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Conservative Mixing: Implications for Selecting Salinity Transport Model Constituents in the San Francisco Estuary (Part 2)

CWEMF Annual Meeting

Session 32

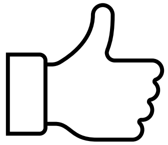
Folsom, CA April 19,2023

Paul Hutton, Ph.D., P.E.
Sujoy Roy, Ph.D.
Tetra Tech, Inc.

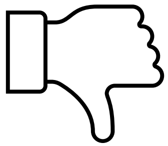
Balancing Tradeoffs in Selection of a Salinity Transport Model Constituent

Specific Conductance (EC)

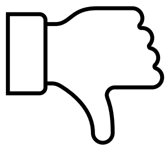
No data translation error



Non-conservative



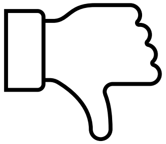
Non-standard practice



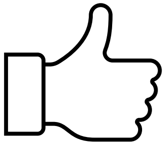
Balancing Tradeoffs in Selection of a Salinity Transport Model Constituent (cont'd)

Practical Salinity

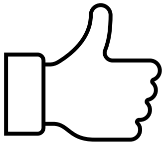
Subject to data translation error



Conservative



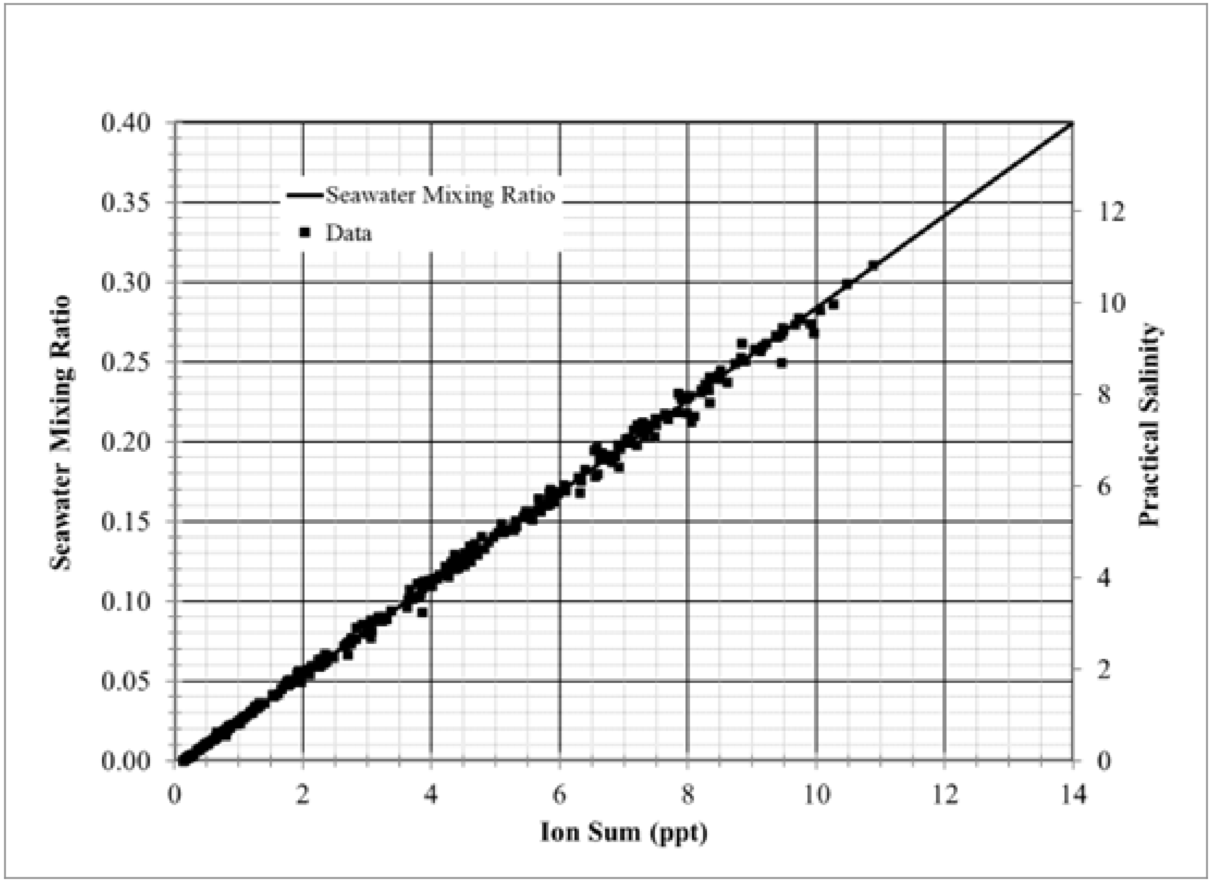
Standard practice



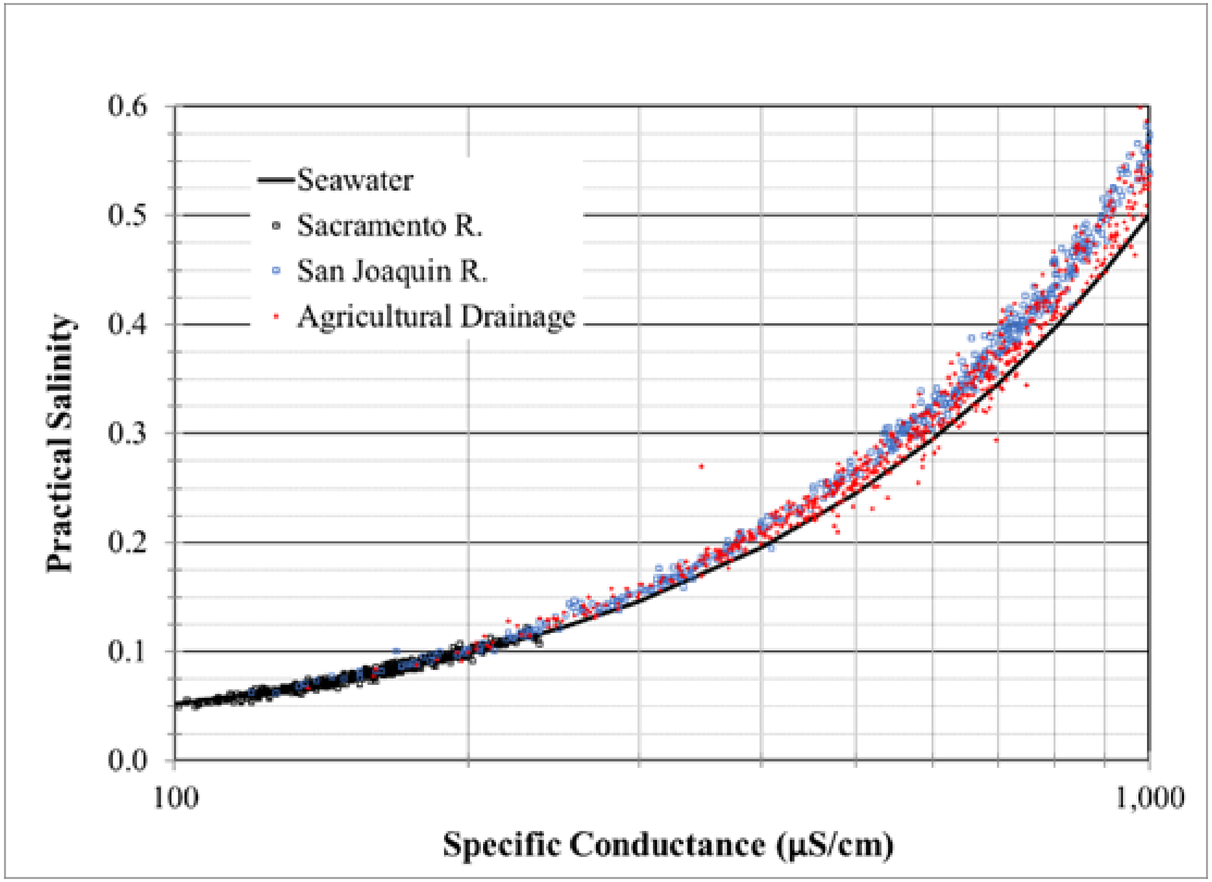
Balancing Tradeoffs in Selection of a Salinity Transport Model Constituent (cont'd)

- Selecting EC as a transport constituent assumes a tradeoff relationship that hasn't been formally evaluated
- How significant is error associated with EC's non-conservative behavior?
- How significant is error associated with data translation between EC and practical salinity?

Practical Salinity Exhibits Conservative Behavior



Relationship Between Practical Salinity and Specific Conductance is Source-Dependent



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An alternative to Practical Salinity…

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Limiting Equivalent Conductance[1,2]

$$\kappa = \sum_i \alpha_i * \lambda_i * C_i$$

κ = limiting equivalent conductance of sample
α_i = fraction of the ith ionic constituent present as the free ion
λ_i = limiting equivalent conductance of the ith ionic constituent
C_i = mass concentration of the ith ionic constituent

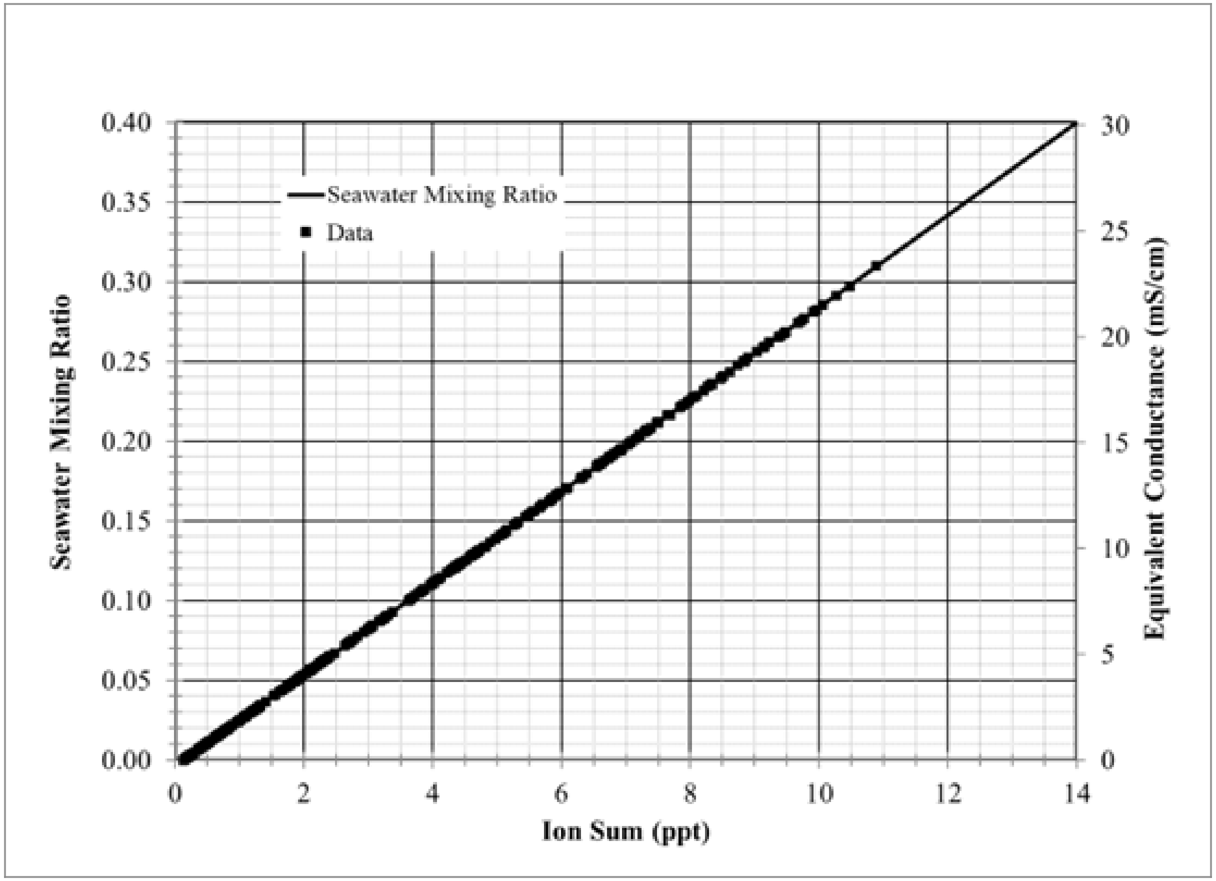
λ is the conductance of an ionic constituent extrapolated to infinite dilution, where interaction between ions in solution disappear and the mobility of individual ions reaches a maximum.

[1] Commonly referred to as "computed" conductance
2 Miller et al., 1988. Specific Conductance: Theoretical Considerations and Application to Analytical Quality Control, U.S. Geological Survey Water Supply Paper 2311.

Ion-Specific Constants for Calculating Limiting Equivalent Conductance

Ion Constituent	α	λ (µS/cm per mg/L)
Br^-	0.99	0.98
Cl^-	0.99	2.15
SO_4^{2-}	0.93	1.66
HCO_3^-	0.98	0.73
Na^+	0.98	2.18
Ca^{2+}	0.88	2.97
Mg^{2+}	0.88	4.36
K^+	0.98	1.88

Limiting Equivalent Conductance has Conservative Behavior



κ can be estimated for seawater as a function of Specific Conductance

$$\frac{\kappa}{\kappa_s} = L_o + L_1 * R^{0.5} + L_2 * R + L_3 * R^{1.5} + L_4 * R^2 + L_5 * R^{2.5}$$

κ = limiting equivalent conductance of sample

κ_s = limiting equivalent conductance of seawater = 75,636 µS/cm

L_i = model constants where $\sum L_i = 1$

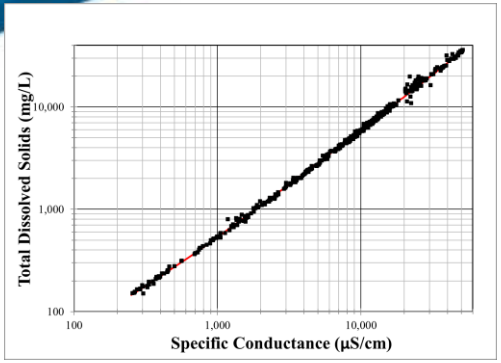
$L_o = 0.0003$; $L_1 = -0.0062$; $L_2 = 0.7237$;

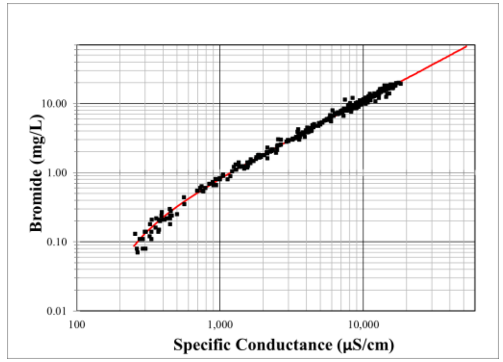
$L_3 = 0.3935$; $L_4 = -0.1851$; $L_5 = 0.0738$

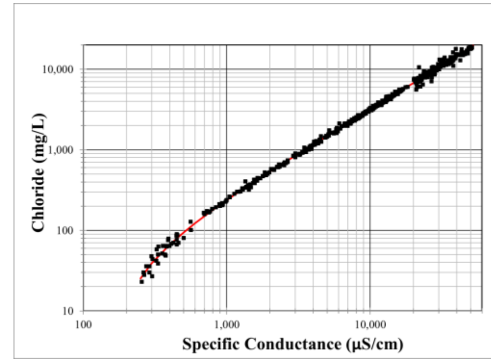
R = conductivity ratio (sample EC ÷ seawater EC)

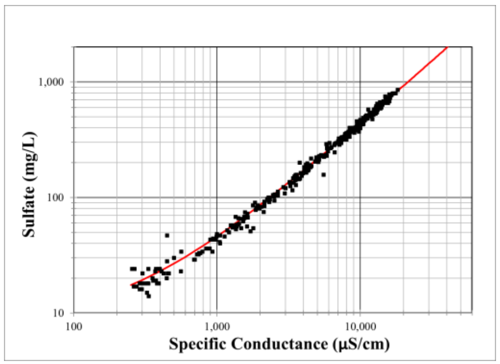
This equation was derived by substituting functional relationships between ion concentrations and R (not shown here) into the mathematical definition of κ

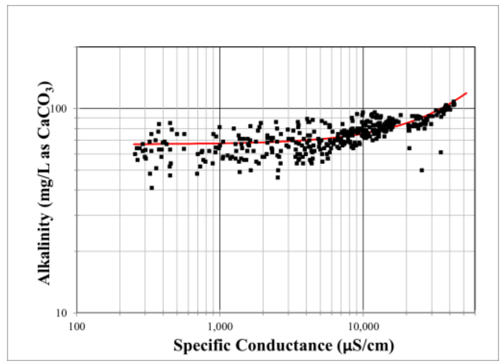
Assume κ = EC when EC < 250 µS/cm

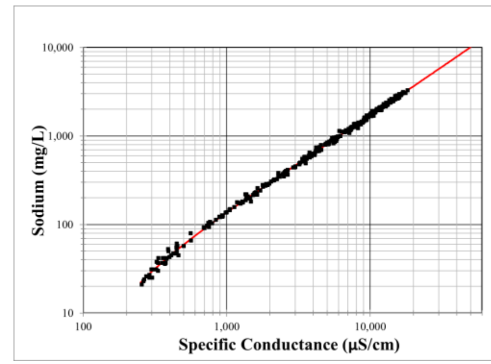

Total Dissolved Solids (mg/L)
10,000
1,000
100
100
1,000
10,000
Specific Conductance (µS/cm)

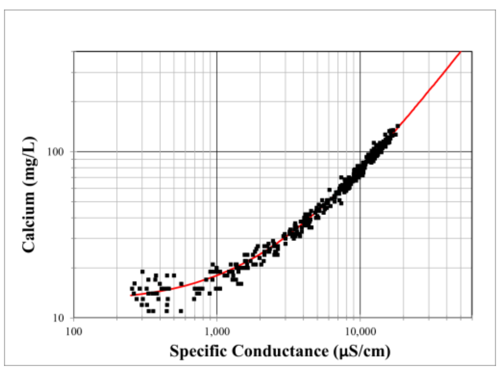

Bromide (mg/L)
10.00
1.00
0.10
0.01
100
1,000
10,000
Specific Conductance (µS/cm)

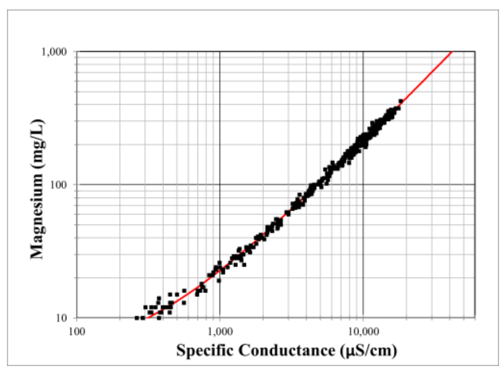

Chloride (mg/L)
10,000
1,000
100
10
100
1,000
10,000
Specific Conductance (µS/cm)

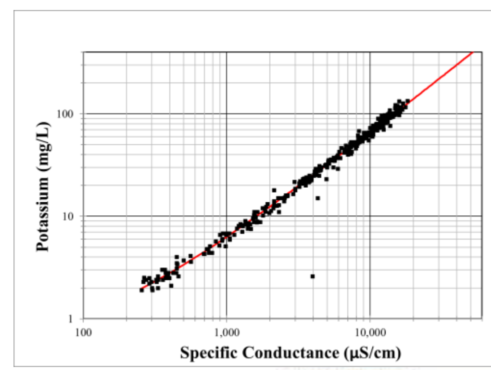

Sulfate (mg/L)
1,000
100
10
100
1,000
10,000
Specific Conductance (µS/cm)


Alkalinity (mg/L as CaCO3)
100
10
100
1,000
10,000
Specific Conductance (µS/cm)

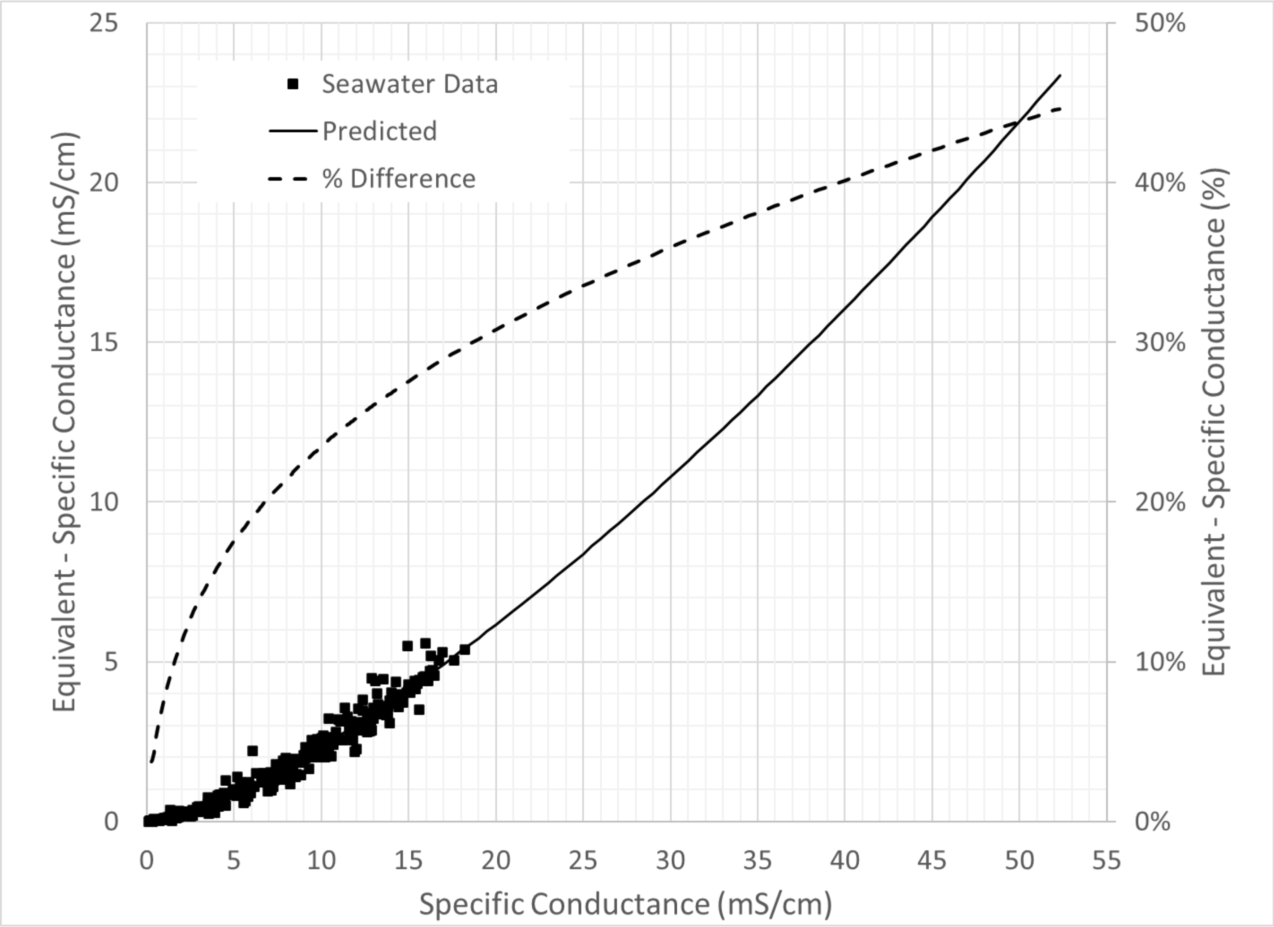

Sodium (mg/L)
10,000
1,000
100
10
100
1,000
10,000
Specific Conductance (µS/cm)


Calcium (mg/L)
100
10
100
1,000
10,000
Specific Conductance (µS/cm)


Magnesium (mg/L)
1,000
100
10
100
1,000
10,000
Specific Conductance (µS/cm)

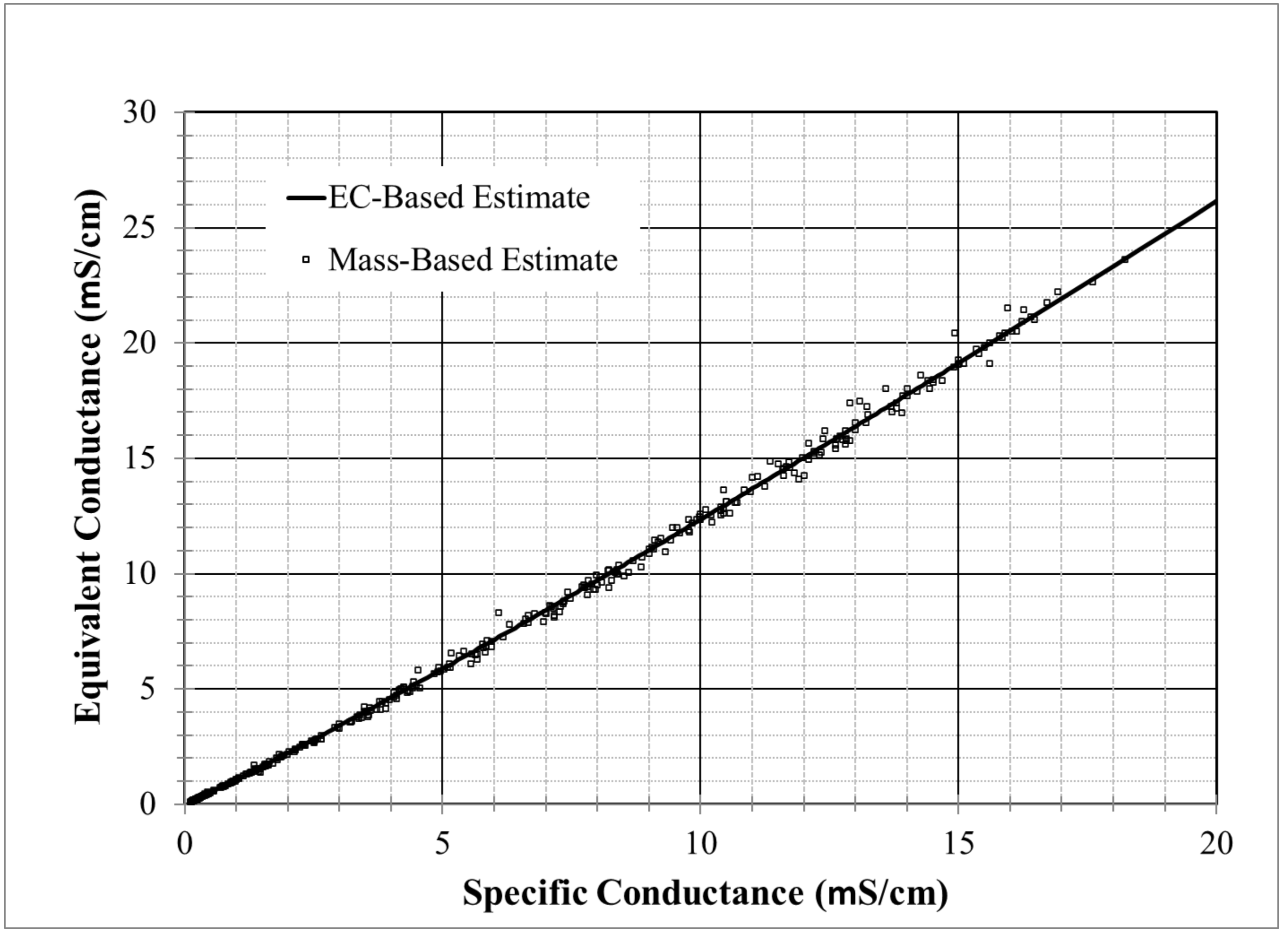

Potassium (mg/L)
100
10
1
100
1,000
10,000
Specific Conductance (µS/cm)

κ & Specific Conductance Comparison

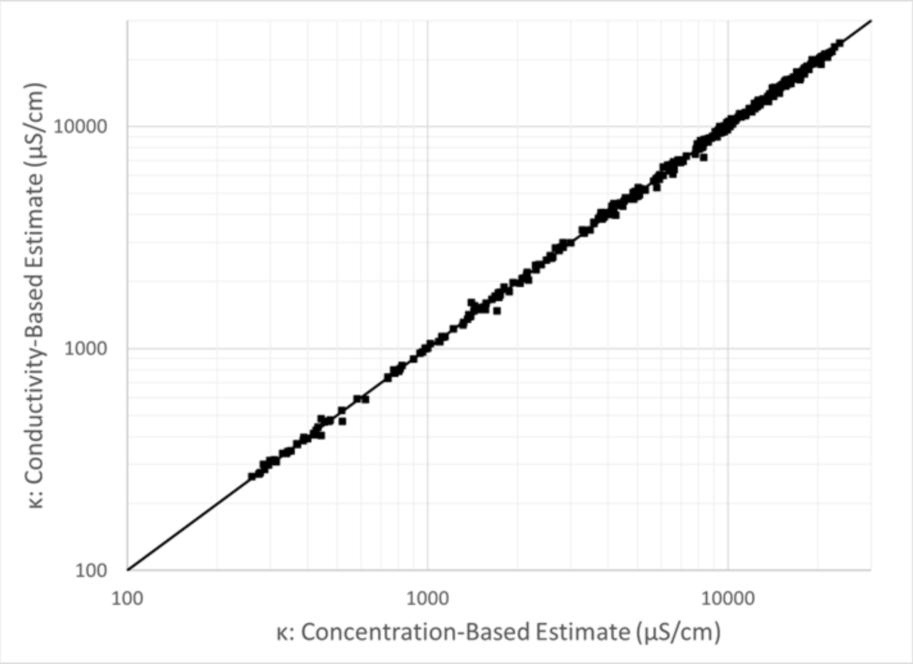


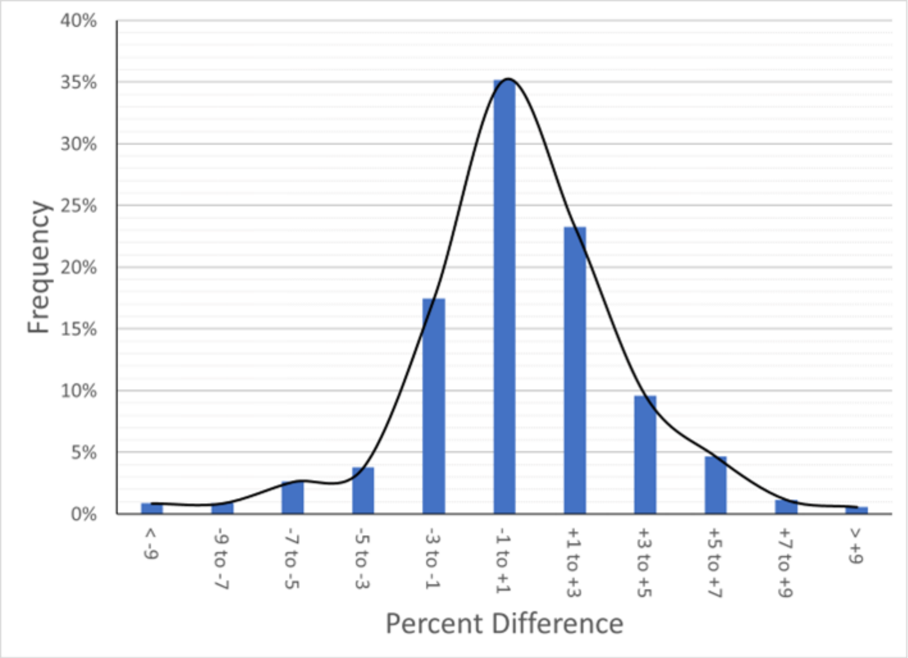
κ vs. Specific Conductance

Comparison of Conductance-Based and Mass-Based Estimates

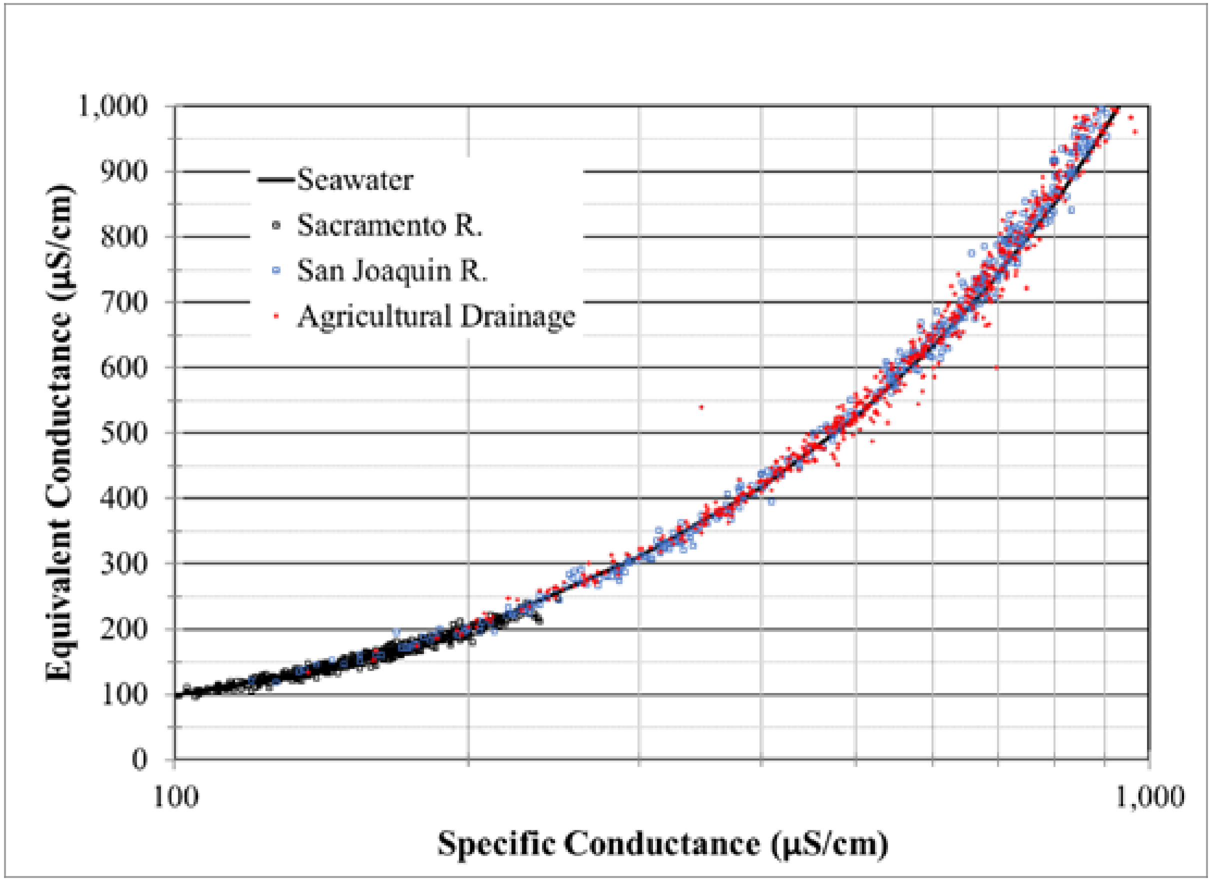


Comparison of Conductance-Based and Mass-Based Estimates of κ





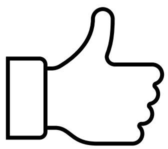
Relationship Between κ and Specific Conductance is not Source-Dependent



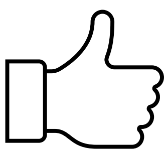
Balancing Tradeoffs in Selection of a Salinity Transport Model Constituent

Limiting Equivalent Conductance (κ)

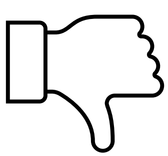
No data translation error



Conservative



Non-standard practice



Findings

- Practical salinity (PSS-78) is a conservative salinity measure.
  - However, relationship between PSS-78 and EC is source dependent
  - Need to account for tradeoff between non-conservative behavior of EC and uncertainty associated with translating between EC and PSS-78
- The choice between PSS-78 and EC as a simulation constituent must account for tradeoff between conservative behavior and translation uncertainty.
- Limiting Equivalent Conductance (κ) is a conservative salinity measure.
  - Relationship between κ and EC is approximately independent of source in the Delta; thus, limited translation uncertainty
  - This measure shows promise for use as a simulation constituent for SF Estuary and the Delta

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Acknowledgements

- This work was made possible through funding from the State Water Contractors.
- The authors acknowledge Arushi Sinha’s contribution to this work through data assembly and screening.