Web-based Visualization of RMA Turbidity and Adult Delta Smelt Modeling Forecasts, Water Year 2012

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Project Summary

The visualizations, images, data files, and documentation shown under this project represent the second year of efforts by Resource Management Associates (RMA) to forecast flows, salinity, turbidity, and adult delta smelt movement within the Sacramento-San Joaquin Delta. Near-term climate predictions are used to inform watershed runoff models that provide boundary conditions to RMA's in-Delta flow and water quality models. These are used to drive an adult delta smelt (*Hypomesus transpacificus*) behavioral model, predicting movement and population distribution two weeks into the future. Metropolitan Water District of Southern California has funded this project in an effort to aid conservation efforts for the endangered smelt as well as reduce smelt mortality at water export locations in the southern Delta. New forecast reports, turbidity visualizations, and smelt distribution maps will be posted on a weekly basis during the wet season (December through March), unless climatic and hydrologic forecasts indicate little future variation in conditions.

Modeling Methodology

The two-dimensional hydrodynamic flow model, RMA2, is used to predict in-Delta flows on a high resolution (≈39,000 nodes) 1D-2D grid. The model includes 3-4 weeks of model spin-up using historical flow data collected at the major river inflow boundaries (Sacramento River at Freeport, San Joaquin River at Vernalis, the Calaveras, Cosumnes, and Mokelumne Rivers, and the Cache Slough/Yolo Bypass region) and recorded exports for the State Water Project, Central Valley Project, and Contra Costa Water District. Forecast flows and exports, along with future Delta Island Consumptive Use and gate operations, are provided by the California Department of Water Resources (DWR) DSM2 model (baydeltaoffice.water.ca.gov/modeling/deltamodeling/models/dsm2/dsm2.cfm) and are modified as necessary based on the professional judgment of RMA (see weekly documentation reports, Table 1). The resulting in-Delta flows are used to drive water quality simulations of salinity and turbidity over the same forecast period. Water quality boundary conditions are taken from observed measurements, collected by local agencies and posted on the California Data Exchange Center website (cdec.water.ca.gov), for the historical spin-up period. Forecasted boundary conditions are developed

using one or more of the following methods: assigned as constant values based on the prior two week period (typically for low-flow or steady flow conditions), predicted based on a rating methodology developed by RMA (see WY2011 final project report), or predicted using the USEPA WARMF model (www.epa.gov/athens/wwqtsc/html/warmf.html) as calibrated to the Sacramento-San Joaquin watershed by Systec Water Resources, Inc. (for higher flow conditions). Modifications to water quality boundary conditions are done on a weekly basis, based on professional judgment and depending on the quality of the observed and predicted data, and are documented in the weekly forecast report (see Tables 2 and 3). Turbidity is modeled using a simple time-dependent exponential decay equation. The two-dimensional distribution of decay coefficients was based on calibration over the 2011 water year and is shown in Figure 1.

Modeled in-Delta salinity, turbidity, and flows are used to drive a particle tracking model with a behavioral component designed to simulate adult delta smelt movement. Fifty-thousand particles are randomly distributed in the Suisun Bay region on November 1, 2011. Particle movement through the end of the forecast period is tracked and proceeds based on the following decision tree:

- If the local salinity experienced by a particle is greater than the maximum prescribed salinity limit
    - Surf (travel with the tide) toward areas of lower salinity
- Else, if local turbidity is below a prescribed minimum limit
    - If the local turbidity gradient is greater than the minimum detectable gradient
        - Surf toward higher turbidity
    - Else
        - Hide (remain in a stationary position until conditions change)
- Else, if local salinity is less than the minimum tolerable limit
    - Surf toward higher salinity
- Else (both local turbidity and salinity are within appropriate limits)
    - Randomly move to explore desirable habitat

Prescribed values of 16 NTU (minimum turbidity), 0.0001 NTU/m (minimum turbidity gradient), 0 ppt (minimum salinity), and 1.5 ppt (maximum salinity) are used for all forecasts.

The full documents detailing the model calibration and performance for water year 2011 are posted in the Related Files section of this Bay-Delta Live project directory.

Web-based Visualization Methodology

Results from the RMA water quality models are output at 15 minute intervals for approximately 60 locations spaced throughout the Delta. These time series data are used to drive the RMA turbidity visualization shown on the Bay-Delta Live website. A new visualization is posted each week, showing one week of historical model results followed by two weeks of forecasted turbidities. The polygons used in the visualizations are colored based on their spatial proximity and hydrologic connectivity to the model output locations, and the output turbidity values at those sites.

To visualize forecasted delta smelt distributions, the Delta is divided into 5 broad regions (see Figure 2). Daily averaged particle populations in each region, given as a percentage of the total number of input particles, are displayed on a map for each forecast. Distribution data are given for three times: the start of the forecast period, one week into the forecast, and two weeks into the forecast. The coarse spatial and temporal resolution of the particle tracking model results are intended to give a broad overview of the in-Delta conditions and were chosen based on the magnitude of uncertainties associated with the smelt behavioral model.

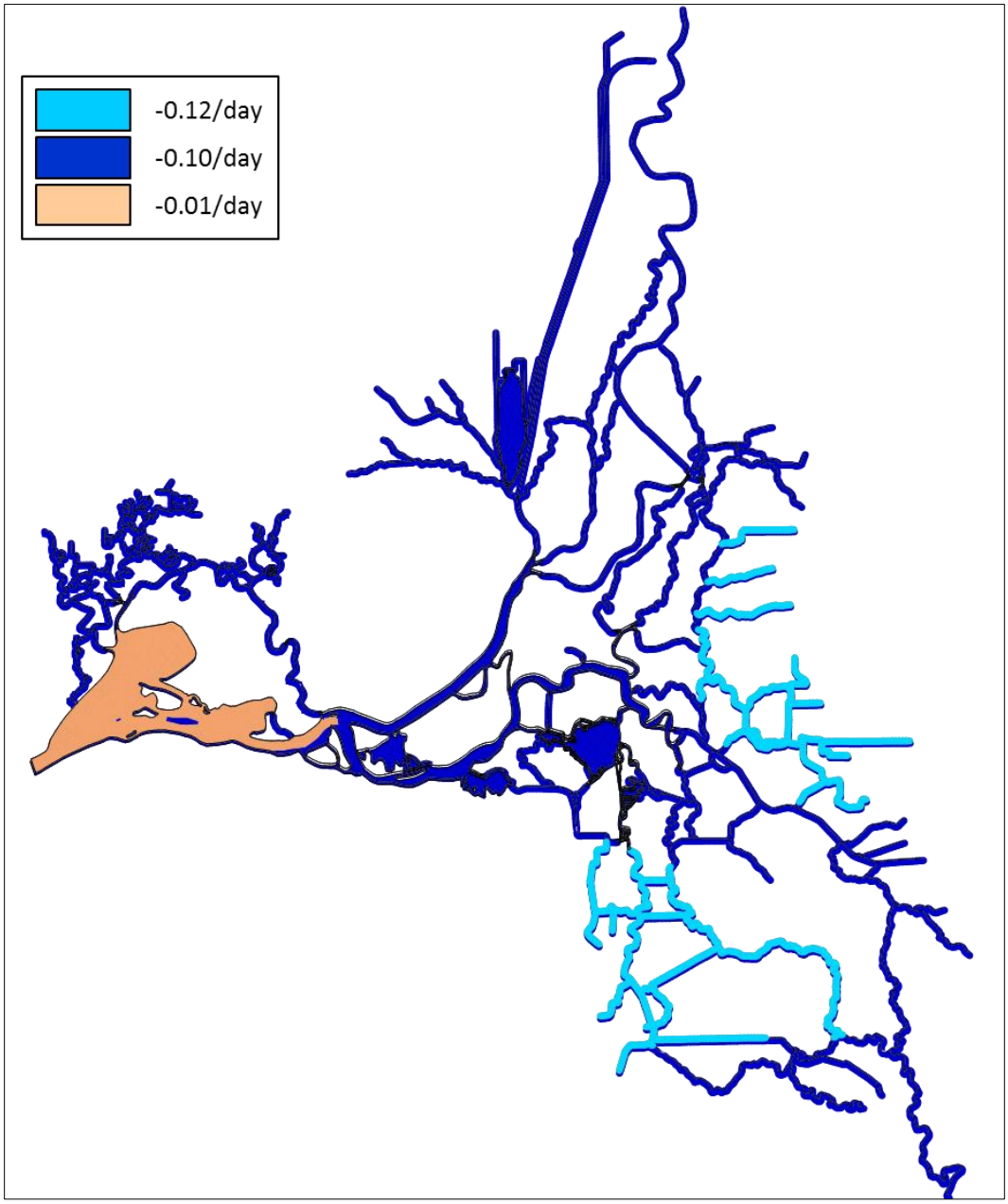

Figure 1 RMA turbidity model decay coefficients and regions.

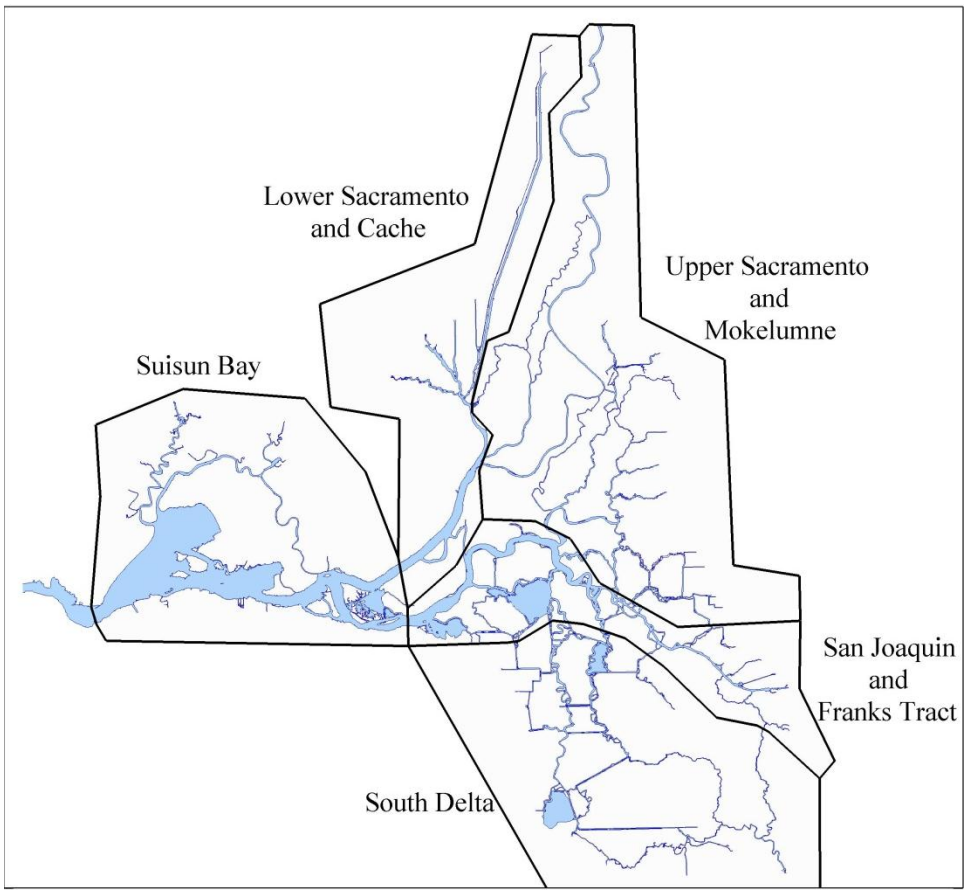

Figure 2 RMA delta smelt behavioral model regions.

Additional Technical Notes, Comments, and Assumptions

- The two-dimensional distributions of mixing coefficients, turbulent diffusion energy losses, and bathymetry data used in the RMA models have been accumulated over many years of applying, calibrating, and validating the models to the Bay-Delta system.
- Turbidity model decay coefficients were calibrated to be most accurate during periods of high flow, when turbidity pulses from inflowing rivers are hypothesized to attract delta smelt into the Delta interior to spawn.
- Since turbidity is not being predicted by a full suspended sediment model, turbidity sources due to wind wave induced resuspension during the forecast period (internal Delta loading) may not be accurately predicted. This has the largest consequences for model accuracy in regions adjacent to large areas of shallow open water areas, such as Suisun Bay, Liberty Island, and Franks Tract.
- Boundary condition data exert a large influence over modeled in-Delta flows and turbidity. As a result, model results are only as accurate as the boundary conditions used to generate them. The accuracy of forecast flows and water quality is usually high for the near term (≈5 days), but declines thereafter. Since it takes approximately five days of travel time for water from the model boundaries to reach the central Delta, we can expect decreased accuracy in our model results after approximately 10 simulation days.

- Adult delta smelt are hypothesized to move in response to local flow and water quality conditions according to the rules listed above. This is a very simplified paradigm for fish behavior and includes no dependence on benthic habitat structure, foraging or schooling instinct, or predator avoidance. As a consequence of the low and sporadic smelt distribution data within recent years (when accurate turbidity boundary condition data were available) the smelt model has not undergone a detailed calibration at Delta locations other than at the southern export locations.
- Each particle tracked in the adult delta smelt model has a deterministic component of motion (e.g., smelt movement along with the local tidal flow) and a stochastic component, designed to simulating the random, dispersive aspects of fish movement. The number of virtual particles used in the smelt behavior simulation (50,000) was chosen large enough so that random aspects of fish movement could be captured and statistically significant conclusions could be drawn from the results. We emphasize here that the initial particle population does not represent any estimate of the adult delta smelt population in Suisun Bay and that there is not a one-to-one correspondence between simulated particles and individual adult delta smelt.
- The RMA models predict flow and turbidity at approximately 39,000 nodes, generating large volumes of data. In order to create an efficient web-based visualization, simplified model output and interpolation is necessary. Figure 3 shows an example of turbidity data visualized with contouring based on values at the full set of nodes in the RMA model. Figure 4 shows the web-based visualization from Bay-Delta Live corresponding to the same time period. Note that while the overall agreement in turbidity distribution is excellent, some polygon interpolation may not reflect RMA model results due to a lack of nearby output locations (e.g., at Sherman Island or Taylor Slough) or due to data extrapolation (e.g., Cache Slough). The complex 2D mixing processes that occur near Threemile Slough and the Mokelumne-San Joaquin confluence are also not included in the simplified visualization. Finally, areas such as the Montezuma Slough region and some east side sloughs are included in the RMA model, but are not shown in the Bay-Delta Live visualization. For a full description of the RMA model grid, please see the Related Files section of this project directory.

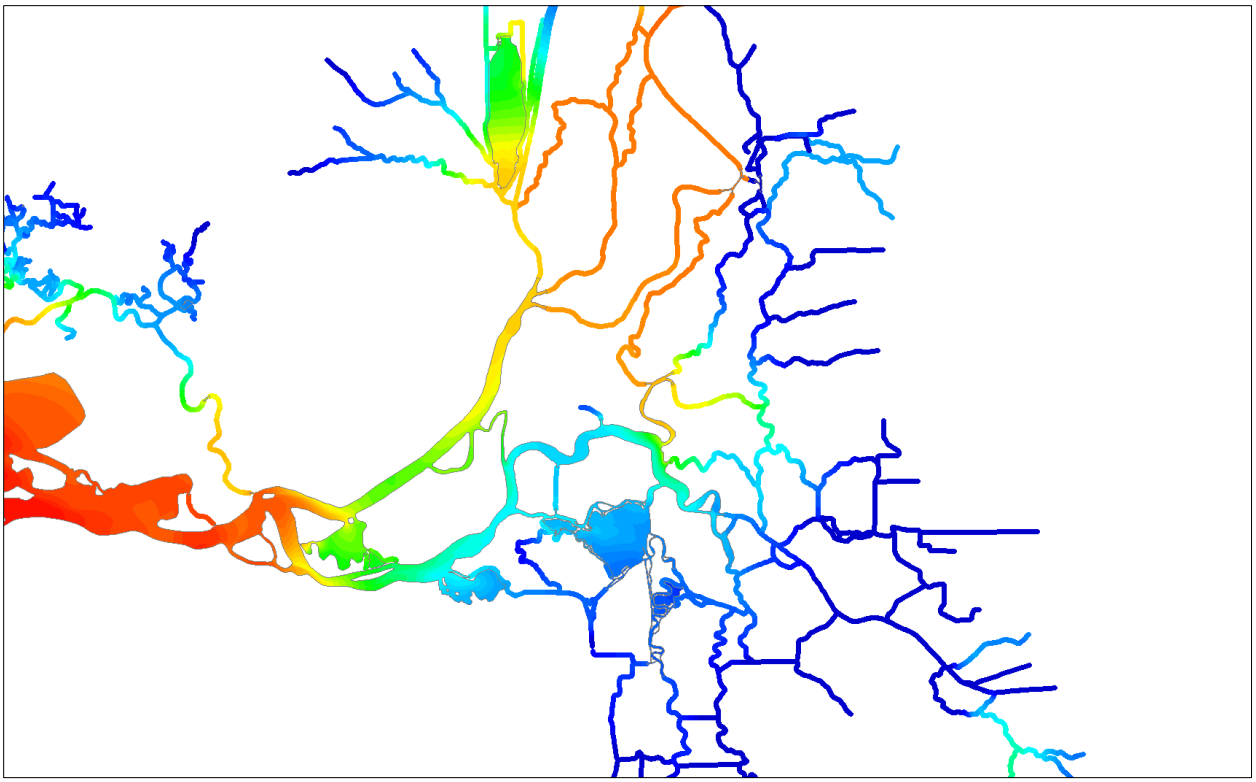

Figure 3 RMA turbidity model results visualization for Dec 25, 2011 12:00 based on interpolation using 39,000 nodes.

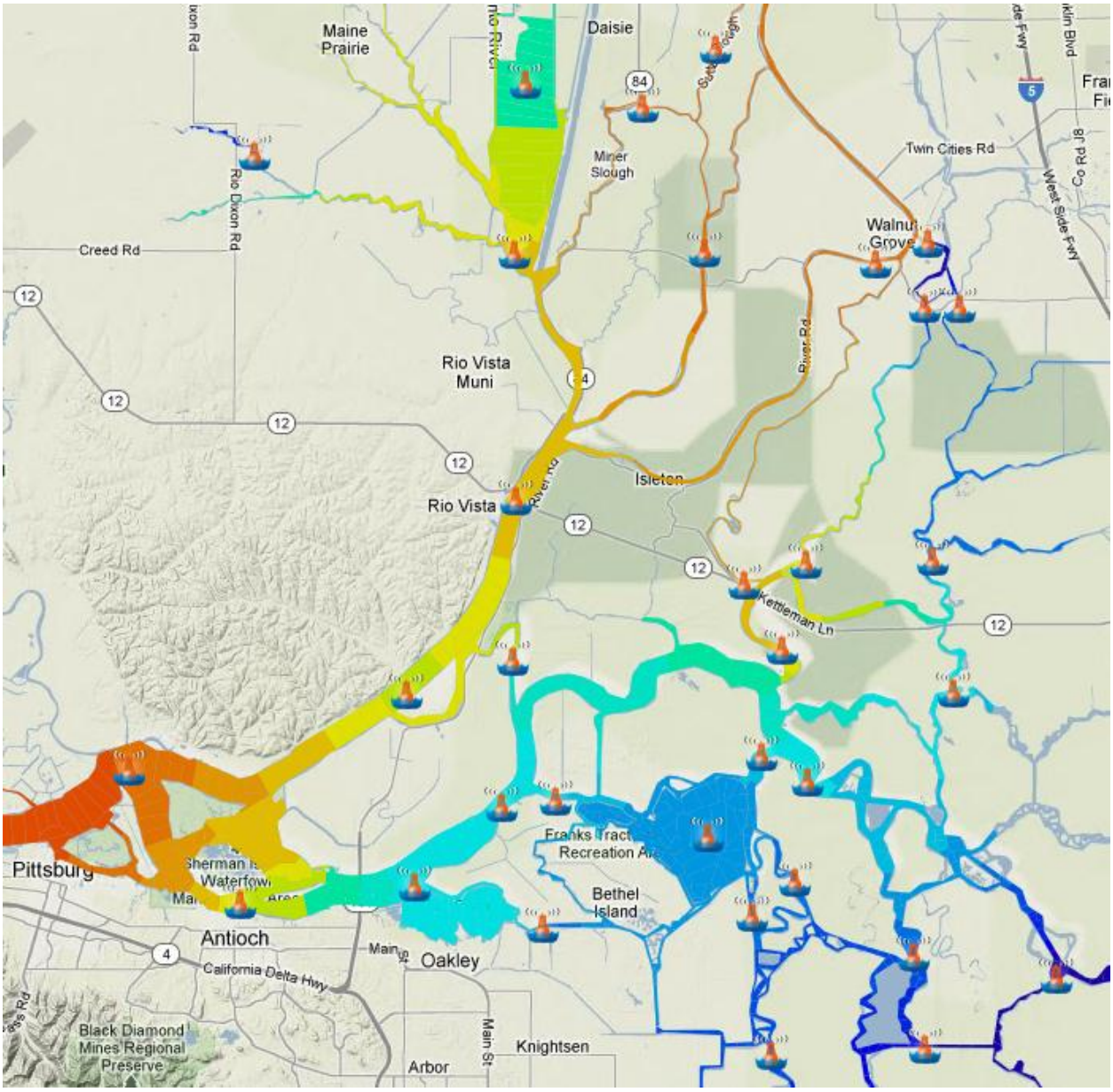

Figure 4 Bay-Delta Live web-based visualization of RMA turbidity model results. Approximately 2,000 polygon are colored based on interpolation between values given at approximately 60 model output locations. Data is for Dec 25, 2011 12:00 as in Figure 3. Buoy icons show the locations of RMA model output.