



Assessment of Estuarine Water Quality at Fort Pulaski National Monument, 2014

Natural Resource Data Series NPS/SECN/NRDS—2015/801



ON THE COVER

Cockspur Island Lighthouse during low tide at Fort Pulaski National Monument in June 2007. Photograph by National Park Service.

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Natural Resource Data Series NPS/SECN/NRDS—2015/801

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Key Findings

In July 2014 the Southeast Coast Network conducted an assessment of water quality around Fort Pulaski National Monument 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. 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 was estimated using Secchi depth measurements and adjusted for naturally occurring water-clarity conditions. All measured parameters were rated as *good*, *fair*, or *poor* based on thresholds set by the EPA.

- Water clarity was rated *poor* at 30% of sites and *good* at 70% of sites.
- Chlorophyll *a* concentrations were rated *fair* at 97% of sites. A single site (3%) sampled in 2014 was rated *good* with low concentrations of chlorophyll *a*.
- Dissolved nutrient concentrations were *good* to *fair* across the assessed area with dissolved inorganic nitrogen (DIN) levels rated *good* at 17 sites (57%) and *fair* at 13 sites (43%). Dissolved inorganic phosphorus (DIP) levels were rated *fair* at all sites (100%).
- Dissolved oxygen levels were rated *good* at 47% of sites and *fair* at 53% of sites.
- A water quality condition summary index was calculated for each site sampled in Fort Pulaski 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 100% of sites.
- Based on the summary water quality index rating for the monument, overall water quality conditions in Fort Pulaski in July 2014 were *fair*, with more than 50% of the sites rated *fair*.

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 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 SECN 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 assessment water-quality monitoring data collected to address objective 3 at Fort Pulaski National Monument (FOPU). Data was collected 12–15 July 2014 (Figure 1, Table 1).

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. Past assessments of water-quality conditions at Fort Pulaski were conducted in August 2007.

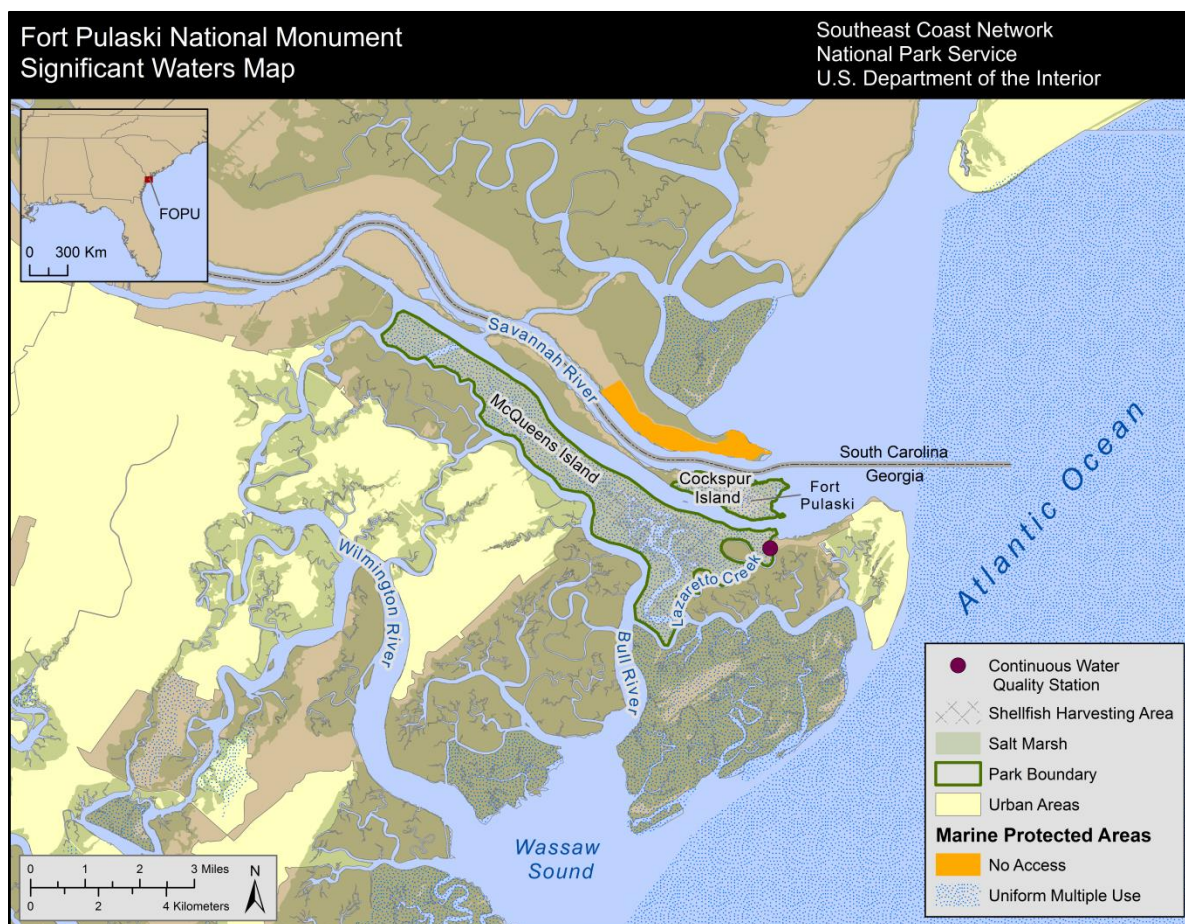


Figure 1. Map of Fort Pulaski National Monument in 2014, showing the location of the SECN fixed water quality monitoring station. The map also indicates areas of salt marsh (USFWS 2013), urbanization (US Census Bureau 2013), 303(d) listed water bodies (EPA 2013), and areas designated as having special uses or restrictions.

Table 1. Map ID, waterbody names and locations, depth, coordinates, and chemical and physical attributes of sampling sites in the vicinity of Fort Pulaski National Monument, July 2014. The table cross-references official site names and Map ID numbers used to present data in this report (Figure 2). All coordinates are in NAD83 Datum, in UTM zone 17. Salinity, pH, water temperature, and dissolved Oxygen are at a depth of one meter.

ID	Water Body	Site Depth (m)	UTMX	UTMY	Site name	Water Temp	SAV	Marine Debris	pH	DO (mg/L)	Salinity (ppt)
01	Savannah River	1.8	502027	3549202	FOPU-12	28.6	No	No	7.43	4.03	18.15
02	Savannah River	3.5	503146	3548779	FOPU-20	28.7	No	No	7.56	4.48	22.8
03	Savannah River South Channel	3.5	501444	3548706	FOPU-08	28.7	No	No	7.42	4.08	18.79
04	Savannah River	6.7	502789	3548392	FOPU-04	28.7	No	No	7.46	4.13	19.05
05	Savannah River South Channel	3.5	502768	3547544	FOPU-28	28.8	No	No	7.45	5	20.2
06	Savannah River	3	506374	3546071	FOPU-11	29.5	No	No	7.74	5.84	25.66
07	Bull River	2.1	501976	3546068	FOPU-16	29.8	No	No	7.16	4.27	24.64
08	Savannah River	3.5	504799	3545755	FOPU-27	29.5	No	No	7.41	4.9	20.29
09	Savannah River channel	1.3	505486	3545238	FOPU-22	29.4	No	No	7.4	4.86	20.51
10	Savannah River	5	507200	3545185	FOPU-15	29.0	No	No	7.72	5.24	27.31
11	Savannah River	3.1	508736	3544804	FOPU-14	28.8	No	No	7.74	4.96	28.51
12	Savannah River	4	510537	3544073	FOPU-30	29.0	No	No	7.85	5.85	30.08
13	Savannah River South Channel	5.5	507251	3543990	FOPU-02	28.6	No	No	7.6	4.97	24.18
14	Savannah River mouth entrance	2.3	511773	3543967	FOPU-03	28.8	No	No	7.85	5.75	30.59
15	Savannah River South Channel	3.5	507703	3543819	FOPU-18	28.9	No	No	7.63	5.79	22.05
16	Savannah River South Channel	3.5	508117	3543773	FOPU-10	29.1	No	No	7.67	6.38	23.01
17	Bull River	7	505247	3543482	FOPU-06	29.0	No	No	7.19	3.61	27.16

Table 1 (continued). Map ID, waterbody names and locations, depth, coordinates, and chemical and physical attributes of sampling sites in the vicinity of Fort Pulaski National Monument, July 2014. The table cross-references official site names and Map ID numbers used to present data in this report (Figure 2). All coordinates are in NAD83 Datum, in UTM zone 17. Salinity, pH, water temperature, and dissolved Oxygen are at a depth of one meter.

ID	Water Body	Site Depth (m)	UTMX	UTMY	Site name	Water Temp	SAV	Marine Debris	pH	DO (mg/L)	Salinity (ppt)
18	Savannah River mouth entrance	2.5	511695	3543443	FOPU-19	28.7	No	No	7.75	5.29	27.89
19	Savannah River mouth entrance	2.5	512110	3543345	FOPU-25	28.7	No	No	7.83	5.72	30.03
20	Savannah River mouth entrance	2.5	511993	3543298	FOPU-09	28.7	No	No	7.78	5.51	28.85
21	Bull River	5.1	505655	3542988	FOPU-29	29.2	No	No	7.19	3.8	26.74
22	Savannah River South Channel	6.5	509525	3542957	FOPU-26	29.0	No	No	7.67	5.97	23.96
23	Savannah River South Channel	2.5	510270	3542578	FOPU-23	29.2	No	No	7.61	5.61	23.67
24	Lazaretto Creek (marsh area)	3.1	507504	3542446	FOPU-13	28.6	No	No	7.42	4.29	30.87
25	Lazaretto Creek	4.5	510943	3542072	FOPU-ALT-01	28.6	No	Wood	7.75	5.29	28.29
26	Lazaretto Creek	1.8	508455	3541846	FOPU-07	28.3	No	No	7.38	4.47	30.46
27	Bull River	4	506978	3540827	FOPU-17	29.2	No	No	7.3	4.01	29.35
28	Chimney Creek	1.8	508291	3539749	FOPU-05	29.7	No	No	7.57	5.3	31.1
29	Chimney Creek	5.5	508149	3539515	FOPU-21	29.7	No	No	7.56	5.3	31.11
30	Bull River	4.5	506689	3539008	FOPU-01	29.2	No	No	7.37	4.3	30.02

Study Area

Fort Pulaski National Monument

Estuaries are semi-enclosed coastal water bodies with free connection to the open sea, within which sea water and fresh water mix. As a key defining feature, estuaries are at the interface of sea water and fresh water, which come together in a dynamic relationship created by ocean tides. Estuaries contain critical habitat for a variety of fish and wildlife species. They serve as nursery habitats for fish, crustaceans, and shellfish and foraging habitat for birds and mammals while providing a multitude of recreational opportunities such as boating, fishing, and bird watching.

Estuarine ecosystems are vulnerable to impacts from various sources, including urban and industrial development. Severe impacts include: alterations to hydrodynamic processes; exposure to levels of chemical contaminants that cause mortality, altered growth, and reduced reproduction; and exposure to more frequent and severe hypoxia (Lerberg et al. 2000). Some nutrient inputs to coastal waters are natural and necessary for a healthy, functioning estuarine ecosystem; however when nutrients from various sources, such as sewage and fertilizers, are introduced into an estuary, the concentration of available nutrients will increase beyond natural background levels. This increase in the rate of supply of organic matter may result in undesirable water-quality conditions, including increased chlorophyll, decreased water clarity, and lower concentrations of dissolved oxygen. In addition, macrobenthic communities in impacted areas are often characterized by low diversity, low numbers of rare and pollution-sensitive species, and low abundances (Lerberg et al. 2000). In areas with increased impervious cover, stormwater runoff is flashier and occurs in greater volumes than in undeveloped areas. This unnatural runoff is often polluted with a wide variety of low-level contaminants that are released into estuaries and can accumulate in sediment (Holland et al. 2004).

Fort Pulaski National Monument is in Chatham County, Georgia along the Savannah River, a few miles from the confluence of the river and the Atlantic Ocean (Figure 1). The monument consists of two islands that were primarily salt marsh until human intervention. Cockspur Island probably supported some coastal hammock forest or woodland, based on the composition of existing vegetation. Cockspur Island was selected for fortification as early as the 18th century. In the early 19th century, as part of the development of the site for defense, the island was modified by the installation of drainage canals and a dike system. The site was later impacted by the deposition of dredge spoil material from the Savannah River, which continued until recent times. During the civil war period, vegetation was removed and kept in early successional stages to enhance visibility. Since the abandonment of the fort in the late 1800s, a large portion of central Cockspur Island has reverted to maritime forest. Currently the upland portions of Cockspur Island (approximately 260 acres) support a mosaic of maritime forest, maritime shrub communities, maintained grasslands, and successional spoil-deposit areas. The island also includes more than 340 acres of tidal shrubland and tidal herbaceous marsh.

McQueen's Island makes up the largest portion of land holdings for the national monument (about 4,900 acres), and the majority of the island consists of salt marsh. A railroad was constructed along the northern edge of the island in 1887 to connect the city of Savannah with Tybee Island. The

railroad was operated until 1933. US Highway 80 was constructed in 1923. The highway crosses the central portion of the island and then continues east along the old railroad grade. In 1994 Chatham County converted the abandoned railroad right-of-way to a multipurpose hiking trail. Both the highway and the converted rails-to-trails areas support habitat for numerous ruderal herbaceous coastal plain species.

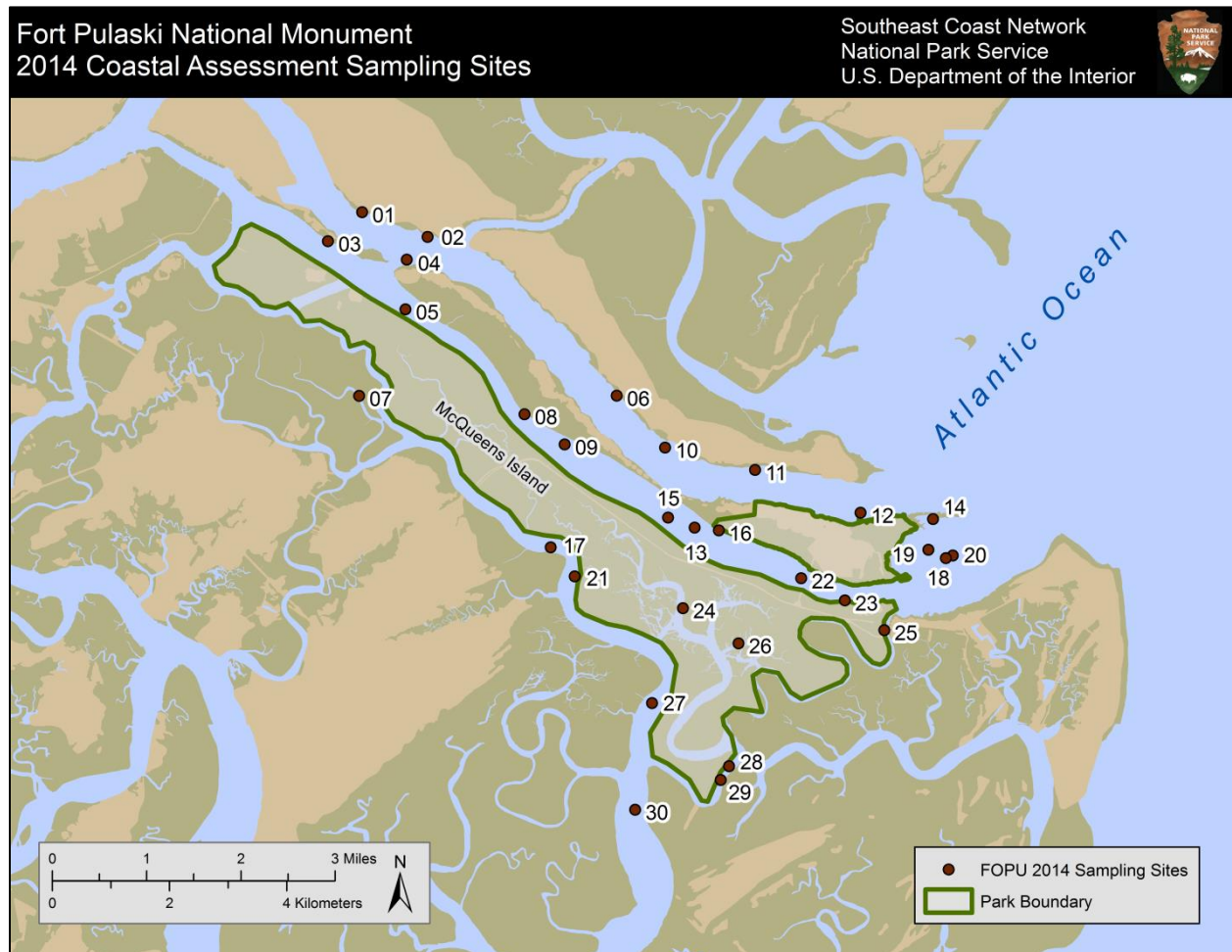


Figure 2. Map showing the location of coastal assessment sites sampled in July 2014 in the vicinity of Fort Pulaski National Monument (FOPU).

Methods

The water-quality assessment was conducted in estuarine and tidal creek waters in the vicinity of the national monument, following the methods developed by the Environmental Protection Agency (EPA) National Coastal Assessment Program (EPA 2009). 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.

Thirty sites in the monument 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 intervals at each site, to measure temperature, pH, dissolved oxygen, and salinity. Chlorophyll *a* levels were measured concurrently, and total and dissolved nutrient samples were collected from 0.5 meters 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 estimate light extinction depths, which were converted to light attenuation coefficients and corrected for naturally occurring turbidity conditions (Smith et al. 2006). Water clarity was not assessed at sites too shallow to ascertain an accurate Secchi depth measurement. When sites were too shallow to access by boat, alternate sites were used.

Water-Quality Assessment Criteria

The categorical assessments (e.g., *good*, *fair*, *poor*) use measurements of chlorophyll *a*, nutrients, 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 consistent *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.

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.

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).

Rating	Water Clarity ¹ (<i>k</i>)	Chlorophyll <i>a</i> (µg/L)	Dissolved Inorganic Nitrogen (mg/L)	Dissolved Inorganic Phosphorus (mg/L)	Dissolved Oxygen (mg/L)
Good	<2.3	<5	<0.1	<0.01	>5
Fair	2.3–2.99	5–20	0.1–0.5	0.01–0.05	2–5
Poor	>3.00	>20	>0.5	>0.05	<2

¹ 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	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 less than 50% of sites are in combined poor and fair 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 more than 50% of sites are in combined poor and fair 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.	

Results

Parameter-Based 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 dissolved oxygen based on each parameter’s corresponding condition category. Inset graphs on Figures 3–7 show the percentage of sites in the assessed area that were categorized in each rating category. The map and graph in Figure 8 summarize monument-wide water quality. Site-specific water-quality data for each parameter are also presented in Table 4.

- Water clarity was rated *poor* at 30% of sites and *good* at 70% of sites.
- Chlorophyll *a* concentrations were rated *fair* at 97% of sites. A single site (3%) sampled in 2014 was rated *good* with low concentrations of chlorophyll *a*.
- Dissolved nutrient concentrations were *good* to *fair* across the assessed area with dissolved inorganic nitrogen (DIN) levels rated *good* at 17 sites (57%) and *fair* at 13 sites (43%). Dissolved inorganic phosphorus (DIP) levels were rated *fair* at all sites (100%).
- Dissolved oxygen levels were rated *good* at 47% of sites and *fair* at 53% of sites.
- A water quality condition summary index was calculated for each site sampled in Fort Pulaski 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 100% of the sampled sites.
- Based on the summary water quality index rating for the monument, overall water quality conditions in Fort Pulaski in July 2014 were *fair*, with more than 50% of the sites rated *fair*.

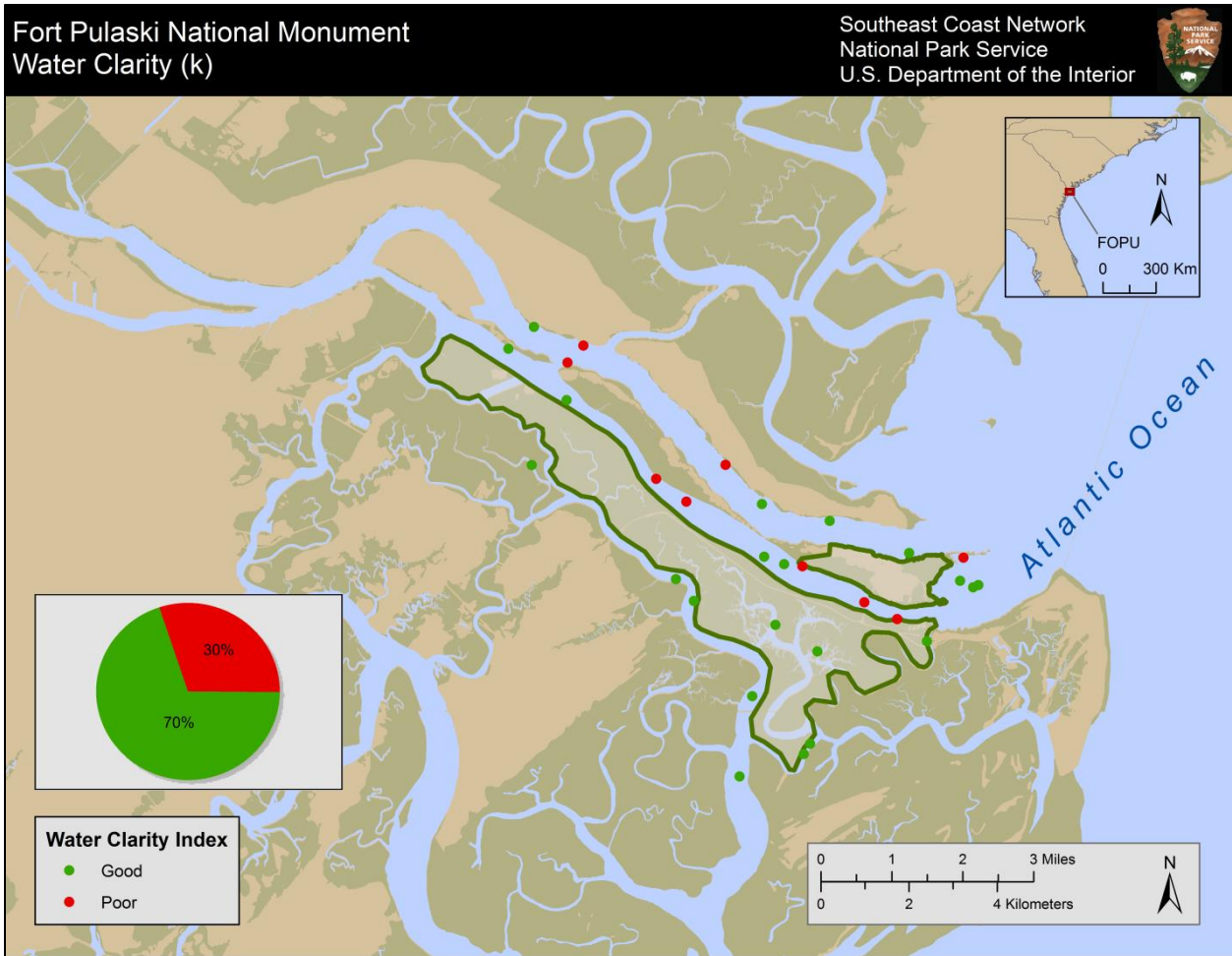


Figure 3. Water clarity index (k) based on light attenuation estimates at sampling sites in the vicinity of Fort Pulaski National Monument in July 2014. Inset graph shows the percentage of sites in each condition category. Missing data indicated locations (not shown) where the water clarity index could not be calculated due to limited water depth (i.e. light penetration to bottom). [Green—good; red—poor]

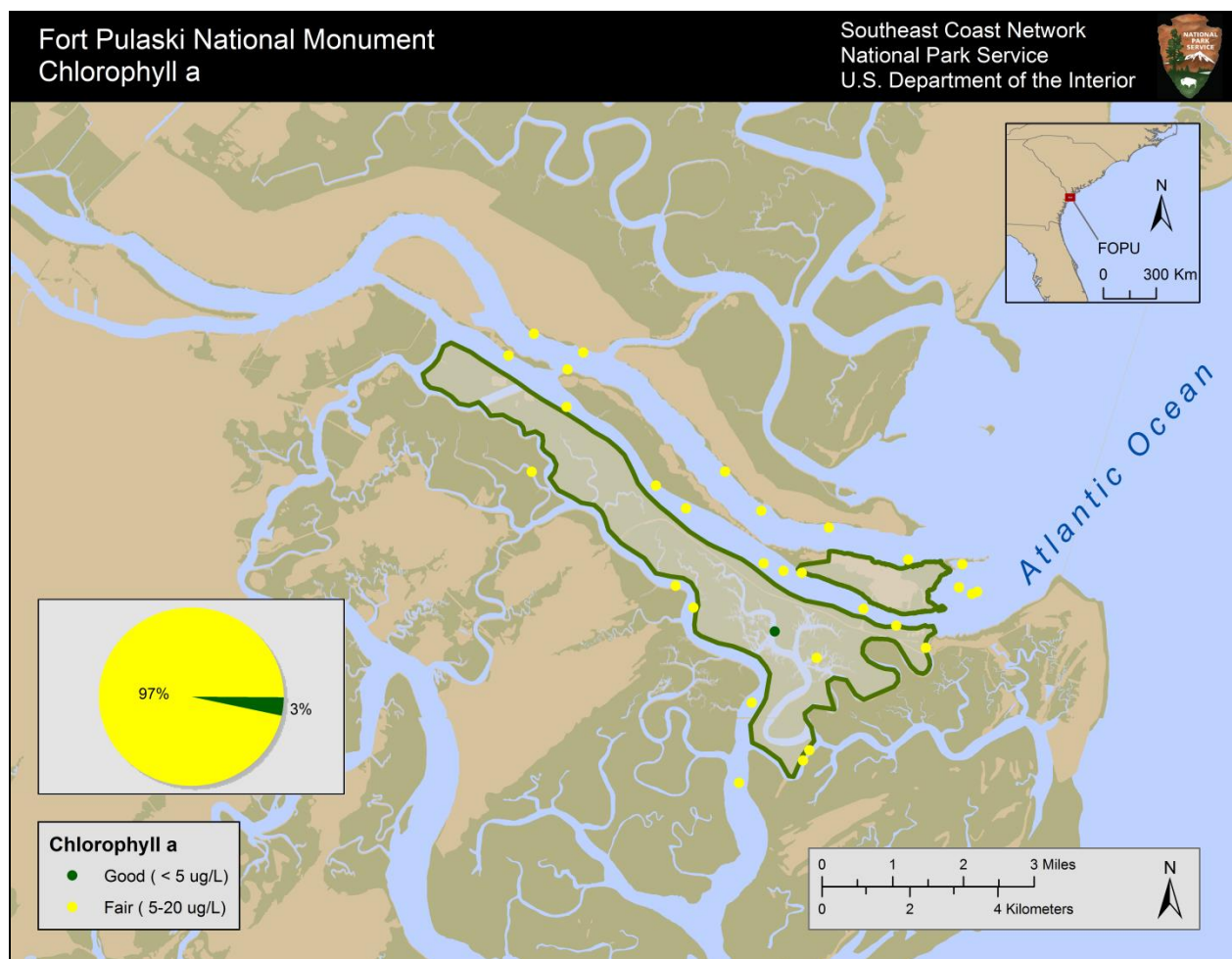


Figure 4. Chlorophyll a concentrations at sampling sites in the vicinity of Fort Pulaski National Monument in July 2014. Inset graph shows the percentage of sites in each condition category. [Green—good; yellow—fair]

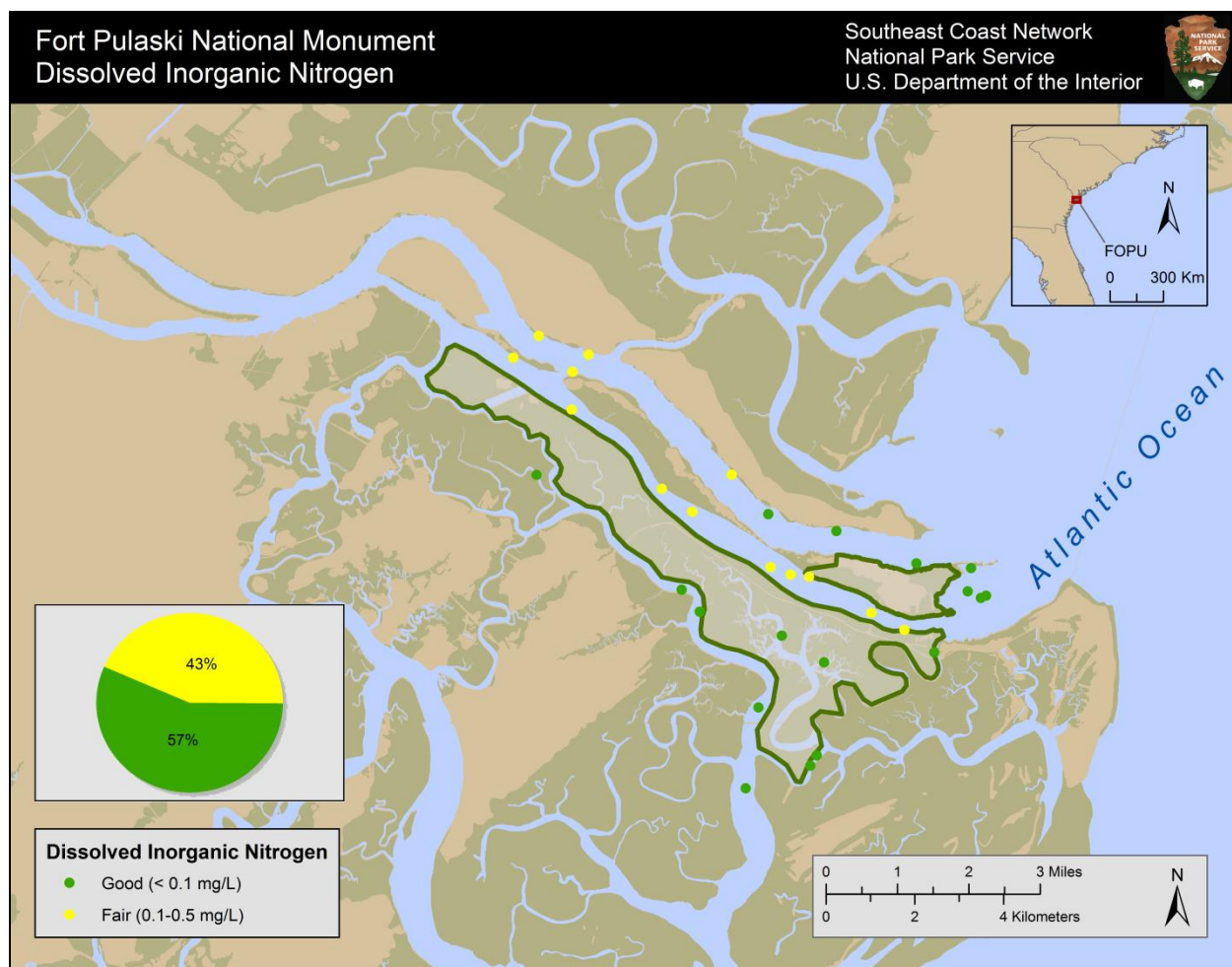


Figure 5. Dissolved inorganic nitrogen concentrations at sampling sites in the vicinity of Fort Pulaski National Monument in July 2014. Inset graph shows the percentage of sites in each condition category. [Green—good; yellow—fair]

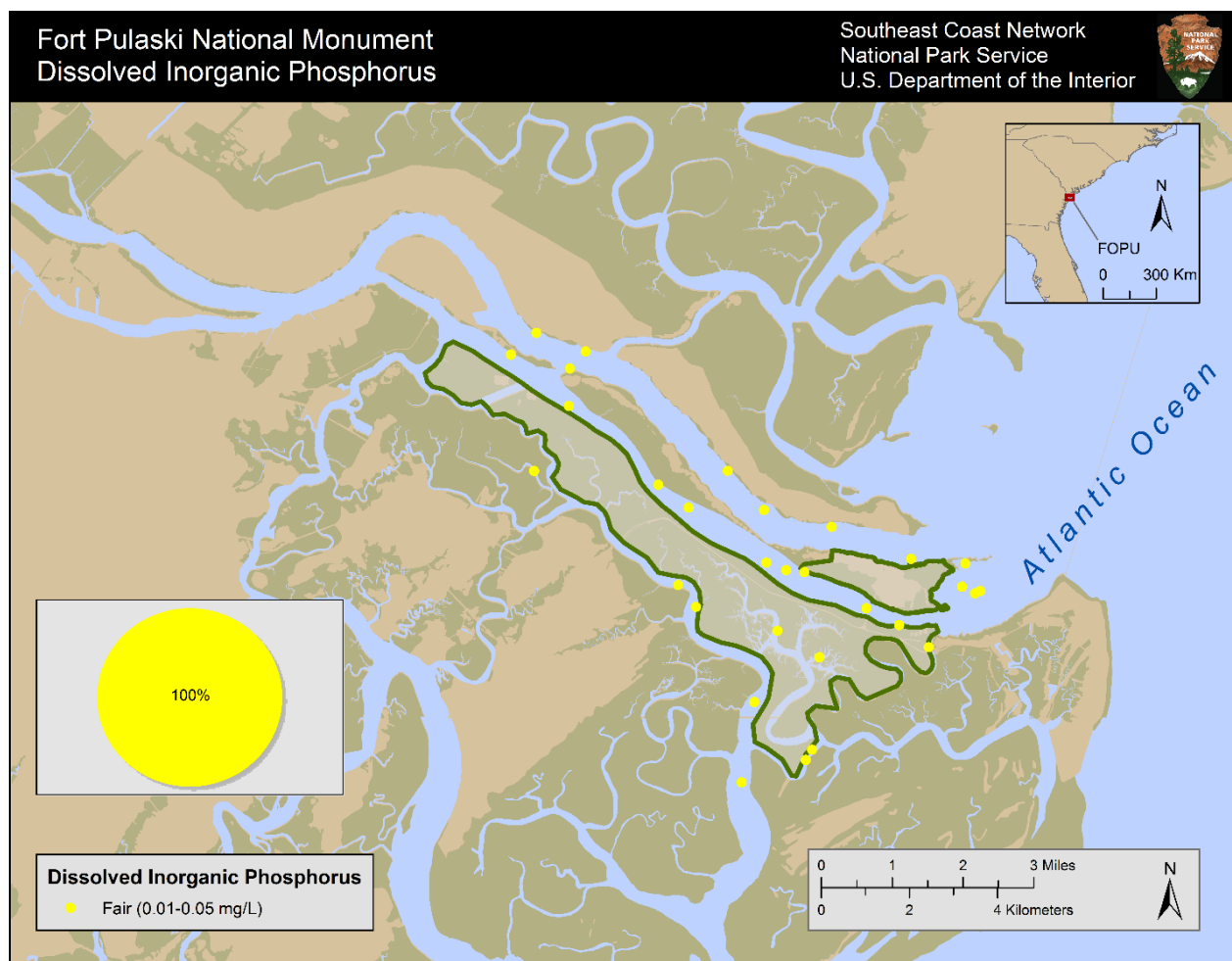


Figure 6. Dissolved inorganic phosphorus concentrations at sampling sites in the vicinity of Fort Pulaski National Monument in July 2014. Inset graph shows the percentage of sites in each condition category. [Yellow—fair]

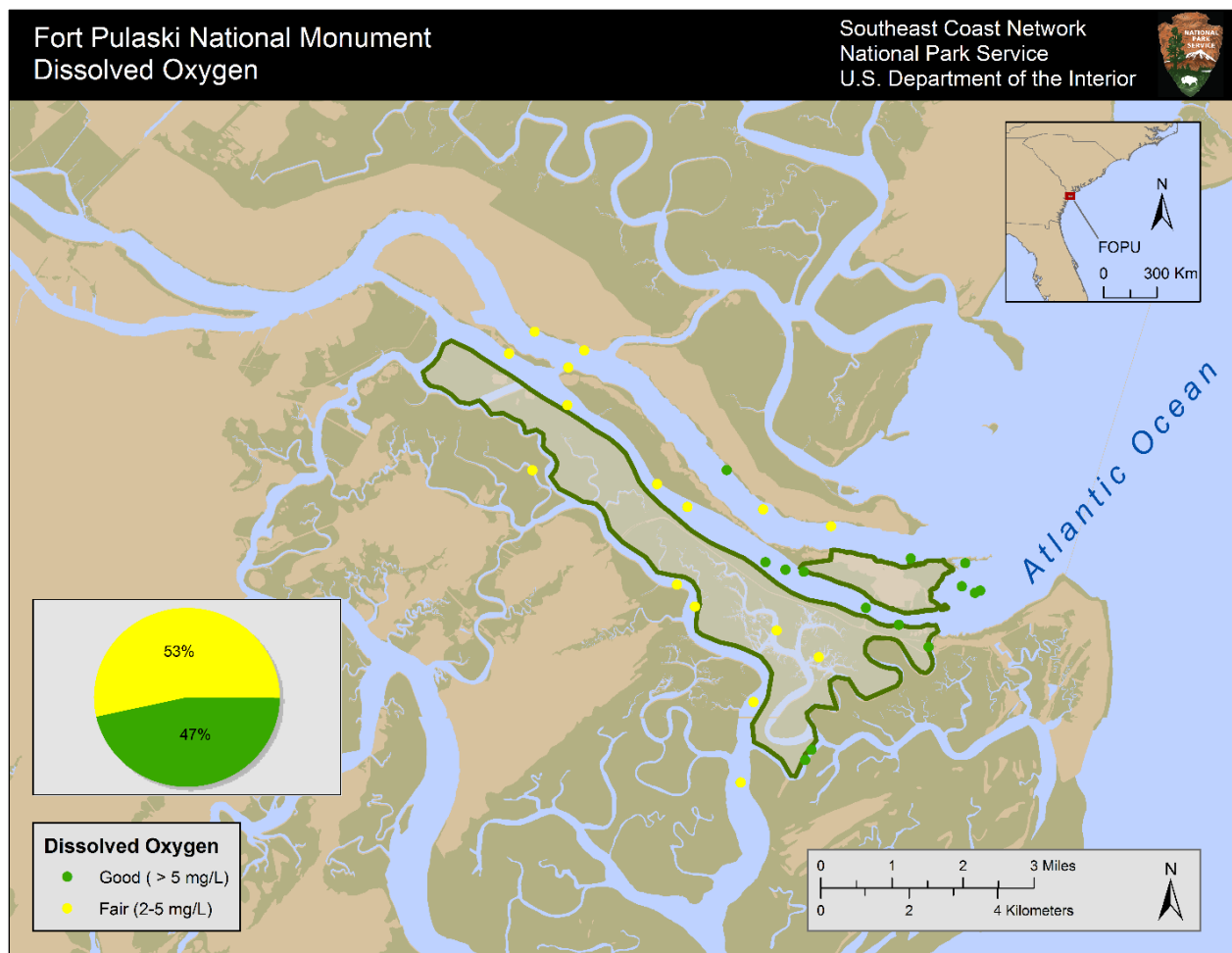


Figure 7. Dissolved oxygen concentrations at sampling sites in the vicinity of Fort Pulaski National Monument in July 2014. Inset graph shows the percentage of sites in each condition category. [Green—good; yellow—fair]

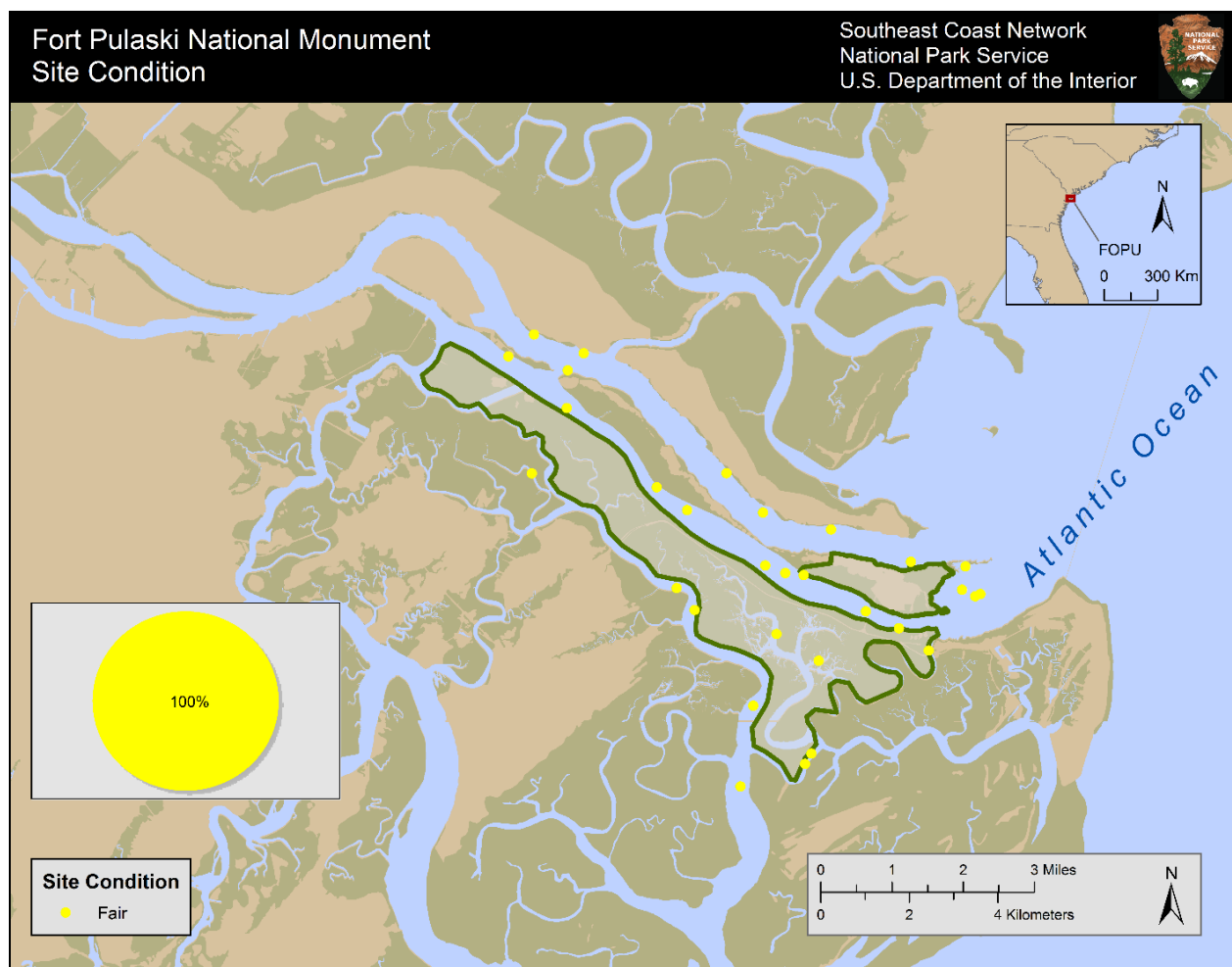


Figure 8. Water quality index rating at sampling sites in the vicinity of Fort Pulaski National Monument in July 2014. Inset graph shows the percentage of sites in each condition category. [Yellow—fair]

Water-Quality Data

Table 4. Water-quality parameter values and assessment conditions for sampling sites in the vicinity of Fort Pulaski National Monument in July 2014. Water Clarity Index (k) values were calculated using the constant for naturally clear estuarine water (Smith et al. 2006). Conditions of assessed parameters are from the EPA (2012a). [^a Green—*good*; ^b yellow—*fair*; ^c red—*poor*; ^d blue—missing data; k—light attenuation coefficient; µg/L—micrograms per liter; N—Nitrogen; mg/L—milligrams per liter; P—Phosphorous]

Map ID	Water Clarity (k)	Chlorophyll a (µg/L)	Dissolved Inorganic N (DIN, mg/L)	Dissolved Inorganic P (DIP, mg/L)	Dissolved Oxygen (DO, mg/L)	Total N (mg/L)	Total P (mg/L)
01	2.00 ^a	8.52 ^b	0.298 ^b	0.0365 ^b	4.0 ^b	0.68	0.0813
02	3.33 ^c	10.42 ^b	0.202 ^b	0.0288 ^b	4.5 ^b	0.68	0.0956
03	2.00 ^a	8.25 ^b	0.268 ^b	0.0331 ^b	4.1 ^b	0.61	0.0653
04	4.00 ^c	10.65 ^b	0.261 ^b	0.0328 ^b	4.3 ^b	0.65	0.0818
05	2.00 ^a	11.82 ^b	0.203 ^b	0.0314 ^b	4.7 ^b	0.58	0.0695
06	5.00 ^c	15.43 ^b	0.117 ^b	0.0233 ^b	5.7 ^a	0.59	0.0973
07	2.00 ^a	5.28 ^b	0.074 ^a	0.0261 ^b	4.3 ^b	0.55	0.0827
08	3.33 ^c	13.90 ^b	0.201 ^b	0.0316 ^b	4.5 ^b	0.67	0.0926
09	5.00 ^c	14.84 ^b	0.186 ^b	0.0316 ^b	4.9 ^b	0.79	0.1361
10	2.00 ^a	13.62 ^b	0.094 ^a	0.0188 ^b	4.8 ^b	0.47	0.0708
11	2.00 ^a	18.62 ^b	0.089 ^a	0.0223 ^b	4.8 ^b	0.51	0.0862
12	1.67 ^a	11.25 ^b	0.033 ^a	0.0161 ^b	5.7 ^a	0.42	0.0650
13	2.00 ^a	11.28 ^b	0.157 ^b	0.0274 ^b	5.1 ^a	0.53	0.0723
14	3.33 ^c	12.46 ^b	0.025 ^a	0.0156 ^b	5.8 ^a	0.47	0.0915
15	1.43 ^a	10.96 ^b	0.158 ^b	0.0264 ^b	5.1 ^a	0.51	0.0642
16	4.00 ^c	17.06 ^b	0.140 ^b	0.0267 ^b	5.4 ^a	0.76	0.1349
17	2.00 ^a	6.60 ^b	0.072 ^a	0.0295 ^b	3.6 ^b	0.62	0.1099
18	2.22 ^a	14.03 ^b	0.073 ^a	0.0205 ^b	5.3 ^a	0.53	0.1043
19	1.43 ^a	11.68 ^b	0.036 ^a	0.0172 ^b	5.7 ^a	0.38	0.0656
20	2.00 ^a	12.76 ^b	0.054 ^a	0.0193 ^b	5.5 ^a	0.43	0.0747
21	2.22 ^a	7.67 ^b	0.078 ^a	0.0297 ^b	3.8 ^b	0.58	0.0999
22	4.00 ^c	16.22 ^b	0.147 ^b	0.0256 ^b	5.8 ^a	0.57	0.0820
23	5.00 ^c	14.72 ^b	0.147 ^b	0.0281 ^b	5.6 ^a	0.82	0.1535
24	1.43 ^a	4.70 ^a	0.060 ^a	0.0284 ^b	4.3 ^b	0.42	0.0740
25	1.54 ^a	14.94 ^b	0.059 ^a	0.0188 ^b	5.1 ^a	0.34	0.0568
26	1.25 ^a	6.04 ^b	0.082 ^a	0.0280 ^b	4.5 ^b	0.31	0.0495

Table 4 (continued). Water-quality parameter values and assessment conditions for sampling sites in the vicinity of Fort Pulaski National Monument in July 2014. Water Clarity Index (k) values were calculated using the constant for naturally clear estuarine water (Smith et al. 2006). Conditions of assessed parameters are from the EPA (2012a). [^a Green—*good*; ^b yellow—*fair*; ^c red—*poor*; ^d blue—missing data; k—light attenuation coefficient; µg/L—micrograms per liter; N—Nitrogen; mg/L—milligrams per liter; P—Phosphorous]

Map ID	Water Clarity (k)	Chlorophyll a (µg/L)	Dissolved Inorganic N (DIN, mg/L)	Dissolved Inorganic P (DIP, mg/L)	Dissolved Oxygen (DO, mg/L)	Total N (mg/L)	Total P (mg/L)
27	1.43 ^a	7.2 ^b	0.069 ^a	0.0294 ^b	4.0 ^b	0.49	0.0841
28	1.43 ^a	7.08 ^b	0.049 ^a	0.0271 ^b	5.3 ^a	0.40	0.0721
29	1.43 ^a	6.27 ^b	0.047 ^a	0.0268 ^b	5.1 ^a	0.40	0.0720
30	1.33 ^a	5.37 ^b	0.059 ^a	0.0290 ^b	4.5 ^b	0.41	0.0686

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