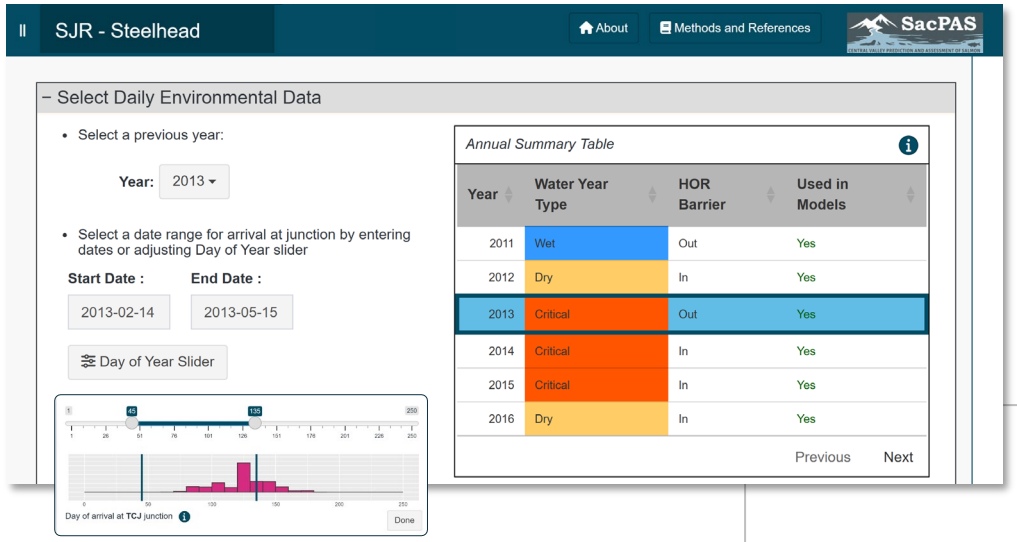
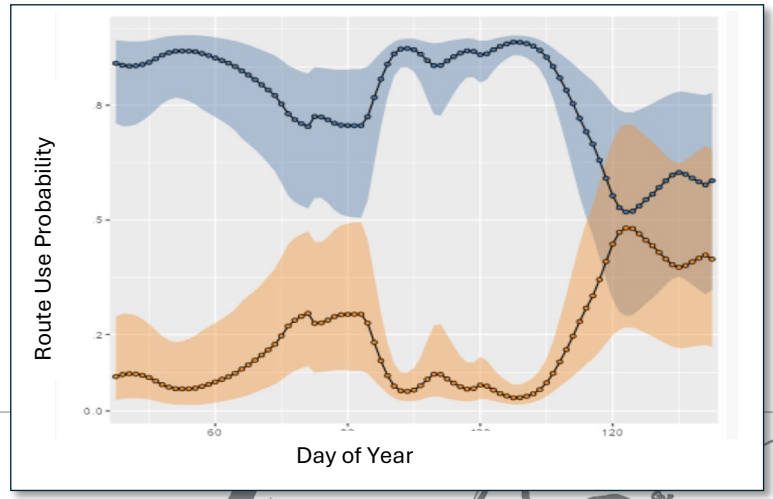
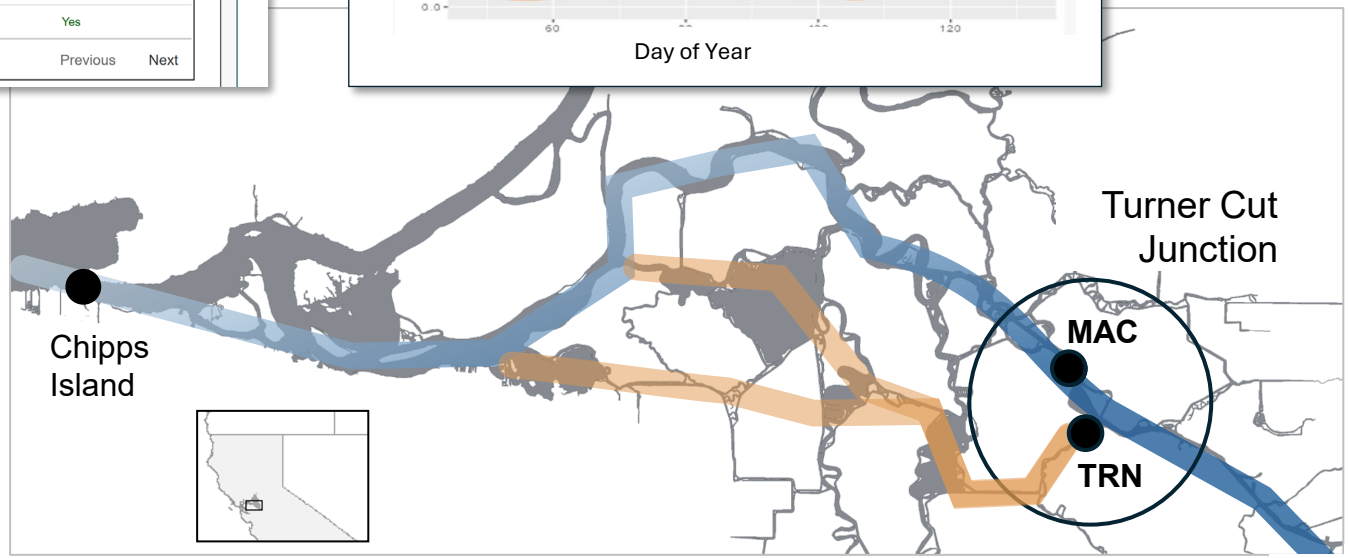
R Shiny App for Predicting Juvenile Steelhead Survival and Route Usage in the San Joaquin River and Delta







Steve Whitlock
Rebecca Buchanan

School of Aquatic and Fishery Sciences

University of Washington

Funding provided by the Bureau of Reclamation under CVPAS project

Steelhead in the Sacramento/San Joaquin Delta

- Central Valley steelhead are threatened under ESA
- High mortality for juvenile Steelhead traversing the Delta
- Uncertainties surrounding how juvenile Steelhead respond to conditions in the Delta
  - Environmental conditions
  - Management activities

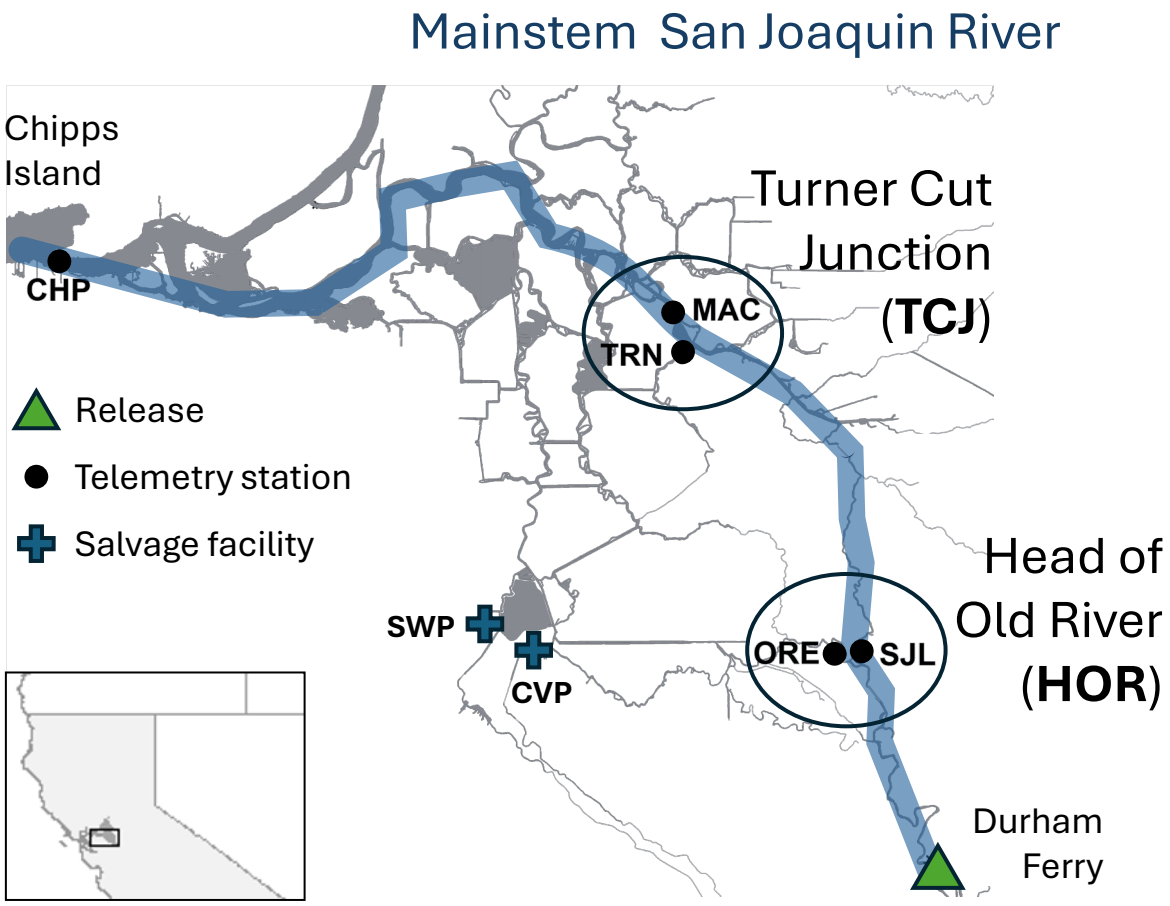




Acoustic Telemetry Studies (2011-2016)

- Design
  - Multiple releases per year (r)
  - Stations set up to monitor junctions where fish may deviate from mainstem

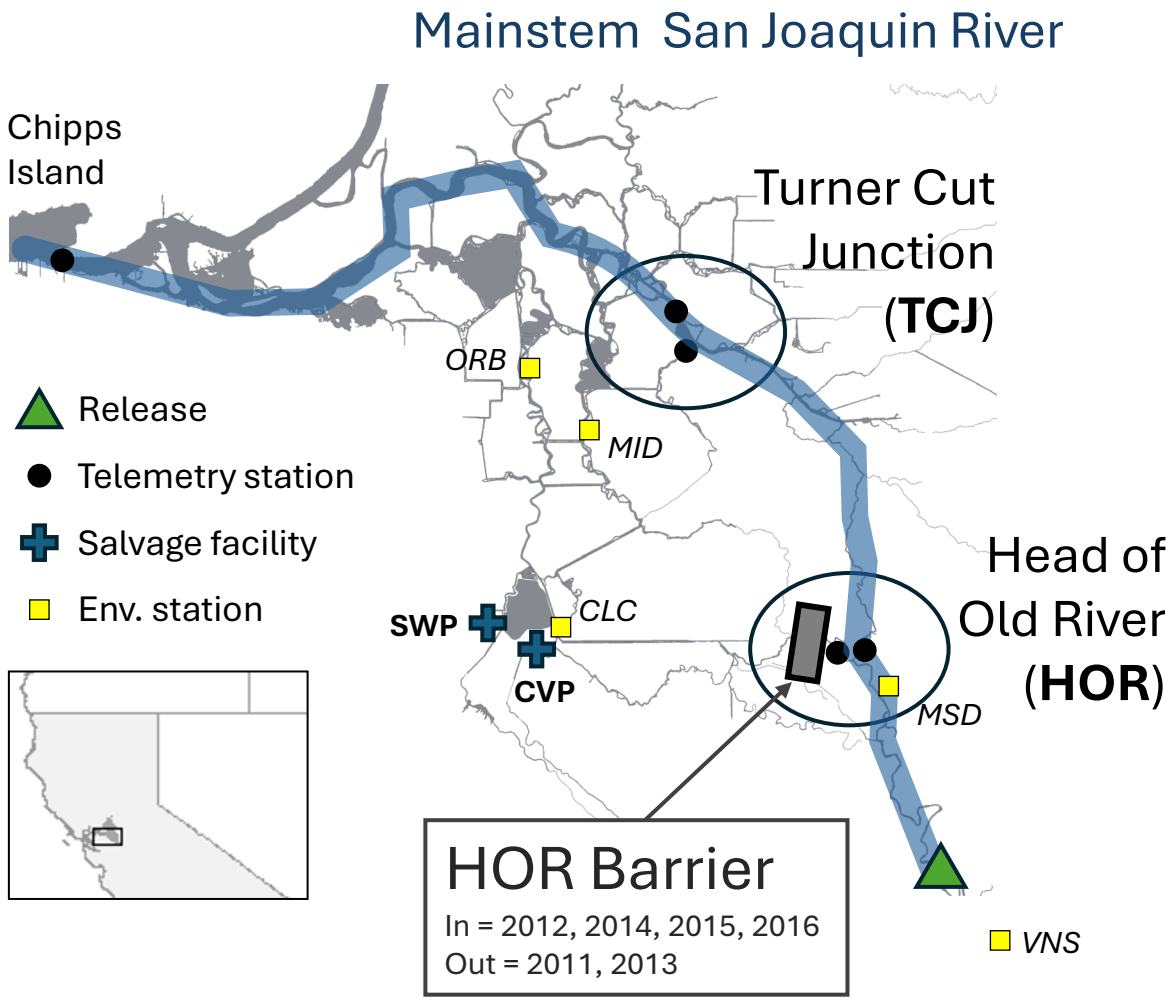
Junction	Route	Remain in Mainstem
HOR	**SJL** (San Joaquin)	Yes
	ORE (Old River Route)	No
TCJ	**MAC** (towards MacDonald Island)	Yes
	TRN (Turner Cut (toward interior Delta)	No



Acoustic Telemetry Studies (2011-2016)

- Design
  - Multiple releases per year (r)
  - Stations set up to monitor junctions where fish may deviate from mainstem
  - Monitor hydrologic conditions across region

Scale	Environmental	Management
Continuous	• Inflow (*VNS*) & Outflow (**CHP**) • Temperature (*CLC*, *MSD*); • Interior Net Flow (*ORB,MID*)	Water exports (**CVP**,**SWP**)
Categorical	Water Year Type: **Critical** → **Dry** → **Below Normal** → **Above Normal** → **Wet**	Barrier at **HOR**



Modeling Based on Acoustic Study Data

Reach-Specific Survival (θ)



Canadian Science Publishing

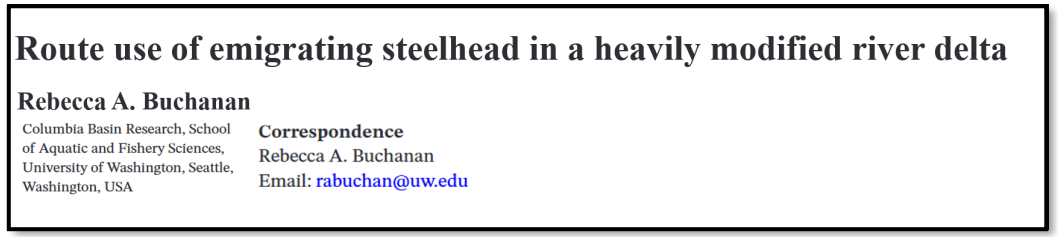
ARTICLE

Outmigration survival of a threatened steelhead population through a tidal estuary

Rebecca A. Buchanan, Elissa Buttermore, and Joshua Israel

Can. J. Fish. Aquat. Sci. **78**: 1869–1886 (2021) dx.doi.org/10.1139/cjfas-2020-0467 Published at www.cdnsciencepub.com/cjfas on 27 May 2021.

Route Usage at Junctions (Ψ)

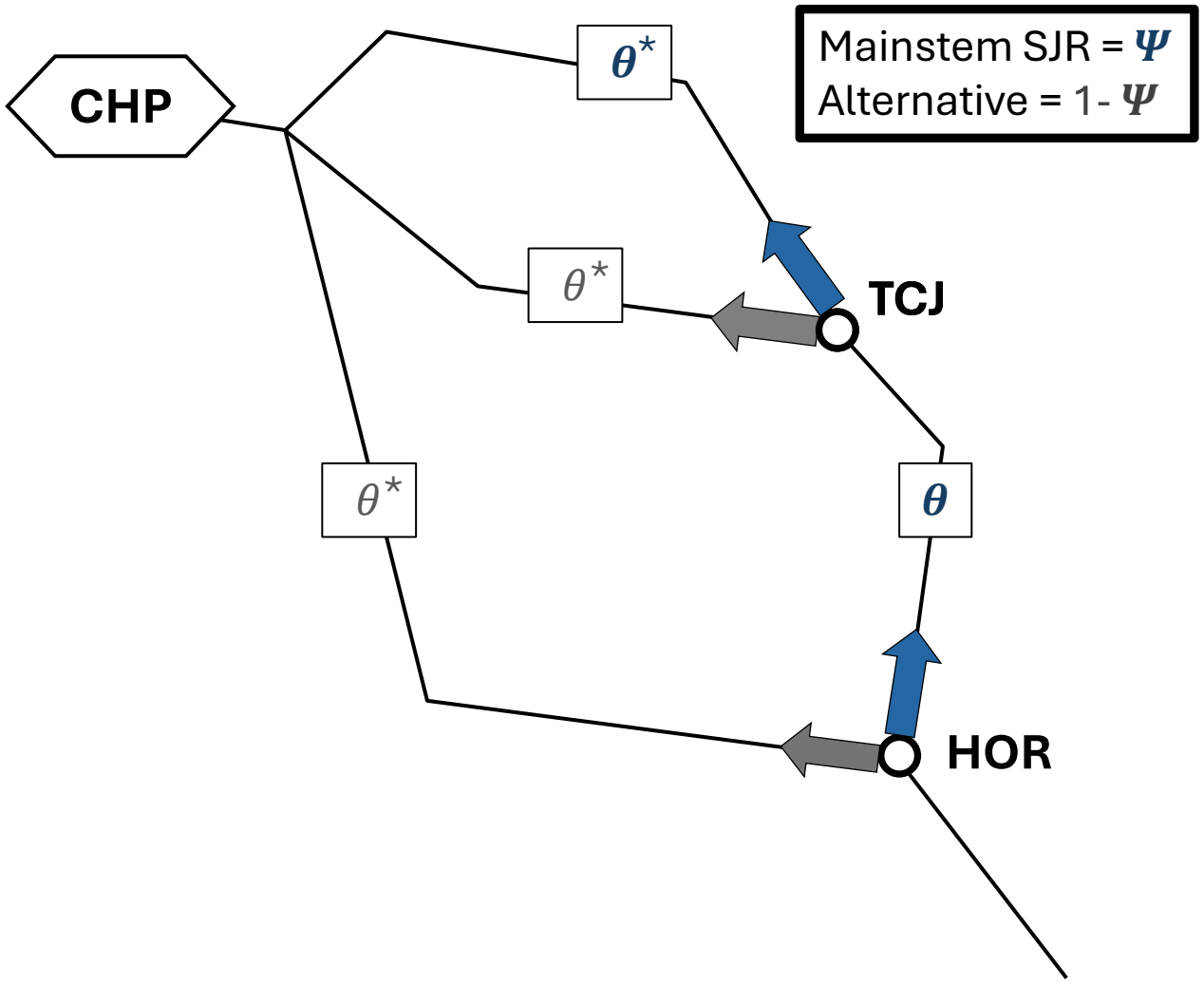


Route use of emigrating steelhead in a heavily modified river delta

Rebecca A. Buchanan

Columbia Basin Research, School of Aquatic and Fishery Sciences, University of Washington, Seattle, Washington, USA

Correspondence
Rebecca A. Buchanan
Email: rabuchan@uw.edu



Modeling Based on Acoustic Study Data

Reach-Specific Survival (θ)



Canadian Science Publishing

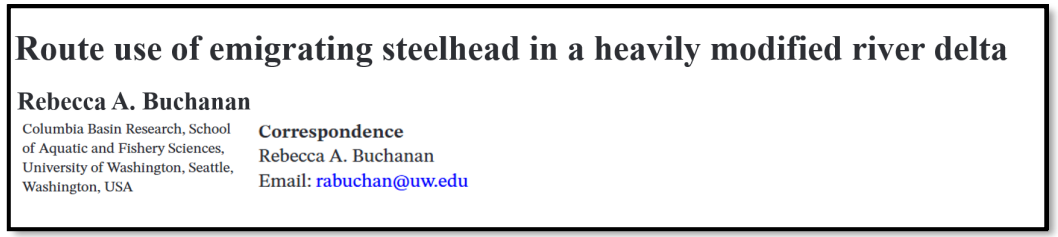
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Email: rabuchan@uw.edu

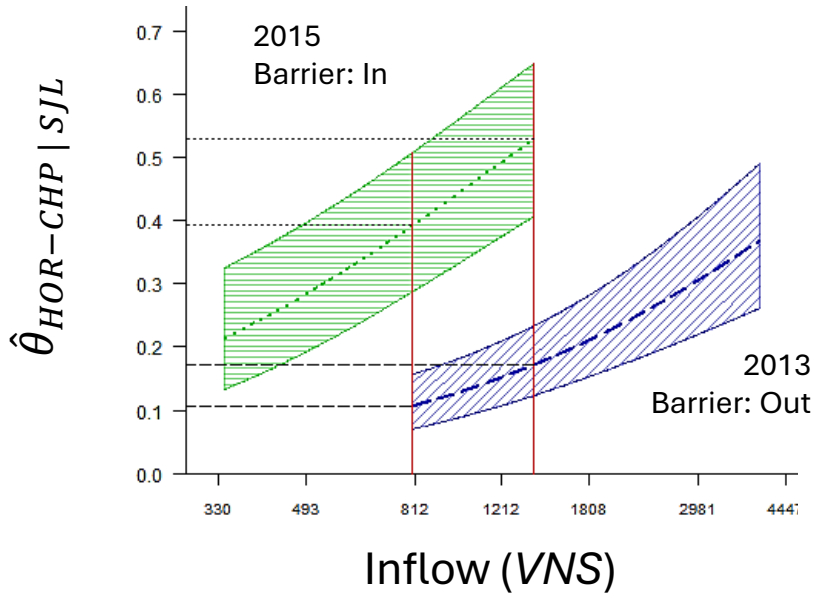
Analytical Approaches

- Fit models with alternative sets of predictors
- Identified top-performing models using ΔAIC
- Model-averaged predictions (Route Usage)

Several Findings from Multi-Year Analyses

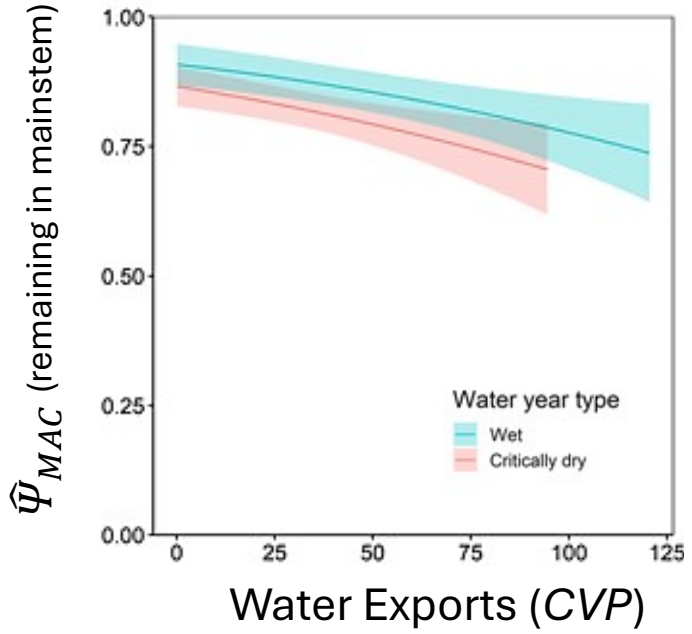
Survival

- Inflow, barrier presence, & fish size affect survival in multiple reaches



Route Use

- Delta inflow (*VNS*), HOR barrier, and *CVP* exports affect routing at TCJ



Goal: Construct application for predicting juvenile Steelhead route use and survival using telemetry study findings

Objective 1: Develop broader modeling framework for combining outputs from component models

- Reformulate models and expand multi-model inference approach

Objective 2: Create a web-based interface for generating predictions

- Select daily inputs from past years or user-uploaded data

About

Inputs

Starting location

Check inputs

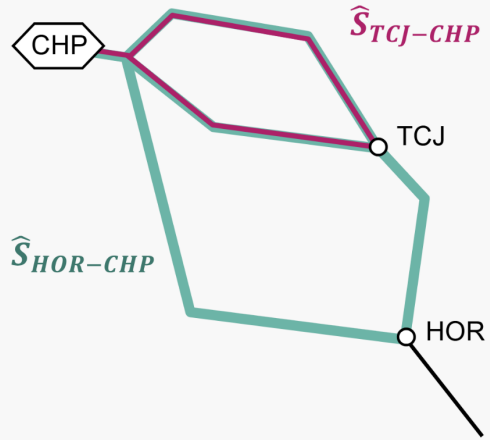
Estimates

San Joaquin River and South Delta Steelhead Survival and Routing Predictions

About

This application generatees survival and route route use predictions for hypothetical groups of San Joaquin River juvenile Steelhead based on the timing of their arrival at key river junctions and a data set defining environmental and operational conditions. The main quantities of interest produced by the app are predicted probabilities of survival to Chipps Island (**CHP**) from either Head of Old River (**HOR**) or Turner Cut Junction (**TCJ**) denoted as $\hat{S}_{HOR-CHP}$ and $\hat{S}_{TCJ-CHP}$ There are multiple paths that juvenile Steelhead may take as they migrate through the Delta and route usage and reach-specific survival rates vary based on environmental conditions and estimates are generated from an ensemble of survival and routing models were obtained by analyzing acoustic telemetry detection data gathered between 2011 and 2016 (Buchanan et al. 2021; Buchanan et al. 2024) .

Select Inputs | Methods and References



Major routes, junctions, and landmarks that juvenile Steelhead encounter while migrating from the San Joaquin River to the Pacific Ocean.

About
Inputs
Estimates

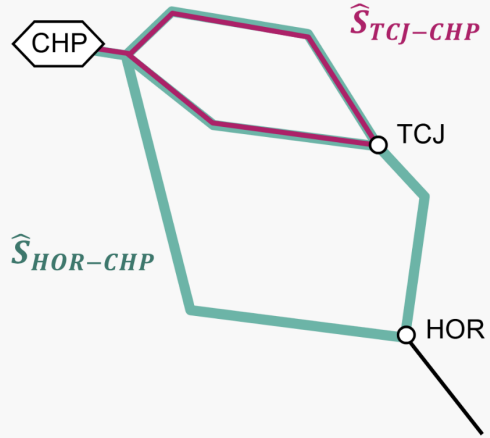
Inputs

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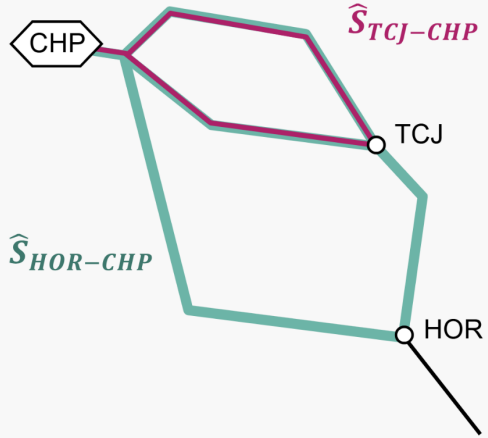
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Select Inputs

Methods and References

Documentation



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About

Inputs

Starting location

Check inputs

Estimates

San Joaquin River and South Delta Steelhead Survival and Routing Predictions

Inputs

Overview:

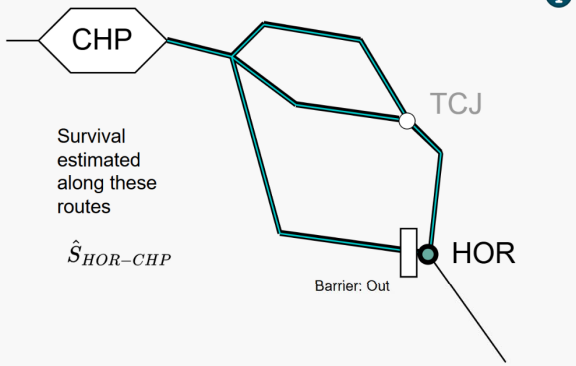
This tool provides predictions of survival and route usage for hypothetical releases of juvenile Steelhead based on their expected location,conditions in the environment, and individual size.

- Select a junction to serve as a starting location for the migration

  Starting Location: HOR

- Select the source to use for daily hydrologic data and export operations; either: (1) a previous year or (2) a user-provided data set

  Source: None



About
Inputs
Starting location
Check inputs
Estimates

San Joaquin River and South Delta Steelhead Survival and Routing Predictions

Inputs

Overview:

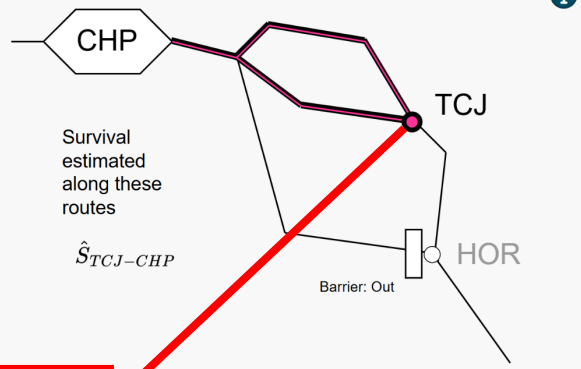
This tool provides predictions of survival and route usage for hypothetical releases of juvenile Steelhead based on their expected location,conditions in the environment, and individual size.

- Select a junction to serve as a starting location for the migration

Starting Location: TCJ

- Select the source to use fo ologic data and export operations; either: (1) a previous year provided data set

Source: None



HOR
TCJ

Starting Location

About

Inputs

Starting location

Check inputs

Estimates

San Joaquin River and South Delta Steelhead Survival and Routing Predictions

Inputs

Overview:

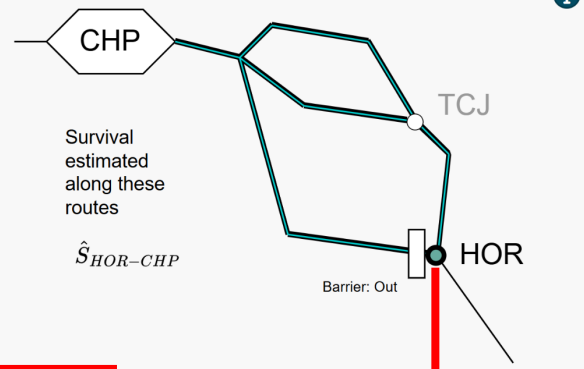
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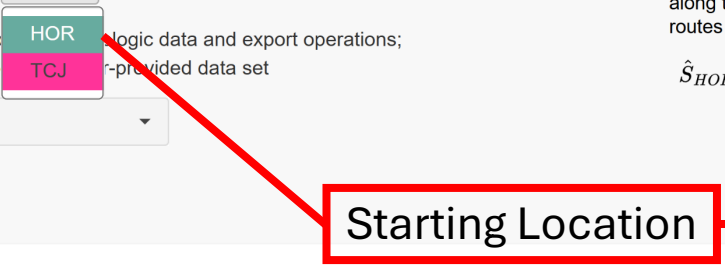
- Select a junction to serve as a starting location for the migration

Starting Location: HOR

- Select the source to use fo ogic data and export operations; either: (1) a previous year -provided data set

Source: None





About

Inputs

Starting location

Check inputs

Estimates

San Joaquin River and South Delta Steelhead Survival and Routing Predictions

Inputs

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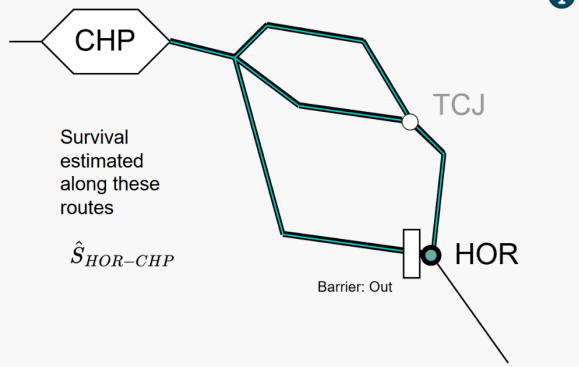
- Select a junction to serve as a starting location for the migration

Starting Location: HOR

- Select the source to use for daily hydrologic data and export operations; either: (1) a previous year or (2) a user-provided data set

Source: Previous year

Previous year
Uploaded file (.csv)
None



SJR - Steelhead

About | Methods and References | SacPAS

- About
- Inputs
  - Starting location
  - Check inputs
- Estimates

San Joaquin River and South Delta Steelhead Survival and Routing Predictions

Inputs

Overview:

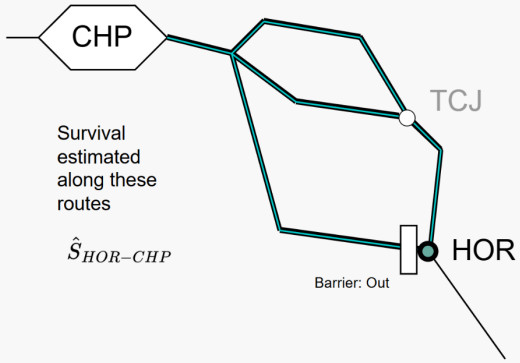
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  Source: Previous year



Select Daily Environmental Data

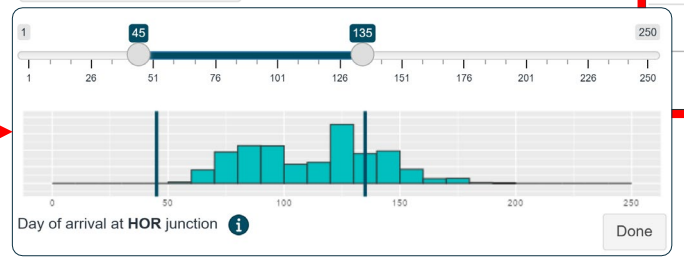
- Select a previous year:

  Year: 2013

- Select a date range for arrival at junction by entering dates or adjusting Day of Year slider

  Start Date : 2013-02-14 **End Date :** 2013-05-15

  Day of Year Slider



Annual Summary Table

Year	Water Year Type	HOR Barrier	Used in Models
2011	Wet	Out	Yes
2012	Dry	In	Yes
2013	Critical	Out	Yes
2014	Critical	In	Yes
2015	Critical	In	Yes
2016	Dry	In	Yes

Previous Next

Year Selection

Date / Day of Year Selection

Day range selection pop-up

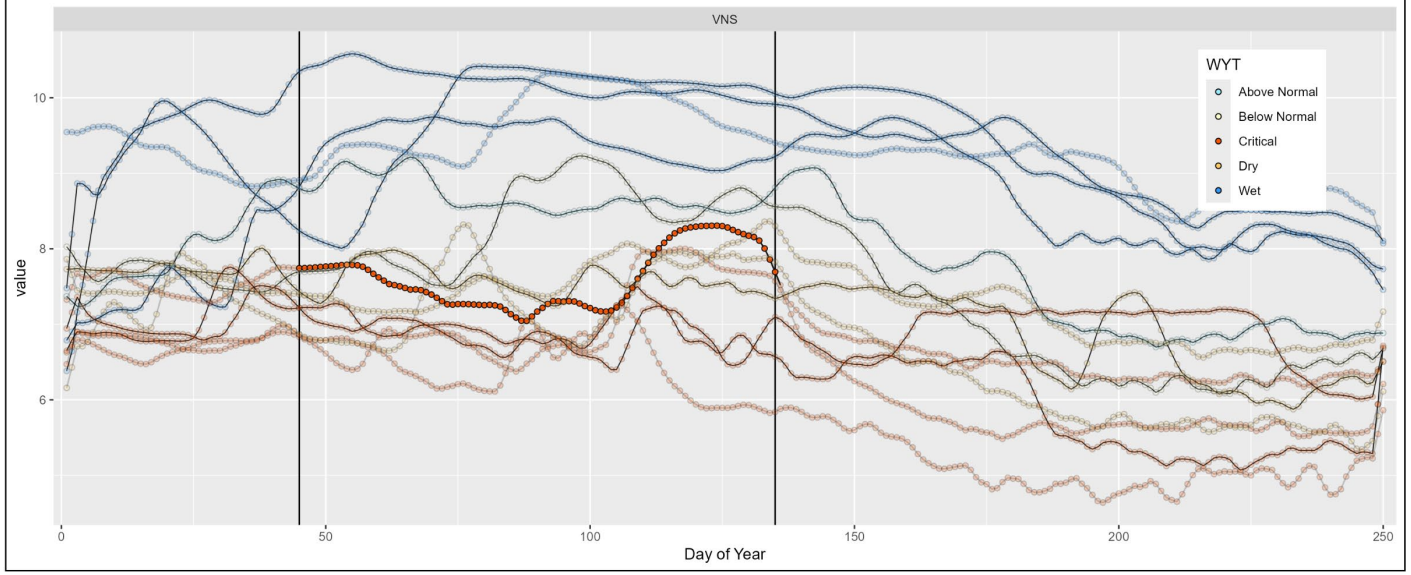
Table shows selected year and attributes

About
Inputs
Starting location
Check inputs
Estimates

View Daily Values

Variable

log(VNS)



+ Select Individual Attributes

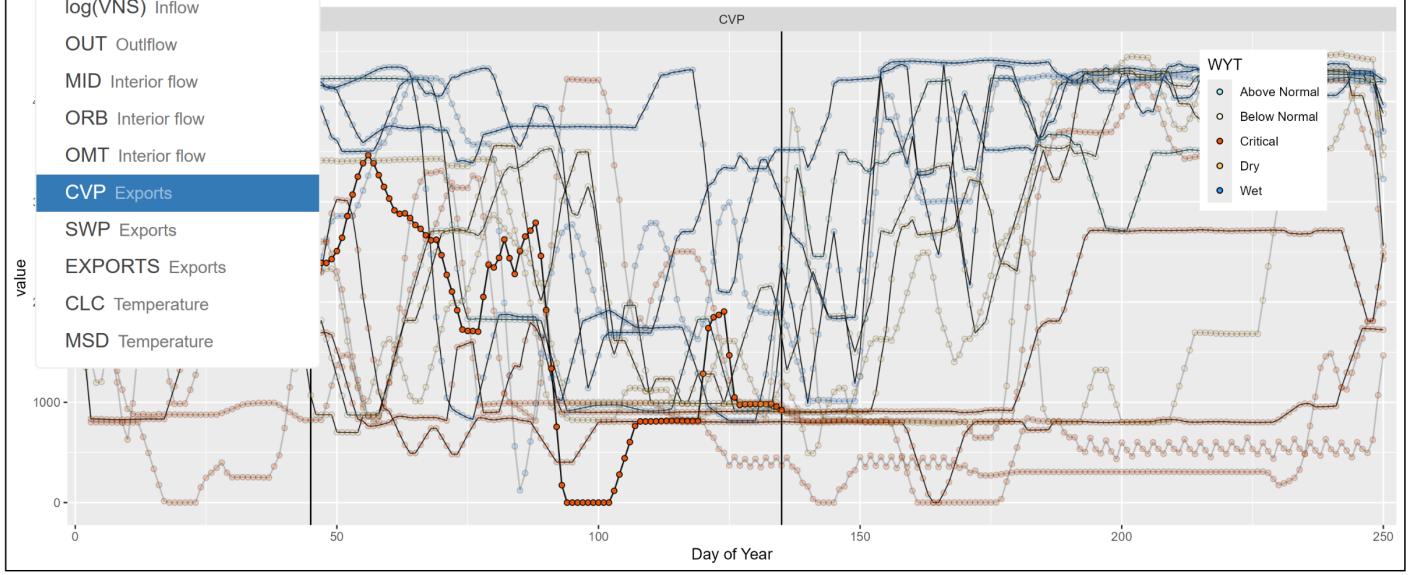
About
Inputs
Starting location
Check inputs
Estimates

View Daily Values

Variable

CVP

- log(VNS) Inflow
- OUT Outlflow
- MID Interior flow
- ORB Interior flow
- OMT Interior flow
- CVP Exports
- SWP Exports
- EXPORTS Exports
- CLC Temperature
- MSD Temperature



SJR - Steelhead

About | Methods and References | SacPAS

About

Inputs

Starting location

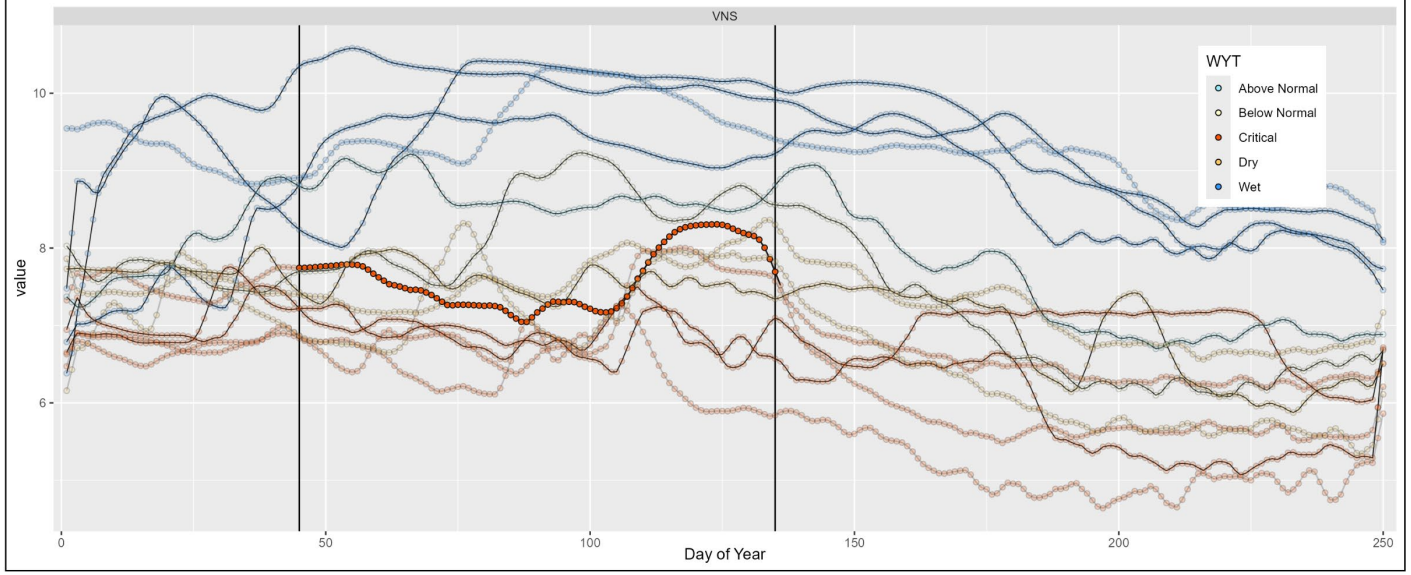
Check inputs

Estimates

View Daily Values

Variable

log(VNS)



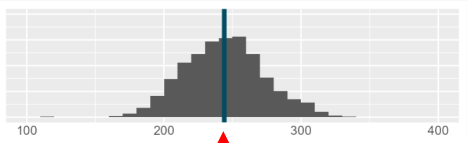
– Select Individual Attributes

Fork Length

- Uses average fork lengths of juvenile Steelhead used in modeling by default.

Fork Length (mm)

244



Fork length of juvenile Steelhead from Six-Year Study

Juvenile Steelhead fork length

Lengths of fish from acoustic studies

About

Inputs

Starting location

Check inputs

Estimates

Inputs

Overview:

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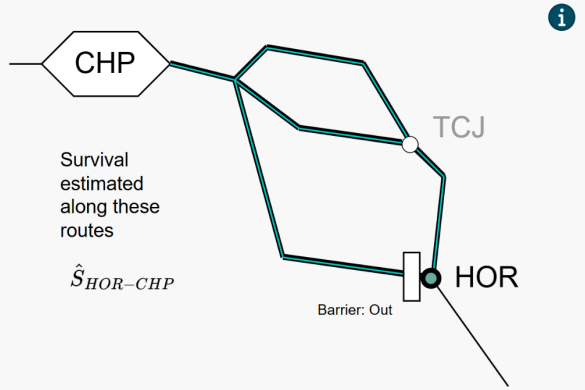
- Select the source to use for daily hydrologic data and export operations; either: (1) a previous year or (2) a user-provided data set

Source: Uploaded file (.csv)

Previous year

Uploaded file (.csv)

None



SJR - Steelhead

About | Methods and References | SacPAS

- About
- Inputs
  - Starting location
  - Check inputs
- Estimates

Inputs

Overview:

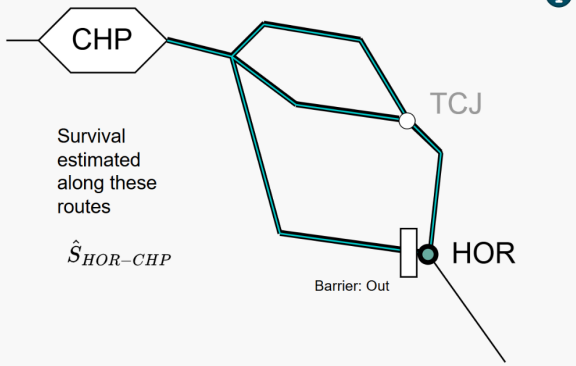
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Source: Uploaded file (.csv)



Load Daily Environmental Data

Upload input data table (.csv)

Browse... No file selected

Load | Reset | Sample CSV

Daily input variable template

Date	Year	WYT	HOR Barrier	log(VNS)	OMT	CVP	SWP	CLC	MSD
2011-01-01	2011	Wet	false	9.55	-4780	4111.3	7142.8	9.82	9.25
2011-01-02	2011	Wet	false	9.55	-4710	4111.3	7142.8	9.8	9.25
2011-01-03	2011	Wet	false	9.53	-3900	4116.2	6925.8	9.83	9.25
2011-01-04	2011	Wet	false	9.56	-3021	4106.4	7359.8	9.83	9.29
2011-01-05	2011	Wet	false	9.59	-3810	4111.6	7790.4	9.7	9.21
2011-01-06	2011	Wet	false	9.61	-4530	4113	8223.8	9.53	9.08

Previous Next

Template showing required inputs

Download a sample version of the CSV table

SJR - Steelhead

About | Methods and References | SacPAS

- About
- Inputs
  - Starting location
  - Check inputs
- Estimates

Inputs

Overview:

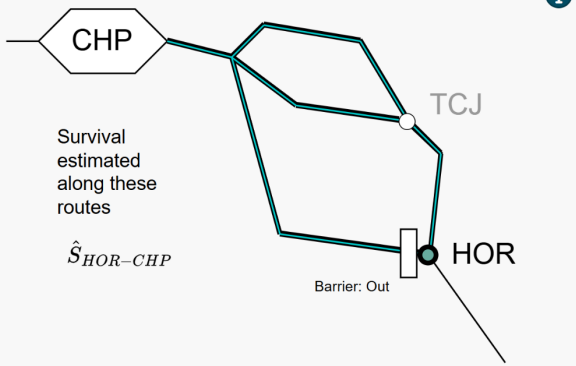
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  Source: Uploaded file (.csv)



+ Load Daily Environmental Data

+ Select Individual Attributes

Check that selected/ uploaded inputs are within the bounds of the model

Check Inputs

Verify that specified values conform with data used to fit component models

Check Inputs | Valid | Reset

Generate Estimates

SJR - Steelhead

About | Methods and References | SacPAS

- About
- Inputs
  - Starting location
  - Check inputs
- Estimates

Inputs

Overview:

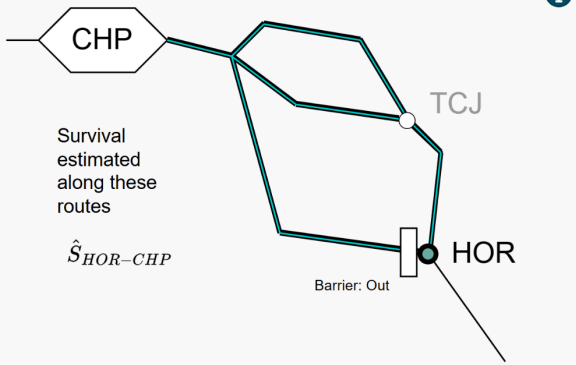
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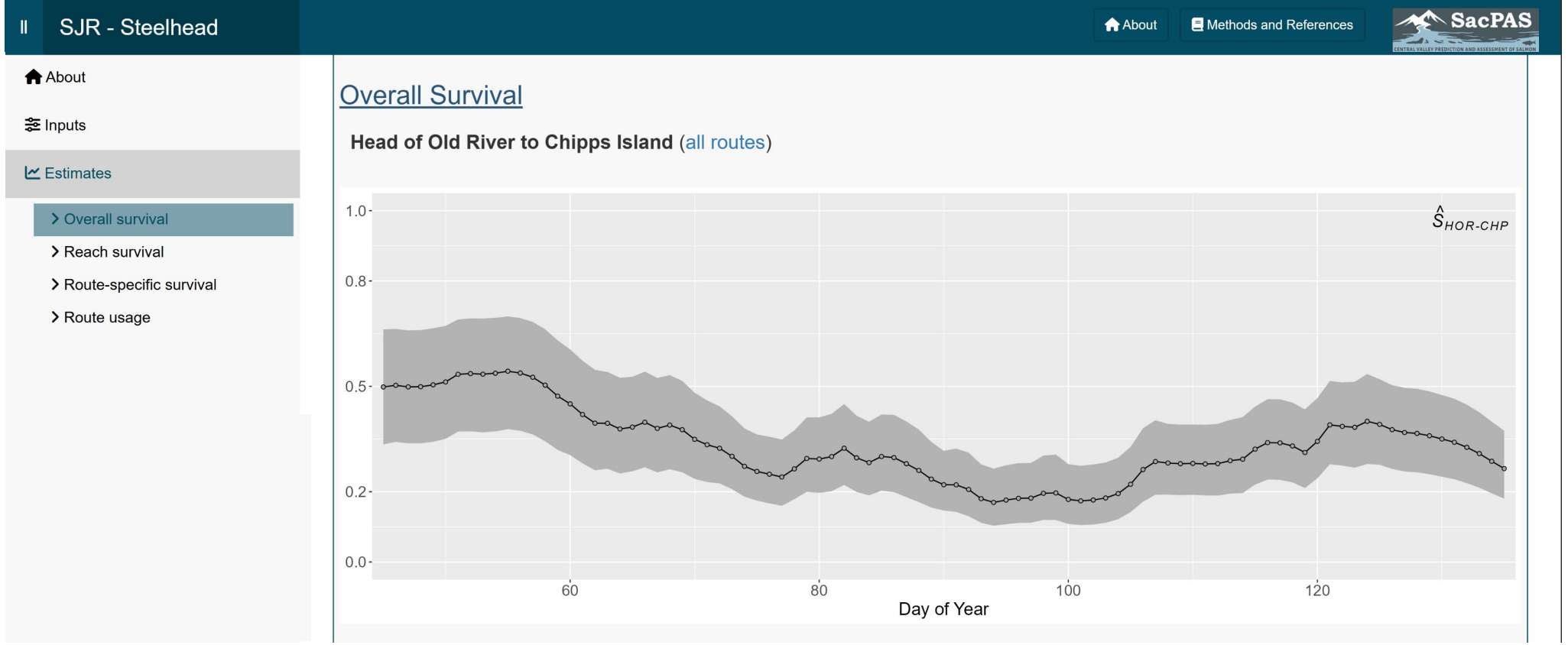
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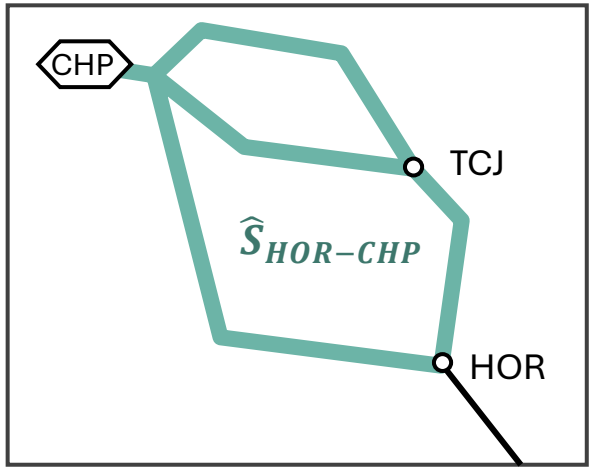
Check Inputs Valid

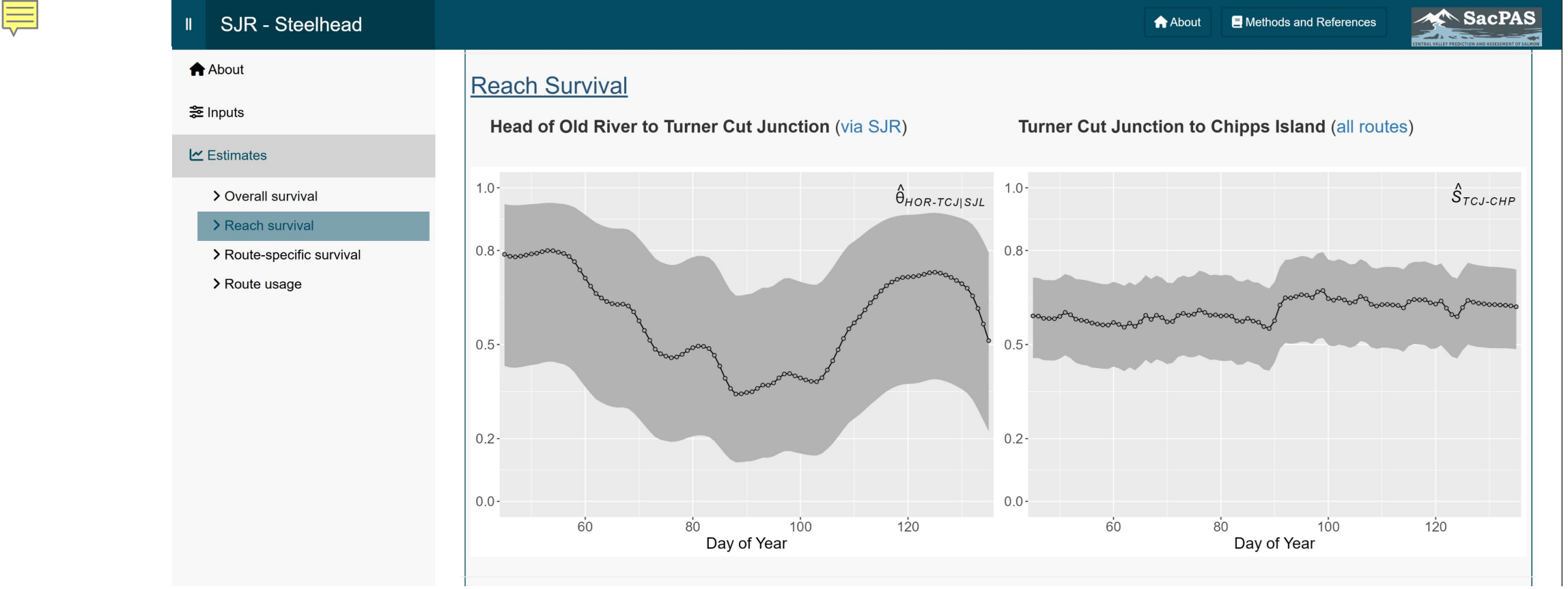
Reset

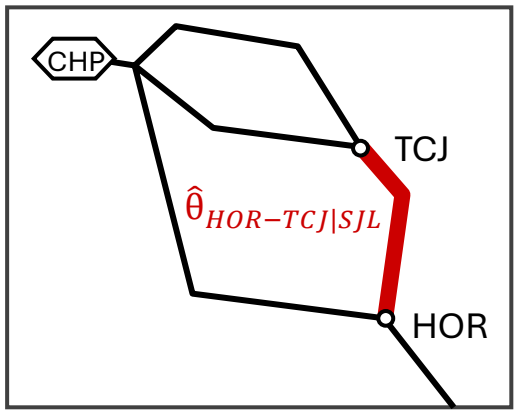
Generate Estimates

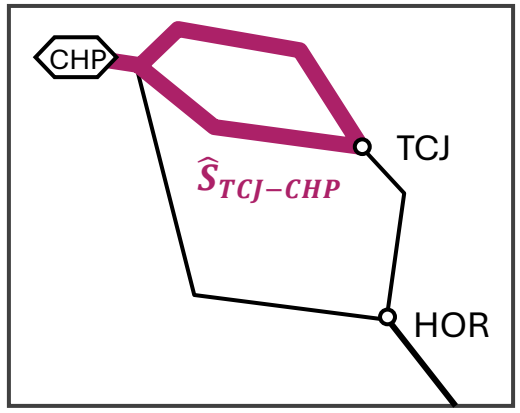
Generate estimates for selected inputs


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$\hat{S}_{HOR\text{-}CHP}$
1.0
0.8
0.5
0.2
0.0
60
80
100
120
Day of Year


CHP
TCJ
$\hat{S}_{HOR-CHP}$
HOR


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$\hat{\theta}_{HOR\text{-}TCJ|SJL}$
$\hat{S}_{TCJ\text{-}CHP}$
1.0
0.8
0.5
0.2
0.0
60
80
100
120
Day of Year

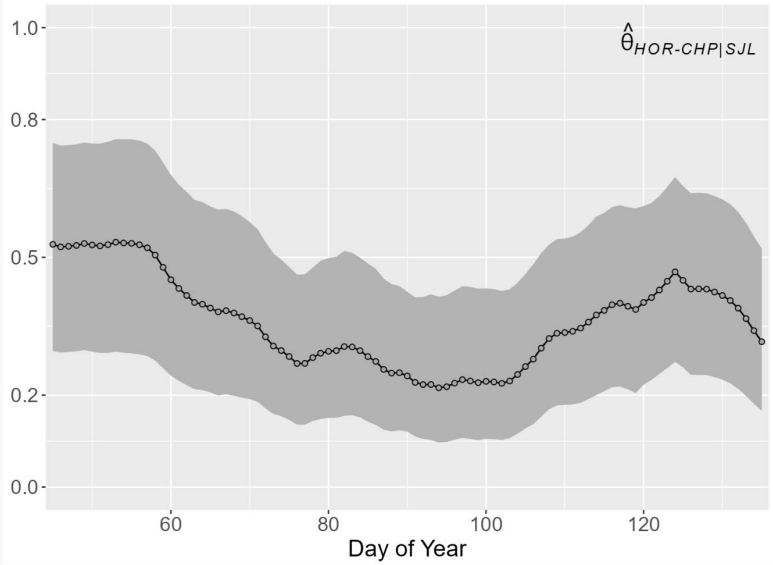

CHP
TCJ
$\hat{\theta}_{HOR-TCJ|SJL}$
HOR

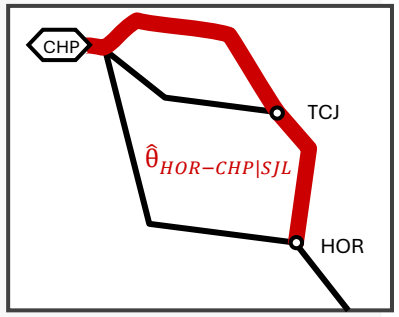

CHP
TCJ
$\hat{S}_{TCJ-CHP}$
HOR

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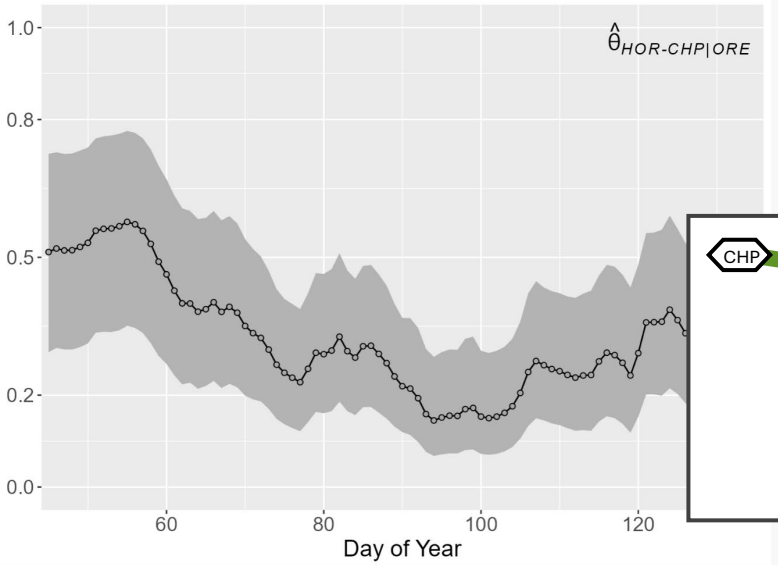
Route-Specific Survival

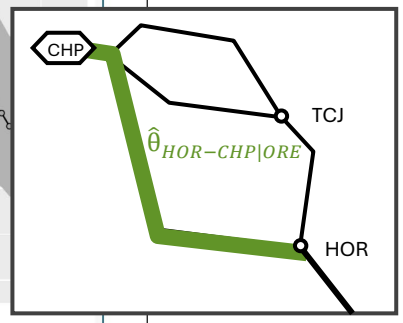
Head of Old River to Chipps Island (via SJR)



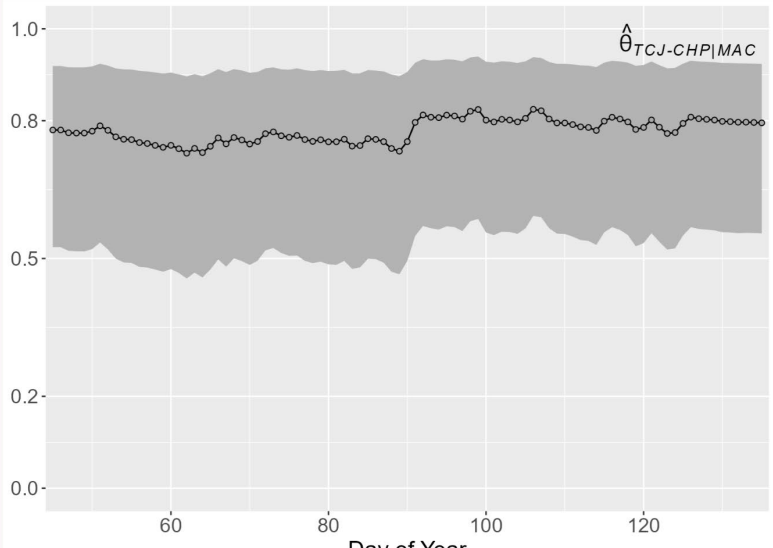


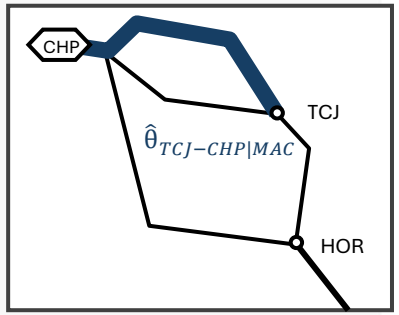
Head of Old River to Chipps Island (via ORE)



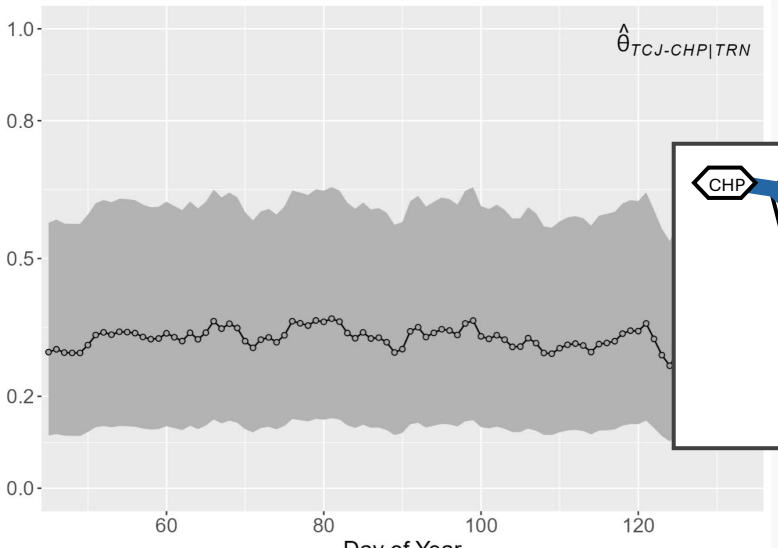


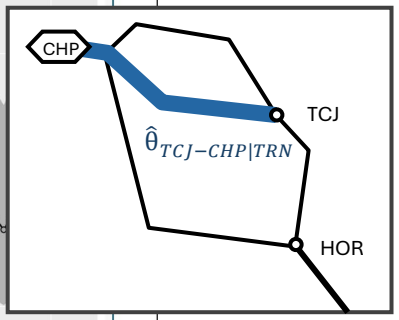
Turner Cut Junction to Chipps Island (via SJR)





Turner Cut Junction to Chipps Island (via TRN)

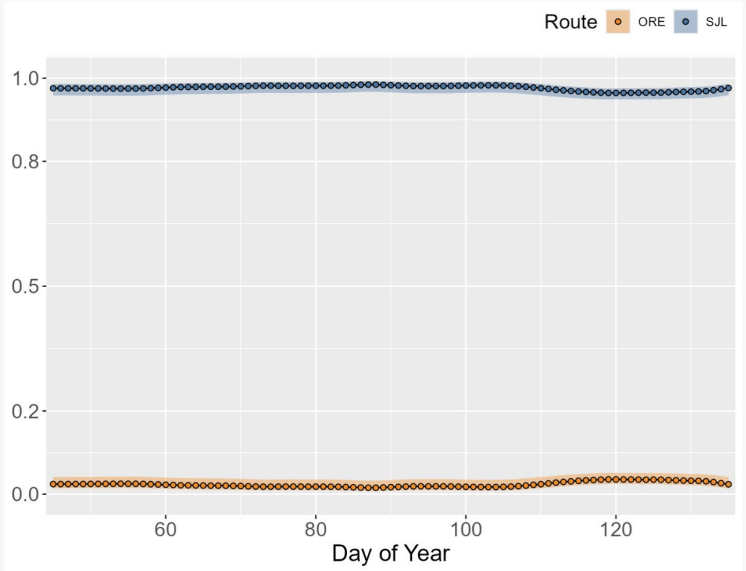




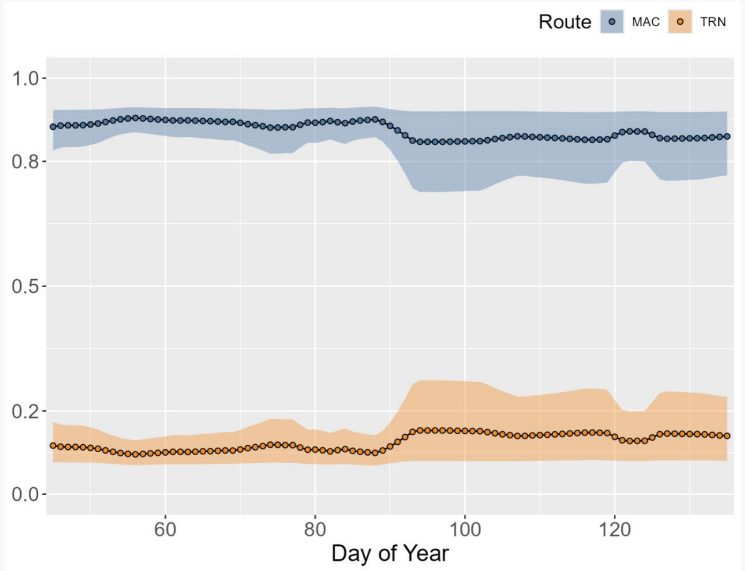
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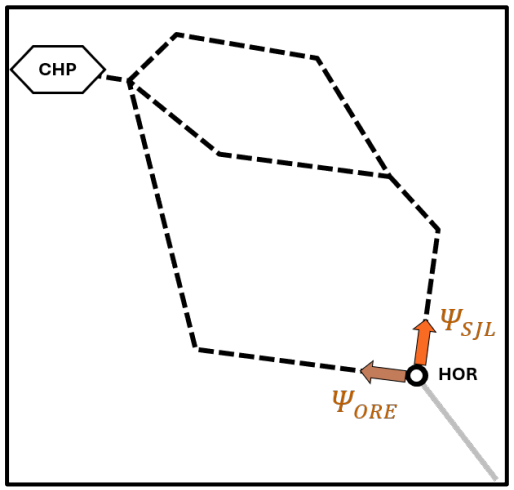
Route Usage

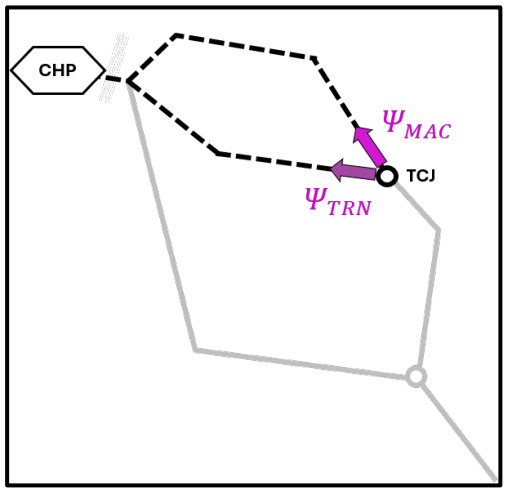
At Head of Old River



At Turner Cut Junction







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- Route usage

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Year	DOY	Parameter	Type	Estimate	SE	LCL	UCL
2013	45	TCJ	route	0.383	0.082	0.239	0.551
2013	46	TCJ	route	0.389	0.081	0.246	0.555
2013	47	TCJ	route	0.391	0.081	0.248	0.556
2013	48	TCJ	route	0.391	0.081	0.248	0.556
2013	49	TCJ	route	0.392	0.081	0.249	0.557
2013	50	TCJ	route	0.396	0.080	0.254	0.559

Previous Next

Download Estimates (.csv)

Next steps

Refine the prediction model

- Revisit sets of environmental and operational variables in original studies (e.g., old definition of OMR)
- Cross-validation to further improve prediction accuracy

Additional features and options

- Travel times between junctions
- Additional settings (tuning parameters, thresholds)

We would love your feedback

Please check out the latest version here:

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SacPAS
CENTRAL VALLEY PREDICTION AND ASSESSMENT OF SALMON

https://www.cbr.washington.edu/sacramento/tools/sthd_surv_rte_pred.html