SURVIVAL AND ROUTE SELECTION OF JUVENILE CHINOOK SALMON IN THE SOUTHERN SACRAMENTO-SAN JOAQUIN RIVER DELTA, 2011

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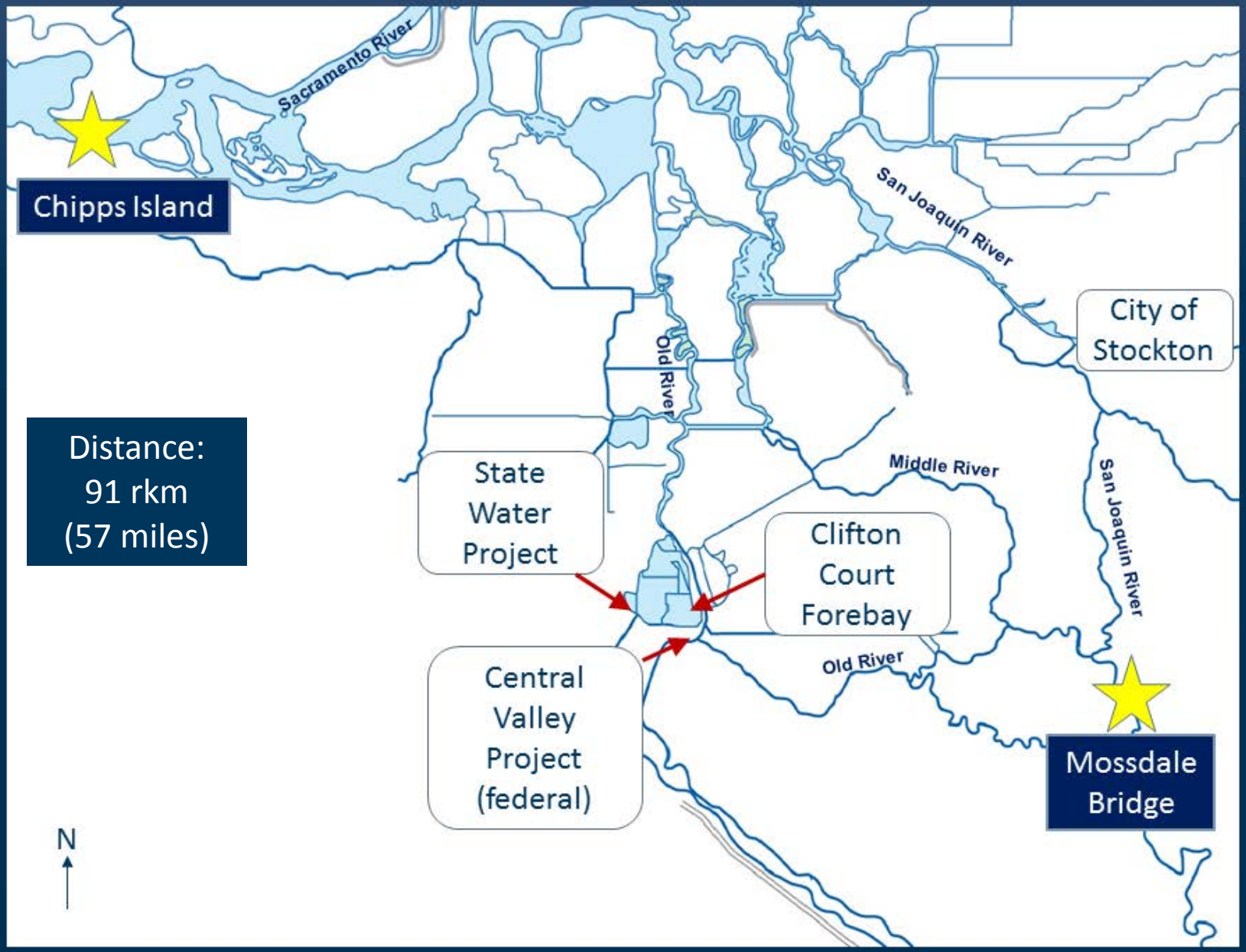
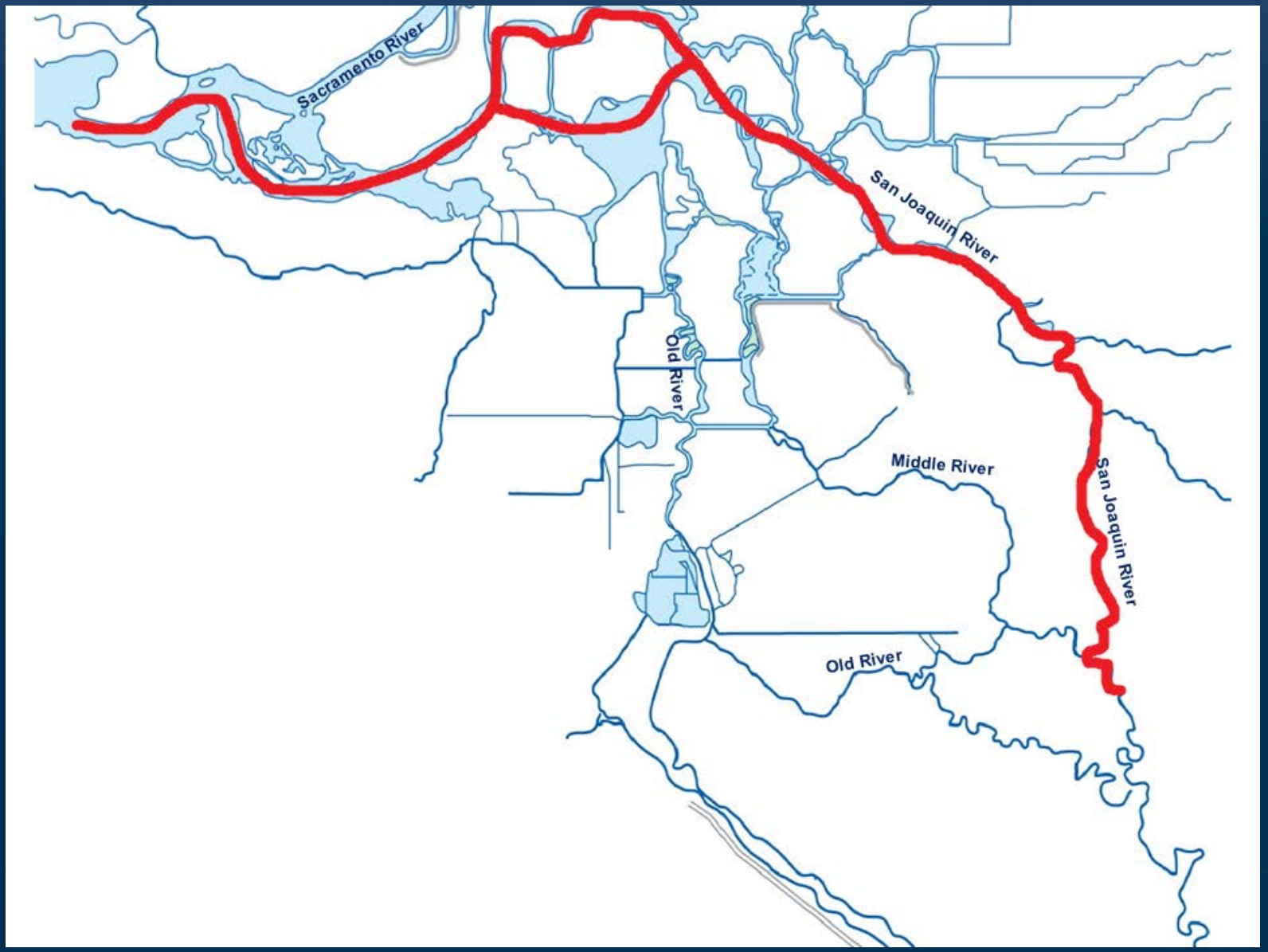
2011 SOUTH DELTA ACOUSTIC TAGGING STUDY

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

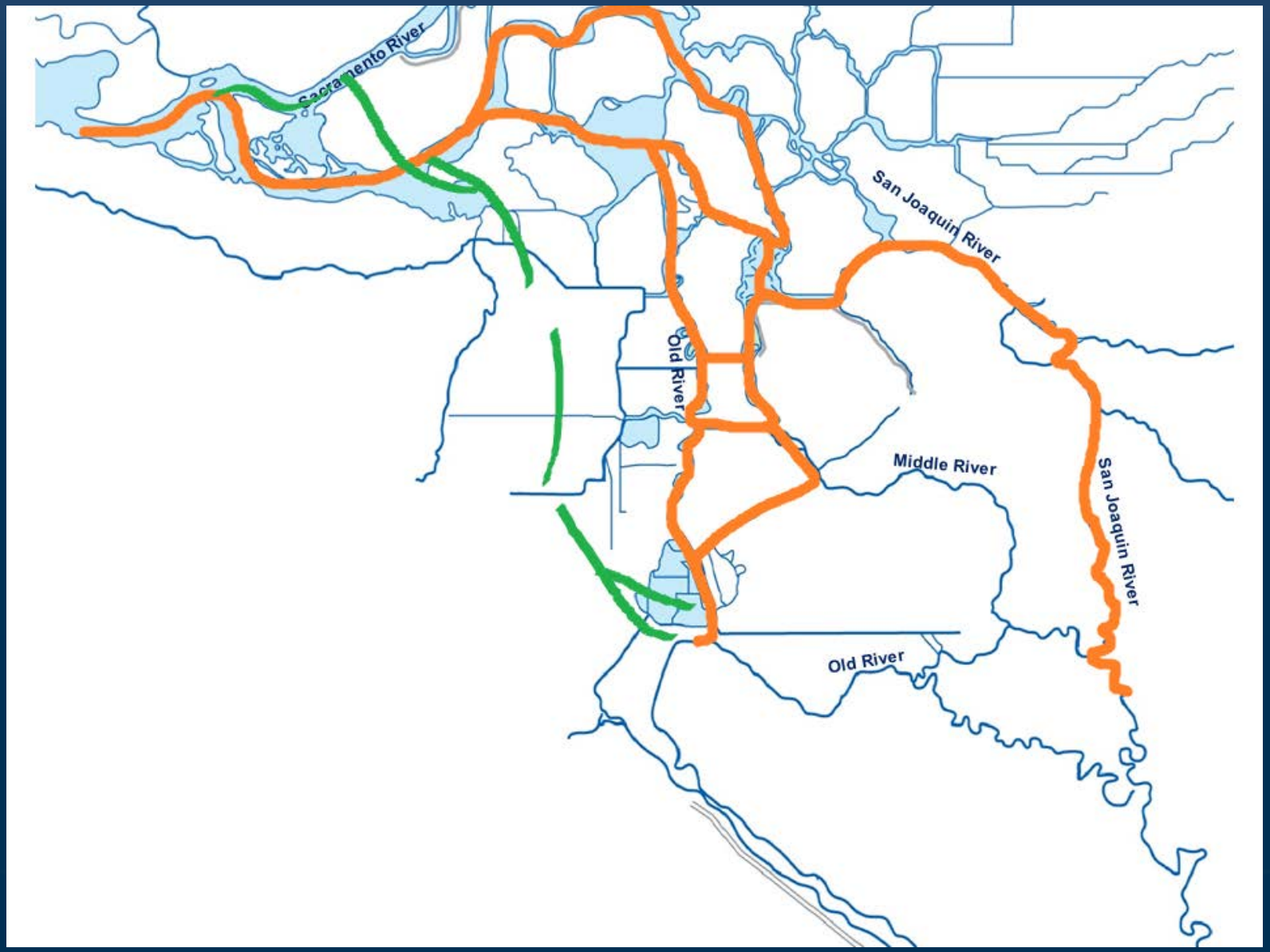
- Juvenile Fall Chinook salmon
- Monitor route usage and survival through Delta
  - Mossdale to Chipps Island
  - Route-specific survival


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

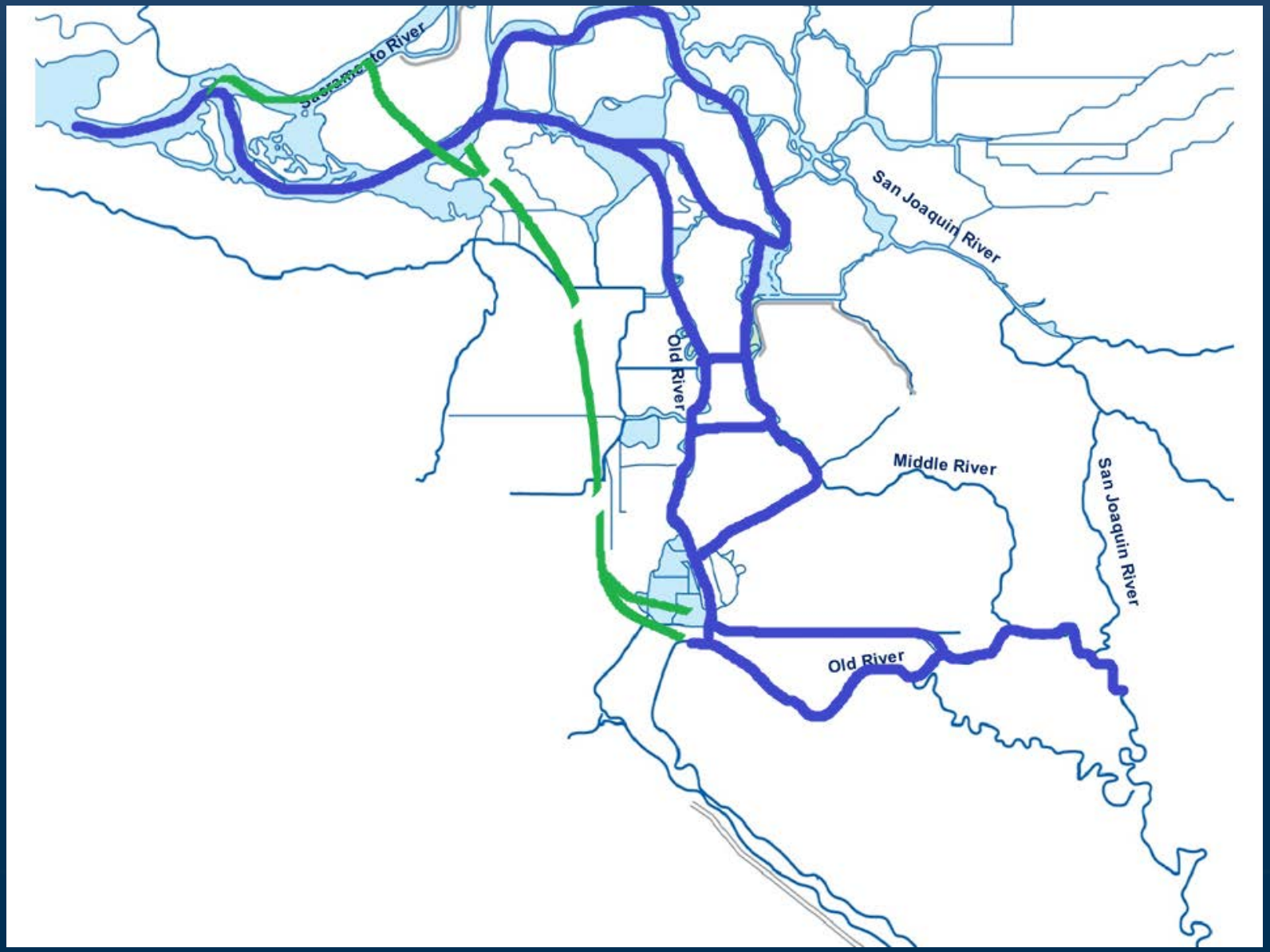
SAN JOAQUIN RIVER ROUTE



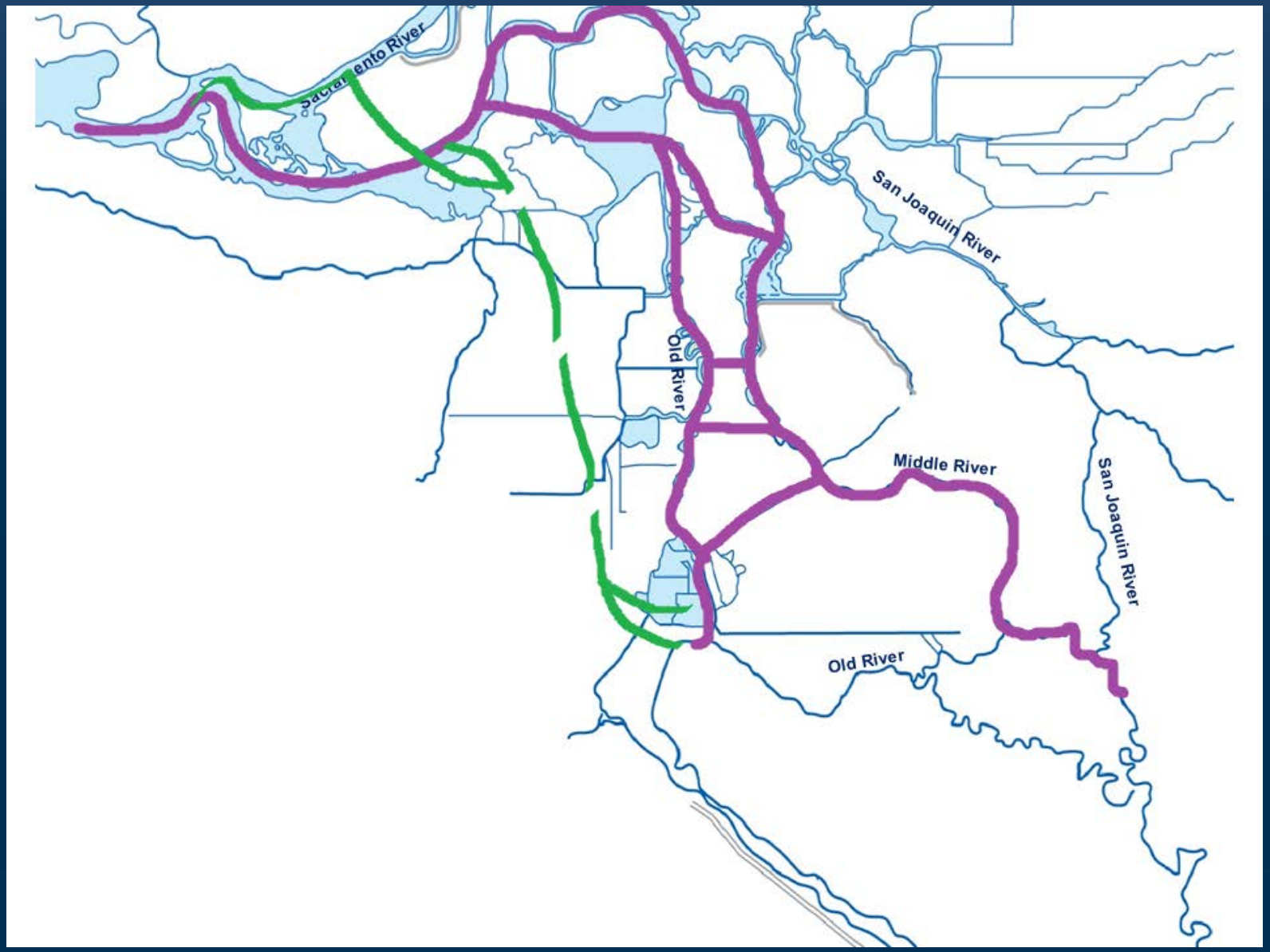
TURNER CUT ROUTE



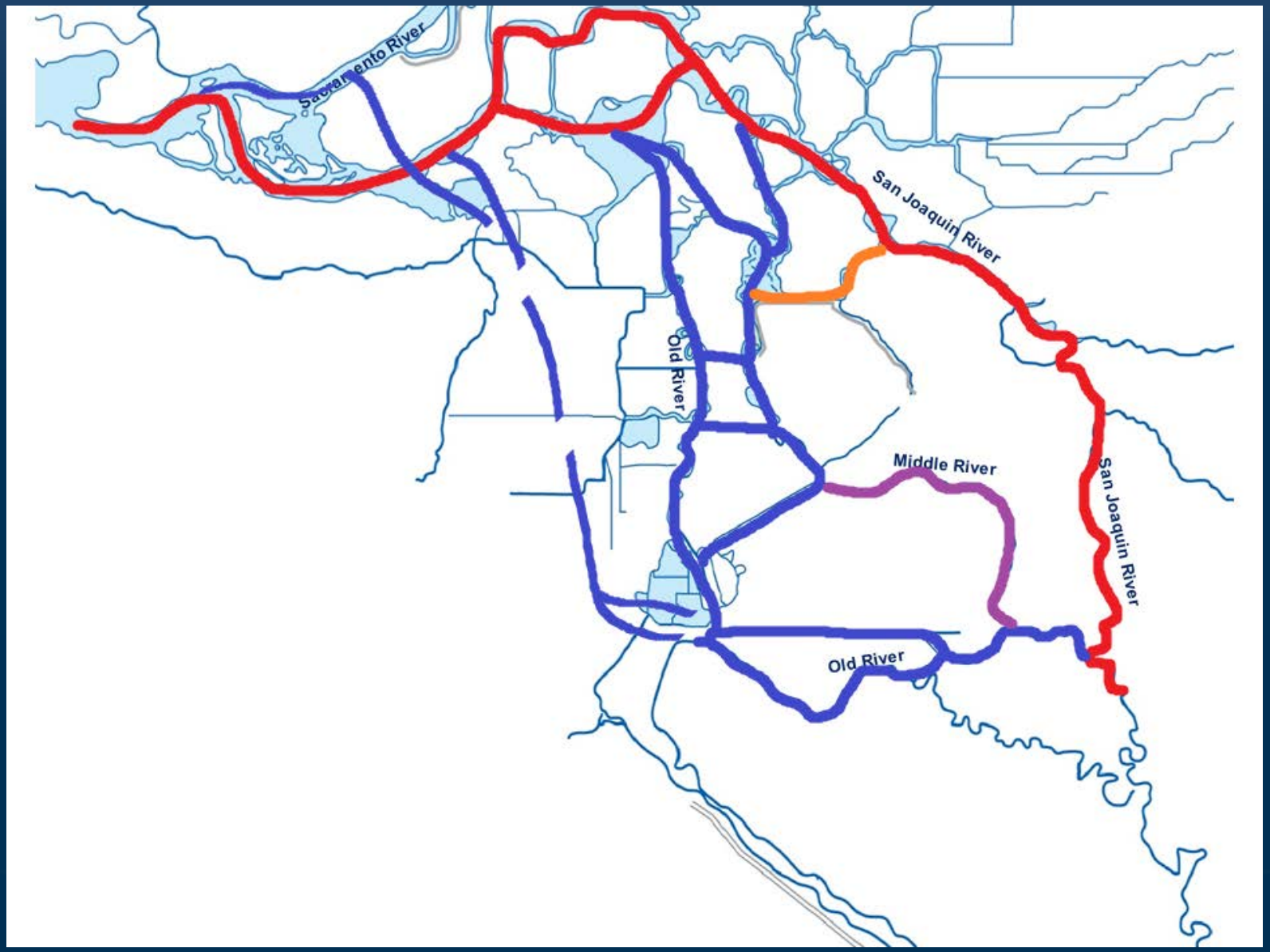
OLD RIVER ROUTE



MIDDLE RIVER ROUTE



ALL ROUTES


Sacramento River
San Joaquin River
Old River
Middle River
San Joaquin River
Old River

2011 TAGGING STUDY: FISH

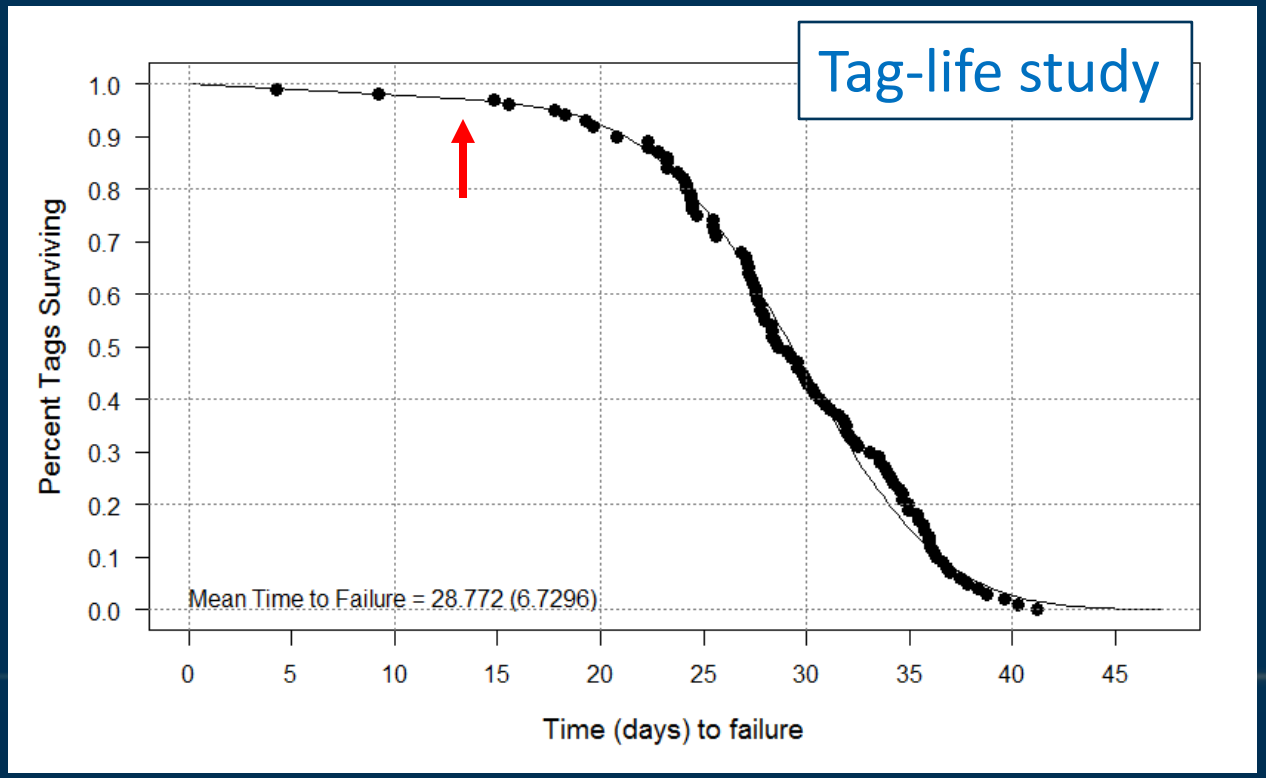
- 1,895 juvenile fall Chinook salmon tagged with acoustic tags
- Source: Merced River Hatchery
- Tagged at Tracy Fish Facility
- Released at Durham Ferry (San Joaquin River)

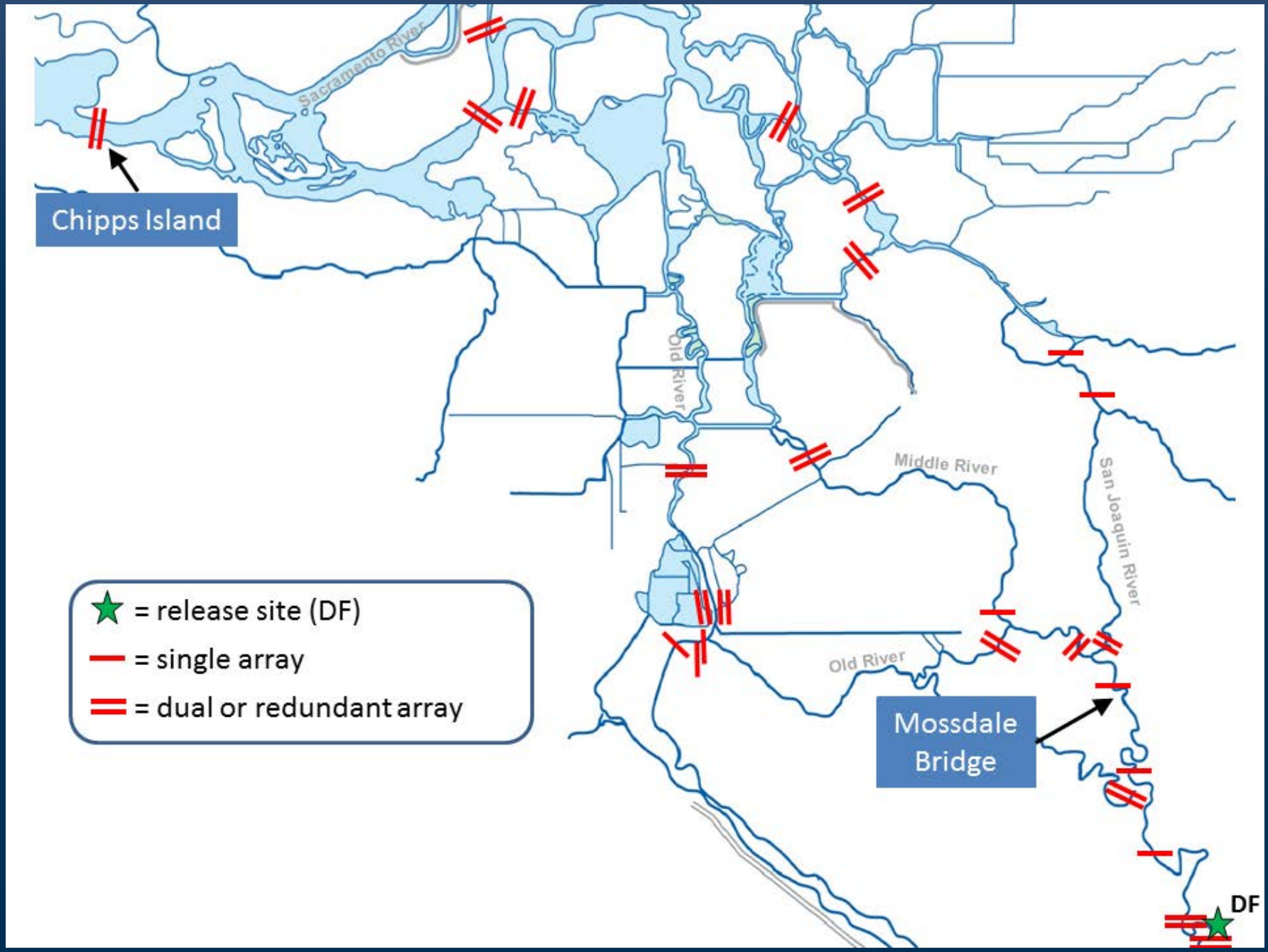
Release Group	No. Fish	Release Dates (2011)	Fish Length (mean; mm)	Fish Weight (mean; g)
1*	475	May 17 – 21	106.0	14.4
2*	473	May 22 – 26	108.2	15.2
3	473	June 7 – 11	114.3	18.3
4	474	June 15 – 19	114.8	18.3
Total	1,895	May 17 – June 19	110.8	16.5

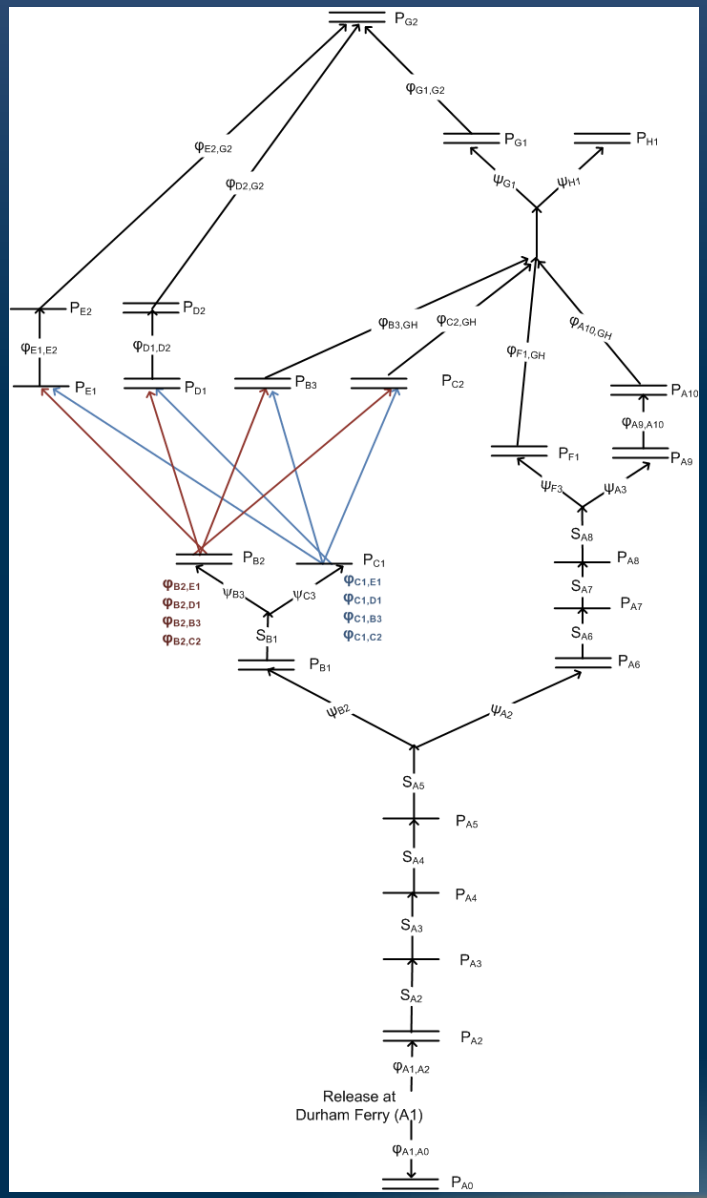
* = during VAMP period (May 1 – 31, 2011)

2011 TAGGING STUDY: TAG

- Hydroacoustics Technology, Inc. (HTI)
- Model: 795Lm
- Size: 0.58 – 0.73 g (mean = 0.65 g)




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



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

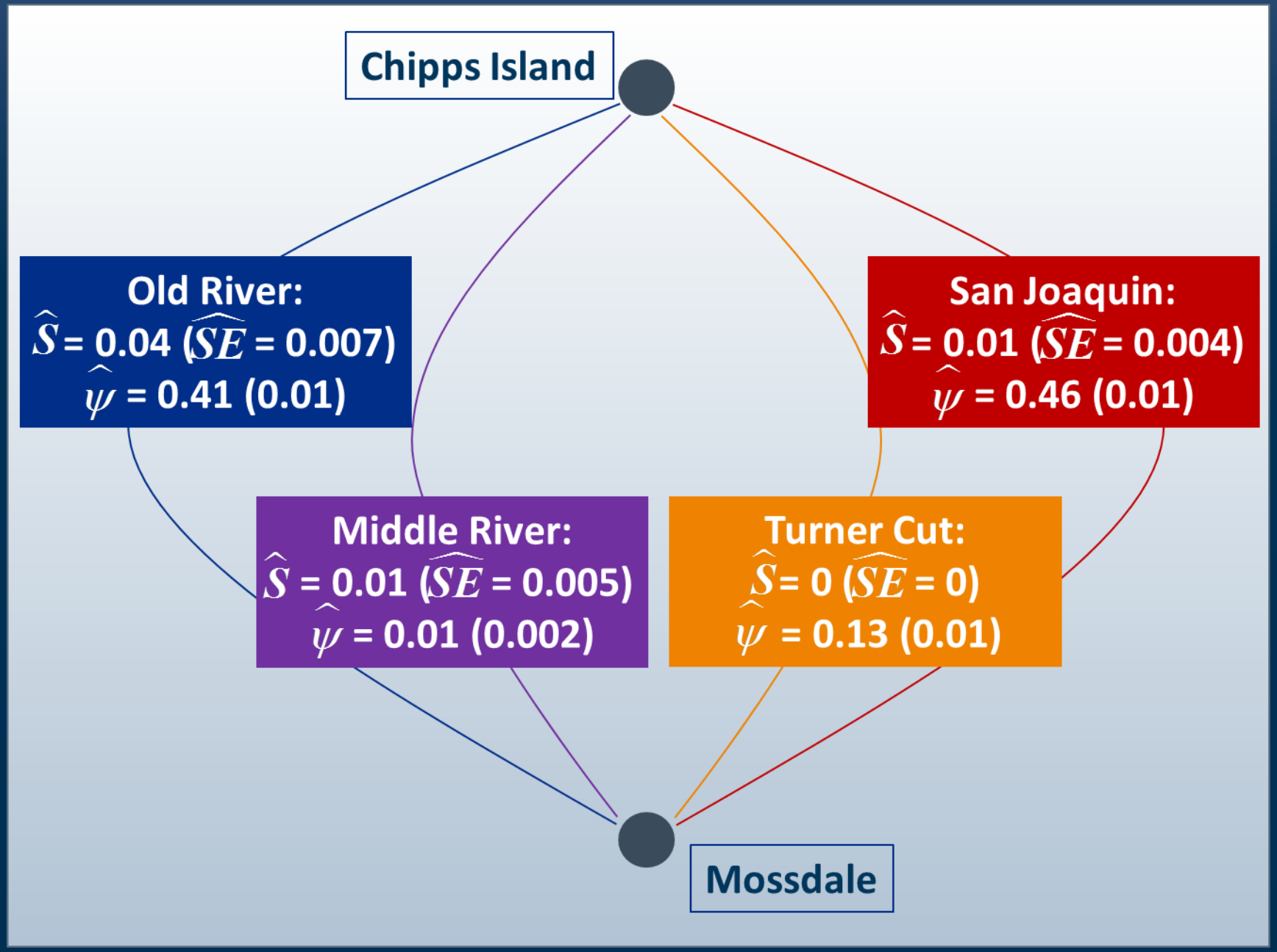
PREDATORS

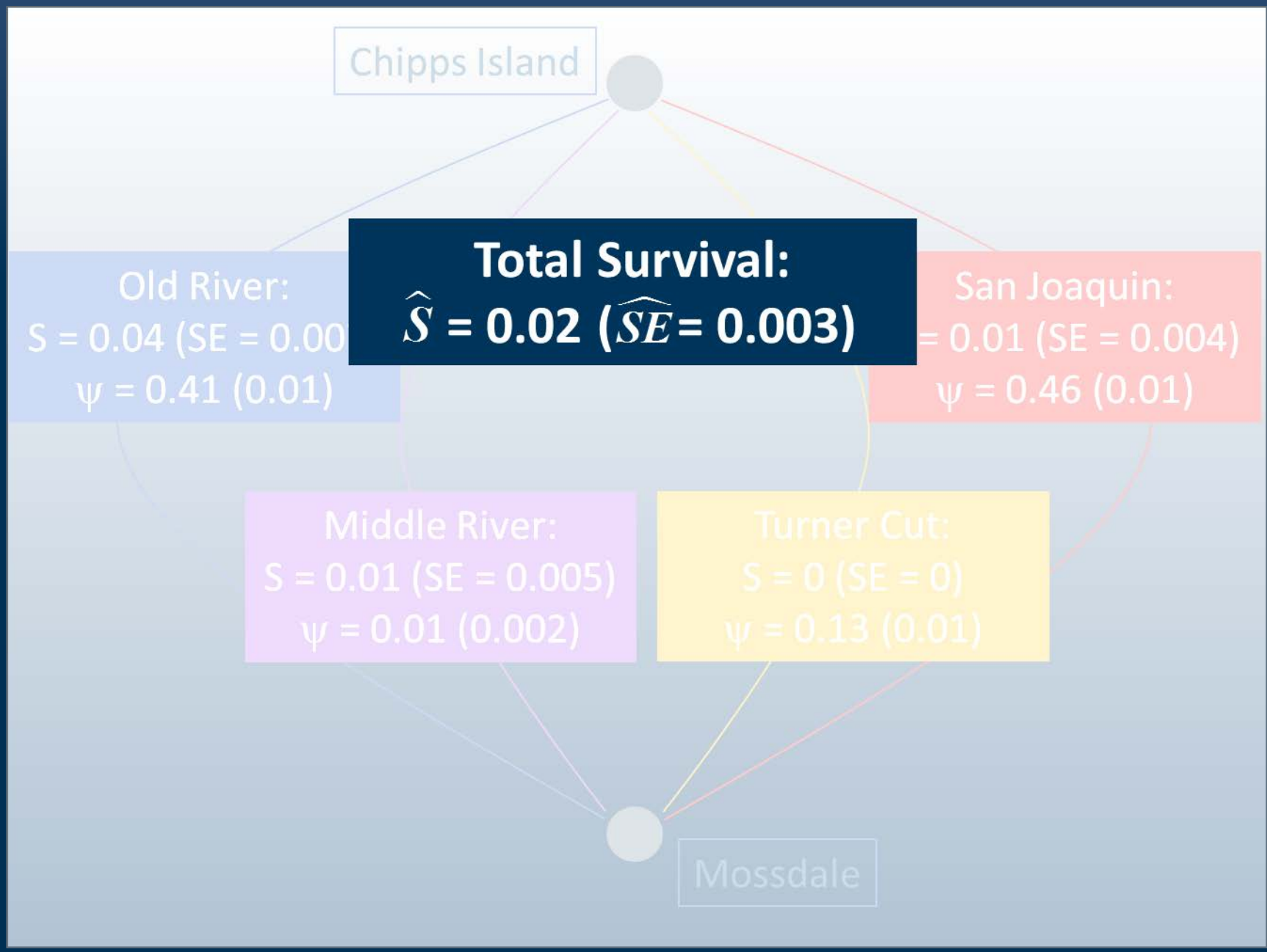
- Problem: Predatory fish eat tagged study fish, then move past receivers
- Result: Biased survival estimates
- Solution: Identify and remove detections from
  - Predators
  - Tags deposited by predators

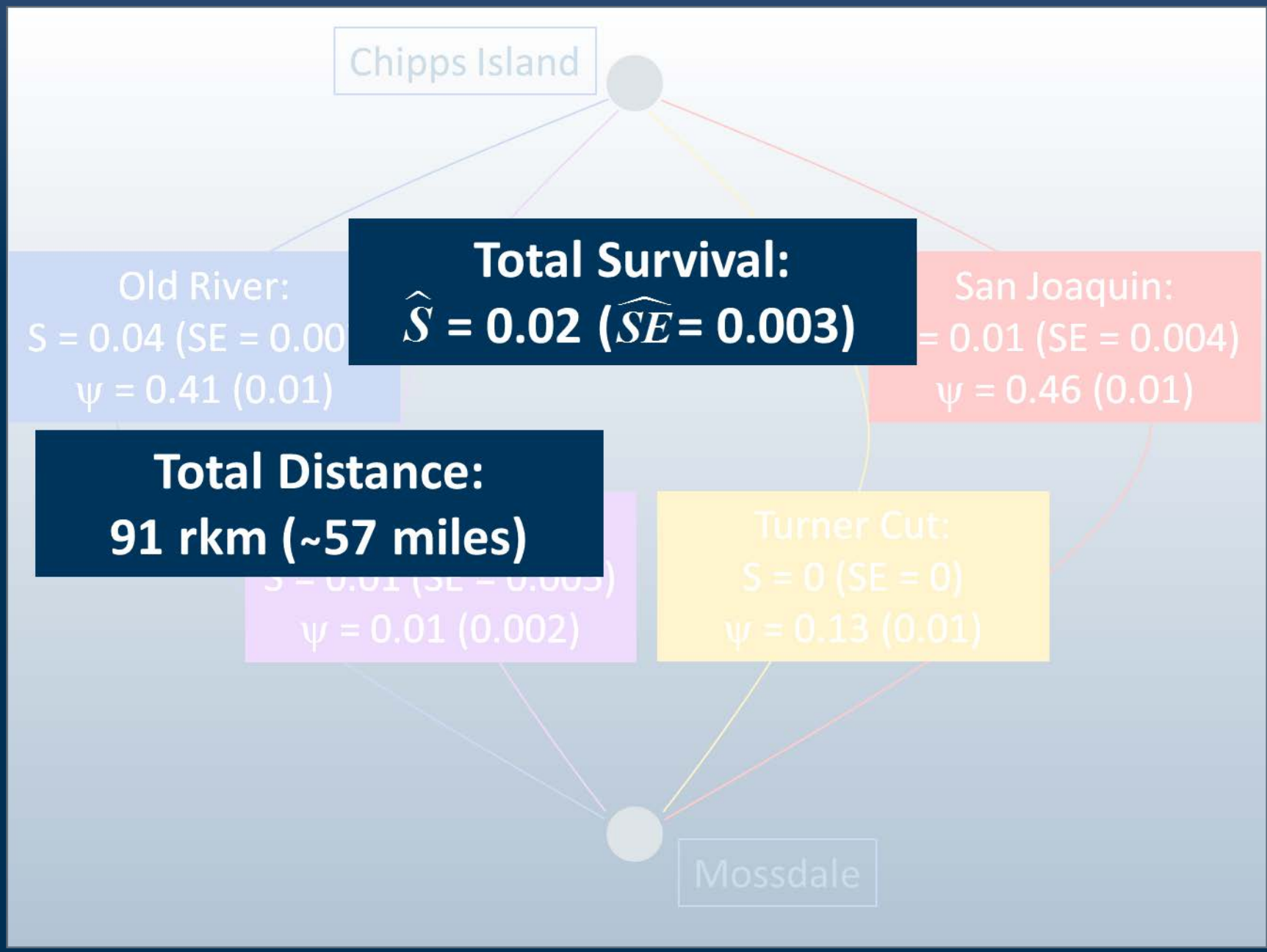
- Predator filter based on
  - Behavior differences between salmon smolts and predatory fish
  - Hydrological conditions

RESULTS: SURVIVAL AND ROUTE USE

REGION: ENTIRE DELTA


Chipps Island
Old River:
$\widehat{S}$ = 0.04 ($\widehat{SE}$ = 0.007)
$\widehat{\psi}$ = 0.41 (0.01)
San Joaquin:
$\widehat{S}$ = 0.01 ($\widehat{SE}$ = 0.004)
$\widehat{\psi}$ = 0.46 (0.01)
Middle River:
$\widehat{S}$ = 0.01 ($\widehat{SE}$ = 0.005)
$\widehat{\psi}$ = 0.01 (0.002)
Turner Cut:
$\widehat{S}$ = 0 ($\widehat{SE}$ = 0)
$\widehat{\psi}$ = 0.13 (0.01)
Mossdale


Chipps Island
Total Survival:
$\widehat{S}$ = 0.02 ($\widehat{SE}$ = 0.003)
Old River:
S = 0.04 (SE = 0.00
ψ = 0.41 (0.01)
San Joaquin:
= 0.01 (SE = 0.004)
ψ = 0.46 (0.01)
Middle River:
S = 0.01 (SE = 0.005)
ψ = 0.01 (0.002)
Turner Cut:
S = 0 (SE = 0)
ψ = 0.13 (0.01)
Mossdale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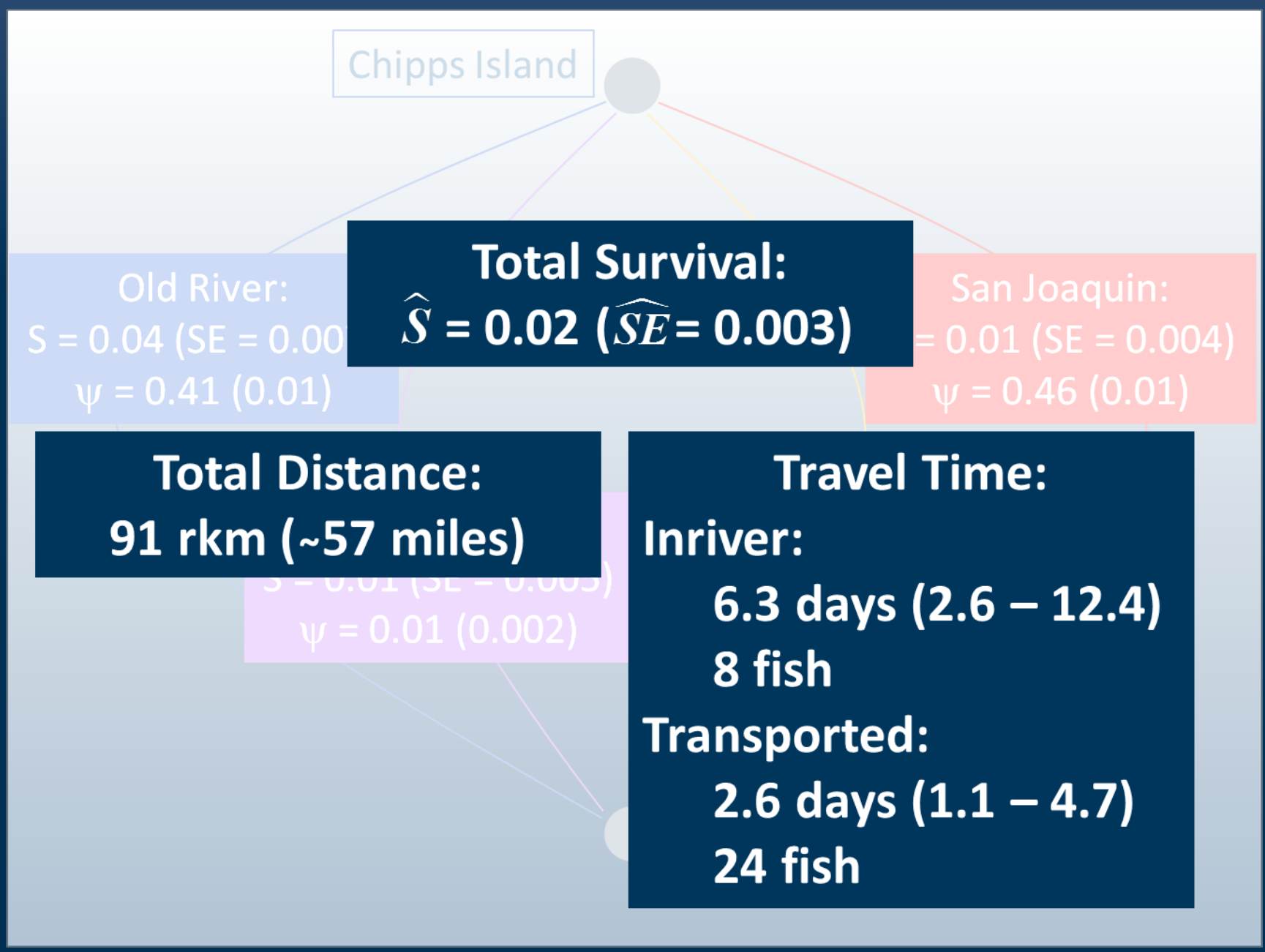
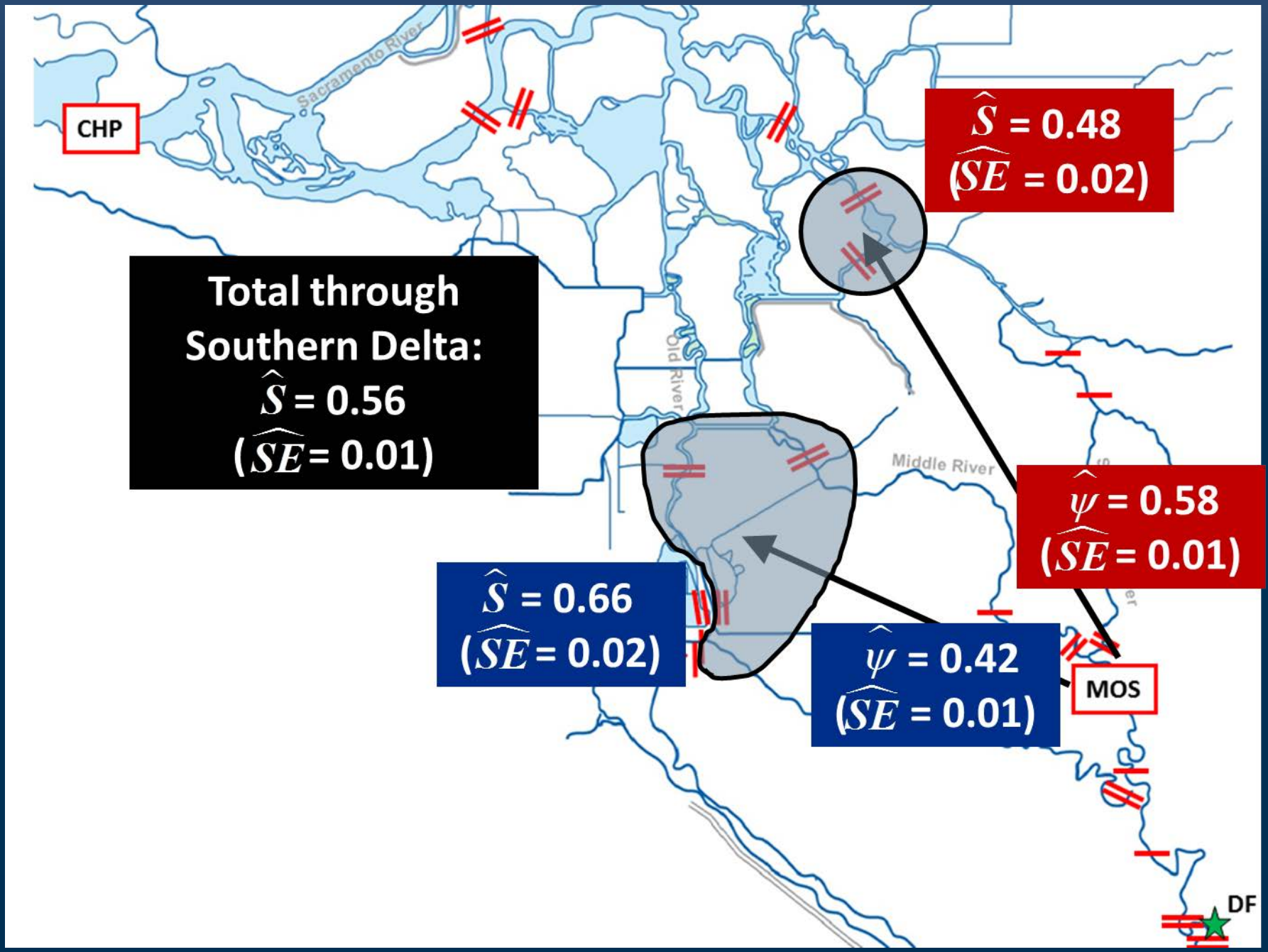
San Joaquin:
= 0.01 (SE = 0.004)
ψ = 0.46 (0.01)
Total Distance:
91 rkm (~57 miles)
ψ = 0.01 (0.002)
Turner Cut:
S = 0 (SE = 0)
ψ = 0.13 (0.01)
Mossdale

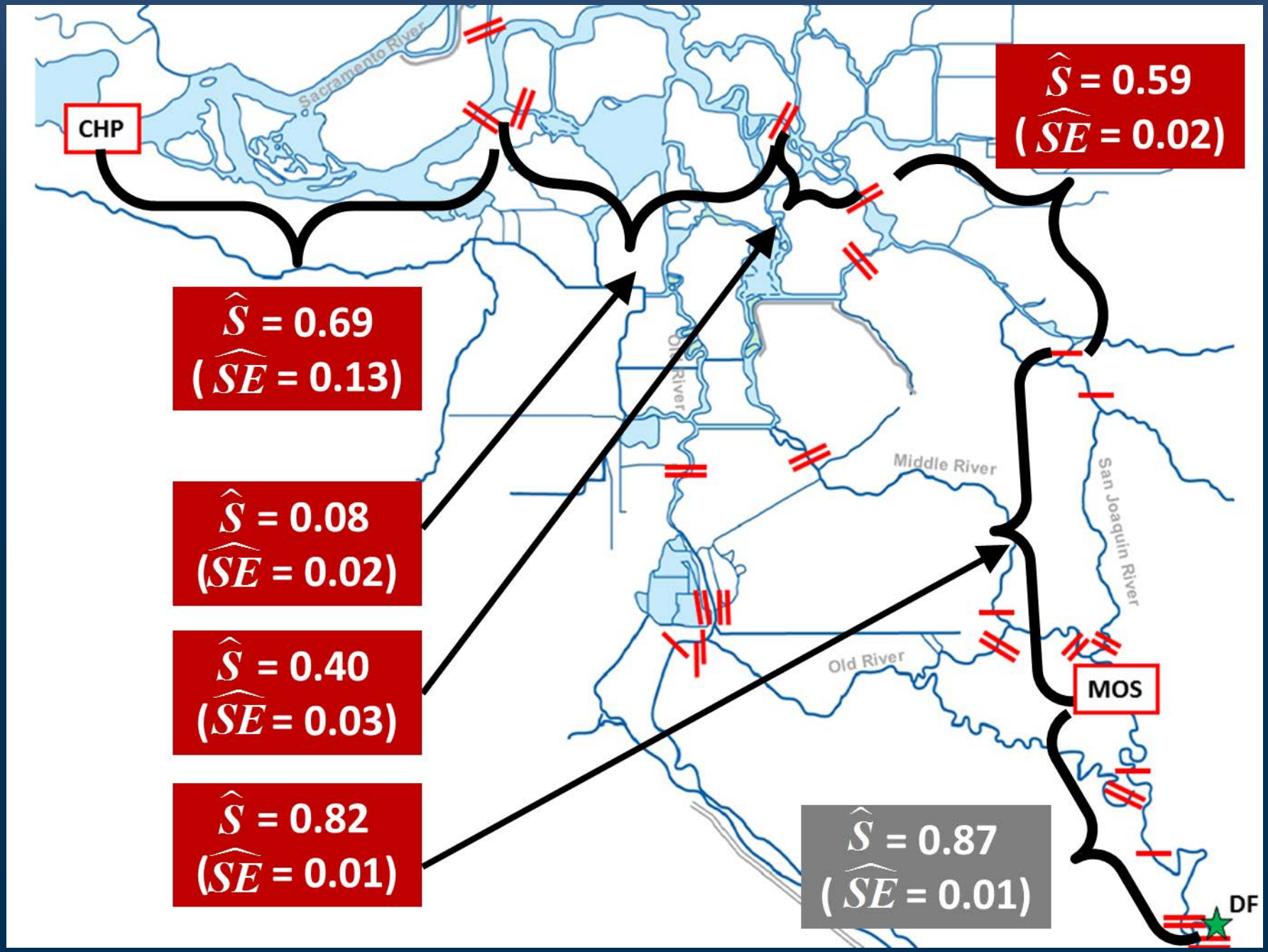

Chipps Island
Old River:
S = 0.04 (SE = 0.00
ψ = 0.41 (0.01)
Total Survival:
$\widehat{S}$ = 0.02 ($\widehat{SE}$ = 0.003)
San Joaquin:
= 0.01 (SE = 0.004)
ψ = 0.46 (0.01)
Total Distance:
91 rkm (~57 miles)
ψ = 0.01 (0.002)
Travel Time:
Inriver:
6.3 days (2.6 – 12.4)
8 fish
Transported:
2.6 days (1.1 – 4.7)
24 fish

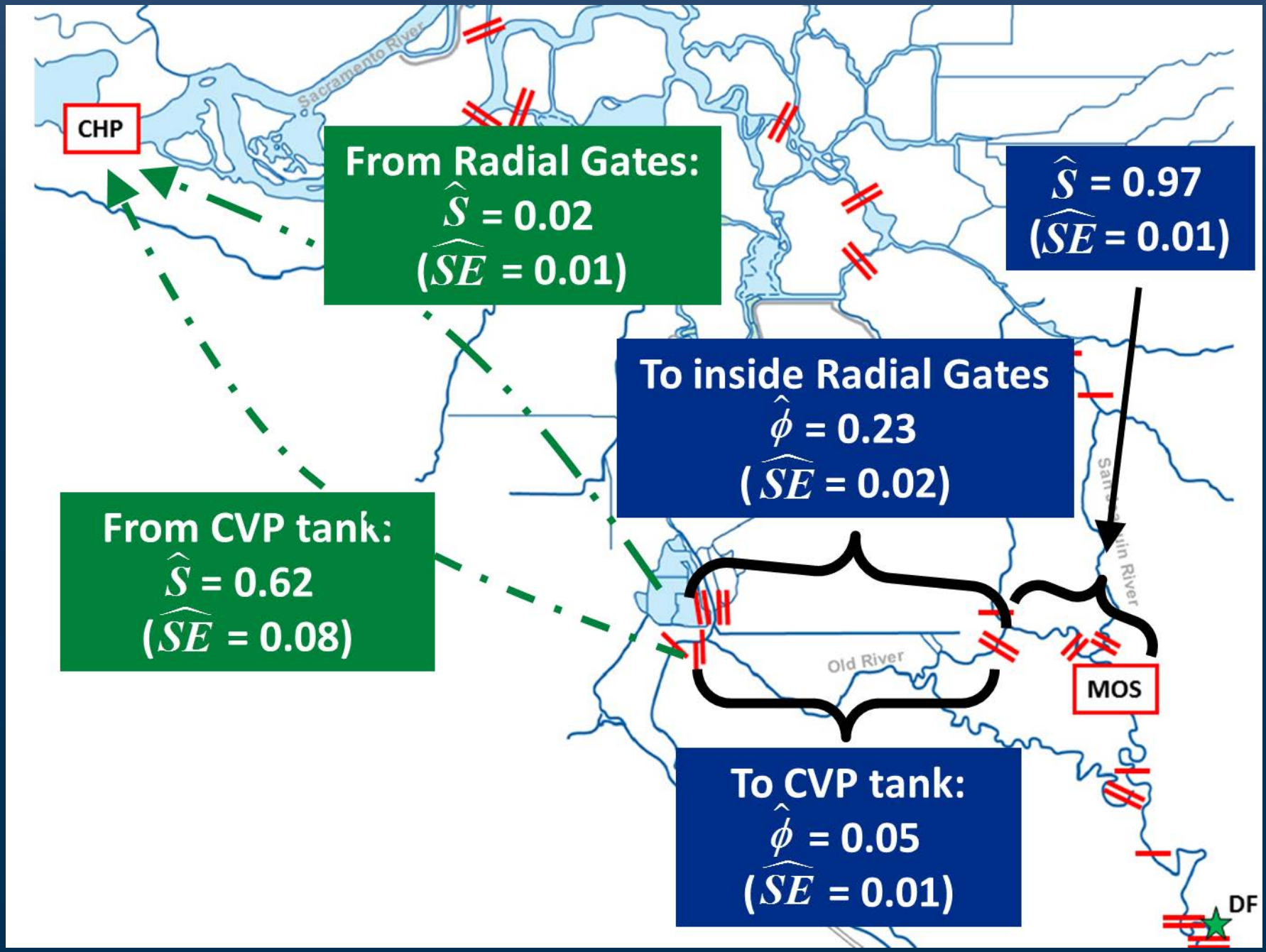
RESULTS: SURVIVAL AND ROUTE USE

REGION: SOUTHERN DELTA


CHP
Sacramento River
Old River
Middle River
MOS
DF
Total through Southern Delta:
$\widehat{S}$ = 0.56
($\widehat{SE}$ = 0.01)
$\widehat{S}$ = 0.48
($\widehat{SE}$ = 0.02)
$\widehat{\psi}$ = 0.58
($\widehat{SE}$ = 0.01)
$\widehat{S}$ = 0.66
($\widehat{SE}$ = 0.02)
$\widehat{\psi}$ = 0.42
($\widehat{SE}$ = 0.01)

REACH SURVIVAL ESTIMATES


CHP
$\widehat{S}$ = 0.59
($\widehat{SE}$ = 0.02)
$\widehat{S}$ = 0.69
($\widehat{SE}$ = 0.13)
$\widehat{S}$ = 0.08
($\widehat{SE}$ = 0.02)
$\widehat{S}$ = 0.40
($\widehat{SE}$ = 0.03)
$\widehat{S}$ = 0.82
($\widehat{SE}$ = 0.01)
$\widehat{S}$ = 0.87
($\widehat{SE}$ = 0.01)
Sacramento River
Middle River
San Joaquin River
Old River
MOS
DF


CHP
Sacramento River
From Radial Gates:
$\hat{S}$ = 0.02
($\widehat{SE}$ = 0.01)
$\hat{S}$ = 0.97
($\widehat{SE}$ = 0.01)
To inside Radial Gates
$\hat{\phi}$ = 0.23
($\widehat{SE}$ = 0.02)
From CVP tank:
$\hat{S}$ = 0.62
($\widehat{SE}$ = 0.08)
Old River
MOS
To CVP tank:
$\hat{\phi}$ = 0.05
($\widehat{SE}$ = 0.01)
DF

CONCLUSIONS: SURVIVAL IN DELTA

- Very low survival through the Delta: 2% in 2011
- Mortality hot spots …
  - Medford Island to Jersey Point (San Joaquin and Frank's Tract)
  - Central Valley Project (getting to holding tank)
  - Clifton Court Forebay (getting from radial gates to CHP via SWP tank)
- … but fixing hot spots may be insufficient
- Old River route had the highest survival through the Delta
- 64% of survivors to Chipps Island went via Central Valley Project holding tank and transport

COMPARE AMONG RELEASE GROUPS

Release Group	No. Fish	Release Dates (2011)	Fish Length (mean; mm)	Fish Weight (mean; g)
1*	475	May 17 – 21	106.0	14.4
2*	473	May 22 – 26	108.2	15.2
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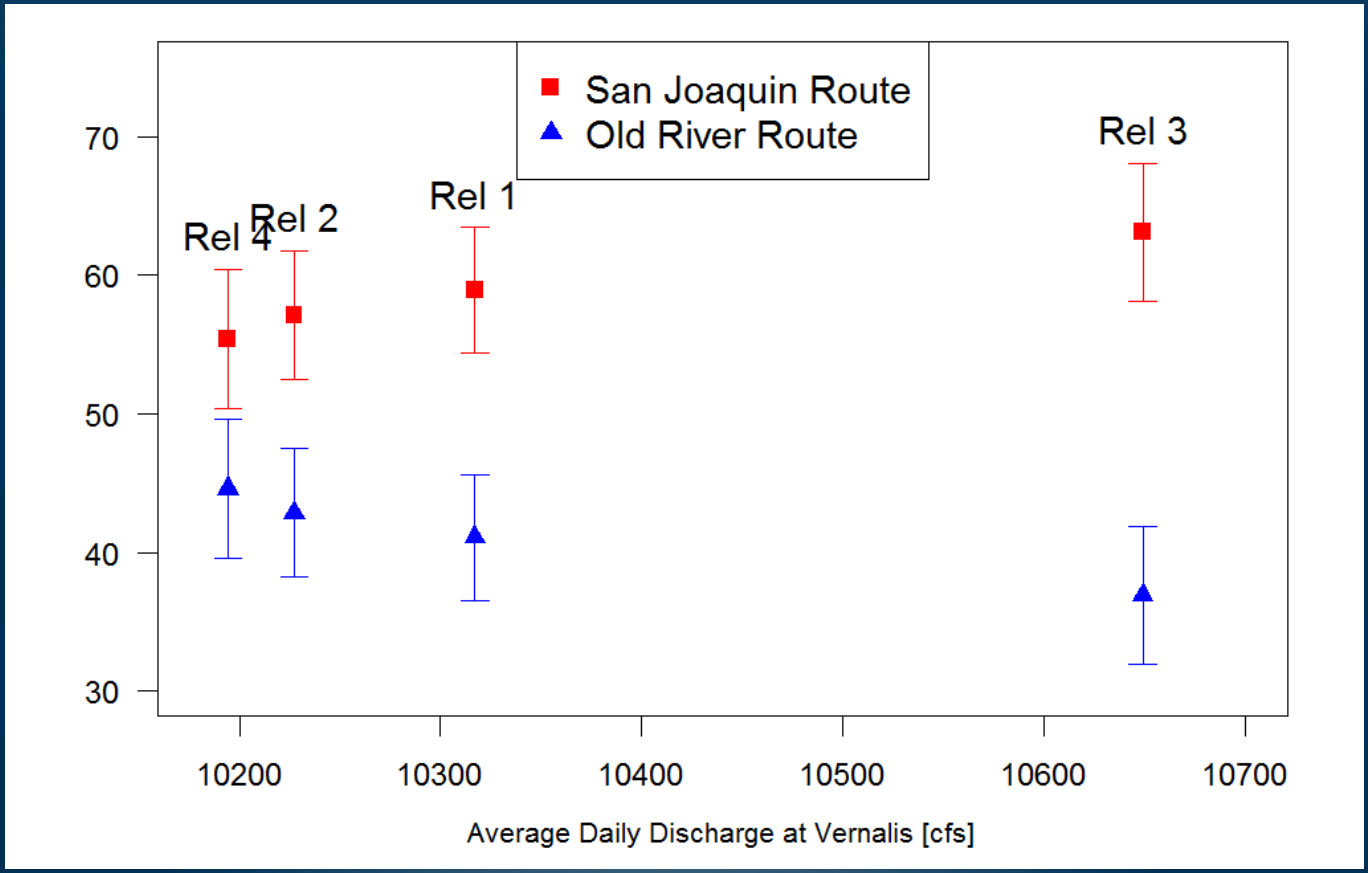
Total	1,895	May 17 – June 19	110.8	16.5

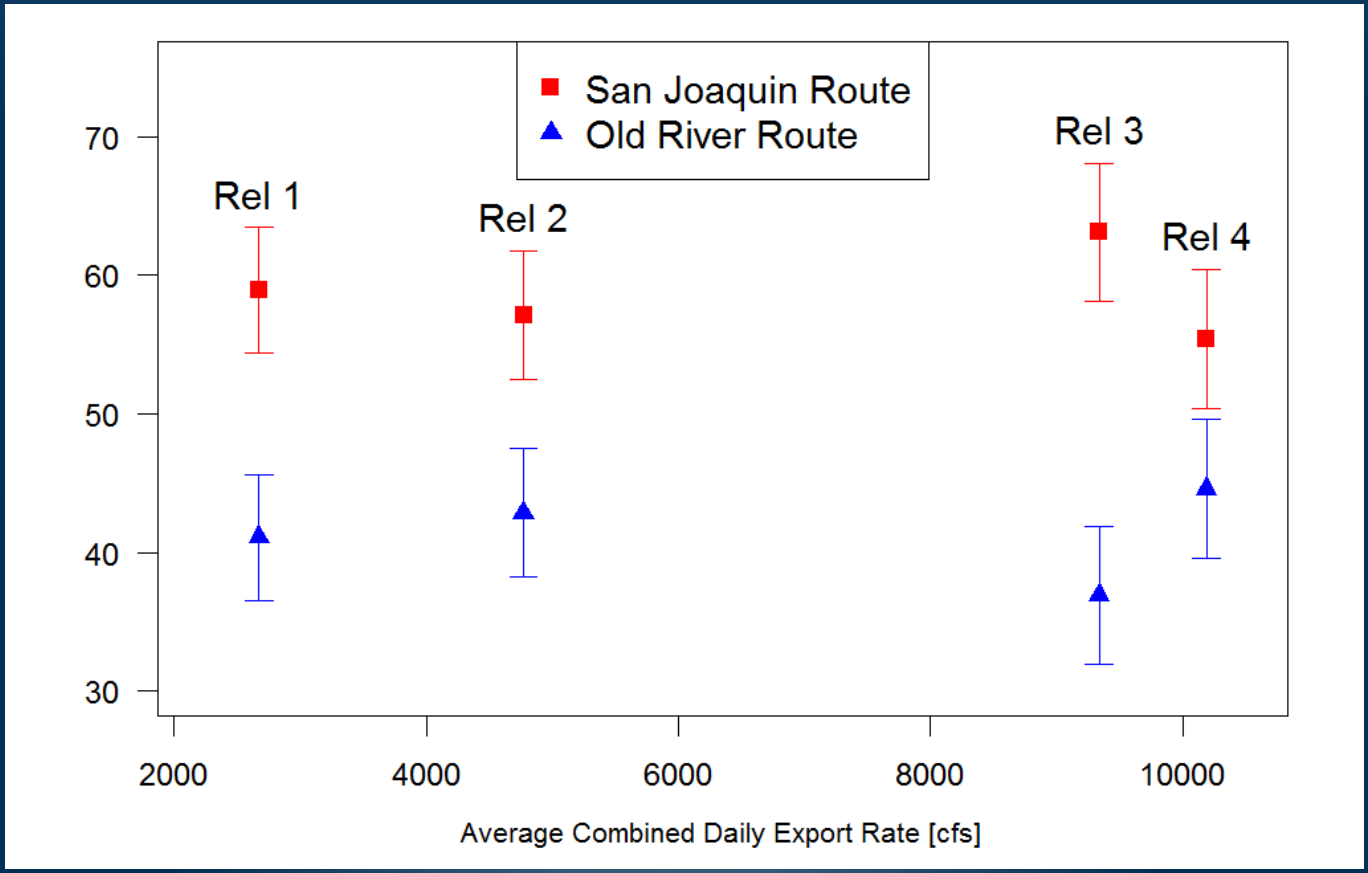
* = during VAMP period (May 1 – 31, 2011)

COMPARE AMONG RELEASE GROUPS

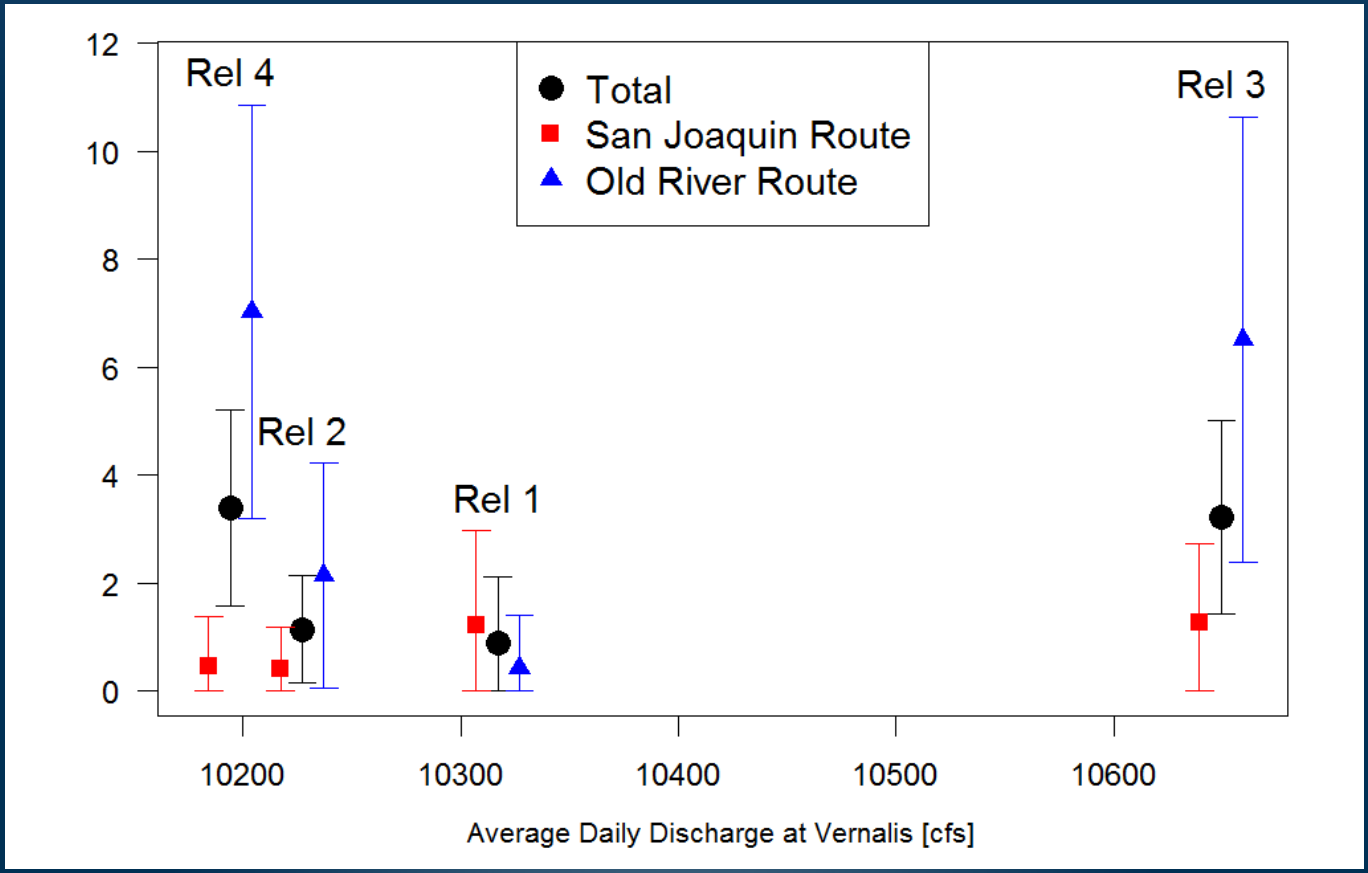
ROUTE ENTRAINMENT (%) VS FLOW: 2011



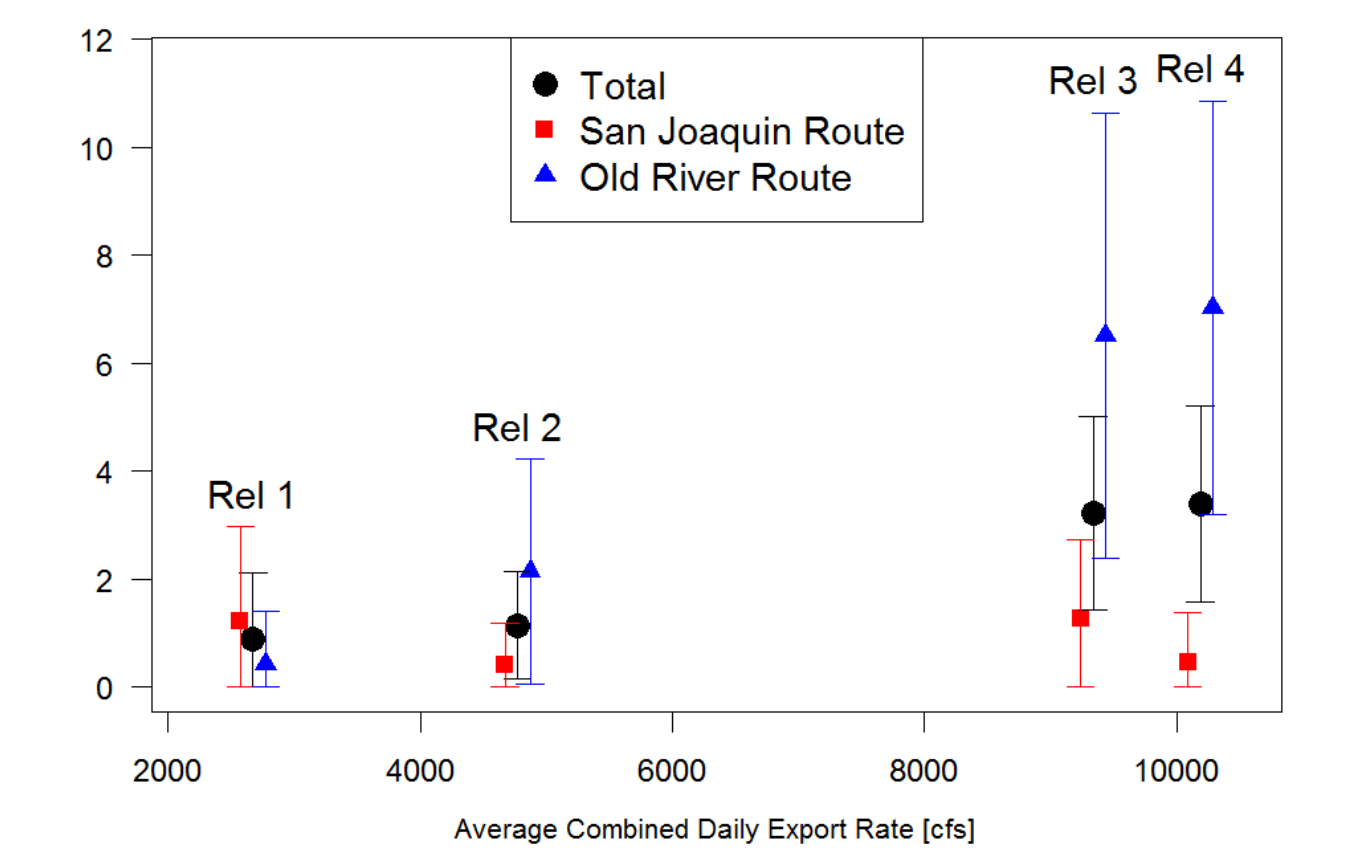
ROUTE ENTRAINMENT (%) VS EXPORTS: 2011



DELTA SURVIVAL VS FLOW: 2011



DELTA SURVIVAL VS EXPORTS: 2011



CONCLUSIONS: WITHIN-YEAR COMPARISONS (2011)

- Route Entrainment at Head of Old River
  - Higher flow ← → more fish stay in San Joaquin
  - No apparent relationship with exports
- Delta Survival
  - Higher survival during period of higher exports
    - Confounded with seasonal effect
    - Driven by survival in Old River route (transport from CVP)
  - No apparent relationship with flow

COMPARE WITH PAST YEARS (VAMP)

COMPARISON WITH PREVIOUS YEARS (VAMP)

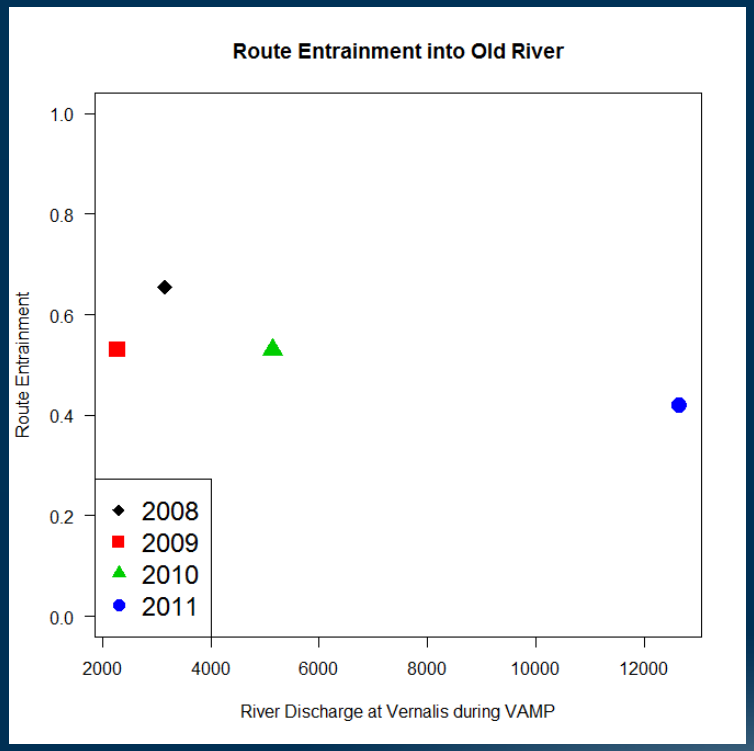
Year	Entrainment into Old River (SE)	Survival through Southern Delta (SE)	Route-Specific Survival to Chipps: San Joaquin	Route-Specific Survival to Chipps: Old River	Total Survival through Delta (SE)
2008*	0.66 (0.03)	NA	0.08 (0.01)	0.06 (0.01)	0.06 (0.01)
2009	0.53 (0.03)	0.06 (0.01)	NA	NA	NA
2010	0.53 (0.02)	0.56 (0.03)	0.04 (0.01)	0.07 (0.01)	0.05 (0.01)
2011**	0.42 (0.01)	0.58 (0.02)	0.008 (0.005)	0.01 (0.006)	0.01 (0.004)

* = minimum estimates of survival due to high tag failure

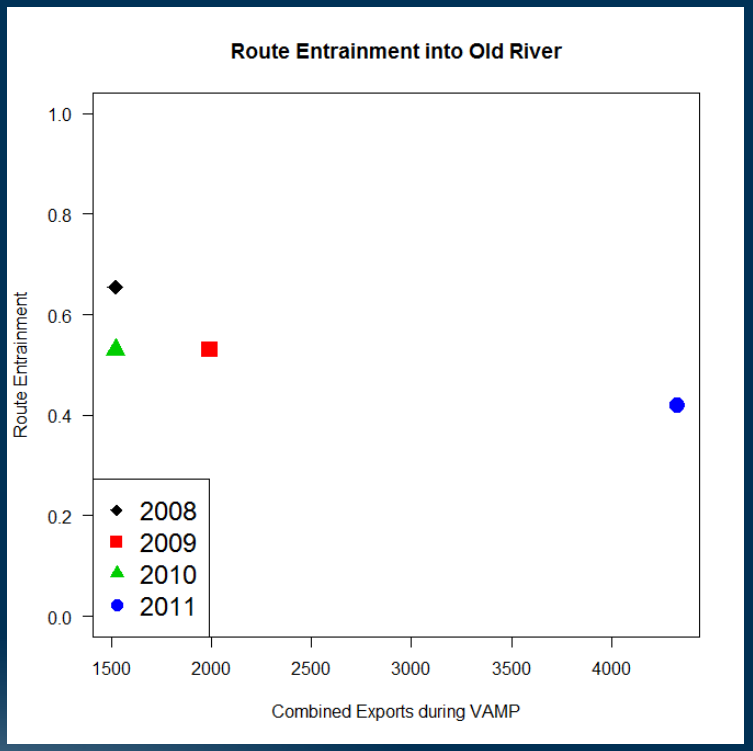
** = release groups during VAMP (first 2 groups)

ROUTE ENTRAINMENT INTO OLD RIVER

vs River Flow at Vernalis

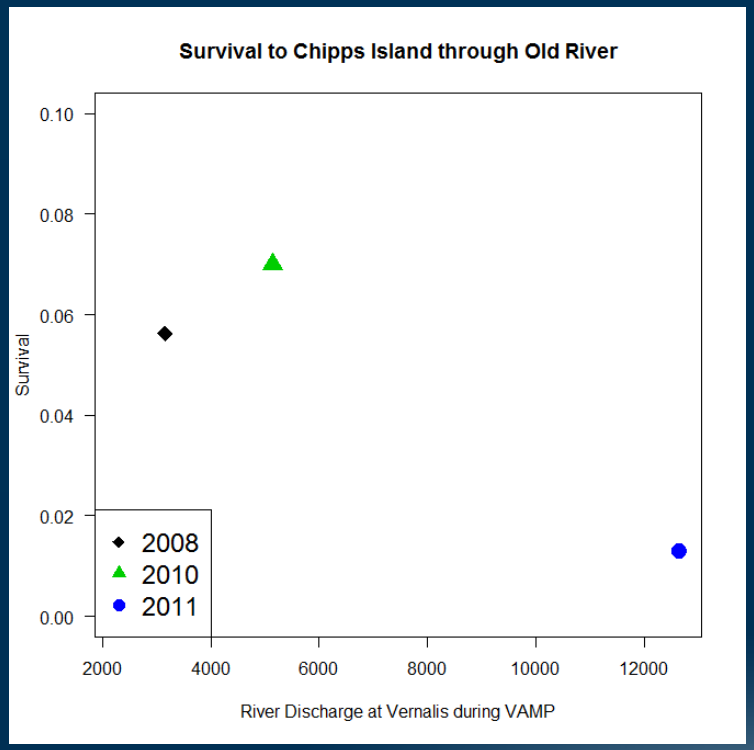


vs Combined Exports

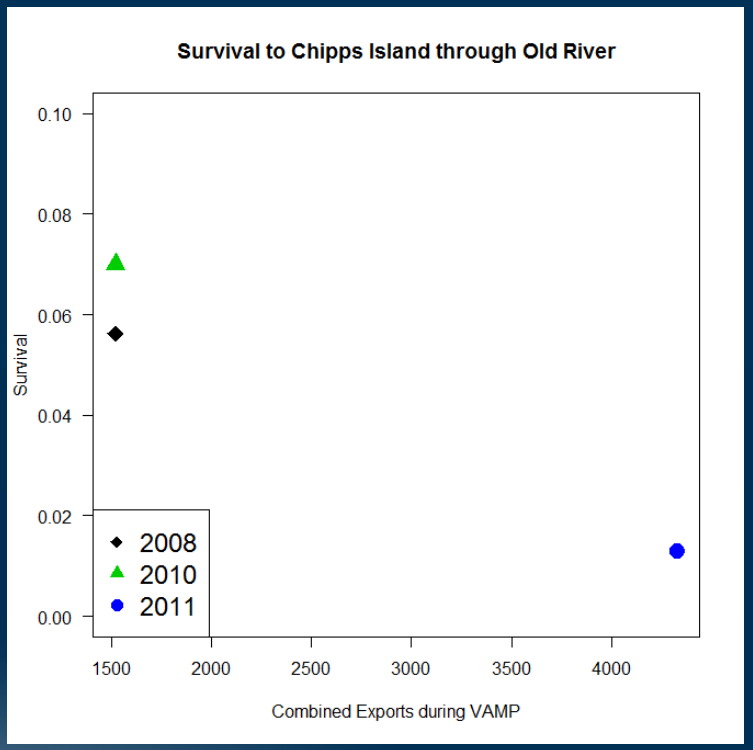


ROUTE-SPECIFIC SURVIVAL THROUGH DELTA: OLD RIVER ROUTE

vs River Flow at Vernalis

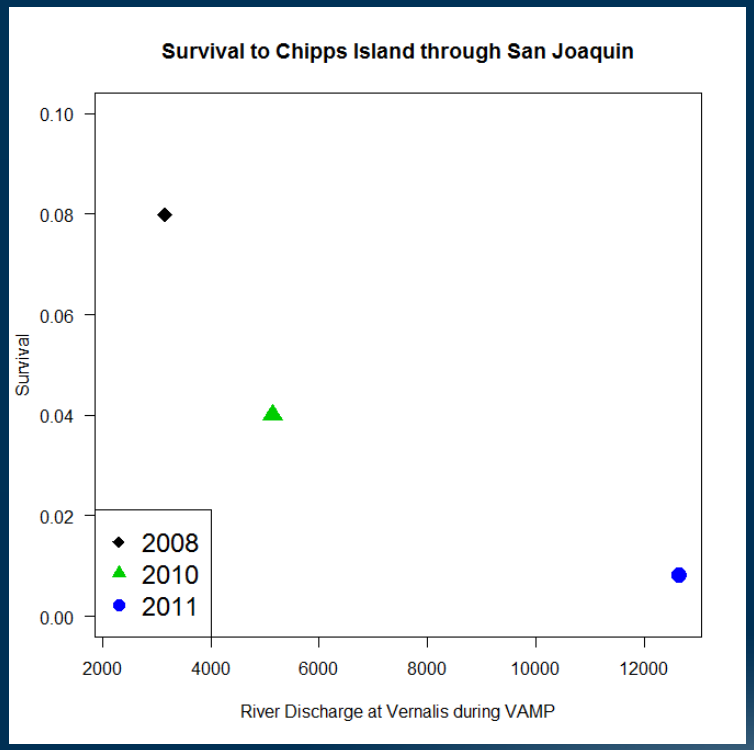


vs Combined Exports

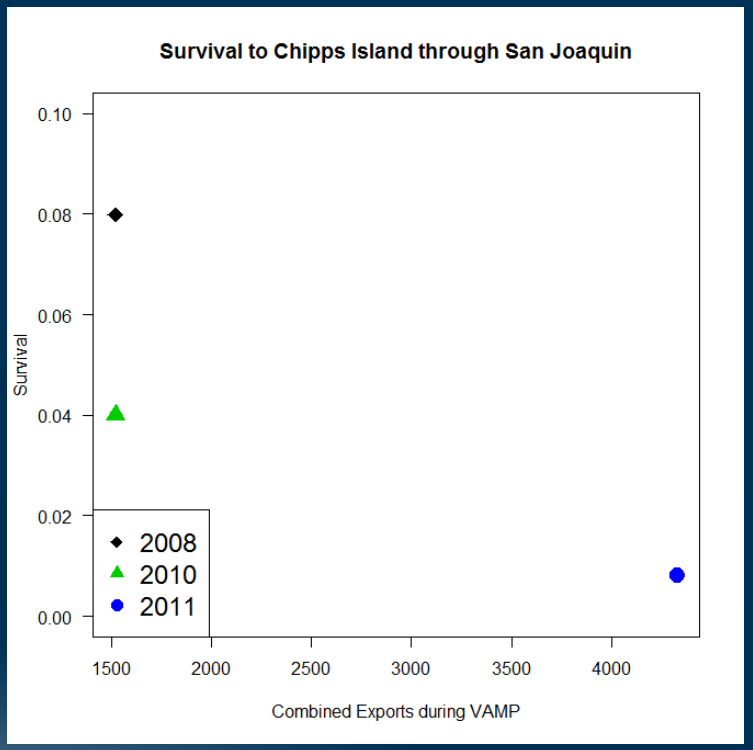


ROUTE-SPECIFIC SURVIVAL THROUGH DELTA: SAN JOAQUIN ROUTE

vs River Flow at Vernalis

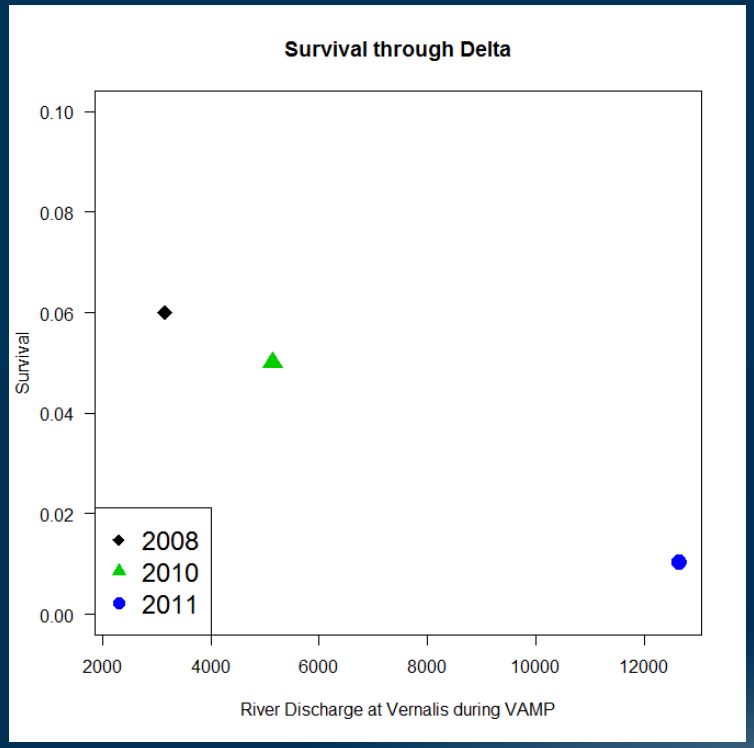


vs Combined Exports

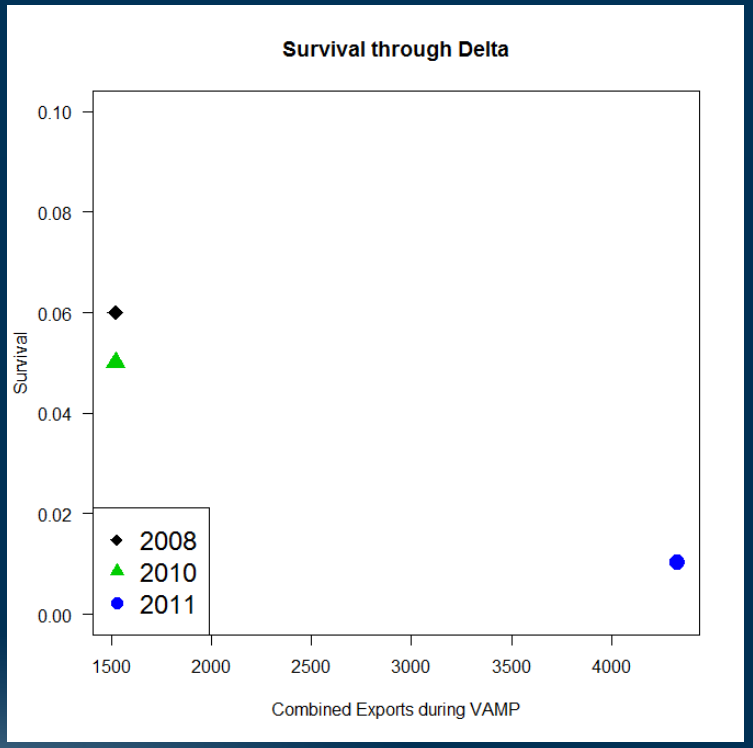


TOTAL SURVIVAL THROUGH DELTA

vs River Flow at Vernalis



vs Combined Exports



CONCLUSIONS: COMPARISONS OVER YEARS

- Route Entrainment into Old River
  - No strong relationship with either flow or exports

- Delta Survival
  - Higher flow ← → lower survival in San Joaquin route and overall
    - But only 3 data points
    - Contradicts CWT studies
  - Exports: Too little across-year variation to detect effect

CONCLUSIONS: OVERALL

- Very low survival in 2011: 2%
  - Low in both routes
  - Lower in San Joaquin Route than in Old River Route
  - Pattern not consistent throughout season
- Within 2011
  - Route entrainment into Old River: negatively correlated with flow at Vernalis
  - Survival through Delta: positively correlated with exports
- Across years
  - Inconsistent patterns
  - 2008 – 2011: Survival through Delta was negatively correlated with flow at Vernalis (3 data points)

- **Recommendation**: Broaden our pool of possible management approaches for consideration

THANKS

- San Joaquin River Group Authority and DWR: funding of analysis
- NMFS: travel
- Signatories to the San Joaquin River Agreement: funding of 2011 tagging study, with
  - California Department of Water Resources
  - U.S. Bureau of Reclamation
- 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 – University of Washington