Fall Run Chinook Pre-Smolt Outmigration to Alternate Rearing Areas in the Sacramento-San Joaquin Valley

28 Oct 2014
Bay-Delta Science Conference
Sacramento, CA

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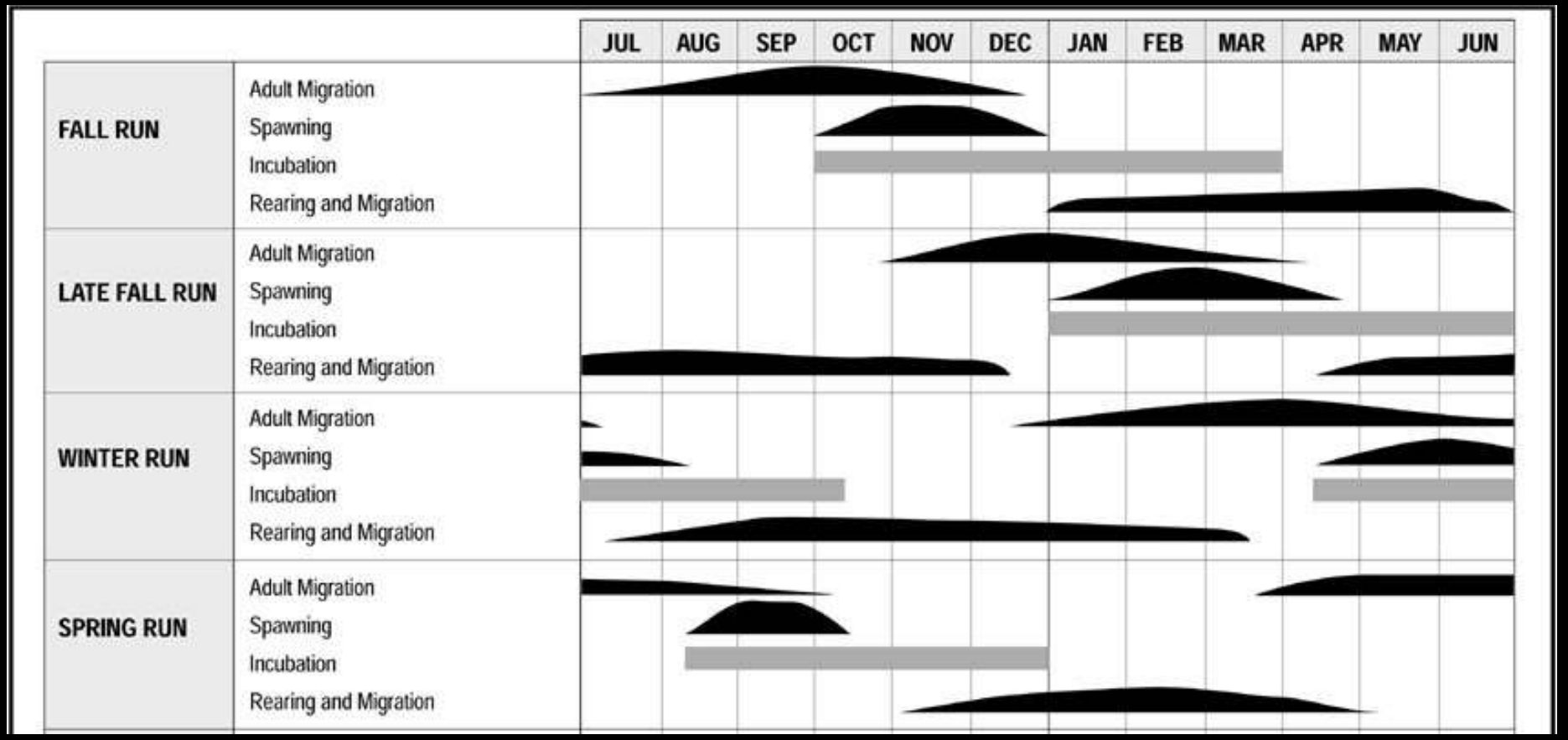
UCSC-SWFSC

Central Valley Fall Run Chinook



Central Valley Fall Run Chinook

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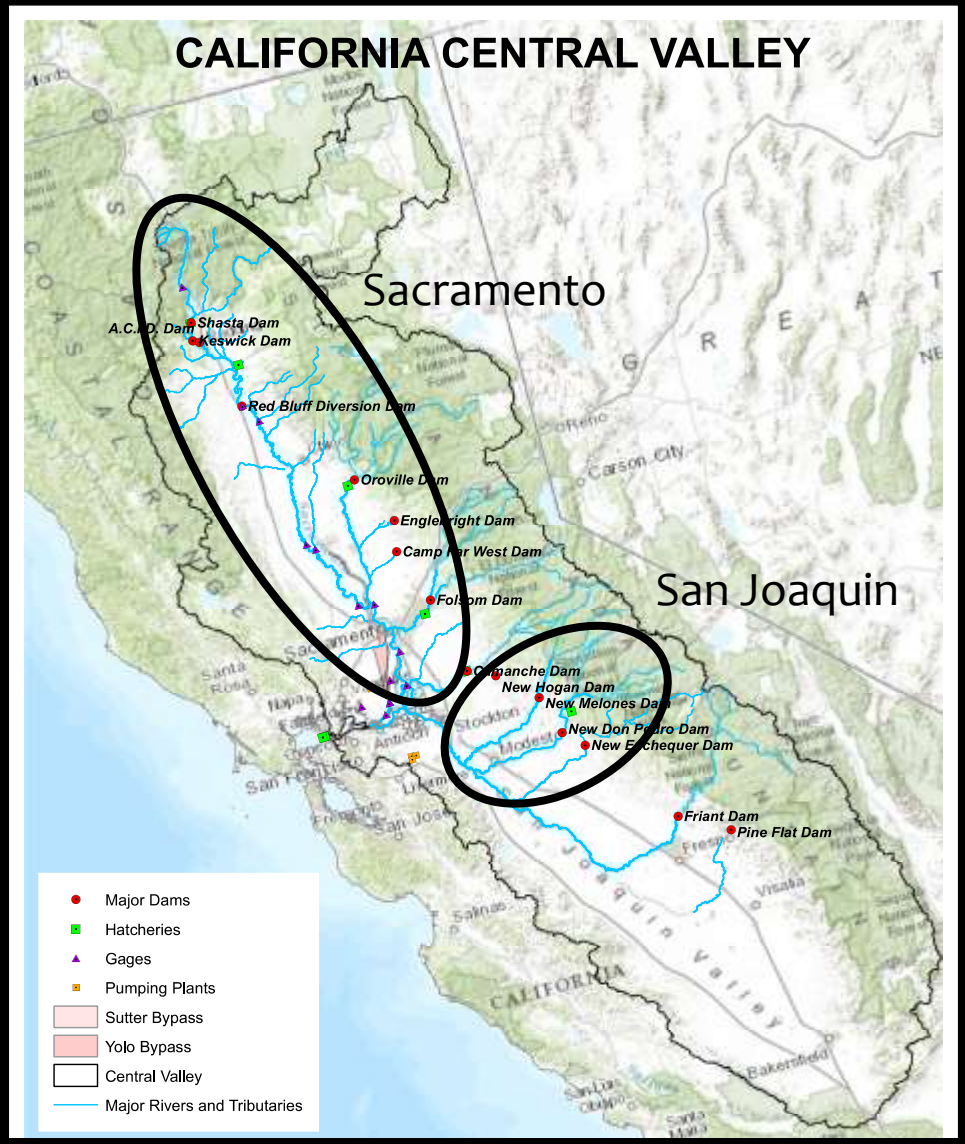
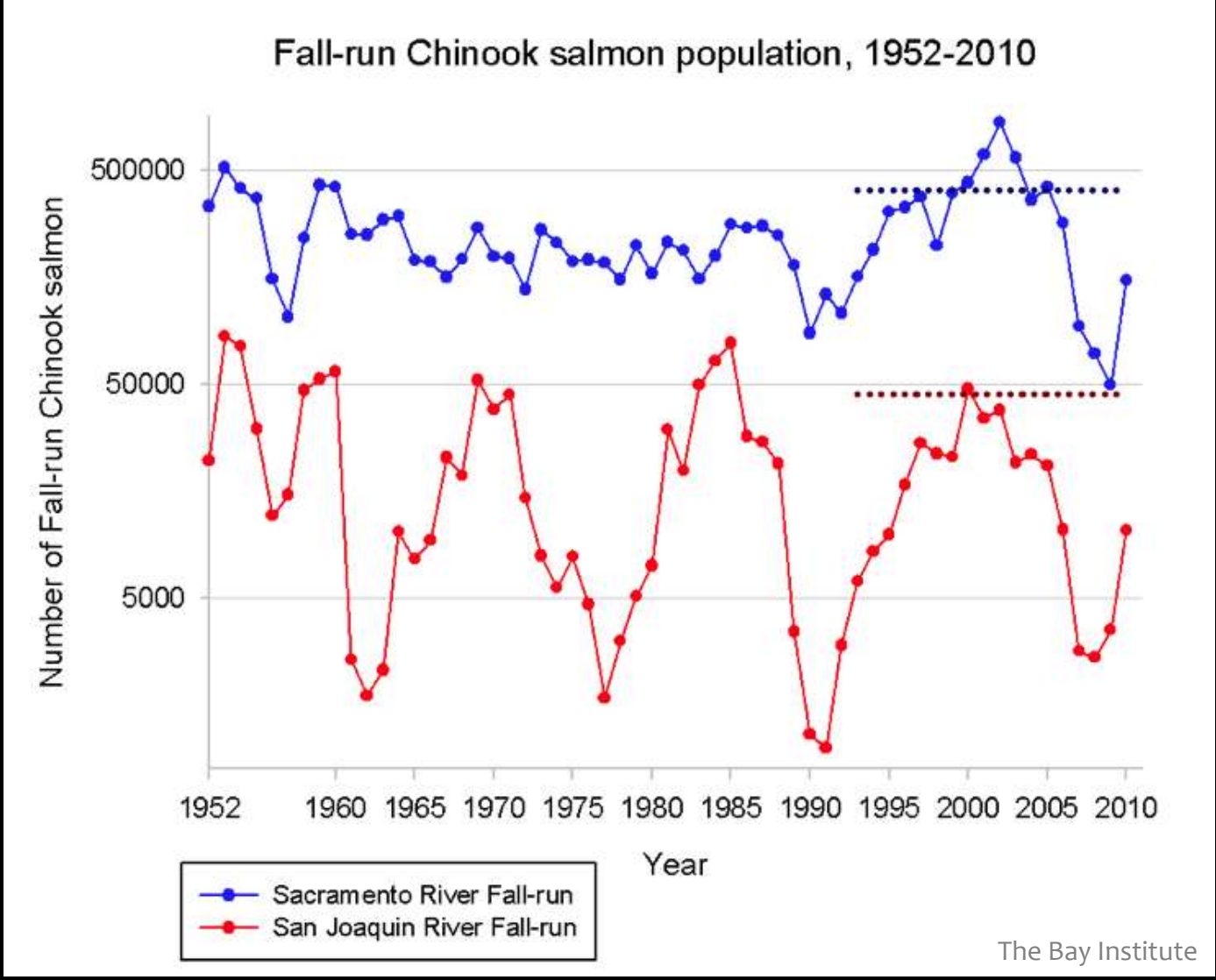


Central Valley Fall Run Chinook

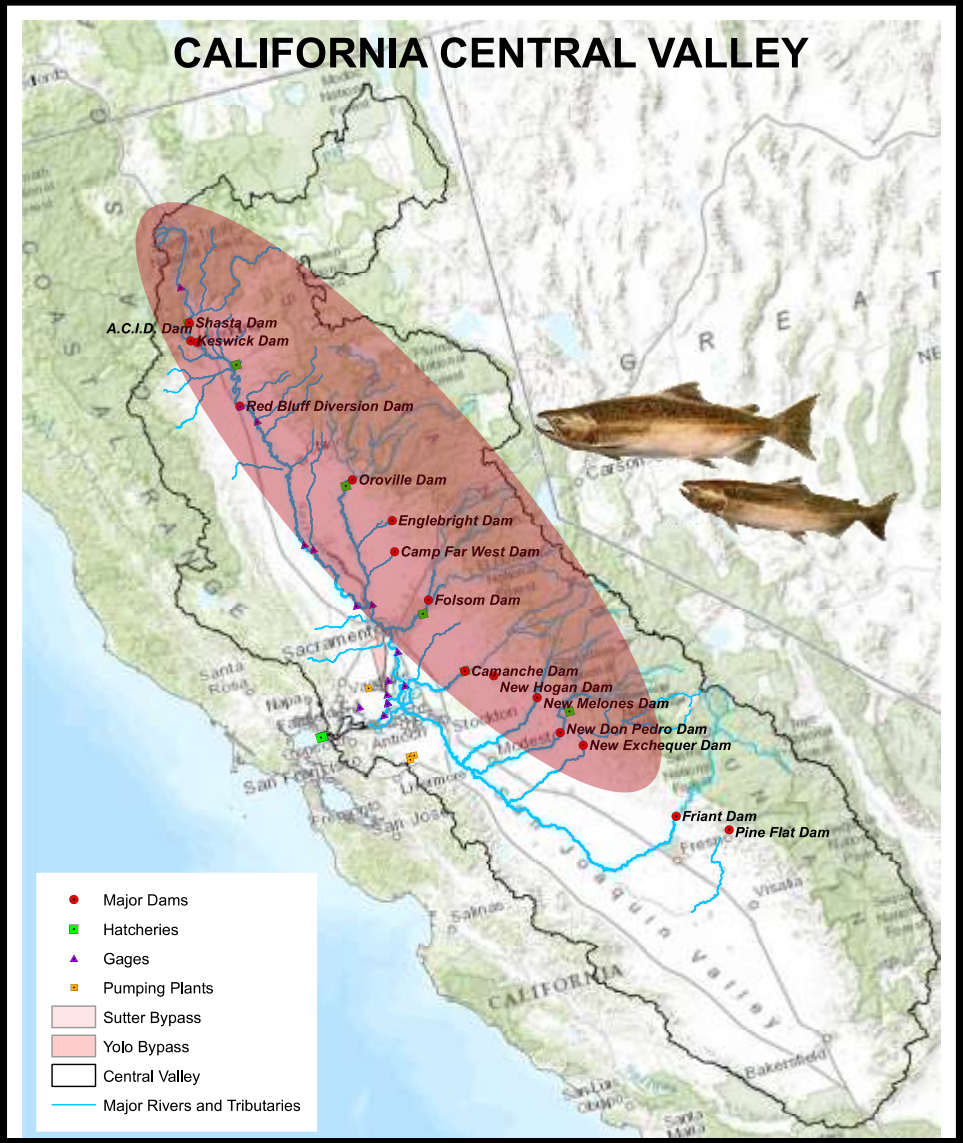


The Bay Institute

Central Valley Chinook

UPMIGRATION
Adult

Central Valley Chinook

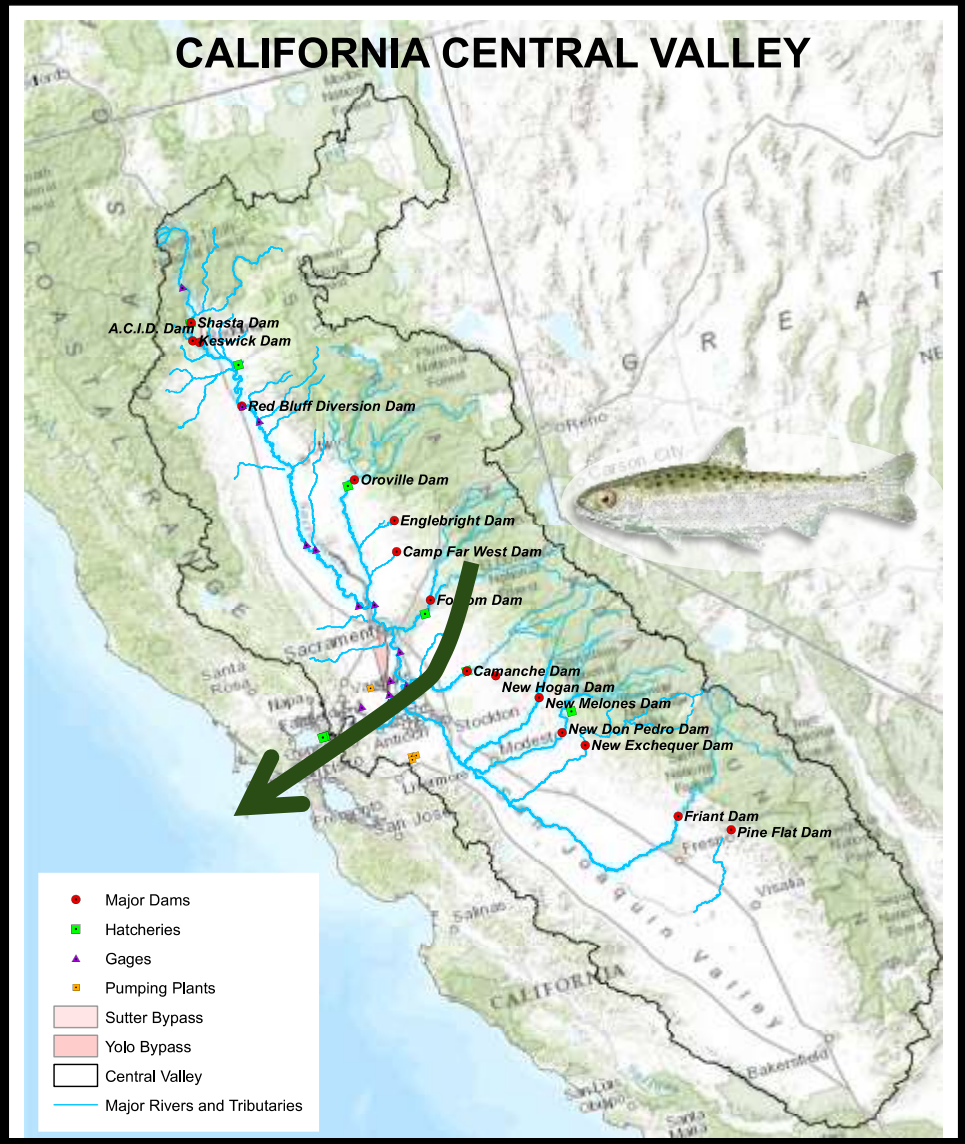


SPAWNING
Spawners

Central Valley Chinook

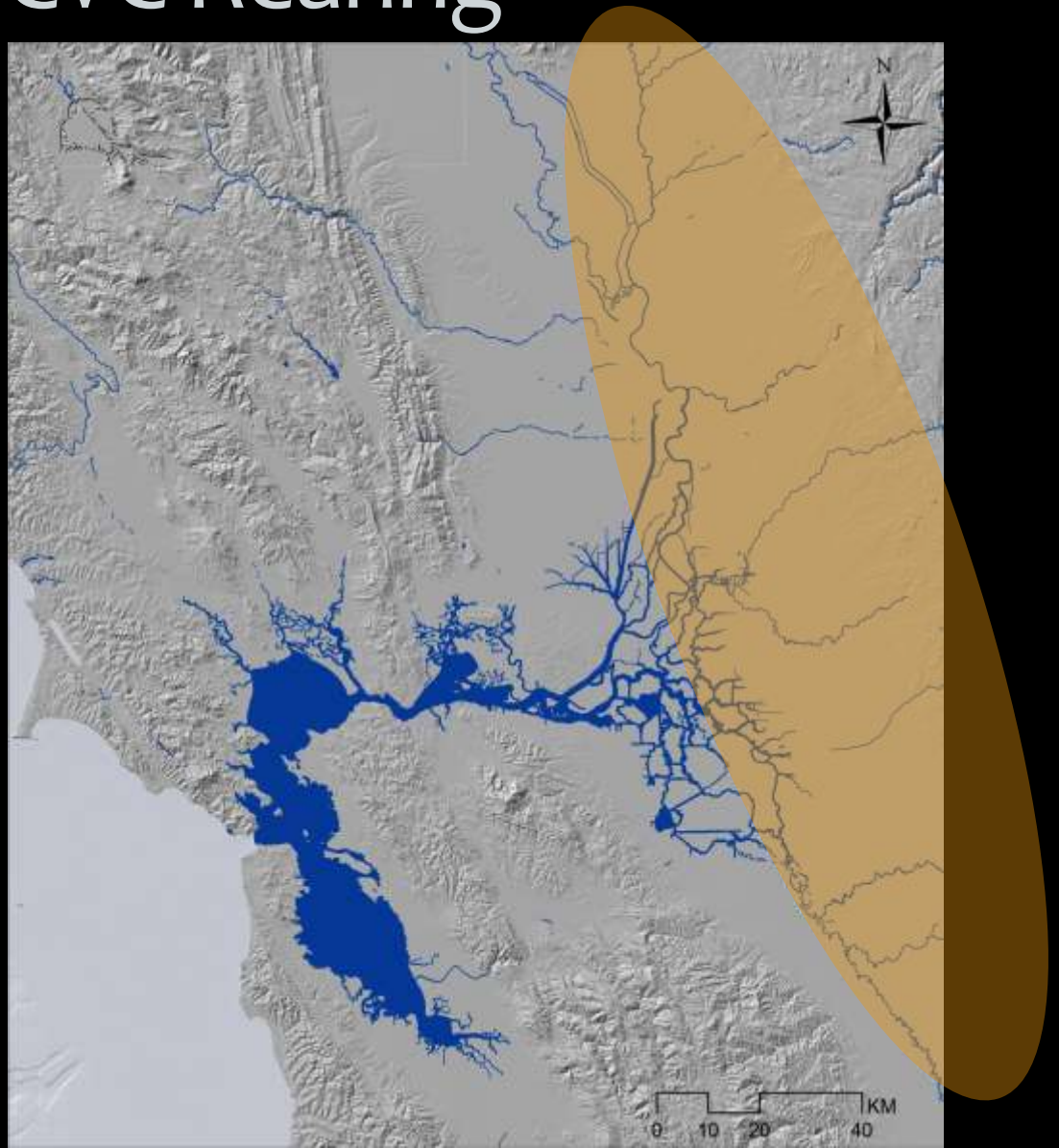
INCUBATION/REARING
Eggs, Alevins, Fry, Parr

Central Valley Chinook



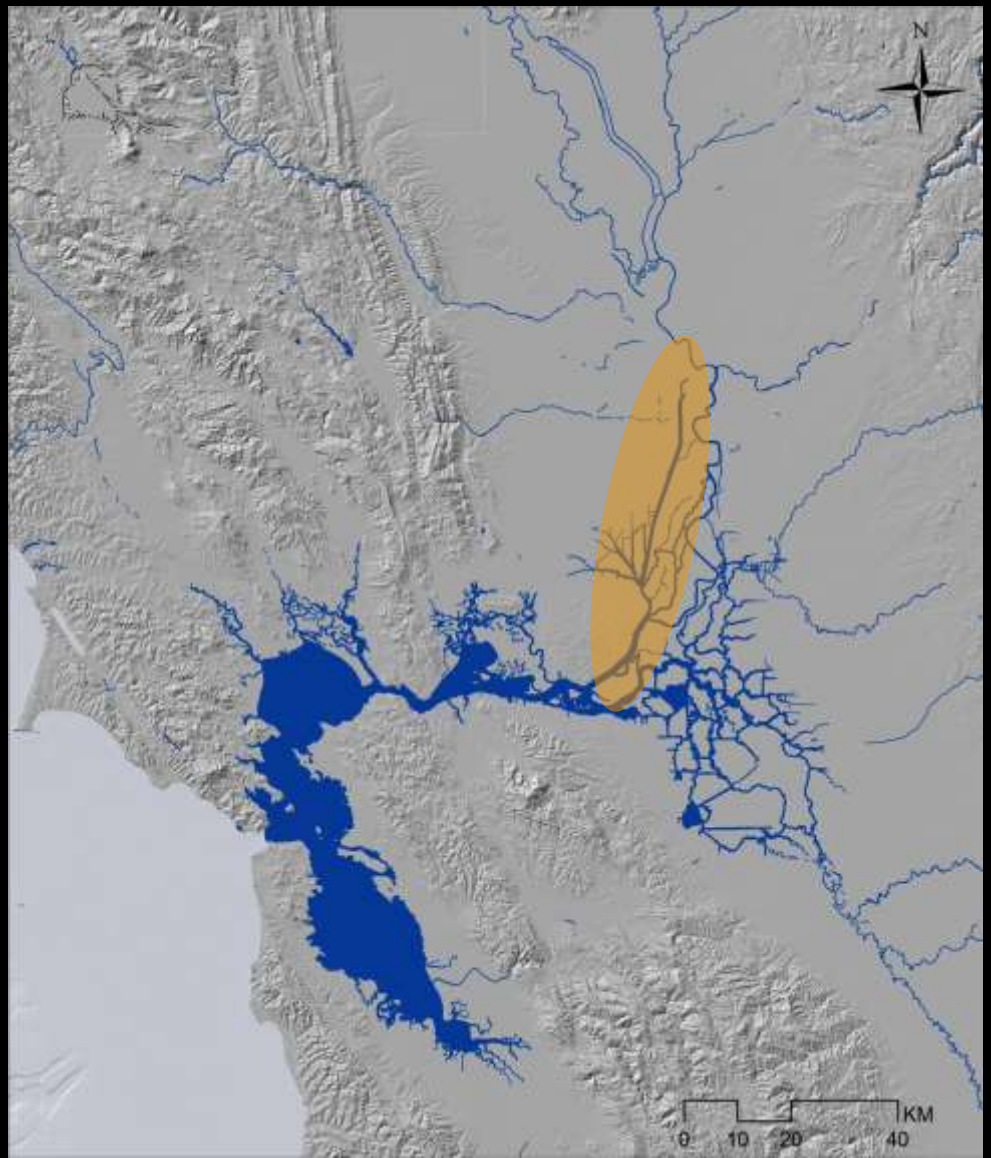
OUTMIGRATION
Smolts

Fall Run CVC Rearing



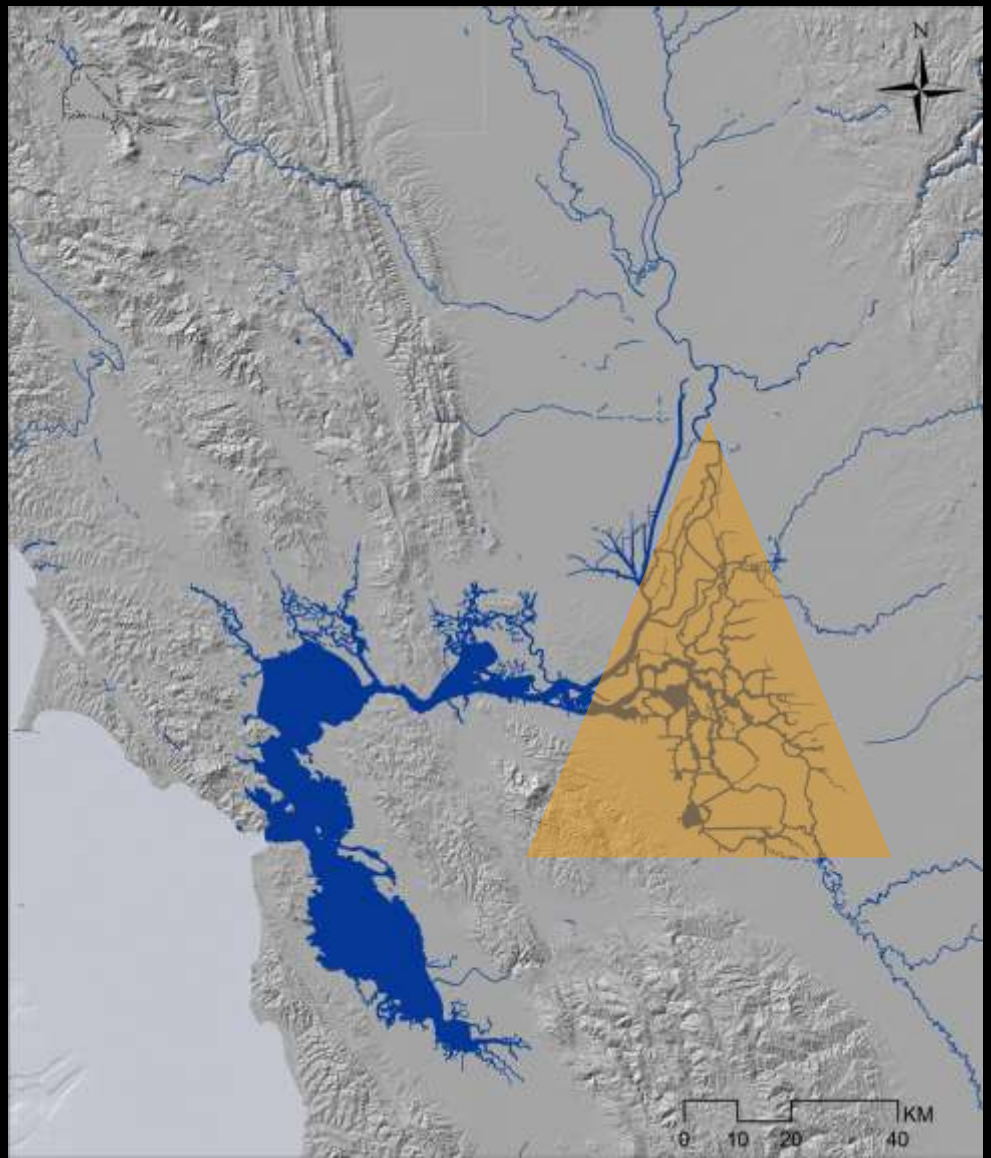
Rivers

Fall Run CVC Rearing



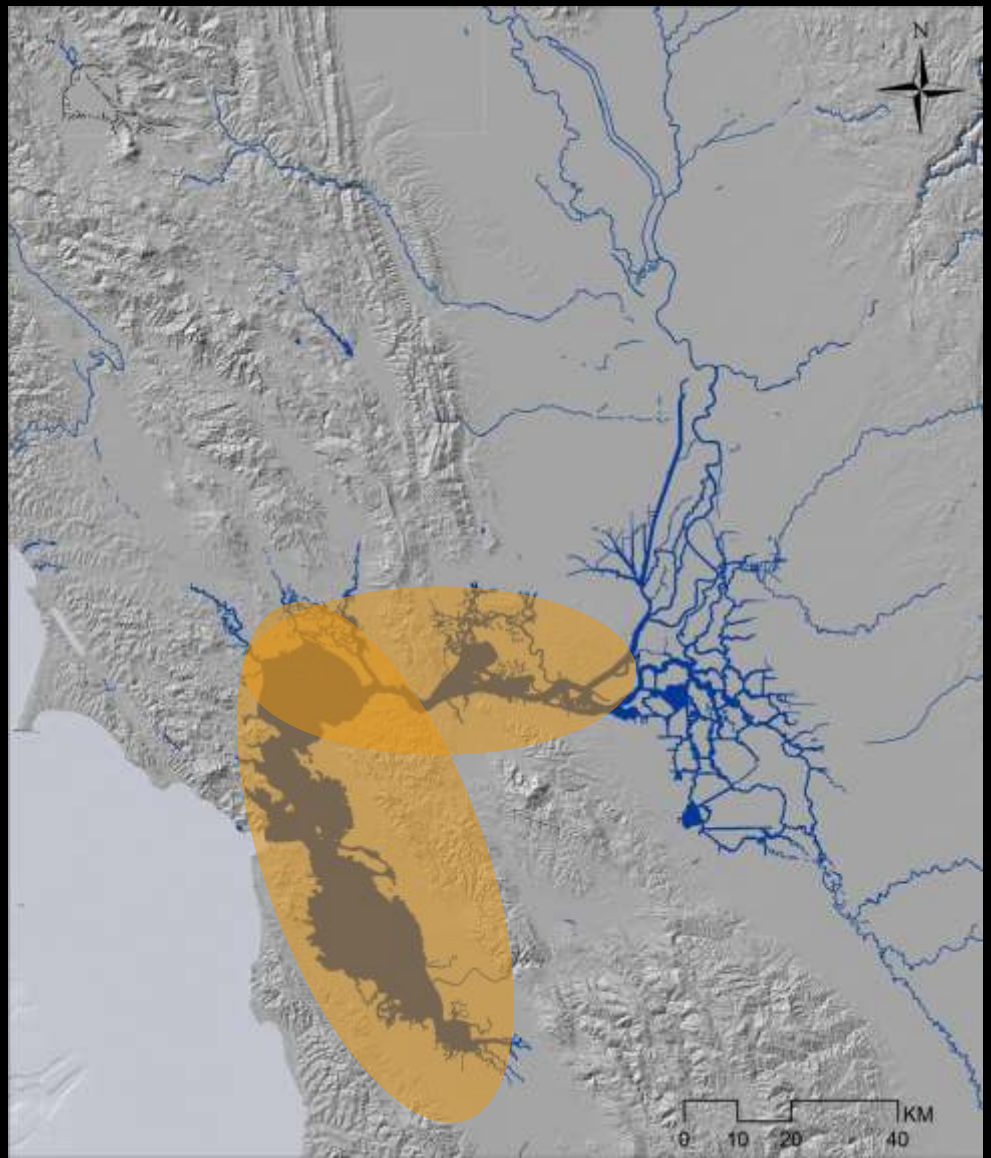
Floodplains

Fall Run CVC Rearing



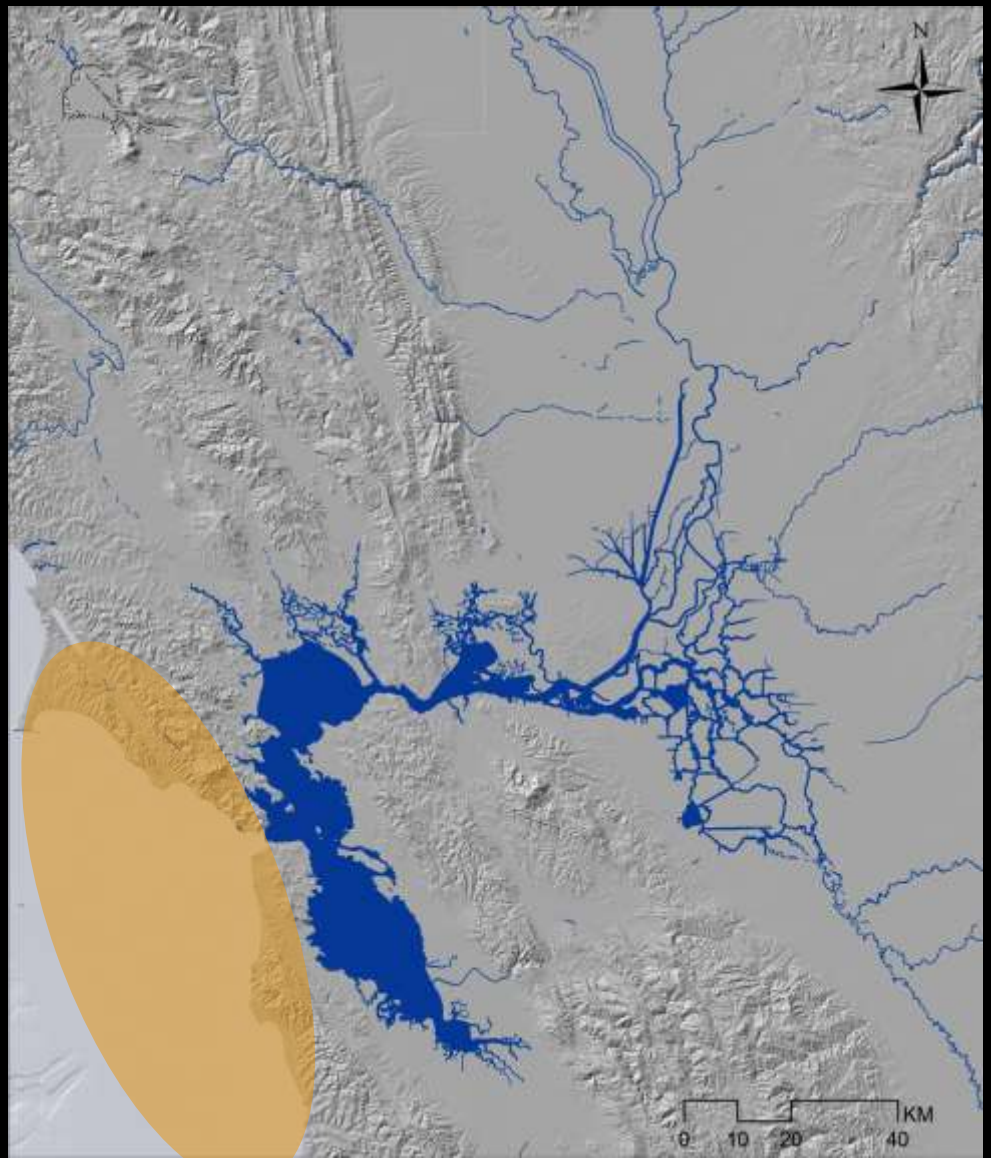
Delta

Fall Run CVC Rearing



Bays

Fall Run CVC Rearing



Ocean?

Alternate Rearing Habitats

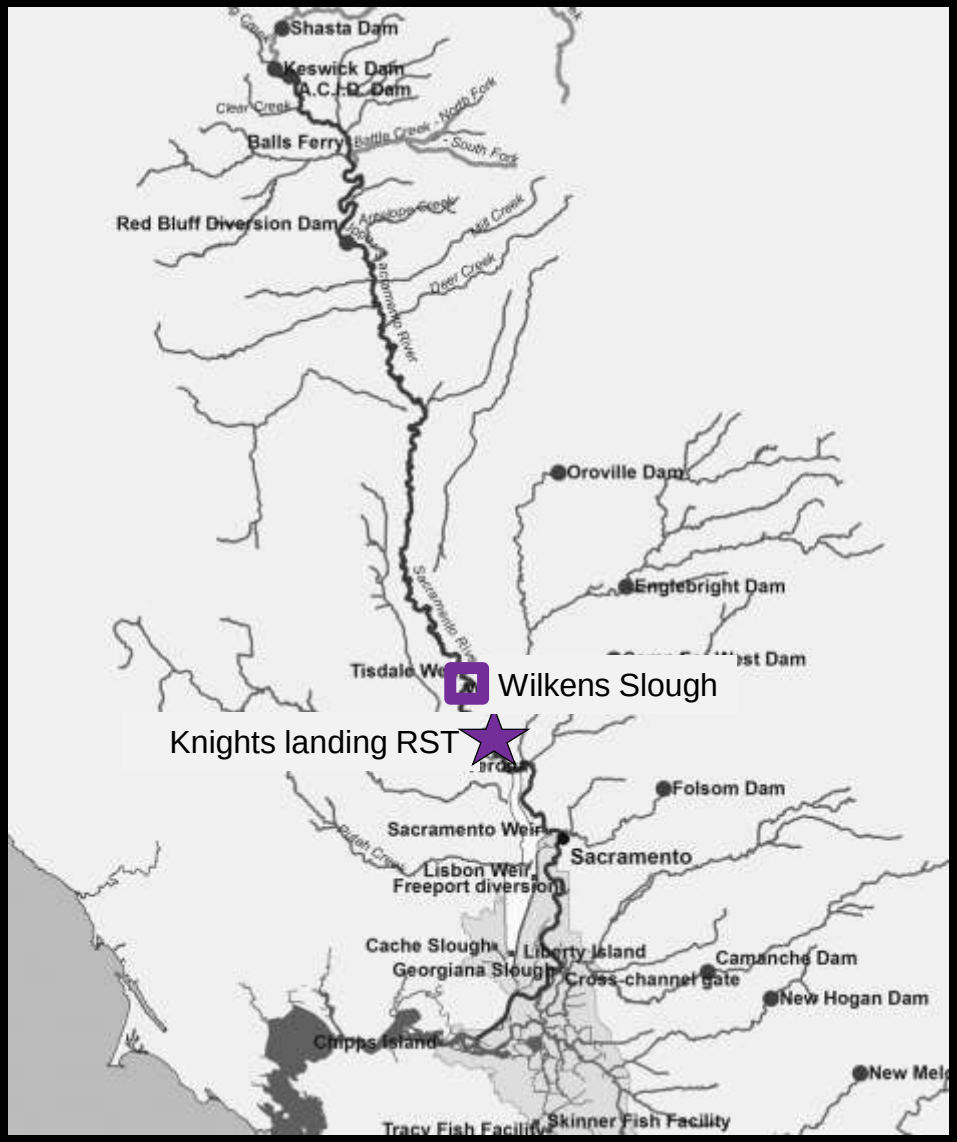
- When do pre-smolts enter these habitats?
- Why do pre-smolts enter these habitats?

  Related to:
  - Physical Environment?
  - Density-dependence?

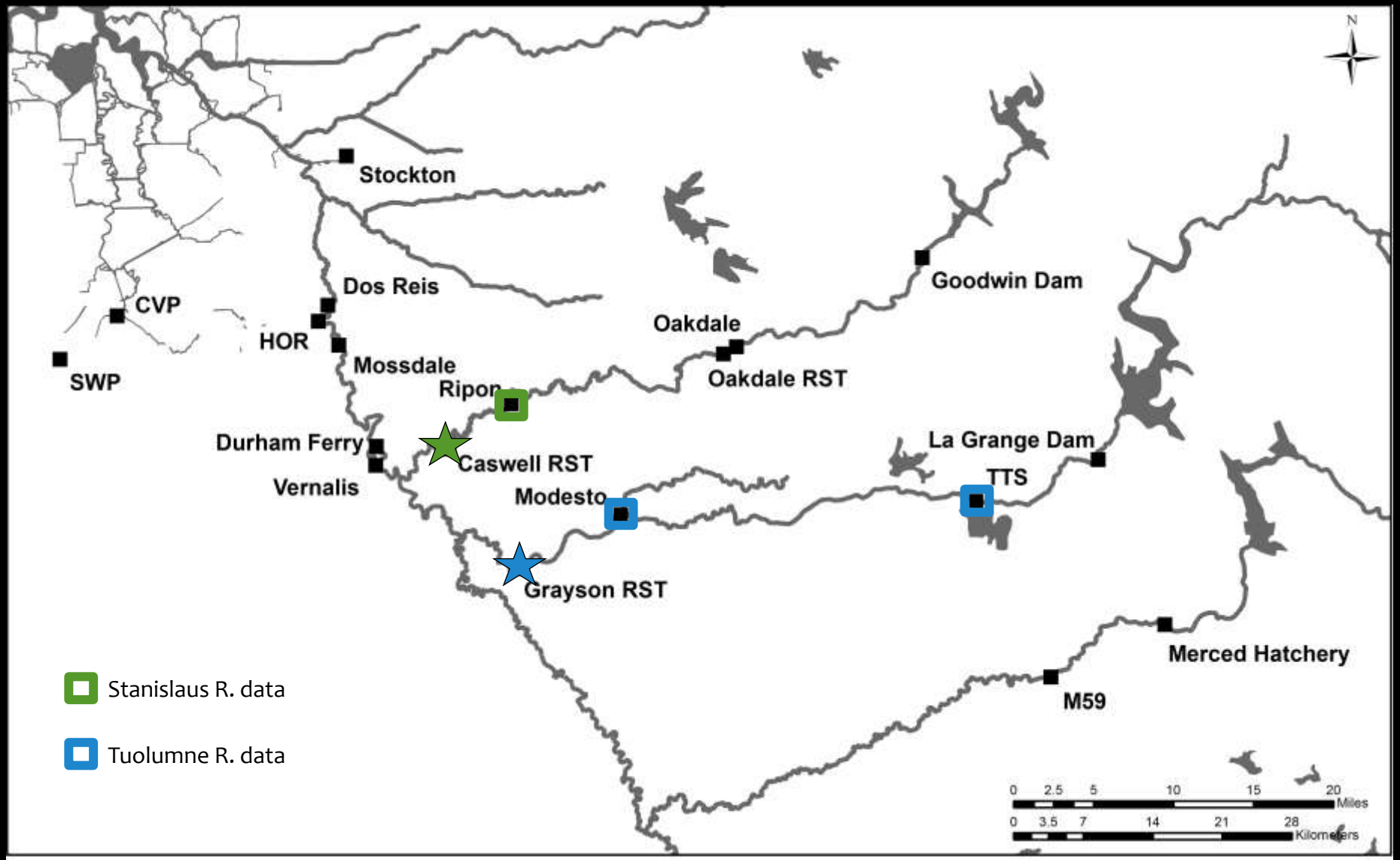
Alternate Rearing Habitats

- When do pre-smolts enter these habitats?
  - Rotary Screw Trap (RST) timeseries

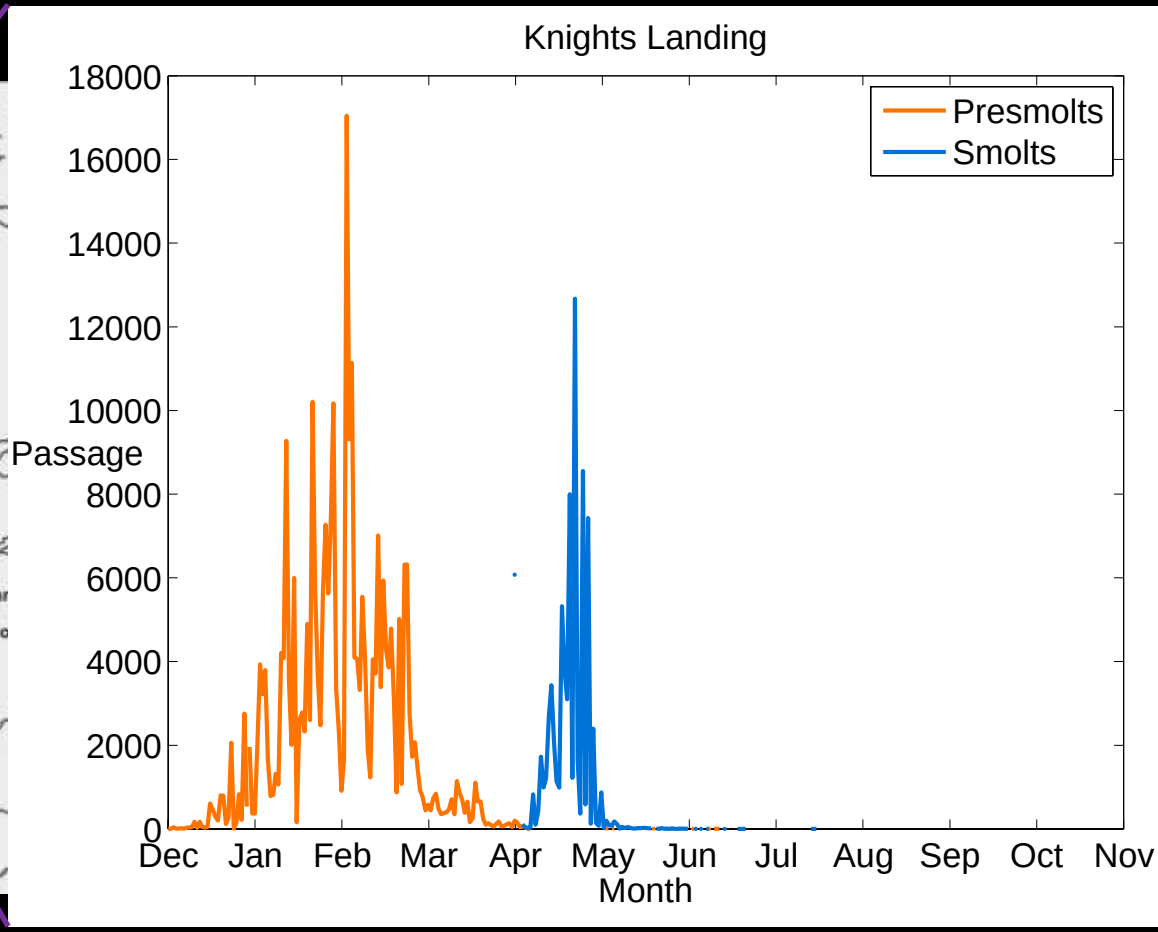
Sacramento River RST



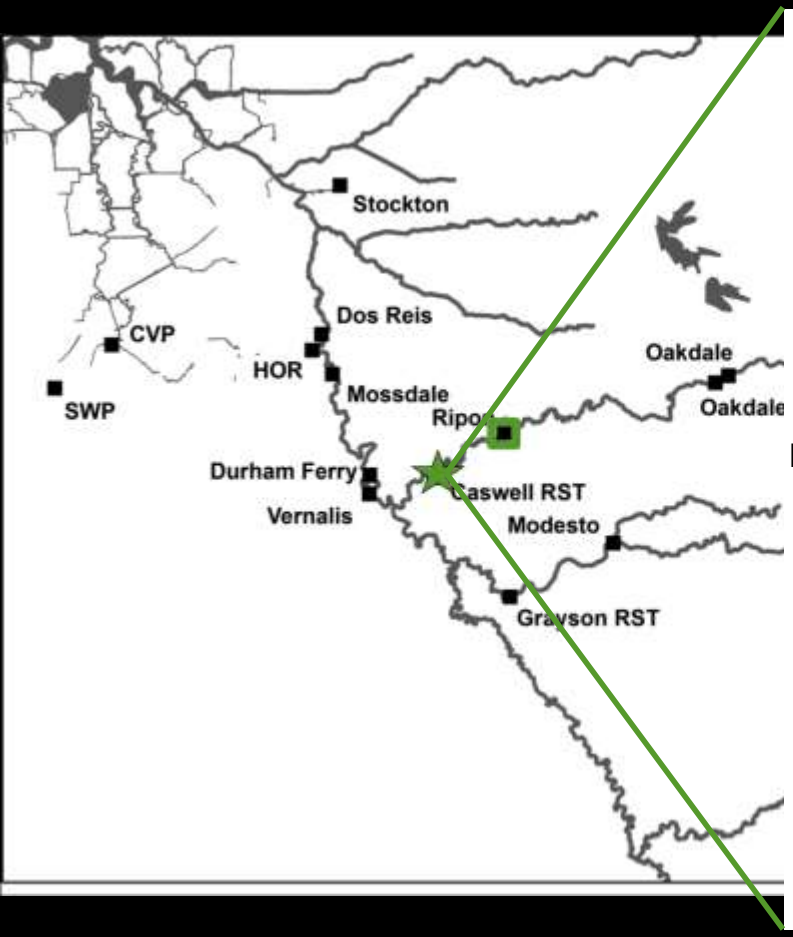
San Joaquin Tributaries RSTs

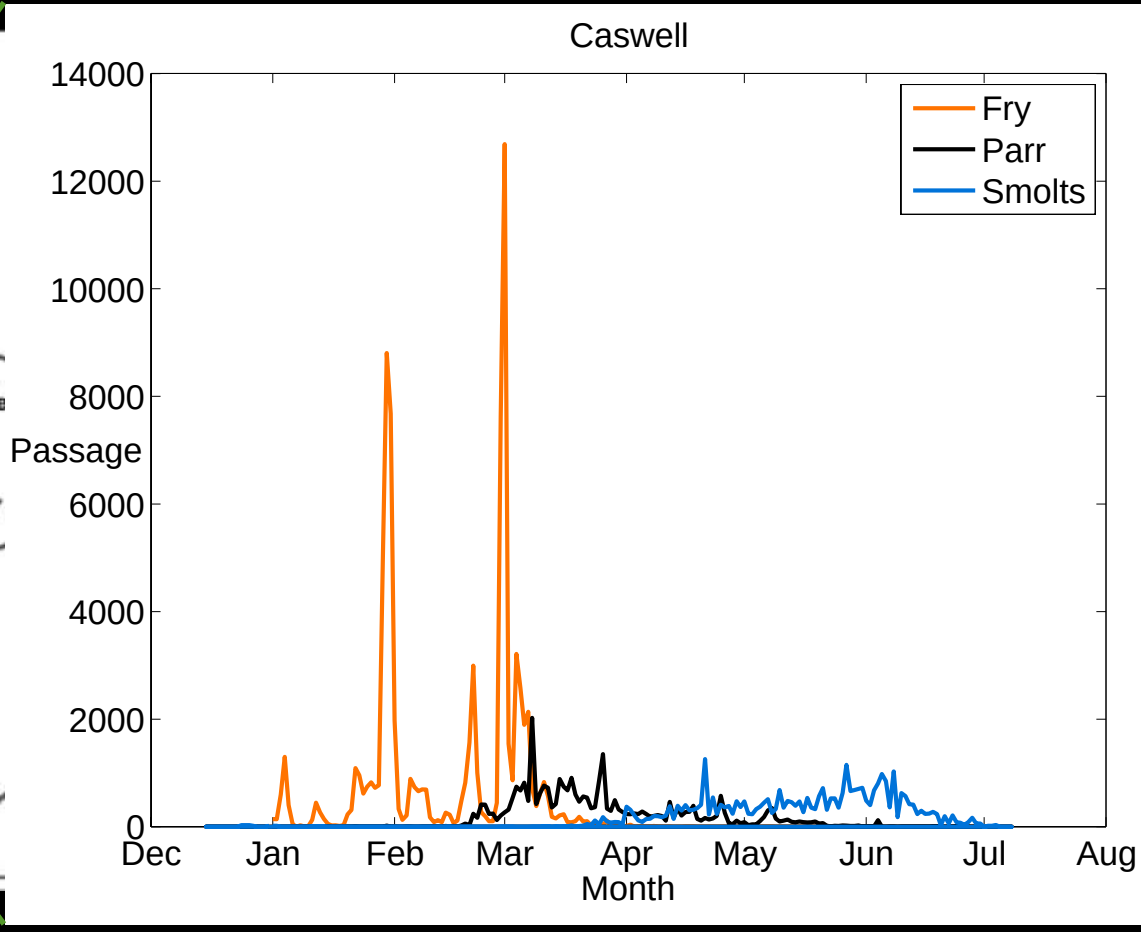


Sacramento River outmigration

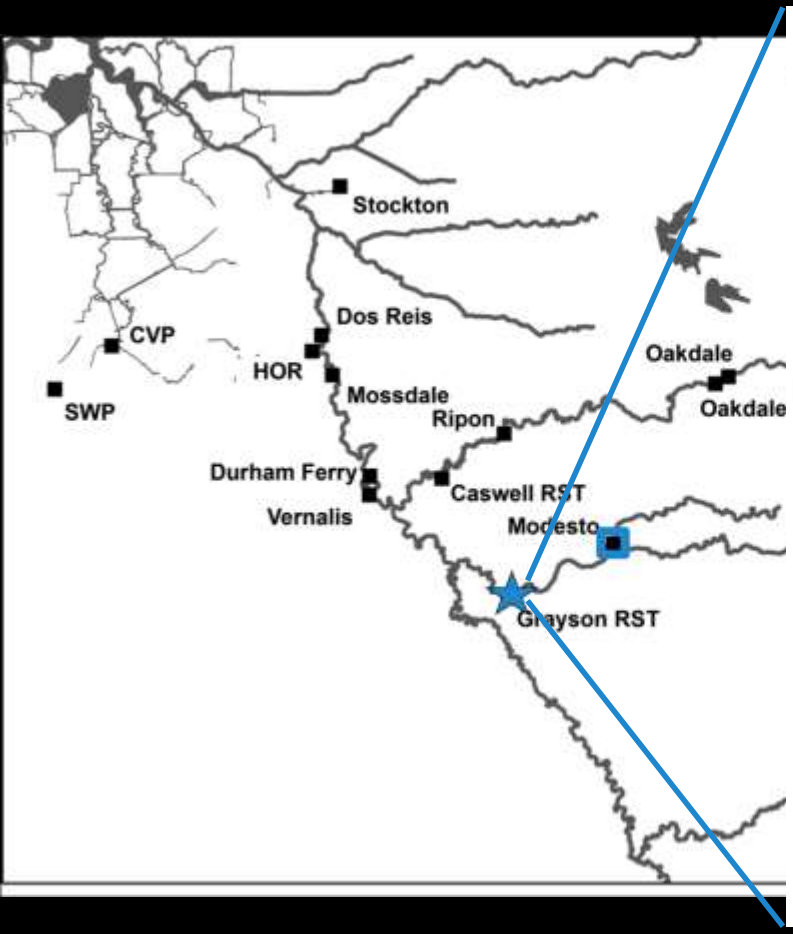


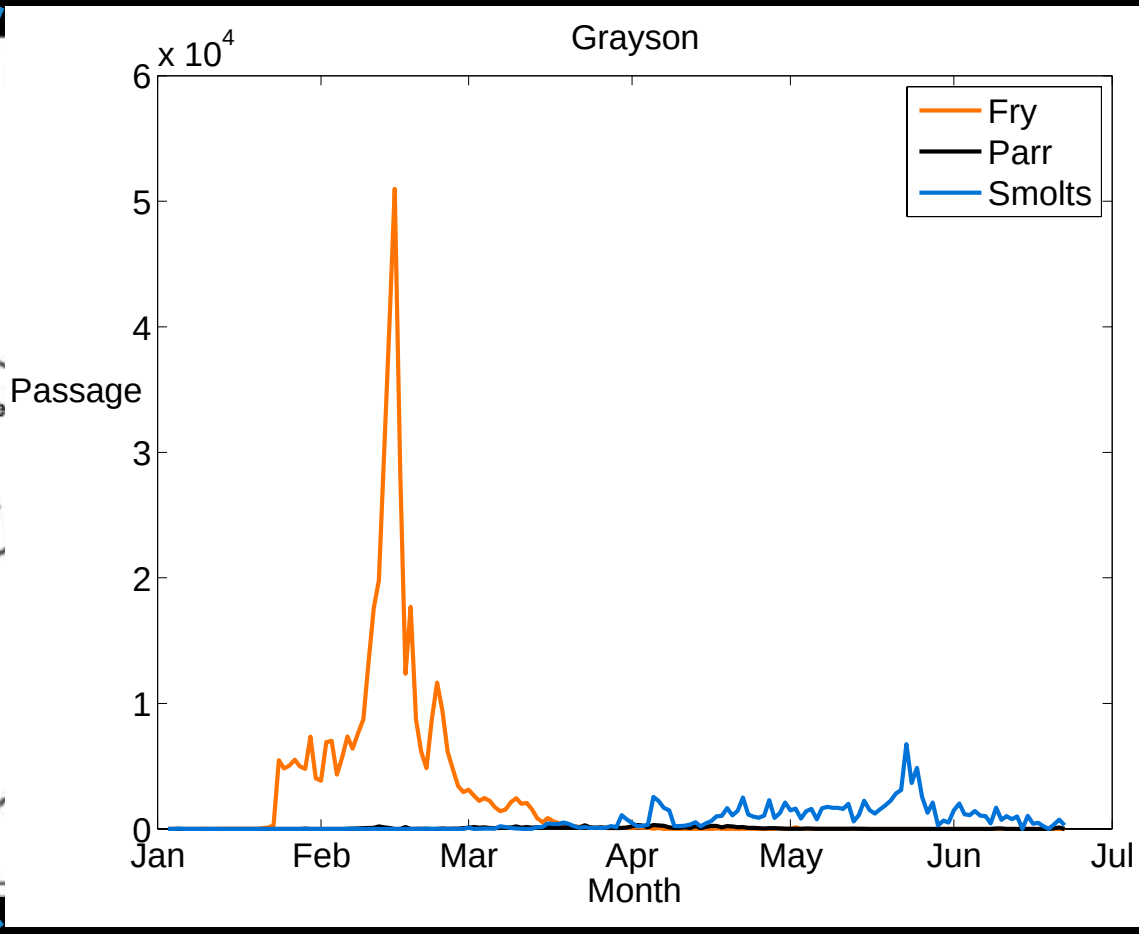
San Joaquin Tributaries outmigration





San Joaquin Tributaries outmigration





Alternate Rearing Habitats

- Why do pre-smolts enter these habitats?

  Related to:

  - Physical Environment?
  - Density-dependence?

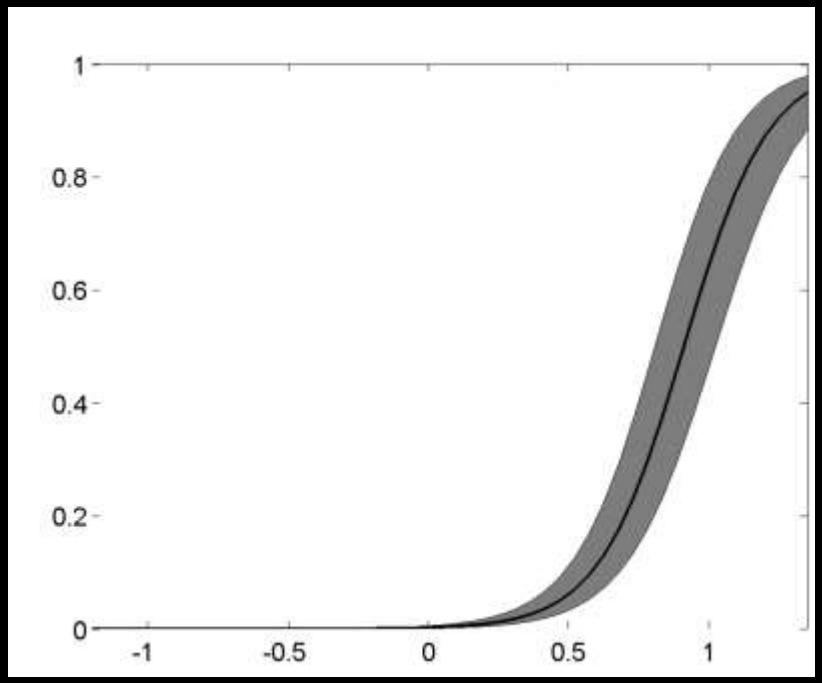
  ➢ Statistical model

Probability of pre-smolt outmigration

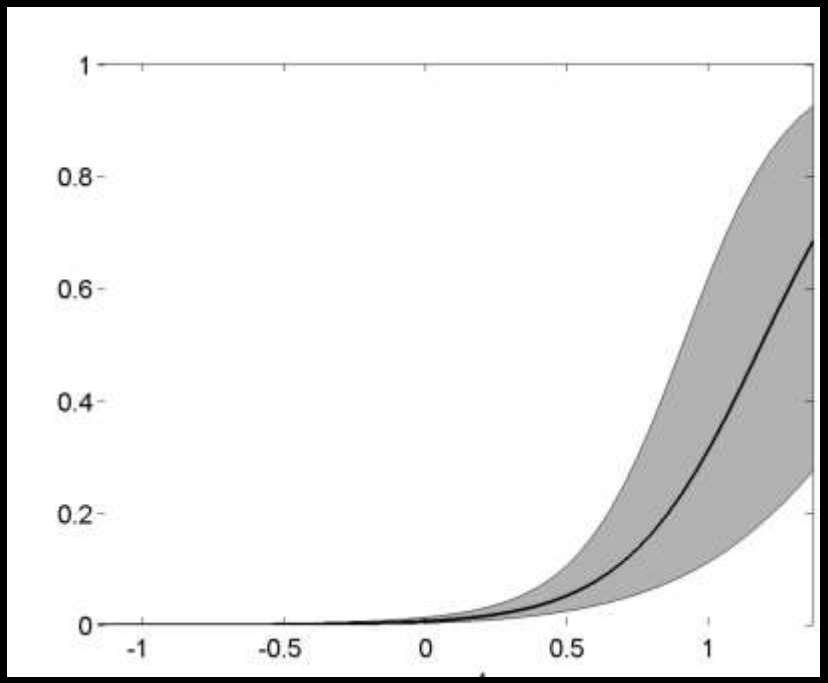
- GLMM of pre-smolts passing river RSTs
  - Migrants ~ Binomial (p, Left)
  - $\text{logit}(p) = \beta X$
  - X: Photo, ΔPhoto, Temp, ΔTemp, Flow, ΔFlow, Escapement, Accum Temp

Knights Landing (Sacramento R)

- X = (+) ΔPhoto (+) ΔFlow (–) ΔPhoto:ΔFlow + ε



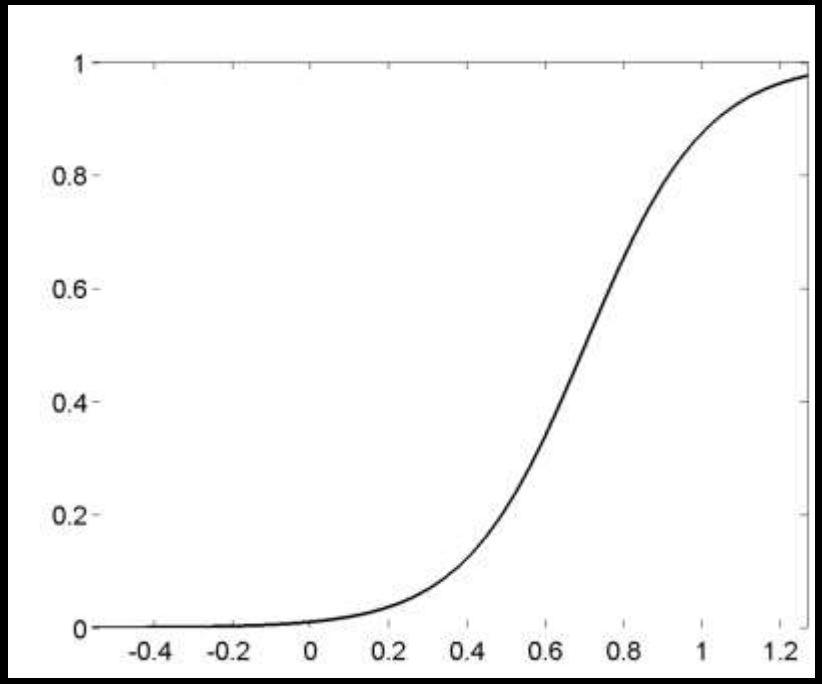
ΔPhoto (h)



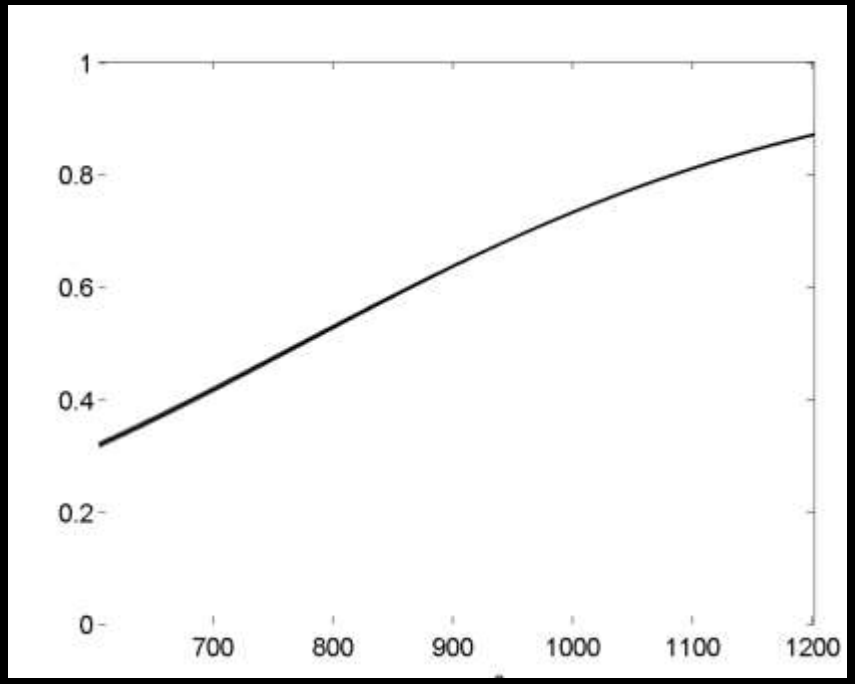
ΔFlow x 10^4 (cfs)

Caswell (Stanislaus R)

- X = (+) ΔPhoto (+) AccTemp (–) ΔPhoto:AccTemp + ε



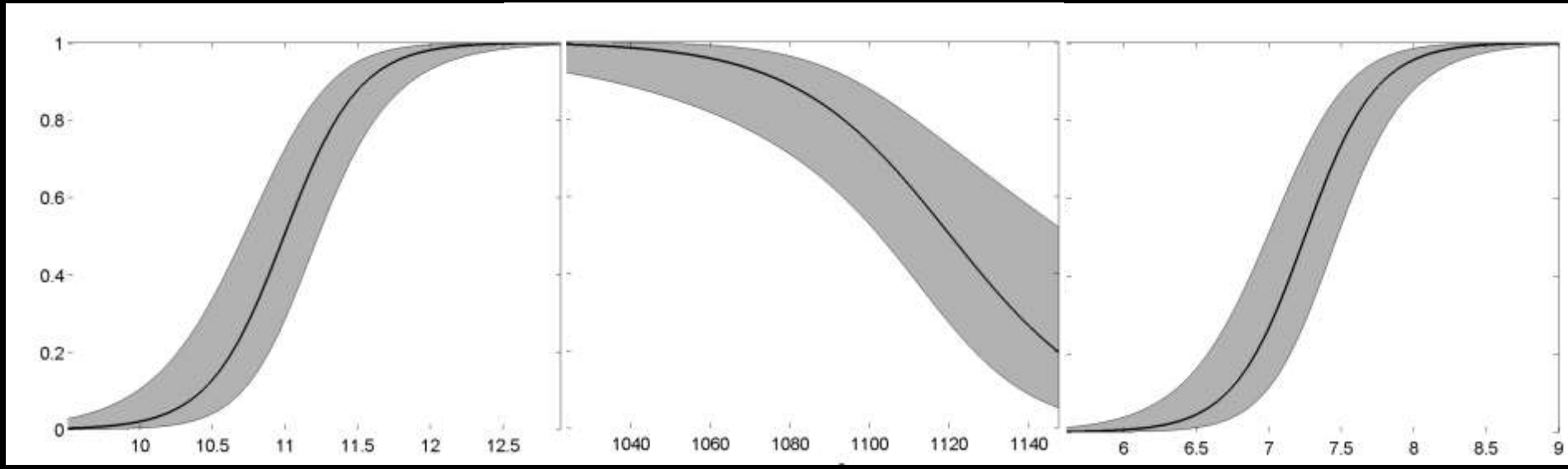
ΔPhoto (h)



AccTemp (°C)

Grayson (Tuolumne R)

- X = (+) Temp (–) AccTemp (+) log(Flow) + ε



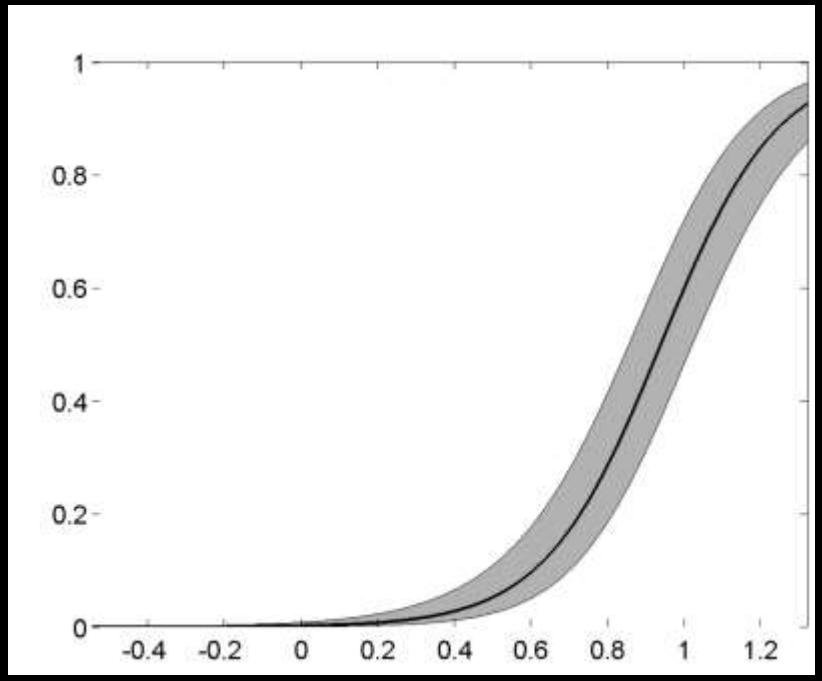
Temp (°C)

AccTemp (°C)

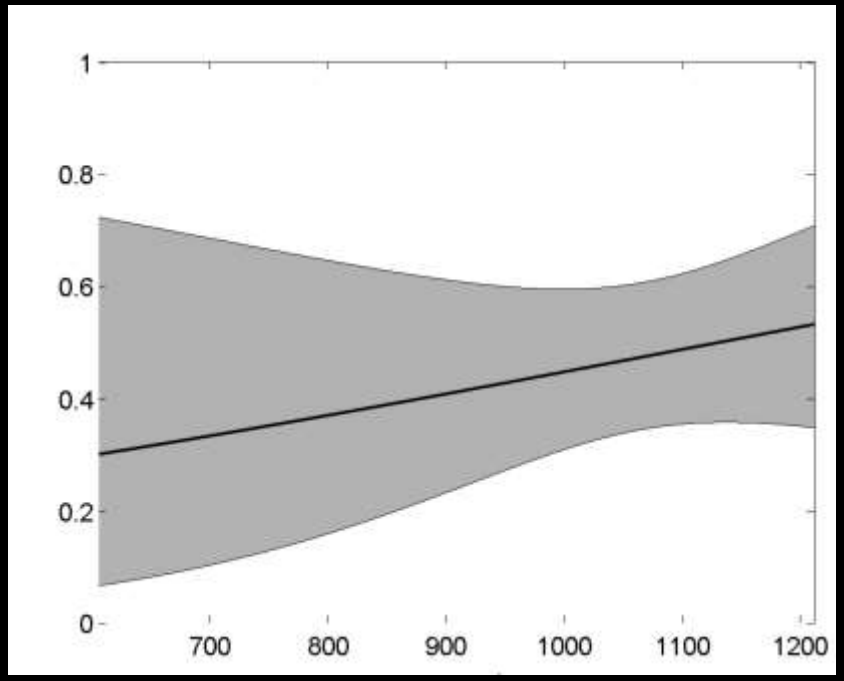
log(Flow) (cfs)

San Joaquin
(Caswell & Grayson combined)

- X = (+) ΔPhoto (+) AccTemp (–) ΔPhoto:AccTemp + ε

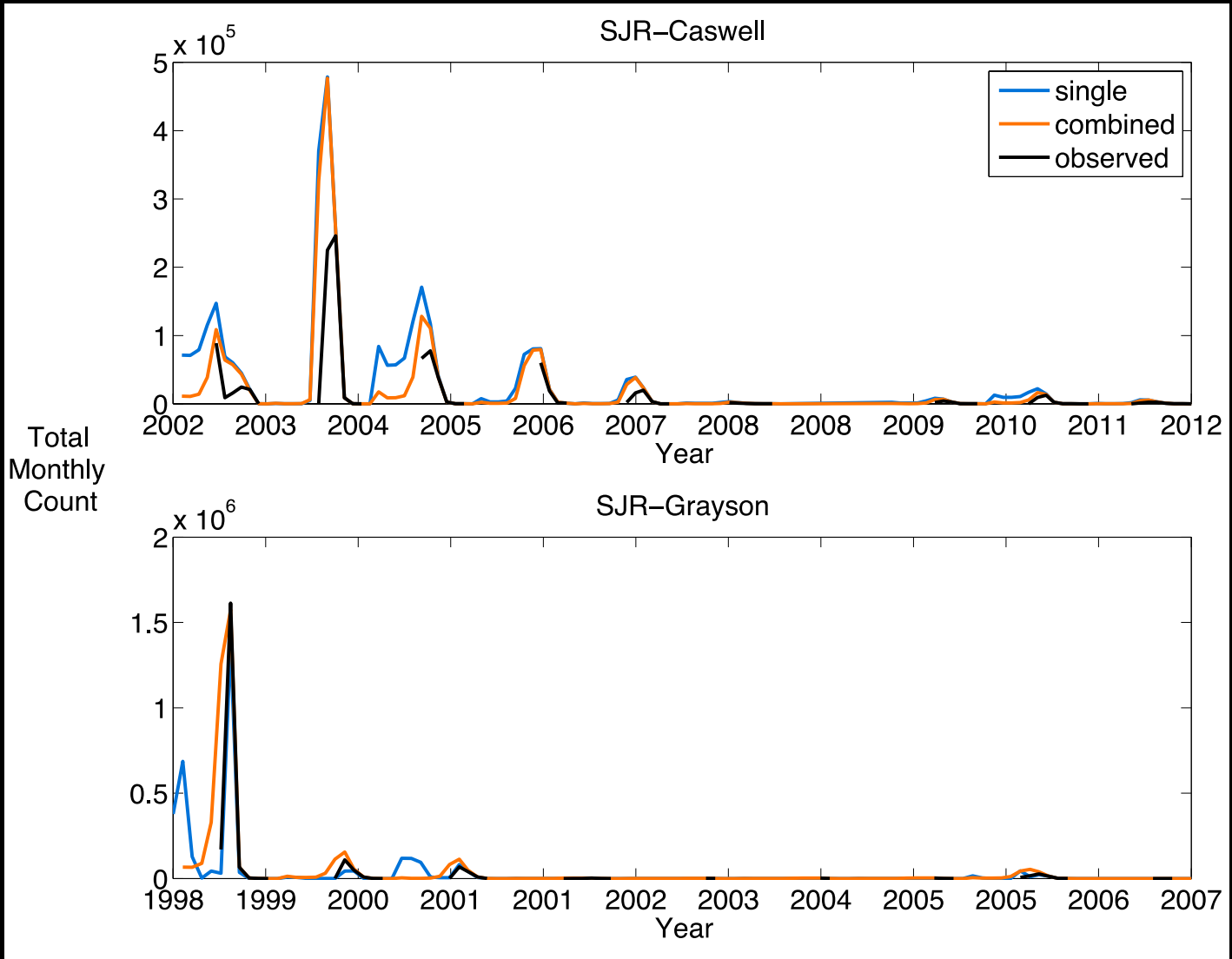


ΔPhoto (h)



AccTemp (°C)

San Joaquin
(Caswell & Grayson combined)



Main findings

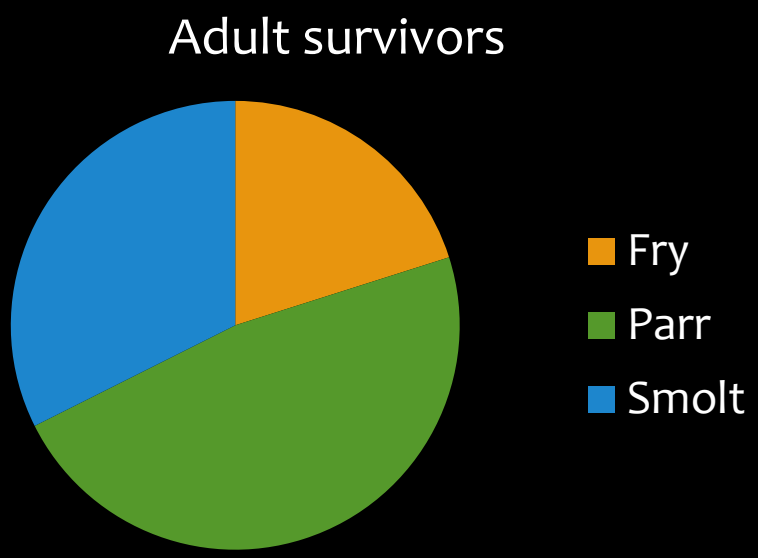
- ΔPhoto and Temp
  - Strong drivers of outmigration for all
  - Highly correlated
- Sacramento R ~ ΔFlow (+)
- San Joaquin tributaries ~ Acc Temp
- Escapement never sig
  - Not density-dependent

Main findings

- Stanislaus R
  - + AccTemp
- Tuolumne R
  - – AccTemp
  - + log(Flow)
- SJR combined → driven by Stan
  - + AccTemp
  - Flow not sig
  - Better predictor of both

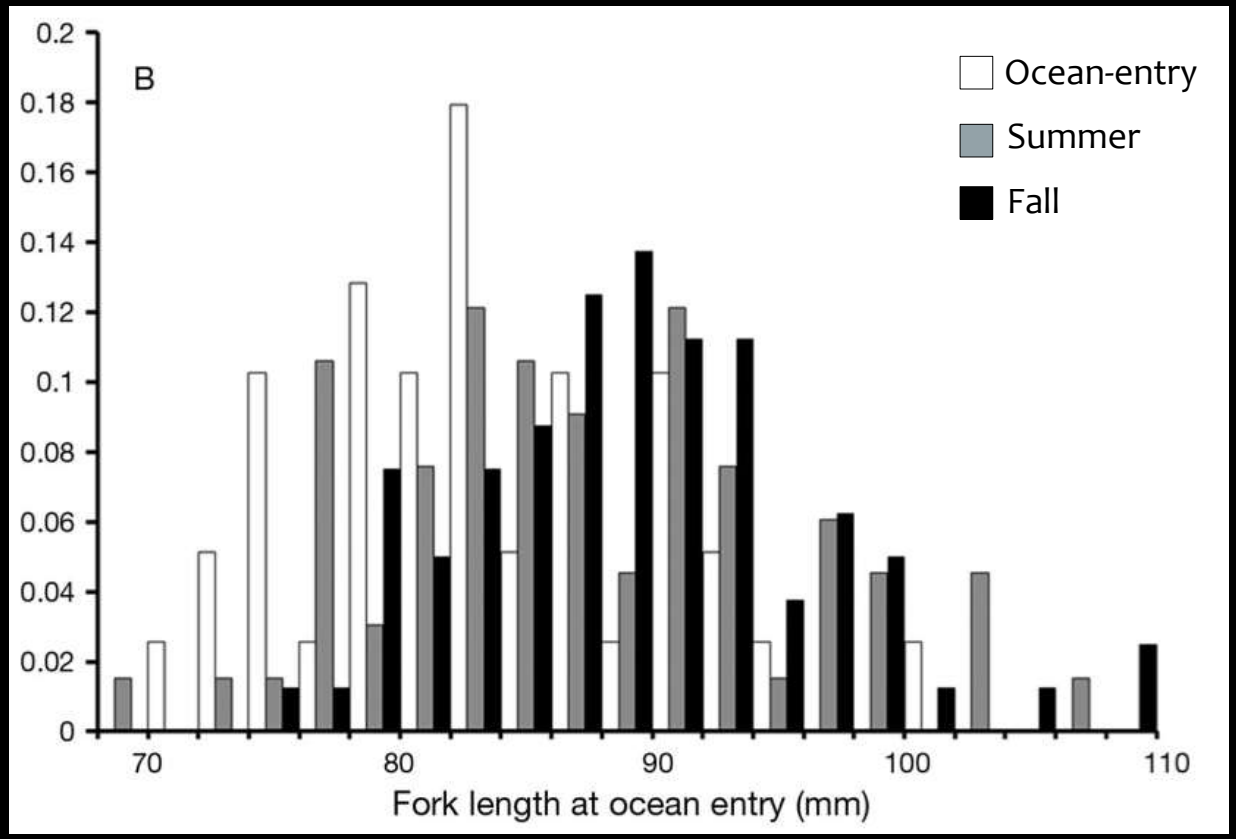
Consequences of pre-smolt outmigration?

- >50% of returning adults outmigrated as fry or parr
  - Sturrock et al. 2013
    - Stanislaus River
    - 2000 (above normal) and 2003 (below normal)
  - Miller et al. 2010
    - Feather R, Sacramento R, Mokelumne R, Stanislaus R
    - 2003 & 2004

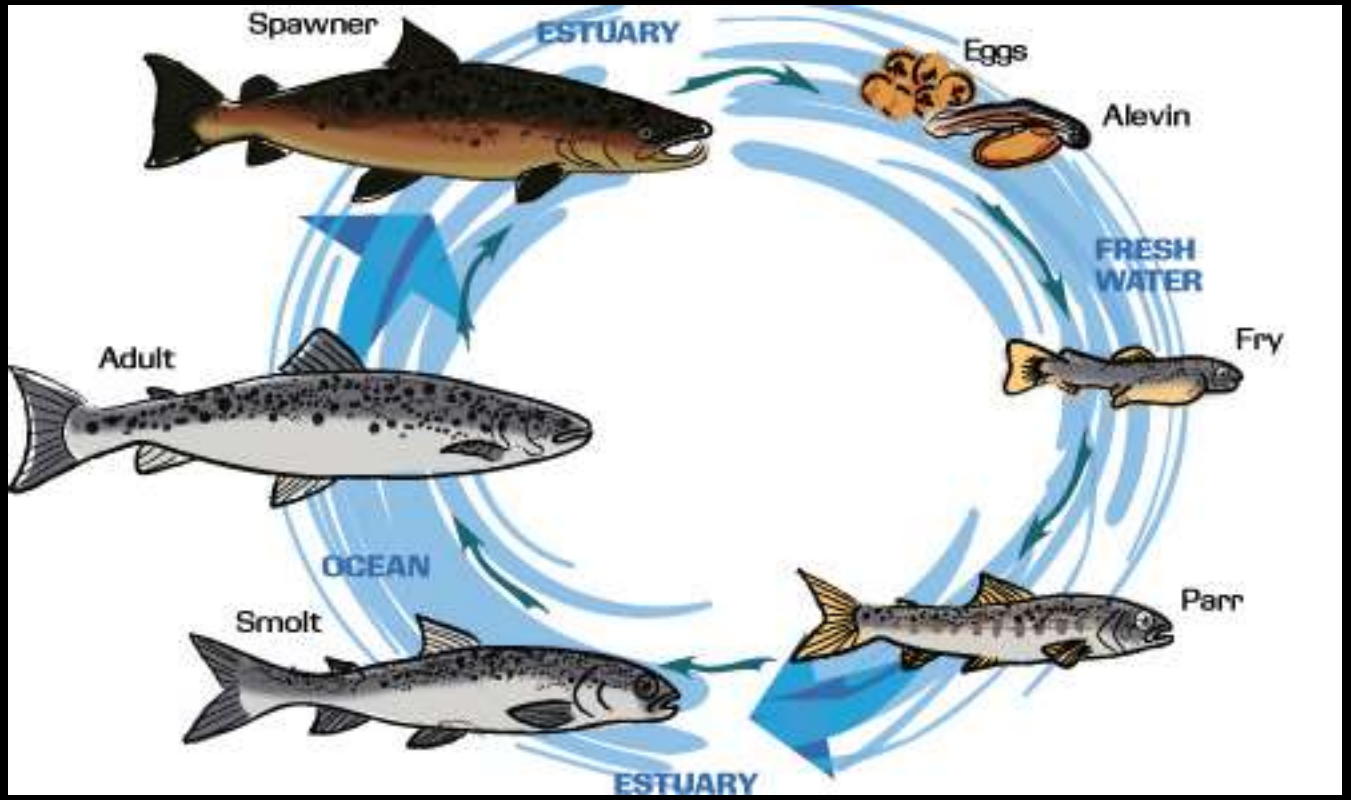


Consequences of pre-smolt outmigration?

- Size selective ocean mortality in some years (Woodson et al. 2013)
  - None in 2000 & 2001
  - Seen in 2005 (low ocean productivity)

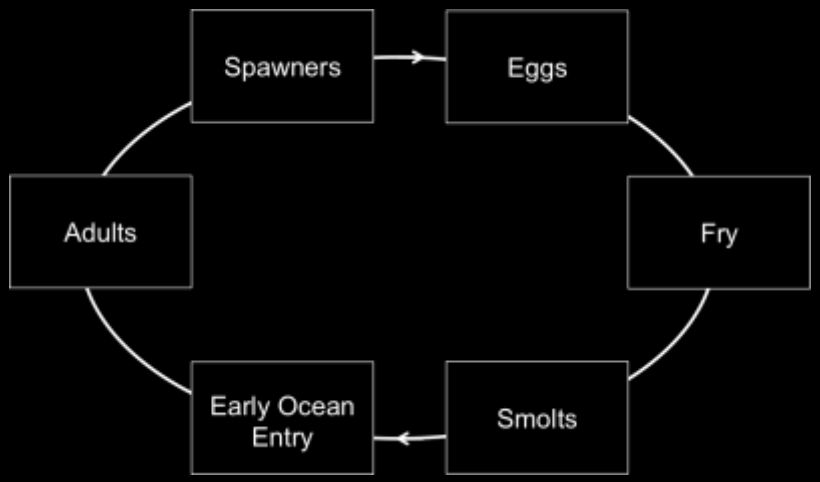


What effect will this have on the salmon population?

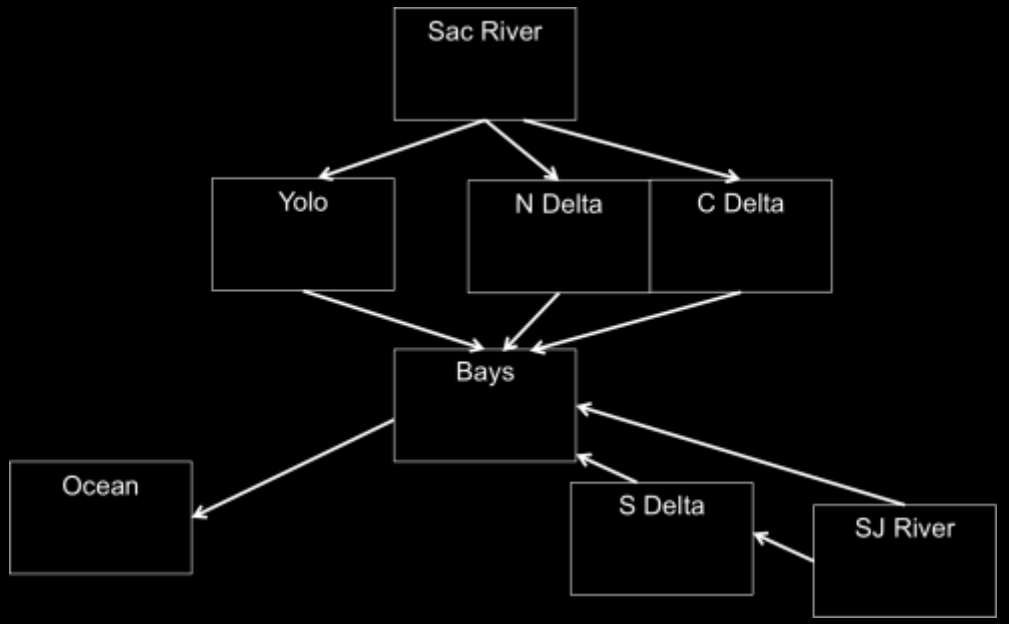


Central Valley Chinook Life Cycle Model

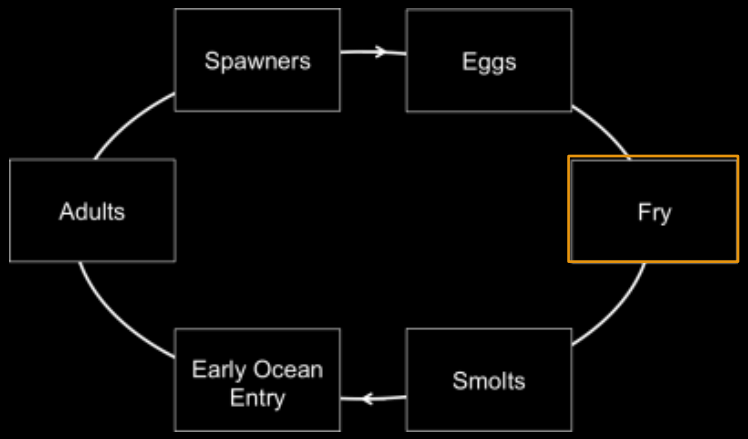
Stage-specific



Habitat-specific

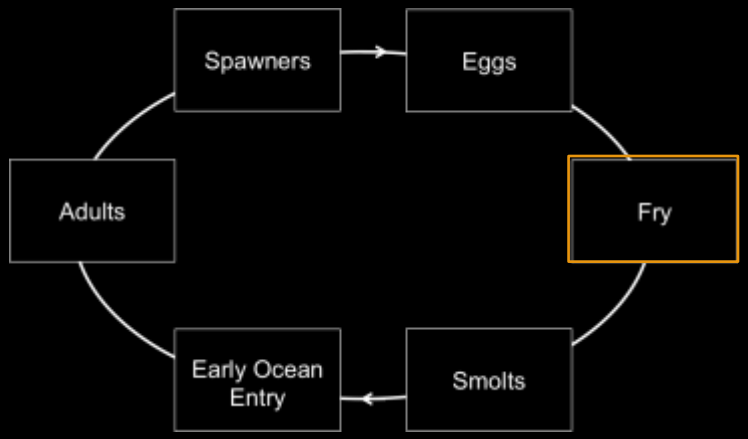


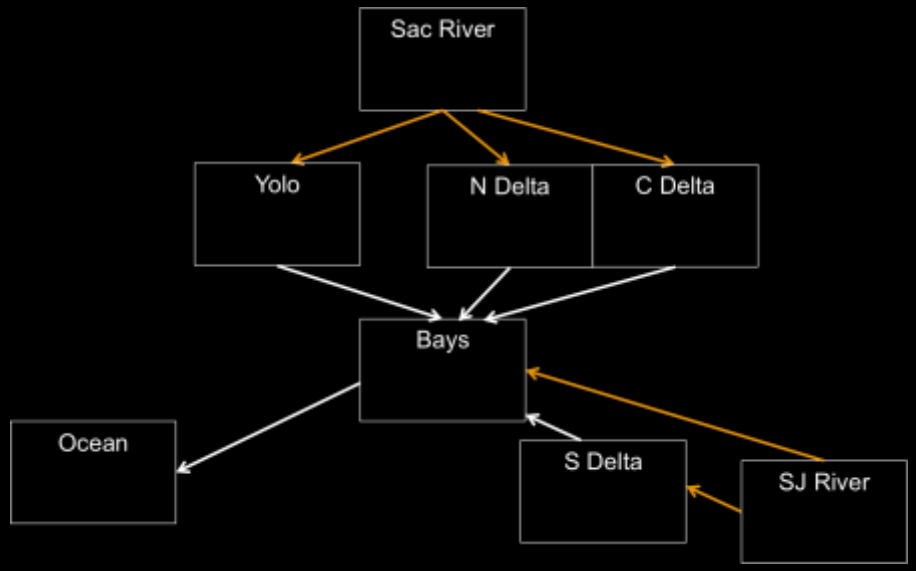
Rearing



Rearing

Fry move to downstream habitats during rearing according to movement function





The movement function uses:

- Habitat-specific fry capacities
- Habitat-specific fry survival rates
- Density-independent migration rate

Effect of pre-smolt outmigration

- Historic effect
  - 1990 – 2012
- Future scenarios
  - Bay-Delta Conservation Plan
  - Climate Change

Acknowledgments

- CVC-LCM Team
  - Flora Cordoleani
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- Doug Threloff
- Carl Messick

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Oct. 28–30, 2014 Sacramento Convention Center
Making Connections
8th Biennial
Bay-Delta Science Conference

Additional Slides

Summary

- ΔPhoto or Temp strong drivers of pre-smolt outmigration
  - ΔFlow influences Sacramento R
  - Acc Temp influences San Joaquin tributaries

- Life Cycle Model to understand how pre-smolt outmigration
  - Timing
  - To different habitats

  impact survival and CVC fall run population

Bay-Delta Conservation Plan

- Restored floodplain, tidal, and channel margin habitat
- Stockton Deep Water Ship Channel dissolved oxygen
- Nonphysical fish barriers
- New North Delta water intake facilities
  - Reduced exports at South Delta pumps
  - Reduced flows in Sacramento R and North Delta
  - Increased juvenile mortality from predators or pumps

BDCP and outmigration

- Restored floodplain, tidal, and channel margin habitat
- Stockton Deep Water Ship Channel dissolved oxygen
- Nonphysical fish barriers
  - No influence on probability of pre-smolt outmigration
  - Pre-smolts that do outmigrate should have higher survival

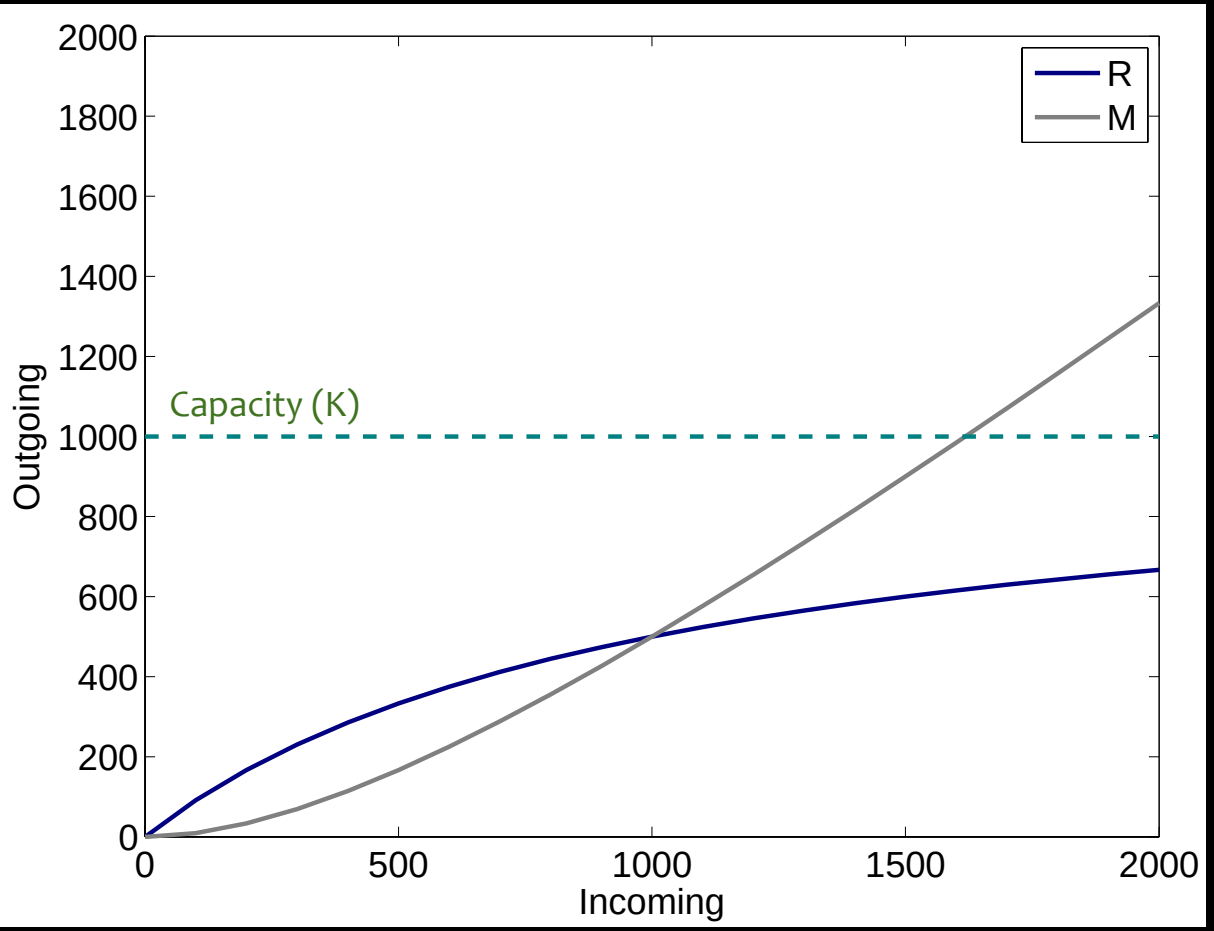
BDCP and outmigration

- New North Delta water intake facilities
  - Reduced exports at South Delta pumps
    - Stronger SJR flows would increase Tuol R pre-smolt outmigration
  - Reduced flows in Sacramento R and North Delta
    - Could decrease Sac R pre-smolt outmigration
  - Increased juvenile mortality from predators or pumps
    - No effect on outmigration

Climate change

- Increased temperature
  - Increase SJR pre-smolt outmigration

Rearing Movement Function

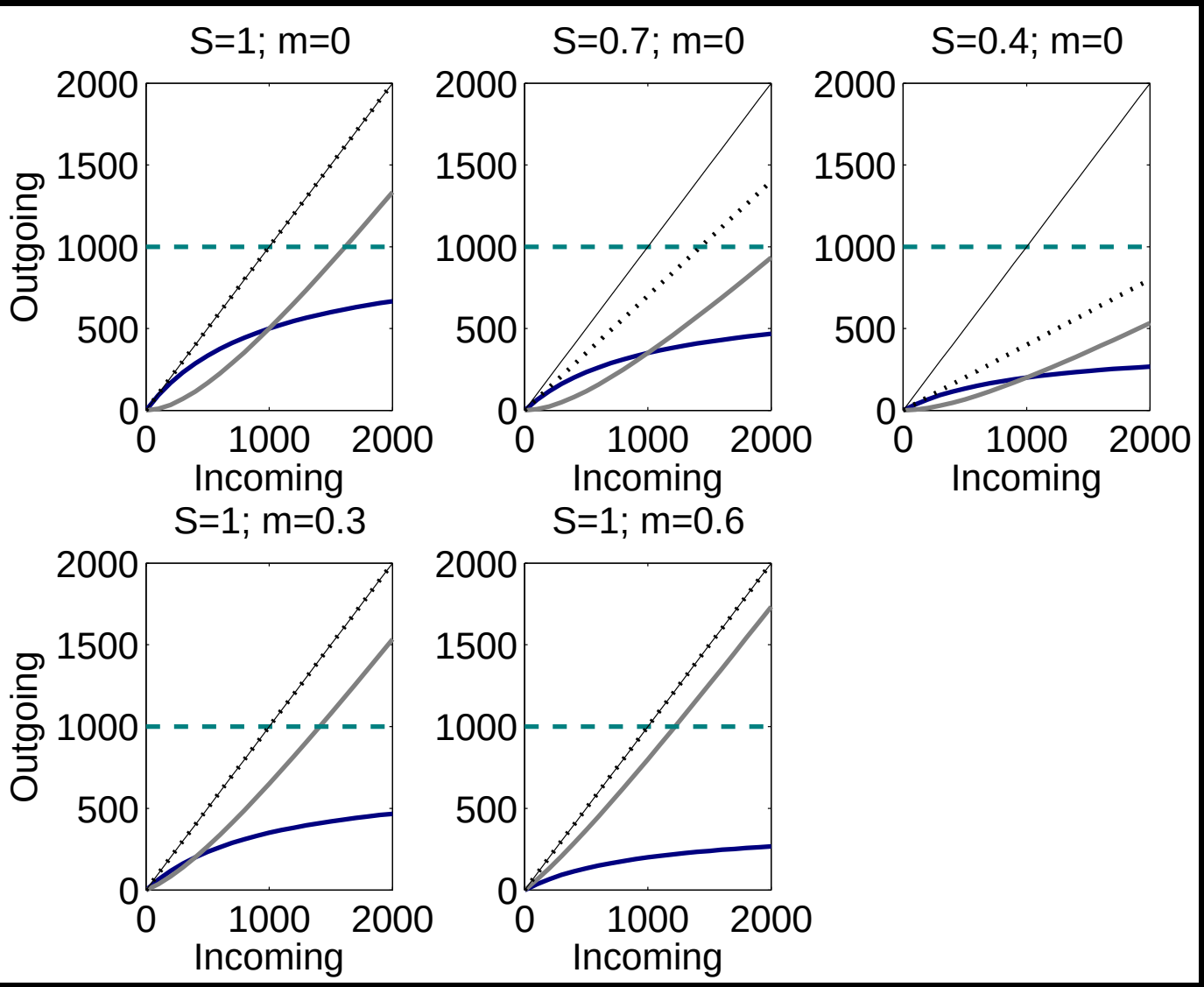


$$R_{i,t} = \frac{\left(S_{i,t} - m_t\right) N_{i,t}}{1 + N_{i,t} / K_{i,t}}$$

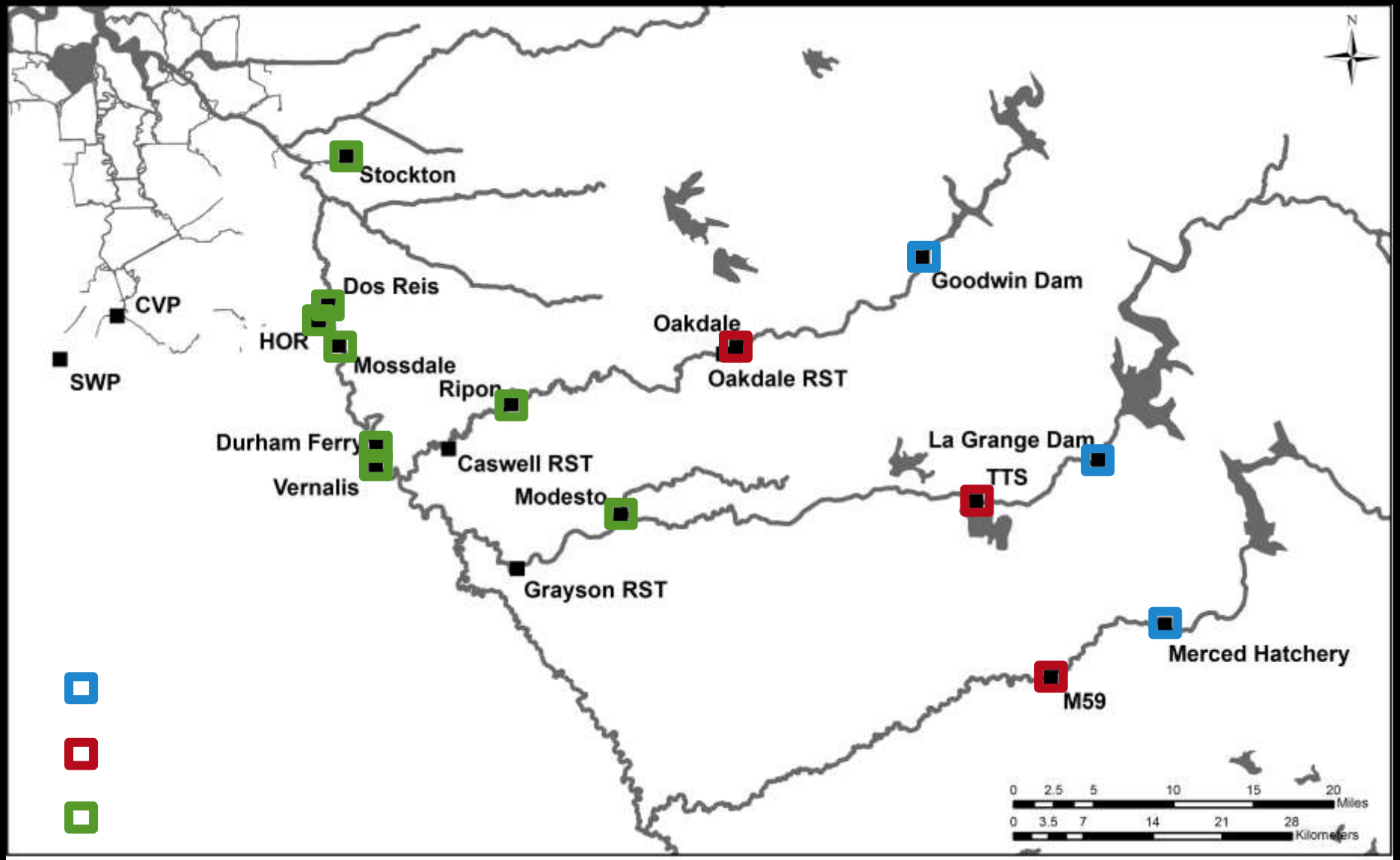
$$M_{i,t} = S_{i,t} N_{i,t} - R_{i,t}$$

Example with S=1, m=0, K=1000

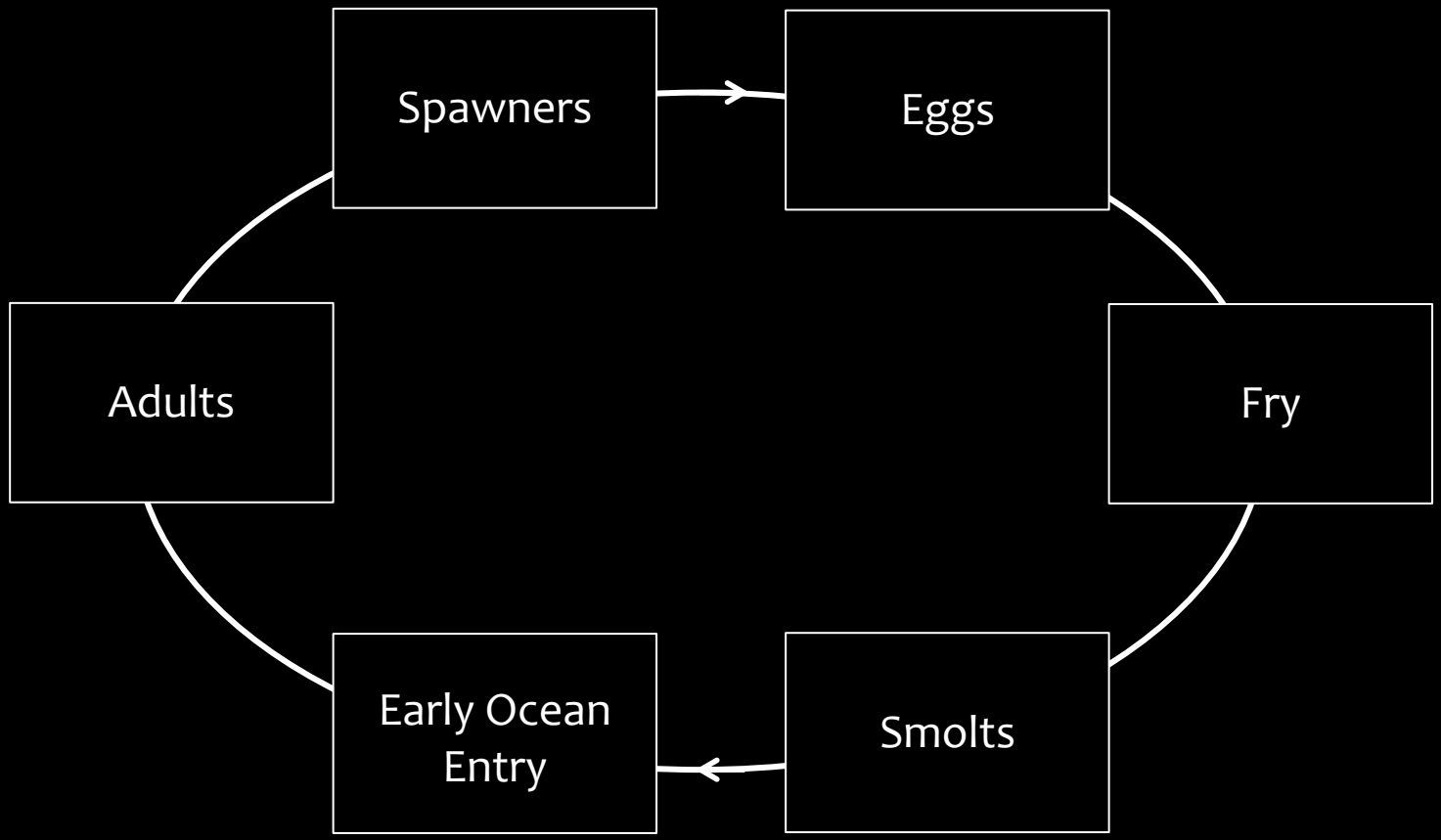
Rearing Movement Function



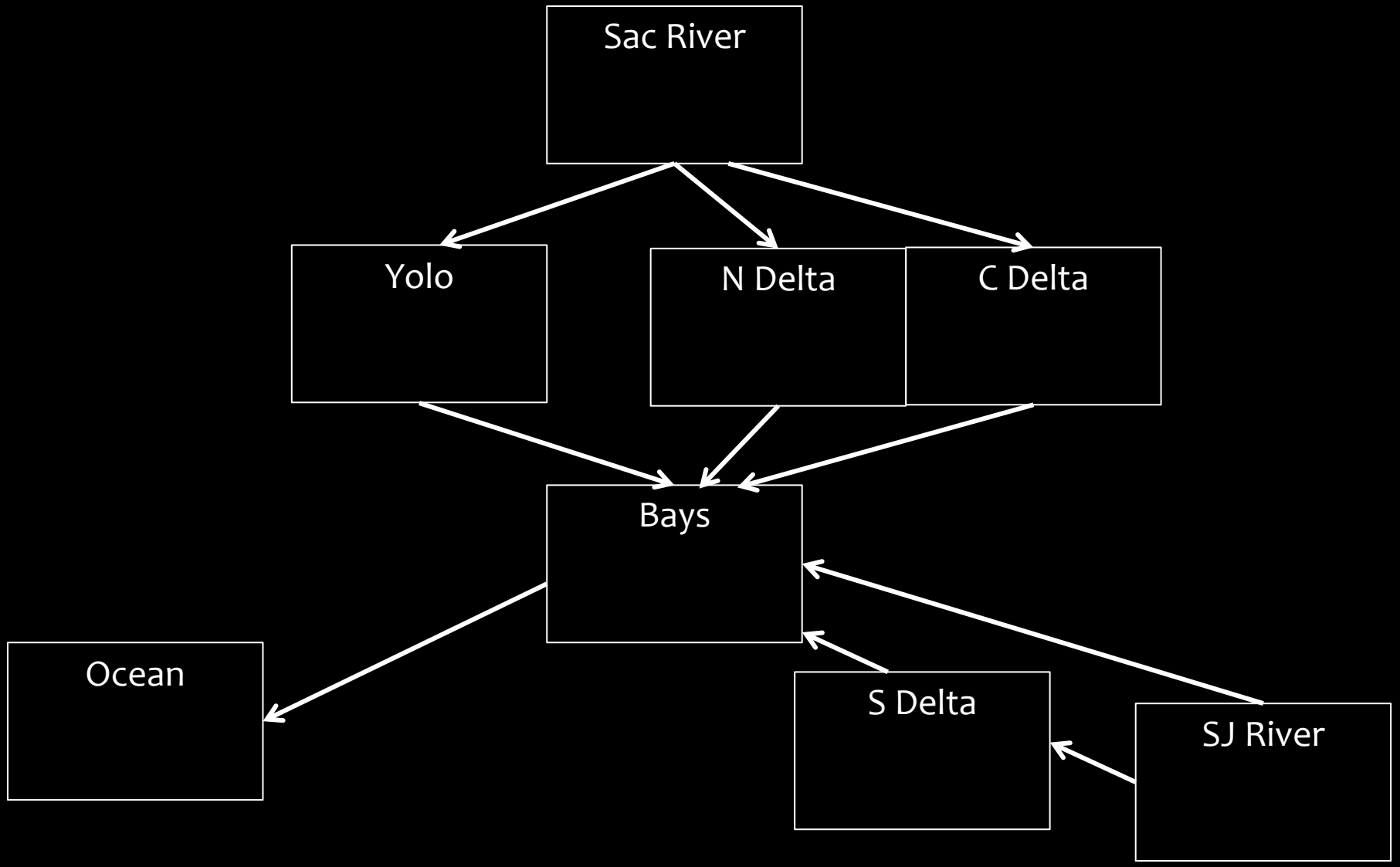
San Joaquin Tributaries

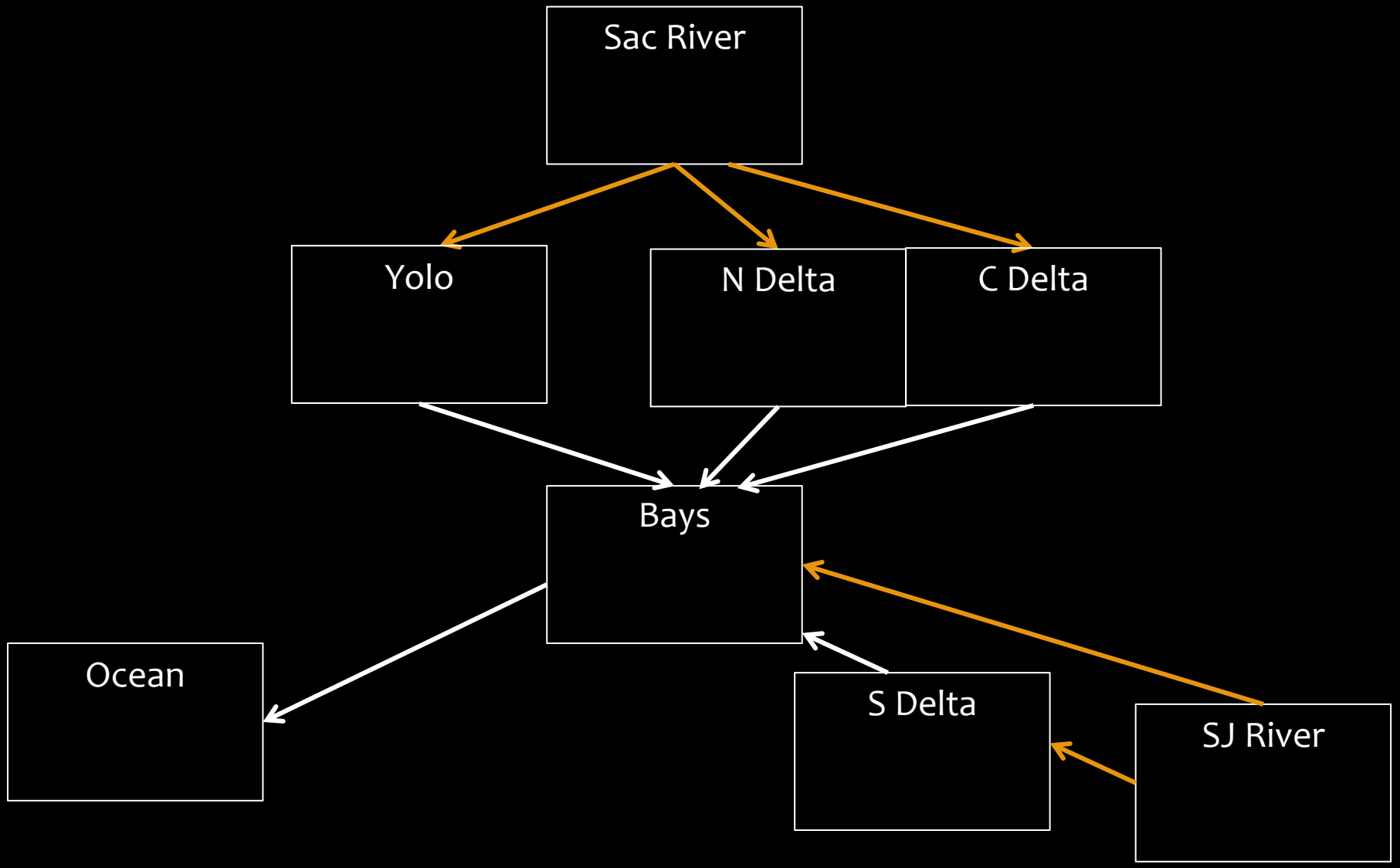


Life Cycle Model Stage Structure



Life Cycle Model Spatial Structure




Sac River
Yolo
N Delta
C Delta
Bays
Ocean
S Delta
SJ River