Understanding juvenile salmon movements and survival in the north Delta

J.R. Burau

US Geological Survey

The "Clarksburg Bend" Pilot experiment

Team

3D tracking – USGS Columbia River Research Lab
Survival modeling – Russ Perry, John Skalski (UW)
Receiver placement, Surgery – Dave Vogel
Hydrodynamics – Jon Burau, Aaron Blake

Focus: Why we are doing what we propose

Less time on: What we are going to do

Problem: dealing with Complexity

The geometry and hydrodynamics of the north Delta is complex.

Consequently the movements and survival of juvenile salmon through the north Delta is also complex.

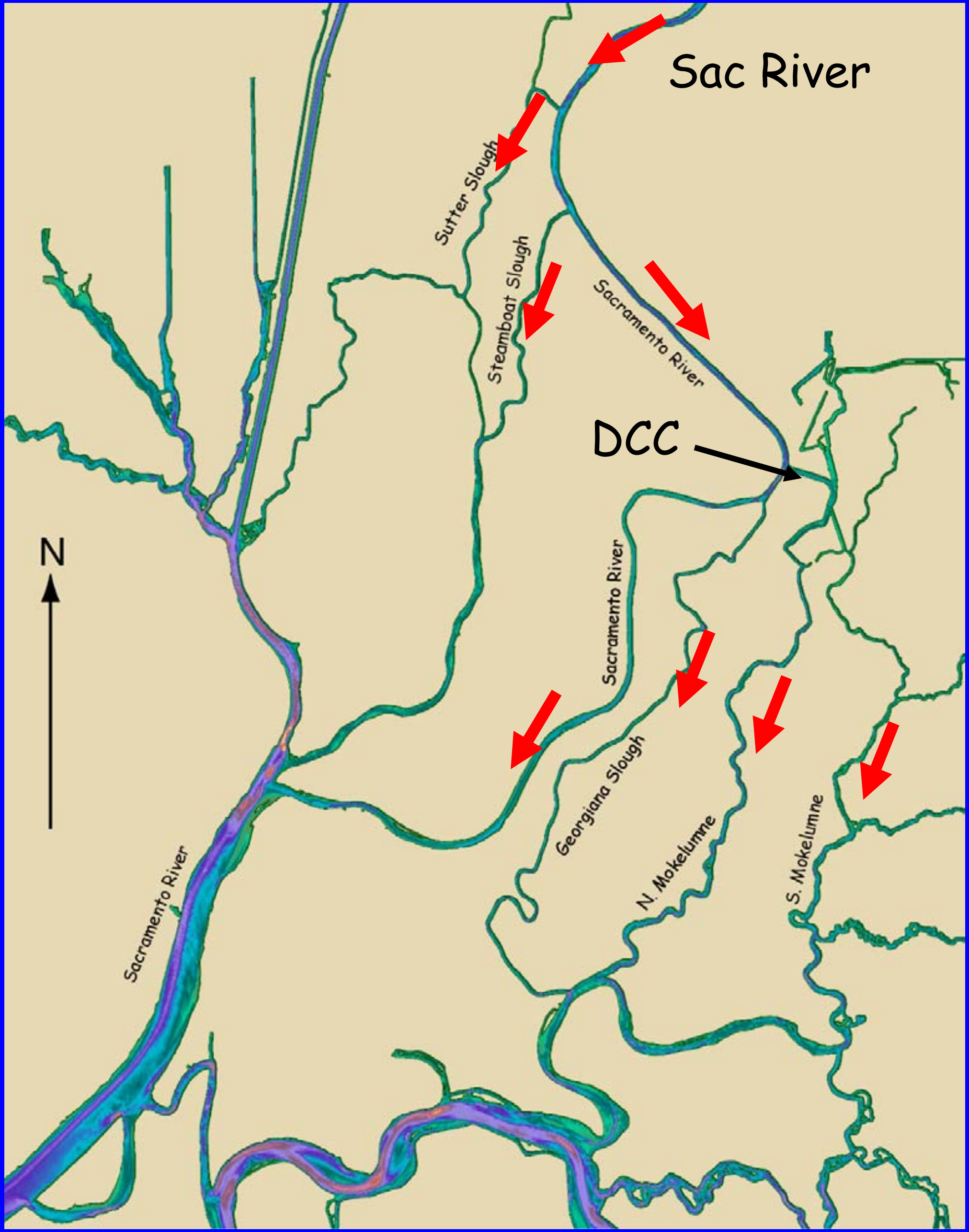
Net flow distributions

Change with:

(1) Sac River flows

(2) DCC operations

Changes in net flow splits likely affect juvenile salmon pathways and Survival?



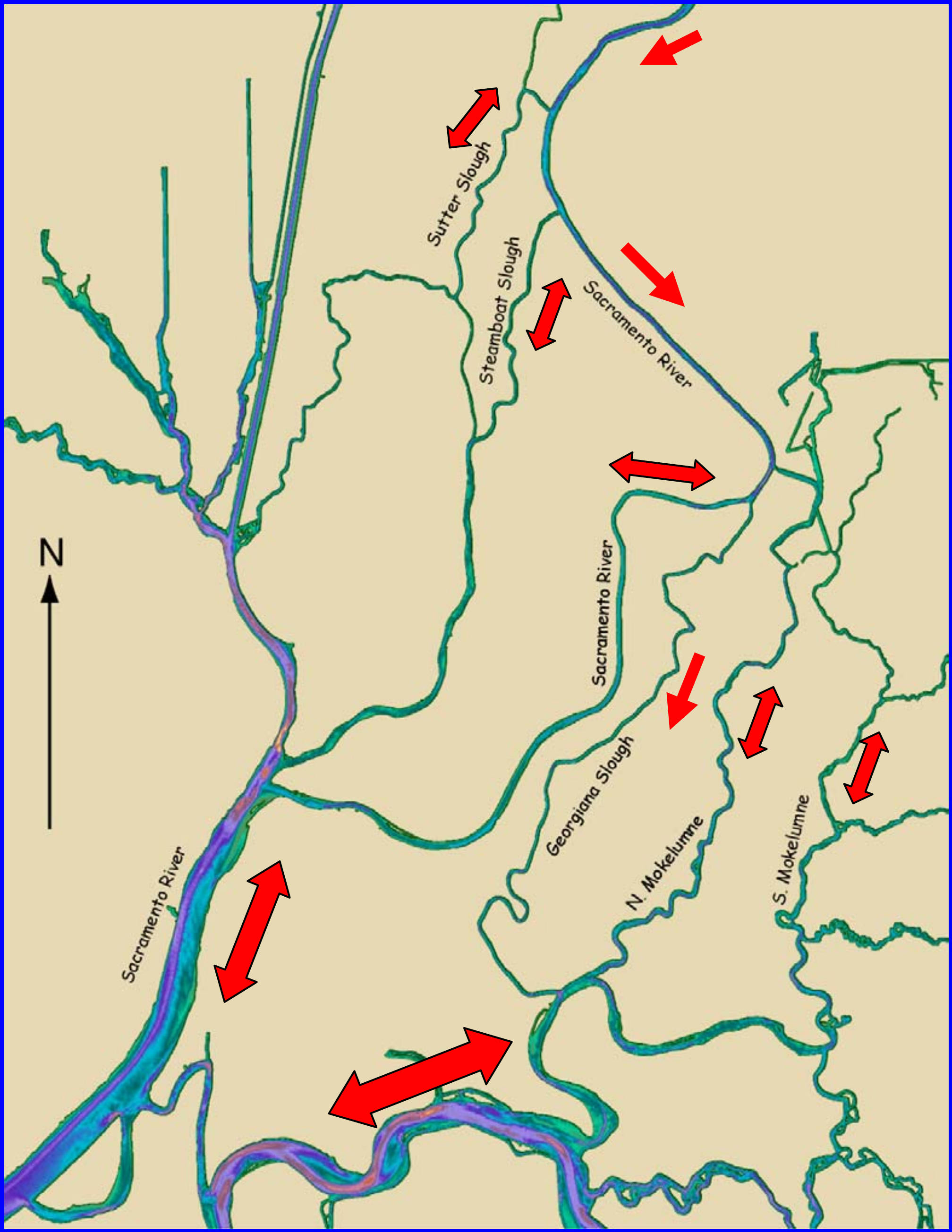
Strongly tidally forced (at low flows)

Change with:

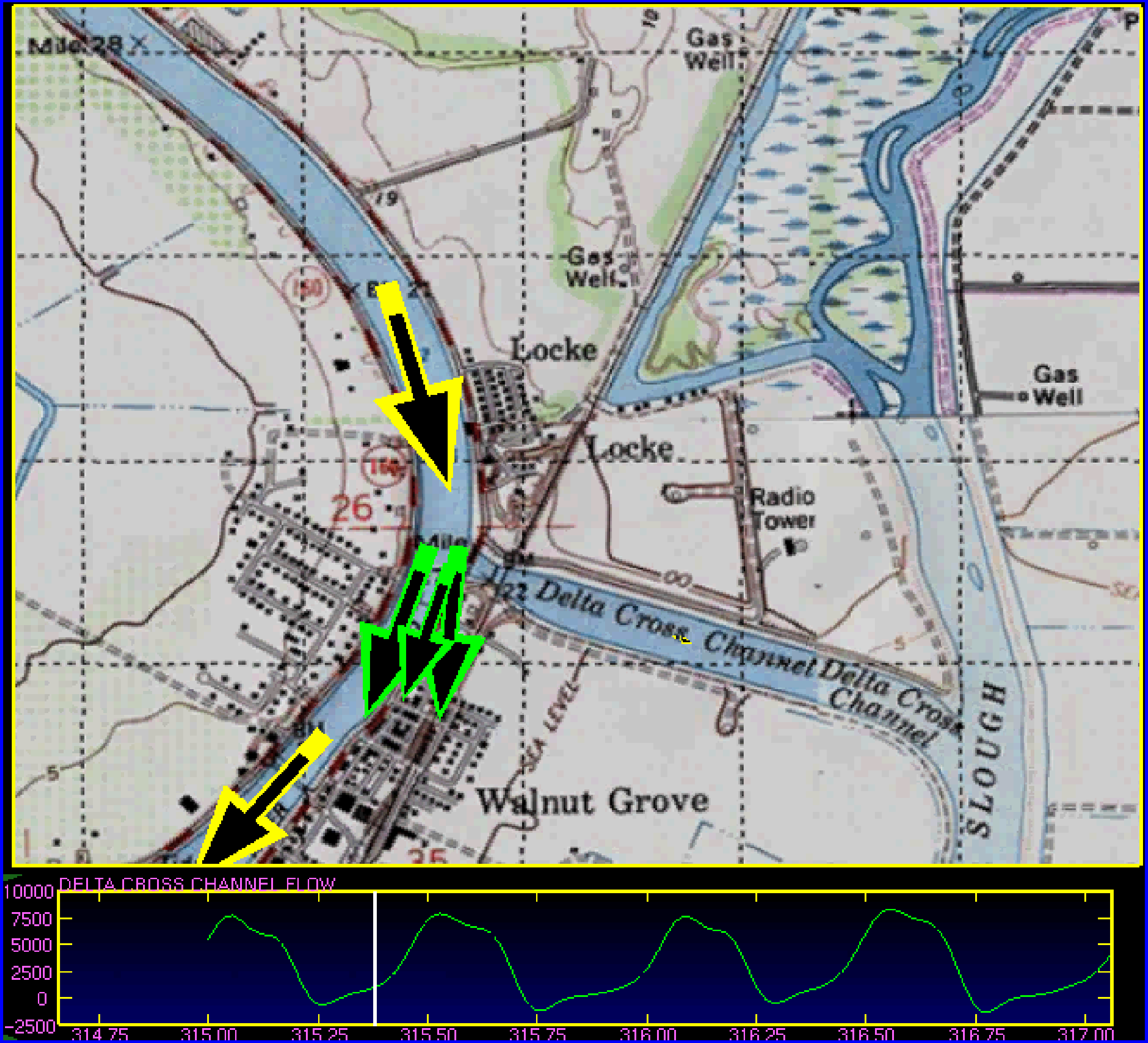
(1) Sac River flows

(2) DCC operations

Changes in tidal flows could affect juvenile salmon pathways and Survival?

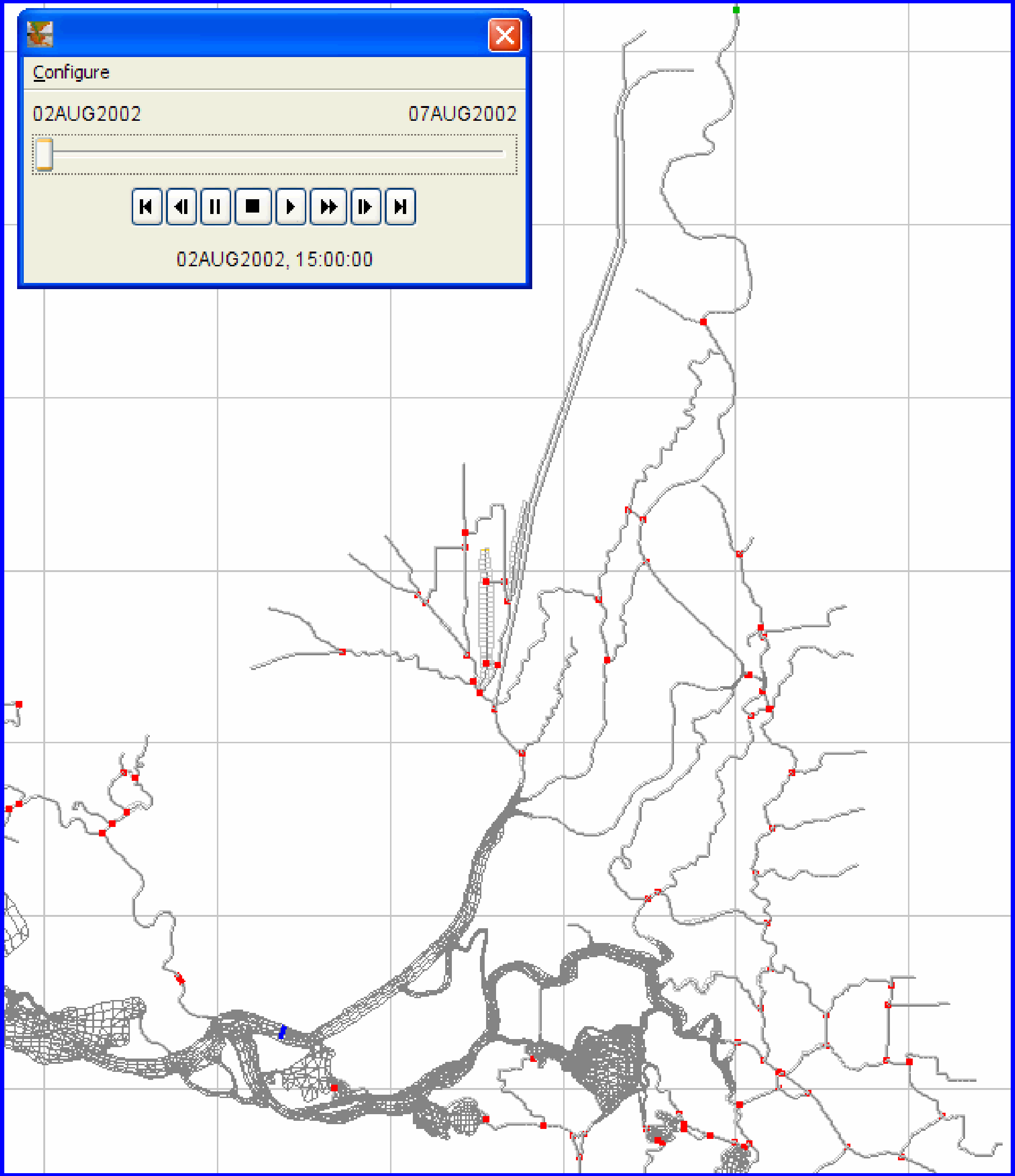


Which leads to complex salmon movements at junctions



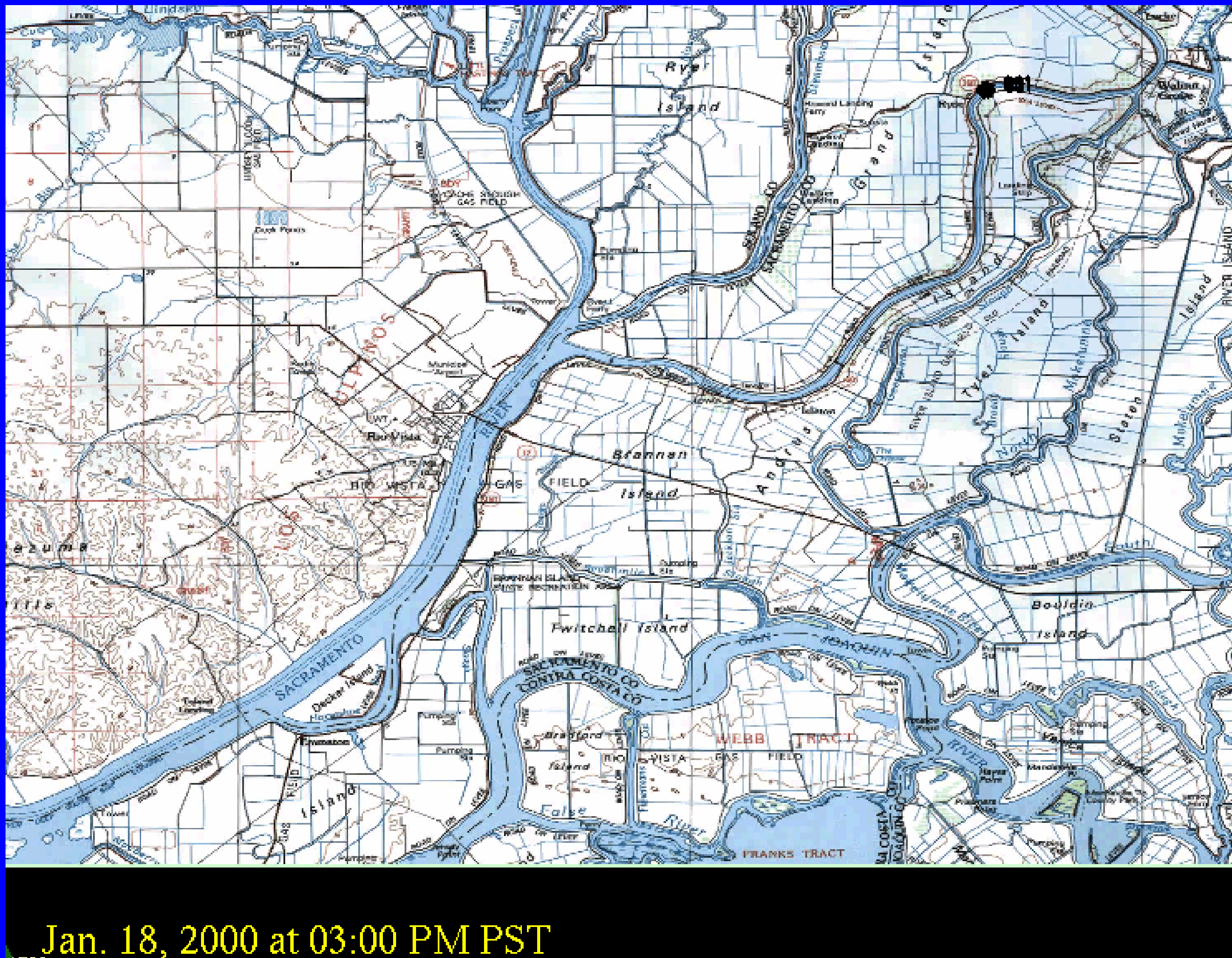
Vogel

So what does this mean in terms of transport?



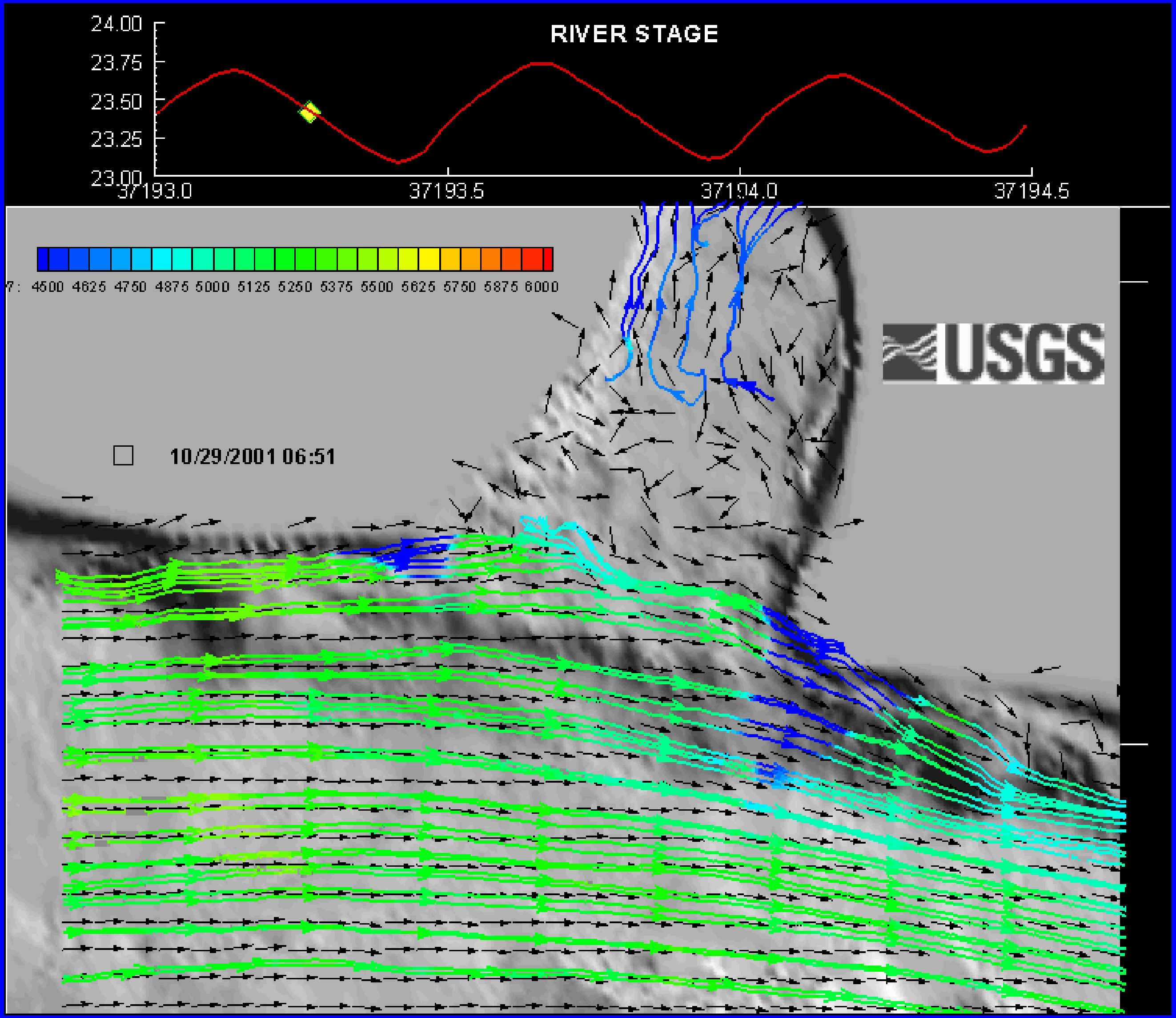
RMA

Radio Tag Results



Vogel

Exchange in Bends in also complex

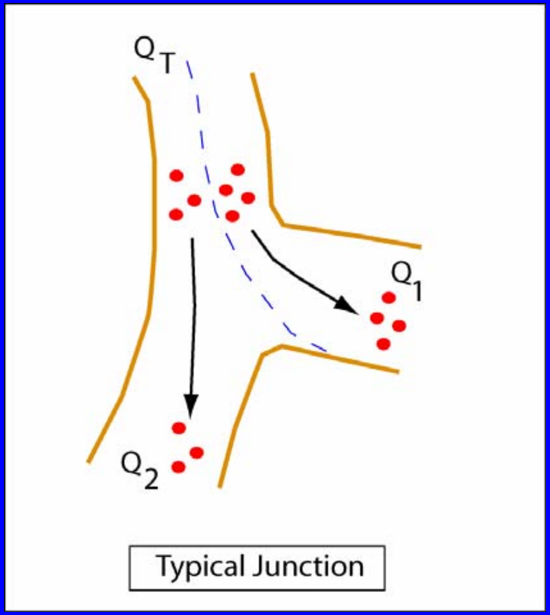


Dinehart

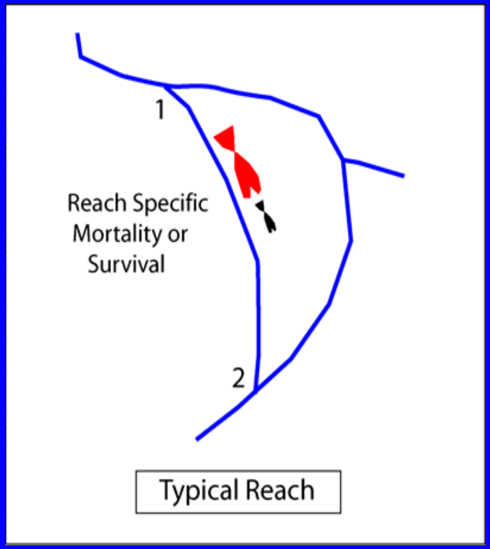
How do we handle this complexity?

Approach: Divide problem into two parts

(1) Entrainment at Junctions



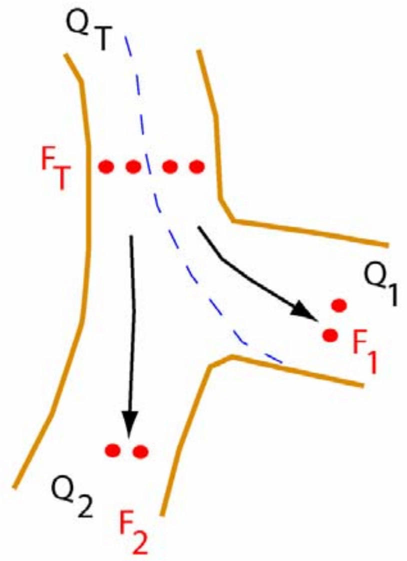
(2) Survival within each reach



Working hypothesis

Junction entrainment is a function of:
up-current juvenile salmon spatial distributions

Model 1 – Fish are laterally homogeneous



If fish are laterally homogeneous

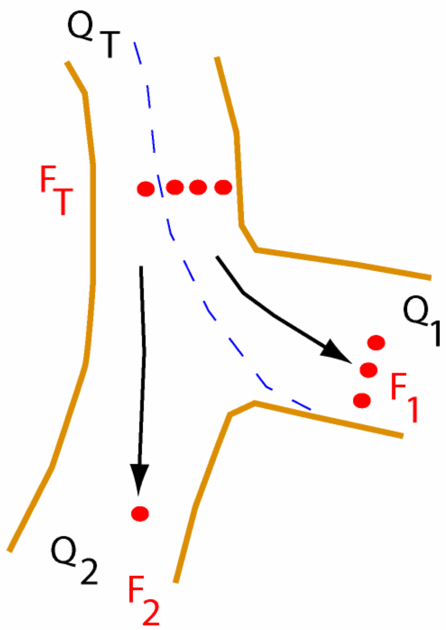
$$F_1 = \frac{Q_1}{Q_T} F_T \quad \text{and} \quad F_2 = \frac{Q_2}{Q_T} F_T$$

Fish are entrained in proportion to the flow split

"Fish go with the flow (discharge)"

(1D particle tracking models (DSM2) implicitly make this assumption)

Model 2 - Fish are laterally Nonhomogeneous



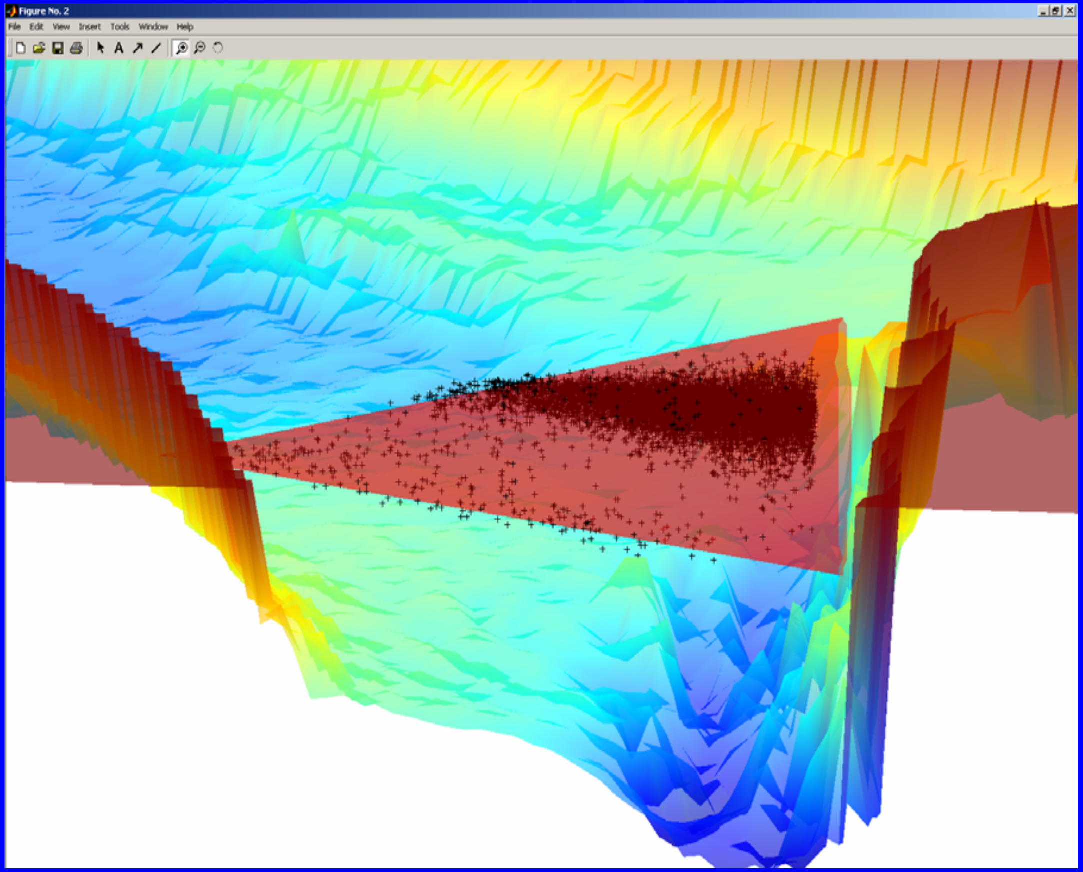
If fish are laterally NONhomogeneous

$$F_1 = \varepsilon \frac{Q_1}{Q_T} F_T \quad \text{and} \quad F_2 = (\varepsilon - 1) \frac{Q_2}{Q_T} F_T$$

$\varepsilon =$ Junction efficiency (0-1)

Fish are NOT entrained in proportion to the flow split

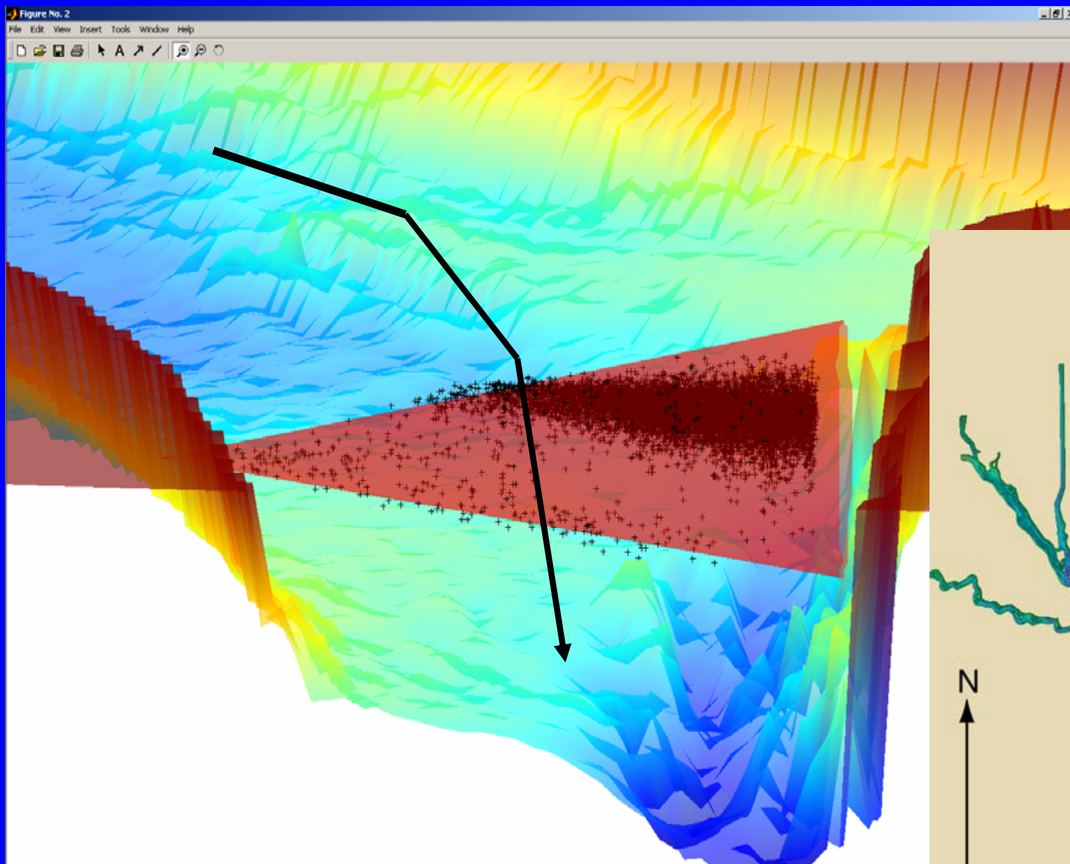
Previous studies, at the DCC and Georgiana Slough junctions, suggest that juvenile salmon are Nonhomogeneously distributed in the water column

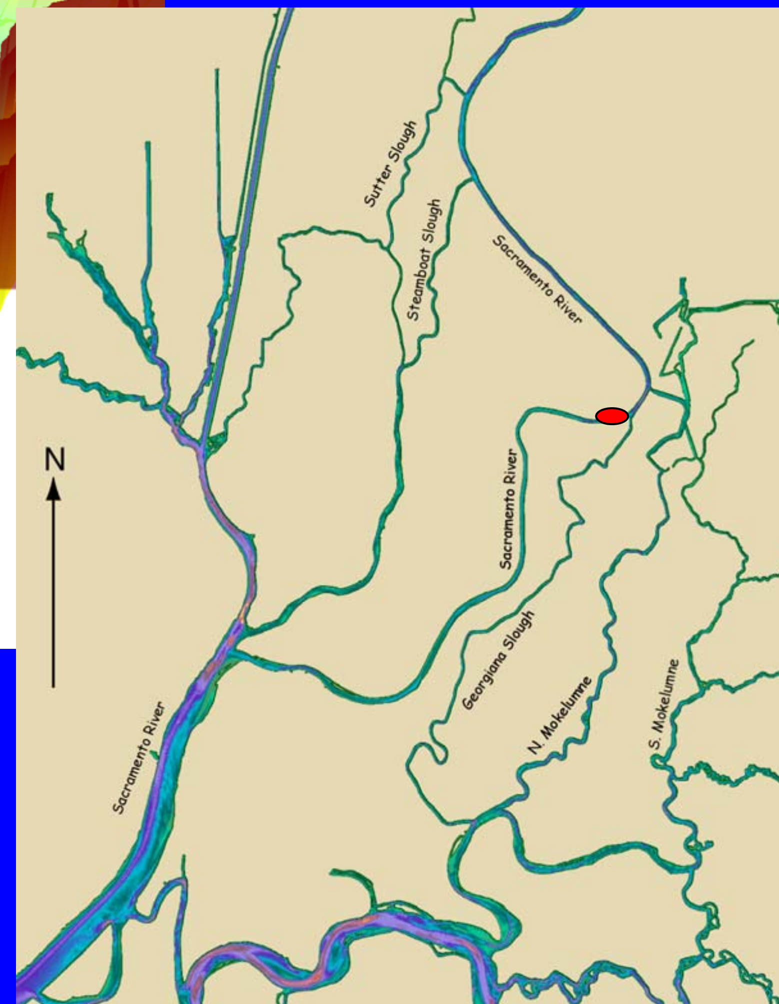


Blake and Horn, 2003, Acoustic tracking of juvenile salmon in the vicinity of the Delta Cross Channel, Sacramento River, California – 2001 study results, USGS, SRI

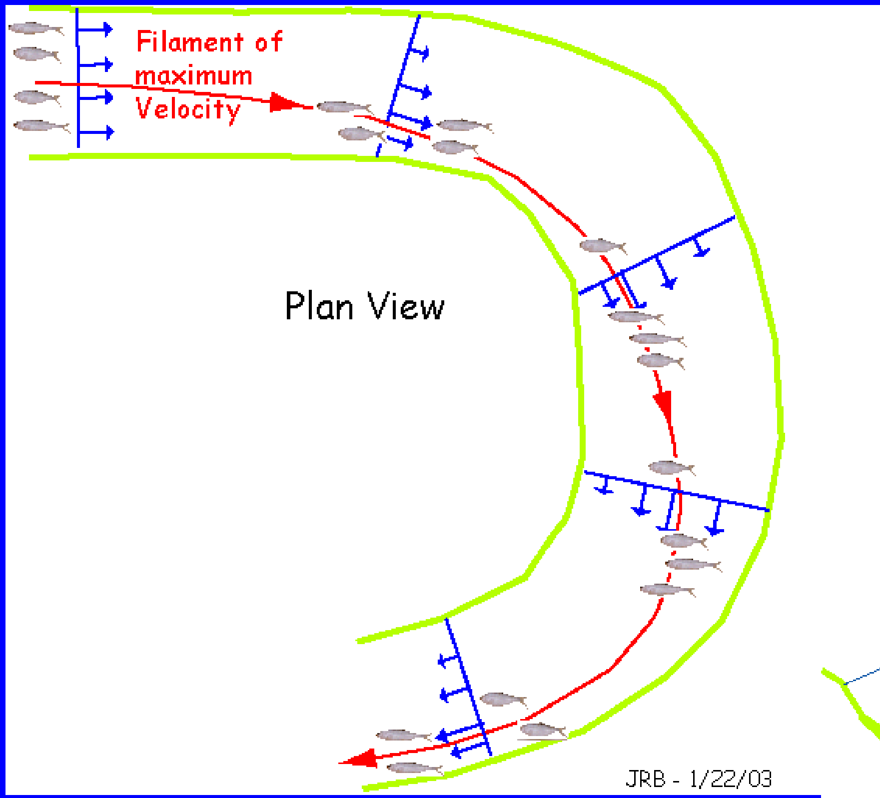
Blake and Horn, 2006, Acoustic tracking of juvenile salmon in the vicinity of Georgiana Slough, Sacramento River, California – 2003 study results, USGS SRI

Data taken in a river bend

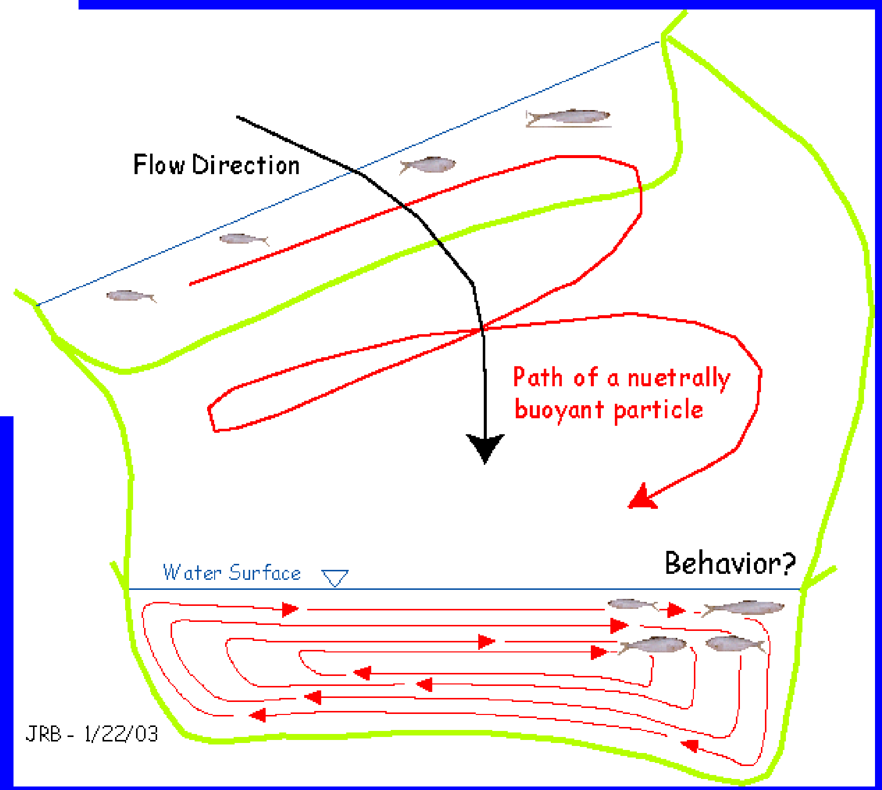




What is so special about river bends?

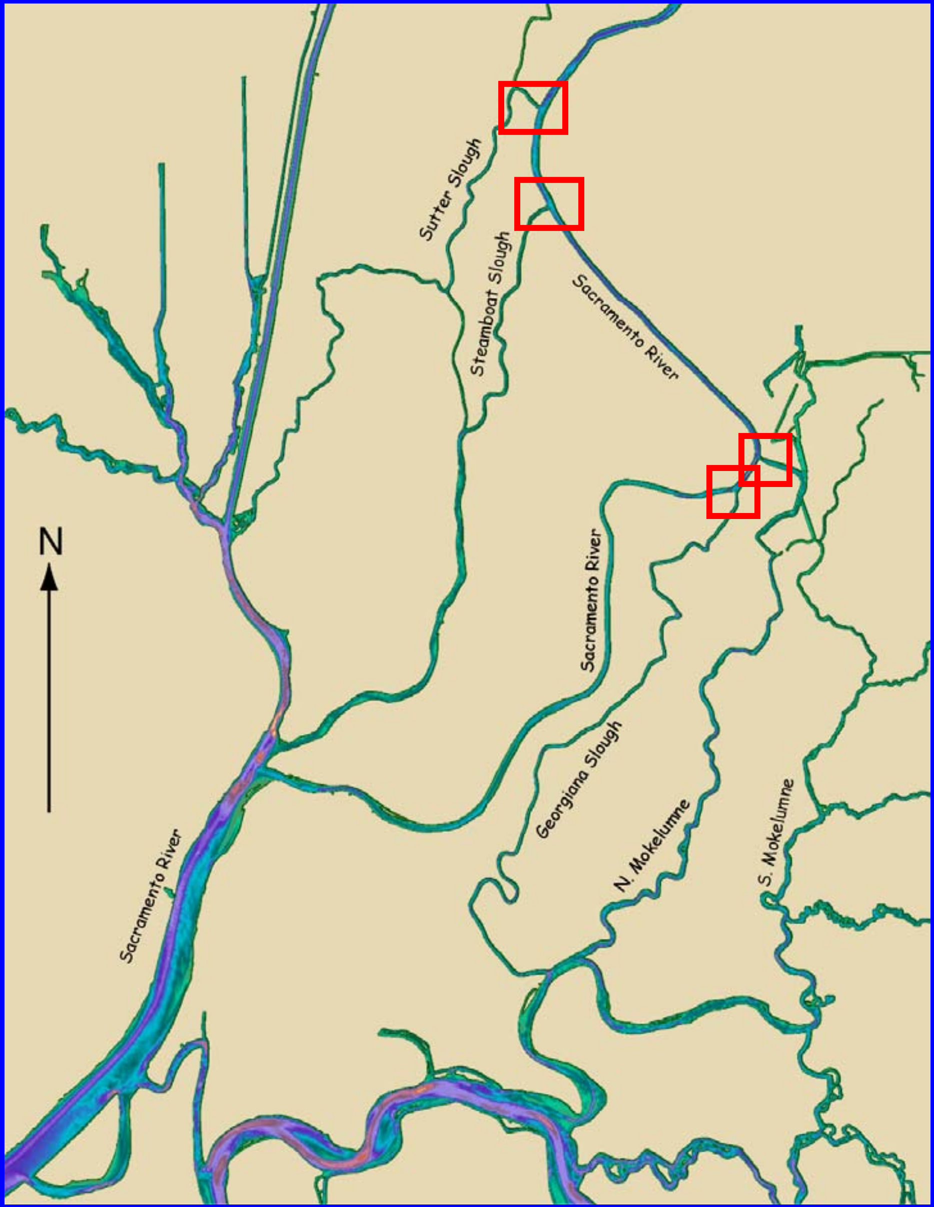


Secondary Circulation



Why do we care about river bends?

Every single north Delta junction occurs on a river bend



Clarksburg Bend experiment
Objectives

(1) Junction entrainment

(2) Reach survival

Clarksburg Bend experiment
Objectives

(1) Junction entrainment

- Study bend hydrodynamics/salmon behavior interaction as a mechanism for generated non-homogeneous juvenile salmon spatial distributions

- Develop behavior submodels for inclusion in individual-based particle tracking models

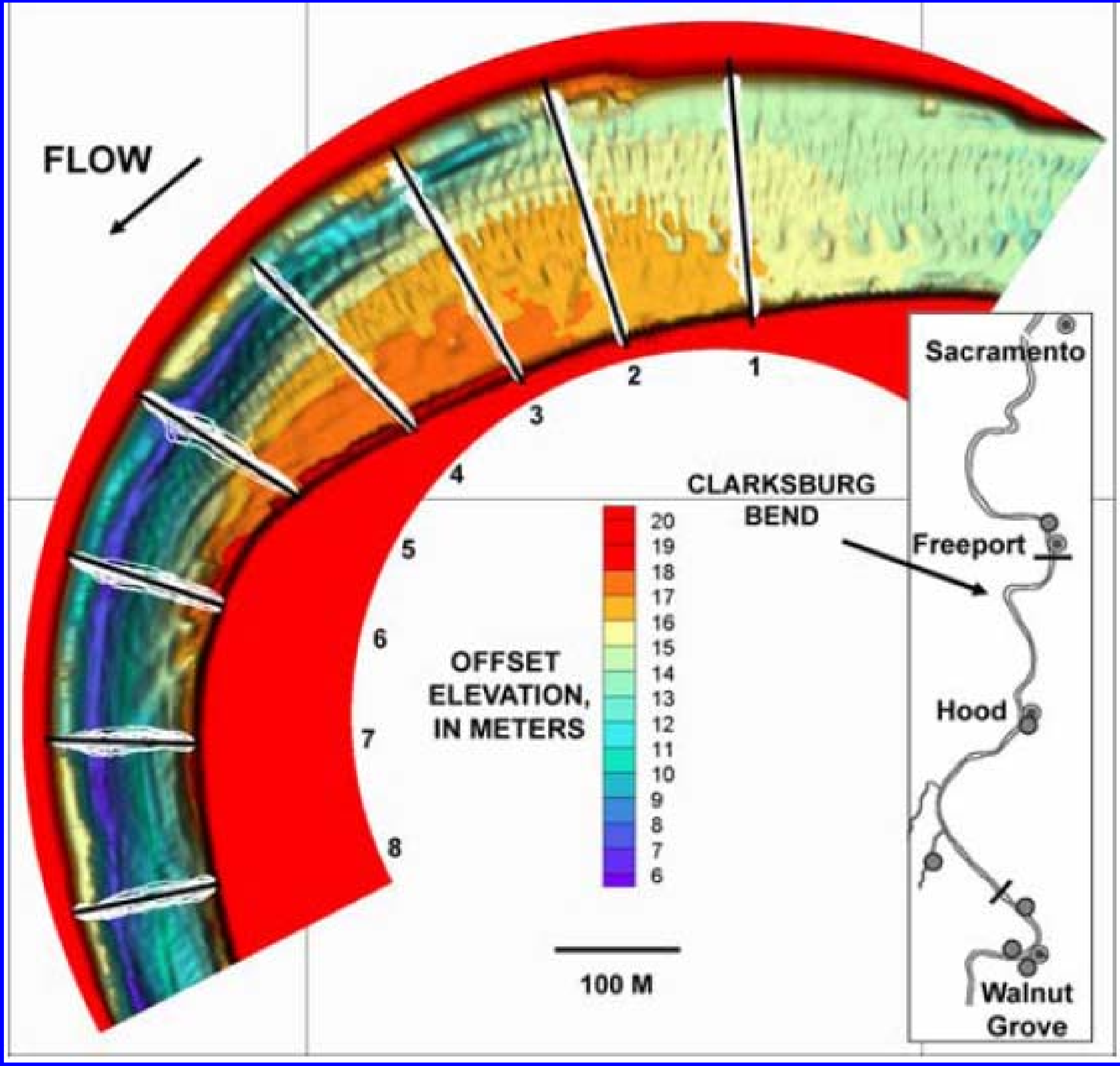
- Test equipment and analytical techniques

Why Study Salmon movements in Clarksburg Bend?

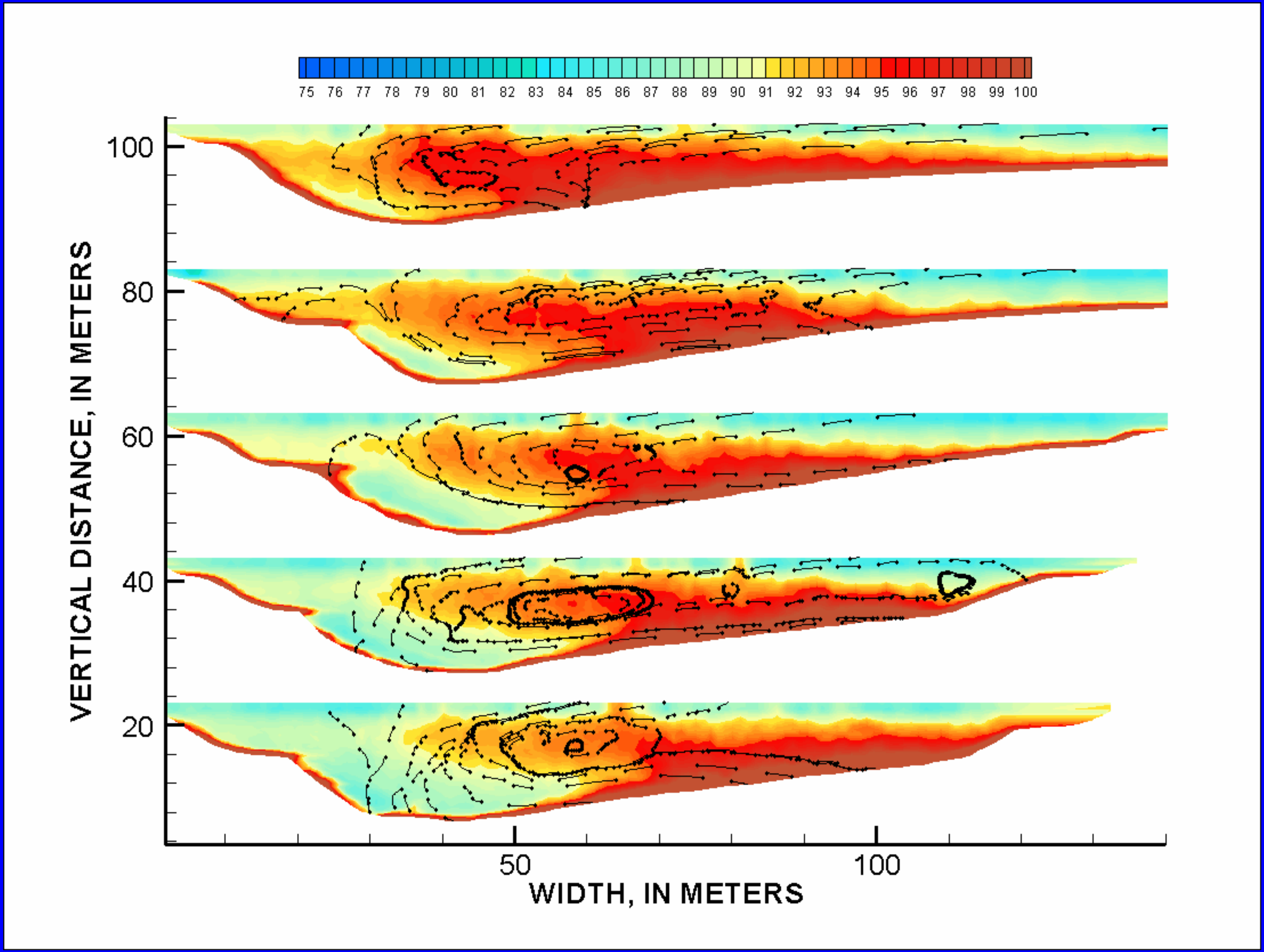
(1) Very tight radius (secondary currents scale with the radius)

(2) Contraction of cross sectional area

(3) No junction to confuse the results

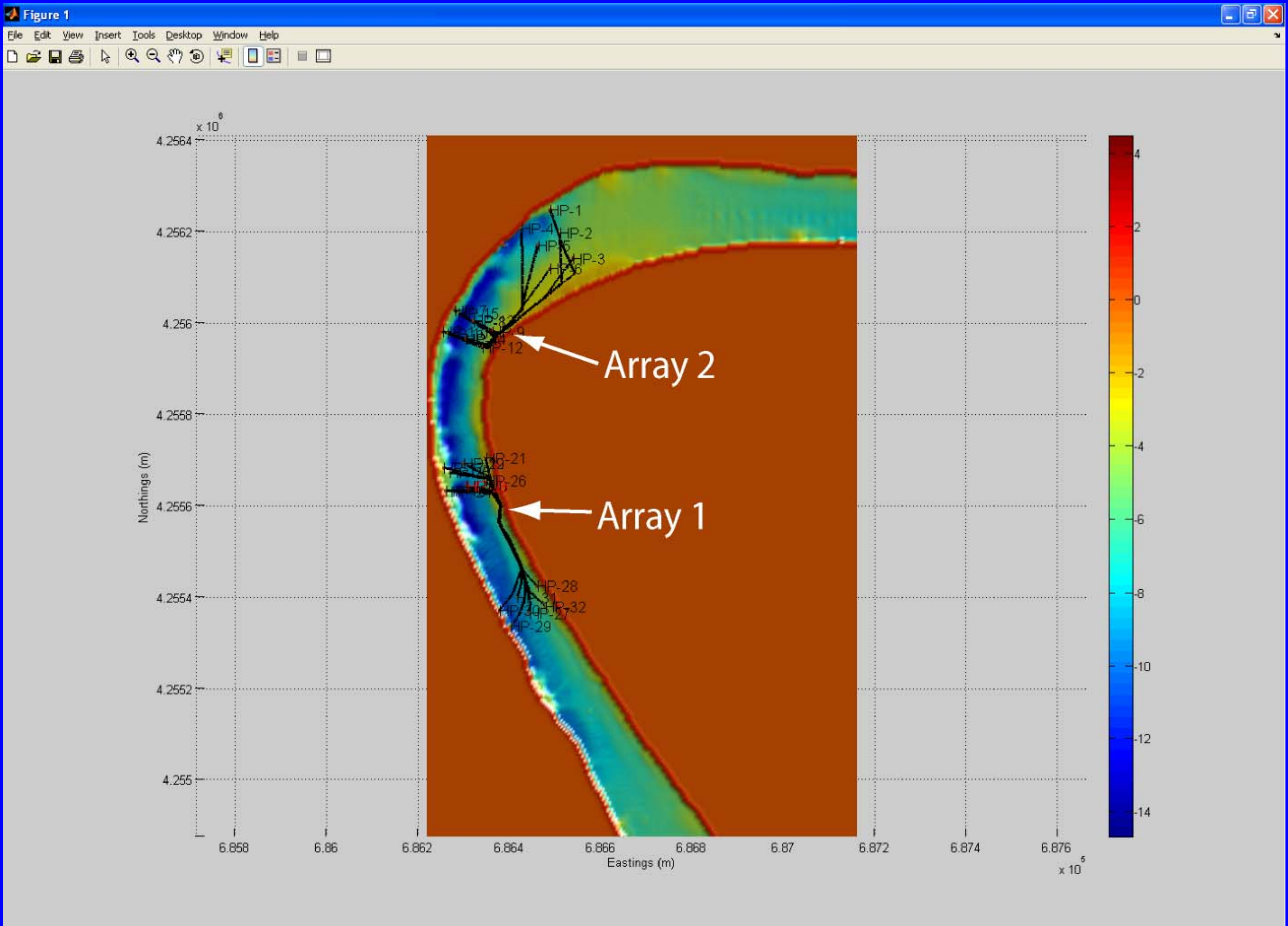


Measurements of Secondary currents in Clarksburg Bend

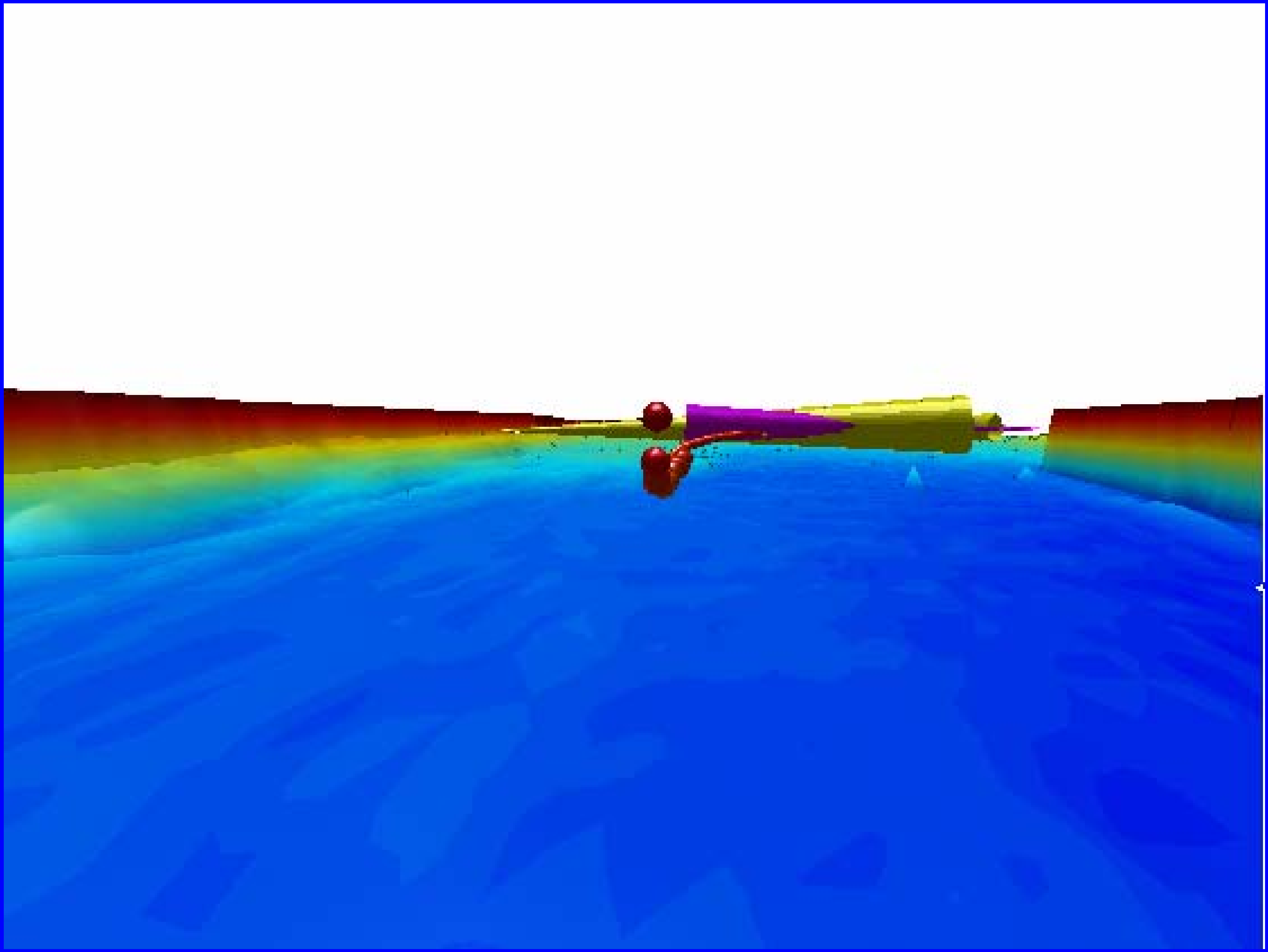


Dinehart, R. and J. Burau, 2005, Averaged indicators of secondary flow in repeated acoustic Doppler current profiler crossings, Water Resources Research

3D Tracking of Acoutically-Tagged salmon in Clarksburg Bend



Example of 3D fish tracking data



Clarksburg Bend experiment
Objectives

(2) Reach survival

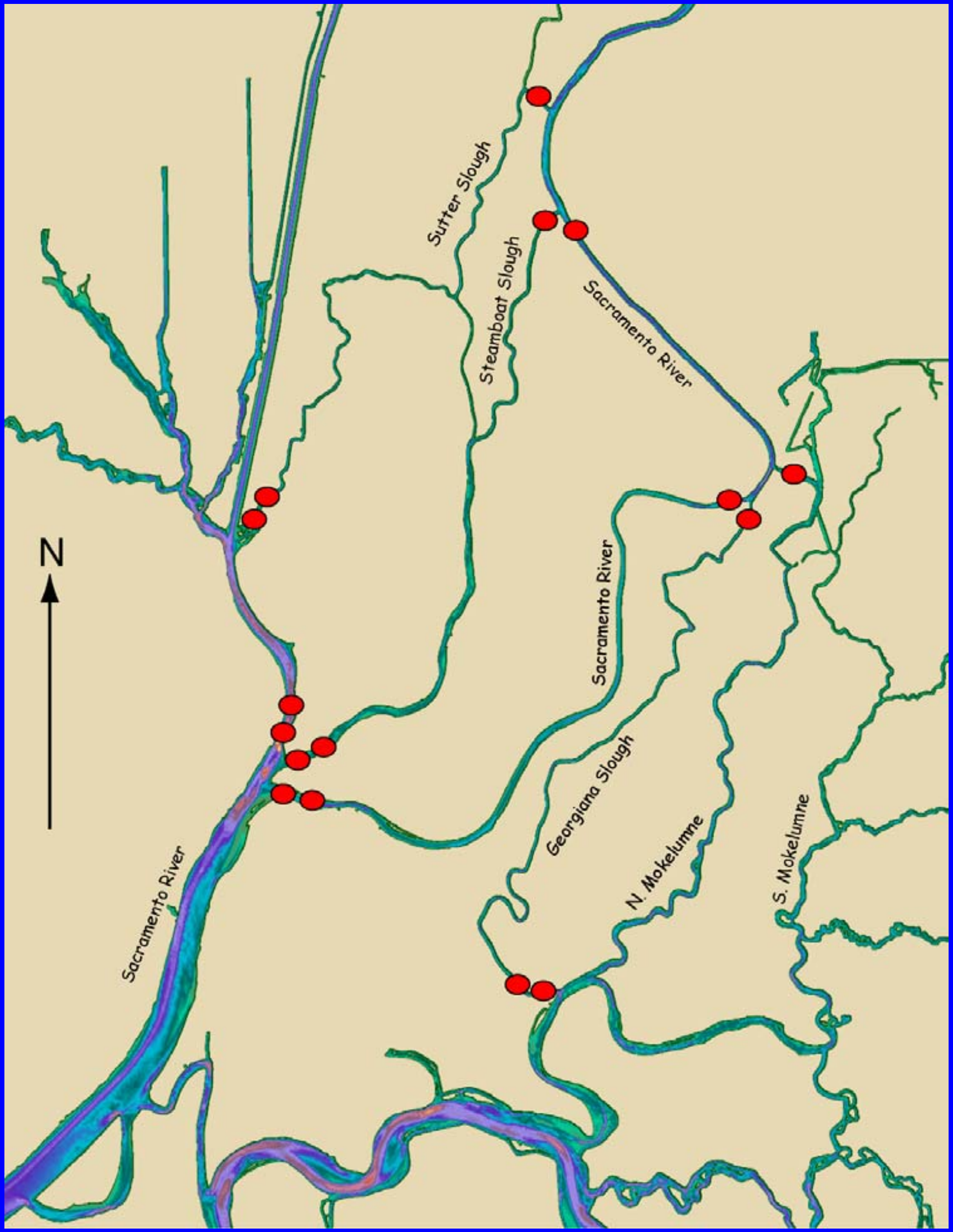
- First-cut estimates of Survival rates

- Test equipment and analytical techniques

Receiver Locations – DCC Closed

Survival Probabilities

Detection Probabilities



Analytical Approach

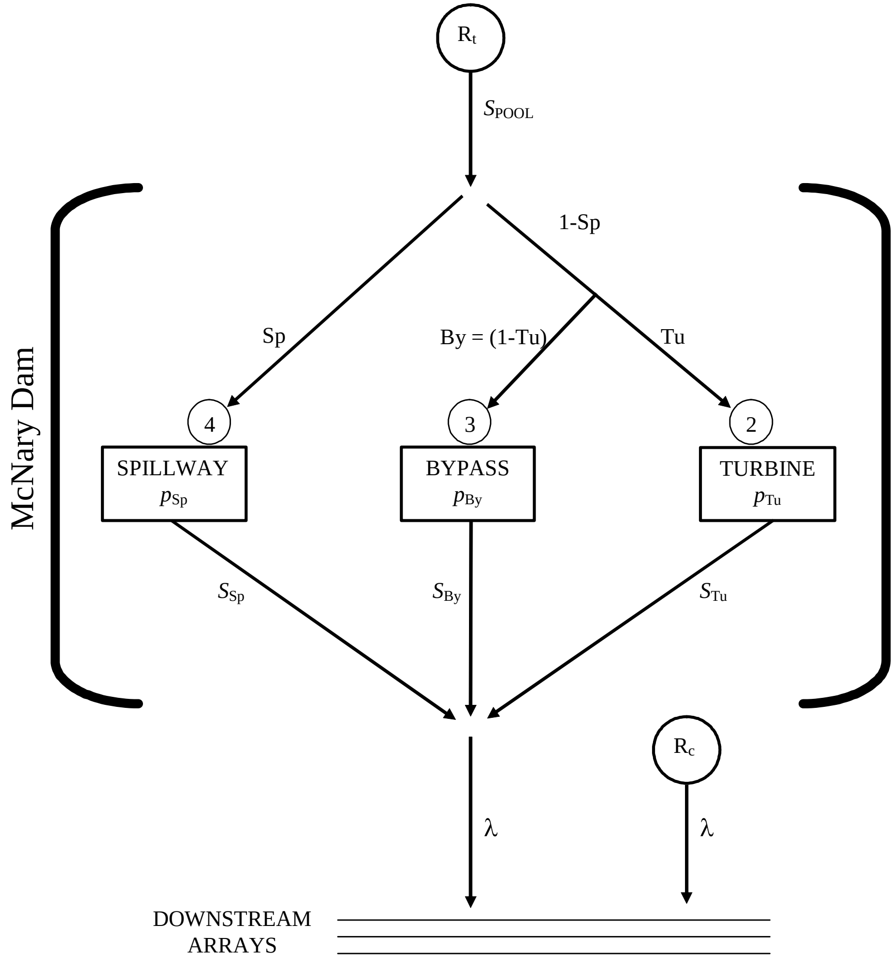


Figure 1. — Schematic of the route-specific survival model developed by Skalski et al. (2002) and used by Perry et al. (2006). Shown are fish release locations (R_t and R_c) and passage (Sp, By, and Tu), detection (P_{Sp}, P_{By}, and P_{Tu}) and survival probabilities (S_{POOL}, S_{Sp}, S_{By}, and S_{Tu}). Circled numbers show coding used in detection histories to indicate the route of passage of each fish. Lambda (λ) is the joint probability of surviving and being detected by telemetry arrays downriver of the dam.

Perry, Skalski (UW)

Release Strategy

300 acoustically tagged fish
Releases at 3 Sac River discharges
(low,med,high)
100 fish per discharge
Releases at (morning, day, eve, night)