EVALUATING THE MEASURED EFFECTS OF OUTFLOW ON SAN FRANCISCO ESTUARY SALINITY IN WATER YEAR 2011

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ABSTRACT

There is a wealth of available data for evaluating salinity in the San Francisco Estuary. Data collected in the Delta and San Francisco Bay during water year 2011 were evaluated to better understand the effects of outflow on seawater intrusion. Water year 2011 was selected because Delta outflow varied widely from approximately 2,500 to 200,000 cfs. Geophysical conductivity (EC), flow elevation, and velocity data collected every 15 minutes at multiple locations, as well as USGS boat survey data, were integrated and evaluated. The data show how salinity varies longitudinally and vertically through the SF Estuary, as well as how the salinity gradients vary in response to tidal flow and net outflow. At any given location, the daily range of EC values caused by tidal excursion is much greater than vertical stratification. Delta outflow is the primary control for seawater intrusion. Other factors such as tidal strength and gravitational circulation play a secondary role. Effective outflows determined by COE also were used to evaluate the daily EC at each monitoring location and to estimate the daily EC variation more accurately than the daily EC range.

INTRODUCTION

Organisms in the San Francisco Estuary are adapted to a wide range of salinity. However, there is concern that landward movement of the salinity gradient could affect many populations. In addition, seawater intrusion can reduce water quality for agriculture and drinking water. As a result, salinity in the estuary and Delta has been extensively studied, measured, and modeled. The purpose of this study was to use the data for one recent wet water year (2011) with extensive data measurements could reveal about salinity patterns and the relationship between Delta outflow and salinity without relying on modeling.

METHODS

Data collected by the USGS, DWR, and USBR in the Delta and San Francisco Bay during water year 2011 were downloaded from USGS, DAYFLOW, and USGS web sites. Data sets were interpolated every 15 minutes from measurements, and evaluated to better understand the effects of outflow on salinity gradients and seawater intrusion. Geophysical conductivity (EC) at surface and near bottom, flow elevation, and velocity data collected at multiple locations, as well as USGS monthly boat survey data were integrated and evaluated.

RESULTS

EC data collected every fifteen minutes are available for many locations in the SF Estuary. The graph below shows data from Suisun Bay.

Daily EC fluctuations are caused by tidal movement, and seasonal EC variations are caused by changes in Delta outflow. High Delta outflow affects EC throughout the SF Estuary.

Minimum and maximum EC at a station are controlled by the tidal movement of the salinity gradient. The daily range of EC values at a location is much greater than the vertical EC stratification.

Delta outflow, the primary control for estuary salinity, is estimated from a flow balance (DAYFLOW) or can be estimated with USGS tidal flow data. Tidal elevations also affect seawater intrusion.

Effective or antecedent outflow (G) as described by CCW was used to estimate the daily surface EC at 15 monitoring locations using negative exponential equations of the form: EC = ECmin + [ECmax - ECmin] * [1 - exp(-coefficient * G)]

The negative exponential equation at Martinez matches the measured daily average surface EC values. The near-bottom EC is higher than the surface EC.

The X2 measurements match the steady-state X2 equation. The yellow dots below are derived from the negative exponential equations described to the left. They represent the effective outflow that corresponds to a surface EC of 0.640 µScm (X2) at each location.

Daily X2, the distance between the Golden Gate and the location of 2 ppm average near-bottom salinity, is calculated in DAYFLOW using an equation that depends on the value for the prior day. The calculated X2 logs the measured X2 response to increased or decreased outflow. The X2 estimate using effective outflow in the steady-state X2 equation is more accurate.

The X2 measurements match the steady-state X2 equation. The yellow dots below are derived from the negative exponential equations described to the left. They represent the effective outflow that corresponds to a surface EC of 0.640 µScm (X2) at each location.

Conclusions

Effective Delta outflow is the primary control for estuary salinity gradients and seawater intrusion. Other factors such as geometry, land movement, and gravitational circulation (vertical EC stratification) play a secondary role. Effective outflow determined by the COE also were used to evaluate the daily EC at each monitoring location and to estimate the daily EC variation more accurately than the daily EC range. Adding a term to represent the high tide (the spring-neap tidal cycle) improves the calculated EC values. This term was a function of the measured difference between the daily maximum stage and 28-day moving average stage at Jersey Point.

Outflow-X2 Relationships

Outflow-EC Relationships

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