

Long-Term Trends and Variability of Suisun Marsh Salinity

Chris Enright

DWR

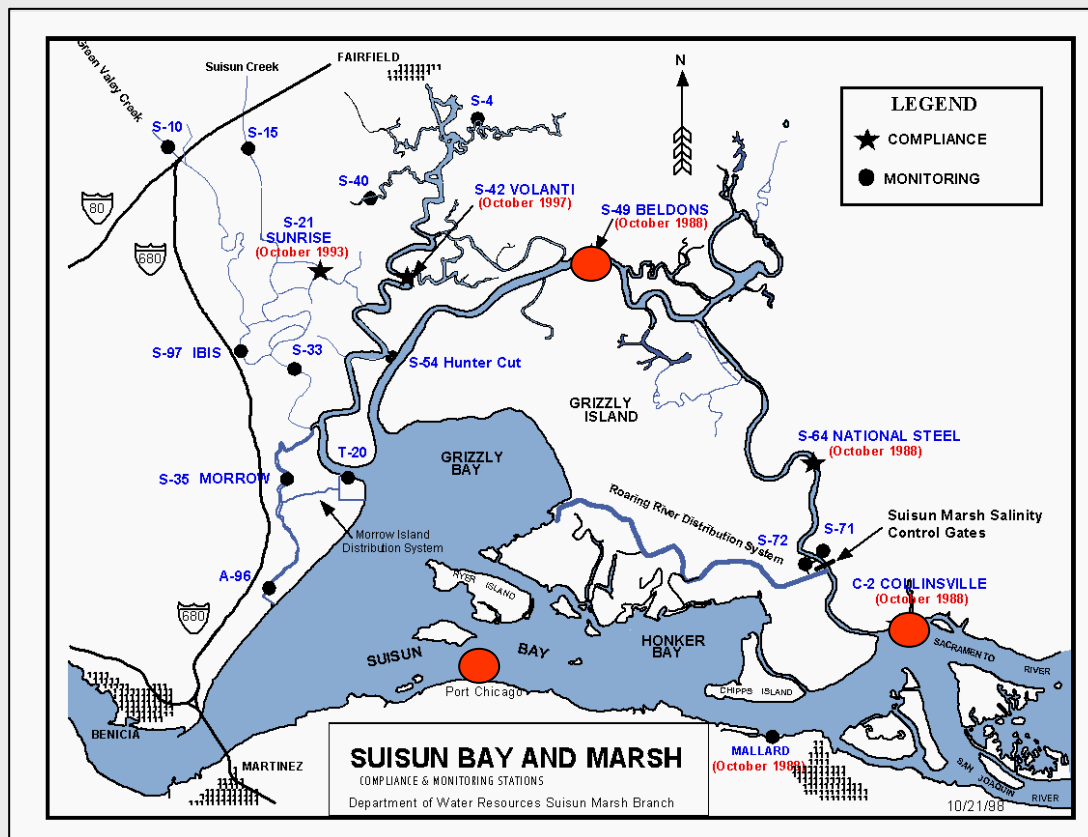
Suisun Marsh Branch

Suisun Marsh Salinity Trends

- Data and methods:
 - precipitation, outflow, salinity
- Long-term trends - “Pre” and “post” project
- 3. Among month trends - “Pre” and “post” project
- 4. Suisun Marsh Salinity Control Gate effect
- 5. Time-scale variability
- 6. Bathymetry trends also affect salinity

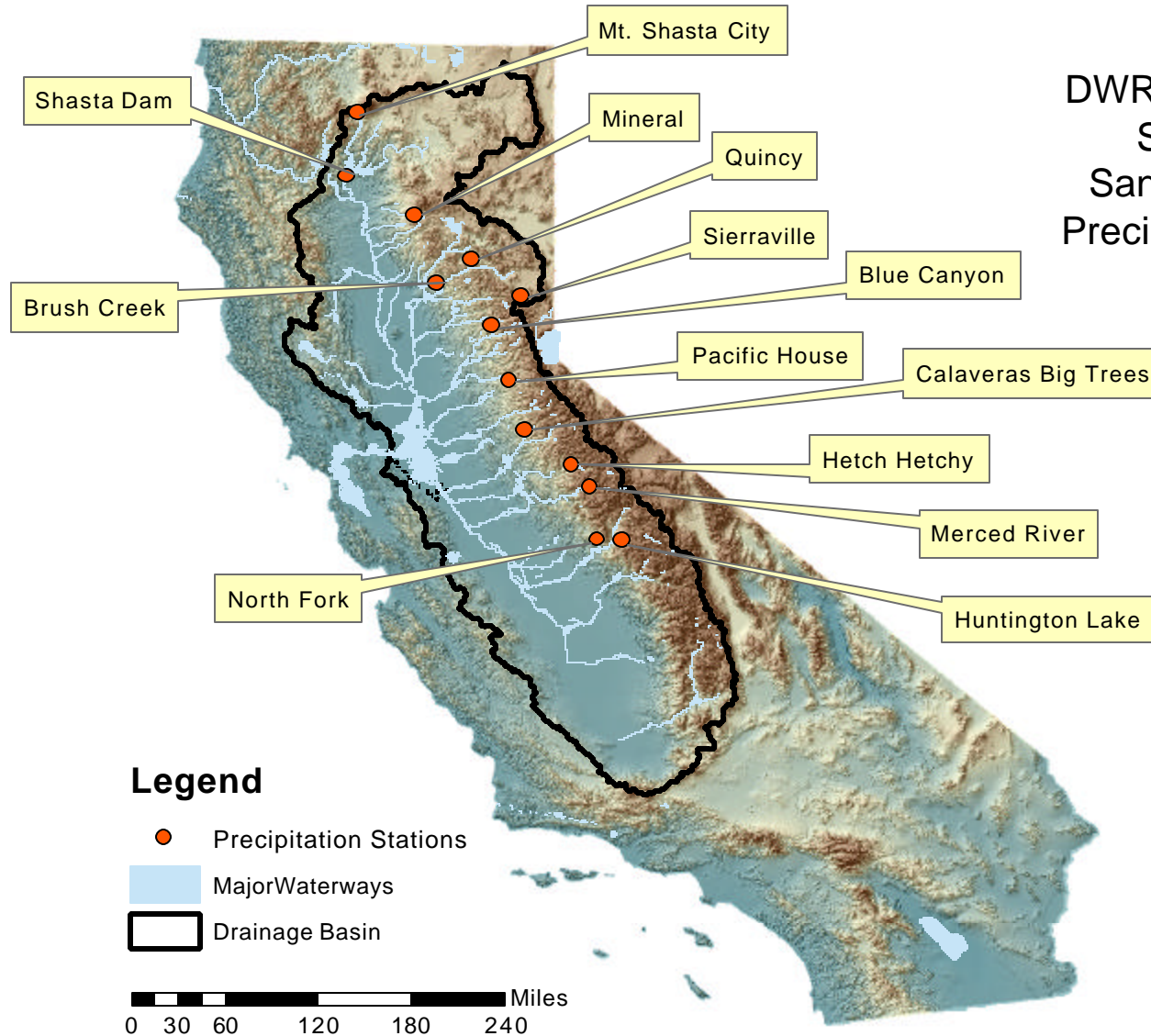
1. Data and Methods

- SF Estuary Watershed Precipitation
- Delta Outflow
- 3 Suisun Marsh/Bay salinity records



1. Data and Methods (cont.)

San Francisco Estuary Watershed Precipitation



DWR Flood Management
Sacramento and
San Joaquin Tributary
Precipitation Stations (13)
1920-2002

1. Data and Methods (cont.)

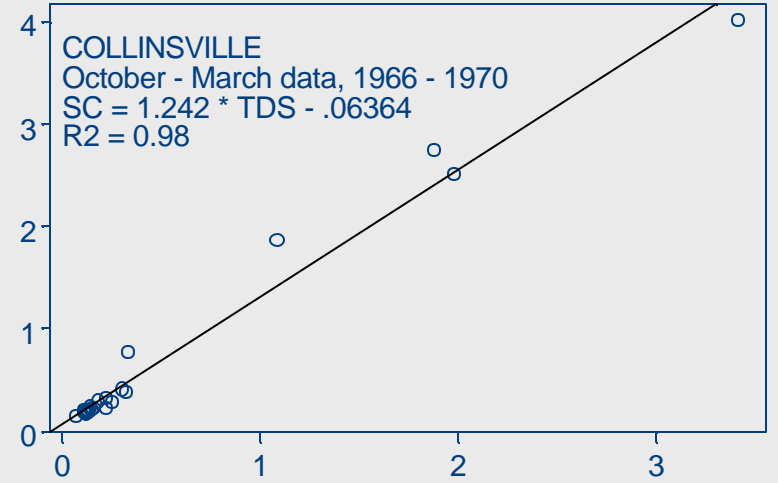
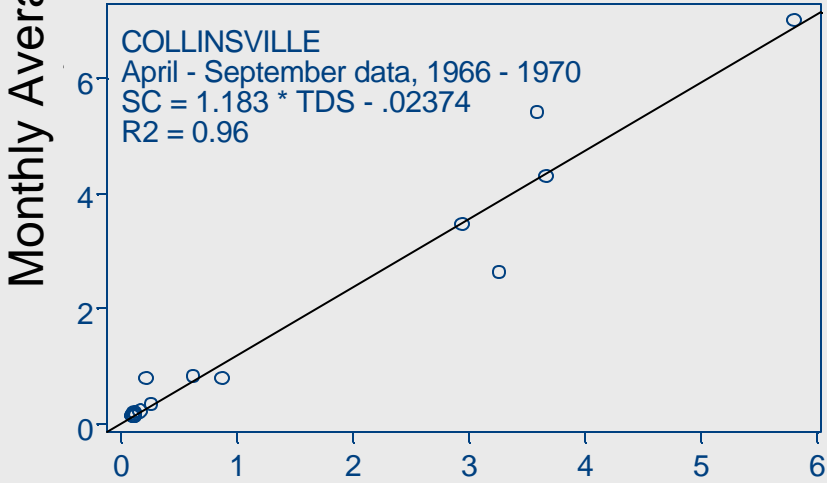
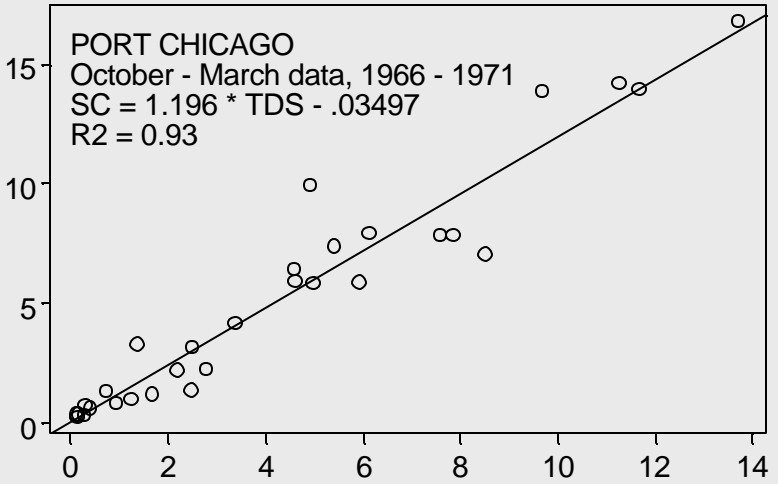
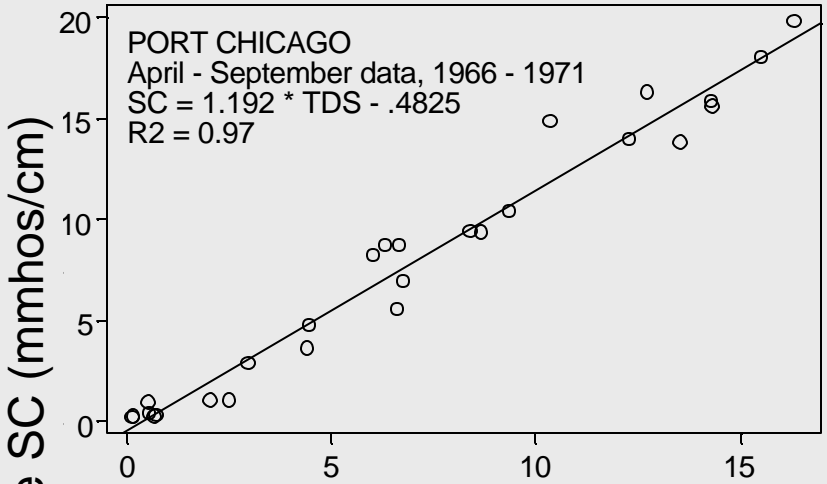
- Monthly average Delta outflow from Dayflow (1929 – 2002)

1. Data and Methods (cont.)

- Long salinity records available for
 - Port Chicago (since 1947)
 - Beldons Landing (since 1929)
 - Collinsville (since 1920)
- 4 day TDS grab samples through 1971
- Continuous SC 1966 to present.
- 4-5 year overlap of grab TDS and continuous SC (Port Chicago & Collinsville)

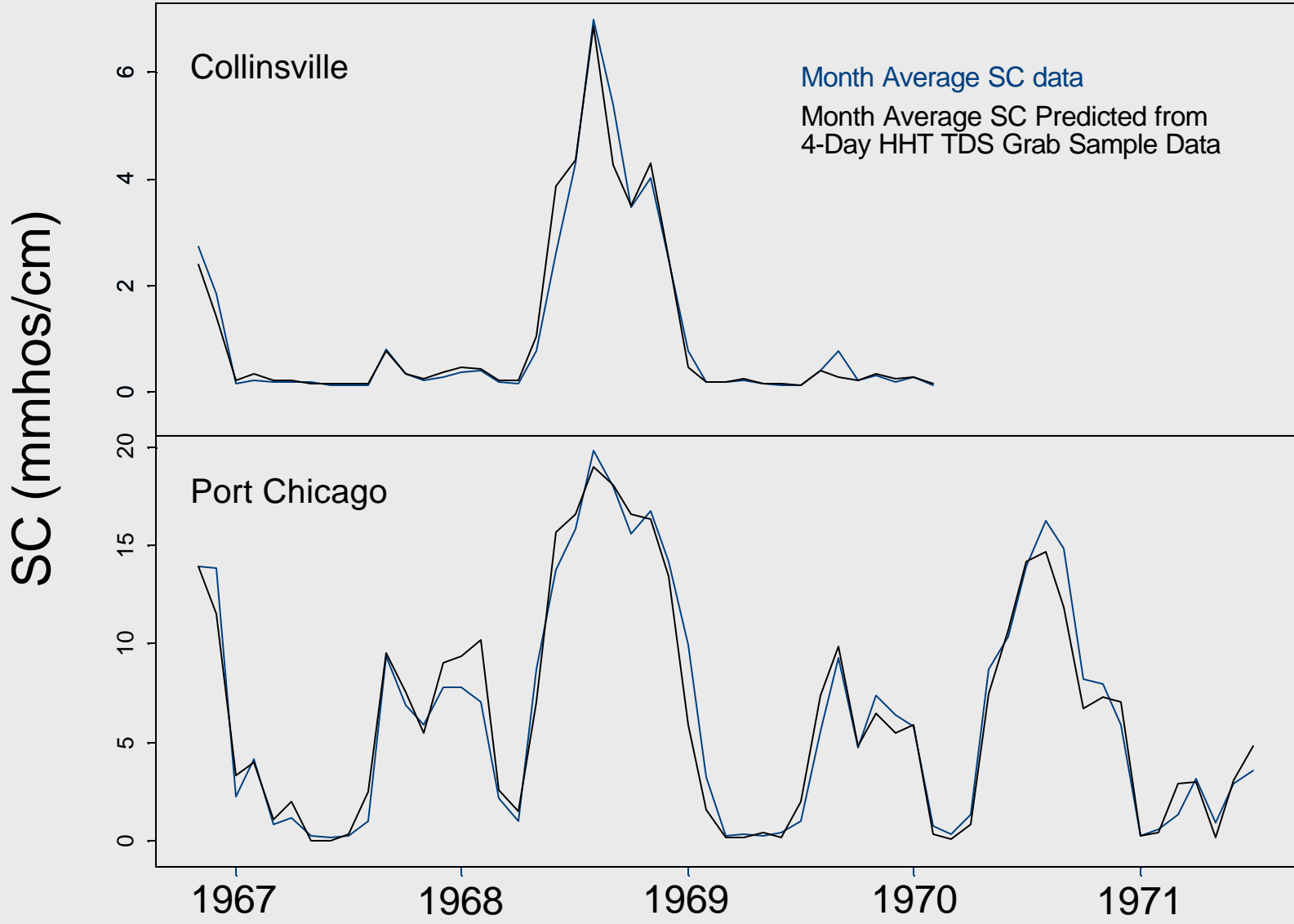
1. Data and Methods (cont.)

Regression of monthly average SC on monthly average high tide grab sample TDS (1966-1971)



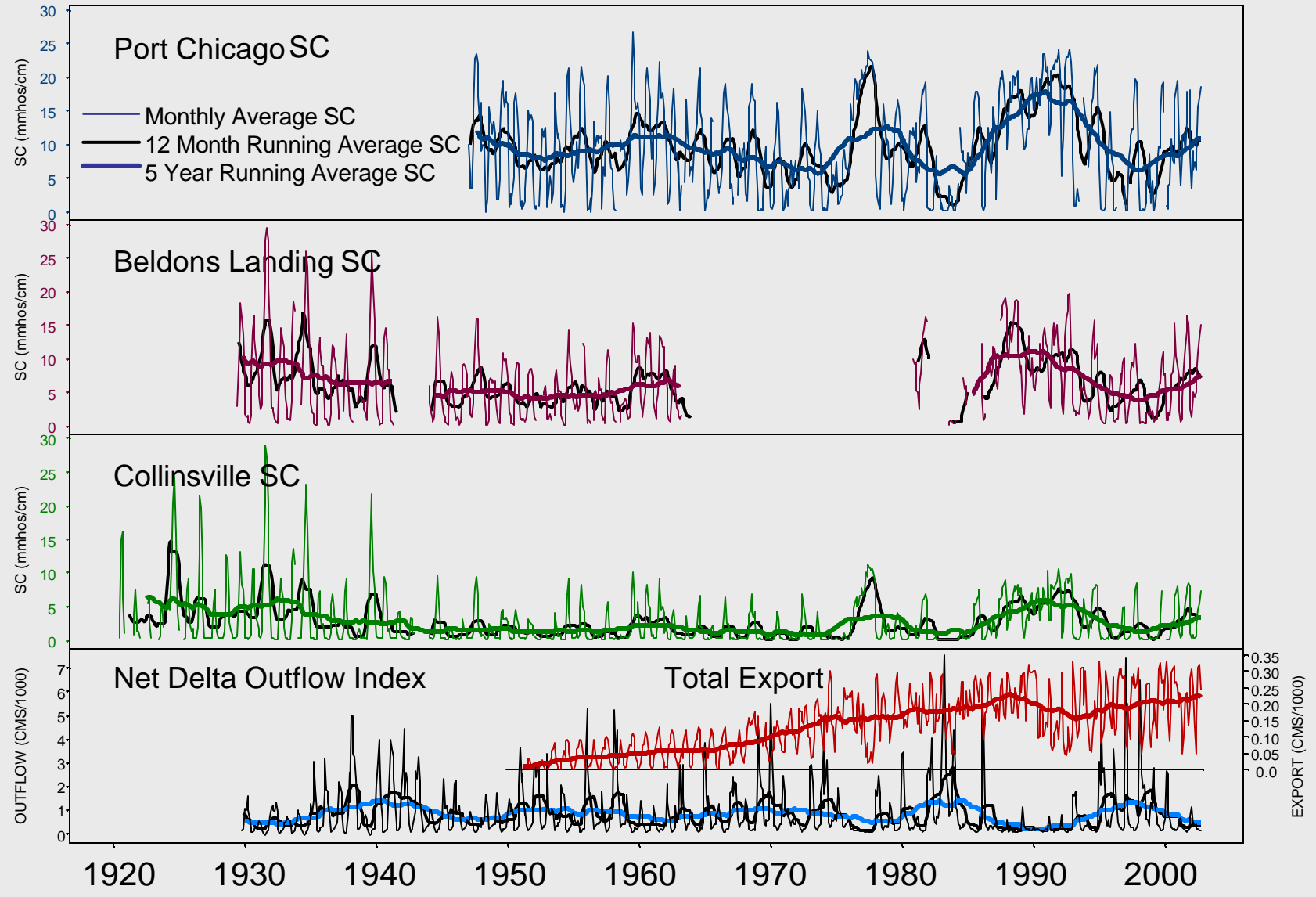
Monthly Average of 4-Day HHT TDS

TDS to SC conversion validation



1. Data and Methods (cont.)

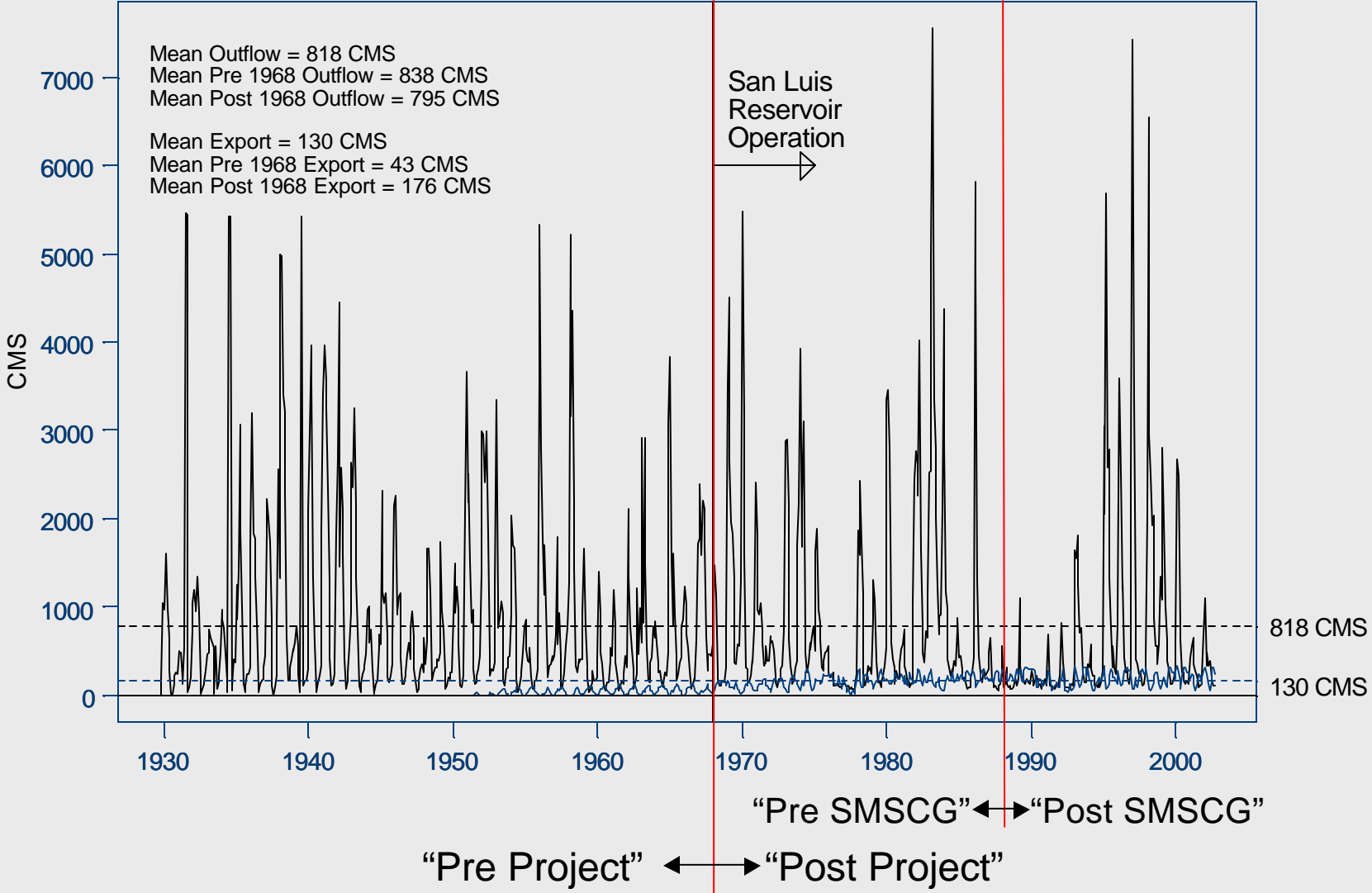
Historical Suisun Marsh/Bay Salinity: 1920 - 2002



2. Long-Term Trends

2. Long-term trends

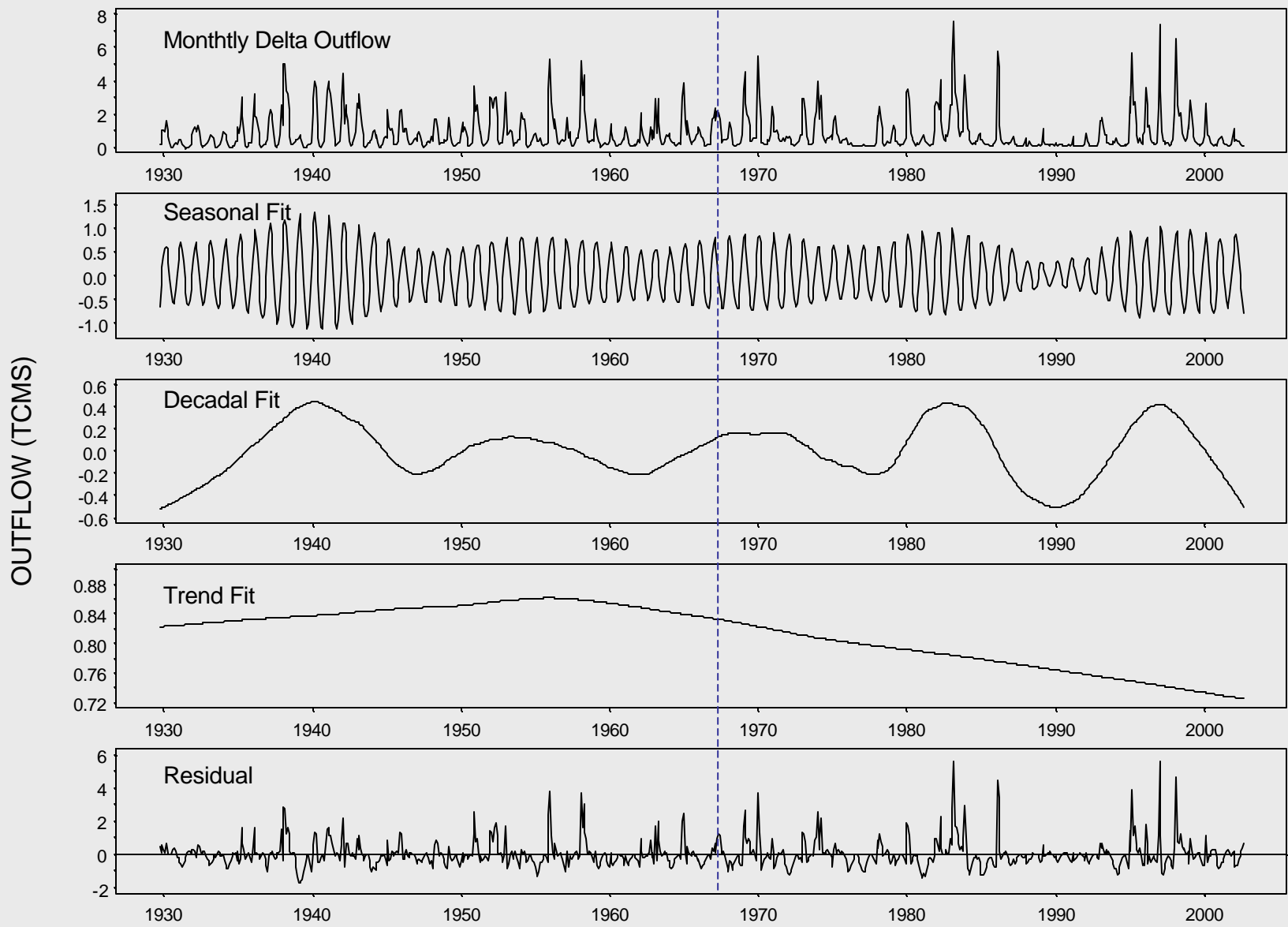
Historical Outflow and Total Export



2. Long-term trends

Delta Outflow

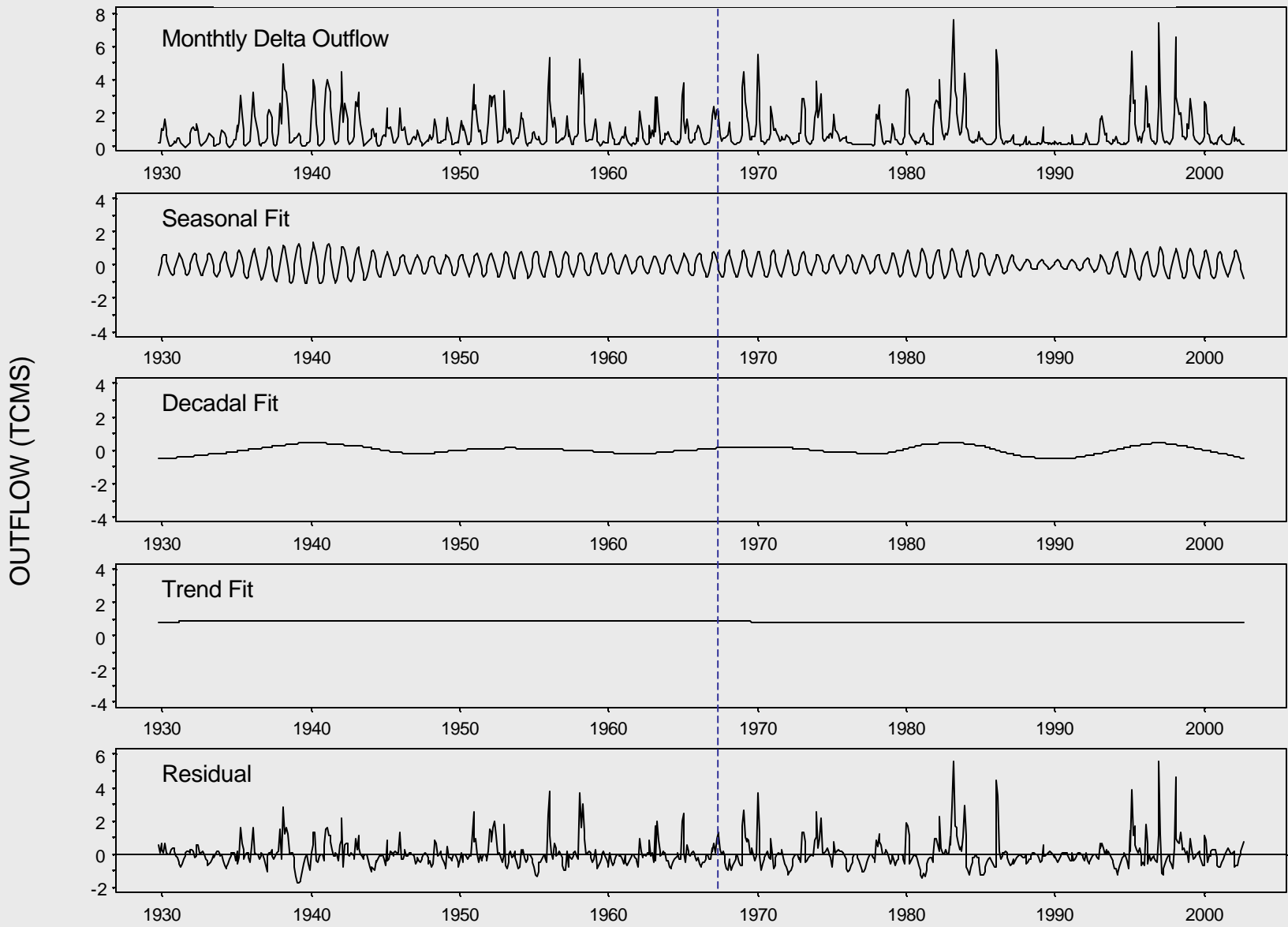
Seasonal LOESS trend decomposition



2. Long-term trends

Delta Outflow

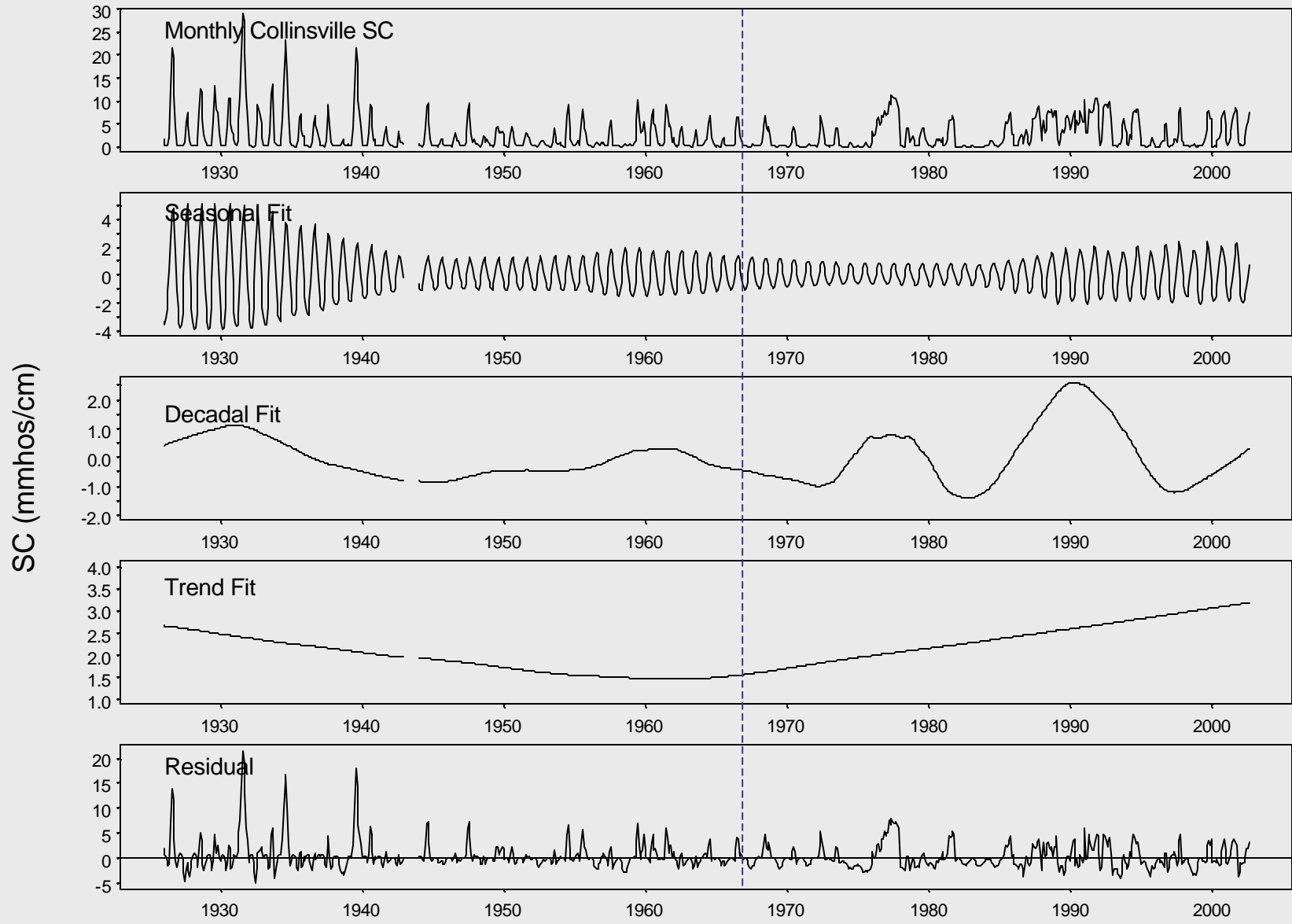
Seasonal LOESS trend decomposition



2. Long-term trends

Collinsville SC

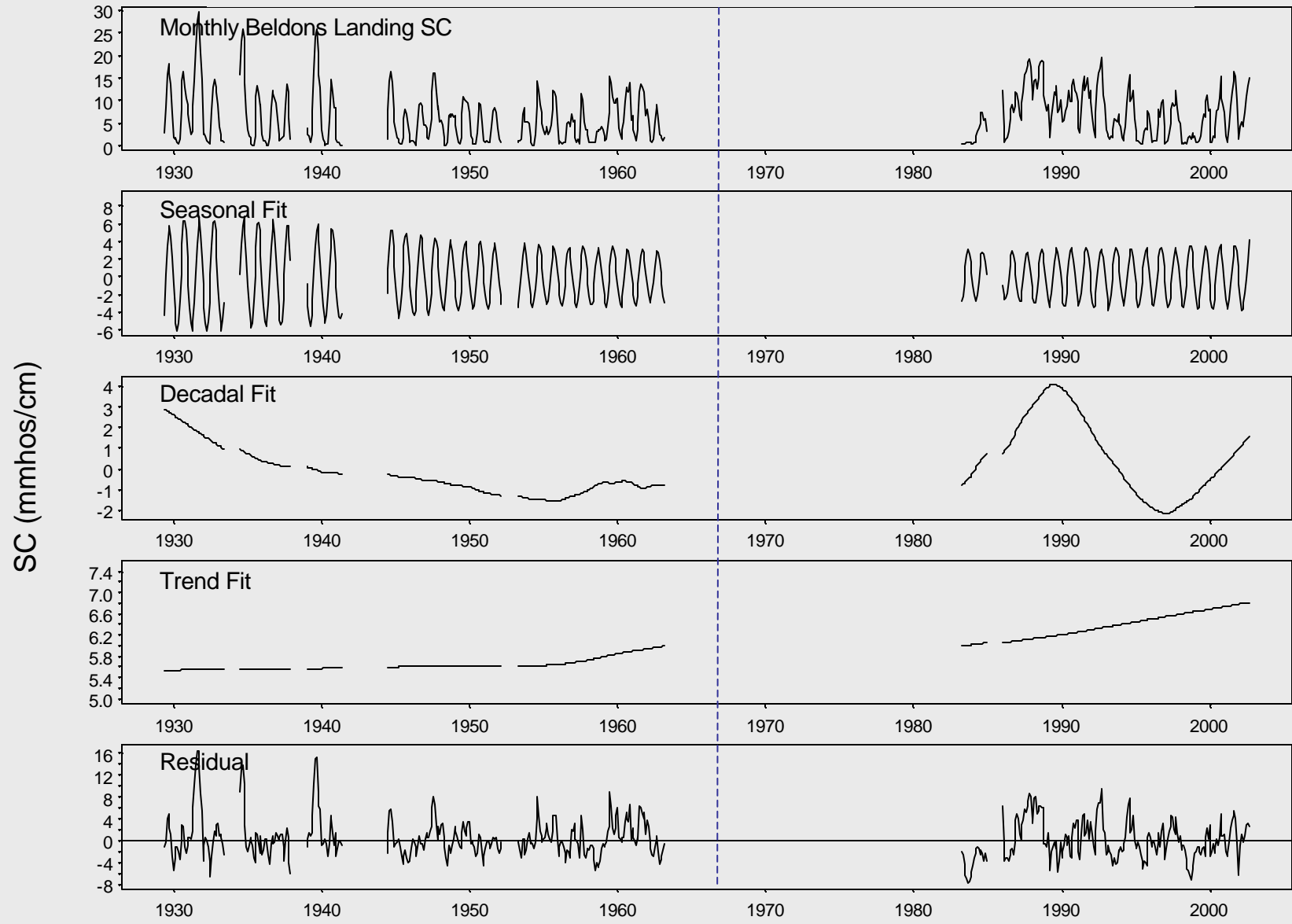
Seasonal LOESS trend decomposition



2. Long-term trends

Beldons Landing SC

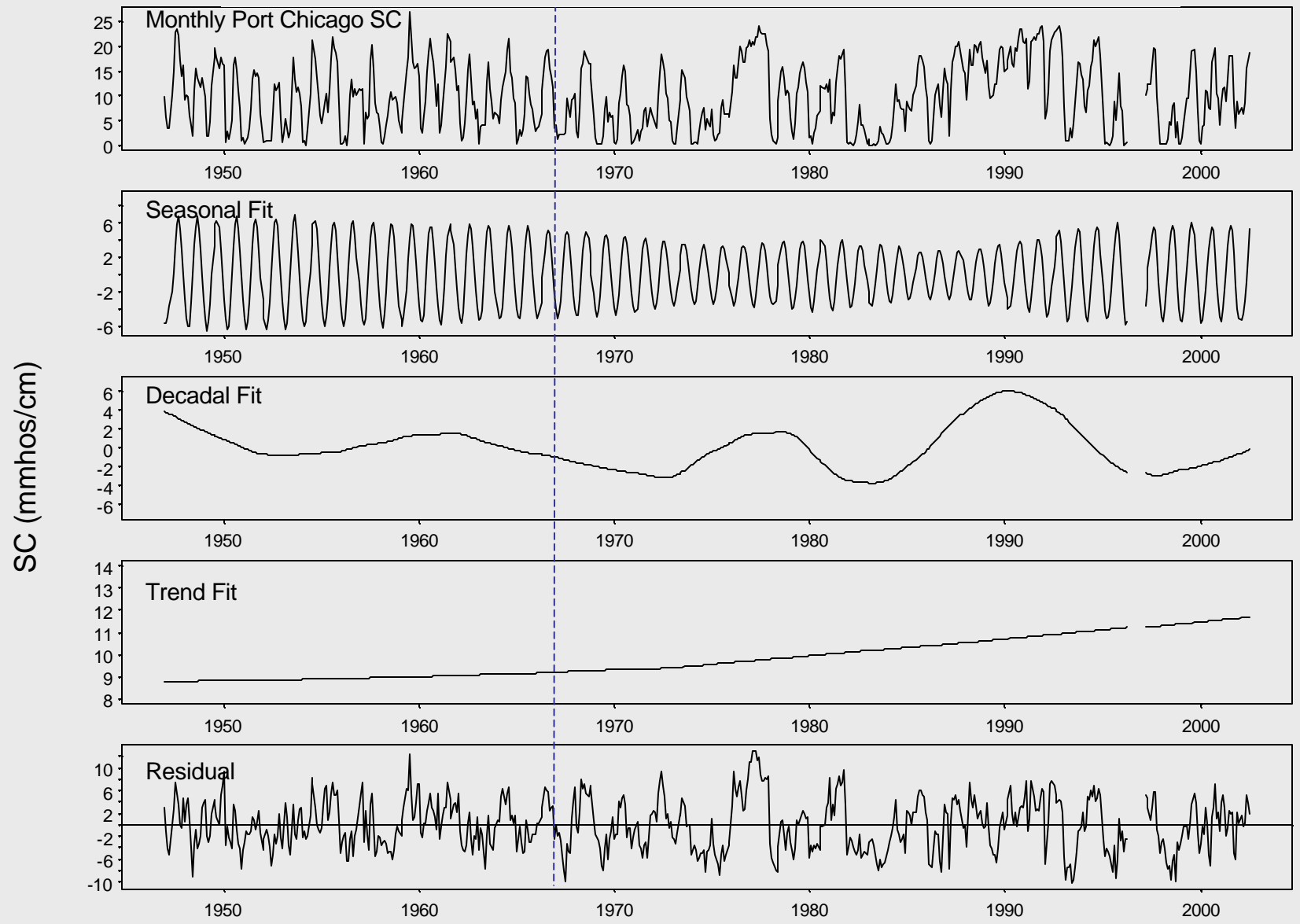
Seasonal LOESS trend decomposition



2. Long-term trends

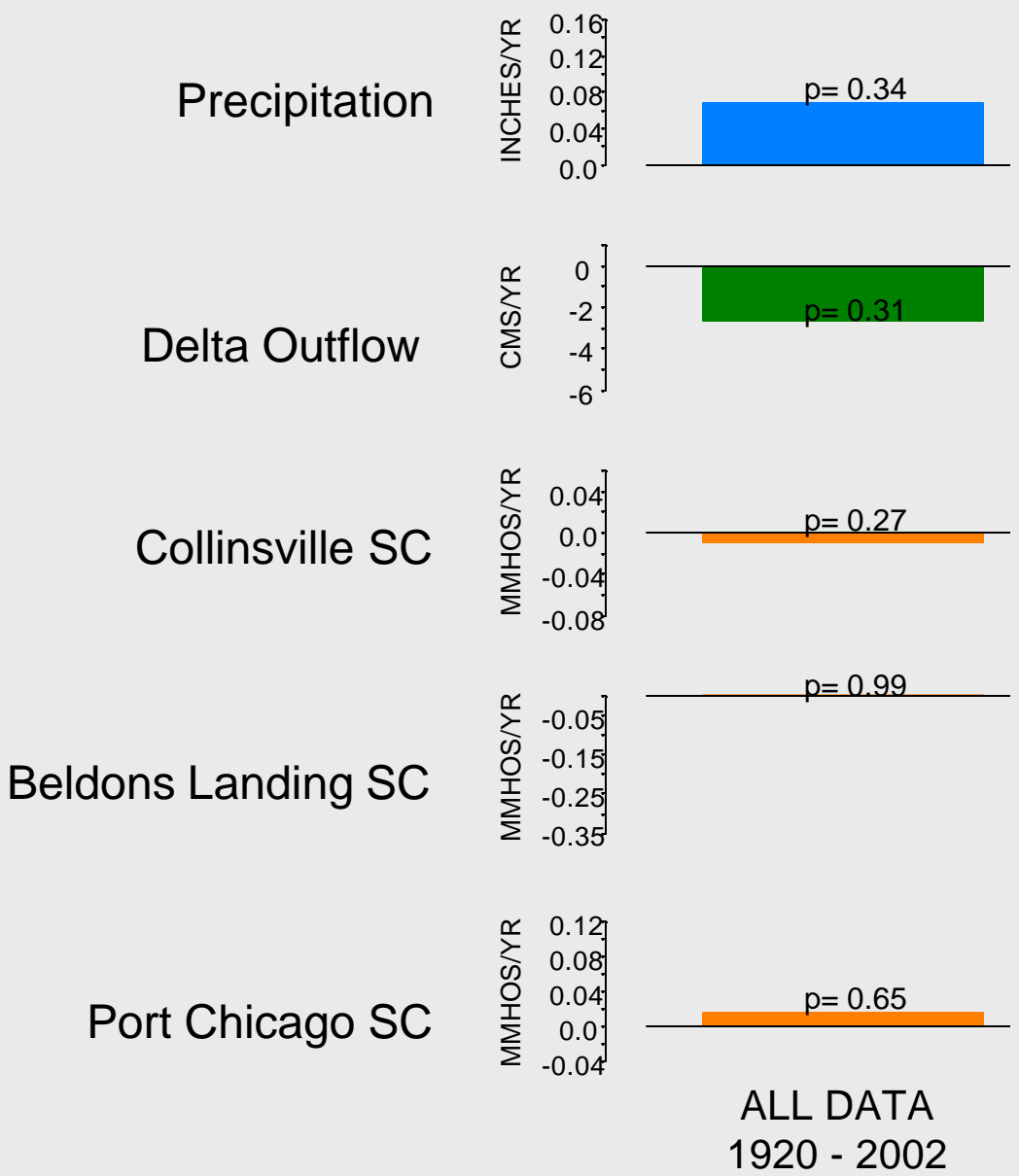
Port Chicago SC

Seasonal LOESS trend decomposition



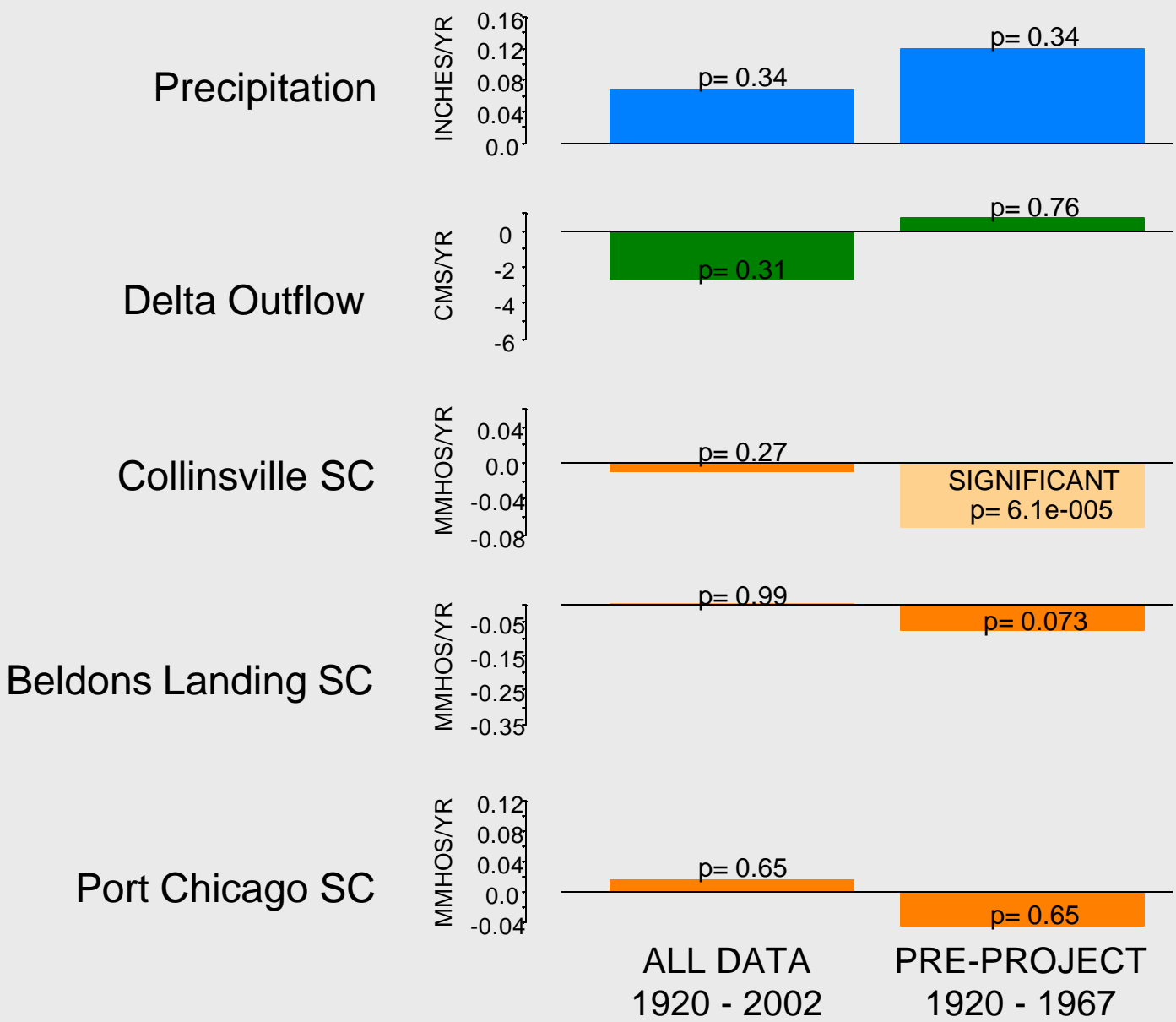
2. Long-term trends

Trends in Annual Data (Kendall Tau)



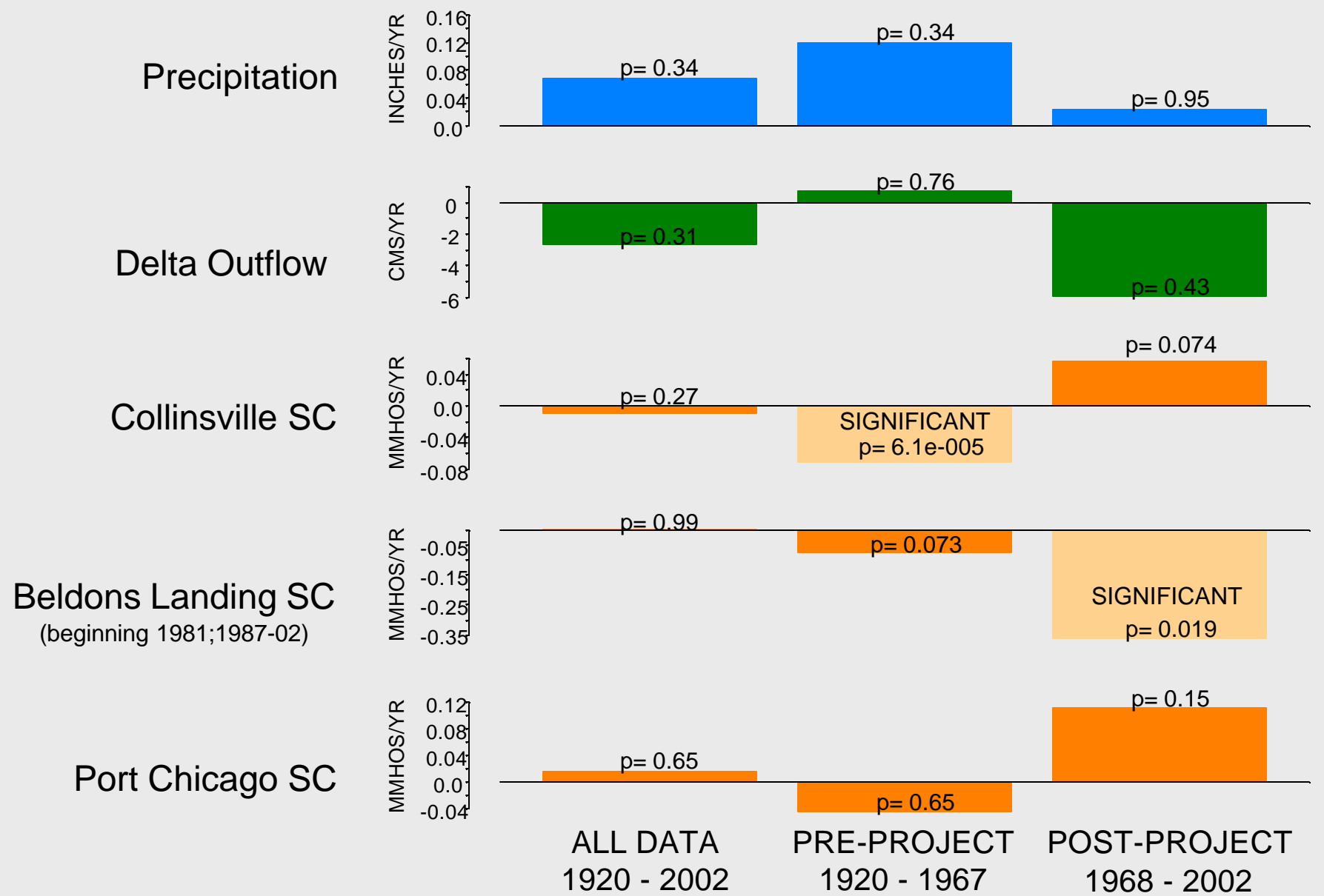
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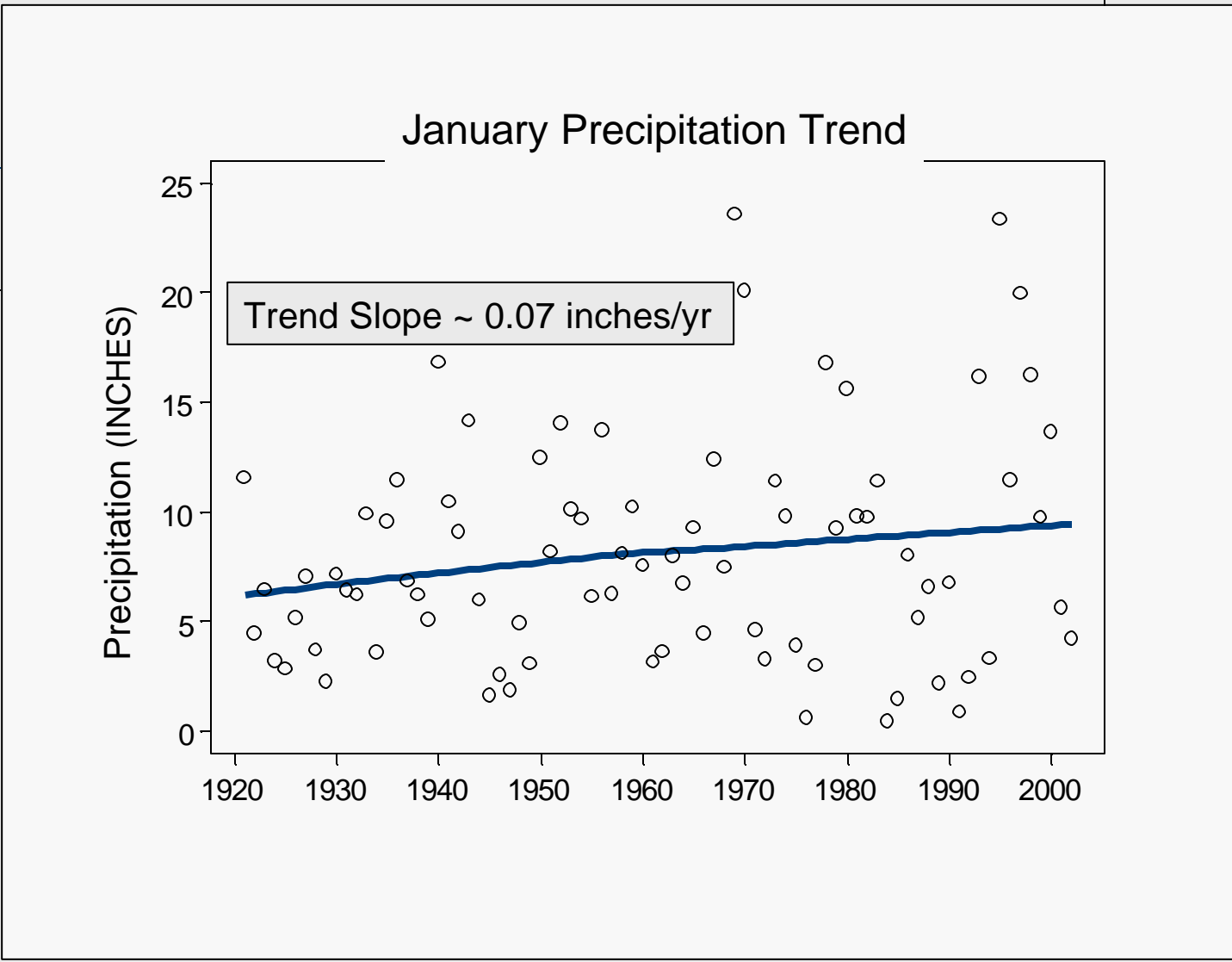
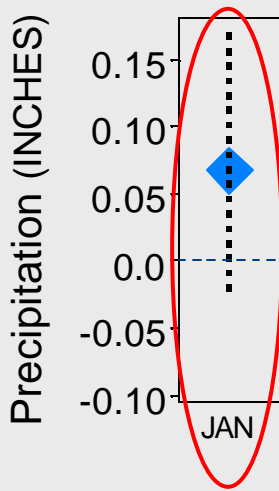
Long-Term Trends:

- Long-term trends are very small compared to seasonal and decadal variability
- Salinity is anti-correlated with outflow except at Beldons Landing.

3. Among Month Trends

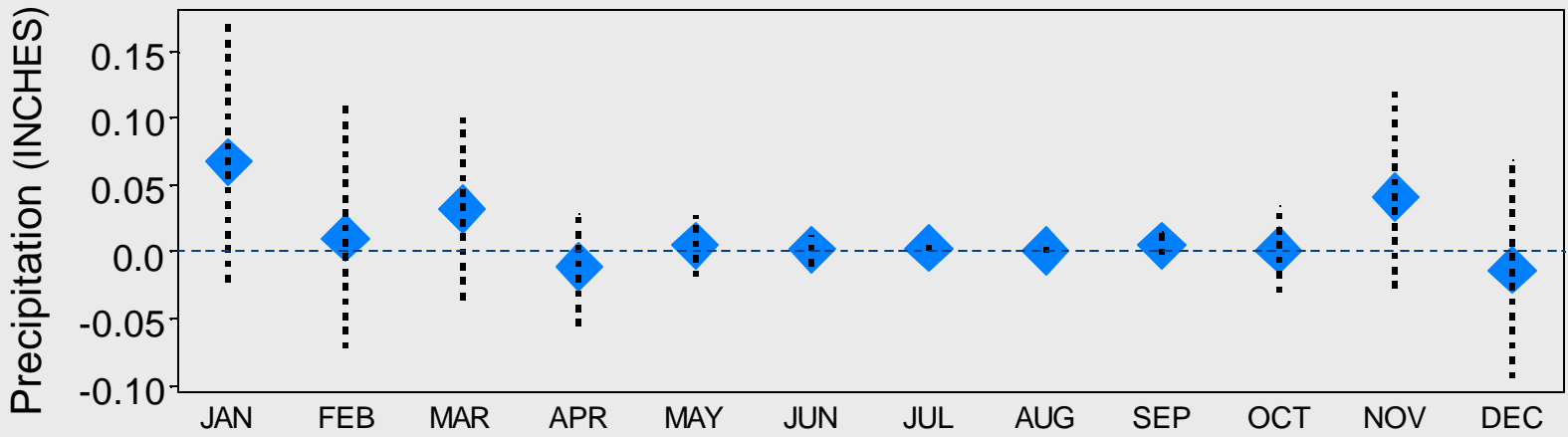
3. Among month trends

Slope of 13-Station **Precipitation** Trend (1921 – 2002)

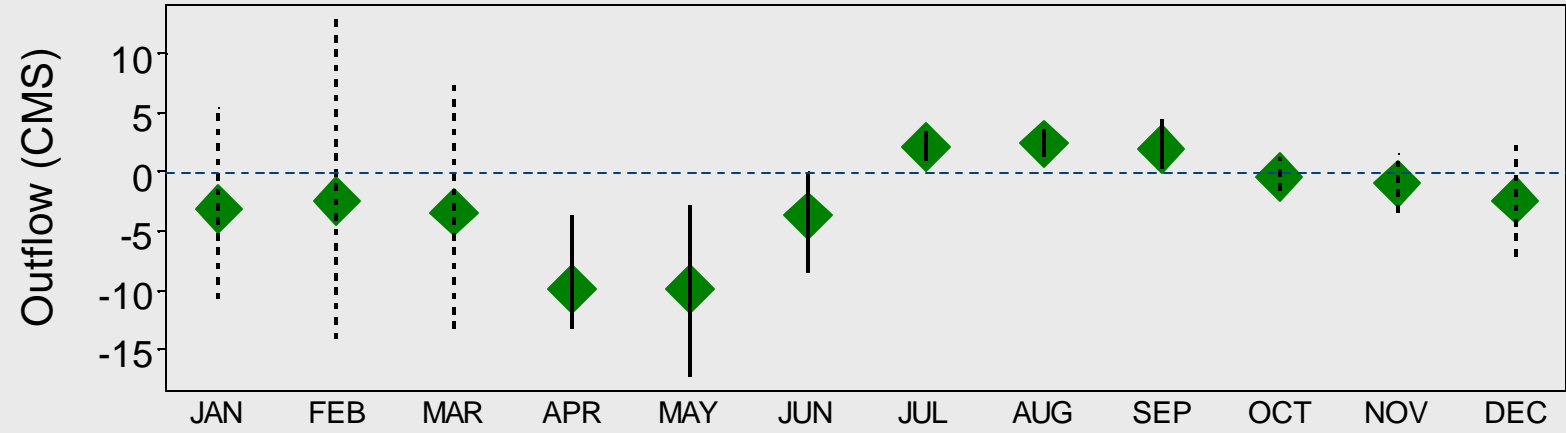


3. Among month trends

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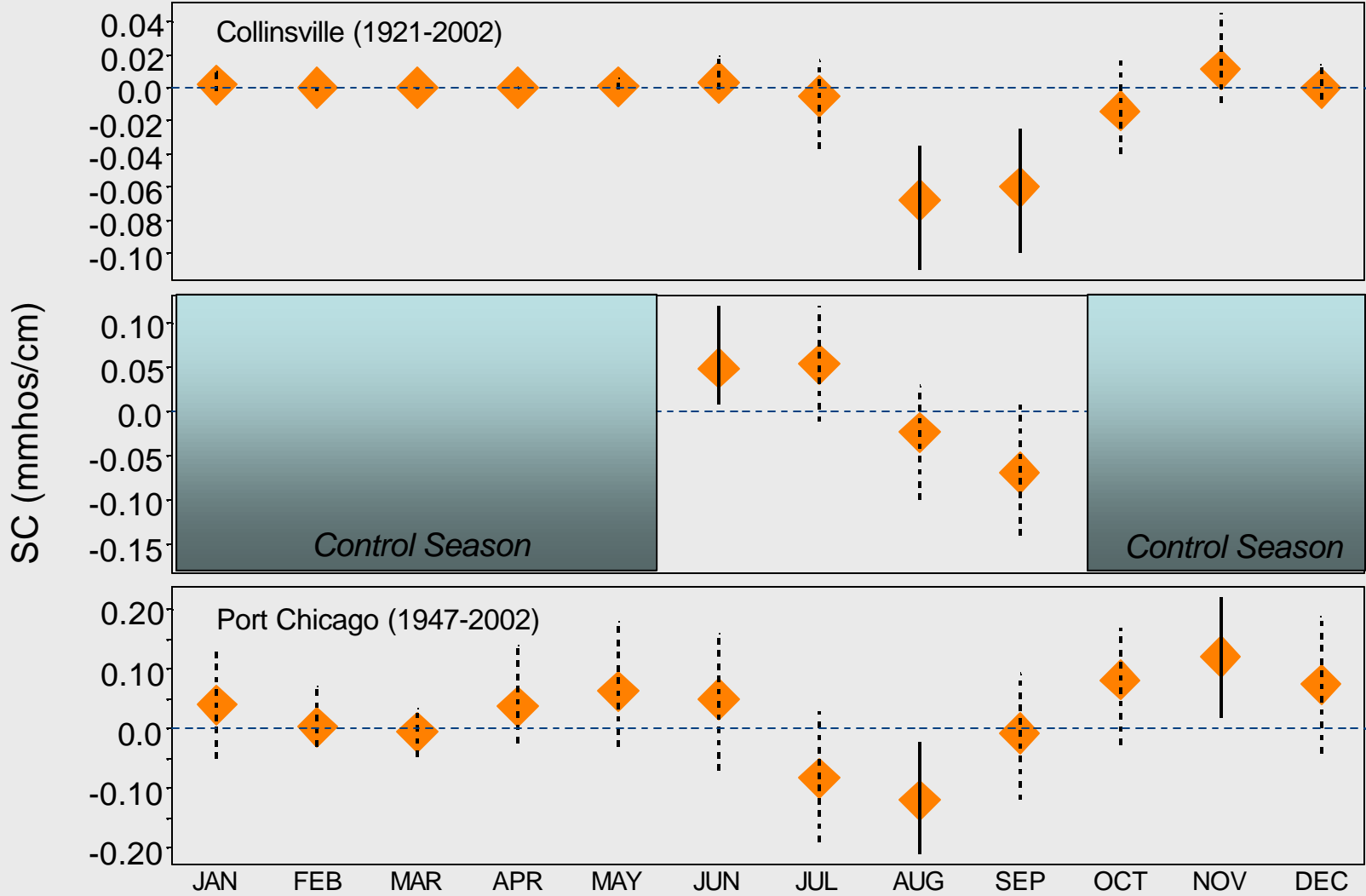


Slope of Delta **Outflow** Trend (1929 – 2002)



3. Among month trends

Slope of **SC** Trend (1921 – 2002)



Among Month Trends:

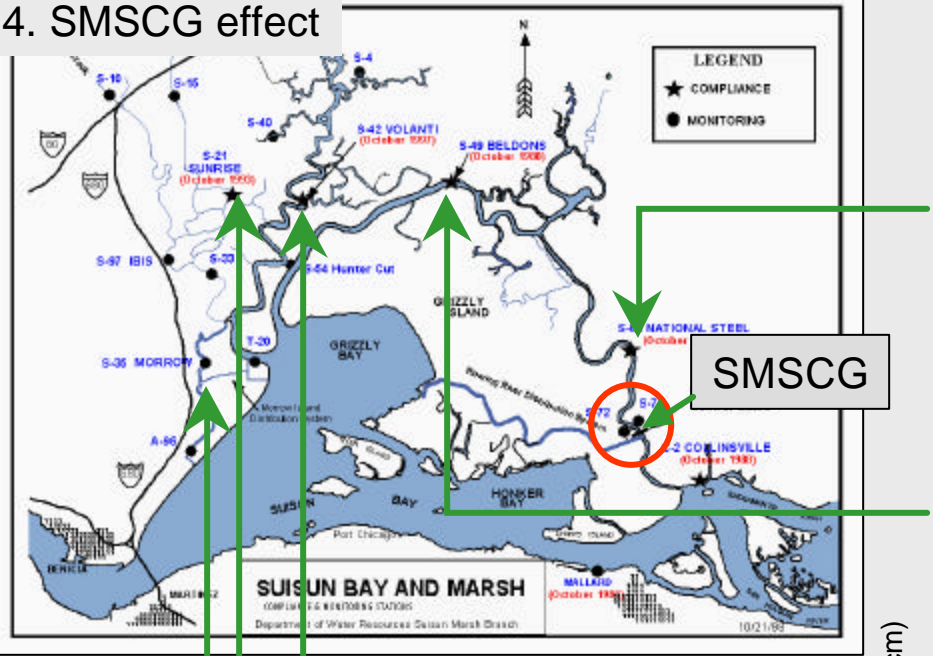
- No significant precipitation trend any month.
- Significant decreases in Delta outflow
 - April, May, June
- Significant increases in Delta outflow
 - July August, September
- Salinity is coherent with outflow
- Beldons Landing: April, May +2 mmhos/cm
October -3 mmhos/cm

4. Suisun Marsh Salinity Control Gate Effect

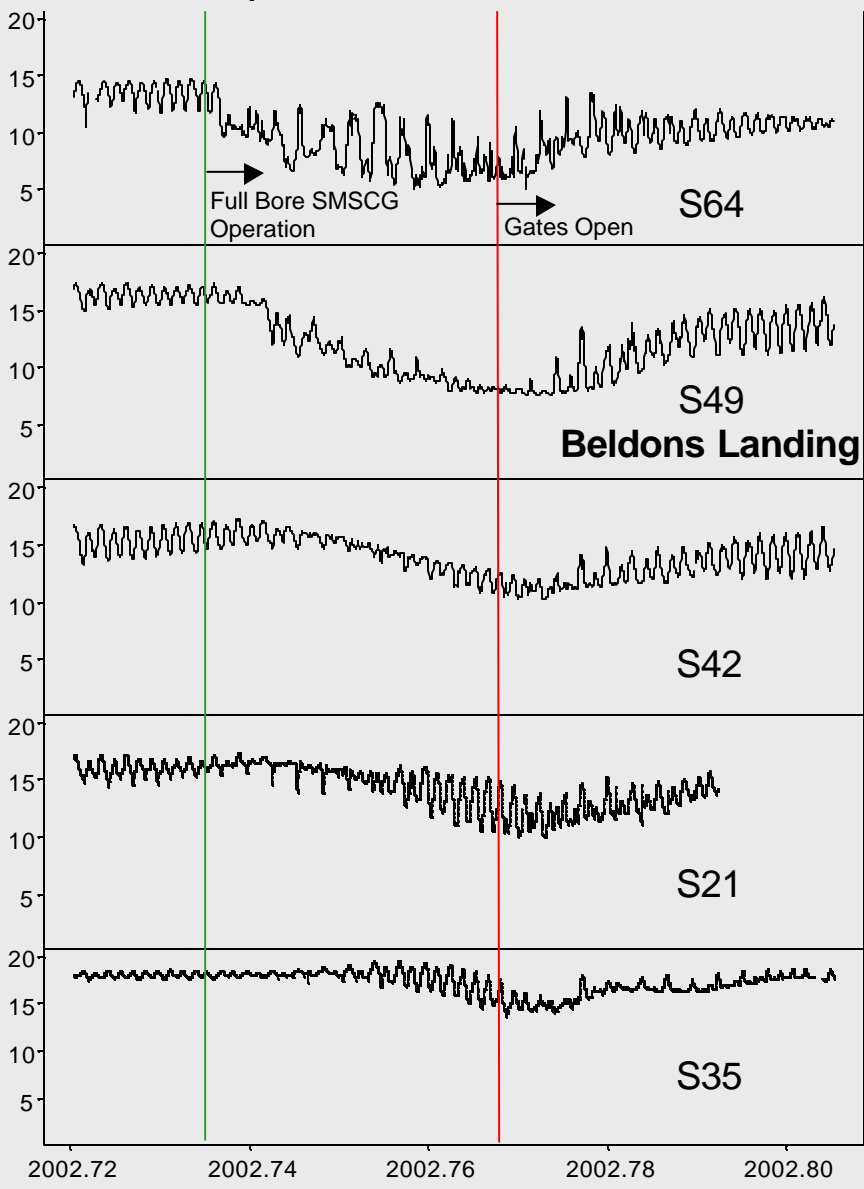
- SMSCG is operated between October and May only when needed to meet salinity standards.



4. SMSCG effect

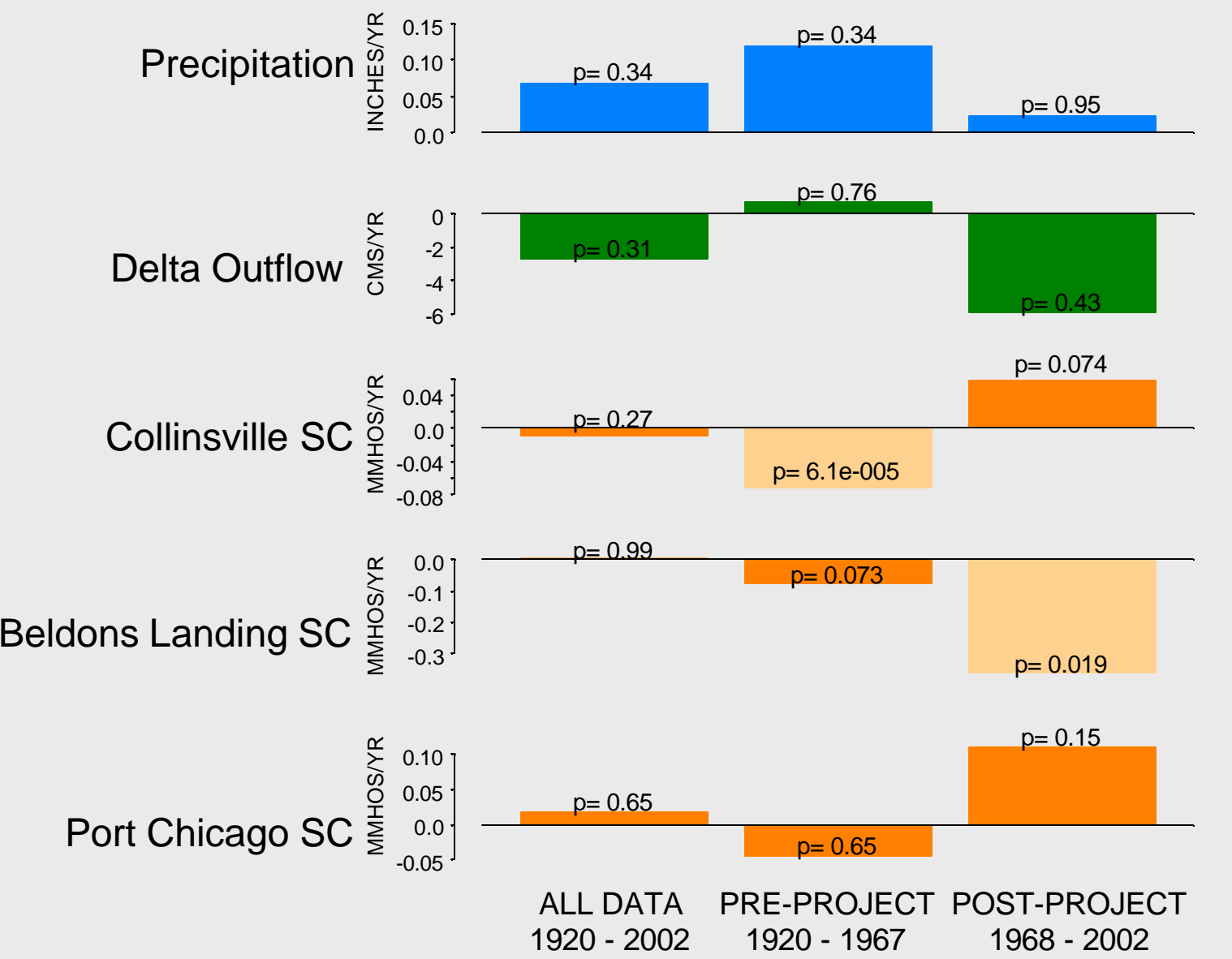


Salinity Response to SMSCG Operation Sept 20 – Oct 20, 2002



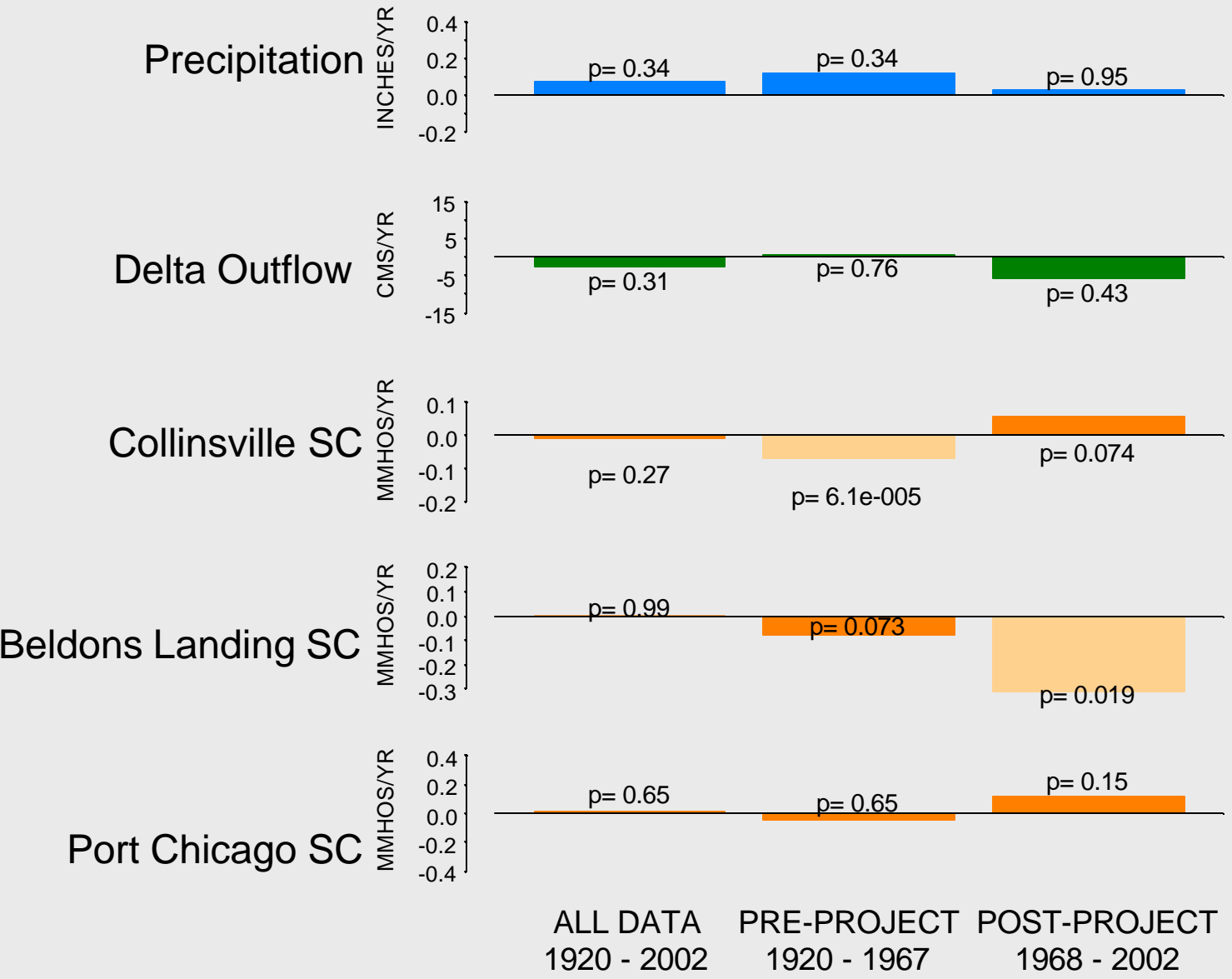
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Trends in Annual Data (Kendall Tau)



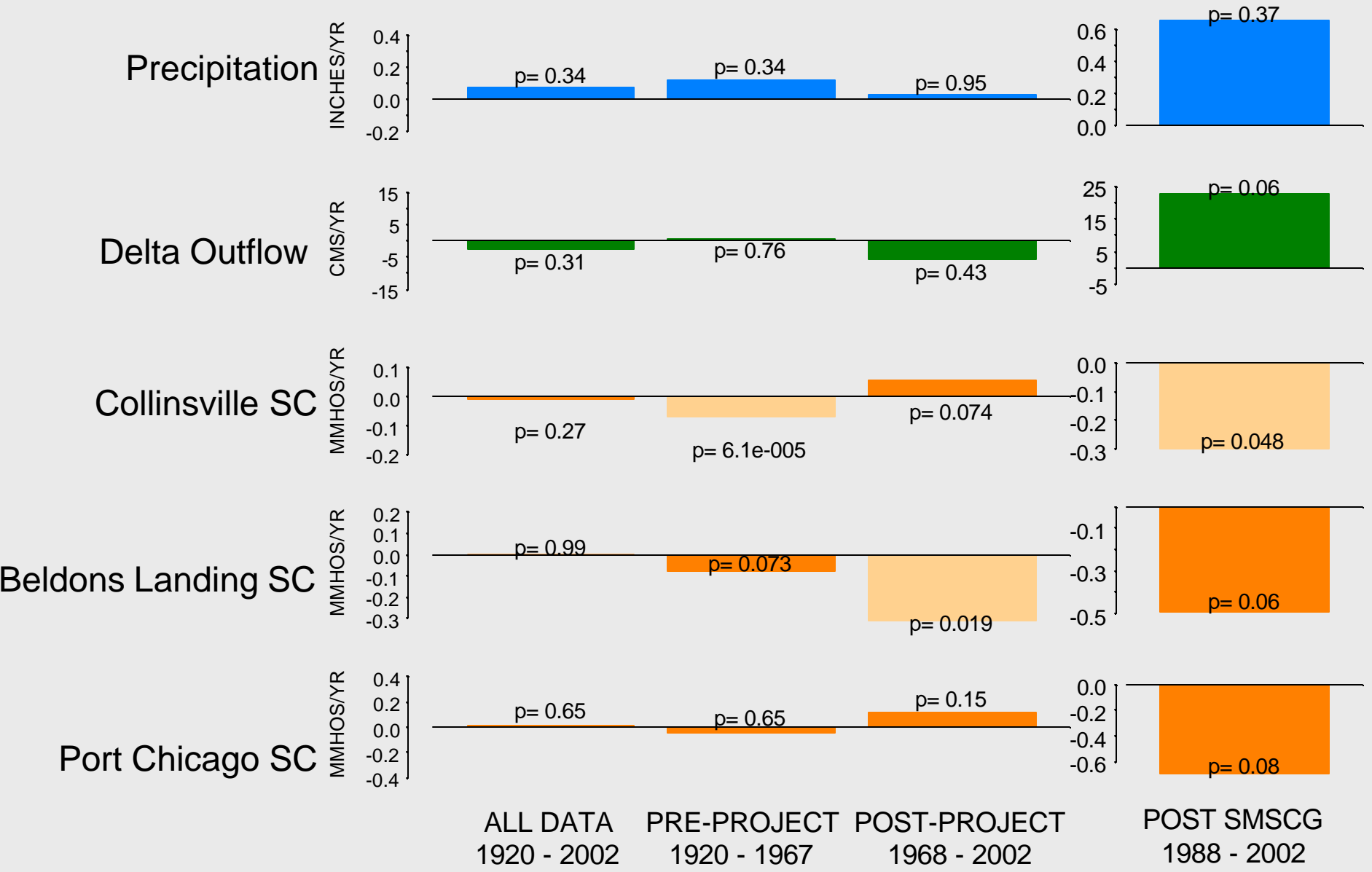
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Trends in Annual Data (Kendall Tau)



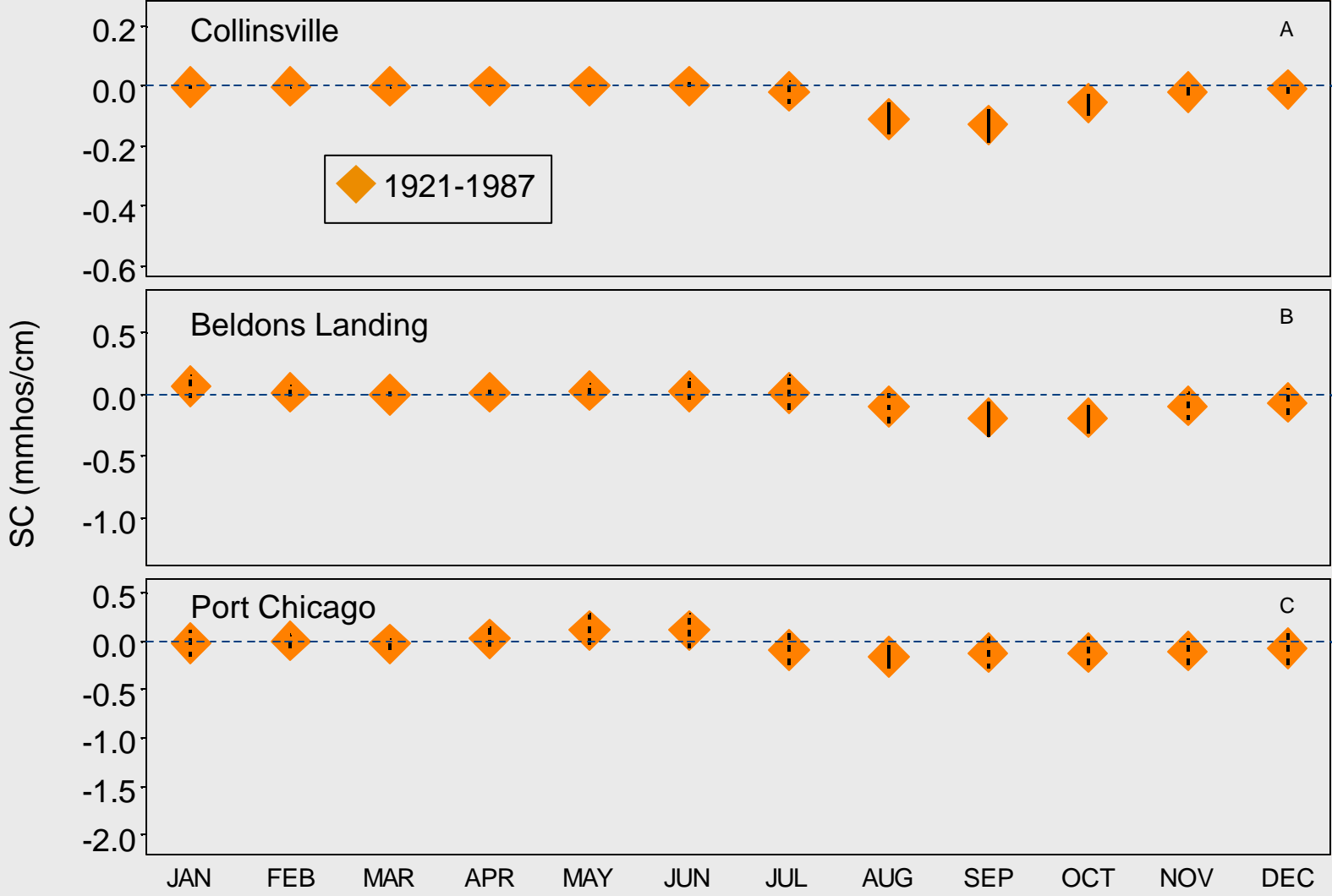
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Trends in Annual Data (Kendall Tau)



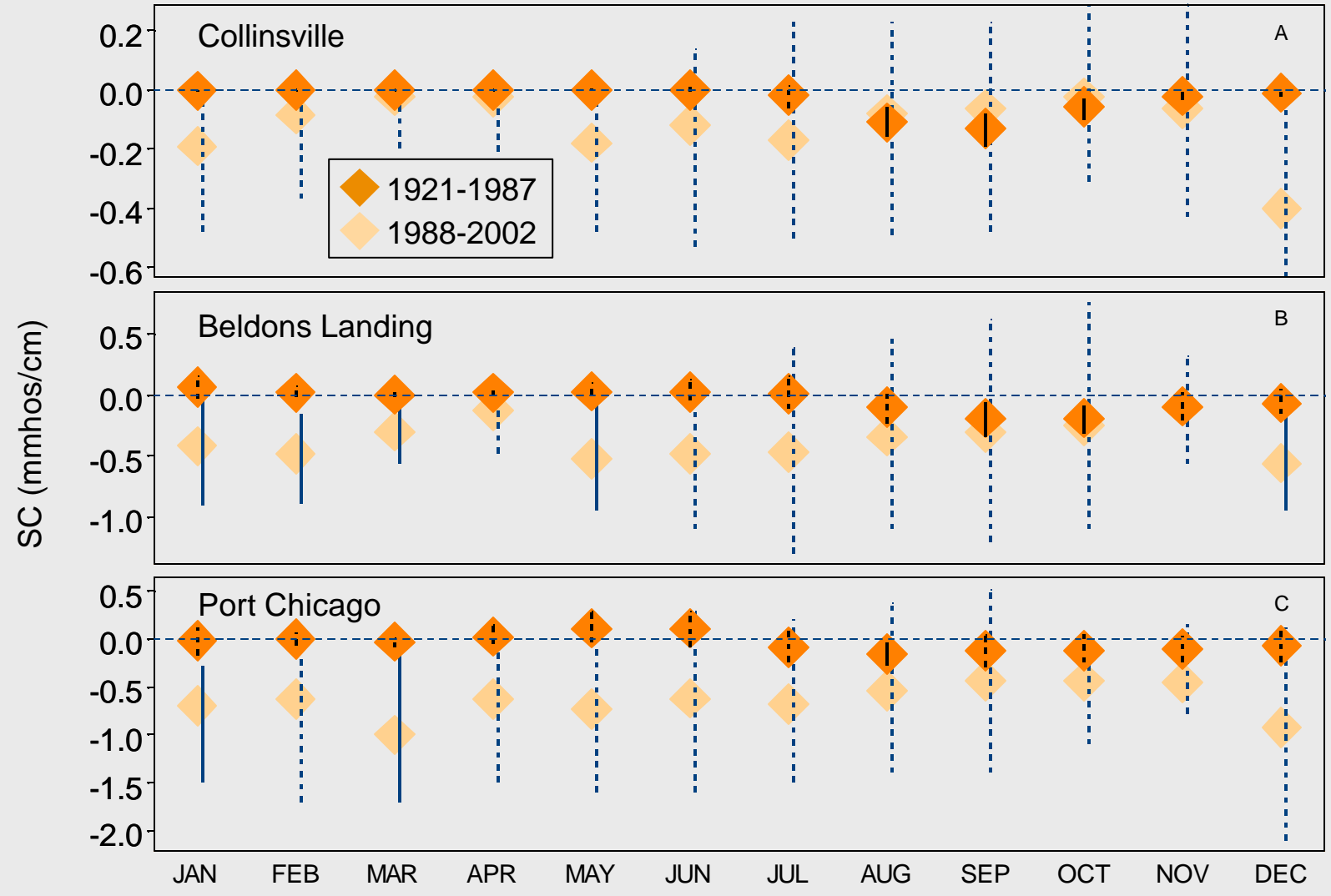
4. SMSCG effect

Slope of **SC** Trend by Month:
Pre- SMSCG Operation (1921-1987)



4. SMSCG effect

Slope of **SC** Trend by Month:
Pre (1921-1987) and Post (1988-2002) SMSCG Operation



Suisun Marsh Salinity Control Gate Effect:

- Works like hell.
- Reduces Suisun Marsh salinity in the Fall (east to west):
 - S64 6-8 mmhos/cm
 - Beldons 5-7
 - S42 4-5
 - S21 3-4
 - S35 1-2

5. Time-Scale Variability

- Decadal, inter-annual, seasonal, spring/neap, sub-tidal, tidal, turbulent.
- Relevant mitigation:
 - What time-scales and magnitudes of variability are important to organisms?

5. Time-Scale Variability

Annual Data CV (s/\bar{x})

	Pre-Project	Post Project
Precipitation	0.57	0.75
Outflow	0.27	0.37
Collinsville	0.77	0.82
Beldons Landing	0.34	0.45
Pt. Chicago	0.25	0.35

5. Time-Scale Variability

Monthly Data CV (s/\bar{x})

	Pre-Project	Post Project
Precipitation	1.18	1.42
Outflow	1.17	1.21
Collinsville	1.17	1.59
Beldons Landing	0.95	0.75
Pt. Chicago	0.65	0.71

6. Other Salinity Trend Drivers

- Sea level rise ~2mm/year
- Climate/Ocean conditions
 - (ENSO 3-5 yr, PDO 20-30 yr)
- Coastal upwelling
- Climate change and runoff to SF Estuary
- Bathymetry: Suisun Bay is erosional since 1922
 - Hydraulic mining debris
 - Reservoir sediment capture
 - Ship channel dredging
 - Dredging for levee building

6. Other Salinity Trend Drivers

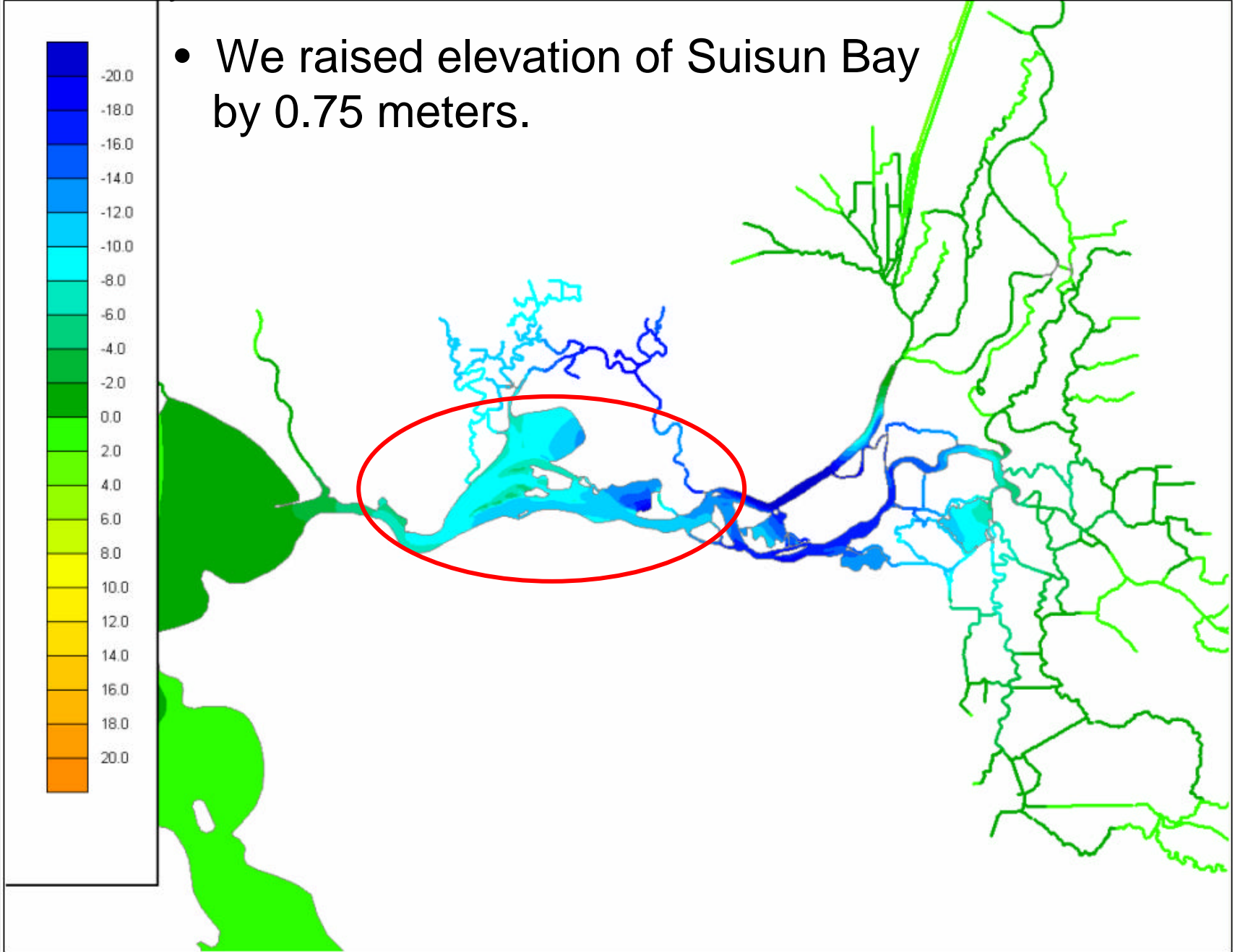
- Sea level rise ~2mm/year
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- *Bathymetry: Suisun Bay is erosional since 1922*
 - Hydraulic mining debris
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Suisun Bay Bathymetry Change

- Eroded 106 cm since 1922 (Cappiella et al.)
- > 100 million cubic meters
- How does deepening Suisun Bay affect the salinity regime? (ask Aaron Miller)

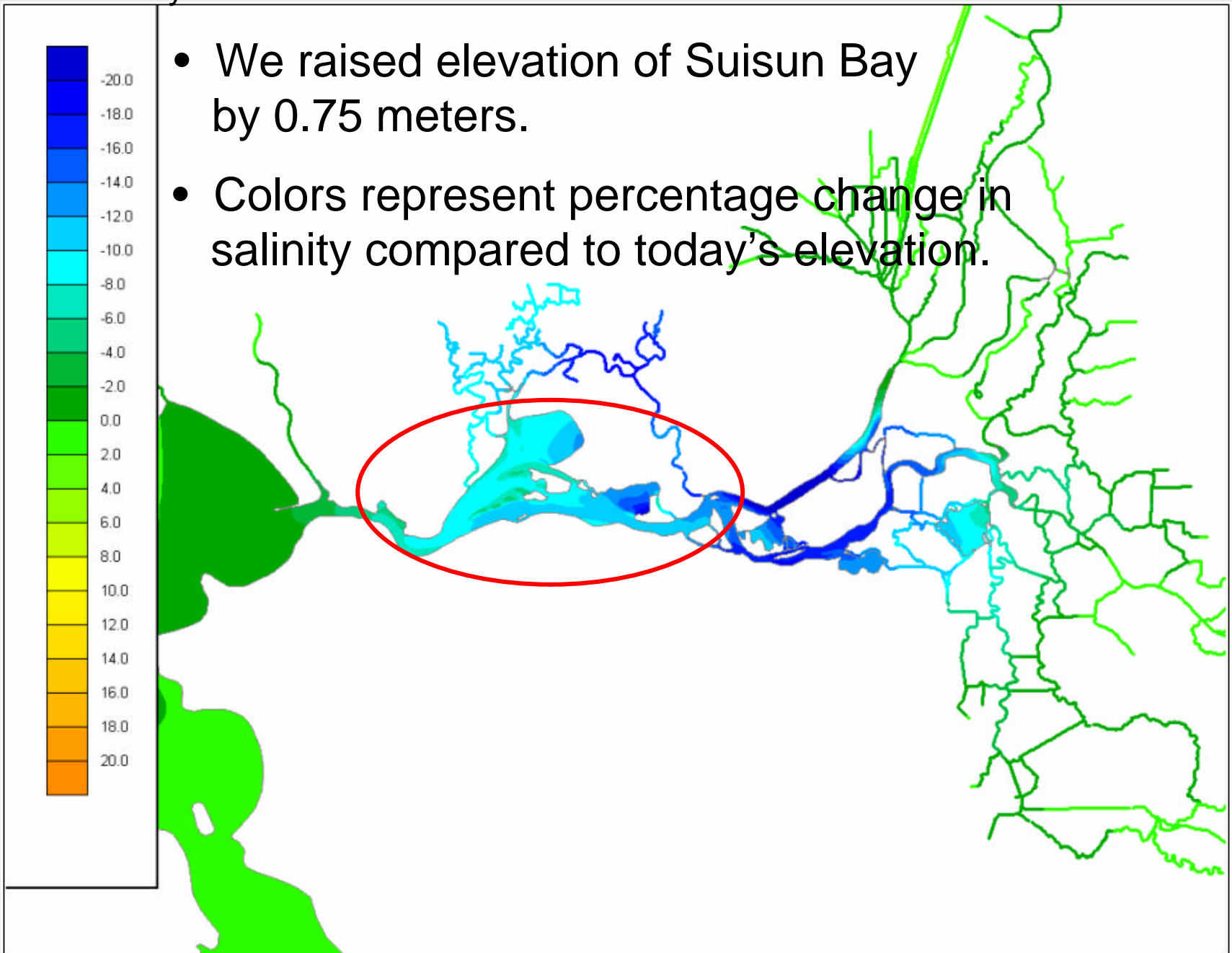
6. Other Salinity Trend Drivers

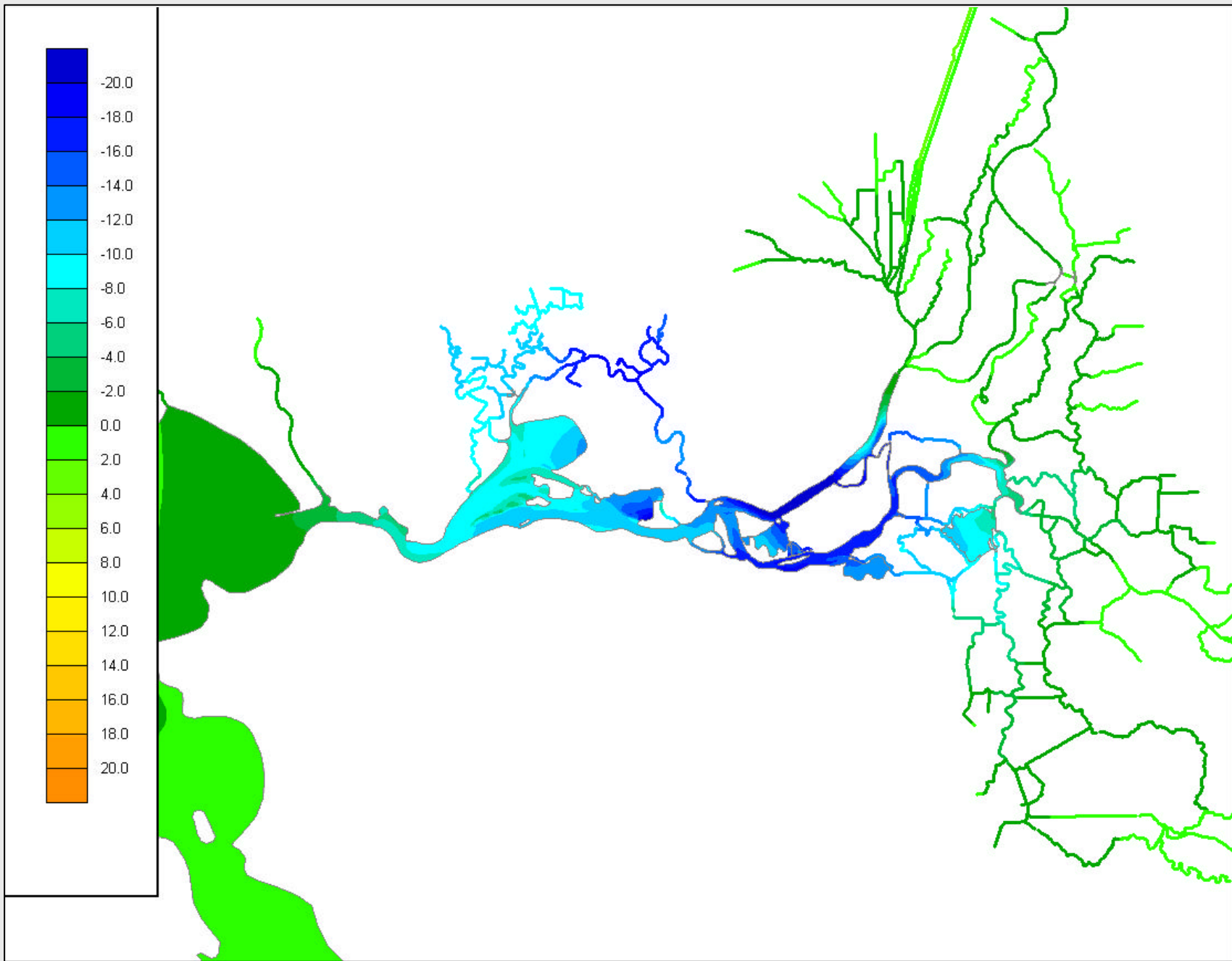
- We raised elevation of Suisun Bay by 0.75 meters.



6. Other Salinity Trend Drivers

- We raised elevation of Suisun Bay by 0.75 meters.
- Colors represent percentage change in salinity compared to today's elevation.





Conclusions

Hydrology

- Precipitation has increased slightly since 1920. Variability is orders of magnitude larger than trend.
- The seasonal distribution of outflow is changed: Lower April, May, June, higher, July, August, September.
- Long-term trend in outflow = -2.7cms/yr , $\sim 22\%$ reduction.

Conclusions (cont.)

Salinity

- Salinity variability is greater in post project period (coherent with precipitation)
- Climate variability overwhelms water project caused trends.
- At Beldons: Up to 1988, salinity was trending lower between August and December.
- Pre-project mean = **6.0**, $s = 2.1$
- Post-project mean = **7.5**, $s = 3.4$

Conclusions (cont.)

SMSCG

- Reduces Beldons Landing salinity by 5-7 mmhos/cm.
- SMSCG reduces salinity more than salinity would have increased without it.

Conclusions (cont.)

Biology

- Salinity is less than ideal May alkali bulrush seed germination salinity 95% of the time at Beldons.
- Water projects have reduced summer/fall salinity variability some native plants/fishes have used to competitive advantage.
- Decrease in salinity variability from seasonal outflow redistribution is probably real, but it's overwhelmed by climate variability.

Thank You

- Callie Harrison
- Victor Pacheco
- Marc Vayssieres
- Brad Tom
- Aaron Miller
- Kate Le
- Steve Culberson

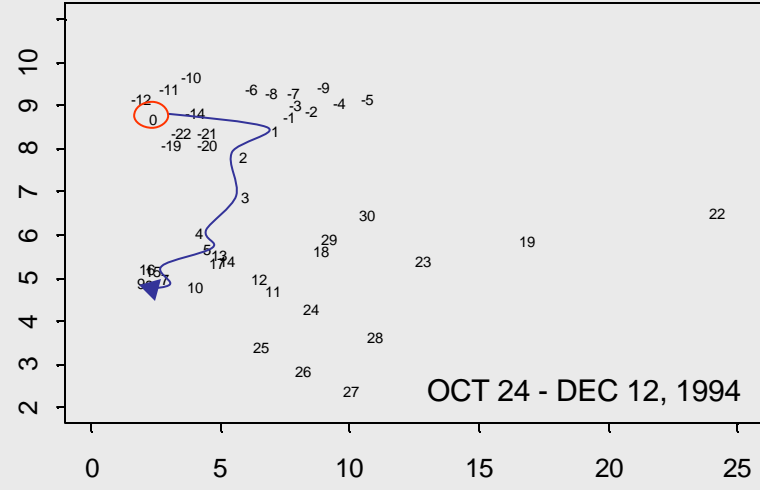
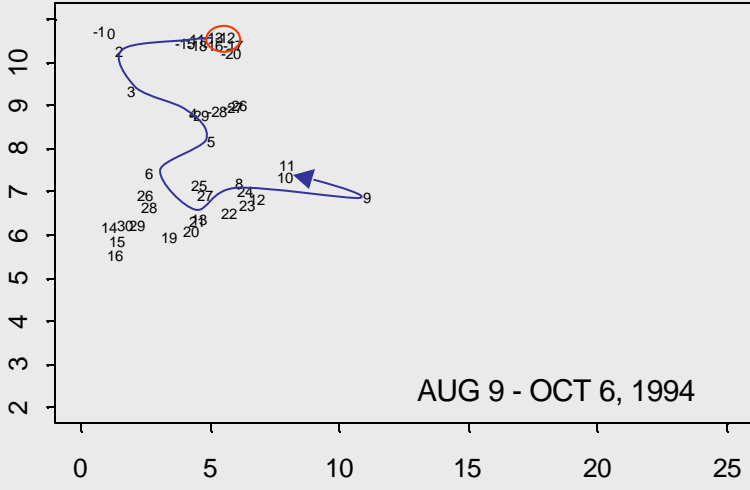
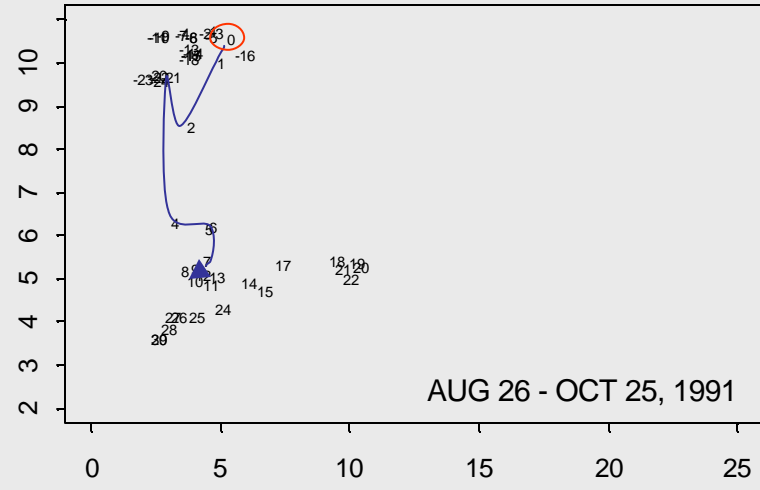
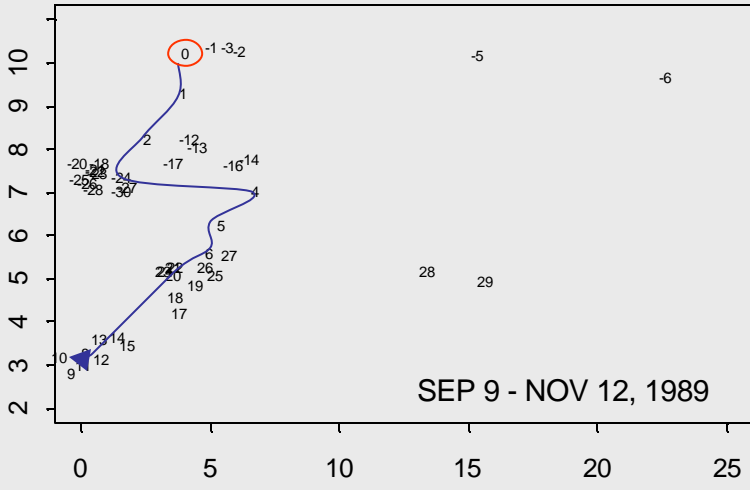
Manuscript Ideas

- Port Chicago LOESS shows increase from 9 to 12 SC, greater than Collinsville and Blanding. This shows the effect of bay scour.

4. SMSCG effect

Beldons Landing Response to SMSCG Operation and Delta Outflow

TDS (PPT)



Delta Outflow (TCFS)