LATE-WINTER WATERS OF YUCATAN STRAITS
A 1968 'Geronimo' Survey in Gulf of Mexico

Reed S. Armstrong

Oceanographic surveys in the Gulf of Mexico have demonstrated that the Yucatan Straits is the area where circulation dynamics are the most intense. For this reason, the water between the Florida Keys, Cuba, and the Yucatan Peninsula was selected for oceanographic investigations during the first manned Apollo spaceflight in 1968. While the spacecraft is operating its sensors, a BCF vessel will survey these waters on a "ground truth" mission. It is hoped this cooperative work will resolve numerous questions about the use of sensors aboard spacecraft to study the oceans.

Between Feb. 8 and March 5, 1968, cruise 20 of the R/V Geronimo (BCF, Galveston, Texas) was made in the Yucatan Straits area (fig. 1). The purposes were to: (1) determine if the survey area was large enough to cover the circulation patterns that might be detected by the Apollo spacecraft sensors--and if the station grid was adequate to bring out these features; and (2) examine the waters in this area of the Gulf of Mexico to establish how the deep water in the Caribbean flows over the relatively shallow sill (about 2,100 m. deep) of the Yucatan Straits.

What Scientists Did

During the cruise, 58 hydrographic stations were occupied to obtain information on temperature, salinity, dissolved oxygen, silicates, and phosphates from the surface to a maximum depth of 4,000 m. In the survey area, 113 bathythermograph casts were made and 34 more casts were made along the return track to Galveston. Additional work during this cruise, not expected to be conducted during the "ground truth" mission, included 96 phytoplankton and zooplankton hauls and 41 sediment grabs and bottom cores.

Temperatures during the cruise were about 25.5° C. or higher in the central part of the survey area but decreased to as low as 20.5° C. north of Campeche Shelf (fig. 2). Temperature on the shelf was about 22.5° C. In the northwestern Straits, the change in surface temperature was as large as 4° C. over a distance of about 56 km. In the central part of the Yucatan Straits, the occurrence of water of about 22.5° C. (surface temperature over the Campeche Shelf) at about 175-200 m. depth proves that upwelling had brought water from about that depth to the surface over the shelf.

Two Cruises Compared

Although reduction of the data has not been completed, the distributions of variables at the surface have indicated some interesting features, particularly when compared to the results of the 12th cruise of the Geronimo a year earlier (Feb. 20 to April 1, 1967). The water temperature was about 0.5° C. lower in the central Straits, and about 3° C. lower on the Campeche Shelf, than during the 1967 cruise. The cool surface water over the shelf north of the Yucatan Peninsula resulted from the upwelling of subsurface water because of the dynamic response to the strong northward current through the Straits.

The temperature differences were considerably greater over the Campeche Shelf than in the central portion during the two cruises. One or more of the following must have occurred: (1) the northward volume transport through the Yucatan Straits was greater in the winter of 1968 than in 1967, thereby causing deeper, colder water to be upwelled during 1968; (2) the northward flow in 1968 was restricted to a narrower width, so that if the volume transport was the same on both occasions, the main flow was confined to a narrow band of high-velocity current in 1968; (3) the core of the current in 1967 was in water so shallow that the bottom physically restricted upwelling; or (4) the winter of 1968 was more severe in the southeastern Gulf (and, therefore, in the northwestern Caribbean)

Mr. Armstrong is Research Oceanographer, BCF, Galveston, Texas 77550.
Note: Contribution No. 274.

U.S. DEPARTMENT OF THE INTERIOR
Fish and Wildlife Service
Sep. No. 835

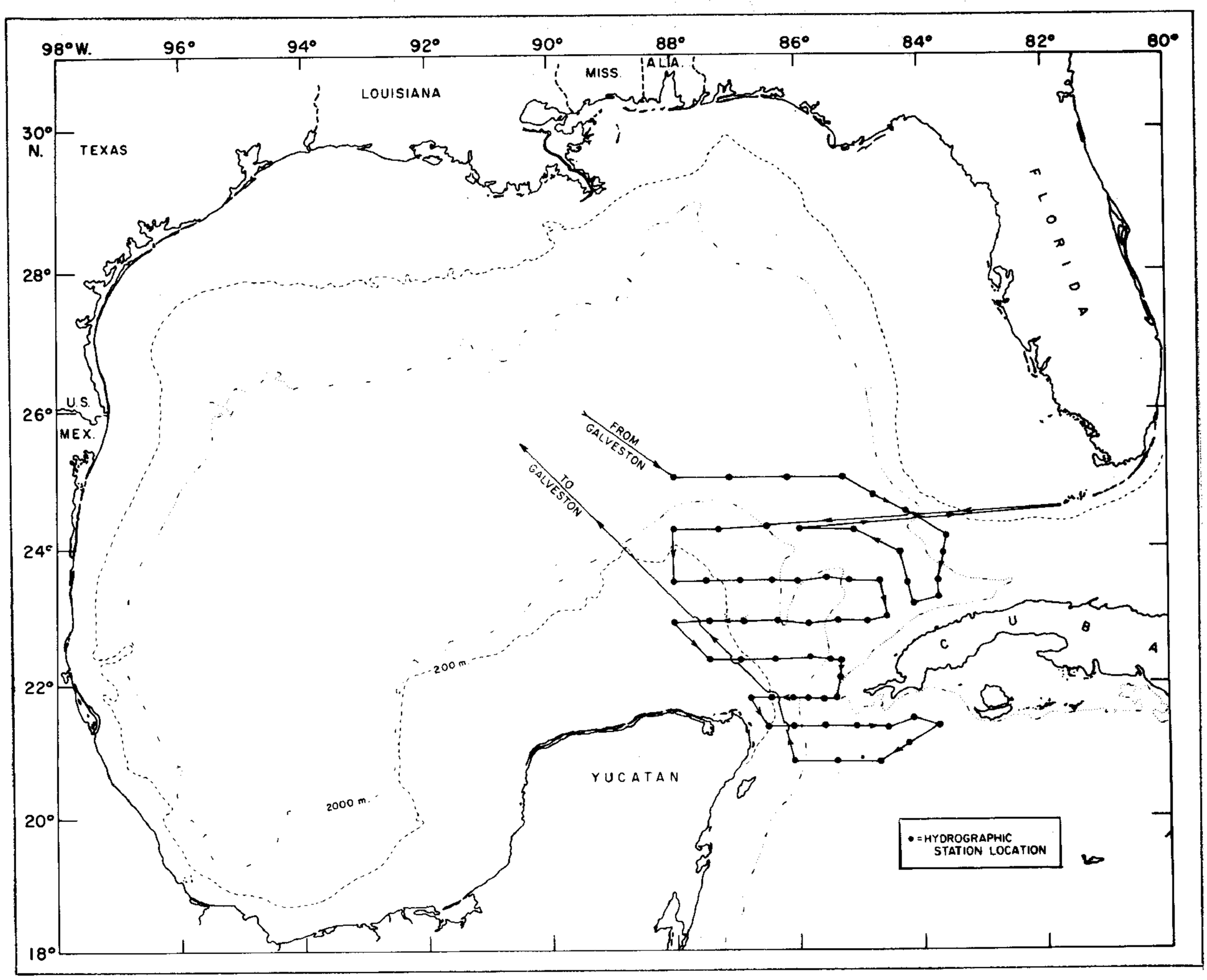

Fig. 1 - Cruise track and station plan for cruise 20 of R/V Geronimo to Yucatan Straits, Feb. 8-March 5, 1968.

than in 1967. To fulfill the last condition, the temperature differences between the two cruise periods would have to be about the same over the entire area, which definitely was not true. The third possibility also can be dropped from consideration because the current core was farther east, in deeper water, in 1967 than in 1968.

Surface salinities in 1968 were 35.8-35.9 p.p.t. (parts per thousand) over most of the central and eastern portion of the survey area--and increased westward to more than 36.5 p.p.t. over a distance of about 65 km. (fig. 3). Maximum surface salinities of about 36.8 p.p.t. were in a cell just north of the western tip of the Yucatan Peninsula. Compared to the surface salinities of the preceding winter, values were about 0.4 p.p.t. higher in the western sector over the shelf, and about 0.1 p.p.t. less over the remaining area. High values on the left-hand side of the northward current were a result of upwelling of deeper, high-salinity water (waters of these salinities were at a depth of about 175-200 m. in the central part of the Yucatan Straits).

The presence of cooler, more saline water over the Campeche Shelf in 1968 indicates that upwelling was more intense than in 1967. Not only was upwelling more intense--but the gradients of temperature and salinity were larger over the continental slope of the Yucatan Peninsula in 1968 than in 1967. Therefore, during winter 1968, the current velocity in the core of the northward flow was greater, and the maximum currents were restricted to a narrower band than during the 1967 cruise.

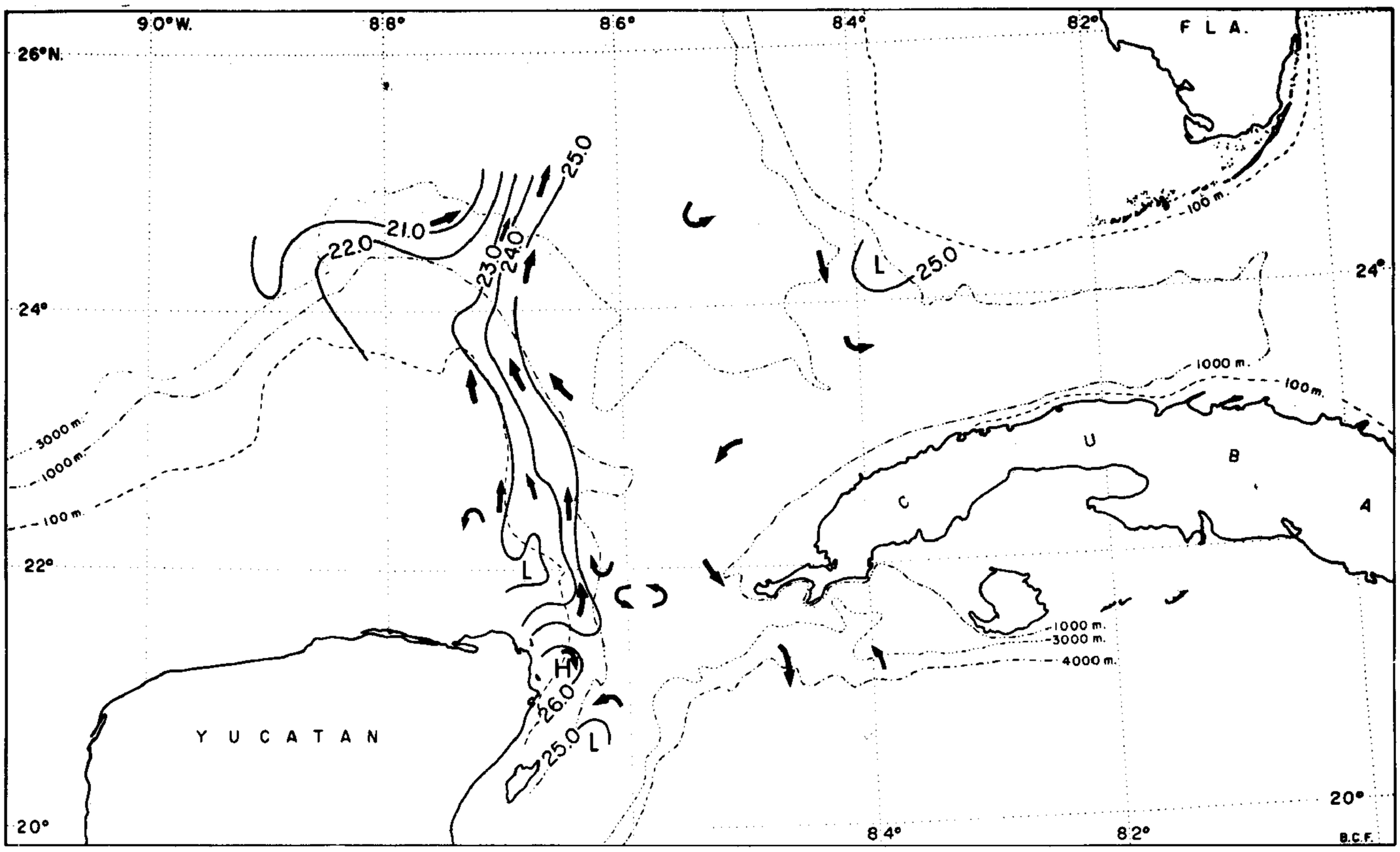

Fig. 2 - Distribution of surface temperature (° C.) and the surface circulation as inferred from the density distribution in the Yucatan Straits and the southern portion of the Gulf of Mexico.

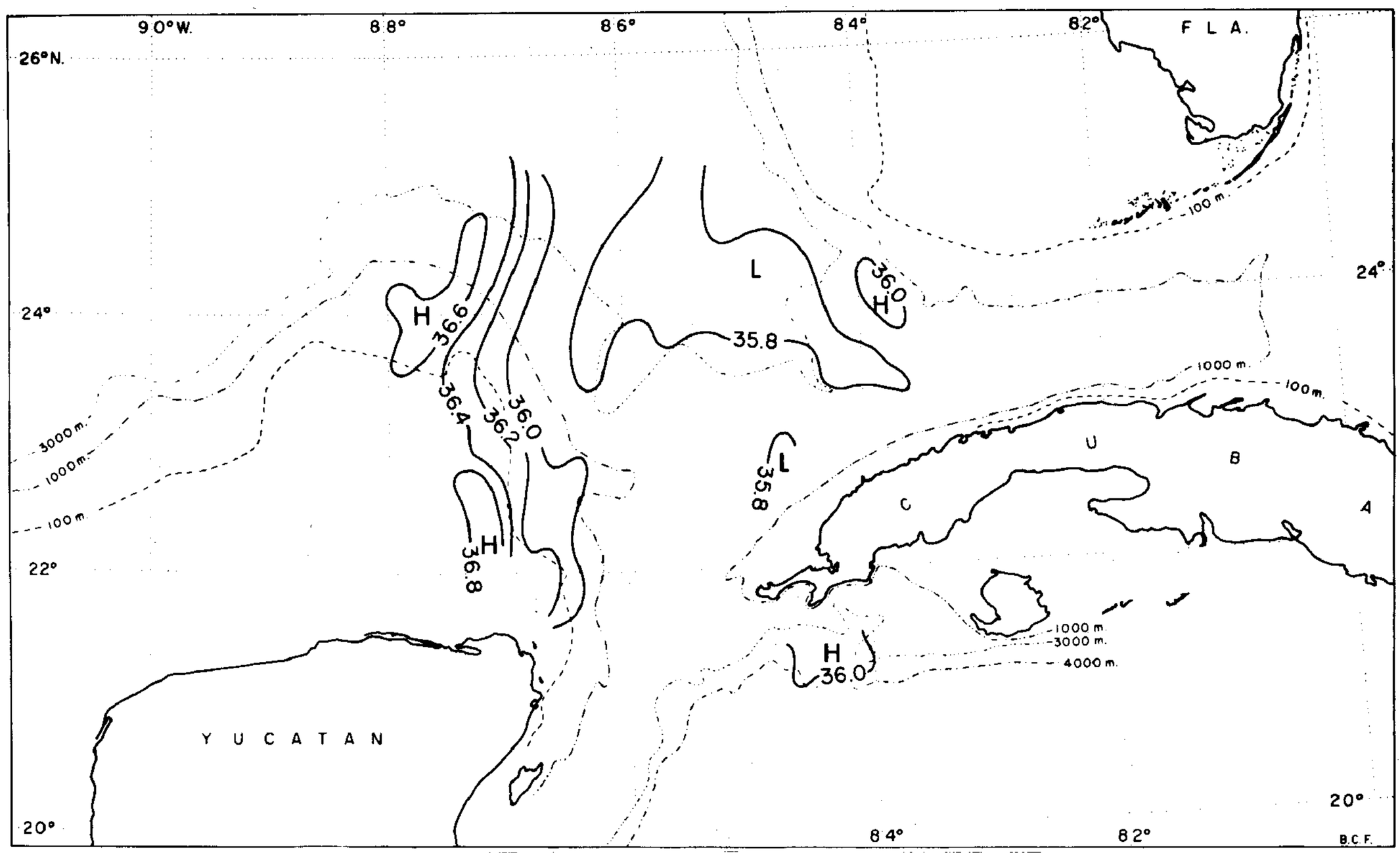

Fig. 3 - Surface salinity distribution (parts per thousand) in the Yucatan Straits and the southern portion of the Gulf of Mexico.

Strong Northward Flow

The predominant feature of the pattern of the surface currents presented in figure 2 (inferred from density distribution at surface) is the strong northward flow along the western side of the Straits. The upwelling over the Campeche Shelf results from this strong current that flows into the Gulf from the Caribbean. A countercurrent off the western tip of Cuba indicates a flow back into the Caribbean. The northward flow and the countercurrent seem to be permanent features. The numerous eddies off the eastern tip of the Yucatan Peninsula indicate a turbulent flow in that area.

A surprising feature in the current pattern is the lack of a well-defined flow and associated upwelling in the southwestern portion of the survey area. The large gradients of temperature and salinity over the slope of the Campeche Shelf should extend southward into the Caribbean. The lack of these gradients, however, probably means that the depth to the bottom below the core of the current and shoreward is so shallow that the bottom physically prevents upwelling in that particular area. The area must be in a turbulent condition that might erode the bottom. Because upwelling could not occur, the dynamics of this turbulent water would require a large slope of the sea surface. The line of eddies indicated in figures 2 and 3, and the presence of the shallow shelf and banks off the western tip of the Yucatan Peninsula, support this concept. If this appraisal is valid, the core of the surface current would have to be near the shore of Yucatan Peninsula--and would be increasingly distant from shore with increasing depth. Analysis of the subsurface data may resolve the question of this interesting feature of the circulation.