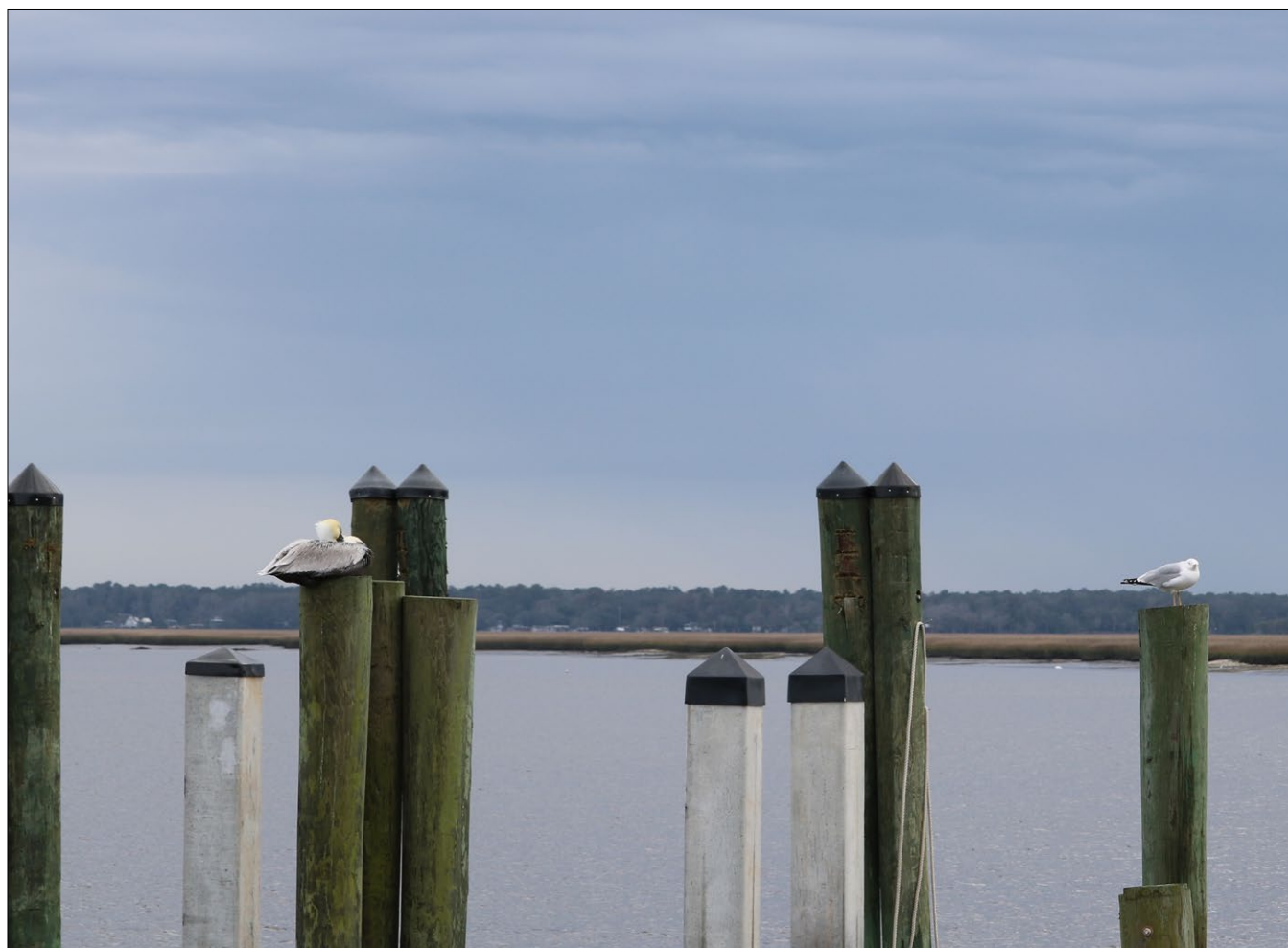




Fixed-Station Water-Quality Monitoring at Cumberland Island National Seashore

2013–2014 Data Summary

Natural Resource Data Series NPS/SECN/NRDS—2017/1130





ON THE COVER

A brown pelican (*Pelecanus occidentalis*) and a ring-billed gull (*Larus delawarensis*) perch on a dock behind the Cumberland Island National Seashore visitor's center. Photo by Wendy Wright.

ON THIS PAGE

The Cumberland Island National Seashore visitor's center in St. Marys, Georgia. Photos by Wendy Wright.

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2013–2014 Data Summary

Natural Resource Data Series NPS/SECN/NRDS—2017/1130

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November 2017
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 website](#) and the [Natural Resource Publications Management website](#). Data summarized in this report can be found at the [Aquarius Web Portal](#). To receive this report in a format optimized for screen readers, please email irma@nps.gov.

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Summary and Key Findings

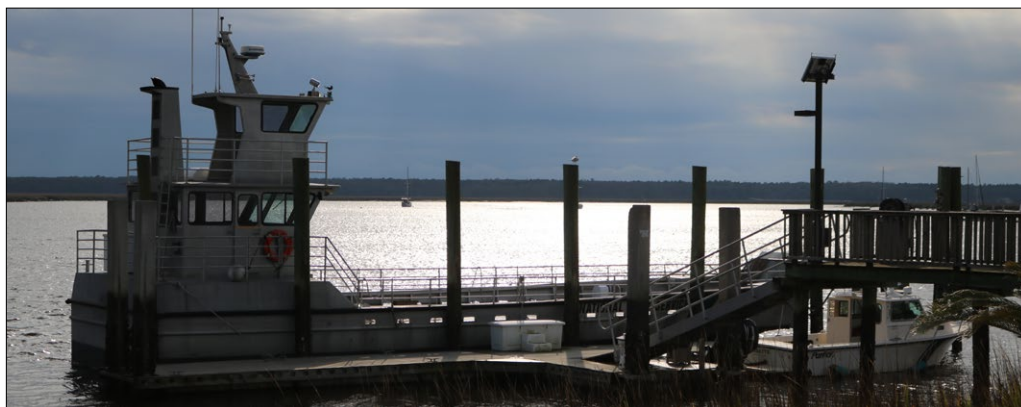
In 2005 the National Park Service (NPS) Southeast Coast Network (SECN) Inventory and Monitoring Program began collecting water-quality data in the estuarine waters near Cumberland Island National Seashore (CUIS) as part of the NPS Vital Signs monitoring program. The current continuous-monitoring data station is located on the Sea Camp dock.

This station collects pH, dissolved oxygen, temperature, salinity, conductivity, turbidity, and water level data every 15 minutes. Southeast Coast Network staff make additional water-quality measurements, which include monthly measurements of water-clarity conditions, nutrient concentrations, and chlorophyll *a* levels. 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 Cumberland Island National Seashore 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. Summary data are presented in annual data reports published by the Southeast Coast Network.

- Monthly water-quality data collected during 2013–2014 at the SECN site near Cumberland Island National Seashore reflected good to fair conditions throughout the two-year period.

- Chlorophyll *a* concentrations were fair (12 visits) to good (12 visits) for the period of record, ranging from 2.98 µg/L to 9.19 µg/L.
- Water clarity was mostly good (17 visits) to fair (6 visits) for the period of record.
- Over the period of record, seven samples were pulled for dissolved inorganic nitrogen (DIN) and dissolved inorganic phosphorus (DIP). Six of the seven DIN concentrations were rated as good, with one fair. Three of the DIP concentrations were good, and four were fair.
- Mean monthly dissolved oxygen levels were fair to good throughout the period, ranging from 4.4 mg/L to 8.5 mg/L. Individual values ranged from 2.0 mg/L in May 2013 to 9.4 mg/L in January 2014.
- Mean monthly pH values ranged from 7.4 to 8.3. Individual readings ranged from 7.1 in September 2014 to 8.5 in January and February 2013.
- Monthly mean turbidity values were highest during February 2013 at 10.9 NTUs. The lowest individual turbidity reading for any given month was 0.0 NTUs, and a maximum reading of 627.9 NTUs was recorded in January 2013.
- Water temperatures in 2013–2014 ranged from a minimum monthly mean of 11.5°C (52.7°F) in January 2014 to a maximum monthly mean of 29.6°C (85.3°F) in August 2014. Individual temperatures ranged from a minimum of 7.4°C (45.3°F) in January 2013 to a maximum of 31.9°C (89.4°F) in July 2014.



Dock behind the visitor's center at Cumberland Island National Seashore. Photo by Wendy Wright.

Cumberland Island National Seashore Significant Waters Map

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



Figure 1. Location of continuous water-quality monitoring station at Cumberland Island National Seashore Sea Camp dock (site CUISseac or CUIS03). Map shows estuarine and marine water resources in the vicinity of Cumberland Island National Seashore in Georgia. Map indicates areas of salt marsh (USFWS 2015), urbanization (USCB 2015), 303(d) listed water bodies (EPA 2015), and areas designated as having special uses or restrictions.

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 Cumberland Island National Seashore 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 Cumberland Island National Seashore.

Cumberland Island National Seashore

Cumberland Island National Seashore is located between the mouths of the Satilla and St. Marys Rivers along the coast of Georgia. As Georgia's southernmost barrier island, Cumberland Island is bound on the east by the Atlantic Ocean and the west by the extensive salt marshes and estuaries of the Cumberland River and Cumberland Sound (Figure 1). The Cumberland Island National Seashore is comprised of the majority of Cumberland Island proper and the surrounding marshes and islands (with the exception of Little Cumberland Island, all of which is privately owned, and several private inholdings on the island itself). The east coast of the island is an almost continuous strip of beaches that face the ocean, whereas the western side is a network of tidal creeks that flow through salt marshes and eventually open out into coastal water. Aquatic habitats associated with the island include marine areas (offshore water and associated bottom areas), tidal creeks, saltwater ponds, intertidal areas (beaches, salt marshes, tide pools), and inland ponds (both brackish and fresh water). Although Cumberland Island is considered relatively pristine in comparison to more highly developed barrier islands, both point and nonpoint sources of pollutants can be found nearby that have the potential to affect the island. In addition to the numerous industrial and municipal waste facilities in the area, the submarine base at Kings Bay is of potential concern due to the effects of channel dredging as well as other activity on the base. There are also a significant number of U.S. Environmental Protection Agency (USEPA) listed Superfund sites nearby, most of which are located in the vicinity of Brunswick, Georgia, a port city located approximately 16 miles (25.7 kilometers) north of Cumberland in Glynn County (Alber et al. 2005).

Weather and Hydrologic Setting

Daily rainfall totals were collected at the Brunswick weather and climate station located approximately 27 miles (43.4 kilometers) northwest of the southern end of Cumberland Island (NCDC 2015) and are included here (Figure 2) as an aid for interpreting water-quality results. The Brunswick weather and climate station is used because it has an extensive period of record. These data are presented for 2013–2014.

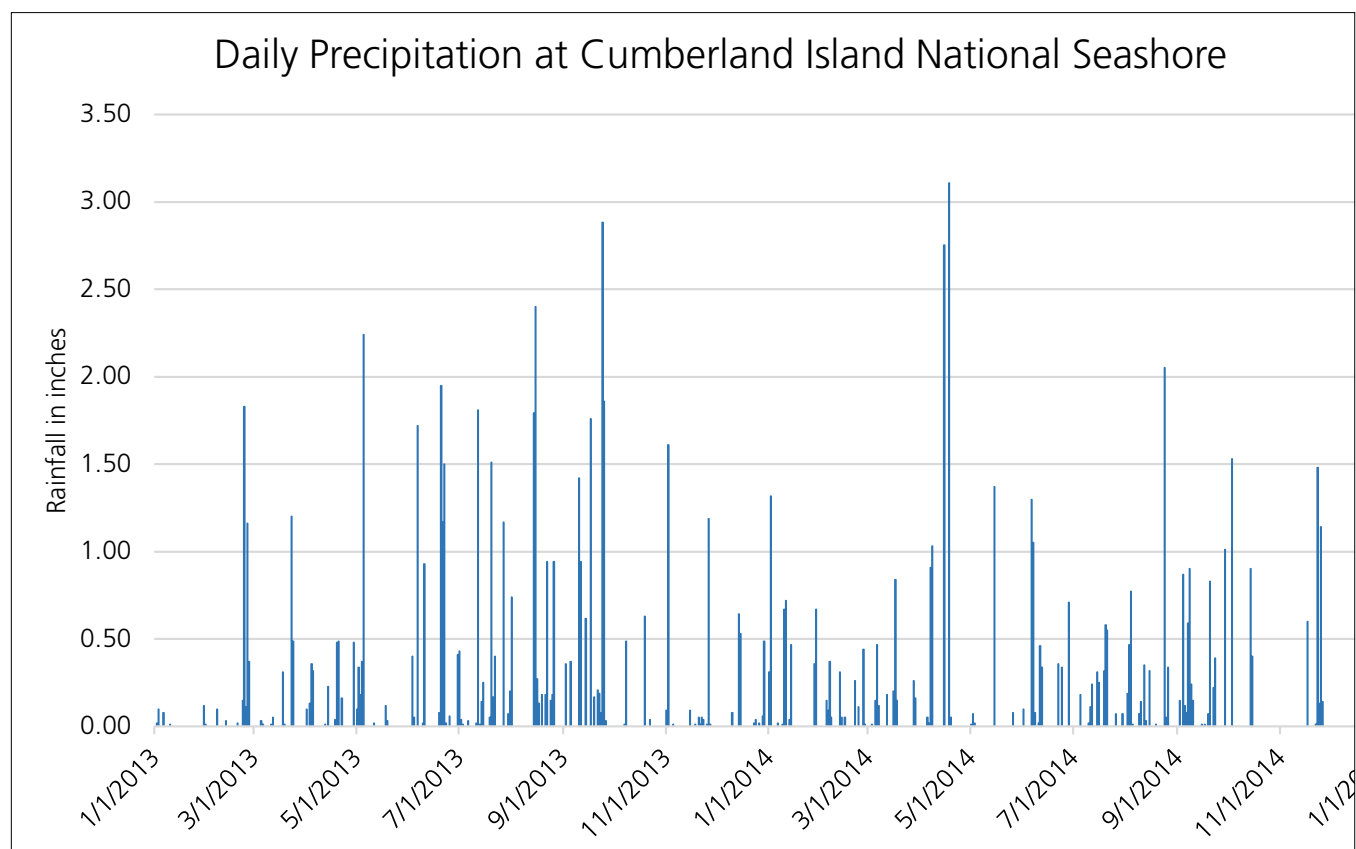


Figure 2. Daily precipitation at Cumberland Island National Seashore January 1, 2013–December 31, 2014. Data source: NOAA-NCDC (2015).

Methods

Data collection at the Cumberland Island NS fixed station 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 Cumberland Island National Seashore fixed-station site is located on the northwest corner, non-floating portion of a large dock owned by the National Park Service (Figure 1, Figure 3). This dock is located near the

Cumberland Island National Seashore’s public camping area known as Sea Camp. It is one of the two docks used for the visitor ferry, and is also used to a lesser extent by private boaters accessing the island and park boats carrying park personnel.

The station is located on a tidal river, which is part of the Intracoastal Waterway. The station is on the backside of a barrier island consisting of complex dune ecosystems, forests and salt marsh. The river has shifting sand bars and heavy siltation issues. The nearby shoreline is highly eroded with accreted sand and silt along the river. There is a relatively recently constructed wooden bulkhead along the shoreline to protect that section of shoreline from erosion.



Figure 3. Continuous data collection platform on Sea Camp Dock at Cumberland Island National Seashore. Photo by Brian Gregory.

Table 1. Location of continuous water-quality monitoring stations at Cumberland Island National Seashore.

Name	Location Description	Location (lat /long)	Period of Record
CUIS01	Plum Orchard dock	30.854866/ -81.467229	1/6/07 to 9/1/10
CUIS02	Old House Creek dock	30.798004/-81.47027	8/3/05 to 9/1/10
CUIS03	Sea Camp Dock	30.764303 / -81.4712	10/1/2010 to present

Continuous Data

Continuously collected data include dissolved oxygen, pH, specific conductance, water temperature, depth, and turbidity. Data are collected at 15-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 sondes were deployed and retrieved by SECN staff.

The data collection platform consists of a 4-inch diameter PVC tube attached vertically to a piling on the Sea Camp boat ramp dock 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.

Table 2. Performance specifications of YSI 6600 EDS data loggers deployed at the continuous monitoring site (YSI 2011) [mg/L—milligrams per liter; mS/cm—milli-Siemens per centimeter ; m—meter; ft—foot; ppt—parts per thousand; NTU—nephelometric turbidity unit].

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)	0.001 m (0.001 ft)	+/- 0.018 m (+/- 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.

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, the Southeast Coast Network transitioned continuous data management tasks to Aquarius (Aquatic Informatics Inc. 2015).

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/>.

Discrete Data

Water sample collection for this project was conducted 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). Cumberland Island National Seashore 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.

Monthly water-quality data collected during 2013–2014 at the Southeast Coast Network site near Cumberland Island National Seashore reflected good to fair conditions throughout the year.

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

Chlorophyll *a* concentrations were fair (12 visits) to good (12 visits) for the period of record, ranging from 2.98 µg/L to 9.19 µg/L.

Water clarity was mostly good (17 visits) to fair (6 visits) for the period of record.

Over the period of record, seven samples were pulled for dissolved inorganic nitrogen (DIN) and dissolved inorganic phosphorus (DIP). Six of the seven DIN concentrations were rated as good, with one fair. Three of the DIP concentrations were good, and four were fair.

Mean monthly dissolved oxygen levels were fair to good throughout the period, ranging from 4.4 mg/L to 8.5 mg/L. Individual values ranged from 2.0 mg/L in May 2013 to 9.4 mg/L in January 2014.

Mean monthly pH values ranged from 7.3 to 8.4. Individual readings ranged from 7.1 in September 2014 to 8.5 in January and February 2013.

Monthly mean turbidity values were highest during February 2013 at 10.9 NTUs. The lowest individual turbidity reading for any given month was 0.0 NTUs, and a maximum reading of 627.9 NTUs was recorded in January 2013. There are no EPA criteria to grade turbidity as good, fair, or poor.

Water temperatures in 2013–2014 ranged from a minimum monthly mean of 11.5°C (52.7°F) in January 2014 to a maximum monthly mean of 29.6°C (85.3°F) in August 2014. Individual temperatures ranged from a minimum of 7.4°C (45.3°F) in January 2013 to a maximum of 31.9°C (89.4°F) in July 2014.

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 Cumberland National Seashore are shown in Table 5. Condition categories generally correspond to those used by the EPA in the National Coastal Condition Report IV (2012).

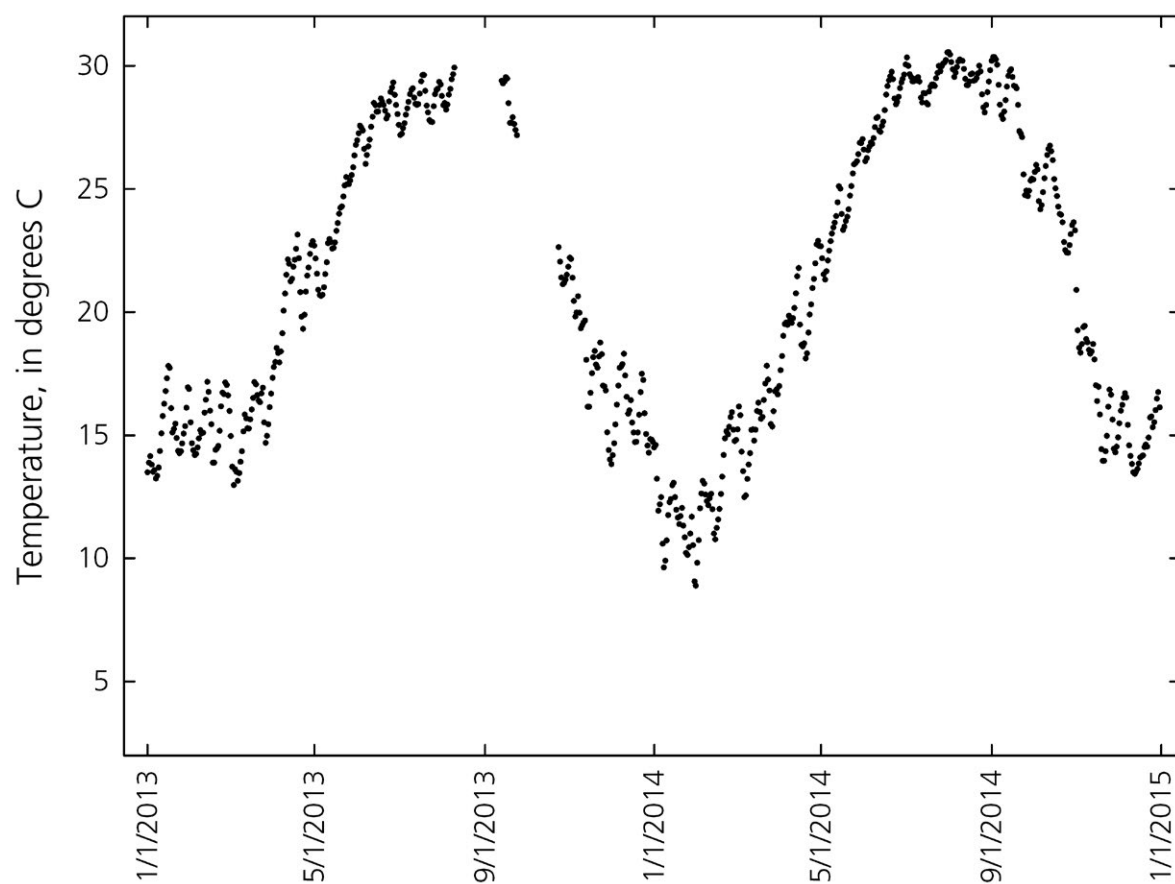


Figure 4. Mean daily water temperature at the Sea Camp dock site at Cumberland Island National Seashore during 2013–2014. Breaks in data record indicate missing and/or flagged data.

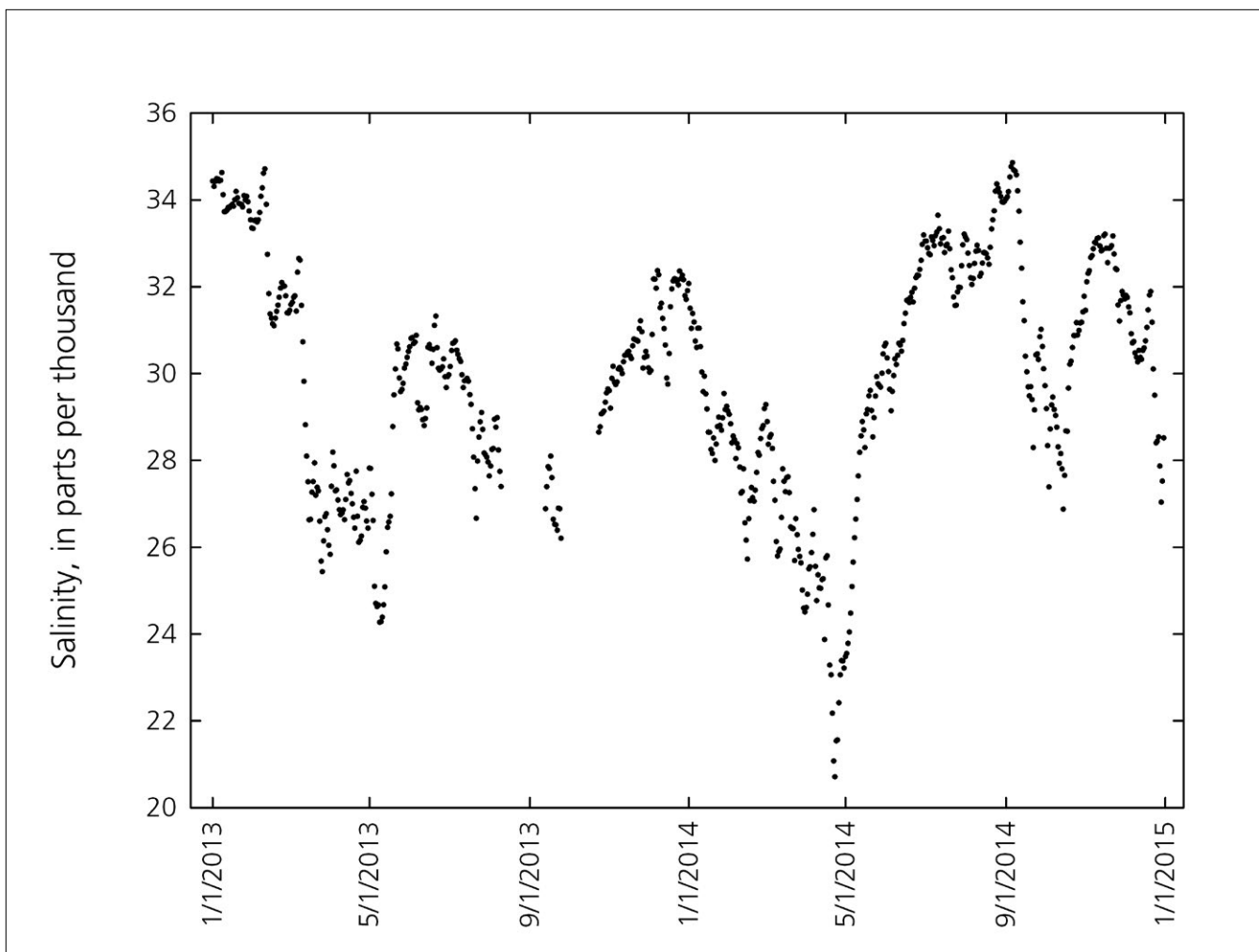


Figure 5. Mean daily values for salinity at the Sea Camp dock site at Cumberland Island National Seashore during 2013–2014. Breaks in data record indicate missing and/or flagged data.

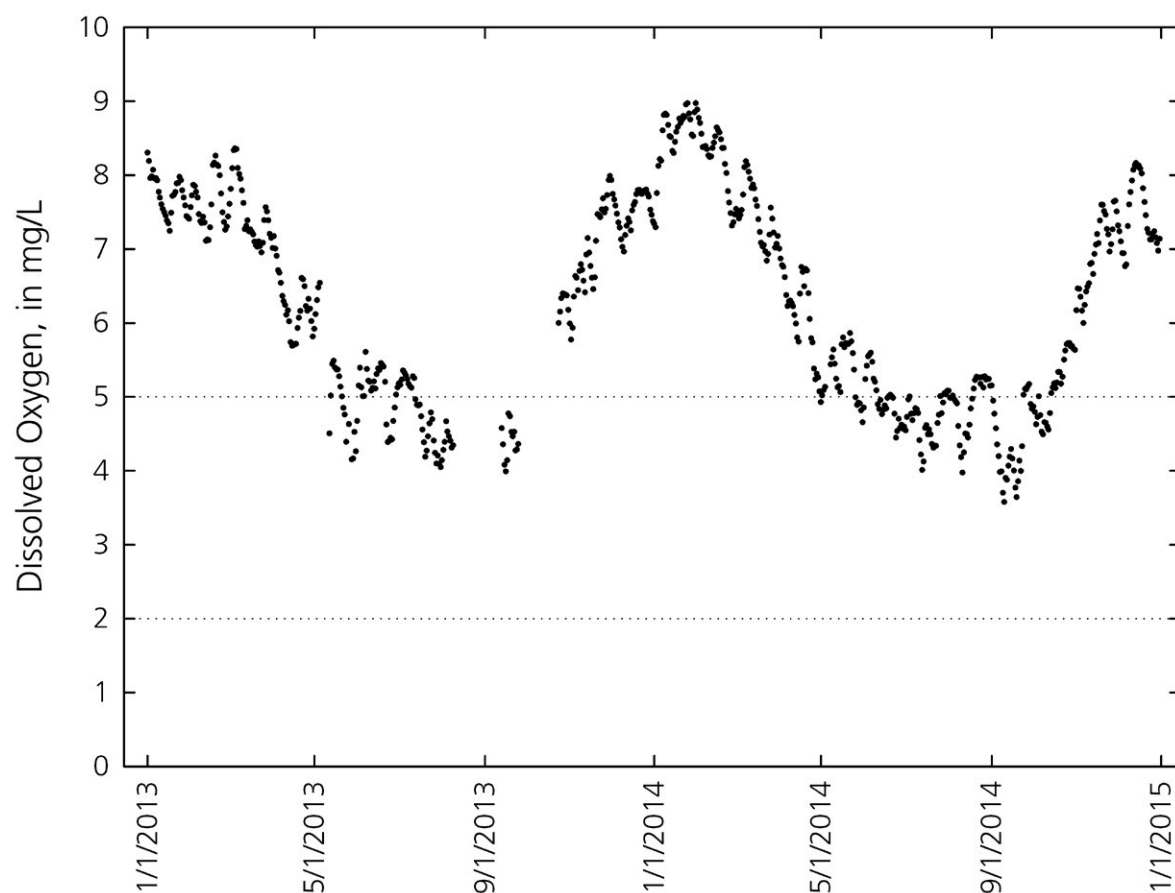


Figure 6. Mean daily values for dissolved oxygen at the Sea Camp dock site at Cumberland Island National Seashore during 2013–2014. Breaks in data record indicate missing and/or flagged data. Dotted lines indicate minimum value for a rating of *good* (5 mg/L) and *fair* (2 mg/L)(EPA 2012).

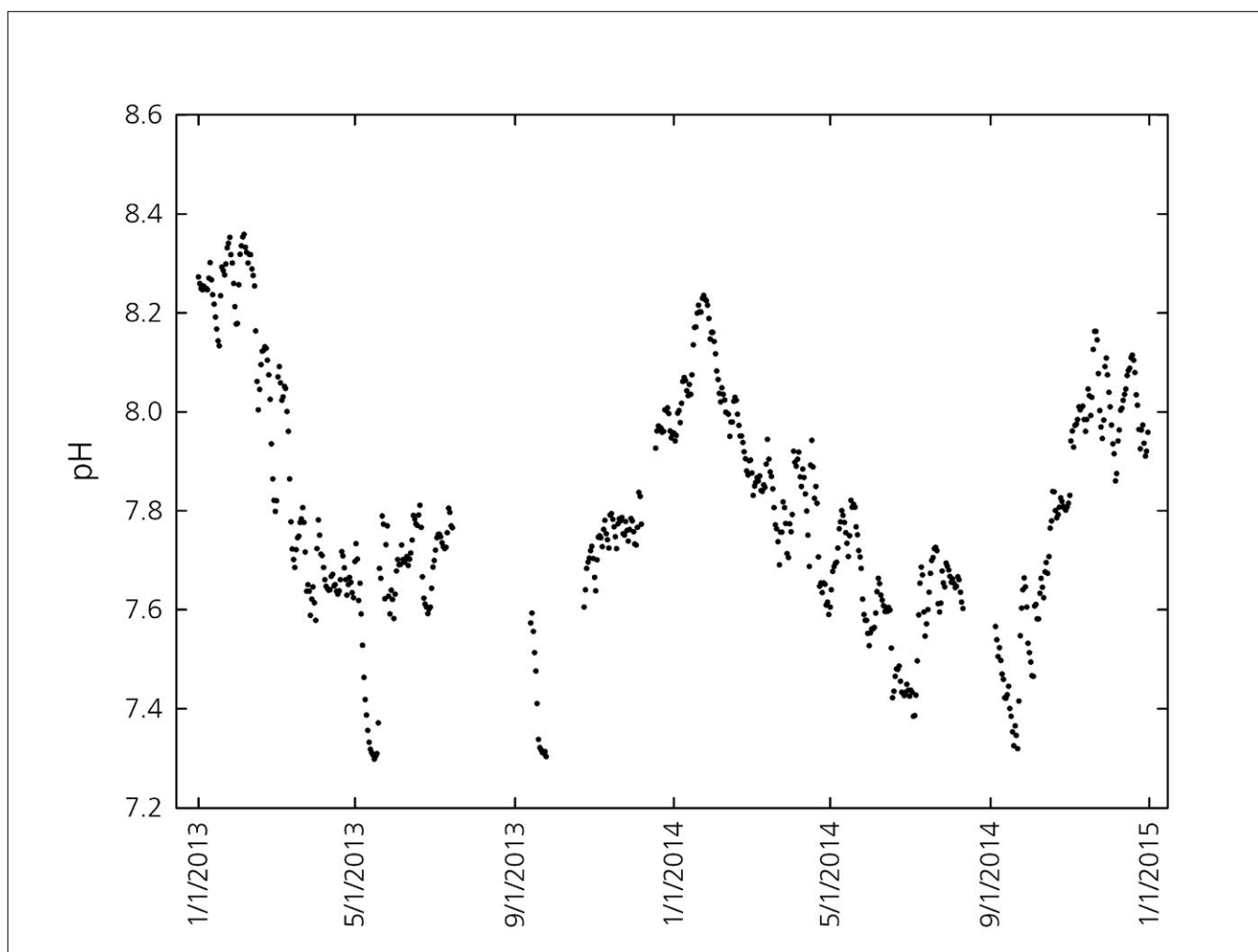


Figure 7. Mean daily values for pH at at the Sea Camp dock site at Cumberland Island National Seashore during 2013–2014. Breaks in data record indicate missing and/or flagged data.

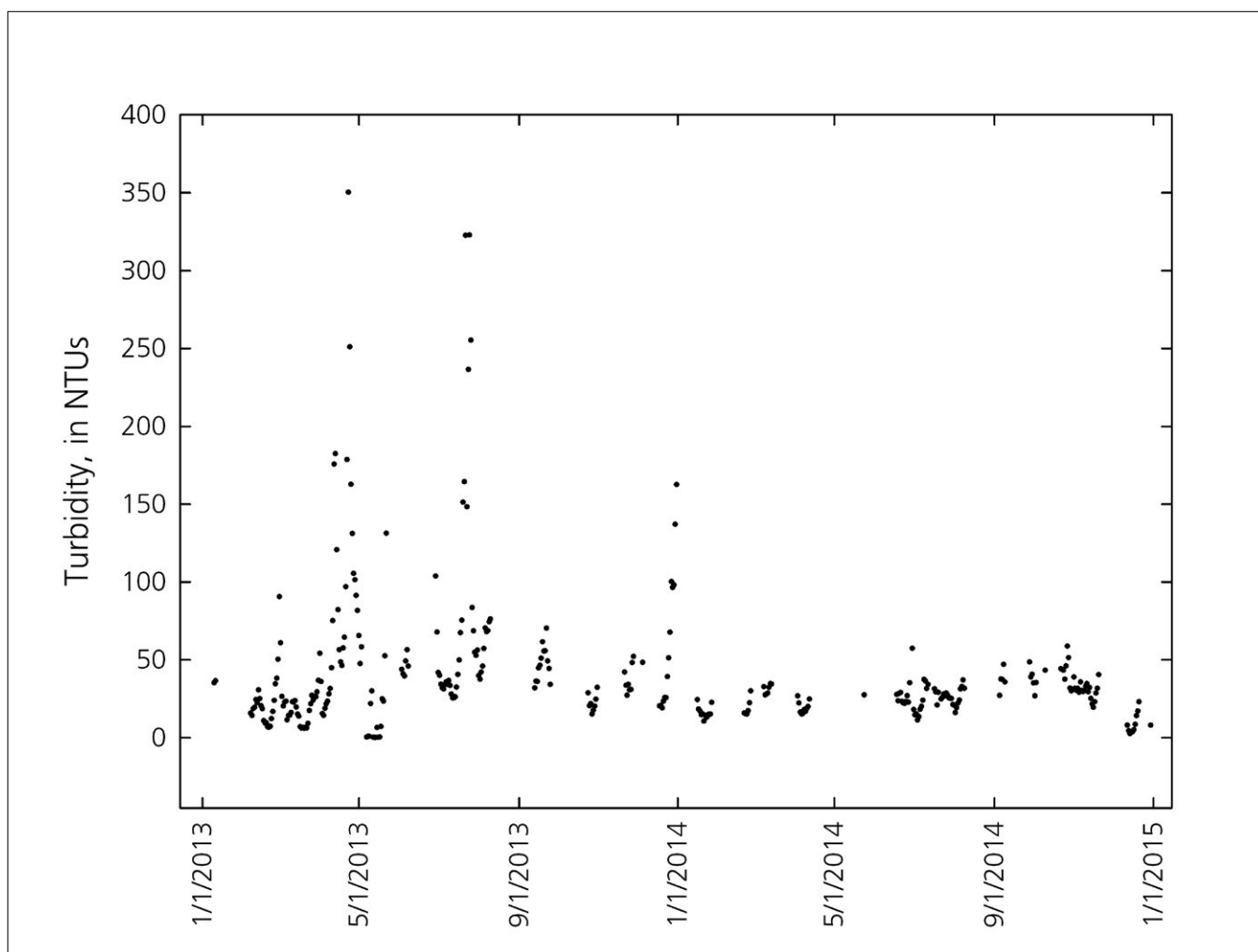


Figure 8. Mean daily values for turbidity (NTUs) at the Sea Camp dock site at Cumberland Island National Seashore during 2013–2014. Breaks in data record indicate missing and/or flagged data.

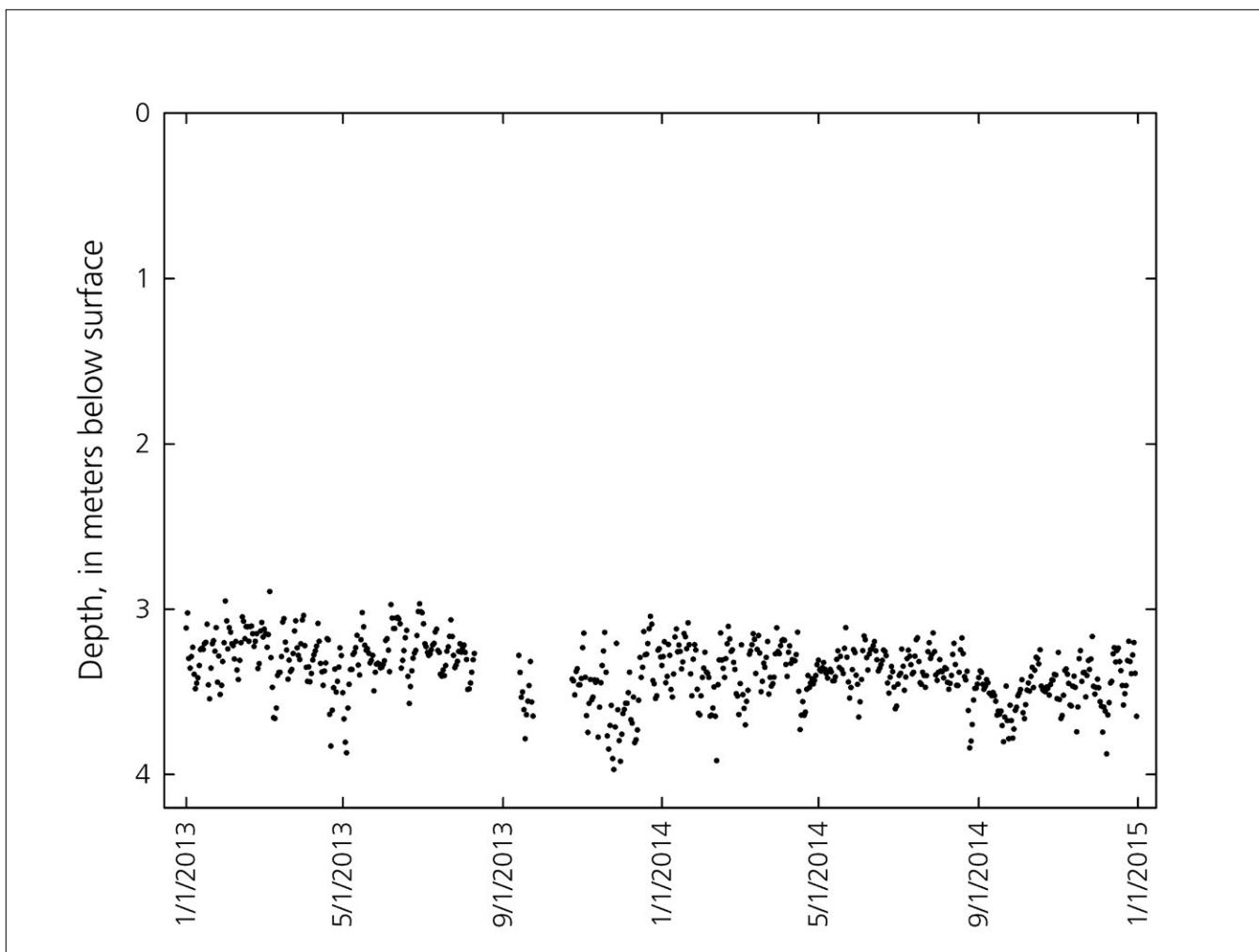


Figure 9. Mean daily values for depth at the Sea Camp dock site at Cumberland Island National Seashore during 2013–2014. Breaks in data record indicate missing and/or flagged data.

Table 4. Monthly minimum, maximum, and mean values for parameters collected by the YSI 6-series data sonde at Cumberland Island National Seashore 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	2976	2976	2976	2976	2974	307
	Minimum	12.2	32.5	5.8	1.82	8	5.9
	Maximum	19.7	35.9	8.7	4.69	8.5	129.3
	Mean	15.1	34	7.7	3.29	8.3	34.7
	SD	1.5	0.4	0.4	0.7	0.08	22.9
	Percent	100%	100%	100%	100%	100%	10%
February 2013 (Expected count 2688)	Actual Count	2688	2688	2688	2688	2686	2136
	Minimum	12.5	31	6.1	1.8	7.8	2.9
	Maximum	18.8	35.6	9	4.72	8.5	164.6
	Mean	15.4	32.5	7.6	3.19	8.2	19.5
	SD	1.1	1.2	0.4	0.7	0.16	15.7
	Percent	100%	100%	100%	100%	100%	79%
March 2013 (Expected count 2976)	Actual Count	2976	2976	2976	2976	2976	2961
	Minimum	11.2	24.4	6.2	1.77	7.5	2.1
	Maximum	18.9	35.4	8.9	4.77	8.2	258.6
	Mean	15.3	28.8	7.5	3.27	7.8	21.5
	SD	1.4	2.5	0.5	0.7	0.16	22.6
	Percent	100%	100%	100%	100%	100%	99%
April 2013 (Expected count 2880)	Actual Count	2880	2880	2880	2880	2880	2811
	Minimum	16.3	24.3	3.9	1.96	7.4	3.6
	Maximum	24.8	31.6	7.9	4.84	8	581.4
	Mean	20.6	27	6.3	3.35	7.7	89.4
	SD	1.9	1.4	0.6	0.7	0.1	84.2
	Percent	100%	100%	100%	100%	100%	98%
May 2013 (Expected count 2976)	Actual Count	2976	2976	2261	2976	2976	1797
	Minimum	20.1	23.7	2	1.91	7.3	0.0
	Maximum	28.1	31.5	7	4.88	8.1	602.4
	Mean	23.4	27.5	5.2	3.36	7.5	31.8
	SD	1.9	2.4	0.9	0.7	0.18	54.5
	Percent	100%	100%	76%	100%	100%	60%
June 2013 (Expected count 2880)	Actual Count	2877	2877	2877	2877	2877	811
	Minimum	25.2	26.8	3	1.82	7.3	11.8
	Maximum	31.4	35.6	6.3	4.82	8.1	257.3
	Mean	27.9	30.1	5.1	3.21	7.7	56.9
	SD	1	1.6	0.5	0.7	0.13	39.3
	Percent	100%	100%	100%	100%	100%	28%

Table 4. (continued) Monthly minimum, maximum, and mean values for parameters collected by the YSI 6-series data sonde at Cumberland Island National Seashore 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	2976	2976	2976	2976	1472	2780
	Minimum	26.3	24.7	2.6	1.65	7.6	6.6
	Maximum	30.6	35.1	6.4	4.59	8	856.6
	Mean	28.5	29.3	4.8	3.25	7.7	76
	SD	0.9	1.9	0.6	0.7	0.09	110.3
	Percent	100%	100%	100%	100%	49%	93%
August 2013 (Expected count 2976)	Actual Count	1016	1024	928	1024	0	930
	Minimum	26.3	24.7	3	2.21	NA	17.7
	Maximum	31.4	33.4	5.8	4.53	NA	267.6
	Mean	29	28.2	4.4	3.34	NA	56.9
	SD	0.8	1.6	0.4	0.6	NA	33.7
	Percent	34%	34%	31%	34%	0%	31%
September 2013 (Expected count 2880)	Actual Count	1252	1305	1297	1250	1305	1231
	Minimum	26.5	24.9	2.5	2.15	7.3	5.3
	Maximum	30.2	32.9	5.8	4.84	7.9	281.8
	Mean	28.4	27.1	4.4	3.52	7.4	46.5
	SD	1	1.7	0.5	0.7	0.15	35.1
	Percent	43%	45%	45%	43%	45%	43%
October 2013 (Expected count 2976)	Actual Count	804	804	804	804	804	802
	Minimum	19.9	28	5.4	2.31	7.5	5.3
	Maximum	24.3	30.8	6.8	4.32	7.9	133.1
	Mean	21.7	29.1	6.3	3.42	7.7	22.9
	SD	0.8	0.7	0.3	0.5	0.08	17.1
	Percent	27%	27%	27%	27%	27%	27%
November 2013 (Expected count 2880)	Actual Count	2880	2880	2880	2880	2880	868
	Minimum	13.1	27.8	5	1.93	7.5	8.4
	Maximum	22.9	33.4	8.3	4.98	8	179.8
	Mean	18.4	30.3	6.9	3.55	7.8	38.2
	SD	2.1	0.9	0.6	0.7	0.09	24.8
	Percent	100%	100%	100%	100%	100%	30%
December 2013 (Expected count 2976)	Actual Count	2975	2975	2975	2975	2075	1517
	Minimum	13.1	29.3	6.3	1.9	7.7	5.7
	Maximum	19.2	35.3	8.3	4.95	8.2	483.4
	Mean	15.9	31.5	7.5	3.44	7.9	59.8
	SD	1.3	1.1	0.3	0.7	0.12	57.7
	Percent	100%	100%	100%	100%	70%	51%

Table 4. (continued) Monthly minimum, maximum, and mean values for parameters collected by the YSI 6-series data sonde at Cumberland Island National Seashore 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	2976	2976	2949	2976	2976	1134
	Minimum	7.4	24.7	6.6	1.44	7.8	3.2
	Maximum	14.9	33.9	9.4	4.95	8.3	83.1
	Mean	11.5	29.7	8.5	3.33	8.1	16.2
	SD	1.5	1.6	0.5	0.7	0.11	9.2
	Percent	100%	100%	99%	100%	100%	38%
February 2014 (Expected count 2688)	Actual Count	2688	2688	2662	2688	2686	591
	Minimum	9.2	23.8	6.7	1.93	7.7	5
	Maximum	17.1	33.4	9.2	4.8	8.3	93.5
	Mean	13	27.8	8.2	3.4	8	19.6
	SD	1.8	1.6	0.5	0.7	0.1	12.7
	Percent	100%	100%	99%	100%	100%	22%
March 2014 (Expected count 2976)	Actual Count	2976	2976	2926	2976	2976	694
	Minimum	11.3	21.5	6.1	1.71	7.5	14.7
	Maximum	19.3	33	8.6	4.92	8.1	78.6
	Mean	15.4	26.8	7.5	3.37	7.8	30.6
	SD	1.5	2	0.4	0.7	0.12	10.5
	Percent	100%	100%	98%	100%	100%	23%
April 2014 (Expected count 2880)	Actual Count	2880	2880	2679	2880	2876	1026
	Minimum	15.7	17.5	2.7	1.26	7.3	4.4
	Maximum	25.1	32.9	7.7	4.82	8.3	74.2
	Mean	19.9	24.2	6.2	3.38	7.8	19.9
	SD	1.7	2.8	0.6	0.7	0.18	10.3
	Percent	100%	100%	93%	100%	100%	36%
May 2014 (Expected count 2976)	Actual Count	2975	2975	2611	2975	2971	215
	Minimum	19.6	20.2	3.1	1.85	7.3	6.7
	Maximum	28.8	34.6	6.7	4.66	8.1	99.6
	Mean	24.1	27.9	5.3	3.36	7.7	35.1
	SD	1.8	2.9	0.6	0.7	0.17	25.5
	Percent	100%	100%	88%	100%	100%	7%
June 2014 (Expected count 2880)	Actual Count	2880	2880	2617	2880	2878	1300
	Minimum	25.1	27.2	2.9	1.94	7.2	0.9
	Maximum	31	36.4	6.4	4.69	8	99.9
	Mean	28.1	31.2	5	3.35	7.5	36
	SD	1.2	1.7	0.5	0.7	0.15	25.6
	Percent	100%	100%	91%	100%	100%	45%

Table 4 (continued). Monthly minimum, maximum, and mean values for parameters collected by the YSI 6-series data sonde at Cumberland Island National Seashore 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	2976	2976	2686	2976	2974	2495
	Minimum	27.2	29.9	2.9	1.86	7.2	0.9
	Maximum	31.9	36.2	6	4.75	8	99.9
	Mean	29.5	32.7	4.6	3.34	7.6	25.3
	SD	0.7	1.1	0.5	0.7	0.12	19.3
	Percent	100%	100%	90%	100%	100%	84%
August 2014 (Expected count 2976)	Actual Count	2974	2974	2772	2974	1062	1126
	Minimum	27.4	29.6	2.8	1.82	7.3	3.5
	Maximum	31.8	36.1	6.1	4.79	8	98.6
	Mean	29.6	33.1	4.9	3.43	7.6	30.9
	SD	0.7	1.2	0.5	0.7	0.13	22
	Percent	100%	100%	93%	100%	36%	38%
September 2014 (Expected count 2880)	Actual Count	2880	2880	2637	2880	2551	1098
	Minimum	23.6	24.8	2	2	7.1	3.2
	Maximum	31.3	36.9	6	4.76	8	100
	Mean	28.1	31.9	4.4	3.57	7.5	45.2
	SD	1.9	2.4	0.6	0.7	0.18	23.5
	Percent	100%	100%	92%	100%	89%	38%
October 2014 (Expected count 2976)	Actual Count	2976	2976	2821	2976	2975	1646
	Minimum	21.3	23.7	3.5	2	7.3	3.7
	Maximum	27.7	34.7	6.3	4.76	8.1	100
	Mean	24.6	29.5	5.1	3.46	7.7	41.3
	SD	1.4	2	0.5	0.7	0.18	21.4
	Percent	100%	100%	95%	100%	100%	55%
November 2014 (Expected count 2880)	Actual Count	2880	2880	2752	2880	2877	1930
	Minimum	12.6	29.8	5.1	1.93	7.7	6.1
	Maximum	23.4	35.1	8.2	4.75	8.3	100
	Mean	17	32.6	6.9	3.45	8	32.7
	SD	2.1	0.9	0.6	0.7	0.12	18.6
	Percent	100%	100%	96%	100%	100%	67%
December 2014 (Expected count 2976)	Actual Count	2976	2976	2874	2976	2974	1172
	Minimum	12.6	24.4	5.7	1.93	7.7	0.0
	Maximum	17.5	34.3	8.6	4.93	8.3	96.8
	Mean	15.1	30.3	7.5	3.44	8	14.0
	SD	1.1	1.7	0.5	0.7	0.12	19.6
	Percent	100%	100%	97%	100%	100%	39%

Table 5. Monthly water-quality data collected at the SECN water-quality site near Cumberland Island National Seashore 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; k—light attenuation coefficient; µg/L—micrograms per liter; mg/L—milligrams per liter; -- data not collected; ¹Light attenuation coefficients (k) were used to assess water-clarity conditions using criteria categories in Smith et al. (2006) which are comparable to the EPA (2012) criteria for the assessed water bodies; ²There are no EPA condition criteria for TDN and TDP].

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 ² (mg/L)	Total Dissolved Phosphorus ² (mg/L)
01/09/2013	2.00 ^a	6.95 ^b	--	--	7.6 ^a	0.28	0.036
02/06/2013	1.00 ^a	3.02 ^a	0.018 ^a	0.0097 ^a	7.2 ^a	0.02	0.020
03/07/2013	1.25 ^a	3.57 ^a	--	--	8.7 ^a	0.23	0.023
04/02/2013	1.11 ^a	3.82 ^a	--	--	6.6 ^a	0.38	0.022
05/01/2013	1.67 ^a	5.26 ^b	0.059 ^a	0.0090 ^a	5.2 ^a	0.40	0.026
06/02/2013	2.00 ^a	7.85 ^b	--	--	5.4 ^a	0.36	0.034
07/11/2013	1.43 ^a	9.19 ^b	--	--	5.5 ^a	0.46	0.035
08/11/2013	2.50 ^b	4.74 ^a	0.158 ^b	0.0239 ^b	--	0.51	0.047
09/12/2013	1.33 ^a	4.22 ^a	--	--	4.5 ^b	0.51	0.049
10/23/2013	2.50 ^b	4.16 ^a	--	--	6.0 ^a	0.44	0.041
11/20/2013	2.50 ^b	5.41 ^b	0.051 ^a	0.0181 ^b	7.6 ^a	0.30	0.033
12/17/2013	1.67 ^a	3.09 ^a	--	--	7.8 ^a	0.24	0.031
01/15/2014	1.43 ^a	5.38 ^b	--	--	8.4 ^a	0.36	0.030
02/20/2014	1.43 ^a	4.51 ^a	0.007 ^a	0.0084 ^a	8.6 ^a	0.32	0.025
04/02/2014	1.25 ^a	2.98 ^a	--	--	6.8 ^a	0.35	0.026
05/23/2014	2.00 ^a	5.41 ^b	0.049 ^a	0.0134 ^b	6.2 ^a	0.40	0.031
06/17/2014	2.50	6.14 ^b	--	--	5.4 ^a	0.47	0.051
07/23/2014	0.67 ^a	5.44 ^b	--	--	4.2 ^b	0.42	0.051
08/13/2014	2.00 ^a	5.87 ^b	--	--	4.6 ^b	0.44	0.062
09/04/2014	1.33 ^a	7.47 ^b	--	--	3.9 ^b	0.42	0.050
10/08/2014	2.50 ^b	3.93 ^a	--	--	4.4 ^b	0.48	0.039
11/05/2014	2.50 ^b	6.19 ^b	0.047 ^a	0.0199 ^b	6.4 ^a	0.37	0.044
12/11/2014	1.67 ^a	3.04 ^a	--	--	7.6 ^a	0.39	0.041

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