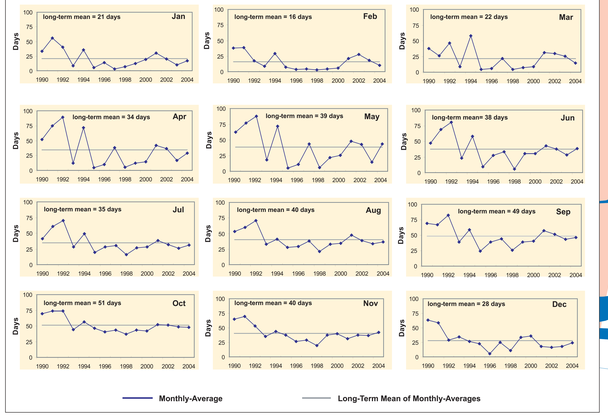
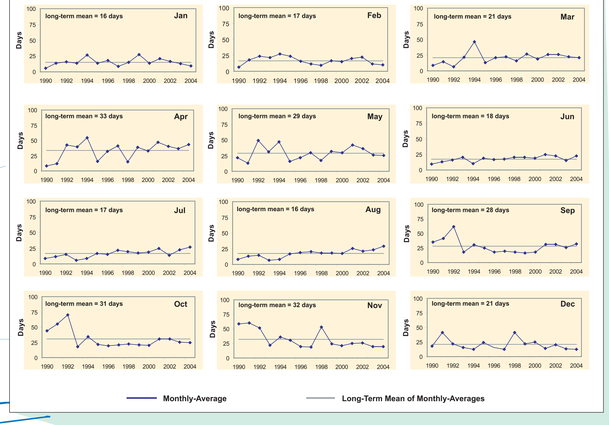
Long-Term Trends of Delta Residence Time

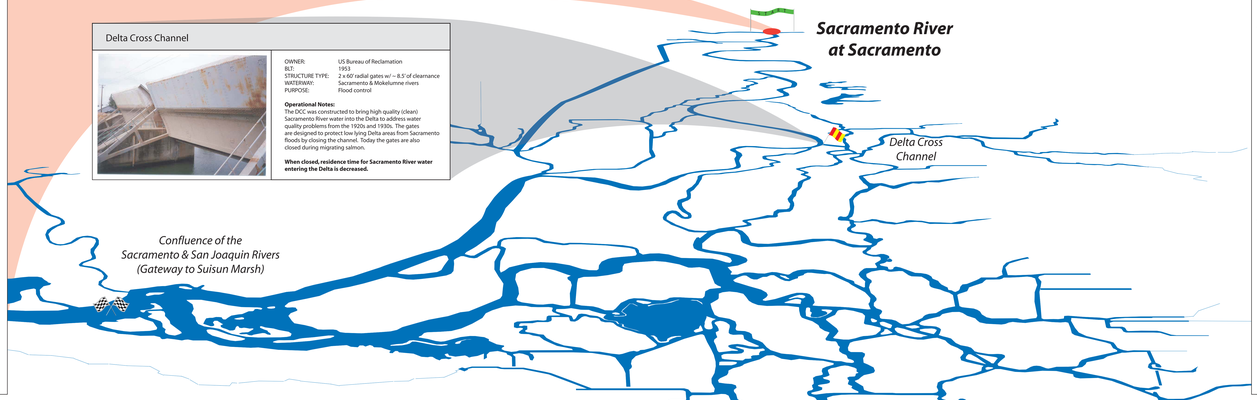
California Department of Water Resources Bay-Delta Office Modeling Support Branch Delta Modeling Section

Monthly-Average and Long-Term Monthly-Average Residence Time Indexes for injections at Sacramento on the Sacramento River



Monthly-Average and Long-Term Monthly-Average Residence Time Indexes for injections at Vernalis on the San Joaquin River





Delta Cross Channel

OWNER: US Bureau of Reclamation
BLT: 1953
STRUCTURE TYPE: 2 x 60' radial gates w/ ~ 8.5' of clearance
WATERWAY: Sacramento & Mokelumne rivers
PURPOSE: Flood control

Operational Notes:
The DCC was constructed to bring high quality (clean) Sacramento River water into the Delta to address water quality problems from the 1920s and 1930s. The gates are designed to protect low lying Delta areas from Sacramento floods by closing the channel. Today the gates are also closed during migrating salmon.

When closed, residence time for Sacramento River water entering the Delta is decreased.

Residence Time in a Tidal Estuary

Travel Time vs. Residence Time

Travel Time is the time it takes for an object or parcel of water to move from one location ( ) to another location ( ). It is usually based on a single path of travel, and calculated using the average velocity of a river. *Travel Time* is a good measure for rivers and streams that are primarily influenced by upstream flows. However, in a tidal estuary such as the Sacramento-San Joaquin Delta, the diurnal tide (/) and complex maze of water bodies make travel time difficult to calculate.

Residence Time is very similar to *Travel Time*, but as its name implies it is a measure of how long a group of objects, such as fish eggs or fish food, are resident to a defined region. It is a good measure of the length of time objects stay in an estuary, because it accounts for influences such as the:

- Dynamic hydrologic interaction river inflows to and human diversions from the estuary,
- Influence of ocean tides,
- Operation of man-made structures such gates and barriers, &
- Extreme events such as floods and levee failure.

Instead of focusing on a single path, *Residence Time* accounts for the multiple paths objects may take through an estuary and all of the influences on objects based on these multiple paths. Objects starting at the same location, may exit the estuary at many different locations. As the inflows from the rivers and human diversions from the estuary change from season to season, these paths and the *Residence Time* associated with these paths will also change. Sudden hydrologic changes can result in dramatic changes in *Residence Time*.

Influence of Structures

Man-made structures ( ) will further alter the rate of travel of the objects. In the Sacramento-San Joaquin Delta, gates and barriers such as the Delta Cross Channel or Head of Old River Fish Protection Barrier may block the passage of objects or parcels of water, and thus directly influence *Residence Time*. Even if an object would not normally pass near such a structure, it may still indirectly influence the path objects take while traveling through an estuary.

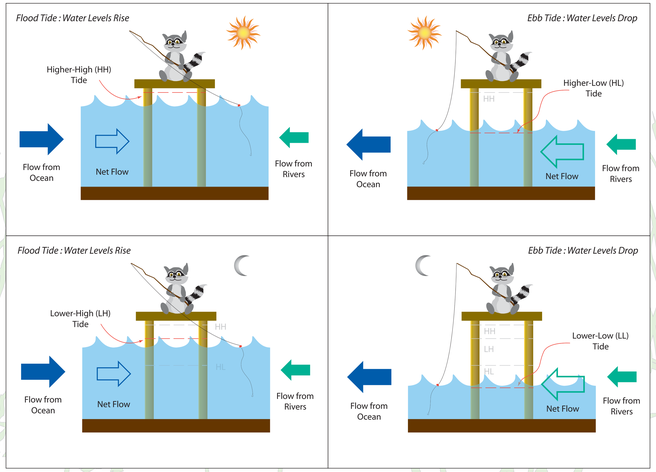
Extreme Events

High outflow conditions associated with flood events will quickly push objects through the estuary. However, in the case of a levee failure objects may surf along flood waters to the point of the levee break, thus even in high flow conditions particles take very different paths before leaving the estuary.

Importance of Tides

In low flow conditions, the daily influence of the diurnal tides will slow down the *Residence Time* of objects. Twice a day ocean water forces its way inland in what is called a *flood tide*. A *flood tide* is the period when the water levels in the estuary are rising because the ocean is literally filling the estuary. Velocities in the estuary tend to slow down and reverse during *flood tides*, sending objects further inland. This process is reversed during an *ebb tide*, and water levels in the estuary will drop as the ocean is now helping to drain the estuary. Objects that were pushed inland during the *flood tide* will now surf the *ebb tide* out to the ocean. Though this process continues approximately twice each day, daily net flow tends to be towards the ocean, and thus objects that did not exit the estuary via a diversion, will eventually make it to sea.

Basic Tide Terminology (Flood vs. Ebb, High vs. Low)



Residence Time Trends

Daily indexes of the residence time associated with parcels of water tracked from the San Joaquin River at Vernalis and the Sacramento River at Sacramento through the entire Delta were used by the interagency, multidisciplinary Pelagic Organism Decline (POD) teams in order to investigate the following question:

Was there a change in hydrodynamic trends in the Delta corresponding with the 2002 POD?

If there was a change, then it was theorized that the monthly-average residence times in 2002, 2003, and 2004 associated with the two major inflows to the estuary would be significantly different than the 1990 through 2004 mean of monthly-average residence time indexes. Residence time is an important factor affecting a number of estuarine processes that may be related to the abundance of the pelagic species of concern.

The monthly-average and long-term mean residence time indexes for the San Joaquin and Sacramento rivers from 1990 through 2004 is shown above. The indexes are sorted by month and quarter. Key findings of the 1990-2004 analysis are as follows:

- Residence time indexes for the San Joaquin and Sacramento rivers were not significantly lower in recent years (2002 - 2004) compared to the longer period mean.
- Sacramento River residence time tended to be higher in the early 1990s (drier years).
- San Joaquin River residence time tended to be higher in the late fall / early winter months in the early 1990s.
- Late summer and early fall tended to have higher residence times.
- Late winter tended to have lower residence times.
- Spring has the greatest variability in residence time.

Head of Old River Fish Protection Barrier

OWNER: CA Dept. of Water Resources
BLT: 1963
STRUCTURE TYPE: rock barrier w/ screened culverts
WATERWAY: San Joaquin & Old rivers
PURPOSE: Fish protection

Operational Notes:
The original Head of Old River Barrier was a rock barge that was submerged at the head of the Old River on the San Joaquin River in fall of 1963 and 1964. It was hoped that the barge would prevent migrating salmon from swimming down the Old River. In 1968, a larger rock barrier was built in front of the sukan barge site. The temporary barrier was not built when flows on the San Joaquin River were high. Starting in 1992 rock was also placed at the flow split in the spring of some years.

The exact configuration of the barrier has changed over the years. More recent configurations include a series of screened culverts that are designed to allow some flow to pass through the barrier, but to prevent fish from traveling down the Old River.

When in place, residence time for San Joaquin River water entering the Delta is increased.

This poster was prepared by Michael Mierzwa with assistance from Jim Wilde and Bob Suits, Delta Modeling Section, DWR
For information on DSM2 and PTM tools:
http://modeling.water.ca.gov
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