Water circulation and renewal in Florida Bay is influenced by flows from the Southwest Florida Shelf and tidal passes

Nelson Melo and Thomas N. Lee

Florida Bay is located at the southern end of Everglades National Park between the mainland and the Florida Keys. The Bay waters interact with adjacent coastal waters of the Southwest Florida Shelf to the west and Florida Keys Atlantic Coastal Zone to the east and southeast. Exchange of Bay interior waters with the Florida Keys Atlantic Coastal Zone is restricted to a few narrow tidal channels in the Keys island chain between Key Largo and Islamorada, whereas water exchange with the Southwest Florida Shelf region takes place across a 40 kilometer (25 mile)-wide open boundary. The combined tidal harmonics of the Gulf of Mexico and the Atlantic produce a mixed tide along this wide western boundary with a tidal range of 1 – 1.5 meters (3 – 5 feet).

Surprisingly, the largest tide in the Gulf of Mexico or on the eastern seaboard of the United States south of Brunswick, Georgia, occurs at the mouth of Shark River. There the tidal range can reach over 2 m (6.5 ft) during spring tides. Not surprising then, Flamingo Channel, which is the northwest entrance to the Bay and only about 10 km (6 mi) from the mouth of Shark River, is the largest open channel to the Bay and has the greatest tidal exchange. The northern boundary of the Bay is fringed with mangroves and coastal lagoons. Freshwater discharge to the Bay is primarily confined to the northeastern region through Taylor Slough and Trout Creek.

The interior of the Bay is made up of a complex network of shallow basins with depths ranging from 1 – 3 m (3 – 10 ft) deep separated by mud banks and mangrove islands. Connection between basins occurs through narrow channels and over the shallow banks. Water depths over the banks are typically less than 0.3 m (1 ft) deep. During periods of low sea level (e.g., winter dry season or strong winds toward the west or southwest), the banks can become exposed, causing

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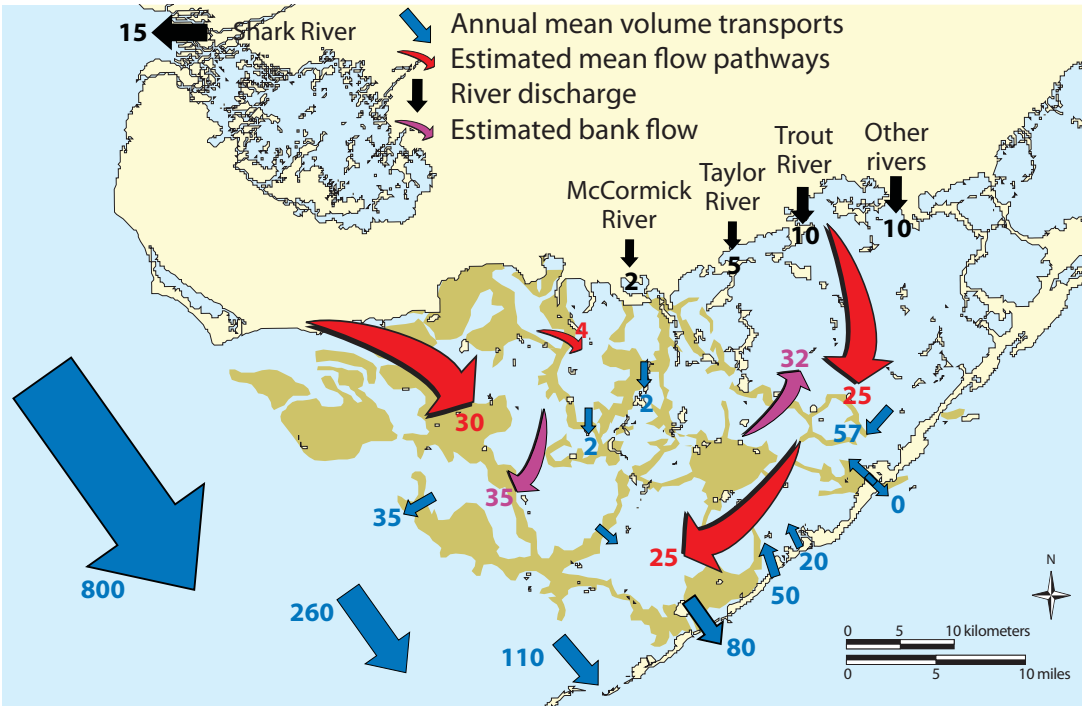
Satellite image of Florida Bay showing the four subregions based on water circulation patterns and water quality.



Annual mean volume transports (m^3/s) in Florida Bay and through the Keys (blue arrows) and estimated mean flow pathways (red arrows) between Florida Bay subregions. River discharge is shown by black arrows. Estimated bankflow is shown by magenta arrows.

further isolation of the interior basins. The mud banks are also primarily responsible for the large landward falloff in tidal range, which decreases from 1.5 m (5 ft) at the open western connection of the Bay to a few centimeters (1 inch) near the northeast boundary of the Bay.

The typical climate of south Florida consists primarily of two seasons: a dry season during winter/spring and a wet season during summer/fall. The balance of freshwater flux, controlled by river discharge, precipitation, and evaporation, is negative during the dry season and positive over the wet season. This leads to increasing salinities in Florida Bay during the dry season and decreasing salinities in the wet season.

The configuration of mud banks and mangrove islands within Florida Bay and differences in the magnitude of volume exchange with adjacent waterbodies together with the isolation of river discharge into the northeast portion of the Bay tend to separate the Bay into four subregions: northeast, north central, southeast, and western.

The subregions of Florida Bay are characterized by prolonged hypersalinity in the north central part and persistent lower salinity in the northeast, with both subregions displaying a large seasonal range of salinity. Salinity of the southeast and western subregions is more typical of the adjacent coastal areas, indicating enhanced water exchange with these regions.

Recent direct measurement of volume transports through channels connecting interior basins have been used together with time series of basin total volume transport derived from sea level measurements to estimate basin flushing rates and residence times and to identify the important physical processes regulating the water renewal. The measurement strategy was applied to the north central, northeast, and western subregions and clearly shows that local wind forcing is the primary flushing

mechanism controlling basin residence times. South Florida winds typically are weak from the east and southeast during the summer, shifting to be more from the northeast during the fall, with increased strength of wind events that can last several days. During the winter and spring seasons, cold fronts move through the region within a period of 3 – 7 days, causing increased winds that rotate clockwise from southwest through northwest to northeast. The cumulative effect from the passage of these wind events drives a mean flow through the basins, with net inflows over the banks and net outflows through the channels. The resulting net basin throughflows are weak and require on the order of 1 year to replace an equivalent mean volume of the north-central and northeast basins.

T. Scott - FGS

Florida Bay comprises a complex network of shallow basins with depths ranging from 1 – 3 m (3 – 10 ft) deep. These basins are separated by mud banks and mangrove islands and are connected by narrow channels through the shallow banks.

Net basin throughflows were found to be significantly larger in the western basin, which resulted in enhanced water exchange with the adjacent coastal waters, moderation of seasonal changes in salinity, and short residence times ranging from 0.5 – 2 months. Estimates of seasonal water balance indicate that groundwater discharge to Florida Bay is negligible.

Florida Bay mean flow pathways were estimated from annual mean volume transport measurements, river discharges, and derived bank flow estimates. The annual river discharge to the Bay of 27 cubic meters per second essentially is trapped in the eastern part with little diluting influence on hypersalinity of the north central Bay. Reduction of hypersalinity events in the Bay and corresponding degradation of water quality will require a diversion of a portion of the river discharge to the central region via McCormick Creek. There is a weak mean flow pathway from Flamingo Channel eastward across the northern banks and then southward through the north central basin of 4 m^3/s. There is also a much stronger clockwise mean flow pattern of about 30 m^3/s from the major arm of Flamingo Channel that feeds an outflow through Rabbit Key basin and through the channels of Nine Mile Bank. However, this recirculation through the western basins is small compared with the 800 m^3/s net southward coastal flow that provides the connection to transport riverine discharges from the Southwest Florida Shelf and Ten Thousand Islands area (including Shark River) to the western basins of Florida Bay and ultimately the Florida Keys Reef Tract.

T.A. Frankovich - FIU

Narrow channels through the shallow banks are marked with paired aids to navigation within Everglades National Park.