CALIFORNIA WATER FIX
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DWR - 1067

BASIS OF SELENIUM MODELING

OVERVIEW OF TESTIMONY

- **Summary**
- **Selenium Model Credibility**
- **Selenium Basics**
- **Delta-wide Selenium Model Methodology**
- **Western Delta Sturgeon Selenium Model Methodology**
- **Selenium Model Outputs**
- **Conclusions**

SUMMARY

- **Calibrated models, which covered the range of predicted water Se concentrations under future conditions, gave reasonable predictions of whole-body Se in fish. Higher enrichment factors (EFs; from water to lowest food-web component) with lower waterborne Se concentrations, as found in calibrating models, are consistent with expectations based on literature (Stewart et al. 2010).**
- **Developing site-specific EFs was essential toward modeling potential future conditions in the Delta and informing water management decisions.**

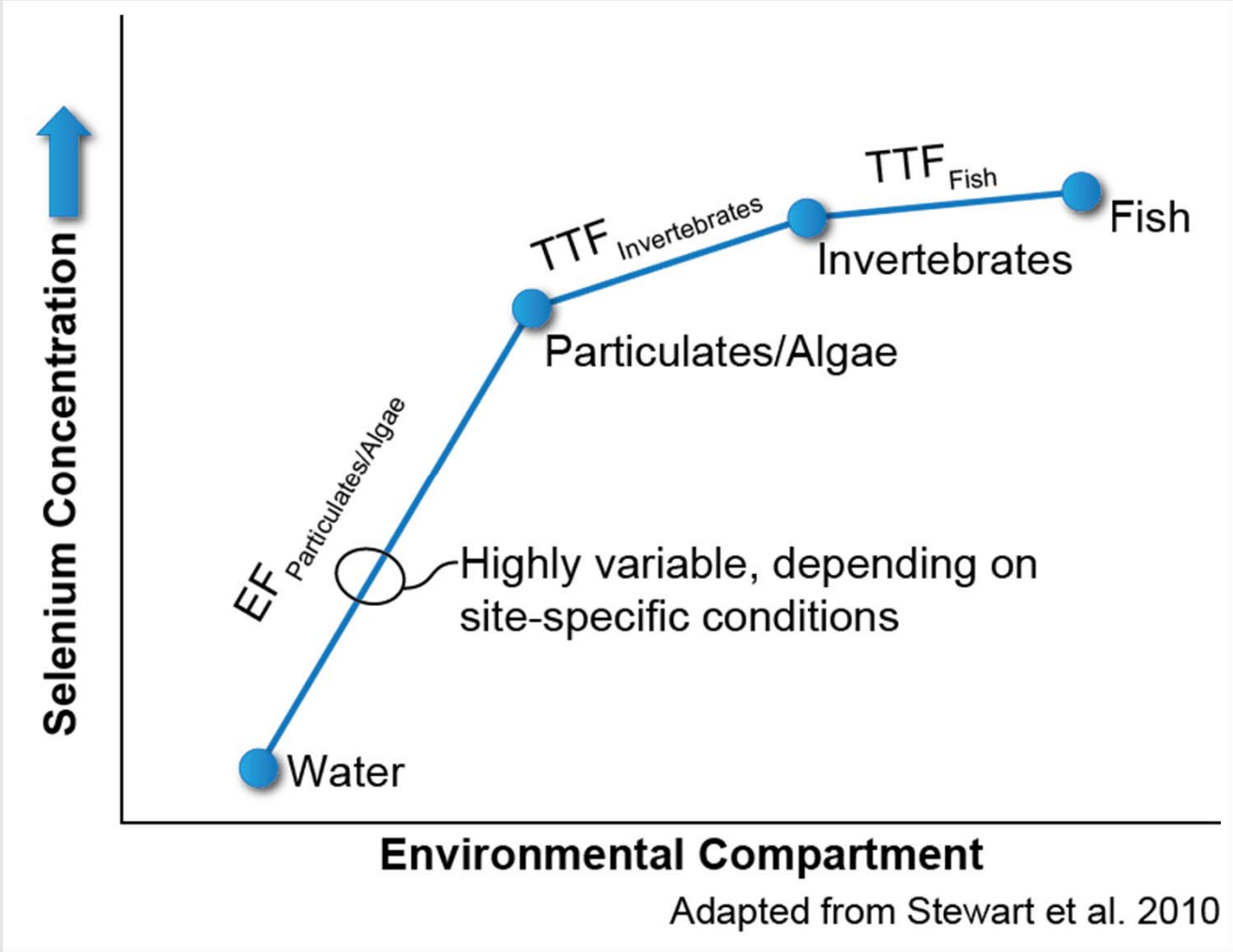
SELENIUM MODEL CREDIBILITY

- **Model**
  - Credibility in models is high because they were based on current published state-of-science approach (Presser and Luoma 2010a, 2010b, 2013) and available data.
  - Higher EFs with lower waterborne Se concentrations (as found in the modeling) are consistent with expectations based on literature (e.g., Stewart et al. 2010).
  - Modeling approach also is consistent with that in subsequently promulgated USEPA (2016) Aquatic Life Ambient Water Quality Criterion for Selenium – Freshwater.
- **Observational Data Input**
  - Whole-body largemouth bass Se data available from seven DSM2 output locations and two Delta inflow locations in 2000, 2005, and 2007 (Foe 2010) were used.

SELENIUM BASICS

- **Site-specific chemical, physical, and biological conditions greatly affect Se bioaccumulation.**
- **Measured Se concentrations in largemouth bass sampled in Years 2000, 2005, and 2007 where Sacramento and San Joaquin Rivers enter the Delta did not differ (Foe 2010), even though Se concentrations in San Joaquin River water are several times higher than those in the Sacramento River.**
- **Enrichment factors (EFs [from water to particulates]), rather than trophic transfer factors (TTFs [particulates to invertebrates and invertebrates to fish]), are typically the most variable contributors to differences in bioaccumulation among locations or time periods.**

GENERALIZED SELENIUM BIOACCUMULATION MODEL

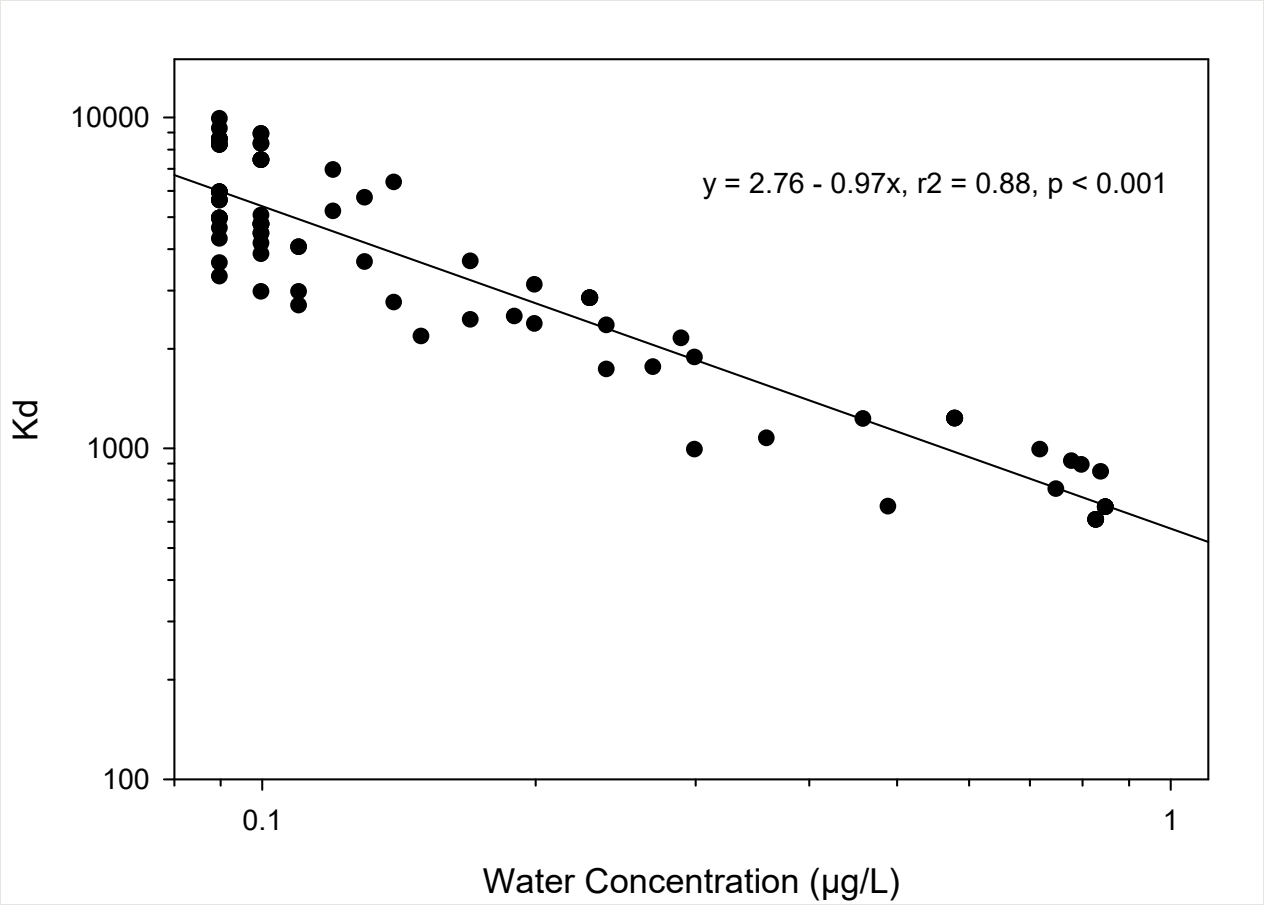


Adapted from Stewart et al. 2010

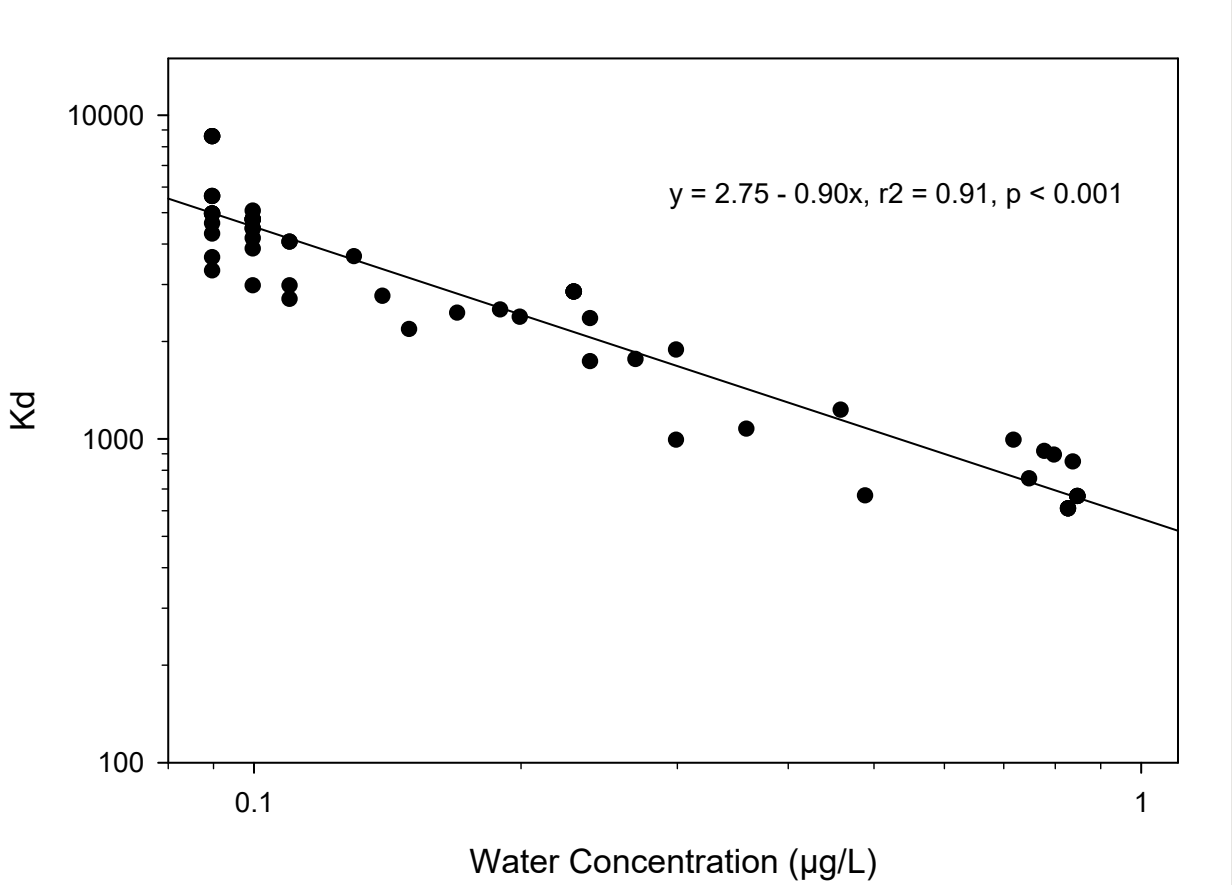
DELTA-WIDE SELENIUM MODEL METHODOLOGY

- **Using literature-based default EFs and TTFs (Model 1) as well as EF measured at a location in the Delta along with default TTFs (Model 2) produced models that did not match measured Se concentrations in largemouth bass, as described in the EIR/EIS.**
- **Therefore, investigated different approaches to deriving EFs and calibrating a Delta-specific bioaccumulation model that best fit uptake from water to whole-body fish. Using measured fish data, default TTFs, and back-calculation of the EFs, found a log-log relationship between the EFs and waterborne Se (Models 3, 4, and 5).**
- **EFs varied between wet/normal years (2000, 2005; median = 2,196) and dry years (2007; median = 6,228), and by location (e.g., Sacramento River median = 4,934; San Joaquin River median = 612).**

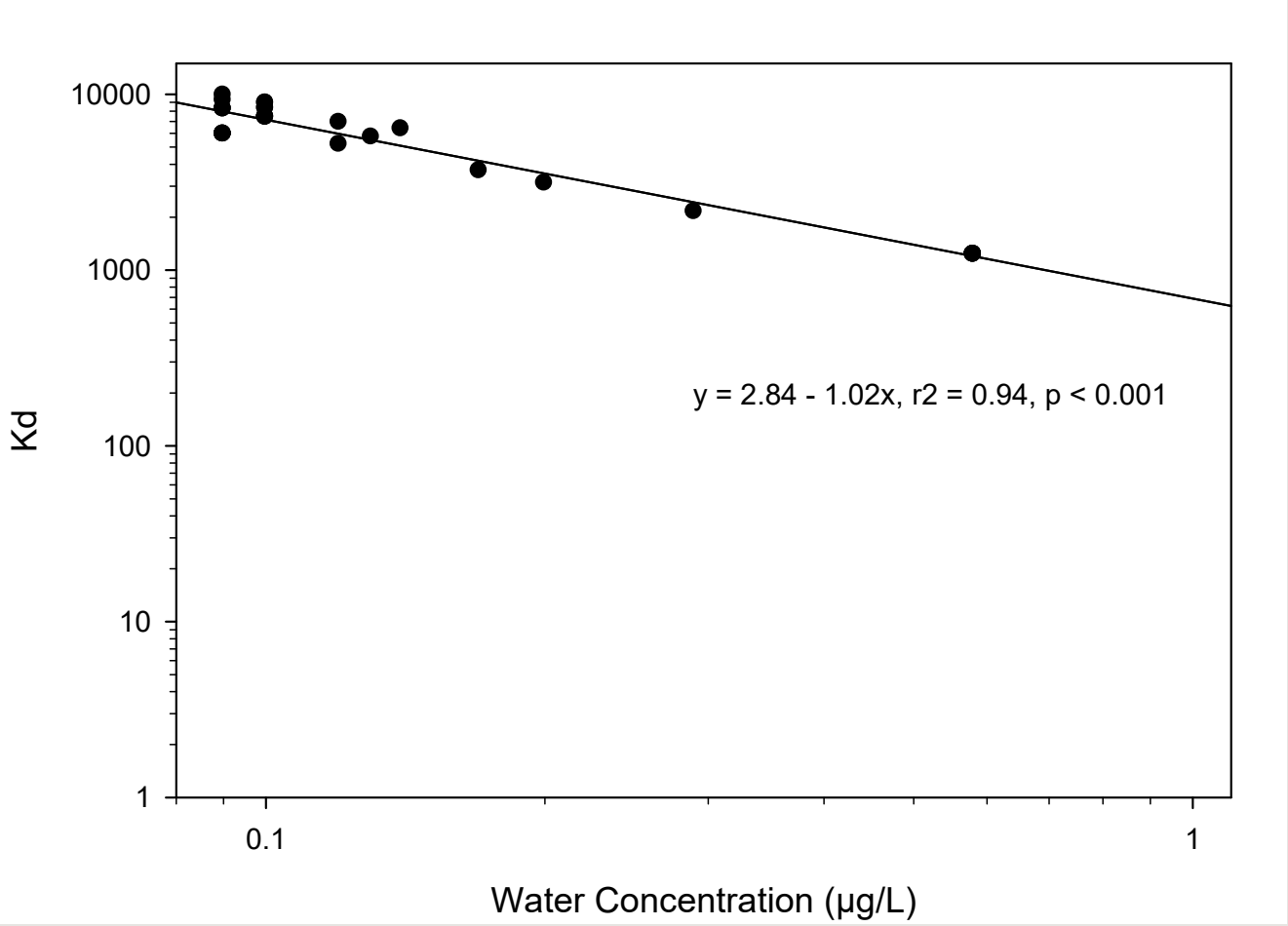
LOG-LOG REGRESSION RELATION OF ESTIMATED EF TO WATERBORNE SE CONCENTRATION FROM MODEL 3 IN ALL YEARS (2000, 2005, AND 2007)



LOG-LOG REGRESSION RELATION OF ESTIMATED EF TO WATERBORNE SE CONCENTRATION FROM MODEL 4 IN NORMAL/WET YEARS (2000 AND 2005)



LOG-LOG REGRESSION RELATION OF ESTIMATED EF TO WATERBORNE SE CONCENTRATION FROM MODEL 5 IN DRY YEARS (2007)



WESTERN DELTA STURGEON SELENIUM MODEL METHODOLOGY

- **Western Delta locations:**
  - Sacramento River at Mallard Island and San Joaquin River at Antioch Ship Channel.
- **Model assumptions:**
  - Used Presser and Luoma (2013) EF values for San Francisco Bay (including Carquinez Strait – Suisun Bay) to estimate Se concentrations in particulates, their assumptions for sturgeon diet, and their TTFs from particulates to diet and from diet to sturgeon.

SELENIUM MODEL OUTPUTS

- **Outputs of Delta-wide model included the following:**
  - Estimated Se concentrations in particulates, the primary form by which Se enters the food web.
  - Estimated Se concentrations in invertebrates.
  - Estimated Se concentrations in whole-body fish (trophic level 3 [TL-3] fish eating invertebrates and TL-4 fish eating TL-3 fish).
  - Estimated Se concentrations in bird eggs, for both invertebrate-eating and fish-eating birds.

SELENIUM MODEL OUTPUTS (CONT'D)

- **Calibrated Models 3, 4, and 5 gave reasonable predictions of whole-body Se in fish.**
- **Modeling for sturgeon at the two western-most locations did not require calibration because it relied on recent data provided by Presser and Luoma (2013).**
- **Following slide illustrates the Delta-wide model outputs.**

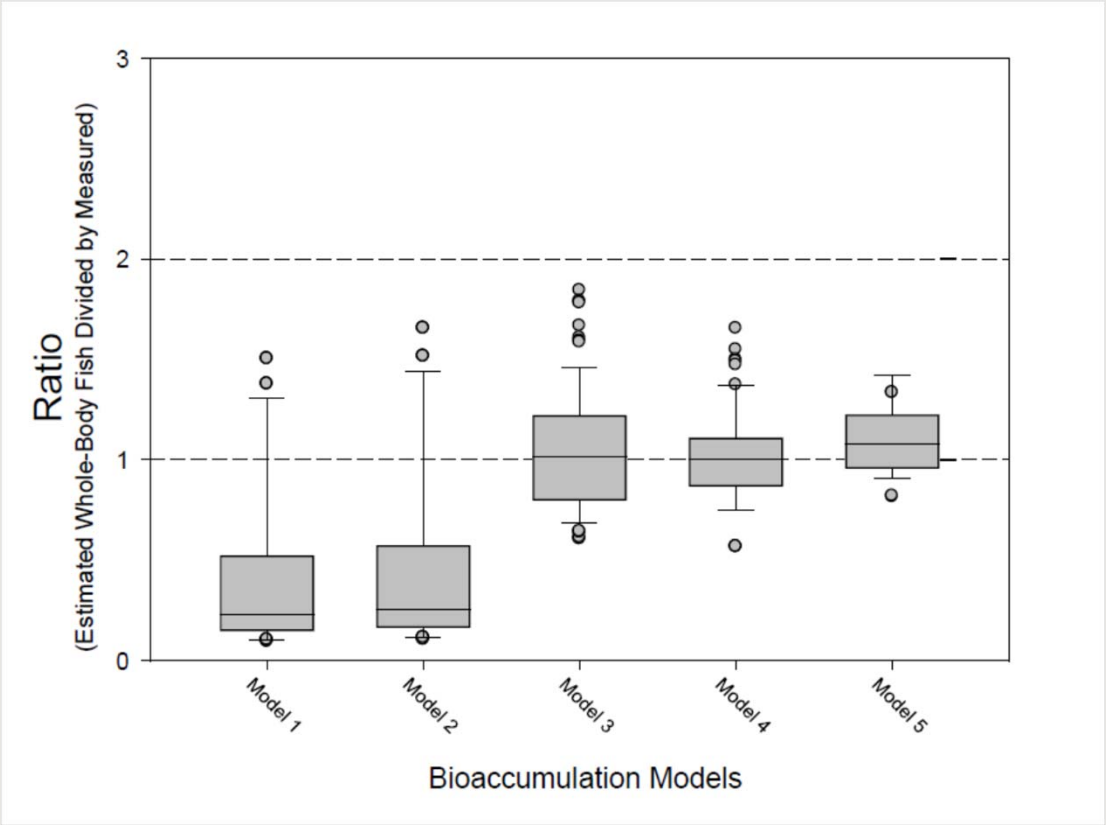
RATIO OF PREDICTED TO OBSERVED SELENIUM CONCENTRATIONS IN LARGEMOUTH BASS

Model 1 and Model 2 produced results did not match measured Se concentrations in largemouth bass, as described in the EIR/EIS, and were not used.

Model 3: Model 2 with EF estimated using all years regression (log EF = 2.76-0.97(logDSM2), as shown in Slide 8)

Model 4: Model 2 with EF estimated using normal/wet years (2000/2005) regression (log EF = 2.75-0.90(logDSM2), as shown in Slide 9)

Model 5: Model 2 with EF estimated using dry years (2007) regression (log EF = 2.84-1.02(logDSM2), as shown in Slide 10)



CONCLUSIONS

- **Calibrated models, which covered the range of predicted water Se concentrations under future conditions, gave reasonable predictions of whole-body Se in fish. Higher EFs with lower waterborne Se concentrations, as found in calibrating models, are consistent with expectations based on literature (Stewart et al. 2010).**
- **Developing site-specific EFs was essential toward modeling potential future conditions in the Delta and informing water management decisions.**