Willamette River Instream Ecological Flow Science Review and Analyses Prioritization

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Willamette Instream Flows

Purpose: Identify instream flows to sustain the river ecosystem and dependent fish, wildlife, and vegetation

- **Social and economic water use considered subsequently**

SWIFT Interdisciplinary Team:

Hydrologists

Geomorphologists

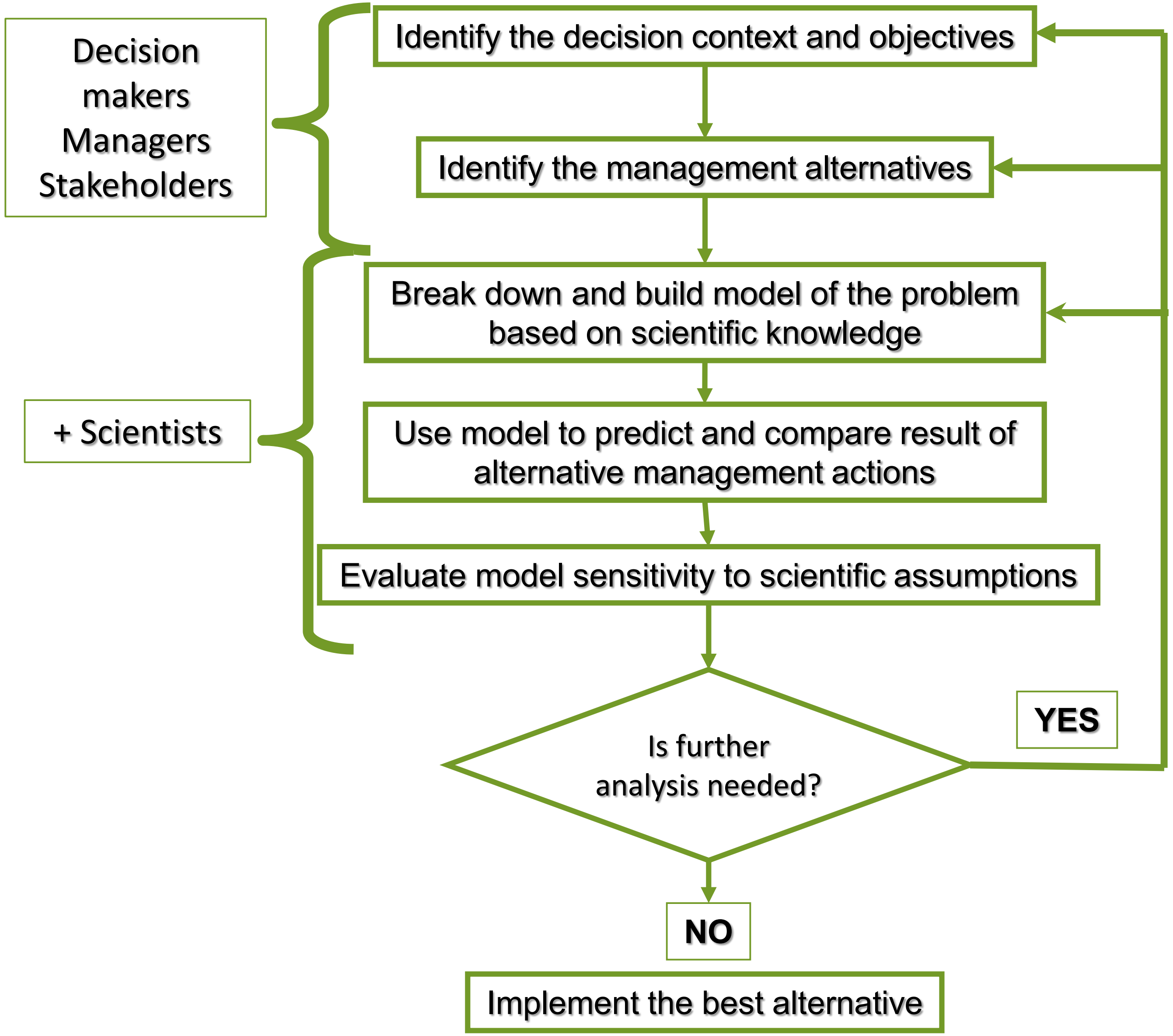
Water quality modelers

Ecologists

Managers

Stakeholders

Structured Decision Making Process



Phase I

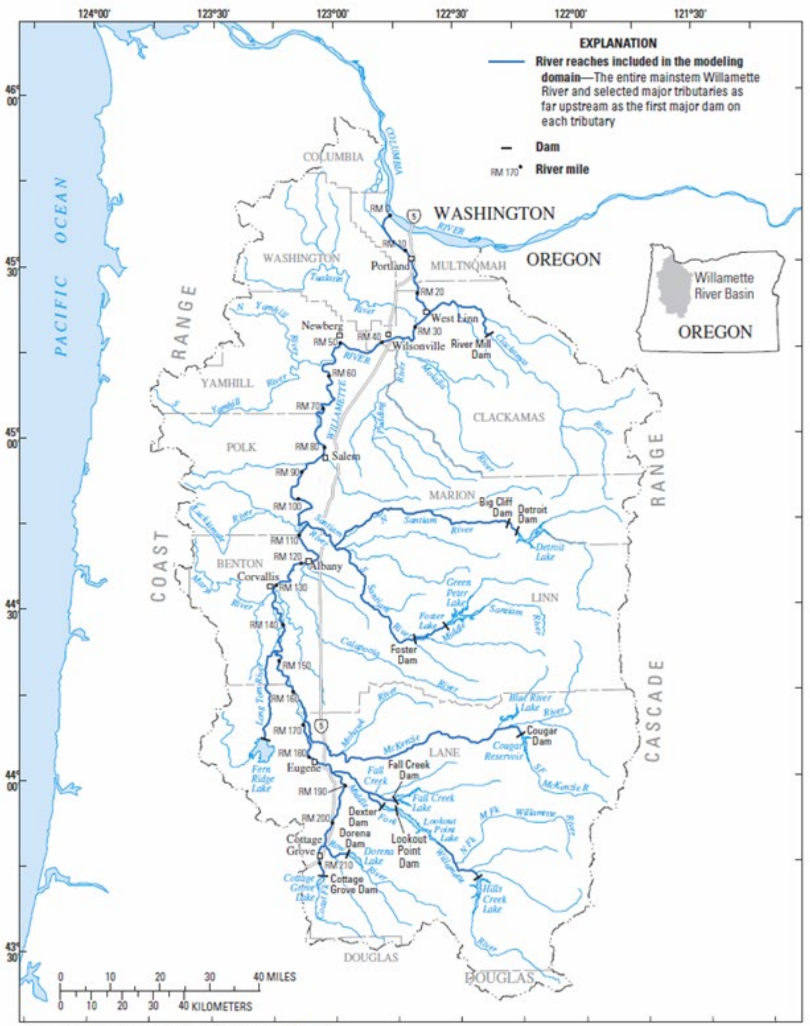
- Identify key knowledge gaps and analyses

Phase 2

- Integration of USGS hydrology (James and Rose) and temperature (Laurel and Stewart) models
- Tributary response
- Additional objectives

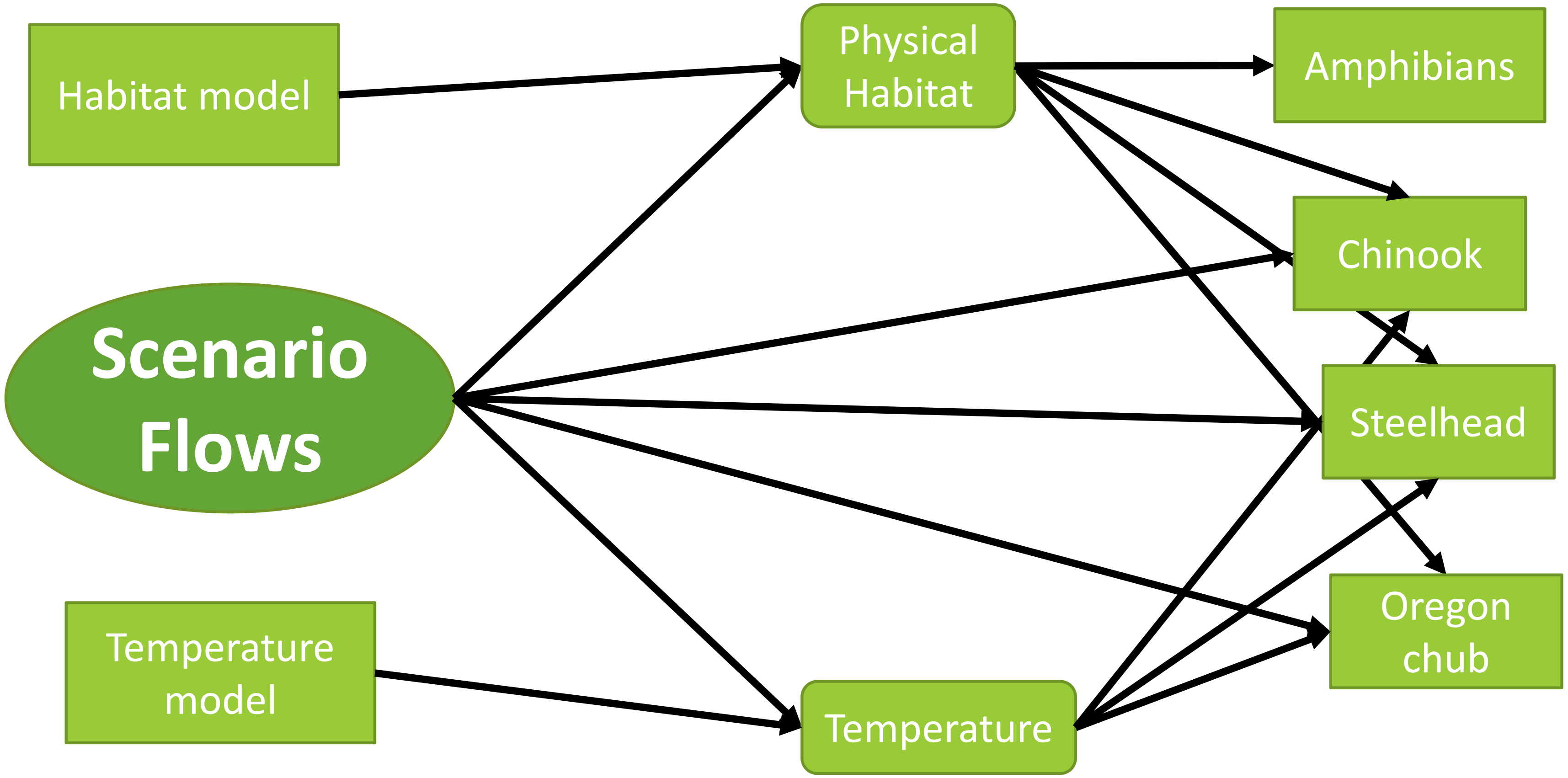
Decision Context

- **Location**: Willamette River system above Willamette Falls
- **Time Period:** Year round
- **Purpose:** Identify instream flow needs for river ecosystem and dependent fish, wildlife and vegetation
- **Willamette and tributaries:** N. & S. Santiam, McKenzie, MF Willamette



Base map modified from U.S. Geological Survey and other digital data sets (1:2,000,000; 1:100,000). Projection: Oregon Lambert Conformal Conic. NAD1983, NGVD1988.

Decision Model Framework

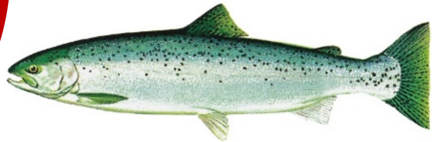


Objectives

Amphibians

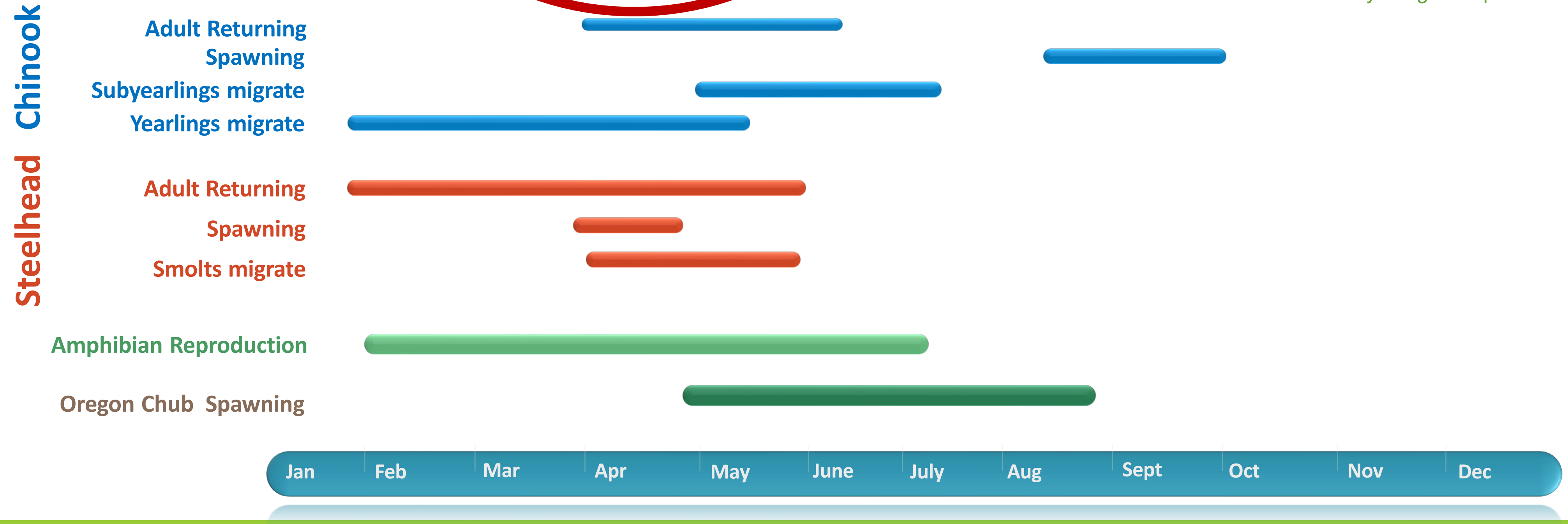
Chinook

Steelhead



Oregon chub

By Oregon Department of Fish & Wildlife



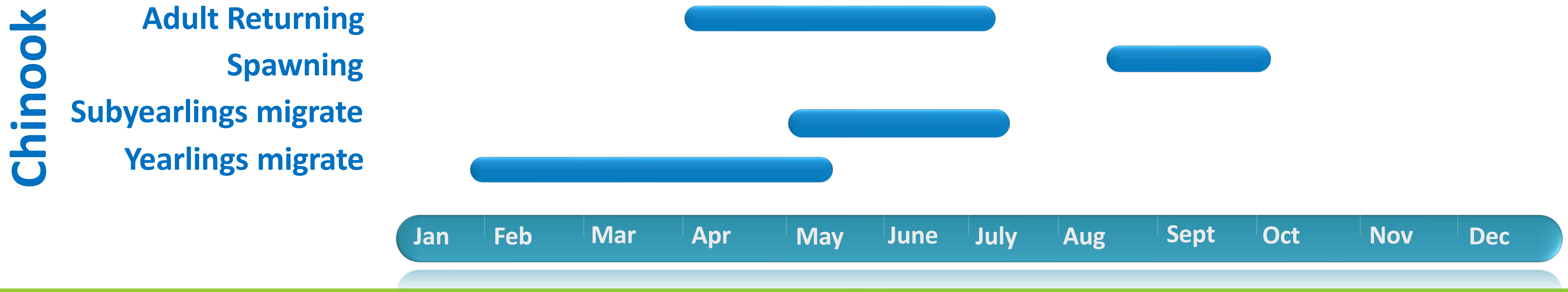
Chinook Streamflow Model

Chinook

- Weekly time step
- Simulated 6 size classes of juveniles:

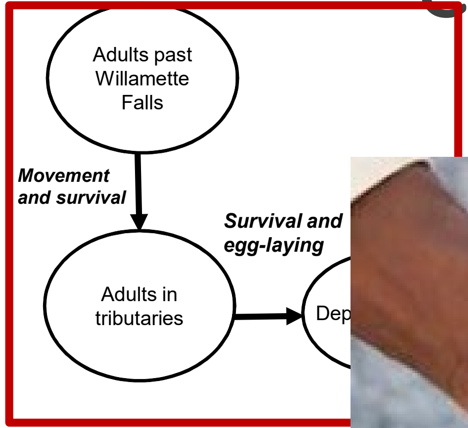
  <60 mm, 60-75 mm, 75-90mm,

  90-105,105-120, >120
- Begins March 1 with adults returning
- User specified initial Adult return

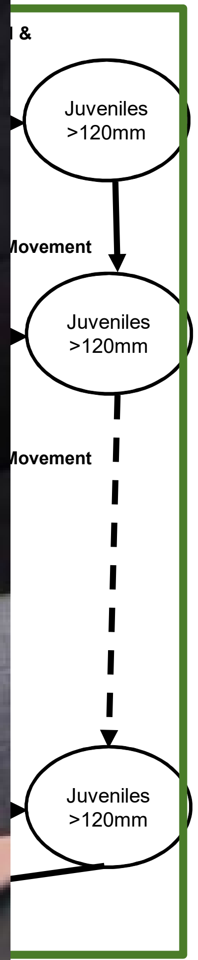


Chinook Salmon Conceptual Model

Arrows represent state transitions

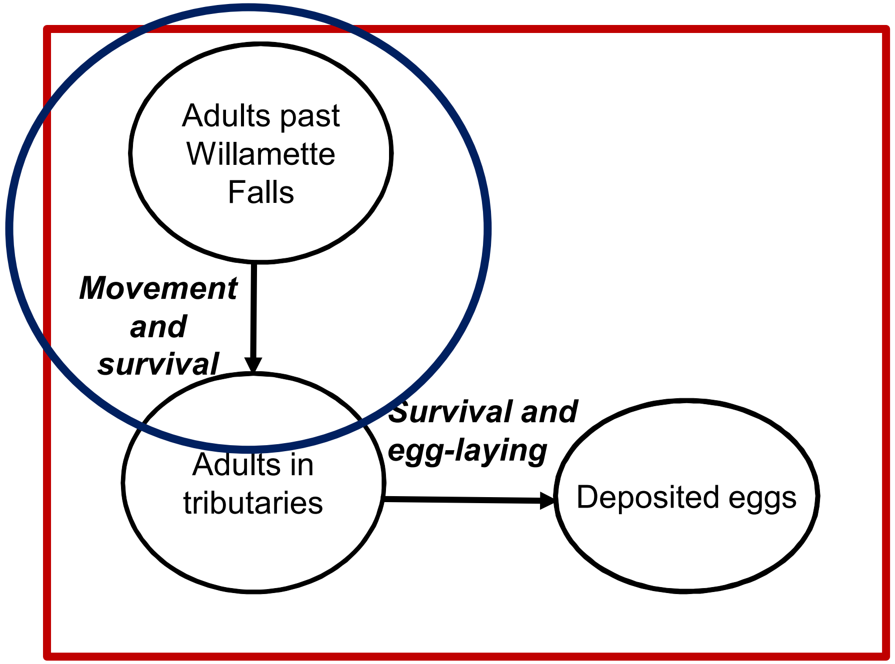


Downstream rea



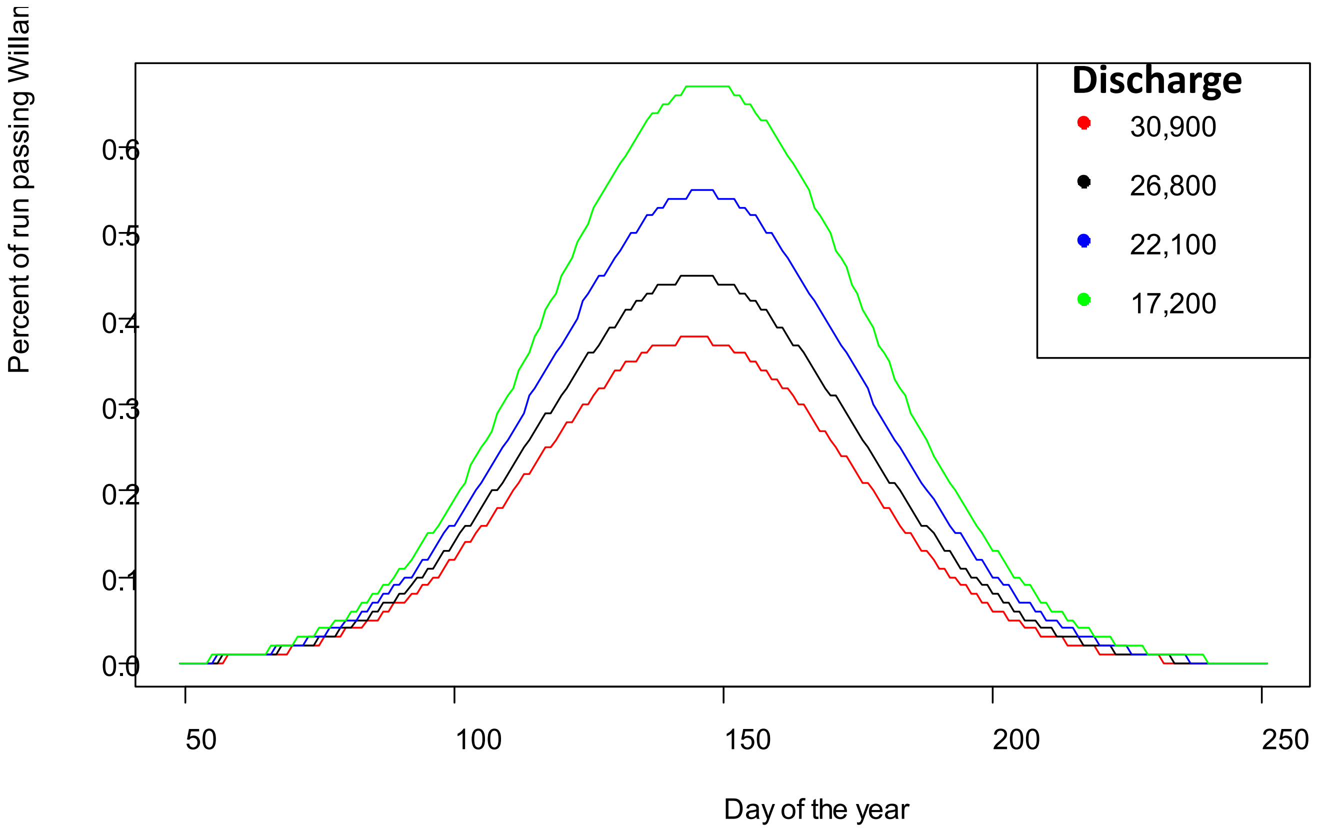
Willamette Fa

Adult Passing Willamette Falls



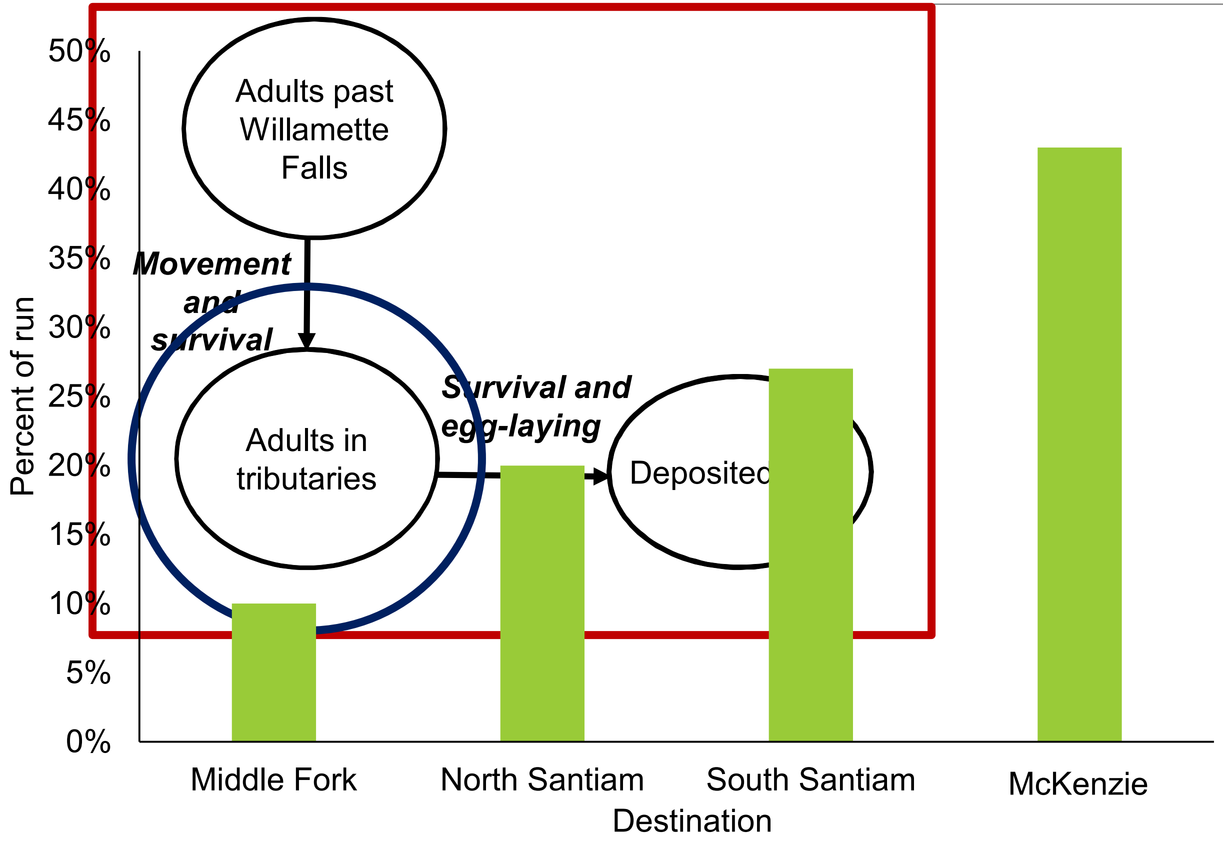
- # of returning adults
- Proportion of adults in individual tributaries
- Adult movement rate
- Degree day accumulation
- Adult survival
- Redd capacity

Adult Passing Willamette Falls



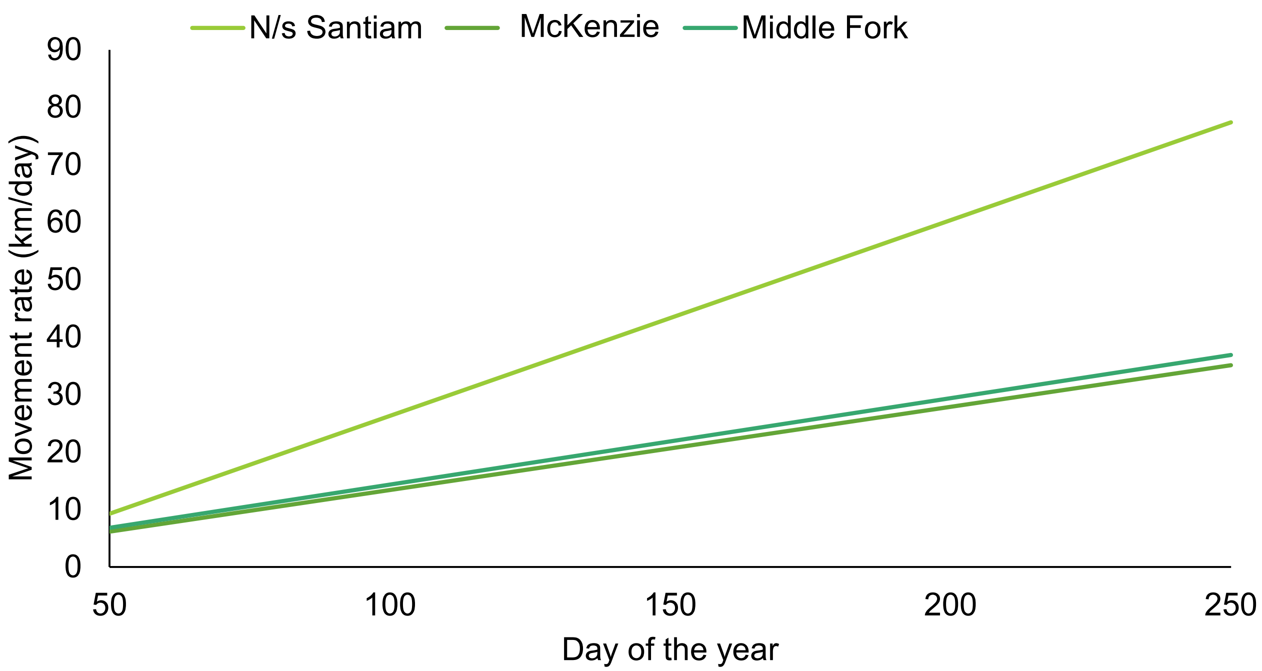
- Model fit to Willamette Falls counts from 2010 to 2016
- Day of year (DOY)
- Salem average daily discharge

Adult Passing Willamette Falls



- Adult fish destination, random assignment multinomial distribution
- Proportions are averages from University of Idaho telemetry studies

Adult Movement

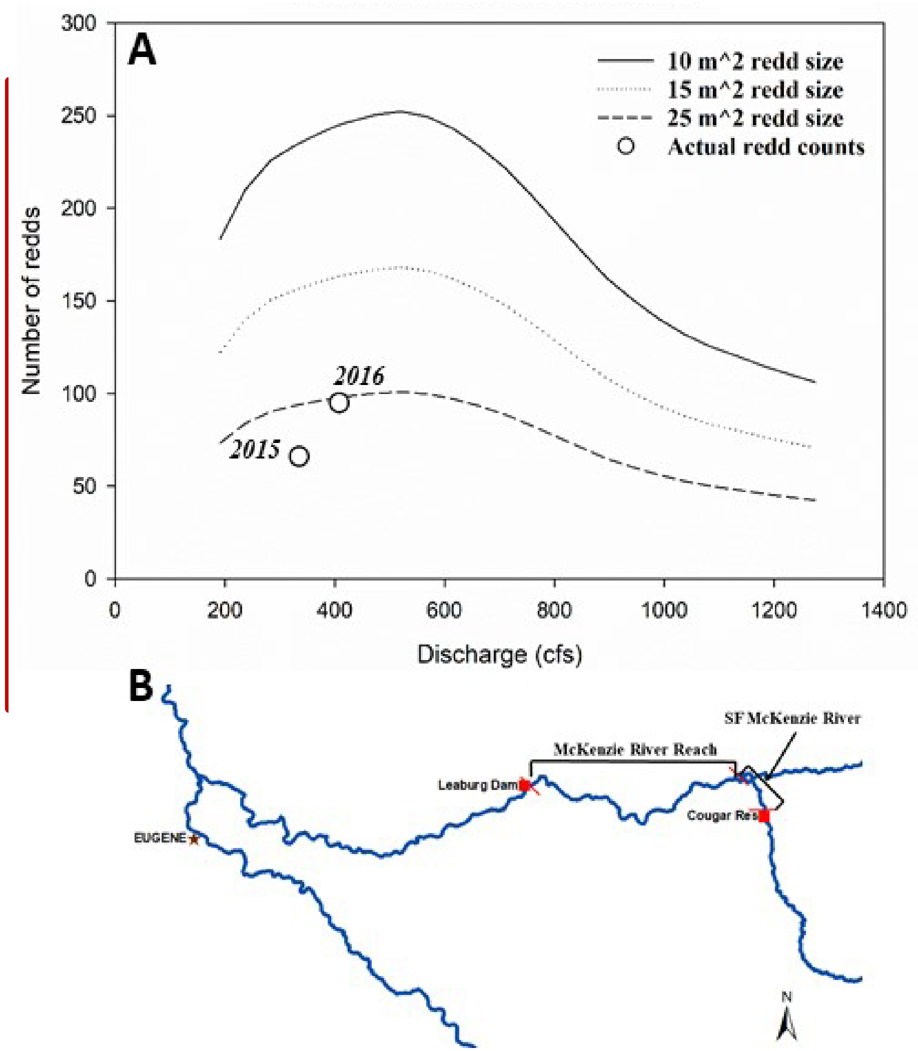


- Movement rate, random assignment normal distribution
- Models from meta analysis of University of Idaho telemetry studies
- Rate~*f*(day of year, average daily temperature)
- Temperature USGS (Laurel and Stewart)

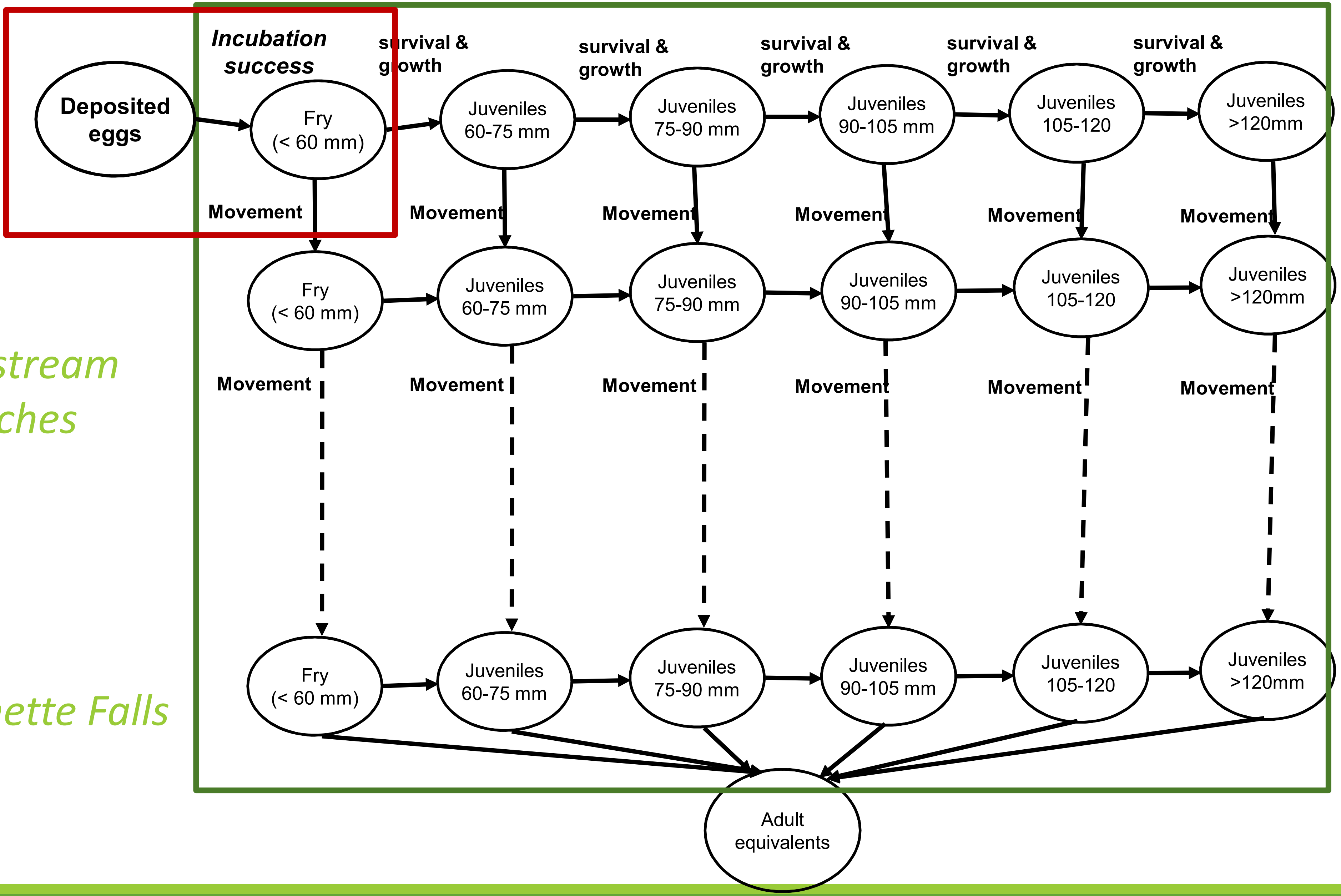
Adult en-route and holding survival

- Adults move through stream network
- Accrue temperatures each segment, *f*(time in segment, ave. temperature segment)
- Random proportion trapped and transported (out of model) based on U of I telemetry studies
- Remaining adults stay below projects accrue degree days
- Adult survival ~ *f*(degree days) from PSM studies
- Temperature from USGS (Laurel and Stewart)

Adult Chinook Spawning



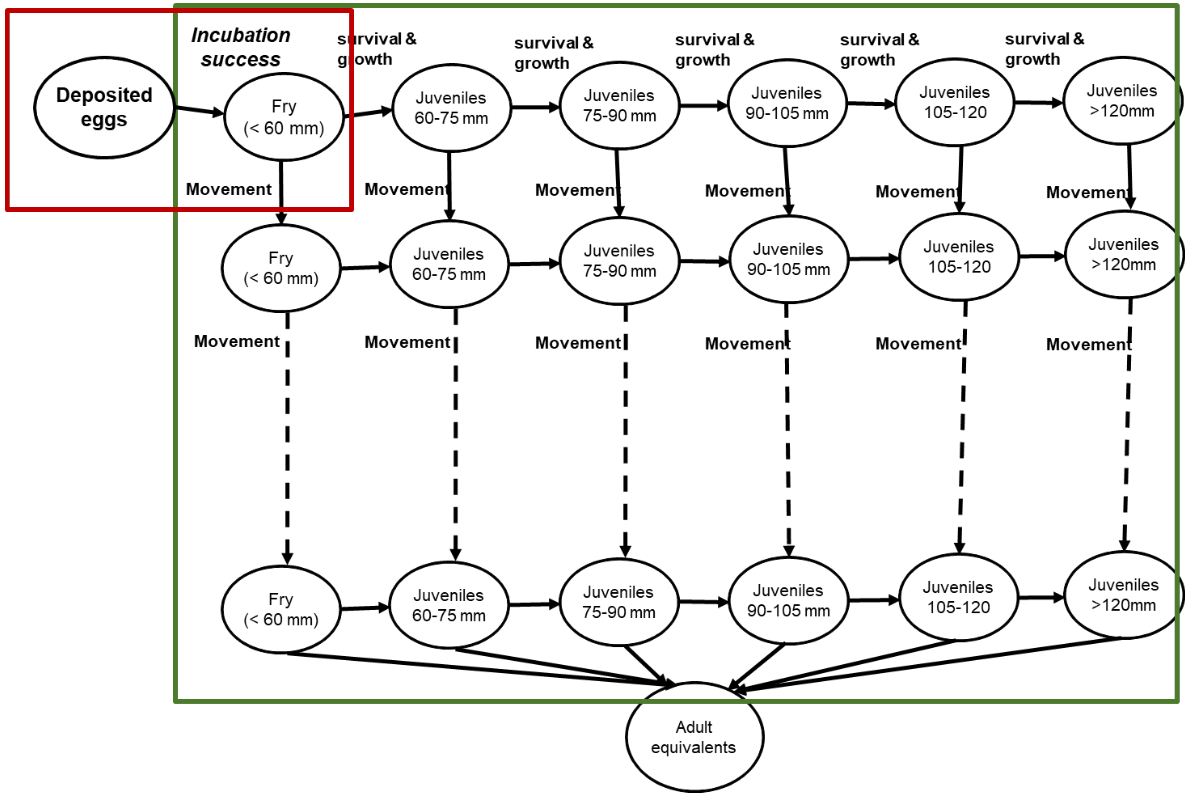
- Sharpe et al. 2017 – Redd counts 2015 - 2016
- Spawning September weeks 2,3,4 (triangle distribution)
- Redd capacity ~*f*(streamflows)
- 50/50 sex ratio, 15 m^2 redd size
- Number redds = min(capacity, no. females)



Downstream reaches

Willamette Falls

Juveniles Passing Willamette Falls

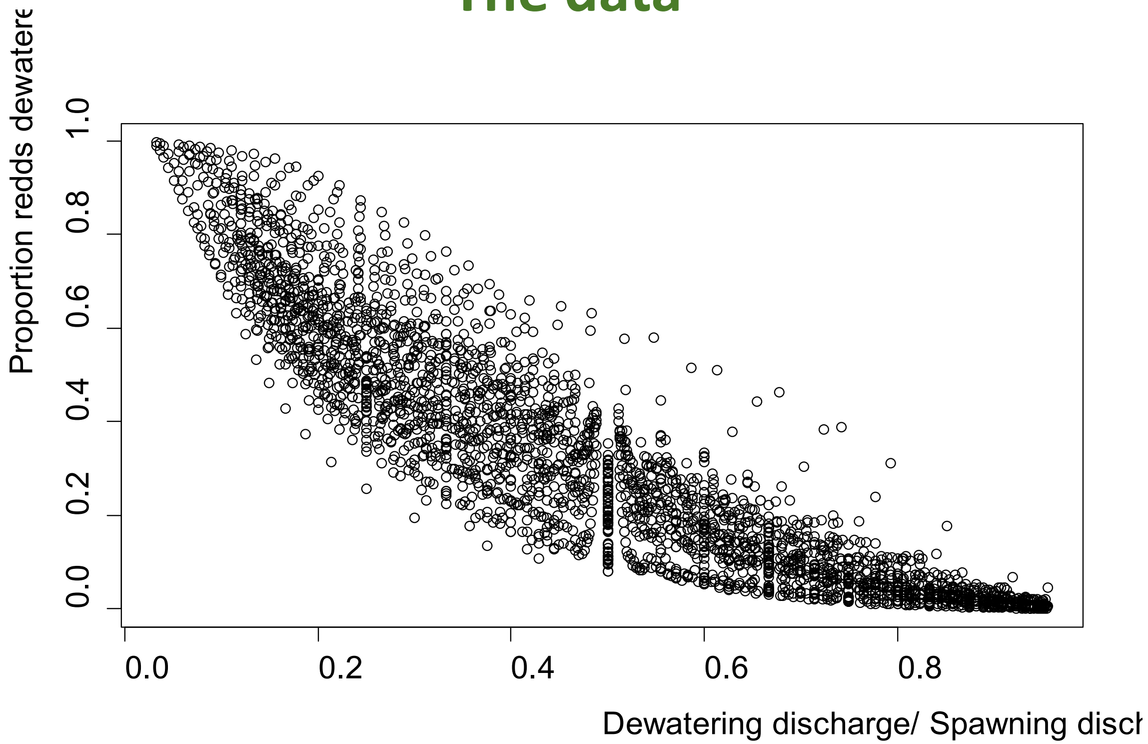


- Redd dewatering
- Egg development and life history
- Growth
- Rearing habitat capacity
- Juvenile survival
- Juvenile movement

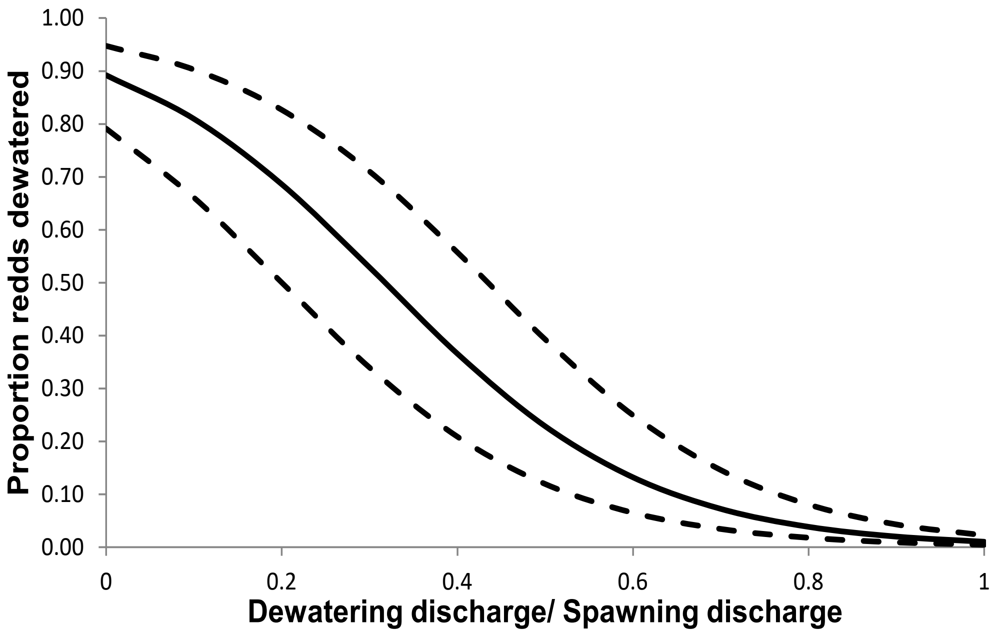
Redd Dewatering

- Meta-analysis of published FWS dewatering studies
- Ratio of dewatered Q/ spawning Q

The data

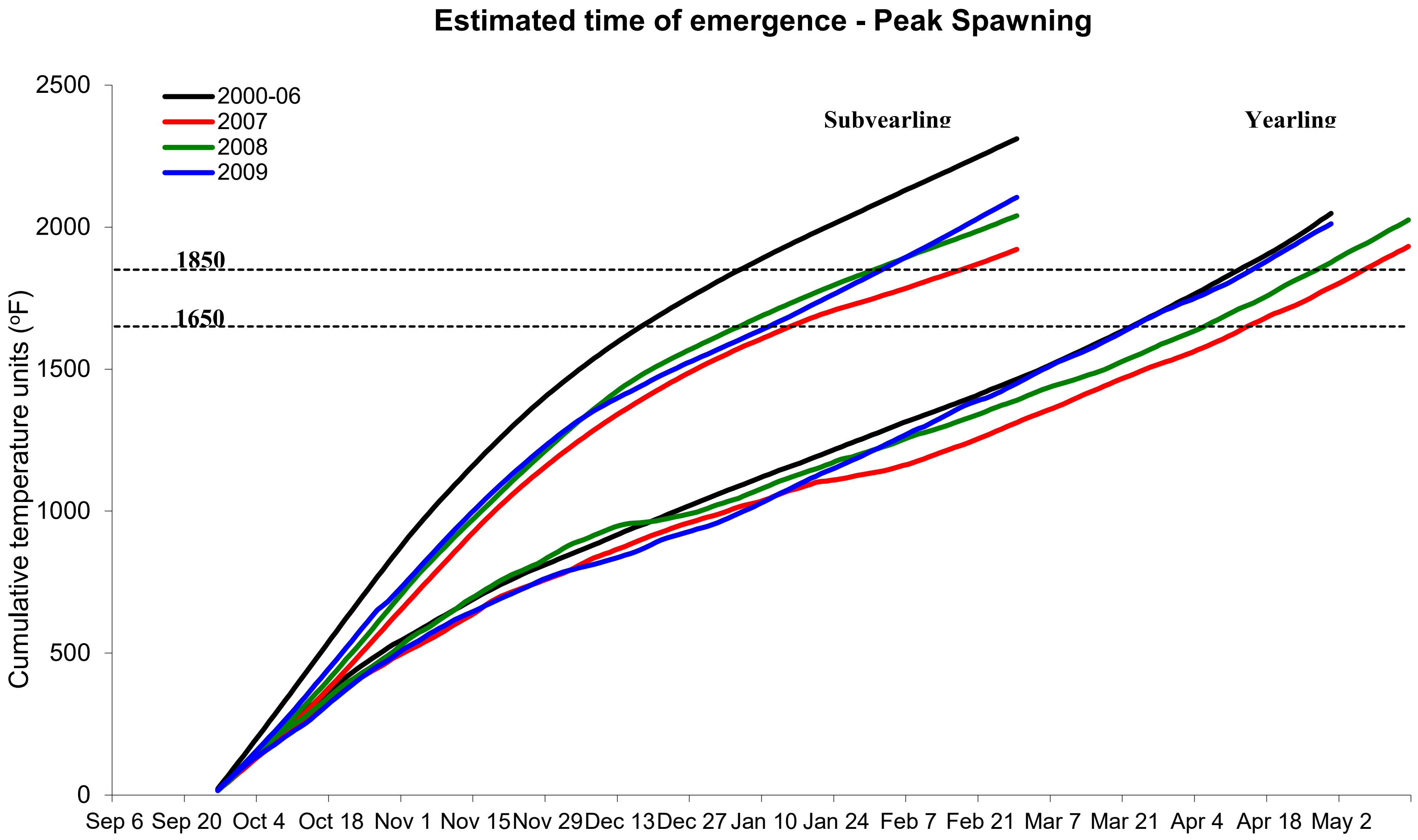


The model



Egg development and life history

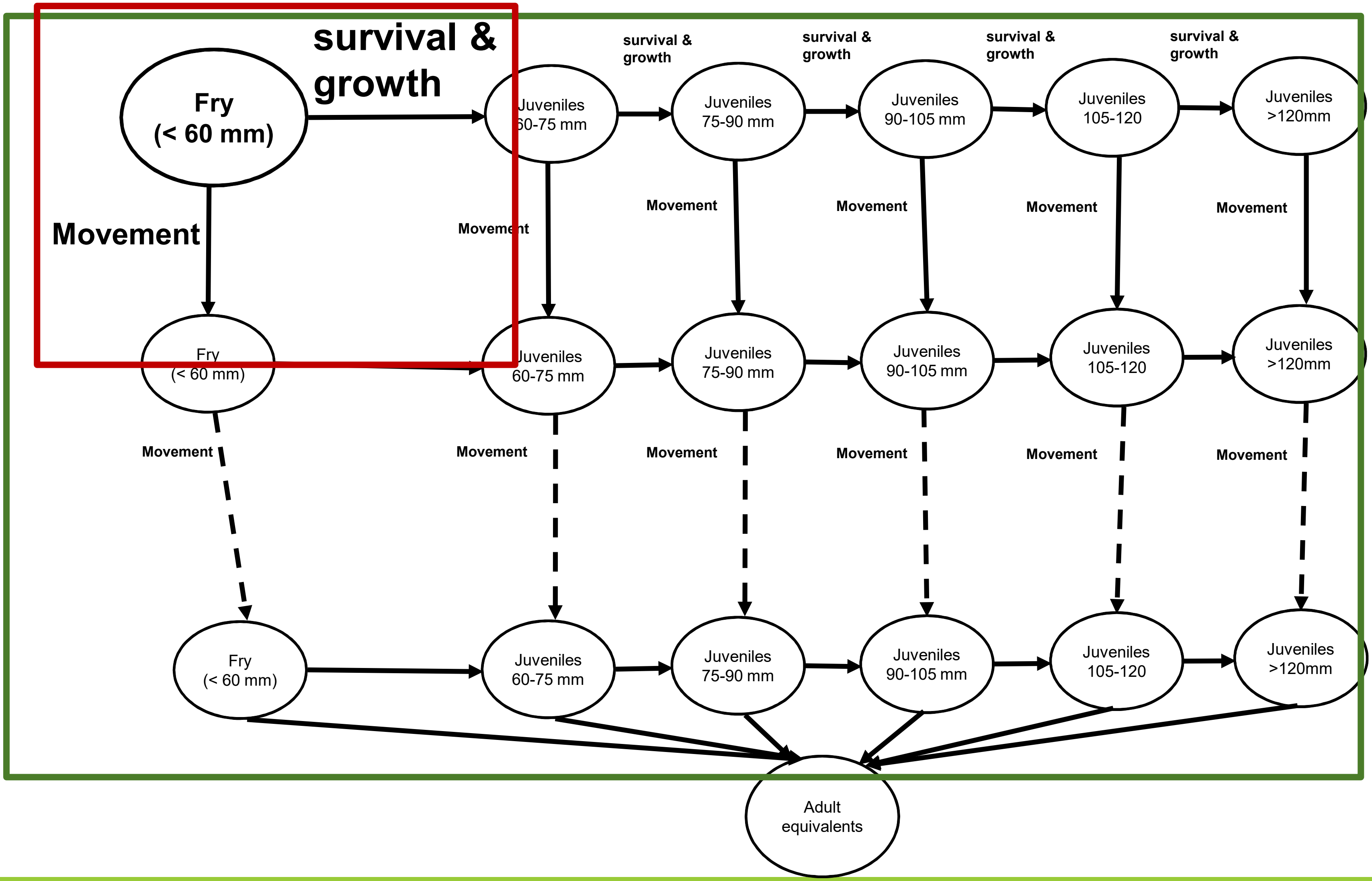
- Example Plot of North Santiam Observed temperature



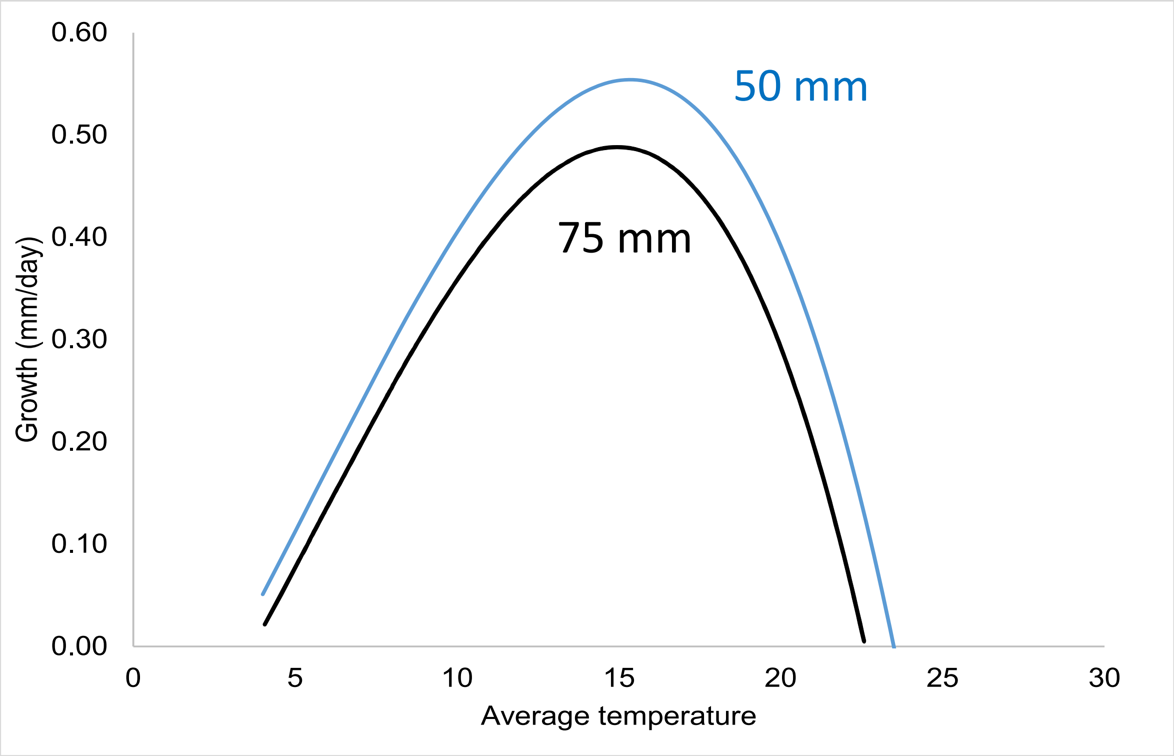
Juvenile Chinook Growth

Downstream reaches

Willamette Falls



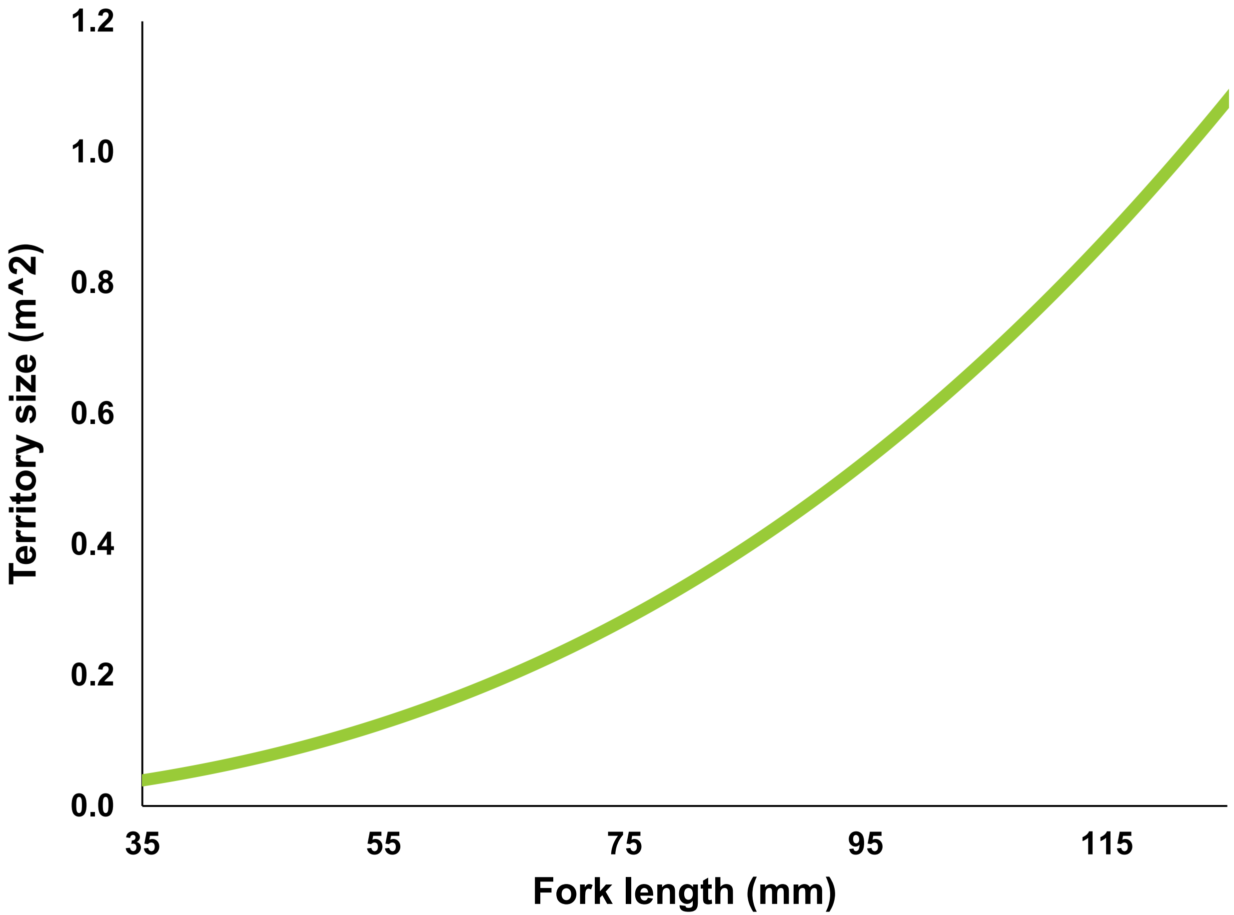
Juvenile Chinook Growth



- Bioenergetic Chinook growth model (Sullivan et al. 2000)
- Parameters fit using Willamette tagged juveniles 1999- 2017
- Assumed ration at 2/3 max.

Juvenile Habitat Capacity

- Habitat estimates, USGS (James and Rose)
- Juvenile territory size, Grant and Kramer (1990)
- Habitat filled largest fish to smallest fish
- Insufficient habitat: move downstream



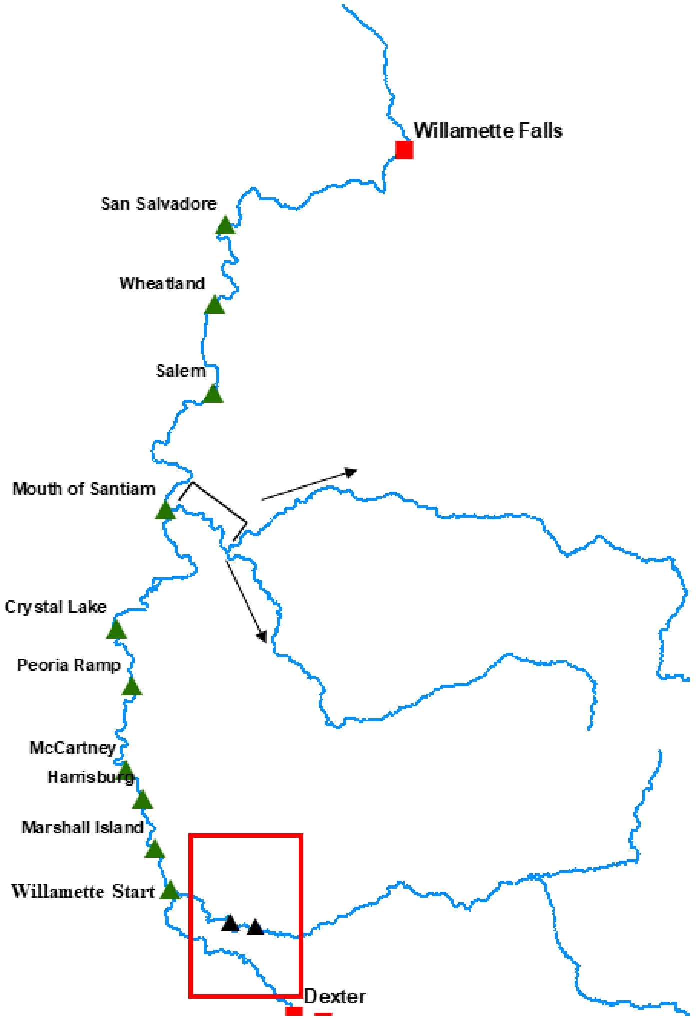
Juvenile Chinook Survival and Movement

- ODFW 244,460 tagged individuals 1999-2017
- Barker, multi-strata, recapture, resight, recovery model
  - Recapture= recaptured via seining
  - Resight= pit tag detections, capture by non-ODFW crews
  - Recovery = recovered mortalities/ tags
- Time intervals- 2 weeks until end of first year, then annual
- Estimable parameters: recapture, recovery, resight probabilities, movement, survival
- Covariates

Juvenile Chinook Survival and Movement

- Survival and movement between sections and to estuary + smolt to adult survival (but S2A will be data limited)

- <u>Candidate variables</u>: **temperature (Laurel and Stewart),** average body size, discharge, relative predator (SMB) abundance (slices), **estimated available habitat (James and Rose)**, body size



Chinook Salmon Conceptual Model

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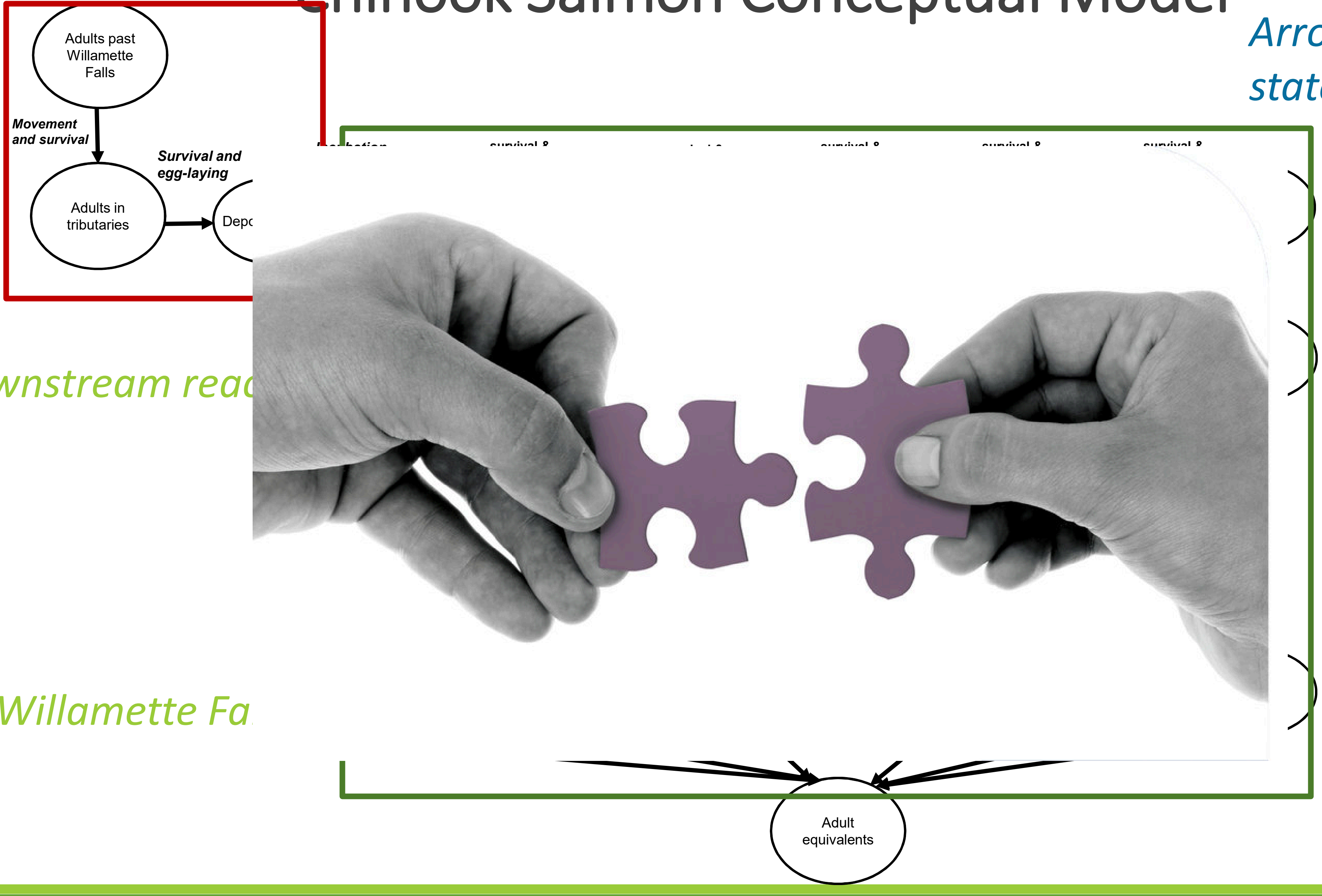
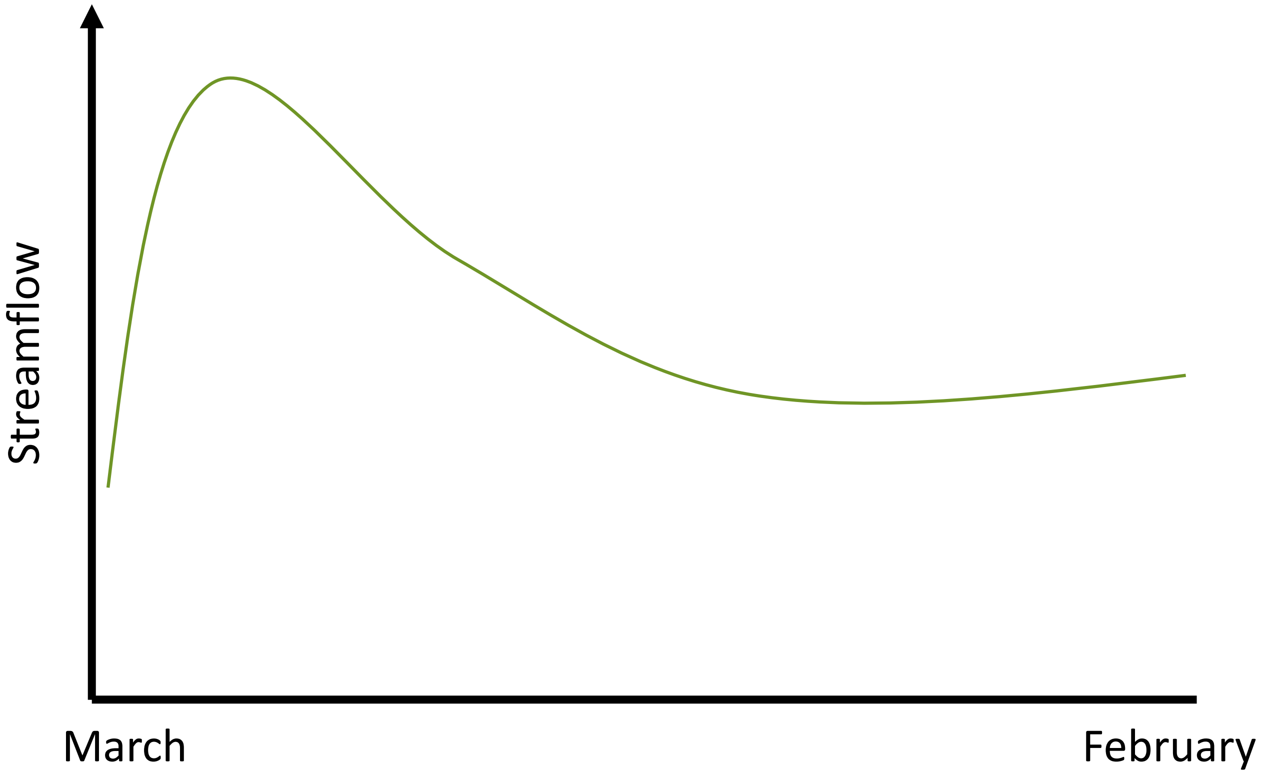


Downstream reac

Willamette Fa

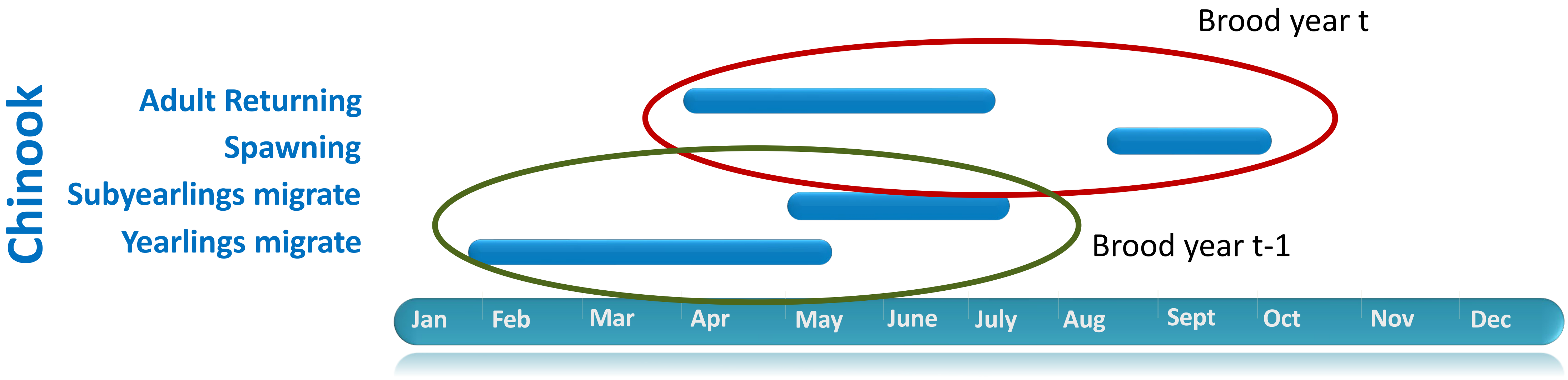
Finding the best flow regimes



- Constrain available water
- Find optimal allocation over time

A Disconnect

Chinook



Solution: 2 Sub-models

System states

Number adults
H_20 storage available

Outcomes

Swim-up
#Redds

But, how do we evaluate tradeoffs?

Outcomes

Number juveniles leaving

Eme

nt

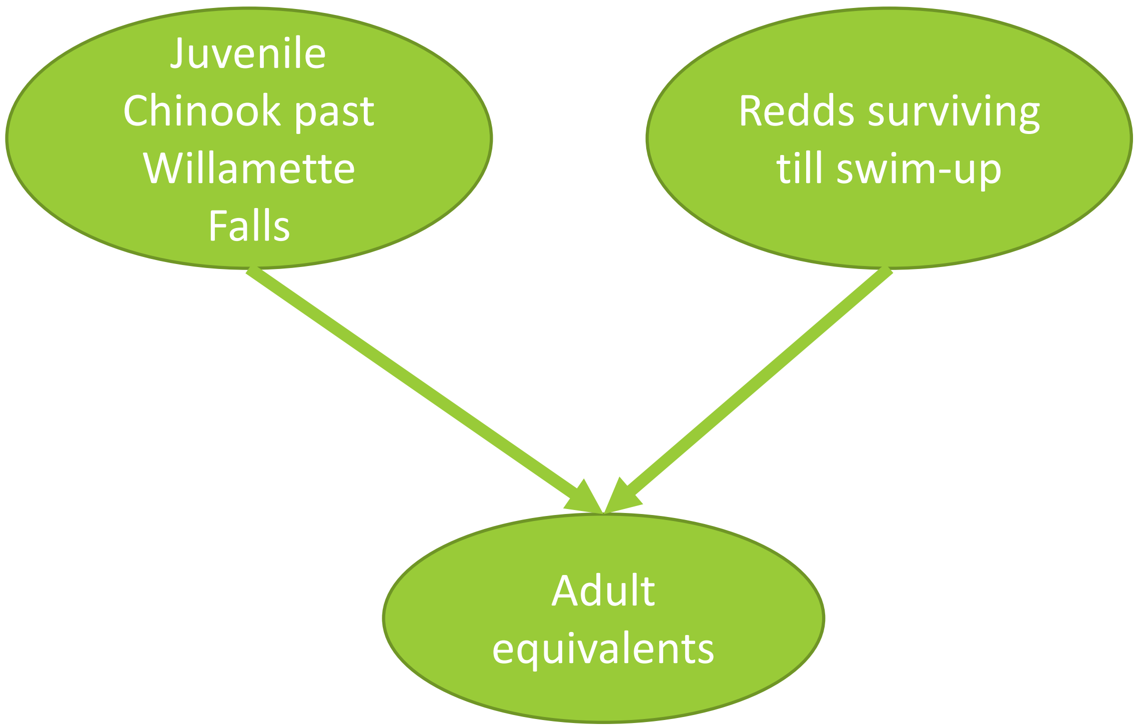
System states

#Redds t-1
Degree days
Subyearlings t-1

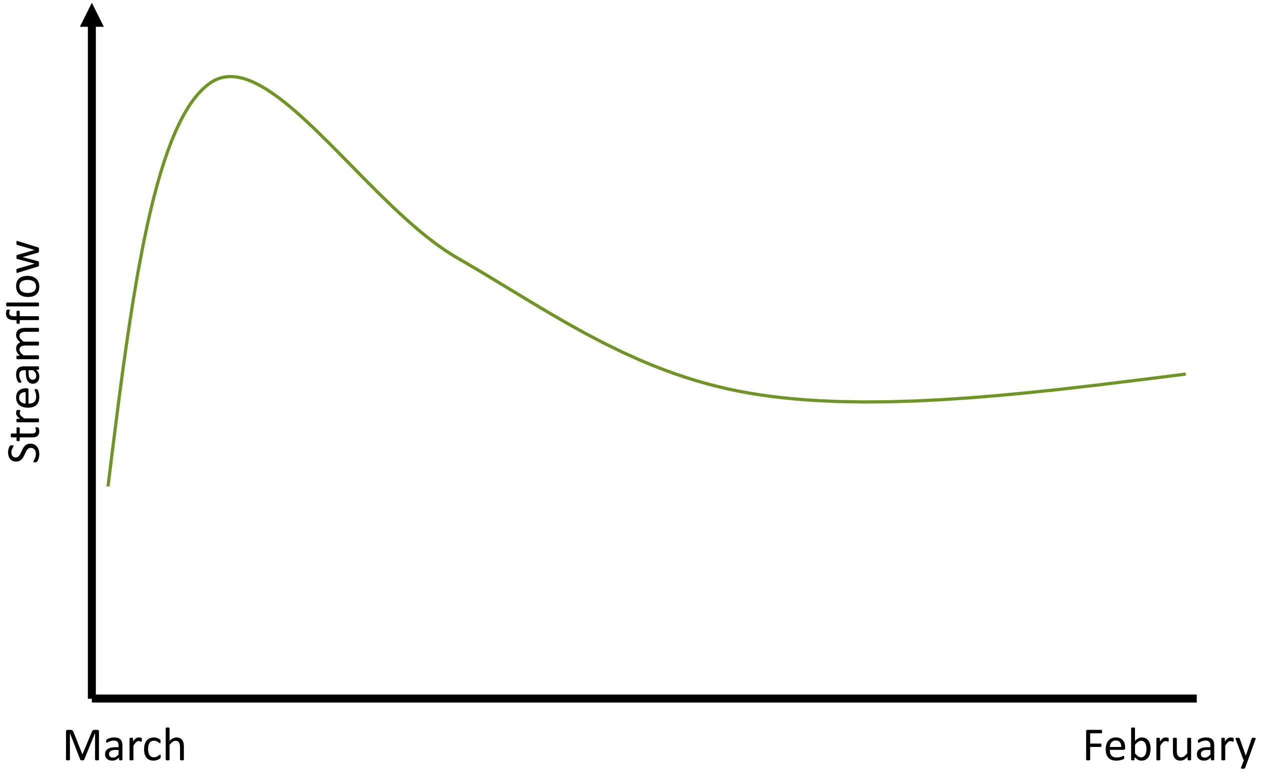
Common currency

- WF to Adult return survival tagged fish
- Expected number adult returns per juvenile
- Use simulation model to estimate expected redd to adult returns
- How much will this affect the evaluation?

Sensitivity analysis



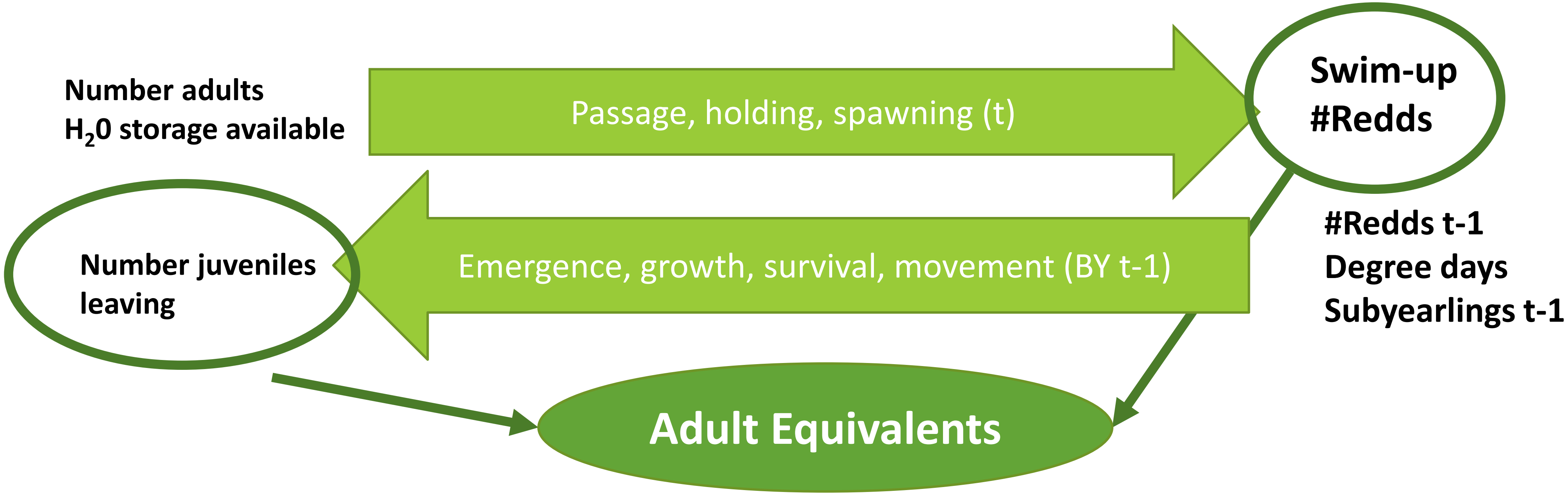
Finding the best flow regimes



- Constrain available water
- Find optimal allocation over time
- Maximize adult equivalents
- Dynamic linear programming
- Heuristic (particle swarm)

Making Models Accessible: Shiny App

- Visualize the objective tradeoffs (Chinook Example)



Shiny App

SWIFT Model Explorer | About | Run Size Estimate | Spawning | Redd Capacity | Rearing | Adult Movement | Chinook Routing | Summary

Chinook Routing

Salem average daily discharge:

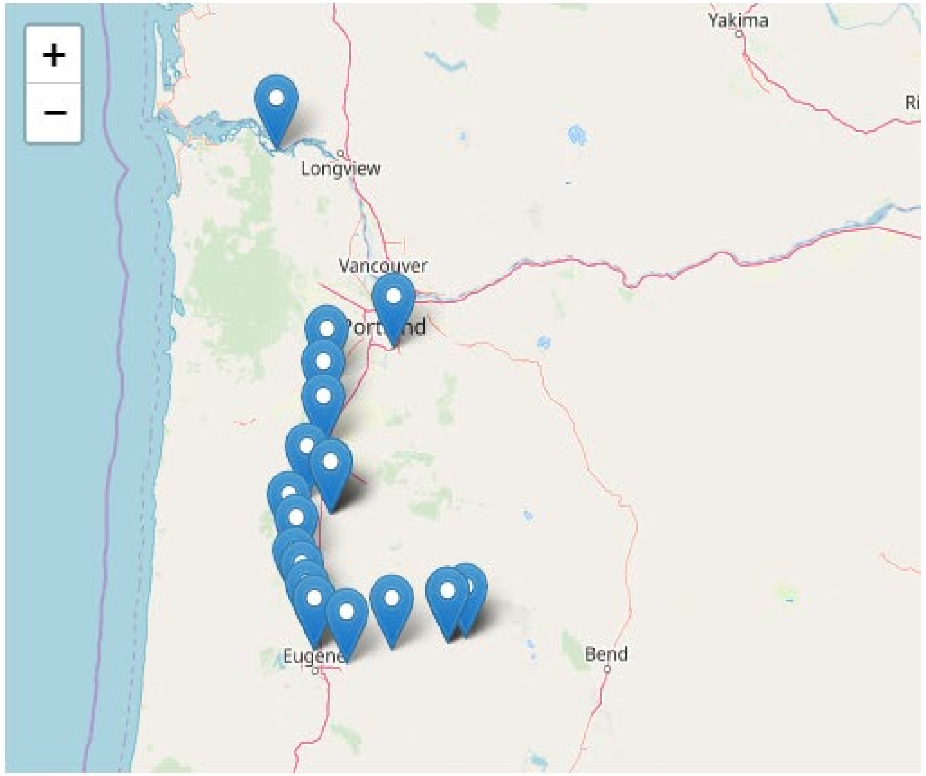
10000

Harrisburg average daily discharge:

10000

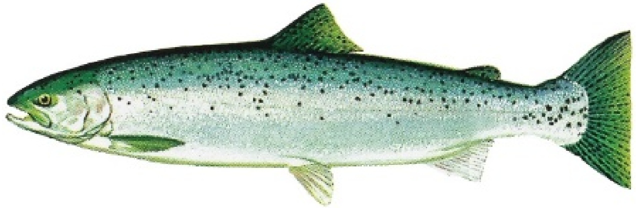
Santiam at Jefferson average daily discharge:

10000



Next Steps

- Identify key uncertainties
- Integrate hydrology and temperature models
- Include tributary responses
- Include additional objectives
- Additional scenarios



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Questions

Solution: 2 Sub-models