An Overview of Delta Hydrodynamics and Transport

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Workshop on the State of the Science on Fish Predation on Salmonids in the Bay-Delta
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How the Delta Works

- Primary Mechanisms
  - Net Flow
  - Tidal Mixing
  - Gravitational Circulation
- Managing Salt Accumulation over the Dry Season
- Water Exports Affect Water Source Distribution
- Some Residence Time Results
California Central Valley River Systems
Commonly Available Data

- Stage
- Flow
- Salinity (EC)
- Turbidity
- Sediment Concentration
- Temperature

What to Look For

- Important net-flow splits (e.g., Sac. River to Delta Cross Channel)
- Gate/barrier operations (e.g., Clifton Court Gates)
- Delta Island Consumptive Use
- Delta Exports
- Low flow, high flow, and transition periods
- The yearly cycle of salt intrusion and flushing
- Spring-neap tidal variation
Observed versus Computed...
What can you see in the wiggly lines?

Example plots from RMA Model Calibration, Water Year 2002
Observed versus Computed...
What can you see in the wiggly lines?

- Tide Phase and Amplitude
- Stage
- Spring-Neap Cycle
- Regional effect of Clifton Court Operation
- Flow
- Effect of Exports on net Flow
- Rate of salt intrusion

Example plots from RMA Model Calibration, Water Year 2002
Figure Credit: Peter E. Smith, USGS, ret., Effects of Turbidity and Hydrodynamics on Distributions of Delta Smelt, 2012 CWEMF Annual Meeting
Tidal and Net Flow

Demonstration of increasing river inflows to bring the net Delta outflow from 2,000 to 100,000 cfs with typical summer exports (not an historic condition)

- Tidal flows dominate the Western Delta
- Net transport of fresh water from north to south typical of summer and fall operation
- As Sacramento Inflow increases, more of the North Delta becomes riverine
- As San Joaquin flow increases the net flows change from south to north in the southern Delta

Animation created by Resource Management Associates, using RMA Model results
River and Estuary

Particles released hourly near Sacramento during a low flow period with the Delta Cross Channel open

- Riverine flow in the Sacramento River down to the Cross Channel
- Some particles pushed in to the Cross Channel and Georgiana Slough primarily on flood tide
- Once particles reach the Rio Vista on the Sacramento River and San Andreas on the San Joaquin River the motion is dominated by tidal flows

Animation created by Resource Management Associates, using RMA Model results
Out-migrant Salmon Tracks
Observations from radio-tagged salmon release

Excursion and Mixing

Groups of Particles released at two locations on the lower Sacramento River near the center of the channel

- Tidal Excursion is on the order of 6 to 9 miles(!) in this area of the Delta
- The water velocity varies vertically and laterally in a channel
- Turbulent mixing causes a group of particles released at one location experience slightly different velocities causing the group to spread over time

Animation created by Resource Management Associates, using RMA Model results
Excursion and Mixing

Particles released hourly at two cross sections of the lower Sacramento River and stopping after traveling for one tidal cycle

- The distribution of particles after traveling for one tidal cycle (~24.75 hours) illustrates the impact of tidal mixing, one of the key processes that brings ocean salinity into the Delta
Salinity
Mixing in the Central Delta during a typical low flow period

- Fresh water moves from north to south drawn by the south Delta exports and in-Delta demand
- Sacramento River water moves through Threemile Slough to the San Joaquin on flood tide
- Tidal flows move higher salinity water from the lower San Joaquin to False River where it is drawn into Franks Tract

Animation created by Resource Management Associates, using RMA Model results
Salt water is heavier than fresh water and will tend to push upstream under the fresh water outflow creating vertical stratification.

Energy from tides and riverine flow can overcome stratification.

The balance of net Delta outflow, tidal mixing, and gravitational circulation controls the intrusion of ocean salt into the Delta.

Animation created by Edward Gross using TRIM3D results
Sacramento River water drawn into the south Delta by exports

San Joaquin River inflow typically higher in salt than other tributary inflows

Salt from the ocean boundary moves slowly eastward over the summer and fall period

Salinity
Tidally averaged Delta salinity distribution (as Electrical Conductivity), 2002 Historic Conditions

Animation created by Resource Management Associates, using RMA Model results
Source Water Fingerprinting
Illustration of the impact of south Delta Exports on the distribution of source water (not an historic condition)

- River inflow held constant while south Delta exports increased from 0 to maximum pumping (lowest net Delta outflow ~3000 cfs)
- With increasing exports
  - Most of San Joaquin and Mokelumne flows taken in by exports
  - Sacramento Water drawn down Old and Middle River
  - Seawater drawn farther into western Delta

Animation created by Resource Management Associates, using RMA Model results
Exposure

Amount of time water has been in the Delta (between River inflow locations and Martinez), Historic 2003 conditions

- Exposure time is lowest in the riverine areas of the Delta
- The longest exposure times occur in dead end sloughs
- Exposure time in western Delta is low during periods of high net Delta outflow and increases significantly through the summer and fall
- Exposure time in the south Delta is mitigated by south Delta exports

Animation created by Resource Management Associates, using RMA Model results
Tracer loading in Liberty Island increases concentration by 1 unit per day, which can be interpreted as the exposure time to Liberty Island.

Outside of Liberty Island, the tracer indicates the region influenced by processes occurring in Liberty Island.

This approach is just one of many analysis techniques related to residence time and influence of discrete regions of the Delta.
Questions?
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