2021 River Report

State of the Lower St. Johns River Basin, Florida

Water Quality

Fisheries

Aquatic Life

Contaminants

Prepared for:

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Cover image: Michael J. Canella, courtesy of Daniel L. Schafer and www.unfedu.floridahistoryonline, digitally manipulated.

1. Background

Written by Heather McCarthy

Appendix 1.2.2.A

TOTAL AREAS OF WETLAND AND DEEPWATER HABITATS

St. Johns River Water Management District - Wetland and Deep Water Habitat Maps
(based on aerial photographs taken between 1972-1980)

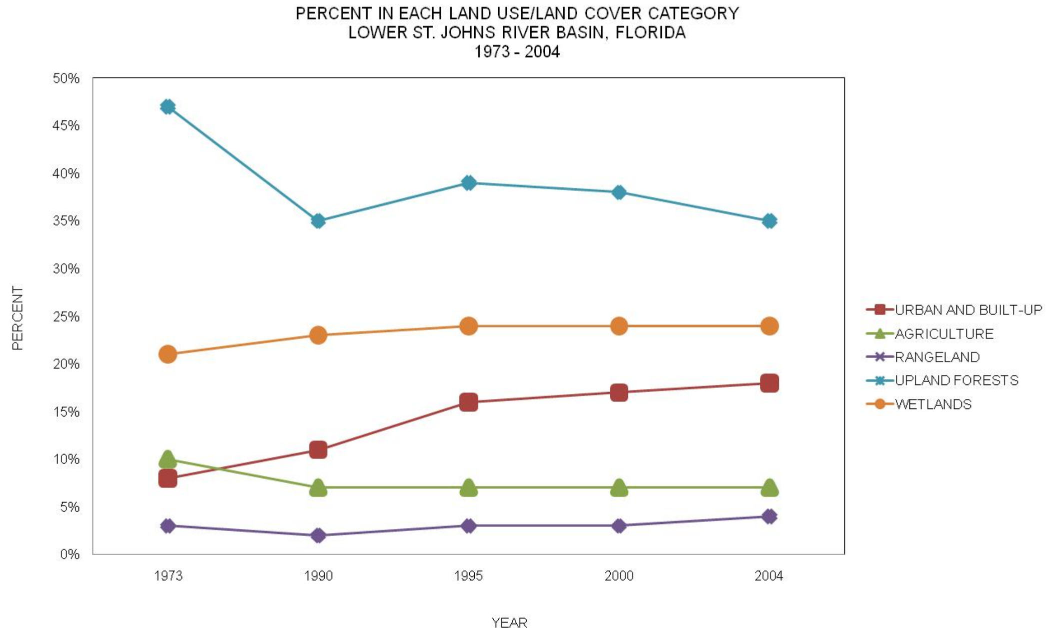
WETLAND & DEEPWATER HABITAT TYPE	ACRES
Deepwater Habitats: marine, riverine, or lacustrine. Does not include estuarine.	128,185
Estuarine unvegetated: estuarine open water and unconsolidated shore. Aquatic beds not identified.	58,208
Estuarine vegetated: estuarine forested scrub-shrub and emergent	25,958
Freshwater forested: palustrine forested and/or scrub-shrub	772,398
Freshwater herbaceous: Palustrine emergent	14,011
Upland: neither wetlands nor deepwater habitats	2,111,448
TOTAL AREA	3,110,209

Appendix 1.2.2.B

TOTAL AREAS OF EACH LAND USE CATEGORY

SJRWMD Land Use/Land Cover Maps (1973, 1990, 1995, 2000, and 2004)

TOTALS IN EACH LAND USE/LAND COVER CATEGORY	1973	1990	1995	2000	2004
URBAN AND BUILT-UP	162,518.02	294,564.38	296,174.98	319,020.10	342,541.06
AGRICULTURE	205,744.61	192,156.16	141,849.12	128,773.38	131,745.62
RANGELAND	70,455.50	40,884.28	55,629.85	55,689.72	66,824.06
UPLAND FORESTS	980,408.70	918,950.84	752,406.39	706,447.17	655,099.77
WATER	158,909.59	515,914.13	169,900.11	153,367.07	165,269.87
WETLANDS	440,048.18	592,807.50	450,596.93	444,187.87	451,717.86
BARREN LAND	75,565.51	10,955.52	4,333.20	6,917.23	14,589.99
TRANSPORTATION, COMMUNICATION AND UTILITIES	6,901.82	39,013.94	39,531.64	37,044.74	40,214.39
PERCENT IN EACH LAND USE/LAND COVER CATEGORY	1973	1990	1995	2000	2004
URBAN AND BUILT-UP	8%	11%	16%	17%	18%
AGRICULTURE	10%	7%	7%	7%	7%
RANGELAND	3%	2%	3%	3%	4%
UPLAND FORESTS	47%	35%	39%	38%	35%
WETLANDS	21%	23%	24%	24%	24%
WATER	7%	20%	9%	8%	9%
BARREN LAND	4%	0%	0%	1%	1%
TRANSPORTATION, COMMUNICATION AND UTILITIES	0%	2%	2%	2%	2%
TOTAL PERCENT	100%	100%	100%	100%	100%



Appendix 1.4.1

Timeline of important environmental milestones for the Lower St. Johns River Basin.

DATE	EVENT
1000-1600s	Timucua communities thrived along the St. Johns River. They fished, hunted, and, beginning in the 1400s, raised crops (**Thunen 2010; UNF 2019**).
1500s-1821	Spanish colonizers attempted to assert control over Florida, establish a fort and missions, while interacting with the large Indigenous population (**Warren 2005; Schafer 2007; Blanton, 2014**).
1773 - 1777	Naturalist William Bartram chronicled his trip up the St. Johns River in Bartram's *Travels*. "Bartram's observations remain an invaluable tool for environmental planning—restoring paradise—in northeastern Florida" (**Davis and Arsenault 2005**).
1821	Adams-Onis Treaty: United States legally acquired Florida (**Blake 1980**).
1835 - 1842	Second Seminole War: Many steamboats were first brought to the St. Johns River to fight the Indians, but continued to operate out of Jacksonville for civilian purposes after the war (**Buker 1992**).
1821-1845	A U.S. Territory since 1821, Florida is granted statehood in 1845.
1845	Florida granted statehood.
1850	Swamp and Overflowed Lands Act: stated that Florida could have from the Federal government any swamp or submerged lands that they successfully drained (**Leal and Meiners 2002**).
1868	Florida's first water pollution law established a penalty for degrading springs and water supplies (**SJRWMD 2010a**).
1870 - 1884	Famed author of *Uncle Tom's Cabin*, Harriet Beecher Stowe, wintered in Mandarin and wrote essays extolling the beauties of the St. Johns River and attracting tourists to Florida (**Blake 1980**).
1870s - 1900	Increasing number of tourists visited Florida via steamboats up the St. Johns River.
1870 - 1900	Trade and lumber helped Jacksonville become the most important city in Florida (**Blake 1980**).
1880	Construction of jetties at the mouth of the St. Johns River was started in order to stabilize the entrance of the shipping channel. They were not finished until 1921 (**Davis 1925**).
1884 - 1896	Water hyacinth introduced into the St. Johns River near Palatka, eventually hindering navigation and posing a serious threat to biotic communities (**McCann et al. 1996**).
1895	The Port of Jacksonville shipping channel was deepened to 15-ft (**GLD&D 2001**).
1906	The Port of Jacksonville shipping channel was deepened to 24 feet (**GLD&D 2001**).
1916	The Port of Jacksonville shipping channel was deepened to 30 feet (**GLD&D 2001**).

1935	Construction of Cross-Florida Barge Canal was initiated.
1937	Construction suspended on Cross-Florida Barge Canal.
1945	River and Harbor Act of 1945 authorized the construction of the Dames Point Fulton Cut. This 34-ft-deep cut-off channel eliminated bends in the shipping channel at Dames Point, Browns Creek and St. Johns Bluff, shortening the channel between the City of Jacksonville and the ocean by about 1.9 miles.
1952	The Port of Jacksonville shipping channel was deepened to 34-ft (**GLD&D 2001**).
1950s	State Board of Health warns that St. Johns River in Jacksonville badly polluted due to discharge of untreated sewage, and threatens to block development (**Crooks 2004**).
1961	Jacksonville completes construction of Buckman Sewage Treatment Plant, connecting sewers on the north side to a treatment plant. Most sewage in Jacksonville continues to flow into the river, untreated (**Crooks 2004**).
1964	Construction resumed on Cross-Florida Barge Canal.
1965	U.S. Congress passes the Water Quality Control Act, giving federal government authority to establish water quality standards (**Merchant 2007**).
1966 - 1967	Sinkholes occurring in Central Florida (within the Upper Basin of the St. Johns River) indicating a serious drop in the water table (**Purdum 2002**).
Dec. 5, 1967	The Florida Air and Water Pollution Control Commission and State Board of Health issued letter to Jacksonville, and "ordered the City within 90 days to furnish plans to end the disposal of 15 million gallons per day of raw sewage into the St. Johns River and its tributaries" (**Crooks 2004**).
1967 - 1968	Voters approved the consolidation of the Jacksonville and Duval County local governments.
1968	As part of the Cross-Florida Barge canal project, the Ocklawaha River was dammed, creating the Rodman Reservoir.
1969	National Environmental Policy Act: required federal agencies to consider the environmental impacts and reasonable alternatives of their proposed actions.
1970s	"Cleanup of the St. Johns River was impressive, but many of its tributaries remained heavily polluted; landfills were opened, but indiscriminate littering of wastes continued; polluting power plants and fertilizer factories closed, but other odors remained" (**Crooks 2004**). "Discharges occur to river of primary treated effluent or raw sewage. Periodic blue-green algal blooms and fish kills" (**DEP 2002**).
1970 - 1971	Florida experiences its worst drought in history (**Purdum 2002**).
1971	Federal government halts construction of Cross-Florida Barge Canal.
1972	Federal and state governments pass landmark environmental laws: • Florida Water Resources Act: established regional water management districts and created a permit system for allocating water use (**Florida Legislature 1972b**).

	• Federal Clean Water Act: required that all U.S. waters be swimmable and fishable (**Congress 1972a**). • Florida Land Conservation Act: authorized the sale of state bonds to purchase environmentally imperiled lands (**Florida Legislature 1972c**). • Florida Environmental Land and Water Management Act: initiated the "Development of Regional Impact" program and the "Area of Critical State Concern" program (**Florida Legislature 1972c**). • Florida Comprehensive Planning Act: called for the development of a state comprehensive plan (**Florida Legislature 1972a**).
1973	Endangered Species Act: conservation of threatened and endangered plants and animals and their habitats (**Congress 1973**).
Mar. 1973	"Press release announced that the St. Johns River south of the Naval Air Station to the Duval County Line at Julington Creek had been deemed safe for water contact sports" (**Crooks 2004**).
1977	Seventy-seven sewage outfalls closed, and the St. Johns River became safe for recreational use again (**Crooks 2004**). Movement to regional wastewater treatment systems providing higher levels of treatment than before.
June 18, 1977	St. Johns River Day Festival marked partial cleanup of the St. Johns River. Mayor Hans Tanzler publicizes by water skiing in the river, near downtown (**Crooks 2004**).
Mid - late 1980s	"Outbreak of Ulcerative Disease Syndrome in fish occurs from Lake George to mouth of river. Exhaustive studies are conducted, but specific cause is not determined" (**DEP 2002**).
1987	Surface Water Improvement and Management (SWIM) Act: Recognized the LSJRB as an area in need of special protection and restoration (**SJRWMD 2008**).
1987	Water Quality Attainment Plan adopted by City of Jacksonville City Council. The plan addressed causes and remedies for non-attainment of water quality criteria.
1988	"The Florida Department of Environmental Regulation delegated authority to permit dredging and filling of wetlands to the St. Johns River Water Management District" (**SJRWMD 2010a**).
1988	"With funding from the SWIM program, the St. Johns River Water Management District began restoration of the Upper Ocklawaha River Basin and the Lower St. Johns River Basin" (**SJRWMD 2010a**).
1989	SJRWMD publishes the first SWIM Plan for the LSJRB.
1990s	"Blue-green algal blooms occur in freshwater portion of the river" (**DEP 2002**).
1991	The *Florida Times-Union* began a monthly series of investigative reports entitled "A River in Decline." This series reported that 17% of septic tanks were failing.In 1990, 47% of tributaries failed to meet appropriate health standards for fecal coliform. In 1990, 50% of privately owned sewage treatment plants violated local regulations. 80% of pollutants in Jacksonville's waterways could be attributed to stormwater runoff (**Crooks 2004**).
Early 1990s	The Florida Department of Environmental Regulation "downgraded formerly pristine areas of Julington

	and Durbin Creeks in southern Duval County from GOOD to FAIR water quality due to stormwater, sewage, and other runoffs from the rapidly growing suburb of Mandarin." Half of the wetlands in this area were destroyed during this time period (**Crooks 2004**).
Late 1990s	Blooms of an exotic freshwater, toxin-producing, blue-green algae called *Cylindrospermopsis* occurred (**DEP 2002**).
1997	The Lower St. Johns River Basin Strategic Planning Session (the "River Summit") led to the development of a 5-year "River Agenda" plan.
1998	Several Florida environmental groups sue the EPA for its failure to enforce the Total Maximum Daily Load (TMDL) provisions in the Federal CWA (*Florida Wildlife Federation, Inc., et al. v. Browner*, (N.D. Fla. 1998) (No. 4:98CV356).
1998	St. Johns River is designated as an American Heritage River (**DEP 2002**).
Sept. 17, 1998	DEP submitted the 1998 303(d) list of impaired waterbodies to the EPA for approval. The 1998 303(d) list included 53 waterbodies in the LSJRB.
1999	Florida legislature enacted the Watershed Restoration Act to provide for the establishment of TMDLs for pollutants of impaired waters as required by the Clean Water Act.
1999	DEP formed a local stakeholders group to review the TMDL model inputs.
April 26, 2001	Florida adopted a new science-based methodology to identify impaired waters as c. 62-303, F.A.C. (Identification of Impaired Surface Waters Rule).
July 2002	DEP appointed the Lower St. Johns River TMDL Executive Committee to advise the Department on the development of TMDLs and a Basin Management Action Plan (BMAP) for the nutrient impairments in the mainstem of the LSJR.
Dec. 3, 2002	Four Florida environmental groups filed suit in federal court against the U. S. EPA for failure of EPA to approve/disapprove Florida's Impaired Waters Rule as being consistent with the CWA (*Florida Public Interest Research Group Citizen Lobby, Inc., et al., v U.S. EPA et al.*)
2002	ACOE began the St. Johns River Harbor Deepening Project (**JAXPORT 2008**). The dredging project deepened "the outer 14 miles of the St. Johns River federal channel from the mouth of the river to Drummond Point" (**GLD&D 2001**). ACOE deepened the channel to 41 feet in areas where there is a limestone rock bottom.
Sept. 4, 2003	DEP determined that most of the freshwater and estuarine segments of the LSJRB were impaired by nutrients.
Aug. 18, 2004	St. Johns Riverkeeper and Linda Young (Southeast Clean Water Network) filed suit against the EPA on the basis that the targets upon which the TMDL were based were not consistent with the existing Class III marine dissolved oxygen criterion.
May 24, 2005	The Executive Committee identified the water quality credit trading approach for the Basin Management Action Plan (BMAP).

Early fall 2005	Large clumps of surface scum, caused by the toxic blue-green algae *Microcystis aeruginosa*, bloomed from Lake George to Jacksonville. Some samples exceeded World Health Organization recommended guidelines (**SJRWMD 2010a**).
2005 - 2008	ACOE extended the harbor deepening from Drummond Point to JAXPORT's Talleyrand Marine Terminal from 38 feet to a depth of 40 feet.
2006	Blooms of algae continue in the St. Johns River. "Algal blooms are caused by a combination of hot, overcast days, calm wind and excessive nutrients in the water, such as fertilizer runoff, stormwater runoff, and wastewater" (**SJRWMD 2010a**).
Jan. 23, 2006	EPA established a new nutrient TMDL for the LSJRB that would meet the dissolved oxygen criteria.
May 25, 2006	Site-Specific Alternative Criteria (SSAC) for dissolved oxygen in the LSJRB (F.A.C. 62-302.800(5)) was adopted by the Florida Environmental Regulation Commission and submitted to the EPA for approval. The SSAC was developed by DEP in cooperation with the SJRWMD.
July 13, 2006	St. Johns Riverkeeper and Clean Water Network filed a suit in federal Court challenging the EPA's approval of rule 62-302.800 (in effect, the SSAC). (*St. Johns Riverkeeper, Inc., et al. v. United States Environmental Protection Agency, et al.*, No. 4:2006cv00332, 2006 (N.D. Fla.))
July 2006	The River Accord: A Partnership for the St. Johns, was established.
Sept. 2006	The project collection process for the LSJRB Mainstem BMAP started, which provided the list of efforts that will implement the TMDL reductions and restore the river to water quality standards.
Oct. 10, 2006	EPA approved Site-Specific Alternative Criteria (SSAC) for dissolved oxygen in the marine portion of the St. Johns River.
2007	The ACOE started studying the impacts of blasting and dredging to deepen the navigation channel to a maintained 45 feet from the mouth of the river to Talleyrand Terminals (**USACE 2007**).
Feb. 1, 2007	The Executive Committee determined the LSJRB Mainstem BMAP load allocation approach, which assigned reduction responsibilities to wastewater plants, industries, agriculture, cities and counties with urban stormwater sources, and military bases with stormwater sources.
April 2007	SJRWMD launched the public awareness initiative, "The St. Johns: It's Your River," in order to help the public understand their personal impacts on the river and their responsibility for the river's condition (**SJRWMD 2010a**).
Jan. 17, 2008	EPA approved the LSJRB nutrient TMDLs based on the recently adopted SSAC.
April 2, 2008	DEP revised the Surface Water Quality Standards (c. 62-302.530, F.A.C.) to match the EPA approved list of TMDLs for nutrients in the LSJRB.
July 17, 2008	Earthjustice (representing the Florida Wildlife Federation, Conservancy of Southwest Florida, Environmental Confederation of Southwest Florida, St. Johns Riverkeeper, and Sierra Club) filed a lawsuit against the EPA "for failing to comply with their nondiscretionary duty to promptly set numeric nutrient criteria for the state of Florida as directed by Section 303(c)(4)(B) of the Clean Water Act" (**Earthjustice**

	2008; *Florida Wildlife Federation, Inc., et al. v. Johnson et al.*, 4:2008cv00324 (N.D. Fla.)).
Aug. 6, 2008	The first annual "State of the River Report for the Lower St. Johns River Basin" was released by researchers at Jacksonville University and the University of North Florida.
Aug. 2008	The LSJRB SWIM Plan Update was released. The plan was prepared by SJRWMD, Wildwood Consulting, Inc., and the Lower St. Johns River Technical Advisory Committee (TAC). The plan outlines milestones, strategies, and objectives to meet goals associated with water quality, biological health, sediment management, toxic contaminants remediation, public education, and intergovernmental coordination.
Oct. 17, 2008	DEP finalized Lower St. Johns River Nutrients TMDL.
Oct. 27, 2008	The final BMAP for the Implementation of TMDLs for Nutrients was adopted by the DEP for the LSJRB main stem. The BMAP was developed by the Lower St. Johns River TMDL Executive Committee in cooperation with the DEP, SJRWMD, local industries, cities, counties, environmental groups, and many other stakeholders.
Jan. 16, 2009	EPA determined that numeric nutrient water quality criteria are necessary under the CWA in Florida. DEP planned to accelerate adoption of such criteria in the state.
May 19, 2009	DEP released Final Drafts of the LSJRB Group 2 Cycle 2 – Verified List and Delist List of Impaired Waters. These lists update the 2004 303(d) list of waters in need of water quality restoration.
July 2009	DEP adopts by rule fecal coliform TMDLs for 22 tributaries to the Lower St. Johns River.
Nov. 2009	DEP adopts by rule several TMDLS: eight for fecal coliform, two for nutrients, five for dissolved oxygen and nutrients, one for dissolved oxygen, and two for lead.
May - Dec. 2010	A major bloom of *Aphanizomenon* and a major fish kill with unusual characteristics occurred in early summer. These events were followed in mid-summer by an additional bloom of *Microcystis* and other cyanobacteria species and a second more typical fish kill. Massive drifts of an unusual, persistent foam occurred from mid-summer through the fall. Unusually high dolphin mortalities occurred May-September. National Oceanic and Atmospheric Administration (NOAA) designated LSJRB dolphin mortalities during the summer of 2010 an Unusual Marine Mammal Mortality Event, initiating a multi-agency task force to investigate the causes.
July 2010	DEP adopted by rule five fecal coliform TMDLs for tributaries to the Lower St. Johns River.
Aug. 2010	The Lower St. Johns River Tributaries BMAP, which addresses fecal coliform TMDLs for fifteen tributaries, was adopted. These fifteen tributaries include Craig Creek, McCoy Creek, Williamson Creek, Fishing Creek, Deep Bottom Creek, Moncrief Creek, Blockhouse Creek, Hopkins Creek, Cormorant Branch, Wills Branch, Sherman Creek, Greenfield Creek, Pottsburg Creek, Upper Trout River, and Lower Trout River. This plan was developed collaboratively by the City of Jacksonville, JEA, Duval County Health Department, Florida Department of Transportation, Tributary Assessment Team, the Basin Working Group Stakeholders, and the Florida Department of Environmental Protection (Tributary BMAP II - **DEP 2010a**).
Nov. 14, 2010	EPA Administrator Lisa P. Jackson signed final "Water Quality Standards for the State of Florida's Lakes and Flowing Waters" (inland waters rule). The final standards set numeric limits, or criteria, on the amount of nutrient pollution allowed in Florida's lakes, rivers, streams and springs. On April 11, 2011,

	DEP requested EPA to withdraw its January 2009 determination that numeric nutrient criteria are necessary in Florida; to repeal November 2010 rulemaking establishing numeric criteria for inland streams, lakes, and springs; and to refrain from establishing any future numeric criteria. On June 13, EPA sent an initial response to DEP's petition. In their response, EPA was prepared to withdraw the federal inland standards if DEP adopted, and EPA approved, their own protective and scientifically sound numeric standards. On March 5, 2012, EPA promulgated an extension of the effective date of the "Water Quality Standards for the State of Florida's Lakes and Flowing Waters" (inland waters rule) by four months to July 6, 2012. (The extension did not affect or change the February 4, 2011 date for the SSAC provision.) This extension afforded the State additional time to finalize their own rule establishing numeric nutrient criteria for the State and submit it for EPA review. On November 30, 2012, EPA approved DEP's standards for numeric nutrient criteria in Florida's flowing waters, springs, lakes, and South Florida estuaries, and in June 2013, EPA approved DEP's criteria for estuaries, and coastal waters (**EPA 2013a**). In October 2014, EPA rescinded federally adopted criteria, and DEP criteria were in effect. While this rule did not include criteria for the Lower St. Johns River Basin, it began a process for numeric criteria later applied to estuary-specific numeric nutrient criteria that do include the LSJRB.
Feb. - April 2011	DEP released final TMDLS for Arlington River for nutrients; Mill Creek for dissolved oxygen and nutrients; and lead in Black Creek and Peters Creek.
May 10, 2011	SJRWMD issued to JEA a single consumptive use permit that consolidated 27 individual permits and allows groundwater withdrawals of up to 142 million gallons per day in 2012 and up to 155 million gallons per day in 2031 if key conditions are met.
July 2013	DEP began an initiative to revise bacteria criteria for Florida's beaches and recreational waters. (**DEP 2014d**).
Sept. 2013	EPA approved DEP's revised criteria for dissolved oxygen, which takes into account stream conditions and percent oxygen saturation (**DEP 2013i).**
Oct. 2013	DEP released a final Florida Mercury TMDL (**DEP 2013c**).
Nov. 2014	The Florida Environmental Regulation Commission (ERC) approved numeric nutrient criteria specific for several estuaries, including the Lower St. Johns River.
Dec. 2014	RockTenn and Rayonier, two companies with facilities in the region, filed a legal challenge to the ERC's approval of the estuary-specific numeric nutrient criteria (**News4JAX 2014**).
Jan. 2015	"St. Johns River Economic Study," by Dr. Courtney T. Hackney, is released to public (**Hackney 2015**).
Jan. 2016	Florida Governor Rick Scott signed into law the Environmental Resources Bill, which defined flow levels for springs, created a management plan for some South Florida watersheds, and set guidelines for the Central Florida Water Initiative, an effort to secure water supply for Central Florida (**CBSMiami 2016**).
July 2016	Florida Environmental Regulation Commission approved changes to Florida water quality criteria.
Oct. 2016	Legal challenges to new water quality standards were set aside by Florida administrative law judge.
April 2017	The St. Johns Riverkeeper filed a federal lawsuit to block plans for the ACOE to dredge 13 miles of the St. Johns River, as part of a harbor deepening project. The suit alleged that the ACOE's analysis of the environmental impact of the dredging project was inadequate and flawed. In addition, the suit alleged

	that the ACOE did not provide for sufficient environmental mitigation as part of the project (**WJCT 2017**).
Sept. 2017	Hurricane Irma struck Florida, dumping 2.2 trillion gallons of water on the region and causing major floods (**SJRWMD 2017b**).
Jan. 2018	U.S. Federal Judge ruled that the Army Corps of Engineers could begin dredging up to thirteen miles of the St. Johns River as part of the Jacksonville Harbor Deepening Project **(News4Jax 2018**).
Feb. 2018	DEP initiated rule-making to establish TMDLs for certain impaired surface waters within the Lower St. Johns River Basin.
Feb. 2018	DEP withdrew amendment to water quality standards rule announced in July 2016. This rule would have established new water quality criteria for 39 chemicals that previously had no limits in Florida (**OSHA 2017**). It would have also updated standards on 43 other chemicals for which standards had not changed since 1992, and increased allowable concentrations of some chemicals, including some released in hydraulic fracking (**DEP 2016e; Klas 2016**).
Feb. 2018	First phase of the Jacksonville Harbor Deepening Project started. In this phase, a contractor hired by the ACOE was to dredge the river to a depth of 47 ft. for three miles from the mouth of the river (**News4Jax 2018**).
Sept. 2018	ACOE contracted with Great Lakes Dredge and Dock Company to complete the second phase of the Jacksonville Harbor Deepening project. Estimated to cost $210 million, this phase involved deepening the river for distance of five additional miles (**ACOE 2018**).
Jan. 2019	Governor Ron DeSantis issued Executive Order 19-12 focusing on water resources. Although focused mostly on South Florida and issues of algae blooms, this Executive Order also: • Instructed DEP to establish a septic tank remediation and grant program; • Instructed water management districts to prioritize accountability and transparency regarding water restoration projects; • Instructed water management districts to prioritize projects that address harmful algae blooms and maximize nutrient reductions; • Instructed DEP to engage with governments and stakeholders to identify alternative water supplies to meet needs of Florida's growing economy, and encourage conservation and reuse of water **(DEP 2019**).
June 2019	A City of Jacksonville Storm Resiliency and Infrastructure Development Review Committee presented findings to the Public. The Committee included members from the City of Jacksonville, JEA, ACOE, U.S. Navy, FDEP, the SJRWMD, and the Federal Emergency Management Agency. Committee Recommended: • Improved Interagency Coordination regarding issues of stormwater planning and infrastructure; • Updates to Land Development Procedures Manual; • Suggested City Ordinances to address such development issues as floodplains, setbacks, bulkheads, and impermeable cover **(COJ 2019).**

Sept. 2019	After devastating the Bahamas, Hurricane Dorian passed to the east of Jacksonville, causing relatively little flooding or wind damage (**News4Jax 2019**).
Sept. 2019	Plans to redevelop downtown Jacksonville raised concerns about pollution and saltwater intrusion in lower St. Johns River near downtown (**Action News Jax 2019**).
Dec. 2019	Amidst allegations of corruption and lack of transparency, JEA's Board of Directors cancelled plans to sell the Jacksonville-owned utility to private interests.
Feb. 2020	In light of recent flooding, Jacksonville city officials consider appointment of a city resilience officer (**Patterson, 2020**).
Feb. 2020	The Federal Government committed an additional $93 million for dredging the St. Johns River. As it stands, the current dredging plan calls for deepening the St. Johns River to 47 ft., from Mayport to Blount Island. JaxPort has also asked for an additional $70 million from the City of Jacksonville toward this dredging project (**News4Jax 2020).**
2020-2021	Beginning in the spring of 2020, the COVID 19 pandemic dramatically affected the entire country. In addition to causing a sharp reduction in economic activity in northeast Florida, the pandemic forced organizations like JEA, the SJRWMD, and DEP to modify their operations in order to protect staff, clients, and the public. Each of these agencies continued to fulfill its responsibilities, but under very different procedures (**Basch 2020**; **JEA 2020; SJRWMD 2020d; DEP 2020f**) As of the summer of 2021, JEA, the SJRWMD, and DEP continue to fulfill their responsibilities, while exercising caution in order to protect public health, that of their stakeholders, and their employees (**DEP 2021; SJRWMD 2021; JEA 2021**).
May 2020	Federal Judge Marcia Morales Howard ruled against the St. Johns Riverkeeper in its suit to halt dredging of the St. Johns River by the ACOE. Judge Morales asserted that the Riverkeeper had not demonstrated that the ACOE had failed to properly consider the environmental consequences of deepening the river from 40 to 47 feet **(Bauerlein 2020).**

<table>
<tr><td>July 2020</td><td>The Florida Legislature passed (and Governor DeSantis signed) the Florida Clean Waterways Act. The so-called “Clean Waterways Act” builds in part upon the work of the state’s Blue-Green Algae Task Force and adopts the following measures:
Transferred monitoring of septic tanks from the Department of Health to DEP, and adopted other measures to enhance the remediation of septic tanks in BMAPs;
Required the creation of wastewater treatment plans for “certain BMAPs” while also providing access to a grant fund for enhancing wastewater treatment and reducing nutrient pollution;
Required DEP to upgrade its stormwater permitting, monitoring and management procedures;
Among other things, required the Department of Agriculture and Consumer Services (DACS) to perform regular monitoring of agricultural producers enrolled in Best Management Practice (BMP) programs;
Required entities engaged in the application of biosolids to enroll in BMP programs and to restrict application of biosolids in other circumstances. Allowed local entities to maintain existing biosolid regulations;
Prevented local government agencies from asserting legal rights for any bodies of water or other elements of the environment, unless permitted by the legislature
Various other provisions (Florida Senate 2020).</td></tr>
<tr><td>June-July 2020</td><td>The Clean Waterways Act garnered mixed reaction from stakeholders. Environmental groups criticized by the bill for ignoring some recommendations of the state’s Blue-Green Algae Task Force, and for not allowing local governments to pass their own laws to protect waterways. Environmentalists also criticized the bill for not going far enough to restrict nutrient discharges from agriculture (Cassels 2020; Turner 2020).</td></tr>
<tr><td>February 2021</td><td>City of Jacksonville’s Special Committee on Resiliency issued its Final Report. It called for a comprehensive response to sea level rise, high intensity storms, and other causes of flooding (Lahav 2021).</td></tr>
<tr><td>June 2021</td><td>The State of Florida’s budget will include $6 million for the phase out of septic tanks in three of Jacksonville’s older neighborhoods (Bauerlein 2021).</td></tr>
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2. Water Quality

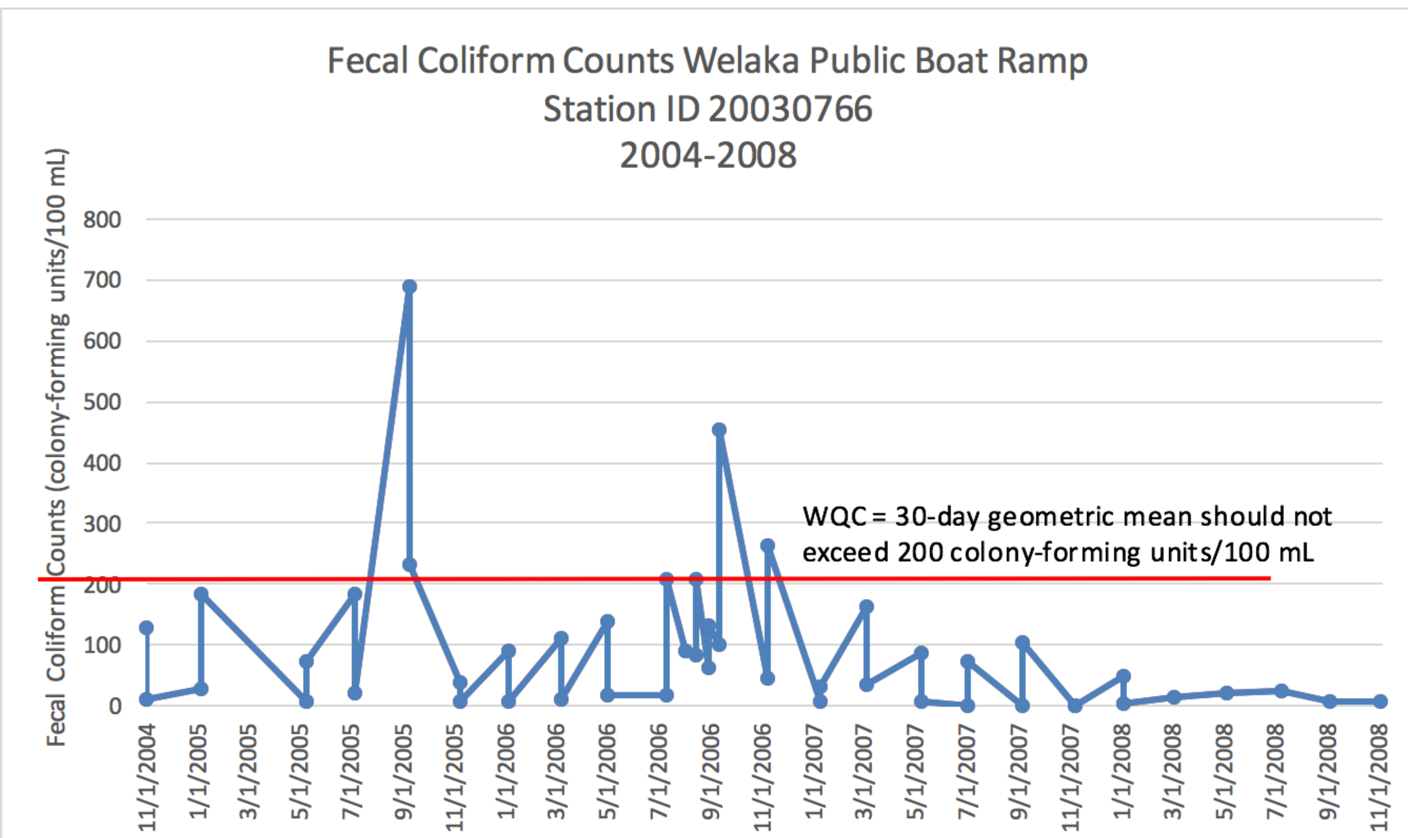
Appendix 2.6.1

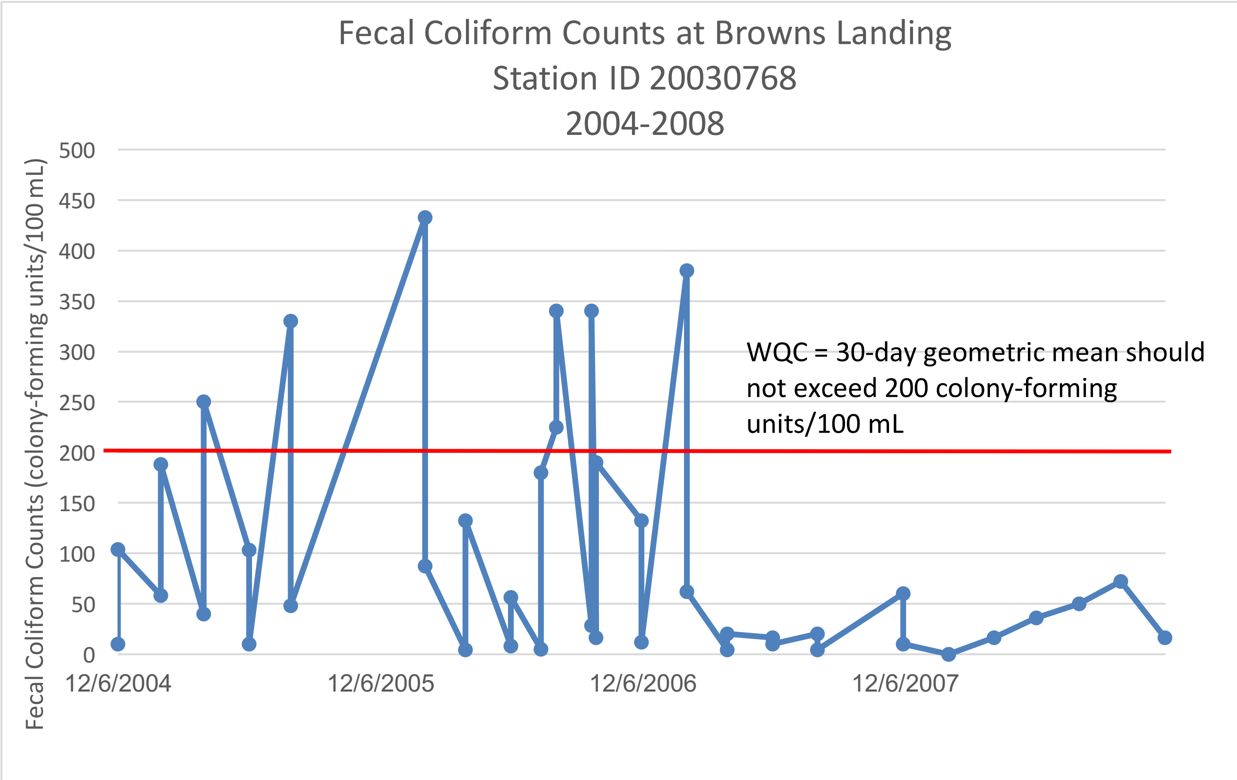
Fecal Coliform Counts for Lower St. Johns River Mainstem from River-at-a-Glance (RAAG) program from FL STORET

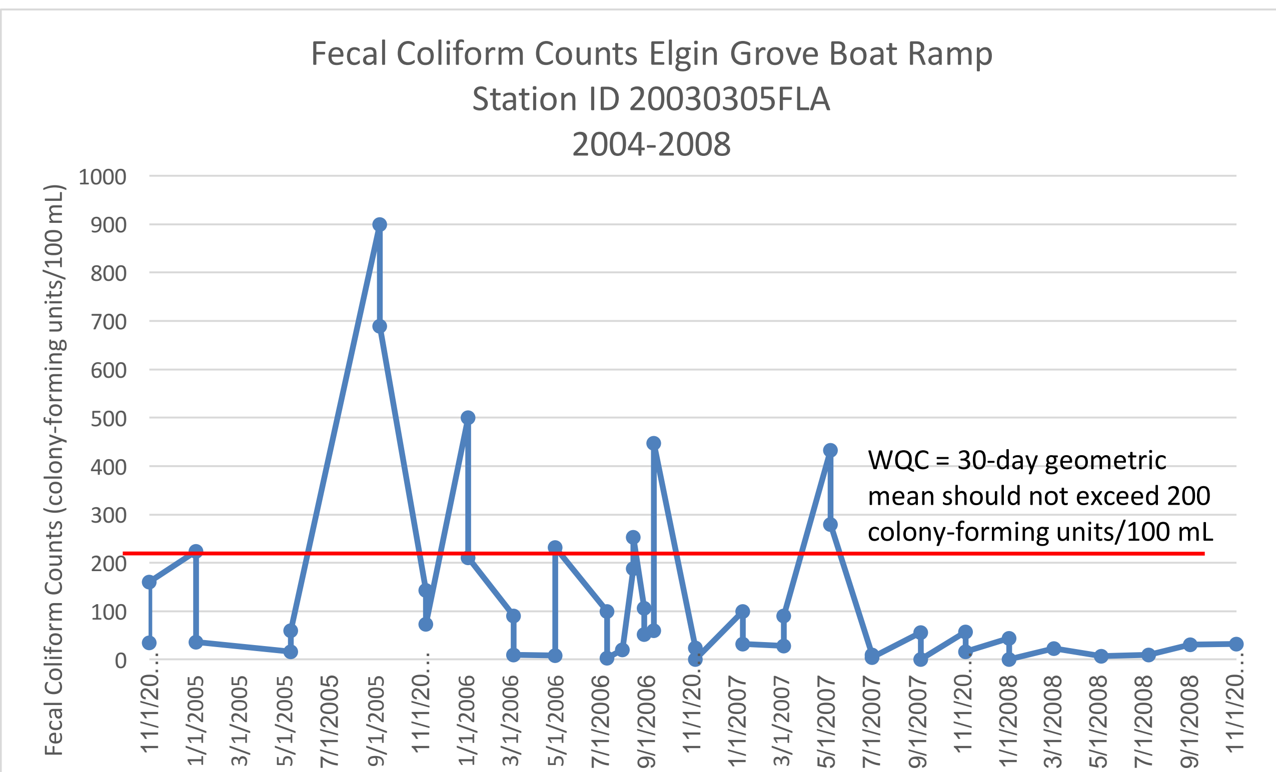
Fecal coliform data were taken through RAAG, but after 2008, levels were low and fecal coliform monitoring was halted. The graphs below show fecal coliform counts at each station of the LSJR RAAG program from 2004 to 2008. The STORET query gathering these data included dates through December 31, 2009, but no data after 2008 appeared.

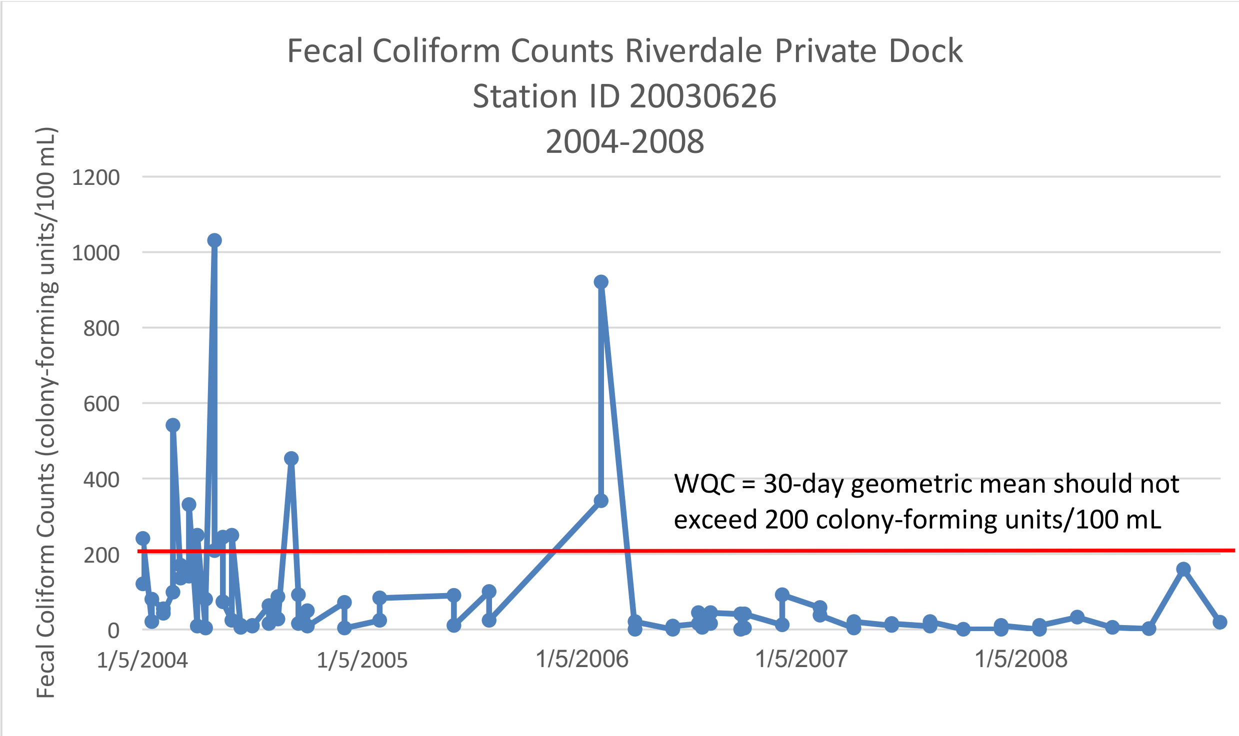
Station Name	Station ID
Welaka Public Boat Ramp	20030766
Browns Landing	20030768
Elgin Grove Boat Ramp	20030305FLA
Riverdale Private Dock	20030626
Orangedale Shands Fishing Pier	20030767
County Dock, Mandarin	20030458
Jacksonville Metro Park Marina	20030312FLA
Arlington Lions Club Boat Ramp	20030764

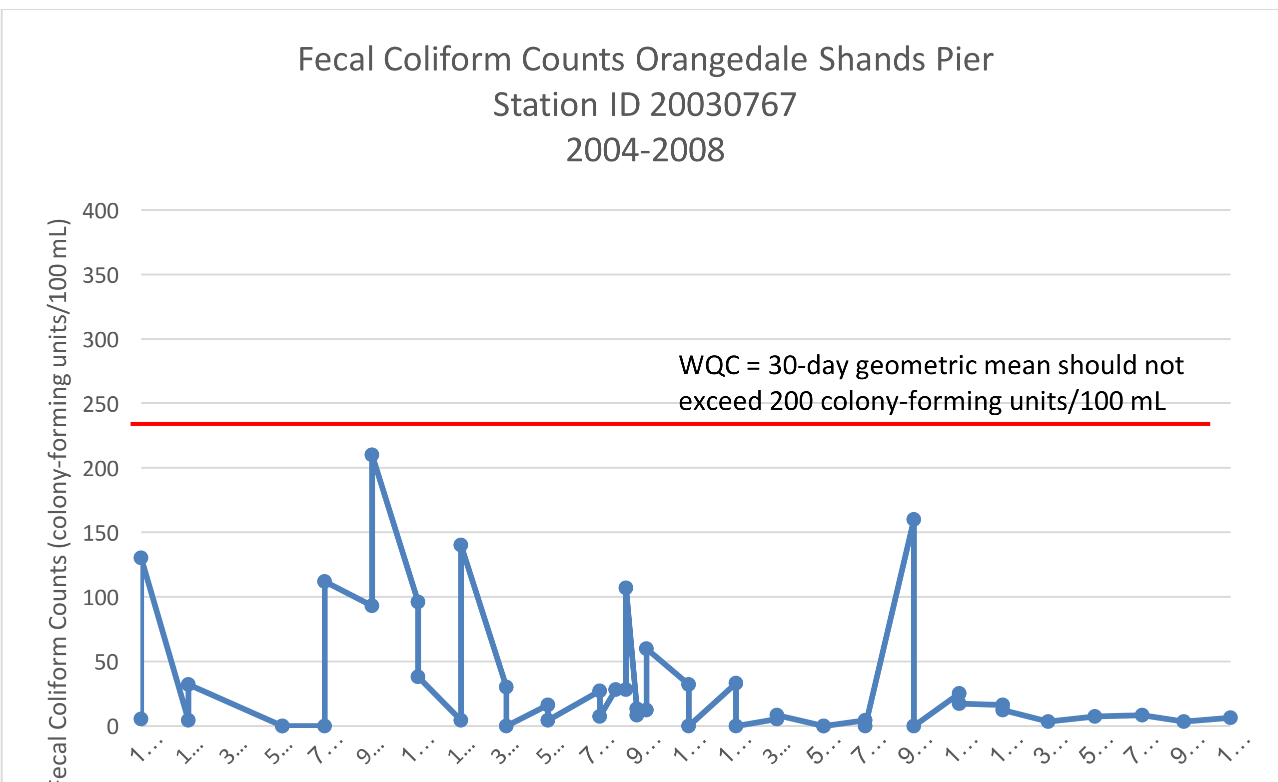
WQC means water quality criterion.

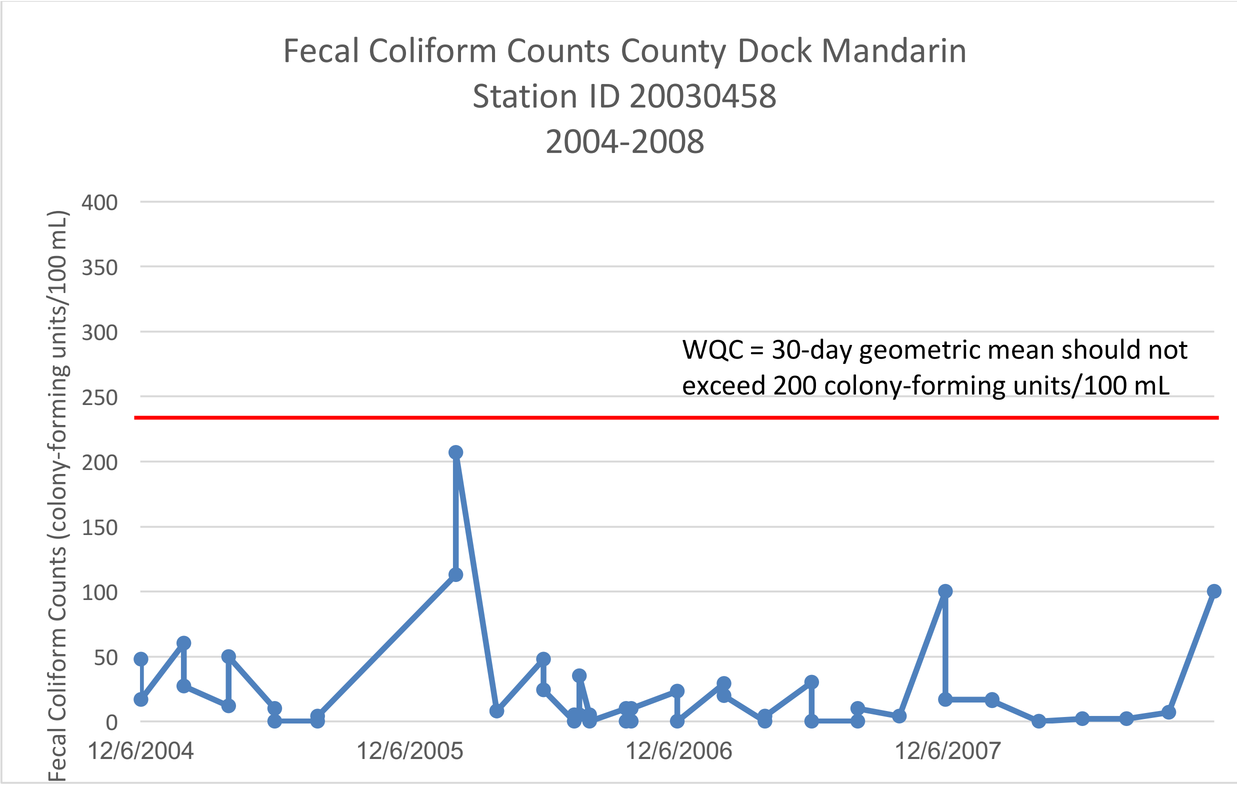


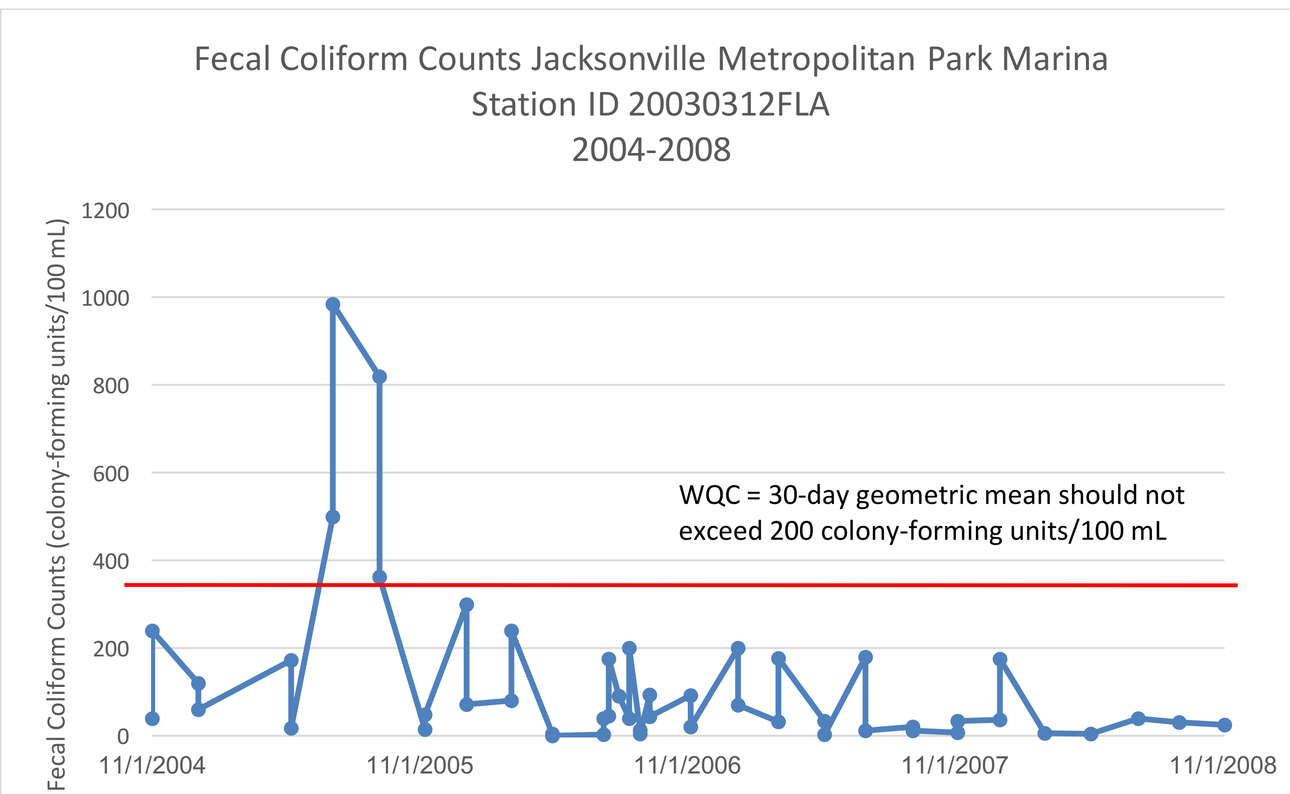

Fecal Coliform Counts at Browns Landing
Station ID 20030768
2004-2008
Fecal Coliform Counts (colony-forming units/100 mL)
0
50
100
150
200
250
300
350
400
450
500
12/6/2004
12/6/2005
12/6/2006
12/6/2007
WQC = 30-day geometric mean should not exceed 200 colony-forming units/100 mL

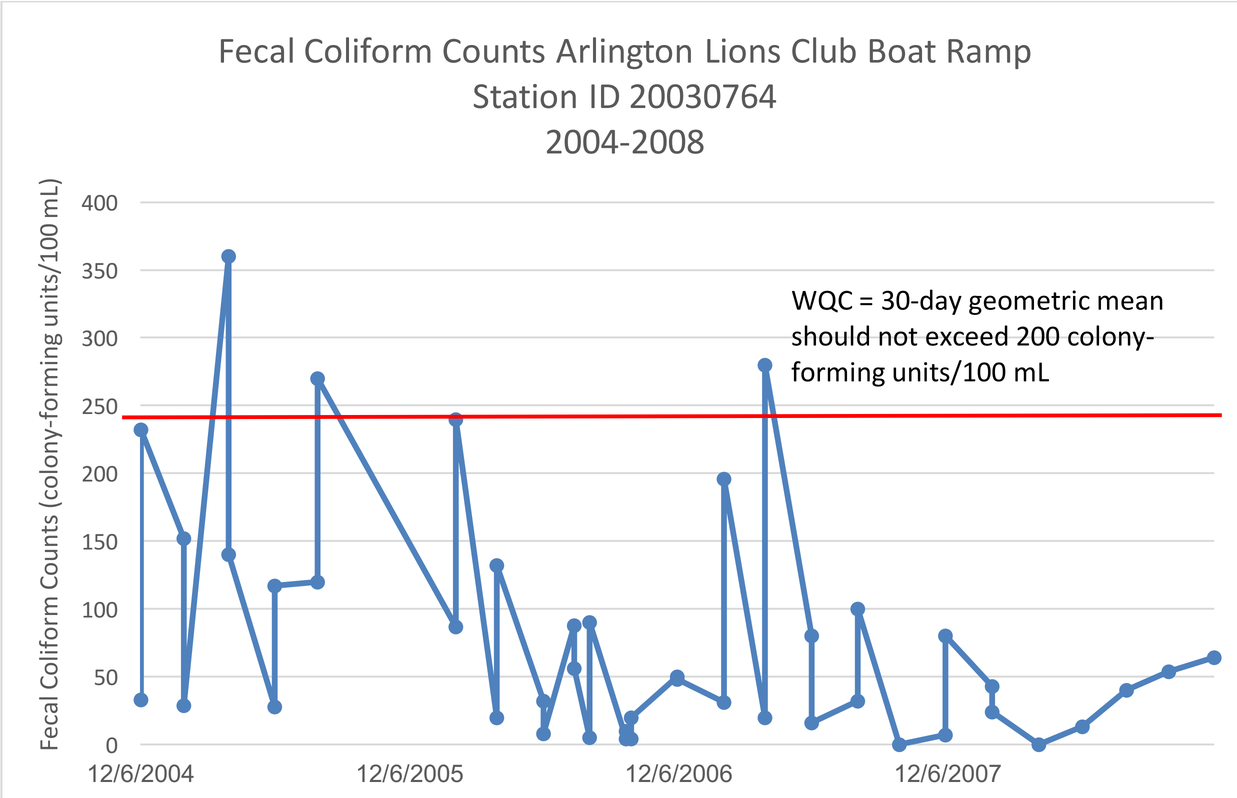

Fecal Coliform Counts Elgin Grove Boat Ramp
Station ID 20030305FLA
2004-2008
Fecal Coliform Counts (colony-forming units/100 mL)
0
100
200
300
400
500
600
700
800
900
1000
11/1/20…
1/1/2005
3/1/2005
5/1/2005
7/1/2005
9/1/2005
11/1/20…
1/1/2006
3/1/2006
5/1/2006
7/1/2006
9/1/2006
11/1/20…
1/1/2007
3/1/2007
5/1/2007
7/1/2007
9/1/2007
11/1/20…
1/1/2008
3/1/2008
5/1/2008
7/1/2008
9/1/2008
11/1/20…
WQC = 30-day geometric mean should not exceed 200 colony-forming units/100 mL


Fecal Coliform Counts Riverdale Private Dock
Station ID 20030626
2004-2008
Fecal Coliform Counts (colony-forming units/100 mL)
1200
1000
800
600
400
200
0
1/5/2004
1/5/2005
1/5/2006
1/5/2007
1/5/2008
WQC = 30-day geometric mean should not exceed 200 colony-forming units/100 mL


Fecal Coliform Counts Orangedale Shands Pier
Station ID 20030767
2004-2008
Fecal Coliform Counts (colony-forming units/100 mL)
400
350
300
250
200
150
100
50
0
WQC = 30-day geometric mean should not exceed 200 colony-forming units/100 mL


Fecal Coliform Counts County Dock Mandarin
Station ID 20030458
2004-2008
Fecal Coliform Counts (colony-forming units/100 mL)
400
350
300
250
200
150
100
50
0
12/6/2004
12/6/2005
12/6/2006
12/6/2007
WQC = 30-day geometric mean should not exceed 200 colony-forming units/100 mL

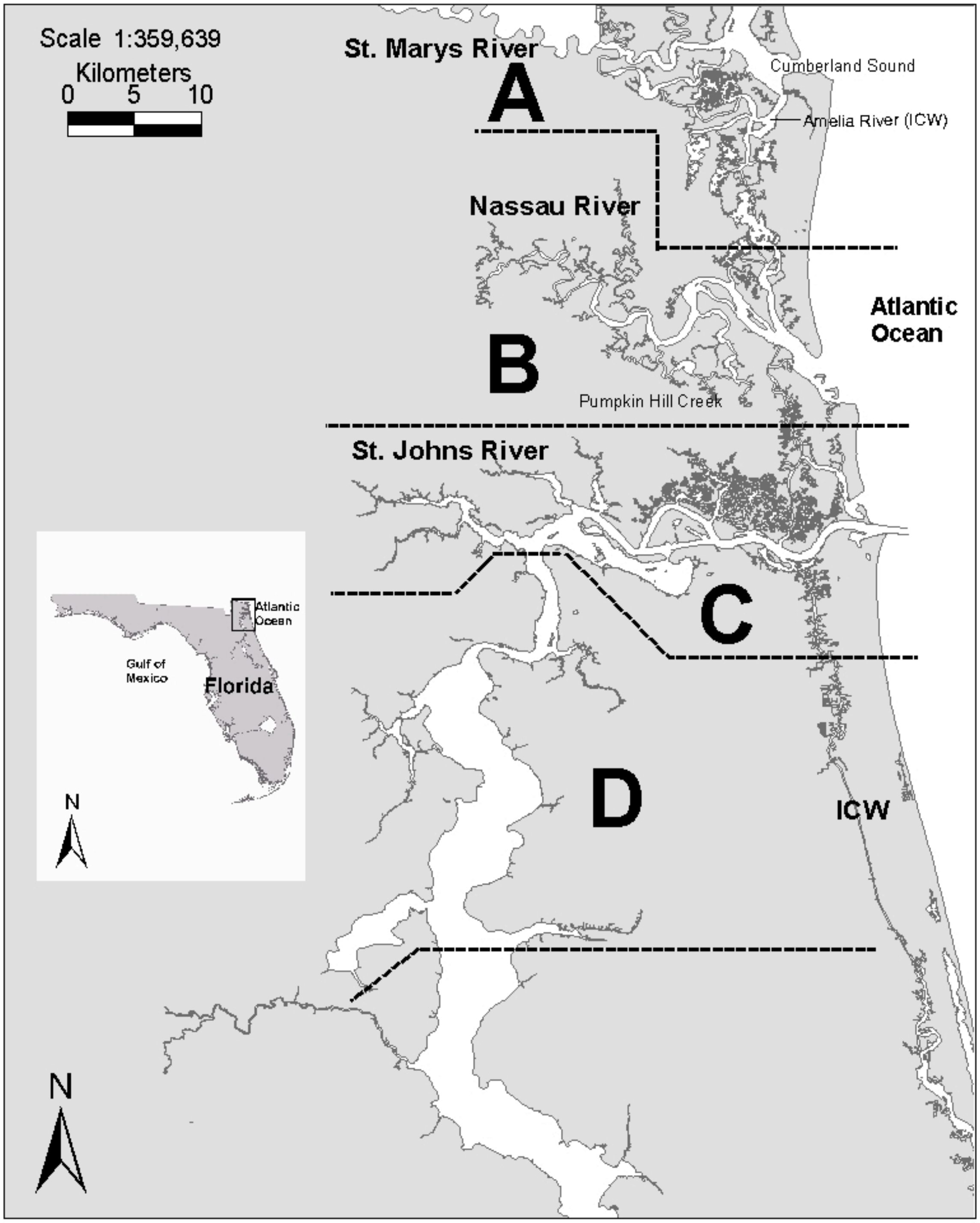

Fecal Coliform Counts Jacksonville Metropolitan Park Marina
Station ID 20030312FLA
2004-2008
Fecal Coliform Counts (colony-forming units/100 mL)
1200
1000
800
600
400
200
0
11/1/2004
11/1/2005
11/1/2006
11/1/2007
11/1/2008
WQC = 30-day geometric mean should not exceed 200 colony-forming units/100 mL


Fecal Coliform Counts Arlington Lions Club Boat Ramp
Station ID 20030764
2004-2008
Fecal Coliform Counts (colony-forming units/100 mL)
400
350
300
250
200
150
100
50
0
12/6/2004
12/6/2005
12/6/2006
12/6/2007
WQC = 30-day geometric mean should not exceed 200 colony-forming units/100 mL

3. Fisheries

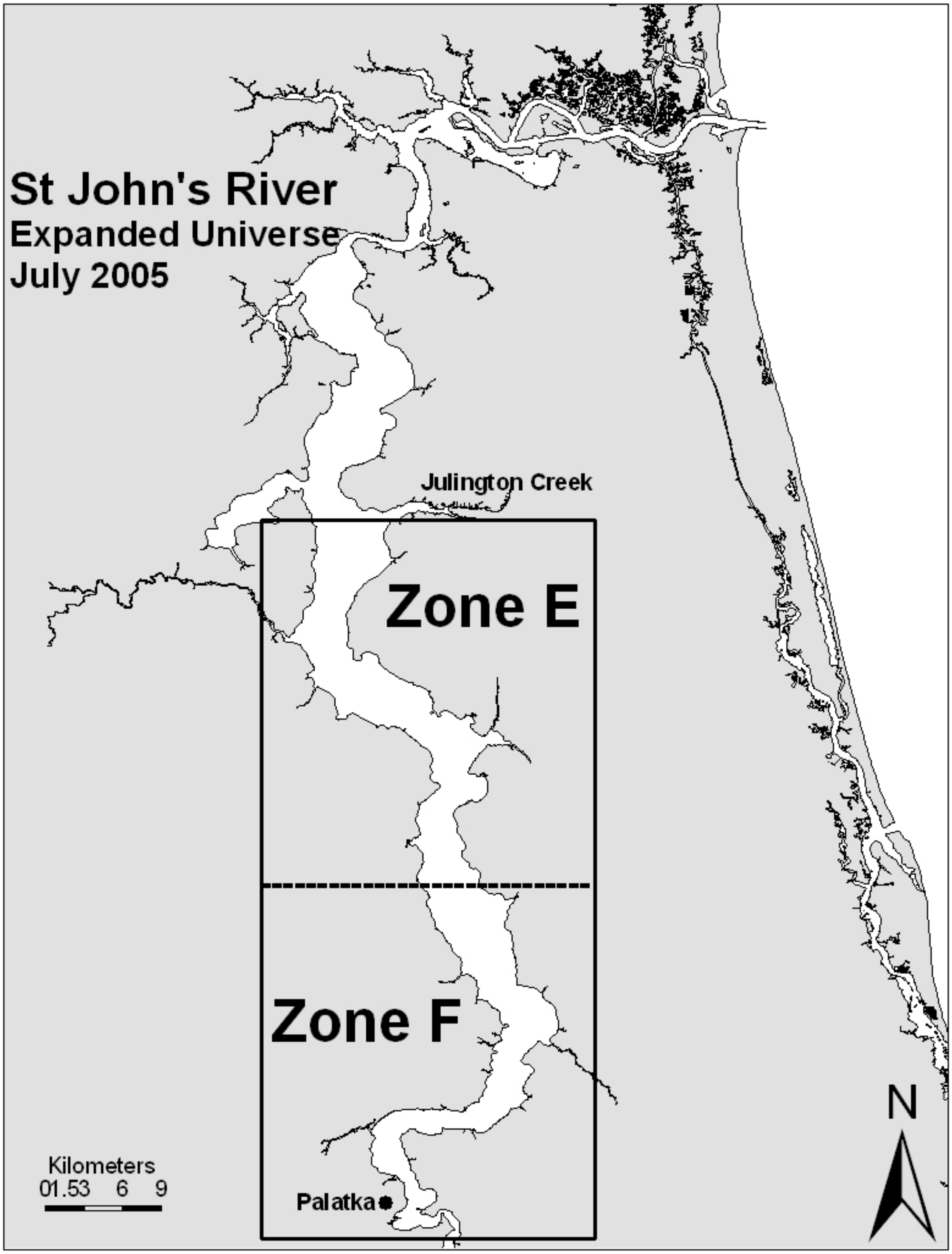
Appendix 3.1.1

Map of areas of St. Johns River sampled by Fish and Wildlife Institute from July 2005 – December 2020 (FWC-FWRI 2021). In this study, the north, middle and southern river sections are FWRI areas C, D, and E/F respectively.



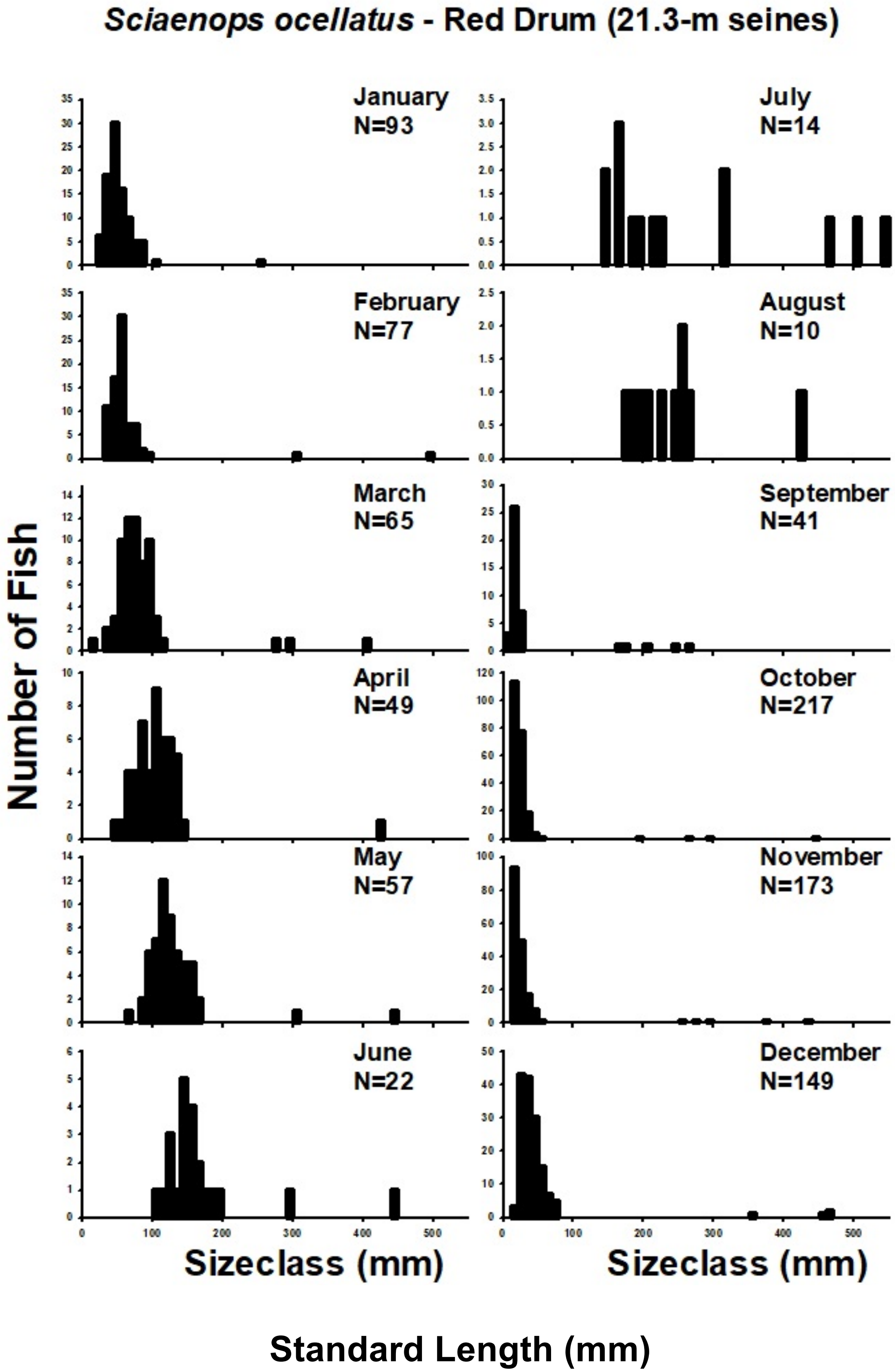
Appendix 3.1.2

Map of areas of St. Johns River sampled by Fish and Wildlife Institute from July 2005 – December 2020 (FWC-FWRI 2021). In this study, the north, middle and southern river sections are FWRI areas C, D, and E/F respectively.



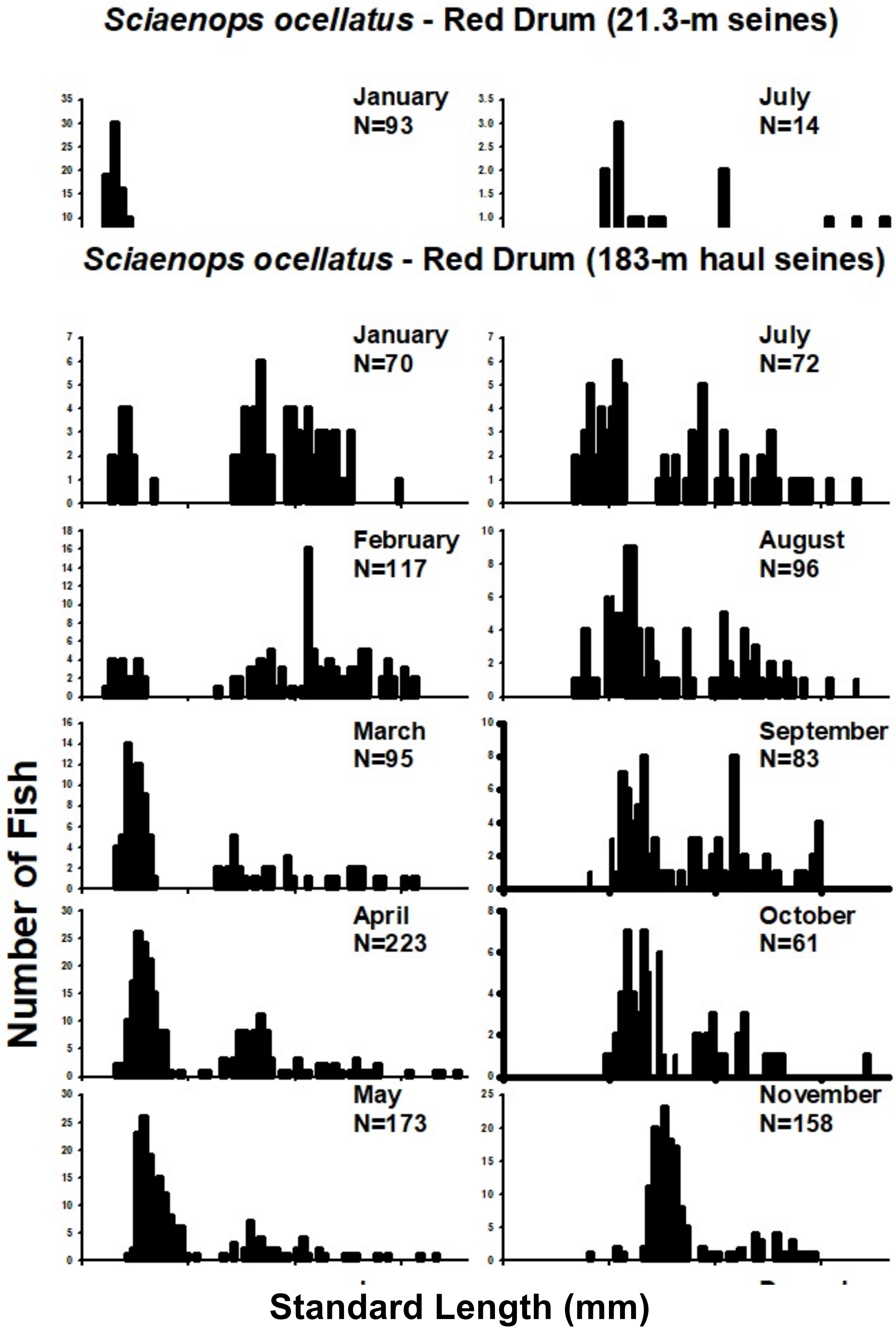
Appendix 3.2.3a

Length frequency diagrams for red drum caught in the lower St. Johns River from 2006 to 2020. All lengths are standard length (SL). The N value represents the number of fish collected for that month from 23.1 m seins.



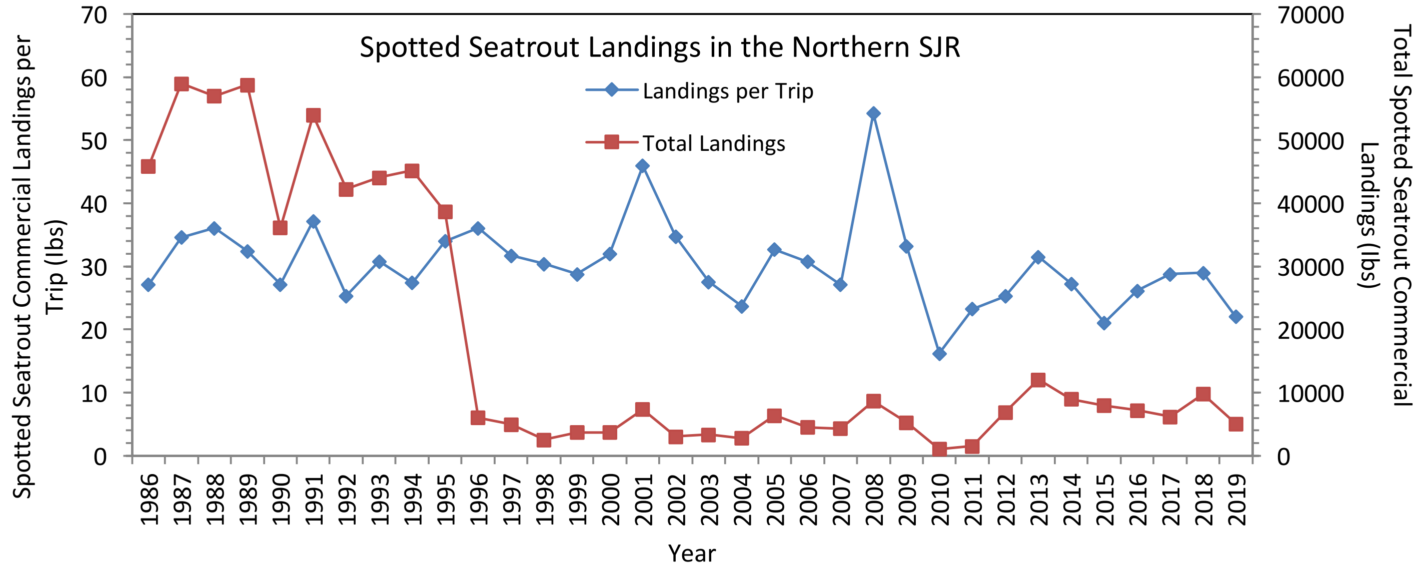
Appendix 3.2.3a

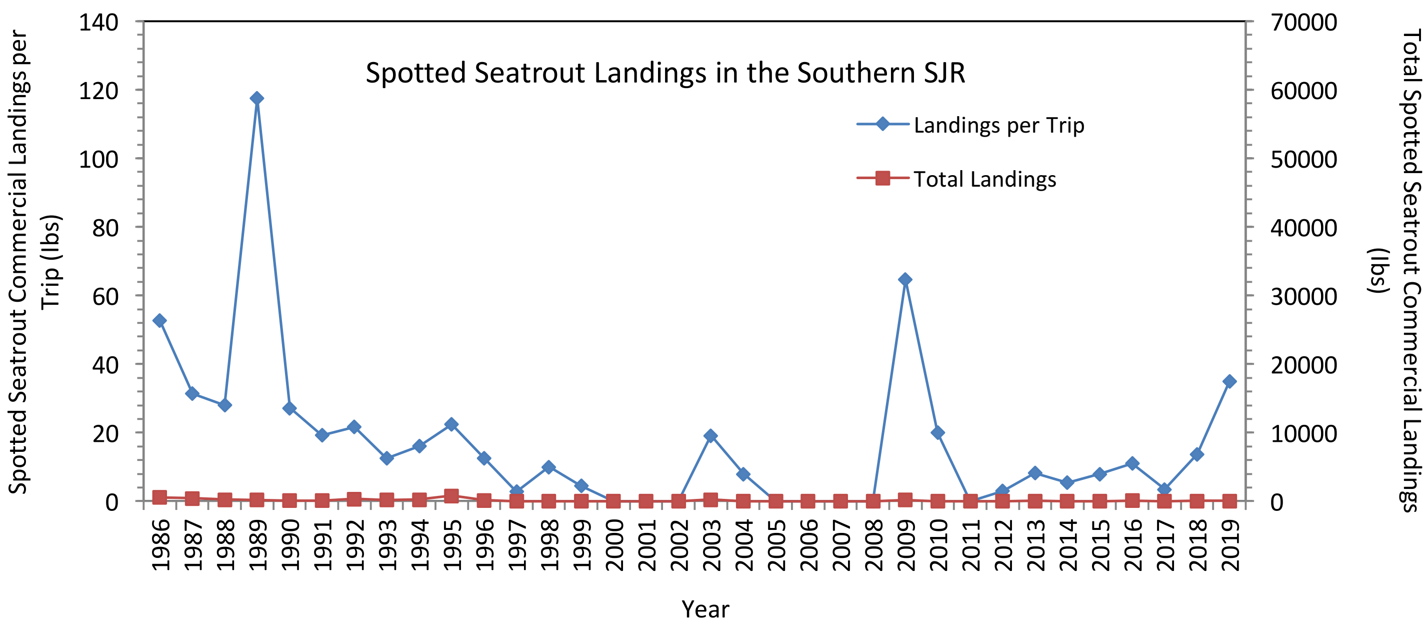
Length frequency diagrams for red drum caught in the lower St. Johns River from 2006 to 2019. All lengths are standard length (SL). The N value represents the number of fish collected for that month from 183 m haul seins.



Appendix 3.2.4a

Yearly comparison of spotted seatrout landings and landing per trip for the northern and southern sections of the lower St. Johns River from 1986 to 2019. Kendall Tau correlation analyses revealed total landings was negatively correlated for the south (τ =-0.336; p=0.003; n=34), north (τ =-0.319; p=0.004; n=34) and whole river (τ =-0.316; p=0.004; n=34) lower St. Johns River. There was a similar trend for catch per trips in the south (τ =-0.300 p=0.006; n=34), north (τ =-0.273; p=0.012; n=34) and whole (τ =-0.316; p=0.004; n=34) lower St. Johns River. Seatrout reported for the counties associated with the south section of the river likely were caught in the Intracoastal Waterway (ICW).

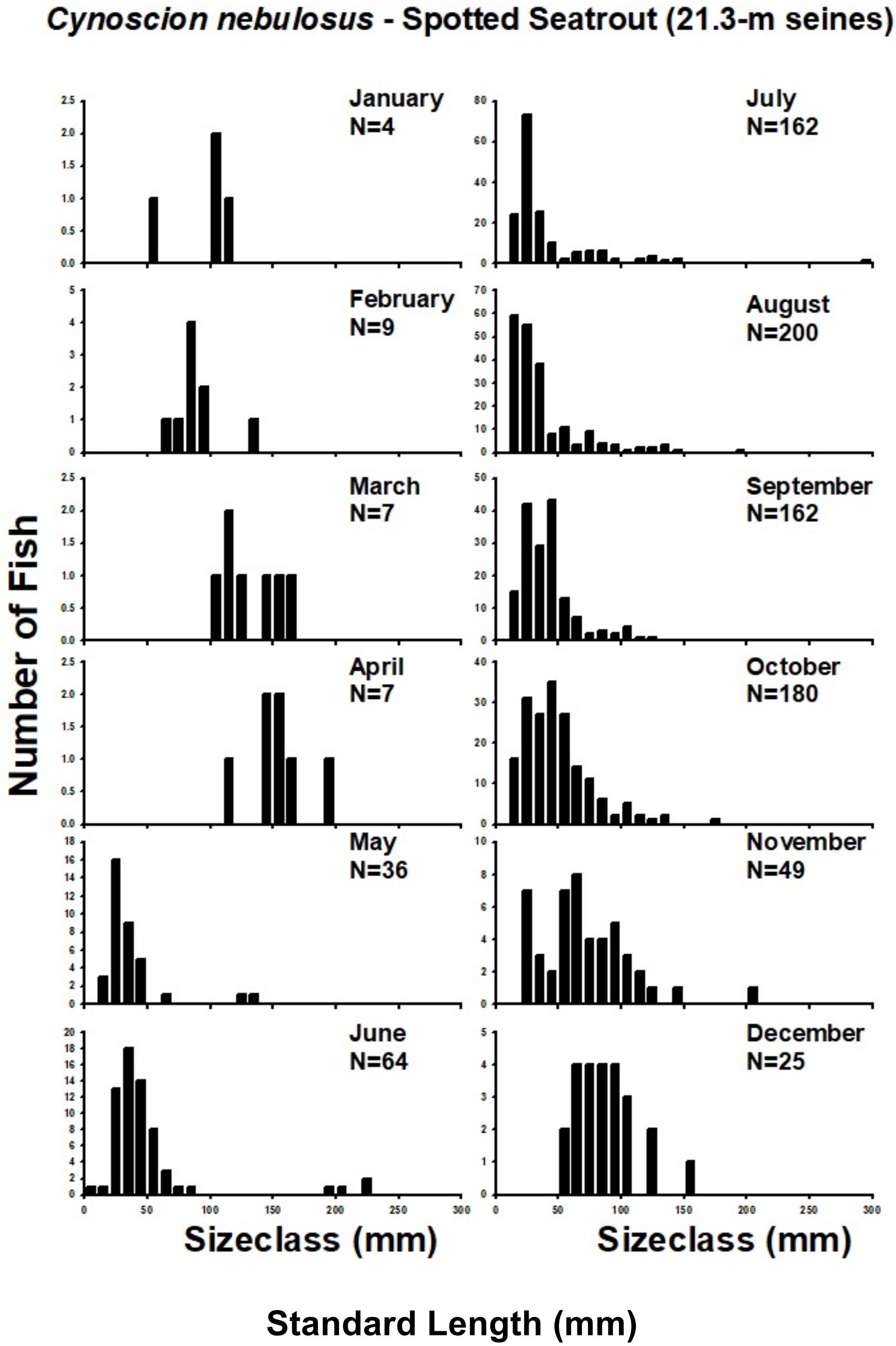




Yearly comparison of spotted seatrout landings and landing per trip for the northern and southern sections of the lower St. Johns River from 1994 to 2019. Kendall Tau correlation analyses revealed total landings was negatively correlated for the south (τ =-0.01; NS), positively correlated north (τ =0.1; NS) and whole river (τ =0.1; NS). There was no trend for catch per trip in the south (τ =-0.06; NS), a negative trend for the north (τ =-0.323; p=0.01; n=26) and whole river (τ =-0.342; p=0.007; n=26). Seatrout reported for the counties associated with the south section of the river likely were caught in the Intracoastal Waterway (ICW).

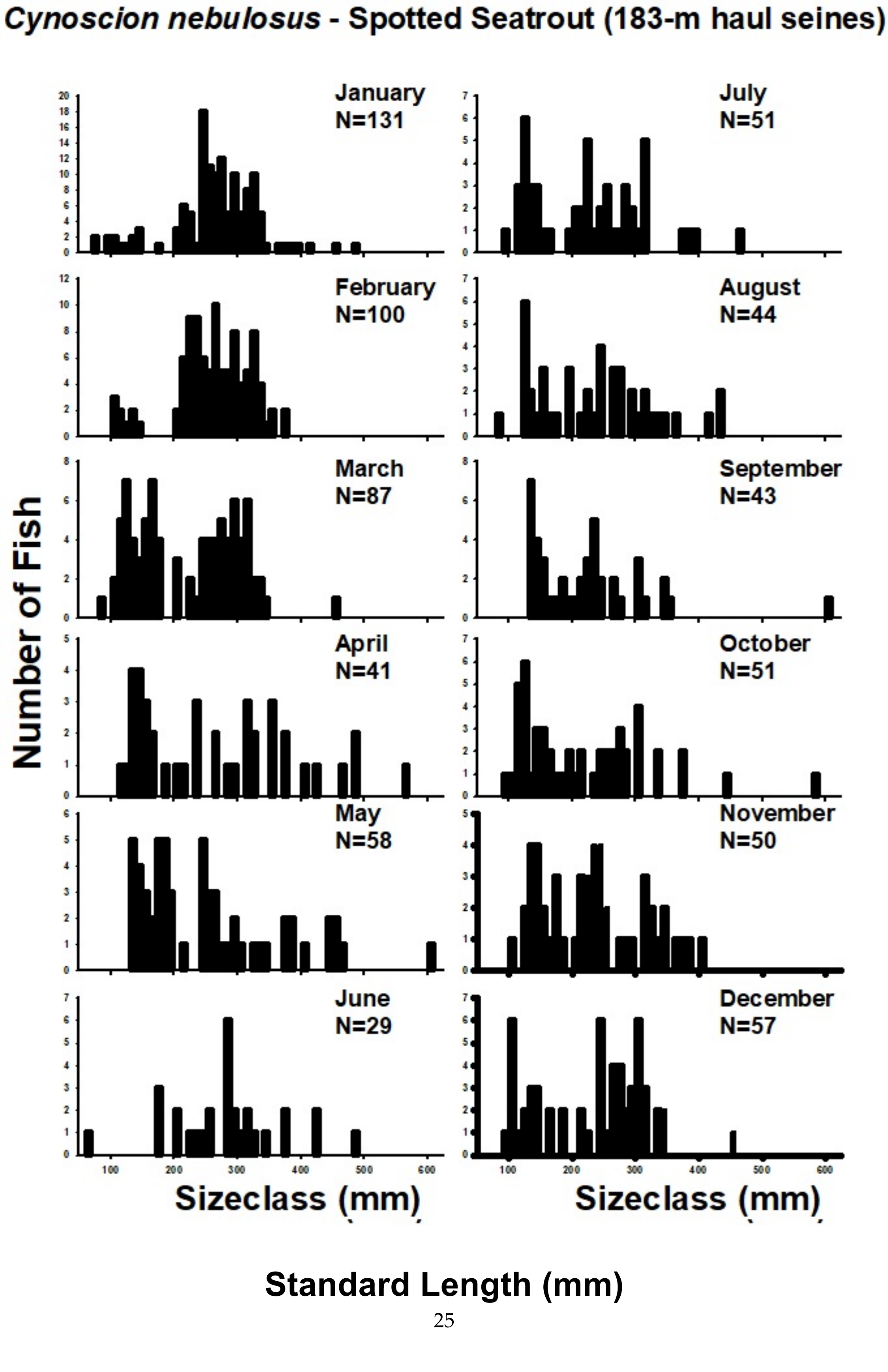
Appendix 3.2.4b

Length frequency diagrams for spotted seatrout caught in the lower St. Johns River from 2006 to 2020. All lengths are standard length (SL). The N value represents the number of fish collected for that month from 21.3 m seins.



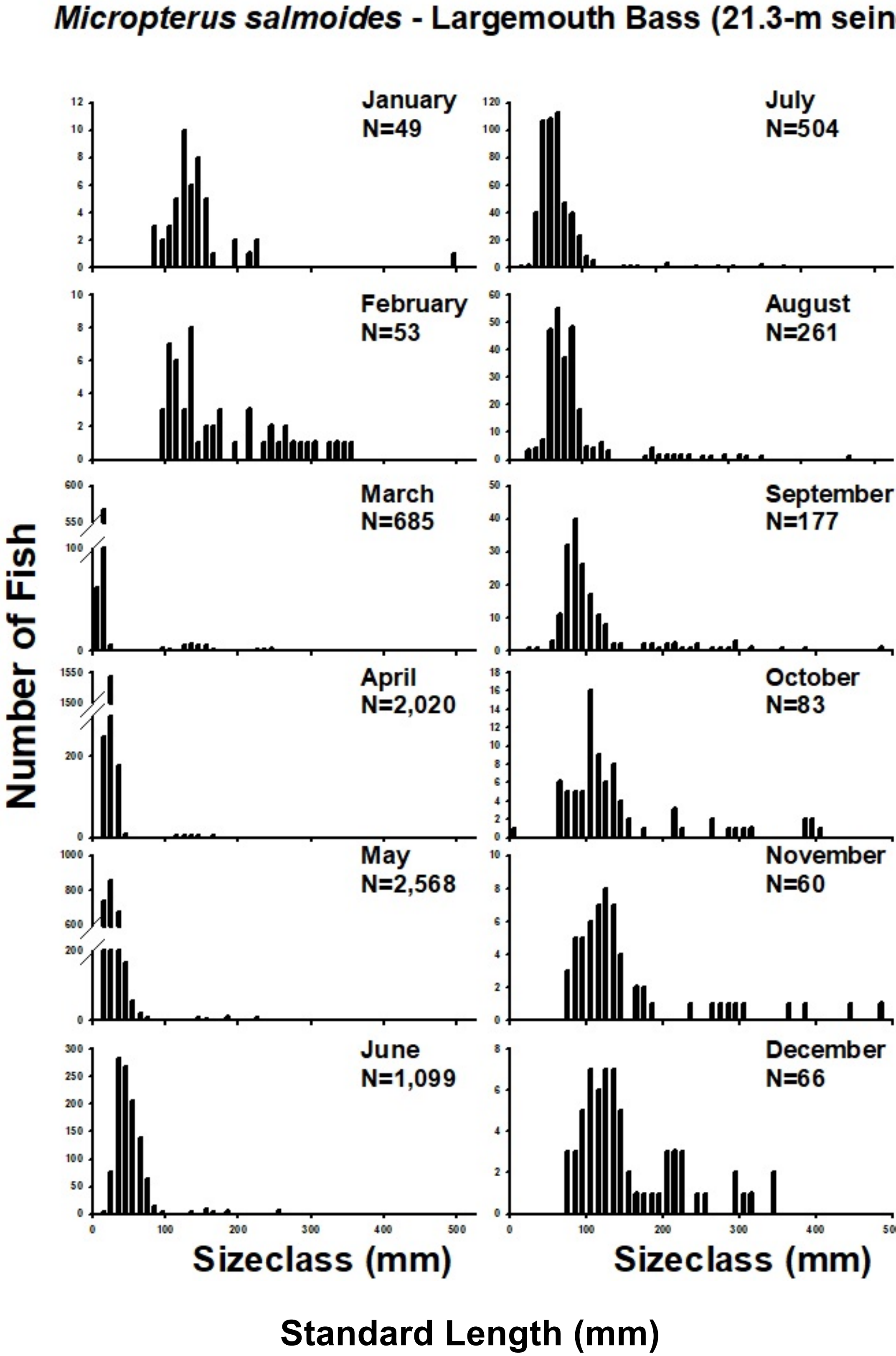
Appendix 3.2.4b

Length frequency diagrams for spotted seatrout caught in the lower St. Johns River from 2006 to 2020. All lengths are standard length (SL). The N value represents the number of fish collected for that month from 183 m haul seins.



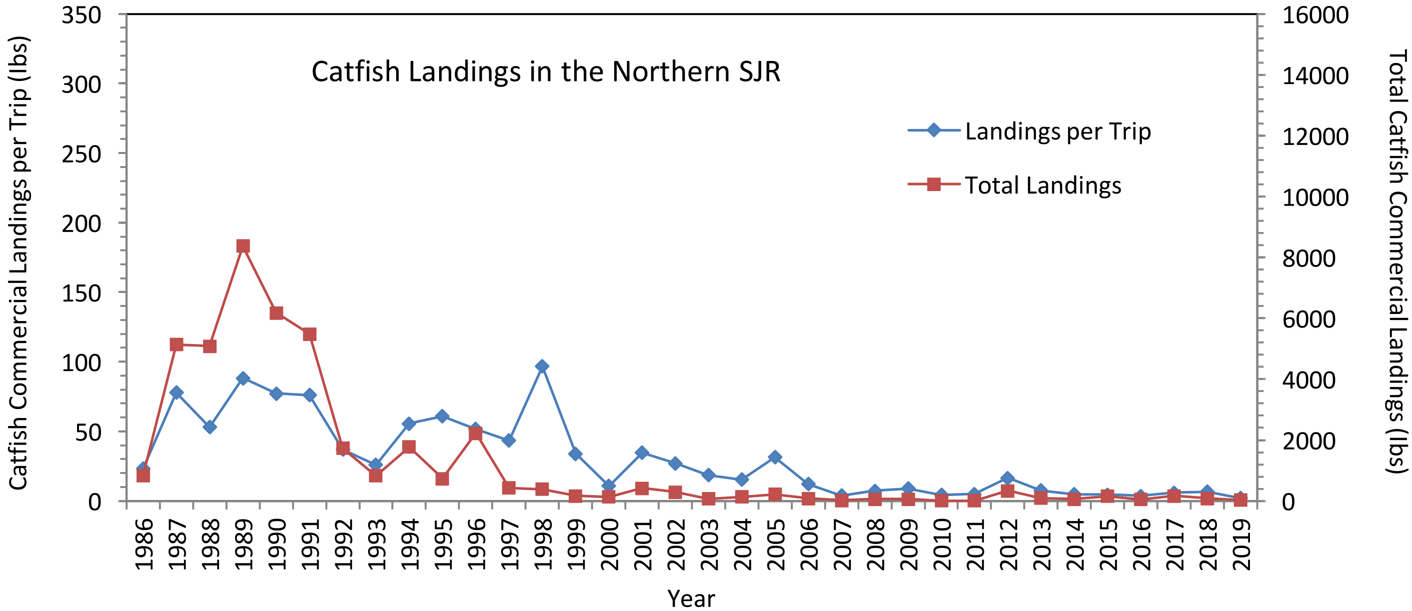
Appendix 3.2.5a

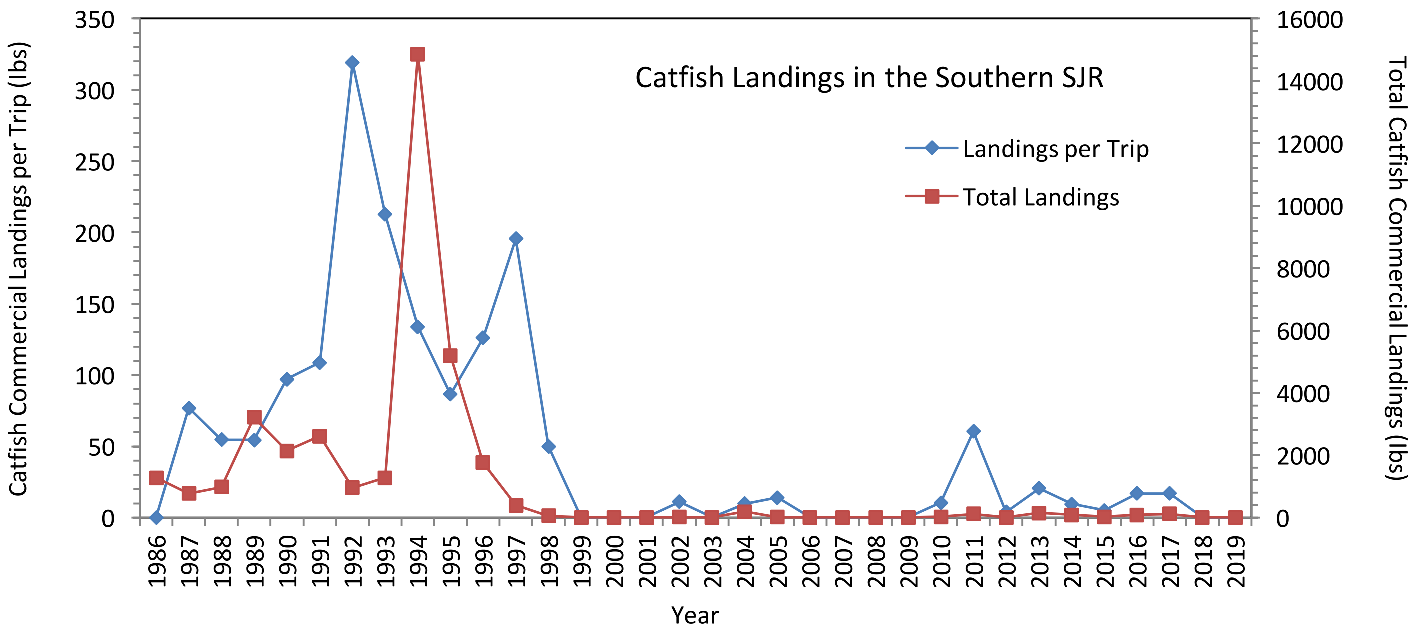
Length frequency diagrams for largemouth bass caught in the lower St. Johns River from 2006 to 2020. All lengths are standard length (SL). The N value represents the number of fish collected for that month from all gears.



Appendix 3.2.6a

Yearly comparison of commercial catfish landings and landing per trip for the northern and southern sections of the lower St. Johns River from 1986 to 2019. Kendall Tau correlation analyses revealed a decreasing trend in landings for the south (τ =-0.370; p=0.001; n=34), north (τ =-0.659; p=2.13E-08; n=34), and whole river (τ =-0.577; p=8.06E-07; n=34). Catch per landing showed a significant decreasing trend for the north (τ =-0.677; p=9.63E-09; n=34), south (τ =-0.315; p=0.004; n=34), and whole river (τ =-0.611; p=1.84E-07; n=34).

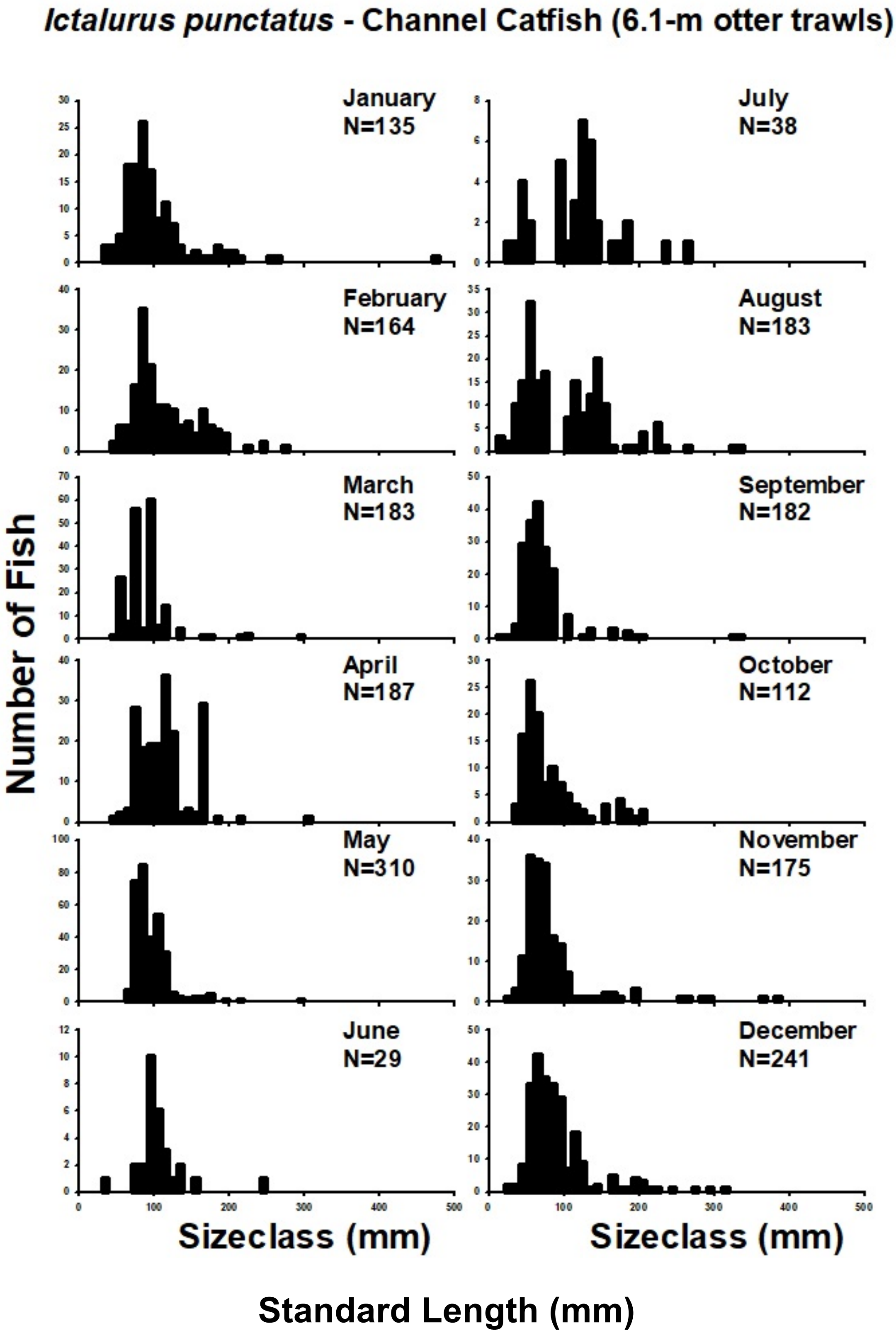




Yearly comparison of commercial catfish landings and landing per trip for the northern and southern sections of the lower St. Johns River from 1994 to 2019. Kendall Tau correlation analyses revealed a decreasing trend in landings for the south (τ =-0.126; NS), north (τ =-0.524; p=8.74-05; n=26), and whole river (τ =-0.444; p=0.0007; n=26). Catch per landing showed a significant decreasing trend for the north (τ =-0.692; p=3.5E-07; n=25), south (τ =-0.206; NS) and whole river (τ =-0.662; p=1.07E-06; n=26).

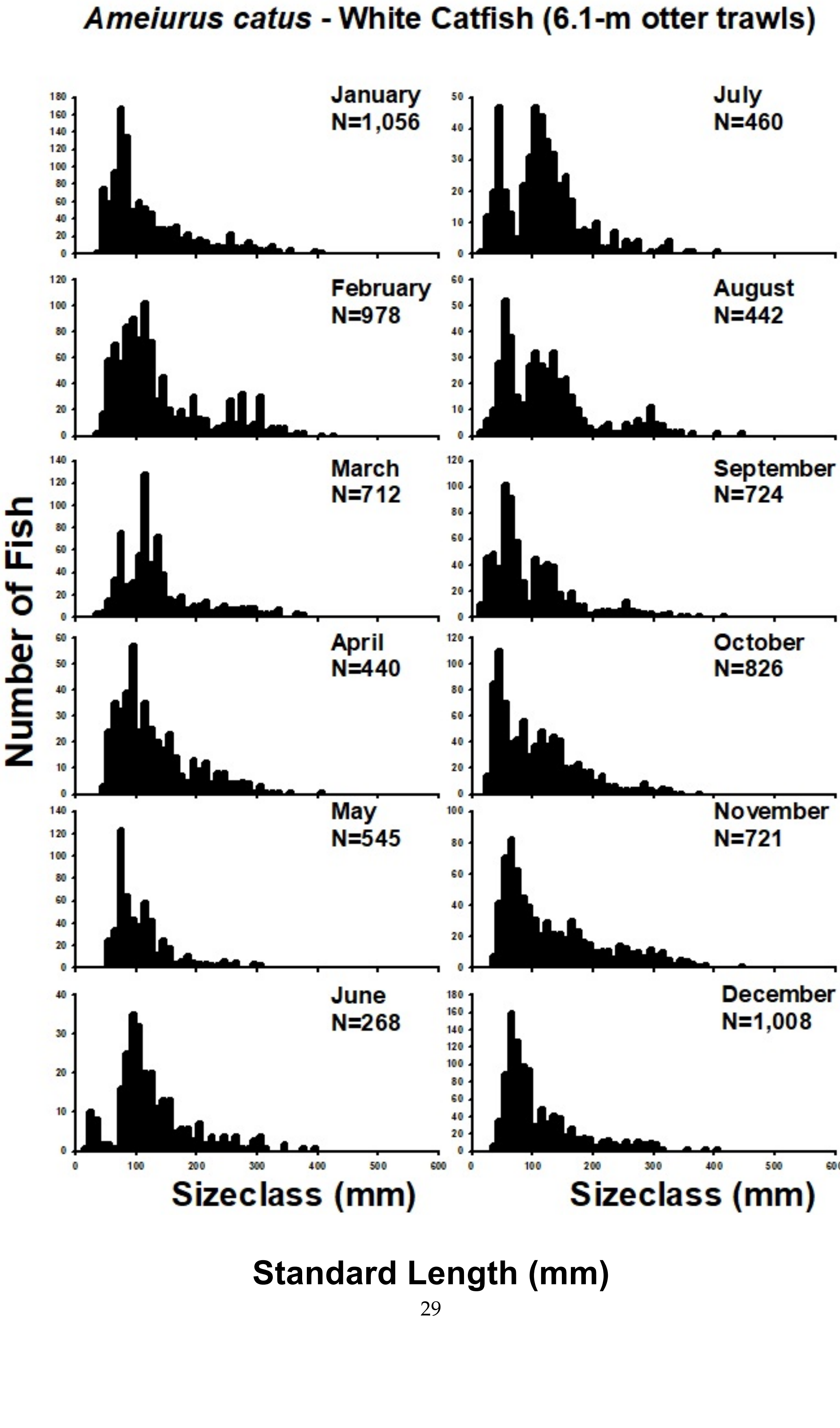
Appendix 3.2.6b

Length frequency diagrams for channel catfish caught in the lower St. Johns River from 2006 to 2020. All lengths are standard length (SL). The N value represents the number of fish collected for that month from 6.1 m otter trawls



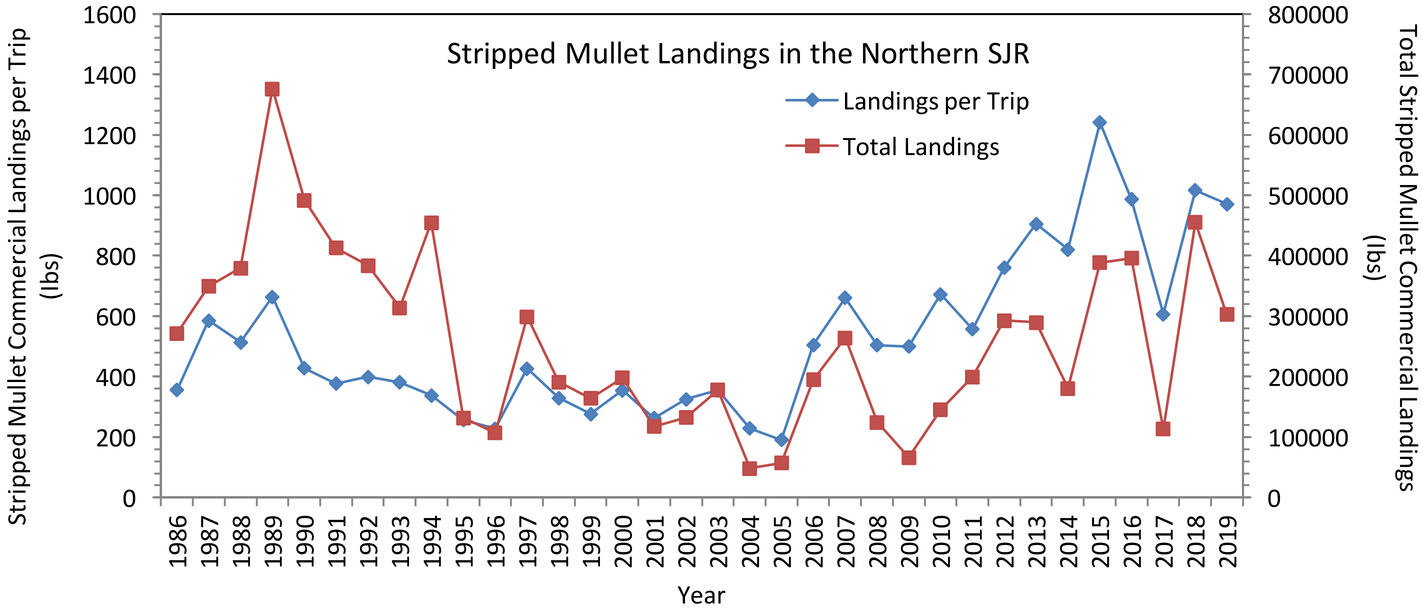
Appendix 3.2.6c

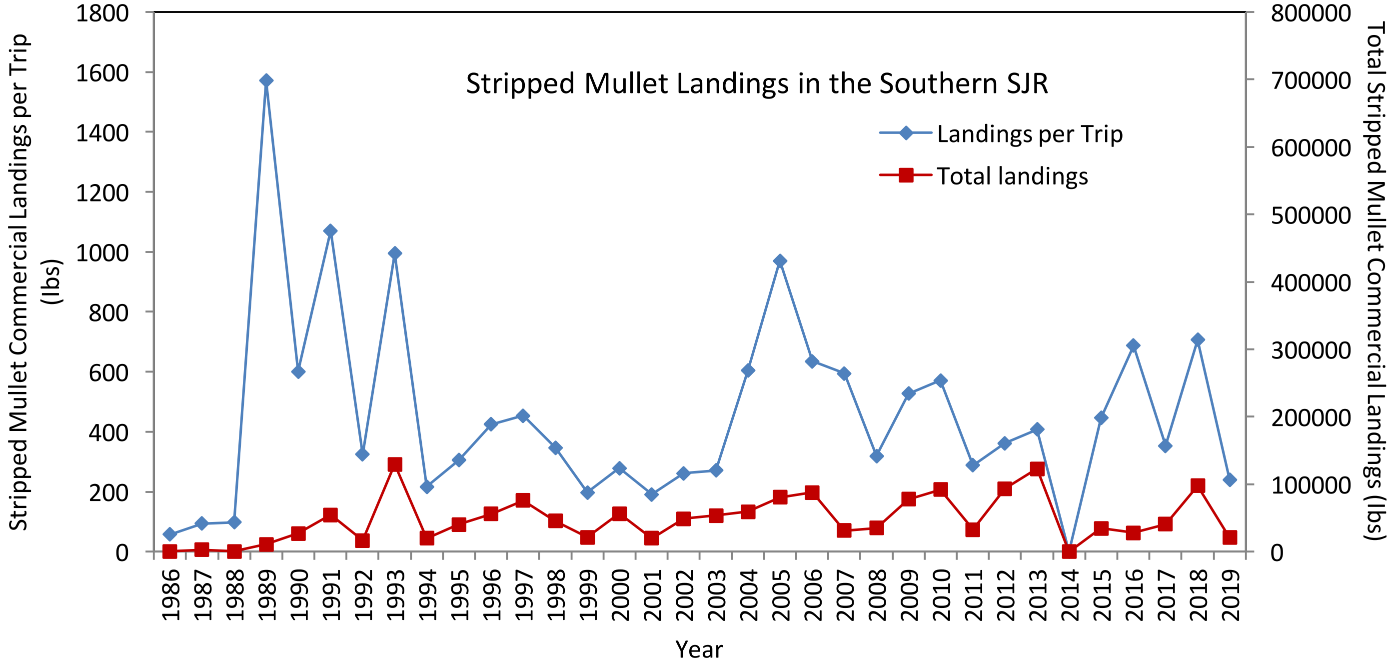
Length frequency diagrams for white catfish caught in the lower St. Johns River from 2006 to 2020. All lengths are standard length (SL). The N value represents the number of fish collected for that month from 6.1 m otter trawls.



Appendix 3.2.7a

Yearly comparison of commercial striped mullet landings and landing per trip for the northern and southern sections of the lower St. Johns River from 1986 to 2019. Kendall Tau correlation analyses revealed a decreasing trend in commercial landings for the north (τ=-0.134; NS), increasing trend in the south (τ=0.387; p=0.0006; n=34), and decreasing trend in the whole river, but this was not significant (τ=-0.08; NS). Catch per trip showed an increasing trend for the north (τ=0.355; p=0.002; n=34), south (τ=0.455; p=7.83E-05; n=34), and overall (τ=0.358; p=0.001; n=34).

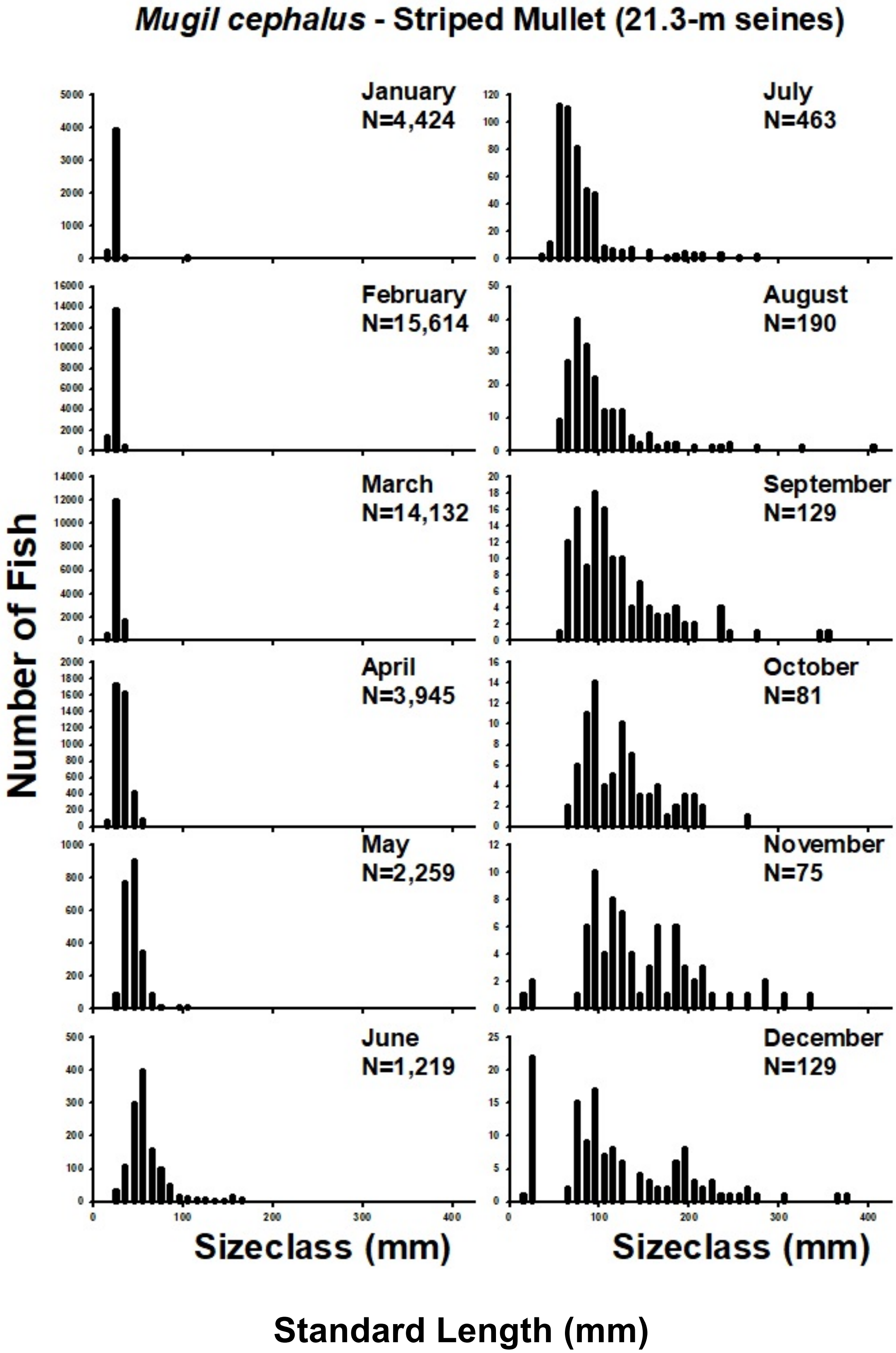




Yearly comparison of commercial striped mullet landings and landing per trip for the northern and southern sections of the lower St. Johns River from 1994 to 2019. Kendall Tau correlation analyses revealed a positive trend in commercial landings for the north (τ=0.268; p=0.03, n=26), south (τ=0.231; p=0.05, n=26), and the whole river (τ=0.268; p=0.03; n=26). Catch per trip showed a significant increasing trend for the north (τ=0.637; p=2.53E-06; n=26), south (τ=0.446; p=0.0007; n=26), and whole river (τ=0.668; p=8.63E-07; n=26).

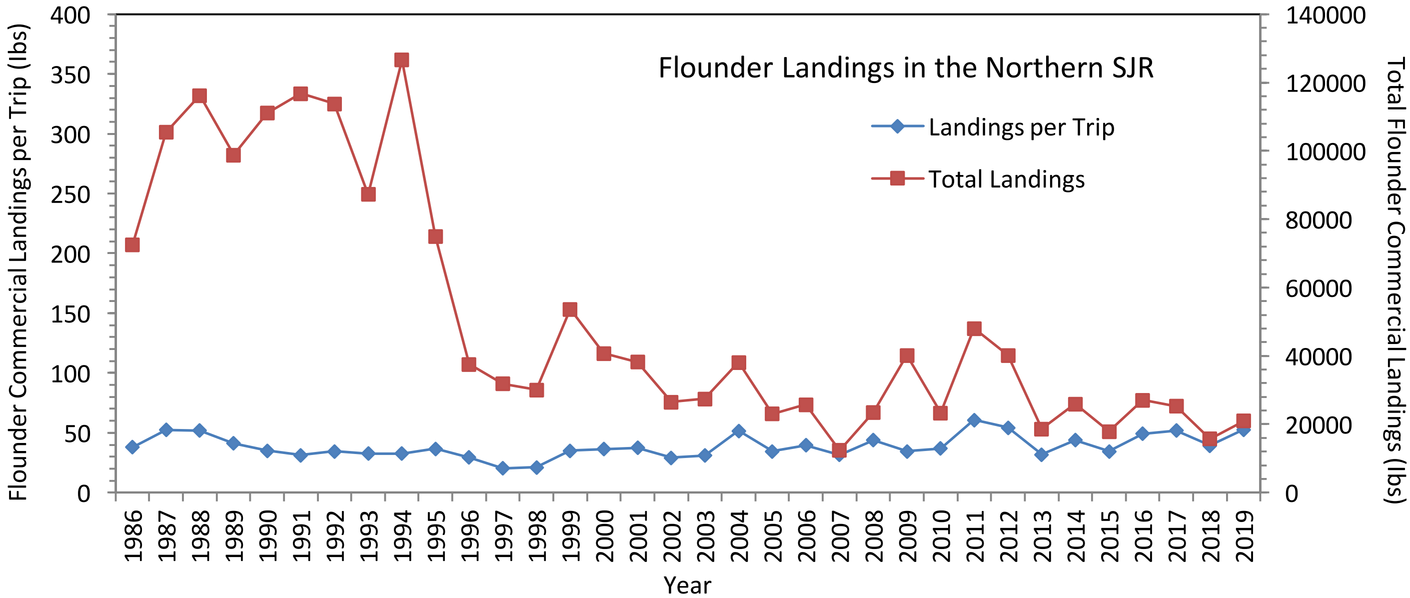
Appendix 3.2.7b

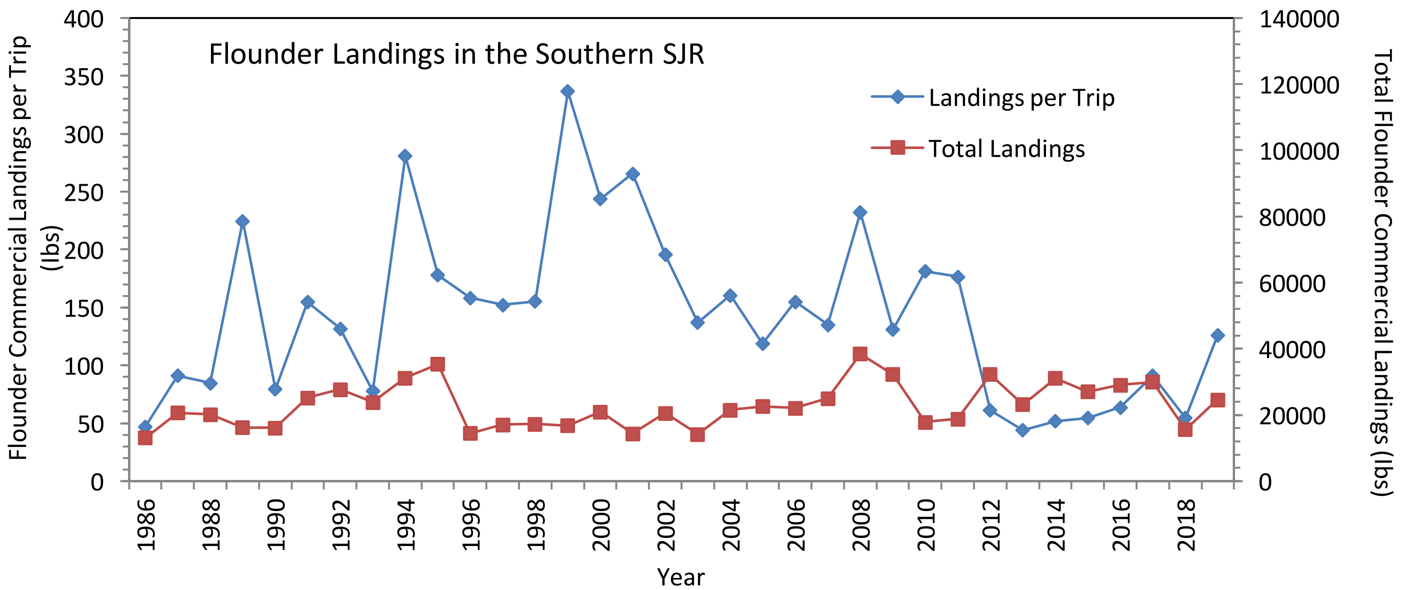
Length frequency diagrams for striped mullet caught in the lower St. Johns River from 2006 to 2020. All lengths are standard length (SL). The N value represents the number of fish collected for that month from 21.3 m seins.



Appendix 3.2.8a

Yearly comparison of southern flounder landings and landing per trip for the northern and southern sections of the lower St. Johns River from 1986 to 2019. Kendall tau correlation analyses revealed decreasing trends in commercial landings in the north (τ =-0.603; p=2.65E-07; n=34), and whole river (τ =-0.471; p=4.48E-05; n=34). There was an increasing trend in the south (τ =0.253; 0.0176; n=34). Catch per landing showed no trends for the north (τ =0.187; NS), or south (τ =-0.169; N.S.) but a decreasing trend for the whole river (τ =-0.223; p=0.032; n=34).

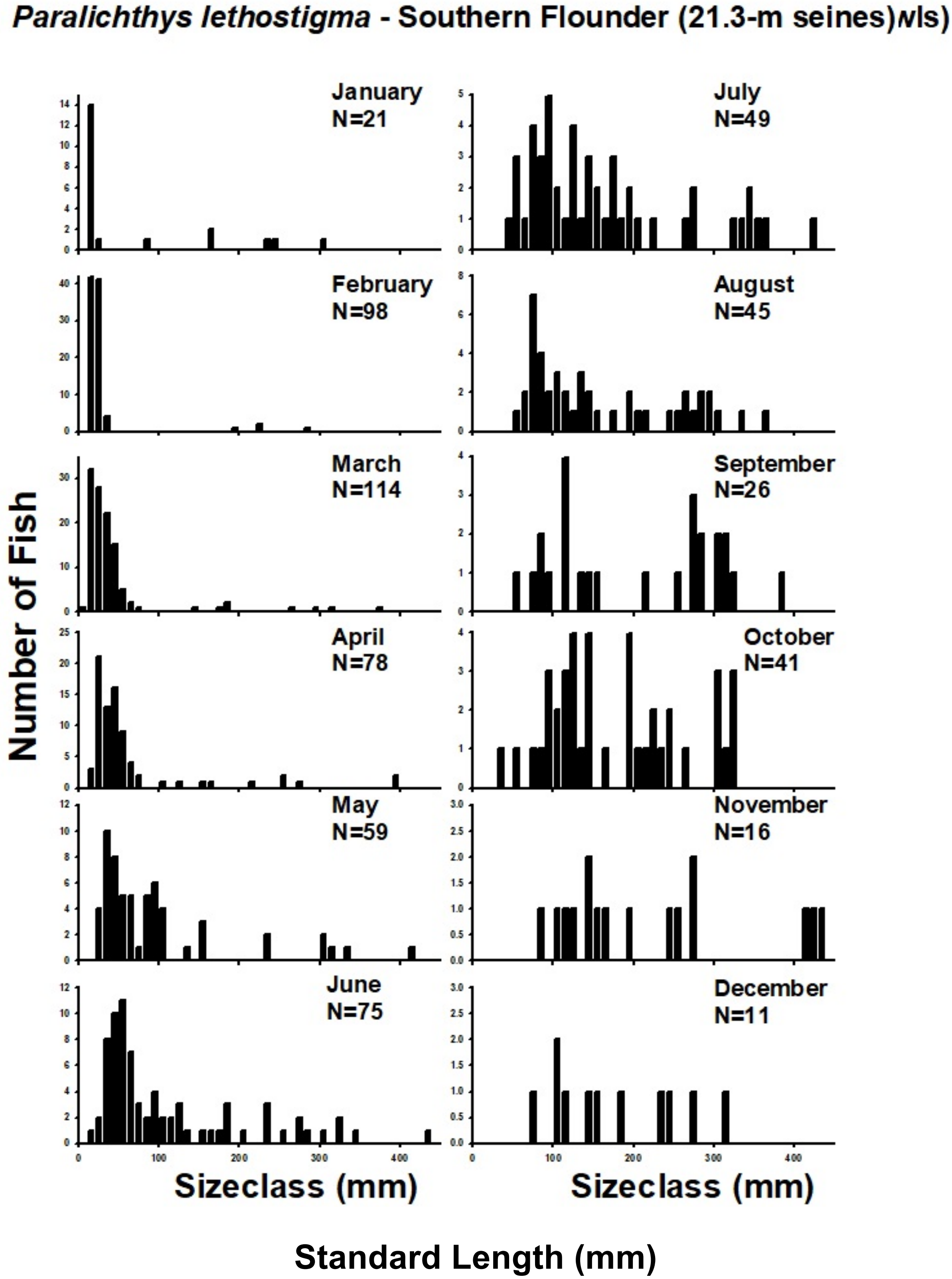




Yearly comparison of southern flounder landings and landing per trip for the northern and southern sections of the lower St. Johns River from 1994 to 2019. Kendall tau correlation analyses revealed decreasing trends in commercial landings in the north (τ =-0.475; p=0.0003; n=26), an increasing trend in the south (τ =0.234; p=0.05; n=26). Overall river sections there was a negative correlation (τ =-0.253; p=0.04; n=26). Catch per trip showed an increasing trend in the north (τ =0.428; p=0.001; n=26). The trend was negative in the south (τ =-0.514; p=0.0001; n=26) and whole river (τ =-0.526; p=8.19E-05; n=26).

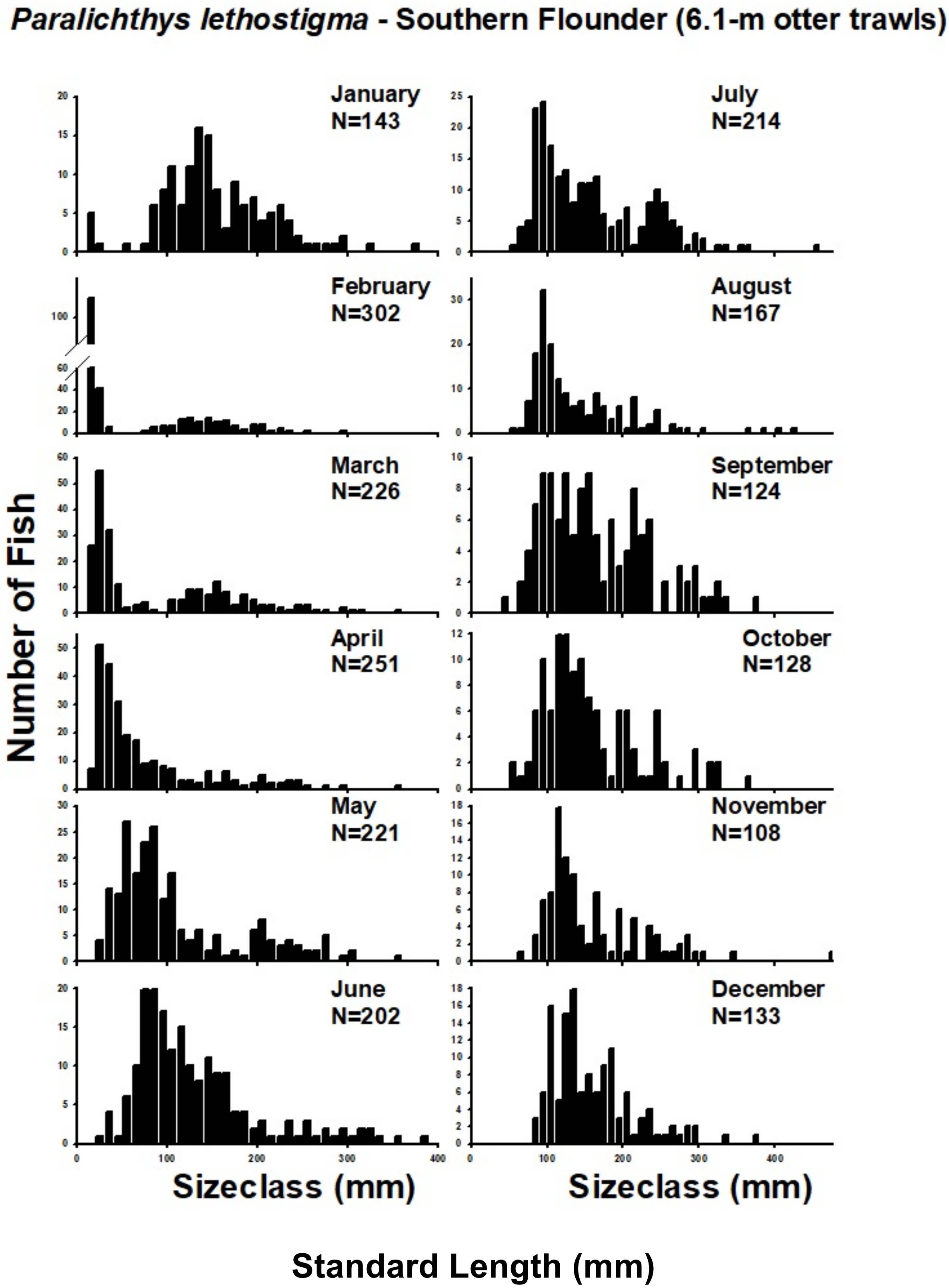
Appendix 3.2.8b

Length frequency diagrams for flounder caught in the lower St. Johns River from 2006 to 2020. All lengths are standard length (SL). The N value represents the number of fish collected for that month from 21.3 m seins.



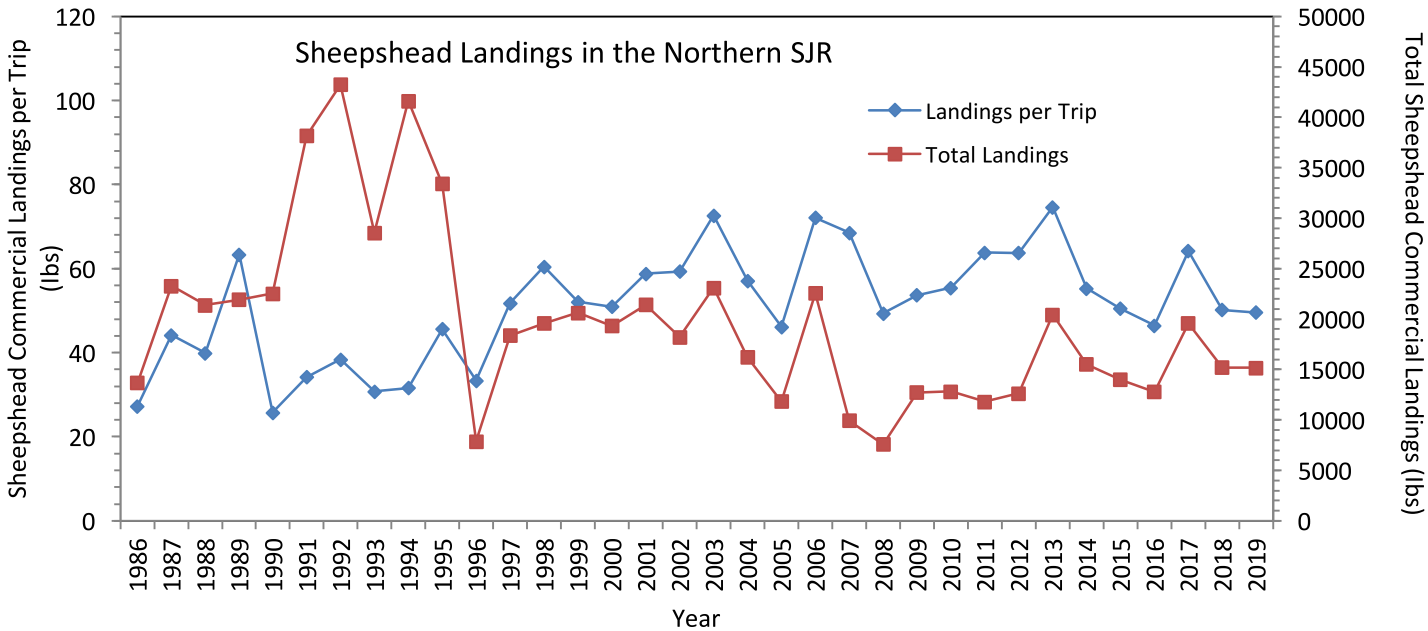
Appendix 3.2.8b

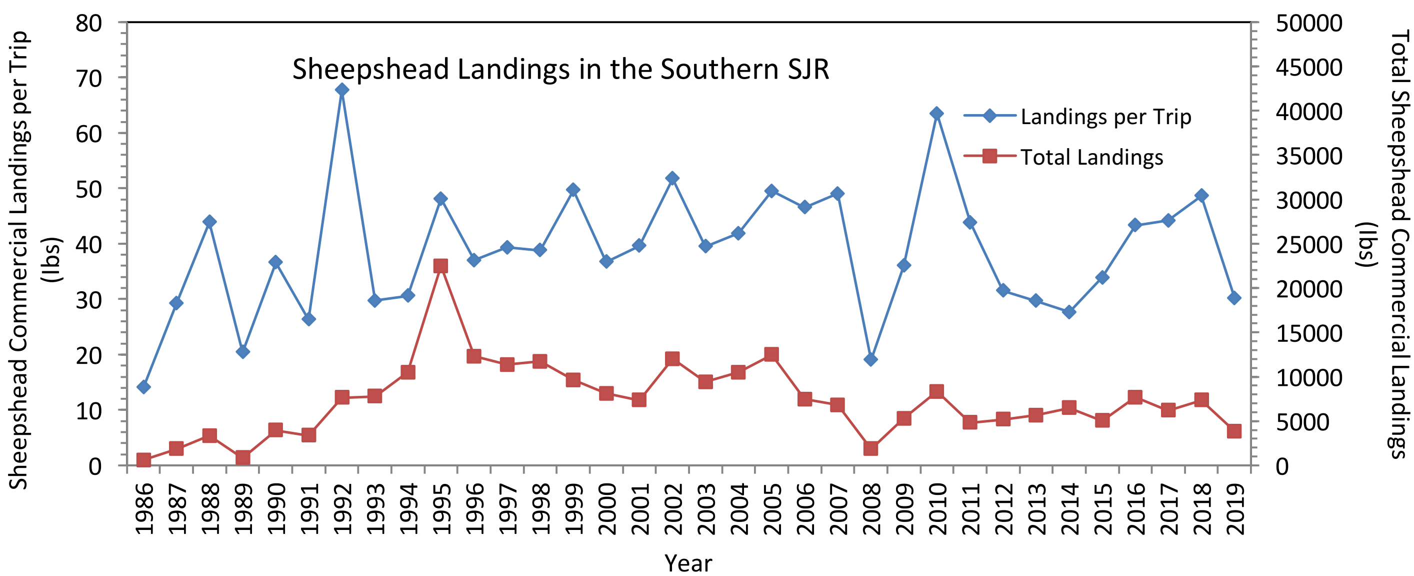
Length frequency diagrams for flounder caught in the lower St. Johns River from 2006 to 2020. All lengths are standard length (SL). The N value represents the number of fish collected for that month from 6.1 m otter trawls.



Appendix 3.2.9a

Yearly comparison of sheepshead landings and landings per trip for the northern and southern sections of the lower St. Johns River from 1986 to 2019. Landings were significantly negatively correlated in the north (τ =-0.351; p=0.0017; n=34), negatively correlated in the south, not significant (τ =-0.005; NS), and negatively correlated over the whole river (τ =-0.305; p=0.006; n=34). There were no statistically significant trends in the south river section for landings per trip (τ =0.148; NS). However, landings per trip indicated a significant positive trend for the north (τ =0.355; p=0.0016; n=34), and whole river (τ =0.294; p=0.007; n=34).

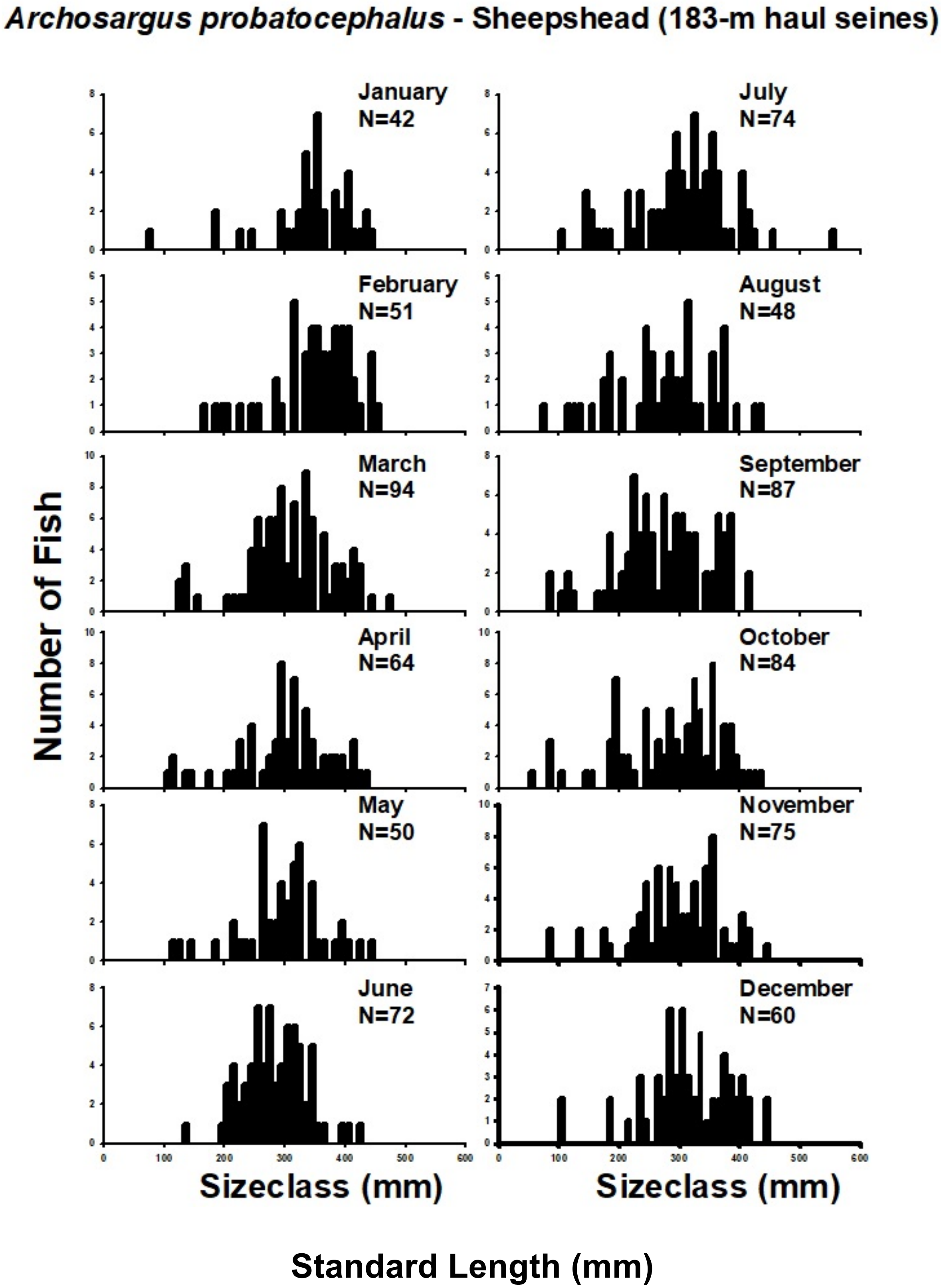




Yearly comparison of sheepshead landings and landings per trip for the northern and southern sections of the lower St. Johns River from 1994 to 2019. There were significant decreasing trends for landings in the north (τ =-0.231; p=0.05; n=26), south ((τ =-0.532; p=6.86E-05; n=26), and whole river (τ =-0.446; p=0.0007; n=26). Landings per trip had no trend for the north (τ =0.151; NS), south ((τ =-0.05; NS), and the whole river (τ =0.089; NS).

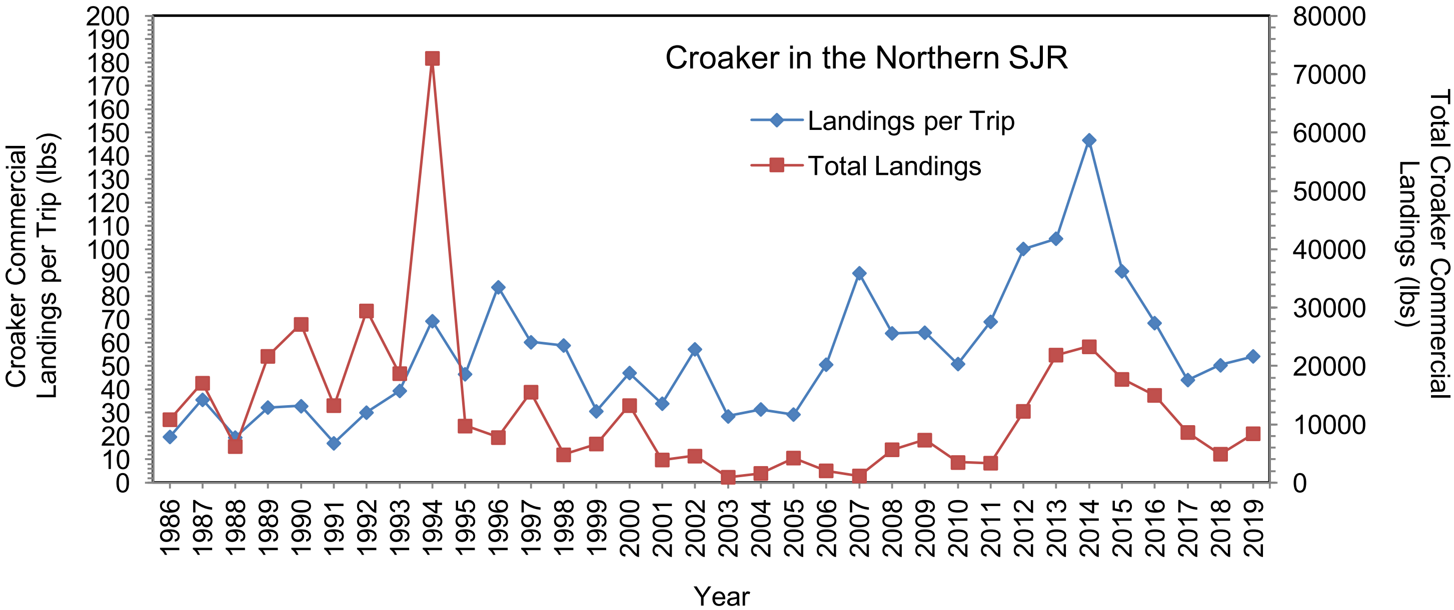
Appendix 3.2.9b

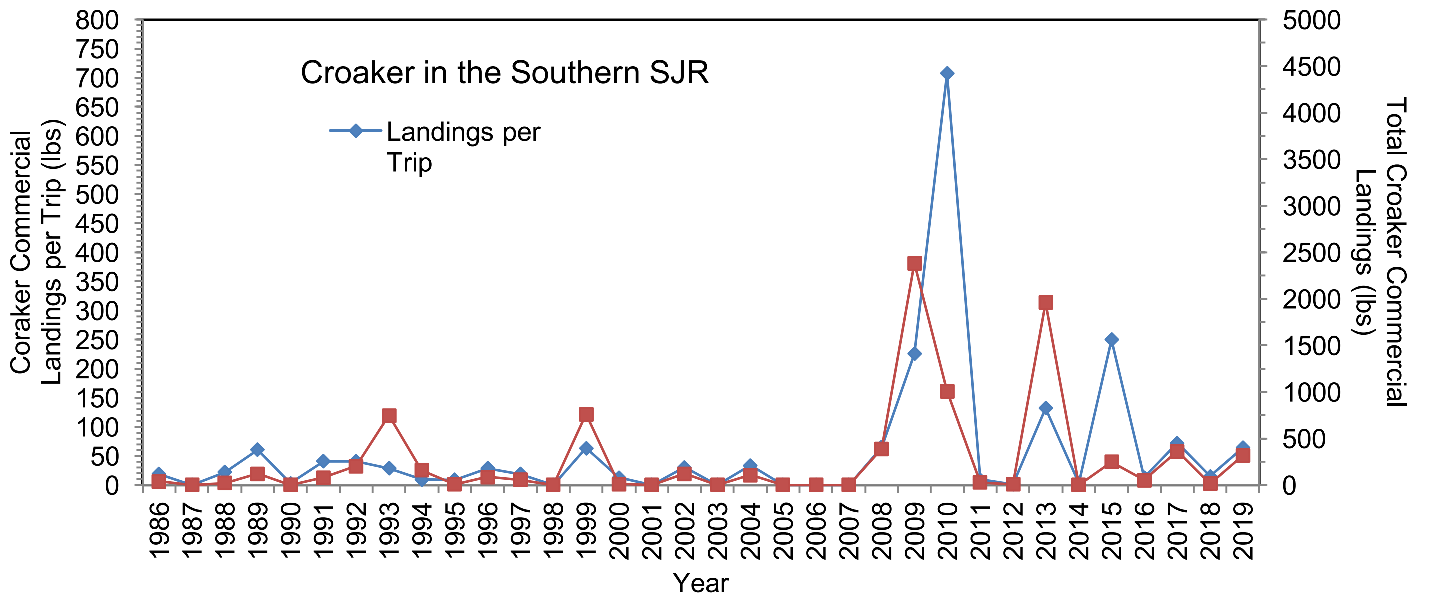
Length frequency diagrams for sheepshead caught in the lower St. Johns River from 2006 to 2020. All lengths are standard length (SL). The N value represents the number of fish collected for that month from 183 m seines.



Appendix 3.2.10a

Yearly comparison of commercial Atlantic croaker landings and landings per trip for the northern and southern sections of the lower St. Johns River from 1986 to 2019. Kendall tau correlation analyses revealed a decreasing trend in landings for the north, but this was not significant (τ =-0.187; NS), nor was the whole river (τ =-0.191; NS). There was no significant trend for the south section of the river (τ =0.113; NS). Landings per trip were positively correlated with significant trends for the north (τ =0.411; p=0.0003; n=34), and whole river (τ =0.383; p=0.0007; n=34). No trend was detected for the south section of the river (τ =0.117; NS).

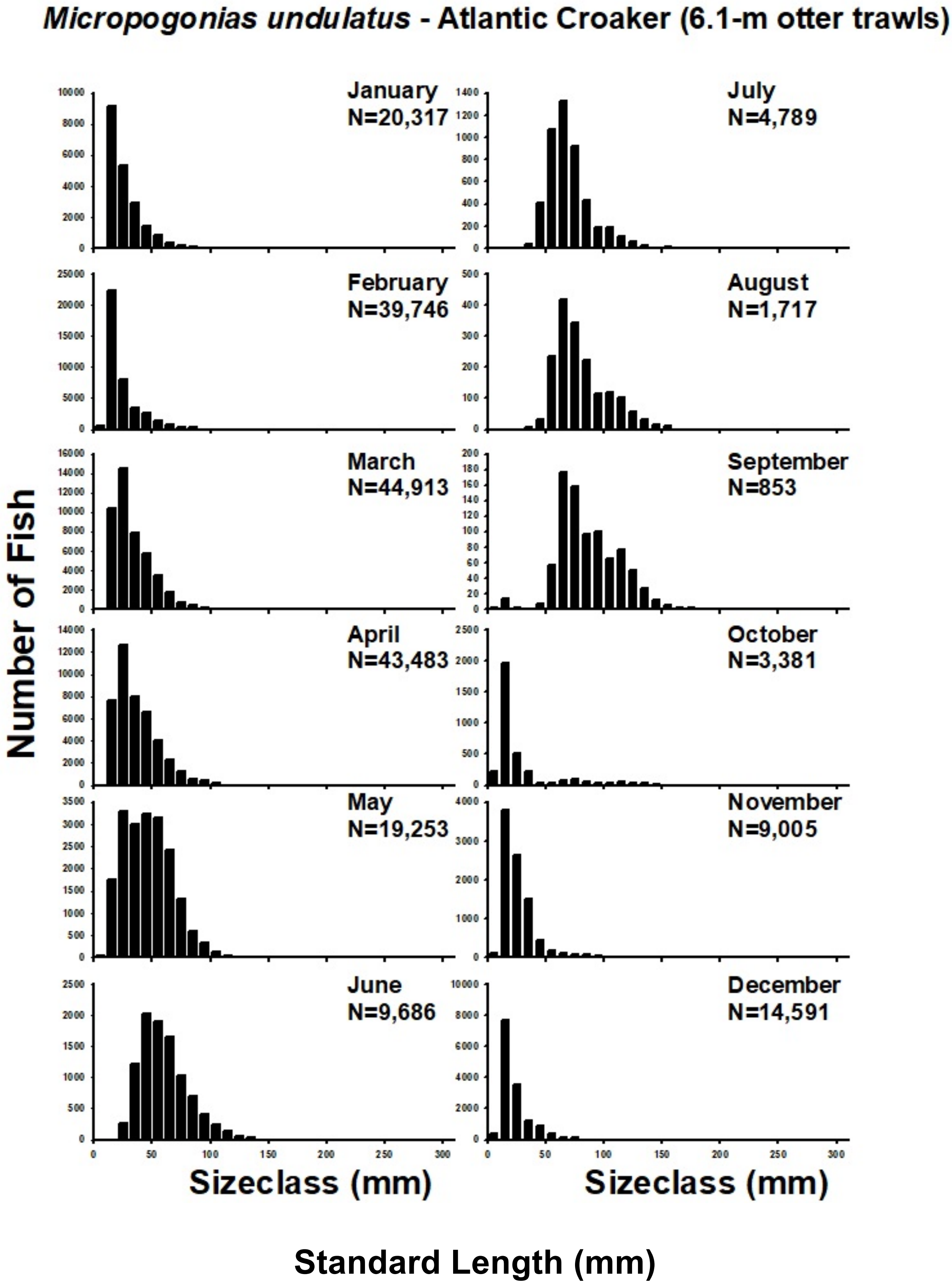




Yearly comparison of commercial Atlantic croaker landings and landings per trip for the northern and southern sections of the lower St. Johns River from 1994 to 2018. Kendall tau correlation analyses revealed no significant trend in landings for the north (τ =0.01; NS), whole river (τ =0.2; NS), and the south (τ =0.01; NS). Catch per trip showed no trend for the north (τ =0.207; NS), but significant increasing trend for the whole river (τ =0.28; p=0.025; n=25), but no trend in the south (τ =0.199; NS).

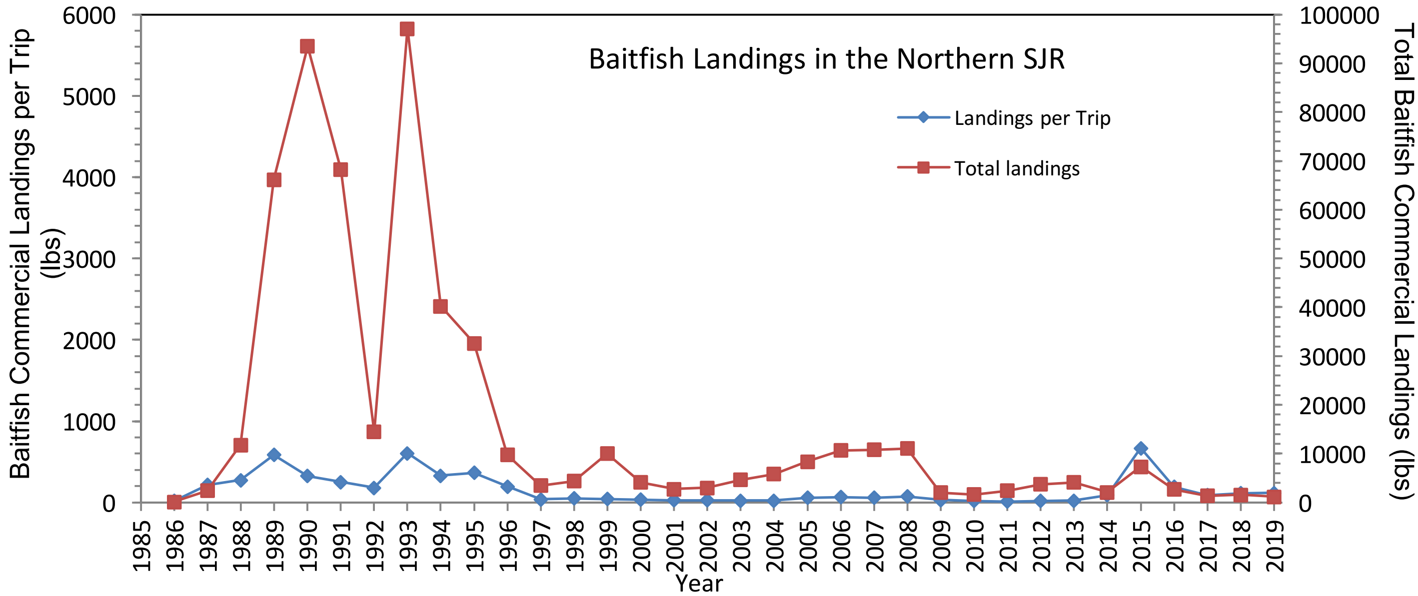
Appendix 3.2.10b

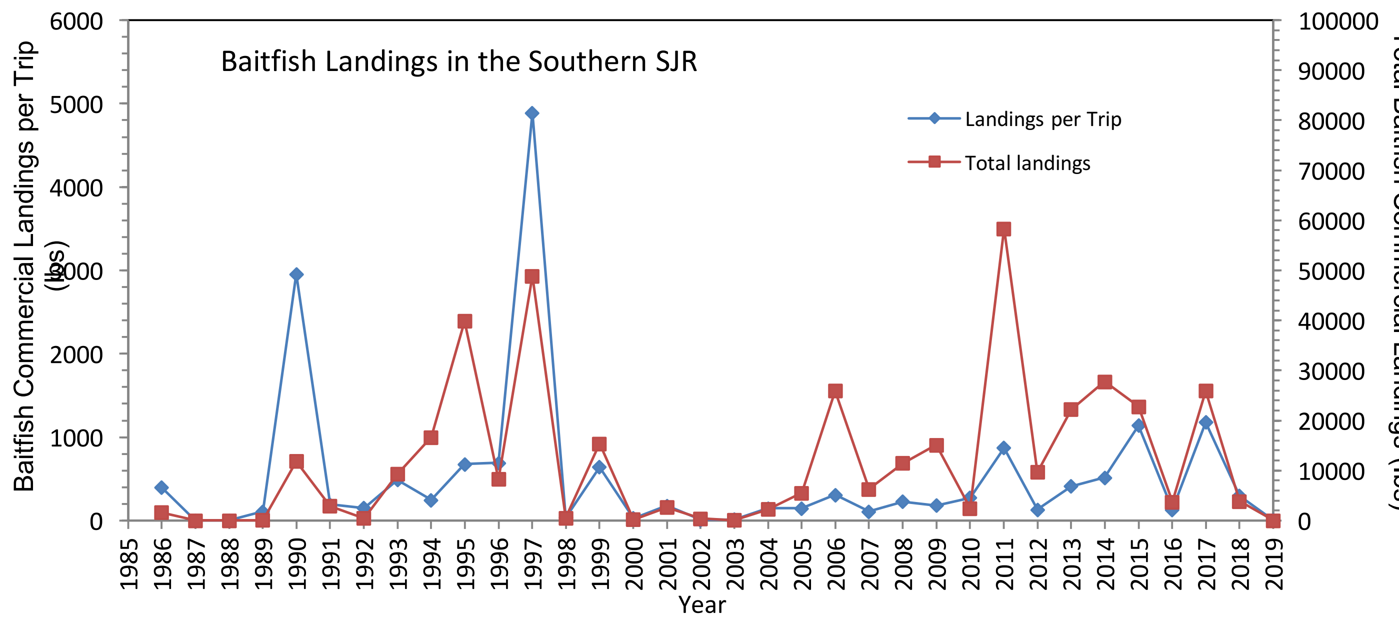
Length frequency diagrams for Atlantic croaker caught in the lower St. Johns River from 2006 to 2020. All lengths are standard length (SL). The N value represents the number of fish collected for that month from 6.1 m otter trawls.



Appendix 3.2.11

Yearly comparison of baitfish landings and landings per trip for the northern and southern sections of the lower St. Johns River from 1986 to 2019. Kendall tau correlation analyses revealed a negative correlation in landings for the north (τ =-0.405; p=0.0004; n=34), and a positive trend in the south (τ =0.243; p=0.02; n=34). No trend was detected for the whole river (τ =-0.09; NS). Landings per trip showed a significant decreasing trends for the north (τ =-0.198; p=0.05; n=33), however, was not significant for the whole river section (τ =-0.109; NS), or the south river section either (τ =0.103; NS).

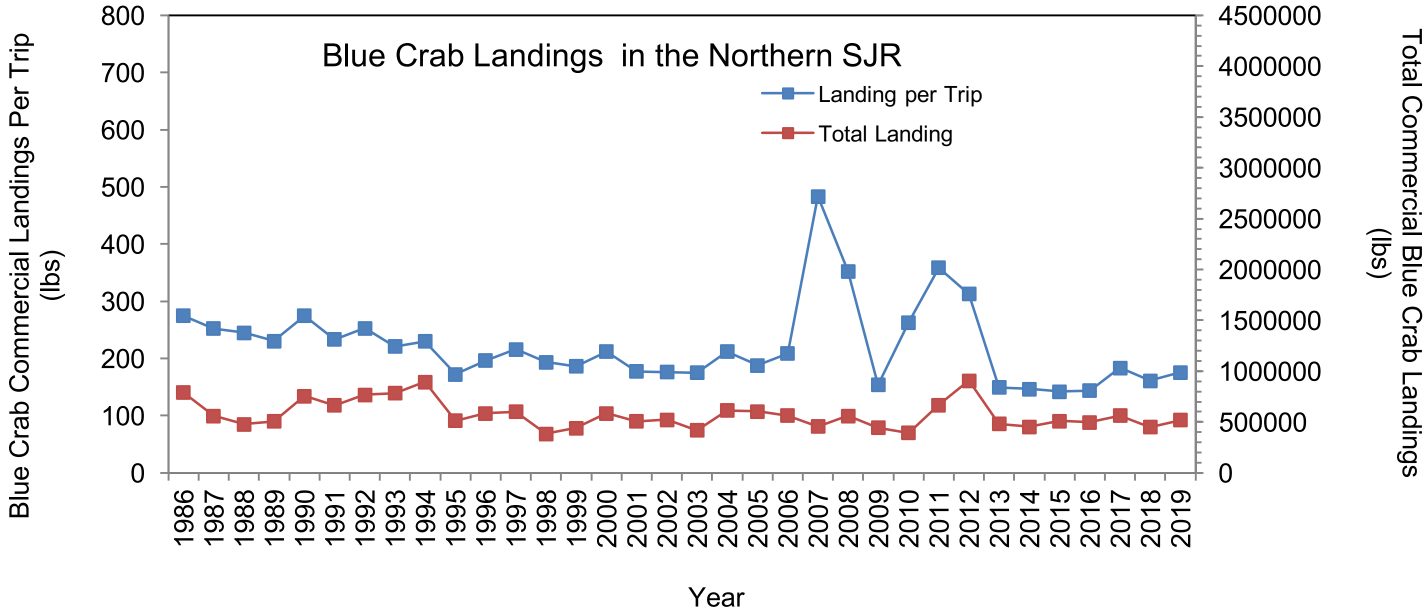


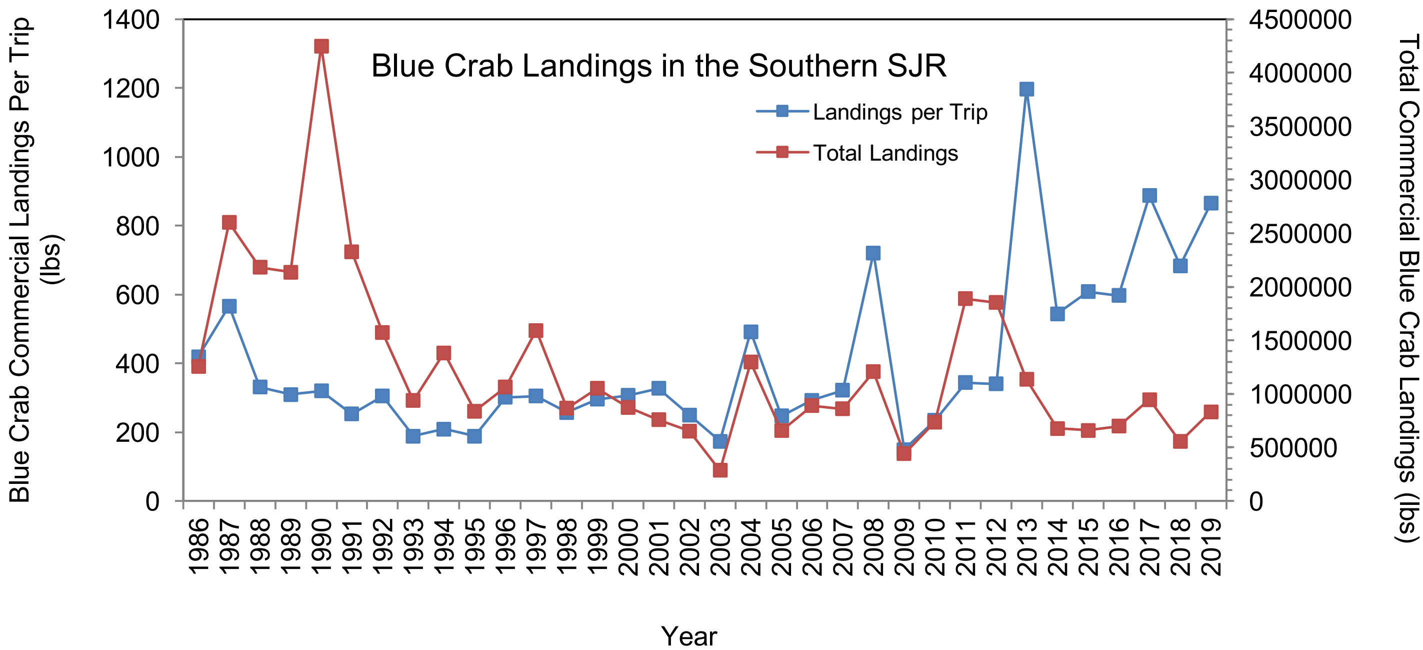


Yearly comparison of baitfish landings and landings per trip for the northern and southern sections of the lower St. Johns River from 1994 to 2019. Kendall tau correlation analyses revealed a decreasing trend in landings for the north (τ =-0.428; p=0.001; n=26), but no trend for the south (τ =0.034; NS), and whole river (τ =-0.09; NS). Catch per trip showed no significance trends for the north section of the river (τ =-0.003; NS), south section (τ =0.046; NS) or the whole river (τ =0.145; NS).

Appendix 3.3.2a

Yearly comparison of commercial landings and landing per trip of blue crabs for the northern and southern sections of the lower St. Johns River from 1986 to 2019. Kendall tau correlation analyses revealed a decreasing trend in landings for the north (τ =-0.216; p=0.04; n=34), south (τ =-0.419; p=0.0002; n=34), and whole river (τ =-0.437; p=0.0001; n=34). Catch per trip showed a significant decreasing trend for the north (τ =-0.380; p=0.0008; n=34), and an increasing trend for the south (τ =0.273; p=0.01; n=34), and the whole river section (τ =0.209; p=0.04; n=34).

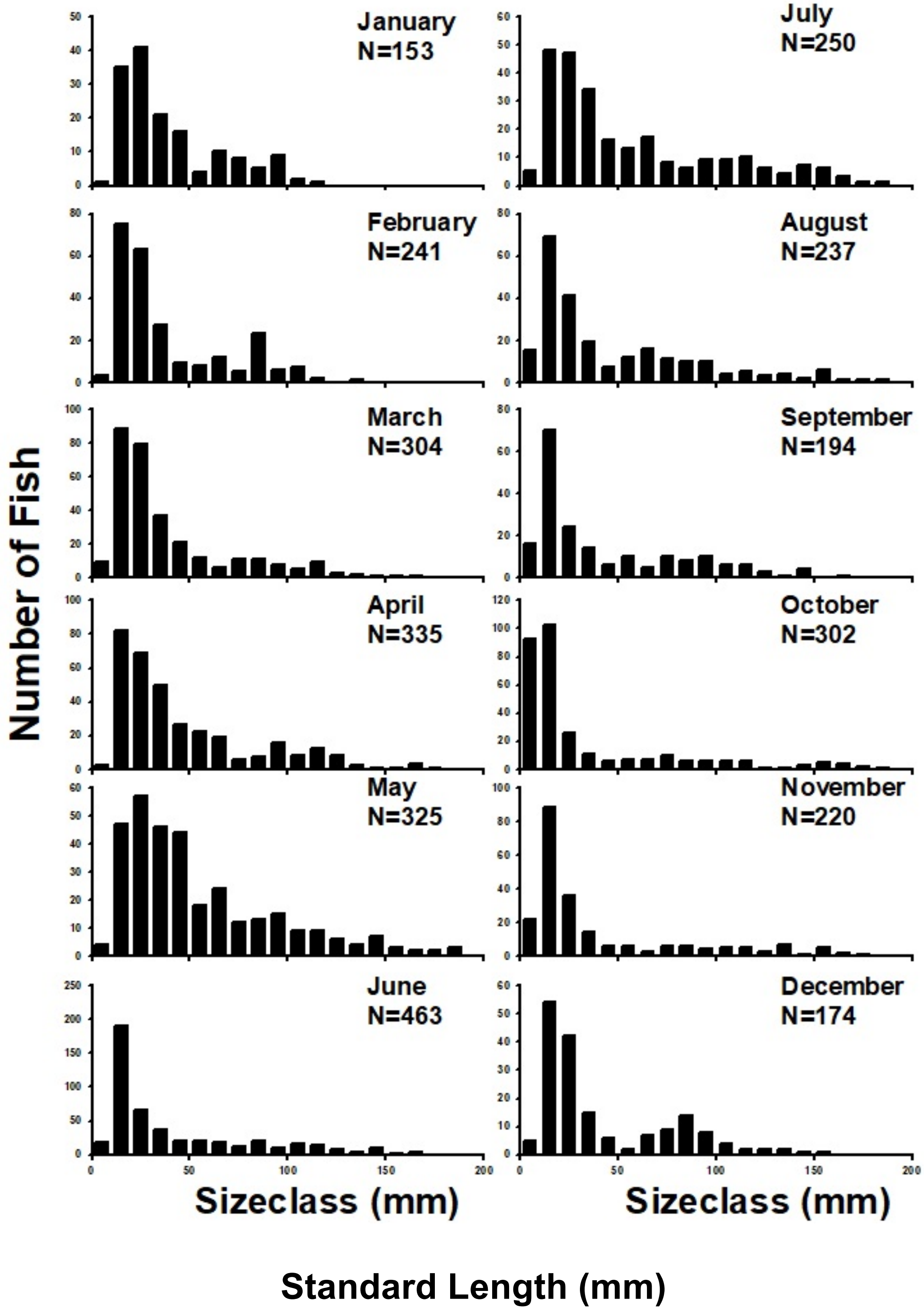




Yearly comparison of commercial landings and landing per trip of blue crabs for the northern and southern sections of the lower St. Johns River from 1994 to 2019. Kendall tau correlation analyses revealed a decreasing trend in landings for the north (τ =-0.095; NS), south (τ =-0.175; NS), and whole river (τ =-0.182; NS). Catch per trip showed a decreasing trend for the north (τ =-0.225; p=0.05; n=26), but a significantly increasing trend for the south (τ =0.501; p=0.0002; n=26), and whole river section (τ =0.495; p=0.0002; n=26).

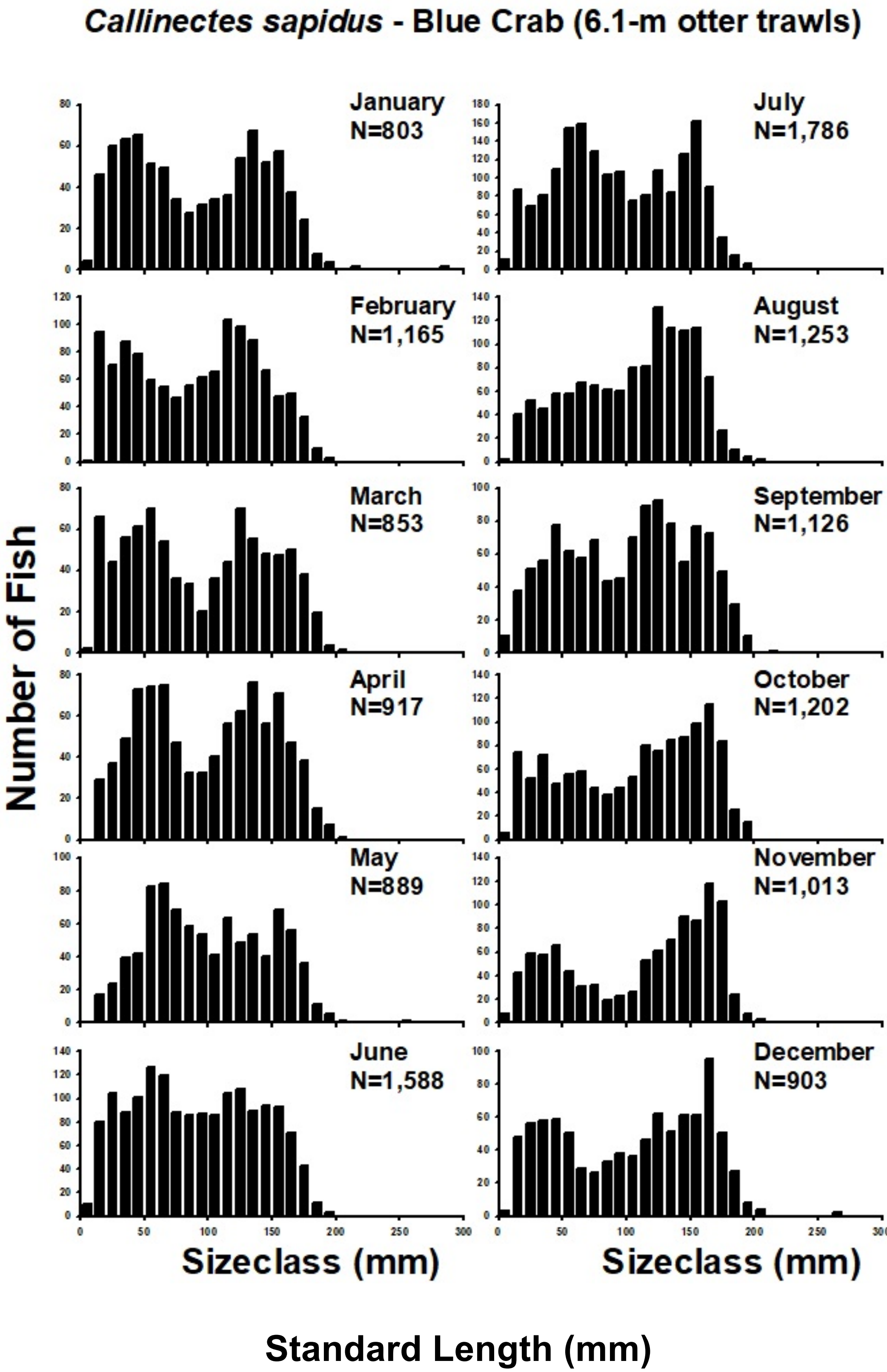
Appendix 3.3.2b

Length frequency diagrams for blue crabs caught in the lower St. Johns River from 2006 to 2020. Standard lengths are measurements of carapace width (mm). The N value represents the number of cabs collected for that month from 21.3 m seines.



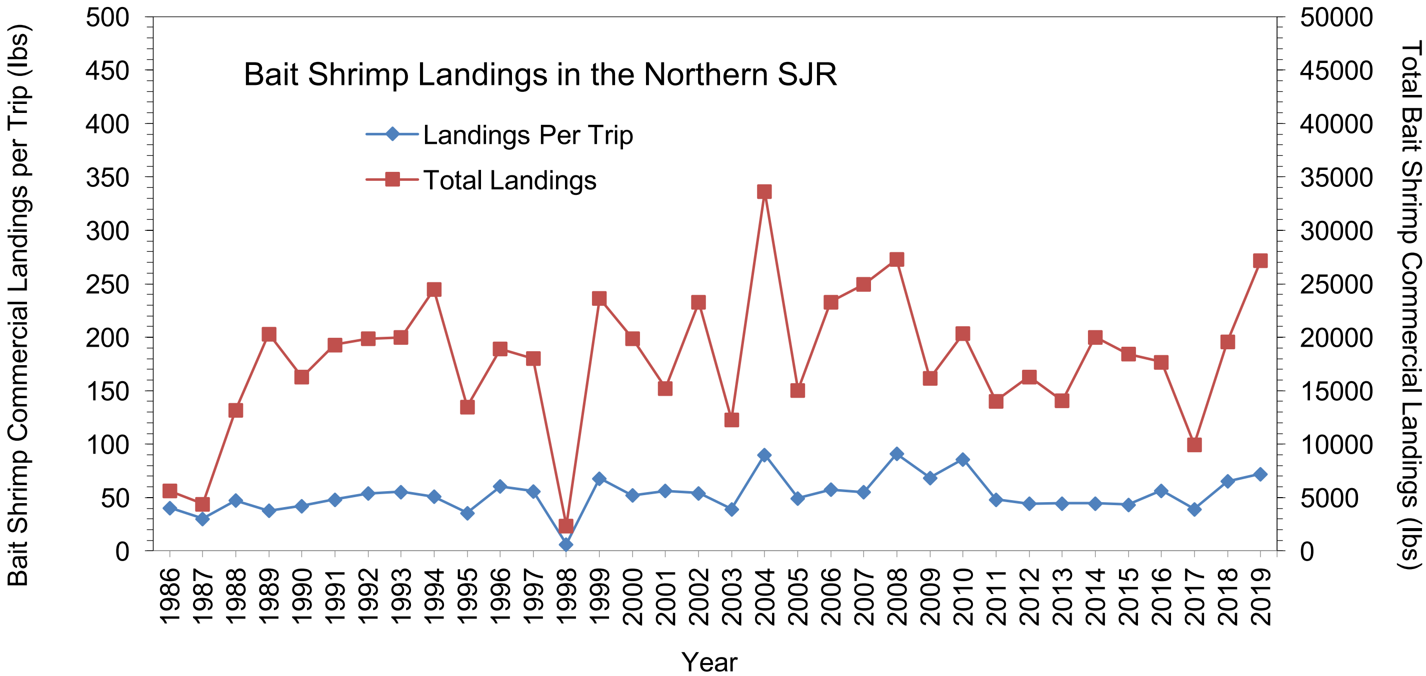
Appendix 3.3.2b

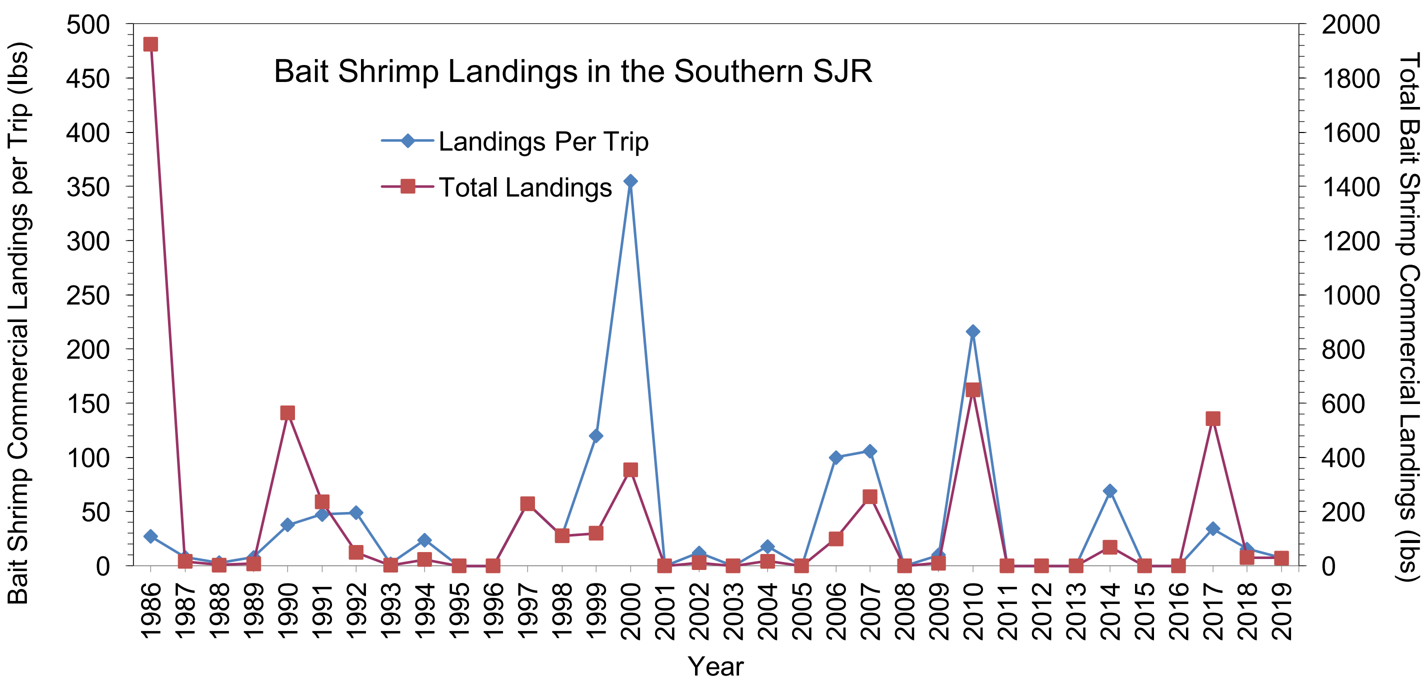
Length frequency diagrams for blue crabs caught in the lower St. Johns River from 2006 to 2020. Standard lengths are measurements of carapace width (mm). The N value represents the number of crabs collected for that month from 6.1 m otter trawls.



Appendix 3.3.3a

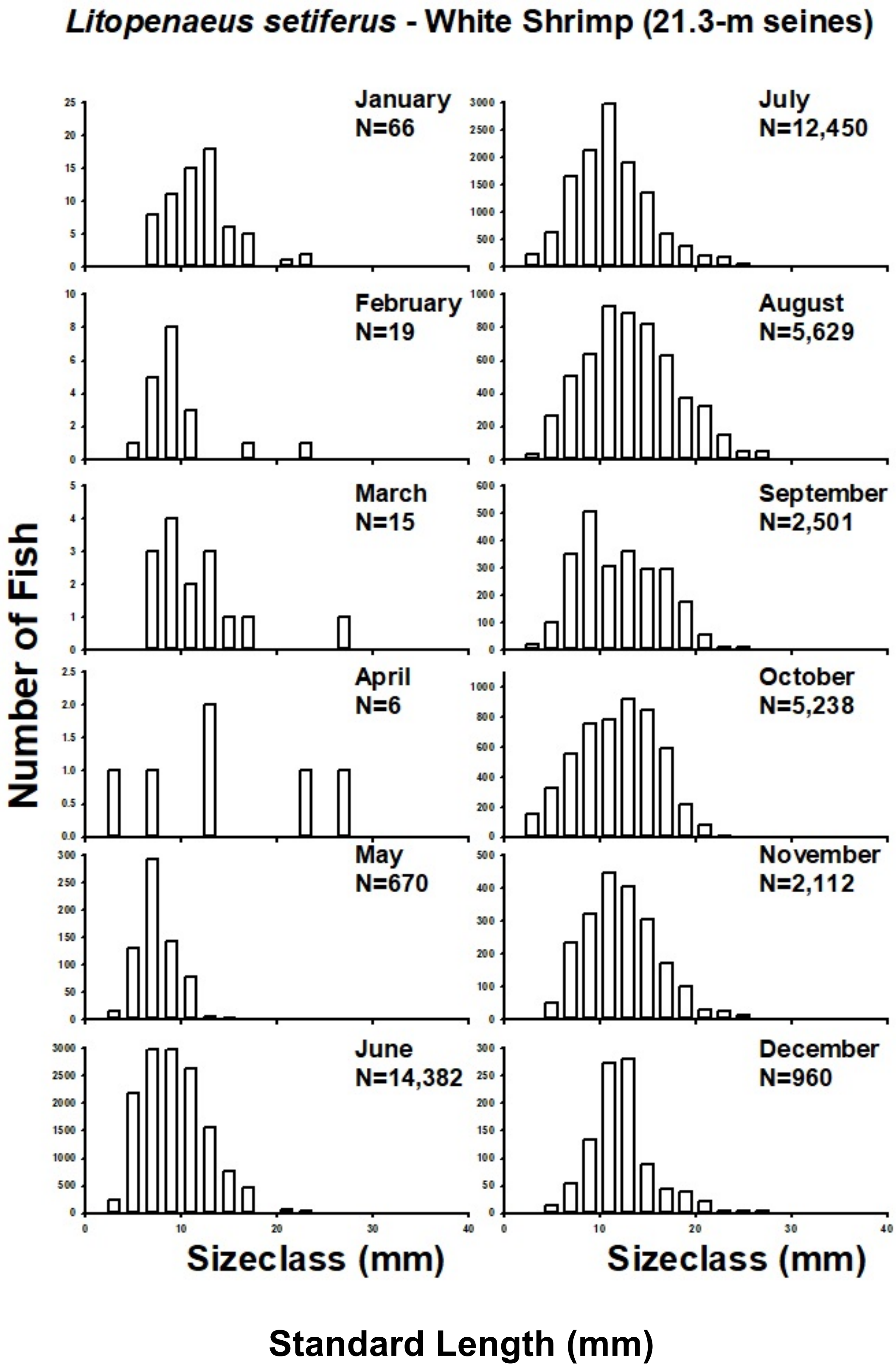
A yearly comparison of commercial landings and landings per trip of bait shrimp for the northern and southern sections of the lower St. Johns River from 1986 to 2019. Kendall tau correlation analyses revealed no trend in landings for the north (τ =0.134; NS), south (τ =-0.150; NS), or whole river section (τ =0.130; NS). There was an increasing trend for landings per trip for the north (τ =0.241; p=0.023; n=34), but no trend for the south (τ =-0.01; NS), or whole river (τ =0.066; NS). Bait shrimp reported for the counties associated with the south section of the river were likely to be caught in the Intracoastal Waterway (ICW).





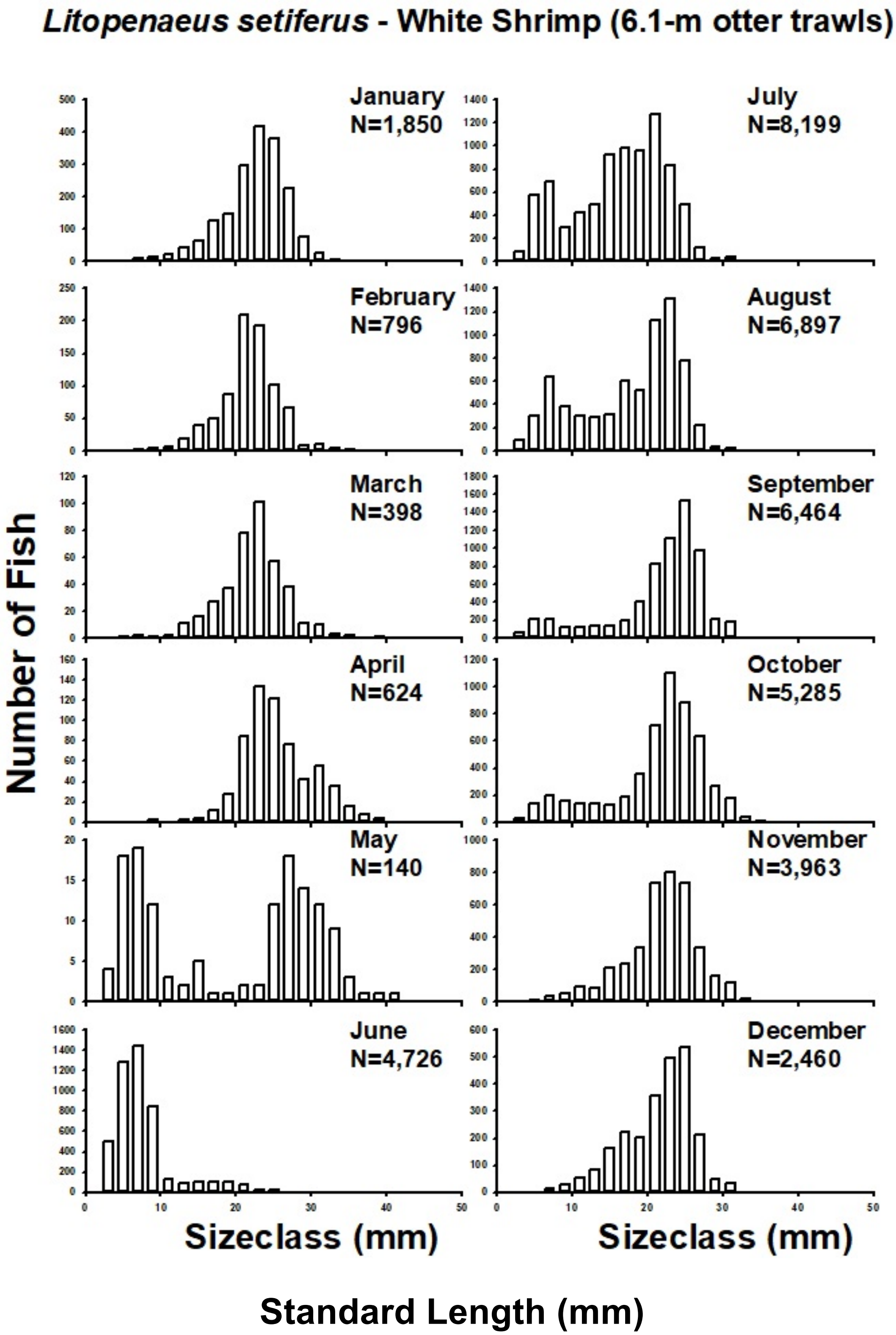
Appendix 3.3.3b

Length frequency diagrams for white shrimp caught in the lower St. Johns River from 2006 to 2020. Standard lengths are measurements of shrimp from tip of rostrum to tip of tail in mm. The N value represents the number of shrimp collected for that month from 21.3 m seines.



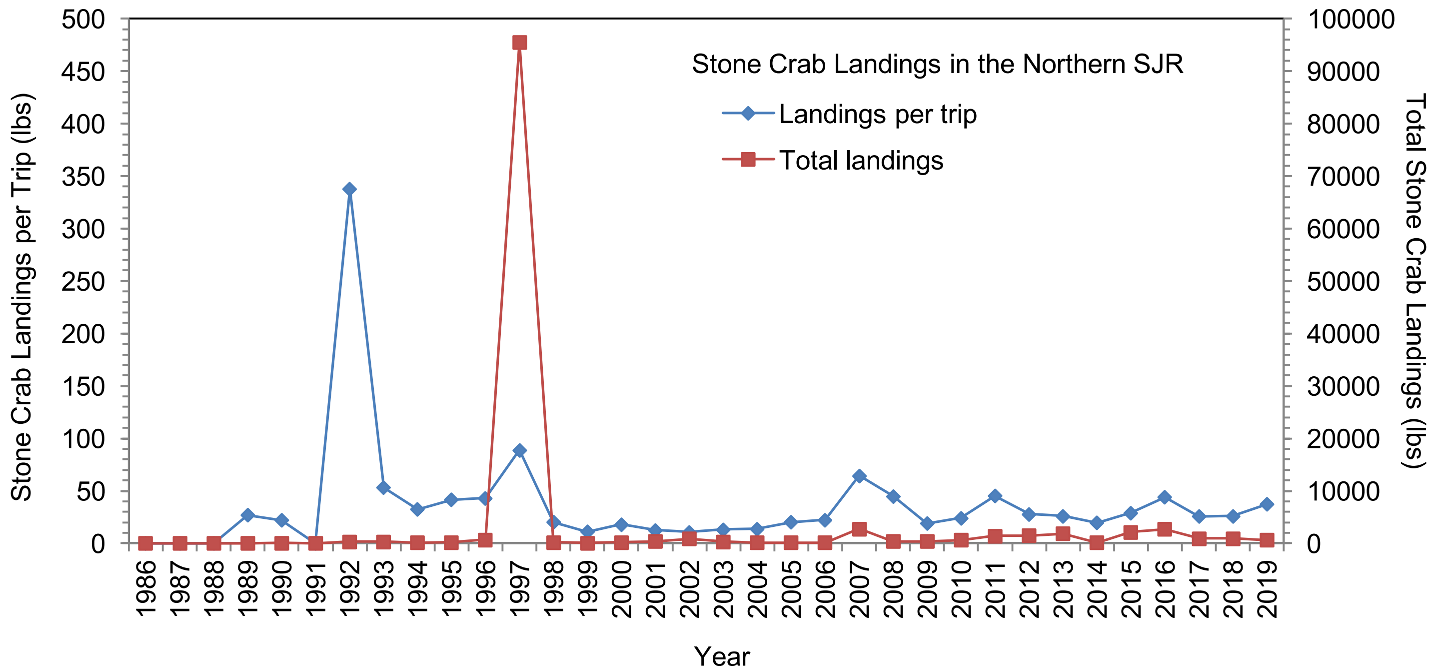
Appendix 3.3.3b

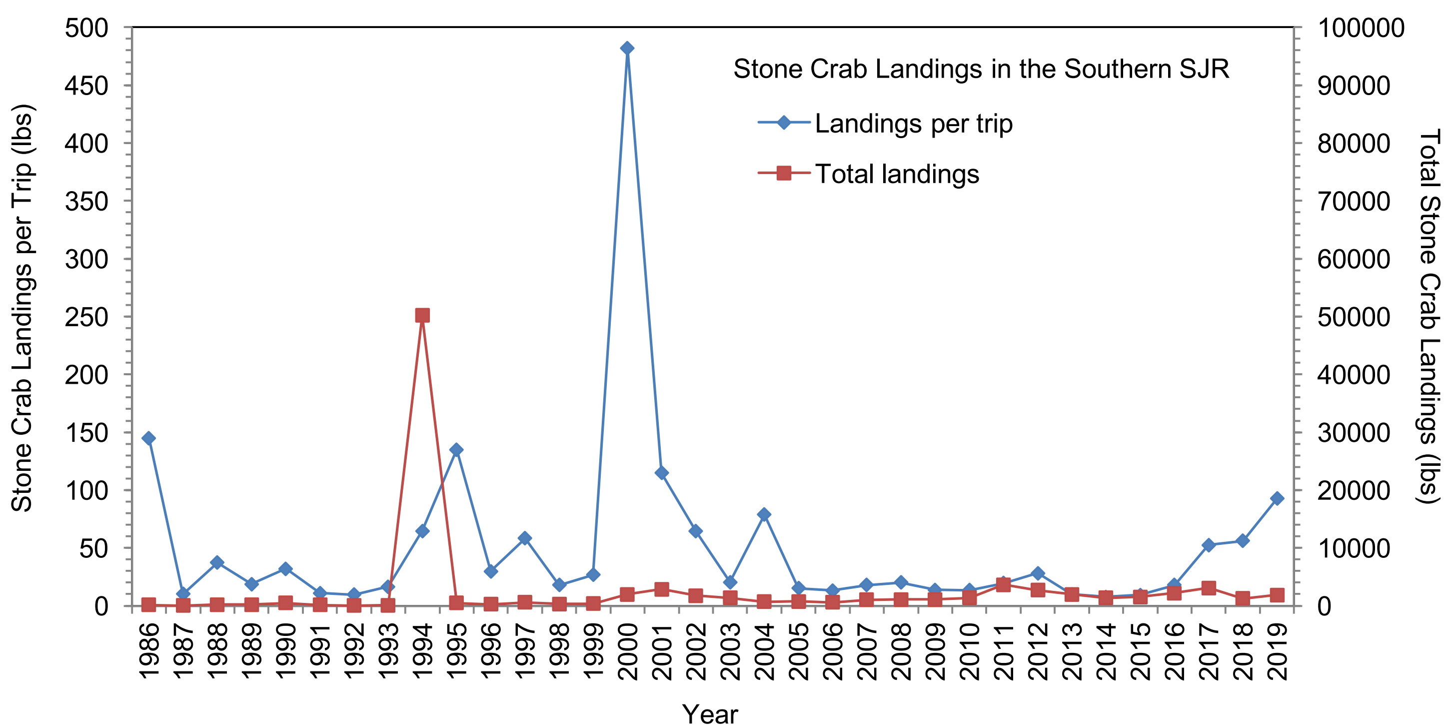
Length frequency diagrams for white shrimp caught in the lower St. Johns River from 2006 to 2020. Standard lengths are measurements of shrimp from tip of rostrum to tip of tail in mm. The N value represents the number of shrimp collected for that month from 6.1 m otter trawls.



Appendix 3.3.4a

A comparison of commercial landings of stone crab for the northern and southern sections of the lower St. Johns River from 1986 to 2019. Kendall tau correlation analyses revealed a significant increasing trend for landings in the north (τ =0.511; p=1.08E-05; n=34), south (τ =-0.560; p=1.59E-06; n=34), and the whole river (τ =0.515; p=9.17E-06; n=34). Catch per trip showed a significant positive trend for the north (τ =0.224; p=0.03; n=34), but was not significant in the south (τ =-0.116; NS), and the whole river (τ =-0.037; NS). Stone crab claws reported for the counties associated with the south section of the river were likely to be caught in the Intracoastal Waterway (ICW).

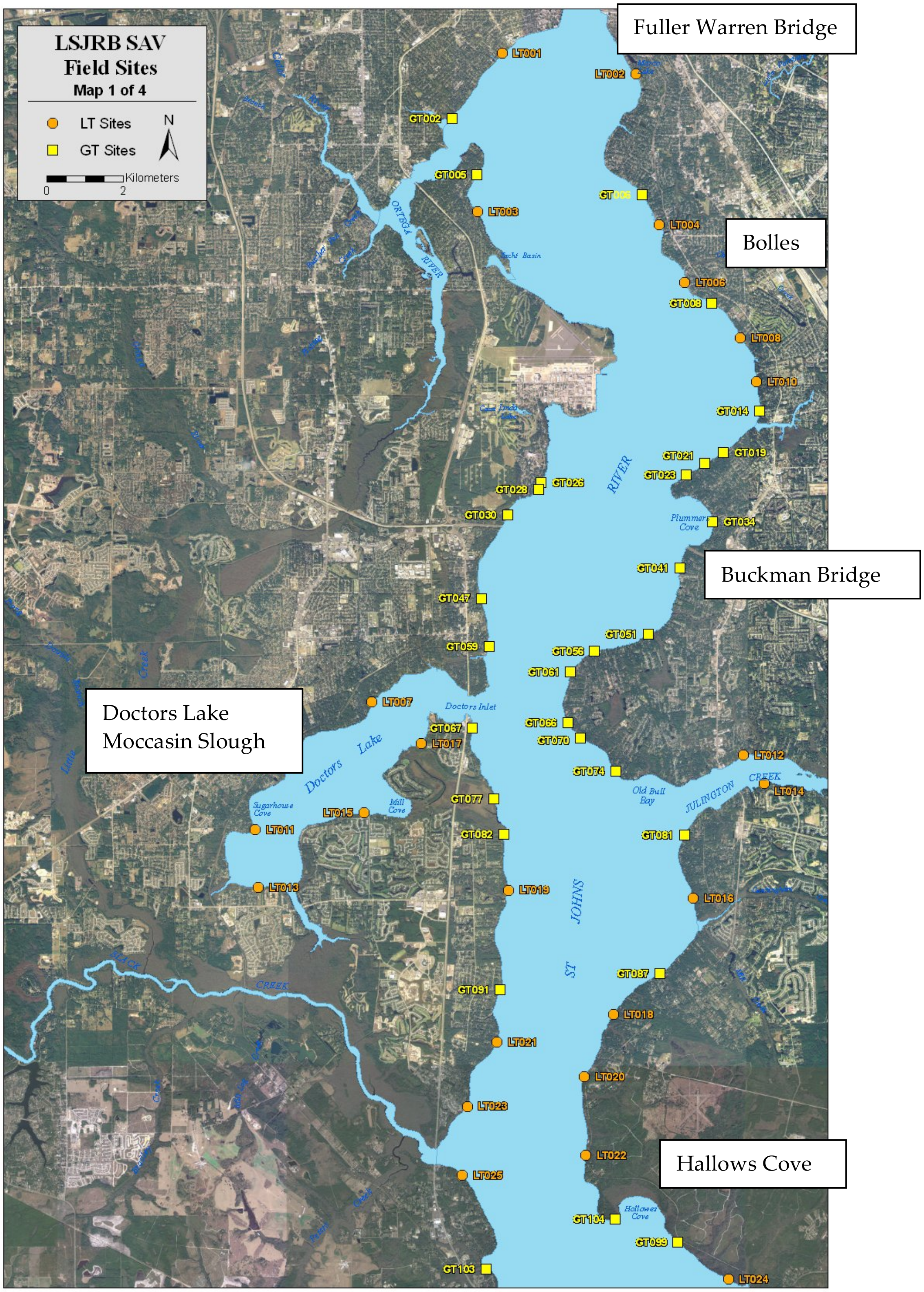




4. Aquatic Life

Appendix 4.1.7.1.A

SAV Transect Locations Map 1



Appendix 4.1.7.1.A

Trends for SAV (GT) sites (LT sites included 2020) from Fuller Warren Bridge to Buckman Bridge: Expected fluctuation given environmental conditions.

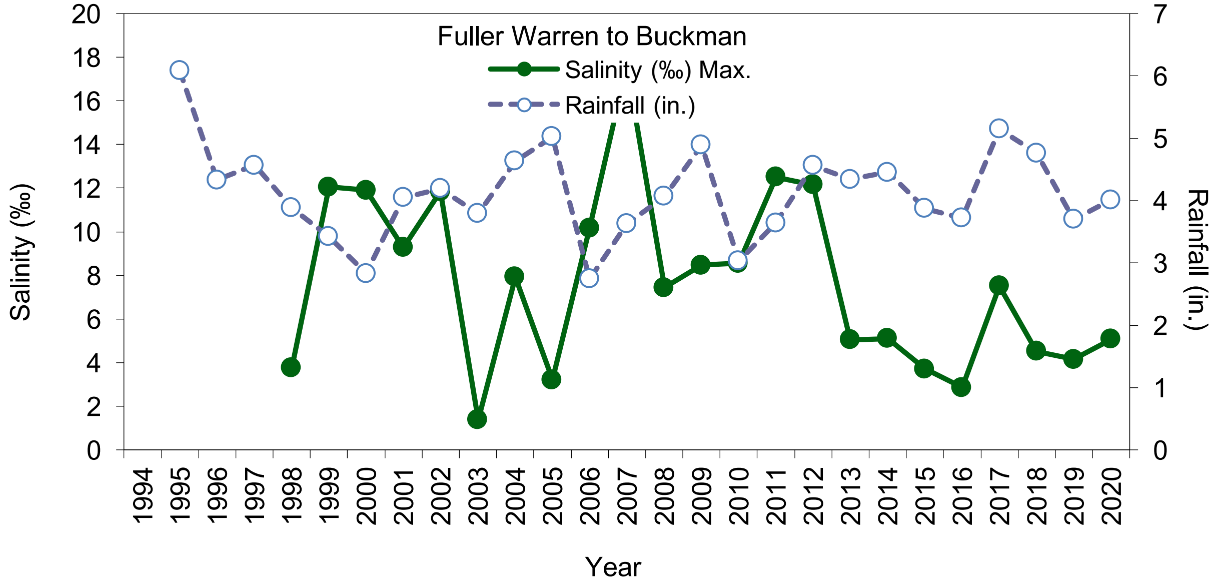


Figure 1. Radar rainfall (1995-2020) and salinity (1998-2020).

Radar rainfall was positively correlated over time (1995-2020), (τ=-0.1787; NS); salinity was NS; rainfall and salinity were negatively correlated (τ=-0.219; NS).

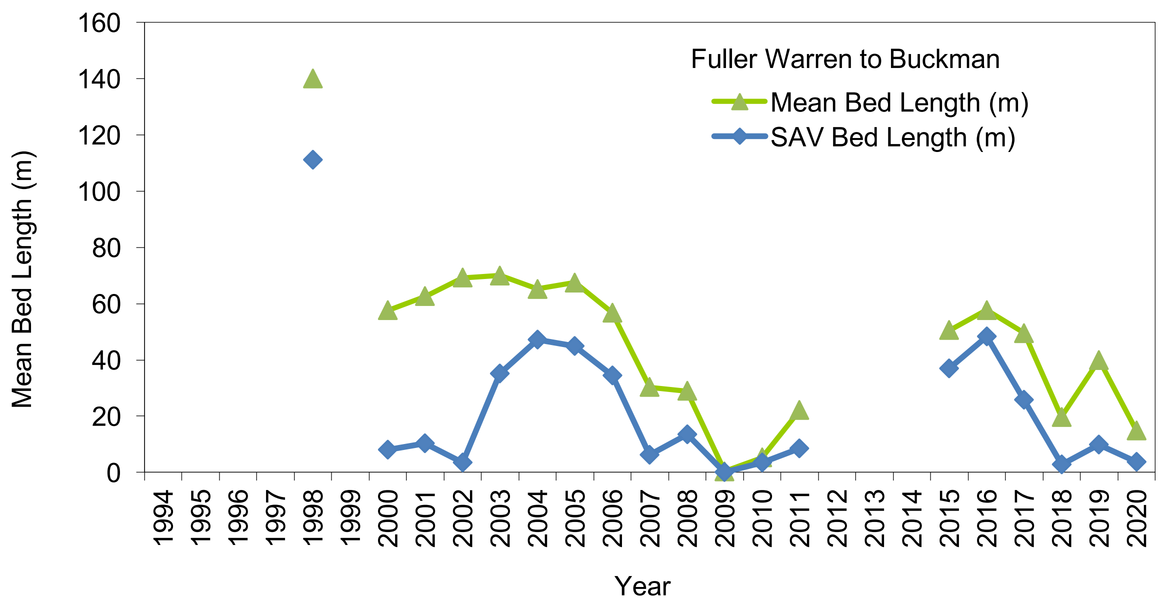


Figure 2. Mean grass bed length in meters (1998, 2000-2011 and 2015-2020).

Mean grass bed length in meters was negatively correlated over time (τ=-0.509; p=0.0011; n=19); mean bed length was negatively correlated with salinity (τ=-0.322; p=0.027; n=19). Mean bed length and rainfall were positively correlated, (τ=0.064; NS).

Mean SAV bed length in meters was negatively correlated over time but not significant (τ=-0.193; NS); mean SAV bed length was negatively correlated with salinity but this was not significant (τ=-0.263; p=0.058; n=19). Mean SAV bed length and rainfall were positively correlated (τ=0.064; NS).

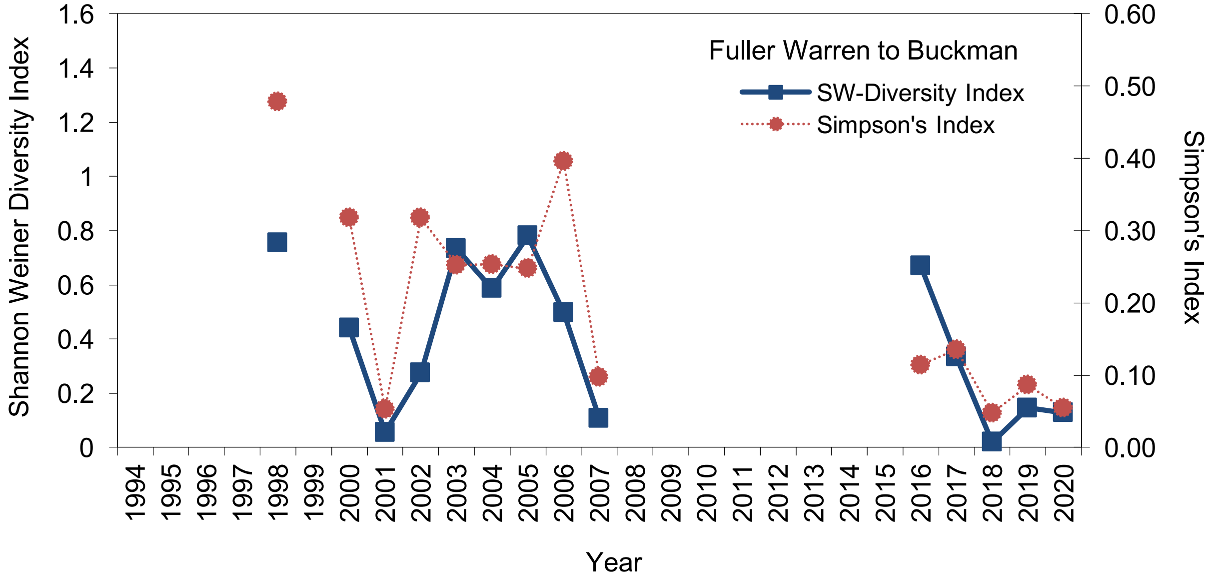


Figure 3. Shannon Weiner Diversity Index and Simpson's Index for grass beds (1998-2007 and 2016-2020).

SWDI was negatively correlated over time, but this was not significant (τ=-0.056; p=0.417; n=9); SWDI was negatively correlated with salinity (τ=-0.611; p=0.011; n=9). SWDI and rainfall were positively correlated, but this was not significant (τ=0.222; p=0.202; n=9). SI was positively correlated over time, (τ=1.0; p=8.73E-05; n=9); SI was positively correlated with salinity, but this was not significant (τ=0.111; p=0.338; n=9). SI and rainfall were positively correlated, but this was not significant (τ=0.222; p=0.202; n=9). SWDI and SI were negatively correlated, but this was not significant (τ=0.056; p=0.417; n=9).

For below average rainfall years (1998-2001) SWDI and Simpsons Index were negatively correlated, but not significant (τ=-1; p=0.058; n=3). For higher than average rainfall years (2001-2005) SWDI was positively correlated (τ=0.8; p=0.025; n=5); Simpsons Index was not significant (τ=0.1195; p=0.385; n=5). For the dry years (2005-2007) SWDI was negatively correlated, but not significant (τ=-1; p=0.058; n=3). For 1989-2020, SWDI was negatively correlated, but not significant (τ=-0.319; NS). For 2016-2020, SWDI was negatively correlated, but not significant (τ=-0.2; NS).

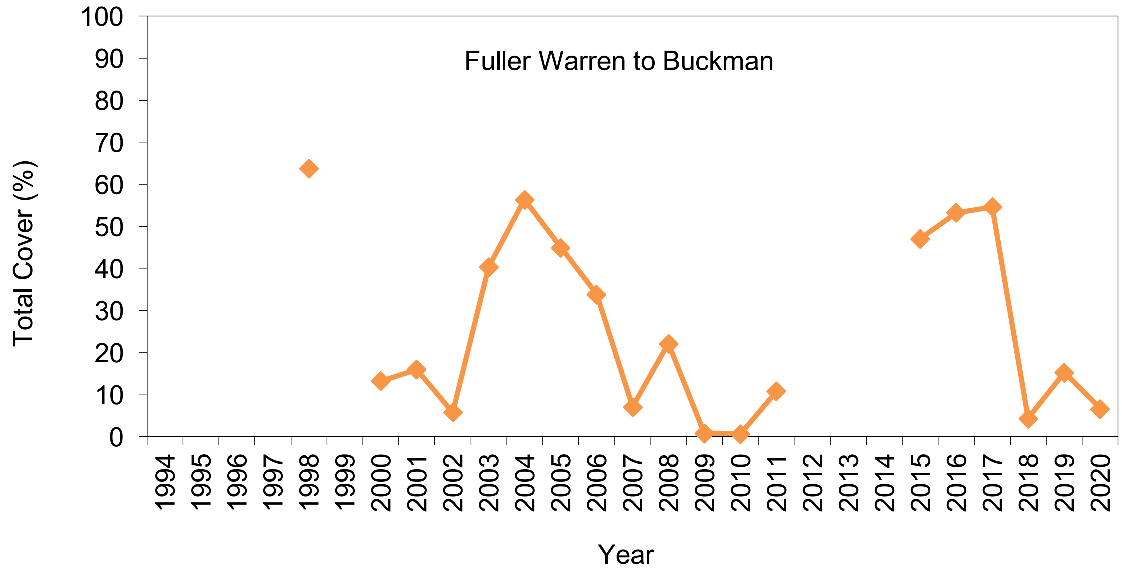


Figure 4. Total cover percent of grass bed (1998, 2000-2011 and 2015-2020).

Total cover percent of grass bed was negatively correlated over time, by not significant (τ=-0.146; p=0.191; n=19); there was a negative correlation between total percent cover and salinity-NS (τ=-0.216; p=0.098; n=19); there was a positive correlation between total percent cover and rainfall-NS (τ=0.099; p=0.276; n=19).

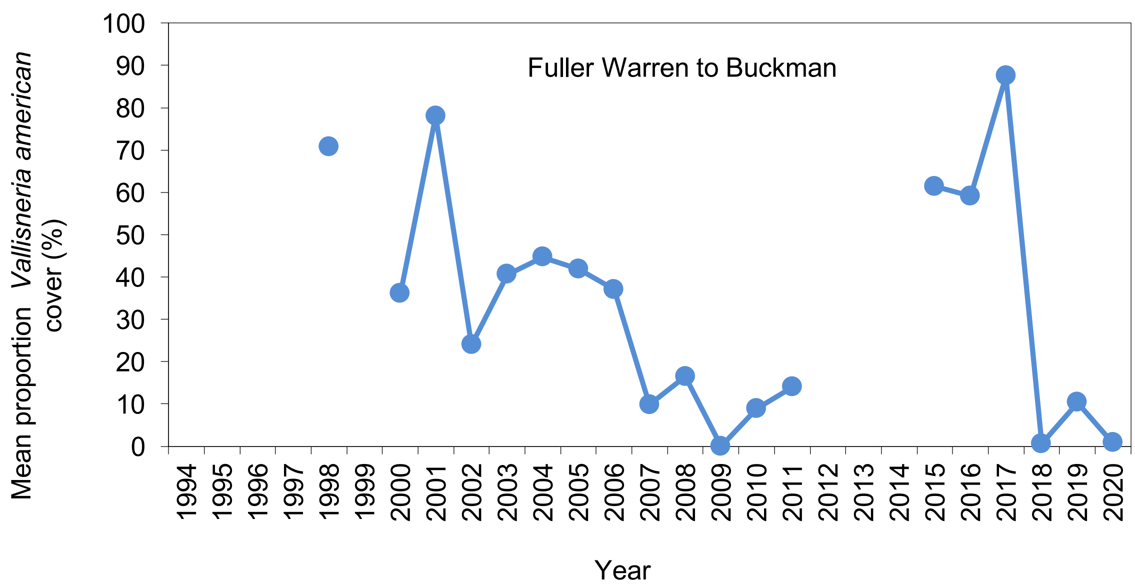


Figure 5. Proportional percent of Tape grass (Vallisneria) cover (1998, 2000-2011 and 2015-2020).

Proportional percent of Tape grass (*Vallisneria*) cover was negatively correlated over time (τ=-0.287; p=0.043; n=19); PPVal was negatively correlated with salinity-NS (τ=-0.146; p=0.191; n=198); PPVal was positively correlated with rainfall-NS (τ=0.1233; p=0.231; n=19).

Table 1. Relative occurrences of SAV species from Fuller Warren to Buckman Bridge (Data 1998-2020).

SAV Species	Relative % occurrence 1998-2007	Relative % occurrence Change 1998-2017	Relative % occurrence Change 2015-2017	Relative % occurrence Change 2018-2020	Relative % occurrence Change 2015	Relative % occurrence Change 2016	Relative % occurrence Change 2017	Relative % occurrence Change 2018	Relative % occurrence Change 2019	Relative % occurrence Change 2020
Vallisneria americana	38	36	69	5	61	64	81	1	14	1
Ruppia maritima	24	20	3	16	3	5	0	11	9	27
Zannichellia palustris	17	9	19	30	8	30	19	28	52	10
Najas guadalupensis	11	5	2	0	1	4	0	0	0	0
Potamogeton pusillus	4	0	0	0	0	0	0	0	0	0
Sagittaria subulata	3	1	2	0	1	4	0	0	0	0
Eleocharis spp.	3	0	0	0	0	0	0	0	0	0
Chara spp.	1	0	0	0	0	0	0	0	0	0
Ceratophyllum demersum	0	0	0	0	0	0	0	0	0	0
Hydrilla verticillata	0	0	0	0	0	0	0	0	0	0
Fontanalis spp.	0	0	0	0	0	0	0	0	0	0
Micranthemum spp.	0	0	0	0	0	0	0	0	0	0

Table 2. Grass bed condition indices, salinity and rainfall from Fuller Warren to Buckman Bridge.

No. of Transects	DATE	Salinity max. (‰)	Rainfall (in.)	Simpson's Index	SW Diversity Index	Mean Bed Length (m)	SAV_Bed Length (m)	Total Cover (%)	Proportional (%) Vallisneria Cover
10	1994								
4	1995		6.08						
11	1996		4.33						
12	1997		4.57						
12	1998	3.77	3.88	0.48	0.75	139.98	111.21	63.86	70.73
12	1999	12.05	3.42						
12	2000	11.91	2.83	0.32	0.44	57.58	7.95	13.24	36.03
12	2001	9.27	4.05	0.05	0.06	62.55	10.32	16.02	77.98
12	2002	11.84	4.19	0.32	0.27	69.2	3.61	5.81	23.94
12	2003	1.38	3.79	0.25	0.73	69.95	35.07	40.34	40.55
12	2004	7.93	4.64	0.25	0.59	65.23	47.24	56.43	44.65
12	2005	3.21	5.03	0.25	0.78	67.52	44.99	45	41.89
12	2006	10.17	2.74	0.4	0.5	56.75	34.51	33.86	37.04
12	2007	17.61	3.63	0.1	0.11	30.27	6.13	7.06	9.83
12	2008	7.44	4.07			29.92	13.42	22.13	16.49
12	2009	8.47	4.89			0.42	0.08	0.83	0
12	2010	8.66	3.03			5.29	3.43	0.71	8.93
9	2011	12.5	3.64			22.11	8.5	10.8	13.96
12	2015	1.38	3.88			50.58	37.03	47.08	61.4
12	2016	2.86	3.72	0.11	0.56	57.69	48.29	53.25	59.09
2	2017	7.52	5.15	0.33	0.33	49.5	25.85	54.67	87.47
17	2018	4.52	4.76	0.68	0.02	50.19	25.91	27.97	37.09
17	2019	4.16	3.70	0.09	0.15	39.98	9.77	15.28	11.01
16	2020	5.08	4.01	0.13	0.05	14.88	3.77	6.67	0.81
	Mean	7.59	3.95	0.27	0.38	49.45	25.11	27.42	35.70
	SD	4.31	0.68	0.17	0.28	30.80	26.56	21.08	26.40

Data: SJRWMD 2021
Salinity maxima used are for SJR near Doctors Inlet.
Rainfall is for the LSJRB.

Table 3. Grass bed condition indices for the east and west banks of SJR between Fuller Warren Bridge and Buckman Bridge.

Location	Statistic	Mean Bed Length (m)	SAV_Bed Length (m)	Total Cover (%)	Proportional (%) *Vallisneria* Cover
East bank SJR	Mean	57.17	31.55	29.56	35.92
141 Transects	SD	42.14	40.63	28.37	28.46
West bank SJR	Mean	31.93	11.97	26.85	19.75
86 Transects	SD	19.77	9.30	26.83	14.02

Data: SJRWMD 2021

Appendix 4.1.7.1.A

Trends for SAV (GT) sites (LT sites included 2019) from Buckman Bridge to Hallows Cove: Expected fluctuation given environmental conditions.

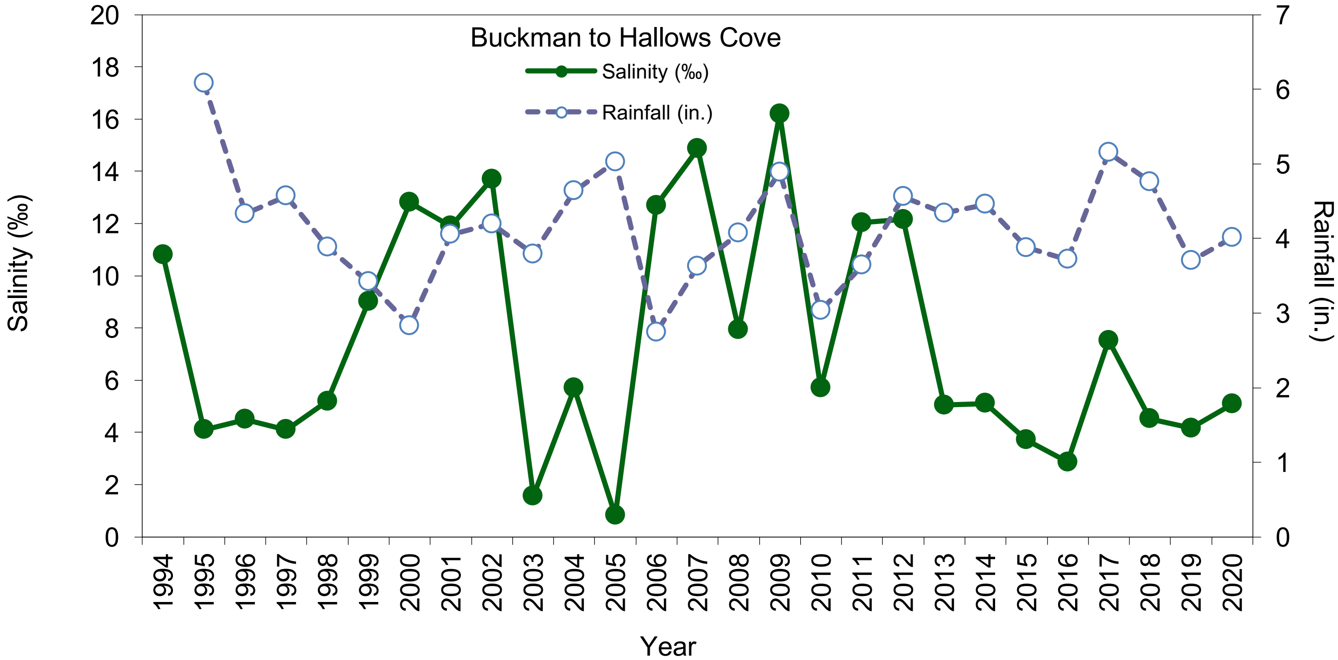


Figure 1. Radar rainfall (1995-2020) and salinity (1998-2020).

Radar rainfall was positively correlated over time (1995-2020), (τ=-0.058; NS); salinity was NS; rainfall and salinity were negatively correlated (τ=-0.189; NS).

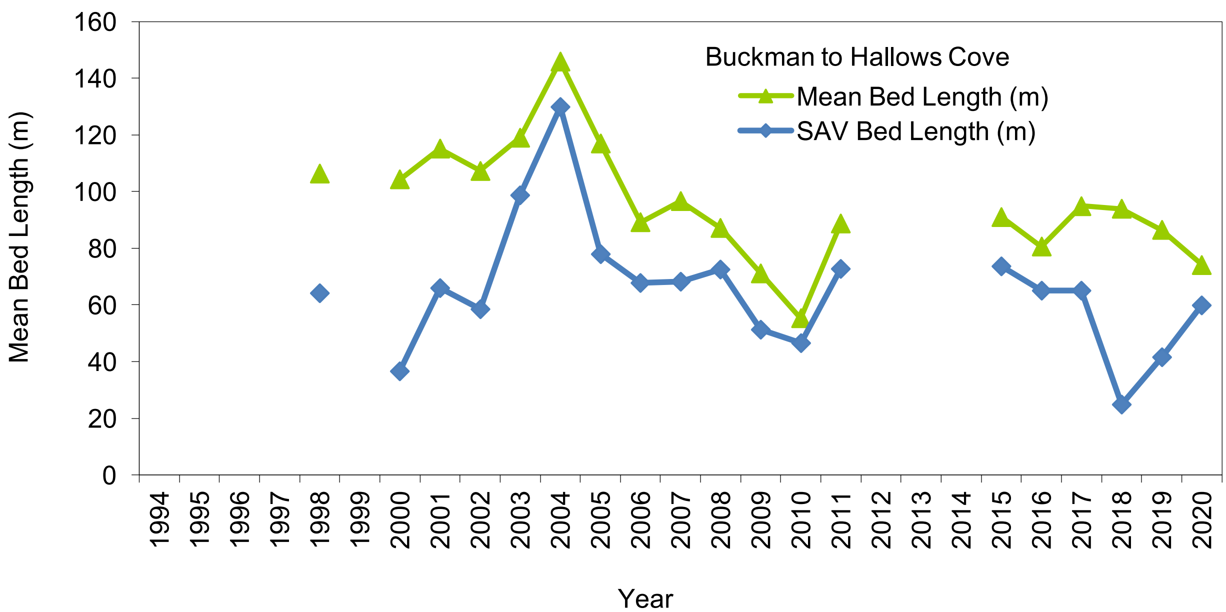


Figure 2. Mean grass bed length in meters (1998, 2000-2011 and 2015-2020).

Mean bed length in meters was negatively correlated over time (τ=-0.357; p=0.016; n=19). Mean bed length (2016-2020) in meters was negatively correlated over time (τ=-1; p=0.021; n=4); mean bed length was negatively correlated with salinity (τ=-0.216; NS). Mean bed length and rainfall were positively correlated, but this was not significant (τ=0.193; NS).

Mean SAV grass bed length in meters was negatively correlated over time, but this was not significant (τ=0.146; NS); mean SAV bed length was negatively correlated with salinity (τ=-0.029; NS). Mean SAV bed length and rainfall were positively correlated, but this was not significant (τ=0.076; NS).

From 2004 to 2010, both the mean bed length and SAV bed length declined significantly over time (τ=-0.905; p=0.002; n=7) and (τ=-0.714; p=0.012; n=7), respectively. In 2011, the indices rebounded slightly to 2008 levels of about 72 m for SAV bed length. From 2015– 2018 SAV extent remains consistent, but average SAV bed length decreased from 73 m to 24 m ((τ=-1.0; p=0.021; n=4). In 2019, the grasses began to recover and the SAV bed length increased from 24 m to 42 m, and further increased in 2020 to 60 m.

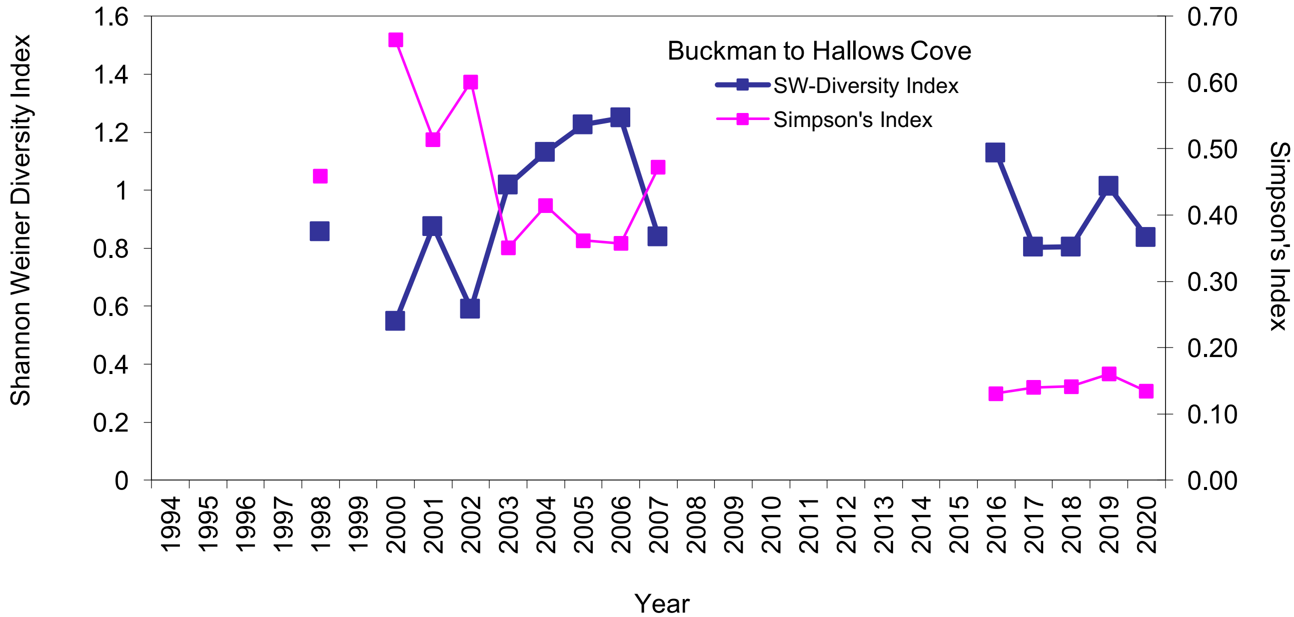


Figure 3. Shannon Weiner Diversity Index and Simpson's Index for grass beds (1998, 2000-2007 and 2016-2020).

SWDI was positively correlated over time (τ=0.5; p=0.030; n=9); SWDI was negatively correlated with salinity, but this was not significant (τ=-0.389; p=0.072; n=9). SWDI and rainfall were positively correlated, but this was not significant (τ=0.222; p=0.202; n=9). SI was negatively correlated over time, but this was not significant (τ=-0.333; p=0.105; n=9); SI was positively correlated with salinity (τ=0.444; p=0.048; n=9). SI and rainfall were negatively correlated, but this was not significant (τ=0.056; p=0.417; n=9). SWDI and SI were negatively correlated (τ=0.722; p=0.0034; n=9).

For below average rainfall years (1998-2001) SWDI and Simpsons Index were positively correlated, but not significant (τ=0.333; p=0.300; n=3). For higher than average rainfall years (2001-2005) SWDI was positively correlated (τ=0.8; p=0.025; n=5); Simpsons Index was not significant (τ=0.1195; p=0.385; n=5). For the dry years (2005-2007) SWDI and Simpsons Index but not significant (τ=-1; p=0.058; n=3). For 1998-2020, SWDI was not significantly different (τ=0.077; p=0.351; n=14). For 2016-2020, SWDI was not significant. Simpsons index decreased over time (τ=-0.582; p=0.0019; n=14).

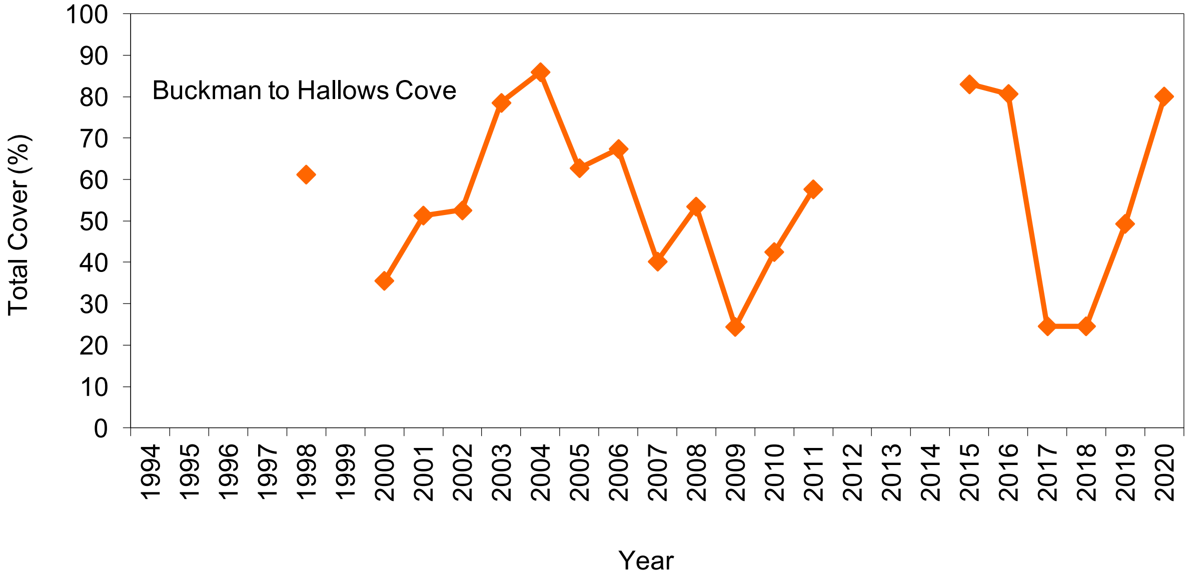


Figure 4. Total cover percent of grass bed (1998, 2000-2011 and 2015-2020).

Total cover percent of grass bed was negatively correlated over time, but this was not significant (τ=-0.076; p=0.325; n=19); there was a negative correlation between total percent cover and salinity (τ=-0.287; p=0.04; n=19); there was a negative correlation between total percent cover and rainfall, but this was not significant (τ=-0.088; p=0.3; n=19).

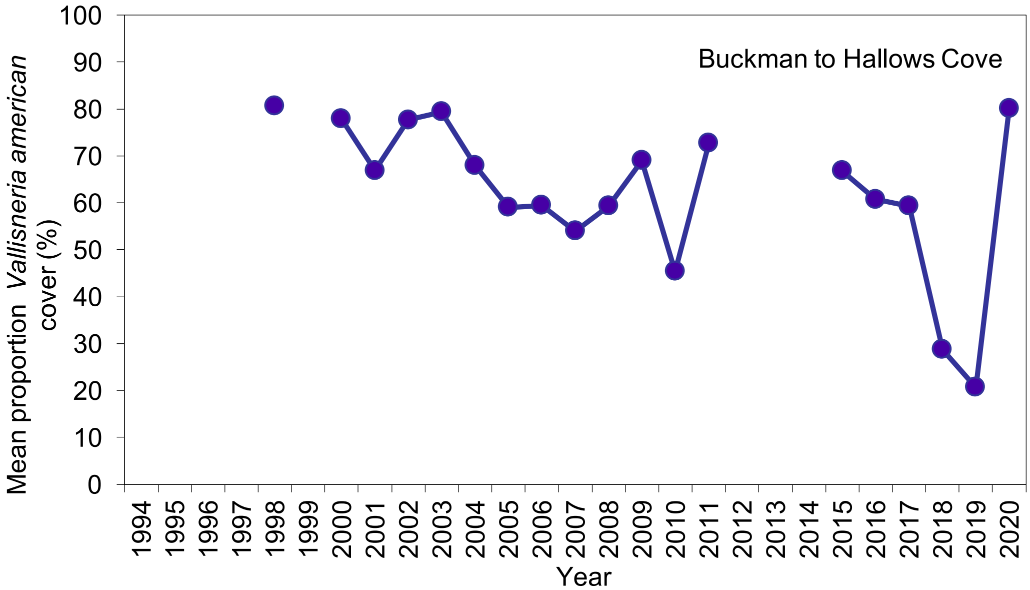


Figure 5. Proportional percent of Tape grass (Vallisineria) cover (1998-2011 and 2015-2020).

Proportional percent of Tape grass (*Vallisneria*) cover was negatively correlated over time (τ=-0.485; p=0.0018; n=19); PPVal was negatively correlated with salinity, but this was not significant (τ=-0.053; NS); there was a negative correlation between PPVal and rainfall, but this was not significant (τ=-0.006; NS).

Table 1. Relative occurrences of SAV species from Buckman Bridge to Hallows Cove (Data 1998-2020).

SAV Species	Relative % occurrence 1998-2007	Relative % occurrence Change 1998-2016	Relative % occurrence Change 1998-2017	Relative % occurrence Change 1915-2017	Relative % occurrence Change 1918-2020	Relative % occurrence Change 2015	Relative % occurrence Change 2016	Relative % occurrence Change 2017	Relative % occurrence Change 2018	Relative % occurrenc e Change 2019	Relative % occurrenc e Change 2020
Vallisneria americana	54	61	49	66	30	83	61	53	29	2	59
Ruppia maritima	15	10	32	26	21	18	25	34	31	0	33
Najas guadalupensis	12	25	4	30	18	67	13	10	7	46	2
Chara spp.	4	4	0	3	8	0	9	1	18	5	1
Zannichellia palustris	4	9	20	6	11	0	4	14	9	21	2
Sagittaria subulata	3	0	0	2	1	0	3	2	1	0	2
Eleocharis spp.	2	0	0	2	1	2	4	0	2	0	0
Micranthemum spp.	2	3	0	3	1	0	0	9	0	2	2
Ceratophyllum demersum	2	0	0	5	1	0	14	0	3	0	0
Potamogeton pusillus	2	4	0	0	0	0	0	0	0	0	0
Hydrilla verticillata	0	0	0	7	0	10	10	**0**	0	0	0
Fontanalis spp.	0	14	0	0	0	0	0	0	0	0	0

Source: SJRWMD 2021

Table 2. Grass bed condition indices, salinity and rainfall from Buckman Bridge to Hallows Cove.

No. of Transects	DATE	Salinity max. (‰)	Rainfall (in.)	Simpsons Index	SW Diversity Index	Mean Bed Length (m)	SAV_Bed Length (m)	Total Cover (%)	Proportional (%) Vallisneria Cover
	1994	10.8							
	1995	4.1	6.08						
	1996	4.5	4.33						
	1997	4.1	4.57						
17	1998	5.2	3.88	0.459	0.857	106.49	64.27	61.28	80.65
	1999	9	3.42						
9	2000	12.8	2.83	0.664	0.548	104.25	36.58	35.52	77.86
17	2001	11.9	4.05	0.514	0.875	115.14	65.91	51.3	66.86
18	2002	13.7	4.19	0.601	0.591	107.32	58.62	52.59	77.65
18	2003	1.57	3.79	0.351	1.017	119.13	98.76	78.55	79.34
18	2004	5.7	4.64	0.414	1.131	145.9	129.95	85.9	67.92
18	2005	0.82	5.03	0.362	1.226	117.09	77.92	62.78	59.03
18	2006	12.7	2.74	0.357	1.249	89.15	67.89	67.39	46.09
18	2007	14.86	3.63	0.472	0.84	96.65	68.24	40.24	44.1
18	2008	7.93	4.07			87.17	72.61	53.48	0.3
18	2009	16.2	4.89			71.06	51.29	24.46	0.23
18	2010	5.7	3.03			55.33	46.67	42.54	
18	2011	12.03	3.64			88.88	72.71	57.74	72.76
13	2015	3.71	3.88			91.04	73.68	83.06	66.77
18	2016	2.86	3.72	0.13	1.13	80.64	65.12	80.65	60.69
15	2017	7.52	5.15	0.14	0.8	94.95	65.07	24.55	59.27
28	2018	4.52	4.76	0.14	0.8	97.89	67.06	54.51	63.79
28	2019	4.15	3.70	0.16	1.01	97.26	65.65	54.22	61.40
28	2020	5.08	4.01	0.13	0.84	74.18	59.91	80.08	56.97
	Mean	7.67	4.09	0.37	0.93	98.07	69.33	56.15	57.92
	SD	4.55	0.80	0.18	0.22	19.98	19.97	18.51	24.08

Data: SJRWMD 2021
Salinity maxima used are for SJR near Doctors Inlet.
Rainfall is for the LSJRB.

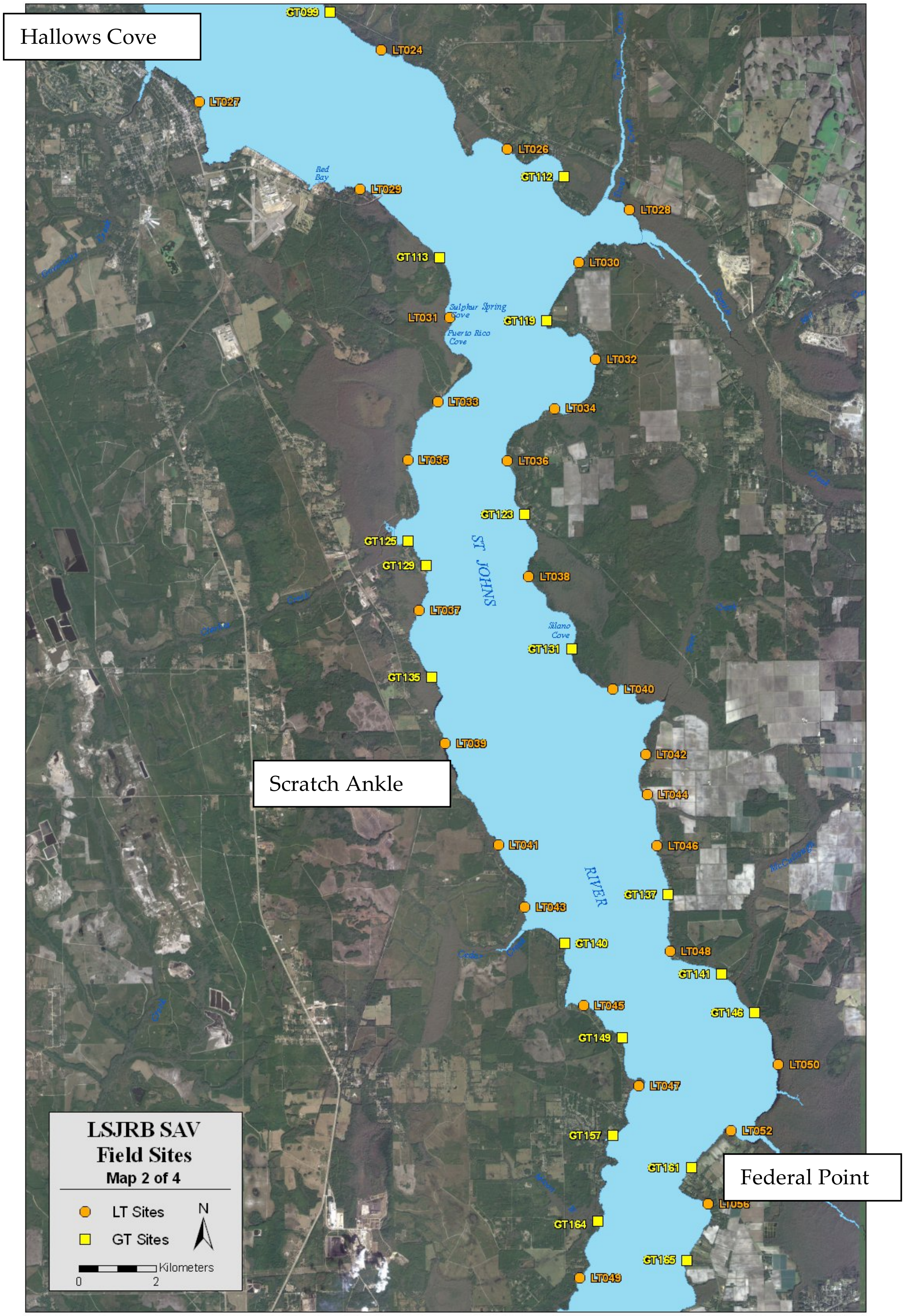
Table 3. Grass bed condition indices for the east and west banks of SJR between Buckman Bridge and Hallows Cove.

Location	Statistic	Mean Bed Length (m)	SAV_Bed Length (m)	Total Cover (%)	Proportional (%) Vallisneria Cover
East bank SJR	Mean	85.72	59.13	55.67	59.25
201 Transects	SD	16.69	19.06	21.45	15.74
West bank SJR	Mean	111.48	75.22	56.85	63.23
139 Transects	SD	31.64	34.23	20.52	19.60

Data: SJRWMD 2021

Appendix 4.1.7.1.B

SAV Transect Locations Map 2



Appendix 4.1.7.2.B

Trends for SAV (GT) sites (LT sites included 2019) from Hallows Cove to Federal Point: Expected fluctuation given environmental conditions.

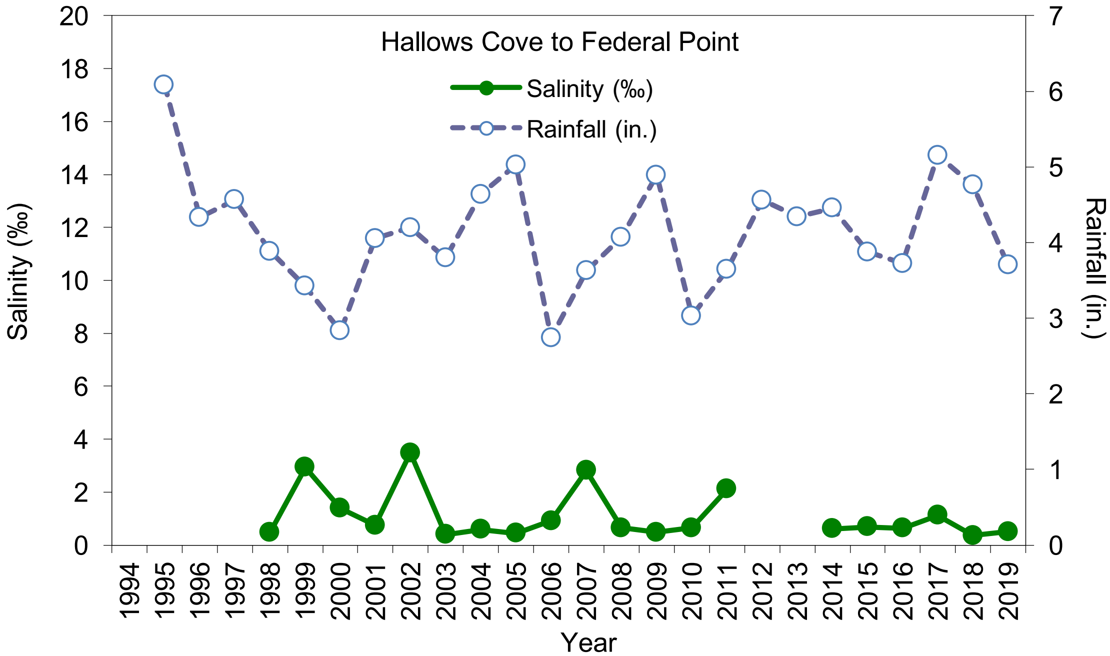


Figure 1. Radar rainfall (1995-2018) and salinity (1998-2019).

Radar rainfall was positively correlated over time, but this was not significant (τ=0.1958; p=0.102; n=22); salinity was negatively correlated over time, but not significant (τ=-0.158; p=0.165; n=20); rainfall and salinity were negatively correlated (τ=-0.295; p=0.035; n=20).

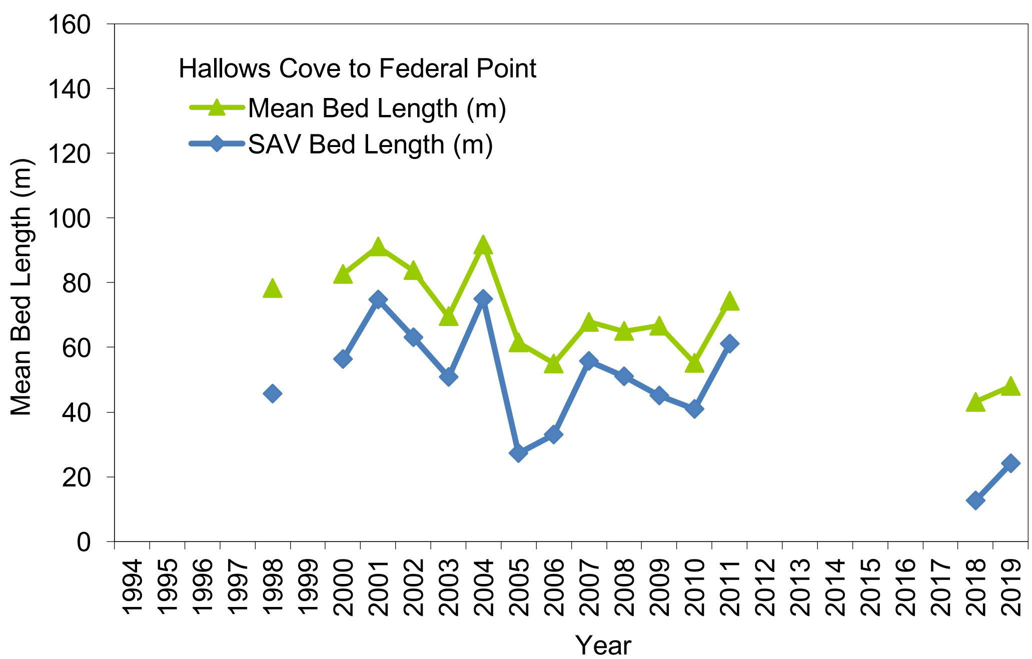


Figure 2. Mean grass bed length in meters (1998, 2000-2011, and 2018-2019).

Mean grass bed length in meters was negatively correlated over time (τ=-0.505; p=0.0044; n=15); mean bed length was positively correlated with salinity, but this was not significant (τ=0.295 p=0.063; n=15). Mean bed length and rainfall were positively correlated, but this was not significant (τ=0.086; p=0.328; n=15). SAV bed length was negatively correlated over time (τ=-0.352; p=0.034; n=15), and positively correlated with salinity (τ=0.448; p=0.01; n=15).

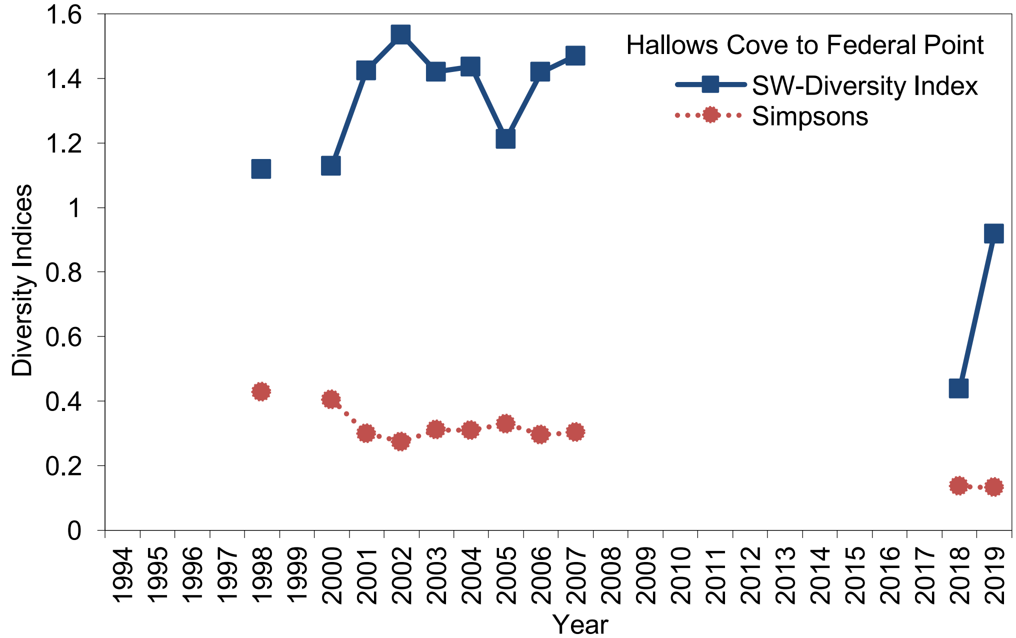


Figure 3. Shannon Weiner Diversity Index and Simpson's Index for grass beds (1998, 2000-2007, and 2018-2019).

SWDI from 1998 to 2007, was positively correlated over time, but this was not significant (τ=0.333; p=0.105; n=9); SWDI was positively correlated with salinity, but this was not significant (τ=-0.333; p=0.105; n=9). SWDI and rainfall were positively correlated, but this was not significant (τ=0.167; p=0.266; n=9). SI was negatively correlated over time, but this was not significant (τ=-0.333; p=0.105; n=9); SI was negatively correlated with salinity (τ=0.444; p=0.048; n=9). SI and rainfall were positively correlated, but this was not significant (τ=0.056; p=0.417; n=9). SWDI and SI were both negatively correlated over time, SWDI was not significant (τ=-0.091; p=0.349; n=11); Simpson Index was (τ=-0.564; p=0.008; n=11). In 2018, both indices were lower than levels recorded in the past. Shannon indicated a recovery in 2019, Simpson continued to decline.

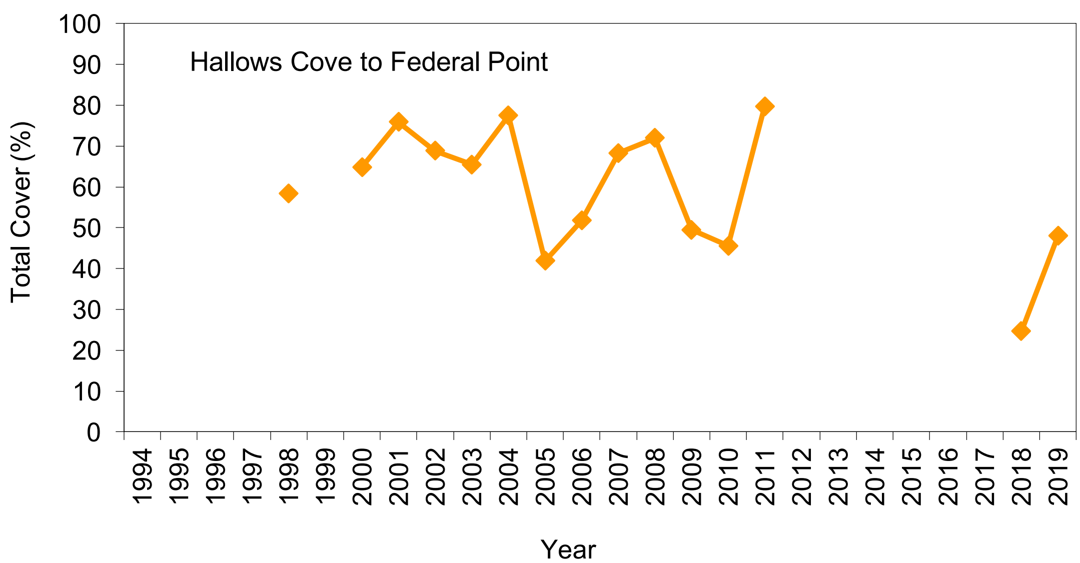


Figure 4. Total cover percent of grass bed (1998, 2000-2011, and 2018-2019).

Total cover percent of grass bed exhibited no correlation over time (τ=-0.2; p=0.149; n=15). There was a positive correlation between total percent cover and salinity (τ=0.448; p=0.01; n=15). There was a negative correlation between total percent cover and rainfall, but this was not significant (τ=0.029; p=0.441; n=15).

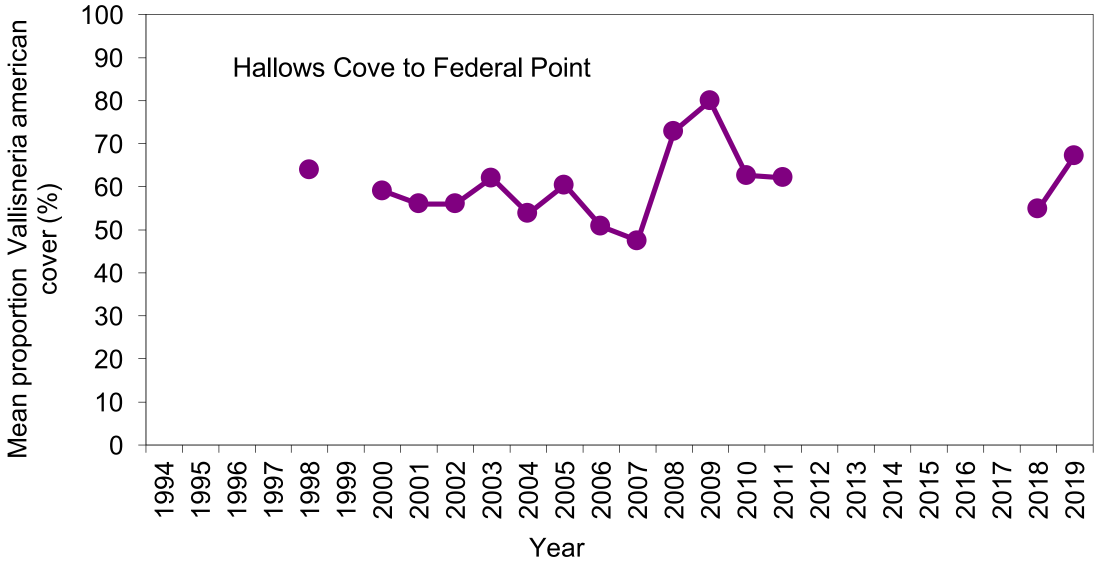


Figure 5. Proportional percent of Tape grass (Vallisneria) cover (1998, 2000-2011, and 2018-2019).

Proportional percent of Tape grass (*Vallisneria*) cover was negatively correlated over time, but this was not significant (τ=-0.086; p=0.328; n=15); PPVal was negatively correlated with salinity (τ=-0.257; p=0.091; n=15); there was a positive correlation between PPVal and rainfall, but this was not significant (τ=0.105; p=0.293; n=15).

Table 1. Relative occurrences of SAV species from Hallows Cove to Federal Point. (Data: 1998-2007, and 2018).

SAV Species	Relative % occurrence 1998-2007	Relative % occurrence Change 2018	Relative % occurrence Change 2019
Vallisneria americana	43	54	67
Najas guadalupensis	15	5	3
Ruppia maritima	11	2	6
Sagittaria subulata	9	4	2
Zannichellia palustris	5	0	1
Micranthemum spp.	4	0	0
Chara spp.	3	11	21
Ceratophyllum demersum	3	3	1
Eleocharis spp.	2	3	6
Hydrilla verticillata	2	5	1
Potamogeton pusillus	2	0	0
Fontanalis spp.	1	0	0

Data source: SJRWMD 2020

Table 2. Grass bed condition indices, salinity and rainfall from Hallows Cove to Federal Point.

No. of Transects	DATE	Salinity max. (‰)	Rainfall (in.)	Simpson's Index	SW Diversity Index	Mean Bed Length (m)	SAV_Bed Length (m)	Total Cover (%)	Proportional (%) Vallisneria Cover
	1994								
	1995		6.08						
	1996		4.33						
	1997		4.57						
10	1998	0.48	3.88	0.43	1.117	78.26	45.59	58.412	63.927
	1999	2.94	3.42						
12	2000	1.39	2.83	0.4	1.128	82.634	56.36	64.858	59.032
13	2001	0.75	4.05	0.3	1.424	91.15	74.808	75.875	56.025
13	2002	3.48	4.19	0.27	1.535	83.796	63.15	68.795	56.001
13	2003	0.4	3.79	0.31	1.42	69.57	50.855	65.45	62.032
13	2004	0.59	4.64	0.31	1.436	91.765	75.015	77.474	53.752
13	2005	0.45	5.03	0.33	1.211	61.413	27.277	41.864	60.383
13	2006	0.91	2.74	0.3	1.419	54.969	33.019	51.776	50.779
13	2007	2.81	3.63	0.3	1.469	67.865	55.735	68.282	47.46
13	2008	0.645	4.07			64.984	51.026	71.931	72.917
13	2009	0.457	4.89			66.692	45	49.439	79.987
13	2010	0.585	3.03			55.154	41	45.555	62.626
13	2011	2.11	3.64			74.385	61.154	79.678	62.128
28	2018	0.36	0.361	0.14	0.437	43.14	12.59	24.66	54.85
34	2019	0.5	0.5	0.13	0.917	48.02	24.16	48.02	67.28
	Mean	1.18	3.67	0.29	1.23	68.92	47.78	59.47	60.61
	SD	1.05	1.39	0.09	0.32	14.90	18.00	15.57	8.39

Data: SJRWMD 2020.
Salinity maxima used are for Scratch Ankle SJRWMD/Racy Pt. NOAA Ports.
Rainfall is for the LSJRB

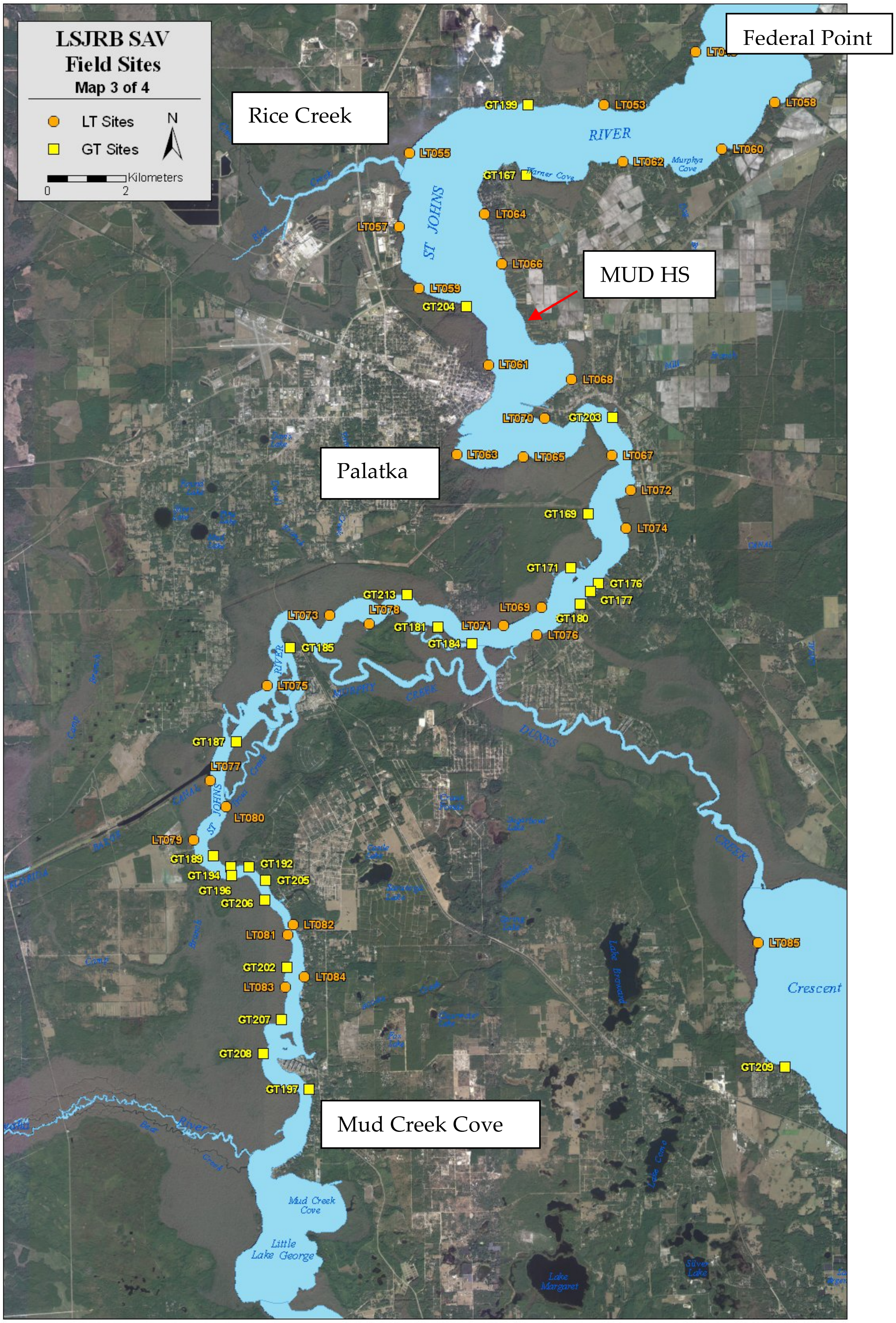
Table 3. Grass bed condition indices for the east and west banks of SJR between Hallows Cove to Federal Point.

Location	Statistic	Mean Bed Length (m)	SAV_Bed Length (m)	Total Cover (%)	Proportional (%) Vallisneria Cover
East bank SJR	Mean	67.25	43.82	56.48	61.55
111 Transects	SD	15.17	15.95	15.34	8.51
West bank SJR	Mean	70.55	53.39	64.03	58.94
109 Transects	SD	17.23	22.61	18.59	10.37

Data: SJRWMD 2020.

Appendix 4.1.7.1.C

SAV Transect Locations Map 3



Appendix 4.1.7.2.C

Trends for SAV (5GT) sites (9LT and 1 HS sites included 2019) from Federal Point to Palatka: Expected fluctuation given environmental conditions.

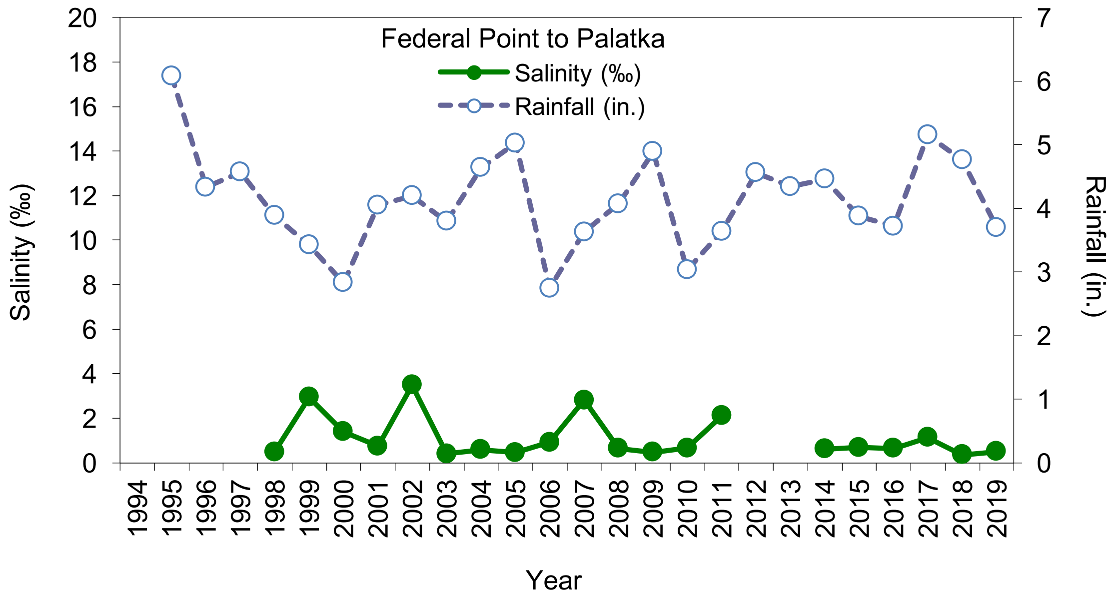


Figure 1. Radar rainfall (1995-2011) and salinity (1998-2011, and 2014-2019).

Radar rainfall was positively correlated over time, but this was not significant (τ=-0.195; p=0.102; n=22); salinity was negatively correlated over time, but this was not significant (τ=-0.158; p=0.165; n=20); rainfall and salinity were negatively correlated (τ=-0.295; p=0.035; n=20).

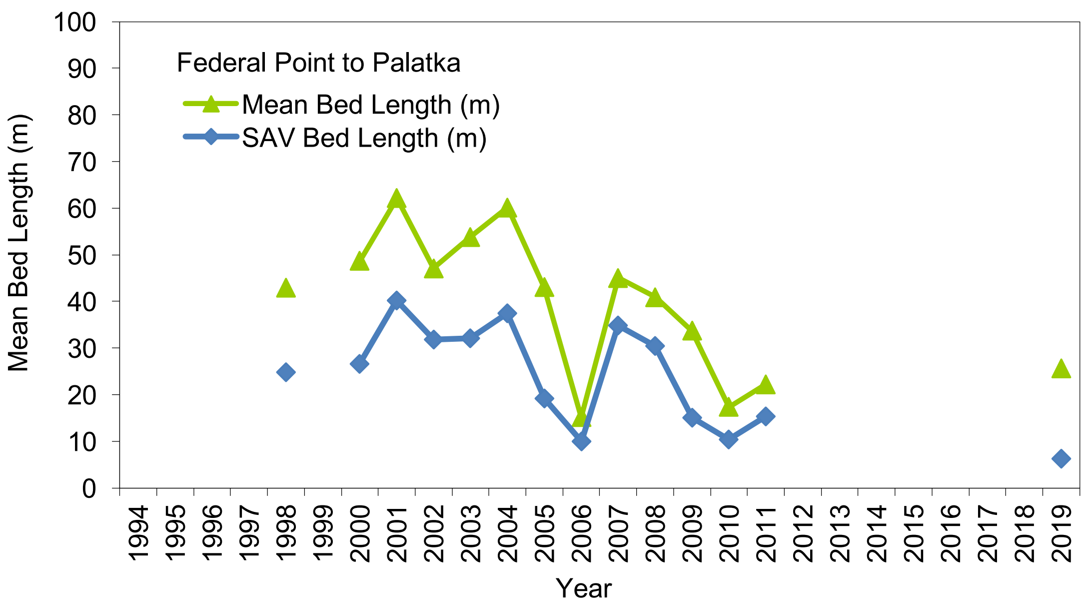


Figure 2. Mean grass bed length in meters (1998-2011, and 2019).

Mean grass bed length in meters was negatively correlated over time (τ=-0.495; p=0.007; n=14); mean bed length was negatively correlated with salinity, but this was not significant (τ=0.033; p=0.435; n=14). Mean bed length and rainfall was positively correlated, but this was not significant (τ=0.297; p=0.07; n=14).

Mean SAV grass bed length in meters was negatively correlated over time (τ=-0.407; p=0.021; n=14); mean SAV bed length was positively correlated with salinity, but this was not significant (τ=0.143; p=0.238; n=14). Mean SAV bed length and rainfall were positively correlated, but this was not significant (τ=0.209; p=0.149; n=14).

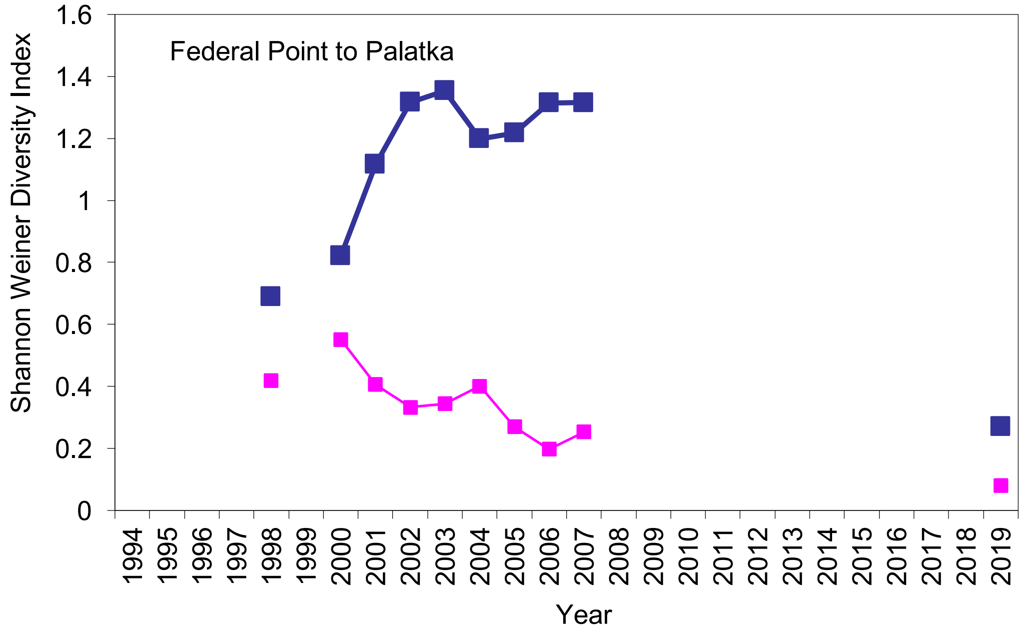


Figure 3. Shannon Weiner Diversity Index and Simpson's Index for grass beds (1998-2007, and 2019).

SWDI was positively correlated over time, but not significant (τ=0.244; p=0.163; n=10); SWDI was positively correlated with salinity, but this was not significant (τ=0.156; p=0.266; n=10). SWDI and rainfall were positively correlated, but this was not significant (τ=0.111; p=0.327; n=10). SI was negatively correlated over time (τ=-0.778; p=0.0009; n=10); SI was positively correlated with salinity, but not significant (τ=0.022; p=0.464; n=10). SI and rainfall were positively correlated, but not significant (τ=0.067; p=0.394; n=10). SWDI and SI were negatively correlated (τ=-0.2; p=0.210; n=10).

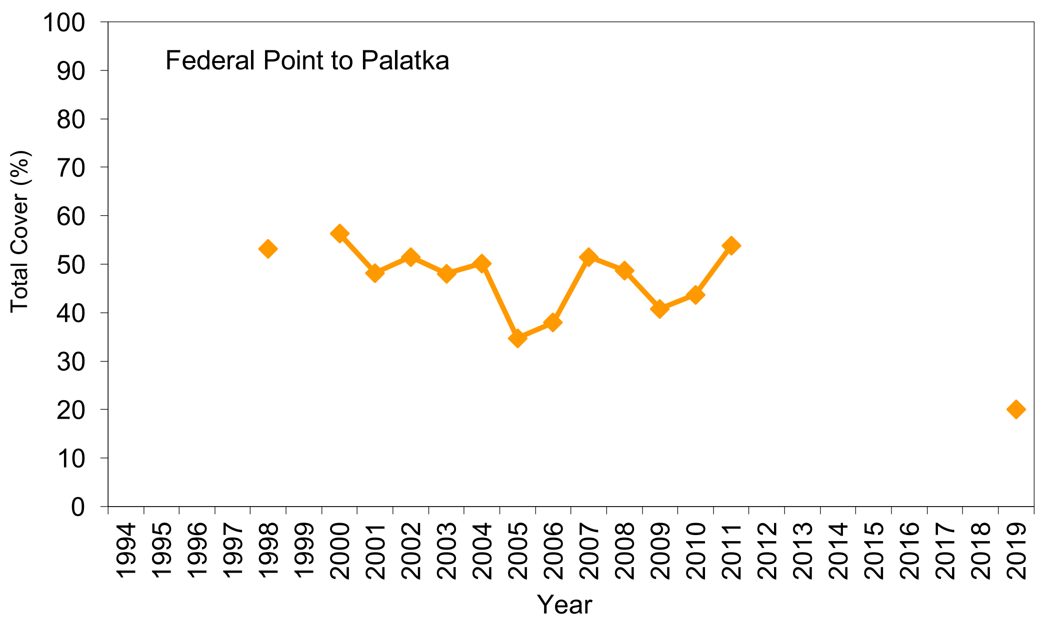


Figure 4. Total cover percent of grass bed (1998-2011, and 2019).

Total cover percent of grass bed was negatively correlated over time, but this was not significant (τ=-0.319; p=0.056; n=14). There was a positive correlation between total percent cover and salinity (τ=0.363; p=0.035; n=14). There was a negative correlation between total percent cover and rainfall, but this was not significant (τ=0.143; p=0.238; n=14).

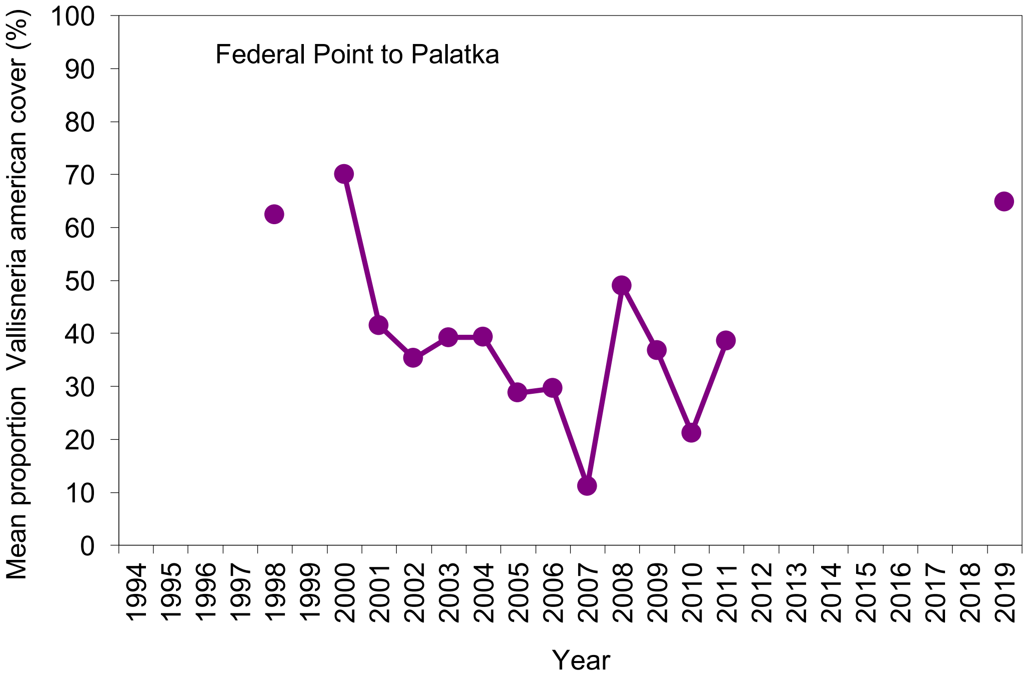


Figure 5. Proportional percent of Tape grass (Vallisineria) cover (1998-2011, and 2019).

Proportional percent of Tape grass (*Vallisneria*) cover was negatively correlated over time, but this was not significant (τ=-0.231; p=0.125; n=14); PPVal was negatively correlated with salinity, but this was not significant (τ=-0.077; p=0.351; n=14); there was no correlation between PPVal and rainfall (τ=-0.055; p=0.392; n=14).

Table 1. Relative occurrences of SAV species from Federal Point to Palatka. (Data: 1998-2007, and 2019).

SAV Species	Relative % occurrence 1998-2007	Relative % occurrence Change 2019
Vallisneria americana	38	65
Najas guadalupensis	22	2
Hydrilla verticillata	7	0
Sagittaria subulata	7	1
Potamogeton pusillus	6	0
Ceratophyllum demersum	6	0
Zannichellia palustris	5	0
Chara spp.	4	0
Micranthemum spp.	3	0
Eleocharis spp.	2	10
Ruppia maritima	1	0
Fontanalis spp.	0	0

Data source: SJRWMD 2020

Table 2. Grass bed condition indices, salinity and rainfall from Federal Point to Palatka.

No. of Transects	DATE	Salinity max. (‰)	Rainfall (in.)	Simpson's Index	SW Diversity Index	Mean Bed Length (m)	SAV_Bed Length (m)	Total Cover (%)	Proportional (%) Vallisneria Cover
	1994								
	1995		6.08						
	1996		4.33						
	1997		4.57						
6	1998	0.48	3.88	0.419	0.689	42.883	24.8	53.219	62.442
	1999	2.94	3.42						
6	2000	1.39	2.83	0.551	0.822	48.712	26.633	56.305	70.089
8	2001	0.75	4.05	0.406	1.116	62.131	40.15	48.154	41.465
8	2002	3.48	4.19	0.333	1.316	47.131	31.794	51.457	35.337
8	2003	0.4	3.79	0.344	1.354	53.863	32.088	48.082	39.244
8	2004	0.59	4.64	0.401	1.199	60.119	37.444	50.178	39.317
8	2005	0.45	5.03	0.27	1.217	43.069	19.144	34.74	28.802
7	2006	0.91	2.74	0.197	1.314	15.15	10.064	37.94	29.646
8	2007	2.81	3.63	0.253	1.316	45.063	34.794	51.5	11.184
8	2008	0.645	4.07			40.938	30.438	48.69	48.94
8	2009	0.457	4.89			33.75	15.125	40.784	36.75
8	2010	0.585	3.03			17.375	10.375	43.667	21.2
7	2011	2.11	3.64			22.286	15.286	53.799	38.663
15	2019	0.5	3.70	0.08	0.27	25.66	6.29	20.07	64.89
	Mean	1.23	3.84	0.33	1.06	39.87	23.89	45.61	40.57
	SD	1.06	0.68	0.13	0.36	15.05	11.11	9.64	16.54

Data: SJRWMD 2020
Salinity maxima used are for Scratch Ankle/Racy Pt. NOAA Ports.
Rainfall is for the LSJRB

Table 3. Grass bed condition indices for the east and west banks of SJR between Federal Point to Palatka.

Location	Statistic	Mean Bed Length (m)	SAV_Bed Length (m)	Total Cover (%)	Proportional (%) Vallisneria Cover
East bank SJR	Mean	53.52	29.54	39.39	44.61
57 Transects	SD	23.88	16.21	11.07	17.93
West bank SJR	Mean	25.96	18.21	51.19	37.14
56 Transects	SD	9.07	10.19	15.22	16.61

Data: SJRWMD 2020
Rice Creek (west bank north of the creek (1 site) SAV decreasing to nothing in 2010 rebounding in 2011
Rice Creek (west bank south of the creek (1 site) bare in 2011.

Appendix 4.1.7.2.C

Trends for SAV (3GT included for 2019 all bare) sites from Palatka to Mud Creek Cove: Expected fluctuation given environmental conditions.

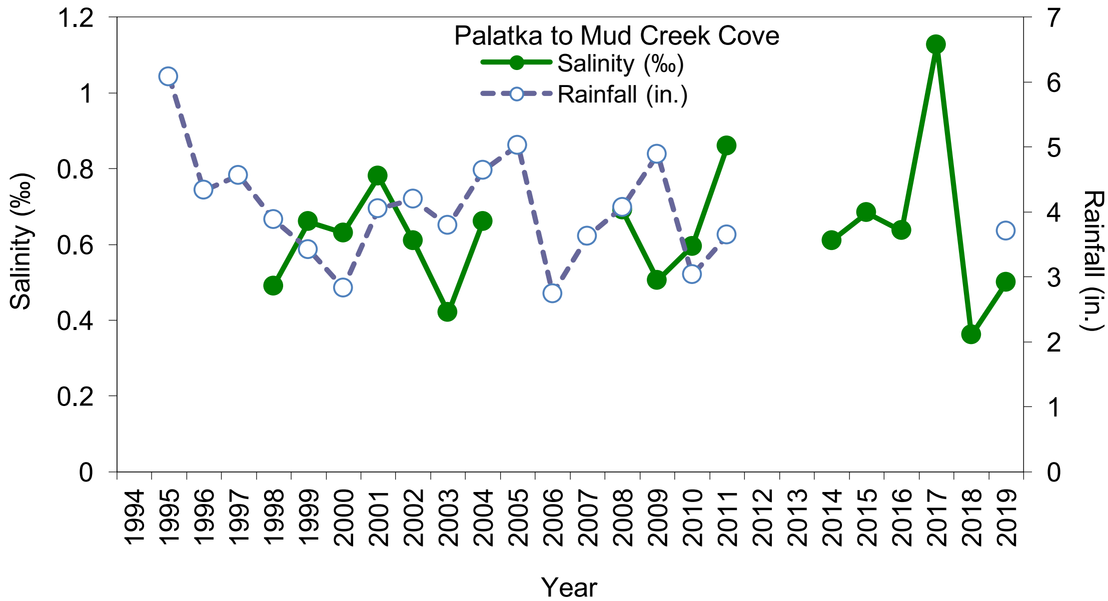


Figure 1. Radar rainfall (1995-2011, and 2019) and salinity (1998-2011, and 2014-2019).

Radar rainfall was negatively correlated over time, but this was not significant (τ=-0.1765; p=0.1614; n=17); salinity was positively correlated over time, but this was not significant (τ=0.1469; p=0.2648; n=11); rainfall and salinity were negatively correlated, but this was not significant (τ=-0.0367; p=0.4376; n=11).

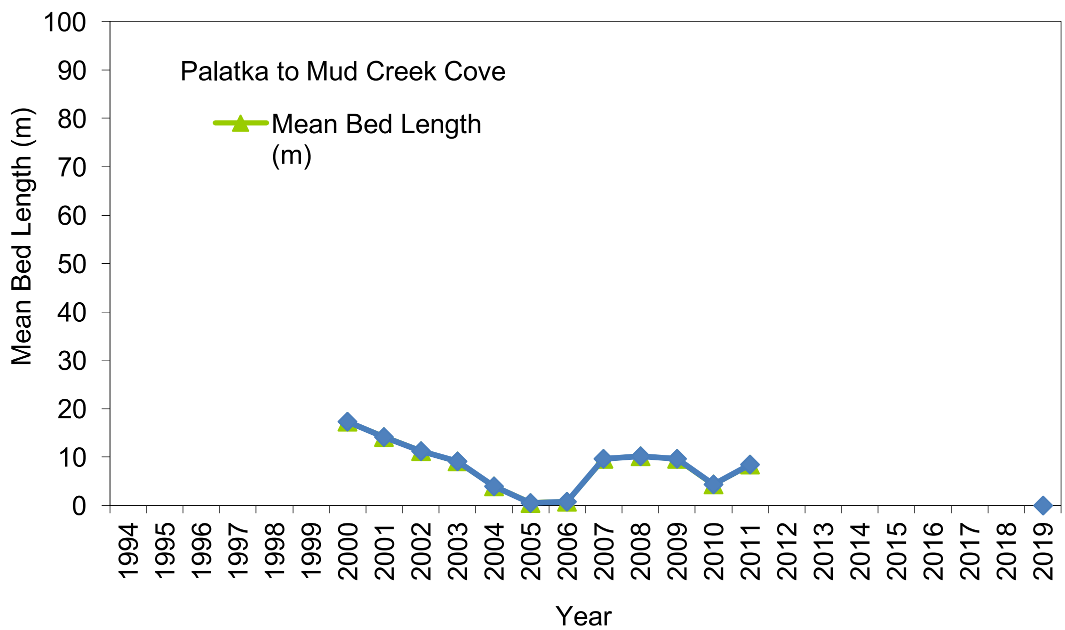


Figure 2. Mean grass bed length in meters (2000-2011, and 2019).

Mean grass bed length in meters was negatively correlated over time (τ=-0.3636; p=0.0499; n=12); mean bed length was positively correlated with salinity, but this was not significant (τ=0.1111; p=0.3383; n=9). Mean bed length and rainfall were negatively correlated, but this was not significant (τ=-0.0606; p=0.3919; n=12).

Mean SAV grass bed length in meters was negatively correlated over time, but this was not significant (τ=-0.212; p=0.1685; n=12); mean SAV bed length was positively correlated with salinity, but this was not significant (τ=0.2778; p=0.1487; n=9). Mean SAV bed length and rainfall were negatively correlated, but this was not significant (τ=-0.0909; p=0.3404; n=12).

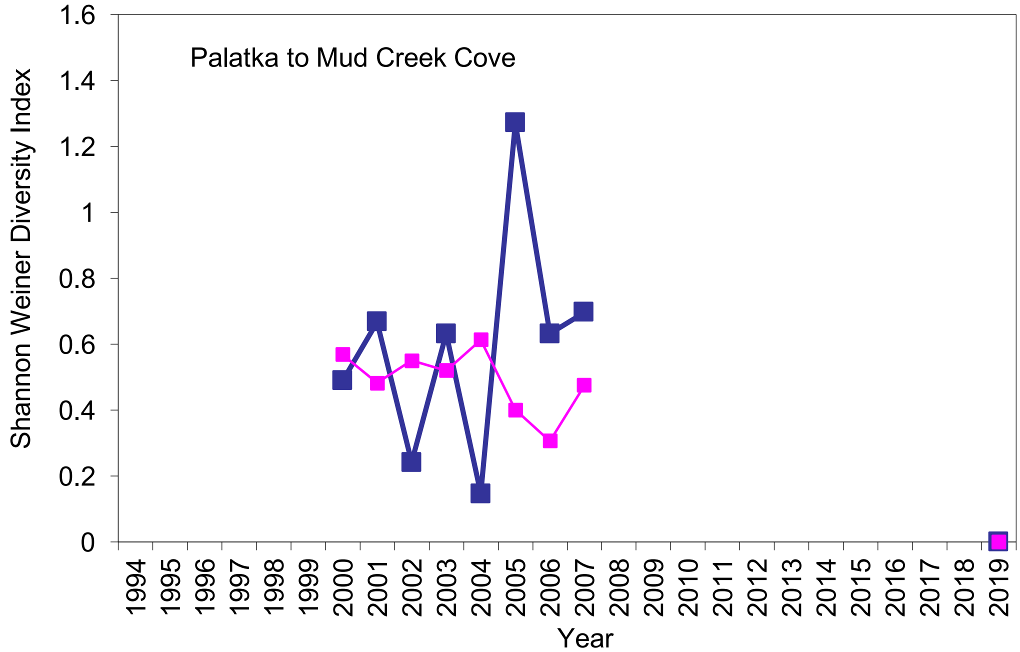


Figure 3. Shannon Weiner Diversity Index for grass beds (2000-2007, and 2019).

SWDI was positively correlated over time, but this was not significant (τ=0.286hj; p=0.161; n=8); SWDI was not correlated with salinity (τ=0.0; p=0.5; n=5). SWDI and rainfall were negatively correlated, but this was not significant (τ=-0.071; p=0.402; n=8). SI was negatively correlated over time, but this was not significant (τ=-0.286; p=0.069; n=8); SI was positively correlated with salinity, but this was not significant (τ=0.2; p=0.312; n=5). SI and rainfall were positively correlated, but this was not significant (τ=0.214; p=0.229; n=8). SWDI and SI were negatively correlated (τ=-0.714; p=0.007; n=8).

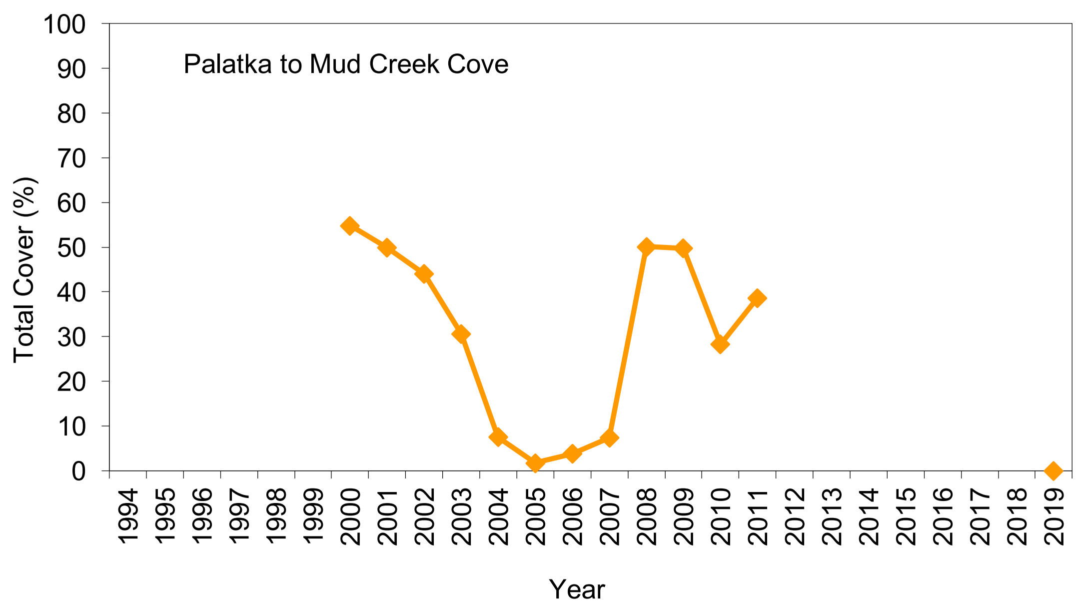


Figure 4. Total cover percent of grass bed 2000-2011, and 2019.

Total cover percent of grass bed was negatively correlated over time, but this was not significant (τ=-0.2121; p=0.1685; n=12). There was a positive correlation between total percent cover and salinity, but this was not significant (τ=0.1111; p=0.3383; n=9). There was a positive correlation between total percent cover and rainfall, but this was not significant (τ=0.0303; p=0.4455; n=12).

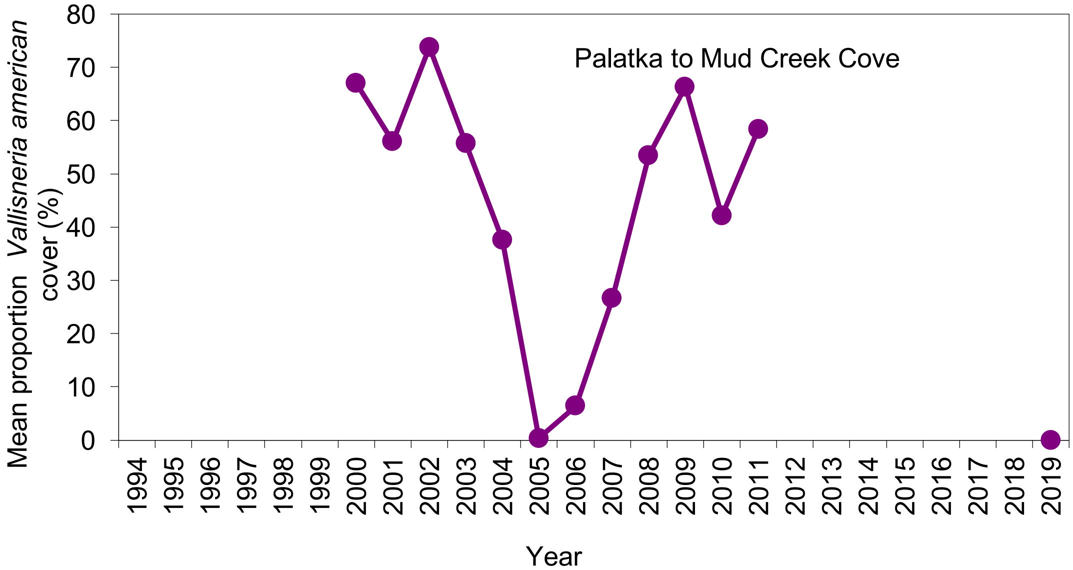


Figure 5. Proportional percent of Tape grass (Vallisineria) cover 2000-2011, and 2019.

Proportional percent of Tape grass (*Vallisneria*) cover was negatively correlated over time, but this was not significant (τ=-0.1515; p=0.2664; n=12); PPVal was not correlated with salinity (τ=0; p=0.5; n=11); there was a positive correlation between PCVal and rainfall, but this was not significant (τ=0.0303; p=0.4455; n=12).

Table 1. Relative occurrences of SAV species from Palatka to Mud Creek Cove. (Data: 1998-2007, and 2019).

SAV Species	Relative % occurrence 1998-2007	Relative % occurrence Change 2019
Vallisneria americana	41	0
Najas guadalupensis	15	0
Sagittaria subulata	14	0
Zannichellia palustris	13	0
Ceratophyllum demersum	10	0
Chara spp.	3	0
Eleocharis spp.	2	0
Hydrilla verticillata	1	0
Ruppia maritima	0	0
Potamogeton pusillus	0	0
Micranthemum spp.	0	0
Fontanalis spp.	0	0

Data source: SJRWMD 2020

Table 2. Grass bed condition indices, salinity and rainfall from Palatka to Mud Creek Cove.

No. of Transects	DATE	Salinity max. (‰)	Rainfall (in.)	Simpson's Index	SW Diversity Index	Mean Bed Length (m)	SAV_Bed Length (m)	Total Cover (%)	Proportional (%) Vallisneria Cover
	1994								
	1995		6.08						
	1996		4.33						
	1997		4.57						
	1998	0.49	3.88						
	1999	0.66	3.42						
11	2000	0.63	2.83	0.568	0.489	17.259	9.924	54.849	66.987
18	2001	0.78	4.05	0.482	0.667	14.189	9.208	49.863	56.059
18	2002	0.61	4.19	0.55	0.241	11.217	6.342	44.062	73.796
19	2003	0.42	3.79	0.52	0.632	9.089	3.966	30.544	55.704
19	2004	0.66	4.64	0.613	0.146	3.942	0.75	7.496	37.593
18	2005		5.03	0.4	1.271	0.497	0.127	1.7	0.351
19	2006		2.74	0.306	0.632	0.785	0.294	3.789	6.42
19	2007		3.63	0.475	0.696	9.593	5.623	7.353	26.622
19	2008	0.69	4.07			10.2	7.1	50.111	53.46
19	2009	0.505	4.89			9.579	6.053	49.743	66.316
19	2010	0.6	3.03			4.316	2.737	28.273	42.105
19	2011	0.86	3.64			8.368	6.316	38.692	58.371
	2012		4.56						
	2013		4.34						
	2014	0.61	4.46						
	2015	0.68	3.88						
	2016	0.64	3.72						
	2017	1.13	5.15						
	2018	0.36	4.76						
3	2019	0.50	3.70	0	0	0	0	0	0
	Mean	0.64	4.13	0.43	0.53	7.62	4.50	28.19	41.83
	SD	0.18	0.76	0.19	0.38	5.37	3.45	21.31	25.87

Data: SJRWMD 2020
Salinity maxima used are for Rice Creek.
Rainfall is for the LSJRB

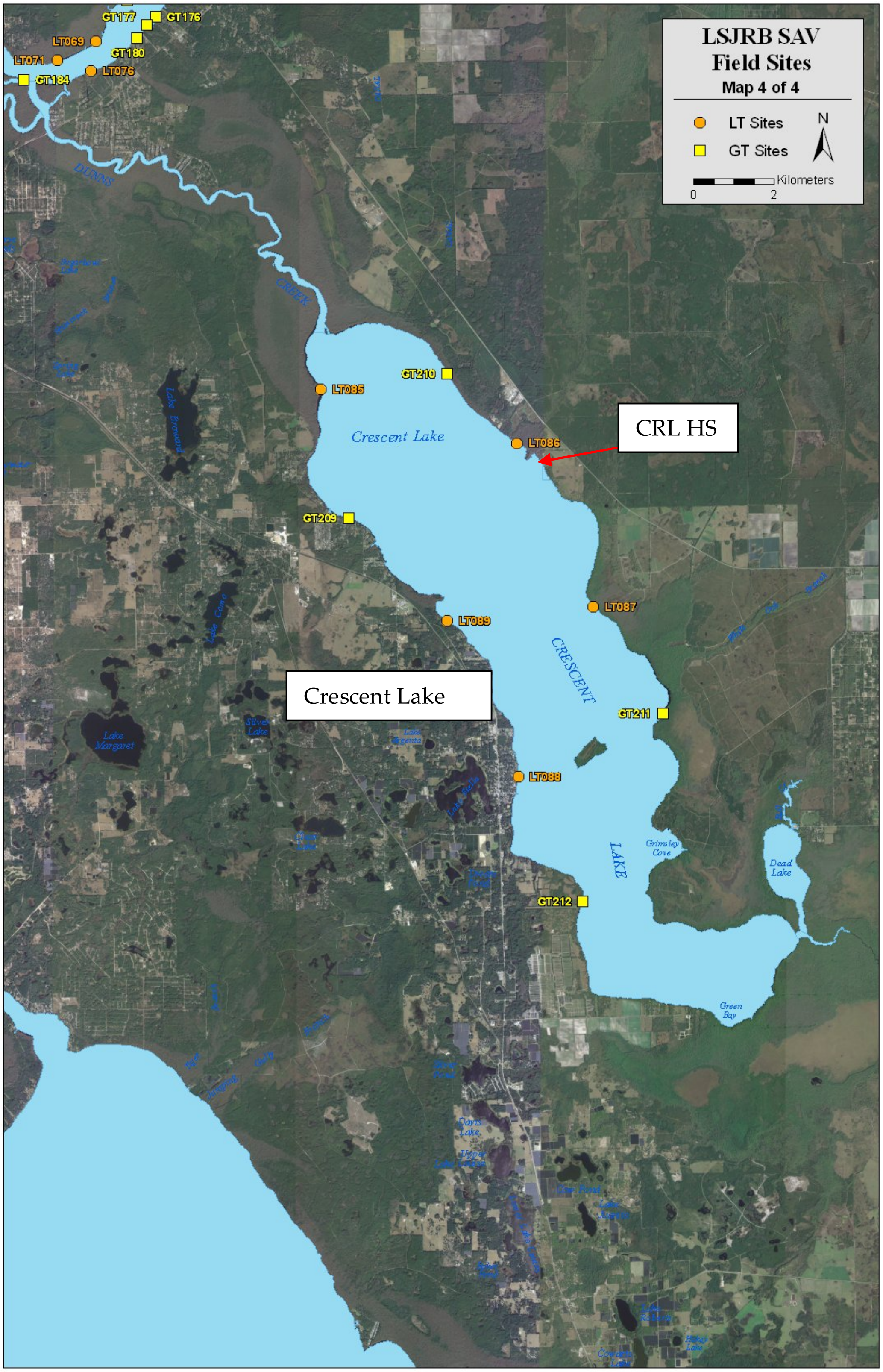
Table 3. Grass bed condition indices for the east and west banks of SJR between Palatka to Mud Creek Cove.

Location	Statistic	Mean Bed Length (m)	SAV_Bed Length (m)	Total Cover (%)	Proportional (%) Vallisneria Cover
East bank SJR	Mean	8.81	4.82	33.16	56.53
129 Transects	SD	4.71	3.05	20.03	26.65
West bank SJR	Mean	7.76	5.15	27.16	29.79
94 Transects	SD	6.85	4.52	22.85	21.23

From Rice Creek to Palatka SAV decreasing to nothing.
Data: SJRWMD 2020

Appendix 4.1.7.1.D

Transect Locations Map 4



Appendix 4.1.7.2.D

Trends for SAV (2GT) (including to 2LT and 1CRL sites) in Crescent Lake: All sites sampled were bare in 2019.

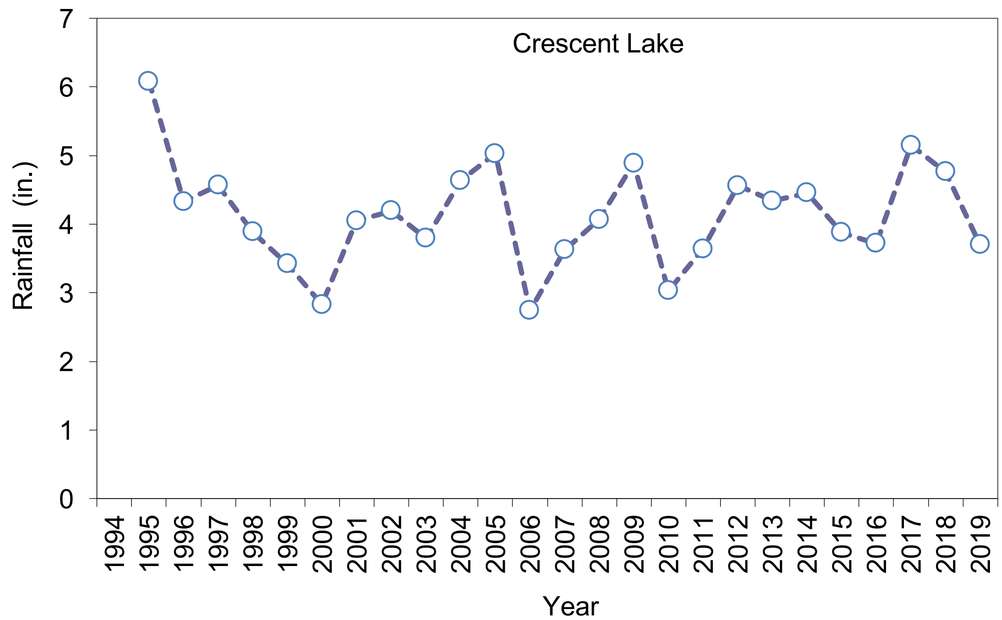


Figure 1. Radar rainfall (1995-2019).

Radar rainfall was negatively correlated over time, but this was not significant (τ=-0.1765; p=0.1614; n=17).

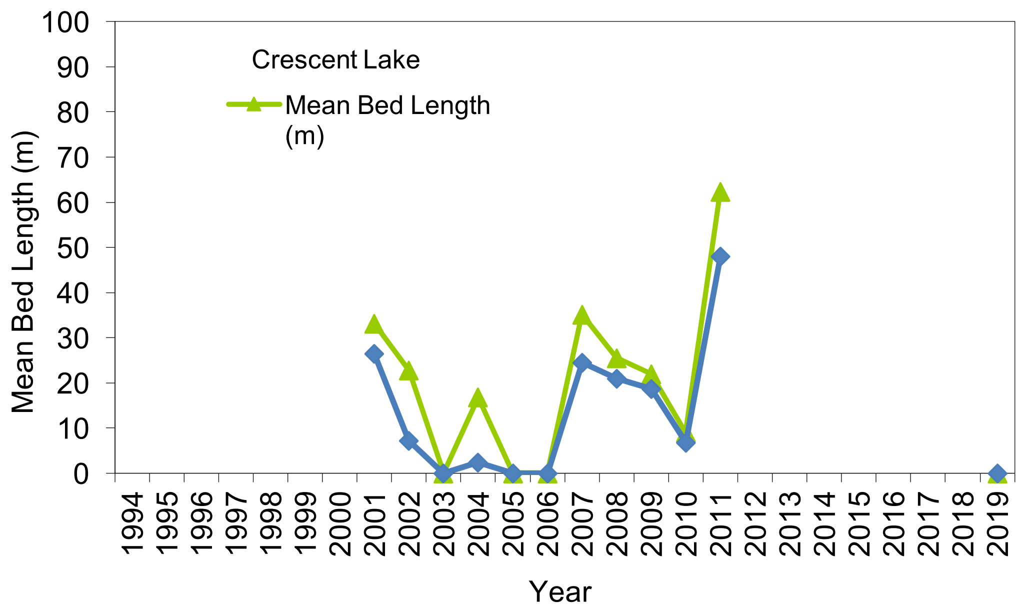


Figure 2. Mean grass bed length in meters (2001-2011, and 2019).

Mean grass bed length in meters was positively correlated over time, but this was not significant (τ=0.1122; p=0.3155; n=11). Mean bed length and rainfall were negatively correlated, but this was not significant (τ=-0.1496; p=0.2609; n=11).

Mean SAV grass bed length in meters was positively correlated over time, but this was not significant (τ=0.1496; p=0.2609; n=11). Mean SAV bed length and rainfall were negatively correlated, but this was not significant (τ=-0.1122; p=0.3155; n=11).

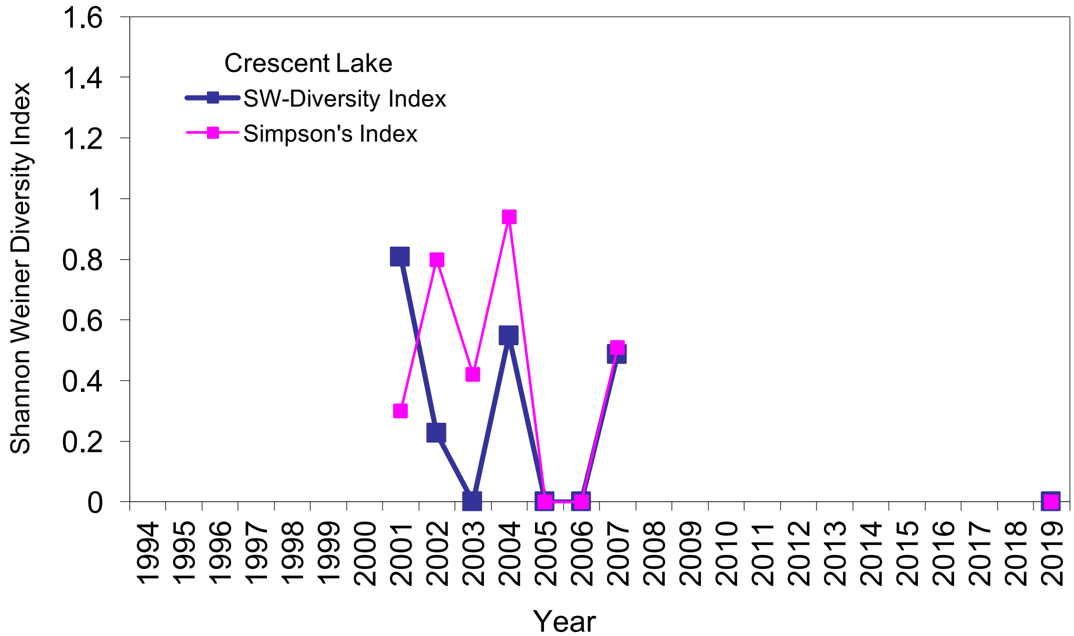


Figure 3. Shannon Weiner Diversity Index for grass beds (2001-2007, and 2019).

SWDI was negatively correlated over time, but this was not significant (τ=-0.309; p=0.165; n=7); SWDI and rainfall were positively correlated, but this was not significant (τ=0.102; p=0.373; n=7). SI was negatively correlated over time, but this was not significant (τ=-0.098; p=0.135; n=7). SI and rainfall were positively correlated, but this was not significant (τ=0.195; p=0.269; n=7). SWDI and SI were positively correlated (τ=0.422; p=0.092; n=7).

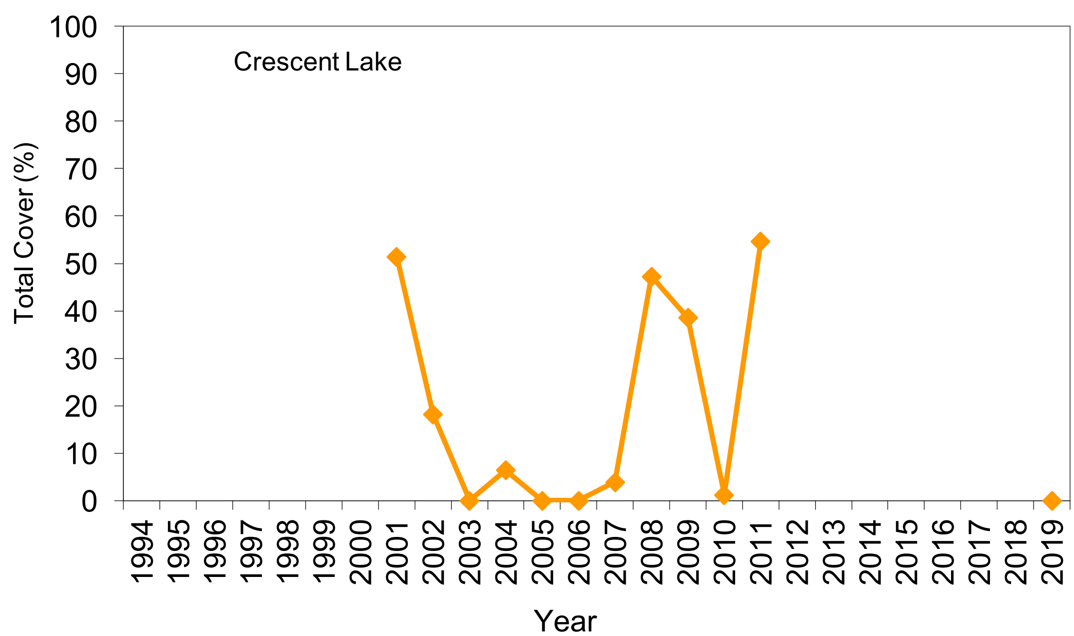


Figure 4. Total cover percent of grass bed (2001-2011, and 2019).

Total cover percent of grass bed was positively correlated over time, but this was not significant (τ=0.1122; p=0.3155; n=11). There was a positive correlation between total percent cover and rainfall, but this was not significant (τ=0.0749; p=0.3744; n=11).

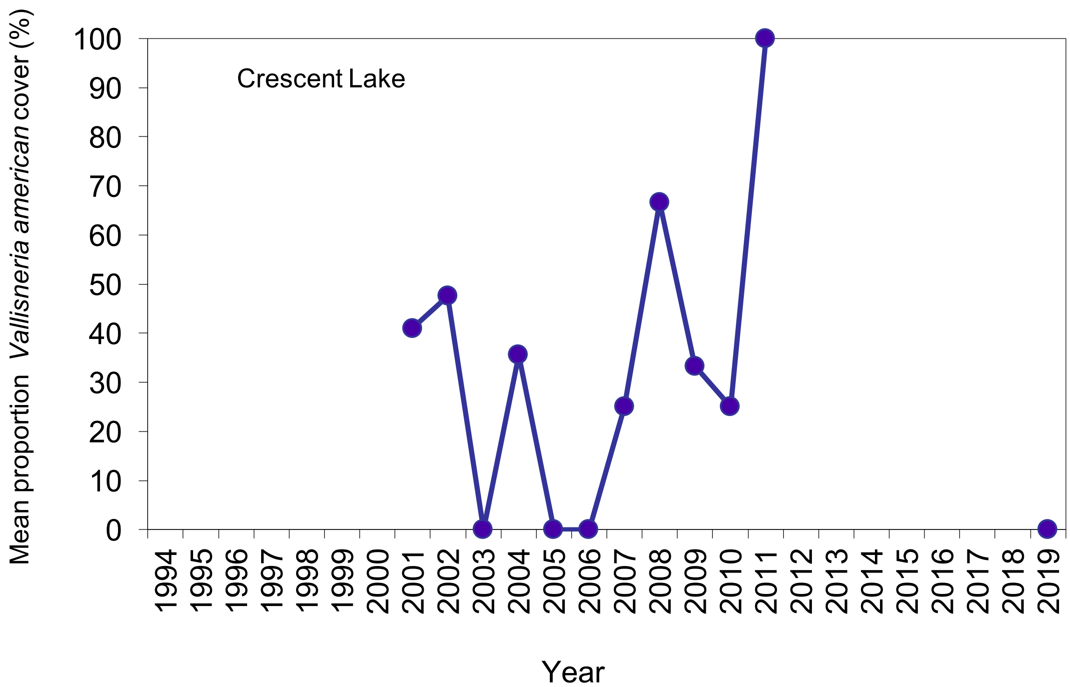


Figure 5. Proportional percent of Tape grass (Vallisineria) cover (2000-2011, and 2019).

Proportional percent of Tape grass (*Vallisneria*) cover was positively correlated over time, but this was not significant (τ=0.1322; p=0.2857; n=11). There was a positive correlation between PVal percent cover and rainfall, but this was not significant (τ=0.0566; p=0.4042; n=11).

Table 1. Ranked order of occurrences of SAV species in Crescent Lake. (Data: 1998-2007, and 2019)

SAV Species	Relative % occurrence 1998-2007	Relative % occurrence Change 2019
Vallisneria americana	76	0
Najas guadalupensis	12	0
Hydrilla verticillata	9	0
Chara spp.	3	0
Ruppia maritima	0	0
Sagittaria subulata	0	0
Zannichellia palustris	0	0
Micranthemum spp.	0	0
Ceratophyllum demersum	0	0
Eleocharis spp.	0	0
Potamogeton pusillus	0	0
Fontanalis spp.	0	0

Data source: SJRWMD 2020

Table 2. Grass bed condition indices and rainfall in Crescent Lake.

No. of Transects	DATE	Salinity max. (‰)	Rainfall (in.)	Simpson's Index	SW Diversity Index	Mean Bed Length (m)	SAV_Bed Length (m)	Total Cover (%)	Proportional (%) Vallisneria Cover
	1994								
	1995		6.08						
	1996		4.33						
	1997		4.57						
	1998		3.88						
	1999		3.42						
	2000		2.83						
4	2001		4.05	0.30	0.81	33.11	26.45	51.46	40.99
4	2002		4.19	0.80	0.23	22.80	7.20	18.19	47.57
4	2003		3.79	0.42	0.00	0.00	0.00	0.00	0.00
4	2004		4.64	0.94	0.55	16.85	2.36	6.44	35.57
4	2005		5.03	0.00	0.00	0.00	0.00	0.00	0.00
4	2006		2.74	0.00	0.00	0.00	0.00	0.00	0.00
4	2007		3.63	0.51	0.49	35.20	24.45	3.92	25.00
4	2008		4.07			25.50	21.00	47.25	66.67
4	2009		4.89			22.00	18.75	38.56	33.33
4	2010		3.03			9.00	6.75	1.25	25.00
3	2011		3.64			62.33	48.00	54.60	100.00
0	2012		4.56						
0	2013		4.34						
0	2014		4.46						
0	2015		3.88						
0	2016		3.72						
0	2017		5.15						
0	2018		4.76						
5	2019		3.70	0.00	0.00	0.00	0.00	0.00	0.00
	Mean		4.13	0.37	0.26	18.90	12.91	18.47	31.18
	SD		0.76	0.37	0.32	18.96	15.06	22.65	30.67

Data: SJRWMD 2020

Table 3. Grass bed condition indices for the east and west banks of Crescent Lake.

Location	Statistic	Mean Bed Length (m)	SAV_Bed Length (m)	Total Cover (%)	Proportional (%) Vallisneria Cover
East bank SJR	Mean	18.90	12.91	18.47	31.18
10 Transects	SD	18.96	15.06	22.65	30.67
14 Transects bare or no data					
West bank SJR	Mean	18.42	10.84	17.15	39.02
16 Transects	SD	15.17	10.93	22.05	36.15
13 Transects bare or no data					

Data: SJRWMD 2020
SAV gone from Crescent Lake sites in 2019.

Appendix 4.1.7.2.E

Trends for SAV (9HS) sites in Lake George in 2019

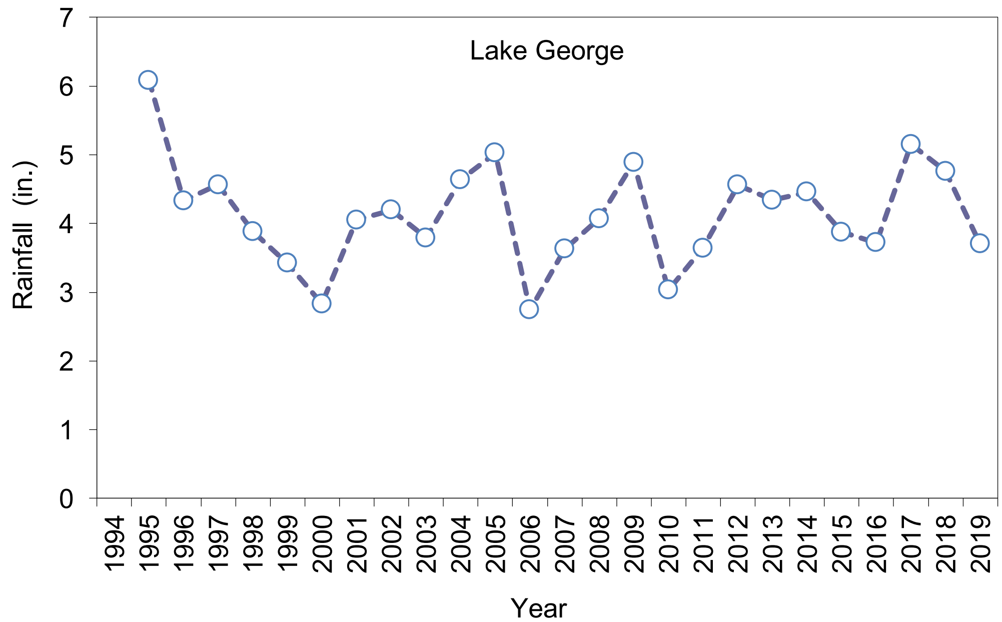


Figure 1. Radar rainfall (1995-2019).

Radar rainfall was negatively correlated over time, but this was not significant (τ=-0.1765; p=0.1614; n=17).

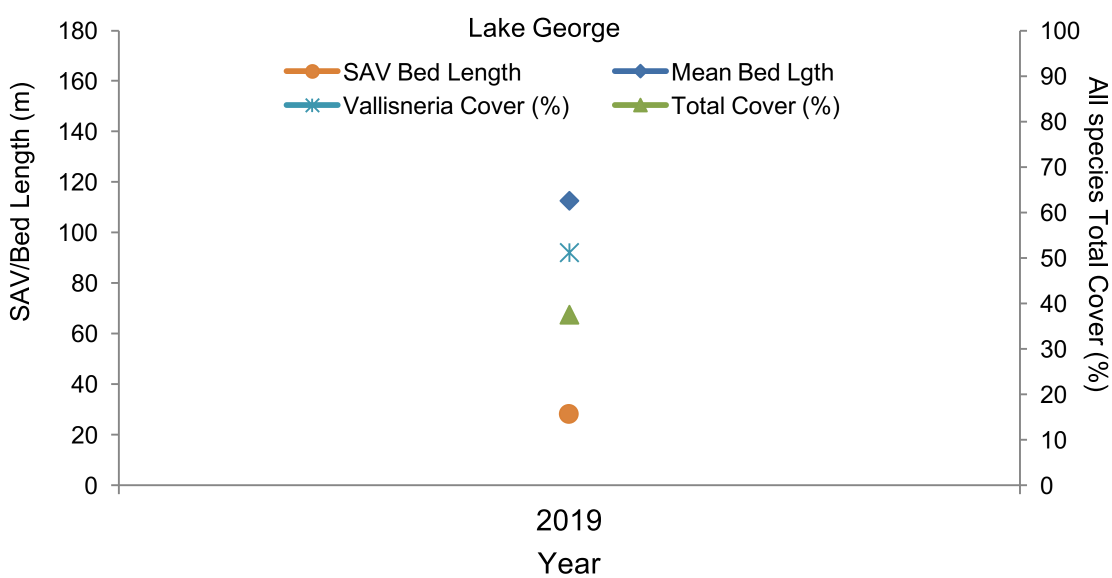


Figure 2. Mean grass bed and bed length in meters (2019) and Total Cover/Vallisneria Cover percent.

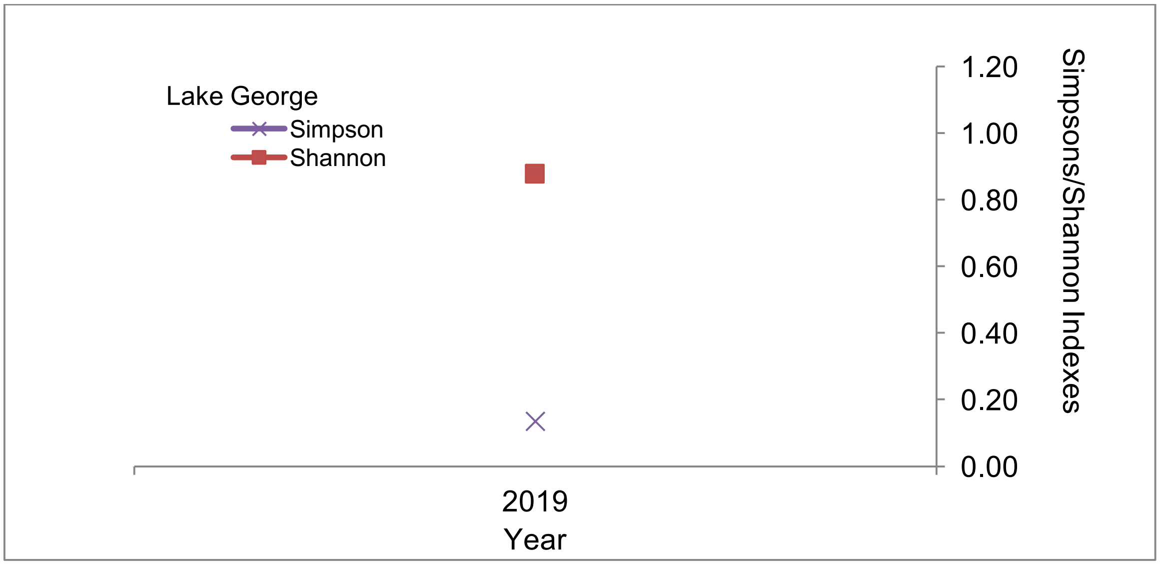


Figure 3. Shannon Weiner and Simpson Diversity Indices for grass beds (2019).

Table 1. Ranked order of occurrences of SAV species in Lake George. (Data: 2019)

SAV Species	Relative % occurrence 2019
Vallisneria americana	51
Chara spp.	39
Ruppia maritima	19
Sagittaria subulata	15
Najas guadalupensis	1
Hydrilla verticillata	0
Zannichellia palustris	0
Micranthemum spp.	0
Ceratophyllum demersum	0
Eleocharis spp.	0
Potamogeton pusillus	0
Fontanalis spp.	0

Data source: SJRWMD 2020

Table 2. Grass bed condition indices and rainfall in Lake George.

No. of Transects	Date	Salinity Max. (‰)	Rainfall (in.)	Simpson's Index	SW Diversity Index	Mean Bed Length (m)	SAV_Bed Length (m)	Total Cover (%)	Proportional (%) Vallisneria Cover
	1994								
	1995		6.08						
	1996		4.33						
	1997		4.57						
	1998		3.88						
	1999		3.42						
	2000		2.83						
	2001		4.05						
	2002		4.19						
	2003		3.79						
	2004		4.64						
	2005		5.03						
	2006		2.74						
	2007		3.63						
	2008		4.07						
	2009		4.89						
	2010		3.03						
	2011		3.64						
	2012		4.56						
	2013		4.34						
	2014		4.46						
	2015		3.88						
	2016		3.72						
	2017		5.15						
	2018		4.76						
9	2019		3.7	0.14	0.88	62.56	27.82	37.42	51.11
	Mean								
	SD								

Data: SJRWMD 2020

Table 3. Grass bed condition indices for the east and west banks of Lake George.

Location	Statistic	Mean Bed Length (m)	SAV_Bed Length (m)	Total Cover (%)	Proportional (%) Vallisneria Cover
East bank SJR	Mean	71.20	14.55	18.98	81.65
2 Transects	SD	5.60	14.25	18.52	18.35
West bank SJR	Mean	65.10	36.10	47.20	44.15
6 Transects	SD	28.66	39.39	27.60	13.35

Data: SJRWMD 2020

Table 4. Salinity, rainfall and grass bed indices for six sections of St. John River from Fuller Warren Bridge to Mud Creek Cove.

River or Lake Section	Data Period	Mean Bed Length (m)	Minus	High	Low	Plus	sd	ci	n
Location									
Fuller Warren to Buckman (FWBK)	1998-19	50.16	18.81	139.98	0.42	81.51	31.35	15.59	18
Buckman to Hallows Cove (BKHC)	1998-19	97.26	77.08	145.90	55.33	117.44	20.18	10.03	18
Hallows Cove to Federal Point (HCFP)	1998-19	68.92	54.02	91.76	43.14	83.82	14.90	8.25	15
Federal Point to Palatka (FPPK)	1998-19	39.87	24.82	62.13	15.15	54.92	15.05	8.69	14
Palatka to Mud Creek Cove (PKMC)	2000-19	All bare in 2019							
Crescent Lake (CL)	2001-19	All bare in 2020							
Fuller Warren to Buckman (FWBK)	1998-19	49.62	18.18	140.00	0.42	81.06	31.44	15.64	18
Buckman to Hallows Cove (BKHC)	1998-19	87.29	71.62	121.58	56.60	102.96	15.67	7.79	18
Hallows Cove to Federal Point (HCFP)	1998-19	67.25	52.08	87.38	42.37	82.42	15.17	8.76	14
Federal Point to Palatka (FPPK)	1998-19	53.52	29.64	94.24	9.67	77.40	23.88	13.79	14
Palatka to Mud Creek Cove (PKMC)	2000-19	All bare in 2019							
Crescent Lake (CL)	2001-19	All bare in 2020							
Fuller Warren to Buckman (FWBK)	1998-19	31.04	9.40	69.45	0.00	52.68	21.64	11.12	18
Buckman to Hallows Cove (BKHC)	1998-19	112.32	79.98	184.12	24.00	144.66	32.34	16.08	18
Hallows Cove to Federal Point (HCFP)	1998-19	70.55	53.32	101.22	43.91	87.78	17.23	9.54	15
Federal Point to Palatka (FPPK)	1998-19	25.96	16.89	43.59	14.25	35.03	9.07	5.24	14
Palatka to Mud Creek Cove (PKMC)	2000-19	All bare in 2019							
Crescent Lake (CL)	2001-19	All bare in 2020							

Source data: SJRWMD 2019

Note: Numbers in parentheses indicate Standard Deviation of the mean. Rainfall average is for the whole LSJRB area 2,755 sq. miles. PKMC and CL sites were bare in 2019. The graphs show statistics for those areas during 2001-2011.

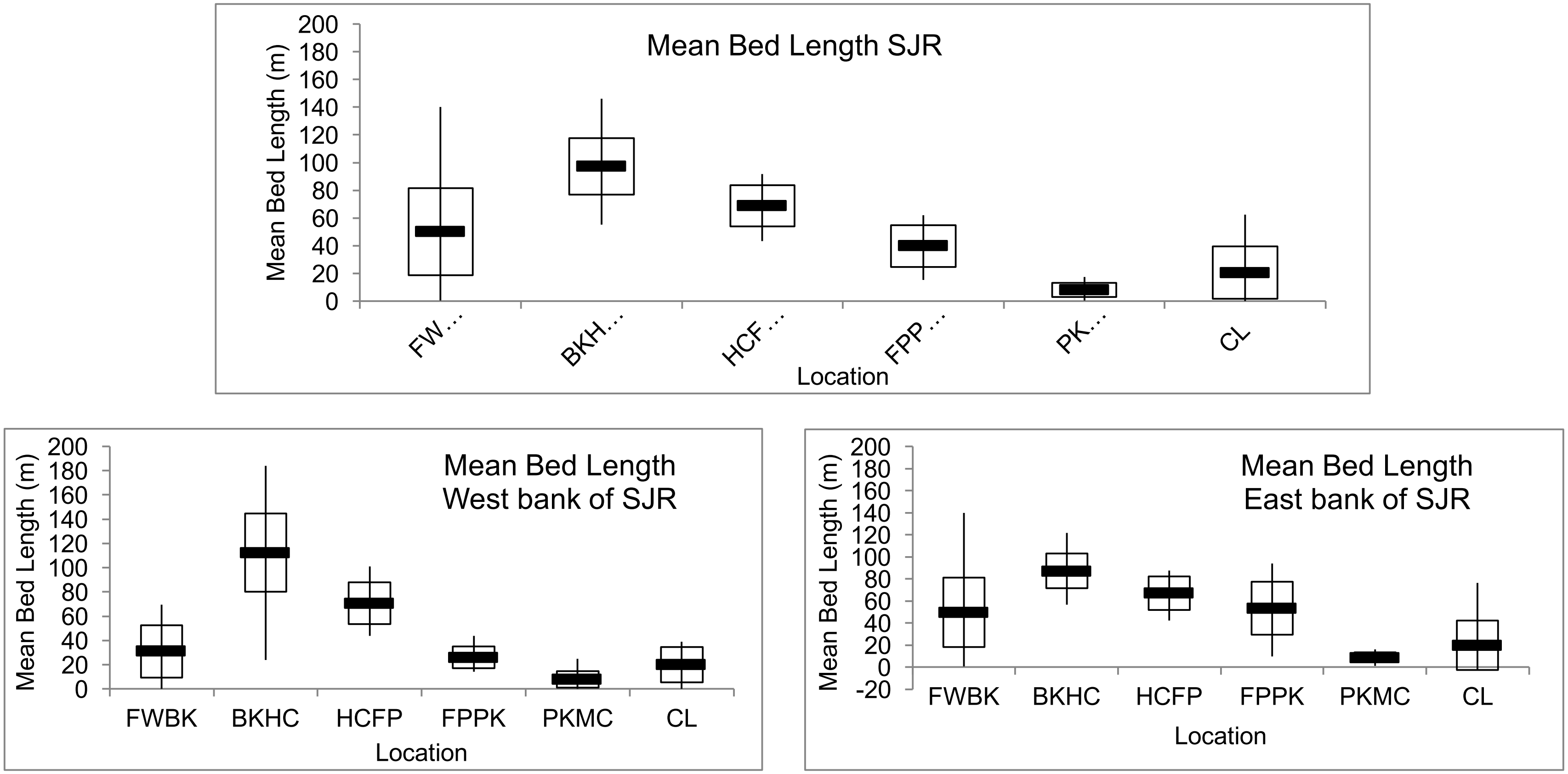


Figure 4. Mean grass bed length (horizontal line) and standard deviation (boxes) compared for six sections of St. Johns River including opposite banks. Vertical lines indicate range (maximum and minimum). See Table 4 for details. PKMC and CL sites were bare in 2019. The graphs show statistics for those areas during 2001-2011, they were bare in 2019.

Table 5. Grass bed indices for six sections of St. John River from Fuller Warren Bridge to Mud Creek Cove.

River or Lake Section		Data Period	Mean Bed Length (m)	Minus	Max	Min	Plus	sd	ci	n
Location										
Fuller Warren to Buckman (FWBK)	Both	1998-19	51.88	17.15	139.98	0.42	86.61	34.73	20.05	14
Buckman to Hallows Cove (BKHC)		1998-15	99.62	77.37	145.90	55.33	121.87	22.25	12.85	14
Hallows Cove to Federal Point (HCFP)		1998-11	72.51	60.14	91.77	54.97	84.88	12.37	7.48	13
Federal Point to Palatka (FPPK)		1998-11	40.96	25.88	62.13	15.15	56.04	15.08	9.11	13
Palatka to Mud Creek Cove (PKMC)		2000-11	8.25	3.18	17.26	0.50	13.33	5.07	3.22	12
Crescent Lake (CL)		2000-11	20.62	1.74	62.33	0.00	39.50	18.88	12.68	11
Fuller Warren to Buckman (FWBK)	East	1998-11	63.11	15.06	187.00	0.00	111.15	48.05	29.03	13
Buckman to Hallows Cove (BKHC)		1998-11	89.60	72.14	121.58	56.60	107.05	17.46	10.55	13
Hallows Cove to Federal Point (HCFP)		1998-11	70.73	58.81	87.38	54.71	82.66	11.92	7.20	13
Federal Point to Palatka (FPPK)		1998-11	55.27	31.38	94.24	9.67	79.17	23.89	14.44	13
Palatka to Mud Creek Cove (PKMC)		2000-11	8.81	4.10	16.01	0.93	13.52	4.71	2.99	12
Crescent Lake (CL)		2000-11	19.86	-2.64	76.50	0.00	42.36	22.50	15.12	11
Fuller Warren to Buckman (FWBK)	West	1998-11	33.98	11.34	69.45	0.00	56.63	22.64	13.68	13
Buckman to Hallows Cove (BKHC)		1998-11	115.01	77.92	184.12	24.00	152.11	37.10	22.42	13
Hallows Cove to Federal Point (HCFP)		1998-11	74.13	58.63	101.22	52.33	89.63	15.50	9.37	13
Federal Point to Palatka (FPPK)		1998-11	26.56	17.42	43.59	14.25	35.71	9.15	5.53	13
Palatka to Mud Creek Cove (PKMC)		2000-11	7.76	0.90	25.05	0.00	14.61	6.85	4.35	12
Crescent Lake (CL)		2000-11	20.09	5.39	38.95	0.00	34.79	14.70	9.88	11

Source data: SJRWMD 2016

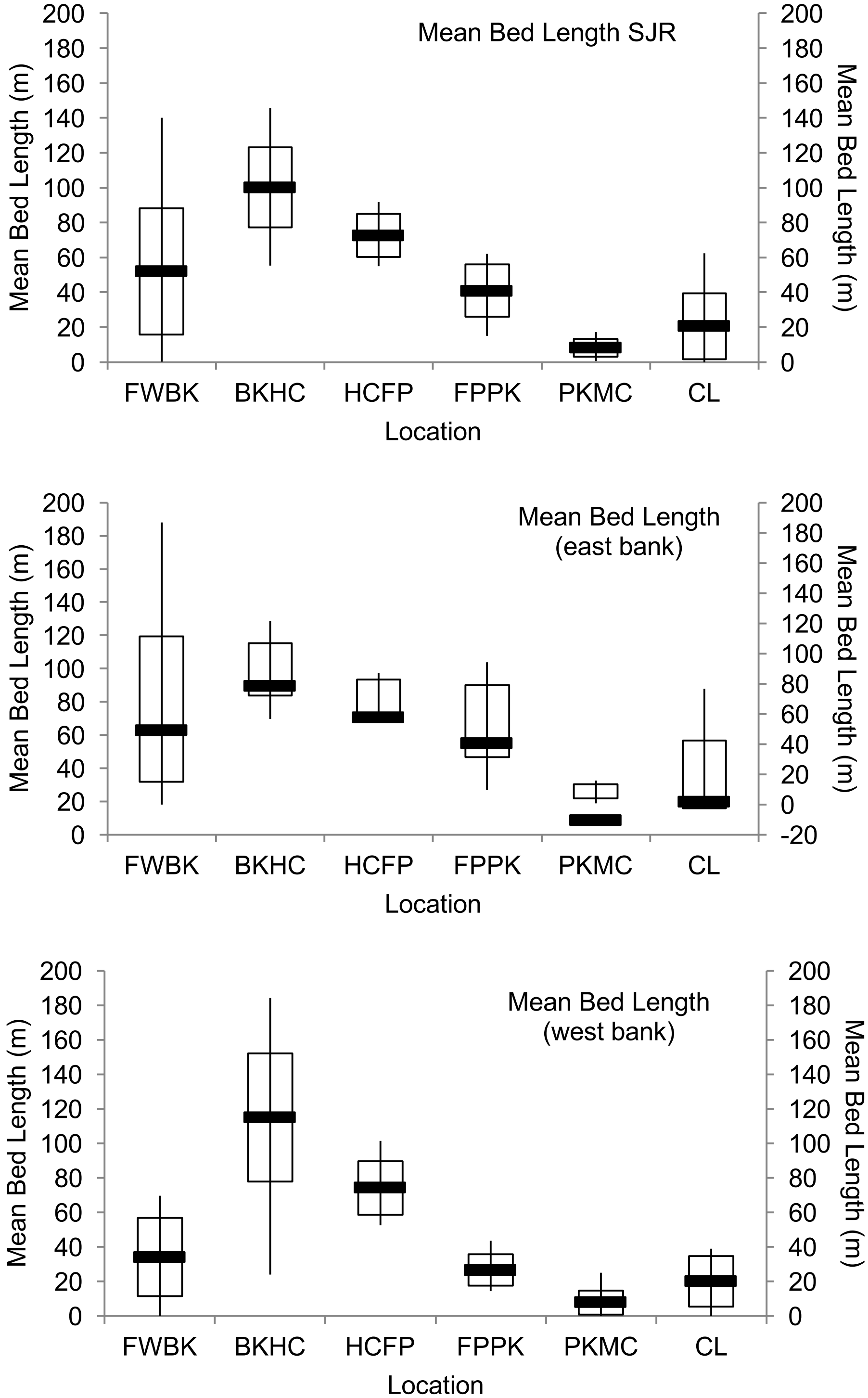


Figure 5. Mean grass bed length (horizontal line) and standard deviation (boxes) compared for six sections of St. Johns River including opposite banks. Vertical lines indicate range (maximum and minimum). See Table 4 for details. Data SJRWMD 2016.

Table 6. Salinity, rainfall and grass bed indices for six sections of St. John River from Fuller Warren Bridge to Mud Creek Cove.

River or Lake Section	Data Period	SAV Bed Length (m)	Minus	High	Low	Plus	sd	ci	n
Location									
Fuller Warren to Buckman (FWBK)	1998-19	25.86	1.25	111.21	0.08	52.97	27.11	13.48	18
Buckman to Hallows Cove (BKHC)	1998-19	65.65	-42.30	129.95	24.79	89.00	23.35	11.61	18
Hallows Cove to Federal Point (HCFP)	1998-19	47.78	-29.78	75.02	12.59	65.78	18	9.97	15
Federal Point to Palatka (FPPK)	1998-19	23.89	-12.78	40.15	6.29	35.00	11.11	6.41	14
Palatka to Mud Creek Cove (PKMC)	2000-19	All bare in 2019							
Crescent Lake (CL)	2001-19	All bare in 2019							
Fuller Warren to Buckman (FWBK)	1998-19	25.01	2.37	111.21	0.08	52.39	27.38	13.61	18
Buckman to Hallows Cove (BKHC)	1998-19	59.79	-40.40	108.11	28.38	79.18	19.39	9.64	18
Hallows Cove to Federal Point (HCFP)	1998-19	43.82	-27.87	63.79	15.23	59.77	15.95	9.21	14
Federal Point to Palatka (FPPK)	1998-19	29.54	-13.33	60.4125	7.07	45.75	16.21	9.36	14
Palatka to Mud Creek Cove (PKMC)	2000-19	All bare in 2019							
Crescent Lake (CL)	2001-19	All bare in 2019							
Fuller Warren to Buckman (FWBK)	1998-19	12.11	0.00	29.47	0	21.80	9.69	4.98	17
Buckman to Hallows Cove (BKHC)	1998-19	75.14	-39.92	164.28	20.01	110.36	35.22	17.51	18
Hallows Cove to Federal Point (HCFP)	1998-19	53.39	-30.78	94.1	9.95	76.00	22.61	12.52	15
Federal Point to Palatka (FPPK)	1998-19	18.21	-8.02	38.84	5.13	28.40	10.19	5.88	14
Palatka to Mud Creek Cove (PKMC)	2000-19	All bare in 2019							
Crescent Lake (CL)	2001-19	All bare in 2019							

Source data: SJRWMD 2019

Note: Numbers in parenthesis indicate Standard Deviation of the mean. Rainfall average is for the whole LSJRB area 2,755 sq. miles. PKMC and CL sites were bare in 2019. The graphs show statistics for those areas during 2001-2011.

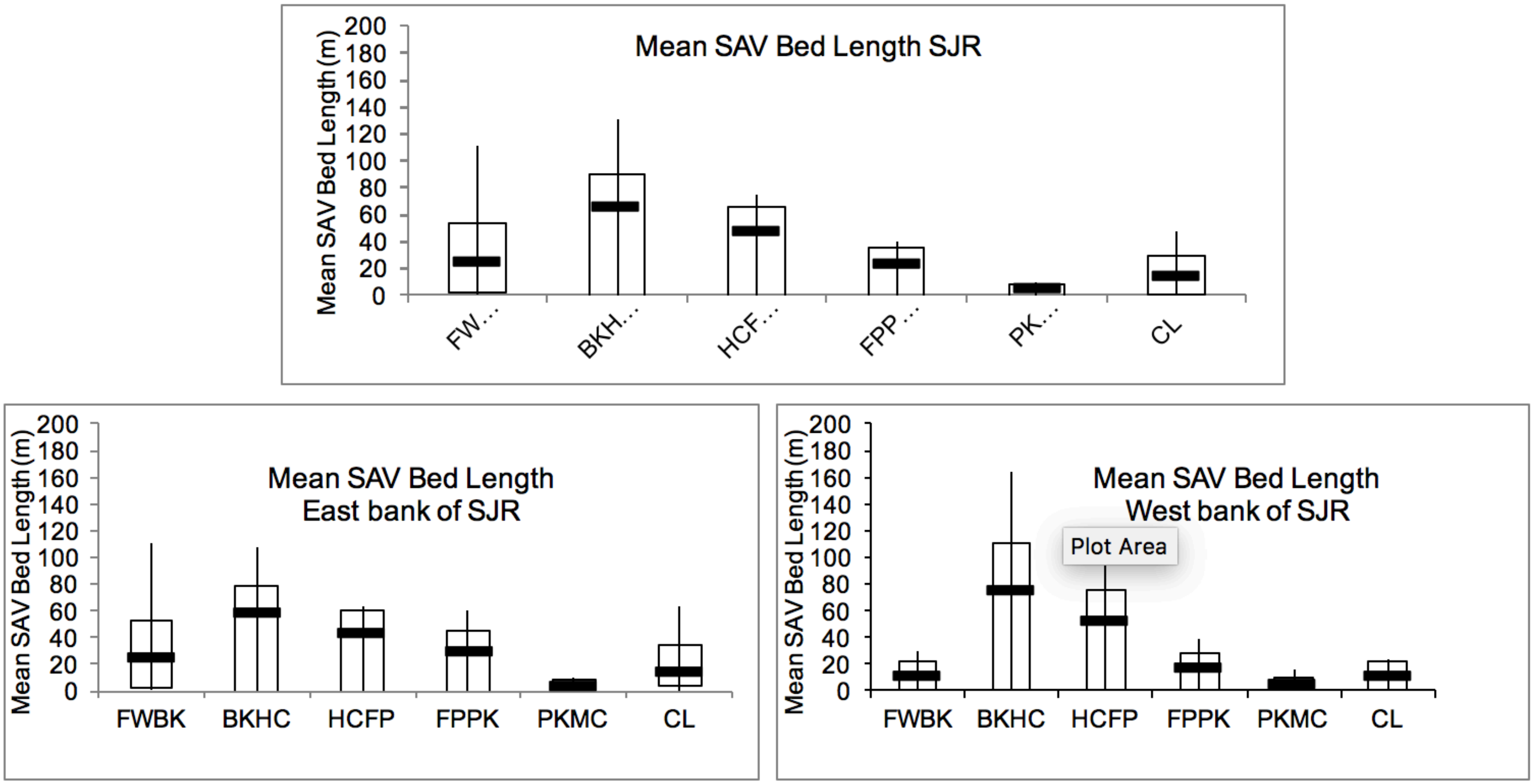
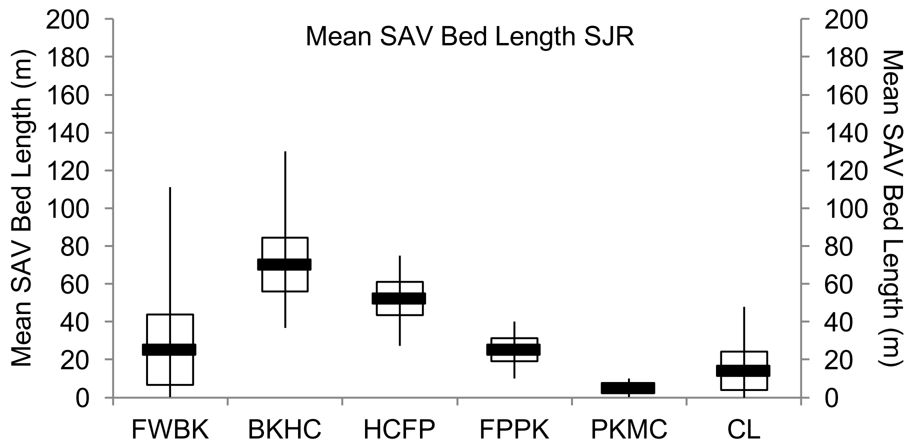


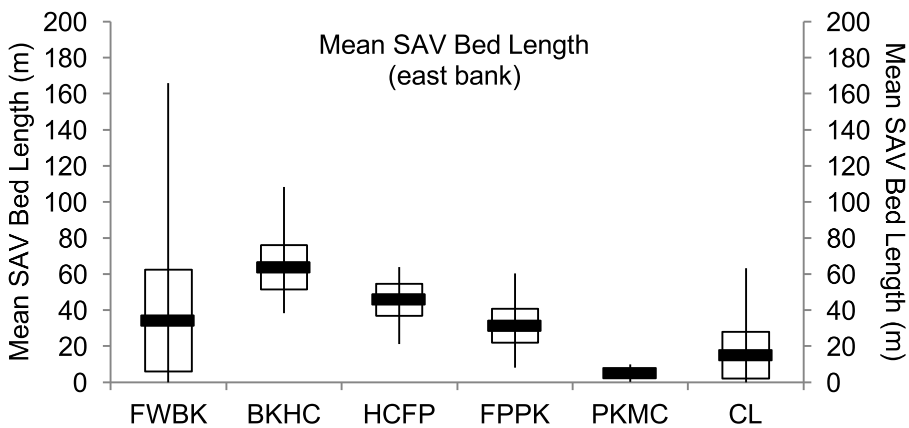
Figure 6. Mean SAV bed length (horizontal line) and standard deviation (boxes) compared for six sections of St. Johns River including opposite banks. Vertical lines indicate range (maximum and minimum). See Table 5 for details. PKMC and CL sites were bare in 2019. The graphs show statistics for those areas during 2001-2011, they were bare in 2019.

Table 7. Grass bed indices for six sections of St. John River from Fuller Warren Bridge to Mud Creek Cove.

River or Lake Section	Data Period	SAV Bed Length (m)	Minus	Max	Min	Plus	sd	ci	n
Fuller Warren to Buckman (FWBK)	1998-15	25.96	8.82	111.21	0.08	43.11	29.69	17.14	14
Buckman to Hallows Cove (BKHC)	1998-15	70.37	57.25	129.95	36.58	83.48	22.71	13.12	14
Hallows Cove to Federal Point (HCFP)	1998-10	52.31	43.63	75.02	27.28	60.98	14.36	8.68	13
Federal Point to Palatka (FPPK)	1998-10	25.24	19.02	40.15	10.06	31.46	10.29	6.22	13
Palatka to Mud Creek Cove (PKMC)	2000-10	4.87	2.76	9.92	0.13	6.98	3.32	2.11	12
Crescent Lake (CL)	2001-10	14.09	3.87	48.00	0.00	24.31	15.21	10.22	11
Fuller Warren to Buckman (FWBK)	1998-10	34.06	5.81	165.70	0.00	62.32	46.75	28.25	13
Buckman to Hallows Cove (BKHC)	1998-10	63.62	51.44	108.11	38.30	75.79	20.15	12.17	13
Hallows Cove to Federal Point (HCFP)	1998-10	45.75	36.92	63.79	21.30	54.59	14.62	8.83	13
Federal Point to Palatka (FPPK)	1998-10	31.27	21.92	60.41	8.00	40.62	15.47	9.35	13
Palatka to Mud Creek Cove (PKMC)	2000-10	4.82	2.88	10.01	0.24	6.75	3.05	1.94	12
Crescent Lake (CL)	2001-10	14.99	2.16	63.00	0.00	27.82	19.09	12.83	11
Fuller Warren to Buckman (FWBK)	1998-10	11.94	6.41	29.47	0.20	17.47	9.16	5.53	13
Buckman to Hallows Cove (BKHC)	1998-10	80.10	57.83	164.28	22.00	102.37	36.85	22.27	13
Hallows Cove to Federal Point (HCFP)	1998-10	59.13	48.29	94.10	34.25	69.98	17.95	10.85	13
Federal Point to Palatka (FPPK)	1998-10	19.21	13.26	38.84	7.50	25.17	9.85	5.95	13
Palatka to Mud Creek Cove (PKMC)	2000-10	5.15	2.28	15.82	0.00	8.03	4.52	2.87	12
Crescent Lake (CL)	2001-10	11.82	4.51	24.40	0.00	19.14	10.89	7.32	11

Source data: SJRWMD 2016





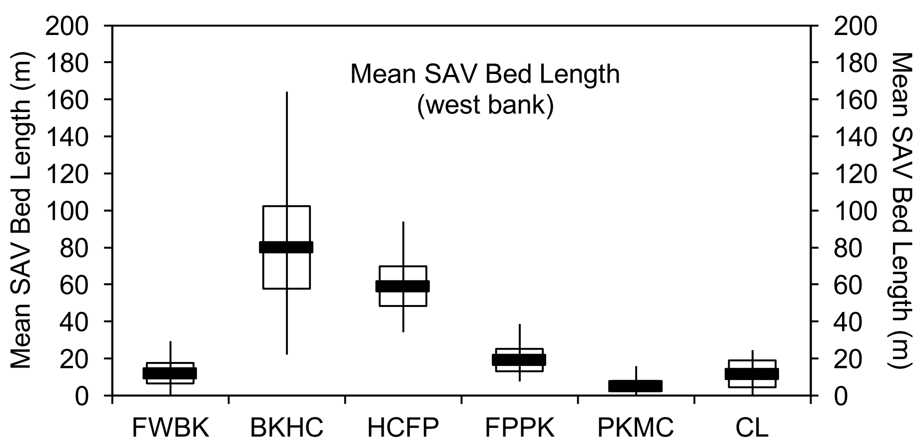


Figure 7. Mean SAV bed length (horizontal line) and standard deviation (boxes) compared for six sections of St. Johns River including opposite banks. Vertical lines indicate range (maximum and minimum). See Table 5 for details. Data SJRWMD 2016.

Table 8. Salinity, rainfall and grass bed indices for six sections of St. John River from Fuller Warren Bridge to Mud Creek Cove.

River or Lake Section	Data Period	Total Cover TC (%)	Minus	High	Low	Plus	sd	ci	n
Location									
Fuller Warren to Buckman (FWBK)	1998-19	27.93	6.31	63.86	0.71	49.55	21.62	10.75	18
Buckman to Hallows Cove (BKHC)	1998-19	54.21	34.22	85.90	24.46	74.20	19.99	9.94	18
Hallows Cove to Federal Point (HCFP)	1998-19	59.47	43.9	79.68	24.66	75.04	15.57	8.62	15
Federal Point to Palatka (FPPK)	1998-19	45.61	35.97	56.30482	20.07	55.25	9.64	5.56	14
Palatka to Mud Creek Cove (PKMC)	2000-19	All bare in 2019							
Crescent Lake (CL)	2001-19	All bare in 2019							
Fuller Warren to Buckman (FWBK)	1998-19	27.26	5.44	63.86	0.71	49.08	21.82	10.85	18
Buckman to Hallows Cove (BKHC)	1998-19	54.22	33.12	87.46	21.24	75.32	21.10	10.49	18
Hallows Cove to Federal Point (HCFP)	1998-19	56.48	41.14	80.50397	29.6	71.82	15.34	8.86	14
Federal Point to Palatka (FPPK)	1998-19	39.39	28.32	63.54178	25.1545	50.46	11.07	6.68	14
Palatka to Mud Creek Cove (PKMC)	2000-19	All bare in 2019							
Crescent Lake (CL)	2001-19	All bare in 2019							
Fuller Warren to Buckman (FWBK)	1998-19	19.73	4.89	41.98	0	34.57	14.84	7.63	17
Buckman to Hallows Cove (BKHC)	1998-19	55.67	35.22	84.16	24.28	76.12	20.45	10.17	18
Hallows Cove to Federal Point (HCFP)	1998-19	64.03	45.44	92.15	19.72	82.62	18.59	10.29	15
Federal Point to Palatka (FPPK)	1998-19	51.19	35.97	68.82102	7.4	66.41	15.22	8.79	14
Palatka to Mud Creek Cove (PKMC)	2000-19	All bare in 2019							
Crescent Lake (CL)	2001-19	All bare in 2019							

Source data: SJRWMD 2019

Note: Numbers in parentheses indicate Standard Deviation of the mean. Rainfall average is for the whole LSJRB area 2,755 sq. miles.

PKMC and CL sites were bare in 2019. The graphs show statistics for those areas during 2001-2011.

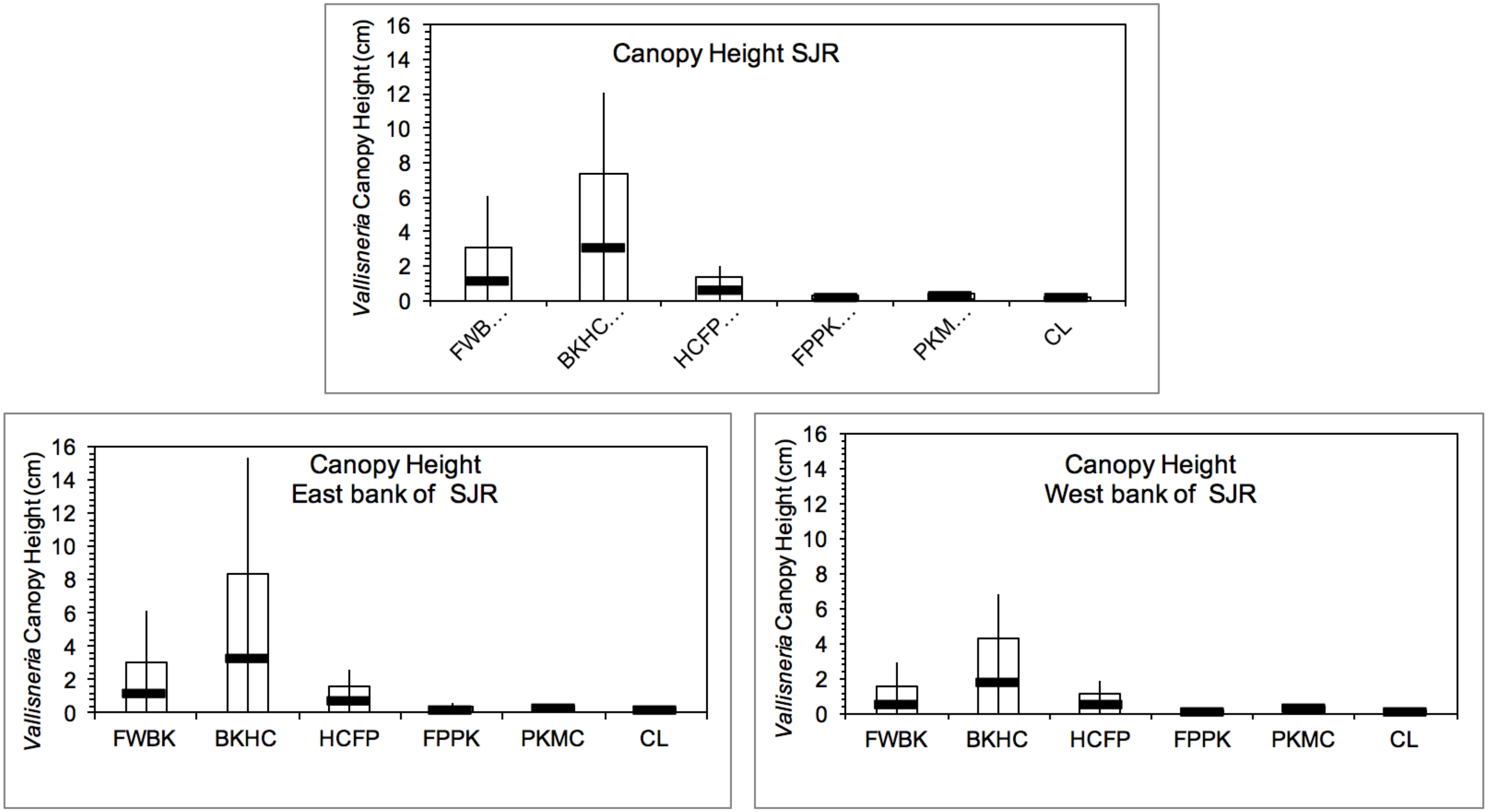


Figure 8. Mean Vallisneria Canopy Height (horizontal line) and standard deviation (boxes) compared for six sections of St. Johns River including opposite banks. Vertical lines indicate range (maximum and minimum). See Table 8 for details. PKMC and CL sites were bare in 2019. The graphs show statistics for those areas during 2001-2011, they were bare in 2019.

Table 9. Grass bed indices for six sections of St. John River from Fuller Warren Bridge to Mud Creek Cove.

River or Lake Section	Data Period	Total Cover (%)	Minus	Max	Min	Plus	sd	ci	n
Fuller Warren to Buckman (FWBK)	1998-15	25.94	4.50	63.86	0.71	47.39	21.45	12.38	14
Buckman to Hallows Cove (BKHC)	1998-15	56.92	38.91	85.90	24.46	74.92	18.00	10.39	14
Hallows Cove to Federal Point (HCFP)	1998-10	63.03	50.49	79.68	41.86	75.57	12.54	7.58	13
Federal Point to Palatka (FPPK)	1998-10	47.58	41.09	56.30	34.74	54.06	6.49	3.92	13
Palatka to Mud Creek Cove (PKMC)	2000-10	30.54	10.12	54.85	1.70	50.96	20.42	12.97	12
Crescent Lake (CL)	2001-10	20.15	-2.81	54.60	0.00	43.11	22.96	15.42	11
Fuller Warren to Buckman (FWBK)	1998-10	27.21	-1.87	78.45	0.00	56.30	29.08	17.57	13
Buckman to Hallows Cove (BKHC)	1998-10	54.25	34.55	87.46	21.24	73.95	19.70	11.90	13
Hallows Cove to Federal Point (HCFP)	1998-10	57.38	42.75	80.50	34.27	72.01	14.63	8.84	13
Federal Point to Palatka (FPPK)	1998-10	40.22	29.17	63.54	25.15	51.27	11.05	6.68	13
Palatka to Mud Creek Cove (PKMC)	2000-10	33.16	13.12	56.99	3.19	53.19	20.03	12.73	12
Crescent Lake (CL)	2001-10	21.27	-2.48	58.15	0.00	45.02	23.75	15.95	11
Fuller Warren to Buckman (FWBK)	1998-10	20.49	5.87	41.98	0.00	35.11	14.62	8.84	13
Buckman to Hallows Cove (BKHC)	1998-10	57.04	39.67	83.44	29.06	74.41	17.37	10.50	13
Hallows Cove to Federal Point (HCFP)	1998-10	69.08	55.90	92.15	47.38	82.27	13.18	7.97	13
Federal Point to Palatka (FPPK)	1998-10	54.56	45.67	68.82	42.90	63.45	8.89	5.37	13
Palatka to Mud Creek Cove (PKMC)	2000-10	27.16	4.31	66.79	0.00	50.01	22.85	14.52	12
Crescent Lake (CL)	2001-10	18.71	-3.71	56.93	0.00	41.13	22.42	15.06	11

Source data: SJRWMD 2016

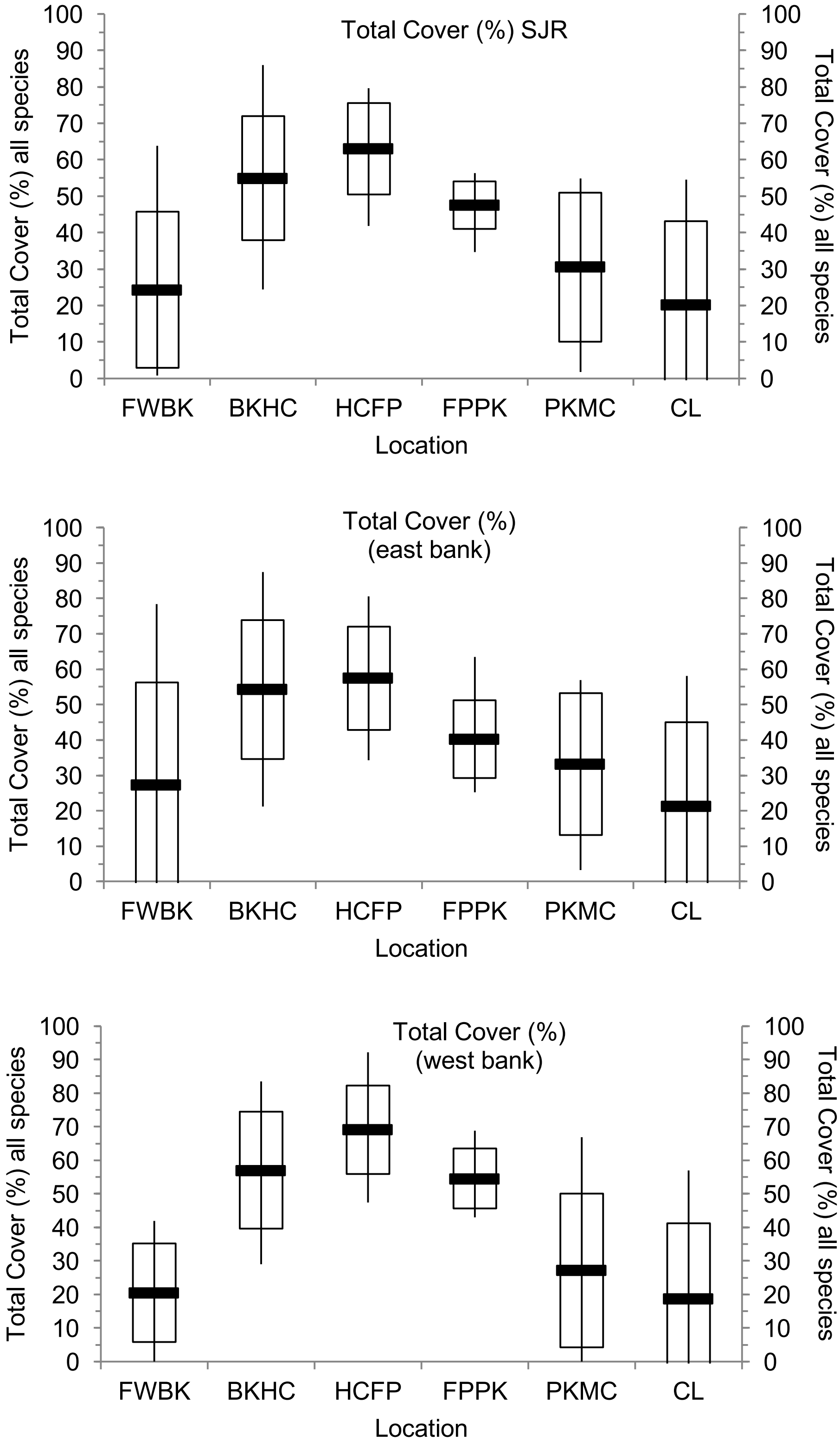


Figure 9. Mean Total Cover Percent of SAV (horizontal line) and standard deviation (boxes) compared for six sections of St. Johns River including opposite banks. Vertical lines indicate range (maximum and minimum). See Table 6 for details. Data SRJWMD 2016.

Table 10. Salinity, rainfall and grass bed indices for six sections of St. John River from Fuller Warren Bridge to Mud Creek Cove.

River or Lake Section	Data Period	Proportional (%) *Vallisneria* Cover PVal (%)	Minus	High	Low	Plus	sd	ci	n
Location									
Fuller Warren to Buckman (FWBK)	1998-19	37.01	10.56	87.47	0.00	63.46	26.45	13.15	18
Buckman to Hallows Cove (BKHC)	1998-19	61.40	44.98	80.65	20.65	77.82	16.42	8.17	18
Hallows Cove to Federal Point (HCFP)	1998-19	60.61	52.22	79.99	47.46	69	8.39	4.65	15
Federal Point to Palatka (FPPK)	1998-19	40.33	23.58	70.08895	11.18385	57.08	16.75	9.67	14
Palatka to Mud Creek Cove (PKMC)	2000-19	All bare in 2019							
Crescent Lake (CL)	2001-19	All bare in 2019							
Fuller Warren to Buckman (FWBK)	1998-19	35.64	8.49	87.47	0	62.79	27.15	13.5	18
Buckman to Hallows Cove (BKHC)	1998-19	59.62	43.51	78.58	20.56	75.73	16.11	8.01	18
Hallows Cove to Federal Point (HCFP)	1998-19	61.55	53.04	80.21	52.6	70.06	8.51	4.92	14
Federal Point to Palatka (FPPK)	1998-19	44.61	26.68	74.93	18.33061	62.54	17.93	10.36	14
Palatka to Mud Creek Cove (PKMC)	2000-19	All bare in 2019							
Crescent Lake (CL)	2001-19	All bare in 2019							
Fuller Warren to Buckman (FWBK)	1998-19	28.4	1.59	86.56703	0	55.21	26.81	13.78	17
Buckman to Hallows Cove (BKHC)	1998-19	63.25	43.08	90.26	20.76	83.42	20.17	10.03	18
Hallows Cove to Federal Point (HCFP)	1998-19	58.94	48.57	79.72	38.97	69.31	10.37	5.74	15
Federal Point to Palatka (FPPK)	1998-19	37.14	20.53	71.87201	12.5	53.75	16.61	9.59	14
Palatka to Mud Creek Cove (PKMC)	2000-19	All bare in 2019							
Crescent Lake (CL)	2001-19	All bare in 2019							

Source data: SJRWMD 2019

Note: Numbers in parentheses indicate Standard Deviation of the mean. Rainfall average is for the whole LSJRB area 2,755 sq. miles.

PKMC and CL sites were bare in 2019. The graphs show statistics for those areas during 2001-2011

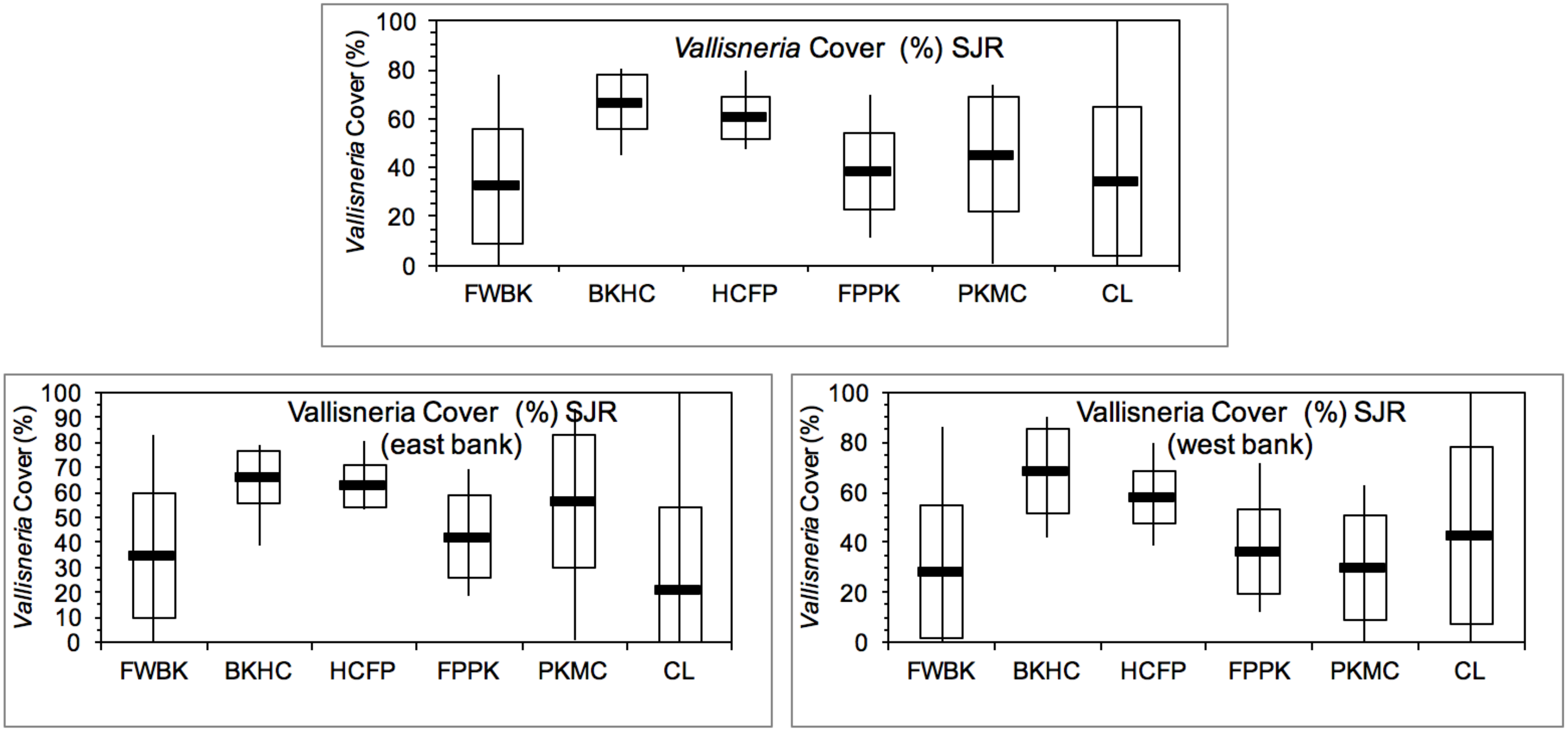
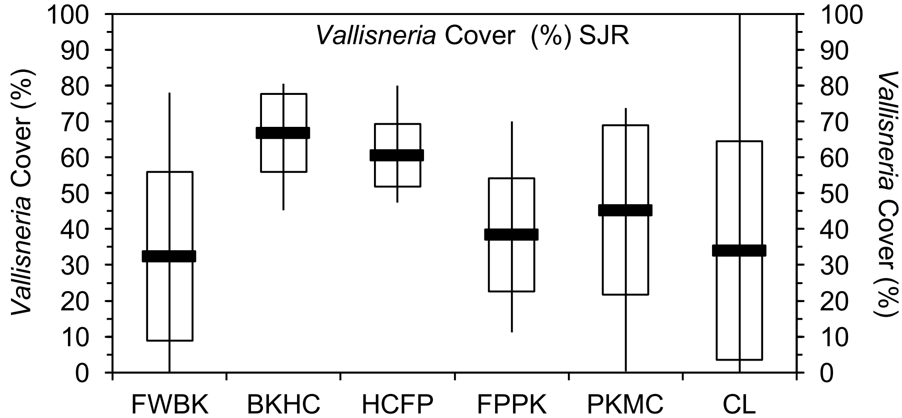


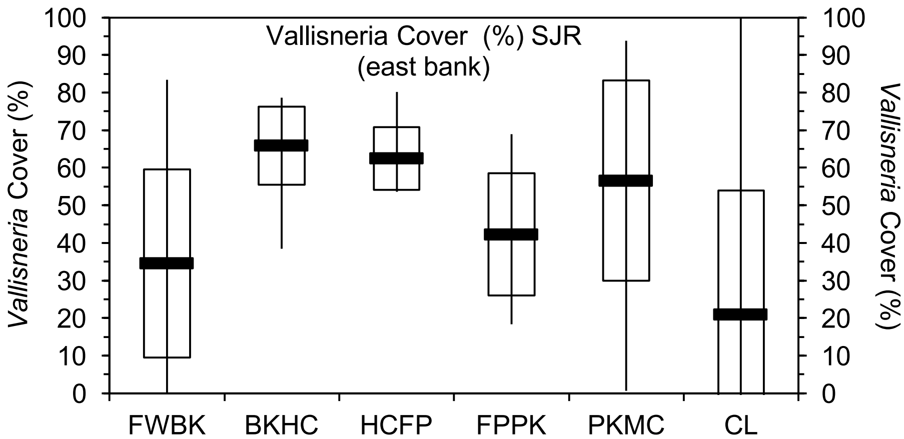
Figure 9. Mean Vallisneria Cover Percent (horizontal line) and standard deviation (boxes) compared for six sections of St. Johns River including opposite banks. Vertical lines indicate range (maximum and minimum). See Table 7 for details. PKMC and CL sites were bare in 2019. The graphs show statistics for those areas during 2001-2011, they were bare in 2019.

Table 11. Grass bed indices for six sections of St. John River from Fuller Warren Bridge to Mud Creek Cove.

River or Lake Section	Data Period	*Vallisneria* Cover (%)	Minus	Max	Min	Plus	sd	ci	n
Fuller Warren to Buckman (FWBK)	1998-15	34.53	10.61	77.98	0.00	58.45	23.92	13.81	14
Buckman to Hallows Cove (BKHC)	1998-15	66.85	56.37	80.65	45.33	77.33	10.48	6.05	14
Hallows Cove to Federal Point (HCFP)	1998-10	60.54	51.85	79.99	47.46	69.24	8.70	5.26	13
Federal Point to Palatka (FPPK)	1998-10	38.44	22.63	70.09	11.18	54.24	15.81	9.55	13
Palatka to Mud Creek Cove (PKMC)	2000-10	45.32	21.70	73.80	0.35	68.93	23.62	15.01	12
Crescent Lake (CL)	2001-10	34.01	3.53	100.00	0.00	64.49	30.48	20.48	11
Fuller Warren to Buckman (FWBK)	1998-10	34.56	9.48	83.33	0.00	59.65	25.09	15.16	13
Buckman to Hallows Cove (BKHC)	1998-10	65.84	55.48	78.58	38.50	76.20	10.36	6.26	13
Hallows Cove to Federal Point (HCFP)	1998-10	62.50	54.20	80.21	53.56	70.79	8.30	5.01	13
Federal Point to Palatka (FPPK)	1998-10	42.28	25.97	68.90	18.33	58.59	16.31	9.86	13
Palatka to Mud Creek Cove (PKMC)	2000-10	56.53	29.88	93.75	0.66	83.18	26.65	16.93	12
Crescent Lake (CL)	2001-10	20.92	-12.16	100.00	0.00	54.00	33.08	22.22	11
Fuller Warren to Buckman (FWBK)	1998-10	28.47	1.96	86.57	0.00	54.97	26.50	16.02	13
Buckman to Hallows Cove (BKHC)	1998-10	68.31	51.42	90.26	41.72	85.21	16.89	10.21	13
Hallows Cove to Federal Point (HCFP)	1998-10	58.20	47.55	79.72	38.97	68.85	10.65	6.44	13
Federal Point to Palatka (FPPK)	1998-10	36.17	19.30	71.87	12.50	53.03	16.87	10.19	13
Palatka to Mud Creek Cove (PKMC)	2000-10	29.79	8.55	62.50	0.00	51.02	21.23	13.49	12
Crescent Lake (CL)	2001-10	42.56	6.90	100.00	0.00	78.22	35.66	23.96	11

Source data: SJRWMD 2016





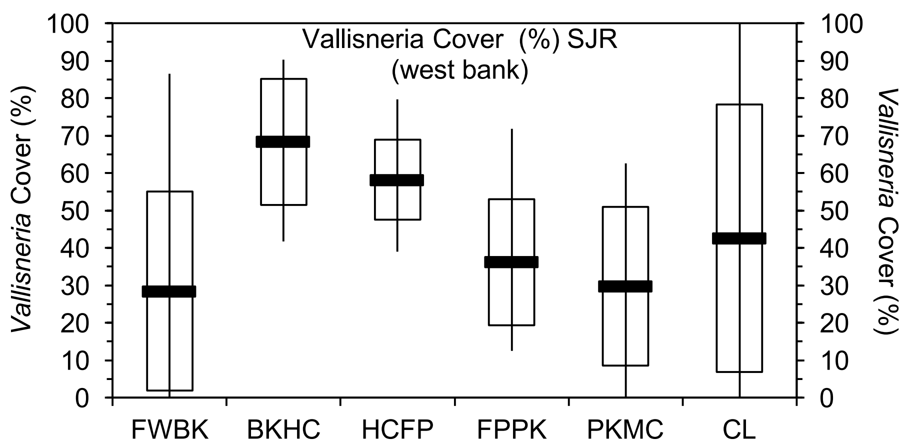


Figure 10. Mean Vallisneria Cover Percent (horizontal line) and standard deviation (boxes) compared for six sections of St. Johns River including opposite banks. Vertical lines indicate range (maximum and minimum). See Table 7 for details. Data SJRWMD 2016.

Table 12. Salinity, rainfall and grass bed indices for six sections of St. John River from Fuller Warren Bridge to Mud Creek Cove.

River or Lake Section	Data Period	*Vallisneria* Canopy Height (cm) Canopy Ht.	Minus	High	Low	Plus	sd	ci	n
Location									
Fuller Warren to Buckman (FWBK)	1998-19	1.13	0.00	6.13	0.00	3.07	1.94	1.30	11
Buckman to Hallows Cove (BKHC)	1998-19	3.02	0.00	12.06	0.04	7.40	4.38	2.94	11
Hallows Cove to Federal Point (HCFP)	1998-19	0.63	-0.09	2.06	0.16	1.35	0.72	0.67	7
Federal Point to Palatka (FPPK)	1998-19	0.15	0.04	0.4	0.053571	0.26	0.11	0.11	7
Palatka to Mud Creek Cove (PKMC)	2000-19	All bare in 2019							
Crescent Lake (CL)	2001-19	All bare in 2019							
Fuller Warren to Buckman (FWBK)	1998-19	1.13	0	6.13	0	3.07	1.94	1.3	11
Buckman to Hallows Cove (BKHC)	1998-19	3.20	0.00	15.36	0.04	8.35	5.15	3.46	11
Hallows Cove to Federal Point (HCFP)	1998-19	0.66	-0.23	2.58	0.07	1.55	0.89	0.74	8
Federal Point to Palatka (FPPK)	1998-19	0.16	-0.02	0.57	0	0.34	0.18	0.15	8
Palatka to Mud Creek Cove (PKMC)	2000-19	All bare in 2019							
Crescent Lake (CL)	2001-19	All bare in 2019							
Fuller Warren to Buckman (FWBK)	1998-19	0.52	-0.48	2.92	0	1.52	1	0.76	9
Buckman to Hallows Cove (BKHC)	1998-19	1.77	-0.78	6.87	0.0445	4.32	2.55	1.71	11
Hallows Cove to Federal Point (HCFP)	1998-19	0.5	-0.11	1.87	0.07	1.11	0.61	0.51	8
Federal Point to Palatka (FPPK)	1998-19	0.11	0.070096	0.166443	0.06125	0.149904	0.039904	0.04	7
Palatka to Mud Creek Cove (PKMC)	2000-19	All bare in 2019							
Crescent Lake (CL)	2001-19	All bare in 2019							

Source data: SJRWMD 2019

Note: Numbers in parentheses indicate Standard Deviation of the mean. Rainfall average is for the whole LSJRB area 2,755 sq. miles.

PKMC and CL sites were bare in 2019. The graphs show statistics for those areas during 2001-2011.

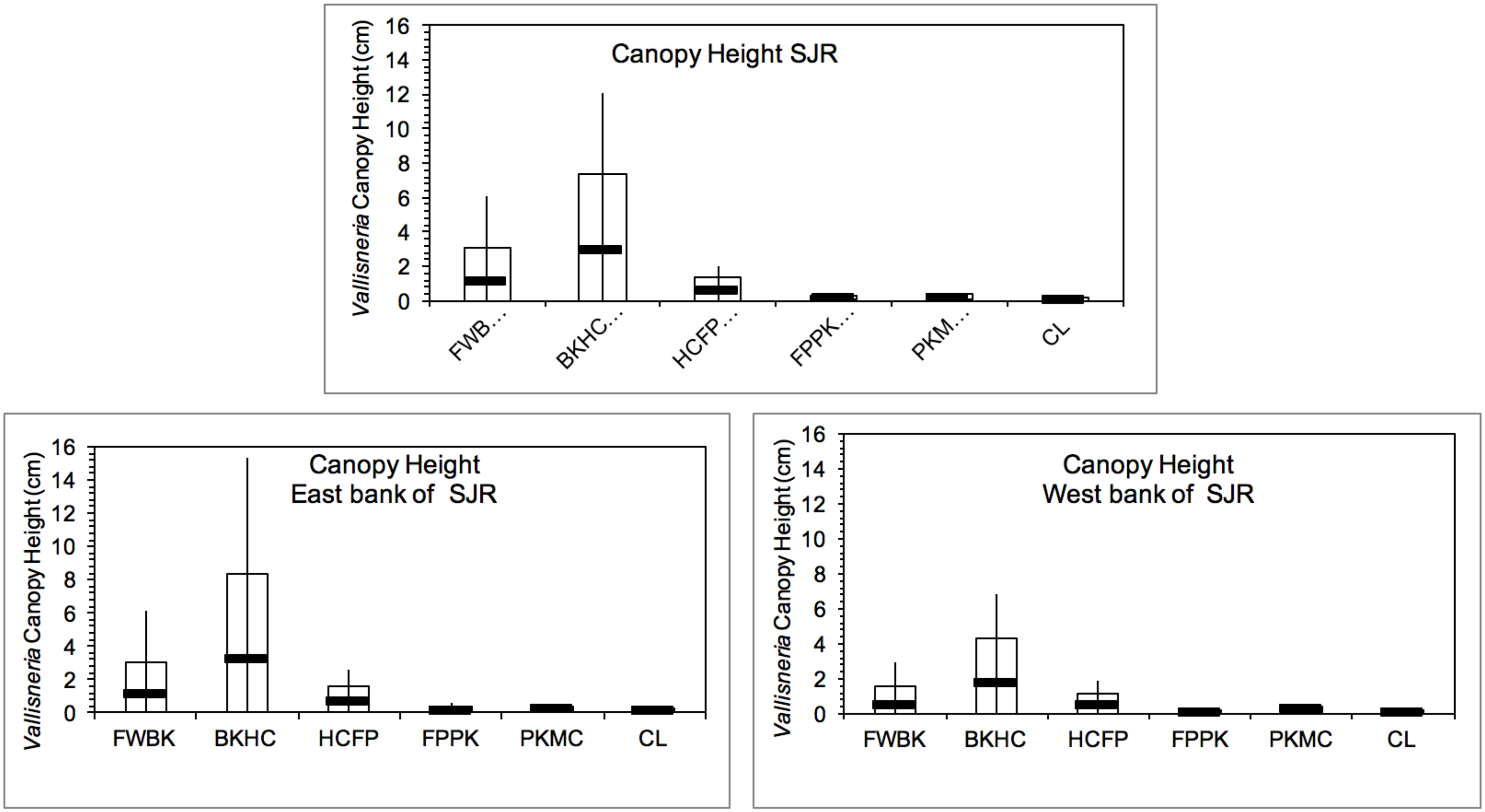


Figure 11. Mean Vallisneria Canopy Height (horizontal line) and standard deviation (boxes) compared for six sections of St. Johns River including opposite banks. Vertical lines indicate range (maximum and minimum). See Table 8 for details. PKMC and CL sites were bare in 2019. The graphs show statistics for those areas during 2001-2011, they were bare in 2019.

Table 13. Grass bed indices for six sections of St. John River from Fuller Warren Bridge to Mud Creek Cove.

River or Lake Section	Data Period	*Vallisneria* Canopy Height (m)	Minus	Max	Min	Plus	sd	ci	n
Fuller Warren to Buckman (FWBK)	1998-15	0.36	0.00	2.44	0.00	1.28	0.92	0.85	7
Buckman to Hallows Cove (BKHC)	1998-15	1.37	-1.97	8.95	0.04	4.71	3.34	3.09	7
Hallows Cove to Federal Point (HCFP)	1998-10	0.24	0.15	0.37	0.16	0.33	0.09	0.11	5
Federal Point to Palatka (FPPK)	1998-10	0.11	0.07	0.16	0.05	0.15	0.04	0.04	6
Palatka to Mud Creek Cove (PKMC)	2000-10	0.22	0.06	0.45	0.00	0.39	0.16	0.17	6
Crescent Lake (CL)	2001-10	0.14	0.03	0.27	0.01	0.24	0.10	0.13	5
Fuller Warren to Buckman (FWBK)	1998-10	0.02	-0.01	0.09	0.00	0.06	0.04	0.04	6
Buckman to Hallows Cove (BKHC)	1998-10	0.12	0.02	0.32	0.04	0.23	0.10	0.11	6
Hallows Cove to Federal Point (HCFP)	1998-10	0.21	0.12	0.36	0.07	0.31	0.09	0.10	6
Federal Point to Palatka (FPPK)	1998-10	0.12	0.07	0.16	0.04	0.16	0.05	0.05	6
Palatka to Mud Creek Cove (PKMC)	2000-10	0.22	0.05	0.46	0.01	0.39	0.17	0.18	6
Crescent Lake (CL)	2001-10	0.15	0.00	0.35	0.00	0.29	0.14	0.18	5
Fuller Warren to Buckman (FWBK)	1998-10	0.01	0.00	0.04	0.00	0.03	0.02	0.02	6
Buckman to Hallows Cove (BKHC)	1998-10	0.08	0.04	0.15	0.04	0.12	0.04	0.04	6
Hallows Cove to Federal Point (HCFP)	1998-10	0.21	0.09	0.39	0.07	0.33	0.12	0.13	6
Federal Point to Palatka (FPPK)	1998-10	0.11	0.07	0.17	0.06	0.15	0.04	0.04	6
Palatka to Mud Creek Cove (PKMC)	2000-10	0.26	0.12	0.43	0.04	0.41	0.14	0.18	5
Crescent Lake (CL)	2001-10	0.13	0.06	0.18	0.01	0.21	0.07	1.00	5

Source data: SJRWMD 2016

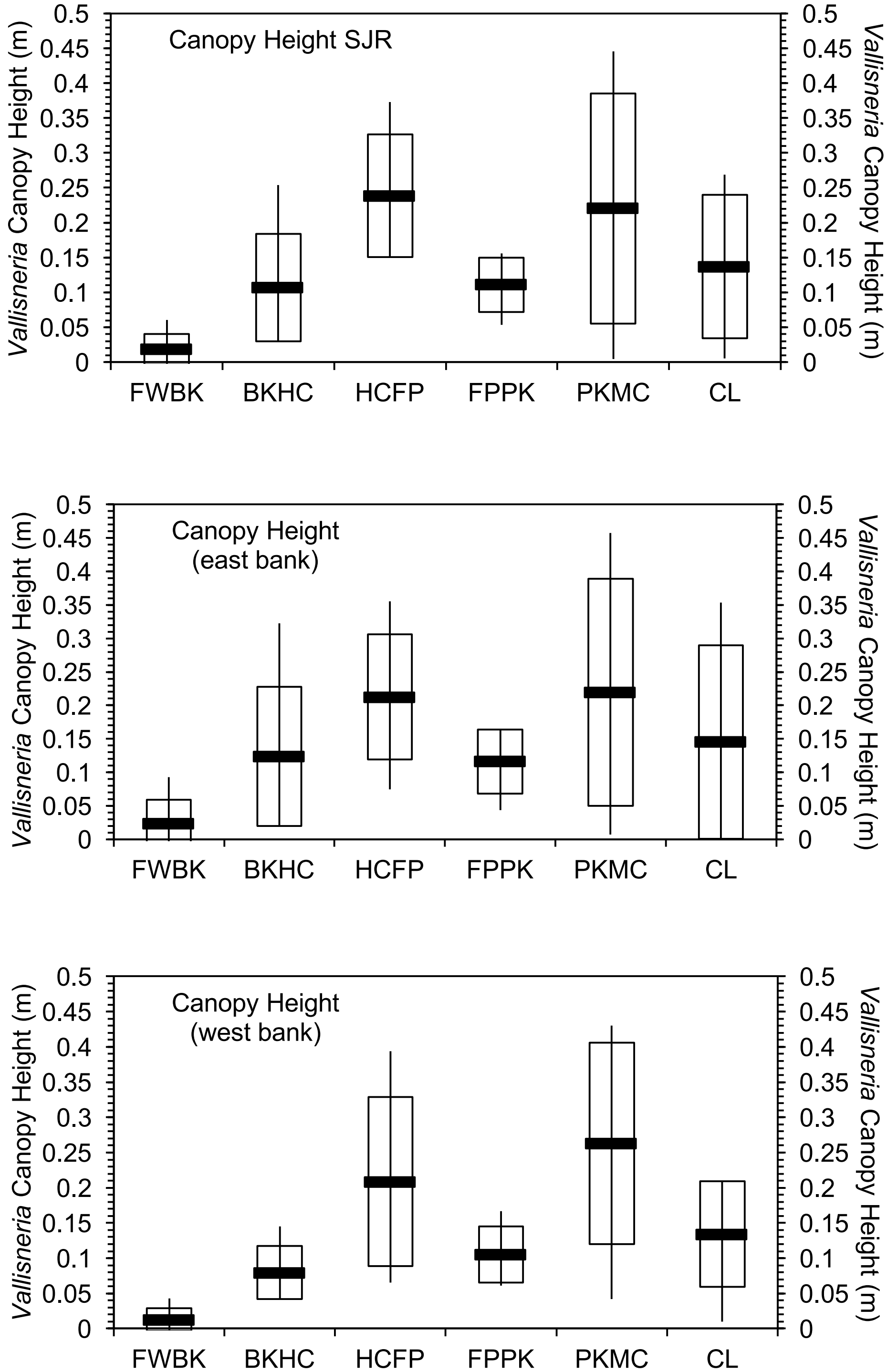


Figure 12. Mean Vallisneria Canopy Height (horizontal line) and standard deviation (boxes) compared for six sections of St. Johns River including opposite banks. Vertical lines indicate range (maximum and minimum). See Table 8 for details. Data SJRWMD 2016.

Table 14. Salinity, rainfall and grass bed indices for six sections of St. John River from Fuller Warren Bridge to Mud Creek Cove.

River or Lake Section	Data Period	Water Depth (m)	Minus	High	Low	Plus	sd	ci	n
Location									
Fuller Warren to Buckman (FWBK)	1998-19	0.35	0.13	0.67	0.04	0.57	0.22	0.15	11
Buckman to Hallows Cove (BKHC)	1998-19	0.57	0.46	0.74	0.37	0.68	0.11	0.07	11
Hallows Cove to Federal Point (HCFP)	1998-19	0.59	0.49	0.68	0.41	0.69	0.1	0.08	7
Federal Point to Palatka (FPPK)	1998-19	0.37	0.27	0.51	0.249834	0.47	0.1	0.09	7
Palatka to Mud Creek Cove (PKMC)	2000-19								
Crescent Lake (CL)	2001-19								
Fuller Warren to Buckman (FWBK)	1998-19	0.35	0.13	0.67	0.04	0.57	0.22	0.15	11
Buckman to Hallows Cove (BKHC)	1998-19	0.58	0.46	0.74	0.39	0.70	0.12	0.08	11
Hallows Cove to Federal Point (HCFP)	1998-19	0.59	0.48	0.77	0.45	0.7	0.11	0.12	8
Federal Point to Palatka (FPPK)	1998-19	0.32	0.11	0.566417	0	0.53	0.21	0.17	8
Palatka to Mud Creek Cove (PKMC)	2000-19								
Crescent Lake (CL)	2001-19								
Fuller Warren to Buckman (FWBK)	1998-19	0.32	0.07	0.68	0	0.57	0.25	0.19	9
Buckman to Hallows Cove (BKHC)	1998-19	0.56	0.44	0.75	0.31	0.68	0.12	0.08	11
Hallows Cove to Federal Point (HCFP)	1998-19	0.56	0.47	0.67	0.37	0.65	0.09	0.08	8
Federal Point to Palatka (FPPK)	1998-19	0.47	0.39	0.572143	0.3115	0.55	0.08	0.07	7
Palatka to Mud Creek Cove (PKMC)	2000-19								
Crescent Lake (CL)	2001-19								

Source data: SJRWMD 2019

Note: Numbers in parentheses indicate Standard Deviation of the mean. Rainfall average is for the whole LSJRB area 2,755 sq. miles.

PKMC and CL sites were bare in 2019. The graphs show statistics for those areas during 2001-2011.

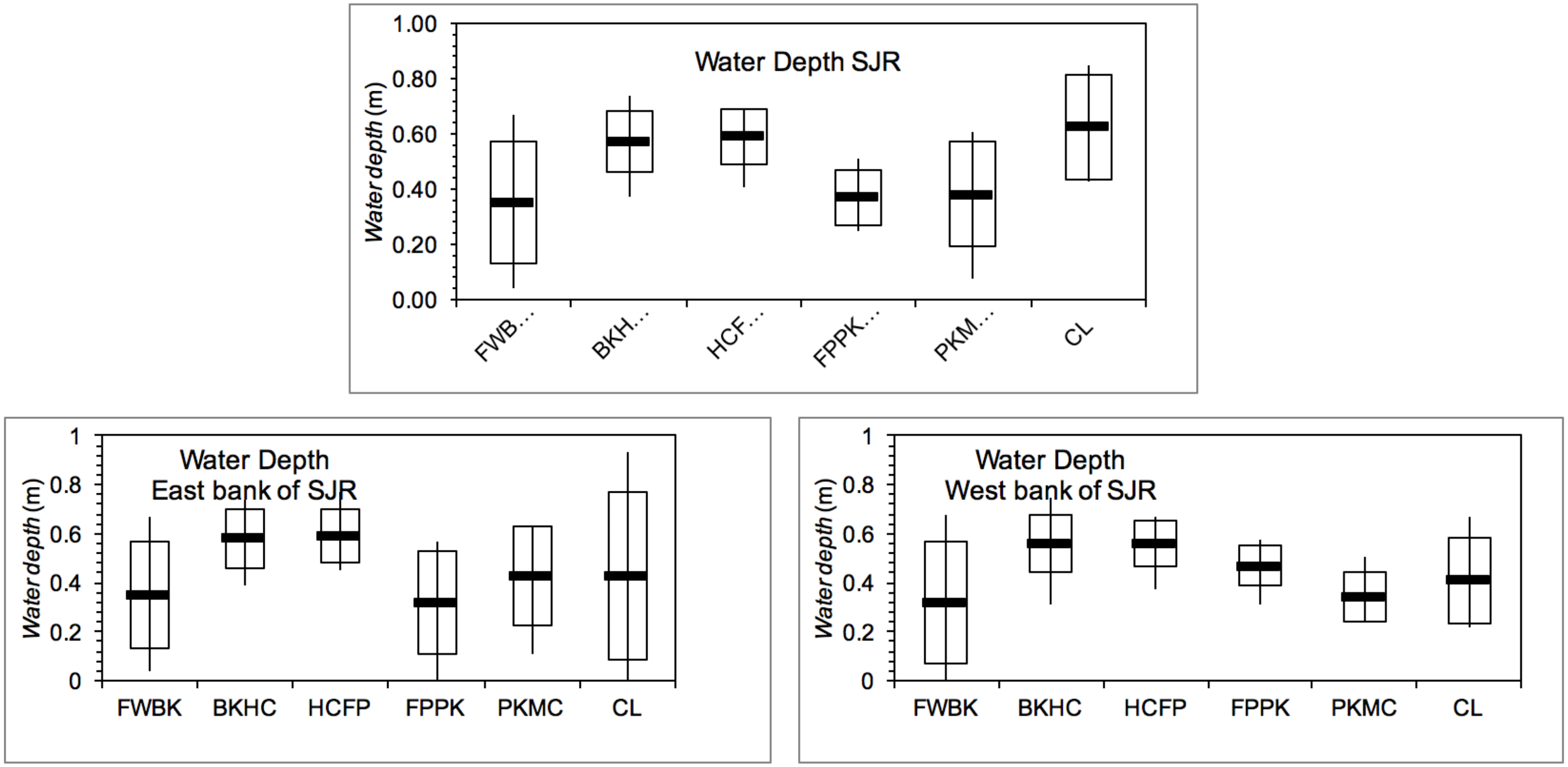
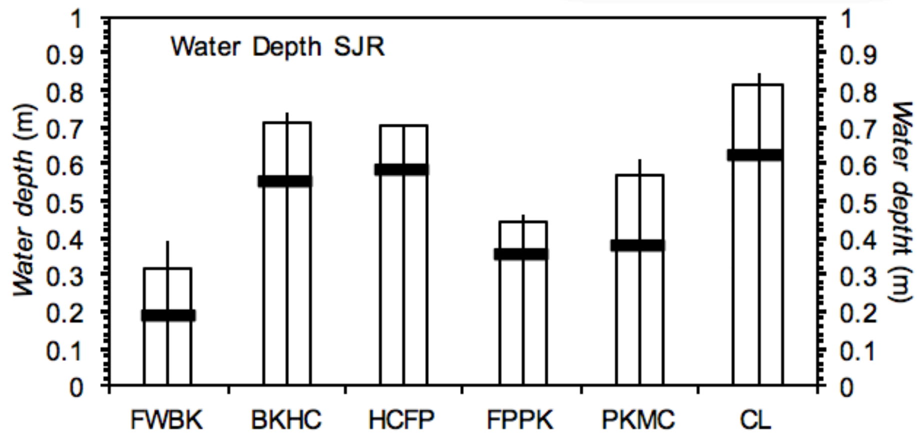


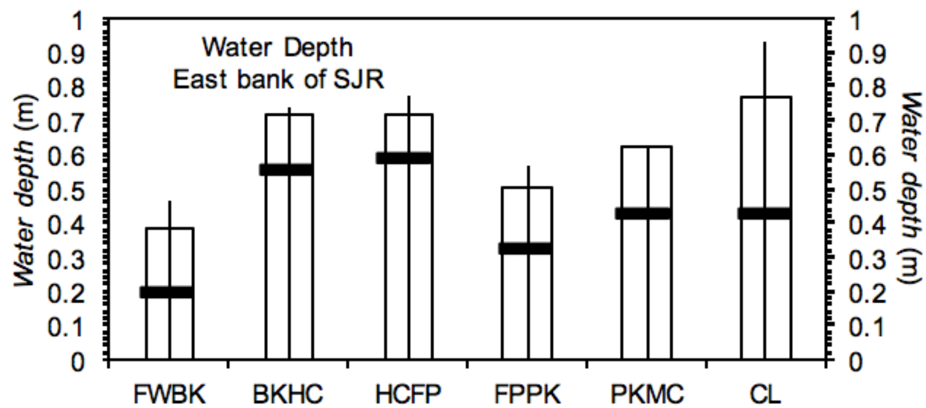
Figure 13. Mean Vallisneria Canopy Height (horizontal line) and standard deviation (boxes) compared for six sections of St. Johns River including opposite banks. Vertical lines indicate range (maximum and minimum). See Table 9 for details. PKMC and CL sites were bare in 2019. The graphs show statistics for those areas during 2001-2011, they were bare in 2019.

Table 15. Grass bed indices for six sections of St. John River from Fuller Warren Bridge to Mud Creek Cove.

River or Lake Section	Data Period	*Vallisneria* Water Depth (m)	Minus	Max	Min	Plus	sd	ci	n
Fuller Warren to Buckman (FWBK)	1998-15	0.25	0.00	0.59	0.04	0.44	0.19	0.18	7
Buckman to Hallows Cove (BKHC)	1998-15	0.57	-0.43	0.74	0.37	0.71	0.14	0.13	7
Hallows Cove to Federal Point (HCFP)	1998-10	0.59	-0.48	0.68	0.41	0.70	0.11	0.14	5
Federal Point to Palatka (FPPK)	1998-10	0.35	-0.26	0.46	0.25	0.44	0.09	0.09	6
Palatka to Mud Creek Cove (PKMC)	2000-10	0.38	-0.19	0.61	0.07	0.57	0.19	0.20	6
Crescent Lake (CL)	2001-10	0.62	-0.43	0.85	0.43	0.82	0.19	0.24	5
Fuller Warren to Buckman (FWBK)	1998-10	0.20	-0.02	0.46	0.00	0.38	0.18	0.19	6
Buckman to Hallows Cove (BKHC)	1998-10	0.56	-0.40	0.74	0.39	0.72	0.16	0.17	6
Hallows Cove to Federal Point (HCFP)	1998-10	0.59	-0.46	0.77	0.45	0.72	0.13	0.14	6
Federal Point to Palatka (FPPK)	1998-10	0.33	-0.16	0.57	0.12	0.50	0.17	0.18	6
Palatka to Mud Creek Cove (PKMC)	2000-10	0.43	-0.23	0.63	0.11	0.63	0.20	0.21	6
Crescent Lake (CL)	2001-10	0.43	-0.08	0.93	0.00	0.77	0.34	0.42	5
Fuller Warren to Buckman (FWBK)	1998-10	0.18	-0.02	0.46	0.00	0.35	0.16	0.17	6
Buckman to Hallows Cove (BKHC)	1998-10	0.56	-0.40	0.75	0.31	0.72	0.16	0.16	6
Hallows Cove to Federal Point (HCFP)	1998-10	0.55	-0.44	0.67	0.37	0.65	0.11	0.11	6
Federal Point to Palatka (FPPK)	1998-10	0.47	-0.38	0.57	0.31	0.56	0.09	0.09	6
Palatka to Mud Creek Cove (PKMC)	2000-10	0.34	-0.24	0.51	0.25	0.44	0.10	0.13	5
Crescent Lake (CL)	2001-10	0.41	-0.24	0.67	0.22	0.59	0.17	0.22	5

Source data: SJRWMD 2016





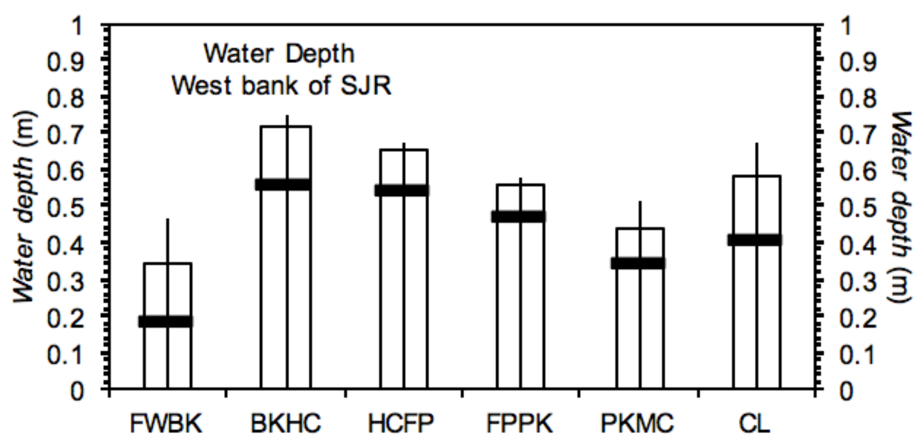


Figure 14. Mean Vallisneria Canopy Height (horizontal line) and standard deviation (boxes) compared for six sections of St. Johns River including opposite banks. Vertical lines indicate range (maximum and minimum). See Table 9 for details. Data source: SJRWMD 2016.

Appendix 4.1.7.1.E

Rainfall, Hurricanes, and El Niño

The average monthly rainfall for the LSJRB was 4.32 inches (1951-1960), compared to 3.72 inches (2016), 5.15 inches (2017), 4.73 inches (2018), and 4.13 inches (2019). The annual average was 47.45 inches (1995-2016), but this increased to 61.80 inches (1995-2017) because of major storms impacting Florida in late 2017. Furthermore, in 2018 major storms contributed to above average annual rainfall of 56.81 inches. In 2019, average annual rainfall was slightly lower 51.38 inches. Kendall tau correlation analysis indicated a decreasing trend in rainfall for the years 1995-2000 (τ = -0.193; p=0.010; n=67). The latter, represents a prolonged period of severe drought (coincides with 1997 El Niño year). This was followed by an increasing trend from 2000-2005 (τ = 0.144; p=0.05; n=60), when rainfall averages approached and exceeded the norm by 2005. Following 2005, another drought ensued (2005-2006) and rainfall declined faster and in a shorter period of time than previously (τ = -0.232; p=0.056; n=24). From 2006-2009, rainfall exhibited an increasing trend (τ = 0.145; p=0.07; n=48) and surpassed the expected norm in 2009. Following 2009, another drought ensued (2009-2010) and rainfall declined faster and in a shorter period of time than previously (τ = -0.217; p=0.068; n=24). Since 2010, monthly rainfall increased again and was at or above normal levels (mean 4.10 inches/mo.) from 2013-2014 (τ = 0.144; p=0.053; n=60). In 2017/2018, above average rainfall (Figure 1) significantly affected the St. Johns River system. In 2019, the amount of precipitation continued to decline below the long-term average.

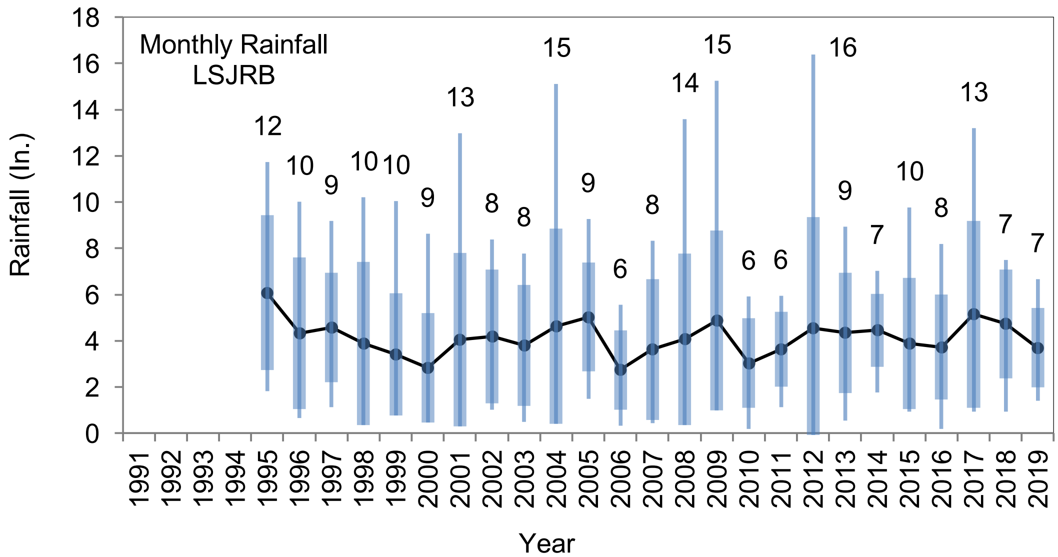


Figure 1. Monthly average radar rainfall for LSJRB (Jun 1995-Dec 2019). Solid line (mean), vertical lines (maximum and minimum), and bars (Standard Deviation of the mean). Average of monthly rainfall for periods 1951-1960 and 1995-2019 were not significantly different. The average monthly rainfall for the LSJRB was 4.32 inches (1951-1960) and 4.13 inches (1995-2018) Data source: SJRWMD 2020.

Note: The long-term mean is a composite mean that includes monthly rainfall for periods 1951-1960 from Rao et al. 1989 and monthly radar rainfall data from the district. The District provides rainfall data from its network of 75 rain gauges to a NexRad contractor. The contractor receives WSR-88D NexRad radar for several stations from the National Weather Service (NWS). The individual radar station data are combined into a radar mosaic that completely covers the SJRWMD territory with an array of pixels. Each pixel is approximately two kilometers by two kilometers in size that is four square kilometers in area. The contractor eliminates any discontinuities and ground clutter from the mosaic using proprietary geographic information system (GIS) algorithms. The contractor combines the gauge and radar data to calculate a gauge-radar ratio and applies the ratio in a radar calibration algorithm to derive a gauge-adjusted rainfall dataset that maintains the spatial signature of the radar data while incorporating the volume estimates from the rain gauges. The resulting gauge-adjusted radar rainfall data are delivered to the District and quality checked. After performing the quality checks, the gauge-adjusted radar rainfall data are uploaded to the District's Oracle database. These data are provisional and subject to change.

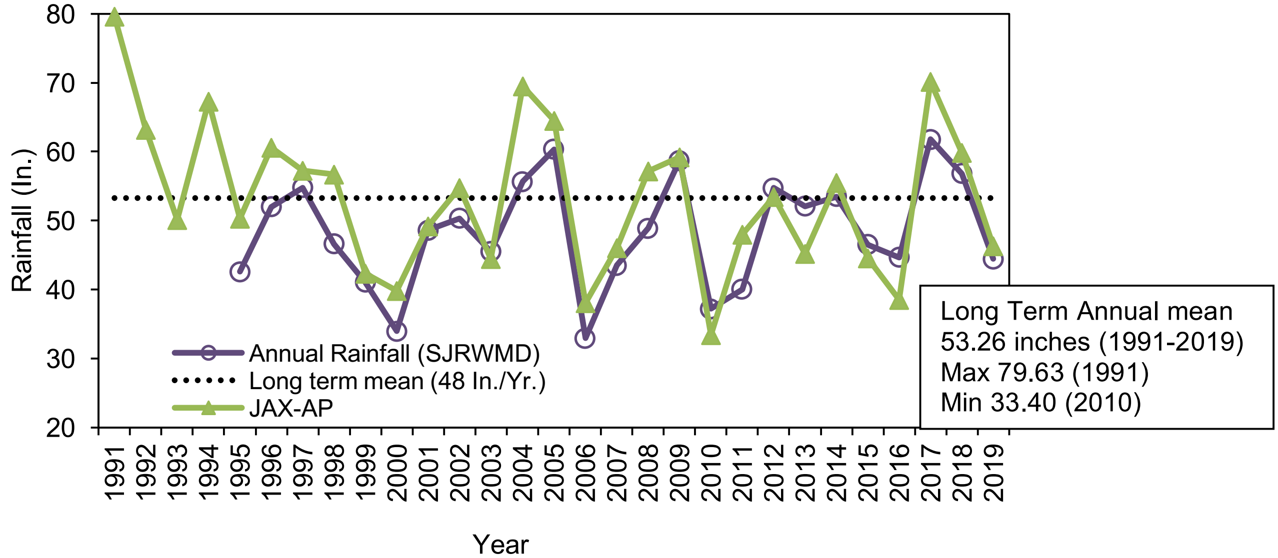


Figure 2. Annual rainfall totals for LSJRB (Jun 1995-Dec 2019. Note: JAX-AP = Jacksonville International Airport. Data source: SJRWMD 2020.

Rainfall can be affected by larger global scale weather events such as El Niño and La Niña that also influence where hurricanes develop in the Atlantic (Table 1). During El Niño fewer hurricanes and major hurricanes develop in the deep Tropics off western Africa. During La Niña more hurricanes form off the western-African coast, and these systems have greater potential for developing into major hurricanes that could impact the U.S. and Caribbean region. The probability for the continental U.S. and the Caribbean Islands to experience a hurricane increase during La Niña, and decrease during El Niño (**NOAA CPC 2020**). In Northeast Florida there exist a natural and somewhat unpredictable cycle of periodic droughts. More recently, a number of these factors have had a cumulative effect in the way they impact the ecology of the LSJRB. The late 1990's experienced a period of declining rainfall which was one of the worse drought periods in Florida history (Figure 2). The effect of El Niño (1997-1998) was sever and exacerbated drought conditions. Then from 2000-2005, rainfall gradually increased on an annual basis again. In 2006, rainfall decreased abruptly and was followed by a shorter period of drought before increasing again in 2007-2009. Drought conditions occurred again during 2009/2010 and it seems with more severity likely indicated by abruptly lower rainfall maxima (Figure 1). The normal average monthly rainfall for the period 1951-1960 was 4.32 inches (Rao et al., 1989), it was higher for the period 1995-2017 (5.15 inches), and considerably above average during 2017 and 2018, and below average for 2019 (Figure 2).

Table 1. Hurricanes affecting LSJRB and El Niño/La Niña years.

Year	Storm order	Storm Type	Name	Date	El Niño La Niña
1995	1	H	ALLISON	JUN 03-06	
	5	H	ERIN	JUL 31-AUG 06	
	10	T	JERRY	AUG 22-28	
Total # of storms 19					
1996	1	T	ARTHUR	JUN 17-21	La Niña
	2	H	BERTHA	JUL 05-14	
	10	T	JOSEPHINE	OCT 04-06	
Total # of storms 13					
1997	1	ST	no name	JUN 01-02	El Niño
	5	H	DANNY	JUL 16-26	
Total # of storms 8					
1998	2	H	BONNIE	AUG 19-30	
	5	H	EARL	AUG 31-SEPT 03	
	7	H	GEORGES	SEP 15-OCT 01	
Total # of storms 14					
1999	4	H	DENNIS	AUG 24-SEP 07	La Niña
	6	H	FLOYD	SEP 07-17	
	9	H	IRENE	OCT 13-19	
Total # of storms 12					
2000	7	H	GORDON	SEP 14-18	La Niña
	12	T	LESLIE	OCT 04-07	
Total # of storms 15					
2001	2	T	BARRY	AUG 02-07	La Niña
Total # of storms 15					

H=Hurricane; TS=Tropical storm; ST=Sub-Tropical storm

This data represents only those storms that had or likely had an impact on the area and were within 200 nautical miles of the coast of Northeast Florida.

Table 1 cont. Hurricanes affecting LSJRB and El Niño/La Niña years.

Year	Storm order	Storm Type	Name	Date	El Niño La Niña
2002	5	T	EDOUARD	SEP 01-06	El Niño
	11	H	KYLE	SEP 20-OCT 12	
Total # of storms 12					
2003	8	T	HENRI	SEP 03-08	
Total # of storms 16					
2004	2	T	BONNIE	AUG 03-13	El Niño
	3	H	CHARLEY	AUG 09-14	
	6	H	FRANCIS	AUG 25-SEP 08	
	9	H	IVAN	SEP 02-24	
	10	H	JEANNE	SEP13-28	
Total # of storms 15					
2005	15	H	OPHELIA	SEP 06-17	Neutral ENSO
	20	T	TAMMY	OCT 05-06	
Total # of storms 28					
2006	1	T	ALBERTO	JUN 10-14	El Niño
	6	H	ERNESTO	AUG 24-SEP 01	
Total # of storms 10					
2007	1	ST	ANDREA	MAY 09-11	La Niña
	2	T	BARRY	JUN 01-02	
Total # of storms 15					
2008	6	TS	FAY	AUG 15-27	La Niña
	8	H	HANNA	AUG 28-SEP 07	
	9	H	IKE	SEP 01-14	
Total # of storms 16					
2009	3	TS	CLAUDETTE	AUG 16-17	El Niño
	4	TS	DANNY	AUG 26-29	
	9	H	IDA	NOV 04-10	
Total # of storms 9					
2010	2	TS	BONNIE	JUL 22-24	La Niña
	5	H	EARL	AUG 25-SEP 04	
	14	TS	NICOLE	SEP 28-29	
Total # of storms 19					

H=Hurricane; TS=Tropical storm; ST=Sub-Tropical storm

This data represents only those storms that had or likely had an impact on the area, and were within 200 nautical miles of the coast of Northeast Florida.

Table 1 cont. Hurricanes affecting LSJRB and El Niño/La Niña years.

Year	Storm order	Storm Type	Name	Date	El Niño La Niña
2011	2	TS	BRET	JUL 17-22	La Niña
	5	TS	EMILY	AUG 2-7	
	9	MH	IRENE	AUG 21-28	
Total # of storms 19					
2012	1	TS	ALBERTO	MAY 19-22	La Niña
	2	TS	BERYL	MAY 26-30	
	4	TS	DEBBY	JUN 23-27	
	9	H	ISAAC	AUG 21-SEP 1	
Total # of storms 19					
2013	1	T	ANDREA	JUN5-7	None
	4	T	DORIAN	JUL23-AUG-3	
Total # of storms 14					
2014	1	H	ARTHUR	JUL1-5	None
Total # of storms 8					
2015	1	TS	ANA	MAY 8-11	El Niño
Total # of storms 8					
2016	2	TS	BONNIE	MAY 27-JUN 4	El Niño
	3	TS	COLIN	JUN 5-7	None
	8	H	HERMINE	AUG 28-SEP 3	La Niña
	10	TS	JULIA	SEP 14-18	La Niña
	13	MH	MATTHEW	SEP 28-OCT 9	La Niña
Total # of storms 15					
2017	5	TS	EMILY	JUL 31-AUG 1	None
	9	MH	IRMA	AUG 30-SEP 12	None
	16	TS	PHILIPPE	OCT 28-29	La Niña
Total # of storms 17					
2018	1	TS	ALBERTO	MAY 25-31	La Niña
	7	TS	GORDON	SEP 3-7	El Niño
	13	MH	MICHAEL	OCT 7-12	El Niño
Total # of storms 15					
2019	4	MH	DORIAN	AUG 24-SEP 7	None
Total # of storms 18					

MH=Major Hurricane; H=Hurricane; TS=Tropical storm;
ST=Sub-Tropical storm

This data represents only those storms that had or likely had an impact on the area, and were within 200 nautical miles of the coast of Northeast Florida. Note that 2015 represents a strong period of El Niño, followed by a transition to La Niña by the end of 2016.

Appendix 4.1.7.1.F

Salinity

Information in this section includes annual salinity variations at the following locations: JU, Bolles, Buckman Bridge, Moccasin Slough, Doctors Lake, Scratch Ankle, and Rice Creek.

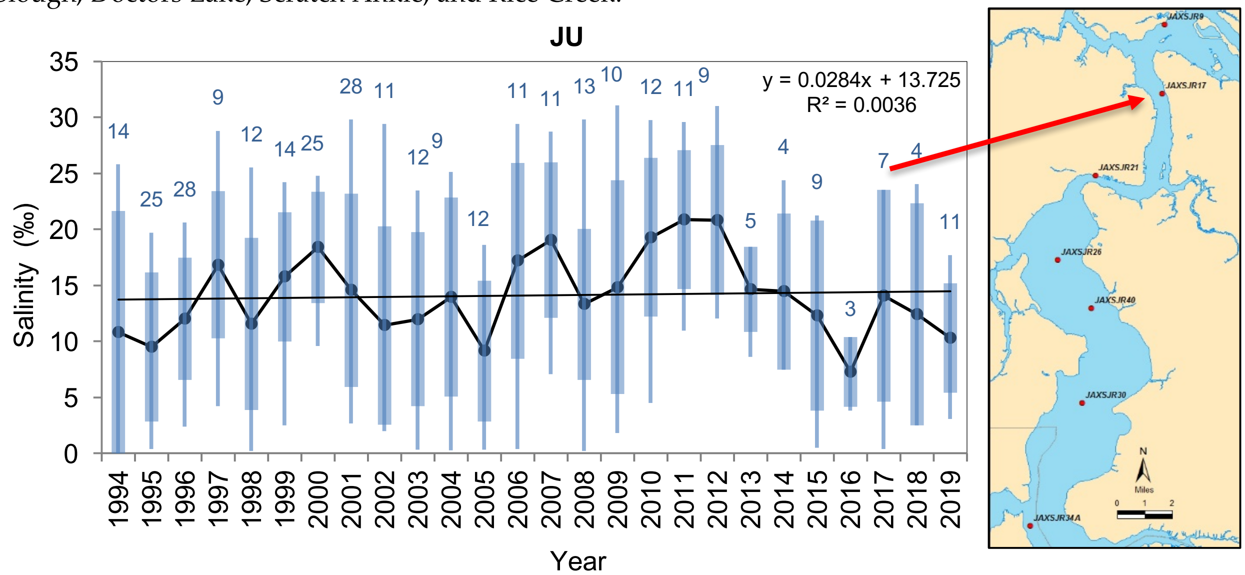


Figure 1. Salinity on the bottom of SJR (near JU) values above the bars indicate the numbers of observations. Solid line (mean), vertical lines (maximum and minimum), and bars (Standard Deviation of the mean). Data source: Bill Karlavige, Environmental Quality Division, City of Jacksonville 2020. JU mean 24.75‰ (SD±5.18) for the maxima. Note that only 5 observation were made in 2013; 4 2014, 3 in 2016, and 4 in 2018.

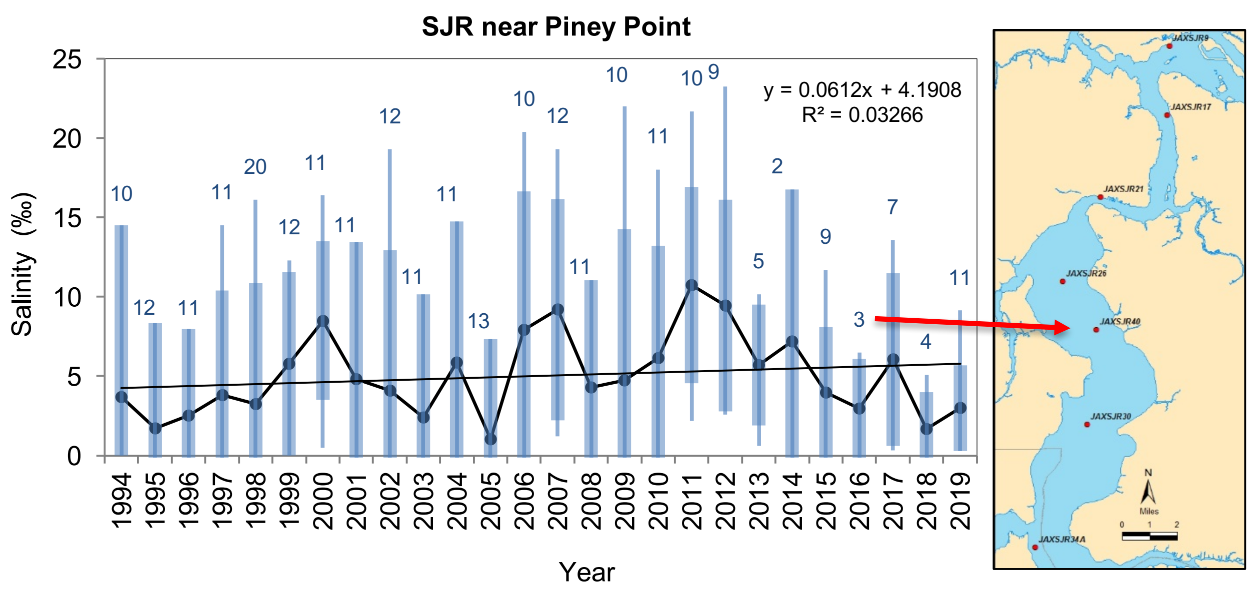


Figure 2. Salinity on the bottom of SJR (Main stem Station SJR40 located mid-channel N. of Piney Pt. 100 m west of green marker 5) values above the bars indicate the numbers of observations. Solid line (mean), vertical lines (maximum and minimum), and bars (Standard Deviation of the mean). Data source: Bill Karlavige, Environmental Quality Division, City of Jacksonville 2020. SJR40 mean 13.50‰ (S.D.±5.46 for the maxima). Note that only 5 observations were made in 2013; 2 in 2014, 3 in 2016, and 4 in 2018.

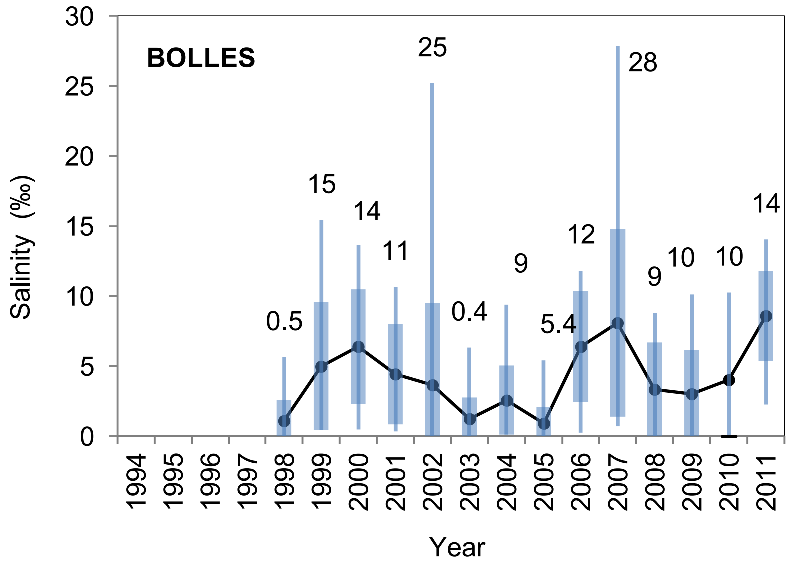


Figure 3. Salinity at SAV monitoring site (near Bolles School) numbers indicate maxima. Solid line (mean), vertical lines (maximum and minimum), and bars (Standard Deviation of the mean). For map location, see Appendix 4.1.7.1.A. Data source: SJRWMD 2012. Bolles mean 12.46‰ (SD±6.70) for the maxima.

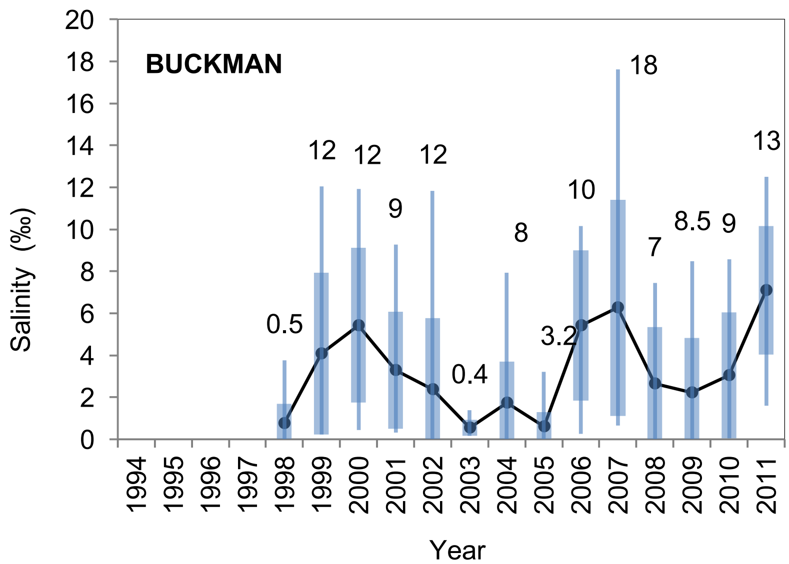


Figure 4. Salinity at SAV monitoring site (near Buckman Bridge) numbers indicate maxima. Solid line (mean), vertical lines (maximum and minimum), and bars (Standard Deviation of the mean). For map location, see Appendix 4.1.7.1.A. Data source: SJRWMD 2012. Buckman mean 9.01‰ (SD±4.27) for the maxima.

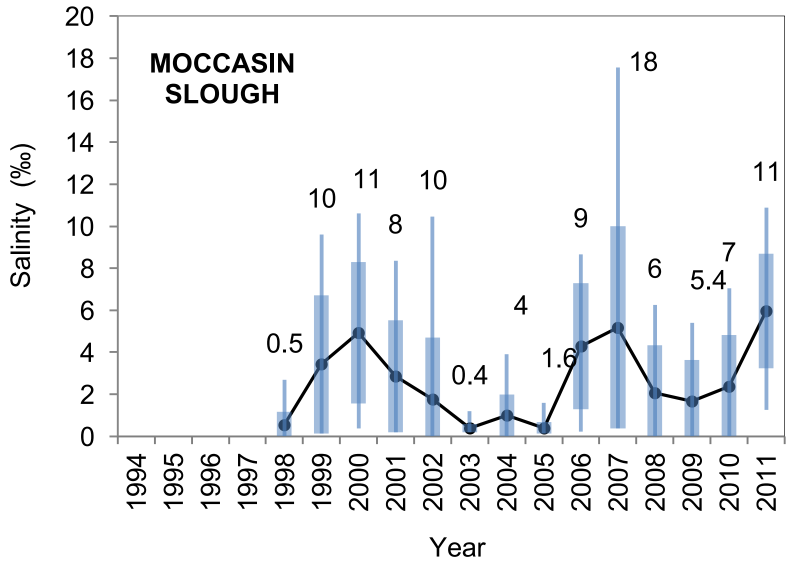


Figure 5. Salinity at SAV monitoring site near Moccasin Slough numbers indicate maxima. Solid line (mean), vertical lines (maximum and minimum), and bars (Standard Deviation of the mean). For map location see Appendix 4.1.7.1.A. Data source: SJRWMD 2012. Moccasin Slough mean 7.44‰ (SD±4.42) for the maxima.

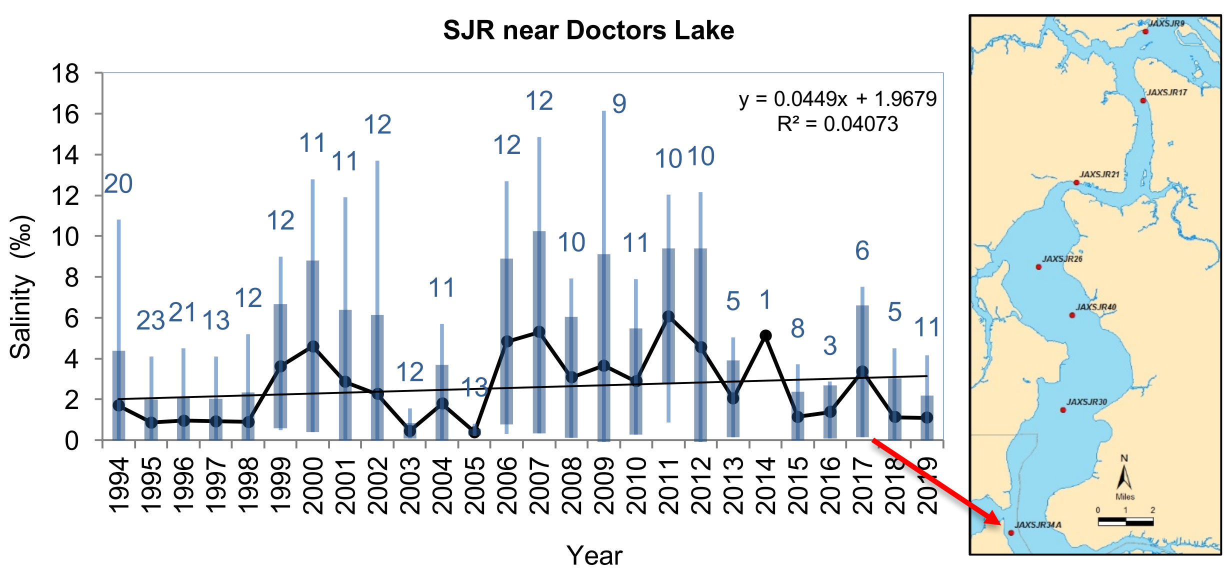


Figure 6a. Salinity in SJR ~ 1000 m south of Doctors Lake (west bank) values above the bars indicate the numbers of observations. Solid line (mean), vertical lines (maximum and minimum), and bars (Standard Deviation of the mean). For map location, see Appendix 4.1.7.1.A. Data source: Bill Karlavige, Environmental Quality Division, City of Jacksonville 2020. Doctors Lake mean 7.64‰ (SD±4.48) for the maxima. Note that only one observation was made in 2014, and 3 in 2016.

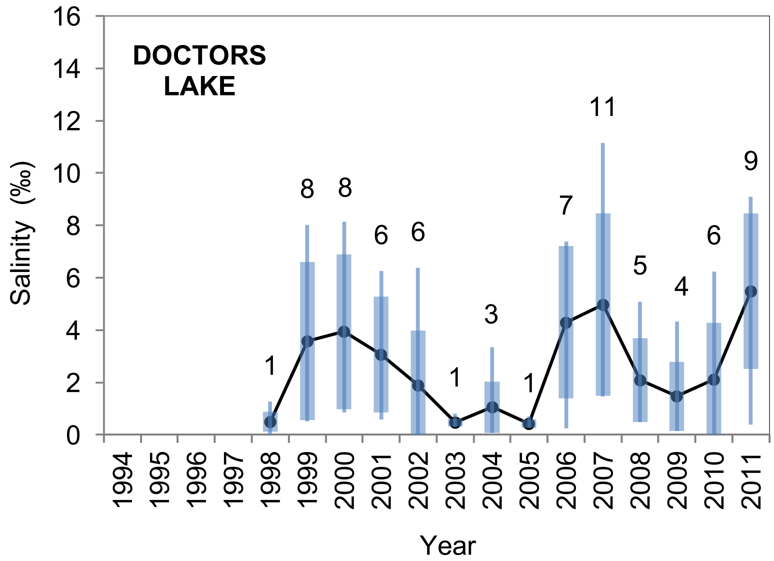


Figure 6b. Salinity at SAV monitoring in Doctors Lake indicate maxima. Solid line (mean), vertical lines (maximum and minimum), and bars (Standard Deviation of the mean). For map location, see Appendix 4.1.7.1.A. Data source: SJRWMD 2012.
Doctors Lake 5.58‰ (SD±3.19) for the maxima.

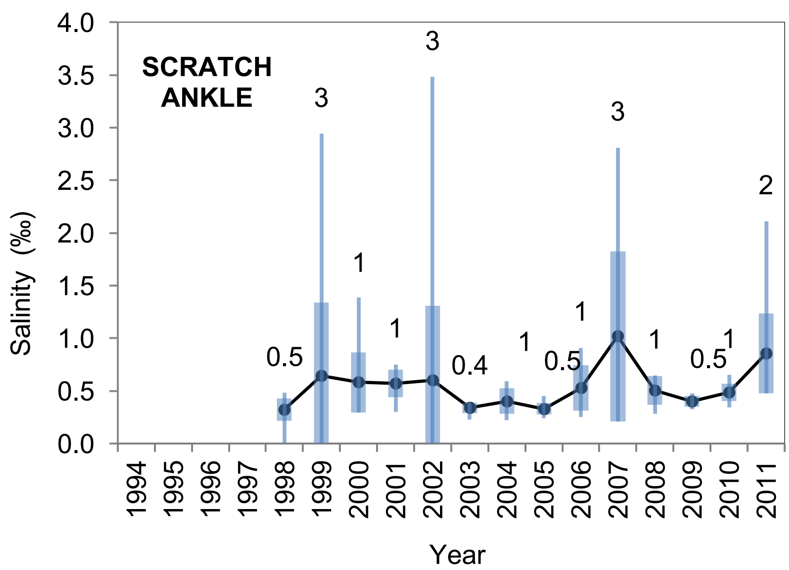


Figure 7. Salinity at SAV monitoring site near Scratch Ankle numbers indicate maxima. Solid line (mean), vertical lines (maximum and minimum), and bars (Standard Deviation of the mean). For map location, see Appendix 4.1.7.1.A. Data source: SJRWMD 2012.
Scratch Ankle mean 1.29‰ (SD±1.08) for the maxima.

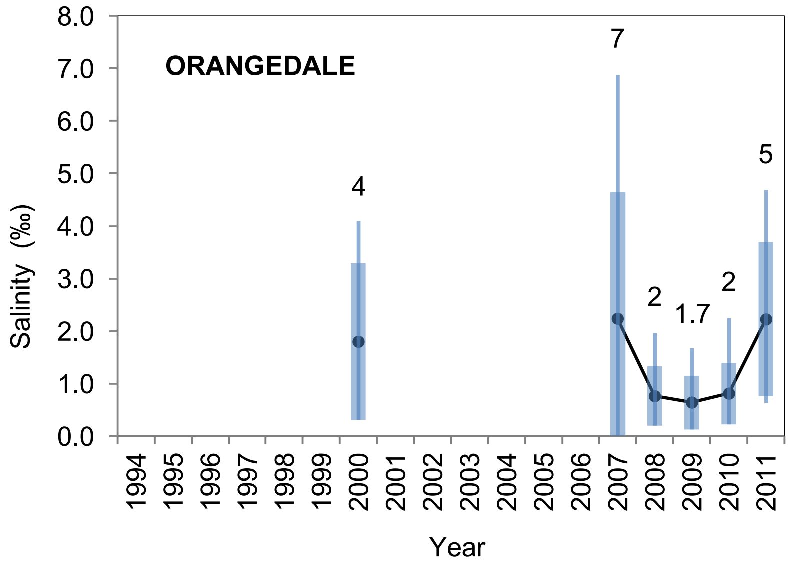


Figure 8. Salinity at SAV monitoring site near Orangedale numbers indicate maxima. Solid line (mean), vertical lines (maximum and minimum), and bars (Standard Deviation of the mean). There was no data for 2001-2006. For map location, see Appendix 4.1.7.1.A. Data source: SJRWMD 2012.
Orangedale mean 3.59‰ (SD±2.02) for the maxima.

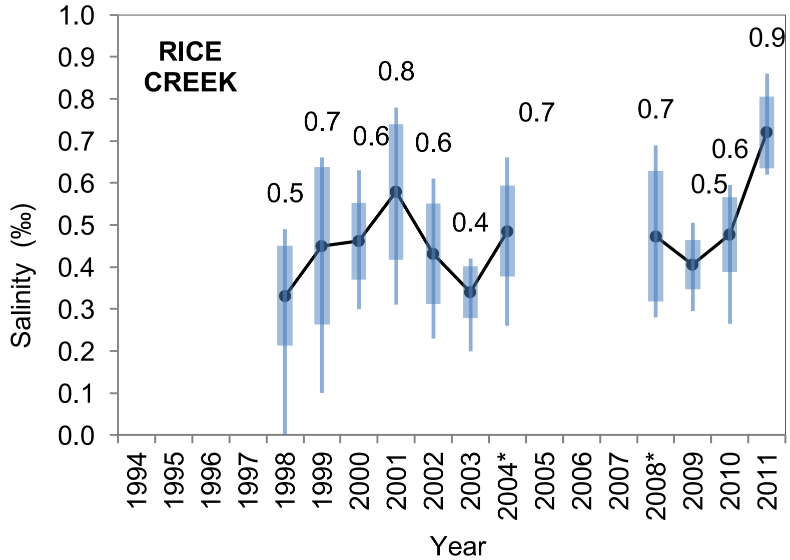


Figure 9. Salinity at SAV monitoring site near Rice Creek numbers indicate maxima. Solid line (mean), vertical lines (maximum and minimum), and bars (Standard Deviation of the mean). There was no data for 2005-2007; 2004 = no data from October to December; 2008* = no data from January to March). For map location see Appendix 4.1.7.1.A. Data source: SJRWMD 2012.*
Rice Creek mean 0.63‰ (SD±0.13) for the maxima.

Data obtained from The City of Jacksonville's Environmental Quality Division "River Run" sampling program was used to determine salinity changes from 1991 – 2019. Data is collected about twice a month at the surface (0.5 m), middle (3-5 m), and bottom (5-10 m) in the water column. Four sites were chosen from the regular ten sampling stations (Figure 10).

1) West bank of SJR 1000m south of Doctors Lake (JAXSJR34A)
2) East bank of SJR 200m north of a large apartment complex near Jacksonville University (JAXSJR17)
3) South bank of SJR just west of Dames Point Bridge, near the western most range marker (JAXSJR9)
4) Main stem of SJR Mid channel N. of Piney Pt. 100 m west of green marker 5 (JAXSJR40)

Kendall's Tau analysis was used because using parametric analyses on small sample sizes is not statistically justified and it requires meeting several assumptions. In addition, it was recommended that "*given the audience for this report I would recommend doing just a correlation analysis and only using nonparametric methods, such as Kendall's tau, instead of trying to meet all the assumptions of a parametric regression analysis.*"[1]

According to Helsel and Hirsch[2], "Mann (1945) first suggested using the test for significance of Kendall's tau where the X variable is time as a test for trend." (The relevant chapter of the above can be accessed at http://pubs.usgs.gov/twri/twri4a3/pdf/chapter12.pdf). This was in the paper "Nonparametric tests against trend" (the statistic appears as T in the paper instead of tau). Moreover, the Unified Guidance by the EPA discusses the Kendall-Mann trend test and can be accessed at (http://www.itrcweb.org/gsmc-1/Content/Resources/Unified_Guidance_2009.pdf, see section 17.3.2. *(Anna Little, Personal communication 2015).*

Kendal Tau correlation analysis revealed that salinity over time had significantly increased at the bottom, middle and surface at SJR near Doctors Lake, Piney Point mid-river, near Jacksonville University and Dames Point Bridge.

Since near zero salinity is associated with freshwater runoff, it is reasonable to assume that from 1994 to 2019 dredging activities have contributed to some of the increase in salinity in the St. John River. However, the amount of salinity increase relative to that contributed from rising sea level is less clear. Also, the period from 1994 to 2019 represents a relatively dryer period. Therefore, reduced freshwater flowing into the river would also contribute to the increase in salinity. However, recent storms in 2017/2018, caused above average rainfall that decreased the salinity in the river for several months.

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1 Personal Communication to: Michael McManus, Senior Aquatic Ecologist, The Nature Conservancy, June 23, 2008

2 Helsel, D.R. and R. M. Hirsch, 2002. Statistical Methods in Water Resources Techniques of Water Resources Investigations, Book 4, Chapter A3. U.S. Geological Survey. 522 pages.

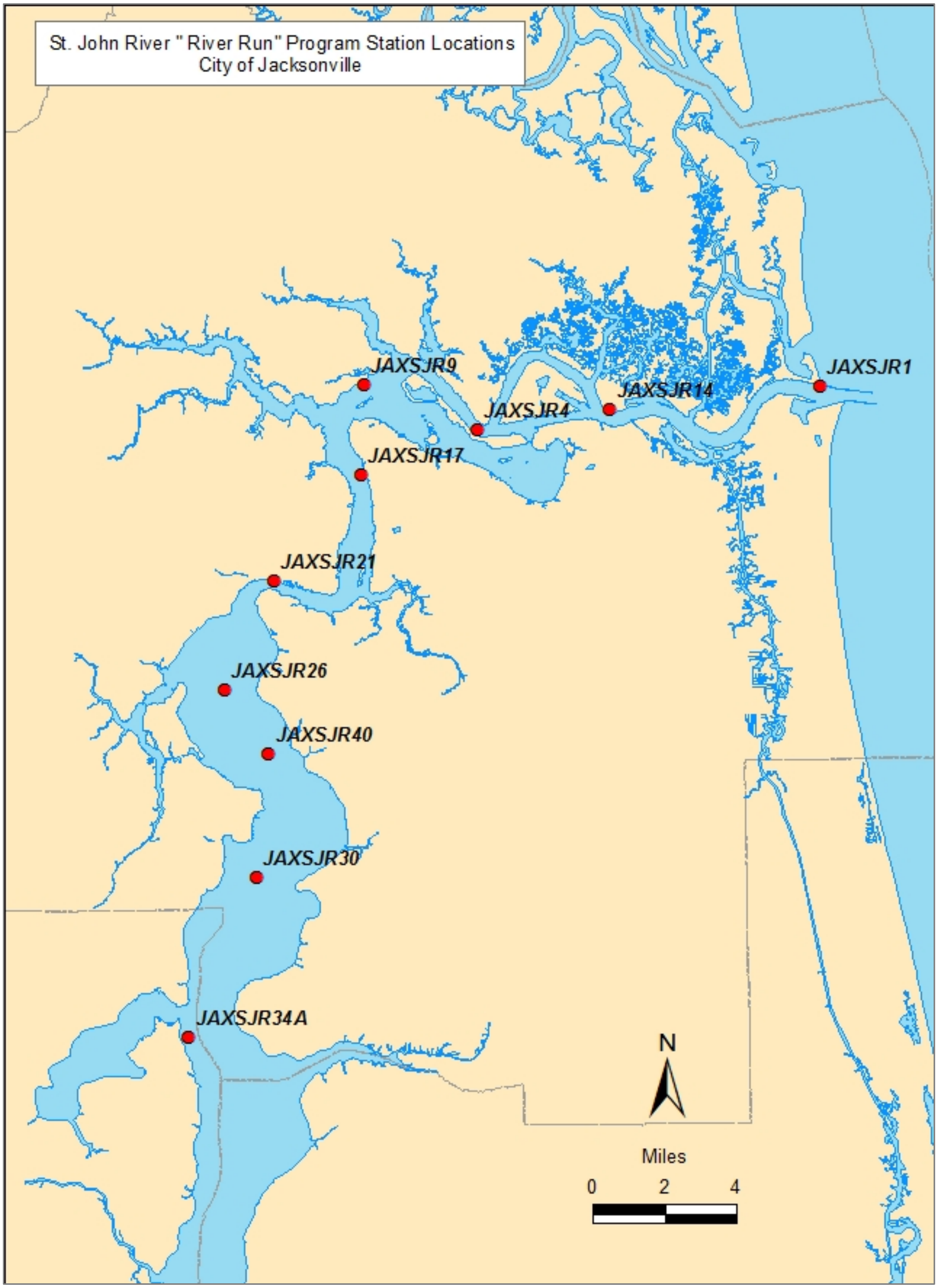


Figure 10. SJR "River Run" Program station locations, City of Jacksonville.

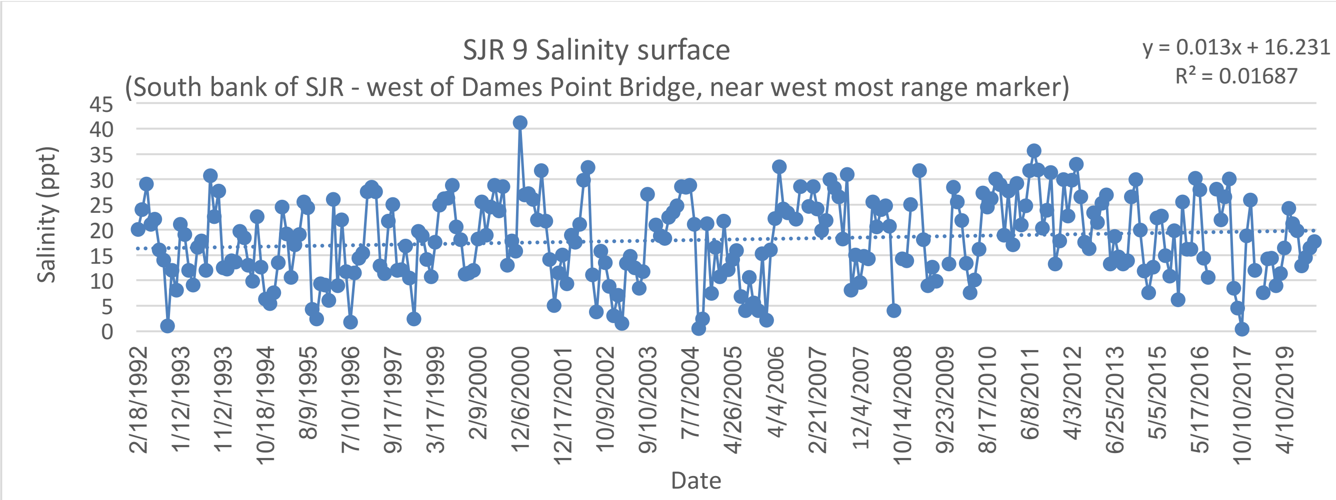


Figure 11. SJR 9 Dames Point Bridge (Surface) 1997-2019 (Kendal Tau 0.0871; p=0.016591; n=265).

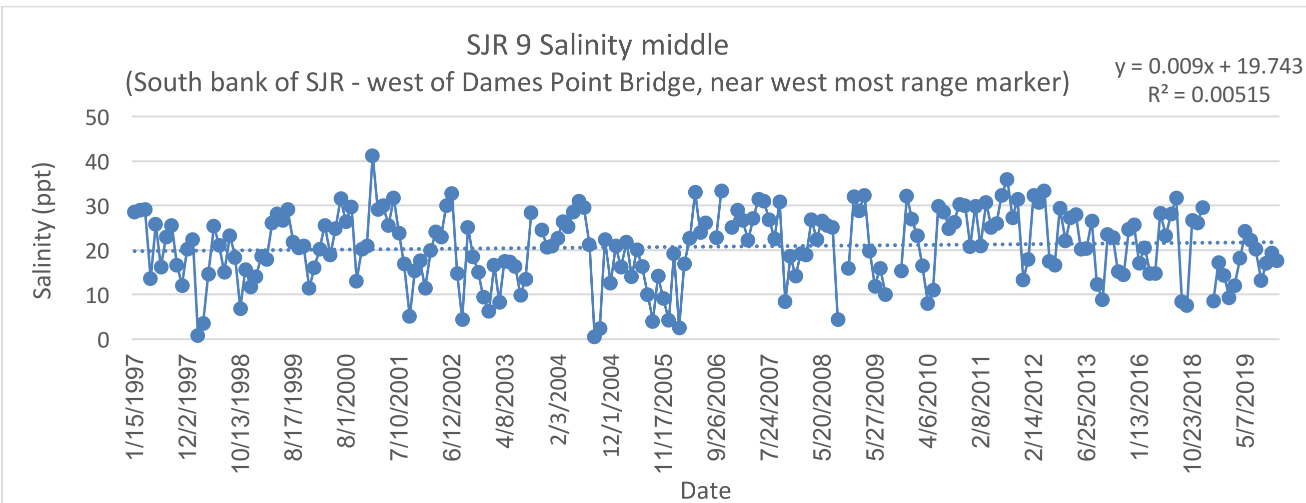


Figure 12. SJR 9 Dames Point Bridge (Middle) 1997-2019 (Kendal Tau 0.0462; p=0.1595; n=210).

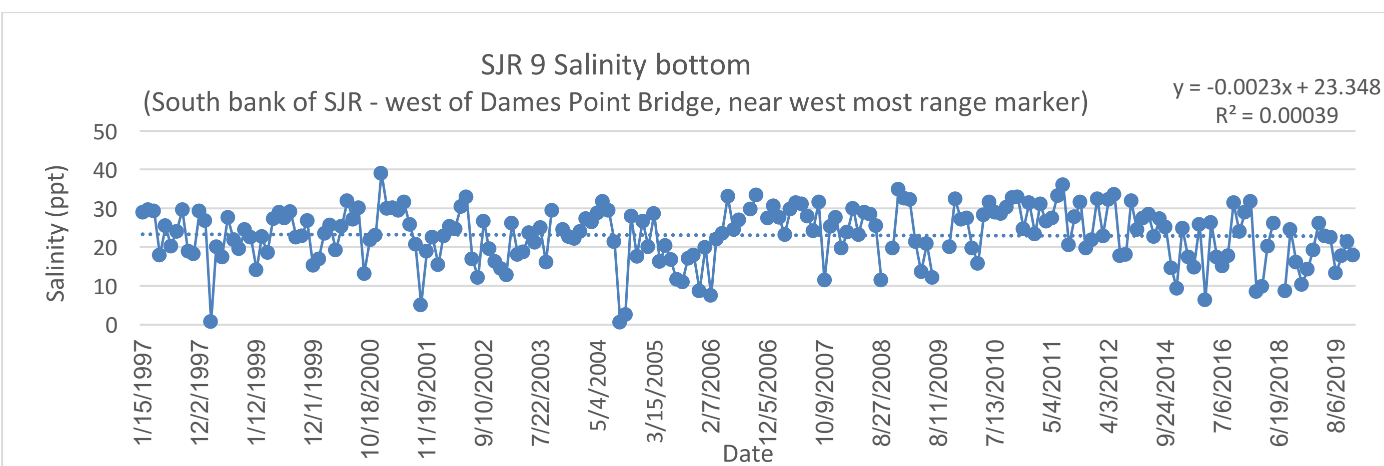


Figure 13. SJR 9 Dames Point Bridge (Bottom) 1997-2019 (Kendal Tau -0.00554; p=0.45841; n=207).

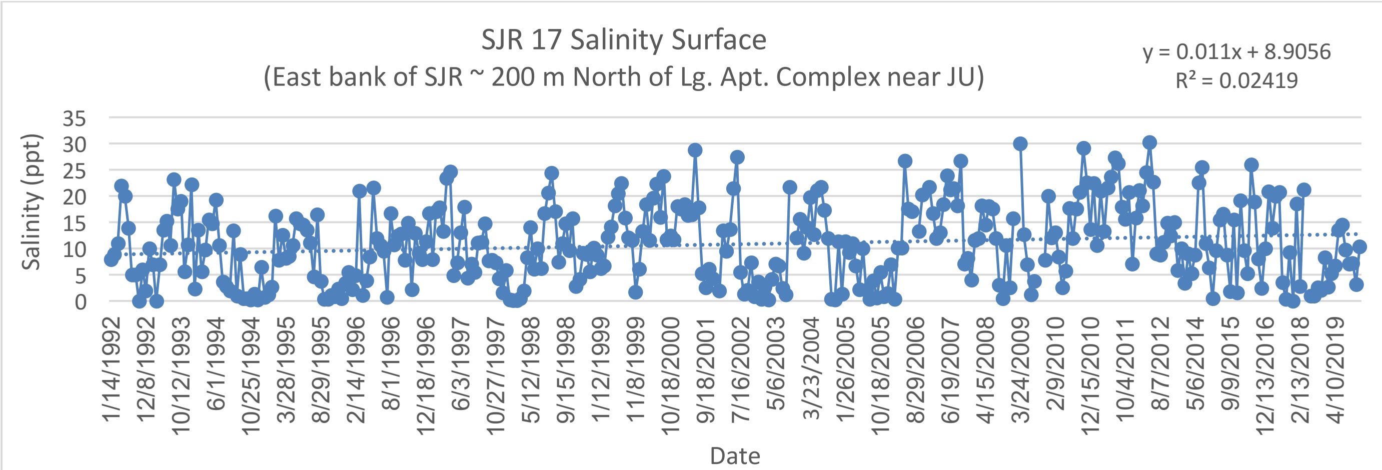


Figure 14. SJR 117 JU (Surface) 1994-2019 (Kendal Tau 0.099; p=0.00293; 350).

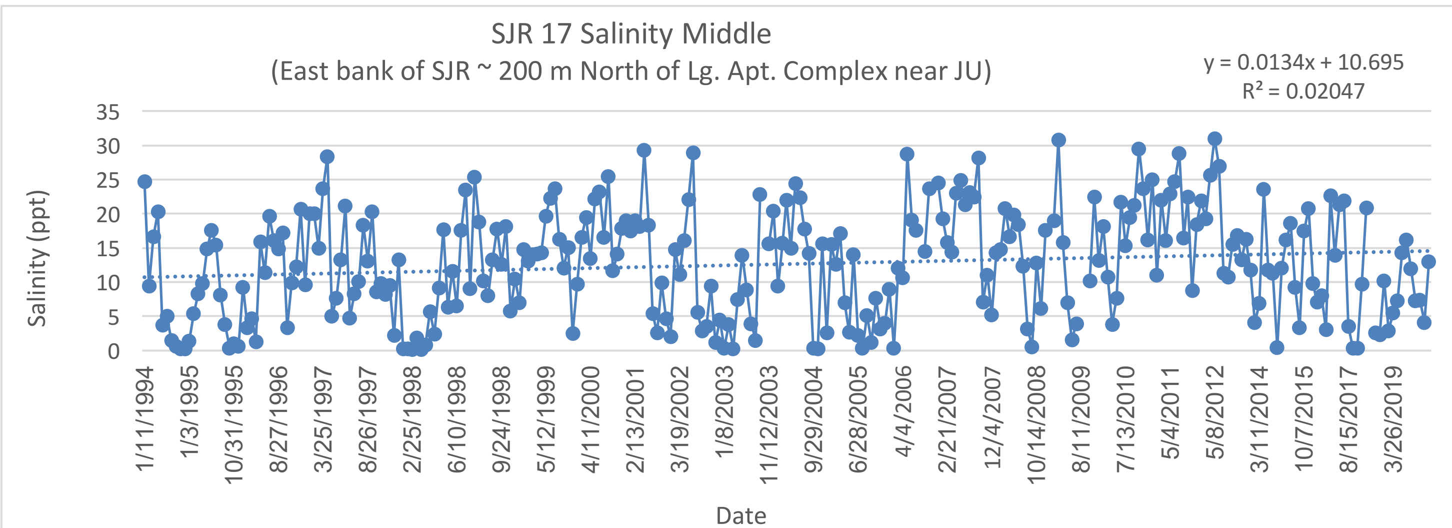


Figure 15. SJR 17 JU (Middle) 1994-2019 (Kendal Tau 0.096; p=0.00797; 282).

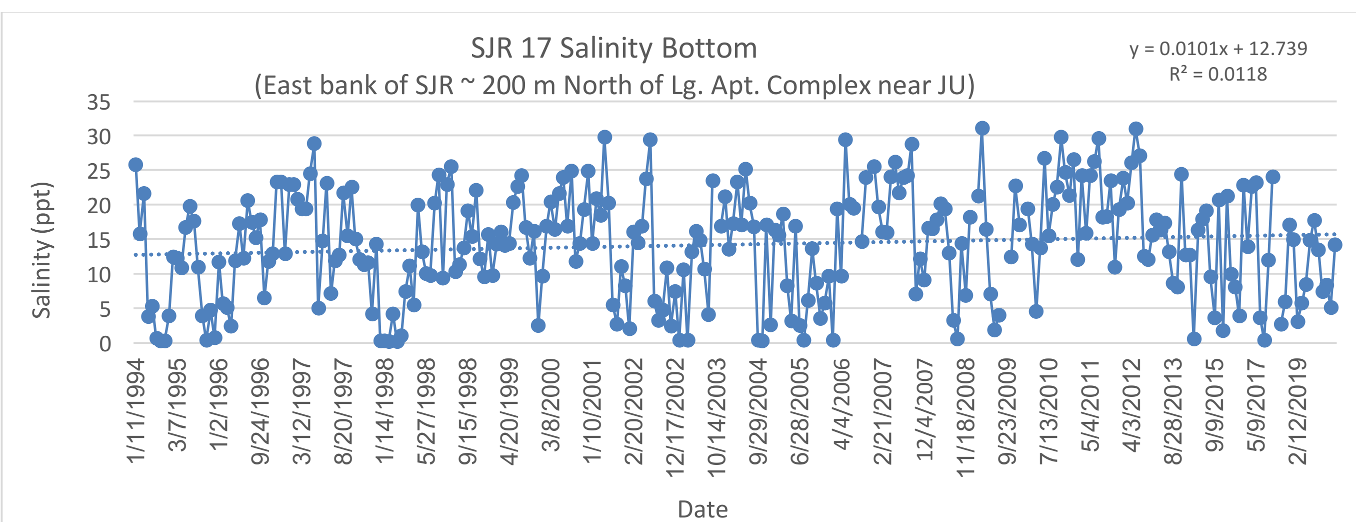


Figure 16. SJR 17 JU (Bottom) 1994-2019 (Kendal Tau 0.068; p=0.04346; 283).

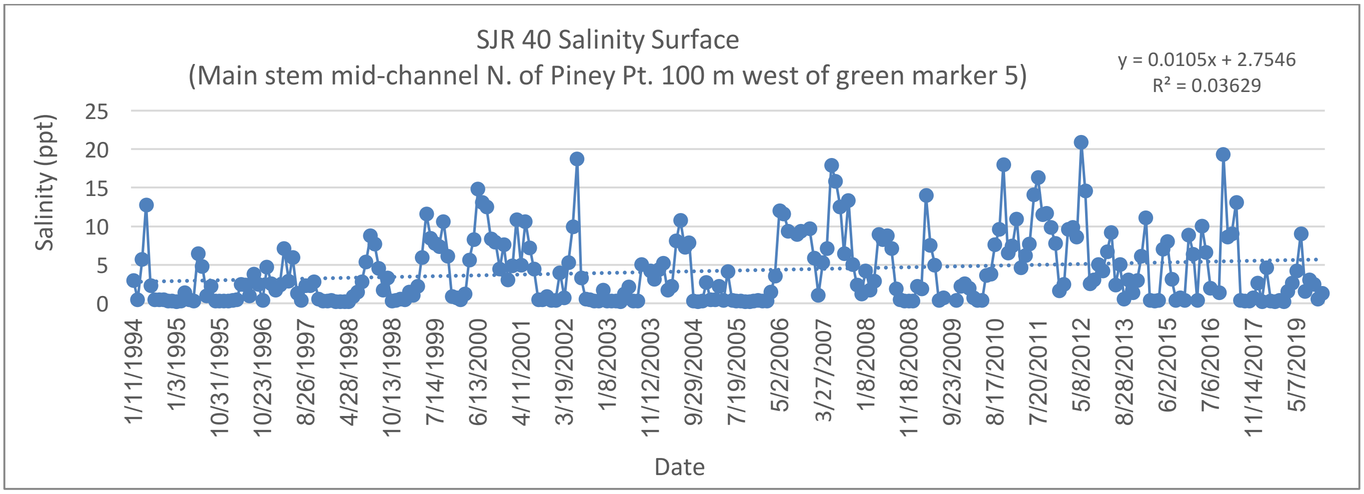


Figure 17. SJR 40 near Piney Point (Surface) 1994-2019 (Kendal Tau 0.124; p=0.0012; 271).

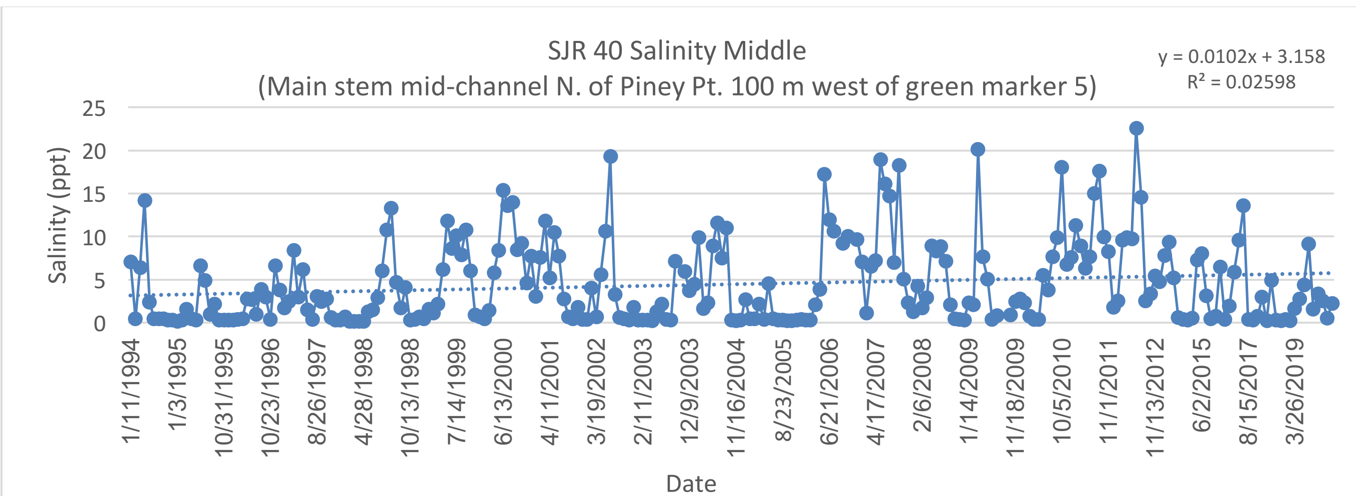


Figure 18. SJR 40 near Piney Point (Middle) 1994-2019 (Kendal Tau 0.109; p=0.0047; 254).

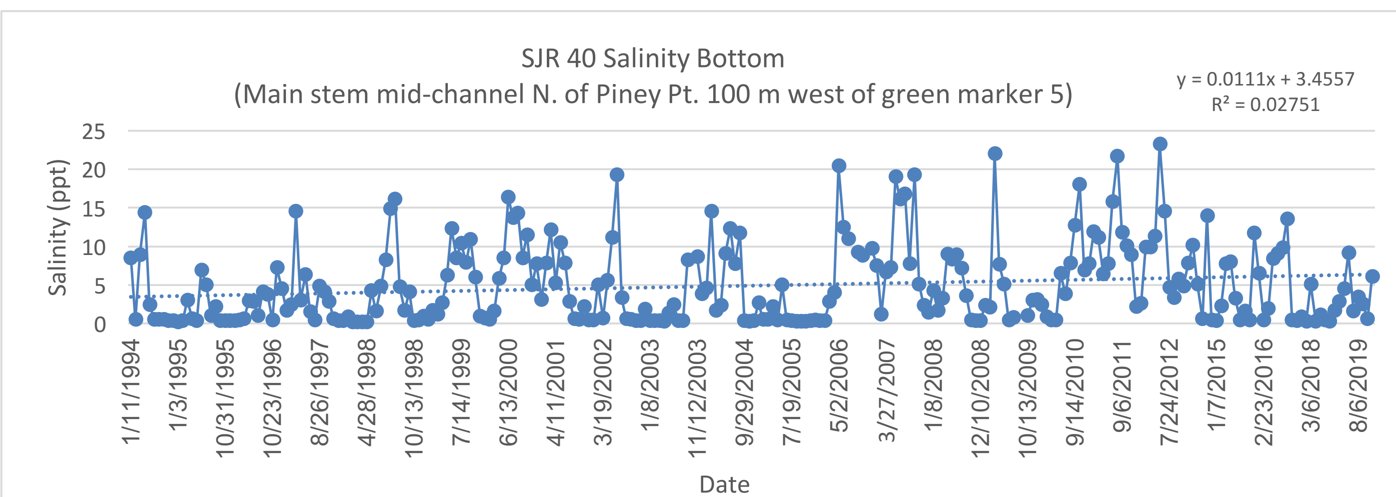


Figure 19. SJR 40 near Piney Point (Bottom) 1994-2019 (Kendal Tau 0.118; p=0.0023; 259).

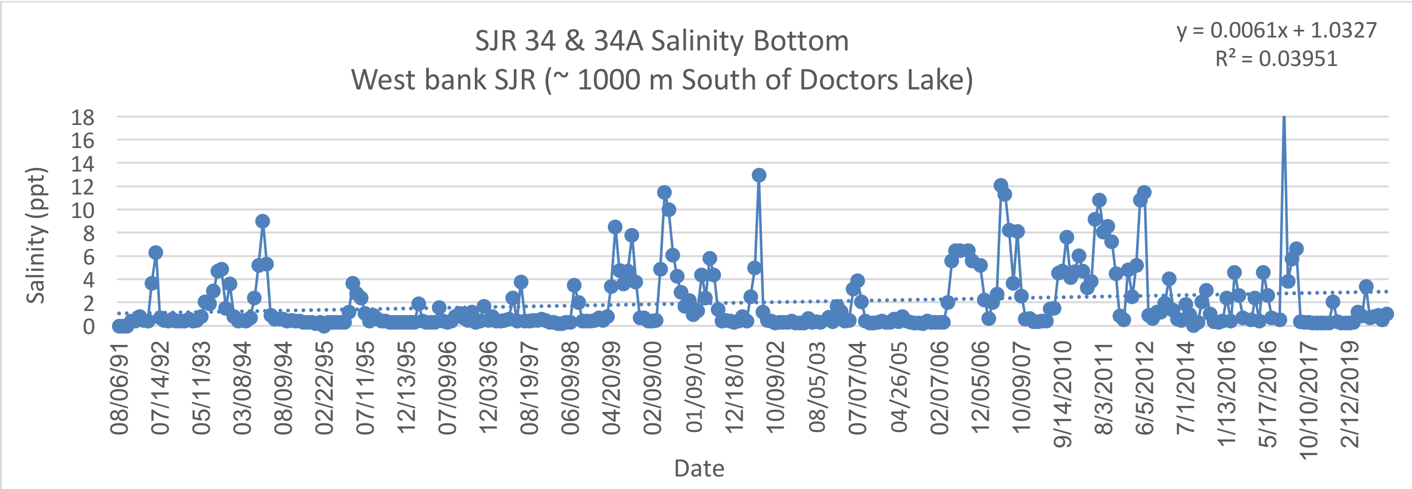


Figure 20. SJR 34/34A West bank SJR ~1000m South of Doctors Lake (Surface) 1991-2019 (Kendal Tau 0.1097; p=0.00214; n=305).

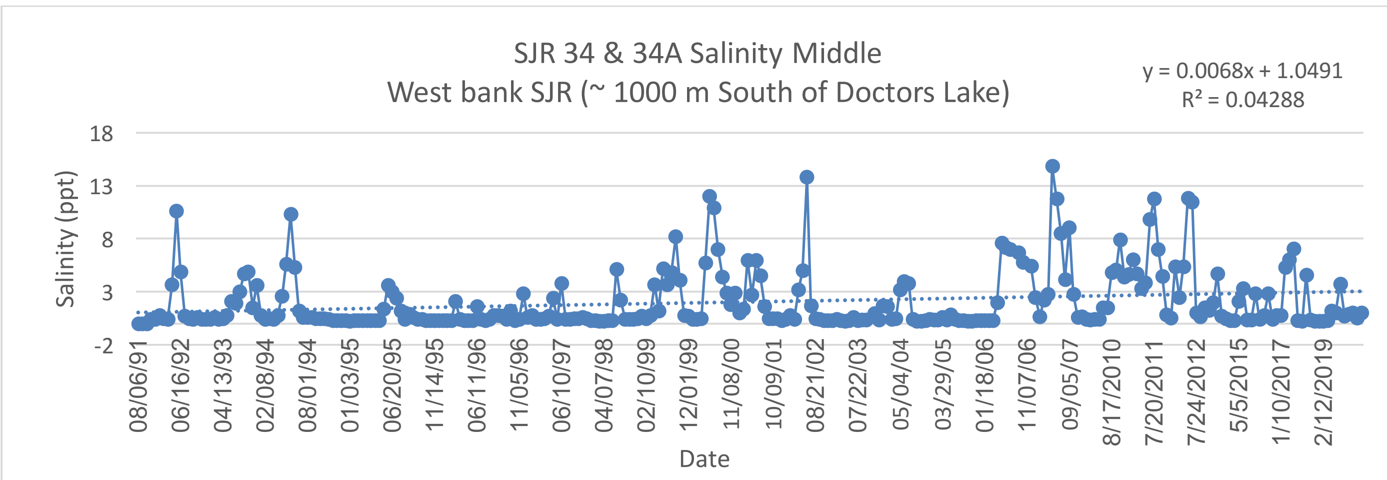


Figure 21. SJR 34/34A West bank SJR ~1000m South of Doctors Lake (Middle) 1991-2019 (Kendal Tau 0.131; p=0.000458; n=287).

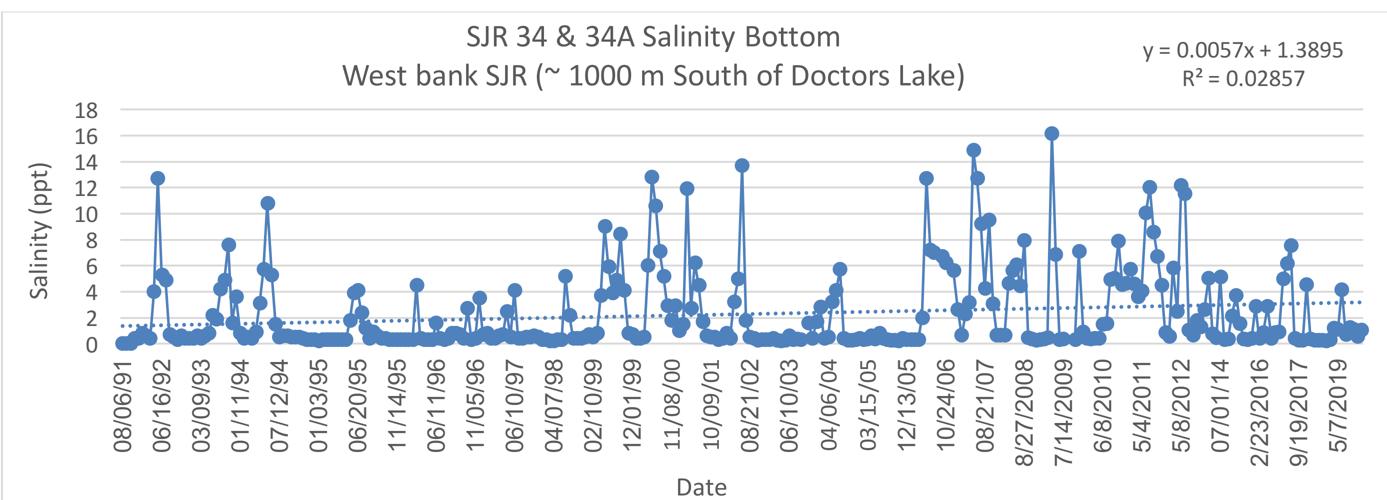


Figure 22. SJR 34/34A West bank SJR ~1000m South of Doctors Lake (Bottom) 1991-2019 (Kendal Tau 0.109; p=0.00206; n=312).

Appendix 4.2.A
Regulatory Definitions of Wetlands

The St. Johns River Water Management District (SJRWMD) issues permits pursuant to part IV of Chapter 373, F.S. (the Florida Department of Environmental Regulation delegated authority over wetland permitting to the SJRWMD in 1988). The U.S. Army Corps of Engineers issues permits pursuant to Section 404 of the Clean Water Act, Section 10 of the Rivers and Harbors Act of 1899, or Section 103 of the Marine Protection, Research and Sanctuaries Act.

GOVERNMENTAL ENTITY (REFERENCE)	WETLAND DEFINITION
U.S. Fish and Wildlife Service (Cowardin *et al.* 1979)	"Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For the purposes of this classification wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes; (2) the substrate is predominantly undrained hydric soil; and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year."
U.S. Army Corps of Engineers (33 CFR 328.3) U.S. Environmental Protection Agency (40 CFR 230.3)	"Wetlands are those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas."
U.S. Soil Conservation Service (National Food Security Act Manual 1988) (The Act is commonly known as the "Swampbuster")	"Wetlands are defined as areas that have a predominance of hydric soils and that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of hydrophytic vegetation typically adapted for life in saturated soil conditions, except lands in Alaska identified as having high potential for agricultural development and a predominance of permafrost soils."
State of Florida (Section 373.019 (17) of the Florida Statutes, and Section 62-340.200 (19) of the Florida Administrative Code)	"'Wetlands' . . . means those areas that are inundated or saturated by surface water or ground water at a frequency and a duration sufficient to support, and [that] under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soils. Soils present in wetlands generally are classified as hydric or alluvial, or possess characteristics that are associated with reducing soil conditions. The prevalent vegetation in wetlands generally consists of facultative or obligate hydrophytic macrophytes that are typically adapted to areas having soil conditions described above. These species, due to morphological, physiological, or reproductive adaptations, have the ability to grow, reproduce or persist in aquatic environments or anaerobic soil conditions" (F.S. § 373.019(17) 1995)

Appendix 4.2.B

The History of Florida's Wetlands

Constants used in calculations:

LAND (acres)	34,647,040
WATER (acres)	2,831,360
TOTAL SURFACE AREA (acres)	37,478,400

DATE	GENERALIZED TIME PERIOD	TOTAL ESTIMATED WETLANDS (acres) FOR TIME PERIOD	SOURCE	PERCENT OF THE TOTAL SURFACE AREA OF FLORIDA REPRESENTED BY WETLANDS	GAIN/LOSS OF WETLANDS DURING GENERALIZED TIME PERIOD	PERCENT OF THEORETICAL 100% REMAINING INTACT AFTER TIME PERIOD ANALYZED	ANNUAL GAIN/LOSS OF WETLANDS PER YEAR	ESTIMATED CUMULATIVE WETLANDS GAIN/LOSS IN FLORIDA (acres)	NOTES
1780's	early 1900's	20,325,013	Dahl, T.E. 1990. *Wetlands Losses in the United States, 1780's to 1980's*. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C. 13 pp.	54.23%				0	The first estimates of wetlands in Florida were based on the acreage granted to the State of Florida under the authority of the Swamp Lands Act of 1850. Dahl, T.E., G.J. Allord. 1999. History of wetlands in the conterminous United States. In *National Water Summary—Wetland Resources: TECHNICAL ASPECTS.* U.S. Geological Survey Water-Supply Paper 2425.
1907	early 1900's	20,300,000	Wright, James O. 1907. *Swamp and Overflowed Lands in the United States: Ownership and Reclamation*, Office of the Experiment Stations Circular 76. Washington, D.C.: U.S. Department of Agriculture. (as cited in Meindl 2005)	54.16%				0	
AVERAGED ESTIMATES FOR GENERALIZED TIME PERIOD	**early 1900's**	**20,312,507**		**54.20%**	**0**	**100.00%**	**0**	**0**	Experts agree that relatively little wetland loss occurred in Florida prior to 1907 (Meindl 2005). This is the starting point for future comparisons.
1923	1920's	16,846,000	Gray, L.C., O.E. Baker, F.J. Marschner, and B.O. Weitz. "The Utilization of Our Lands for Crops, Pasture and Forests." in U.S. Department of Agriculture, *Agriculture Yearbook 1923.* U.S. Government Printing Office, Washington, D.C., 1923. (as cited in Meindl 2005)	44.95%				-3,479,013	
1920	1920's	17,900,000	Stoutamire, Ralph. *Drainage and Water Control in Florida*, Florida Department of Agriculture Bulletin 51, Tallahassee, Florida, 1931. (as cited in Meindl 2005)	47.76%				-2,425,013	

DATE	GENERALIZED TIME PERIOD	TOTAL ESTIMATED WETLANDS (acres) FOR TIME PERIOD	SOURCE	PERCENT OF THE TOTAL SURFACE AREA OF FLORIDA REPRESENTED BY WETLANDS	GAIN/LOSS OF WETLANDS DURING GENERALIZED TIME PERIOD	PERCENT OF THEORETICAL 100% REMAINING INTACT AFTER TIME PERIOD ANALYZED	ANNUAL GAIN/LOSS OF WETLANDS PER YEAR	ESTIMATED CUMULATIVE WETLANDS GAIN/LOSS IN FLORIDA (acres)	NOTES
AVERAGED ESTIMATES FOR GENERALIZED TIME PERIOD	**1920's**	**17,373,000**		**46.35%**	**-2,939,507**	**85.53%**	**-146,975**	**-2,939,507**	Because Florida's population was relatively modest at the time, experts agree that it is hard to believe that almost 3 million acres of wetlands were lost between 1907 and the early 1920's (Meindl 2005).
1956	mid-1950's	17,200,000	Shaw, Samuel P., and C. Gordon Fredine. 1956. *Wetlands of the United States: Their Extent and Their Value to Waterfowl and Other Wildlife*, U.S. Fish and Wildlife Service Circular 39. Washington, D.C.: U.S. Department of the Interior, 1956. (as cited in Meindl 2005)	45.89%				700,000	Bases on aerial photographs. Agriculture was most significant source of wetlands loss, especially in the marshes forming the headwaters of the St. Johns River near Fellsmere (Meindl 2005)
1954	mid-1950's	12,779,000	Hefner, John M. 1986. "Wetlands in Florida: 1950s to 1970s," *Proceedings of the Conference: Managing cumulative Effects in Florida Wetlands*, ed. E.D. Estevez, J. Miller, J. Morris, and R. Hamman, Omnipress: Madison, WI. (as cited in Meindl 2005)	34.10%					
AVERAGED ESTIMATES FOR GENERALIZED TIME PERIOD	**mid-1950's**	**14,989,500**		**40.00%**	**-2,383,500**	**73.79%**	**-79,450**	**-5,323,007**	
1973	mid-1970's	8,300,000	Hampson, Paul S. 1984. Wetlands in Florida, Florida Bureau of Geology Map Series 109, Tallahassee, Florida: Florida Bureau of Geology. (as cited in Meindl 2005)	22.15%				-4,479,000	Based on 1972-1974 satellite imagery. Aerial photo interpretation techniques are more accurate for wetland identification than satellite data (Federal Geographic Data Committee (FGDC). 1992. Application of Satellite Data for Mapping and Monitoring Wetlands, FGDC Wetlands Subcommittee Technical Report I. Reston, Virginia: U.S. Geological Survey)
1974	mid-1970's	11,334,000	Hefner, John M. 1986. "Wetlands in Florida: 1950s to 1970s," Proceedings of the Conference: Managing cumulative Effects in Florida Wetlands, ed. E.D. Estevez, J. Miller, J. Morris, and R. Hamman, Omnipress: Madison, WI. (as cited in Meindl 2005)	30.24%				-1,445,000	Based on a subsample of aerial photographs.
mid-1970's	mid-1970's	11,298,600	Frayer, W.E., and J.M. Hefner. 1991. *Florida Wetlands: Status and Trends, 1970's to 1980's*. U.S. Department of the Interior, Fish and Wildlife Service, Atlanta, Georgia. 33 pp.	30.15%				-3,690,900	Based on a different subsample of aerial photographs.

DATE	GENERALIZED TIME PERIOD	TOTAL ESTIMATED WETLANDS (acres) FOR TIME PERIOD	SOURCE	PERCENT OF THE TOTAL SURFACE AREA OF FLORIDA REPRESENTED BY WETLANDS	GAIN/LOSS OF WETLANDS DURING GENERALIZED TIME PERIOD	PERCENT OF THEORETICAL 100% REMAINING INTACT AFTER TIME PERIOD ANALYZED	ANNUAL GAIN/LOSS OF WETLANDS PER YEAR	ESTIMATED CUMULATIVE WETLANDS GAIN/LOSS IN FLORIDA (acres)	NOTES
AVERAGED ESTIMATES FOR GENERALIZED TIME PERIOD	**mid-1970's**	**10,310,867**		**27.51%**	**-4,678,633**	**50.76%**	**-233,932**	**-10,001,640**	"Man's assault on wetlands reached its peak during the decades following World War II" (Dahl 1991).
mid-1980's	mid-1980's	11,038,300	Frayer, W.E., and J.M. Hefner. 1991. *Florida Wetlands: Status and Trends, 1970's to 1980's*. U.S. Department of the Interior, Fish and Wildlife Service, Atlanta, Georgia. 33 pp.	29.45%				-260,300	
1985	mid-1980's	11,424,500	Dahl, T.E. 2005. *Florida's wetlands: an update on status and trends 1985 to 1996.* U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C. 80 pp.	30.48%				125,900	Dahl had access to more detailed aerial photos which permitted more precise determination of forested wetlands (Dahl pers. comm., as cited in Meindl 2005).
AVERAGED ESTIMATES FOR GENERALIZED TIME PERIOD	**mid-1980's**	**11,231,400**		**29.97%**	**920,533**	**55.29%**	**92,053**	**-9,081,107**	Net increases in total wetlands are attributed to increases in manmade freshwater ponds (Dahl 2005).
1996	mid-1990's	11,371,900	Dahl, T.E. 2005. *Florida's wetlands: an update on status and trends 1985 to 1996.* U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C. 80 pp.	30.34%				-52,600	When Dahl re-analyzed the mid-1980's maps and compared them to mid-1990's maps, he calculated a net loss of wetlands equal to 52,600 acres (Dahl 2005).
AVERAGED ESTIMATES FOR GENERALIZED TIME PERIOD	**mid-1990's**	**11,371,900**		**30.34%**	**140,500**	**55.98%**	**14,050**	**-8,940,607**	St. Petersburg Times reporters compared satellite images dated late 1980's and 2003 and found a loss of 84,000 acres. Pittman, Craig, and Matthew Waite. 2005, May 22. St. Peterburg Times Special Report: Florida's Vanishing Wetlands. St. Petersburg Times. <http://www.sptimes.com/2006/webspecials06/wetlands/> Last modified Dec. 14, 2006. Accessed Sept. 21, 2007.

Appendix 4.2.C

Details of Wetland Vegetation Analyses

CONSOLIDATION OF DIFFERING WETLAND CLASSIFICATION SCHEMES											
		1973 CLASSIFICATION	1973 (sq meters)	1990 CLASSIFICATION	1990 (sq meters)	1995 CLASSIFICATION	1995 (sq meters)	2000 CLASSIFICATION	2000 (sq meters)	2004 CLASSIFICATION	2004 (sq meters)
FORESTED WETLANDS	WETLAND HARDWOOD FORESTS	Hardwood Swamp (Riverine)	988,572,207.55	**wetland hardwood forests**	152,814.46	**wetland hardwood forests**	49,810.35	**Wetland Hardwood Forests**	0.00	**Wetland Hardwood Forests**	0.00
		Bayheads & Bogs	39,688,753.82	bay swamps	18,002,947.34	bay swamps	32,226,315.28	Bay swamps	41,552,881.78	Bay swamps	44,644,778.43
				mangrove swamps	0.00	mangrove swamps	0.00	Mangrove swamp	43,879.84	Mangrove swamp	0.00
				gum swamps	0.00						
				titi swamps	11,500.83						
				river/lake swamp (bottomland)	527,716,015.61	river/lake swamp (bottomland)	229,986,477.51				
		Mangroves	0.00	inland ponds and sloughs	0.00						
		Coastal Hammock	16,532,071.44	mixed wetland hardwoods	0.00	mixed wetland hardwoods	83,989,625.11	Mixed wetland hardwoods	736,885,789.38	Mixed wetland hardwoods	613,363,852.02
								Cabbage palm wetland	195,548.29	Cabbage palm wetland	0.00
								Cabbage palm hammock	7,191,185.77	Cabbage palm hammock	4,531,668.31
				cabbage palm savannah	0.00	cabbage palm savanna	0.00	Cabbage palm savannah	0.00	Cabbage palm savannah	0.00
				wetland coniferous forest	26,377,296.69	**wetland coniferous forest**	108,074,050.51	**Wetland Coniferous Forest**	8,798.76	**Wetland Coniferous Forest**	0.00
	WETLAND CONIFEROUS FOREST	Riverine Cypress	205,293,145.06	cypress	123,324,671.84	cypress	55,245,682.12	Cypress	124,085,546.51	Cypress	129,288,851.92
				pond pine	0.00	forested depressional pine	894,653.17	Pond pine	319,962.18	Pond pine	220,917.21
				southern red cedar	0.00			Hydric pine flatwoods	121,270,231.77	Hydric pine flatwoods	140,762,058.99
		Cypress Dome	101,413,940.10	cypress - pine - cabbage palm	60,660.25						
	WETLAND FORESTED MIXED	Hydric Hammock	267,543,756.23	**wetland forested mixed**	765,066,793.89	**wetland forested mixed**	1,001,363,619.97	**Wetland Forested Mixed**	433,748,035.31	**Wetland Forested Mixed**	430,614,994.50
NON-FORESTED WETLANDS	VEGETATED NON-FORESTED WETLANDS			**vegetated non-forested wetlands**	78,218.19	**vegetated non-forested wetlands**	0.00	**Vegetated Non-Forested Wetlands**	0.00	**Vegetated Non-Forested Wetlands**	0.00
		Fresh Water Marsh	67,126,154.32	freshwater marshes	93,798,481.00	freshwater marshes	73,700,275.85	Freshwater marshes	65,983,557.54	Freshwater marshes	45,193,162.86
		Salt Marsh	81,816,254.39	saltwater marshes	71,503,425.59	saltwater marshes	73,849,779.77	Saltwater marshes	74,325,628.53	Saltwater marshes	74,516,459.28
		Wet Prairies	12,382,846.54	wet prairies	18,021,229.77	wet prairies	28,264,900.62	Wet prairies	36,587,793.60	Wet prairies	94,759,766.59
				emergent aquatic vegetation	7,939,863.34	emergent aquatic vegetation	3,302,825.17	Emergent aquatic vegetation	6,577,031.10	Emergent aquatic vegetation	6,507,924.12
		Marine Meadow	0.00	submergent aquatic vegetation	0.00	submergent aquatic vegetation	0.00				
				mixed scrub-shrub wetland (predominately willow and wax myrtle)	110,585,002.84	mixed scrub-shrub wetland	131,813,648.99	Mixed scrub-shrub wetland	148,597,615.90	Mixed scrub-shrub wetland	242,783,671.69
	NON-VEGETATED WETLANDS			**non-vegetated wetland**	485,286.90	**non-vegetated wetland**	795833.0163	**Non-vegetated Wetland**	1,385,667.55	**Non-vegetated Wetland**	850,666.83
		Tidal Flat	505,871.85	tidal flats	0.00						
				shorelines (zone between low tide mark and the farthest point inland to which wave action transports beach materials; beaches are not included here)	0.00						
				intermittent ponds	0.00						
				oyster bars	0.00						

Appendix 4.2.D

Chi-square Goodness-of-Fit Tables Comparing the Proportional Change in Vegetation Types (Forested Wetlands and Non-forested Wetlands) Between Consecutive Years

1973 vs 1990	Forested Wetlands	Non-forested Wetlands	Total
Observed Frequency	360,937.16	74,724.86	435,662.02
(Observed Percentage)	(83%)	(17%)	(100%)
Expected Frequency	396,452.44	39,209.58	435,662.02
(Expected Percentage)	(91%)	(9%)	(100%)

degrees of freedom = 1, n = 2

chi-square = 35,350.60

p is less than or equal to 0.001.

The distribution is highly significant.

1990 vs 1995	Forested Wetlands	Non-forested Wetlands	Total
Observed Frequency	373,568.13	77,026.75	450,594.88
(Observed Percentage)	(83%)	(17%)	(100%)
Expected Frequency	373,993.75	76,601.13	450,594.88
(Expected Percentage)	(83%)	(17%)	(100%)

degrees of freedom = 1, n = 2

chi-square = 2.85

Not significant.

For significance at 0.05 level, chi-square should be greater than or equal to 3.841.

1995 vs 2000	Forested Wetlands	Non-forested Wetlands	Total
Observed Frequency	362,071.13	82,396.17	444,467.30
(Observed Percentage)	(81%)	(19%)	(100%)
Expected Frequency	368,907.86	75,559.44	444,467.30
(Expected Percentage)	(83%)	(17%)	(100%)

degrees of freedom = 1, n = 2

chi-square = 745.30

p is less than or equal to 0.001.

The distribution is highly significant.

2000 vs 2004	Forested Wetlands	Non-forested Wetlands	Total
Observed Frequency	336,898.23	114,803.97	451,702.19
(Observed Percentage)	(75%)	(25%)	(100%)
Expected Frequency	411,049.00	40,653.20	451,702.19
(Expected Percentage)	(81%)	(19%)	(100%)

degrees of freedom = 1, n = 2

chi-square = 148,626.15

p is less than or equal to 0.001.

The distribution is highly significant.

Appendix 4.4.1

Table 1. Species from federal lists occurring in the Lower St. Johns River Basin.

Category	Common	Scientific	Code	County
Mammals	West Indian (Florida) Manatee	*Trichechus manatus latirostris*	T	Duval, Clay, St. Johns, Putnam, Flagler, Volusia
	Anastasia Isl. Beach Mouse	*Peromyscus polionotus phasma*	E	St. Johns
Birds	Bald Eagle	*Haliaeetus leucocephalus*	MC	Duval, Clay, St. Johns, Putnam, Flagler, Volusia
	Everglade Snail Kite	*Rostrhamus sociabilis plumbeus*	E	Volusia
	Piping Plover	*Charadrius melodus*	T	Duval, St. Johns, Volusia
	Florida Scrub-jay	*Aphelocoma coeruluscens*	T	Clay, St. Johns, Putnam, Flagler, Volusia
	Wood Stork	*Mycteria americana*	T	Duval, Clay, St. Johns, Putnam, Flagler, Volusia
	Red-cockaded Woodpecker	*Picoides botealis*	E	Duval, Clay, Putnam, Flagler, Volusia
Fish	none			St. Johns, Volusia
	Gulf Sturgeon	*Acipenser oxyrhynchus desotoi*	T	Flagler
	Shortnose Sturgeon	*Acipenser brevitostrum*	E	Duval, Clay, Putnam
Reptiles	Eastern Indigo Snake	*Dymarchon corais couperi*	T	Duval, Clay, St. Johns, Putnam, Flagler, Volusia
Amphibians	none			Duval, Clay, St. Johns, Putnam, Flagler
Mollusks	none			Duval, Clay, St. Johns, Putnam, Flagler, Volusia
Crustaceans	none			Duval, Clay, St. Johns, Putnam, Flagler, Volusia
Plants	none			Duval, St. Johns, Flagler
	Chapman's Rhododendron	*Rhododendron chapmanii*	E	Clay
	Etonia Rosemary	*Conradina etonia*	E	Putnam,
	Rugel's Pawpaw	*Deeringothamnus rugelii*	E	Volusia
	Okeechobee gourd	*Cucurbita okeechobeensis ssp.*	E	Volusia

Note: E= Endangered, T=Threatened; MC=Management Concern
Source: USFWS 2020

FLORIDA'S ENDANGERED SPECIES, THREATENED SPECIES, AND SPECIES OF SPECIAL CONCERN

FLORIDA FISH AND WILDLIFE CONSERVATION COMMISSION

Source: FWC 2021 (Double click this link to view the status of species protected under State Laws.)

Appendix 4.4.1.A
Synoptic Counts

Table 2. Synoptic aerial surveys of manatees, east and west coasts of Florida, 1991 to 2019.

Year	Date	East	West	Total
1991	January 23–24	687	580	1,267
1991	February 17–18	828	650	1,478
1992	January 17–18	904	940	1,844
1995	January 21–22	669	787	1,456
1995	February 06–07	917	906	1,823
1996	January 09–10	1,223	1,054	2,277
1996	February 18–19	1,452	1,178	2,630
1997	January 19–20	906	1,335	2,241
1997	February 13	797	918	1,715
1998	January 29–30	1,110	908	2,018
1999	January 6	842	1,023	1,865
1999	February 23	900	1,123	2,023
1999	March 6	960	1,400	2,360
2000	January 16–17	634	1,012	1,646
2000	January 26–27	1,138	1,085	2,223
2001	January 05–06	1,559	1,741	3,300
2002	March 1	864	894	1,758
2003	January 9	1703	1140	2,843
2003	January 21–22	1813	1314	3,127
2003	January 26–28	1,705	1,311	3,016
2004	February 20	1,198	1,307	2,505
2005	January 26	1,594	1,549	3,143
2006	February 13-17	1,639	1,474	3,113
2007	January 30–February 1	1,412	1,405	2,817
2009	January 19–23	2,153	1,654	3,807
2010	January 12–15	2,780	2,296	5,076
2011	January 20 and 24	2,432	2,402	4,834
2014	January 24 and 27	2,315	2,509	4,824
2015	February 16, 20, 23	3,333	2,730	6,063
2016	February 11, 12, 13	3,292	2,958	6,250
2017	January 30-February 2	3,488	3,132	6,620
2018	January 6,7 and 8	3,731	2,400	6,131
2019	January 28 – Feb 5	2,394	3,339	5,733

Source: FWRI 2021
Note: No synoptic survey in 2008, 2012, 2013, and 2020.

Appendix 4.4.1.A

Manatees Blue Springs

Kendall's tau correlation indicated an increasing trend in total manatees seen at Blue Spring State Park over time (τ = 0.964; p = 7.26E-23; n = 49) (Figure 1).

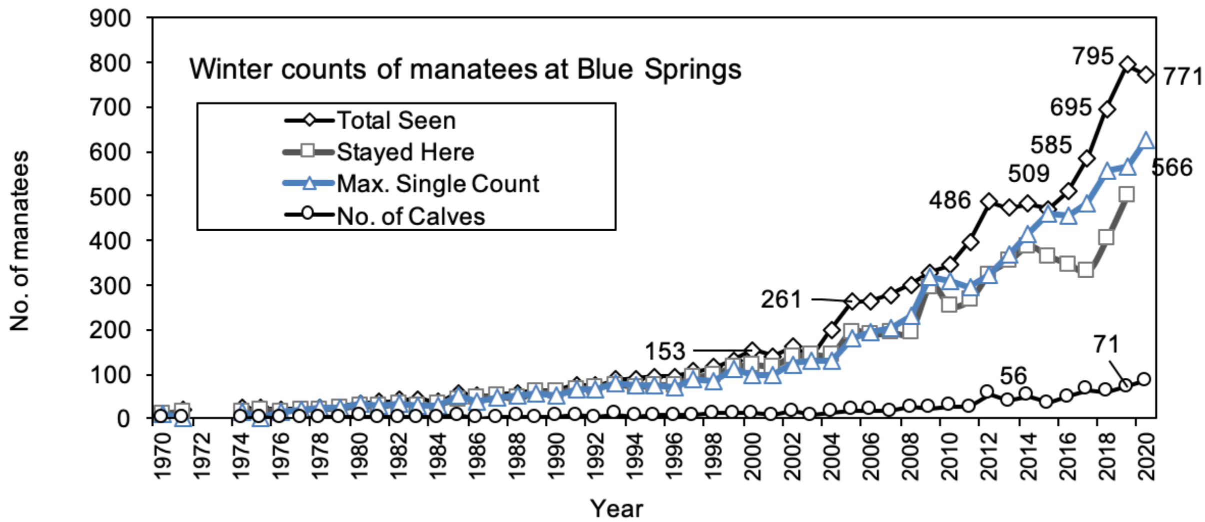
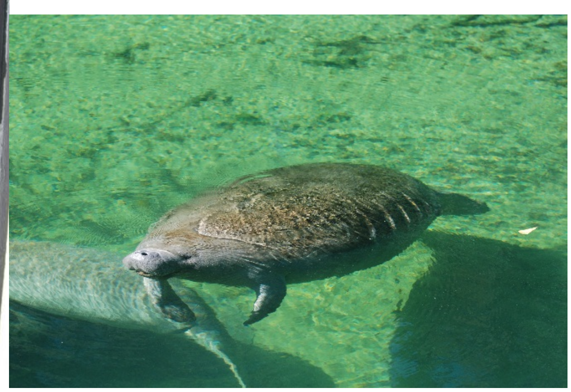


Figure 1. Total number of manatees counted during winter at Blue Springs State Park (Volusia County 1970-2019/20). Data provided by Wayne Hartley, Park Specialist, Blue Springs State Park, 2021.

Source: G. Pinto



Source: Chelsea Bohaty

Source: G. Pinto

Appendix 4.4.1.A

Manatees

<u>Mean number of manatees (11 yr. smoothed data):</u> Kendall's tau correlation was positively correlated on mean number of manatees per survey over time in LSJRB (Figure 2a-d) (τ =0.481; p=0.0002; n=27). Mean number of manatees per survey was negatively correlated with salinity (τ =-0.280 p=0.02; n=27). Mean monthly rainfall was negatively correlated with salinity, but this was not significant (τ =-0.173; NS).

For the period <u>1995-2000</u> (drought), rainfall was negatively correlated with salinity (τ =-0.966; p=0.03; n=6) and year (τ =-0.867; p=0.007; n=6). Manatee numbers were negatively correlated over this period, but not significant (τ =-0.667; p=0.425; n=6).

For the period <u>2000-2005</u> (recovery), rainfall was negatively correlated with salinity (τ =-0.333; p=0.174; n=6) but was not significant. Rainfall was positively correlated over time (τ =-0.733; p=0.019; n=6). Total number of manatees was positively correlated over time (τ =0.733; p=0.019; n=6) and negatively correlated with salinity, but not significant (τ =-0.333; p=0.174; n=6).

For the period <u>2005-2009</u> (drought 2005/2006, then recovery 2006/2009, then drought 2009/2010), rainfall was negatively correlated with salinity, but this was not significant (τ =-0.2; p=0.312; n=5). There was a positive correlation with rainfall over time until 2009 (τ =0.2; p=0.312; n=5) after which in 2010 rainfall declined abruptly. Total and mean numbers of manatees were negatively correlated over time, but they were not significant (τ =-0.6; p=0.071; n=5), however, in 2010, manatee numbers showed a rebound from an all-time low in 2009. However, from 2005-2010, SHDC was negatively correlated over time (τ =-0.867; p=0.007; n=6) and salinity, but the latter was not significant (τ =-0.333; p=0.174; n=6).

For the period <u>2009-2020</u> (drought 2005/2006, then recovery 2006/2009, then drought 2009/2010, recovery 2010-2014, then a steady increase from 2014-2018) rainfall was positively correlated with salinity, but this was not significant (τ =0.242; NS; n=12). There was a positive correlation with rainfall over time, but this was not significant (τ =0.03; NS;). Mean numbers of manatees were positively correlated over time (τ =0.545; p=0.007; n=12) with a rebound in manatee numbers from an all-time low in 2009. Note that there is a precipitous drop in the annual manatee mean following Hurricane Irma in 2017.

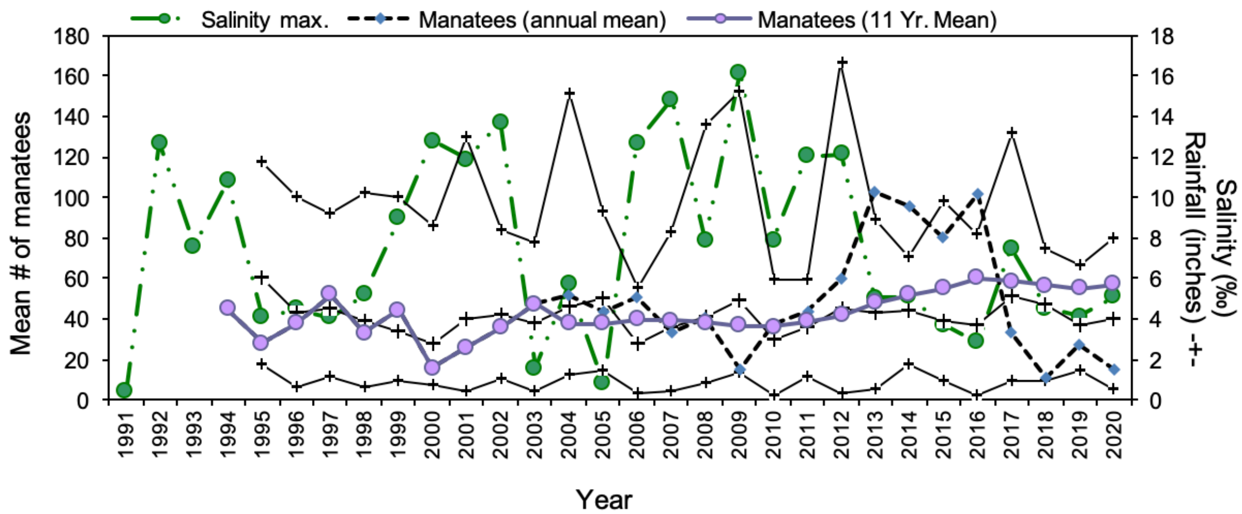


Figure 2a. Mean numbers of manatees per survey in Duval County and adjacent waters (JU data), salinity maxima in SJR near Doctors Lake (COJEQD data), and annual average monthly radar rainfall (--+-- Maximum, Mean, Minimum) for the LSJRB (SJRWMD data).

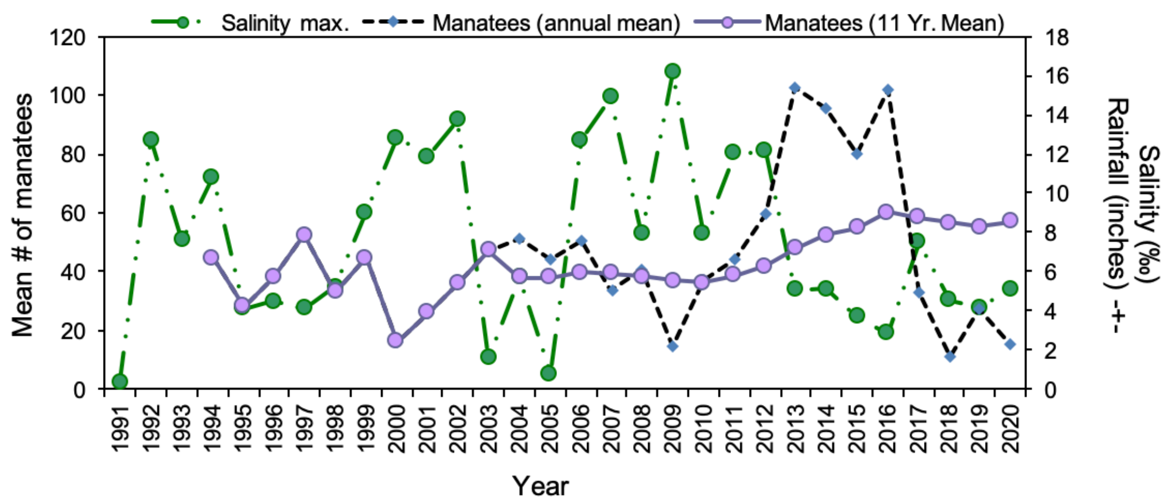


Figure 2b. Mean numbers of manatees per survey in Duval County and adjacent waters (JU data), salinity maxima in SJR near Doctors Lake (COJEQD data).

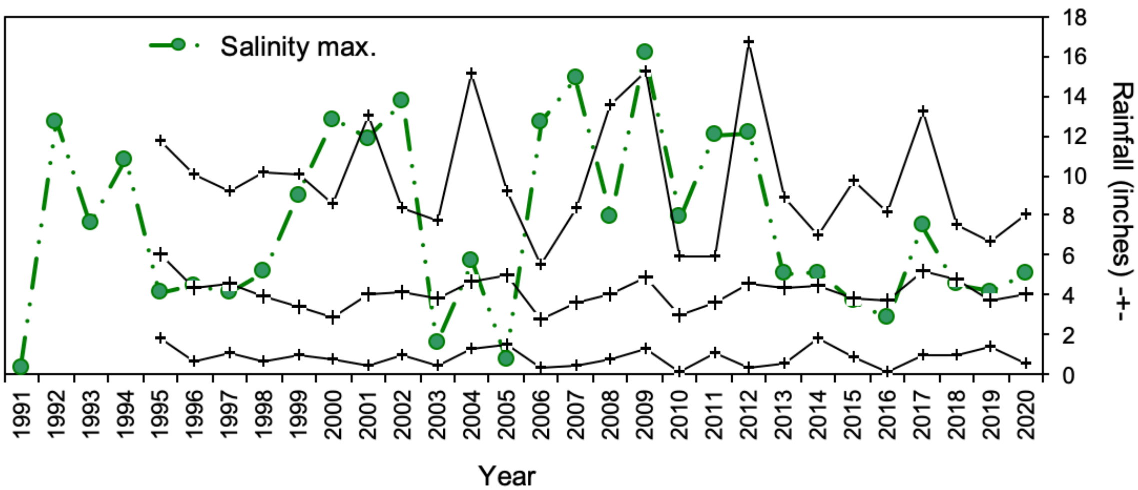


Figure 2c. Salinity maxima in SJR near Doctors Lake (COJEQD data) and annual average monthly radar rainfall (-+- Maximum, Mean, Minimum) for the LSJRB (SJRWMD data).

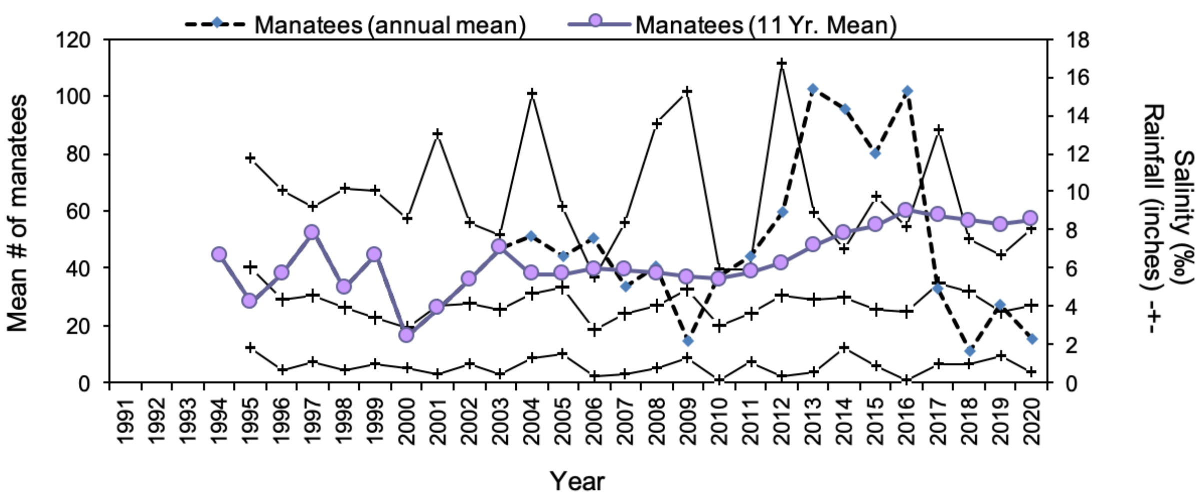


Figure 2d. Mean numbers of manatees per survey in Duval County and adjacent waters (JU data), and annual average monthly radar rainfall (-+- Maximum, Mean, Minimum) for the LSJRB (SJRWMD data).

<u>Single Highest Day Count of manatees:</u> Kendall's tau correlation was positive on number of manatees in LSJRB over time (Figure 3a-c) (τ =0.046; NS; n=27) but this was not significant. SHDC was negatively correlated with salinity, but this was not significant (τ =-0.163; NS). Rainfall was negatively correlated with salinity, but this was not significant (τ =-0.173; NS).

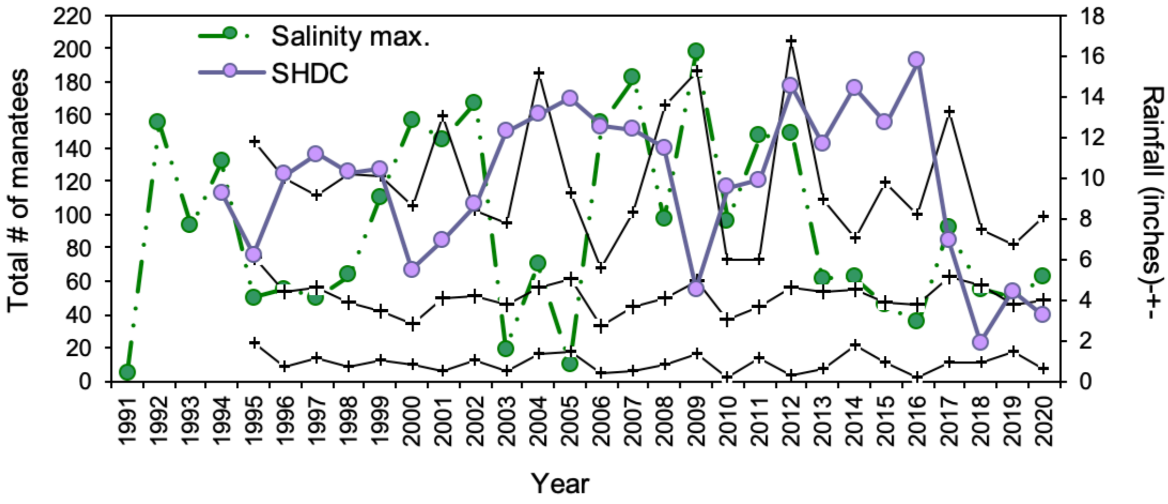


Figure 3a. Single Highest Day Count of manatees in Duval County and adjacent waters (JU data), salinity maxima in SJR near Doctors Lake (COJEQD data), and annual average monthly radar rainfall (-+- Maximum, Mean, Minimum) for the LSJRB (SJWMD data).

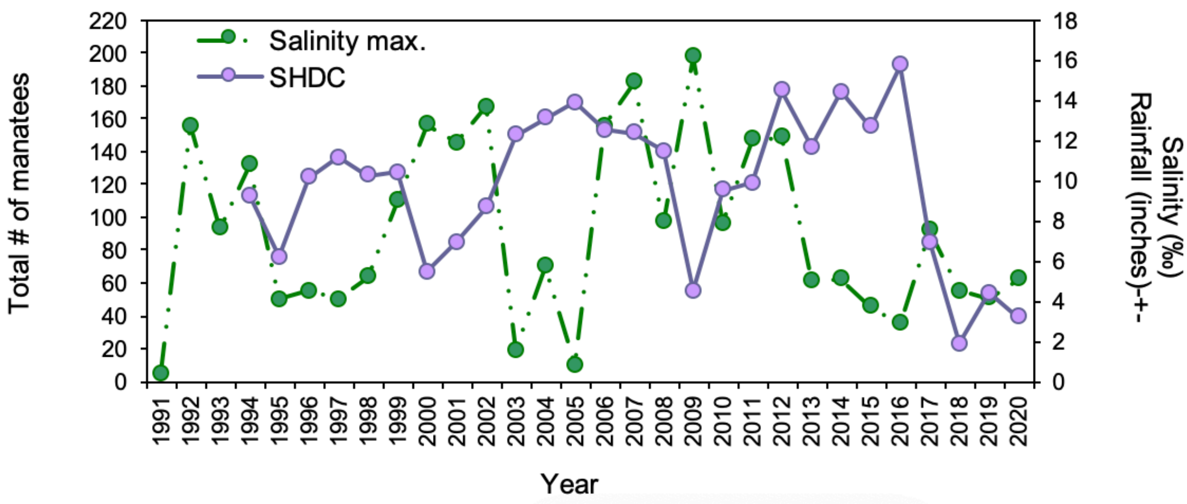


Figure 3b. Single Highest Day Count of manatees per survey in Duval County and adjacent waters (JU data), salinity maxima in SJR near Doctors Lake (COJEQD data).

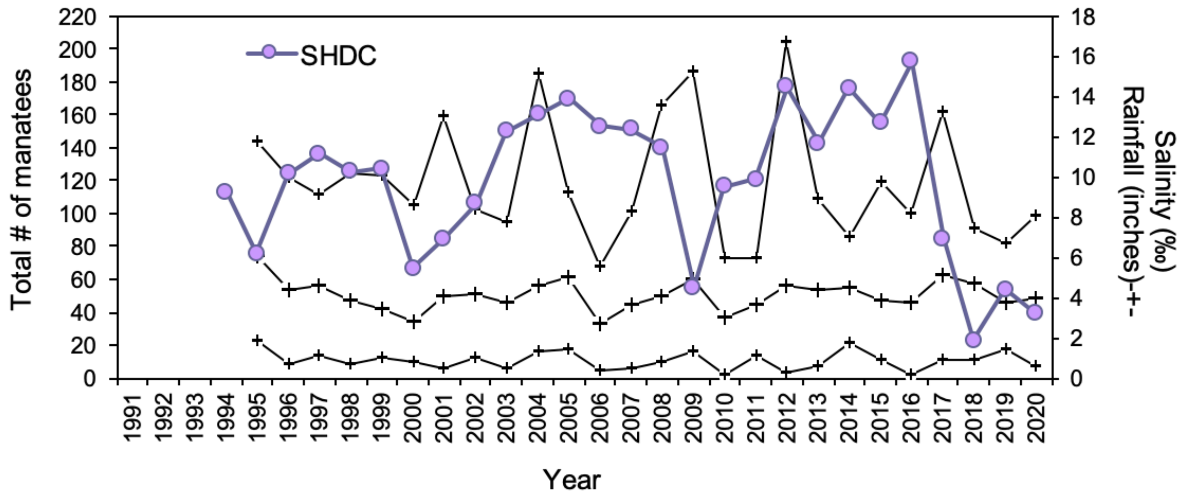


Figure 3c. Mean numbers of manatees per survey in Duval County and adjacent waters (JU data), and annual average monthly radar rainfall (-+- Maximum, Mean, Minimum) for the LSJRB (SJRWMD data).

<u>**JU:**</u> Kendall's tau correlation (Figure 4a) indicated a positive correlation on mean numbers of manatees per survey over time (τ =0.26; p=0.03; n=27). There was a positive correlation between total numbers of manatee and salinity at JU (τ =0.412; p=0.001; n=27). There was no correlation between mean number of manatees and rainfall, or salinity at JU. There was no correlation with rainfall over time.

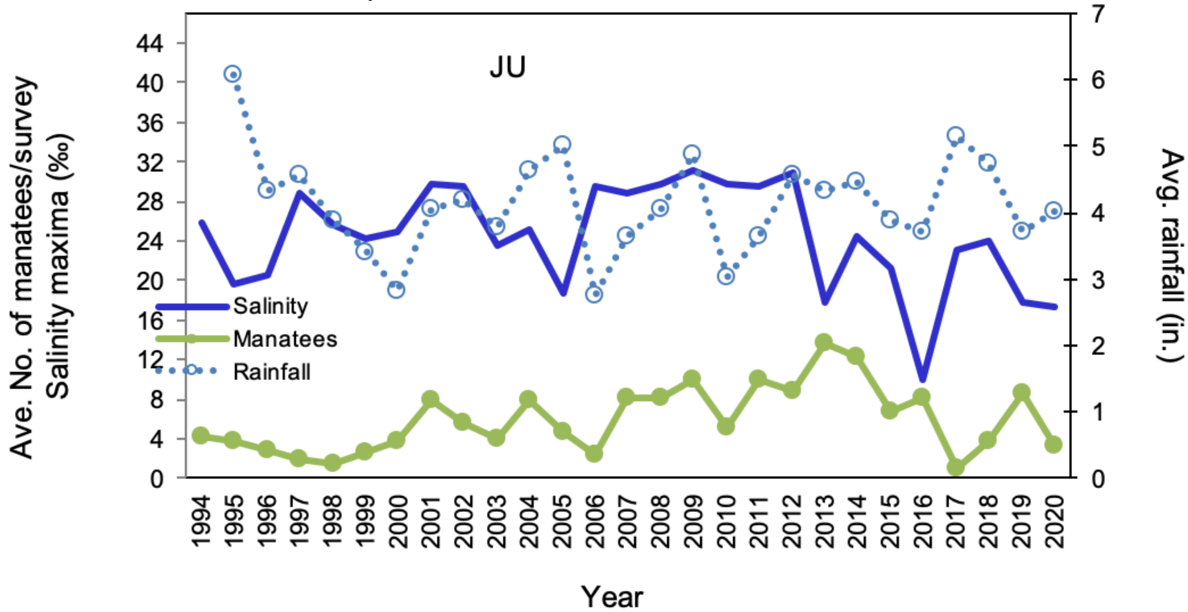


Figure 4a. Average number of manatees/survey near JU (JU data), salinity maxima (COJEQD data for site near JU) and LSJRB radar annual average monthly rainfall (SJRWMD data).

<u>**JU 1994-2000:**</u> Kendall's tau correlation (Figure 4a) indicated a negative correlation on mean numbers of manatees per survey over time, but this was not significant (τ =-0.429; p=0.088; n=7). There was a negative correlation between mean numbers of manatee and salinity, but this was not significant (τ =-0.238; p=0.226; n=7). There was a positive correlation between mean number of manatees and rainfall, but this was not significant (τ =0.067; p=0.425; n=6). Salinity and rainfall were negatively correlated, but this was not significant (τ =-0.2; p=0.287; n=6).

<u>**JU 2000-2005:**</u> Kendall's tau correlation (Figure 4a) indicated a positive correlation on mean numbers of manatees per survey over time, but this was not significant (τ =0.2; p=0.287; n=6). There was a negative correlation between mean numbers of manatee and salinity, but this was not significant (τ =-0.330;p=0.174; n=6). There was a positive correlation between mean number of manatees and rainfall (τ =0.467; p=0.09; n=6). Salinity and rainfall were negatively correlated, but this was not significant (τ =-0.2; p=0.287; n=6).

<u>**JU 2005-2015:**</u> Kendall's tau correlation (Figure 4a) indicated a positive correlation on mean numbers of manatees per survey over time, but this was not significant (τ =0.127; p=0.293; n=11). There was a positive correlation between mean numbers of manatee and salinity, but this was not significant (τ =0.345; p=0.070; n=11). There was a positive correlation between mean numbers of manatee and rainfall, but this was not significant (τ =0.018; p=0.469; n=11). Salinity and rainfall were positively correlated, but this was not significant (τ =0.091; p=0.349; n=11). Rainfall was positively correlated over time, but not significant (τ =0.091; p=0.349; n=11).

<u>BOLLES:</u> Kendall's tau correlation (Figure 4b) was negative over time on mean numbers of manatees per survey, but this was not significant (τ =-0.293; p=0.02; n=27). There was a negative correlation between mean numbers of manatee and salinity, but this was not significant (τ =-0.178; NS). There was no correlation between mean number of manatees and rainfall. Salinity and rainfall at BOLES were not correlated. There was no correlation with rainfall over time.

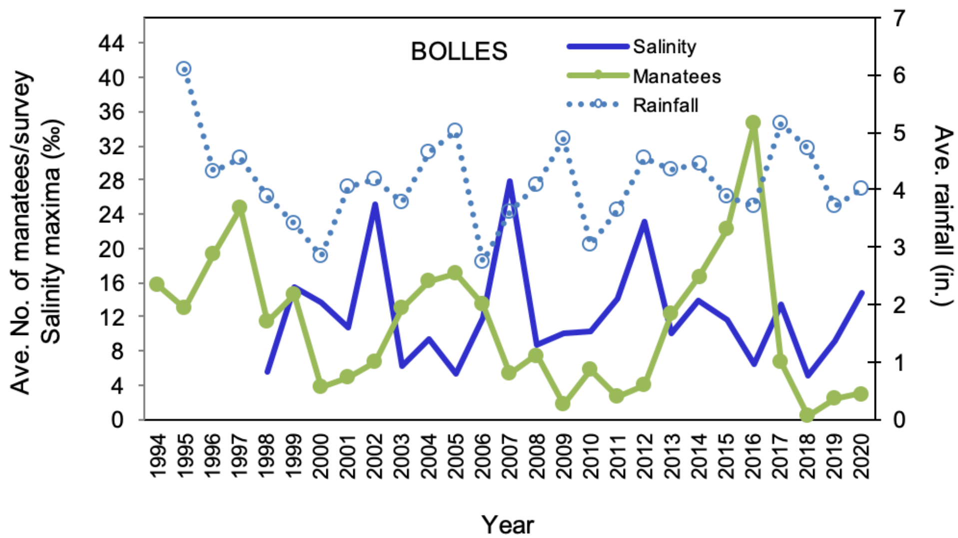


Figure 4b. Average number of manatees/survey near Boles School (JU data), salinity maxima, and LSJRB annual average monthly radar rainfall (SJRWMD data).

<u>BOLLES 1994-2000:</u> Kendall's tau correlation (Figure 4b) indicated a negative correlation on mean numbers of manatees per survey over time, but this was not significant (τ =-0.333; p=0.147; n=7). There was a positive correlation between mean numbers of manatee and salinity, but this was not significant (τ =0.333; p=0.301; n=3). There was a positive correlation between mean number of manatees and rainfall, but this was not significant (τ =0.467; p=0.094; n=6). Salinity and rainfall were negatively correlated, but this was not significant (τ =-0.333; p=0.301; n=3). Rainfall was negatively correlated over time (τ =-0.867; p=0.0073; n=6).

<u>BOLLES 2000-2005:</u> Kendall's tau correlation (Figure 4b) indicated a positive correlation on mean numbers of manatees per survey over time (τ =1; p=0.002; n=6). There was a negative correlation between mean numbers of manatee and salinity (τ =-0.6; p=0.045; n=6). There was a positive correlation between mean number of manatees and rainfall (τ =0.733; p=0.019; n=6). Salinity and rainfall were negatively correlated, but this was not significant (τ =-0.333; p=0.174; n=6). Rainfall was positively correlated over time (τ=0.733; p=0.019; n=6).

<u>BOLLES 2005-2012:</u> Kendall's tau correlation (Figure 4b) indicated a negative correlation on mean numbers of manatees per survey over time (τ =-0.5; p=0.042; n=8). There was a negative correlation between mean numbers of manatee and salinity, but this was not significant (τ =-0.338; p=0.226; n=7). There was a negative correlation between mean number of manatees and rainfall, but this was not significant (τ =-0.286; p=0.161; n=8). Salinity and rainfall were negatively correlated, (τ =-0.524; p=0.05; n=7). Rainfall was negatively correlated over time, but not significant (τ=-0.071; p=0.402; n=8).

BUCKMAN: Kendall's tau correlation (Figure 4c) was a negative correlation over time on mean numbers of manatees per survey (τ =0.293; p=0.02; n=27). There was a negative correlation between mean numbers of manatee and salinity, but this was not significant (τ =-0.368; p=0.007; n=23). There was a negative correlation between mean number of manatees and rainfall (τ =-0.25; p=0.05; n=24). Salinity and rainfall was not significant, as well as, rainfall and time.

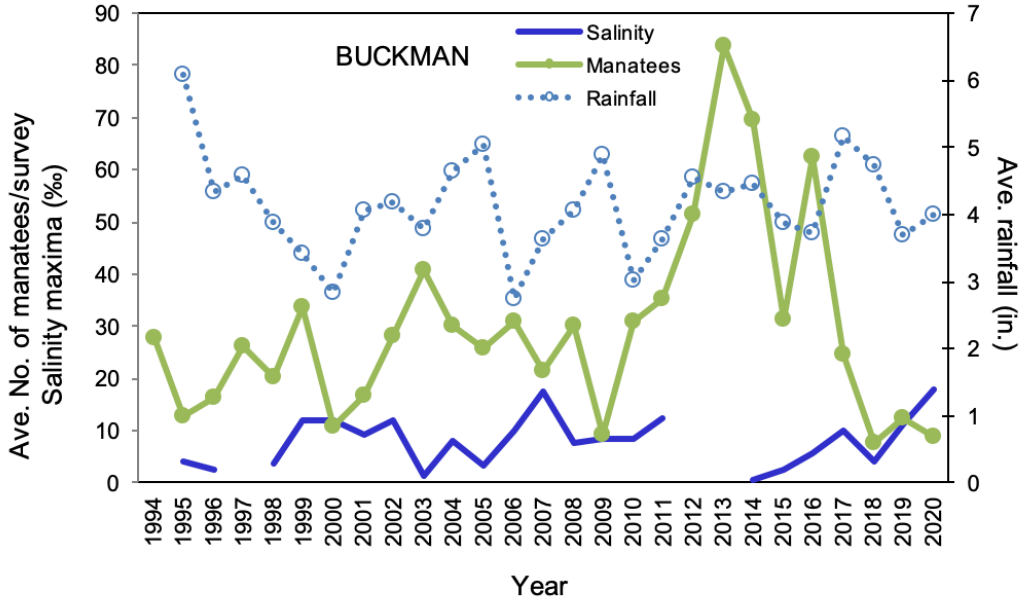


Figure 4c. Average number of manatees/survey near Buckman Bridge (JU data), salinity maxima, and LSJRB annual average monthly radar rainfall (SJRWMD data).

BUCKMAN 1994-2000: Kendall's tau correlation (Figure 4c) indicated a negative correlation on mean numbers of manatees per survey over time, but this was not significant (τ =-0.048; p=0.440; n=7). There was a positive correlation between mean numbers of manatee and salinity, but this was not significant (τ =-0.333; p=0.301; n=3). There was a positive correlation between mean number of manatees and rainfall, but this was not significant (τ =0.067; p=0.425; n=6). Salinity and rainfall were negatively correlated, but this was not significant (τ =-0.333; p=0.301; n=3). Rainfall was negatively correlated over time (τ =-0.867; p=0.0.0073; n=6).

BUCKMAN 2000-2005: Kendall's tau correlation (Figure 4c) indicated a positive correlation on mean numbers of manatees per survey over time, but this was not significant (τ =0.467; p=0.094; n=6). There was a negative correlation between mean numbers of manatee and salinity (τ =-0.6; p=0.045; n=6). There was a positive correlation between mean number of manatees and rainfall, but this was not significant (τ =0.2; p=0.287; n=6). Salinity and rainfall were negatively correlated, but this was not significant (τ =-0.333; p=0.174; n=6). Rainfall was positively correlated over time (τ =0.733; p=0.019; n=6).

BUCKMAN 2005-2012: Kendall's tau correlation (Figure 4c) indicated a positive correlation on mean numbers of manatees per survey over time (τ =0.5; p=0.042; n=8). There was a positive correlation between mean numbers of manatee and salinity, but this was not significant (τ =0.238; p=0.226; n=7). There was a negative correlation between mean number of manatees and rainfall, but this was not significant (τ =0.143; p=0.310; n=8). Salinity and rainfall were negatively correlated, (τ =-0.524; p=0.05; n=7). Rainfall was positively correlated over time, but not significant (τ =-0.071; p=0.402; n=8).

DOCTORS LAKE and MOCCASIN SLOUGH: These two locations have similar data and are located in the same part of the river; however, the data sources are different (Figure 4d). Kendall's tau correlation on the Doctors Lake data was positive over time on total number of manatees per survey (τ =0.348; p=0.005; n=27). There was no correlation between mean numbers of manatees and salinity. There was no significant correlation between mean number of manatees and rainfall, or salinity. Rainfall was no correlated with salinity or manatees.

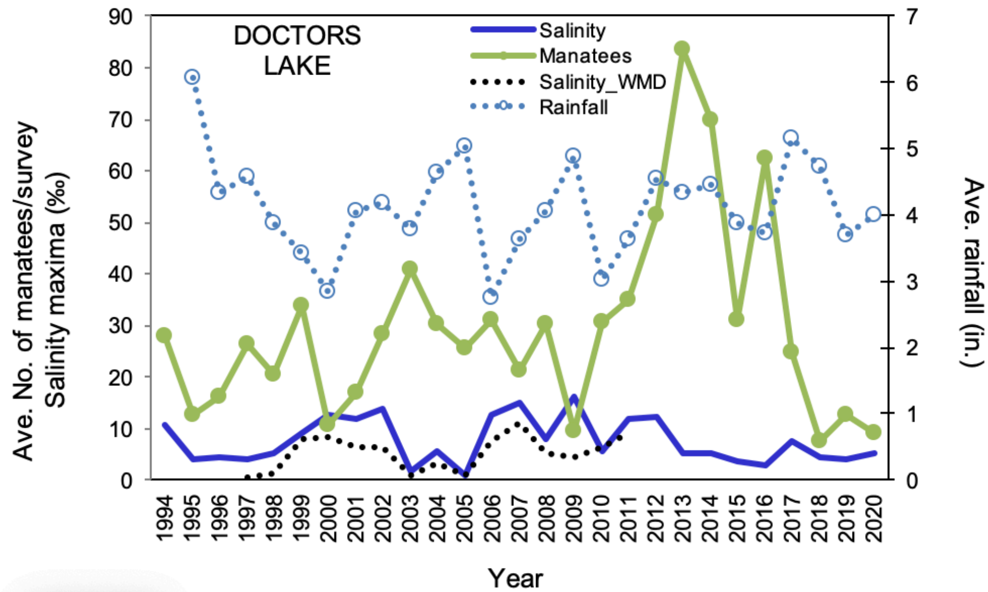


Figure 4d. Average number of manatees/survey in SJR near Doctors Lake (JU data), salinity maxima (COJEQD data), and LSJRB annual average monthly radar rainfall (SJRWMD data).

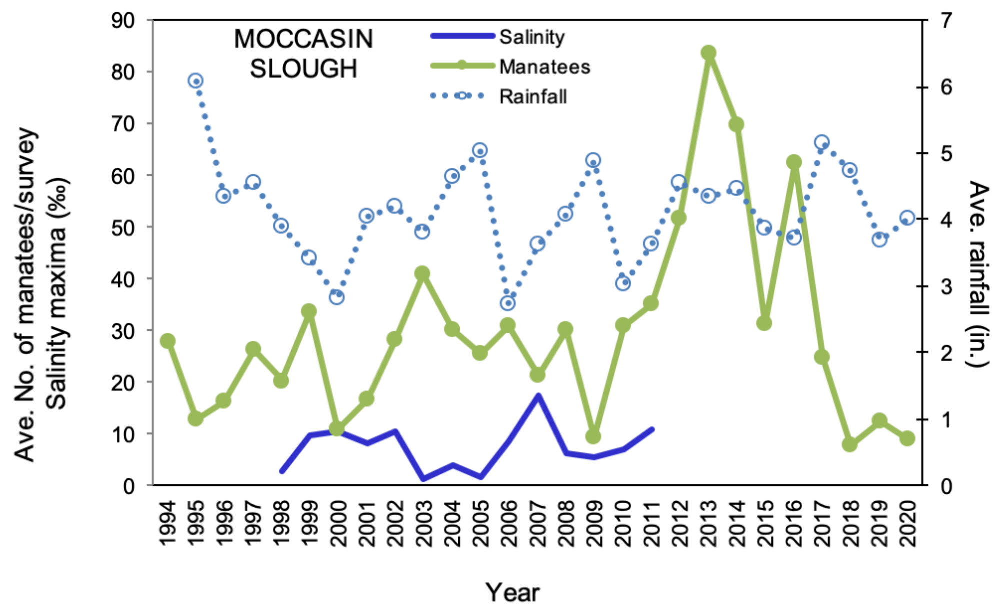


Figure 4e. Average number of manatees/survey near Moccasin Slough (JU data), salinity maxima, and LSJRB annual average monthly radar rainfall (SJRWMD data).

DOCTORS LAKE and MOCCASIN SLOUGH: 1995-2000: Kendall's tau correlation (Figure 4d) indicated a positively correlation on mean numbers of manatees per survey over time, but this was not significant (τ =-0.2; p=0.287; n=6). There was no correlation between mean numbers of manatee and salinity (τ =0; p=0.500; n=6). There was a negative correlation between mean number of manatees and rainfall, but this was not significant (τ =-0.067; p=0.425; n=6). Salinity and rainfall were negatively correlated (τ =-0.966; p=0.003; n=6). Rainfall was negatively correlated over time (τ =-0.867; p=0.007; n=6).

DOCTORS LAKE and MOCCASIN SLOUGH: 2000-2005: Kendall's tau correlation (Figure 4d) indicated a positive correlation on mean numbers of manatees per survey over time, but this was not significant (τ =0.467; p=0.094; n=6). There was a negative correlation between mean numbers of manatee and salinity, but this was not significant (τ =-0.333; p=0.174; n=6). There was a positive correlation between mean number of manatees and rainfall (τ =0.2; p=0.287; n=6). Salinity and rainfall were negatively correlated, but this was not significant (τ =-0.333; p=0.174; n=6). Rainfall was positively correlated over time, but not significant (τ =0.733; p=0.019; n=6).

DOCTORS LAKE and MOCCASIN SLOUGH: 2005-2012: Kendall's tau correlation (Figure 4d) indicated a negative correlation on mean numbers of manatees per survey over time, (τ =-0.5; p=0.042; n=8). There was a negative correlation between mean numbers of manatee and salinity, (τ =-0.5; p=0.042; n=8). There was a negative correlation between mean number of manatees and rainfall, but not significant (τ =-0.286; p=0.161; n=8). Salinity and rainfall were negatively correlated, but this was not significant (τ =-0.071; p=0.402; n=8). Rainfall was positively correlated over time, but not significant (τ =0.071; p=0.402; n=8).

SCRATCH ANKLE: Kendall's tau correlation (Figure 4f) was positive over time on mean numbers of manatees per survey (τ =-0.392; p=0.001; n=19). There was a positive correlation between mean numbers of manatee and salinity, but this was not significant (τ =0.121; p=0.274; n=14). There was a negative correlation between mean number of manatees and rainfall, but this was not significant (τ =-0.255; p=0.07; n=18). Salinity and rainfall at were negatively correlated, (τ =-0.341; p=0.045; n=14). Rainfall was negatively correlated over time, but not significant (τ =-0.111; p=0.260; n=18).

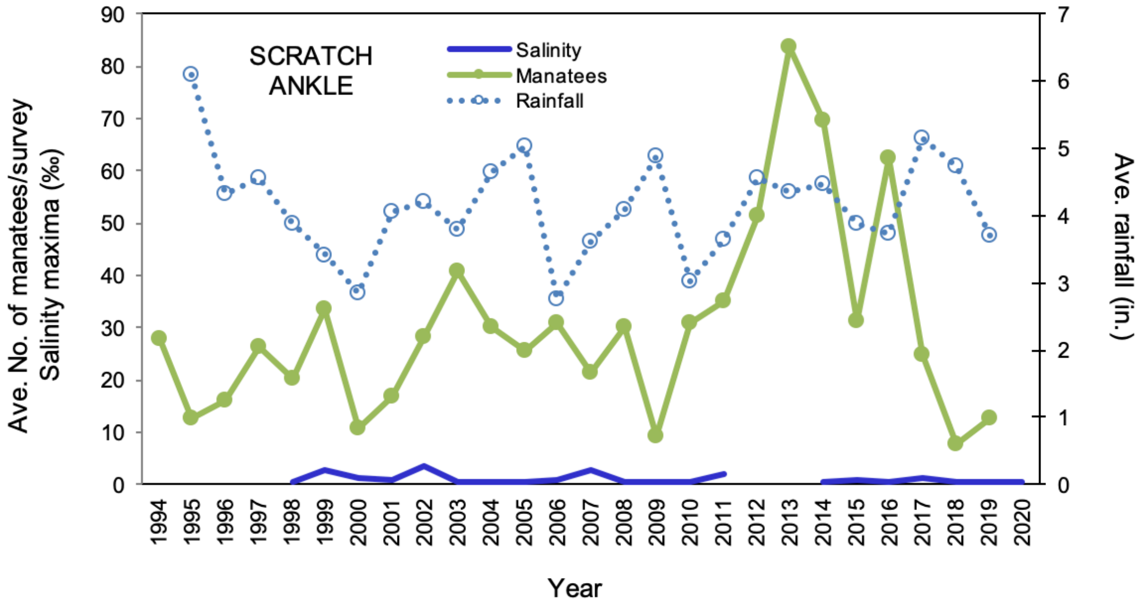


Figure 4f. Average number of manatees/survey possible in SJR near Scratch Ankle (JU data), salinity maxima, and LSJRB annual average monthly radar rainfall (SJRWMD data).

SCRATCH ANKLE: 1995-2000: Kendall's tau correlation (Figure 4f) was positive on mean numbers of manatees per survey over time, but this was not significant (τ =0.2; p=0.0.287; n=6). There was a positive correlation between mean numbers of manatee and salinity, but this was not significant (τ =0.333; p=0.3; n=3). There was a negative correlation between mean number of manatees and rainfall, but this was not significant (τ =-0.067; p=0.425; n=6). Salinity and rainfall were negatively correlated, but this was not significant (τ =-0.333; p=0.300; n=3). Rainfall was negatively correlated over time (τ =-0.867; p=0.007; n=6).

SCRATCH ANKLE: 2000-2005: Kendall's tau correlation (Figure 4f) was positive correlation on mean numbers of manatees per survey over time, but this was not significant (τ =0.467; p=0.09; n=6). There was a negative correlation between mean numbers of manatee and salinity, but this was not significant (τ =-0.467; p=0.09; n=6). There was a positive correlation between mean number of manatees and rainfall, but this was not significant (τ =0.2; p=0.287; n=6). Salinity and rainfall were negatively correlated, but this was not significant (τ =-0.2; p=0.287; n=6). Rainfall was positively correlated over time (τ =0.733; p=0.019; n=6).

SCRATCH ANKLE: 2005-2012: Kendall's tau correlation (Figure 4f) indicated a positive correlation on mean numbers of manatees per survey over time, (τ =0.5; p=0.042; n=8). There was a positive correlation between mean numbers of manatee and salinity, but this was not significant (τ =0.333; p=0.147; n=7). There was a negative correlation between mean number of manatees and rainfall, but this was not significant (τ =-0.143; p=0.310; n=8). Salinity and rainfall were negatively correlated (τ =-0.620; p=0.025; n=7). Rainfall was negatively correlated over time, but this was not significant (τ =-0.071; p=0.402; n=8).

RICE CREEK: Kendall's tau correlation (Figure 4g) was positive over time on mean numbers of manatees per survey (τ =0.392; p=0.001; n=19). There was a positive correlation between mean numbers of manatee and salinity, but this was not significant (τ =0.147; p=0.265; n=11). There was a negative correlation between mean number of manatees and rainfall, but this was not significant (τ =-0.255; p=0.07; n=18). Salinity and rainfall were negatively correlated, but this was not significant (τ =-0.0367; p=0.438; n=11). Rainfall was negatively correlated over time, but not significant (τ =-0.111; p=0.260; n=18).

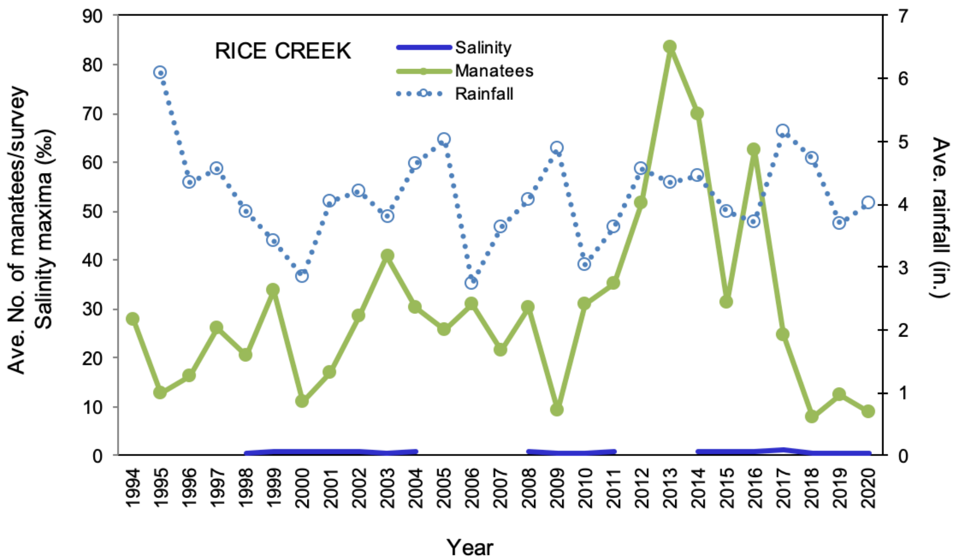


Figure 4g. Average number of manatees/survey possible in SJR near Rice Creek (JU data), salinity maxima, and LSJRB annual average monthly radar rainfall (SJRWMD data).

RICE CREEK: 1995-2000: Kendall's tau correlation (Figure 4g) was positive on mean numbers of manatees per survey over time, but this was not significant (τ =-0.2; p=0.287; n=6). There was a negative correlation between mean numbers of manatee and salinity, but this was not significant (τ =0.067; p=0.425; n=6). There was a positive correlation between mean number of manatees and rainfall (τ =-0.333; p=0.301; n=3). Salinity and rainfall were negatively correlated, but were not significant (τ =-0.333; p=0.301; n=3). Rainfall was positively correlated over time (τ =-0.333; p=0.301; n=6).

RICE CREEK: 2000-2005: Kendall's tau correlation (Figure 4g) was positive correlation on mean numbers of manatees per survey over time, but this was not significant (τ =0.467; p=0.09; n=6). There was a positive correlation between mean numbers of manatee and salinity, but this was not significant (τ =0.2; p=0.287; n=6). There was a negative correlation between mean number of manatees and rainfall, but this was not significant (τ =-0.4; p=0.164; n=5). Salinity and rainfall were positively correlated, but this was not significant (τ =0.2; p=0.312; n=5). Rainfall was negatively correlated over time, but this was not significant (τ =-0.2; p=0.312; n=5).

RICE CREEK: 2005-2012: Kendall's tau correlation (Figure 4g) indicated a positive correlation on mean numbers of manatees per survey over time, but this was not significant (τ =0.071; p=0.1402; n=8). There was a positive correlation between mean numbers of manatee and salinity, but this was not significant (τ =0.667; p=0.087; n=4). There was a negative correlation between mean number of manatees and rainfall, but this was not significant (τ =-0.143; p=0.310; n=8). Salinity and rainfall were negatively correlated, but this was not significant (τ =-0.333; p=0.248; n=4). Rainfall was negatively correlated over time, but this was not significant (τ =0.071; p=0.402; n=8).

Table 1a. Summary of manatee deaths in the LSJRB 1980 through December 2020.

County	Time Period	Total Deaths	Watercraft Propeller, Impact, or Both	Watercraft Percent	Human, Other Inc. Lock (1) 2016 Duval	Perinatal (Natural or Undetermined)	Cold Stress	Natural, Other (inc. Red Tide)	Verified (not recovered)	Undetermined (Not recovered, Too decomposed, Other)	Undetermined Other
Clay	**1980-1984**	2	0	0		1	0	1			
	1985-1989	4	0	0		1	1			1	1
	1990-1994	12	6	50		1	3			2	
	1995-1999	11	2	18		3	2	1	1	2	
	2000-2004	14	3	21	1	5	3			2	
	2005-2009	15	2	13		3	4	1		5	
	2010-2014	19	2	11		4	5			7	1
	2015-2019	7	0	0		1	3			3	
	2020-2024	2	0	0		2	0				
Sum (1980-2020)		86	15	17	1	21	21	3	1	22	2
Duval	1975-1979	37	14	38	1	2	0		3	3	14
	1980-1984	35	11	31		2	0	6	2		14
	1985-1989	60	21	35	1	5	10	6	1	9	7
	1990-1994	50	18	36	6	8	4	5		6	3
	1995-1999	49	13	27		7	5	4		19	1
	2000-2004	61	23	38		12	7	2	1	16	
	2005-2009	63	33	52		6	9	1	1	12	1
	2010-2014	67	16	24	2	13	22		1	13	
	2015-2019	56	11	20	3	10	17	4	1	10	
	2020-2024	9	0	0	2	1	2			1	3
Sum (1980-2020)		450	146	32	14	64	76	28	7	86	29
Flagler	**1980-1984**	0									
	1985-1989	0									
	1990-1994	1				1					
	1995-1999	0									
	2000-2004	0									
	2005-2009	25	6	24		8	3	2		6	
	2010-2014	13	1	8		5	4		1	2	
	2015-2019	20	1	5		10	5	2		2	
	2020-2024	4	1	25		1	1			1	
Sum (1980-2019)		63	9	14	0	25	13	4	1	11	0

Table 1a. Summary of manatee deaths in the LSJRB 1980 through December 2020.

County	Time Period	Total Deaths	Watercraft Propeller, Impact, or Both	Watercraft Percent	Human, Other	Perinatal (Natural or Undetermined)	Cold Stress	Natural, Other (inc. Red Tide)	Verified (not recovered)	Undetermined (Not recovered, Too decomposed, Other)	Undetermined Other
Putnam	**1980-1984**	5	3	60		0	0				2
	1985-1989	6	2	33		0	2			1	1
	1990-1994	8	3	38		3	0			1	1
	1995-1999	6	2	33		1	0	1		2	
	2000-2004	10	1	10		0	4			5	
	2005-2009	8	0	0		1	2	1		4	
	2010-2014	33	4	12		2	13	1	1	11	1
	2015-2019	25	4	16		7	3		1	10	
	2020-2024	11	1	9		2	1			3	4
Sum (1980-2020)		112	20	18	0	16	25	3	2	37	9
St. Johns	**1980-1984**	9	1	11		0	0	2			
	1985-1989	19	1	5		1	1				
	1990-1994	11	0	0		1	0			1	
	1995-1999	11	2	18		0	0	1		4	
	2000-2004	11	3	27		1	2			4	
	2005-2009	16	3	19		1	3	1		8	
	2010-2014	23	1	4	1	3	10	1		6	1
	2015-2019	27	6	22	1	5	9	1		5	
	2020-2024	9	1	11		0	2	1			5
Sum (1980-2020)		136	18	13	2	12	27	7	0	28	6
LSJRB	1975-1979	28	16	57	1	3	0		3	5	6
	1980-1984	51	15	29	0	3	0	9	2	0	16
	1985-1989	89	24	27	1	7	14	6	1	11	9
	1990-1994	82	27	33	6	14	7	5	0	10	4
	1995-1999	77	19	25	0	11	7	7	1	27	1
	2000-2004	96	30	31	1	18	16	2	1	27	0
	2005-2009	127	44	35	0	19	21	6	1	35	1
	2010-2014	155	24	15	3	27	54	2	3	29	2
	2015-2019	135	22	16	4	35	35	7	2	30	0
	2020-2024	35	3	9	2	4	8	1	0	5	12
Sum (1980-2020)		812	205	25	17	138	162	45	11	174	45

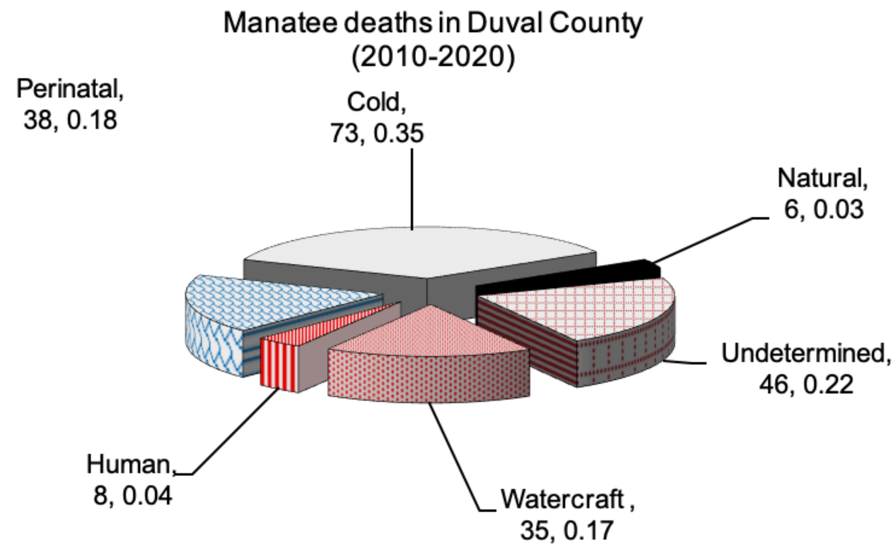


Figure 5a. Manatee deaths in LSJRB 2010 through December 2020.

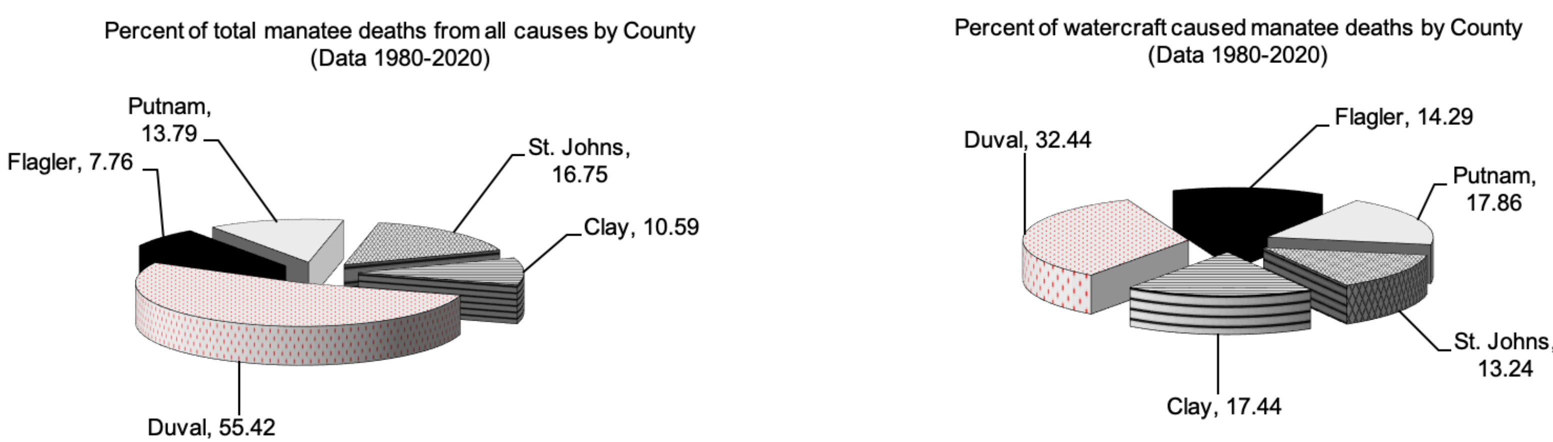


Figure 5b. Manatee deaths in LSJRB 1980 through December 2020.

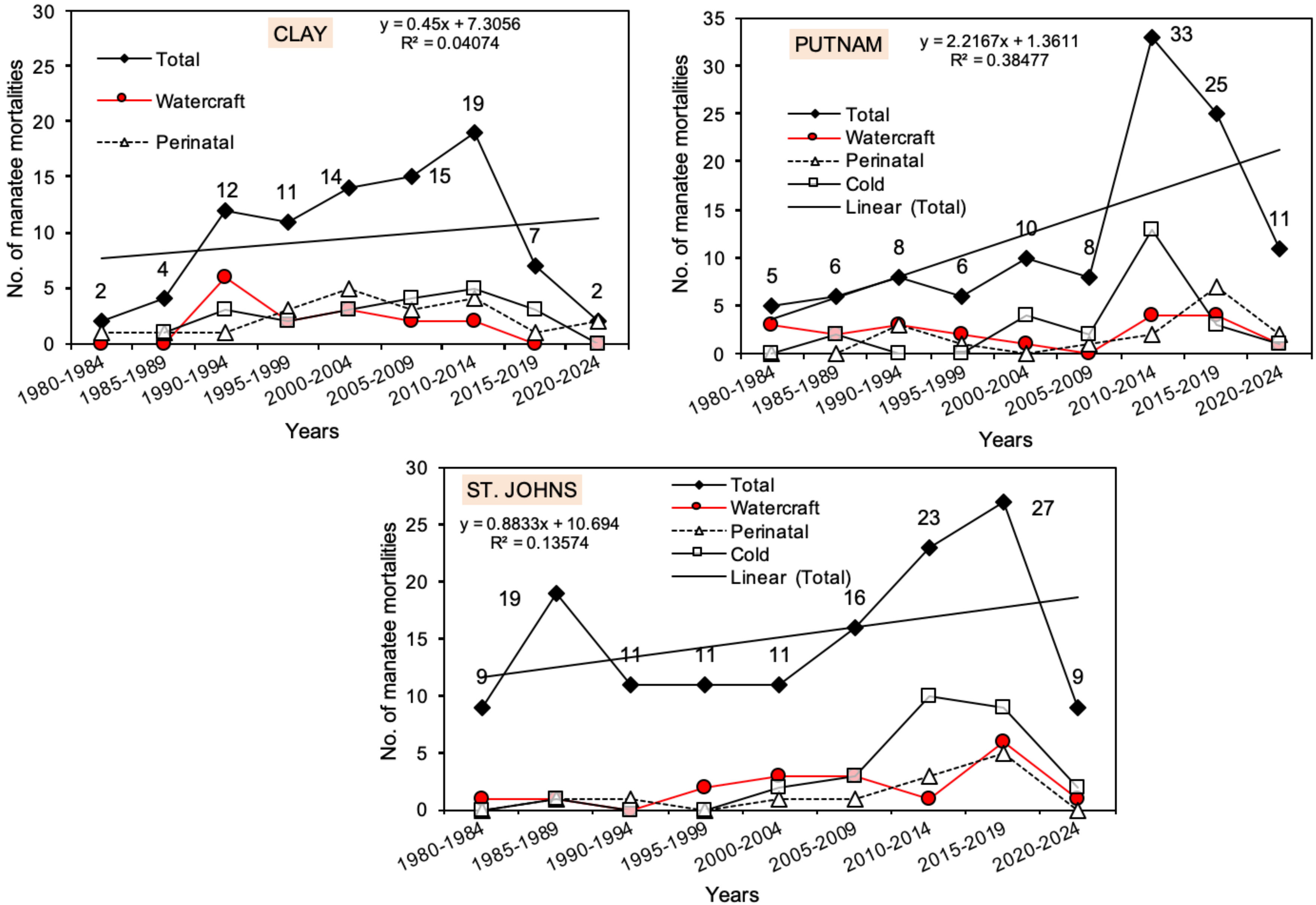


Figure 6. Summary of total, watercraft, perinatal, and cold stress deaths by county in LSJRB 5 year intervals from 1980-2019 (except 2020-2024).

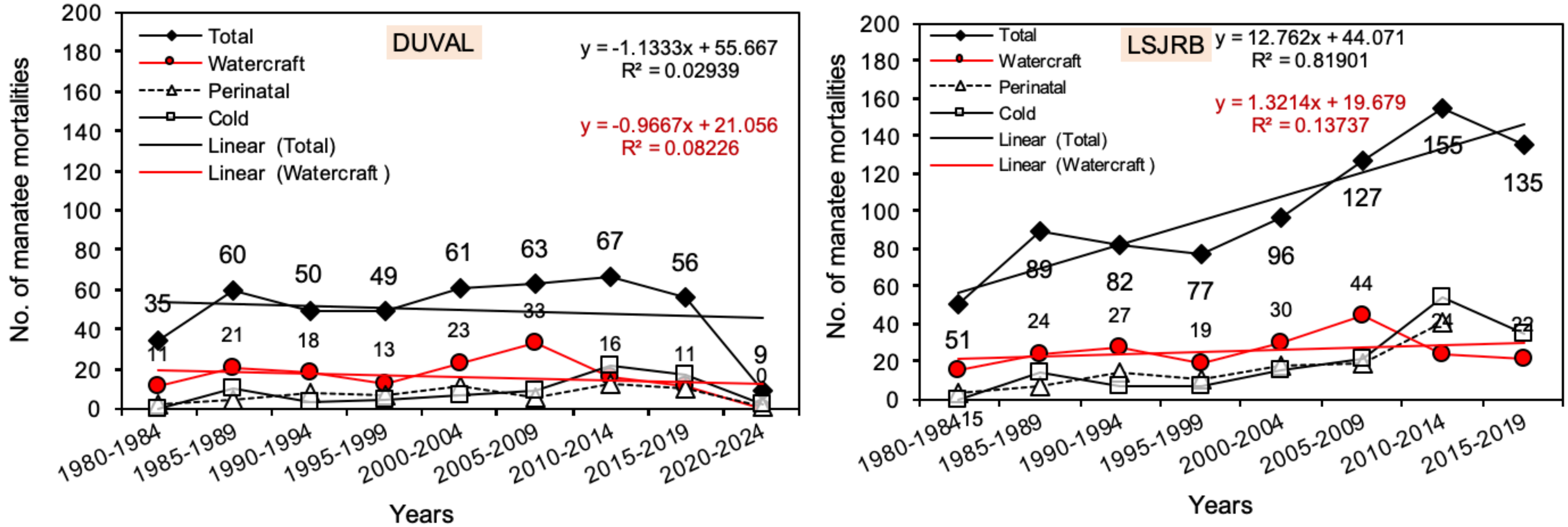


Figure 6.cont. Summary of total, watercraft, perinatal, and cold stress deaths by county in LSJRB 5 year intervals from 1980-2019 (except 2020-2024).

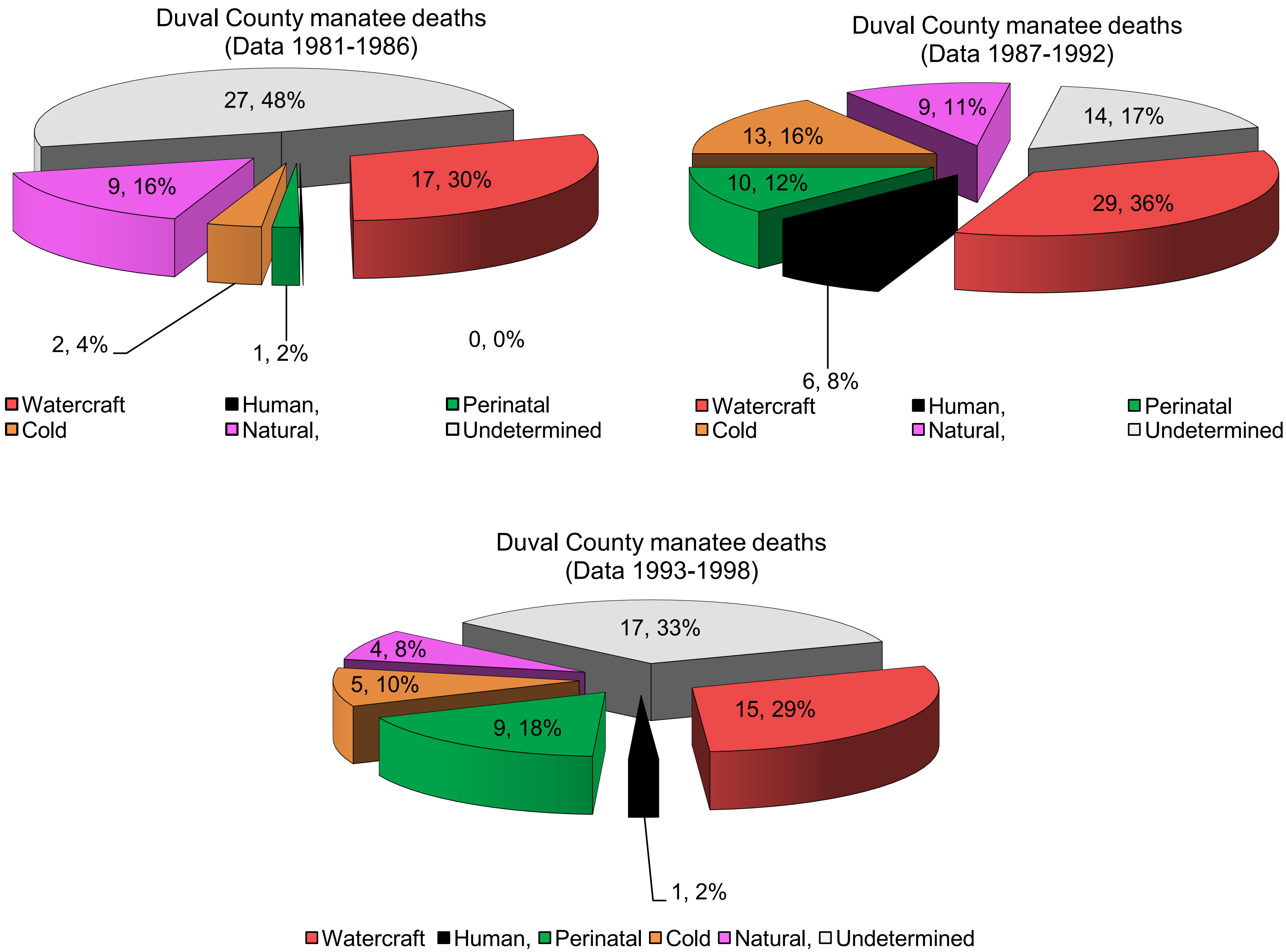
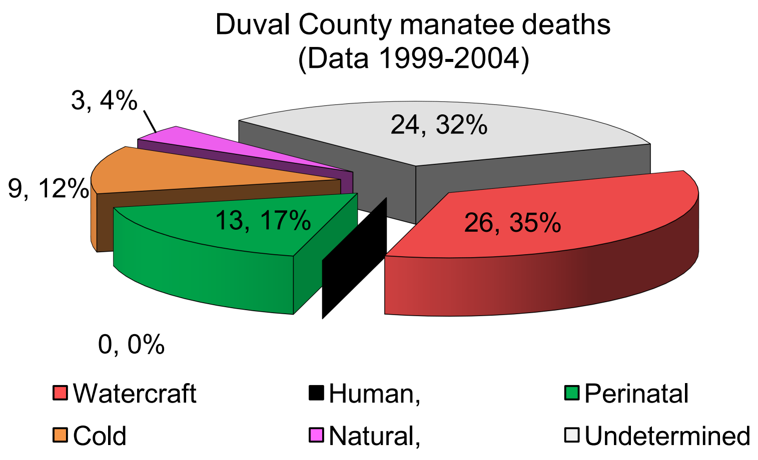


Figure 7. Manatee deaths in Duval County 1981-86; 1987-92; and 1993-1998.



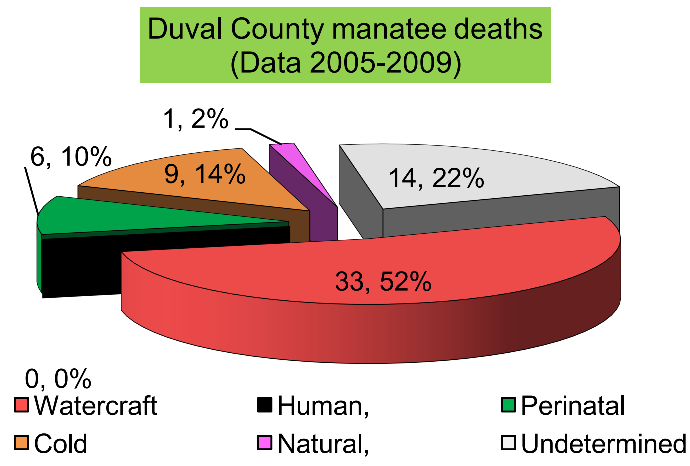
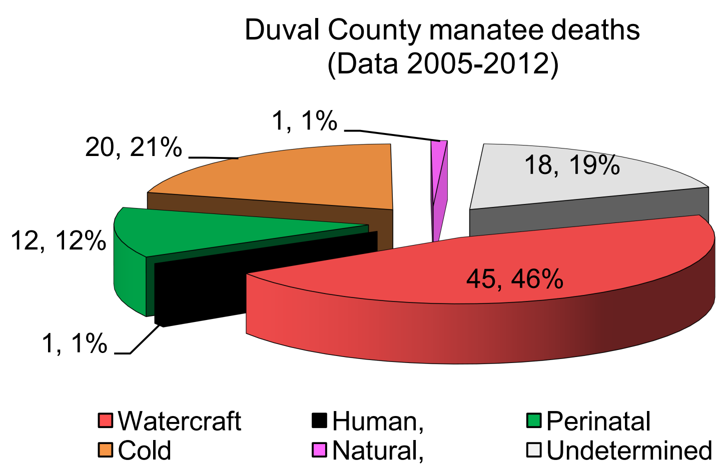


Figure 7 cont. Manatee deaths in Duval County 1999-2004 and 2005-2009.



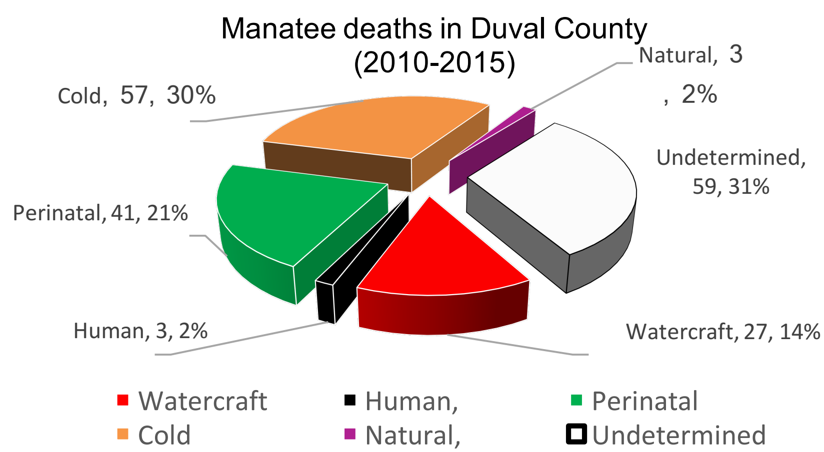
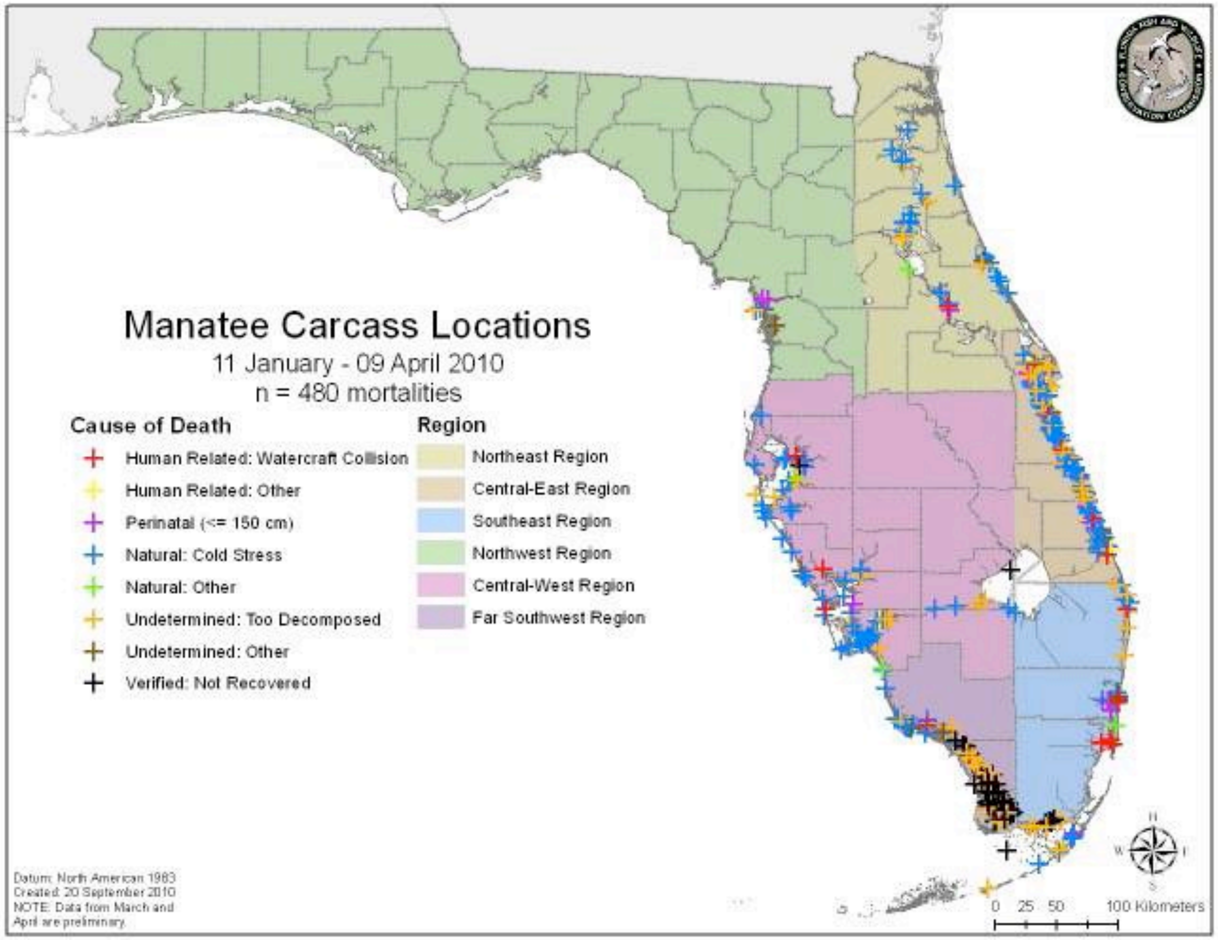
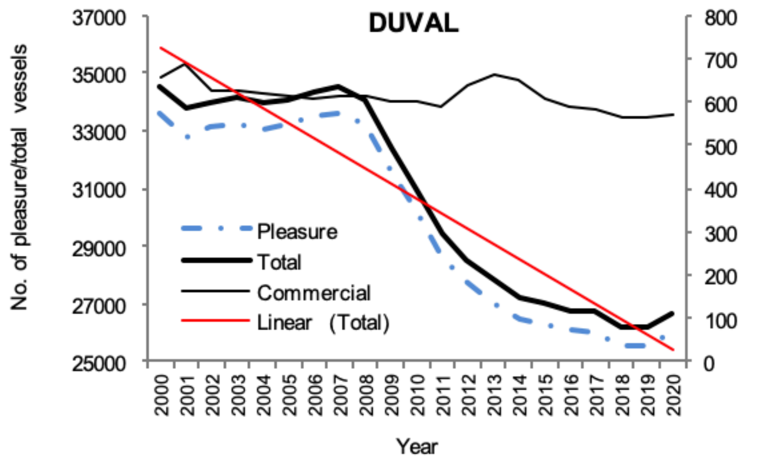


Figure 7 cont. Manatee deaths in Duval County 2005-2012 and 2010-2015.

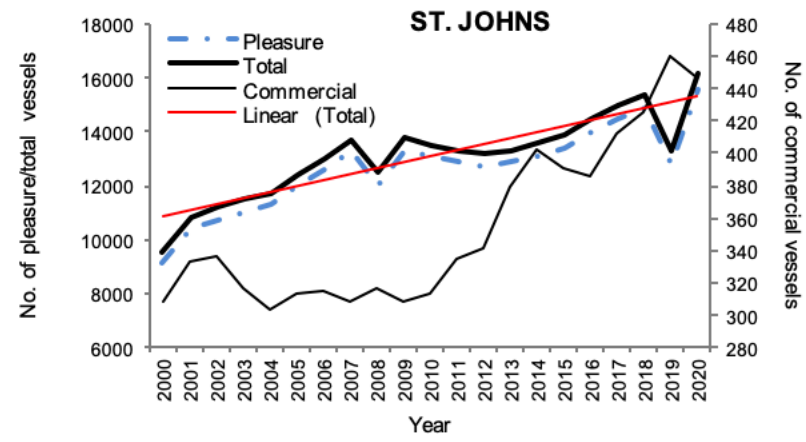


Distribution of manatee carcasses reported in Florida, January 11–April 9, 2010. These dates mark the extent of the 2010 cold-related manatee mortality event. Manatees in all regions except the northwest suffered unusually high mortality (FWRI 2011c).

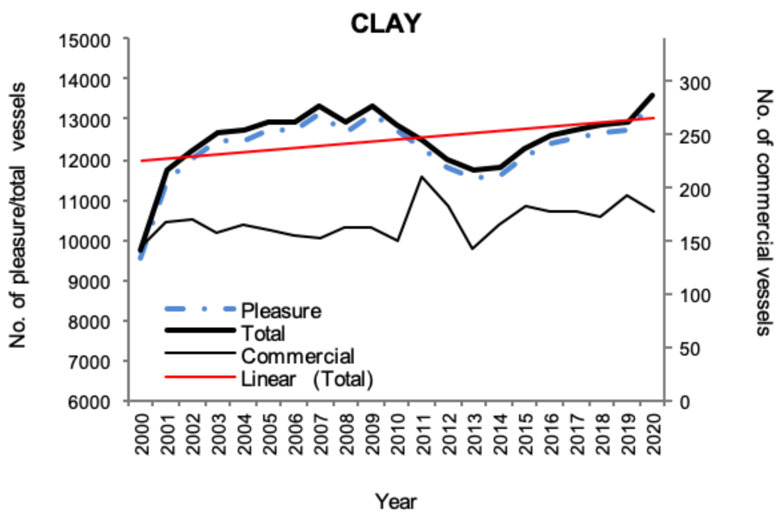
Source: **http://myfwc.com/media/434666/Webarticle_cold_event_2010_new_version_120910_3.pdf**



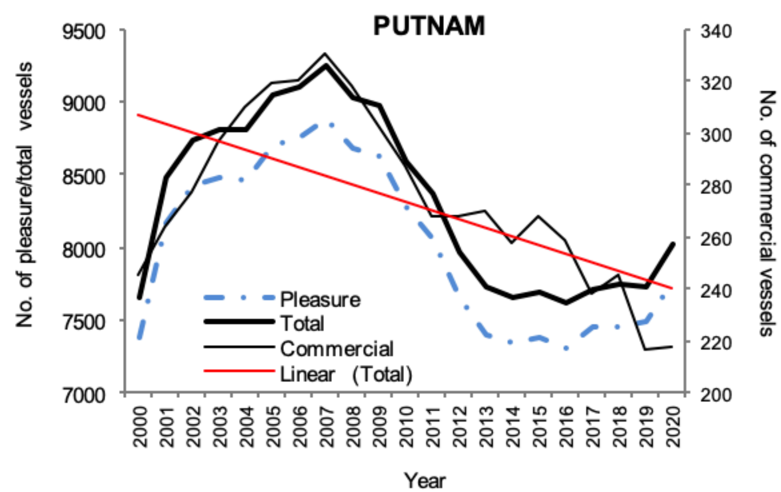
Trend decreasing: $R^2=0.8769$; $y=-521.84x + 36374$



Trend increasing: $R^2=0.7938$; $y=223.65x + 10637$

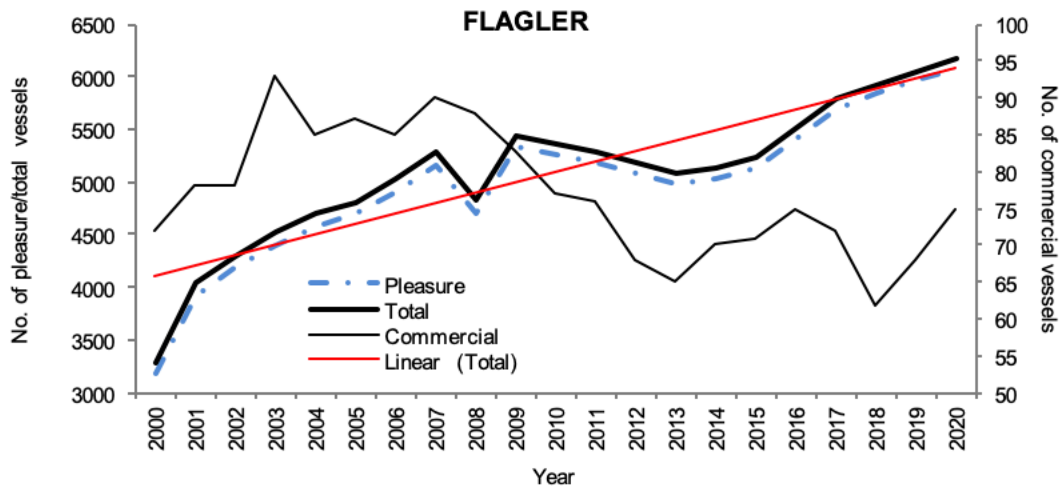


Trend increasing: $R^2=0.1474$; $y=51.249x + 11938$



Trend decreasing: $R^2=0.3853$; $y=-59.558x + 8974$

Figure 8. Summary of total, pleasure, and commercial vessels by county in LSJRB (2000-2020). Regression trend reflects total vessels.



Trend increasing: $R^2=0.8017$; $y=98.564x + 4007.5$

Figure 8.cont. Summary of total, pleasure, and commercial vessels by county in LSJRB (2000-2018). Regression trend reflects total vessels.

Appendix 4.4.2.A

Bald Eagles

Over the long term (1929-2020) Kendall's tau correlation indicated an increasing trend in Bald Eagles over time (Figures 1 and 2). When considering the effects of sampling effort, expressed as number of Bald Eagles per party hour ($\tau = 0.446$; p=2.455E-08; n=70). Considering raw numbers only, the trend was similar ($\tau = 0.515$; p=1.43E-10; n=70).

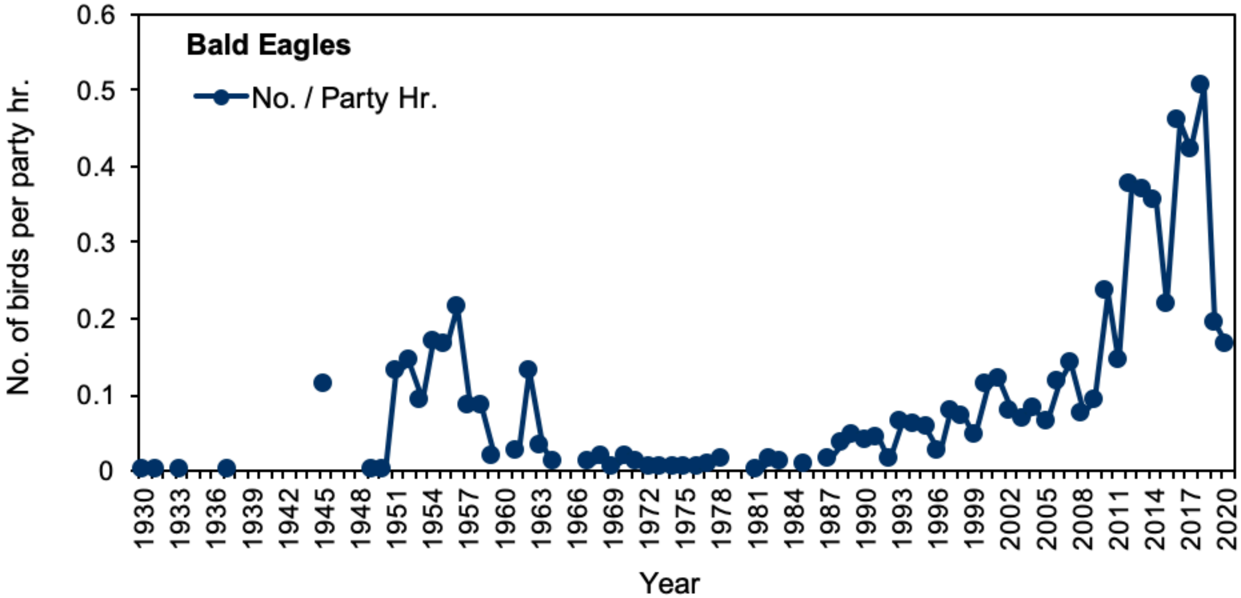


Figure 1. Long-term trend in the number of Bald Eagles counted per party hour during winter bird surveys (1929/30-2019/20) in Jacksonville, FL (Data: Audubon 2021).

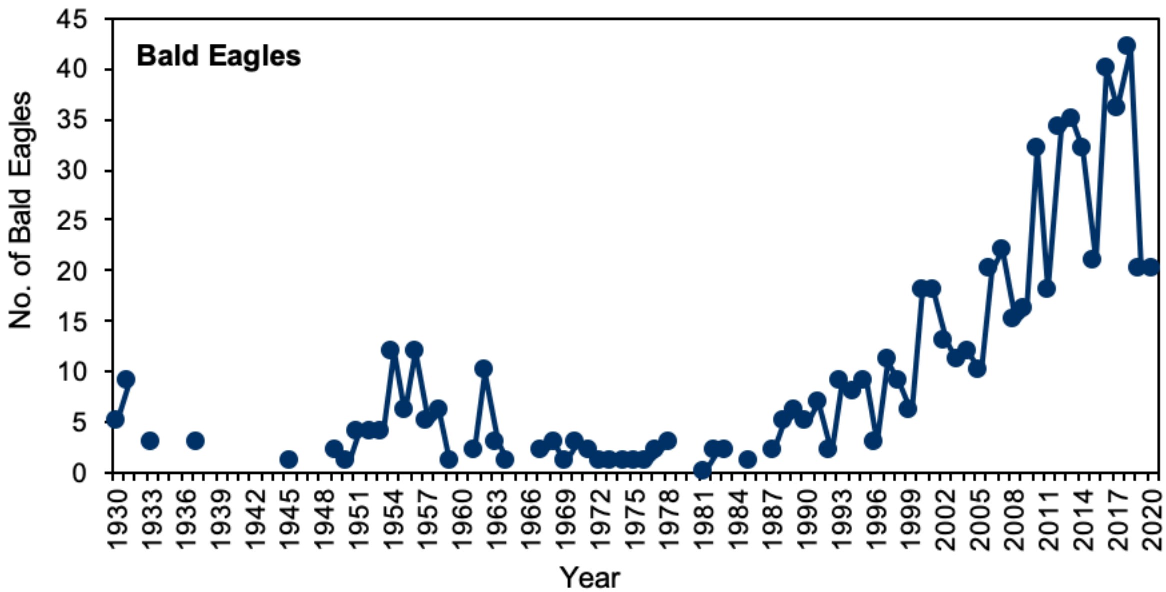


Figure 2. Long-term trend in the number of Bald Eagles counted during winter bird surveys (1929/30-2019/20) in Jacksonville, FL (Data: Audubon 2021).

More recent data (1981-2020) indicated that the increase in population was more pronounced (Figure 3). Kendall's tau correlation indicated an almost exponential increase in Bald Eagles over time (τ = 0.776; p=3.52E-12; n=38) and this correlates well with conservation measures banning the use of the pesticide DDT in the late 1960's (Figures 1 and 2). When considering the effects of sampling effort, expressed as number of Bald Eagles per party hour (τ = 0.764; p=7.34E-12; n=38).

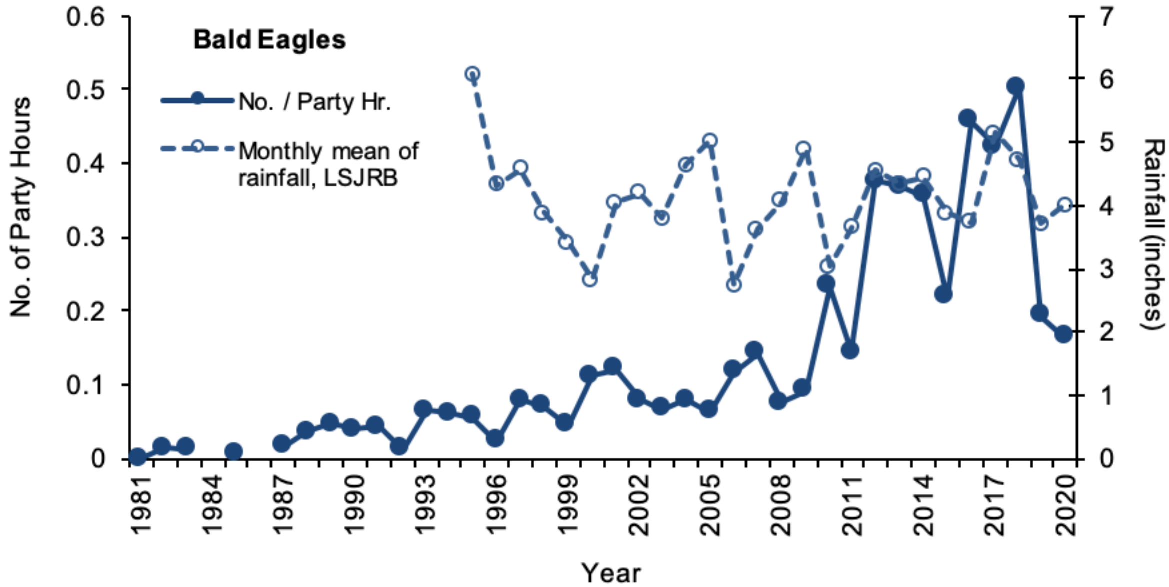


Figure 3. Recent trend in the number of Bald Eagles counted per party hour during winter bird surveys (1981-2019/20) in Jacksonville, FL (Data: Audubon 2021). Annual average monthly radar rainfall data for LSJRB included (Data: SJRWMD 2021a).

Rainfall data (1996-2020) was included in the analysis (Figure 3, 4) was found to be negatively correlated with Bald Eagles, but not significant with respect to numbers of eagles (τ = -0.068; p=0.318; n=25) and party hours of effort (τ = 0.033; p=0.408; n=25). Over this time period (1996-2020) Kendall's tau correlation indicated increase in Bald Eagles over time (τ = 0.622; p=6.63E-06; n=25) and when considering the effects of sampling effort, expressed as number of Bald Eagles per party hour (τ = 0.62; p=6.99E-06; n=25) the trend was similar.

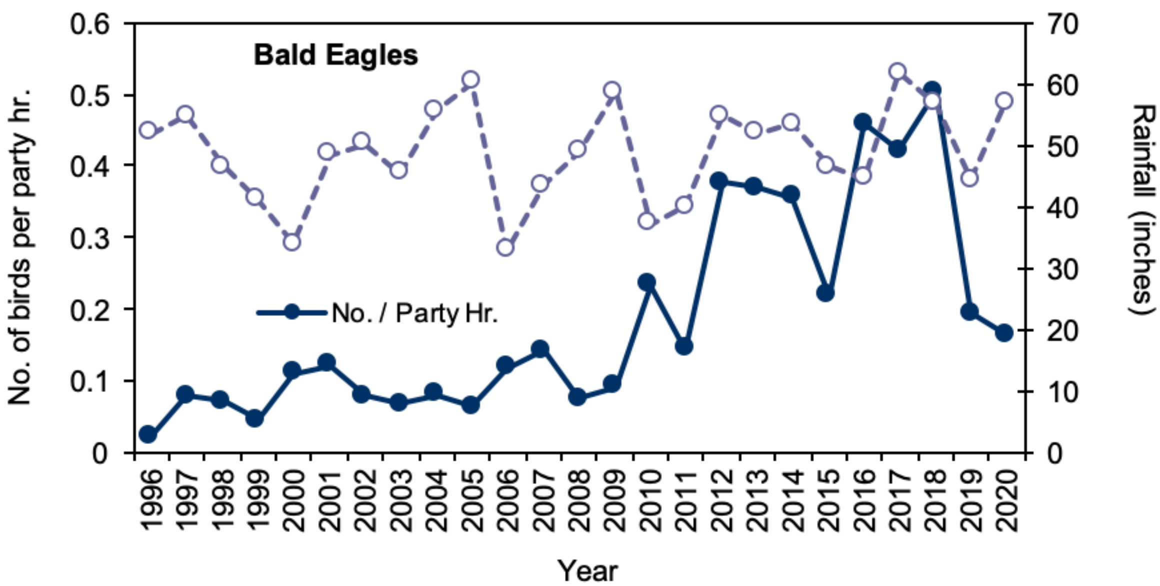


Figure 4. Short-term trend in the number of Bald Eagles and annual average monthly rainfall.

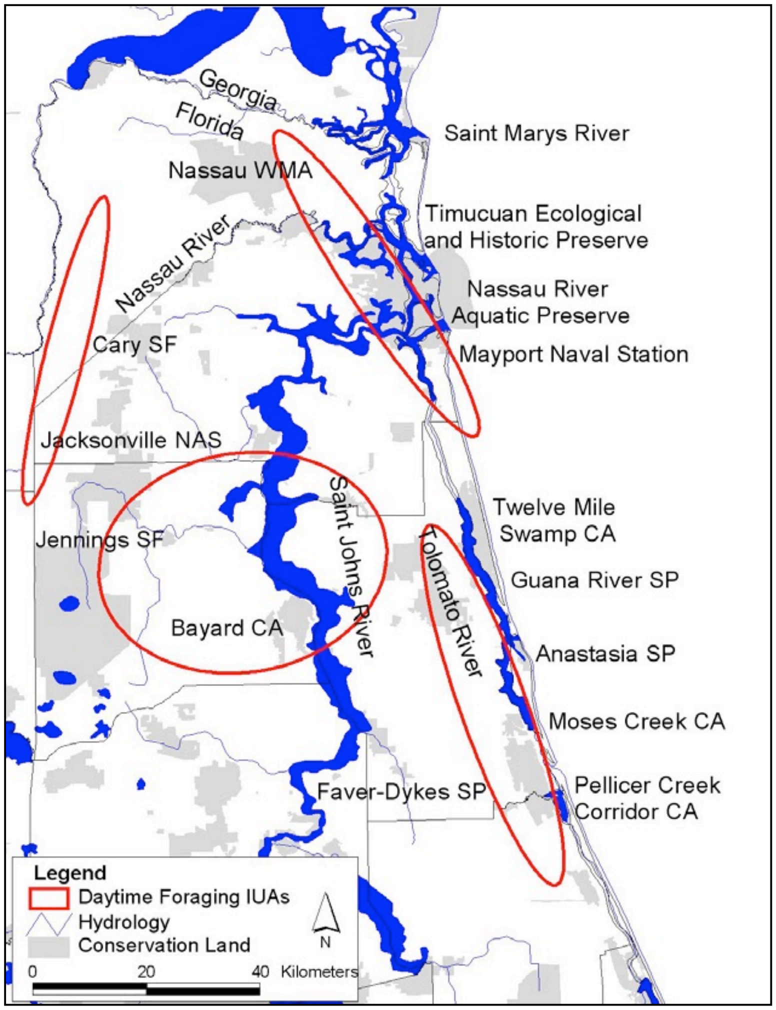


Figure 5. Important use areas of the Florida Bald Eagle: sub-adult eagle migratory locations, Florida Data. Source: Bald Eagle Research Maps. FWC 2010.[3]

[3] Mojica, E.K. 2006. Migration, home range, and important use areas of Florida sub-adult bald eagles. Master's thesis, University of Georgia. Athens, GA. http://www.myfwc.com/docs/WildlifeHabitats/FL_Bald_Eagle_IUAs.pdf

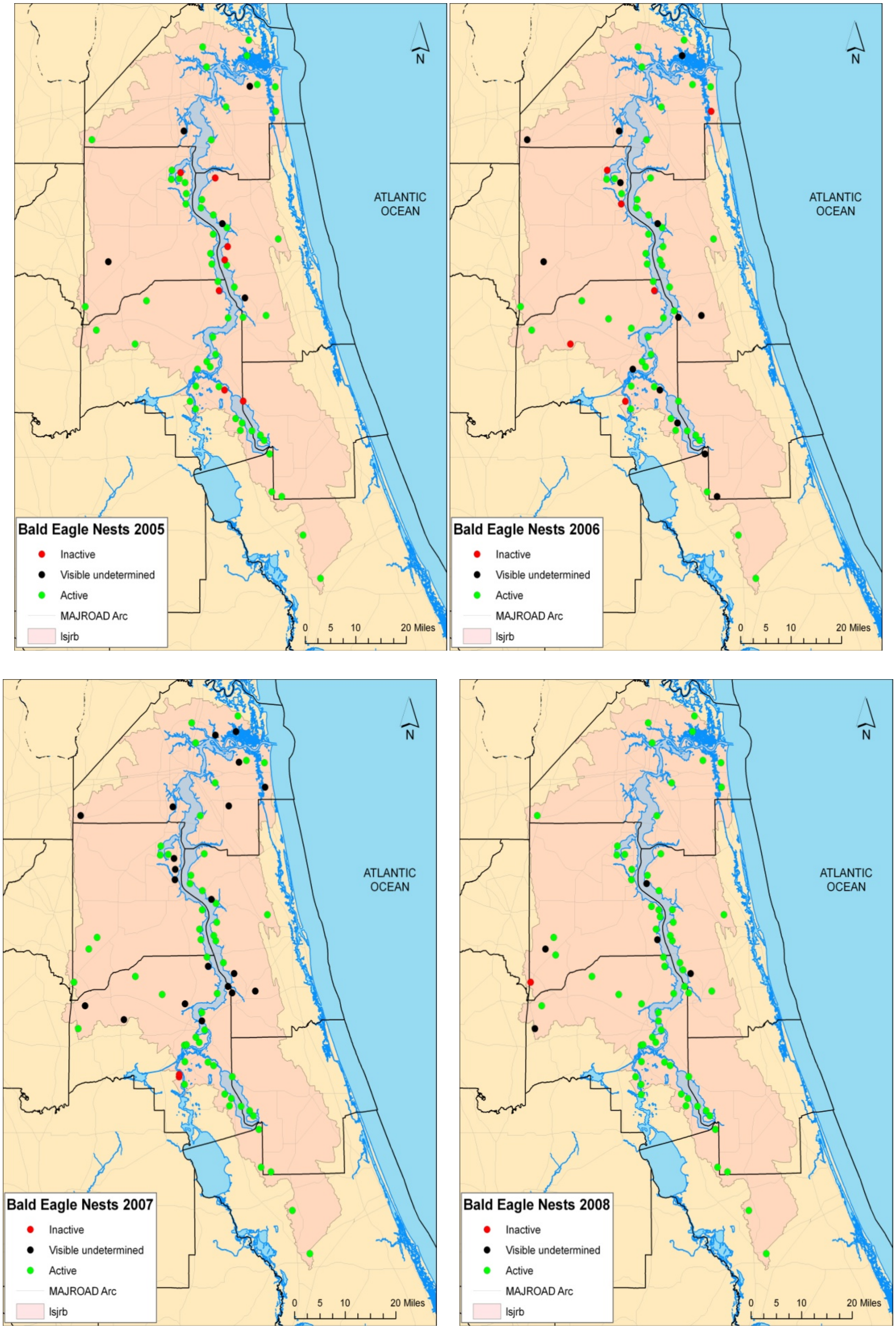


*Figure 6. Bald eagle nesting sites in LSJRB 2005-2010. (Source data: **FWC 2011**)*

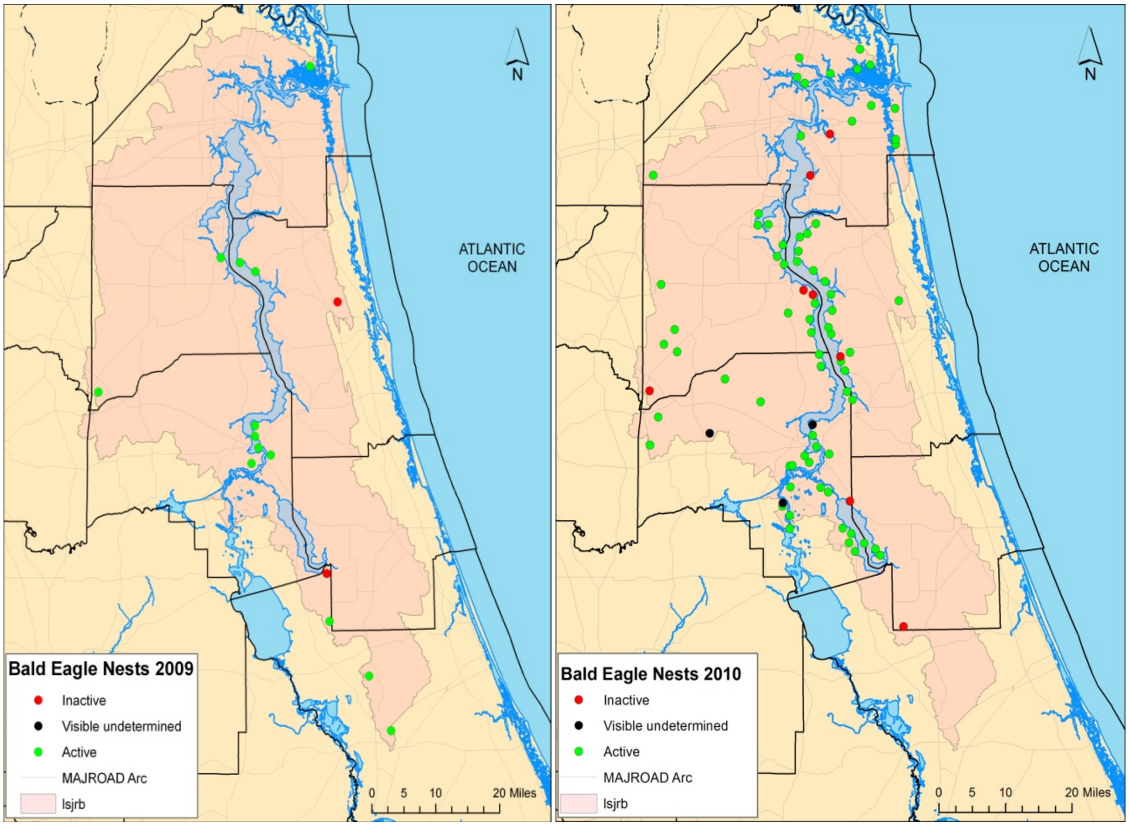


*Figure 6 continued. Bald eagle nesting sites in LSJRB 2005-2010 (Source data: **FWC 2011**).*

Appendix 4.4.3.A

Wood Storks

Over the long term (1962-2020) Kendall's tau correlation indicated an increasing trend in Wood Storks over time (Figures 1 and 2). When considering the effects of sampling effort, expressed as number of Wood Storks per party hour (τ = 0.637; p=1.34E-12; n=57). Considering raw numbers only, the trend was similar (τ = 0.587; p=5.69E-11; n=57).

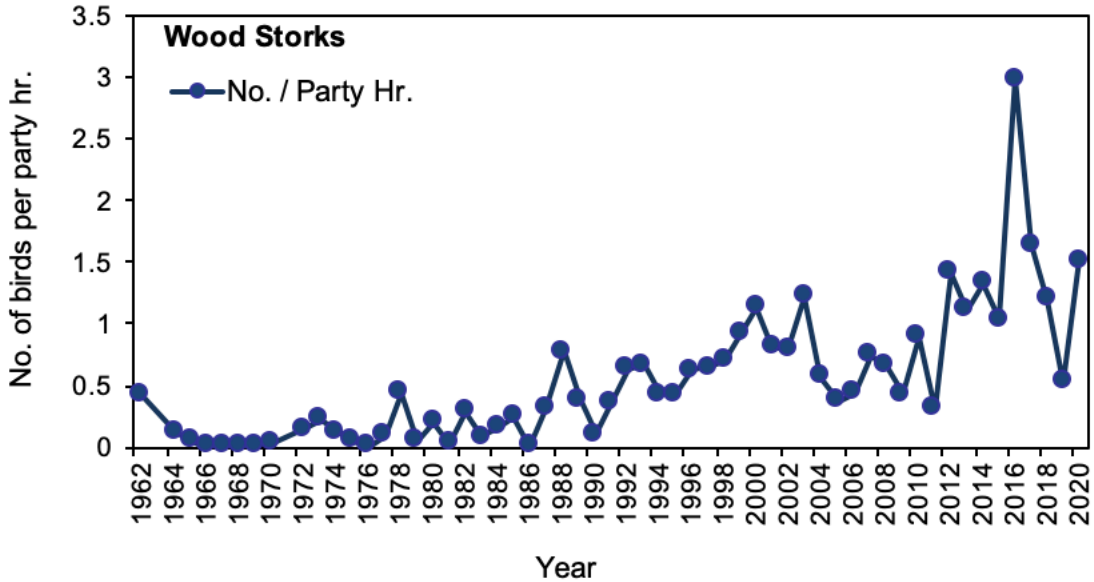


Figure 1. Long-term trend in the number of Wood Storks counted per party hour during winter bird surveys (1961/62-2019/20) in Jacksonville, FL (Data: Audubon 2021).

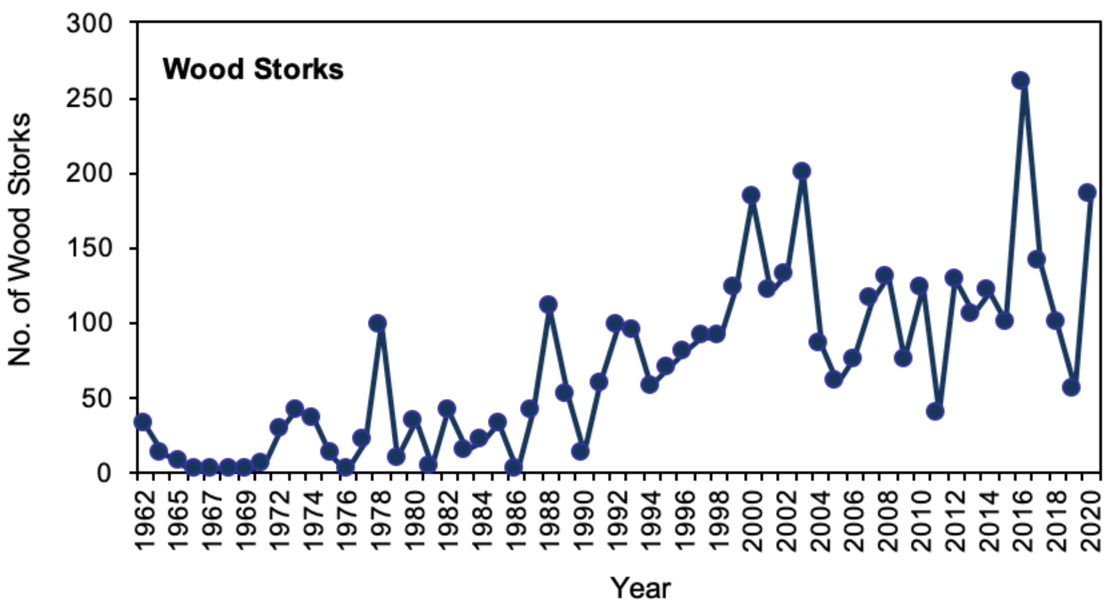


Figure 2. Long-term trend in the number of Wood Storks counted during winter bird surveys (1961/62-2019/20) in Jacksonville, FL (Data: Audubon 2021).

More recent data (1986-2020) indicated that the increase in population was more erratic (Figure 3). Kendall's tau correlation indicated a marked increase in Wood Storks over time ($\tau = 0.351$; p=0.0015; n=35). When considering the effects of sampling effort, expressed as number of Wood Storks per party hour ($\tau = 0.466$; p=4.18E-05; n=35) the trend was similar.

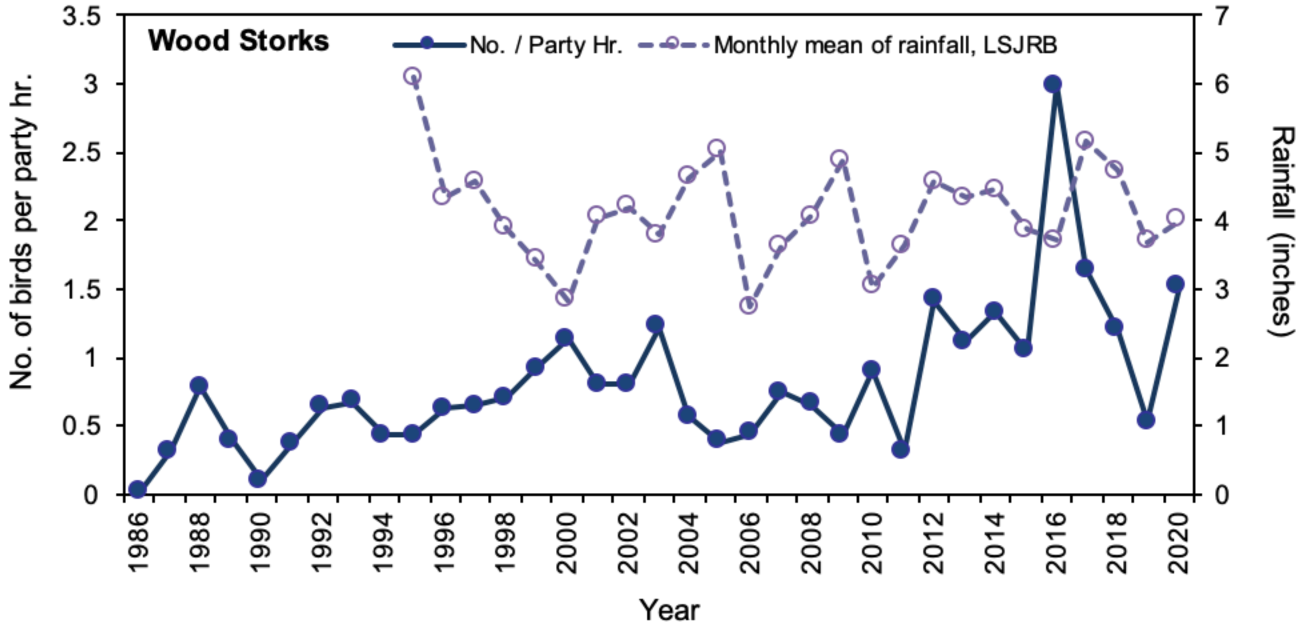


Figure 3. Recent trend in the number of Wood Storks counted per party hour during winter bird surveys (1985/86-2019/20) in Jacksonville, FL (Data: Audubon 2021). Annual average monthly radar rainfall data for LSJRB included (Data: SJRWMD 2021a).

Rainfall data (1995-2020) was included in the analysis (Figures 3 and 4) was found to be negatively correlated, but not significant, with Wood Storks when party hours of effort were considered ($\tau = -0.077$; p=0.291; n=26) and the raw numbers ($\tau = -0.186$; p=0.09; n=26).

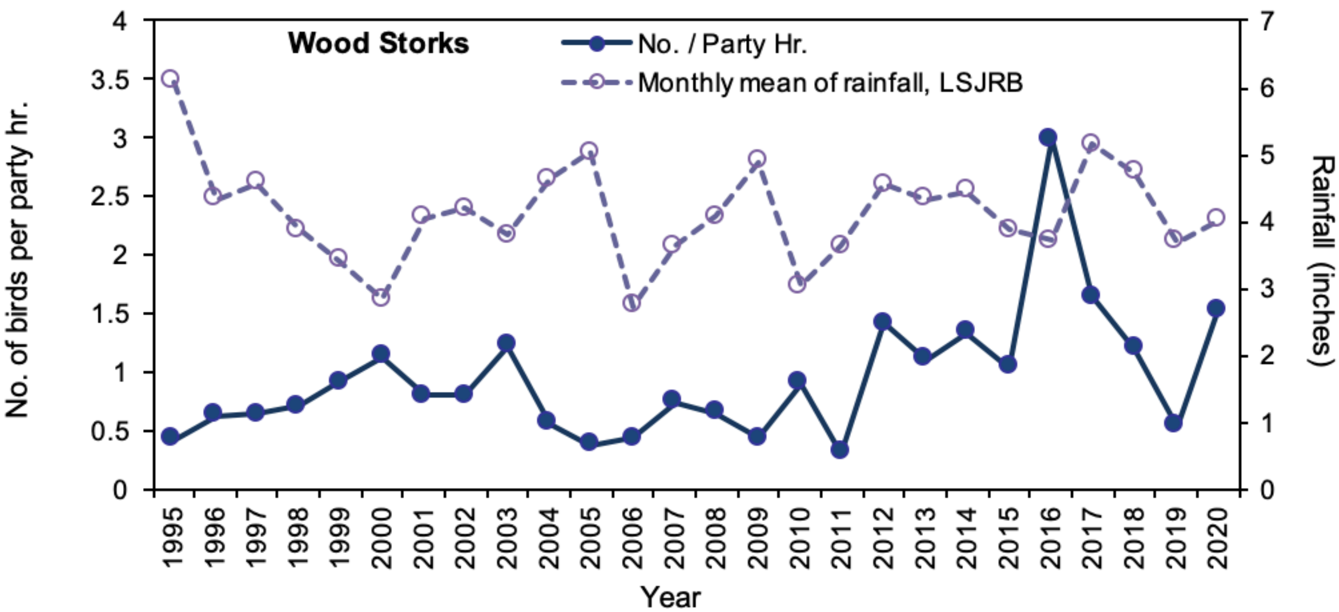


Figure 4. Short-term trend in the number of Wood Storks and annual average monthly rainfall.

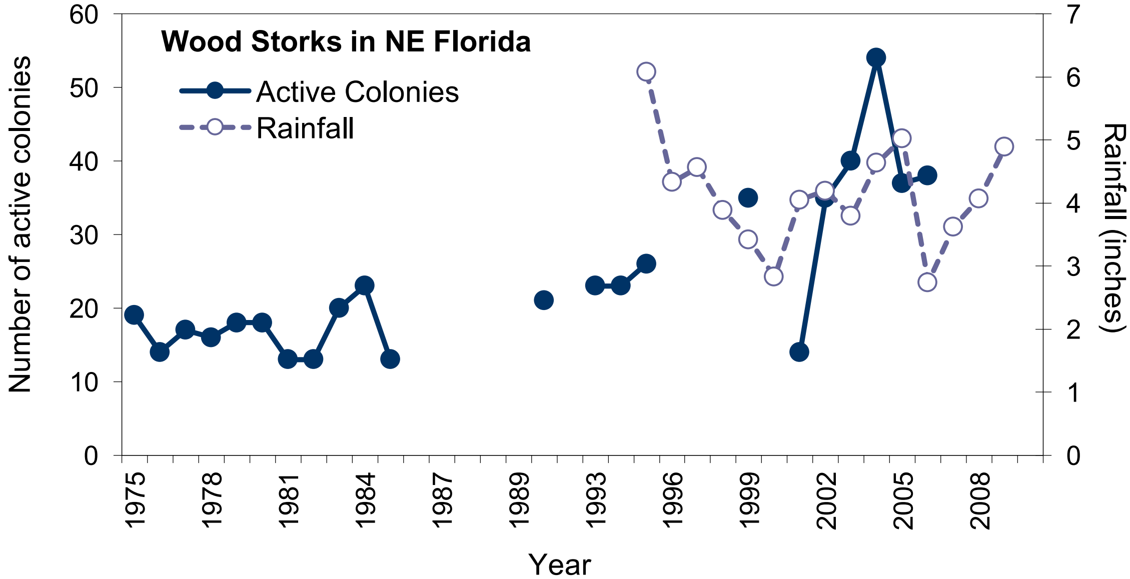


Figure 5. (From: Brook and Dean, 2008) Active Wood Stork colonies in the southeastern U.S., 1975-2006, with annual average monthly radar rainfall data added for LSJRB 1995-2010 (SJRWMD 2010).

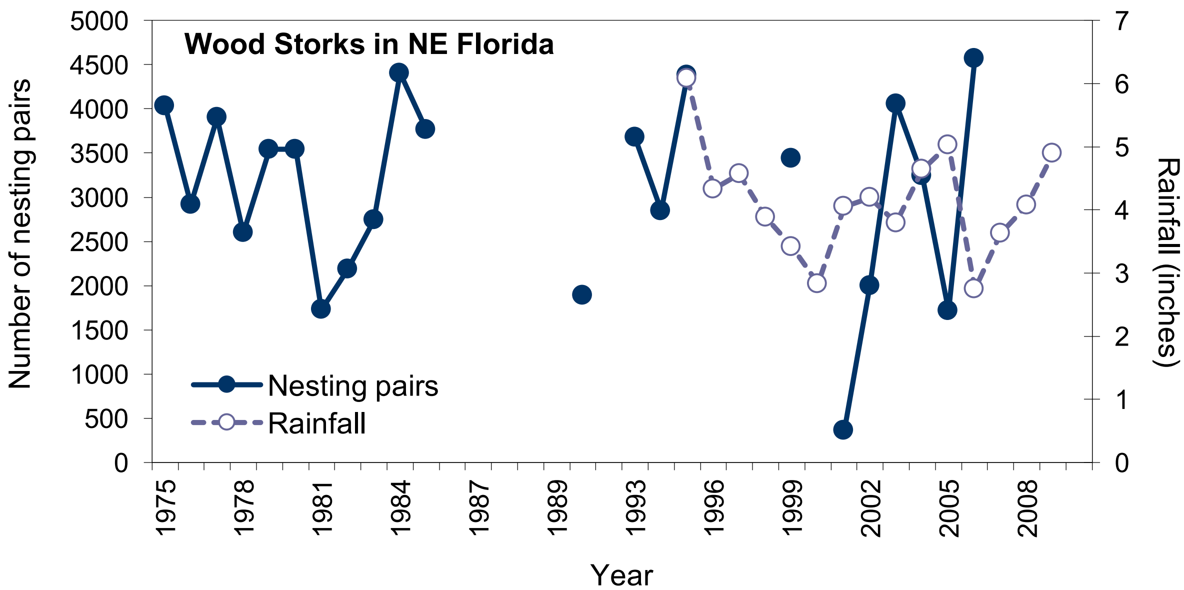


Figure 6. (From: Brook and Dean, 2008) Nesting pairs of Wood Storks in the southeastern U.S., 1975-2006, with annual average monthly radar rainfall data added for LSJRB 1995-2010 (SJRWMD 2010).

Above data from Brook and Dean (1975-2006) was looked at with accompanying rainfall data (Figures 5 and 6). Kendall's tau correlation indicated a marked increase in active colonies of wood storks over time throughout the northeast Florida area (τ =0.601; p=4.58E-05; n=22). When considering numbers of nesting pairs there was a negative correlation over time but this was not significant (τ =-0.052; p=0.367; n=22). With rainfall added in the analysis, there was a negative correlation with nesting pairs, but with no significance (τ =-0.467; p=0.09; n=6).

Appendix 4.4.3.B

Wood Storks

The wood stork colony at the Jacksonville Zoo and Gardens appears to be leveling off (Figure 1). Kendall's tau correlation indicated an increasing trend in wood storks pairs (nests) over time (τ =0.313; p=0.02; n=23). There was a positive correlation with number of chicks per nest over time (Figure 2), but this was not significant (τ =-0.199; p=0.098; n=22). Also, there was a positive correlation with number of fledglings over time, but this was not significant (τ =0.194; p=0.097; n=23) (Figure 3). Rainfall was positively correlated over time, with no significance (τ =0.003; p=0.491; n=26). Kendall's tau correlation indicated a negative correlation of wood stork pairs with rainfall, but this was not significant (τ =-0.011; p=0.468; n=23). There was a positive correlation of the number of chicks per nest with rainfall, but this was not significant (τ =0.009; p=0.477; n=22). Number of fledglings were negatively correlated with rainfall, but this was not significant (τ =-0.075; p=0.307; n=23).

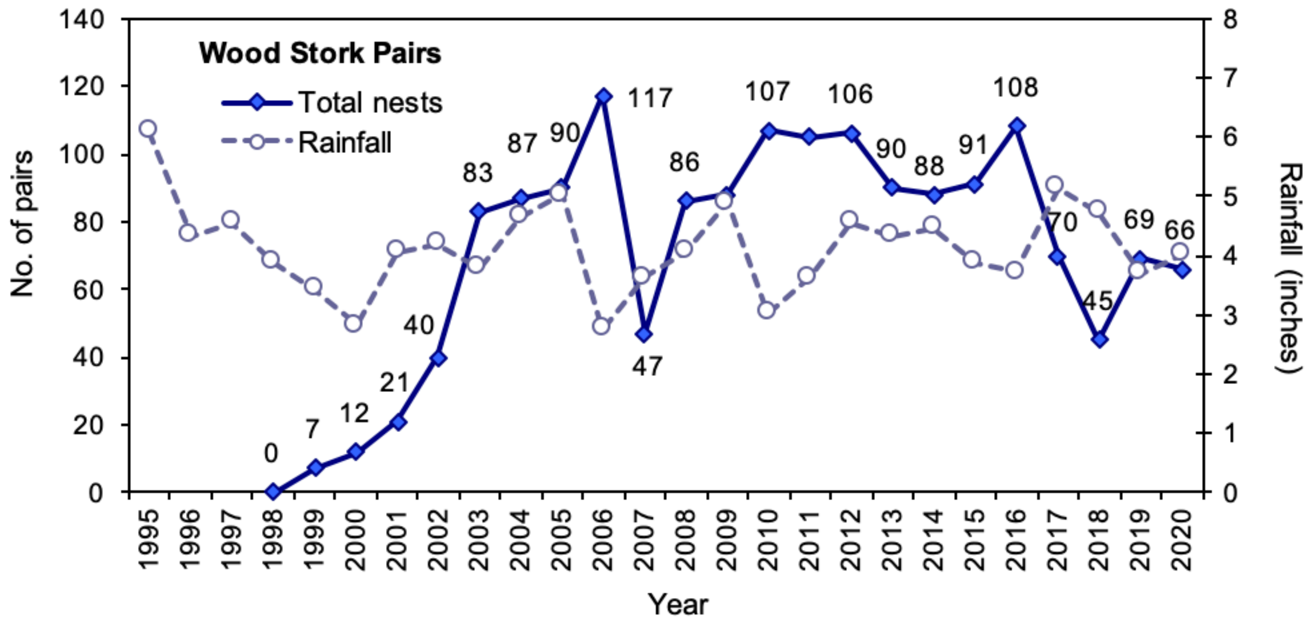


Figure 1. Numbers of wood stork pairs at Jacksonville Zoo (1998-2020). Note: Official data starts in 2003 (Source: Donna Bear-Hull, 2021). Annual average monthly rainfall SJWMD 2021a.

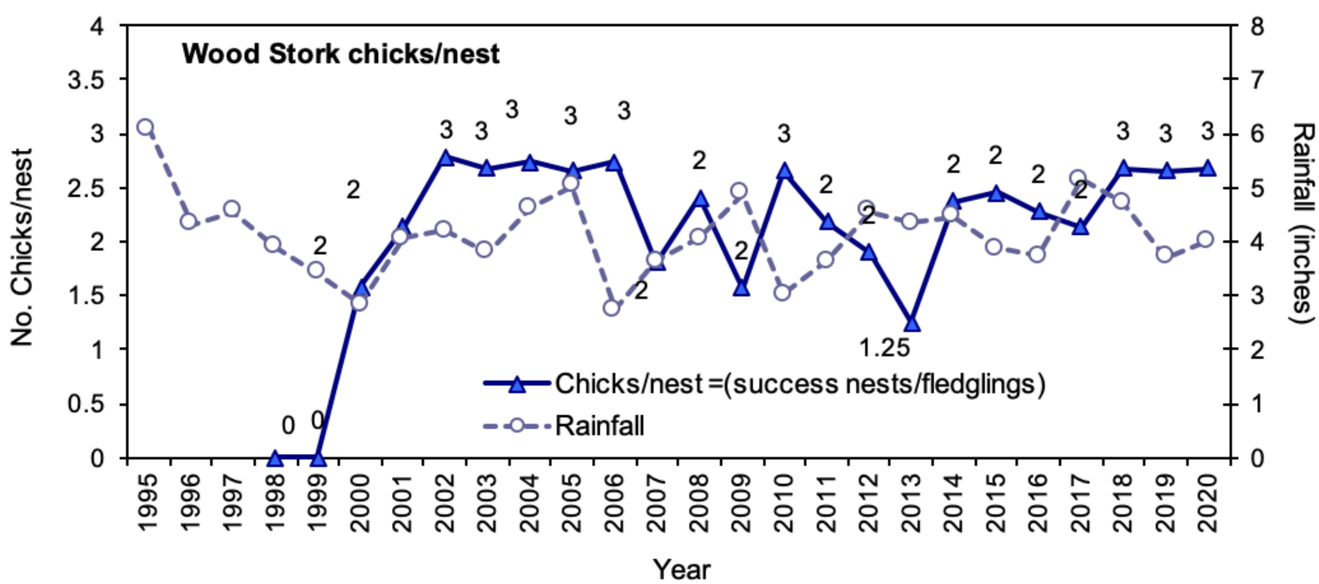


Figure 2. Numbers of wood stork chicks per nest at Jacksonville Zoo (1998-2020). Note: Official data starts in 2003 (Source: Donna Bear-Hull, 2021). Annual average monthly rainfall SJWMD 2021a.

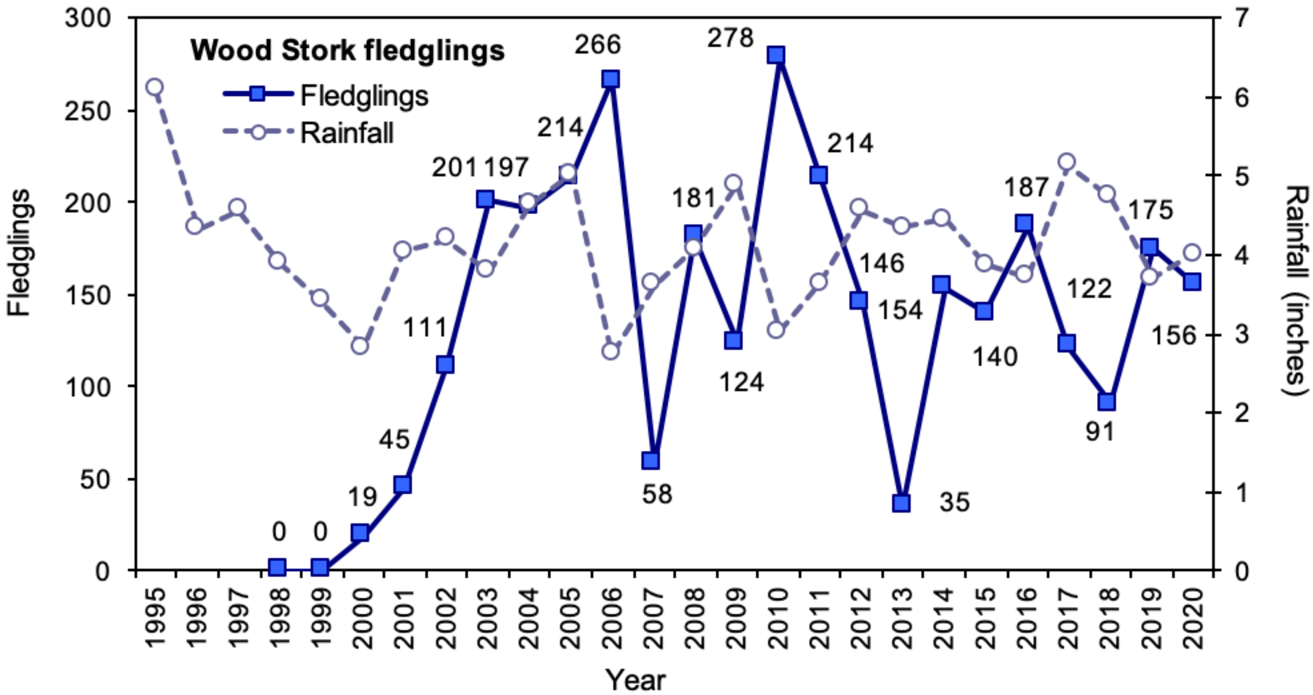


Figure 3. Numbers of wood stork fledglings at Jacksonville Zoo (1998-2020). Note: Official data starts in 2003 (Source: Donna Bear-Hull, 2021). Annual average monthly rainfall SJWMD 2021a.

The following graphs show average fledgling rate (chicks/nest/year). This parameter serves as an indicator of wood stork productivity and can be used to compare different colonies. Kendall's tau correlation on zoo data indicated a negative correlation between average fledgling rate over time, but the relationship was not significant (τ =-0.063; p=0.336; n=23). Average fledgling rate was positively correlated with rainfall but not significant (τ =0.024; p=0.437; n=23).

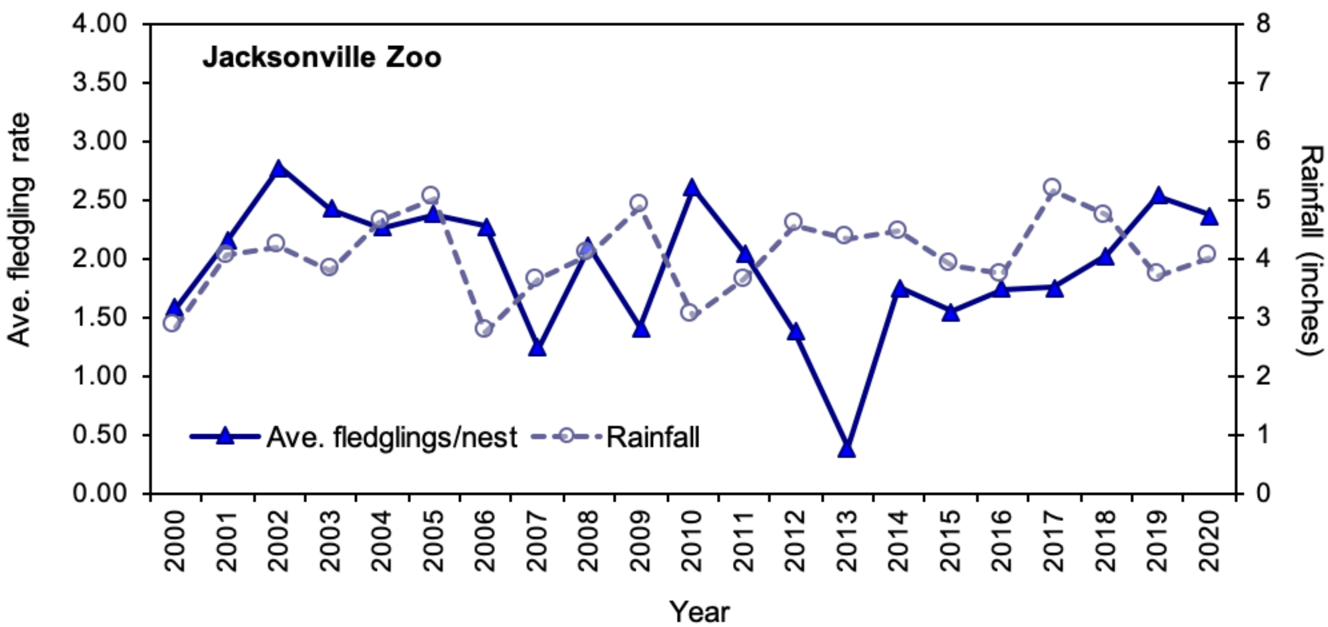
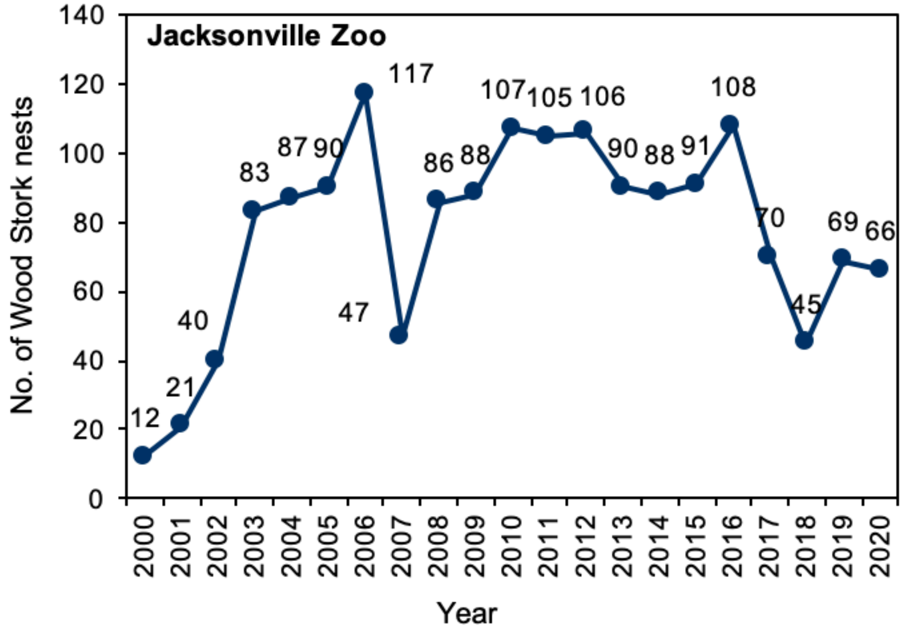


Figure 4. Average fledglings rate (chicks/nest/year) of wood storks at Jacksonville Zoo (2003-2020). This colony is characterized by live oak within a savannas exhibit (Source data: Donna Bear-Hull, 2021; James Rodgers, 2011). Annual average monthly rainfall SJWMD 2021a.



A success is defined as at least one successful hatch. The mean success rate of nests at the zoo increased from 90% (2009) to 98% (2010); then decreased to 72% (2012), and further to 31% (2013), but then increased again to 74% (2014), 81% (2015), 78% 2016, 81% in 2017, and then declined to 76% in 2018.In 2019, it was 96% and in 2020 89%.

Figure 5. Number of wood stork nests at Jacksonville Zoo (2003-2020) (Source data: Donna Bear-Hull, 2021; USFWS 2020. Southeast US Wood Stork Nesting Effort Database USFWS 2005, 2007, 2015, 2016, 2017, 2018, 2019, and 2020).

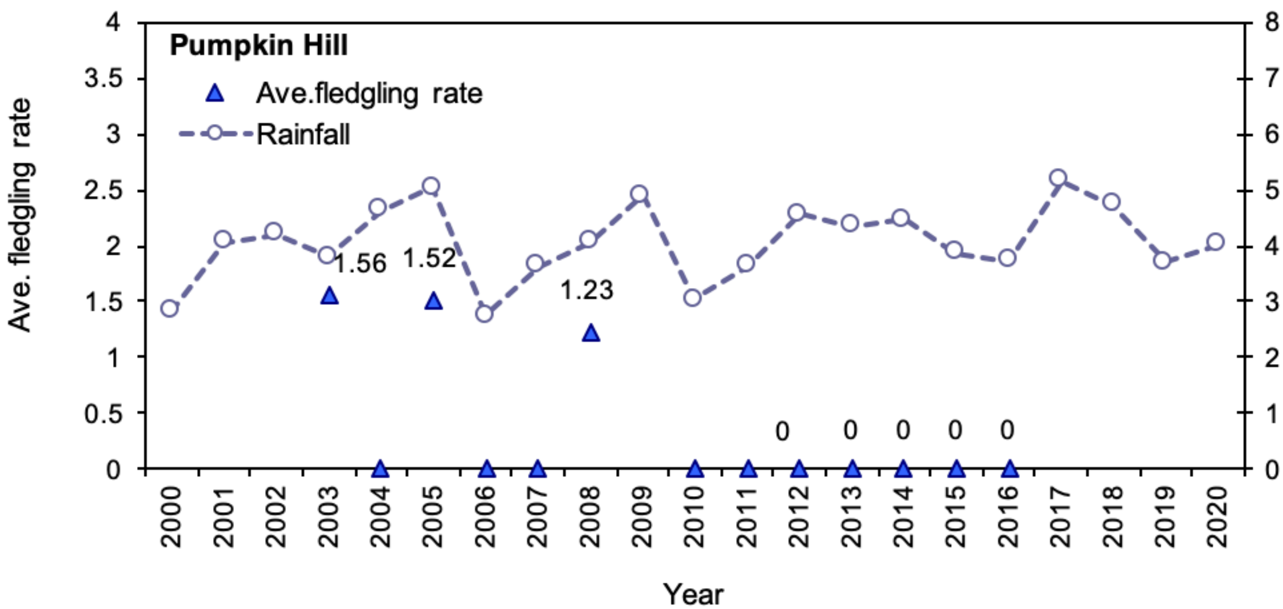


Figure 6. Average fledglings rate (chicks/nest/year) of wood storks at Pumpkin Hill (2003-2016). There are two colonies at this site which is characterized by cypress-dominated domes. In 2004, 2006, 2007, 2010 thru 2016 there was no wood stork activity. In 2009 and 2017, the colony was described as being active, but no data was available. From 2017 thru 2020, no data was available (Source data: USFWS 2021. Southeast US Wood Stork Nesting Effort Database; Rodgers et al., 2008a, b). Annual average monthly rainfall SJWMD 2021a.

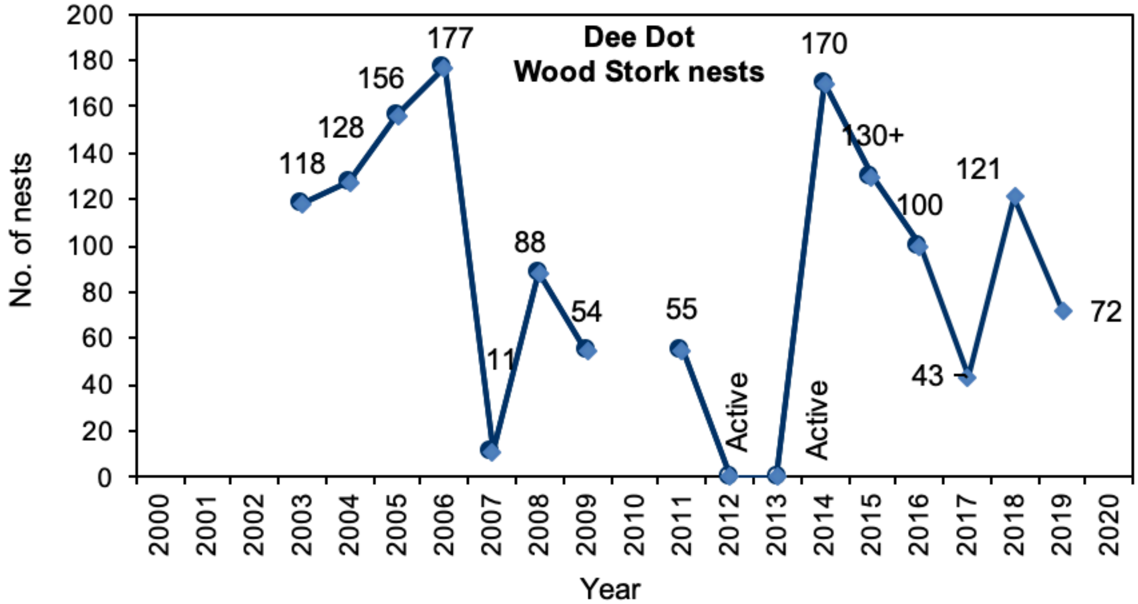


Figure 7. Number of wood stork nests at Dee Dot (2003-2020) (Source data: USFWS 2021. Southeast US Wood Stork Nesting Effort Database 2021; Rodgers et al., 2008a, b).

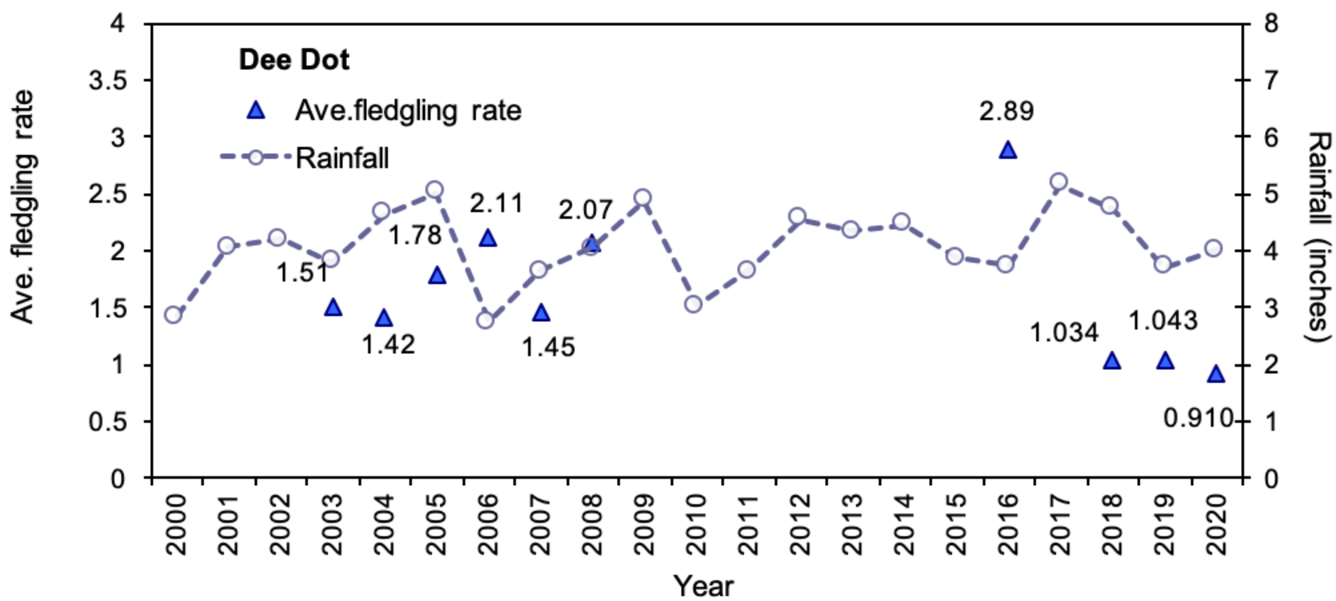


Figure 8. Average fledglings rate (chicks/nest/year) of wood storks at Dee Dot (2003-2020). This colony is associated with a remnant cypress swamp in an impounded lake, 2009 data was not available (Source data: USFWS 2012. Southeast US Wood Stork Nesting Effort Database 2021; Rodgers et al., 2008a, b). Annual average monthly rainfall SJWMD 2021a.

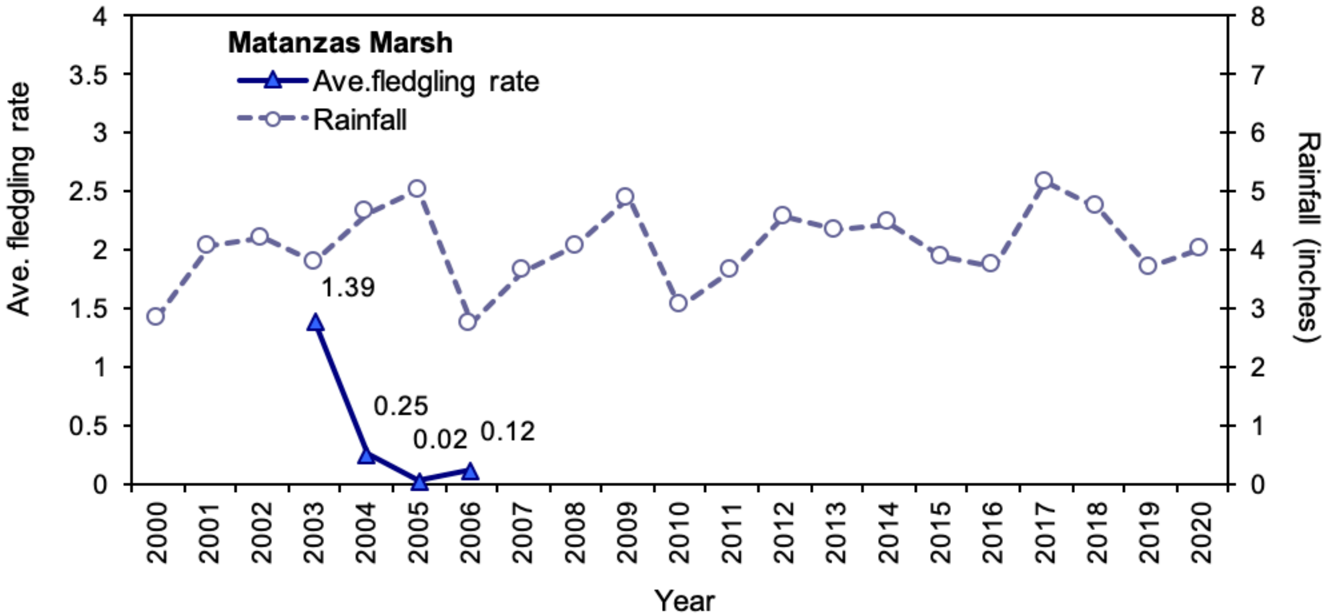


Figure 9. Average fledglings rate (chicks/nest/year) of wood storks at Matanzas Marsh (2003-2006). This colony is associated with an isolated cypress and gum–dominated dome. A total of 18-42 nests were recorded in 2005, and 68 nests in 2006. From 2007-2011 the nest count was zero each year (Source data: USFWS 2013. Southeast US Wood Stork Nesting Effort Database; Rodgers et al., 2008a, b). Annual average monthly rainfall SJWMD 2021a.

5. Contaminants

Appendix 5.1.A

Sediment Quality Guidelines Used in Contaminant Data Analysis[1,2]

Contaminant	Threshold Effects Level (TEL)	Probable Effects Level (PEL)
Copper (ppm)	18.7	108.2
Chromium	52.3	160.4
Zinc	124	271
Lead	30.24	112.18
Silver	0.73	1.77
Cadmium	0.676	4.21
Selenium	18.7	108.2
Mercury	0.13	0.696
Anthracene (ppb)	46.85	245
Acenaphthene	6.71	88.9
Naphthalene	34.57	390.64
Fluoranthene	112.82	1493.54
Benzo[a]anthracene	74.83	692.53
Pyrene	152.66	1397.6
Chrysene	107.77	845.98
Indeno(1,2,3-c,d)pyrene [4]	17.32	600
Dibenzo(a,h)anthracene	6.22	134.62
Benzo(g,h,i)perylene [5]	300	670
Benzo(a)pyrene	88.81	763.22
2-Methylnaphthalene	20.21	201.28
Benzo(b+k)Fluoranthene [6]	27.2	1800
Benzo(e)pyrene [3]	-	-
Perylene[3]	-	-
4,4'-DDT (ppb)	1.19	4.77
4,4'-DDD	1.22	7.81
4,4'-DDE	2.07	374.17
Aldrin [7]	-	9.5
Dieldrin	0.715	4.3
Heptachlor [8]	-	0.3
Heptachlor epoxide [9]	0.6	2.74
Endrin[9]	2.67	62.4
Endrin Aldehyde	-	-
Total PCBs (ppb)	21.55	188.79

1 National Oceanic and Atmospheric Administration. 1999. Screening Quick Reference Tools. Seattle (WA): Assessment and Restoration Division, Office of Response and Restoration.
2 MacDonald D.D. 1994 November. Chapter 6: Numerical Sediment Quality Assessment Guidelines for Florida Coastal Waters. Approach to the Assessment of Sediment Quality in Florida Coastal Waters. Vol 1. Development and Evaluation of Sediment Quality Assessment Guidelines. Tallahassee (FL): Report to Florida Department of Environmental Protection
3 Insufficient data to derive sediment quality assessment guidelines
4 Instead of marine TEL, used freshwater *Hyallella azteca* lowest adverse effects level; for PEL, used Apparent Effects Threshold based on Microtox assay
5 Instead of marine TEL, used freshwater Upper Effects Threshold, and for PEL, marine Apparent Effects Threshold, both based on Microtox
6 Instead of marine TEL, used freshwater *Hyallella azteca* lowest adverse effects level; for PEL, used Apparent Effects Threshold based on Echinoderm larvae, infaunal community impacts
7 Instead of marine PEL, used marine Apparent Effects Threshold based on amphipods and echinoderm larvae
8 Instead of marine PEL, used marine Apparent Effects Threshold based on bivalves
9 Instead of marine

Appendix 5.3.A

Steps for Calculating Estimated Total PCB Concentrations

1. Concentrations in sediments for PCBs 44, 52, 66, 105, 118, 128, 180, and 206 were compiled for each site for which data were available for all 8 congeners (out of the total 209 congeners that exist).
2. Concentrations in sediments for PCBs 44, 52, 66, 105, 118, 128, 180, and 206 were summed for each site.
3. The summed concentrations of the 8 congeners listed above were compared to the 23 congeners analyzed by Battelle and SJRWMD (1996-2003), and an average ratio of the concentrations of the 8 congeners to the concentrations of the 23 congeners was calculated and that ratio was 0.47. Thus, the 8 congeners we examined represented 47% of the amount of the 23 congeners that Battelle and SJRWMD analyzed.
4. Battelle and SJRWMD noted that the 23 congeners that they analyzed represented, on average, 42% of the total PCBs that exist (Durrell et al. 2004).
5. The ratio of the 8 congeners we examined to total PCB concentrations is 0.47 x 0.42 = 0.20; thus the 8 congeners we examined represent approximately 20% of the total PCBs.
6. The sum of the concentrations of the 8 congeners that we examined was multiplied by 5 to obtain an estimate of the total PCBs that were present at each site.