

Surface Water Salinity Mapping of Estero Bay and San Carlos Bay, Lee County, Florida

M.J. Byrne¹ and J.N. Flanigin¹

¹U.S. Geological Survey, Fort Myers, Florida

Introduction

Surface water salinity mapping can be used as a qualitative and quantitative tool for evaluating water transport and residence time in rivers and estuaries. Fourteen salinity maps were created from data collected over an 18-month period. These maps show seasonal variability, rivers of significance, and hydrologic barriers, such as islands, ridges, mangrove embankments, that prevent water from going between bays and rivers. We captured periods of high discharge from Lake Okeechobee and surrounding areas, as well as low-flow conditions.

Project Location

Estero Bay and San Carlos Bay (fig. 1) are located on the southwestern coast of Florida at the southern end of Charlotte Harbor. Lake Okeechobee, via the Caloosahatchee River, drains into San Carlos Bay, Matlacha Pass and Pine Island Sound. The watershed of the Caloosahatchee River covers approximately 1,300 square miles. Surface-water discharge to San Carlos Bay during the 2003 water year (October 1, 2002 through September 30, 2003) exceeded 1 million acre-feet, with approximately half coming from Lake Okeechobee. The mean flow for the 1966 to 2003 water years is approximately 600,000 acre-feet, with wide variation between years.

Water from Lake Okeechobee and surrounding areas enters Estero Bay via the Caloosahatchee River through Matanzas Pass. This freshwater can potentially carry large amounts of suspended organic material that can result in the reduction of water clarity, increased sedimentation in certain areas and sharp reductions in salinity. Freshwater discharges from Lake Okeechobee may directly impact the health of estuaries within Estero Bay

Methods

Data Collection

To measure salinity and temperature, a flow-through chamber was attached to the transom of a boat 20 cm below the water surface, and a probe was inserted in the chamber. The probe was connected to a data logger with a Global Positioning Satellite (GPS) unit and recorded salinity, temperature, time and location every 5 seconds (about every 5 to 10 meters) while the boat was moving. For salinity surveys, two boats were used simultaneously to reduce the time required for data collection. One boat was used to measure the mouth of the Caloosahatchee River, San Carlos Bay, and the five passes connecting Estero Bay to the Gulf of Mexico. The other boat measured the major tributaries entering Estero Bay, and Estero Bay. One day of sampling typically yielded about 7,000-8,000 measurements.

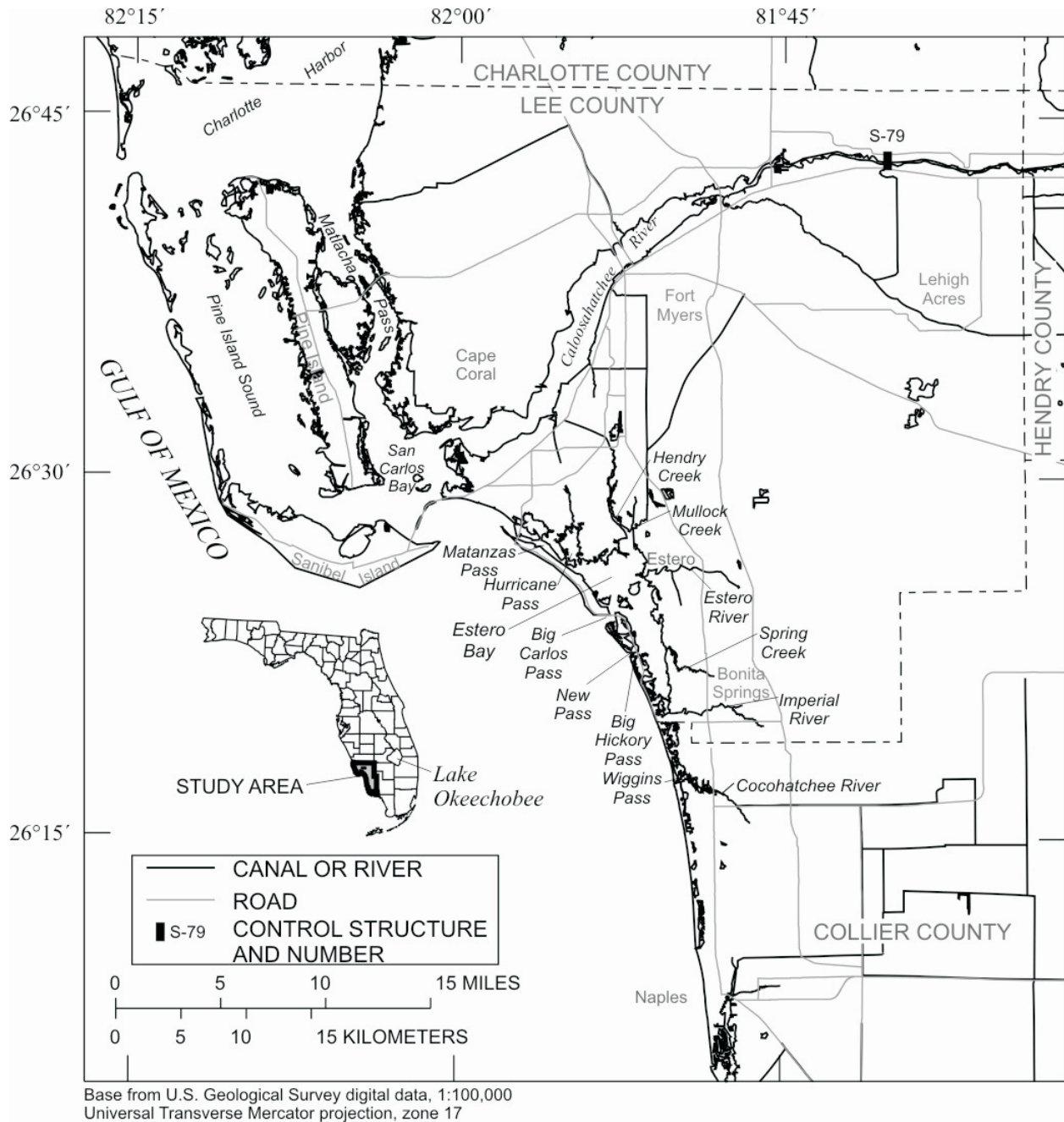


Figure 1. Map of the project area.

Data Analysis

The data were sorted in a spreadsheet to eliminate outliers, and then converted into a shapefile layer using ESRI ArcView. The data in the shapefile were interpolated using the inverse distance weighted (IDW) method in ESRI ArcMap, power of 2, cell size 102, and the default search radius. The IDW method assumes the values closest to each other are most alike and assigns the greatest weight to closest values. Line barriers were used to help keep points in one river from affecting a point in another river that was separated by a hydrologic barrier.

The data were interpreted qualitatively and quantitatively. It was possible to detect spatial and temporal salinity variations by visually inspecting the maps. The impact of hydrologic divides and sources of fresh water were also evaluated using the maps. Statistical variability both temporally and spatially were then determined using analysis of variance (ANOVA).

Results and Discussion

Certain trends are revealed by the salinity maps (figs. 2 and 3). Salinity in the Gulf of Mexico north of Matanzas Pass is lower than salinity south of Big Carlos Pass. The hydrologic divides that segment Estero Bay and San Carlos Bay greatly affect their salinities. Imperial River discharge flows southward and northward in equal magnitudes (fig. 3). The trends can best be seen during extreme events, such as high discharge periods from Lake Okeechobee (fig. 3).

The salinity north of Matanzas Pass is lower than salinity south of Big Carlos Pass due to two possible scenarios: (1) flow from the northern part of Estero Bay, with a prevailing north current, is great enough to lower salinity, (2) flow from the Caloosahatchee River lowers salinity south of San Carlos Bay. The prevailing evidence suggests that the lower salinity is due to freshwater releases in the Caloosahatchee River and Lake Okeechobee.

The salinity maps illustrate how hydrologic divides interrupt and redirect the flow of water. Islands along the causeway to Sanibel Island prevent much of the water in San Carlos Bay from flowing in a southerly direction, thereby depriving Estero Bay of fresh water. Hell Peckney Bay is hydrologically linked to Matanzas Pass but is divided from the rest of Estero Bay, probably due to changes in elevation. Waters entering Estero Bay from Lake Okeechobee have their greatest impact on this portion of the bay. Mound Key, in the center of Estero Bay, borders a mudflat that constricts the flow from Mullock Creek and Estero River. Because of this, water north of Mound Key has a shorter residence time and lower salinity than water south of Mound Key.

Imperial River conveys freshwater from a large basin and empties out through Big Hickory Pass and Wiggins Pass. During the rainy season (fig. 3) the freshwater discharge extends far beyond the mouth of the river. The symmetric salinity patterns for this outflow (fig. 3) suggest about only half of the freshwater discharge from the river reaches southern Estero Bay.

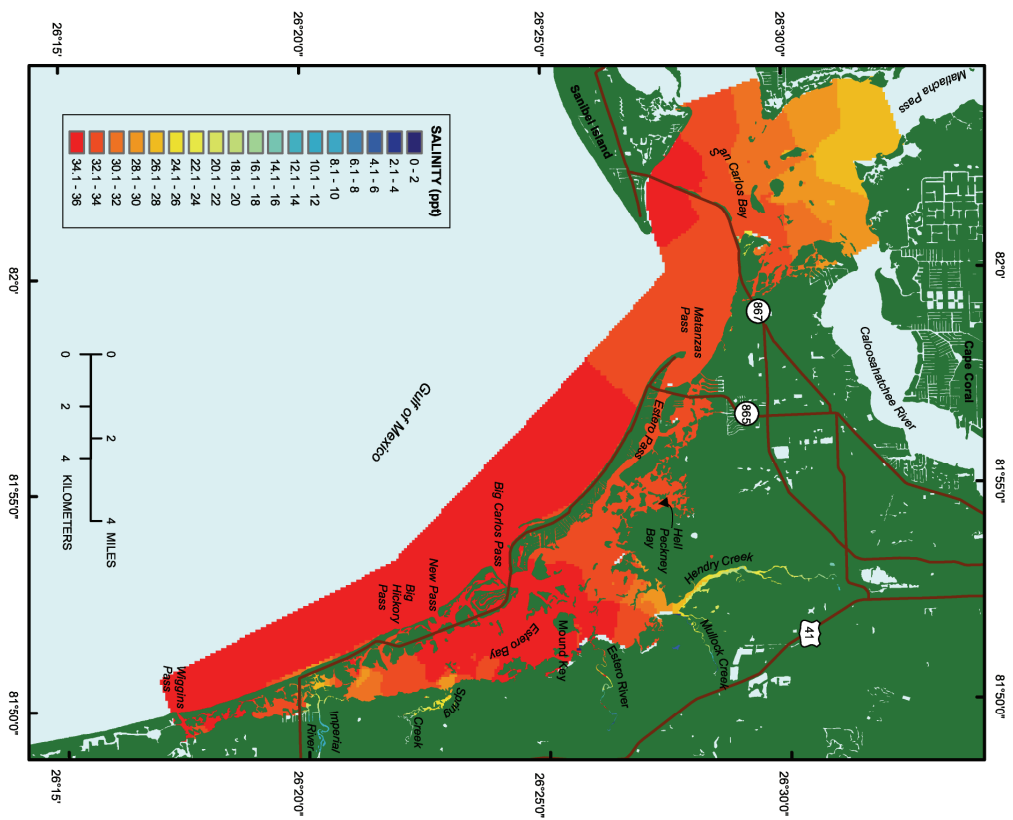


Figure 2. Estero Bay salinity, March 7, 2003.

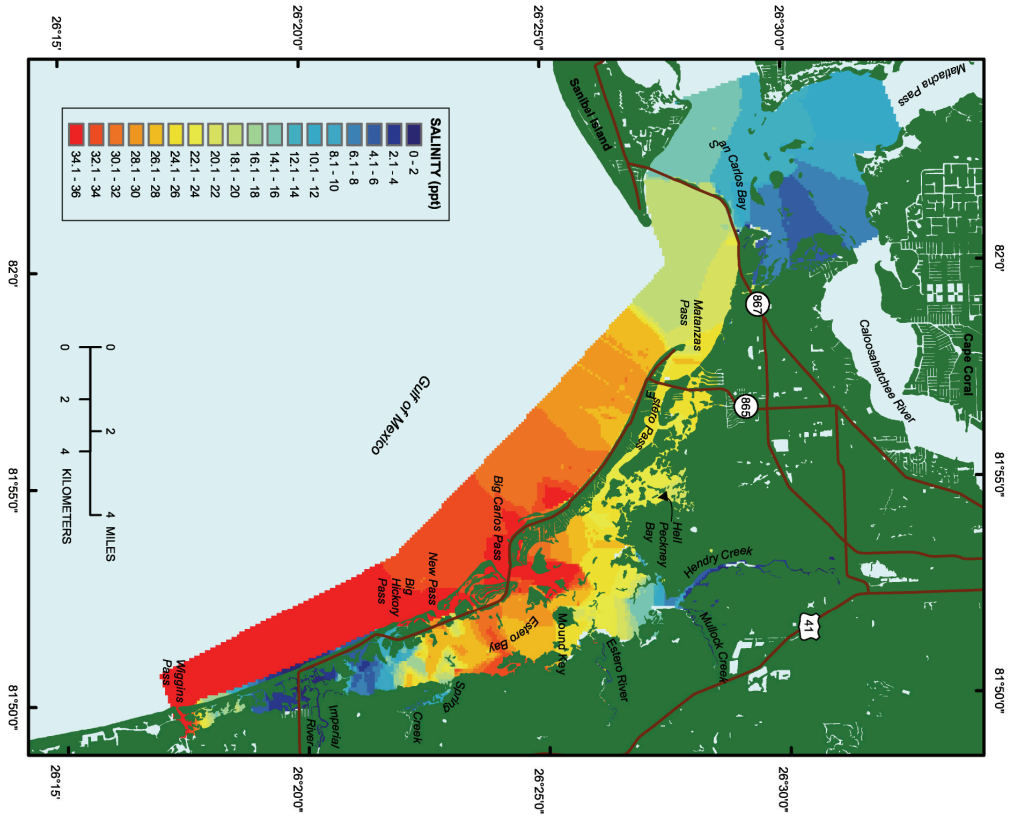


Figure 3. Estero Bay salinity, October 10, 2003.