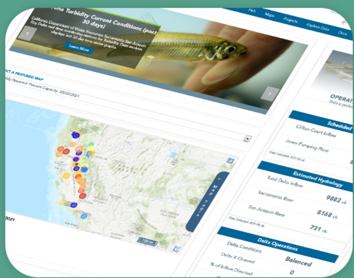
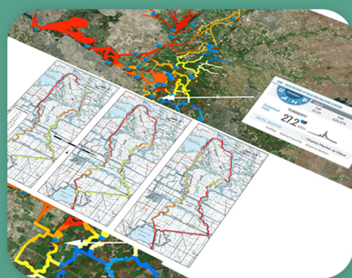
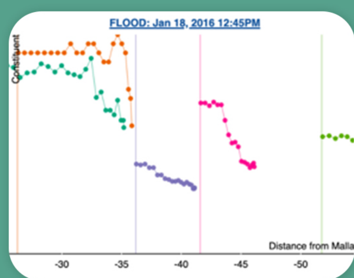
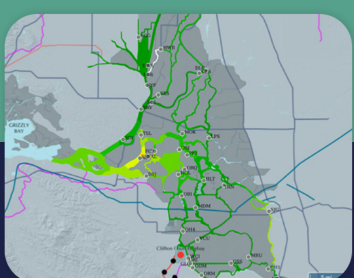
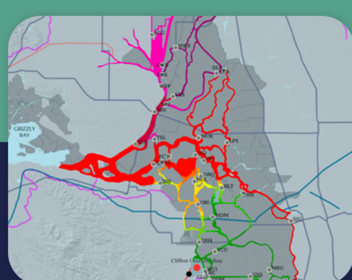
CONSTITUENT TRACKER SUMMARY REPORT











BAY-DELTA LIVE

April 21,2021

USGS
science for a changing world

Jon Burau
John Donovan

34NORTH
WEB • DATA • GIS

Nathan Hemenway
Dave Osti

Contents

Constituent Tracker Overview

Version and Access

The Constituent Tracker version 1.0.0 is currently available to a specified user group on www.baydeltalive.com. General stakeholder use will be available in Fall of 2021. The tool is currently implemented for modeling turbidity and electrical conductivity. Additional constituents will be available in future versions.

Turbidity Model:
https://www.baydeltalive.com/current_conditions/constituent-tracker-turbidity
Electrical Conductivity Model:
https://www.baydeltalive.com/current_conditions/constituent-tracker-electrical-conductivity

For access to latest version of model and help guide, email support@opennrm.org.

What is the Constituent Tracker? An Overview.

Water quality variability in the Delta is, at its core, governed by the movement of water quality fields that move at timescales that vary from the rapid twice daily movements of the tides. These tidal movements (which can be on the order of 8 miles in the western Delta) also respond to changes in river flows, the spring/neap (14 day) cycle and pumping. All of these factors can quickly change the water quality constituent field. These changes often happen much faster than the response of water project operations, with response times that can take days or weeks.

In collaboration with USGS (concept and algorithm development) and DWR (transect data), this project summary describes a water quality constituent tracking tool that assimilates real-time time-series data collected at fixed stations in the Delta. The development of this project aims to advance the Bay-Delta Live (BDL) data management platform and leverage the Delta's sensor network and also provides data and decision support tools for viewing and analyzing continuous water quality conditions at finer spatial scales. This data assimilation tool may be incorporated into existing monitoring programs to evaluate current conditions, assess turbidity, salinity and nutrient conditions, supplement or replace DWR early warning turbidity transect operations, as well as help to evaluate changes due to wetland restoration, flow alteration, gate installations and other management actions.

Area of Interest

The Sacramento-San Joaquin Bay Delta is an inland river delta and estuary in California. The total area of the Delta, including both land and water, is about 1,100 square miles and is the hub of California's water supply, supplying fresh water to two-thirds of the state's population and millions of acres of farmland. Saltwater from the San Francisco Bay mixes with fresh water from the Sacramento, San Joaquin, and other rivers to create the largest estuary on the West Coast. This estuary provides habitat critical to the survival of many fish and wildlife species. It is also a rich agricultural area, a recreational wonderland, and a complex ecosystem that is home to a variety of wildlife.

The conveyance of water from north to south relies on the movement of that water through the Delta and its maze of levees and islands and maintaining the right balance of saltwater and fresh water. Careful operations of the State Water Project (SWP) and federal Central Valley Project (CVP) are critical to keeping the balance, especially in the face of new and ongoing water management challenges.

Modeling of Expected Constituent Concentration Field

The ability to quantitatively understand constituent dynamics in the Delta is hindered by the ability to accurately calculate and visualize data from the existing flow measurement network (USGS and DWR collect flow (stage, velocity, discharge)) (Figure. 1).

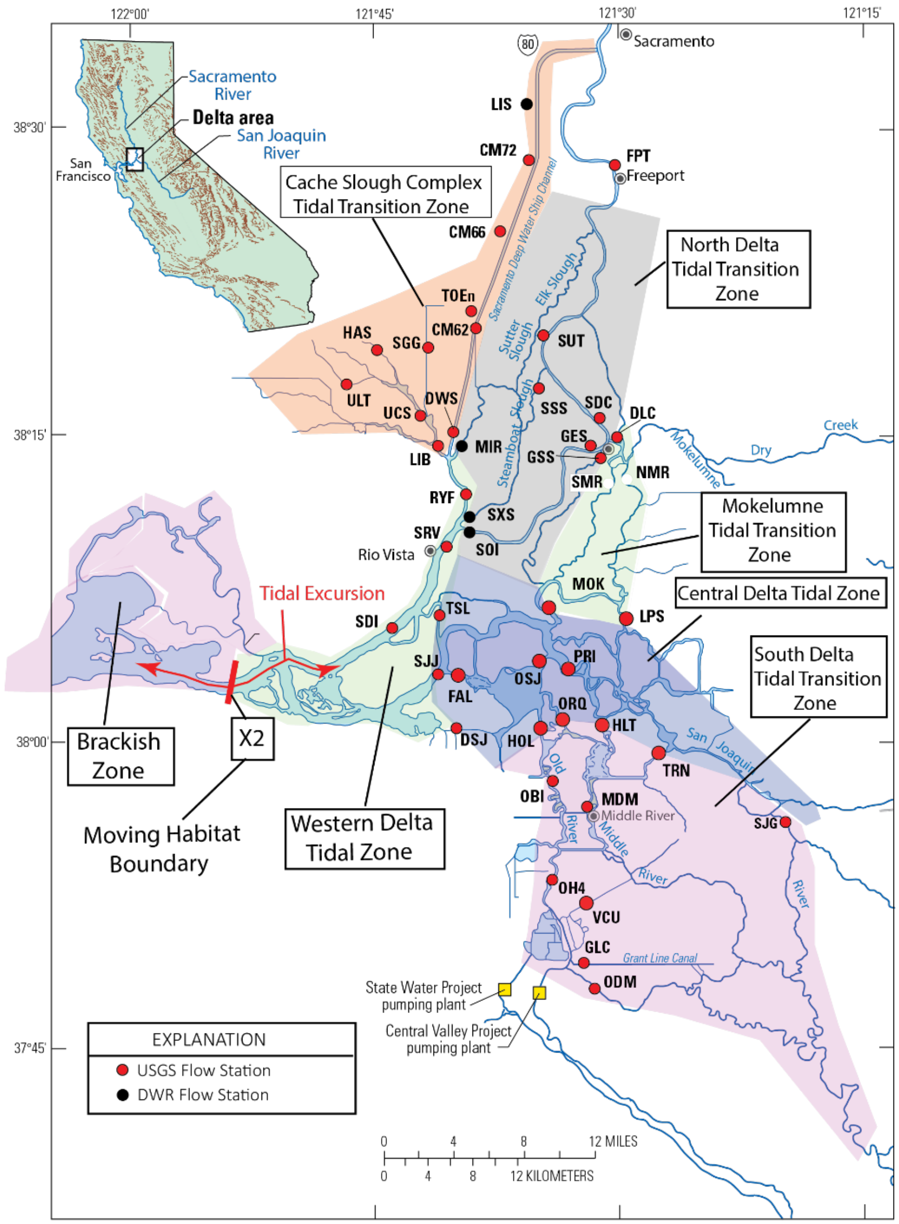


Figure 1: Delta Regions (zones) and Fixed Monitoring Station flow and water quality network. X2 is a moving boundary that moves daily with the tides (~8 miles a day twice a day) and at longer timescales with changes in Delta Outflow.

Current spatial distribution plots (www.baydeltalive.com/turbidity) show that constituent distributions in the Delta appear to be well-behaved fields when in fact the spatial constituent gradients vary significantly over the tidal excursion. These current methods of interpolation yield the approximate spatial distribution of constituents, but for management action and water operations, the true details of the gradients in the constituent fields are needed. To accomplish this goal, USGS developed a 1D transport equation and data assimilation method (funded by DWR and DSP) to fill in the details of the spatial structure in the constituent fields between sampling stations in the North Delta using a conservative tracer.

Building on the USGS transport equations and techniques, 34 North applied these techniques to develop a web-based real time tool to visualize the detailed constituent field throughout the Delta. While the algorithms will be most accurate in the North Delta, stakeholders can explore spatial maps and near real time visualizations throughout the watershed where continuous monitoring is present.

The Problem of Tidal Aliasing

The primary problem with measuring or monitoring water quality in the Delta, is that the tides quickly move the water quality constituent spatial structure which distorts the measured spatial structure. For example, if a field sampling effort starts at the end of ebb, monitoring is occurring when the constituent is as far out of the South Delta as it is going to be for that day. The tidal currents are literally moving the turbidity field during sampling. The turbidity transect shown in figure 2, is an example of this phenomena. It begins at the end of ebb and finishes at the end of flood (e.g. roughly 6 hours). The turbidity measurements during the early part of the transect will more closely represent the position of the turbidity field as far north as it will be for a given tidal day, while the portion of the transect taken near the end of flood will more closely represent of the position of the turbidity field when it is as far south as it will be during the tidal day.

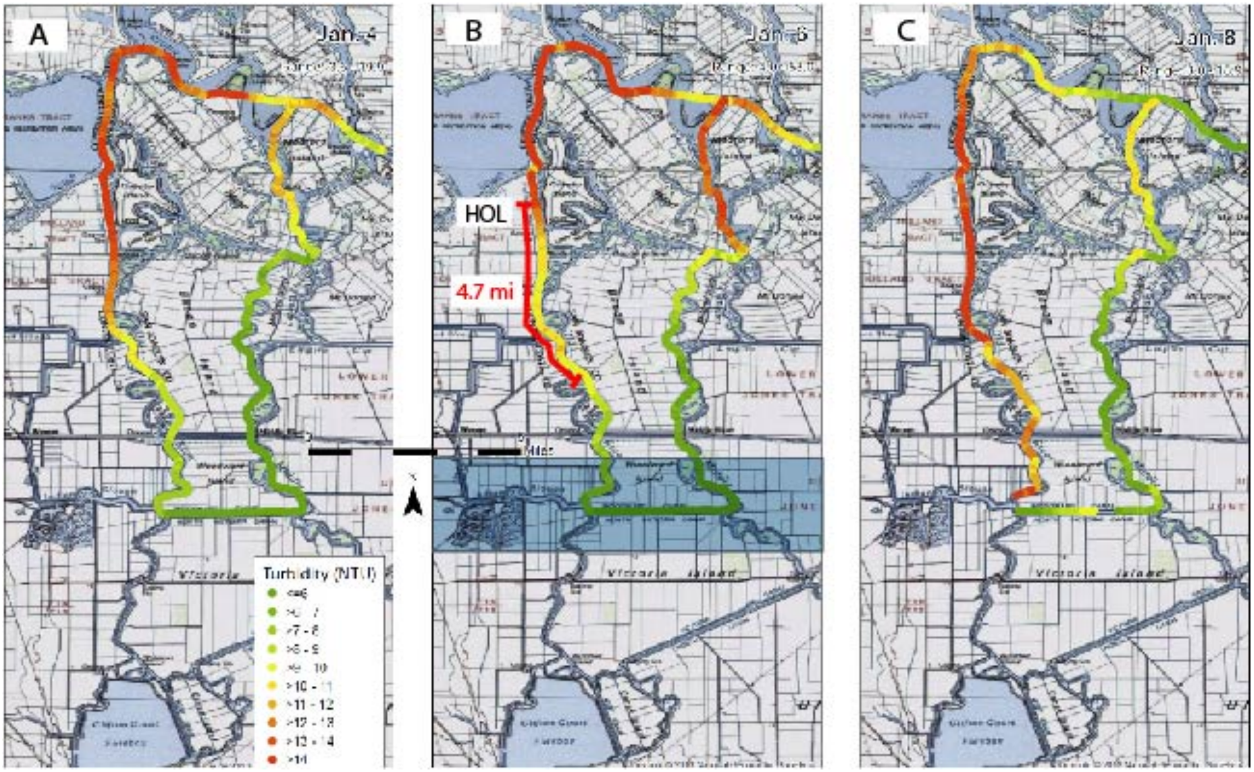


Figure 2. DWR biweekly spatial mapping of the turbidity distribution in the loop from Old River to Woodward Canal to Middle River, to the San Joaquin to Old River is used by the Delta Smelt Working Group - a multi-agency regulatory entity that provides guidance to the water project operators on compliance with State and Federal Delta Smelt biological opinions. To obtain the example "heat" maps shown in figure 2, DWR drags a water quality Sonde behind a boat while collecting GPS position data.

The spatial distribution of water quality constituents over the transect shown can move up to about ~4.5 miles, a distance known as the tidal excursion. The tidal excursion is the distance a parcel of water travels with the tidal currents in ½ tidal cycle. An Eulerian estimate of the tidal excursion is, $L_{ex}(km) = 0.1424 * U(cm/s)$ (see Appendix A for origin of this relationship). To estimate the tidal excursion in Old River we note the peak flood currents at station HOL (a WQ sensor on Old River immediately south of Franks Tract (see figure 2) are roughly 43 cm/s (1.75 ft/s), which gives an Eulerian tidal excursion estimate of 7.5 km (4.7 mi) based on eq. A.5. The length of Old River between Franks Tract and Clifton Court Forebay (CCFB) is 25 km (16mi), so the tidal excursion, and by extension the location of the turbidity field, can move by as much as 1/3 the length of Old River between Franks Tract and CCFB, respectively. To get a sense of the scale of the movements of water quality constituents within Old River, consider that if the high turbidity region near station HOL were mapped at the end of ebb, it would move to the position shown on Figure 3. (January 11), the distance shown by the red line placed west of Old River.

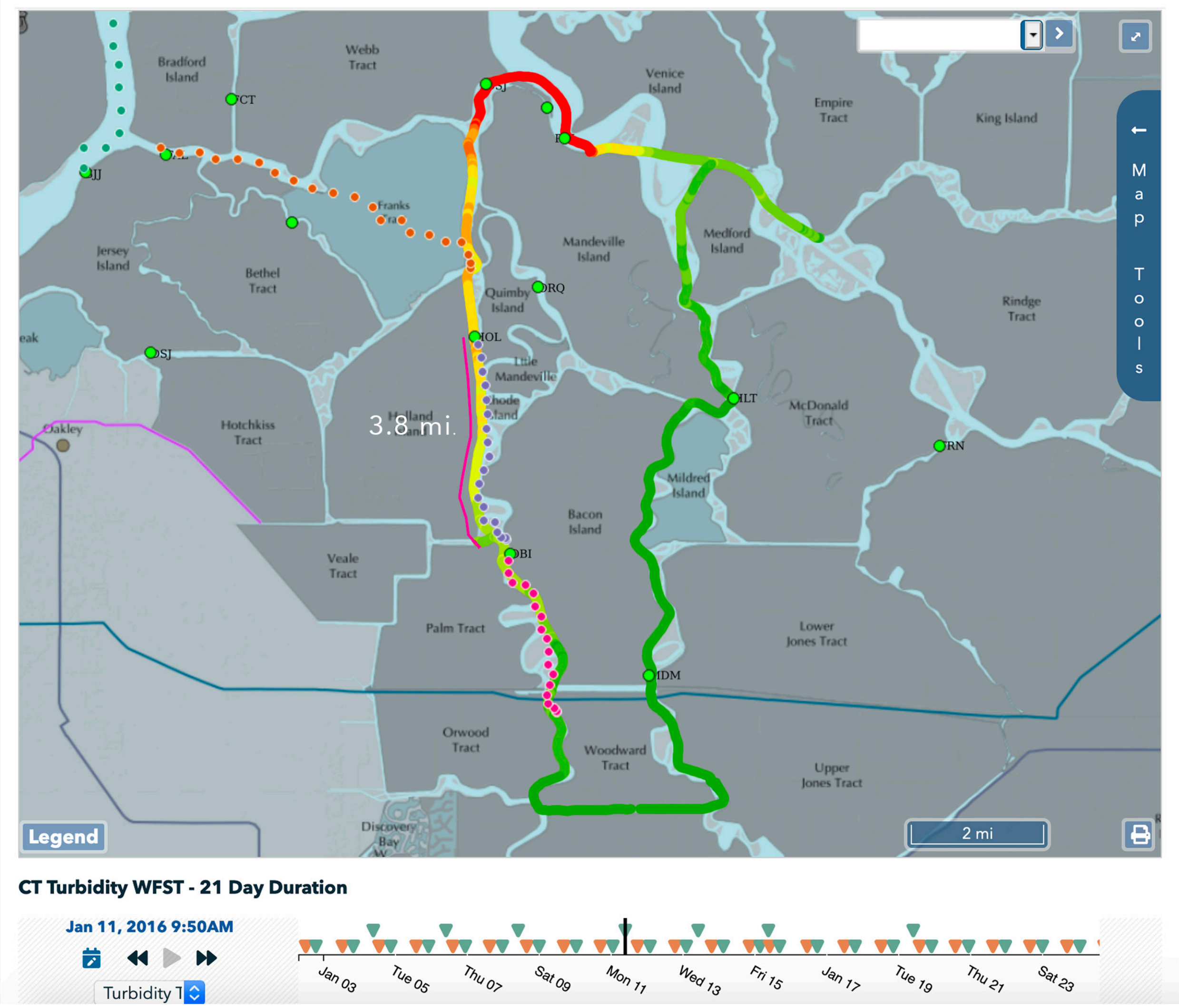


Figure 3. These transect take approximately 6 hours to complete depending on the tidal currents and weather (which is often inclement), roughly ½ of the principal tidal period of 12.42 hours (M2 partial tide). Turbidity transects collected by DWR by dragging a YSI sonde by boat (Courtesy of the 1/11/16 Delta Smelt Working Group notes).

This well-known phenomenon is known as tidal aliasing: which is the collection of spurious data when the sampling time is a significant fraction of the fundamental period of the phenomena being measured – in our case the M2 partial tide, which has a period of 12.42 hours. Basically, the boat-measured spatial distribution is highly aliased (distorted) because the turbidity field moves a significant distance with the tidal currents during the period the boat is collecting data.

An Answer to Tidal Aliasing: Project Relevance and Benefits

The Constituent Tracker Tool (CT) combines measured observations of water quality constituents and measured velocities to produce graphical products based on the tidal excursions of these constituents from their slack-water distributions (viewing data at a constant point in tide). The CT uses an advection-based model to make near real time estimations of the position of a constituent to better inform water operations and their regulatory impacts. For example, there are a number of different regulatory triggers aimed at protecting delta smelt that can impact water operations. The main triggers being salvage at the pumps and elevated turbidities in the central and south Delta. For example, reductions in pumping are required when the 14-day average turbidity exceeds 12 NTU at stations PRI, HOL, and VCU (Figure 1). These decisions and triggers along with other regulatory actions are evaluated over a period of days. By improving data collection techniques and tools for near real time analysis this project will:

1. Help support decision making to manage water projects at a finer scale.
2. Obviate the need for on-the-water boat transects.
3. Provide non-aliased estimates of the location of the turbidity field at slack water after the max flood and ebb each day, stringing together images of the turbidity field at slack after max flood.
4. Improve project operational response to water quality variability.
5. Improve understanding of how constituent fields move at variable timescales.
6. Demonstrate that water quality conditions are influenced by twice daily rapid and powerful tidal cycles (affecting up to 8 miles of water quality conditions in the western Delta).
7. Support decision making for the Delta Smelt Working Group and reduce reliance on DWR turbidity transect data and maps.

Using this tool within existing regulatory frameworks will provide a better understanding of constituent fields in the central and south Delta and will have the collateral benefit of increasing water supply reliability and potentially exports of water to regions south of the Delta.

Project Approach

Our overall approach in the development of the Constituent Tracker is to make the best use of a detailed knowledge of transport processes and of all of the data collected in the Delta (time series collected within channels and near junctions, drifter data, etc.) in order to provide the most realistic near real-time maps of water quality constituent spatial distributions.

Using linear interpolation on a grid via the Laplace equation (hereafter referred to as grid interpolation) we can provide reasonable Delta-scale estimates of constituent distributions at either a constant point in time or constant point in tide. Constituent concentration spatial gradients can be more accurately estimated within either a maximum flood or ebb tidal excursion of the data collection location using the assumption of pure advection.

The Constituent Tracker grid coverage extents (Figure 4) from the Sacramento River where it meets the Deep Water Ship Channel in the north down to the Chipps Island in the West to the San Joaquin River at Mossdale Bridge in the south. In order to map the station particles using the advection algorithm, the project divided the rivers into 13 reaches, grouping appropriate stations within each reach. Both the EC and Turbidity maps pair over 40 stations with velocity and the water quality constituent.

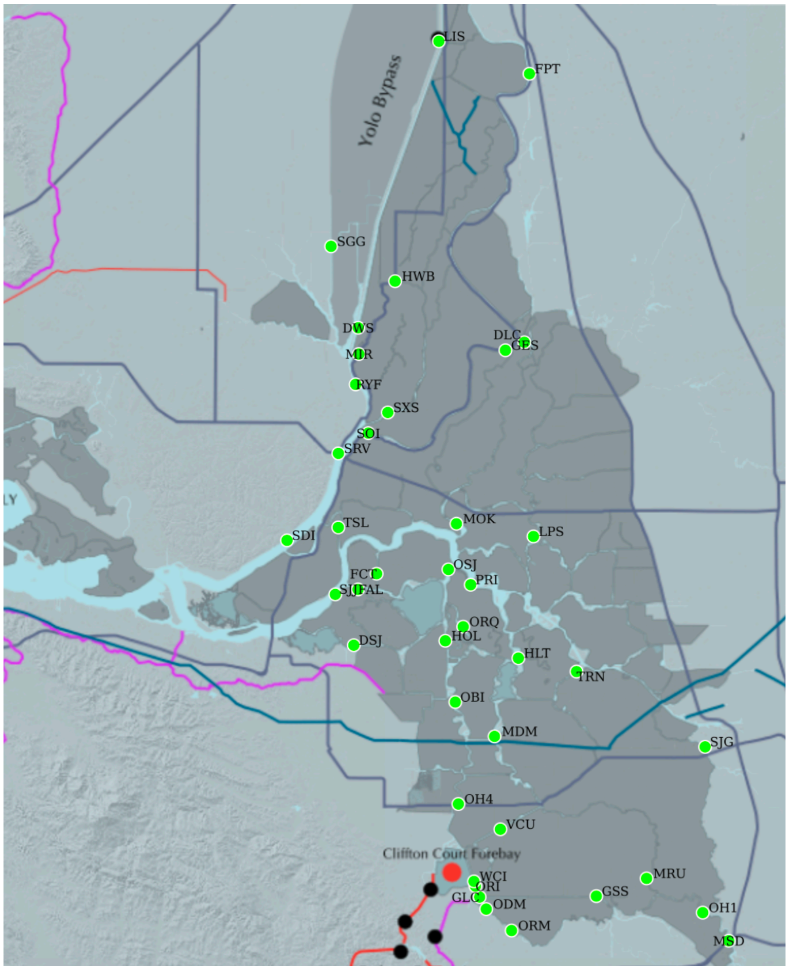


Figure 4. – Grid coverage and the location of USGS fixed site flow and water quality sampling locations. The constituent tracker would also utilize DWR-run flow and water quality gages in the Delta to increase the precision of the spatial maps produced using this approach.

Turbidity Reaches and CDEC Stations:

- Sacramento River (SAC): SDI, SRV, SOI, GES, FPT
- Steamboat Slough (STM): SRV, SXS, FPT
- Sutter Slough (SUT): RYF, MIR, HWB, FPT
- Cache Slough (CSC): SDI, SRV, RYF, DWS, LIS
- North Mokelumne (NMK): MOK, DLC
- South Mokelumne (SMK): LPS, DLC
- Old River (OLD): SJJ, FAL, HOL, OBI, OH4, WCI
- Middle River (MID): MOK, OSJ, ORQ, HLT, MDM, VCU, WCI
- San Joaquin River (SJ): SJJ, OSJ, PRI, TRN, SJG, MSD

San Joaquin West (SJW): ORI, GLC, ODM, ORM, MRU, OH1
Dutch Slough (DUT): SJJ, DSJ
Fisherman's Cut (FIS): SJJ, FAL, FCT
Threemile Slough (THR): SDI, TSL
Georgiana's Slough (GEO): MOK, GSS, GES
Liberty Island (LIB): RYF, SGG

Dynamically Weighted Grid

The results of these data assimilation processes are displayed using a custom GIS grid, explained above. Constituent values for each polygon are generated using a weighted algorithm provided by RMA (DeGeorge, John; Andrews, Steve. 2011. User Information for 34 North Polygon Weighting Program Resource Management Associates) based on solving the Laplace equation which effectively linearly interpolate across each polygon in the grid.

Previous versions of the CT linear interpolation used a fixed station list, which was problematic given there can be occasional gaps in the data either because the station actually goes down or the real time data feed breaks, causing the interpolation within the reach that includes the data gap to fail.
The current CT solves this problem by using a Dynamic Weighting Algorithm, where stations with a data gap are dropped from the interpolation algorithm. The CT can compensate for missing data in the visualizations using the data that is available. Data is provided by the California Data Exchange Center (CDEC). CDEC is the data service of choice because it is the only source that aggregates the data from USGS, DWR, USBR and other organization sources.

Error Handling and Traceback

Before placing data into the grid cells for interpolation, the CT applies a series of filters and algorithms to data collected from the CDEC web services. Transmitting data from over 44 field stations which are managed by multiple agencies via a web services API and ingested into web browsers can introduce the potential for many failure points during any given model run.

Easily finding and diagnosing any of these potential failures is important to minimize the amount of downtime and to maximize model accuracy. Model accuracy is enhanced by a loop of information that captures important events that occur during individual model runs. This information is used to report the performance of the model and the interaction between the real time data, the filters and algorithms, the finite element grid and the linear interpolation using the Laplace equation.

These visual and textual cues are displayed within the user feedback interface for each station during each tidal cycle. For example, metadata related to the signal to noise ratio may be accessed by clicking on the station icon on the map. Changing the color of a station's icon indicates the quality of the signal to noise ratio and this can be determined by a visual inspection of the map interface.

Traceback Details include:

1. Tidal signal presence or absence for each station during each tidal cycle.
2. Signal to Noise algorithm value per station, per tidal cycle.
3. If target station has no signal, indicate downstream sequence of stations and indicate next station that reports a tidal signal within the target stations' badge.
4. Report the metadata for each stations' cycle to cycle algorithm results.
5. Report Integration algorithm metadata in order to color code each stations' icon to indicate presence or absence of a tidal signal.
6. Program station icon to toggle between two different colors (signal or no signal) during each tidal cycle.
7. CDEC Errors: Dynamically scan the data array table for each station to report station data results or errors.
8. Copy over metadata from each cycle to cycle algorithm to each Integration cycle so user can access metadata results per each tidal cycle.
9. Analyze metadata in all the traceback loops and report back to USGS, DWR and other stakeholders in order to discuss enhancements and refine accuracy in real world conditions.

Data Assimilation and Display

The Constituent Tracker linearly interpolates the spatial distributions to a common point in tide (not time) where the common points in tide (phase) are at slack after max flood and at slack after max ebb. Spatial maps that are ***linearly*** interpolated to a common point in tide give us a Delta scale estimate of the extreme positions of the constituent fields that occur within a tidal day: either fully into the Delta (slack after max flood) or out of the Delta (slack after max ebb).

Identifying the peak ebb/flood set in a given tidal day is non-trivial because the peak currents during flood and ebb tides can be similar, if not identical (Figure 5) during the spring/neap cycle. The period of similar peak currents occurs during periods when the diurnal inequality is minimal, which typically occurs during the transition between spring and neap tides, or on places/times when river flows create unidirectional flows. Thus, picking out the maximum flood ebb/sets can be challenging.

Given this ambiguity, *the CT uses the maximum tidal excursion associated with each tide instead of the max current speed to pick the max ebb/flood set*. The tidal excursion - the time integral of velocity from slack to slack (Equation A.1) – doesn't rely solely on the current extremes but *includes the duration* of a given tide in the calculation which gives us better discrimination between tide cycles. Because this project is *focused on comparing the extreme positions of constituent fields over a tidal cycle,* the tidal excursion is a calculated quantity needed for phase 2. Because the tidal excursion uses the integral of the velocity over the tide cycle, changes in the spring/neap cycle are much more apparent in the tidal excursion. In the example shown in Figure 6, and generally in the Delta, the tidal excursions during spring tides are roughly 40% longer than during neaps, and, importantly for this project, differences in the tidal excursion between tides are greater.

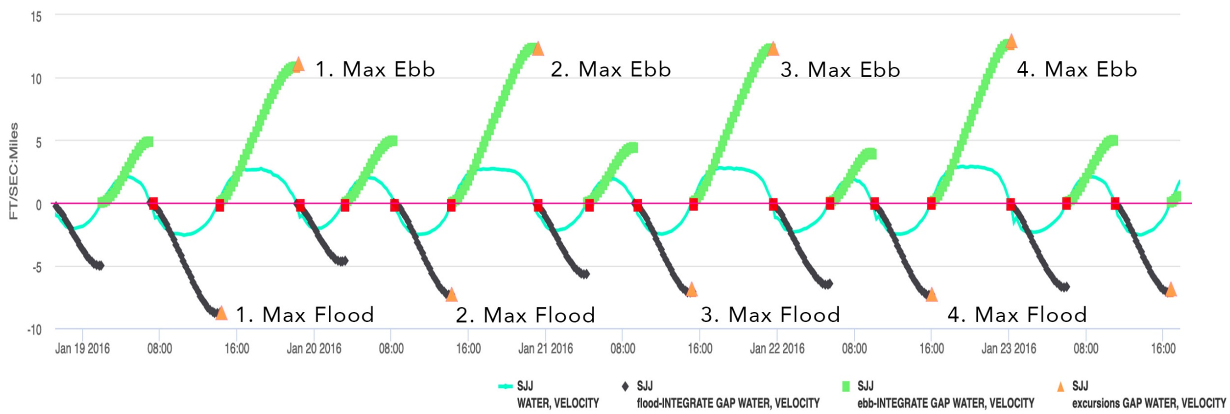


Figure 5 – Time series plot of velocity (blue-green line, scale not shown) and the tidal excursion: green = ebb & black = flood, time integral of velocity from slack to slack, maximum excursion (orange triangles) and slack water periods (red squares on the red zero line) at Jersey Point.

The maximum salinity intrusion into the Delta that occurs within a tidal day occurs at slack after flood tide Figure X. Whereas, the lowest EC's are associated with slack after ebb tides, the extreme positions of the salinity field over a tidal day, which are the most important positions of the salt field to water project and fisheries resource managers and are much more accurate measures of the spatial structure of constituents than taking transects using a boat, as described above. The fact that EC and the tidal currents are in quadrature (e.g. 90 degrees out of phase) is a strong indication that transport of EC at this station is advection dominated, as it is throughout the Delta, consistent with the principal assumption on which this project is based.

Finally, Figures 7 and 8 show how EC varies over the spring/neap cycle, where the maximum salinity intrusion on each day declines as the daily maximum flood tide declines in the transition between spring to neap tides.

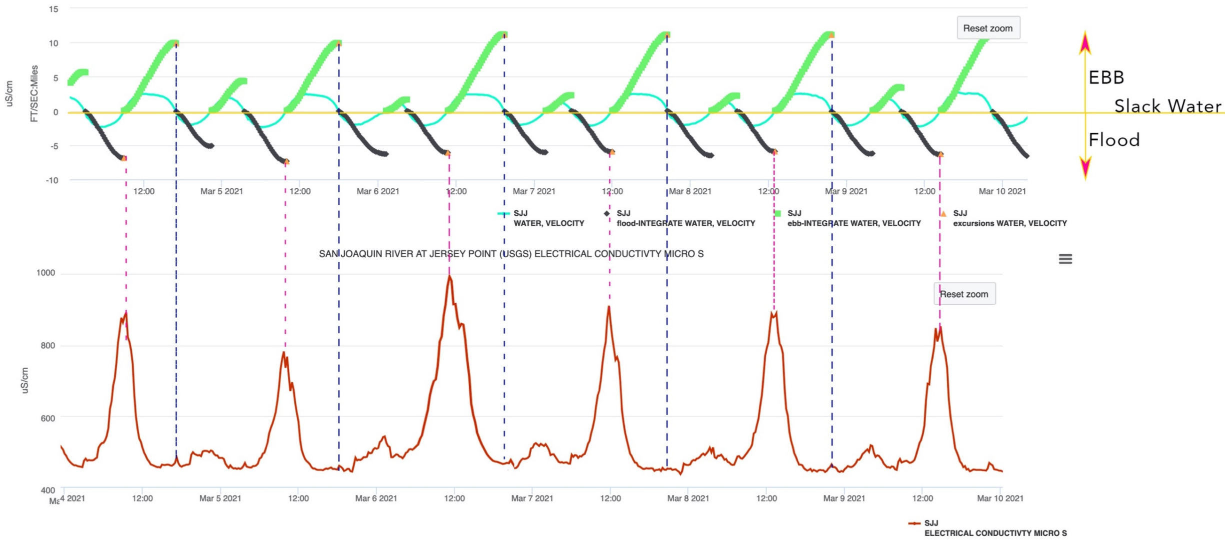


Figure 6. Time series of electrical conductivity (bottom panel) and tidal excursion (green line; ebb, black line; flood, top panel) and water velocity (blueline, top panel) collected at the San Joaquin River at Jersey Point (March 4-5, 2021). Vertical dashed blue line indicates slack after max ebb and the vertical dashed purple line represents slack after flood tide.

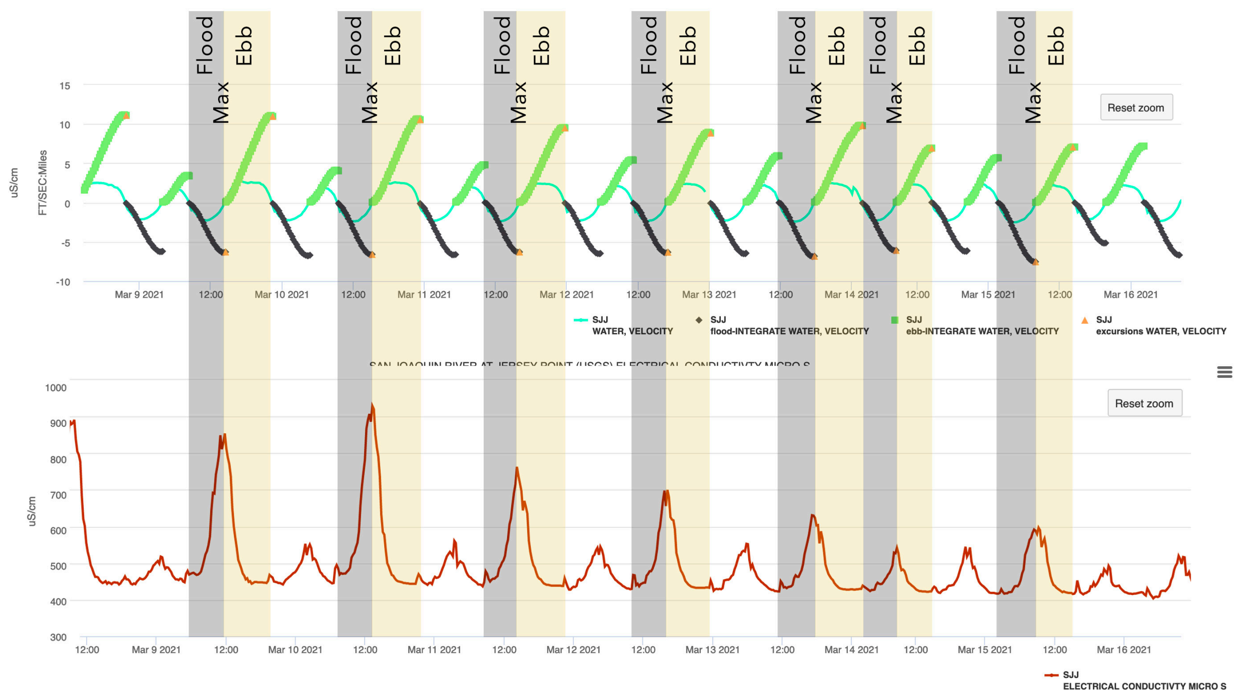


Figure 7. Time series of electrical conductivity (top panel) and tidal excursion (cyan line, bottom panel) and water velocity (green line, bottom panel) collected at the San Joaquin River at Jersey Point (November 23 – December 3, 2015.

Advection Algorithm

The advection algorithm calculates the excursion distance from each station in the CT model from phase 1 to estimate the spatial variability in constituents between stations. Excursion track results are obtained by integrating the velocity at each station for each tidal period. Placing these points onto a map allows a fine-grained view of the constituents and how they are spaced between stations on a river reach.

The CT has geo-referenced each water quality station on a grid. By doing so, the CT can then plot the location and distance of the excursion points across this grid. By doing so we are able to:

1. Place excursion points on map
2. Track point positions
3. Presents tools for reporting and tracking points

Fortunately, the work identifying the max ebb/flood set in project phase 1 can be used to simply affiliate the incremental distance water has traveled from each station for each time a water quality and velocity measurement is recorded (Figure 7). The particles contain copious amounts metadata including the stations' constituent value. At the mapping of these excursions (e.g. at every particle location, or point on the map in Figure 8), the particles' value is transferred to the underlying grid cell.

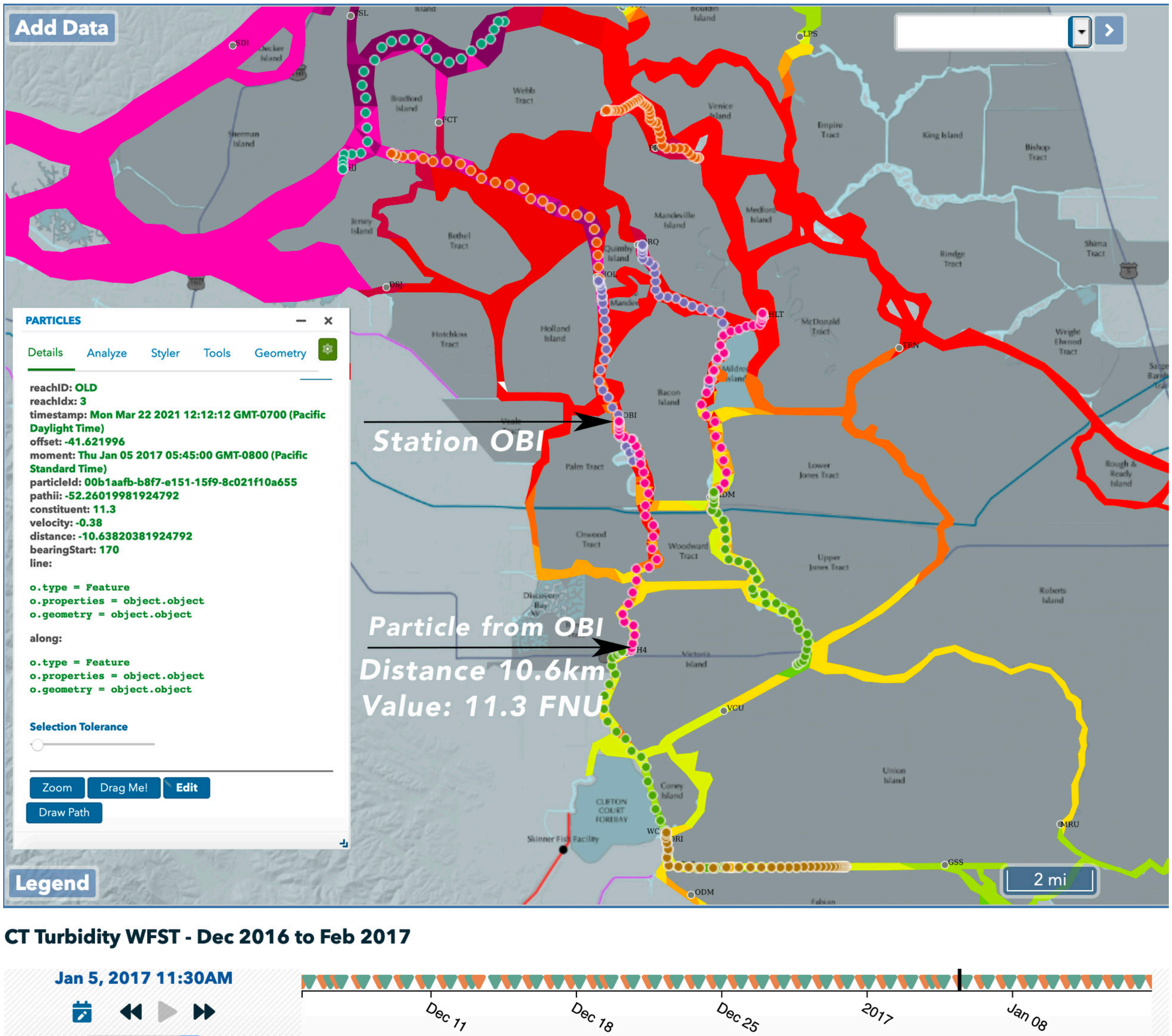


Figure 8. Particle Tracking from Station OBI on Max Flood. Distance traveled = 10km (6.59 mi)

Tideline

The existing map timeline used to display the Constituent Tracker, constant point in tide misrepresents the movement through the max flood and max ebb points at slack water. 34 North created the tideline (Figure 9) to communicate slack water at max flood and max ebb tide cycles. This tideline allows for added complexity of describing and moving through "relative" time. The tideline provides the user with a graphical user interface to interact with the visualizations at various tide periods.

Tideline Details:

- Each point represents an excursion at a particular station. All stations line up on the x-axis visually capture the '*constant*' in constant point in tide.
- Each column in the tideline represents a flood or an ebb in the tide cycle.
- Roll over each point to reveal the time stamp for each station's individual slack water time, excursion distance and related metadata.
- Tideline enables the user to move the animation to a specific constant point in tide.
- The spread on the y-axis provides a visual que to recognize ebb and flood tide intensities and spring and neap cycles.
- Time UTC function: Defaults to the aggregation of slack water at each station. Toggle to UTC and the tideline uncorrelates data and turns the x-axis into time. This is a way to communicate to users tide versus time visualizations.

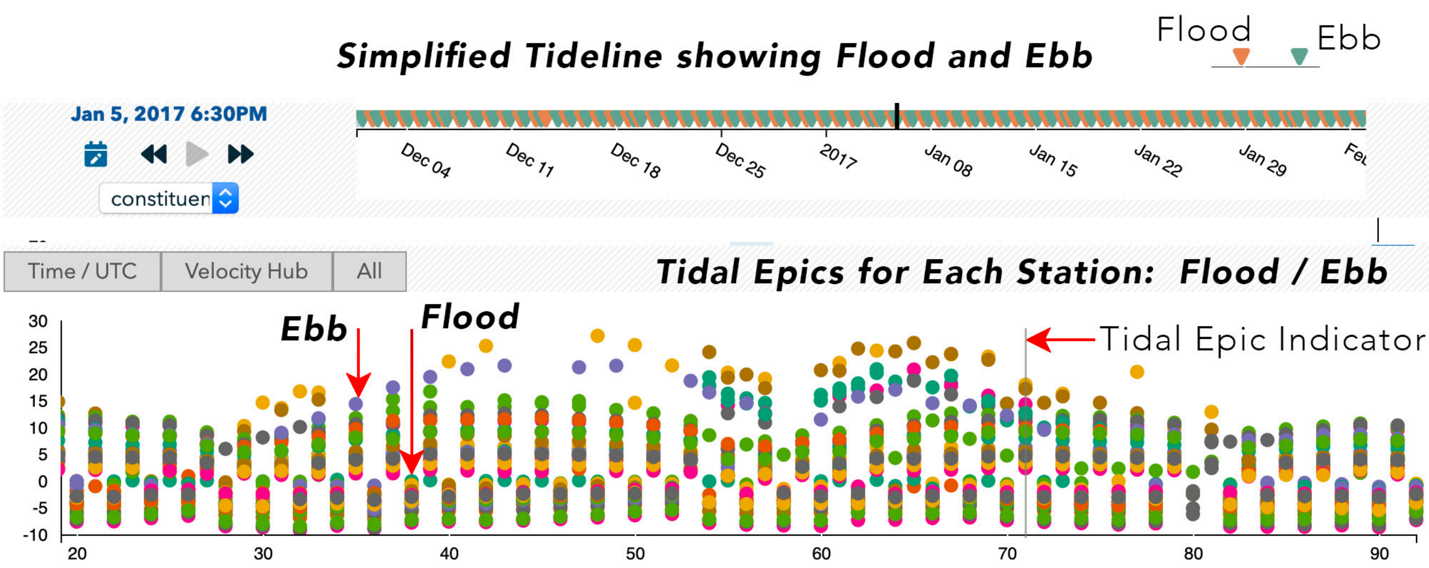


Figure 9. Tideline Graphical Interface. Each point represents the tidal excursion estimate at slack water from a real time station for each max flood and max ebb tide.

Velocity Hub

The constant point in tide provides the temporal gradient of the constituent across the Delta and the advection particle tracking provides a finer grain spatial resolution between the station on a reach in 1-dimension. The Velocity Hub (Figure 10) is the tool to manage particle tracking that occurs within reaches and provide higher spatial resolution of continent fields between station. For example, as the particle is placed within a grid cell, the color/value of that grid cell is updated with a more spatially accurate value.

Delta Reaches:

Sacramento River (SAC): SDI, SRV, SOI, GES, FPT
Steamboat Slough (STM): SRV, SXS, FPT
Sutter Slough (SUT): RYF, MIR, HWB, FPT
Cache Slough (CSC): SDI, SRV, RYF, DWS, LIS
North Mokelumne (NMK): MOK, DLC
South Mokelumne (SMK): LPS, DLC
Old River (OLD): SJJ, FAL, HOL, OBI, OH4, WCI
Middle River (MID): MOK, OSJ, ORQ, HLT, MDM, VCU, WCI
San Joaquin River (SJ): SJJ, OSJ, PRI, TRN, SJG, MSD
San Joaquin West (SJW): ORI, GLC, ODM, ORM, MRU, OH1
Dutch Slough (DUT): SJJ, DSJ
Fisherman's Cut (FIS): SJJ, FAL, FCT
Threemile Slough (THR): SDI, TSL
Georgiana's Slough (GEO): MOK, GSS, GES
Liberty Island (LIB): RYF, SGG

The Velocity Hub (vHub) (Figure 9) is the graphical user interface developed to display the advection algorithm results or visualize particle tracking from each station in a reach. The vHub on the tideline initiates the user UI element that display and explains functionality for particle tracking. Clicking on a reach will draw the excursions on the map for each slack water selected on the tideline. The user can advance the tides using the forward and back buttons on the player controls and can select the Flood/Ebb/All toggle button to advance the data per tidal epic.

Velocity Hub Details:

Graph Track: Graphs the particle's 1-dimensional track or distance. On the chart x-axis the distance the particle moves. The y-axis is the constituent value. This provides a visual inspection of the quality of the data and performance of the algorithm.

Graph Excursion: Shows the difference between 1-D algorithm and the gross excursion.

Map all Tracks: Add the particle to the map.
Reach Manager: Activates reach and tracks that are active on the map for visual inspection.

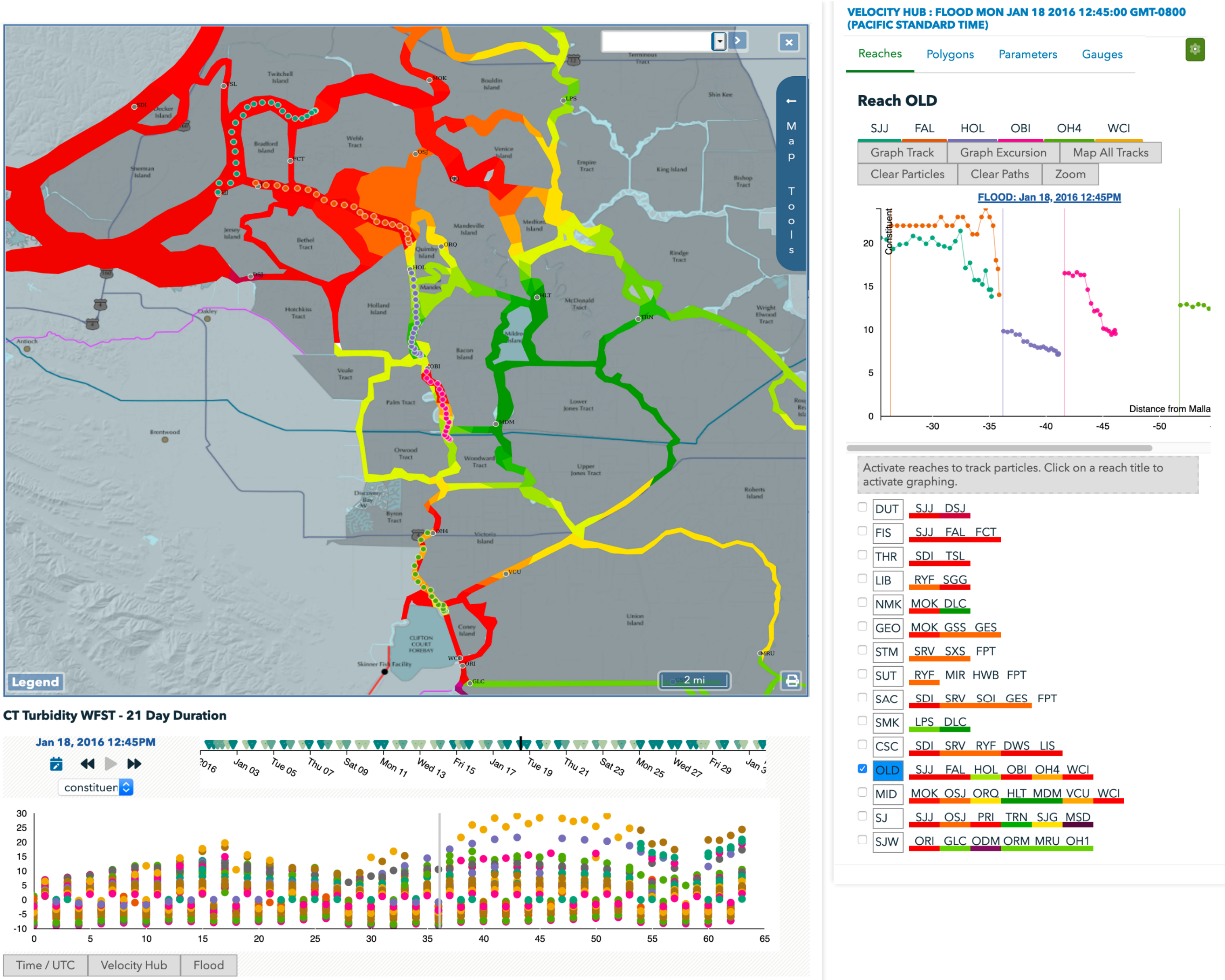


Figure 10. Image of the map, velocity hub and the tideline. The upper right graph displays the excursion data and distances from Mallard for the selected Old River Reach. The particles are displayed on the maps.

Operations Data

Additional data are provided to managers to supplement CT results with SWP and CVP water operations and fishery survey results. Data has been aggregated and archived for access back to 2011. Users run the CT and the Operations and Fisheries components automatically fetch and report on the operational status of the State Water Project and Central Valley Project facilities at the Harvey Banks Pumping Plant and the Tracy Pumping plant respectively. The date for which data is reported is controlled by the map timeline and automatically updates as the user moves through time on the Constituent Tracker. Each metric represents a snapshot of time series data and can be viewed as a single day value according to the current date of the map timeline or as a time series with data extending back in time from the current date displayed on the timeline. The reported metrics include daily pumping rates in cubic feet per second (CFS), daily salvage of Chinook Salmon, Delta Smelt, and Longfin Smelt, and the estimated daily inflow into the Clifton Court Forebay. Pumping rate and river flow data all come from the California Data Exchange Center (CDEC). The estimated Clifton Court inflow is calculated as the average daily mean of the difference in flow (CFS) between stations ORI and WCI. Since ORI and WCI are positioned upstream and downstream of the Clifton Court inflow respectively, the loss of flow between the two stations is assumed to be entering the forebay.

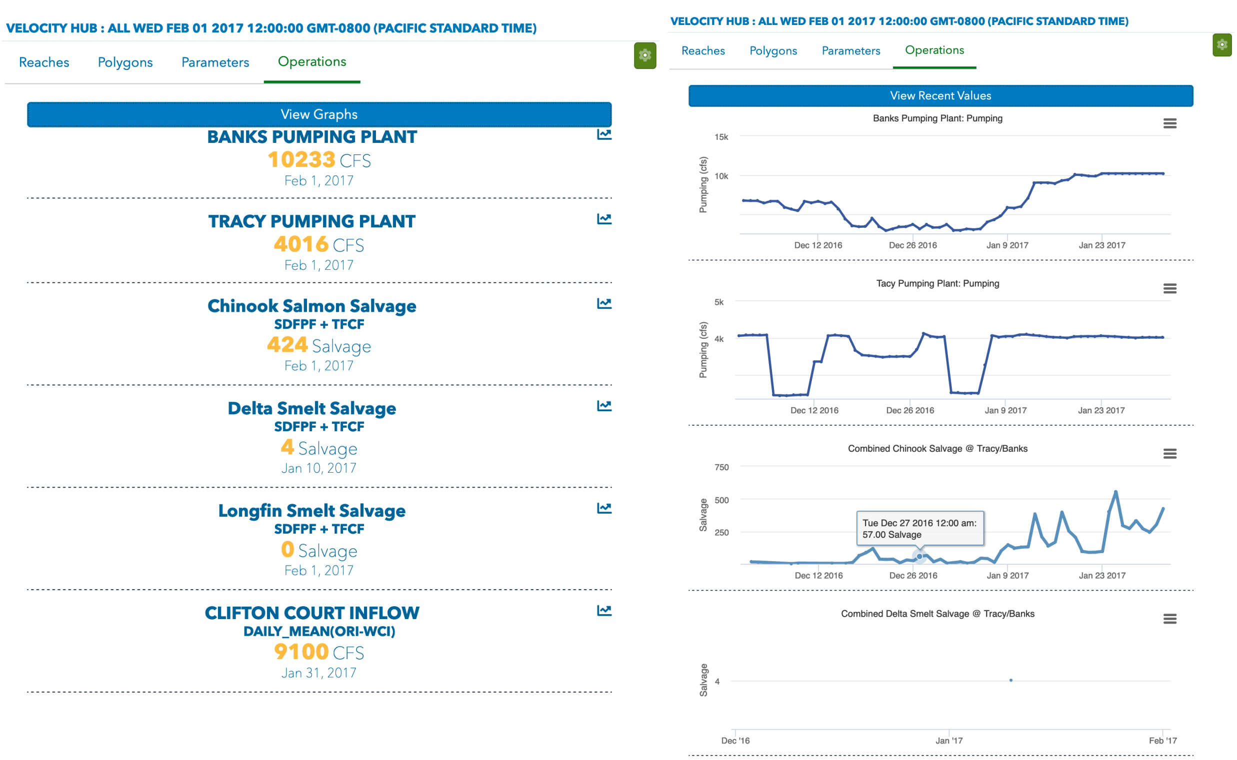
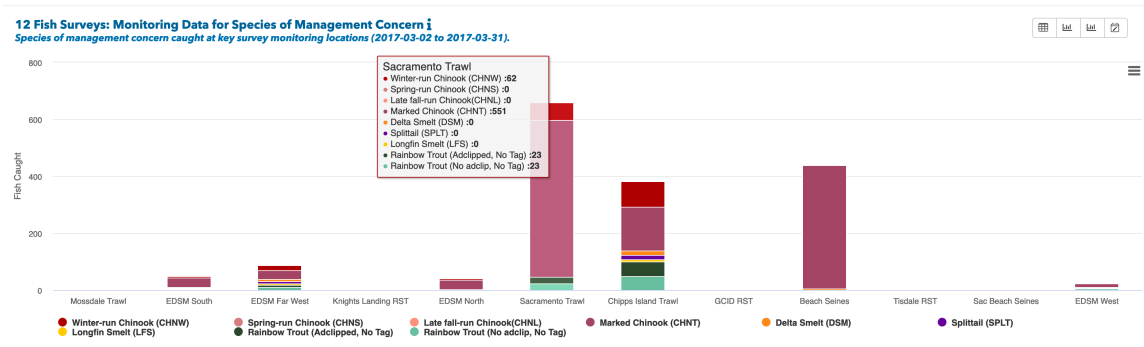
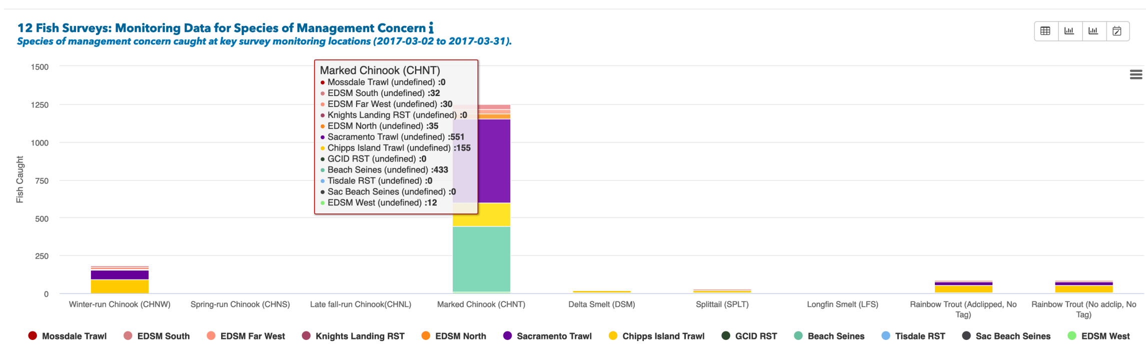


Figure 11: Two different views of the operational data are available. Single day values (left) and graphical time series data (right).

Fish Species of Management Concern

The Fish Species of Management Concern chart reports cumulative catch data from fish monitoring surveys across the Delta for user-defined periods of time. The fish monitoring surveys include: the Sacramento, Mossdale, and Chips Island trawls; the Glen-Colusa Irrigation Dam (GCID), Tisdale, and Knights Landing rotary screw traps; the Sacramento Beach Seines; and the various EDSM survey locations. The fish species include Winter Run Chinook, Spring Run Chinook, Late-Fall Run Chinook, Tagged Chinook, Delta Smelt, Longfin Smelt, Splittail, and Rainbow Trout (either clipped or unclipped). This group of species was selected due to their relevance for operational and ecological management in the Delta. The data can be viewed as stacked column charts organized by either survey location or species, or in tabular format (see below). Using the calendar icon in the top right corner of the visual the user can define a custom date range or a duration to go back from the date currently displayed on the map timeline. If a duration is selected, the visual will automatically update as the user moves through time on the timeline.





12 Fish Surveys: Monitoring Data for Species of Management Concern

Species of management concern caught at key survey monitoring locations (2017-03-02 to 2017-03-31).

Show 25 entries | CSV | Excel | PDF | Print | Previous 1 Next

Location	Total Catch	Fall-run Chinook (CHNF)	Winter-run Chinook (CHNW)	Spring-run Chinook (CHNS)	Late fall-run Chinook(CHNL)	Marked Chinook (CHNT)	Delta Smelt (DSM)	Splittail (SPLT)	Longfin Smelt (LFS)	Rainbow Trout (Adclipped, No Tag)	Rainbow Trout (No adclip, No Tag)
Beach Seines	470	403	0	0	0	433	4	1	0	0	0
Chipps Island Trawl	326	6	90	0	0	155	14	17	7	50	50
EDSM Far West	76	6	17	0	0	30	7	10	4	9	9
EDSM North	42	26	5	0	0	35	0	0	0	1	1
EDSM South	46	25	7	0	0	32	4	0	1	3	3
EDSM West	23	10	2	0	0	12	0	2	0	4	4
GCID RST	0	0	0	0	0	0	0	0	0	0	0
Knights Landing RST	0	0	0	0	0	0	0	0	0	0	0
Mossdale Trawl	0	0	0	0	0	0	0	0	0	0	0
Sac Beach Seines	0	0	0	0	0	0	0	0	0	0	0
Sacramento Trawl	736	319	62	0	0	551	0	0	0	23	23
Tisdale RST	0	0	0	0	0	0	0	0	0	0	0

Showing 1 to 12 of 12 entries | Previous 1 Next

Figure 12: The three views of survey catch data. The data can be viewed as column chart organized by survey location (top), as a column chart organized by species (middle), or in tabular format.

Algorithms

The CT tackles the reality of real time data by first running a series of signal processing algorithms to prepare the data. The procedure is as follows:

1. Analyzing the Data:
    a. Fill data gaps (4 hours maximum fill)
    b. Smooth and Normalized Velocity data
    c. Identifying slack water from velocity:
        i. Zero Crossing
        ii. Peaks and Valleys
        iii. High to High (Hi2Hi)
        iv. Low to Low (Lo2Lo)
2. Heuristic Algorithms: Making Decisions with the Data:
    a. Signal to Noise Algorithm to identify a good signal: Yes or No.
        i. If yes – Identify the start and end of tidal epic using Velocity:
            1. Zero Crossing
            2. Hi2Hi
            3. Lo2Lo
        ii. If no – the application moves down stream along a predefined river reach to the next station and runs the same data check.
    b. Run the Flood and Ebb Integrates
    c. Find & record the excursion times and distances

Appendix A– Eulerian Tidal Excursion Estimate

The tidal excursion, L_u, the maximum distance traveled by a parcel of water on a single tide, can be estimated based on a local Eulerian velocity measurements, $u(t)$, simply as:

$$L_{ex} = \int_{t_0}^{t_1} u(t)dt \quad \text{(A.1)}$$

where t_0 is the time of slack water and t_1 is the next slack water.

If we let $t_0 = 0$ and $t_1 = \frac{P}{2} = \frac{\pi}{\omega}$, and the tidal currents can be reasonably approximated by a single partial tide, $u(t) = U \sin \omega t$, then equation 1 becomes

$$L_{ex} = \int_0^{\pi/\omega} U \sin \omega t dt = -\frac{U}{\omega}[t \cos \omega t|_0^{\pi/\omega} \quad \text{(A.2)}$$

$$L_{ex} = -\frac{2U}{\omega} \quad \text{(A.3)}$$

L_{ex}= U*P/pi (A.4)

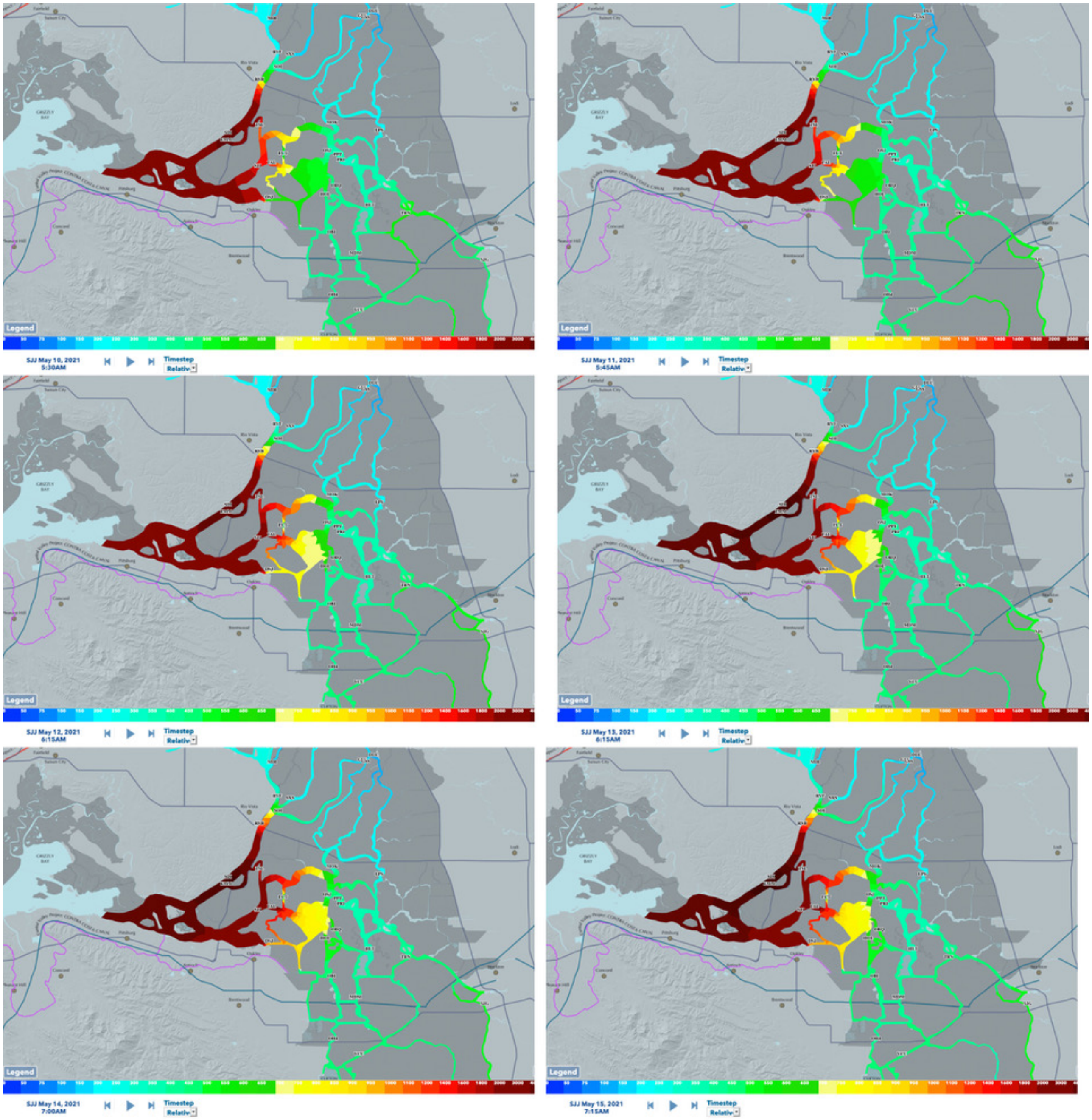
Now, if we assume the tidal currents in the Delta are well represented by the M2 tide, P=12.42 hrs, t_1 = 6.21 hrs, or , $\omega = 1.404x10^{-4} rad/s$, and the peak currents are in cm/s, the tidal excursion is

$$L_{ex}(km) = 0.1424 * U(cm/s) \quad \text{(A.5)}$$

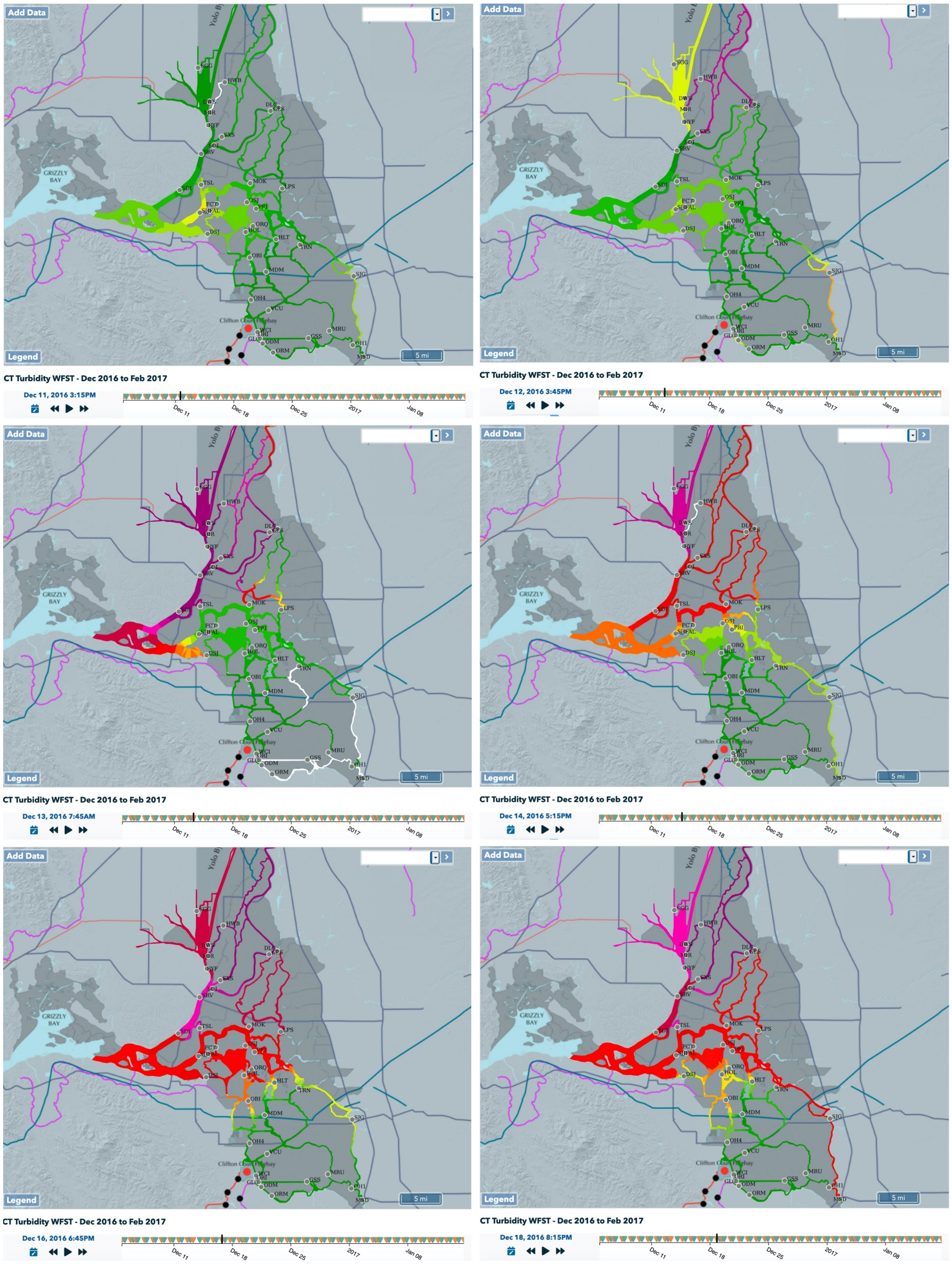
L_{ex}(mi) = 2.6969*U(ft/s) (A

Appendix B: Use Cases

EC intrusion into Franks Track on the Max Flood Tide. May 10, 2021 to May 15, 2021

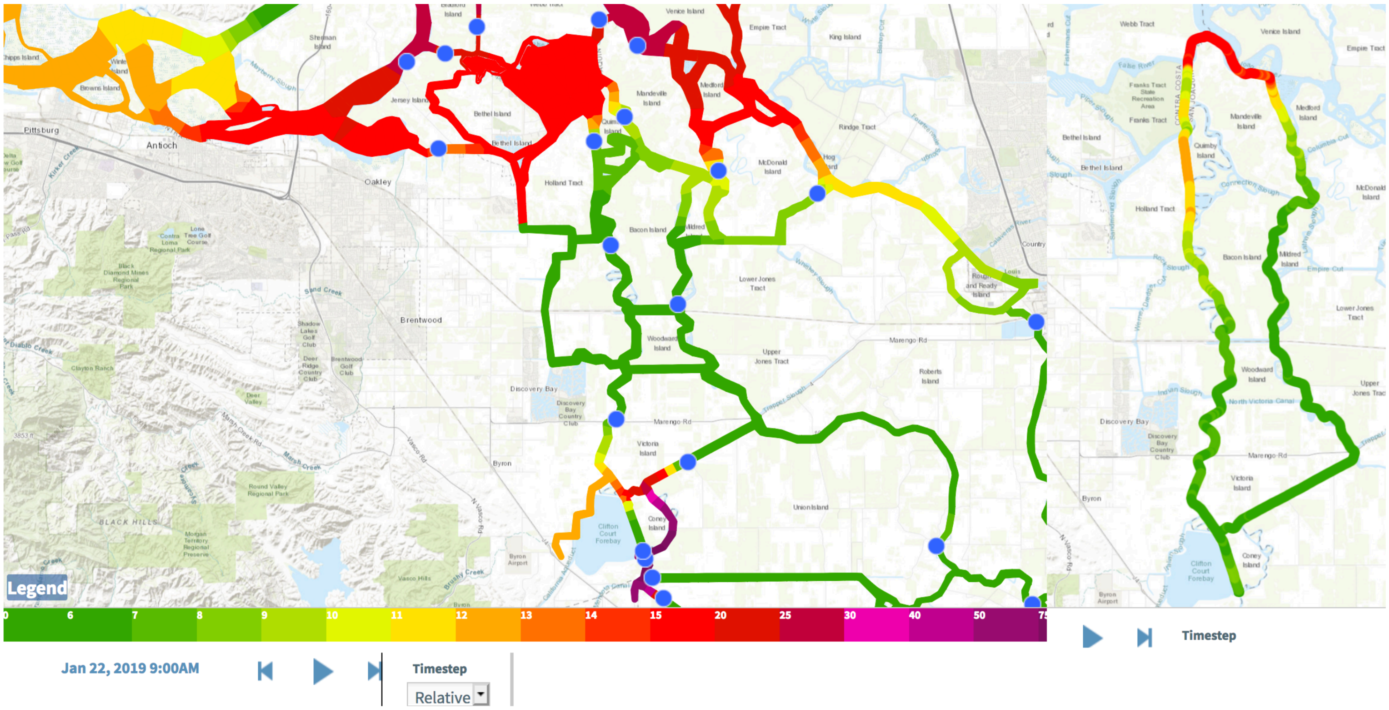


Turbidity First Flush 2016



First Flush December 2016: CT – Turbidity at slack after Max Flood

DWR Transect with Particle Tracking



Constituent Tracker: Jan 22 9:00 am

DWR Transects: 1/22

Appendix C: References and Guiding Documents

DeGeorge, John; Andrews, Steve. 2011. User Information for 34 North Polygon Weighting Program. Resource Management Associates. https://www.baydeltalive.com/docs/24407

The Delta. California Department of Water Resources. https://water.ca.gov/Water-Basics/The-Delta

The napkin