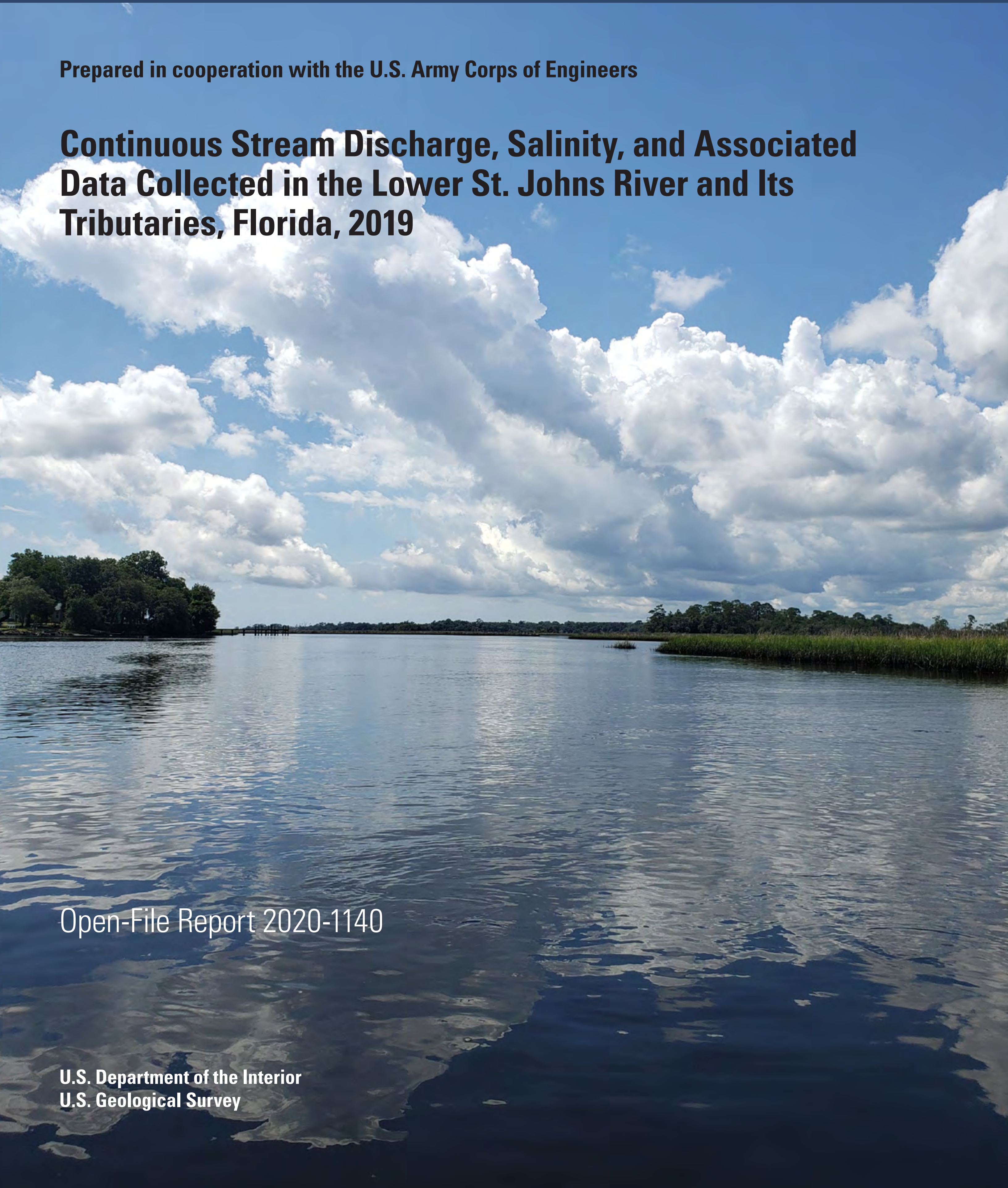
Prepared in cooperation with the U.S. Army Corps of Engineers

Continuous Stream Discharge, Salinity, and Associated Data Collected in the Lower St. Johns River and Its Tributaries, Florida, 2019



Open-File Report 2020-1140

U.S. Department of the Interior
U.S. Geological Survey

Cover. Looking south (downstream) from site 02246825 Clapboard Creek near Jacksonville, Florida. Photograph by Cody Hazelbaker, U.S. Geological Survey.

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By Patrick J. Ryan

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U.S. Department of the Interior
DAVID BERNHARDT, Secretary

U.S. Geological Survey
James F. Reilly II, Director

U.S. Geological Survey, Reston, Virginia: 2020

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Conversion Factors

U.S. customary units to International System of Units

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Flow rate	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

°F = (1.8 × °C) + 32.

Datum

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88).

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Supplemental Information

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (μS/cm at 25 °C).

Abbreviations

JAXPORT	Jacksonville Port Authority
NOAA	National Oceanic and Atmospheric Administration
ppt	parts per thousand
SJRWMD	St. Johns River Water Management District
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey

Continuous Stream Discharge, Salinity, and Associated Data Collected in the Lower St. Johns River and Its Tributaries, Florida, 2019

By Patrick J. Ryan

Abstract

The U.S. Army Corps of Engineers, Jacksonville District, is deepening the St. Johns River channel in Jacksonville, Florida, from 40 to 47 feet along 13 miles of the river channel beginning at the mouth of the river at the Atlantic Ocean, in order to accommodate larger, fully loaded cargo vessels. The U.S. Geological Survey, in cooperation with the U.S. Army Corps of Engineers, monitored stage, discharge, and (or) water temperature and salinity at 26 continuous data collection stations in the St. Johns River and its tributaries.

This is the fourth annual report by the U.S. Geological Survey on data collection for the Jacksonville Harbor deepening project. The report contains information pertinent to data collection during the 2019 water year, from October 2018 to September 2019. No changes to the previously installed data collection network were made during this period.

Discharge and salinity varied widely during the data collection period, which included above-average rainfall for all counties in the study area over the 3-month period from November to January, below-average annual rainfall for all counties, and effects from Hurricane Dorian in September 2019. Total annual rainfall for all counties ranked third among the annual totals computed for the 4 years considered for this study. Annual mean discharge at Durbin Creek was highest among the tributaries, followed by Trout River, Ortega River, Julington Creek, Pottsburg Creek, Broward River, Cedar River, Clapboard Creek, and Dunn Creek. The annual mean discharge for each of the main-stem sites was lower for the 2019 water year than for the 2018 water year. Since the beginning of the study in 2016, the St. Johns River at Astor station computed its lowest annual mean discharge, the Jacksonville station recorded its second lowest, and the Buffalo Bluff station recorded its second highest in 2019.

Among the tributary sites, annual mean salinity was highest at Clapboard Creek, the site closest to the Atlantic Ocean, and was lowest at Durbin Creek, the site farthest from the ocean. Annual mean salinity data from the main-stem sites on the St. Johns River indicate that salinity decreased with distance upstream from the ocean, which was expected. Relative to annual mean salinity calculated for the 2018 water year, annual mean salinity at all monitoring locations was higher for the 2019 water year except at the main-stem site below Shands Bridge and at the tributary sites of Durbin Creek and Julington Creek, which remained the same. The 2019 annual mean salinity at Dunn Creek was the highest on record for that site, and Clapboard Creek and Trout River were the second highest on record for those sites.

Introduction

The St. Johns River flows 310 miles (mi) northward through the eastern half of Florida, through Jacksonville, and into the Atlantic Ocean (fig. 1). The river consists of lakes, marshes, and seagrass beds, as well as the main river channel (herein referred to as the “main stem”) that, near its mouth, can accommodate cruise ships and cargo vessels with access to the Atlantic Ocean. Jacksonville Harbor is located along the first 20 river miles, beginning at the mouth of the St. Johns River where it empties into the Atlantic Ocean. Jacksonville Harbor currently can only accommodate small cargo vessels or large cargo vessels loaded below maximum capacity because of the authorized channel depth of 40 feet (ft). Dredging an additional 7 ft will allow the port to accommodate larger, fully loaded vessels. Beginning at the mouth, the U.S. Army Corps of Engineers (USACE) plans to deepen the first 13 river miles (USACE, 2014). Dredging construction began February 2018 (Jacksonville Port Authority [JAXPORT], 2018).

Salinity models indicate that the harbor deepening may alter salinity in part of the study area, potentially causing (1) salinity stress in some wetlands and submerged aquatic vegetation and (2) changes in some fish and macroinvertebrate distributions (USACE, 2014). Surface-water monitoring, required by permit, includes the collection of water temperature, salinity, and (or) stage, velocity, and streamflow data for at least 6 months prior to dredging, continuously throughout dredging, and for 10 years following dredging (Florida Department of Environmental Protection, 2016). The U.S. Geological Survey (USGS), in cooperation with the USACE, is

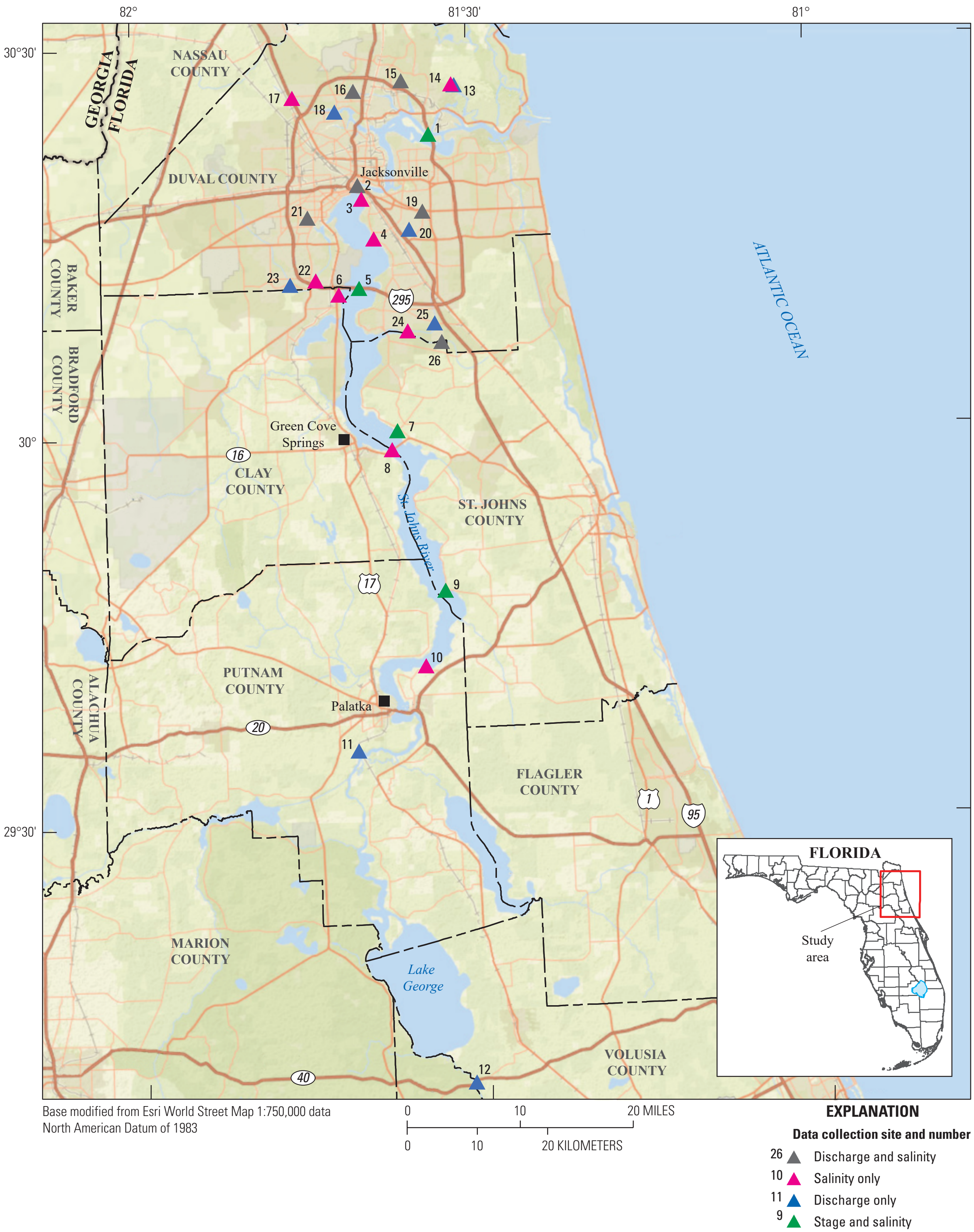

Figure 1. U.S. Geological Survey data collection sites on the St. Johns River and its tributaries. Map image is the intellectual property of Esri and is used herein under license.

responsible for monitoring all parameters at the gage locations listed in the permit that were not already being monitored by other entities as of January 2016, the beginning of the initial data collection period (Florida Department of Environmental Protection, 2016). The streamflow and water-quality monitoring network was used to collect baseline data in the St. Johns River and its tributaries prior to dredging and can be used to discern changes, if any, during and after dredging.

This report provides an overview of the data collected from 26 surface-water discharge and water-quality sites along the St. Johns River and its tributaries (1) under predredging conditions and (2) during the second year of dredging and fourth year of the study, specifically from October 2018 to September 2019 (figs. 1 and 2). The report documents the data collection sites, methods used to compute discharge and salinity, and parameters monitored at each site. The first 3 years of the study are described in Ryan (2018, 2019, 2020).

The data collected during this study are available from the USGS National Water Information System database (USGS, 2020).

Methods

The methods of data collection and processing, as well as the sites used for data collection, are described in the following sections. The descriptions of data collection sites are separated into those along the St. Johns River and those along its tributaries (table 1).

Methods of Data Collection and Processing

Stage data (gage height, in feet, referenced to the North American Vertical Datum of 1988) were collected at 15-minute intervals using various types of equipment, depending on location requirements, in accordance with USGS standards (Sauer and Turnipseed, 2010a). Discharge was routinely measured by using various types of equipment, depending on depth, velocity, and environmental conditions, in accordance with USGS standards (Sauer and Turnipseed, 2010b). Because of tidal and (or) wind effects, discharge was computed, in cubic feet per second, using the index-velocity method at most sites, in accordance with USGS techniques and methods (Levesque and Oberg, 2012). Discharge was computed using a stage-discharge relation at a few sites where tidal influence was not substantial (Rantz and others, 1982). Where applicable, discharge data were filtered by using the Godin low-pass filter to remove principal tidal frequencies from unit values (Godin, 1972). By convention, the USGS designates ebb (seaward) flow as positive flow and flood (landward) flow as negative flow. The residuals are not total freshwater flows, but instead, a combination of seaward freshwater flows from the watershed and landward saltwater flows from the marine environment, along with storm surges from hurricanes or tropical storms.

Water temperature, in degrees Celsius, and specific conductance, in microsiemens per centimeter at 25 degrees Celsius, were measured at intervals of 1 hour or less in accordance with USGS techniques and methods (Wagner and others, 2006). Water-quality meters were installed in situ at sites in freshwater environments. A pump and intake system was installed at sites in harsh saltwater environments to reduce fouling. This setup consisted of a meter housed inside a polyvinyl chloride chamber in a shelter. In this case, water was pumped into the chamber for 1–2 minutes before each measurement and drained from the chamber between measurements. The recording interval was reduced to one measurement per hour because of the power requirements for the pump setup. Because the chamber drains between measurements, water-quality parameters can be measured at multiple levels with one meter, if necessary. A rating table was used to convert specific conductance, in microsiemens per centimeter, to salinity, in parts per thousand (Wagner and others, 2006). Salinity was calculated for every site where water temperature and specific conductance were measured.

Missing discharge data can usually be attributed to equipment malfunction, either with the stage sensor or velocity meter (if the index-velocity method is used). For tidally filtered discharge calculation, the Godin low-pass filter requires 35 hours of continuous data before and after each data point (Godin, 1972). A data gap greater than 2 hours, therefore, results in a data gap of 3 days in the tidally filtered discharge record. For sites that include a pump setup, missing water-quality data are usually a consequence of power or pump failure, which prevents water from filling the chamber where the meter is housed. Biological fouling is a more common problem with meters installed in situ, where algal growth and crustaceans can affect the conductance measurement port or the temperature probe, both of which provide data used to calculate salinity. In either case, the affected values are not used, creating gaps in the final record.

Rainfall data for Duval, Clay, St. Johns, Putnam, and Volusia Counties in 2019 were obtained from the St. Johns River Water Management District (SJRWMD), which provides details about how average monthly rainfall data are compiled for counties in their district (SJRWMD, 2020). The period of record rainfall data to determine a long-term countywide average was compiled using National Oceanic and Atmospheric Administration (NOAA) rain gages in central and north Florida through 2009. Jacksonville Harbor and all monitoring sites included in this study are located within Duval County, except the St. Johns River sites at Astor in Volusia County, Dancy Point and Buffalo Bluff in Putnam County, Racy Point and Shands Bridge in St. Johns County, and above Buckman Bridge near the left bank in Clay County (fig. 1; table 1).

Quantile plots were created to show percentiles for annual discharge data collected at monitoring sites that have at least 10 years of record and a full contemporary year of data.

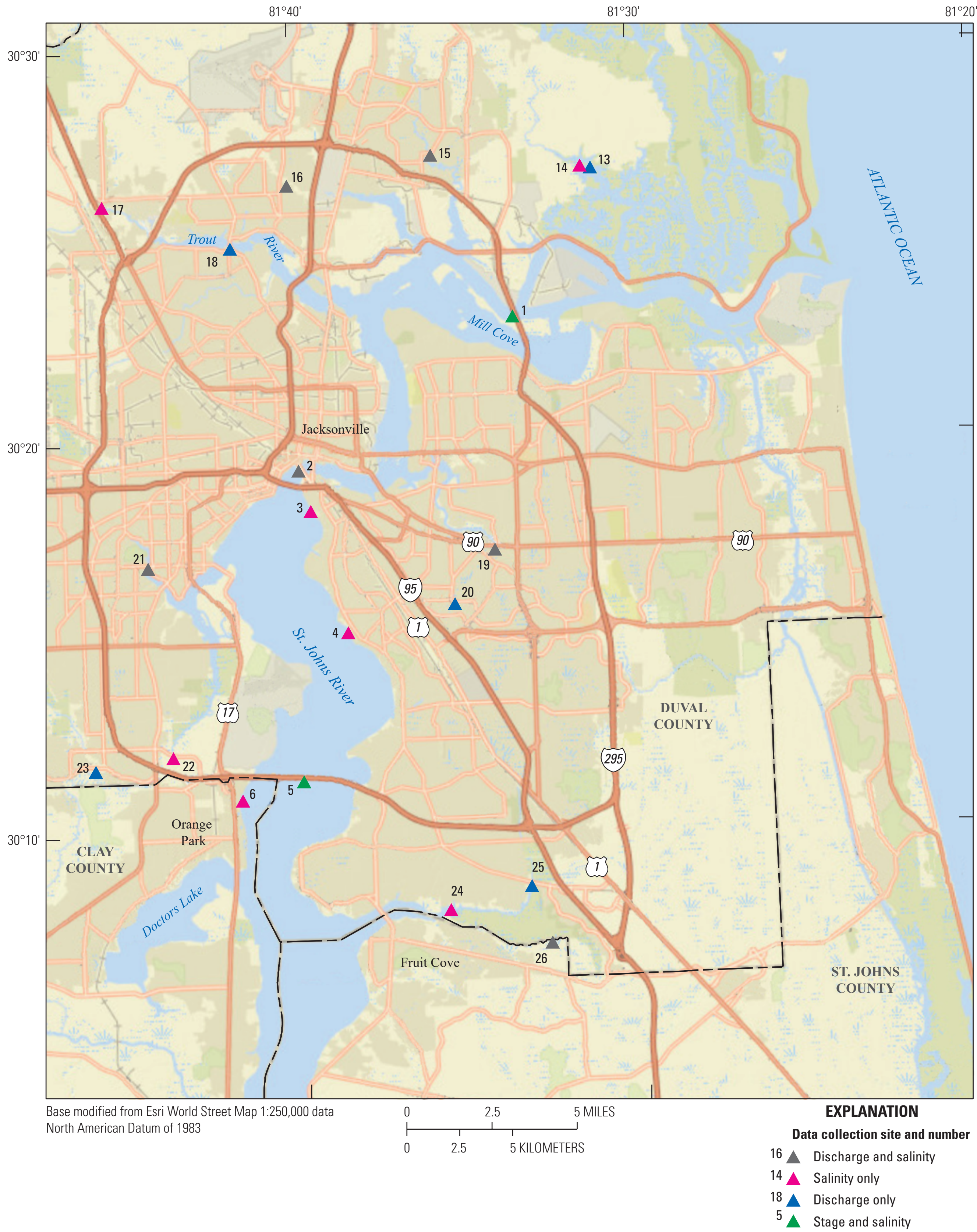

Figure 2. U.S. Geological Survey data collection sites in Clay, Duval, and St. Johns Counties, Florida. Map image is the intellectual property of Esri and is used herein under license.

Table 1. U.S. Geological Survey data collection sites on the main stem of the St. Johns River and its tributaries and parameters published during the 2019 water year.

[USGS, U.S. Geological Survey; x, parameter measured; --, parameter not measured; NA, not applicable]

Map number	USGS site number	USGS site name	Discharge	Gage height	Velocity	Temperature	Specific conductance	Salinity	River mile
		St. Johns River							
1	302309081333001	St Johns River Dames Point Bridge at Jacksonville, Fla.	--	x	x	x	x	x	10
2	02246500	St. Johns River at Jacksonville, Fla.	x	x	x	x	x	x	23
3	301817081393600	St. Johns River below Marco Lake at Jacksonville, Fla.	--	--	--	x	x	x	25
4	301510081383500	St. Johns River at Christopher Point near Jacksonville, Fla.	--	--	--	x	x	x	29
5	301124081395901	St. Johns River Buckman Bridge at Jacksonville, Fla.	--	x	--	x	x	x	34
6	301057081414800	St. Johns River above Buckman Bridge at Jacksonville, Fla.	--	--	--	x	x	x	35
7	02245340	St. Johns River below Shands Bridge near Green Cove Springs, Fla.	--	x	--	x	x	x	49
8	295856081372301	St. Johns River Shands Bridge near Green Cove Springs, Fla.	--	--	--	x	x	x	50
9	02245290	St. Johns River at Racy Point near Hastings, Fla.	--	x	--	x	x	x	64
10	294213081345300	St. Johns River at Dancy Point near Spuds, Fla.	--	--	--	x	x	x	71
11	02244040	St. Johns River at Buffalo Bluff near Satsuma, Fla.	x	x	--	--	--	--	90
12	02236125	St. Johns River at Astor, Fla.	x	x	--	--	--	--	127
		Tributaries							
13	02246825	Clapboard Creek near Jacksonville, Fla.	x	x	--	--	--	--	NA
14	302657081312400	Clapboard Creek above Buckhorn Bluff near Jacksonville, Fla.	--	--	--	x	x	x	NA
15	02246804	Dunn Creek at Dunn Creek Road near Eastport, Fla.	x	x	--	x	x	x	NA
16	02246751	Broward River below Biscayne Boulevard near Jacksonville, Fla.	x	x	--	x	x	x	NA

Map number	USGS site number	USGS site name	Discharge	Gage height	Velocity	Temperature	Specific conductance	Salinity	River mile
		Tributaries—Continued							
17	302609081453300	Trout River below U.S. 1 at Dinsmore, Fla.	--	--	--	x	x	x	NA
18	02246621	Trout River near Jacksonville, Fla.	x	x	--	--	--	--	NA
19	02246518	Pottsburg Creek at U.S. 90 near South Jacksonville, Fla.	x	x	--	x	x	x	NA
20	02246515	Pottsburg Creek near South Jacksonville, Fla.	x	x	--	--	--	--	NA
21	02246459	Cedar River at San Juan Avenue at Jacksonville, Fla.	x	x	--	x	x	x	NA
22	301204081434900	Ortega River Salinity at Jacksonville, Fla.	--	--	--	x	x	x	NA
23	02246318	Ortega River at Kirwin Road near Jacksonville, Fla.	x	x	--	--	--	--	NA
24	300803081354500	Julington Creek at Hood Landing near Bayard, Fla.	--	--	--	x	x	x	NA
25	02246160	Julington Creek at Old St August Road near Bayard, Fla.	x	x	--	--	--	--	NA
26	022462002	Durbin Creek near Fruit Cove, Fla.	x	x	--	x	x	x	NA

The quantile plots group the annual peak discharges by water year. For this report, the 2019 water year includes data from October 1, 2018, to September 30, 2019. The resulting plots show how the 2019 water year discharge at a given station compares with that of previous water years. For discharges affected by tidal fluctuations, annual mean tidally filtered discharge was used to construct the plot.

Boxplots were created to provide a visual reference of median, interquartile range, and other useful statistics. These boxplots were constructed using all approved unit values of salinity and show salinity differences between water years. Outliers, maximum salinity, and minimum salinity were not incorporated into these plots to preserve a meaningful scale.

Description of St. Johns River Main-Stem Sites

All sites on the main stem of the St. Johns River have substantive tidal influence, and therefore, the calculated discharge is tidally filtered. No changes to the main-stem monitoring network occurred during this year of the study.

The farthest upstream discharge monitoring site on the St. Johns River is in Astor, Fla., at the State Road 40 Bridge (table 1; river mile 127). Approximately 37 mi downstream, discharge is also calculated for the St. Johns River at Buffalo Bluff (river mile 90). Tidally filtered discharge values have been computed since 1994 at both Astor and Buffalo Bluff. The farthest upstream water-quality monitoring station along the St. Johns River is located at Dancy Point (river mile 71). Water temperature and specific conductance are measured at an approximate depth of 11.5 ft below the average high-tide level. Stage, water temperature, and specific conductance are monitored farther downstream near the right bank of the St. Johns River at Racy Point (river mile 64). The water-quality parameters are measured at an approximate depth of 2.5 ft below the average high-tide level. Water temperature and specific conductance are collected near the channel of the St. Johns River at Shands Bridge (river mile 50). This location was historically monitored from April 1995 to September 2001 at multiple depths and from April 2008 to September 2009 at the middle depth. The meter was reinstalled in May 2018 at the middle-depth location of 10 ft below the average high-tide level. Just downstream near the right bank, stage, water temperature, and specific conductance are measured at an approximate depth of 8.5 ft below the average high-tide level at the St. Johns River below Shands Bridge (river mile 49).

A monitoring station is located near the left bank of the St. Johns River just upstream from Buckman Bridge. Water temperature and specific conductance are measured at an approximate depth of 4 ft below the average high-tide level at this station, St. Johns River above Buckman Bridge (river mile 35). A monitoring station at Buckman Bridge (river mile 34) near the main channel measures stage, water temperature, and specific conductance. The water-quality parameters are measured with separate pump setups and intakes at two different depths. One water-quality meter is used in the chamber and monitors both water properties at each depth. All water-quality parameters are monitored at approximate depths of 8 ft (top) and 16 ft (bottom) below the average high-tide level. Water-quality monitoring stations at Christopher Point (river mile 29) and Marco Lake (river mile 25) measure water temperature and specific conductance at an approximate depth of 4 ft below the average high-tide level for each location. These sites are characterized by relatively shallow water having an average depth of less than 6 ft and represent river conditions in seagrass beds near the shore.

The St. Johns River at Jacksonville, Fla., data collection station, located near downtown Jacksonville at Acosta Bridge (river mile 23), is the farthest downstream gage that calculates discharge. Stage and discharge were previously monitored before the dredging study began, but water temperature and specific conductance data collection began in October 2015 at an approximate depth of 11 ft below the average high-tide level. The monitoring equipment was moved to the center of the channel in April 2018 because of fender construction, and the intake was installed at a new depth of 17 ft below the average high-tide level. Velocity and streamflow direction data collection were added in October 2017. Tidally filtered discharge values have been computed since 1996. A monitoring station at Dames Point Bridge in Jacksonville (river mile 10) measures stage, velocity, water temperature, and specific conductance; calculation of salinity began in October 2016. All water-quality data are collected at approximate depths of 15 ft (top) and 22 ft (bottom) below the average high-tide level by using one water-quality meter and pump setup with separate intakes, similar to those used at the station at Buckman Bridge. At Dames Point, the collection of stage data began in October 2017, and the collection of velocity and streamflow direction data began in May 2018.

Description of Tributary Sites

No changes to the tributary monitoring network occurred during this year of the study. A monitoring station on Julington Creek at Old St. Augustine Road calculates discharge 6.7 mi upstream from the confluence of Julington Creek and the St. Johns River (table 1). A nearby water-quality monitoring station measures water temperature and specific conductance at an approximate depth of 3.5 ft below the average high-tide level and is located approximately 3 mi downstream from Old St. Augustine Road on Julington Creek at Hood Landing.

Durbin Creek is monitored for stage, discharge, water temperature, specific conductance, and salinity 3.5 mi upstream from the confluence with Julington Creek and 6.8 mi upstream from the confluence with the St. Johns River. The water-quality parameters are measured at an approximate depth of 3 ft below the average high-tide level. These locations are all tidally influenced, but large amounts of rainfall, resulting in increased discharge, can obscure the tidal signal.

Ortega River is monitored for stage and discharge at Argyle Forest Boulevard (Kirwin Road), 11 mi upstream from the confluence of the Ortega and St. Johns Rivers. Discharge has been computed intermittently at this location since 2002, and a stage-discharge rating was used for discharge computation during the study period, as no tidal influence is apparent in the stage data. A water-quality monitoring station that measures water temperature and specific conductance at an approximate depth of 6.5 ft below the average high-tide level is located at the bridge on Collins Road approximately 3 mi downstream from Kirwin Road at the Ortega River. Tidal influence is evident in the salinity data during times of low flow or increased stage in the St. Johns River.

The monitoring station on Cedar River measures stage, water temperature, and specific conductance at San Juan Avenue, 1.5 mi upstream from the confluence of the Cedar and St. Johns Rivers. The water-quality parameters are monitored at an approximate depth of 6 ft below the average high-tide level. Historical, tidally filtered discharge values have been computed intermittently since 2002. Wind, tide, and rainfall all substantively affect flow and salinity at Cedar River, and vertically stratified, bidirectional flow is commonly measured when strong winds occur opposite the direction of flow.

The station at Pottsburg Creek near South Jacksonville measures stage and is 7.3 mi upstream from the confluence of Pottsburg Creek and the St. Johns River. A stage-discharge rating was used for discharge computation during the study period. The data indicate tidal influence when stage is very low in the creek and elevated in the St. Johns River, but discharge measurements confirm the validity of the stage-discharge relation. Pottsburg Creek is monitored for stage, discharge, water temperature, specific conductance, and salinity at U.S. 90, 5.2 mi upstream from the confluence of Pottsburg Creek and the St. Johns River. The water-quality parameters are monitored at an approximate depth of 4 ft below the average high-tide level. This location has a more pronounced tidal signal than the upstream location on Pottsburg Creek, and discharge and salinity are affected primarily by rainfall and elevated stage in the river.

The monitoring station for Trout River calculates discharge at Lem Turner Road, 5 mi upstream from the confluence of the Trout and St. Johns Rivers. Water temperature and specific conductance are measured 9.3 mi upstream from the confluence at an approximate depth of 6 ft below the average high-tide level. Broward River is monitored for stage, discharge, water temperature, specific conductance, and salinity near Biscayne Boulevard, 6.3 mi upstream from its confluence with the St. Johns River. The water-quality parameters are monitored at an approximate depth of 4.5 ft below the average high-tide level. Discharge and salinity at these stations have a pronounced tidal signal, even when stage is elevated.

Dunn Creek is monitored for stage, discharge, water temperature, specific conductance, and salinity at Dunn Creek Road, 5.3 mi upstream from the confluence of Dunn Creek and the St. Johns River. The monitoring station for Clapboard Creek calculates discharge near Sheffield Road, 4.5 mi upstream from the confluence of Clapboard Creek and the St. Johns River. Water temperature and specific conductance are measured at a location 0.5 mi upstream. The water-quality parameters are monitored at approximate depths of 5.5 and 6.5 ft below the average high-tide level. Discharge and salinity fluctuations at these stations are dependent on rainfall in the relatively small drainage area and on wind effects from the St. Johns River, owing to the proximity of the sites to the river and Atlantic Ocean.

Results

Because of the large study area and diversity of sites, discharge and salinity varied widely during the period. As expected, salinities were lowest at the tributary sites farthest from the ocean and highest during periods of low flow in the St. Johns River. Discharge also increased at both the tributary and main-stem sites during periods of increased rainfall.

Rainfall, daily discharge, and salinity plots for the 2019 water year (October 2018–September 2019) are presented in the following sections where applicable. A year refers to a water year in these sections unless otherwise noted. Daily discharge is tidally filtered at sites where substantive tidal fluctuations occur. Salinity values are not filtered and include daily maximum, minimum, and mean values. Instantaneous values can be accessed via the USGS National Water Information System database (USGS, 2020). Annual mean discharges are calculated only for sites having at least an entire year of discharge record. The annual mean is not calculated for partial years of record when stations were installed. Quantile plots are only available for sites with a minimum of 10 years of streamflow record.

Rainfall

Duval County rainfall for the 2019 water year (October 2018–September 2019) was 6.5 inches (in.) below the long-term average. Monthly total rainfall ranged from 4.0 in. below average in September to 3.7 in. above average in December (fig. 3). The only months with rainfall above the long-term average were November, December, and January, which produced a total rainfall accumulation that was 7.3 in. above the cumulative average based on monthly rainfall data from SJRWMD (2020). Duval County had the lowest yearly rainfall compared to the cumulative long-term average of the five counties included in this study. Hurricane Dorian bypassed the study area off the coast of Florida in early September but contributed little rainfall to the study area, as evidenced by the below-average monthly rainfall (fig. 3). Yearly rainfall averaged 2.8 in. and 2.6 in. below average for Clay and St. Johns Counties, respectively, which was slightly more yearly rainfall than that of Duval County (SJRWMD, 2020). Rainfall for Clay County and St. Johns County ranged from 4.8 and 4.3 in. above average in December to 3.7 and 4.1 in. below average in September, respectively (figs. 4 and 5).

Rainfall for Putnam County and Volusia County was 3.0 and 1.6 in. below the average yearly total, respectively (SJRWMD, 2020). Rainfall for Putnam County ranged from 5.8 in. above average in December to 3.7 in. below average in September (fig. 6). Rainfall for Volusia County ranged from 3.4 in. above average in December to 2.4 in. below average in March (fig. 7). Like the other counties in this study area, the largest consecutive 3-month above-average rainfall for Putnam and Volusia Counties occurred during the months of November–January, totaling 9.2 in. and 4.5 in. above the cumulative average, respectively.

Main-Stem Sites

The parameters collected on the main stem of the St. Johns River are affected by many factors, including tidal influence, rainfall, and wind. Heavy rainfall typically increases discharge and decreases salinity, and the tidal influence introduces more fluctuations than a nontidal system. Strong easterly winds can increase salinity in the St. Johns River as ocean water with higher salinity is pushed upstream and can lower or even produce negative discharge for multiple days. When the wind calms or changes direction, discharge typically increases sharply as this ocean water and other tributary inflows exit the river.

St. Johns River at Astor, Florida—Daily tidally filtered discharge at Astor ranged from −2,880 to 8,640 cubic feet per second (ft^3/s) during the 2019 water year, with an annual mean of 2,470 ft^3/s (fig. 8). A comparison of historical annual mean tidally filtered flows indicated that 2019 streamflow was at the 22d percentile of the 25 years of record; the median tidally filtered annual mean flow for the period of record is 2,780 ft^3/s (fig. 9). Discharge this year was influenced by slightly below-average rainfall in Volusia County, resulting in below-average annual mean discharge (fig. 7).

St. Johns River at Buffalo Bluff near Satsuma, Florida—Daily tidally filtered discharge at Buffalo Bluff ranged from −10,400 to 19,900 ft^3/s during the 2019 water year, with an annual mean of 4,780 ft^3/s (fig. 10). There were 2 days of missing data in January caused by equipment malfunction. A comparison of historical annual mean tidally filtered flows indicated that 2019 streamflow was at the 63d percentile; the median tidally filtered flow for the period of record is 4,400 ft^3/s (fig. 11). The largest tidally filtered discharge for the 2019 water year occurred in early September after a 3-day period of negative flows caused by strong easterly winds from Hurricane Dorian.

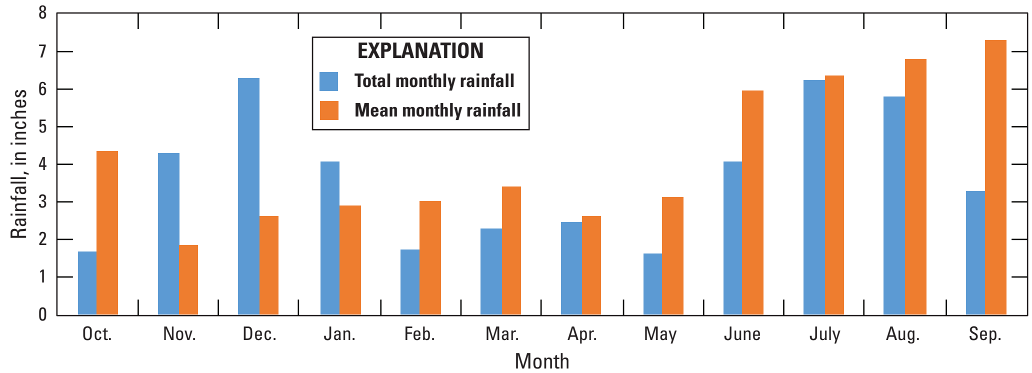

Figure 3. Graph of 2019 water year monthly rainfall and mean monthly rainfall for Duval County (St. Johns River Water Management District [SJRWMD], 2020).

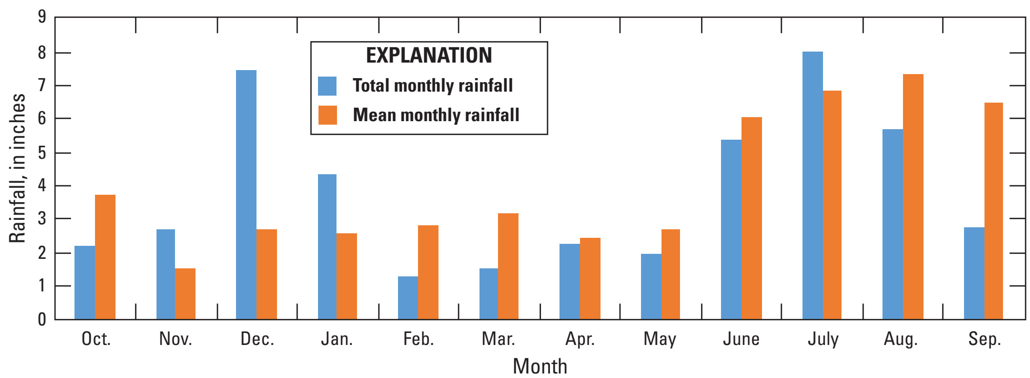

Figure 4. Graph of 2019 water year monthly rainfall and mean monthly rainfall for Clay County (St. Johns River Water Management District [SJRWMD], 2020).

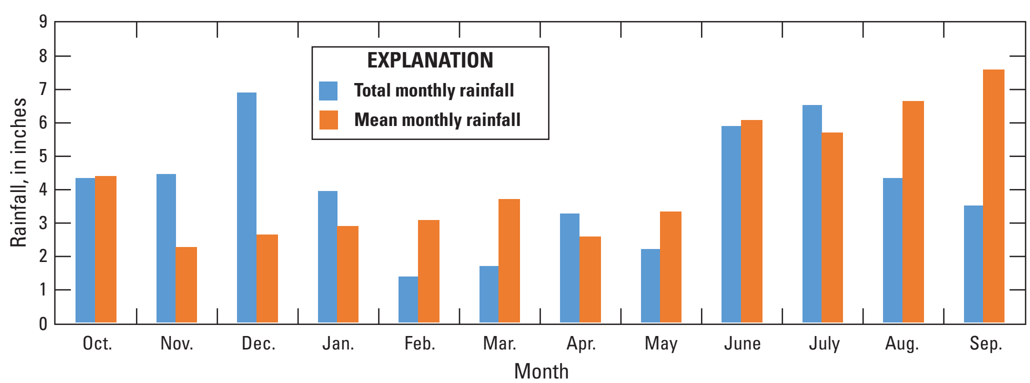

Figure 5. Graph of 2019 water year monthly rainfall and mean monthly rainfall for St. Johns County (St. Johns River Water Management District [SJRWMD], 2020).

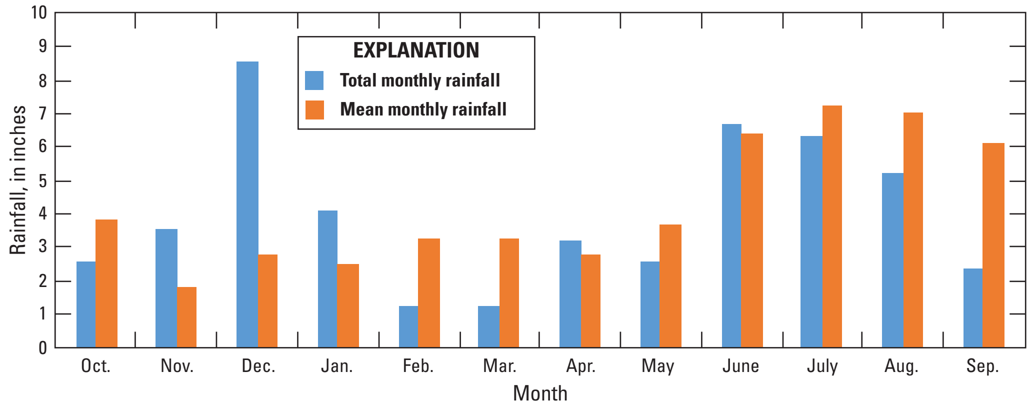

Figure 6. Graph of 2019 water year monthly rainfall and mean monthly rainfall for Putnam County (St. Johns River Water Management District [SJRWMD], 2020).

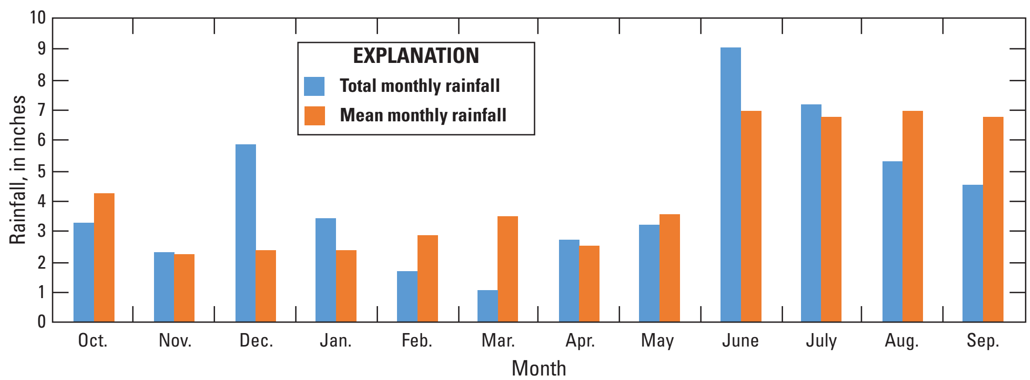

Figure 7. Graph of 2019 water year monthly rainfall and mean monthly rainfall for Volusia County (St. Johns River Water Management District [SJRWMD], 2020).

St. Johns River at Dancy Point near Spuds, Florida—Salinity on the St. Johns River at Dancy Point ranged from 0.2 to 0.6 parts per thousand (ppt) during the 2019 water year, with a median and mean of 0.4 ppt (fig. 12). The salinity data show daily fluctuations caused by tidal effects and rainfall, and a gradual increase from February to June. The median salinity for 2019 ranked second among those calculated for the 3 years over the study period (fig. 13).

St. Johns River at Racy Point near Hastings, Florida—Salinity on the St. Johns River at Racy Point ranged from 0.1 to 0.6 ppt during the 2019 water year, with a median and mean of 0.4 ppt (fig. 14). The general pattern shows a salinity increase from March to May and relatively constant values through the end of the year. Salinity typically decreases in the summer because of increased rainfall, which was below average from July to September in St. Johns County (fig. 5). The 2019 salinity median and interquartile range were higher than those in 2018, which has incomplete record because the monitoring station was installed that year (fig. 15).

St. Johns River Shands Bridge near Green Cove Springs, Florida—Salinity on the St. Johns River at Shands Bridge ranged from 0.2 to 1.0 ppt during the 2019 water year, with a median of 0.3 ppt and mean of 0.4 ppt (fig. 16). Fluctuations are similar to those at Racy Point and occur because of tidal influence and rainfall. The salinity peaked in early September, when Hurricane Dorian moved north parallel to the Florida coast and pushed ocean water upstream into the St. Johns River. A boxplot of salinity data shows a higher mean and larger interquartile range in 2019 compared to 2018, which has incomplete record because the monitoring station was installed that year (fig. 17).

St. Johns River Below Shands Bridge near Green Cove Springs, Florida—Salinity on the St. Johns River below Shands Bridge ranged from 0.2 to 0.6 ppt during the 2019 water year with a median of 0.4 ppt and mean of 0.3 ppt (fig. 18). Daily salinity data were not recorded for 8 days in October, 7 days in June, 3 days in July, and 12 days in September because of equipment malfunction. The maximum salinity of 0.6 ppt is less than the maximum of 1.0 ppt at the nearby station at Shands Bridge most likely because the monitoring equipment is located near the right bank instead of near the center of the river channel. The 2019 mean salinity is lower than that of 2017, but the medians are equal (fig. 19). This observation and the larger interquartile range in 2017 are due to the higher salinity recorded in 2017 (5.2 ppt maximum) compared to 2019 (0.6 ppt maximum).

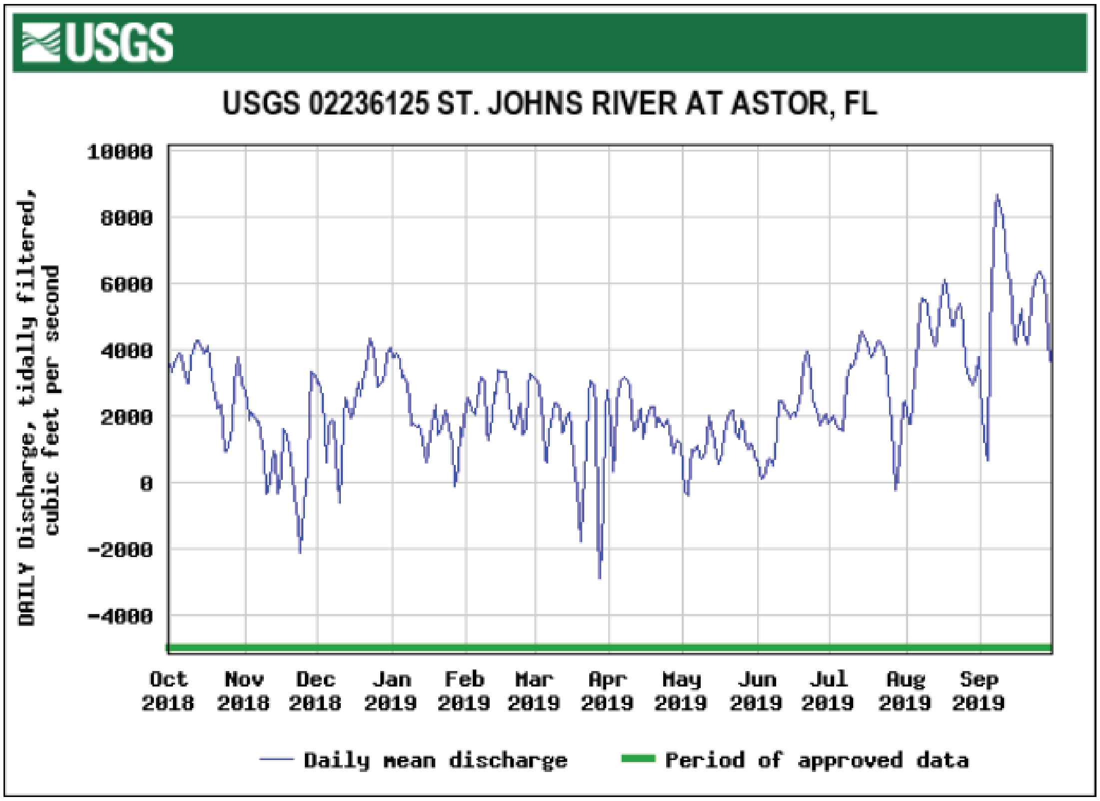

Figure 8. Daily mean tidally filtered discharge for St. Johns River at Astor, Florida.

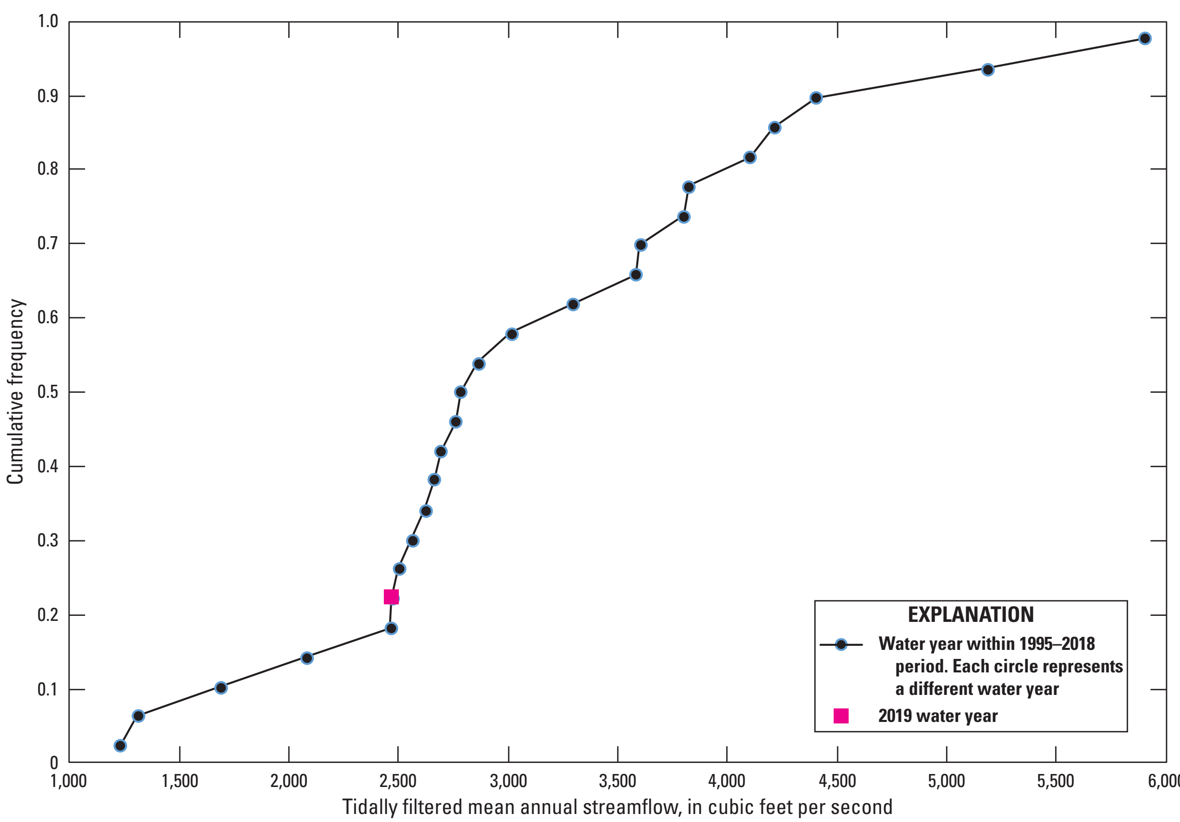

Figure 9. Annual mean tidally filtered streamflow data for St. Johns River at Astor, Florida.

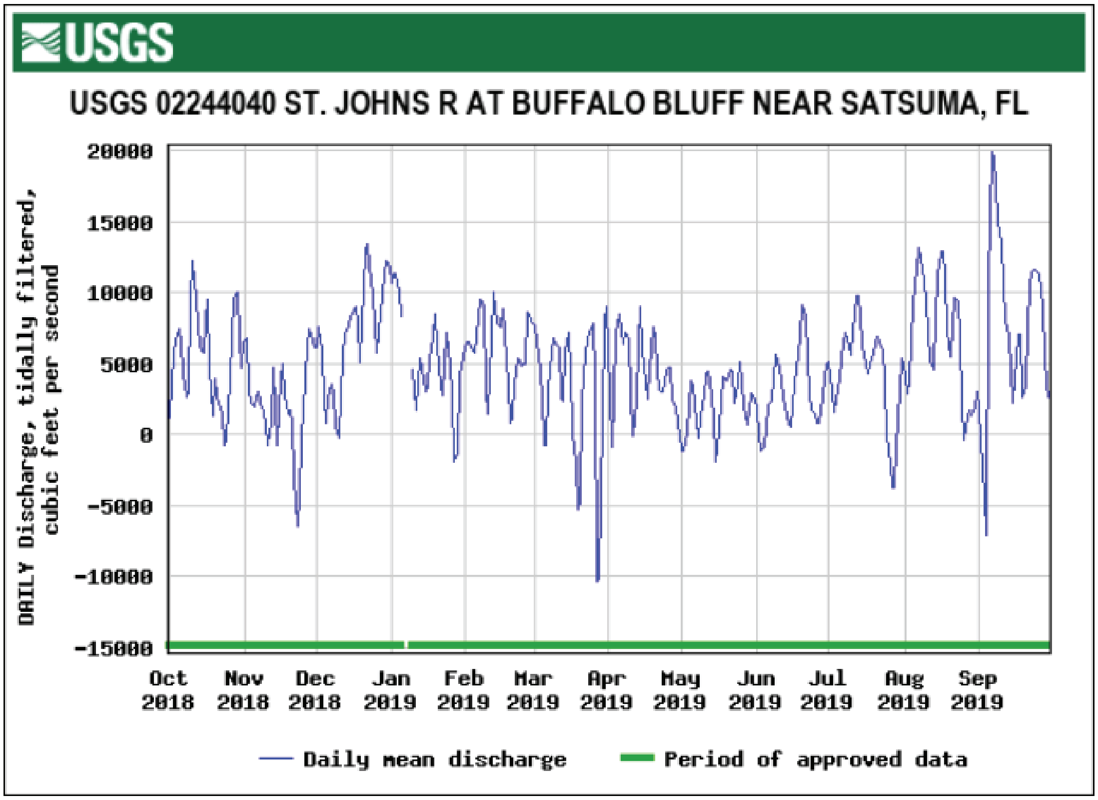

Figure 10. Daily mean tidally filtered discharge for St. Johns River at Buffalo Bluff near Satsuma, Florida.

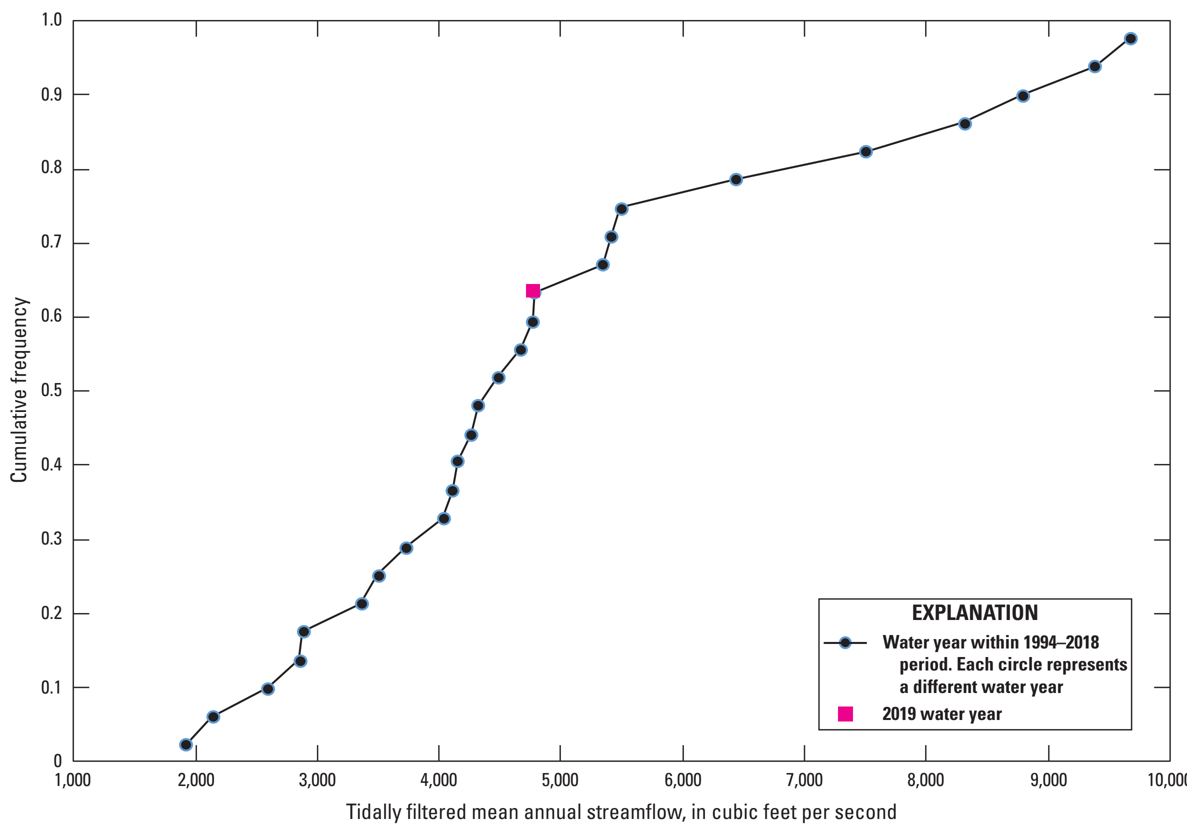

Figure 11. Annual mean tidally filtered streamflow data for St. Johns River at Buffalo Bluff near Satsuma, Florida.

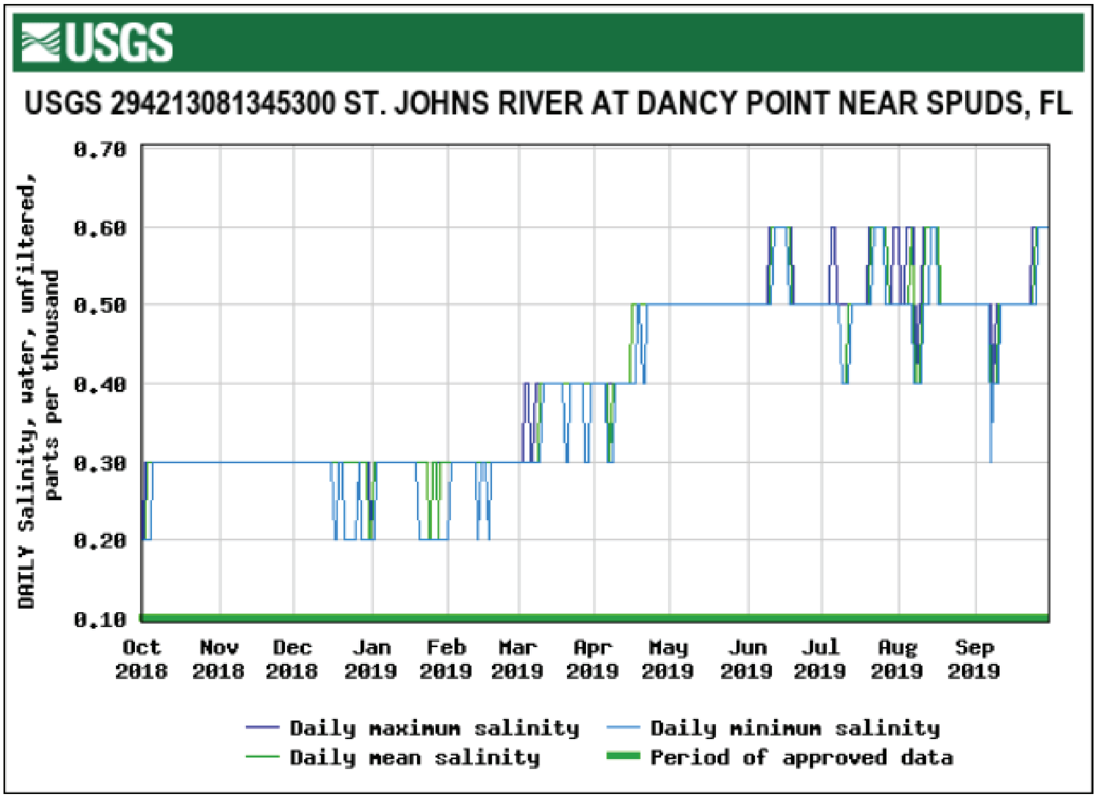

Figure 12. Daily maximum, minimum, and mean salinity for St. Johns River at Dancy Point near Spuds, Florida.

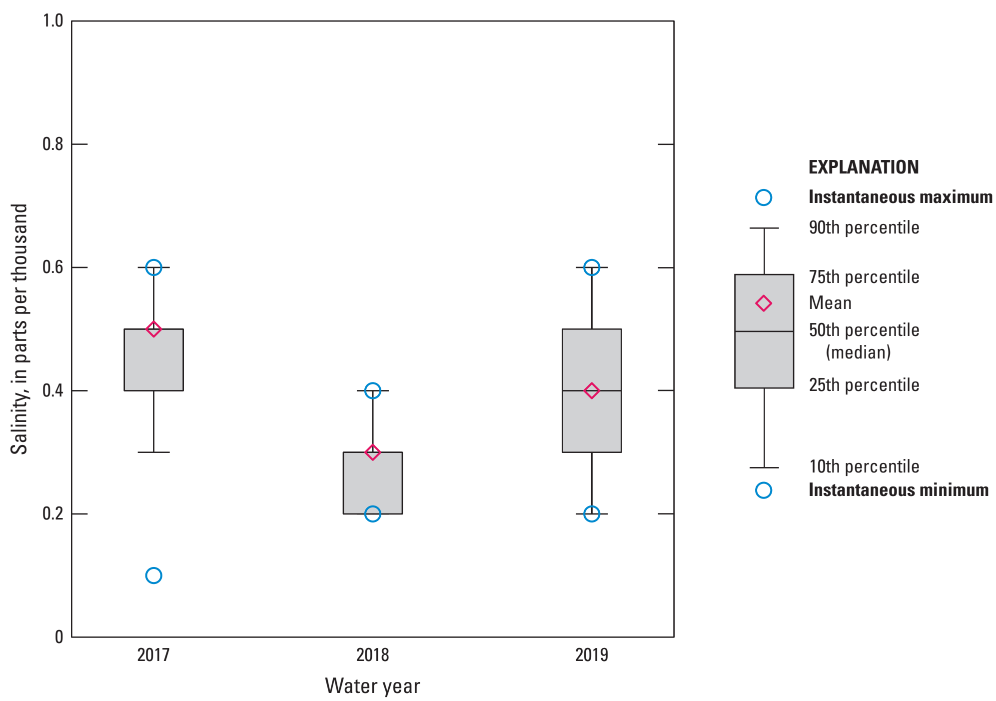

Figure 13. Salinity data for St. Johns River at Dancy Point near Spuds, Florida.

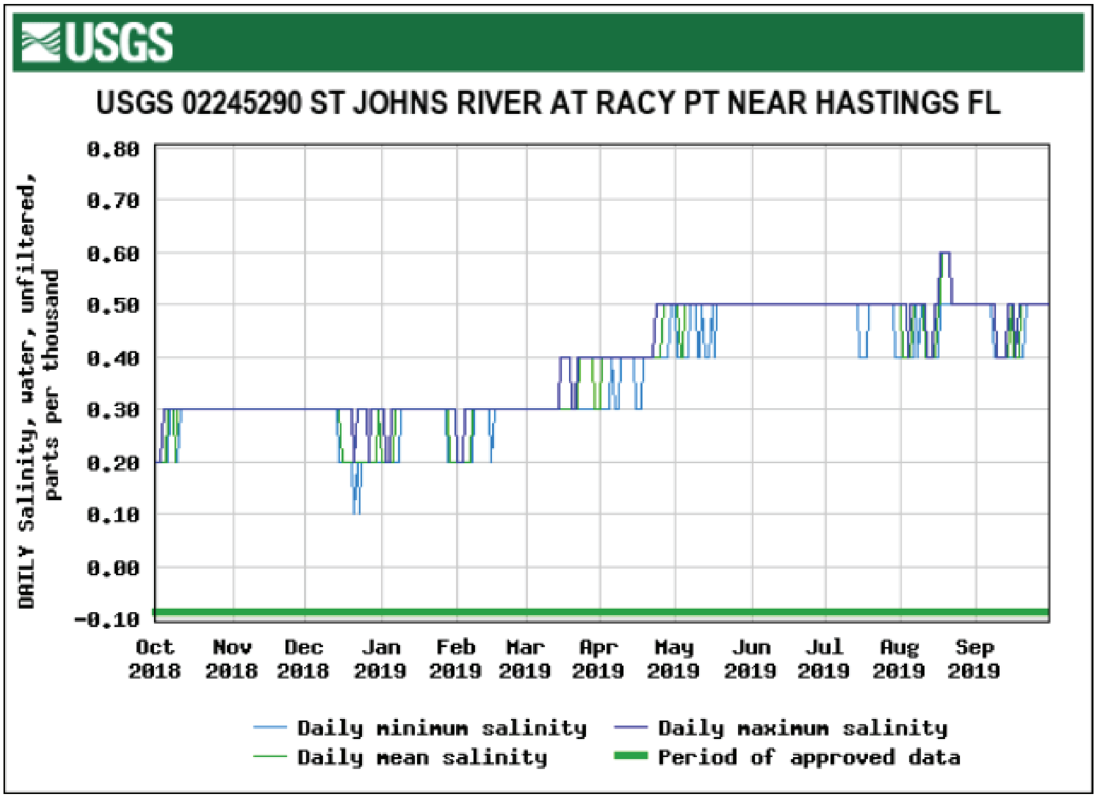

Figure 14. Daily maximum, minimum, and mean salinity for St. Johns River at Racy Point near Hastings, Florida.

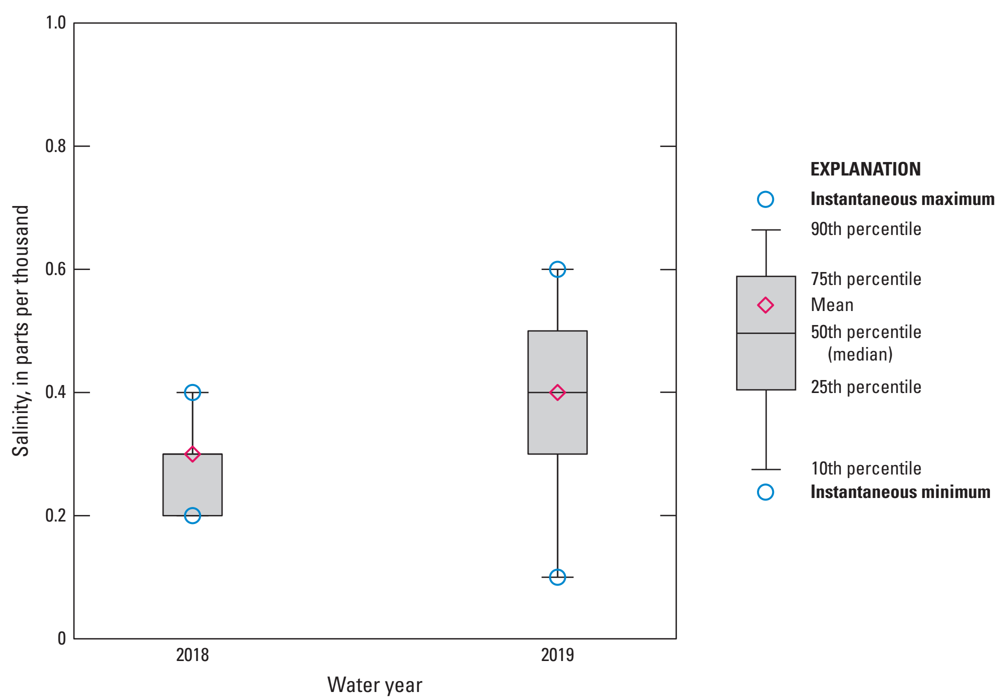

Figure 15. Salinity data for St. Johns River at Racy Point near Spuds, Florida.

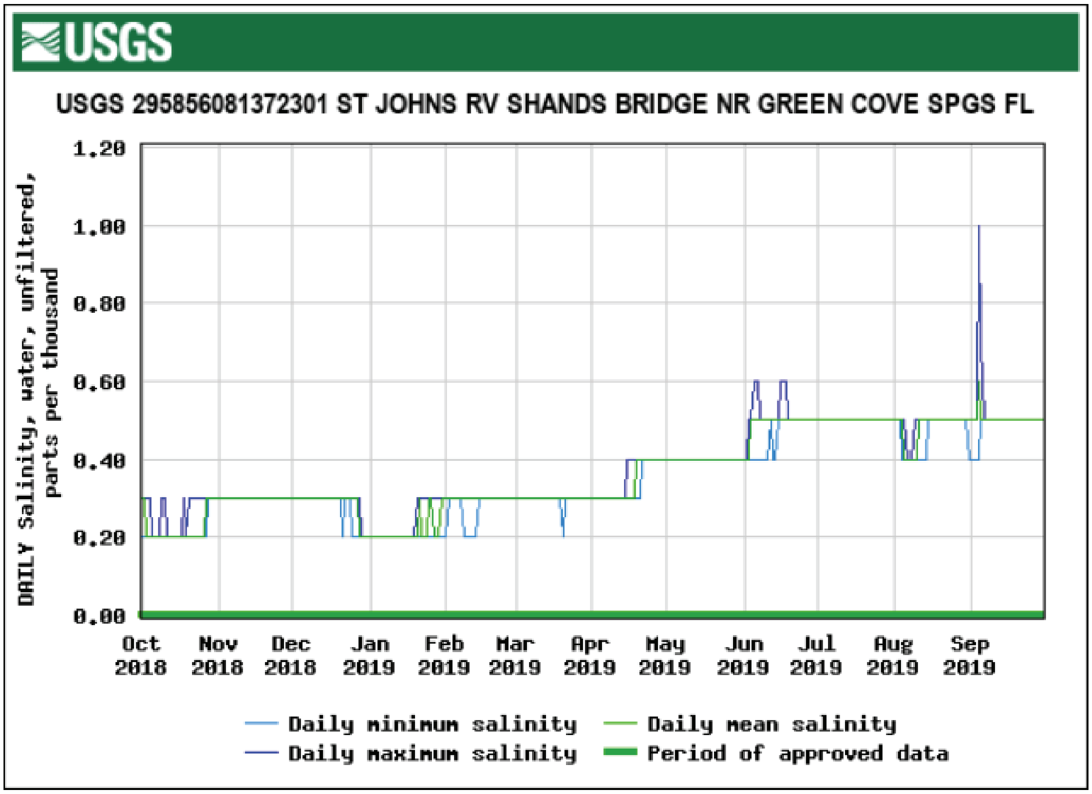

Figure 16. Daily maximum, minimum, and mean salinity for St. Johns River Shands Bridge near Green Cove Springs, Florida.

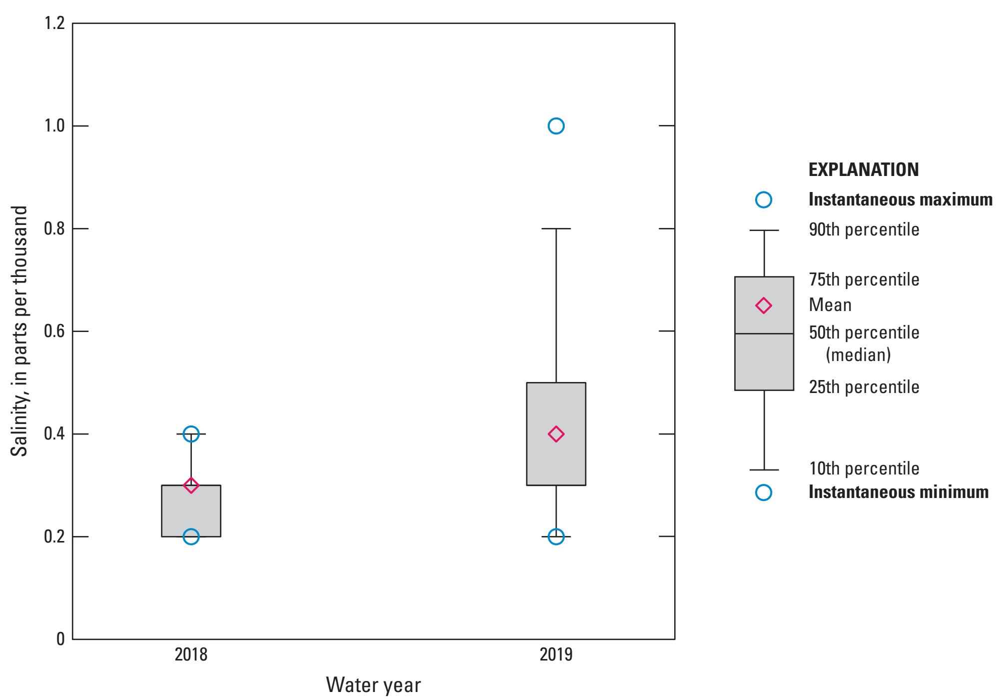

Figure 17. Salinity data for St. Johns River Shands Bridge near Green Cove Springs, Florida.

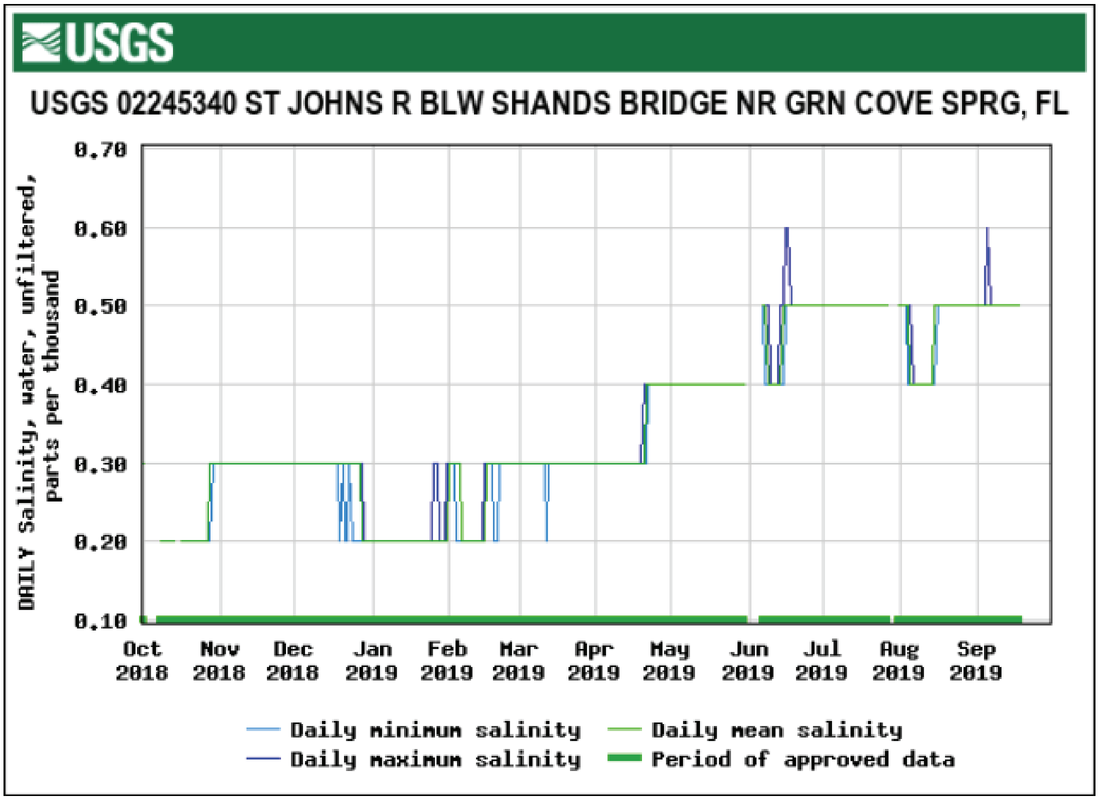

Figure 18. Daily maximum, minimum, and mean salinity for St. Johns River below Shands Bridge near Green Cove Springs, Florida.

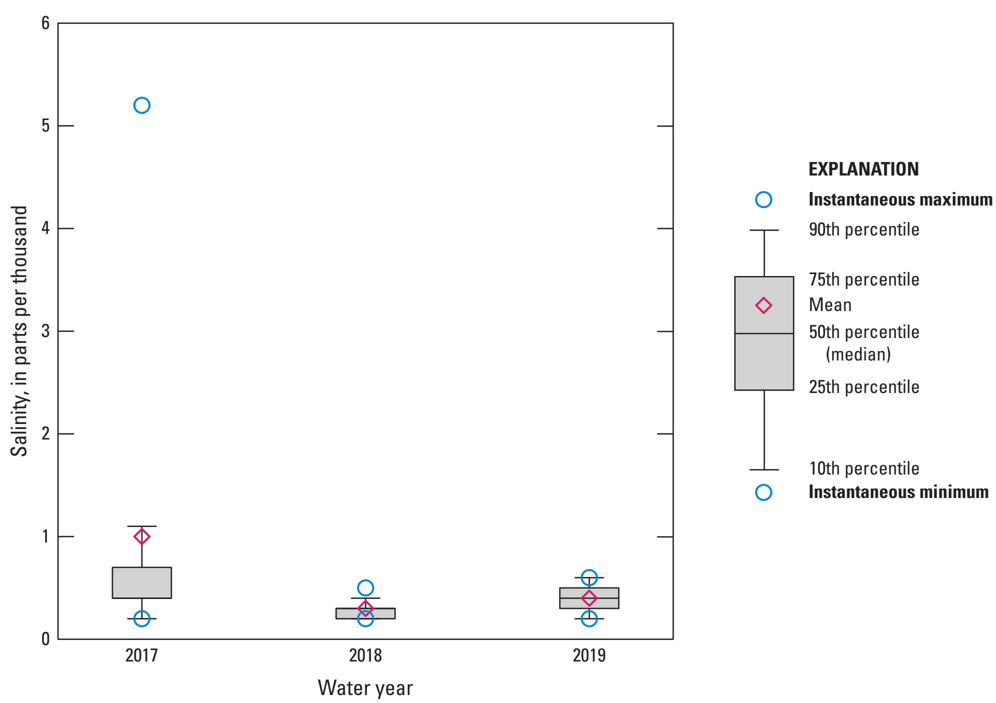

Figure 19. Salinity data for St. Johns River below Shands Bridge near Green Cove Springs, Florida.

St. Johns River above Buckman Bridge at Jacksonville, Florida—Salinity on the St. Johns River above Buckman Bridge ranged from 0.2 to 10 ppt during the 2019 water year, with a median of 0.8 ppt and mean of 1.5 ppt (fig. 20). The salinity was highest in September, which was also the month with the lowest rainfall relative to the average in Clay County for the year (fig. 4) and that included effects from Hurricane Dorian. The median and mean salinity for 2019 were both higher than those for 2018, although 2018 has incomplete record because the monitoring station was installed that year (fig. 21).

St. Johns River Buckman Bridge at Jacksonville, Florida—Salinity on the St. Johns River at Buckman Bridge ranged from 0.2 to 14 ppt for the top location during the 2019 water year, with a median of 1.1 ppt and mean of 1.8 ppt, and from 0.2 to 16 ppt for the bottom location, with a median of 1.1 ppt and mean of 2.0 ppt (figs. 22 and 23). The monitoring station did not record water-quality data at the top location for 15 days from October to November, nor during short periods in February, March, and July, because of equipment malfunction. The 2019 median and mean salinity at both the top and bottom locations ranked second among those calculated for the 3 years of salinity data analyzed for this site (figs. 24 and 25).

St. Johns River at Christopher Point near Jacksonville, Florida—Salinity at Christopher Point ranged from 0.2 to 21 ppt during the 2019 water year, with a median of 2.3 ppt and mean of 2.9 ppt (fig. 26). Salinity was not computed for 8 days in June because of equipment malfunction. The 2019 median and mean both ranked third among those computed for the 4 years of the study (fig. 27).

St. Johns River Below Marco Lake at Jacksonville, Florida—Salinity at Marco Lake ranged from 0.2 to 27 ppt during the 2019 water year, with a median of 4.6 ppt and mean of 5.4 ppt (fig. 28). Salinity was not computed for short periods in July and August because of equipment malfunction. Like Christopher Point, the 2019 median and mean both ranked third among those computed for the 4 years of the study (fig. 29).

St. Johns River at Jacksonville, Florida—Daily tidally filtered discharge at the St. Johns River at Jacksonville ranged from −43,500 to 52,500 ft^3/s during the 2019 water year, with an annual mean of 3,570 ft^3/s (fig. 30). Salinity ranged from 0.2 to 31 ppt over this same period, with a median of 6.1 ppt and mean of 6.9 ppt (fig. 31). Salinity was not computed for short periods in April, June, and July because of equipment malfunction. A large rise in tidally filtered discharge occurred in early September after 12 days of negative flows, which were most likely influenced by wind from Hurricane Dorian. A comparison of historical annual mean tidally filtered flows indicated that the 2019 streamflow was at the 33d percentile; the median tidally filtered flow for the period of record is 5,490 ft^3/s (fig. 32). Annual mean tidally filtered streamflow record was used from 1997 onward because of data collection gaps in the historical data prior to 1997. The 2019 mean and median salinity are within 1 ppt of those calculated for 2016 and 2017, and the maximum salinity ranks second out of the 4 years of the study (fig. 33).

St. Johns River Dames Point Bridge at Jacksonville, Florida—Salinity on the St. Johns River at Dames Point Bridge ranged from 0.6 to 36 ppt for the top location during the 2019 water year, with a median and mean of 22 ppt, and from 0.6 to 36 ppt for the bottom location, with a median of 24 ppt and mean of 23 ppt (figs. 34 and 35). Salinity was not calculated for 15 days in October at the bottom location and for short periods in December at both locations because of equipment malfunction. Salinity during the year was generally lower at the top location relative to the bottom and fluctuated weekly at both locations because of upstream conditions. The 2019 mean salinity for both locations ranked in the middle of those calculated for the 3 years of the study (figs. 36 and 37).

Tributary Sites

The parameters collected on the tributaries of the St. Johns River are mainly affected by rainfall and, at most sites, by tidal fluctuations. Heavy rainfall typically increases discharge and decreases salinity, and the tidal influence introduces more daily fluctuation at tidal sites than at nontidal sites. Like the main stem, tributaries of the St. Johns River are also affected by strong easterly winds. Because of their distance from the ocean, tributary sites and main stem sites farther upstream require prolonged or extremely strong winds, such as those from a hurricane, to experience increased salinity.

Julington Creek at Old St. Augustine Road near Bayard, Florida—Daily tidally filtered discharge at Julington Creek ranged from −23.7 to 195 ft^3/s during the 2019 water year, with an annual mean flow of 25.3 ft^3/s (fig. 38). Multiple discharge peaks above 100 ft^3/s occurred from November to January as a result of above-average rainfall in Duval County (fig. 3). Discharge was not calculated for 8 days in September because of equipment malfunction.

Julington Creek at Hood Landing near Bayard, Florida—Salinity at Julington Creek at Hood Landing ranged from 0.1 to 1.0 ppt during the 2019 water year, with a median and mean of 0.2 ppt (fig. 39). Salinity increased above 0.5 ppt for portions of the period from May to July during a time of below-average rainfall in Duval County (fig. 3). The 2019 mean salinity ranked third among those computed for the 4 years of the study (fig. 40).

Durbin Creek near Fruit Cove, Florida—Daily tidally filtered discharge at Durbin Creek ranged from −0.72 to 351 ft^3/s during the 2019 water year, with an annual mean of 72.9 ft^3/s (fig. 41). Tidally filtered discharge peaked above 250 ft^3/s five times over the year but also remained below 100 ft^3/s from March through June. Discharge was not calculated for 3 days in September because of equipment malfunction. Salinity ranged from 0.1 to 0.3 ppt with a median and mean of 0.1 ppt (fig. 42). The boxplot for Durbin Creek salinity data in 2019 shows the same median as calculated for the previous 3 years of the study and includes no whiskers because of the low and steady salinities of freshwater flows through the creek (fig. 43).

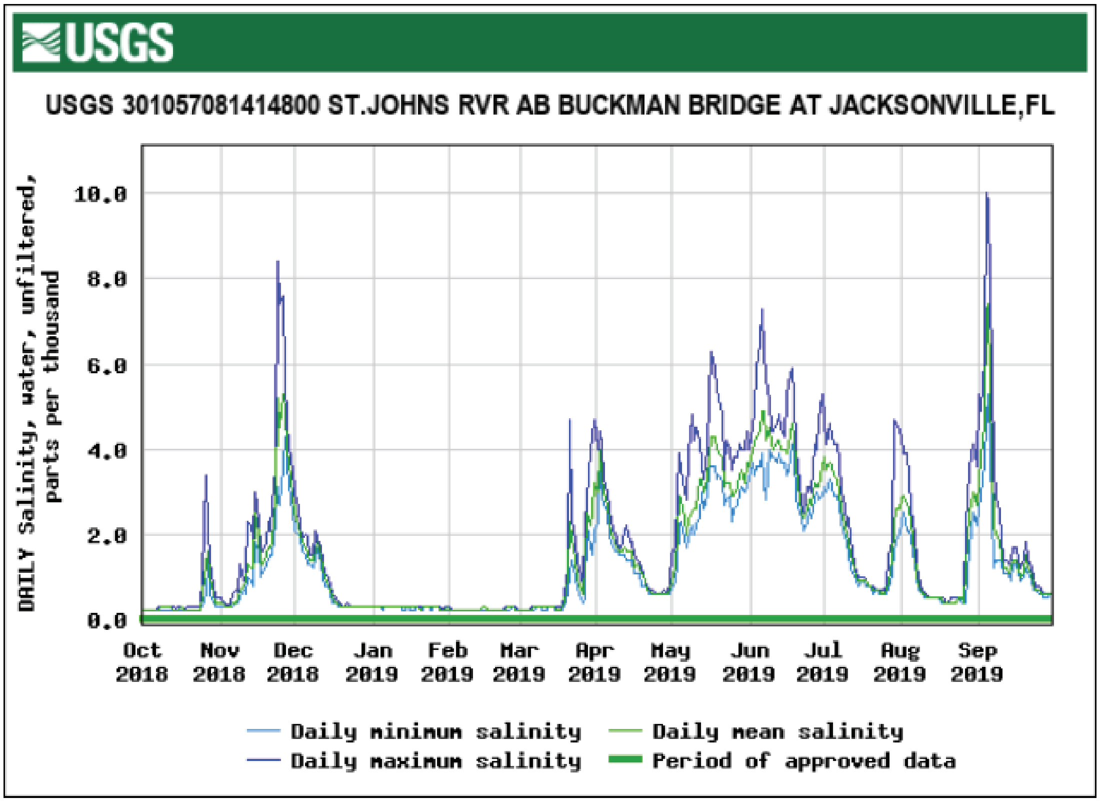

Figure 20. Daily maximum, minimum, and mean salinity for St. Johns River above Buckman Bridge at Jacksonville, Florida.

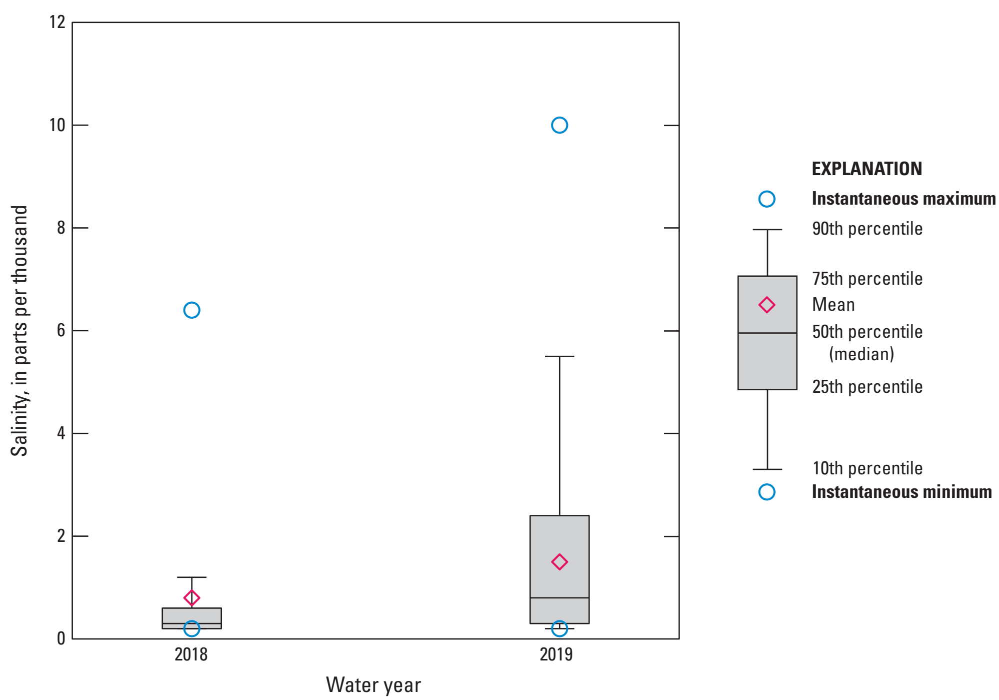

Figure 21. Salinity data for St. Johns River above Buckman Bridge at Jacksonville, Florida.

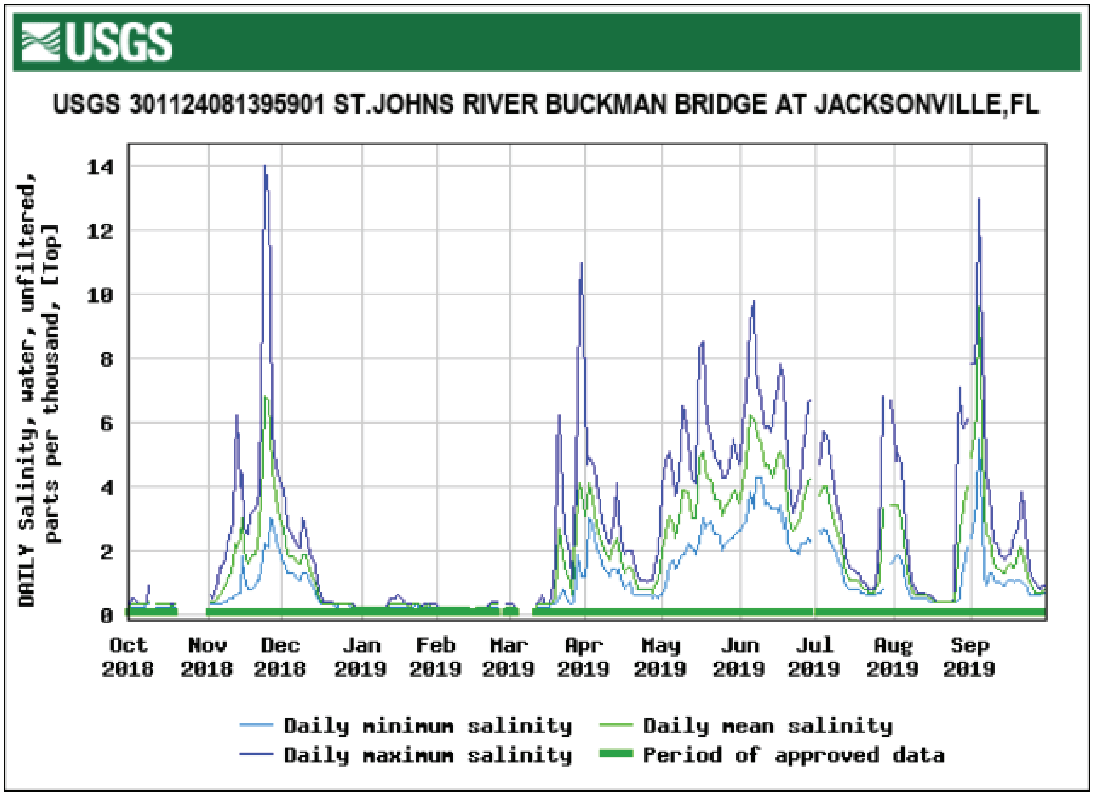

Figure 22. Daily maximum, minimum, and mean salinity for top location of St. Johns River Buckman Bridge at Jacksonville, Florida.

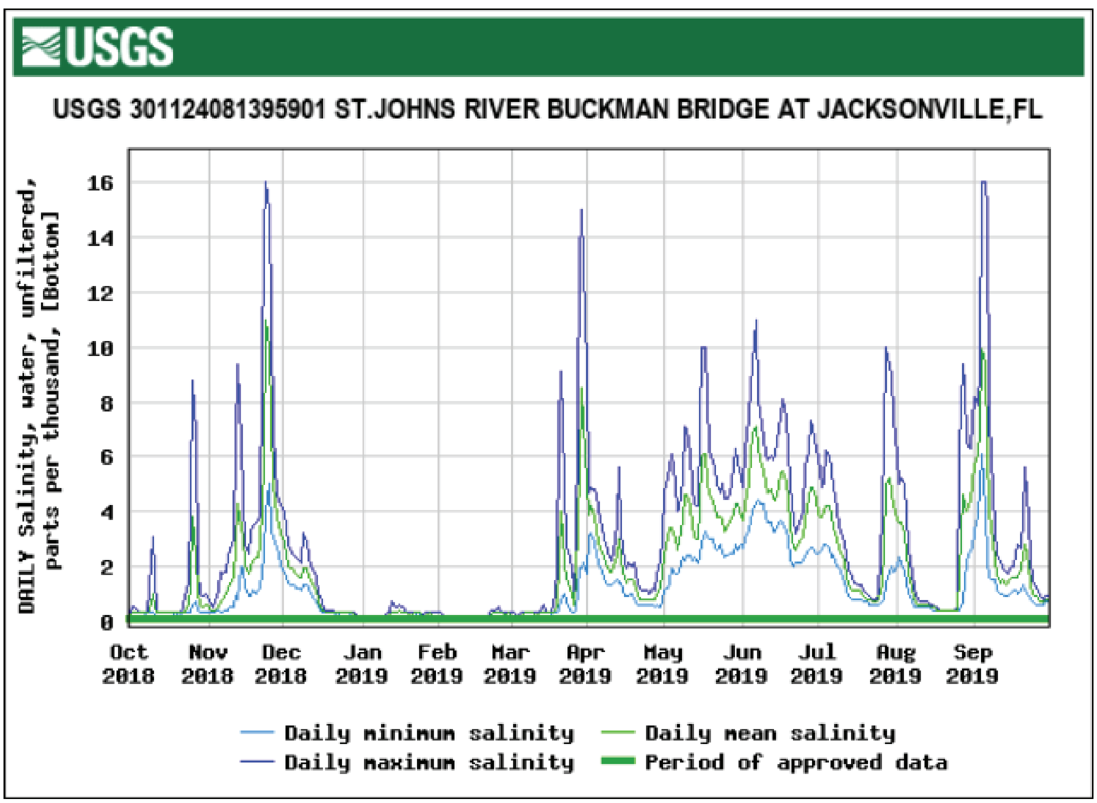

Figure 23. Daily maximum, minimum, and mean salinity for bottom location of St. Johns River Buckman Bridge at Jacksonville, Florida.

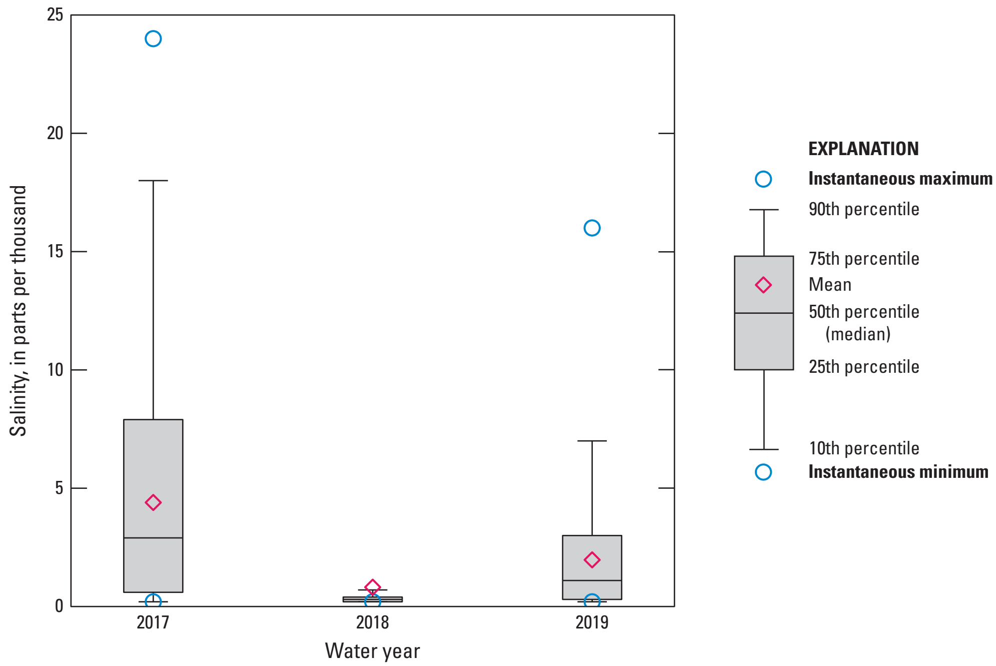

Figure 24. Salinity data for top location of St. Johns River Buckman Bridge at Jacksonville, Florida.

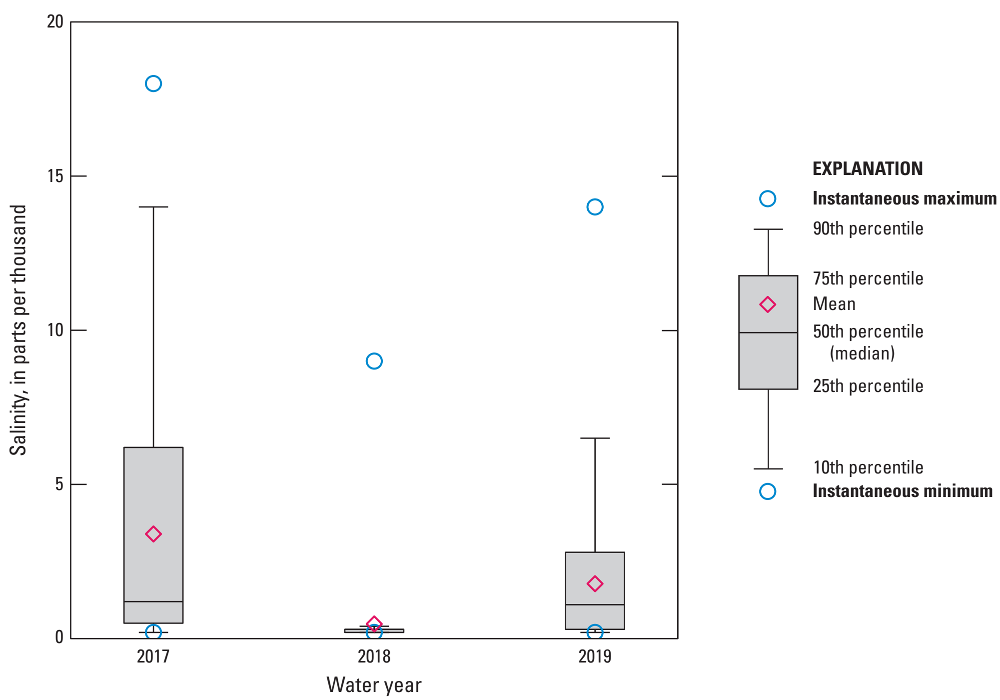

Figure 25. Salinity data for bottom location of St. Johns River Buckman Bridge at Jacksonville, Florida.

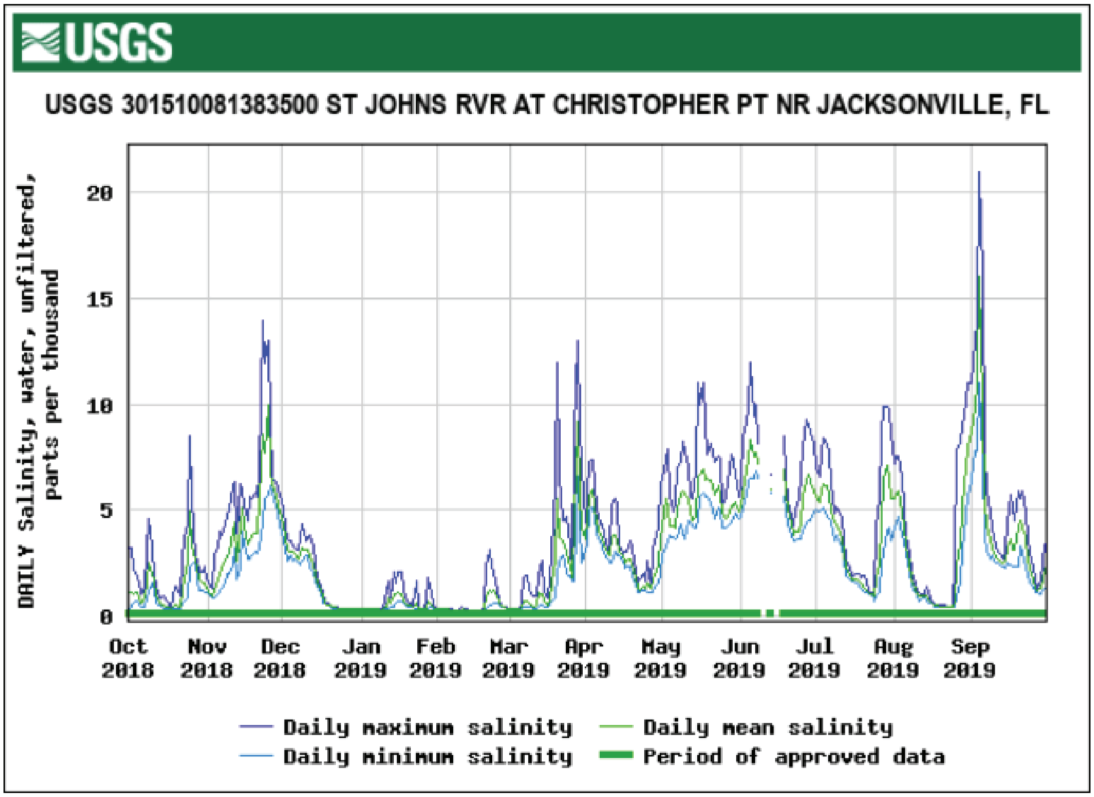

Figure 26. Daily maximum, minimum, and mean salinity for St. Johns River at Christopher Point near Jacksonville, Florida.

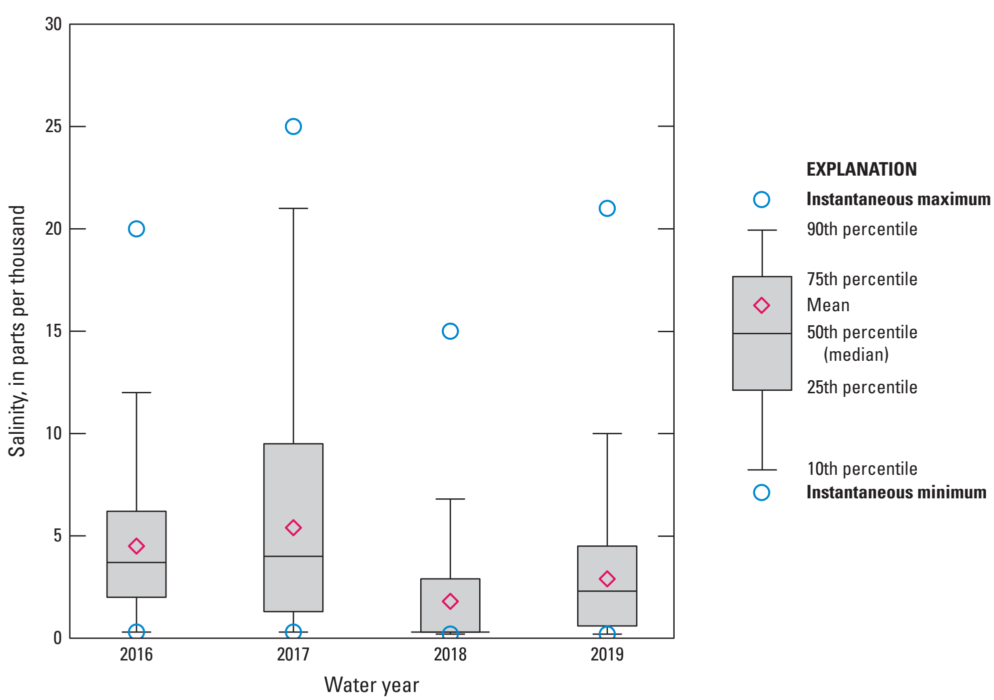

Figure 27. Salinity data for St. Johns River at Christopher Point near Jacksonville, Florida.

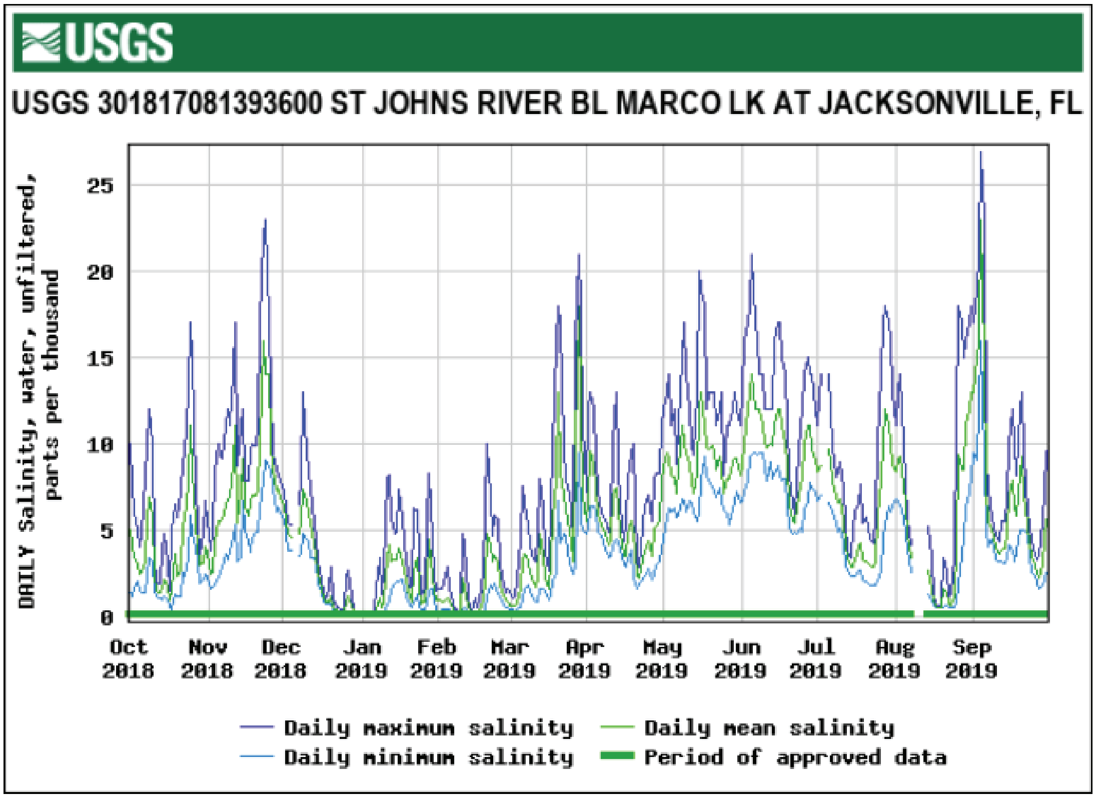

Figure 28. Daily maximum, minimum, and mean salinity for St. Johns River below Marco Lake at Jacksonville, Florida.

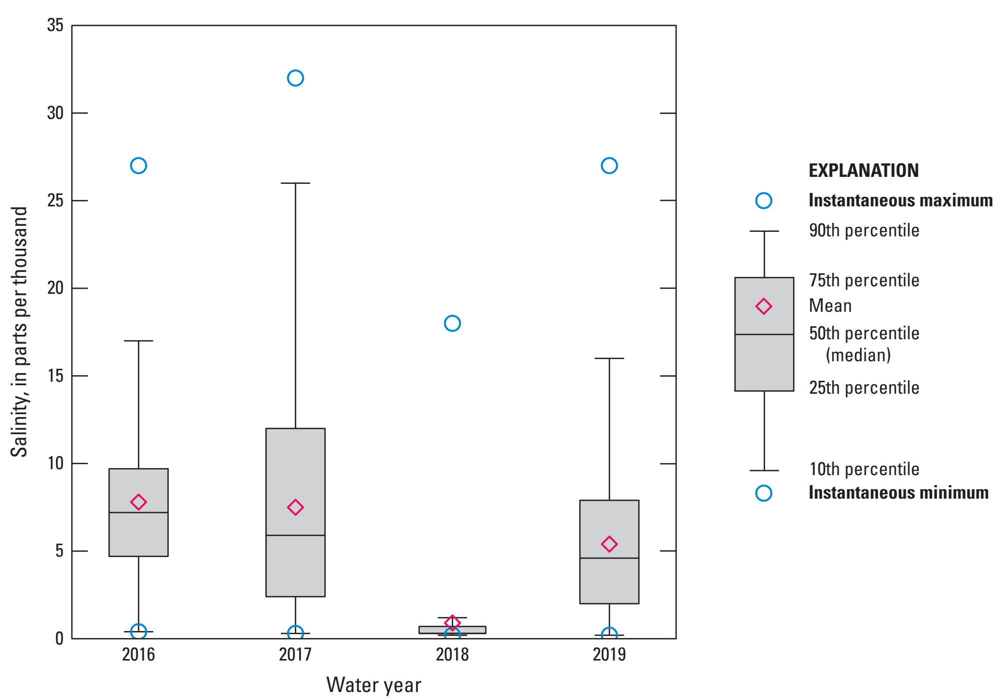

Figure 29. Salinity data for St. Johns River below Marco Lake at Jacksonville, Florida.

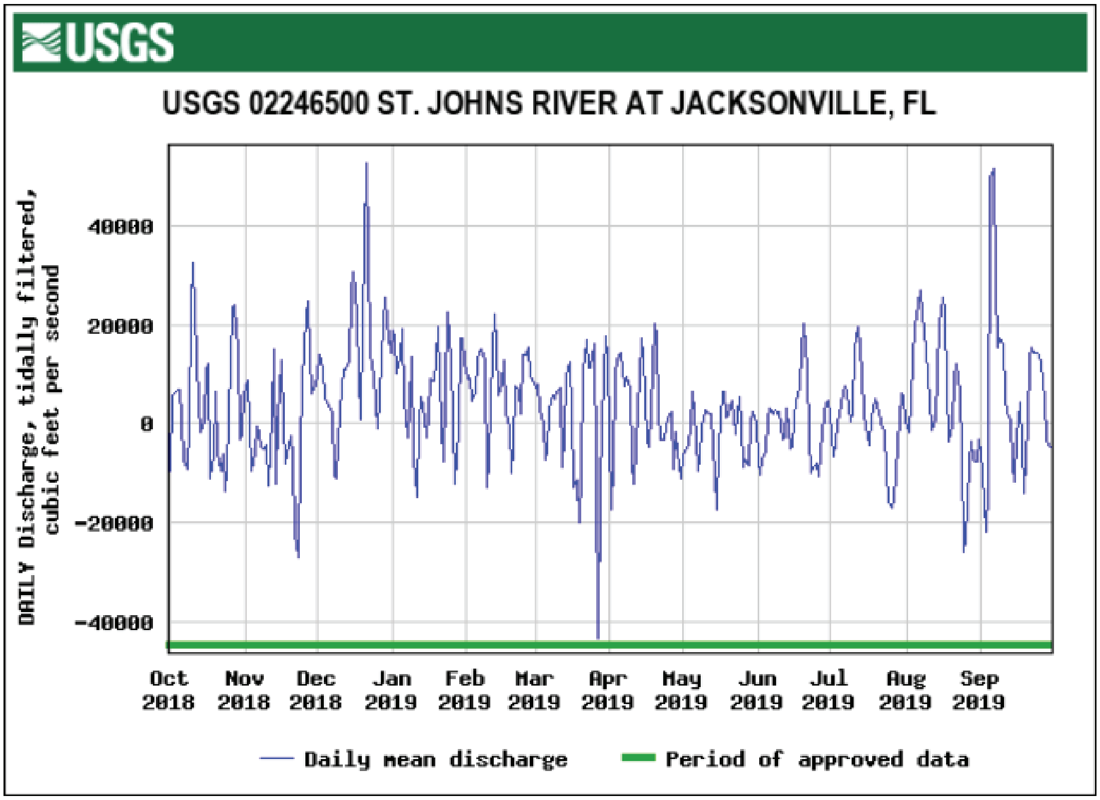

Figure 30. Daily mean tidally filtered discharge for St. Johns River at Jacksonville, Florida.

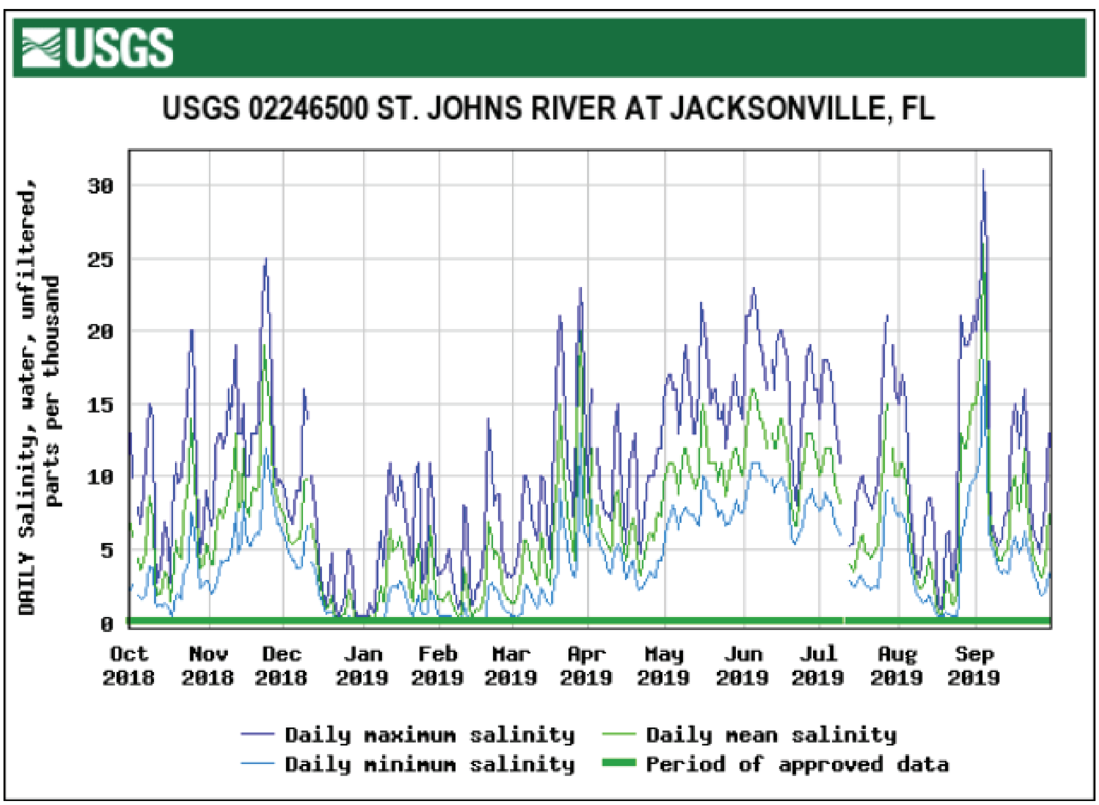

Figure 31. Daily maximum, minimum, and mean salinity for St. Johns River at Jacksonville, Florida.

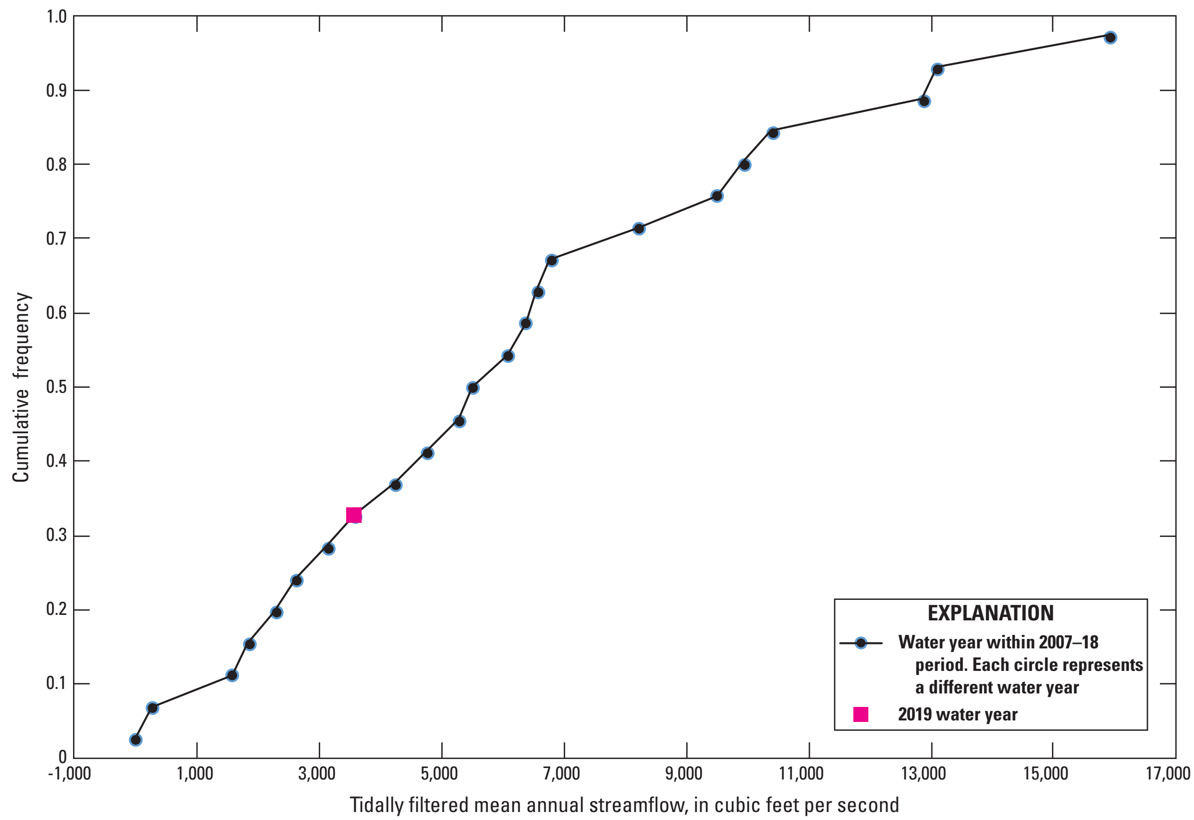

Figure 32. Annual mean tidally filtered streamflow data for St. Johns River at Jacksonville, Florida.

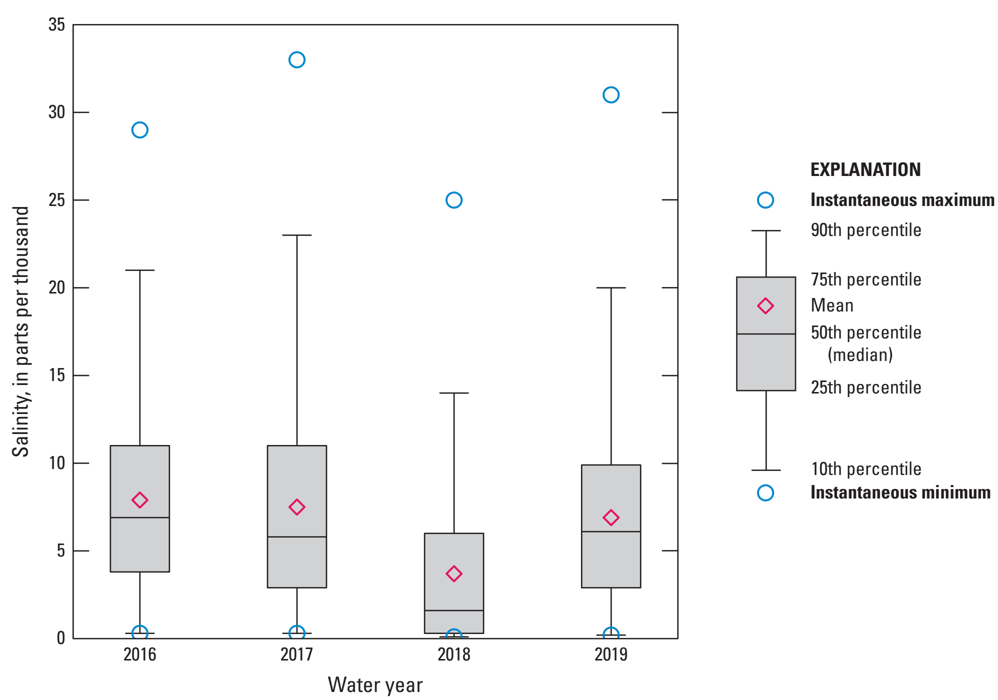

Figure 33. Salinity data for St. Johns River at Jacksonville, Florida.

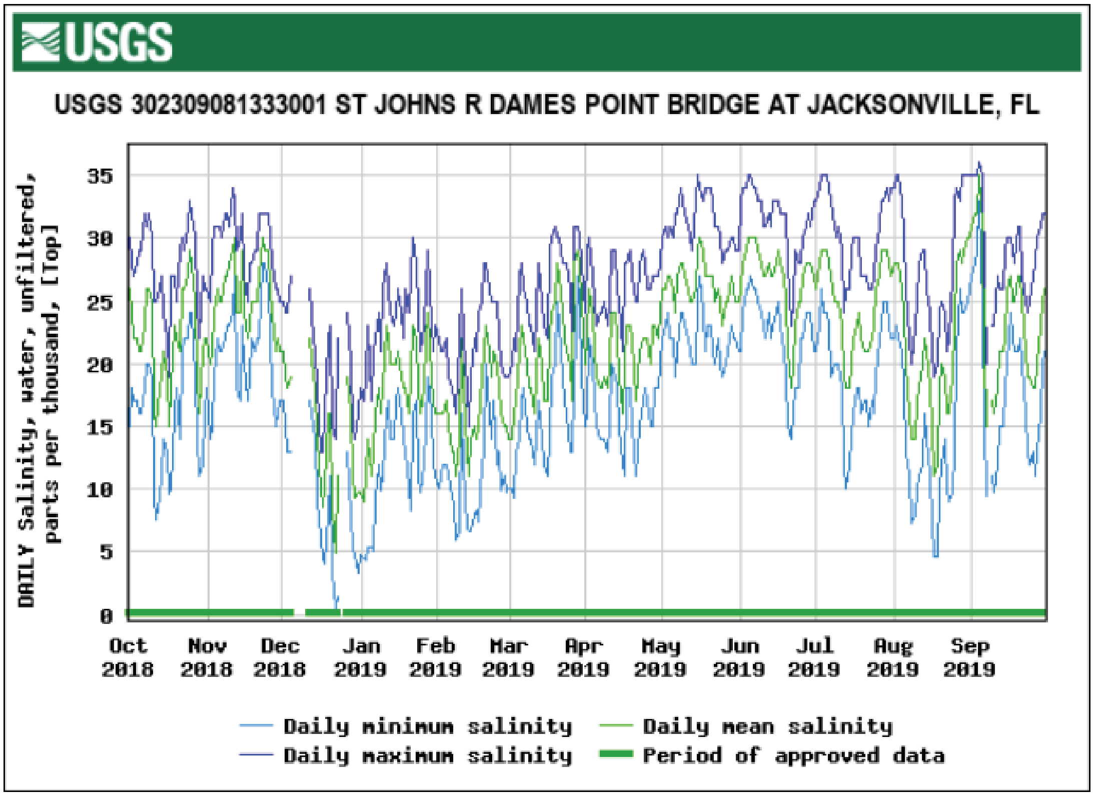

Figure 34. Daily maximum, minimum, and mean salinity for top location of St. Johns River Dames Point Bridge at Jacksonville, Florida.

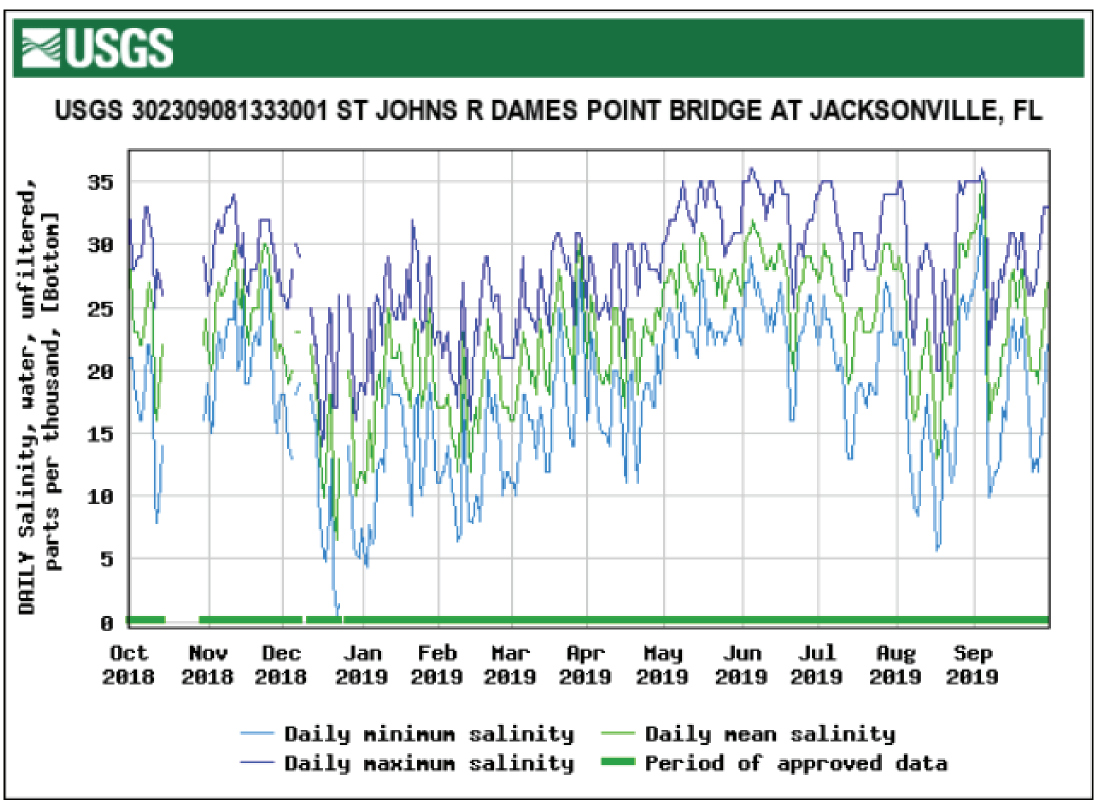

Figure 35. Daily maximum, minimum, and mean salinity for bottom location of St. Johns River Dames Point Bridge at Jacksonville, Florida.

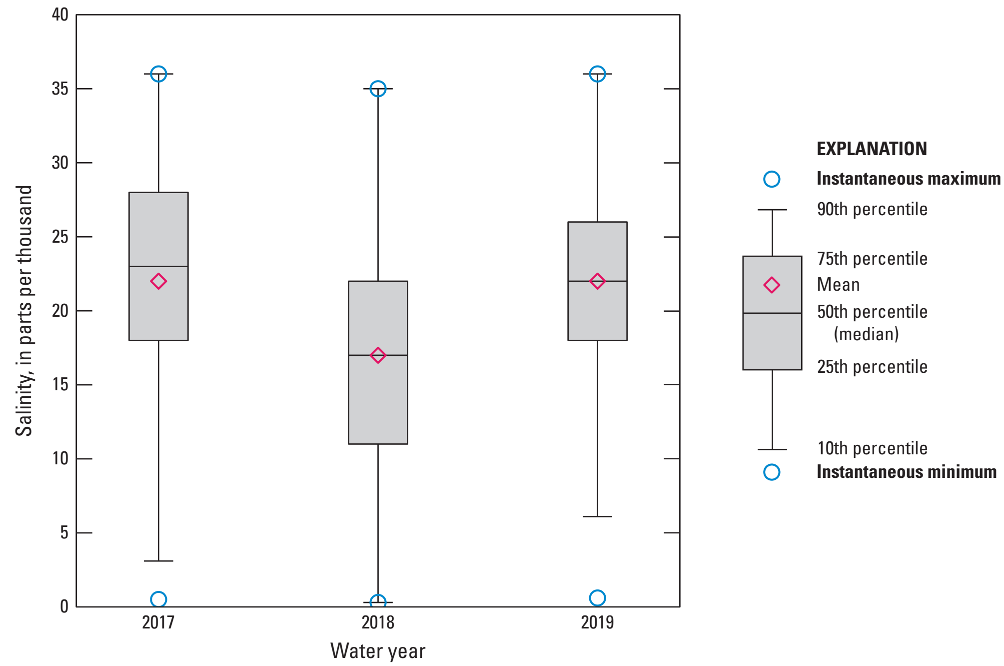

Figure 36. Salinity data for top location of St. Johns River at Dames Point Bridge at Jacksonville, Florida.

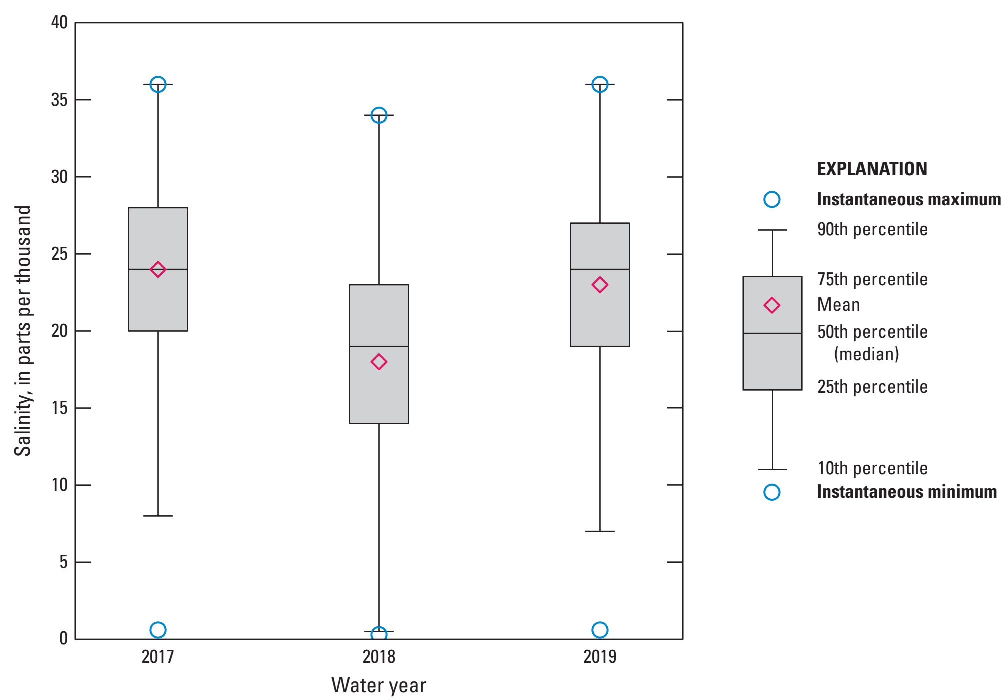

Figure 37. Salinity data for bottom location of St. Johns River at Dames Point Bridge at Jacksonville, Florida.

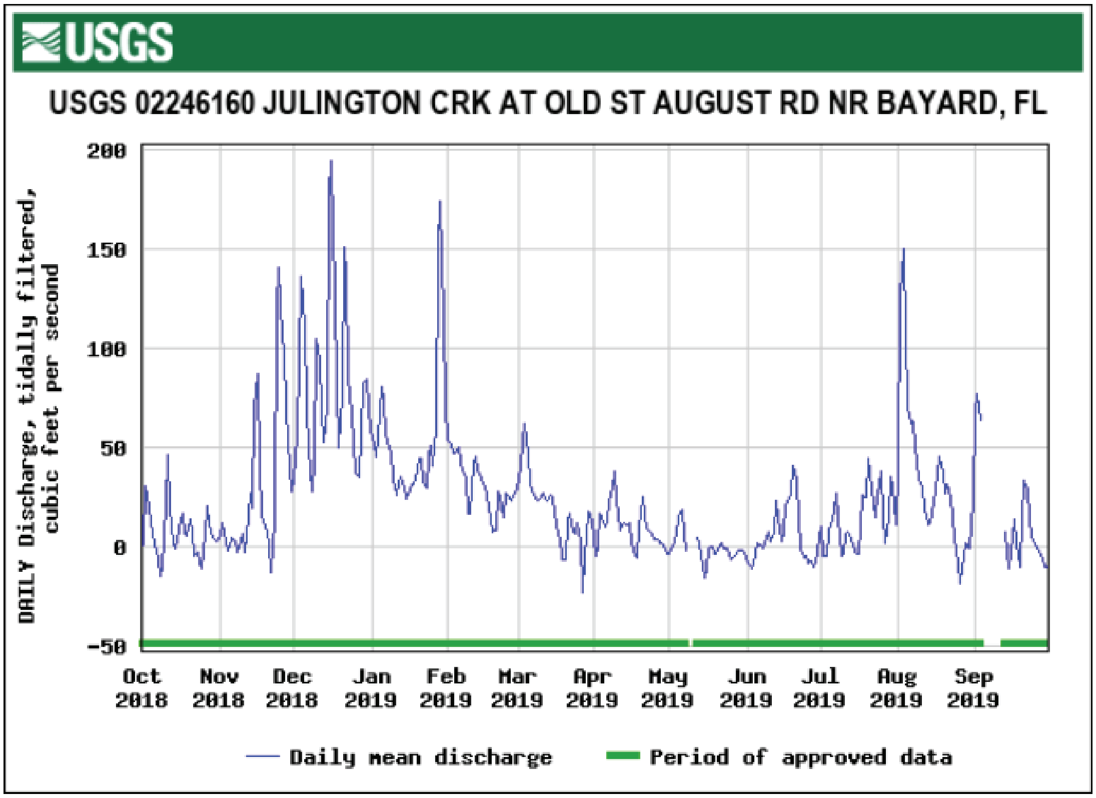

Figure 38. Daily mean tidally filtered discharge for Julington Creek at Old St. Augustine Road near Bayard, Florida.

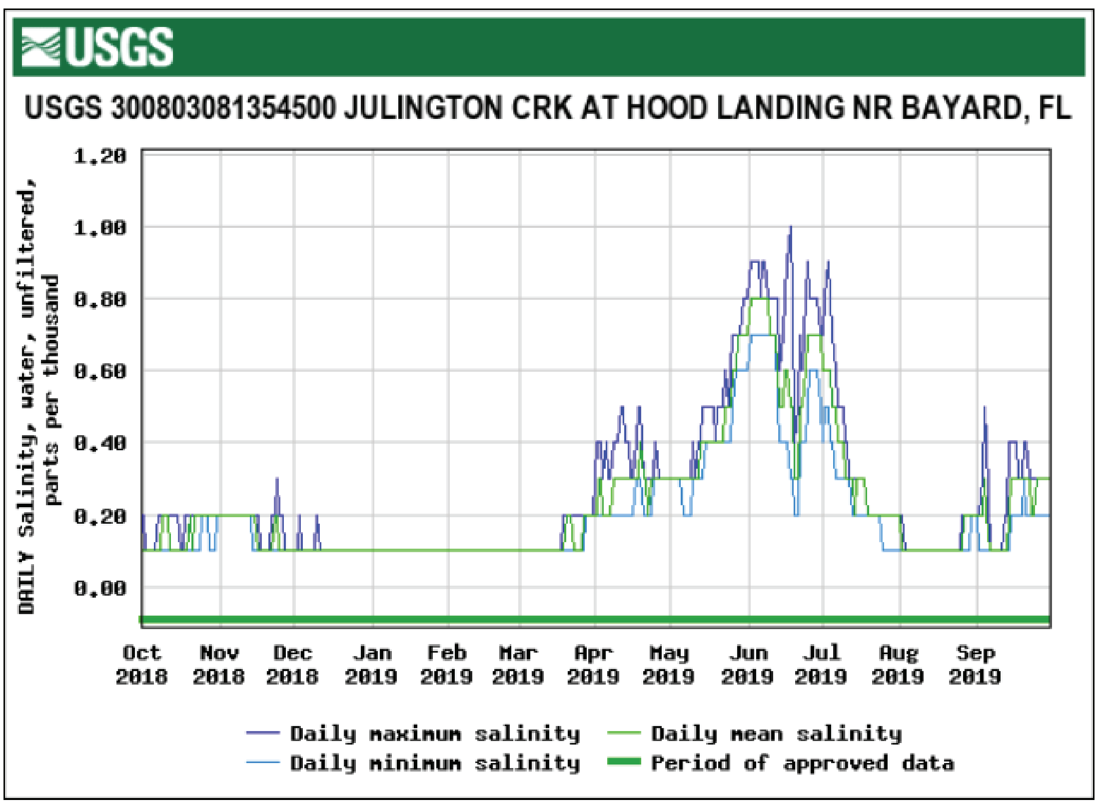

Figure 39. Daily maximum, minimum, and mean salinity for Julington Creek at Hood Landing near Bayard, Florida.

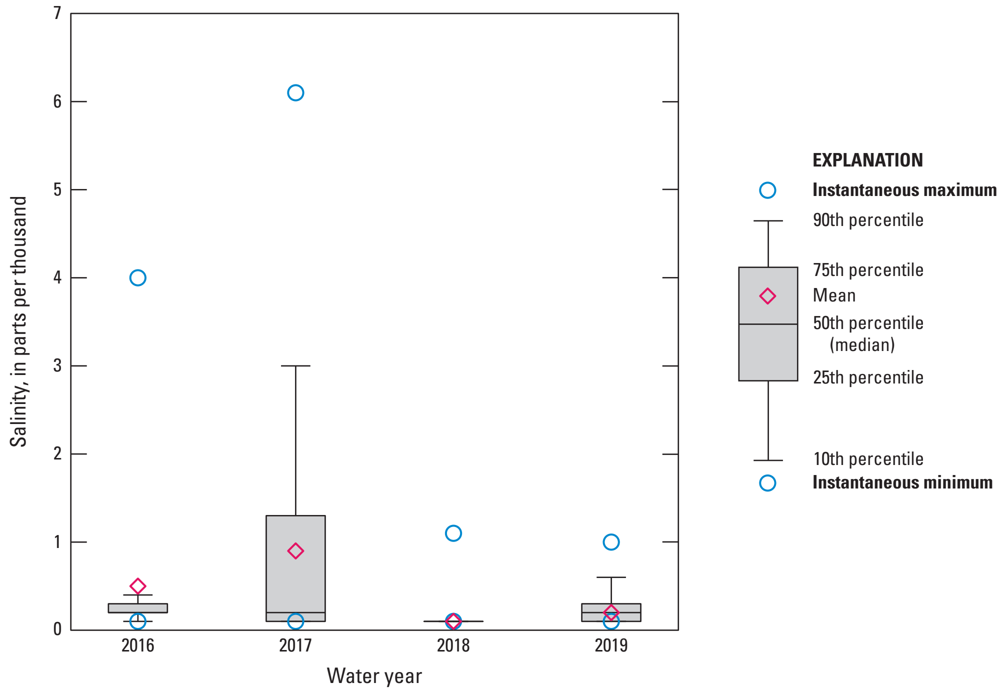

Figure 40. Salinity data for Julington Creek at Hood Landing near Bayard, Florida.

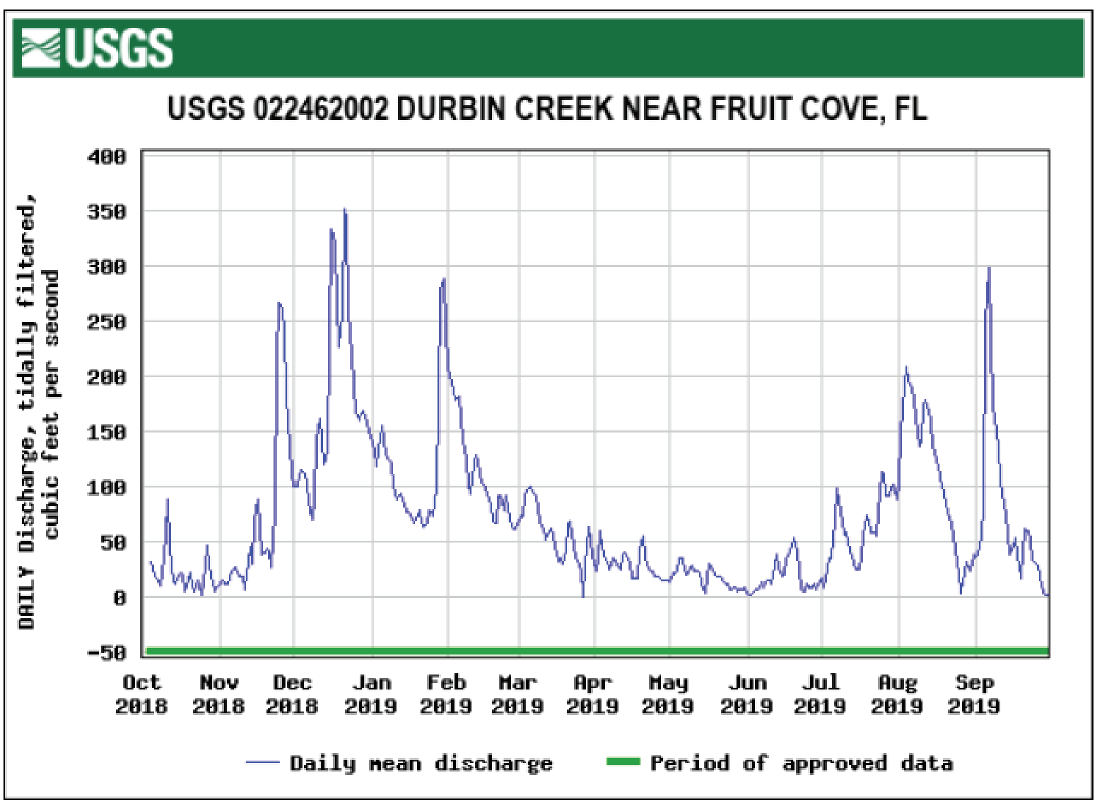

Figure 41. Daily mean tidally filtered discharge for Durbin Creek near Fruit Cove, Florida.

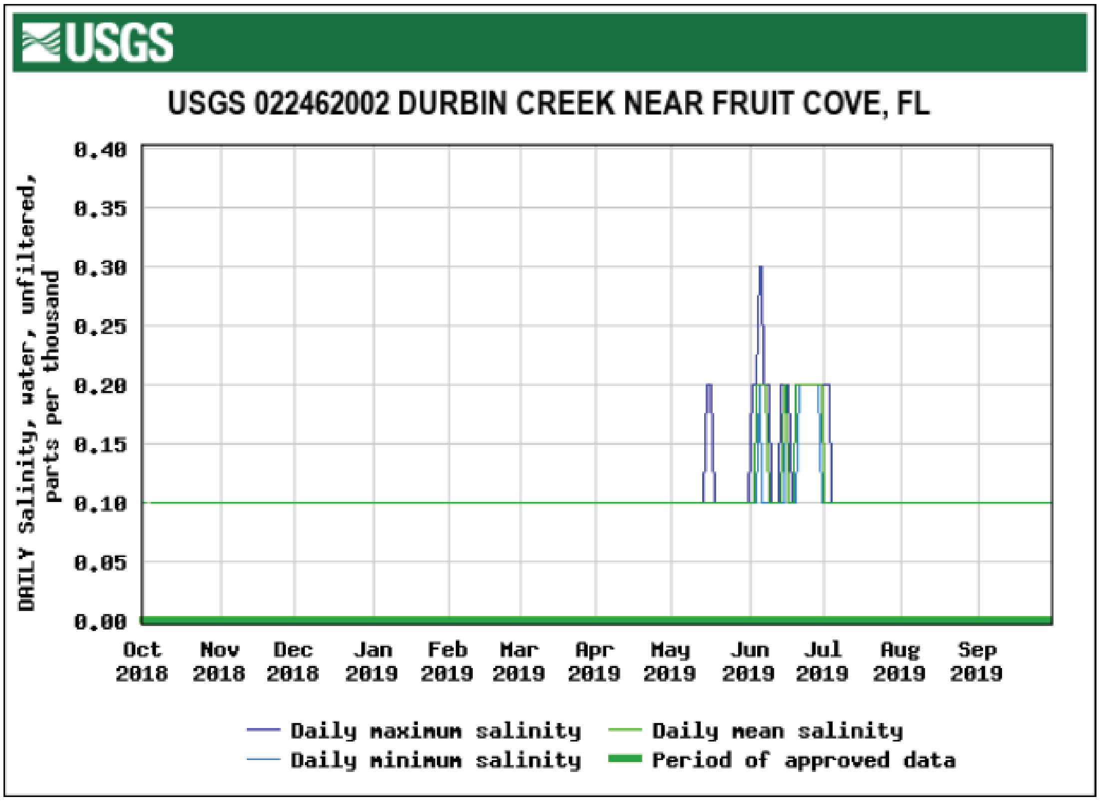

Figure 42. Daily maximum, minimum, and mean salinity for Durbin Creek near Fruit Cove, Florida.

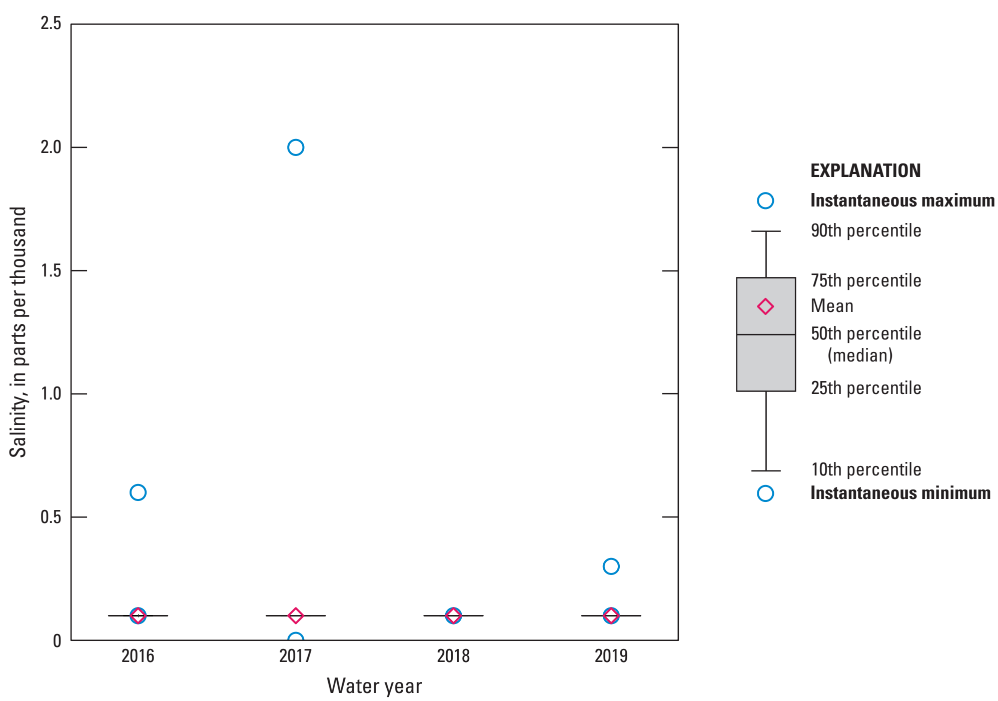

Figure 43. Salinity data for Durbin Creek near Fruit Cove, Florida.

Ortega River at Kirwin Road near Jacksonville, Florida—Daily discharge for Ortega River ranged from 3.77 to 297 ft^3/s during the 2019 water year, with an annual mean of 39.8 ft^3/s (fig. 44). Like other tributary sites, Ortega River had multiple large discharge peaks in December and January (four peaks above 200 ft^3/s) followed by smaller peaks and generally low flows until August. The peak streamflow for the period of record ranked in the 30th percentile (fig. 45). The peak streamflow record does not include 2016, which has incomplete record because the monitoring station was installed that year.

Ortega River Salinity at Jacksonville, Florida—Salinity at Ortega River ranged from 0.0 to 10 ppt during the 2019 water year, with a median of 0.1 ppt and mean of 0.5 ppt (fig. 46). Salinity was not calculated for an extended period in March and April because of equipment malfunction. Increases in maximum daily salinity values were calculated in May and June during periods of low discharge in Ortega River. The highest salinity value in the 2019 water year was calculated in early September at a time when most stations on the St. Johns River calculated negative streamflow when Hurricane Dorian moved north parallel to the Florida coast. The 2019 mean salinity ranked second among those calculated for the 4 years of the study, but the median salinity remained the same for all 4 years (fig. 47).

Cedar River at San Juan Avenue at Jacksonville, Florida—Daily tidally filtered discharge at Cedar River ranged from −39.4 to 310 ft^3/s during the 2019 water year, with an annual mean of 14.7 ft^3/s (fig. 48). Salinity ranged from 0.0 to 22 ppt, with a median of 1.5 ppt and mean of 2.2 ppt (fig. 49). Daily value tidally filtered discharge was not calculated for 9 days in November, 7 days in December, and 4 days in September because of equipment malfunction. The second-highest yearly salinity peak of the 4-year period of record occurred in early September during a week of negative tidally filtered discharge caused by effects from Hurricane Dorian. The 2019 mean salinity matched the mean salinity calculated in 2016, and the median salinity ranked first among those calculated for the 4 years of the study (fig. 50).

Pottsburg Creek near South Jacksonville, Florida—Daily discharge for Pottsburg Creek at Bowden Road ranged from 2.42 to 243 ft^3/s during the 2019 water year with an annual mean flow of 19.6 ft^3/s (fig. 51). Daily mean discharge peaked above 200 ft^3/s only twice, and both peaks occurred in December. Discharge was estimated for 17 days in May and June because of equipment malfunction.

Pottsburg Creek at U.S. 90 near South Jacksonville, Florida—Daily tidally filtered discharge at Pottsburg Creek at U.S. 90 ranged from −13.8 to 240 ft^3/s during the 2019 water year with an annual mean flow of 24.5 ft^3/s (fig. 52). Daily value tidally filtered discharge was not calculated for short periods in December and February, and for 15 days in May and June because of equipment malfunction. Salinity ranged from 0.0 to 7.7 ppt, with a median of 0.4 ppt and mean of 0.9 ppt (fig. 53). Peak salinity exceeded 5 ppt during parts of March through July during periods of below-average rainfall in Duval County (fig. 3). The 2019 mean salinity ranked third among those computed for the 4 years of the study, but the 2019 median ranked second and matched the median in 2017 (fig. 54).

Trout River near Jacksonville, Florida—Daily tidally filtered discharge at Trout River ranged from −246 to 685 ft^3/s during the 2019 water year, with an annual mean flow of 54.0 ft^3/s (fig. 55). Tidally filtered discharge exceeded 600 ft^3/s five times during the period.

Trout River Below U.S. 1 at Dinsmore, Florida—Salinity at Trout River below U.S. 1 ranged from 0.0 to 13 ppt during the 2019 water year, with a median of 1.2 ppt and mean of 2.7 ppt (fig. 56). Daily maximum salinity values peaked above 8 ppt once in November and during portions of May through July. The second-highest maximum yearly salinity of the 4-year period of record occurred in early June. The 2019 mean salinity ranked third, and the median salinity ranked second among those calculated for the 4 years of the study (fig. 57).

Broward River Below Biscayne Blvd. near Jacksonville, Florida—Daily tidally filtered discharge at Broward River ranged from −21.2 to 164 ft^3/s during the 2019 water year with an annual mean flow of 18.5 ft^3/s (fig. 58). Salinity ranged from 0.0 to 13 ppt, with a median of 0.7 ppt and mean of 1.6 ppt (fig. 59). Discharge was relatively consistent during the period, with only one peak of daily tidally filtered discharge exceeding 150 ft^3/s (fig. 58). Salinity increased above 8 ppt multiple times from May through September coinciding with below-average rainfall in Duval County (fig. 3). The 2019 mean salinity ranked third, and the median salinity ranked second among those calculated for the 4 years of the study (fig. 60).

Dunn Creek at Dunn Creek Road near Eastport, Florida—Daily tidally filtered discharge at Dunn Creek ranged from −11.1 to 84.8 ft^3/s during the 2019 water year with an annual mean flow of 10.4 ft^3/s (fig. 61). Discharge was relatively consistent during the period, with only 2 days of daily tidally filtered discharge exceeding 60 ft^3/s. Salinity ranged from 0.1 to 16 ppt, with a median of 3.0 ppt and mean of 3.6 ppt over this period (fig. 62). Salinity increased above 15 ppt in July and September during a period of below-average rainfall in Duval County (fig. 3). The 2019 mean and median salinity were the highest among those calculated for the 4 years of the study (fig. 63). Daily value tidally filtered discharge data were not calculated for 4 days in June, and salinity data were not calculated for 13 days in August because of equipment malfunction.

Clapboard Creek near Jacksonville, Florida—Daily tidally filtered discharge at Clapboard Creek ranged from −146 to 206 ft^3/s during the 2019 water year, with an annual mean flow of 14.5 ft^3/s (fig. 64). Tidally filtered discharge remained below 200 ft^3/s for the entire period except during one peak in September. The annual mean flow of 14.5 ft^3/s ranked third for the 4-year period of record considered for this study.

Clapboard Creek Above Buckhorn Bluff near Jacksonville, Florida—Salinity at Clapboard Creek ranged from 7.0 to 31 ppt during the 2019 water year with a median and mean of 21 ppt (fig. 65). The lowest salinity occurred in late January, during the only 3-month period of above-average rainfall in Duval County (fig. 3). The 2019 mean and median salinity both matched the 2017 values and ranked in the middle of those calculated for the 4 years of the study (fig. 66).

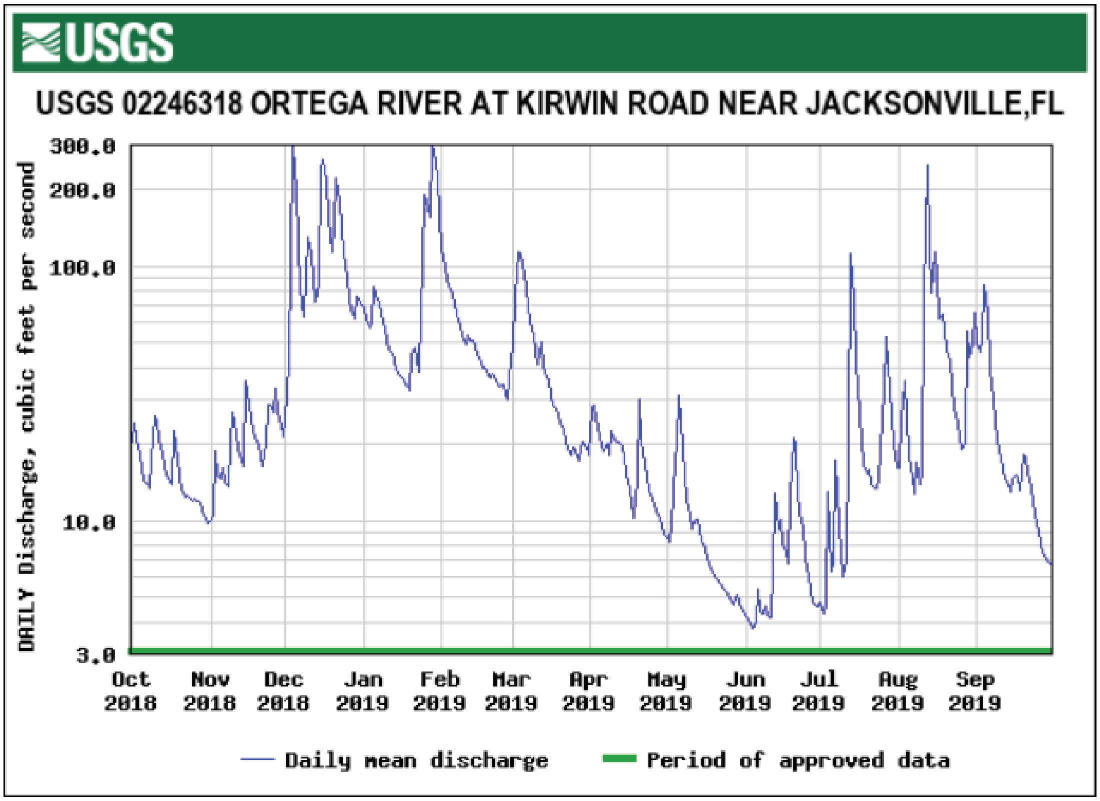

Figure 44. Daily mean discharge for Ortega River at Kirwin Road near Jacksonville, Florida.

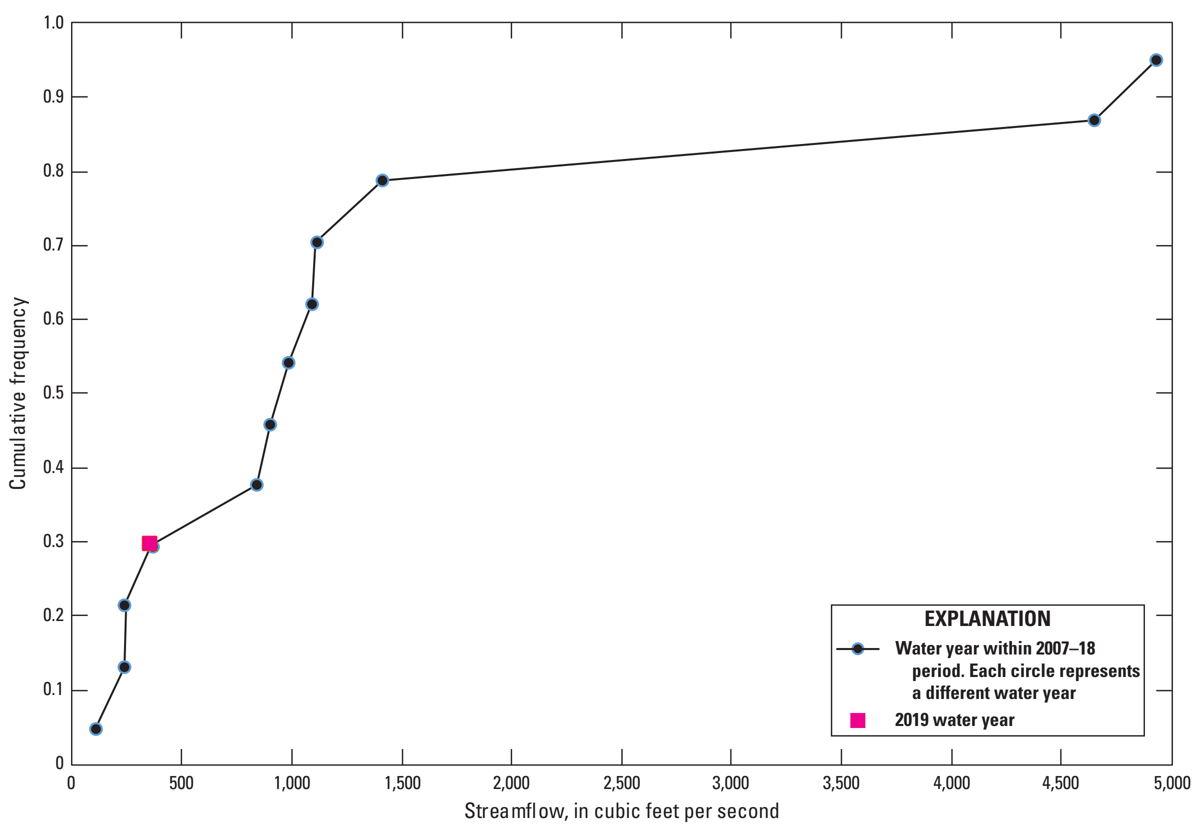

Figure 45. Peak streamflow at Ortega River at Kirwin Road near Jacksonville, Florida.

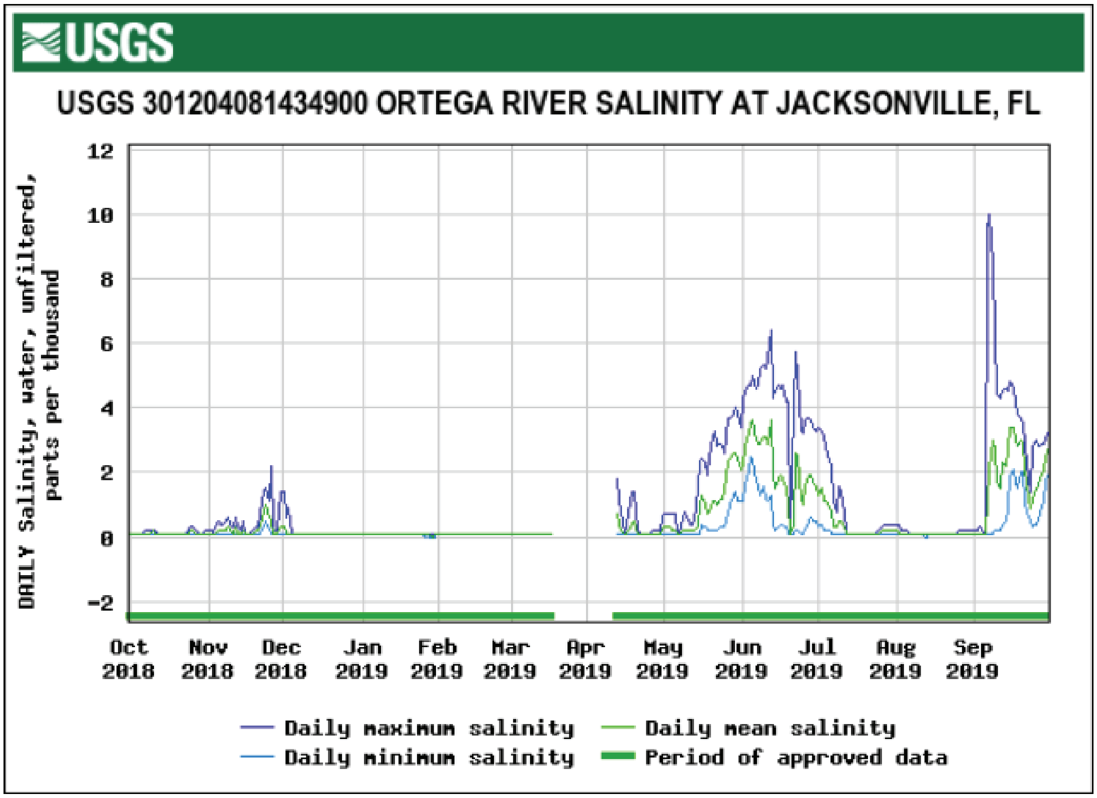

Figure 46. Daily maximum, minimum, and mean salinity for Ortega River Salinity at Jacksonville, Florida.

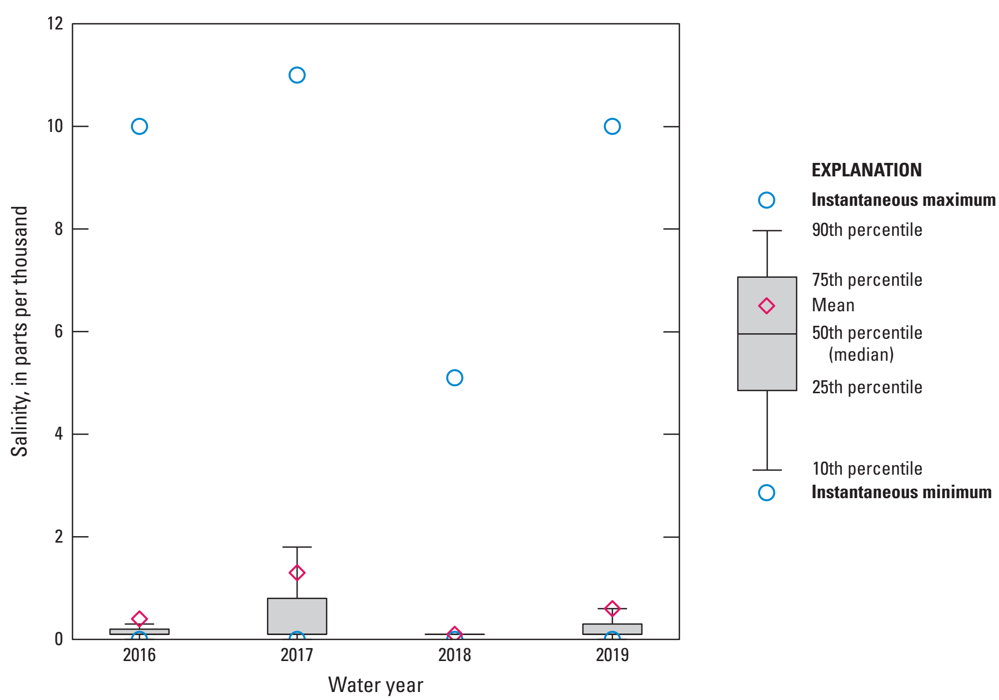

Figure 47. Salinity data for Ortega River at Kirwin Road near Jacksonville, Florida.

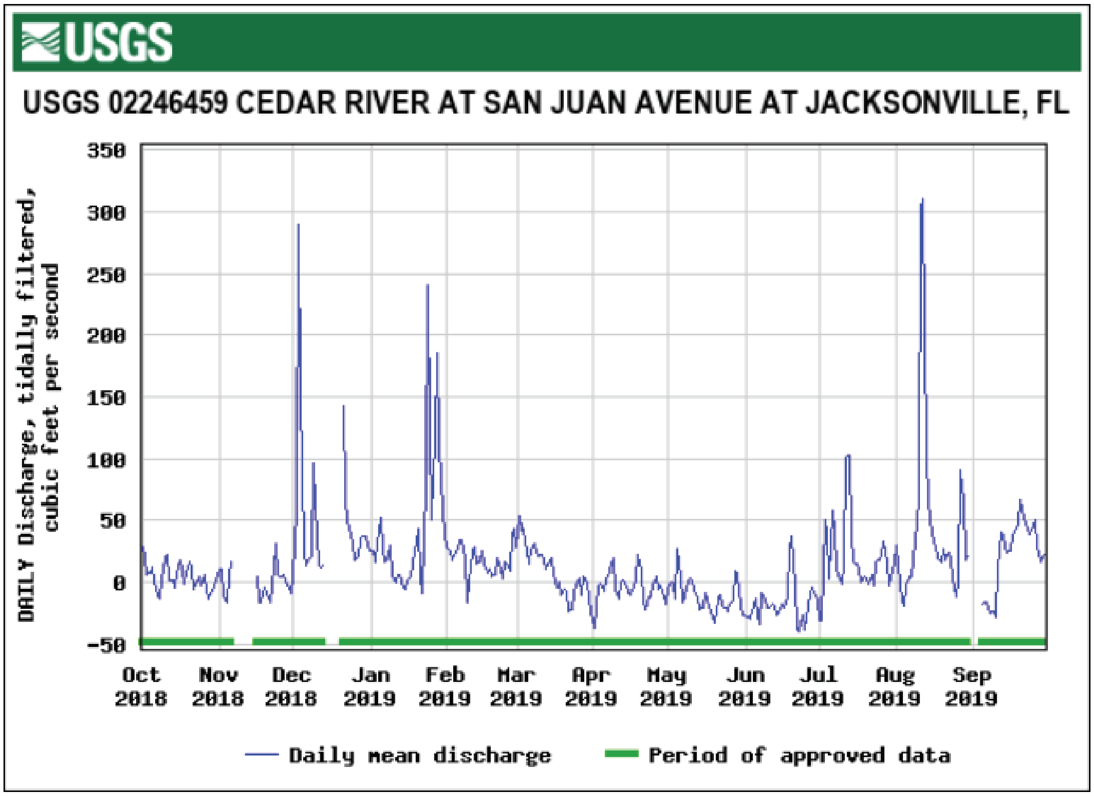

Figure 48. Daily mean tidally filtered discharge for Cedar River at San Juan Avenue at Jacksonville, Florida.

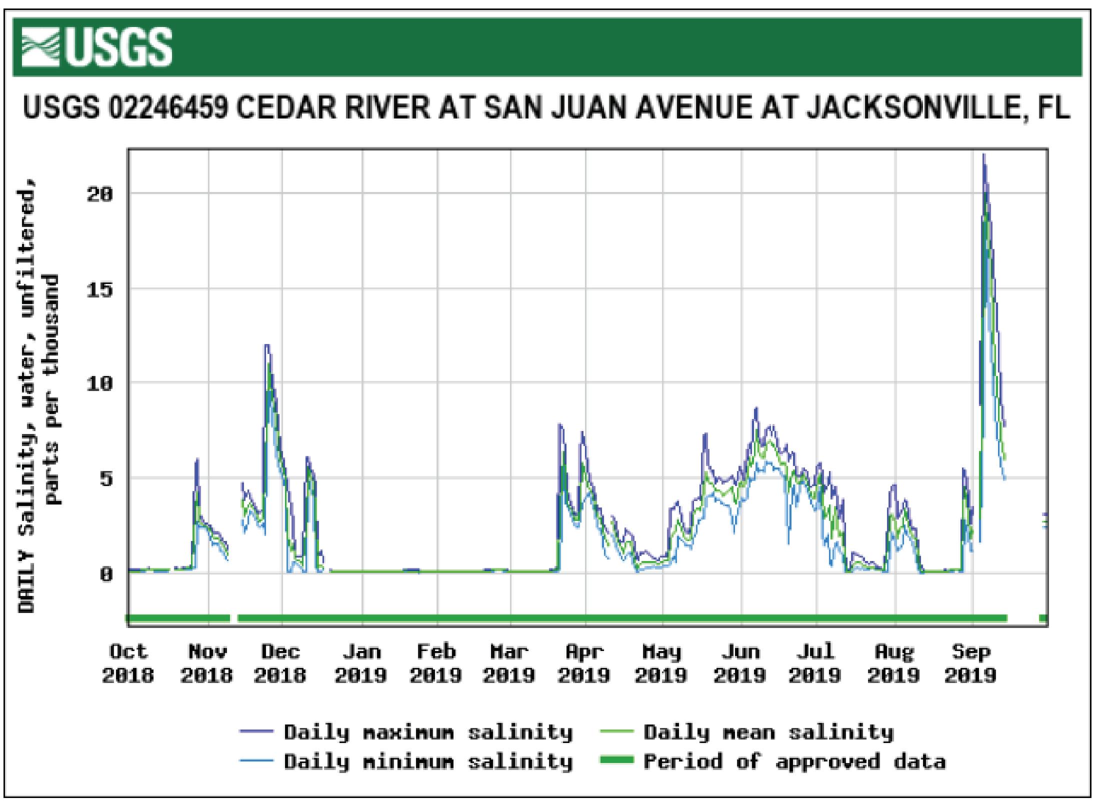

Figure 49. Daily maximum, minimum, and mean salinity for Cedar River at San Juan Avenue at Jacksonville, Florida.

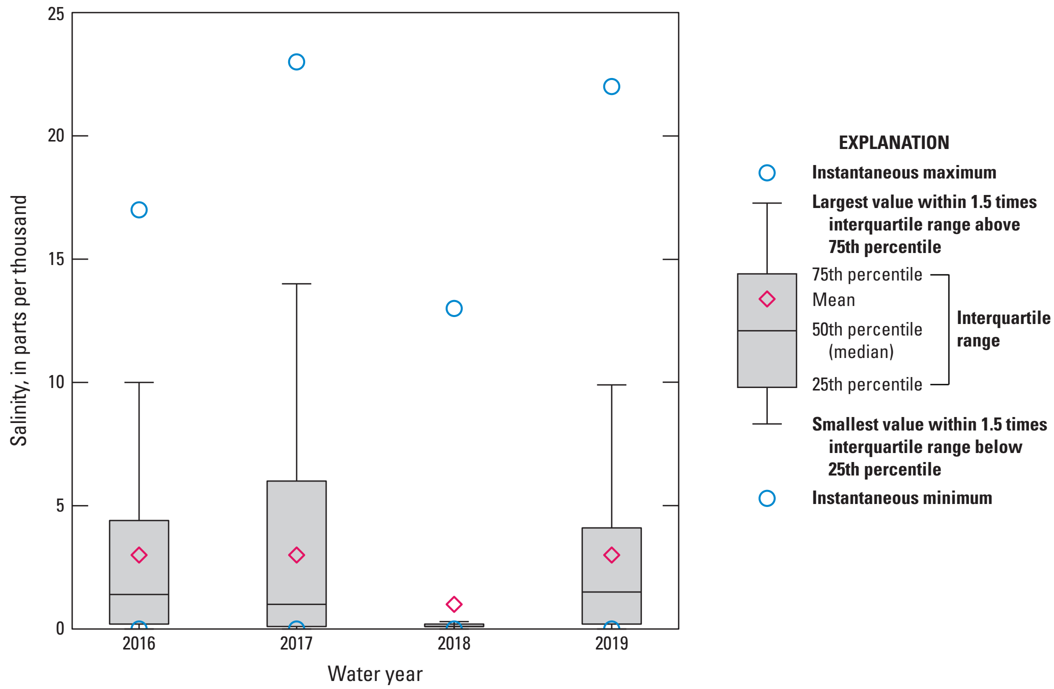

Figure 50. Salinity data for Cedar River at San Juan Avenue at Jacksonville, Florida.

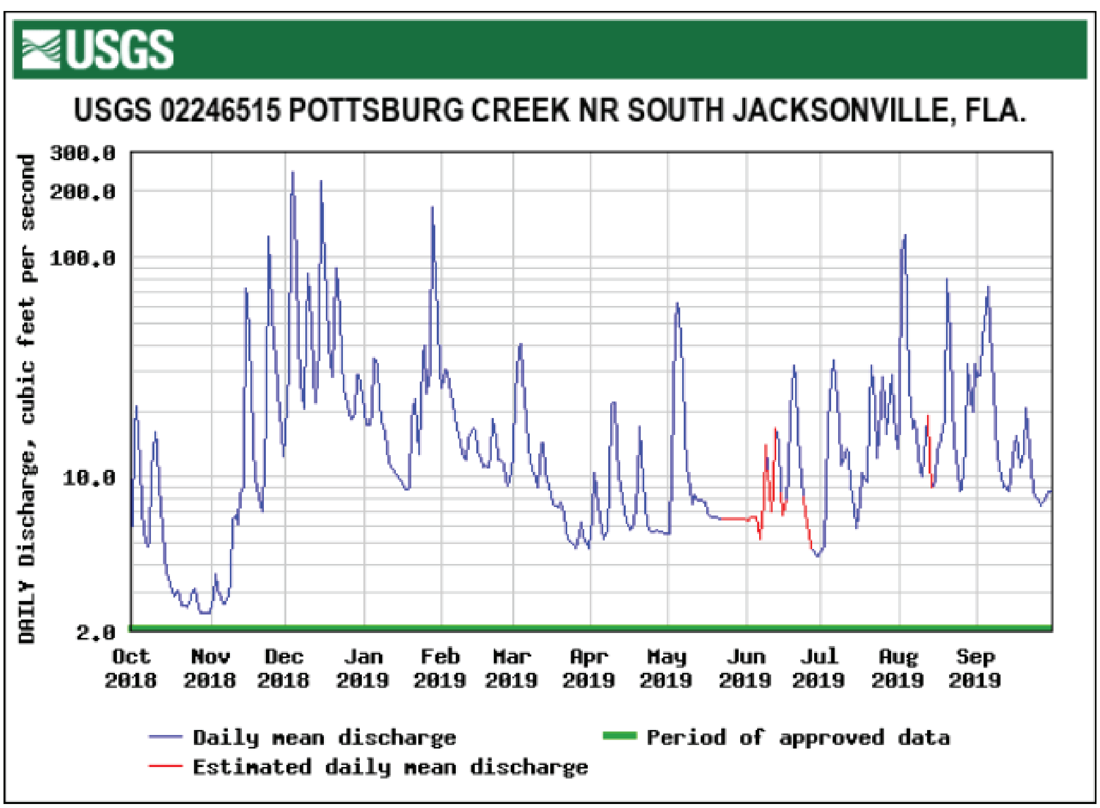

Figure 51. Daily mean discharge for Pottsburg Creek near South Jacksonville, Florida.

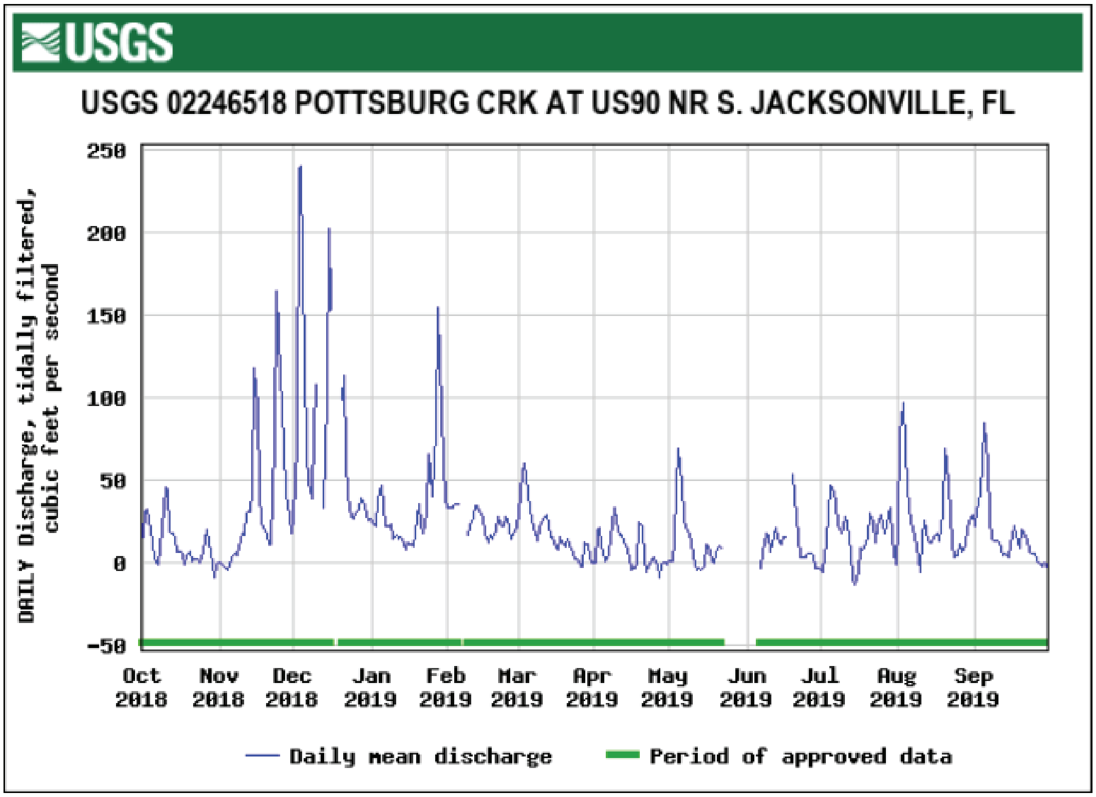

Figure 52. Daily mean tidally filtered discharge for Pottsburg Creek at U.S. 90 near South Jacksonville, Florida.

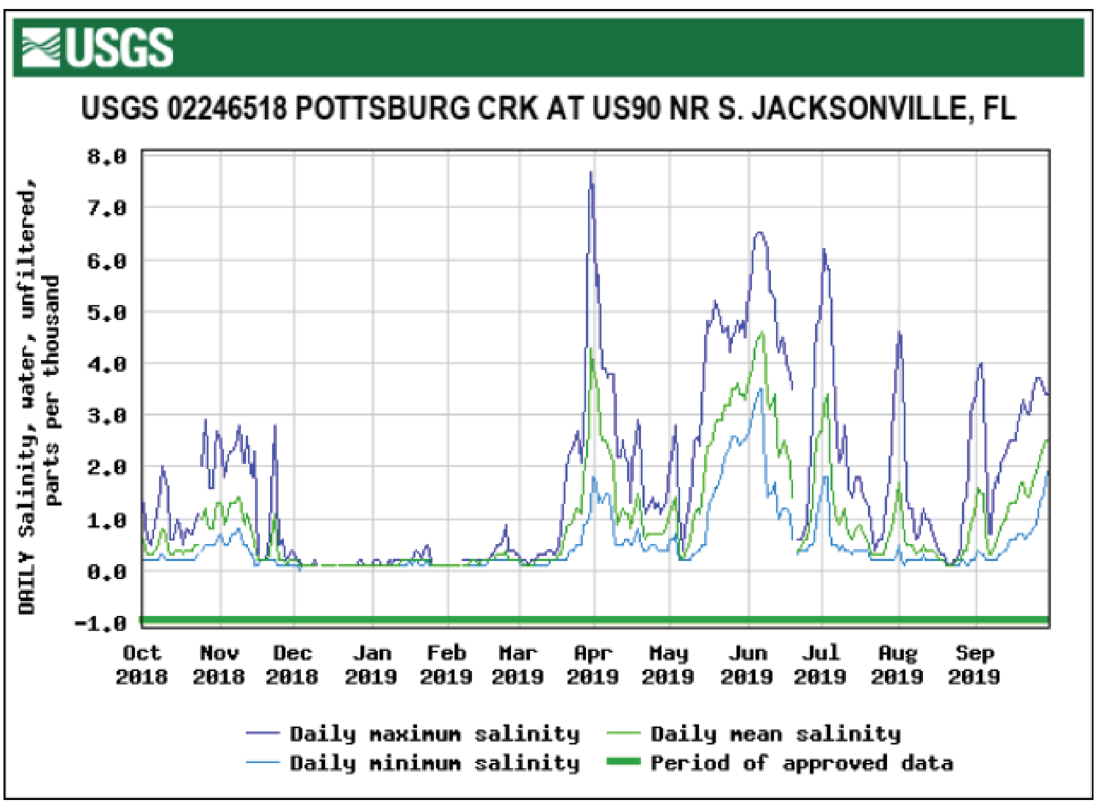

Figure 53. Daily maximum, minimum, and mean salinity for Pottsburg Creek at U.S. 90 near South Jacksonville, Florida.

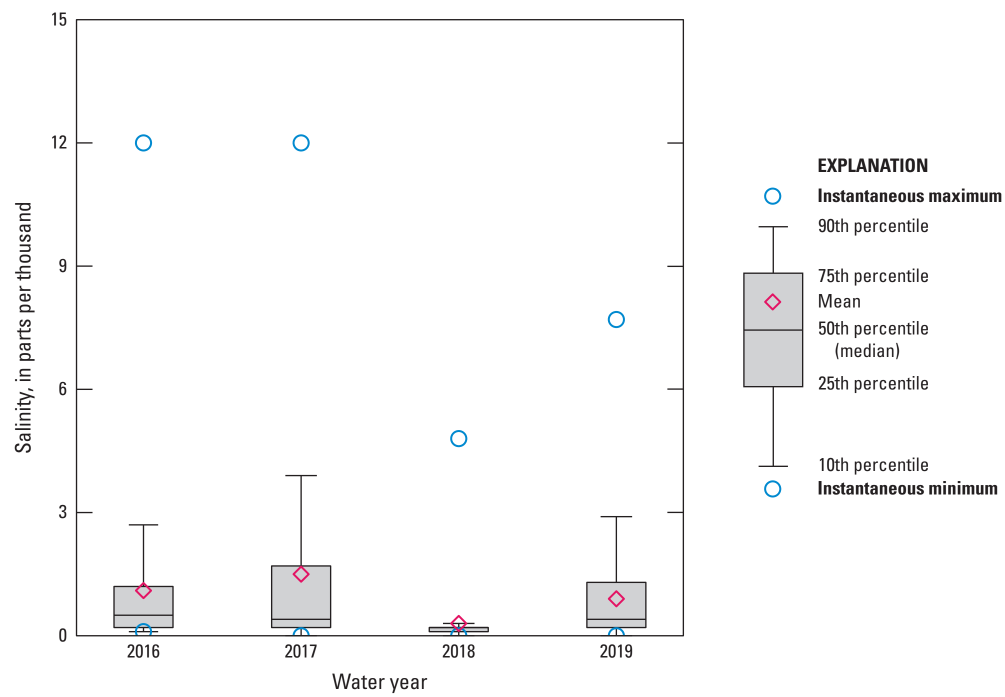

Figure 54. Salinity data for Pottsburg Creek at U.S. 90 near South Jacksonville, Florida.

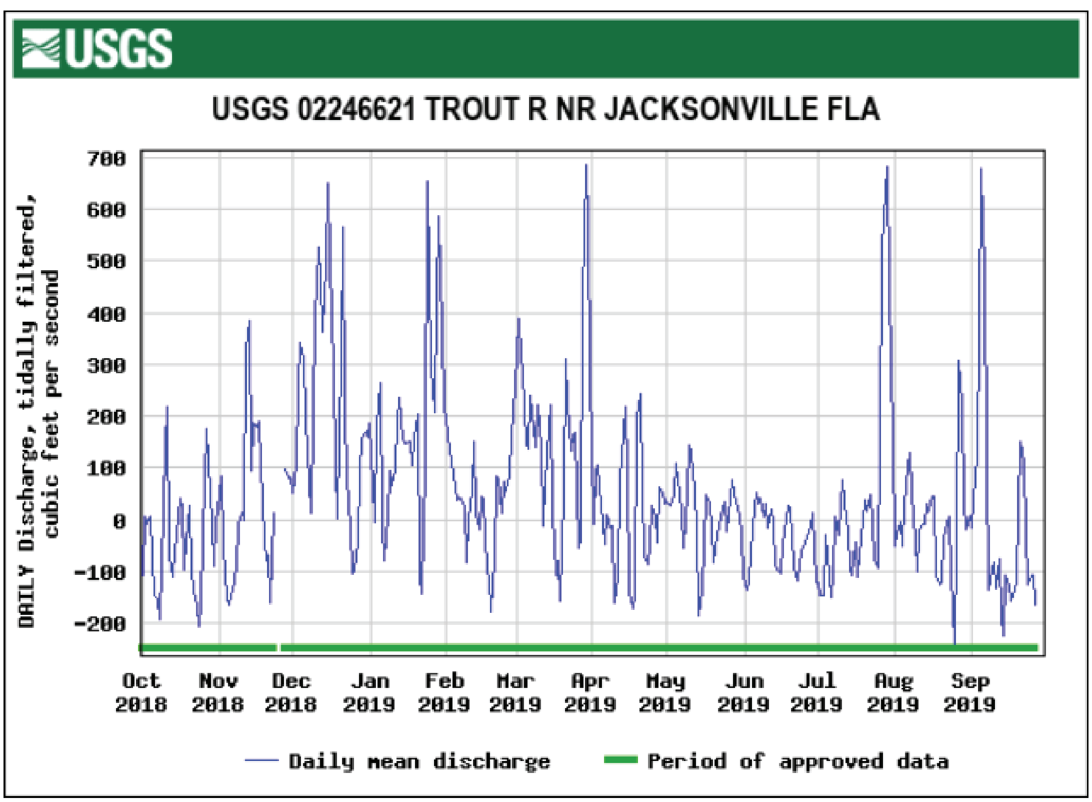

Figure 55. Daily mean tidally filtered discharge for Trout River near Jacksonville, Florida.

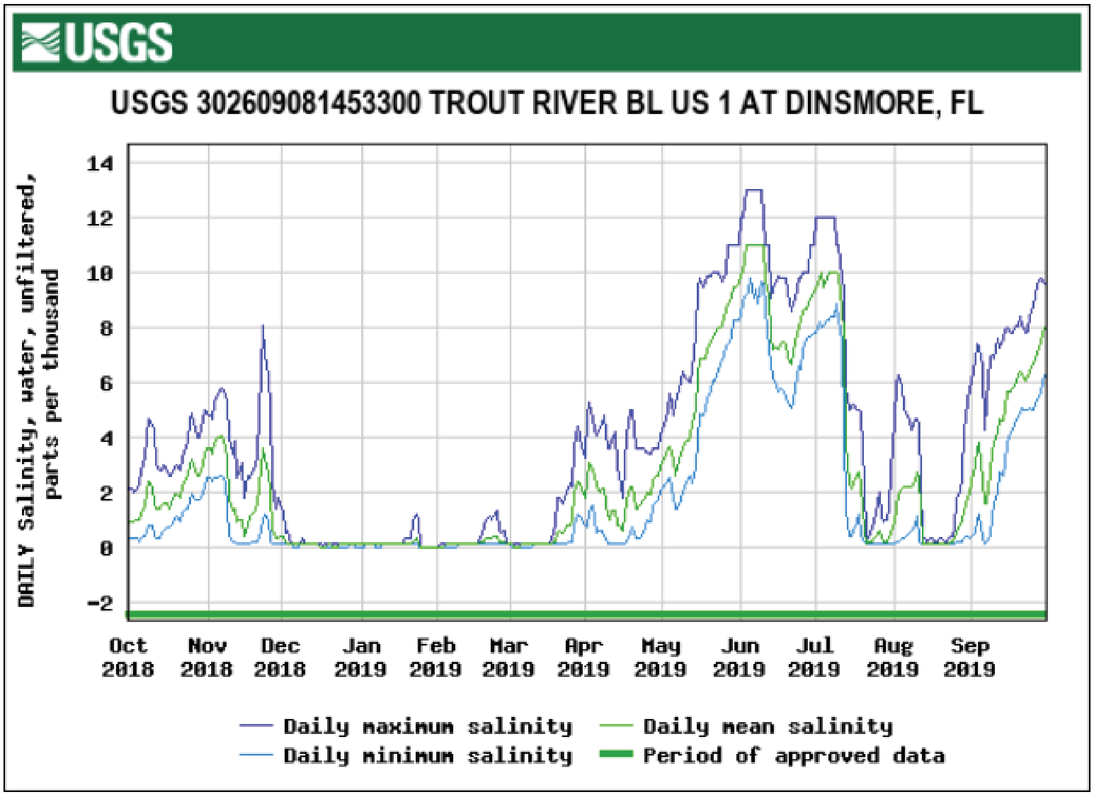

Figure 56. Maximum, minimum, and mean daily salinity for Trout River below U.S. 1 at Dinsmore, Florida.

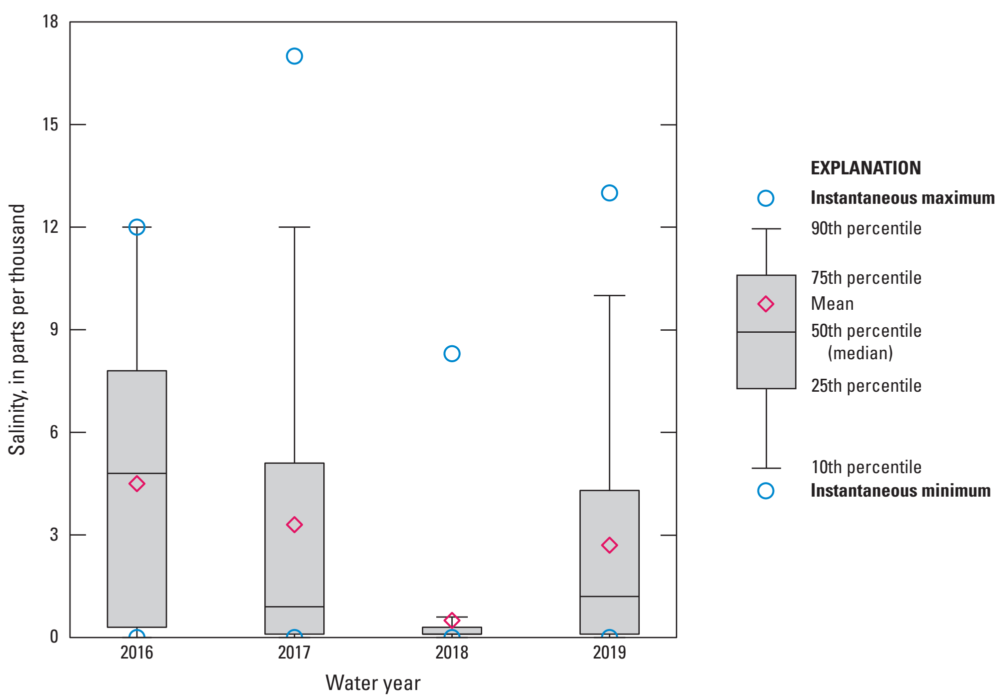

Figure 57. Salinity data for Trout River below U.S. 1 at Dinsmore, Florida.

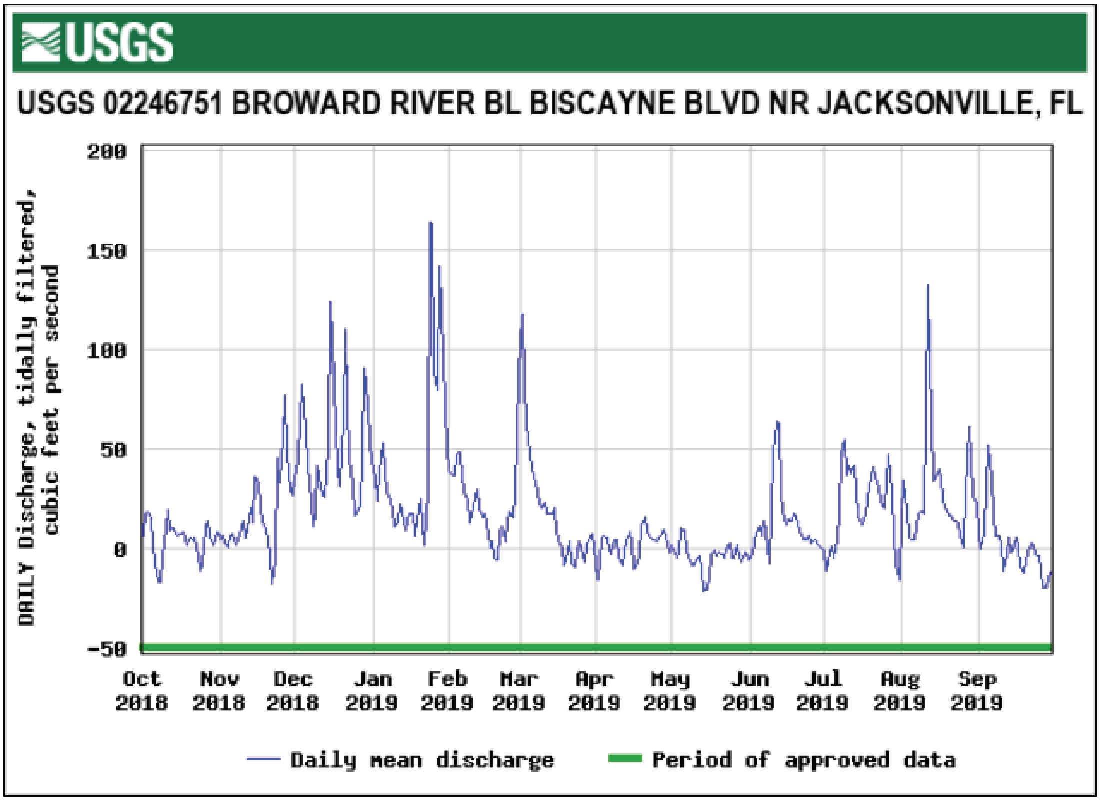

Figure 58. Daily mean tidally filtered discharge for Broward River below Biscayne Boulevard near Jacksonville, Florida.

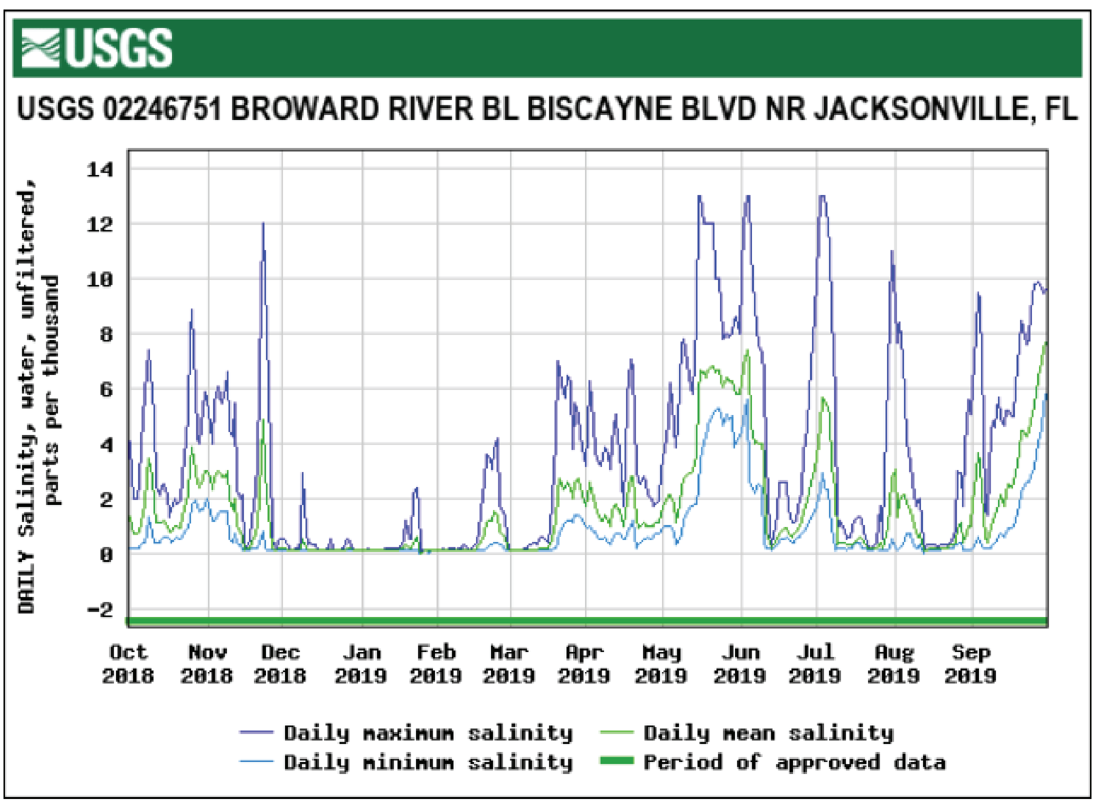

Figure 59. Daily maximum, minimum, and mean salinity for Broward River below Biscayne Boulevard near Jacksonville, Florida.

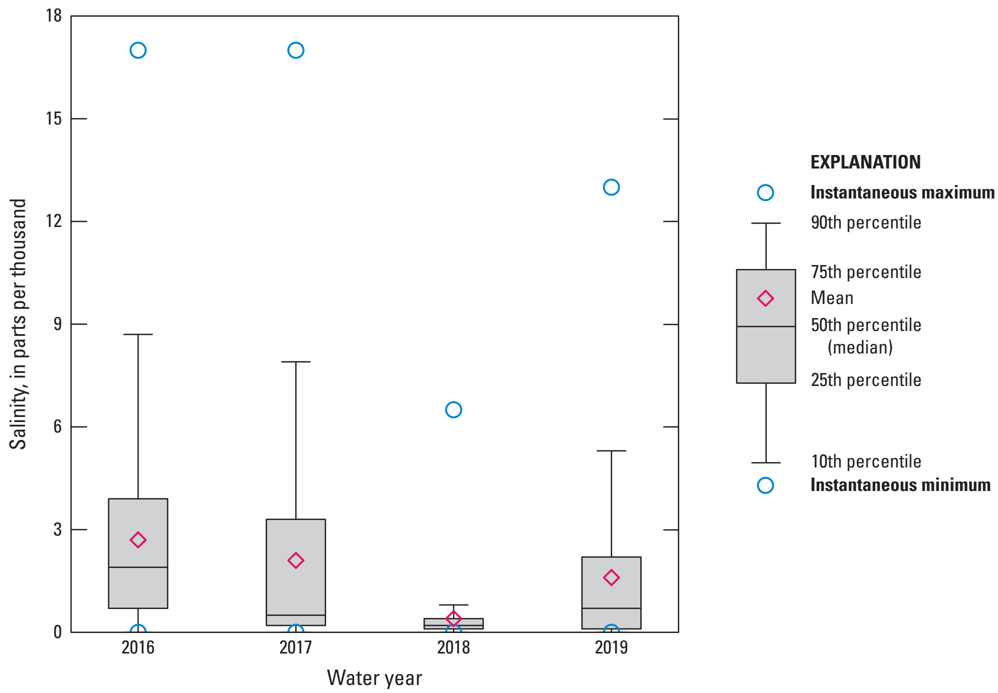

Figure 60. Salinity data for Broward River below Biscayne Boulevard near Jacksonville, Florida.

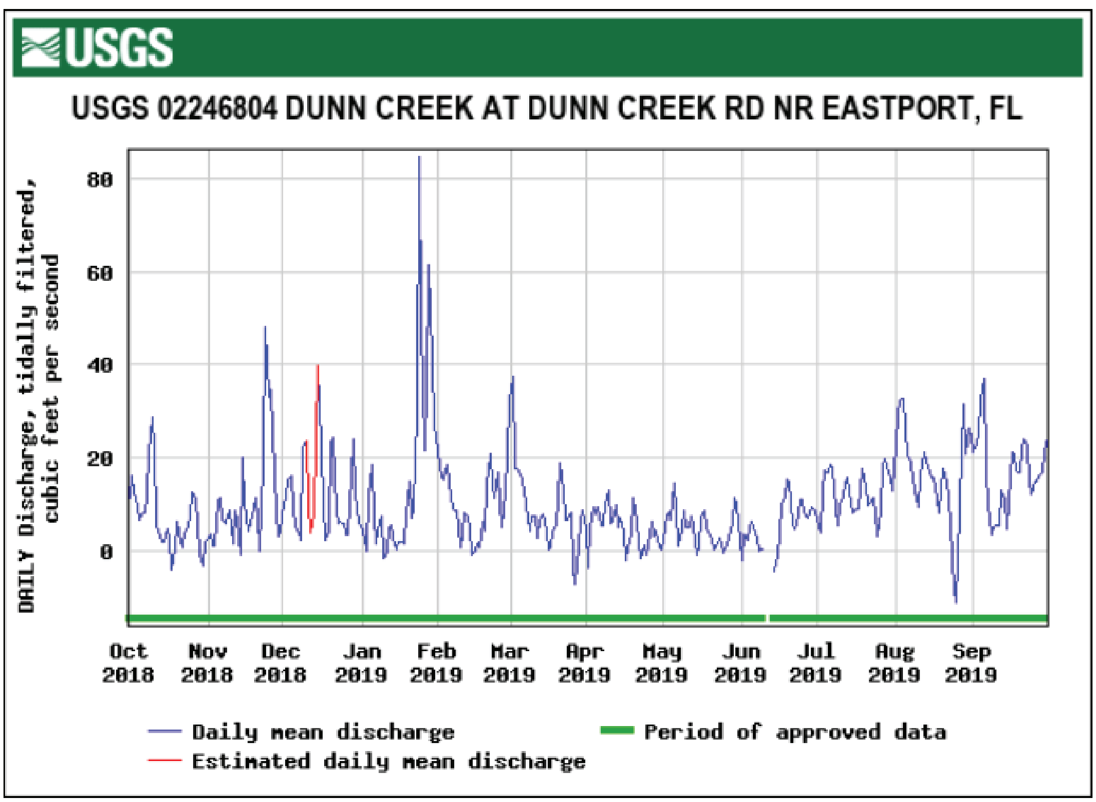

Figure 61. Daily mean tidally filtered discharge for Dunn Creek at Dunn Creek Road near Eastport, Florida.

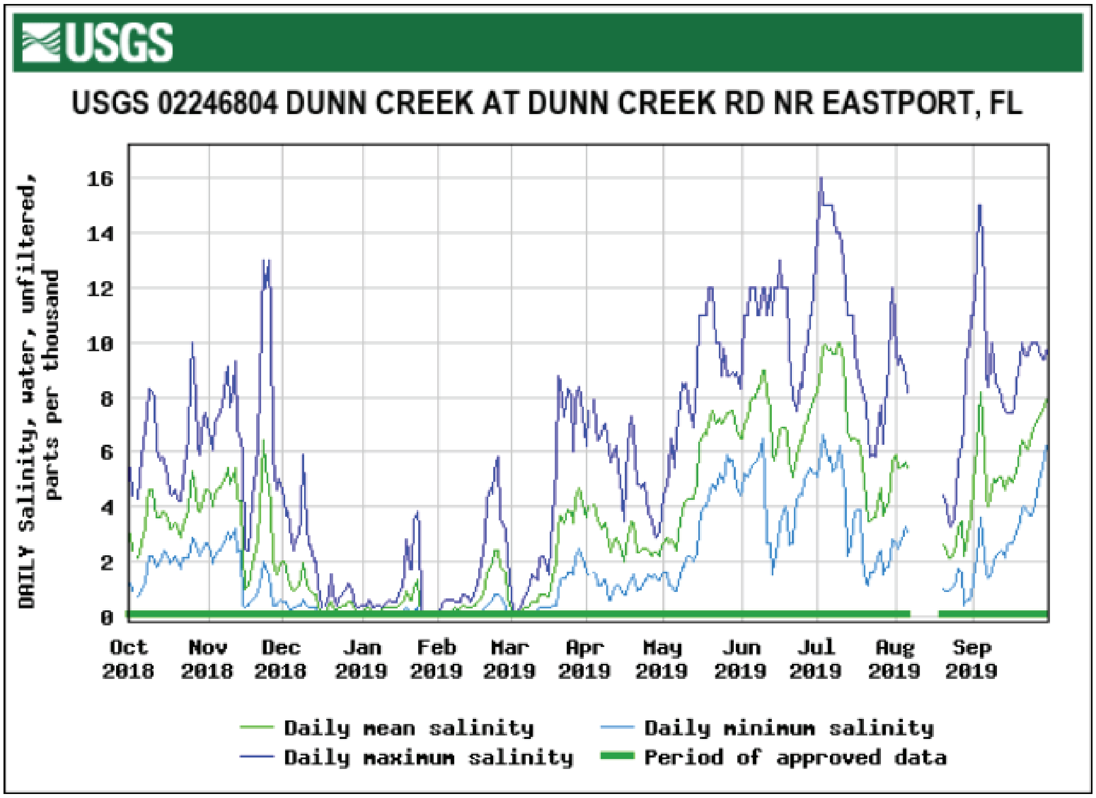

Figure 62. Daily maximum, minimum, and mean salinity for Dunn Creek at Dunn Creek Road near Eastport, Florida.

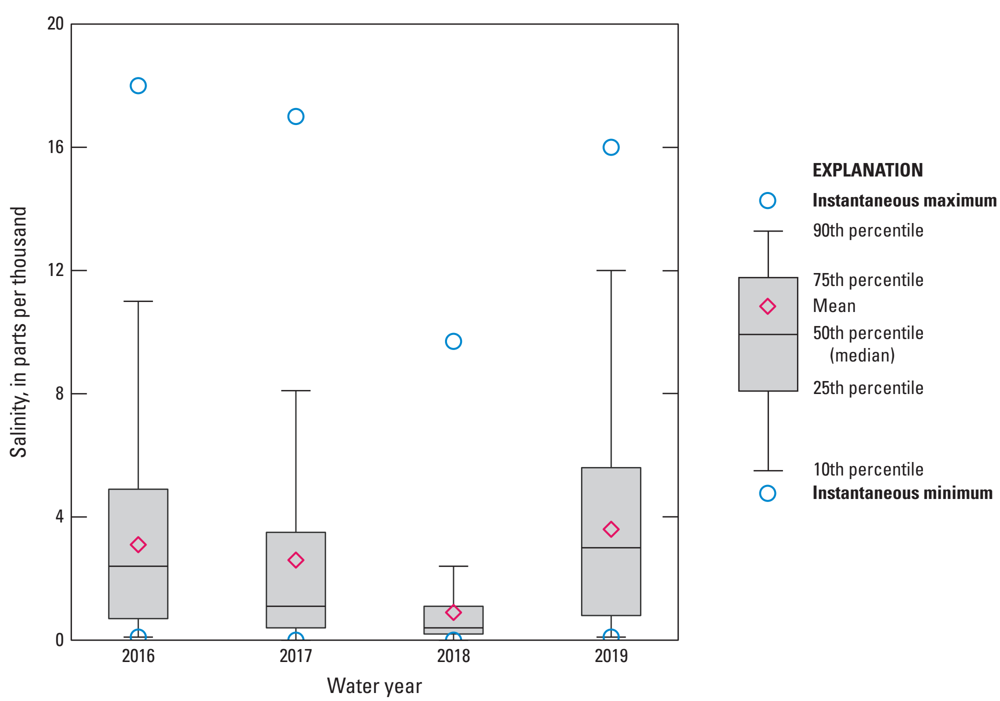

Figure 63. Salinity data for Dunn Creek at Dunn Creek Road near Eastport, Florida.

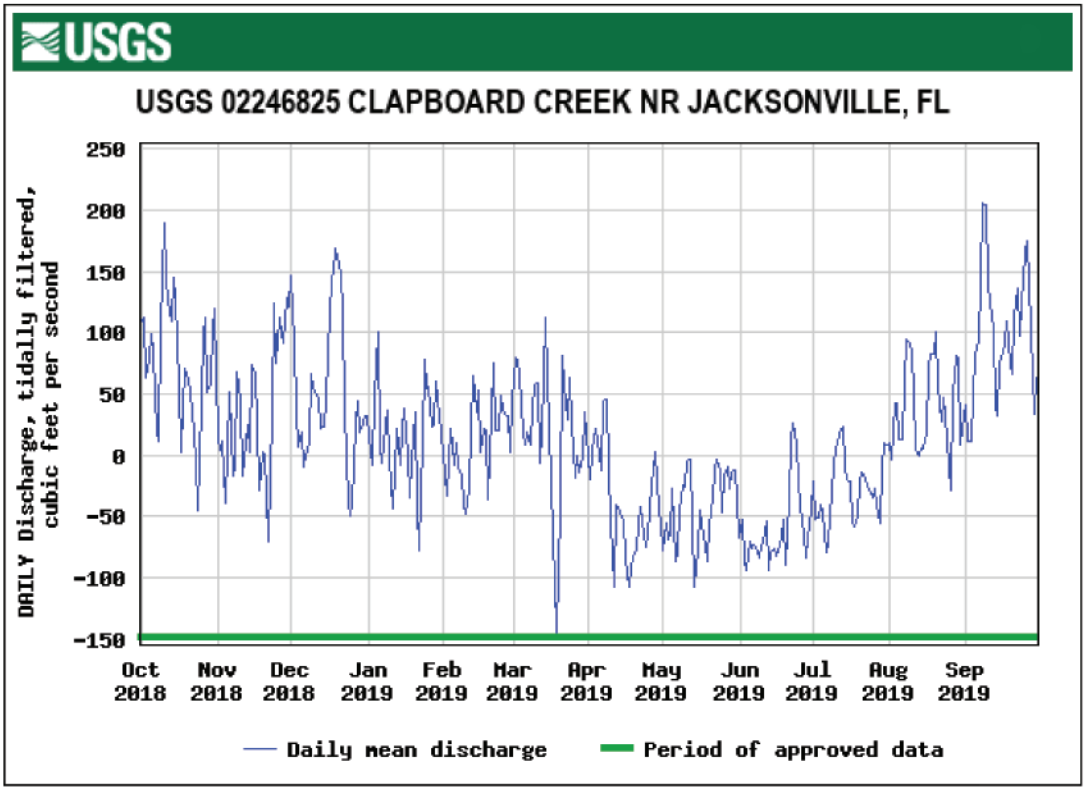

Figure 64. Daily mean tidally filtered discharge for Clapboard Creek near Jacksonville, Florida.

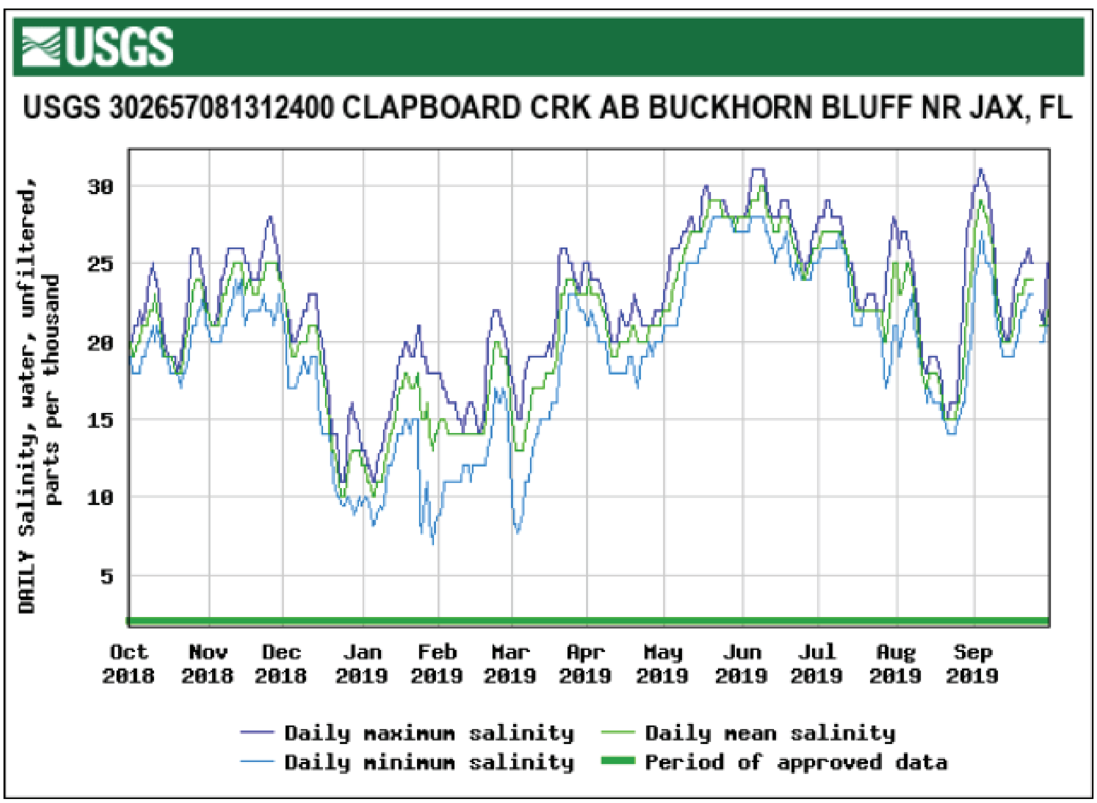

Figure 65. Daily maximum, minimum, and mean salinity for Clapboard Creek above Buckhorn Bluff near Jacksonville, Florida.

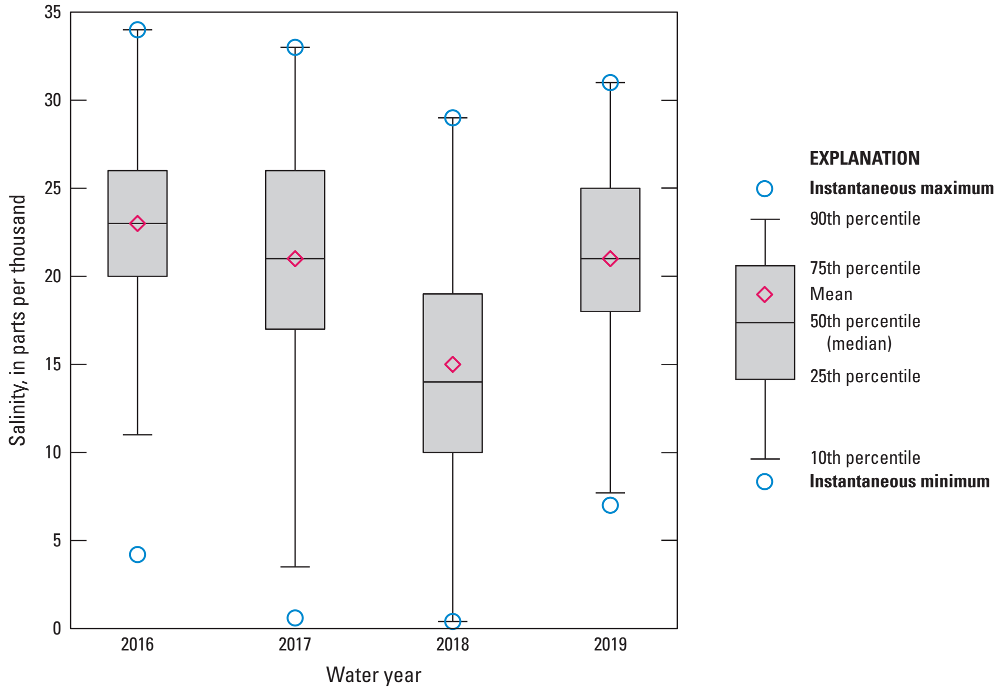

Figure 66. Salinity data for Clapboard Creek above Buckhorn Bluff near Jacksonville, Florida.

Hurricane Dorian

Hurricane Dorian never made landfall in Florida but influenced hydrologic conditions in the study area in early September. Although rainfall in the study area was below average (fig. 3), winds from the storm affected both the main stem and tributaries. Strong northeast winds pushed water from the Atlantic Ocean into the St. Johns River as the storm moved north off the coast on September 4 (National Weather Service National Hurricane Center and Central Pacific Hurricane Center, 2019). Sustained wind speeds above 20 miles per hour from the northeast were recorded at NOAA weather station Jacksonville Naval Air Station (NOAA, 2020) on multiple days prior to the storm's arrival. Peak negative tidally filtered discharges were computed at the St. Johns River at Jacksonville site (fig. 67) and as far upstream as the St. Johns River at Buffalo Bluff site on September 4 (fig. 68). Salinity values also increased at all main-stem sites as the storm approached, but the effects were observed a few days later at some tributary sites such as the peak at the Ortega River at Jacksonville site on September 7 (fig. 69). After the hurricane bypassed the study area, a sharp rise in discharge and a decrease in salinity occurred as the strong east winds subsided, as observed at the St. Johns River at Jacksonville site (figs. 67 and 70).

Discharge and Salinity Site Comparison

Analysis of the annual mean tidally filtered discharge for the 2019 water year along the main stem of the St. Johns River indicates that streamflow increased with distance downstream except at the St. Johns River at Jacksonville site, which was lower than that of the upstream site, St. Johns River at Buffalo Bluff (fig. 71). This also occurred in 2016 and can be attributed to below-average rainfall, tidal effects, and influence from Hurricane Dorian. Relative to the 2018 water year, annual mean discharge for the 2019 water year was lower for each of the main-stem sites. The St. Johns River at Astor site recorded its lowest annual mean discharge over the 4 years considered for this study, while the Buffalo Bluff site ranked second and the Jacksonville site ranked third. Of the tributaries, annual mean tidally filtered discharge was highest at Durbin Creek, followed by Trout River, Ortega River, Julington Creek, Pottsburg Creek, Broward River, Cedar River, Clapboard Creek, and Dunn Creek, whose annual mean was lowest (fig. 72). Annual mean discharge at all tributary monitoring sites was lower for the 2019 water year than for the 2018 water year (fig. 72). Relative to the 2018 water year, countywide annual rainfall for the 2019 water year was lower in all five counties and ranked third among the annual rainfall totals for the past 4 years (fig. 73).

Annual mean salinity for the main-stem sites generally decreased with distance upstream, which was expected (fig. 74). Of all sites in 2019, Dames Point had the highest annual mean salinities, which were 22 ppt near the surface and 23 ppt near the bottom of the water column. The annual mean salinities for the St. Johns River at Dancy Point, Racy Point, and Shands Bridge were equal (0.4 ppt), and the station below Shands Bridge was slightly lower (0.3 ppt) in 2019. The monitoring location below Shands Bridge is near the riverbank and is more likely to be affected by runoff than are the sites near the main channel. The 2019 annual mean salinity was

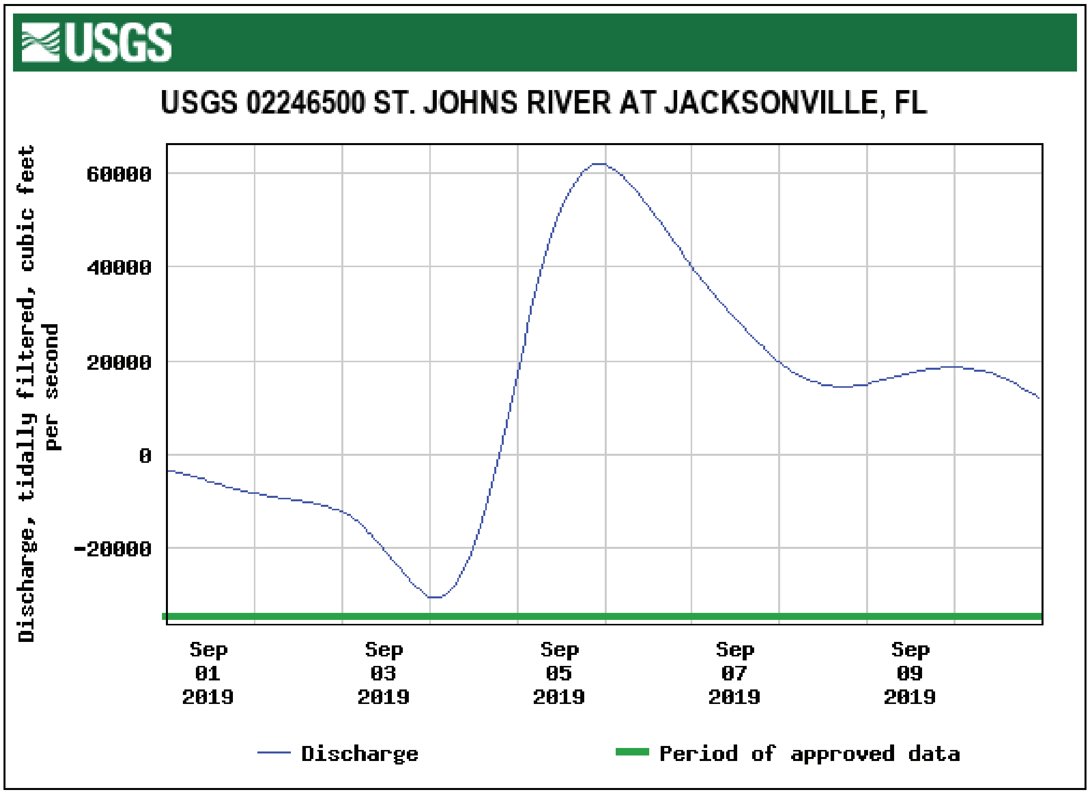

Figure 67. Instantaneous tidally filtered discharge during Hurricane Dorian at St. Johns River at Jacksonville, Florida.

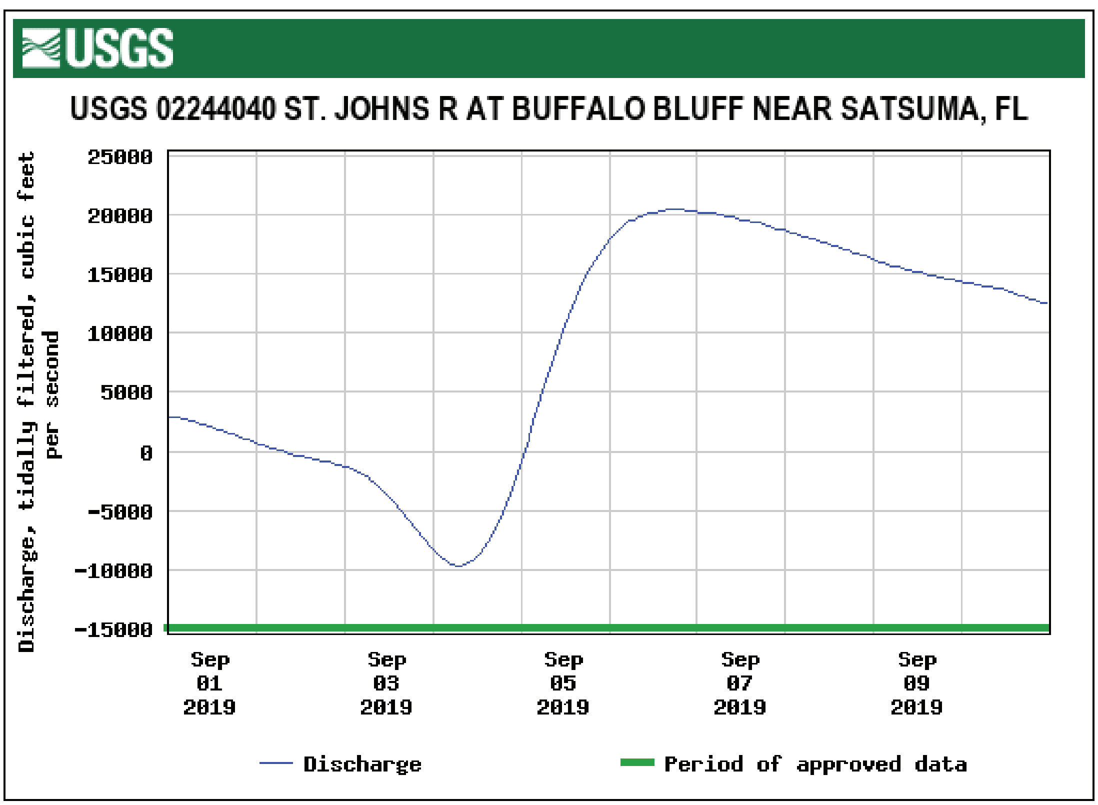

Figure 68. Instantaneous tidally filtered discharge during Hurricane Dorian at St. Johns River at Buffalo Bluff near Satsuma, Florida.

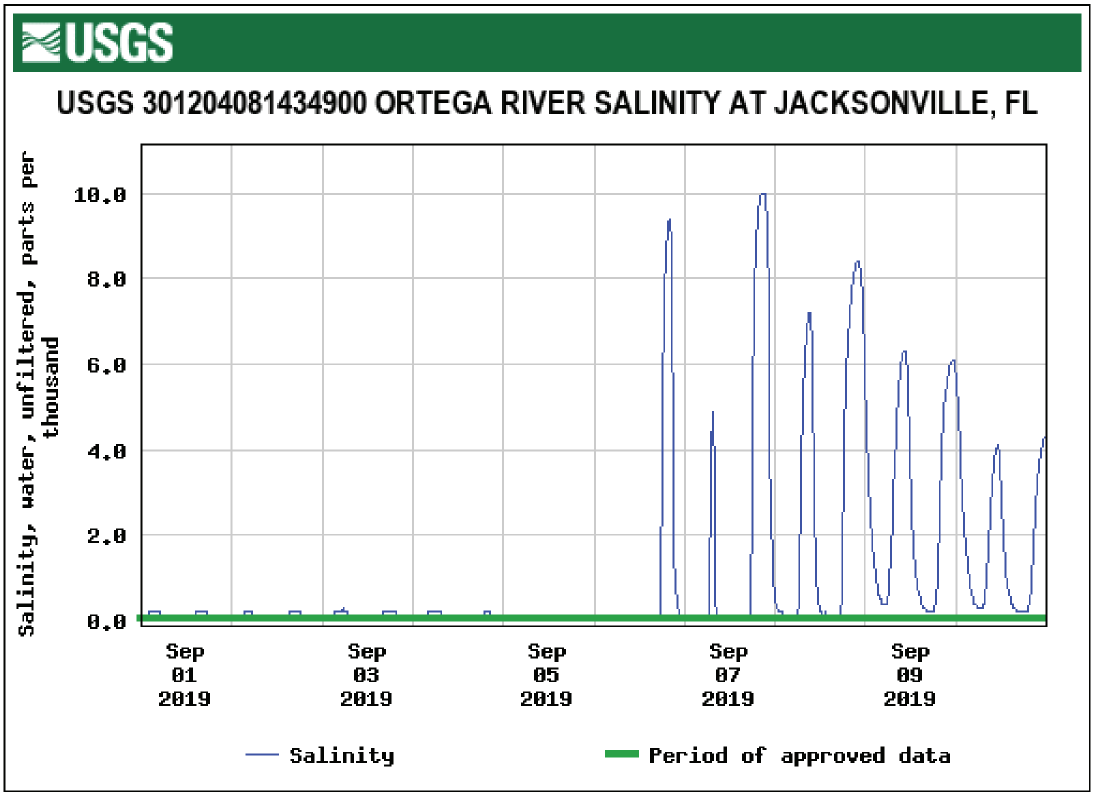

Figure 69. Instantaneous salinity during Hurricane Dorian at Ortega River at Jacksonville, Florida.

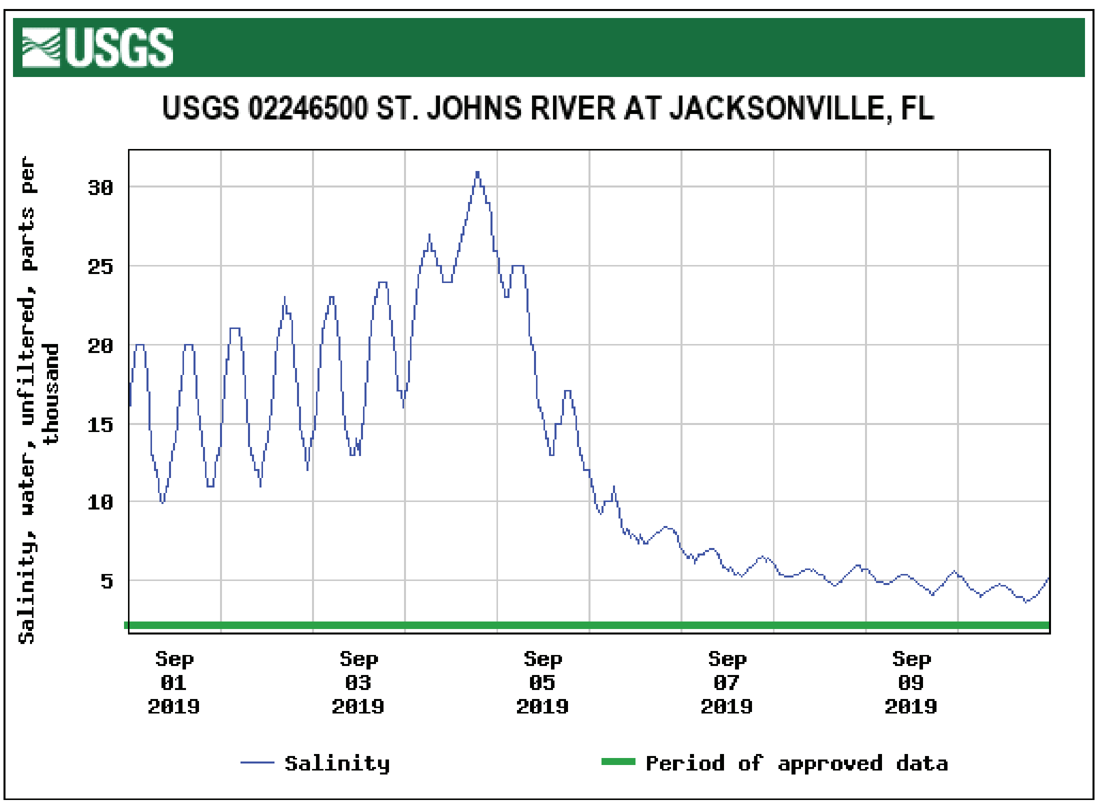

Figure 70. Instantaneous salinity during Hurricane Dorian at St. Johns River at Jacksonville, Florida.

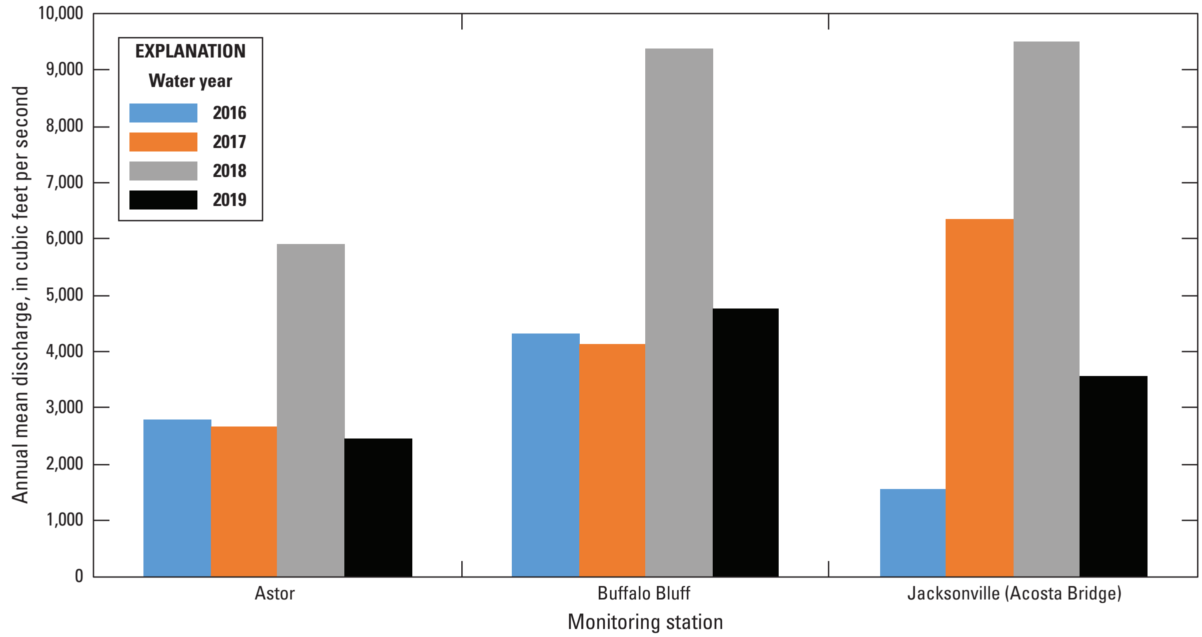

Figure 71. Annual mean tidally filtered discharge at St. Johns River main-stem monitoring sites.

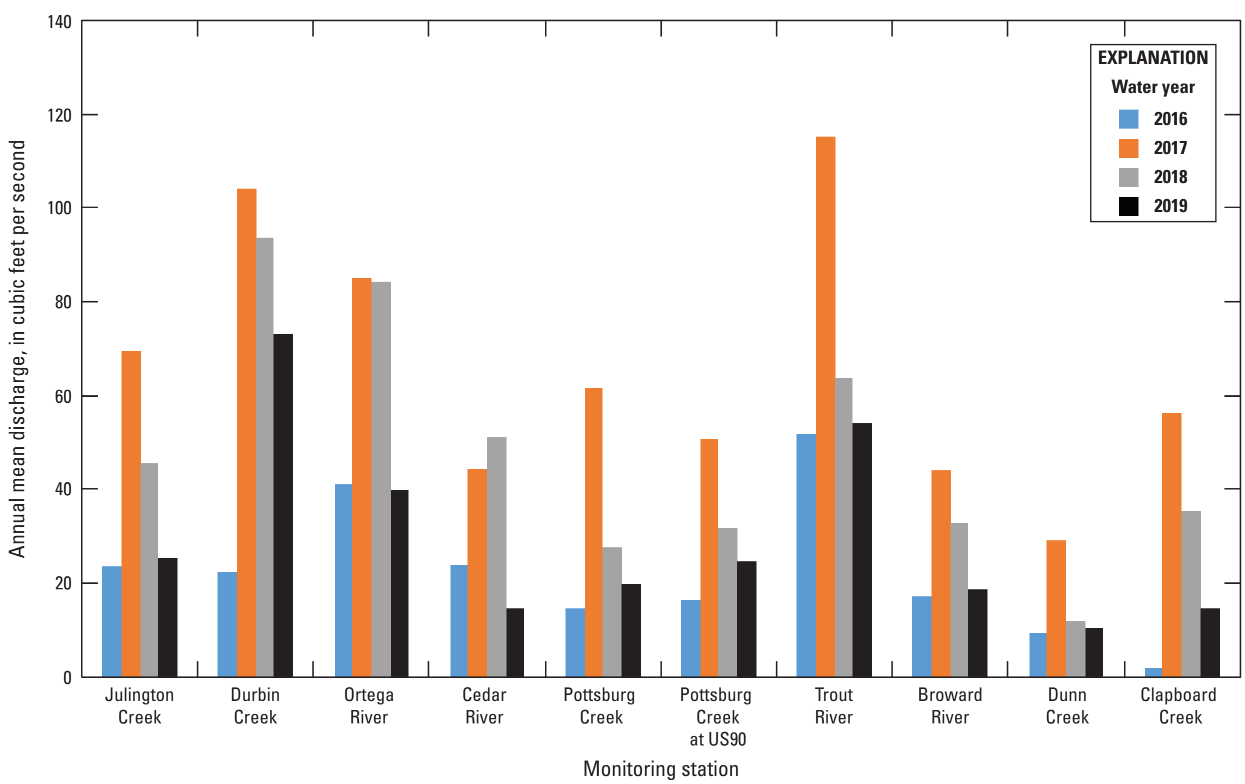

Figure 72. Annual mean discharge at St. Johns River tributary monitoring sites.

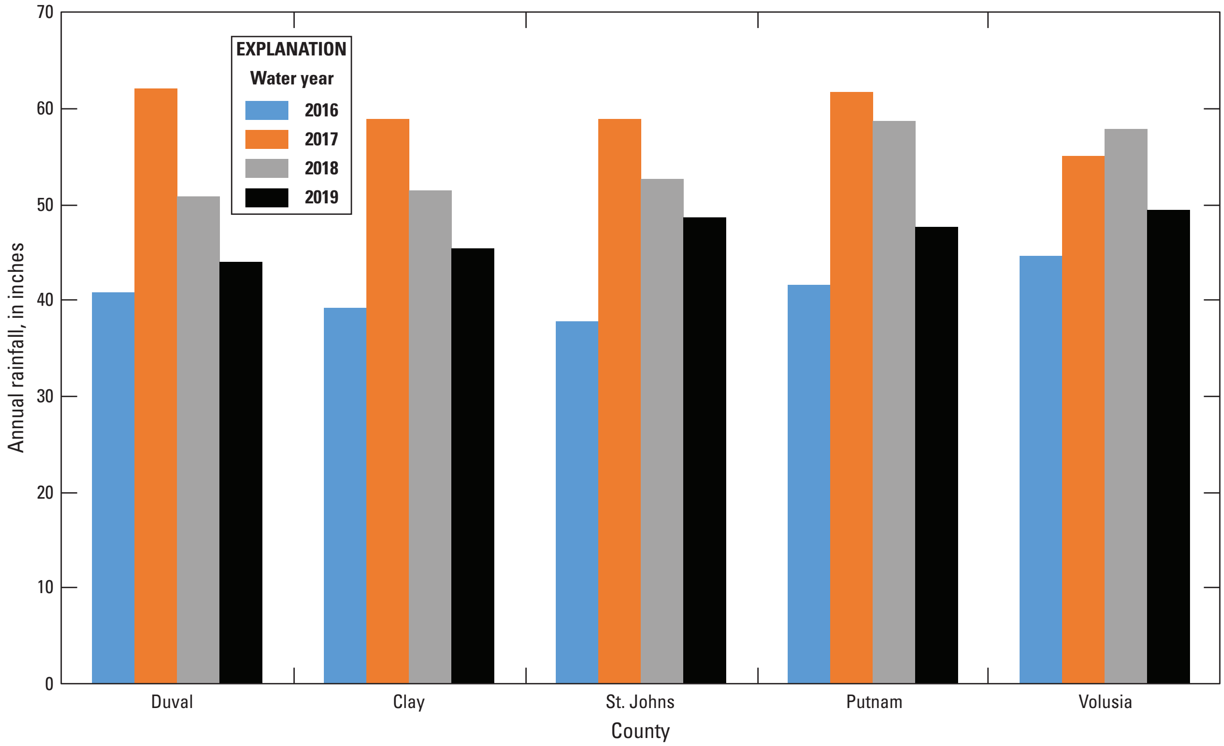

Figure 73. Annual rainfall for Duval, Clay, St. Johns, Putnam, and Volusia Counties.

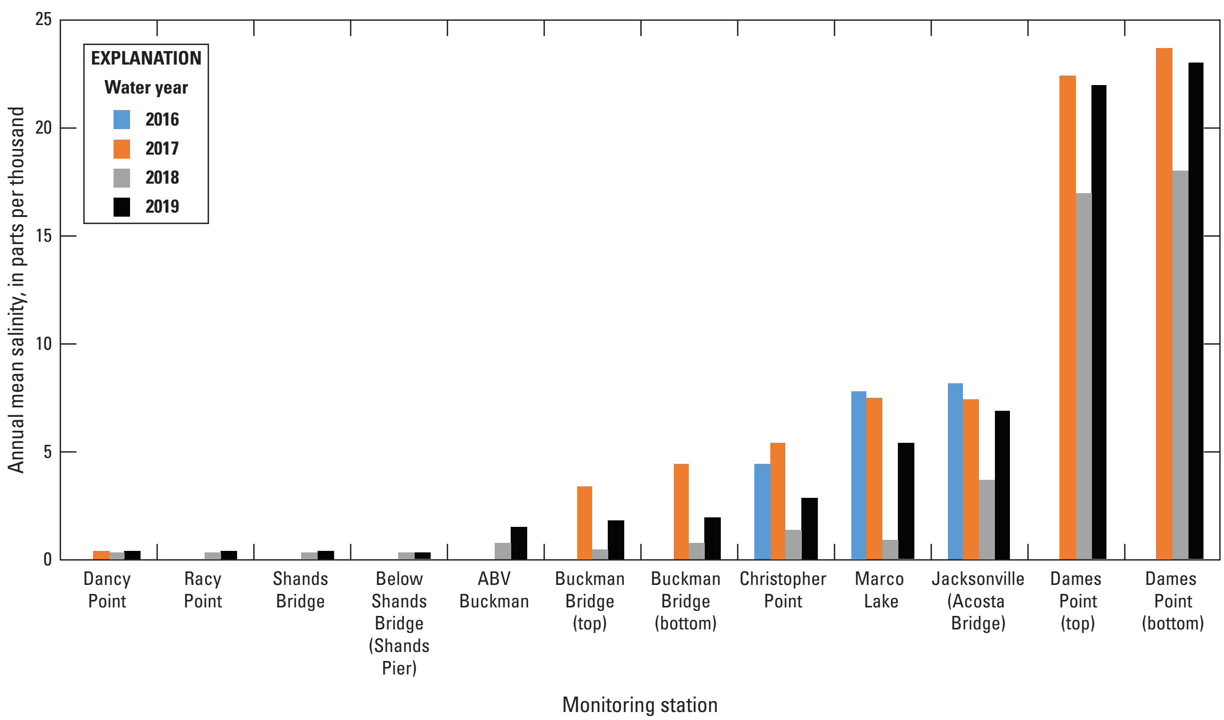

Figure 74. Annual mean salinity at St. Johns River main-stem monitoring sites.

higher than that of 2018 but lower than that of 2017 (where applicable) at all main-stem sites except the site below Shands Bridge, which remained the same (fig. 74).

Clapboard Creek had the highest annual mean salinity (21 ppt) of all tributaries in 2019 because of its proximity to the Atlantic Ocean. Durbin Creek (0.2 ppt) and Julington Creek (0.2 ppt) salinities were the lowest of all monitoring locations and both were slightly lower than that of Ortega River (0.5 ppt) (fig. 75). A simple comparison of annual mean salinity among tributary sites and between the 2018 and 2019 water years indicates salinity was higher in 2019 at all locations except Durbin Creek and Julington Creek, which remained the same (fig. 75). The 2019 salinity at the tributary sites, when compared to all 4 years of the study, ranked first at Dunn Creek, second at Clapboard Creek, and third at Julington Creek, Ortega River, Cedar River, Pottsburg Creek, Trout River, and Broward River. Durbin Creek salinity remained the same at 0.1 ppt for all 4 years. The yearly rainfall total for Duval County also ranked third among those computed for the 4 years considered for this study (fig. 73).

Summary

The U.S. Geological Survey, in cooperation with the U.S. Army Corps of Engineers, collected data during the 2019 water year, from October 2018 to September 2019, at 26 sites on the St. Johns River and its tributaries. This period of data collection was concurrent with river dredging, which was initiated in February 2018 by the U.S. Army Corps of Engineers as part of its project to deepen the first 13 river miles of Jacksonville Harbor. Data collection began in the 2016 water year, and this is the fourth annual report of the study. Stage was measured at 17 sites, discharge was calculated at 13 sites, and water temperature and specific conductance data were collected at 19 sites; all parameters were measured at some sites. Salinity was calculated for each site where water temperature and specific conductance data were collected. Data were collected over a range of hydrologic conditions, including a period of above-average rainfall in Duval, Clay, St. Johns, Putnam, and Volusia Counties from November to January and below-average yearly rainfall for all five counties.

Of the tributaries, annual mean tidally filtered discharge at Durbin Creek was highest, followed by that of Trout River, Ortega River, Julington Creek, Pottsburg Creek, Broward River, Cedar River, Clapboard Creek, and Dunn Creek. The closest tributary site to the Atlantic Ocean, Clapboard Creek, had the highest annual mean salinity of the tributaries, and Durbin Creek had the lowest of all monitoring locations, being slightly lower than that of Julington Creek. Annual mean salinities for the main-stem sites indicate that salinity decreases with distance upstream from the ocean, which was expected. Annual mean salinity at all sites in the 2019 water year was higher than that of the 2018 water year except for Durbin Creek and Julington Creek, which remained the same. The 2019 salinity at the tributary sites, when compared to all 4 years of the study, ranked first at Dunn Creek, second at Clapboard Creek, and third at Julington Creek, Ortega River, Cedar River, Pottsburg Creek, Trout River, and Broward River. Durbin Creek salinity remained the same at 0.1 ppt for all 4 years. The yearly rainfall total for Duval County also ranked third among those computed for the 4 years considered for this study. Many factors—such as wind, rainfall, and hurricanes—influence flow and salinity within the study area.

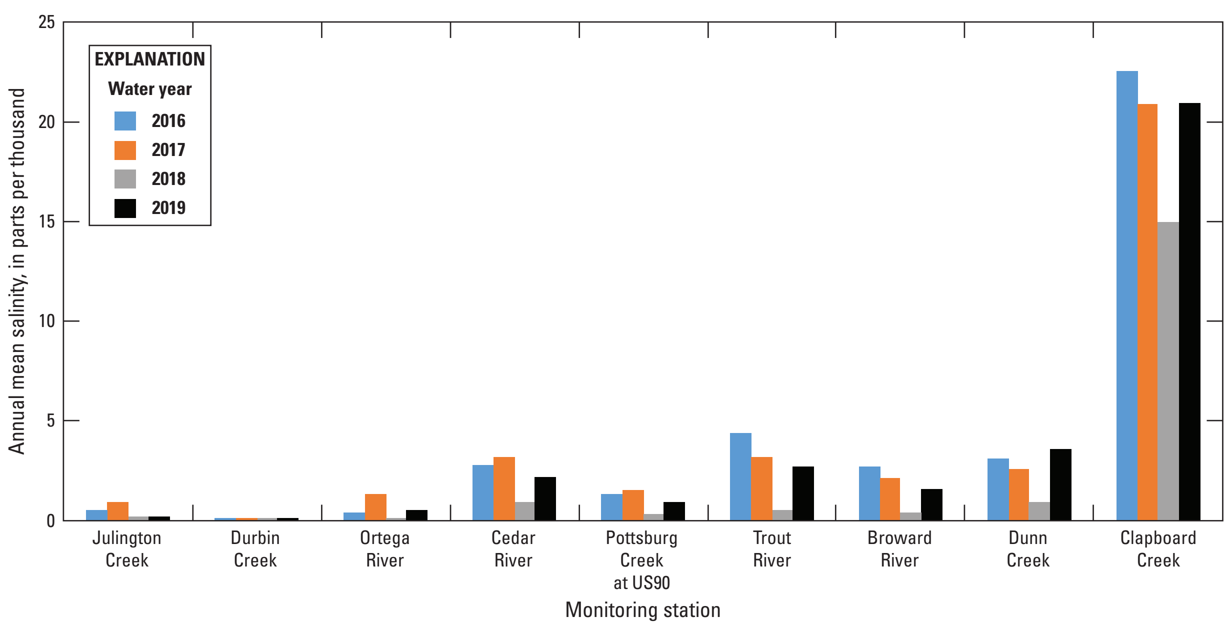

Figure 75. Annual mean salinity at St. Johns River tributary monitoring sites.

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