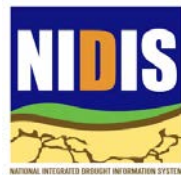


Coastal Salinity Index (CSI)

NOAA Eastern Region Climate Services Webinar
October 29, 2020

Matt Petkewich, U.S. Geological Survey
Kirsten Lackstrom, Carolinas Integrated Sciences and Assessments



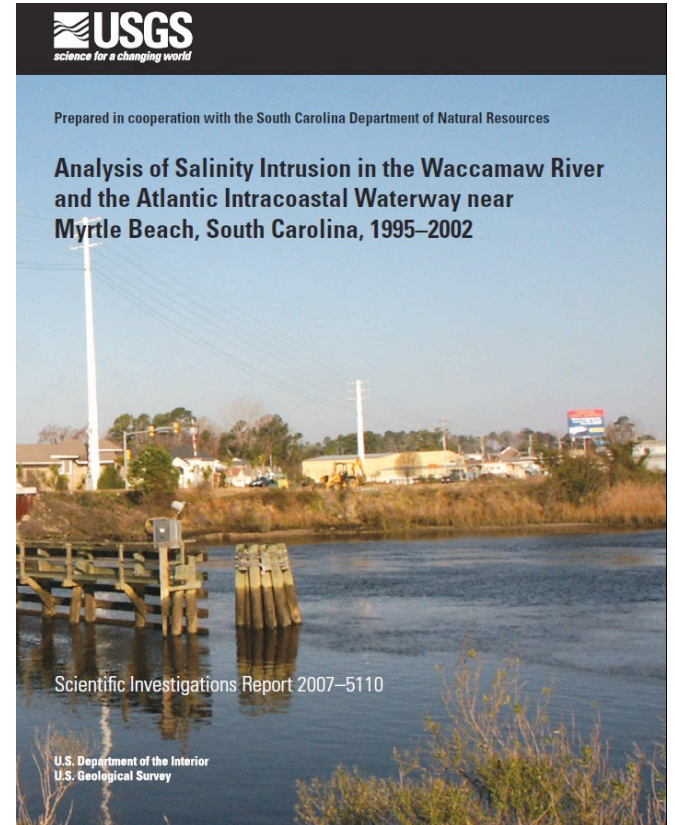
Motivation



Source: Michael Childress/Clemson

Fisheries

Municipal
and Industrial
Intake
Closures



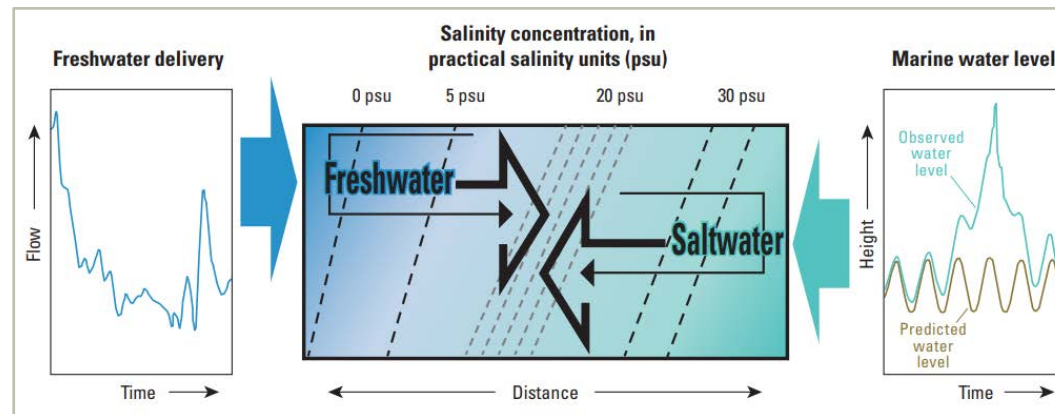
Source: Chandler Green/CISA

Habitat
Change

Overview

- Indicator of salinity changes and location of the freshwater-saltwater interface
- Focus of the NIDIS Coastal Carolinas Drought Early Warning System (DEWS)

- Precipitation
- Drought
- Flood/tropical storms
- GW discharge
- ET
- Streamflow regulation
- Water extraction (agriculture, industry, PW supply)



- Tides
- Winds
- Tropical storms
- Sea-level rise

Societal, economic, ecological effects

- Vegetation tolerance (habitat, storm-surge protection)
- Fisheries (fish, crabs, oysters)
- Drinking water intakes
- Industrial water intakes
- Algal blooms
- Tourism/Recreation

Source: Conrads, P.A., Rodgers, K.D., Passeri, D.L., Prinos, S.T., Smith, C., Swarzenski, C.M., and Middleton, B.A., 2018, Coastal estuaries and lagoons – The delicate balance at the edge of the sea: U.S. Geological Survey Fact Sheet 2018-3022, 4 p. <https://doi.org/10.3133/fs20183022>.

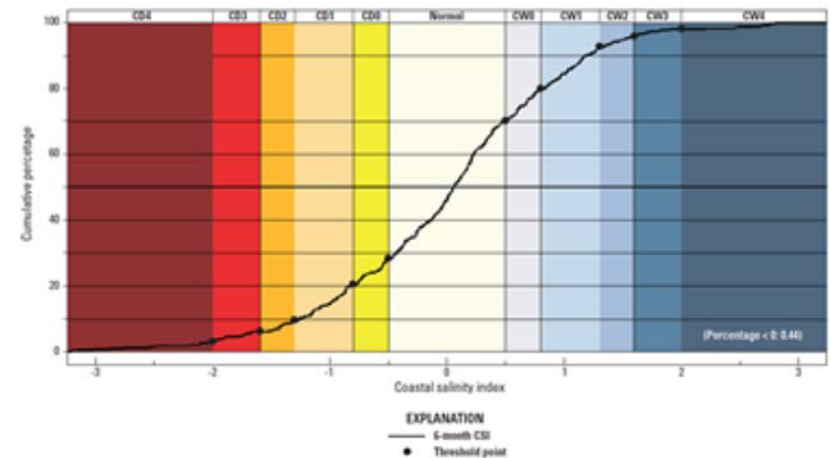
Approach and methods

Table 1. Coastal salinity classifications, descriptions, and threshold values.

[Brackets and parentheses in the ranges indicate inclusion (brackets) or exclusion (parentheses) of a value in the listed range. CSI, Coastal Salinity Index; CD, coastal drought; NA, not applicable; CW, coastal wet; ∞, infinity]

| Coastal salinity classification | Description | Color | Range | CSI threshold value | Cumulative percentage |
|---------------------------------|-----------------------------------|----------------|------------------|---------------------|-----------------------|
| CD4 | Exceptional salinity conditions | Dark Red | (∞ , -2] | -2 | 2 |
| CD3 | Extreme salinity conditions | Red | (-2.0 to -1.6] | -1.6 | 5 |
| CD2 | Severe salinity conditions | Orange | (-1.6 to -1.3] | -1.3 | 10 |
| CD1 | Moderate salinity conditions | Light Orange | (-1.3 to -0.8] | -0.8 | 20 |
| CD0 | Abnormal salinity conditions | Yellow | (-0.8 to -0.5] | -0.5 | 30 |
| Normal | Normal salinity conditions | Light Yellow | (-0.5 to 0.5] | NA | 70 |
| CW0 | Abnormal freshwater conditions | Light Blue | (0.5 to 0.8] | 0.5 | 80 |
| CW1 | Moderate freshwater conditions | Blue | (0.8 to 1.3] | 0.8 | 90 |
| CW2 | Severe freshwater conditions | Dark Blue | (1.3 to 1.6] | 1.3 | 95 |
| CW3 | Extreme freshwater conditions | Very Dark Blue | (1.6 to 2.0] | 1.6 | 98 |
| CW4 | Exceptional freshwater conditions | Black | (2, ∞) | 2 | 100 |

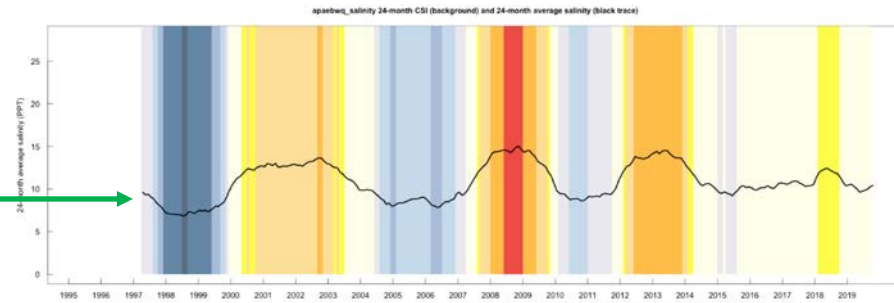
- Similar approach to the Standardized Precipitation Index (SPI)
- Indicates drought and wetter conditions over multiple time periods (1- to 24 months)
- >18 years period of record



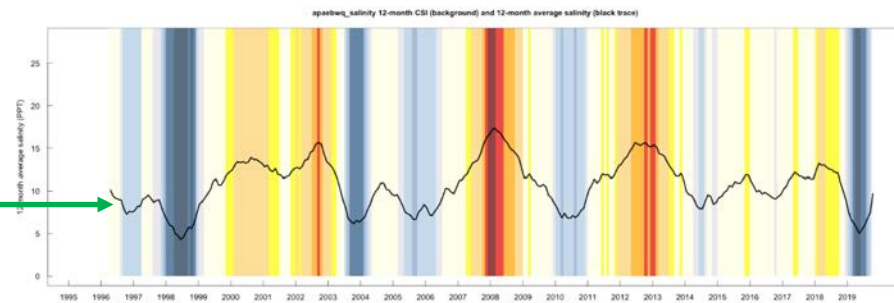
Source: Petkewich, M.D., Lackstrom, K., McCloskey, B.J., Rouen, L.F., and Conrads, P.A., 2019, Coastal Salinity Index along the southeastern Atlantic coast and the Gulf of Mexico, 1983 to 2018: U.S. Geological Survey Open-File Report 2019-1090, 26 p., <https://doi.org/10.3133/ofr20191090>.

Example graphs

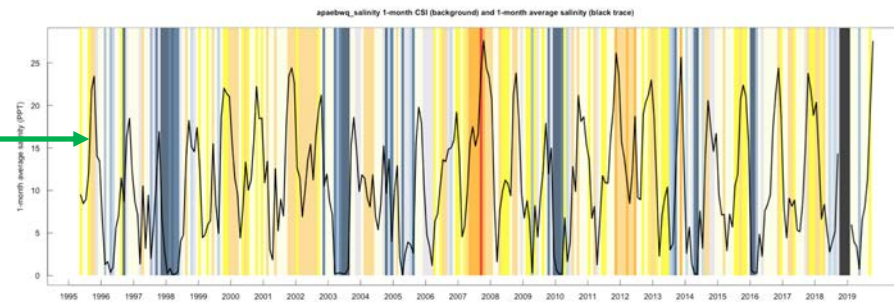
The black line for the CSI-24 shows the 24-month average salinity



For the CSI-12, the 12-month average salinity is shown



For the CSI-1, the 1-month average salinity is shown



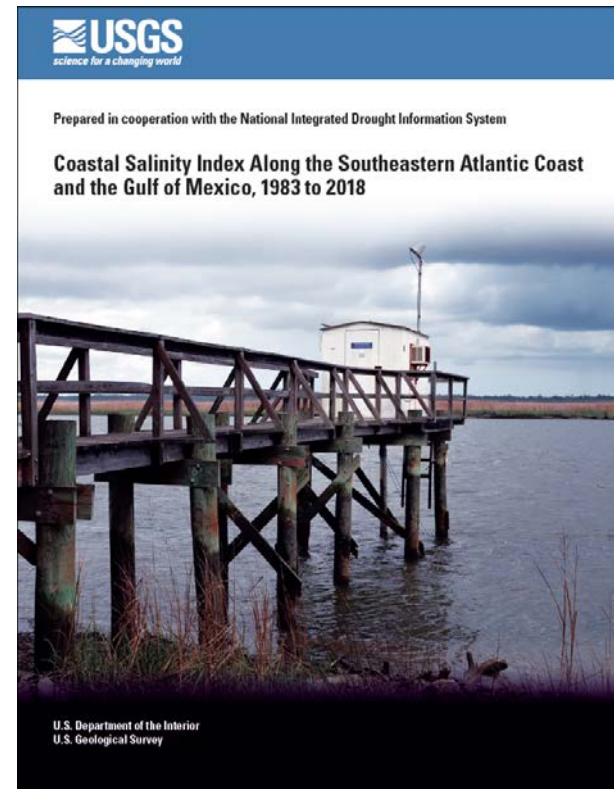
East Bay Bottom Station, APAEBWQ
Apalachicola National Estuarine Research Reserve

EXPLANATION: CD, coastal drought; CW, coastal wet; Period of record: 05/1995 - 10/2019



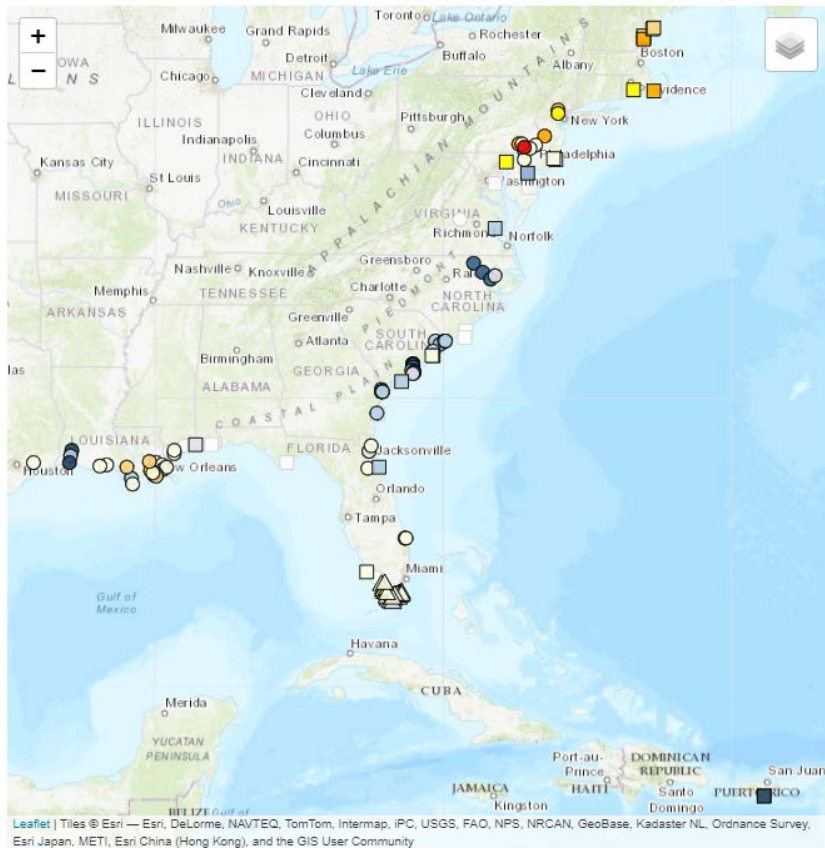
Products and resources (2017-2019)

- **CSI R-package**
 - GitHub
- **Historic CSIs** along the Gulf and SE Atlantic coasts
 - USGS ScienceBase Catalog
- **Real-time CSIs**
 - 17 stations in NC, SC, and GA; USGS South Atlantic Water Science Center website
 - 12 stations in South Florida; USGS Coastal Everglades Depth Estimation Network (EDEN) website



<https://doi.org/10.3133/ofr20191090>

USGS Community for Data Integration project (2020)



- **Identify and integrate new salinity datasets**
 - USGS
 - National Park Service (Everglades)
 - National Estuarine Research Reserve System (NERRS)
- **Enhance existing website and user interface to accommodate new CSIs**
- **Develop CSI R-scripts for use in ecological analyses**

Landing/Home Page (1)

Coastal Salinity Index
Home About CSI Additional Data Resources

The Coastal Salinity Index (CSI) utilizes salinity data to characterize saline (drought) and freshwater (wet) conditions in coastal areas. The CSI is site-specific and can be computed for multiple time intervals from 1- to 24-months, to help users evaluate response to monthly (and longer) precipitation and streamflow conditions. The CSI was developed to characterize coastal drought, monitor changing salinity conditions, and improve understanding of the effects of changing salinities on fresh and saltwater ecosystems, fish habitat, and freshwater availability for municipal and industrial use.

The CSI is a standardized probability index. A value of zero indicates historical mean salinity amount, and positive and negative values represent increasingly fresh and saline conditions, respectively. The CSI uses the same classification scheme as the U.S. Drought Monitor for high saline, or drought, conditions.

Real-time Coastal Salinity Index Map

Explanation

Time Interval of CSI Values: 1-month

| Coastal Salinity Classification | Description | Threshold Values | Color | Cumulative Percentage |
|---------------------------------|-----------------------------------|------------------|----------------|-----------------------|
| CD4 | Exceptional salinity conditions | -2.00 or less | Black | 2 |
| CD3 | Extreme salinity conditions | -1.99 to -1.60 | Red | 5 |
| CD2 | Severe salinity conditions | -1.59 to -1.30 | Orange | 10 |
| CD1 | Moderate salinity conditions | -1.29 to -0.80 | Yellow | 20 |
| CD0 | Abnormal salinity conditions | -0.79 to -0.50 | Light Yellow | 30 |
| Normal | Normal salinity conditions | -0.49 to 0.50 | White | 70 |
| CW0 | Abnormal freshwater conditions | 0.51 to 0.80 | Light Blue | 80 |
| CW1 | Moderate freshwater conditions | 0.81 to 1.30 | Blue | 90 |
| CW2 | Severe freshwater conditions | 1.31 to 1.60 | Dark Blue | 95 |
| CW3 | Extreme freshwater conditions | 1.61 to 2.00 | Very Dark Blue | 98 |
| CW4 | Exceptional freshwater conditions | 2.01 or more | Black | 100 |
| Not Available | Missing Data | | White | |

Data last updated on 2020-10-26.
 CD = Coastal Drought
 CW = Coastal Wet

Agency Shapes

- U.S. Geological Survey (USGS)
- National Estuarine Research Reserves (NERRS)
- ▲ National Park Service (NPS)

User-selected CSI time interval (default = 1-month CSI)

CSI Classification Table

Station Legend

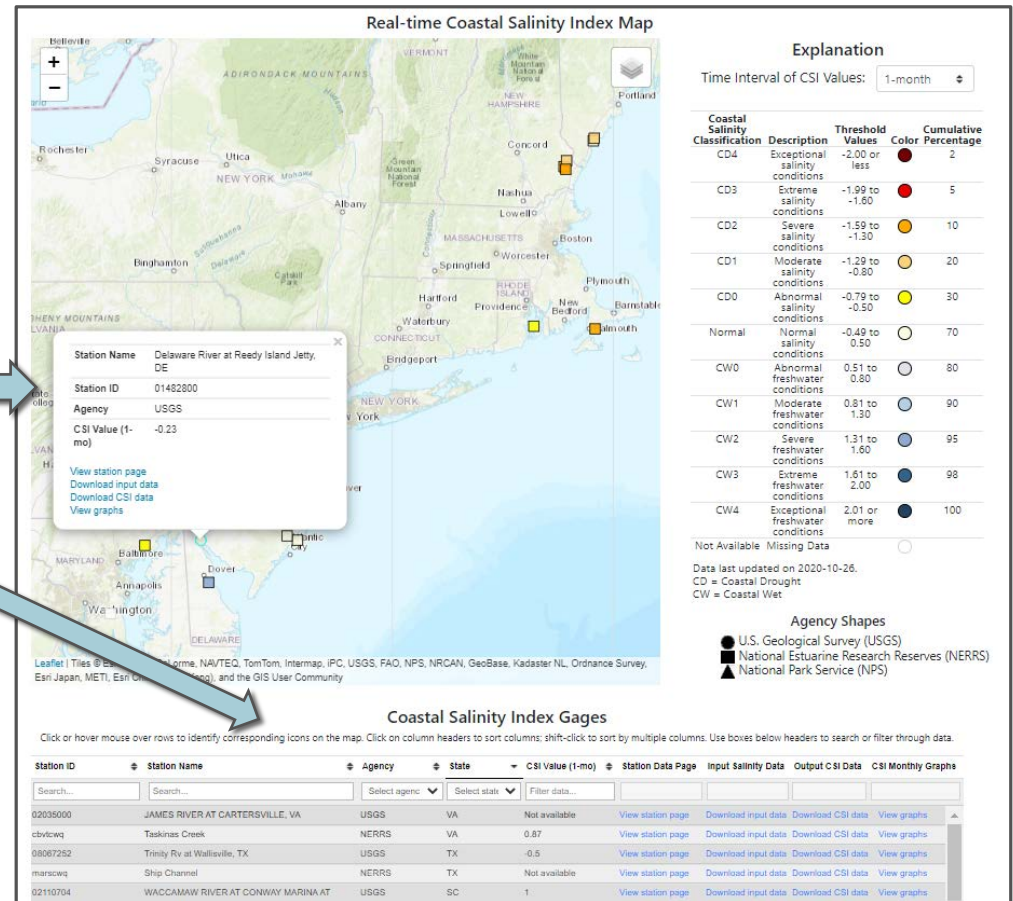
Interactive Map (see station pop-ups on next slide)

Landing/Home Page (2)

Station pop-ups allow user to:

- link to station page (originating agency)
- download input salinity data (.csv files)
 - download CSI values (.csv files)
 - access CSI graphs

Links are also available in the Station Table



Landing/Home Page (3)

**CSI Station Table
Sortable and
Searchable
(by multiple parameters)**

Link to:
Station information (agency website)
Input salinity data (.csv files)
Output CSI values (.csv files)
CSI graphs

Coastal Salinity Index Gages

Click or hover mouse over rows to identify corresponding icons on the map. Click on column headers to sort columns; shift-click to sort by multiple columns. Use boxes below leaders to search or filter through data.

| Station ID | Station Name | Agency | State | CSI Value (1-mo) | Station Data Page | Input Salinity Data | Output CSI Data | CSI Monthly Graphs |
|----------------------------------------|-------------------------------------------------|--------------------------------------------|-------------------------------------------|---------------------------------------------|-----------------------------------|-------------------------------------|-----------------------------------|-----------------------------|
| <input type="text" value="Search..."/> | <input type="text" value="Search..."/> | <input type="text" value="Select agency"/> | <input type="text" value="Select state"/> | <input type="text" value="Filter data..."/> | | | | |
| 02035000 | JAMES RIVER AT CARTERSVILLE, VA | USGS | VA | Not available | View station page | Download input data | Download CSI data | View graphs |
| cbvtowq | Taskinas Creek | NERRS | VA | 0.87 | View station page | Download input data | Download CSI data | View graphs |
| 08067252 | Trinity Rv at Wallisville, TX | USGS | TX | -0.5 | View station page | Download input data | Download CSI data | View graphs |
| marsowq | Ship Channel | NERRS | TX | Not available | View station page | Download input data | Download CSI data | View graphs |
| 02110704 | WACCAMAW RIVER AT CONWAY MARINA AT CONWAY, SC | USGS | SC | 1 | View station page | Download input data | Download CSI data | View graphs |
| 02110755 | AIW AT BRIARCLIFFE ACRES AT N. MYRTLE BEACH, SC | USGS | SC | 0.93 | View station page | Download input data | Download CSI data | View graphs |
| 02110760 | AIW @ MYRTLEWOOD GOLF COURSE @ MYRTLE BEACH, SC | USGS | SC | 0.8 | View station page | Download input data | Download CSI data | View graphs |
| 02110770 | AIW AT GRAND STRAND AIRPORT N. MYRTLE BEACH, SC | USGS | SC | 1.15 | View station page | Download input data | Download CSI data | View graphs |
| 02110777 | AIW AT HIGHWAY 9 AT NIXONS CROSSROADS, SC | USGS | SC | 1.25 | View station page | Download input data | Download CSI data | View graphs |
| 021108125 | WACCAMAW RIVER NEAR PAWLEY'S ISLAND, SC | USGS | SC | 0.86 | View station page | Download input data | Download CSI data | View graphs |

About the CSI Page

| Coastal Salinity Index | | Home | About CSI | Additional Data | Resources |
|----------------------------------|---------------------------------------------|------|-----------|-----------------|-----------|
| About the Coastal Salinity Index | | | | | |
| ▼ Motivation | Why was the CSI developed? | | | | |
| ▼ Methods | How is the CSI calculated? | | | | |
| ▼ CSI Classifications | CSI Classification Table | | | | |
| ▼ How to Read Stacked Graphs | Example CSI stacked graph with explanations | | | | |
| ▼ Use Cases | In progress | | | | |
| ▼ Future Work | <1-month intervals; additional datasets | | | | |
| ▼ Data Disclaimers | Provisional and final data | | | | |
| ▼ Contact | Project team information | | | | |

Click on each sub-page heading to access content

Additional Real-Time Data (1)

Coastal Salinity Index

[Home](#)
[About CSI](#)
[Additional Data](#)
[Resources](#)

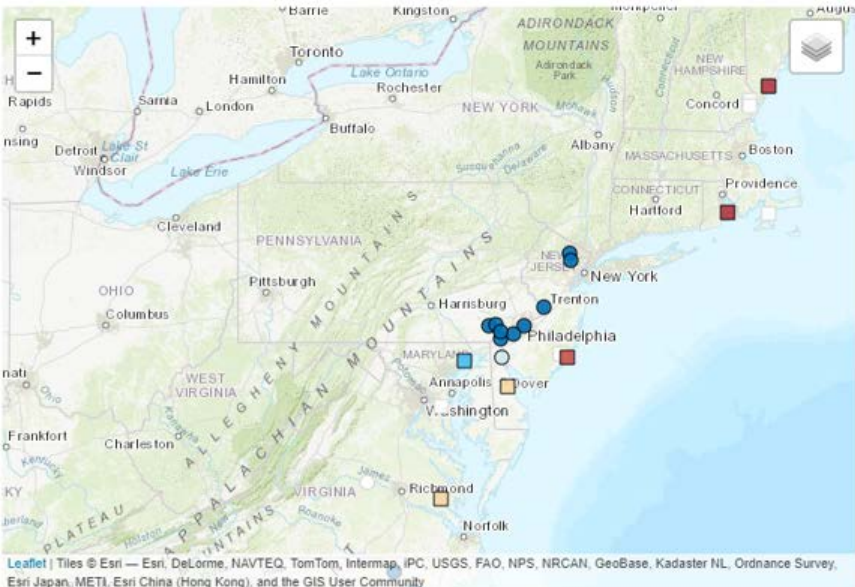
Additional Real-time Data

The CSI depicts the response to monthly (and longer) precipitation and streamflow conditions rather than hourly to daily fluctuations. The maps and graphs on this page show the latest real-time trends in salinity, water temperature, and gage height at the CSI sites.

Select a variable and time interval to view average salinity, water temperature, or gage-height conditions over the past 7 days, 14 days, 1 month, 2 month, or 3 months. By averaging over these time intervals, water conditions are more indicative of recent hydrological conditions than current conditions.

Note: Gage height is the height of water in the stream above a constant reference point. For the purposes of this website, gage-height record that has not been converted to a unified datum is limited to data from the agency where the gage is located at single location and specific measuring point.

Click on sites on the map to view links to data and graphs. All real-time data are provisional and subject to revision.



Explanation

Data: Salinity - Average

Time: Salinity - Change

- Water Temperature - Average
- Water Temperature - Change
- Gage Height - Average Percentile
- Gage Height - Change

- 0.0 - 2.9 PPT
- 3.0 - 6.9 PPT
- 7.0 - 11.9 PPT
- 12.0 - 17.9 PPT
- 18.0 - 29.9 PPT
- ≥ 30.0 PPT
- Data Not Available

Parts Per Thousand (PPT)

Agency Shapes

- U.S. Geological Survey (USGS)
- National Estuarine Research Reserves (NERRS)
- ▲ National Park Service (NPS)

Available Data
 Salinity
 Water Temperature
 Gage Height

- ≤ 0.5 PPT
- 0.6 - 2.9 PPT
- 3.0 - 6.9 PPT
- 7.0 - 11.9 PPT
- 12.0 - 17.9 PPT
- 18.0 - 29.9 PPT
- ≥ 30.0 PPT
- Data Not Available

Parts Per Thousand (PPT)

Additional Real-Time Data (2)

Coastal Salinity Index Home About CSI **Additional Data** Resources

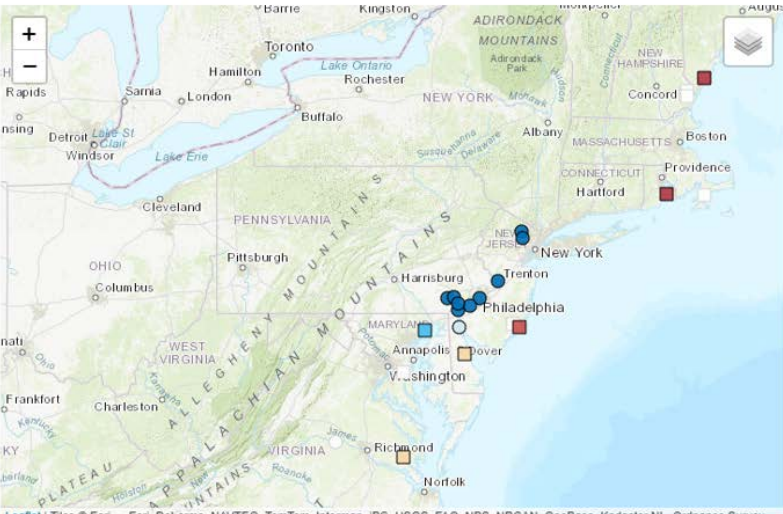
Additional Real-time Data

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Click on sites on the map to view links to data and graphs. All real-time data are provisional and subject to revision.



Explanation

Data: Salinity - Average

Time Interval: 7-day

- 7-day
- 14-day
- 1-month
- 2-month
- 3-month

- ≤ 0.5 PPT
- 0.6 - 2.9 PPT
- 3.0 - 6.9 PPT
- 7.0 - 11.9 PPT
- 12.0 - 17.9 PPT
- 18.0 - 29.9 PPT
- ≥ 30.0 PPT
- Data Not Available

Parts Per Thousand (PPT)

Agency Shapes

- U.S. Geological Survey (USGS)
- National Estuarine Research Reserves (NERRS)
- National Park Service (NPS)

Leaflet | Tiles © Esri — Esri, DeLorme, NAVTEQ, TomTom, Intermap, IPC, USGS, FAO, NPS, NRCAN, GeoBase, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), and the GIS User Community

Time Intervals

- 7-day
- 14-day
- 1-month
- 2-month
- 3-month

- ≤ 0.5 PPT
- 0.6 - 2.9 PPT
- 3.0 - 6.9 PPT
- 7.0 - 11.9 PPT
- 12.0 - 17.9 PPT
- 18.0 - 29.9 PPT
- ≥ 30.0 PPT
- Data Not Available

Parts Per Thousand (PPT)

Additional Real-Time Data (3) - Salinity 7-Day Average Example

Station Data
Input data
Time series
CSI stacked graphs



Coastal Salinity Index

Home About CSI **Additional Data** Resources

Additional Real-time Data

The CSI depicts the response to monthly (and longer) precipitation and streamflow conditions rather than hourly to daily fluctuations. The maps and graphs on this page show the latest real-time trends in salinity, water temperature, and gage height at the CSI sites.

Select a variable and time interval to view average salinity, water temperature, or gage-height conditions over the past 7 days, 14 days, 1 month, 2 month, or 3 months. By averaging over these time intervals, water conditions are more indicative of recent hydrological conditions than current conditions.

Note: Gage height is the height of water in the stream above a constant reference point. For the purposes of this website, gage-height record that has not been converted to a unified datum is limited to data from the agency where the gage is located at single location and specific measuring point.

Click on sites on the map to view links to data and graphs. All real-time data are provisional and subject to revision.

| | |
|--------------------------|------------------------------------------|
| Station Name | Delaware River at Reedy Island Jetty, DE |
| Station ID | 01482800 |
| Agency | USGS |
| Average Salinity (7-day) | 6.83 PPT |

[Access input data \(7-day\)](#)
[View salinity time series \(7-day average\)](#)
[View 30 day moving window average graph](#)
[View stacked graphs](#)

Explanation

Data: Salinity - Average

Time Interval: 7-day

- ≤ 0.5 PPT
- 0.6 - 2.9 PPT
- 3.0 - 6.9 PPT
- 7.0 - 11.9 PPT
- 12.0 - 17.9 PPT
- 18.0 - 29.9 PPT
- ≥ 30.0 PPT
- Data Not Available

Parts Per Thousand (PPT)

Agency Shapes

- U.S. Geological Survey (USGS)
- National Estuarine Research Reserves (NERRS)
- ▲ National Park Service (NPS)

Leaflet | Tiles © Esri — Esri, DeLorme, NAVTEQ, TomTom, Intermap, IPC, USGS, FAO, NPS, NRCAN, GeoBase, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), and the GIS User Community

Additional Real-Time Data (4) - Water Temperature 7-Day Change Example

Coastal Salinity Index

Home About CSI **Additional Data** Resources

Additional Real-time Data

The CSI depicts the response to monthly (and longer) precipitation and streamflow conditions rather than hourly to daily fluctuations. The maps and graphs on this page show the latest real-time trends in salinity, water temperature, and gage height at the CSI sites.

Select a variable and time interval to view average salinity, water temperature, or gage-height conditions over the past 7 days, 14 days, 1 month, 2 month, or 3 months. By averaging over these time intervals, water conditions are more indicative of recent hydrological conditions than current conditions.

Note: Gage height is the height of water in the stream above a constant reference point. For the purposes of this website, gage-height record that has not been converted to a unified datum is limited to data from the agency where the gage is located at single location and specific measuring point.

Click on sites on the map to view links to data and graphs. All real-time data are provisional and subject to revision.

| | |
|--------------------------------------------|------------------------------------------|
| Station Name | Delaware River at Reedy Island Jetty, DE |
| Station ID | 01482800 |
| Agency | USGS |
| Current Average Water Temperature (7-day) | 18.07 °C |
| Previous Average Water Temperature (7-day) | 18.27 °C |
| Change in Water Temperature (7-day) | -0.2 °C |

[Access input data \(7-day\)](#)
[View temperature time series \(7-day average\)](#)
[View 30 day moving window average graph](#)
[View stacked graphs](#)

Explanation

Data: Water Temperature - Chang

Time Interval: 7-day

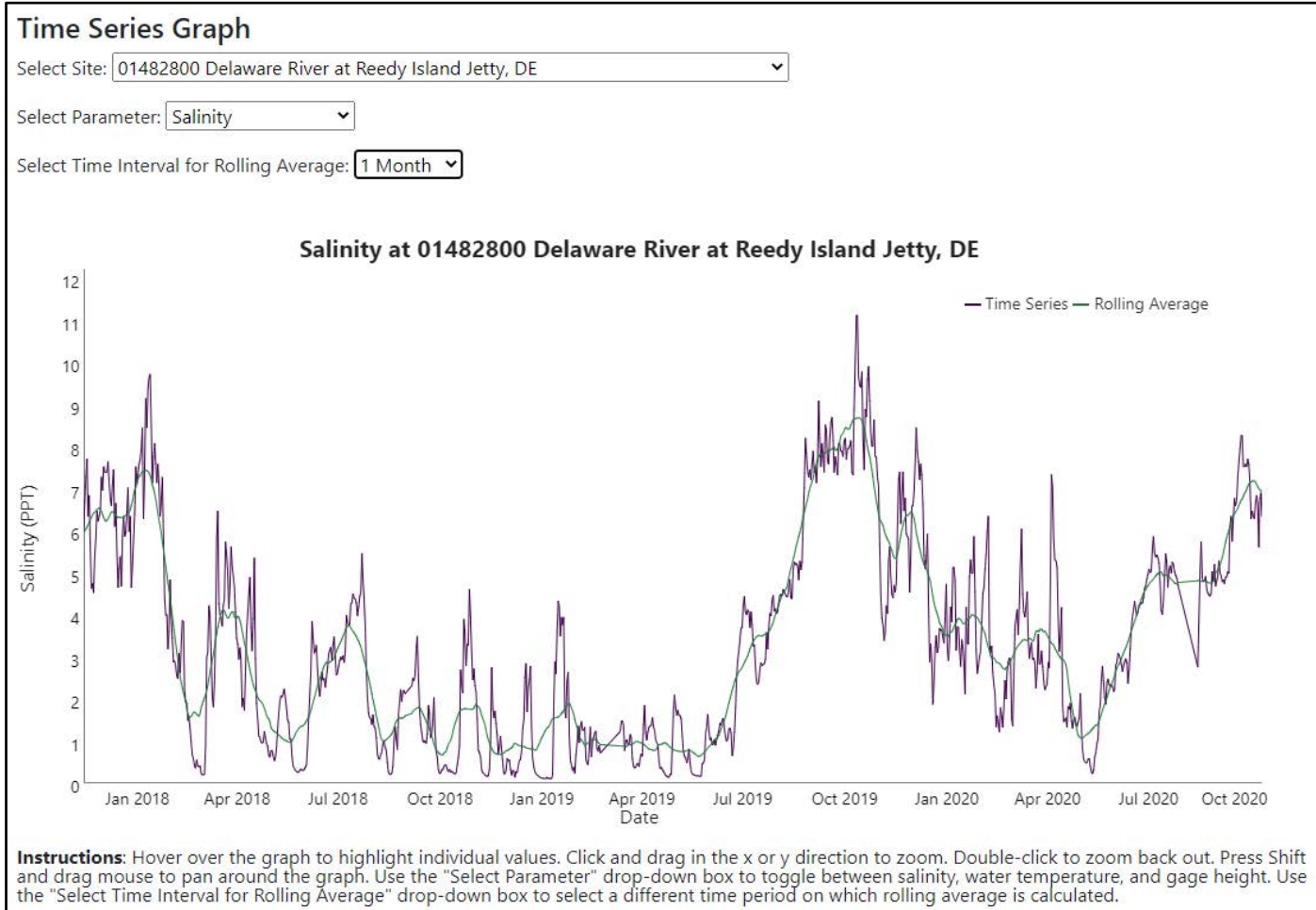
Units: ° Celsius

- ↓ ≤ -2 °C
- ↓ -1.9 to -1.0 °C
- ↓ -0.9 to 0 °C
- ↑ 0.1 to 1.0 °C
- ↑ 1.1 to 2.0 °C
- ↑ 2.1 to 3.0 °C
- ↑ ≥ 3.1 °C
- Not Available

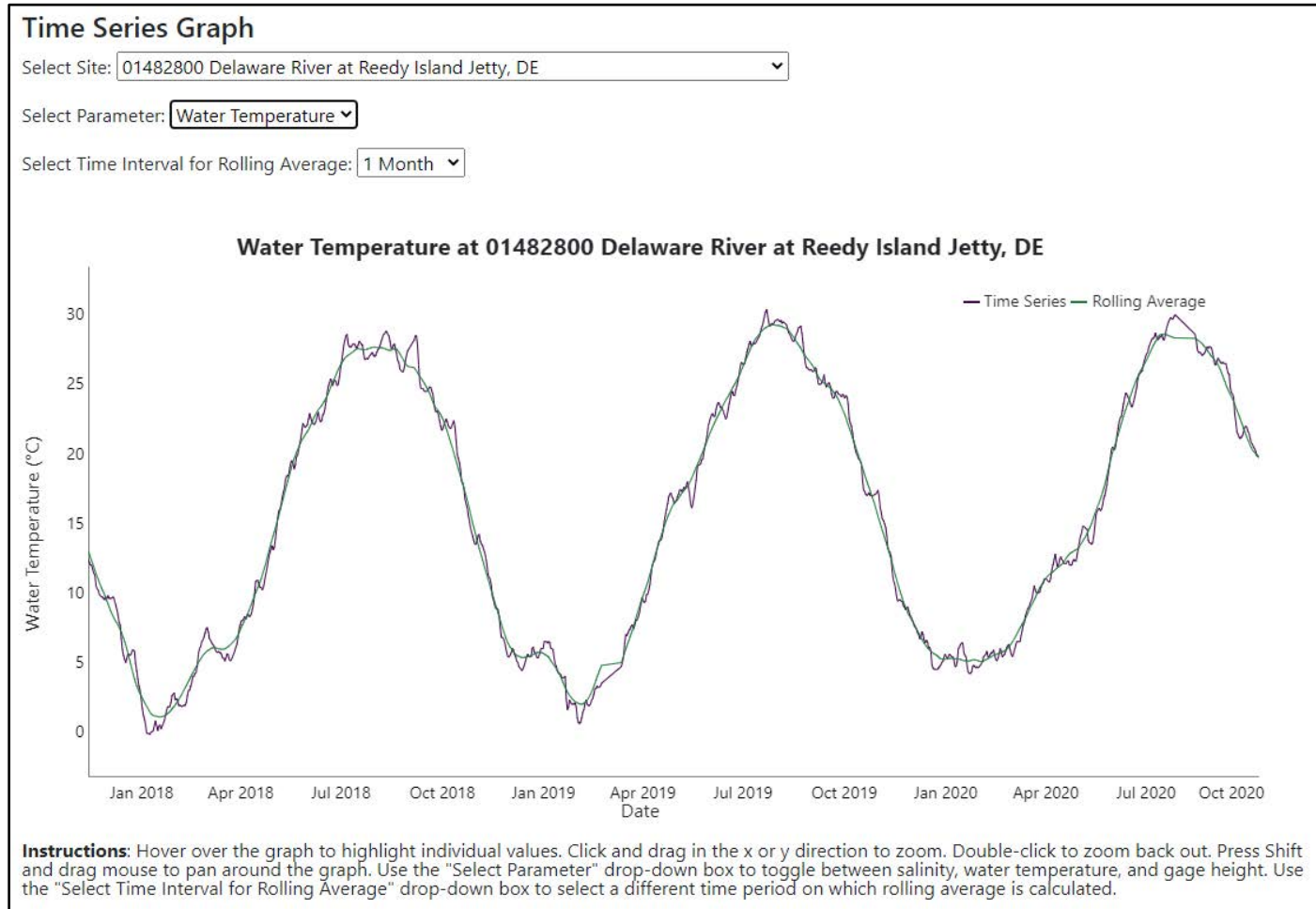
Degrees Celsius (°C)

Station Data
Input data
Time series
CSI stacked graphs

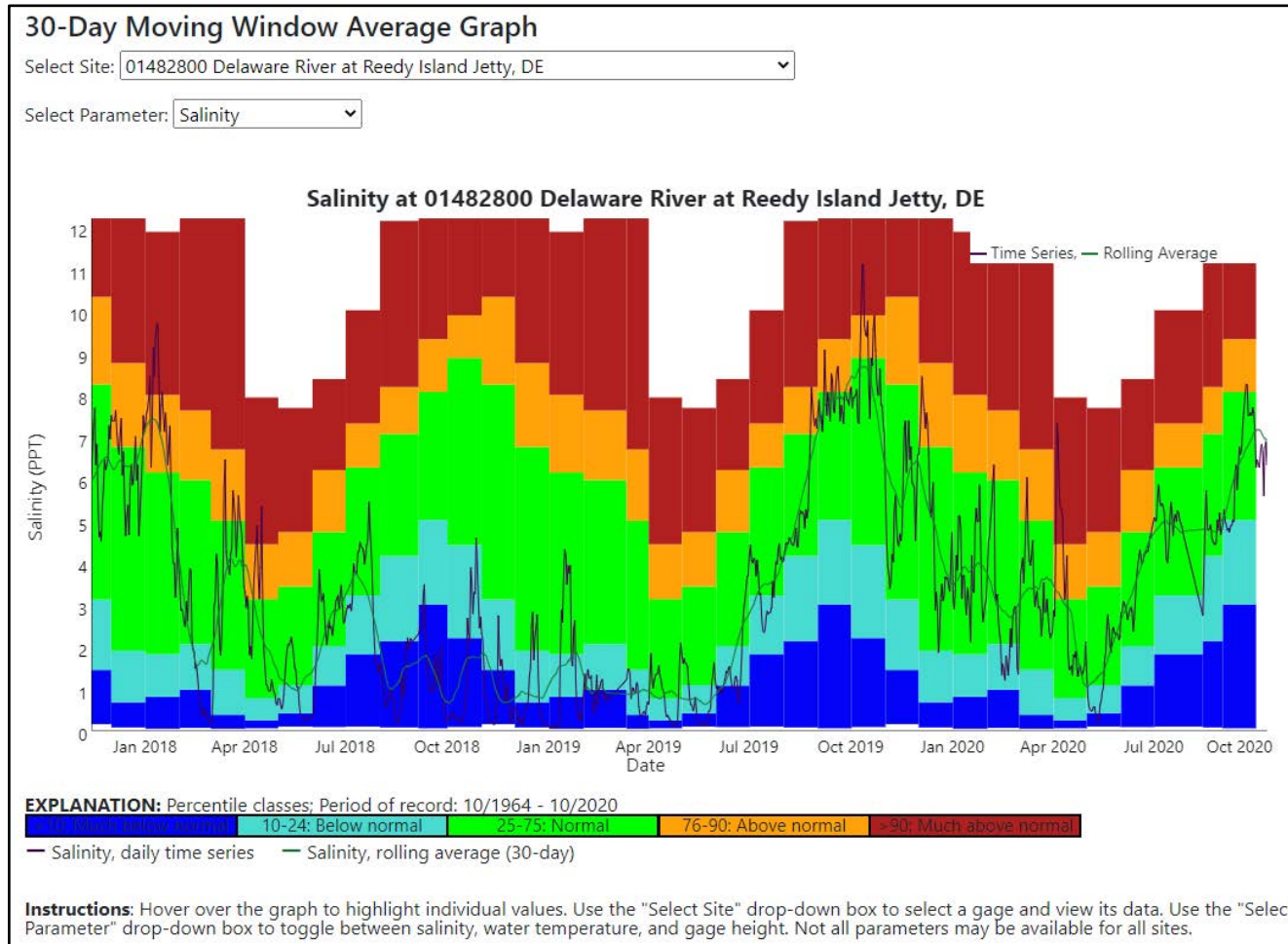
Additional Real-Time Data: Graphs (1)



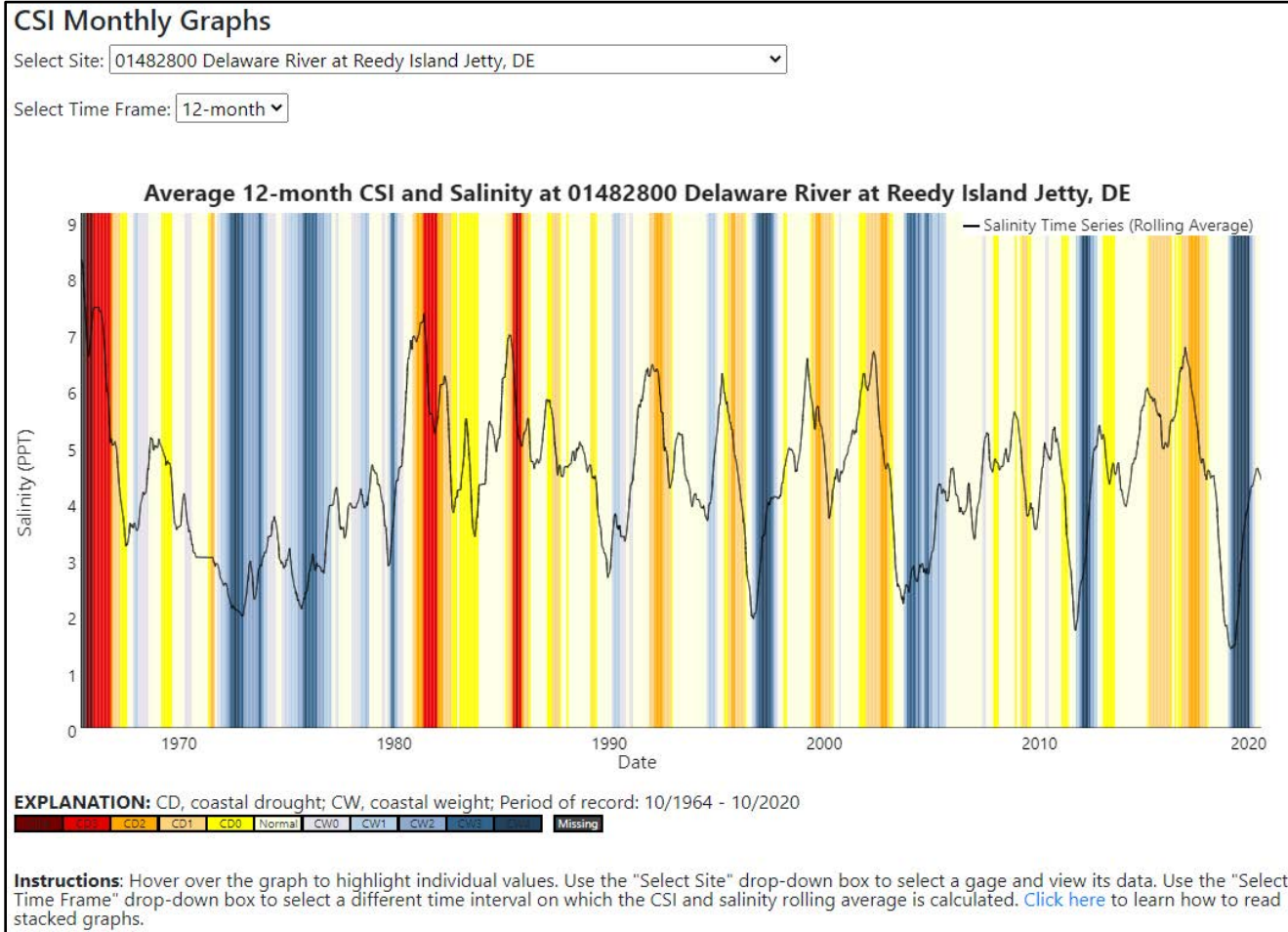
Additional Real-Time Data: Graphs (2)



Additional Real-Time Data: Graphs (3)



Additional Real-Time Data: Graphs (4)



Resources Page

CSI tools and resources

Publications

Project partners, supporters, and funders

USGS
science for a changing world

Coastal Salinity Index [Home](#) [About CSI](#) [Additional Data](#) [Resources](#)

Resources

R Package

An R package was developed for consistency and ease of computation of salinity data. It includes pre-processing, filling missing values, computing the CSI, post-processing, plotting, and generating supporting metadata. This software package is available for download from the [Geological Survey R Archive Network \(GRAN\)](#) or [GitHub](#).

Real-time Data

Real-time CSIs are currently available on this site and the [USGS South Florida Information Access \(SOFIA\) Coastal Everglades Depth Estimation Network \(CEDN\) site](#). These real-time CSIs were selected for USGS National Water Information System (NWIS) stations where long-term specific conductance and salinity data are being collected.

User Guide

Rouen, L.F., Lackstrom, K., Petkewich, M.D., and McCloskey, B.J., 2019. [Coastal Salinity Index: User Guide](#).

Published Data

Petkewich, M.D., McCloskey, B.J., Rouen, L.F., and Conradi, P.A., 2019. [Coastal Salinity Index for Monitoring Drought: U.S. Geological Survey data release](#). <https://doi.org/10.5066/99MQ2H82>.

Conradi, P.A., 2016. [Development of a Coastal Drought Index Using Salinity Data](#). U.S. Geological Survey data release. <http://dx.doi.org/10.5066/7TDT9W08>.

Publications

Petkewich, M.D., Lackstrom, K., McCloskey, B.J., Rouen, L.F., and Conradi, P.A., 2019. [Coastal Salinity Index along the southeastern Atlantic coast and the Gulf of Mexico, 1983 to 2018](#). U.S. Geological Survey Open-File Report 2019-1090, 26 p. <https://doi.org/10.3133/ofr20191090>.

Conradi, P.A., K.D. Rodgers, D.L. Passeri, S.T. Prinos, C. Smith, C.M. Swarzenski, B.A. Middleton, 2018. [Coastal estuaries and lagoons: The delicate balance at the edge of the sea](#), USGS Fact Sheet 2018-3022. <https://doi.org/10.3133/fs20183022>.

Conradi, P.A. and L.S. Darby, 2017. [Development of a Coastal Drought Index Using Salinity Data](#). *Bull. Amer. Meteor. Soc.*, 98, 753-766. <https://doi.org/10.1175/BAMS-D-15-00171.1>.

Nolan, C. B., D.L. Tufford, and D.R. Chalcraft, 2016. [Remote Assessment of Coastal Land Managers for Drought Onset Indicators in the Southeastern United States](#). *Journal of Coastal Research*, 32 (5), 1016-1024. <https://doi.org/10.2112/JCOASTRES-D-15-00182.1>.

Meetings

Lackstrom, K. and Petkewich, M.D. Coastal Salinity Index webinar. 10/17/2019 [[Slideshow \(pdf\)](#), [Audio \(mp3\)](#)]

Related Materials

U.S. Drought Monitor classification applied to NC stream gage sites.

Partners

National Integrated Drought Information System (NIDIS)
The Coastal Carolinas DEWS is supported by NIDIS, an interagency program tasked with improving the nation's capacity to manage and prepare for drought-related risks and impacts.

NOAA's **Regional Integrated Sciences and Assessments (RISA)** program supports research teams that help expand and build the nation's capacity to prepare for and adapt to climate variability and change.

Carolina Integrated Sciences & Assessments (CISA) is one of 11 **Regional Integrated Sciences & Assessments (RISA)** programs in the U.S. and funded by NOAA. These interdisciplinary research teams are designed to help expand and build the nation's capacity to prepare for and adapt to climate variability and change. Established in 2003, CISA works with a variety of organizations in the Carolinas to enhance to region's capacity to plan for and respond to drought. Additional information about CISA's research and activities related to the Coastal Salinity Index.

Acknowledgements

National Oceanic and Atmospheric Administration (NOAA)
National Integrated Drought Information System (NIDIS)
Climate Program Office
Regional Integrated Sciences and Assessments (RISA) programs
U.S. Army Corp of Engineers, Jacksonville District
U.S. Geological Survey (USGS) Greater Everglades Priority Ecosystems Science

Thank you

CSI website link (current website)

<https://www2.usgs.gov/water/southatlantic/projects/coastalsalinity/home.php>

CSI R-package

<https://github.com/USGS-R/CSI>

USGS South Atlantic Water Science Center

Contact Matt Petkewich at mdpetkew@usgs.gov

