Visualizing juvenile salmonid behavior, mortality, and salvage in the Delta: Practical application of an individual-based model

Travis Hinkelman, Bradley Cavallo, David Delaney

Model Overview

- Objective
  - Create practical tool that allows managers and biologists to explore how water project operations affect the number and timing of migrating juvenile salmonids arriving at Chipps Island or export facilities

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  - Fish interact with environment at local spatial scale
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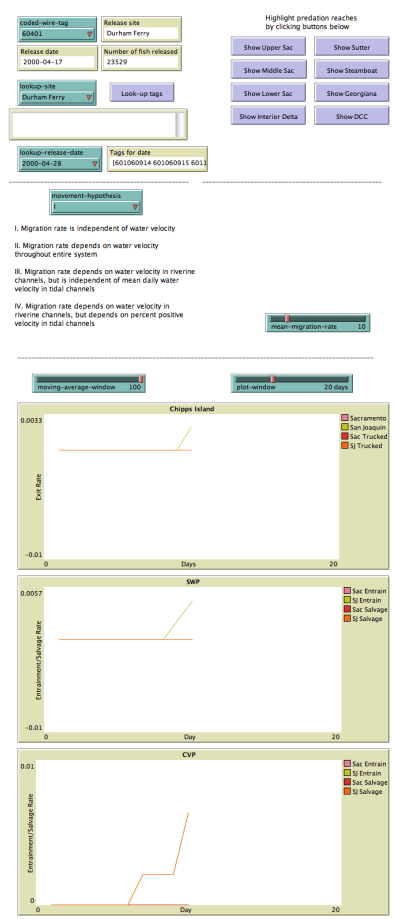
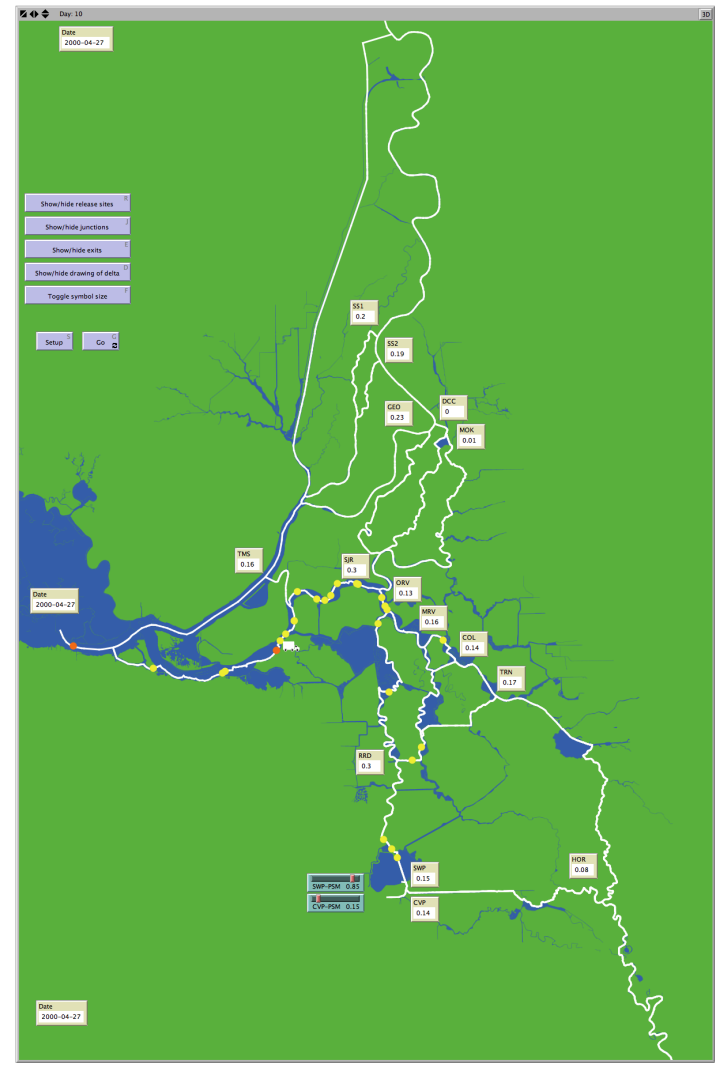
- Individual-Based Delta Passage Model (IB-DPM)
  - Fish interact with environment at local spatial scale
  - Allows for visualization of fish movement
- Key modeling decision
  - Model net displacement (i.e., daily migration rate)

Modeling Platform

- Multi-agent programmable modeling environment
- Free, open-source, and cross-platform
- Easy to learn
  - Highly readable syntax
  - Excellent documentation
  - Widgets for GUI elements
- Easy to use
  - No programming required to explore models
- Powerful
  - Built-in parameter sweeping tool
  - Parallel processing





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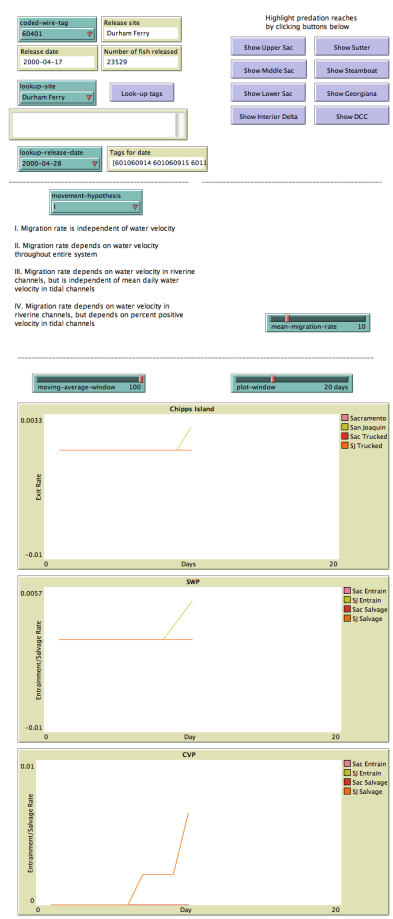
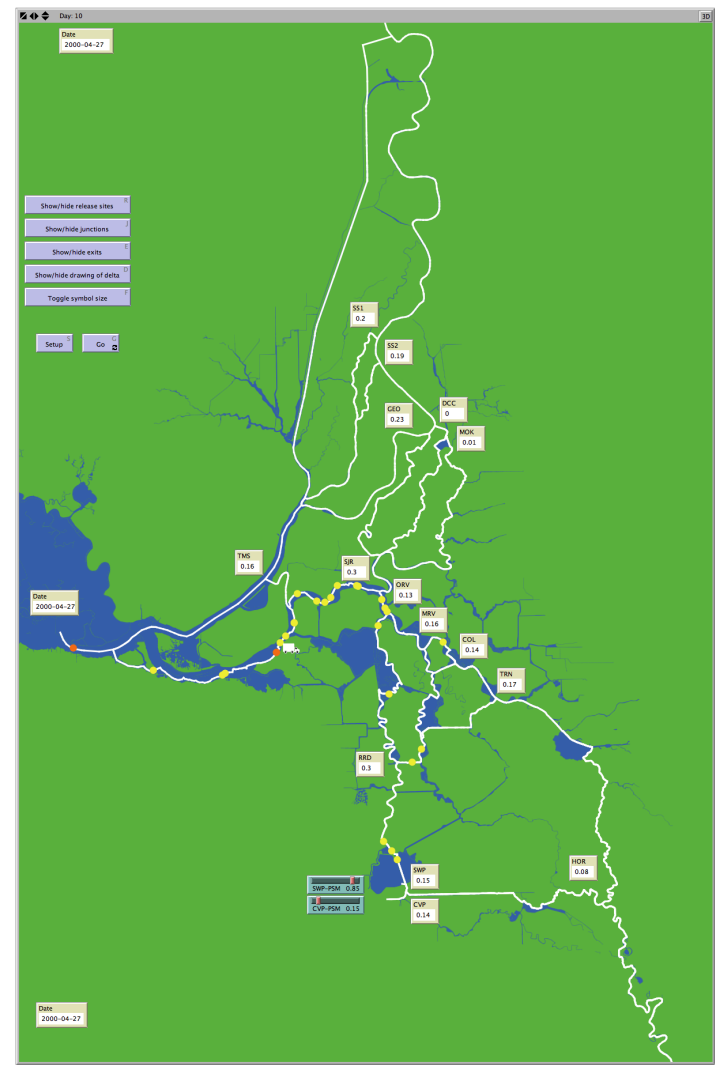
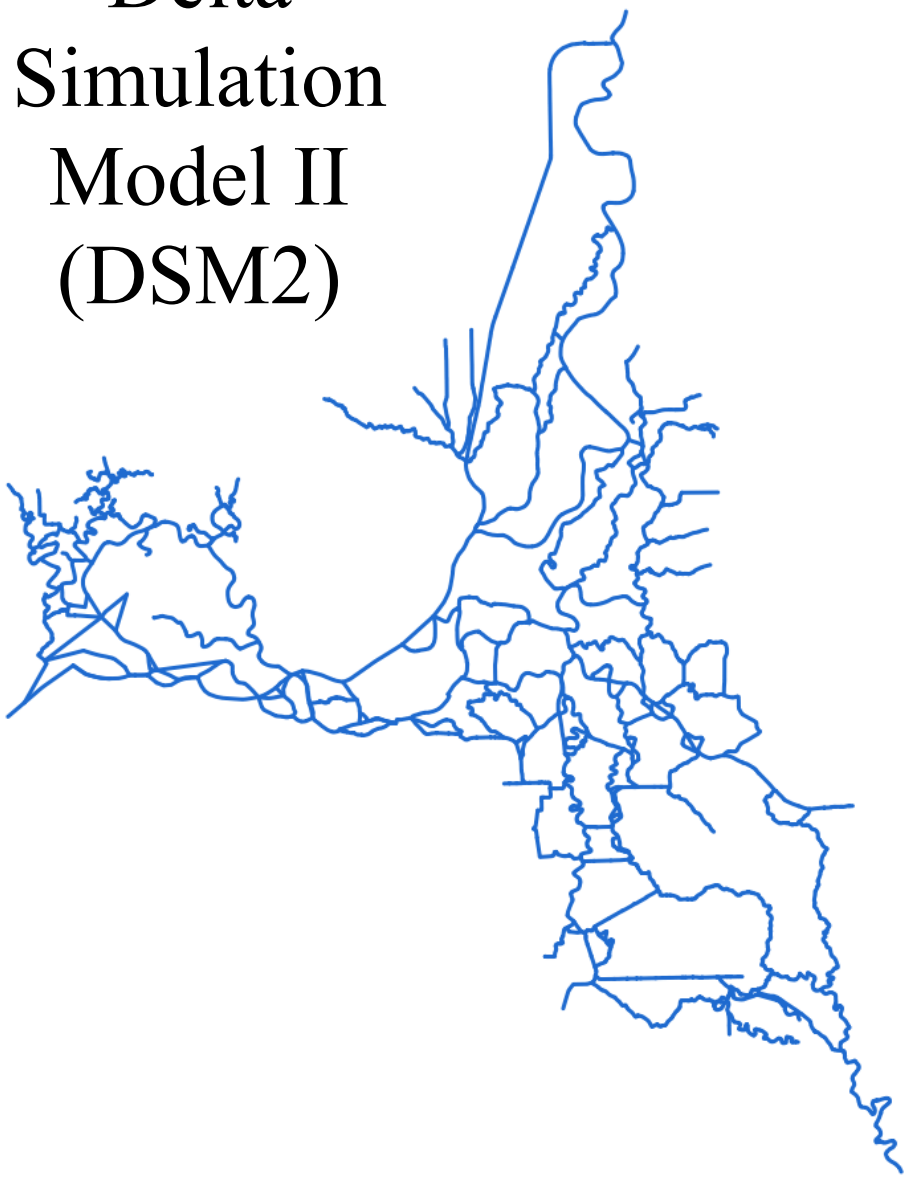




Hydrodynamics

Delta Simulation Model II (DSM2)



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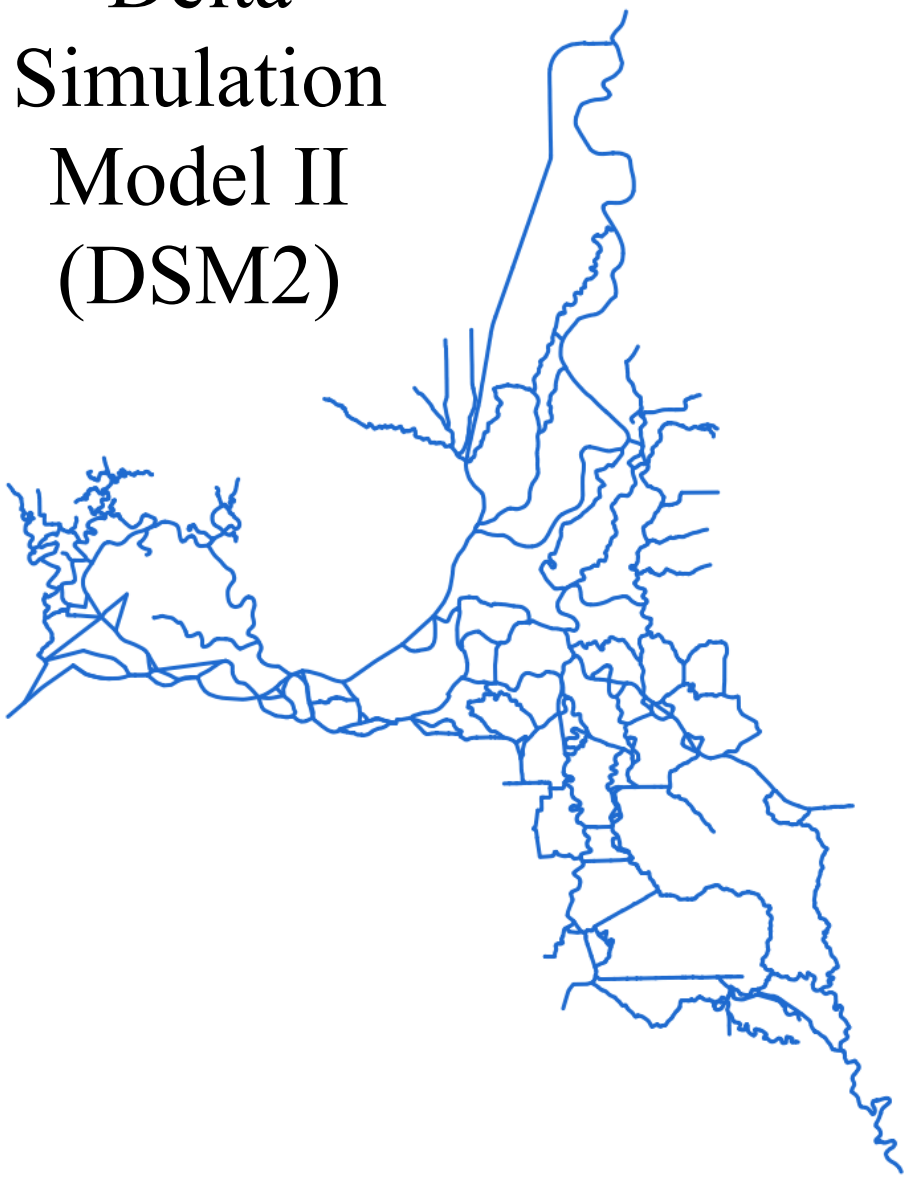

Historical simulations

Hydrodynamics

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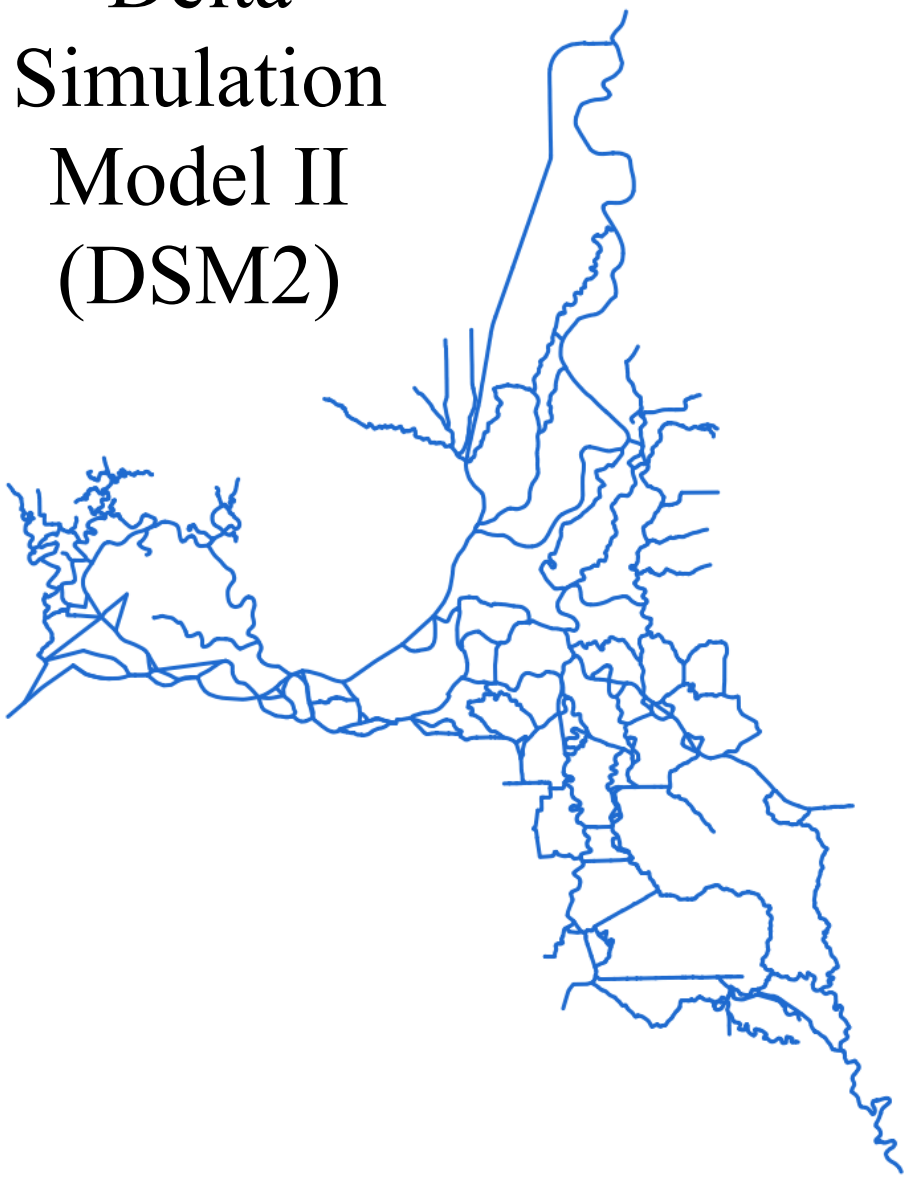

Historical simulations

Planning simulations

Hydrodynamics

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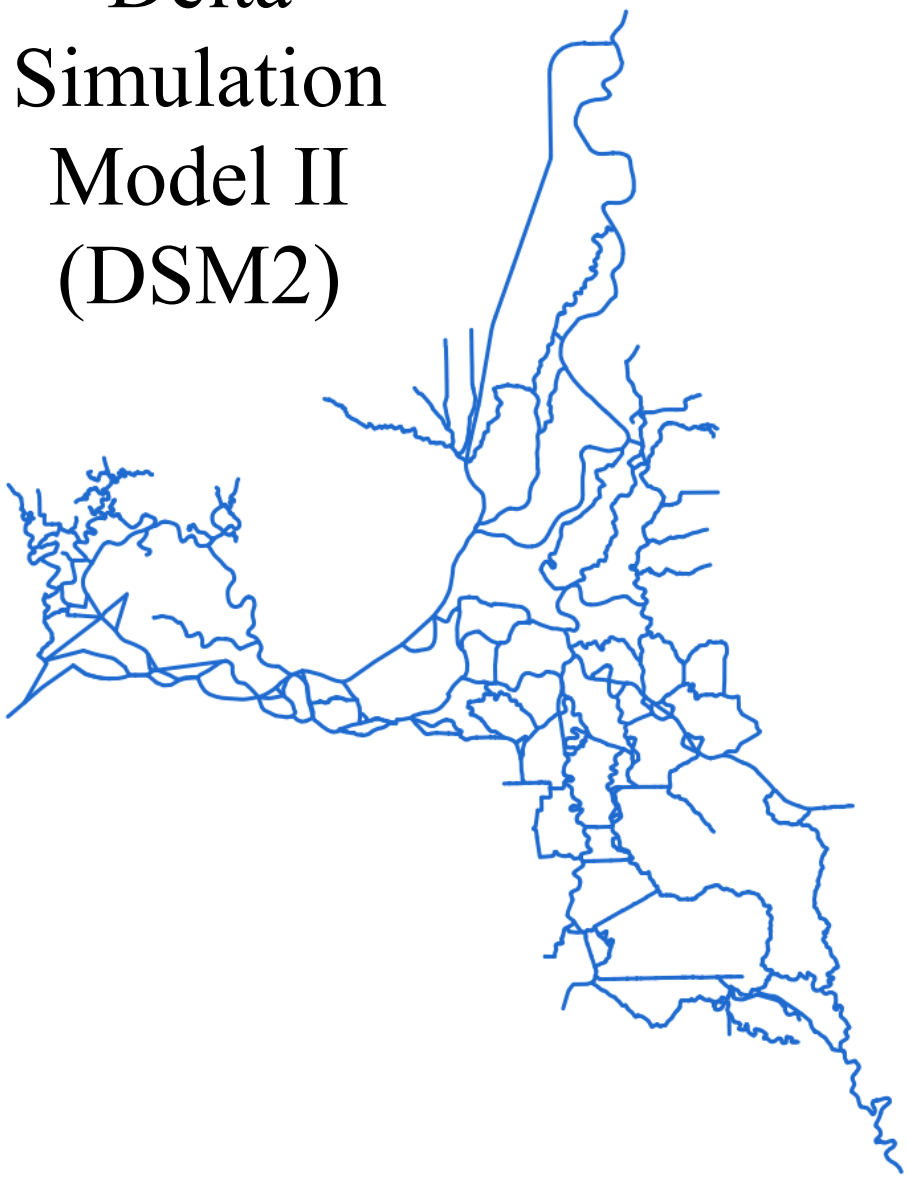

Daily mean velocity

Proportion positive velocity

Hydrodynamics

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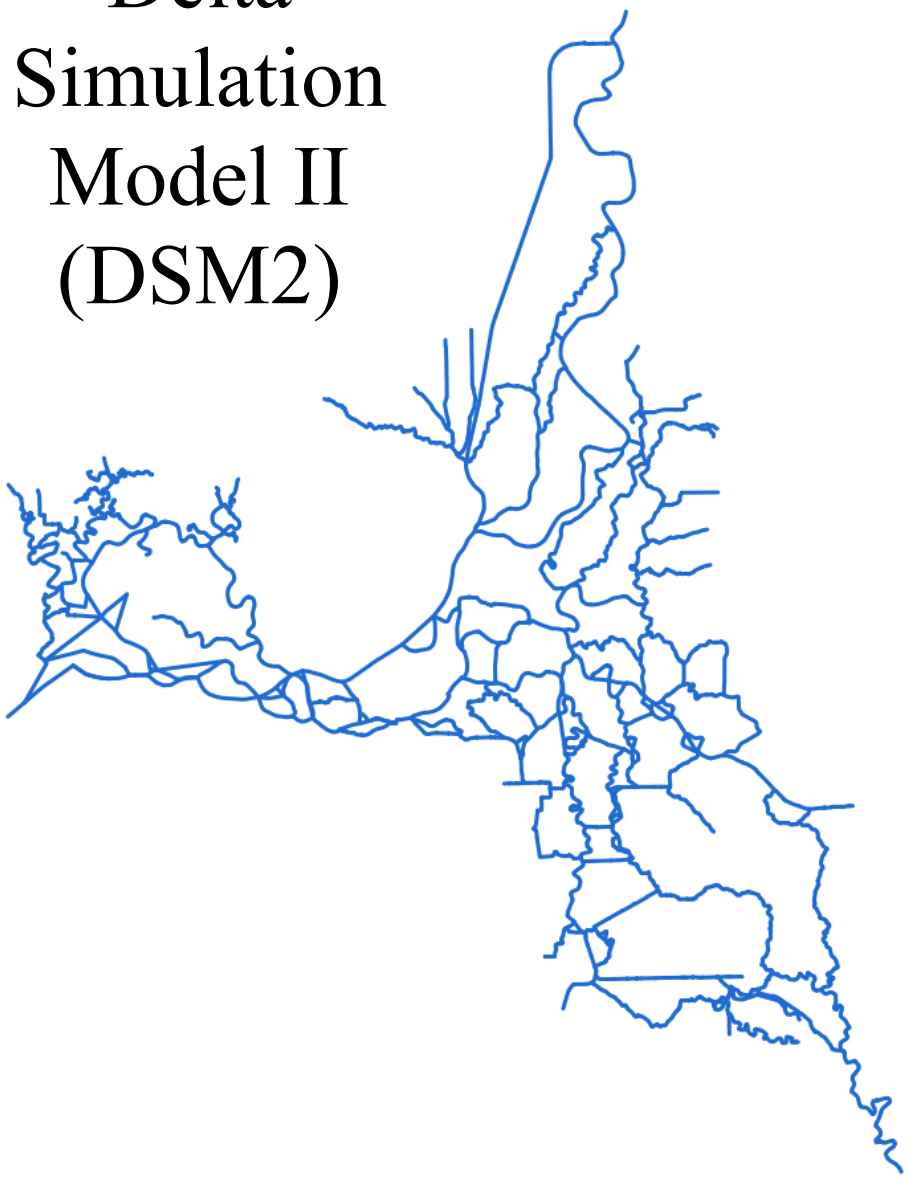
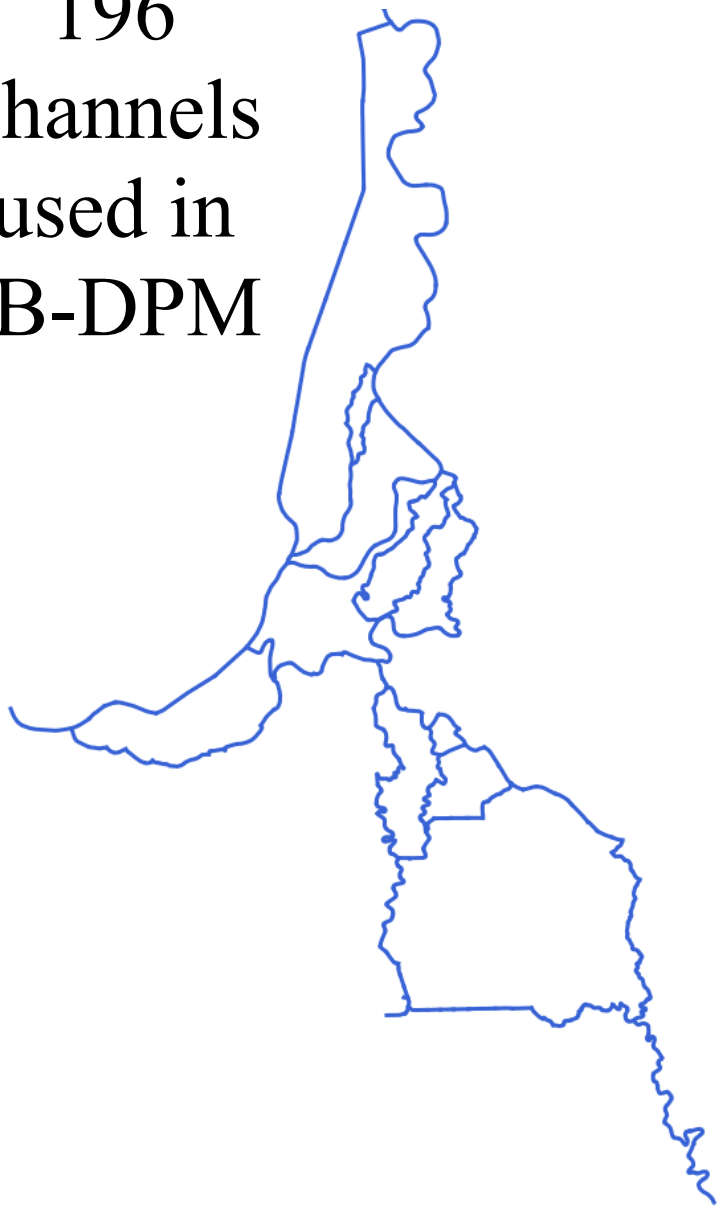
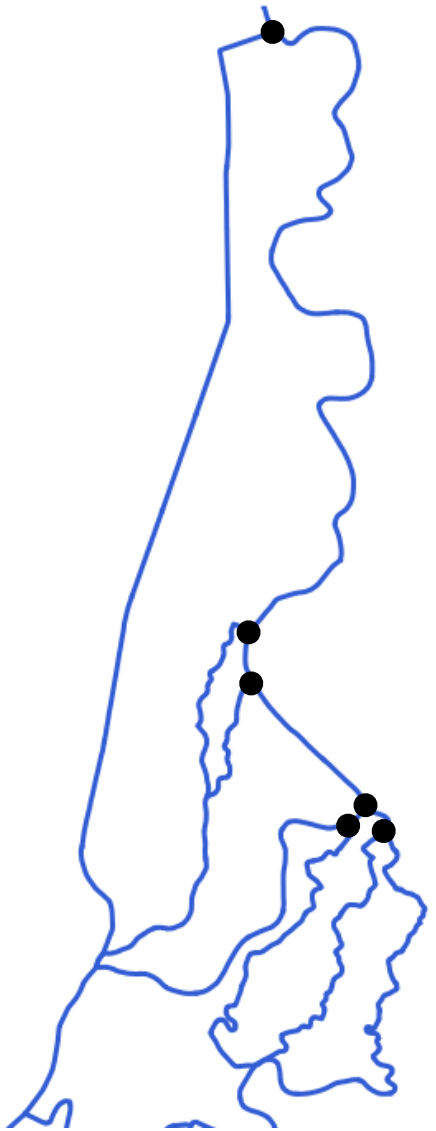


196 channels used in IB-DPM

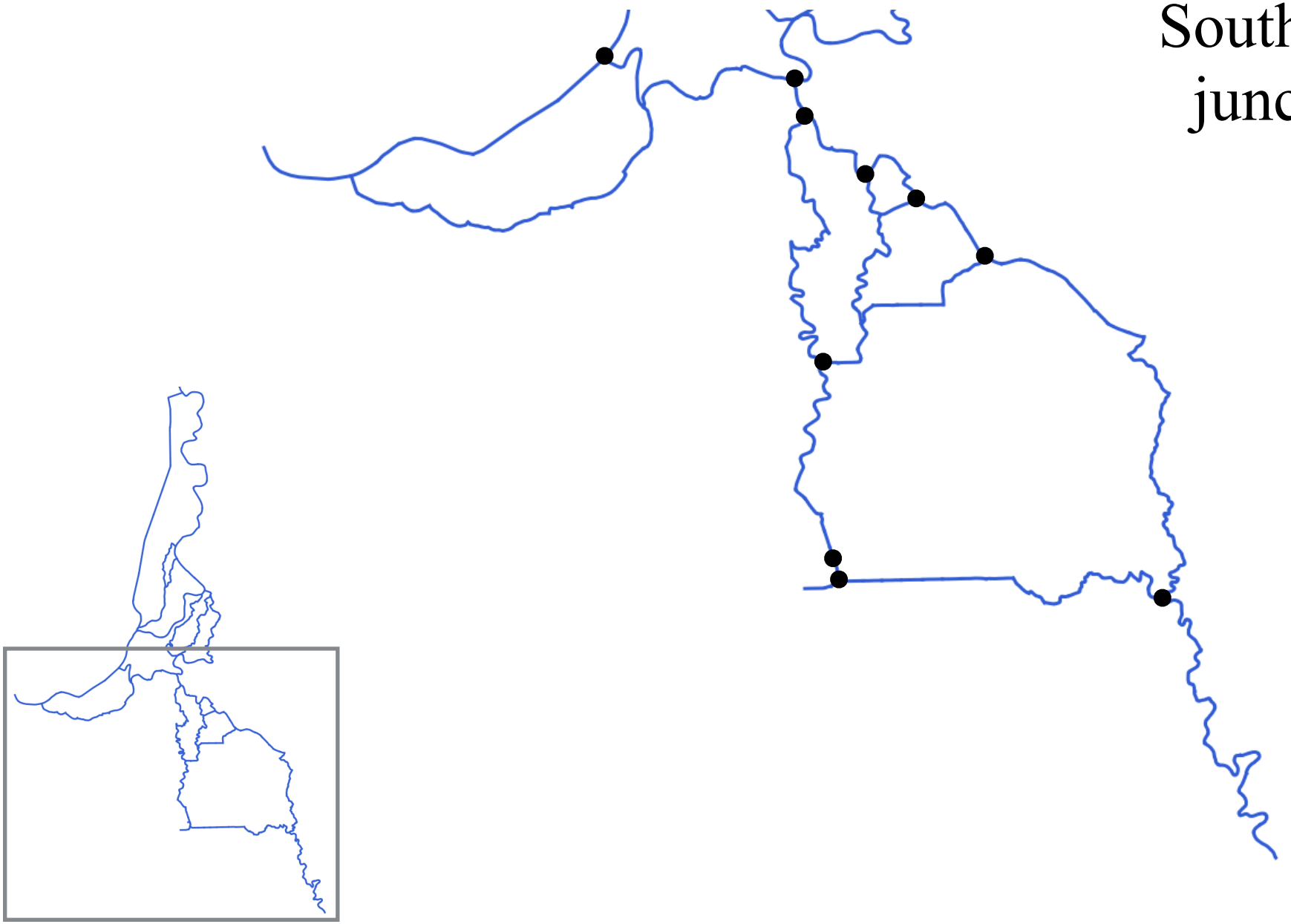


Routing



North Delta junctions

Routing



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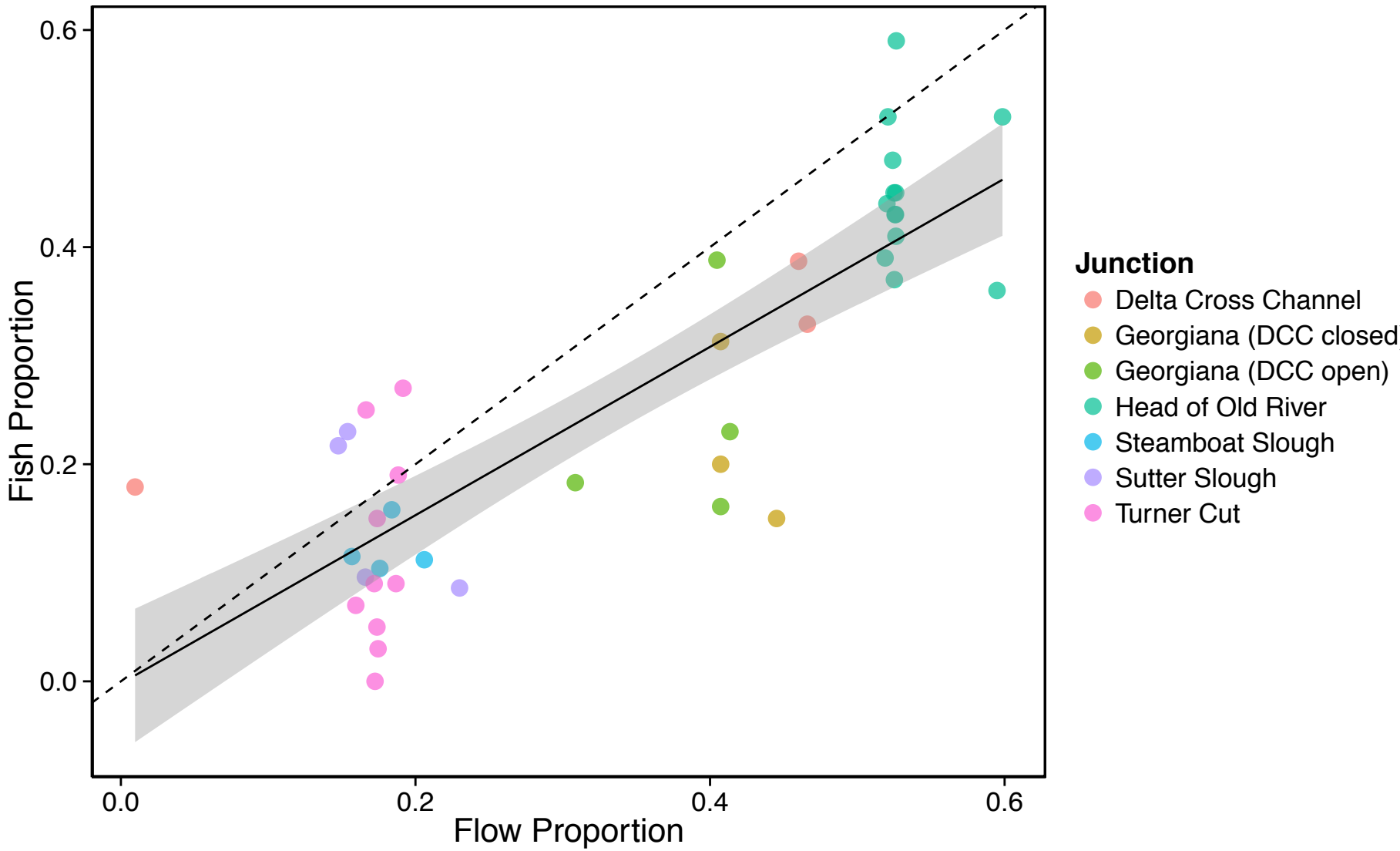
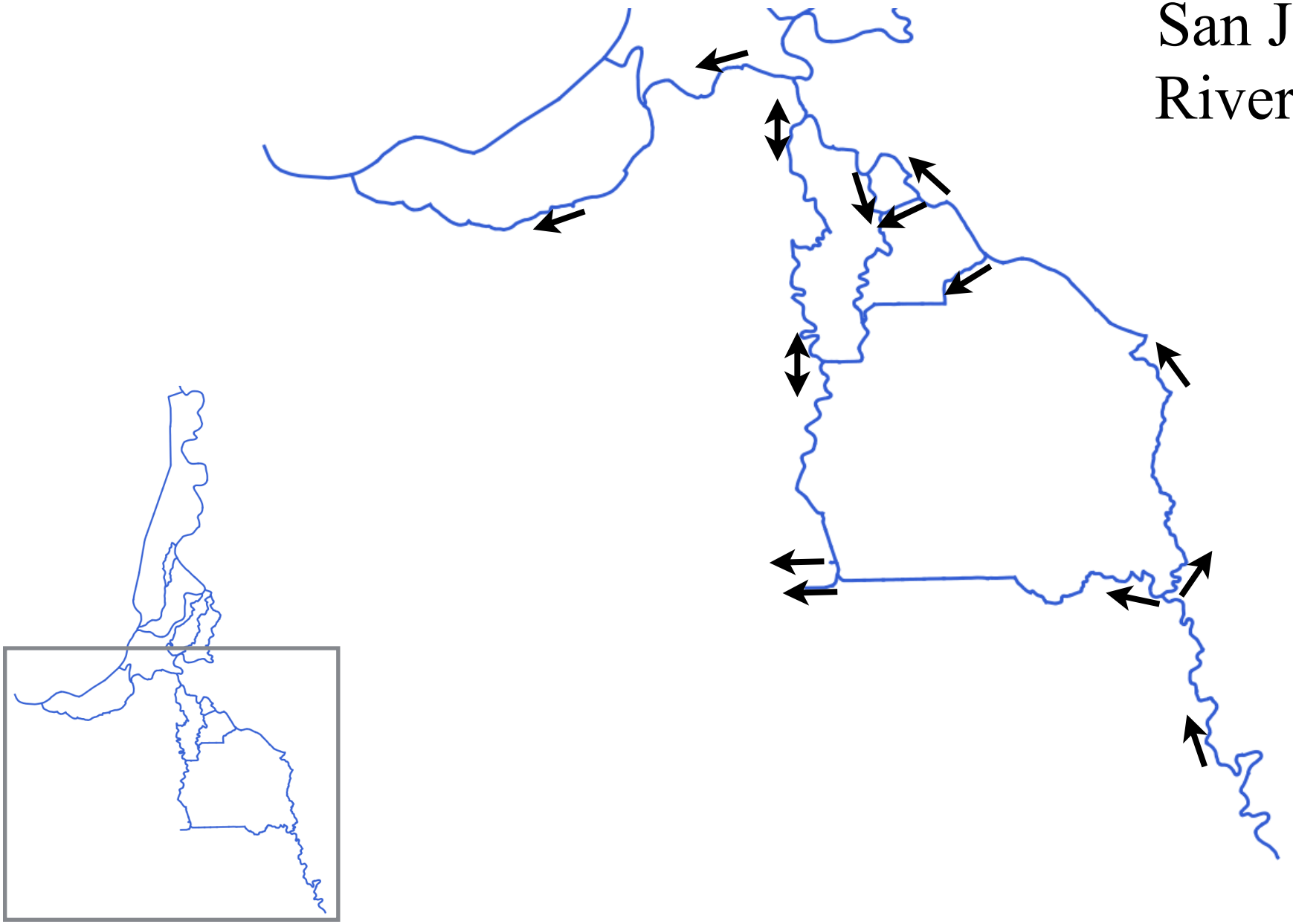


Cavallo et al. *In Review*

Routing



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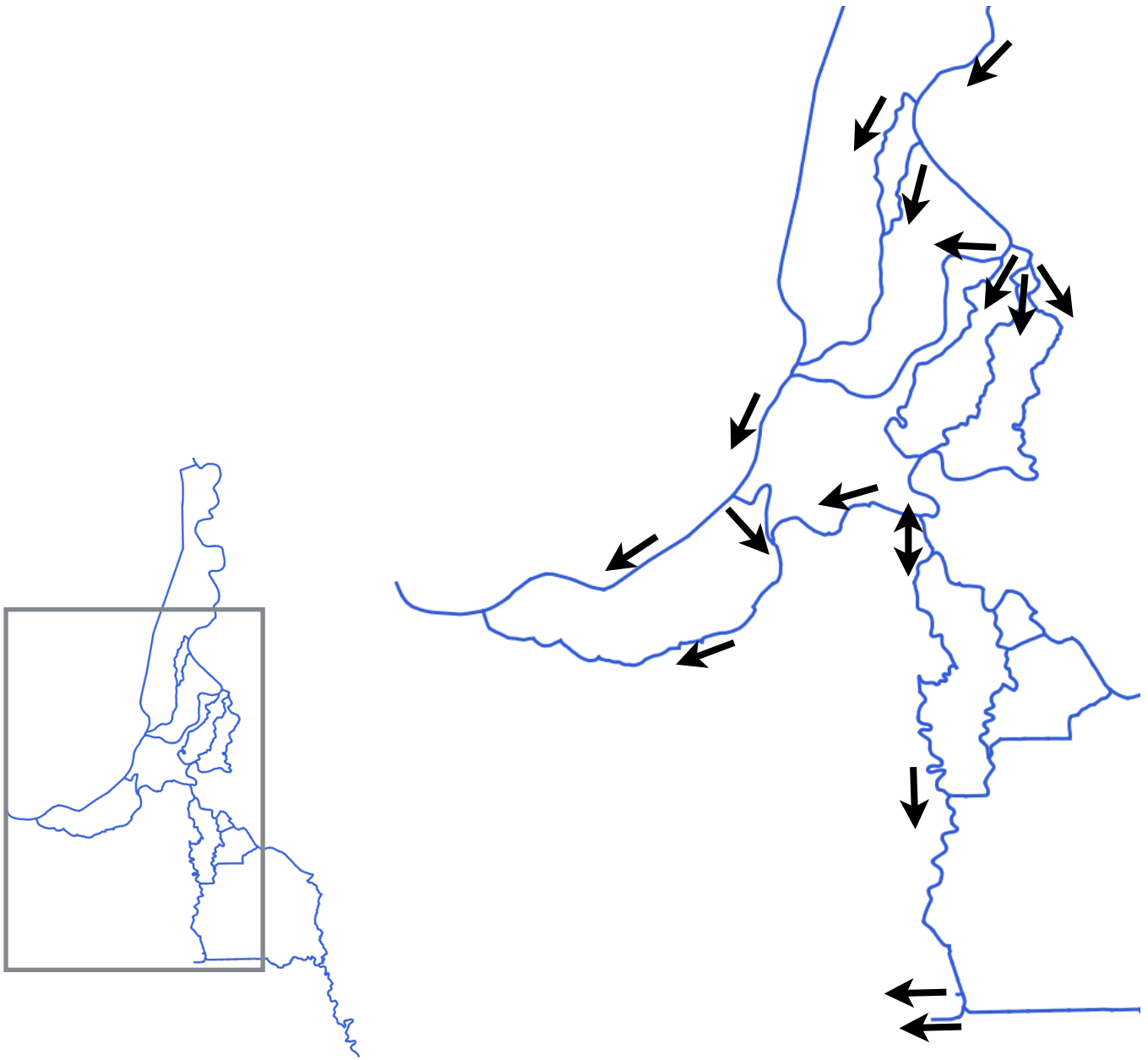

Sacramento River routes

Survival

- Exposure model
  - Depends on travel time

Anderson et al. 2005.
Ecological Modelling

Survival

- Exposure model
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- Gauntlet model
  - Depends on distance traveled

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- XT model
  - Depends on travel time and distance traveled

Anderson et al. 2005.
Ecological Modelling

Survival

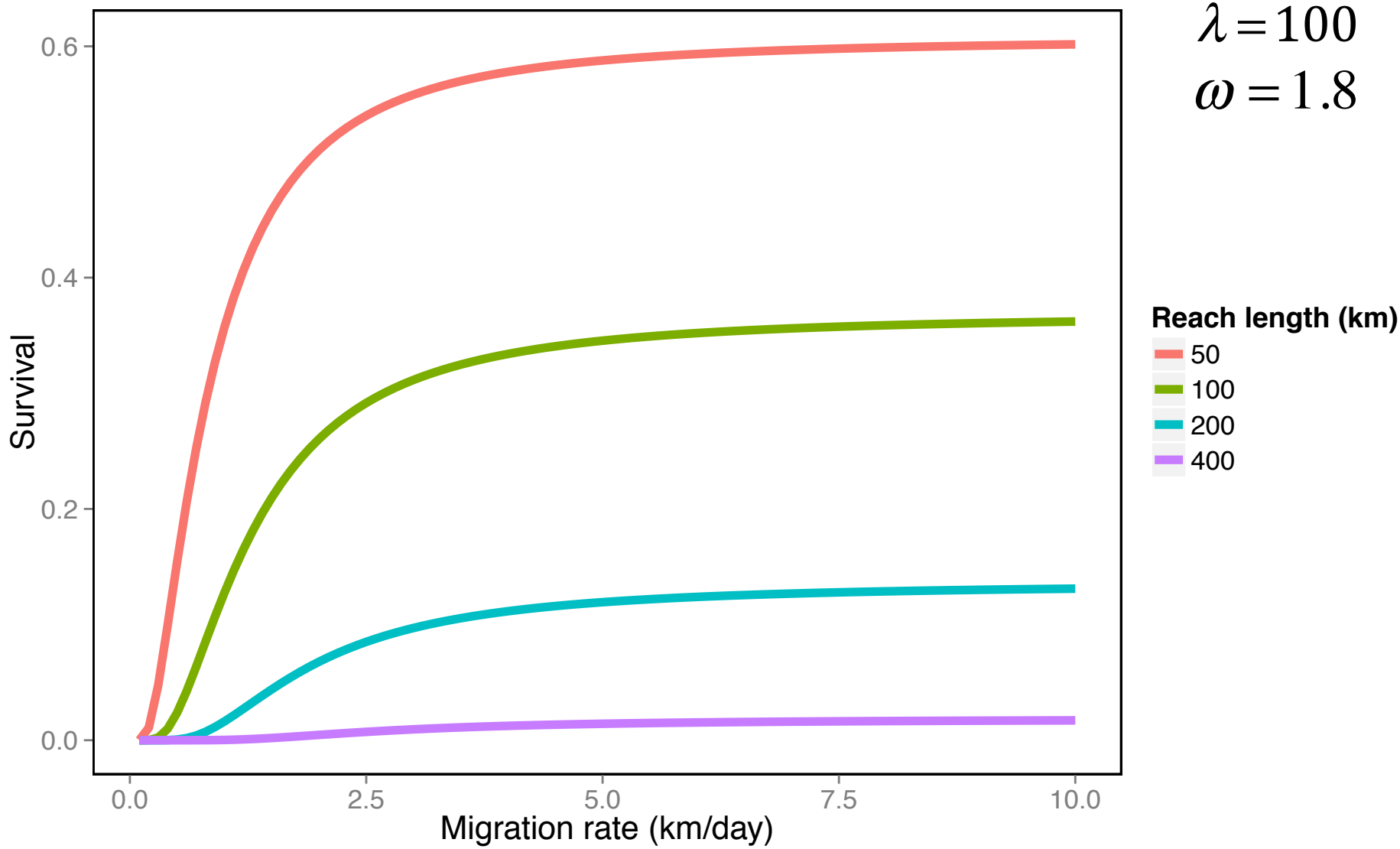
- Exposure model
  - Depends on travel time
- Gauntlet model
  - Depends on distance traveled
- XT model
  - Depends on travel time and distance traveled
  - Best fit for 8 reaches in Delta for late-fall Chinook

Perry et al. 2014
IEP Talk

Survival

$$S = \exp\left(-\frac{1}{\lambda}\sqrt{x^2 + \omega^2 t^2}\right)$$

XT Model



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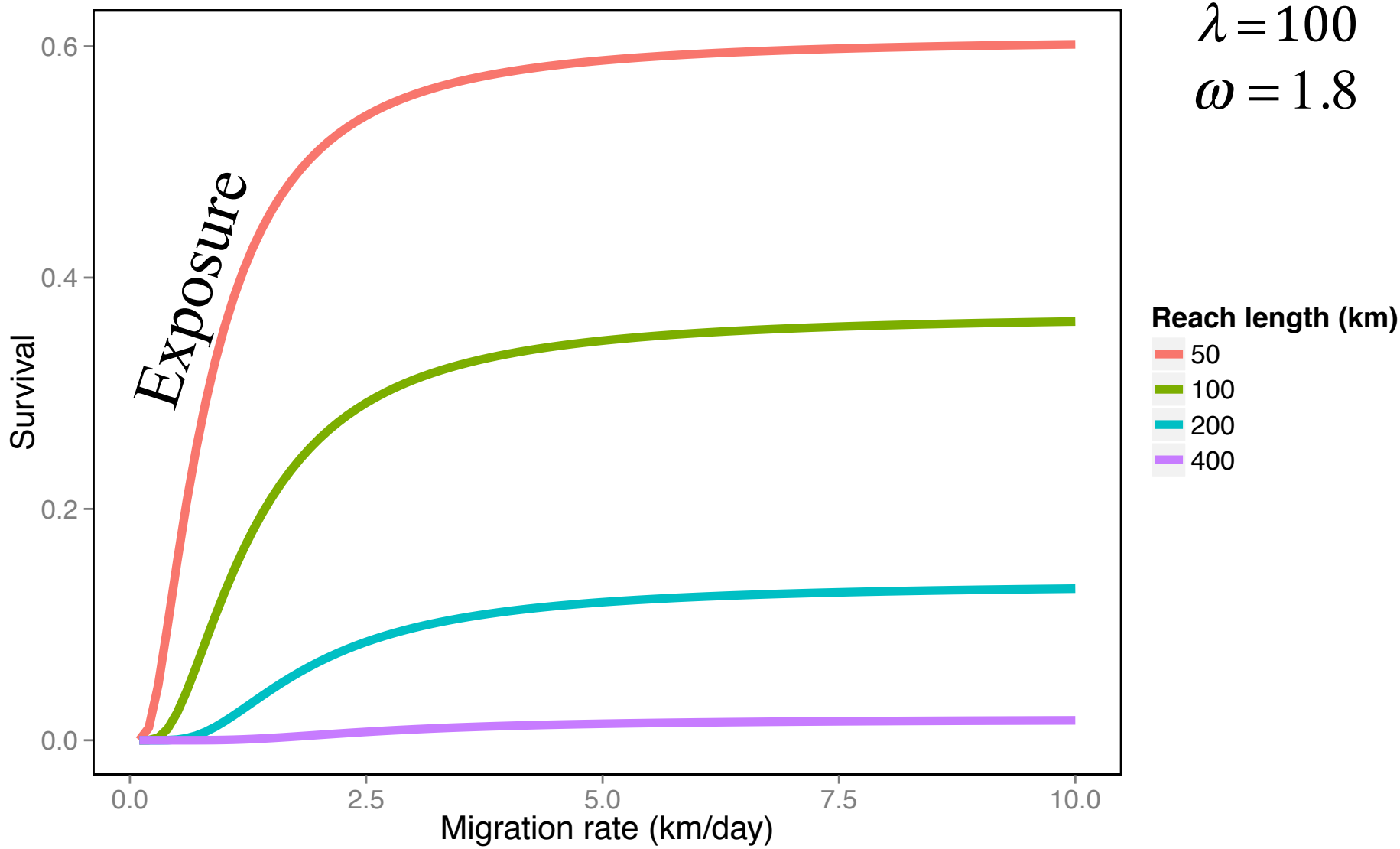

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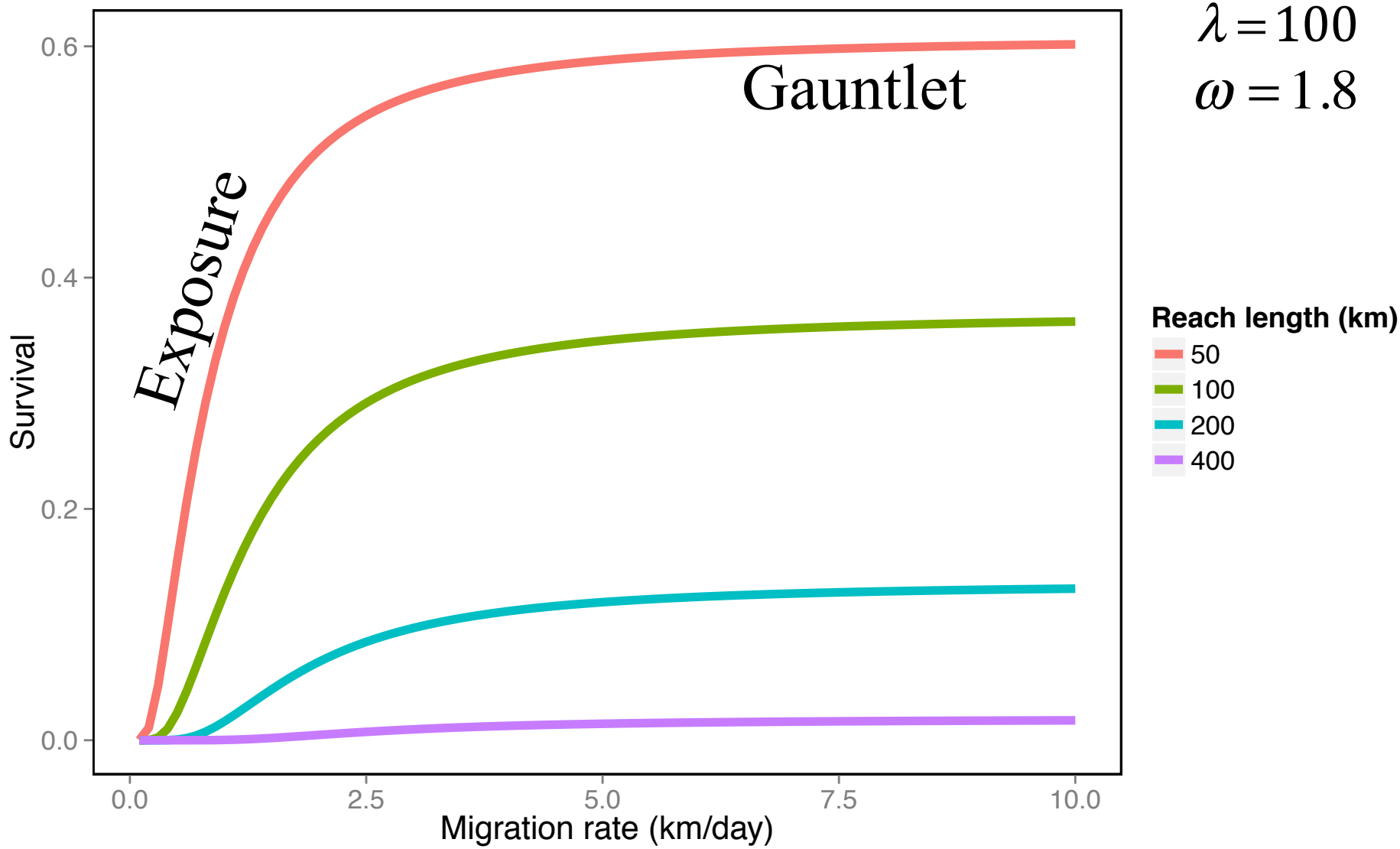
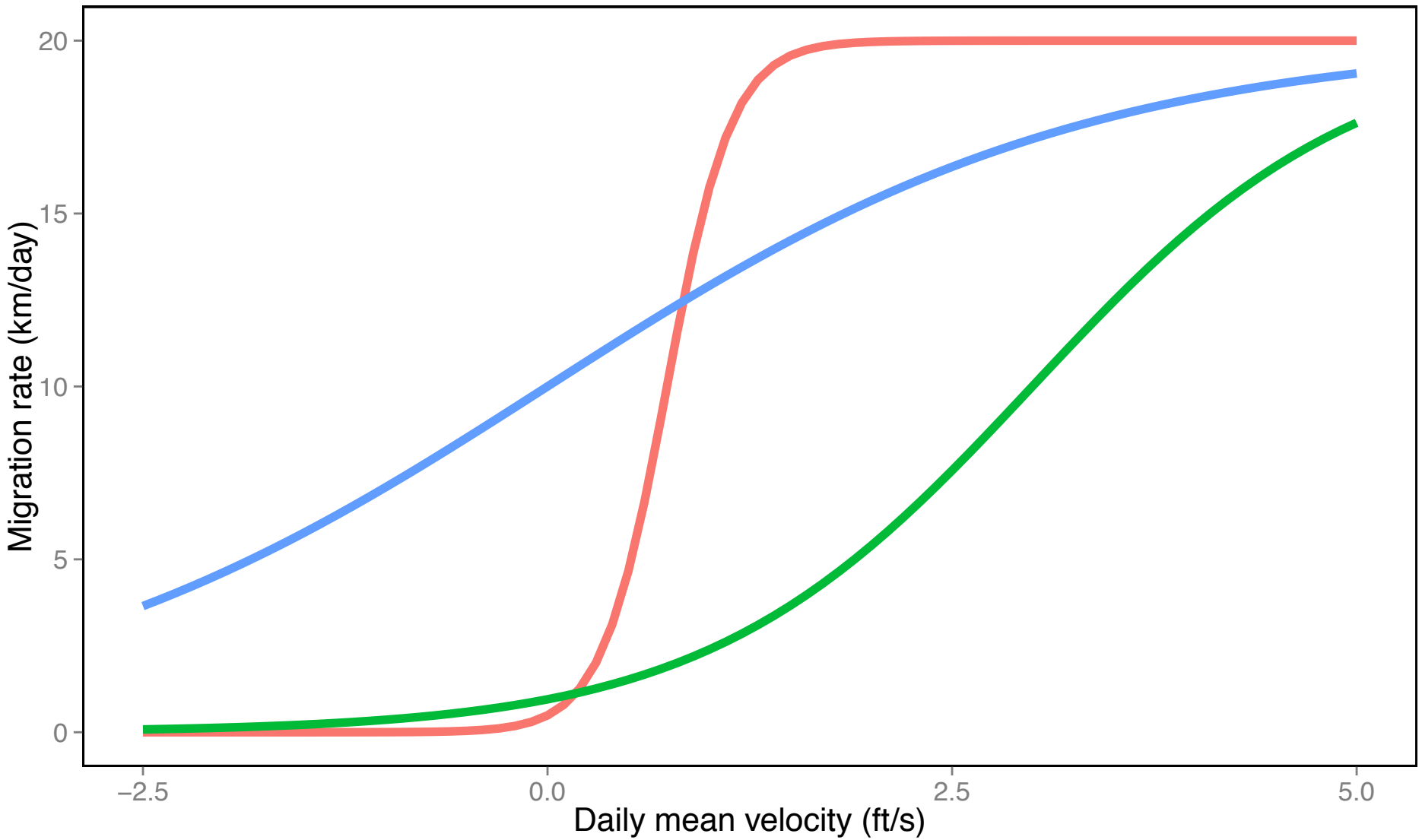


Anderson et al. 2005. Ecological Modelling

Migration Rate

$$y = \frac{a}{1 + be^{-cx}}$$

Three-parameter logistic function



Migration Rate Calibration

- Acoustic telemetry data

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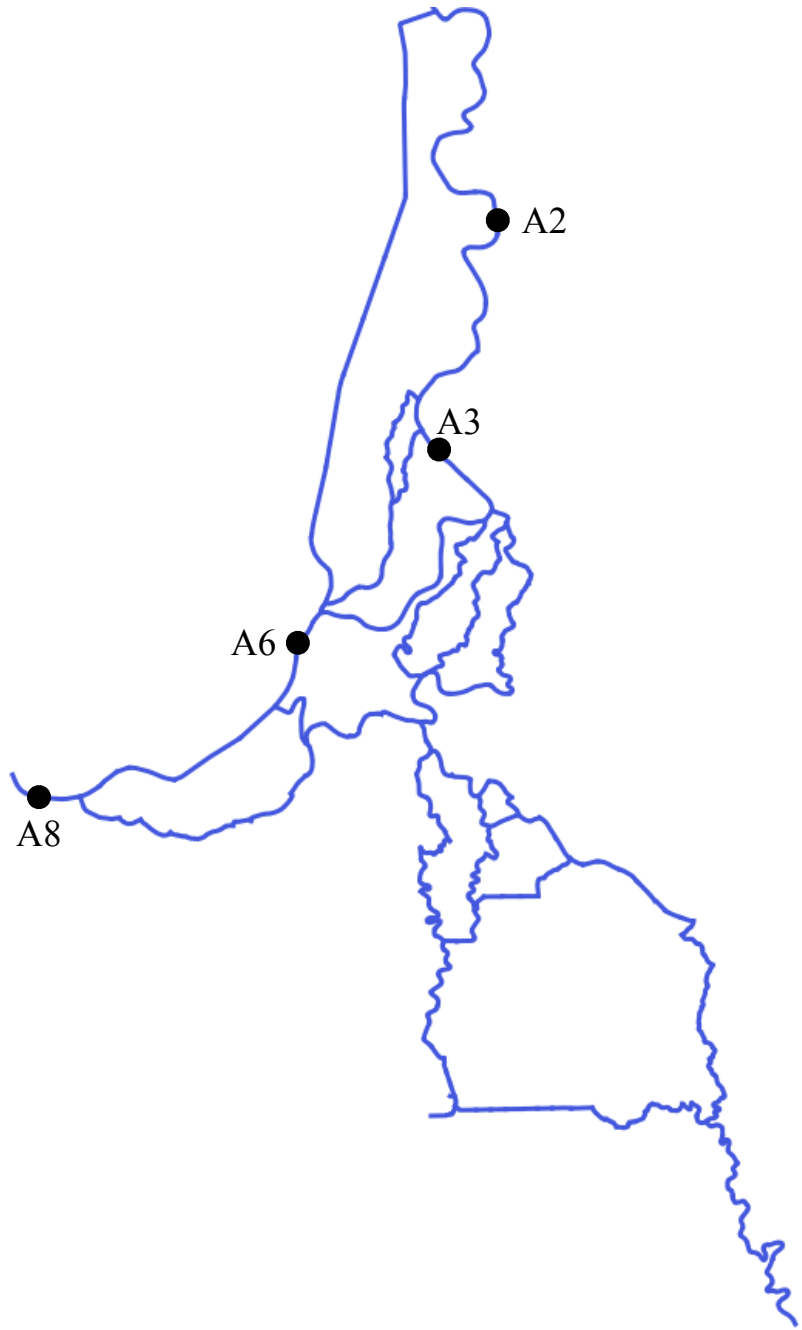

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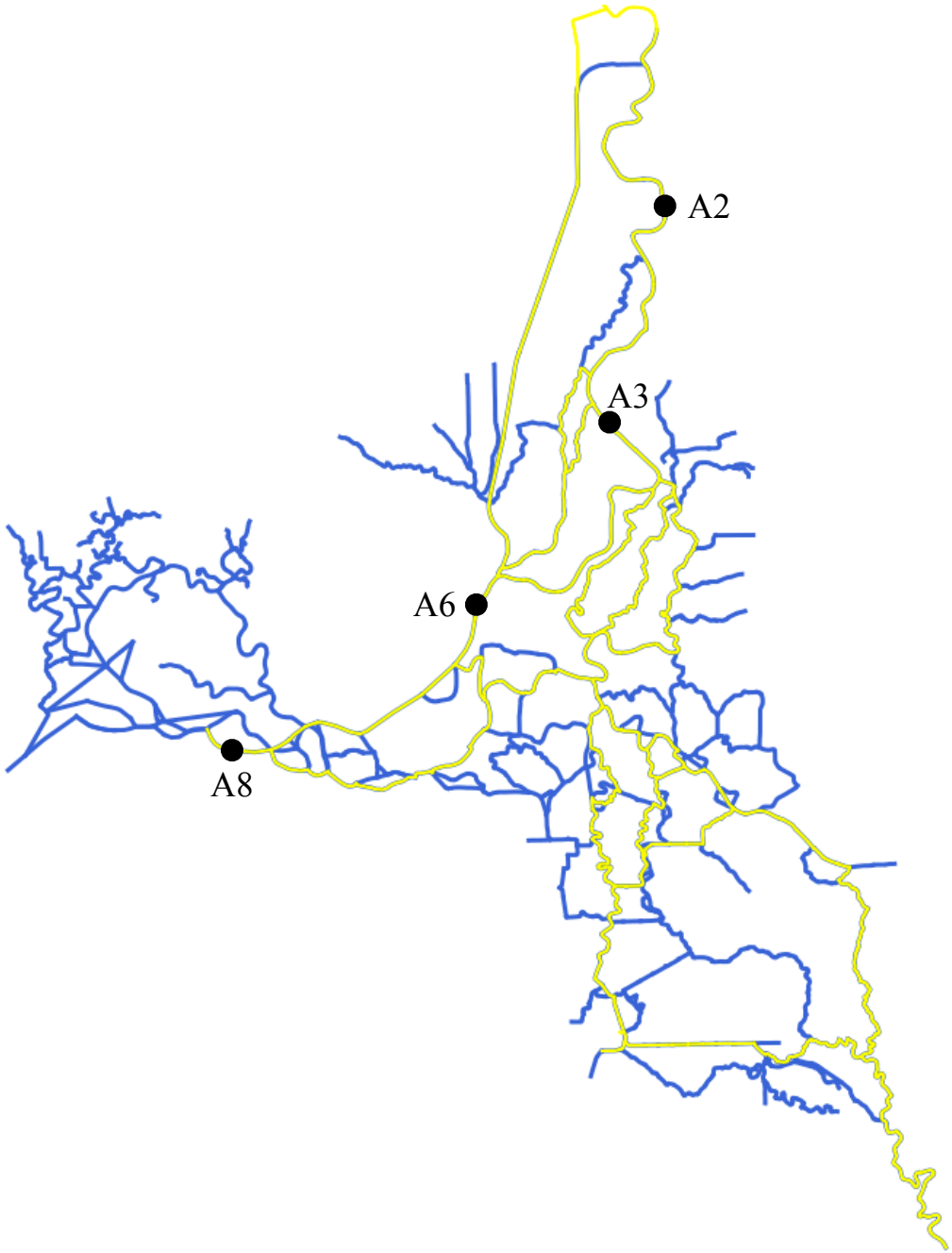

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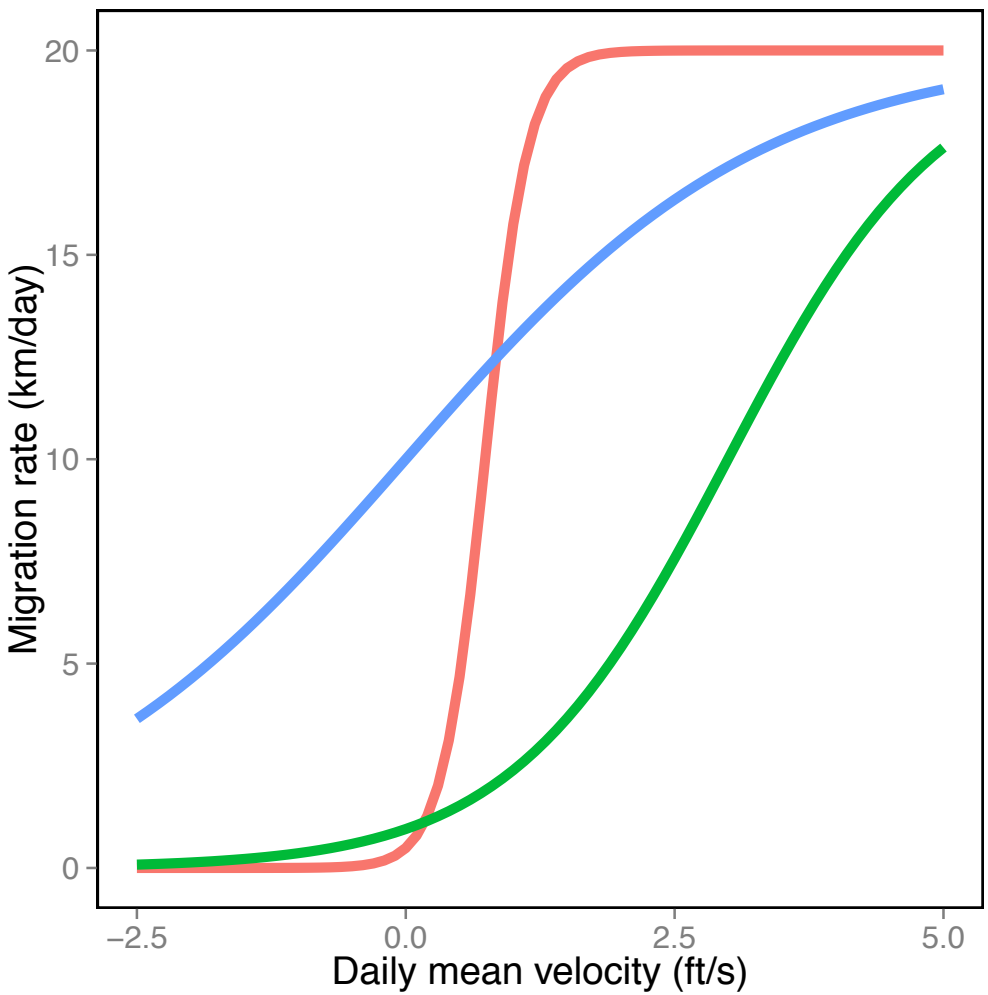

- Latin hypercube sampling

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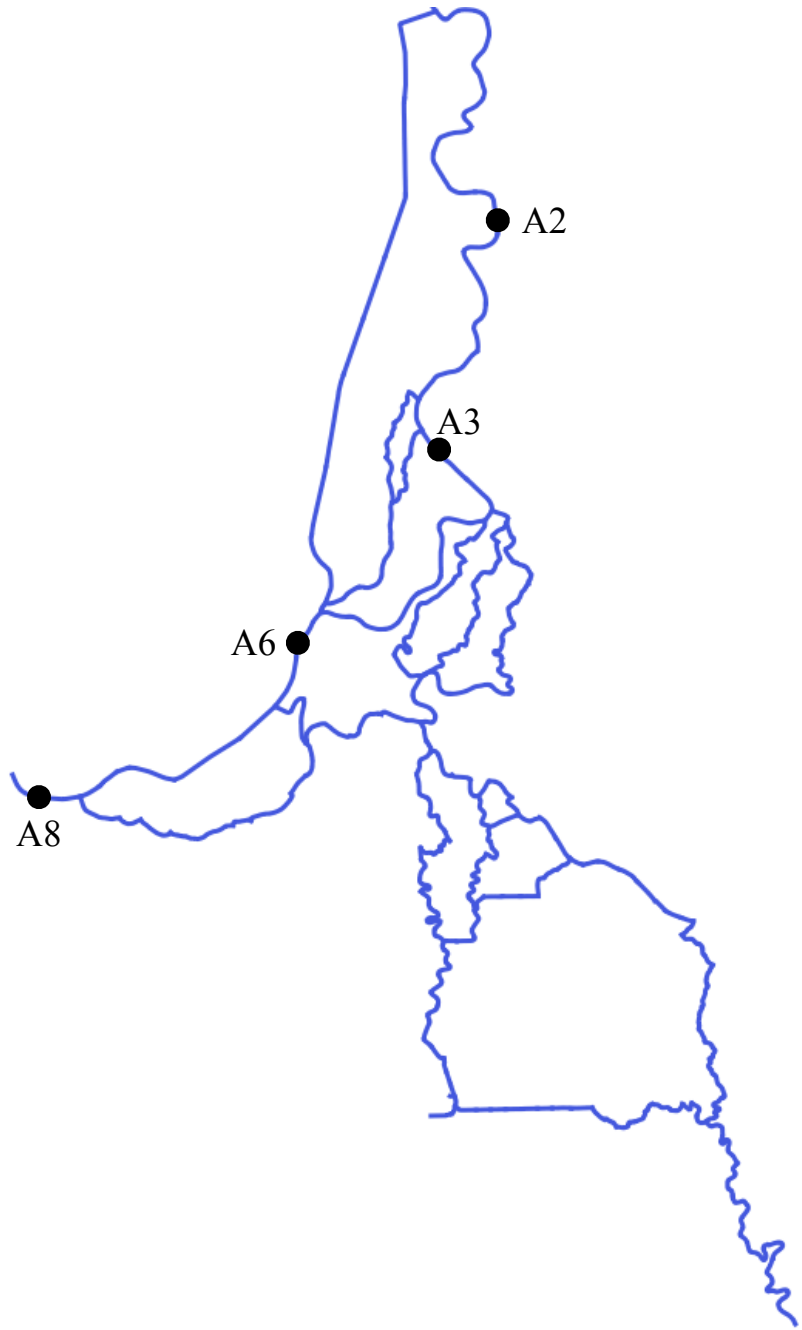
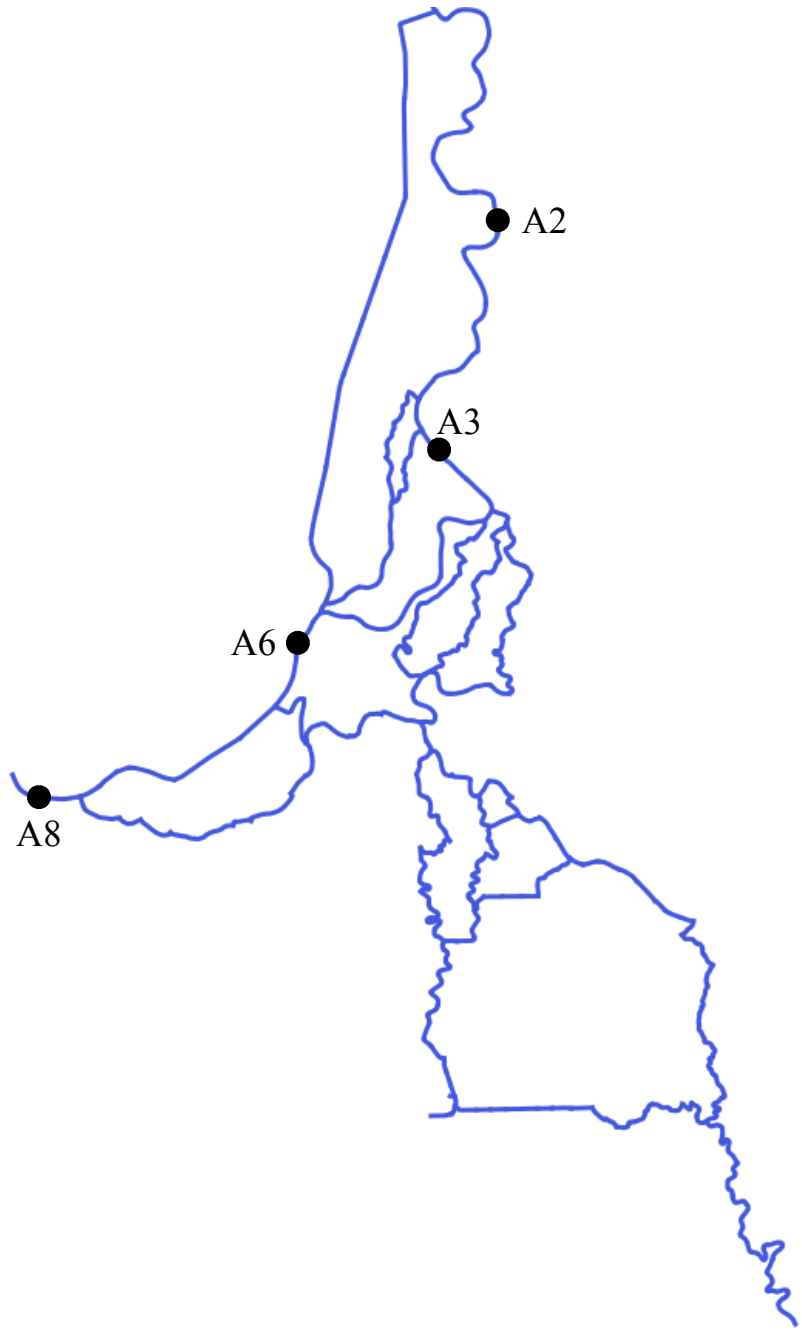


- Latin hypercube sampling
- Set survival to one
- Remove routing options

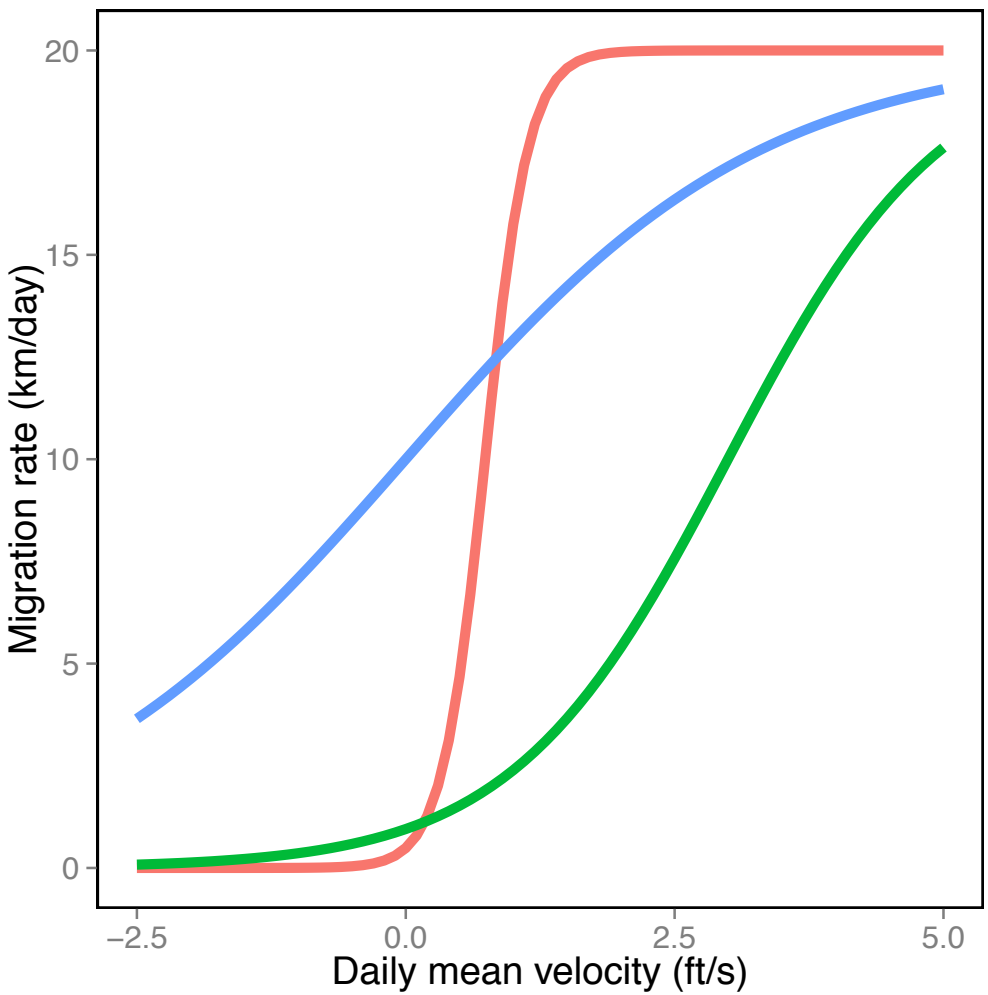
Migration Rate Calibration



- Latin hypercube sampling
- Set survival to one
- Remove routing options
- Record travel time of model fish
- Calculate percent error in travel time

Migration Rate Calibration

$$y = \frac{a}{1 + be^{-cx}}$$



- Latin hypercube sampling
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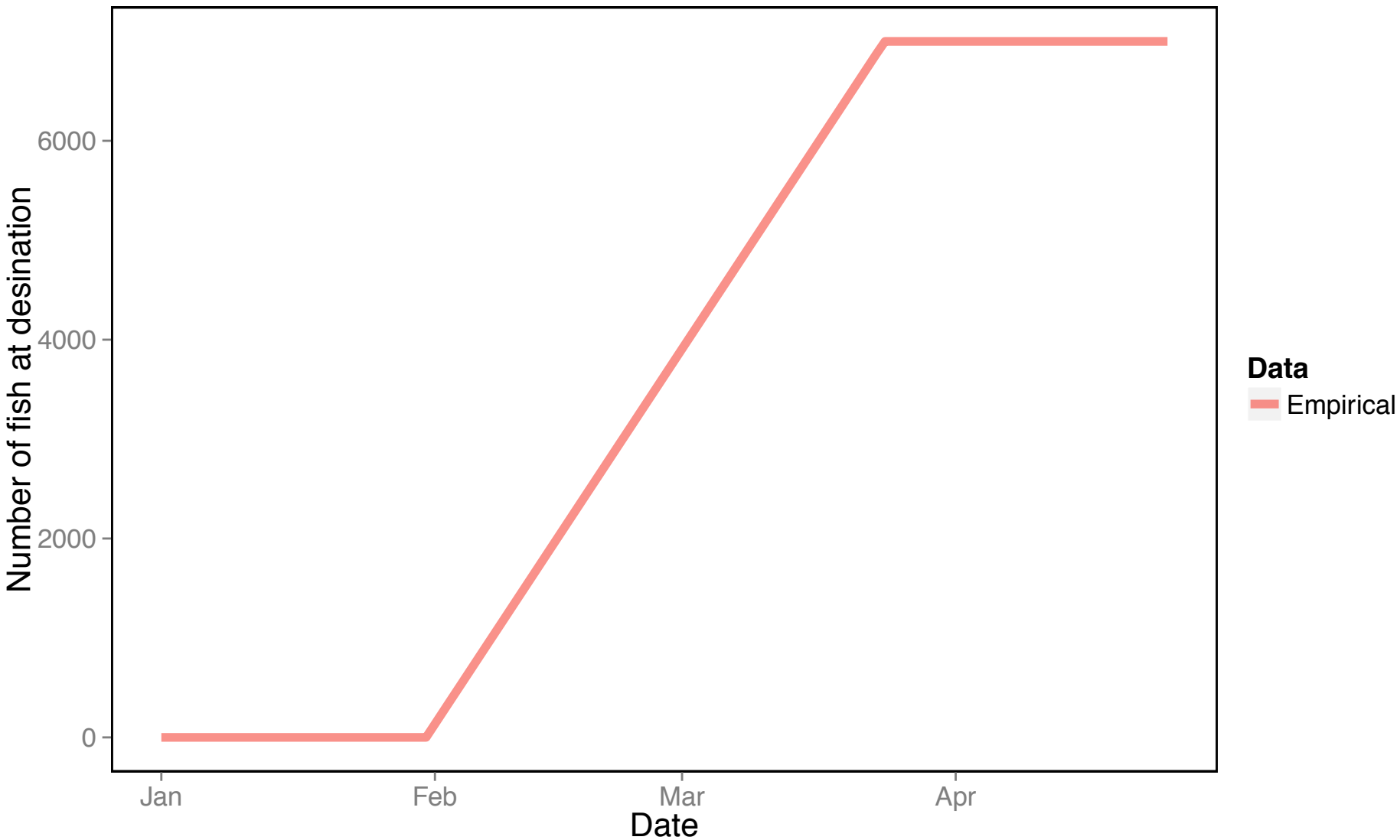
- Record travel time of model fish
- Calculate percent error in travel time
- Spatial median (L1 median)

Model Testing

- 109 coded-wire-tag releases
- Test accuracy of arrival numbers and arrival timing
  - Expanded catch
  - First and last date of catch

Model Testing



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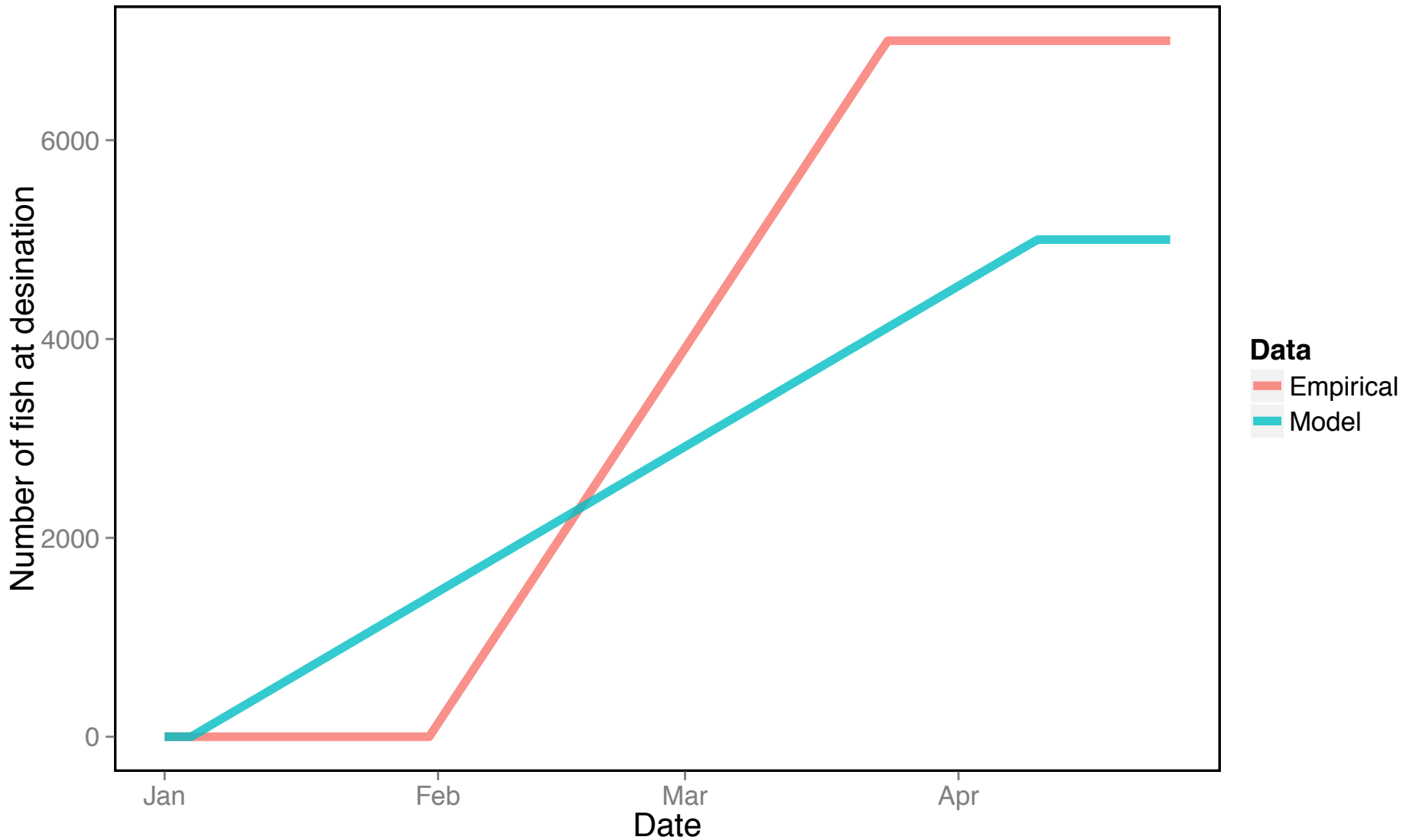

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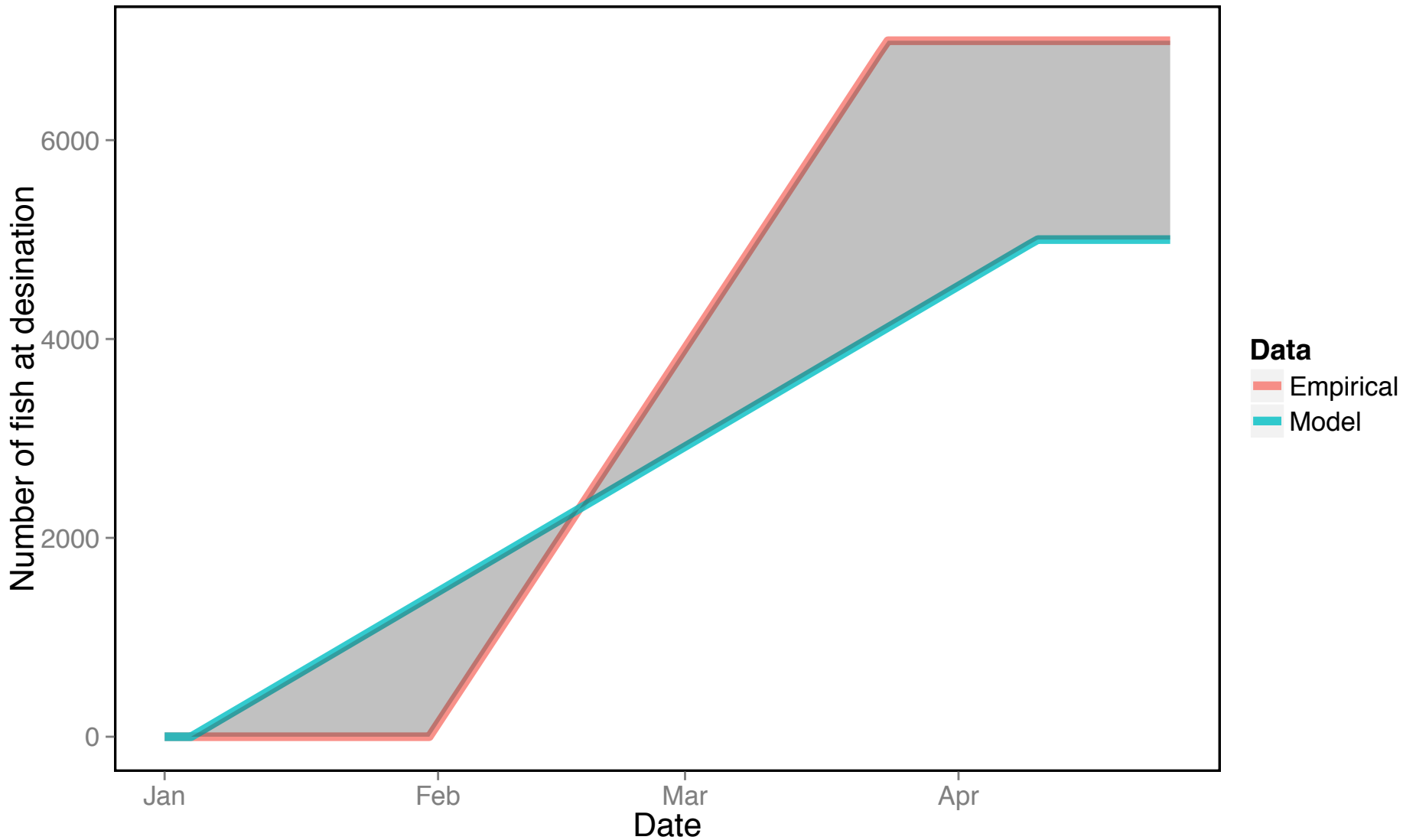

Model Testing

- 109 coded-wire-tag releases
- Test accuracy of arrival numbers and arrival timing
  - Expanded catch
  - First and last date of catch
- Factors associated with release group
  - Location
  - Number
  - Fork length

Gaming Version

- DSM2 Hydro planning simulations
  - Factorial combination of gates, inflows, exports
    - HORB: in, out
    - DCC: open, closed
    - CVP: 0, 1250, 2500, 3750, 5000
    - SWP: 0, 2500, 5000, 75000, 10000
    - Sacramento: 10000, 25000, 40000, 55000, 70000
    - San Joaquin: 1000, 5500, 10000, 14500, 19000
- User can also override default values for routing, survival, and migration rate

Acknowledgments

- Russell Perry (USGS)
- Rebecca Buchanan (Univ. of Washington)
- Pat Brandes (USFWS)
- Kevin Clark (CDWR)
- Tara Smith (CDWR)
- Min-Yeng Tu (CDWR)
- Ben Nolting (Case Western Reserve Univ.)