Is net flow (OMR) a meaningful metric for juvenile salmonids? Evidence from hydrodynamic analyses and tagging studies.

Bradley Cavallo

Delta Juvenile Salmon Publications

In prep

S. Zeug and **B. Cavallo**. 2014. Influence of tides, river inflow and export pumping on water velocities in a freshwater estuary with applications to juvenile anadromous fishes. In Prep.

In review

Cavallo, B. 2014. Use of a ratio confuses interpretation in hierarchical modeling of juvenile Chinook salmon survival as a function of Sacramento-San Joaquin Delta water exports. In review, North American Journal of Fisheries Management.

Cavallo, B. et al. 2014. Predicting juvenile Chinook routing in riverine and tidal channels of a freshwater estuary. In review, Environmental Biology of Fishes.

Accepted

Zeug, S. and **B. Cavallo**. 2014. Controls on the entrainment of juvenile Chinook salmon (*Oncorhynchus tshawytscha*) into large water diversions and estimates of population-level loss. Accepted at PLOS ONE.

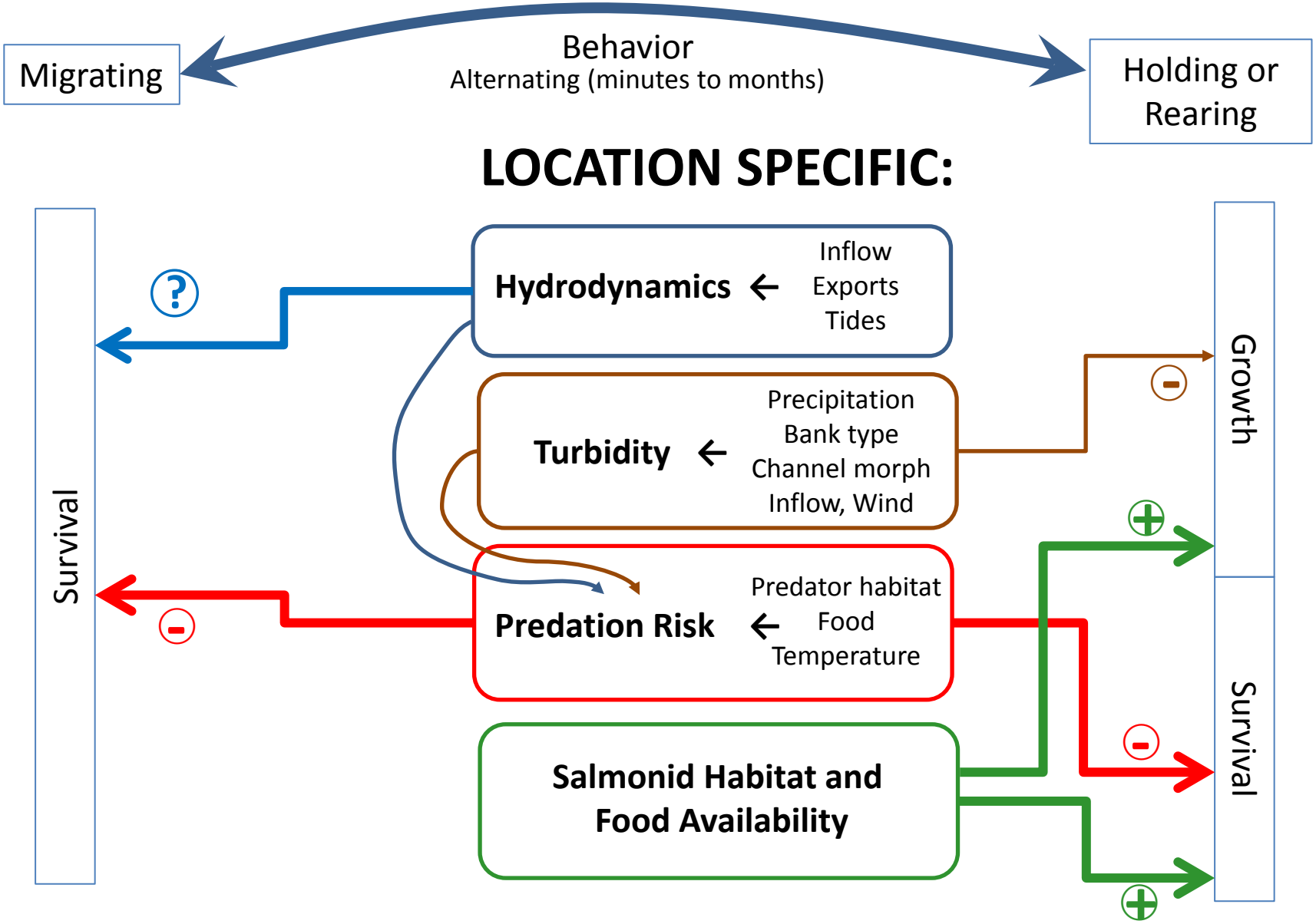
Published

Zeug, S. and **B. Cavallo**. 2013. Influence of estuary conditions on the recovery rate of coded-wire-tagged Chinook salmon (*Oncorhynchus tshawytscha*) in an ocean fishery. Ecology of Freshwater Fish 22:157-168.

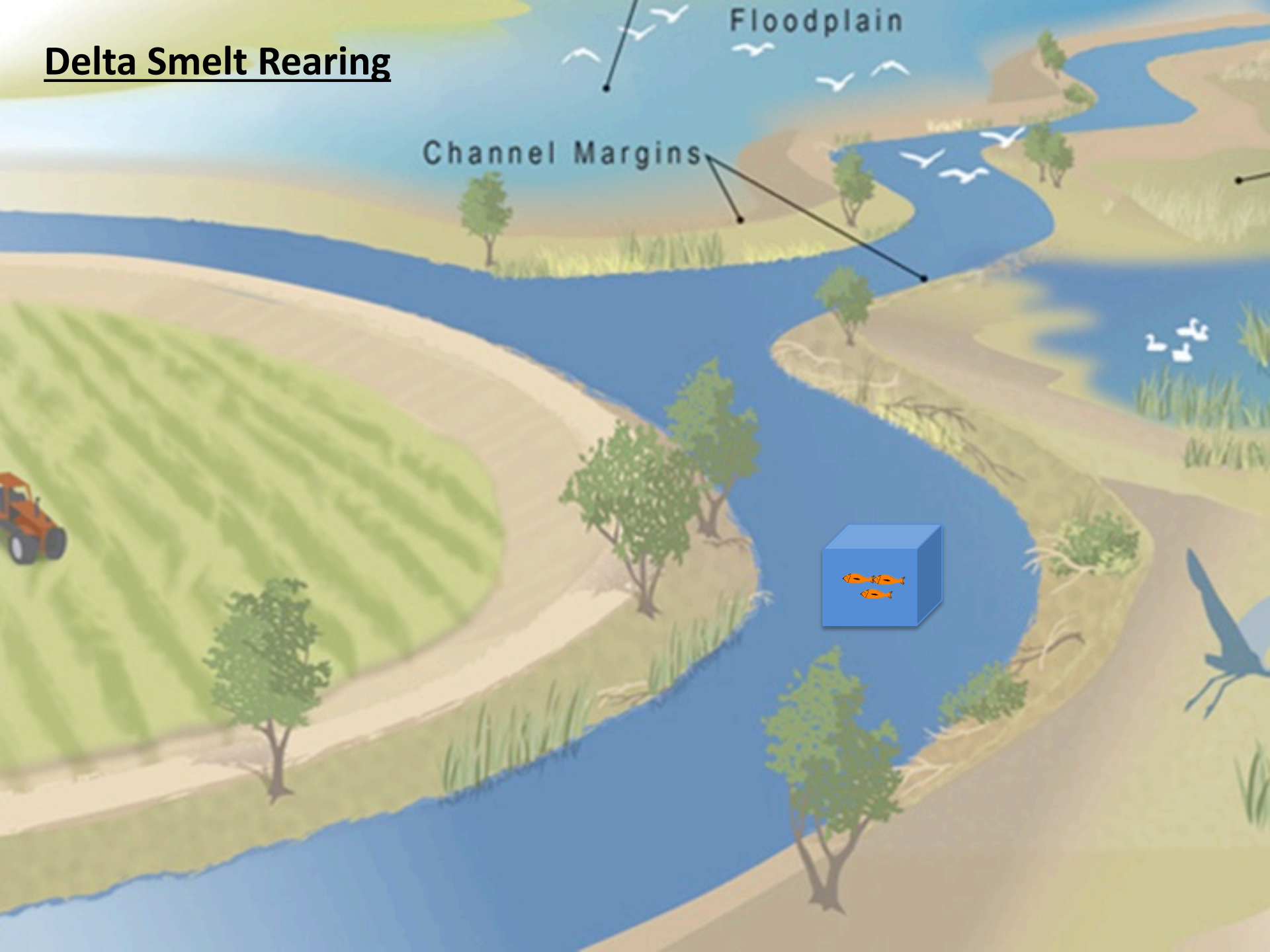
Cavallo, B., J. Merz, J. Setka. 2012. Effects of predator and flow manipulation on Chinook salmon (*Oncorhynchus tshawytscha*) survival in an imperiled estuary. Environmental Biology of Fish, published online April 2012. DOI 10.1007/s10641-012-9993-5

Juvenile salmon ≠ Delta smelt

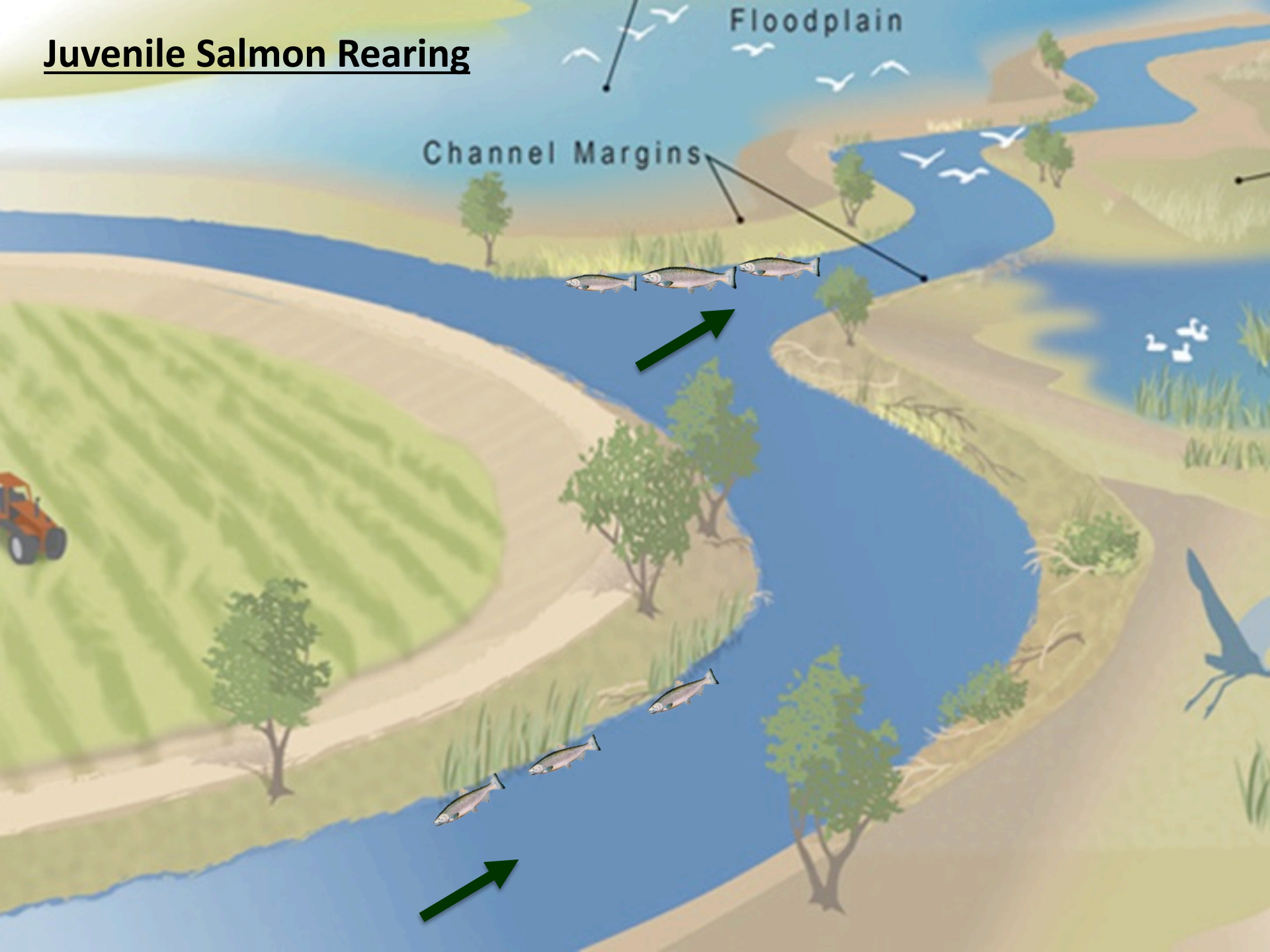
Delta Juvenile Salmonid Conceptual Model (fry, parr or smolt)



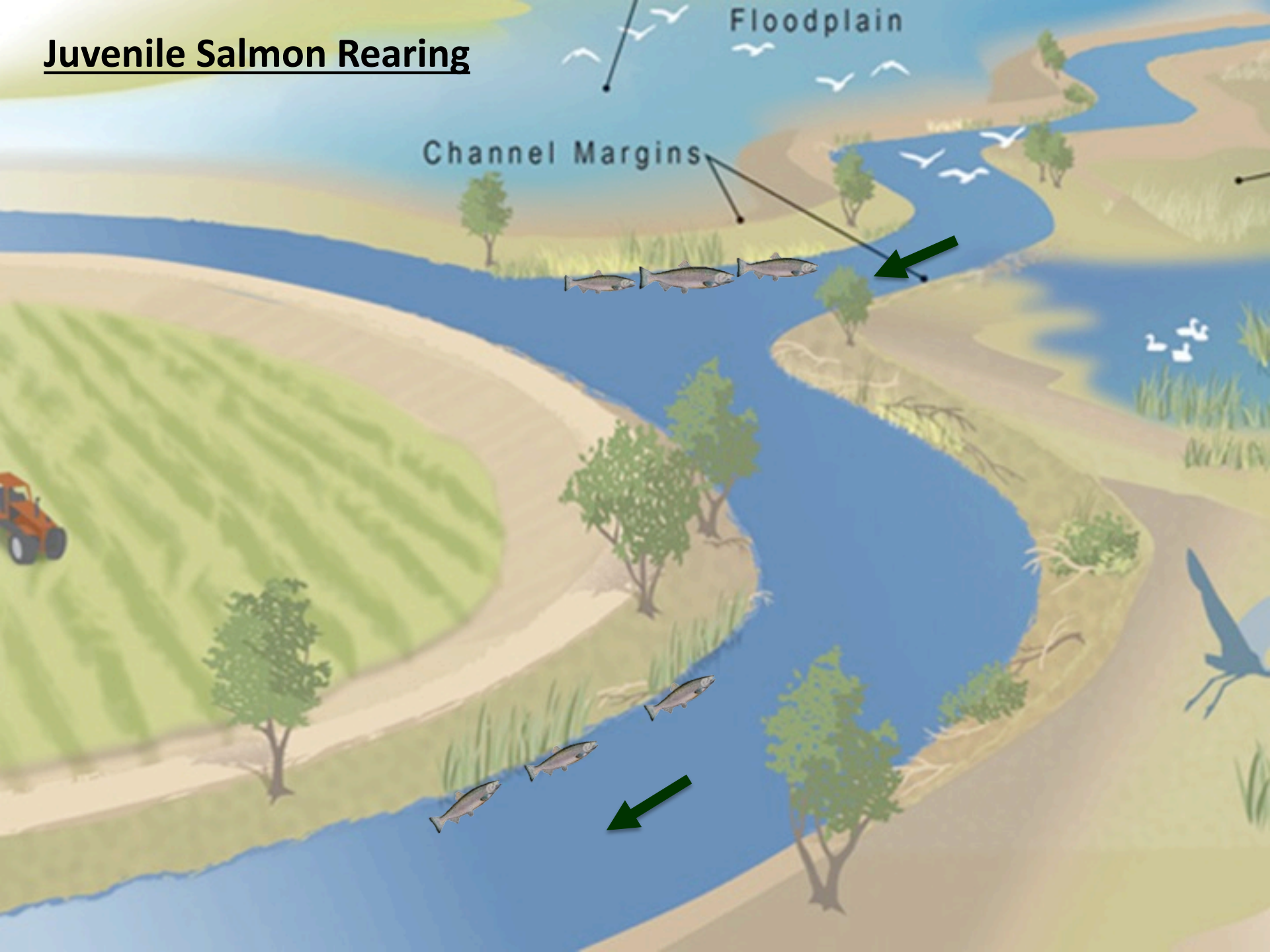
Delta Smelt Rearing



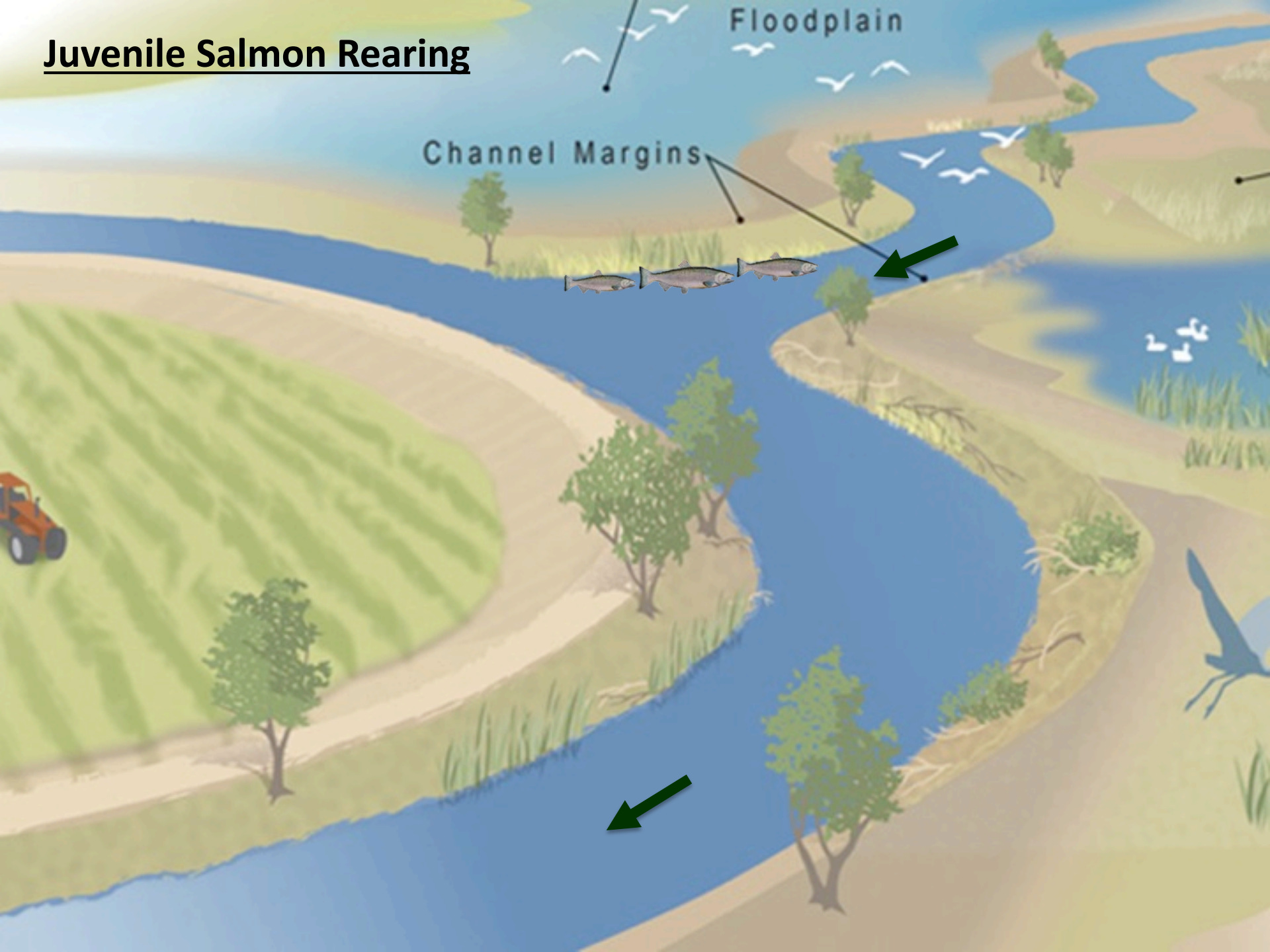
Juvenile Salmon Rearing



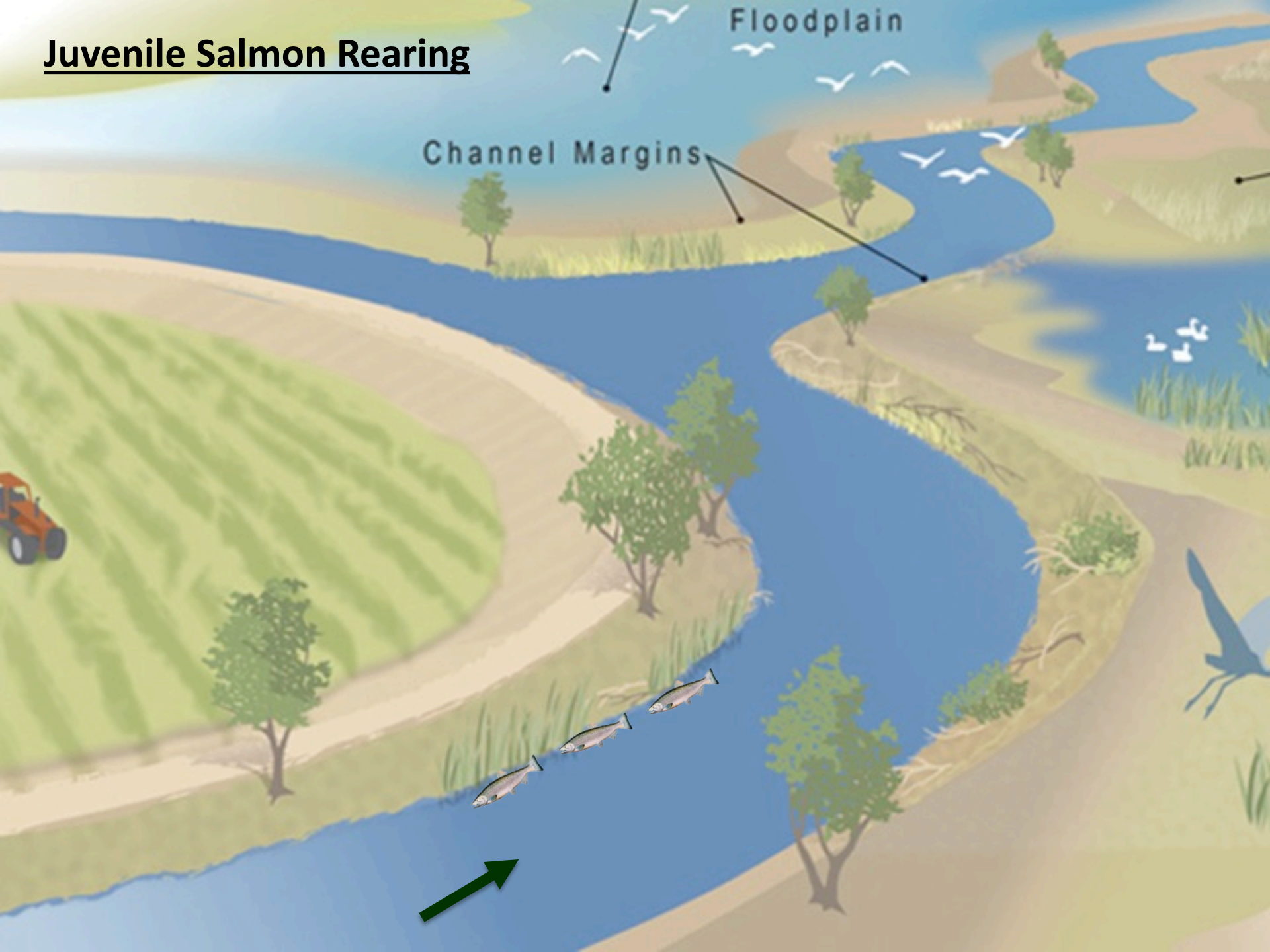
Juvenile Salmon Rearing



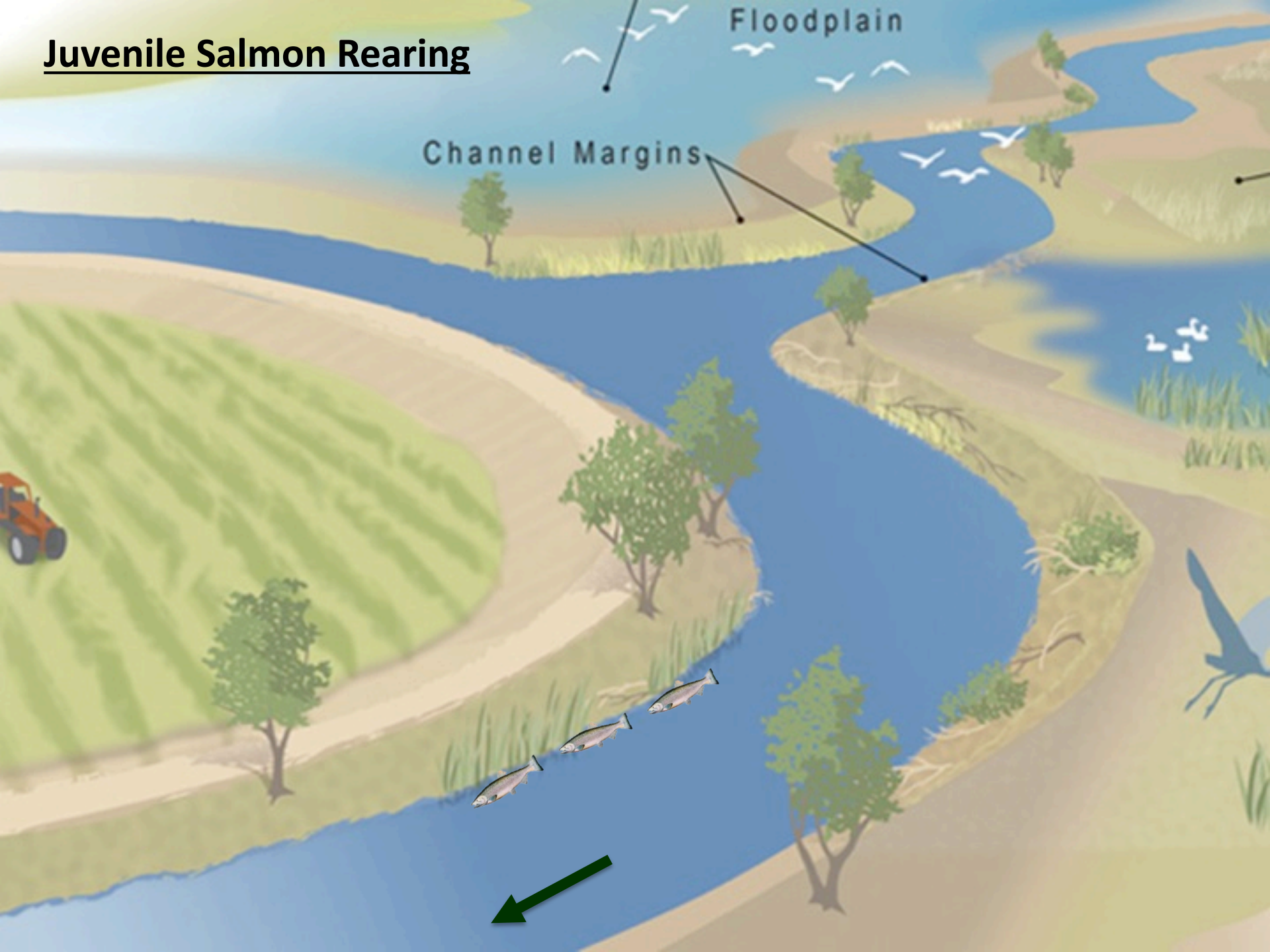
Juvenile Salmon Rearing



Juvenile Salmon Rearing



Juvenile Salmon Rearing

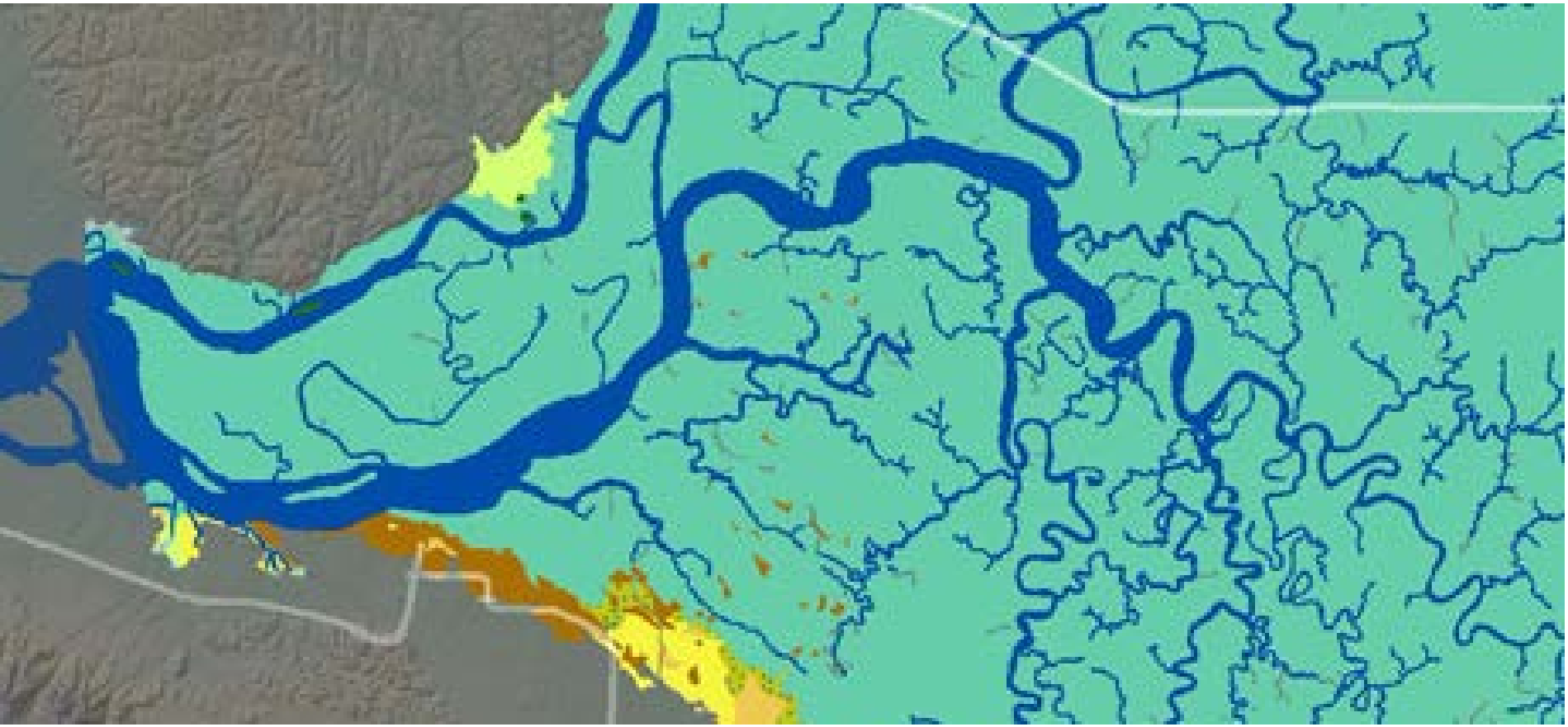


Juvenile Salmon Behavior

- Rearing
  - Non-natal rearing common
  - Oriented to shallow, edge habitats
  - Feed on benthic invertebrates (not zooplankton)

- Migrating
  - Fast, directional swimming
  - Ability to navigate

Tidal Channels in Historic Delta



Source: http://www.sfei.org/DeltaHEStudy

Net flow or instantaneous velocities?

http://glimmer.rstudio.com/hinkelman/simulated-delta-velocity/

River/Slough/Cut

Middle River

Channel

144

Map size

500 750 1,000

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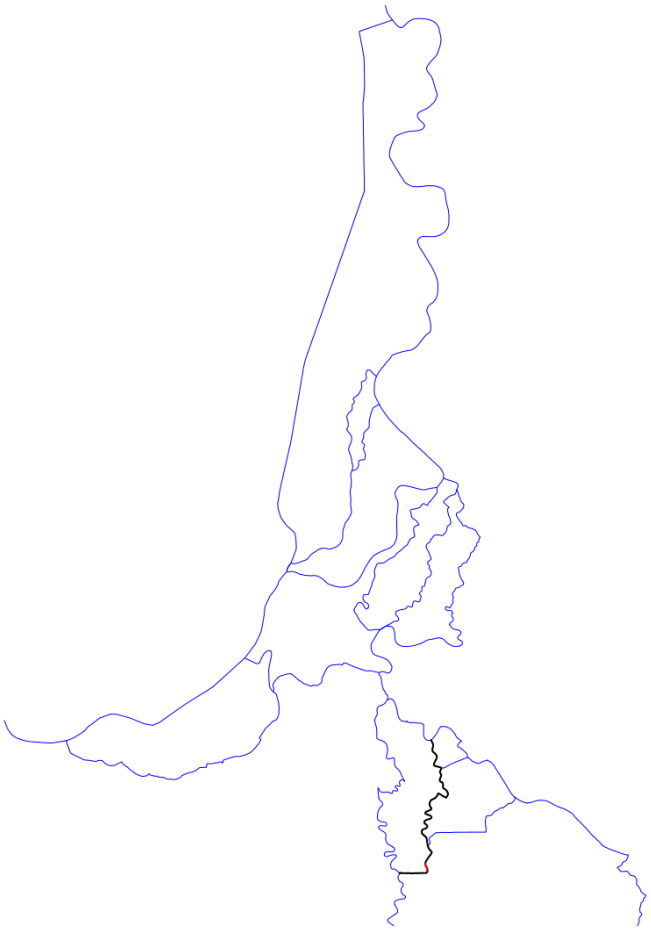
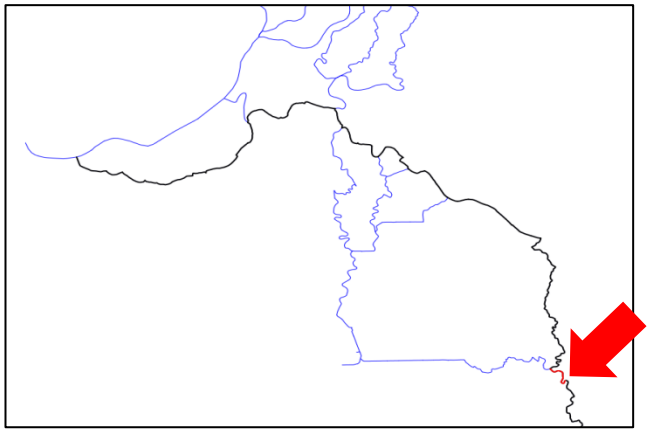
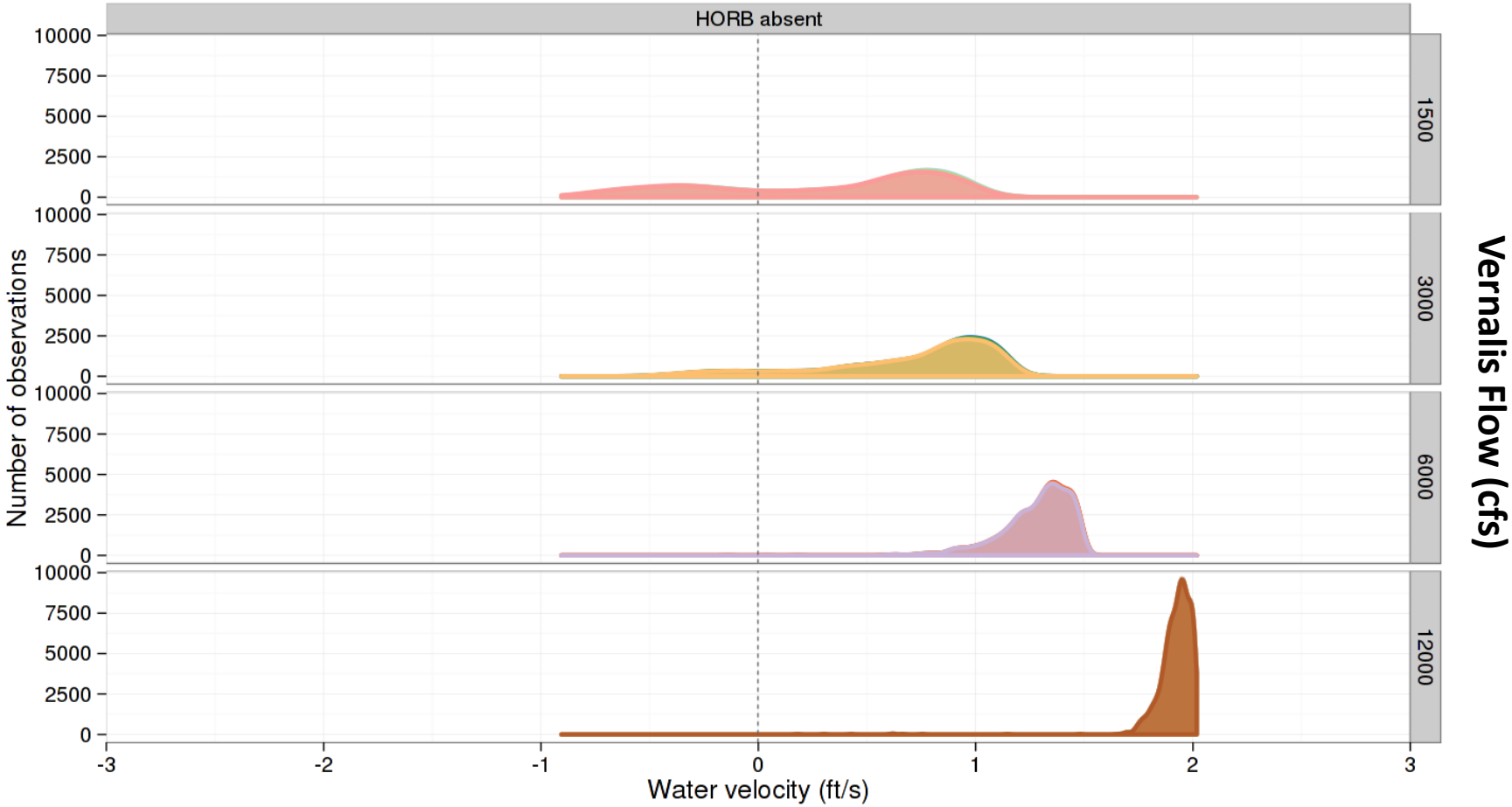
Plot Map



San Joaquin River, Channel 8

density dissimilarity >0.75

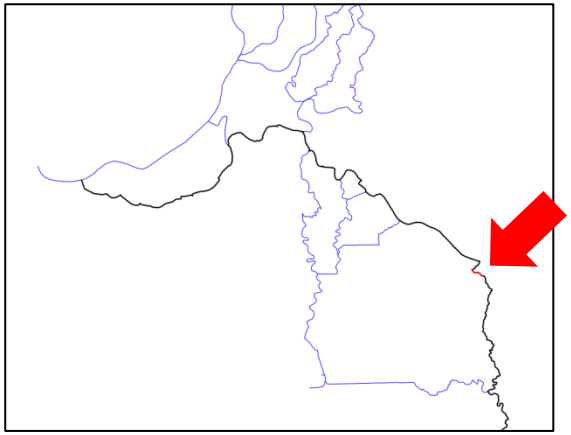


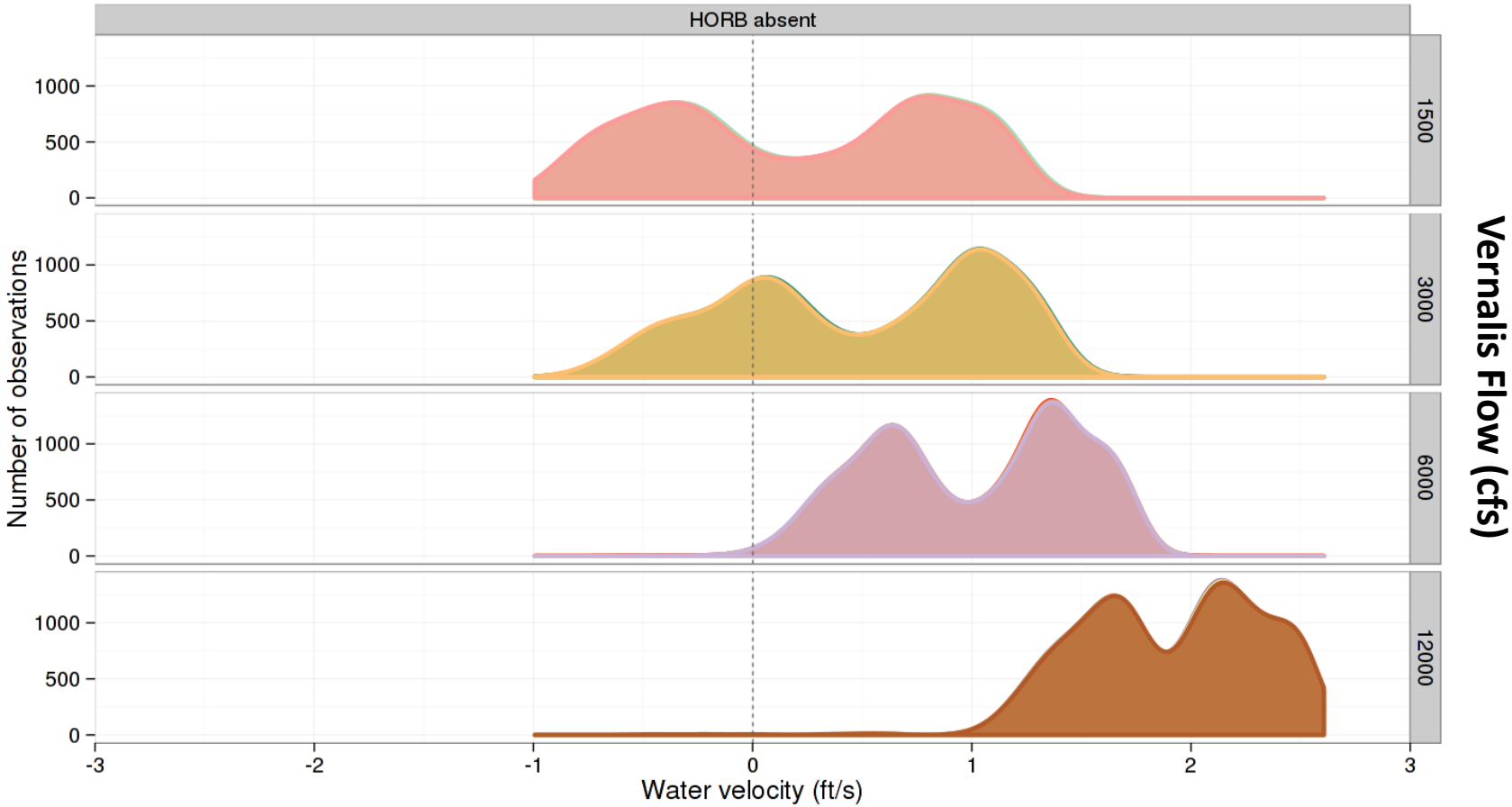


Available: http://glimmer.rstudio.com/hinkelman/simulated-delta-velocity/

San Joaquin River, Channel 15

density dissimilarity >0.75

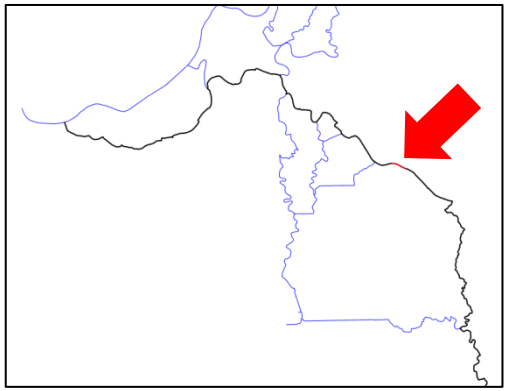


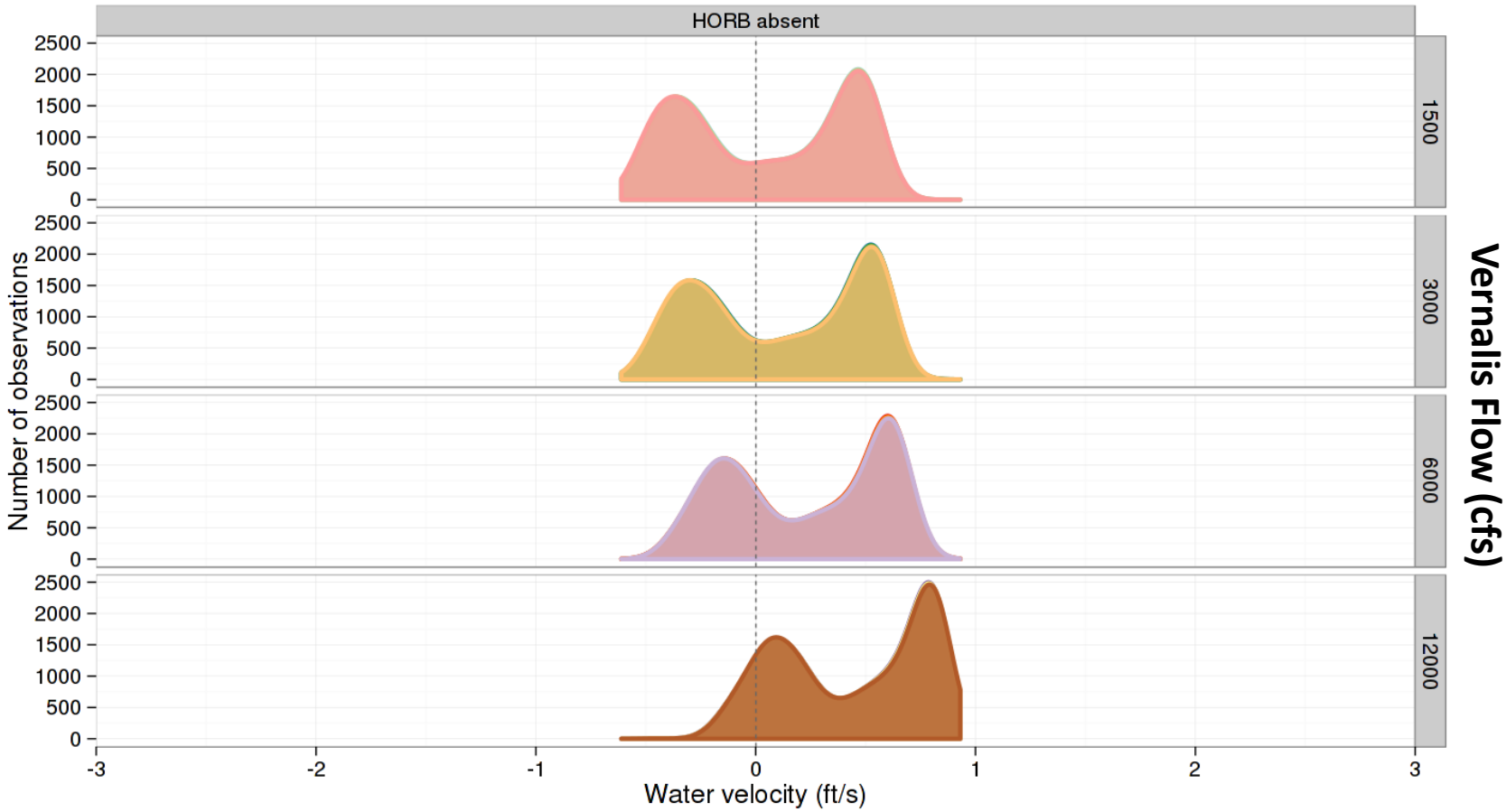


Available: http://glimmer.rstudio.com/hinkelman/simulated-delta-velocity/

San Joaquin River, Channel 23

density dissimilarity <0.25

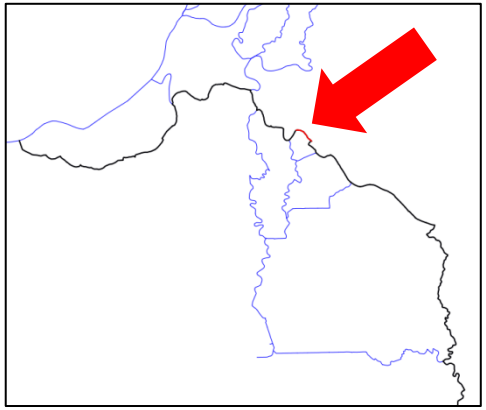


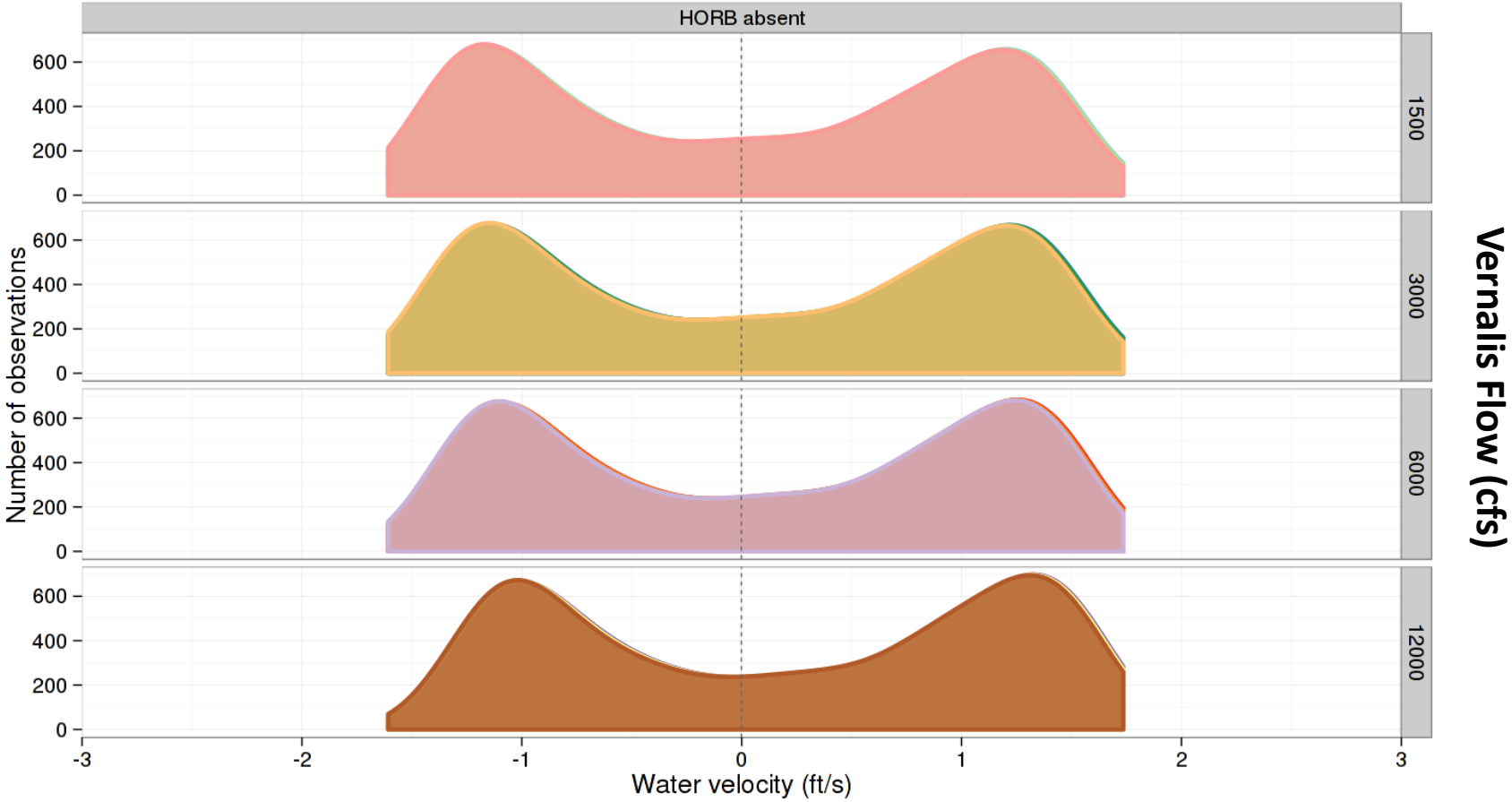


Available: http://glimmer.rstudio.com/hinkelman/simulated-delta-velocity/

San Joaquin River, Channel 37

density dissimilarity < 0.25

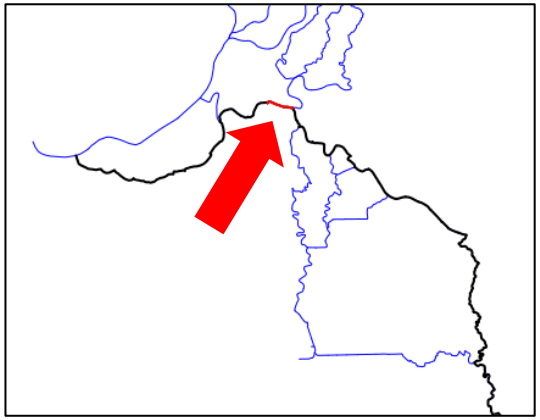


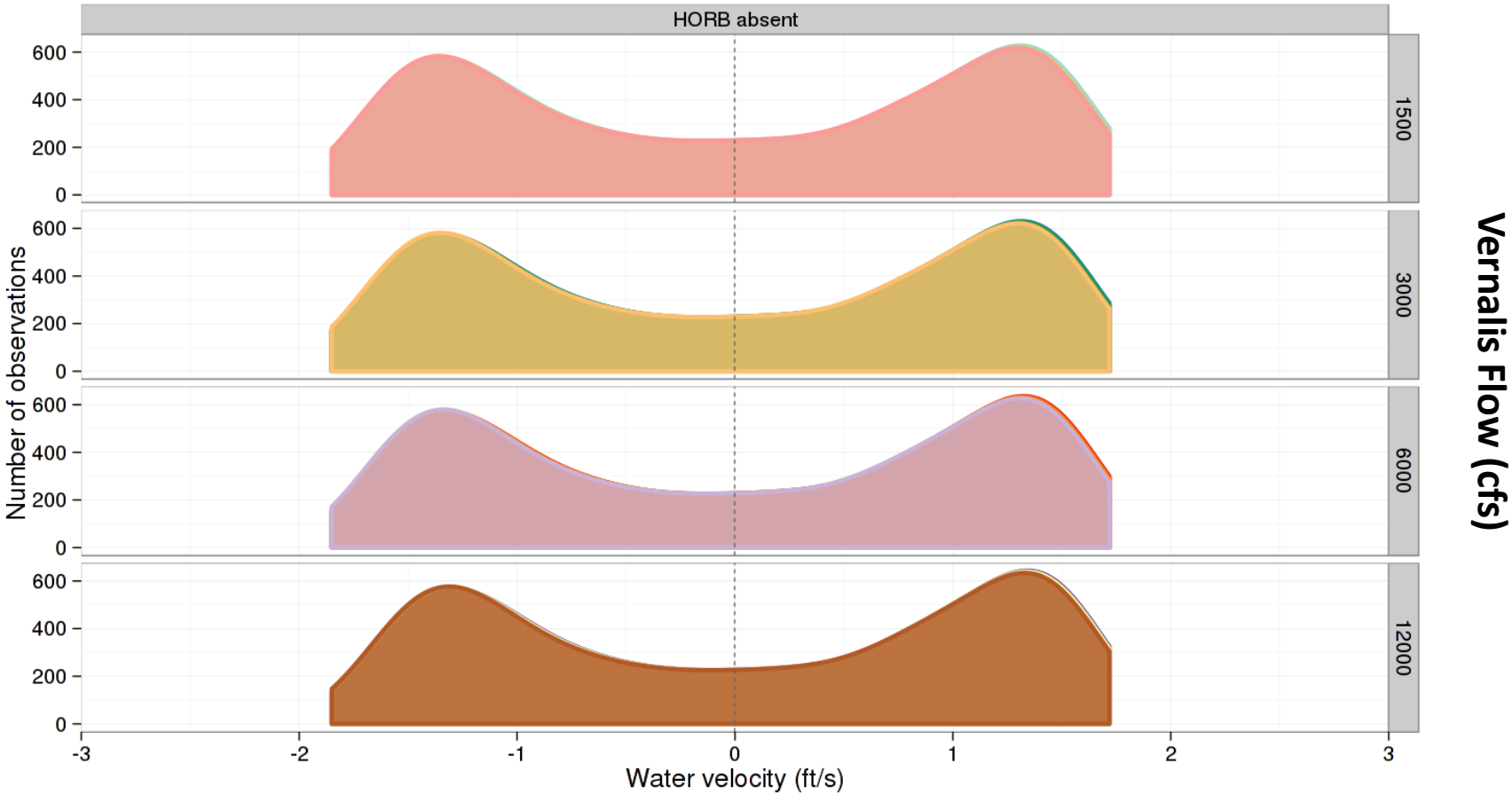


Available: http://glimmer.rstudio.com/hinkelman/simulated-delta-velocity/

San Joaquin River, Channel 45

density dissimilarity < 0.15





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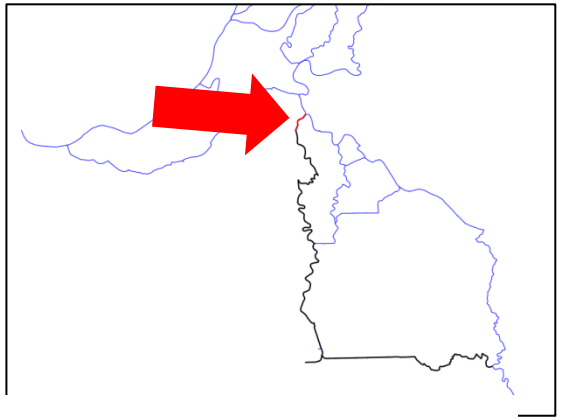
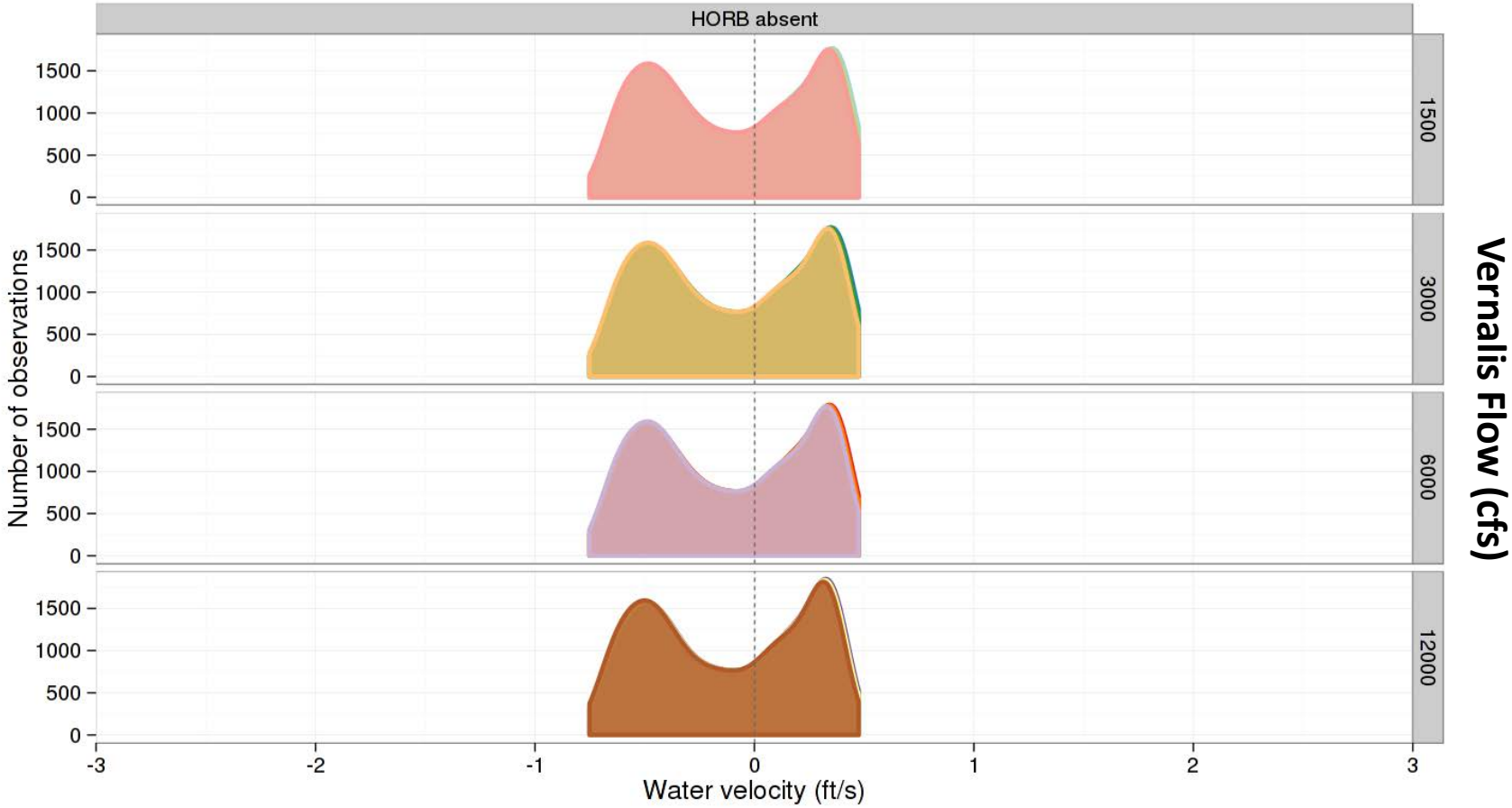
Old River, Channel 124

density dissimilarity < 0.25

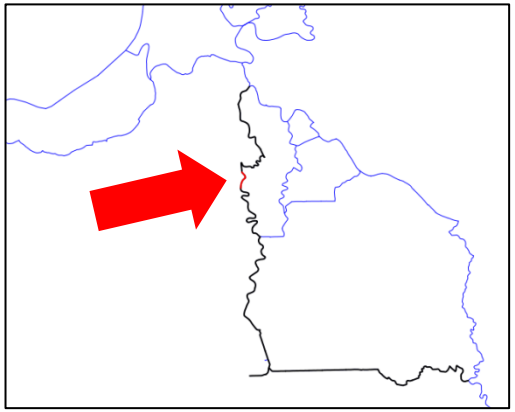


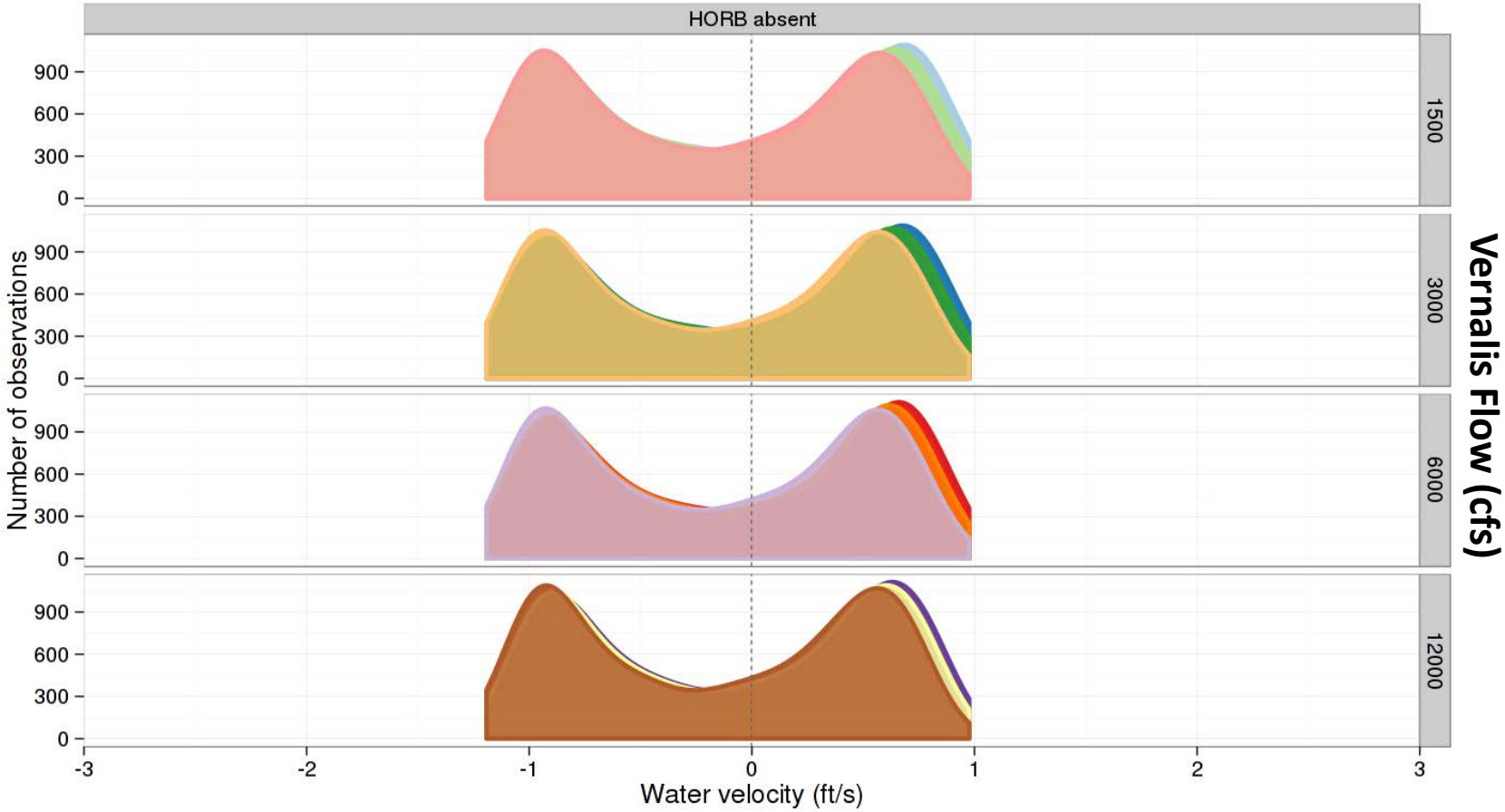


Available: http://glimmer.rstudio.com/hinkelman/simulated-delta-velocity/

Old River, Channel 111

density dissimilarity ≅ 0.30

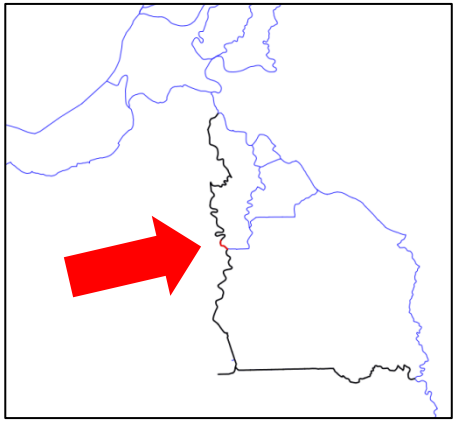


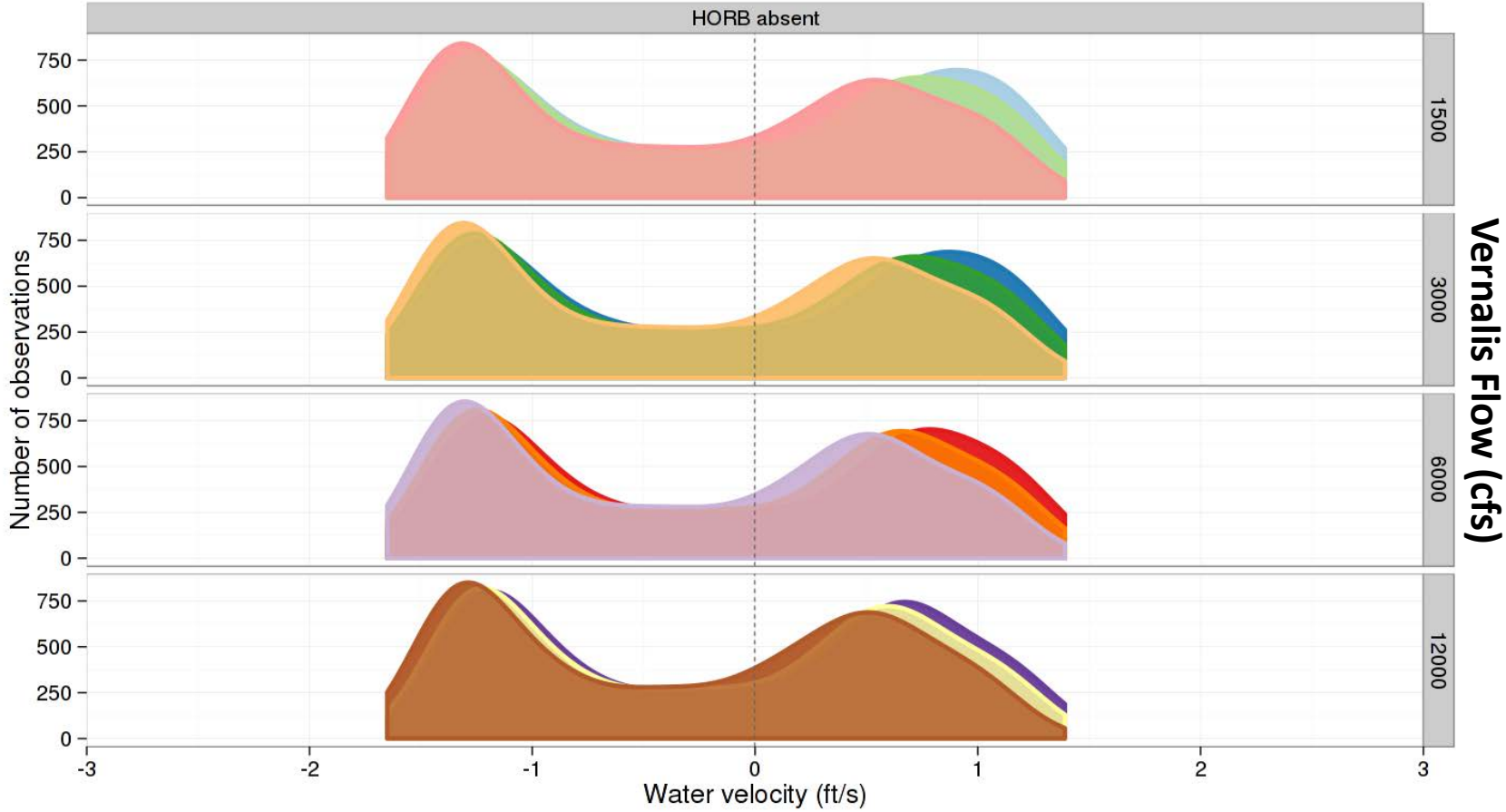


Available: http://glimmer.rstudio.com/hinkelman/simulated-delta-velocity/

Old River, Channel 97

density dissimilarity ≅ 0.40

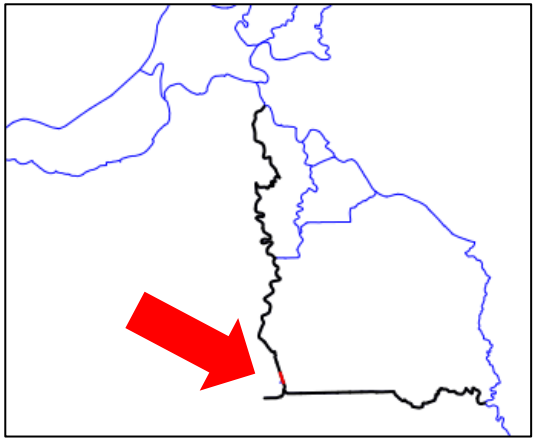


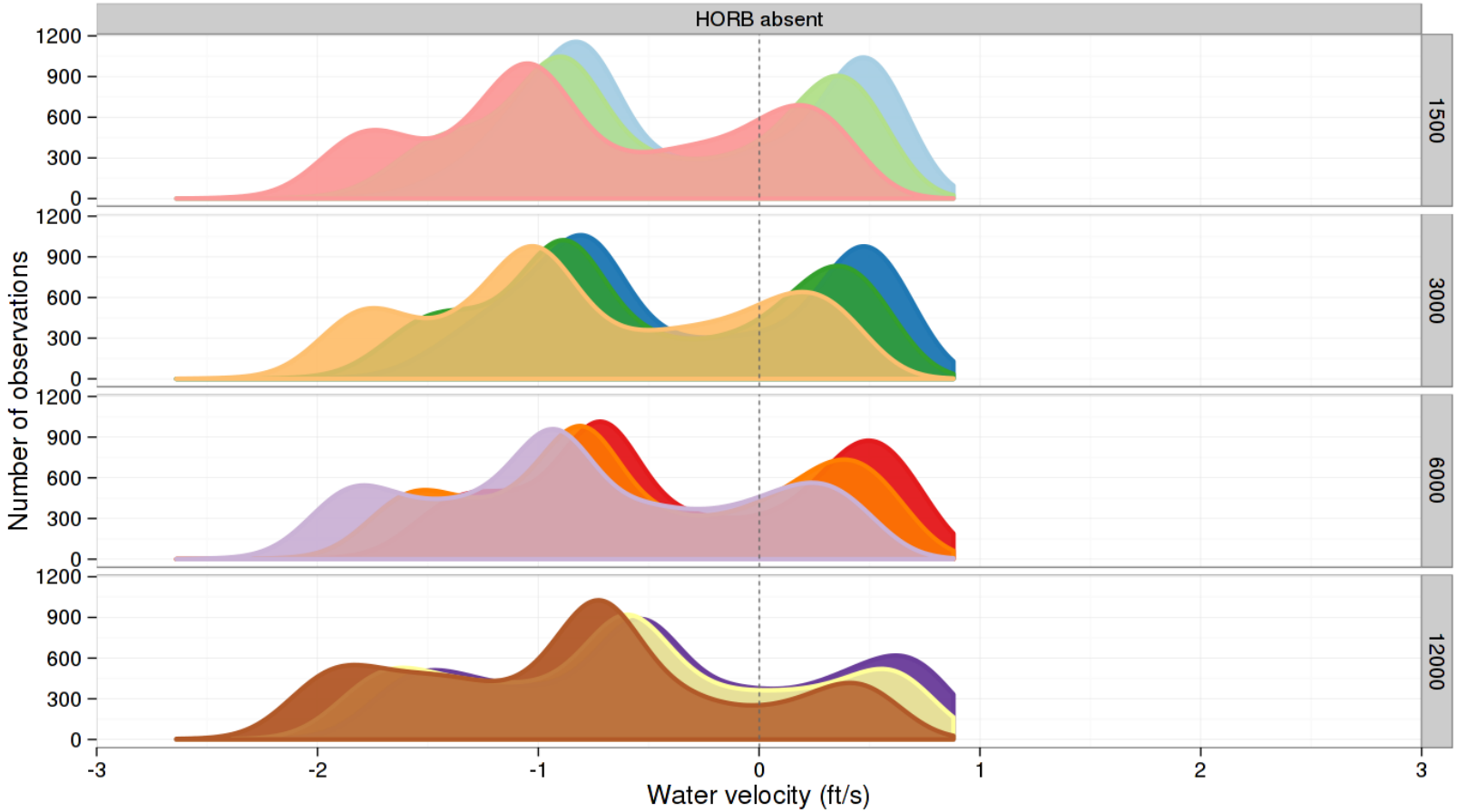


Available: http://glimmer.rstudio.com/hinkelman/simulated-delta-velocity/

Old River, Channel 232

density dissimilarity >0.75



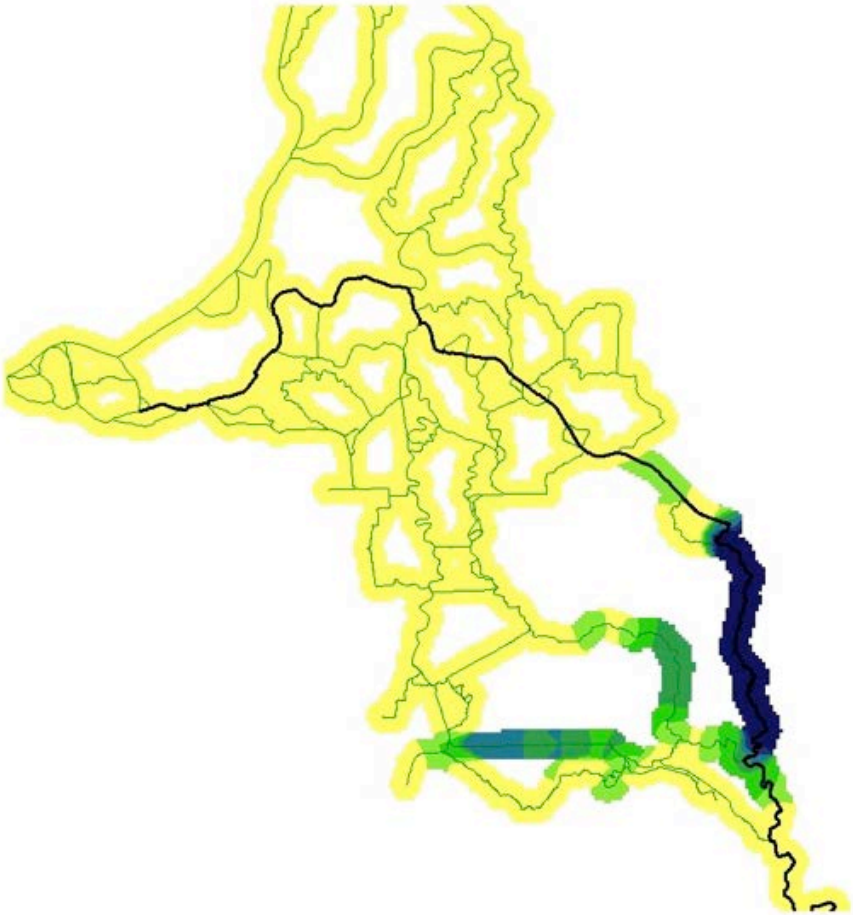


Density Dissimilarity Index, Vernallis inflows

< 0.25	0.30	0.40	0.50	0.60	0.70	> 0.75

Vernalis Flow (cfs)

3,000 To 6,000

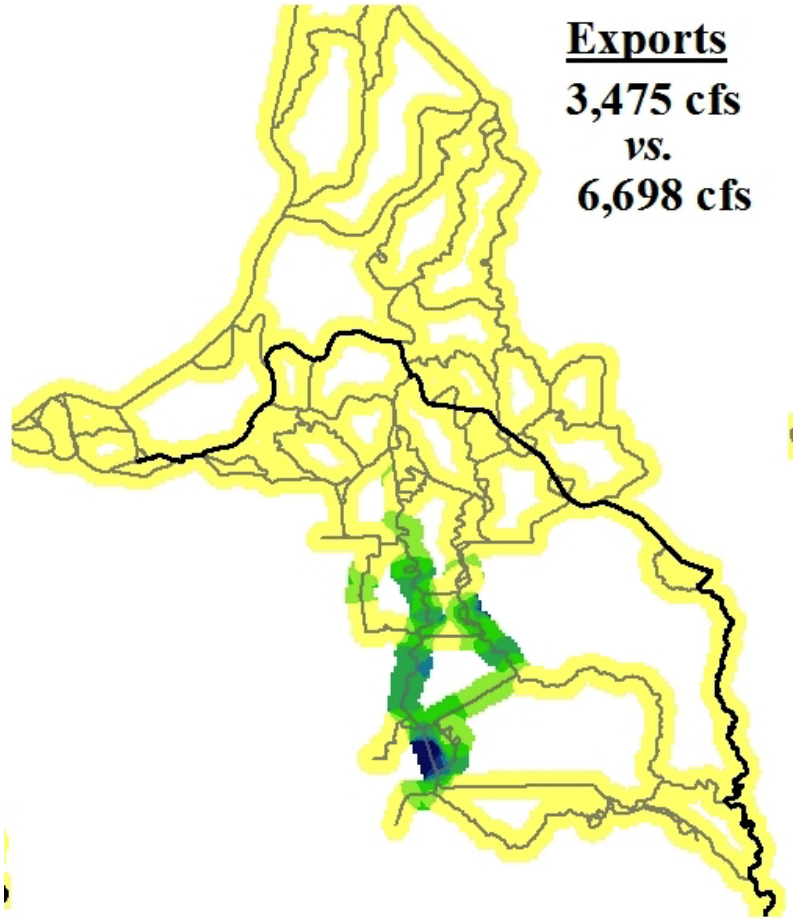


Density Dissimilarity Index, -2,500 vs. -5,000 OMR

< 0.25	0.30	0.40	0.50	0.60	0.70	> 0.75

Vernalis Flow (cfs)

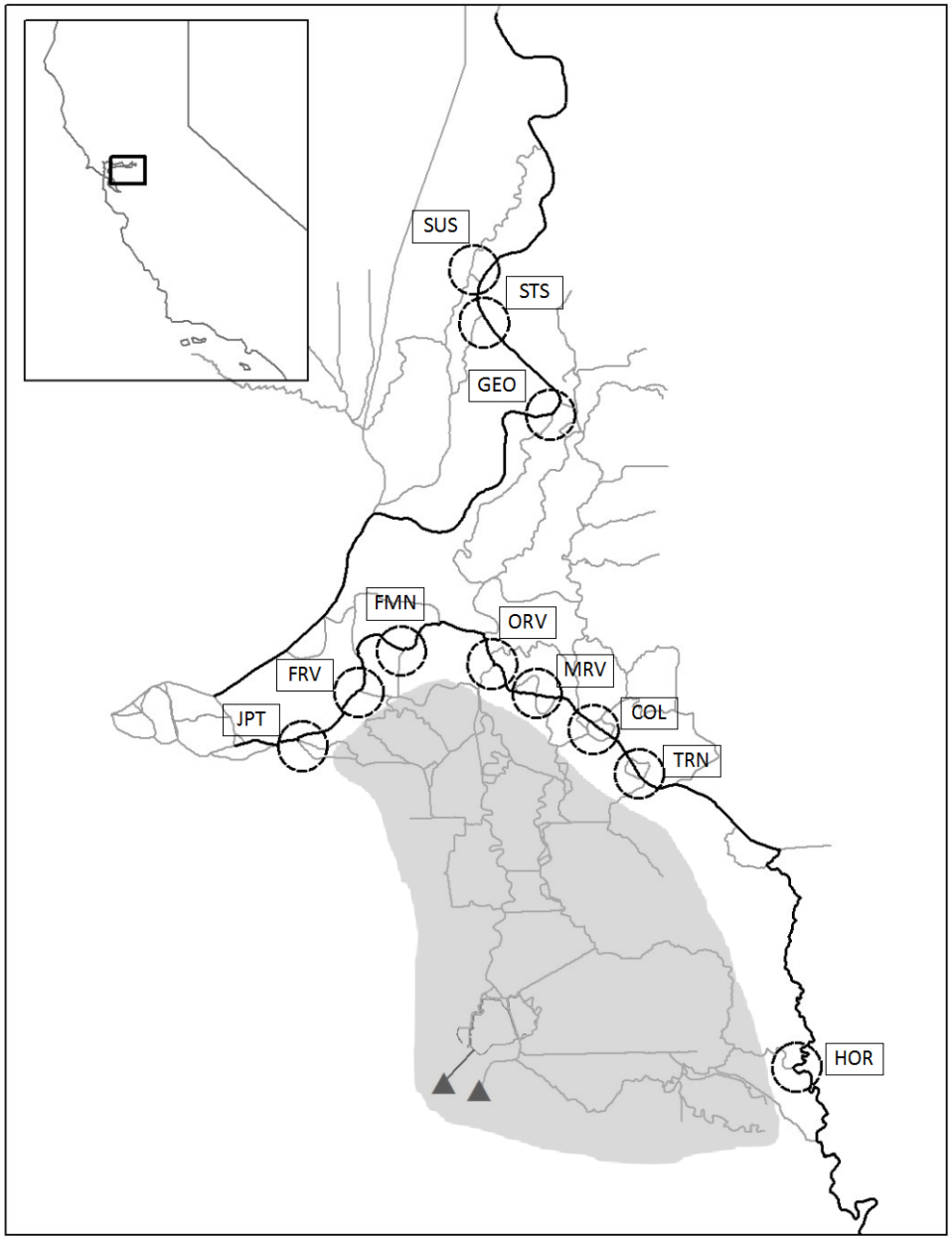
3,000



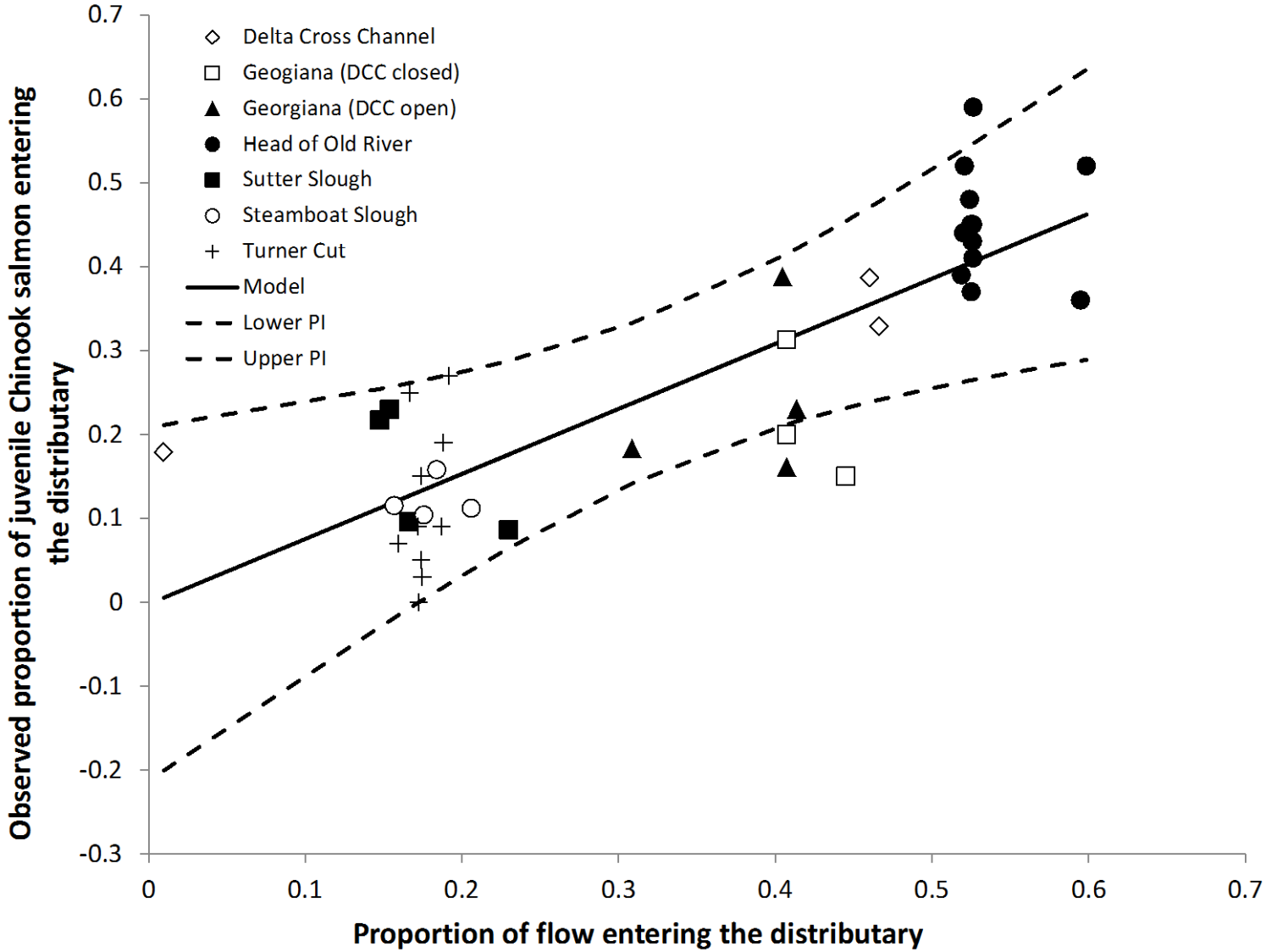
Fish Routing at Junctions

Cavallo, B. et al. 2014. Predicting juvenile Chinook routing in riverine and tidal channels of a freshwater estuary. In review, Environmental Biology of Fishes.

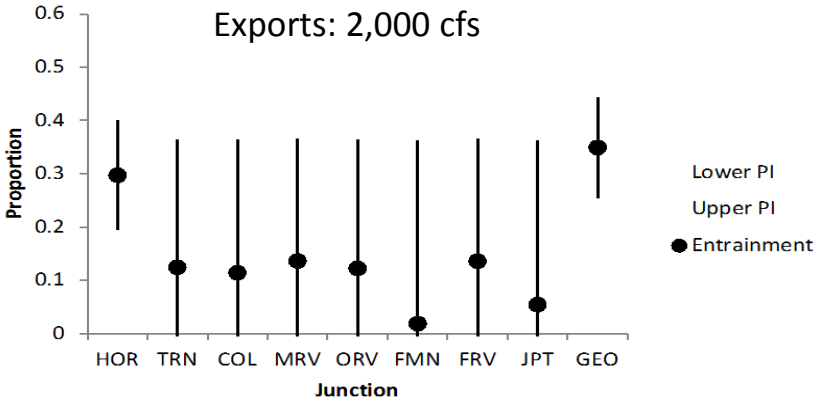
Fish Routing at Junctions

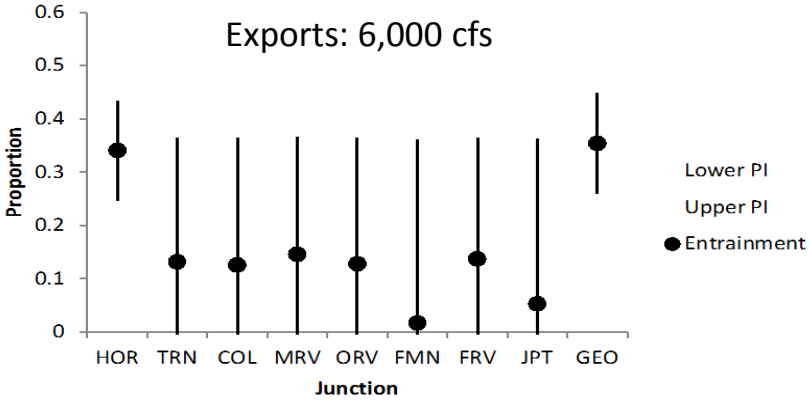


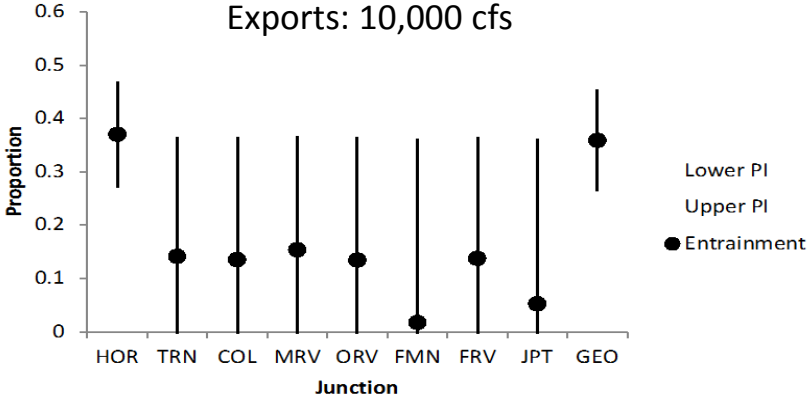
Fish Routing at Junctions



Fish Routing at Junctions





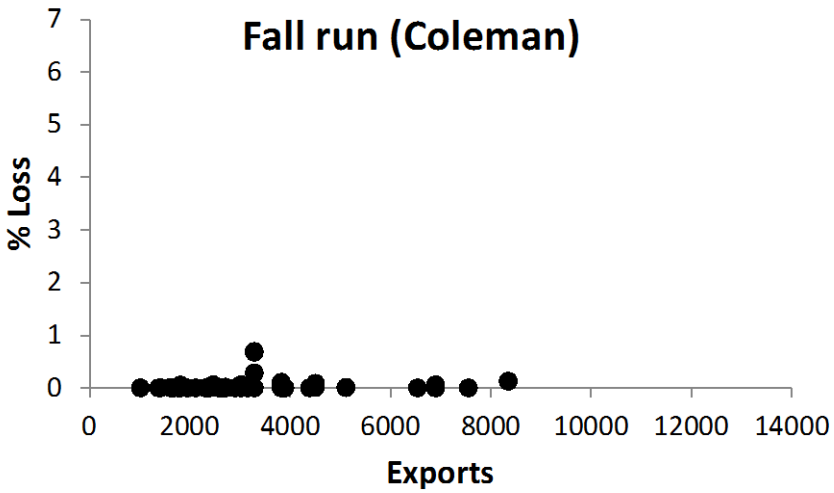


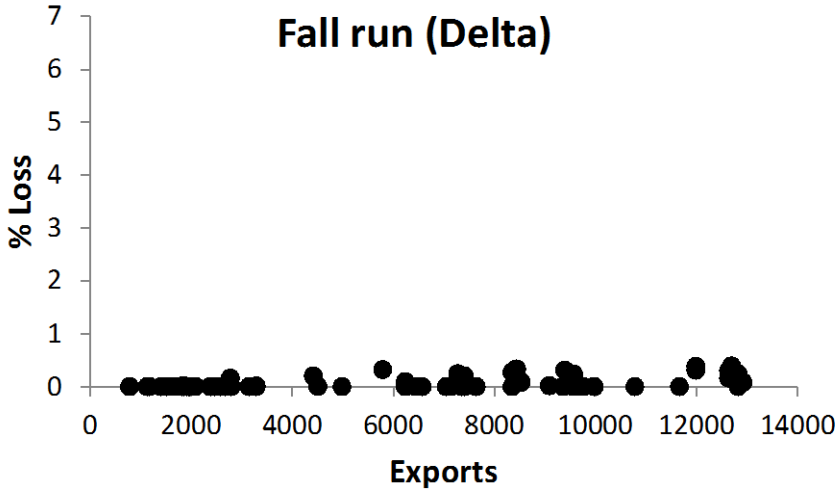
Means with 95% prediction intervals for predicted routing at nine Delta junctions under three export levels.

South Delta Entrainment Loss

Zeug, S. and **B. Cavallo**. 2014. Controls on the entrainment of juvenile Chinook salmon (*Oncorhynchus tshawytscha*) into large water diversions and estimates of population-level loss. Accepted at PLOS ONE.

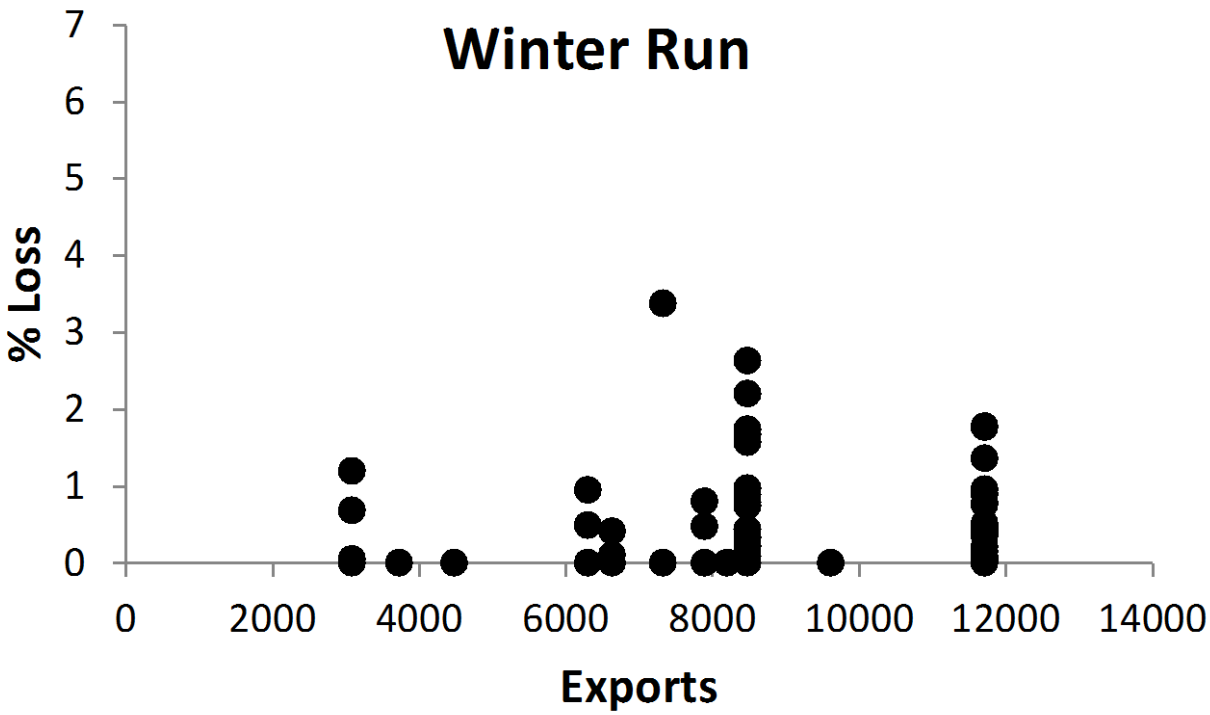
South Delta Entrainment, Proportional Loss





1993-2007
419 release groups
0.01% “loss” (average)

South Delta Entrainment, Proportional Loss



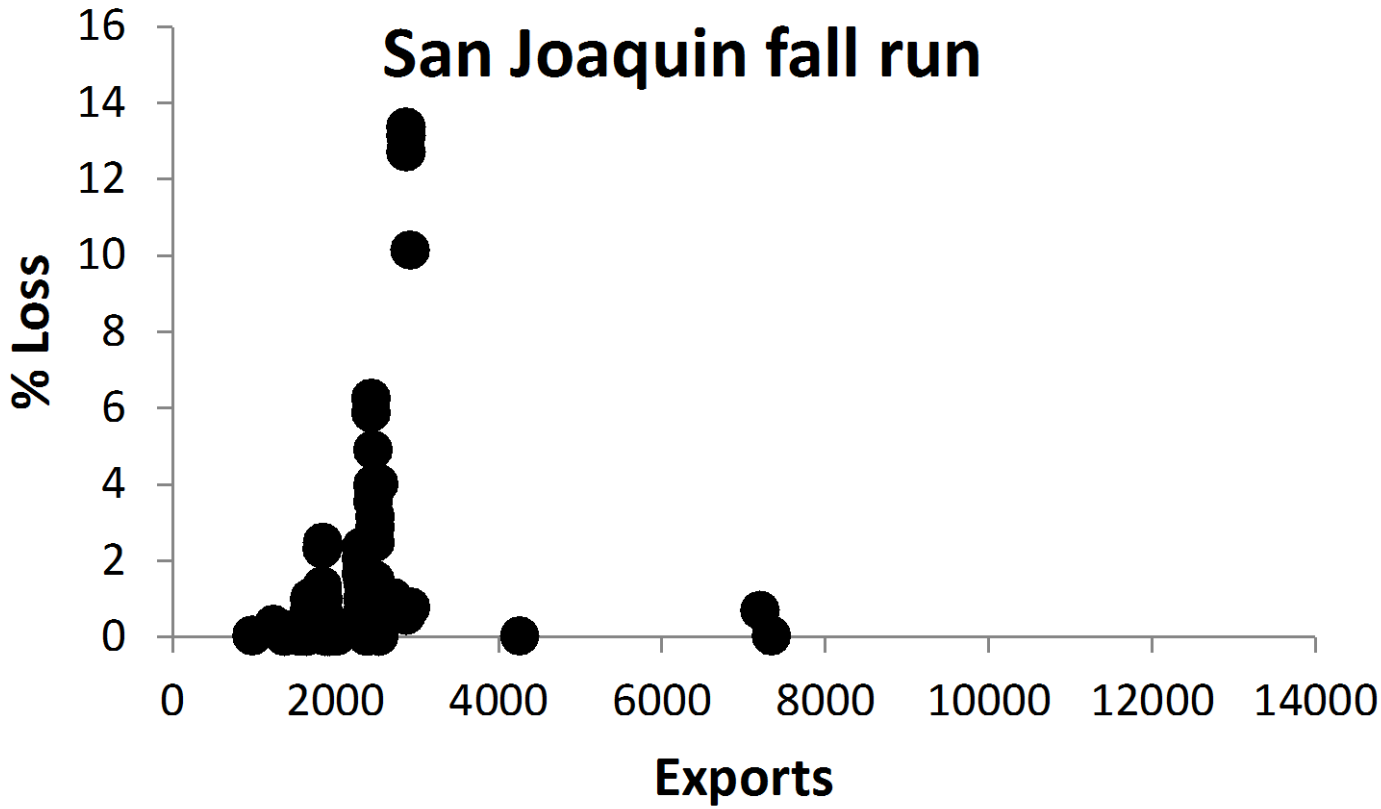
1993-2007
178 release groups
0.05% “loss” (average)

South Delta Entrainment, Proportional Loss

Spring Chinook (hatchery)
6.8 million CWTed fish
26 release groups
0.0002% “loss” (average)

Spring Chinook (wild)
2.8 million CWTed fish
161 release groups
0.0005% “loss” (average)

South Delta Entrainment, Proportional Loss



1993-2007
313 release groups (7 million fish)
1.4% “loss” (average)

South Delta Entrainment, Proportional Loss

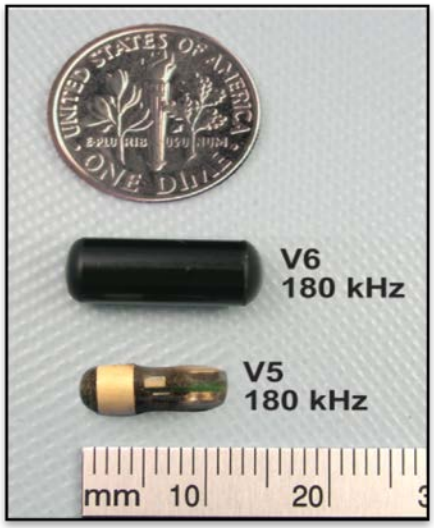
Sac model	AIC	Δ AIC	AIC_weight
exports	2543.018	0	0.999313
OMR	2557.584	14.566	0.000687
SJ flow	2619.85	76.832	2.07E-17
Sac flow	2659.833	116.815	4.3E-26

San Joaquin model	AIC	Δ AIC	AIC_weight
exports	3274.14	0	1
SJ flow	3303.316	29.176	4.62E-07
OMR	3311.442	37.302	7.94E-09

OMR-Survival

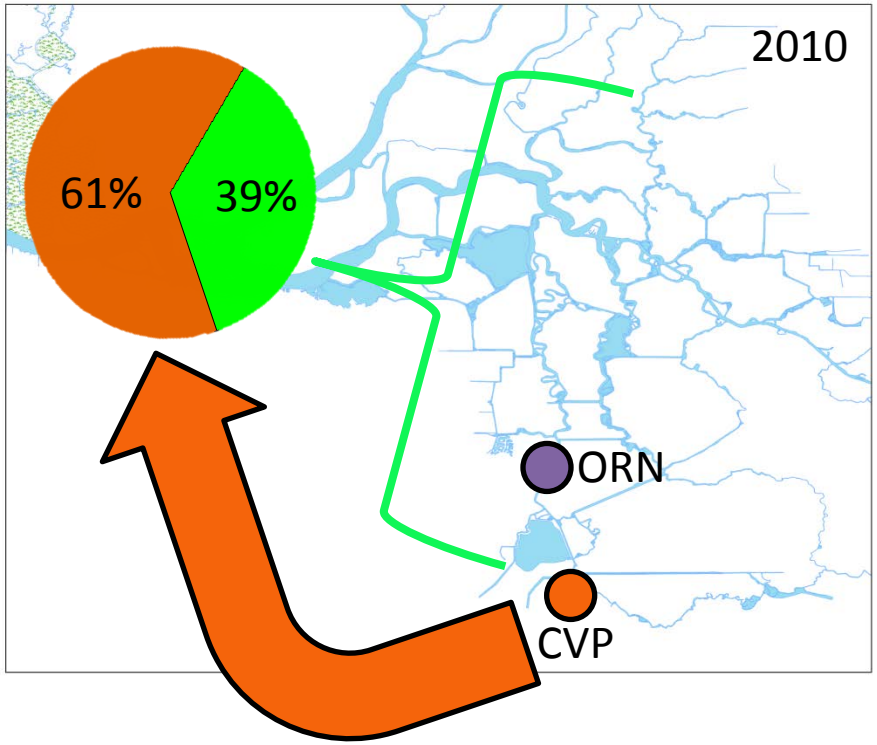
OMR-Survival

- 2012 Stipulation Study (presentation tomorrow)
- VAMP acoustic telemetry studies



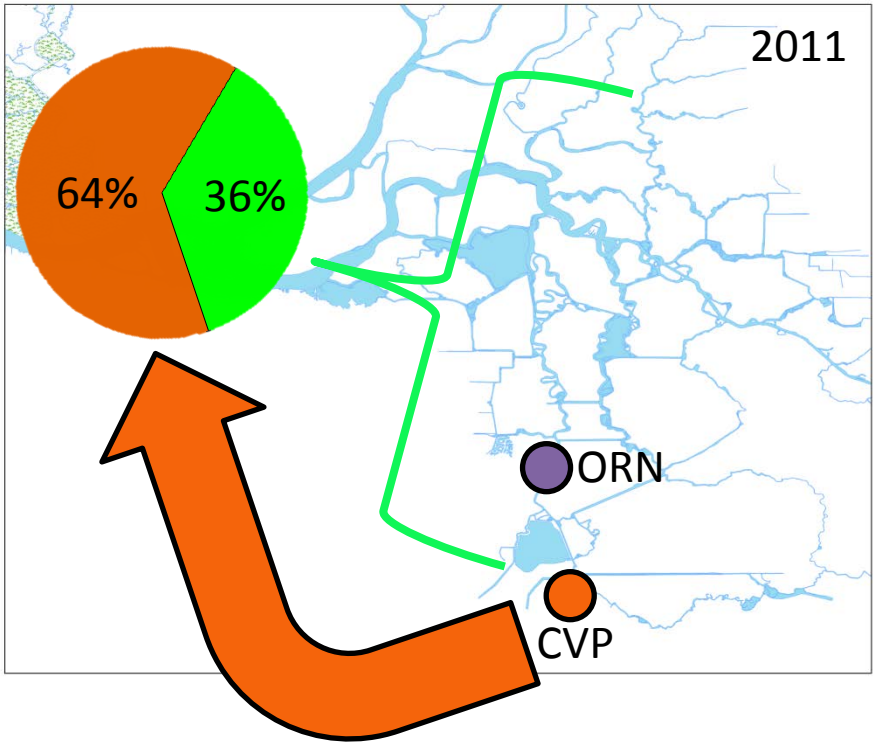
VAMP Acoustic Studies: Survival to Chipps Island

- 2010:
  - Joint probability of moving from Old River North (ORN) to Chipps Island and surviving:
    - 0.01, SE = 0.01



VAMP Study: % of survivors to Chipps Island

- 2010:
  - Joint probability of moving from Old River North (ORN) to Chipps Island and surviving:
    - 0.01, SE = 0.01
- 2011:
  - Joint probability of moving from Old River North (ORN) to Chipps Island and surviving:
    - 0.01, SE = 0.01



Both years, low exports and *positive* OMR flows

Recap

Recap

- Juvenile salmonids less vulnerable to “net” flow than smelt
- “Net” flow not a good index of velocity change
- Exports have a different effect on velocities than SJR inflow
  - OMR conflates these effects
- Interior Delta survival poor regardless of OMR