JUVENILE SALMONID SURVIVAL THROUGH THE SAN JOAQUIN DELTA IN THE PRESENCE OF PREDATORY FISH, 2010-2011

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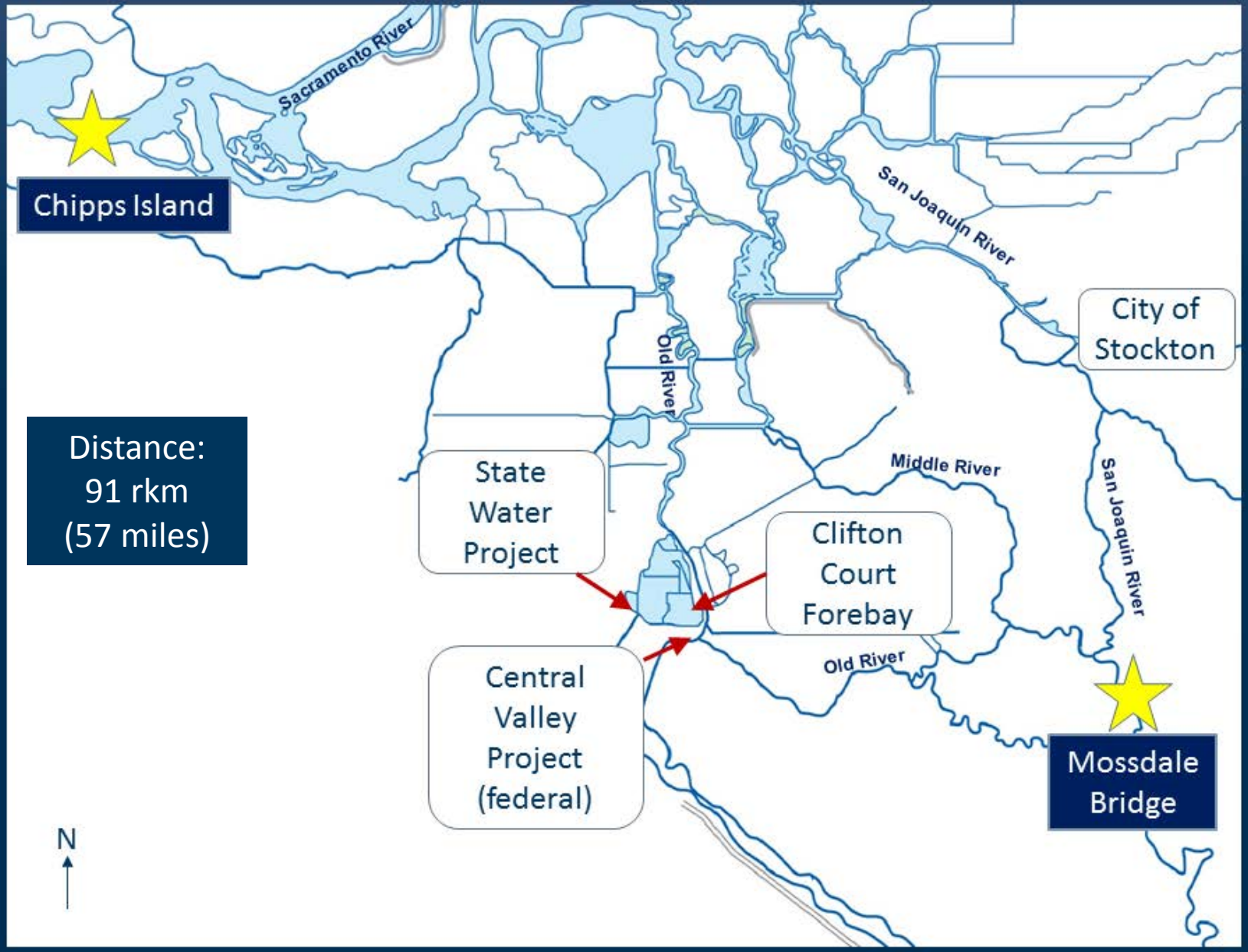
OUTLINE

- Overview of acoustic-tag studies (Chinook and Steelhead)
- Predation problem
- Results
  - Fall Chinook 2010
  - Fall Chinook 2011
  - Steelhead 2011 (preliminary results)
- Conclusions
- Future, on-going studies

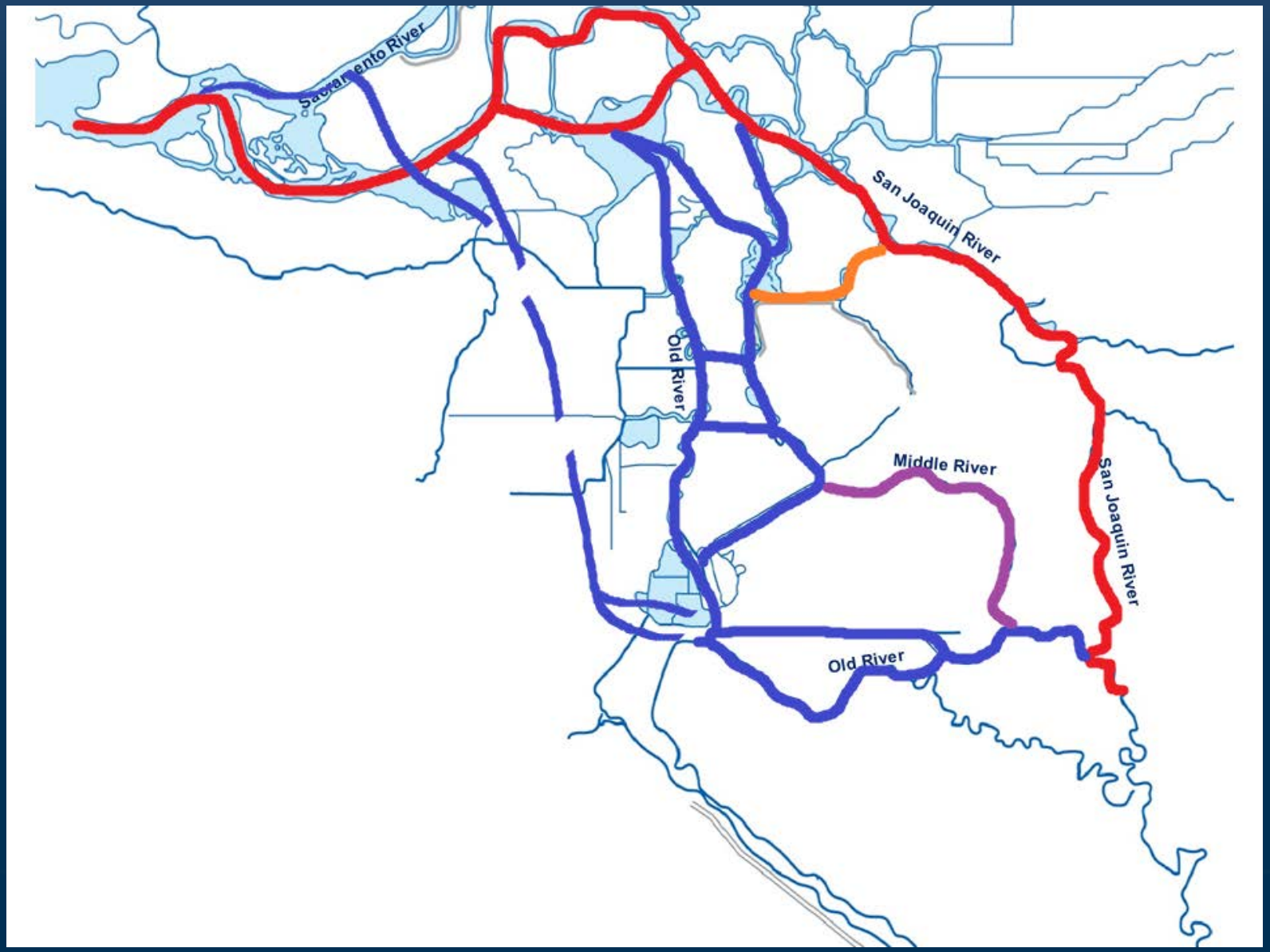
SOUTH DELTA ACOUSTIC TAGGING STUDIES

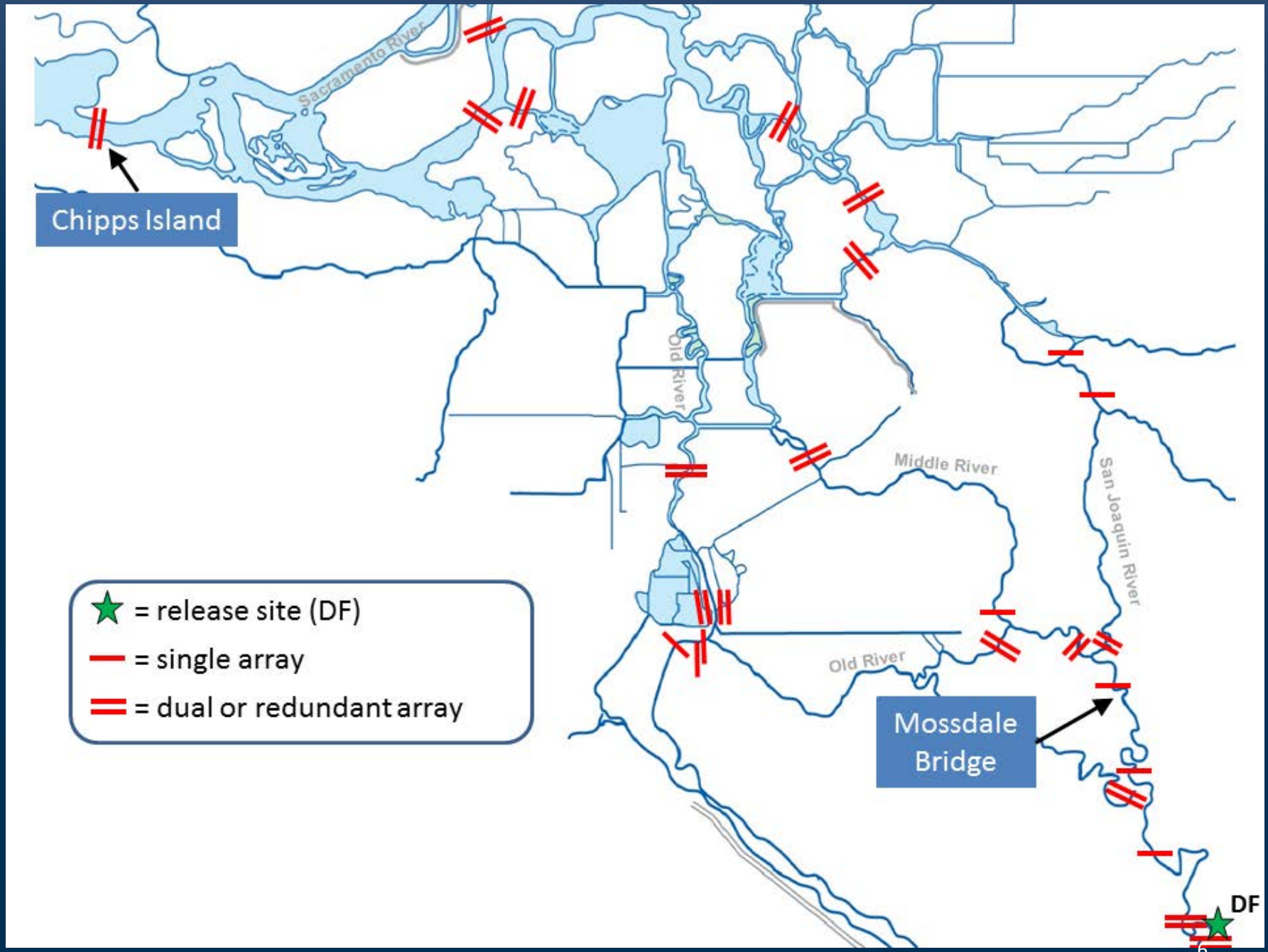
- Vernalis Adaptive Management Program
- South Delta Temporary Barriers Study
- 6-Year Steelhead Study
- USFWS, USBR, USGS, DWR, SJRGA

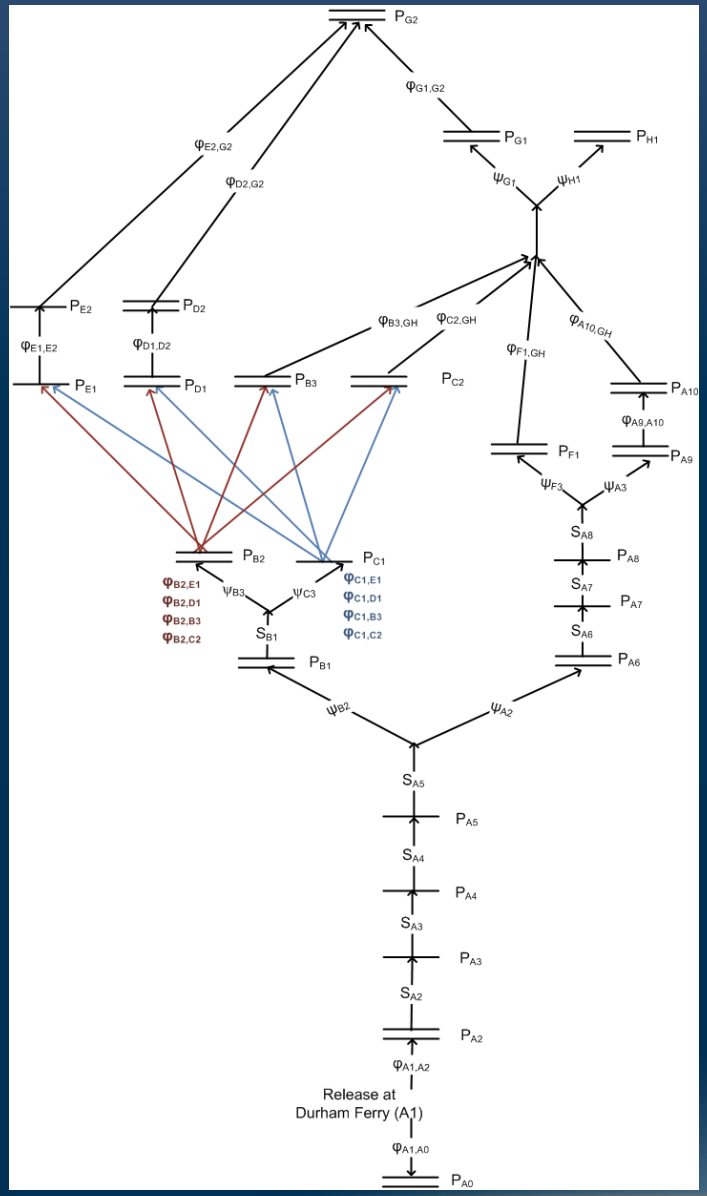
- Juvenile Fall Chinook salmon
- Juvenile steelhead
- Monitor route usage and survival through Delta
  - Mossdale to Chipps Island
  - Route-specific survival
- 2010, 2011


Sacramento River
Chipps Island
San Joaquin River
City of Stockton
Old River
Distance:
91 rkm
(57 miles)
State Water Project
Middle River
San Joaquin River
Clifton Court Forebay
Old River
Central Valley Project (federal)
Mossdale Bridge
N

FISH ROUTES TO CHIPPS ISLAND




Sacramento River
Chipps Island
Old River
Middle River
San Joaquin River
Old River
Mossdale Bridge
= release site (DF)
= single array
= dual or redundant array
DF



RELEASE-RECAPTURE MODEL

- Estimates
  - Reach Survival Probabilities
  - Route Entrainment Probabilities
  - Transition Probabilities
  - Detection Probabilities
- Model fit in Program USER:
  - www.cbr.washington.edu/paramest/user
  - Point estimates
  - Standard errors
  - Residuals

PREDATORS

- Problem: Predatory fish eat tagged study fish, then move past receivers
- Result: Biased survival estimates
- Solution: Identify and remove detections from predators
- Predator filter
  - Behavior differences
  - Residence time
  - Migration rate
  - Movements between receivers
  - Total travel time
  - Discharge, water velocity, tidal cycle (movements against flow)
- Spatially explicit rule

PREDATOR FILTER: BEHAVIORAL ASSUMPTIONS

- Salmon smolts
  - Are actively migrating downriver
  - Are unlikely to move against flow
  - Are unlikely to linger around a receiver
  - May linger or move upriver temporarily with reverse flow
- Juvenile steelhead
  - Salmon smolt assumptions, with:
  - May linger in a given area, but will eventually move downstream
- Predatory fish (e.g., Striped Bass)
  - May move against flow
  - May linger in a given area
  - May move either very quickly or very slowly between detection sites

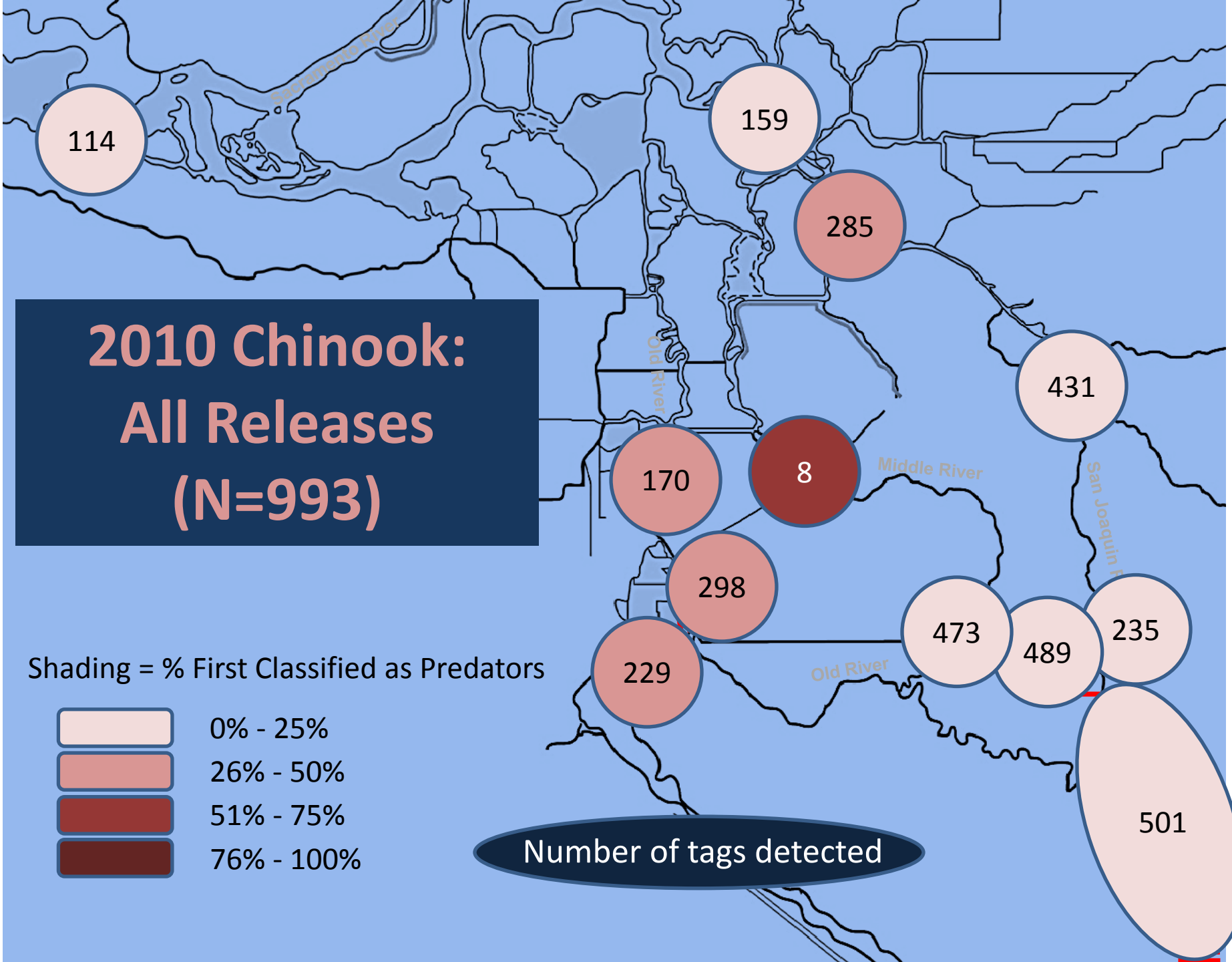
RESULTS

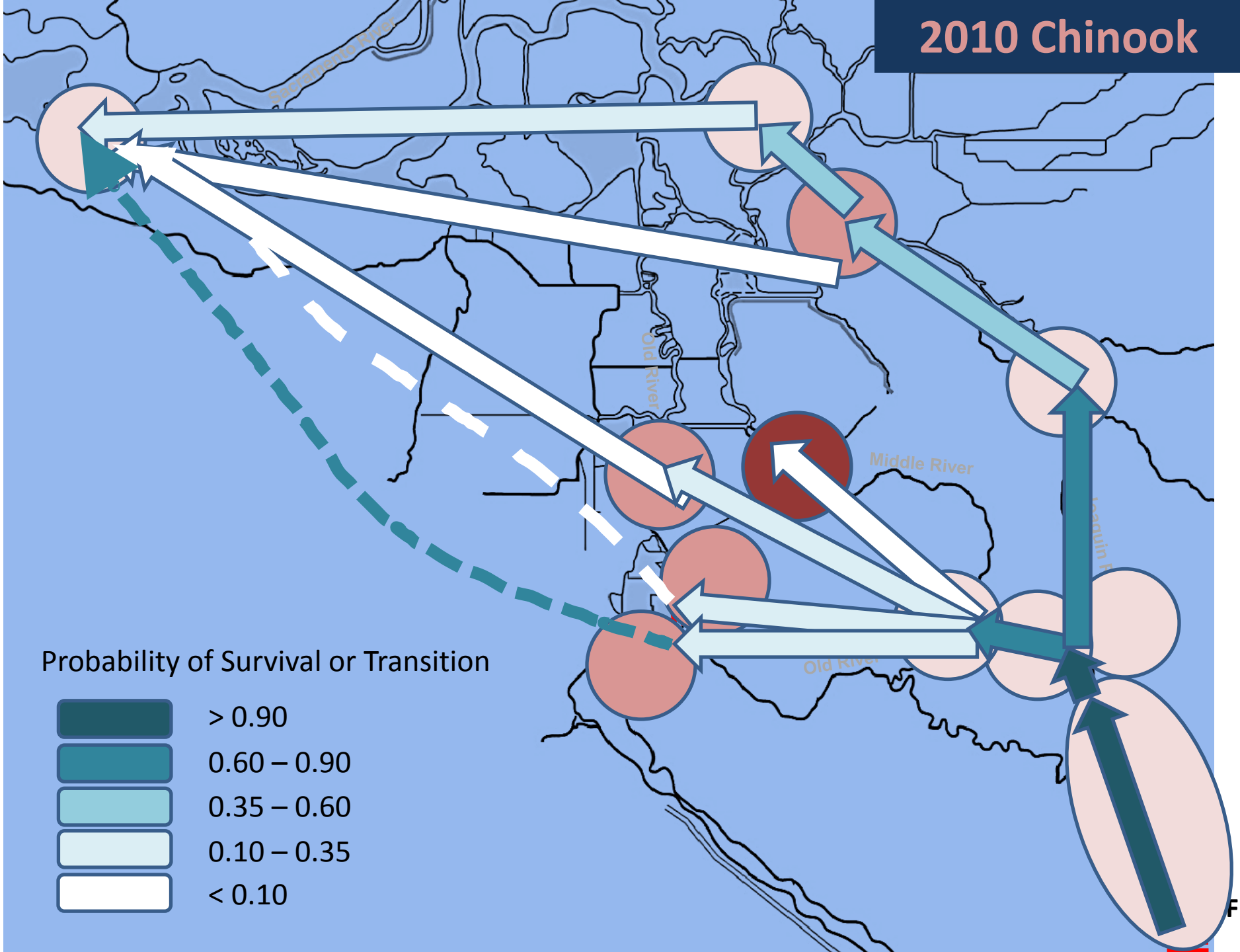
- Where predation occurs
  - Predator filter results
  - Reach survival estimates
- Also: estimates of
  - Route-specific survival
  - Route entrainment
  - Total survival
- Observed travel time

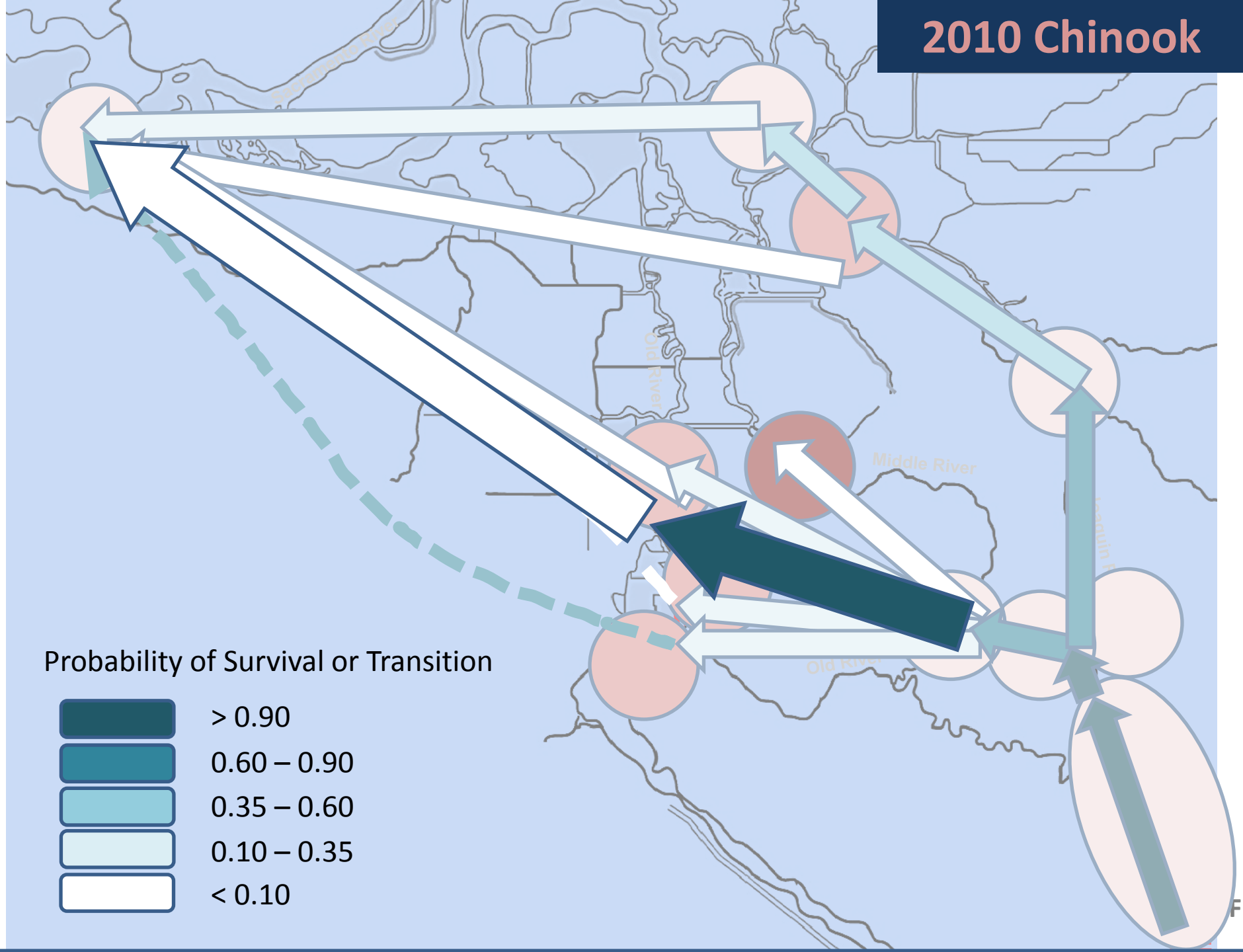
2010 Fall Chinook Salmon

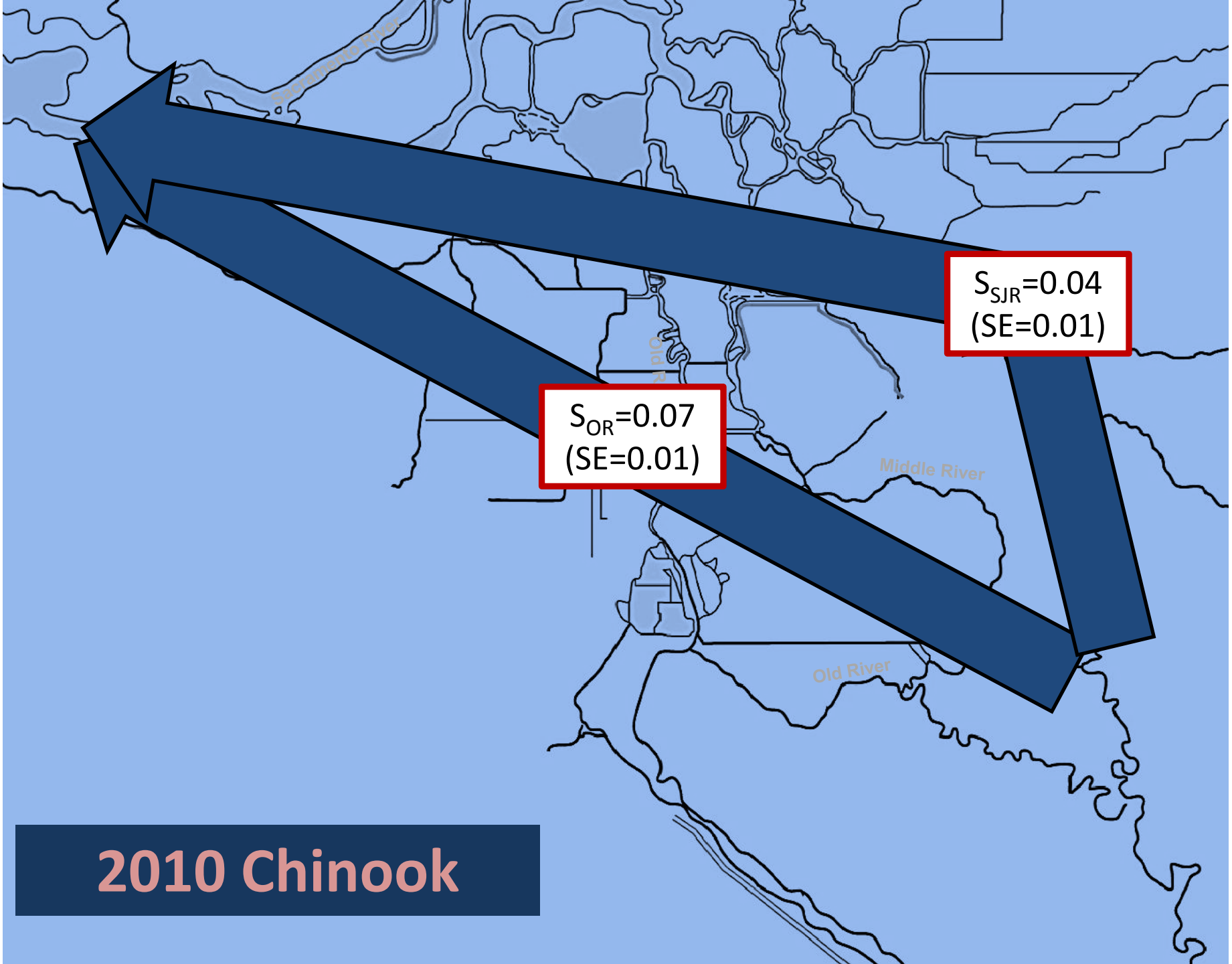
Released April 27 – May 20

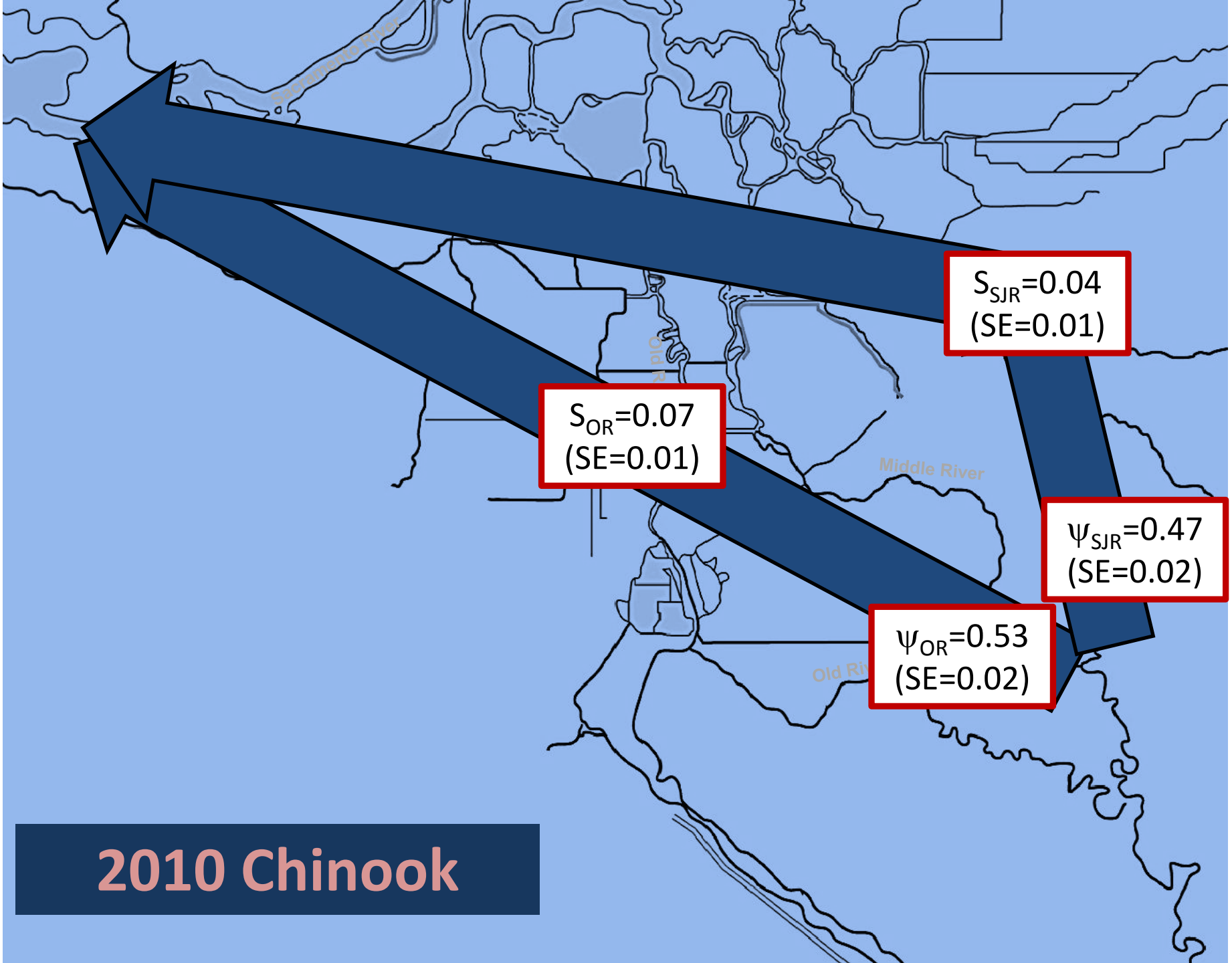
Average fork Length = 111 mm

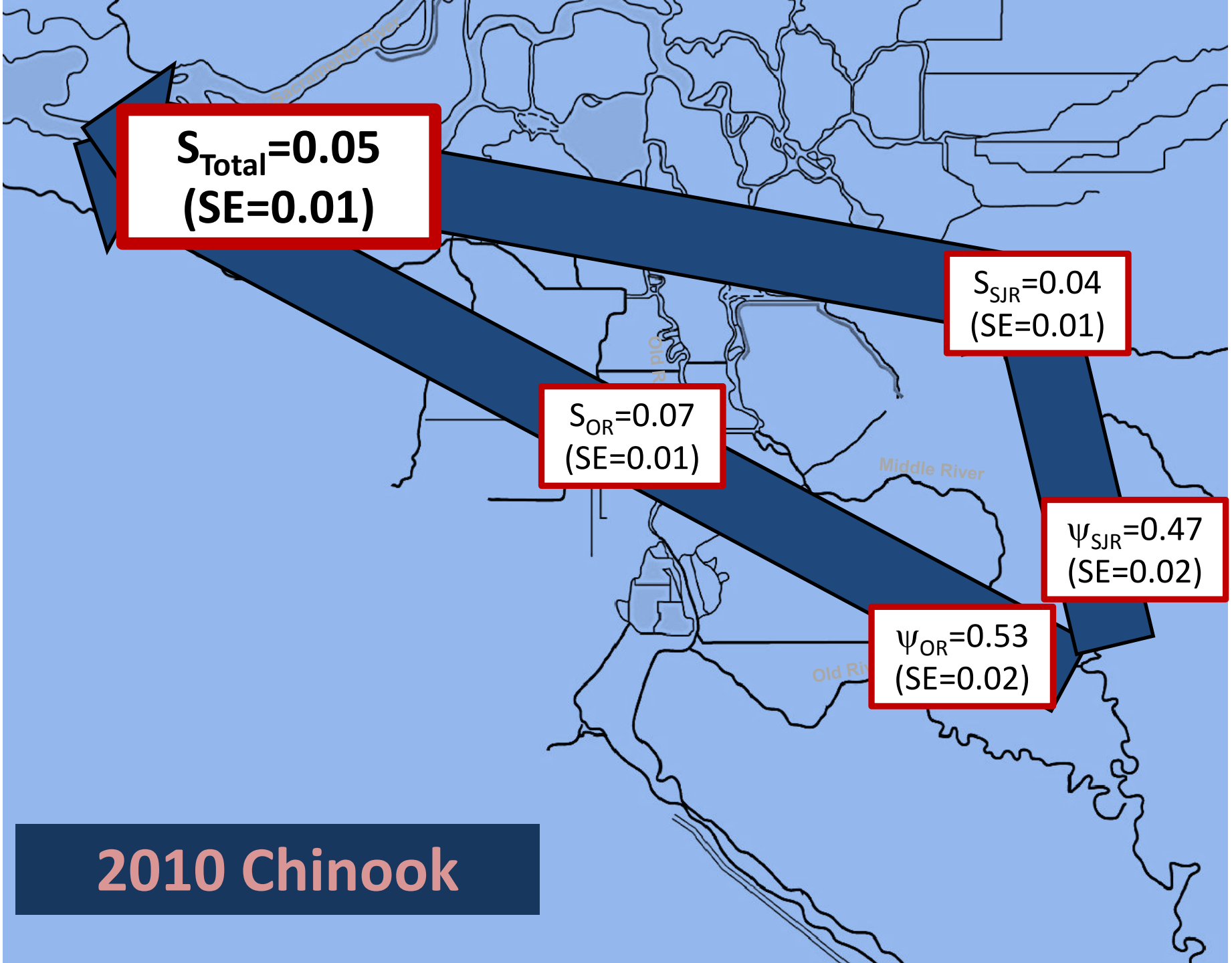

2010 Chinook:
All Releases
(N=993)
Sacramento River
Old River
Middle River
San Joaquin R
Old River
114
159
285
431
170
8
298
229
473
489
235
501
Shading = % First Classified as Predators
0% - 25%
26% - 50%
51% - 75%
76% - 100%
Number of tags detected

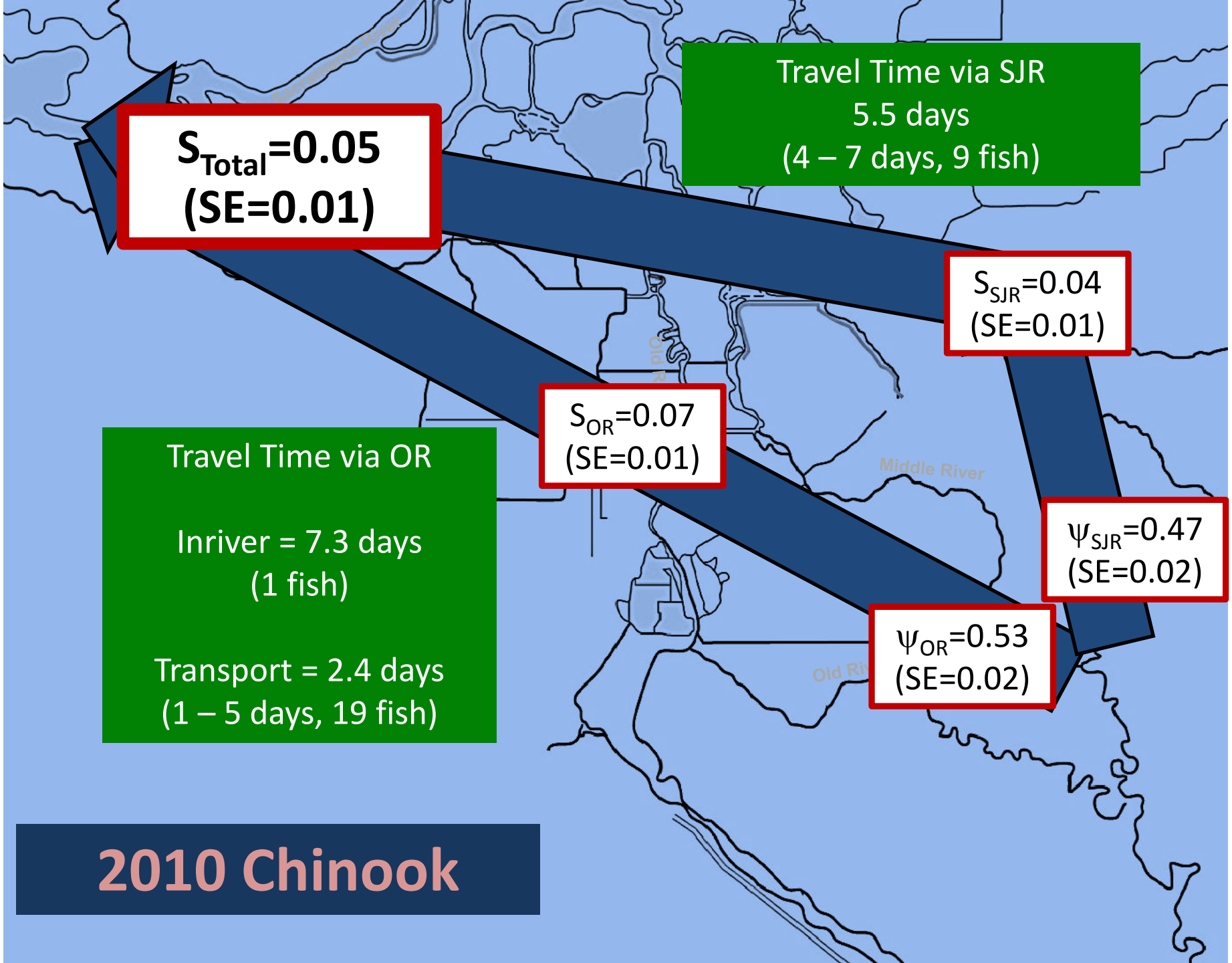

2010 Chinook
Sacramento River
Old River
Middle River
Old River
Probability of Survival or Transition
> 0.90
0.60 – 0.90
0.35 – 0.60
0.10 – 0.35
< 0.10


2010 Chinook
Old River
Middle River
Old River
Probability of Survival or Transition
> 0.90
0.60 – 0.90
0.35 – 0.60
0.10 – 0.35
< 0.10


Sacramento River
Old R
Middle River
Old River
S_{SJR}=0.04
(SE=0.01)
S_{OR}=0.07
(SE=0.01)
2010 Chinook


Sacramento River
Old R
Middle River
Old Riv
S_{SJR}=0.04
(SE=0.01)
S_{OR}=0.07
(SE=0.01)
ψ_{SJR}=0.47
(SE=0.02)
ψ_{OR}=0.53
(SE=0.02)
2010 Chinook

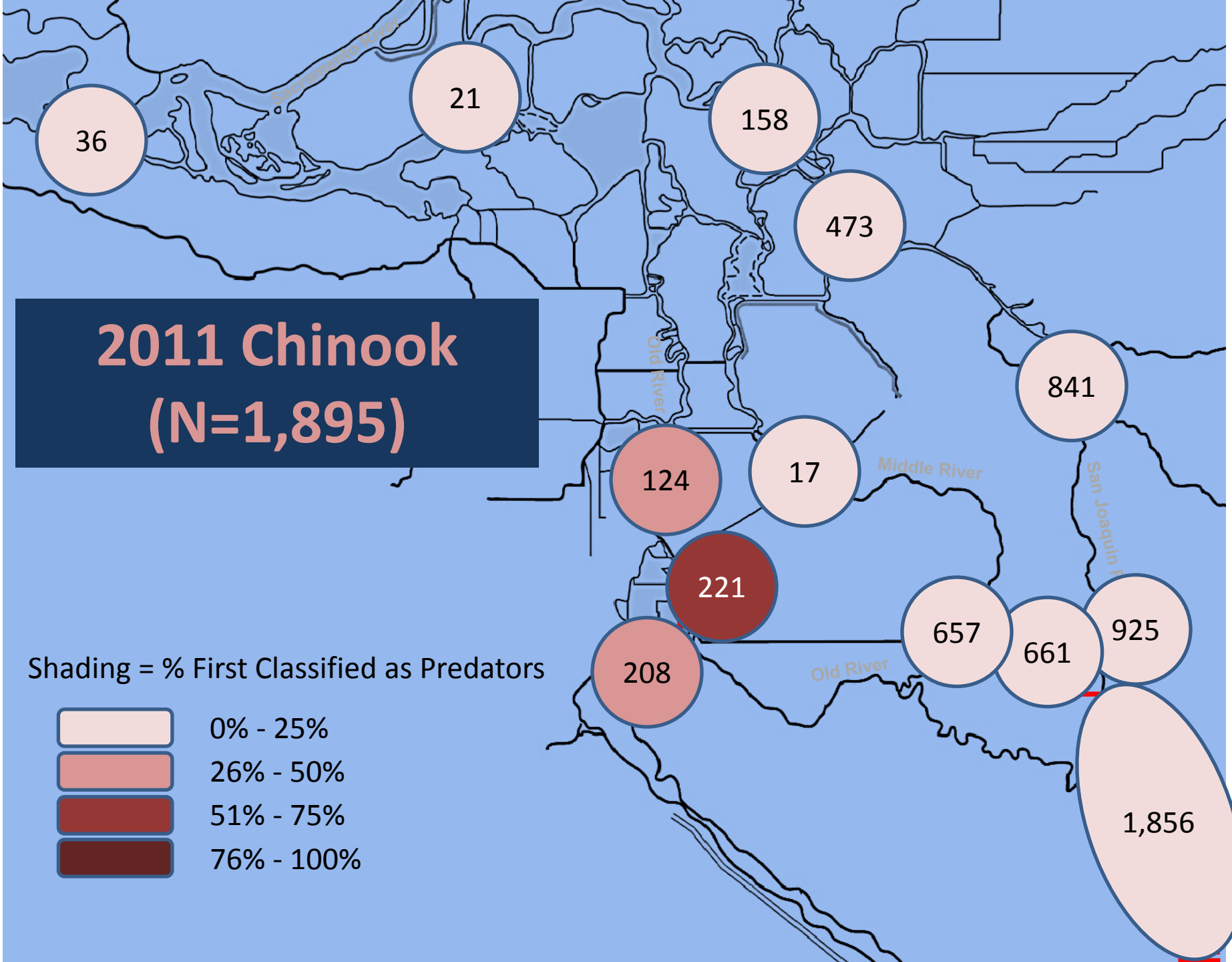

S_{Total}=0.05
(SE=0.01)
S_{SJR}=0.04
(SE=0.01)
S_{OR}=0.07
(SE=0.01)
ψ_{SJR}=0.47
(SE=0.02)
ψ_{OR}=0.53
(SE=0.02)
Middle River
2010 Chinook

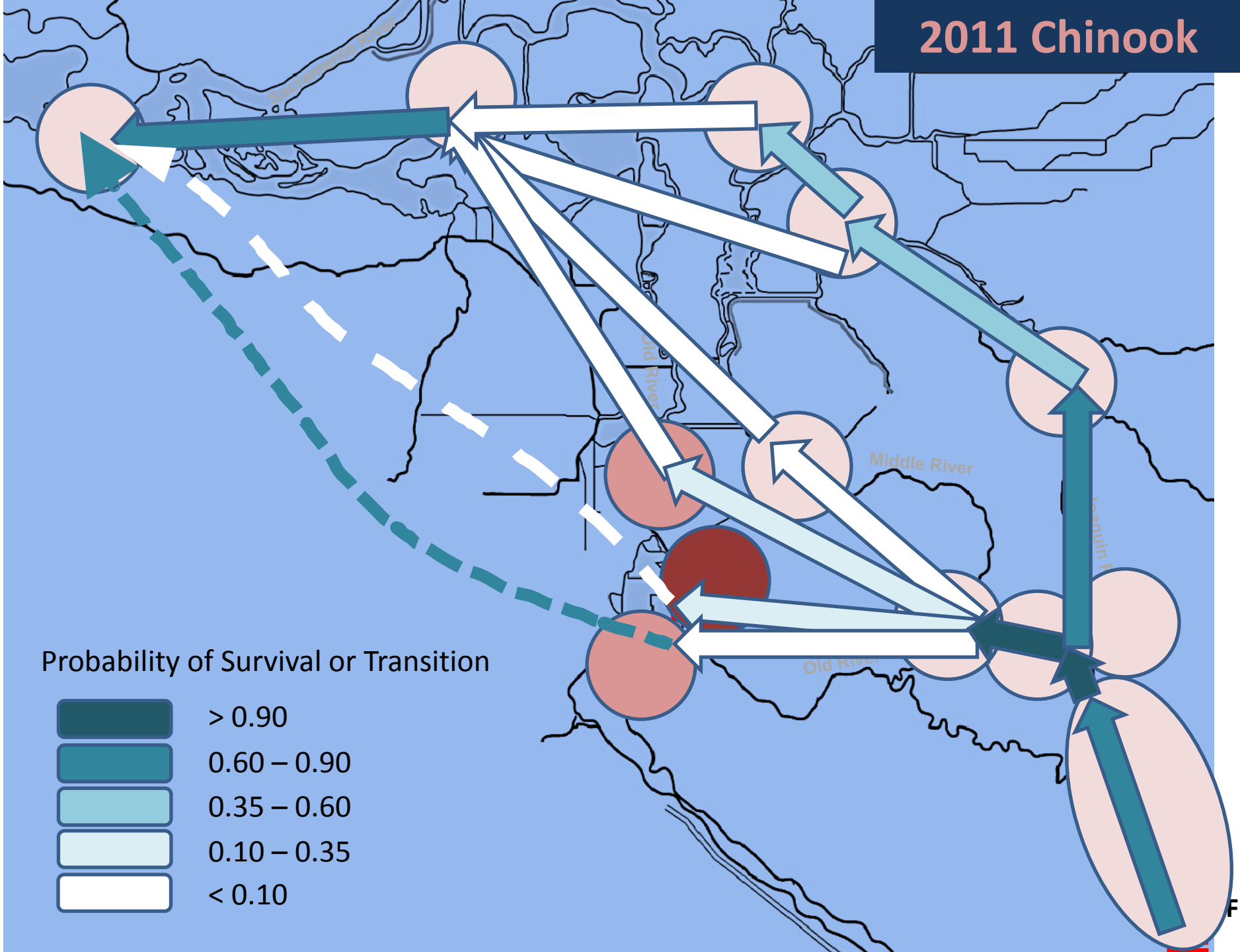

Sacramento River
Old R
Middle River
Old Ri
S_{Total}=0.05
(SE=0.01)
Travel Time via SJR
5.5 days
(4 – 7 days, 9 fish)
S_{SJR}=0.04
(SE=0.01)
S_{OR}=0.07
(SE=0.01)
Travel Time via OR
Inriver = 7.3 days
(1 fish)
Transport = 2.4 days
(1 – 5 days, 19 fish)
ψ_{SJR}=0.47
(SE=0.02)
ψ_{OR}=0.53
(SE=0.02)
2010 Chinook

2011 Fall Chinook Salmon

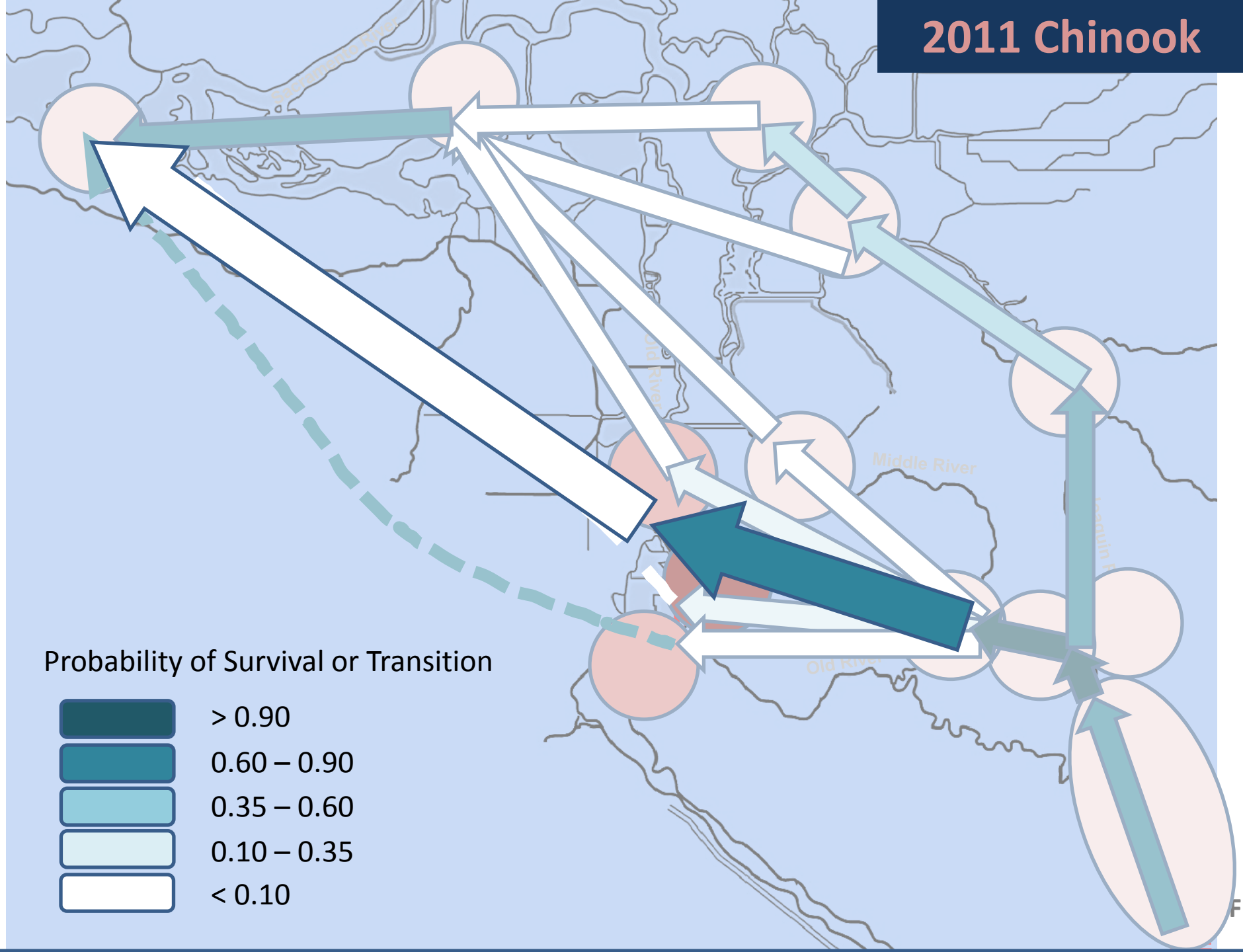
Released May 17 – June 19

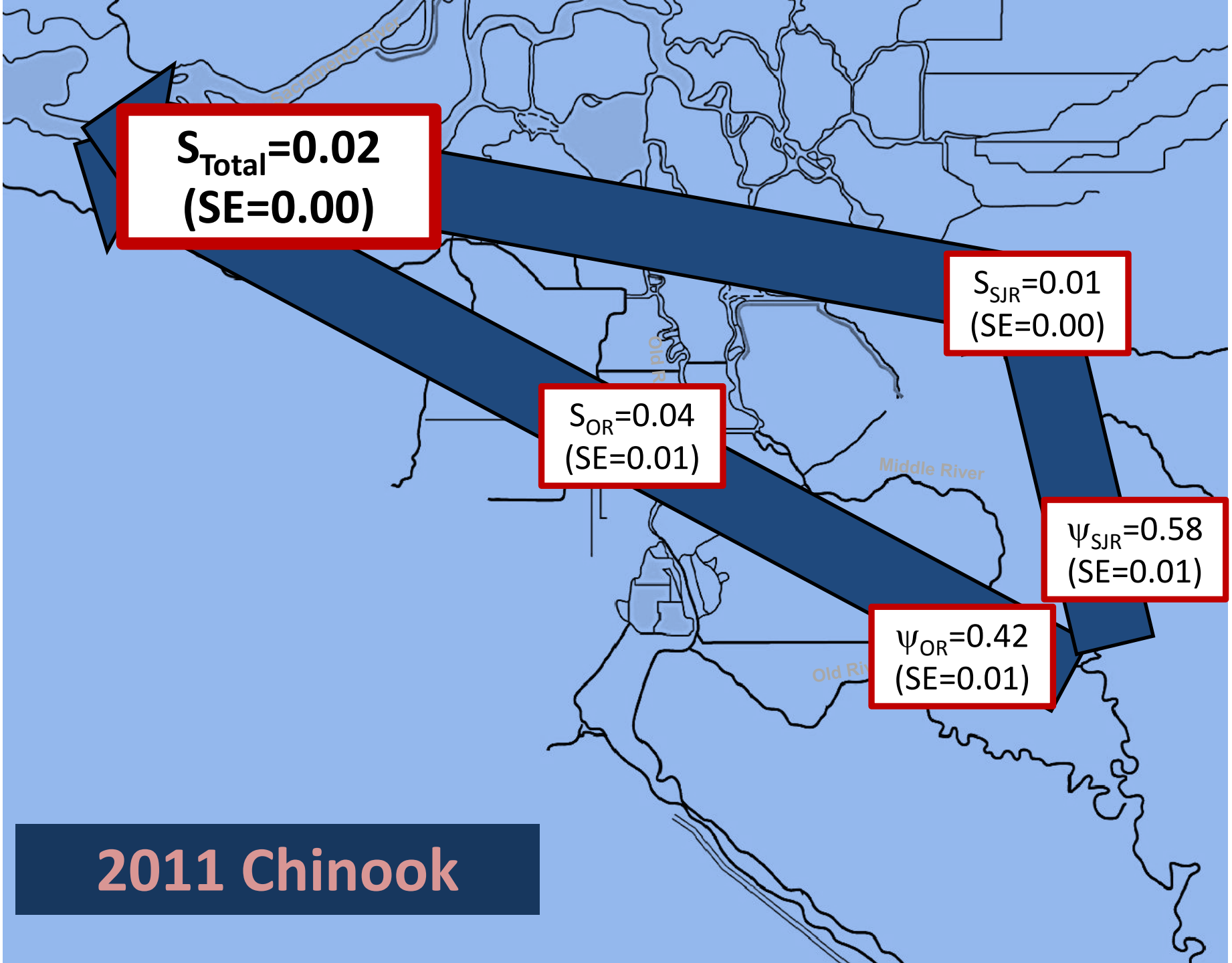
Average fork length = 111 mm

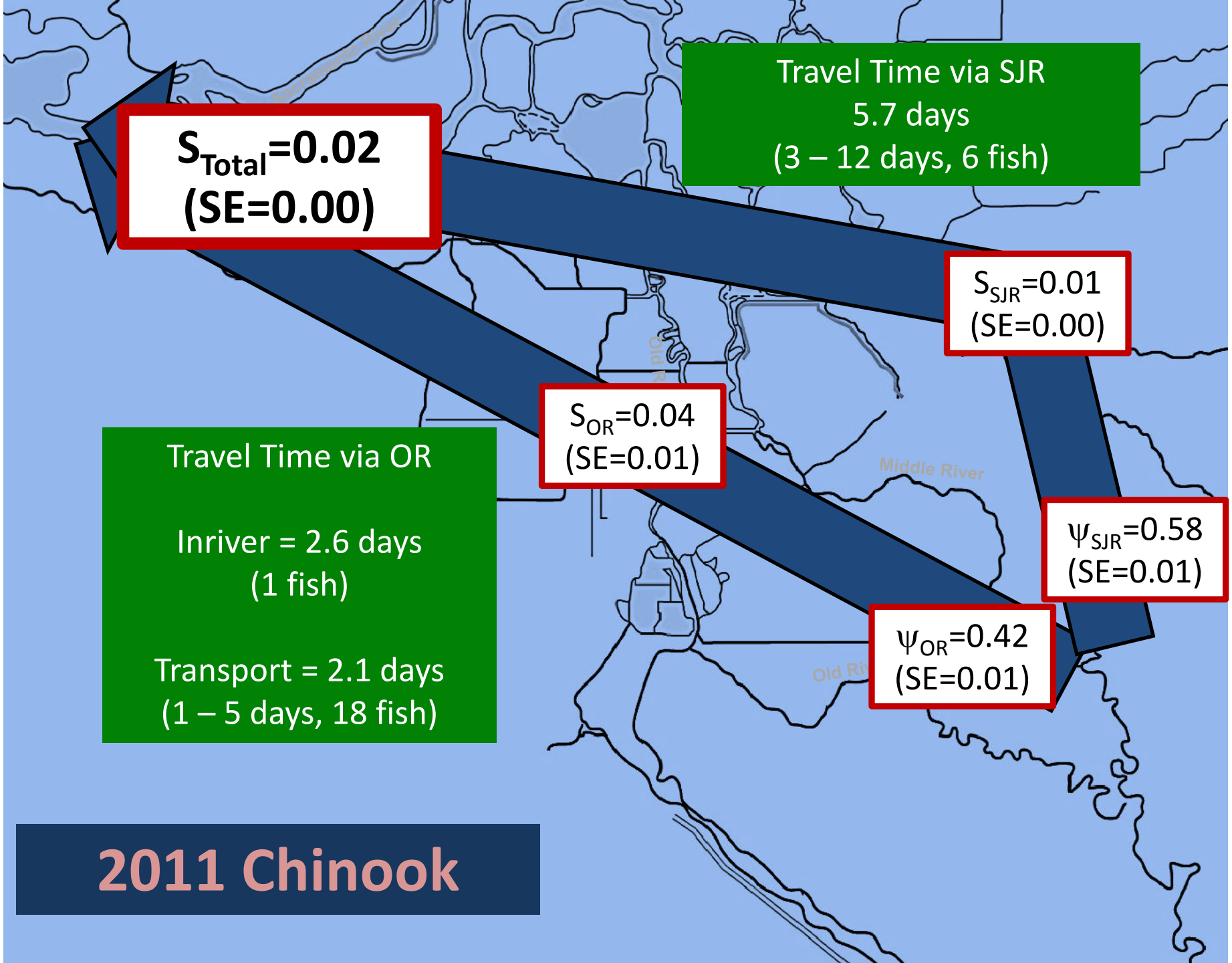

2011 Chinook
(N=1,895)
Sacramento River
Old River
Middle River
San Joaquin R
Old River
36
21
158
473
841
124
17
221
208
657
661
925
1,856
Shading = % First Classified as Predators
0% - 25%
26% - 50%
51% - 75%
76% - 100%


2011 Chinook
Sacramento River
Old River
Middle River
Old River
Probability of Survival or Transition
> 0.90
0.60 – 0.90
0.35 – 0.60
0.10 – 0.35
< 0.10

2011 Chinook




S_{Total}=0.02
(SE=0.00)
S_{SJR}=0.01
(SE=0.00)
S_{OR}=0.04
(SE=0.01)
ψ_{SJR}=0.58
(SE=0.01)
ψ_{OR}=0.42
(SE=0.01)
Middle River
2011 Chinook

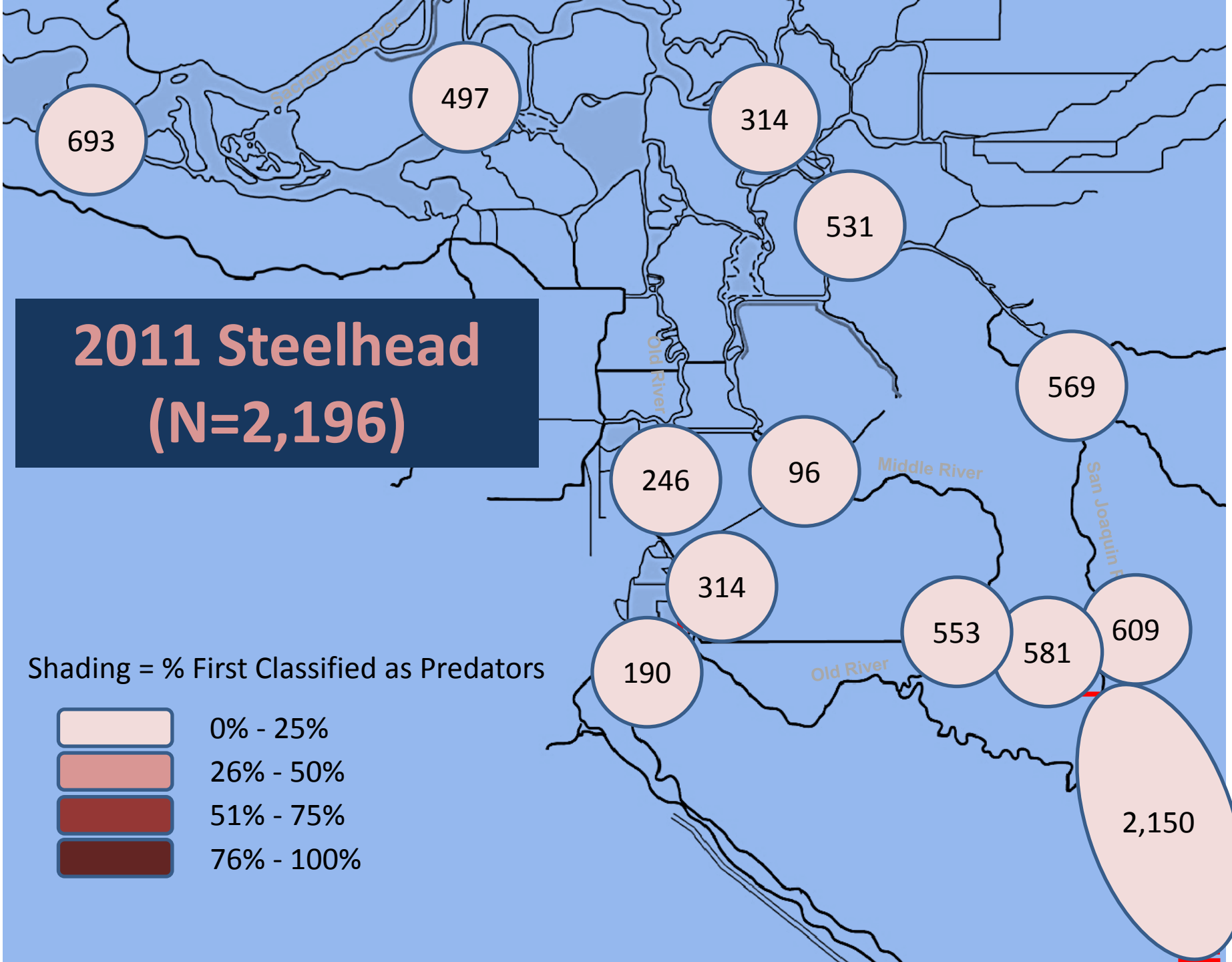

Travel Time via SJR
5.7 days
(3 – 12 days, 6 fish)
S_{Total}=0.02
(SE=0.00)
S_{SJR}=0.01
(SE=0.00)
S_{OR}=0.04
(SE=0.01)
Travel Time via OR
Inriver = 2.6 days
(1 fish)
Transport = 2.1 days
(1 – 5 days, 18 fish)
ψ_{SJR}=0.58
(SE=0.01)
ψ_{OR}=0.42
(SE=0.01)
Middle River
2011 Chinook

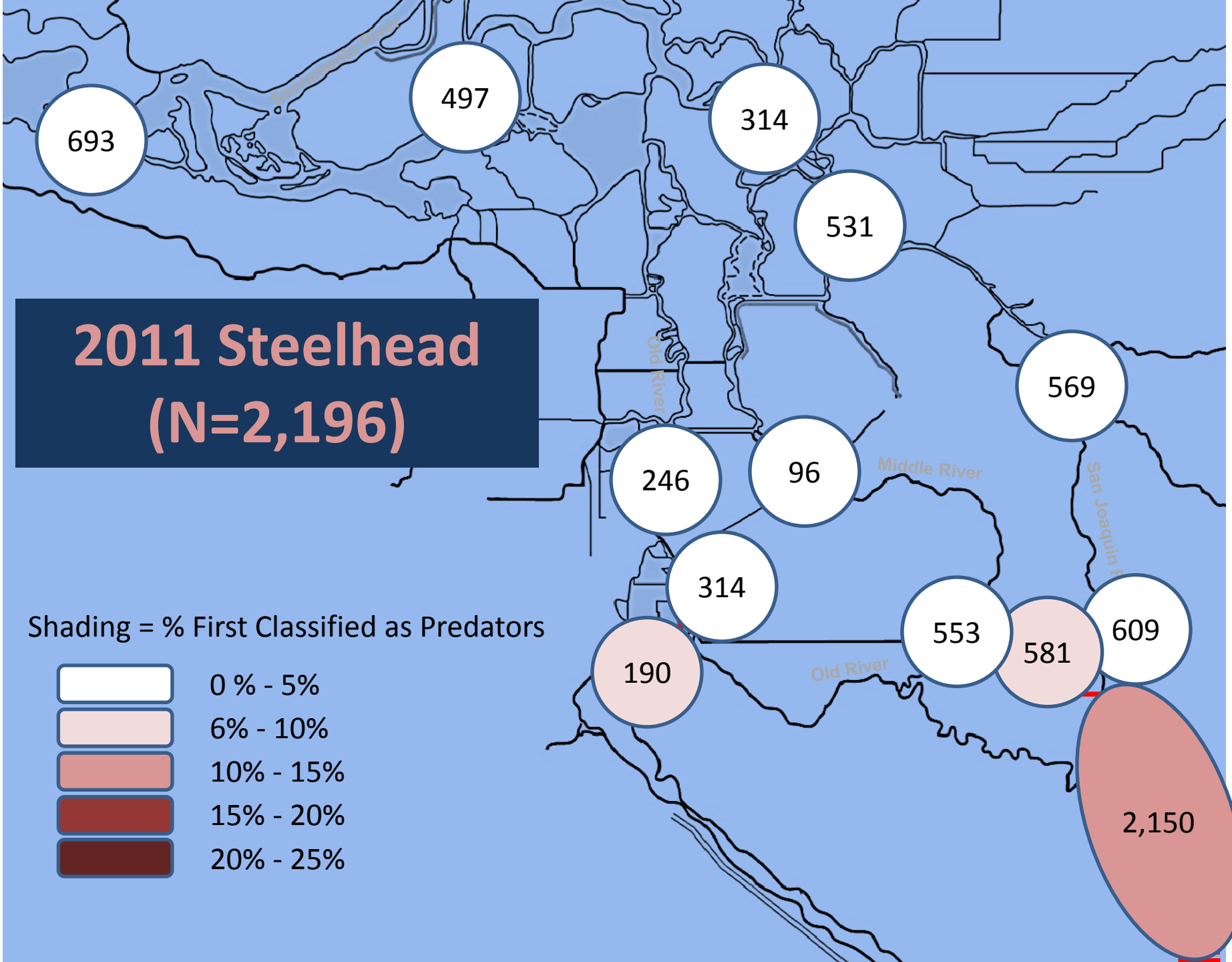
2011 Steelhead

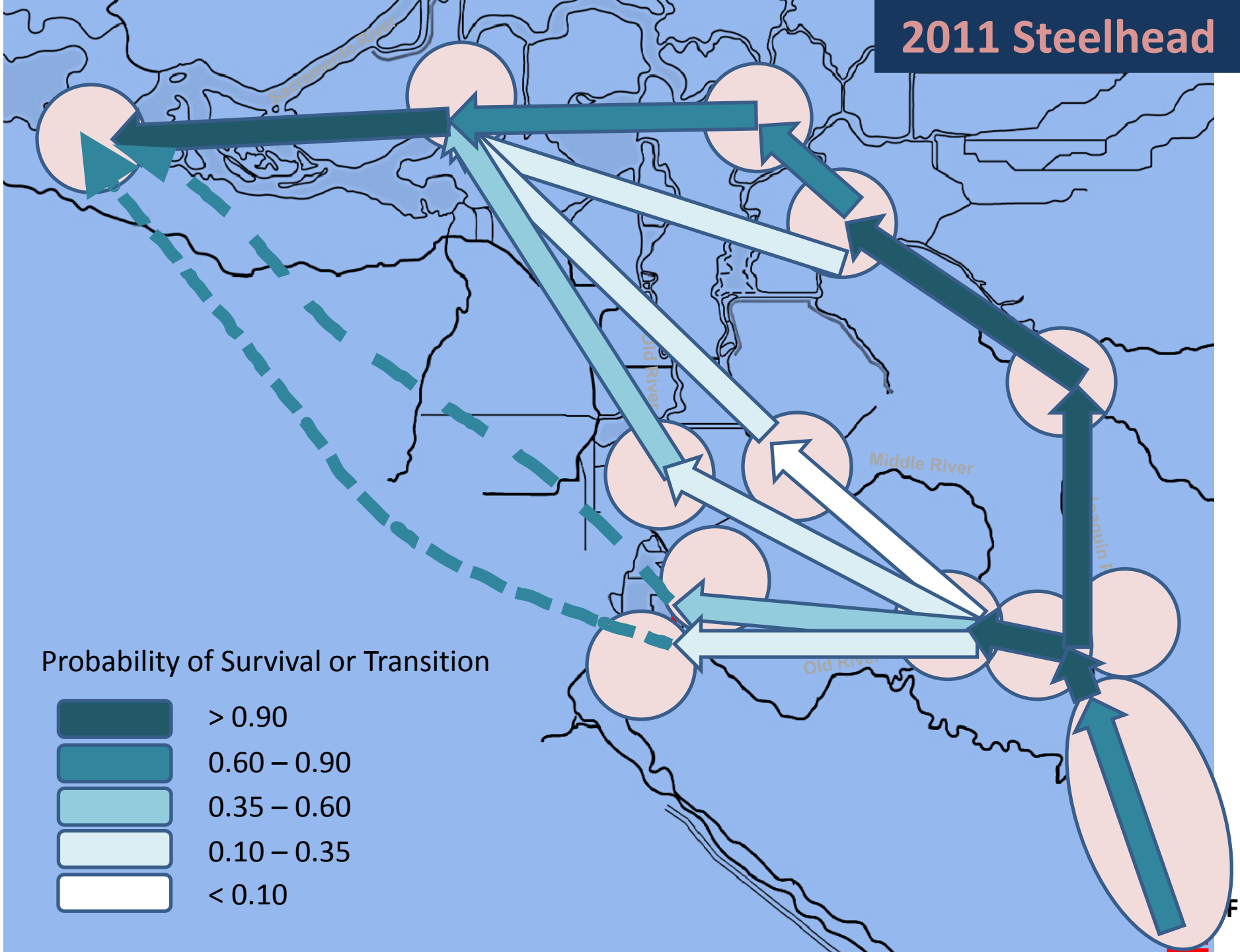
Released March 22 – 26, May 3 – June 18

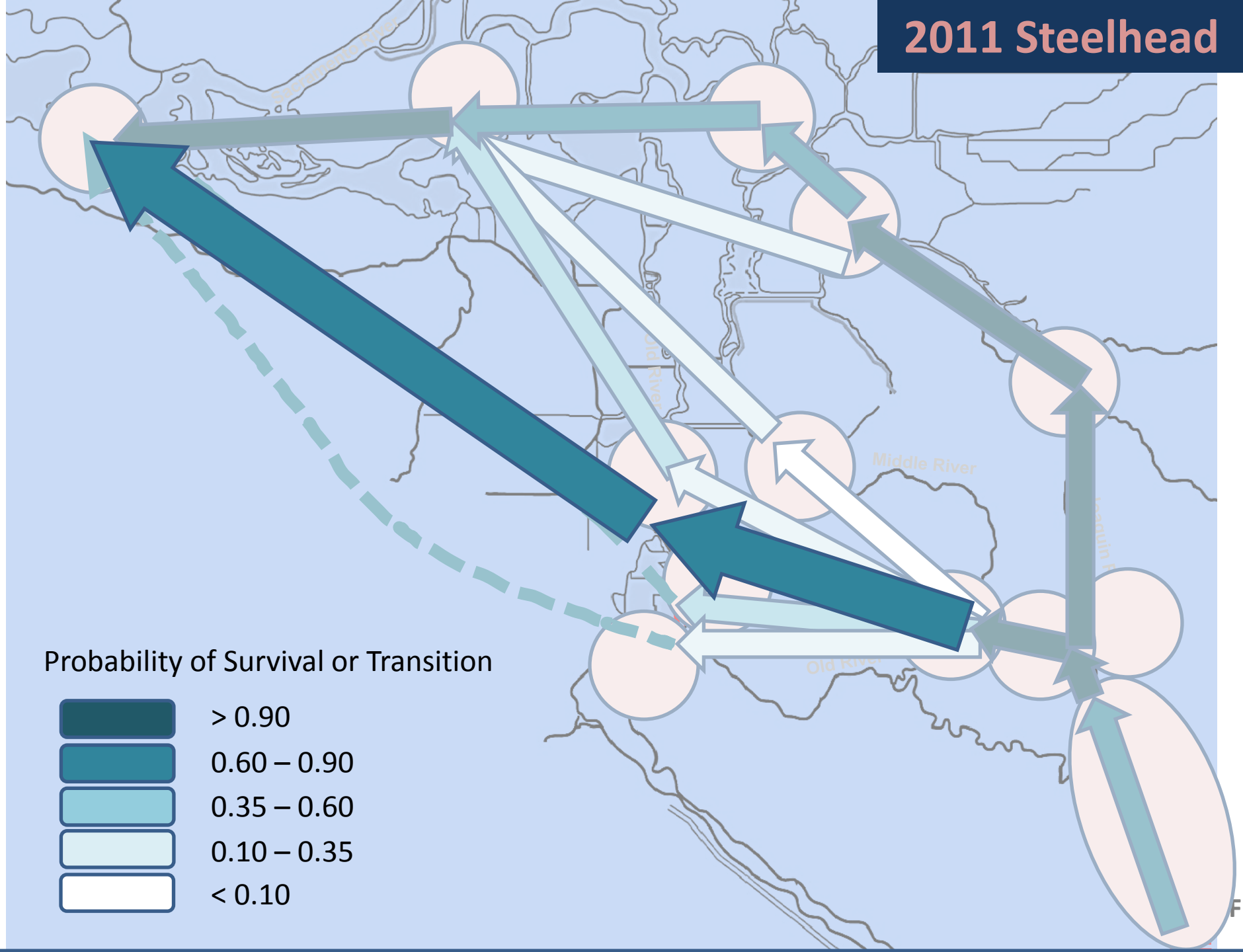
Average fork length = 277 mm

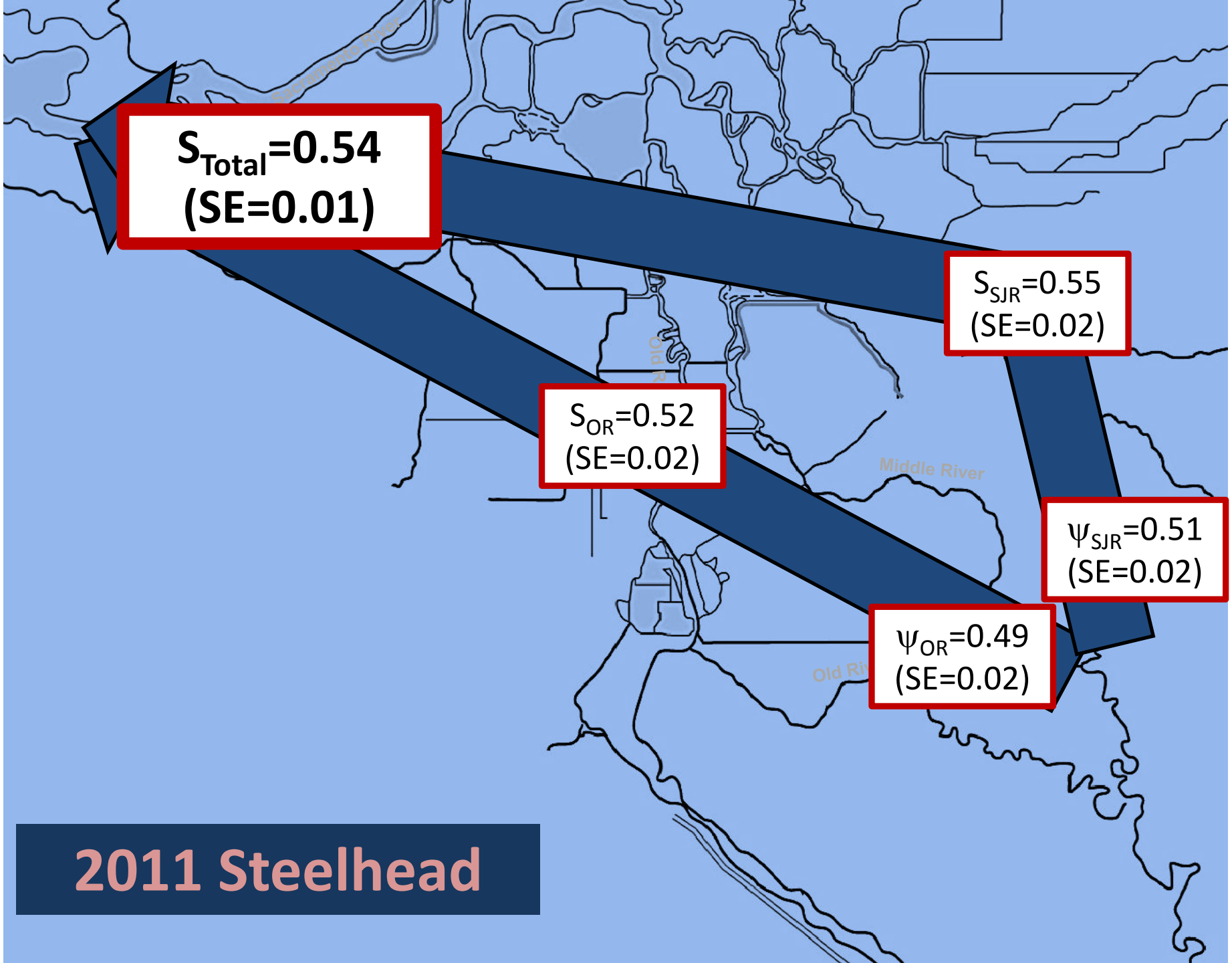
Preliminary results

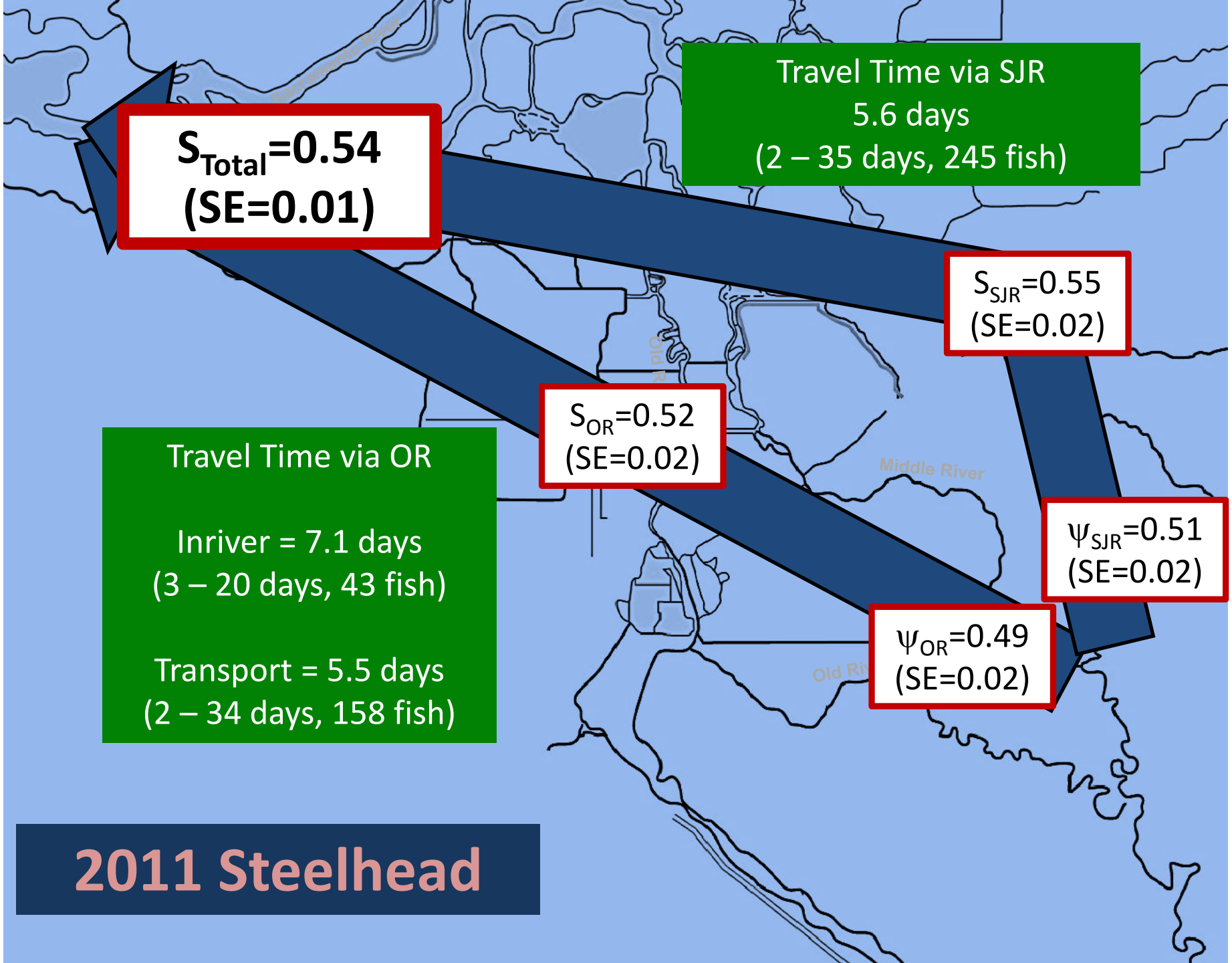

2011 Steelhead
(N=2,196)
693
497
314
531
569
246
96
314
553
581
609
190
2,150
Sacramento River
Old River
Middle River
San Joaquin R
Old River
Shading = % First Classified as Predators
0% - 25%
26% - 50%
51% - 75%
76% - 100%


2011 Steelhead
(N=2,196)
693
497
314
531
569
246
96
314
553
581
609
190
2,150
Sacramento River
Old River
Middle River
San Joaquin R
Old River
Shading = % First Classified as Predators
0 % - 5%
6% - 10%
10% - 15%
15% - 20%
20% - 25%


2011 Steelhead
Sacramento River
Old River
Middle River
Old River
Probability of Survival or Transition
> 0.90
0.60 – 0.90
0.35 – 0.60
0.10 – 0.35
< 0.10

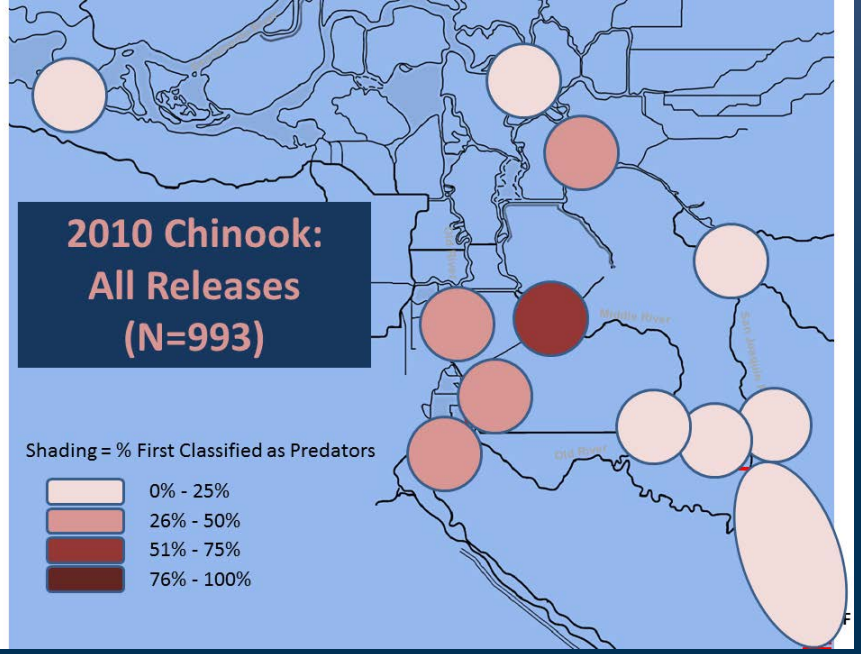

2011 Steelhead
Sacramento River
Old River
Middle River
Old River
Probability of Survival or Transition
> 0.90
0.60 – 0.90
0.35 – 0.60
0.10 – 0.35
< 0.10


S_{Total}=0.54
(SE=0.01)
S_{SJR}=0.55
(SE=0.02)
S_{OR}=0.52
(SE=0.02)
ψ_{SJR}=0.51
(SE=0.02)
ψ_{OR}=0.49
(SE=0.02)
Middle River
2011 Steelhead

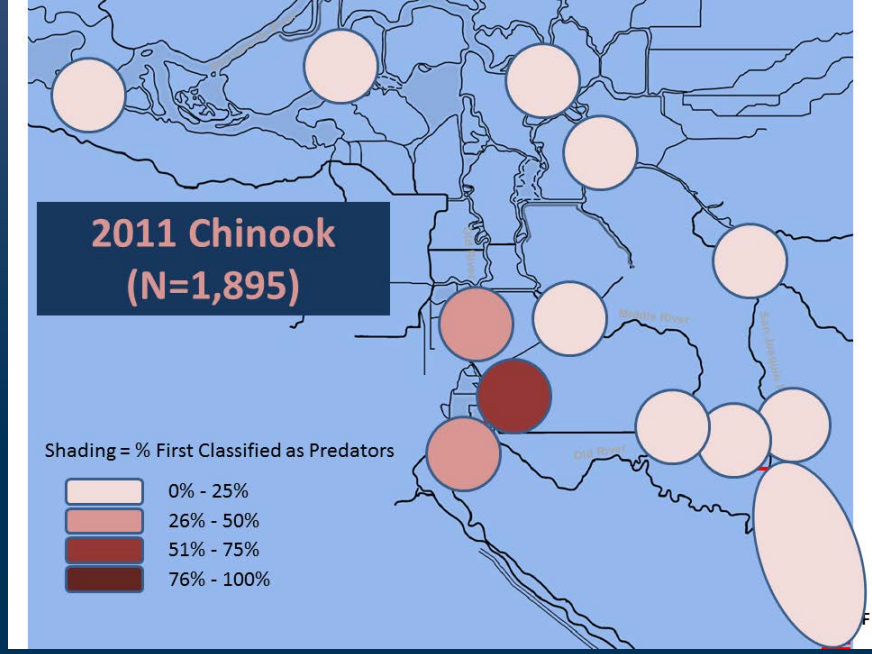

Travel Time via SJR
5.6 days
(2 – 35 days, 245 fish)
S_{Total}=0.54
(SE=0.01)
S_{SJR}=0.55
(SE=0.02)
S_{OR}=0.52
(SE=0.02)
Travel Time via OR
Inriver = 7.1 days
(3 – 20 days, 43 fish)
Transport = 5.5 days
(2 – 34 days, 158 fish)
ψ_{SJR}=0.51
(SE=0.02)
ψ_{OR}=0.49
(SE=0.02)
Middle River
2011 Steelhead

SUMMARY AND CONCLUSIONS

- Information on predation from acoustic-tag data
  - Tag detections classified as coming from predators (predator filter)
  - Reach survival estimates (release-recapture model)

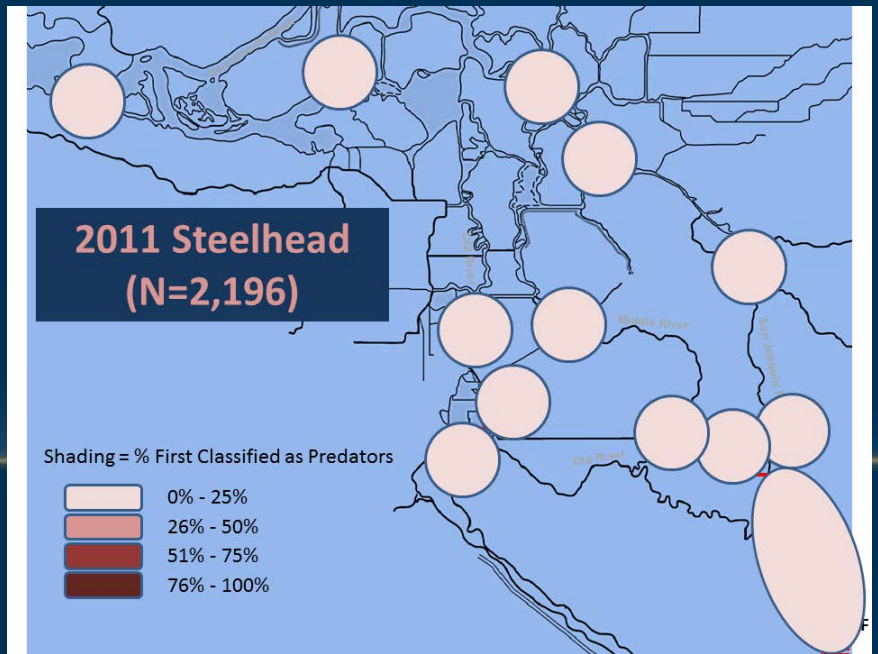


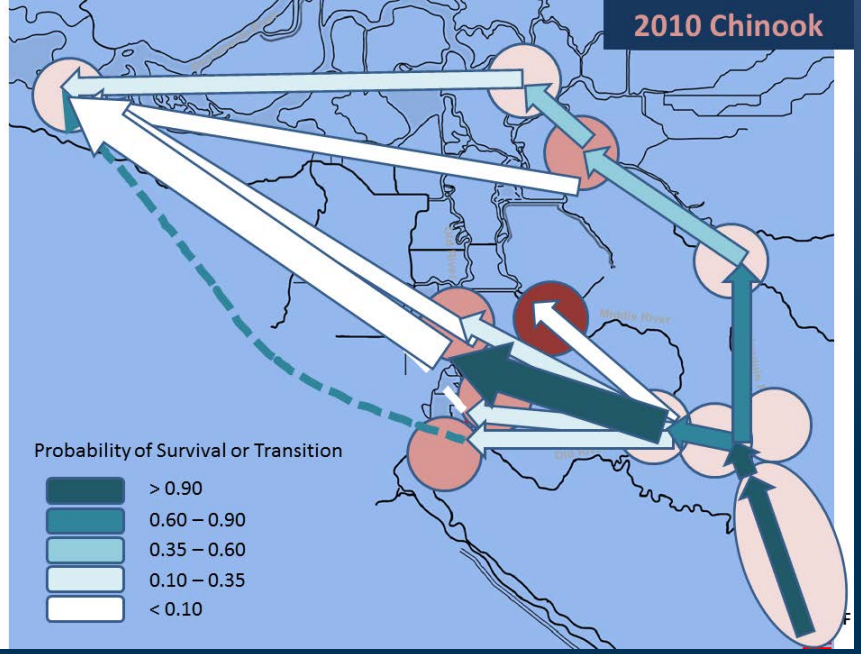
Released April 27 – May 20
FL = 111 mm (average)



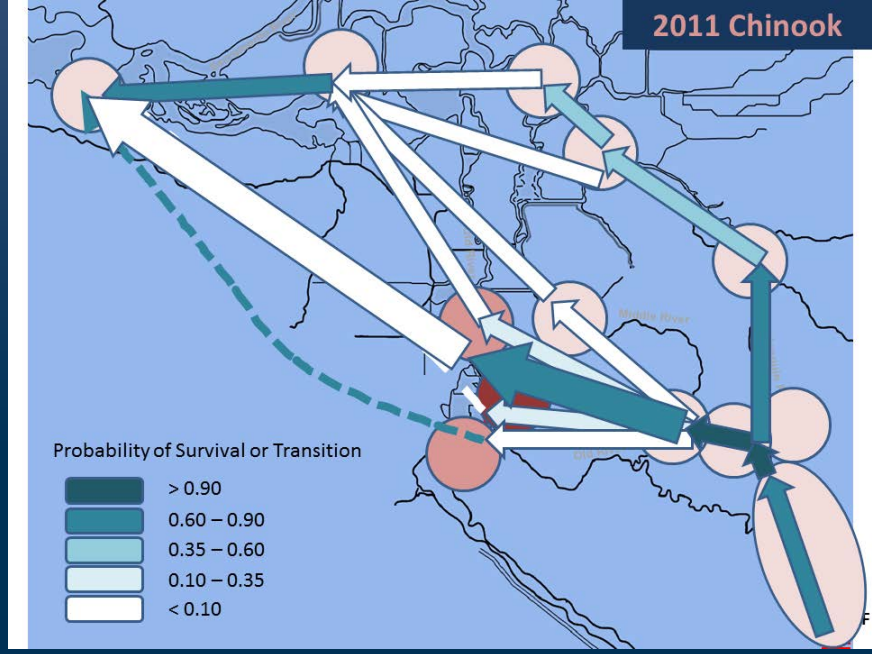
Released May 17– June 19
FL = 111 mm (average)

Released March 22 – 26,
May 3 – June 18
FL = 277 mm (average)





Released April 27 – May 20
FL = 111 mm (average)



Released May 17– June 19
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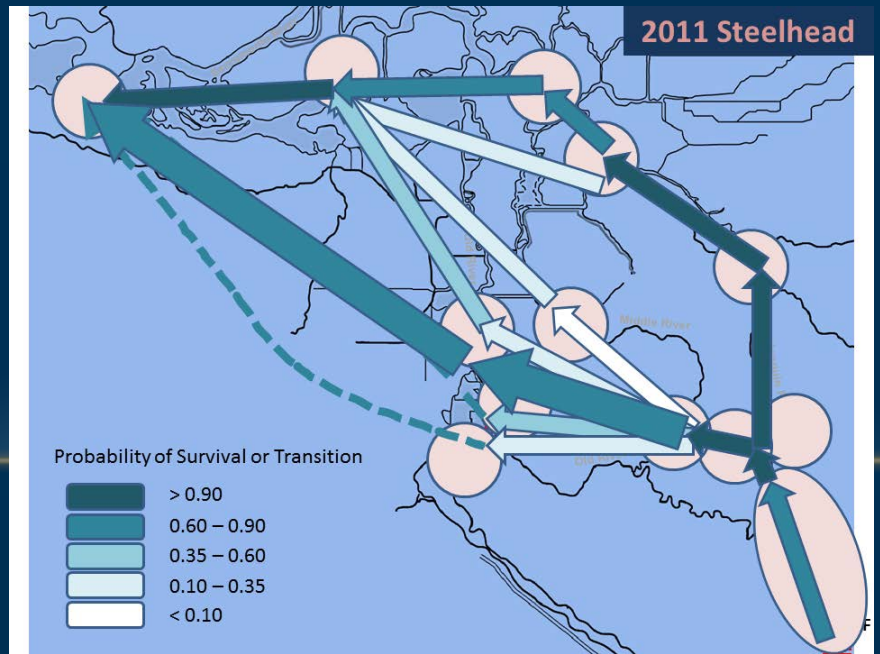
Released March 22 – 26,
May 3 – June 18
FL = 277 mm (average)



ON-GOING AND FUTURE STUDIES

- **On-going**
  - San Joaquin River to Chipps Island
    - 6-year steelhead study (USBR): 2011-2017
    - Fall Chinook (USFWS): 2012-2013 (2014?)
  - 2012 Stipulation Study (San Joaquin River, Delta): Cramer Fish Sciences
  - Sacramento River to SF Bay: Chinook (NMFS, UCD, Cramer Fish Sciences, DWR, DFW)
- **Future**
  - Retrospective analysis of historical data (Hanson Environmental)
    - Juvenile survival (indirect assessment of predation)
  - Predator removal study (NMFS – Hayes)
  - Fish behavior and survival with water exports, tides
    - South Delta Salmon Research Collaborative (SDSRC) Work Group
    - NMFS, DWR, USFWS, USBR, UW, Cramer Fish Sciences, Hanson Environmental, State Water Contractors, Water Districts
    - Need tag that identifies predation (2015 or later?)

THANKS

- San Joaquin River Group Authority
- US Bureau of Reclamation
- California DWR
- California DFW
- NMFS
- Delta Science Program
- Signatories to the San Joaquin River Agreement
- Many people involved in planning and implementing tagging study
  - Scott Brewer – USGS (data processing)
- Predator filter discussion:
  - Josh Israel, Brent Bridges – USBR
  - Pat Brandes – USFWS
  - Jon Burau, Chris Vallee, Jason Romine – USGS
  - Kevin Clark, Ryan Reeves, Mike Cane – DWR
  - Phil Sandstrom – UC Davis
- John Skalski, Rich Townsend, Jim Anderson – University of Washington