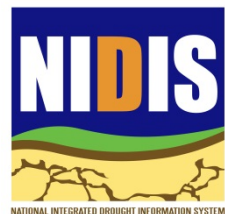


Coastal Salinity Index

Webinar

October 17, 2019



In Honor of

Paul Anthony Conrads

(1957 - 2017)



Outline

- What is the Coastal Salinity Index?
- New products and resources
- Next steps
- Applications



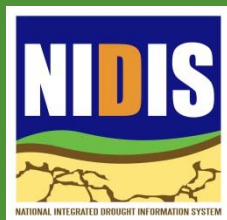
COASTAL SALINITY INDEX

User Guide

v1.0 – February 2019

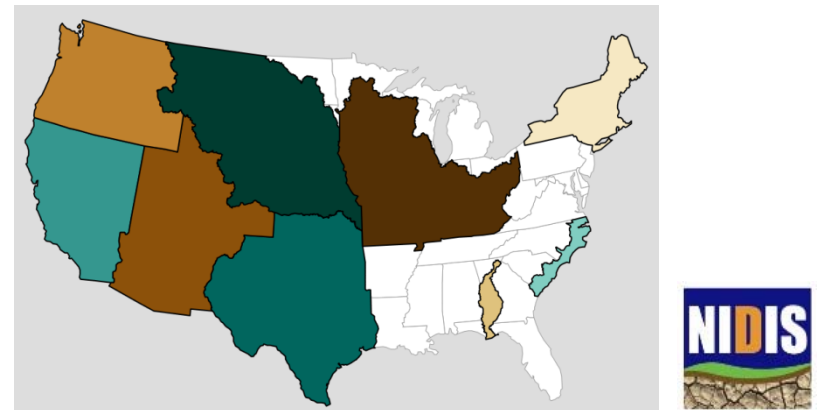
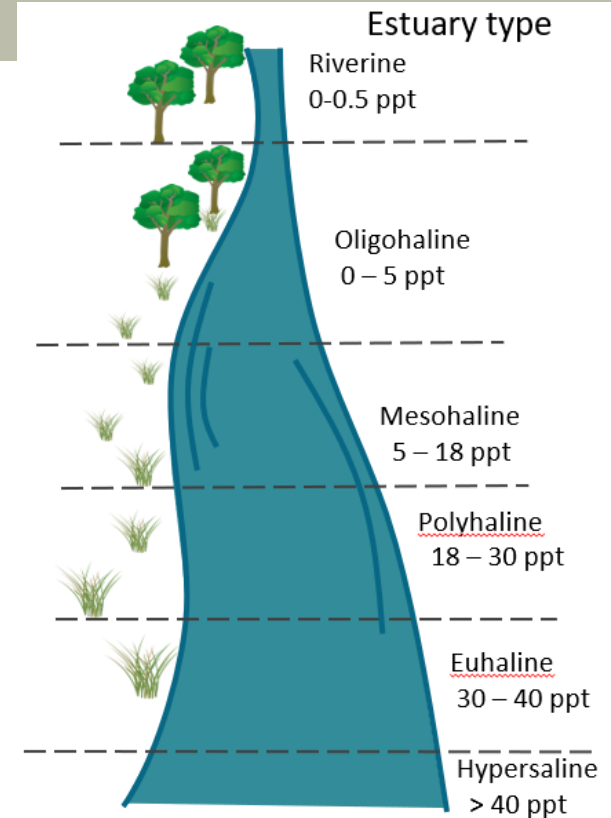
Lauren Rouen, Kirsten Lackstrom, Matthew Petkewich, Bryan McCloskey

https://www2.usgs.gov/water/southatlantic/projects/coastalsalinity/files/CSI_User_Guide.pdf



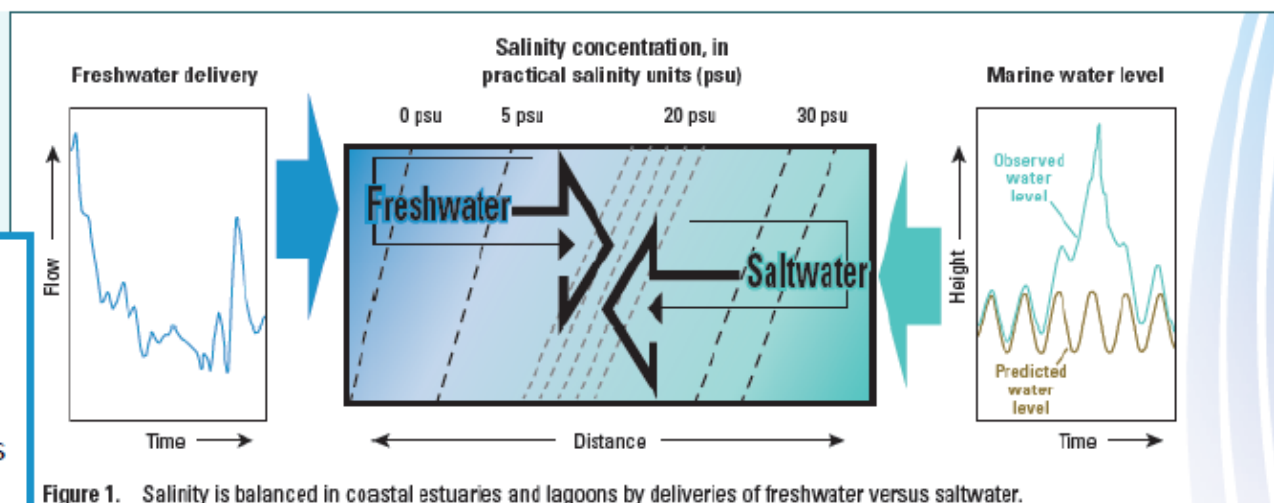
Motivation

- Key stressors during drought: salinity and reduced freshwater availability
- Focus of the Coastal Carolinas Drought Early Warning System (DEWS)
- “Can a unique index be developed to characterize coastal drought?”



Why was the Coastal Salinity Index (CSI) developed?

- Droughts uniquely affect coastal ecosystems and water resources through changes in salinity conditions and the location of the freshwater-saltwater interface.
- Commonly-used drought indices use inputs such as precipitation volume, streamflow, temperature, evaporation, and soil moisture conditions, but these indices do not capture the changing salinity dynamics that affect coastal areas during drought.
- The CSI was developed as a tool to monitor changing salinities in coastal surface water bodies and associated effects on estuarine habitats and freshwater availability for ecological, municipal, and industrial needs.



High precipitation, such as caused by storms, contributes to high flows, causing decreased salinity levels in the estuary.

Low precipitation, such as caused by drought, contributes to low river flows, causing increased salinity levels in the estuary. Wind patterns can also contribute to changes in the location of the freshwater-saltwater interface. 5

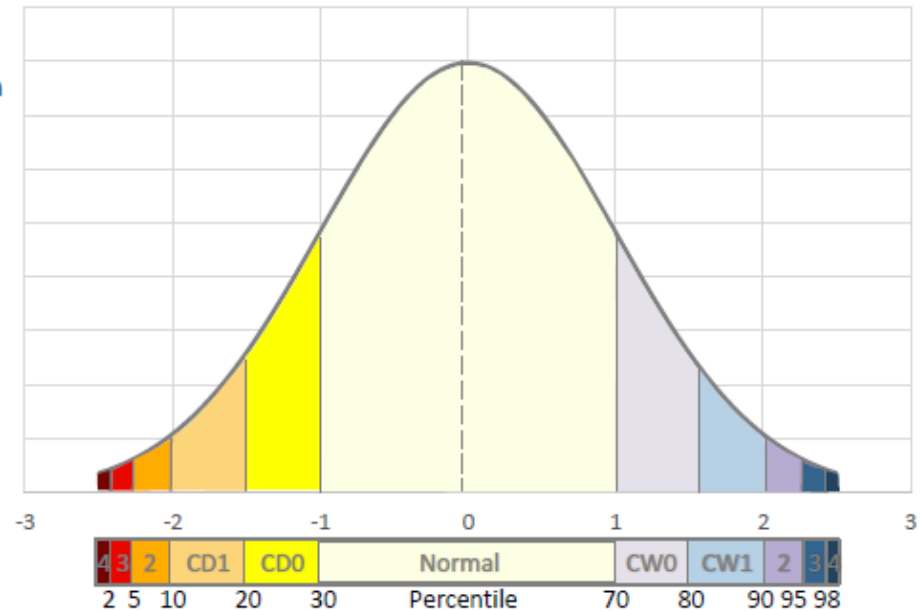
What is the Coastal Salinity Index (CSI)?

- The CSI is a drought index tool that uses salinity data to characterize saline (drought) and freshwater (wet) conditions in coastal surface waters.
- The CSI uses an approach similar to the Standardized Precipitation Index (SPI) to show the probability of recording a given amount of salinity.
- The CSI can be computed for multiple time intervals from 1 to 24 months to characterize short- and long-term conditions.
- The CSI does **not** depict hourly to daily salinity fluctuations, but the response to monthly (and longer) precipitation and streamflow conditions.



How is the CSI calculated?

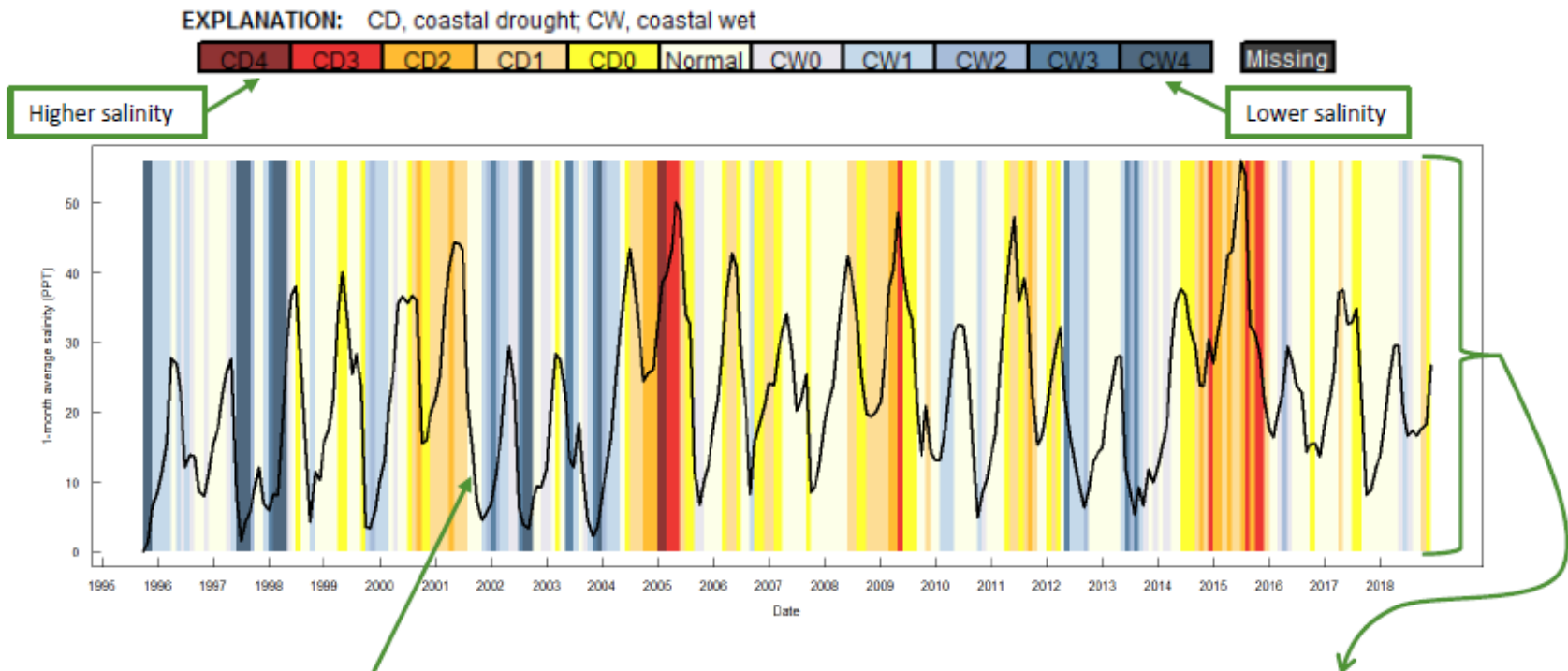
- Monthly mean salinity data are fit to a gamma distribution and then normalized (mean of zero and standard deviation of one).
- Index values are standard deviations from the normalized mean values.
- An index value of zero indicates historical mean salinity.
- Negative and positive values represent increasingly saline and fresh conditions, respectively.
 - CD: Coastal drought
 - CW: Coastal wet
- SPI threshold values were used to develop the coastal drought thresholds and designations.



Coastal Salinity Classification	Description	Icon	Range	CSI Threshold values	Cumulative percentage
CD4	Exceptional salinity conditions	●	$(\infty, -2]$	-2	2
CD3	Extreme salinity conditions	●	$(-2.0 \text{ to } -1.6]$	-1.6	5
CD2	Severe salinity conditions	●	$(-1.6 \text{ to } -1.3]$	-1.3	10
CD1	Moderate salinity conditions	●	$(-1.3 \text{ to } -0.8]$	-0.8	20
CD0	Abnormal salinity conditions	●	$(-0.8 \text{ to } -0.5]$	-0.5	30
Normal	Normal salinity conditions	○	$(-0.5 \text{ to } 0.5]$	0	70
CW0	Abnormal freshwater conditions	●	$(0.5 \text{ to } 0.8]$	0.5	80
CW1	Moderate freshwater conditions	●	$(0.8 \text{ to } 1.3]$	0.8	90
CW2	Severe freshwater conditions	●	$(1.3 \text{ to } 1.6]$	1.3	95
CW3	Extreme freshwater conditions	●	$(1.6 \text{ to } 2.0]$	1.6	98
CW4	Exceptional freshwater conditions	●	$(2, \infty)$	2	100

Creating a stacked CSI plot—step by step

The CSI can be used for short-, medium-, and long-term coastal evaluation depending on the computational interval selected. The computed 1-month CSI (CSI-1) for a location on McCormick Creek (near Key Largo, Fla.) characterizes the short-term salinity conditions.



The black line depicts the average monthly salinity.

Background colors depict the coastal drought classes (CD0 to CD4; yellow-red color ramp) and coastal freshwater classes (CW0 to CW4; blue color ramp), as shown on the legend above. Extended drought periods, such as seen in 2005, and freshwater periods, as seen in 1997–1998, can be quickly identified.

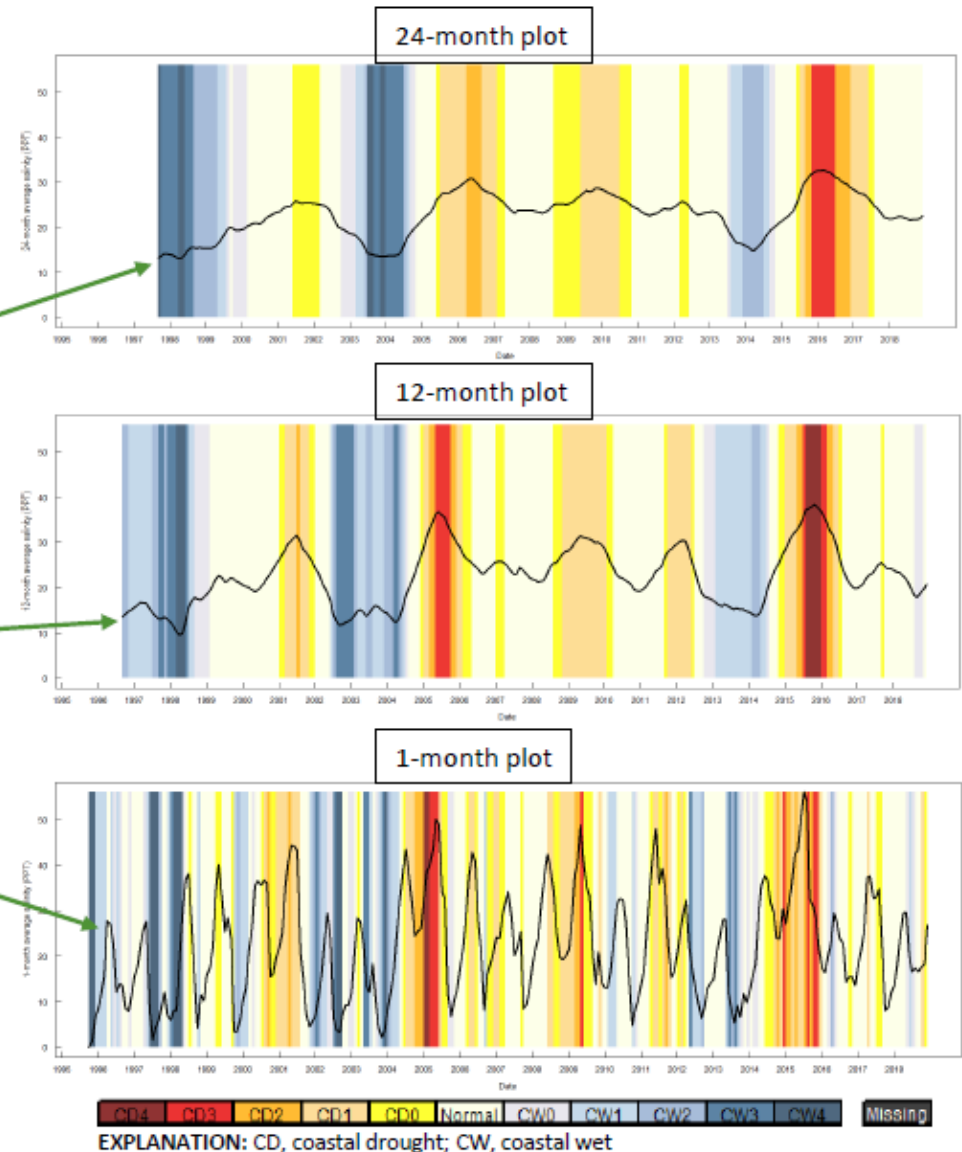
Creating a stacked CSI plot to show short- to long-term conditions

To evaluate medium- and long-term coastal salinity conditions, the CSI can also be computed for 12-month (CSI-12) and 24-month (CSI-24) intervals, respectively.

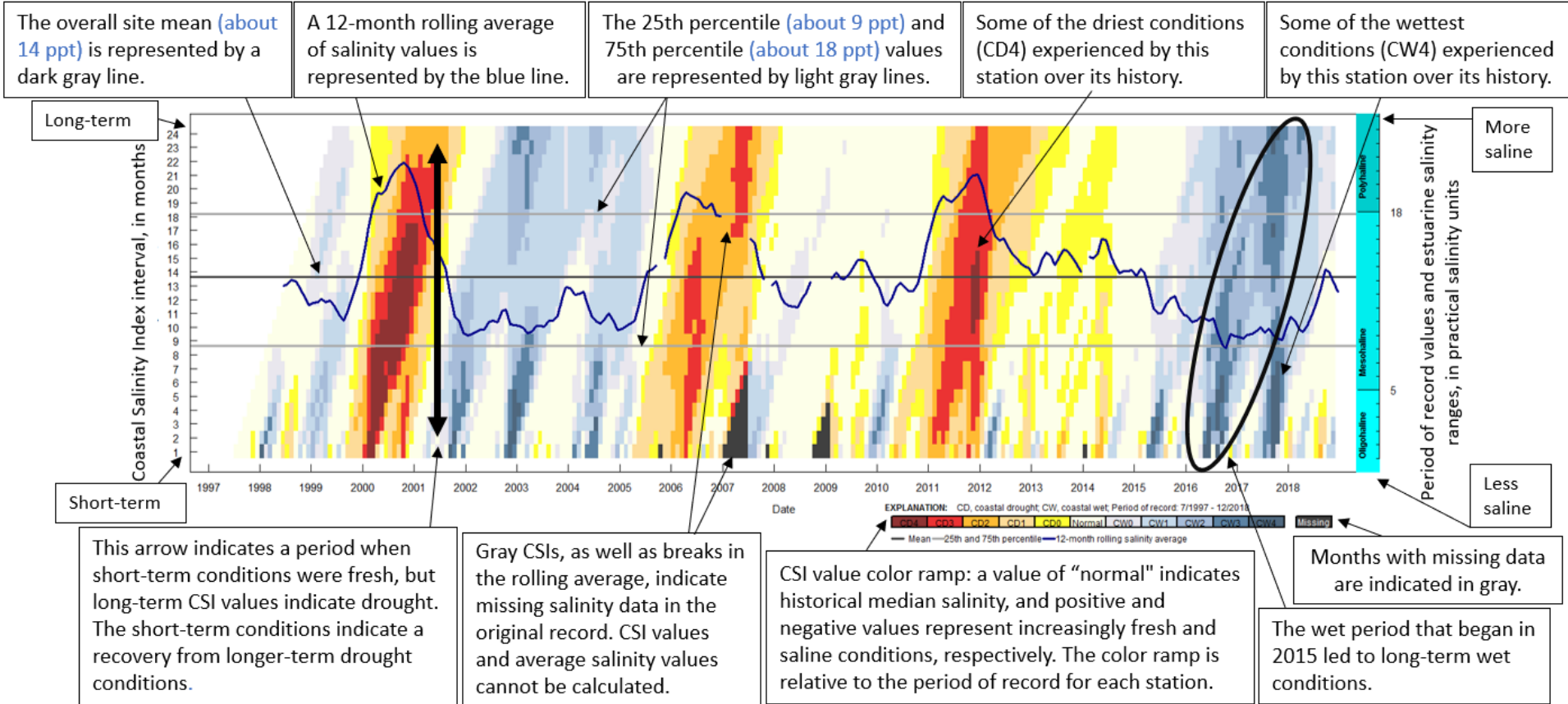
The black line for the CSI-24 shows the 24-month average salinity

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

And for the CSI-1, the 1-month average salinity is shown



Reading the stacked graph (USGS Station 08017095)



New products and resources

- Distributable CSI software package
 - CSI R-package available through GitHub
- Computation of CSIs along Gulf and SE Atlantic Coast
 - Available through the USGS ScienceBase Catalog
- Real-time CSI computation and dissemination
 - 17 stations in NC, SC, and GA available through the USGS South Atlantic Water Science Center website
 - 12 stations in South Florida available through the USGS Coastal Everglades Depth Estimation Network (EDEN) website
- CSI report and User Guide

CSI R-package

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

USGS-R / CSI Unwatch 3 Star 1 Fork 1 README.md

[Code](#) [Issues 0](#) [Pull requests 0](#) [Projects 1](#) [Wiki](#) [Security](#) [Insights](#)

Import timeseries in various formats; interpolate missing data; calculate CSI and related metrics; output CSV and graphical representations.

138 commits 1 branch 0 releases 1 contributor

Branch: master New pull request Create new file Upload files Find file Clone or download

McCloskey Merge branch 'master' of <https://github.com/bmccloskey/CSI> Latest commit 8099f0c 4 minutes ago

R	Bug fix: Start with column 4, not 3, in NA count.	5 days ago
inst/extdata	Import functions added "mindays" parameter -- default 15 -- removing ...	3 months ago
man	"groupedx" parameter added.	3 months ago
tests	CSlimport_daily init	2 years ago
vignettes	added error checking to CSlimport	2 years ago
.Rbuildignore	CSlimport_daily init	2 years ago
.gitignore	Add vignette file to project	2 years ago
.travis.yml	init Travis	2 years ago
CSI.Rproj	Add vignette file to project	2 years ago
DESCRIPTION	Fixes made for low-range second y-axis.	4 months ago
NAMESPACE	Import functions added "mindays" parameter -- default 15 -- removing ...	3 months ago
README.Rmd	update readme file	last year
README.md	Address fixed in readme.	4 minutes ago

CSI

Calculate the monthly Coastal Salinity Index (CSI) for monthly, daily, or interval salinity or specific conductance data for suites of gages.

Installation instructions

To install the CSI package, you must be using R 3.0 or greater and run the following command:

```
devtools::install_github("USGS-R/CSI")
```

Reporting bugs

Please consider reporting bugs and sending questions to bmccloskey@usgs.gov.


coverage unknown build failing

Disclaimer

This software is in the public domain because it contains materials that originally came from the U.S. Geological Survey, an agency of the United States Department of Interior. For more information, see the [official USGS copyright policy](#)

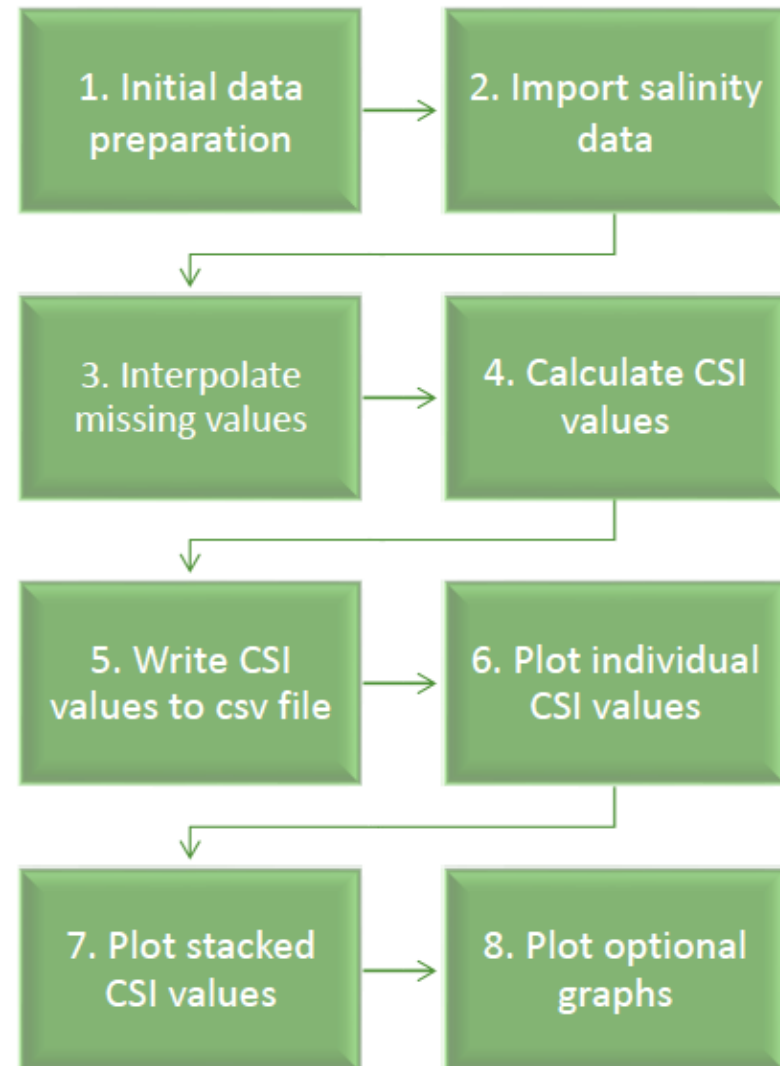
Although this software program has been used by the U.S. Geological Survey (USGS), no warranty, expressed or implied, is made by the USGS or the U.S. Government as to the accuracy and functioning of the program and related program material nor shall the fact of distribution constitute any such warranty, and no responsibility is assumed by the USGS in connection therewith.

This software is provided "AS IS."

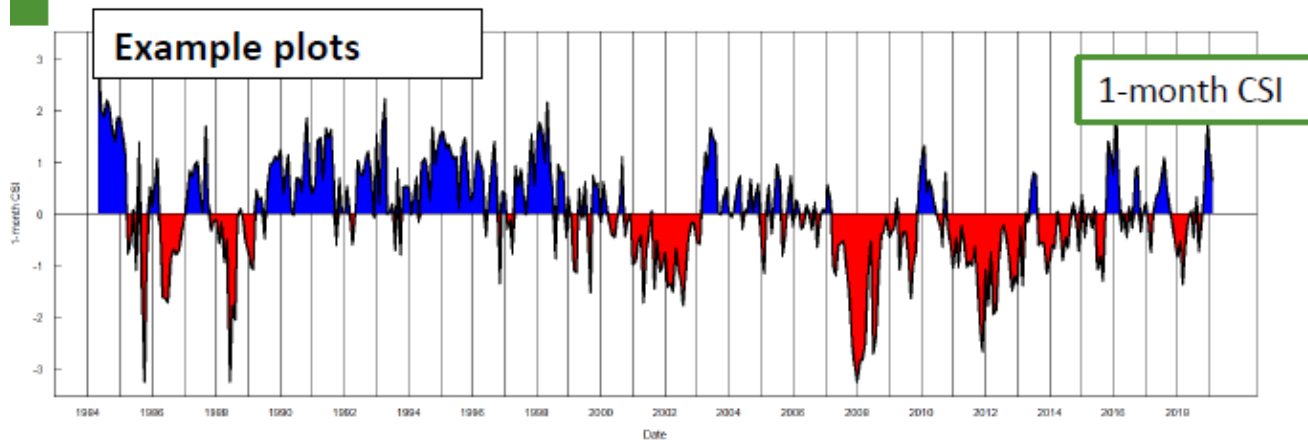


Computing the CSI using the CSI R package—general steps

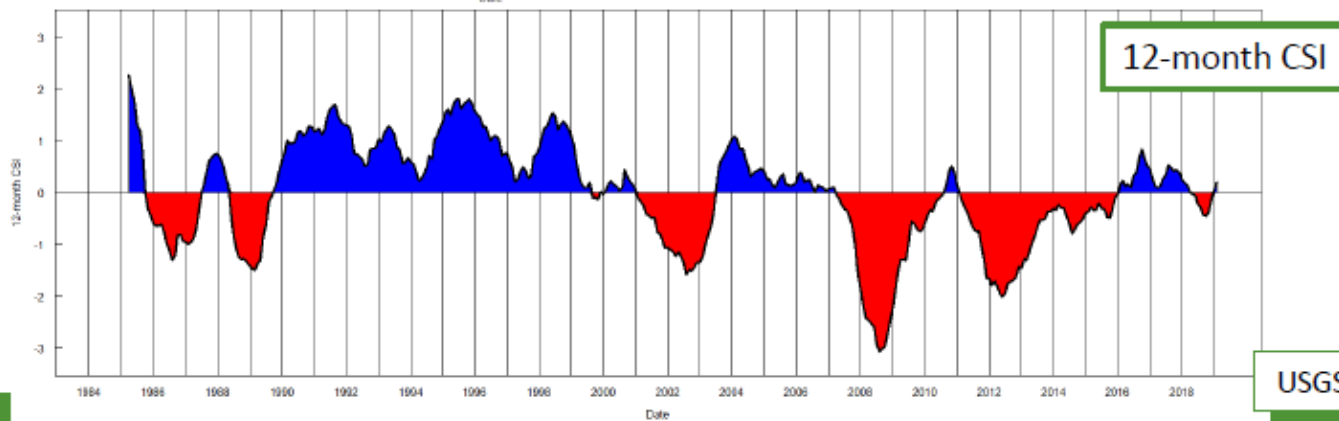
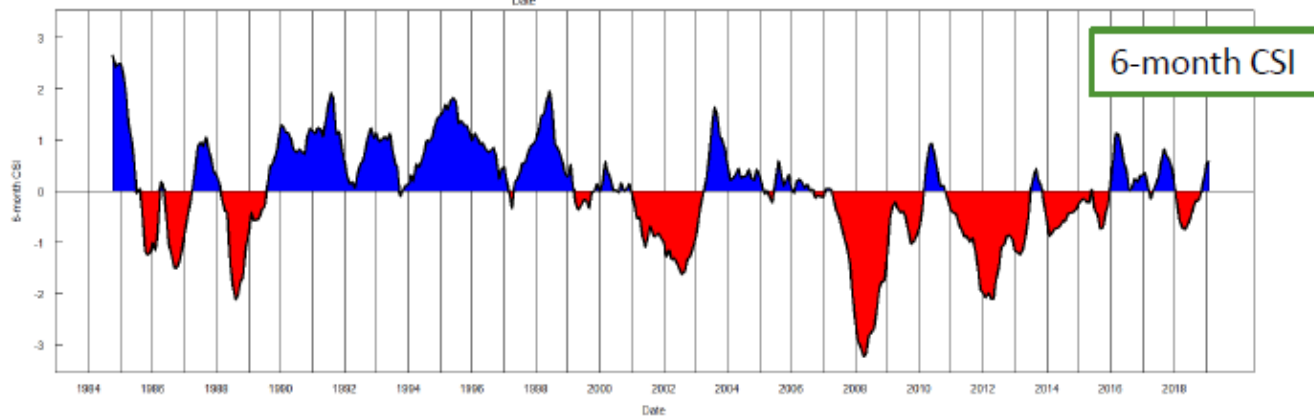
1. Initial data preparation
2. Import salinity data. Any source can be used (some data cleanup may be required—see package documentation for details on input formats). The U.S. Geological Survey (USGS) and National Estuarine Research Reserve System (NERRS) are two good sources of consistent data that have been used to calculate CSIs. Station data may be collected at any frequency from, for example, 6 to 30 minutes to hourly, daily, and so on. Specific conductance data can be converted to salinity within the R package.
3. Estimating missing values by interpolation, if desired
4. Calculate CSI values. Values are calculated for individual stations and are relative to each site.
5. Write CSI values to csv file
6. Plot CSI values on individual plot
7. Plot CSI values on stacked plot
8. Plot optional graphs



R package output—departure from mean plots



Departure from mean plots show wetter-than-average conditions (positive CSI values) in blue, and drier-than-average conditions (negative CSI values) in red.



Historic CSIs

<https://www.sciencebase.gov/catalog/item/5852c109e4b0e2663625ed92>

USGS
science for a changing world

ScienceBase-Catalog Communities Help ▾

Log in

ScienceBase Catalog → USGS Data Release Products → Coastal Salinity Index for Mo...

Coastal Salinity Index for Monitoring Drought

View ▾

Dates

Publication Date : 2019-08-22
Start Date : 1983
End Date : 2018

Citation

Petkewich, M.D., McCloskey, B.J., Rouen, L.F., and Conrads, P.A., 2019, Coastal Salinity Index for monitoring drought, U.S. Geological Survey data release, <https://doi.org/10.5066/P9MQLNL2>.

Summary

To address the data and information gap for characterizing coastal drought, a coastal salinity index (CSI) was developed using salinity data (Conrads 2016; Conrads and Darby, 2017). The CSI uses an approach similar to the Standardized Precipitation Index (SPI), a readily available drought index that is widely used for monitoring meteorological droughts (McKee and others, 1993). The CSI substitutes total monthly precipitation with monthly mean salinity data to determine the probability of recording a given salinity value in a particular month. The initial investigation demonstrated that the index could be used to delineate short- and long-term drought (saline) and wet (high freshwater inflow) conditions; however, to advance the use of the CSI as a general drought monitoring tool, wider-ranging CSI calculations need to be available to the scientific community. To build on the pilot study, the U.S. Geological Survey (USGS), the National Integrated Drought Information System (NIDIS), and collaborators from the Carolinas Integrated Sciences and Assessments (CISA) team identified three general activities to enhance the use and application of the CSI. First, a software package was developed for the consistent computation of the CSI that includes preprocessing of salinity data, filling missing data, computing the CSI, post-processing, and generating the supporting metadata. This software package is available for download from a USGS GitHub repository (<https://github.com/USGS-R/CSI>). Second, the CSI has been computed at sites along the Southeastern Atlantic Ocean (Florida to North Carolina), the Gulf of Mexico (Texas to Florida) and Puerto Rico to increase the opportunity

... show more ...

Contacts

Point of Contact : Matthew D Petkewich
Originator : Bryan J McCloskey, Matthew D Petkewich
Metadata Contact : Matthew D Petkewich
Publisher : U.S. Geological Survey
USGS Mission Area : Water Resources
SDC Data Owner : South Atlantic Water Science Center
Distributor : U.S. Geological Survey - ScienceBase

Map »



Communities

- USGS Data Release Products

Associated Items

- preceded by Development of a Coastal Drought Index Using Salinity Data
- View Associated Items

Tags

Categories : Data
Theme : brackish, ecology, estuary, field monitoring stations, mesohaline, oligohaline, salinity, water quality
Place : Everglades National Park
Harvest Set : USGS Science Data Catalog (SDC)

Provenance

Historic CSIs

<https://www.sciencebase.gov/catalog/item/5852c109e4b0e2663625ed92>

Attached Files

Click on title to download individual files attached to this item or [download all](#) files listed below as a compressed file.

CSI_Station_List.xlsx	20.57 KB
Alabama.zip	2.78 MB
Florida.zip	67.43 MB
Georgia.zip	30.44 MB
Louisiana.zip	29.65 MB
Mississippi.zip	2.38 MB
North Carolina.zip	17.47 MB
Puerto Rico.zip	1.87 MB
South Carolina.zip	58.03 MB
Texas.zip	4.76 MB
ReadMe_CSI_data_release_structure.txt	 4.33 KB
CSI_information_table.pdf	57.35 KB
Coastal_Salinity_Index_for_Monitoring_Drought.xml <i>Original FGDC Metadata</i>	 23.07 KB View
CSI_User_Guide.pdf	1.74 MB

Related External Resources

Type: Web Link

Coastal Salinity Index R package	https://github.com/USGS-EDEW/CSI
Coastal Salinity Index: USGS South Atlantic Water Science Center	https://www2.usgs.gov/water/southatlantic/projects/coastalsalinity/home.php
Coastal Salinity Index: Coastal Everglades Depth Estimation Network (EDEN)	https://sofia.usgs.gov/eden/coastal.php

Purpose

The data were collected in the field under the (1) U.S. Geological Survey (USGS), (2) National Estuarine Research Reserve System (NERRS), (3) Georgia Coastal Ecosystems Long Term Ecological Research (LTER), and (4) Lower Colorado River Authority (LCRA) stream gaging programs to meet the needs of the collection agency and any cooperating agency for each gage. To advance the use of the Coastal Salinity Index (CSI) as a drought monitoring tool, CSI calculations need to be made available to the scientific community.

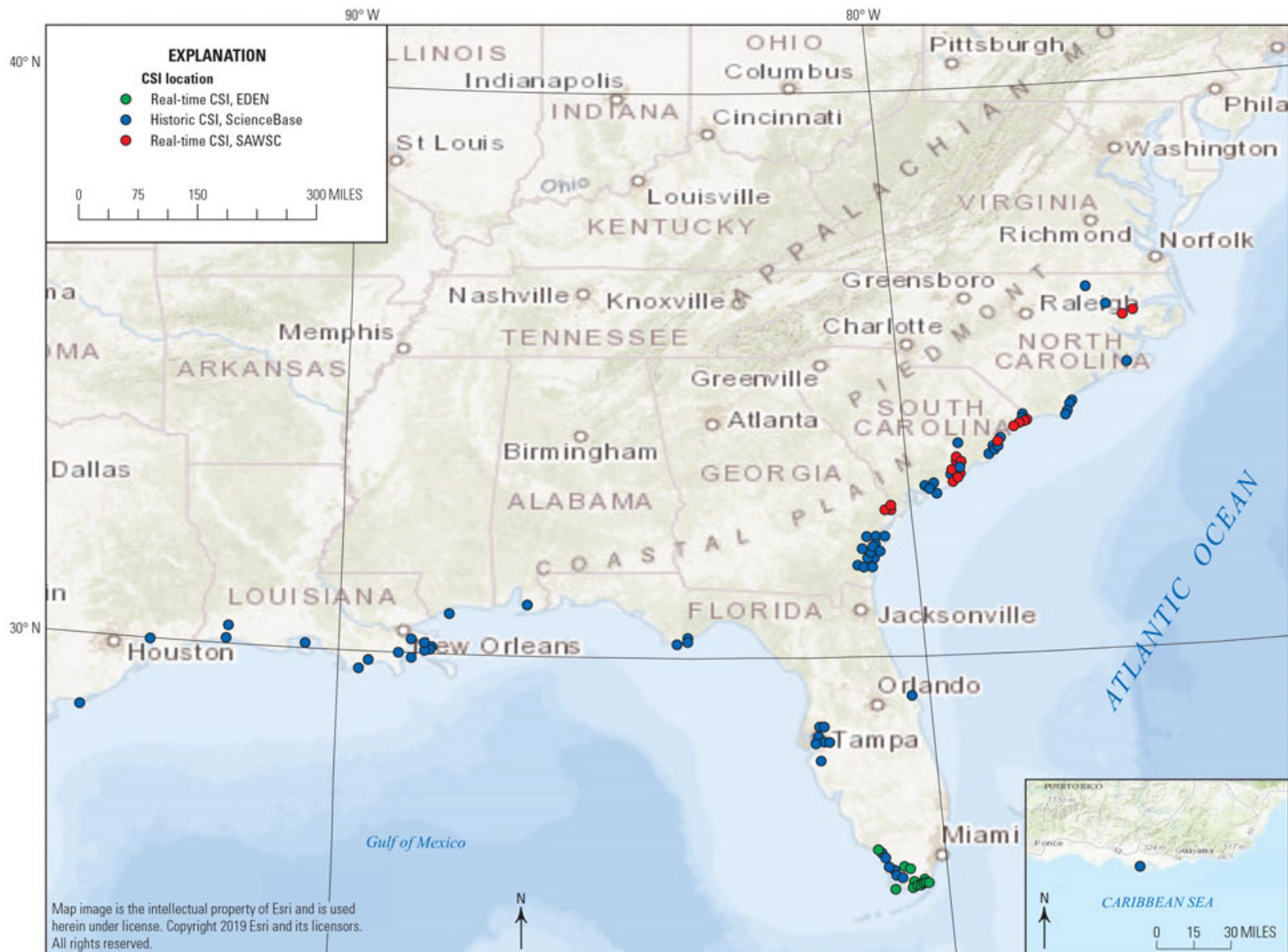
Additional Information

Identifiers

Type	Scheme	Key
DOI	https://www.sciencebase.gov/vocab/category/item/identifier	doi:10.5066/P9MQLNL2

Historic CSI

The historic CSIs calculations for prioritized sites are available through the USGS ScienceBase Catalog <https://www.sciencebase.gov/catalog/item/5852c109e4b0e2663625ed92>.



Caption: Locations of the salinity-monitored water-quality sites used in the Coastal Salinity Index calculations.

Real-time CSIs

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

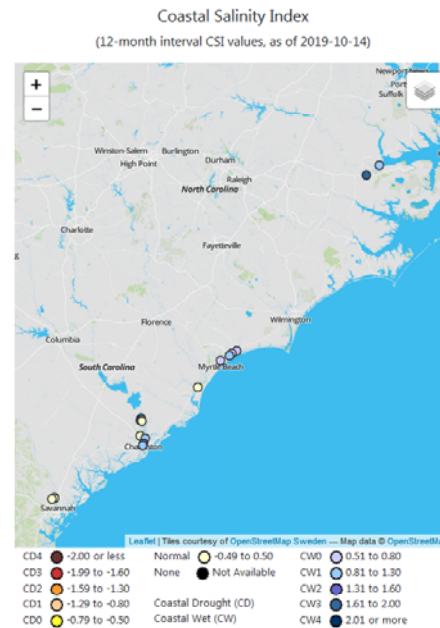
Coastal Salinity Index: CSI Home

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 Coastal Salinity Index (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.

Click on the station icon to access the following information:

- The station identification **number**, station **name** and a **link** to the National Water Information System (NWIS) station current conditions page data.
- The current **CSI 12-month interval value**.
- The **CSI stacked graph** that allows the user to evaluate short (1-month) to long- (24-month) conditions in one graph. Go to the [About the CSI](#) tab to learn how to read and interpret the CSI stacked graph.
- A link to **all the CSI graphs** for that particular gage.

[Explanation for stacked graph.](#)



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 (see table 1 on [About the CSI](#) tab).

The map on this page shows real-time CSI calculations (12-month interval) for 17 USGS-operated stations in North Carolina, South Carolina, and Georgia. The data used on this site come from the USGS NWIS database. All real-time data are provisional and subject to revision.

Salinity index values are calculated at the end of the day; the displayed values on the map are for the previous day (2019-10-14).

For more information about the development of this index, see [About the CSI](#).

Questions or problems with the web pages? Contact rsyoung@usgs.gov.

Questions concerning CSI? Contact mdpetkew@usgs.gov.

South Atlantic CSI Gages

Input Salinity Data [\[one file for all gages\]](#)
Hover mouse over Station Number to identify icon on the map

Station Number	Station Name	Output CSI Data
0208114150	ROANOKE RIVER AT NC 45 NR WESTOVER, NC	0208114150.csv
02081094	ROANOKE RIVER AT JAMESVILLE, NC	02081094.csv
02110777	ANW AT HIGHWAY 9 AT NIXONS CROSSROADS, SC	02110777.csv
02110770	ANW AT GRAND STRAND AIRPORT N, MYRTLE BEACH, SC	02110770.csv
02110755	ANW AT BRIARCLIFFE ACRES AT N, MYRTLE BEACH, SC	02110755.csv
02110760	ANW @ MYRTLEWOOD GOLF COURSE @ MYRTLE BEACH, SC	02110760.csv
02130815	WACCAMAW R NR HAGLEY LAND, NR PAWLEYS ISLAND, SC	02130815.csv
02172020	W BRANCH COOPER R @ PIMLICO NR MONCKS CORNER, SC	02172020.csv
02172040	BACK RIVER AT DUPONT INTAKE NR KITTREDDGE, SC	02172040.csv
02172050	COOPER R NR GOOSE CREEK, SC	02172050.csv
021720677	COOPER RIVER @ FILBIN CREEK @ NORTH CHARLESTON, SC	021720677.csv
021720698	WANDO RIVER ABOVE MT PLEASANT, SC	021720698.csv
021720709	COOPER RIVER AT U.S. HWY 17 AT CHARLESTON, SC	021720709.csv
021720710	COOPER RVR @ CUSTOMS HOUSE (AUX) @ CHARLESTON, SC	021720710.csv
021989784	L BACK RIVER ABOVE LUCKNOW CANAL, NR LIMEHOUSE, SC	021989784.csv
021989791	LITTLE BACK RIVER AT F&W DOCK, NEAR LIMEHOUSE, SC	021989791.csv
02198920	SAVANNAH RIVER AT GA 25, AT PORT WENTWORTH, GA	02198920.csv

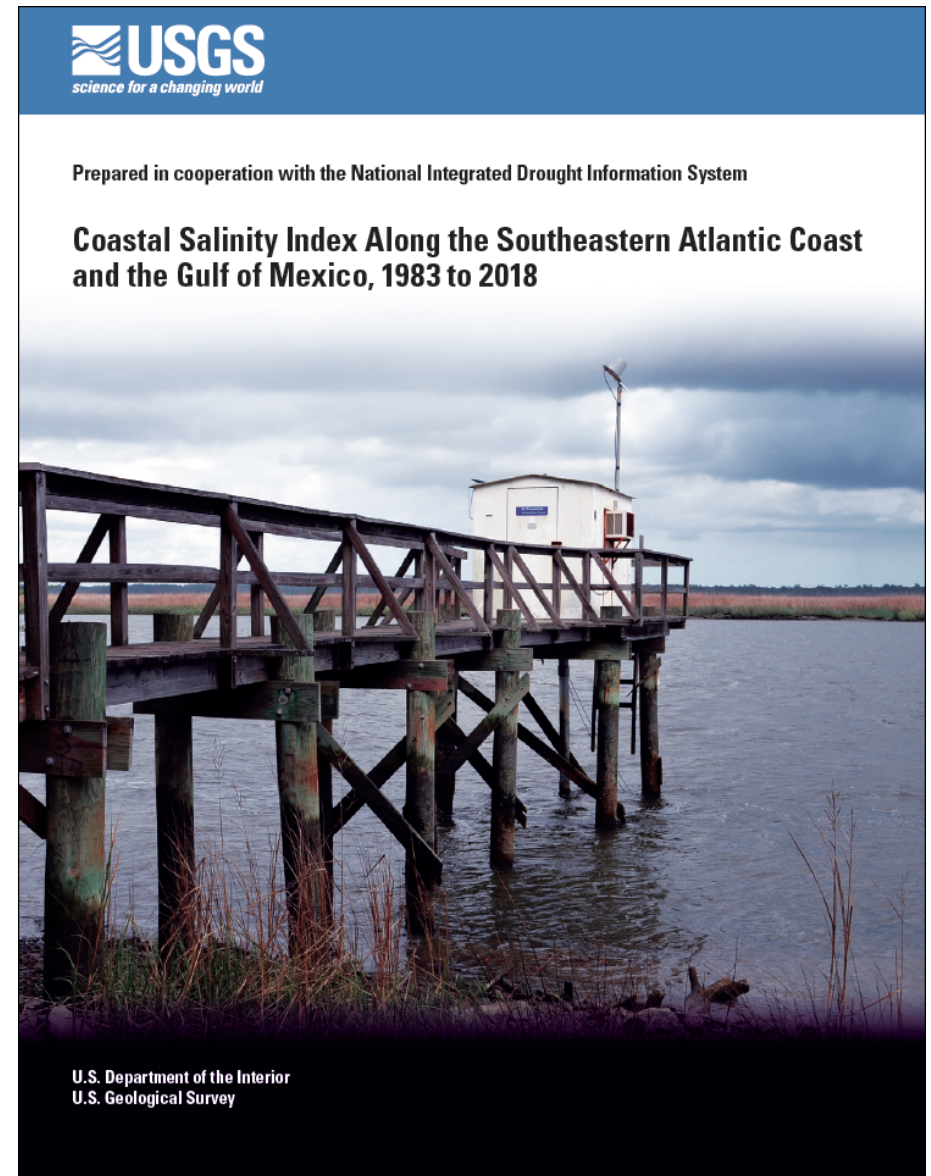
Coastal Salinity Index (CSI) Information

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

Open-File Report

<https://pubs.usgs.gov/of/2019/1090/ofr20191090.pdf>

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



Next steps and future plans

- Proposals to USGS and NOAA-NIDIS
- Expand the real-time CSI network
 - East coast, Gulf of Mexico
- Case studies to:
 - Analyze drought, salinity, and ecological linkages
 - Identify critical thresholds and decision points
 - Evaluate use for resource and drought management



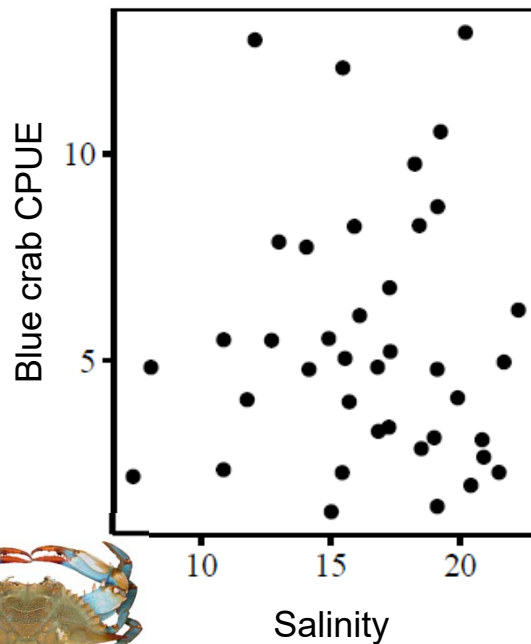
Applications, examples and updates from:

- Mike Kendrick (SCDNR)
- Dani Weissman (Univ. of Maryland)

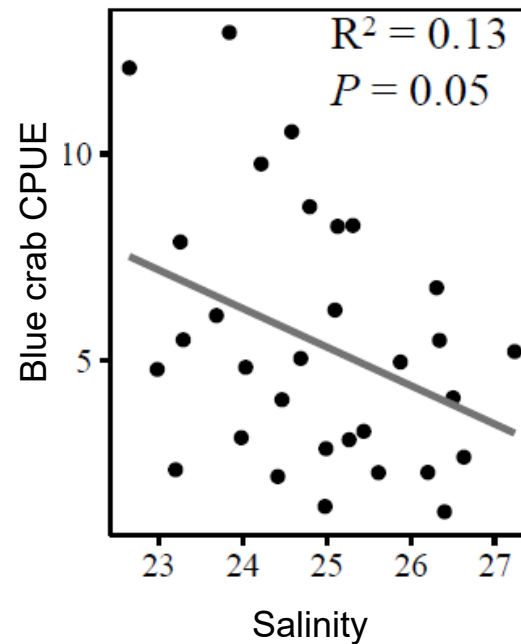
Using an integrated salinity metric to predict blue crab abundance



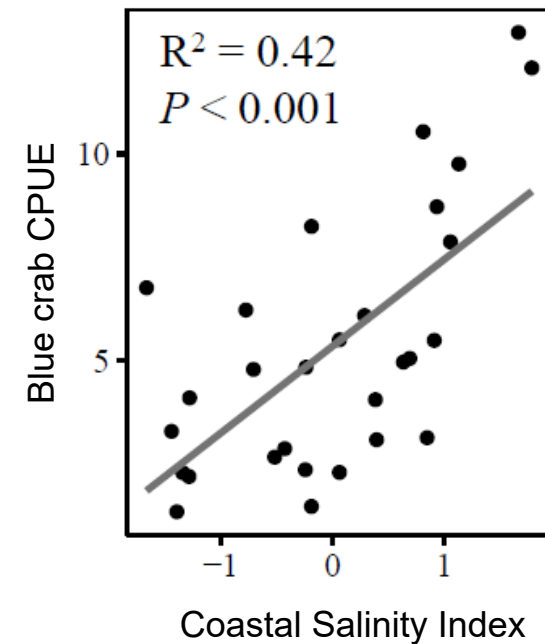
YSI Annual Salinity



USGS annual salinity



CSI 24-month

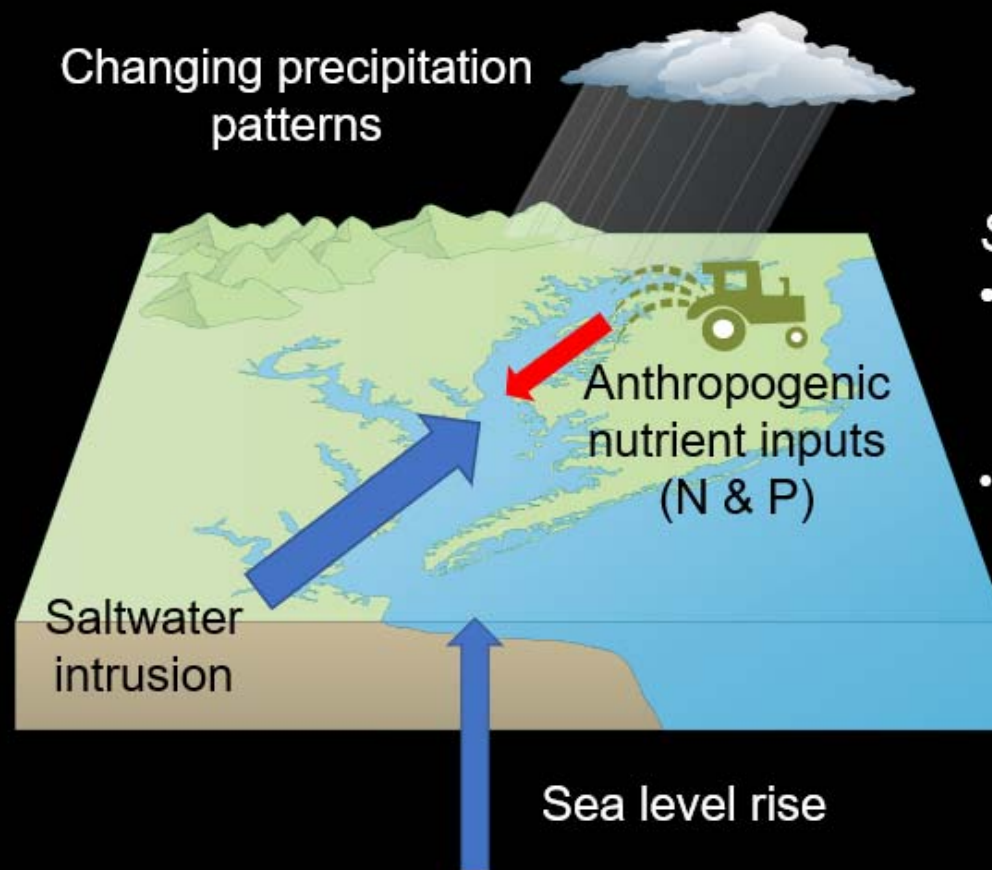


Czwartacki and Kendrick,
unpubl.

Linking coastal drought conditions to nutrient concentrations through salinity measurements in the Chesapeake Bay

Dani Weissman – University of Maryland

Drivers of nutrient inputs to the estuary:



Images from <https://ian.umces.edu> image library

Monthly time scales:

- How well does salinity correlate with N and P concentrations at monitoring stations?

Seasonal to interannual time scales:

- Does the CSI correlate more strongly with N and P concentrations than salinity?
- *Preliminary data: in some cases, yes.*

Can extreme saltwater intrusion events as indicated by the CSI shift the dominant driver of nutrient inputs in some tidal tributaries?

Questions and Discussion

USGS South Atlantic Water Science Center

Contact Matt Petkewich at mdpetkew@usgs.gov

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

Carolinas Integrated Sciences & Assessments (CISA)

Contact Kirsten Lackstrom at lackstro@mailbox.sc.edu

https://cisa.sc.edu/projects_salinity.html

