

enhanced Particle Tracking Model



NOAA FISHERIES
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION



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USGS
science for a changing world



UNIVERSITY OF CALIFORNIA
SANTA CRUZ

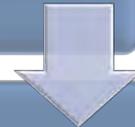


Outline

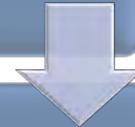
Represented Delta
biophysics



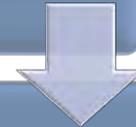
Why ePTM?



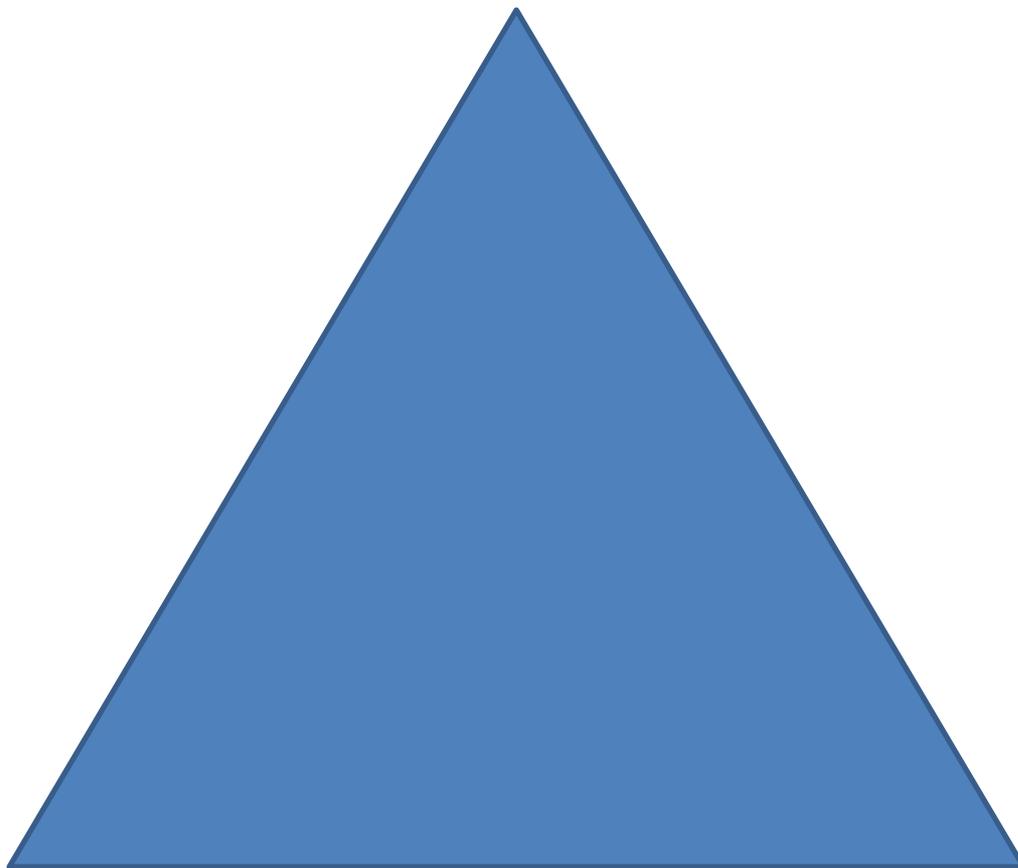
Modeling overview



Cross validation



Conclusions

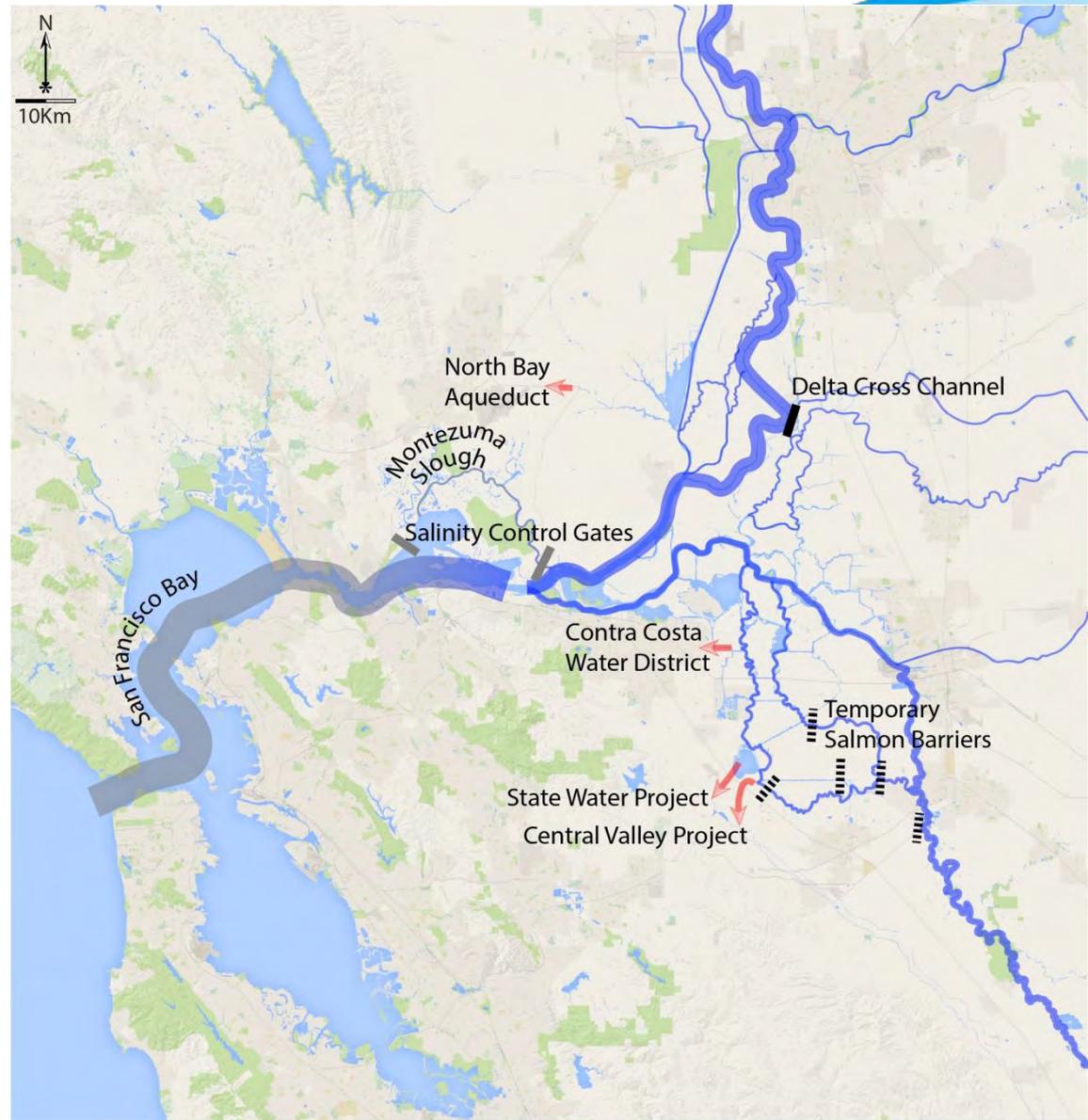


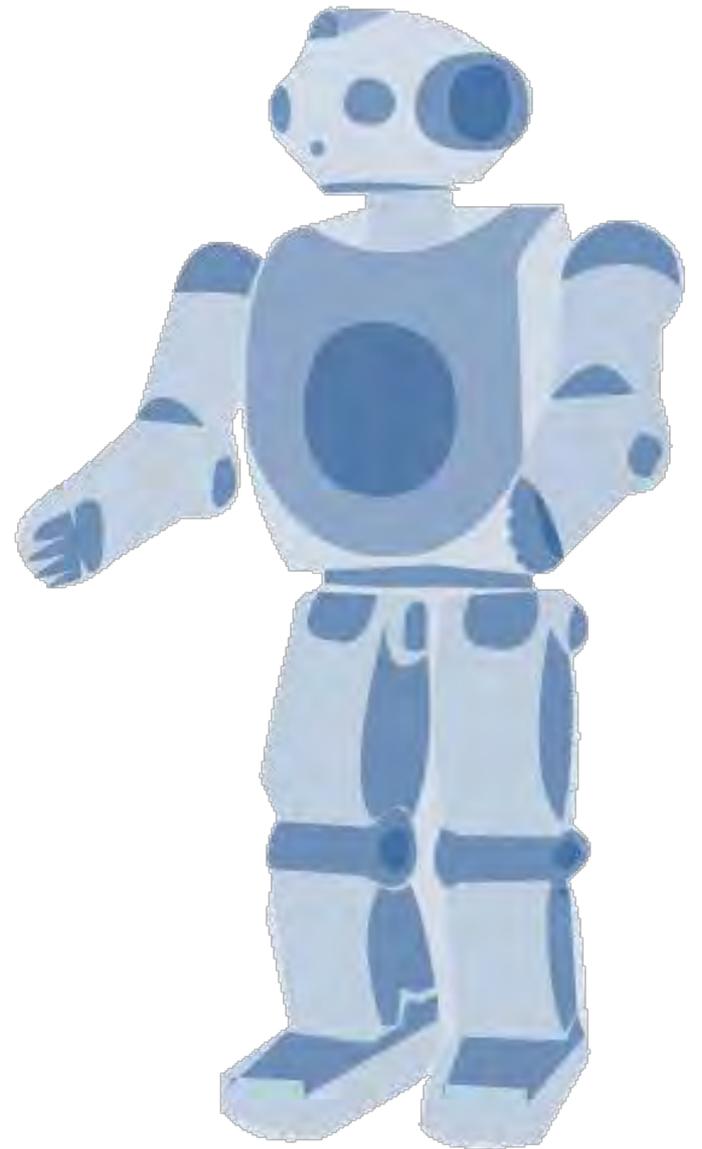


Sacramento-San Joaquin Delta

Hydrodynamic model representing:

- Major rivers
- Tides
- Water operations
- Exports
- Interventions







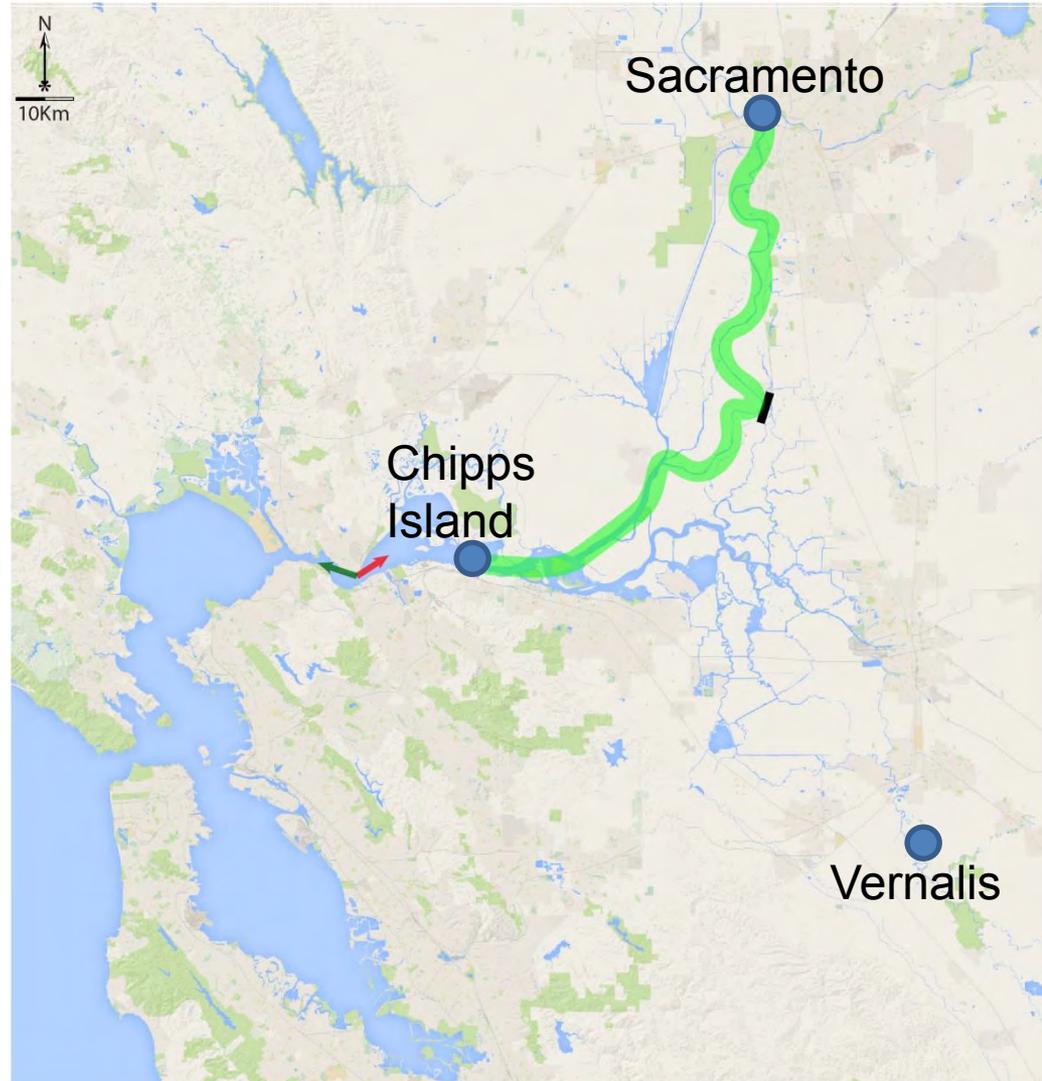
Why is the model useful? To:

Features	Statistical models	ePTM
Incorporate new salmon migration science		✓
Analyze out-of-sample scenarios		✓
Analyze alternative scenarios		✓
Build mechanistic intuition about system		✓
Multi-scale spatial and temporal resolution of processes	✓	✓
Provide insights into data collection, planning and management		✓
Scalable	✓	✓
Generalizable		✓



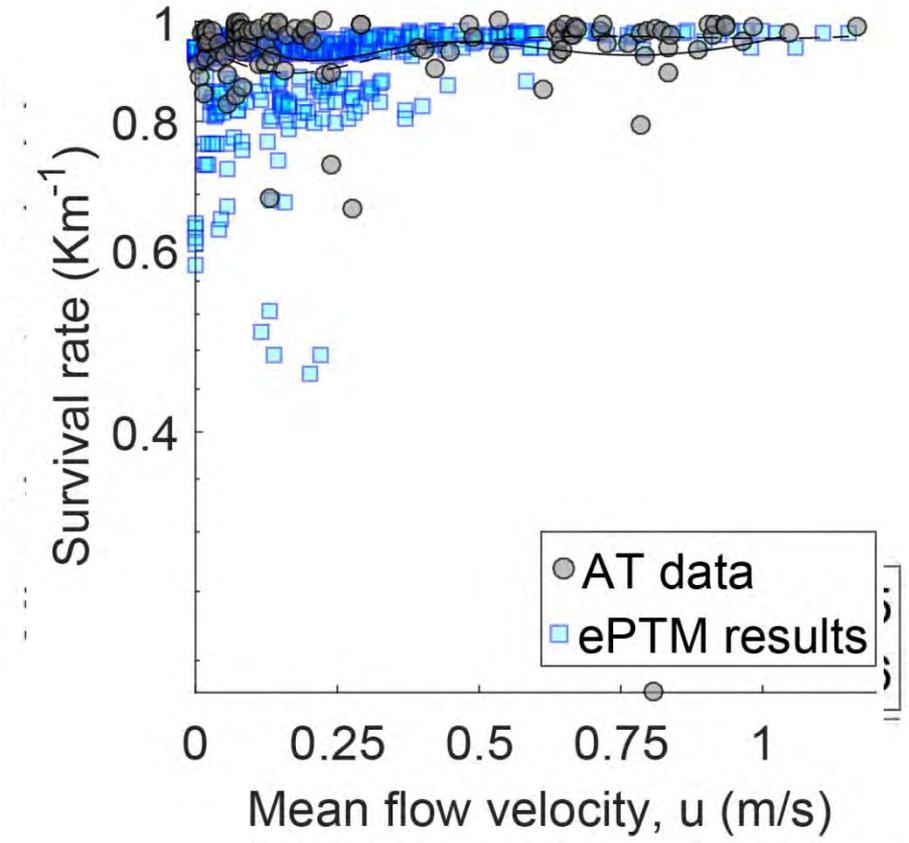
Why is the model useful? Routing at junctions and migratory pathways

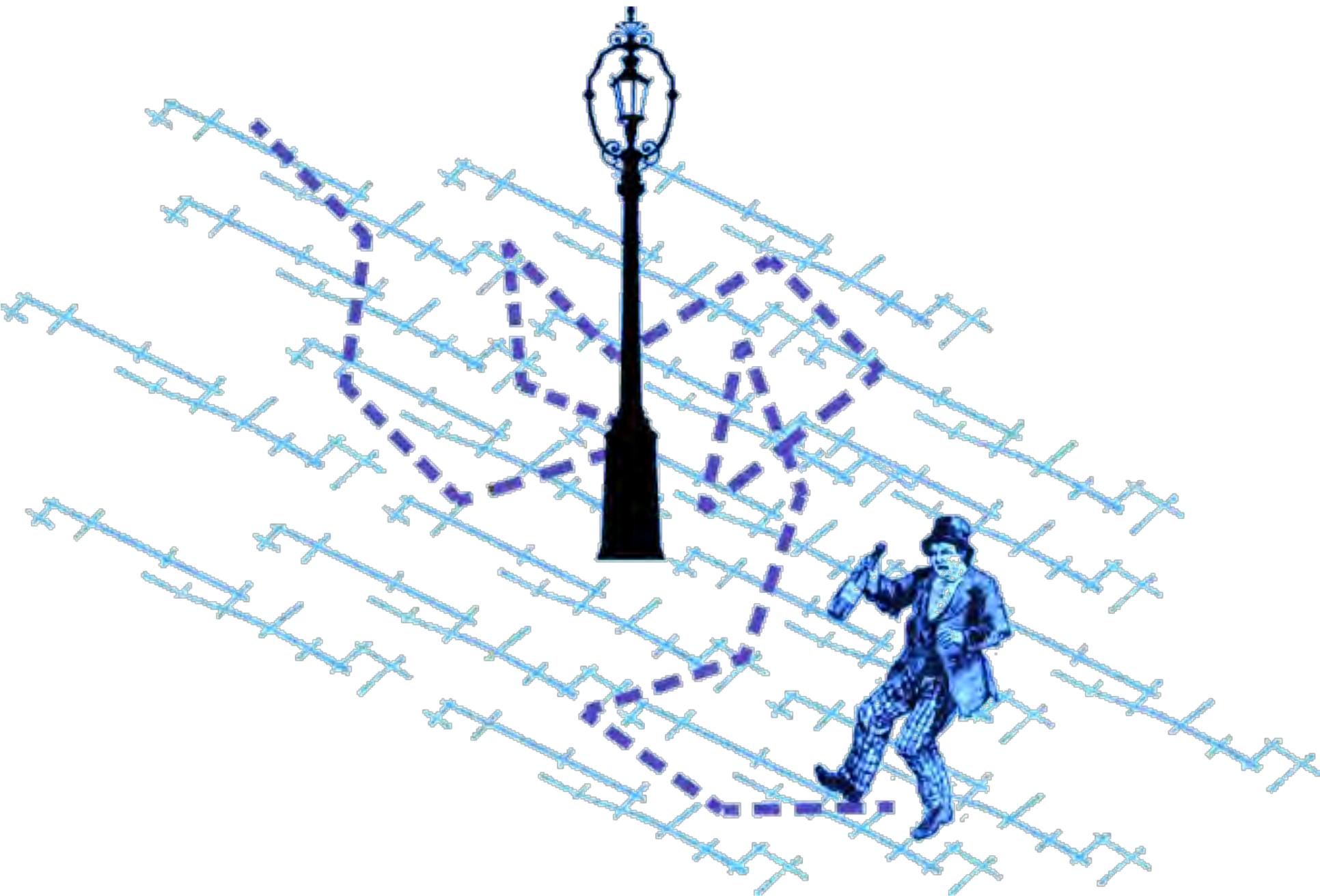
**Sacramento to Chipps Island via
Gaining Straghtout Ditch
and the Kings and Dutch
Cross Channel**



Why is the model useful? Survival rates

- Outmigration rate of tagged juveniles vs simulated juveniles
- Survival rate per kilometer of reach of tagged juveniles vs simulated juveniles







Range of behaviors

- **Passive particles that do not swim**

$$\log[L(\theta|data)] = -1617$$

ePTM behaviors

Simulated juvenile salmon:

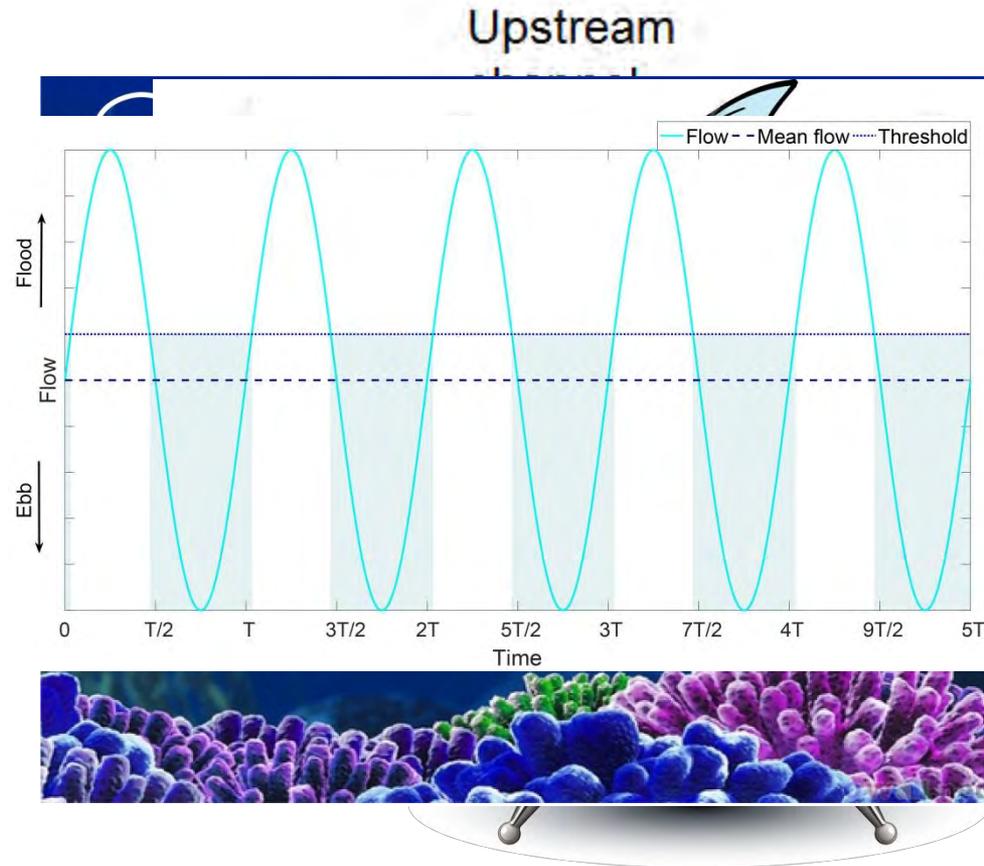
- always swim downstream
- drift during the flood phase of the tide
- hold during the flood phase of the tide
- swim when the tide falls and drift otherwise
- swim when the tide falls and hold otherwise
- swim towards higher salinity
- swim at night and hold during the day
- swim with constant speed towards the ocean
- swim with constant speed downstream
- hold above a certain threshold during the flood phase of the tide, are more likely to swim during the night than during the day

$$\log[L(\theta|data)] = -1327$$

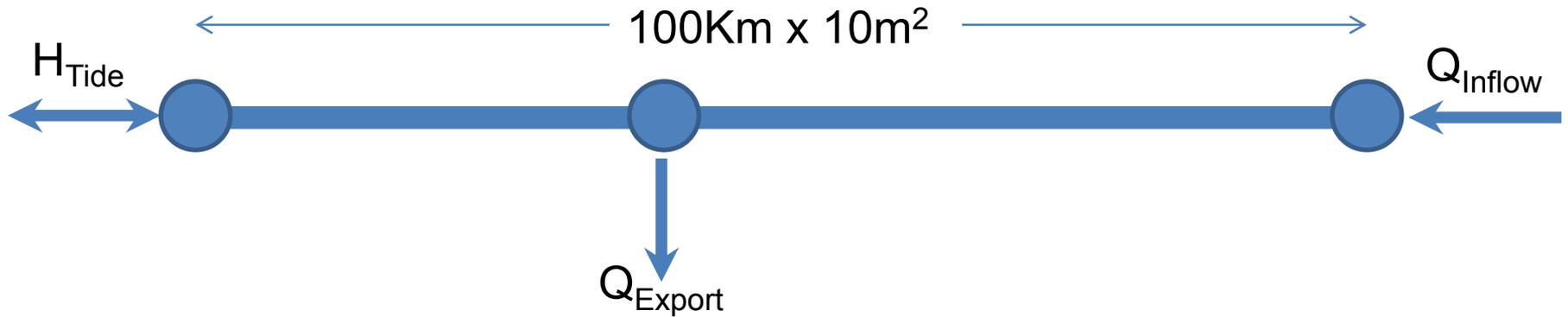
$$\log[L(\theta|data)] = -801$$

ePTM behavior agents

- Swimming
 - Selective Tidal Stream Transport
 - Probability of swimming during the day
 - Probability of mis-assessing downstream direction
 - Predation Mortality (X-T model) [Anderson et al., 2005]
 - Mean free path length between predation events
 - Random predator encounter speed



Model parameter interactions



Hydrodynamics

Q_{Inflow} (m ³ /s)	$Q_{Export} : Q_{Inflow}$	H_{tide} (m)
40	0.5 	± 1 

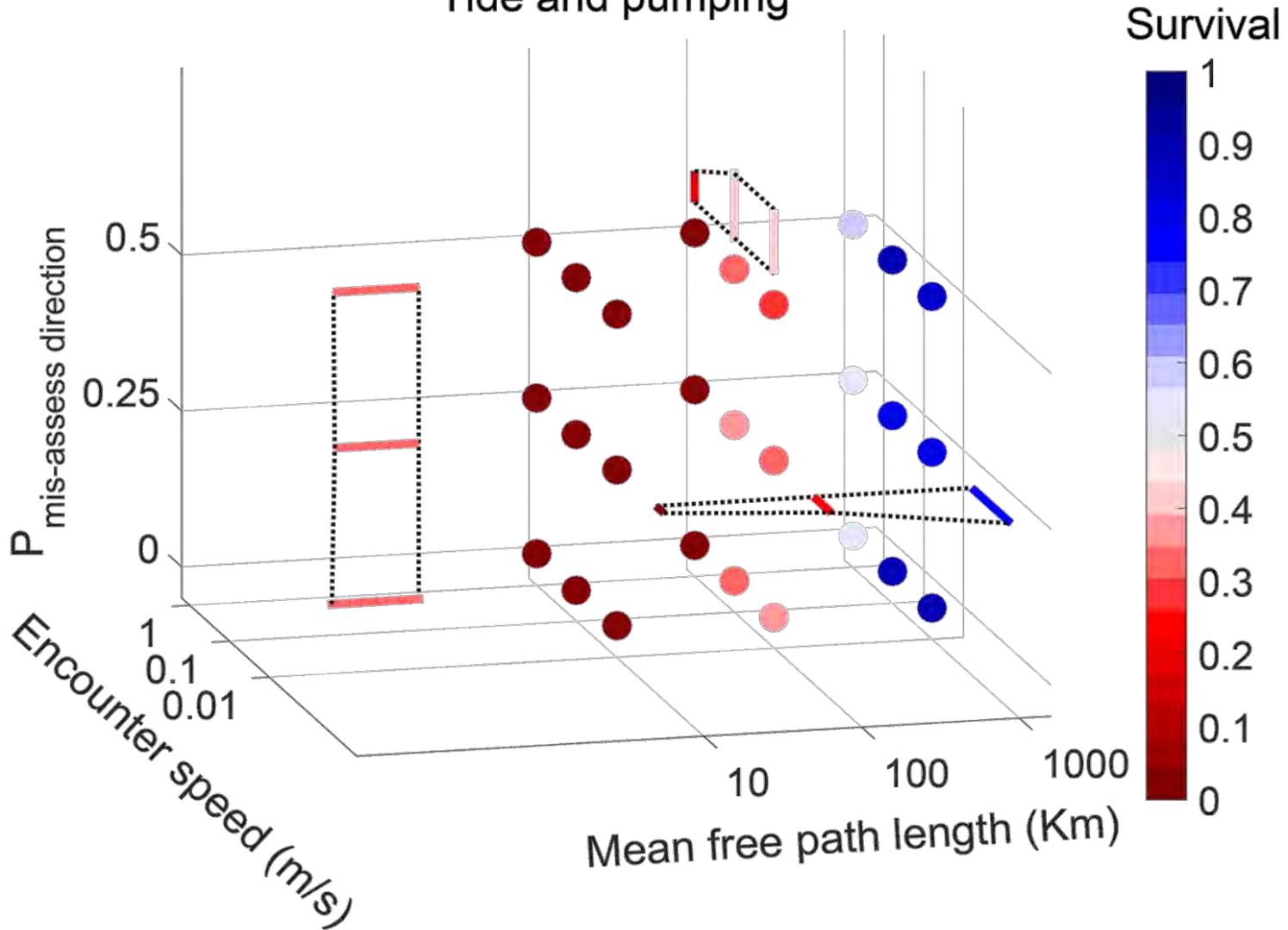
Biology

Sub-models	Parameters
Direction assessment	c, β
Predation	λ, ω



Model parameter interactions

Tide and pumping





Parameter estimation

Literature review and expert consultation

Gaussian process regression

Monte Carlo Markov chain

Swimming

Predation

Confusion

Acoustic telemetry data

ePTM results

Estimated model parameters

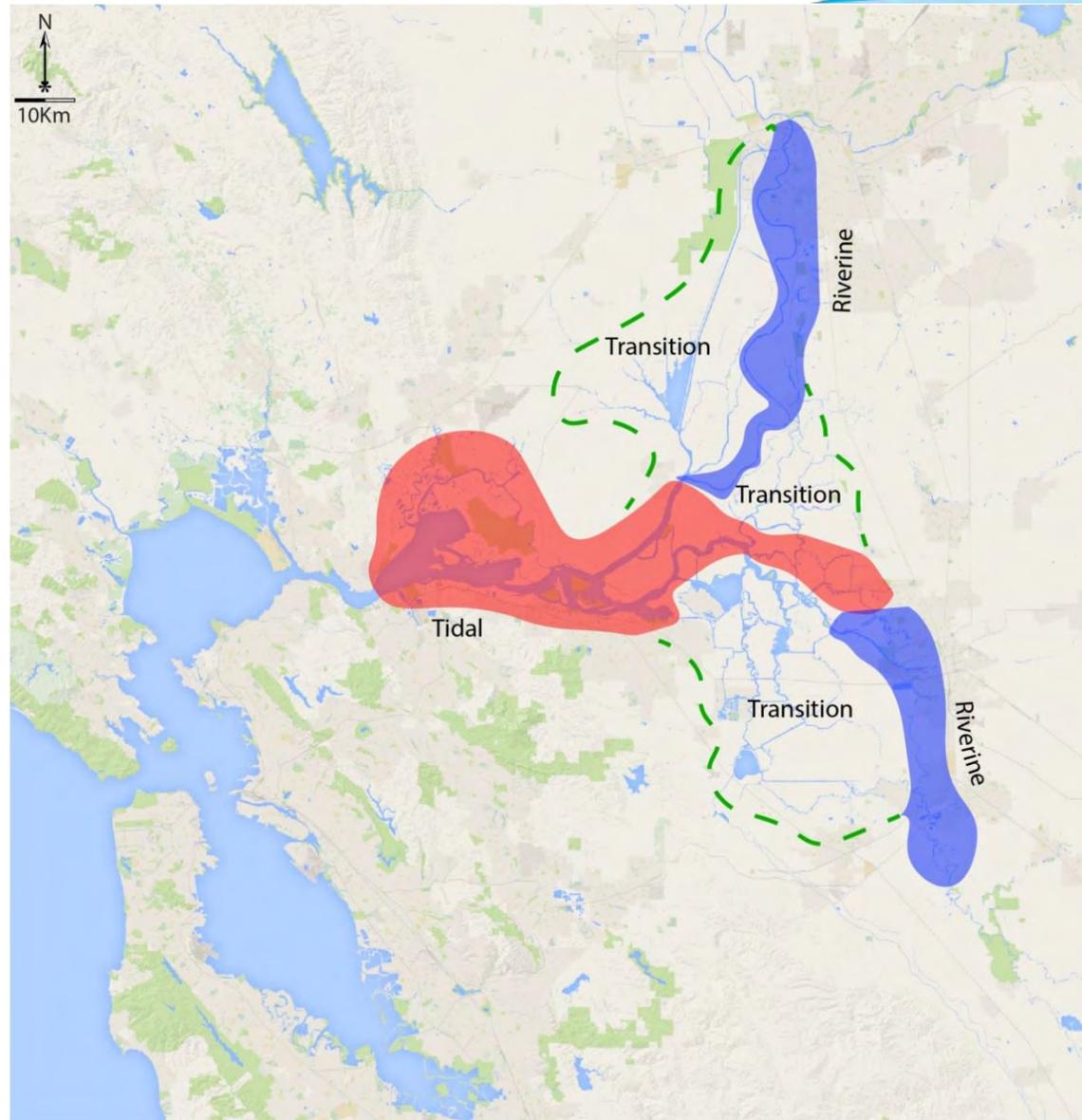
Setting prior bounds on parameter ranges

Comparing model results and data

Estimating maximum likelihood

Parameter distributions

- Allows for spatial distribution in behavior attributes
- Expect behavior to respond to flow characteristics
 - Riverine
 - Transition
 - Tidal



See Chapman et al. (2013)

CHECK LABELS ON CHEMICAL CONTAINERS



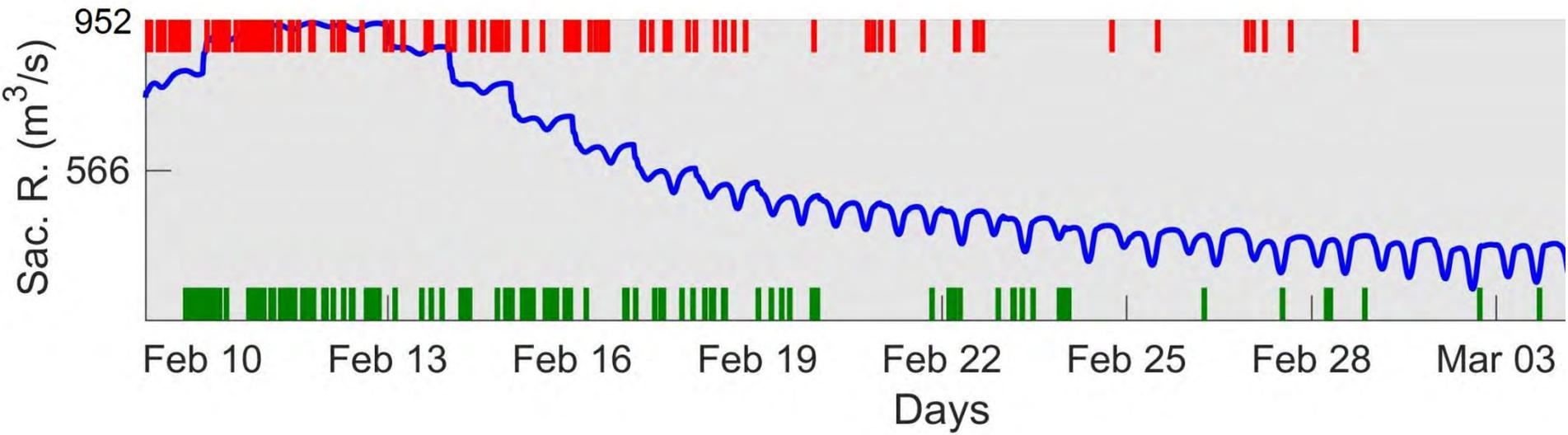
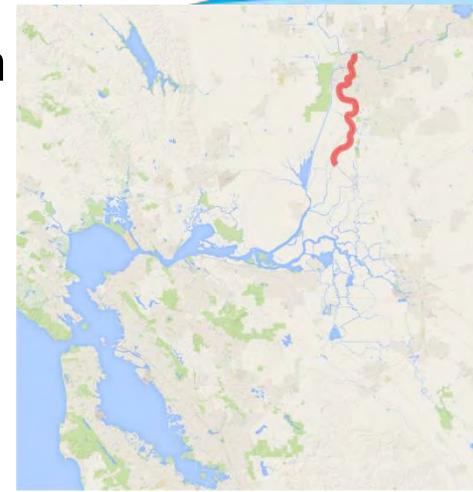
EVERY CHEMICAL CONTAINER MUST HAVE A WARNING LABEL



North Delta: 9-Feb-2015 Release of JSATS Chinook Salmon

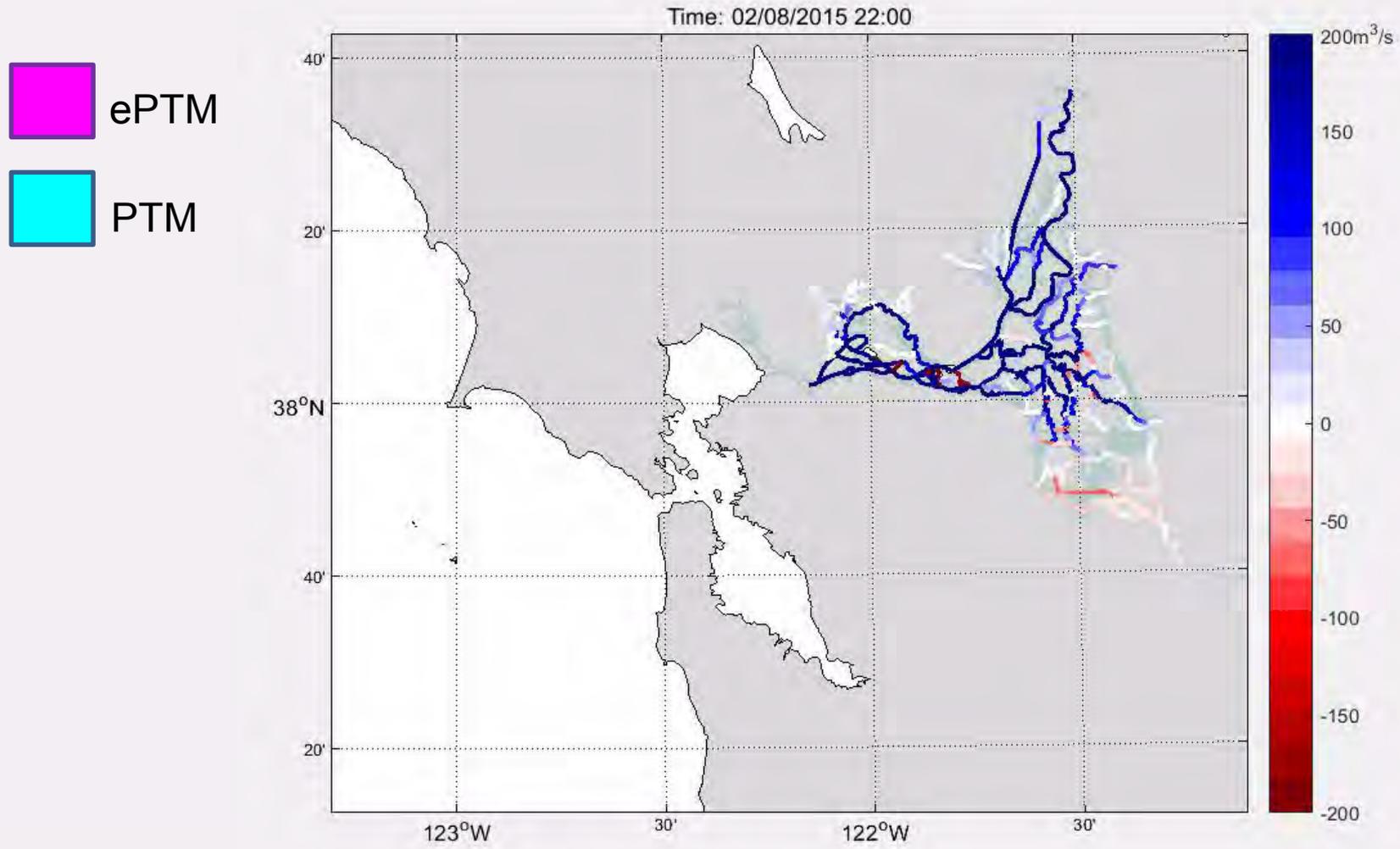
117 tagged fish detected

5000 ePTM fish released with arrival distribution of tagged fish at I Street Bridge



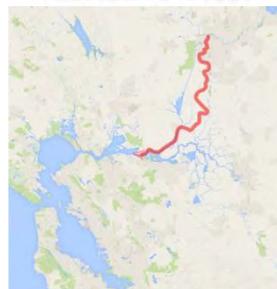
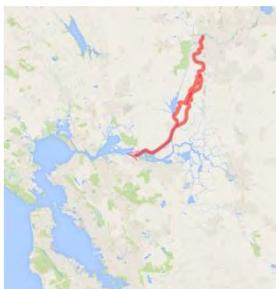
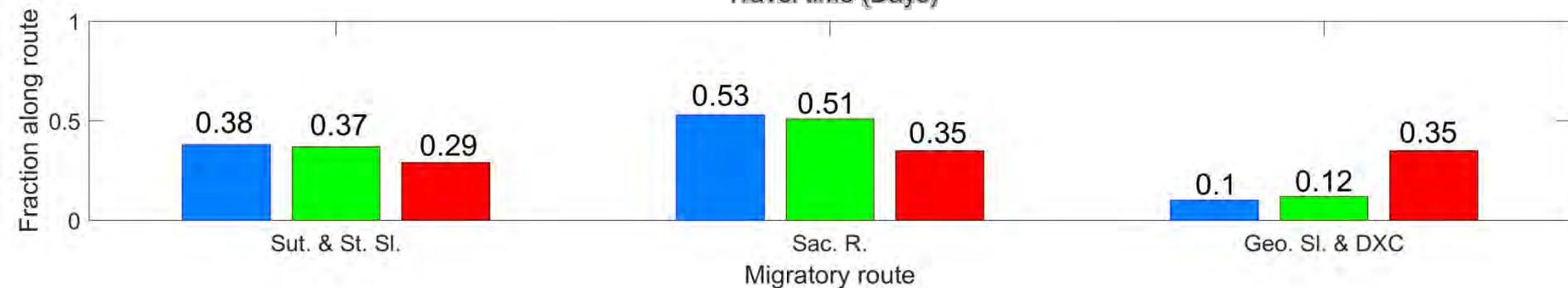
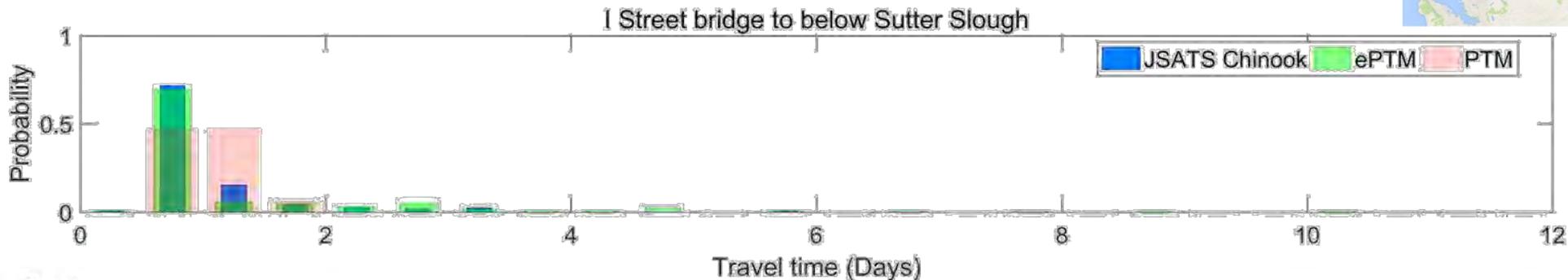
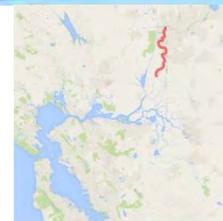


North Delta: 9-Feb-2015 Release of JSATS Chinook Salmon

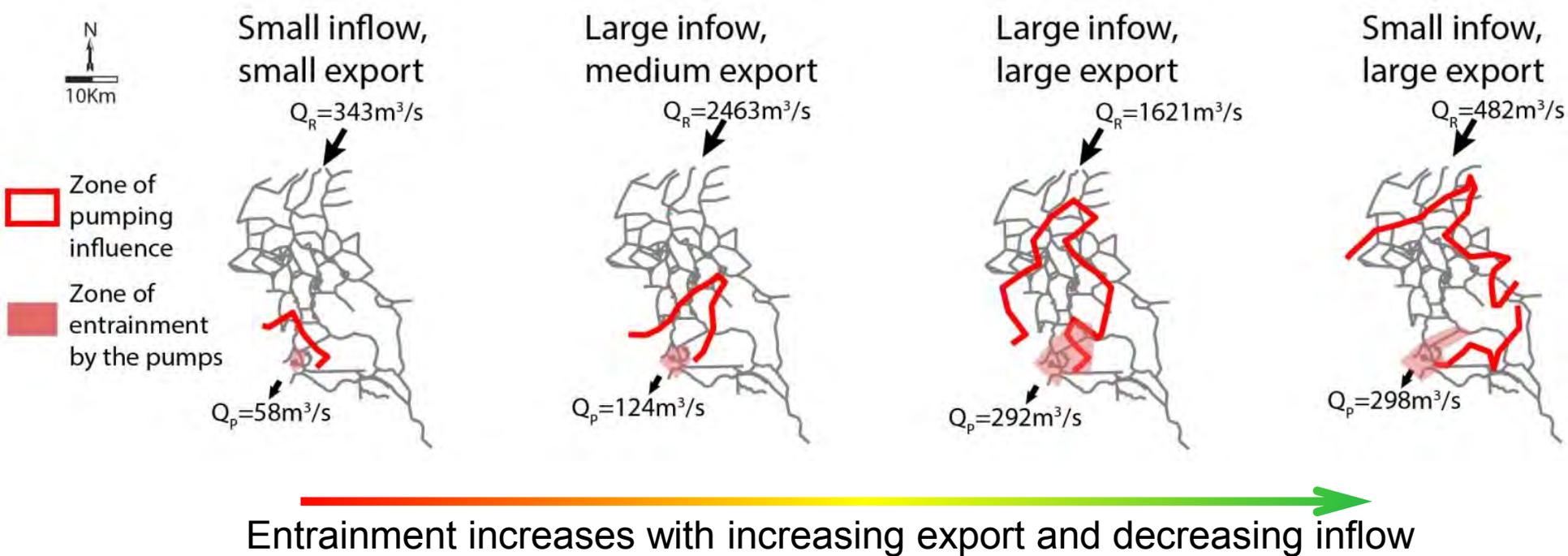


North Delta

9-Feb-2015 Release of JSATS Chinook Salmon



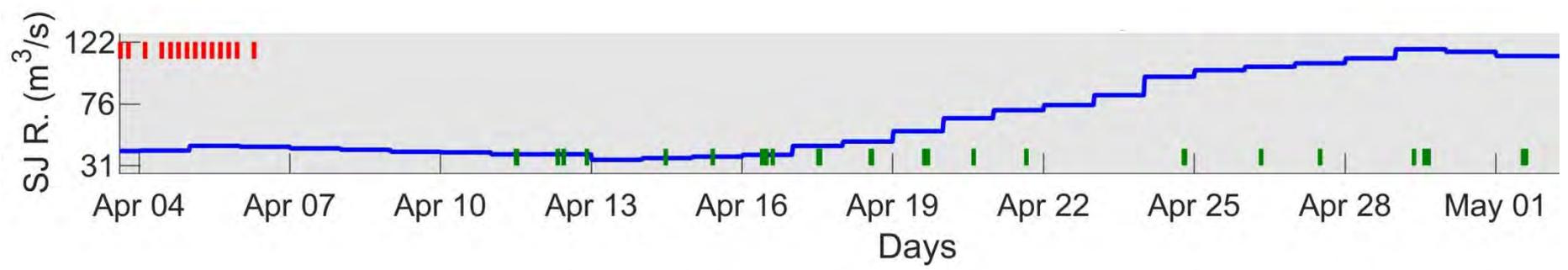
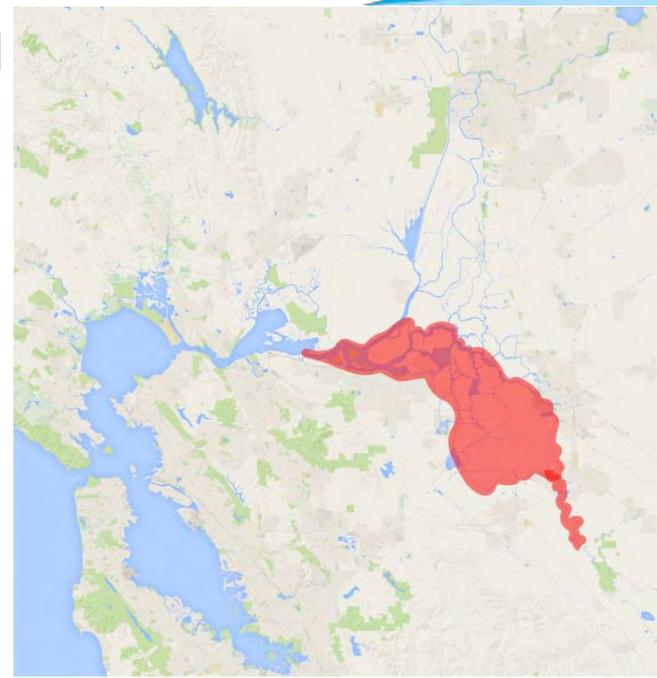
Effect of pumping on entrainment



South Delta: 3-Apr-2013 Release of VAMP steelhead

32 tagged fish detected

5000 ePTM fish released with release distribution of tagged fish at Durham Ferry

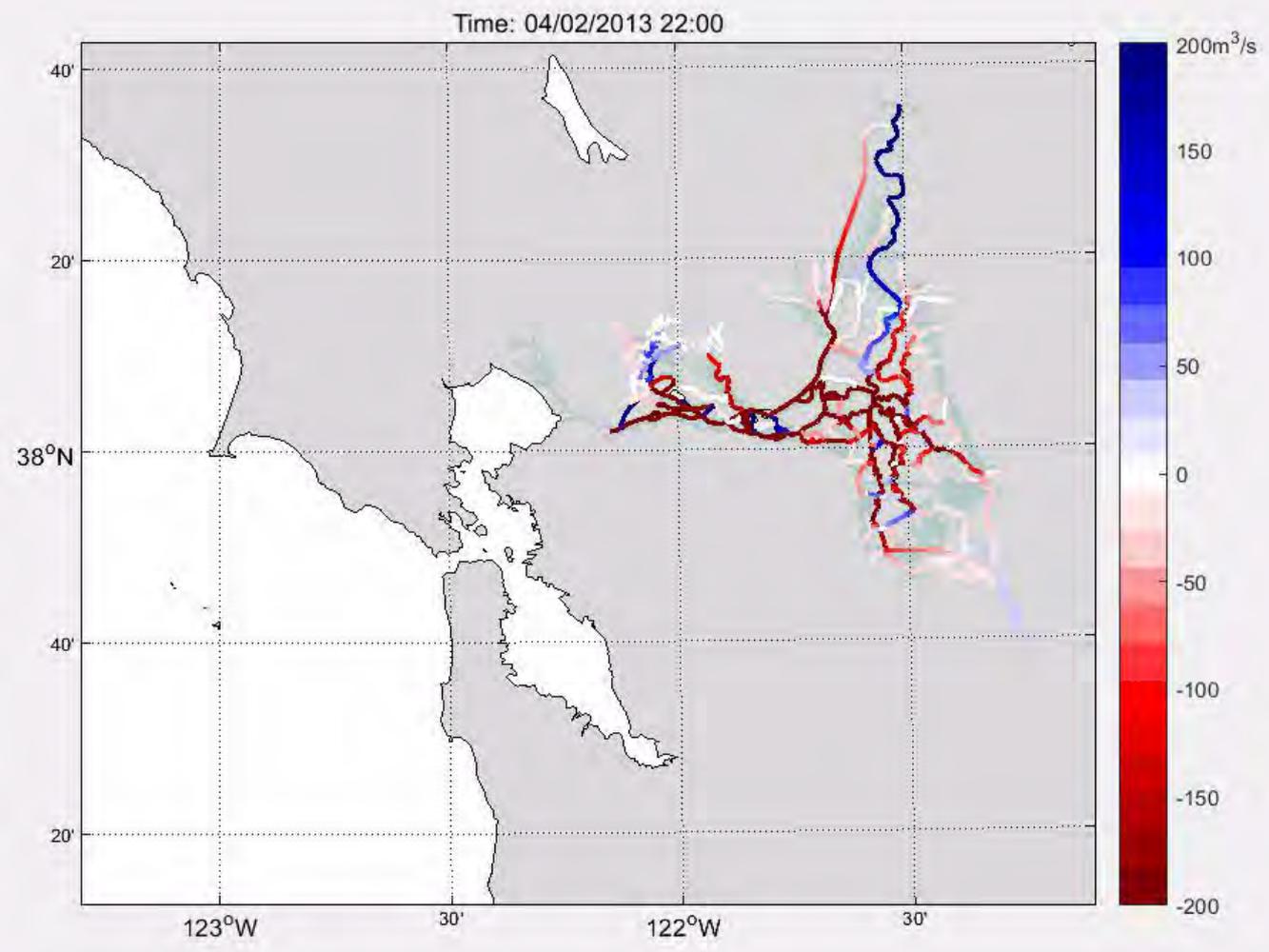




South Delta: 3-Apr-2013 Release of VAMP steelhead

 ePTM

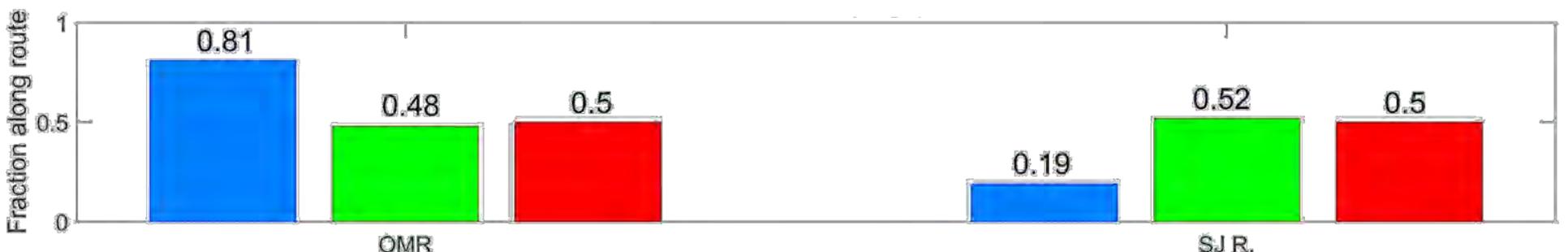
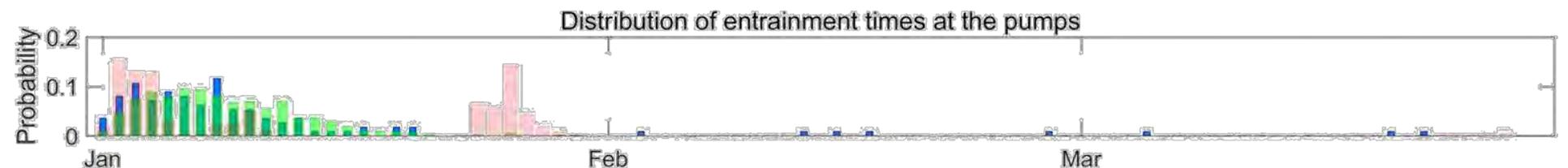
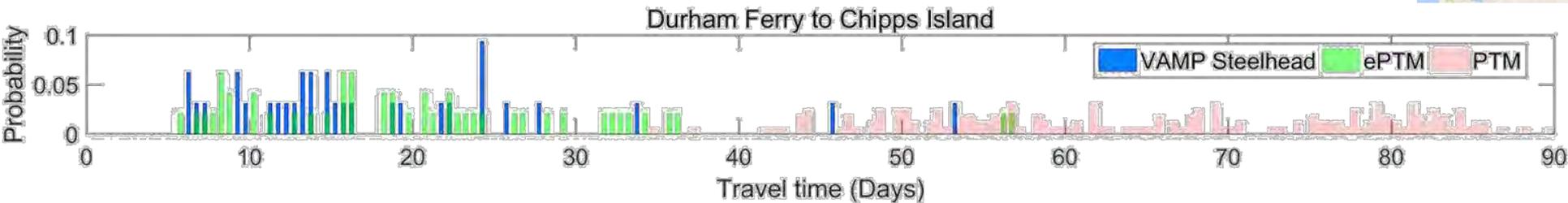
 PTM



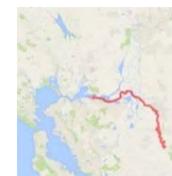


South Delta

3-Apr-2013 Release of VAMP steelhead



Migratory route







Status of ePTM

- Mechanisms are based on
 - acoustic tagging study observations
 - observed behaviors in similar species/systems
- Model sub-models and parameters estimates are completely data-driven
- Has a wide array of behaviors to choose from... lots of flexibility!

Does it get general trends right?



Does it indicate effects of various physical and biological drivers?

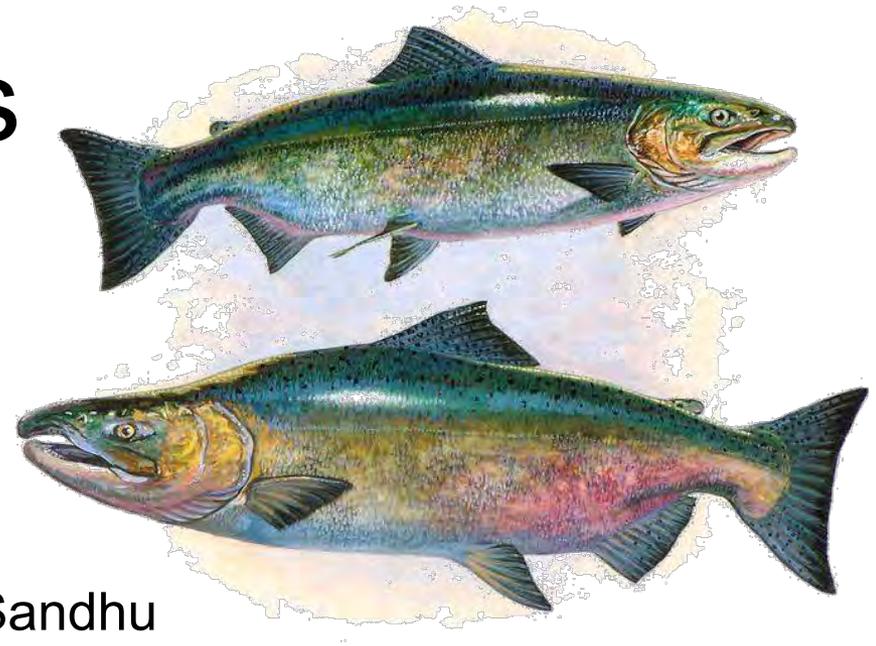


Putting it all together: ePTM performance

- Recovers survival vs flow relationship without explicit attribution
- Recovers migration rates reasonably well
- Models for predation and probability of mis-assessing the downstream direction impact survival in different ways
- Performs better than PTM on predicting travel times and arrival times at key locations
- Predicts routing through key junctions better than PTM
- Can provide a mechanism driven tool for understanding effects of water operations on salmon migration
- Fast, scalable and robust to out-of-sample hydrological and water operations events



Acknowledgements



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- Review: Ben Martin, Miles Daniels, Peter Dudley, Noble Hendrix

