Measurement Of Tidal Flows In The Sacramento-San Joaquin Delta, California

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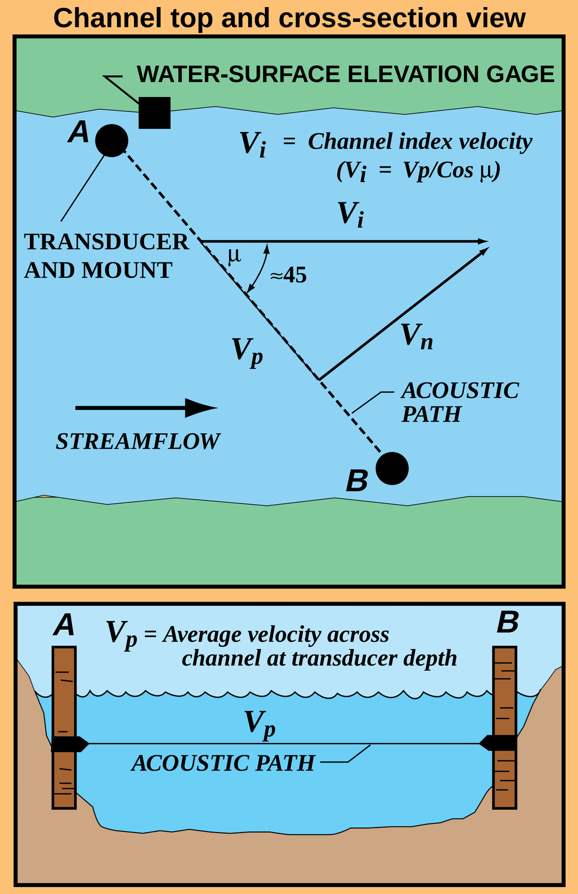
BACKGROUND

The Sacramento-San Joaquin Delta is the hub of the State of California's water supply and distribution system. Runoff is captured in the northern part of the State and later released and transported though the Delta to State and Federal export facilities located at the southern boundary of the Delta near Tracy. The water is then pumped into the California Aqueduct and Delta-Mendota Canal for use south of the Delta, including the Los Angeles area. The exportation of water from the Delta is thought to have created several problems within the estuary, primarily with regard to declining fish populations and degradation of water quality; the drinking water supply for 20 million Californians passes through the Delta. To solve these problems, a knowledge of the hydrodynamics of the Delta is required. There has been a lack of measured flow data thoughout the Delta because the flows are very dynamic due to tides that propagate from San Francisco Bay. Over the last several years, the U.S. Geological Survey (USGS) has been using acoustic technology to measure the flows in the Delta. Measured flow data are needed:

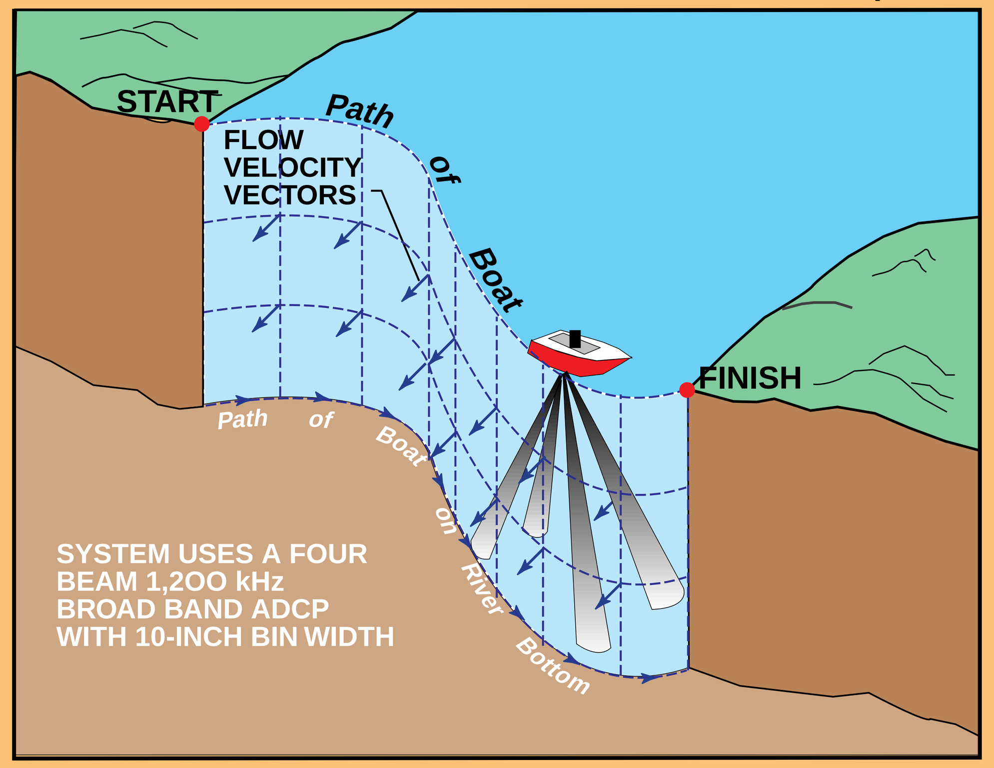
1. to gain an understanding of the hydrodynamics of the Delta,
2. to determine the quantity of water flowing from the Delta into San Francisco Bay (commonly referred to as Delta outflow), and
3. to calibrate and validate flow and transport models of the Delta.

ACOUSTIC TECHNOLOGY BEING USED TO MEASURE DELTA FLOWS

ULTRASONIC VELOCITY METER STATION
Channel top and cross-section view



ACOUSTIC DOPPLER DISCHARGE MEASURING SYSTEM (ADDMS)



Ultrasonic velocity meter (UVM): A UVM (Laenen, 1985) transmits acoustic pulses back and forth across a channel and precisely measures the travel time of each pulse. The difference in travel time between a pair of back and forth pulses provides an average velocity (V_P) across the channel at the depth of the transducers. The measured velocity (V_P) is not an average cross-sectional velocity and is referred to as an "index velocity" (V_I) that is used when processing the data to determine an average cross-sectional velocity.

Acoustic Doppler current profiler (ADCP): An ADCP based portable flow measuring system is used to make fast and accurate flow measurements of a channel for use in calibrating a UVM . Velocity and depth are measured and the flow computed as the ADCP traverses the channel. Flow measurements of 600-foot wide channels can be made in 2 to 3 minutes with an accuracy of 2% (Simpson and Oltmann, 1993) using only a two-man crew.

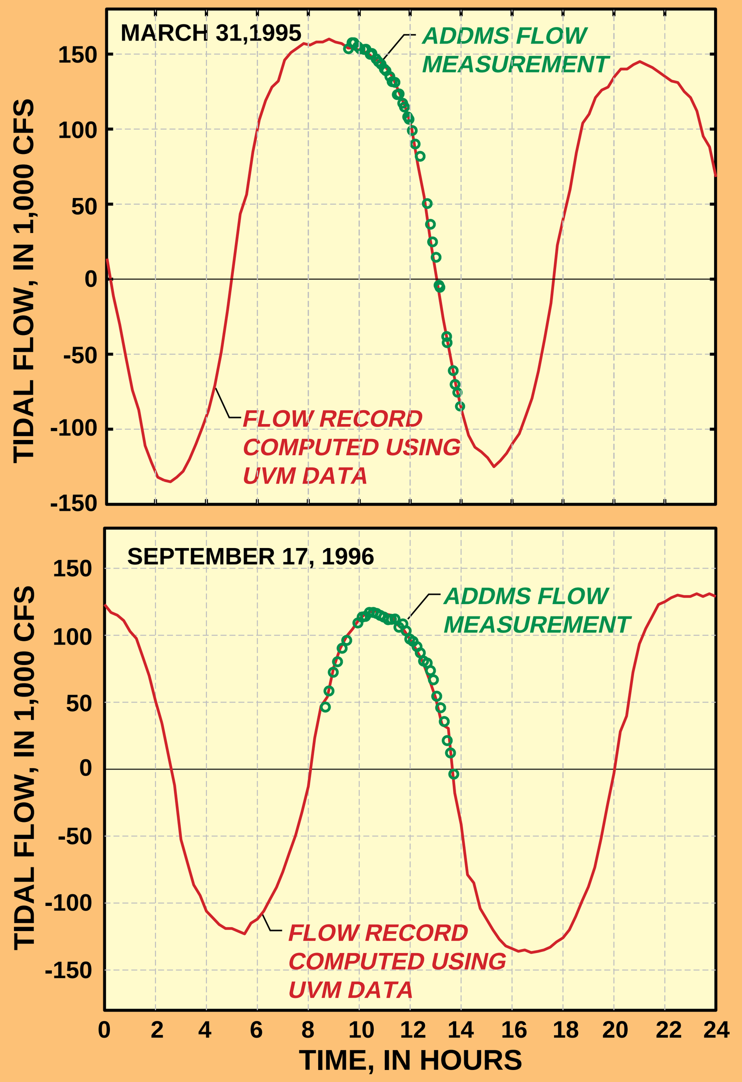
A 15-minute interval UVM tidal flow record is computed by multiplying channel cross-sectional area by average channel cross-sectional velocity. Water-surface elevation is measured at the UVM station and converted to channel cross-sectional area by a relation defined from channel geometry surveys. Average channel cross-sectional velocities are determined from ADDMS measurements and are used to define a UVM index-velocity and average channel cross-sectional velocity relation.

ULTRASONIC VELOCITY METER STATIONS IN THE DELTA

SACRAMENTO-SAN JOAQUIN DELTA

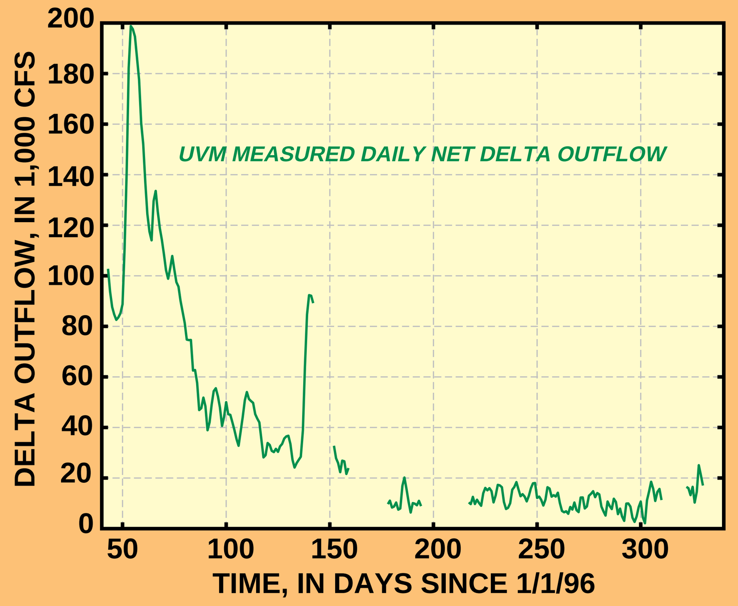
Each red dot on the UVM site map shows the location of a UVM flow-monitoring station. Sites were chosen to monitor critical flow splits or quantities. For example, an indirect measure of flow through the Delta Cross Channel (DCC) and Georgiana Slough is obtained by taking the difference of the flow records for sites 2 and 3. Also, an indirect measure of Delta outflow is being computed by combining the flows for sites 4, 5, 6, and 7. Sites 8 and 9 monitor the effects of the exportation of water from the south Delta by State and Federal water projects. A widely distributed network of site locations was also desired for use in model calibration and validation.

Site Number	Site Name	Start Date Of Data Collection
1	Sacramento River At Freeport	October 1979
2	Sacramento River Upstream of Delta Cross Channel	December 1992
3	Sacramento River Downstream of Georgiana Slough	January 1993
4	Sacramento River At Rio Vista	April 1995
5	Threemile Slough	February 1994
6	San Joaquin River At Jersey Point	May 1994
7	Dutch Slough	February 1996
8	Old River At Bacon Island	January 1987
9	Middle River At Bacon Island	January 1987
10	San Joaquin River At Stockton	August 1995



Tidal-flow hydrographs for the UVM flow-monitoring site on the San Joaquin River at Jersey Point (site 6) and several ADDMS flow measurements are shown in the above plots. Note the large range in the tidal flow throughout the day which is typical of flows throughout the Delta.

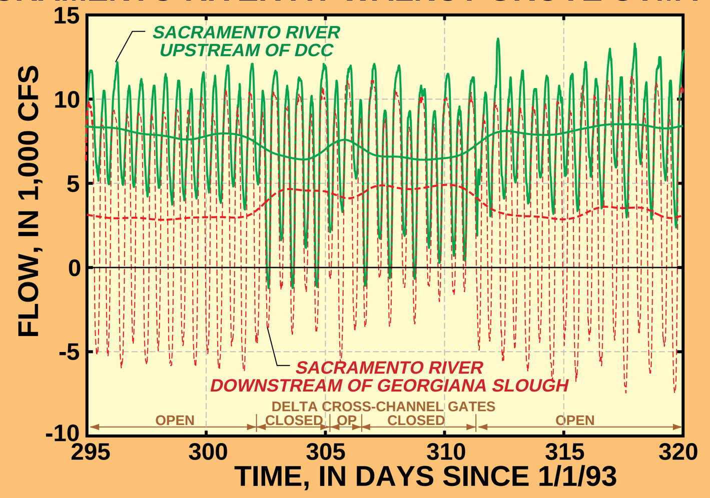
MEASUREMENT OF DELTA OUTFLOW



A measure of daily net flow from the Delta into Suisun Bay is a quantity those studying the Bay and Delta have been seeking since the 1920's. Since February 1996, an indirect measure of daily net Delta outflow has been obtained (shown in plot above) by combining the UVM measured flows for sites 4, 5, 6, and 7. Delta outflow estimates have been previously calculated using a flow mass-balance approach which uses an imprecise estimate of Delta consumptive use, and does not account for the effects of the filling and draining of the Delta due to the spring-neap tidal cycle nor atmospheric pressure effects which can be significant.

EFFECTS OF DELTA CROSS-CHANNEL GATE OPERATION ON FLOWS IN THE VICINITY OF WALNUT GROVE

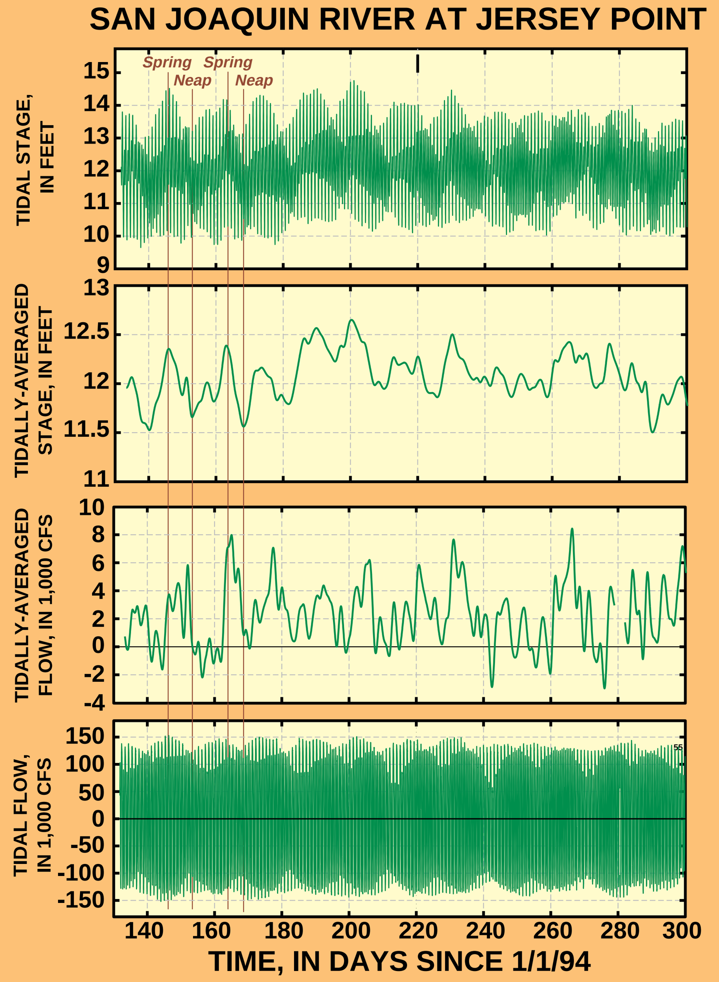
SACRAMENTO RIVER AT WALNUT GROVE UVM FLOWS



The above plot shows tidal and tidally-averaged UVM flow data for the Sacramento River upstream of Delta Cross Channel (DCC) (site 2), the Sacramento River downstream of Georgiana Slough (site 3), and the status of the DCC gates. Notice the dramatic effect that closure of the gates has on the magnitude of the tidal and tidally-averaged flows at both sites. The net flow at the upstream site decreases by about 2,000 cfs which results in an increase in the combined flow down Sutter and Streamboat Sloughs of about 2,000 cfs.

FILLING AND DRAINING OF DELTA DURING SPRING-NEAP TIDAL CYCLE

SAN JOAQUIN RIVER AT JERSEY POINT



The top two plots show tidal and tidally-averaged water-surface elevation (stage) data for the San Joaquin River at Jersey Point (site 6). These plots clearly demonstrate that the net elevation of the Delta rises and falls during the spring-neap tidal cycle. The bottom two plots show tidally-averaged and tidal UVM flow data. These flow data demonstrate how the Delta fills and drains during the spring-neap tidal cycle.

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REFERENCES:

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Simpson, M.R., and Oltmann, R.N., 1993, Discharge measurement using an acoustic Doppler current profiler: U.S. Geological Survey Water-Supply Paper 2395, 34 p.