An Extended-Delta Hydrodynamic Model Framework for Sea Level Rise Analysis to Support Resource Management Planning for the Sacramento-San Joaquin River Delta

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16 April 2012

US Army Corps of Engineers
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Climate Change Issues

- Global Warming
- Precipitation
- Hydrology
- Water Resources
- Flood Protection
- Sea Level Rise

Sacramento-San Joaquin Delta 3D EFDC Model Framework

- Hydrodynamic, sediment and water quality model developed by U.S. Army Corps of Engineers, Sacramento District to provide 3D modeling tool for planning evaluations & resource management
- Delta Model domain includes Sacramento River (Verona)-San Joaquin River (Vernalis) –Delta-Suisun Bay-Carquinez Strait
- Environmental Fluid Dynamics Code (EFDC)

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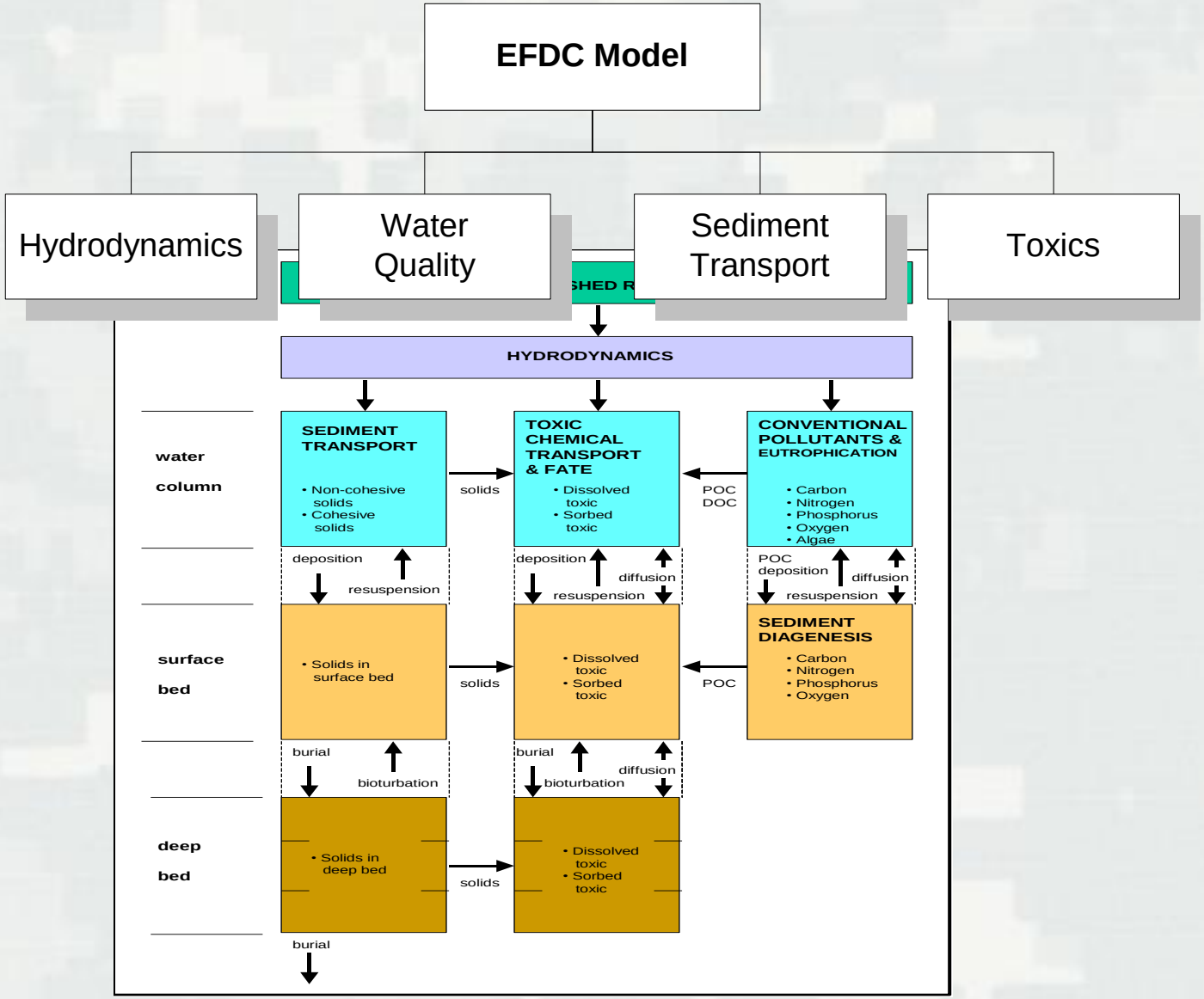

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Extended-Delta EFDC Hydrodynamic Model

- Developed to evaluate potential impacts of Sea Level Rise on water level and salinity intrusion
- Domain extended to include San Pablo Bay, San Francisco Bay and Pacific Ocean 27 miles offshore to Farallon Islands
- Finer grid used for center deep channels in San Francisco Bay and San Pablo Bay

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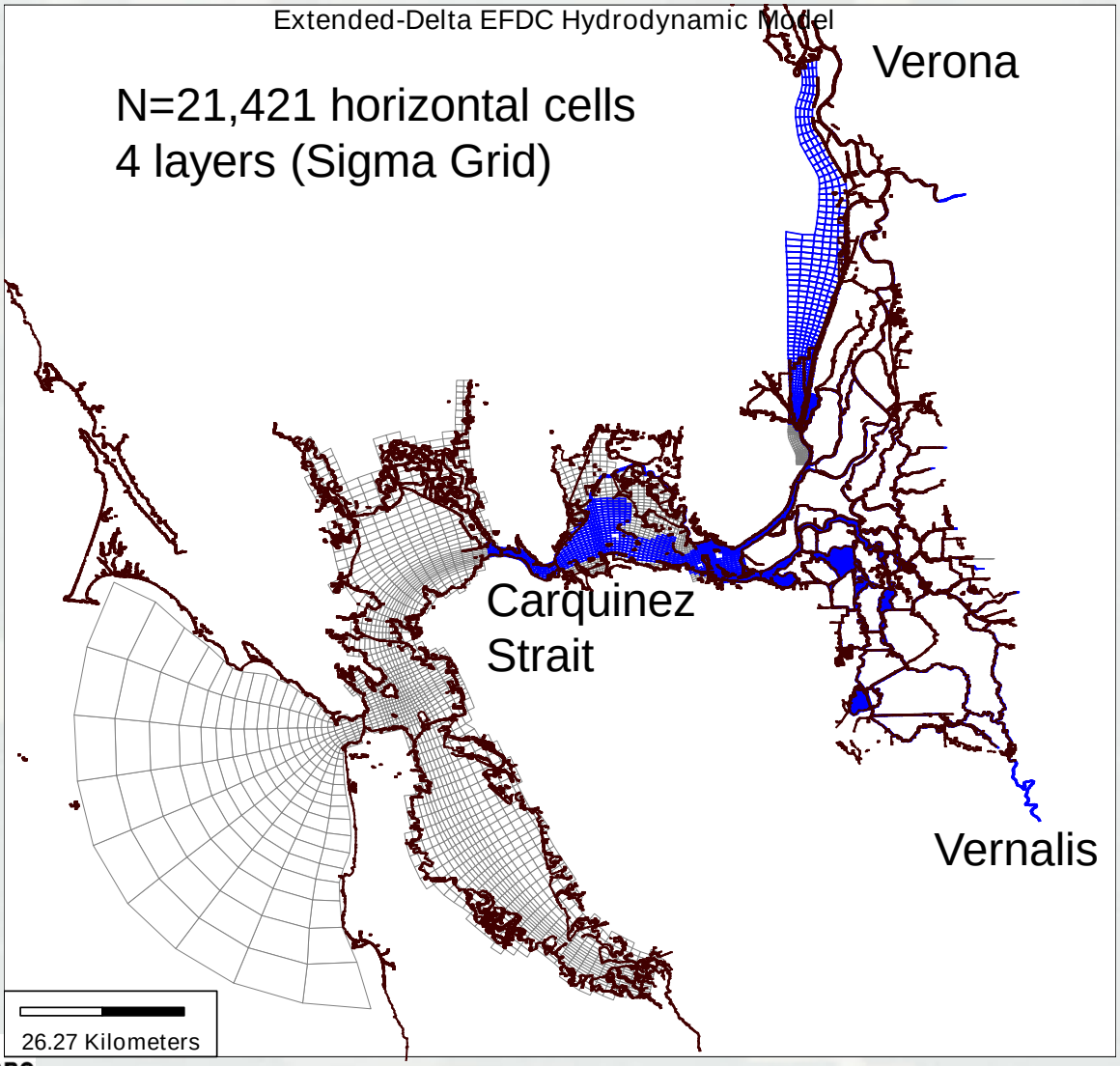

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Legend

▲ Extended Model Boundary

Extended-Delta_EFDC

Bathy

- -92.327 - -20.075
- -20.074 - -3.666
- -3.665 - 16.350
- 16.351 - 79.121

Extended Delta Model Domain and Grid

0 3.757.5 15

Miles

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Extended Delta EFDC Model Model Calibration (2004)

- Open ocean BC: water level at Point Reyes; water temperature & salinity at Farallon Is.
- Selected calibration results
  - ► Water surface elevation
  - ► Salinity
- 2004 calibration data used as base case for SLR scenarios

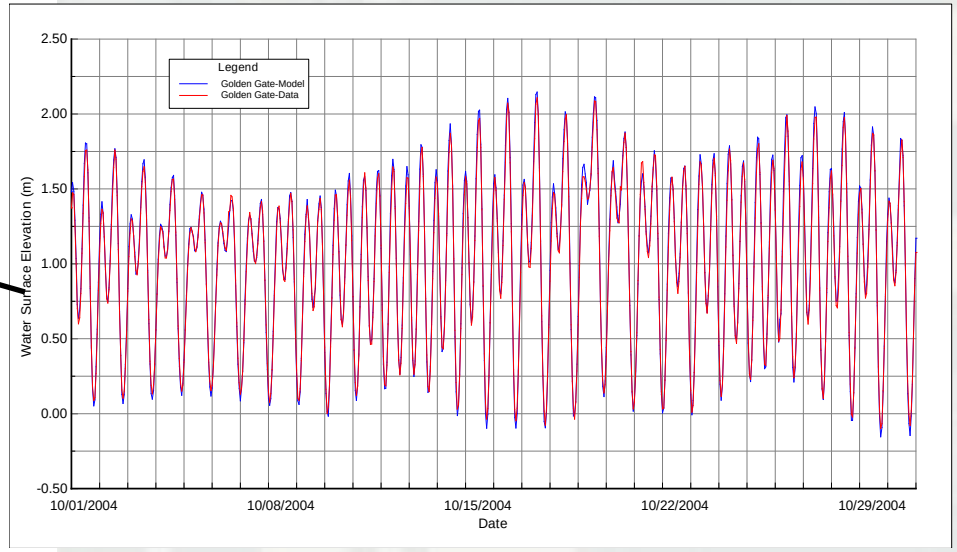
Water Surface Elevation Golden Gate, Oct 2004

Stage Calibration and Validation Stations in the Domain

Legend

- Stage Stations
- Extended-Delta_EFDC

0 3.5 7 14
Miles



RMS=0.05 m; Relative RMS Error=1.6%

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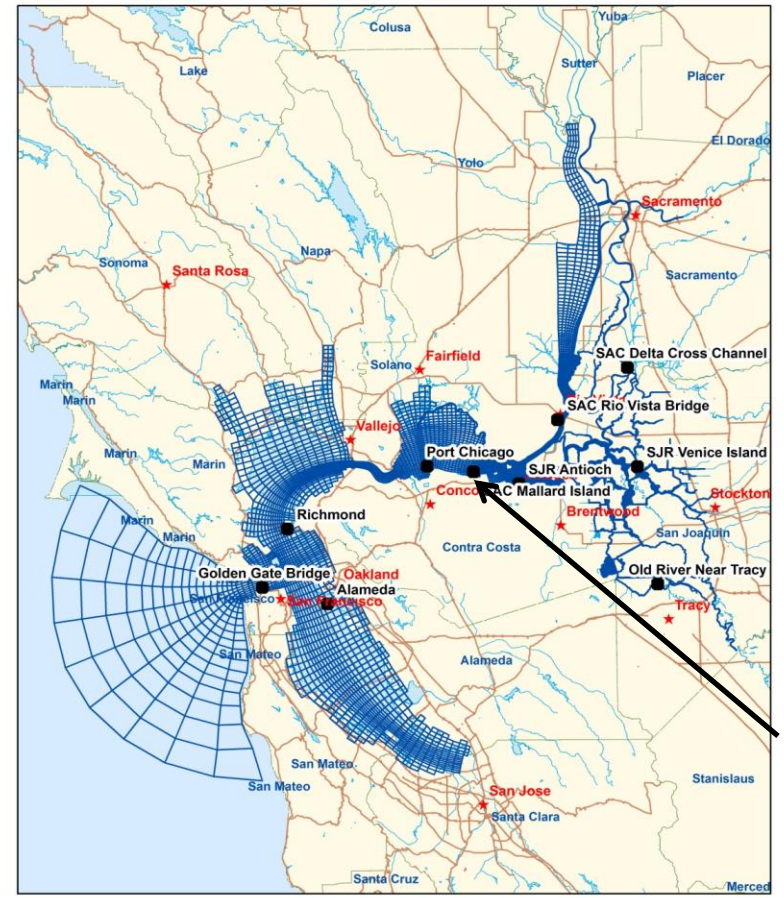
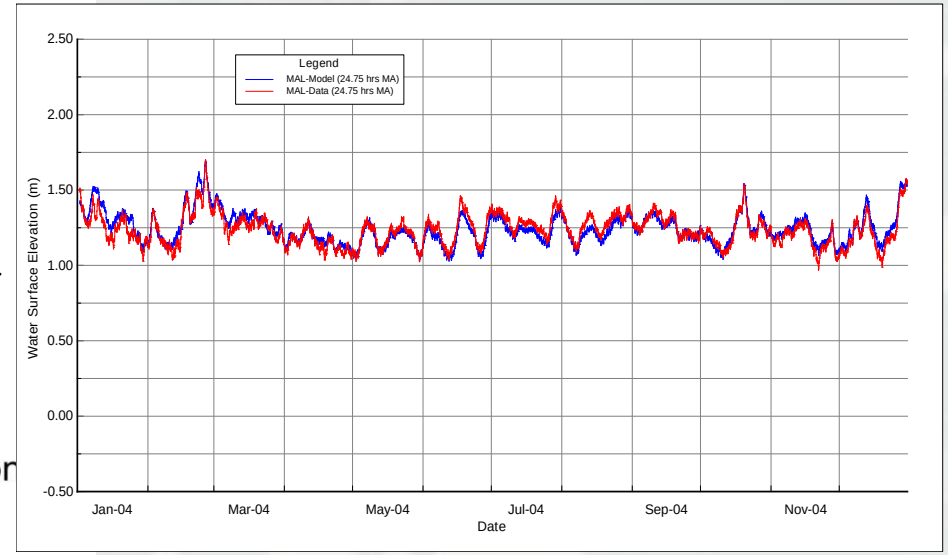
Water Surface Elevation Mallard Island (MAL) 24.75 hr Filtered Jan-Dec 2004



Stage Calibration and Validation Stations in the Domain



RMS=0.06 m; Relative RMS Error=3.6%

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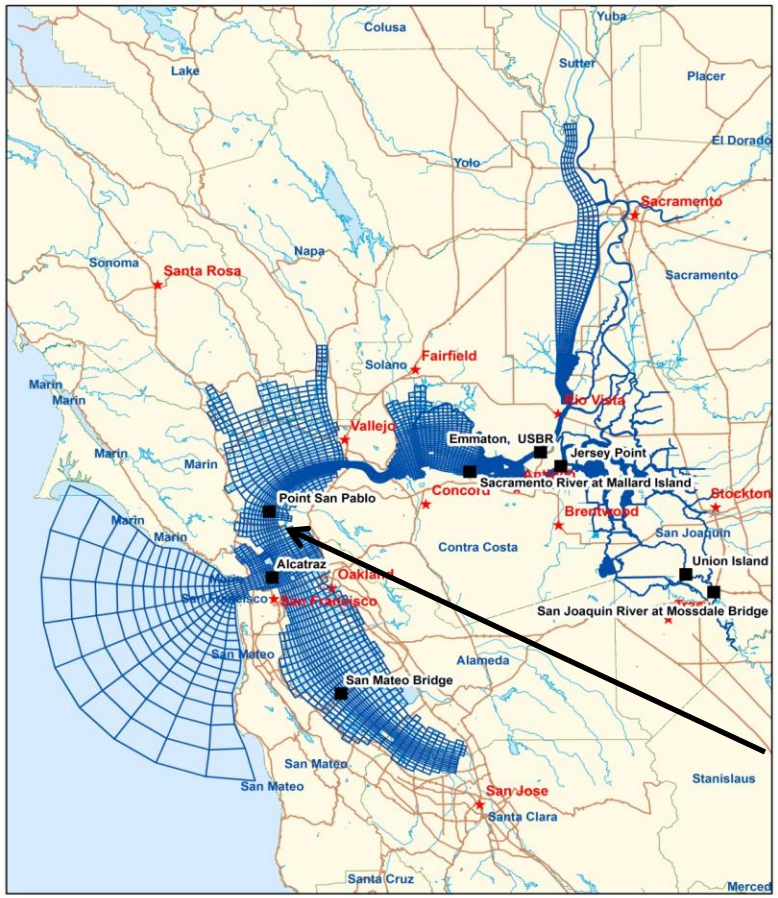
Surface Salinity
Port San Pablo (PSP)
24.75 hr Filtered
Jan-Dec 2004

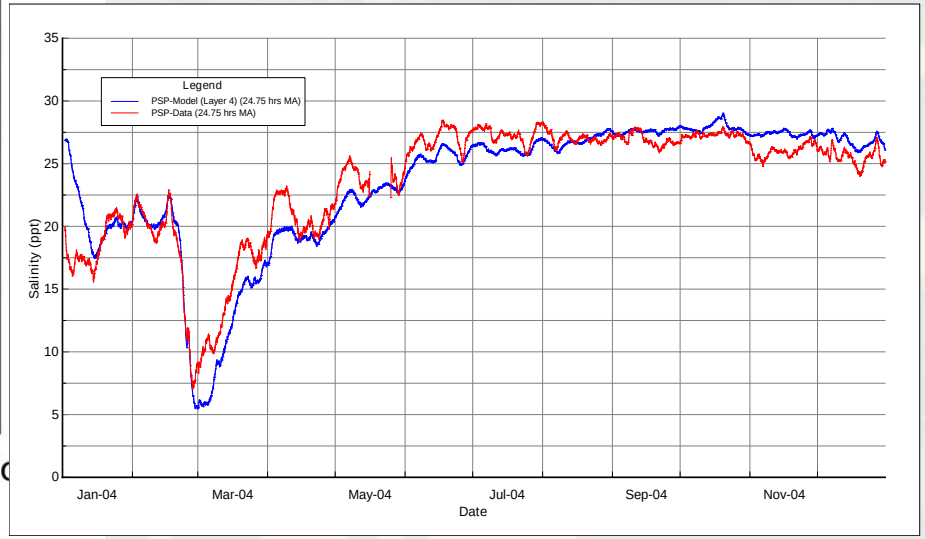


Salinity Calibration and Validatic
Stations in the Domain

Legend

- Salinity Stations
- Extended-Delta_EFDC

0 3.5 7 14
Miles



RMS=2.3 ppt; Relative RMS Error=8.1%

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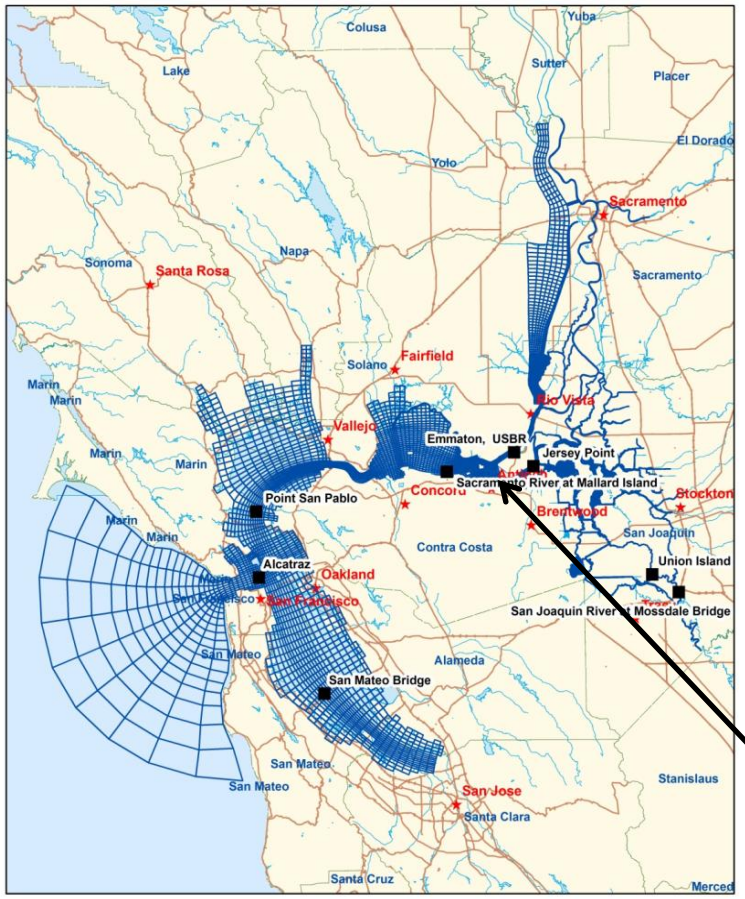
Bottom Salinity
Mallard Island (MAL)
24.75 hr Filtered
Jan-Dec 2004

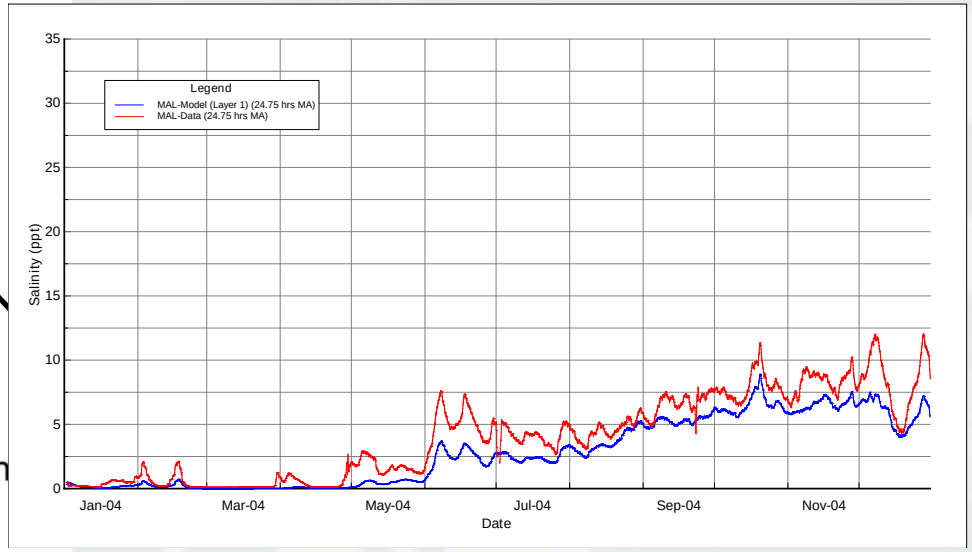


Salinity Calibration and Validation Stations in the Domain

Legend

- Salinity Stations
- Extended-Delta_EFDC

0 3.5 7 14
Miles



RMS=1.8 ppt; Relative RMS Error=9.3%

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Extended Delta EFDC Model Sea Level Rise Analysis

- 3D 4-layer model-> barotropic/baroclinic flow
- Freshwater (Flow, T,S) and offshore open BC (T,S) from 2004 calibration (Base Case)
- Open BC for Water Level based on 2004 tide signal at Point Reyes + SLR (50, 100 yr)
- Land subsidence rate of 1.5 mm/yr defines offset in bathymetry of -0.15 m for 100 yr case

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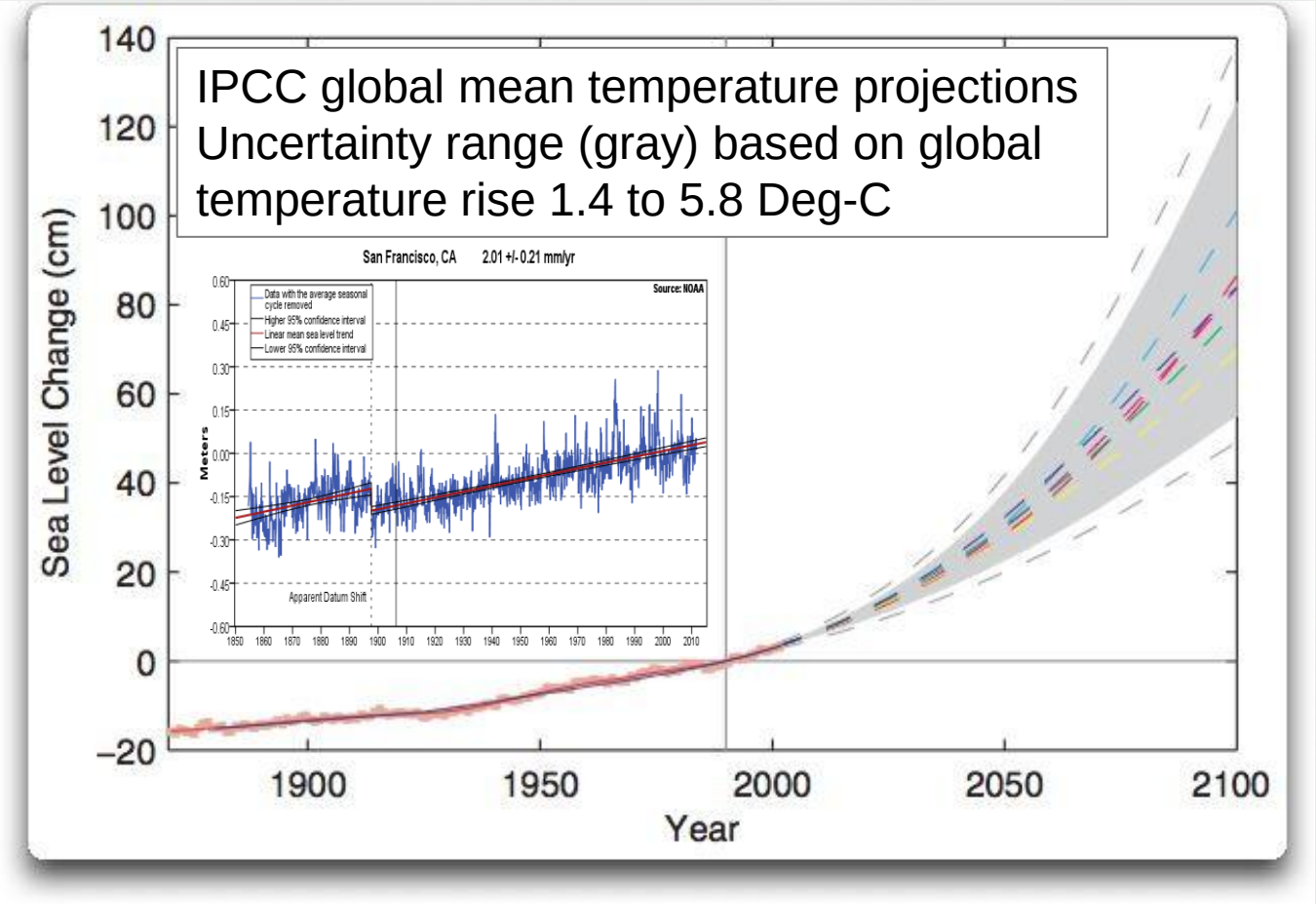
Sea Level Rise: Historical & Projections (Rahmstorf, 2007)



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Extended Delta EFDC Model SLR Analysis (9 Cases)

Land Subsidence (m)	0	0	-0.15
Sea Level Rise Scenario	50 Yr (m)	100 Yr (m)	100 Yr (m)
Low	0.10	0.20	0.2
Intermediate	0.20	0.52	
High	0.59	1.68	1.68
Source: USACOE (2009) EC 1165-2-211			

Literature	100 Yr (m)
Calif. Climate Change Center, CCCC (2006)	0.13 - 0.89
Int'l Panel Climate Change, IPCC (2007)	0.18 - 0.59
Delta Risk Mgmt Strategy, DRMS(2008)	0.20 - 1.40

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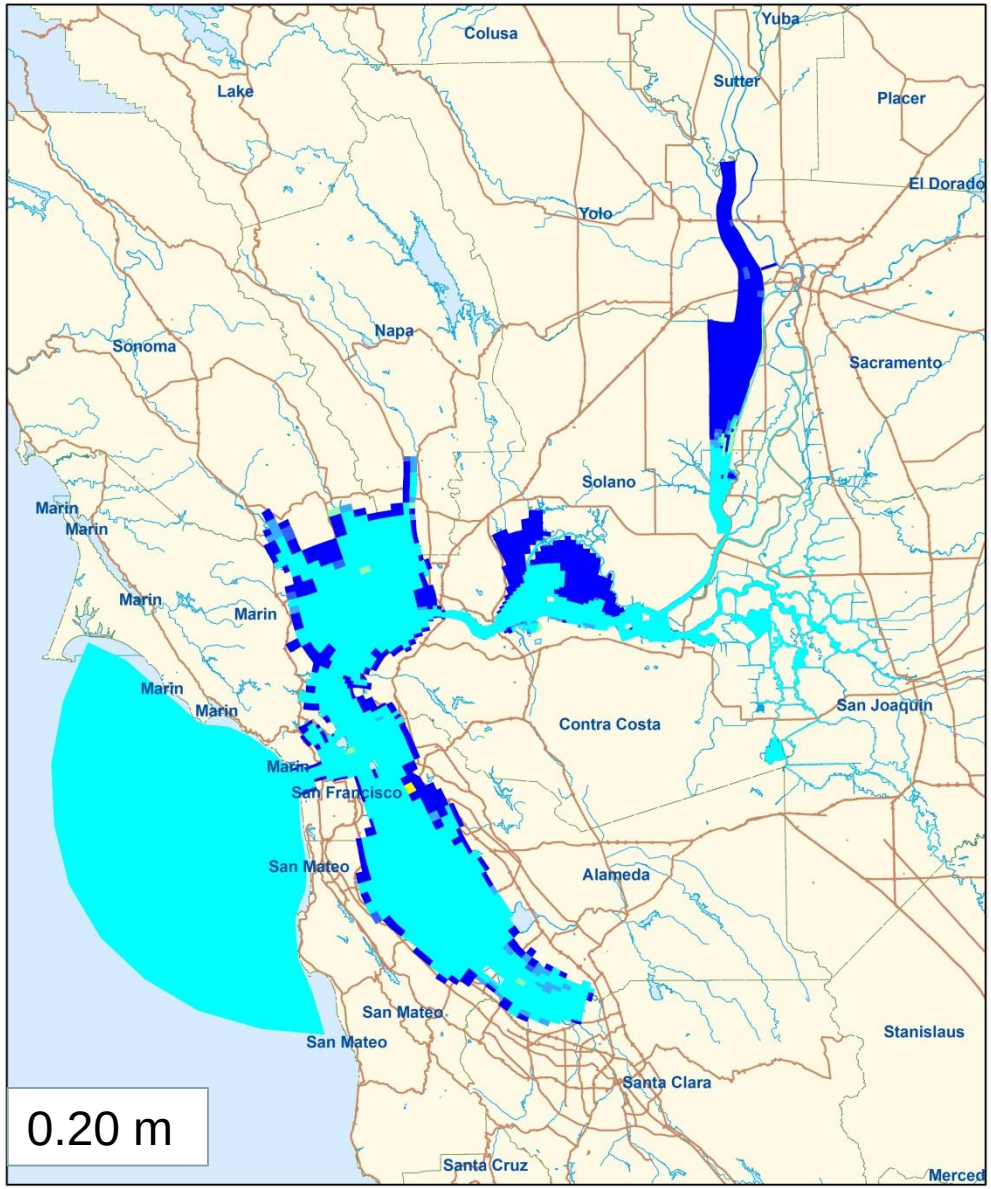
SLR Impact Metrics

- Max Difference in Water Level & Depth-Avg Salinity tracked at each grid cell as [SLR Scenario – Base Case] over simulation period (Jan-Dec 2004)
- Bottom salinity sections: Golden Gate to Sacramento; Golden Gate to Clifton Court; wet spring & dry summer conditions

SLR Impact on Water Level

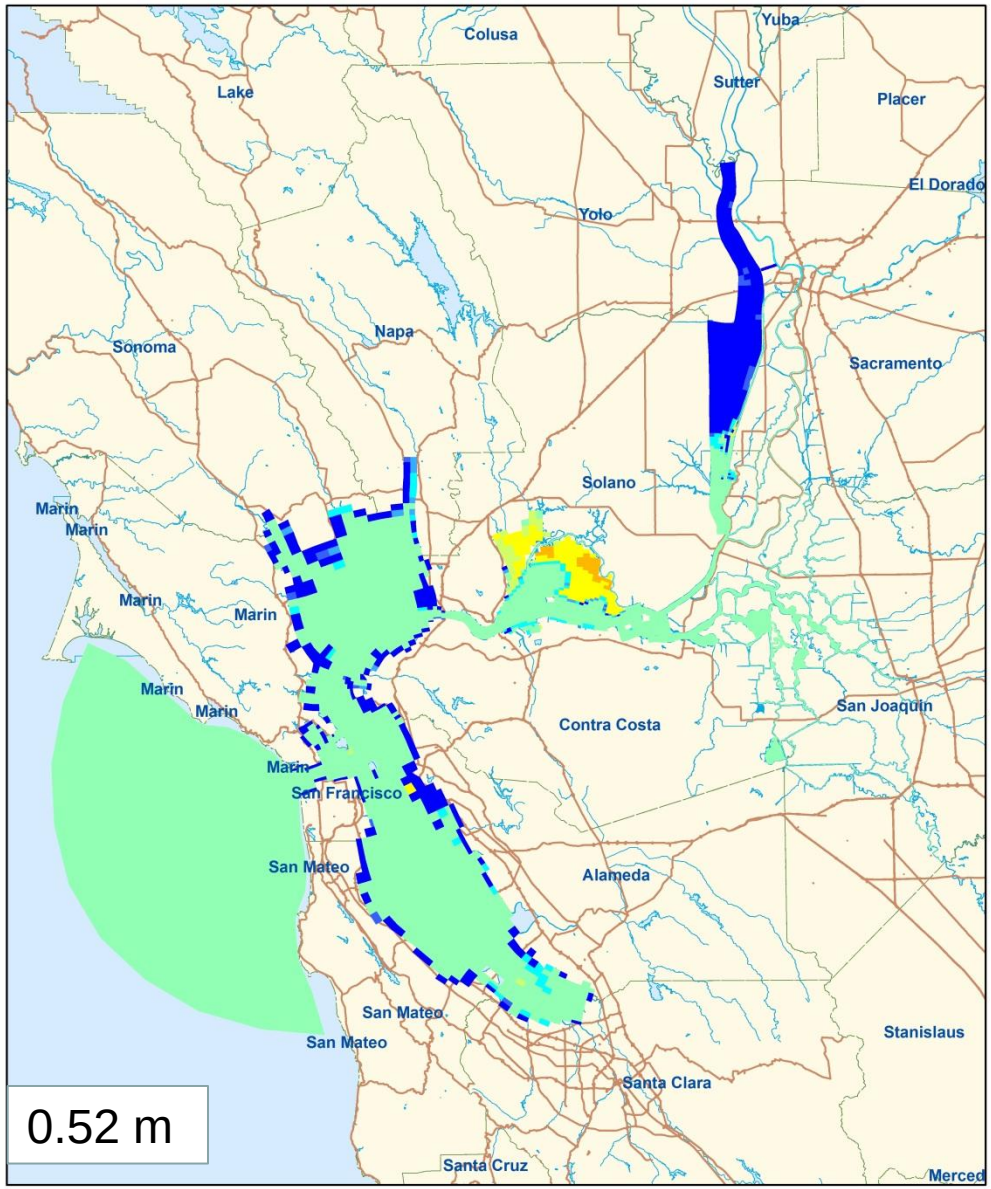


Legend

Max WSE Difference (m)	
0.00 - 0.05	1.01 - 1.50
0.06 - 0.10	1.51 - 2.00
0.11 - 0.20	2.01 - 2.50
0.21 - 0.50	2.51 - 3.00
0.51 - 1.00	3.01 - 5.00

Maximum Water Surface Difference
100-year Low SLR

0 3.757.5 15
Miles

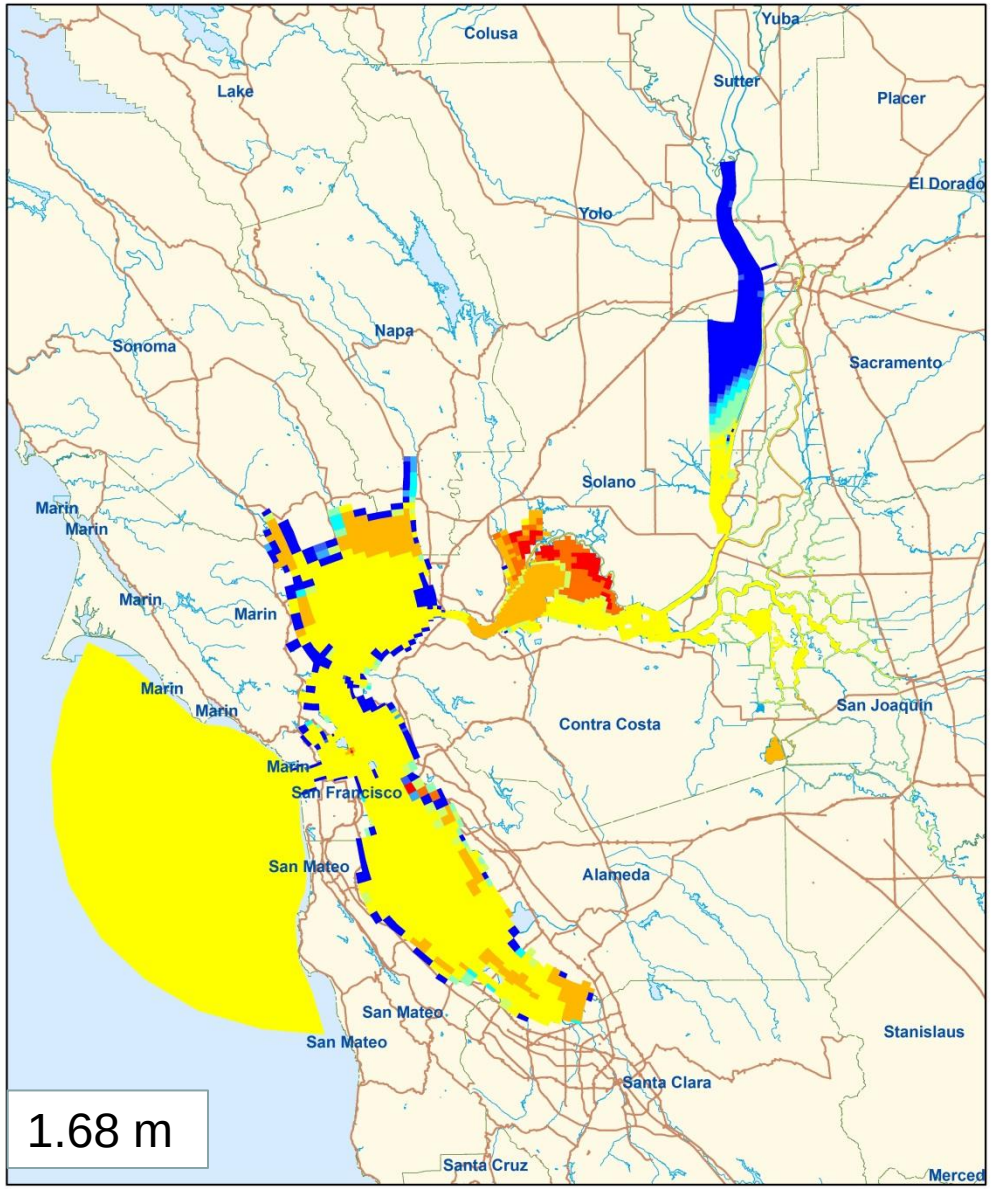


Legend

Max WSE Difference (m)	
0.00 - 0.05	1.01 - 1.50
0.06 - 0.10	1.51 - 2.00
0.11 - 0.20	2.01 - 2.50
0.21 - 0.50	2.51 - 3.00
0.51 - 1.00	3.01 - 5.00

Maximum Water Surface Difference
100-year Intermediate SLR

0 3.757.5 15
Miles

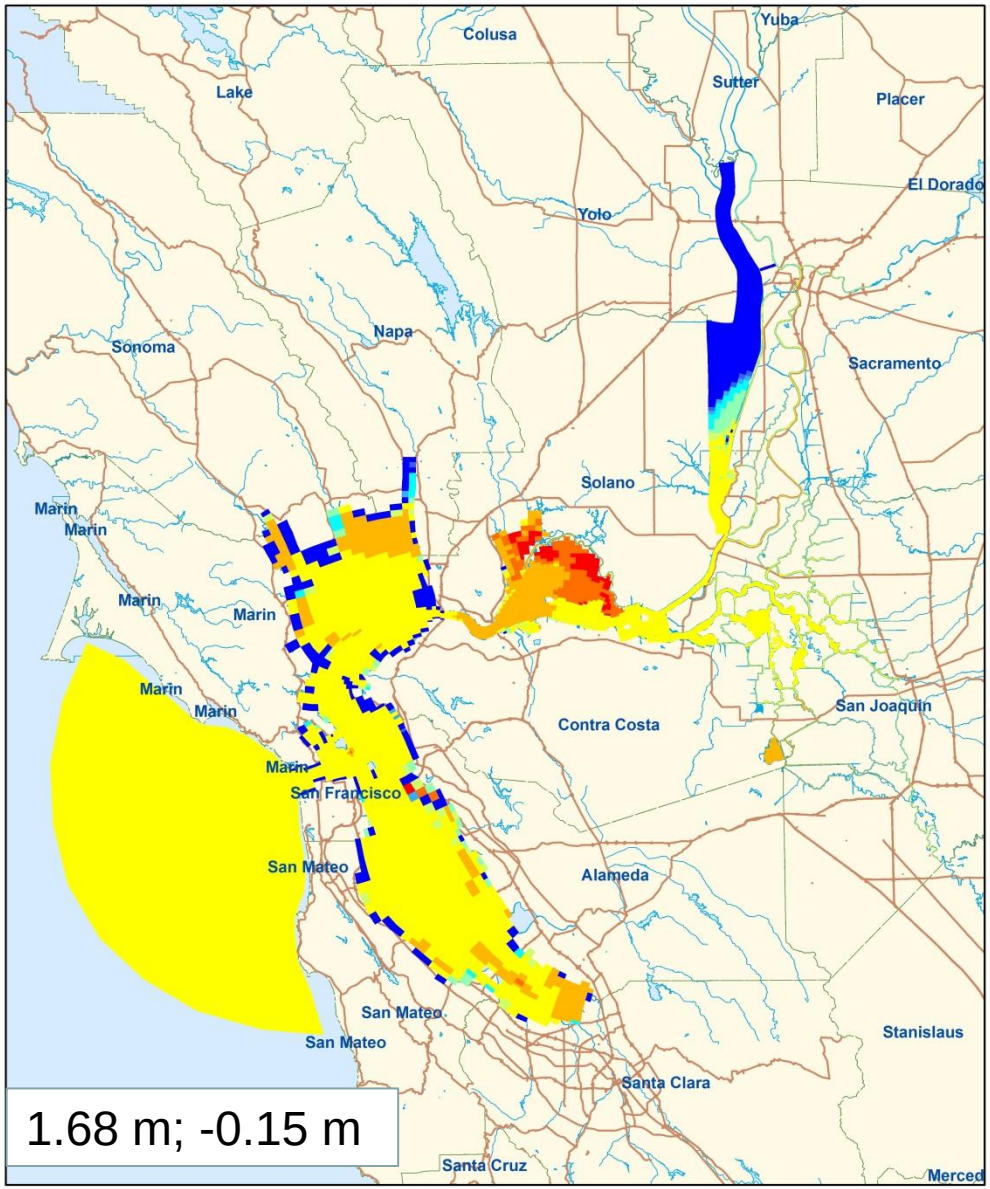


Legend

Max WSE Difference (m)	
0.00 - 0.05	1.01 - 1.50
0.06 - 0.10	1.51 - 2.00
0.11 - 0.20	2.01 - 2.50
0.21 - 0.50	2.51 - 3.00
0.51 - 1.00	3.01 - 5.00

Maximum Water Surface Difference
100-year High SLR

0 3.757.5 15
Miles



Legend

Max WSE Difference (m)	
0.00 - 0.05	1.01 - 1.50
0.06 - 0.10	1.51 - 2.00
0.11 - 0.20	2.01 - 2.50
0.21 - 0.50	2.51 - 3.00
0.51 - 1.00	3.01 - 5.00

Maximum Water Surface Difference
100-year High SLR with Subsidence

0 3.757.5 15
Miles

SLR Impact on Water Level Findings

- Suisun Bay and South Yolo Bypass areas show largest Water Level impact from SLR
- Suisun Bay: largest increases during summer low flow from rivers; large shallow mud flats of marsh amplify tide signal with maximumWater Level related to low flow
- South Yolo Bypass: largest increase along fresh-salt water interface in wet spring season

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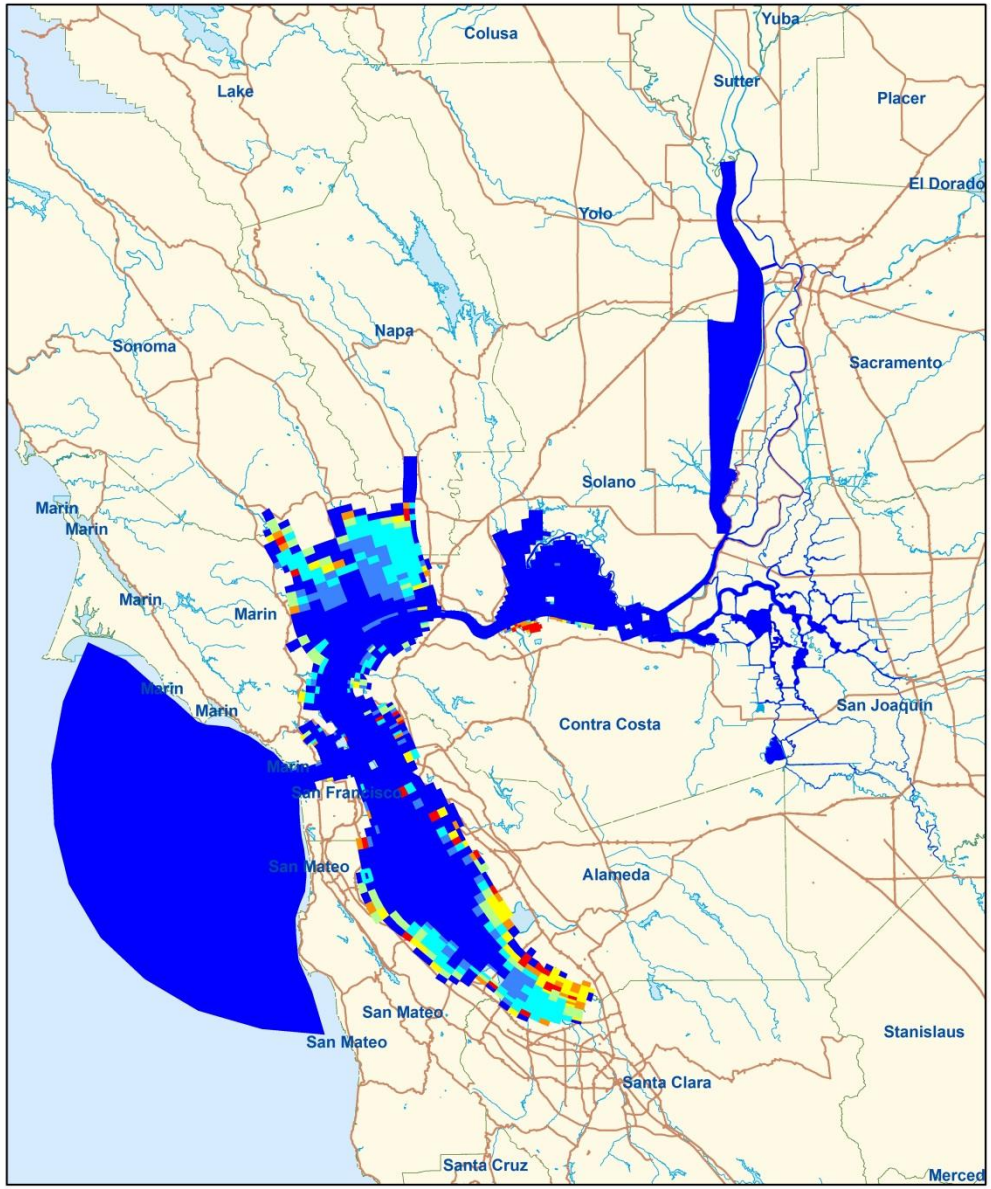
SLR Impact on Salinity



Legend

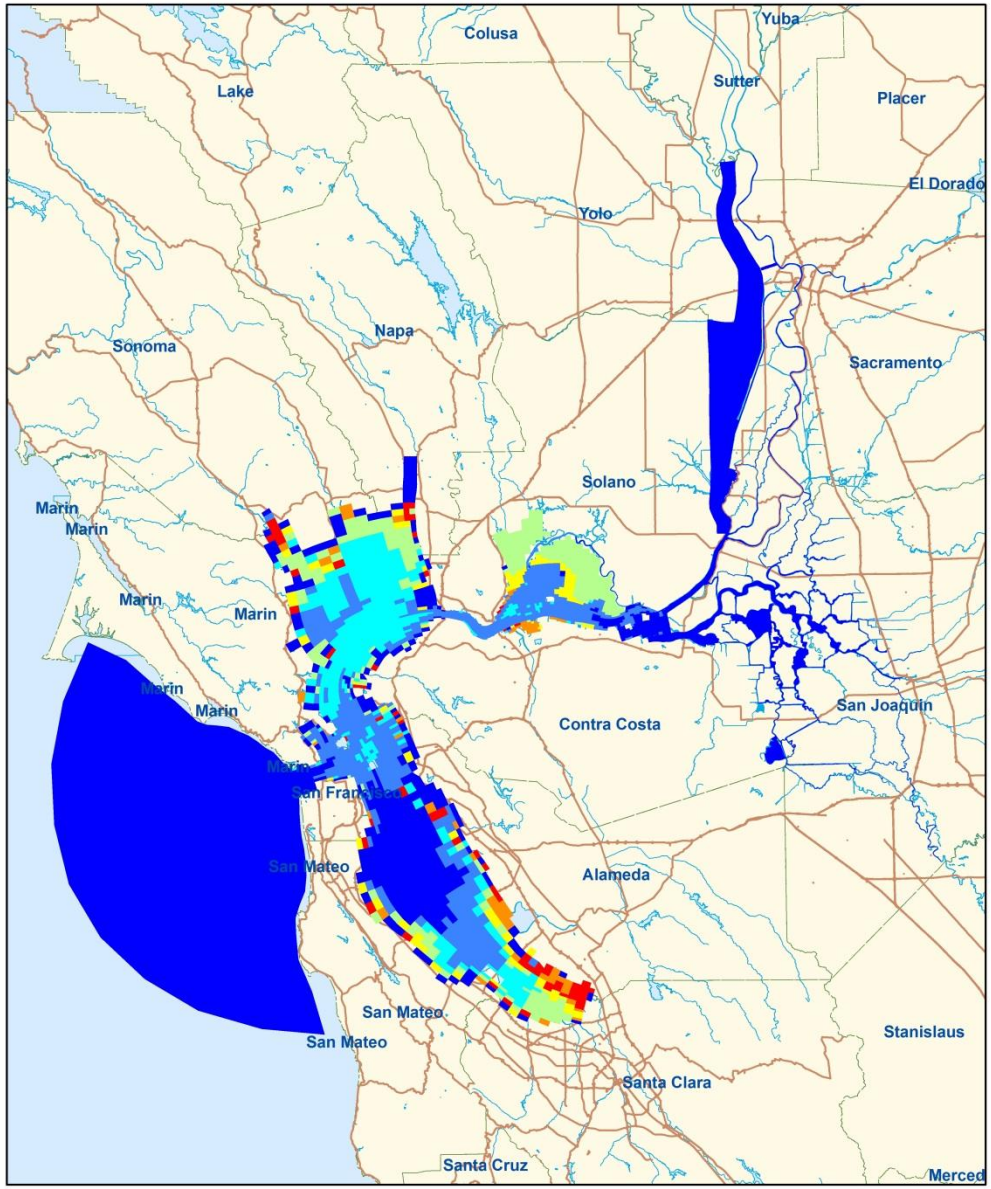
Max Salinity Difference (ppt)

- 0.00 - 1.00
- 1.01 - 2.00
- 2.01 - 5.00
- 5.01 - 10.00
- 10.01 - 15.00

Maximum Salinity Difference 100-year Low SLR

0 3.5 7 14

Miles



Legend

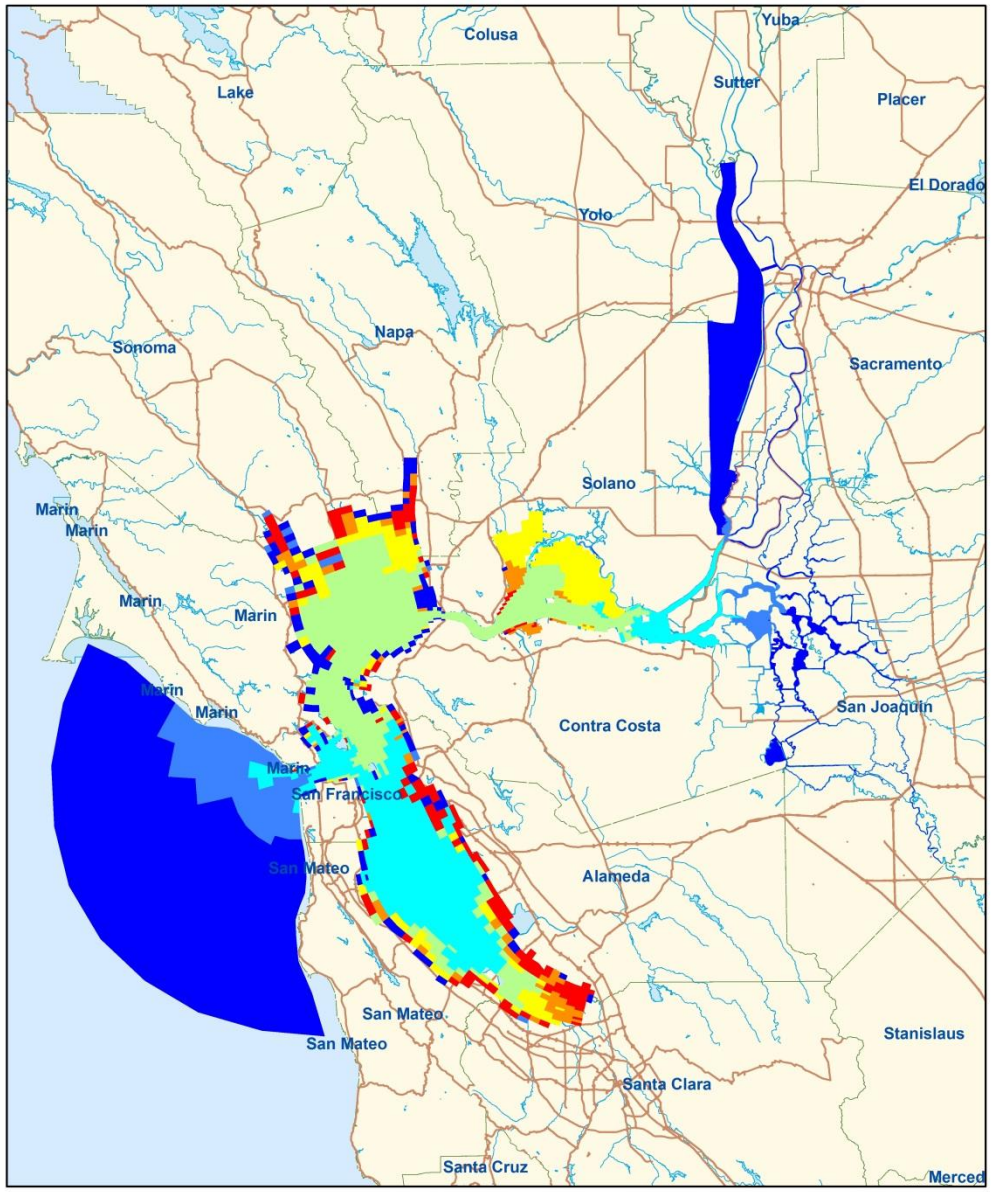
Max Salinity Difference (ppt)

- 0.00 - 1.00
- 1.01 - 2.00
- 2.01 - 5.00
- 5.01 - 10.00
- 10.01 - 15.00

Maximum Salinity Difference
100-year Intermediate SLR

0 3.757.5 15

Miles



Legend

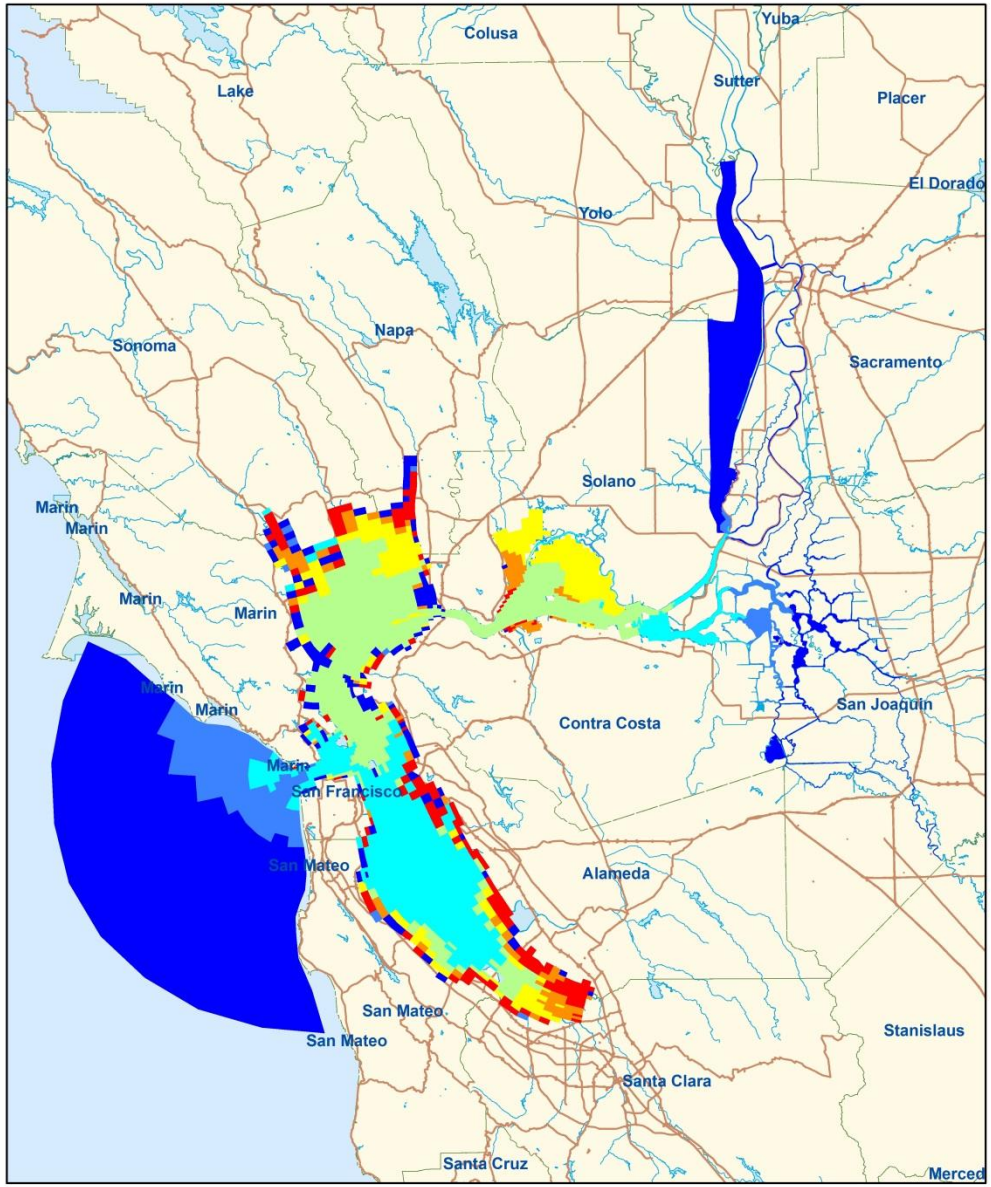
Max Salinity Difference (ppt)

- 0.00 - 1.00
- 1.01 - 2.00
- 2.01 - 5.00
- 5.01 - 10.00
- 10.01 - 15.00

Maximum Salinity Difference
100-year High SLR

0 3.5 7 14

Miles



Legend

Max Salinity Difference (ppt)

- 0.00 - 1.00
- 1.01 - 2.00
- 2.01 - 5.00
- 5.01 - 10.00
- 10.01 - 15.00

Maximum Salinity Difference
100-year High SLR with Subsidence

0 3.5 7 14
Miles

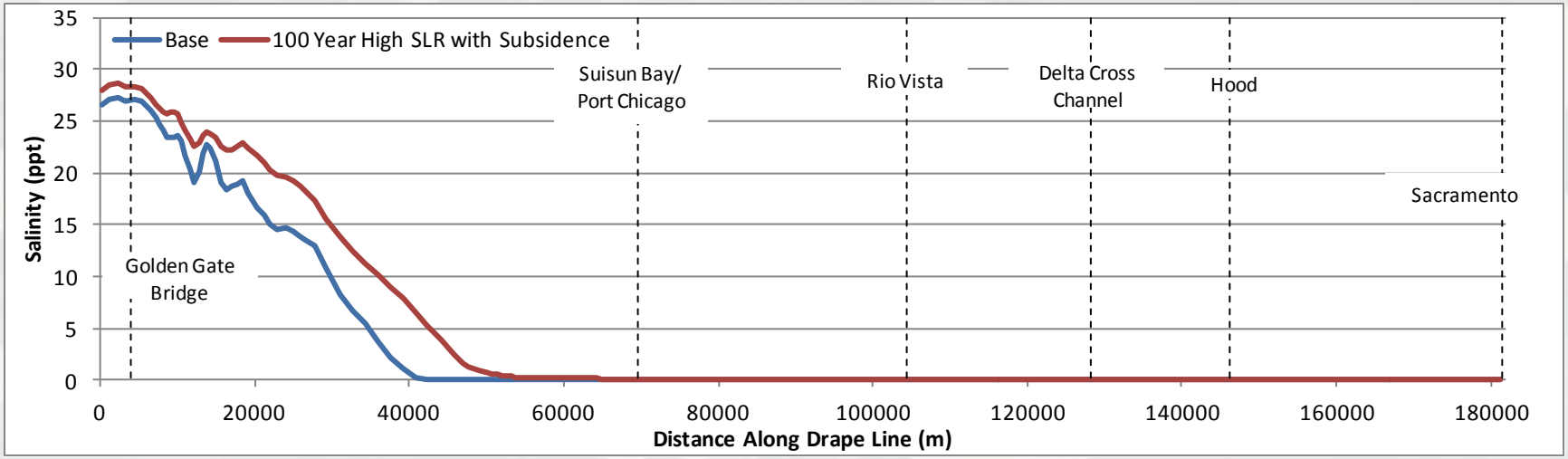
SLR Impact on Salinity Findings

- Bottom salinity increased in SF Bay and Delta by 0.45-8.7 ppt; Suisun Bay, San Pablo Bay & Carquinez Strait show largest salinity impact during wet spring conditions

100 Yr,High SLR,Subsidence

Flood Tide (3/1/2004 03:00)

Golden Gate to Sacramento



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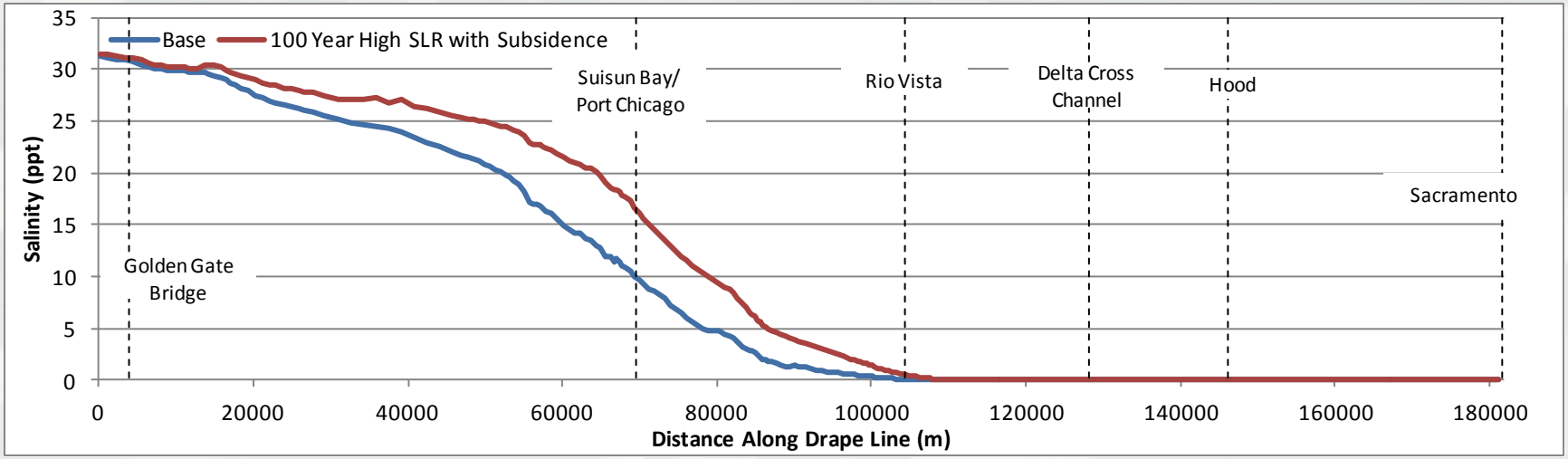
100 Yr,High SLR,Subsidence

Ebb Tide (7/3/2004 05:00)

Golden Gate to Sacramento



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SLR Impact on Salinity Findings

- Shift in bottom salinity intrusion for 2 ppt location for 100 Yr High SLR (1.68 m) with subsidence compared to Base Case:
  - ~ 12 km for dry summer conditions/ebb tide
  - ~ 10 km for wet spring conditions/flood tide

Extended Delta EFDC Model Summary

- Provides USACOE Sacramento District, other Federal/State agencies and Stakeholders with an advanced 3D model framework
- Essential tool for increased understanding of consequences of natural events and issues such as SLR for planning level evaluations
- Sets standard for determination of significance of project impacts

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Discussion

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