Monitoring Flow at the Sacramento Deep Water Ship Channel

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Acknowledgments

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- **Data Scientists:** DWR-Central District, Dave Huston, and Karen Lam Fat Chong Him
Two Talks

- Part 1: Ship Channel Flow Investigation
- Part 2: Current Events in DWR Flow Monitoring
  - New Monitoring Stations
  - Increased Accuracy
  - Increased Safety
  - Improved Telemetry and Data Storage
Summary

Purpose: A fish migration study needed flow monitoring at the Sacramento Deep Water Ship Channel.

Two flow estimation approaches were evaluated.

1. Velocity Index Method (Acoustic Doppler)
2. Orifice + Vertical Slot Equations (Acoustic Doppler Calibration)
Study Purpose – Fish Migration

San Francisco Bay
San Pablo Bay
Stockton
Sacramento
San Joaquin River
Consumnes River
Mokelumne River
Calaveras River
Stanislaus River
Tuolumne

Thru-Δ
Ship Channel

Exports

Tides

Map showing fish migration pathways through the Sacramento and San Joaquin river systems, including the Thru-Δ and Ship Channel. Major rivers indicated include the Sacramento River, Consumnes River, Mokelumne River, and Calaveras River.
William G. Stone Ship Locks

- Large Ship Bay - 640’ x 86’
- Decommissioned in mid 1980’s and de-authorized in 2000
- Reactivated for fish passage study in 2003 and 2004
- Currently non-operational
1. Upstream Side of Sacramento Gate + Lock Operation

- Boat Moves in as Gate Opens
- Gate Closes
- Ships Channel Gate
- Water Equalizes
- Boats Moves Out as Gate Opens
- It Leaks

Sacramento River and the Gate
2. Downstream Side of Sacramento Gates + Unintended Flow Paths
2. Center Gap in the Sacramento River Gate @ High Flow

Delta H = 5 ft
(January 2006)
3. Downstream Side of Ship
Channel Gate @ Low Flow

Velocity Contour Plot

Depth
0 ft 18 ft 86 ft
Distance
0.00 0.25 0.50 ft/s
Index Velocity Approach

\[ Q = V_{\text{average}} \times A \]
Head Difference Approach

- Orifice Equation (Eq. 1)
  \[ Q = AK \sqrt{2g\Delta h} \]

- Simplified to
  \[ Q = AK \sqrt{\Delta h} \]

where,

- \( A = \text{area} = 1' \times \text{stage} \)
- \( K = 2.5 \) (from boat measured flow)
- \( \Delta h = \text{head difference} \)
- \( \Delta h = \text{Sacramento River Elevation} - \text{Ship Channel Elevation} \)
Translation of Known Elevation Data

San Francisco Bay
San Pablo Bay
Sacramento River
American River
Consumnes River
Mokelumne River
Calaveras River
Stanislaus River
Tuolumne River
San Joaquin River
Sacramento
RVB
IST
locks

San Francisco Bay
San Pablo Bay
Stage data for Eq. 1 required

General linear regression equation used:

\[ y = 1.22x - 2.2 \]

where,

\[ y = \text{stage at boat lock} \]
\[ x = \text{stage at RVB} \]
\[ 2.2 = \text{empirical number created to make the stage at the boat lock and IST equivalent at zero flow} \]
Fish Ladder Flow Equation

- Vertical Slot Equation (Eq. 2\textsuperscript{1})

\[ Q = \alpha \left( \frac{y_0}{b_0} \right) - \gamma, \]

where,
\[ \alpha \ & \gamma = 3.77 \ & \ -20 \]
\[ y_0 = \text{water depth} \]
\[ b_0 = \text{slot width} = 1 \text{ foot} \]

Predictions of Measured Flow: water elevation based

<table>
<thead>
<tr>
<th>Time</th>
<th>Flow (cfs)</th>
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<tbody>
<tr>
<td>May 21, 2003</td>
<td>150.0</td>
</tr>
<tr>
<td>July 25, 2003</td>
<td>100.0</td>
</tr>
<tr>
<td>Nov. 25, 2003</td>
<td>-50.0</td>
</tr>
<tr>
<td>Aug. 9, 2005</td>
<td>0.0</td>
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</table>

- **Measured Flow**
- **Vertical Slot**
  - 3:1
  - 1:1
- **Orifice**
Prediction of Measured Flow

Recipe for success:
3 parts vertical slot equation
1 part orifice equation
Gate Operation Events & 2003 -2004 Flow Data

- Measured flow
- Calculated flow
- Gate openings

Date/Time:
- 12/10/2002 0:00
- 3/20/2003 0:00
- 6/28/2003 0:00
- 10/6/2003 0:00
- 1/14/2004 0:00
- 4/23/2004 0:00
- 8/1/2004 0:00
Part 1 Conclusions

- Velocity Index Method was not judged appropriate for the velocities observed during the period of record.

- Water Surface Difference Method provided a reasonable fit of observed data.

- Recommendation: Future studies should include a stage monitoring at the Port of Sacramento.
Intermission
Part 2.

Current Events in DWR Flow Monitoring
Expanding Flow Monitoring Network

- San Joaquin River at Mossdale
- San Joaquin River at Lathrop
- Old River at Head
- Clifton Court Intake Group
- Montezuma Slough at the Salinity Gates
- West Grantline Canal at Permanent Barrier Site
- San Joaquin River at Rough and Ready Island
- Knights Landing Ridge Cut
- Middle River at Undine Road
Data Base and Telemetry

- **Data Base and Processing – Hydstra**
  - Specialized database for hydraulic and hydrologic data.
  - Improved storage, processing, and deliver of data.

- **Telemetry**
  - From GOES Satellite to Cell Modems.
  - Allows higher bandwidth and two way communications.
  - Lower cost maintenance and decreased downtime.
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