1980

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Florida Sci. 43(2):65-74. 1980.

Physical Sciences

HYDROGRAPHIC FEATURES OF FORT PIERCE INLET, FLORIDA

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ABSTRACT: *Circulation of the Fort Pierce Inlet and adjacent portions of the Indian River on Florida's Central East Coast was investigated during a 2 yr period. The currents were predominantly tidally driven, with wind effects becoming more important in the shallower areas of the Indian River and with increasing distance from the Inlet area. Variations in the salinity structure of the waters in the inlet area occur largely with the tidal stage.**

THE inlet at Fort Pierce, Florida (27°28'N 80° 18'W) is 1 of 3 tidal inlets connecting the Atlantic Ocean with the southern portion of the Indian River. The latter is part of an extensive barrier island estuarine lagoonal system extending along the central east coast of Florida. Coastal oceanic water passing through the inlets of Fort Pierce, Sebastian and St. Lucie (41 km to the north, 37 km to the south of Fort Pierce, respectively) encounters fresh water from tributaries that empty into the Indian River on its western bank. The fresh water sources are near the inlets and flow into the adjoining parts of the Indian River.

A study of the circulation and waters encountered in sections of the Indian River adjoining the Fort Pierce Inlet, required an investigation of the currents and water structures in an area encompassing the Fort Pierce Inlet and harbor. Preliminary results and the salient hydrographic features observed during this 2 yr investigation (mostly during the summer months) are described.

DESCRIPTION OF STUDY AREA—The present inlet and main ship channel at Fort Pierce is man-made, replacing a natural, but ephemeral inlet and channel, which had been located about 2 mi further north (Walton, 1974). The main channel is maintained at a depth of 7 m and extends from the ocean through the inlet into the Indian River where it intersects and crosses the Intracoastal Waterway to end in a basin forming the Fort Pierce harbor. A

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*The costs of publication of this article were defrayed in part by the payment of charges from funds made available in support of the research which is the subject of this article. In accordance with 18 U.S.C. § 1734, this article must therefore be hereby marked "*advertisement*" solely to indicate this fact.

large shallow (~1 m) grass flat, locally referred to as Jim Island flats, lies to the north of the main channel and is partially exposed at low tide. This area is separated from a deeper (~2 m) north-south aligned channel on its eastern side by a sill which is partially exposed at mean water (Fig. 1).

The Fort Pierce Inlet exerts a broad influence on the circulation and waters in the northern and southern adjoining sections of the lagoon and in the near coastal zone (von Zweck et al., 1974, 1975, 1976). The effect of tidal action at the inlet extends about 35 km into the northern branch of the river. The water passing through the inlet has been observed to move as far as 7-8 km north from the inlet area. The discharge from the inlet into the ocean is easily recognizable by its color as it spreads along the beach (Sedwick, 1973).

The largest source of fresh water in the study area is Taylor Creek which is part of a Florida Flood Control System and enters the Indian River on its western bank in the northern part of the study area (Fig. 1).

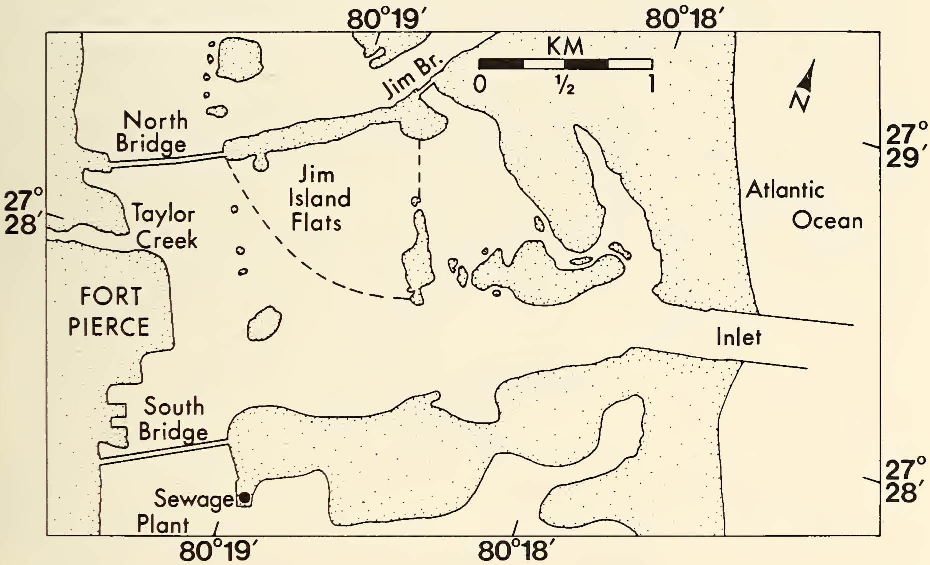


Fig. 1. Map of area under investigation.

The oceanic tide and the tide within the inlet area is essentially semidiurnal with a very weak diurnal component. Sedwick (1973) reported an average oceanic tidal range of about 1 m at the inlet entrance and 0.2 m at the Fort Pierce City Dock, corresponding to an 80% reduction in tidal range. The National Ocean Survey tidal height tables show a lag of the Fort Pierce tide behind the ocean tide of 2.5 hr for low tide and 2 hr for high tide.

Observational procedures—Salinity, temperature and current data were collected under varying tidal and meteorological conditions at sites located throughout the Fort Pierce Inlet and harbor area, as well as the adjoining sections of the Indian River. This effort was complemented by hourly vertical salinity, temperature and current profiles, and meteorological observations from a number of 13 hr anchor stations at selected sites.

A direct readout CSTD was used for the vertical salinity and temperature profiles; current speeds and directions were measured using direct readout current meters and drogue drift observations. In an attempt to better determine the overall circulation pattern, a comprehensive dye drift study was undertaken (Richardson, 1977). The dye study was carried out under both flood and ebb conditions by releasing premeasured amounts of dye near the time of maximum flow and observing their motion and dispersal by aerial photography.

Circulation—The circulation in the Fort Pierce Inlet and harbor area is predominantly tidally driven. Tidal harmonic analysis of a 29 da current record from the inlet shows that approximately 93% of the variance of the current flow can be accounted for by tidal constituents.

The most probable surface current patterns for the Fort Pierce Inlet and harbor area near the period of maximum flood and ebb flows are in Figs. 2 and 3, respectively. These patterns represent composites of dye drift observations obtained on 14, 16, and 24 July 1975 under flooding conditions and on 6 and 7 August 1975 under ebbing conditions. The dye drift patterns were obtained from visual observations from the air and from boats at times of maximum tidal flow, as predicted for the Fort Pierce Inlet by the *Tidal Current Tables* (National Ocean Survey, 1975).

Similar composites for tidal flows at a depth of 1.5 m were formed for the same area from drogue drift observations collected during 1974. Figs. 4 and 5 present these subsurface currents within ± 1 hour of the predicted max-

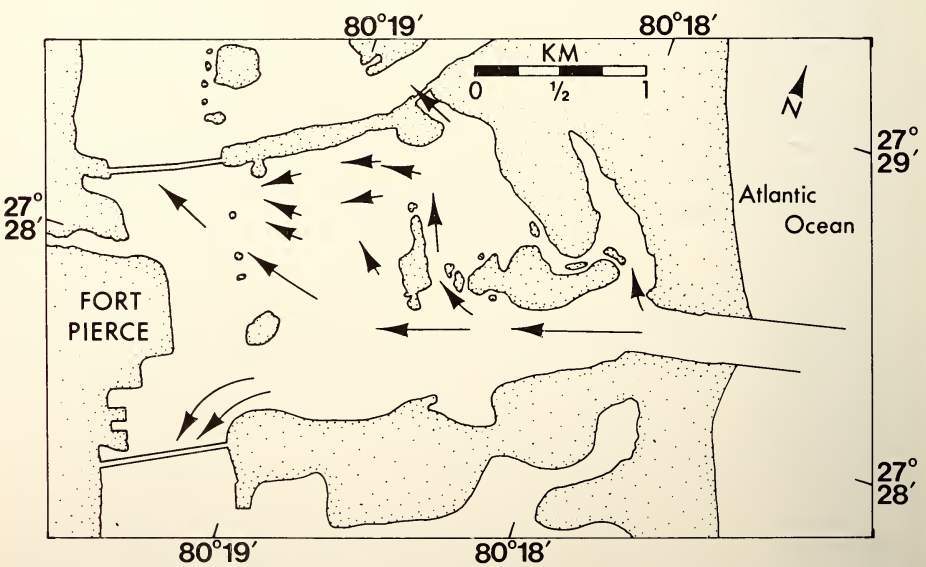


Fig. 2. Surface flood current pattern.

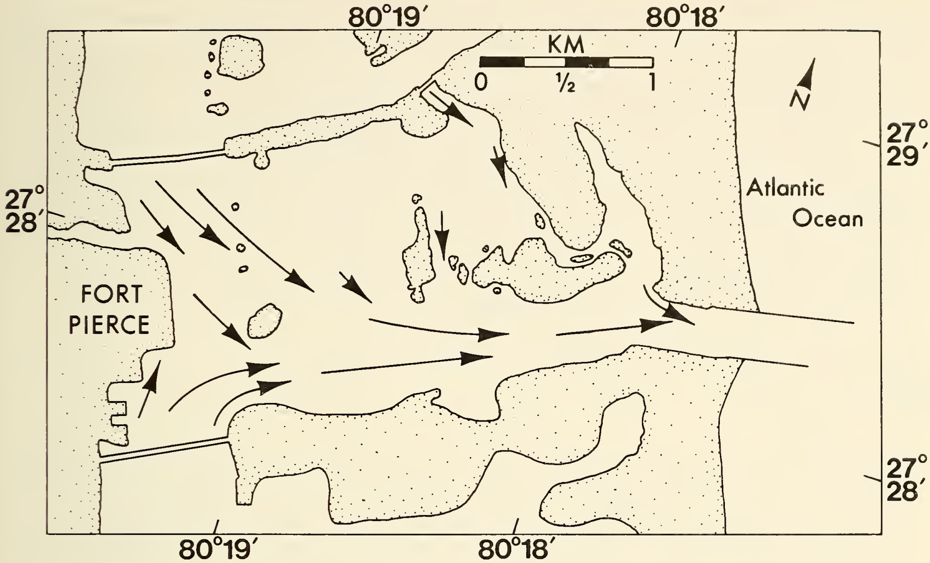


FIG. 3. Surface ebb current pattern.

imum ebb and flood currents. Ratios of estimated observed currents speeds to the predicted speeds for the inlet are shown next to the arrows indicating the paths of the drogue.

The current patterns conform closely to the local bathymetry, with major flows occurring in the larger channels. The flow across the Jim Island

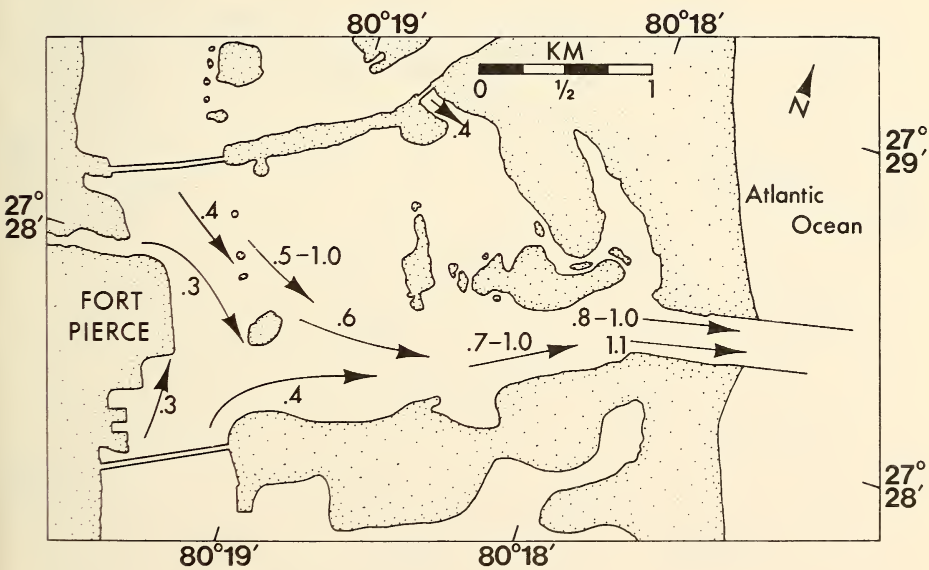


FIG. 4. Subsurface ebb current pattern.

TABLE 1. Volume transports (m^3/sec) at time of maximum currents predicted by NOS Tidal Current Tables.

	EBB (m^3/sec)	FLOOD (m^3/sec)
Transect 1 (North Bridge)	**	550
Transect 2 (South Bridge)	1100	1100
Transect 3 (Inlet)	1400	1900
Transect 4 (Jim Creek)	200	300
Transect 5 (Taylor Creek)	60	20
Sewage Treatment Plant	1-2*	1-2*

*Data supplied by the City of Fort Pierce.
**Data not available.

flats is generally weak because the east-west flow is reduced by the sill on its eastern boundary. The outflow at the mouth of Taylor Creek is confined in a shallow (~0.5m) surface layer and is directed into the Indian River while the flow of the deeper layer in this area reverses its direction with the flood and ebb tide.

Table I gives estimates of transports entering and leaving the study area near times of maximum ebb and flood flow. These estimates were obtained by vertical and horizontal integrations of the velocity profiles measured along a number of transects.

Data for volume transport at North Bridge at ebb tide are unavailable, it is however reasonable to assume that this transport is approximately the

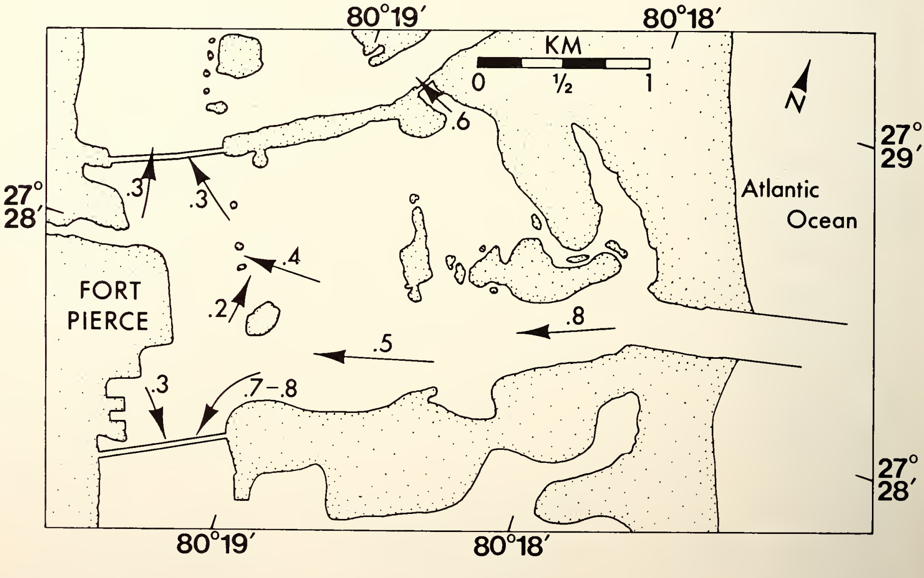
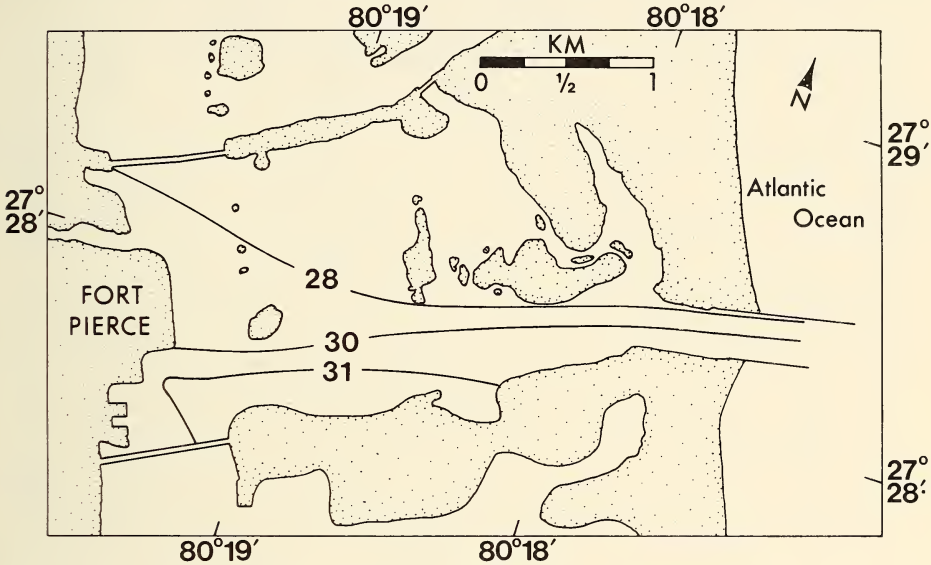


FIG. 5. Subsurface flood current pattern.

same at flood tide. This would result in an underestimation of the transport through the inlet.

Salinity and Temperature—The horizontal and vertical salinity structure of the water in the inlet/harbor area is predominantly controlled by the stage of the tide and the tidal currents.

Representative surface and subsurface (2 m depth) salinity distributions for both ebb and flood tide are shown in Figs. 6a, b and 7a, b respectively.



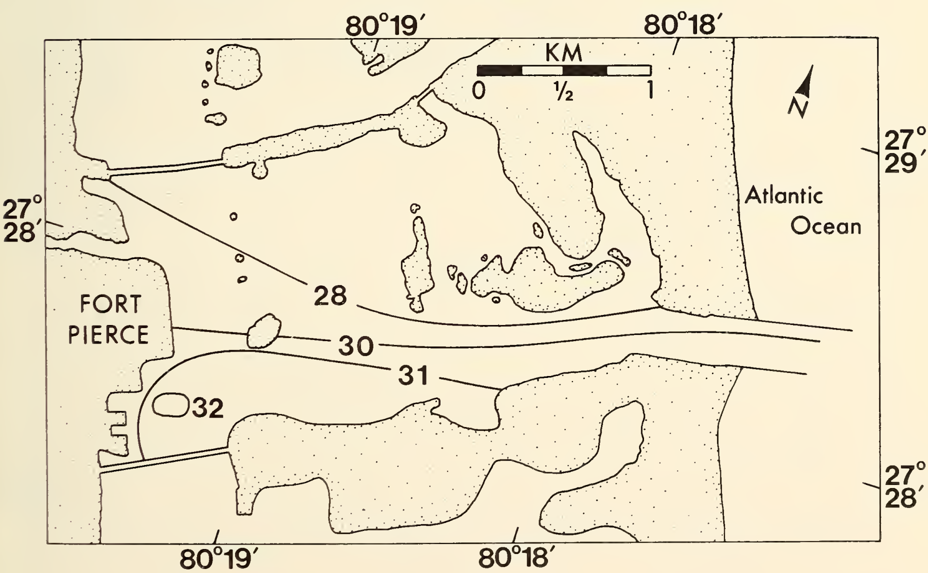


Fig. 6a. Surface salinity distribution during ebb tide.

Fig. 6b. Subsurface salinity distribution during ebb tide.

During ebb flow the influence of Taylor Creek water on the surface salinities extends across the Intracoastal Waterway into the inlet. The water in the inlet itself is vertically well mixed by the turbulent flow. In the beginning stages of the ebb tide, water from Taylor Creek passes over the Jim Island flats, as the ebb progresses, the flow moves off the flats and through a channel at its southern edge. A flood tide forces the freshwater back, forming a distinct salt wedge at the mouth of Taylor Creek. Although this salt wedge is

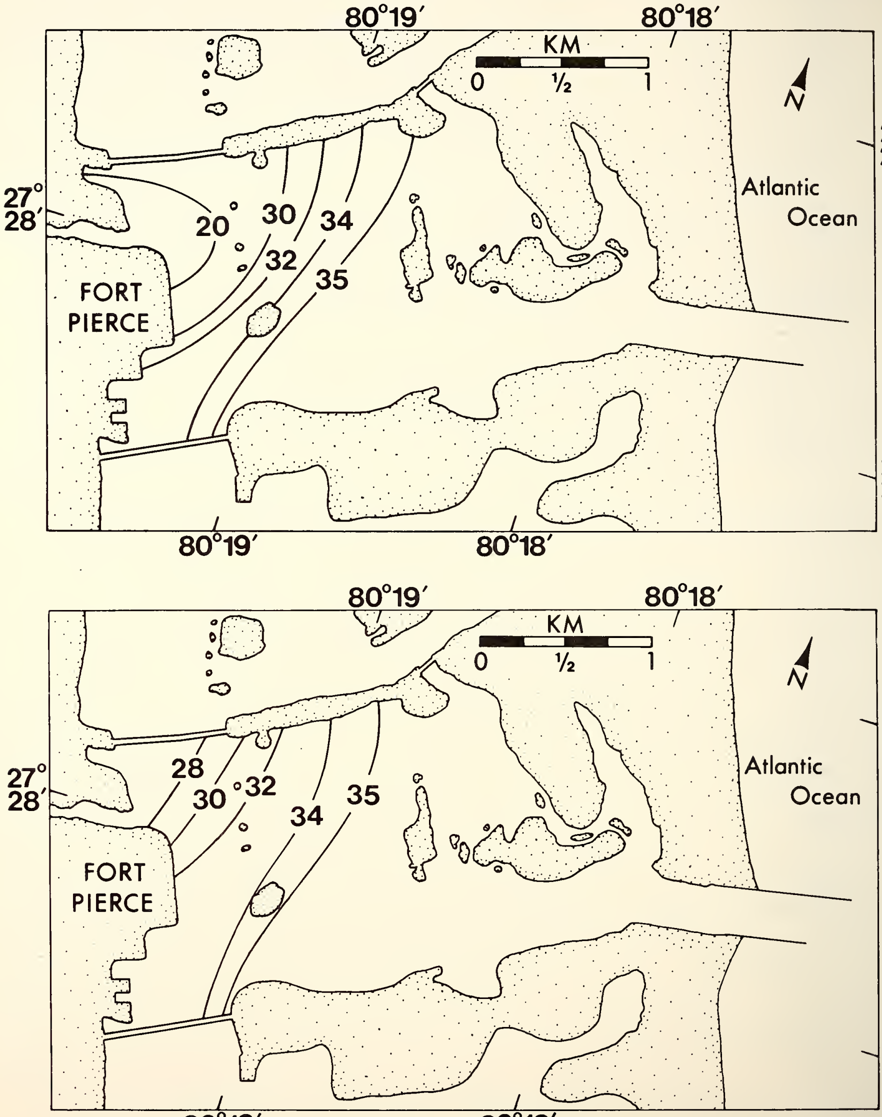
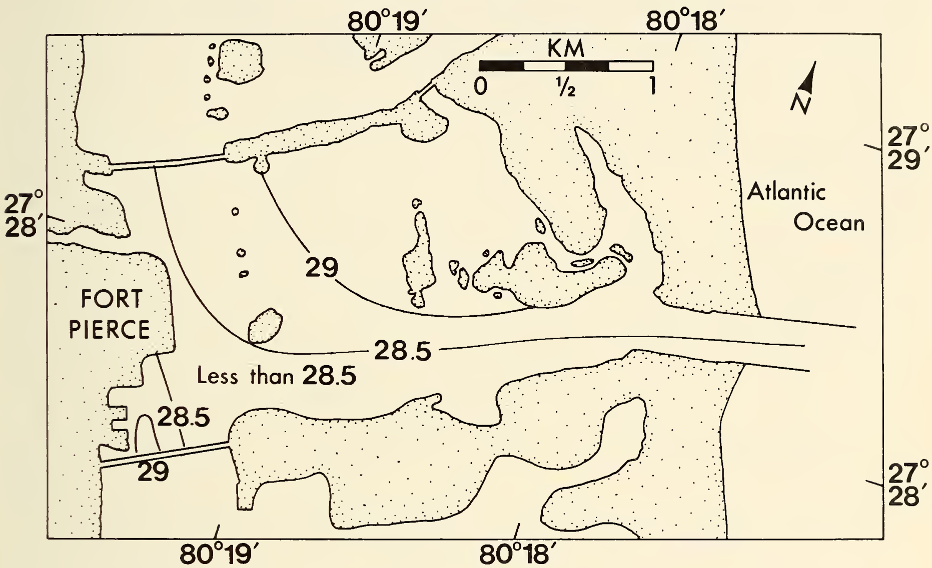


Fig. 7a. Surface salinity distribution during flood tide.

Fig. 7b. Subsurface salinity distribution during flood tide.

observed during both ebb and flood tide, it is most pronounced at an incoming tide. Vertical salinity differences up to 30 ppt have been observed at the mouth of the creek.

The thermal structure of the inlet area waters is shown in Figs. 8a, b (surface and subsurface temperatures at ebb tide) and 9a, b (surface and subsurface, flood tide). These figures represent a composite temperature distribution based on numerous sampling days between January and August



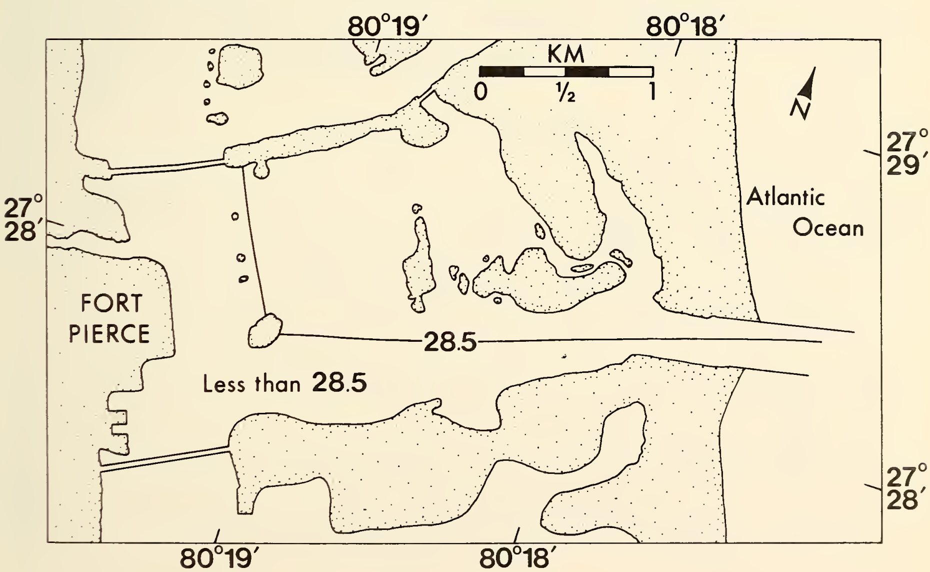
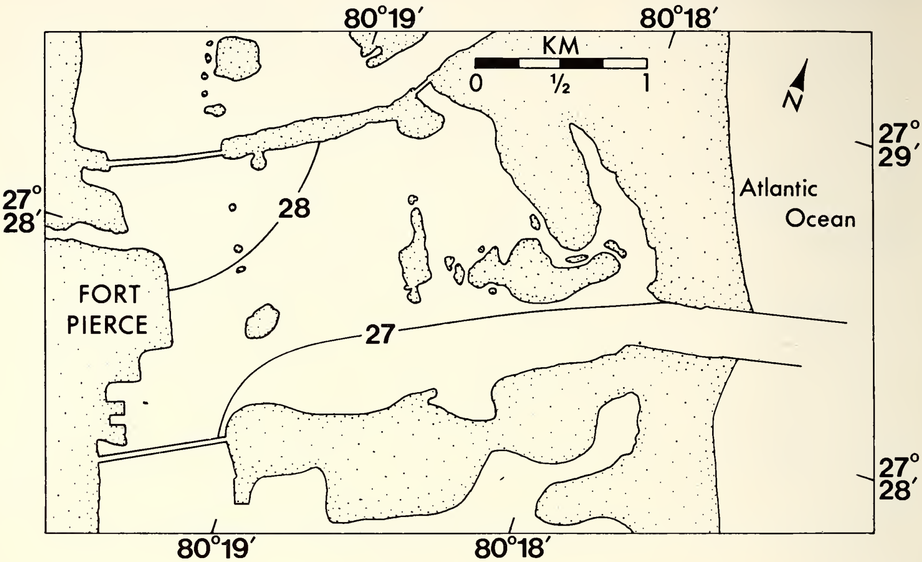


Fig. 8a. Surface temperature distribution during ebb tide.

Fig. 8b. Subsurface temperature distribution during ebb tide.

1974, and represent a typical thermal distribution for this area; no large horizontal temperature differences were consistently observed. Taylor Creek appeared to be a source of slightly warmer water, in contrast to the cooler ocean water entering this area during a flood tide. The very shallow waters of the Jim Island grass flat were one of the warmer areas. Under ebb conditions, the largest temperature difference found in the inlet area is slightly



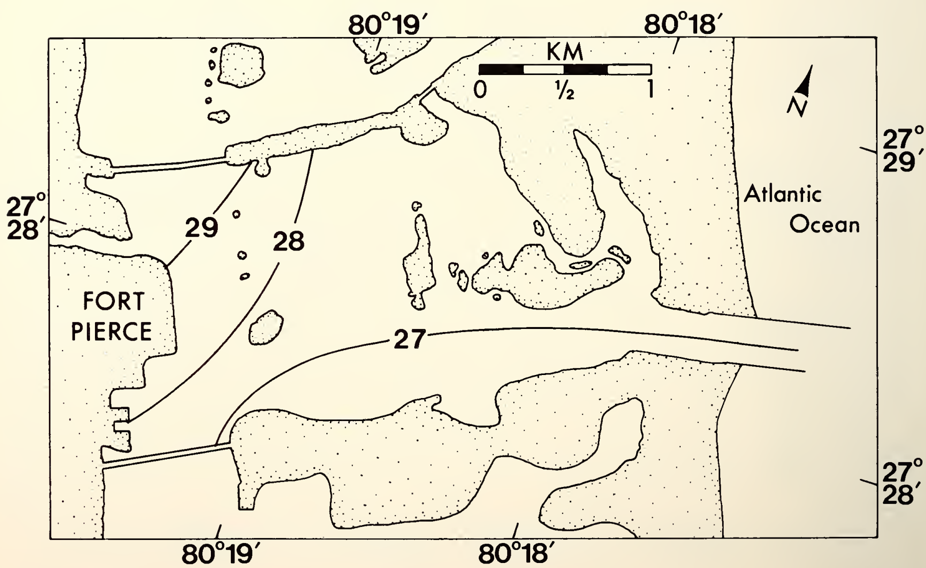


Fig. 9a. Surface temperature distribution during flood tide.

Fig. 9b. Subsurface temperature distribution during flood tide.

more than one half degree Celsius, while for flood conditions, the range is over 2° Celsius.

Three different waters are encountered in the inlet area and can be visually identified as to their sources by their distinctive colors. Taylor Creek water is dark brown due to high concentrations of tannic acid; Indian River water has a brownish-green tint and the coastal oceanic water is bluish-green. As these waters are moved by the tidal currents, sharp interfaces are formed between them. Because there exists a high correlation between the color of the water and its salinity, the sharp color interfaces also point out salinity discontinuities. The downstream portions of the interfaces disappear by vertical and horizontal mixing.

SUMMARY: 1. The circulation present in the Fort Pierce Inlet area is predominantly tidally driven. Wind driven currents modify the circulation pattern over the shallow Jim Island tidal flats.

2. Salinity of the inlet waters is governed largely by the tidal flow, with higher salinities being observed during a flood tide, and lower salinities during an ebb. The Taylor Creek outflow affects salinities to varying degrees depending on the state of the tide by creating horizontal salinity gradients. A salt wedge exists at the mouth of Taylor Creek during both phases of the tidal flow, but is more pronounced during the flood.

3. The thermal structure appears to be relatively constant, with the largest temperature variation encountered being slightly more than 2° Celsius.

4. The circulation pattern is largely affected by topographical features, including islands, shoal areas, grass flats, and dredged channels.

ACKNOWLEDGMENT—This work was supported by the Harbor Branch Foundation, Inc., Fort Pierce, Florida, as part of the Indian River Coastal Zone Study. The support is herewith gratefully acknowledged.

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