



Assessment of Estuarine Water Quality at Cumberland Island National Seashore

2022 Data Summary



Looking east toward Cumberland Island from the Brickhill River site.

NPS / SECN

Assessment of estuarine water quality at Cumberland Island National Seashore: 2022 data summary

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Abstract

In July 2022 the Southeast Coast Network assessed water-quality at Cumberland Island National Seashore 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 2014). 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 calculated when possible. All measured parameters were rated as good, fair, or poor based on thresholds set by the EPA (2012).

The purpose of this document is to report the most recently collected data from the seashore 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 Cumberland Island National Seashore were conducted in July 2007, August 2012, and August 2017 as part of NPS Inventory and Monitoring efforts.

Executive Summary

In July 2022 the Southeast Coast Network assessed water-quality at Cumberland Island National Seashore 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 2009). 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 calculated when possible. All measured parameters were rated as good, fair, or poor based on thresholds set by the EPA (2012).

- Water clarity was rated good at all thirty sites (100%).
- Chlorophyll *a* concentrations were rated fair at all thirty sites (100%).
- Dissolved inorganic nitrogen (DIN) concentrations were good at all thirty sites (100%).
- Dissolved inorganic phosphorus (DIP) concentrations were good at three sites (10%) and fair at twenty-seven sites (90%).
- Dissolved oxygen concentrations (bottom) were rated good at twenty-four sites (80%) and fair at six sites (20%).
- A water-quality condition summary index was calculated for each site sampled at Cumberland Island National Seashore based on the categorical assessments of chlorophyll *a*, DIN and DIP concentrations, dissolved oxygen, and water clarity. This summary index indicated good water-quality conditions at three sites (10%) and fair water quality conditions at twenty-seven sites (90%).
- See [supplemental materials](#) to compare the distribution of good, fair, and poor ratings for each parameter across the period of record.
- Based on the summary water-quality index rating, overall water-quality conditions at Cumberland Island National Seashore during 2022 sampling were fair.
- The summary water-quality index rating is consistent with findings from 2007–2017.

Introduction

Overview

Due to the importance of water resources to park management from ecological, regulatory, and visitor experience perspectives, estuarine water and sediment quality in and around parks were selected to be monitored by the National Park Service (NPS) Inventory and Monitoring Division's Southeast Coast Network (SECN; DeVivo et al. 2008). Since 2005, the network has employed a multiscale approach to assess estuarine resources in seven park units located in North Carolina, Georgia, and Florida. Data collected as part of this effort are intended help resource managers: (1) better understand ecological processes and impacts caused by development, (2) make informed management decisions, and (3) form/maintain strategic partnerships to monitor and improve water quality conditions in and around park units. In addition, given the diverse and dynamic nature of estuaries, this monitoring is intended to capture the spatial and temporal variability of these systems. Monitoring at permanent fixed stations using continuous data loggers and discrete samples allow for evaluation of temporal patterns in core water quality parameters (dissolved oxygen, pH, salinity, temperature, and turbidity) and nutrients (nitrogen and phosphorus) and chlorophyll *a*.

While fixed-station monitoring provides fine resolution data to determine diel, monthly, and seasonal fluctuations in water quality, it lacks spatial extent. To fill this gap, spatial variability of water and sediment quality is determined with park-wide assessments every five years. These assessments include discrete sampling of nutrients, water quality parameters, and evaluation of sediment contaminants following methods developed by the Environmental Protection Agency-National Coastal Assessment Program. This monitoring approach leads to an understanding of the spatiotemporal status and variability of estuarine water quality and yields information useful to park management.

The Southeast Coast Network's monitoring approach is extensively documented in the Protocol for Monitoring Estuarine Water and Sediment Quality in Selected Southeast Coast Network Parks: Protocol Narrative (Starkey et al. 2023) and associated Standard Operating Procedures (SOPs). Version 1.0 of the protocol (Gregory et al. 2013) was implemented between 2007 and 2018. Version 2.0 of the protocol was implemented 2019 to present and was updated to align with new technology and techniques documented in revised Standard Operating Procedures. Monitoring objectives remain consistent across both versions of the protocol.

Monitoring Objectives

The Southeast Coast Network identified an overall goal of monitoring the status and trends in water and sediment quality in estuaries surrounding SECN parks. To meet this goal, data are collected and analyzed to meet four specific monitoring objectives. These objectives remain consistent across both versions of the protocol (Gregory et al. 2013; Starkey et al. 2023) and are listed below:

1. Determine diel and seasonal water-quality patterns for five core parameters (dissolved oxygen, salinity, temperature, pH, and turbidity) at selected coastal areas near SECN parks using fixed-station continuous data loggers.

2. Determine monthly and seasonal patterns in nutrients (nitrogen and phosphorus) and chlorophyll *a* at selected coastal areas near SECN parks by collecting discrete water samples.
3. Determine status and spatial variability of water and nutrient conditions in estuarine waters every five years near SECN parks.
4. Determine status and spatial variability of benthic sediment quality (organic contaminants, carbon, and metal levels) every 10 years in estuarine waters near SECN parks.

This report summarizes water-quality monitoring data collected during a parkwide assessment to address objective 3 at Cumberland Island National Seashore. Data were gathered from July 6 to July 8, 2022. The purpose of this document is to report the most recently collected data from the seashore 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 Environmental Protection Agency (EPA). Previous synoptic assessments of water-quality conditions at Cumberland Island National Seashore were conducted in July 2007, August 2012, and August 2017 as part of I&M monitoring efforts (Gregory et al. 2010; Wright et al. 2013; Starkey et al. 2024).

Study Area

Cumberland Island National Seashore

Cumberland Island National Seashore is located off the coast of Georgia between St. Andrews Sound and the mouth of the St. Marys River. At 17.5 miles (28.2 kilometers) long, the seashore is one of the largest and most diverse barrier islands on the Atlantic Coast (Figure 1). Almost half of its 36,415 acres (14,737 hectares) are *Spartina*-dominated salt marsh habitat. These areas include mud flats and six tidal creeks which provide the habitat for a diverse marine-based fauna. The island is known for nesting loggerhead sea turtles, abundant shore birds, undeveloped dune fields, maritime forest ecosystems, and historic structures. Cumberland Island provides habitat for 18 federally listed threatened or endangered species (Alber et al. 2005); although most are terrestrial or bird species, several species of sea turtles are commonly observed along the beaches and West Indian Manatees are occasionally sighted in estuarine areas.

Cumberland Island National Seashore was established in 1972 to preserve the scenic, scientific, and historical values of the island as well as to provide public outdoor recreational uses to its visitors. Specified areas of Cumberland Island are also part of the South Atlantic-Carolinian Biosphere Reserve and are permanently protected in a primitive state. The northern half of the island has also been designated a wilderness area. This unspoiled environment, once prevalent on all the barrier islands, provides a unique opportunity to experience the flora and fauna of a natural coastal ecosystem.

Water-quality conditions in Cumberland Sound and the Cumberland River are influenced by freshwater inflows mainly from the St. Marys River to the south, the Crooked River near the middle portion of the island and the Satilla River on its northern boundary. St. Marys, Georgia, like other coastal communities, faces increased residential development pressure. The cities of Jekyll Island, Georgia and Brunswick, Georgia located just north of Cumberland Island (as well as Fernandina Beach, Florida located just to the south) have potential to affect water-quality conditions due to the large amount of wood pulp processing, manufacturing, and shipping activities that occur. Jekyll Island, Georgia, just across St. Andrews Sound from Cumberland Island's northern boundary, is a relatively small resort community but has a permitted wastewater discharge on its southern end.



Figure 1. Fixed-station water-quality monitoring sites and estuarine and marine water resources in the vicinity of Cumberland Island National Seashore. Indicated are areas of salt marsh (FWS 2024), urbanized area (USCB 2023), 303(d) listed water bodies (EPA 2022), and areas designated with special uses or restrictions. NPS / SECN

Other activities—such as dredging along the estuarine waters just south and east of the island to maintain the submarine access channel to Kings Bay Submarine Base—have the potential to cause episodic deterioration of the water-quality as well as the scenic attributes of the south end of Cumberland Island. Transportation corridors such as rail, interstate highways, and the intracoastal waterway are also potential sources of pollution, particularly catastrophic spills. The Georgia coast has been experiencing an era of fast growth in new residential communities, many of which have sought to incorporate marinas. Recreational pressure could increase on the island, and the threat to resources and critical habitats may also intensify. Erosion on the western side of the island has been a recent concern of resource management at Cumberland Island National Seashore and investigated by local researchers (Jackson 2006, 2010, 2015), the USGS (Calhoun and Riley 2016), and the Southeast Coast Network (Bateman-McDonald 2020). The only aquatic areas in the vicinity of the park to be 303(d) listed are the Amelia River just south of Cumberland Island, the St. Marys River, and parts of Cumberland Sound along the island’s southern tip for elevated mercury levels in fish (Figure 1).

Methods

The water-quality assessment was conducted in estuarine waters in the vicinity of the Cumberland Island National Seashore, 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 adapted and integrated into protocols tailored specifically to parks in the Southeast Coast Network (Starkey et al. 2023). Site selection and sampling methodology are briefly outlined in the following sections.

In 2022, thirty sites in estuarine waters near the seashore 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). 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.

Table 1. Site name, waterbody name and location, depth, coordinates, and chemical and physical attributes of sampling sites at Cumberland Island National Seashore, July 6–8, 2022. 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 (1.6 feet) unless water depth was too shallow in which case it was measured at 0.1 meters (0.3 feet). [SAV—sub-aquatic vegetation; m—meters; °C—degrees Celsius; PSU—practical salinity units].

Site Name	Water Body	UTMX	UTMY	SAV	Debris	Site Depth (m)	Water Temp (°C)	pH	Salinity (PSU)
CUIS01_2022	Cumberland Sound	455206	3396427	No	No	7.0	30.31	7.89	34.79
CUIS02_2022	Cumberland Sound	454006	3407198	No	No	3.5	29.93	7.56	33.43
CUIS03_2022	Cumberland River	457251	3422216	No	No	7.6	30.89	7.98	34.49
CUIS04_2022	St. Andrews Sound	459634	3426409	No	No	5.8	30.25	8.00	34.69
CUIS05_2022	Cumberland River	452314	3414953	No	No	3.1	30.33	7.54	33.38
CUIS06_2022	Cumberland Sound	453064	3401435	No	No	2.0	30.47	7.87	34.31
CUIS07_2022	Cumberland Sound	453505	3406457	No	No	2.5	30.38	7.66	33.05
CUIS08_2022	Cumberland River	456159	3421272	No	No	9.1	30.30	7.71	33.58
CUIS09_2022	Cumberland River	452539	3418795	No	No	2.5	30.29	7.63	33.25
CUIS10_2022	Cumberland Sound	453041	3399619	No	No	4.4	30.49	7.81	33.75
CUIS11_2022	Cumberland Sound	452912	3409442	No	No	2.6	30.26	7.64	32.94
CUIS12_2022	Cumberland River	458661	3424182	No	No	7.7	30.44	7.99	34.42
CUIS13_2022	Cumberland Sound	453434	3398205	No	No	1.4	30.49	7.84	34.08
CUIS14_2022	Cumberland Sound	454103	3403315	No	No	1.0	30.27	7.76	33.62
CUIS15_2022	Brickhill River	455029	3414603	No	No	5.2	31.82	7.62	33.19
CUIS16_2022	Cumberland River	455142	3419958	No	No	5.8	30.35	7.70	33.39
CUIS17_2022	Cumberland Sound	456751	3397929	No	No	5.5	29.99	7.93	34.93
CUIS18_2022	Cumberland Sound	454059	3404453	No	No	2.6	30.30	7.75	33.59
CUIS19_2022	Brickhill River	457103	3418343	No	No	3.8	30.50	7.82	33.97
CUIS20_2022	Mumford Creek	454216	3416648	No	No	3.8	31.23	7.65	33.32
CUIS21_2022	Cumberland River	451487	3416144	No	No	4.8	30.53	7.61	33.36

Table 1 (continued). Site name, waterbody name and location, depth, coordinates, and chemical and physical attributes of sampling sites at Cumberland Island National Seashore, July 6–8, 2022. 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 (1.6 feet) unless water depth was too shallow in which case it was measured at 0.1 meters (0.3 feet). [SAV—sub-aquatic vegetation; m—meters; °C—degrees Celsius; PSU—practical salinity units].

Site Name	Water Body	UTMX	UTMY	SAV	Debris	Site Depth (m)	Water Temp (°C)	pH	Salinity (PSU)
CUIS22_2022	Cumberland Sound	452902	3400695	No	No	0.8	30.65	7.85	33.98
CUIS23_2022	Cumberland River	453518	3410904	No	No	0.6	30.33	7.59	32.77
CUIS24_2022	Cumberland River	456078	3421778	No	No	6.5	30.82	7.99	34.46
CUIS25_2022	Cumberland Sound	452621	3399371	No	No	3.4	30.50	7.78	32.81
CUIS26_2022	Cumberland Sound	454343	3401904	No	No	8.4	30.53	7.84	34.18
CUIS27_2022	Cumberland Sound	452749	3408967	No	No	3.3	30.46	7.66	32.89
CUIS28_2022	Cumberland River	458120	3422597	No	No	2.0	30.73	7.96	34.47
CUIS29_2022	Cumberland Sound	454633	3397544	No	No	5.7	30.37	7.86	34.14
CUIS30_2022	Cumberland Sound	453796	3400052	No	No	2.7	30.72	7.83	33.49

Cumberland Island National Seashore
2022 Parkwide Assessment Sampling Sites

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



Figure 2. Map showing the location of parkwide assessment sites sampled in July 2022 at Cumberland Island National Seashore. NPS / SECN

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) 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 feet) 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]). Cumberland Island National Seashore uses a constant (*c*) of 1.0 because the area is “naturally turbid” (EPA 2016). 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 network parks. Water clarity was not assessed at sites with excessive current or depths too shallow to ascertain an accurate Secchi measurement. When sites were too shallow to access by boat, or were located in heavily trafficked channels where safety was a concern, alternate sites were used.

Water-Quality Assessment Criteria

The categorical assessments (e.g., good, fair, poor) use measurements of chlorophyll *a*, nutrient concentrations, bottom dissolved oxygen, and water clarity (Table 2) and are intended to characterize acutely degraded water-quality conditions at a site. 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 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.

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 and at the same park over time based on the percentage of sites that fall within the good, fair, or poor categories.

Table 2. Water-quality monitoring condition criteria for water-quality parameters collected by the Southeast Coast Network based on thresholds set by EPA (2012) [$\mu\text{g/L}$ —micrograms per liter; mg/L —milligrams per liter].

Rating	Water Clarity (k) ^A	Chlorophyll a ($\mu\text{g/L}$)	Dissolved Inorganic Nitrogen (DIN) (mg/L)	Dissolved Inorganic Phosphorus (DIP) (mg/L)	Dissolved Oxygen (mg/L)
Good	< 2.30	< 5	< 0.1	< 0.01	>5
Fair	2.30–2.99	5–20	0.1–0.5	0.01–0.05	2–5
Poor	> 2.99	> 20	> 0.5	> 0.05	<2

^A Light 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 ^A	Park Water-Quality Index Rating ^A
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

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

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 Cumberland Island National Seashore’s water-quality conditions during the assessment. Site-specific water-quality data for each parameter are also presented in Table 4. For comparison with past assessments, maps and condition rating summary graphs for sample years 2007–2022 can be found in the supplementary materials.

- Water clarity was rated good at all thirty sites (100%).
- Chlorophyll *a* concentrations were rated fair at all thirty sites (100%).
- Dissolved inorganic nitrogen concentration was good at all thirty sites (100%).
- Dissolved inorganic phosphorus concentration was good at three sites (10%) and fair at twenty-seven sites (90%).
- Dissolved oxygen concentration (bottom) was rated good at twenty-four sites (80%) and fair at six sites (20%).
- A water-quality condition summary index was calculated for each site sampled at Cumberland Island National Seashore based on the categorical assessments of chlorophyll *a*, DIN and DIP concentrations, dissolved oxygen, and water clarity. This summary index indicated good water-quality conditions at three sites (10%) and fair water quality conditions at twenty-seven sites (90%).
- These findings are consistent with assessments from 2007–2022, with the proportion of condition ratings in the good and fair categories remaining relatively consistent (see [supplemental materials](#)). The one exception is dissolved oxygen, which has shown improvement in the proportion of sites rated as good. In 2007 and 2012, 20% and 33% of sites respectively were rated as good, whereas in 2017 and 2022, 70% and 77% of sites were rated as good. Graphs of each parameter’s condition rating throughout the period of record are provided in the [supplemental materials](#).
- The distribution of good, fair, and poor ratings for each parameter across the period of record can be seen using the maps provided in the [supplemental materials](#).
- Based on the summary water-quality index rating, overall water-quality conditions at Cumberland Island National Seashore during 2022 sampling were fair. Previous assessments indicated overall park water-quality ratings of fair in 2007, 2012, and 2017. This suggests relatively stable overall water-quality throughout the period of record.

Cumberland Island National Seashore
2022 Water Clarity (k)

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

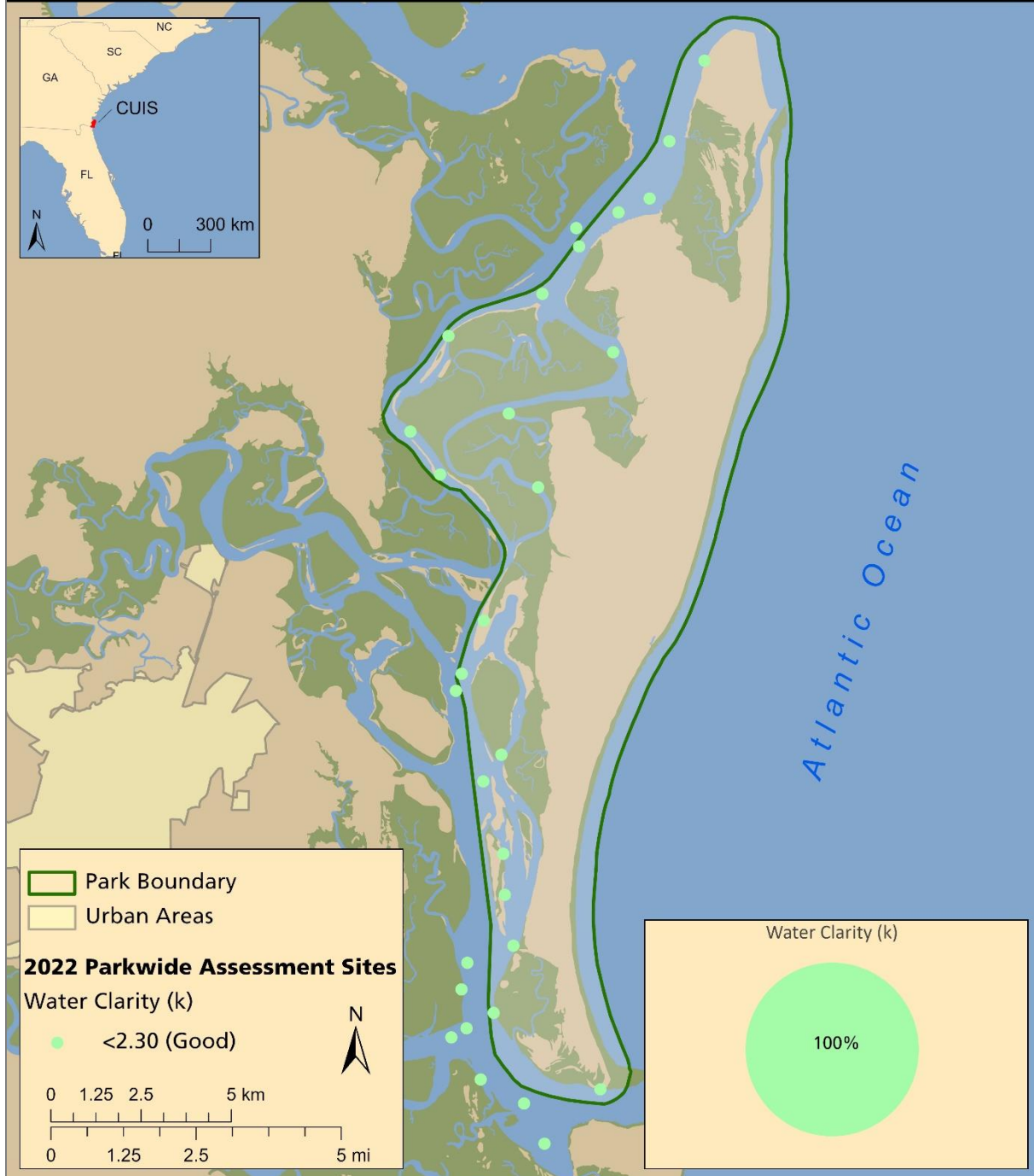


Figure 3. Water clarity ratings for sites sampled at Cumberland Island National Seashore July 6–8, 2022. Inset graph shows the percent of sites in each condition category [Green—good]. NPS / SECN

Cumberland Island National Seashore
2022 Chlorophyll a

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



Figure 4. Chlorophyll a concentrations for sites sampled at Cumberland Island National Seashore July 6–8, 2022. Inset graph shows the percent of sites in each condition category [yellow—fair]. NPS / SECN

Cumberland Island National Seashore
2022 Dissolved Inorganic Nitrogen

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



Figure 5. Dissolved inorganic nitrogen concentrations for sites sampled at Cumberland Island National Seashore July 6–8, 2022. Inset graph shows the percent of sites in each condition category [Green—good]. NPS / SECN



Figure 6. Dissolved inorganic phosphorus concentrations for sites sampled at Cumberland Island National Seashore July 6–8, 2022. Inset graph shows the percent of sites in each condition category [Green—good; yellow—fair]. NPS / SECN

Cumberland Island National Seashore
2022 Dissolved Oxygen

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



Figure 7. Dissolved oxygen concentrations for sites sampled at Cumberland Island National Seashore July 6–8, 2022. Inset graph shows the proportion of sites in each condition category [Green—good; yellow—fair]. NPS / SECN

Cumberland Island National Seashore
2022 Site Water Quality Rating

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



Figure 8. Water-quality index rating for sites sampled at Cumberland Island National Seashore July 6–8, 2022. Inset graph shows the proportion of sites in each condition category [Green—good; yellow—fair].
NPS / SECN

Table 4. Water-quality parameter values and assessment conditions for sampling sites in the vicinity of Cumberland Island National Seashore July 6–8, 2022. Water clarity was assessed using light attenuation values (k) using a constant (1.0) for estuarine waters that are “naturally turbidity” (Smith et al. 2006) and assessment categories that correspond to EPA (2012). Condition of other assessed parameters based on EPA (2012) [Green^D—good; yellow^E—fair; red^F—poor; *result was less than or equal to the Method Detection Limit [MDL reported]; 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	Water Clarity (k) ^A	Chlorophyll a (µg/L) ^B	Dissolved Oxygen (DO, mg/L) ^B	Dissolved Inorganic Nitrogen (DIN, mg/L) ^B	Dissolved Inorganic Phosphorus (DIP, mg/L) ^B	Total Dissolved Nitrogen (mg/L) ^{B,C}	Total Dissolved Phosphorus (mg/L) ^{B,C}	Site WQ Index Rating
CUIS01_2022	0.9 ^D	8.06 ^E	5.6 ^D	0.0221 ^D	0.0085 ^D	0.25	0.027	Good ^D
CUIS02_2022	1.4 ^D	8.48 ^E	4.1 ^E	0.0290 ^D	0.0251 ^E	0.34	0.050	Fair ^E
CUIS03_2022	0.8 ^D	6.64 ^E	6.1 ^D	0.0145 ^D	0.0272 ^E	0.24	0.047	Fair ^E
CUIS04_2022	0.7 ^D	5.48 ^E	6.0 ^D	0.0132 ^D	0.0295 ^E	0.26	0.056	Fair ^E
CUIS05_2022	1.7 ^D	7.41 ^E	4.7 ^E	0.0257 ^D	0.0224 ^E	0.41	0.047	Fair ^E
CUIS06_2022	0.9 ^D	8.77 ^E	5.7 ^D	0.0175 ^D	0.0109 ^E	0.30	0.030	Fair ^E
CUIS07_2022	1.1 ^D	6.97 ^E	5.1 ^D	0.0257 ^D	0.0193 ^E	0.33	0.043	Fair ^E
CUIS08_2022	0.7 ^D	7.73 ^E	4.8 ^E	0.0593 ^D	0.0351 ^E	0.39	0.068	Fair ^E
CUIS09_2022	1.0 ^D	8.48 ^E	5.1 ^D	0.0453 ^D	0.0315 ^E	0.34	0.051	Fair ^E
CUIS10_2022	0.8 ^D	8.45 ^E	5.4 ^D	0.0206 ^D	0.0120 ^E	0.30	0.032	Fair ^E
CUIS11_2022	1.3 ^D	6.45 ^E	5.0 ^E	0.0270 ^D	0.0201 ^E	0.34	0.043	Fair ^E
CUIS12_2022	0.6 ^D	6.53 ^E	5.8 ^D	0.0137 ^D	0.0270 ^E	0.26	0.049	Fair ^E
CUIS13_2022	0.9 ^D	8.23 ^E	5.8 ^D	0.0154 ^D	0.0097 ^D	0.27	0.027	Good ^D
CUIS14_2022	1.0 ^D	7.74 ^E	5.7 ^D	0.0182 ^D	0.0158 ^E	0.30	0.037	Fair ^E
CUIS15_2022	1.1 ^D	10.95 ^E	4.9 ^E	0.0361 ^D	0.0279 ^E	0.34	0.051	Fair ^E

^A Light 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.

^B Where µg/L = micrograms per liter, N = Nitrogen; mg/L = milligrams per liter; P = Phosphorous.

^C There are no EPA condition criteria for TDN and TDP.

^D Conditions are assessed as good using parameters from the EPA (2012) (also with a green background).

^E Conditions are assessed as fair using parameters from the EPA (2012) (also with a yellow background).

Table 4 (continued). Water-quality parameter values and assessment conditions for sampling sites in the vicinity of Cumberland Island National Seashore July 6–8, 2022. Water clarity was assessed using light attenuation values (k) using a constant (1.0) for estuarine waters that are “naturally turbidity” (Smith et al. 2006) and assessment categories that correspond to EPA (2012). Condition of other assessed parameters based on EPA (2012) [Green^D—good; yellow^E—fair; red^F—poor; *result was less than or equal to the Method Detection Limit [MDL reported]; 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	Water Clarity (k) ^A	Chlorophyll a (µg/L) ^B	Dissolved Oxygen (DO, mg/L) ^B	Dissolved Inorganic Nitrogen (DIN, mg/L) ^B	Dissolved Inorganic Phosphorus (DIP, mg/L) ^B	Total Dissolved Nitrogen (mg/L) ^{B,C}	Total Dissolved Phosphorus (mg/L) ^{B,C}	Site WQ Index Rating
CUIS16_2022	0.7 ^D	8.74 ^E	5.1 ^D	0.0479 ^D	0.0339 ^E	0.38	0.062	Fair ^E
CUIS17_2022	1.3 ^D	10.24 ^E	5.6 ^D	0.0152 ^D	0.0115 ^E	0.25	0.032	Fair ^E
CUIS18_2022	0.9 ^D	8.03 ^E	5.3 ^D	0.0230 ^D	0.0191 ^E	0.33	0.044	Fair ^E
CUIS19_2022	0.9 ^D	11.11 ^E	5.5 ^D	0.0431 ^D	0.0335 ^E	0.29	0.053	Fair ^E
CUIS20_2022	1.1 ^D	11.22 ^E	5.2 ^D	0.0471 ^D	0.0335 ^E	0.33	0.055	Fair ^E
CUIS21_2022	1.7 ^D	10.00 ^E	5.0 ^E	0.0182 ^D	0.0202 ^E	0.33	0.042	Fair ^E
CUIS22_2022	1.3 ^D	10.32 ^E	5.8 ^D	0.0181 ^D	0.0106 ^E	0.26	0.029	Fair ^E
CUIS23_2022	1.4 ^D	10.59 ^E	4.6 ^E	0.0426 ^D	0.0282 ^E	0.35	0.054	Fair ^E
CUIS24_2022	0.8 ^D	6.61 ^E	5.8 ^D	0.0131 ^D	0.0262 ^E	0.22	0.045	Fair ^E
CUIS25_2022	0.8 ^D	8.89 ^E	5.5 ^D	0.0313 ^D	0.0116 ^E	0.32	0.029	Fair ^E
CUIS26_2022	0.8 ^D	9.54 ^E	5.6 ^D	0.0182 ^D	0.0143 ^E	0.29	0.038	Fair ^E
CUIS27_2022	1.0 ^D	7.17 ^E	5.1 ^D	0.0277 ^D	0.0159 ^E	0.33	0.036	Fair ^E
CUIS28_2022	1.1 ^D	9.08 ^E	6.3 ^D	0.0166 ^D	0.0299 ^E	0.23	0.054	Fair ^E
CUIS29_2022	0.8 ^D	7.36 ^E	5.3 ^D	0.0170 ^D	0.0097 ^D	0.25	0.025	Good ^D
CUIS30_2022	1.1 ^D	9.46 ^E	5.7 ^D	0.0159 ^D	0.0107 ^E	0.27	0.028	Fair ^E

^A Light 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.

^B Where µg/L = micrograms per liter, N = Nitrogen; mg/L = milligrams per liter; P = Phosphorous.

^C There are no EPA condition criteria for TDN and TDP.

^D Conditions are assessed as good using parameters from the EPA (2012) (also with a green background).

^E Conditions are assessed as fair using parameters from the EPA (2012) (also with a yellow background).

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