Impacts of Interior Delta Flows on NMFS Endangered Species Act Listed Species

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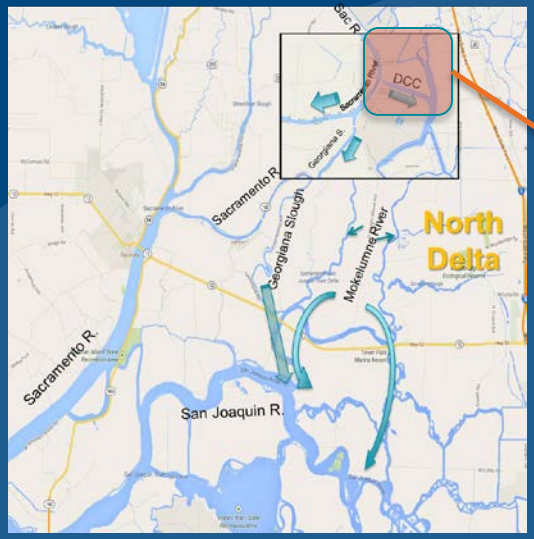
NMFS ESA Listed Species That May be Affected in the Delta

- Sacramento River Winter-run Chinook Salmon Evolutionarily Significant Unit – Endangered
- Central Valley Spring-run Chinook Salmon Evolutionarily Significant Unit – Threatened
- California Central Valley Steelhead Distinct Population Segment – Threatened
- Southern Distinct Population Segment of North American Green Sturgeon - Threatened

NMFS RPA Actions for Protecting Juvenile Fish Outmigrating Through Delta



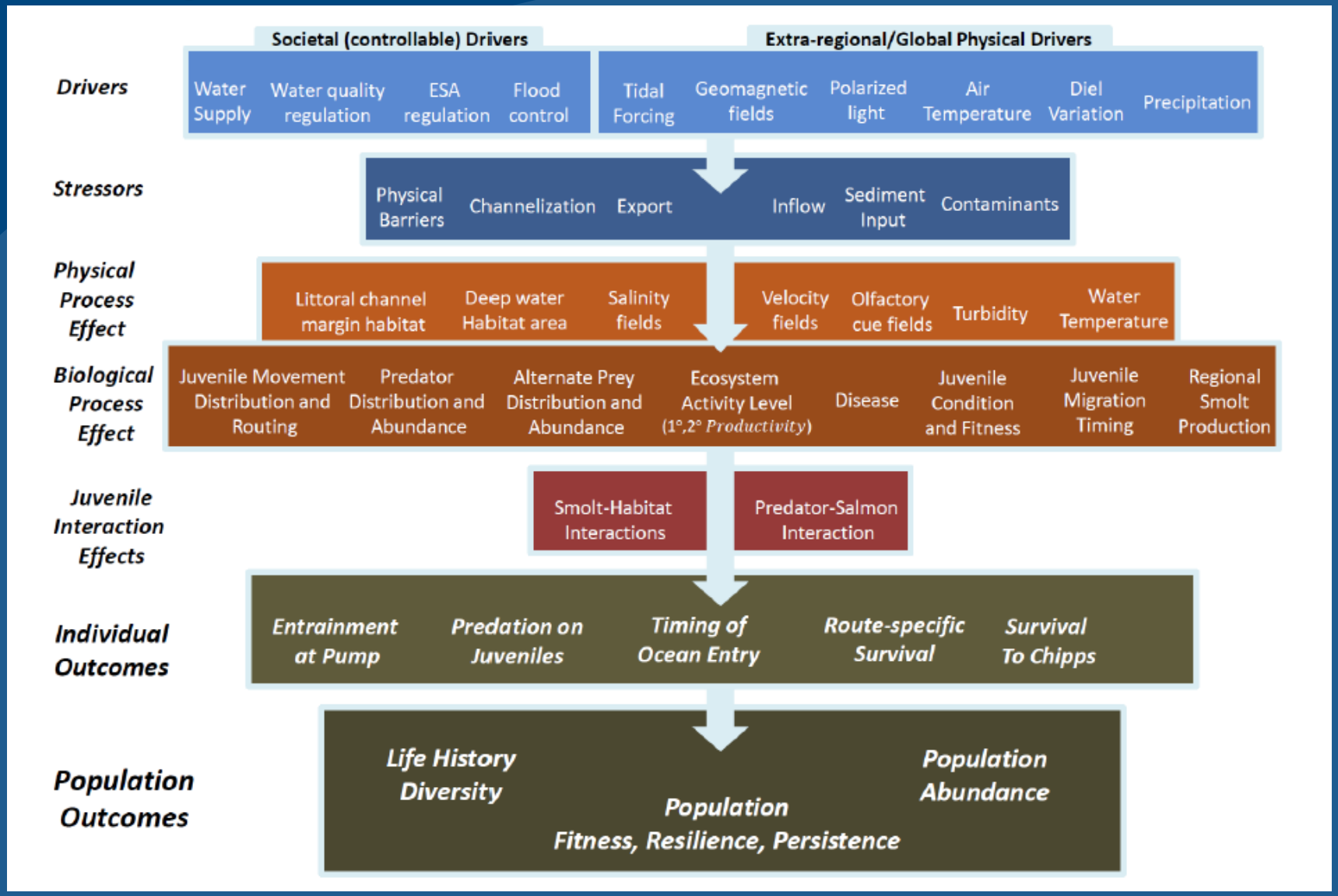
Element	Trigger	Action
DCC Gates	Number of out-migrating fish @ Knights Landing /Sherwood Harbor	Close Gates

Element	Trigger	Action
OMR Flow	Number of salvaged fish	Make OMR flow less negative
Water Export	Number of salvaged fish or SJR flow	Reduce exports

Scientific Support for the RPA Actions

- Large Quantities of Juvenile Fish Entrained to Water Export Facilities
- Juvenile Fish Entrainment Correlated to Water Export or OMR flow
- Lower Juvenile Fish Survival in Entrainment Routes

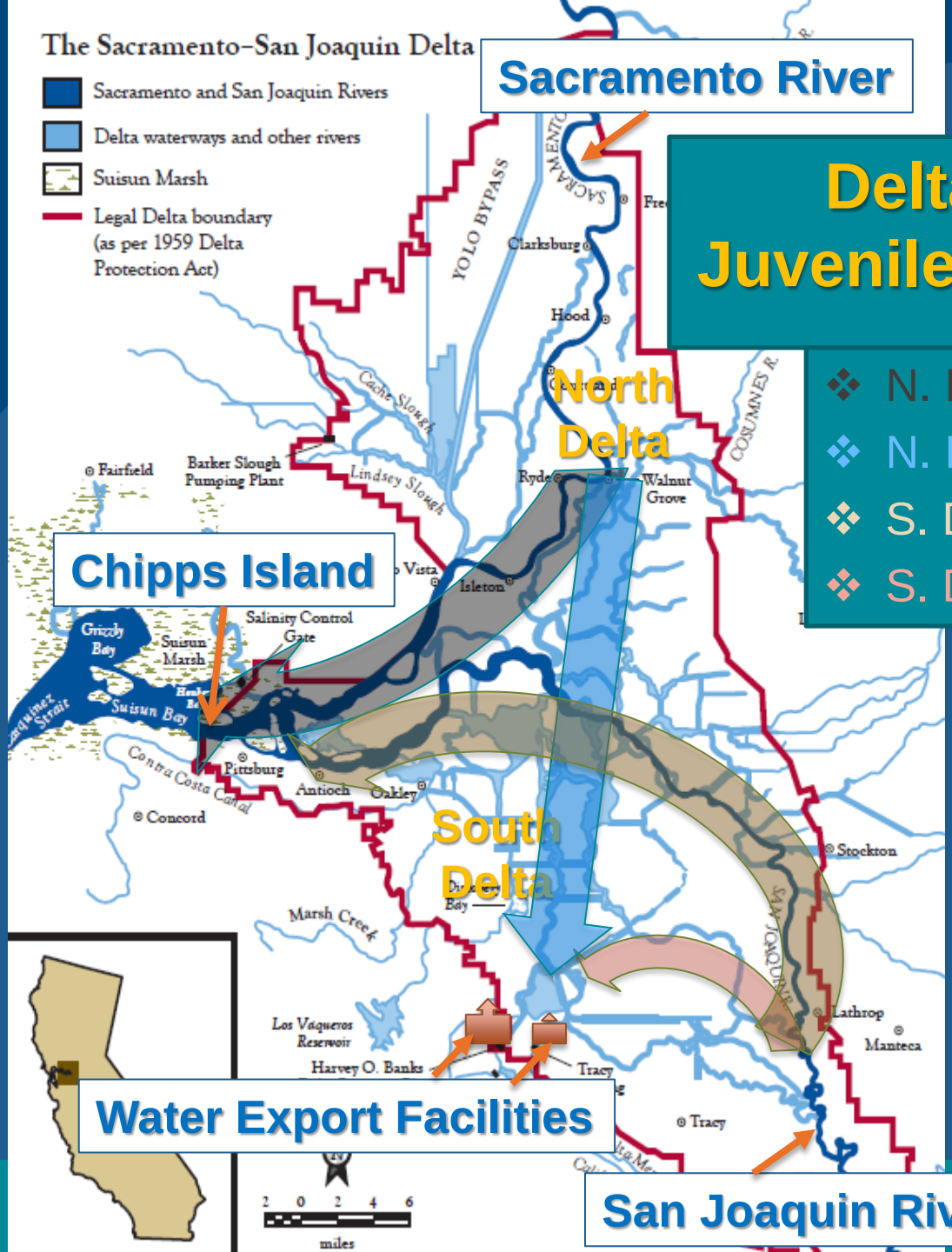
Conceptual Model for Delta Salmonid Juvenile Survival



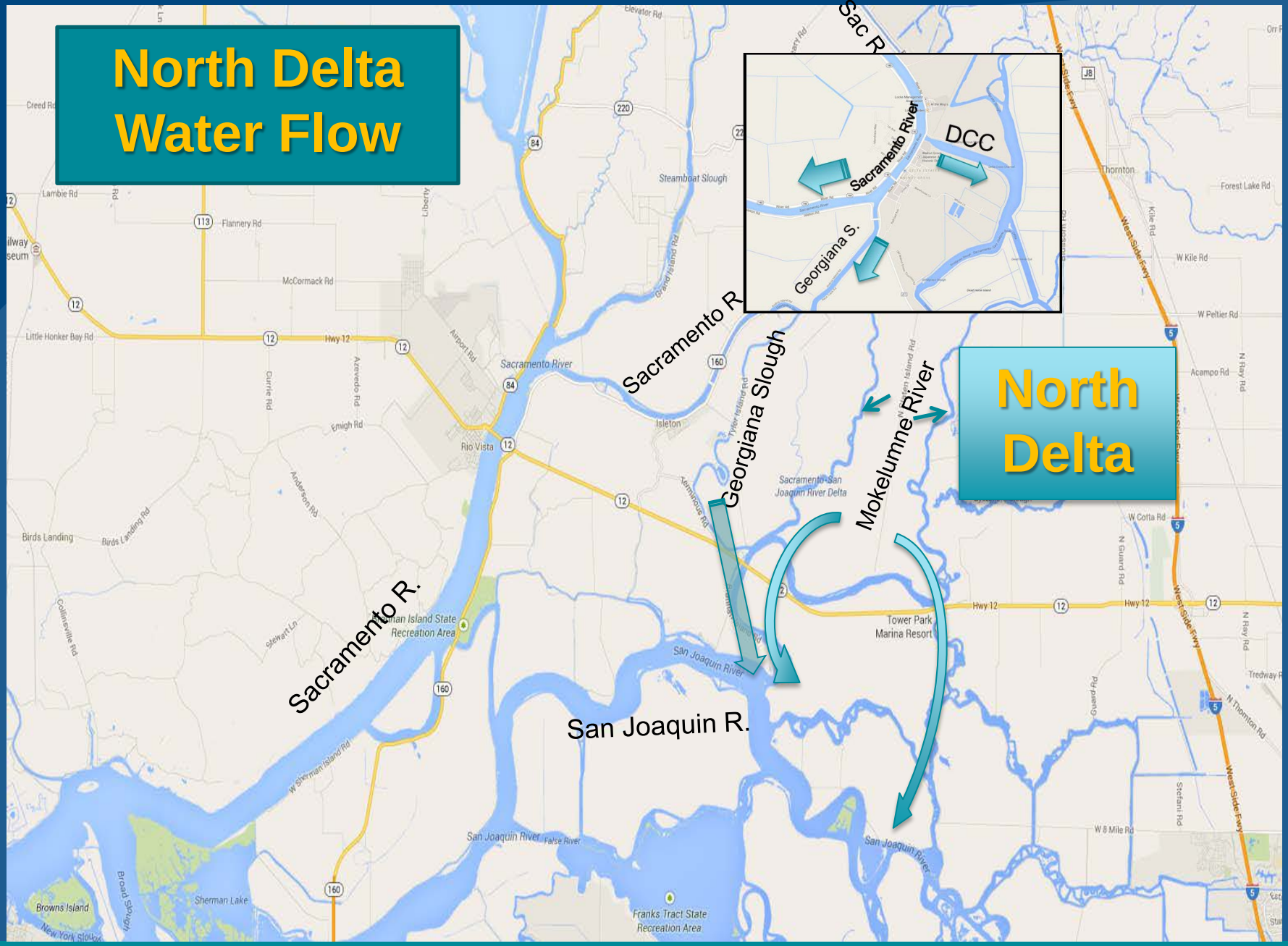
(South Delta Salmonid Research Collaboration 2014)

Delta Water Flow and Juvenile Salmonid Movement

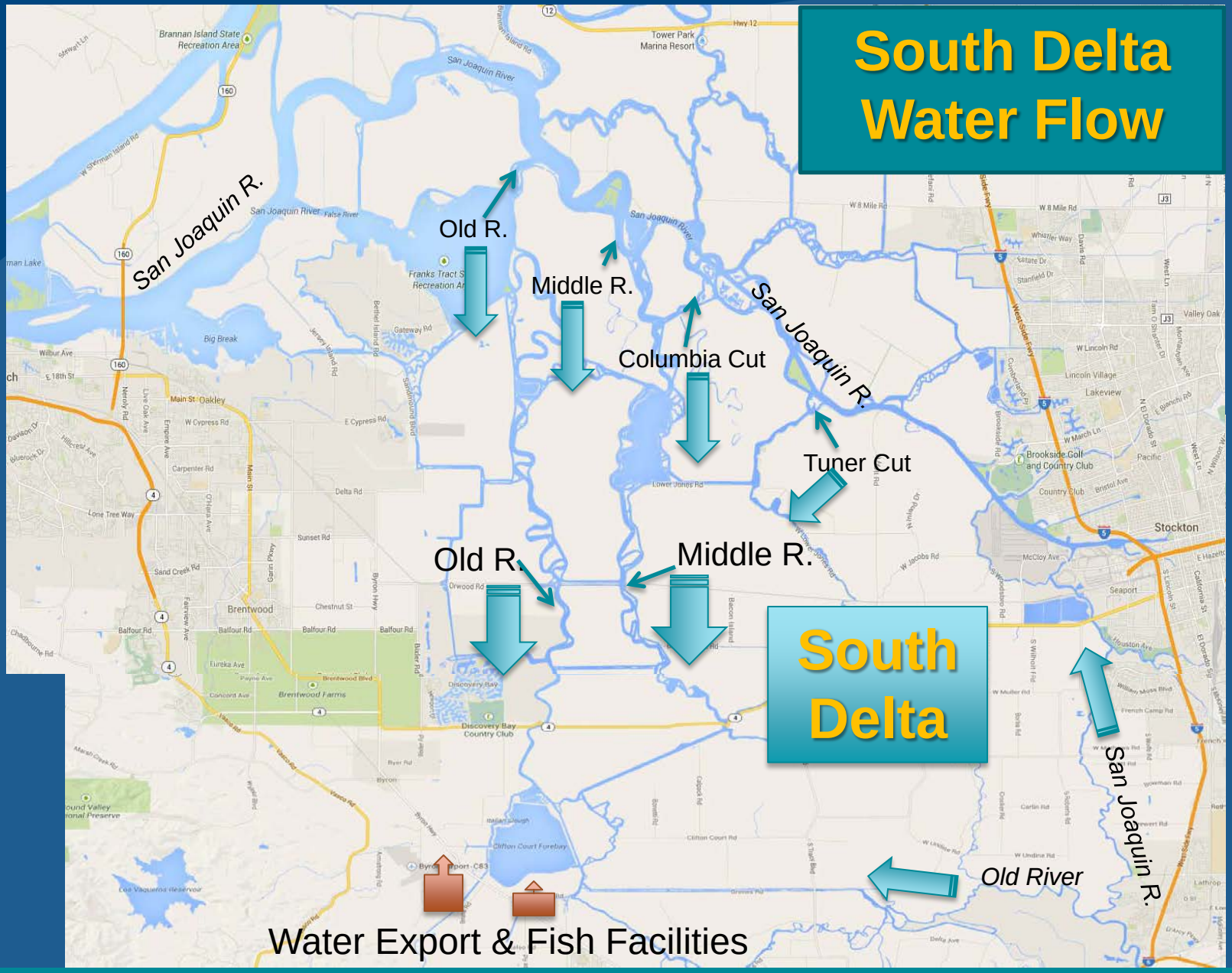
- N. Delta - Chipps Island (CI)
- N. Delta – S. Delta – WEF – CI
- S. Delta - CI
- S. Delta – WEF - CI



North Delta Water Flow

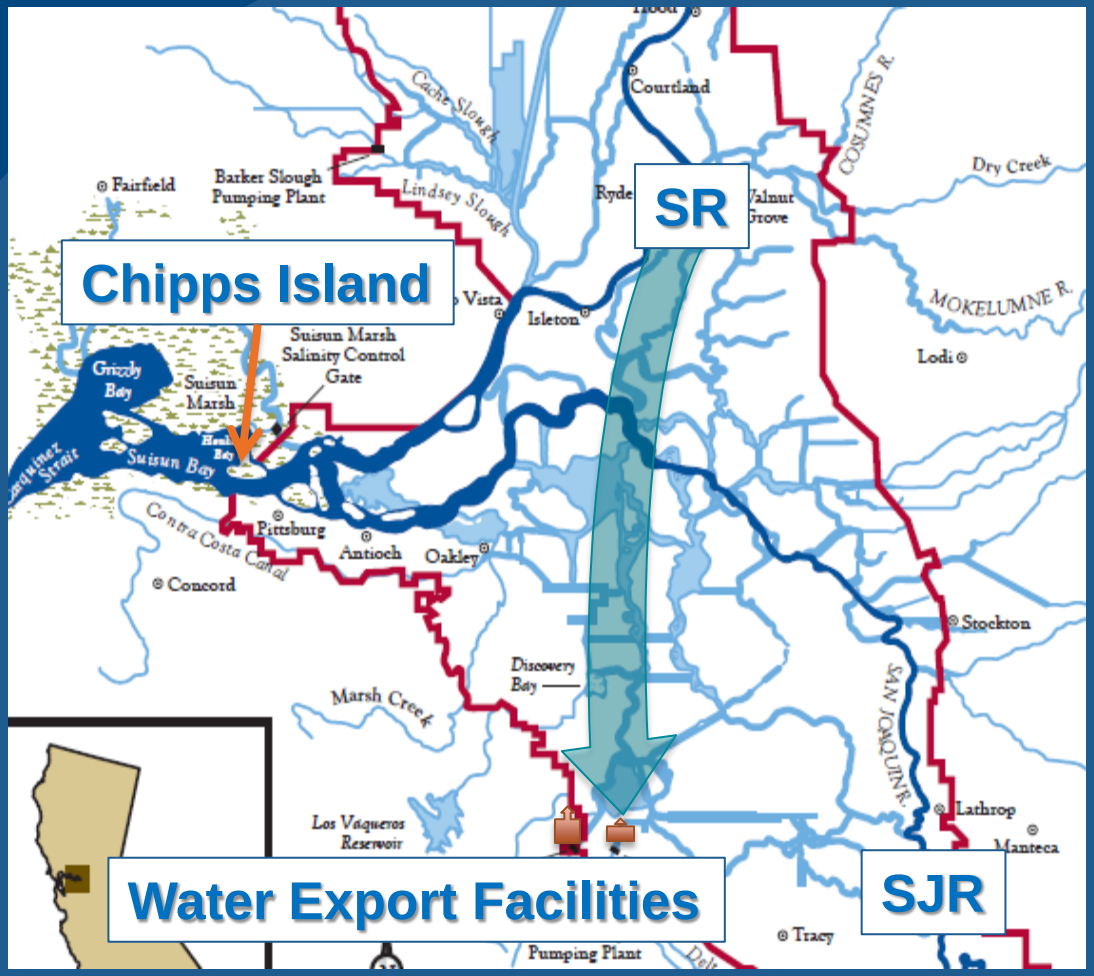


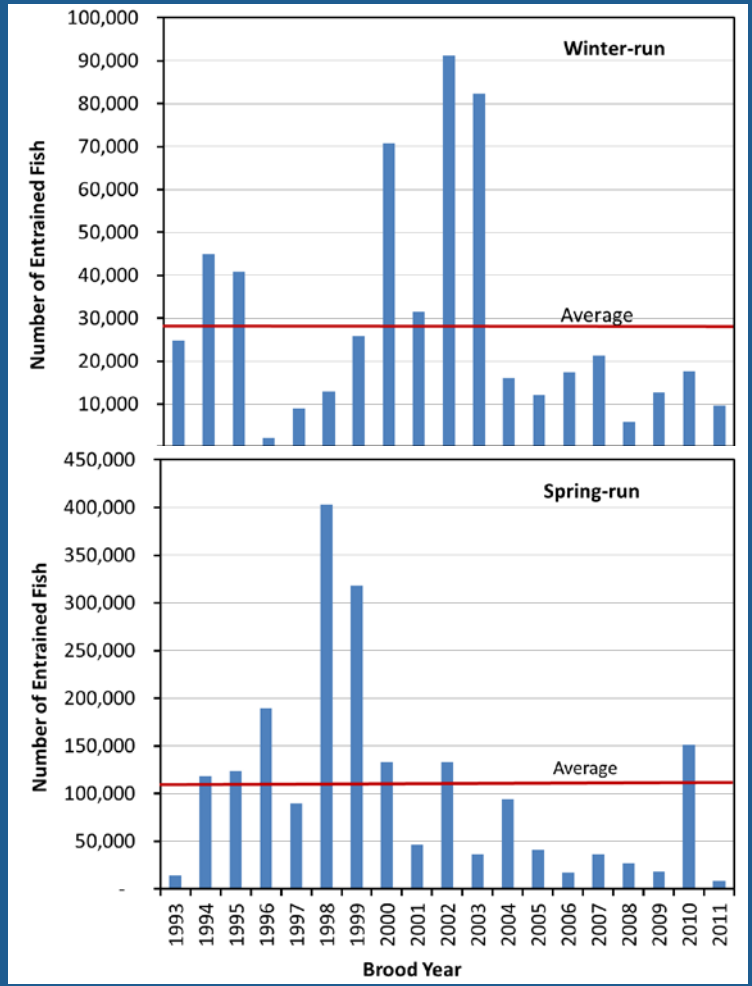
South Delta Water Flow



Juvenile Chinook Entrainment to Water Export Facilities

(Wild and Hatchery)

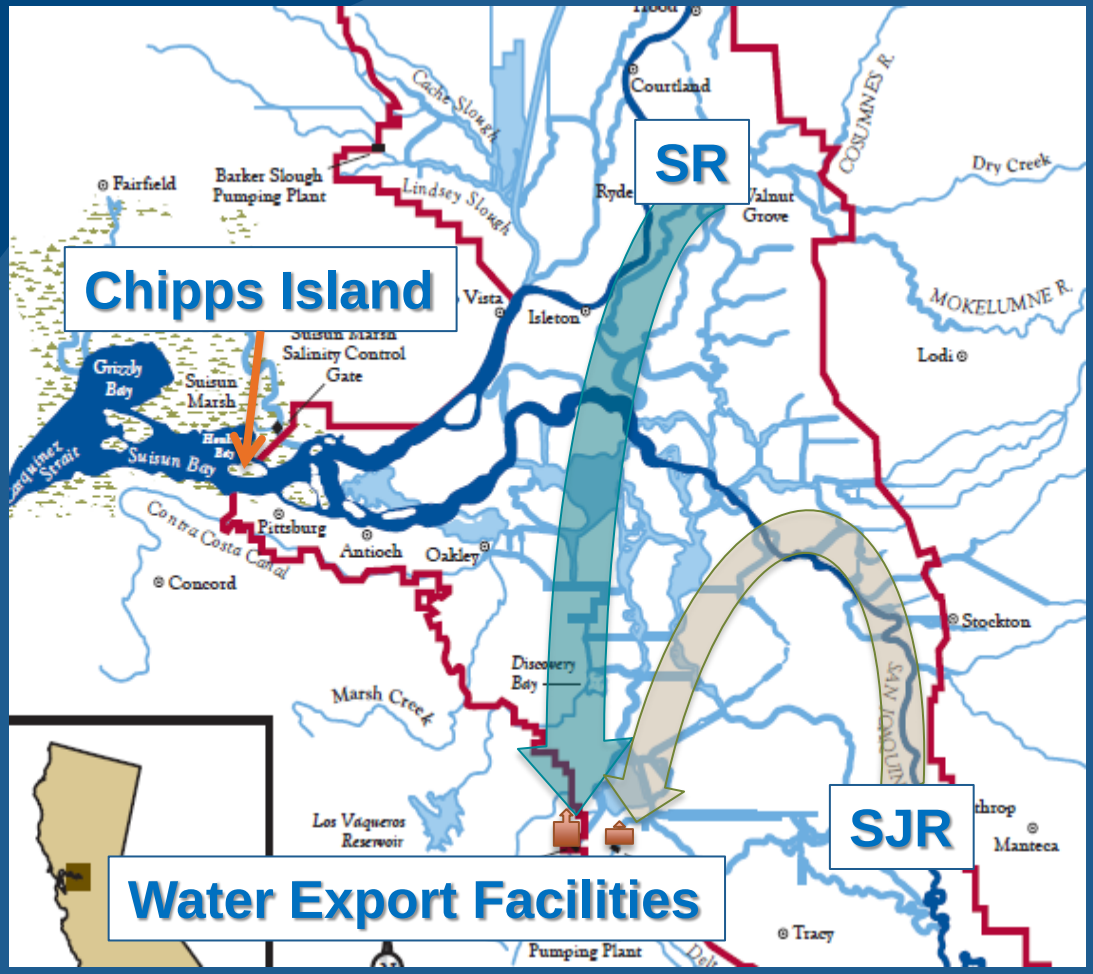


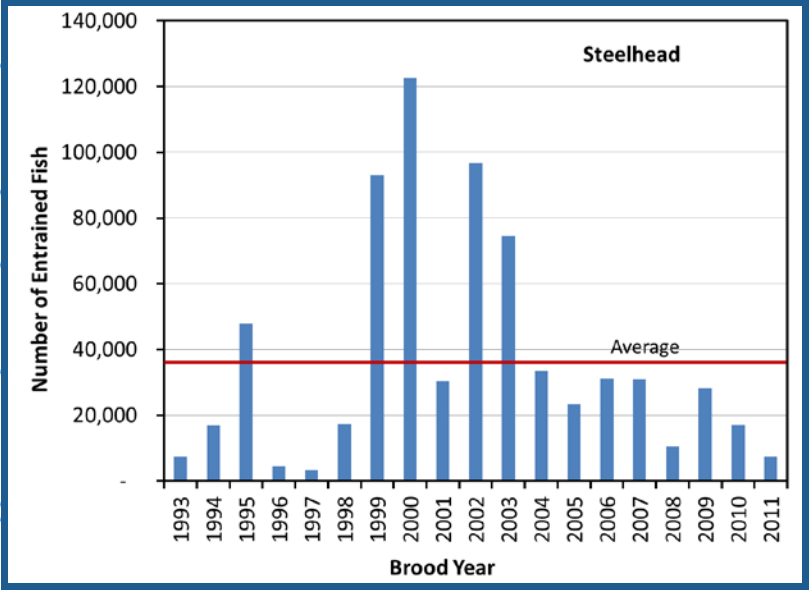


(Entrainment is sum of salvage and loss. Runs are assigned based on the length-at-date method.)

Juvenile Steelhead Entrainment to Water Export Facilities

(Wild and Hatchery)





~90% from SR

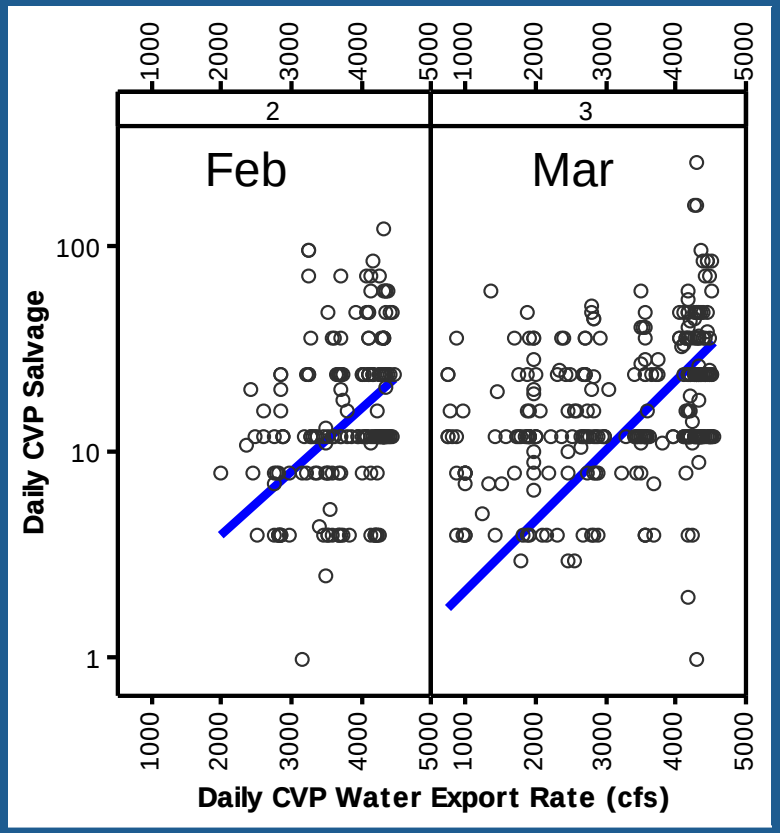
~10% from SJR

(Entrainment is sum of salvage and loss.)

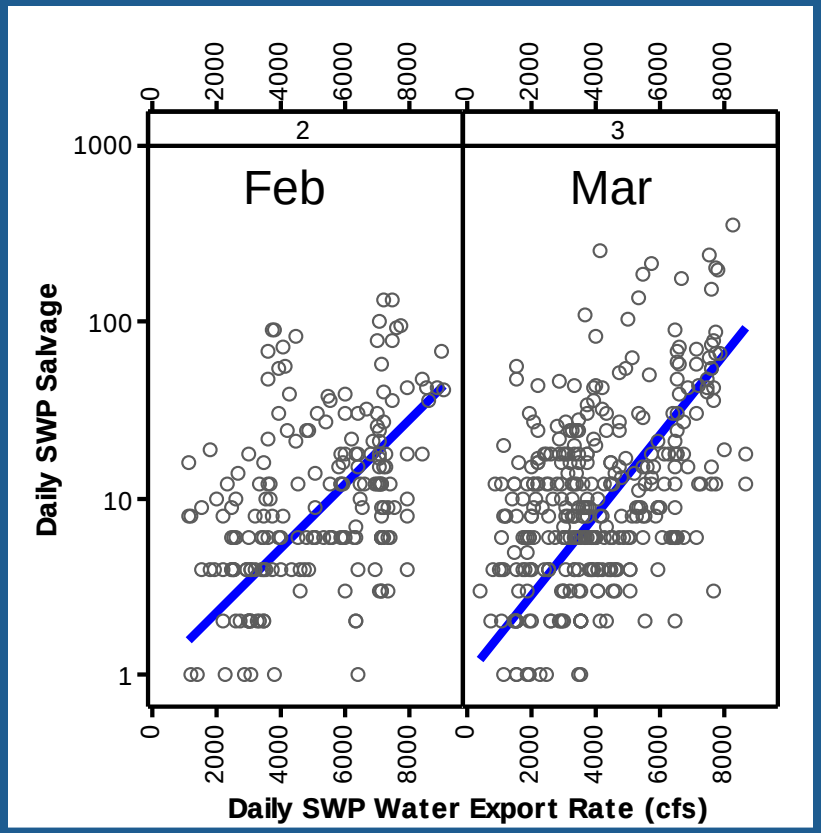
Wild Juvenile Winter-run Chinook Salmon

Daily Salvage Increases with Increasing Water Export

CVP



SWP

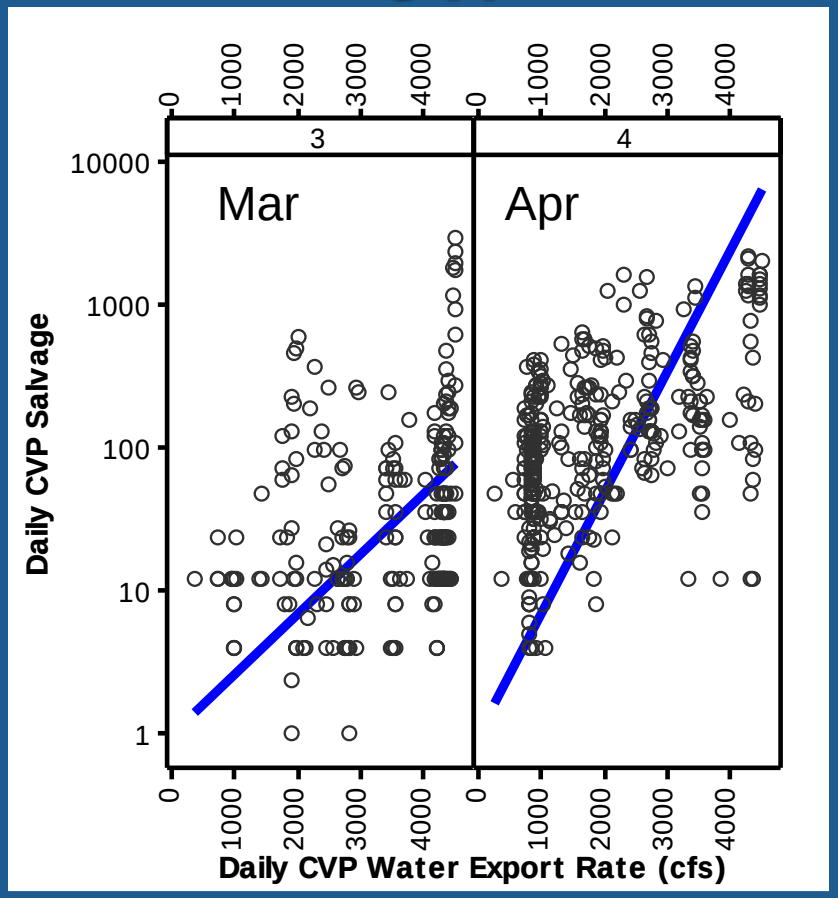


(1993-2011 Data)

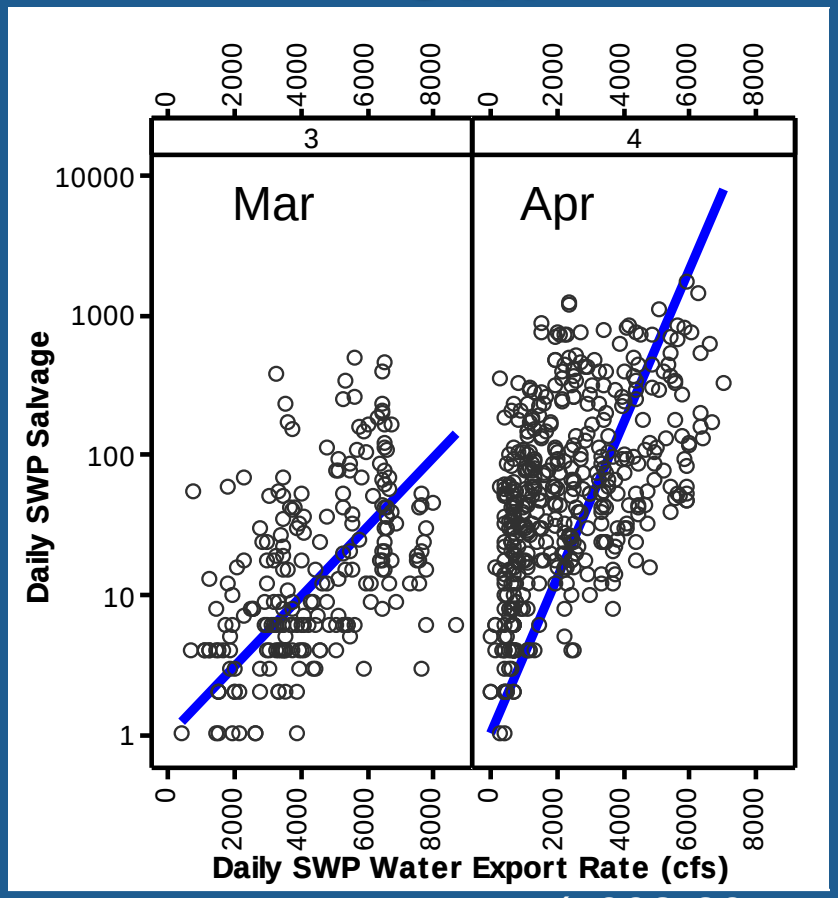
Wild Juvenile Spring-run Chinook Salmon

Daily Salvage Increases with Increasing Water Export

CVP



SWP

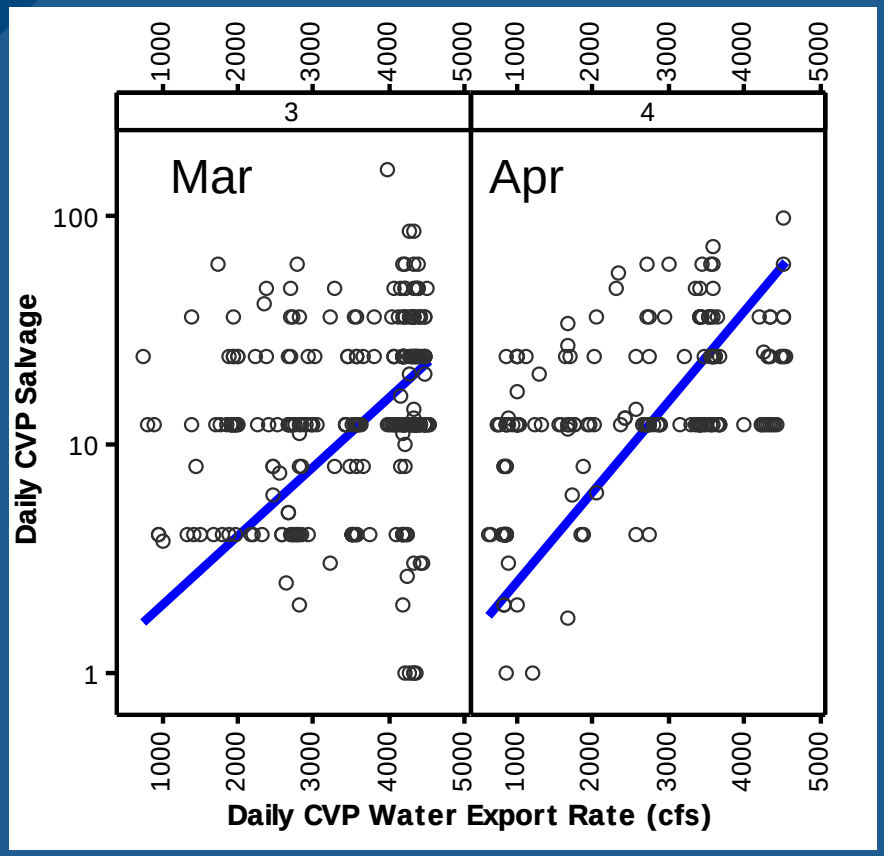


(1993-2011 Data)

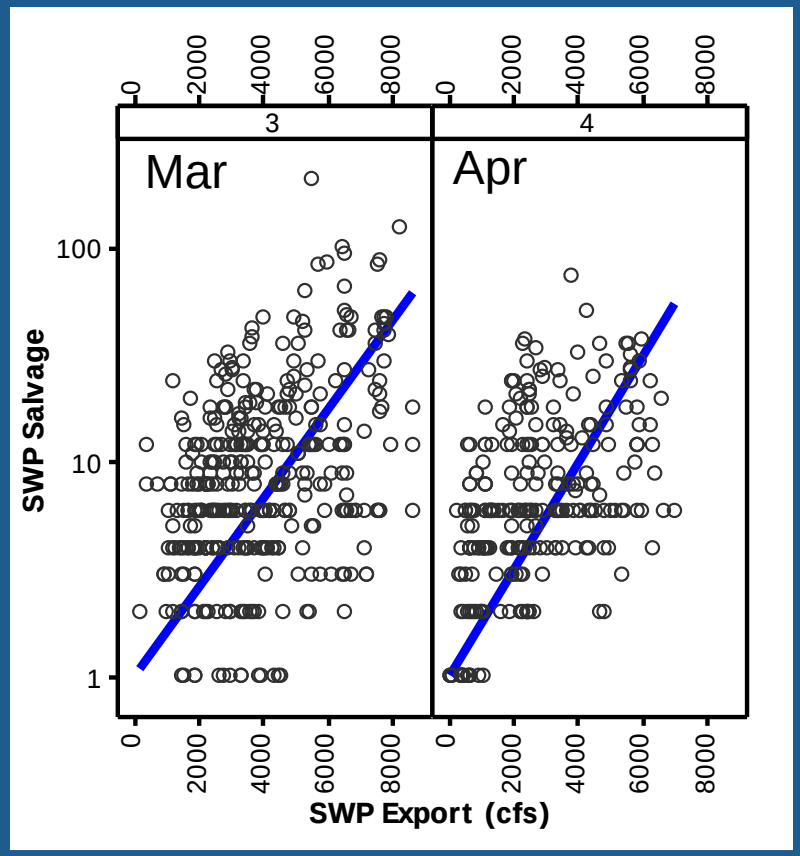
Wild Juvenile Steelhead

Daily Salvage Increases with Increasing Water Export

CVP



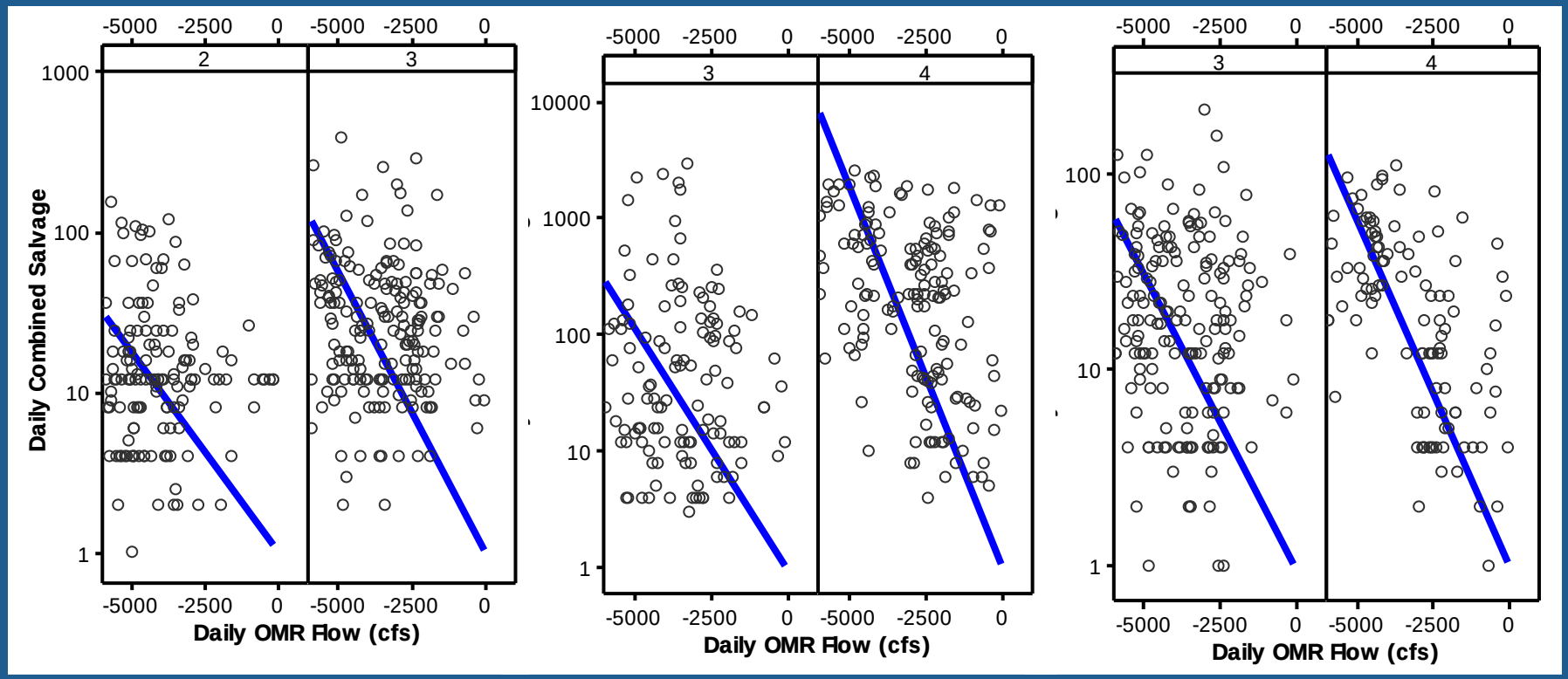
SWP



(1993-2011 Data)

Wild Juvenile Chinook and Steelhead

Daily Salvage Decreases as OMR Flows become Less Negative



(1993-2011 Data)

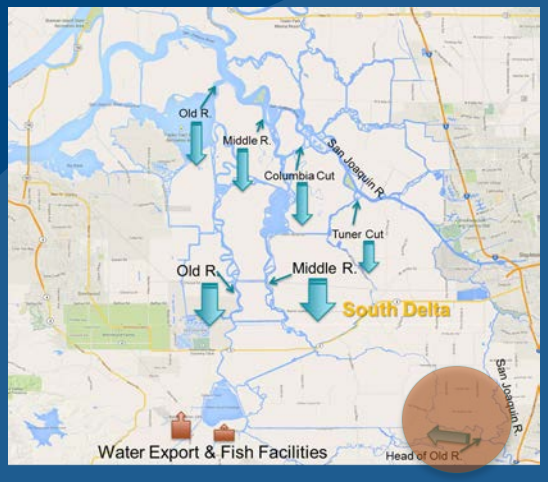
Stepwise Multiple Linear Regression for Salvage

Number of models that selected the "most important" Variables

Variables	Number of Models			
	Winter-run	Spring-run	Steelhead	Total
Water Export (CVP, SWP, or Combined)	12	9	11	32
Delta Juvenile Fish Abundance	11	12	6	29
Tide Height (-)	4	8	3	15
Inflow (Sac River, SJ River (-), or Combined)	2	5	4	11
Delta Outflow	1	5	1	7
SJ River Inflow to Water Export Ratio (-)	2	4	0	6
OMR Flow (-)	1	2	2	5

(1993-2011 Data)

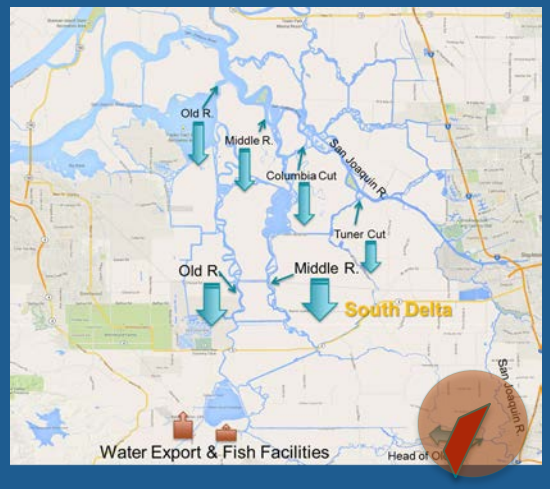
OMR Flow Strongly Correlated to Water Export



Head of Old River Barrier: No

$$Q_{OMR} = -555 - 0.897\ Q_{EXP} + 0.552\ Q_{SJR}$$

$$N = 5815 \quad r^2 = 0.971$$



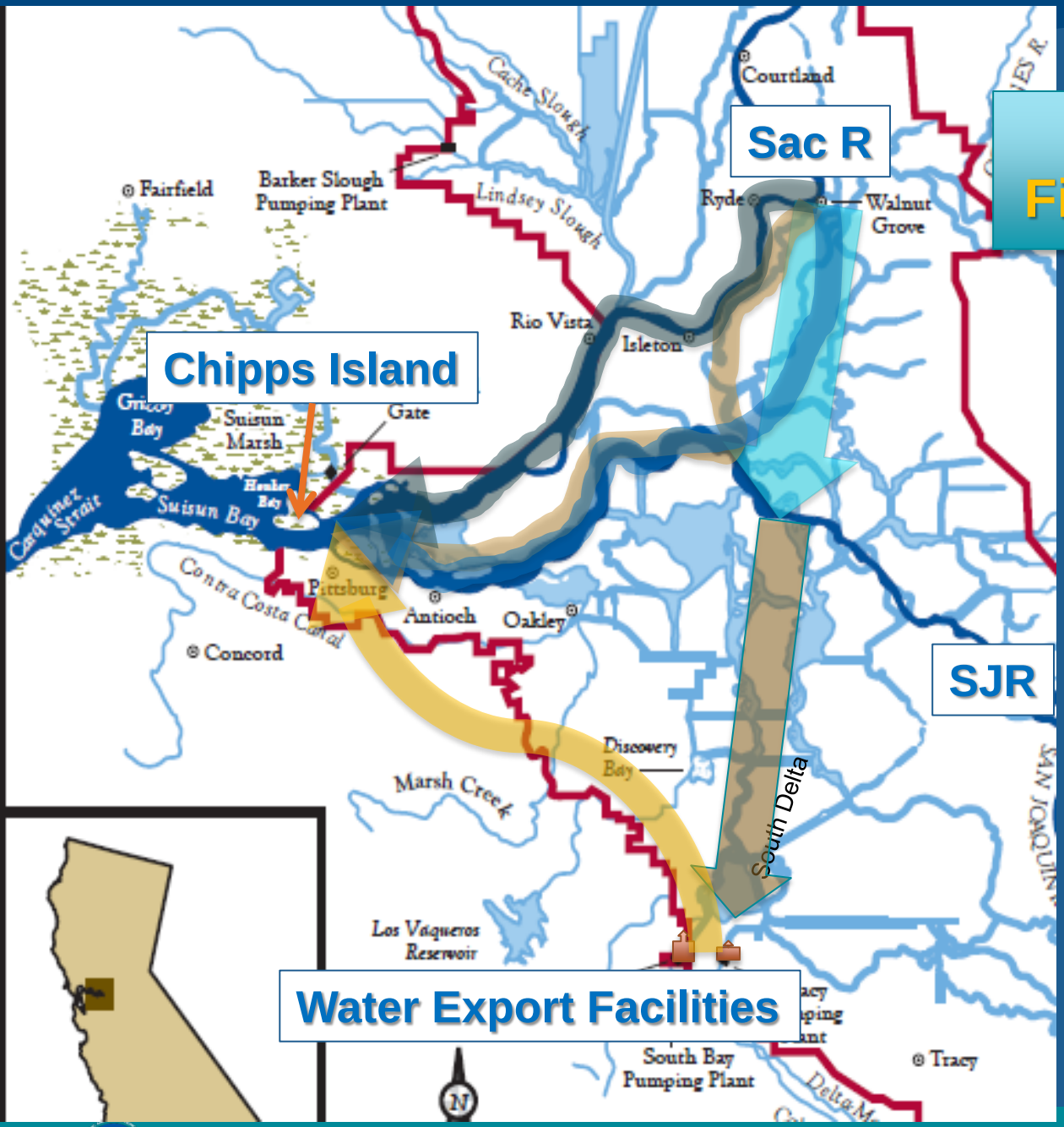
Head of Old River Barrier: Yes

$$Q_{OMR} = -1109 - 0.669\ Q_{EXP} + 0.092\ Q_{SJR}$$

$$N = 230 \quad r^2 = 0.766$$

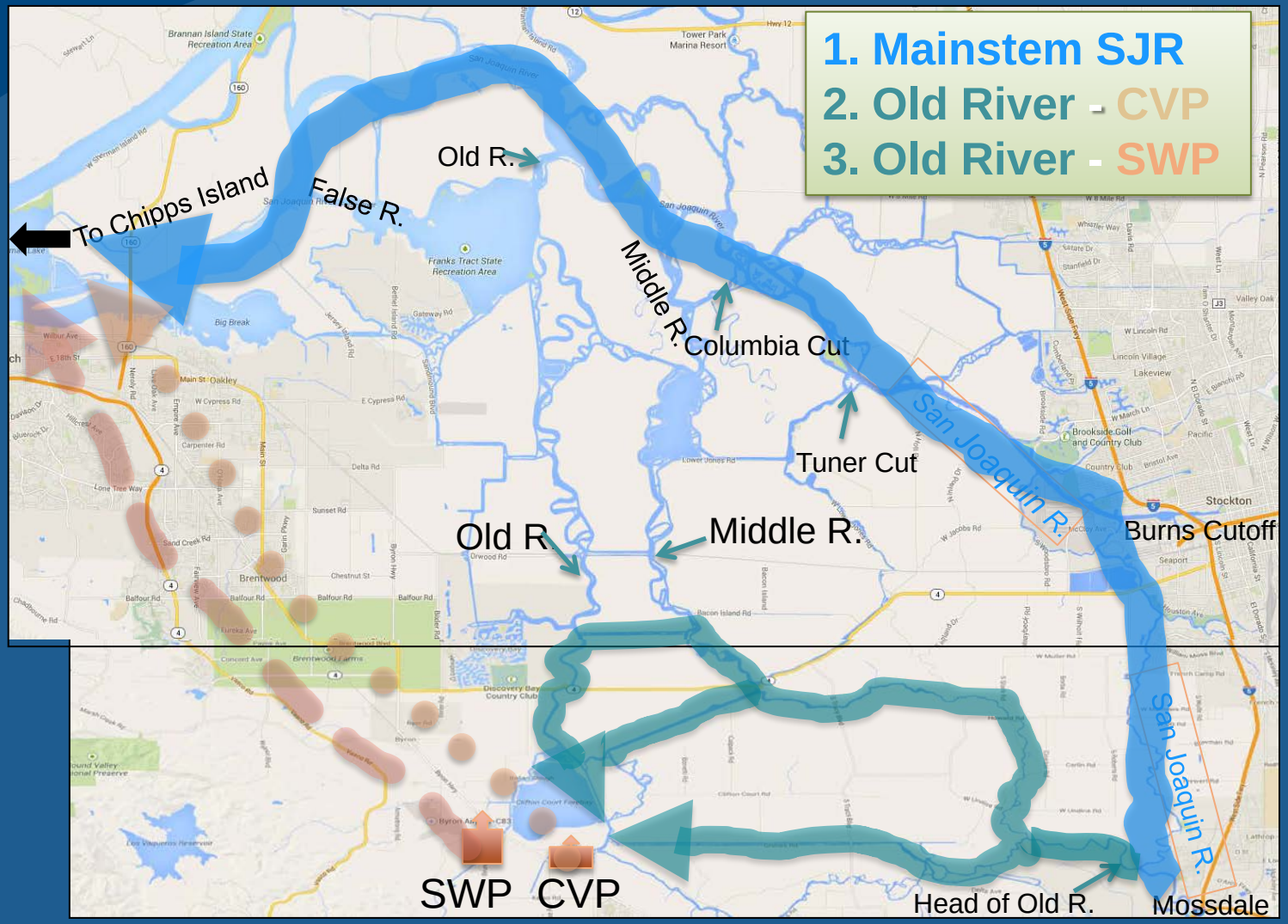
(1987-2012 Data)

Sac River Juvenile Fish Migration Routes



1. Mainstem Sac River
2. Delta Cross Channel
3. Georgiana Slough
4. DCC/GS – OMR – Export Facilities

SJ River Juvenile Fish Migration Routes



Juvenile Chinook Survival to Chipps Island

Area	Route	Survival	
		CWT	AT
North Delta	Mainstem Sac River	0.51 ①	0.40 ③
	Delta Cross Channel	N/A	0.16 ③
	Georgiana Slough	0.14 ①	0.22 ③
South Delta	Mainstem SJ River	0.39 ②	0.01-0.04 ④
	Old River - CVP	0.21 ②	0.03 ④
	Old River - SWP		0.005 ④
N. Delta & S. Delta	DCC/GS - OMR - CVP	N/A	0.04 ⑤
	DCC/GS - OMR - SWP	N/A	0.01 ⑤

1. USFWS 2001, 2003, 2005, 2007
2. Brandes and McLain 2001
3. Perry 2010
4. Buchanan 2012, Buchanan *et al*. 2013
5. Estimated

Conclusions

- Large quantities of juvenile salmonids are entrained to water export facilities
- Juvenile fish entrainment increases with increasing water export and Juvenile abundance, and shows an increasing trend as OMR flows become more negative
- Juvenile fish survival decreases from the mainstem Sacramento River to interior North Delta to South Delta
- Measures to reduce juvenile fish entrainment to interior N. Delta and S. Delta (*e.g.*, DCC gates closure and restriction of OMR flow or water export) will increase their overall Delta survival