VAMP and South Delta Salmonid Smolt Survival Studies

Pat Brandes
USFWS – Stockton

With help from
Ken Newman (USFWS),
Rebecca Buchanan (UW) and
Josh Israel (USBR)

Talk Outline

Summarize 30 years of studies in 20 minutes????

Background

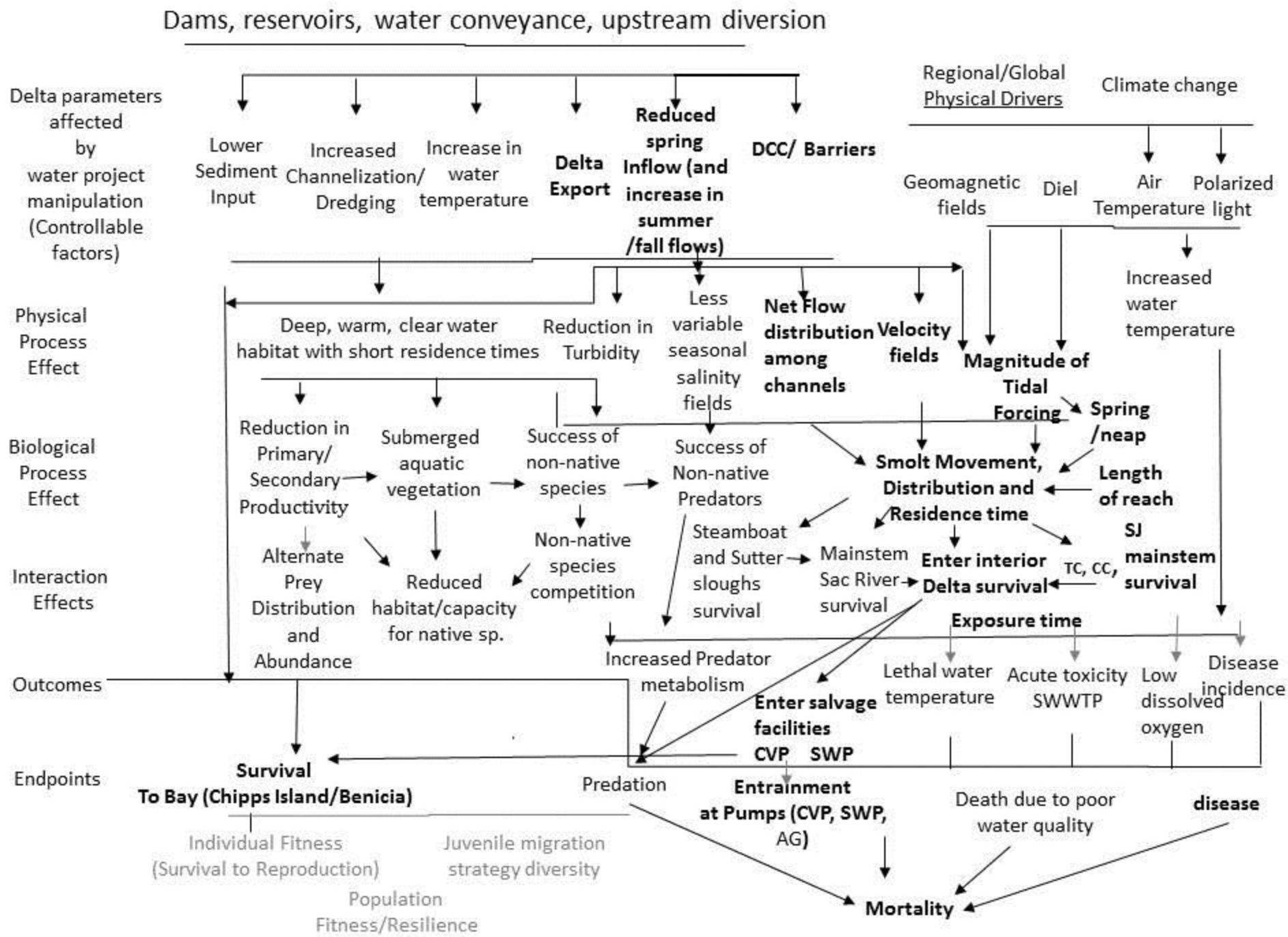
- Conceptual model
- Results of VAMP CWT studies with HORB
- Historical estimates of Delta survival

Modeling of CWT data – VAMP and pre-VAMP

Results of 2008, 2009, 2010, 2011 - VAMP

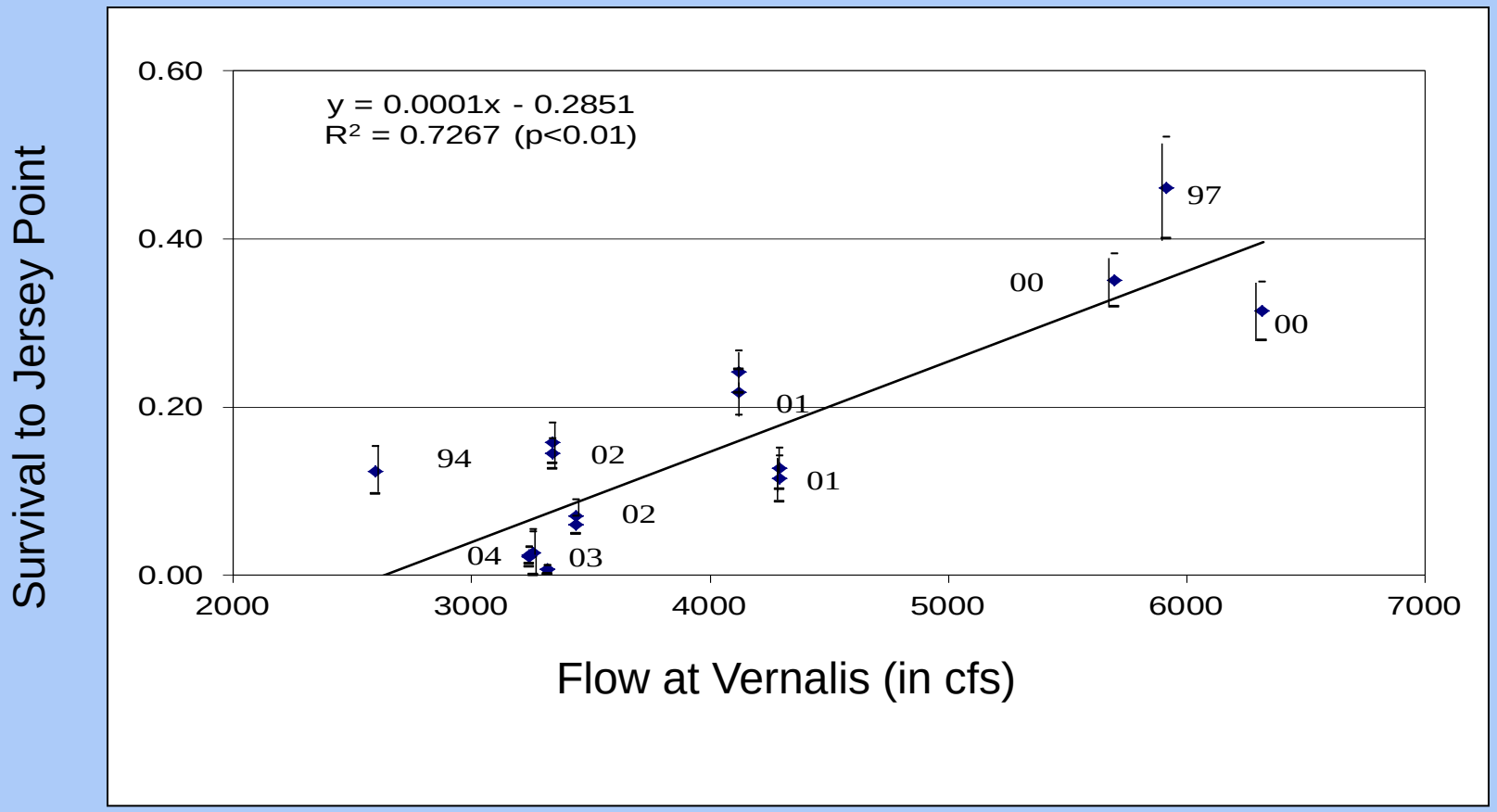
Results of 2012 Chinook and 2011 and 2012 steelhead acoustic studies

Lessons learned - Next steps


Dams, reservoirs, water conveyance, upstream diversion
Delta parameters affected by water project manipulation (Controllable factors)
Lower Sediment Input
Increased Channelization/ Dredging
Increase in water temperature
Delta Export
Reduced spring Inflow (and increase in summer /fall flows)
DCC/ Barriers
Regional/Global Physical Drivers
Climate change
Geomagnetic fields
Diel
Air Temperature
Polarized light
Physical Process Effect
Deep, warm, clear water habitat with short residence times
Reduction in Turbidity
Less variable seasonal salinity fields
Net Flow distribution among channels
Velocity fields
Magnitude of Tidal Forcing
Increased water temperature
Spring /neap
Length of reach
Biological Process Effect
Reduction in Primary/ Secondary Productivity
Submerged aquatic vegetation
Success of non-native species
Success of Non-native Predators
Smolt Movement, Distribution and Residence time
Interaction Effects
Alternate Prey Distribution and Abundance
Reduced habitat/capacity for native sp.
Non-native species competition
Steamboat and Sutter sloughs survival
Mainstem Sac River survival
Enter interior Delta survival
TC, CC,
SJ mainstem survival
Exposure time
Outcomes
Increased Predator metabolism
Lethal water temperature
Acute toxicity SWWTP
Low dissolved oxygen
Disease incidence
Enter salvage facilities CVP SWP
Endpoints
Survival To Bay (Chipps Island/Benicia)
Predation
Entrainment at Pumps (CVP, SWP, AG)
Death due to poor water quality
disease
Individual Fitness (Survival to Reproduction)
Juvenile migration strategy diversity
Population Fitness/Resilience
Mortality

VAMP included installation of a Physical Head of Old River barrier (with culvert structure in 2001)

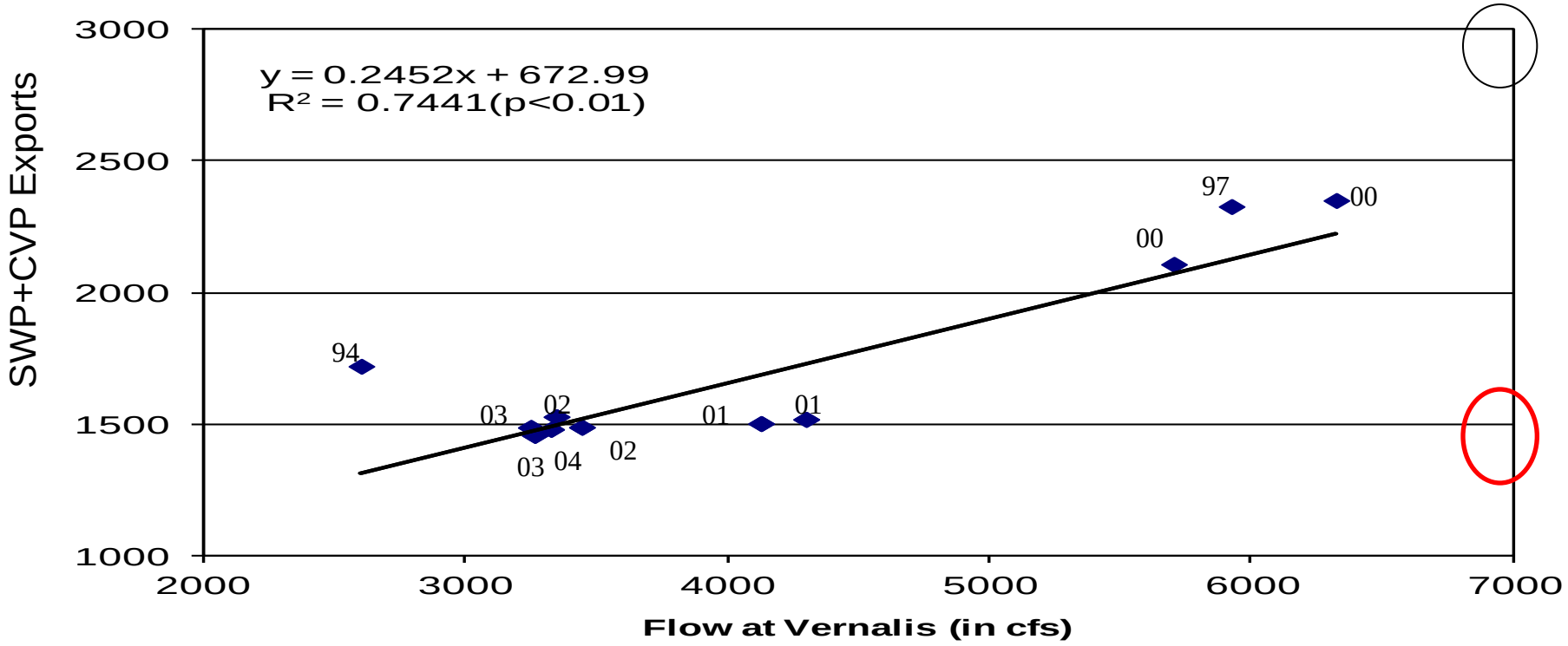
Estimate of survival from Mossdale or Durham Ferry to Jersey Point versus flow at Vernalis with a physical HORB (pre-VAMP and VAMP).



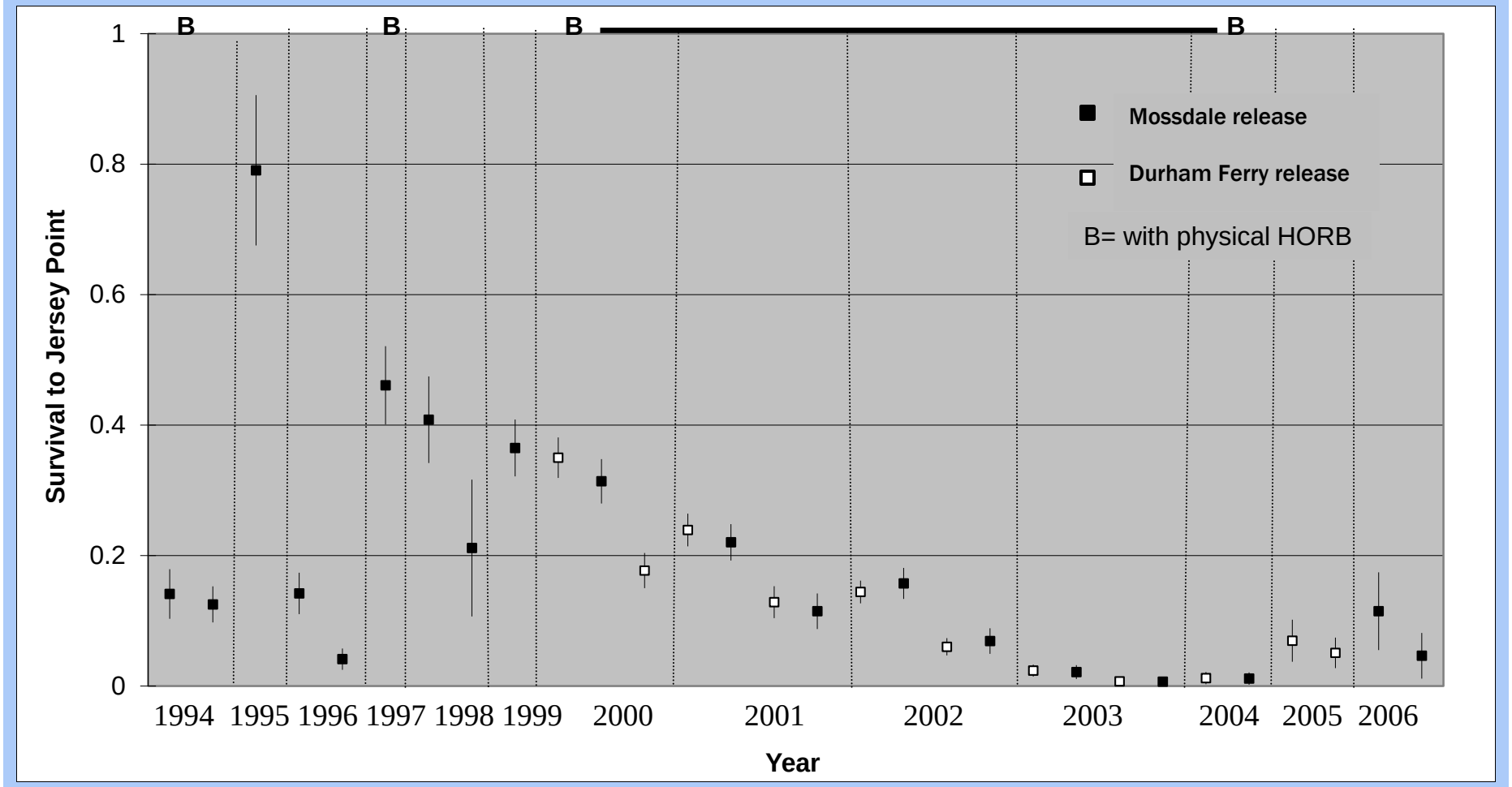
Recoveries made at Chipps Island, Antioch and in ocean fishery

Source: SJRG, 2007 – 2006 VAMP Annual Report

Flows and Exports with HORB during VAMP



Estimates of smolt survival (+/- 2 SE) from Mossdale or Durham Ferry to Jersey Point with or without HORB



Source Brandes et al., 2008. VAMP summary report, Ocean recoveries for 2004-2006 not included

Survival from Mossdale (with HORB) or Dos Reis to Jersey Point at four different ranges of flow

Survival appears to be decreasing over time for any one flow level

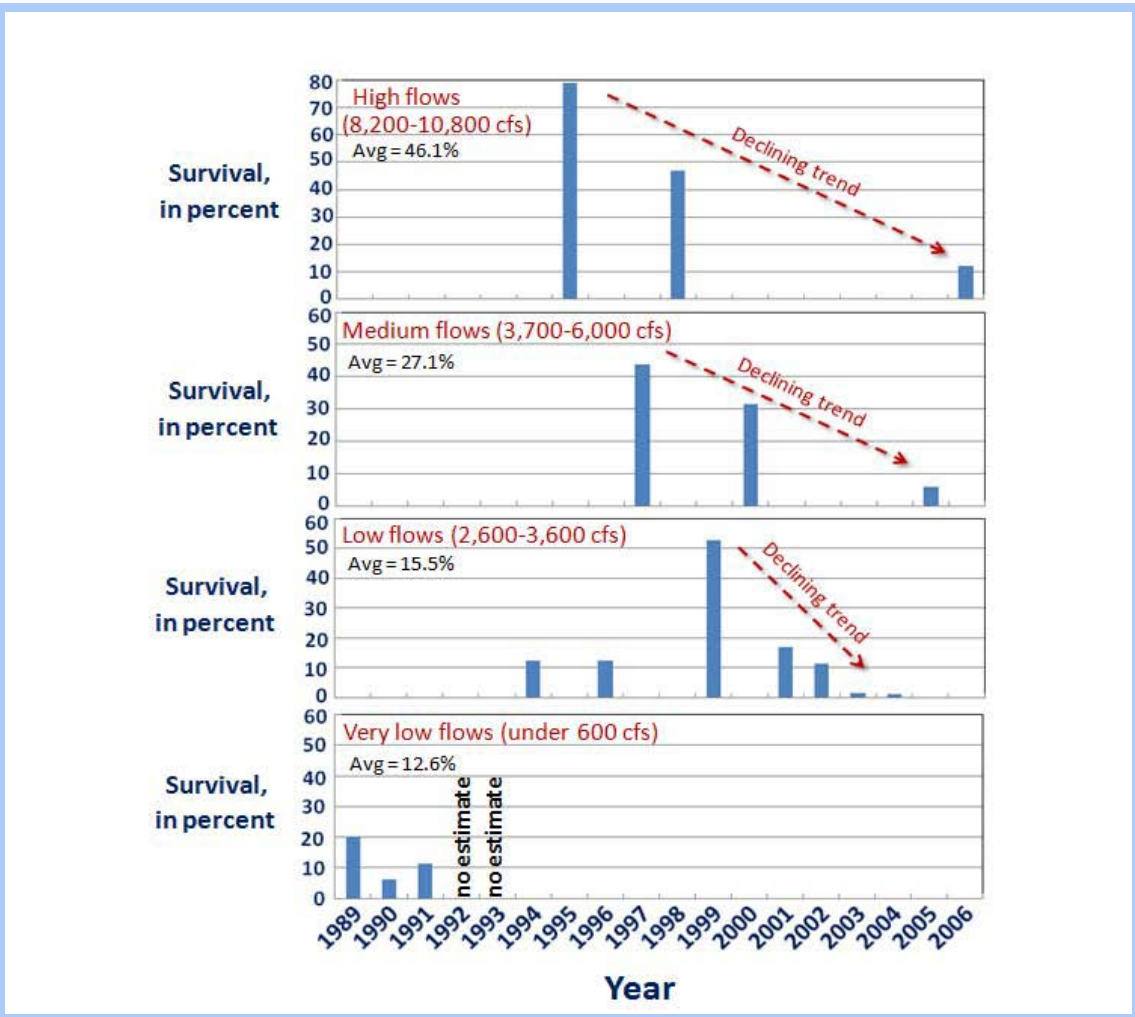
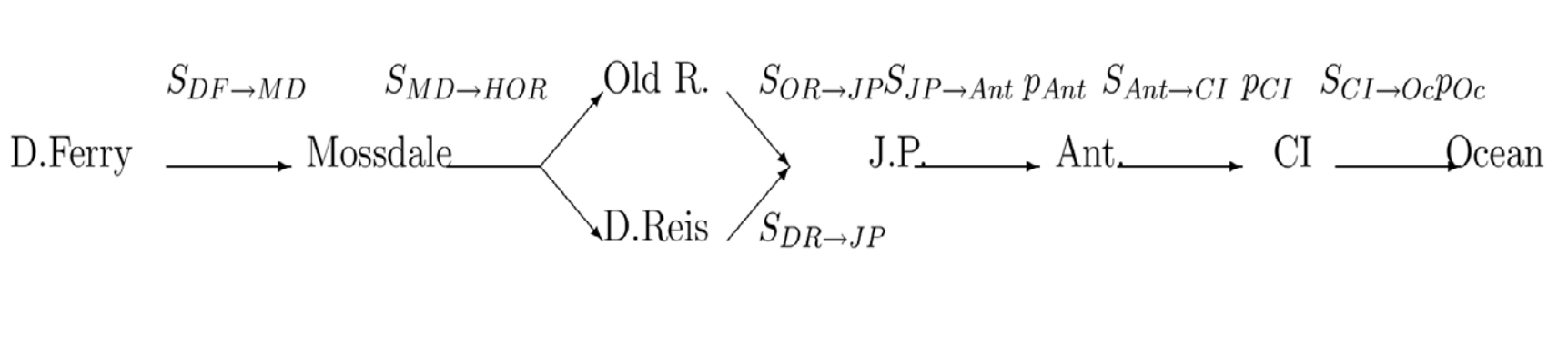


Figure 8: from 2010 VAMP Peer Review Panel Report

CWT Model: Paths+probabilities



Data used: 35 release recovery sets between 1985 and 2006

within sets
- various release locations (i.e. Durham Ferry, Mossdale, Dos Reis, Old River and Jersey Point)
- various recovery locations (i.e. Antioch (since 2000), Chipps Island, ocean fishery)

212 observations

Used Bayesian Hierarchical Models – incorporates various levels of uncertainty

Source: Newman, handout to peer review panel, 3/2010

Focus On Models For Survival Down San Joaquin And Survival Down Old River

$$E[logit(S_{DR \to JP})] = \xi_0 + \xi_1 \text{Flow}_{Dos.Reis} + \xi_2 \text{Exports}_{Dos.Reis}$$
$$E[logit(S_{OR \to JP})] = \zeta_0 + \zeta_1 \text{Flow}_{OldRiver} + \zeta_2 \text{Exports}_{Dos.Reis}$$

Model Probabilities for four different models

Models	$S_{MD \to JP}$	$S_{OR \to JP}$
Constant	0.38	0.45
Flow	0.29	0.23
Exports	0.17	0.21
Both	0.16	0.11

MD -> JP = DR-> JP, assume 100% survival between MD ->DR

Source: Newman, handout to peer review panel, 3/2010

Parameters corresponding to Flow and Exports for the four averaged models

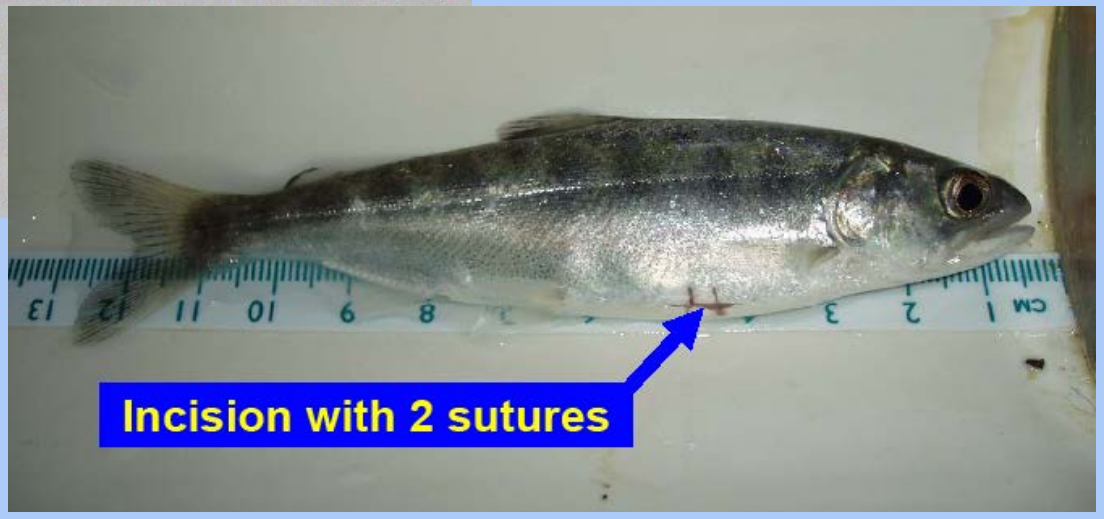
Covariate	Average	SD	2.5%	median	97.5%
SJ-flow	0.16	0.25	-0.09	0.0	0.77
SJ-exports	0.07	0.19	-0.17	0.0	0.61
OR-flow	0.04	0.22	-0.42	0.0	0.62
OR-exports	0.04	0.20	-0.32	0.0	0.60

"Strongest" effect: increases in San Joaquin flow increases survival in San Joaquin River route

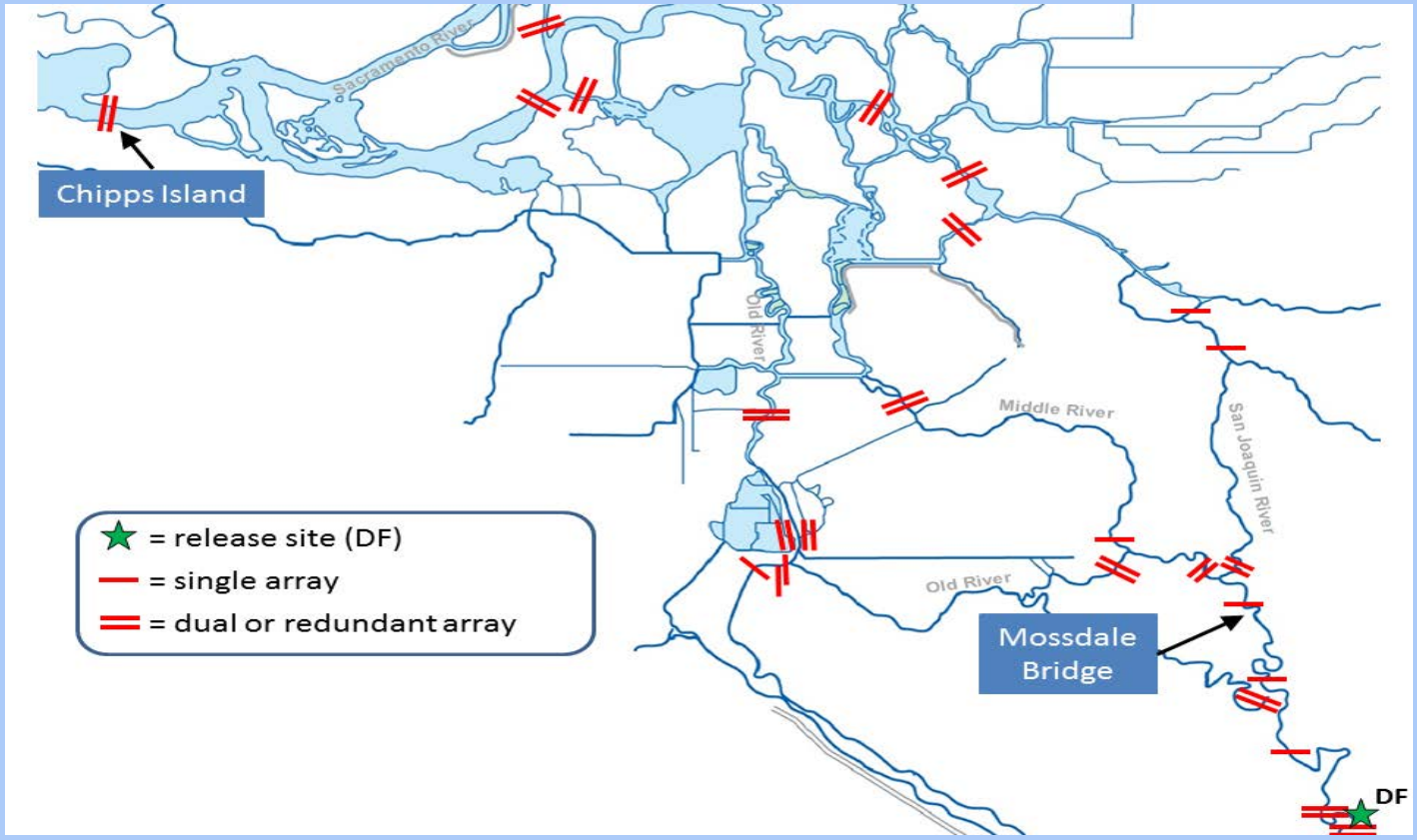
Key finding: Usually higher survival if stay in San Joaquin River than if go down Old River - but lots of environmental variation

Source: Newman, handout to peer review panel, 3/2010

Transition to acoustic tags to estimate survival



Receiver Array and release sites for VAMP in 2011
Similar receiver network in 2012-2014



2006, 2007: Pilot

2008: receivers at JP and CI but premature tag failure - potential bias

2009; no receivers at JP or CI

2010: No receivers at JP in 2010 (supplemental releases at Stockton and in Old River)

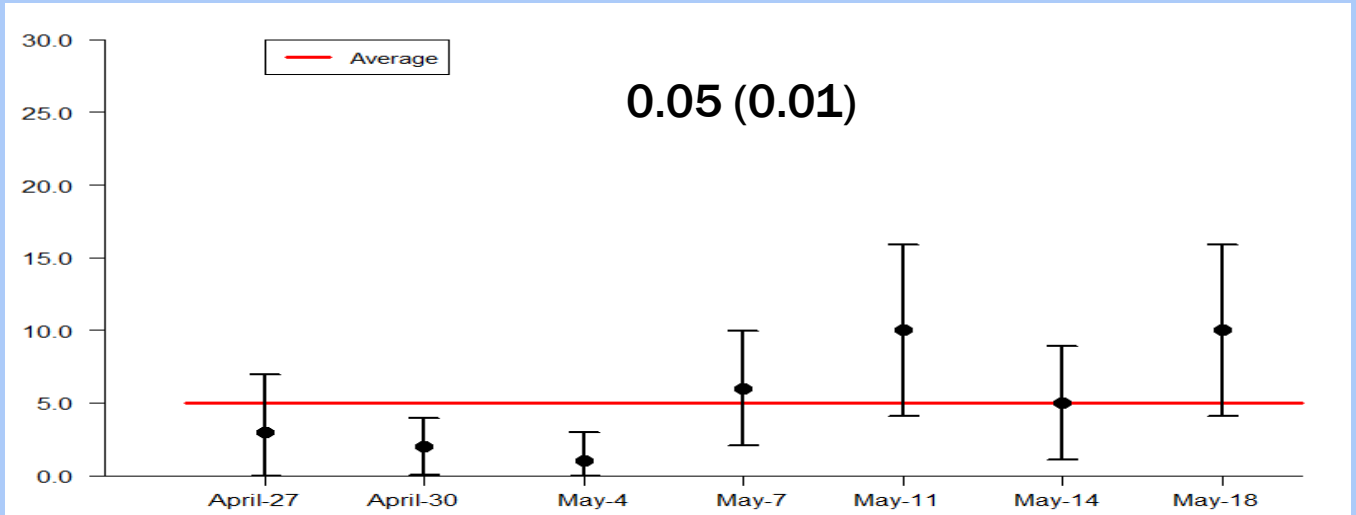
2011- Last year of VAMP, but receivers at JP and CI
2012 – 2013 Transition to VEMCO V5's,
2014- VEMCO V4's, Mokelumne River fish instead of Merced fish

Predation Filter for Study Fish (2009 – 2014)

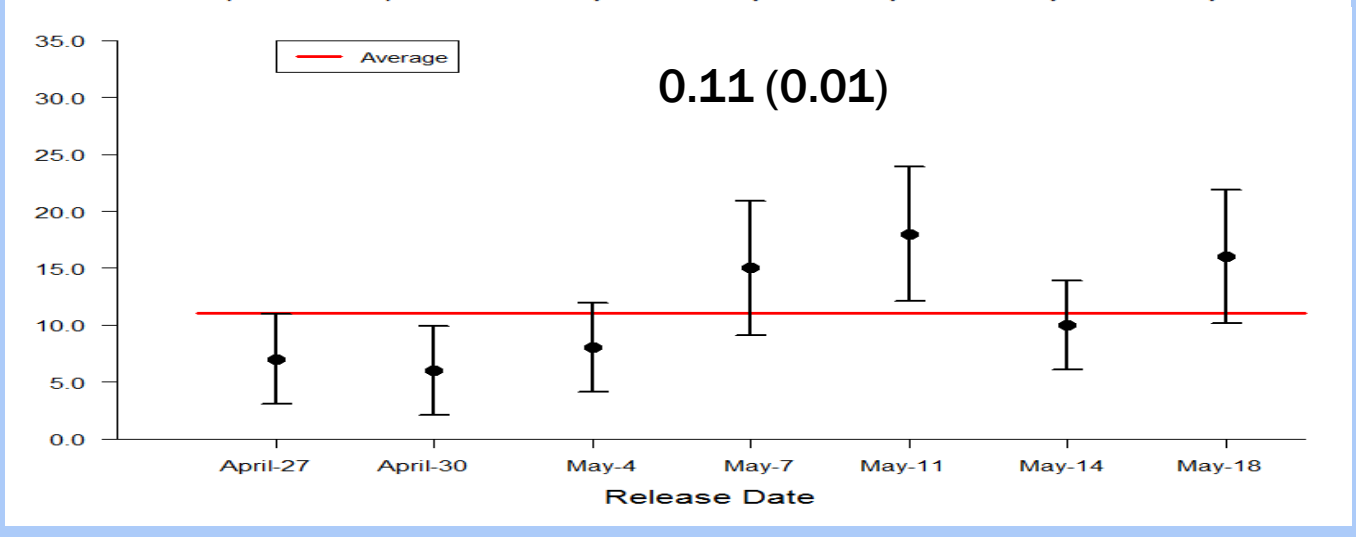
- **Assumption**: All tag detections indicate survival of live study fish
- **Violation**: Predatory fish eat tagged study fish, then move past detection site
- Removal of detections from tags eaten by predators based on:
  - Behavior patterns: travel time, residence time
  - Environmental conditions: river flow, water velocity, river stage
  - detections at all sites
- Assumptions
  - Salmon smolts unlikely to move against flow
  - Salmon smolts are actively migrating downriver
  - May move upriver temporarily with flow

2010 SURVIVAL TO CHIPPS ISLAND

With "predator detections" removed

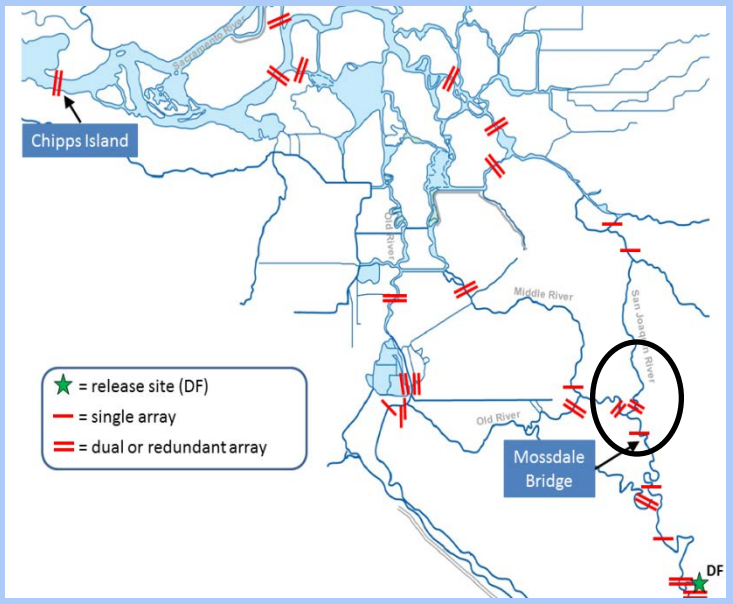


With all detections



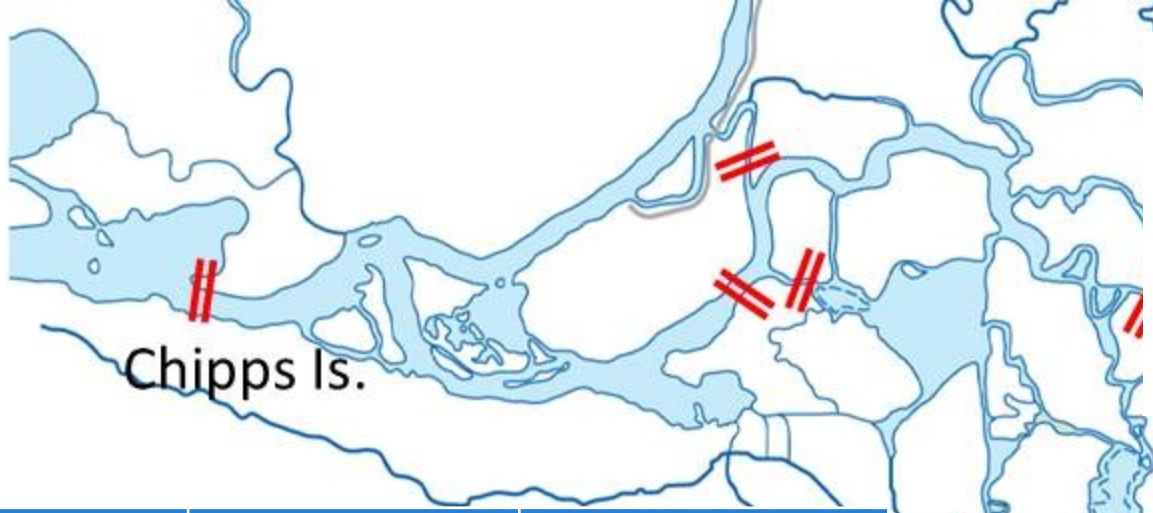
COMPARING PROPORTION ENTERING OLD RIVER USING ACOUSTIC TAGS (2008-2012)

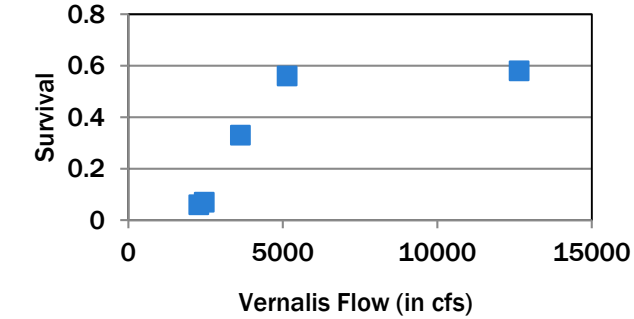
Year	Average Percent entering Old River (SE)	Type of HORB
2008*	66 (3)	None
2009	53 (3)	Non-physical
2010	53 (2)	Non-physical
2011	42 (1)	None
2012	2 (1)	Physical HORB



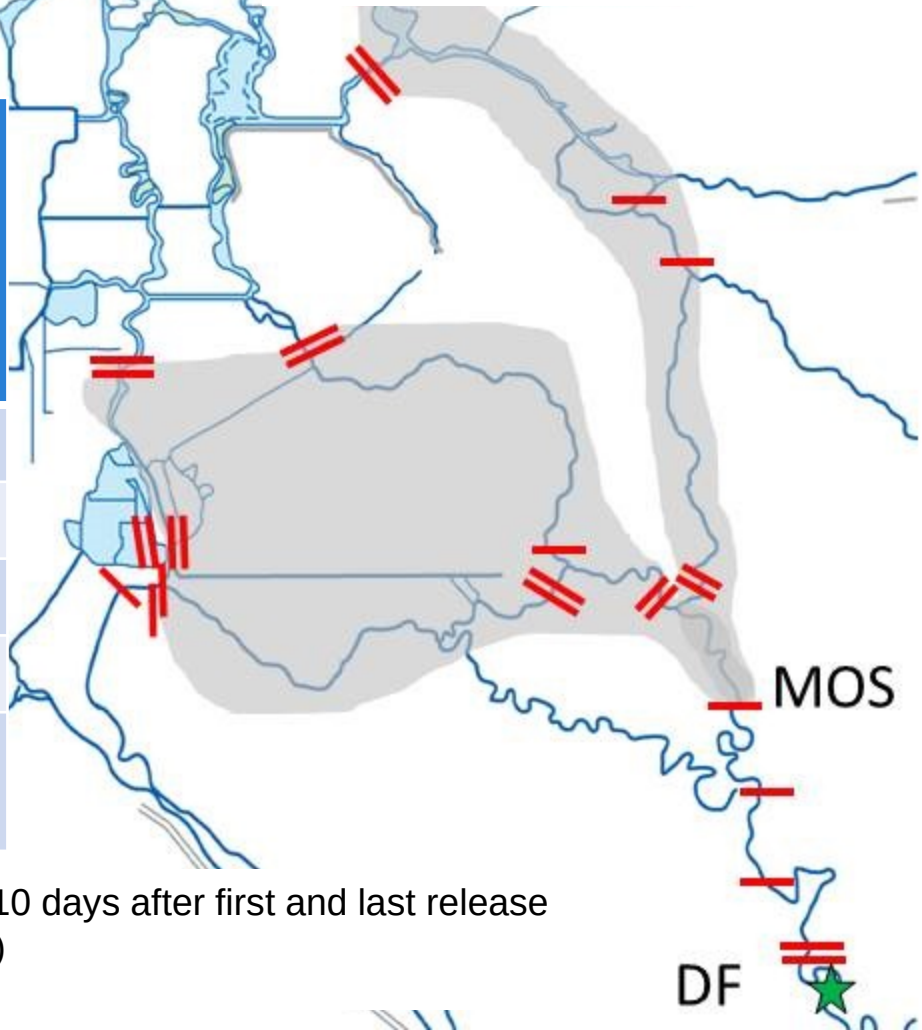
= * minimum estimates of survival due to high tag failure, but also could be biased high as no predator filter was used.

In general, without a HORB, as flows increase, less flow/salmon in Old River (SJRGA, 2013)



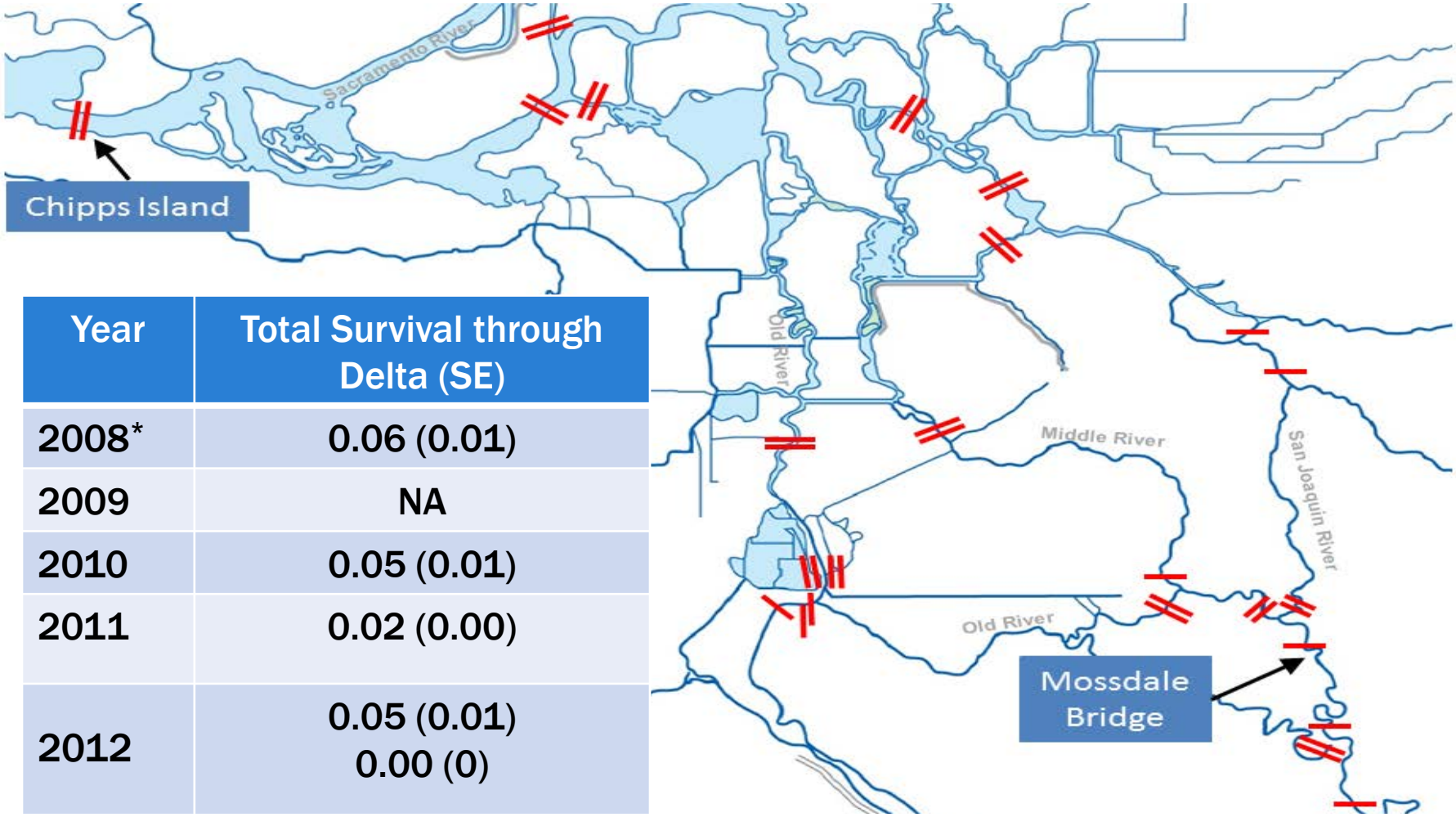


Year	Survival through Southern Delta (SE)	Average Vernalis Flow
2008*	NA	
2009	0.06 (0.01)	2280
2010	0.56 (0.03)	5140
2011**	0.58 (0.02)	12650
2012	0.33 (0.03) 0.07 (0.01)	3628 2457



= Flow during VAMP period or average during period 10 days after first and last release
** only first two releases in 2011 (during VAMP period)

Survival from Mossdale to Chipps Island



Year	Total Survival through Delta (SE)
2008*	0.06 (0.01)
2009	NA
2010	0.05 (0.01)
2011	0.02 (0.00)
2012	0.05 (0.01) 0.00 (0)

= * minimum estimates of survival due to high tag failure, but no predator filter

Survival (per km) from Mossdale to Chipps Island

	Survival estimate per km (S^1/km)							
	SJR Fall Chinook						SJR Steelhead	
Reach	2008	2009	2010	2011	2012		2011	2012
Mossdale to Chipps Island (91 rkm)			0.968	0.958	0.962		0.993	0.986

Chinook

2011, 2012

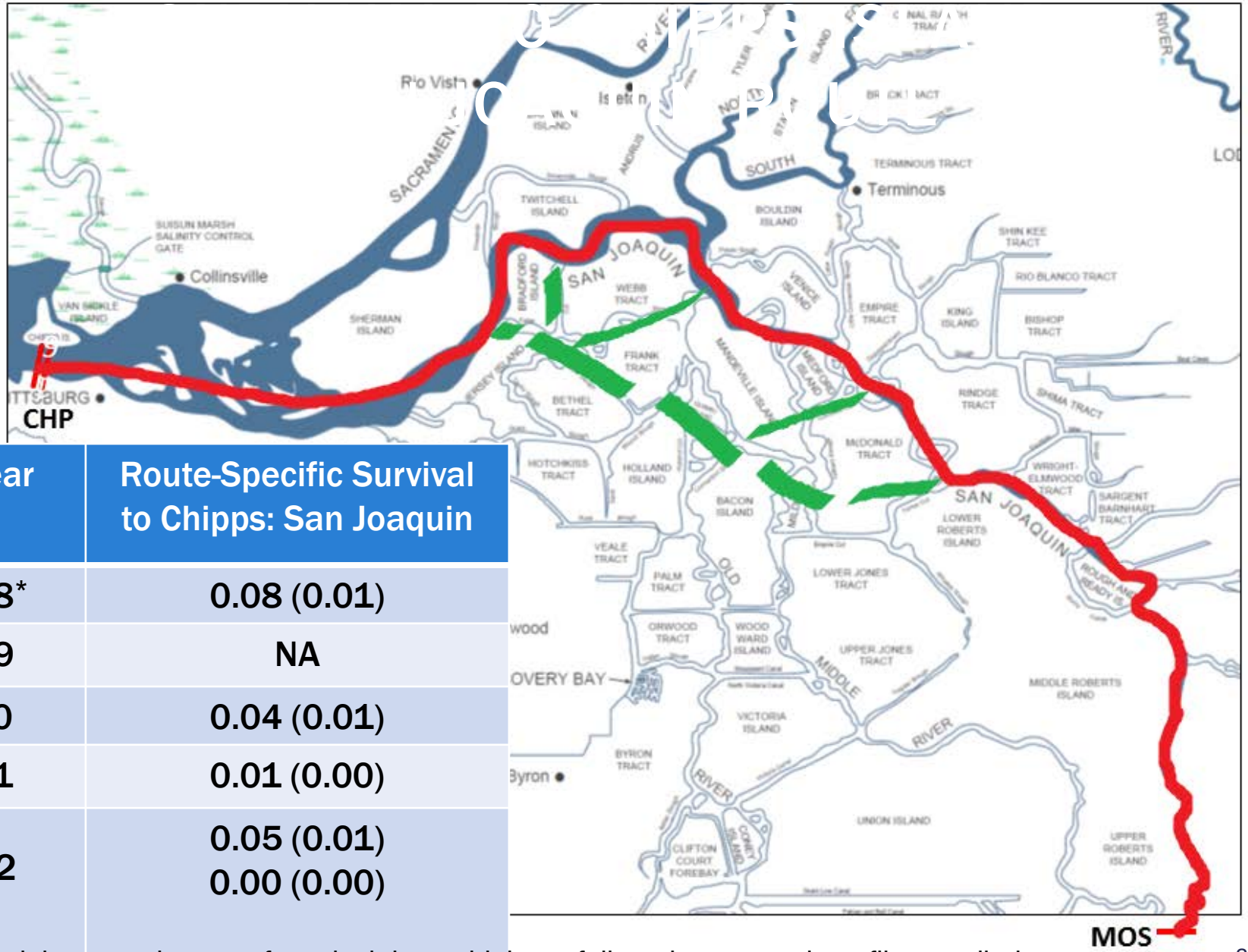
2010

Steelhead

2012

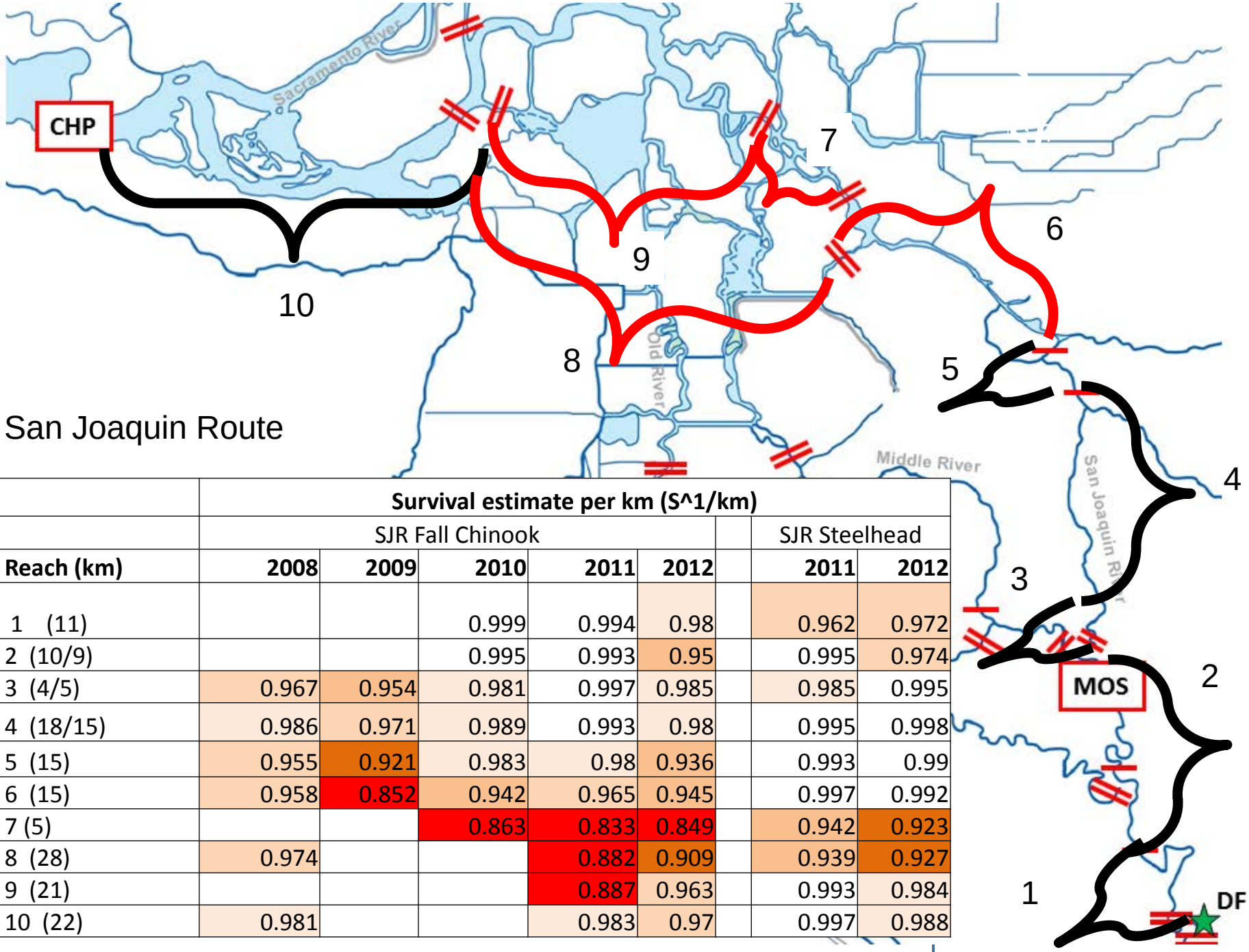
2011

Survival per km	Total Survival from Mossdale to Chipps Island
0.83	0
0.88	0
0.9	0.0001
0.92	0.0005
0.93	0.0014
0.95	0.0094
0.96	0.0244
0.97	0.0626
0.98	0.1591
0.985	0.2528
0.989	0.3655
0.99	0.4007
0.995	0.6337
0.997	0.7608



Year	Route-Specific Survival to Chipps: San Joaquin
2008*	0.08 (0.01)
2009	NA
2010	0.04 (0.01)
2011	0.01 (0.00)
2012	0.05 (0.01) 0.00 (0.00)

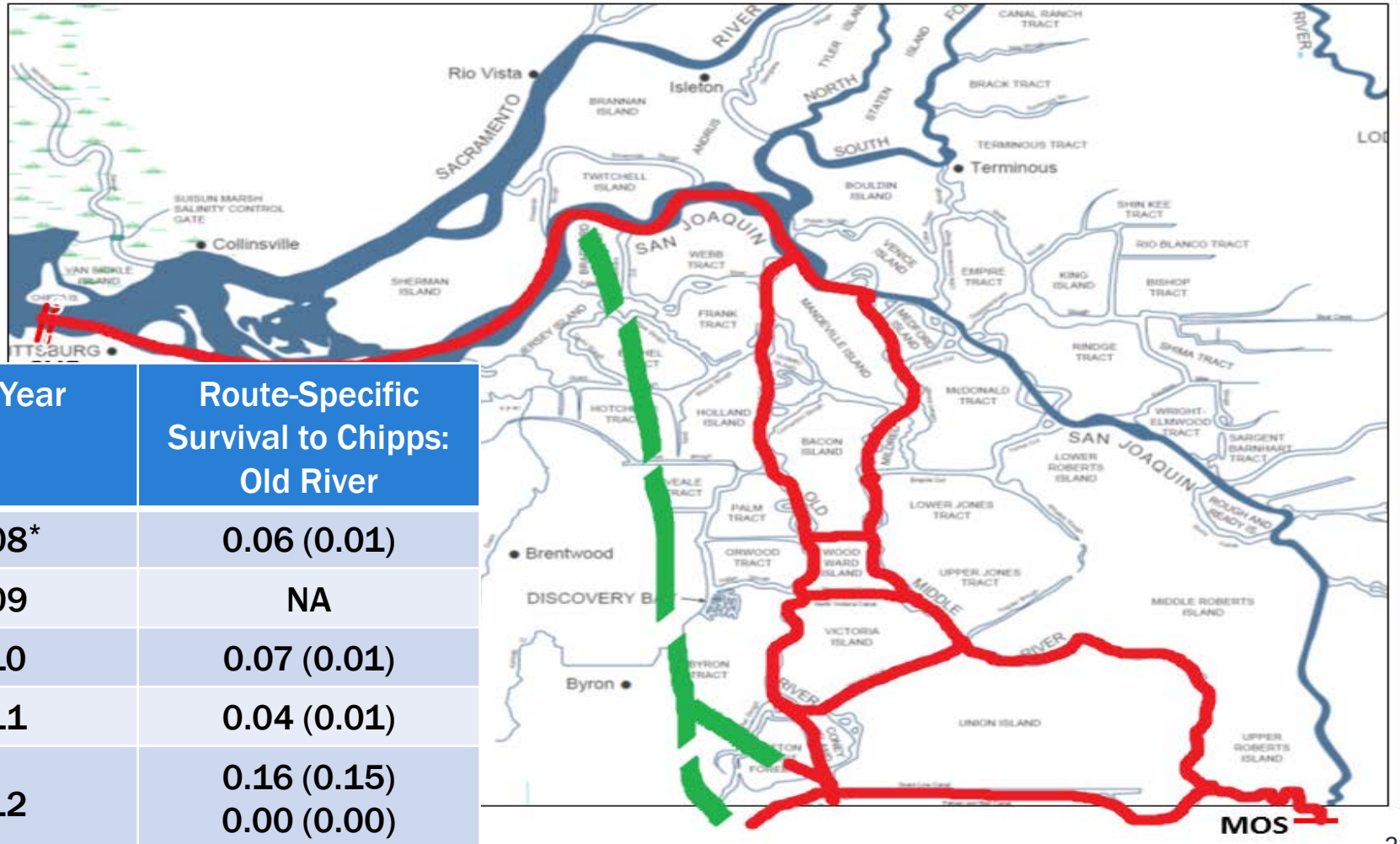
= * minimum estimates of survival due to high tag failure, but no predator filter applied



San Joaquin Route

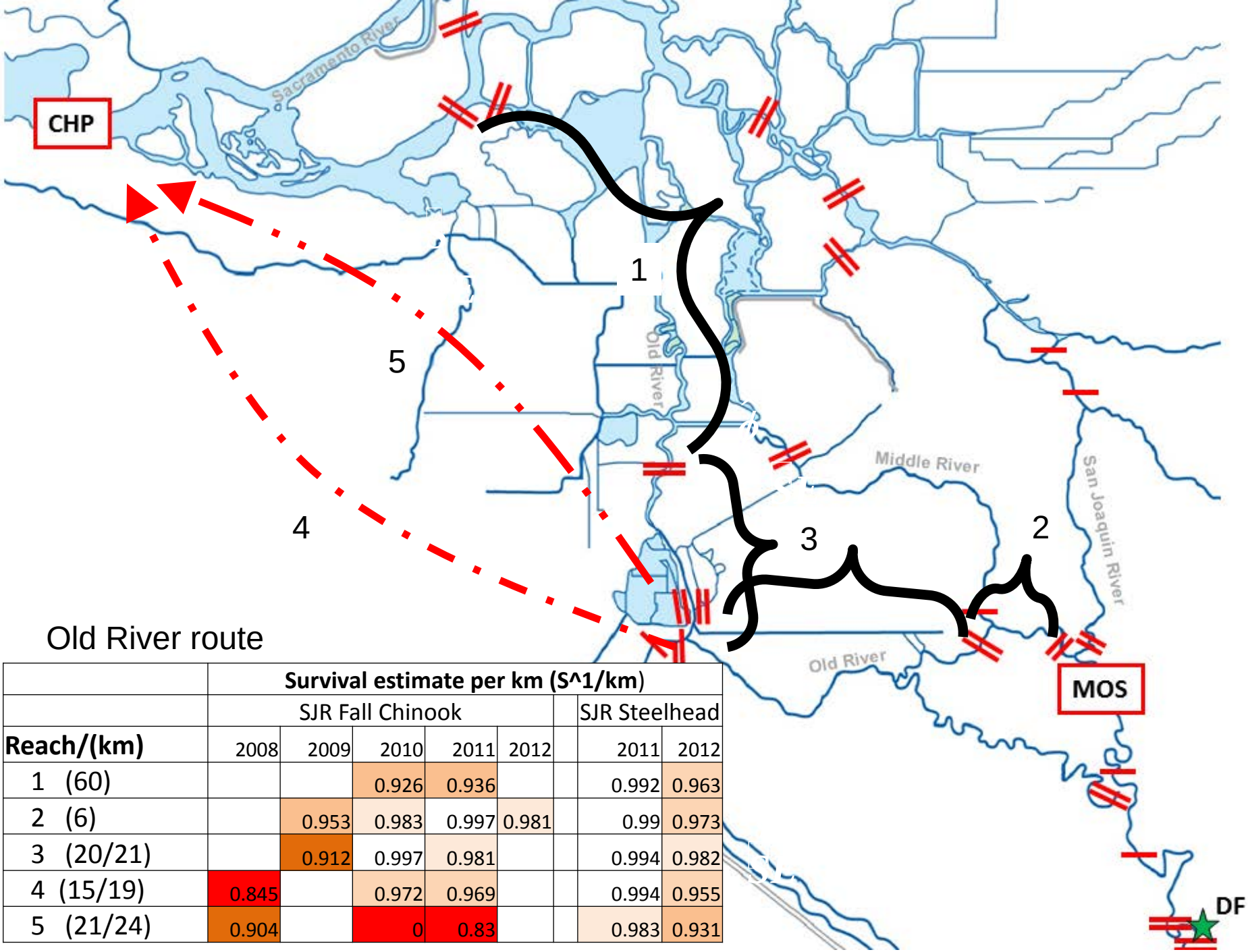
	Survival estimate per km (S^1/km)							
	SJR Fall Chinook						SJR Steelhead	
Reach (km)	**2008**	**2009**	**2010**	**2011**	**2012**		**2011**	**2012**
1 (11)			0.999	0.994	0.98		0.962	0.972
2 (10/9)			0.995	0.993	0.95		0.995	0.974
3 (4/5)	0.967	0.954	0.981	0.997	0.985		0.985	0.995
4 (18/15)	0.986	0.971	0.989	0.993	0.98		0.995	0.998
5 (15)	0.955	0.921	0.983	0.98	0.936		0.993	0.99
6 (15)	0.958	0.852	0.942	0.965	0.945		0.997	0.992
7 (5)			0.863	0.833	0.849		0.942	0.923
8 (28)	0.974			0.882	0.909		0.939	0.927
9 (21)				0.887	0.963		0.993	0.984
10 (22)	0.981			0.983	0.97		0.997	0.988

SURVIVAL TO CHIPPS ISLAND: OLD RIVER ROUTE



Year	Route-Specific Survival to Chipps: Old River
2008*	0.06 (0.01)
2009	NA
2010	0.07 (0.01)
2011	0.04 (0.01)
2012	0.16 (0.15) 0.00 (0.00)

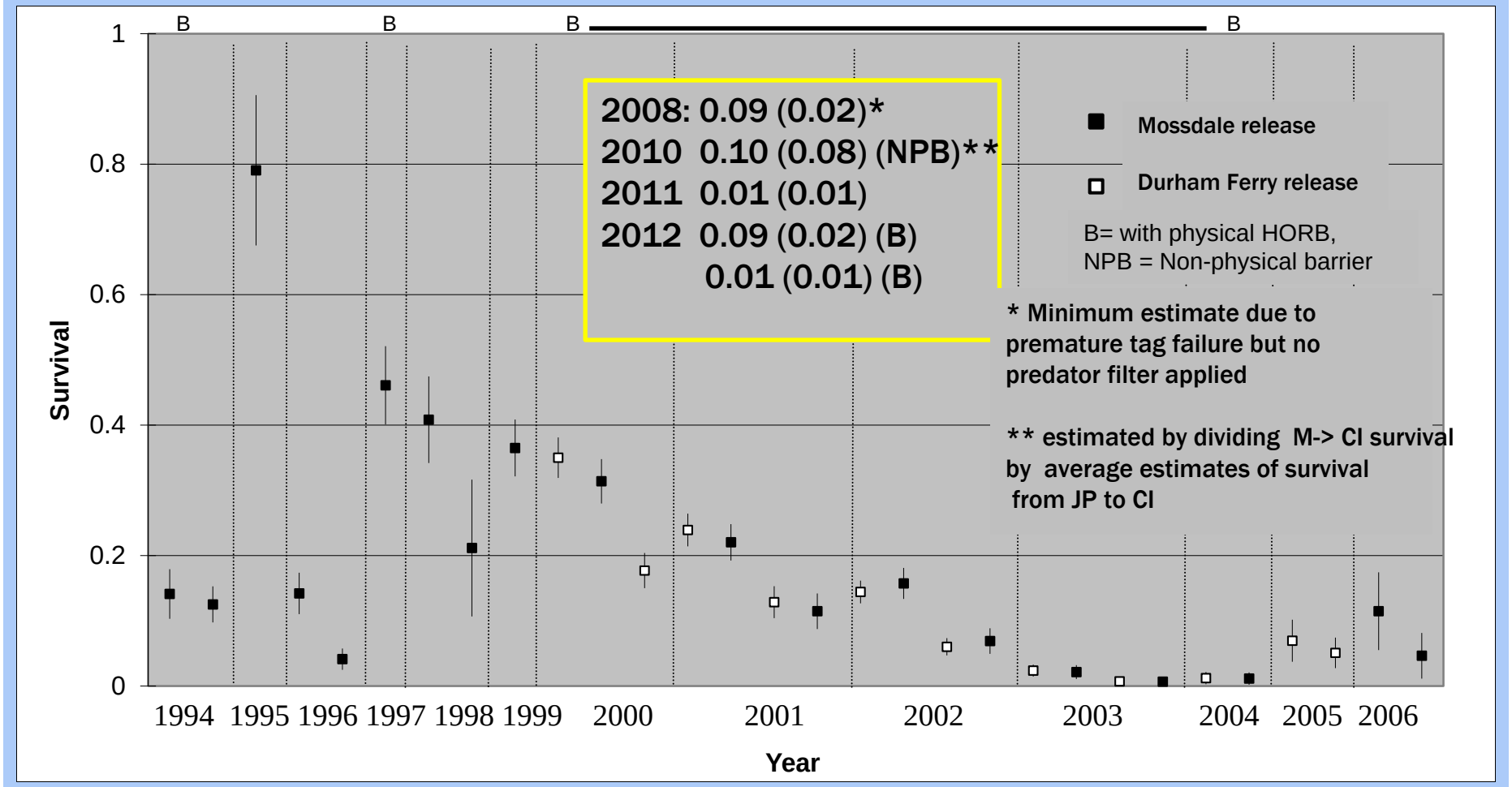
= * minimum estimates of survival due to high tag failure, but no predator filter applied



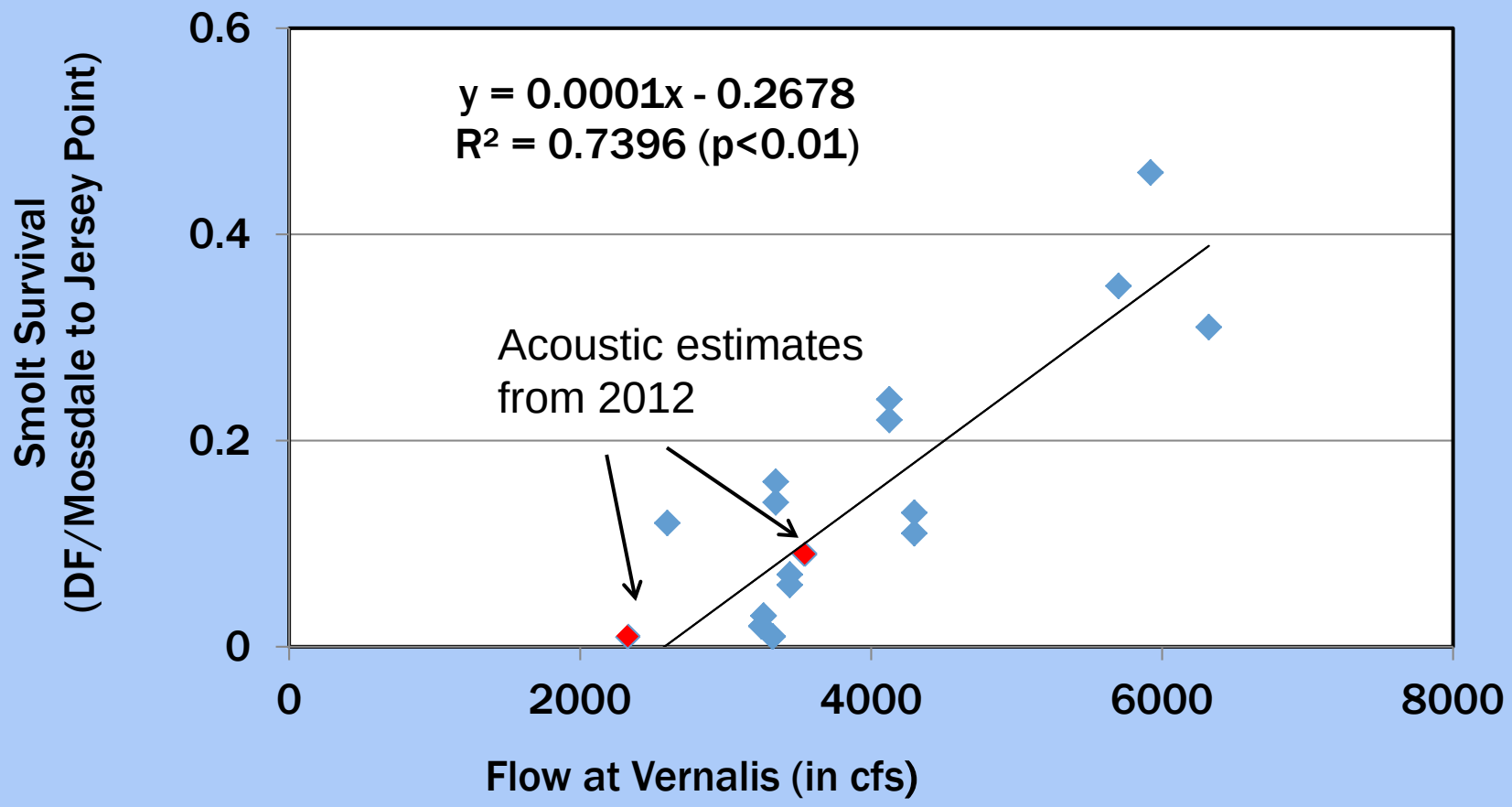
Old River route

	Survival estimate per km (S^1/km)							
	SJR Fall Chinook						SJR Steelhead	
Reach/(km)	2008	2009	2010	2011	2012		2011	2012
1 (60)			0.926	0.936			0.992	0.963
2 (6)		0.953	0.983	0.997	0.981		0.99	0.973
3 (20/21)		0.912	0.997	0.981			0.994	0.982
4 (15/19)	0.845		0.972	0.969			0.994	0.955
5 (21/24)	0.904		0	0.83			0.983	0.931

Comparison of estimated smolt survival in 2008 - 2012 (acoustic tags) from Mossdale to Jersey Point to past estimates of survival from Mossdale or Durham Ferry to Jersey Point (CWT) between 1994 and 2006



Smolt Survival with HORB



What did we learn from VAMP ?

- Survival increase with increased flows with the HORB in place

- Can’t always get the conditions you want to test
  (no 7000 cfs with 1500 and 3000 exports)

- Lots of variability and noise in the system - replication important

- It was good to have a structured, long term design so replication was incorporated and annual funding was assured

- Project operators and tributary operators could cooperate to minimize fluctuations in flows and exports

- Mechanisms are hard to identify with such a gross tool (CWT).

What have we learned since VAMP ?

Acoustic tags allow survival to be measured with greater precision and for smaller reaches

But….assessing predation on acoustic tags is still uncertain

Tag size limiting

There are mortality hot spots in the San Joaquin River and Old River.

No longer clear which route is better in recent years: Old River or San Joaquin River

- In most recent years, no significant difference in survival between two routes (low power) but both are BAD!!! –

but the relationship between flow and survival with the HORB still seems to hold.

It will take a long time to understand the factors influencing survival and it will take a long-term, commitment to answer management questions (expectations need to be realistic).

- responses and environment/habitat may be changing
- environmental noise is huge
- studies are expensive – and no long term funding has been identified

NEXT STEPS

Waiting for results from 2013 – low flow year and no HOR barrier
- multiple estimates of both salmon and steelhead

Multiple year analyses planned for Chinook– 2010-2013 - IEP funded — would like to combine CWT and acoustic in the future

Conducting studies in 2014 – low flow year with physical barrier (8 culverts)
- multiple estimates for salmon (MOK) and steelhead
- added receivers at Benicia as back-up to Chipps

2015 -2016:
- Steelhead study continues through 2016 as part of NMFS OCAP BiOP
- Salmon studies do not have funding after 2014
- It would be cost-effective to estimate salmon survival through 2016

Continue to estimate survival, build models, test hypotheses and refine criteria for assessing predation on tagged fish.