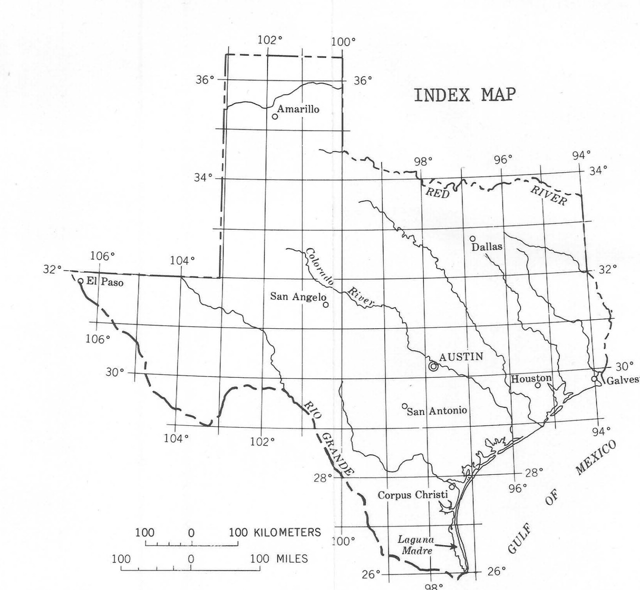

EXPLANATION GIVEN ON SHEET 1

MAPS SHOWING DRIFT PATTERNS ALONG THE SOUTH TEXAS COAST, 1970-1973

By
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INTRODUCTION

An investigation of the rates and directions of drift in the northwestern Gulf of Mexico was initiated in January 1970 as part of a program to study depositional processes and sediment movement off the south Texas coast. The drift of surface water was measured by the net movement of ballasted drift bottles, and the drift of bottom water was determined by plastic seabed drifters of the Woodhead type, a type that has come into general use for bottom drift studies (for example, Bumpus, 1965; Harrison and others, 1967; Conomos and others, 1970).

Several drift studies in the northwestern Gulf of Mexico preceded this study. Kimsey and Temple (1963, 1964) released drift bottles seasonally over the entire width of the shelf. They discovered major seasonal changes in the direction of the coastwise surface currents and a seasonally shifting convergence zone. Their studies, covering two years, suggested that the seasonal changes in current patterns were similar from year to year. Although they presented some information on currents near the sea floor, their data were not extensive enough to define the areal and seasonal variations in bottom drift. Watson and Behrens (1970) conducted further drift-bottle studies, restricting their area of investigation to the inner shelf along the southern Texas coast, while increasing their frequency of release to monthly. They found convergences of nearshore surface drift along this section of coast during some of the year and showed that many aspects of the drift patterns were related to local winds.

The present study is intermediate between that of Watson and Behrens (1970) and that of Kimsey and Temple (1963, 1964) in area of coverage, resembles that of Kimsey and Temple in frequency of release, and differs from both in the closer spacing of release points and in the extensive use of bottom drifters.

METHODS

The drifters were prepared for release essentially in the way described by Conomos and others (1970). Five surface drifters and five bottom drifters were released at each of 48 stations on each release date by dropping them from an airplane whose location was fixed by Loran A or by Tacan. The release points were 12 nautical miles (22 kilometers) apart along four lines paralleling the coast between Aransas Pass, Texas, and the mouth of the Rio Grande. These lines were 1, 10, 20, and 30 nautical miles (2, 19, 37, and 56 km) offshore in water depths averaging about 30, 90, 130, and 190 feet (9, 27, 40, and 58 meters). Releases were made seasonally from January 1970 to April 1973, with the exception of a gap in the winter of 1971. The drifters were recovered by the general public.

RESULTS

General pattern of drifter returns

The number of drifters returned varied with the season, the distance of the release point from shore, and the type of drifter; overall, 20 percent of the released drifters were recovered (table 1). Almost all of the drifters were found on the Gulf of Mexico beaches from a point 10 miles (16 km) north of Aransas Pass to a point 100 miles (160 km) south of the mouth of the Rio Grande. Only a few were found on beaches north and south of these points, in the lagoons and bays, or by shrimp boats at sea. Most recoveries were made within 60 days of the release date, and most of those from the line closest to shore were made within 10 days of release. The net drift velocities, which were calculated from the straight-line distance and the elapsed time between release and recovery, and which are thus minimum velocities, ranged from 0.18 to 46 km/day. Recoveries made more than 60 days after release were disregarded.

Returns of drifters within a few days after each release from points scattered along the whole coastline from Aransas Pass to the Rio Grande create some confidence in the promptness and geographical representativeness of recoveries in this area. On the other hand, the rarity of returns from the barrier-island beaches north of Aransas Pass and from parts of the Mexican coast may be due in part to factors other than coastal circulation, as those sections are less accessible to visitors.

Drift patterns revealed by individual releases

January 16, 1970.--A relatively large number of bottom drifters and relatively few surface drifters were recovered. The drift was uniformly southward, both at the surface and near the sea floor, at all distances from shore.

April 28, 1970.--A tongue of rapid southward flow at the surface extended far to the south; it was bounded on the shoreward side by a zone of northward surface drift. In the nearshore zone, the bottom drift was generally southward beneath northward drifting surface water.

July 13, 1970.--Many surface drifters were recovered, while relatively few bottom drifters were found. The tongue of southward surface drift was much less extensive than in the spring, but southward bottom drift extended far to the south beneath northward surface drift.

November 4, 1970.--The drift pattern was rather confused, but a tendency to southward drift can be discerned in the northern part of the area, as well as a northward drift in the southern part of the area.

May 27, 1971.--The drift was mainly to the north, both at the surface and the bottom, except in the northernmost part of the area where a tongue of southward drift was present. Some southward surface drift occurred in southern parts of the nearshore zone.

September 7, 1971.--Two erratically moving hurricanes, Edith and Fern, passed over the area shortly after release of the drifters. The recoveries were too few and erratic in pattern to justify inclusion in this report.

December 6, 1971.--Few surface drifters were recovered, except from the inner line, but a relatively large percentage of bottom drifters was recovered. The drift was mainly southward, except in the nearshore zone where northward drift was common both at the surface and at the bottom.

April 4, 1972.--A large number of surface drifters was recovered. Drift was mainly southward in the northern part of the area and northward in the southern part of the area. In the nearshore zone, the surface drift was largely southward and the bottom drift was largely northward.

August 29, 1972.--Few surface drifters and only one bottom drifter were returned. Drift in the northern part of the area was to the south, and drift in the southern part of the area was to the north. Southward drift occurred throughout the nearshore zone.

October 4, 1972.--The drift was almost uniformly southward, both at the surface and near the sea floor, at all distances from shore.

January 18, 1973.--Many bottom drifters were recovered, while surface-drifter recoveries were uncommon, except from the inner line. The drift was uniformly southward throughout the area, except for scattered northward drift in the nearshore zone.

April 11, 1973.--Southward surface drift occurred in the northern third of the area, while northward surface drift occurred in the rest of the area and throughout the nearshore zone. Southward bottom drift extended southward beyond the area of southward surface drift.

DISCUSSION

Coastwise components of drift

A comparison of our data with previous drift studies (Kimsey and Temple, 1963, 1964; Watson and Behrens, 1970) off the south Texas coast confirms the existence of a yearly cycle of seasonally changing patterns of coastwise water movement. These seasonal changes in water movement can be accounted for to a large extent by seasonally changing winds (fig. 1). However, as noted by Kimsey and Temple (1964), the pattern characteristic of a given season can be delayed, prematurely stopped, or modified by winds atypical of the season.

In accordance with seasonal variations in wind direction, southward drift is best developed during the winter, whereas northward drift is best developed during the summer. Southward drift is best developed in the northern part of the study area and northward drift is best developed in the south due to variations in the orientation of the shoreline relative to the predominant southeasterly winds. Uniformly southward winter drift (January 1970) and uniformly northward summer drift (reported by Watson and Behrens, 1970) define the extremes of seasonal variation along the south Texas coast, but these extreme conditions may not occur every year.

During many spring and fall seasons and parts of some summers and winters, a drift convergence occurs along the southern Texas coast. The position of convergence tends to shift northward during the spring and southward during the fall, though probably with some reversals not evident from seasonally spaced studies. Within a few miles from shore, for example, the direction of drift is known to shift from day to day as the wind shifts. The poor definition of the convergence following the release of November 1970 is suggestive of irregular changes in the drift pattern during the recovery period.

The convergences shown by our data are complex in structure, both in the horizontal plane and in vertical sections. Several of the maps (for example, July 1970) show tonguelike projections of surface flow in one direction bounded on one or both sides by areas of opposing water movement. However, drift in opposing directions along different release lines may be due in part to the fact that drifters from different release lines tend to be in the water for differing lengths of time and, therefore, may be exposed to differing conditions.

The convergence near the sea floor is sometimes many miles south of the surface convergence (especially July 1970), suggesting that in vertical section the convergence zone slopes southward. Less commonly (April 1972), the convergence near the sea floor is north of the surface convergence. The separation of surface and bottom convergences may be the result of density stratification related to the temperatures and salinities of the two converging water masses. Well-defined temperature and salinity stratification is known to exist at times off the southern Texas coast (Jones, Copeland, and Hoese, 1965), but the distribution of water density has never been determined over a large enough area to evaluate the possible existence of converging water masses of differing character.

Both this study and that of Watson and Behrens (1970) show that southward drift is often more extensive than can be explained by the relation of local wind direction to shoreline direction; that is, the convergence often lies south of the point at which the wind direction is normal to the shoreline. A complete explanation for this phenomenon cannot be given at the present time, but the anomalous southward flow may be a "coastal jet" of the kind described theoretically by Csanady (1967, 1968) and Birchfield (1967) and observed in Lake Ontario by Scott and Landsberg (1969). A coastal jet, which flows to the right of an observer facing offshore in the northern hemisphere, is produced by a Coriolis effect on a seaward-sloping wedge of coastal water, the seaward slope being due to setup by the wind, in some cases accentuated by the presence of a seaward-thinning wedge of relatively warm or brackish low-density surface water. Similar types of drift, though not explicitly called coastal jets, have been observed on the Atlantic Continental Shelf of the United States (Bumpus, 1969) and on the Pacific Continental Shelf near the mouth of the Columbia River during the winter (Barnes, Duxbury, and Morse, 1972).

Onshore and offshore components of drift

As recovery of seaward-moving drifters is very unlikely, differences between the numbers of bottom and surface drifters recovered are normally the only evidence of seaward currents to be expected from drift studies. Consistently greater recoveries of one type of drifter might indicate that type to be more durable, more easily transported, or more readily discovered on the beach than the other type. A seasonal reversal of the ratio of bottom-drifter recoveries to surface-drifter recoveries, however, would preclude these explanations and would suggest that surface and bottom drift have opposed onshore and offshore components and that these components are reversed seasonally. Some indications of the reliability of this type of evidence have been given by Harrison and others (1967).

The ratio of bottom-drifter recoveries to surface-drifter recoveries on the south Texas coast shows significant seasonal variations. In winter, the number of bottom-drifter recoveries tends to be relatively large compared to the number of surface-drifter recoveries, while in summer the opposite tends to be true (table 1). In fall and spring the recovery ratio varies considerably. This pattern of recoveries suggests that onshore surface drift is best developed during summer conditions, but that an offshore component of surface drift exists at least locally or temporarily during winter conditions. Onshore bottom drift, according to the evidence given by recovery ratios, is best developed during winter conditions; during summer conditions, the bottom drift may have an offshore component. The offshore bottom drift, suggested by relatively low recovery rates of bottom drifters, was confirmed on several occasions by the recovery of bottom drifters at sea, the drifters having moved offshore from their release points.

Onshore surface drift during the summer is a result of the predominantly onshore southeasterly winds. The tendency to offshore surface drift during the winter is evidently related to northerly winds, which are common at this time and which usually have at least slightly offshore components. Onshore or offshore components of bottom drift in opposition to the components of surface drift are to be expected from the steady state requirement that no net flow normal to shore can exist.

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