



Fixed-Station Water-Quality Monitoring at Timucuan Ecological and Historic Preserve:

2013-2014 Data Summary

Natural Resource Data Series NPS/SECN/NRDS—2015/978



Fixed-Station Water-Quality Monitoring at Timucuan Ecological and Historic Preserve:

2013-2014 Data Summary

Natural Resource Data Series NPS/SECN/NRDS—2015/978

Wendy Wright and Peter Mockus

National Park Service
135 Phoenix Road
Athens, Georgia 30605

September 2015

U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado

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.

Views, statements, findings, conclusions, recommendations, and data in this report do not necessarily reflect views and policies of the National Park Service, U.S. Department of the Interior. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the U.S. Government.

This report is available from the Southeast Coast Network (<http://science.nature.nps.gov/im/units/secn>) and the Natural Resource Publications Management website (<http://www.nature.nps.gov/publications/nrpm>). Data summarized in this report can be found at the Aquarius Web Portal, at <https://irma.nps.gov/aqwebportal/>. To receive this report in a format optimized for screen readers, please email irma@nps.gov.

Please cite this publication as:

Wright, W., and P. Mockus. 2015. Fixed-station water-quality monitoring at Timucuan Ecological and Historic Preserve: 2013–2014 data summary. Natural Resource Data Series NPS/SECN/NRDS—2015/XXX. National Park Service, Fort Collins, Colorado.

Contents

	Page
Figures	v
Tables	v
Summary and Key Findings	vii
Continuous Monitoring	vii
Discrete Sampling	vii
Acknowledgments	ix
Introduction	1
Timucuan Ecological and Historic Preserve	1
Weather and Hydrologic Setting	2
Methods	3
Sampling Locations	3
Continuous data	4
Discrete data	6
Assessment Criteria	6
Results	7
Discrete data	18
Literature Cited	21

Figures

	Page
Figure 1. Cedar Point at the southern tip of Black Hammock Island.	ix
Figure 2. Locations of Southeast Coast Network and City of Jacksonville water-quality monitoring stations in Timucuan Ecological and Historic Preserve during 2013–2014.	x
Figure 3. Daily precipitation at Jacksonville Craig Municipal Airport near Timucuan Ecological and Historic Preserve, January 1 2013–December 31 2014.	2
Figure 4. Continuous data collection platform used at Timucuan Ecological and Historic Preserve.	4
Figure 5. Mean daily water temperature at the Kingsley Plantation station (TIMUking) during 2013–2014.	8
Figure 6. Mean daily values for salinity at the Kingsley Plantation station (TIMUking) during 2013–2014.	9
Figure 7. Mean daily values for dissolved oxygen at Kingsley Plantation station (TIMUking) during 2013–2014.	10
Figure 8. Mean daily pH at the Kingsley Plantation station (TIMUking) during 2013–2014.	11
Figure 9. Mean daily turbidity (NTUs) at the Kingsley Plantation station (TIMUking) during 2013–2014.	12
Figure 10. Mean daily depth at the Kingsley Plantation station (TIMUking) during 2013–2014.	13

Tables

	Page
Table 1. Monitoring station identification codes, locations, names, and types of data collected at stations in the Timucuan Ecological and Historic Preserve water-quality monitoring network, 2013–2014.	3
Table 2. Performance specifications of YSI 6600 EDS data loggers deployed at Kingsley Plantation (TIMUking) during 2013–2014).	5
Table 3. Performance specifications of YSI EXO2 datasondes deployed at Kingsley Plantation (TIMUking) during 2014.	5
Table 4. Coastal water-quality monitoring condition criteria for water-quality parameters collected by the Southeast Coast Network. Based on thresholds set by the EPA (2012).	6
Table 5. Monthly minimum, maximum and mean values for parameters collected by the YSI datasondes at Kingsley Plantation (TIMUking) during 2013–2014.	14
Table 6. Monthly water-quality data collected at the Southeast Coast Network site near Timucuan Ecological and Historic Preserve during 2013–2014.	18

Summary and Key Findings

In 2003, the Northeast Florida Water Quality Preservation Group—a coalition composed of the Florida Department of Environmental Protection (FDEP), Office of Coastal and Aquatic Managed Areas (CAMA), the National Park Service (NPS), and the Nature Conservancy—was formed by official Memorandum of Understanding to “collaborate to preserve, protect, and enhance water quality” of Timucuan Ecological and Historic Preserve (TIMU, Timucuan) in northern Florida. In 2006, the National Park Service Southeast Coast Network (SECN) in cooperation with the City of Jacksonville, Florida and CAMA established a jointly-operated water-quality monitoring network within the Preserve’s boundaries to provide relevant water-quality information to resource managers locally and at Timucuan. This network is currently composed of 13 sites—12 of which are monitored every other month by the City of Jacksonville for nutrients and chlorophyll *a* —with one additional site monitored continuously by the Southeast Coast Network for pH, dissolved oxygen, temperature, specific conductance, turbidity and water level. Fixed-station water-quality monitoring at Timucuan is part of the SECN Inventory & Monitoring (I&M) Program, which routinely collects data at seven coastal park units located along the southeastern U.S. Summary findings below are based on continuous data and bimonthly discrete sampling collected during 1 January 2013–31 December 2014.

Continuous Monitoring

- Continuous data were collected at one fixed-station site (TIMUking, Figure 2) by the Southeast Coast Network.
- Mean monthly dissolved oxygen levels were *good* throughout the entire year, ranging from a high of 8.2 mg/L in January 2013 to a low of 5.2 mg/L in October 2013. Individual dissolved oxygen readings ranged from 2.2 mg/L in September 2014 to 9.4 mg/L in January 2014.
- Mean monthly pH values ranged from a low of 7.8 in October 2013 to a high of 8.1 in January 2014 with very little variability throughout the year. Individual pH readings ranged from 7.3 in October 2013 to 8.3 in several months.
- Monthly mean turbidity values ranged from 4.4 NTU in February 2013 to 36.1 NTU in May 2014. Individual turbidity readings ranged from near 0 NTUs in August 2014 to 365.8 NTUs in May 2014.
- Mean monthly water temperatures ranged from 12.4 °C (54.3 °F) in January 2014 to 29.4 °C (84.9 °F) in July and August 2014. Individual temperature readings ranged from 9.1 °C (48.4 °F) in January 2014 to 31.9 °C (89.4 °F) in July 2014.
- The tidal range for site TIMUking was approximately 2.8 m.

Discrete Sampling

- Monthly water-quality data (discrete samples) were collected at 12 sites by the City of Jacksonville, Florida near the Timucuan Ecological and Historical Preserve (Figure 2) during 2013–2014, for a total of 57 sampling events which reflected a wide range of conditions. Not all parameters were measured at every sampling event.
- Water clarity was mostly *good* (43 samples), with five *fair* readings, and three *poor* readings. The *poor* readings were at sites TIM1 and TIM2.
- Dissolved inorganic nitrogen concentrations were *good* for a majority of the samples (19), and *fair* for 10. Dissolved inorganic phosphorus concentrations were mostly *fair* (23 samples) and *poor* (21 samples).
- Chlorophyll *a* concentrations were *good* for 24 samples, *fair* for 22 samples, and *poor* for three samples.
- Discrete dissolved oxygen sampling across the 12 sites was mostly *good* (35 samples) and *fair* (13 samples). The *fair* readings were located at sites TIM1 through TIM6, in the Upper Nassau River Basin.

Acknowledgments

The National Park Service Southeast Coast Network would like to thank Betsy Deuerling, City of Jacksonville, Environmental Quality Division, for her assistance with data management, analysis, and technical support.



Figure 1. Cedar Point at the southern tip of Black Hammock Island. Photo courtesy of Charles Stankiewicz.

Timucuan Ecological and Historic Preserve Significant Waters Map

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

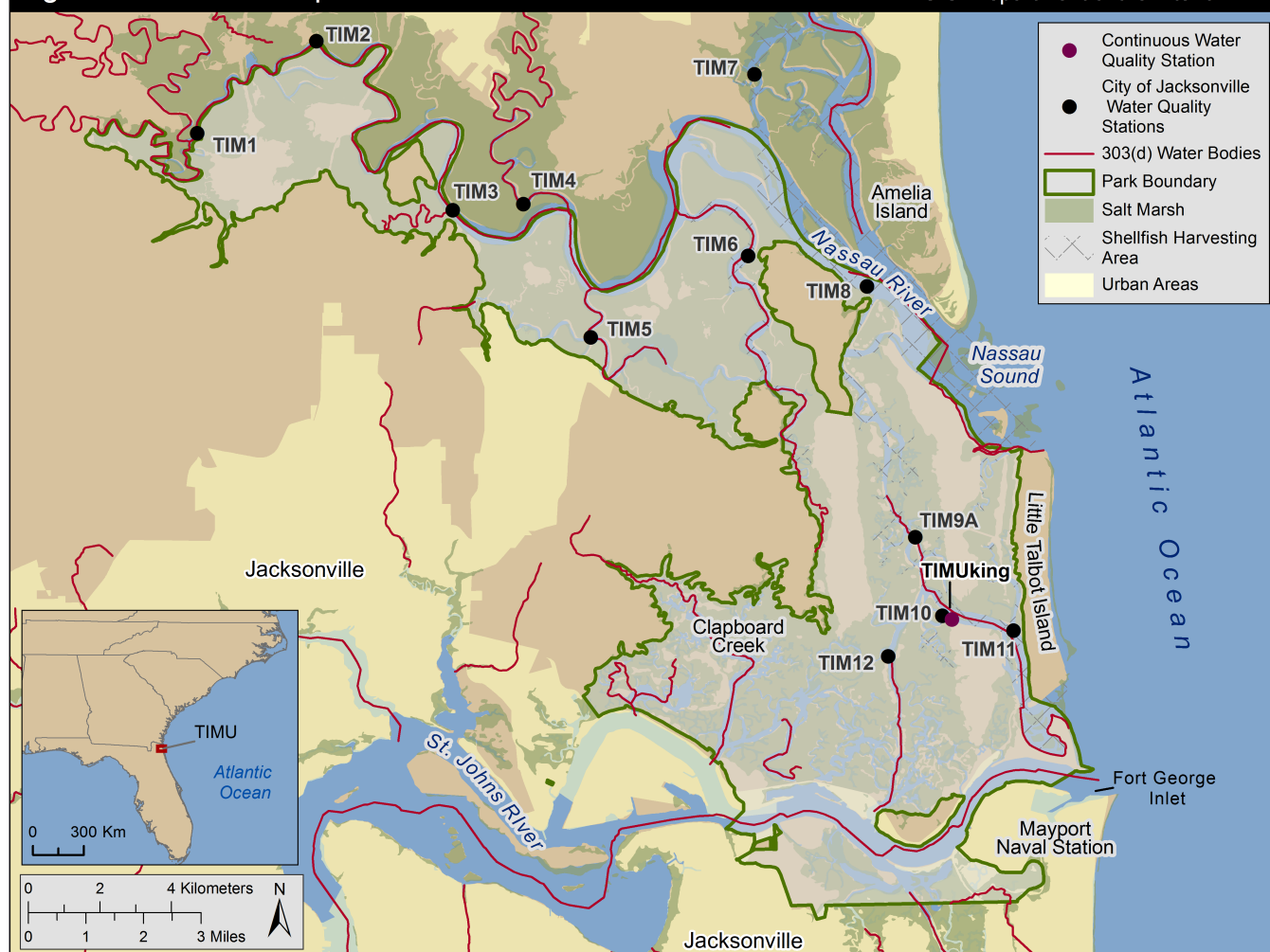


Figure 2. Locations of Southeast Coast Network and City of Jacksonville water-quality monitoring stations in Timucuan Ecological and Historic Preserve during 2013–2014. Depicted are areas of salt marsh (USFWS 2015), urban areas (United States Census Bureau 2015), 303(d) listed areas (EPA 2015), and shell fish harvesting areas (FDEP 2014).

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 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 in the vicinity of park units, and contribute to a better understanding of park 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 has implemented a two-pronged monitoring approach which consists of collecting data from continuously recording fixed stations located in each park unit and also collecting periodic discrete water samples for analysis (Gregory et al. 2013). When combined, these two approaches provide a more complete understanding of physical processes, diurnal and seasonal variations, and spatial patterns during critical portions of the year than either could if implemented singularly.

The Southeast Coast Network has identified four specific monitoring objectives 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 below:

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 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) every ten years in estuarine waters.

This report provides an annual summary of data collected at Timucuan Ecological and Historic Preserve during 2013–2014 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 across Timucuan Ecological and Historic Preserve.

Timucuan Ecological and Historic Preserve

Timucuan Ecological and Historic Preserve (TIMU) encompasses 18,600 hectares (46,000 acres) of salt marsh and coastal hammock habitat in addition to estuarine, marine, and brackish open waters (Figure 2). Timucuan Ecological and Historic Preserve contains the seaward confluence of the Nassau and St. Johns Rivers along the northeastern coast of Florida in Duval County and is contained entirely within the city limits of Jacksonville. The preserve includes several rare and vulnerable natural communities including coastal strand, maritime hammock, scrub, and shell mound habitat. National Park Service facilities within the preserve include the Fort Caroline visitor center and maintenance area, the Theodore Roosevelt area with park headquarters, Kingsley Plantation, the Ribault Club, and the historic Broward House. Other state and city parks in the area include Big and Little Talbot Island State Parks, Fort George Island Cultural State Park, Little Jetties Park, Huguenot Memorial Park, and the Sisters Creek Park and boat ramp (Anderson et al. 2005).

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

The most recent water-quality study conducted within Timucuan by the National Park Service Southeast Coast Network Inventory and Monitoring Program consisted of a synoptic evaluation of water quality conditions at 30 sites sampled during August 2013 (Wright et al. 2013). Results from this snapshot of conditions were compared to water-quality criteria used by the EPA (2012), and indicated that general water-quality conditions were *good* at 30% of the sites sampled, *fair* at 67%, and *poor* at 3%. *Poor* water-quality ratings were most commonly due to elevated levels of dissolved inorganic phosphorus observed in the more upstream reaches of the Nassau and St. Johns River as well as inland areas along Clapboard Creek (Wright et al. 2013).

Park-wide, the water-quality rating for the area in and around Timucuan Ecological and Historic Preserve was *fair*, with less than 10% of the sites rating poor, and 70% of the sites rating either *fair* or *poor*.

Weather and Hydrologic Setting

Daily precipitation totals are included as an aid to interpreting water-quality results and were derived from data collected at the Jacksonville Craig Municipal Airport station (14 miles [22.5 km] east of Timucuan) by the National Climatic Data Center. These data are presented as daily precipitation for 2013–2014 (NCDC 2015; Figure 3).

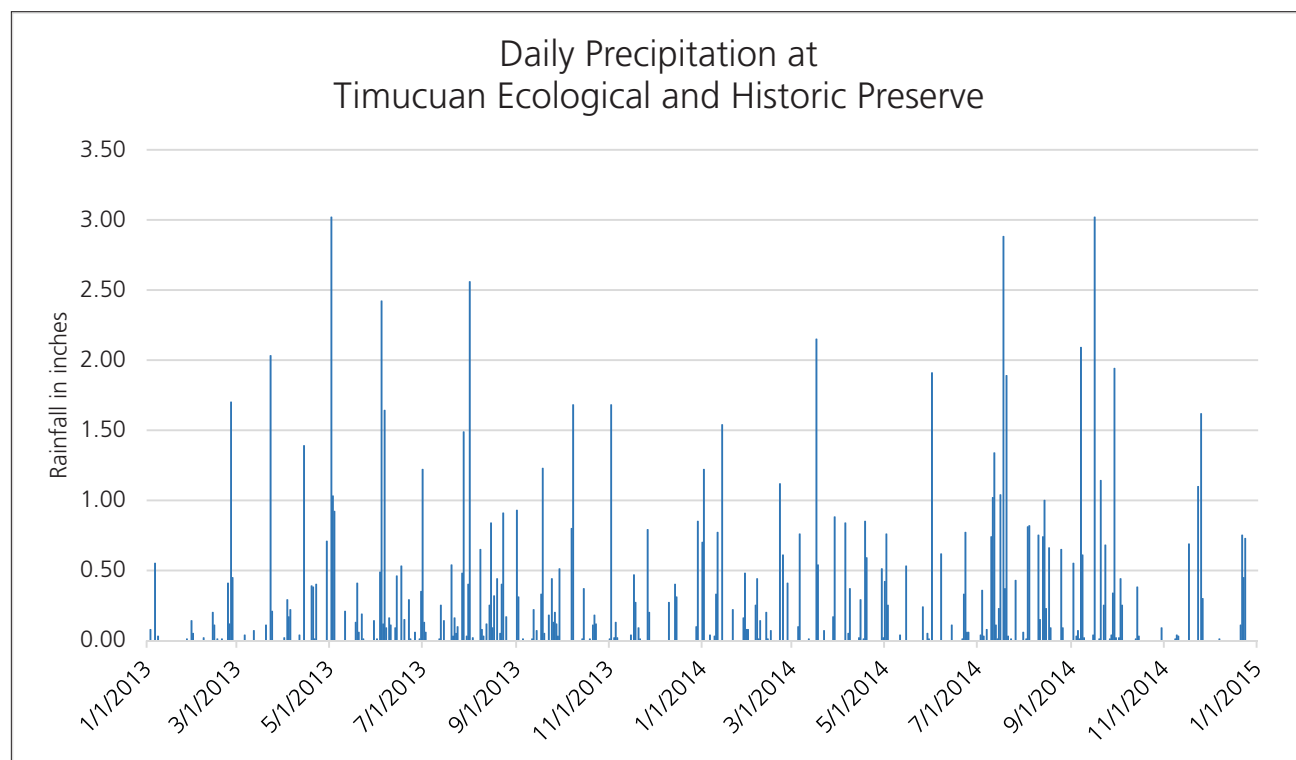


Figure 3. Daily precipitation at Jacksonville Craig Municipal Airport near Timucuan Ecological and Historic Preserve, January 1 2013–December 31 2014. Data source: NCDC (2015).

Methods

Data collection at sites in this network are modeled after an ongoing water-quality monitoring program established by the National Estuarine Research Reserve Program (Wenner and Geist 2001) and protocols that are in compliance with Florida Department of Environmental Protection's standard operating procedures (FDEP 2014). Detailed field and lab standard operating procedures and methods have been reported for the continuously collected data in Gregory et al. (2013). Methods for both are briefly summarized in the following sections. Relative water levels and tidal amplitude information collected by the Southeast Coast Network are made available in this report as additional relevant data to help interpret changes and patterns observed in water-quality data.

This report summarizes water-quality data collected at 13 sites (Table 1), 12 of which are monitored periodically for nutrients and chlorophyll *a*, and one site at Kingsley Plantation (TIMUking) which is monitored continuously for dissolved oxygen, pH, specific conductance, water temperature, depth, and turbidity.

Sampling Locations

The fixed-station site (TIMUking) is located on the Fort George River at the northeast corner of the elevated section of the dock at Kingsley Plantation within the boundaries of Timucuan Ecological and Historic Preserve (Figure 2). The sampling location is approximately four river miles from the Atlantic Ocean and is predominantly salt water. This area experiences heavy boating traffic on weekends in the spring and summer. The nearby shoreline is lined with *Spartina sp.* and *Juncus sp.*, with some oyster beds present. Due to tidal ranges, and the presence of numerous sandbars, there is a risk of high turbidity, especially during low tide events.

Table 1. Monitoring station identification codes, locations, names, and types of data collected at stations in the Timucuan Ecological and Historic Preserve water-quality monitoring network, 2013–2014.

[COJWQ—City of Jacksonville Department of Water Quality; SECN—National Park Service, Southeast Coast Network].

NPS Station ID	Latitude	Longitude	Location Name and Description	Type of Data	Responsible for Collection	Responsible for Reporting
TIM1	30.562	-81.659	Thomas Creek at confluence with Nassau River	discrete	COJWQ	SECN
TIM2	30.586	-81.625	Nassau River approximately 50 m downstream of I-95 bridge	discrete	COJWQ	SECN
TIM3	30.543	-81.585	Nassau River at confluence with Deese Creek	discrete	COJWQ	SECN
TIM4	30.545	-81.564	Lofton Creek approximately 50 m upstream from confluence with Nassau River	discrete	COJWQ	SECN
TIM5	30.511	-81.544	Edwards Creek at confluence with Samples Creek	discrete	COJWQ	SECN
TIM6	30.532	-81.498	Pumpkin Hill Creek, east of Broward Island and northwest of Black Hammock Island	discrete	COJWQ	SECN
TIM7	30.578	-81.497	Alligator Creek approximately 50 m upstream from confluence with Nassau River	discrete	COJWQ	SECN
TIM8	30.525	-81.464	Nassau River at confluence with Sisters Creek	discrete	COJWQ	SECN
TIM9A	30.461	-81.449	Sisters Creek (ICWW Marker 67)	discrete	COJWQ	SECN
TIM10	30.442	-81.441	Garden Creek approximately 50 m upstream of confluence with Ft. George River	discrete	COJWQ	SECN
TIM11	30.438	-81.421	Ft. George River at northeast corner of island	discrete	COJWQ	SECN
TIMUking	30.441	-81.439	Kingsley Plantation Dock	continuous	SECN	SECN
TIM12	30.431	-81.457	Sisters Creek near mouth of Cedar Point Circle (ICWW Marker 77)	discrete	COJWQ	SECN



Figure 4. Continuous data collection platform used at Timucuan Ecological and Historic Preserve (TIMUking). Photo shows sonde housing and locking cap. Photo by Peter Mockus, SECN Staff.

Continuous data

Continuously collected data include dissolved oxygen, pH, specific conductance, temperature, depth and turbidity. Data were collected at 30-minute intervals using YSI datasondes (Model 6600) in 2013. In January 2014, the site was changed over to YSI EXO2 datasondes. The sondes are deployed for 3- to 5-week intervals depending on routine instrument maintenance schedules. The data collection platform (mount, Figure 4) consists of a 4-inch diameter PVC pipe attached vertically to a piling at the Kingsley Plantation dock with the sonde suspended within. All mounts were designed to keep the sonde 0.5 meters above the bottom substrate, with a carriage bolt inserted through the housing at the submerged end to prevent instrument loss should the attachment hardware fail. A locking cap on the top of the PVC pipe prevents unwanted tampering. To extend development intervals and combat biofouling (growth of barnacles and algae), anti-fouling paint is applied to the PVC pipe (Figure 4). The sonde guard is covered with 0.25-inch

brass or plastic mesh to prevent fish, crabs, and detritus from entering the protective housing, as this intrusion could skew measurements or damage the instrument's 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 2011) with additional instructions provided by 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 location in Athens, Georgia. After post-retrieval processing is complete, the sonde is cleaned, reconditioned, and readied for re-deployment with methods outlined by YSI (2011). Performance specifications of the YSI 6600 are shown in Table 2. Performance specifications of the YSI EXO 2 are shown in Table 3.

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 made 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 Kingsley Plantation (TIMUking) 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.

Table 3. Performance specifications of YSI EXO2 datasondes deployed at Kingsley Plantation (TIMUking) during 2013–2014 (YSI 2014).

Parameter	Range	Resolution	Accuracy
Dissolved oxygen (% saturation)	0 to 500%	0.10%	0 to 200%: +1% reading or 1% air sat, whichever is greater 200 to 500%: +5% reading
Dissolved oxygen (mg/L)	0 to 50 mg/L	0.01 mg/L	0 to 20 mg/L: +1% of reading or 0.1 mg/L 20 to 50 mg/L: +5% of reading
Conductivity	0 to 200 mS/cm	0.0001 to 0.01 mS/cm range-dependent	0-100 mS/cm +0.5% of reading or 0.001 mS/cm, whichever is greater
Temperature	-5 to +50 °C	0.001 degrees Celcius	-5 to +35 °C: +0.01 °C 35 to 50 °C: +0.05 °C
pH	0 to 14	0.01 units	+0.1 pH units within +10 °C of calibration temperature; +0.2 pH units for entire temp range
Depth	Shallow: 0 to 33 feet (10 meters)	0.001 feet (0.001 meters)	Shallow: +0.04% FS (+0.013 feet or +0.004 meters)
Turbidity	0 to 4000 FNU	0 to 999 FNU: 0.01 FNU 1000 to 4000 FNU: 0.1 FNU	0 to 999 FNU: 0.3 FNU or 2% of reading, whichever is greater. 1000 to 4000 FNU: 0.1 FNU

Discrete data

Water sample collection for this project is conducted by the City of Jacksonville according to Florida Department of Environmental Protection's standard operating procedures (FDEP 2014). Site visits include the deployment of a multi-parameter sonde to collect pH, specific conductance, dissolved oxygen, temperature, depth, and turbidity. Secchi depth is measured using a standard 8-inch diameter black and white Secchi disk. Water samples are collected as grabs in clean, field-rinsed, sample containers. Unfiltered samples are placed on ice prior to shipment for lab analyses. . Original chain of custody paperwork accompanies all samples to the laboratory. Nutrient data were analyzed by Florida Department of Environmental Quality labs and chlorophyll *a* data were analyzed by a laboratory contracted by the National Park Service (ALS Environmental, formerly Columbia Analytical Services, Inc.).

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* is one of three values depending on the water bodies' 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).

Timucuan Ecological and Historic Preserve 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). Although this method of estimating water-clarity condition is generally used when information on light transmission properties of the water column are missing, the Southeast Coast Network is reporting derived values for data consistency among other SECN park units and recently collected datasets where water-column light transmission information was not collected.

Assessment Criteria

Water quality was assessed for each of the parameters following the East/Gulf Coast site criteria in the EPA's National Coastal Assessment IV Report (EPA 2012; Table 4) using data from the monthly samples. 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 (2012) criteria for the assessed water bodies.

Table 4. Coastal water-quality monitoring condition criteria for water-quality parameters collected by the Southeast Coast Network. Based on thresholds set by the EPA (2012) for naturally turbid conditions.

Rating	Water Clarity (<i>k</i>) ¹	Chlorophyll <i>a</i> (µg/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	2.3–2.99	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 USEPA (2012) criteria for the assessed water bodies.

Results

Continuous data were collected at one fixed-station site (TIMUking) by the Southeast Coast Network.

Mean monthly dissolved oxygen levels were *good* throughout the entire year, ranging from a high of 8.2 mg/L in January 2013 to a low of 5.2 mg/L in October 2013. Individual dissolved oxygen readings ranged from 2.2 mg/L in September 2014 to 9.4 mg/L in January 2014.

Mean monthly pH values ranged from a low of 7.8 in October 2013 to a high of 8.1 in January 2014 with very little variability throughout the year. Individual pH readings ranged from 7.3 in October 2013 to 8.3 in several months.

Monthly mean turbidity values ranged from 4.4 NTU in February 2013 to 36.1 NTU in May 2014. Individual turbidity readings ranged from 0 NTUs in August 2014 to 365.8 NTUs in May 2014.

Mean monthly water temperatures ranged from 12.4 °C (54.3 °F) in January 2014 to 29.4 °C (84.9 °F) in July and August 2014. Individual temperature readings ranged from 9.1 °C (48.4 °F) in January 2014 to 31.9 °C (89.4 °F) in July 2014.

The tidal range for site TIMUking was approximately 2.8 m.

Monthly water-quality data (discrete samples) were collected across 12 sites by the City of Jacksonville, Florida near the Timucuan Ecological and Historical Preserve during 2013–2014, for a total of 57 samples which reflected a wide range of conditions. Not all parameters were measured at every sampling event.

Water clarity was mostly *good* (43 samples), with five *fair* readings, and three *poor* readings. The *poor* readings were at sites TIM1 and TIM2 (Figure 2).

Dissolved inorganic nitrogen concentrations were *good* for a majority of the samples (19), and *fair* for 10. Dissolved inorganic phosphorus concentrations were mostly *fair* (23 samples) and *poor* (21 samples).

Chlorophyll *a* concentrations were *good* for 24 samples, *fair* for 22 samples, and *poor* for three samples.

Discrete dissolved oxygen samples across the 12 sites were mostly *good* (35 samples) and *fair* (13 samples). The *fair* readings were located at sites TIM1 through TIM6, in the Upper Nassau River Basin (Figure 2).

Continuous Data

Figures 5 through 10 depict the daily mean for each parameter for the 2013–2014 period. Relative water depth collected by SECN staff at the site (Figure 10) 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 5. 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 where 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. When the percentage of values is low, the statistics (mean, maximum, and minimum) may be less accurate than months where all data were used in the calculation of summary statistics.

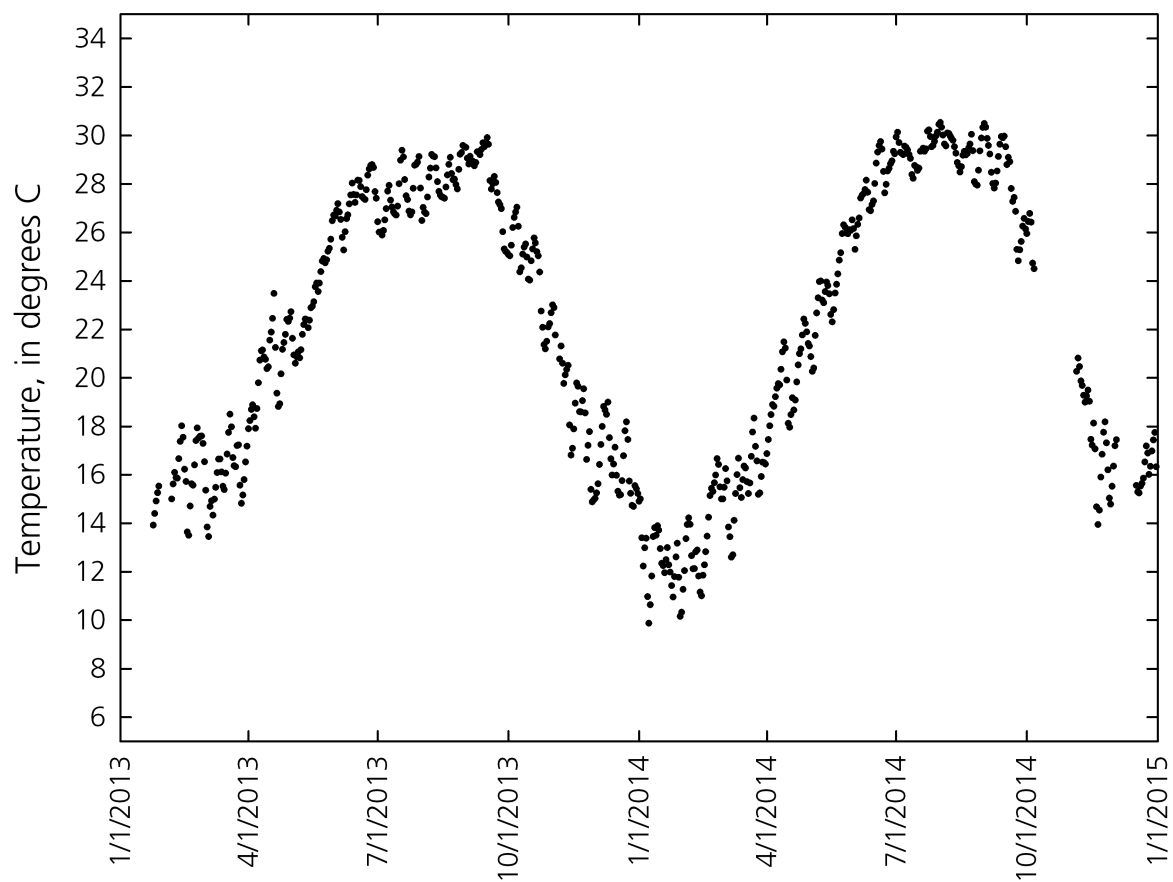


Figure 5. Mean daily water temperature at the Kingsley Plantation station (TIMUking) during 2013–2014. Breaks in data record indicate missing and/or flagged data.

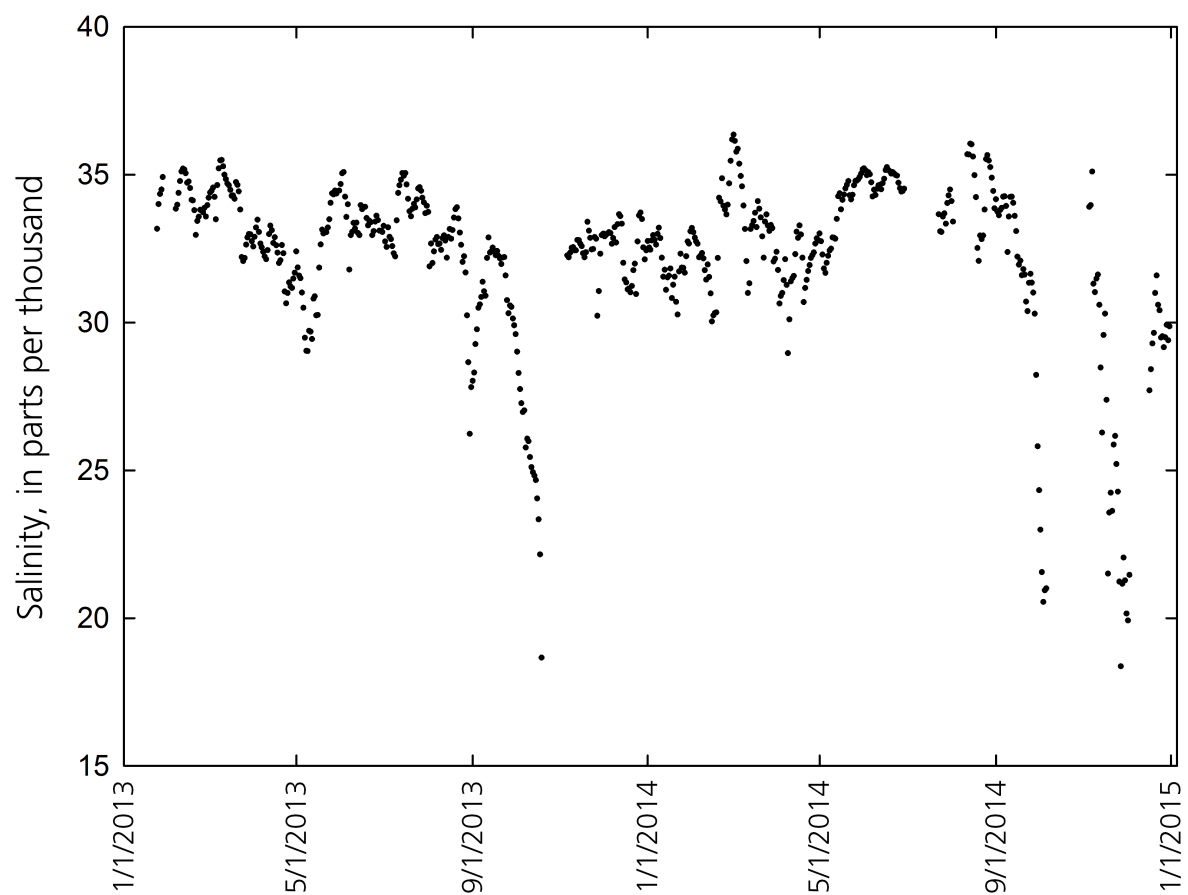


Figure 6. Mean daily values for salinity at the Kingsley Plantation station (TIMUKing) during 2013–2014. Breaks in data record indicate missing and/or flagged data.

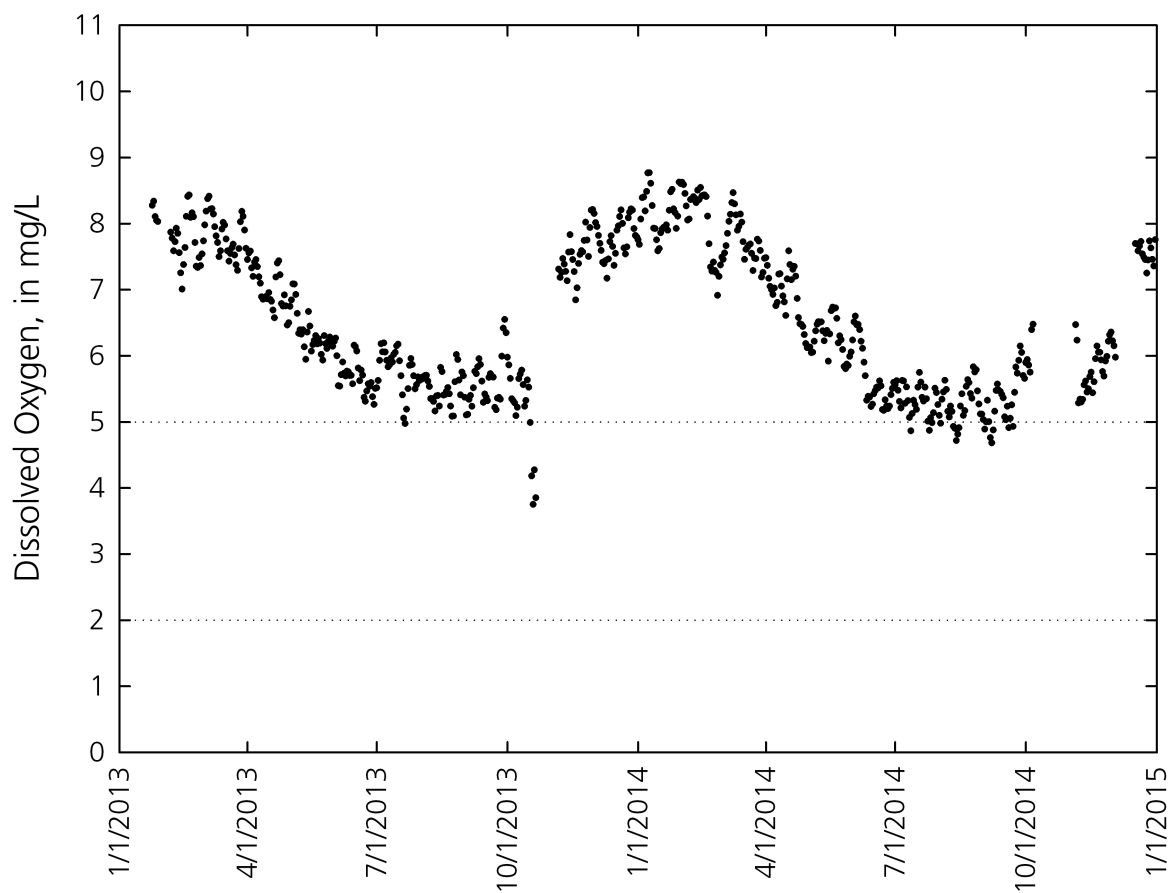


Figure 7. Mean daily values for dissolved oxygen at Kingsley Plantation station (TIMUking) during 2013–2014. Breaks in data record indicate missing and/or flagged data. Dotted lines indicate minimum value for a rating of *good* (5 mg/L) and *fair* (2 mg/L)(USEPA 2012).

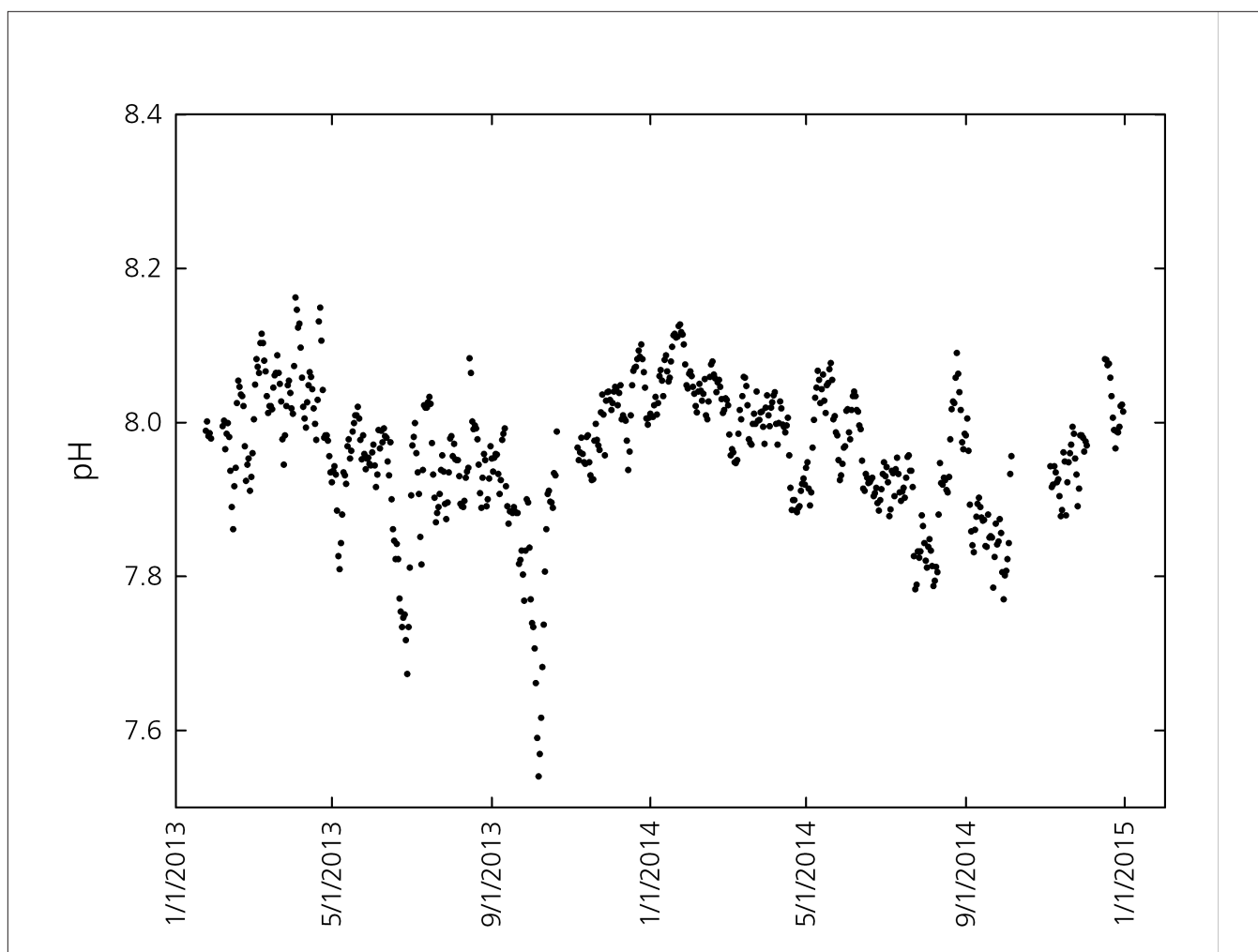


Figure 8. Mean daily pH at the Kingsley Plantation station (TIMUking) during 2013–2014. Breaks in data record indicate missing and/or flagged data.

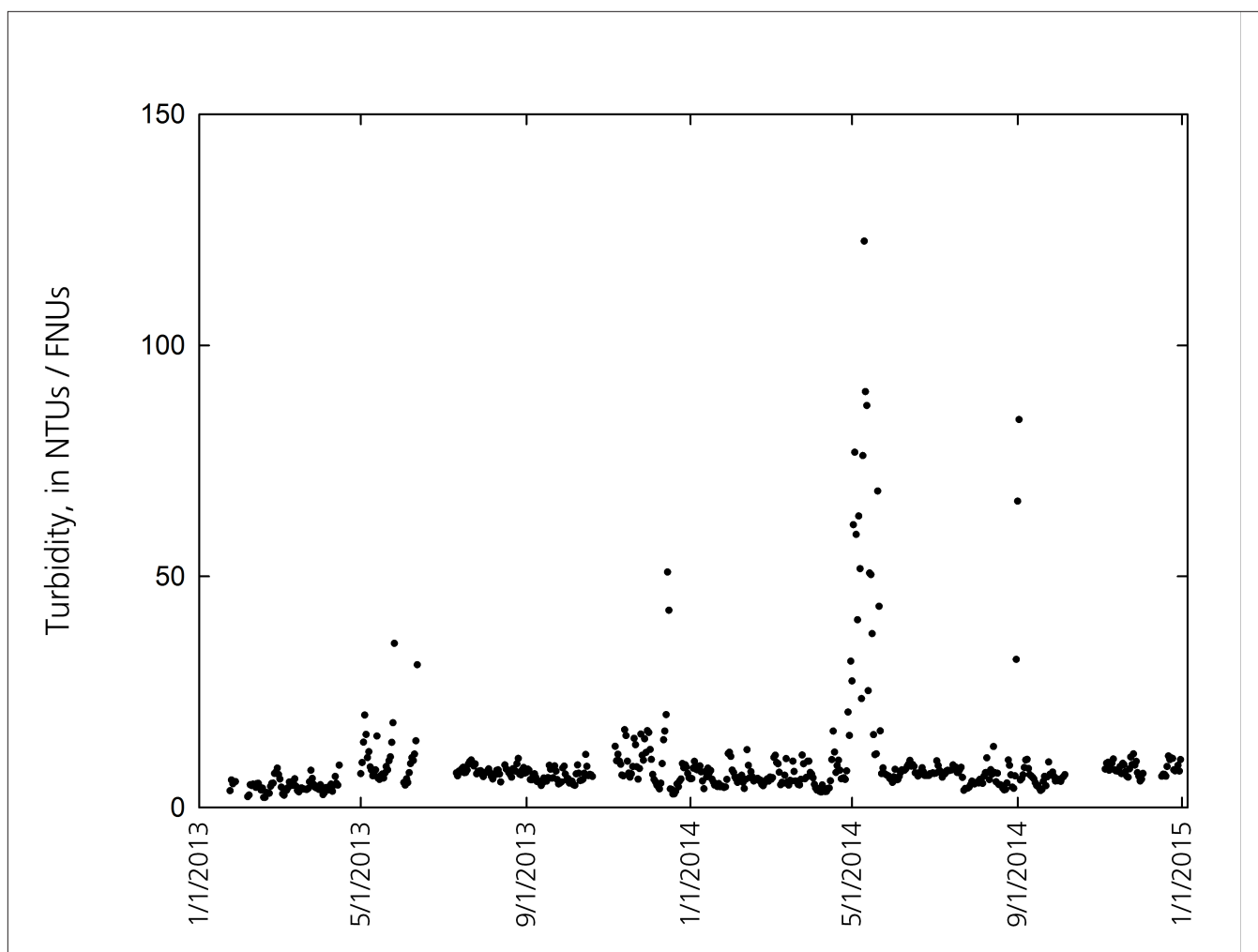


Figure 9. Mean daily turbidity (NTUs) at the Kingsley Plantation station (TIMUKing) during 2013–2014. Breaks in data record indicate missing and/or flagged data.

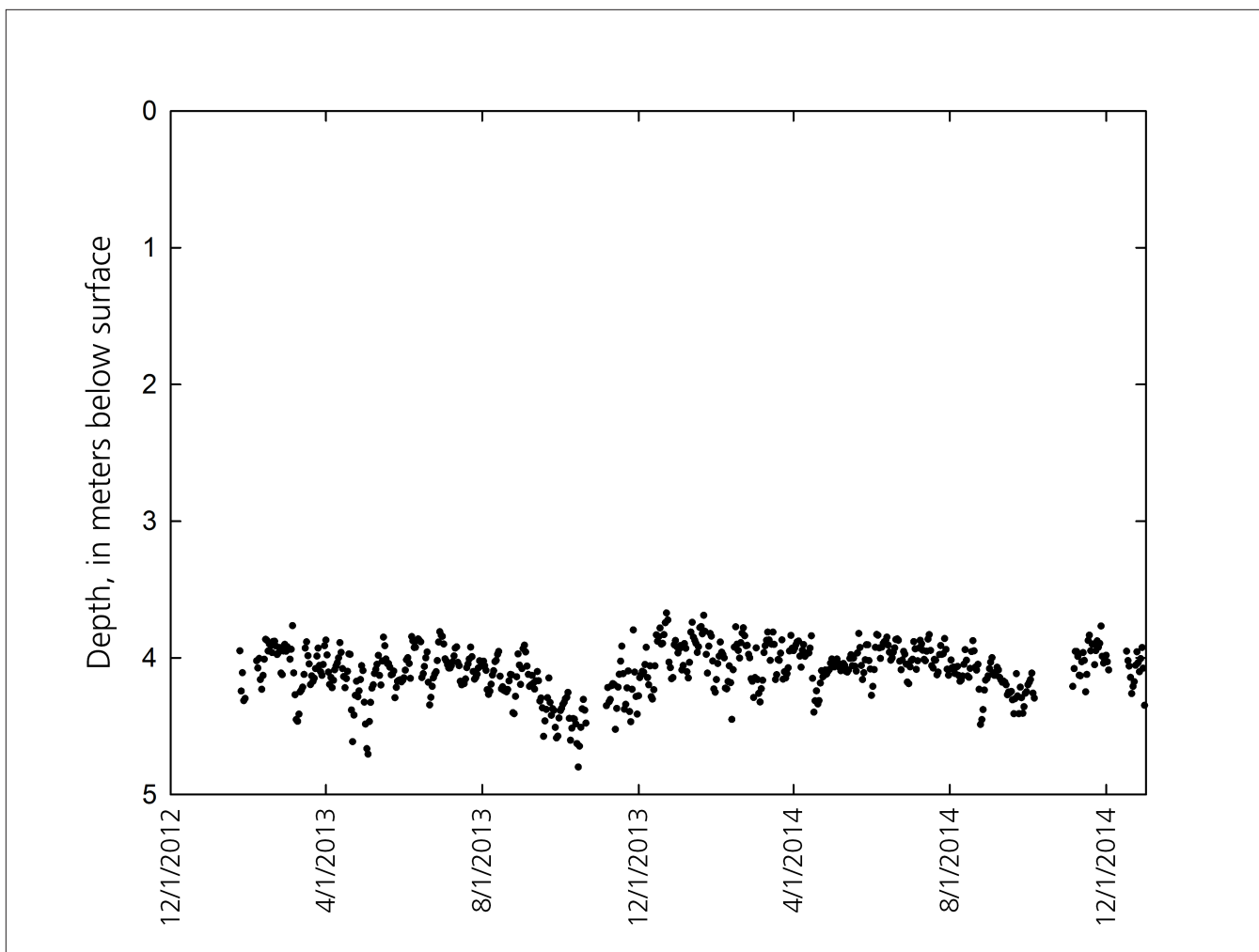


Figure 10. Mean daily depth at the Kingsley Plantation station (TIMUKing) during 2013–2014. Breaks in data record indicate missing and/or flagged data.

Table 5. Monthly minimum, maximum, and mean values for parameters collected by the YSI datasondes at Kingsley Plantation (TIMUKing) during 2013–2014. Percentage of values for each month indicates the number data points collected during one calendar month of data collection divided by the total number of expected points for a complete month of data.

	Temperature, °C	Salinity, PPT	Dissolved Oxygen, mg/L	Depth, m	pH	Turbidity, NTU
January 2013 (Expected count 1488)						
Actual Count	282	282	282	282	282	282
Minimum	13.2	30.3	6.7	3.26	7.9	2.4
Maximum	16.6	35.4	8.9	5.13	8.1	12.0
Mean	14.8	34.2	8.2	4.17	8.0	5.0
Standard Deviation	0.8	1.0	0.4	0.50	0.05	1.7
Percent	19%	19%	19%	19%	19%	19%
February 2013 (Expected count 1344)						
Actual Count	1130	1130	1130	1130	1130	1130
Minimum	12.6	29	5.8	2.98	7.8	0.7
Maximum	19.3	35.9	9.0	5.21	8.1	65.4
Mean	16.2	34.2	7.7	3.99	8.0	4.4
Standard Deviation	1.4	1	0.5	0.50	0.08	3.1
Percent	84%	84%	84%	84%	84%	84%
March 2013 (Expected count 1488)						
Actual Count	1488	1488	1488	1488	1488	1488
Minimum	11.8	30.7	6.2	2.95	7.8	1.4
Maximum	19.7	36.4	8.8	5.30	8.2	18.6
Mean	16.0	34.1	7.8	4.09	8.0	4.6
Standard Deviation	1.3	1.3	0.5	0.60	0.08	1.9
Percent	100%	100%	100%	100%	100%	100%
April 2013 (Expected count 1440)						
Actual Count	1439	1439	1439	1439	1439	743
Minimum	15.9	29.7	5.1	3.05	7.8	0.4
Maximum	24.4	35.1	8.3	5.30	8.3	61.1
Mean	20.4	32.3	7.0	4.14	8.0	4.8
Standard Deviation	1.8	1	0.6	0.50	0.12	3.6
Percent	100%	100%	100%	100%	100%	52%
May 2013 (Expected count 1488)						
Actual Count	1488	1488	1488	1488	1488	1248
Minimum	19.7	18.3	3.6	3.10	7.6	1.8
Maximum	27.8	36.0	7.7	5.32	8.2	148.3
Mean	23.2	32.0	6.4	4.18	7.9	11.1
Standard Deviation	1.9	3.0	0.7	0.60	0.11	9.2
Percent	100%	100%	100%	100%	100%	84%
June 2013 (Expected count 1440)						
Actual Count	1440	1440	1440	1440	1440	564
Minimum	24.5	26.1	2.6	2.99	7.4	2.4
Maximum	30.1	36.3	7.9	5.29	8.2	85.0
Mean	27.4	33.5	5.7	4.03	7.9	12.3
Standard Deviation	1.1	1.8	0.9	0.60	0.16	13.3
Percent	100%	100%	100%	100%	100%	39%

Table 5 (continued)

	Temperature, °C	Salinity, PPT	Dissolved Oxygen, mg/L	Depth, m	pH	Turbidity, NTU
July 2013 (Expected count 1488)						
Actual Count	1488	1488	1488	1488	1488	1035
Minimum	24.1	25.6	3.2	2.91	7.5	1.2
Maximum	30.7	36.8	7.9	5.06	8.1	53.2
Mean	27.5	33.8	5.8	4.05	7.9	8.1
Standard Deviation	1.3	1.7	0.8	0.50	0.12	3.6
Percent	100%	100%	100%	100%	100%	70%
August 2013 (Expected count 1488)						
Actual Count	1487	1487	1487	1487	1487	1411
Minimum	24.6	17.9	2.7	3.16	7.5	0.1
Maximum	30.8	36.1	7.2	5.19	8.2	45.9
Mean	28.2	32.2	5.5	4.16	8.0	7.7
Standard Deviation	1.2	2.6	0.8	0.50	0.13	3.8
Percent	100%	100%	100%	100%	100%	95%
September 2013 (Expected count 1440)						
Actual Count	1440	1440	1440	1440	1440	1438
Minimum	24.6	18.2	3.0	3.15	7.6	0.7
Maximum	31.2	34.8	7.9	5.35	8.3	21.0
Mean	28.3	31.2	5.6	4.26	7.9	6.7
Standard Deviation	1.4	2.2	0.8	0.50	0.13	3.2
Percent	100%	100%	100%	100%	100%	100%
October 2013 (Expected count 1488)						
Actual Count	1488	981	1031	1026	1031	981
Minimum	20.6	10.9	1.4	3.37	7.3	0.7
Maximum	27.7	30.0	7.2	5.48	8.1	22.0
Mean	24.5	24.7	5.2	4.44	7.8	6.7
Standard Deviation	1.7	4.2	0.9	0.50	0.15	3.1
Percent	100%	66%	69%	69%	69%	66%
November 2013 (Expected count 1440)						
Actual Count	1405	1229	1229	1229	1229	1229
Minimum	14.1	24.5	5.5	3.13	7.8	3.3
Maximum	23.6	34.6	8.6	5.41	8.1	184.5
Mean	19.0	32.4	7.5	4.24	8.0	11.0
Standard Deviation	2.2	1.1	0.5	0.5	0.08	8.0
Percent	98%	85%	85%	85%	85%	85%
December 2013 (Expected count 1488)						
Actual Count	1488	1488	1488	1488	1488	1488
Minimum	14.2	21.7	5.9	2.88	7.8	0.6
Maximum	19.9	34.6	8.6	5.17	8.2	95.2
Mean	16.5	32.5	7.8	4.01	8.0	10.3
Standard Deviation	1.4	1.6	0.4	0.6	0.07	13.2
Percent	100%	100%	100%	100%	100%	100%

Table 5 (continued)

	Temperature, °C	Salinity, PPT	Dissolved Oxygen, mg/L	Depth, m	pH	Turbidity, NTU
January 2014 (Expected count 1488)						
Actual Count	1488	1488	1488	1488	1488	1488
Minimum	9.1	21.1	5.7	2.65	7.9	2.1
Maximum	15.4	35.7	9.4	5.20	8.2	22.7
Mean	12.4	32.1	8.1	3.95	8.1	6.9
Standard Deviation	1.4	2.2	0.6	0.6	0.06	3.5
Percent	100%	100%	100%	100%	100%	100%
February 2014 (Expected count 1344)						
Actual Count	1344	1344	1344	1344	1344	1344
Minimum	10.1	25.7	5.9	2.94	7.8	2.8
Maximum	18.0	38.4	9.2	5.12	8.2	31.4
Mean	13.6	32.6	8.0	4.01	8.0	6.4
Standard Deviation	1.8	2.3	0.6	0.5	0.06	2.5
Percent	100%	100%	100%	100%	100%	100%
March 2014 (Expected count 1488)						
Actual Count	1488	1488	1488	1488	1488	1488
Minimum	11.8	21.2	5.5	2.85	7.7	2.1
Maximum	19.9	37.6	8.9	5.22	8.2	33.0
Mean	15.6	33.7	7.7	4.04	8.0	7.3
Standard Deviation	1.5	2.5	0.5	0.6	0.07	3.6
Percent	100%	100%	100%	100%	100%	100%
April 2014 (Expected count 1440)						
Actual Count	1440	1440	1440	1440	1440	1429
Minimum	15.5	22.8	4.5	2.93	7.7	0.4
Maximum	25.3	36.1	8.3	5.21	8.2	169.1
Mean	19.8	31.8	6.9	4.06	8.0	7.9
Standard Deviation	1.9	2.2	0.7	0.5	0.11	12.9
Percent	100%	100%	100%	100%	100%	99%
May 2014 (Expected count 1488)						
Actual Count	1488	1488	1488	1488	1488	1437
Minimum	19.0	27.4	3.4	2.96	7.7	2.5
Maximum	28.2	36.4	7.7	5.03	8.2	365.8
Mean	23.8	33.7	6.3	4.03	8.0	36.1
Standard Deviation	2.0	1.8	0.8	0.5	0.12	56.2
Percent	100%	100%	100%	100%	100%	97%
June 2014 (Expected count 1440)						
Actual Count	1440	1407	1440	1440	1440	1439
Minimum	24.5	30.2	2.7	2.93	7.7	2.4
Maximum	30.9	36.9	7.7	5.00	8.2	28.3
Mean	27.9	34.8	5.7	3.98	8.0	7.7
Standard Deviation	1.4	1.0	0.9	0.5	0.12	2.5
Percent	100%	98%	100%	100%	100%	100%

Table 5 (continued)

	Temperature, °C	Salinity, PPT	Dissolved Oxygen, mg/L	Depth, m	pH	Turbidity, NTU
July 2014 (Expected count 1488)						
Actual Count	1487	454	1487	1487	1487	1468
Minimum	27.4	24.2	2.4	2.89	7.6	0.1
Maximum	31.9	37.9	7.6	5.06	8.1	30.1
Mean	29.4	33.7	5.3	3.99	7.9	7.0
Standard Deviation	0.8	2.6	0.9	0.5	0.12	2.9
Percent	100%	31%	100%	100%	100%	99%
August 2014 (Expected count 1488)						
Actual Count	1488	1089	1488	1488	1488	1471
Minimum	26.8	23.5	2.4	2.98	7.6	0
Maximum	32.0	37.8	7.5	5.15	8.3	241.6
Mean	29.4	34.5	5.3	4.12	7.9	7.2
Standard Deviation	0.9	2.1	0.9	0.5	0.14	11.9
Percent	100%	73%	100%	100%	100%	99%
September 2014 (Expected count 1440)						
Actual Count	1440	1440	1440	1437	1440	1440
Minimum	23.7	24.1	2.2	3.03	7.5	0.2
Maximum	31.2	36.8	7.1	5.13	8.2	205.4
Mean	28.2	32.3	5.3	4.21	7.9	11.1
Standard Deviation	1.7	2.4	0.8	0.5	0.13	24.3
Percent	100%	100%	100%	100%	100%	100%
October 2014 (Expected count 1488)						
Actual Count	316	316	316	314	316	316
Minimum	23.6	15.0	3.9	3.26	7.6	1.9
Maximum	27.3	27.2	7.9	5.11	8.1	50.0
Mean	25.7	21.8	6.1	4.21	7.9	6.3
Standard Deviation	1.0	2.3	0.8	0.5	0.15	3.2
Percent	21%	21%	21%	21%	21%	21%
November 2014 (Expected count 1440)						
Actual Count	1266	1266	1266	1266	1266	1266
Minimum	12.9	7.8	3.8	2.95	7.8	4.0
Maximum	21.7	35.42	7.5	5.11	8.1	22.4
Mean	17.6	27.0	5.8	4.00	7.9	8.6
Standard Deviation	2.1	5.4	0.5	0.5	0.08	2.5
Percent	88%	88%	88%	88%	88%	88%
December 2014 (Expected count 1488)						
Actual Count	910	910	910	910	910	909
Minimum	14.3	12.5	4.9	3.08	7.8	3.4
Maximum	18.5	33.8	8.5	5.15	8.2	148.9
Mean	16.4	28.0	7.3	4.08	8.0	8.2
Standard Deviation	0.9	4.6	0.7	0.6	0.09	5.4
Percent	61%	61%	61%	61%	61%	61%

Discrete data

Water-quality data collected by City of Jacksonville at fixed sites in Timucuan Ecological and Historic Preserve during 2013–2014 are shown in Table 6 below. Condition categories generally correspond to those used by the EPA in the National Coastal Condition Report IV (2012).

Table 6. Monthly water-quality data collected at the Southeast Coast Network site near Timucuan Ecological and Historic Preserve during 2013–2014. Water clarity was assessed using light attenuation values (k) using a constant for estuarine water with naturally turbid conditions (Smith et al. 2006) and assessment categories that correspond to USEPA (2012). Condition of other assessed parameters based on USEPA (2012). [^aGreen—good; ^byellow—fair; ^cred—poor; k—light attenuation coefficient; µg/L—micrograms per liter; mg/L—milligrams per liter; -- data not collected].

Site	Date	Water Clarity (k)	Chlorophyll a (µg/L)	Dissolved Oxygen (mg/L)	Dissolved Inorganic Nitrogen (mg/L)	Dissolved Inorganic Phosphorus (mg/L)	Total Phosphorus (mg/L)	Total Nitrogen (mg/L)
TIM01	3/5/2013	5.00 ^c	27.2 ^c	8.5 ^a	0.065 ^a	0.1620 ^c	0.3	1.2279
	8/6/2013	2.94 ^b	3.4 ^a	2.9 ^b	0.087 ^a	0.1210 ^c	0.171	1.2503
	10/8/2013	2.27 ^a	3.1 ^a	4.7 ^b	0.074 ^a	0.0977 ^c	0.139	1.2234
	4/22/2014	1.67 ^a	2.3 ^a	4.3 ^b	--	0.0730 ^c	--	--
	5/20/2014	2.63 ^b	9.8 ^b	4.9 ^b	0.105 ^b	0.1070 ^c	0.214	1.53
TIM02	3/5/2013	3.13 ^c	30.3 ^c	9.1 ^a	0.068 ^a	0.1150 ^c	0.181	0.9047
	8/6/2013	3.13 ^c	4.0 ^a	2.9 ^b	0.125 ^b	0.1220 ^c	0.19	1.2371
	10/8/2013	2.13 ^a	2.2 ^a	4.7 ^b	0.082	0.0888 ^c	0.121	1.1694
	4/22/2014	2.00 ^a	1.5 ^a	5.1 ^a	--	0.0720 ^c	--	--
	5/20/2014	2.50 ^b	5.4 ^b	5.0 ^a	0.094 ^a	0.1020 ^c	0.16	1.022
TIM03	3/5/2013	2.00 ^a	8.6 ^b	9.1 ^a	0.083 ^a	0.0661 ^c	0.114	0.6322
	8/6/2013	1.92 ^a	7.0 ^b	3.9 ^b	0.205 ^b	0.0629 ^c	0.0766	1.034
	10/8/2013	2.00 ^a	3.6 ^a	4.3 ^b	0.139 ^b	0.0663 ^c	0.0997	0.9672
	4/22/2014	1.67 ^a	2.9 ^a	5.7 ^a	--	0.0820 ^c	--	--
	5/20/2014	2.00 ^a	6.7 ^b	5.0 ^a	0.131 ^b	0.0560 ^c	0.108	1.113
TIM04	3/5/2013	0.97 ^a	7.2 ^b	9.0 ^a	0.059	0.0509 ^c	0.0822	0.8621
	8/6/2013	1.67 ^a	7.6 ^b	4.2 ^b	0.171 ^b	0.0551 ^c	0.0894	1.106
	10/8/2013	1.79 ^a	4.3 ^a	4.4 ^b	0.097 ^a	0.0544 ^c	0.0623	0.8504
	4/22/2014	2.38 ^b	3.1 ^a	5.6 ^a	--	0.0480 ^b	--	--
	5/20/2014	1.52 ^a	6.7 ^b	5.2 ^a	0.096 ^a	0.0460 ^b	0.066	0.863
TIM05	8/6/2013	1.79 ^a	8.2 ^b	3.8 ^b	0.187 ^b	0.0585 ^c	0.0976	0.953
	4/22/2014	1.82 ^a	2.9 ^a	5.8 ^a	--	0.0500 ^b	--	--
	5/20/2014	1.43 ^a	6.7 ^b	5.4 ^a	0.080 ^a	0.0400 ^b	0.059	0.733
TIM06	8/6/2013	2.38 ^b	8.6 ^b	3.9 ^b	0.185 ^b	0.0546 ^c	0.0929	1.14
	4/22/2014	1.39 ^a	2.9 ^a	5.9 ^a	--	0.0400 ^b	--	--
	5/20/2014	1.39 ^a	7.6 ^b	5.5 ^a	--	0.0360 ^b	0.064	--
TIM07	4/22/2014	1.72 ^a	4.4 ^a	6.1 ^a	--	0.0330 ^b	--	--
	5/20/2014	0.82 ^a	7.0 ^b	6.0 ^a	--	0.0380 ^b	--	--
	9/24/2014	1.25 ^a	--	--	0.140 ^b	--	--	--

Table 6 (continued)

Site	Date	Water Clarity (k)	Chlorophyll <i>a</i> (µg/L)	Dissolved Oxygen (mg/L)	Dissolved Inorganic Nitrogen (mg/L)	Dissolved Inorganic Phosphorus (mg/L)	Total Phosphorus (mg/L)	Total Nitrogen (mg/L)
TIM08	3/5/2013	0.57 ^a	2.6 ^a	9.7 ^a	0.039 ^a	0.0279 ^b	0.0729	0.3209
	8/6/2013	1.19 ^a	9.4 ^b	5.2 ^a	0.120 ^{ab}	0.0490 ^b	0.0786	1.0075
	4/22/2014	1.05 ^a	4.3 ^a	7.4 ^a	--	0.0290 ^b	--	--
	5/20/2014	0.58 ^a	3.6 ^a	7.1 ^a	--	0.0290 ^b	0.067	--
	9/24/2014	1.11 ^a	--	6.2 ^a	--	--	--	--
	10/14/2014	--	11.2 ^b	--	--	--	--	--
TIM09A	3/5/2013	0.52 ^a	2.3 ^a	--	0.038 ^a	0.0284 ^b	0.0965	0.2449
	8/6/2013	1.39 ^a	12.8 ^b	5.8 ^a	0.039 ^a	0.0426 ^b	0.0859	0.885
	4/22/2014	0.95 ^a	--	6.2 ^a	--	0.0290 ^b	--	--
	5/20/2014	1.00 ^a	--	6.7 ^a	--	0.0310 ^b	0.11	--
	9/24/2014	1.30 ^a	--	5.6 ^a	0.079 ^a	--	--	--
	10/14/2014	--	9.2 ^b	--	--	--	--	--
TIM10	3/5/2013	0.52 ^a	2.6 ^a	--	0.043 ^a	0.0734 ^c	0.0834	0.4136
	8/6/2013	1.39 ^a	21.7 ^c	6.1 ^a	0.040 ^a	0.0425 ^b	0.1	0.809
	4/22/2014	0.98 ^a	4.4 ^a	7.4 ^a	--	0.0280 ^b	--	--
	5/20/2014	0.64 ^a	2.7 ^a	7.3 ^a	--	--	0.061	--
	9/24/2014	1.00 ^a	--	6.4 ^a	--	--	--	--
	10/14/2014	--	11.3 ^b	--	--	--	--	--
TIM11	3/5/2013	0.56 ^a	2.3 ^a	--	0.045 ^a	0.0259 ^b	0.148	0.6034
	4/22/2014	1.09 ^a	4.0 ^a	7.8 ^a	--	0.0280 ^b	--	--
	5/20/2014	--	1.5 ^a	7.2 ^a	--	--	0.06	--
	9/24/2014	1.11 ^a	--	6.7 ^a	--	--	--	--
	10/14/2014	--	5.2 ^b	--	--	--	--	--
TIM12	8/6/2013	1.19 ^a	17.9 ^b	6.5 ^a	0.046 ^a	0.0460 ^b	0.0783	0.927
	4/22/2014	0.98 ^a	3.4 ^a	6.4 ^a	--	0.0310 ^b	--	--
	5/20/2014	0.72 ^a	7.1 ^b	6.5 ^a	--	0.0370 ^b	0.083	--
	9/24/2014	1.32 ^a	--	6.2 ^a	--	--	--	--
	10/14/2014	--	9.2 ^b	--	--	--	--	--

Literature Cited

- Anderson, S. M., C. Katin, and W. R. Wise. 2005. Assessment of coastal water resources and watershed conditions at Timucuan Ecological and Historic Preserve. NPS/NRWRD/NRTR—2005/340, Fort Collins, Colorado.
- Aquatic Informatics Inc. 2015. Aquarius ver. 3.8; Hydrologic Workstation Edition, Copyright 2004–2015.
- DeVivo, J. C., C. J. Wright, M. Byrne, E. M. DiDonato, and T. Curtis. 2008. Vital signs monitoring in the Southeast Coast Inventory and Monitoring Network. Natural Resource Report NPS/SECN/NRR—2008/061. National Park Service, Fort Collins Colorado.
- Florida Department of Environmental Protection (FDEP). 2014. Standard Operation Procedures. 2014 DEP SOPs (effective 7/30/2014). Available online at: <http://www.dep.state.fl.us/water/sas/sop/sops.htm> (accessed September 2015).
- Gregory, M. B., J. C. DeVivo, E. M. DiDonato, C. J. Wright, and E. Thompson. 2013. Protocol for monitoring estuarine water and sediment quality in selected Southeast Coast Network parks. Natural Resource Report NPS/SECN/NRR—2013/644. National Park Service, Fort Collins, Colorado.
- National Climatic Data Center (NCDC). 2015. Daily precipitation for Jacksonville Craig Municipal Airport station, 2013–2014. Data available online at <http://www.ncdc.noaa.gov/data-access> (accessed September 2015).
- Smith, L. M., V. D. Engle, and J. K. Summers. 2006. Assessing Water Clarity as a Component of Water Quality in Gulf of Mexico Estuaries. *Environmental Monitoring & Assessment* 115:29–305.
- U.S. Fish and Wildlife Service (USFWS). 2015. National Wetlands Inventory website. Available at <http://www.fws.gov/wetlands/> (accessed September 2015).
- United States Census Bureau. 2015. Census 2010 Gateway website. <http://www.census.gov/2010census/> (accessed September 2015).
- United States Environmental Protection Agency. (EPA) 2012. National coastal condition report IV. EPA-842-R-10-003, Washington D.C. 20460.
- United States Environmental Protection Agency (EPA). 2015. Geospatial data downloads website. Available at [http://water.epa.gov/scitech/datait/tools/waters/data/downloads.cfm#303\(d\) Listed Impaired Waters](http://water.epa.gov/scitech/datait/tools/waters/data/downloads.cfm#303(d) Listed Impaired Waters) (accessed September 2015).
- Wagner, R. J., R. W. Boulger, Jr., C. J. Oblinger, and B. A. Smith. 2006. Guidelines and standard procedures for continuous water-quality monitors—Station operation, record computation, and data reporting: U.S. Geological Survey techniques and methods 1–D3.
- Wenner, E. L., and M. Geist. 2001. The National Estuarine Research Reserves Program to monitor and preserve estuarine waters. *Coastal Management* 29:1–17.
- Wright, W., M. B. Gregory, and J. Asper. 2013. Assessment of estuarine water quality at Timucuan Ecological and Historic Preserve, 2013. Natural Resource Data Series NPS/SECN/NRDS—2013/598. National Park Service, Fort Collins, Colorado.
- YSI Incorporated. 2011. YSI 6-Series multiparameter water quality sondes user manual, revision H. Yellow Springs, Ohio.
- YSI Incorporated. 2014. EXO User Manual: Advanced Water Quality Monitoring Platform, revision E. Yellow Springs, Ohio.

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

National Park Service
U.S. Department of the Interior



Natural Resource Stewardship and Science

1201 Oak Ridge Drive, Suite 150
Fort Collins, Colorado 80525

www.nature.nps.gov

EXPERIENCE YOUR AMERICA™