BUREAU OF RECLAMATION

# Sensitivity Analysis of Old and Middle River Flows on Particle Fates

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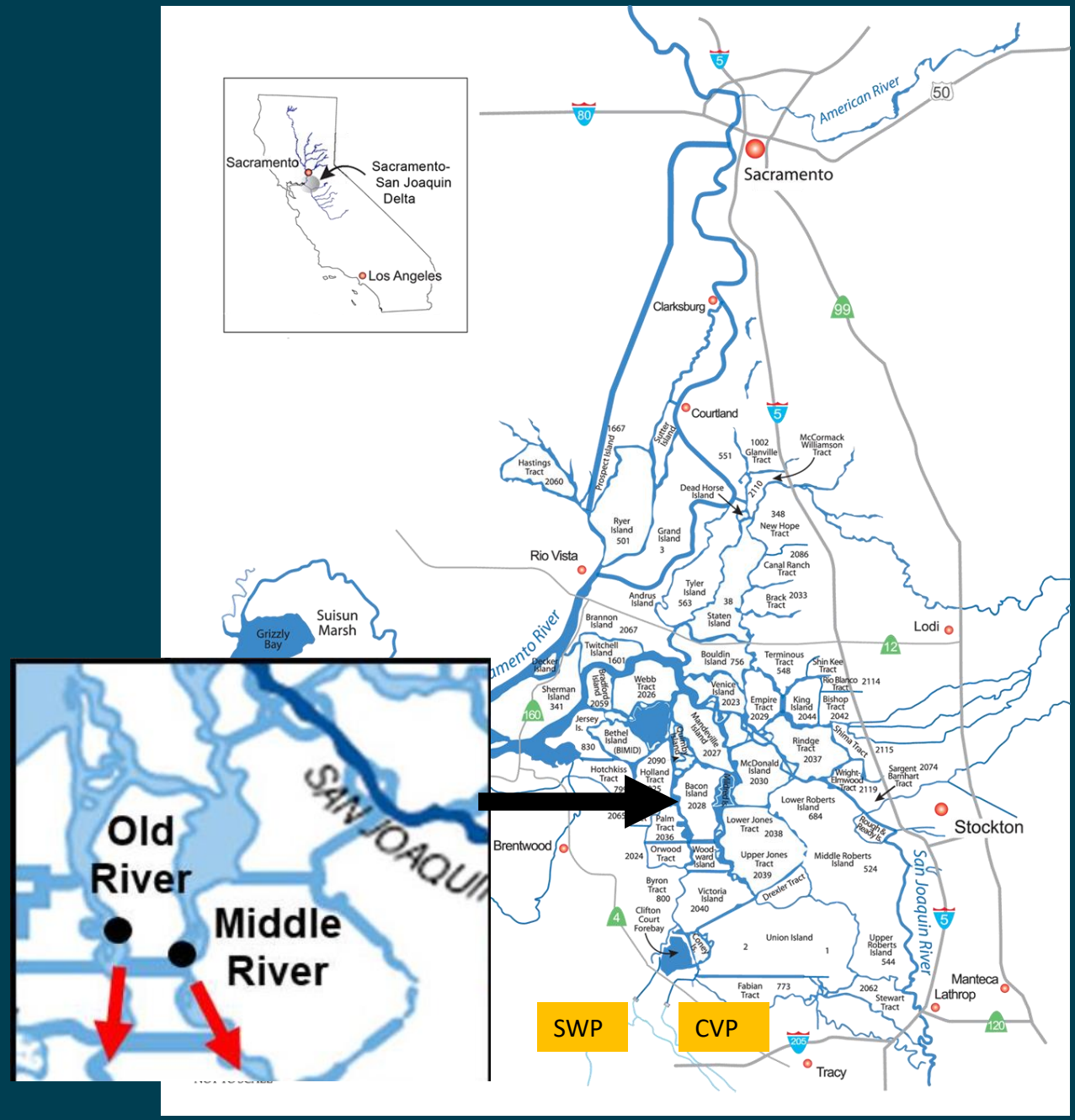
# Introduction

- **Water flow in the Delta is directly influenced by the Jones and Banks Pumping Plants**
- **Water from the Delta is exported southward through the Jones and Banks Pumping Plants (SWP and CVP).**
- **Pumping is managed to minimize the impact on protected fish species during the fish migration season (Dec to Jun)**
- **Combined flow in the Old and Middle Rivers (OMR flow) is a measure of water export influence.**

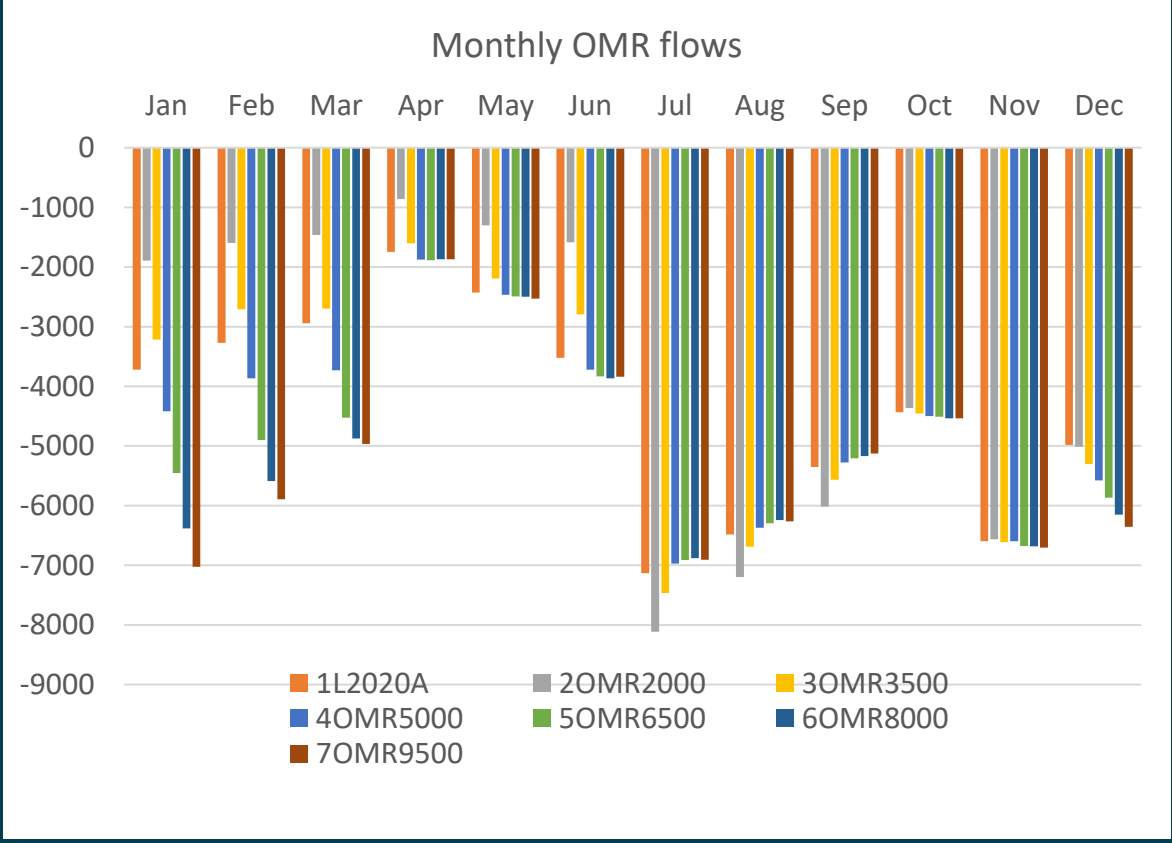


# Introduction – OMR Limits

- **L2020A: dynamic OMR flow limit that varies by month, water year type, and specific flow triggers**
- **OMR2000: limit of -2,000 cfs , most positive flow**
- **OMR3500: limit of -3,500 cfs**
- **OMR5000: limit of -5,000 cfs**
- **OMR6500: limit of -6,500 cfs, most negative flow**
- **OMR8000: limit of -8,000 cfs, used to assess the point at which the OMR flow limit becomes ineffective**
- **OMR9500: limit of -9,500 cfs**

- **Biological Assessment (BA) Alternative 2v1 (Alt 2v1) without a Temporary Urgency Change Petition (TUCP)**

# Introduction – OMR Limits



# Approach

- Conduct Calsim III simulations under OMR limits on Delta operations (100 years of planning simulation)
- Run DSM2 HYDRO, PTM, and ECO-PTM models
- Evaluate fate based on month, Sacramento River and San Joaquin River flow bin,  and particle insertion location

**Sacramento River Flow Bin**

| Bin | Min Flow (cfs) | Max Flow (cfs) |
|---|---|---|
| lo | 0 | 13416 |
| med | 13416 | 24726 |
| hi | 24726 | N/A |

**San Joaquin River Flow Bin**

| Bin | Min Flow (cfs) | Max Flow (cfs) |
|---|---|---|
| lo | 0 | 1984 |
| med | 1984 | 4097 |
| hi | 4097 | N/A |

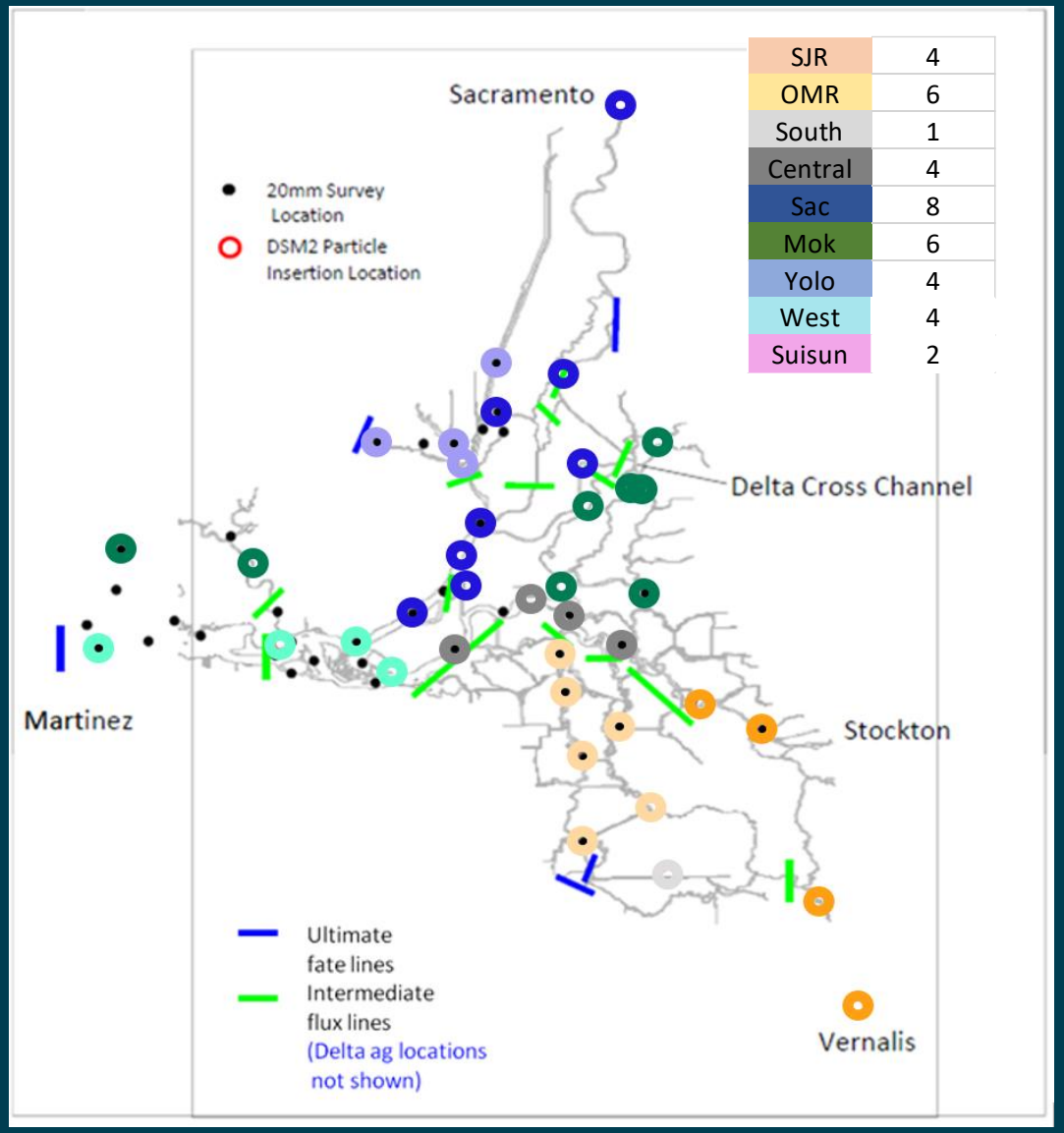
# Approach

- **PTM**
  - **Naturally-buoyant Particles (NP): flowing in the whole water column (larval Delta Smelt)**
  - **Position-oriented Particles (PP) : flowing near the water surface (larval Longfin Smelt)**

- **ECO-PTM**
  - **Salmon Particles (SP) : fish like behavior**

# PTM Particle Insertion Locations

- 39 insertion locations
- 9 regions color-coded
- December through June period
- Insertion started on the 1st of the month
- 4000 particles evenly injected over a 24.75-hour period
- Fate of particles at the end of 45 days after insertion is computed

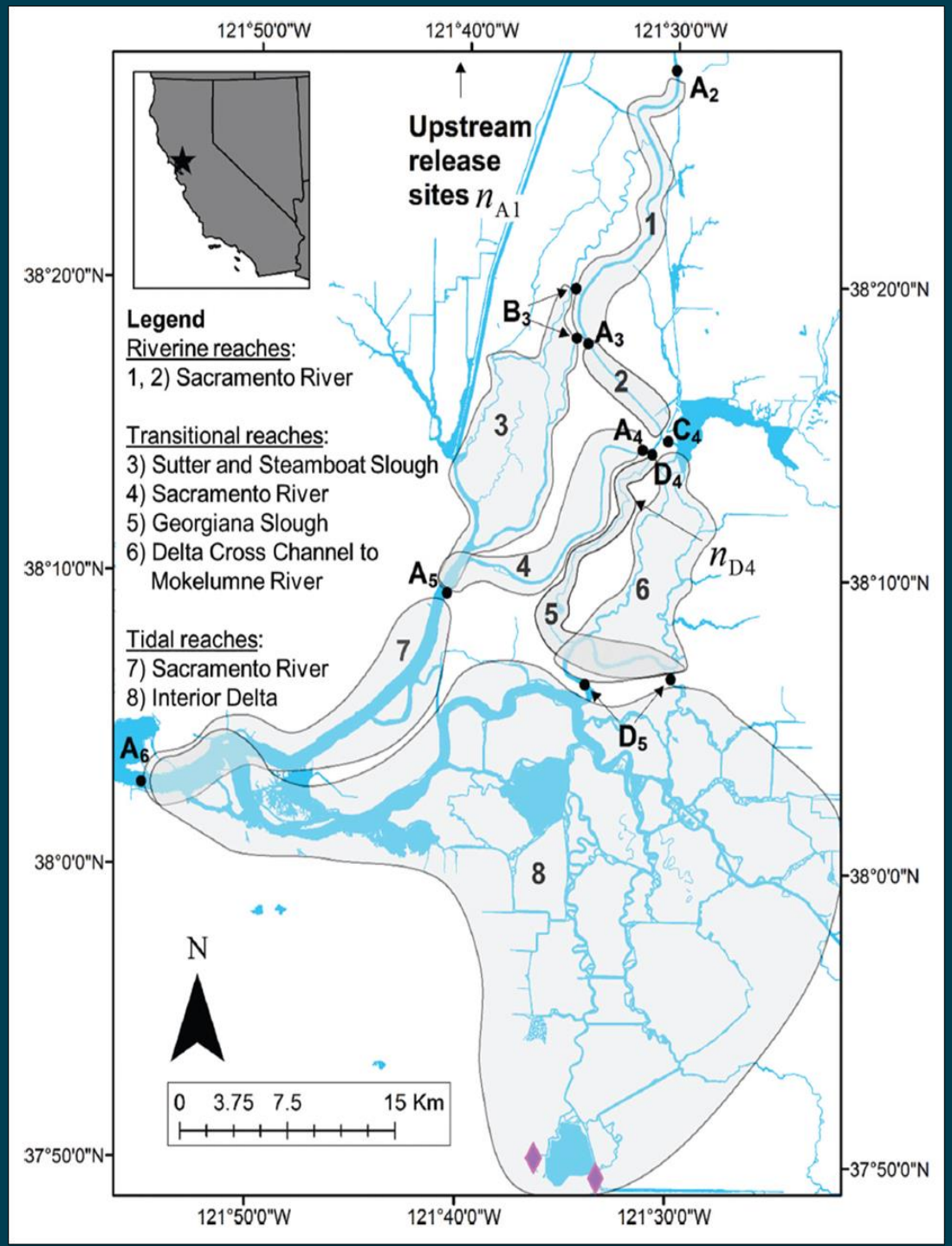


# PTM Particle Fates Examined at

- **West of Chipps:** Particles that pass Chipps Island
- **South Delta Entrainment:** Particle entrained into SWP and CVP pumping plants.
- **Remaining in Delta:** Particles that remain within the system after 45 days.
- **Crossed SJR to S Delta:** Particles cross San Joaquin River into the south Delta

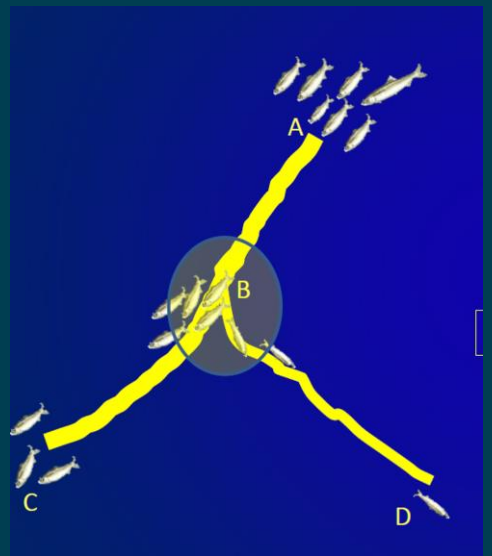
# ECO-PTM Reaches

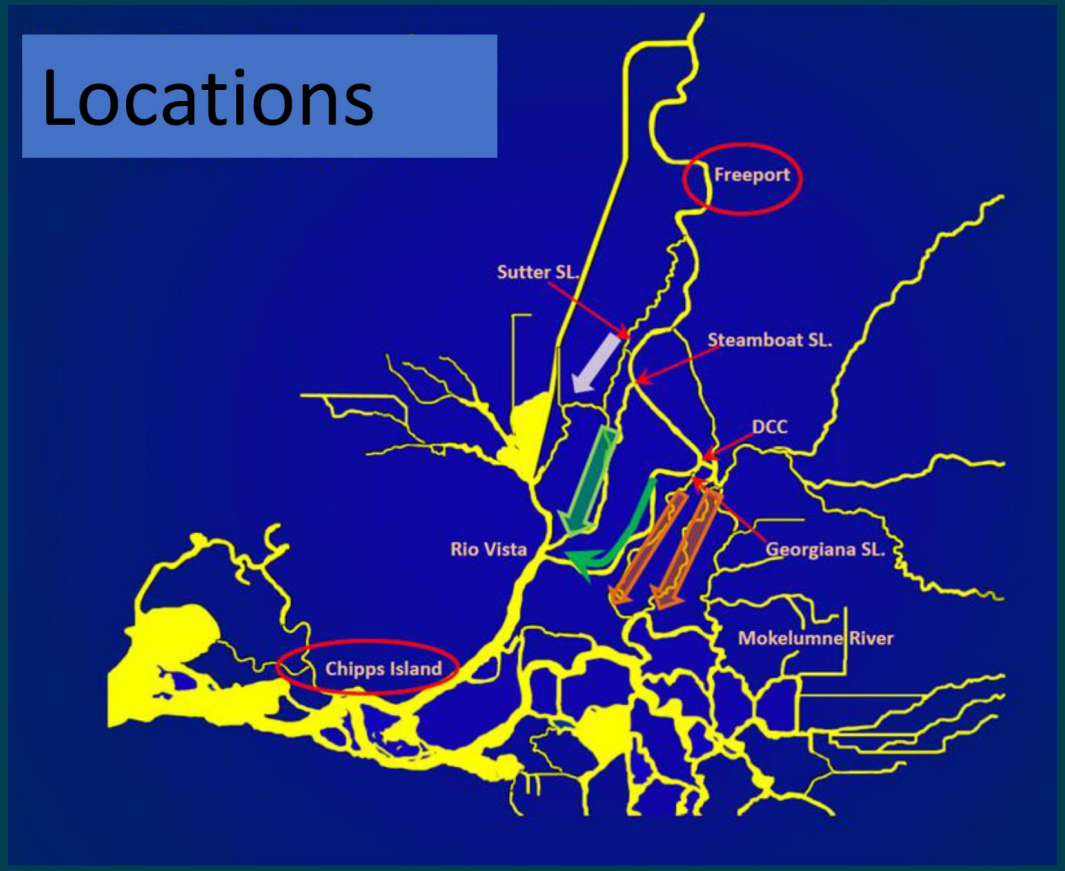
- 396 Simulations: Beginning of each month from December to March in the period from Dec 1922 to Mar 2021
- Insertion location: Sacramento River near Freeport
- 9600 Particles: 100 particles are released every 15 mins in 24 hours



# ECO-PTM Reaches

- Survival Rate
- Routing Ratio
- Travel Time



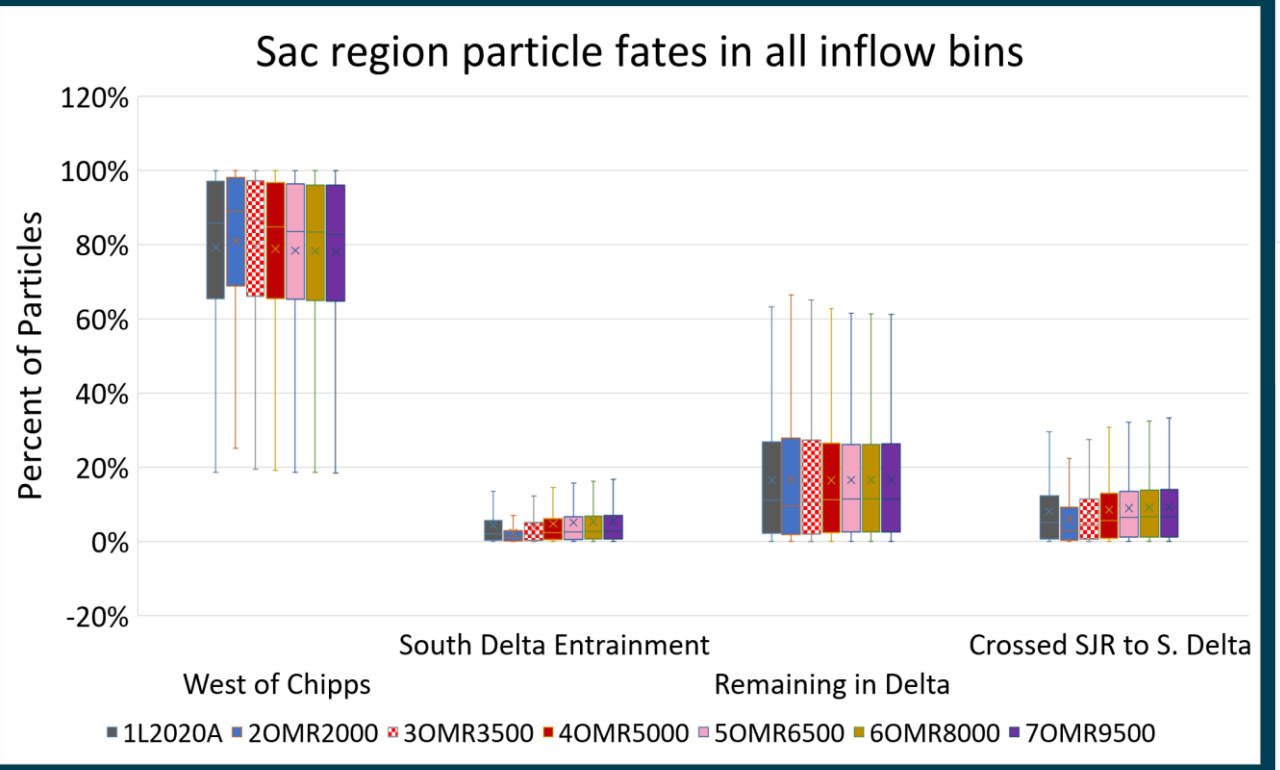



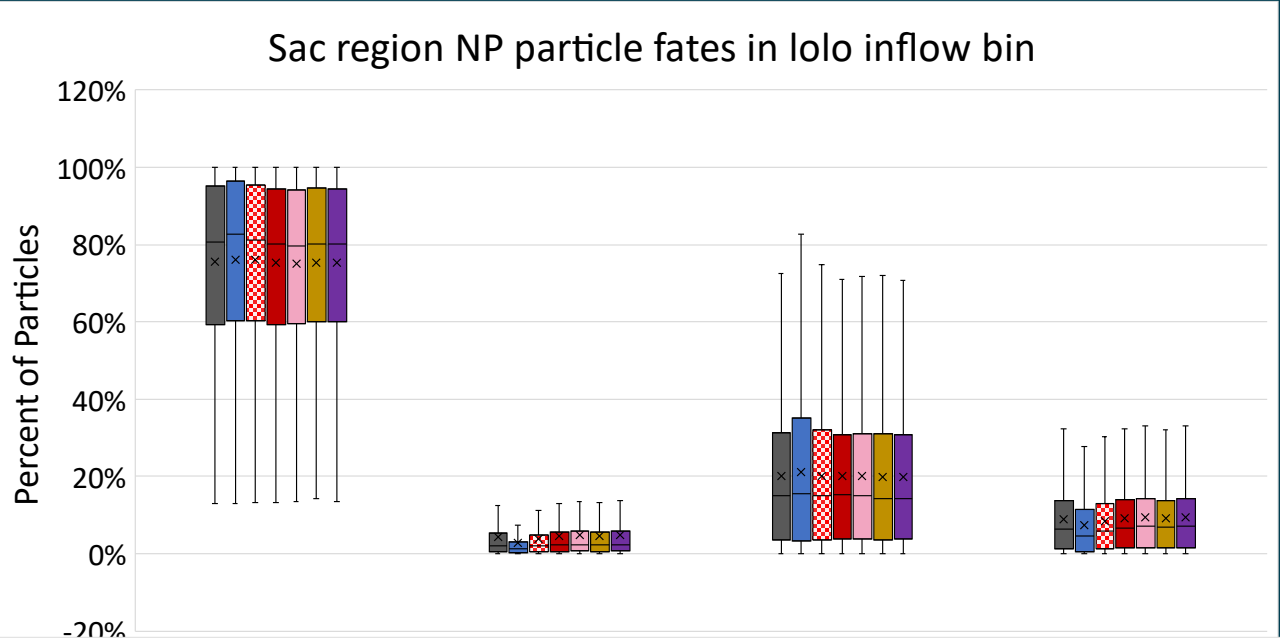

Source: ECO-PTM Application:Assess Effectiveness of Fish Barriers (Wang 2020)

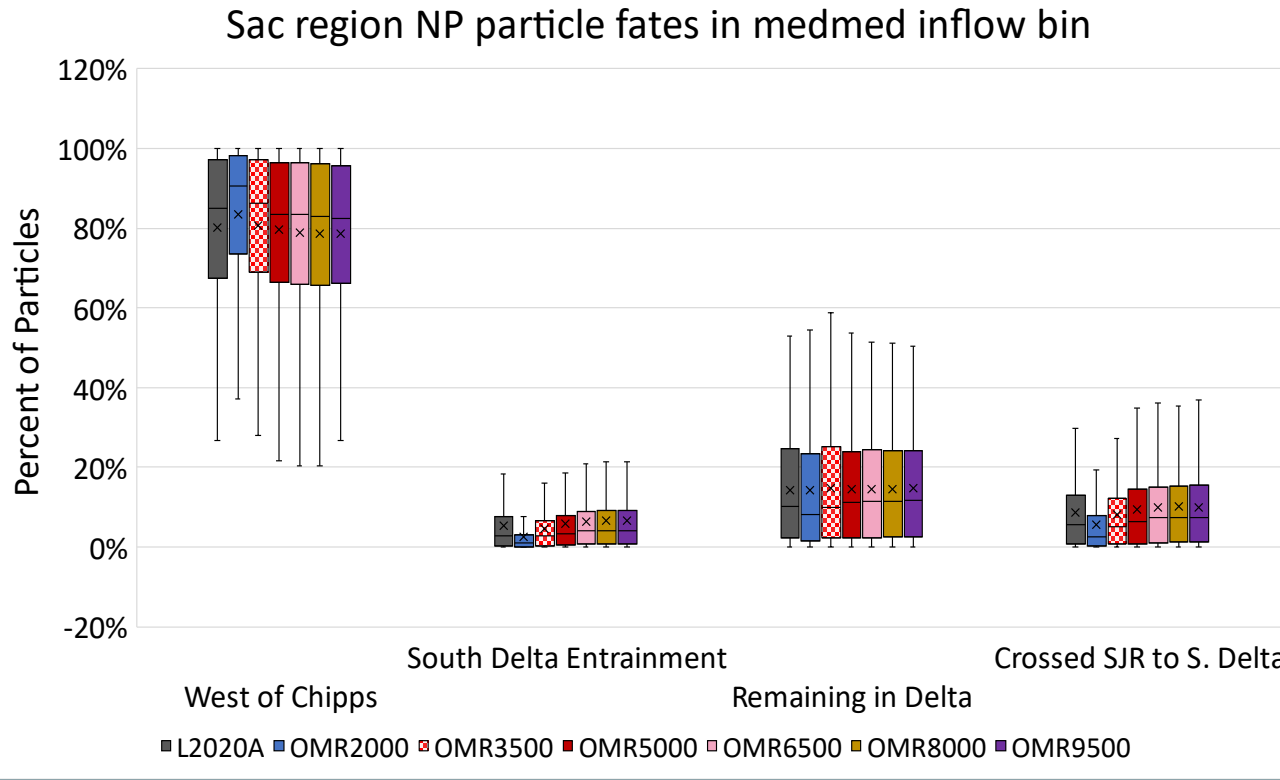
Limitation: not calibrated in the south delta

# Results:

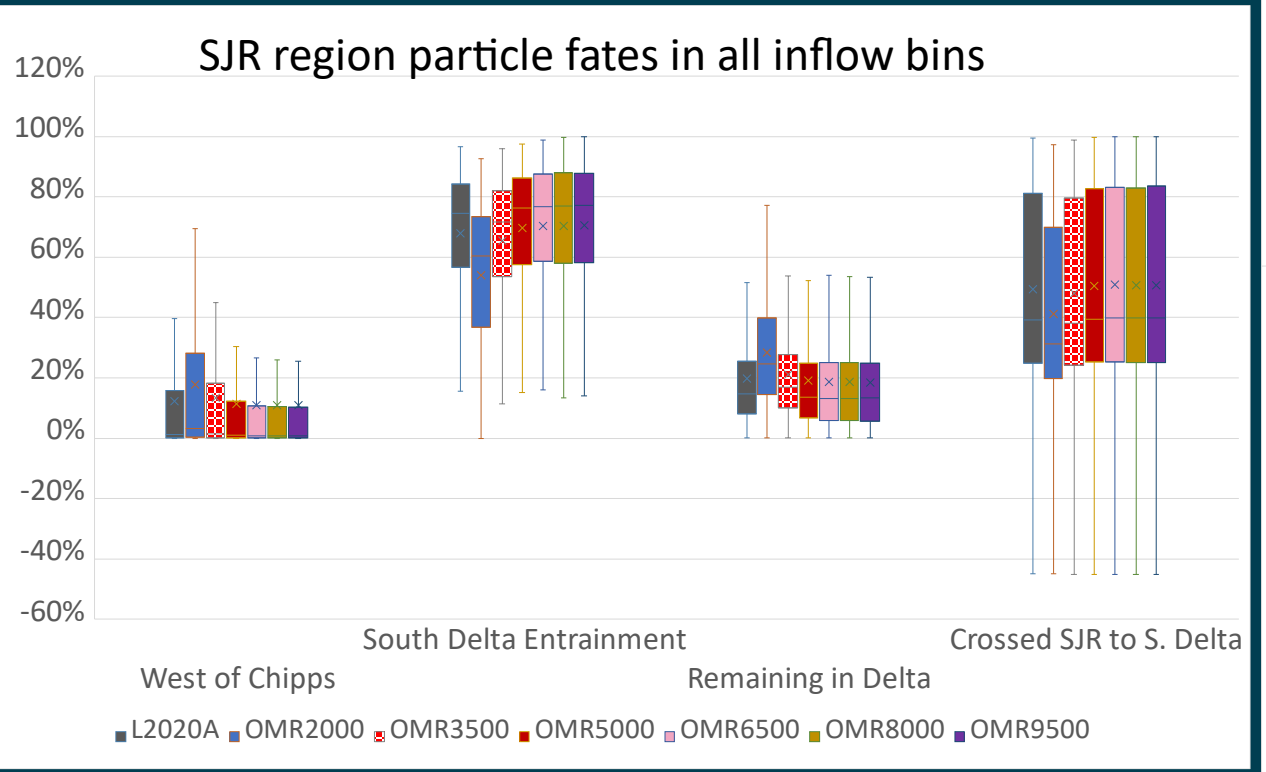
# Example NP Results: Sac Region Particles Fates

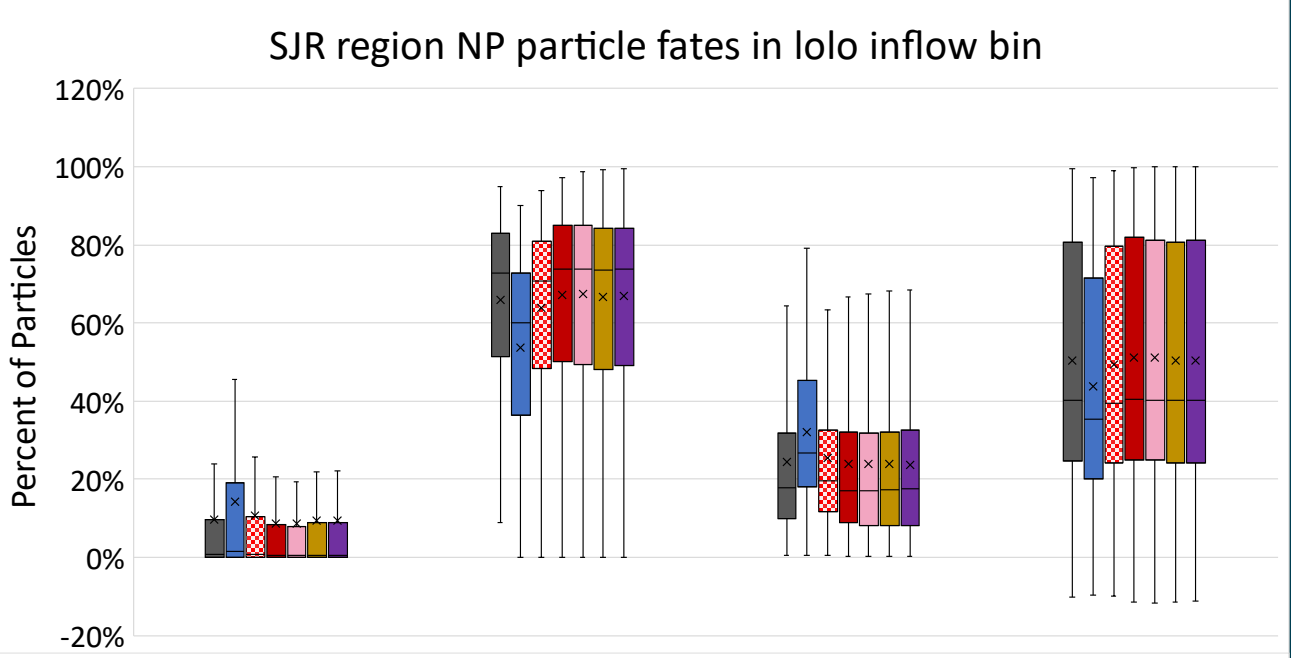


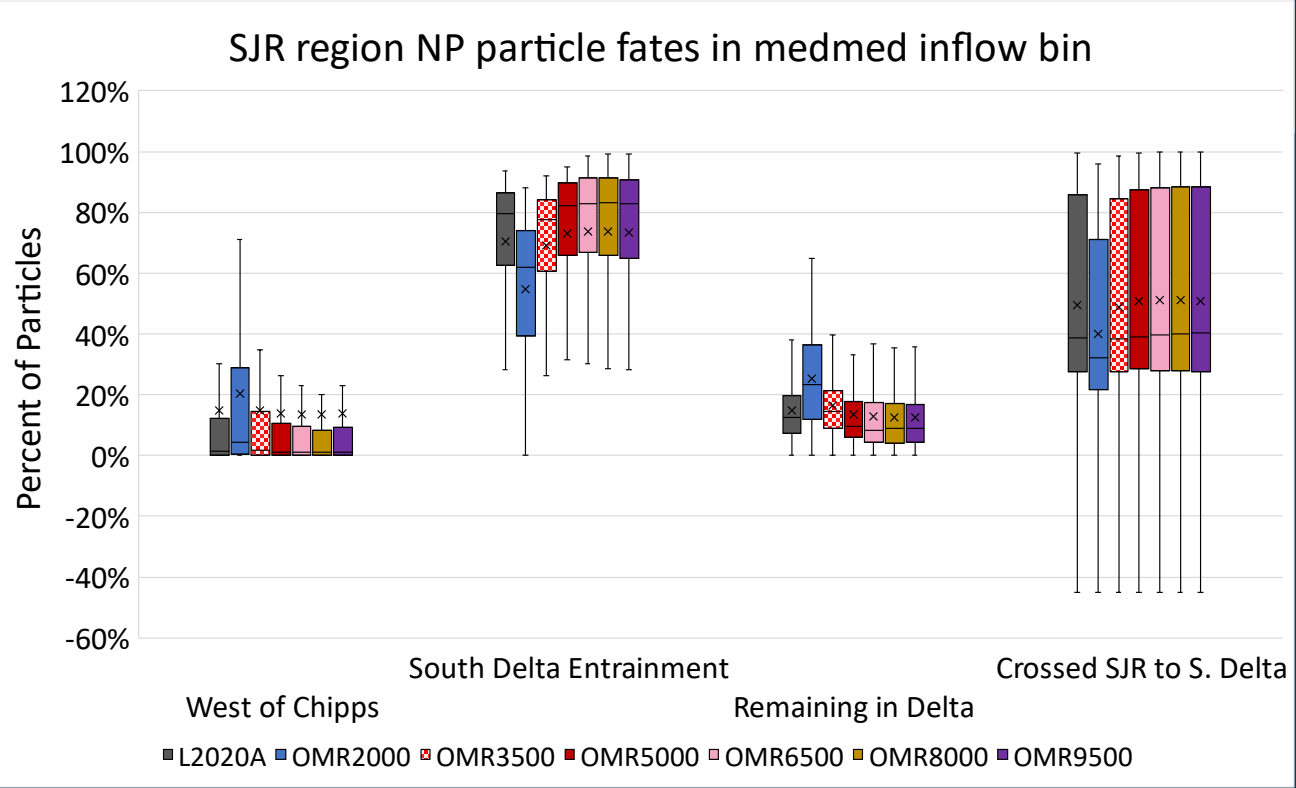



# Example NP Results: SJR Region Particles Fates



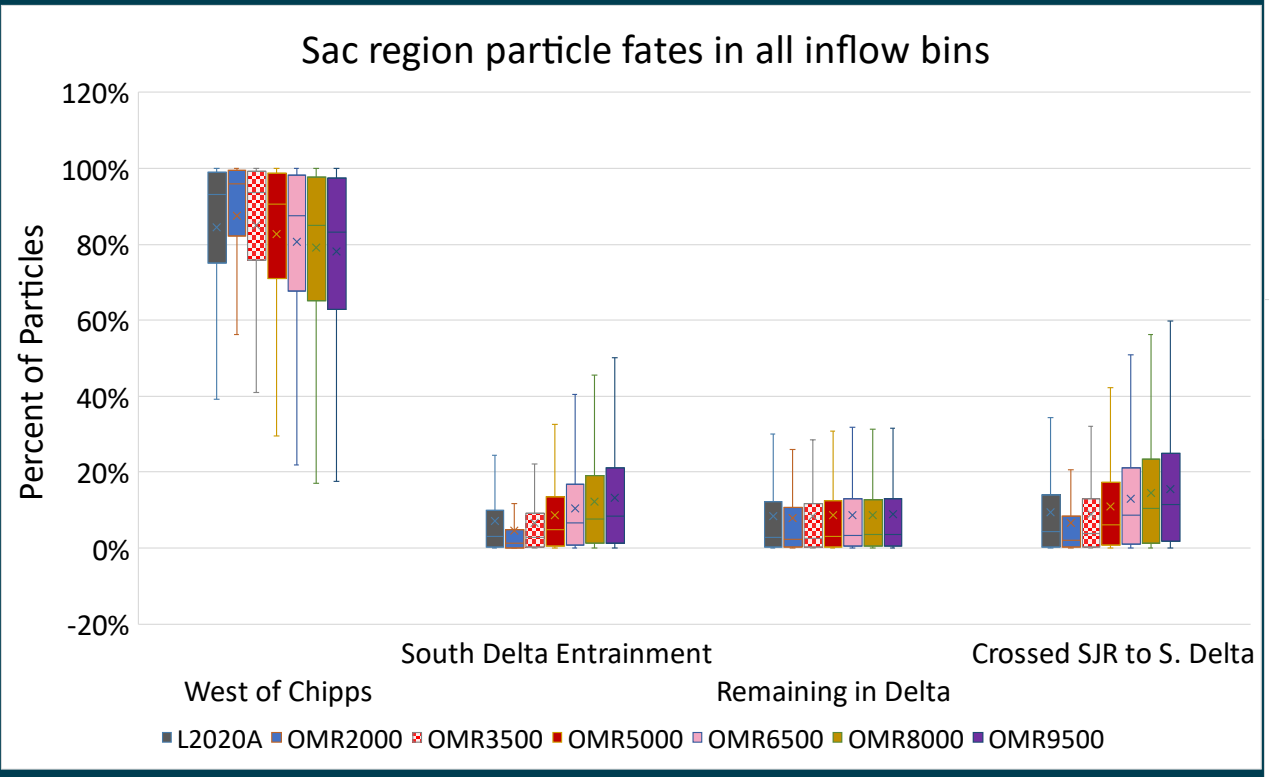



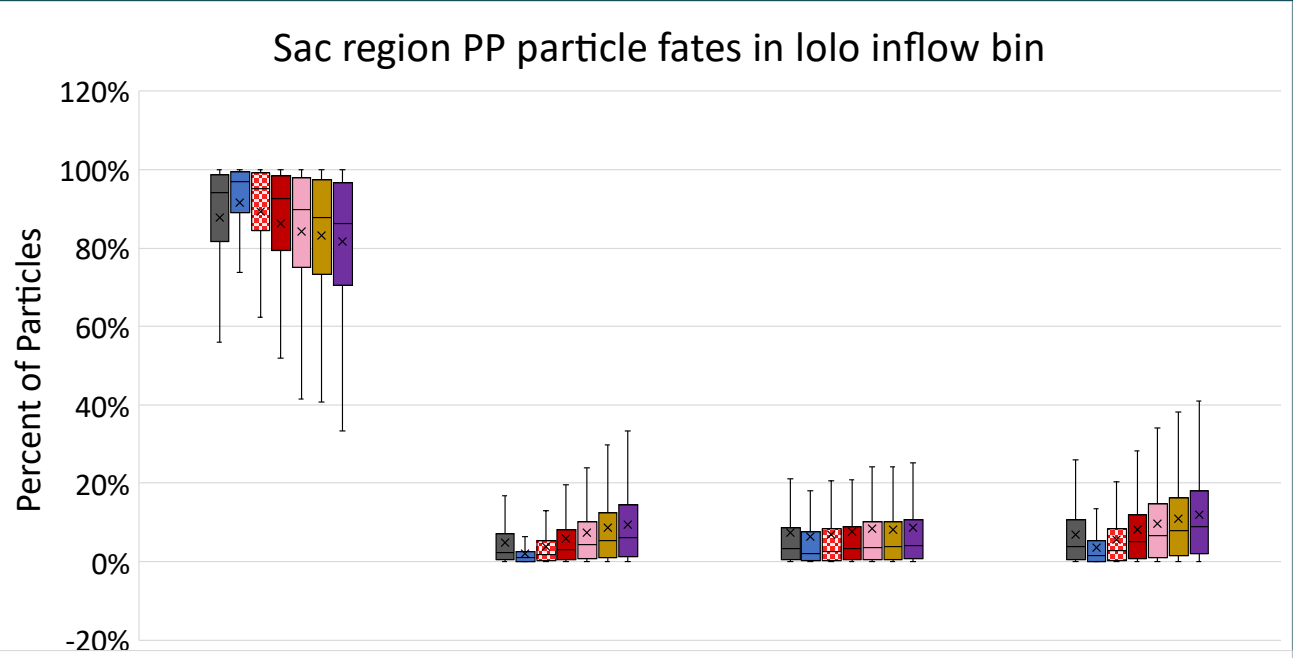
# Example NP Results: SJR Region Particles Fates

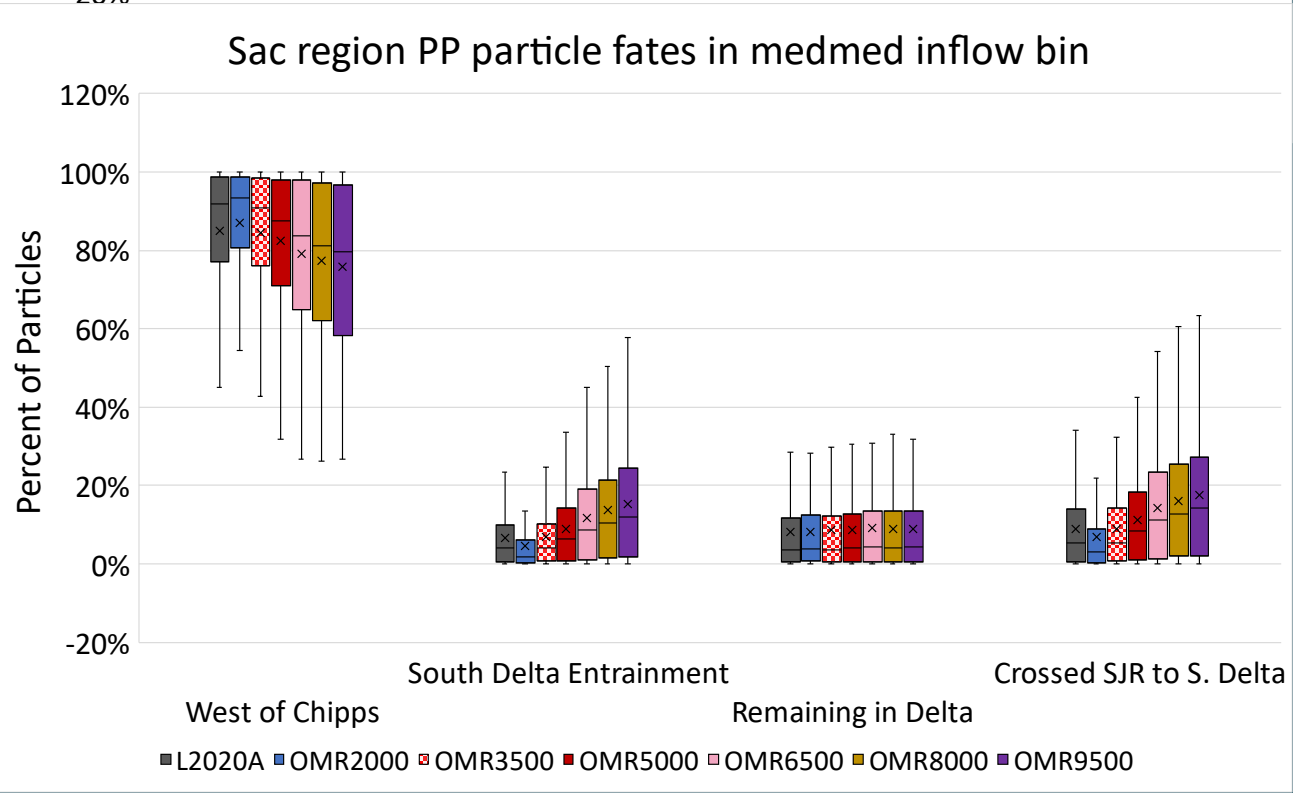
| Sacramento River Region | | | | | | | |
|---|---|---|---|---|---|---|---|
| Particle fates | L2020A | OMR2000 | OMR3500 | OMR5000 | OMR6500 | OMR8000 | OMR9500 |
| West of Chipps ↓ | 79.2% | 81.0% | 79.7% | 78.8% | 78.4% | 78.2% | 78.1% |
| Entrained at Exports ↑ | 4.3% | 2.3% | 3.8% | 4.7% | 5.1% | 5.3% | 5.4% |
| Remaining in Delta – | 16.5% | 16.7% | 16.5% | 16.5% | 16.5% | 16.5% | 16.6% |
| Crossed SJR to S. Delta ↑ | 8.1% | 6.0% | 7.5% | 8.5% | 8.9% | 9.1% | 9.2% |

| San Joaquin River Region | | | | | | | |
|---|---|---|---|---|---|---|---|
| Particle fates | L2020A | OMR2000 | OMR3500 | OMR5000 | OMR6500 | OMR8000 | OMR9500 |
| West of Chipps ↓ | 12.2% | 17.7% | 13.3% | 11.3% | 10.9% | 10.9% | 11.0% |
| Entrained at Exports ↑ | 68.0% | 53.9% | 65.6% | 69.6% | 70.3% | 70.4% | 70.5% |
| Remaining in Delta ↓ | 19.8% | 28.3% | 21.1% | 19.0% | 18.8% | 18.7% | 18.5% |
| Crossed SJR to S. Delta ↑ | 49.4% | 41.2% | 48.0% | 50.4% | 50.8% | 50.7% | 50.7% |

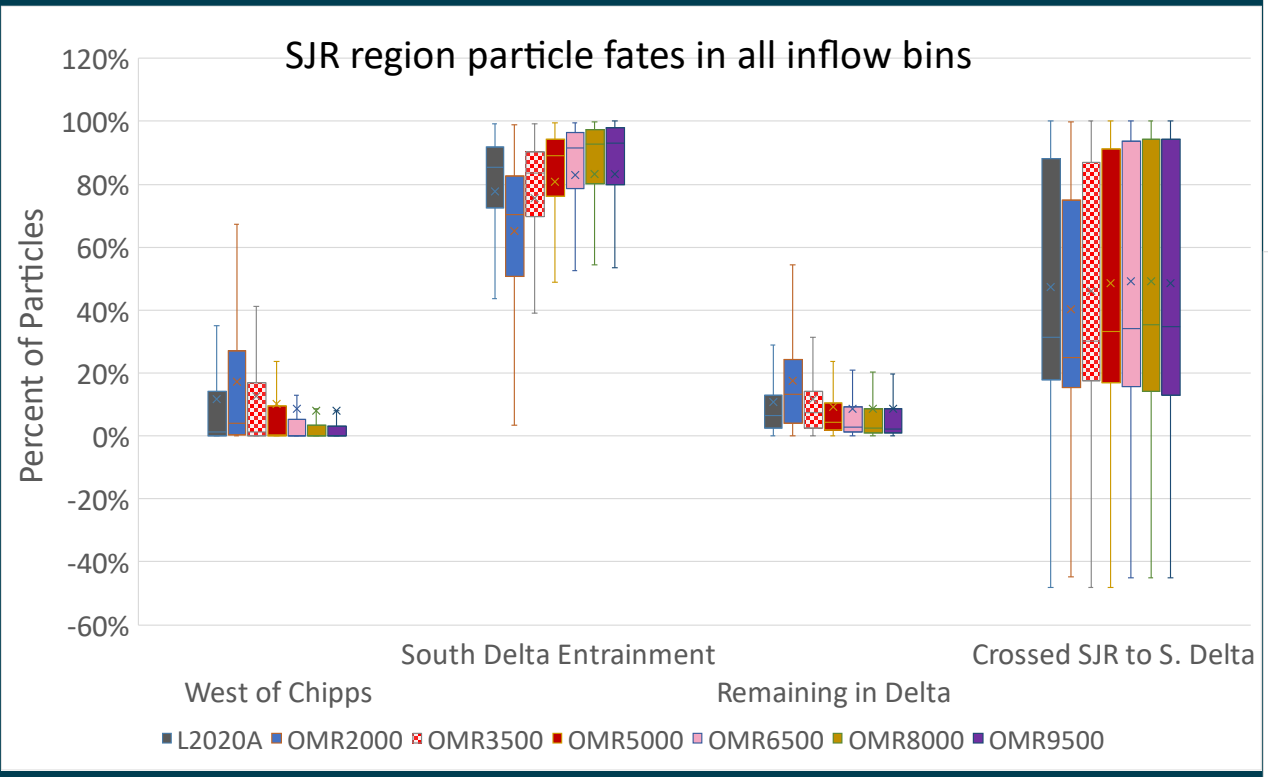
# Example PP Results

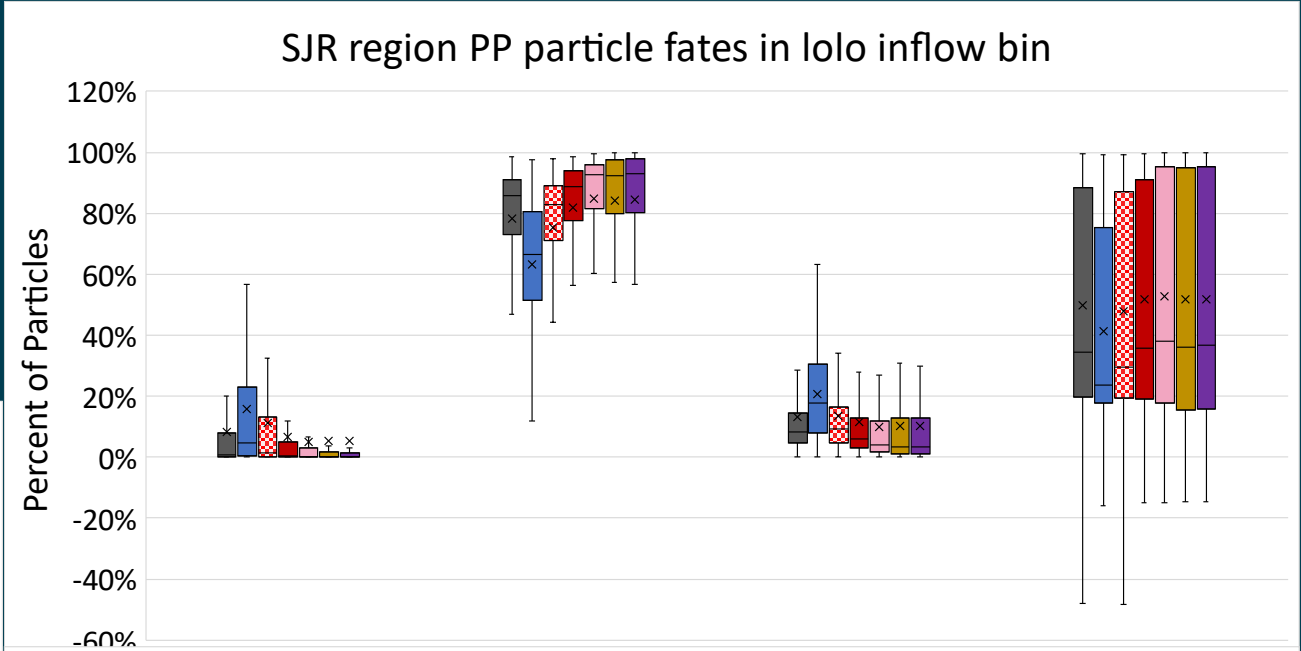


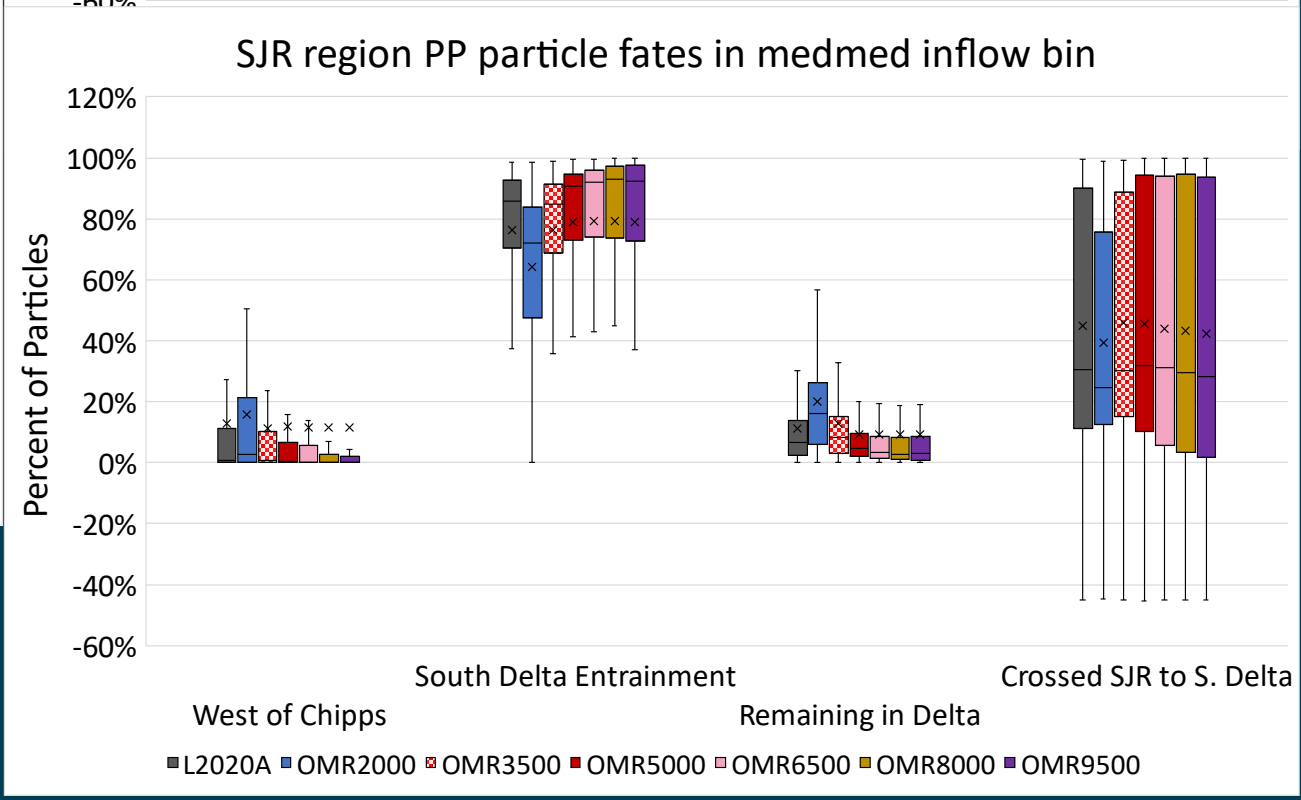



# Example PP Results



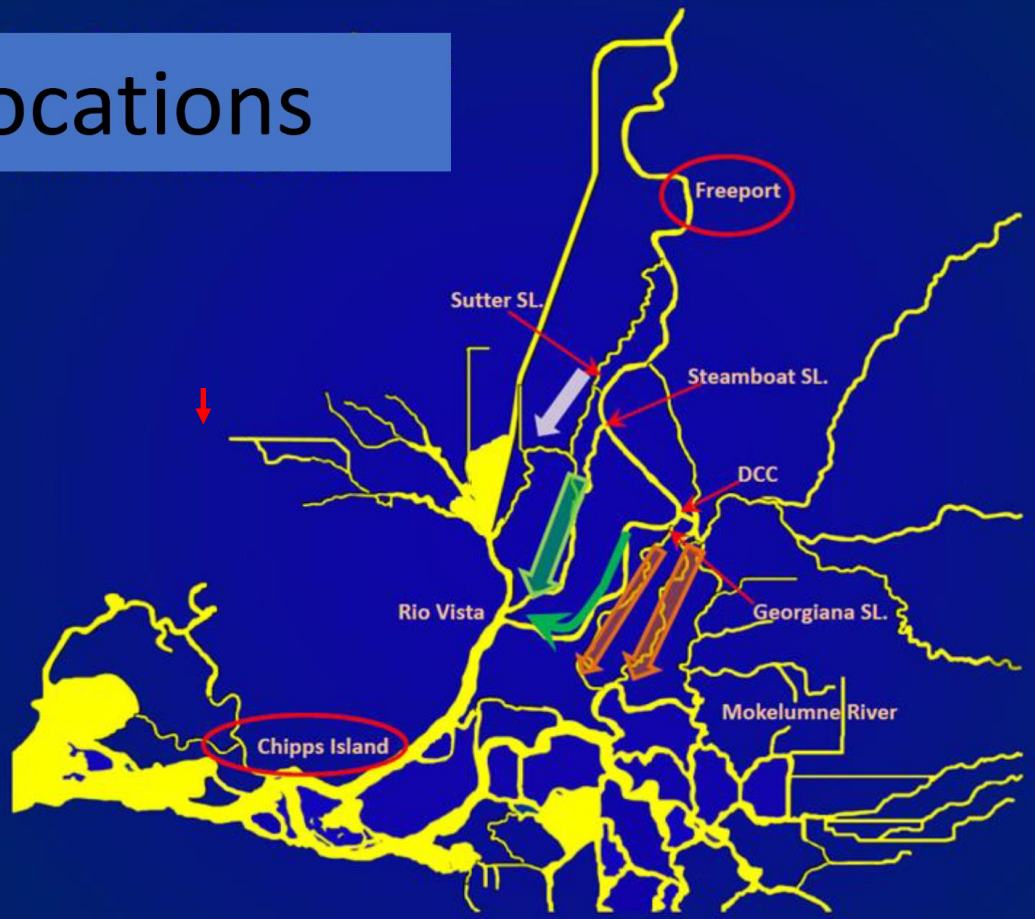
# Example PP Results

| Sacramento River Region | | | | | | | |
|---|---|---|---|---|---|---|---|
| Particle fates | L2020A | OMR2000 | OMR3500 | OMR5000 | OMR6500 | OMR8000 | OMR9500 |
| West of Chipps ↓ | 84.5% | 87.4% | 84.9% | 82.7% | 80.7% | 79.1% | 78.0% |
| Entrained at Exports ↓ | 7.2% | 4.6% | 6.7% | 8.7% | 10.6% | 12.1% | 13.2% |
| Remaining in Delta ↑ | 8.3% | 7.9% | 8.4% | 8.6% | 8.8% | 8.7% | 8.8% |
| Crossed SJR to S. Delta ↑ | 9.4% | 6.7% | 8.9% | 11.0% | 12.9% | 14.4% | 15.5% |

| San Joaquin River Region | | | | | | | |
|---|---|---|---|---|---|---|---|
| Particle fates | L2020A | OMR2000 | OMR3500 | OMR5000 | OMR6500 | OMR8000 | OMR9500 |
| West of Chipps ↓ | 11.6% | 17.3% | 12.7% | 10.0% | 8.6% | 8.1% | 8.1% |
| Entrained at Exports ↑ | 77.7% | 65.0% | 75.7% | 80.8% | 82.8% | 83.3% | 83.3% |
| Remaining in Delta ↓ | 10.7% | 17.6% | 11.6% | 9.2% | 8.5% | 8.6% | 8.6% |
| Crossed SJR to S. Delta ↑ | 47.2% | 40.1% | 46.0% | 48.5% | 49.3% | 49.1% | 48.5% |

# SP Results-Routine ECO-PTM

## Locations




Source: ECO-PTM Application:Assess Effectiveness of Fish Barriers (Wang 2020)

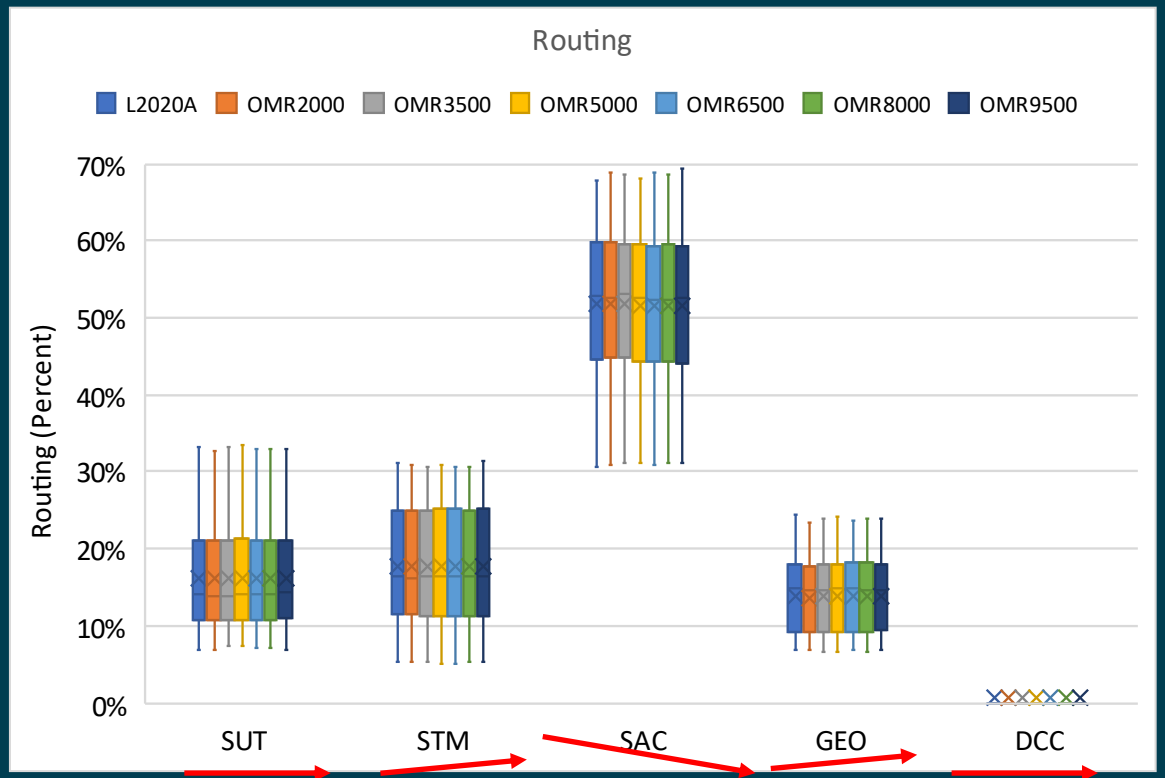
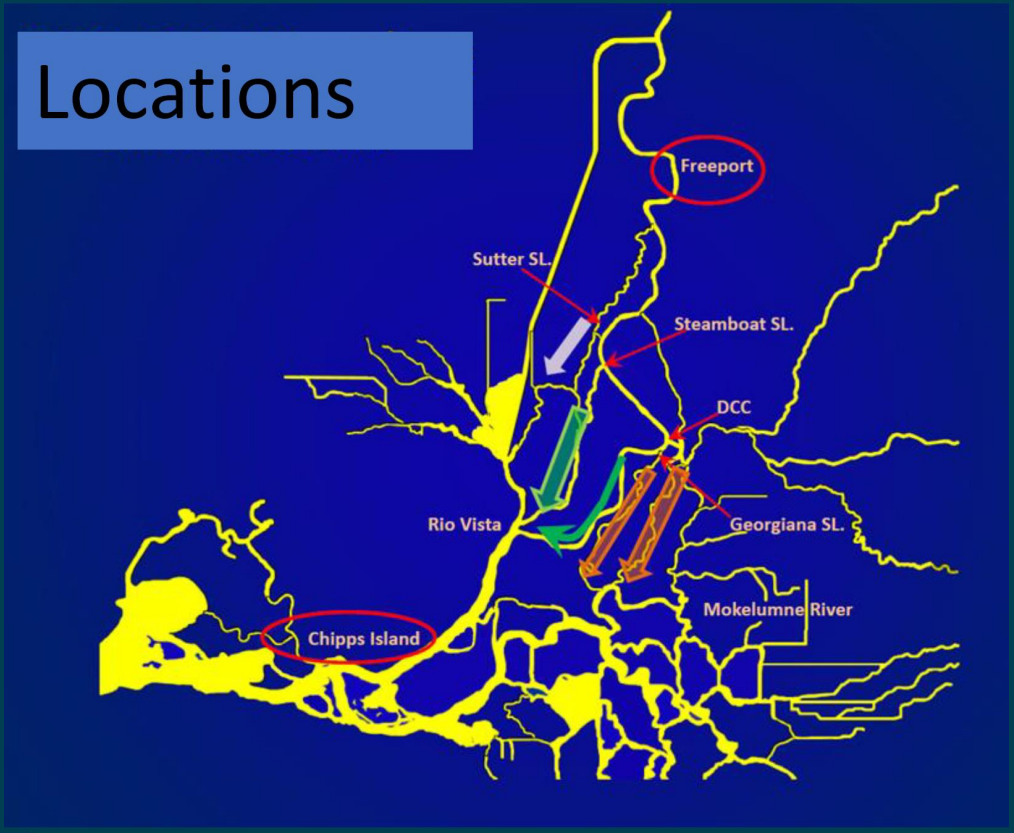



Table 3.—Mean routing ratios under various OMR conditions

| Routing ratio | L2020A | OMR2000 | OMR3500 | OMR5000 | OMR6500 | OMR8000 | OMR9500 |
|---|---|---|---|---|---|---|---|
| SUT | 16.1% | 16.1% | 16.1% | 16.1% | 16.1% | 16.1% | 16.1% |
| STM | 17.7% | 17.6% | 17.7% | 17.7% | 17.7% | 17.7% | 17.8% |
| SAC | 51.8% | 51.9% | 51.8% | 51.6% | 51.6% | 51.6% | 51.5% |
| GEO | 13.8% | 13.7% | 13.8% | 13.8% | 13.8% | 13.9% | 13.9% |
| DCC | 0.7% | 0.7% | 0.7% | 0.7% | 0.7% | 0.7% | 0.7% |

# SP Results-Survival Rate ECO-PTM

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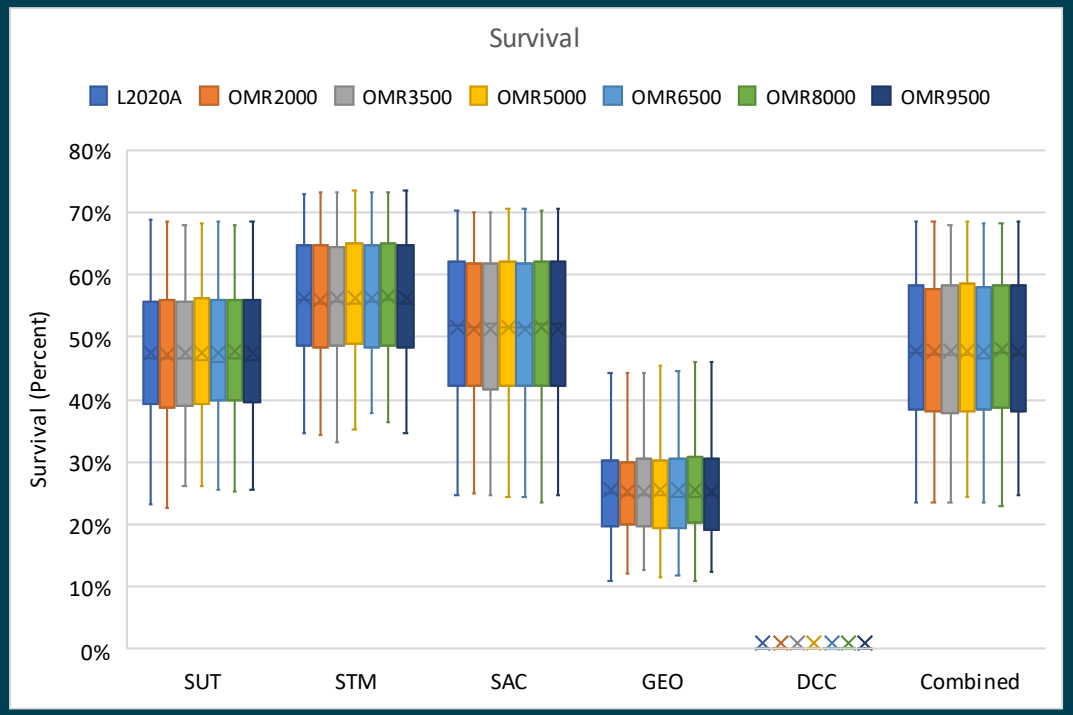
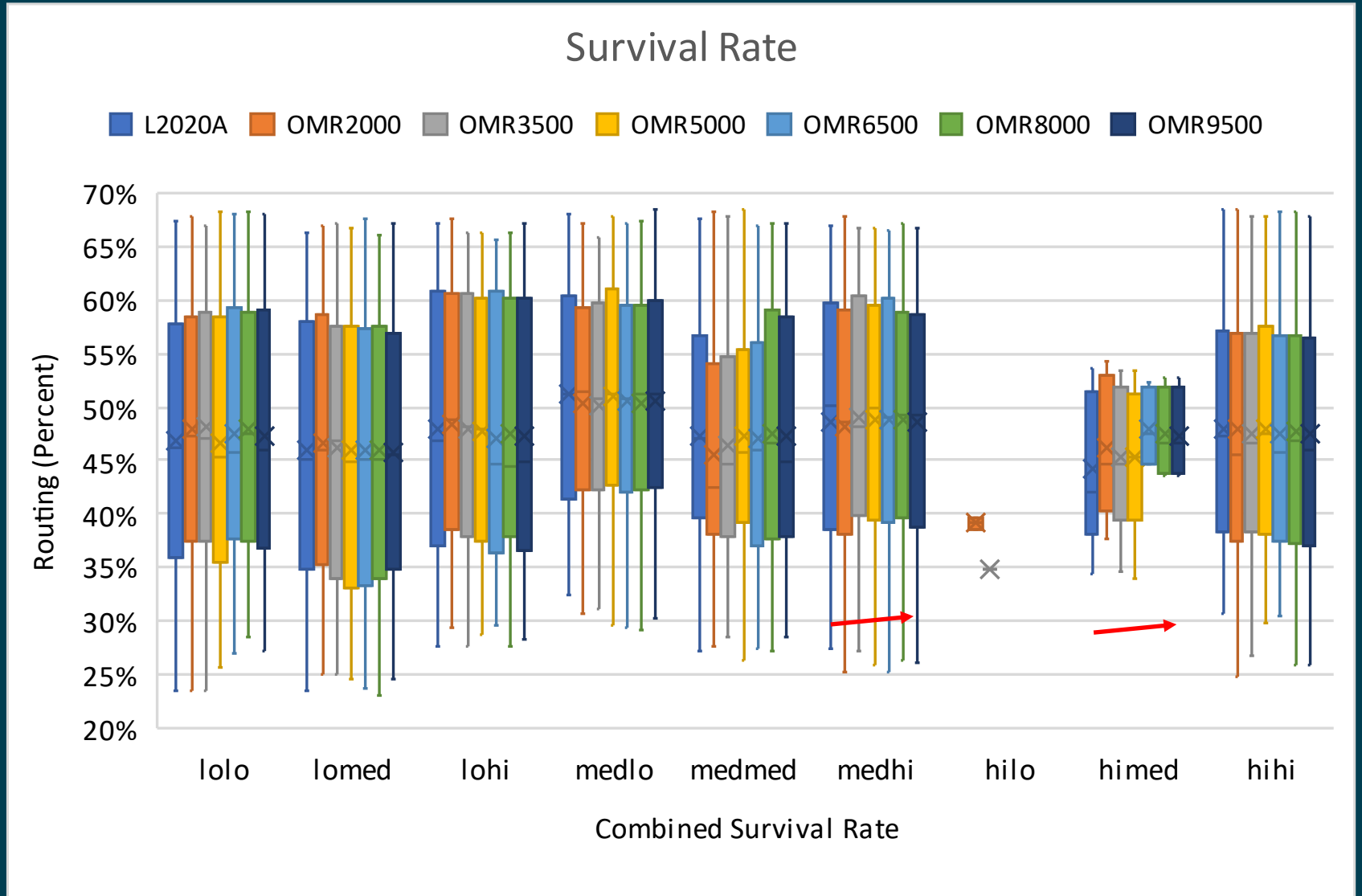



Table 4.—Survival rates in each routine under various flow conditions

| Survival rate | L2020A | OMR2000 | OMR3500 | OMR5000 | OMR6500 | OMR8000 | OMR9500 |
|---|---|---|---|---|---|---|---|
| **Survival Rates in All Month from Dec to March** | | | | | | | |
| **SUT** | 47.5% | 47.2% | 47.4% | 47.5% | 47.5% | 47.7% | 47.5% |
| **STM** | 56.3% | 56.0% | 56.3% | 56.3% | 56.3% | 56.5% | 56.2% |
| **SAC** | 51.4% | 51.2% | 51.3% | 51.4% | 51.4% | 51.6% | 51.3% |
| **GEO** | 25.4% | 25.3% | 25.3% | 25.5% | 25.4% | 25.5% | 25.3% |
| **DCC** | 0.9% | 1.0% | 0.9% | 0.9% | 0.9% | 0.9% | 0.9% |
| **TOTAL** | 47.9% | 47.7% | 47.8% | 47.9% | 47.8% | 48.0% | 47.8% |

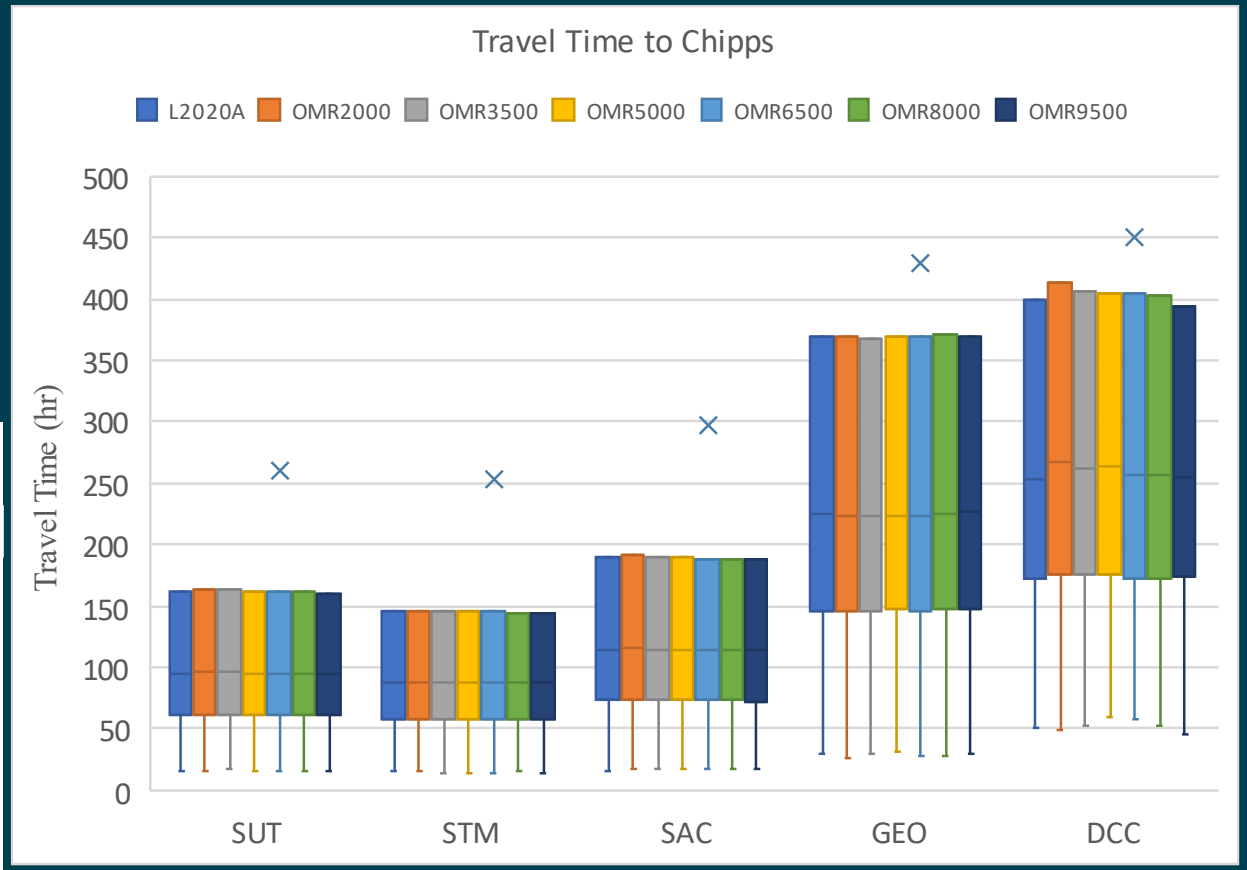
# SP Results-Survival Rate Different Flow Bins



# SP Results-Travel Time

Table 5.—Median fish travel times from Sacramento River at Port to Chipps Island through each routine

| | SUT | STM ↓ | SAC ↓ | GEO | DCC ↓ |
|---|---|---|---|---|---|
| **Medium** | | | | | |
| L2020A | 95.5 | 88.1 | 114.7 | 225.0 | 253.8 |
| OMR2000 | 95.9 | 88.4 | 115.4 | 223.3 | 267.3 |
| OMR3500 | 95.8 | 88.1 | 114.4 | 222.8 | 261.4 |
| OMR5000 | 95.4 | 87.7 | 114.2 | 224.1 | 264.0 |
| OMR6500 | 95.6 | 87.9 | 113.8 | 223.2 | 257.1 |
| OMR8000 | 94.8 | 87.6 | 113.8 | 224.2 | 257.0 |
| OMR9500 | 94.8 | 87.5 | 113.5 | 225.9 | 255.4 |



# Summary:

- **OMR flow is a reliable indicator of water export**
  - **PTM and ECO-PTM models were used to predict the fate of various fish particles:**
  - **Naturally-buoyant Particles(NP) - Larval Delta Smelt**
  - **Position-oriented Particles (PP) - Larval Longfin Smelt**
  - **Salmon Particles (SP) – Juvenile Salmon**
- **OMR flow impacts on NP and PP particles:**
  - **Reduces the number of particles passing Chipps Island**
  - **Increases the number of particles crossing the San Joaquin River (SJR) to South Delta and Entrainment at Exports.**
  - **Impacts SJR-inserted particles more significantly than SAC-inserted particles.**
  - **OMR limits can improve the performance of PP particles more significantly than NP particles.**
- **OMR flow impacts on SP particles:**
  - **Reduces salmon routing through the Sacramento River.**
  - **Overall salmon survival is not sensitive to OMR flows, but slightly more sensitive in certain flow bins.**
  - **Travel times are reduced in the Steamboat Slough (STM) and Sacramento River (SAC).**

# Acknowledgements:


- Model Division, Bay Delta Office
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