Salt Influx from Land and Sea

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Freshwater faces a warmer and saltier future from headwaters to coasts: climate risks, saltwater intrusion, and biogeochemical chain reactions

Biogeochemistry

Aims and scope →

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Overview

1. **Freshwater Faces a Saltier Future**

2. **Climate Variability Amplifies Salinity Risks**

3. **Double Trouble: Salt from Land and Sea**

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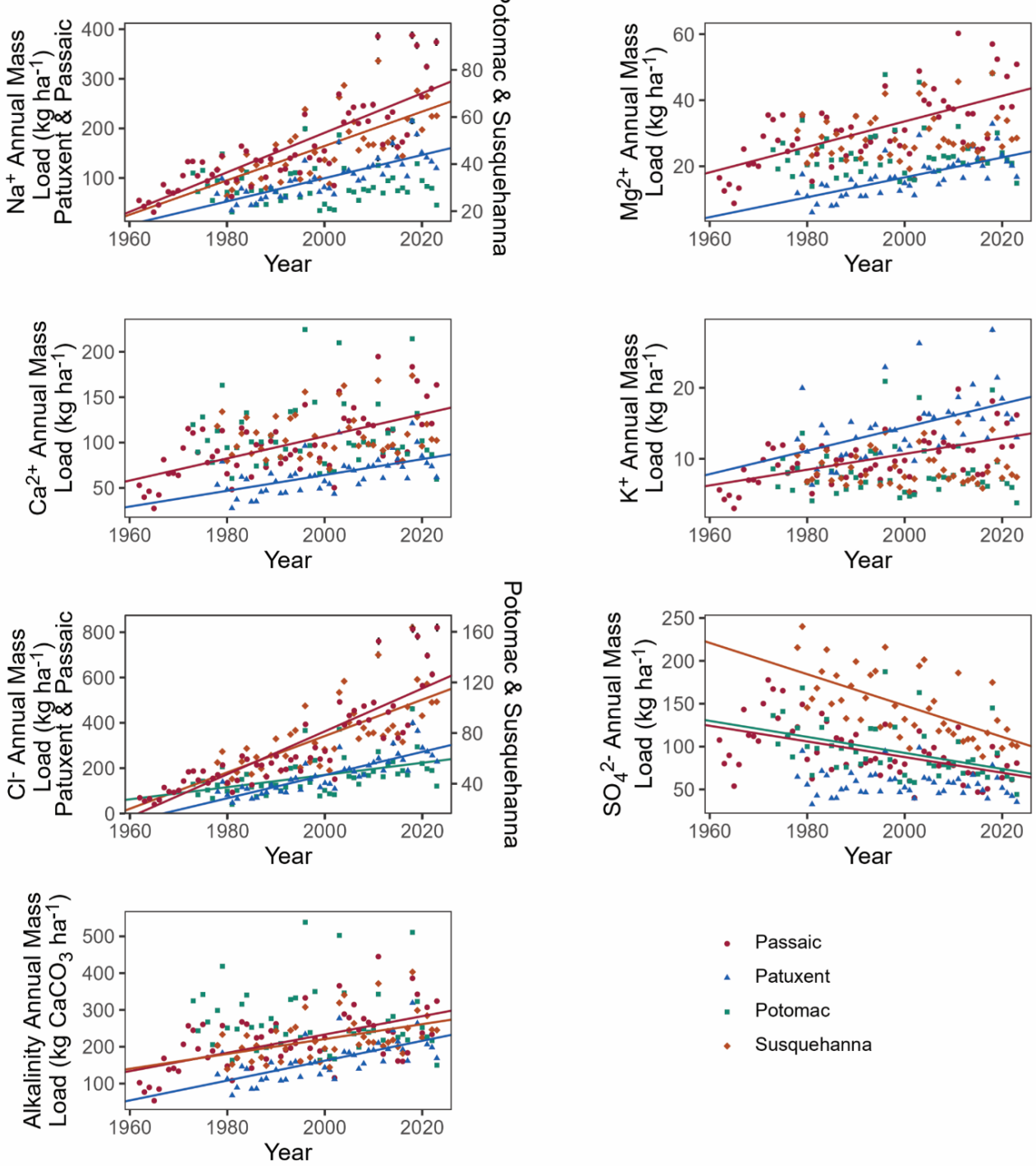


Freshwater Faces a Saltier Future

-Increasing salt loads in rivers

-Increasing water hardness

-Increasing corrosion potential

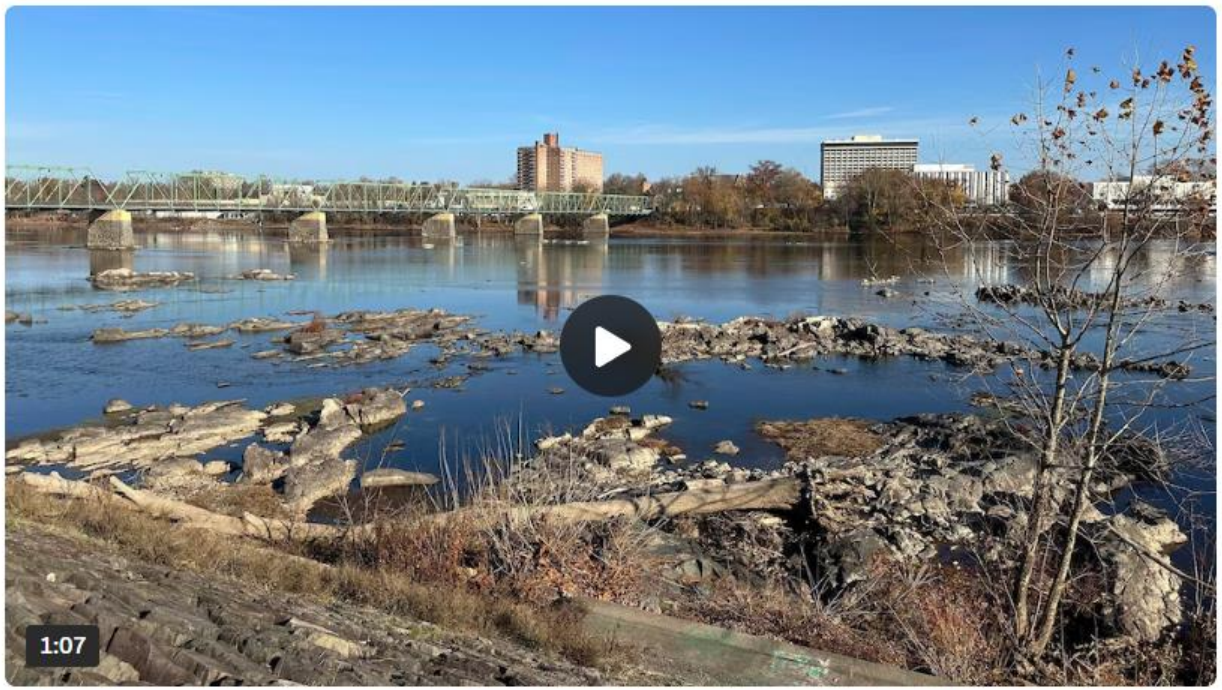
Kaushal et al. (2025)

abc NEWS Video Live Shows Shop

Ocean salt water entering Delaware River due to drought and sea level rise, water managers say

Drinking water is not yet impacted, but officials are taking urgent measures.

By Julia Jacobo, Daniel Manzo, and Daniel Peck
November 27, 2024, 5:14 PM



Drought causing saltwater to enter Delaware River More than 17 million people get their drinking water from the Delaware River basin, according to environmental nonprofit American Rivers.

Officials again monitoring salt water in Mississippi River as possible drinking water threat

Chelsea Brasted

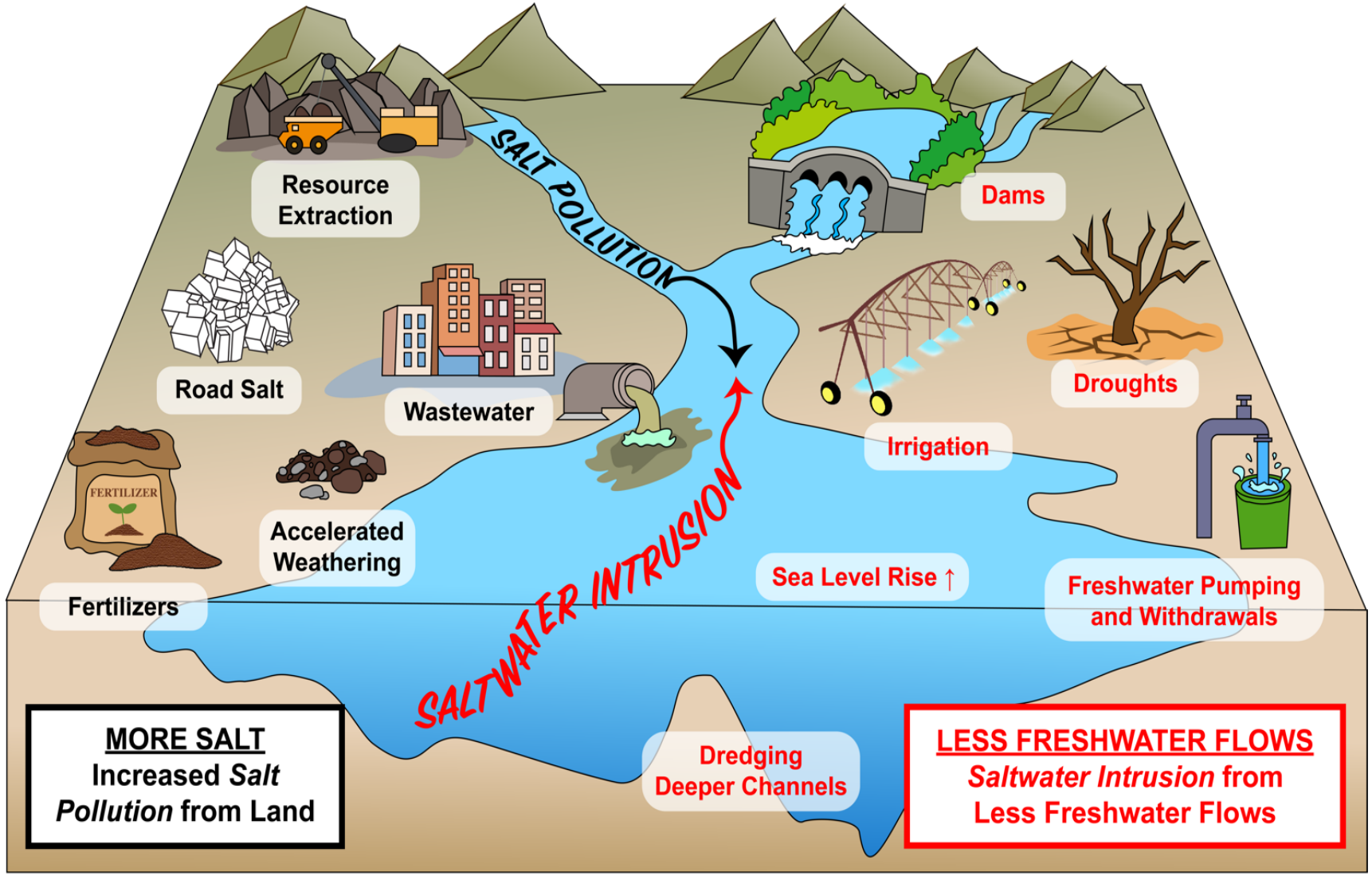
U.S. Army Corp of Engineers vessels move silt on the Mississippi River onto an underwater sill to slow the flow of saltwater intrusion Oct. 9, 2023, in Belle Chasse. Photo: Justin Sullivan/Getty Images

Salt water is again creeping its way up the Mississippi River, reprising its role as southeast Louisiana's late-summer boogeyman.

Why it matters: Most communities get their drinking water from the Mississippi River, and the salt threatens that ability.

The latest: The Army Corps of Engineers measured the salt water "toe," or leading point, at river mile 23.6 late last week, creeping north by a mile and a half over about two days, according to Army Corps spokesman Matt Roe.

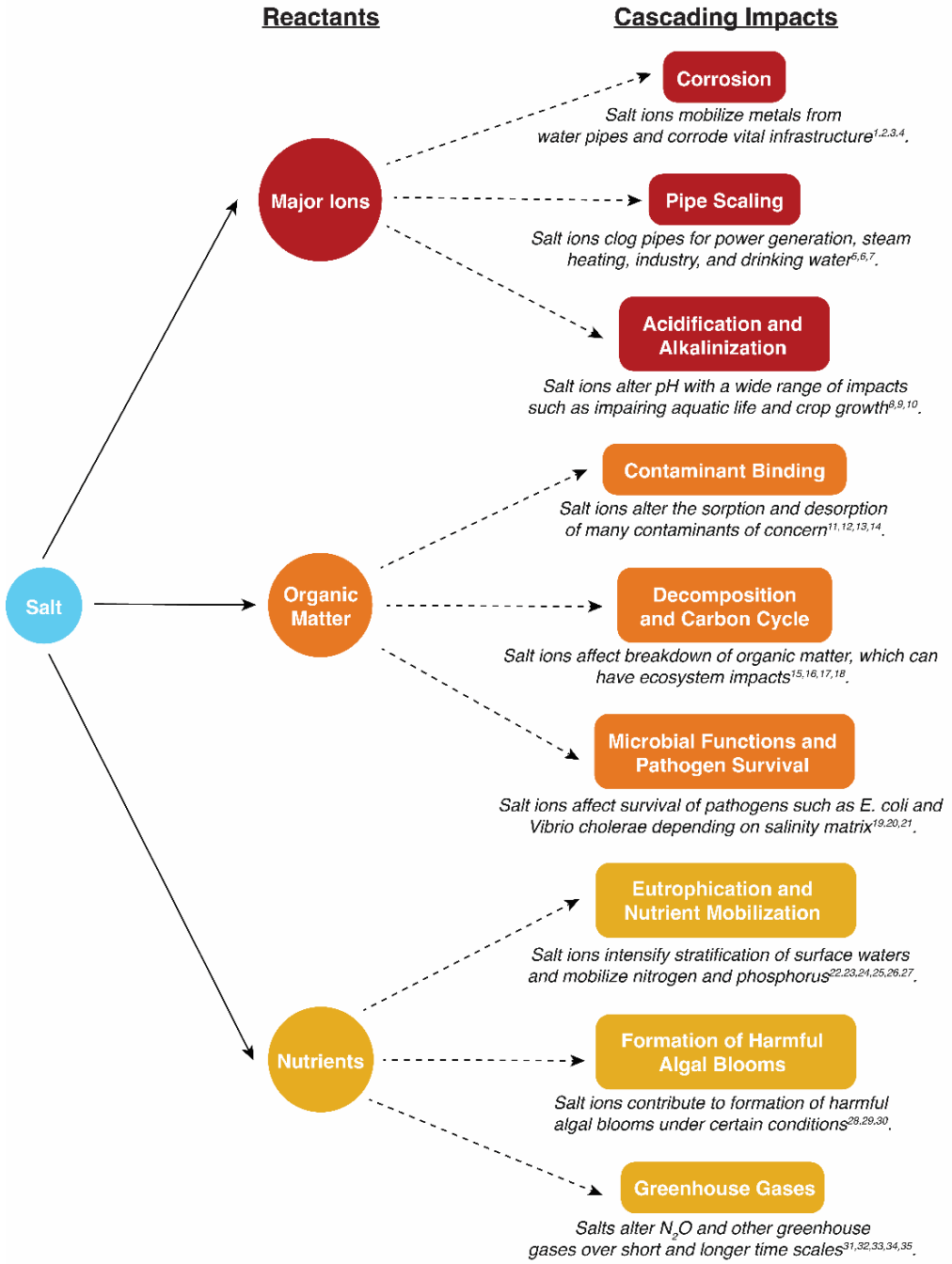
DOUBLE TROUBLE



Salinization from Both Land and Sea

Kaushal et al. (2025)

Salinization Chain Reaction Risks



Potomac Conservancy

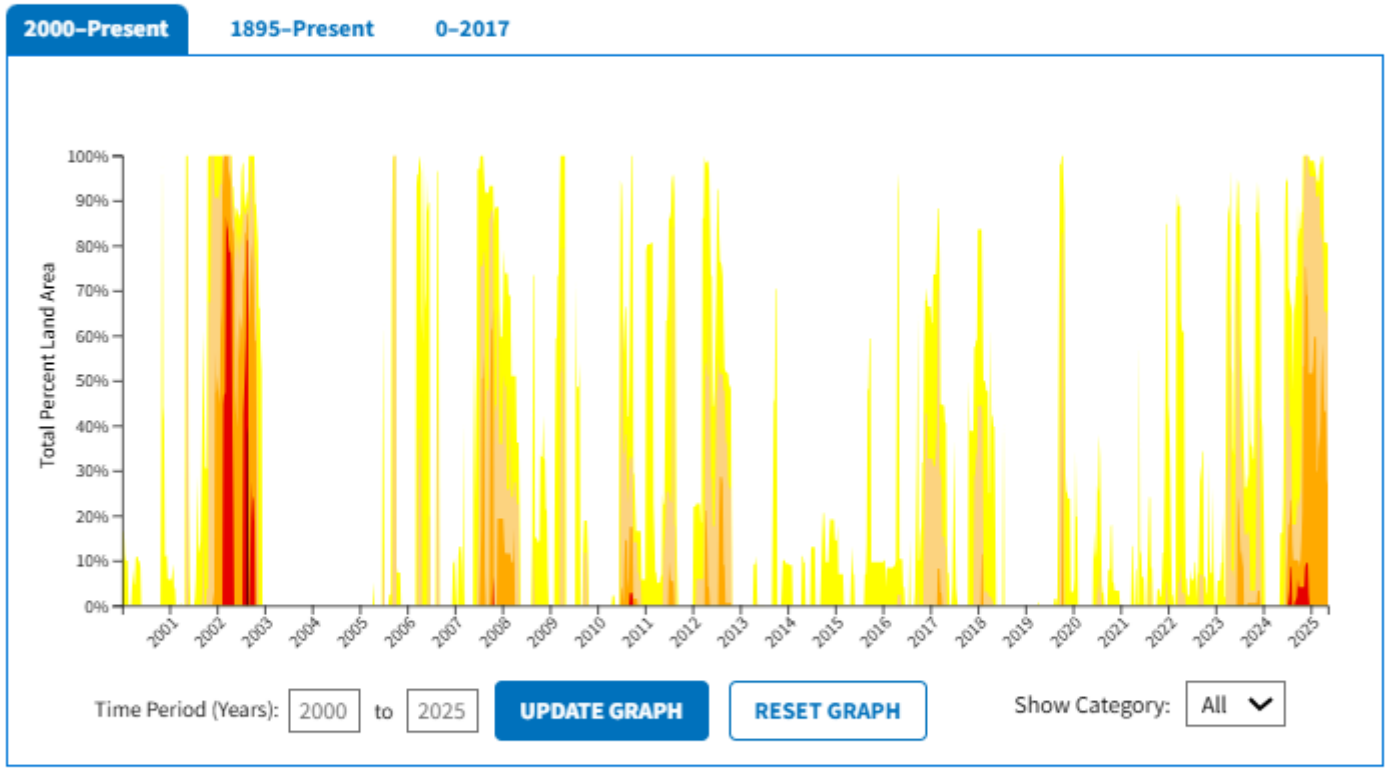
Alexandria Economic Development Partner...
Potomac River Generating Station - AE...

Kaushal et al. (2025)

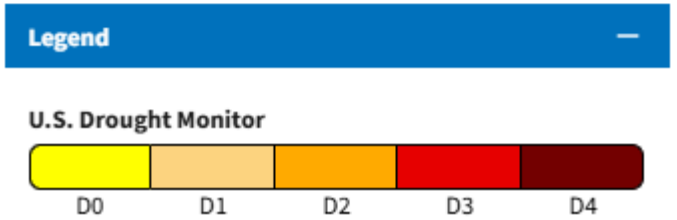
2. Climate Variability Amplifies Salinity Risks

Historical Drought Conditions in Maryland

Drought is a normal climate pattern that has occurred in varying degrees of length, severity, and size throughout history. Below, you can look back at past drought conditions for Maryland according to 3 historical drought indices. The U.S. Drought Monitor is a weekly map that shows the location and intensity of drought across the country since 2000. The Standardized Precipitation Index (SPI) is a monthly depiction of drought based on precipitation (with data going back to 1895). And the paleoclimate data uses tree-ring reconstructions to estimate drought conditions before we had widespread instrumental records, going back to the year 0 for some parts of the U.S. View more historical conditions.



The U.S. Drought Monitor (2000–present) depicts the location and intensity of drought across the country. Every Thursday, authors from NOAA, USDA, and the National Drought Mitigation Center produce a new map based on their assessments of the best available data and input from local observers. The map uses five categories: Abnormally Dry (D0), showing areas that may be going into or are coming out of drought, and four levels of drought (D1–D4). Learn more.



Potomac River levels dropping as drought expands across D.C. area again

Water supply is sufficient for now, but Potomac River flow rates are low and the water tastes funny

June 15, 2023

4 min

The Potomac River in Point of Rocks, Md., is pictured Monday, when the flow rate got low enough to trigger daily monitoring. (Craig Hudson for The Washington Post)

D.C.

D.C. region under drought watch as officials advise limiting water use

Officials says short showers and other limits on water use can help the region as heat continues.

July 29, 2024

3 min 109

The White's Ferry boat launch ramp area is a popular place for locals to enjoy the cool waters of the Potomac River in Poolesville. (Michael S. Williamson/The Washington Post)

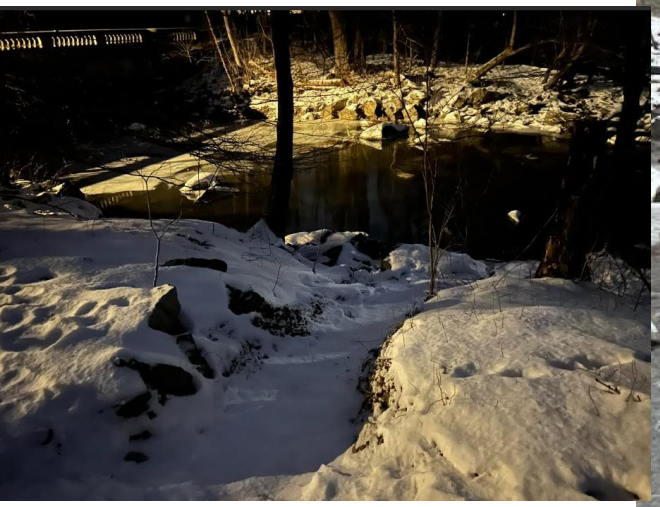
Officials eye Potomac water levels for drought preparations

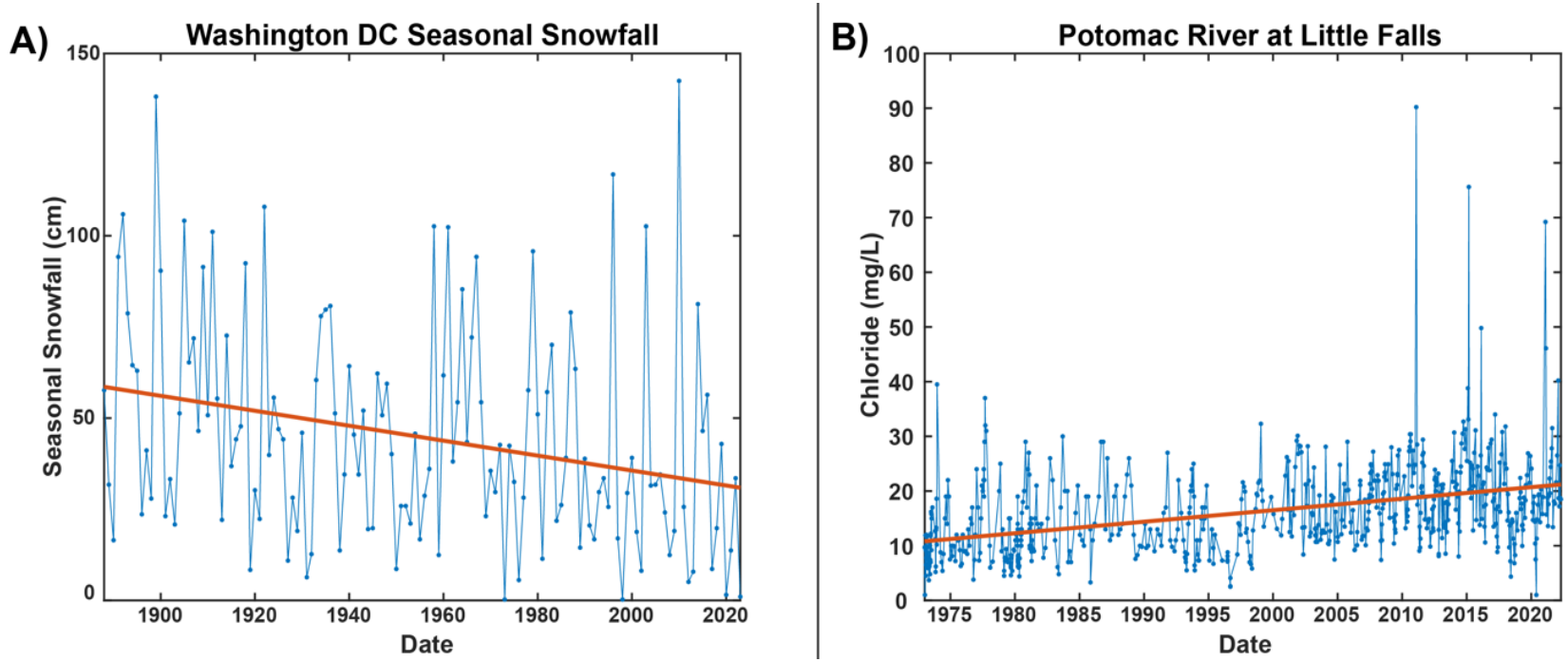
September 1, 2023

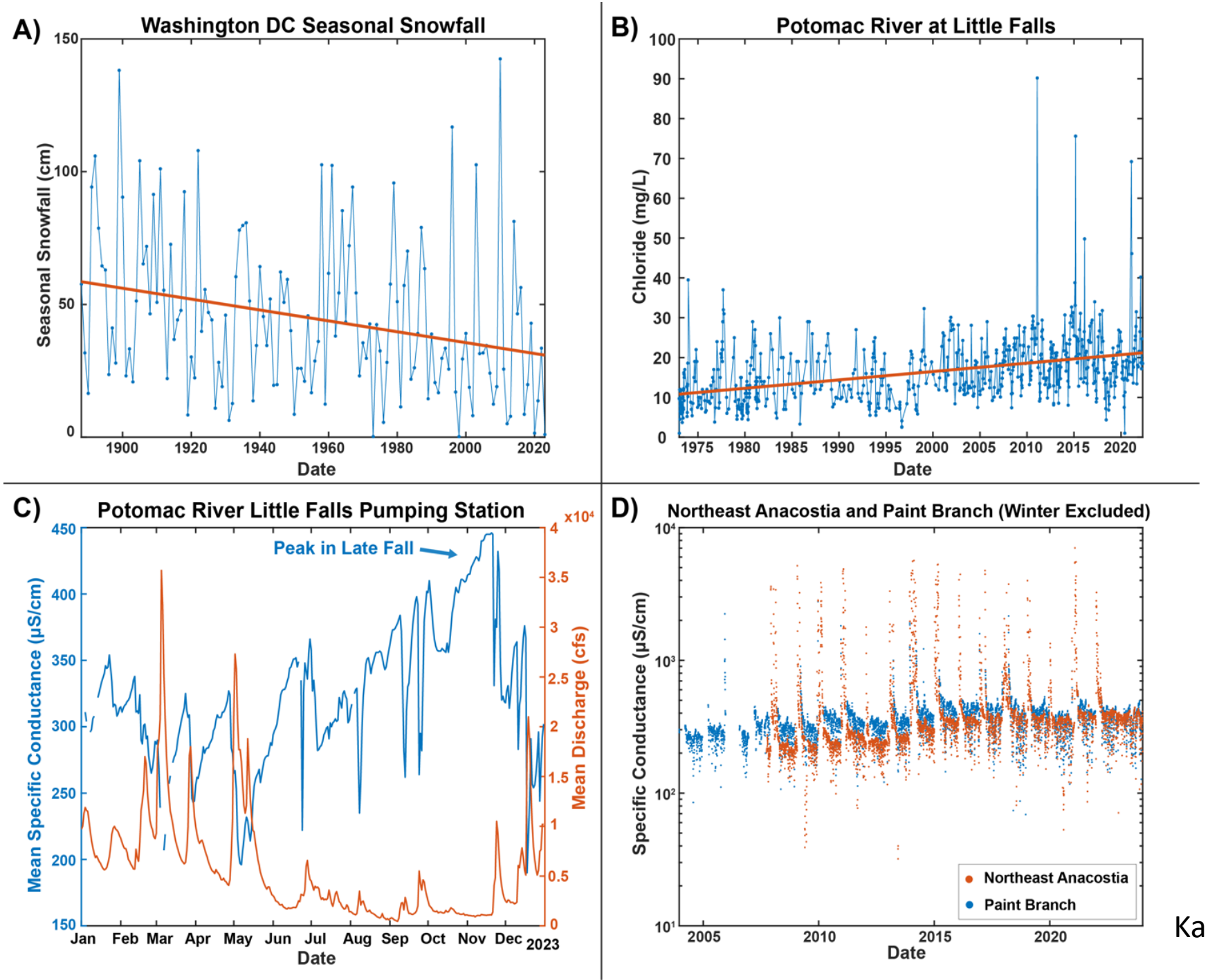
4 min

People ride paddle boards on the Potomac River near Key Bridge in Washington on June 25. (Bonnie Jo Mount/The Washington Post)

A Snowy Winter, but a Mostly Dry Spring?



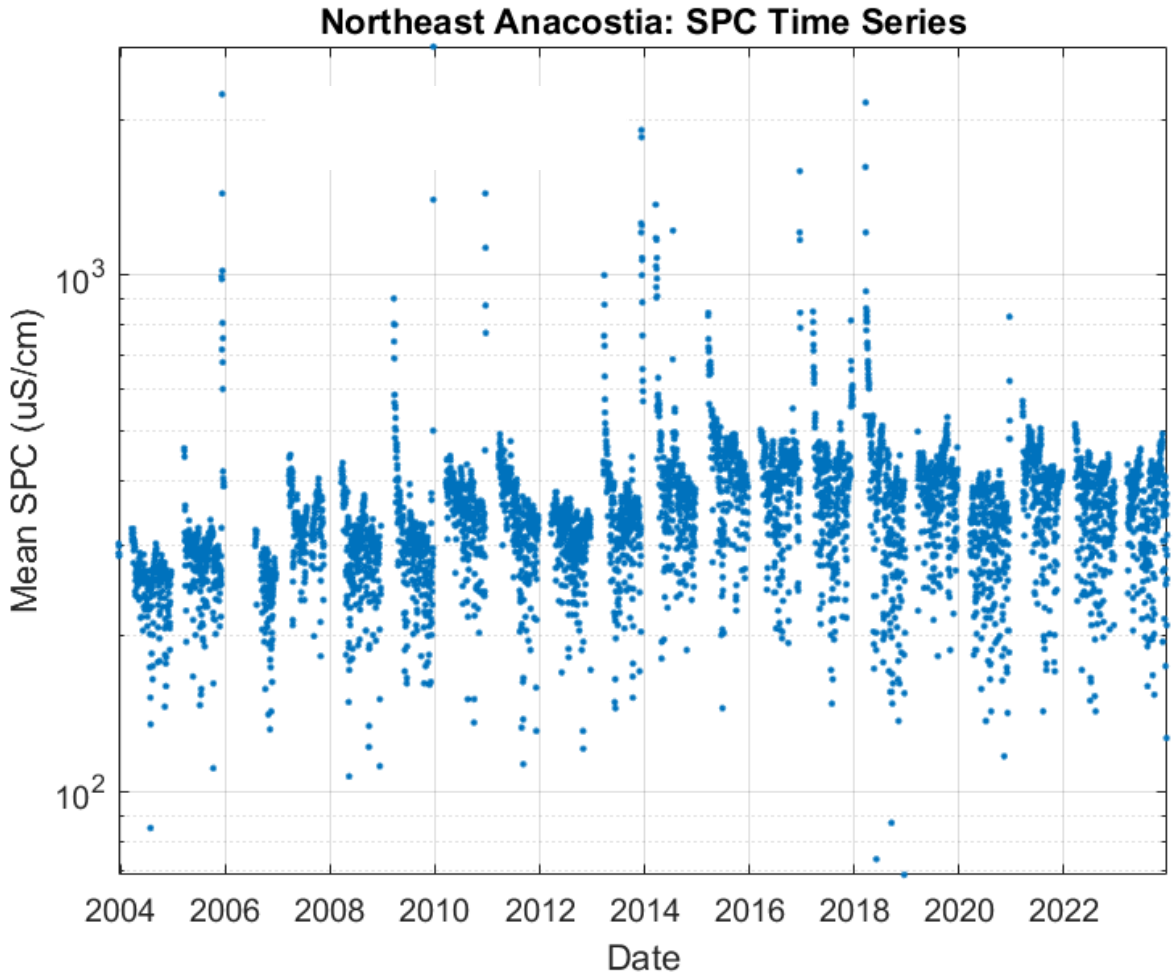

A)
Washington DC Seasonal Snowfall
Seasonal Snowfall (cm)
150
100
50
0
1900
1920
1940
1960
1980
2000
2020
Date
B)
Potomac River at Little Falls
Chloride (mg/L)
100
90
80
70
60
50
40
30
20
10
0
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Date



Kaushal et al. (2025)

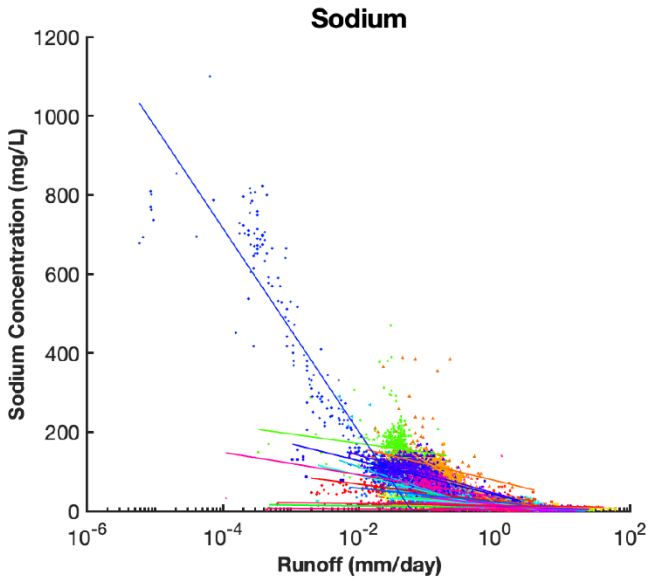
Salt Never Gets Completely Flushed Out

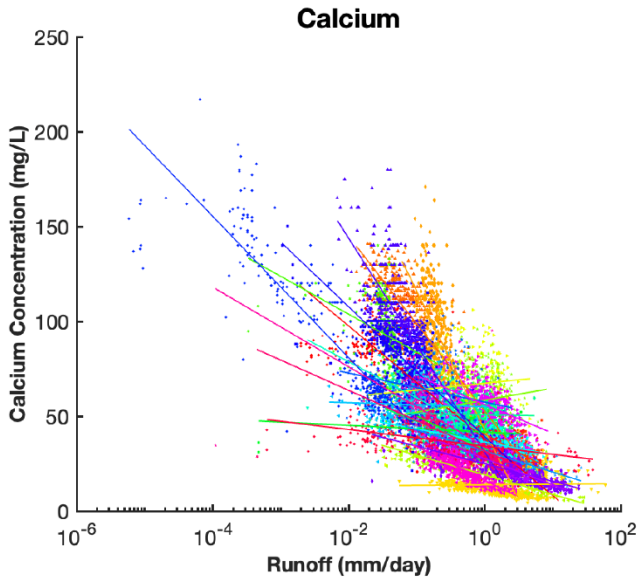
Salt Accumulation during Non-Winter Months

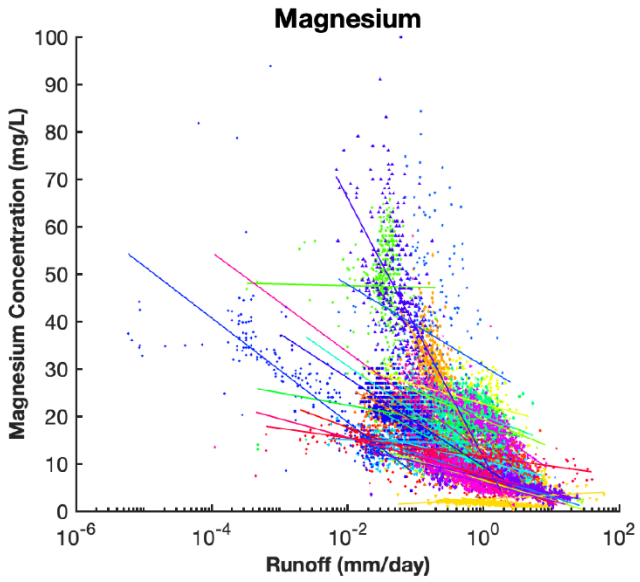


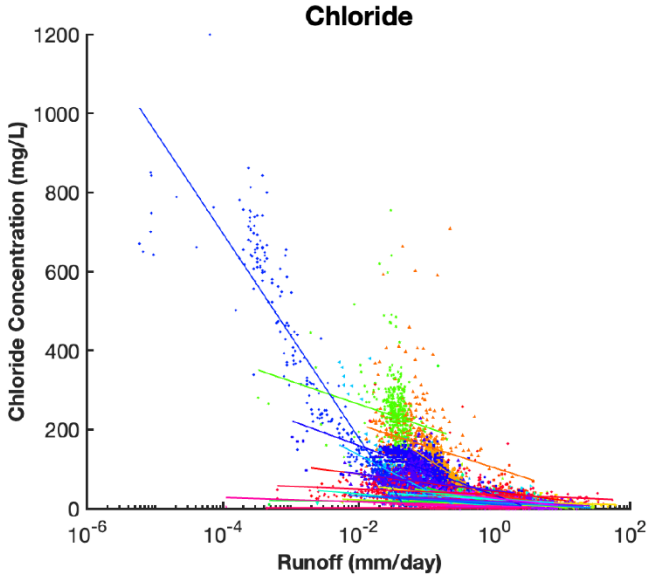
Kaushal et al. (2025)

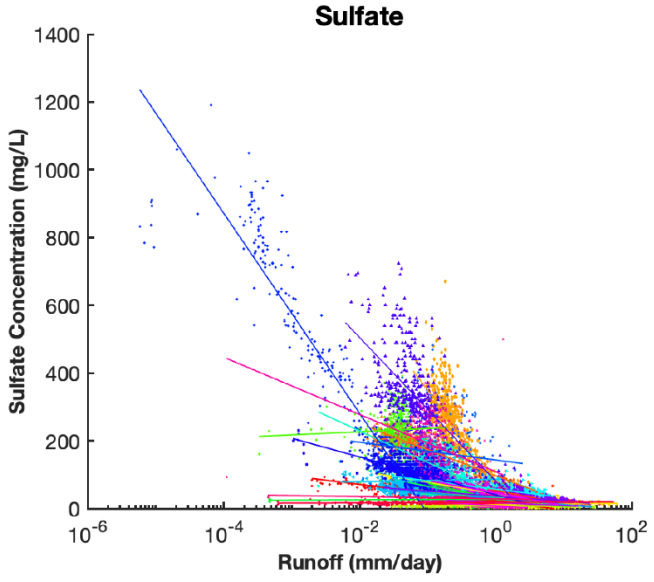
Salt Never Gets Completely Flushed Out across the U.S.











- L Arkansas R NR: Sedgwick,KS
- (COE) Atchafalaya River: Melville, LA
- Cherry Creek: Denver, CO
- Colorado River near CO-UT State Line
- Connecticut River: Thompsonville, CT
- Des Moines River: Keosauqua, IA
- Fanno Creek: Durham, OR
- Iowa River: Wapello, IA
- Jordan River @ 1700 South: Salt Lake City, UT
- Mississippi River: Belle Chasse, MS
- Mississippi River: Clinton, IA
- Mississippi River: Francisville, LA
- Mississippi River below Grafton, IL
- Missouri River: Hermann, MO
- Ohio River at Cannelton Dam: Cannelton, IN
- Platte River: Louisville, NE
- Potomac River at Chain Bridge: Washington, DC
- Red River of the North: Grand Forks, ND
- Rio Grande: El Paso, TX
- Santa Ana River below Prado Dam, CA
- South Platte River near Kersey, CO
- Susquehanna River: Conowingo, MD
- Taku River near Juneau, AK
- Wabash River: New Harmony, IN
- Yakima River: Kiona, WA
- Yellowstone River: Sidney, MT
- Yukon River: Pilot Station, AK
- Zollner Creek: Mt. Angel, OR

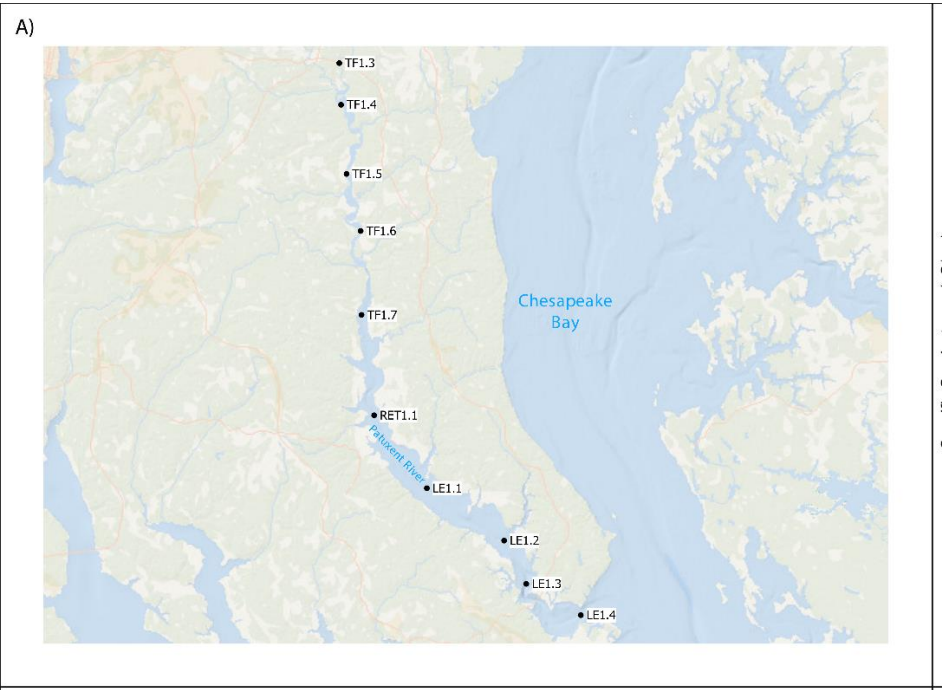
Kaushal et al. (2025)

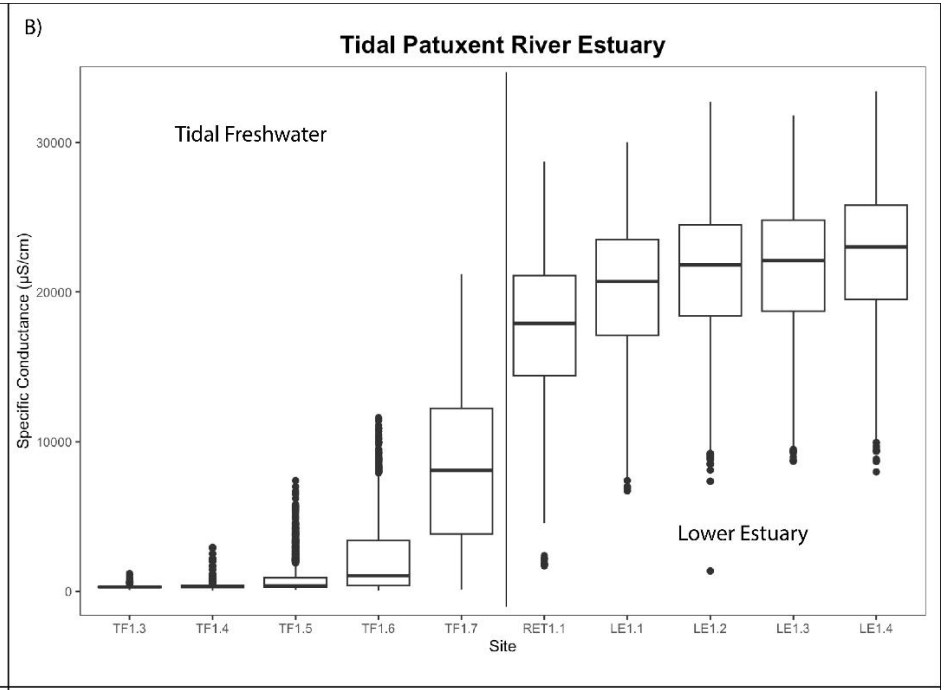
Watershed Salt Retention Ranges from 2-90% Globally

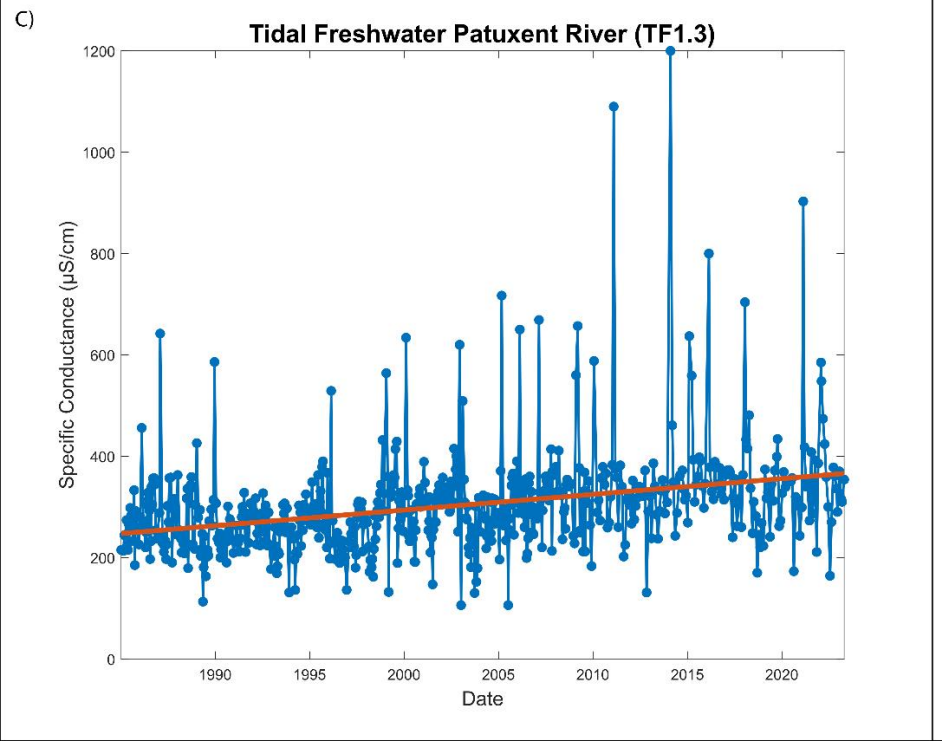
% Cl- Retained	Location	Period	Watershed area (km2)	Reference
36%	Chicago, Illinois, USA	30 years (1990-2020)	18600	Van Meter and Ceisel, 2024
35%	Lake Constance Catchment, Switzerland Germany and Austria	1 year (2006)	11000	Mueller and Gachter, 2012
72%	Minneapolis/St Paul MN, USA	5 years (2000-2005)	4150	Novotny et al., 2009
40-90%	Southern Ontario, Canada	Each water year 2007-2011	40.5 to 406	Oswald et al., 2019
28-45%	Chicago, Illinois, USA	5 months (Nov 1972 to April 1973)	376.5	Wulkowicz and Saleem, 1974
32%	New York, USA	1 year (Nov 1971- Nov 1972)	396	Diment et al., 1973
52%	New York, USA	1 year (Nov 1970- Nov 1971)	396	Diment et al., 1973
11-40%	Vermont, USA	1 year (1970)	111.2	Kunkle, 1971
50-65%	Helsinki, Finland	1.5 years (July 1998 - Dec 1999)	1.7 to 24.4	Ruth, 2003
35%	Boston Metro, Massachusetts, USA	4 months (December 1969 - March 1970)	168.4	Huling and Hollocher, 1972
55%	Toronto Metro, Ontario, Canada	2 years (1989-1990)	104	Howard and Haynes, 1993
59%	Rochester, New York, USA	1 year (1969-1970)	435	Bubeck et al., 1971
34-69%	New York, USA	1 year (2012-2014)	1000	Gutchess et al., 2016
10.8-23.5%	Ontario, Canada	1 year (2004-2005)	27	Meriano et al., 2009
10-47%	New Hampshire, USA	1 year (Oct 2006 - Sept 2007)	1.42 to 78.5	Trowbridge et al., 2010
53%	Alberta, Canada	Each water year for 2010-2017	12971	Laceby et al., 2019
40%	City of Toronto, Ontario, Canada	Each water year for 2004-2008	100	Perera et al., 2013
2-62%	Pennsylvania, USA	Annually for 2011-2018	73.9 to 934	Rossi et al., 2022

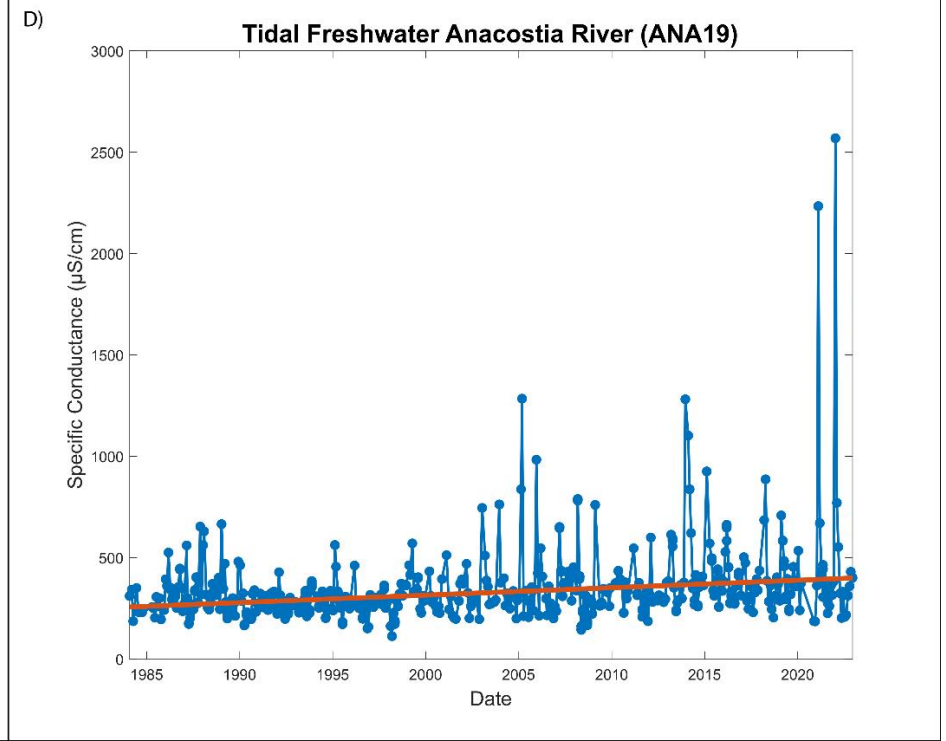
Kaushal et al. (2025)

3. Double Trouble: Salt from Land and Sea







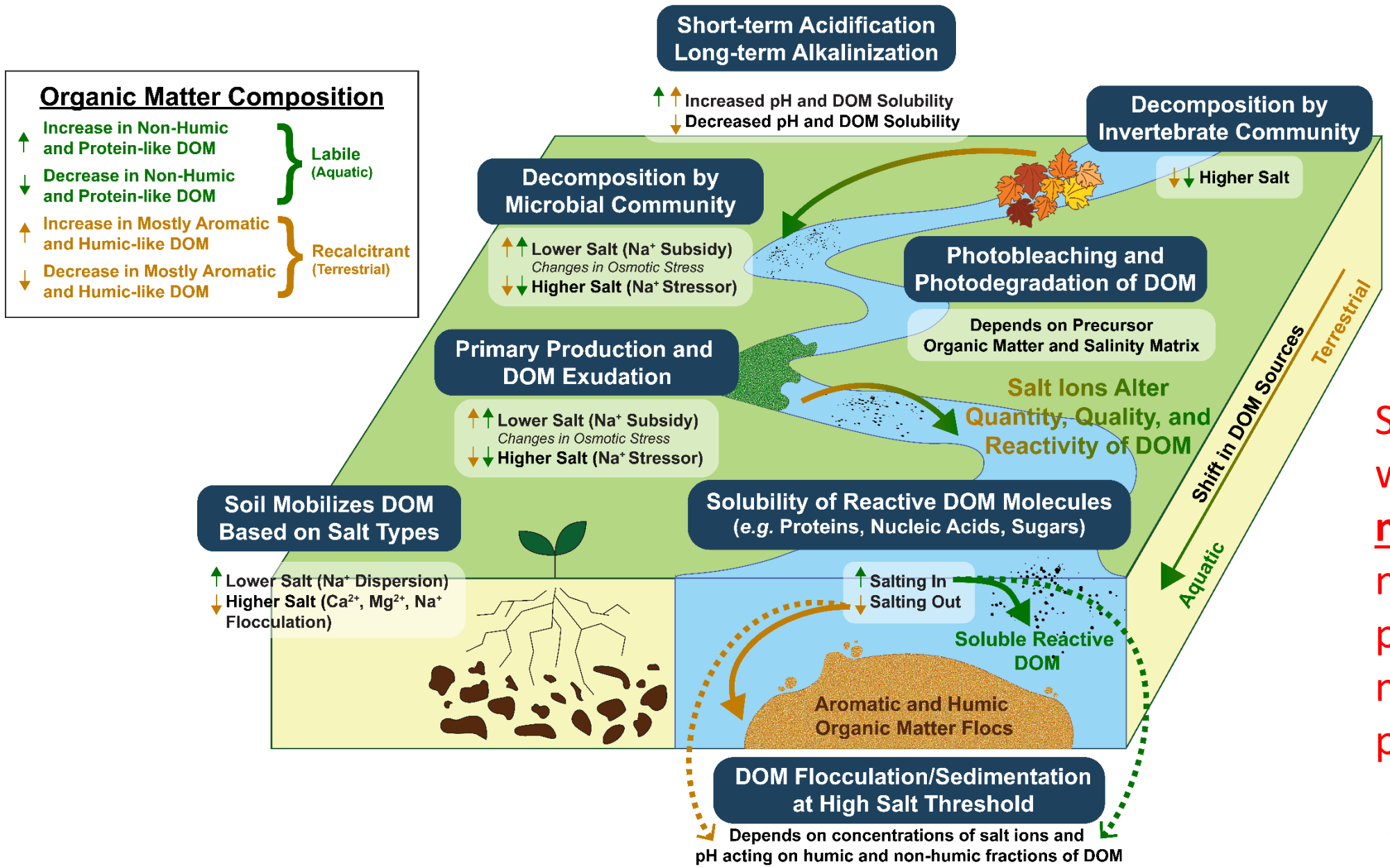


Saltwater is getting fresher, but freshwater is getting saltier

Increasing salinization of tidal freshwaters

Kaushal et al. (2025)

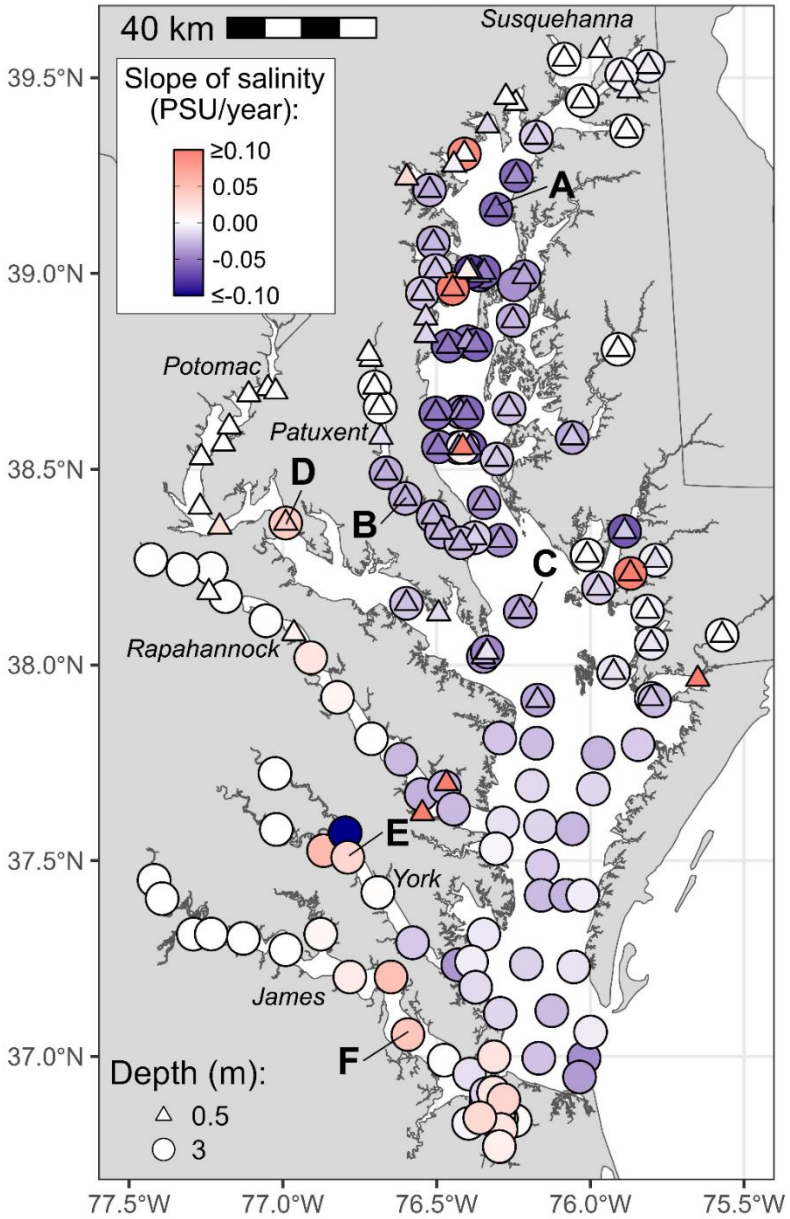
Salt Impacts Carbon Cycling:
From Headwaters to Coastal Waters

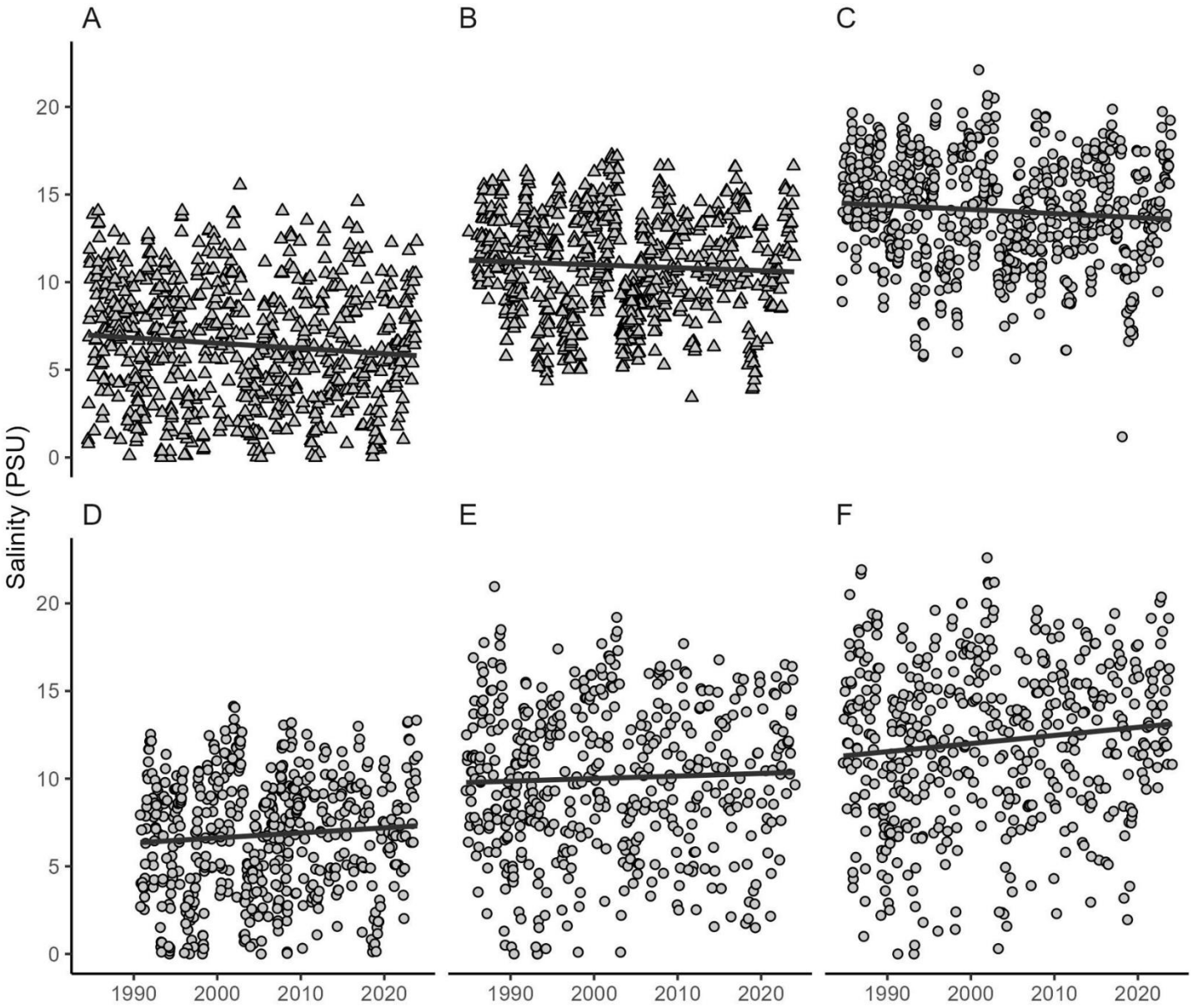


Salinity impacts water quality in **many** ways: nitrogen, carbon, phosphorus, and metals and alters pH and acidity…

Kaushal et al. (2025)

Increasing Salinization of Tidal Rivers





Kaushal et al. (2025)

Virginia county looks to Rappahannock River as groundwater runs dry

Lauren Hines-Acosta Jan 29, 2025 2

News by Topic

Ag & the Bay Special Series

The sun rises over the Rappahannock River along Cory Garrett's farm in Caroline County, VA, in January 2017.

Cory Garrett

The groundwater supplies that growing communities east of Interstate 95 in Virginia have relied on for decades are beginning to dwindle. But some are concerned that turning Chesapeake Bay rivers into a secondary source of water for the growing region could put a strain on the larger system.

In Caroline County, VA, officials are decades into their search for future water supplies. Still, they are struggling to find a source that satisfies the county's farming and fishing communities while allowing for industrial and residential growth along the I-95 corridor.

According to the Virginia Department of Environmental Quality (DEQ), the county has experienced significant declines in groundwater over the last 20 years. Officials are concerned that it could run completely dry by 2055 — and that's if the water stays clean enough for use. Already, wells in the town of Bowling Green are contaminated with high levels of radioactive elements.

With supplies already low, the state's control over what remains is stringent. The county draws water from 16 wells in the Eastern Virginia Groundwater Management Area. This area covers most counties east of I-95 and the Coastal Plain aquifer system, and DEQ reduced withdrawal rates from that system between 2014 and 2017. The agency told the General Assembly in 2018 that still more reductions are necessary.

"[The aquifer] is super important to us, because it's the only water source that we have," Caroline County supervisor Jeffery Sili said.

But now, DEQ is requiring the county to consider other options, including drawing water from nearby rivers.

The county's population has grown 7.5% between 2010 and 2020, but the number of connections to the county's water system has grown even more, quadrupling in the last five years, according to county administrator Charles Culley. Even if the number of connections were to stay the same, the county estimates that it would need more than 3 million gallons a day of new water supply in 30 years. Culley credits the growth to businesses

AMERICAN RIVERS

AMERICAN RIVERS ANNOUNCES RAPPAHANNOCK RIVER AS ONE OF AMERICA'S MOST ENDANGERED RIVERS®

APRIL 15, 2025

Contact: Hawk Hammer, National Communications and Media Director, Hhammer@americanrivers.org

4/16/2025 Washington D.C. — Declining groundwater levels and a lack of comprehensive water supply planning amidst rapid population growth and expanding industries in Virginia has landed the Rappahannock River as #6 on American Rivers' list of America's Most Endangered Rivers® of 2025.

Conclusions

- Freshwater faces a saltier future with chain reactions across systems
- Salinity risks are becoming amplified with climate variability
- Salinity risks are spreading from small headwaters to large tidal rivers
- Growing need for regional salt risk management

Establishing A Science Partnership to Understand Salinization



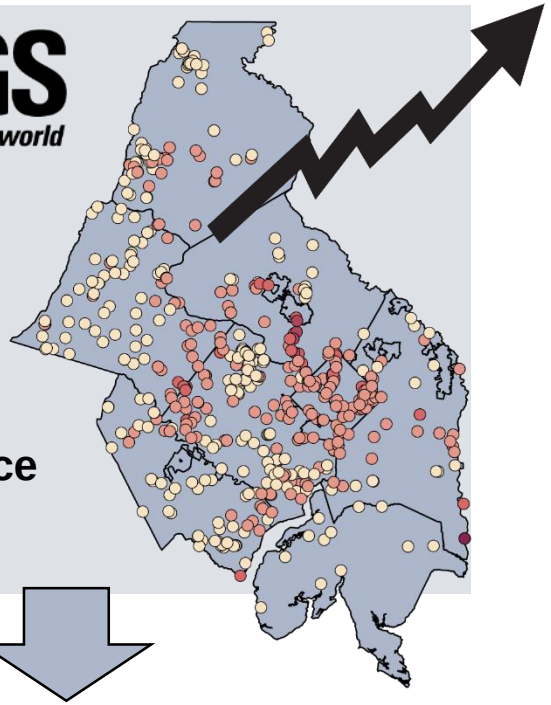




Vision: A collaborative scientific partnership is needed to address a complex, regional issue…

USGS science for a changing world

Monitoring networks can characterize patterns over time and space



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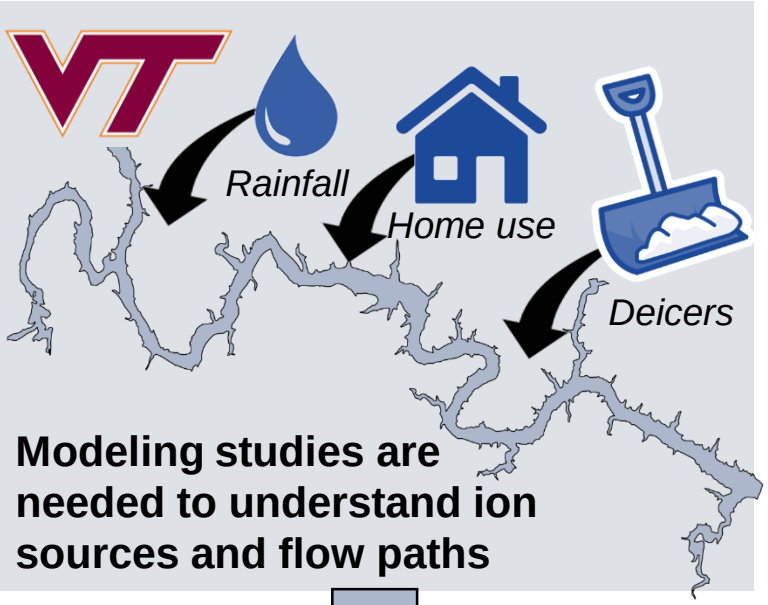
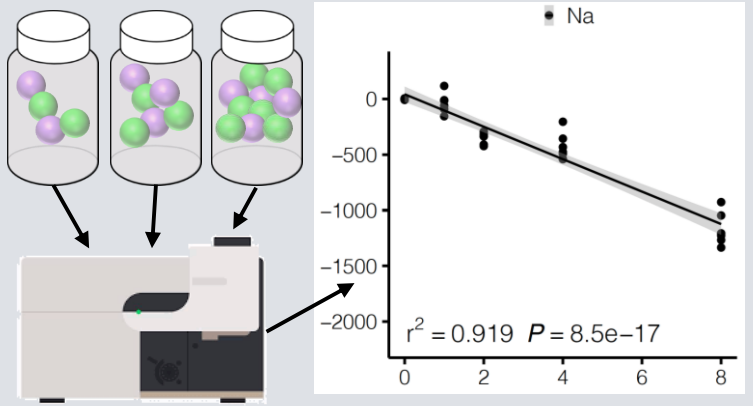


Modeling studies are needed to understand ion sources and flow paths

Field and lab experiments are needed to evaluate impacts and mechanisms



Synthesizing this knowledge is needed to understand and manage FSS in the MWCOG region

Thanks also to **Jimmy Webber**, USGS!