In cooperation with the Texas Water Development Board

Discharge Between San Antonio Bay and Aransas Bay, Southern Gulf Coast, Texas, May–September 1999

Along the Gulf Coast of Texas, many estuaries and bays are important habitat and nurseries for aquatic life. San Antonio Bay and Aransas Bay, located about 50 and 30 miles northeast, respectively, of Corpus Christi, are two important estuarine nurseries on the southern Gulf Coast of Texas (fig. 1). According to the Texas Parks and Wildlife Department, "Almost 80 percent of the seagrasses [along the Texas Gulf Coast] are located in the Laguna Madre, an estuary that begins just south of Corpus Christi Bay and runs southward 140 miles to South Padre Island. Most of the remaining seagrasses, about 45,000 acres, are located in the heavily traveled San Antonio, Aransas and Corpus Christi Bay areas" (Shook, 2000).

Population growth has led to greater demands on water supplies in Texas. The Texas Water Development Board, the Texas Parks and Wildlife Department, and the Texas Natural Resource Conservation Commission have the cooperative task of determining inflows required to maintain the ecological health of the State's streams, rivers, bays, and estuaries. To determine these inflow requirements, the three agencies collect data and conduct studies on the need for instream flows and freshwater/saline water inflows to Texas estuaries.

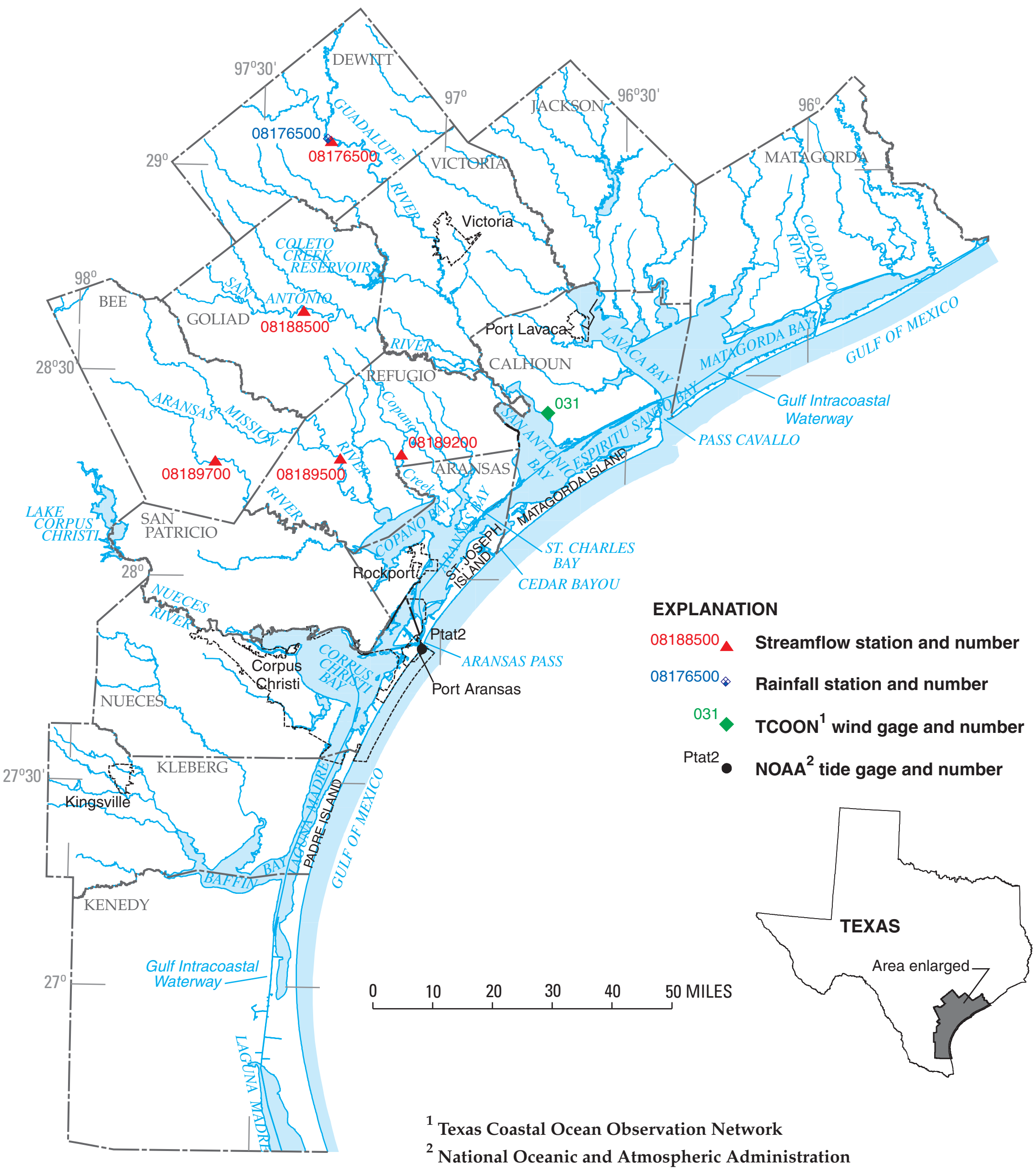

Figure 1. Southern Gulf Coast of Texas.

To assist in the determination of freshwater inflow requirements, the U.S. Geological Survey (USGS), in cooperation with the Texas Water Development Board, conducted a hydrographic survey of discharge (flow) between San Antonio Bay and Aransas Bay during the period May–September 1999. Automated instrumentation and acoustic technology were used to maximize the amount and quality of data that were collected, while minimizing personnel requirements. This report documents the discharge measured at two sites between the bays during May–September 1999 and describes the influences of meteorologic (wind and tidal) and hydrologic (freshwater inflow) conditions on discharge between the two bays. The movement of water between the bays is controlled primarily by prevailing winds, tidal fluctuations, and freshwater inflows. An adequate understanding of mixing and physical exchange in the estuarine waters is fundamental to the assessment of the physical, chemical, and biological processes governing the aquatic system.

Physical Setting

San Antonio Bay and Aransas Bay are separated from the Gulf of Mexico by barrier islands—San Antonio Bay by Matagorda Island and Aransas Bay by St. Joseph Island. San Antonio Bay covers an area of about 100 square miles, and Aransas Bay covers an area of about 70 square miles. The bays are "generally less than 6 feet deep" (McGowen and others, 1976, p. 10). Espiritu Santo Bay and Matagorda Bay are located just to the north of San Antonio Bay (fig. 1); and Ayres Bay, Mesquite Bay, Carlos Bay, and Aransas Bay are located to the south of San Antonio Bay (fig. 2).

Freshwater inflow to San Antonio Bay is predominantly from the Guadalupe and San Antonio Rivers (fig. 1). No major freshwater tributaries flow into Aransas Bay although the Aransas River, Mission River, and Copano Creek flow into Copano Bay, which flows into Aransas Bay (fig. 1). The main connection to the Gulf of Mexico for San Antonio Bay is through Pass Cavallo at the southern end of Matagorda Bay (fig. 1). For Aransas Bay, the main connection to the Gulf is through Aransas Pass at the southern end of Aransas Bay. Cedar Bayou, a natural pass that connects Mesquite Bay and the Gulf of Mexico (fig. 2), is the only direct connection to the Gulf between San Antonio Bay and Aransas Bay.

San Antonio Bay and Aransas Bay are hydraulically connected by the Gulf Intracoastal Waterway (GIWW) (fig. 1), a dredged channel that runs along the entire Gulf Coast. The GIWW is a maintained navigation channel that is more than 300 feet wide and about 15 feet deep. Cedar Dugout, a channel between Bludworth Island and a small unnamed island (fig. 2), is about 250 feet wide and 13 feet deep. Cedar Reef is an oyster reef that extends about 1 mile from the same small unnamed island to St. Joseph Island. During the study period, there were several instances when water did not flow over Cedar Reef, as the tide level was below the crest of the reef.

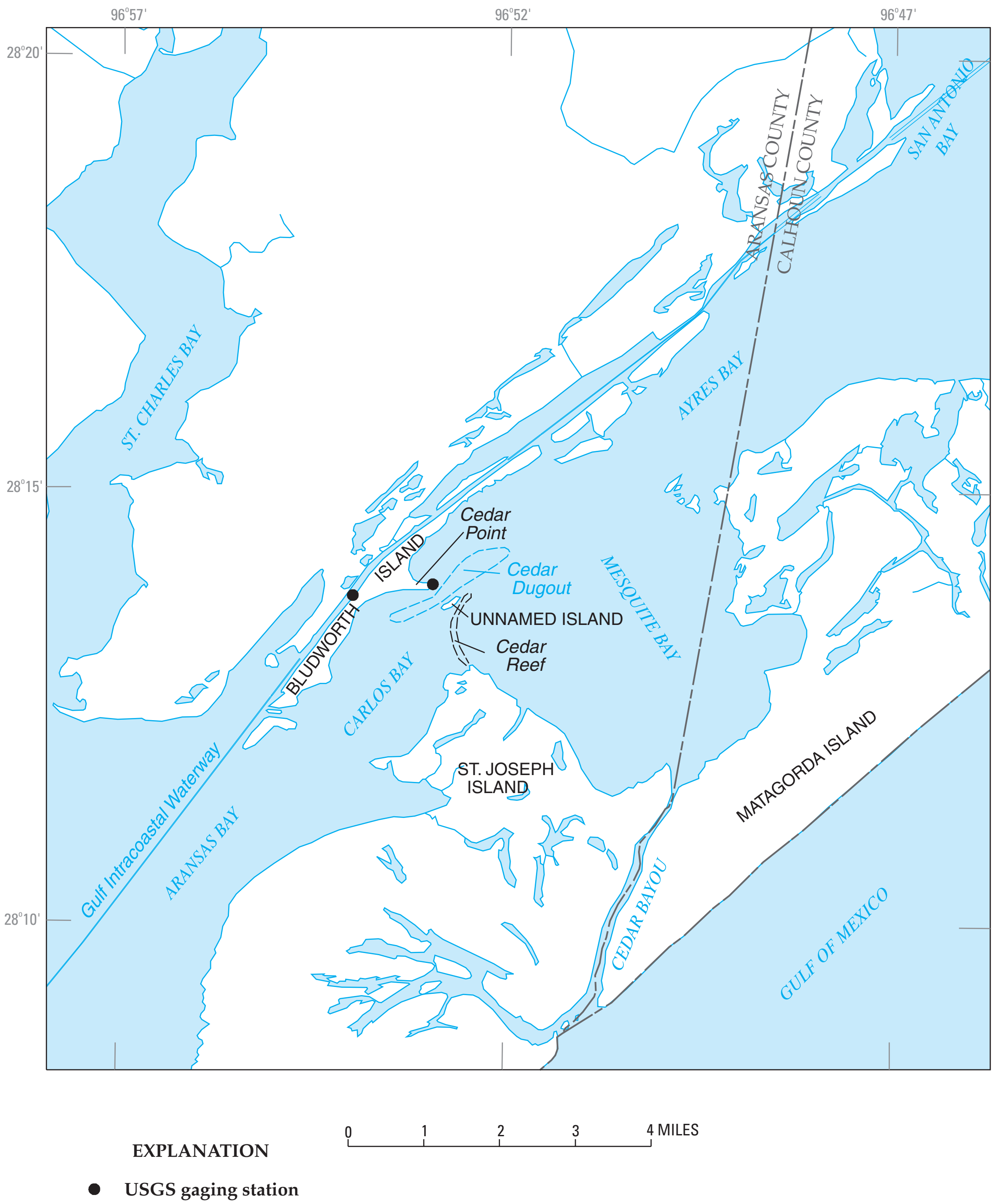

Figure 2. Study area, San Antonio Bay and Aransas Bay.

Table 1. Estimated net monthly discharge volumes at three sites between San Antonio Bay and Aransas Bay, Texas, May–September, 1999

Site number	Site name	Net discharge volume (acre-feet)				
		May	June	July	August	September
1	Gulf Intracoastal Waterway at Bludworth Island	122,600	19,000	2,300	-100,600	112,200
2a	Cedar Dugout near Cedar Point at Bludworth Island	56,000	3,380	90	-29,700	18,800
2b	Cedar Reef near Cedar Point at Bludworth Island	50,500	-16,700	-4,630	-8,980	10,000

Data Collection and Discharge Computation

Hourly wind data (velocity and direction) were obtained for a Texas Coastal Ocean Observation Network (TCOON) station on San Antonio Bay (fig. 1) (Texas A&M University-Corpus Christi Conrad Blucher Institute, 2000); and Gulf of Mexico hourly tide data (water-surface altitude [stage] relative to sea level) were obtained from a National Oceanic and Atmospheric Administration (NOAA) tidal station at Port Aransas (National Oceanic and Atmospheric Administration, 2000). Streamflow data for inflow tributaries (San Antonio River, Guadalupe River, Aransas River, Mission River, and Copano Creek) were available from existing USGS streamflow stations (08188500, 08176500, 08189700, 08189500, and 08189200, respectively). Rainfall data were available from USGS rainfall station 08176500 on the Guadalupe River in Dewitt County.

During the period May 1–September 30, 1999, the USGS operated gaging stations at the GIWW at Bludworth Island and at Cedar Dugout near Cedar Point (fig. 2). Equipment at these stations included acoustic velocity meters, data-collection platforms (DCP), and a submersible pressure transducer. Instantaneous measurements of flow direction and water velocity were made at both stations using the acoustic velocity meters. Instantaneous measurements of water stage were made only at the GIWW station because of equipment availability. Water-stage data recorded at the GIWW station were assumed representative of conditions at all locations in the study area. Data were recorded at 15-minute intervals and transmitted by the DCPs to the USGS database at 4-hour intervals.

Discharge measurements were made at the GIWW and Cedar Dugout stations at various velocities and stages using a boat-mounted acoustic Doppler current profiler (ADCP). For each

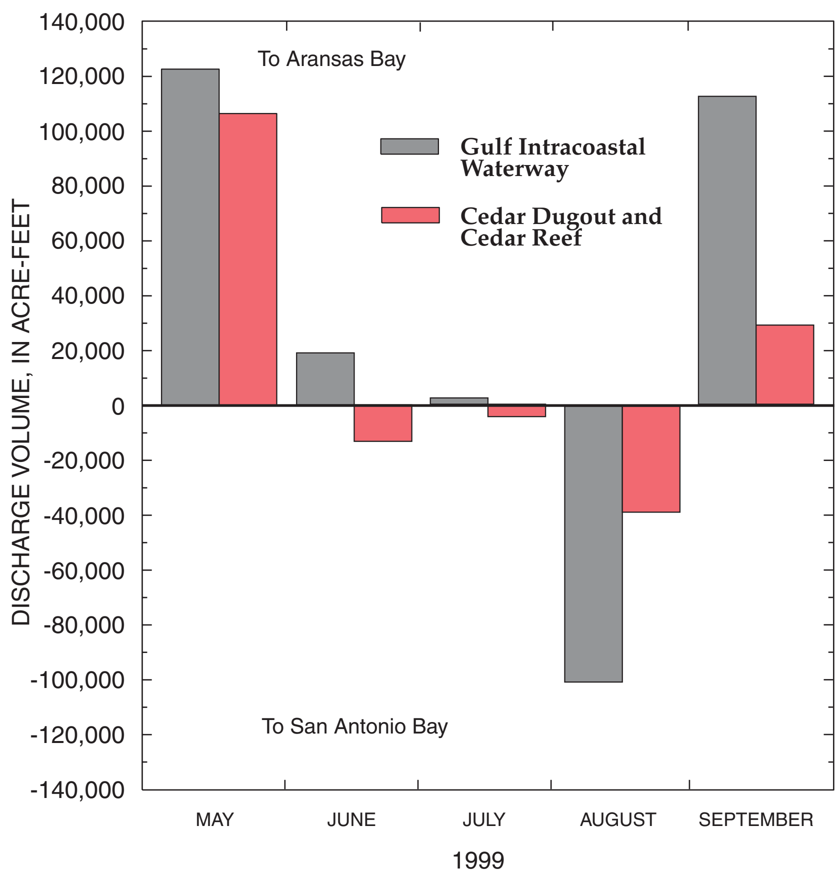

Figure 3. Net monthly discharge volumes for two stations between San Antonio Bay and Aransas Bay, May–September 1999. Positive indicates direction is from San Antonio Bay toward Aransas Bay; negative indicates reverse direction.

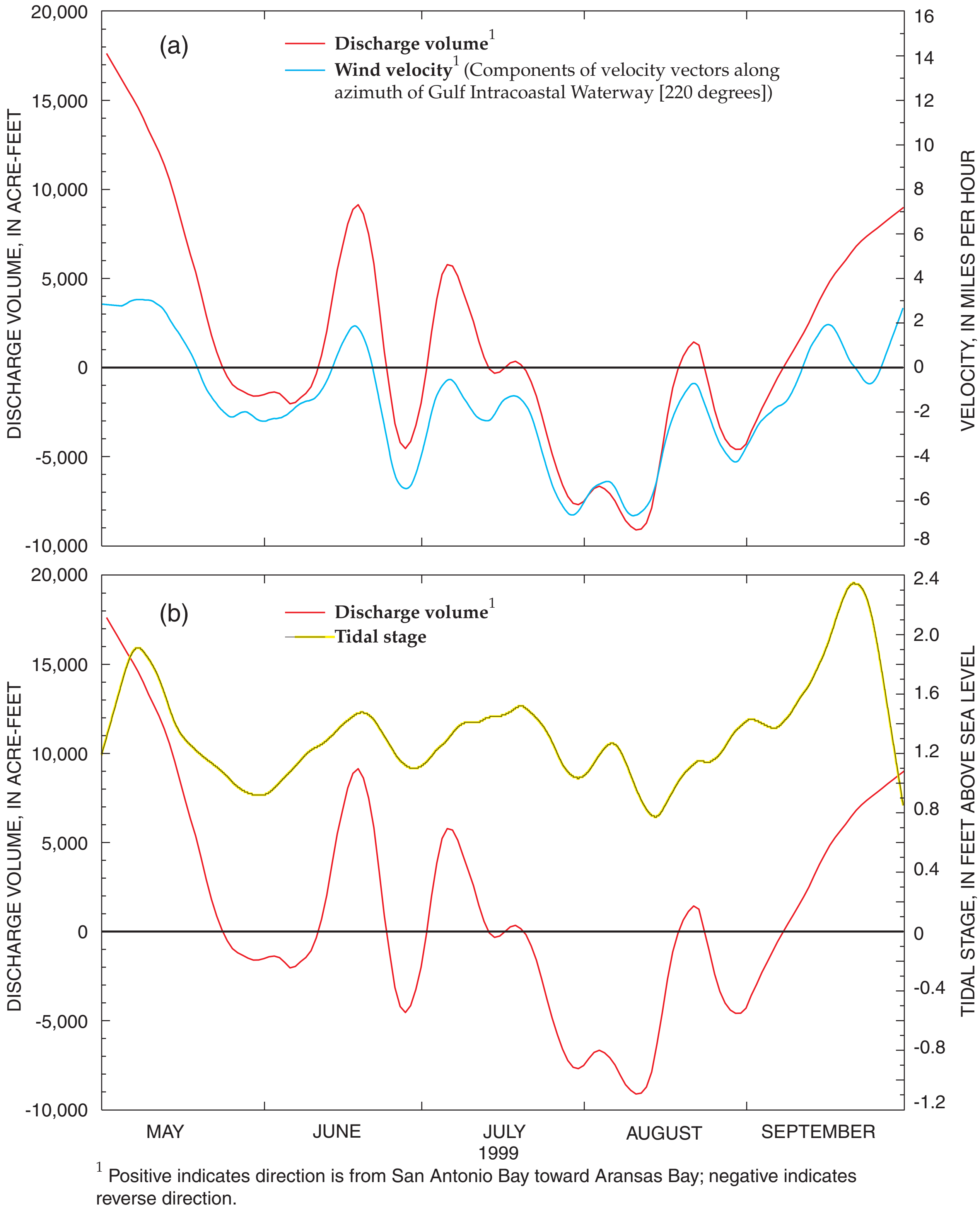

Figure 4. Daily discharge volume between San Antonio Bay and Aransas Bay and (a) wind velocity and (b) Gulf of Mexico tidal stage, May–September 1999. The graphs have been smoothed using the Friedman Supersmoothing technique (MathSoft Inc., 1999).

discharge measurement, as the boat traversed the flow transect, the ADCP was used to measure water depth, water velocity, and distance at about 20 locations along the transect; velocity was measured at two or three different depths at each location. The data were used to compute a total discharge for the transect. Discharge across Cedar Reef (fig. 2) was intermittent. When tides were sufficiently high, there was some shallow (less than 1 foot deep) discharge across Cedar Reef. Because the ADCP equipment

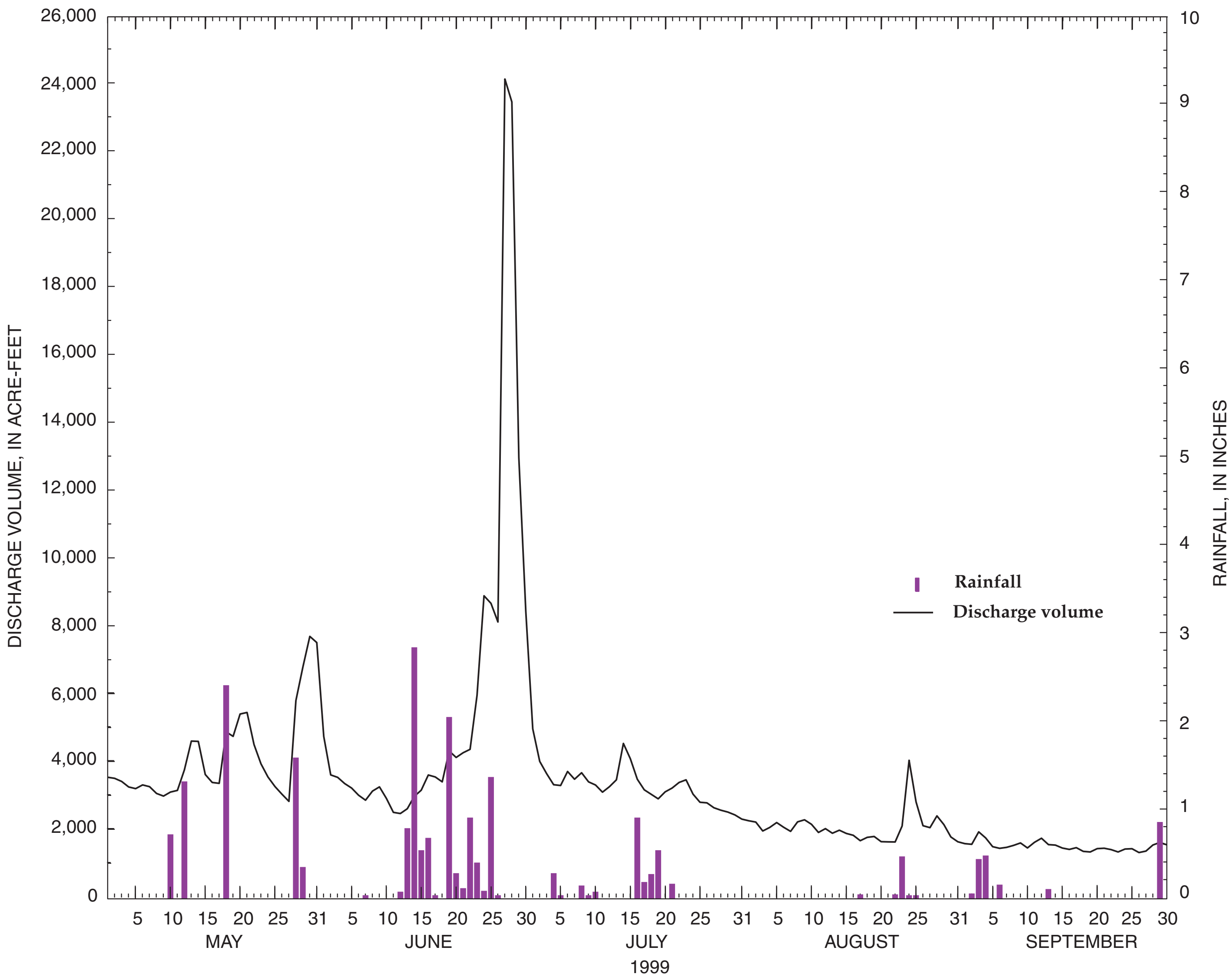

Figure 5. Daily rainfall at USGS station 08176500 and total daily discharge volume from five USGS streamflow stations into San Antonio Bay and Aransas Bay.

cannot be used for shallow depths, the additional discharge across Cedar Reef was measured using wading and current meter techniques (Rantz and others, 1982).

For both stations, corresponding discharge and instantaneous velocity and stage measurements were used to develop velocity-stage-discharge relations using regression methods described by Dunn and others (1997) and East and others (1998). The regression equations allow computation of discharge from single velocity or single velocity and stage measurements. A third regression equation was developed for Cedar Reef. Velocity and stage data used to develop the regression for Cedar Dugout provided a suitable index of flow over Cedar Reef. These data thus were related to discharge measurements made at Cedar Reef to develop the third regression equation.

The discharge data for the three sites were used to compute the daily volume of discharge between San Antonio Bay and Aransas Bay. The daily volumes were summed for each month (May, June, July, August, and September) (table 1). The direction of net discharge at the GIWW site was the same as that at Cedar Dugout for all months although the magnitude of flow was less in Cedar Dugout. However, the direction of net discharge at Cedar Reef was not the same as that at the other two sites during the months of June and July. Intermittent periods of flow over Cedar Reef during June and July typically corresponded to periods when the wind was blowing from Aransas Bay toward San Antonio Bay. Therefore, during those periods when the tide was above the crest of the reef, there were more instances of negative discharge (flow direction from San Antonio Bay to Aransas Bay) than positive discharge.

The monthly discharge volumes for Cedar Dugout and Cedar Reef were then summed and graphed with the concurrent monthly data for the GIWW site (fig. 3). Figure 3 indicates that the net discharge in the GIWW almost always was greater than the net discharge in Cedar Dugout and Cedar Reef combined. This appears reasonable, as the GIWW is a well-maintained channel that is larger than Cedar Dugout/Cedar Reef. In late spring (May) and early fall (September), the net discharge was from San Antonio Bay to Aransas Bay. During the summer months of June and July when the net discharge between the two bays was much smaller, the directions of net discharge were opposite in the GIWW and Cedar Dugout/Cedar Reef because of flow over Cedar Reef toward San Antonio Bay. In August, the net discharge increased and was from Aransas Bay to San Antonio Bay.

Relation of Discharge to Meteorologic and Hydrologic Conditions

Discharge in coastal environments commonly is affected by meteorologic conditions such as wind and tidal fluctuations. Because water in the relatively shallow bays and estuaries is easily driven by wind, the direction of flow often is influenced by the prevailing wind direction. Similarly, the magnitude and direction of discharge change with the ebb and flow of tides. The influence of wind and tides on the discharge between San Antonio and Aransas Bays is apparent when graphs of discharge volume and wind velocity and of discharge volume and tidal stage during the study period (fig. 4) are compared. There is a close relation between discharge volume and wind velocity during May–September 1999 (fig. 4a); and there was a noticeable relation between discharge volume and tidal stage (fig. 4b), although the relation is not as close as that between discharge volume and wind velocity.

Total gaged freshwater inflow to the two bays during the study period (sum of flows from USGS stations 08188500, 08176500, 08189700, 08189500, 08189200) (fig. 5) was about 515,000 acre-ft, of which about 97 percent flowed into San Antonio Bay from the San Antonio and Guadalupe Rivers. About 23 percent of this inflow resulted from a series of rainstorms in the Guadalupe and San Antonio River Basins during June 13–25. Comparison of daily discharge volume entering San Antonio Bay during the study period (fig. 5) with daily discharge between the bays (fig. 4) shows no discernible relation. The influence of wind and tides on discharge between the bays seemed to be much more substantial than the influence of freshwater flow into San Antonio Bay during the study.

A final note—in the development of the regression equations to relate measured discharge to instantaneous flow velocity and stage, wind velocity and tidal stage were used as explanatory variables. Despite the apparent relations between discharge and wind velocity and discharge and tidal stage, neither wind velocity nor tidal stage significantly improved the regressions; thus they were not included in the final equations to estimate discharge from instantaneous flow velocity and stage. A possible explanation for wind and tide data not significantly contributing to the estimation of discharge is that discharge is lagged in time relative to wind velocity and tidal stage.

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