



Assessment of Estuarine Water and Sediment Quality at Timucuan Ecological and Historic Preserve *2018 Data Summary*

Natural Resource Data Series NPS/SECN/NRDS—2019/1236





ON THIS PAGE

Coastal assessment site TIMU-04 in Sisters Creek, near Timucuan Ecological and Historic Preserve. NPS photo / SECN.

ON THE COVER

View of the salt marsh and Pumpkin Hill Creek from coastal assessment site TIMU-12 near Timucuan Ecological and Historic Preserve. NPS photo / SECN.

Assessment of Estuarine Water and Sediment Quality at Timucuan Ecological and Historic Preserve

2018 Data Summary

Natural Resource Data Series NPS/SECN/NRDS—2019/1236

Eric N. Starkey, Wendy Wright, and Christopher S. Cooper

National Park Service
Southeast Coast Inventory and Monitoring Network
135 Phoenix Drive
Athens, GA 30605

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Summary and Key Findings

In July 2018 the Southeast Coast Network conducted an assessment of water quality at Timucuan Ecological and Historic Preserve as part of the National Park Service Vital Signs Monitoring Program.

Monitoring was conducted following methods developed by the Environmental Protection Agency (EPA) as part of the National Coastal Assessment Program (EPA 2010). Laboratory analysis measured chlorophyll *a* and total and dissolved concentrations of nitrogen and phosphorous. Field measurements included water temperature, pH, dissolved oxygen, and salinity. Water clarity, which requires a Secchi depth measurement, was obtained when possible. All measured parameters were rated as good, fair, or poor based on thresholds set by the EPA (2012).

- Water clarity was rated fair at sixteen sites (52%), poor at fourteen sites (45%), and could not be sampled at one site (3%).
- Chlorophyll *a* concentration was rated good at ten sites (32%), fair at fourteen sites (45%), and poor at seven sites (23%).
- Dissolved inorganic nitrogen (DIN) concentration was good at twenty-six sites (84%), and fair at the remaining five sites (16%).
- Dissolved inorganic phosphorus (DIP) concentration

was good at one site (3%), fair at twenty-nine sites (94%), and poor at one site (3%).

- Dissolved oxygen concentration was rated good at seventeen sites (55%) and fair at fourteen (45%).
- A water-quality condition summary index was calculated for each site sampled in Timucuan Ecological and Historic Preserve based on the categorical assessments of chlorophyll *a*, DIN and DIP concentrations, dissolved oxygen, and water clarity. This summary index indicated fair water-quality conditions at twenty-four sites (77%) and poor water-quality conditions at seven sites (23%).
- Based on the summary water-quality index rating, overall water-quality conditions at Timucuan Ecological and Historic Preserve during sampling in 2018 were poor. This rating is due to more than 20% of sites being ranked as having poor water-quality conditions resulting from low water clarity and elevated chlorophyll *a*.
- For sediment, ecological condition was ranked as good at thirty-one sites (100%). As a result, no adverse impacts to benthic organisms due to sediment contamination are anticipated at any of the sampled sites. This ranking was assigned according to the 2010 Environmental Protection Agency, National Coastal Condition Assessment (NCCA) thresholds for sediment chemistry.



Sunrise over Browns Creek near Timucuan Ecological and Historic Preserve. NPS photo / SECN.

Introduction

Water resources are important to park management from ecological, regulatory, and visitor experience perspectives; therefore, estuarine water quality in and around parks was selected as one of several vital signs to be monitored by the National Park Service (NPS) Inventory and Monitoring (I&M) Program (DeVivo et al. 2008). Data collected as a part of this effort are intended to foster a better understanding of water resources in and around parks and contribute to a better understanding of park ecological processes and physical systems (Gregory et al. 2013).

To effectively monitor a diverse and dynamic set of estuarine water resources, the NPS Southeast Coast I&M Network (SECN) implemented a two-pronged monitoring approach, which consists of collecting periodic discrete and continuously recorded data from fixed stations located in each park combined with periodic synoptic assessments of water quality at a larger spatial scale in the waters surrounding park areas (Gregory et al. 2013). When implemented together, these approaches give a more complete picture of physical processes, diurnal and seasonal variations, and spatial patterns during critical portions of the year.

The network identified four specific monitoring objectives for which data are collected and analyzed as part of this effort (Gregory et al. 2013):

1. Determine daily and seasonal water-quality patterns for five core parameters (dissolved oxygen, salinity, temperature, pH, and turbidity) at fixed monitoring stations using continuous data loggers.
2. Determine monthly and seasonal patterns in nutrient concentrations (nitrogen, phosphorus, and chlorophyll *a*) by collecting discrete water samples.
3. Determine status and spatial variability of water and nutrient chemistry conditions in estuarine waters every five years.
4. Determine status and spatial variability of benthic sediment quality (organic contaminants, carbon, and metal levels) in estuarine waters every ten years.

This report summarizes coastal water-quality monitoring data collected during a synoptic assessment to address objectives 3 and 4 at Timucuan Ecological and Historic Preserve. Data was gathered from 9 July to 12 July 2018. The purpose of this document is to report the most recently collected data from within the monument as part of an ongoing long-term water-quality monitoring program. This report was designed to provide water-quality monitoring data to managers as a concise summary in the context of applicable federal standards developed by the EPA. Previous synoptic assessments of water-quality conditions at Timucuan Ecological and Historic Preserve were conducted in July 2008 and August 2013 as part of I&M monitoring efforts (Gregory et al. 2011; Wright et al. 2013).

Study Area

Timucuan Ecological and Historic Preserve

Timucuan Ecological and Historic Preserve encompasses 18,600 hectares (46,000 acres) of salt marsh and coastal hammock habitat in addition to estuarine, marine, and brackish open waters (Figure 1). The park includes the seaward confluence of the Nassau and St. Johns Rivers and is along the northeastern coast of Florida in Duval County and entirely within the city limits of Jacksonville. Timucuan Ecological and Historic Preserve includes several rare and vulnerable natural communities including coastal strand, maritime hammock, scrub, and shell mound habitat. Other state and city parks in the area include Big and Little Talbot Island State Parks, Fort George Island Cultural State Park, Little Jetties Park, Huguenot Memorial Park, and the Sisters Creek Park and boat ramp (Anderson et al. 2005).

Water resources are an integral part of the park with approximately 75% of the protected area composed of wetlands and open water. These resources include numerous tidal creeks, portions of the Nassau and St. Johns Rivers, Sisters Creek/Intracoastal Waterway (ICWW), and the Fort George River. The park's estuarine setting serves as a vital ecological link between freshwater habitats and the ocean. The waters of Timucuan Ecological and Historic Preserve have been affected by land use in the surrounding watersheds. Examples of water-quality effects applicable to the park include nonpoint source pollution from urban and agricultural areas, elevated metal concentrations in the sediments of the St. Johns River, effects of several Superfund sites and landfills, and water pollution from malfunctioning septic systems within and adjacent to Timucuan Ecological and Historic Preserve (Anderson et al. 2005).

Timucuan Ecological and Historic Preserve Significant Waters Map

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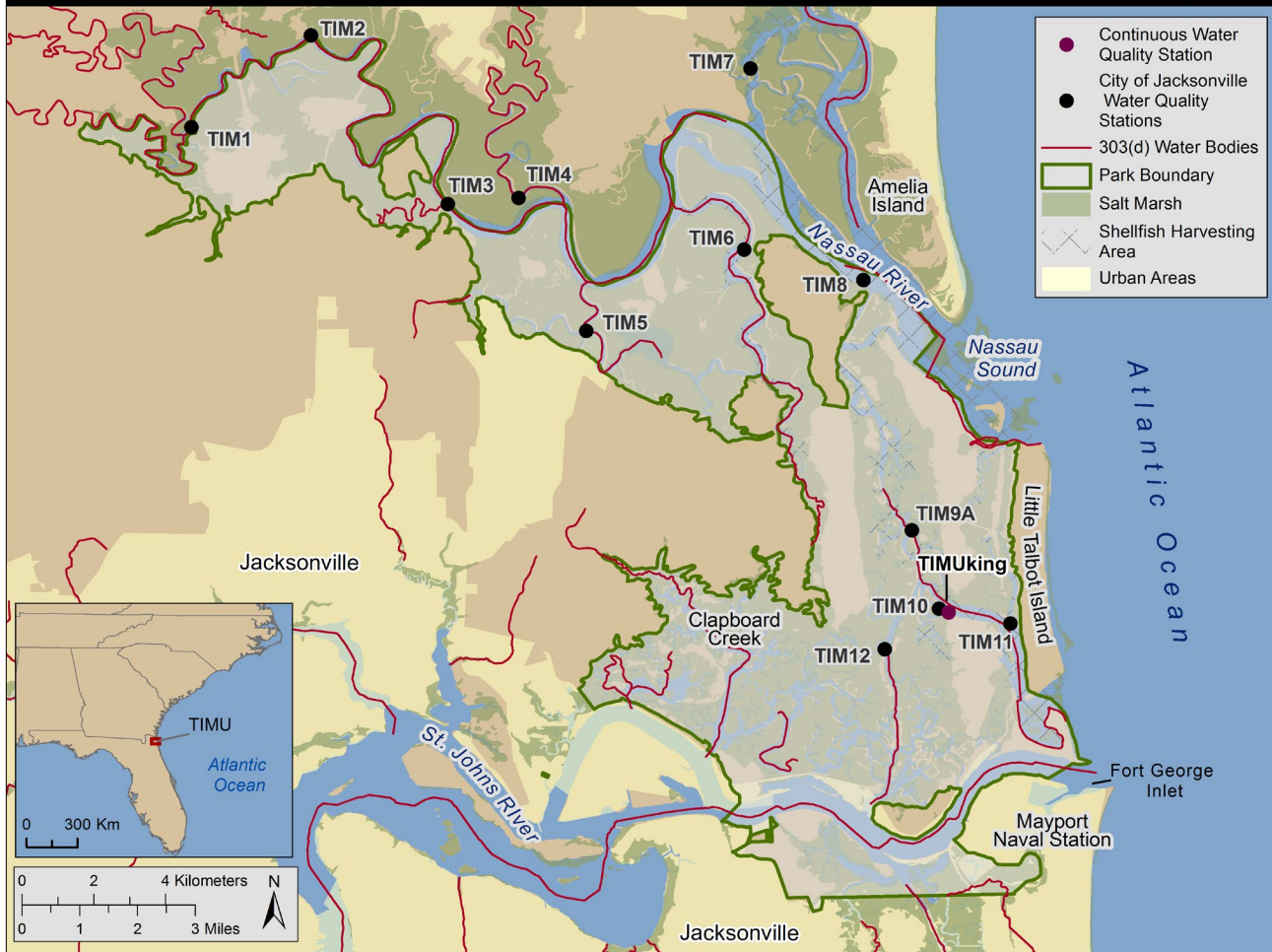


Figure 1. Map of Southeast Coast Network and City of Jacksonville fixed station sampling sites and significant waters near Timucuan Ecological and Historic Preserve in 2018. Indicated are areas of salt marsh (USFWS 2019), urbanized areas (USCB 2019), 303(d) listed water bodies (USEPA 2019), areas designated as having special uses or restrictions such as oyster harvest areas or inclusion on National Rivers Inventory (NPS 2009) and fixed station sites monitored by either the Southeast Coast Network or the City of Jacksonville.

Table 1. Site name, waterbody name and location, depth, coordinates, and chemical and physical attributes of sampling sites at Timucuan Ecological and Historic Preserve, July 9–12, 2018. The table references site names used to present data in this report (Figure 2). All coordinates are in NAD83 Datum, in UTM zone 17. Salinity, pH, and water temperature measured at a depth of 0.5 meters. ^aSampled at 0.1 meters due to shallow water. [SAV—sub-aquatic vegetation; m—meters; °C—degrees celcius; ppt—parts per thousand].

Site Name	Water Body	UTMX	UTMY	SAV	Debris	Site Depth (m)	Water Temp (°C)	pH	Salinity (ppt)
TIMU-01	Pumpkin Hill Creek	452333	3377160	No	No	3.8	29.5	7.3	19.4
TIMU-02	Nassau River	444457	3378877	No	No	5.3	29.6	6.9	9.5
TIMU-03	St. Johns River	460844	3363706	No	No	6.2	29.9	8.0	22.8
TIMU-04	Sisters Creek	456243	3362657	No	No	2.1	29.5	7.9	16.7
TIMU-05	Gunnison Cut	456596	3369649	No	No	1.2	31.0	7.8	24.6
TIMU-06	Nassau River	449592	3380721	No	No	1.3	30.2	7.2	16.9
TIMU-07	St. Johns River	452189	3362414	No	No	6.6	29.6	7.9	21.6
TIMU-08	Cedar Point Creek	454333	3365685	No	No	0.7	29.5	7.5	18.4
TIMU-09	Clapboard Creek	450157	3368778	No	No	5.6	29.5	7.4	13.7
TIMU-10	Nassau River	453247	3378776	No	No	6.1	29.6	7.9	31.5
TIMU-11 ^a	Sisters Creek	456579	3367931	No	No	0.6	31.2	7.7	23.1
TIMU-12	Pumpkin Hill Creek	453788	3374048	No	No	1.1	29.3	7.1	15.6
TIMU-13	Nassau River	448803	3376945	No	No	8.1	30.1	7.0	13.0
TIMU-14	Nassau River	454364	3377588	No	No	8.5	29.4	8.0	33.5
TIMU-15	Sisters Creek	456542	3362823	No	No	2.0	31.7	7.6	19.3
TIMU-16	Nassau River	455369	3377136	No	No	6.1	29.6	8.0	34.2
TIMU-17	Nassau River	447156	3378742	No	No	2.2	29.9	7.0	11.8
TIMU-18	Nassau River	443392	3381624	No	No	8.1	29.4	6.8	7.0
TIMU-19	St. Johns River	458997	3363687	No	No	4.2	29.4	8.1	33.1
TIMU-20	St. Johns River	456633	3361424	Yes	No	9.2	29.3	8.0	28.4
TIMU-21	Simpson Creek	459387	3368925	No	No	2.0	31.5	7.9	29.9
TIMU-22	Nassau River	450442	3381298	No	No	3.9	29.8	7.7	28.5
TIMU-23	St. Johns River	453260	3362696	No	No	4.1	29.8	7.9	19.4
TIMU-24	Clapboard Creek	451682	3366094	No	No	1.2	29.5	7.9	17.4
TIMU-25	Browns Creek	448152	3366268	No	No	1.2	29.7	7.8	20.6
TIMU-26	Nassau River	455572	3377681	No	No	2.8	29.2	8.0	34.8
TIMU-27	Deep Creek	457095	3364632	No	No	2.1	30.5	7.4	20.0
TIMU-28	Sawpit Creek	455149	3375654	No	No	2.2	29.8	7.9	32.0
TIMU-29	Nassau River	443670	3379604	No	No	1.4	29.4	6.9	11.8
TIMU-30	Nassau River	444843	3378329	No	No	2.0	30.0	6.8	8.0
TIMU-31 ^a	Nassau River	452990	3379368	No	No	0.8	29.8	7.8	30.4

Timucuan Ecological and Historic Preserve 2018 Coastal Assessment Sites

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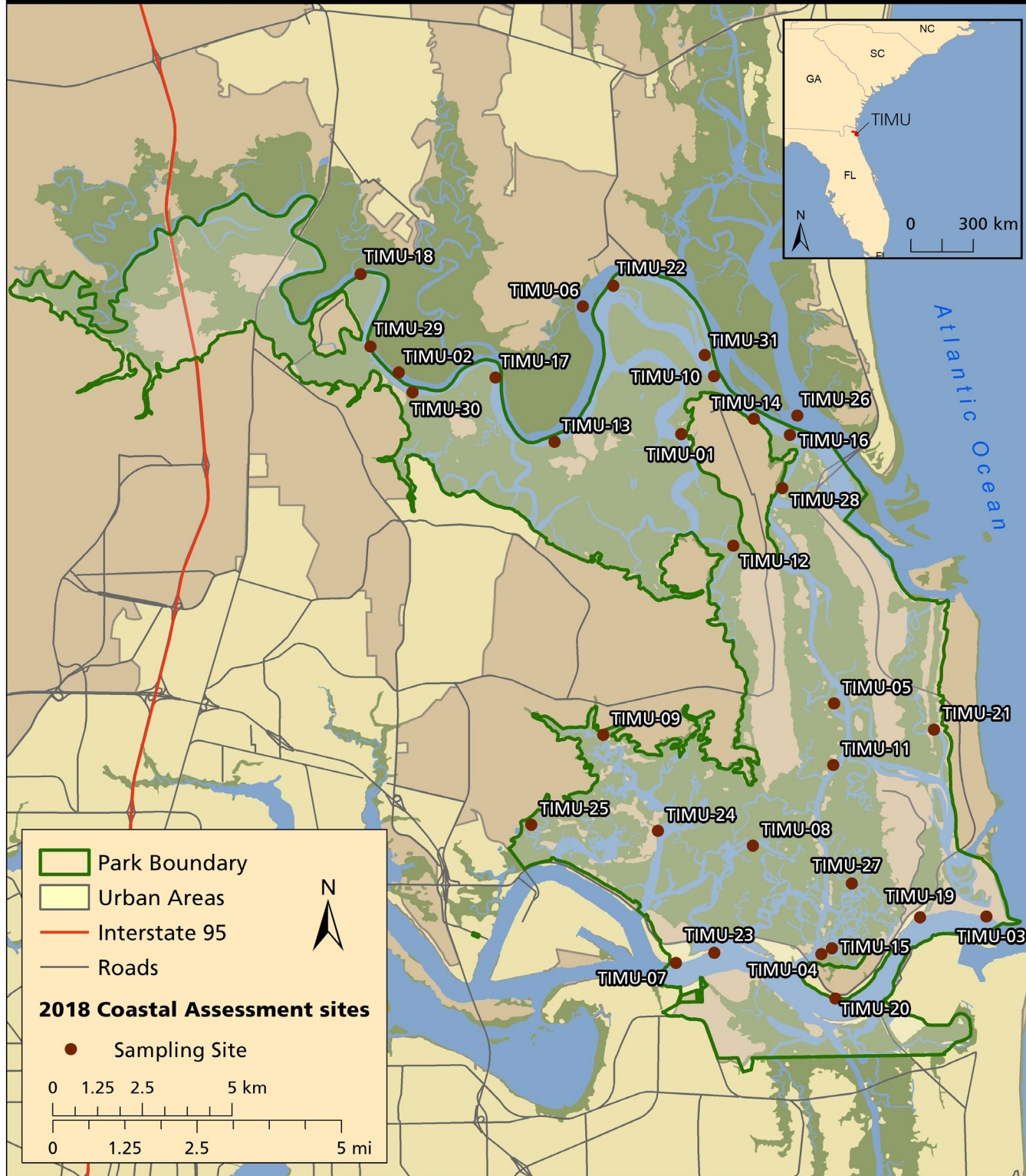


Figure 2. Map showing the location of coastal assessment sites sampled in July 2018 at Timucuan Ecological and Historic Preserve.

Methods

The water-quality assessment was conducted in estuarine and tidal creek waters in the vicinity of the preserve, following the methods developed by the Environmental Protection Agency (EPA) National Coastal Assessment Program (EPA 2010). Descriptions of the water-quality parameters and the assessment criteria are from the EPA National Coastal Assessment IV Report (EPA 2012). Methods used for these assessments were partially adapted and integrated into protocols tailored specifically to parks in the Southeast Coast Network (Gregory et al. 2013). Site selection and sampling methodology are briefly outlined in the following sections.

In 2018, thirty-one sites in the preserve's waters were randomly selected for monitoring following methods developed by the EPA (Table 1, Figure 2; Stevens 1997; Stevens and Olsen 1999; Stevens and Olsen 2004). A pool of alternate sites was selected in case any of the original sites were not accessible. This method of randomly selecting spatially-balanced sites provides managers with a statistically valid estimate of the overall conditions of the assessed resource within or around the park.

Water-Quality Data Collection

The water-quality assessment conducted during this sampling period incorporated hydrographic profiles at 0.5–1.0 meter (1.6–3.3 feet [ft]) intervals at each site, to measure temperature, pH, dissolved oxygen, and salinity. Chlorophyll *a* and total dissolved nutrient samples were collected from 0.5 meters (1.6 ft) below the surface. Chlorophyll *a* samples were processed using known volumes of water samples that were filtered onto glass-fiber filters then refrigerated and submitted for laboratory analysis.

Water clarity was estimated at each site using a Secchi disk to determine light extinction depths, which were converted to light attenuation coefficients (*k*) using the equation: $K = c / \text{Secchi depth (in meters)}$ where “*c*” is a constant that corresponds to the water body’s naturally occurring clarity conditions (i.e., *c* = 1.0 for naturally turbid conditions, *c* = 1.4 for normal turbidity conditions, or *c* = 1.7 for waters supporting submerged aquatic vegetation (SAV) restoration [Smith et al. 2006; EPA 2016]). Timucuan Ecological and Historic Preserve uses a coefficient of 1.4 for naturally turbid conditions. This method of estimating water-clarity condition is generally used when information on light transmission in the water column is missing. The Southeast Coast Network is reporting derived values to maintain data consistency across other network parks. Water clarity was not assessed at sites with excessive current or when they were too shallow to ascertain an accurate Secchi depth measurement. When sites were too shallow to access by boat, or when they were located in shipping channels, alternate sites were used.

Water-Quality Assessment Criteria

The categorical assessments (e.g., good, fair, poor) use measurements of chlorophyll *a*, nutrients, bottom dissolved oxygen, and water clarity (Table 2) and are intended to characterize acutely degraded water-quality conditions. The assessments do not consistently identify sites that experience occasional or infrequent hypoxia, nutrient enrichment, or decreased water clarity. Therefore, a rating of poor for the water-quality index means that the site likely exhibited consistently poor conditions before or after the assessment period. If a site is designated fair or good, the site did not experience poor conditions on the date of sampling; however, the site could be characterized by poor conditions for short time periods.

Table 2. Coastal water-quality monitoring condition criteria for water-quality parameters collected by the Southeast Coast Network. Based on thresholds set by the EPA (2012) [µg/L—micrograms per liter; mg/L—milligrams per liter].

Rating	Water Clarity (k) ¹	Chlorophyll <i>a</i> (µg/L)	Dissolved Inorganic Nitrogen (DIN) (mg/L)	Dissolved Inorganic Phosphorus (DIP) (mg/L)	Dissolved Oxygen (mg/L)
Good	< 1.61	< 5	< 0.1	< 0.01	> 5
Fair	1.61–2.30	5–20	0.1–0.5	0.01–0.05	2–5
Poor	> 2.30	> 20	> 0.5	> 0.05	< 2

¹Light attenuation coefficients (*k*) were used to assess water-clarity conditions using criteria categories in Smith et al. (2006) which are comparable to the EPA (2012) criteria for the assessed water bodies.

Table 3. Condition criteria used for water-quality assessment summaries at individual sampling sites and parks.

Rating	Site Water-Quality Index Rating ¹	Park Water-Quality Index Rating
Good	A maximum of one indicator is rated fair, and no indicators are rated poor.	Less than 10% of sites are in poor condition, and more than 50% of sites are in good condition.
Fair	One indicator is rated poor, or two or more indicators are rated fair.	10% to 20% of sites are in poor condition, or 50% or less of sites are in good condition.
Poor	Two or more of the five indicators are rated poor.	More than 20% of sites are in poor condition.
Missing	Two components of the indicator are missing and the available indicators do not suggest a fair or poor rating.	NA

¹Park and site water-quality index ratings are adapted from ratings established by the EPA (2012).

Site assessments were also made using an index that combines the ratings for each parameter into a site-specific water-quality index rating. This index allows for general comparisons between sites in a park (Table 3) and can be used to summarize overall conditions in the waters around a park. This rating also allows general comparisons between parks based on the percentage of sites that fall within the good, fair, or poor categories.

Sediment Data Collection

Sediment samples were collected by taking multiple grabs at each site using a 6.8-kilogram (kg; 24-pound [lbs]) Ponar Sampler with a sample area of 152 × 152 millimeter (mm; 6 × 6 inches [in]). The top 23 centimeters (cm; 0.78–1.2 in) from each sample were composited and split into three separate samples that were analyzed for organic contaminants, metals, total organic carbon (TOC), and grain size. Samples were stored on wet ice or in a refrigerator until completion of analysis by the contracted laboratory.

Sediment Assessment Criteria

The Southeast Coast Network uses Environmental Protection Agency (EPA) National Coastal Condition Assessment (NCCA) sediment quality guidelines (SQG) for estuarine waters to assess the degree of sediment contamination. These SQGs include the mean Effects-Range Median Quotient (mERM-Q) and Logistic Regression Model (LRM). Together, the mERM-Q and LRM provide a holistic interpretation of sediment chemistry and its potential effects on benthic organisms.

Table 4. Thresholds for sediment chemistry used to determine ecological condition by site (U.S. EPA 2010) [mERM-Q—mean Effects-Range Median Quotient; LRM—Logistic Regression Model; Pmax—maximum probability].

Rank	Threshold
Good	mERM-Q < 0.1 and LRM Pmax ≤ 0.5
Fair	mERM-Q ≥ 0.1 - ≤ 0.5 or LRM Pmax > 0.5 - < 0.75
Poor	mERM-Q > 0.5 or LRM Pmax ≥ 0.75

The mERM-Q approach assesses the relative degree of sediment contamination and estimates the probability of toxicity to benthic organisms from sediment contaminants (EPA 2016). Calculation of mERM-Q relies upon the Effects Range Low (ERL) and Effects Range Median (ERM) values shown in Table 4. ERM is the median concentration of a contaminant observed to have adverse biological effects in the literature studies examined. While ERL is the 10th percentile concentration of a contaminant represented by studies demonstrating adverse biological effects in the literature. Ecological effects are not likely to occur at contaminate concentrations below the ERL criterion.

The LRM approach calculates the probability of observing a toxic effect based on individual contaminant concentrations and the maximum probability (Pmax) of observing toxicity from all contaminants in a sample (EPA 2016). Values used in the LRM-Pmax calculation (B_0 and B_1) can be found in Table 5.

Previous coastal assessments conducted by the network and the EPA used % Total Organic Carbon (TOC) as a rating factor for sediment quality. However, in 2010, the EPA updated its methods to reflect current practices and %TOC is no longer a component of the sediment quality index. As a result, %TOC has been reported below for comparison with past reports, but was not used in determination of ecological condition by site.

Table 5. Sediment quality guideline values used to calculate mERM-Q and LRM-Pmax (EPA 2016).

Sediment Chemicals Analyzed	Units	ERL	ERM	Used to calculate mERM-Q	B ₀	B ₁	Used to calculate LRM-Pmax
Antimony	µg/g	–	–	–	-0.9005	2.411	X
Arsenic	µg/g	8.2	70	X	-4.1407	3.1674	X
Cadmium	µg/g	1.2	9.6	X	-0.34	2.5073	X
Chromium	µg/g	81	370	X	-6.4395	2.9952	X
Copper	µg/g	34	270	X	-5.7878	2.9325	X
Lead	µg/g	46.7	218	X	-5.4523	2.7662	X
Mercury	µg/g	0.15	0.71	X	0.8041	2.5461	X
Nickel	µg/g	20.9	51.6	–	-4.6119	2.7658	X
Silver	µg/g	1	3.7	X	-0.1117	1.9684	X
Zinc	µg/g	150	410	X	-7.9834	3.342	X
Acenaphthene	ng/g	16	500	X	-3.6165	1.7532	X
Acenaphthylene	ng/g	44	640	X	-2.962	1.3797	X
Anthracene	ng/g	85.3	1100	X	-3.6574	1.4854	X
Fluorene	ng/g	19	540	X	-3.7146	1.8071	X
2-methylnapthalene	ng/g	70	670	X	-3.7579	1.7833	X
Napthalene	ng/g	160	2100	X	-3.7753	1.6152	X
Phenanthrene	ng/g	240	1500	X	-4.4576	1.6768	X
Benz(a)anthracene	ng/g	261	1600	X	-4.2013	1.5747	X
Benzo(a)pyrene	ng/g	430	1600	X	-4.3005	1.5832	X
Chrysene	ng/g	384	2800	X	-4.3241	1.5372	X
Dibenz(a,h)anthracene	ng/g	63.4	260	X	-3.6308	1.7692	X
Fluoranthene	ng/g	600	5100	X	-4.4574	1.4787	X
Pyrene	ng/g	665	2600	X	-4.708	1.5854	X
Total DDT	ng/g	1.6	46.1	X	–	–	–
Total PCB congeners	ng/g	22.7	180	X	-3.4613	1.3488	X
Total PAHs*	ng/g	4020	44800	–	–	–	–

Results

Parameter-Based Water Condition Assessments

Figures 3–7 illustrate the spatial distribution of sampling sites and the corresponding ratings for water clarity, chlorophyll *a*, dissolved inorganic nitrogen (DIN), dissolved inorganic phosphorus (DIP), and bottom-reading dissolved oxygen (DO) based on each parameter's corresponding condition category. Inset graphs on Figures 3–7 show the proportion of sites in the assessed area that were placed in each rating category. The map and graph in Figure 8 summarize preserve-wide water quality. Site-specific water-quality data for each parameter are also presented in Table 6.

Water clarity was rated fair at sixteen sites (52%), poor at fourteen sites (45%), and could not be evaluated at one site (3%) due to strong current.

Chlorophyll *a* concentration was rated good at ten sites (32%), fair at fourteen sites (45%), and poor at seven sites (23%) sampled in 2018.

Dissolved inorganic nitrogen (DIN) concentration was good at twenty-six sites (84%), and fair at the remaining five sites (16%).

Dissolved inorganic phosphorus (DIP) concentration was good at one site (3%), fair at twenty-nine sites (94%), and poor at one site (3%).

Dissolved oxygen concentration was rated good at seventeen sites (55%) and fair at fourteen (45%).

A water-quality condition summary index was calculated for each site sampled in Timucuan Ecological and Historic Preserve based on the categorical assessments of water clarity, chlorophyll *a*, DIN and DIP concentrations, and dissolved oxygen. This summary index indicated fair water-quality conditions at 24 sites (77%) and poor water-quality conditions at 7 sites (23%). The most common causes of poor ratings were water clarity and elevated chlorophyll *a* concentrations.

Based on the summary water-quality index rating, overall water-quality conditions at Timucuan Ecological and Historic Preserve during sampling in 2018 were poor. This rating is due to more than 20% of sites being ranked as having poor water-quality conditions resulting from low water clarity and elevated chlorophyll *a*.

Sediment Condition Assessments

Metal and organic contaminant concentration data is provided in Tables 7, 8a, and 8b. Figure 9 is a map which show the spatial distribution of sampling sites and the corresponding ratings for ecological condition based on sediment chemistry. The inset graph shows the percentage of sites in each ecological condition rating category (good, fair, poor). Data used to make the map and graph are shown in Table 9. Ecological condition was ranked as good at thirty-one sites (100%). As a result, no adverse impacts to benthic organisms due to sediment contamination are anticipated at any of the sampled sites. These rankings were assigned according to the 2010 Environmental Protection Agency, National Coastal Condition Assessment (NCCA) thresholds for sediment chemistry.

Timucuan Ecological and Historic Preserve Water Clarity (k)

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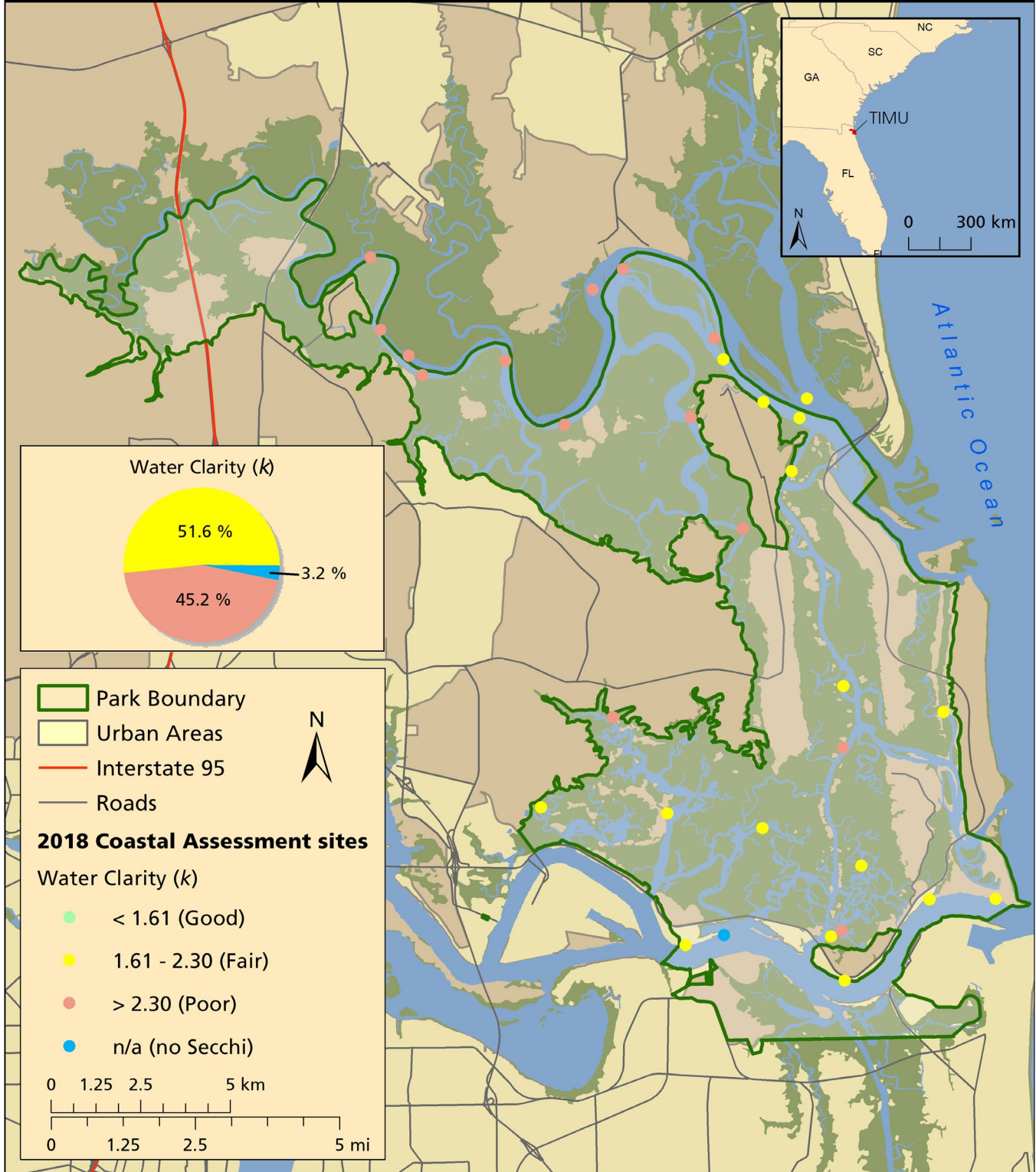


Figure 3. Water clarity ratings at sampling sites at Timucuan Ecological and Historic Preserve in July 2018. Inset graph shows the percent of sites in each condition category [yellow—fair; red—poor; blue—n/a].

Timucuan Ecological and Historic Preserve Chlorophyll a

Southeast Coast Network
National Park Service
U.S. Department of the Interior

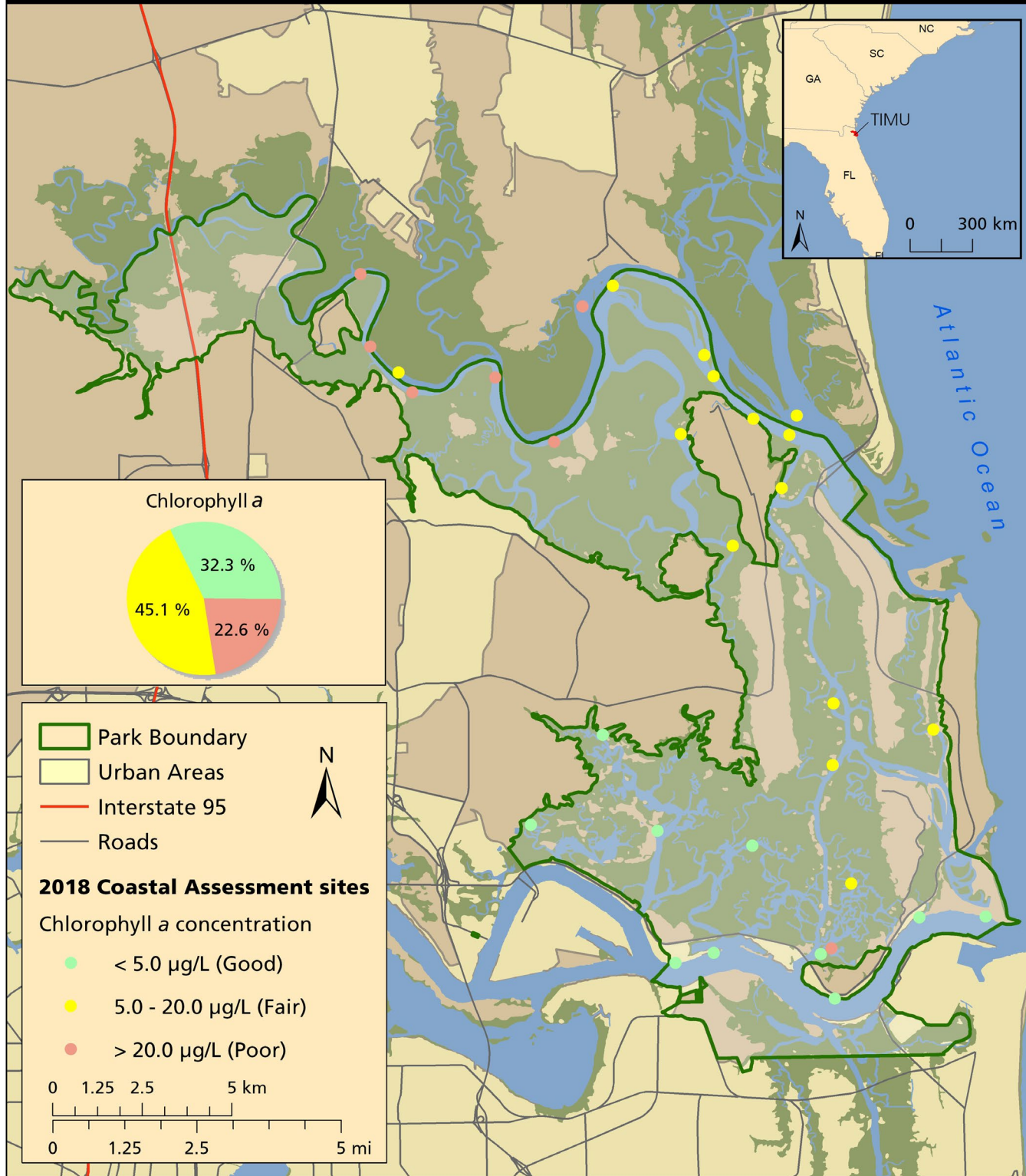


Figure 4. Chlorophyll a concentrations at Timucuan Ecological and Historic Preserve in July 2018. Inset graph shows the percent of sites in each condition category [green—good; yellow—fair; red—poor].

Timucuan Ecological and Historic Preserve Dissolved Inorganic Nitrogen

Southeast Coast Network
National Park Service
U.S. Department of the Interior

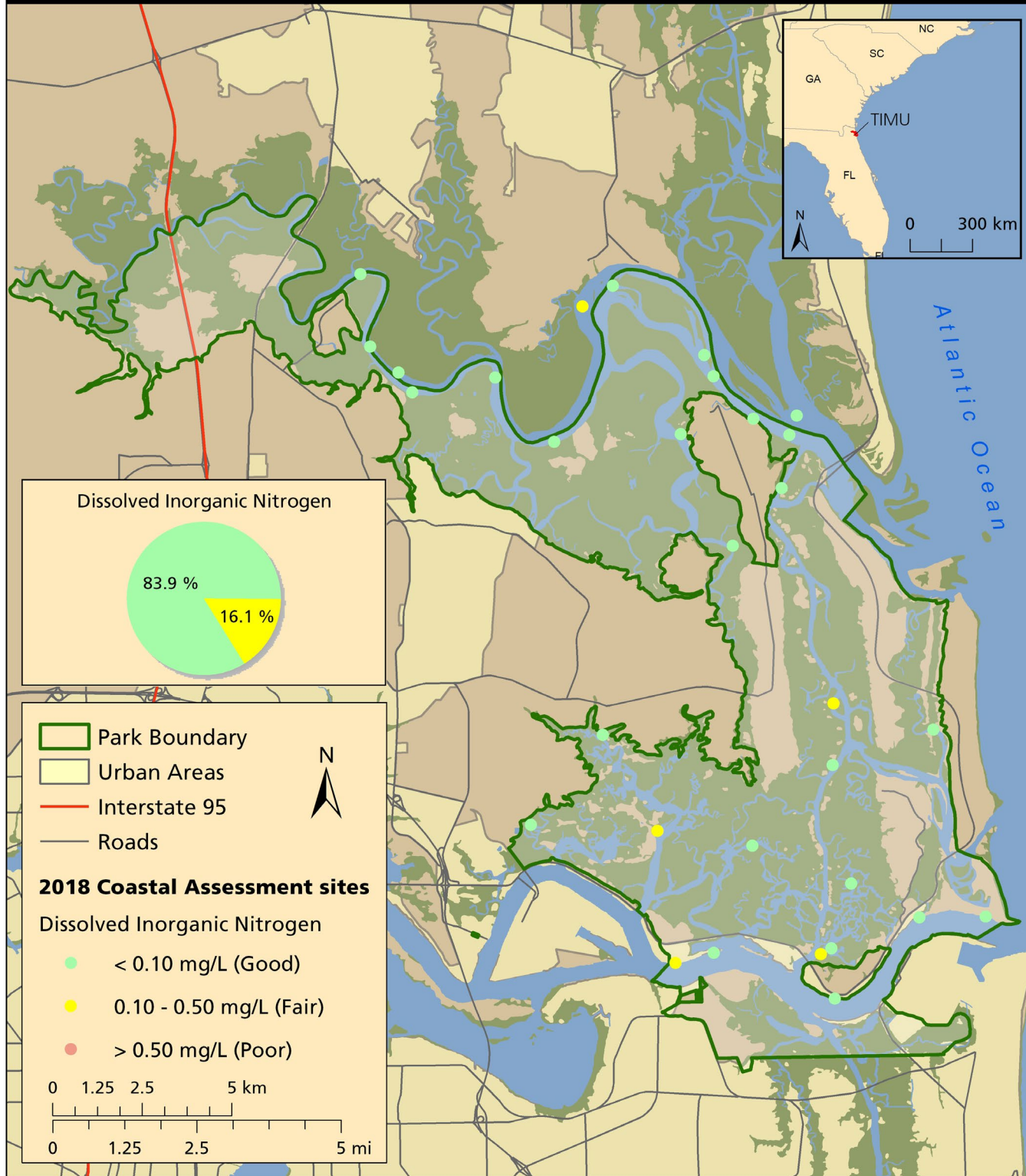


Figure 5. Dissolved inorganic nitrogen concentrations at sampling sites at Timucuan Ecological and Historic Preserve in July 2018. Inset graph shows the percent of sites in each condition category [green—good; yellow—fair].

Timucuan Ecological and Historic Preserve Dissolved Inorganic Phosphorus

Southeast Coast Network
National Park Service
U.S. Department of the Interior

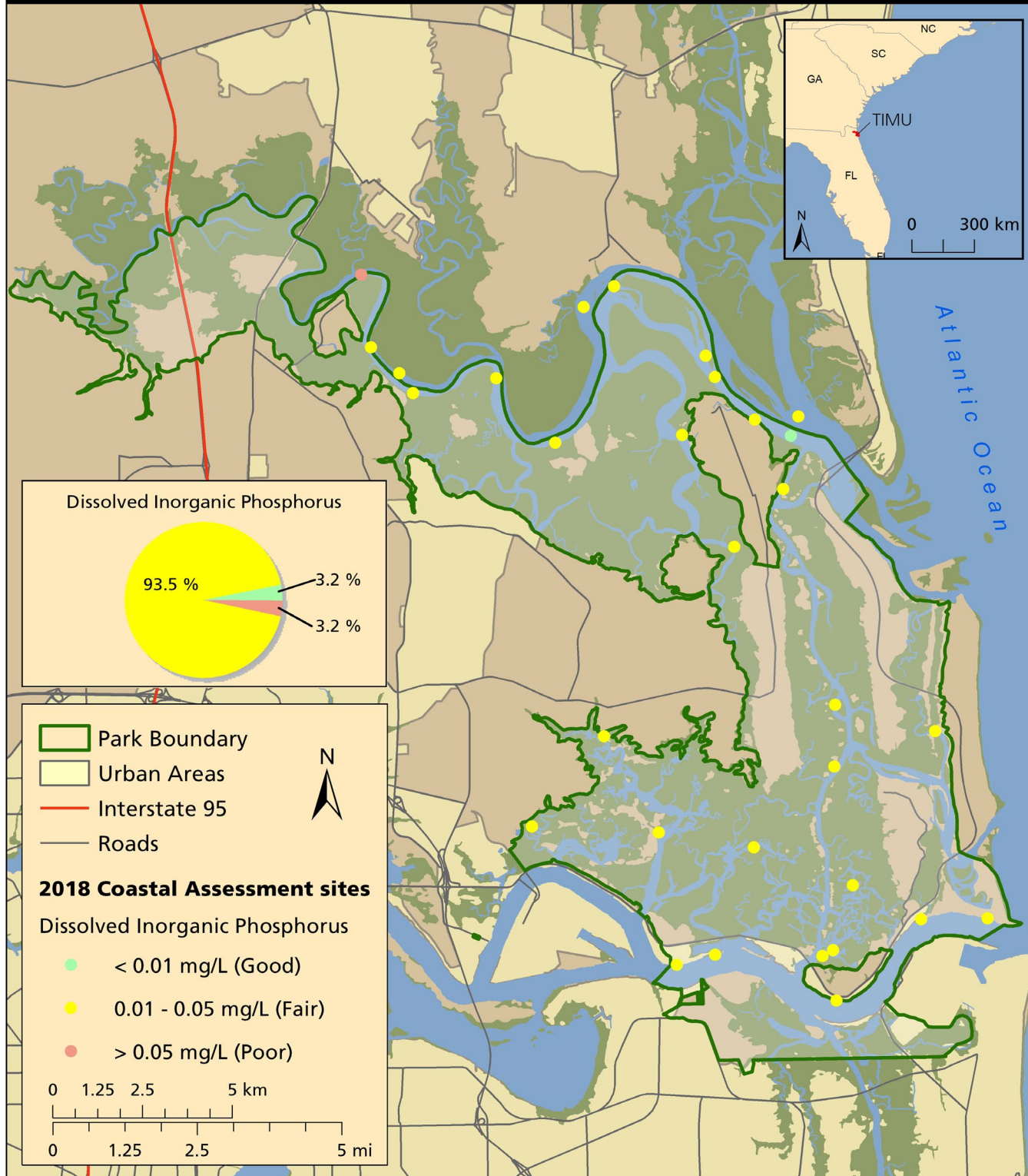


Figure 6. Dissolved inorganic phosphorus concentrations at sampling sites at Timucuan Ecological and Historic Preserve in July 2018. Inset graph shows the percent of sites in each condition category [green—good; yellow—fair; red—poor].

Timucuan Ecological and Historic Preserve Dissolved Oxygen

Southeast Coast Network
National Park Service
U.S. Department of the Interior

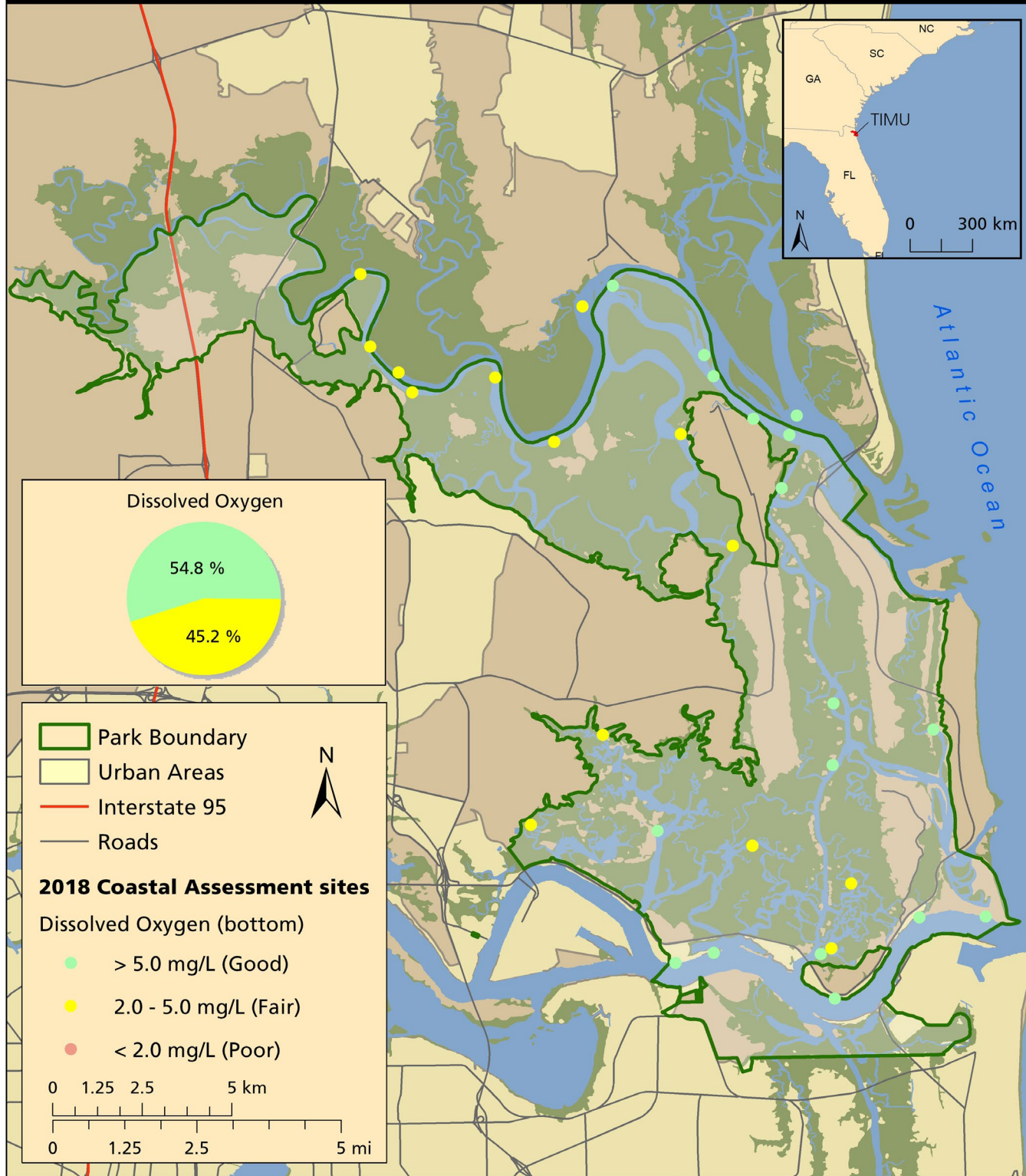


Figure 7. Dissolved oxygen concentrations at sampling sites at Timucuan Ecological and Historic Preserve in July 2018. Inset graph shows the proportion of sites in each condition category [green—good; yellow—fair].

Timucuan Ecological and Historic Preserve Site Water Quality Index Ratings

Southeast Coast Network
National Park Service
U.S. Department of the Interior

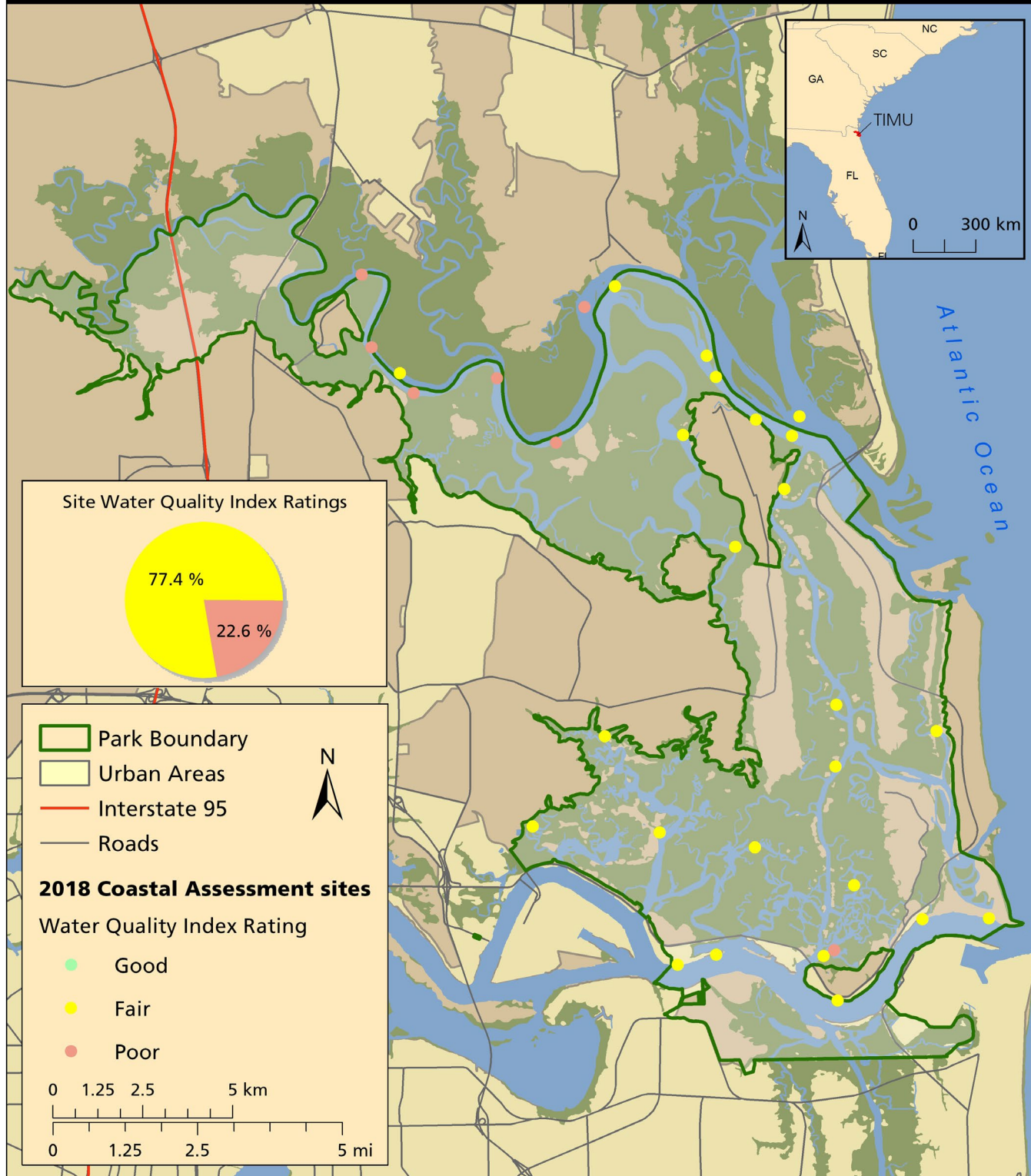


Figure 8. Water-quality index rating at sampling sites in the vicinity of Timucuan Ecological and Historic Preserve in July 2018. Inset graph shows the proportion of sites in each condition category [yellow—fair; red—poor].

Timucuan Ecological and Historic Preserve Ecological Condition

Southeast Coast Network
National Park Service
U.S. Department of the Interior

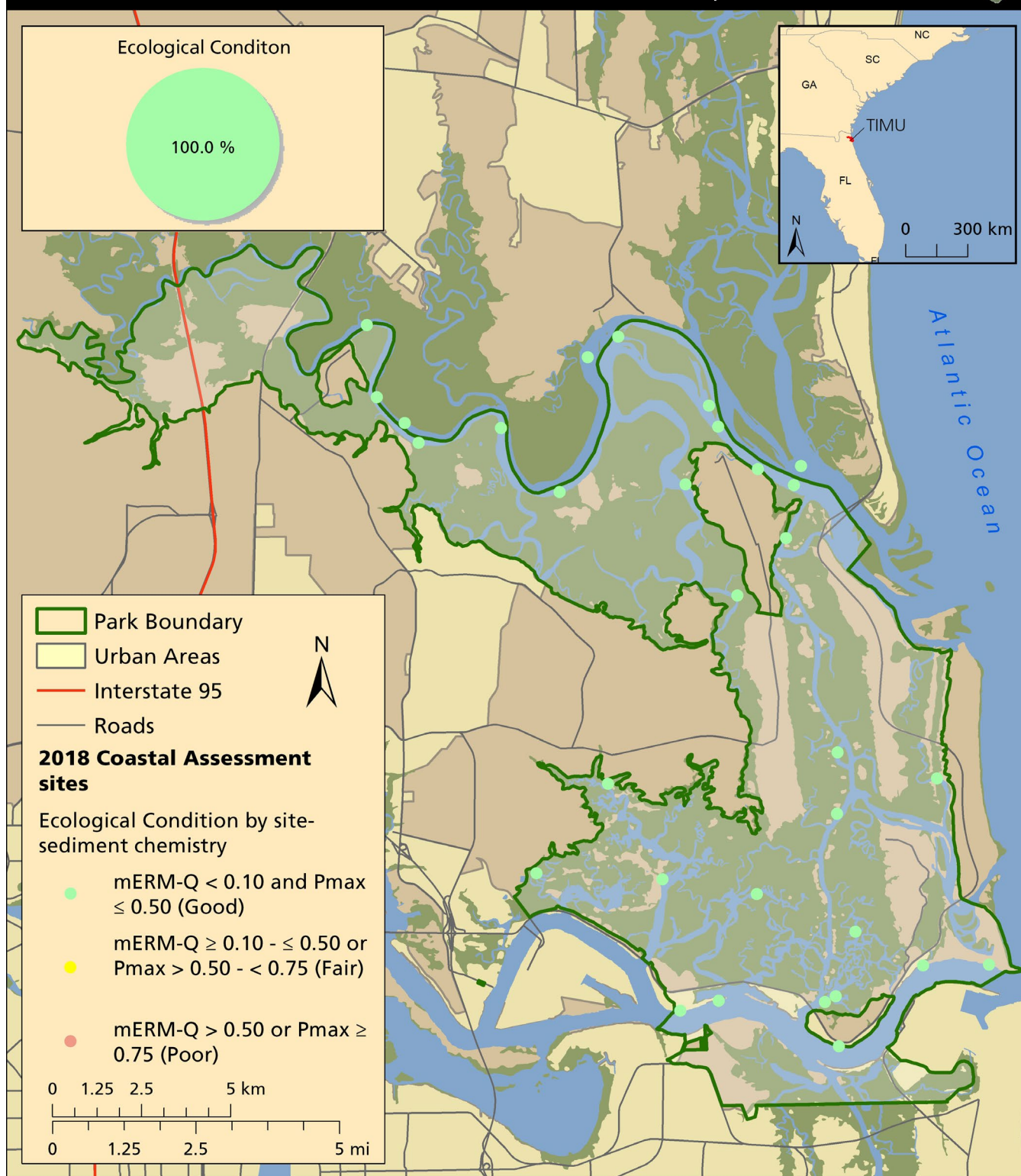


Figure 9. Spatial distribution of sampling sites and the corresponding ratings for ecological condition based on sediment chemistry. Inset graph shows the proportion of sites in each condition category [green—good].

Water-Quality Data

Table 6. Water-quality parameter values and assessment conditions for sampling sites in the vicinity of Timucuan Ecological and Historic Preserve July 9–12, 2018. Water clarity was assessed using light attenuation values (k) using a constant (1.4) for estuarine waters with naturally turbid conditions (Smith et al. 2006) and assessment categories that correspond to EPA (2012). Condition of other assessed parameters based on EPA (2012) [Green^a—good; yellow^b—fair; red^c—poor; k—light attenuation coefficient; µg/L—micrograms per liter; N—Nitrogen; mg/L—milligrams per liter; P—Phosphorous; – — data not collected;]. Dissolved oxygen concentrations are taken near the bottom (deepest reading).

Site Name	Water Clarity (k ¹)	Chlorophyll a (µg/L)	Dissolved Oxygen (DO, mg/L)	Dissolved Inorganic N (DIN, mg/L)	Dissolved Inorganic P (DIP, mg/L)	Total Dissolved N ² (mg/L)	Total Dissolved P ² (mg/L)
TIMU-01	2.8 ^c	16.74 ^b	4.3 ^b	0.039 ^a	0.0189 ^b	0.49	0.039
TIMU-02	4.7 ^c	18.07 ^b	4.0 ^b	0.095 ^a	0.0456 ^b	0.78	0.067
TIMU-03	1.9 ^b	3.23 ^a	6.1 ^a	0.087 ^a	0.0378 ^b	0.47	0.053
TIMU-04	1.9 ^b	3.20 ^a	5.3 ^a	0.115 ^b	0.0482 ^b	0.57	0.062
TIMU-05	1.9 ^b	12.04 ^b	6.1 ^a	0.120 ^b	0.0207 ^b	0.40	0.040
TIMU-06	4.7 ^c	23.64 ^c	4.9 ^b	0.150 ^b	0.0237 ^b	0.06	0.048
TIMU-07	2.3 ^c	3.10 ^a	5.4 ^a	0.110 ^b	0.0386 ^b	0.46	0.053
TIMU-08	2.0 ^b	3.49 ^a	4.3 ^b	0.075 ^a	0.0413 ^b	0.56	0.062
TIMU-09	2.8 ^c	4.92 ^a	4.5 ^b	0.067 ^a	0.0455 ^b	0.61	0.068
TIMU-10	2.3 ^b	9.97 ^b	5.2 ^a	0.007 ^a	0.0122 ^b	0.29	0.032
TIMU-11	3.5 ^c	13.38 ^b	5.8 ^a	0.012 ^a	0.0204 ^b	0.41	0.041
TIMU-12	2.8 ^c	15.57 ^b	3.6 ^b	0.014 ^a	0.0176 ^b	0.64	0.039
TIMU-13	5.6 ^c	23.57 ^c	4.4 ^b	0.025 ^a	0.0319 ^b	0.68	0.056
TIMU-14	2.3 ^b	14.03 ^b	5.5 ^a	0.007 ^a	0.0100 ^b	0.20	0.025
TIMU-15	2.8 ^c	21.09 ^c	4.8 ^b	0.048 ^a	0.0363 ^b	0.47	0.055
TIMU-16	1.8 ^b	5.54 ^b	5.7 ^a	0.007 ^a	0.0082 ^a	0.20	0.027
TIMU-17	5.6 ^c	25.14 ^c	4.3 ^b	0.034 ^a	0.0359 ^b	0.68	0.057
TIMU-18	3.5 ^c	21.05 ^c	3.8 ^b	0.079 ^a	0.0546 ^c	0.85	0.077
TIMU-19	1.8 ^b	3.94 ^a	6.2 ^a	0.034 ^a	0.0157 ^b	0.29	0.032
TIMU-20	1.8 ^b	2.66 ^a	6.0 ^a	0.068 ^a	0.0293 ^b	0.35	0.043
TIMU-21	1.9 ^b	6.41 ^b	6.6 ^a	0.024 ^a	0.0151 ^b	0.31	0.039
TIMU-22	2.8 ^c	17.05 ^b	5.1 ^a	0.007 ^a	0.0138 ^b	0.36	0.035
TIMU-23	—	2.86 ^a	5.1 ^a	0.090 ^a	0.0424 ^b	0.49	0.056
TIMU-24	1.9 ^b	2.33 ^a	5.2 ^a	0.101 ^b	0.0460 ^b	0.54	0.061
TIMU-25	2.3 ^b	2.81 ^a	4.7 ^b	0.074 ^a	0.0426 ^b	0.50	0.061
TIMU-26	1.8 ^b	11.56 ^b	5.4 ^a	0.008 ^a	0.0106 ^b	0.17	0.025
TIMU-27	2.3 ^b	15.69 ^b	4.2 ^b	0.042 ^a	0.0358 ^b	0.52	0.061
TIMU-28	1.9 ^b	7.17 ^b	5.6 ^a	0.023 ^a	0.0116 ^b	0.25	0.030
TIMU-29	5.6 ^c	42.92 ^c	4.0 ^b	0.055 ^a	0.0348 ^b	0.64	0.054
TIMU-30	5.6 ^c	26.70 ^c	4.3 ^b	0.090 ^a	0.0475 ^b	0.77	0.070
TIMU-31	2.8 ^c	14.73 ^b	5.2 ^a	0.023 ^a	0.0134 ^b	0.31	0.031

¹Light attenuation coefficients (k) were used to assess water-clarity conditions using criteria categories in Smith et al. (2006) which are comparable to the EPA (2012) criteria for the assessed water bodies.

²There are no EPA condition criteria for TDN and TDP.

Table 7. Concentrations of select metals for sites sampled at Timucuan Ecological and Historic Preserve, July 9–12, 2018. All results are presented in mg/kg [*—result was greater than or equal to the Method Detection Limit (MDL) but below the Practical Quantitation Limit (PQL); **—result was less than the Method Detection Limit]. **Note:** No sediment sample was taken at Site TIMU-23 due to strong current and rocky/oyster laden substrate.

Site	Antimony	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Zinc
TIMU-01	0.6**	1.3*	0.081*	5.9	0.79*	2.2	0.0095	2.5	5.6
TIMU-02	0.55**	0.69**	0.044**	2.9	0.45**	1.1	0.0044*	1.2	2.8
TIMU-03	0.52*	0.99*	0.041**	0.95	0.43**	0.19**	0.0021*	0.18*	1.5
TIMU-04	1.2*	6.7	0.47	26	8.2	10	0.044	13	45
TIMU-05	1.5**	12	0.81	43	8.9	14	0.045	22	54
TIMU-06	0.51**	0.69*	0.04**	1.3	0.42**	0.54*	0.0023*	0.47	1.5
TIMU-07	0.57**	1.3*	0.07*	4.1	0.85*	1.6	0.01	1.6	5.7
TIMU-08	0.69**	2.8*	0.19*	11	3	5	0.025	4.9	16
TIMU-09	0.75**	3.5*	0.24*	11	2.9	4.5	0.024	6	17
TIMU-10	0.54**	0.68**	0.043**	1.6	0.45**	0.62*	0.0026*	0.45	1.7
TIMU-11	0.53**	1.3*	0.098*	5.5	0.74*	2.1	0.0041*	2.1	5.7
TIMU-12	0.5**	5	0.29	13	2.4	4.5	0.021	7.3	18
TIMU-13	0.5**	0.64**	0.043*	0.92	0.42**	0.19**	0.0019*	0.23*	1.2
TIMU-14	0.72*	5	0.041**	2.1	0.42**	0.19**	0.006	1.4	3.2
TIMU-15	0.61**	2.7*	0.2*	9.5	2.9	3.9	0.021	4.4	17
TIMU-16	0.59*	2*	0.038**	1.4	0.39**	0.17**	0.0028*	0.59	1.9
TIMU-17	0.54**	0.72*	0.043**	2.6	0.62*	1.3	0.0035*	0.95	2.2
TIMU-18	0.6**	0.79*	0.048**	2.4	0.5**	1.2	0.0068*	1.1	2.8
TIMU-19	0.52**	0.88*	0.041**	1.6	0.43**	0.46*	0.003*	0.29*	1.6
TIMU-20	0.64**	2.7*	0.16*	9.2	1.8	3.1	0.022	4.1	12
TIMU-21	0.49**	0.84*	0.039**	2	0.41**	0.62*	0.00086**	0.58	2
TIMU-22	0.48**	0.61**	0.039**	0.86	0.4**	0.36*	0.00083**	0.19*	1
TIMU-24	0.79**	4.5	0.36	14	5.1	7.4	0.051	7.4	29
TIMU-25	1.3**	9.3	0.76	29	11	14	0.11	18	63
TIMU-26	0.53**	2*	0.091*	5.3	0.62*	1.3	0.0038*	2.6	5.2
TIMU-27	0.84*	3.8	0.051**	5.4	0.7*	0.24**	0.0088	2.7	9.3
TIMU-28	0.56**	1.6*	0.078*	4.2	0.47**	1.5	0.0069	1.7	4.2
TIMU-29	0.49**	3.2	0.2	11	1.7	3.6	0.018	5.5	12
TIMU-30	0.46**	2*	0.17*	8.9	1.2	3.2	0.013	4.3	9.7
TIMU-31	0.58**	1.6*	0.089*	5	0.48**	1.5	0.0057*	1.9	5.3

Table 8a. Organic contaminant concentrations (Acenaphthene–Chrysene) for sites sampled at Timucuan Ecological and Historic Preserve, July 9–12, 2018. All results are presented in mg/kg.[*—result was greater than or equal to the Method Detection Limit (MDL) but below the Practical Quantitation Limit (PQL); **—result was less than the MDL]. **Note:** No sediment sample was taken at Site TIMU-23 due to strong current and rocky/oyster laden substrate.

Site	Acenaph- thene	Acenaph- thylene	Anthracene	Fluorene	2-Methyl- naphthalene	Naphthalene	Phenan- threne	Benzo(A) Anthracene	Benzo(A) Pyrene	Chrysene
TIMU-01	0.0049**	0.0065**	0.0067**	0.0056**	0.047	0.064	0.0058**	0.0078**	0.011**	0.0082**
TIMU-02	0.0043**	0.0057**	0.006**	0.0049**	0.0039**	0.004**	0.0052**	0.007**	0.0098**	0.0073**
TIMU-03	0.0042**	0.0055**	0.0057**	0.0047**	0.0037**	0.0039**	0.005**	0.0067**	0.0094**	0.007**
TIMU-04	0.0092**	0.012**	0.013**	0.01**	0.0081**	0.0085**	0.011**	0.015**	0.021**	0.015**
TIMU-05	0.012**	0.016**	0.016**	0.014**	0.011**	0.011**	0.014**	0.019**	0.027**	0.02**
TIMU-06	0.0041**	0.0055**	0.0057**	0.0047**	0.0037**	0.0038**	0.0049**	0.0066**	0.0094**	0.007**
TIMU-07	0.0045**	0.006**	0.0062**	0.0051**	0.004**	0.0042**	0.0054**	0.0072**	0.01**	0.0076**
TIMU-08	0.0055**	0.0073**	0.0076**	0.0063**	0.0049**	0.0051**	0.0066**	0.0088**	0.012**	0.0093**
TIMU-09	0.006**	0.008**	0.0083**	0.0069**	0.0054**	0.0056**	0.0072**	0.0097**	0.014**	0.01**
TIMU-10	0.017**	0.023**	0.024**	0.02**	0.046	0.035*	0.021**	0.028**	0.039**	0.029**
TIMU-11	0.0042**	0.0056**	0.0058**	0.0048**	0.0037**	0.0039**	0.005**	0.0067**	0.0095**	0.0071**
TIMU-12	0.004**	0.0052**	0.0054**	0.0045**	0.0035**	0.0037**	0.0047**	0.0064**	0.009**	0.0067**
TIMU-13	0.0041**	0.0054**	0.0056**	0.0046**	0.0036**	0.0038**	0.0048**	0.0065**	0.0092**	0.0068**
TIMU-14	0.015**	0.02**	0.021**	0.018**	0.034*	0.028*	0.018**	0.025**	0.035**	0.026**
TIMU-15	0.0048**	0.0064**	0.0066**	0.0055**	0.0043**	0.0045**	0.0057**	0.0077**	0.011**	0.0081**
TIMU-16	0.017**	0.022**	0.023**	0.019**	0.048	0.037*	0.02**	0.027**	0.038**	0.029**
TIMU-17	0.0044**	0.0058**	0.006**	0.005**	0.0039**	0.0041**	0.0053**	0.0071**	0.01**	0.0074**
TIMU-18	0.0049**	0.0064**	0.0067**	0.0055**	0.085	0.11	0.0058**	0.0078**	0.011**	0.0082**
TIMU-19	0.0042**	0.0055**	0.0057**	0.0047**	0.0037**	0.0039**	0.005**	0.0067**	0.0094**	0.007**
TIMU-20	0.0051**	0.0068**	0.0071**	0.0059**	0.0046**	0.0048**	0.0061**	0.0083**	0.012**	0.0087**
TIMU-21	0.004**	0.0053**	0.0054**	0.0045**	0.0035**	0.0037**	0.0047**	0.0064**	0.009**	0.0067**
TIMU-22	0.0039**	0.0052**	0.0054**	0.0045**	0.044	0.062	0.0047**	0.0063**	0.0089**	0.0067**
TIMU-24	0.0063**	0.0084**	0.0087**	0.0072**	0.0056**	0.0059**	0.013*	0.013*	0.017	0.014*
TIMU-25	0.011**	0.015**	0.015**	0.013**	0.0098**	0.01**	0.013**	0.018**	0.025**	0.019**
TIMU-26	0.019**	0.025**	0.026**	0.022**	0.035*	0.029*	0.023**	0.031**	0.043**	0.032**
TIMU-27	0.005**	0.0067**	0.0069**	0.0057**	0.0045**	0.0047**	0.006**	0.0081**	0.011**	0.0085**
TIMU-28	0.019**	0.026**	0.027**	0.022**	0.047*	0.037*	0.023**	0.031**	0.044**	0.033**
TIMU-29	0.004**	0.0053**	0.0055**	0.0045**	0.0036**	0.0037**	0.0048**	0.0064**	0.009**	0.0067**
TIMU-30	0.0037**	0.0049**	0.0051**	0.0042**	0.0033**	0.0035**	0.0044**	0.006**	0.0084**	0.0063**
TIMU-31	0.018**	0.024**	0.025**	0.021**	0.042*	0.033*	0.022**	0.03**	0.042**	0.031**

Table 8b. Organic contaminant concentrations (Dibenz(A,H)Anthracene – Total PCBs) for sites sampled at Timucuan Ecological and Historic Preserve, July 9–12, 2018. All results are presented in mg/kg. [*—result was greater than or equal to the Method Detection Limit (MDL) but below the Practical Quantitation Limit (PQL); **—result was less than the Method Detection Limit]. **Note:** No sediment sample was taken at Site TIMU-23 due to strong current and rocky/oyster laden substrate.

Site	Dibenz(A,H) Anthracene	Fluoranthene	Pyrene	Low Molecular Weight PAH	High Molecular Weight PAH	Total PAHs	P,P-DDE	P,P-DDT	Total PCBs
TIMU-01	0.0065**	0.0072**	0.0077**	0.1405	0.0484	0.2428	0.0032**	0.007**	0.047**
TIMU-02	0.0058**	0.0064**	0.0069**	0.034	0.0432	0.1094	0.0031**	0.0068**	0.046**
TIMU-03	0.0056**	0.0061**	0.0066**	0.0327	0.0414	0.1049	0.00055**	0.0012**	0.0081**
TIMU-04	0.012**	0.023*	0.022*	0.0718	0.108	0.2611	0.0065**	0.014**	0.096**
TIMU-05	0.016**	0.018**	0.019**	0.094	0.119	0.303	0.0081**	0.018**	0.12**
TIMU-06	0.0055**	0.0061**	0.0065**	0.0324	0.0411	0.1042	0.00058**	0.0013**	0.0087**
TIMU-07	0.006**	0.0066**	0.0071**	0.0354	0.0445	0.1134	0.0032**	0.007**	0.047**
TIMU-08	0.0074**	0.0081**	0.0087**	0.0433	0.0543	0.1433	0.0039**	0.0087**	0.058**
TIMU-09	0.0081**	0.0089**	0.0096**	0.0474	0.0603	0.1525	0.0043**	0.0096**	0.064**
TIMU-10	0.023**	0.025**	0.027**	0.186	0.171	0.485	0.0011**	0.0023**	0.016**
TIMU-11	0.0056**	0.0062**	0.0066**	0.033	0.0417	0.1059	0.0029**	0.0065**	0.043**
TIMU-12	0.0053**	0.0058**	0.0063**	0.031	0.0395	0.0999	0.0027**	0.006**	0.04**
TIMU-13	0.0054**	0.006**	0.0064**	0.0319	0.0403	0.1024	0.00054**	0.0012**	0.008**
TIMU-14	0.021**	0.023**	0.025**	0.154	0.155	0.423	0.0028**	0.0063**	0.042**
TIMU-15	0.0064**	0.0071**	0.0076**	0.0378	0.0479	0.1214	0.0032**	0.007**	0.047**
TIMU-16	0.023**	0.025**	0.027**	0.186	0.169	0.481	0.00097**	0.0022**	0.014**
TIMU-17	0.0059**	0.0065**	0.007**	0.0345	0.0439	0.1111	0.0032**	0.007**	0.047**
TIMU-18	0.0065**	0.0071**	0.0077**	0.2243	0.0483	0.3442	0.0033**	0.0072**	0.048**
TIMU-19	0.0056**	0.0061**	0.0066**	0.0327	0.0414	0.1049	0.0027**	0.0059**	0.039**
TIMU-20	0.0069**	0.0087*	0.0086*	0.0404	0.0532	0.1395	0.0033**	0.0074**	0.049**
TIMU-21	0.0053**	0.0058**	0.0063**	0.0311	0.0395	0.1	0.0028**	0.0061**	0.041**
TIMU-22	0.0053**	0.0058**	0.0063**	0.1297	0.0393	0.2147	0.00052**	0.0012**	0.0077**
TIMU-24	0.0085**	0.032	0.027	0.0551	0.1115	0.2322	0.0045**	0.01**	0.067**
TIMU-25	0.015**	0.032	0.029	0.0868	0.138	0.3118	0.0075**	0.017**	0.11**
TIMU-26	0.026**	0.028**	0.03**	0.179	0.19	0.51	0.0012**	0.0027**	0.018**
TIMU-27	0.0067**	0.0074**	0.008**	0.0395	0.0497	0.1265	0.0035**	0.0078**	0.052**
TIMU-28	0.026**	0.029**	0.031**	0.201	0.194	0.541	0.0031**	0.007**	0.047**
TIMU-29	0.0054**	0.0059**	0.0063**	0.0314	0.0397	0.1007	0.0028**	0.0062**	0.042**
TIMU-30	0.005**	0.0055**	0.0059**	0.0291	0.0371	0.0938	0.0024**	0.0054**	0.036**
TIMU-31	0.025**	0.027**	0.029**	0.185	0.184	0.506	0.003**	0.0067**	0.045**

Table 9. Ecological condition, based on sediment, for sites sampled at Timucuan Ecological and Historic Preserve, July 9–12, 2018. Ecological condition was determined using the thresholds for sediment chemistry in U.S. EPA NCCA 2010. Total Organic Carbon % is presented for comparison with previous coastal assessments [green^a—good]. **Note:** No sediment sample was taken at Site TIMU-23 due to strong current and rocky/oyster laden substrate.

Site	Ecological Condition by Site	Total Organic Carbon %
TIMU-01	Good ^a	0.24
TIMU-02	Good ^a	0.18
TIMU-03	Good ^a	0.01
TIMU-04	Good ^a	0.39
TIMU-05	Good ^a	0.37
TIMU-06	Good ^a	0.01
TIMU-07	Good ^a	0.15
TIMU-08	Good ^a	0.36
TIMU-09	Good ^a	0.52
TIMU-10	Good ^a	0.02
TIMU-11	Good ^a	0.11
TIMU-12	Good ^a	0.71
TIMU-13	Good ^a	0.01
TIMU-14	Good ^a	0.16
TIMU-15	Good ^a	0.27
TIMU-16	Good ^a	0.14
TIMU-17	Good ^a	0.05
TIMU-18	Good ^a	0.15
TIMU-19	Good ^a	0.01
TIMU-20	Good ^a	0.24
TIMU-21	Good ^a	0.04
TIMU-22	Good ^a	0.01
TIMU-24	Good ^a	0.54
TIMU-25	Good ^a	0.89
TIMU-26	Good ^a	0.08
TIMU-27	Good ^a	0.34
TIMU-28	Good ^a	0.07
TIMU-29	Good ^a	0.66
TIMU-30	Good ^a	0.44
TIMU-31	Good ^a	0.07

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1201 Oak Ridge Drive, Suite 150
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