Loss & Salvage Predictor Tool on SacPAS

W. Nicholas Beer
and Jennifer L. Gosselin

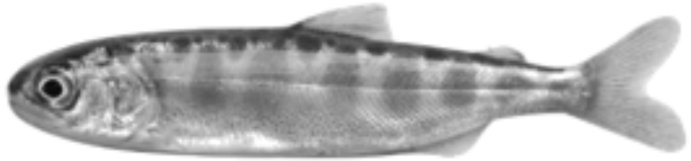
SacPAS
CENTRAL VALLEY PREDICTION AND ASSESSMENT OF SALMON

COLUMBIA BASIN RESEARCH

UNIVERSITY of WASHINGTON



Loss and Salvage



- **Sacramento River juvenile winter-run Chinook Salmon and Steelhead**

- **Entrainment** into pumping facilities in the Sacramento - San Joaquin Delta
  - Federal Central Valley Project (Jones Pumping Plant)
  - State Water Project (Harvey O. Banks Pumping Plant)

- **Salvage**: counts of fish salvaged from pumping facilities;

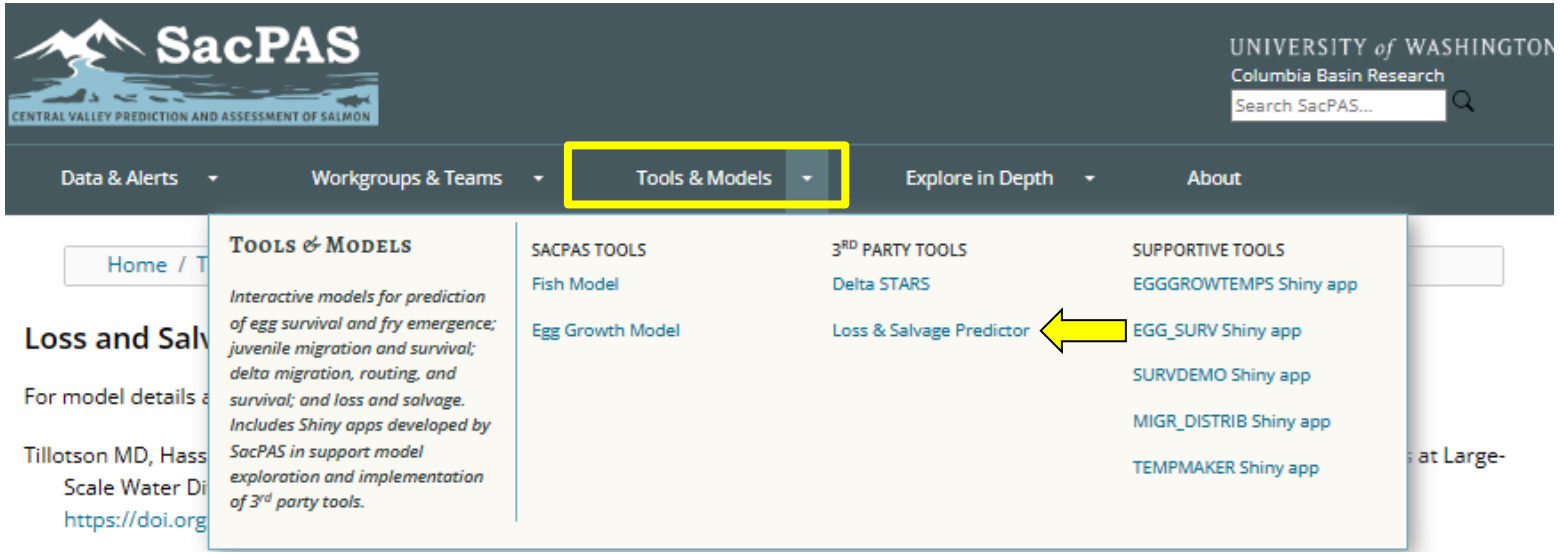
  collected and released near Delta exit

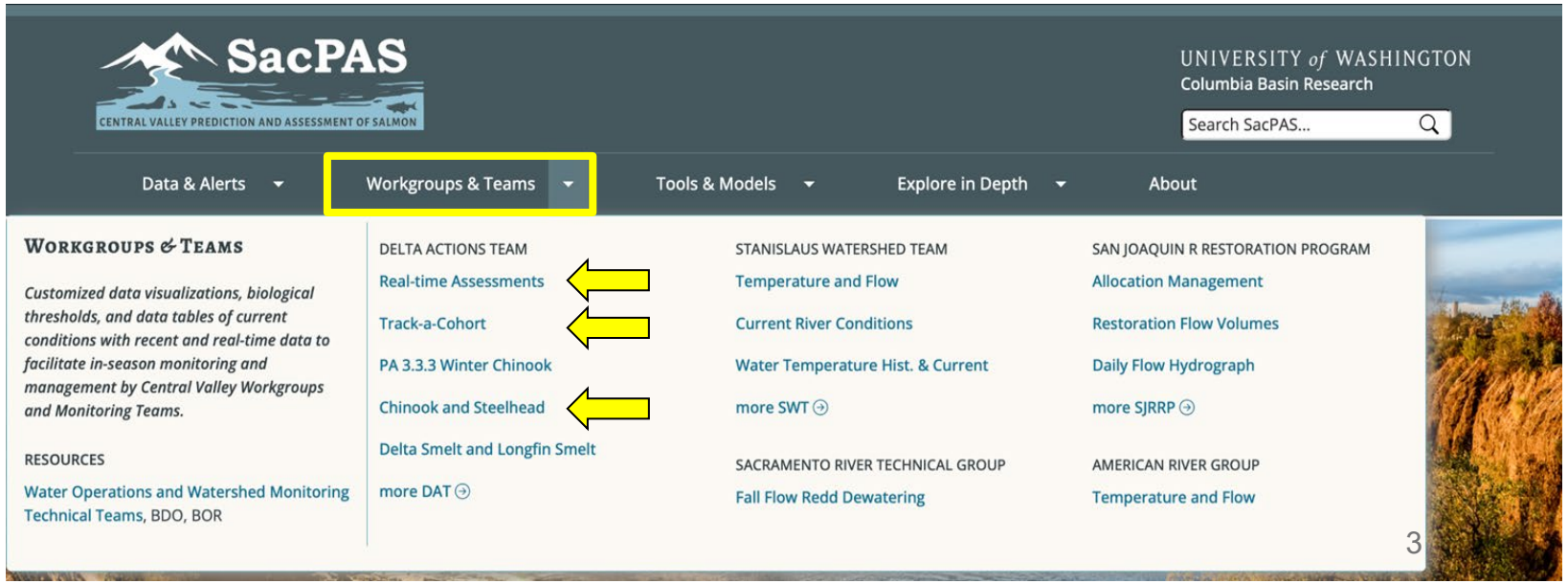
- **Loss**: estimates of fish that died, based on counts of salvaged fish,

  incl. estimated survival parameters and other assumptions (Kimmerer 2008)

Tools & Models

Workgroups & Teams

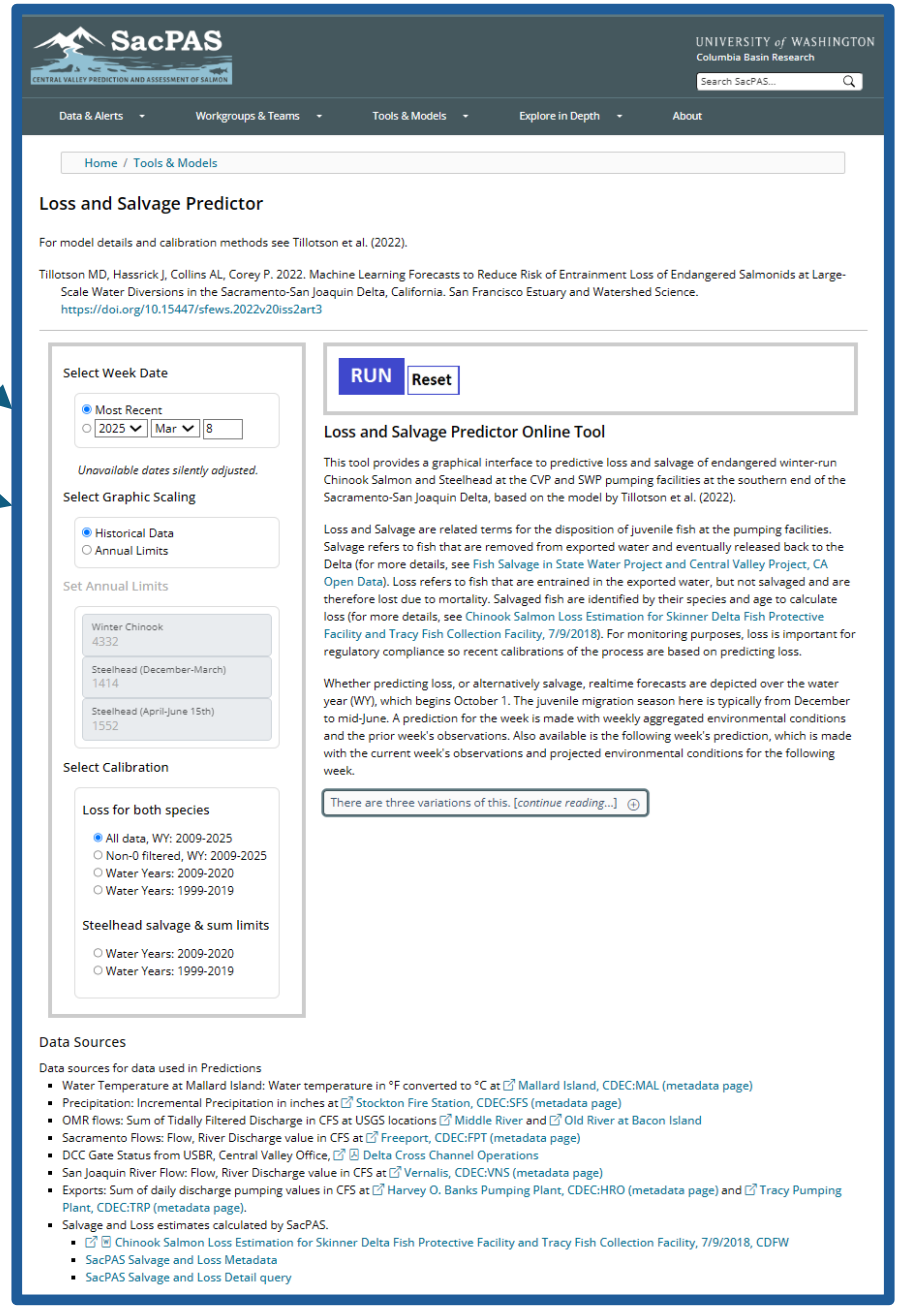




Time controls

Display controls

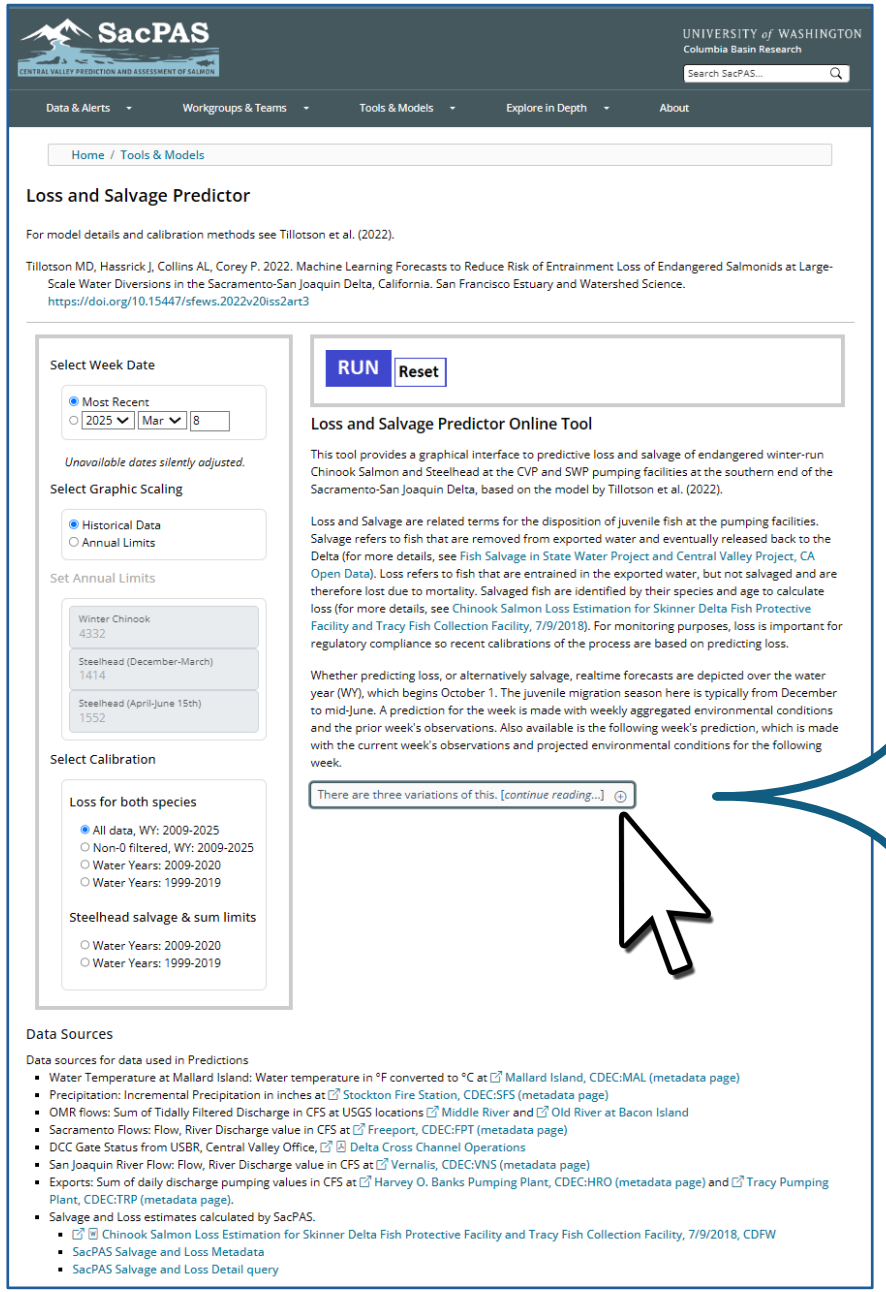
Calibration data controls



Time controls

Display controls

Calibration data controls



There are three variations of this. [*continue reading...*]

1. **The "Most Recent" run**, which uses current environmental conditions for the current week's forecast of loss/salvage and projects those conditions one week into the future for the next week's forecast of loss.
2. **A historical run**, which depicts observed environmental conditions and observed loss/salvage.
3. **A hindcast of a historical year** that was not included in the selected calibration data set.

There are several model calibrations to choose from:

Loss for both species

- **All data, WY 2009-2025**: Version 3, the current model calibration, and the default, includes all data available in these water years.
- **Non-0 filtered data, WY 2009-2025**: Version 3, is an alternative model calibration and includes all data except for the days with 0 counts of fish.
- **WY 2009-2020**: Version 2 model calibration predicting loss for both winter-run and steelhead.
- **WY 1999-2019**: Version 1 model calibration predicting loss for both winter-run and steelhead

Steelhead salvage & sum limits

- **WY 2009-2020**: Version 2 model calibration predicting loss for winter-run and salvage for steelhead
- **WY 1999-2019**: Version 1 model calibration predicting loss for winter-run and salvage for steelhead

Over the years, management practices have changed and data (e.g., OMR flow) may have missing historical values. Users may want to select the calibration that reflects years of more current operations and more complete environmental data. Older calibrations are still made available in case users want to access these. Additionally, although loss is always computed for winter-run Chinook salmon, the user may select the legacy management target: "salvage" for Steelhead.

Environmental variables used for prediction include weekly averages of Old and Middle River flow (OMR), combined CVP and SWP exports, San Joaquin River flow at Vernalis, Sacramento River flow at Freeport, and water temperature at Mallard Island, as well as cumulative rainfall (inches) over the Delta area and the Delta Cross Channel gate status. The default calibration ("All data, WY: 2009-2025") uses the 7-day sum of precipitation for consistency with the one week aggregation of all the other variables, whereas previous calibration used a 5-day sum. The changes in results are negligible and the 7-day sum of precipitation is more aligned in temporal resolution with the other weekly variables.

Results from the Loss and Salvage Predictor tool for historical years draw from existing model calibration runs for each species. Thus, historical results will be the same point estimates and confidence bounds in the query outputs. This is different from the outputs in Track-a-Cohort, where each time the model is rerun with near-real-time data, the values for historical point estimates and confidence bounds will differ due to randomization in the `randomForest` R function, but are statistically equivalent.

Graphics include: Observations for the current water year (small circles). The forecast window (green triangle) with high, median and low projections (short lines). The historical accumulated take (grey line) and 95% confidence bounds on the observed cumulative fraction of the total for the week (grey area).

Version Release History

Version 3: recalibration using data from 2009–2025, including improved QCed OMR data. For consistency, the "All data, WY 2009-2025" data set is also used in the Track-a-Cohort prediction of Weekly Loss of Juveniles in the Delta. Released 2026-10-20.

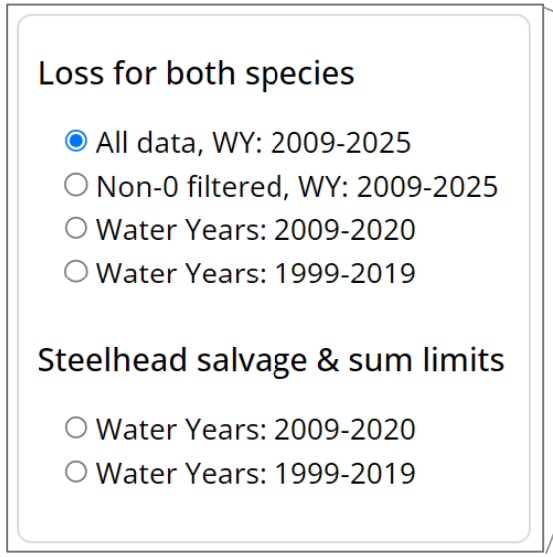
Version 2: recalibration using only data from 2009–2020, reflecting years of more current operations and more complete environmental data. Released in 2021-Jan.

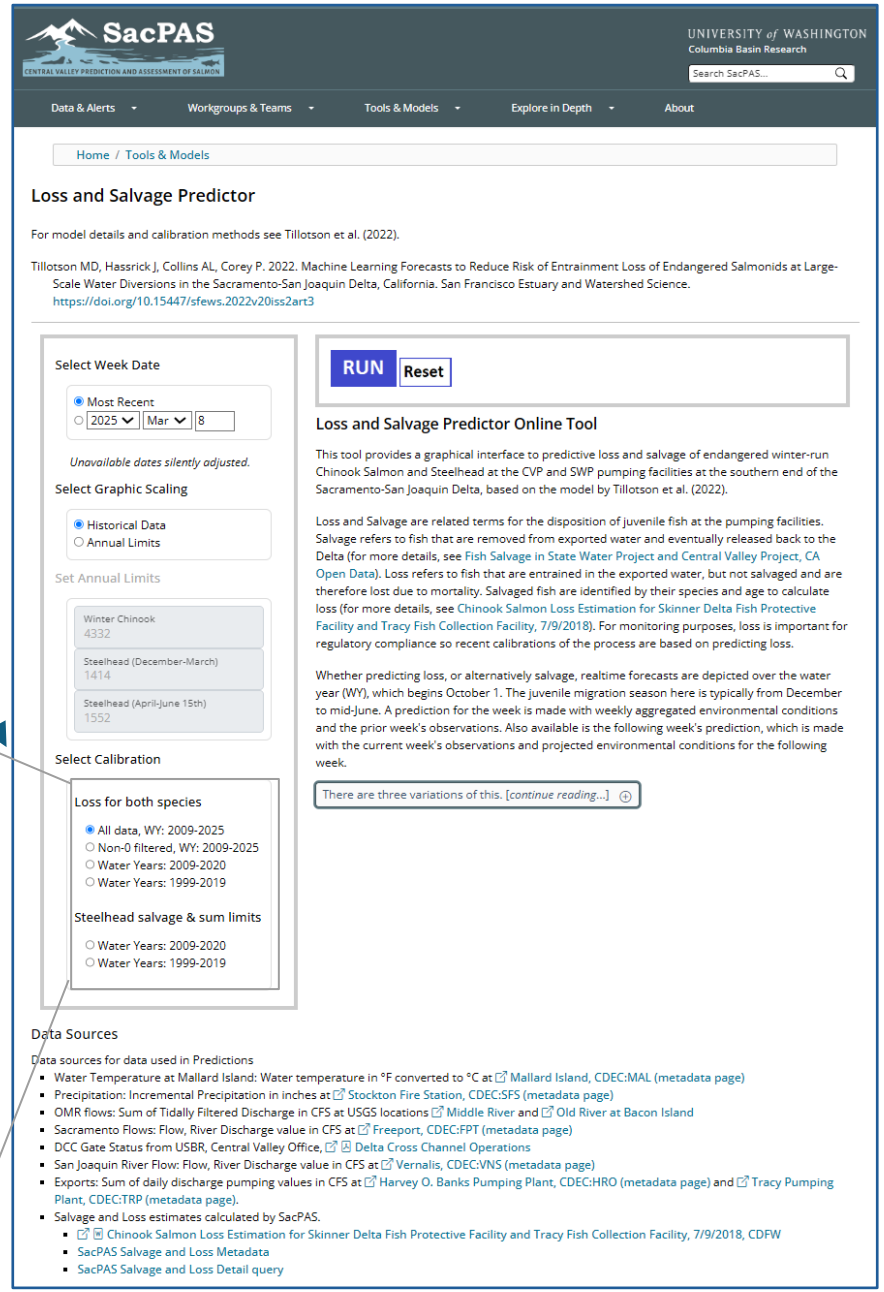
Version 1: original release of the tool in 2020-Jun with calibration provided by Michael Tillotson (personal communication).

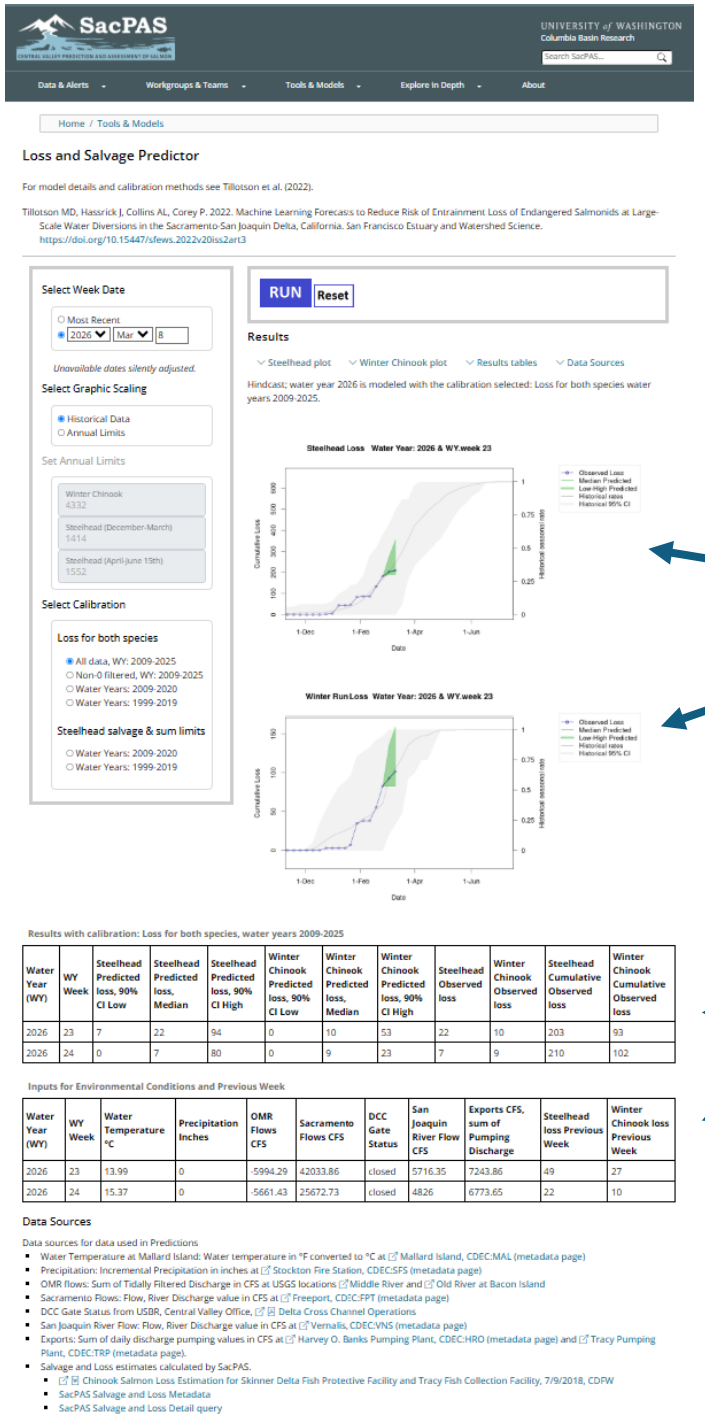
Calibration data controls

Versions:

V3
V3
V2
V1







Water Year (WY)	WY Week	Steelhead Predicted loss, 90% CI Low	Steelhead Predicted loss, Median	Steelhead Predicted loss, 90% CI High	Winter Chinook Predicted loss, 90% CI Low	Winter Chinook Predicted loss, Median	Winter Chinook Predicted loss, 90% CI High	Steelhead Observed loss	Winter Chinook Observed loss	Steelhead Cumulative Observed loss	Winter Chinook Cumulative Observed loss
2026	23	7	22	94	0	10	53	22	10	203	93
2026	24	0	7	80	0	9	23	7	9	210	102

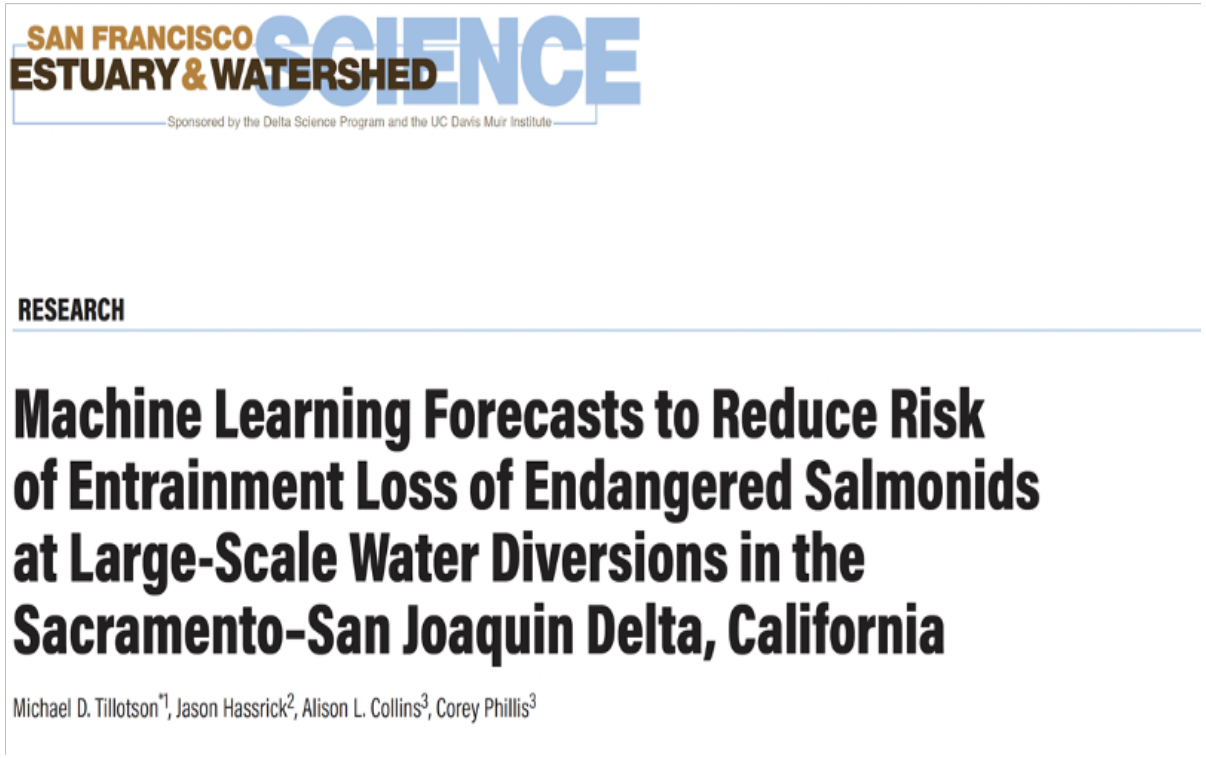
Water Year (WY)	WY Week	Water Temperature °C	Precipitation Inches	OMR Flows CFS	Sacramento Flows CFS	DCC Gate Status	San Joaquin River Flow CFS	Exports CFS, sum of Pumping Discharge	Steelhead loss Previous Week	Winter Chinook loss Previous Week
2026	23	13.99	0	-5994.29	42033.86	closed	5716.35	7243.86	49	27
2026	24	15.37	0	-5661.43	25672.73	closed	4826	6773.65	22	10

Graphical results

Tabled results

Metadata

Loss & Salvage model (Tillotson et al. 2022)



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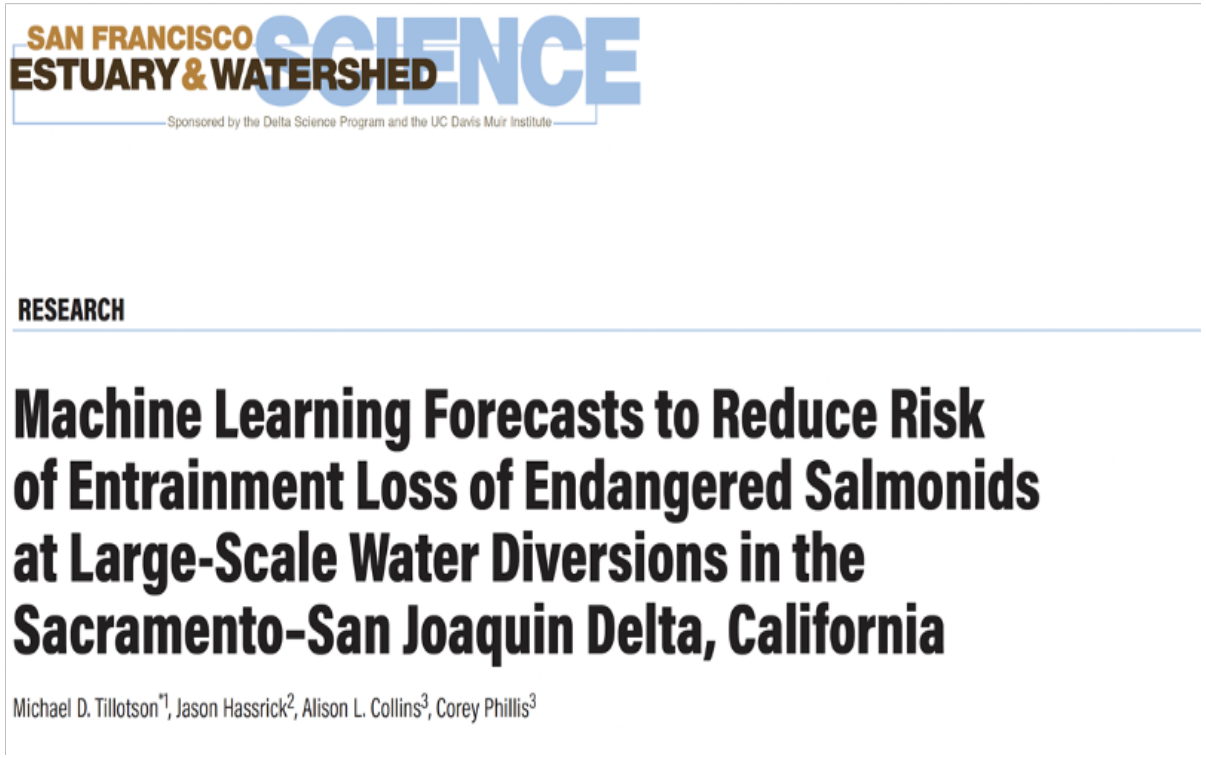
RESEARCH

Machine Learning Forecasts to Reduce Risk of Entrainment Loss of Endangered Salmonids at Large-Scale Water Diversions in the Sacramento-San Joaquin Delta, California

Michael D. Tillotson[*1], Jason Hassrick[2], Alison L. Collins[3], Corey Phillis[3]

- **Outputs:** Weekly predictions of Chinook & Steelhead loss at the combined pumping facilities

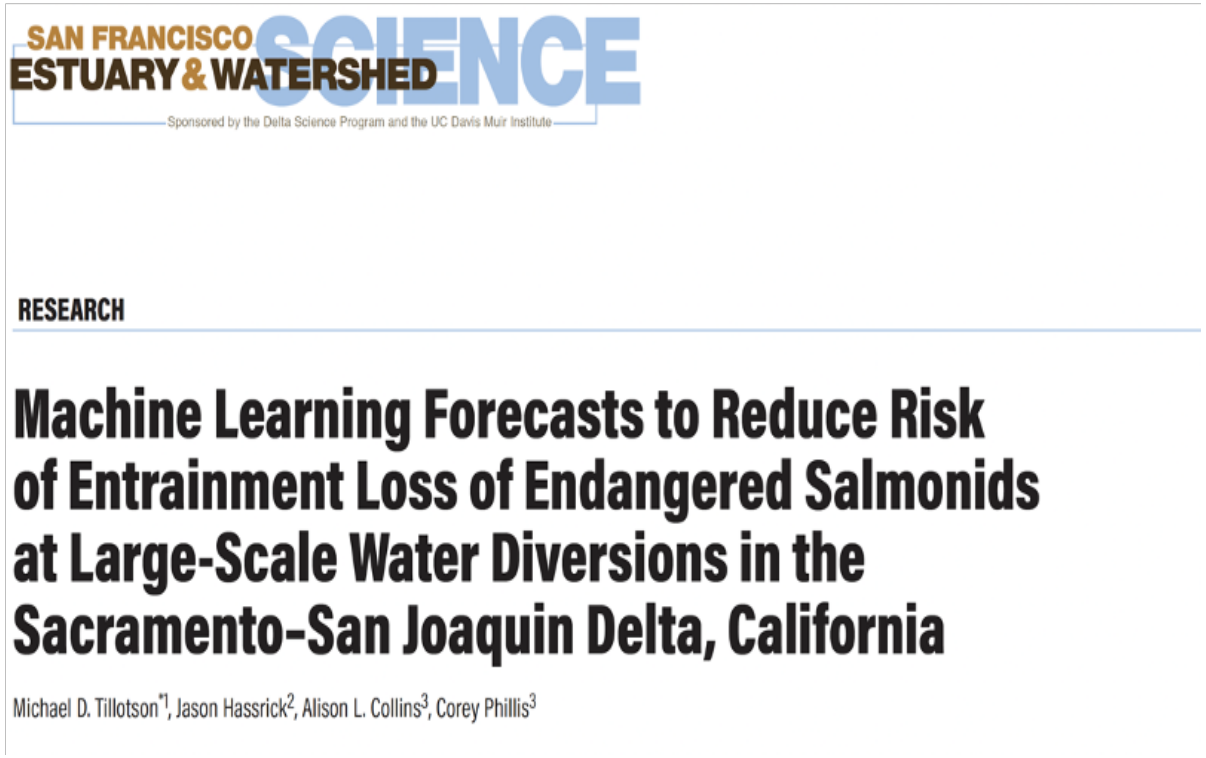
Loss & Salvage model (Tillotson et al. 2022)



- **Outputs:** Weekly predictions of Chinook & Steelhead loss at the combined pumping facilities

- **Method:** Machine Learning using a Quantile Regression Forest (QRF)

Loss & Salvage model (Tillotson et al. 2022)



- **Method:** Machine Learning using a Quantile Regression Forest (QRF)

A non-parametric method to make probabilistic predictions.

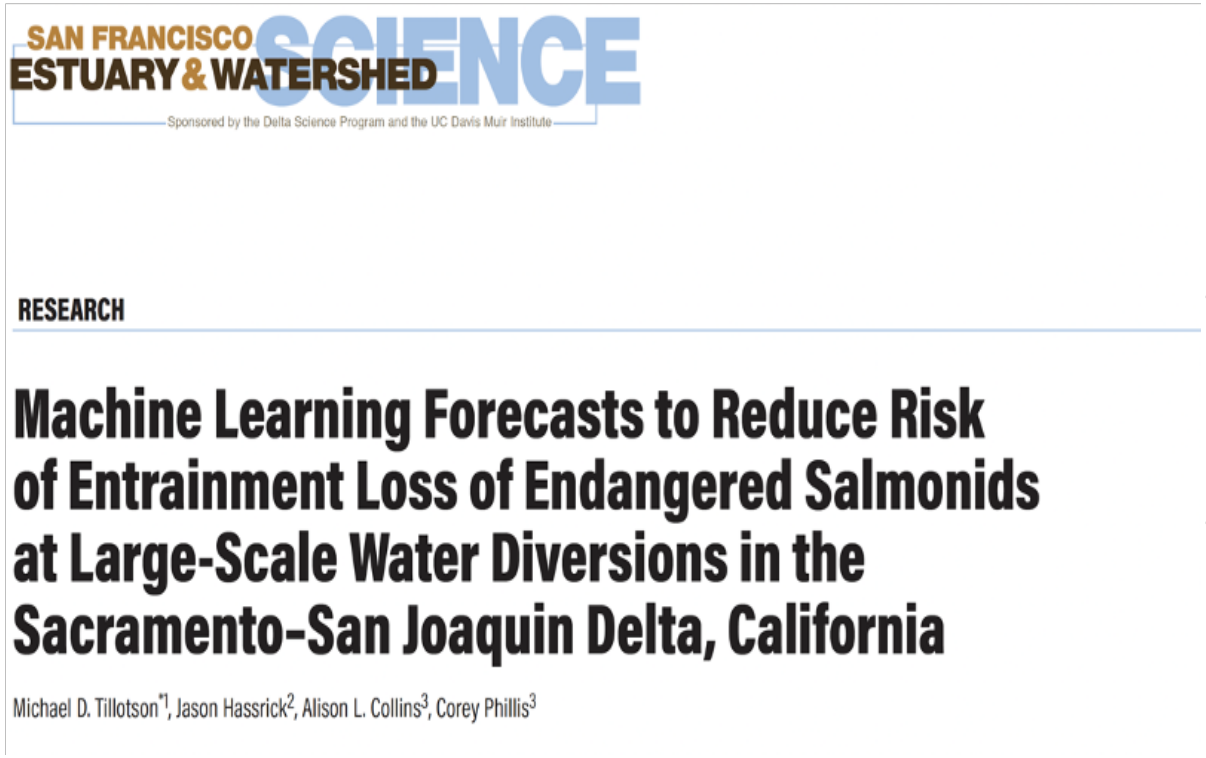
Explanatory variables:
- predictors are hypothesized to be meaningful to the response

Assumptions:
- historical data used for the training data set are representative of the forecast period
- future “behaves” like the past

Limitations:
- no physical nor biological mechanisms in model

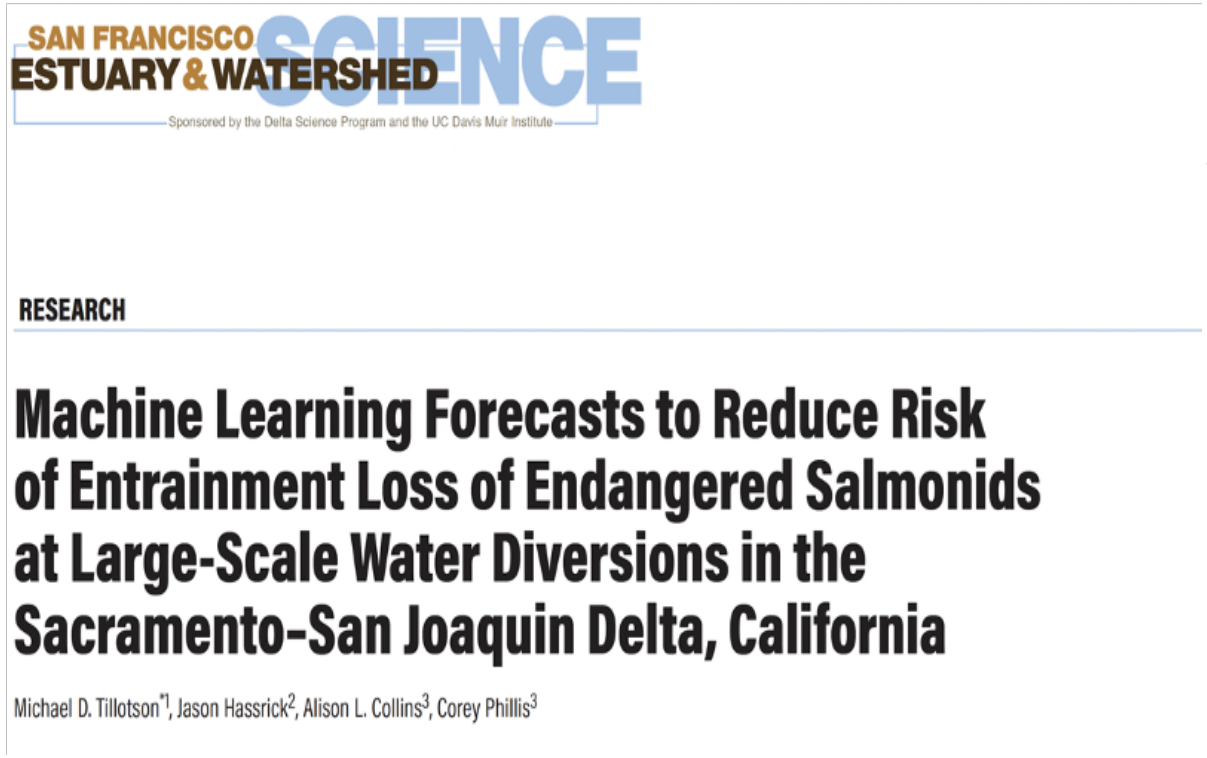
Not needed for QRF to be predictive

Loss & Salvage model (Tillotson et al. 2022)



- **Outputs:** Weekly predictions of Chinook & Steelhead loss at the combined pumping facilities
- **Method:** Machine Learning using Quantile Regression Forests
- **Inputs:** historical observations of loss, environmental conditions, operations

Loss & Salvage model (Tillotson et al. 2022)



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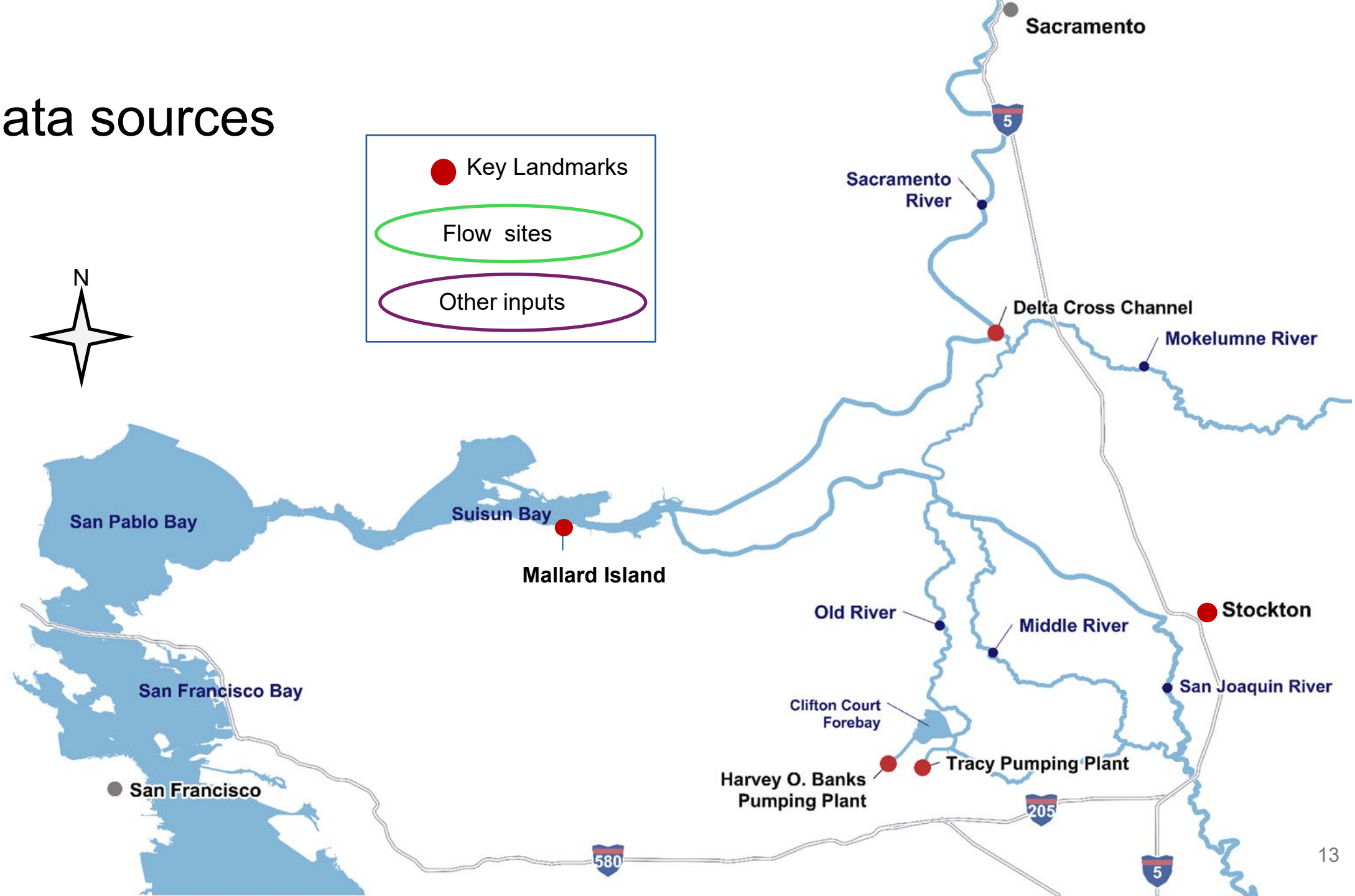
RESEARCH

Machine Learning Forecasts to Reduce Risk of Entrainment Loss of Endangered Salmonids at Large-Scale Water Diversions in the Sacramento-San Joaquin Delta, California

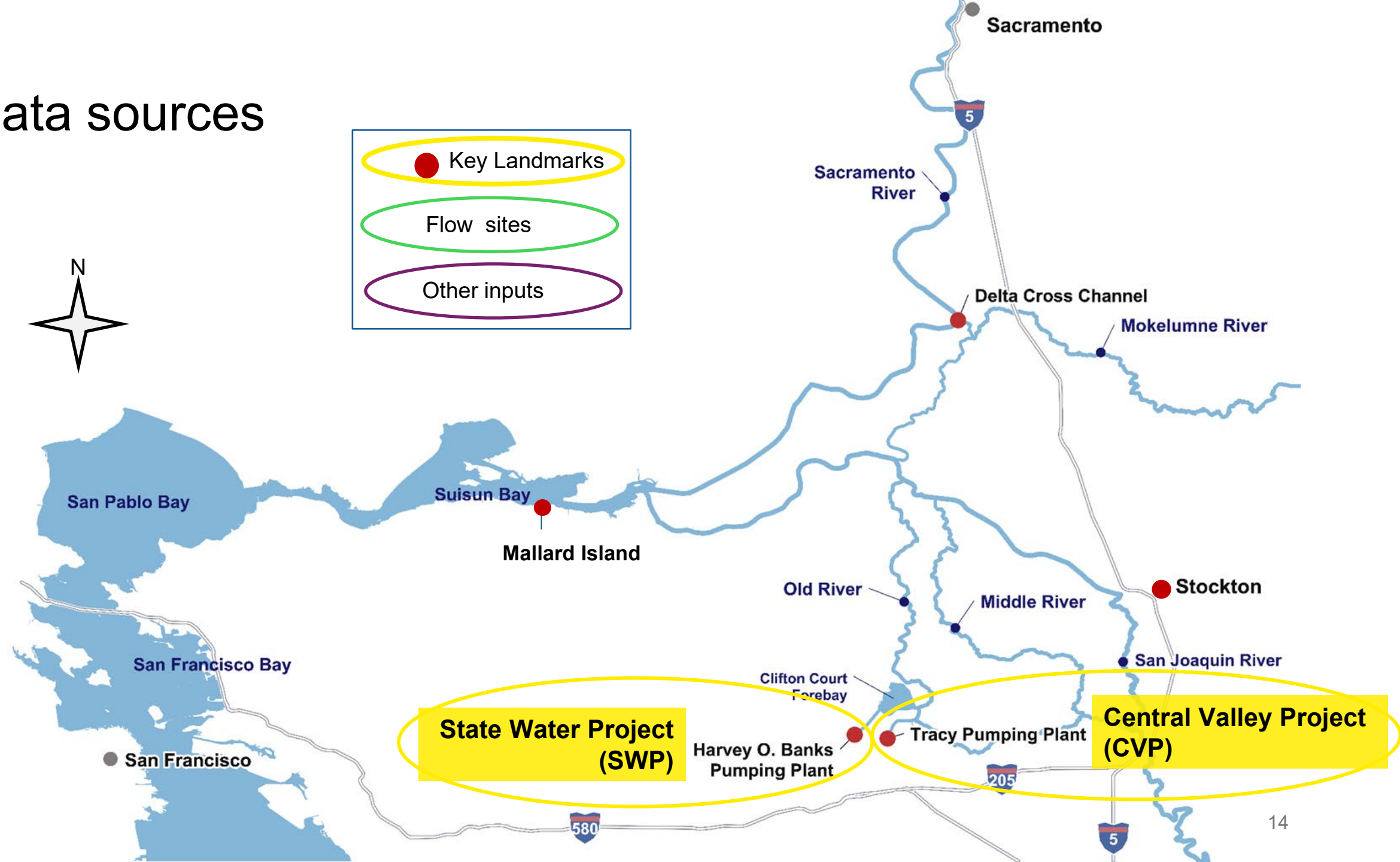
Michael D. Tillotson[*1], Jason Hassrick[2], Alison L. Collins[3], Corey Phillis[3]

- **Inputs:** historical observations of loss, environmental conditions, operations
  - Previous week loss
  - Week of the water year
  - Old & Middle River flow (OMR)
  - Sacramento River flow
  - San Joaquin River flow
  - Exports from CVP and SWP combined
  - DCC status (open/close)
  - Temperature Mallard Island
  - Precipitation at Stockton Fire Station

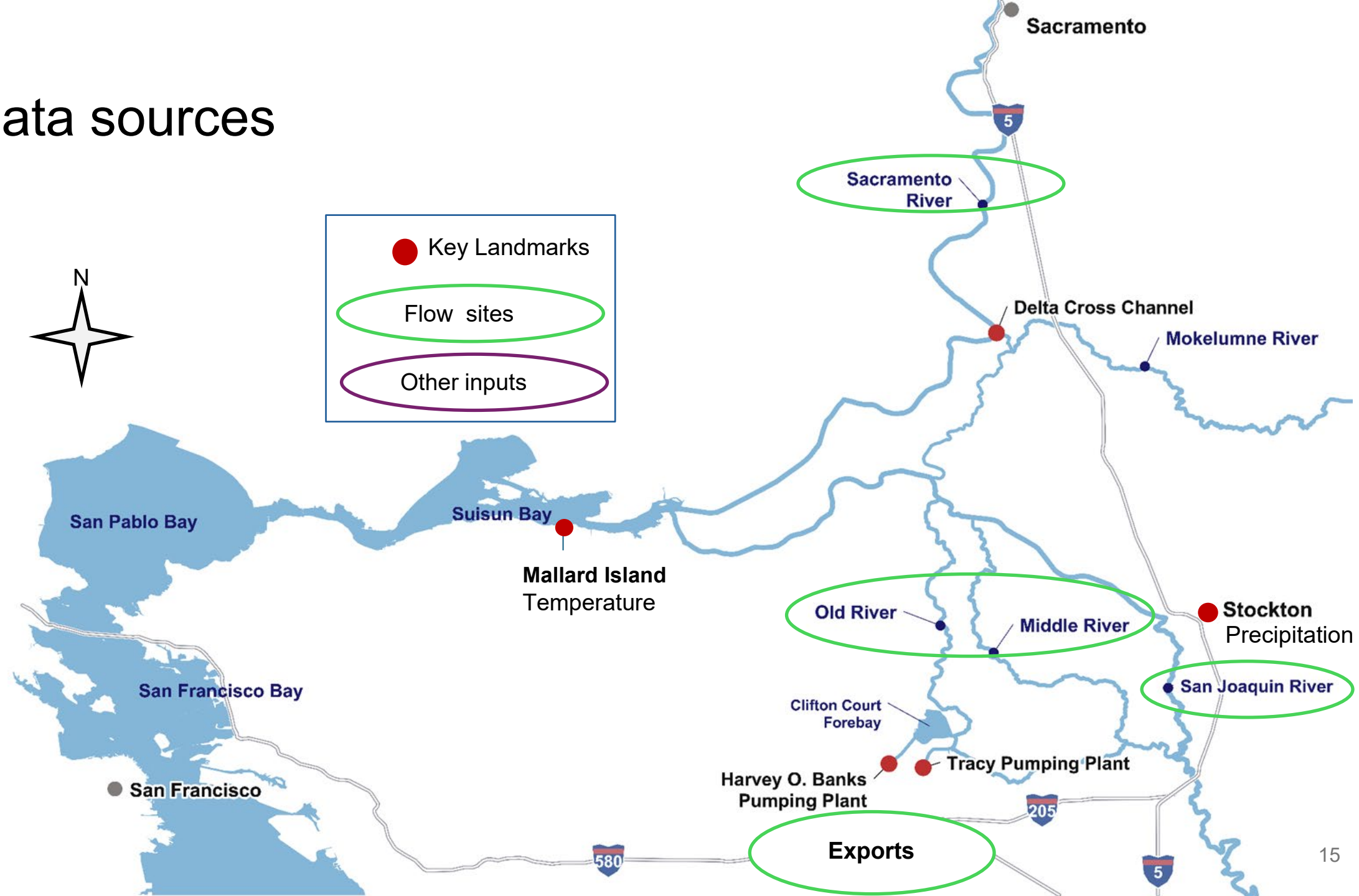
Data sources



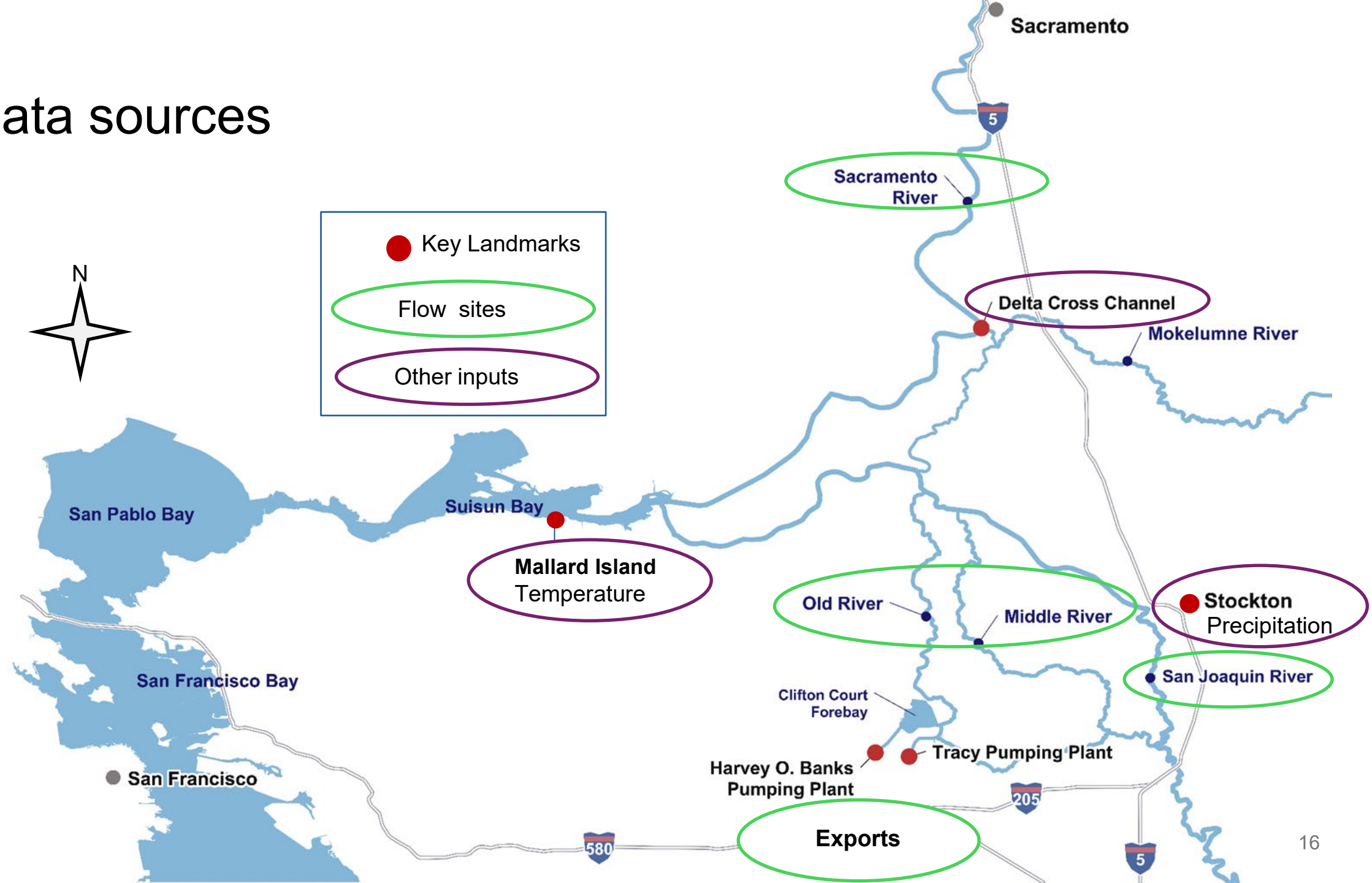
Data sources



Data sources



Data sources



Data and Results Summary

17 years
2009 - 2025

884 weeks

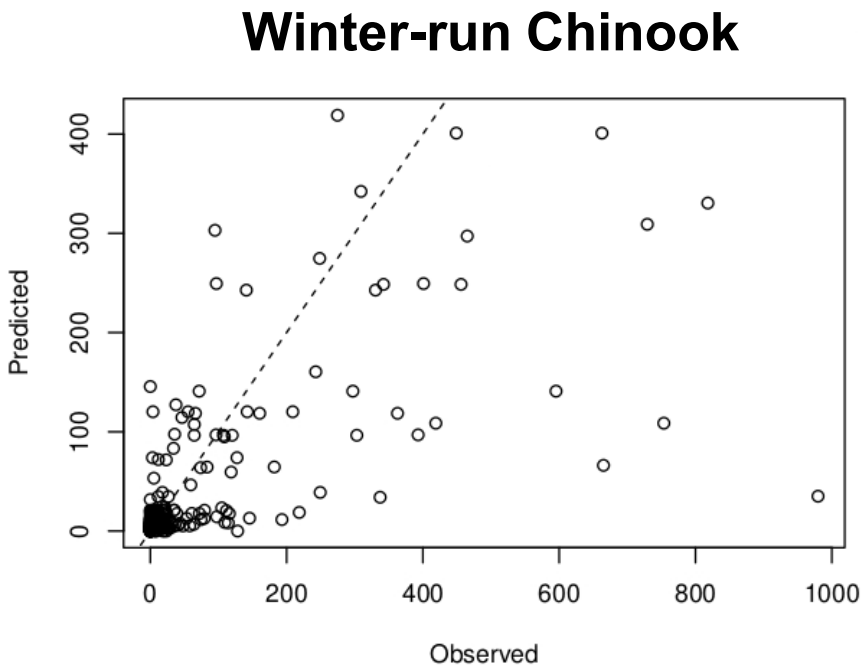
	Winter-run	Steelhead
weeks with fish	21%	34%
During weeks with fish:		
Mean # of fish per week	91	74
Median # of fish per week	19	26
Max # of fish per week	980	779
DCC gate closed	98%	89%
R^2 of predicted vs. observed	0.51	0.62
Tillotson[1] R^2	0.44	0.60

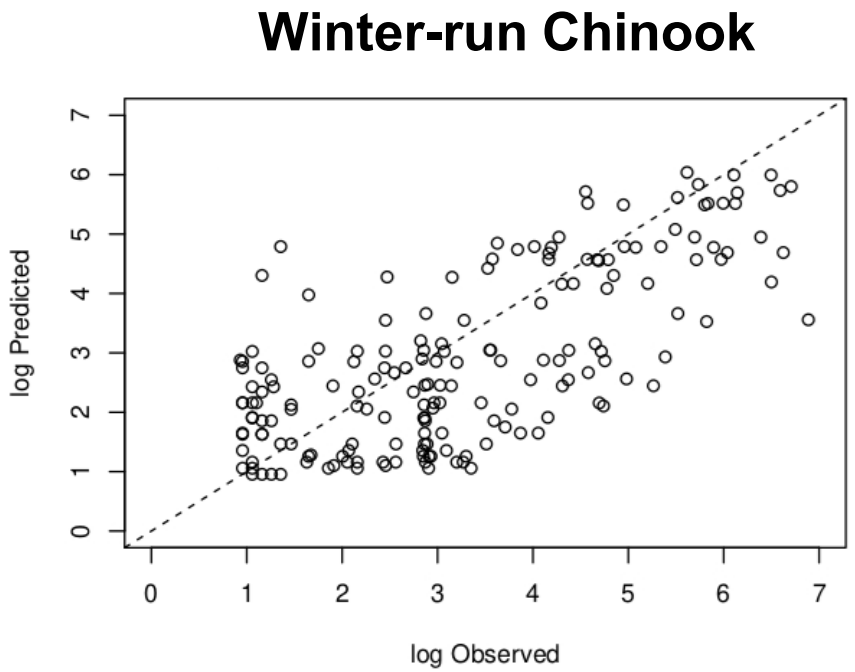
[1]From a cross-validation analysis

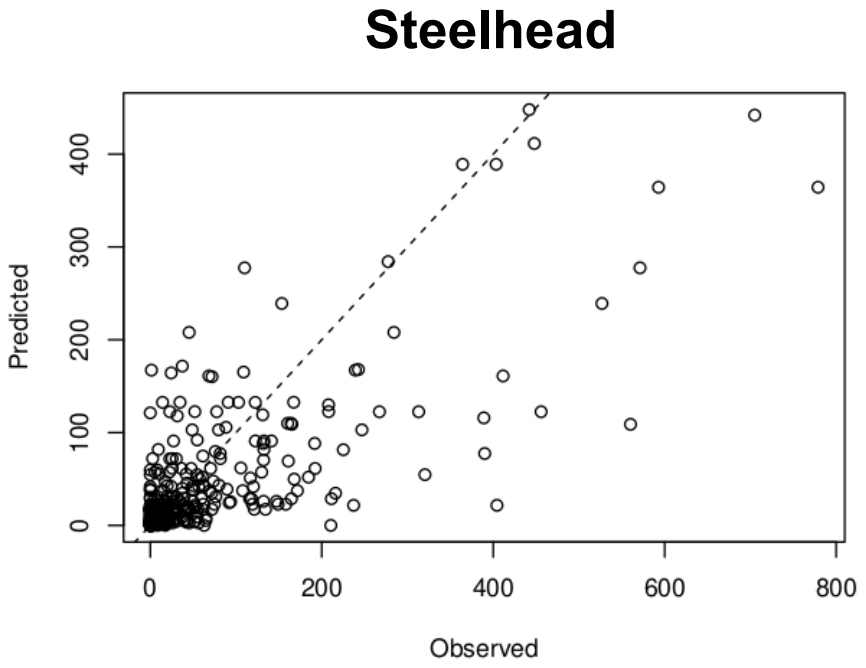
Results

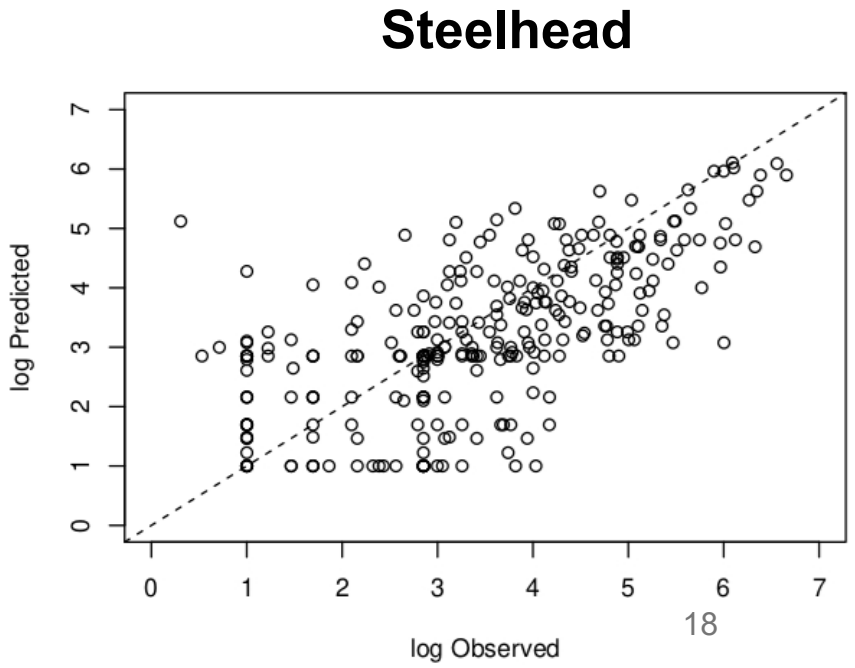
Predicted vs Observed

(2009-2025 data)



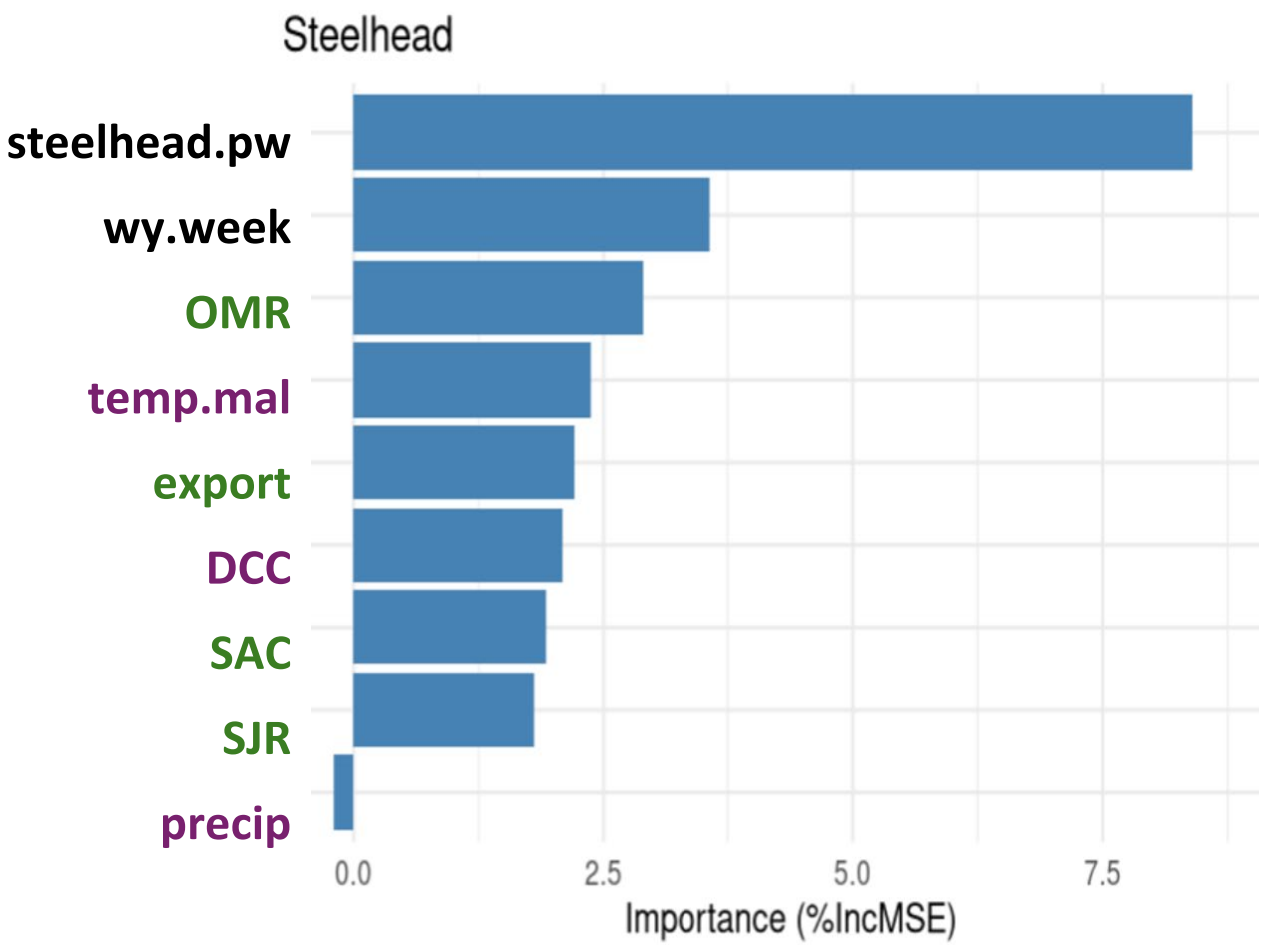


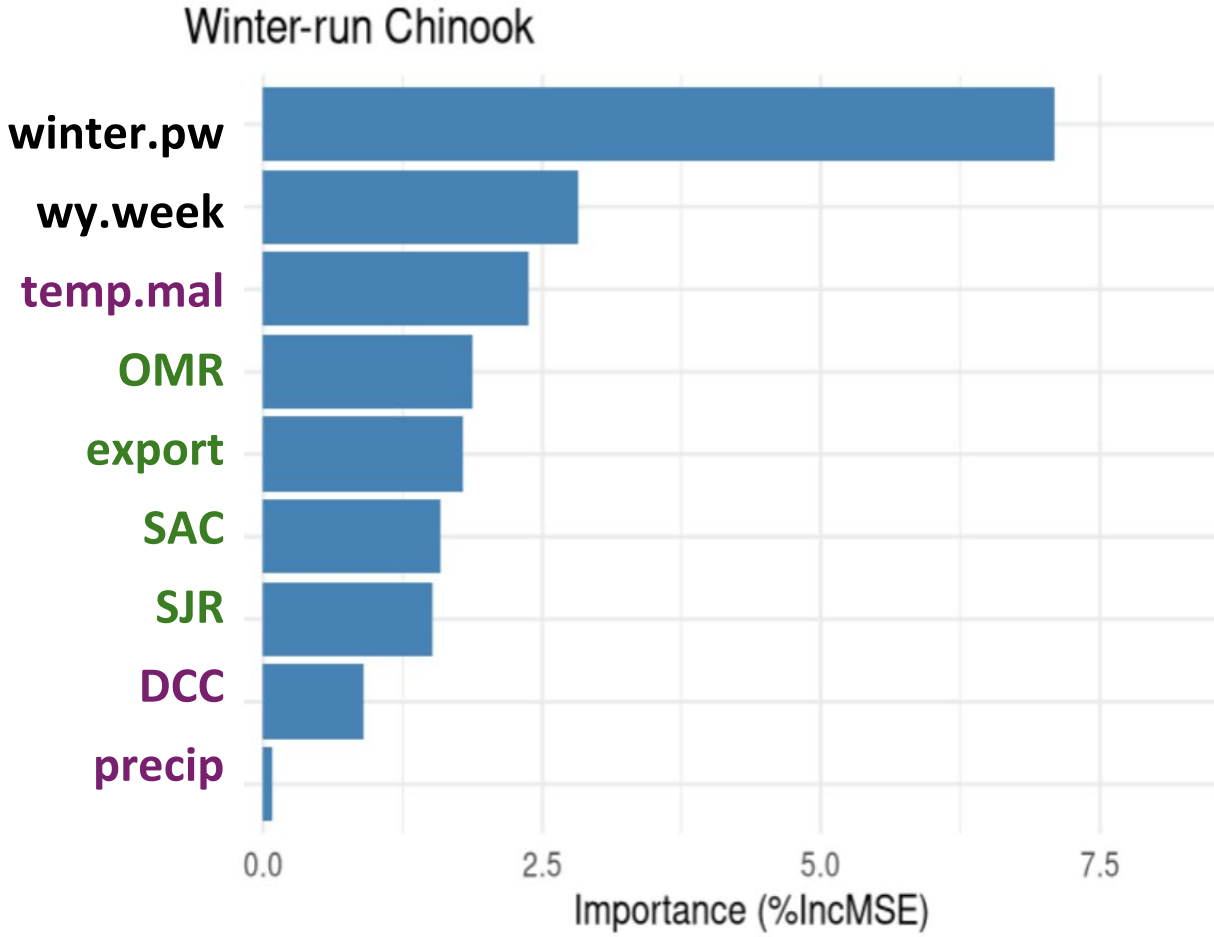




Predictor	Abbreviation
Previous week loss for Steelhead & winter-run Chinook	steelhead.pw winter.pw
Week of the water year	wy.week
Old & Middle River flow	OMR
Sacramento River flow	SAC
San Joaquin River flow	SJR
Exports from CVP and SWP combined	export
DCC status (open/close)	DCC
Temperature Mallard Island	temp.mal
Precipitation at Stockton Fire Station	precip

Importance: "The increase in Mean Squared Error if that predictor is randomly permuted during the calibration"





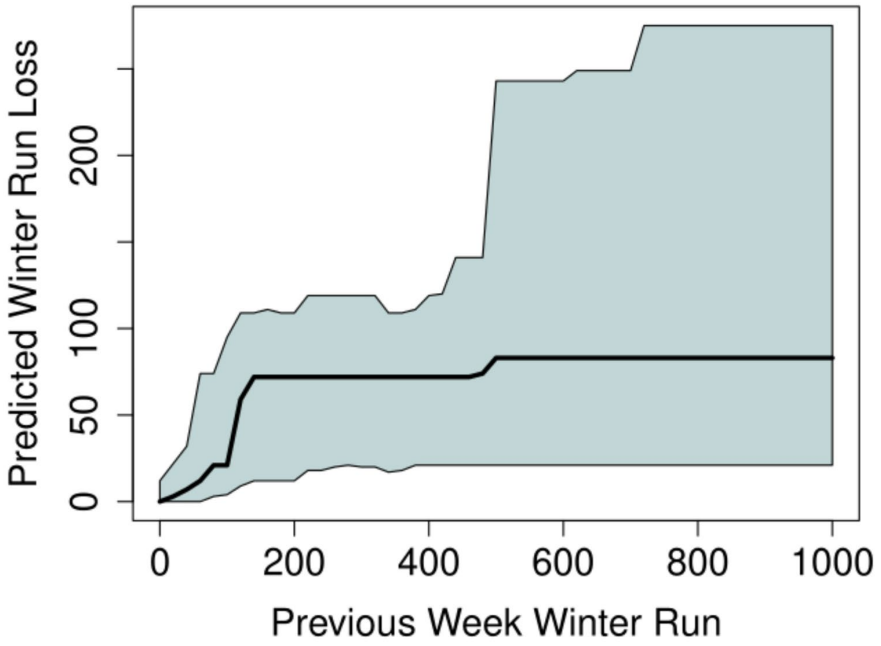
Marginal Plots

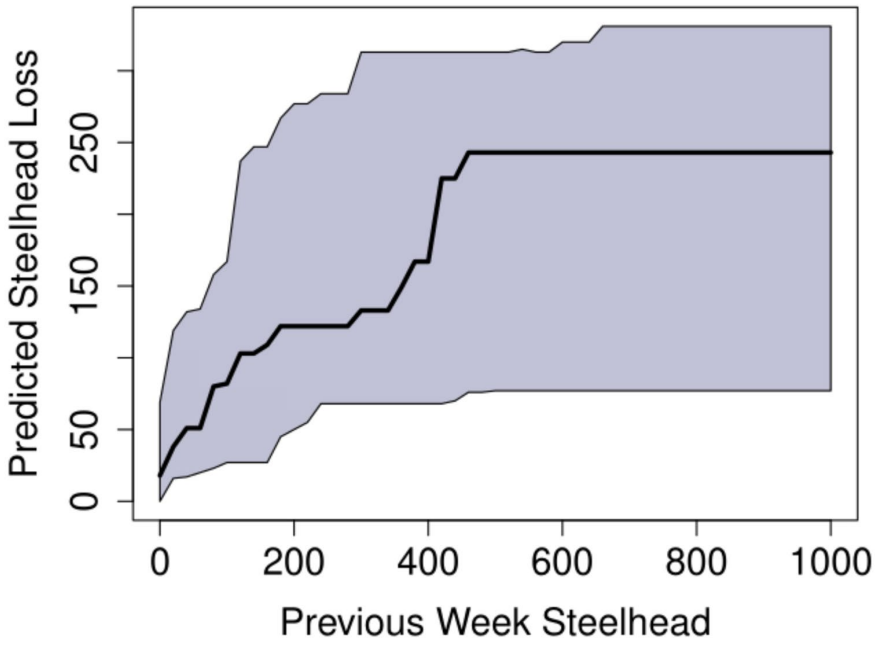
Previous week loss

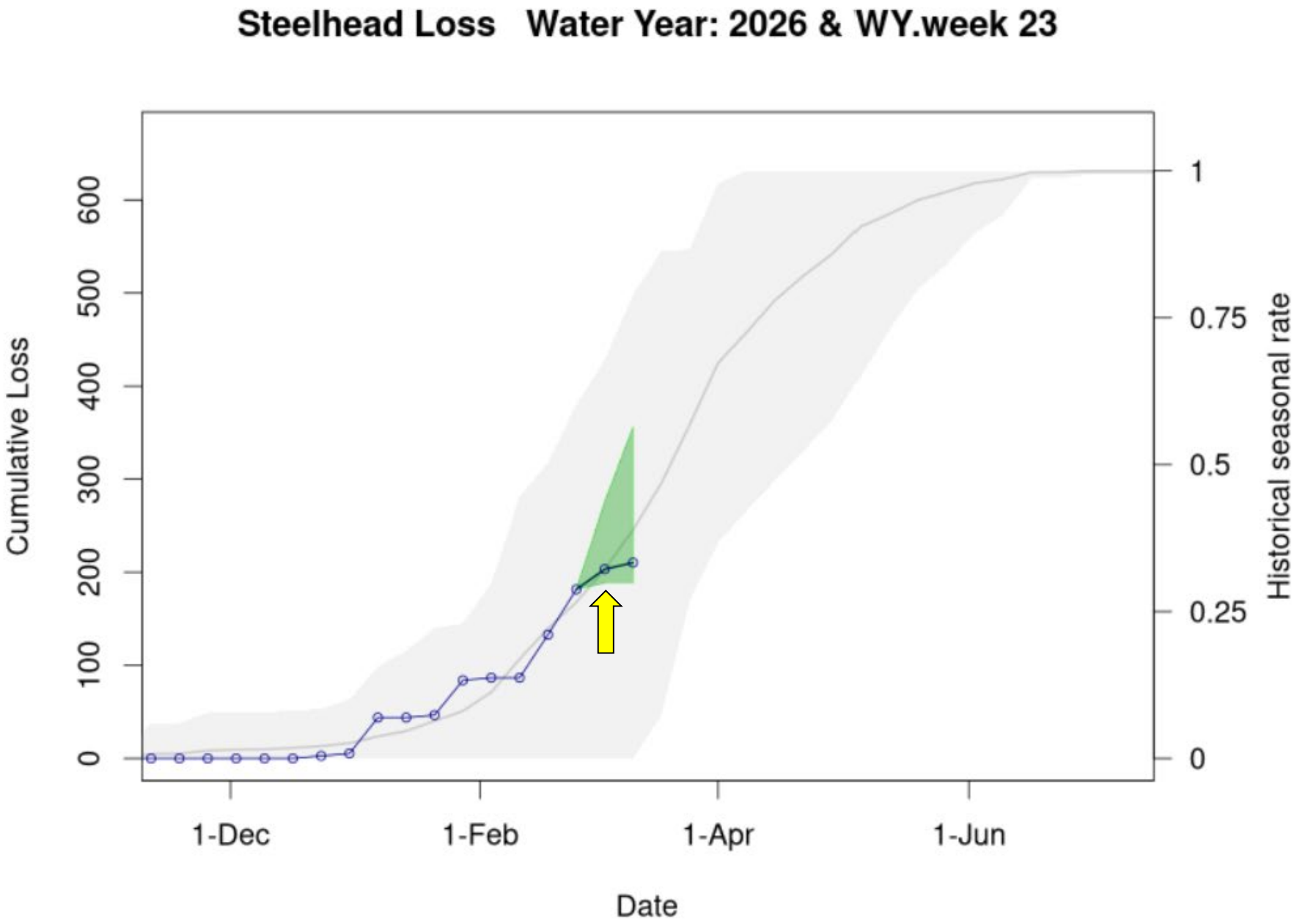
Sensitivity of predicted loss to range of previous week loss.

Shaded area is the 80% prediction interval around the median line.

Other predictors:
- week 25
- DCC closed
- set to average

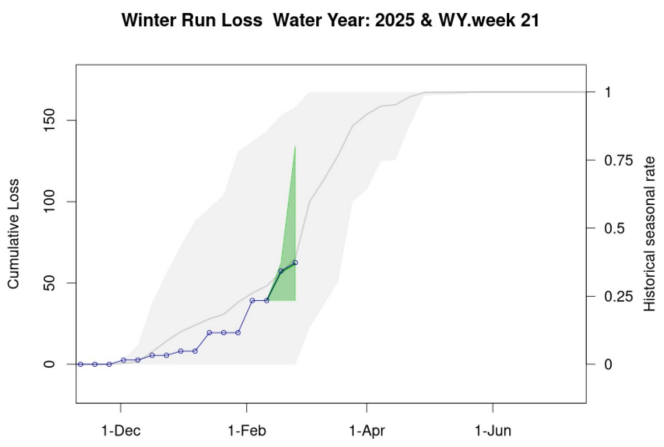


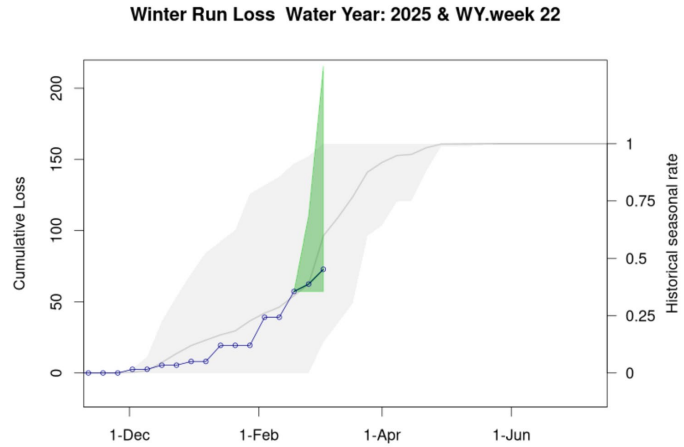


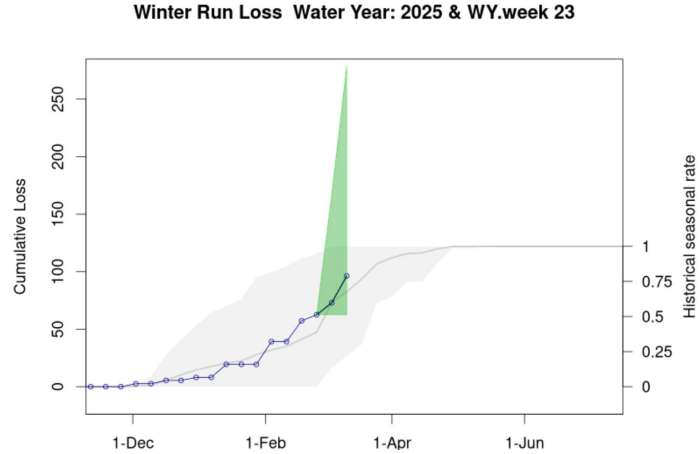


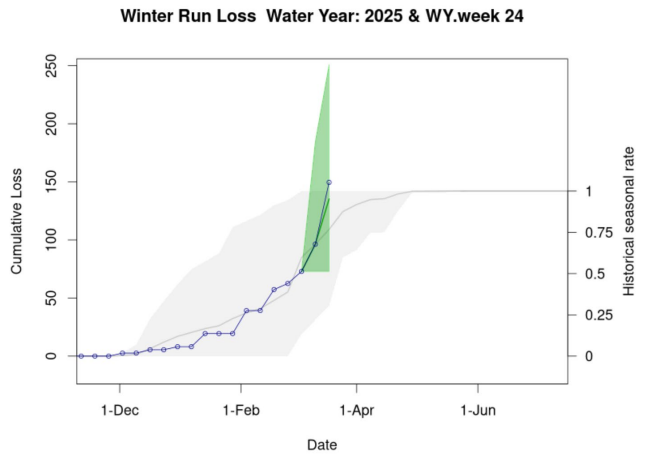
Example hindcast:

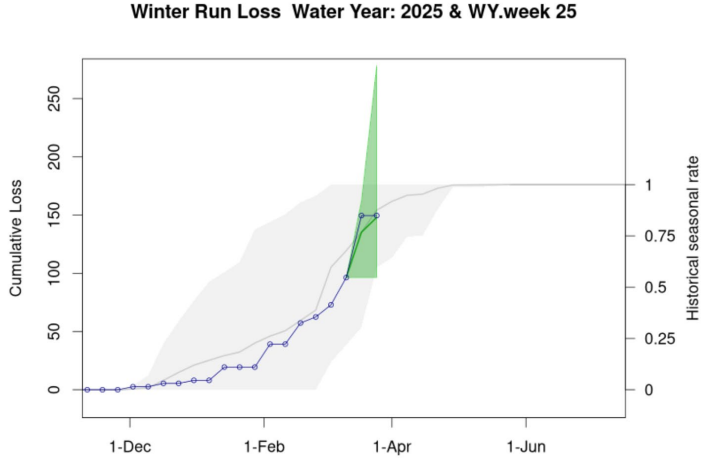
2026 March 8

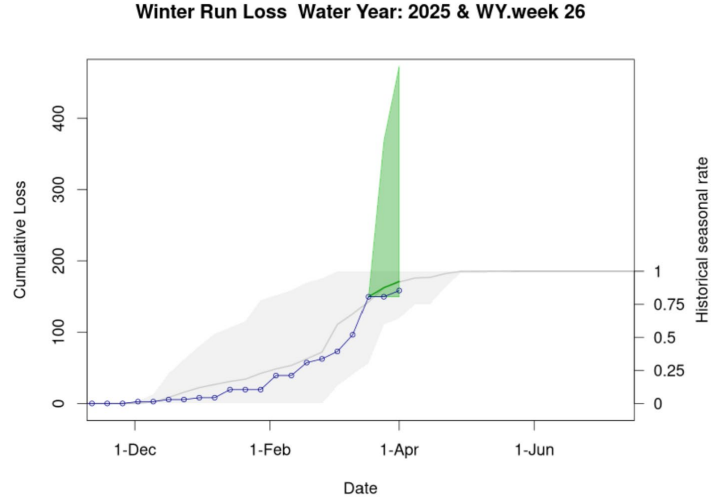


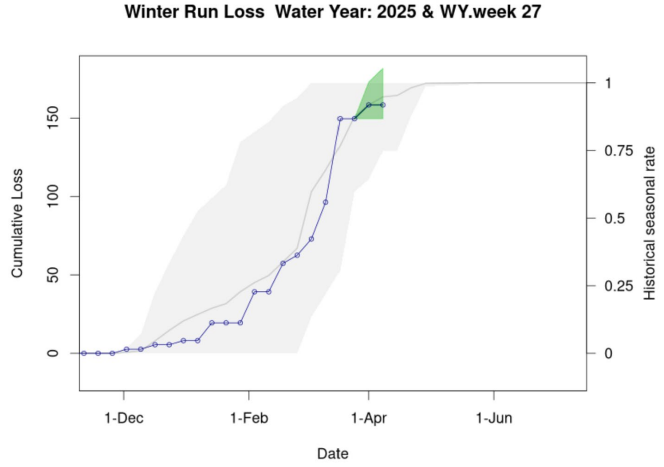


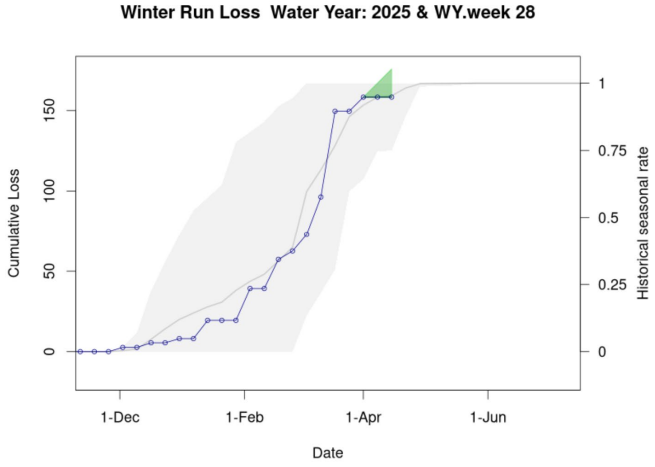












Week-to-week predictions from February (week 21) to April (week 28) for natural-origin winter-run in 2025.

Annual incidental take limit : **494**

Final observed loss: **158**

Loss & Salvage Tool Results

Results with calibration: Loss for both species, water years 2009-2025

Water Year (WY)	WY Week	Steelhead Predicted loss, 90% CI Low	Steelhead Predicted loss, Median	Steelhead Predicted loss, 90% CI High	Winter Chinook Predicted loss, 90% CI Low	Winter Chinook Predicted loss, Median	Winter Chinook Predicted loss, 90% CI High	Steelhead Observed loss	Winter Chinook Observed loss	Steelhead Cumulative Observed loss	Winter Chinook Cumulative Observed loss
2025	21	11	55	120	0	17	23	56	18	159	57
2025	22	11	50	106	0	5	72	50	5	209	63

Inputs for Environmental Conditions and Previous Week

Water Year (WY)	WY Week	Water Temperature °C	Precipitation Inches	OMR Flows CFS	Sacramento Flows CFS	DCC Gate Status	San Joaquin River Flow CFS	Exports CFS, sum of Pumping Discharge	Steelhead loss Previous Week	Winter Chinook loss Previous Week
2025	21	11.03	0.04	-5325.71	71055.32	closed	1985.74	6405.71	42	0
2025	22	12.54	0	-5977.14	57634.4	closed	1545.57	6110.14	55	17

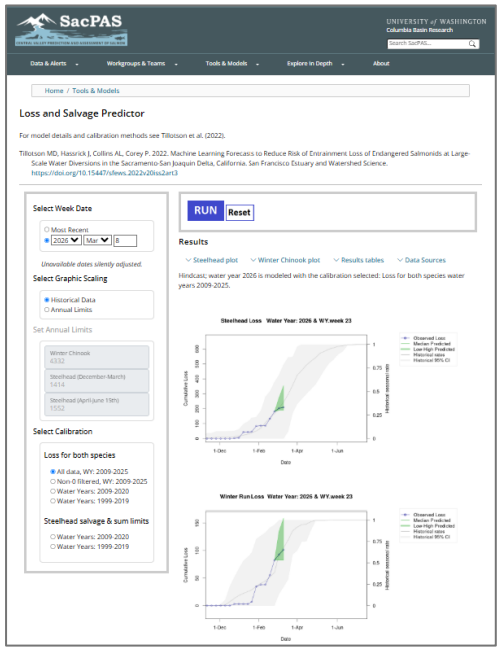
Loss & Salvage Decision Support Tools on SacPAS

Tools & Models	Workgroups & Teams: Delta Actions Team

Loss & Salvage Decision Support Tools on SacPAS

Tools & Models

Loss & Salvage Predictor
with User Interface

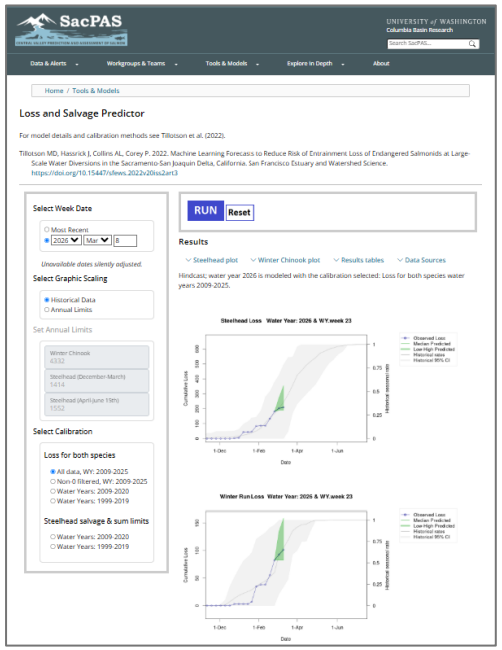


Workgroups & Teams: Delta Actions Team

Loss & Salvage Decision Support Tools on SacPAS

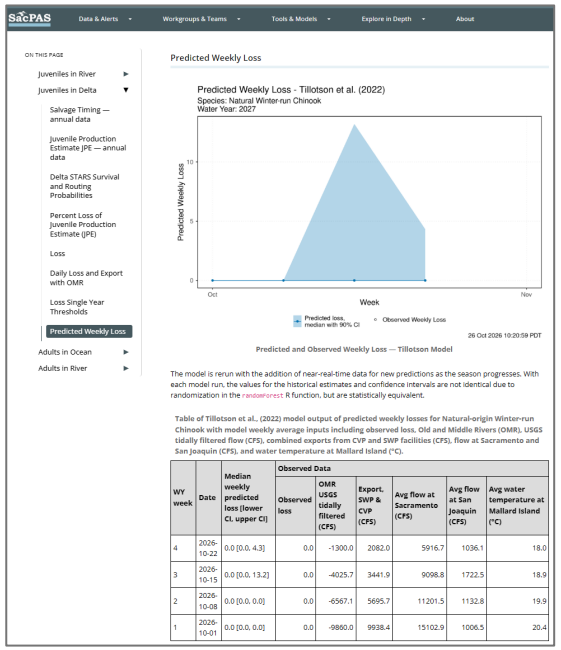
Tools & Models

Loss & Salvage Predictor
with User Interface



Workgroups & Teams: Delta Actions Team

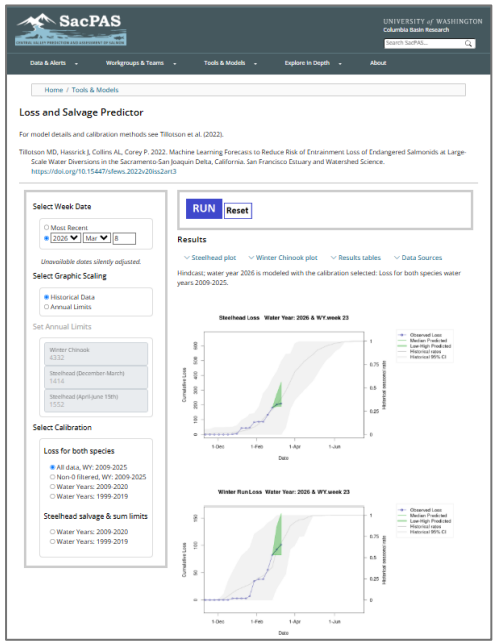
Track-a-Cohort
Juveniles in Delta



Loss & Salvage Decision Support Tools on SacPAS

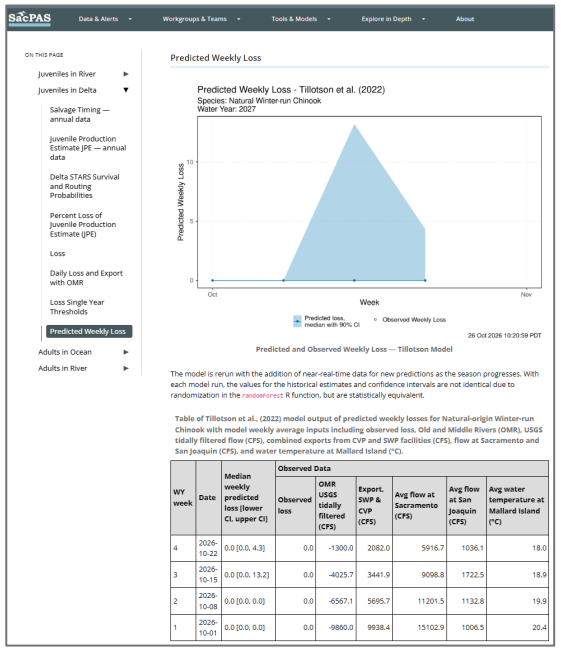
Tools & Models

Loss & Salvage Predictor
with User Interface

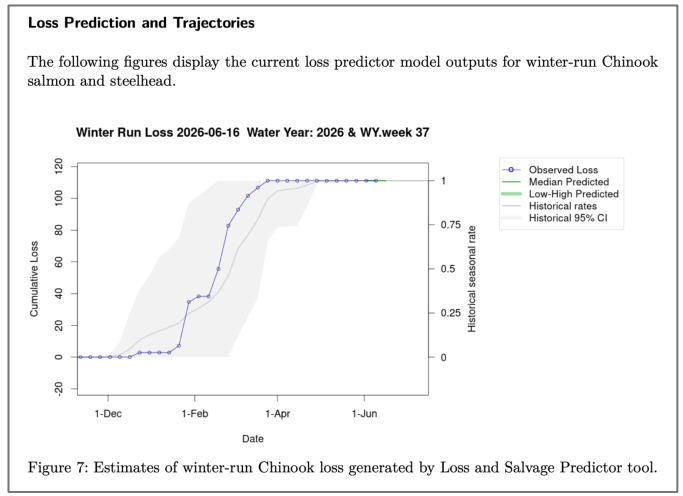


Workgroups & Teams: Delta Actions Team

Track-a-Cohort
Juveniles in Delta



Real Time Assessment
for Delta Operations

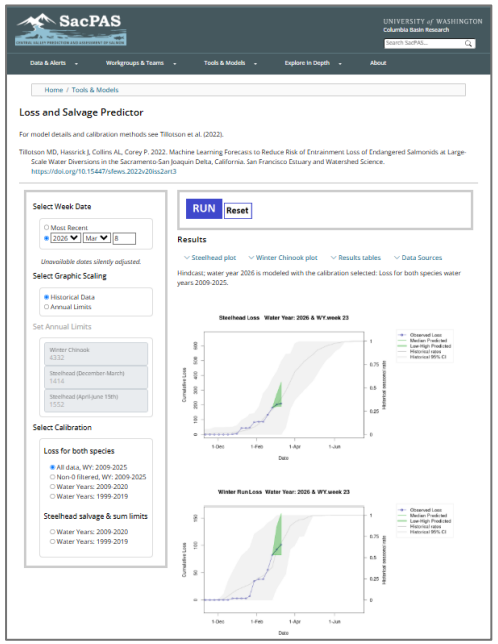


Loss & Salvage Decision Support Tools on SacPAS

Tools & Models

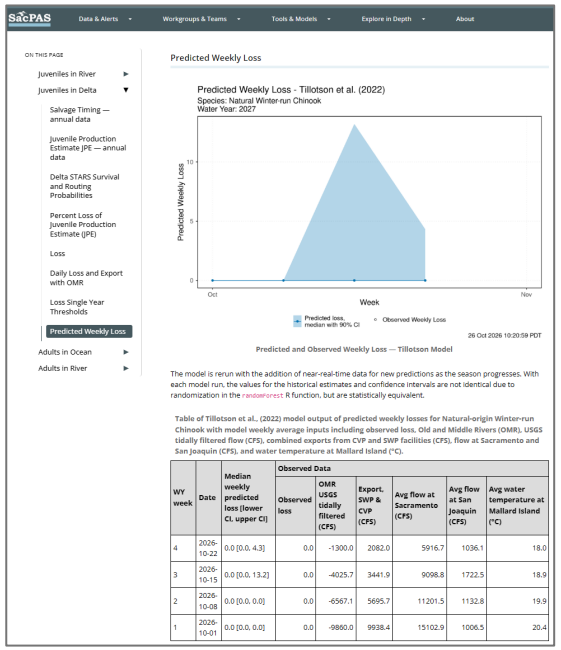
Workgroups & Teams: Delta Actions Team

Loss & Salvage Predictor
with User Interface



- User input of customized data sets
- User input of scenarios data
- Predictions for next week or historical

Track-a-Cohort
Juveniles in Delta



Real Time Assessment
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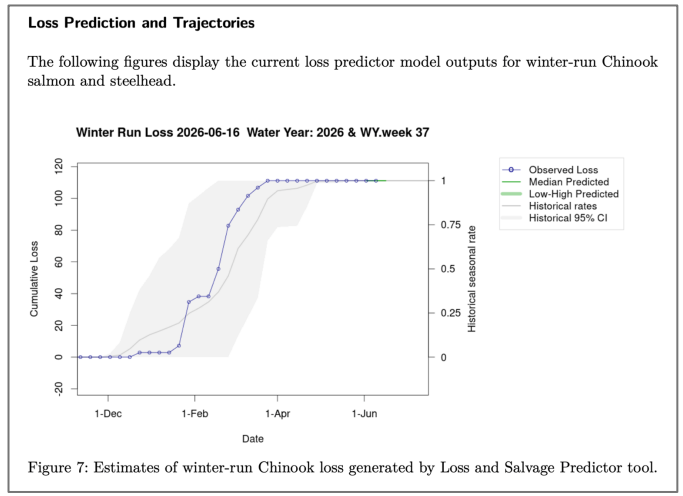


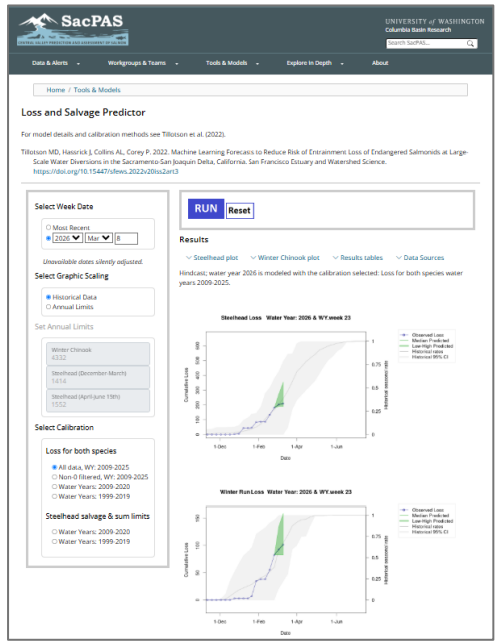
Figure 7: Estimates of winter-run Chinook loss generated by Loss and Salvage Predictor tool.

Loss & Salvage Decision Support Tools on SacPAS

Tools & Models

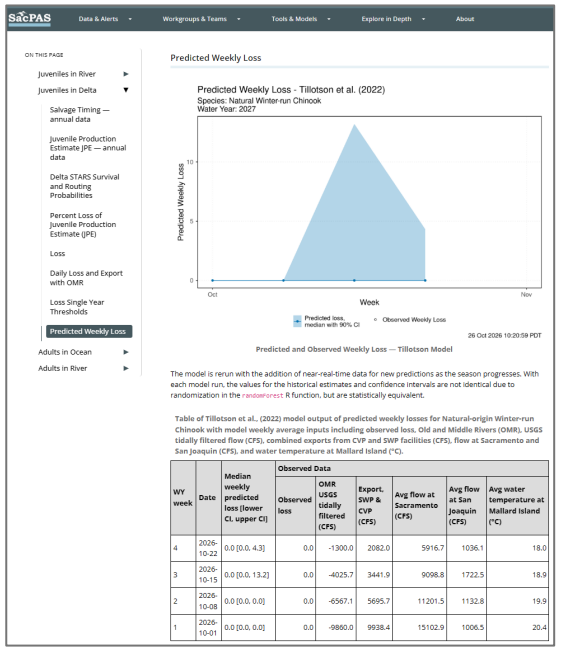
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Loss & Salvage Predictor
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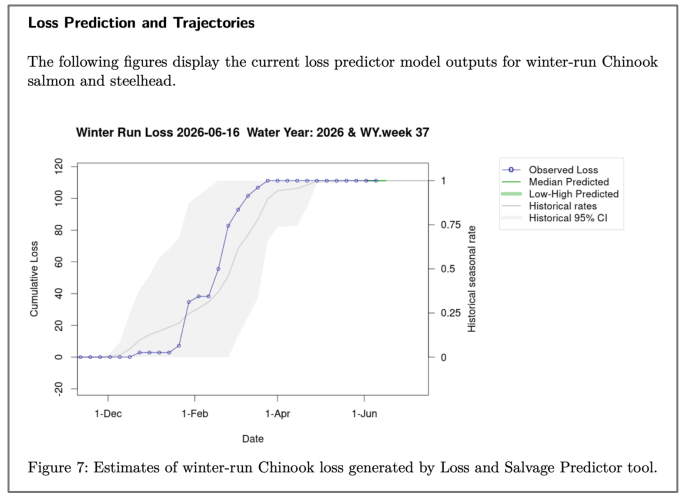
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Track-a-Cohort
Juveniles in Delta



- Predicted weekly loss automatically generated daily (Figure and Table)

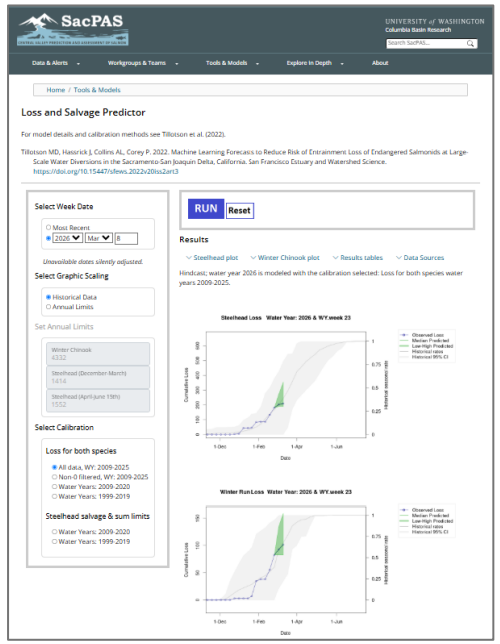
Real Time Assessment
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Loss & Salvage Decision Support Tools on SacPAS

Tools & Models

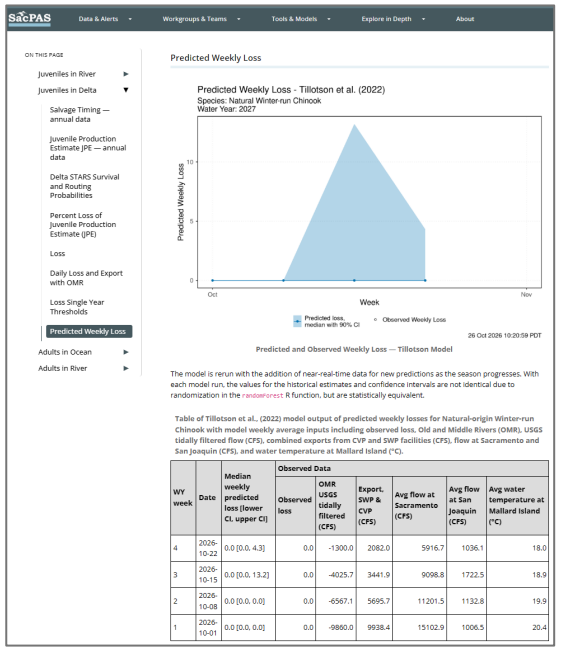
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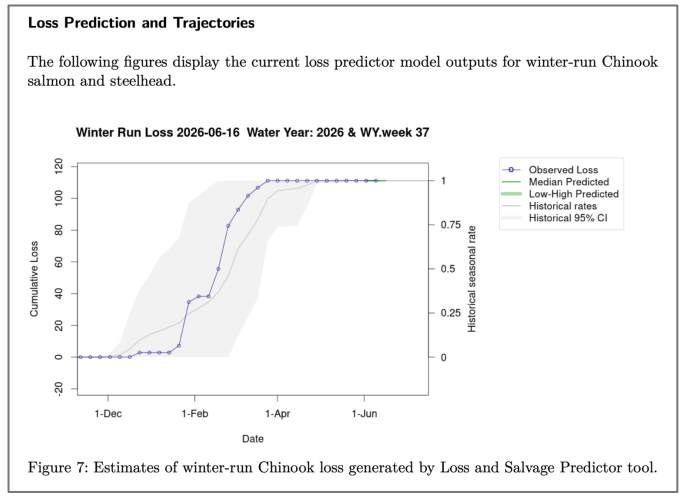
Workgroups & Teams: Delta Actions Team

Track-a-Cohort
Juveniles in Delta



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Real Time Assessment
for Delta Operations

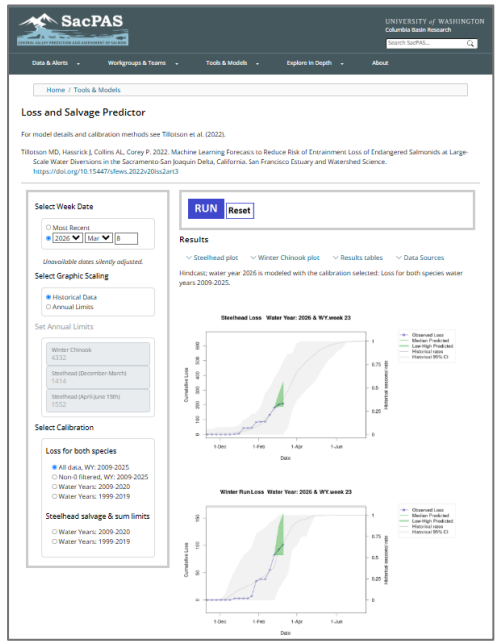


- Observed and predicted weekly loss automatically generated for weekly assessments

Loss & Salvage Decision Support Tools on SacPAS

Tools & Models

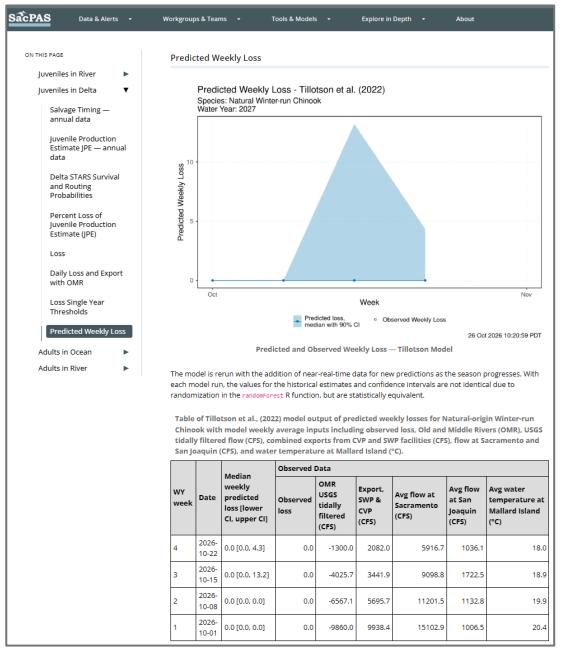
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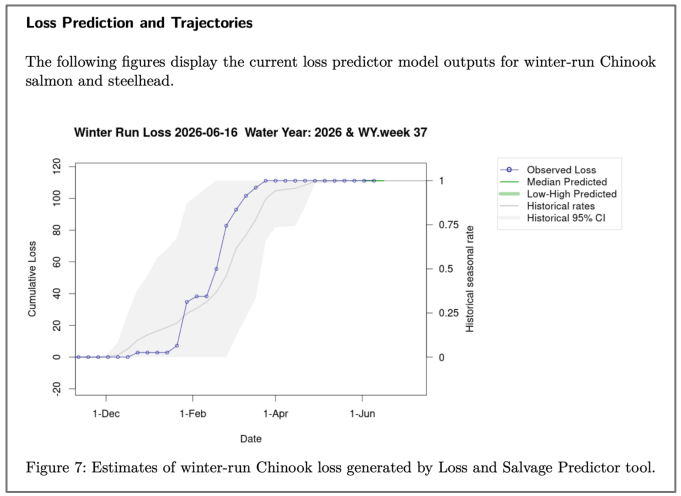
Workgroups & Teams: Delta Actions Team

Track-a-Cohort
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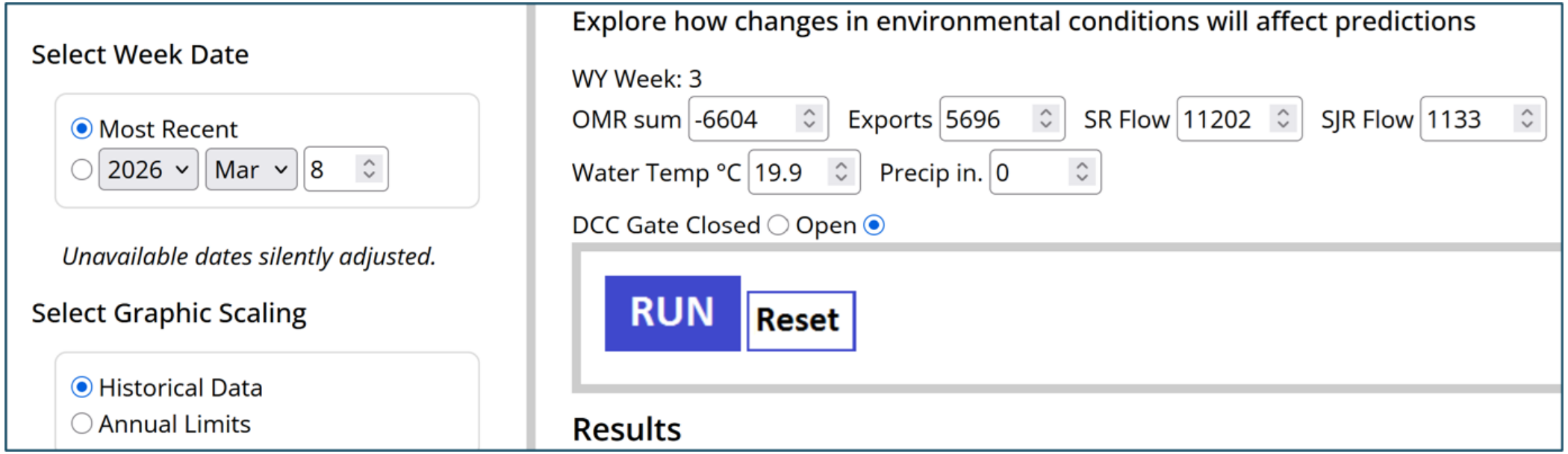
Real Time Assessment
for Delta Operations



- Observed and predicted weekly loss automatically generated for weekly assessments

Loss & Salvage Decision Support Tools on SacPAS

Predict next week with optional user-controlled **scenarios** of the predictors



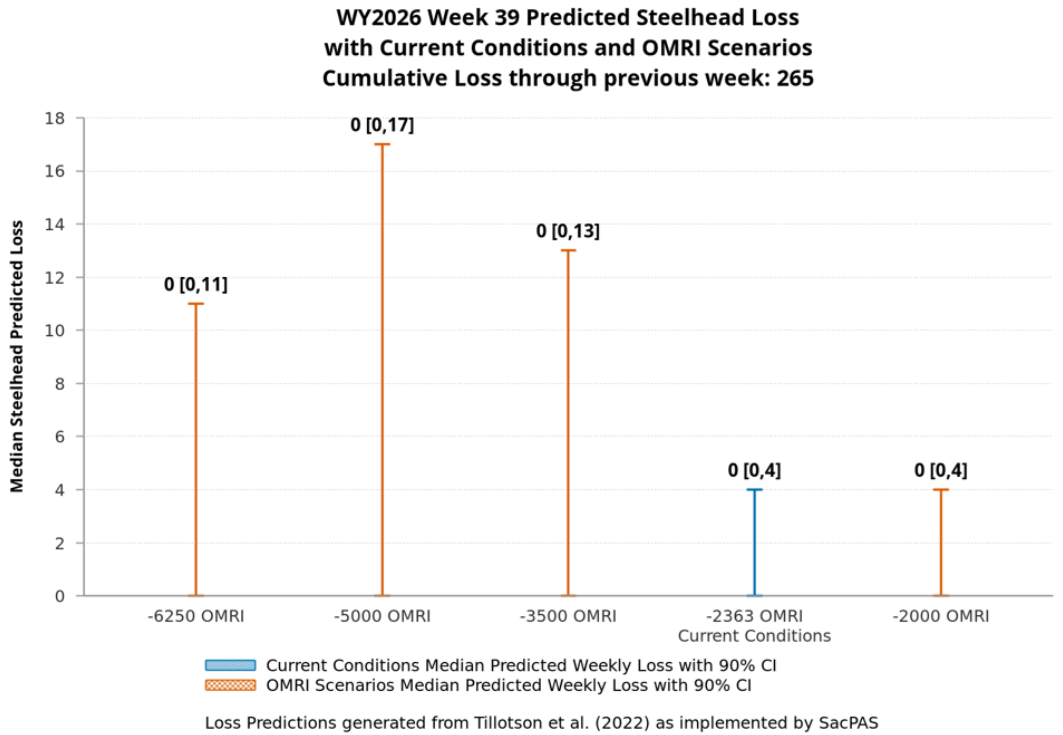
Loss & Salvage Decision Support Tools on SacPAS

Workgroups & Teams: Delta Actions Team

Supporting Data and Visualizations -- Current conditions and fishes

- Chinook and steelhead
  - Includes data for Winter Chinook, Spring Chinook, and steelhead in juvenile monitoring datasets and Salvage database, and monitoring of current conditions. Updated daily.

OMRI scenarios:



Loss & Salvage Predictor Tool

Questions?

Acknowledgments

CDFW, Bay Delta Region, for the Loss & Salvage data

Bureau of Reclamation

Lisa Elliott (GOTR) Josh Israel