San Joaquin River
Fall-run Chinook
Salmon Population Model

“SalSim”
Management Challenges

• Ecosystem limiting factors
• RPA’s protective for salmon
• South Delta inflow objectives
• FERC instream flow objectives
• Hatchery augmentation influence
• Restore delta ecosystem concurrent with water supply reliability
• Water temperature standards
• Friant Restoration Program
Tough Questions

• What are the primary production parameters within the inland, delta, and ocean ecosystem and what are the relative influences of these parameters on salmon production?
• How can temperature goals, critical for salmon production, be implemented and still maintain the other legally recognized beneficial water uses?
• What is the natural production fraction of SJR salmon stocks for purposes of evaluating restoration efforts?
• What seasonal flow magnitude, duration and frequency for improving inland salmon production is needed now?
• What are the “pass through” benefits that accrue from releasing additional water from the tributaries as this water passes into the mainstem and through the South Delta?
• What are the various juvenile salmon life history stage to adult survival relationships?
Project Team

Active Role:
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- Ivan Mlaker
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Support Role:
- Tim Heyne
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- Richard Starfield
- Scott Fortmann-Roe
- Dr. Brian Wells
Model goals and objectives

- Develop a fishery planning tool:
  - Informs flow decisions
  - Has broad scientific community acceptance
  - Advances fishery science
    - identifying testable hypotheses & implementing new studies
    - refining existing studies & data collection
  - Has broad management utility & confidence
  - Has broad spectrum accessibility
  - Is cutting-edge: a full web-based application
  - Is fully transparent
Model Evolution

- 2005: SWRCB Periodic Review
  - Built simple salmon production model
  - Preliminary flow recommendations
- 2006: Peer review (V.1)
- 2007: Model Contracting
- 2008: Preliminary Model Refinement
  - Peer Review response
  - Intermediate models (V.1.5 & V.1.6)
- 2009: Nothing (contract funding frozen)
- 2010: Advanced Model Refinement
- 2012: Peer Review (SalSim)
- 2012: Fishery Agencies Feedback
- 2012: Update to the SWRCB
SalSim Overview

SalSim is an integrated system-wide model designed to assess fish production (salmon) response to water management strategies in the San Joaquin River Basin.

- Contains three sub-models
  - Water Operation Model
  - Water Temperature Model
  - Salmon Model

- Contains three inter-related geographical areas
  - Inland
  - Delta
  - Ocean
SalSim – Package Design

**Water Operations Model**
Define reservoir operations

**Water Temperature Model**
Water Temperature Response

**Salmon Model**
Fish Production

**System Specific Input Data**

**DSS Output File**

**GUI output**

**CSV Output Files**

**External Data Sources (optional)**

**External Models**
(CALSIM II => HEC-5Q, etc.)

**Flow & Temperature Data**
SalSim - Geographical Areas

- New Melones Reservoir
- New Don Pedro Reservoir
- Lake McClure
- Millerton Reservoir
- Mossdale
- Delta
- Stanislaus
- Tuolumne
- Inland
- San Joaquin River
- Merced
- Friant
SalSim Design

Inland Module
Stanislaus, Tuolumne, Merced, Friant, SJR

Homing Module
Stray in/out and Escapement to Stanislaus, Tuolumne, Merced, Friant

MRH Module

Delta Module
Mossdale to Chipp’s Island

Ocean Module

Escapement (observed)

Final Fitting

Escapement (Simulated)

Initial Fitting

RST Count (observed)

RST Count (Simulated)
Converts female spawners data to redds (nests). Then, on a salmon redds by reach basis, takes eggs in the redds and develops them in time and space into juveniles (alevins, fry, parr and smolts). Juvenile fish development, survival and movement within the river is tracked on a daily basis. Module output consists of the number of juveniles leaving the river to the mainstem SJR by life stage (fry, parr and smolt).

**Inland Module**
(Stanislaus, Tuolumne, Merced, Friant)

**Development and Survival Factors**
- Flow
- Water temperature
- Density dependence
- Predators areas

**Movement Factors**
- Slow, medium and fast cohorts
- Velocity and flow (including rate of change)
- Temperature
- Floodplain encroachment
Takes the juveniles leaving the individual tributaries, by life stage, and computes how many survive the journey from the confluences to Mossdale on a daily basis. Module output consists of the number of juvenile fish surviving on a daily basis between each tributary’s confluence with the SJR and the SJR at Mossdale.

**Survival and Development Factors**
- Flow
- Water temperature

**Movement Factors**
- Velocity and flow (including rate of change)
- Temperature
Juvenile Delta Module

Takes daily number of fry/parr/smolt arriving at in the SJR at Mossdale and routes them through the delta by estimating survival on a daily basis. Module output consists of number of fry/parr/smolts surviving through the delta for the entire year (daily survivors are aggregated into a yearly total).

Survival Factors
- Inflow to the Delta
- Water temperature entering Delta
- Water export
- Striped bass abundance
- HORB status (by day)
Taking the Juvenile Delta Module output (aggregated annual total number of smolts surviving to Chipp's Island) it predicts the probability of: being harvested in the sport fishery, being harvested in the commercial fishery, and escaping inland to spawn. In addition, it predicts the probability of these events occurring by age of fish (for age 2, age 3, and age 4). Module output is number of juveniles that successfully survive to adult and returned to the inland Central Valley to spawn (by age).

Aging and Survival Factors
• Sport fishing (Cal & Ore)
• Troll fishing (Cal & Ore)
• Ocean conditions (upwelling)
<table>
<thead>
<tr>
<th>Model</th>
<th>Type</th>
<th>Location &amp; Generality</th>
<th>Temporal Resolution</th>
<th>Spatial Resolution</th>
<th>Management Analysis</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>OBAN</td>
<td>Statistical life cycle</td>
<td>Sacramento Chinook Winter run version and Spring run version</td>
<td>Production season</td>
<td>Lumped inland section</td>
<td>Variety of lumped factors (incl. gravel, dam storage, exports, fish regs.)</td>
<td>Statistically rigorous</td>
<td>Lack of resolution for weekly water releases</td>
</tr>
<tr>
<td>SALMOD + WEAP</td>
<td>Detailed life cycle</td>
<td>General and adaptable to different locations</td>
<td>Daily</td>
<td>Fine</td>
<td>Implicitly linked through dependence on hydrology</td>
<td>Biologically detailed</td>
<td>Lack of statistical rigor, unsuitable for management studies, no ocean component</td>
</tr>
<tr>
<td>IOS (= JPE + DPM + Ocean)</td>
<td>Explanatory, exploratory</td>
<td>Sacramento Chinook salmon</td>
<td>Daily, degree-day</td>
<td>Fine</td>
<td>Management actions embedded</td>
<td>Biological life cycle and process oriented</td>
<td>Lack of statistical rigor</td>
</tr>
<tr>
<td>Shiraz</td>
<td>Multistage GIS-based</td>
<td>Sacramento inland production</td>
<td>Daily</td>
<td>Very fine</td>
<td>Not management oriented, but various actions implicitly</td>
<td>Explore impacts of climate change</td>
<td>Lack of statistical rigor; difficult to validate</td>
</tr>
<tr>
<td>SLAM</td>
<td>Strings modules together</td>
<td>General</td>
<td>Relatively coarse</td>
<td>Relatively coarse</td>
<td>Uncertain</td>
<td>Unsure</td>
<td>Unsure</td>
</tr>
<tr>
<td>ORCM</td>
<td>Individual-based, spatially explicit, habitat detailed, bioenergetic growth model</td>
<td>General</td>
<td>Daily</td>
<td>local feeding territories</td>
<td>Hydrology dependent, juvenile production</td>
<td>generality and biological detail</td>
<td>Inland only, many parameters</td>
</tr>
<tr>
<td>SALSIM</td>
<td>Multistage developmental and statistical movement</td>
<td>San Joaquin Fall Run Chinook. Can be refitted in other systems</td>
<td>Daily Inland, weekly Delta, seasonal ocean</td>
<td>Mile by mile inland, two regions: Delta and ocean</td>
<td>Management oriented for scenario comparisons</td>
<td>temp driven development, statistical rigorous, designed for management</td>
<td>No explicit ecology</td>
</tr>
</tbody>
</table>