Enhanced Particle Tracking Model (ePTM): Development & Pilot Application

NOAA FISHERIES
Southwest Fisheries Science Center
&
California Central Valley Area Office

Vamsi Krishna Sridharan (SWFSC) and Barbara Byrne (CCVAO)

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Questions to the Panel on ePTM

1. Does the panel have any suggestions on if and how model calibration could be improved?

2. How much does the spatial and temporal resolution of the model affect its application to physical and biological questions?

3. How useful is the current model as a basis for real-time operations decisions for assessing effects on listed salmonids?

4. Does the panel have any recommendations for additional work that will increase confidence in model output such as accounting for and reporting uncertainty?

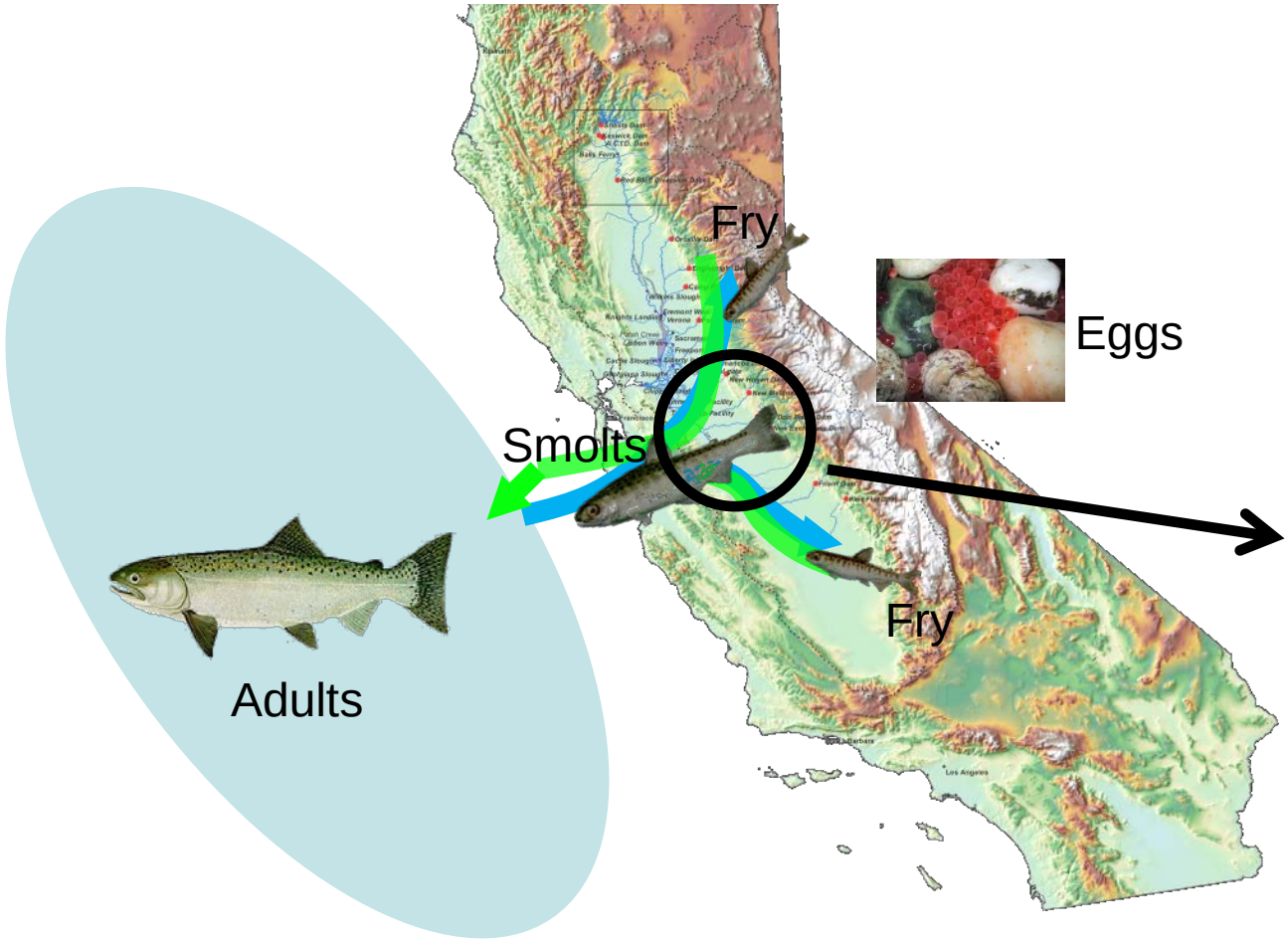
ePTM Model Development

Vamsi Krishna Sridharan, Southwest Fisheries Science Center (Santa Cruz, CA)

- Role of ePTM in Life Cycle Model
- ePTM description
- ePTM calibration
- Behavior parameters and spatial patterns
- ePTM validation
- Uses and on-going developments

Role of ePTM: Big picture

- Part of larger Central Valley Salmon Life Cycle Model
- Useful “what happened” and “what if” tool

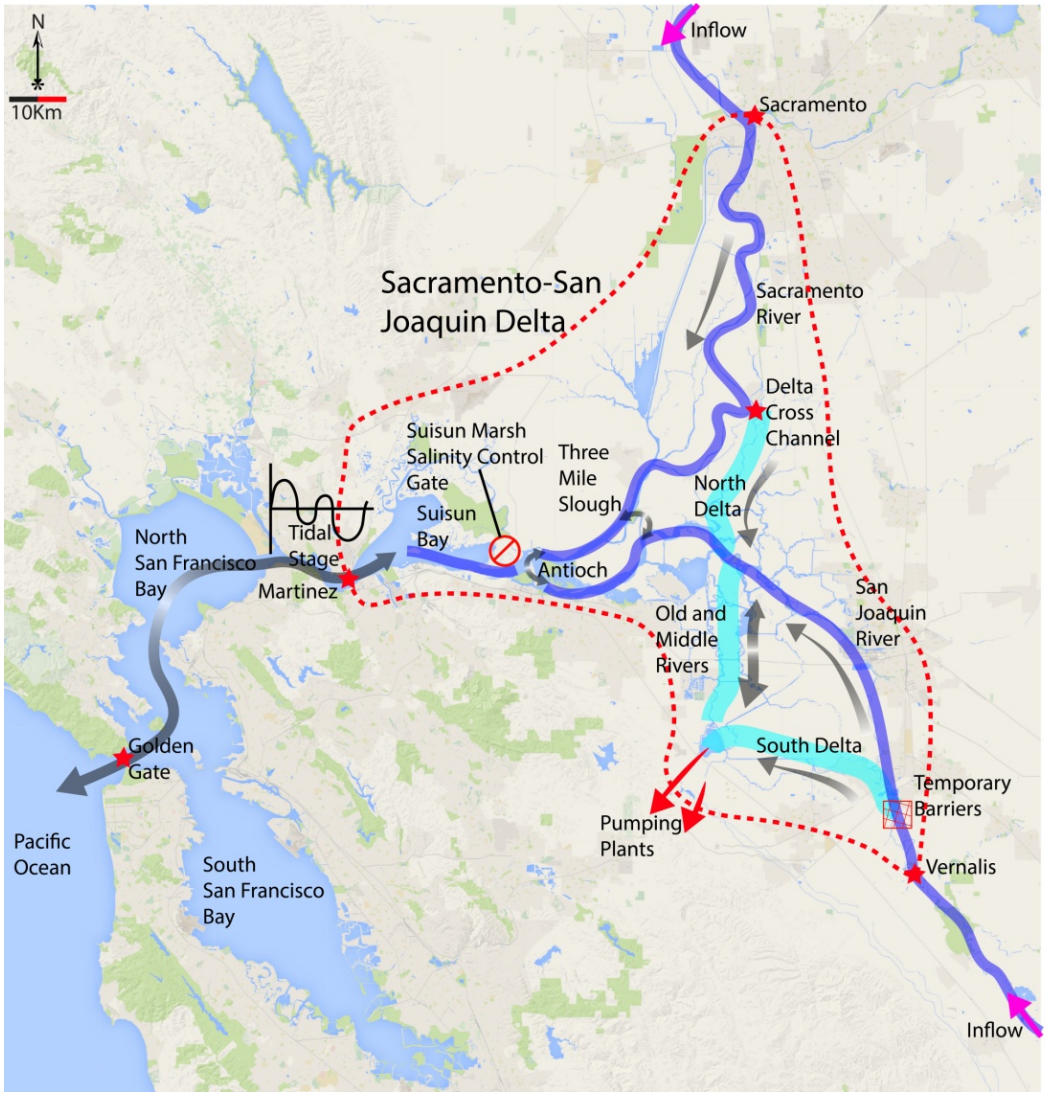


Delta elements include:
-- ePTM
-- habitat capacity

Role of ePTM: Tackling stressors

Multiple stressors:

- Flow regime management



Role of ePTM: Tackling stressors

Multiple stressors:

- Flow regime management
- Predation

Largemouth Bass

Smallmouth Bass

Striped Bass

Sacramento Pikeminnow

Green Sunfish

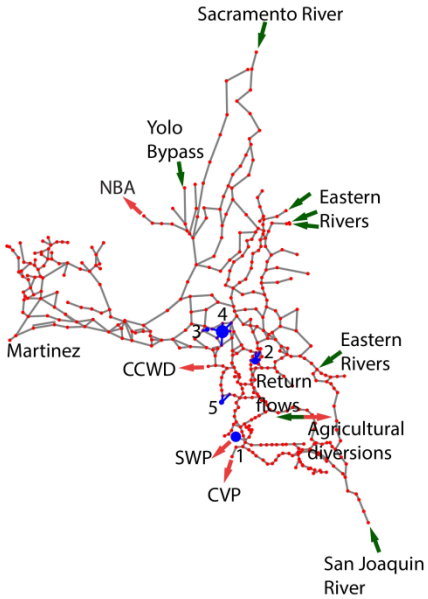
Crappie

Channel Catfish

White Catfish

ePTM description: Framework

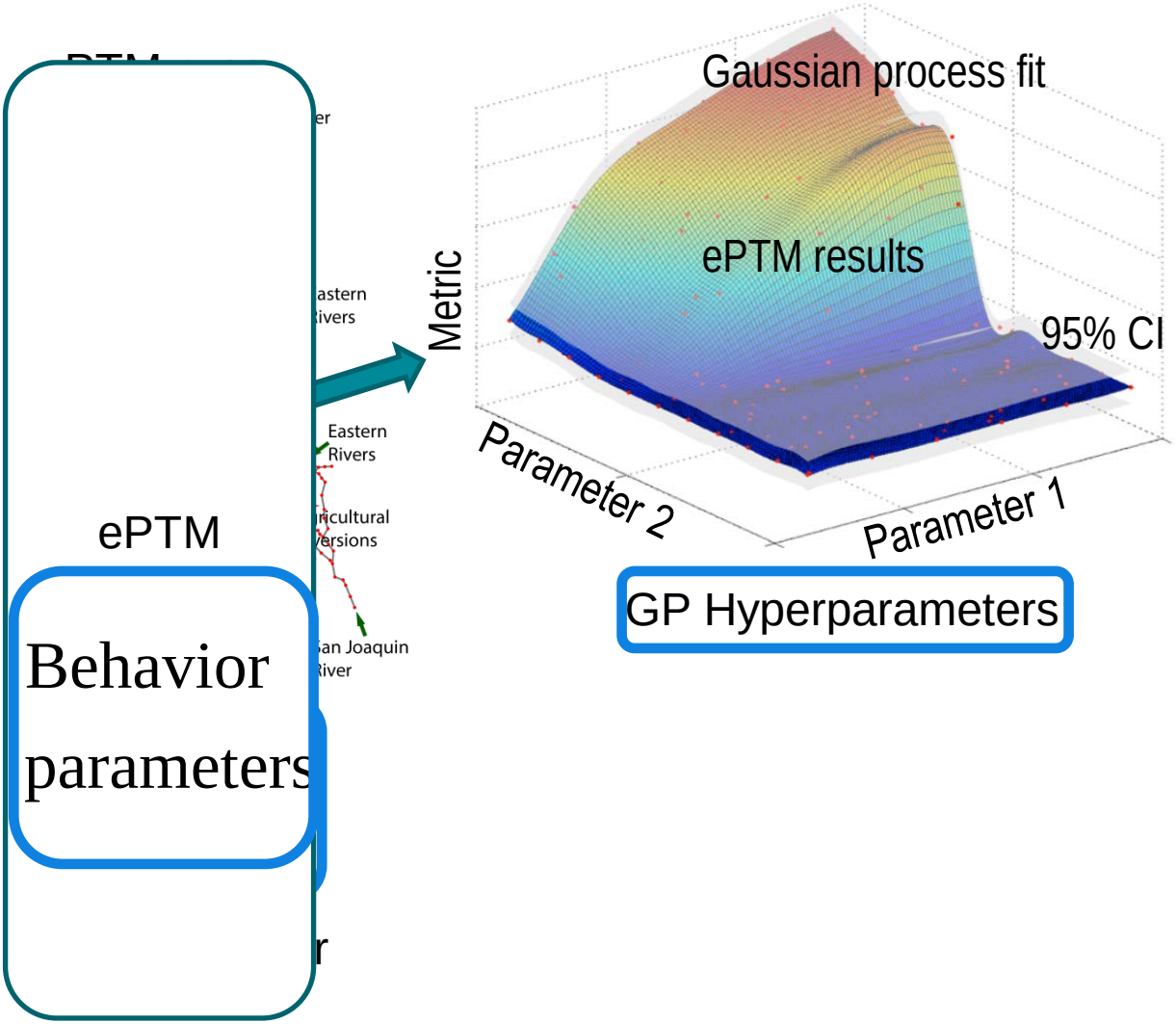
ePTM runs



$$V_{\text{SWIM}}, \lambda, \omega,$$
$$P_{\text{DAY SWIM}}$$

Other behavior

ePTM description: Framework



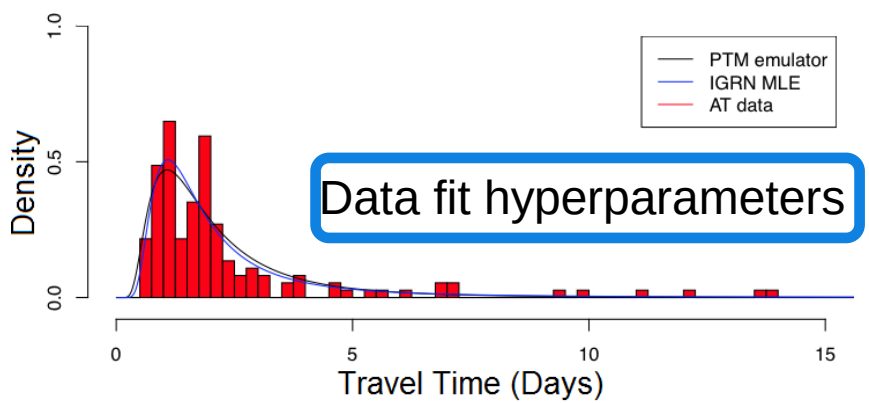
ePTM description: Framework

ePTM

Behavior parameters

ePTM Emulator

GP Hyperparameters



Data fit hyperparameters

ePTM description: Framework

ePTM

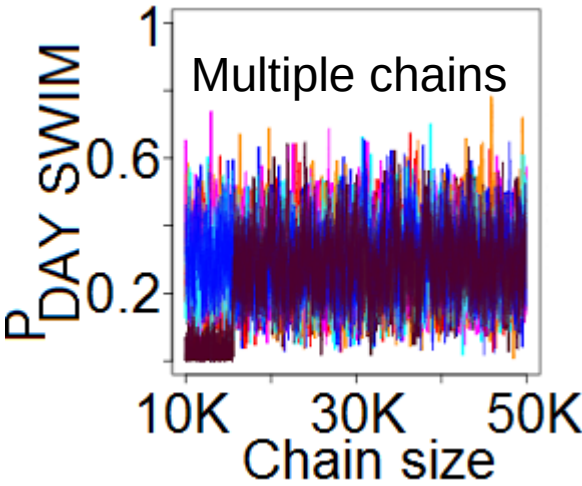
Behavior parameters

ePTM Emulator

GP Hyperparameters

Observations: Coded Wire Tag & Accoustic Telemetry

Data fit hyperparameters



ePTM description: Framework

ePTM

Behavior parameters

ePTM Emulator

GP Hyperparameters

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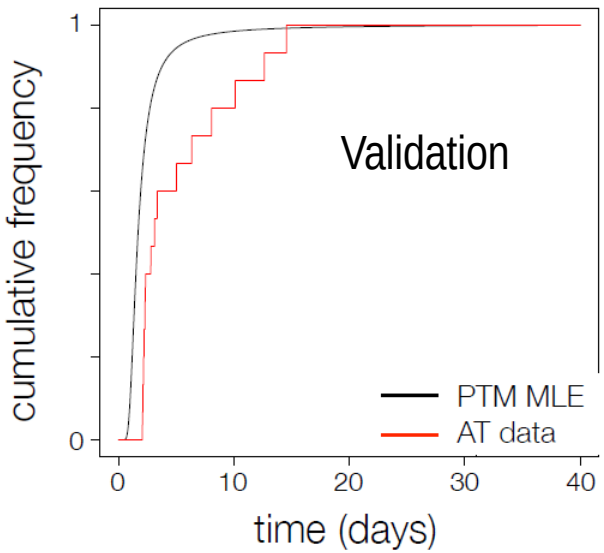
Observations: Coded Wire Tag & Accoustic Telemetry

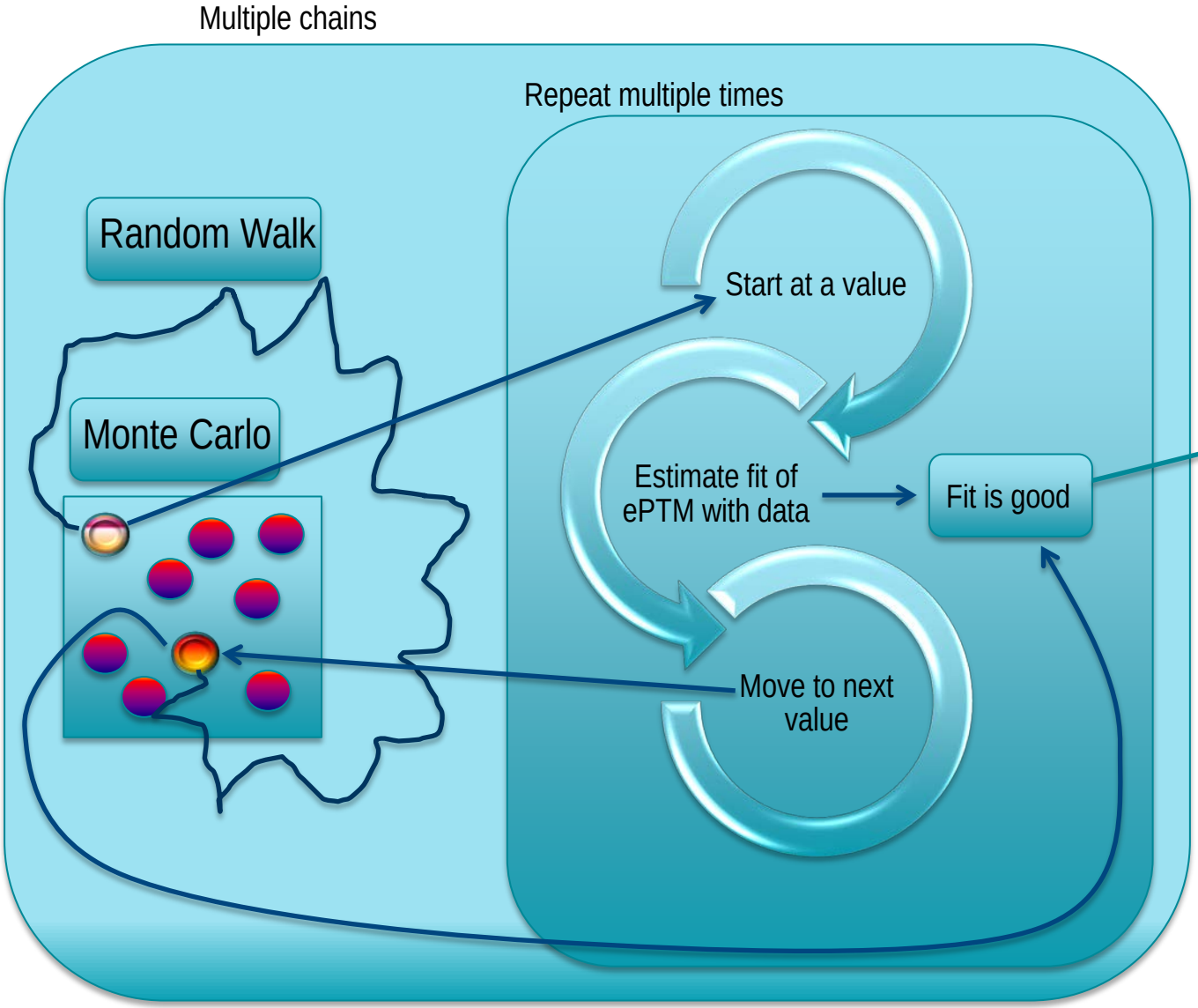
Data fit hyperparameters

Monte Carlo Markov Chain Calibration

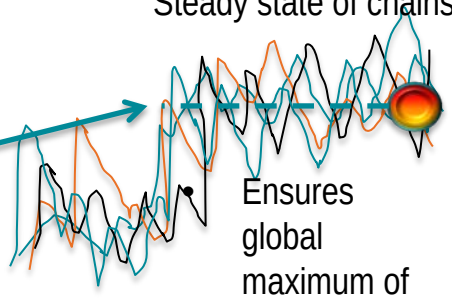


MCMC

For a behavior parameter:

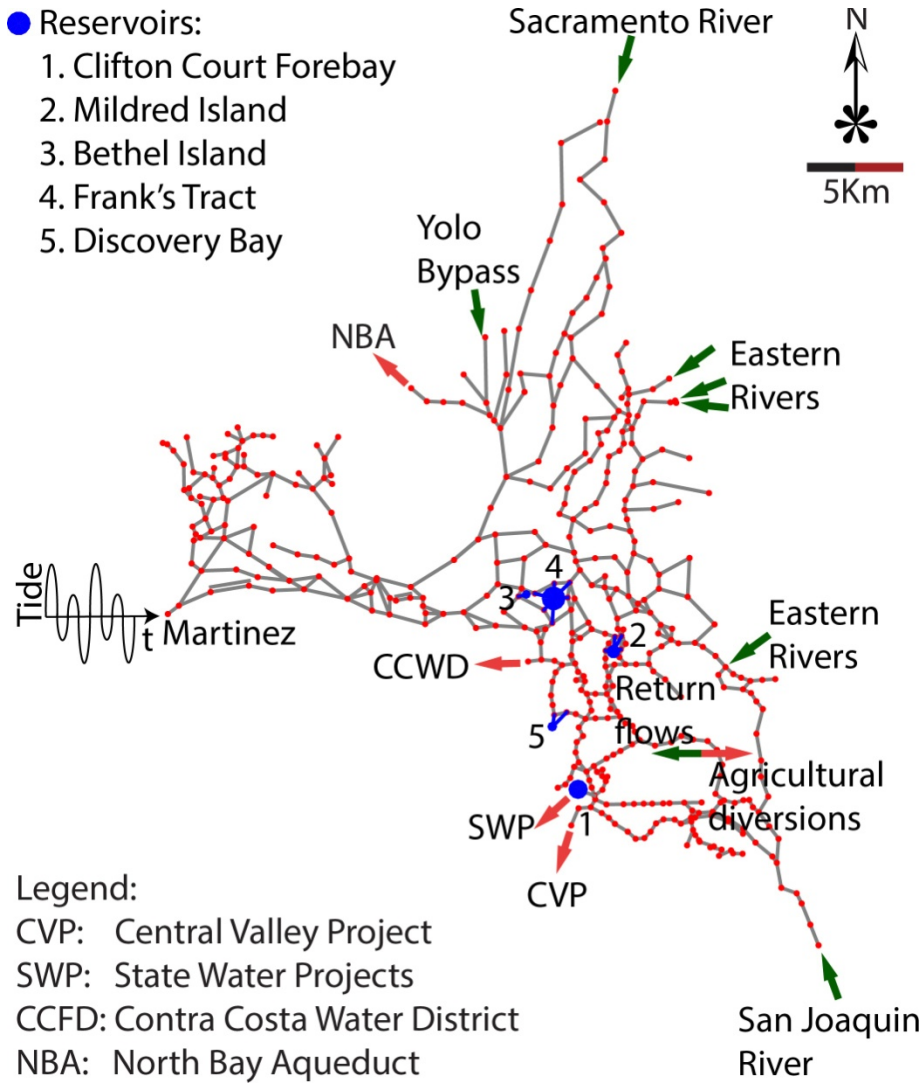


Steady state of chains



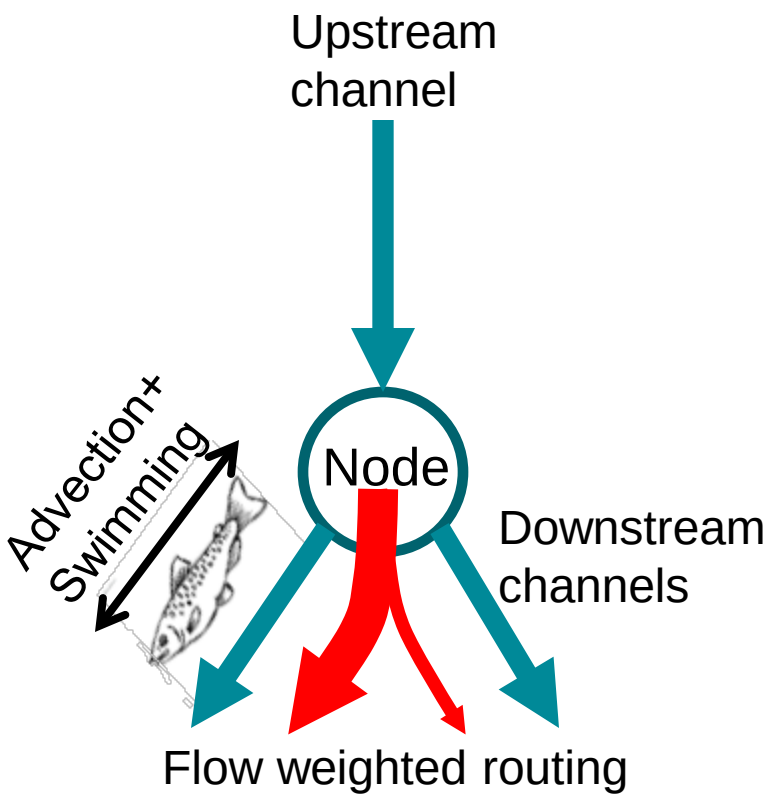
- Ensures global maximum of fit
- Ensures no co-dependencies
- Ensures unbiased sampling

ePTM description: Hydrodynamic model



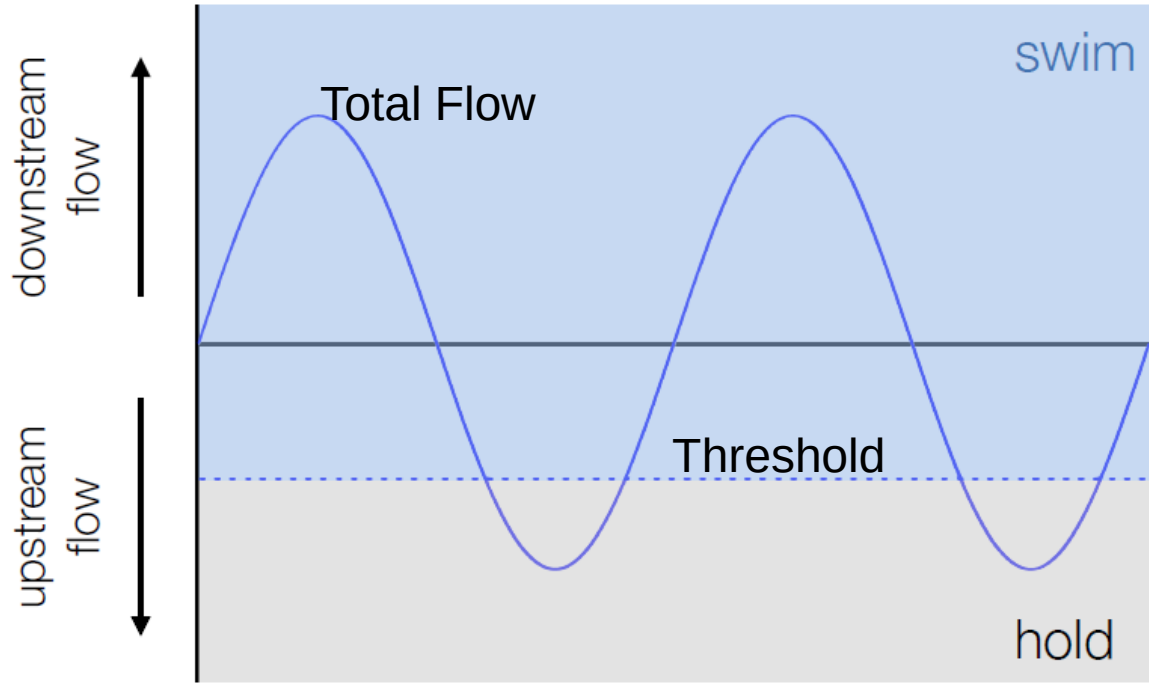
ePTM Description: Behavior dynamics

- Behavior
  - Swimming speed



ePTM Description: Behavior dynamics

- Behavior
  - Swimming speed
  - Temporal swimming pattern: selective tidal stream transport
  - Confusion

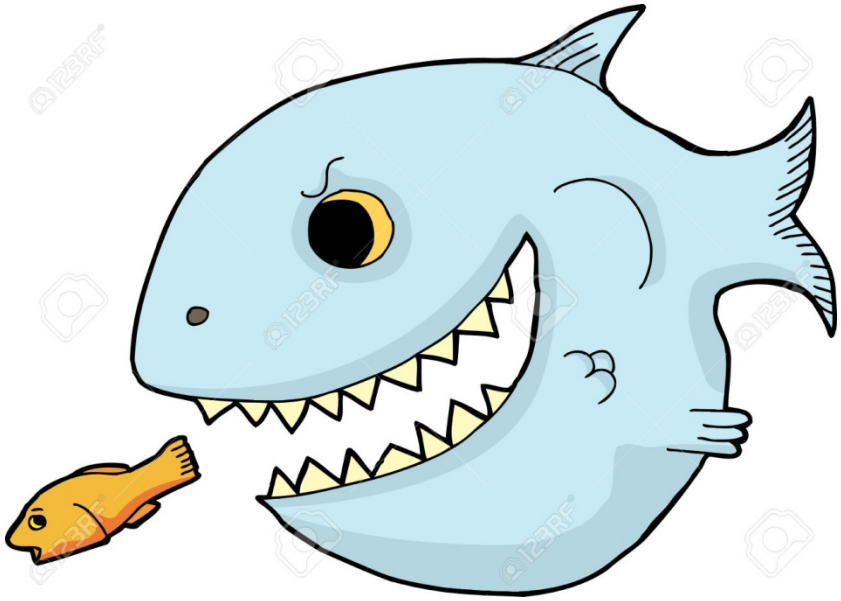


ePTM Description: Behavior dynamics

- Behavior
  - Swimming speed
  - Temporal swimming pattern
  - Confusion

- Mortality
  - Mean free travel path length
  - Predator encounter speed

XT predation model



Source: Anderson et al., 2005 (Ecol. Mod.)

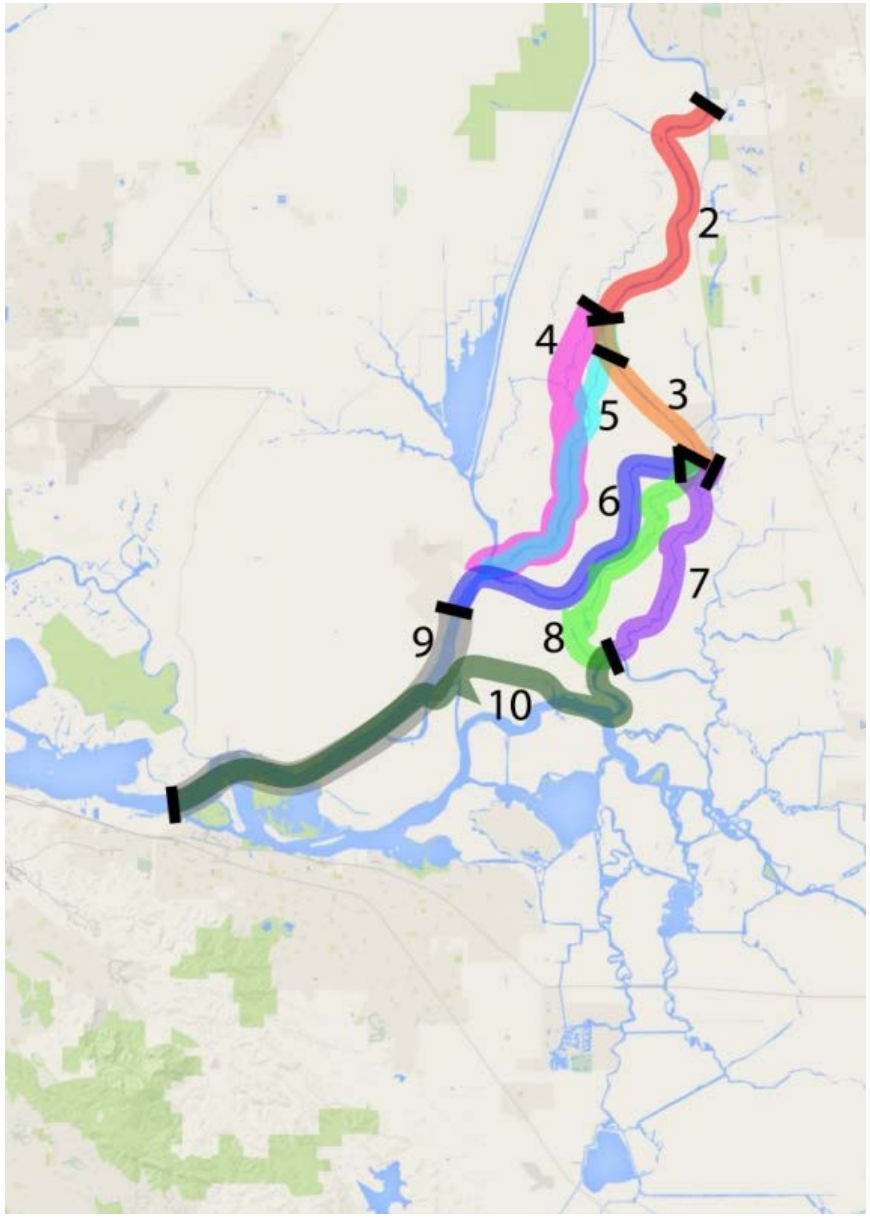
Calibration: Field data

- Coded-wire tag

Scenario	Release location	Release date	Number released	Survival fraction to Chipps Island	Number recovered at CVP	Number recovered at SWP
1	Discovery Park	1/16/2007	53,054	0.4	79	244
2	Ryde	1/18/2007	35,541	0.33	47	171
3	Ryde	12/9/2005	50,036	0.52	12	3
4	Sherman Island	12/12/2005	24,365	1.17*	0	0
5	Ryde	12/9/2004	49,515	0.6	0	0
6	Sherman Island	12/10/2004	24,148	0.65	0	0
7	Ryde	12/6/2002	49,629	0.4	24	18
8	Georgiana Slough	1/3/2002	77,053	0.22	96	294
9	Ryde	1/5/2002	52,864	0.71	12	6
10	Isleton	12/11/1999	53,426	0.34	0	0
11	Georgiana Slough	12/20/1999	64,515	0.35	60	22
12	Isleton	12/21/1999	49,089	0.53	0	4
13	Georgiana Slough	12/1/1998	69,180	0.18	12	16
14	Ryde	12/2/1998	48,207	0.74	0	0
15	Georgiana Slough	12/29/1998	68,492	0.27	24	24
16	Ryde	12/30/1998	48,549	0.38	0	0
17	Ryde	12/5/1997	46,756	0.67	0	18
18	Georgiana Slough	1/13/1998	66,893	0.26	24	0
19	Ryde	1/14/1998	49,059	0.94	0	0
20	Miller Park	12/2/1996	50,437	0.37	0	6
21	Miller Park	1/14/1997	43,241	0.25	0	0
22	Ryde	1/11/1996	30,281	0.67	12	0
23	Isleton	12/5/1994	30,220	0.57	0	6
24	Isleton	1/5/1995	31,557	0.39	48	183

Calibration: Field data

- Coded-wire tag
- Acoustic-telemetry



Calibration: Workflow

PTM emulation

- Span parameter space
- Prepare best fit surfaces

Field observations

- Model metrics using mark-recapture model
- Use emulated metrics to fit observation metrics

MCMC

- Estimate MLE for range of sampled emulator output metrics that match observed metrics
- Pick MLE parameter set

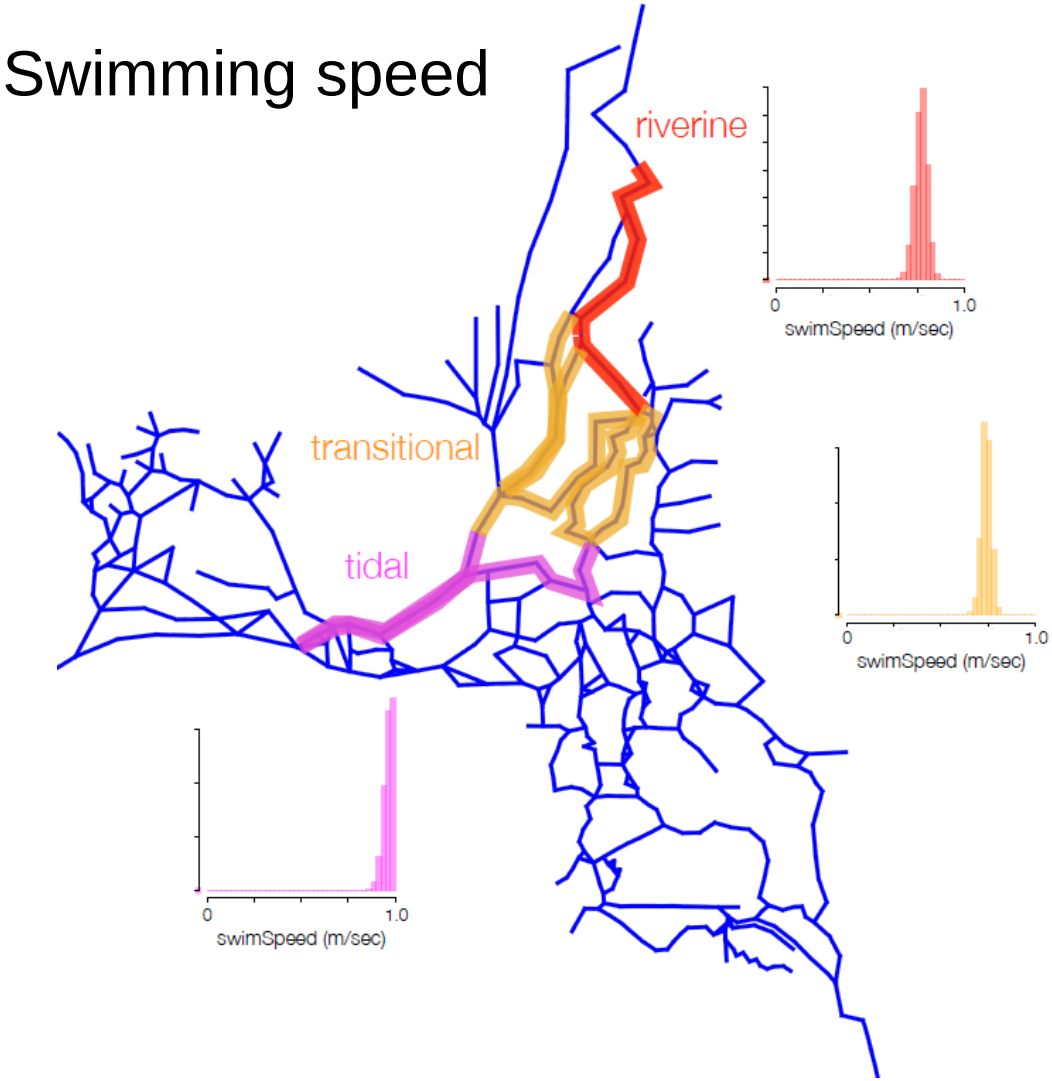
Behavior parameters

- Swimming, predation and mortality

Parameter	Description	Values
swimSpeed	Active swimming speed (m/s)	Variable
holdThr	Upstream flow velocity (m/s)	Variable
constProbConfusion	Logistic regression constant (-)	Variable
slopeProbConfusion	Logistic regression slope (-)	-0.25
probAsses	Probability of assessment of downstream direction (Timestep^{-1})	0.01
tideCountThr	Flow direction update frequency (cpd)	2
λ	Mean free path (Km)	Variable
ω	Random movement speed (cm/s)	Variable

Behavior parameters

- Spatial variability



Behavior parameters

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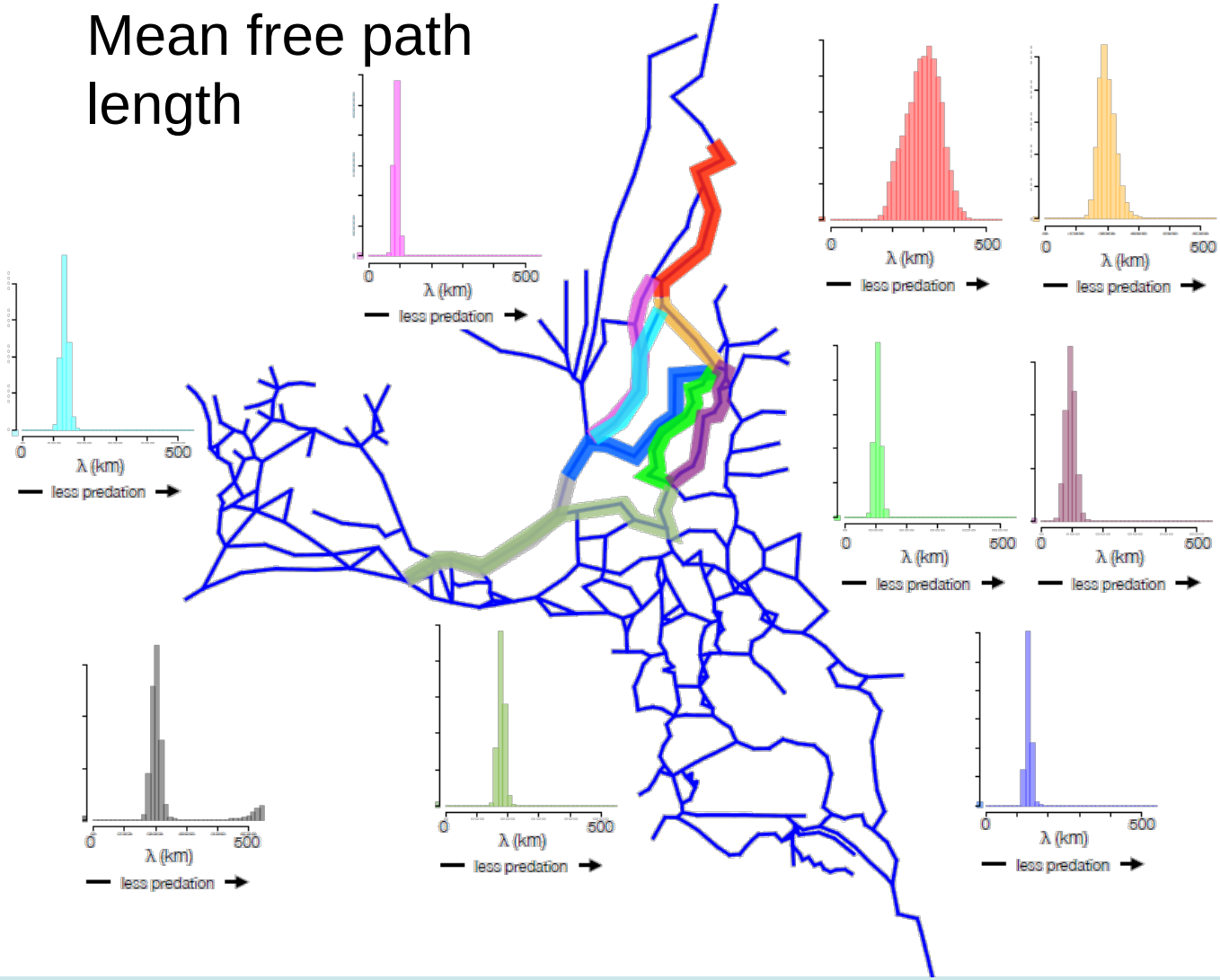
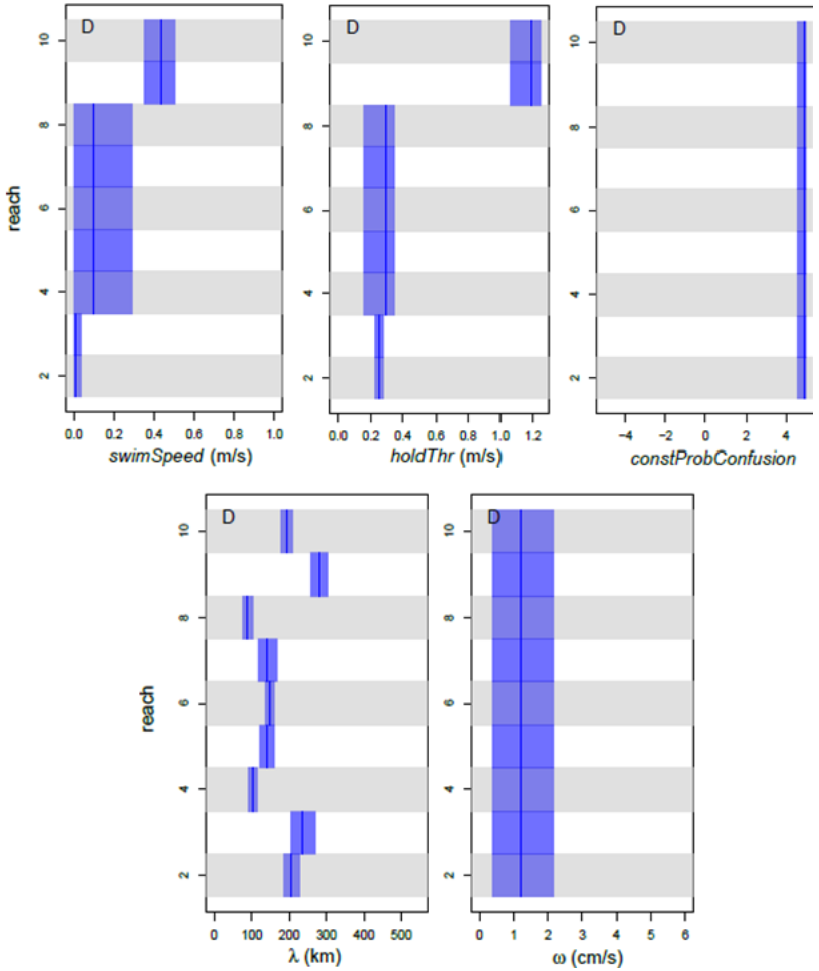


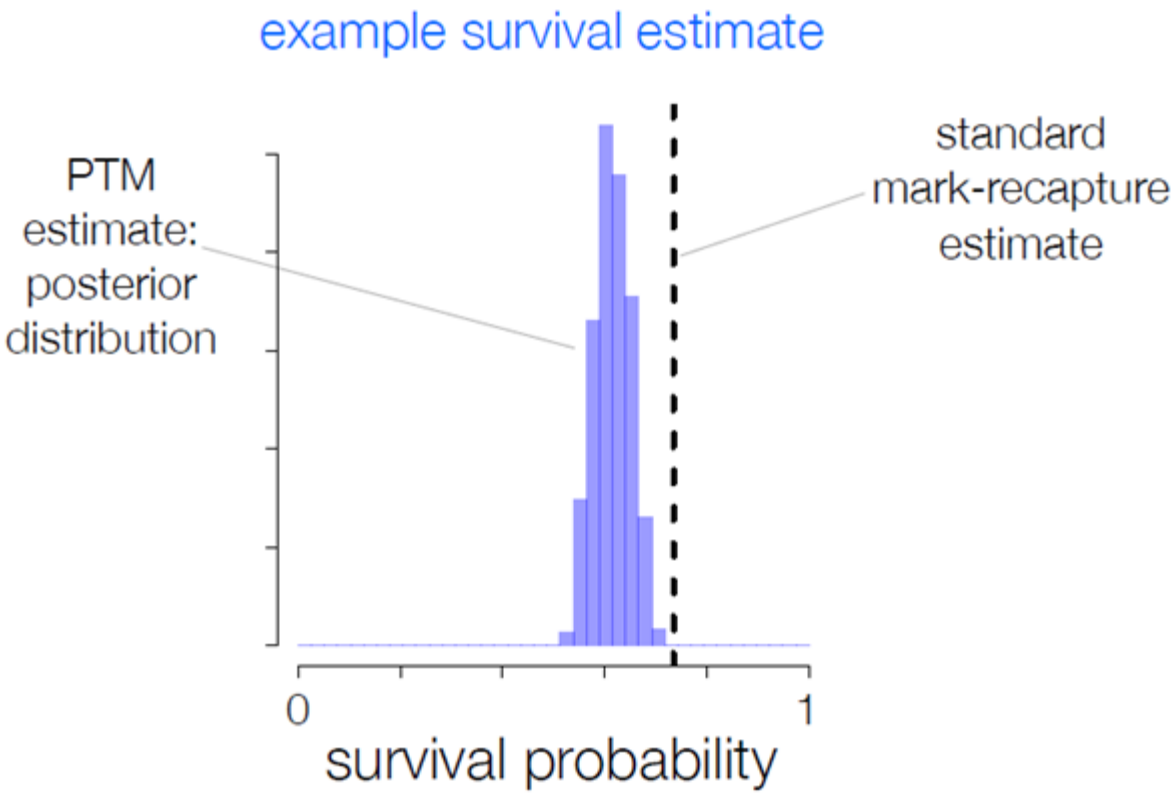
Behavior parameters

- Realistic expected values



Validation

- Survival probability at Chipps Island



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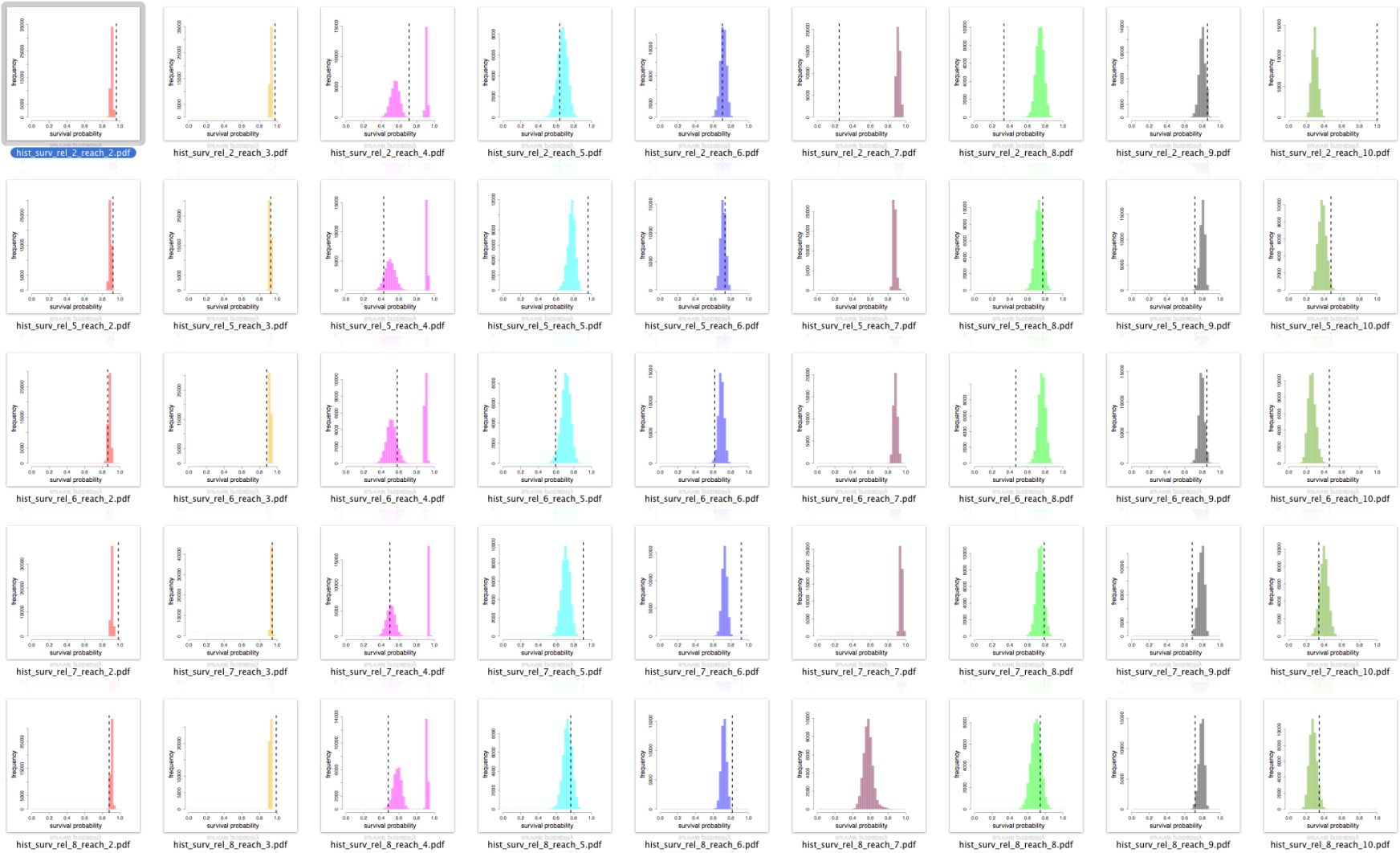
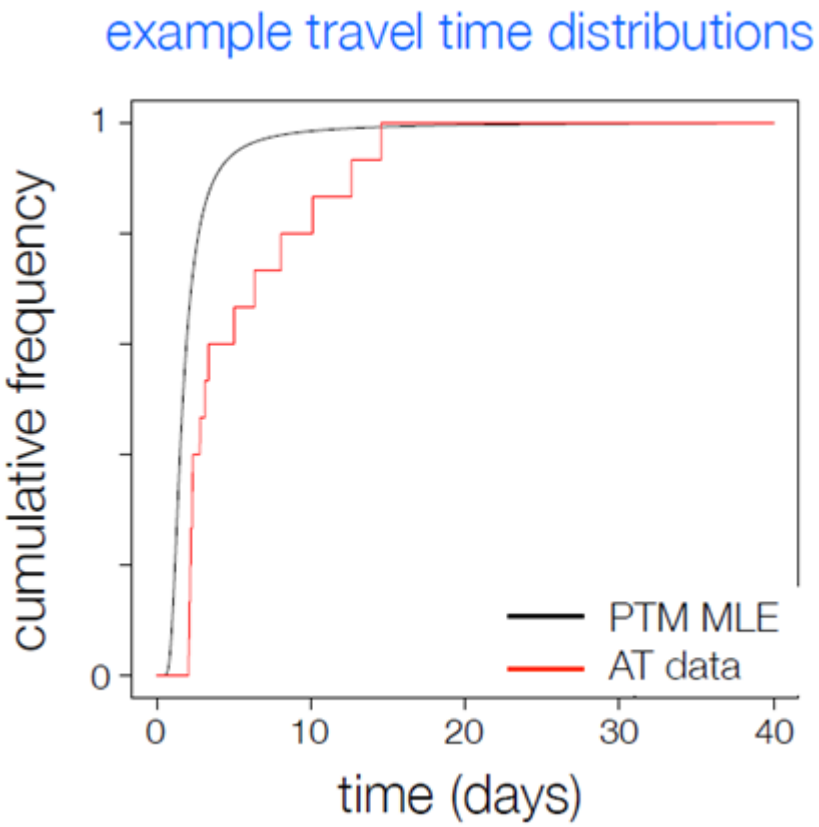


Validation

- Travel time to Chipps Island



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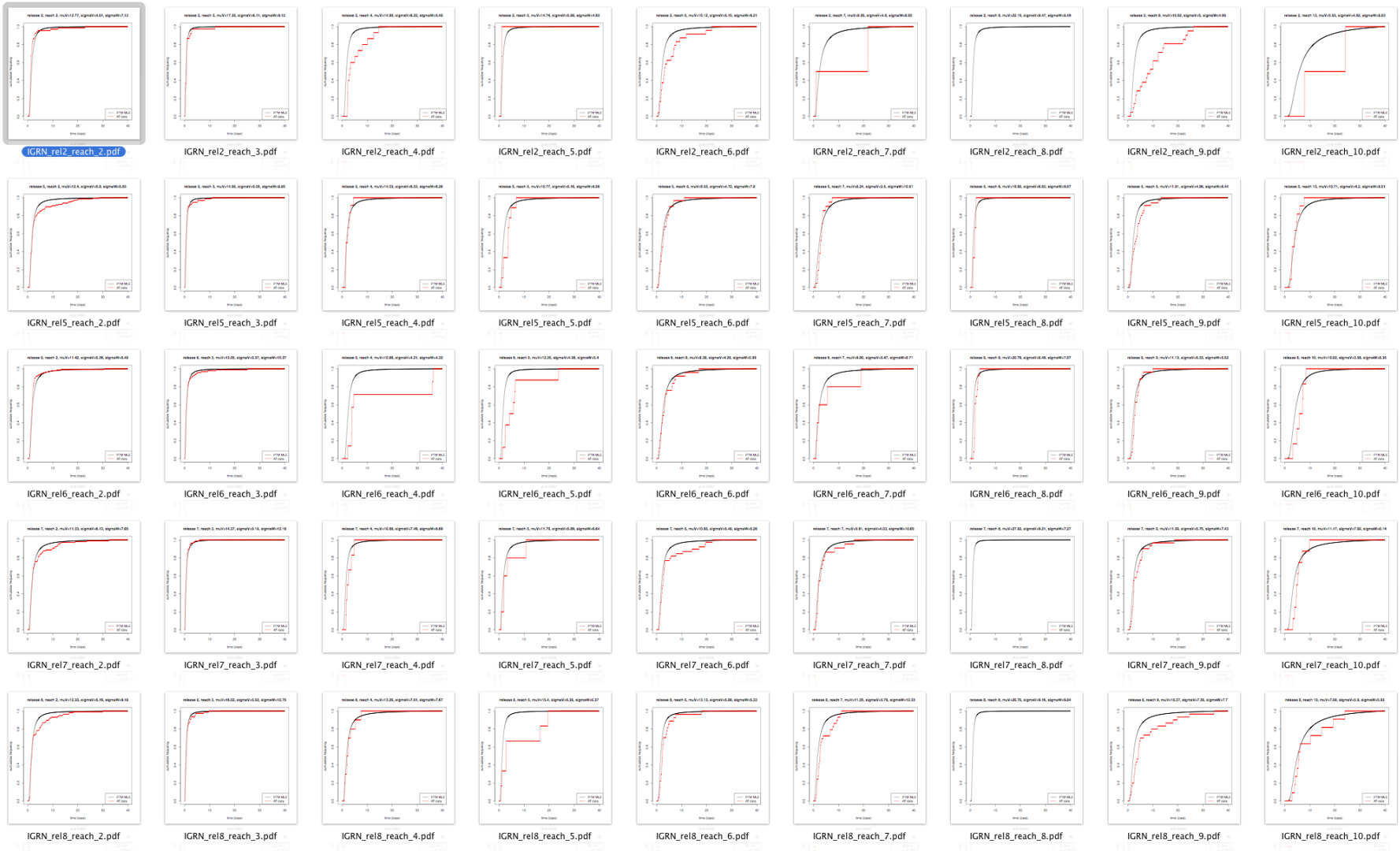
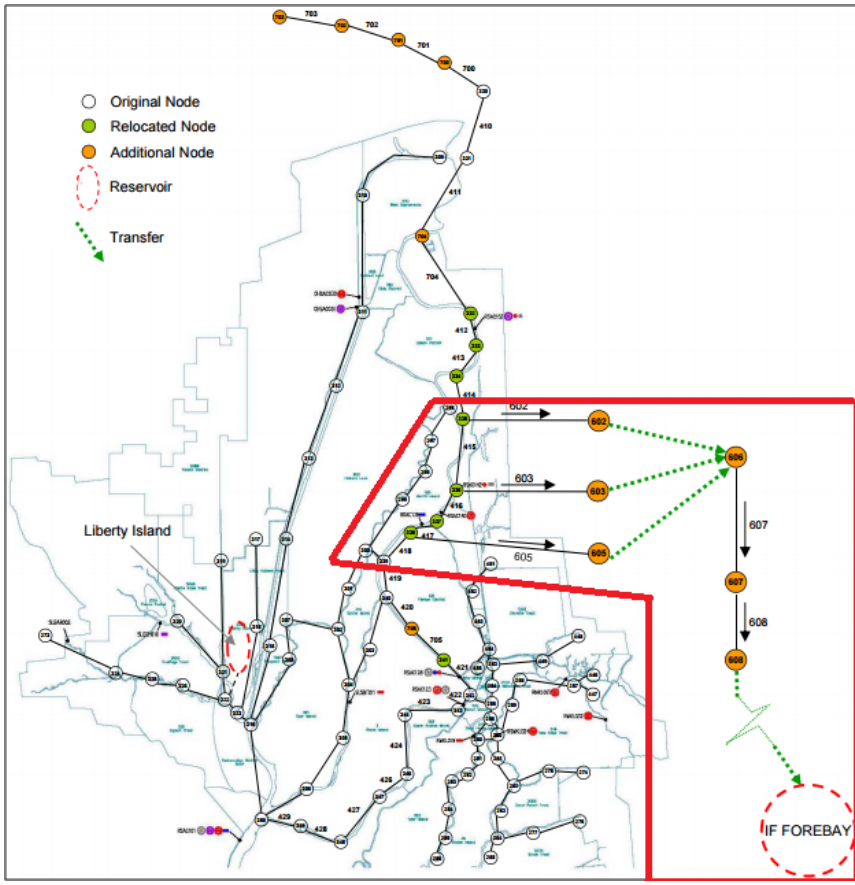


Applications and on-going developments

- Applications
  - *Long Term planning*:
    - Alternative water use scenarios
    - Climate change
    - Species population dynamics and survival



Applications and on-going developments

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  - *Short term operations*:
    - Gate and barrier operations
    - Flow routing

Applications and on-going developments

- Applications
  - *Long Term planning*:
    - Alternative water use scenarios
    - Climate change
    - Species population dynamics and survival
  - *Short term operations*:
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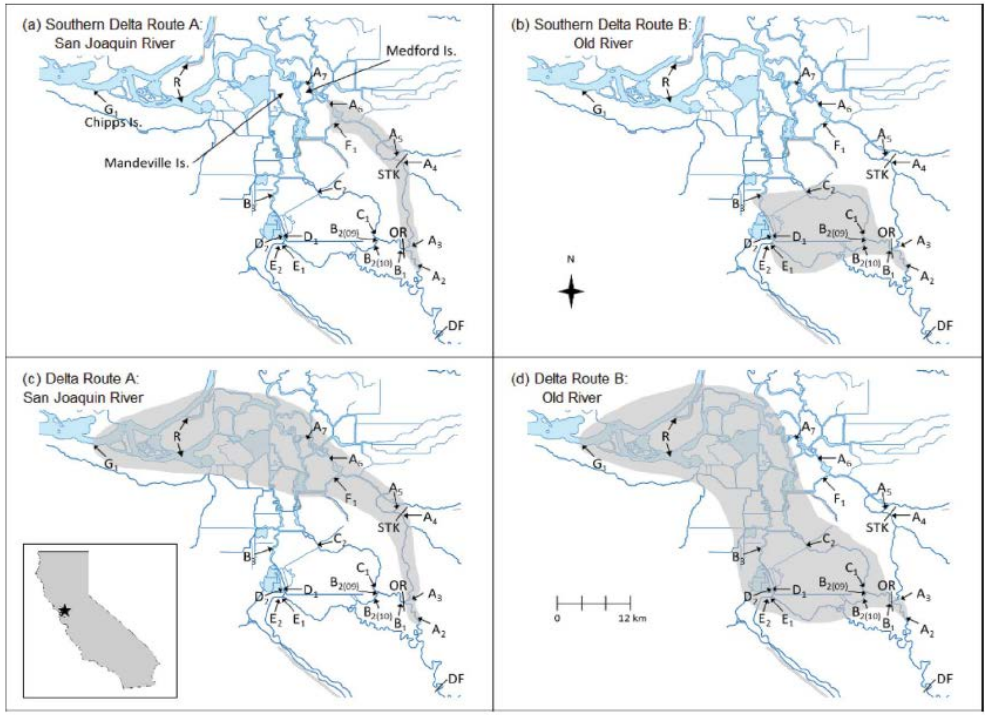
    - Flow routing
- On-going developments
  - Improved calibration
  - Extended parameter set
  - Improved physics
  - Expanding to the entire Delta



ePTM Pilot Application

Barb Byrne, California Central Valley Area Office (Sacramento, CA)

- Pilot Application objective
- Example 1: Old & Middle River flow flexibility during February 2015
- Example 2: Drought operations during April and May, 2015

Pilot Application Objective

the same time. Real-time acoustic receivers will be deployed along the Sacramento River and Delta at various locations. DOSS will review the real-time acoustic tag data to determine the likely timing and distribution of the hatchery winter-run in the Sacramento River and into the Delta, and advise NMFS and Water Operations Management Team (WOMT) of potential risk of hatchery winter-run to the influences of the hydrodynamic effects of increased exports during the sporadic storm events. Beginning in March 2015, enhanced Particle Tracking Model (PTM) modeling will also be utilized to inform real time OMR limits and in consideration of any requests for flexibility in OMR flow management.

"dry run" only during WY 2015

2015 Drought Strategy available online at: http://www.ca.gov/Drought/pdf/Interagency-2015-Drought-Strategy_12-11-14.pdf

ePTM Pilot Application process

DAYS 1-3	**Task:** Draft ops & ePTM scenarios **Who:** Relevant agencies, DOSS	**Task:** Hydrology forecast **Who:** DWR
DAYS 4-8	**Task:** Review scenarios **Who:** relevant agencies, DOSS	**Task:** Generate final DSM2 files **Who:** DWR

ePTM Pilot Application process

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These steps will likely occur even if no ePTM is planned.

ePTM Pilot Application process

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DAYS 9-10	Task: Run DSM2 Hydro and Qual modules Who: NMFS	Task: Configure ePTM files for particle insertion location and timing Who: NMFS
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DAYS 12-14	Task: Process ePTM results Who: NMFS	

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Thanks to: Tracy Hinojosa, James Edwards, & Dan Yamanaka

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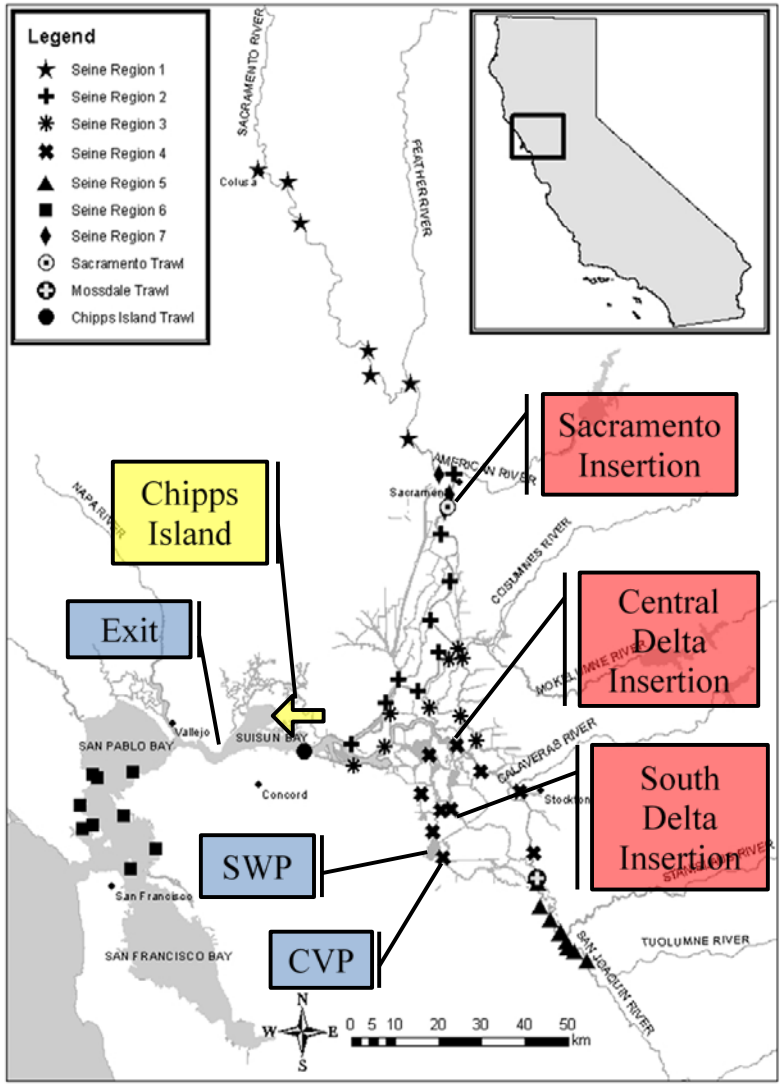
Thanks to: Cathy Marcinkevage, Doug Jackson, Evan Sawyer, & Meiling Roddam

Example 1: OMR Flexibility – *ops scenario*

- 5 days with daily OMR more negative than -5,000 cfs

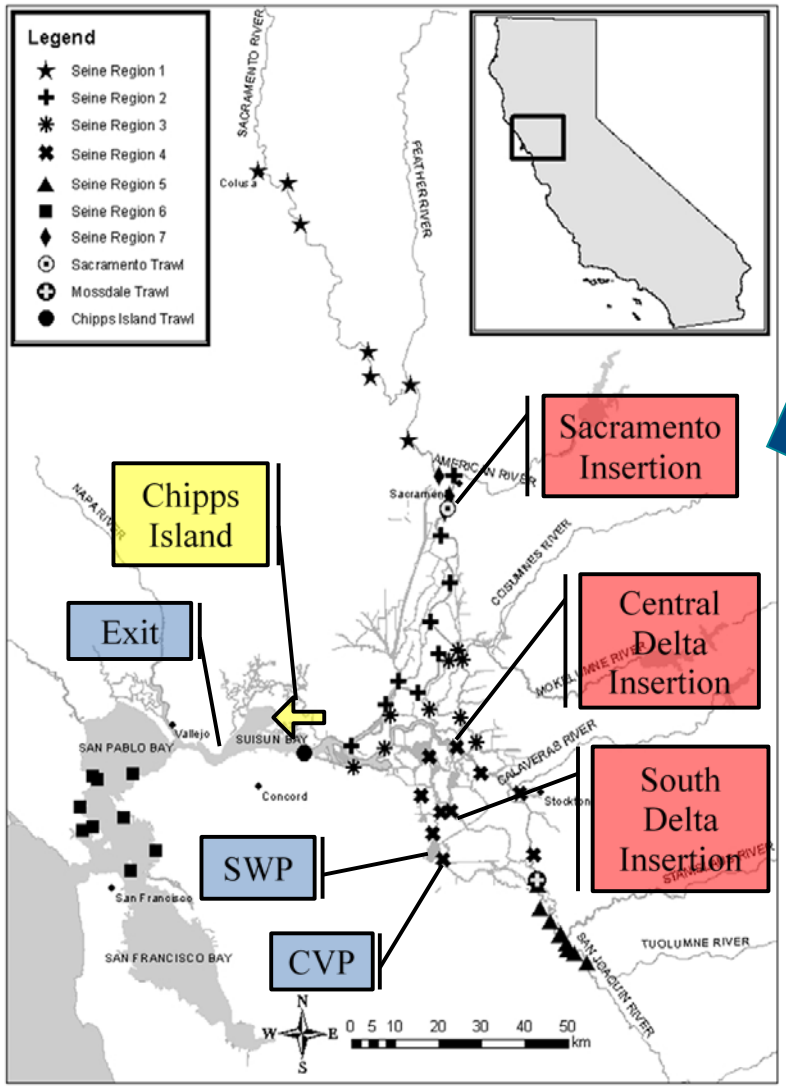
			Baseline			Proposed Action		
Date	Freeport Flow (cfs)	Vernalis Flow (cfs)	Outflow (cfs)	Combined Exports (cfs)	OMR	Outflow (cfs)	Combined Exports (cfs)	OMR
6-Feb	9,543	890	7,219	2,575	~-2000	7,219	2,575	~-2000
7-Feb	10,640	870	11,238	4,075	-3,500	11,238	4,075	-3,500
8-Feb	22,738	940	14,421	5,175	-4,500	14,421	5,175	-4,500
9-Feb	48,840	1,230	33,223	5,775	-5,000	33,223	5,775	-5,000
10-Feb	54,900	2,590	62,620	6,000	-5,000	62,620	6,000	-5,000
11-Feb	53,900	2,500	65,480	6,500	-5,000	65,480	6,500	-5,000
12-Feb	52,900	2,400	57,685	6,600	-5,000	56,285	8,000	-6,250
13-Feb	49,900	2,300	54,344	6,500	-5,000	52,944	7,900	-6,250
14-Feb	46,900	2,200	45,980	6,500	-5,000	44,630	7,850	-6,250
15-Feb	43,900	2,100	42,560	6,400	-5,000	41,135	7,825	-6,250
16-Feb	40,900	2,000	39,360	6,400	-5,000	37,960	7,800	-6,250
17-Feb	37,900	1,900	36,310	6,300	-5,000	36,310	6,300	-5,000
18-Feb	34,900	1,800	33,210	6,300	-5,000	33,210	6,300	-5,000
19-Feb	31,900	1,700	30,110	6,300	-5,000	30,110	6,300	-5,000

Example 1: OMR Flexibility – *ePTM scenario*



- **NMFS Species focus:** winter-run Chinook
- **Insertion points:** Sacramento, Central Delta & South Delta
- **Outputs:** e-Particle fates, Chipps flux, & mortality
- **Scenarios:** Baseline and OMR Flex
- **Duration:** ~3 weeks (Feb 11-March 2)

Example 1: OMR Flexibility – *ePTM scenario*



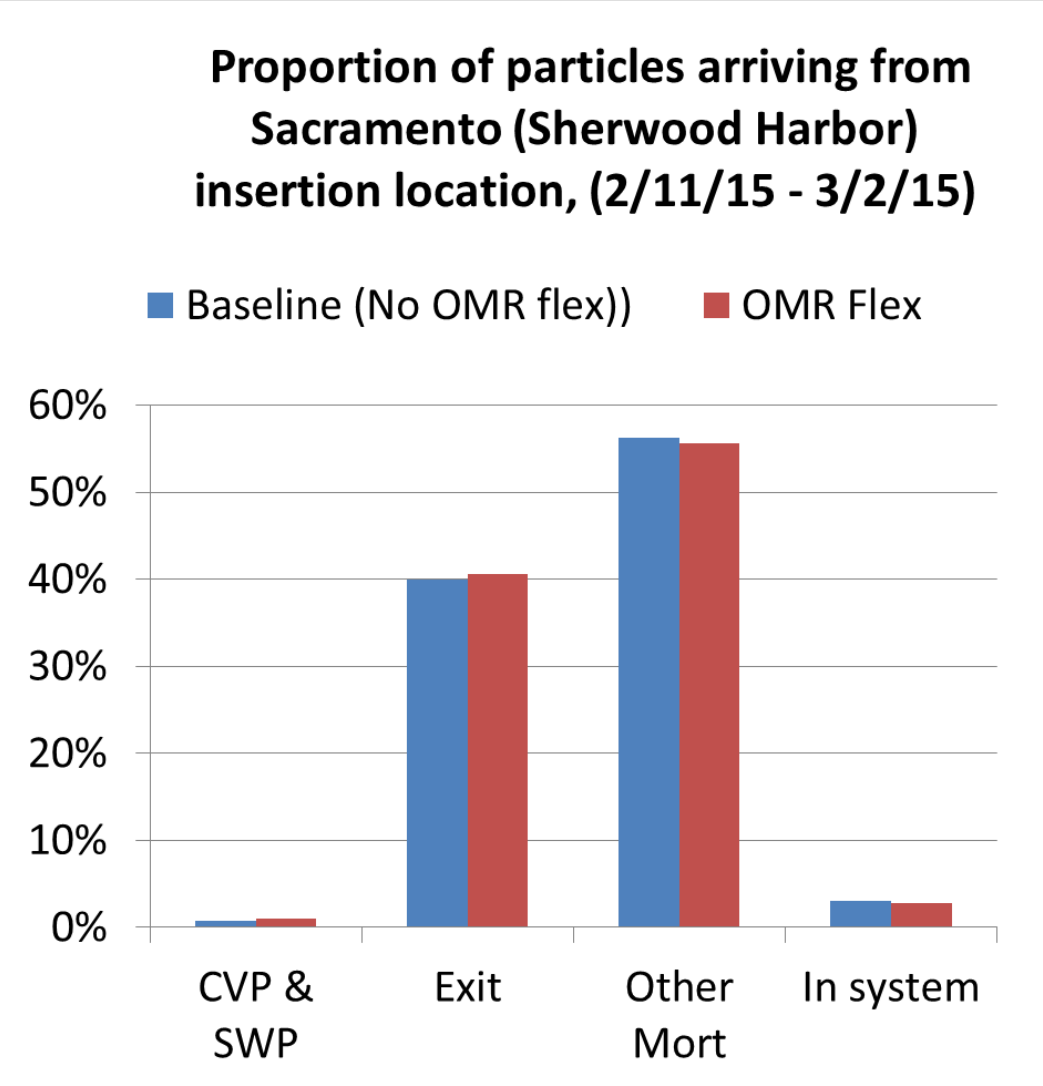
Monitoring linkages:

Sherwood Harbor Trawl

Prisoners Point Trawl

Middle River acoustic receiver

Example 1: OMR Flexibility -- *results*



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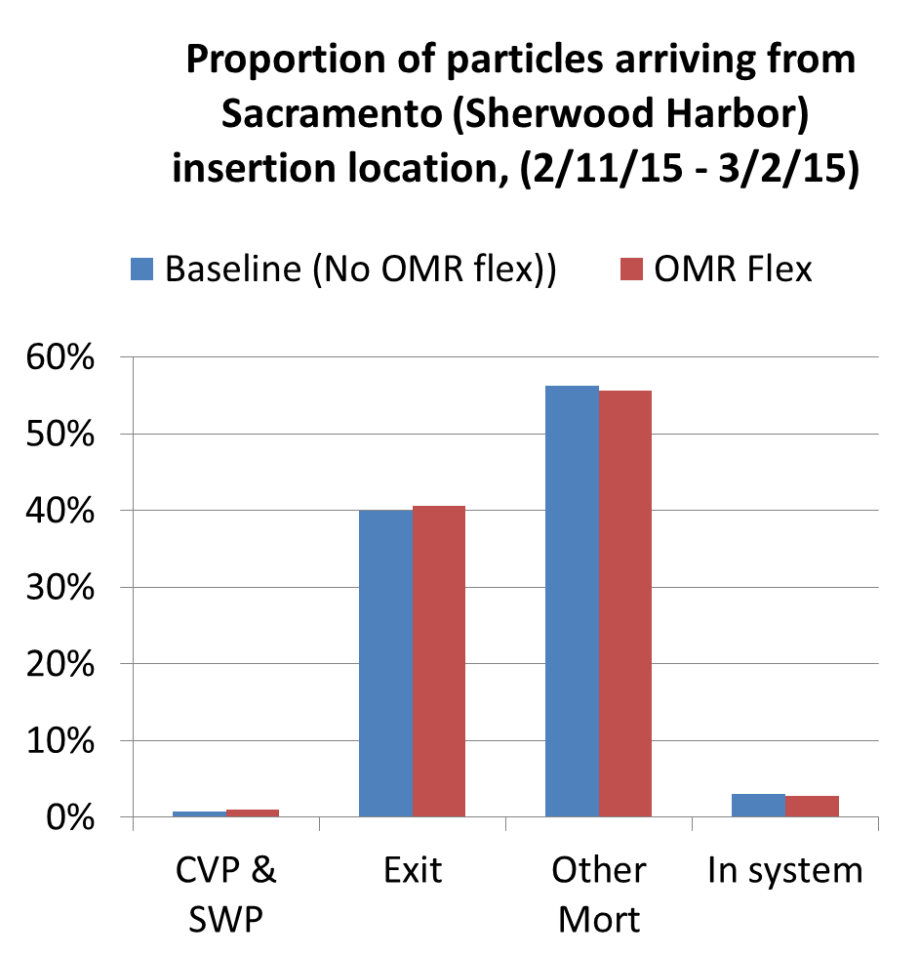

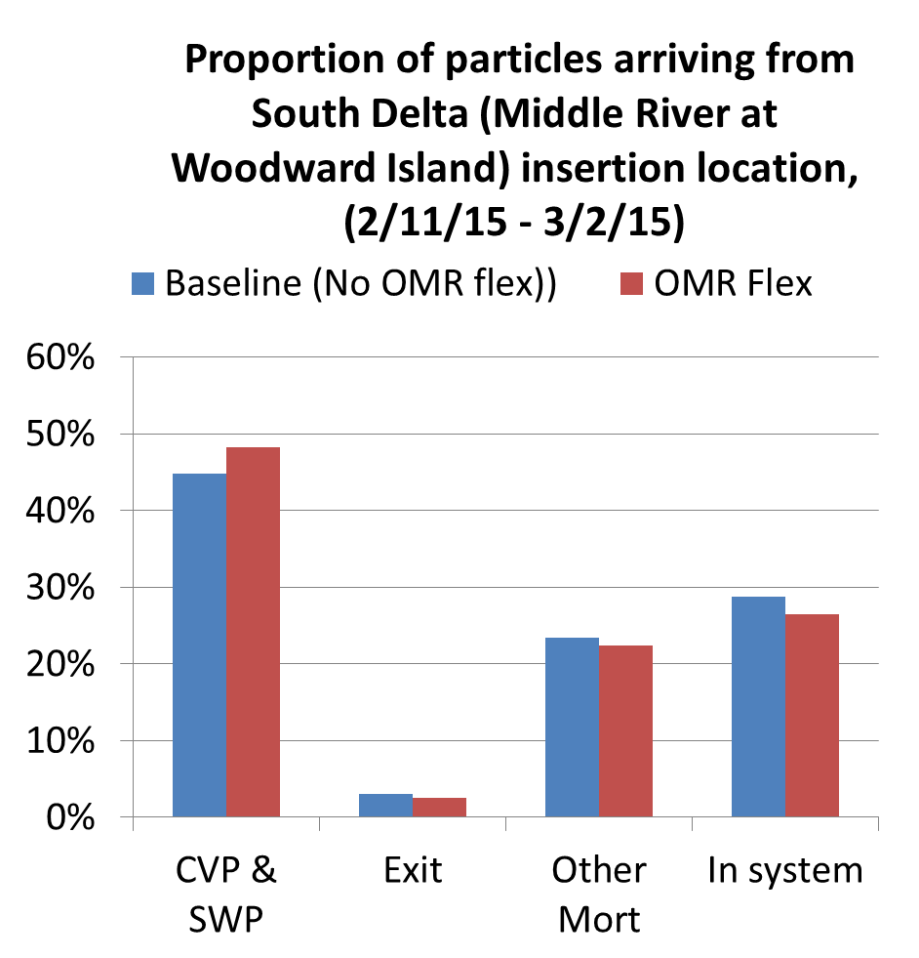

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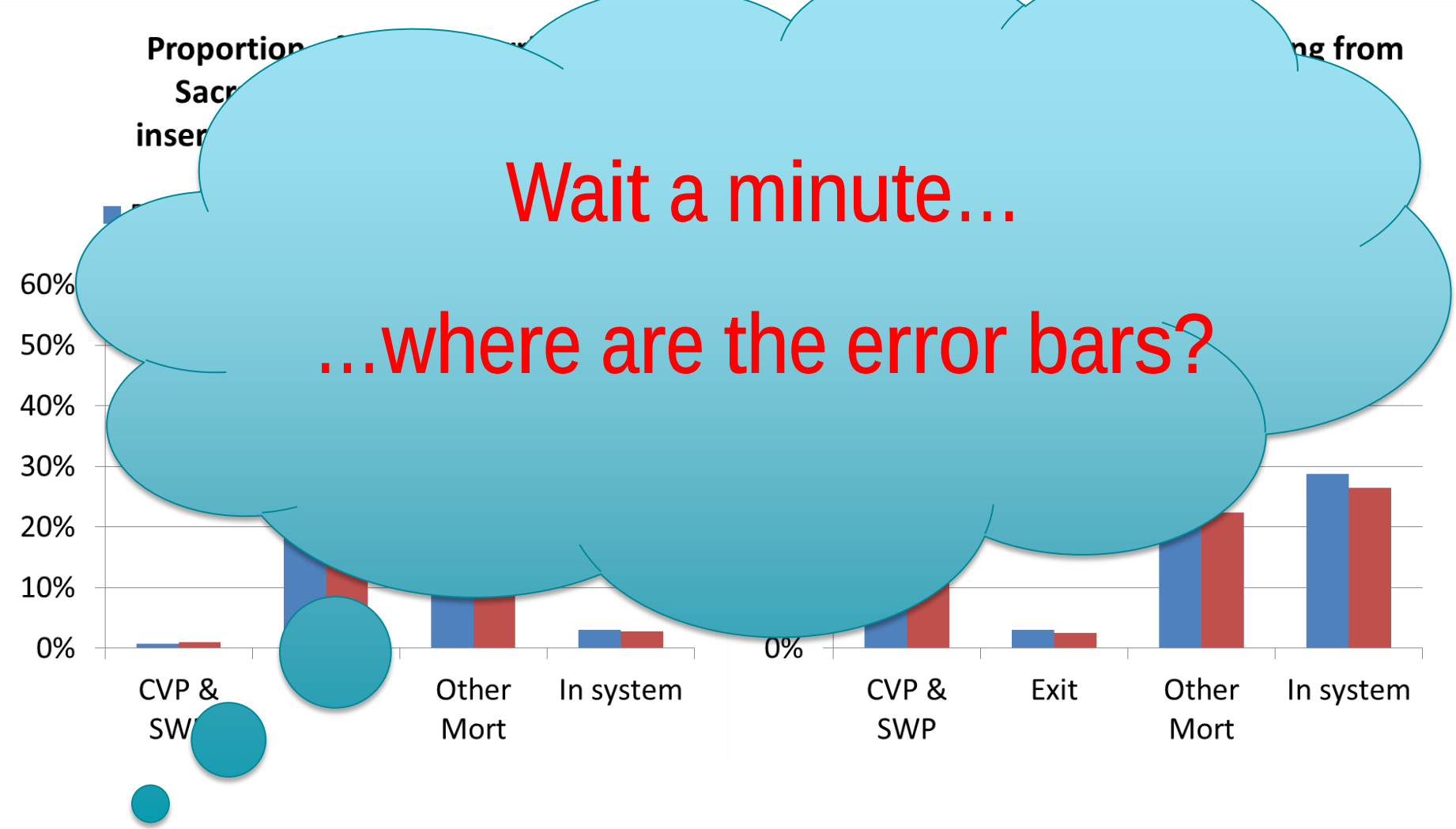
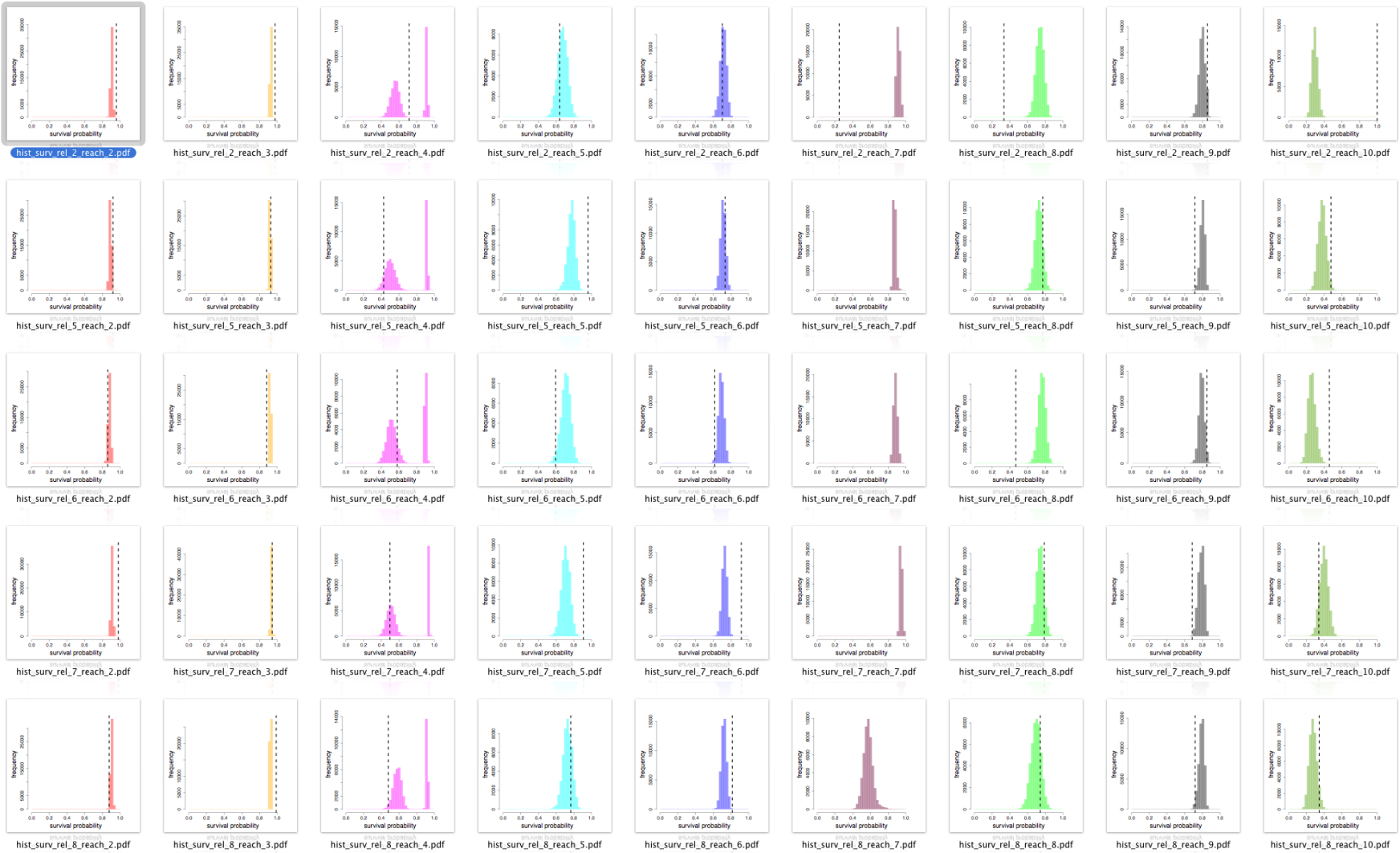


Variability in model parameters

- Survival probability



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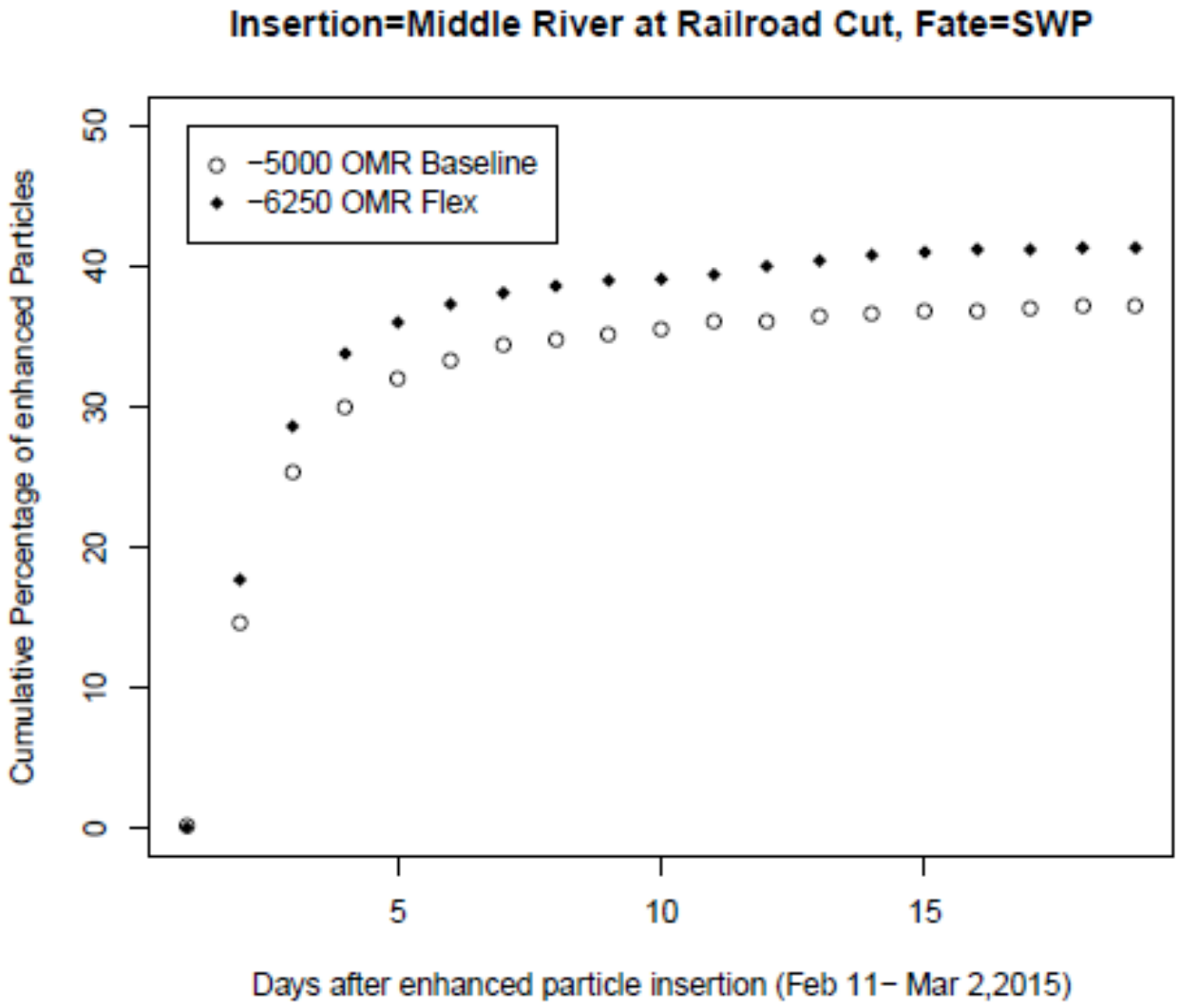

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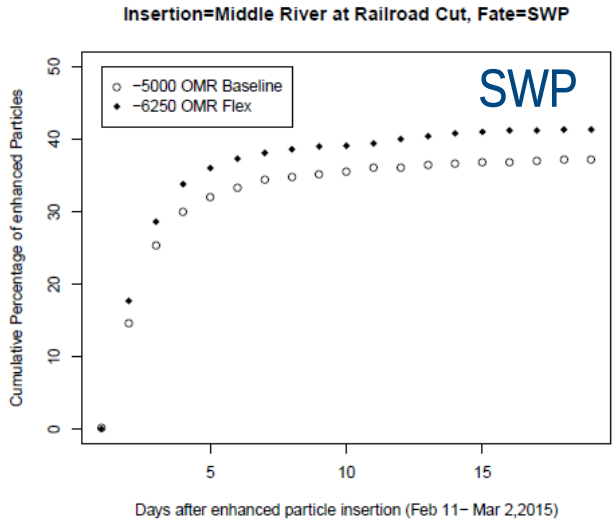
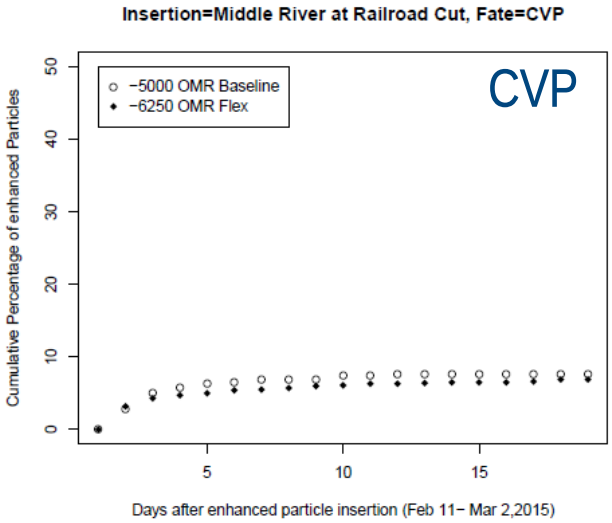
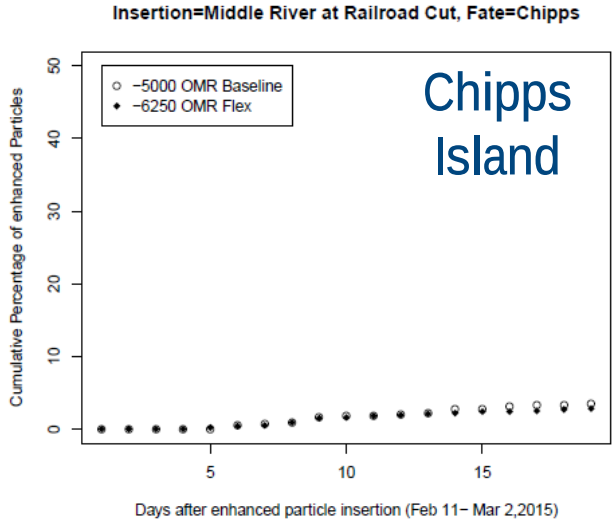
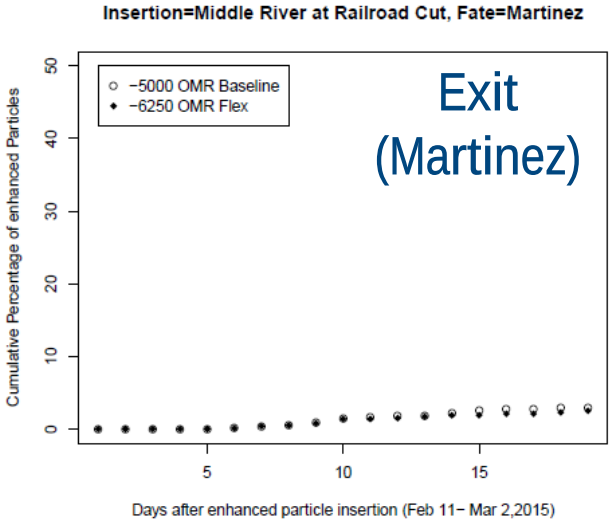
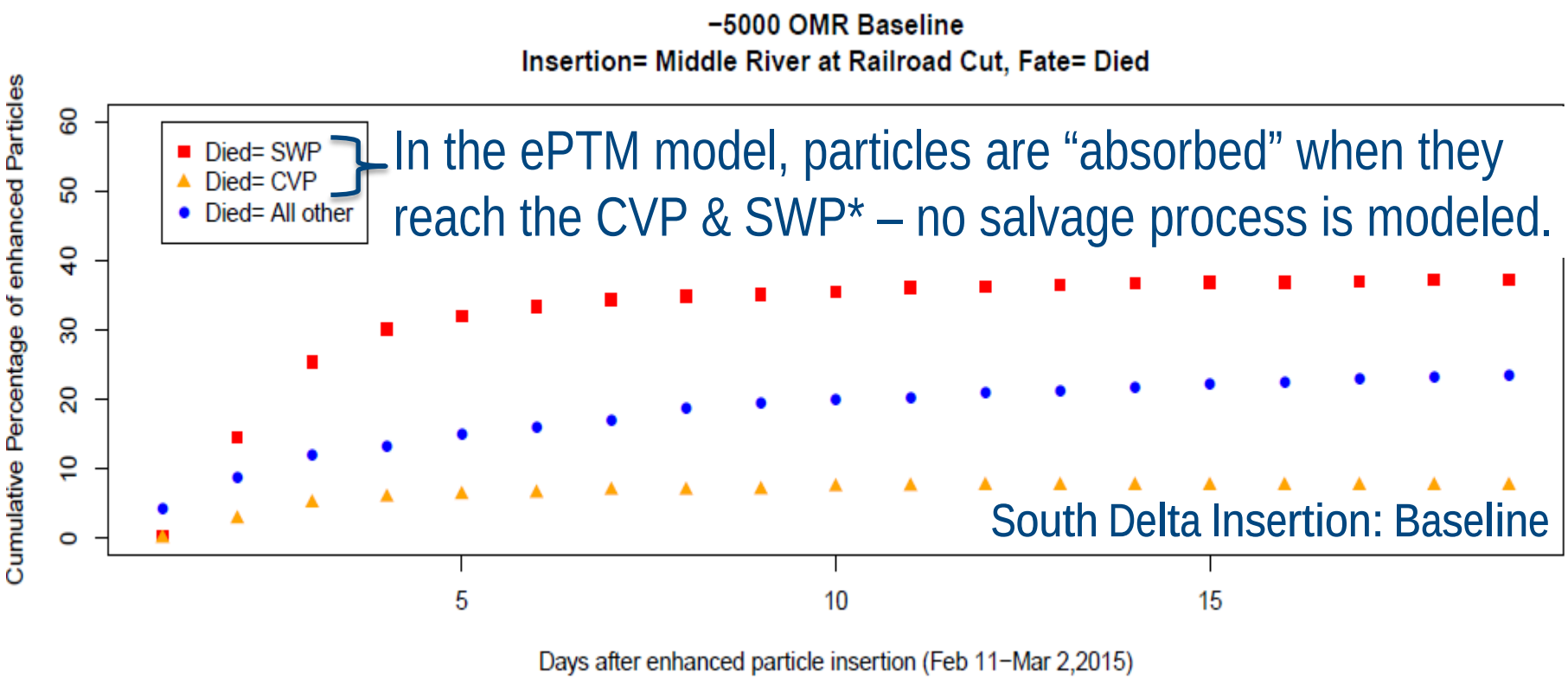








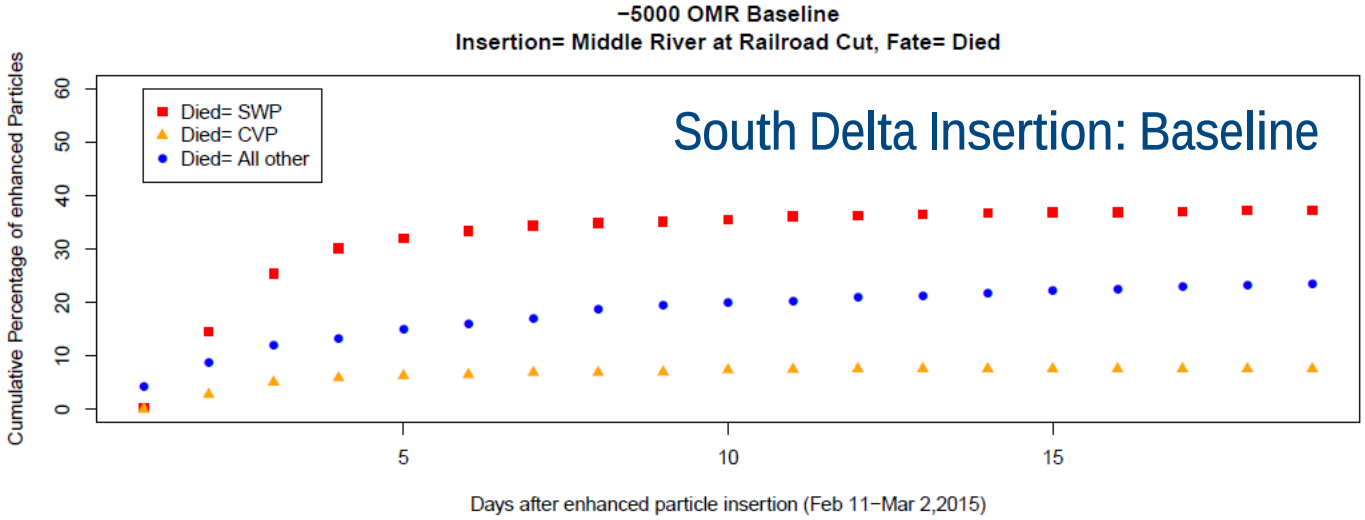
Example 1: OMR Flexibility -- *results*

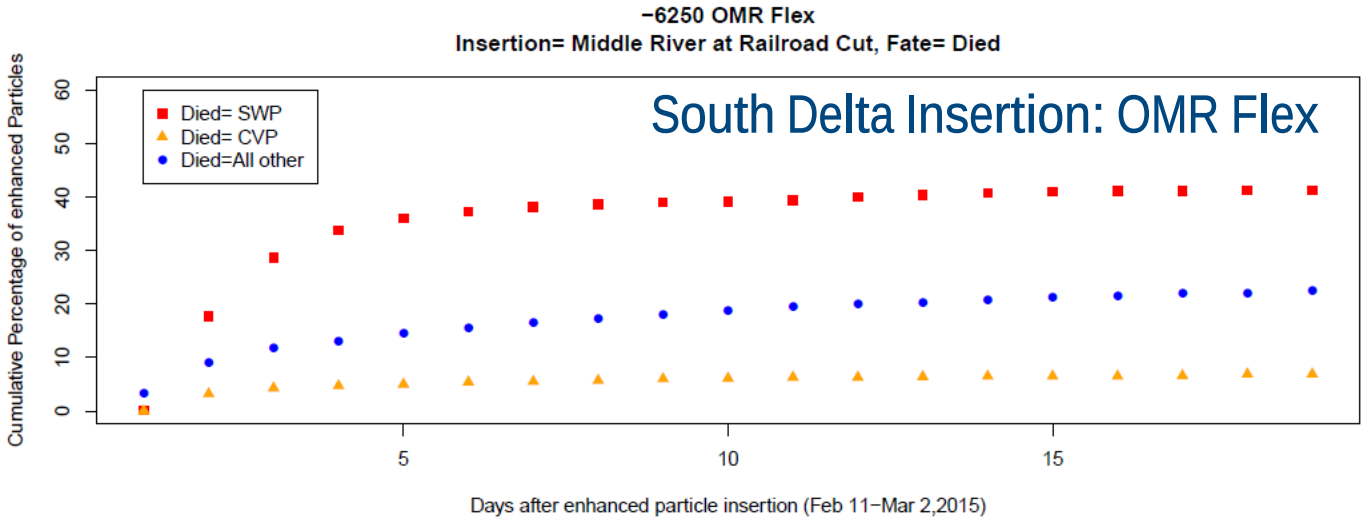


In the ePTM model, particles are "absorbed" when they reach the CVP & SWP* – no salvage process is modeled.

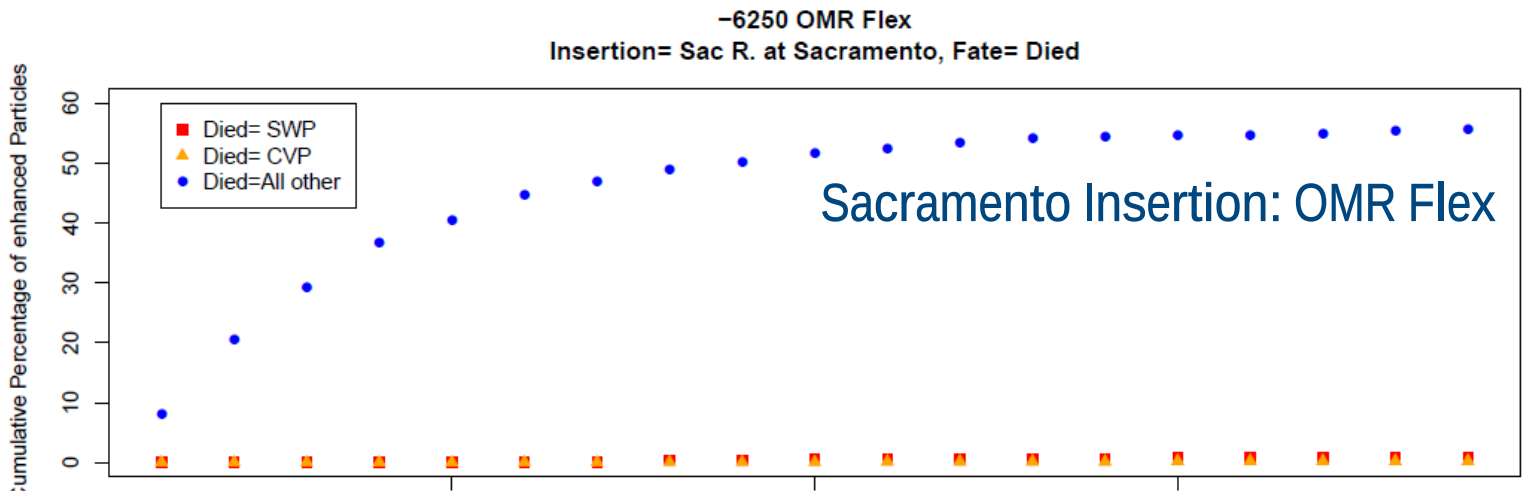
*particles also "absorbed" at Martinez

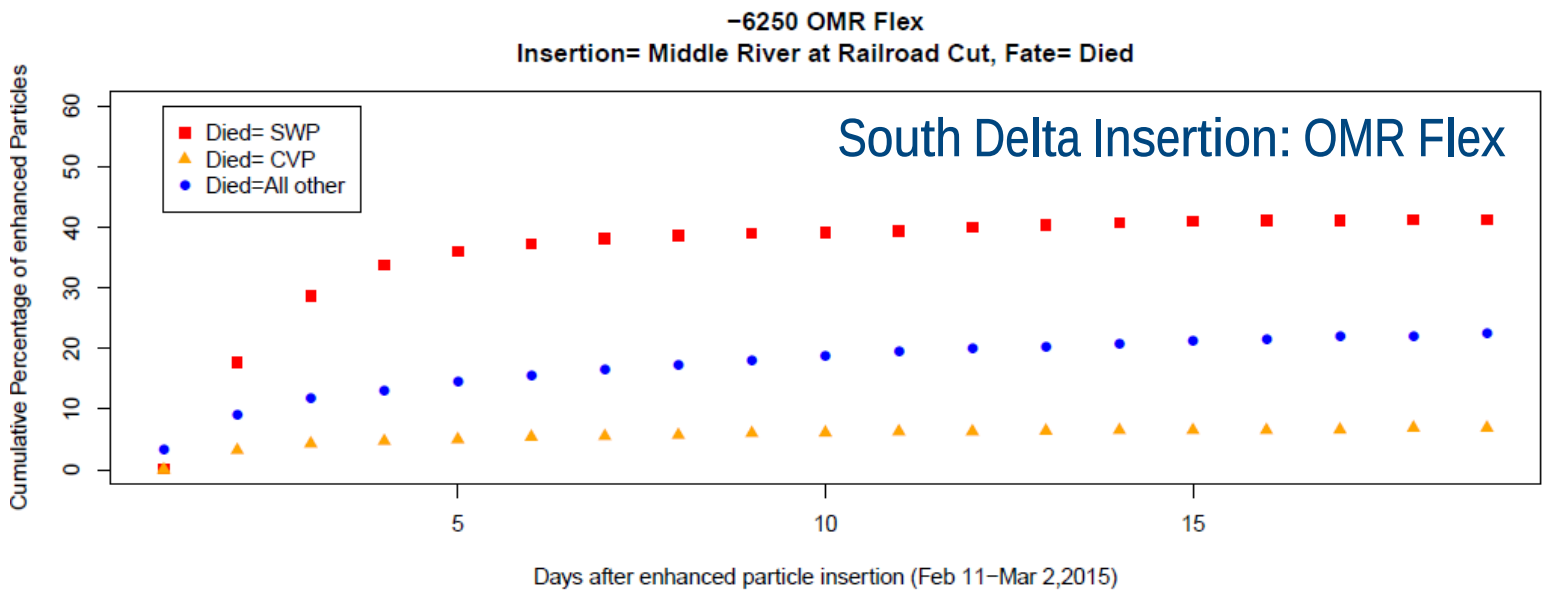
Example 1: OMR Flexibility -- *results*





Example 1: OMR Flexibility -- *results*





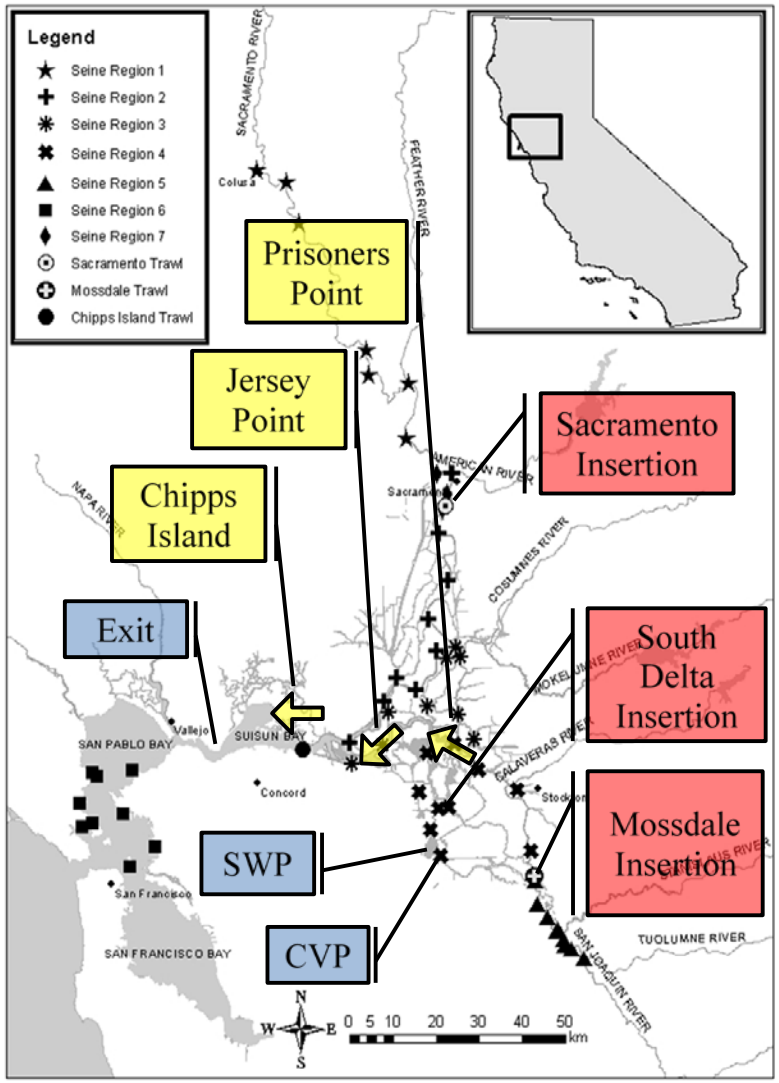
Example 2: April-May Drought Operations -- *ops*

Scenario	Delta Outflow	Vernalis flow	Combined Exports (cfs)	DCC Status
Baseline **(Hydro 1)**	7,100	D-1641 base + D-1641 April pulse	1,500	Closed
Lower inflows & DCC Closed **(Hydro 2)**	4,000	Lower base + lower April pulse	1,500	Closed
Lower inflows & DCC Open **(Hydro 2')**	4,000	Lower base + lower April pulse	1,500	Open for 2 months

Higher vs. lower flows

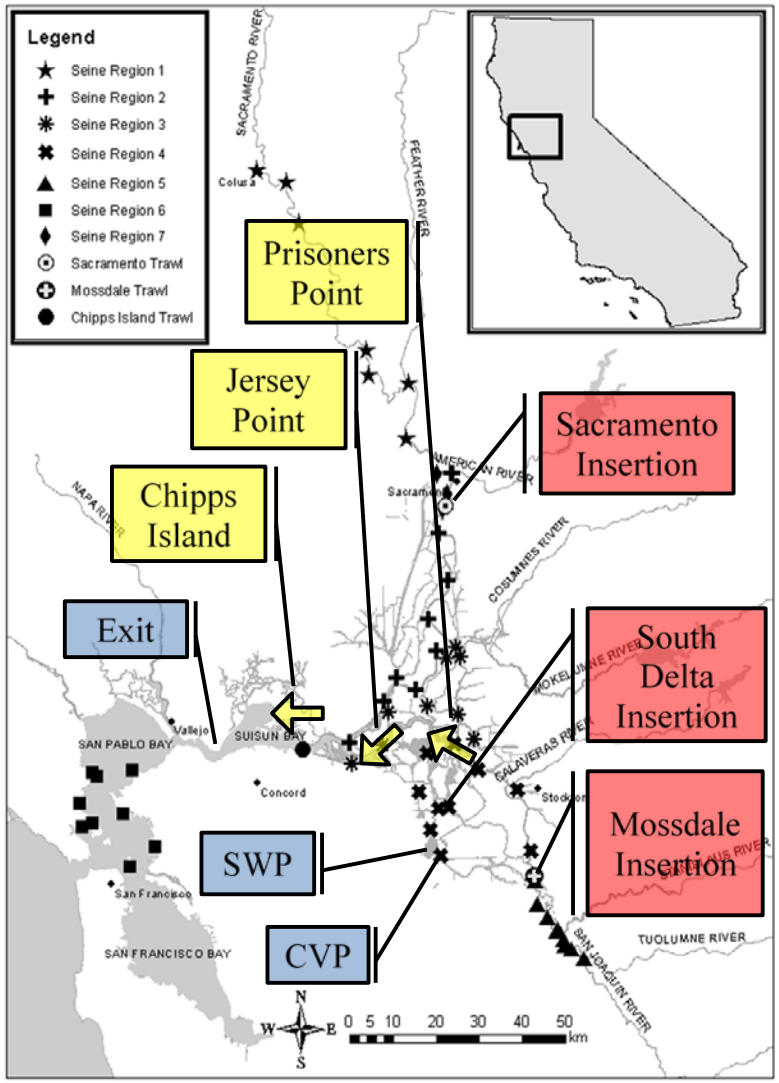
DCC closed vs. open

Example 2: April-May Drought Operations -- *ePTM*



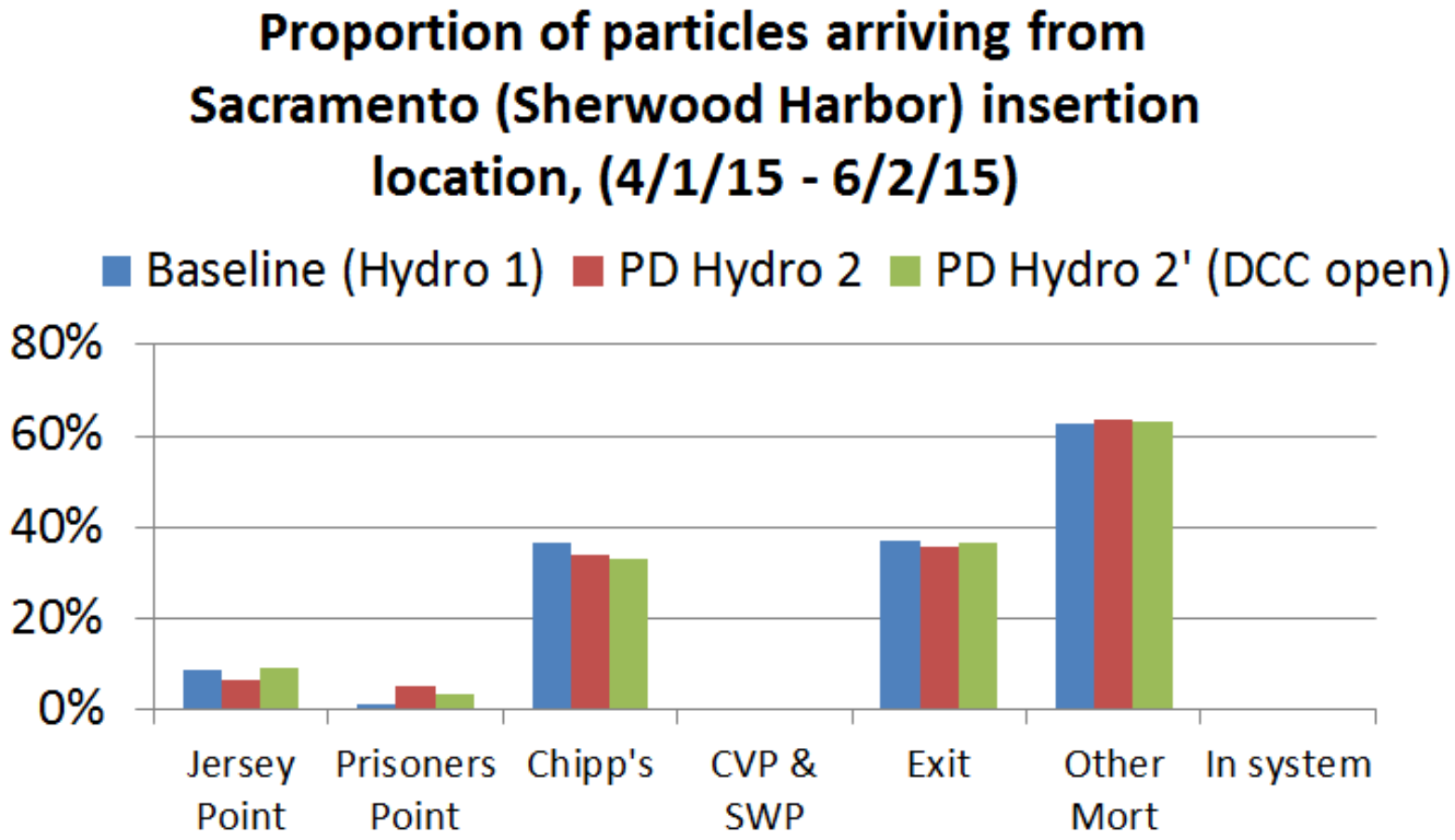
- **NMFS Species focus:** WR, SR, steelhead
- **Insertion points:** Sacramento, South Delta, and Mossdale
- **Outputs:** e-Particle fates, Chipps flux, Jersey Pt. flux, Prisoners Pt. flux & mortality

Example 2: April-May Drought Operations -- *ePTM*

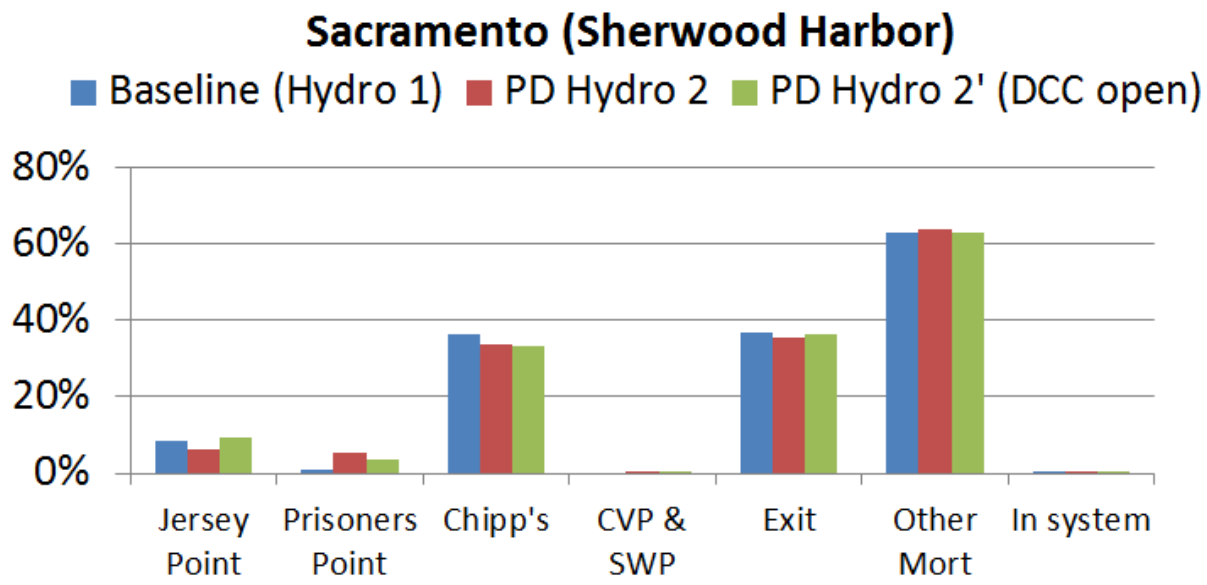


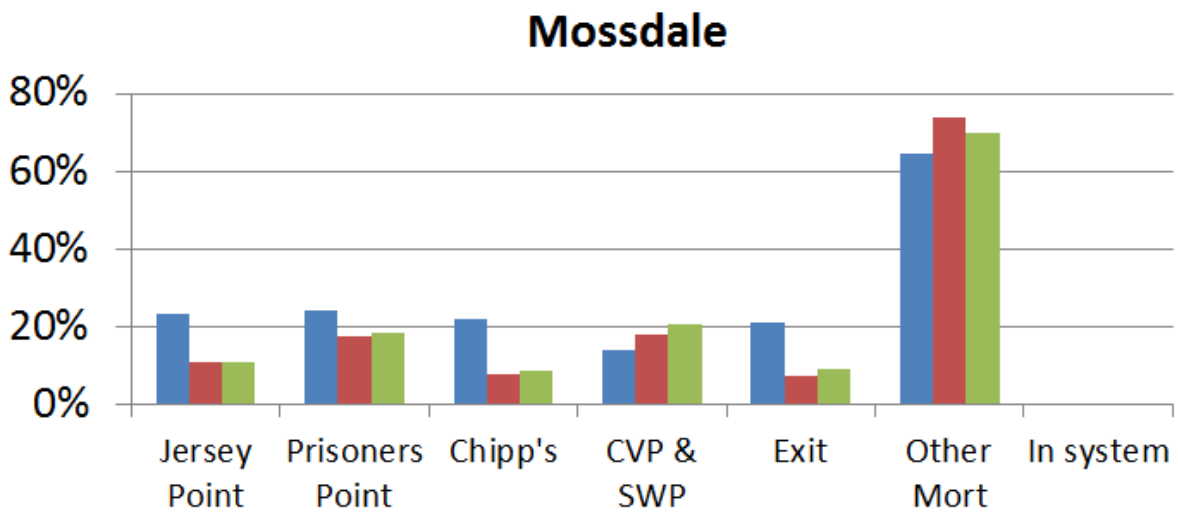
- Scenarios:
  - *Hydro 1*
  - *Hydro 2*
  - *Hydro 2'*
- Duration: 2 months (April – May)

Example 2: April-May Drought Operations -- *results*



Example 2: April-May Drought Operations -- *results*





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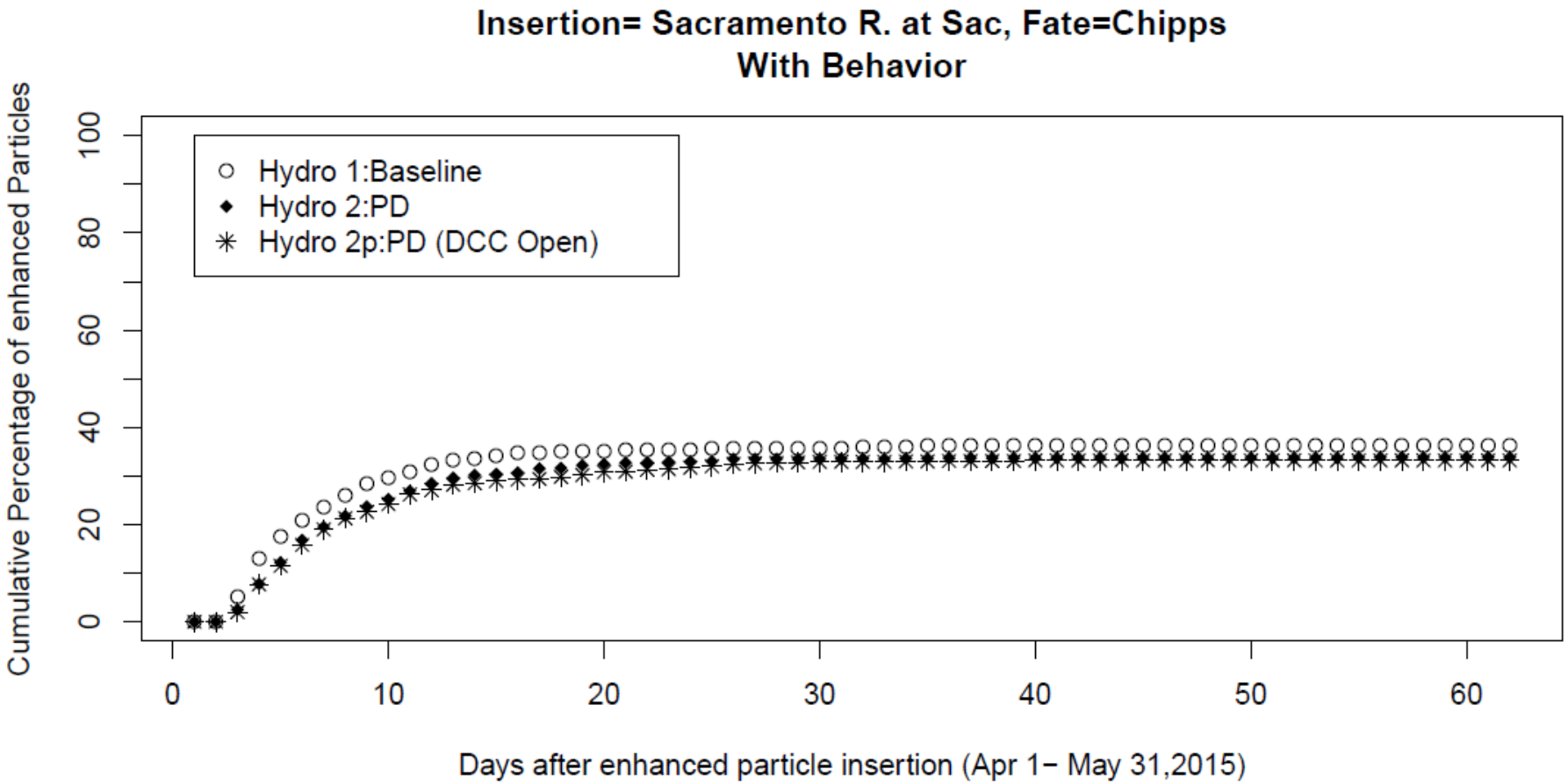

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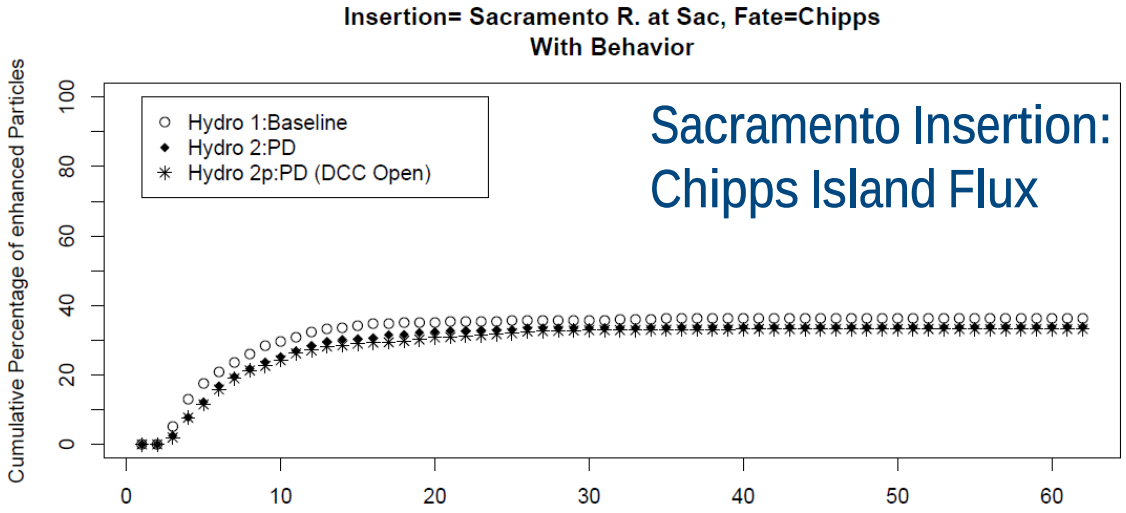

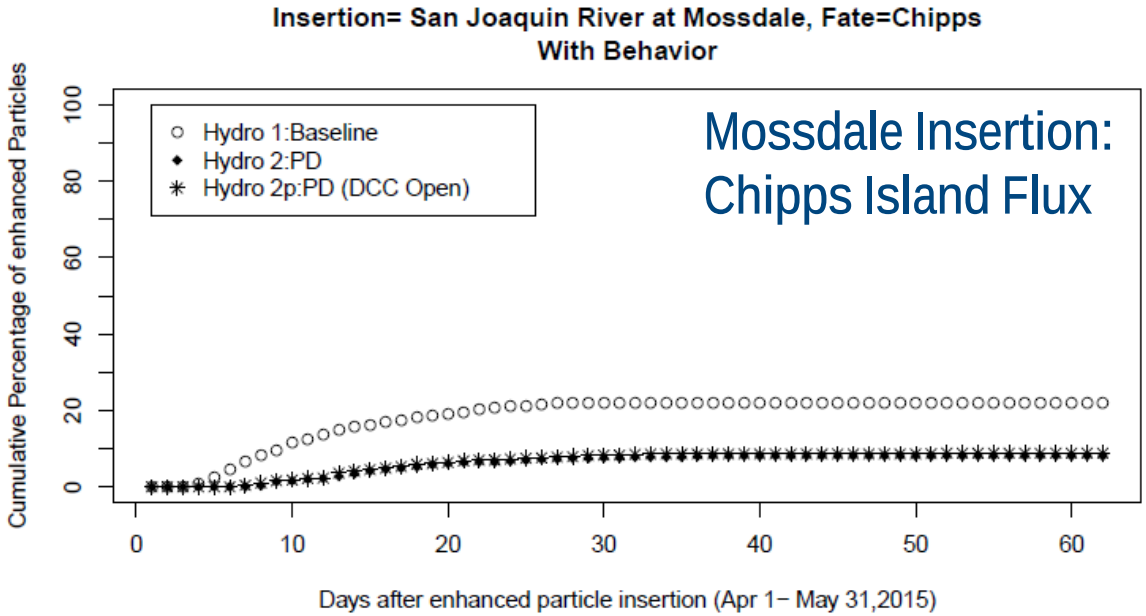

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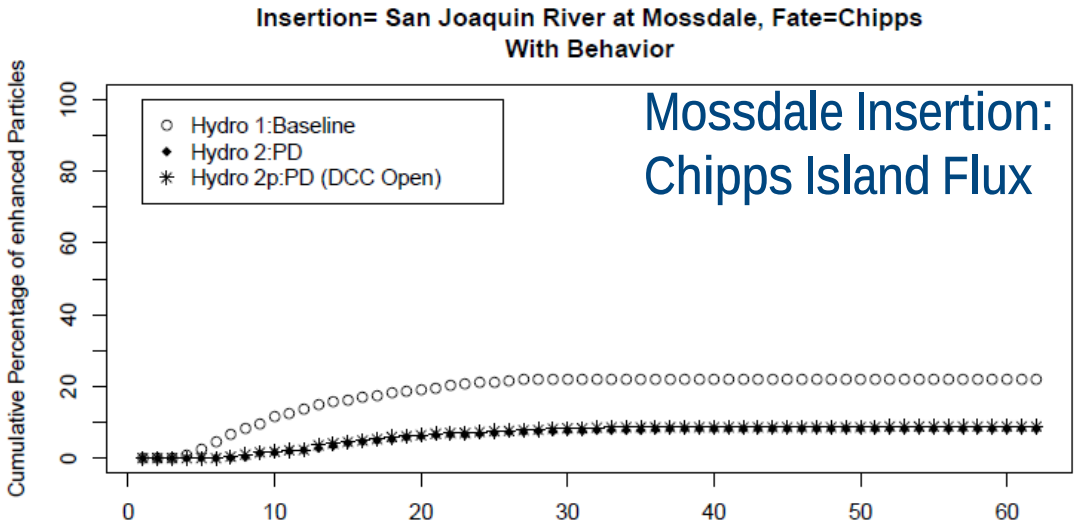
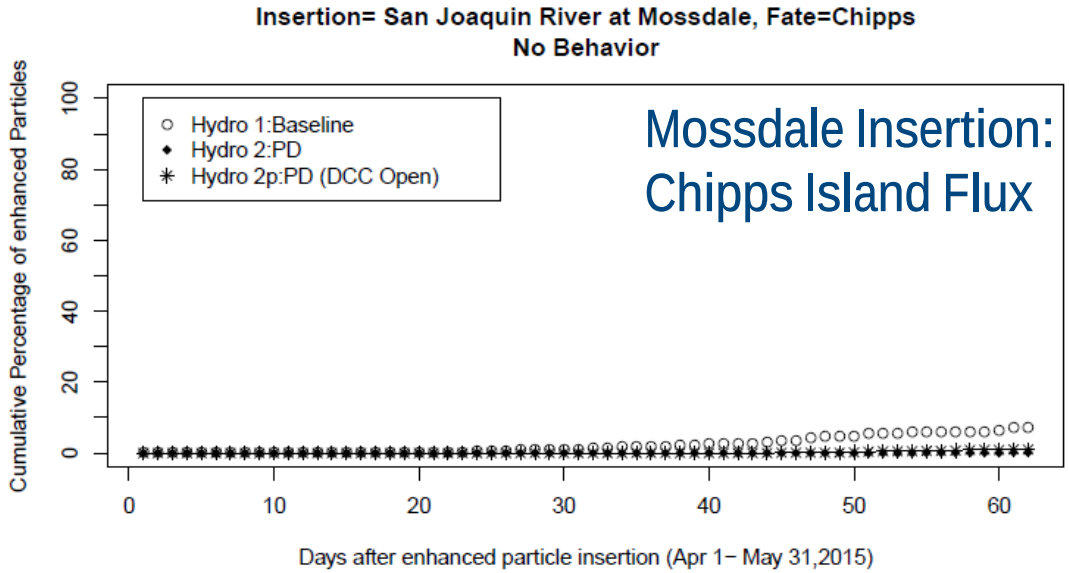
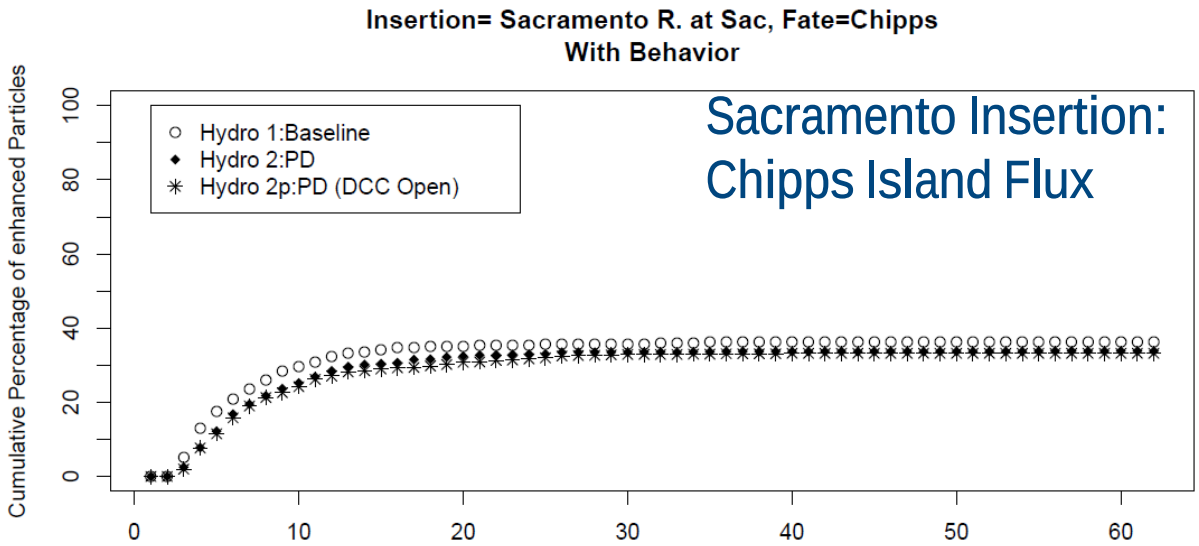


ePTM

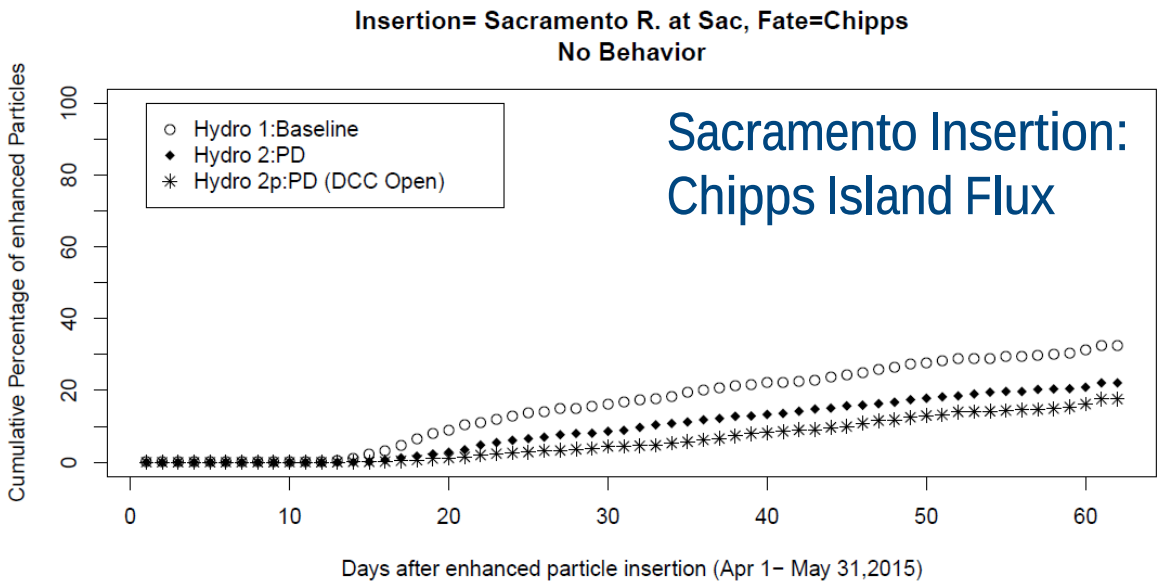


standard PTM

Example 2: April-May Drought Operations -- *results*



ePTM



standard PTM

Some Observations & Lessons Learned from the Pilot Application Effort

Model Output

- ePTM results on duration of outmigration of fish through the Delta are more similar to field data than are standard PTM results
- ePTM results showing directional trends in cumulative particle fates between scenarios and between insertion locations seem to make sense

ePTM logistics

- Worked out a lot of process issues…
- …but “real-time” use of ePTM needs 1-2 weeks lead time

Next steps

- Explore options for comparing spatial patterns (of mortality or e-particle distributions) in scenario analysis

Questions to the Panel on ePTM

1. Does the panel have any suggestions on if and how model calibration could be improved?

2. How much does the spatial and temporal resolution of the model affect its application to physical and biological questions?

3. How useful is the current model as a basis for real-time operations decisions for assessing effects on listed salmonids?

4. Does the panel have any recommendations for additional work that will increase confidence in model output such as accounting for and reporting uncertainty?