



Fixed-Station Water-Quality Monitoring at Fort Pulaski National Monument

2013–2014 Data Summary

Natural Resource Data Series NPS/SECN/NRDS—2017/1137



ON THE COVER

Boats docked near a boat ramp on Lazaretto Creek at Highway 80. Fort Pulaski is located just north of the highway on Cockspur Island. Photo courtesy of Eric Starkey.

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The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Data Series is intended for the timely release of basic data sets and data summaries. Care has been taken to assure accuracy of raw data values, but a thorough analysis and interpretation of the data has not been completed. Consequently, the initial analyses of data in this report are provisional and subject to change.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner. This report received informal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data. Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

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Summary and Key Findings

In 2005 the National Park Service (NPS) Southeast Coast Network (SECN) Inventory and Monitoring Program began collecting water-quality data in the estuarine waters near Fort Pulaski National Monument (FOPU) as part of the NPS Vital Signs monitoring program. The continuous-monitoring data station is located at Lazaretto Creek.

This station collects pH, dissolved oxygen, temperature, salinity, conductivity, turbidity, and water level data every 30 minutes. Southeast Coast Network staff make additional water quality measurements, which include monthly measurements of water clarity conditions, nutrient concentrations, and chlorophyll *a* levels.

Southeast Coast Network staff follow methods that were adapted from the water-quality monitoring program established by the National Estuarine Research Reserve Program (Wenner and Geist 2001). Data and results are compared to EPA criteria (EPA 2012) which rate conditions as good, fair, or poor.

The Fort Pulaski National Monument fixed-station water-quality monitoring site is part of the SECN estuarine water- and sediment-quality monitoring effort, which routinely collects data in the vicinity of seven coastal park units located along the southeastern U.S. coast (DeVivo et al. 2008; Gregory et al. 2013). Information collected by this monitoring program will be used to help managers make better-informed decisions by understanding trends and variability related to water-quality conditions in park waters.

Highlights from the 2013–2014 data record are summarized in this report.

- Monthly water-quality data collected during 2013–2014 at the Southeast Coast Network site near Fort Pulaski National Monument reflected generally good to fair conditions throughout the period of record, with the exception of two poor water clarity readings.
- Chlorophyll *a* concentrations were mostly fair (seventeen samples) for the period of record, with seven samples rated as good.
- Water clarity was mostly good (19 visits) with two fair and two poor ratings.
- Mean monthly dissolved oxygen levels were good throughout the period, ranging from a 5.0 mg/L in 10.1 mg/L. Individual readings ranged from 2.4 mg/L in July 2014 to 10.9 in January 2014.
- Mean monthly pH values ranged from a low of 7.4 to a high of 8.0. Individual measurements ranged from 6.9 in July 2013 to 8.2 in multiple months.
- Monthly mean turbidity values ranged from 17.1 NTUs to 37 NTUs. The lowest individual turbidity reading for any given month was 0.0 NTUs, and a maximum reading of 370.9 NTUs was recorded in July 2013.
- Water temperatures in 2013–2014 ranged from a minimum monthly mean of 9.0°C (48.2°F) in January 2014 to a maximum monthly mean of 29.3°C (84.7°F) in August 2014. Individual temperatures ranged from a minimum of 6.3°C (43.4°F) in January 2014 to a maximum of 31.1°C (88.0°F) in August 2013. No temperature readings were taken during the spring or summer months.
- The tidal range at Fort Pulaski National Monument is 3.9 meters (12.8 feet).

Fort Pulaski National Monument Significant Waters Map

Southeast Coast Network
National Park Service
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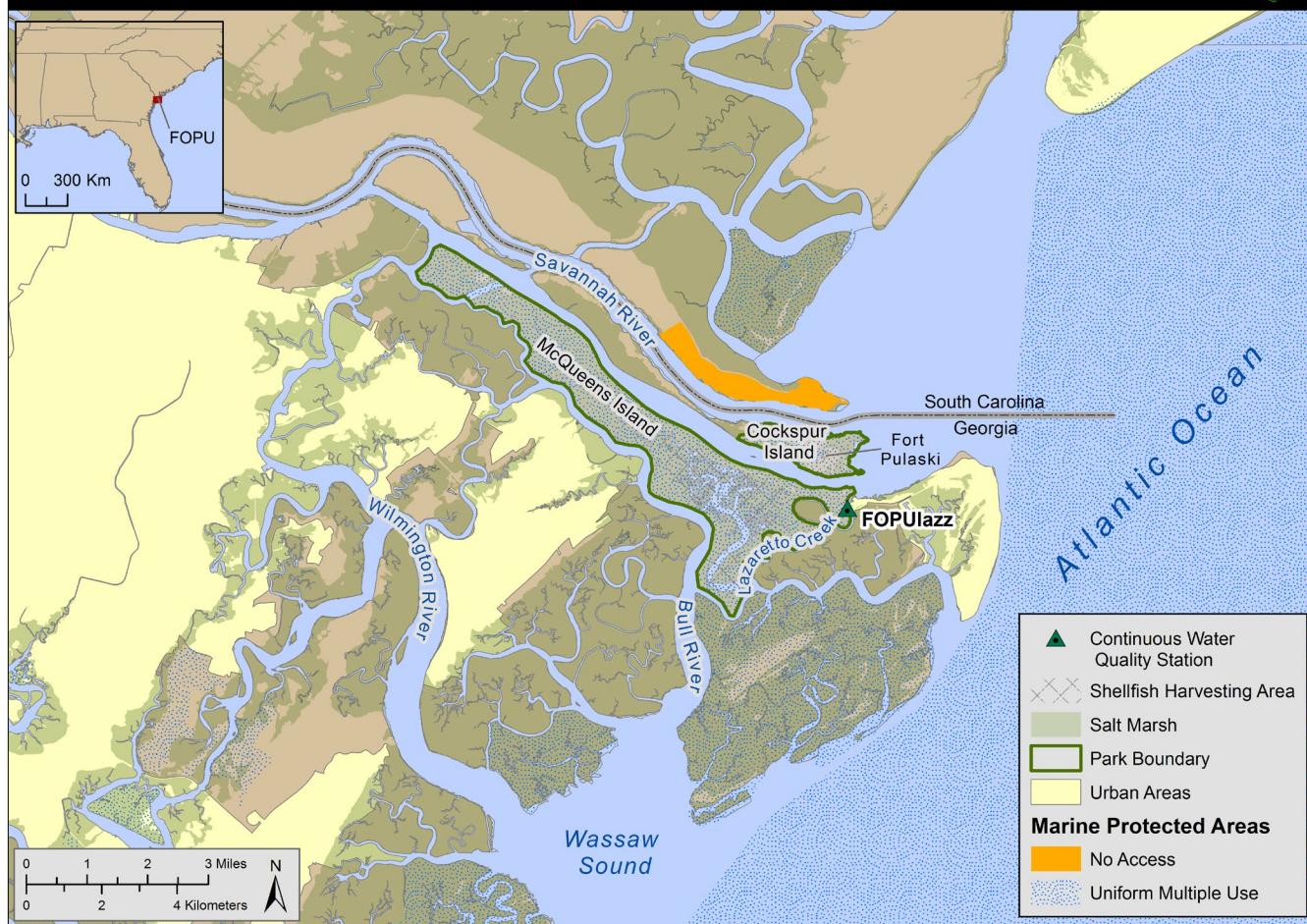


Figure 1. Map showing estuarine and marine water resources at Fort Pulaski National Monument in Georgia. Depicted are areas of salt marsh (U.S. Fish and Wildlife Service 2013), urbanization (United States Census Bureau 2013), 303(d) listed water bodies (United States Environmental Protection Agency 2017), and areas designated as having special uses or restrictions (National Oceanic and Atmospheric Administration 2013).

Introduction

Due to the importance of water resources to park management from ecological, regulatory, and visitor experience perspectives, 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 near park units, and contribute to a better understanding of ecological processes and physical systems in the region (Gregory et al. 2013).

To effectively monitor diverse and dynamic estuarine water resources, the Southeast Coast Network (SECN) implemented a two-pronged monitoring approach. This approach consists of both data collection from continuously recording fixed stations located in each park, and collection of periodic discrete water samples for analysis (Gregory et al. 2013). When combined, these approaches provide a more complete picture of physical processes, diurnal and seasonal variation, and spatial patterns during critical portions of the year than either approach could provide if implemented singularly.

The Southeast Coast Network has identified four specific monitoring objectives (detailed below) for which data are collected and analyzed as part of this effort (Gregory et al. 2013). The contents of this report address objectives 1 and 2:

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 nutrients (nitrogen, phosphorus, and chlorophyll *a*) at fixed monitoring stations through collection of 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 provides an annual summary of data collected during 2013–2014 at Fort Pulaski National Monument and places these values in context of current water-quality

criteria suggested by the U.S. Environmental Protection Agency (EPA 2012), as well as concurrent regional climatic conditions that may influence local water-quality conditions. This report is intended to provide park resource managers and partners with information on the short-term variability and seasonal trends in water quality at Fort Pulaski National Monument.

Fort Pulaski National Monument

Fort Pulaski National Monument is near the mouth of the Savannah River Estuary in Georgia (Figure 1). The monument is composed of a series of small islands surrounded by tidally-influenced river channels and creeks. The primary habitats of the monument are maritime forest, intertidal salt marsh, and the main channel of the estuary with its associated tidal creeks. Although there are no major sources of pollutants at Fort Pulaski itself, both point and nonpoint sources of pollutants can be found nearby that have the potential to affect its water resources. Wastewater treatment plants and pulp and paper mills are the primary point sources of organic matter and nutrient loading in the lower Savannah River watershed. Numerous industries (including 20 Superfund sites) release contaminants to the groundwater, soil, or air, and there are also contaminants associated with dredge spoil sites. In addition, the Port of Savannah is located upstream of the Fort Pulaski study area resulting in high volumes of shipping traffic on the river (McFarlin and Alber 2005).

There have been numerous alterations to the Savannah River that have likely affected water-quality conditions at Fort Pulaski, including deepening and widening of the channel for navigation and the operation of tide gates and upstream dams. Efforts by state and federal agencies to further deepen the channel are currently underway. The Savannah Harbor Expansion Project would involve deepening approximately 35 miles (56.3 kilometers) of the navigation channel an additional 5 feet (1.5 meters) and widening bends at 12 locations. Concerns associated with the deepening include its effects on water conditions (i.e., salinity, dissolved oxygen, water clarity, contaminant concentrations), and how those in turn might affect freshwater wetlands and aquatic resources (e.g., striped bass, shortnose sturgeon). Ongoing population growth and accompanying development in the area is also a potential concern, as these processes could alter the amount and quality of overland runoff from newly-developed areas.

Recent studies have indicated that nutrient concentrations generally decrease along the longitudinal gradient of the estuary as river water becomes increasingly diluted by salt water from the ocean. Sample data summarized by the National Coastal Assessment program (USEPA 2005) indicated that 63% of the dissolved inorganic nitrogen observations were good and 37% were fair (none were poor). In terms of phosphate, 93% of the observations were considered fair; 5% were good, and 2% were poor. These conclusions are based on very limited observations, as only two to four stations were sampled each year in the tidal creeks and estuary associated with Fort Pulaski, and on a one-time basis only. A two-year effort by USGS (between 2002 and 2003), at which two stations adjacent to the park were sampled regularly, yielded higher proportions of nutrients considered fair or poor. In 2007, a study conducted by the Southeast Coast Network (SECN) collected data from 30 sites around the park and found generally good

water-clarity conditions and good to fair dissolved oxygen conditions. Metal concentrations in benthic sediments were slightly elevated around Fort Pulaski; however, only levels of arsenic and nickel were elevated to levels deemed fair by the EPA at 10 of the 30 sites. Total PCB concentration was slightly elevated at a single site in the South Channel of the Savannah River (Gregory et al. 2010). Nutrient concentrations were not assessed as part of this study.

Weather and Hydrologic Setting

Daily rainfall totals were collected at the Savannah International Airport by the National Climate Data Center (NOAA-NCDC 2015) and are included here (Figure 2) as an aid for interpreting water-quality results. The airport is located approximately 20 miles (32.2 kilometers) northwest of Fort Pulaski National Monument. These data are presented for 2013–2014.

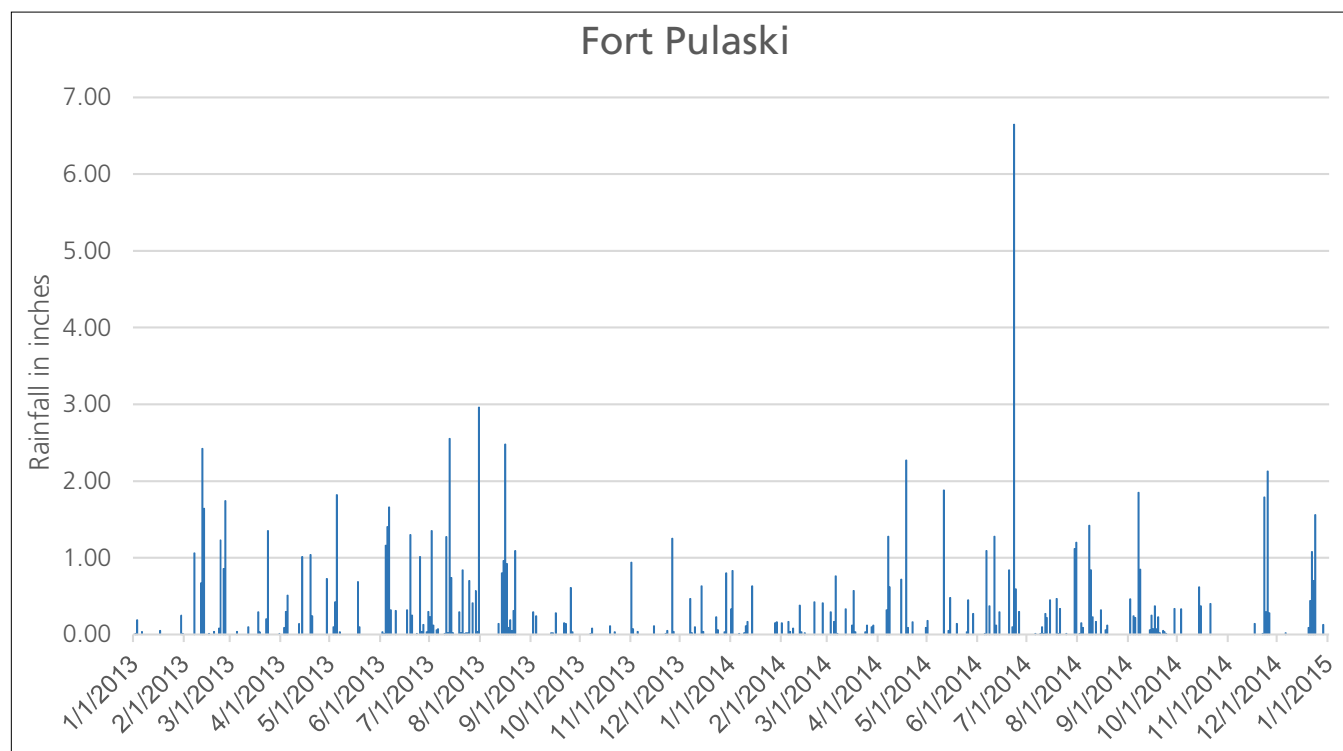


Figure 2. Daily precipitation at Fort Pulaski National Monument January 1, 2013–December 31, 2014. Data source: NOAA-NCDC (2015).

Methods

Data collection at the Fort Pulaski site is modeled after an ongoing water-quality monitoring program established by the National Estuarine Research Reserve System (NERRS) program (Wenner and Geist 2001). Detailed field and laboratory standard operating procedures and methods have been outlined for the continuously collected data in Gregory et al. (2013). Methods for both are briefly summarized in the following sections.

Sampling Location

The fixed station at Fort Pulaski National Monument is located on a dock at Lazaretto Creek (Figure 3). This site regularly experiences heavy boat traffic in spring, summer, and fall.

Table 1. Location of continuous water-quality monitoring site at Fort Pulaski National Monument during 2013–2014.

Name	Location Description	Location (lat /long)	Period of Record
FOPulazz	Lazaretto Creek Fishing Dock	32.014137 / -80.88412	8/14/2006 to present



Figure 3. Continuous data collection platform at Fort Pulaski National Monument. Photo by Eric Starkey, SECN staff.

Continuous Data

Continuously collected data include dissolved oxygen, pH, specific conductance, water temperature, depth and turbidity. Data are collected at 30-minute intervals using YSI data sondes (Model 6600). Sondes are deployed in three- to five-week intervals depending on routine instrument maintenance schedules.

The data collection platform consists of a 4-inch diameter PVC tube attached vertically to a piling on a municipal fishing pier with the sonde suspended within and approximately 0.5 meters from the bottom (Figure 3). Water is allowed to freely circulate via openings cut into the PVC housing. A locking cap on the top of the PVC tube prevents unwanted tampering, and a carriage bolt inserted through the housing at the submerged end prevents instrument loss should the attachment hardware fail. Anti-fouling paint is used on the PVC tube to extend deployment intervals, which are sometimes shortened due to excessive biofouling. The sonde guard is covered with 0.25-inch brass or plastic mesh screen to prevent fish, crabs, and detritus from entering the protective housing, which could skew measurements or damage the instrument probes. Additional details on initial site selection and installation procedures can be found in Gregory et al. (2013).

Prior to deployment, the data sonde is calibrated according to YSI recommendations for pH (two-point calibration), dissolved oxygen, specific conductance, depth, and turbidity (two-point calibration) (YSI Incorporated 2011; Gregory et al. 2013). After instrument retrieval, data sondes are returned

to the laboratory where post-deployment readings are made using calibration standards to evaluate the accuracy and validity of the data collected for that deployment period. All pre-deployment and post-retrieval calibration information is recorded on calibration data sheets that are archived at the Southeast Coast Network office in Athens, Georgia. After post-retrieval processing is complete, the sonde is cleaned, reconditioned, and readied for redeployment following methods outlined by YSI (2011). Performance specifications of the YSI 6600 are shown in Table 2.

Data generated during the deployment periods are reviewed and certified by SECN staff prior to being made available to park staff or the public. During 2013, as the Southeast Coast Network transitioned continuous data management tasks to Aquarius (Aquatic Informatics Inc. 2015), all parameters were certified with undefined grades, and invalid (i.e., unusable) data were deleted from the data set.

Beginning in January 2014, turbidity, dissolved oxygen, specific conductance, and pH values were assigned grades of excellent, good, fair, or poor—and corrections to these values were made when appropriate—based on differences between pre-calibration and post-calibration measurement data based on guidance from USGS (Wagner et al. 2006). Temperature and depth data were neither graded nor corrected, but were assumed accurate unless post-calibration data indicated a failure. As with previous years, invalid or unusable data were deleted from datasets prior to publication. Data sets are available at the NPS Aquarius Web Data Portal at <https://irma.nps.gov/aqwebportal/>.

Table 2. Performance specifications of YSI 6600 EDS data loggers deployed at Fort Pulaski National Monument during 2013–2014 (YSI 2011).

Parameter	Range	Resolution	Accuracy
Dissolved Oxygen (% saturation)	0–500%	0.1%	0 to 200%: +/- 2% of reading or 2% air saturation, whichever is greater.
Dissolved Oxygen (mg/L)	0–50 mg/L	0.01 mg/L	0 to 20 mg/L: +/- 2% of reading or 0.2 mg/L whichever is greater.
Conductivity	0–100 mS/cm	0.001 to 0.1 mS/cm; range dependent	+/- 0.5% of reading + 0.001 mS/cm
Temperature	-5–50 °C	0.01 °C	+/- 0.15 °C
pH	0 to 14 units	0.01 units	+/- 0.2 unit
Depth	0–9 m (0–30 ft)	0.001m (0.001ft)	+/- 0.018m (+/- 0.06 ft.)
Salinity	0–70 ppt	0.01 ppt	+/- 1% of reading or 0.1 ppt, whichever is greater.
Turbidity	0–1000 NTU	0.1 NTU	+/- 2% of reading or 0.3 NTU, whichever is greater.

Discrete Data

Water sample collection for this project was collected by SECN staff. Secchi depth was measured with standard equipment—an 8-inch black and white Secchi disk. Water samples were collected as grabs in lab-cleaned and field-rinsed containers. Filtration was conducted using a 0.45-micron filter, and samples were transported and shipped on wet ice. QA/QC field sampling included both field blanks and duplicates collected on random dates throughout the year. Filtered samples and chlorophyll filters were placed on ice prior to shipment for laboratory analyses. Original chain-of-custody paperwork accompanied all samples to the laboratory. Data collection standard operating procedures are further documented in Gregory et al. (2013).

Water-clarity conditions were derived from estimated light attenuation coefficients (k) using the equation: $k = a / Z_{\text{Secchi}}$ where Z is Secchi depth (in meters) and $a = 1.0$ (“ a ” is assigned to one of three values depending on the water body’s naturally occurring clarity conditions—i.e., $a = 1.0$ for naturally turbid conditions, $a = 1.4$ for moderately turbid conditions, or $a = 1.7$ for clear water estuaries). Fort Pulaski National Monument uses a coefficient of 1.0 for naturally turbid conditions. These constants were estimated for each

water-clarity class based on values reported in the literature (Smith et al. 2006). 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 and recently collected datasets where water column light transmission information was not collected.

Assessment Criteria

Water quality was assessed for each of the parameters using data from the monthly samples, and following the East/Gulf Coast site criteria in the EPA National Coastal Assessment IV Report (EPA 2012; Table 3). The categorical assessments (i.e., *good*, *fair*, and *poor*) use measurements of chlorophyll a , nutrients, dissolved oxygen, and water clarity and are intended to highlight a range of conditions including acutely degraded water-quality conditions. Light attenuation coefficients (k) were used to assess water-clarity conditions using criteria categories in Smith et al. (2006) which are equivalent to the EPA criteria for the assessed water bodies.

Table 3. Coastal 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) ¹	Chlorophyll a ($\mu\text{g/L}$)	Dissolved Inorganic Nitrogen (DIN) (mg/L)	Dissolved Inorganic Phosphorus (DIP) (mg/L)	Dissolved Oxygen (mg/L)
Good	< 2.3	< 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

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.

Results

Monthly water-quality data collected during 2013–2014 at the Southeast Coast Network monitoring site near Fort Pulaski National Monument reflected mostly good to fair conditions throughout the period of record, with the exception of two poor water clarity readings.

Chlorophyll *a* concentrations were mostly fair (seventeen samples) for the period of record, with seven samples rated as good.

Water clarity was mostly good (19 visits) with two fair and two poor ratings.

Mean monthly dissolved oxygen levels were good throughout the period, ranging from a 5.0 mg/L in 10.1 mg/L. Individual readings ranged from 2.0 mg/L in July 2014 to 10.9 in January 2014.

Mean monthly pH values ranged from a low of 7.4 to a high of 8.0. Individual measurements ranged from 6.9 in July 2013 to 8.2 in multiple months.

Monthly mean turbidity values ranged from 17.1 NTUs to 37 NTUs. The lowest individual turbidity reading for any given month was 0.0 NTUs, and a maximum reading of 370.9 NTUs was recorded in July 2013.

Water temperatures in 2013–2014 ranged from a minimum monthly mean of 9.0°C (48.2°F) in January 2014 to a maximum monthly mean of 29.3°C (84.7°F) in August 2014. Individual temperatures ranged from a minimum of 6.3°C (43.4°F) in January 2014 to a maximum of 31.1°C (88.0°F) in August 2013.

The tidal range at Fort Pulaski National Monument is 3.91 meters (12.8 feet).

Continuous Data

Figures 4 through 8 depict the daily mean for each parameter for the entire data collection period. Relative water depth collected by SECN staff at the site (Figure 9) is included in this section as an aid to data interpretation because it includes information that shows daily tidal fluctuations.

Summary statistics (minimum, maximum, mean, and standard deviation) are provided in Table 4. The percentage-of-values field indicates the level of completeness of the monthly data sets used for calculating mean, maximum, and minimum statistics, and equals the number of valid data points collected (i.e., not missing or flagged) divided by the total number of expected points for a complete month of data. For those months in which all of the data were either missing and/or flagged, the percentage of values is 0 and no statistics (mean, maximum, or minimum) are presented. For months in which the percentage of values is low, the statistics (mean, maximum, and minimum) may be less accurate than for months in which all data were used in the calculation of summary statistics.

Discrete Data

Monthly water-quality data collected during 2013–2014 at the SECN site near Fort Pulaski National Monument are shown in Table 5. Condition categories generally correspond to those used by the EPA in the National Coastal Condition Report IV (2012).

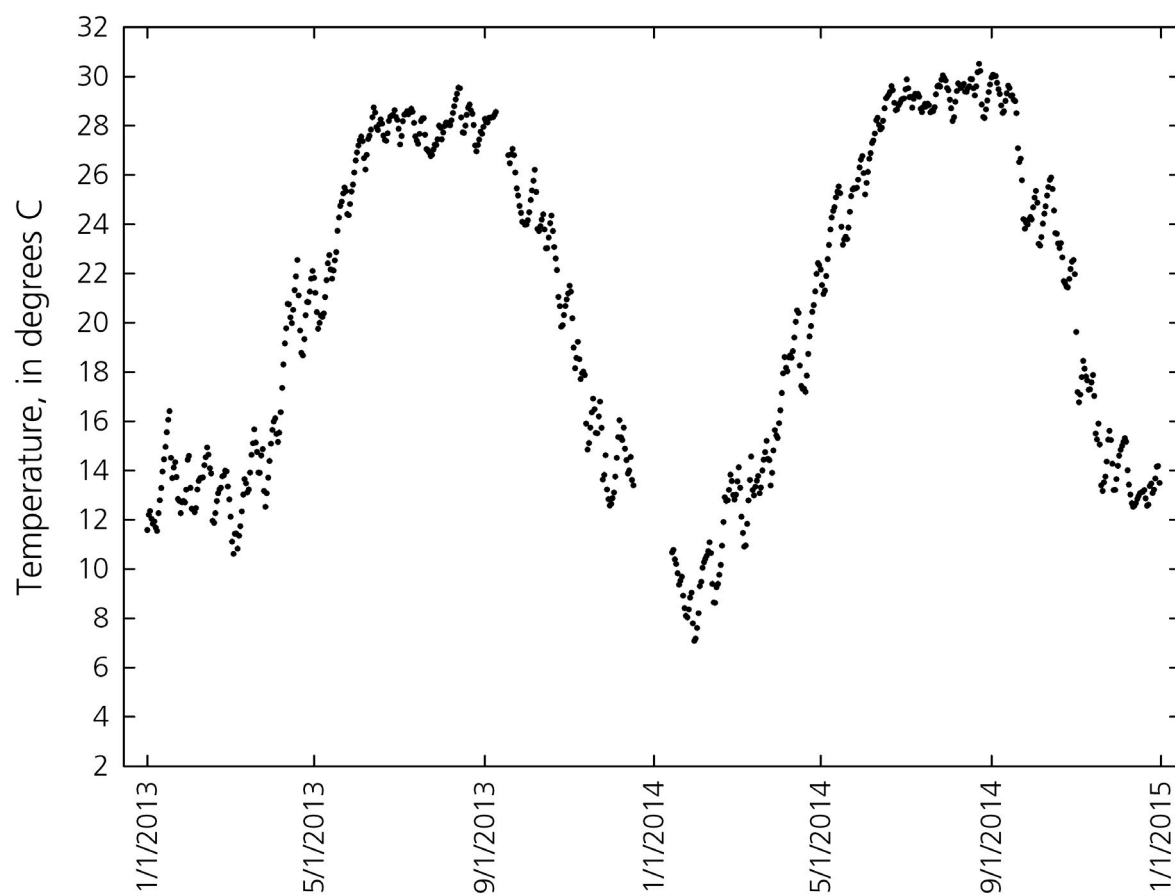


Figure 4. Mean daily water temperature at Fort Pulaski National Monument during 2013–2014. Breaks in data record indicate missing and/or flagged data.

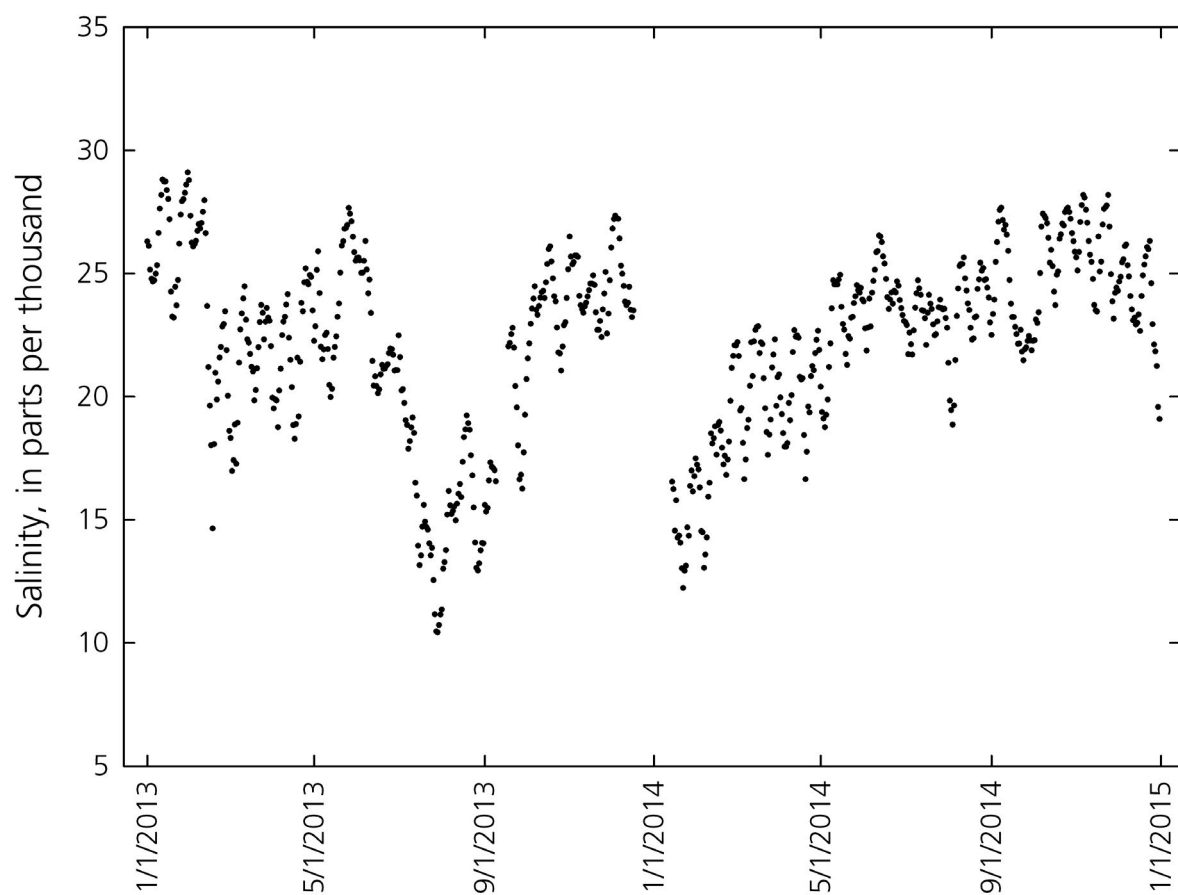


Figure 5. Mean daily values for salinity at Fort Pulaski National Monument during 2013–2014. Breaks in data record indicate missing and/or flagged data.

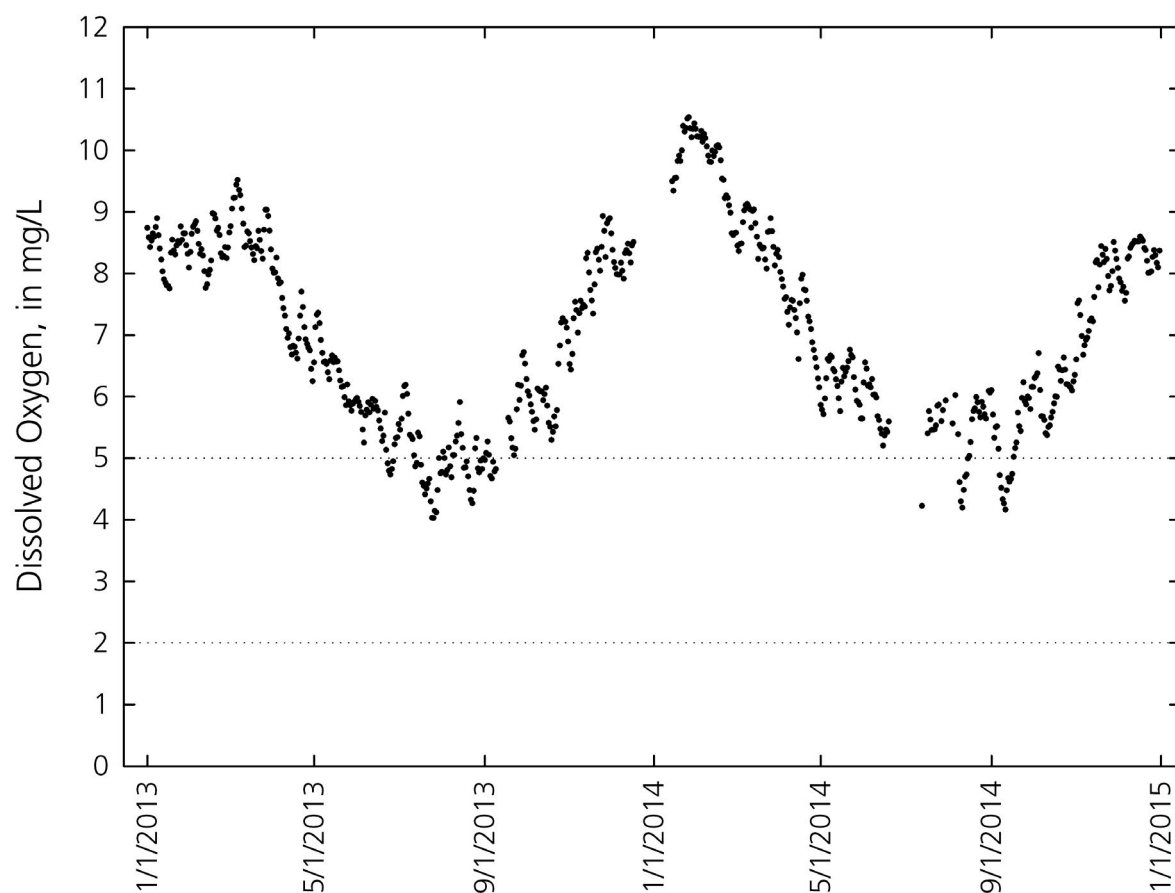


Figure 6. Mean daily values for dissolved oxygen at Fort Pulaski National Monument during 2013–2014. Breaks in data record indicate missing and/or flagged data. Dotted lines indicate minimum value for a rating of *good* (5 mg/L) and *fair* (2 mg/L)(EPA 2012).

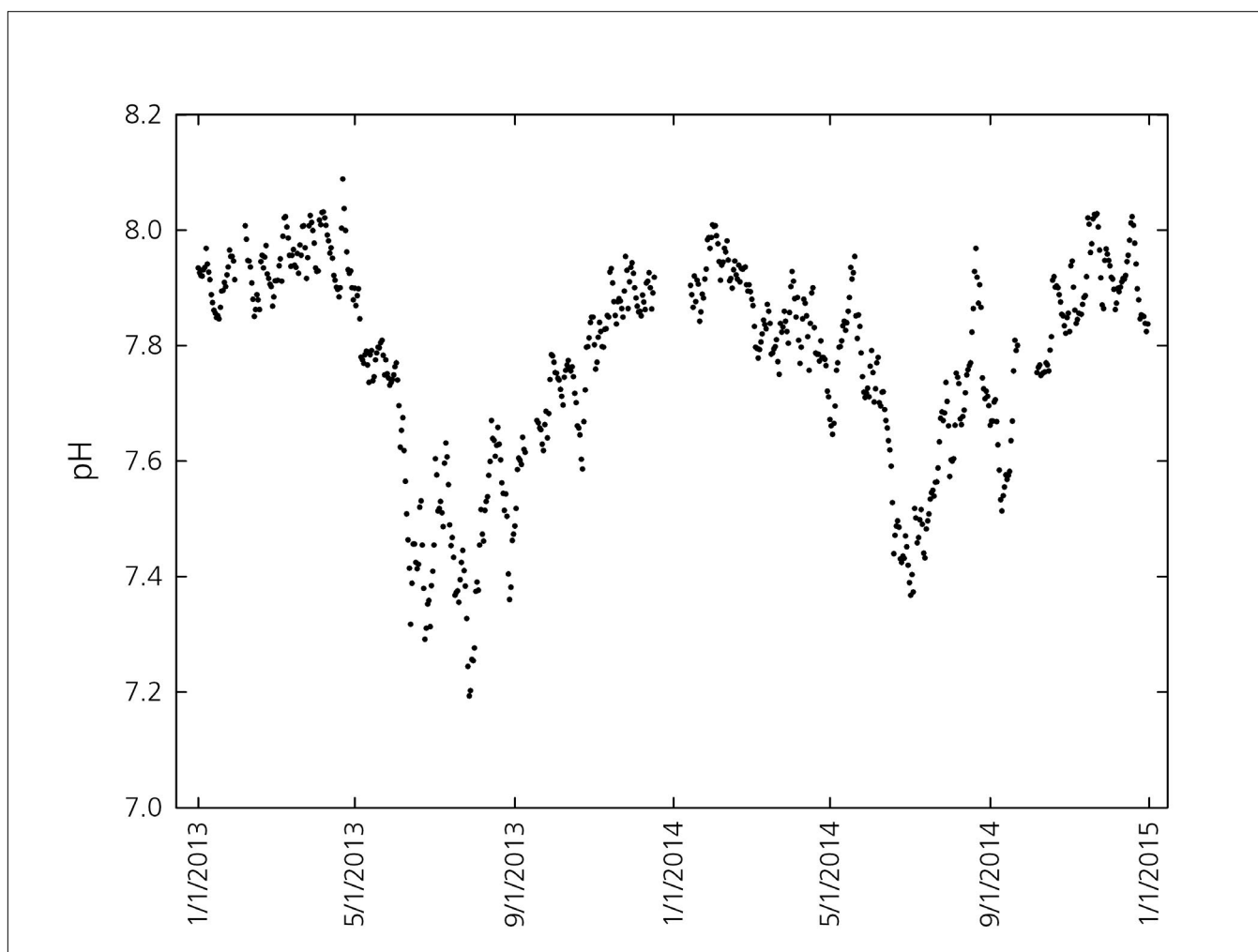


Figure 7. Mean daily values for pH at Fort Pulaski National Monument during 2013–2014. Breaks in data record indicate missing and/or flagged data.

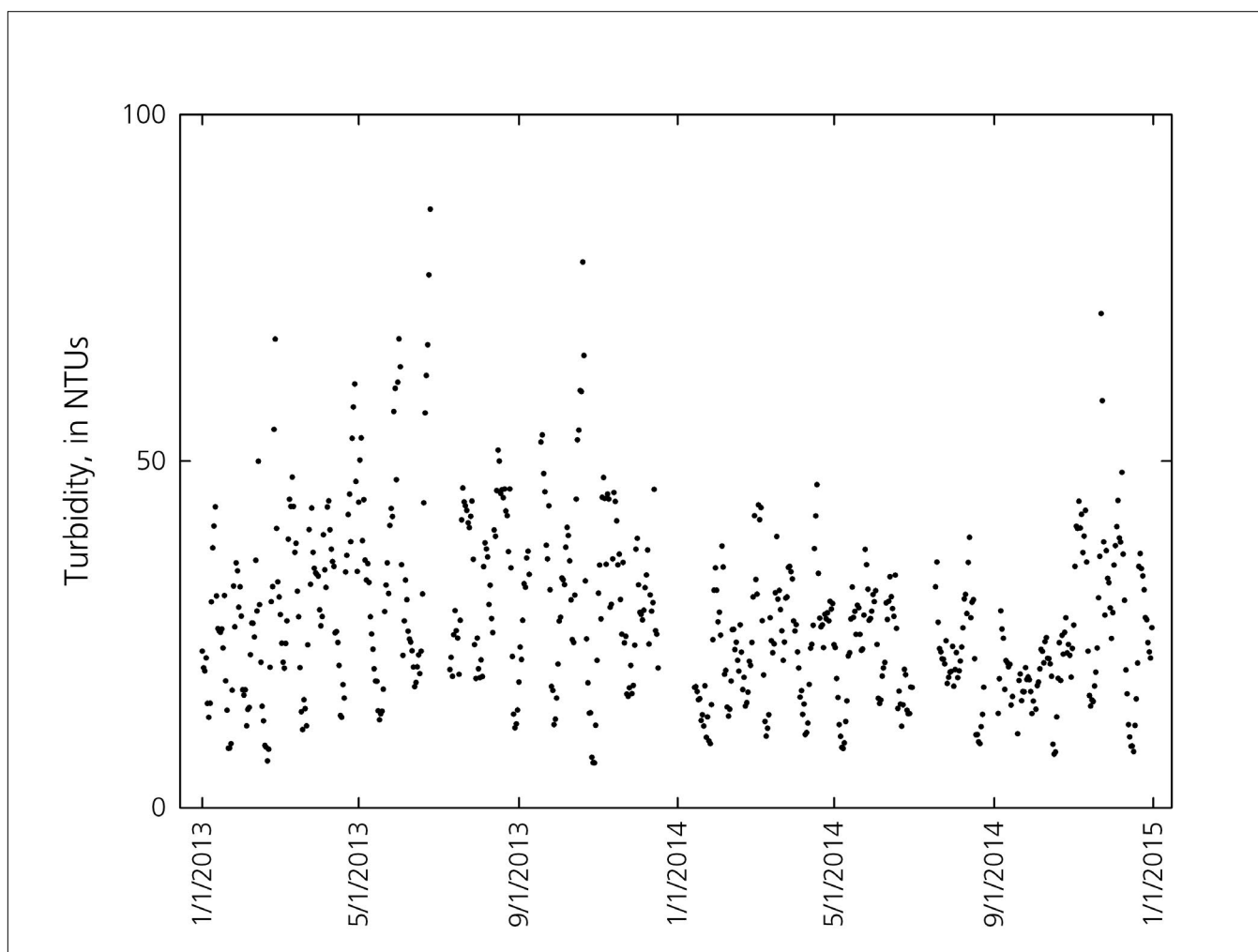


Figure 8. Mean daily values for turbidity (NTUs) at Fort Pulaski National Monument during 2013–2014. Breaks in data record indicate missing and/or flagged data.

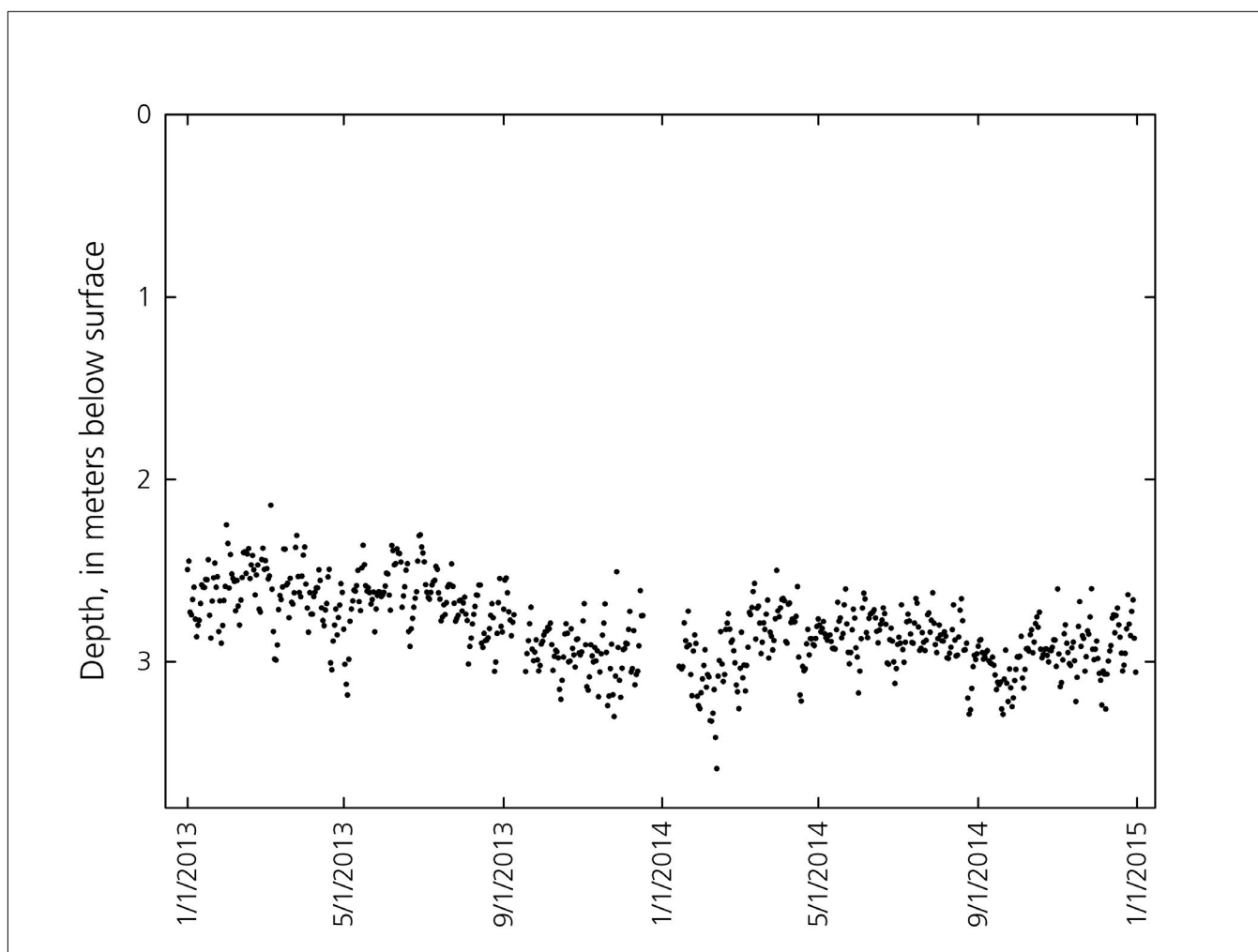


Figure 9. Mean daily values for depth at Fort Pulaski National Monument during 2013–2014. Breaks in data record indicate missing and/or flagged data.

Table 4. Monthly minimum, maximum, and mean values for parameters collected by the YSI 6-series data sonde at Fort Pulaski National Monument during 2013–2014. Percent of values for each month indicates the number of data points collected during one calendar month of data collection divided by the total number of expected points for a complete month of data [PPT—parts per thousand; mg/L—milligrams per liter; m—meter; NTU—nephelometric turbidity unit; SD—standard deviation].

Month / Expected count	Metric	Temperature (°C)	Salinity (PPT)	Dissolved Oxygen, (mg/L)	Depth (m)	pH	Turbidity (NTU)
January 2013 (Expected count 2976)	Actual Count	1488	1488	1488	1488	1385	1488
	Minimum	10.9	19.9	7.1	1.02	7.8	4.5
	Maximum	17.6	33.6	9.2	4.16	8.1	149.9
	Mean	13.3	26.5	8.4	2.65	7.9	24.4
	SD	1.4	2.8	0.4	0.8	0.06	15.9
	Percent	100%	100%	100%	100%	93%	100%
February 2013 (Expected count 2688)	Actual Count	1344	1344	1344	1344	1135	1344
	Minimum	10.7	10.9	7.1	1	7.7	4.2
	Maximum	16.1	31.8	9.5	4.21	8.1	153.2
	Mean	13.4	23.3	8.4	2.53	7.9	24.7
	SD	0.9	4.4	0.4	0.8	0.09	20.2
	Percent	100%	100%	100%	100%	84%	100%
March 2013 (Expected count 2976)	Actual Count	1488	1488	1488	1488	1488	1488
	Minimum	9.6	9.9	7.7	0.95	7.7	6.2
	Maximum	16.9	30.8	9.9	4.21	8.2	118.5
	Mean	13.2	21.4	8.8	2.59	8	29.8
	SD	1.5	3.8	0.4	0.8	0.09	17.3
	Percent	100%	100%	100%	100%	100%	100%
April 2013 (Expected count 2880)	Actual Count	1440	1440	1440	1440	1440	1440
	Minimum	14.6	11.3	5.3	1.19	7.7	7.1
	Maximum	23.9	30.5	8.6	4.29	8.2	156.5
	Mean	19.2	21.9	7.2	2.69	8	34.2
	SD	2.3	3.8	0.6	0.8	0.11	22.2
	Percent	100%	100%	100%	100%	100%	100%
May 2013 (Expected count 2976)	Actual Count	1488	1488	1488	1488	1488	1471
	Minimum	19.3	13.4	4.5	1.09	7.5	7.4
	Maximum	27.9	31.6	7.9	4.3	8.1	370.9
	Mean	23	24	6.4	2.69	7.8	33.3
	SD	2.1	3.7	0.6	0.8	0.12	24.3
	Percent	100%	100%	100%	100%	100%	99%
June 2013 (Expected count 2880)	Actual Count	1440	1440	1440	1440	1435	1192
	Minimum	25.6	13.7	3.8	0.98	7.1	8.3
	Maximum	30.4	31.6	8.1	4.32	8	252.8
	Mean	27.8	22.6	5.5	2.55	7.5	37
	SD	0.8	3.8	0.6	0.8	0.18	29.4
	Percent	100%	100%	100%	100%	100%	83%

Table 4 (continued). Monthly minimum, maximum, and mean values for parameters collected by the YSI 6-series data sonde at Fort Pulaski National Monument during 2013–2014. Percent of values for each month indicates the number of data points collected during one calendar month of data collection divided by the total number of expected points for a complete month of data [PPT—parts per thousand; mg/L—milligrams per liter; m—meter; NTU—nephelometric turbidity unit; SD—standard deviation].

Month / Expected count	Metric	Temperature (°C)	Salinity (PPT)	Dissolved Oxygen, (mg/L)	Depth (m)	pH	Turbidity (NTU)
July 2013 (Expected count 2976)	Actual Count	1488	1488	1488	1488	1485	1074
	Minimum	25.5	3.4	3.4	0.84	6.9	6
	Maximum	30.1	28.4	7.6	4.13	8.1	198.7
	Mean	27.7	15.8	5	2.63	7.4	31.5
	SD	0.9	5.3	0.8	0.8	0.21	25
	Percent	100%	100%	100%	100%	100%	72%
August 2013 (Expected count 2976)	Actual Count	1488	1488	1488	1488	1488	1479
	Minimum	26.2	6.7	3.3	1.26	7.1	4.1
	Maximum	31.1	25.2	8	4.33	8.1	312.3
	Mean	28.2	15.5	5	2.79	7.5	32.8
	SD	0.9	4.1	0.6	0.8	0.2	30.5
	Percent	100%	100%	100%	100%	100%	99%
September 2013 (Expected count 2880)	Actual Count	1111	1111	1111	1109	1111	1111
	Minimum	23.4	8.6	3.3	1.39	7.2	4.7
	Maximum	29.7	29.1	7.4	4.29	8.1	187.4
	Mean	26.7	18.4	5.5	2.85	7.6	32
	SD	1.7	4.1	0.7	0.7	0.16	24.7
	Percent	77%	77%	77%	77%	77%	77%
October 2013 (Expected count 2976)	Actual Count	1488	1488	1488	1488	1488	1485
	Minimum	19.1	16.2	4.3	1.46	7.5	2.8
	Maximum	27.1	29.9	7.8	4.27	8.1	266
	Mean	23.2	23.6	6.1	2.93	7.7	32.3
	SD	1.8	2.8	0.7	0.7	0.15	25.7
	Percent	100%	100%	100%	100%	100%	100%
November 2013 (Expected count 2880)	Actual Count	1440	1440	1440	1440	1440	1440
	Minimum	11.7	18.1	5.4	1.37	7.6	5.8
	Maximum	22	30.6	9.2	4.53	8.1	130.6
	Mean	16.7	24.2	7.8	2.99	7.9	31.8
	SD	2.3	2.6	0.7	0.8	0.1	20.4
	Percent	100%	100%	100%	100%	100%	100%
December 2013 (Expected count 2976)	Actual Count	841	841	841	841	841	841
	Minimum	12.1	17.6	7.3	1.38	7.8	7.3
	Maximum	17.4	31	8.9	4.41	8.1	150.5
	Mean	14.3	25.2	8.2	2.9	7.9	29.8
	SD	1.1	3	0.3	0.8	0.08	17.3
	Percent	57%	57%	57%	57%	57%	57%

Table 4 (continued). Monthly minimum, maximum, and mean values for parameters collected by the YSI 6-series data sonde at Fort Pulaski National Monument during 2013–2014. Percent of values for each month indicates the number of data points collected during one calendar month of data collection divided by the total number of expected points for a complete month of data [PPT—parts per thousand; mg/L—milligrams per liter; m—meter; NTU—nephelometric turbidity unit; SD—standard deviation].

Month / Expected count	Metric	Temperature (°C)	Salinity (PPT)	Dissolved Oxygen, (mg/L)	Depth (m)	pH	Turbidity (NTU)
January 2014 (Expected count 2976)	Actual Count	882	882	882	882	880	864
	Minimum	6.3	7	9.1	1.57	7.6	4.1
	Maximum	11.3	27.5	10.9	4.75	8.2	72.8
	Mean	9	15	10.1	3.02	7.9	17.1
	SD	1.2	4	0.4	0.8	0.13	11.1
	Percent	59%	59%	59%	59%	59%	58%
February 2014 (Expected count 2688)	Actual Count	1344	1344	1344	1344	1344	1282
	Minimum	7	7.4	7.7	1.42	7.7	4.9
	Maximum	15.9	29.5	10.6	4.6	8.1	80.2
	Mean	10.8	17.5	9.7	3.06	7.9	21.6
	SD	1.8	4.3	0.6	0.8	0.09	11.6
	Percent	100%	100%	100%	100%	100%	95%
March 2014 (Expected count 2976)	Actual Count	1488	1488	1488	1488	1488	1381
	Minimum	10.2	11.2	7.5	0.98	7.6	5.4
	Maximum	16.9	30.3	9.6	4.72	8.1	93.9
	Mean	13.6	20.5	8.6	2.84	7.8	27.6
	SD	1.3	3.8	0.4	0.8	0.1	15.6
	Percent	100%	100%	100%	100%	100%	93%
April 2014 (Expected count 2880)	Actual Count	1440	1440	1440	1440	1434	1370
	Minimum	14.9	11.3	5.2	1.25	7.5	5.2
	Maximum	23.7	29.9	9.2	4.39	8.2	110.3
	Mean	19	20.3	7.3	2.85	7.8	24.3
	SD	1.8	4.1	0.7	0.8	0.15	14.6
	Percent	100%	100%	100%	100%	100%	95%
May 2014 (Expected count 2976)	Actual Count	1488	1488	1409	1488	1481	1415
	Minimum	20.6	11.6	4.6	1.14	7.5	3.8
	Maximum	27.5	31	8.3	4.32	8.1	101.4
	Mean	24.2	22.7	6.2	2.84	7.8	22.6
	SD	1.7	3.6	0.6	0.8	0.15	14.8
	Percent	100%	100%	95%	100%	100%	95%
June 2014 (Expected count 2880)	Actual Count	1440	1440	1098	1440	1433	1360
	Minimum	24.6	16.8	4	1.28	7.2	0.2
	Maximum	30.6	32.1	7.3	4.37	8	112.6
	Mean	28.1	24.3	5.8	2.85	7.6	21.1
	SD	1.3	3.1	0.6	0.8	0.19	16.1
	Percent	100%	100%	76%	100%	100%	94%

Table 4 (continued). Monthly minimum, maximum, and mean values for parameters collected by the YSI 6-series data sonde at Fort Pulaski National Monument during 2013–2014. Percent of values for each month indicates the number of data points collected during one calendar month of data collection divided by the total number of expected points for a complete month of data [PPT—parts per thousand; mg/L—milligrams per liter; m—meter; NTU—nephelometric turbidity unit; SD—standard deviation].

Month / Expected count	Metric	Temperature (°C)	Salinity (PPT)	Dissolved Oxygen, (mg/L)	Depth (m)	pH	Turbidity (NTU)
July 2014 (Expected count 2976)	Actual Count	1488	1488	1015	1488	1474	657
	Minimum	28	16.7	2.4	1.2	7.1	4.7
	Maximum	30.7	31.2	7.4	4.4	8	97.5
	Mean	29.2	23.2	5.5	2.84	7.5	23.5
	SD	0.6	2.8	0.7	0.8	0.16	14.1
	Percent	100%	100%	68%	100%	99%	44%
August 2014 (Expected count 2976)	Actual Count	1488	1488	1227	1488	1485	1073
	Minimum	27.6	14.9	3.3	1.14	7.4	0.3
	Maximum	30.9	30.4	7.3	4.38	8.2	130.6
	Mean	29.3	23.4	5.4	2.93	7.7	21.2
	SD	0.7	3.3	0.8	0.8	0.16	17.6
	Percent	100%	100%	82%	100%	100%	72%
September 2014 (Expected count 2880)	Actual Count	1440	1440	1321	1440	1060	1141
	Minimum	23	17.3	3.4	1.37	7.3	0
	Maximum	31	31.4	7	4.38	8	98.1
	Mean	27.7	24	5.3	3.06	7.6	18
	SD	2.3	3.2	0.8	0.7	0.16	14.8
	Percent	100%	100%	92%	100%	74%	79%
October 2014 (Expected count 2976)	Actual Count	1488	1488	1301	1488	1222	1402
	Minimum	20.8	18.4	4.4	1.28	7.6	0
	Maximum	26.9	31.6	8.1	4.37	8.2	71.7
	Mean	23.6	25.8	6.1	2.93	7.8	19.5
	SD	1.4	2.8	0.6	0.8	0.15	12.8
	Percent	100%	100%	87%	100%	82%	94%
November 2014 (Expected count 2880)	Actual Count	1440	1440	1388	1440	1440	1357
	Minimum	11.8	17.4	5.8	1.18	7.7	6.7
	Maximum	21.7	33.3	8.9	4.32	8.2	124.4
	Mean	15.9	25.9	7.7	2.92	7.9	32.1
	SD	1.9	2.7	0.6	0.8	0.11	20.3
	Percent	100%	100%	96%	100%	100%	94%
December 2014 (Expected count 2976)	Actual Count	1488	1488	1432	1488	1488	1437
	Minimum	12	13.1	6.8	1.19	7.7	4
	Maximum	15.9	30.1	9	4.51	8.2	111.3
	Mean	13.5	24	8.2	2.92	7.9	26.2
	SD	0.9	3.1	0.4	0.8	0.1	16.3
	Percent	100%	100%	96%	100%	100%	97%

Table 5. Monthly water-quality data collected at the Southeast Coast Network site near Fort Pulaski National Monument during 2013–2014. Water clarity was assessed with light attenuation values (k) using a constant for estuarine water with moderately turbid conditions (Smith et al. 2006) and assessment categories that correspond to EPA (2012) criteria. Condition of other assessed parameters based on EPA (2012). [^agreen—good; ^byellow—fair; ^cred—poor; k¹—light attenuation coefficient; µg/L—micrograms per liter; mg/L—milligrams per liter; -- data not collected].

Collection Date	Water Clarity (k) ¹	Chlorophyll a (µg/L)	Dissolved Inorganic Nitrogen (mg/L)	Dissolved Inorganic Phosphorus (mg/L)	Dissolved Oxygen (mg/L)	Total Dissolved Nitrogen (mg/L) ²	Total Dissolved Phosphorus (mg/L) ²
01/08/2013	2.00 ^a	6.04 ^b	--	--	8.79 ^a	0.34	0.0386
02/05/2013	1.25 ^a	3.77 ^a	0.07540 ^a	0.0182 ^b	8.88 ^a	0.23	0.0288
03/05/2013	1.33 ^a	5.94 ^b	--	--	9.64 ^a	0.30	0.0286
04/04/2013	2.50 ^b	10.54 ^b	--	--	8.51 ^a	0.32	0.0236
05/02/2013	1.67 ^a	6.31 ^b	0.15930 ^b	0.0164 ^b	7.01 ^a	0.41	0.0304
06/03/2013	1.43 ^a	7.06 ^b	--	--	5.14 ^a	0.29	0.0349
07/09/2013	1.82 ^a	17.72 ^b	--	--	5.93 ^a	0.60	0.0487
08/16/2013	1.67 ^a	11.09 ^b	0.12190 ^b	0.0259 ^b	4.79 ^b	0.40	0.0433
09/10/2013	3.33 ^c	14.98 ^b	--	--	6.13 ^a	0.33	0.0326
10/21/2013	2.50 ^b	4.85 ^a	--	--	5.22 ^a	0.41	0.0439
11/19/2013	1.25 ^a	4.88 ^a	0.11950 ^b	0.0246 ^b	7.80 ^a	0.36	0.0357
12/18/2013	1.11 ^a	4.69 ^a	--	--	8.72 ^a	0.29	0.3160
01/14/2014	1.67 ^a	5.71 ^b	--	--	9.40 ^a	0.29	0.0245
02/18/2014	1.00 ^a	3.73 ^a	0.03700 ^a	0.0109 ^b	9.86 ^a	0.22	0.0217
04/01/2014	2.13 ^a	8.11 ^b	--	--	7.89 ^a	0.31	0.0310
05/21/2014	1.33 ^a	8.85 ^b	0.21500 ^b	0.0218 ^b	6.09 ^a	0.60	0.0602
06/18/2014	2.22 ^a	11.72 ^b	--	--	5.80 ^a	0.350	0.0407
07/16/2014	4.00 ^c	11.31 ^b	0.12360 ^b	0.0275 ^b	--	0.37	0.0407
08/10/2014	2.00 ^a	10.74 ^b	--	--	4.10 ^b	0.40	0.0576
09/02/2014	1.33 ^a	10.29 ^b	--	--	--	0.41	0.0508
10/06/2014	2.00 ^a	6.25 ^b	--	--	5.00 ^a	0.34	0.0477
11/03/2014	1.11 ^a	4.17 ^a	0.12700 ^b	0.0306 ^b	6.90 ^a	0.40	0.0513
12/16/2014	0.77 ^a	1.97 ^a	--	--	8.40 ^a	0.35	0.0416

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.

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

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