Willamette Instream Flow Project: Integrated Tools for the Evaluation of Alternative Flow Management Strategies

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Context: Willamette Water Allocation

Water allocation:

Agricultural irrigation

Municipal

Industrial use

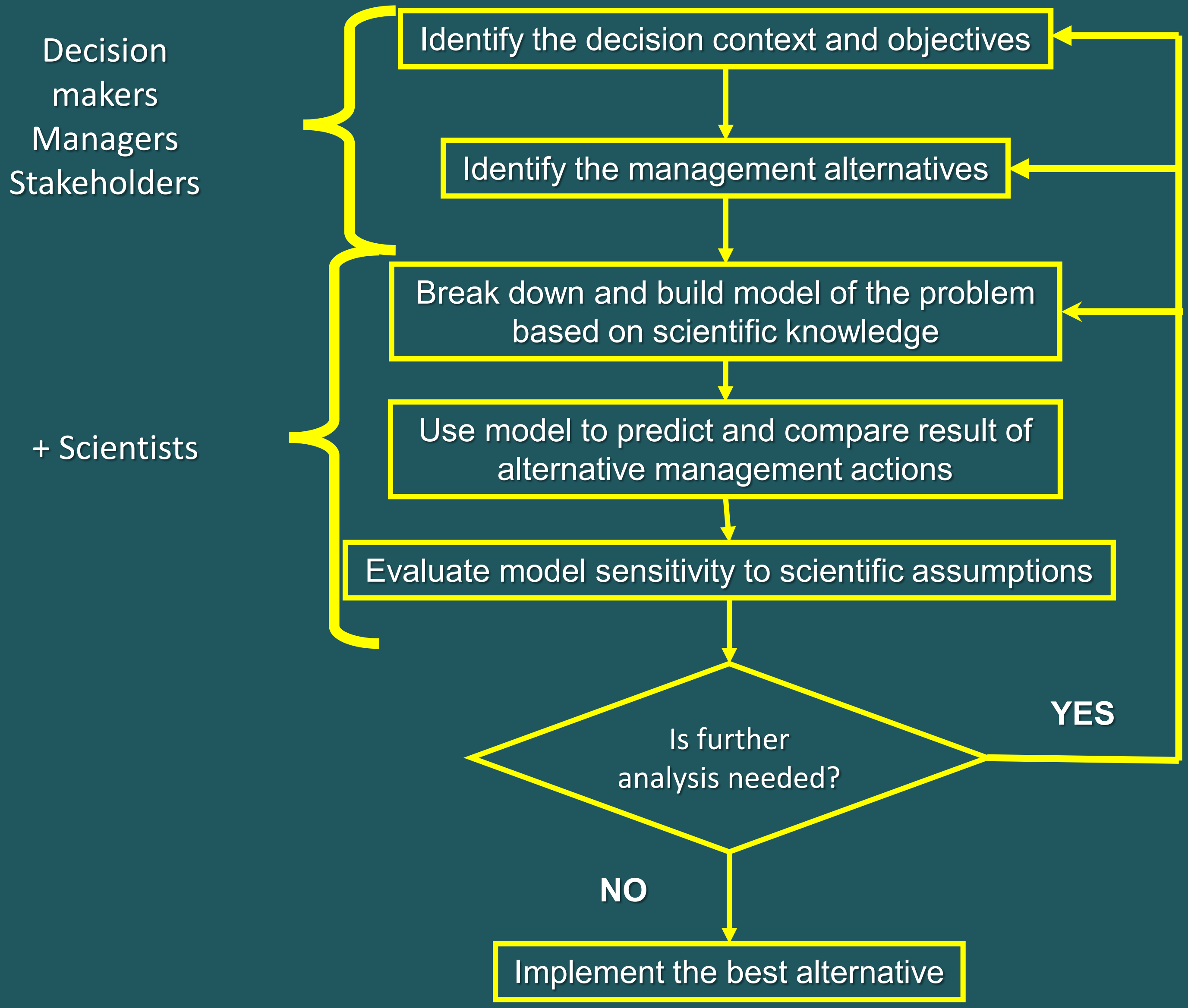
Ecosystem needs

BiOp

- Flow targets
- Temperature targets

Managers: What are the optimal flow regimes?
What are the tradeoffs?

Structured Decision Making Process



Phase I

- Identify key knowledge gaps and analyses

Phase 2

- Integration of hydrology and temperature models
- Tributary response
- Additional objectives

Science of Willamette Instream Flows Team

SWIFT - team of experts to review and develop science for instream flows

Interdisciplinary Team:

Hydrologists

Geomorphologists

Water quality modelers

Ecologists

Managers

Public Stakeholders

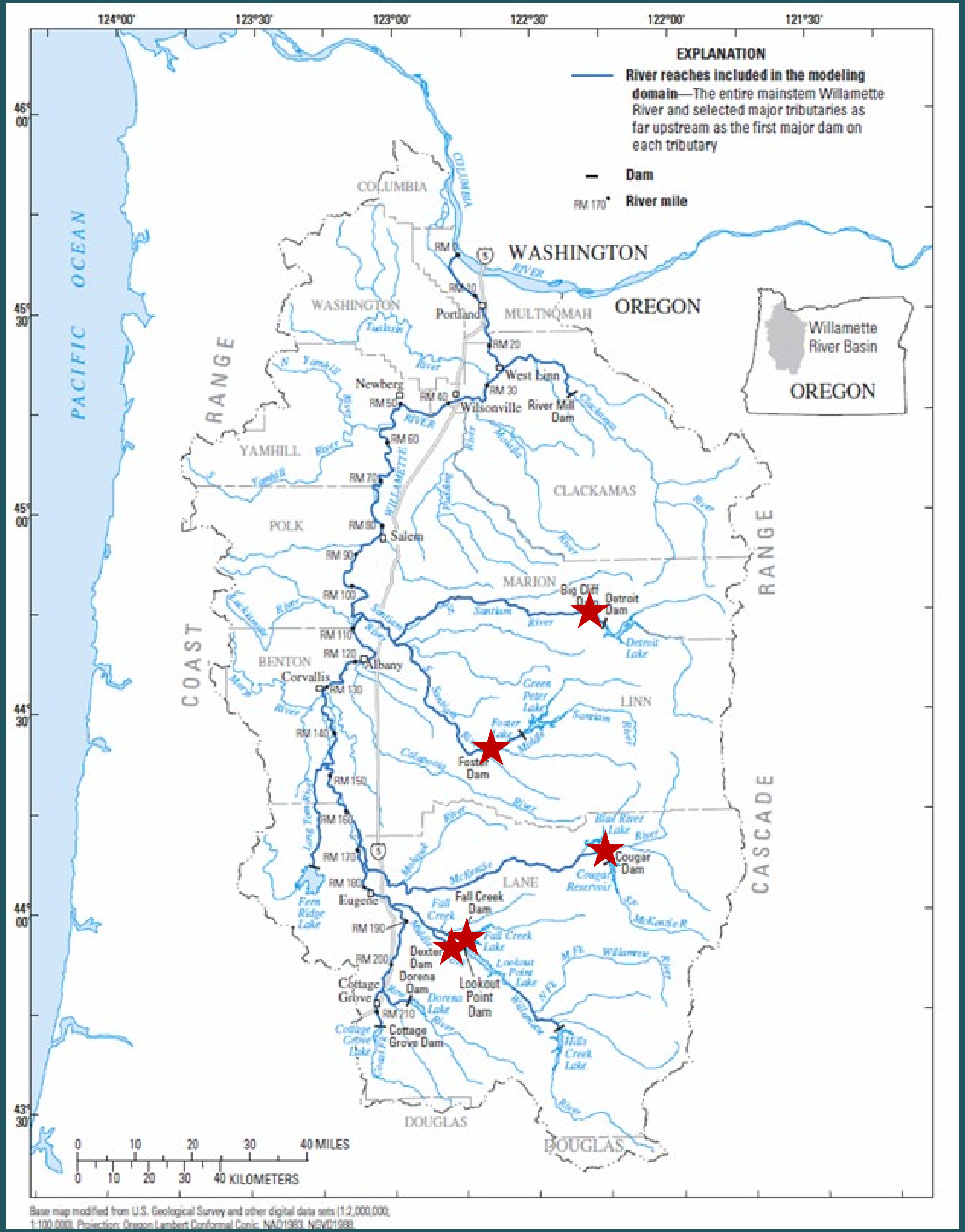
Decision Context

Location: Willamette River system above Willamette Falls

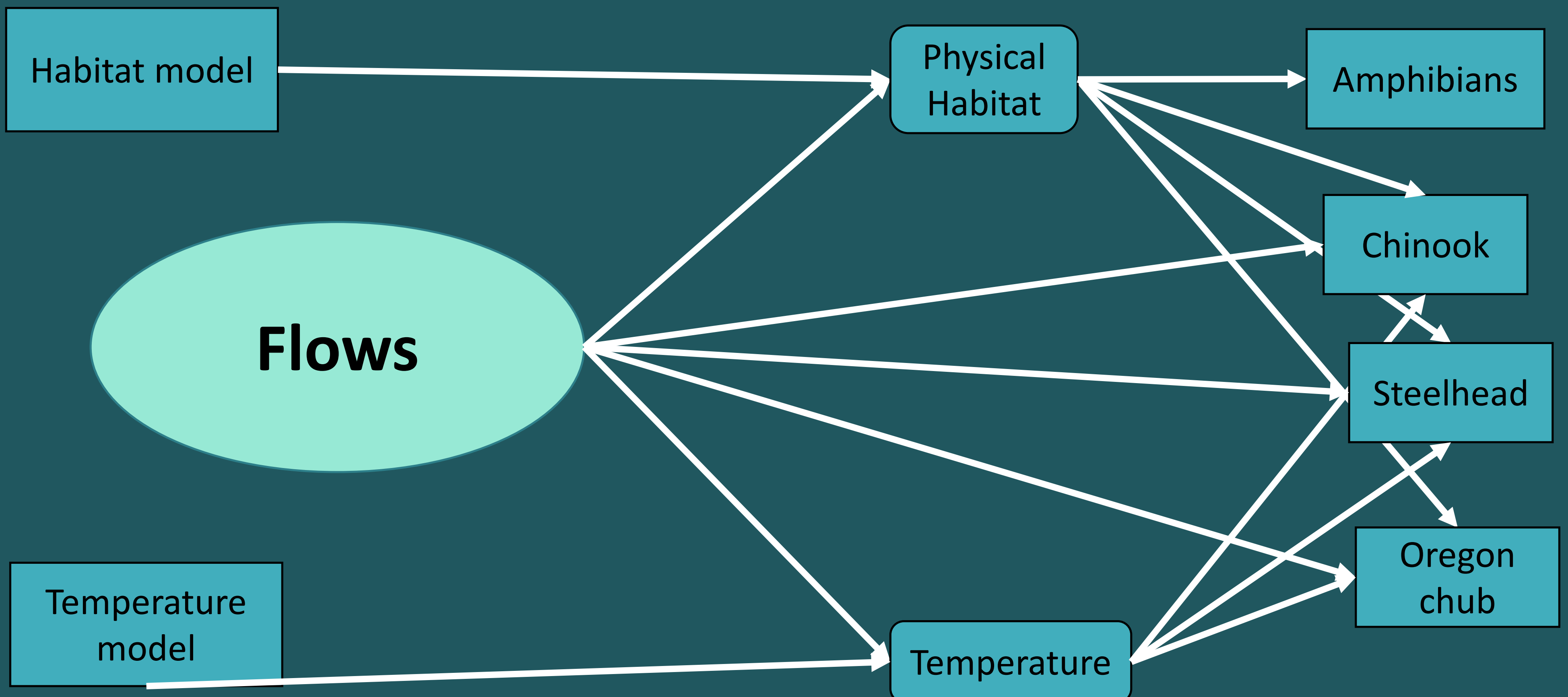
Time Period: Year round

Purpose: Identify instream flow needs for river ecosystem and dependent fish, wildlife and vegetation

Willamette and tributaries: N. & S. Santiam, McKenzie, MF Willamette, below USACE dams



Decision Model Framework

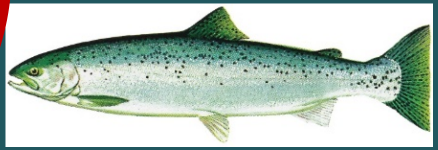


Objectives

Amphibians

Chinook

Steelhead

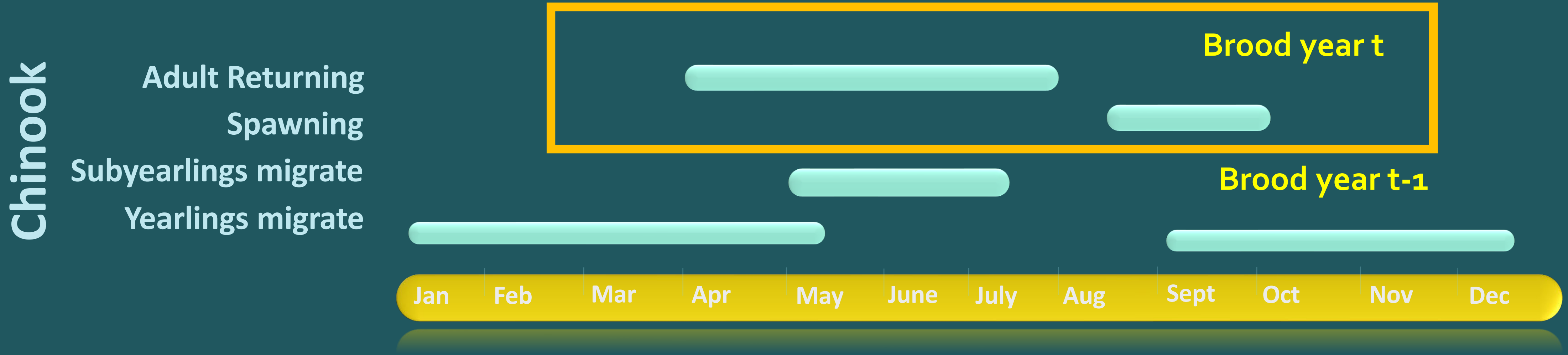


Oregon chub

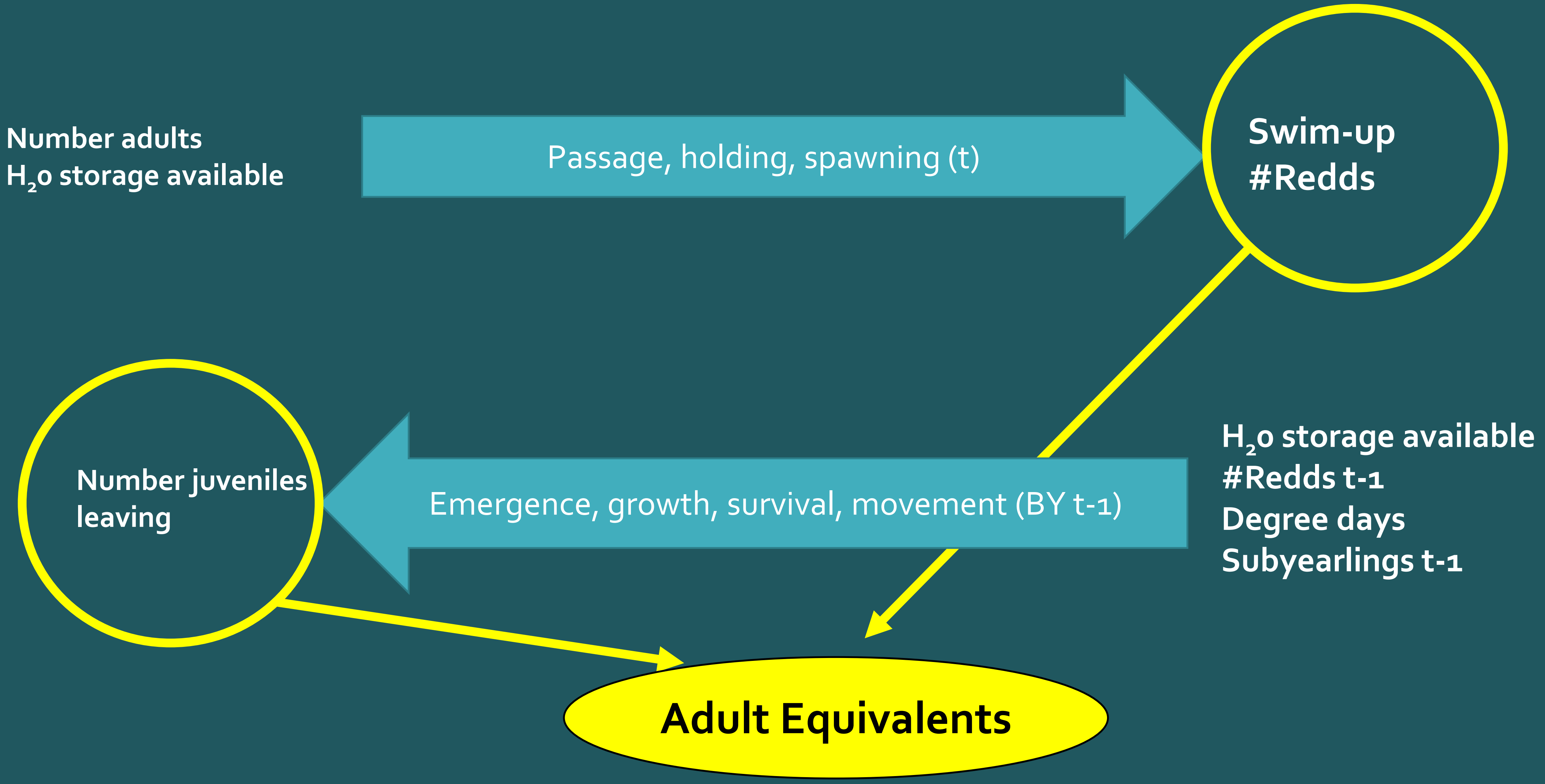
By Oregon Department of Fish & Wildlife

A Disconnect

Chinook



Solution: 2 Sub-models

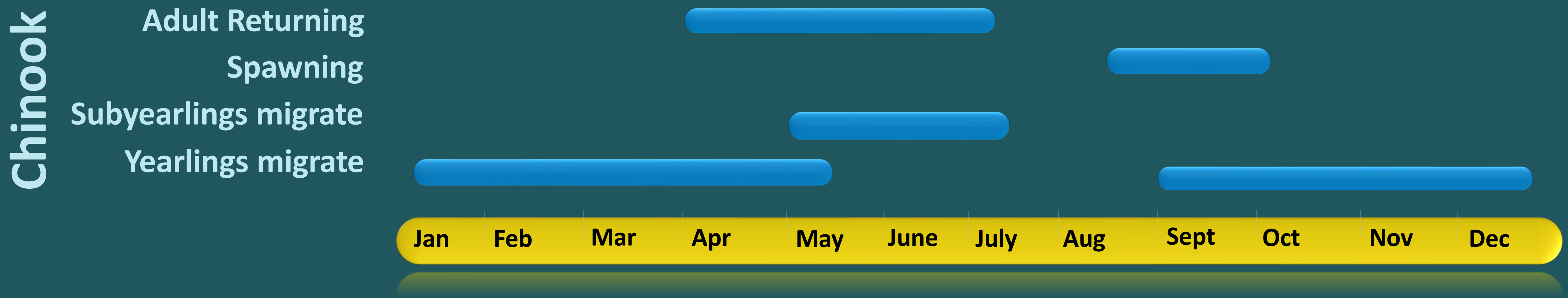


Chinook Streamflow Models

Chinook

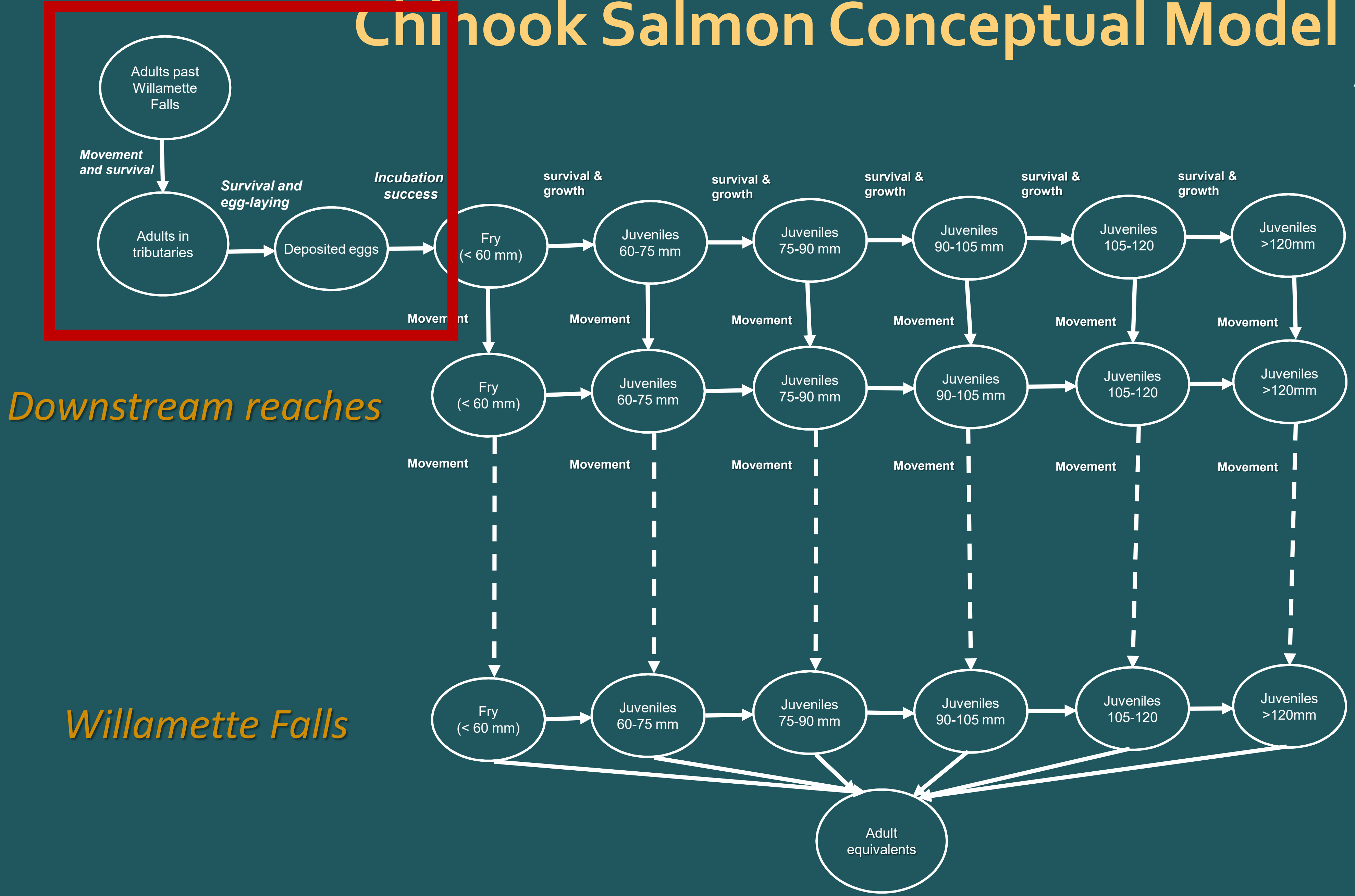
- Weekly time step
- Simulated 6 size classes of juveniles:

  <60 mm, 60-75 mm, 75-90mm, 90-105, 105-120, >120
- Begins March 1 with adults returning
- Adult submodel user specified runsize, % hatchery
- Juvenile submodel user specified redds, subyearlings t-1

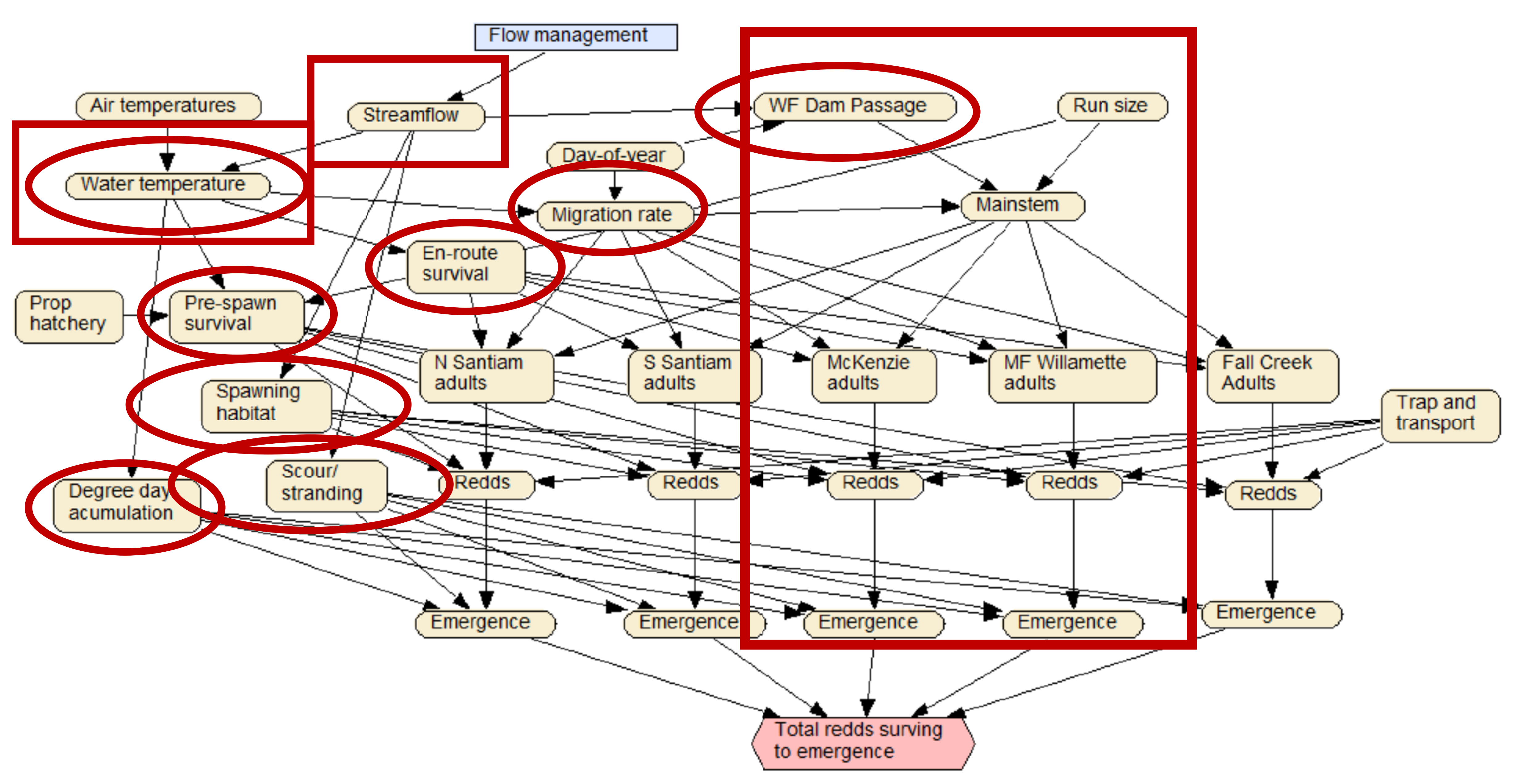


Chinook Salmon Conceptual Model

Arrows represent state transitions



Adult Chinook Salmon Conceptual Model



Adult en-route and prespawn survival

Adults move through stream network

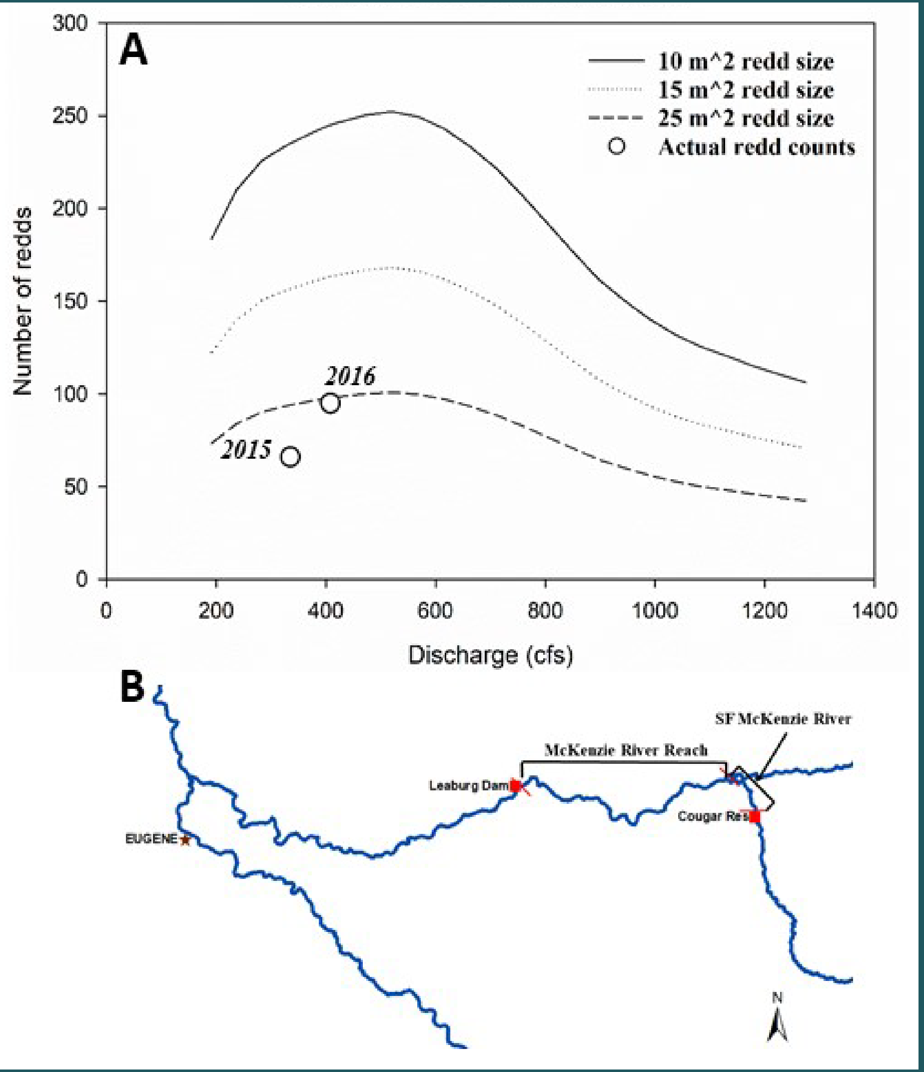
Accrue temperatures each segment, survival ~ *f*(time in segment, ave. temperature segment)

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

Adult Chinook Spawning



Spawning September weeks 2,3,4 (triangle distribution)

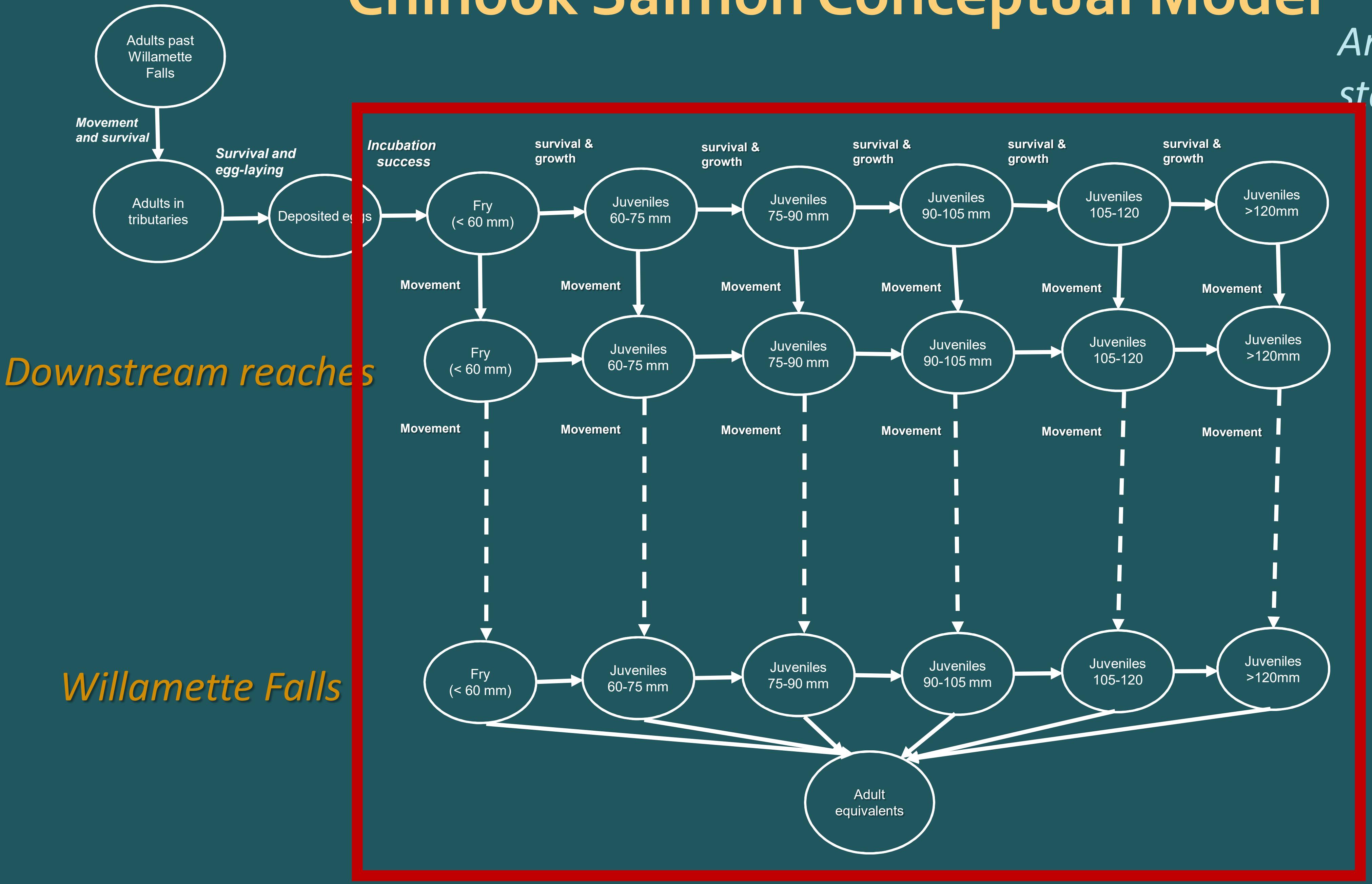
Redd capacity ~ *f*(streamflows)

60/40 sex ratio, 9.5 m^2 redd size

Number redds = min(capacity, no. females)

Chinook Salmon Conceptual Model

Arrows represent state transitions



Juvenile growth, movement, survival

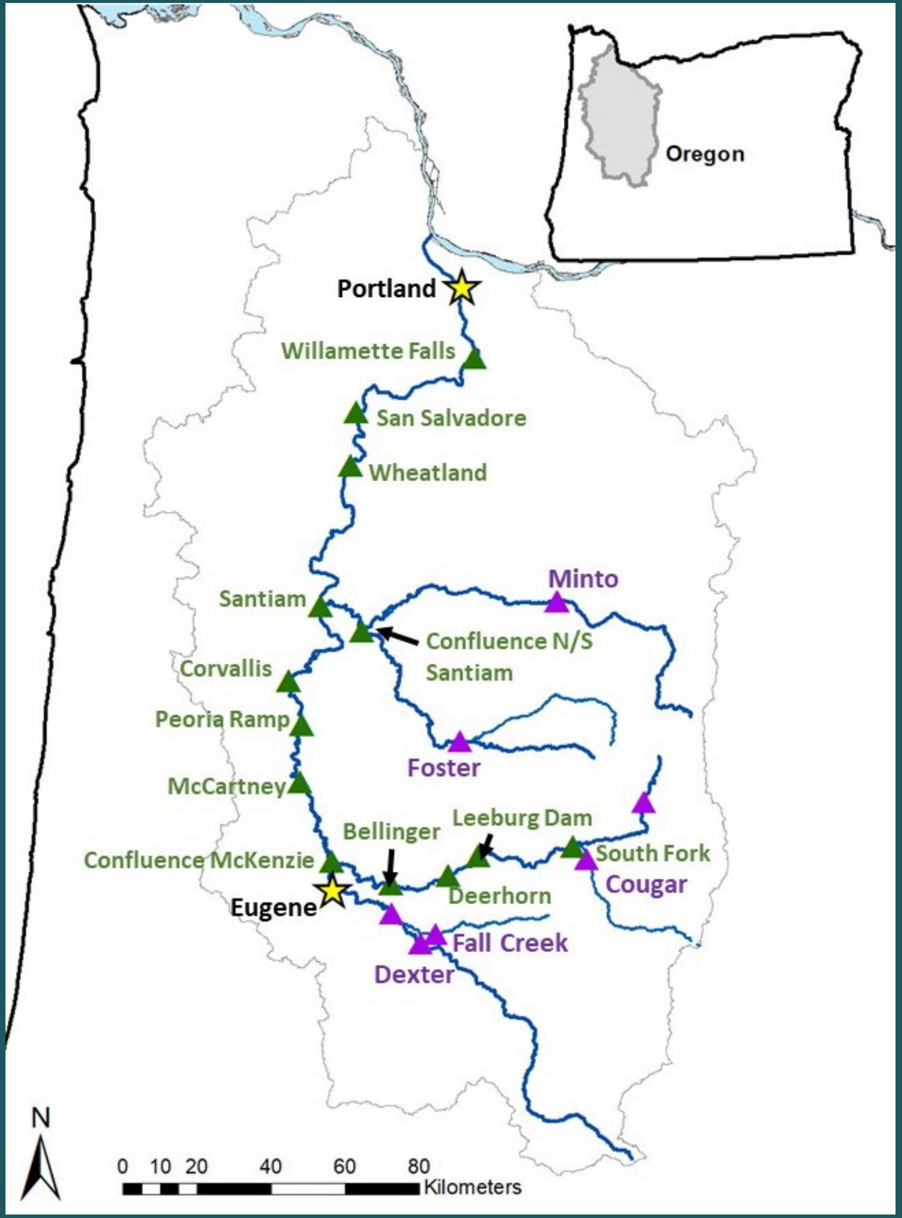
17 reaches

Flow habitat – all mainstem

N. & S. Santiam (McKenzie) PHSBSIM estimates (placeholders)

User specified yearling Chinook occupy available habitat in natal reaches

Chinook fry emergence in natal reaches ~*f*(degree days)



Juvenile growth, movement, survival

Fill available habitats, habitat capacity ~*f*(flow, fish body size)

Habitat capacity < habitat needed (2 alternatives):

1) *move to downstream segment
2) density dependent mortality

Grow ~ *f*(temperature)

Survival ~ *f*(temperature, body size, segment)

Seasonal movement

Subyearlings leave Mar-Jul length, 105-120 mm size group

Yearlings > 120 mm size group leave Oct->Apr

All remaining yearlings leave Apr

Physical models and inputs

17 Reaches

<u>Inputs:</u>

-Q @ 5 USACE projects

-Air temperature NOAA stations

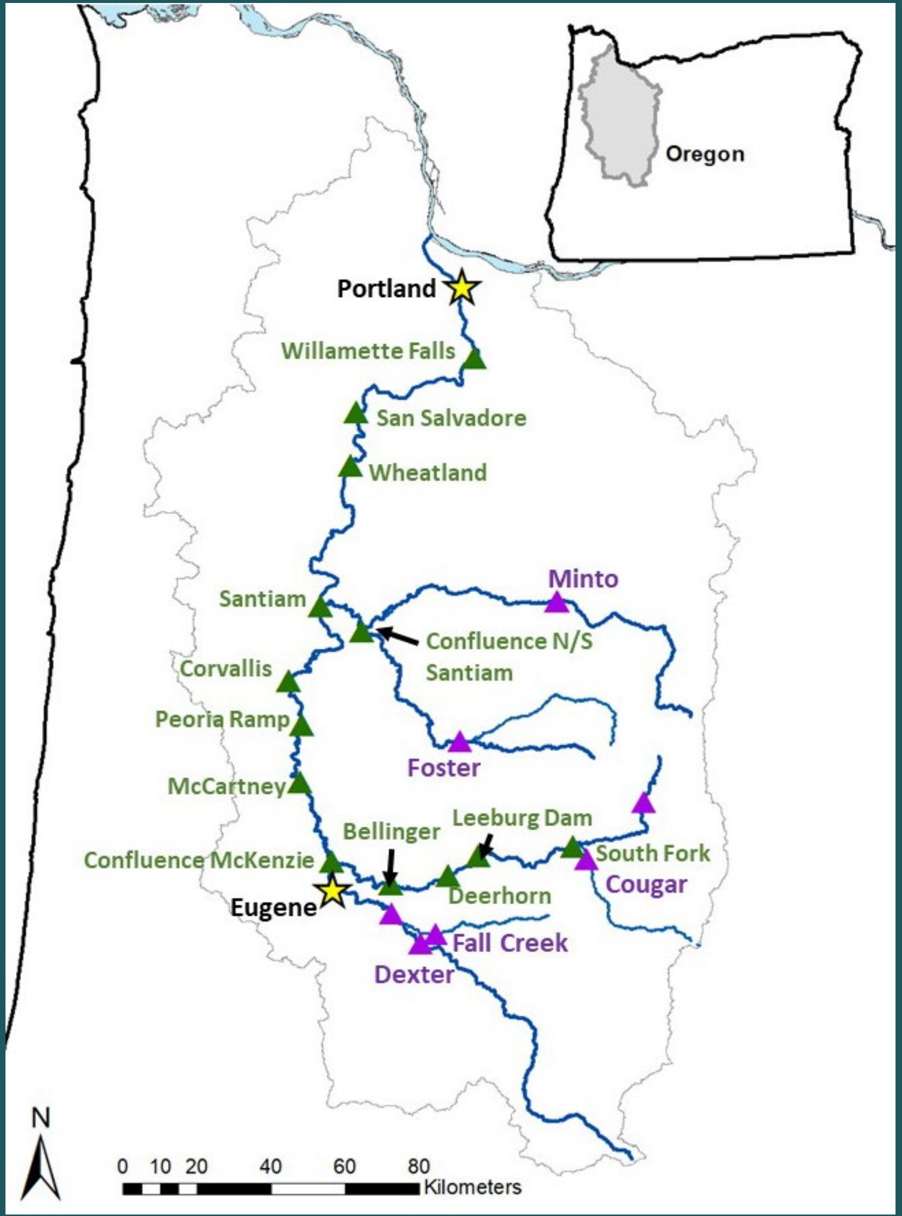
Streamflow models ~ *f*(upstream gage Q)

H_2O temperature ~ *f*(Q, Air Temperature)

Spawning habitat ~ *f*(Q, redd size)

Redd stranding/scour ~ *f*(Q)

Rearing habitat ~*f*(Q)



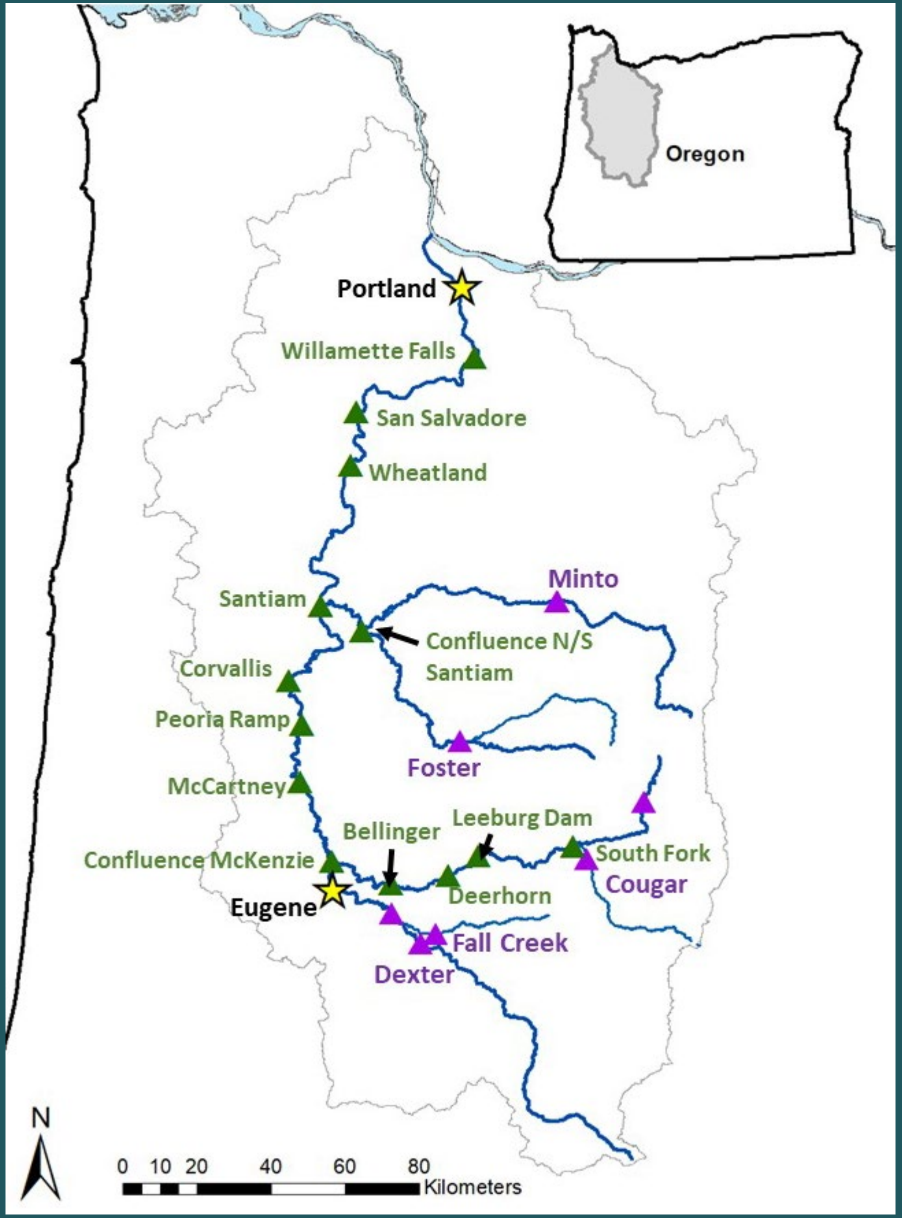
Adult Submodel Calibration

2008-2017

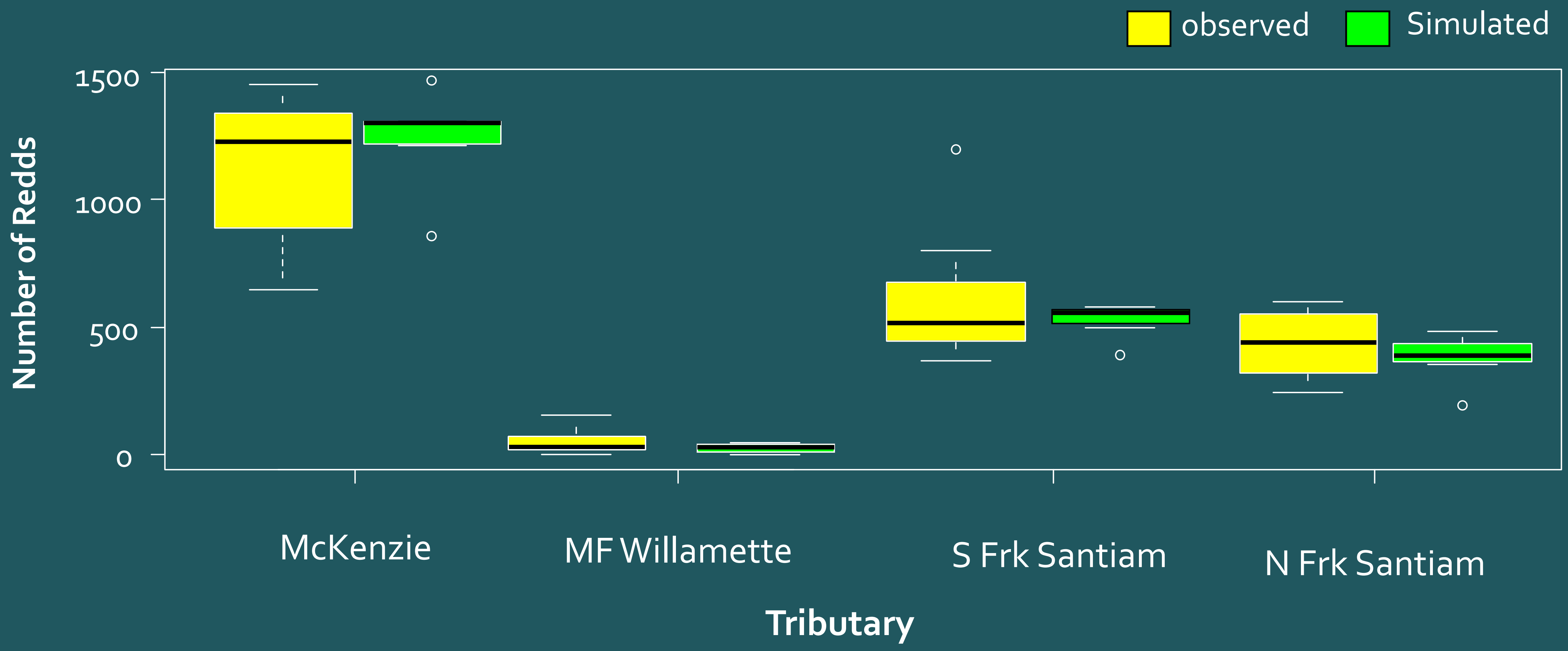
Observed

- Q USGS gages
- Air Temperature
- Run size
- Proportion hatchery origin

Minimize differences observed vs predicted number redds



Calibration: Estimated number of redds



Finding the best flow regimes

Constrain available water

- Each USACE project
- Water Years: Deficit, Adequate

Water management season: April 1-October 1

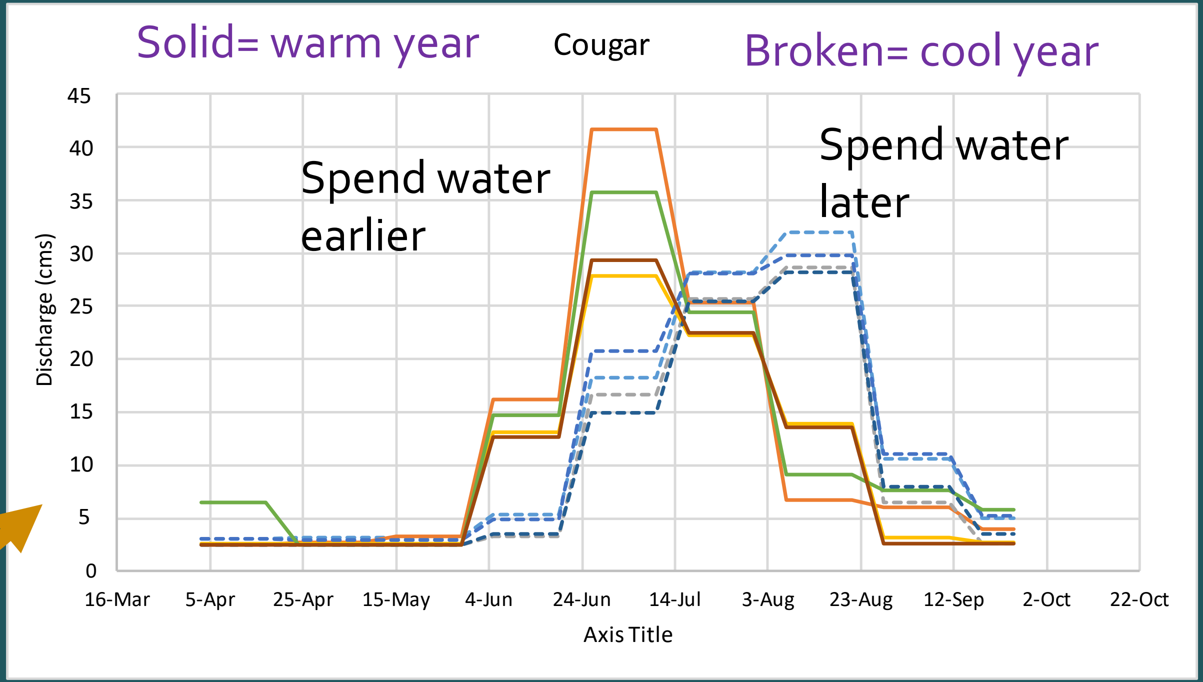
Climate year: cool (2011) & warm (2015)

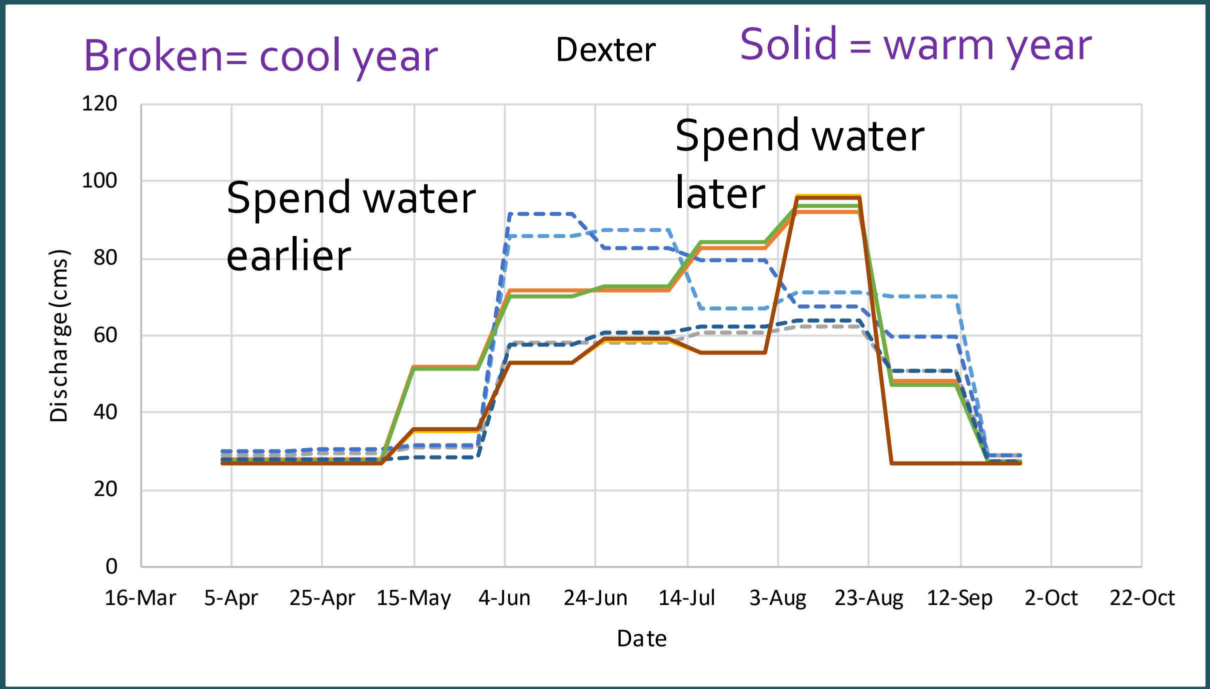
Find optimal allocation over time, 3 week periods

- Base flows
- Management flows

Maximize number emergence redds (adult submodel) and adult equivalents (juvenile submodel)

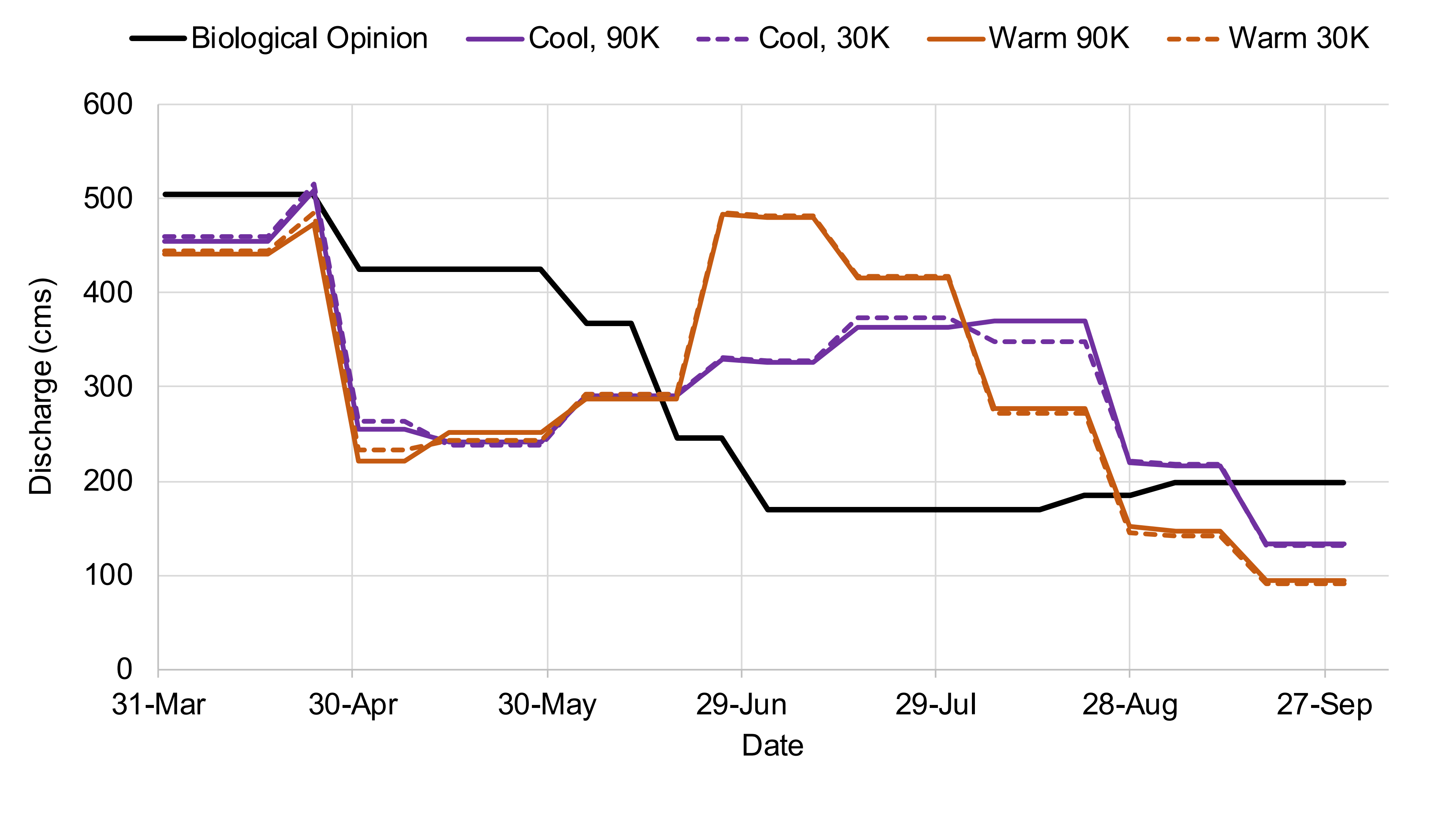
Nonlinear Optimization with Constraints (*NlcOptim)*





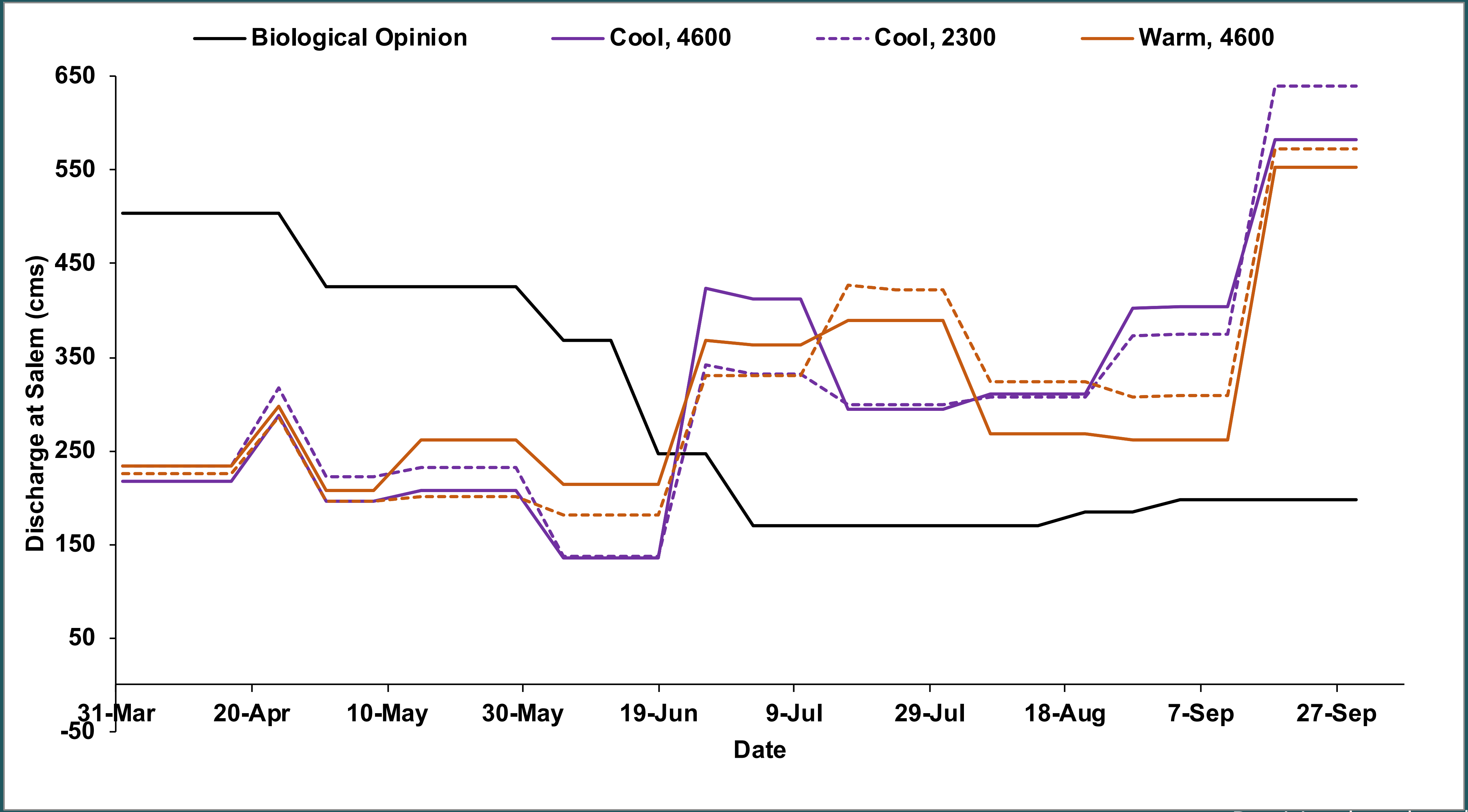
Provisional results subject to revision

Estimated optimal adult flow regimes vs BiOp flows
Adequate water year



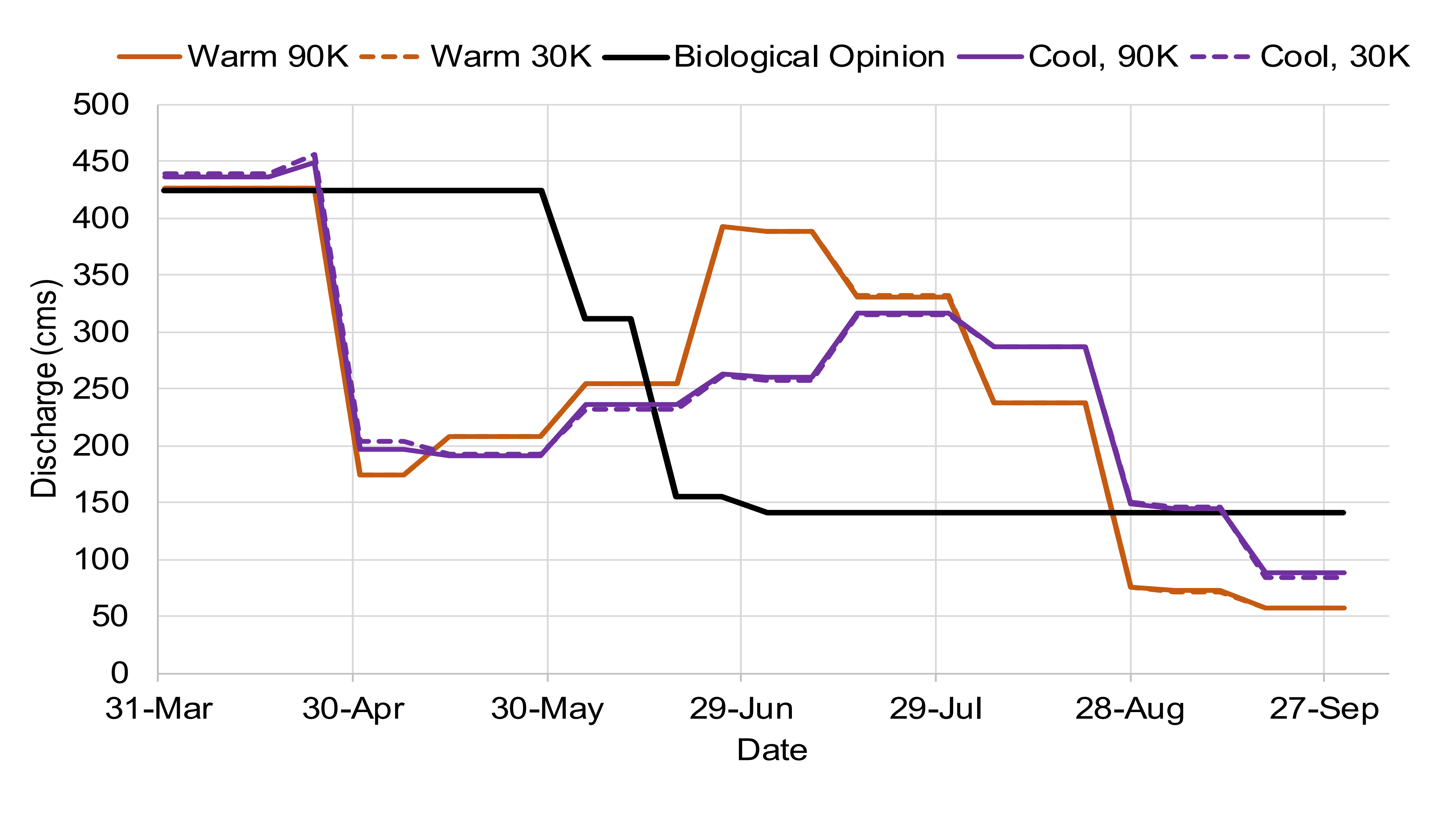
Provisional results subject to revision

Estimated optimal *juvenile* flow regimes vs BiOp flows
Adequate water year



Provisional results subject to revision

Estimated adult optimal flow regimes vs BiOp flows Deficit water year



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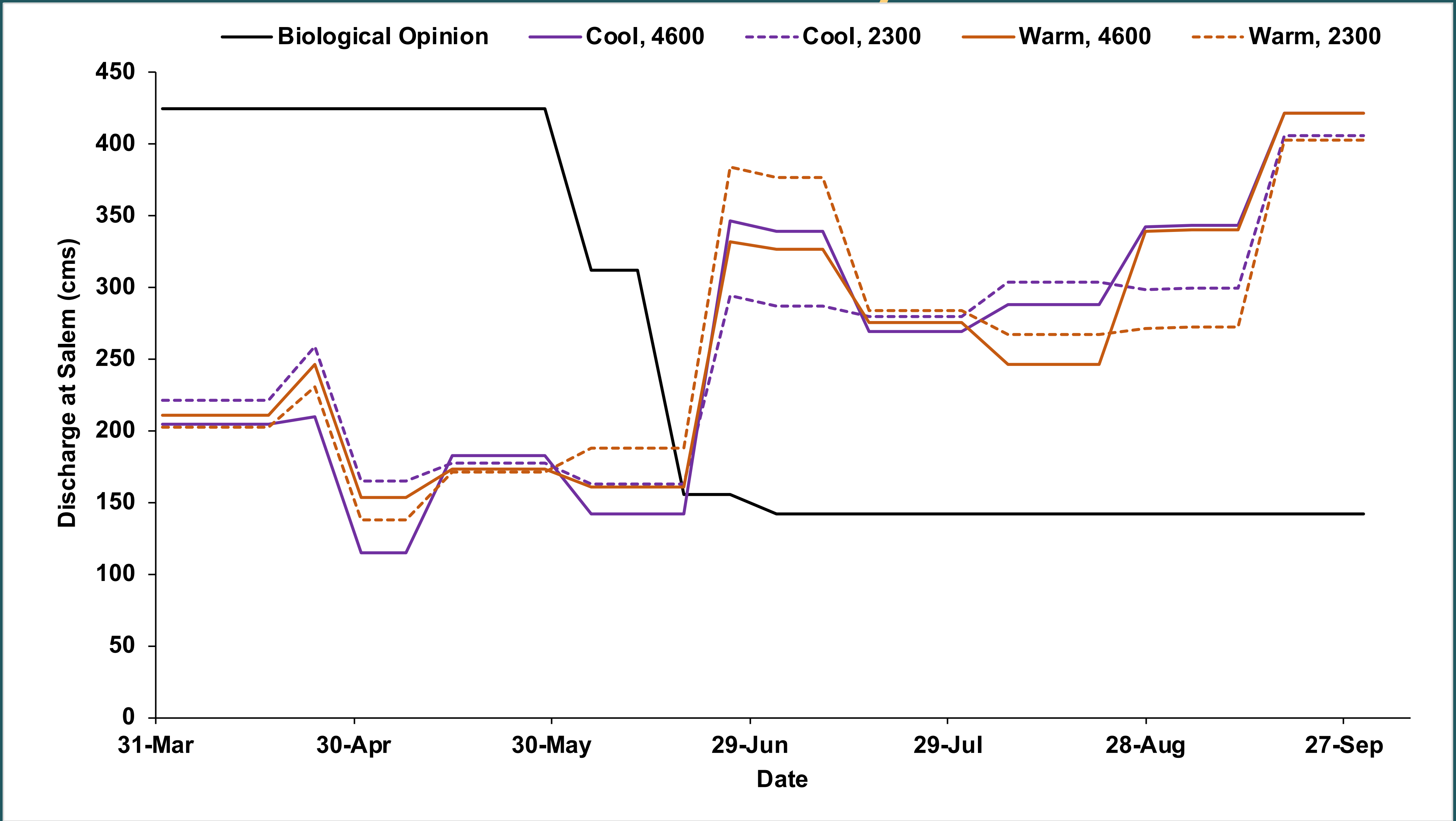
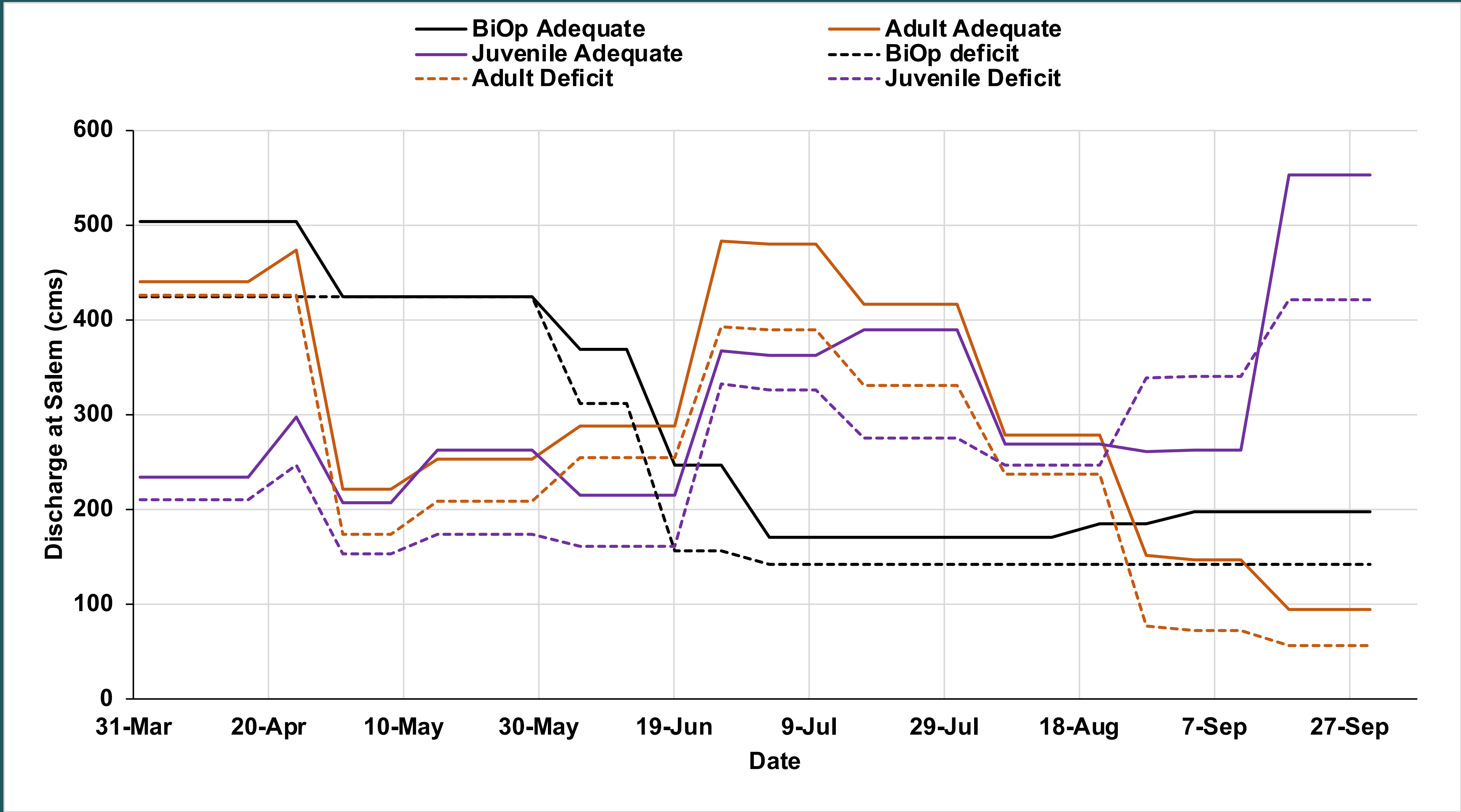
Estimated juvenile optimal flow regimes vs BiOp flows
Deficit water year



Provisional results subject to revision

Estimated optimal flow regimes vs BiOp flows Warm years, high run size and redds



Provisional results subject to revision

Conclusions

Can use decision models to identify optimal flow regimes (other management actions)

Basis flow management strategy, tradeoffs

Ideally, integrated with flow management operations models (ReSim)

<u>Next steps</u>

- Chinook: incorporate trib. habitat, update survival, and calibrate
- Integrate Steelhead and Oregon Chub
- Uncertainty and sensitivity

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