Southeast Coast Network

National Park Service
Inventory and Monitoring Division

Standard Operating Procedure 2.2.08

Fixed-Station Water-Quality Data Summary Reporting Manual—Version 2.0

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Summary

The following standard operating procedure (SOP) outlines the format and general approach to developing data summary reports for data collected at fixed water-quality monitoring stations. Natural Resource Data Series (NRDS) reports are intended for the timely release of basic data sets and data summaries. These reports provide managers with the status of water-quality conditions and are not intended to synthesize multiple years of data and determine trends. In addition, this SOP may not cover all park-specific exceptions and reporting needs. Fixed-Station water quality summary reports for each park, published after 2016, serve as the template to generate subsequent reports. See NPS Integrated Resource Management Applications Portal to search for the latest SECN fixed-station data summary reports.

Revision Log

Revision Date	Author	Changes Made	Reason for Change	New Version #
1/17/2013		Citation updated and clarifications made	Protocol publication and clarifications based on publication of 2011 data reports	1.0
09/27/2021	E. N. Starkey	Citation and procedures updated. Title changed for consistency with other SOPs. Procedures updated to reflect the latest NRDS template and SECN report preparation procedures.	Changes to data export and report preparation since original publication.	2.0

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Fixed-Station Activities and Workflow Summary

An overview of fixed-station activities and workflow are presented in Figure 1. SOPs are presented left to right in the general order of operations for each activity. This SOP (2.2.08) pertains to fixed-station data reporting and is part of the Data Processing and QA/QC activity.

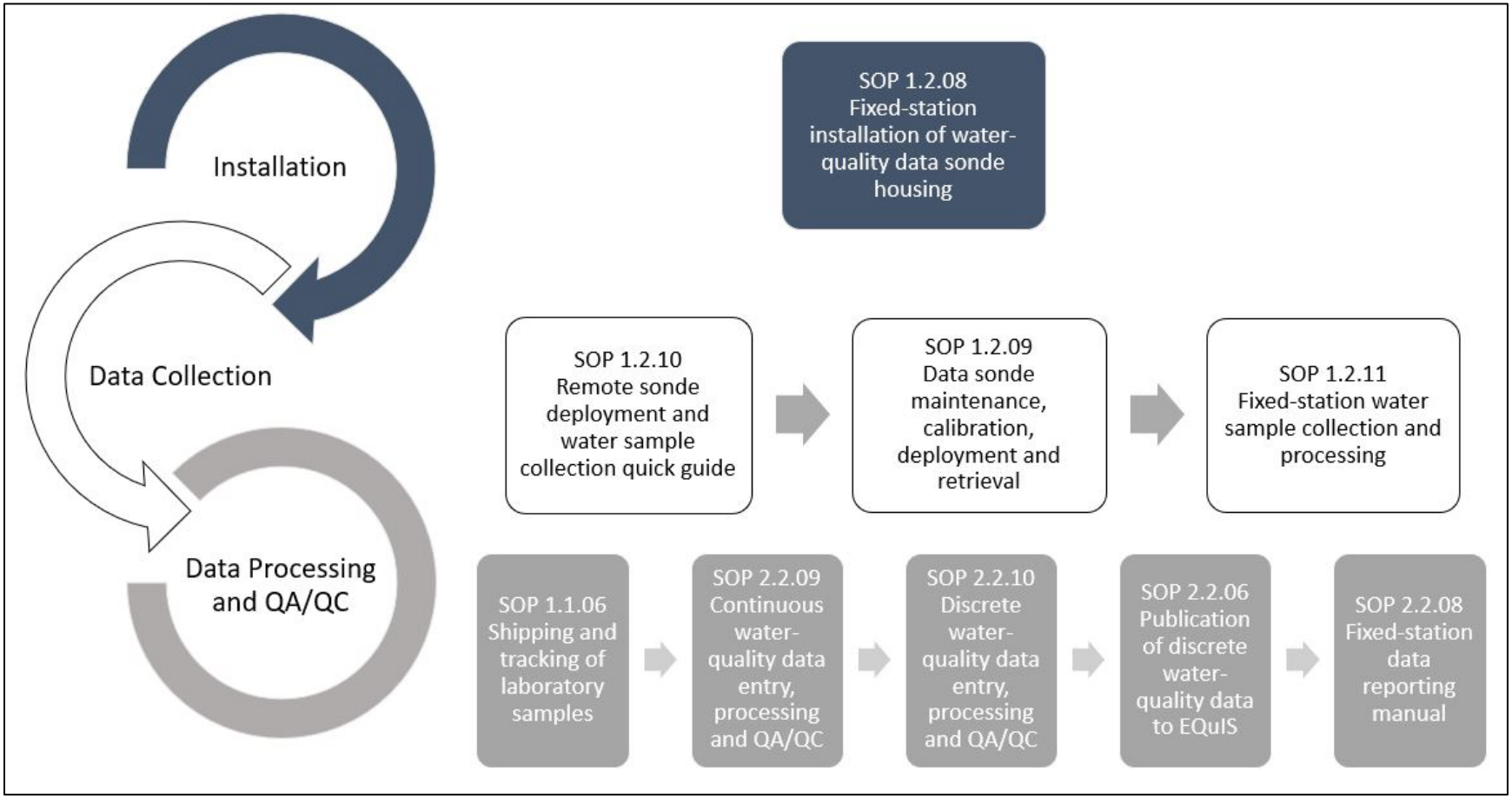

Figure 1. Fixed-station activities and workflow. SOPs are presented left to right in the general order of operations for each activity.

Required Access and Software

- Access to NPS Network.
- Access to the NPS Power BI Report Server – Estuarine Water-quality Reports (Estuarine Water Quality - Power BI Report Server). For access contact SECN Data Manager Wendy Wright (wendy_wright@nps.gov).
- Access to Aquatic Informatics' Aquarius Time Series NG v2020.1 or newer on the NRSS server. For access contact the NPS Aquarius system administrator Dean Tucker (dean_tucker@nps.gov). See https://doimspp.sharepoint.com/sites/nps-nrss-wrd/data/Aquarius%20NG%20Documents/00_Getting_Started_Aquarius.docx for more information.
- Aquarius Time Series Client Software. See https://doimspp.sharepoint.com/sites/nps-nrss-wrd/data/Aquarius%20NG%20Documents/00_Getting_Started_Aquarius.docx for more information.
- Microsoft Excel
- Microsoft Word
- ArcGIS 10.7 or above, with existing map templates for the park-wide assessment
- R and R Studio

Overview

This standard operating procedure (SOP) outlines the format and general approach to developing data summary reports for discrete and continuous data collected at fixed water-quality monitoring stations. Natural Resource Data Series (NRDS) reports are intended for the timely release of basic data sets and data summaries. These reports provide managers with the status of water-quality conditions and are not intended to synthesize multiple years of data and present trends. The instructions herein are presented as an example, but because implementation of the fixed-station component may differ among parks, report authors will use reports published after 2016 as park-specific templates when generating new reports. See NPS Integrated Resource Management Applications Portal to search for the latest SECN fixed-station data summary reports.

Prior to reporting, all data will have cleared the quality assurance and quality control procedures outlined in SOP 2.2.09 *Fixed-Station Continuous Water-Quality Data Entry, Processing, and QA/QC* (Starkey and McCay 2022a) and SOP 2.2.10 *Fixed-Station Discrete Water-Quality Data Entry, Processing, and QA/QC* (Starkey and McCay 2022b; Figure 1). If, during report preparation, a data error is discovered, the SECN aquatic ecologist must work with the SECN data manager to rectify the issue within the SECN data system. All corrections will be applied prior to report publication and release.

Report Authorship

Report authorship will follow guidelines published in the Southeast Coast Network's SOP 2.1.03 *Southeast Coast Network Authorship Guidelines*—Version 3.0 (SECN 2019).

How to Submit Reports to Editing

Prior to preparing reports, the lead author will meet with the regional editor and discuss the preferred format for submission. As of the writing of this SOP, the acting editor prefers that the following be submitted for each report.

- Text in a Microsoft Word Normal Template document, with defined headers (e.g., Heading 1, Heading 2, etc.), and placeholders indicating where each table and figure should be located.
- Tables are submitted in a single Microsoft Excel file.
- Figures are labeled (e.g., Figure1_Sunset-over-MosquitoLagoon, Figure2_DailyMeanDO, etc.) and submitted in a single folder for the report.

Data Summary Report Outline

Data summary reports will include the following major sections, figures, and tables. **The example reports in Appendix A and reports published on IRMA after 2016 should serve as templates for future reports.**

Major Sections

- Summary and Key Findings
- Introduction
- Study Area
- Weather and Hydrologic Setting
- Methods
    - Sampling Location
    - Continuous Data
    - Discrete Data
    - Assessment Criteria
- Results
    - Continuous Data
    - Discrete Data

- Literature Cited

List of Figures and Tables

Specifics for each figure and table are discussed below. Note that *PARK*, *MONTH*, *YEAR,* and *STATION NAME, STATION ID* change for each report.

Figures

- Figure 1. Location of continuous water-quality monitoring station at PARK (STATION ID).
- Figure 2. Daily precipitation at STATION NAME, weather and climate station (COOP #####), near PARK MONTH, DAY, YEAR–MONTH, DAY, YEAR.
- Figure 3. Air temperature and precipitation departure from 30-year mean (YEAR–YEAR) at STATION NAME weather and climate station (COOP #####) MONTH, DAY, YEAR–MONTH, DAY, YEAR.
- Figure 4. Continuous data collection station photo (STATION ID).
- Figure 5. Mean daily water temperature at STATION NAME at PARK during YEAR-YEAR.
- Figure 6. Monthly box plot of water temperature at the STATION NAME at PARK during YEAR-YEAR
- Figure 7. Mean daily values for salinity at STATION NAME at PARK during YEAR-YEAR.
- Figure 8. Monthly box plot of salinity at STATION NAME at PARK during YEAR-YEAR
- Figure 9. Mean daily values for dissolved oxygen at STATION NAME at PARK during YEAR-YEAR.
- Figure 10. Monthly box plot of dissolved oxygen at STATION NAME at PARK during YEAR-YEAR
- Figure 11. Mean daily values for pH at STATION NAME at PARK during YEAR-YEAR.
- Figure 12. Monthly box plot of pH at STATION NAME at PARK during YEAR-YEAR.
- Figure 13. Mean daily values for turbidity (FNU) at STATION NAME at PARK during YEAR-YEAR.
- Figure 14. Monthly box plot of turbidity (FNU) at STATION NAME at PARK during YEAR-YEAR
- Figure 15. Mean daily values for depth at STATION NAME at PARK during YEAR-YEAR.
- Figure 16. Monthly box plot of depth at STATION NAME at PARK during YEAR-YEAR.

Tables

- Table 1. Location of continuous water-quality monitoring stations at PARK, YEAR-YEAR *(period of performance)*.
- Table 2. Performance specifications of YSI EXO2 datasondes deployed at the continuous monitoring site.
- Table 3. Coastal water-quality monitoring condition criteria for water-quality parameters collected by the Southeast Coast Network based on thresholds set by EPA.
- Table 4. Monthly minimum, maximum, and mean values for parameters collected at PARK during YEAR-YEAR.
- Table 5. Monthly water-quality data collected at PARK during YEAR-YEAR.

Data Export from SECN Water-Quality Monitoring Database

Access the NPS Power BI Report Server (Figure 2) – Estuarine Water-quality Reports (Estuarine Water Quality - Power BI Report Server). Run the following reports and export them to Word for subsequent formatting and inclusion in the data summary report.

1. Fixed_NutrientOutputForAnnualReporting (becomes report table 5)
    a. Calculations for dissolved inorganic nitrogen (DIN) and water clarity are done when the report is generated. Dissolved Inorganic Phosphorus is equivalent to PO4.
        i. DIN = NO23+NH_4
        ii. Water clarity is estimated at each station using a Secchi disk to determine light extinction depths, which are then converted to light attenuation coefficients (k) using the equation: k = c / Secchi depth (in meters), where "c" is a constant that corresponds to the water body's naturally occurring clarity conditions (Turbidity class). The value of c = 1.0 for naturally turbid conditions, c = 1.4 for normal turbidity conditions, or c = 1.7 for waters supporting submerged aquatic vegetation (SAV) restoration (Smith et al. 2006, EPA 2016). The terminology used by the EPA (2016) and Smith et al. (2006) differ, yet the constants and ratings are the same. **Water clarity criteria are park dependent (Table 1). This SOP's (2.2.08) Table 1 is useful to crosswalk the terminology and criteria to be used in each park.**

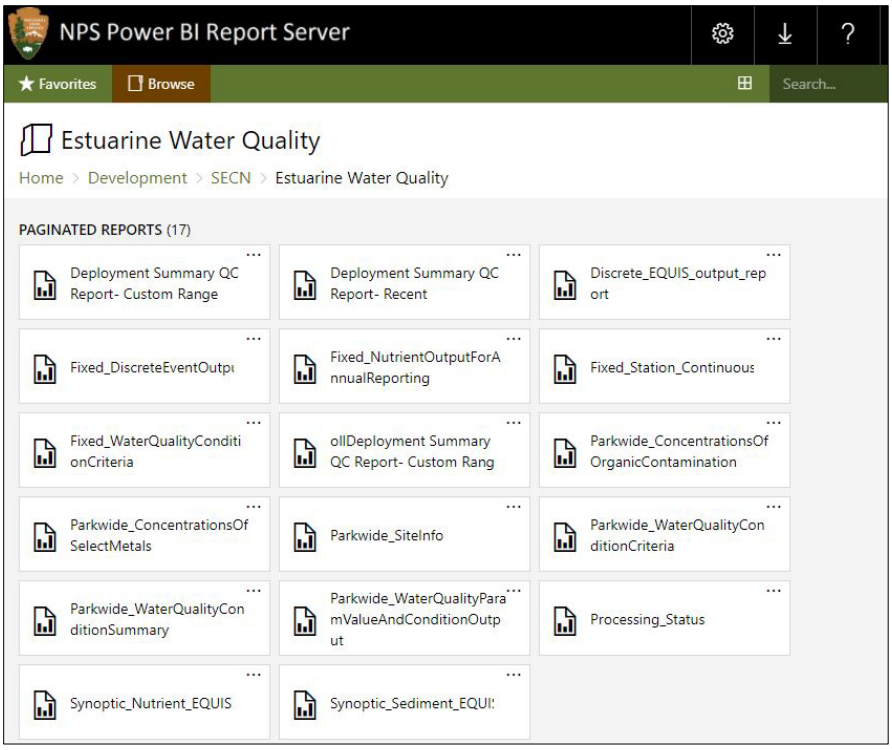

Figure 2. NPS Power BI Report Server – Estuarine Water-quality Reports.

Table 1. Turbidity classes, constants and light attenuation coefficients used to evaluate water clarity in each park (modified from Smith et al. [2006] and EPA [2016]). SAV—sub-aquatic vegetation.

Parks[1]	Turbidity Class from EPA 2016	Turbidity Class from Smith et al. 2006	Constant ©	Light attenuation coefficients (*k*) for a rating of "Good"	Light attenuation coefficients (*k*) for a rating of "Fair"	Light attenuation coefficients (*k*) for a rating of "Poor"
CUIS, FOPU	Naturally Turbid	High	1.0	< 2.30	2.30-2.99	> 2.99
CAHA, CALO, FOMA, TIMU	Normal Turbidity	Moderate	1.4	< 1.61	1.61-2.30	> 2.30
CANA	SAV Restoration	Low	1.7	< 0.92	0.92-1.61	> 1.61

[1] Parks in each turbidity class were confirmed by the EPA in 2018, see also EPA 2016.

Data Download from Aquarius Time-Series using R

This section outlines how to download the time-series data that will be used to generate the daily mean graphs and box plots for report figures 5–16.

- Connect to the DOI network.
- Ensure that you have access to Aquarius Time-Series NG. For access contact the NPS Aquarius system administrator Dean Tucker (dean_tucker@nps.gov).
- Install R and Rstudio.
- Ensure that timeseries_client.R is in your working directory.
- Open the R-script "Data Extraction from Aquarius" (Appendix B).
    - Modify station name and dates as needed.
    - Run the script.
- Check that both the instantaneous and daily data have been downloaded for each parameter.

Data Download for Weather and Hydrologic Setting

This section outlines how to download the precipitation data used to make report figure 2 and how to create the temperature departure from mean graph for report figure 3. Both are done via the Climate Analyzer site Southeast Coast National Parks (climateanalyzer.us). The original data for all tables and graphs are the National Weather Service Cooperative Observer Program (COOP) stations and Remote Automated Weather Stations (RAWS).

Precipitation data

- Use a web browser to navigate to http://www.climateanalyzer.us/secn or select the station-specific links below.
    - CAHAocbr01 Manteo Dare Co AP (climateanalyzer.us)
    - CALOmidm02 Morehead City 2 WNW (climateanalyzer.us)
    - CALOshak01 Morehead City 2 WNW (climateanalyzer.us)
    - CANAvctr01 Titusville (climateanalyzer.us)
    - CONGbann01 Congaree (climateanalyzer.us)
    - CONGccbr01 Congaree (climateanalyzer.us)
    - CUISseac03 Brunswick Malcolm McKinnon Airport (climateanalyzer.us)
    - FOMAvctr01 Federal Point (climateanalyzer.us)
    - FOPUlazz01 Savannah International Airport (climateanalyzer.us)
    - TIMUking01 Jacksonville Beach (climateanalyzer.us)

- Select the COOP or RAWS weather station that corresponds to the SECN water-quality monitoring station of interest and navigate to the "daily table."
- Select the start and end year. This corresponds to the years to be covered by the report (e.g., 2017–2019).
- A table of precipitation, temperature max, temperature min, and snow depth will appear in the browser. Click on the link at the top of the screen "Click Here To Download This Table As A Spreadsheet."
- Save the .csv file locally (preferably to the R working directory for the report).

Departure from 30-year mean

- Use a web browser to navigate to http://www.climateanalyzer.us/secn or select the weather station specific links below. *Note that as of the writing of this SOP several sites have a period of record less than 30 years. For these locations, links to alternate stations have been provided.
    - CAHAocbr01 — Manteo Dare Co AP (climateanalyzer.us)
    - CALOmidm02 — Morehead City 2 WNW (climateanalyzer.us)
    - CALOshak01 — Morehead City 2 WNW (climateanalyzer.us)
    - CANAvctr01 — Titusville (climateanalyzer.us) *
      Daytona Beach International Airport (climateanalyzer.us)
    - CONGbann01 — Congaree (climateanalyzer.us) *
      Columbia Metro Airport (climateanalyzer.us)
    - CONGccbr01 — Congaree (climateanalyzer.us) *
      Columbia Metro Airport (climateanalyzer.us)
    - CUISseac03 — Brunswick Malcolm McKinnon Airport (climateanalyzer.us)
    - FOMAvctr01 — Federal Point (climateanalyzer.us)
    - FOPUlazz01 — Savannah International Airport (climateanalyzer.us)
    - TIMUking01 — Jacksonville Beach (climateanalyzer.us)
- Select the COOP or RAWS weather station that corresponds to the SECN water-quality monitoring station of interest and navigate to "Graphs," "Departures from 30 year avgs.," "One calendar year" OR "Any start/end dates and show all months in those years."

- Select the start and end year and the desired 30-year range for comparison (e.g., 1981–2010).
- The departure from 30-year average graph will appear. Use the links above the graph to save a copy (the .png format is preferred for reports).

Create Figures

All daily mean graphs and monthly box plots are created using R and the R-Scripts in Appendix B. Instantaneous data for each parameter (.csv) and the downloaded precipitation data must be in the working directory for the R-script to work (Figure 3). After running the script, the graphs will also appear in the working directory (Figure 3).

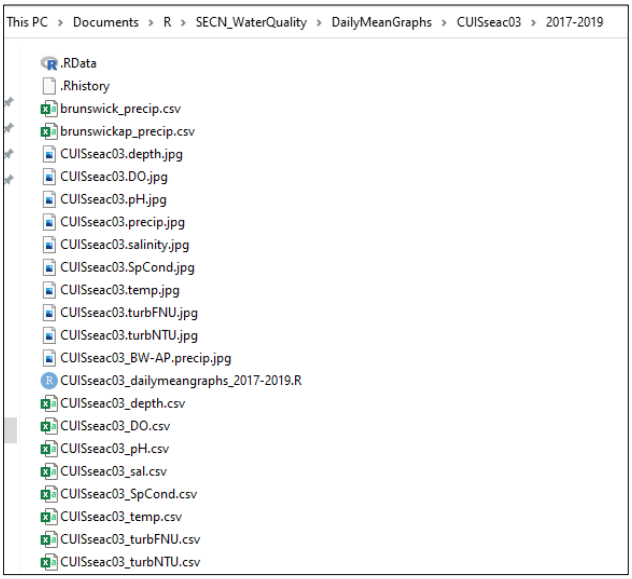

Figure 3. Screenshot of the working directory for generation of daily mean graphs for the 2017–2019 CUISseac03 fixed station report.

Daily Mean Graphs

- Open the "Daily Means Graphs" R-script (Appendix B).
- Set the working directory.
- Modify script for the desired monitoring station and dates of interest.
- Keep the data threshold (data.thresh) set to 80. This will only compute daily means for days with greater than 80% data coverage.
- Turn on/off smoothed lines as appropriate.
- Run the script. Note that the last 30 lines of the script are used to create the precipitation graph (see the next section).

- Double check the working directory to ensure each parameter has a daily mean graph.

Precipitation Graph

- Open the "Daily Means Graphs" R-script (Appendix B).
- Set the working directory.
- Scroll to the last 30 lines of the script ## Daily Precip Graph ##
- After modifying the input file (.csv), date range, and export file name, run the last 30 lines of code.
- Double check the working directory to ensure that a precipitation graph has been created.

Box Plots

- Open the "Box Plots" R-script (Appendix B).
- Set the working directory.
- After modifying the input file (.csv), date range, and export file names, run the code.
- Double check the working directory to ensure that all box plots have been created.

Create Mean, Maximum, Minimum Table

- Open the monthly "mean, maximum and minimum table" R-script (Appendix B).
- Set the working directory.
- Ensure that the 30.minute.expected.counts.csv or 15.minute.expected.counts.csv file is in the working directory. This file contains the number of expected data points for each month of the year (i.e., Table 2).
- Modify the input file (.csv), date range, and output file names.
- Note that the R-script contains a section to compute the daily statistics (# commented out) but for the mean, maximum, and minimum table only use the section to compute monthly statistics.
- Run the code and double check the working directory to ensure that a minimum, maximum, mean .csv has been created (Figure 4).
- The resulting .csv table will be pasted into MS Word for final formatting. This will become report Table 4.

Table 2. Expected number of water quality observations for each parameter each month for 30-minute and 15-minute data.

Month	Number of Days	Number of Expected WQ Observations Non-Leap (30 min)	Number of Expected WQ Observations Non-Leap (15 min)	Number of Expected WQ Observations Leap (30 min)	Number of Expected WQ Observations Leap (15 min)
1	31	1488	2976	1488	2976
2[a]	28	1344	2688	1392	2784
3	31	1488	2976	1488	2976
4	30	1440	2880	1440	2880
5	31	1488	2976	1488	2976
6	30	1440	2880	1440	2880
7	31	1488	2976	1488	2976
8	31	1488	2976	1488	2976
9	30	1440	2880	1440	2880
10	31	1488	2976	1488	2976
11	30	1440	2880	1440	2880
12	31	1488	2976	1488	2976

[a]29 days if leap year (2020, 2024, 2028, 2032, 2036, 2040, 2044)

	A	B	C	D	E	F	G	H	I
1		Temperatu	Salinity, PS	Specific Co	Dissolved (	Depth, m	pH	Turbidity, FNU	
2	Month	January	January	January	January	January	January	January	
3	Year	2017	2017	2017	2017	2017	2017	2017	
4	Minimum	10.9	28.6	44.4	5.2	1.7	7.6	Inf	
5	Maximum	18.9	33.9	51.6	8.5	4.8	8.2	NA	
6	Mean	15.7	30.6	47.2	7.3	3.2	7.9	NA	
7	Standard D	1.7	0.9	1.2	0.5	0.7	0.1	NA	
8	Expected (	2976	2976	2976	2976	2976	2976	2976	
9	Actual Cou	2975	2970	2970	2972	2975	2975	0	
10	Percent Co	100	100	100	100	100	100	0	
11	Month	February	February	February	February	February	February	February	
12	Year	2017	2017	2017	2017	2017	2017	2017	
13	Minimum	13.5	27	42.1	5	1.7	7.4	Inf	
14	Maximum	21.5	34.2	52	8.4	4.5	8	NA	
15	Mean	17.1	29.9	46.1	7.1	3.2	7.8	NA	
16	Standard D	1.4	1.4	1.9	0.5	0.7	0.1	NA	
17	Expected (	2688	2688	2688	2688	2688	2688	2688	
18	Actual Cou	2688	2684	2684	2681	2688	2688	0	
19	Percent Co	100	100	100	100	100	100	0	

Figure 4. Screen shot of the mean, maximum, minimum .csv file in Microsoft Excel.

Main Report Figures

Open the park specific report template (i.e., reports published after 2016) and update the figures. Note the figure numbers shown in the SOP may not match the templates because some parks have chlorophyll and blue green algae data from sensors, while others do not.

Prior to publication of any map ensure that:

- The park boundary is still current and accurate.
- All coverages are the most current available (e.g., 303(d), urban areas, special use areas)
- New maps created in Arc GIS have been saved as CMYK PDF or .jpeg format and are 6.5 inches (16.5 centimeters) wide (no taller than 8 inches [20.3 centimters]) and 600 dpi for portrait maps, and 8.5 inches (21.6 centimeters) wide (no taller than 6 inches [15.2 centimeters]) and 600 dpi for landscape.

Figure 1 Location Map of Park

See the example template on the SECN GIS drive: CUIS_SigWaters_20201106_CSC.mxd. Report figure 1 shows: park boundaries, SECN and collaborator fixed water-quality monitoring stations, salt marsh, impaired waters (i.e., 303d), urban areas, and important miscellaneous features such as restricted areas and pole/troll zones (Figure 5). Saltmarsh areas are determined using data from the United States Fish and Wildlife Service (e.g., FWS 2022). Urbanized areas are determined using data from the United States Census Bureau (e.g., USCB 2020), and impaired 303(d) listed waters are determined using data from the United States Environmental Protection Agency (e.g., EPA 2022).

Figure 2 Daily Precipitation

Report figure 2 shows the daily mean precipitation over the reporting period (Figure 6). The figure is the result of data compiled from COOP or RAWS stations. Procedures for creating the graph are outlined above.

Figure 3 Departure from 30-year Mean

This figure shows the air temperature and precipitation departure from the 30-year mean (Figure 7). The figure is the result of data compiled from COOP or RAWS stations. Procedures for creating the graph are outlined above. Note that on occasion, due to period of record, the station used for this graph may differ from the one used for daily precipitation. Mention any discrepancies in the figure caption and explanatory text.

Figure 4 Monitoring Station Photo

This figure is a picture of the SECN monitoring station and includes the sonde tube and structure that it is affixed to. The photo shows enough of the site so that new park and SECN staff can find the station in the field (Figure 8).

Figures 5, 7, 9, 11, 13, 15 Mean Daily Values for Parameters

These figures depict the daily means for each parameter over the entire data collection period (Figures 9–14). Each daily mean plot may include a smoothed line generated using a generalized

additive model (GAM) and 95% confidence interval to highlight patterns in the data. Daily mean dissolved oxygen will include dashed lines that indicate the thresholds for good (above 5 mg/L), fair (2–5 mg/L), and poor (less than 2 mg/L) criteria.

Figures 6, 8, 10, 12, 14, 16 Monthly Box Plots for Parameters

These figures depict the monthly distribution of data for each parameter for the entire data collection period (Figures 15–20). For multi-year reports, the boxes will be color coded by year.

Figure 5. Example report figure 1. Location of continuous water-quality monitoring station at Cumberland Island National Seashore Sea Camp dock (CUISseac03).

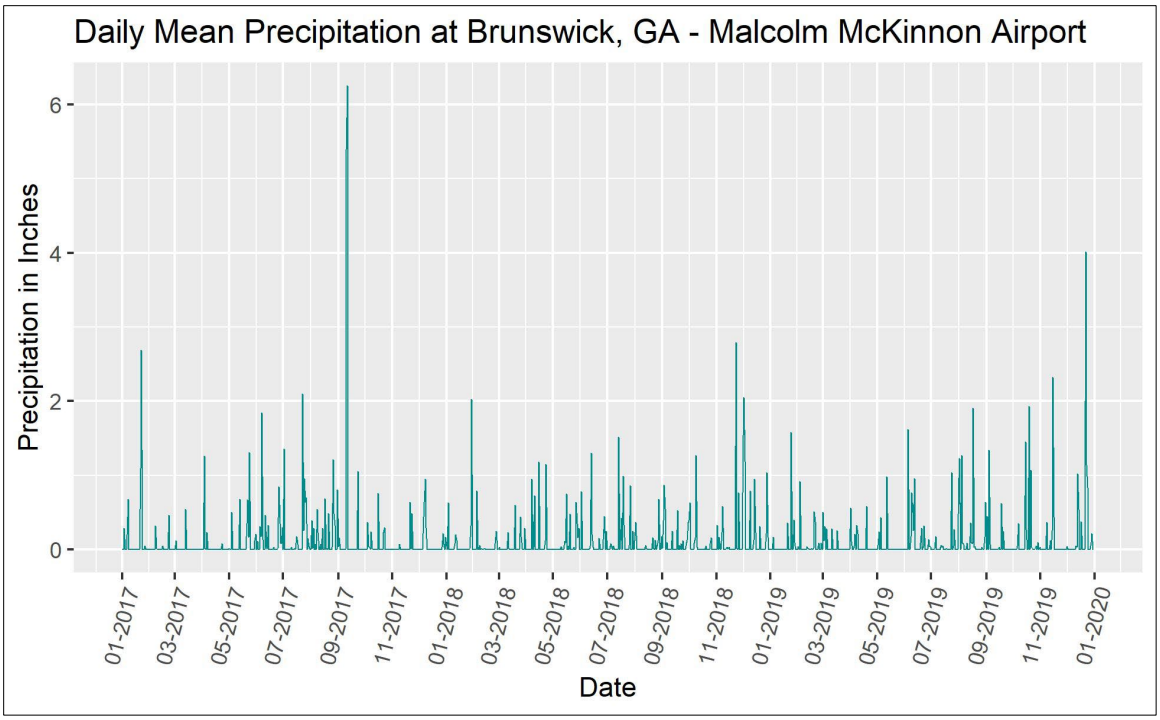

Figure 6. Example report figure 2. Daily precipitation at Brunswick, Georgia, weather and climate station (COOP #91340), near Cumberland Island National Seashore January 1, 2017–December 31, 2019.

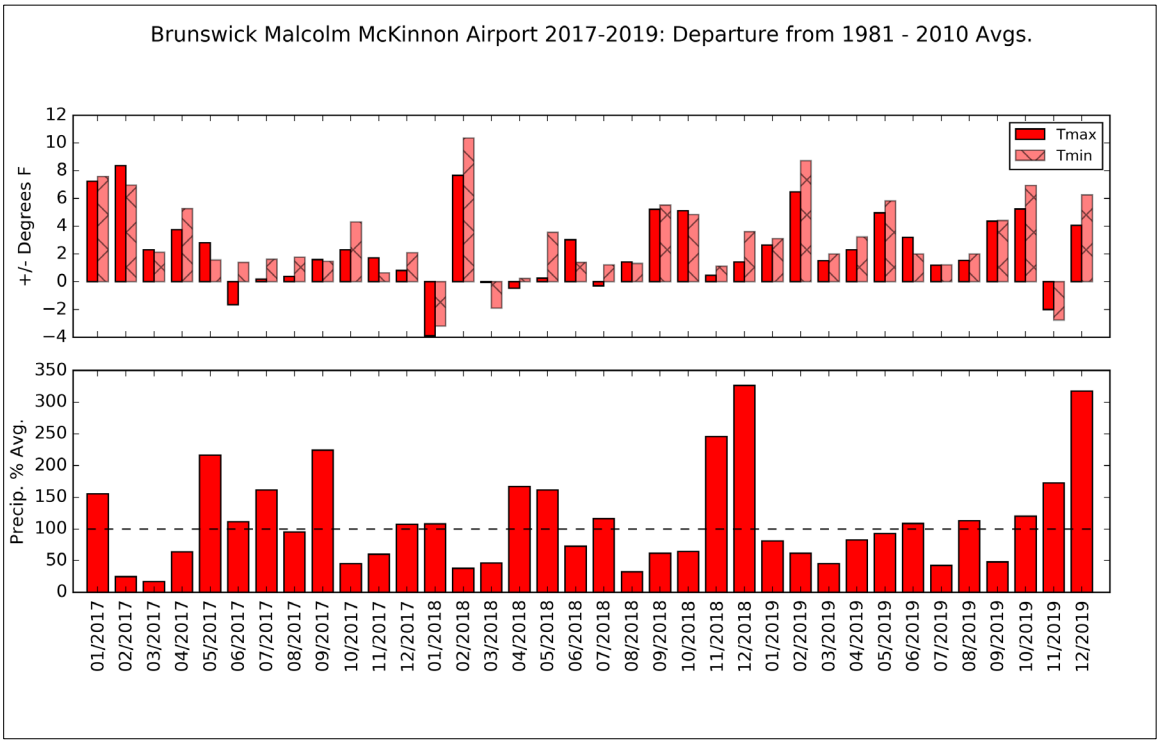

Figure 7. Example report figure 3. Air temperature and precipitation departure from 30-year mean (1981–2010) at Brunswick Malcolm McKinnon Airport weather and climate station (COOP #91340) for January 1, 2017–December 31, 2019.

Figure 8. Example report figure 4. Continuous water-quality monitoring station on Sea Camp dock at Cumberland Island National Seashore.

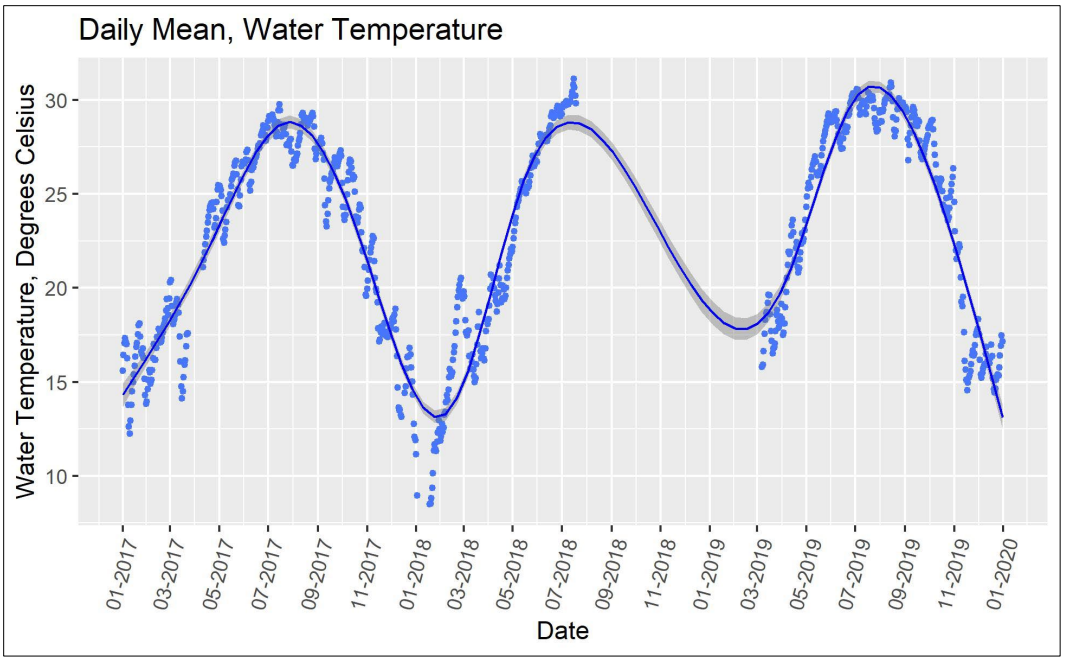

Figure 9. Example report figure 5. Mean daily water temperature at the Sea Camp dock site at Cumberland Island National Seashore during 2017–2019. The solid line represents data smoothed using a generalized additive model (GAM). Shading indicates the 95% confidence interval. Breaks in data record indicate missing or screened data.

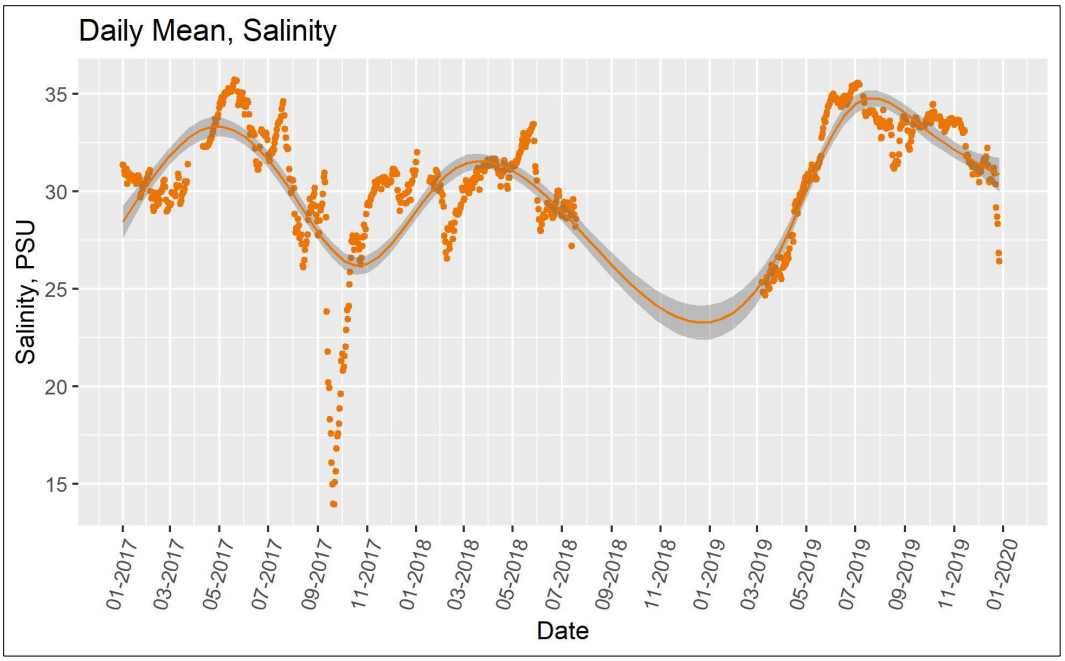

Figure 10. Example report figure 7. Mean daily values for salinity at the Sea Camp dock site at Cumberland Island National Seashore during 2017–2019. The solid line represents data smoothed using a generalized additive model (GAM). Shading indicates the 95% confidence interval. Breaks in data record indicate missing or screened data.

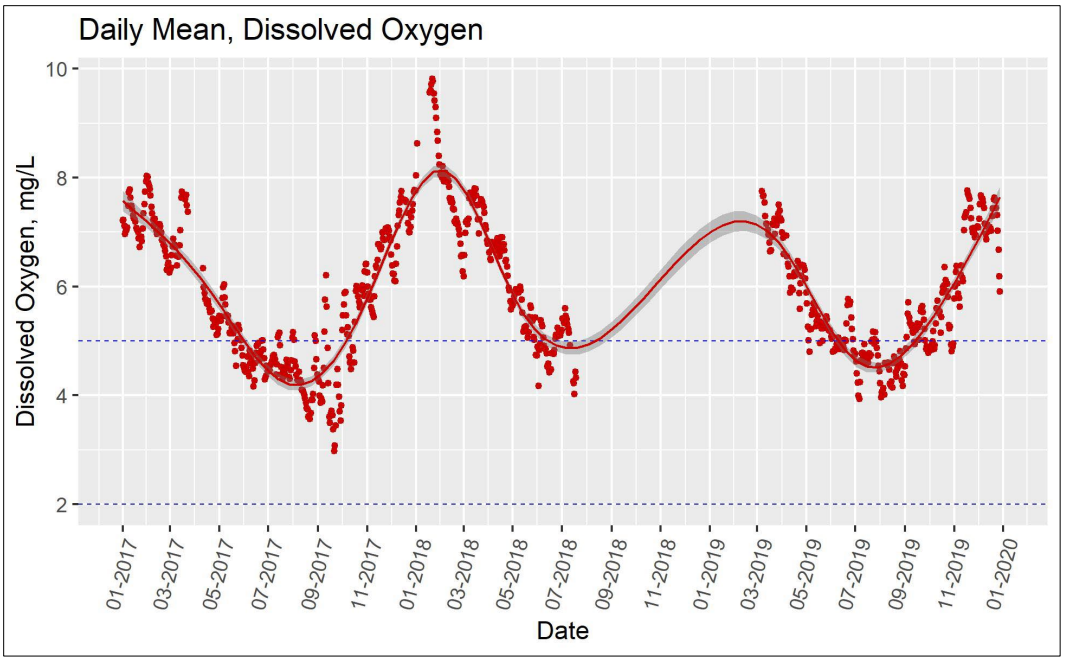

Figure 11. Example report figure 9. Mean daily values for dissolved oxygen at the Sea Camp dock site at Cumberland Island National Seashore during 2017–2019. The solid line represents data smoothed using a generalized additive model (GAM). Shading indicates the 95% confidence interval. Breaks in data record indicate missing or screened data. Dashed lines indicate thresholds for good (above 5 mg/L), fair (2–5 mg/L), and poor (less than 2 mg/L) criteria.

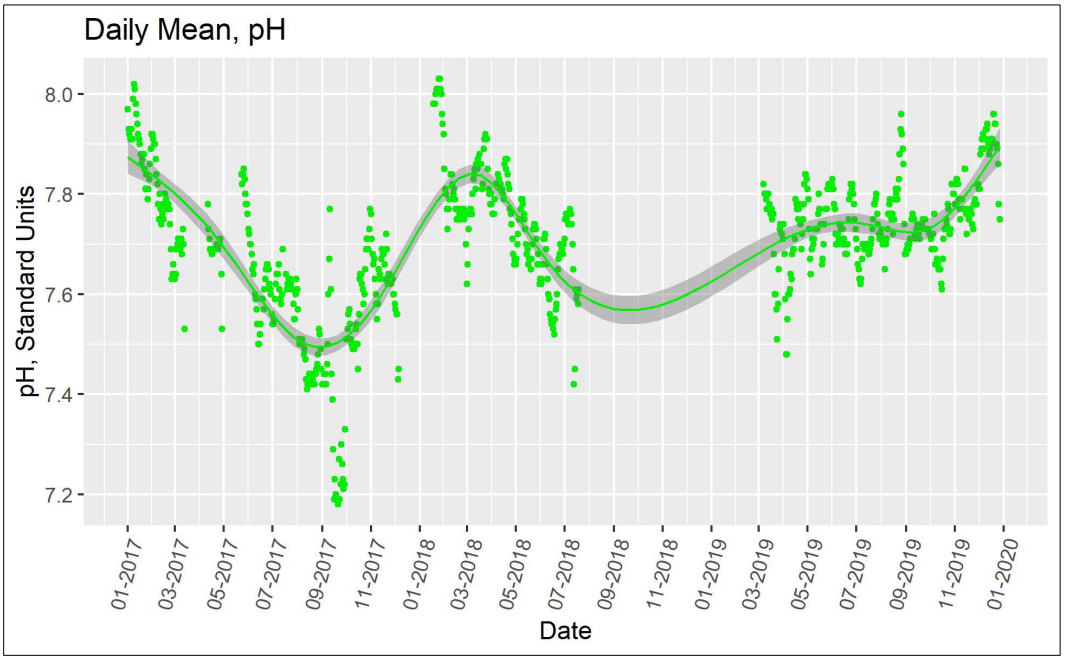

Figure 12. Example report figure 11. Mean daily values for pH at the Sea Camp dock site at Cumberland Island National Seashore during 2017– 2019. The solid line represents data smoothed using a generalized additive model (GAM). Shading indicates the 95% confidence interval. Breaks in data record indicate missing or screened data.

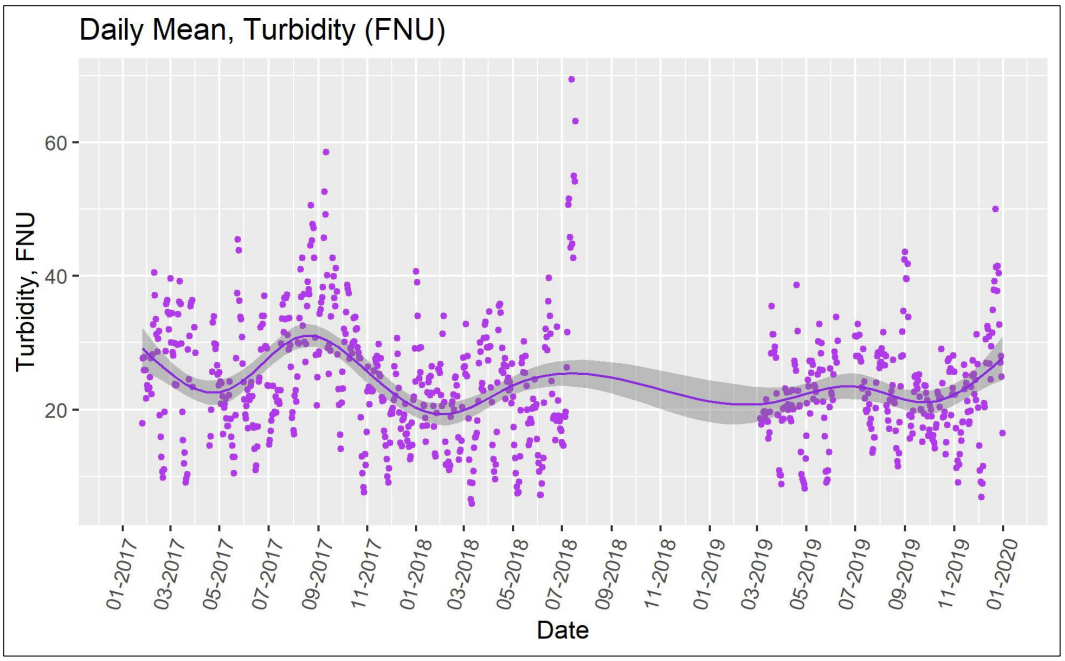

Figure 13. Example report figure 13. Mean daily values for turbidity (formazin nephelometric unit [FNU]) at the Lazaretto Creek site at Fort Pulaski National Monument during January 2018–December 2019. The solid line represents data smoothed using a generalized additive model (GAM). Shading indicates the 95% confidence interval. Breaks in data record indicate missing or screened data.

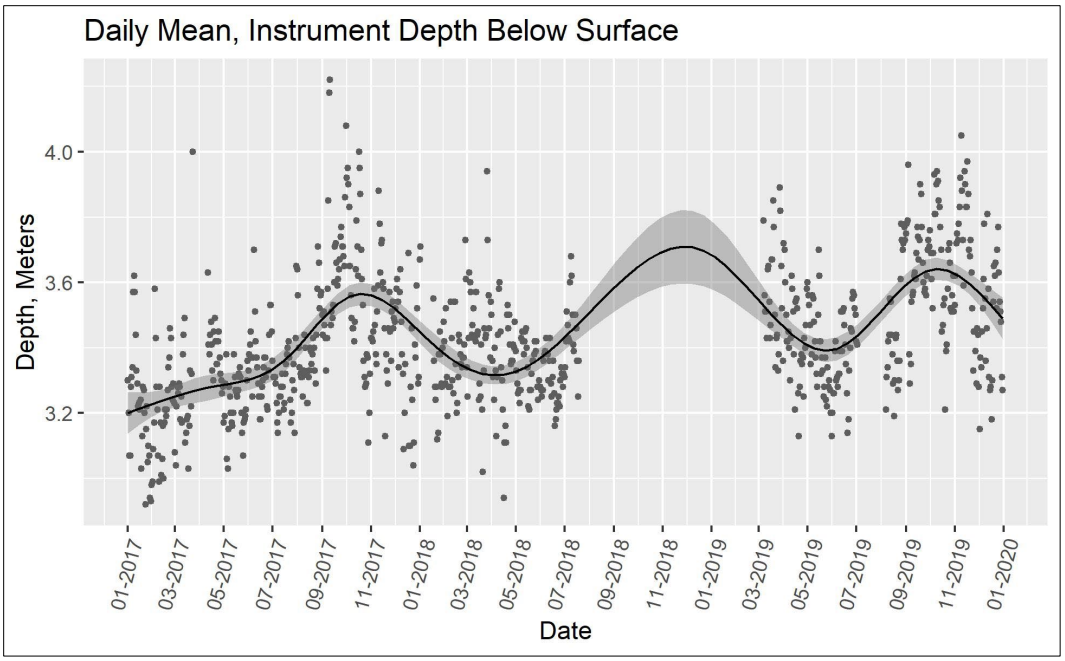

Figure 14. Example report figure 15. Mean daily values for depth at the Sea Camp dock site at Cumberland Island National Seashore during 2017–2019. The solid line represents data smoothed using a generalized additive model (GAM). Shading indicates the 95% confidence interval. Breaks in data record indicate missing or screened data.

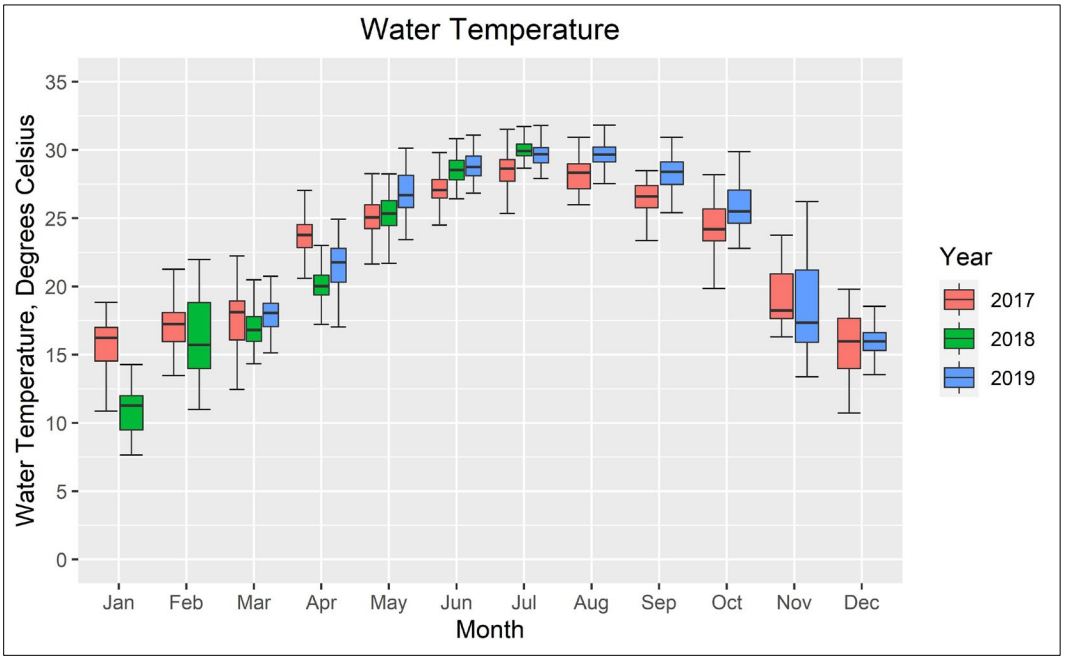

Figure 15. Example report figure 6. Monthly box plot of water temperature at the Sea Camp dock site at Cumberland Island National Seashore, 2017–2019. Missing monthly boxes indicate missing or screened data.

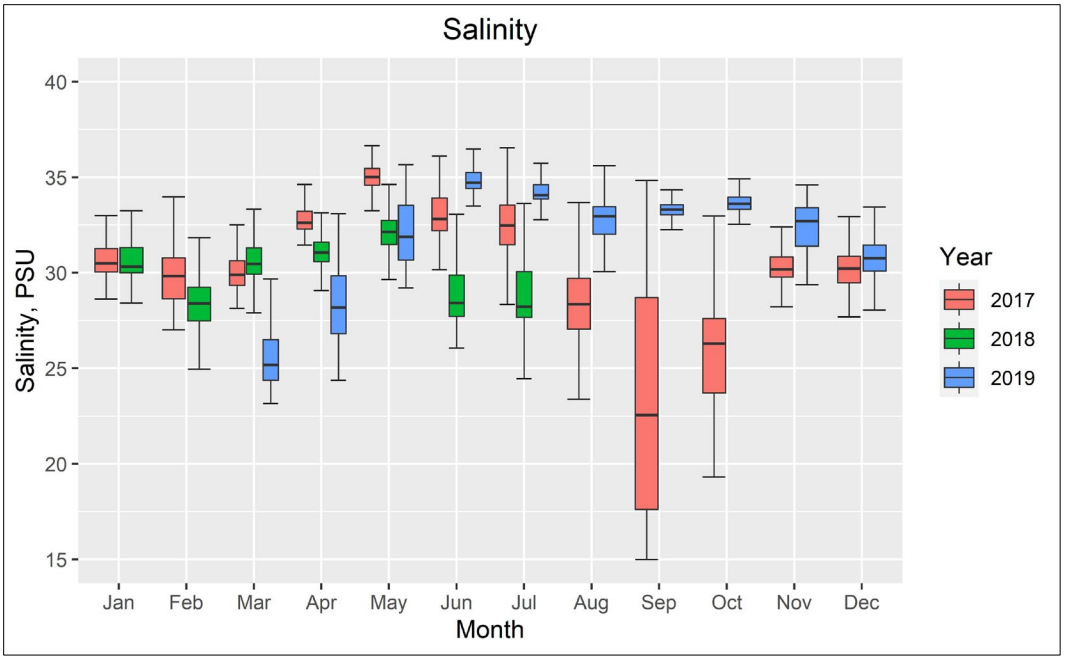

Figure 16. Example report figure 8. Monthly box plot of salinity at the Sea Camp dock site at Cumberland Island National Seashore, 2017–2019. Missing monthly boxes indicate missing or screened data. Note that Hurricane Irma occurred in September 2017.

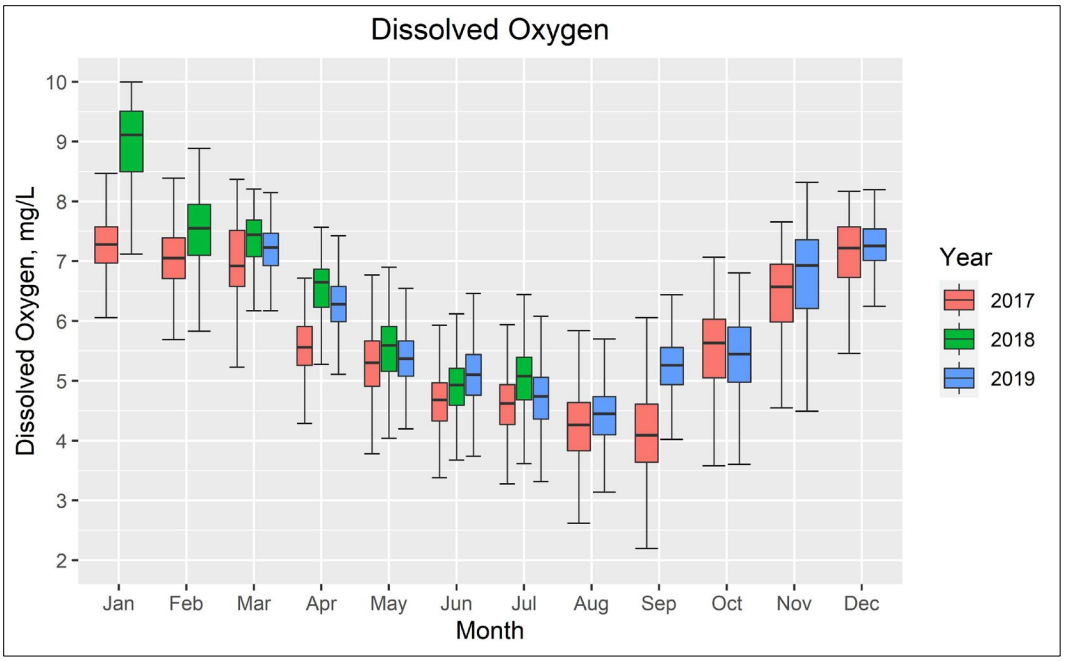

Figure 17. Example report figure 10. Monthly box plot of dissolved oxygen at the Sea Camp dock site at Cumberland Island National Seashore, 2017–2019. Missing monthly boxes indicate missing or screened data.

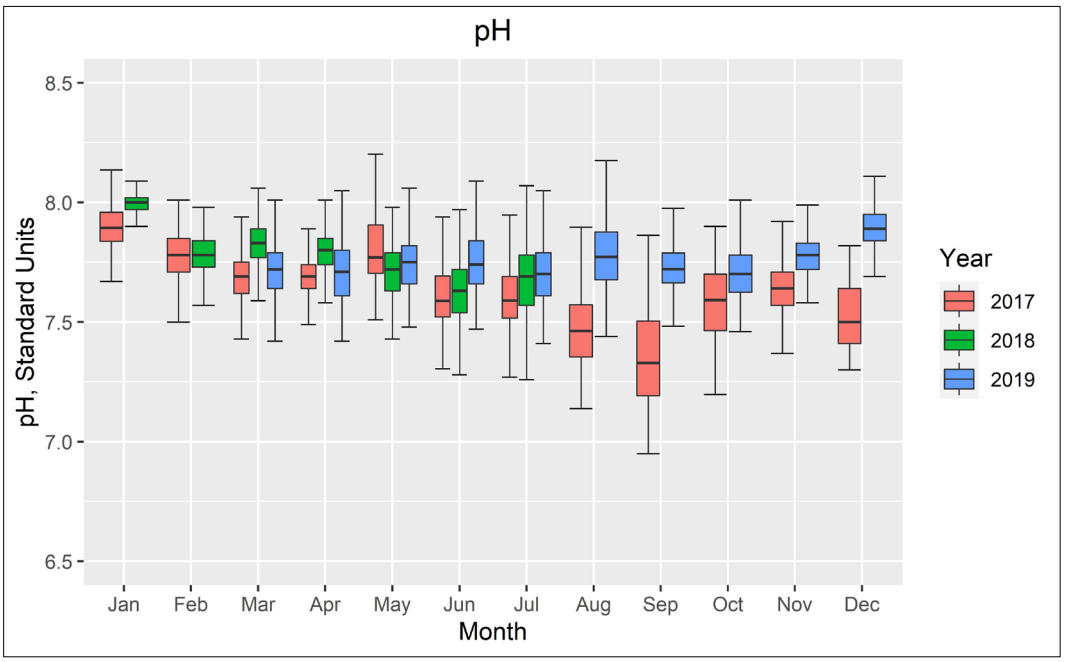

Figure 18. Example report figure 12. Monthly box plot of pH at the Sea Camp dock site at Cumberland Island National Seashore, 2017–2019. Missing monthly boxes indicate missing or screened data.

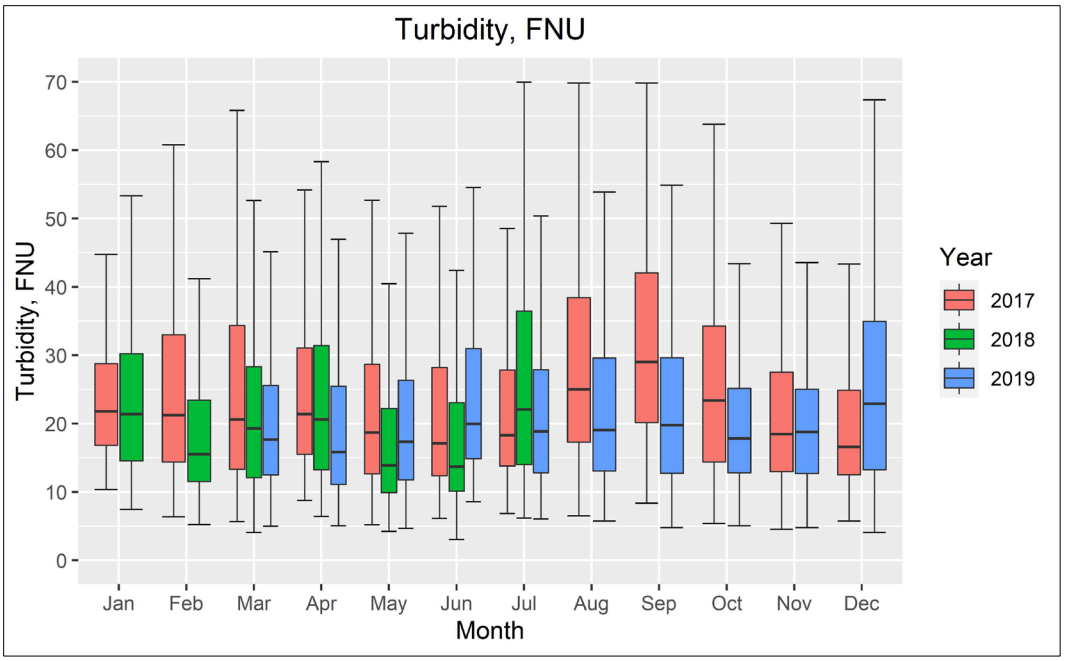

Figure 19. Example report figure 14. Monthly box plot of turbidity (FNU) at the Lazaretto Creek site at Fort Pulaski National Monument, 2018– 2019. Missing monthly boxes indicate missing or screened data.

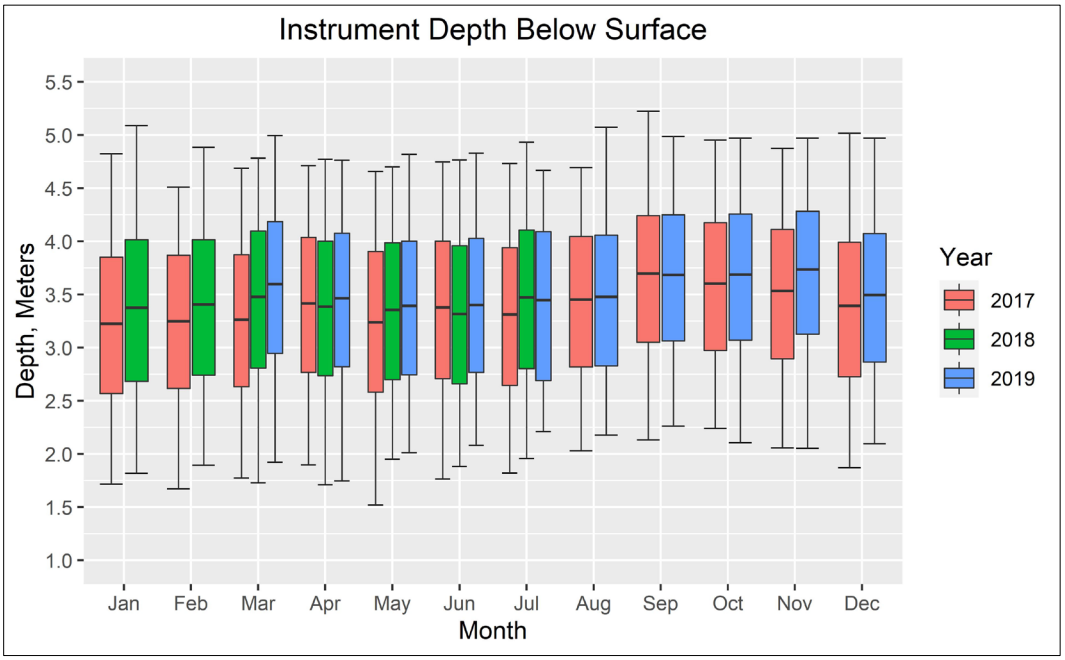

Figure 20. Example report figure 16. Monthly box plot of depth at the Lazaretto Creek site at Fort Pulaski National Monument, 2017–2019. Missing monthly boxes indicate missing or screened data.

Main Report Tables

After updating the figures, the tables are updated.

Table 1 Monitoring Station Location

Report table 1 indicates the locations of all network and partner water-quality monitoring stations within the park. The following is included in the table (Table 3): Station name, brief location description, latitude, longitude, and period of record. This table will only be updated when a station is added or retired.

Table 3. Example report table 1. Location of continuous water-quality monitoring stations at Cumberland Island National Seashore 2005–2019.

Name	Location Description	Location (lat /long)	Period of Record
CUISplum01	Plum Orchard dock	30.854866 / -81.467229	1/6/07 to 9/1/10
CUISold02	Old House Creek dock	30.798004 / -81.47027	8/3/05 to 9/1/10
CUISseac03	Sea Camp dock	30.764303 / -81.47126	10/1/2010 to present

Table 2 Performance Specifications of Data Sonde

Report table 2 (Table 4) indicates the performance specifications for the sensors installed on the sonde during the period of data collection. These specifications are provided by the manufacturer and do not change with frequency.

Table 4. Example report table 2. Performance specifications of YSI EXO2 datasondes deployed at the continuous monitoring site since January 2018 (YSI 2014). [mg/L—milligrams per liter; mS/cm—milli-Siemens per centimeter; m—meter; ft—foot; ppt—parts per thousand; NTU—nephelometric turbidity unit; FNU—formazin nephelometric unit].

Parameter	Range	Resolution	Accuracy
Dissolved oxygen (% saturation)	0 to 500%	0.10%	0 to 200%: +1% reading or 1% air saturation, 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 Celsius	-5 to +35 °C: +0.01 °C 35 to 50 °C: +0.05 °C

Parameter	Range	Resolution	Accuracy
pH	0 to 14	0.01 units	+0.1 pH units within +10 °C of calibration temperature +0.2 pH units for entire temperature range
Depth	Shallow: 0 to 33 feet (10meters)	0.001 feet (0.001 meters)	Shallow: +0.04% FS (+0.013 feet or +0.004 meters)
Turbidity	0 to 4,000 FNU	0 to 999 FNU: 0.01 FNU 1000 to 4,000 FNU: 0.1 FNU	0 to 999 FNU: 0.3 FNU or 2% of reading, whichever is greater. 1000 to 4,000 FNU: 0.1 FNU

Table 3 Parameter Condition Criteria

Report table 3 (Table 5) contains coastal water-quality monitoring condition criteria for water-quality parameters collected by the Southeast Coast Network. All criteria are based on thresholds set by the EPA (2012). **Water clarity criteria are park dependent (Table 1). Criteria for other parameters remain constant across sampled parks.**

Table 5. Example report table 3. Coastal water-quality monitoring condition criteria for water-quality parameters collected by the Southeast Coast Network. Based on thresholds set by the EPA (2012) [µg/L—micrograms per liter; mg/L—milligrams per liter].

Rating	Water Clarity(*k*)[1]	Chlorophyll a (µg/L)	Dissolved Inorganic Nitrogen (DIN) (mg/L)	Dissolved Inorganic Phosphorus (DIP) (mg/L)	Dissolved Oxygen(mg/L)
Good	< 0.92	< 5	< 0.1	< 0.01	> 5
Fair	0.92–1.61	5–20	0.1–0.5	0.01–0.05	2–5
Poor	> 1.61	> 20	> 0.5	> 0.05	< 2

[1]Light attenuation coefficients (k) were used to assess water-clarity conditions using criteria categories in Smith et al. (2006) which are comparable to the EPA (2012) criteria for the assessed water bodies.

Table 4 Monthly Mean Minimum, Maximum, and Mean Values for Parameters

Report table 4 (Table 6) contains monthly summary statistics (mean, minimum, maximum, and standard deviation). 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.

Table 6. Example report table 4 (truncated to 4 months). Monthly minimum, maximum, and mean values for parameters collected by the data sonde at Cumberland Island National Seashore during 2017–2019. 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 [PSU—practical salinity units; mg/L—milligrams per liter; m—meter; NTU—nephelometric turbidity unit; FNU—formazin nephelometric unit; SD—standard deviation; NA—no data]. Note: Months with no data were not included.

Month	Metric	Temperature (°C)	Salinity (PSU)	Dissolved Oxygen (mg/L)	Depth (m)	pH (Units)	Turbidity (NTU)	Turbidity (FNU)
January 2017	Minimum	10.9	28.6	44.4	5.2	1.7	7.6	0.5
	Maximum	18.9	33.9	51.6	8.5	4.8	8.2	114.2
	Mean	15.7	30.6	47.2	7.3	3.2	7.9	20
	SD	1.7	0.9	1.2	0.5	0.7	0.1	14.5
	Expected Count	2976	2976	2976	2976	2976	2976	2976
	Actual Count	2975	2970	2970	2972	2975	2975	2595
	Percent Coverage	100	100	100	100	100	100	87
February 2017	Minimum	13.5	27	42.1	5	1.7	7.4	3.2
	Maximum	21.5	34.2	52	8.4	4.5	8	108.5
	Mean	17.1	29.9	46.1	7.1	3.2	7.8	20.7
	SD	1.4	1.4	1.9	0.5	0.7	0.1	15.9
	Expected Count	2688	2688	2688	2688	2688	2688	2688
	Actual Count	2688	2684	2684	2681	2688	2688	2321
	Percent Coverage	100	100	100	100	100	100	86
March 2017	Minimum	12.5	28.1	43.7	5	1.8	7.4	9.6
	Maximum	22.2	33.7	51.4	8.4	4.7	7.9	83.5
	Mean	17.6	30	46.3	7	3.2	7.7	29.2
	SD	1.9	0.9	1.3	0.6	0.7	0.1	13.9

Month	Metric	Temperature (°C)	Salinity (PSU)	Dissolved Oxygen (mg/L)	Depth (m)	pH (Units)	Turbidity (NTU)	Turbidity (FNU)
	Expected Count	2976	2976	2976	2976	2976	2976	2976
	Actual Count	2149	2150	2150	2149	2150	1193	828
	Percent Coverage	72	72	72	72	72	40	28
April 2017	Minimum	20.1	31.5	48.3	3.7	1.9	7.5	4.7
	Maximum	27.1	36.3	54.8	6.7	4.7	8	52.1
	Mean	23.6	32.8	50.2	5.5	3.4	7.7	15.1
	SD	1.3	0.8	1.1	0.5	0.7	0.1	7.1
	Expected Count	2880	2880	2880	2880	2880	2880	2880
	Actual Count	1887	1792	1792	1885	1887	1702	1146
	Percent Coverage	66	62	62	65	66	59	40

Table 5 Monthly Water-Quality Data

Report table 5 (Table 7) summarizes monthly water-quality data for each parameter and the associated condition rating (Good, Fair, Poor). Data are reported out to the precision shown in Table 7. For 508 compliance, all color coding for ratings of Good, Fair, and Poor use the following Red (R), Green (G), and Blue (B) colors. Good: R=164, G=252, B=168; Fair: R=255, G=255, B=153; Poor: R=241, G=153, B=135.

Water Clarity

Water clarity criteria are park dependent (Table 1). Criteria for other parameters remain constant across sampled parks. Table 1 is useful to crosswalk the terminology and criteria to be used in each park.

Chlorophyll a, Dissolved Inorganic N, Dissolved Inorganic P, Total N, and Total P

These parameters are reported directly from the SECN Estuarine Water-Quality Monitoring Database and mirror results from the analytical lab. Note that when results are less than or equal to the Method Detection Limit [MDL], the MDL is reported. There are no EPA condition criteria for TDN and TDP.

Note that dissolved inorganic nitrogen (DIN) is calculated as NO_{23} + NH_4 and that DIP = PO_4.

Dissolved Oxygen

For consistency with NCCA protocols, the Southeast Coast Network reports near-bottom dissolved oxygen (for fixed stations this is equal to the lowest point in the sonde deployment tube).

Table 7. Example report table 5. Monthly water-quality data collected at Cumberland Island National Seashore during 2017–2019. 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 is 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; NA— 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)
1/26/2017	1.67[a]	4.62[a]	NA	NA	7.6[a]	0.34	0.028
3/23/2017	1.11[a]	2.19[a]	NA	NA	7.2[a]	0.43	0.027
4/11/2017	1.33[a]	3.55[a]	NA	NA	6.1[a]	0.33	0.024
5/23/2017	2.50[b]	5.25[b]	0.093[a]	0.0483[b]	5.2[a]	0.40	0.038
6/21/2017	2.00[a]	8.71[b]	NA	NA	4.5[b]	0.40	0.041
7/18/2017	2.00[a]	10.89[b]	NA	NA	3.9[b]	0.48	0.043
10/17/2017	4.00[c]	6.39[b]	NA	NA	5.2[a]	0.54	0.038

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)
12/14/2017	2.86 [b]	4.71 [a]	NA	NA	7.8 [a]	0.45	0.029
1/17/2018	4.00 [c]	7.32 [b]	NA	NA	9.2 [a]	0.29	0.030
2/9/2018	1.11 [a]	3.50 [a]	0.057 [a]	0.0103 [b]	7.3 [a]	0.33	0.028
3/27/2018	1.33 [a]	4.45 [a]	NA	NA	7.2 [a]	0.29	0.027
5/10/2018	1.00 [a]	5.99 [b]	0.026 [a]	0.0079 [a]	5.9 [a]	0.34	0.028
6/7/2018	1.25 [a]	10.30 [b]	NA	NA	5.1 [a]	0.38	0.026
7/19/2018	2.50 [b]	14.80 [b]	NA	NA	4.2 [b]	0.49	0.035
3/21/2019	10.00 [c]	9.79 [b]	NA	NA	6.5 [a]	0.34	0.021
4/12/2019	1.67 [a]	5.24 [b]	NA	NA	5.2 [a]	0.34	0.026
5/7/2019	1.67 [a]	8.54 [b]	0.095 [a]	0.0099 [a]	4.5 [b]	0.34	0.029
6/4/2019	1.67 [a]	7.37 [b]	NA	NA	3.1 [b]	0.36	0.051
7/2/2019	2.00 [a]	10.16 [b]	NA	NA	4.6 [b]	0.31	0.045
8/7/2019	3.33 [c]	12.09 [b]	0.092 [a]	0.0185 [b]	3.9 [b]	0.41	0.045
8/29/2019	2.22 [a]	7.79 [b]	0.049 [a]	0.0203 [b]	3.6 [b]	0.32	0.042
10/8/2019	2.00 [a]	4.64 [a]	NA	NA	4.9 [b]	0.34	0.052
11/14/2019	1.33 [a]	3.33 [a]	0.029 [a]	0.0201 [b]	6.7 [a]	0.32	0.045
12/9/2019	1.25 [a]	5.15 [b]	NA	NA	6.7 [a]	0.27	0.038

[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

Summary, Key Findings and Results

The summary, key findings and results sections in the report covers the following:

- Where the data were collected (e.g., park and station name).
- Key partners
- Citation of the methods
- The period of record covered by the report

- Cite any previous fixed-station reports that are useful for comparison
- Brief description of major storm events such as hurricanes that may have influenced data collected during the period of record covered by the report
- Indicate the parameters measured during the period of record
- Summarize each field measure/parameter
    - Chlorophyll *a* concentration range and % samples rated as Good, Fair and Poor
    - Water clarity range and % samples rated as Good, Fair and Poor
    - Mean monthly dissolved oxygen range and % of daily means rated as Good, Fair and Poor
    - pH monthly mean minimum, maximum and overall range
    - Turbidity monthly mean minimum, maximum and overall range
    - Water temperature monthly mean minimum, maximum and overall range

It is important to remember that Natural Resource Data Series (NRDS) reports are meant to be a basic release of data and include summary statistics and findings. More detailed discussion related to findings occurs in other publications such as a Natural Resource Report (NRR) and/or directly with natural resource managers. Caution must be used if making statements that interpret findings or attribute causation.

Other Sections of the Fixed-Station Data Report

Close review of the Introduction, Park Information, Weather and Hydrologic Setting, and Methods sections will occur as the report is assembled. While these sections do not change with frequency, they may require periodic updates.

Literature Cited

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 115:291–305.

Southeast Coast Network (SECN). 2019. Southeast Coast Network authorship guidelines—Version 3.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—2.1.03. Southeast Coast Network, Athens, Georgia. DataStore - Standard Operating Procedure - (Code: 2260360) (nps.gov) (last accessed June 2022).

Starkey, E. N., and D. McCay. 2022a. Fixed-station continuous water-quality data entry, processing, and QA/QC —Version 1.0. Southeast Coast Network Standard Operating Procedure NPS/SECN/SOP—2.2.09. Southeast Coast Network, Athens, Georgia. Available at: https://irma.nps.gov/DataStore/Reference/Profile/2284604 (last accessed June 2022).

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United States Census Bureau. 2020. Census 2010 Gateway website. Available at: http://www.census.gov/2010census/ (last accessed June 2022).

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United States Environmental Protection Agency (EPA). 2022. Geospatial Data Downloads website. Available at: Water Data and Tools | US EPA (last accessed June 2022).

U.S. Fish and Wildlife Service (FWS). 2022. National Wetlands Inventory website. Available at: http://www.fws.gov/wetlands/ (last accessed June 2022).

Appendix A. Example Fixed-Station Reports Found on IRMA

2017–2019

Starkey, E. N., and D. McCay. 2021. Fixed-station water-quality monitoring at Cape Hatteras National Seashore: 2017–2019 data summary. Natural Resource Data Series NPS/SECN/NRDS—2021/1335. National Park Service, Fort Collins, Colorado. Available at: DataStore - Published Report - (Code: 2288146) (nps.gov) (last accessed June 2022).

Starkey, E. N., and D. McCay. 2021. Fixed-station water-quality monitoring at Cape Lookout National Seashore: 2017–2019 data summary. Natural Resource Data Series NPS/SECN/NRDS—2021/1336. National Park Service, Fort Collins, Colorado. Available at: DataStore - Published Report - (Code: 2288152) (nps.gov) (last accessed June 2022).

Starkey, E. N., and D. McCay. 2021. Fixed-station water-quality monitoring at Cumberland Island National Seashore: 2017–2019 data summary. Natural Resource Data Series NPS/SECN/NRDS—2021/1334. National Park Service, Fort Collins, Colorado. Available at: DataStore - Published Report - (Code: 2288144) (nps.gov) (last accessed June 2022).

Starkey, E. N., and D. McCay. 2021. Fixed-station water-quality monitoring at Fort Pulaski National Monument: 2017–2019 data summary. Natural Resource Data Series NPS/SECN/NRDS—2021/1333. National Park Service, Fort Collins, Colorado. Available at: DataStore - Published Report - (Code: 2288140) (nps.gov) (last accessed June 2022).

Appendix B. R Scripts

R scripts for the following processes are available in an IRMA repository at https://irma.nps.gov/DataStore/Reference/Profile/2287567.

- Data Extraction from Aquarius
- Daily Means Graph Creation
- Box Plots Creation
- Monthly Mean, Maximum and Minimum Table Creation