An Overview of the Stream Salmonid Simulator for the Trinity River

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Trinity DSS Workshop
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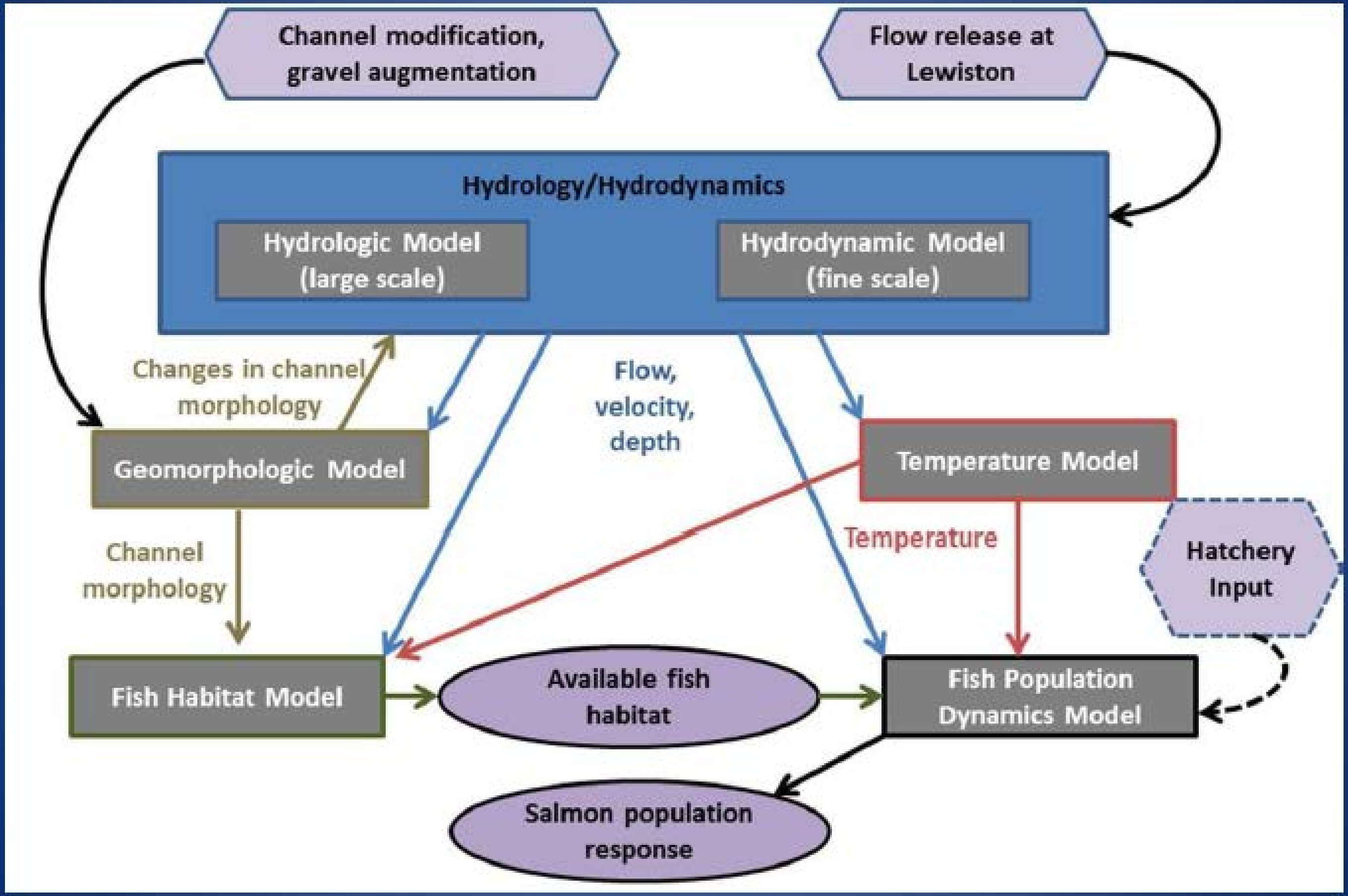
Overview

- Relevance to Decision Support System
- Underlying Basis and Structure
- Running S3 for DSS Workshop
- Model output for 2012

Why is a Fish Production Model Important?

Decision Support System - TRRP Conceptual Integrated Model



Source: James T. Peterson. 2013. Decision Support System framework for adaptive management. Presentation at TRRP 2013 Science Symposium TRRP's Scientific Advisory Board Review of Phase 1; January 8, 2013.

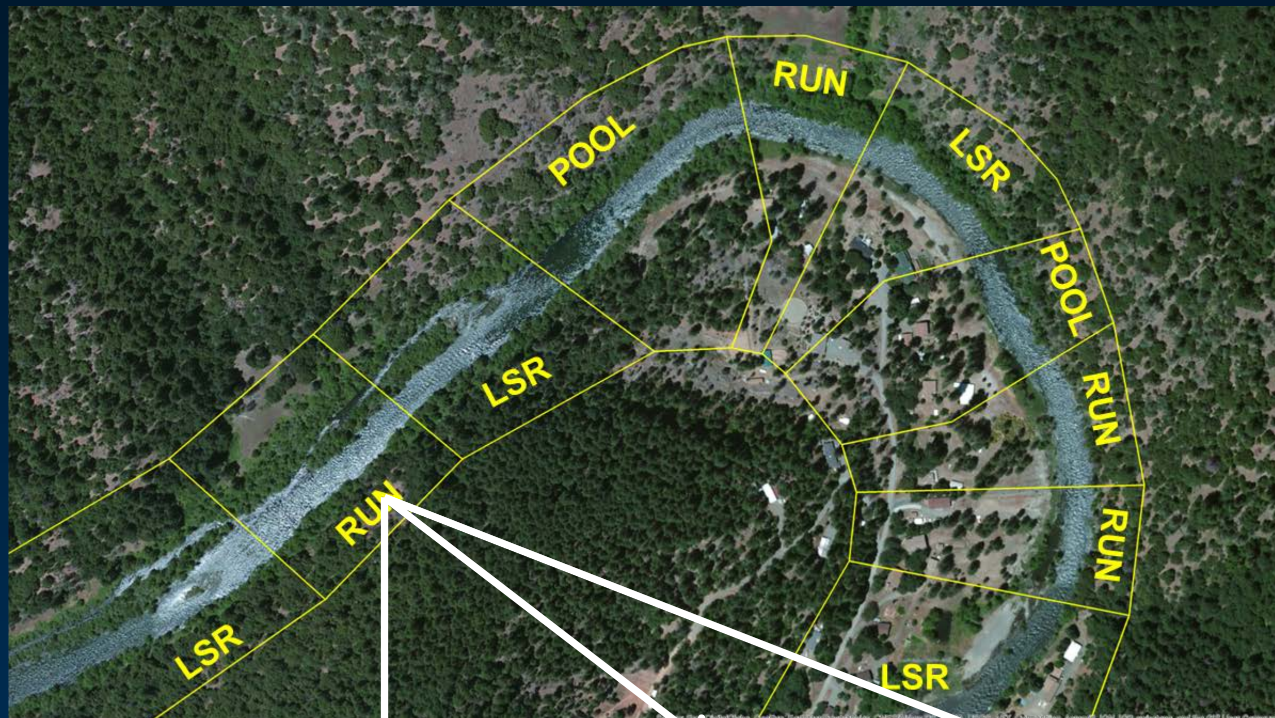
Why is a Fish Production Model Important?

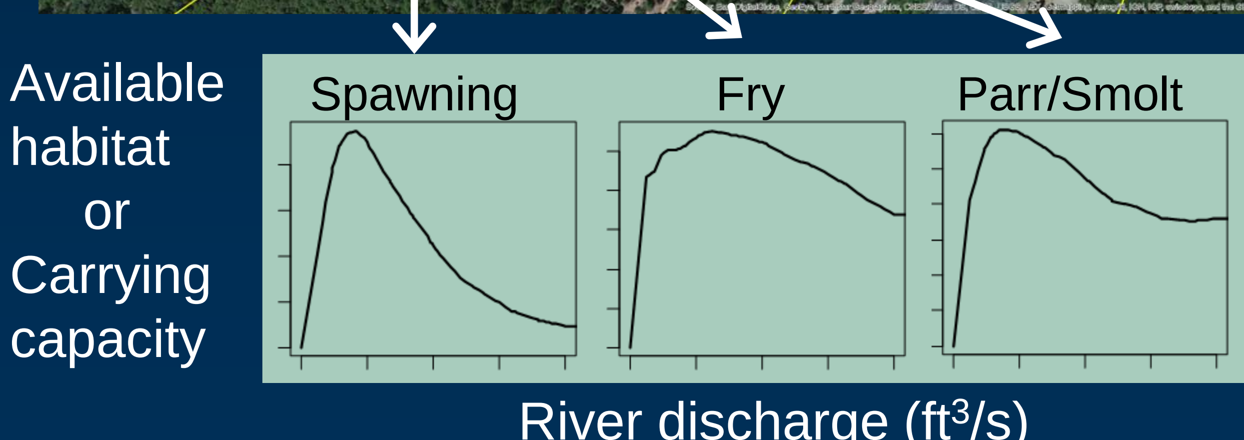
- Quantify response of fish populations to
  - Habitat restoration
  - Flow and temperature management
- Understand possible mechanisms of response
  - Comparing alternative hypotheses
- Identify data gaps for monitoring
- Aid in decision making

Underlying Basis of S3 Model

- Habitat constrains production
- Habitat quantity and quality
  - depth
  - velocity
  - cover
  - Water temperature
- Quantity and quality affected by
  - River discharge
  - Physical habitat structure
- Habitat requirements vary by life stage

Discharge Affects Habitat Area and Carrying Capacity





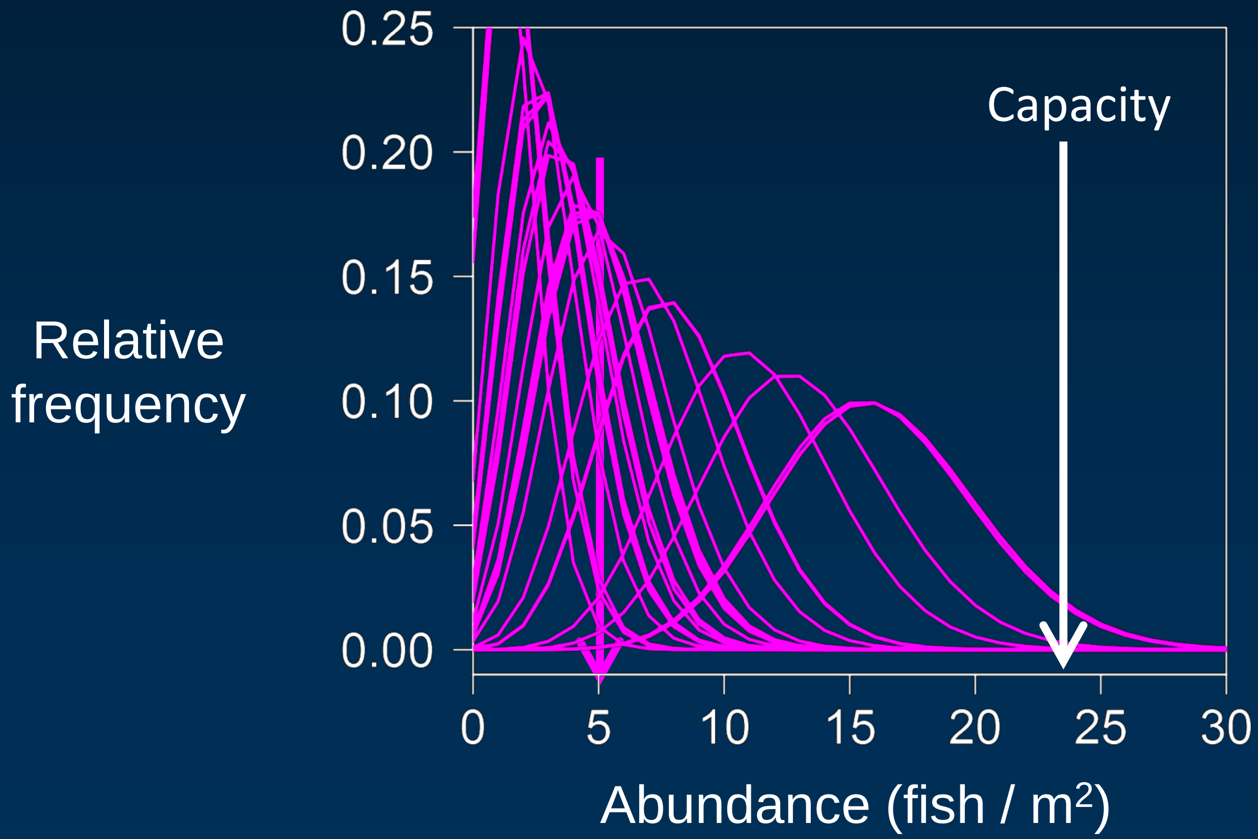
Abundance Model (N-mixture) ⇔ Capacity

Abundance = f(depth, velocity, cover) + f(time, location)

Probability Distribution: Variation in mean abundance

Mean abundance

Variation in space and over time



= an upper limit of this distribution; e.g., 95%

Life Stages Modeled

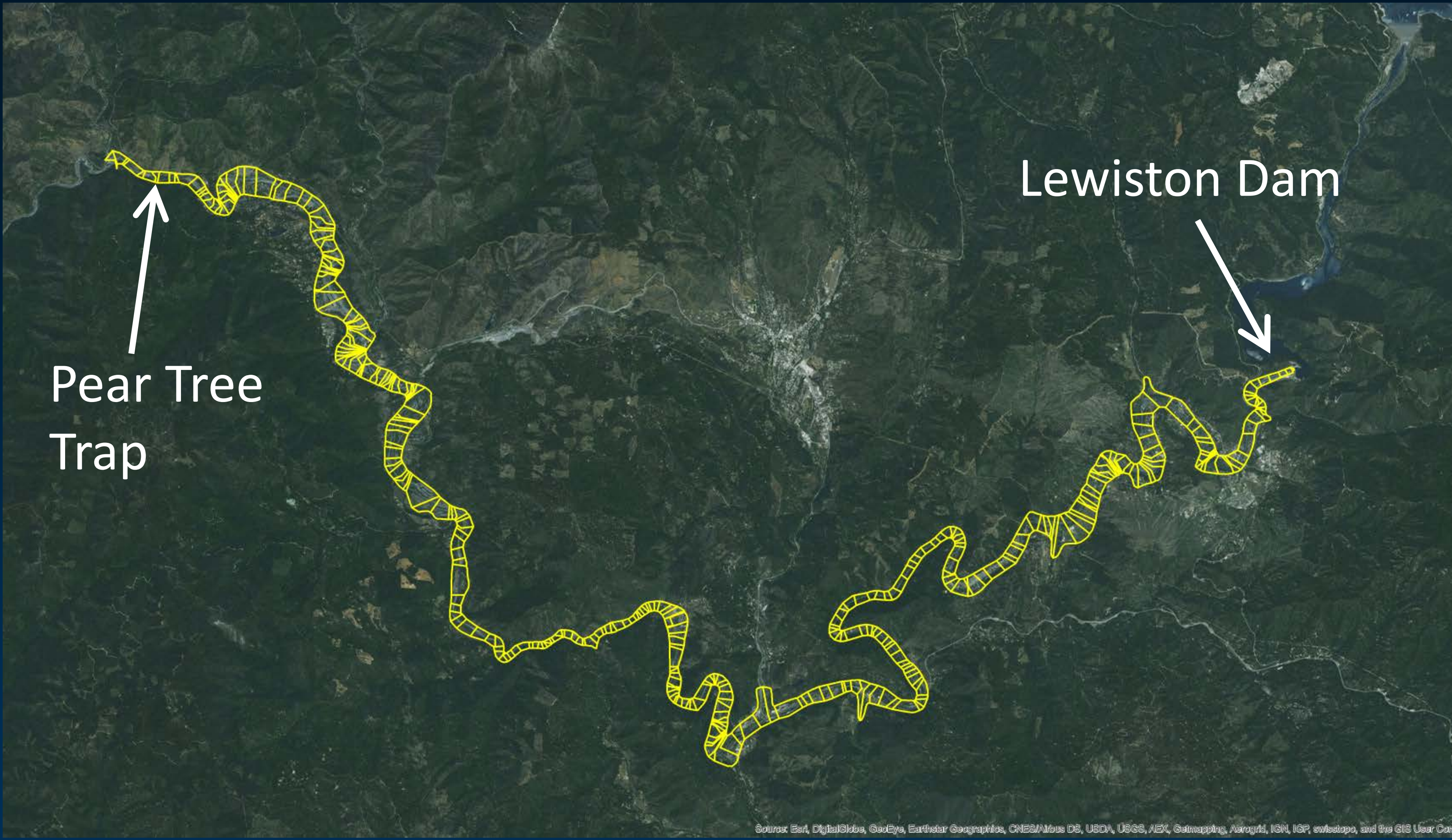
- Spawning to juvenile emigration
  - Egg Deposition to Emergence
  - Fry (< 55 mm)
  - Parr (55 – 90 mm)
  - Smolt (> 90 mm)

- Ultimate Goal: complete the life cycle
  - Ocean life stage
  - Spawner migration submodel

Spatial Extent and Resolution

- The habitat unit
  - Pool, Riffle, Run
  - Mean length ~ 100 meters
- Phase 1 (FY15-16)
  - Lewiston Dam to Pear Tree (Upper 40 miles)
  - 356 habitat units
- Phase 2 (FY 17)
  - Extend to Klamath
  - Connect to Klamath S3 model

Meso-Habitat Units in S3



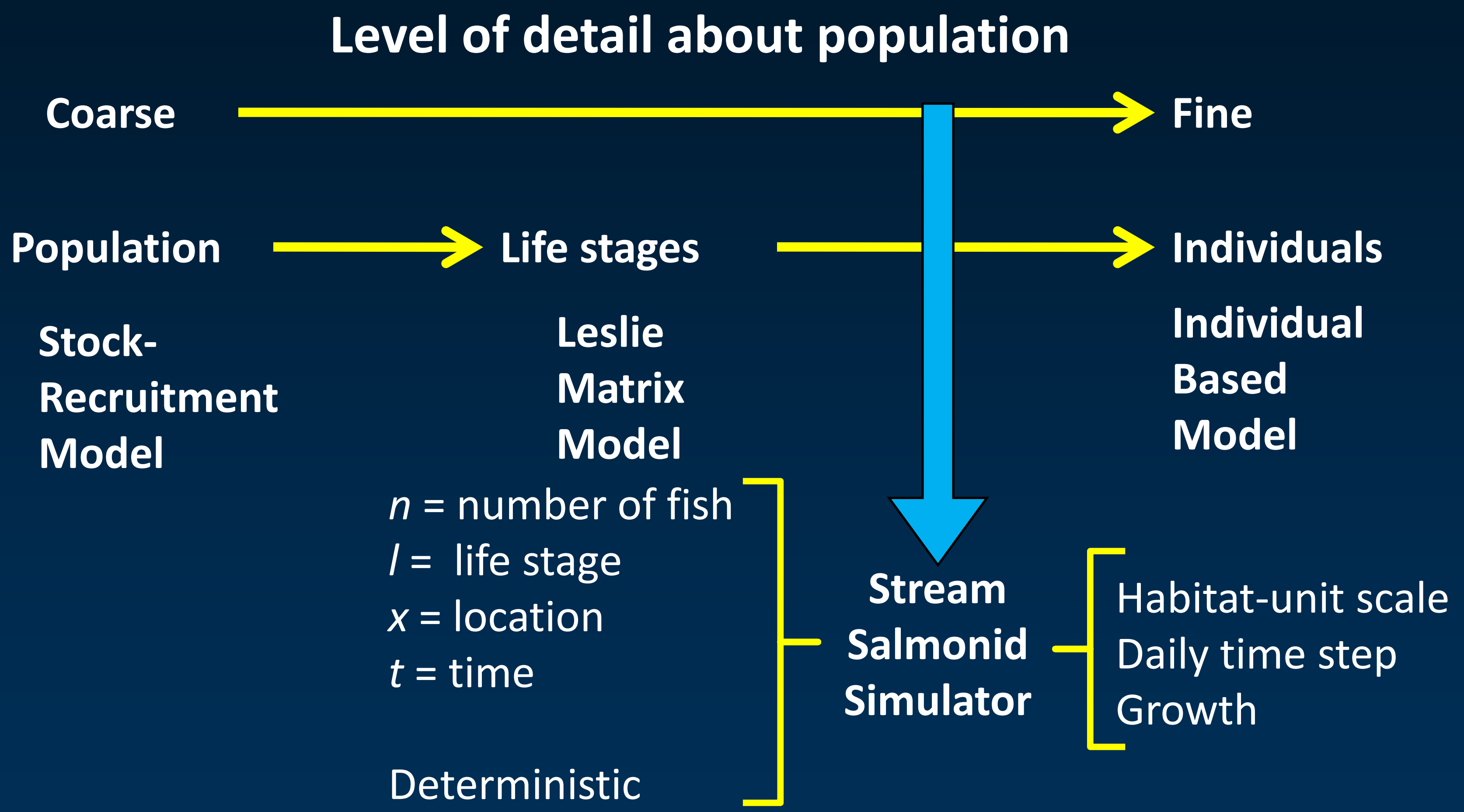
356 habitat units (Type: Pool, Run, LSR, MSR, SSR)

Temporal Extent and Resolution

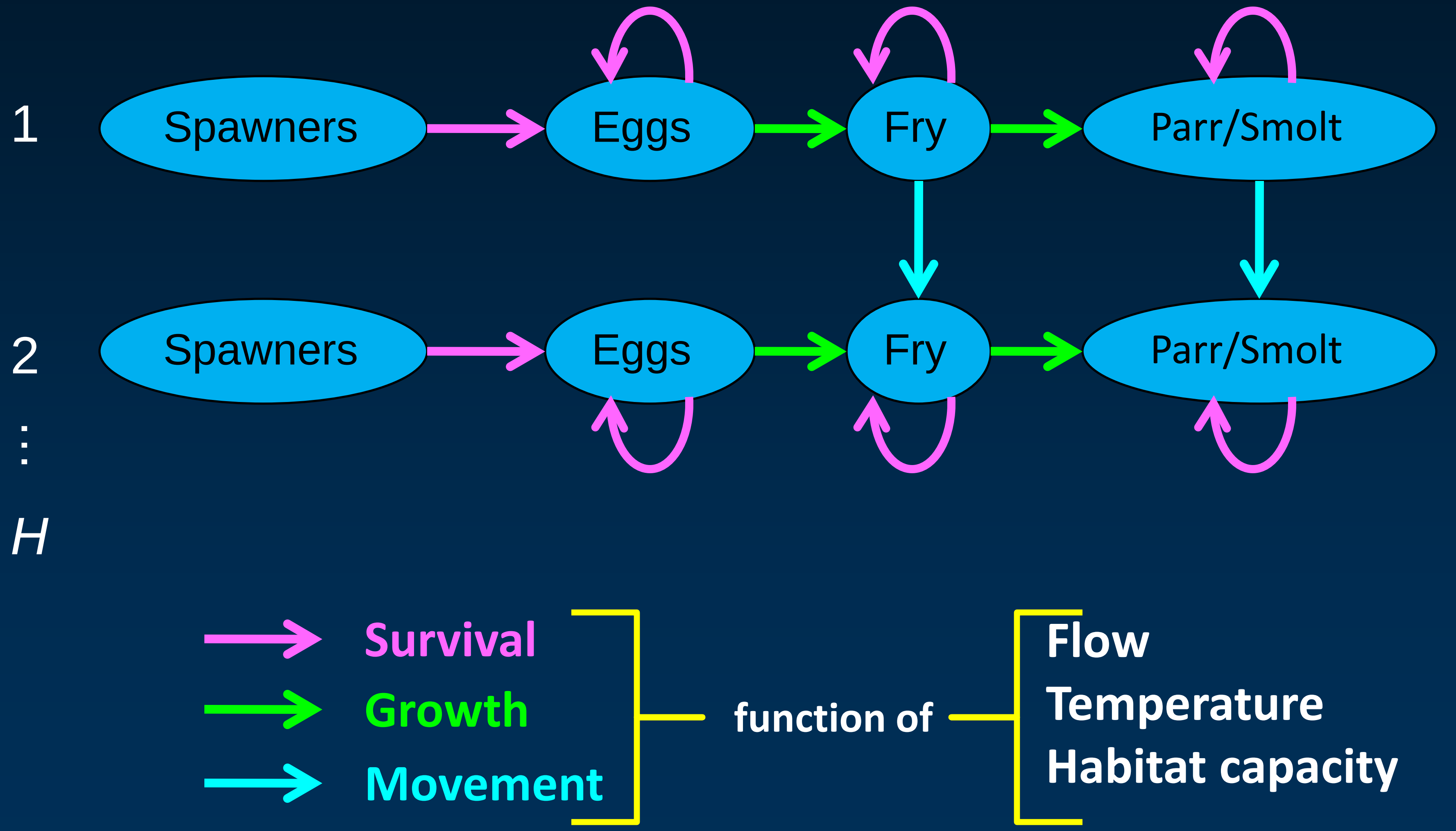
- Extent
  - Starts at beginning of spawning
  - mid-August → mid-August

- Resolution
  - Daily time step
  - Rates are daily
    - Mortality, movement, growth

The Spectrum of Model Complexity



Demographic Processes at each time step



Running S3 for the DSS Workshop

- Status
  - Built and running
  - Just starting model calibration

- Run model for 2012
  - Match historical inputs
  - Fit model to historical outputs
    - Weekly abundance passing Pear Tree trap
  - Estimate key parameters
    - Movement, Survival

Running S3 for the DSS Workshop

- Use fitted model to evaluate scenarios
  - ROD hydrograph
  - “Natural” hydrograph
- Assess uncertainty
  - Model outputs
  - Model structure

Biological Inputs

Spawners

- 4,649 spawners
- Distributed spatially and temporally
- Based on carcass and redd surveys

Juveniles entering from

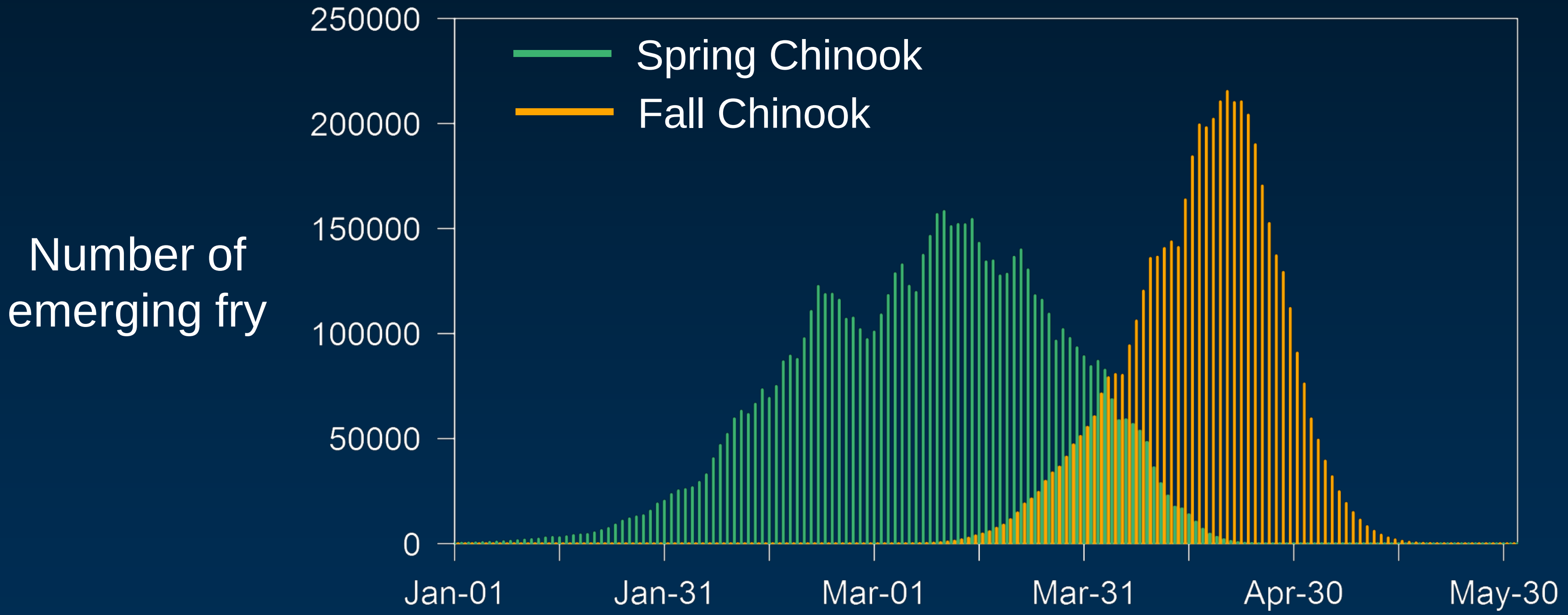
- Tributaries
- Hatchery
  - 2.6 million fry released in 2012

Spawning and Egg Life Stages

- Survival
  - Baseline natural mortality
  - Thermal Tolerance
  - Redd scour
  - Redd superimposition

- Emergence
  - Function of degree-days
  - Beacham and Murray (1990)

Emergence Timing



Juvenile Growth Model

- Wisconsin BioEnergetics model
  - Revised consumption function
    - (Plumb et al. 2015)
  - Proportion of maximum consumption
    - Set to 0.66

Estimating Juvenile Movement and Survival Parameters

- Three parameters to estimate
  - 1 survival parameter
  - 2 movement parameters
- Fit model to data
  - Adjust parameters
  - Run model
  - Compare to weekly abundance at Pear Tree trap
- Optimization routine to find best fit

Juvenile Chinook Survival

- Constant daily mortality rate (estimated)
- Upper thermal tolerance

- Other possible models:
- Density-dependence
- Predation

Source: www.napavalleyregister.com/articles/2008/02/1...

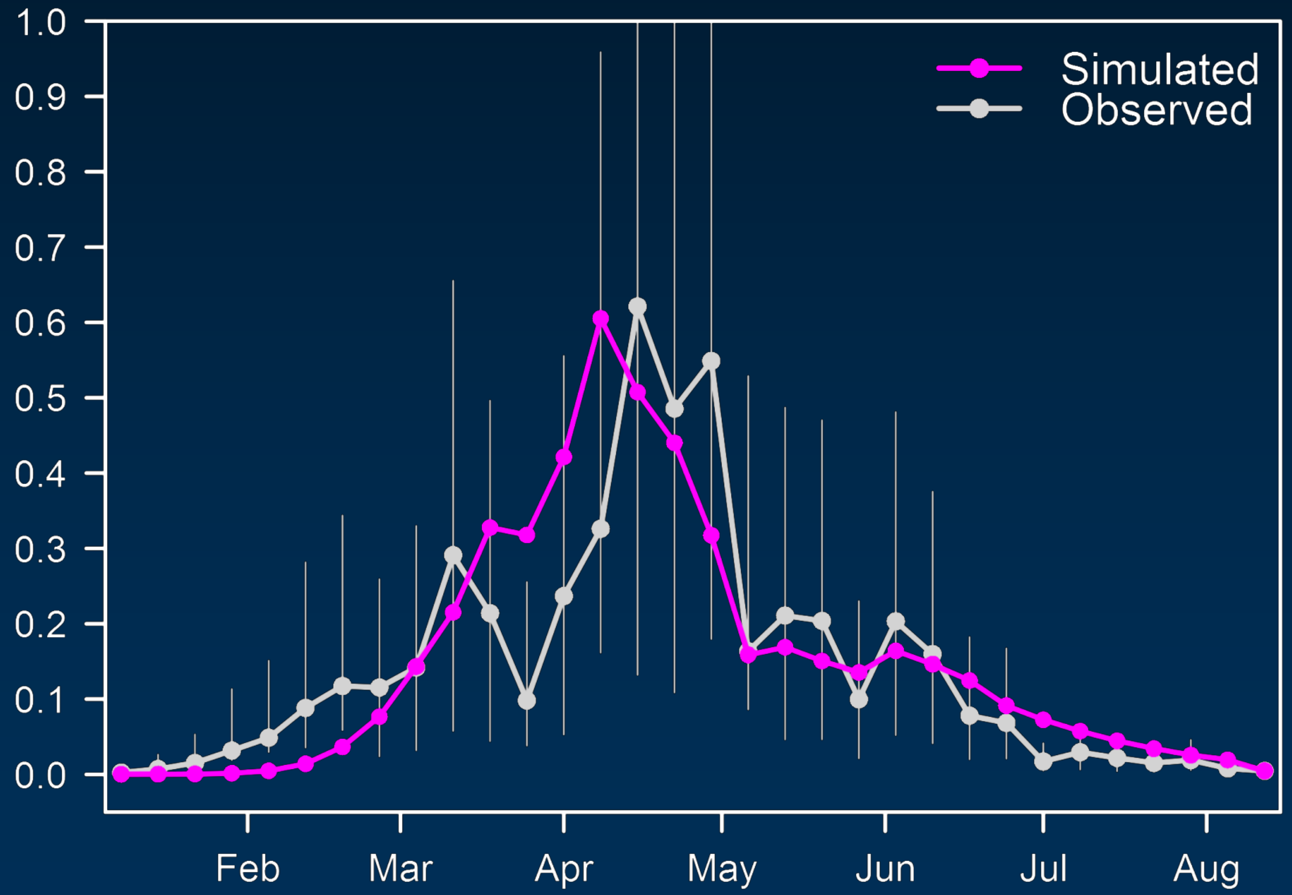
Juvenile Chinook Movement "Mover-Stayer" Model

- Stayers
  - P_{stay} = Probability of staying in habitat unit
  - 1- P_{stay} = probability of moving
  - Density dependent
  - Estimated intercept
- Movers
  - Exponentially distributed movement distance
  - Estimated mean distance moved

Weekly Abundance at Pear Tree in 2012

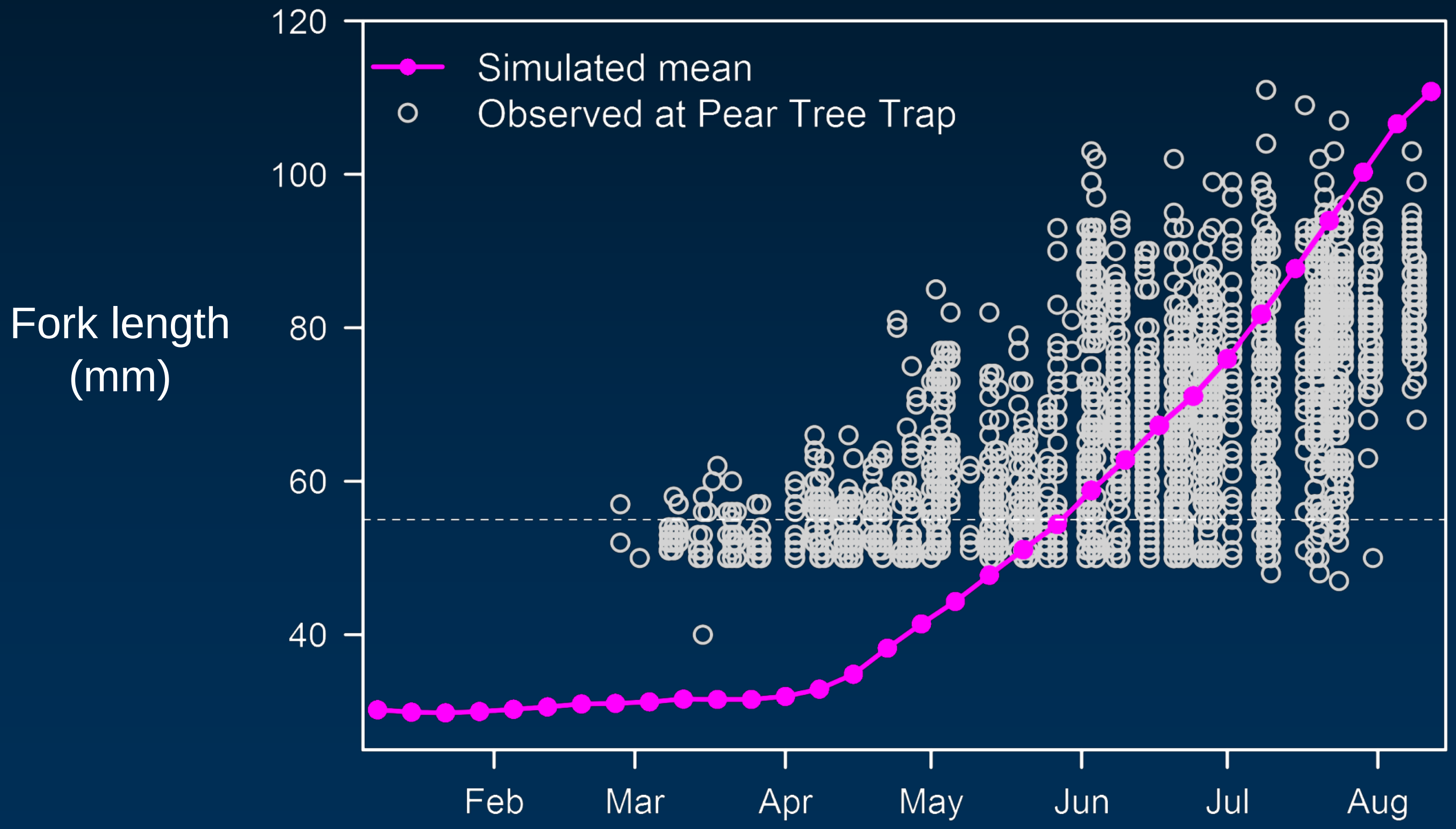
Goodness of fit

Juvenile Chinook abundance (millions)



Fish Length at Pear Tree in 2012

Goodness of fit

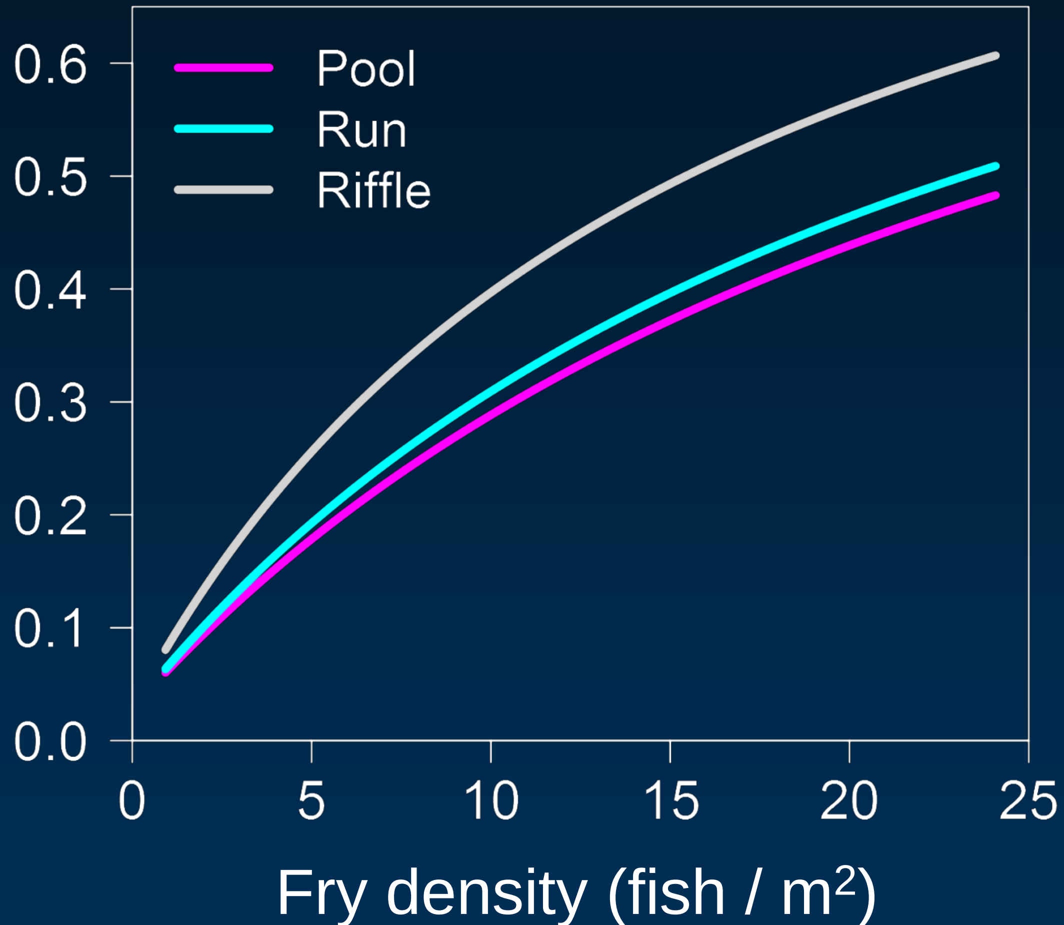


Parameter Estimates

Parameter	Estimate	95% Confidence interval
Daily survival probability	0.982	0.981 – 0.983
Mean movement distance (km/day)	11.1	10.4 – 11.9
Probability of moving (as abundance → 0 fish)	0.028	0.027 – 0.030

Mover-Stayer Model

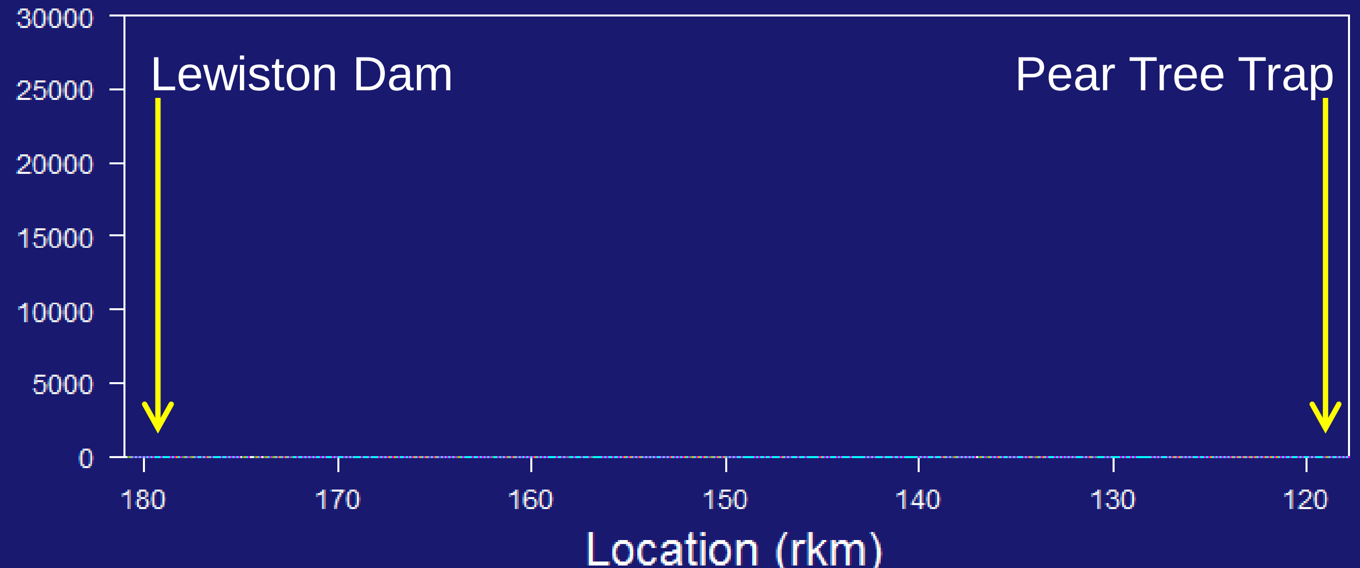
Probability of moving
$(1 - P_{stay})$



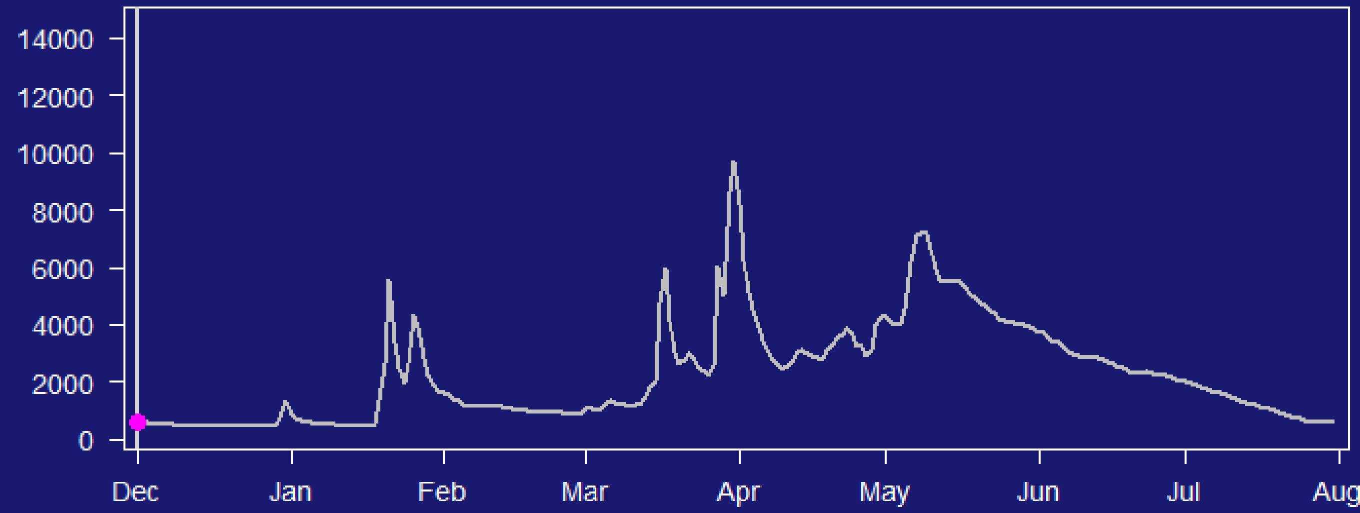
Spatial Distribution of Daily Abundance

Juvenile Chinook abundance

- Spring
- Fall
- TRH Spring
- TRH Fall



Discharge at Pear Tree (ft^3/s)



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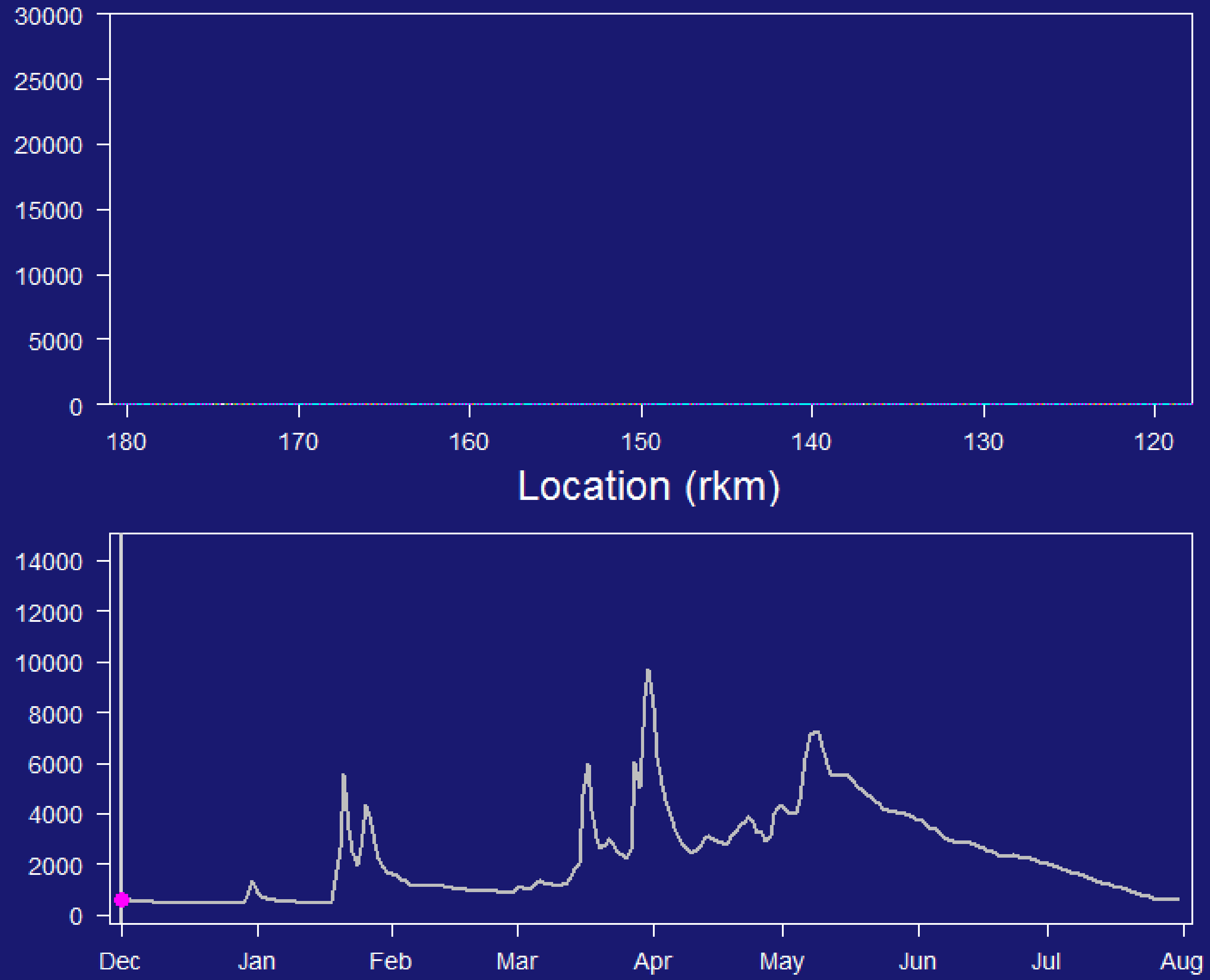

Summary

- Good fit for single year
- Parameter values make sense
  - Habitat capacity affects density and movement
- Captures temporally varying habitat
  - Sensitive to flow variation
- Flexible modeling structure
  - Alternative sub-models
- Useful for evaluating management actions

Acknowledgements

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Trinity River Restoration Program

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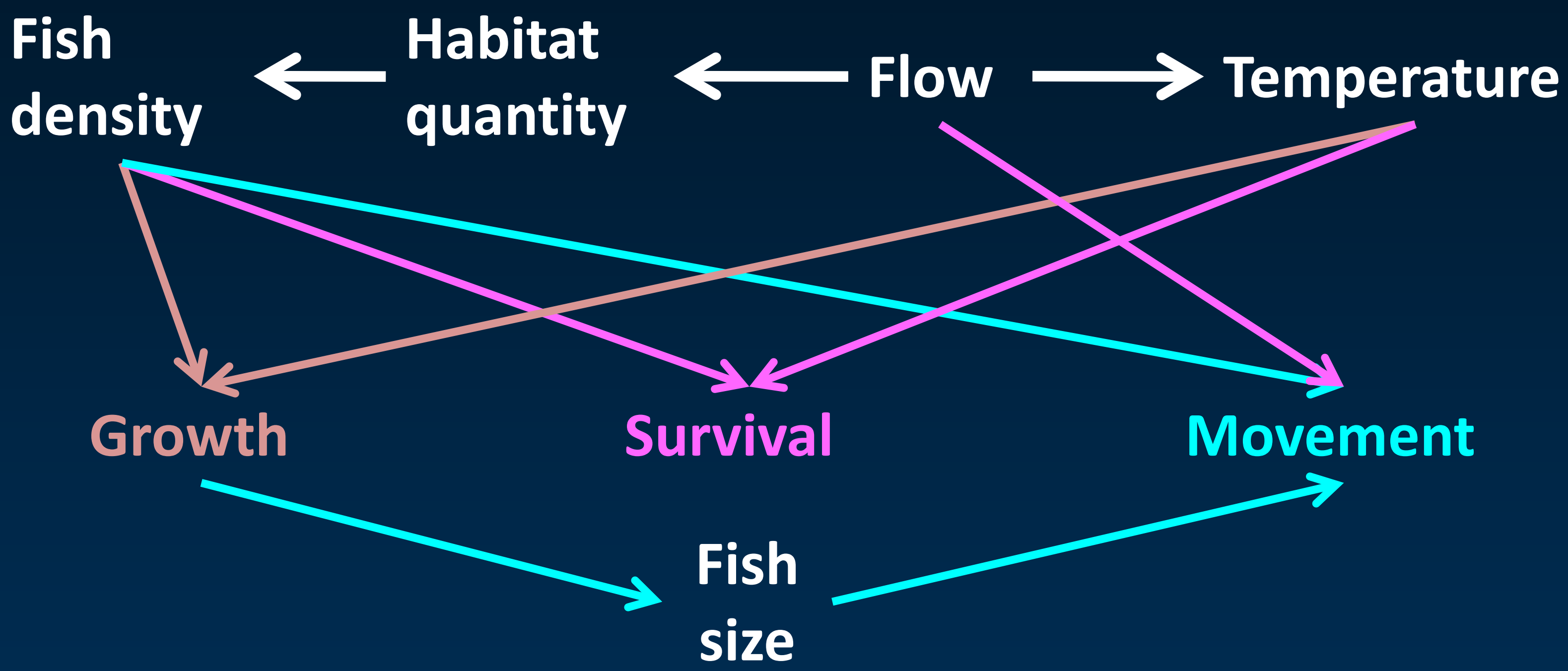
Modeling Platform

- R: A Language and Environment for Statistical Computing
- Advantages:
  - Open source
  - Mature programming language
  - Rich set of statistical and graphical packages
- Disadvantages
  - Speed – it's slow!
- Fortran for computationally intensive parts

Physical Drivers: Discharge and Temperature



- Varies by life stage
- Both direct and indirect links