



Fixed-Station Water-Quality Monitoring at Cape Hatteras National Seashore

2015–2016 Data Summary

Natural Resource Data Series NPS/SECN/NRDS—2019/1205



ON THE COVER

Sunset over the dunes on Ocracoke Island. NPS photo / Brian Gregory.

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Mark Hynds and Eric N. Starkey

National Park Service
135 Phoenix Road
Athens, Georgia 30605

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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.

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Contents

	Page
Figures	iv
Tables	iv
Summary and Key Findings	v
Introduction	1
Cape Hatteras National Seashore	1
Weather and Hydrologic Setting	2
Methods	3
Sampling Location	3
Continuous Data	4
Discrete Data	5
Assessment Criteria	5
Results	6
Continuous Data	6
Discrete Data	6
Literature Cited	17

Figures

	Page
Figure 1. Location of continuous water-quality monitoring station at Cape Hatteras National Seashore.	vi
Figure 2. Daily precipitation at Ocracoke Island weather and climate station near Cape Hatteras National Seashore January 1, 2015–December 31, 2016	
Figure 3. Continuous data collection platform on the Cape Hatteras National Seashore dock near the visitor center parking lot.	3
Figure 4. Mean daily water temperature at Ocracoke near Cape Hatteras National Seashore during 2015–2016	7
Figure 5. Mean daily values for salinity at Ocracoke near Cape Hatteras National Seashore during 2015–2016	8
Figure 6. Mean daily values for dissolved oxygen at Ocracoke near Cape Hatteras National Seashore during 2015–2016.	9
Figure 7. Mean daily values for pH at Ocracoke near Cape Hatteras National Seashore during 2015–2016	10
Figure 8. Mean daily values for turbidity (NTUs) at Ocracoke near Cape Hatteras National Seashore during 2015–2016.	11
Figure 9. Mean daily values for depth at Ocracoke near Cape Hatteras National Seashore during 2015–2016.	12

Tables

	Page
Table 1. Location of continuous water-quality monitoring station at Cape Hatteras National Seashore during 2015–2016.	3
Table 2. Performance specifications of YSI 6600 data loggers deployed at the continuous monitoring site	4
Table 3. Coastal water-quality monitoring condition criteria for water-quality parameters collected by the Southeast Coast Network	5
Table 4. Monthly minimum, maximum, and mean values for parameters collected by the YSI 6-series data sonde at Cape Hatteras National Seashore during 2015–2016.	15
Table 5. Monthly water-quality data collected at the Southeast Coast Network site near Cape Hatteras National Seashore during 2015–2016	16

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 Cape Hatteras National Seashore (CAHA) as part the NPS Vital Signs Monitoring Program. The continuous-monitoring data station is located at a dock at the Ocracoke Village boat ramp.

This station collects conductivity, dissolved oxygen, pH, salinity, temperature, 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).

The Cape Hatteras 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.

Highlights from the 2015–2016 data record are summarized in this report. The site was down for maintenance issues from August 2015 to May 2016. This data summary contains

data for January through July in 2015, and June through December in 2016. The limited data availability should be taken into consideration when reading this summary.

- Chlorophyll *a* concentrations were good for seven samples and fair for two samples. Values ranged from 1.62 µg/L to 12.91 µg/L.
- Water clarity was good for four visits and poor for one visit (March 2015).
- Mean monthly dissolved oxygen concentrations were good throughout the period, ranging from a low of 5.68 mg/L in September 2016 to a high of 11.78 mg/L in March 2015. No daily average dissolved oxygen concentration fell below 6.6 mg/L.
- Mean monthly pH values ranged from a low of 7.7 in April 2015 to a high of 8.7 in August 2016. The daily mean value ranged from 7.9 to 8.2.
- Monthly mean turbidity values were highest during February 2015 at 18.2 NTUs. The lowest individual turbidity reading for any given month was 0.0 NTUs, and a maximum reading of 75.2 NTUs was recorded in October 2016.
- Water temperatures in 2015–2016 ranged from a minimum monthly mean of 4.8 °C (40.6 °F) in February 2015 to a maximum monthly mean of 28.7 °C (83.7 °F) in July 2016. Individual temperatures ranged from a minimum of -1.1 °C (30.0 °F) in February 2015 to a maximum of 33.2 °C (91.8 °F) in June 2015.

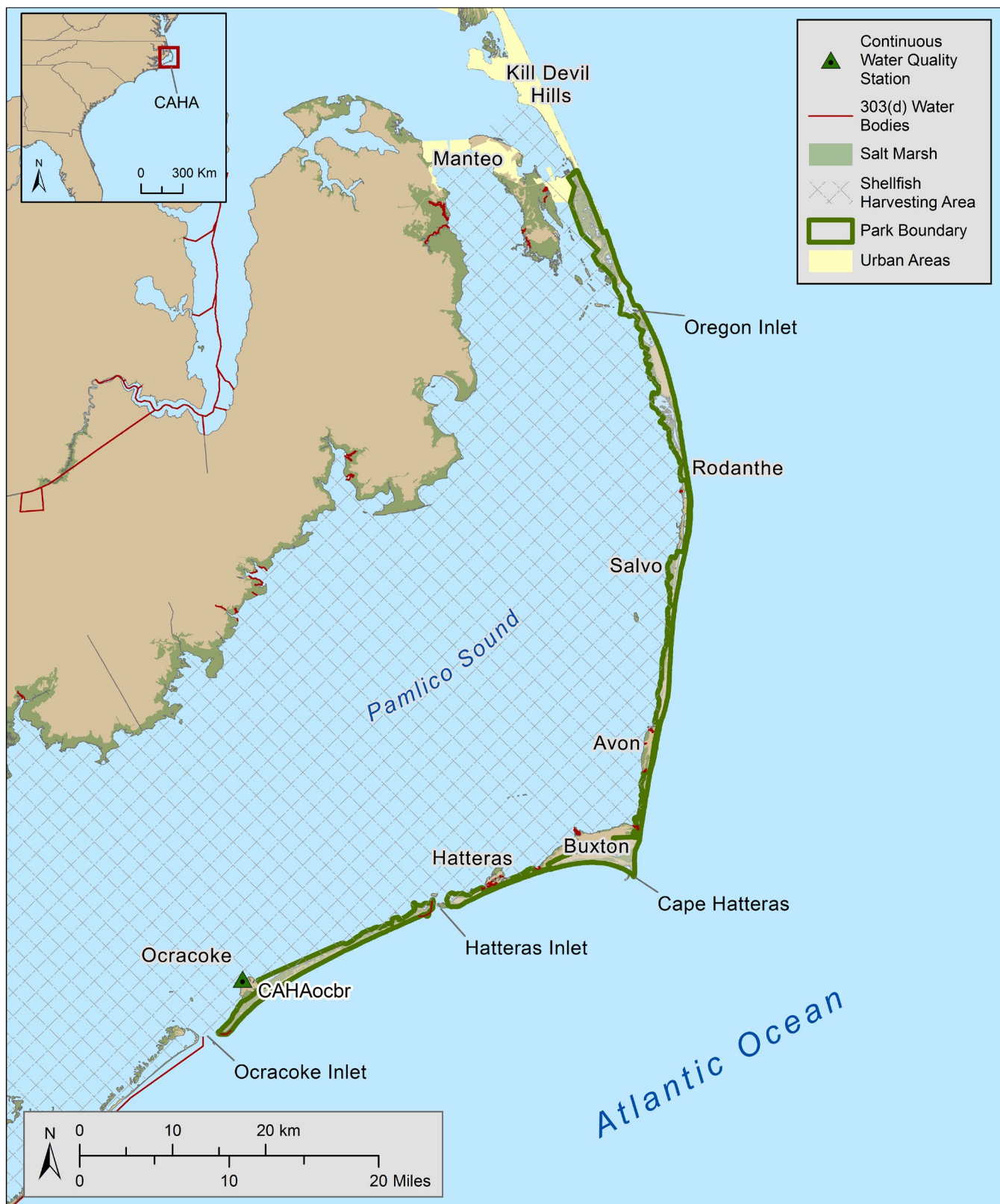


Figure 1. Location of continuous water-quality monitoring station at Cape Hatteras National Seashore. Map shows estuarine and marine water resources in the vicinity of Cape Hatteras National Seashore in North Carolina and indicates areas of salt marsh (USFWS 2019), urbanization (USCB 2019), 303(d) listed water bodies (EPA 2019), and areas designated as having special uses or restrictions (NC OneMap 2017).

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, pH, salinity, temperature, 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 2015–2016 at Cape Hatteras 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 Cape Hatteras National Seashore.

Cape Hatteras National Seashore

Cape Hatteras National Seashore is the northern-most park unit in the Southeast Coast Inventory and Monitoring Network (Figure 1). Located along the northern section of the Outer Banks, Cape Hatteras contains 35,400 acres (55 square miles) of land and 74 miles (119 kilometers) of beaches. The U.S. Fish and Wildlife Service (USFWS) administers the Pea Island National Wildlife Refuge within the boundary of the seashore. Seashore marshes contribute heavily to primary estuarine productivity and provide habitat for numerous wildlife and aquatic species. The unique and varied habitats, such as mature broad-leafed evergreen forest and shrub, freshwater marsh, and bog, support an unusual assemblage of aquatic, terrestrial, and avian species. Buxton Woods also overlies, protects, and provides for recharge of an important freshwater aquifer. The seashore was recently designated a Globally Important Bird Area by the National Audubon Society (NAS 2019) because of the importance of seashore habitats for avian breeding, migration, and wintering.

External developmental pressure affects Cape Hatteras from Nags Head and nine smaller towns that border the seashore. Visitor and recreational uses represent the major categories of threat to the integrity of natural resources on Cape Hatteras. Replacement of natural areas with impervious surfaces increases storm water runoff with its associated contaminants, so it may be of potential concern to offshore water quality. Many areas in the vicinity of the seashore have water bodies that have recently been 303(d) listed. Shell fishing was prohibited in areas south of Kill Devil Hills and Manteo due to elevated pathogen levels, and several smaller areas along the seashore have been 303(d) listed. Previous sampling (in 2015) by the Southeast Coast Network in the vicinity of Cape Hatteras indicated good water-quality conditions on the sound side of the park. But two sites near Manteo did exhibit fair but degrading conditions, with elevated total nitrogen, and chlorophyll *a* concentrations, and low water-clarity conditions (Wright 2016).

Weather and Hydrologic Setting

Daily rainfall totals were collected at the Ocracoke Island weather and climate station on www.climateanalyzer.org and are included here (Figure 2) as an aid for interpreting water-quality results. These data are presented for 2015–2016.

Additional climate data and analyses, such as departure from 30-year averages and extended drought and precipitation information, are available for individual interpretation on the [Southeast Coast Network Climate Analyzer Website](http://www.seaclimateanalyzer.org). This additional data may add context to the data presented in this report.

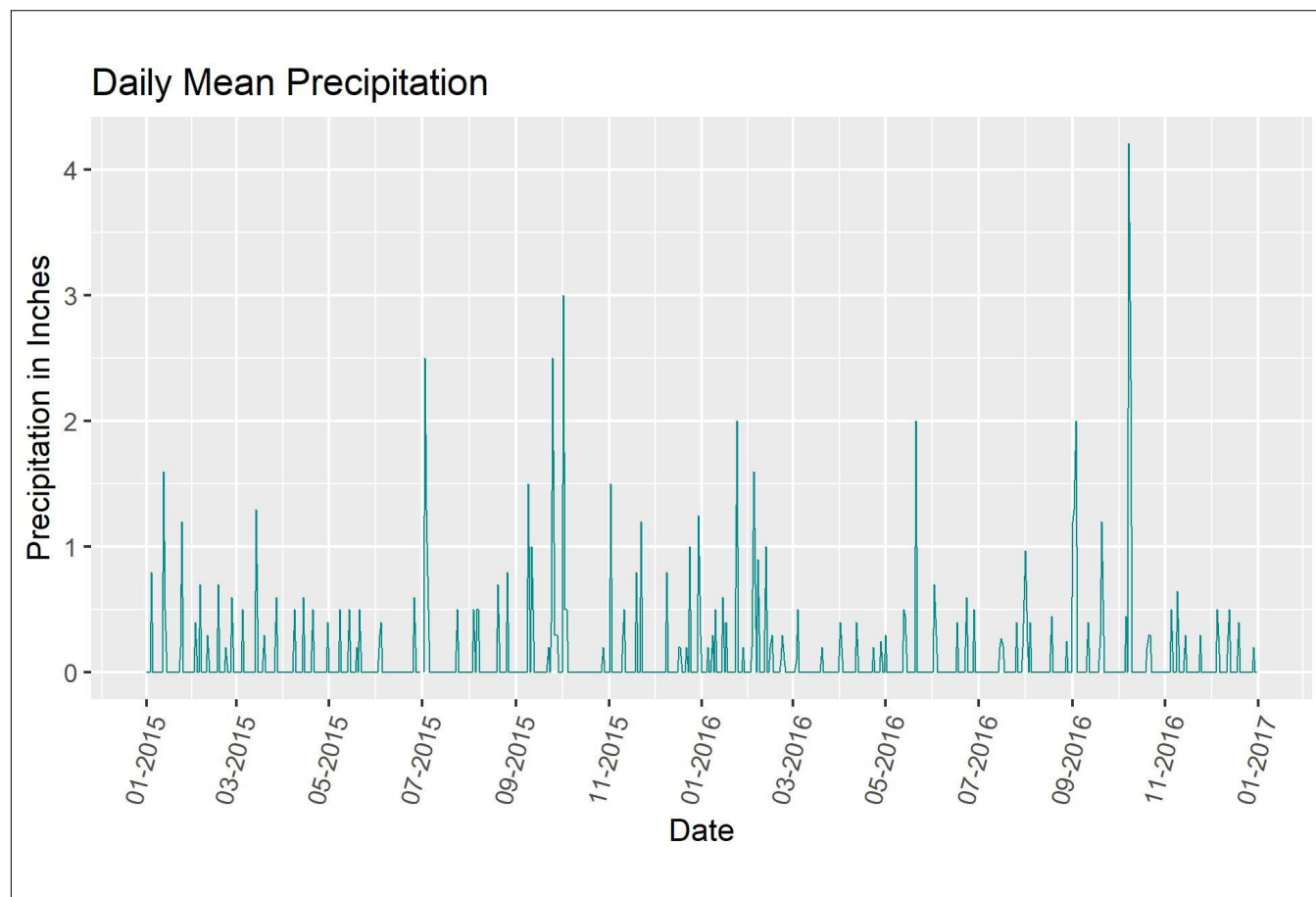


Figure 2. Daily precipitation at Ocracoke Island weather and climate station near Cape Hatteras National Seashore January 1, 2015–December 31, 2016. Data obtained from NOAA (NOAA-NCDC 2019) through The Climate Analyzer (www.climateanalyzer.org/secn; The Climate Analyzer 2019).

Methods

Data collection at the Cape Hatteras 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 Cape Hatteras National Seashore is on the seashore dock at the Ocracoke boat ramp behind the visitor center parking lot (Table 1, Figures 1 and 3). This site regularly experiences heavy boat traffic in spring, summer, and autumn. Water-quality concerns in this area include a high salinity outfall from a water treatment plant and septic system overflows during periods of high water levels.

Table 1. Location of continuous water-quality monitoring station at Cape Hatteras National Seashore during 2015–2016.

Name	Location Description	Location (lat /long)	Period of Record
CAHA	Pamlico Bay at Ocracoke Boat Ramp Dock	35.11836/-75.98594	11/4/2005 to present



Figure 3. Continuous data collection platform on the Cape Hatteras National Seashore dock near the visitor center parking lot. NPS photo / Brian Gregory.

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 sondes were deployed and retrieved by Cape Hatteras National Seashore staff.

The data collection platform consists of a 4-inch (10.2-centimeters) diameter PVC tube attached vertically to a piling on the Ocracoke boat ramp dock with the sonde suspended within and approximately 0.5 meters (1.3 feet) 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 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. In 2013, the Southeast Coast Network transitioned continuous data management tasks to Aquarius.

Beginning in January 2015, dissolved oxygen, pH, specific conductance, temperature and turbidity 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. USGS guidance served as the basis for data grades and corrections (Wagner et al. 2006). As with previous years, invalid or unusable data were deleted from data sets prior to publication. Data sets are available at the [NPS Aquarius Web Data Portal](#). (Aquatic Informatics Inc. 2015).

Discrete Data

Water sample collection for this project was conducted by Cape Hatteras park staff. Secchi depth was measured with a standard 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: $K_d = c / \text{Secchi depth (in meters)}$ and $c = 1.0$. “ c ” 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 normal turbidity conditions, or $a = 1.7$ for waters supporting submerged aquatic vegetation (SAV) restoration (EPA 2016). Cape Hatteras National Seashore uses a coefficient of 1.4 for normal turbidity 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.

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	<1.61	<5	<0.1	<0.01	>5
Fair	1.61–2.30	5–20	0.1–0.5	0.01–0.05	2–5
Poor	>2.30	>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 good for seven samples and fair for two samples. Values ranged from 1.62 µg/L to 12.91 µg/L.

Water clarity was good for four visits and poor for one visit (March 2015).

Mean monthly dissolved oxygen concentrations were good throughout the period, ranging from a low of 5.68 mg/L in September 2016 to a high of 11.78 mg/L in March 2015. No daily average dissolved oxygen concentration fell below 6.6 mg/L.

Mean monthly pH values ranged from a low of 7.7 in April 2015 to a high of 8.7 in August 2016. The daily mean value ranged from 7.9 to 8.2.

Monthly mean turbidity values were highest during February 2015 at 18.2 NTUs. The lowest individual turbidity reading for any given month was 0.0 NTUs, and a maximum reading of 75.2 NTUs was recorded in October 2016.

Water temperatures in 2015–2016 ranged from a minimum monthly mean of 4.8 °C (40.6 °F) in February 2015 to a maximum monthly mean of 28.7 °C (83.7 °F) in July 2016. Individual temperatures ranged from a minimum of -1.1 °C (30.0 °F) in February 2015 to a maximum of 33.2 °C (91.8 °F) in June 2015.

Continuous Data

Figures 4 through 9 depict the daily mean for each parameter for the entire data collection 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. Data gaps exist from August 2015–May 2016 because the site was down for maintenance issues.

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 2015–2016 at the SECN site near Cape Hatteras National Seashore are shown in Table 5. Data collection for Cape Hatteras was incomplete for the years 2015 and 2016, and these results do not demonstrate seasonal variations which would be expected in a complete data set. Condition categories generally correspond to those used by the EPA in the National Coastal Condition Report IV (EPA 2012; Table 3).

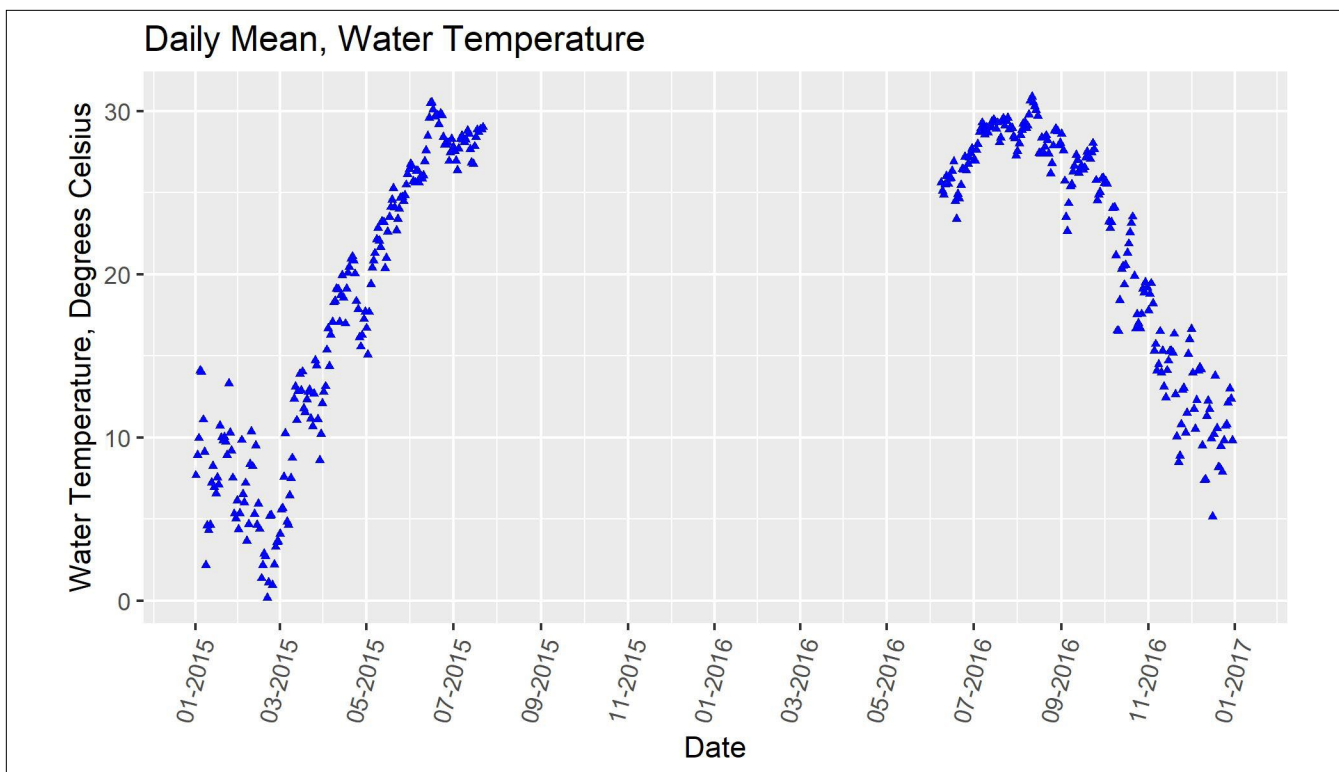


Figure 4. Mean daily water temperature at Ocracoke near Cape Hatteras National Seashore during 2015–2016. Breaks in data record indicate missing and/or flagged data.

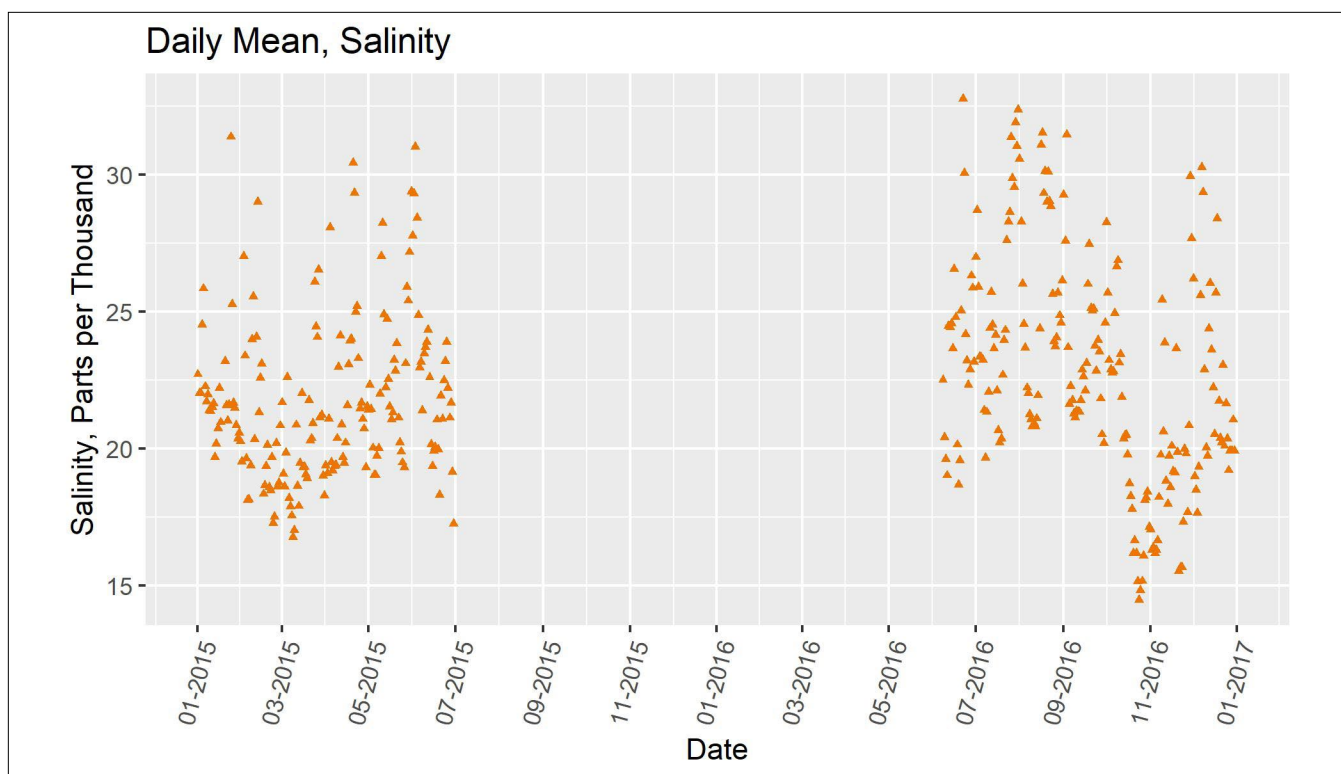


Figure 5. Mean daily values for salinity at Ocracoke near Cape Hatteras National Seashore during 2015–2016. Breaks in data record indicate missing and/or flagged data.

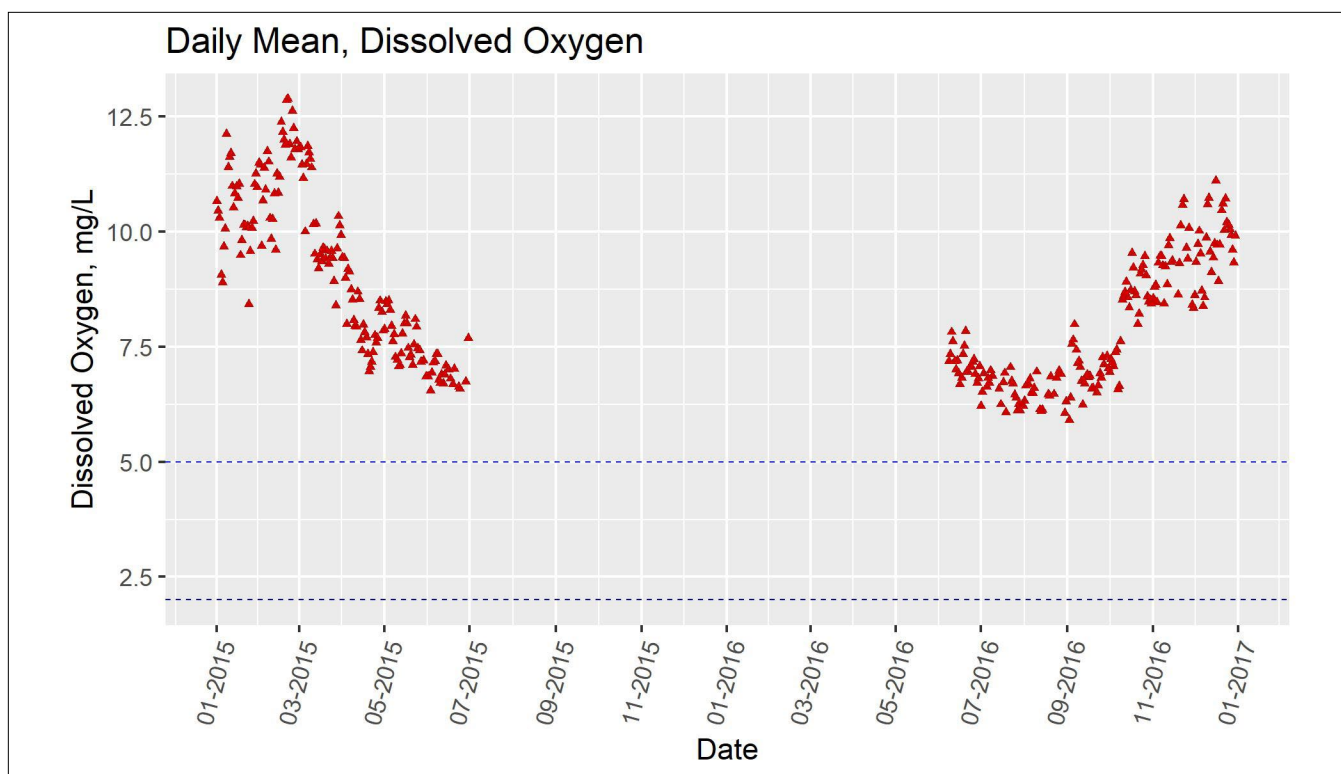


Figure 6. Mean daily values for dissolved oxygen at Ocracoke near Cape Hatteras National Seashore during 2015–2016. Breaks in data record indicate missing and/or flagged data. Dashed lines indicate thresholds for good (above 5 mg/L), fair (2–5 mg/L), and fair (less than 2 mg/L) criteria.

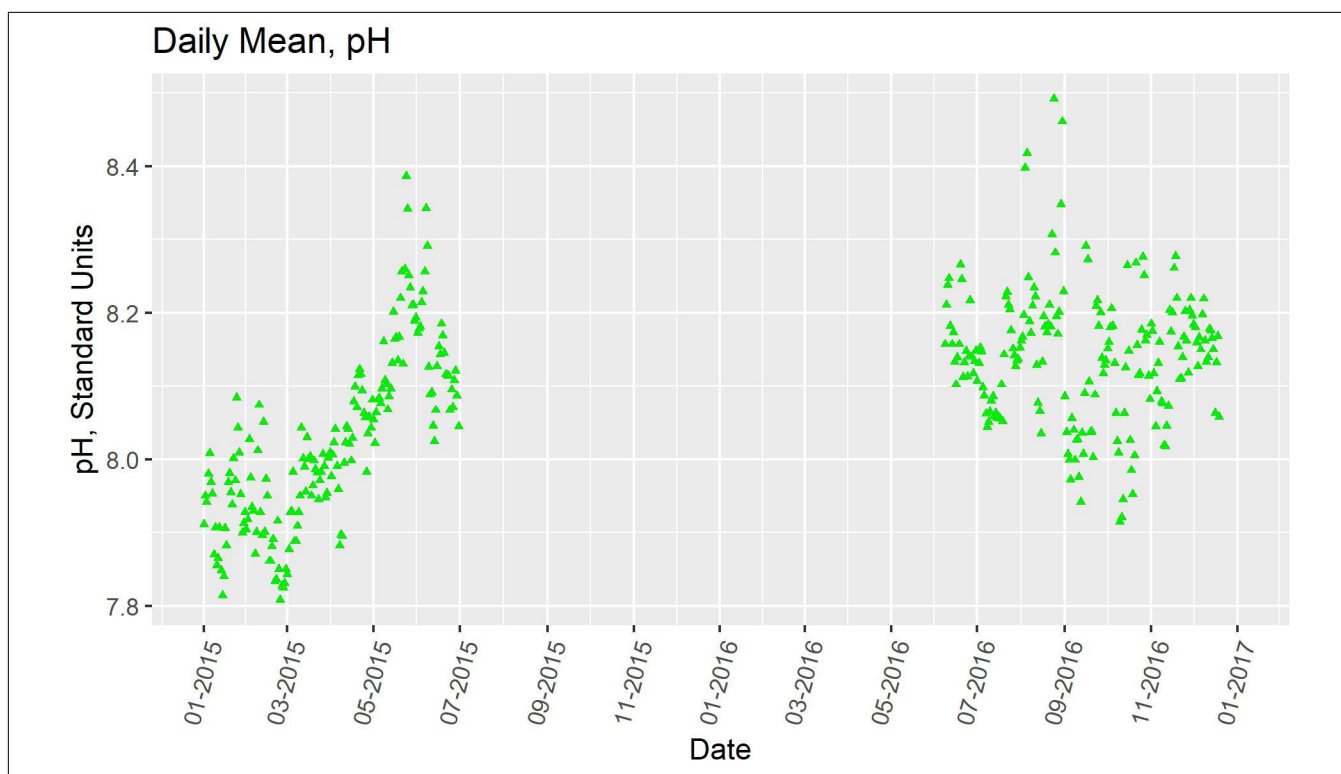


Figure 7. Mean daily values for pH at Ocracoke near Cape Hatteras National Seashore during 2015–2016. Breaks in data record indicate missing and/or flagged data.

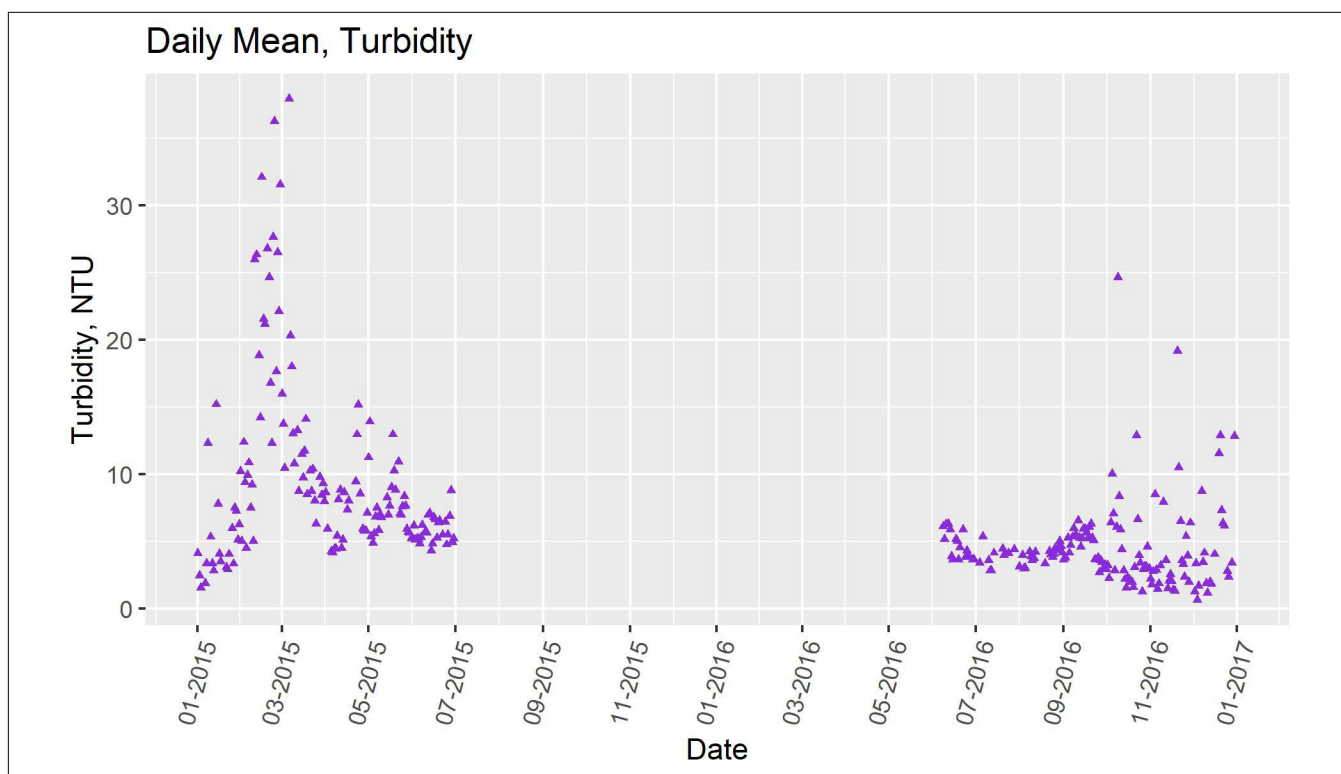


Figure 8. Mean daily values for turbidity (NTUs) at Ocracoke near Cape Hatteras National Seashore during 2015–2016. Breaks in data record indicate missing and/or flagged data.

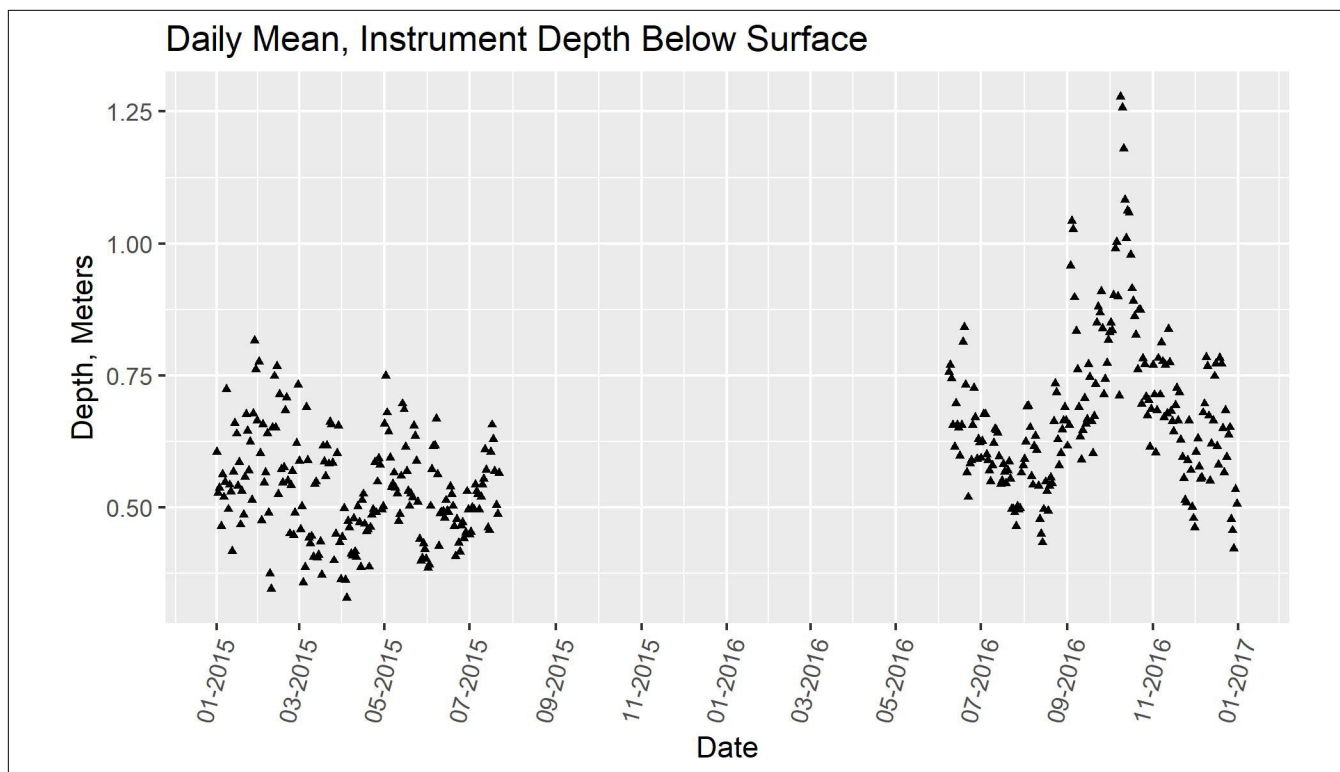


Figure 9. Mean daily values for depth at Ocracoke near Cape Hatteras National Seashore during 2015–2016. Breaks in data record indicate missing and/or flagged data.

Table 4. Monthly minimum, maximum, and mean values for parameters collected by the YSI 6-series data sonde at Cape Hatteras National Seashore during 2015–2016. Percent of values for each month indicates the number of data points collected during one calendar month of data collection / 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]. **Note:** Months with no data were not included.

Month / Expected count	Metric	Temperature (°C)	Salinity (PPT)	Dissolved Oxygen, (mg/L)	Depth (m)	pH	Turbidity (NTU)
January 2015 (Expected count 1488)	Actual Count	1487	1396	1487	1487	1487	1304
	Minimum	0.3	18	7.8	0.28	7.8	0.8
	Maximum	16.4	34.5	12.8	0.92	8.1	42.8
	Mean	8.2	22.2	10.5	0.59	7.9	5.6
	SD	3	2.8	0.9	0.1	0.07	4.6
	Percent	100%	94%	100%	100%	100%	88%
February 2015 (Expected count 1344)	Actual Count	1344	1342	1344	1344	1338	1256
	Minimum	-1.1	15.7	8.8	0.23	7.8	2.5
	Maximum	12.5	33.4	13.2	1.01	8.2	47.5
	Mean	4.8	20.8	11.4	0.58	7.9	18.2
	SD	3	3.6	1	0.1	0.08	10.7
	Percent	100%	100%	100%	100%	100%	93%
March 2015 (Expected count 1488)	Actual Count	1487	1487	1487	1487	1487	1338
	Minimum	2.4	16.2	7.5	0.22	7.8	4.2
	Maximum	16.3	33.4	12.5	0.82	8.1	45.1
	Mean	10.4	20.3	10.2	0.51	8	12.6
	SD	3.3	3.1	1.1	0.1	0.06	7.3
	Percent	100%	100%	100%	100%	100%	90%
April 2015 (Expected count 1440)	Actual Count	1439	1439	1439	1439	1439	1258
	Minimum	11.1	17.7	6.1	0.17	7.7	2.7
	Maximum	23.2	34.7	10.4	0.7	8.2	53.7
	Mean	17.8	22.2	8.1	0.47	8	7.6
	SD	2.3	3.6	0.8	0.1	0.08	4.9
	Percent	100%	100%	100%	100%	100%	87%
May 2015 (Expected count 1488)	Actual Count	1488	1488	1345	1488	1488	1331
	Minimum	13.3	17.4	6	0.32	8	3.3
	Maximum	27.9	34.2	9.5	0.86	8.5	51.6
	Mean	22.5	22.6	7.6	0.55	8.2	7.9
	SD	2.8	3.2	0.7	0.1	0.1	4.5
	Percent	100%	100%	90%	100%	100%	89%
June 2015 (Expected count 1440)	Actual Count	1440	1440	1155	1436	1440	1284
	Minimum	24.4	14.7	4.9	0.28	8	2.6
	Maximum	33.2	35.1	9.7	0.76	8.5	23.4
	Mean	27.9	22.7	6.9	0.49	8.1	6
	SD	1.8	3.7	0.8	0.1	0.08	2.6
	Percent	100%	100%	80%	100%	100%	89%

Table 4 (continued). Monthly minimum, maximum, and mean values for parameters collected by the YSI 6-series data sonde at Cape Hatteras National Seashore during 2015–2016. Percent of values for each month indicates the number of data points collected during one calendar month of data collection / 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]. **Note:** Months with no data were not included.

Month / Expected count	Metric	Temperature (°C)	Salinity (PPT)	Dissolved Oxygen, (mg/L)	Depth (m)	pH	Turbidity (NTU)
July 2015 (Expected count 1488)	Actual Count	1075	19	19	1073	24	25
	Minimum	24.6	16.3	5.7	0.32	8	4.8
	Maximum	30.9	18.3	8.4	0.75	8.1	15.6
	Mean	28.1	17	7	0.53	8	7.4
	SD	1.1	0.5	0.8	0.1	0.02	2.2
	Percent	72%	1%	1%	72%	2%	2%
June 2016 (Expected count 1440)	Actual Count	1129	1129	967	1129	1129	942
	Minimum	22.1	18.1	5.5	0.38	8	2
	Maximum	28.7	35.3	9.5	0.98	8.4	20.6
	Mean	25.9	23.7	7.2	0.67	8.2	4.8
	SD	1.3	4.1	0.7	0.1	0.08	2.3
	Percent	78%	78%	67%	78%	78%	65%
July 2016 (Expected count 1488)	Actual Count	1488	1488	1174	1483	1488	1146
	Minimum	25.6	19	4.7	0.34	7.9	1.5
	Maximum	31.1	36.3	9.6	0.83	8.3	22
	Mean	28.7	25.3	6.6	0.57	8.1	4.7
	SD	1.1	4.3	0.8	0.1	0.07	2.2
	Percent	100%	100%	79%	100%	100%	77%
August 2016 (Expected count 1488)	Actual Count	1488	1488	1161	1488	1488	1186
	Minimum	25.3	19.8	4.6	0.35	7.9	1.8
	Maximum	32.2	36.2	9.6	0.85	8.7	19.7
	Mean	28.6	25.4	6.6	0.59	8.2	4.2
	SD	1.4	4	0.8	0.1	0.14	1.7
	Percent	100%	100%	78%	100%	100%	80%
September 2016 (Expected count 1440)	Actual Count	1440	1440	1231	1440	1440	1397
	Minimum	21.6	19.2	5.2	0.46	7.8	1.4
	Maximum	30.2	34	9.7	1.25	8.5	49.8
	Mean	26.2	23.6	6.9	0.77	8.1	4.9
	SD	1.5	3	0.8	0.1	0.11	3.1
	Percent	100%	100%	85%	100%	100%	97%
October 2016 (Expected count 1488)	Actual Count	1488	1488	1396	1488	1488	1418
	Minimum	15.3	14.1	5.8	0.52	7.8	0.4
	Maximum	26.5	31.2	10.3	1.62	8.4	75.2
	Mean	20.7	20.2	8.3	0.89	8.1	4.6
	SD	2.9	4	1	0.2	0.12	5.8
	Percent	100%	100%	94%	100%	100%	95%

Table 4 (continued). Monthly minimum, maximum, and mean values for parameters collected by the YSI 6-series data sonde at Cape Hatteras National Seashore during 2015–2016. Percent of values for each month indicates the number of data points collected during one calendar month of data collection / 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]. **Note:** Months with no data were not included.

Month / Expected count	Metric	Temperature (°C)	Salinity (PPT)	Dissolved Oxygen, (mg/L)	Depth (m)	pH	Turbidity (NTU)
November 2016 (Expected count 1440)	Actual Count	1440	1440	1284	1440	1440	1311
	Minimum	7.5	14.9	7.4	0.36	7.9	0.2
	Maximum	20.6	35.1	11.4	1	8.4	31.5
	Mean	14.2	19.5	9.4	0.67	8.1	4.1
	SD	2.9	4.6	0.8	0.1	0.08	4.5
	Percent	100%	100%	89%	100%	100%	91%
December 2016 (Expected count 1488)	Actual Count	1488	1488	1404	1488	903	1311
	Minimum	3.4	16.2	7.6	0.28	8	0
	Maximum	18.3	35	12	0.97	8.3	45.9
	Mean	10.9	22.1	9.8	0.62	8.2	4.7
	SD	2.7	4.3	0.8	0.1	0.05	5
	Percent	100%	100%	94%	100%	61%	88%

Table 5. Monthly water-quality data collected at the Southeast Coast Network site near Cape Hatteras National Seashore during 2015–2016. 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). [^a Green—good; ^b yellow—fair; ^c red—poor; k—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)	Total Dissolved Phosphorus (mg/L)
01/21/2015	1.40 ^a	1.62 ^a	–	–	10.6 ^a	0.26	0.022
03/06/2015	2.80 ^c	12.91 ^b	–	–	11.8 ^a	0.33	0.024
06/07/2016	1.12 ^a	4.41 ^a	–	–	8.3 ^a	0.26	0.020
07/20/2016	1.40 ^a	6.91 ^b	–	–	7.2 ^a	0.33	0.020
08/25/2016	1.12 ^a	4.60 ^a	0.026 ^a	0.0099 ^a	6.3 ^a	0.49	0.030
9/22/2016	–	4.81 ^a	–	–	5.7 ^a	0.34	0.007
10/20/2016	–	4.26 ^a	–	–	8.7 ^a	0.36	0.013
11/13/2016	–	3.01 ^a	0.023 ^a	0.0028 ^a	9.7 ^a	0.31	0.011
12/19/2016	–	4.81 ^a	–	–	10.2 ^a	0.34	0.007

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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