Overview of results from North delta hydrodynamic and salmon outmigration studies

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Research focus:

Developing management tools through

Process level (mechanistic) understanding

Interaction between

Salmon outmigrant behavior

and

hydrodynamic processes

Focus on management tools

(1) North Delta residual flow model

(2) North Delta salmon survival model

(3) Individual-based 3D model of salmon outmigration

Outline

Conceptual framework

(Jon)

(1) Entrainment in junctions

(2) Channel survival

North Delta residual flows

(Jon)

Methodology, digital filter response

North Delta salmon survival model

(Jon, Aaron)

Outline (con't)

Review of Georgiana Slough Pilot study (Jon)

Study activities, conditions

Results from hydroacoustics (Aaron)

Hydroacoustic results

Acoustic tag results

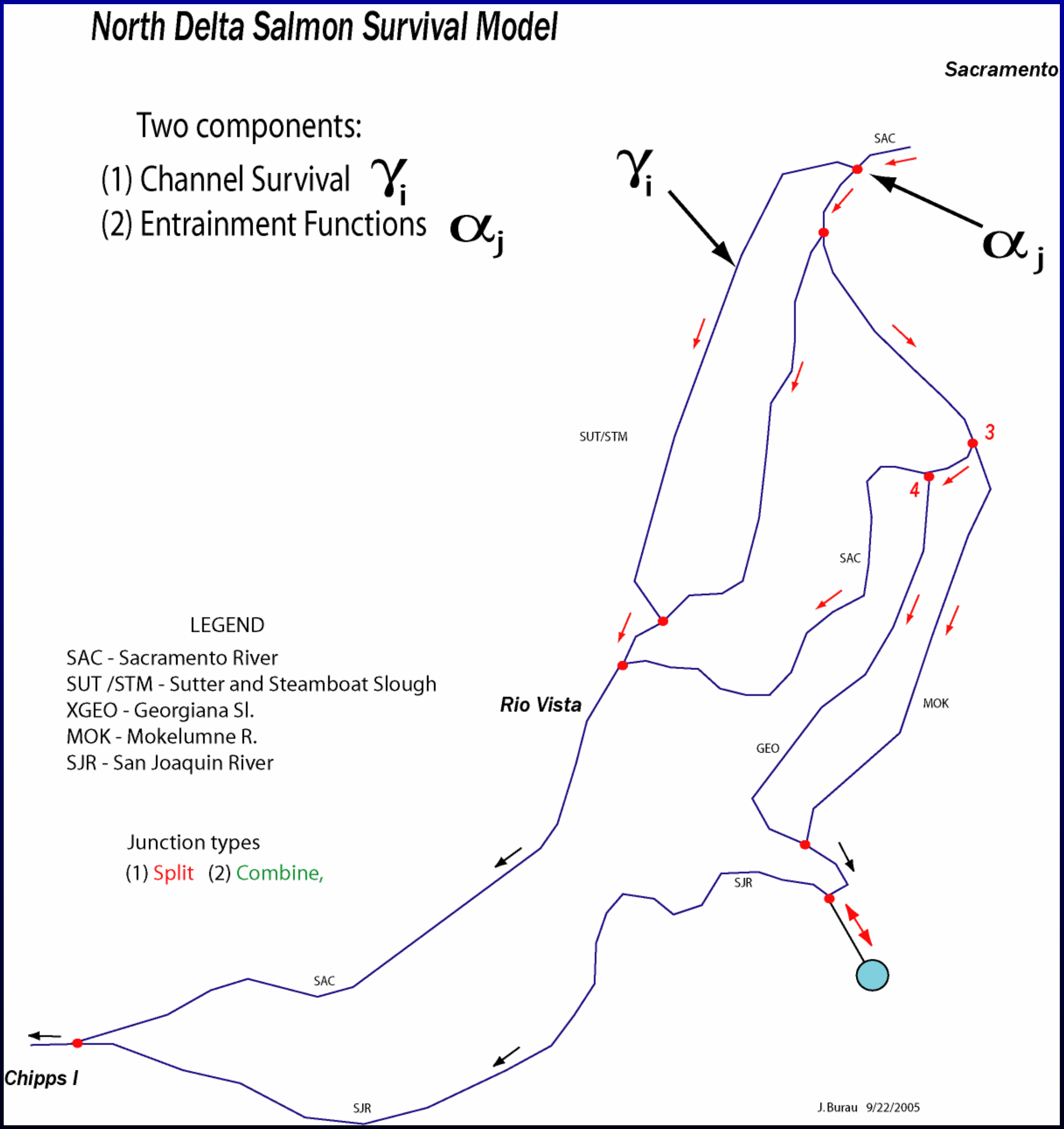
3D particle tracking experiments (Aaron)

Junction entrainment as a function of

the interaction between secondary circulation and behavior

Conclusions and Future studies (Jon)

Conceptual Framework



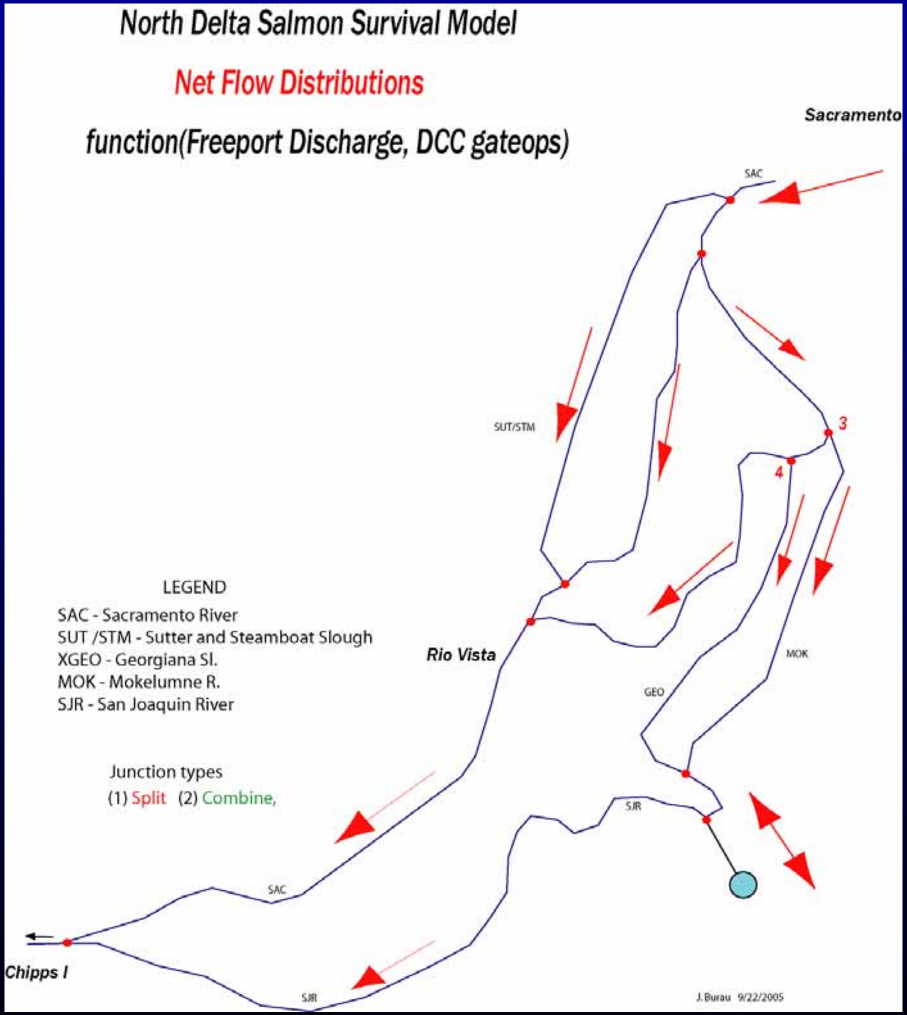
γ - Jon

α - Aaron

Building salmon survival model

(Step 1)

Net flows in North Delta channels

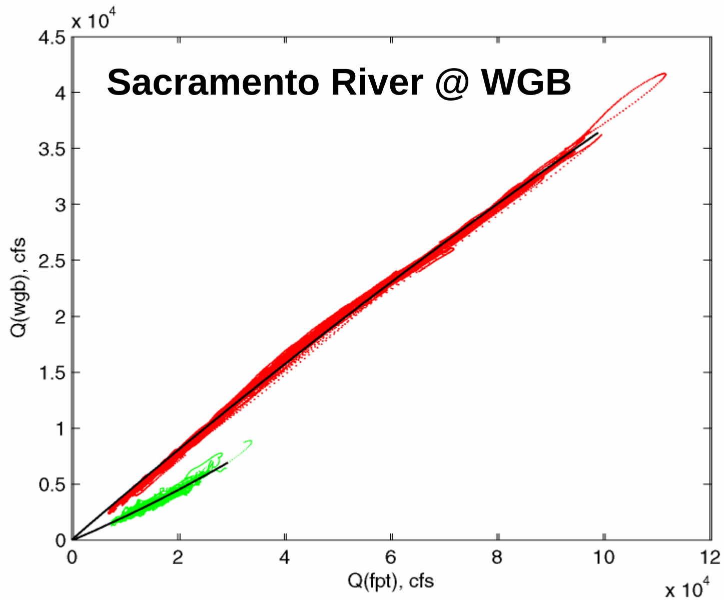


North Delta Discharge Relations

(based on ~11 years of data)

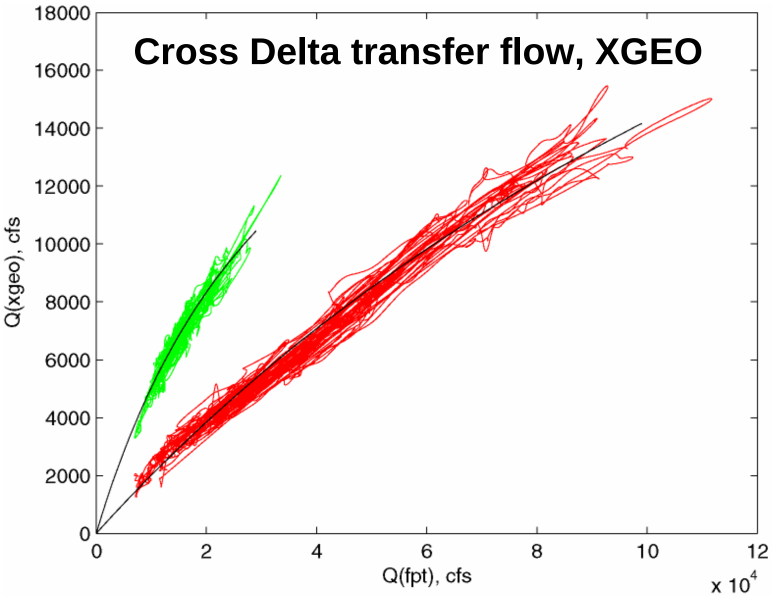
$$Q_i^o = \frac{1}{a_i^o + b_i^o / Q_{fpt}}$$

$$Q_i^c = \frac{1}{a_i^c + b_i^c / Q_{fpt}}$$



DCC Closed
Number of data points = 41347
Squared correlation coefficient = 0.99763
y^-1 = 2.84336e-6 + 2.43811/x
RMS error of prediction = 426.6098

DCC Open
Number of data points = 37874
Squared correlation coefficient = 0.92482
y^-1 = -2.31471xe-5 + 4.86944/x
RMS error of prediction = 294.58396

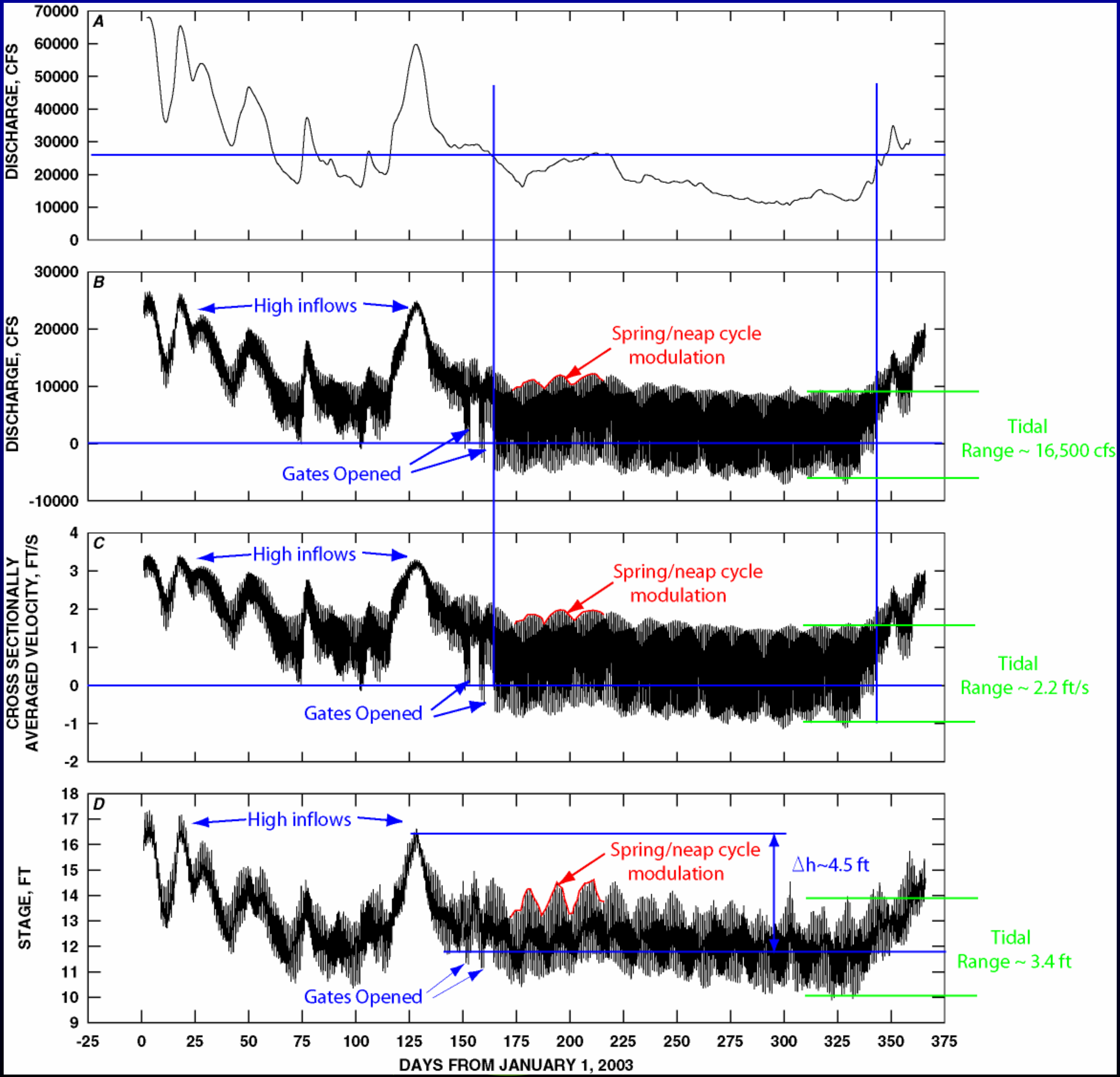


DCC Closed
Number of data points = 34332
Squared correlation coefficient = 0.980995
y^-1 = 2.263736xe-5 + 4.7498/x
RMS error of prediction = 450.28245

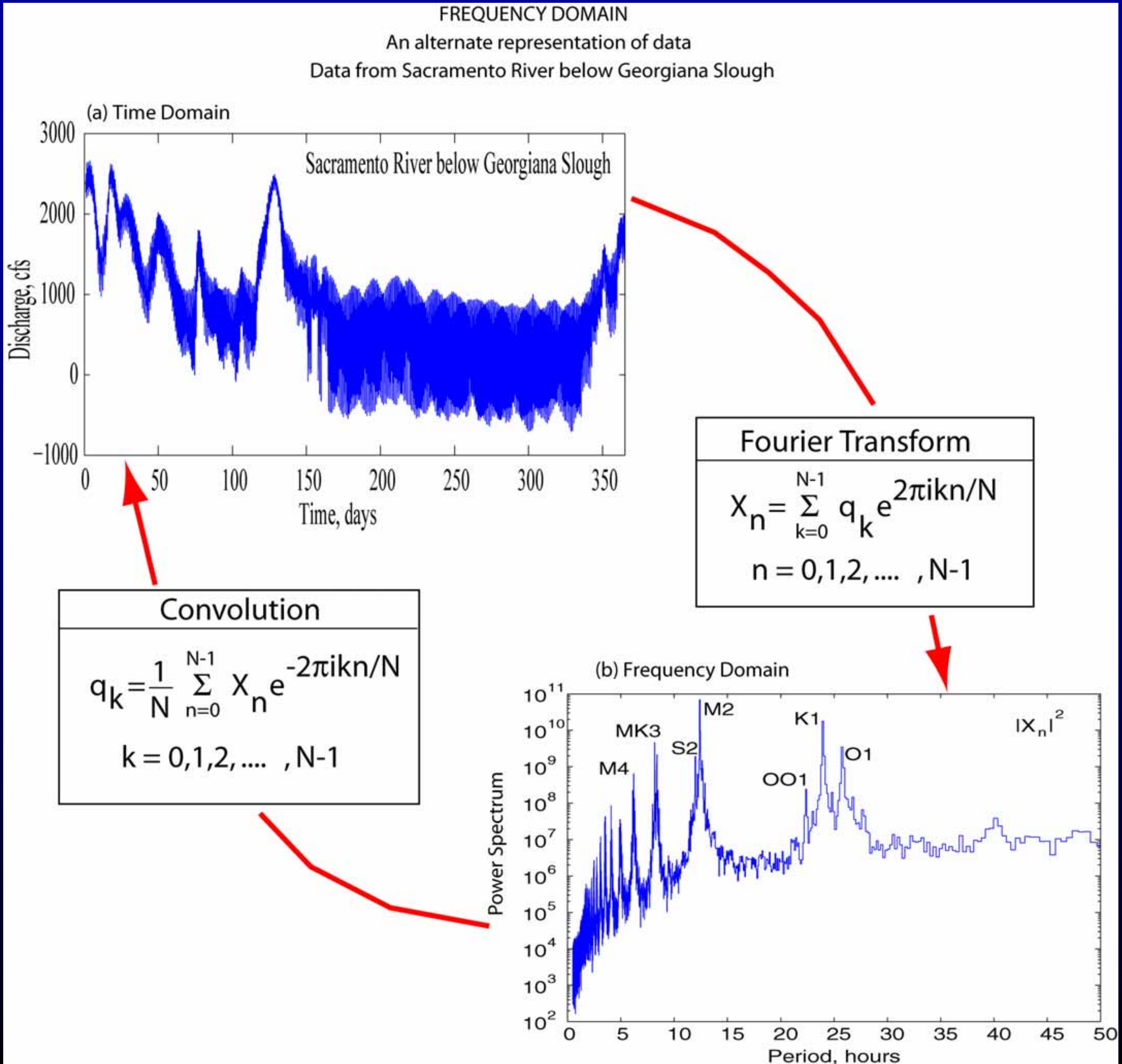
DCC Open
Number of data points = 37592
Squared correlation coefficient = 0.9333
y^-1 = 4.1552xe-5 + 1.570164/x
RMS error of prediction = 353.586

Flow Model - demo

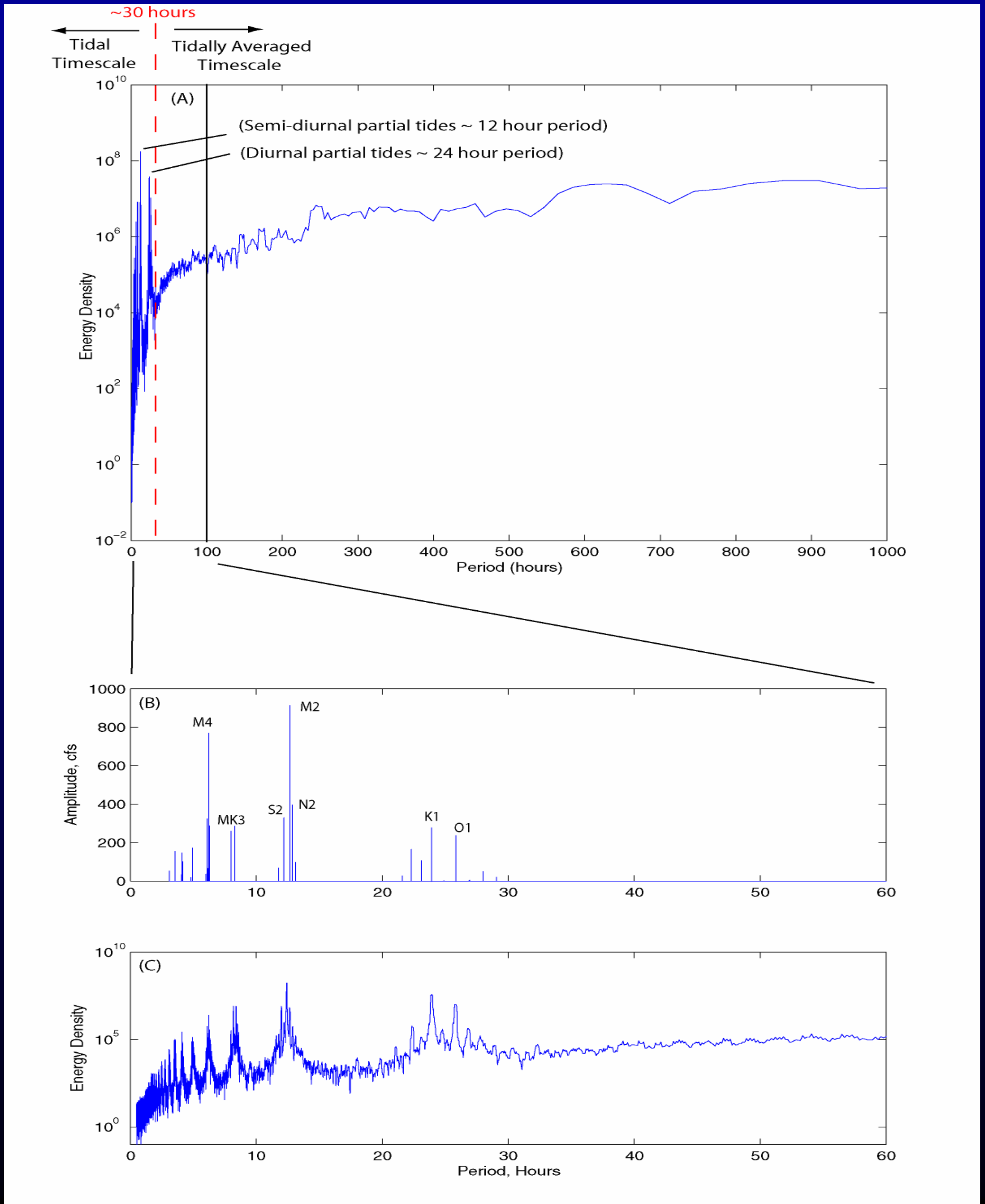
Raw Data – Sacramento River below Walnut Grove



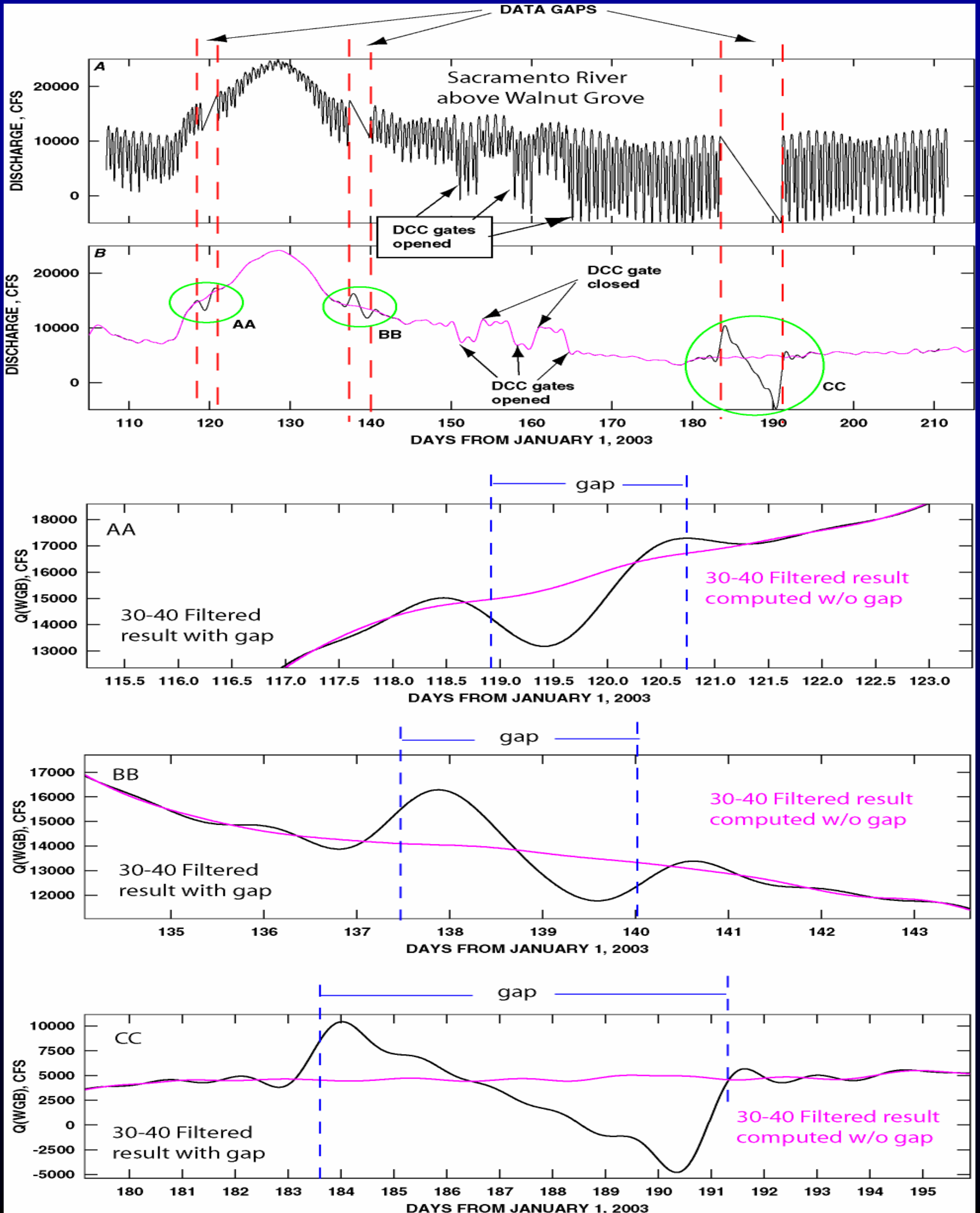
Transform time series into the frequency domain



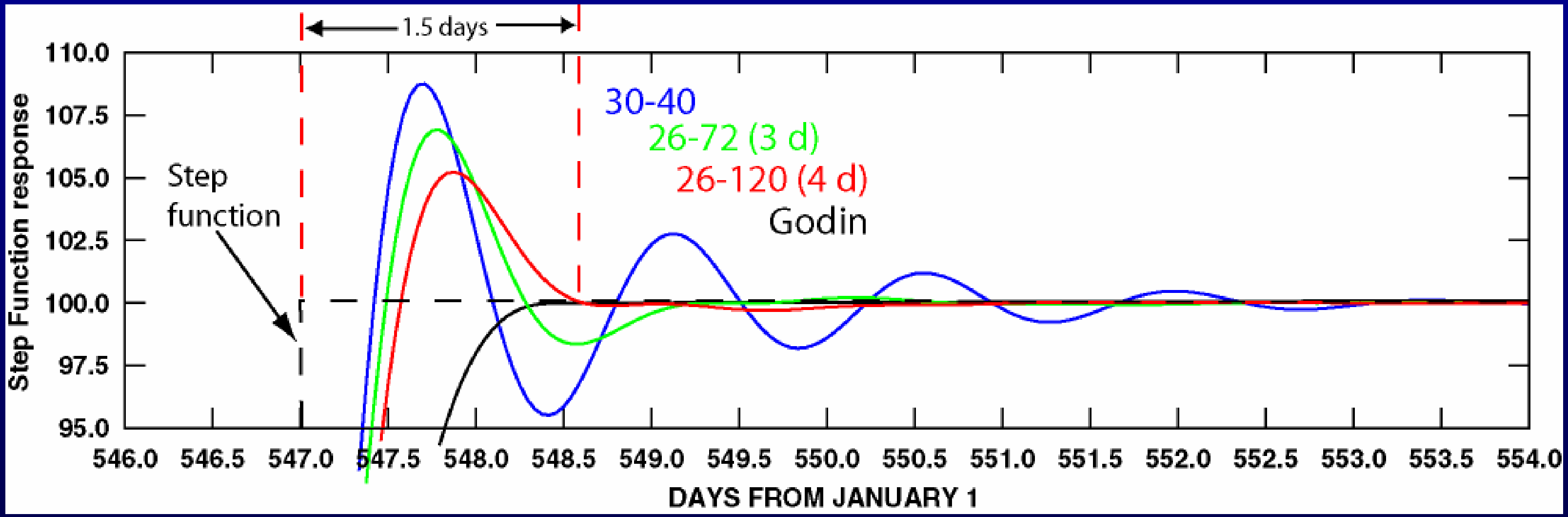
Power Spectral Density @ Station WGB



Problem: all tidal filters ring near step function changes

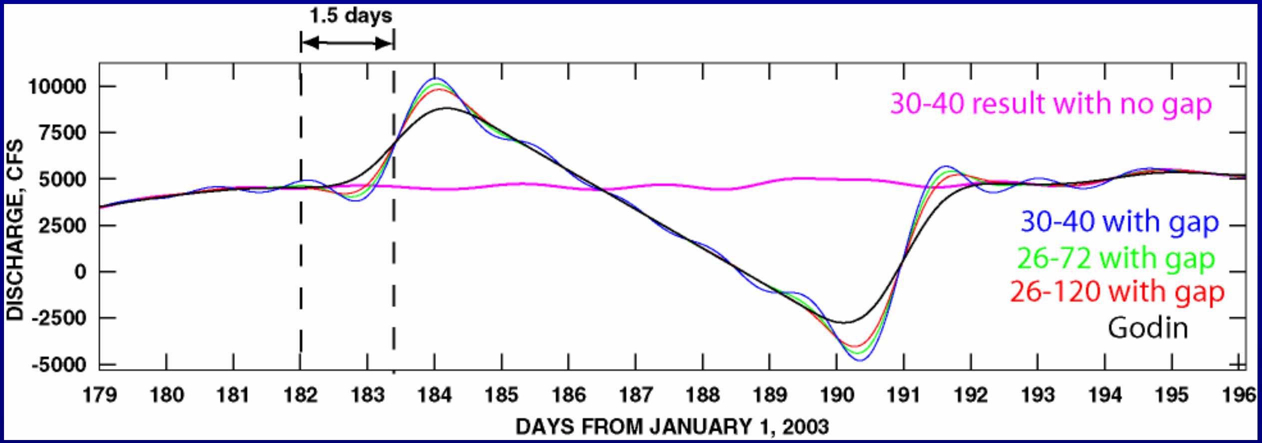


Problem: all tidal filters ring near step function changes

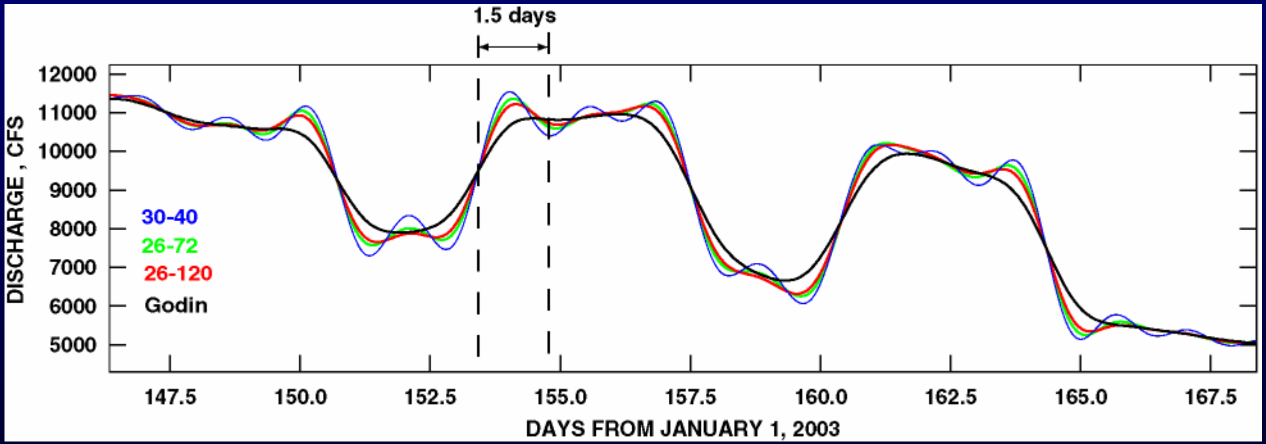


Home

Solution: Use Godin filter – remove 1.5 days



Gap response



DCC gateop response

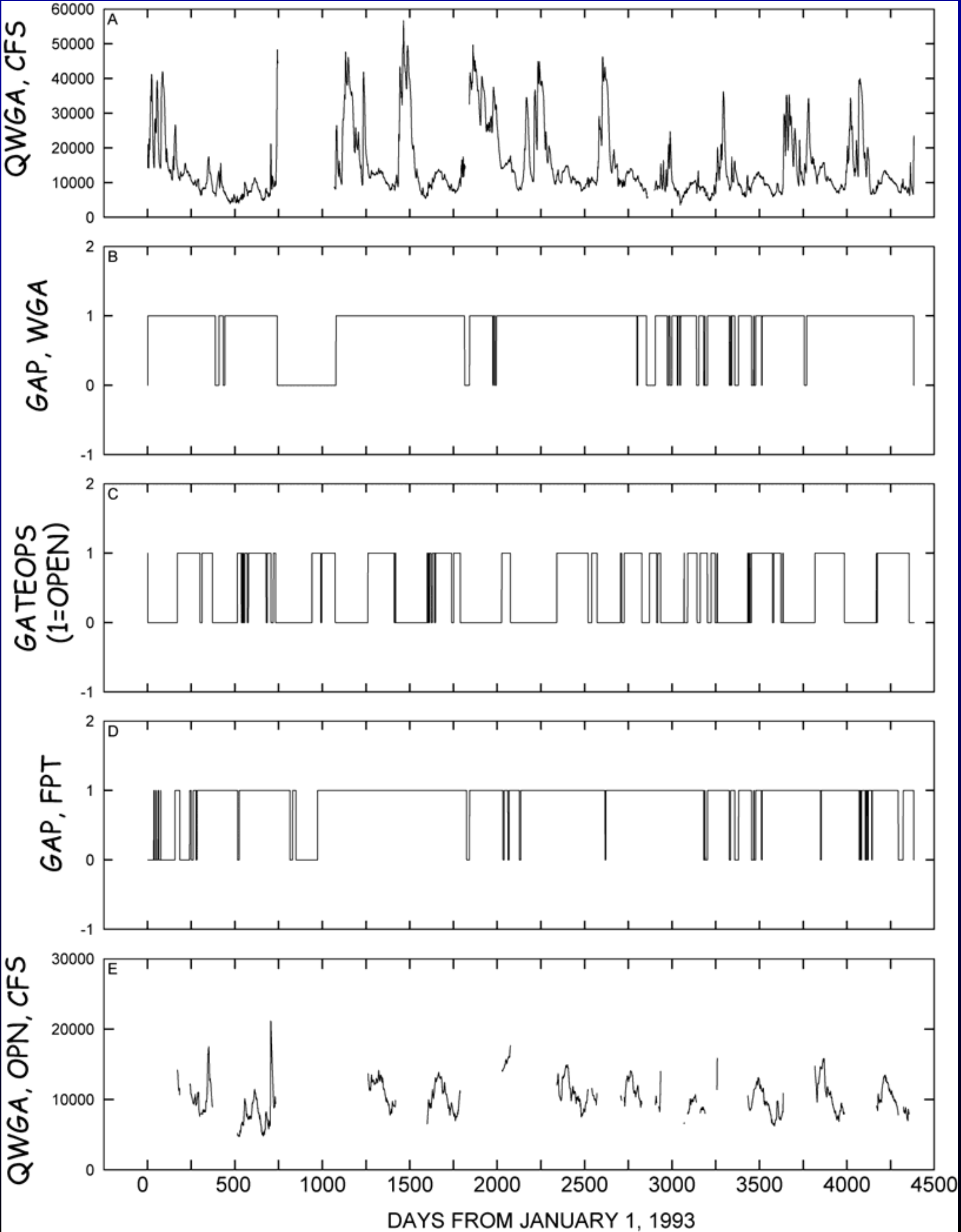
Home

So how do we remove filter roll-off associated with data gaps and DCC gateops from data sets?

Use masks

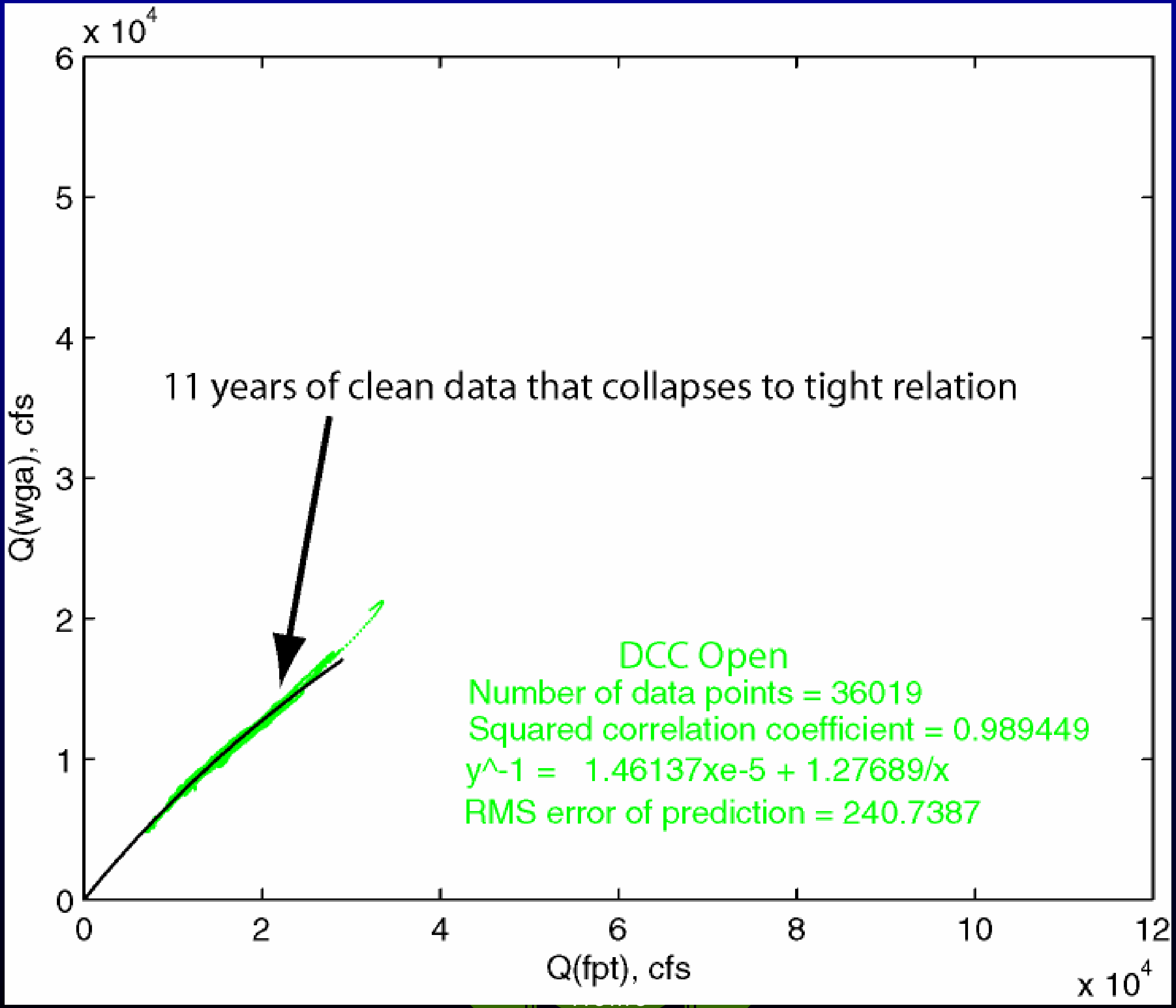
$$Q_{wga}^{open}(t) = M_{DCCgates}^{open}(t) M_{fpt}^{gap}(t) M_{wga}^{open}(t) Q_{wga}(t)$$

Use of masks


A
B
C
D
E
QWGA, CFS
GAP, WGA
GATEOPS
(1=OPEN)
GAP, FPT
QWGA, OPN, CFS
60000
50000
40000
30000
20000
10000
0
2
1
0
-1
30000
20000
10000
0
500
1000
1500
2000
2500
3000
3500
4000
4500
DAYS FROM JANUARY 1, 1993

End result of attention to detail

Clean, scientifically defensible, highly correlated relations



Filter ringing

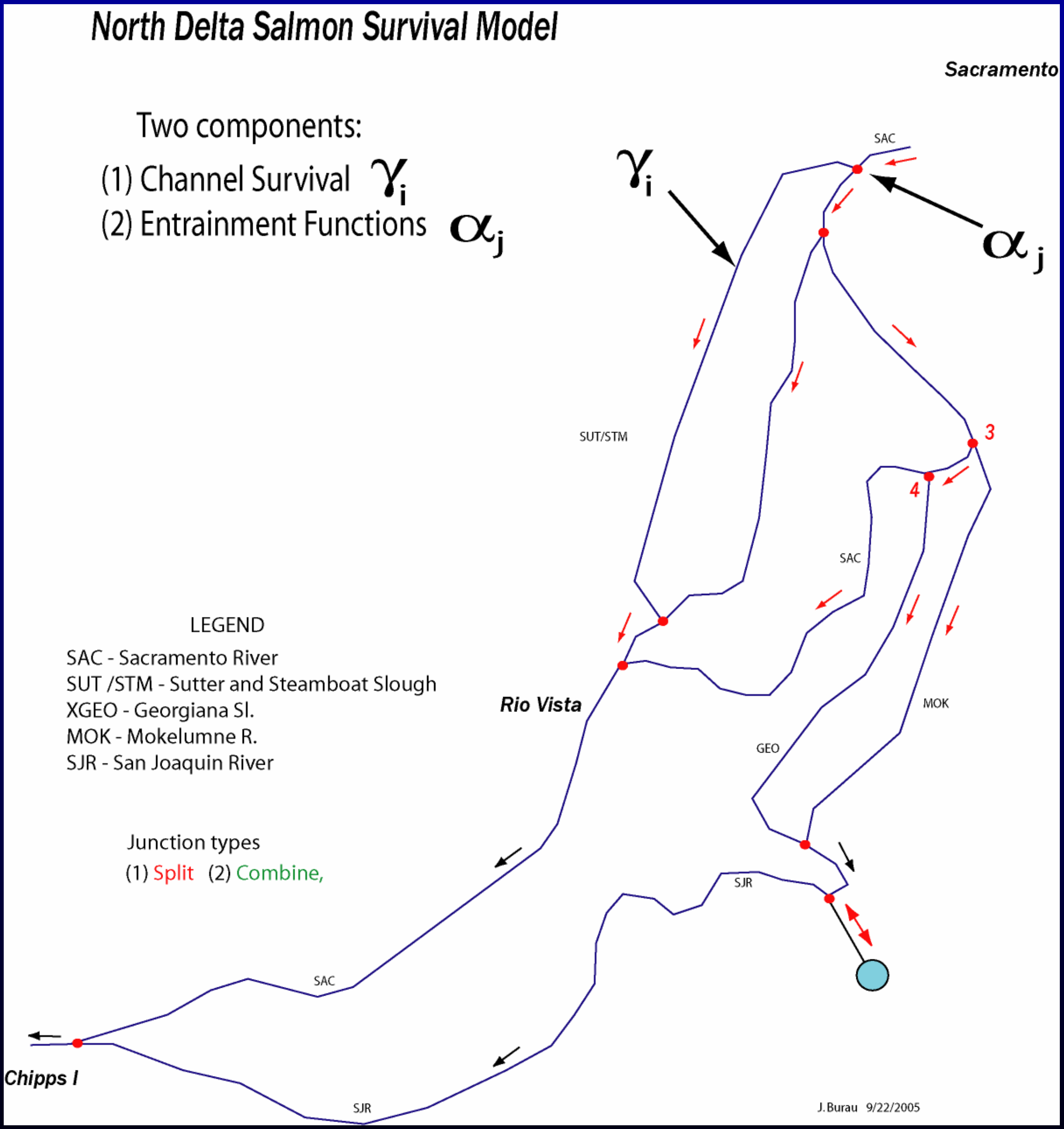
Implication for DCC gate operations

A 24-hr tidal-timescale experiment

will require a 4-day closure to resolve the

effects on the net flows

Conceptual Framework



γ **- Jon**

Survival Rates

Based on exposure time

$$\gamma_i = c_0 - c_1 \frac{\Delta t}{T_{\max}}$$

Travel time

$$\Delta t_i = L_i / v_i$$

Velocity estimate

$$v_i = \frac{Q_i}{A_i}$$

Mortality Rate

$$\beta_i = 1 - \gamma_i$$

Building salmon survival model

(Step 2)

Entrainment Functions

Entrainment function

Based on Ratio of the discharges

$\varepsilon = 0$ **Fish go with the flow**

$$\begin{cases} \varepsilon \geq 0 & \alpha_k = \dfrac{Q_{j_{k,1}}}{Q_{j_{k,0}}} + \left(1 - \dfrac{Q_{j_{k,1}}}{Q_{j_{k,0}}}\right) * \varepsilon \\ \varepsilon < 0 & \alpha_k = \dfrac{Q_{j_{k,1}}}{Q_{j_{k,0}}} * \left(1 - abs(\varepsilon)\right) \end{cases}$$

Big Question: $\varepsilon = f(?????)$

Accounting

Keeping track of where fish go and where they die

(1) Split junction, k

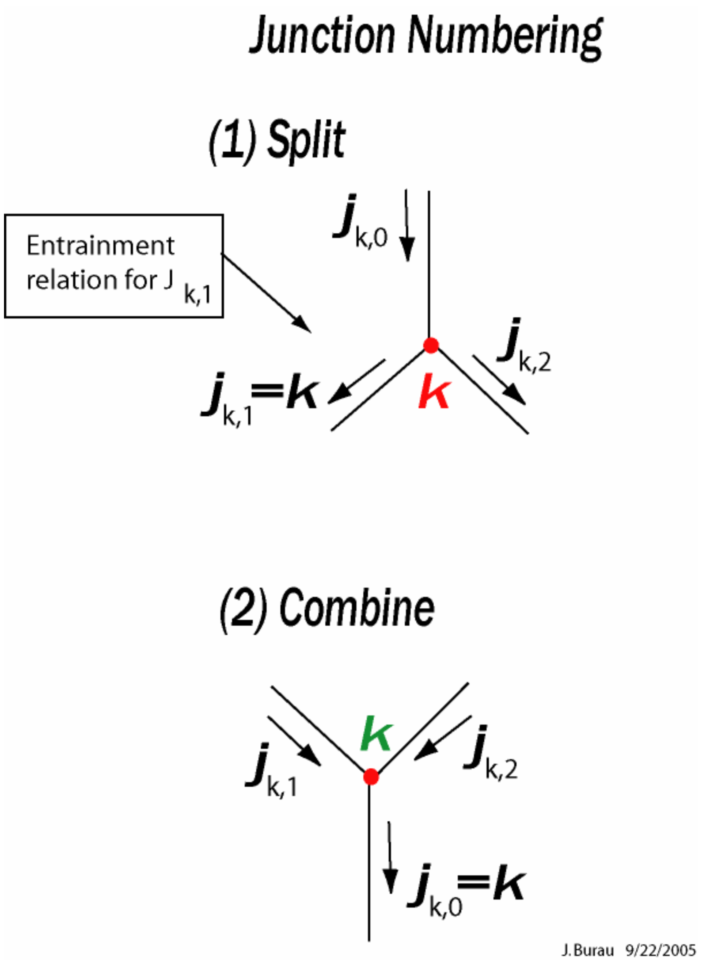
$$N_{j_{k,1},1} = \alpha_{j_{k,1}} N_{j_{k,0},2} \qquad N_{j_{k,1},2} = \gamma_{j_{k,1}} N_{j_{k,1},1} \qquad M_{j_{k,1}} = \beta_{j_{k,1}} N_{j_{k,1},1}$$

$$N_{j_{k,2},1} = (1-\alpha_{j_{k,1}}) N_{j_{k,0},2} \qquad N_{j_{k,2},2} = \gamma_{j_{k,2}} N_{j_{k,2,},1} \qquad M_{j_{k,2}} = \beta_{j_{k,2}} N_{j_{k,2},1}$$

$$N_{j_{k,0},1} = N_{j_{k,1},2} + N_{j_{k,2},2} \qquad N_{j_{k,0},2} = \gamma_{j_{k,0}} N_{j_{k,0},1} \qquad M_{j_{k,0}} = \beta_{j_{k,0}} N_{j_{k,0},1}$$

(2) Combine junction, k

Used Finite element-based number scheme – don’t have to change code to change geometry



Accounting code - simplicity

```
c-----------------------------------------
      subroutine distribute
c-----------------------------------------
c
        do jx = 1,jmx
            k = jord(jx)
             if(jtype(k).eq.1) then
c..............................................Split junction
                        N(j(k,1),1) = a(j(k,1))*N(j(k,0),2)
                        N(j(k,1),2) = g(j(k,1))*N(j(k,1),1)
                        M(j(k,1)) = b(j(k,1))*N(j(k,1),1)
c
                        N(j(k,2),1) = (1.-a(j(k,1)))*N(j(k,0),2)
                        N(j(k,2),2) = g(j(k,2))*N(j(k,2),1)
                        M(j(k,2)) = b(j(k,2))*N(j(k,2),1)
c
              else
c..............................................Combine junction
                        N(j(k,0),1) = N(j(k,1),2) + N(j(k,2),2)
                        N(j(k,0),2) = g(j(k,0))*N(j(k,0),1)
                        M(j(k,0)) = b(j(k,0))*N(j(k,0),1)
              end if
      end do
c
      return
       end
c
```

Fish Model - demo