Life-cycle models for Yakima River *O. mykiss*: a tool for evaluating environmental influence on life history strategy and abundance

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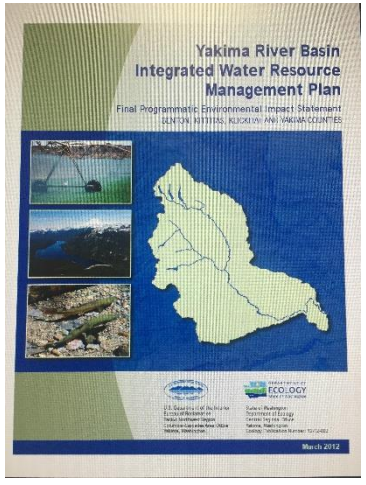
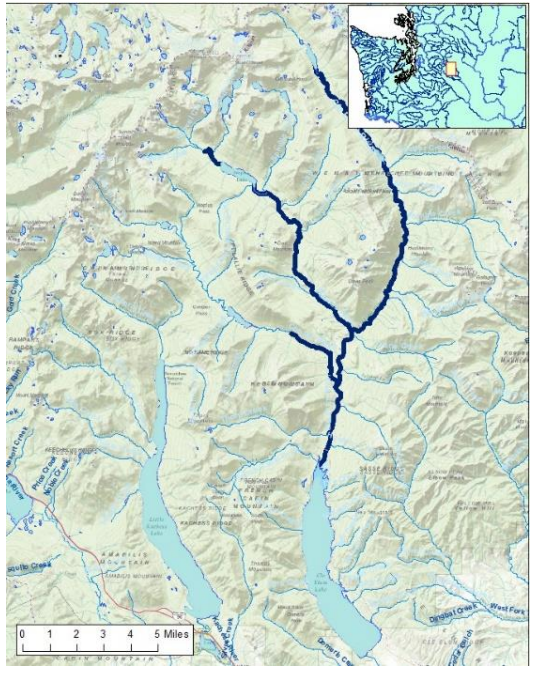
Why do we need improved life-cycle models for Yakima River *O. mykiss*?

- Yakima River steelhead are ESA listed though have increased in abundance in past 10 years
- Much restoration and recovery work being done and basin is subject to climate change impacts
- Many residents fish here; data available on these fish!
- Some available models don’t consider resident individuals
- Some available models that do incorporate residents don’t consider how environment affects life history decision

Current and future *O. mykiss* model applications in the Yakima Basin

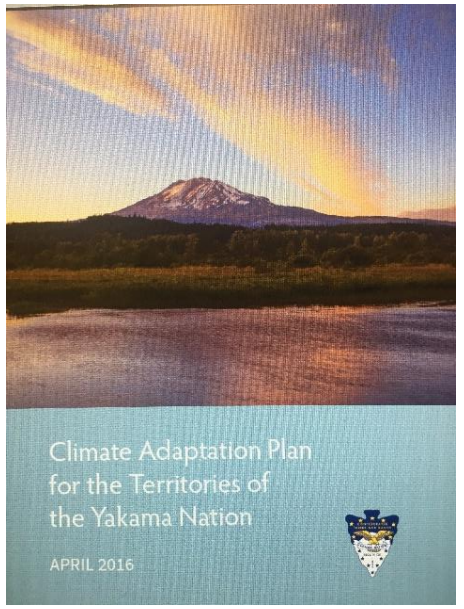
- Yakima River Basin Integrated Water Resource Management Plan
  - Evaluate benefits of habitat enhancement
    - Example: Lake Cle Elum fish passage--66 km of new habitat

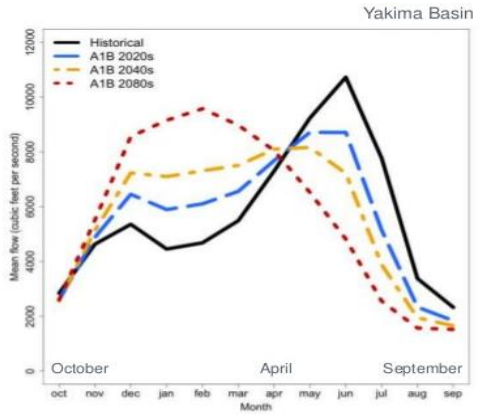




Current and future *O. mykiss* model applications in the Yakima Basin

- Climate Adaptation Plan
  - Current and future population bottlenecks due to flow and temperature changes?
  - Restoration/preservation priorities under altered climate?





Model scenarios

<u>In basin:</u>

- Freshwater temperature and flow changes due to global warming
- Manastash habitat opening, Lake Cle Elum passage restoration
- Flow conditions affecting Roza Dam to McNary Dam survival
- Kelt reconditioning

Model scenarios

<u>Out of basin:</u>

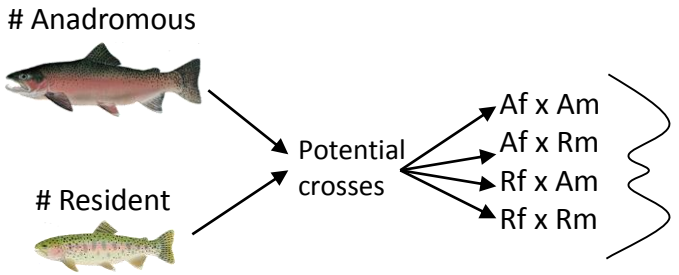
- SAR variation due to ocean conditions
- SAR variation due to changes in smolt outmigration timing at Bonneville Dam
- Columbia River migration survival under different hydropower system conditions
- Avian and pinniped predation at Bonneville Dam area and lower Columbia River estuary

Existing models

1. Anadromous/resident *O. mykiss* abundance and reproductive success life-cycle models x 2 (developed for Yakima River by Ian Courter, Chris Frederiksen, et al.)

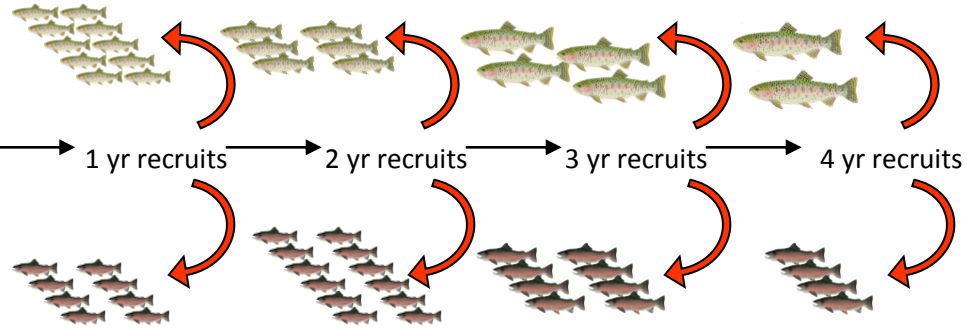
O. mykiss life-cycle model synopsis

1) Abundance and eggs:



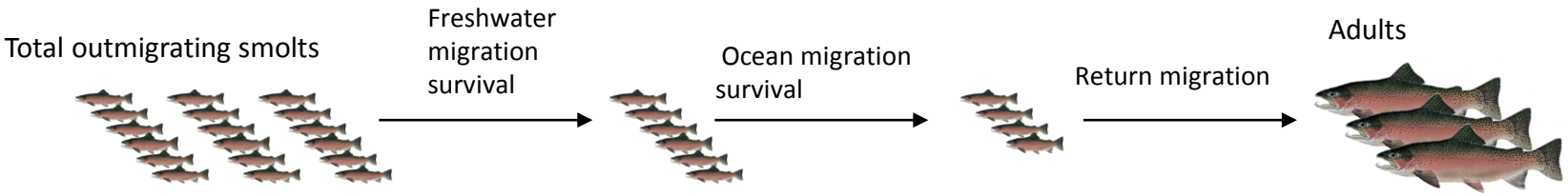
2) Freshwater growth & recruitment

2a) Resident age classes & proportions maturing



2b) Anadromous recruitment & smolt age

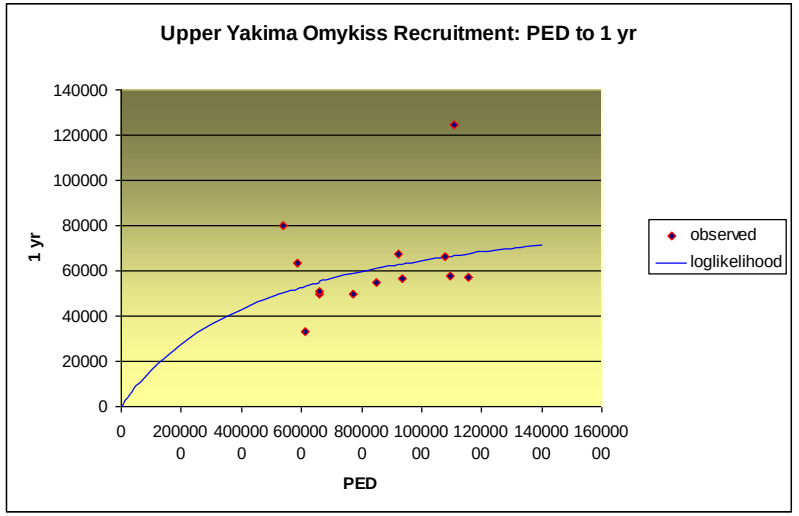
3) Anadromous survival & adult returns



Development of freshwater recruitment curves

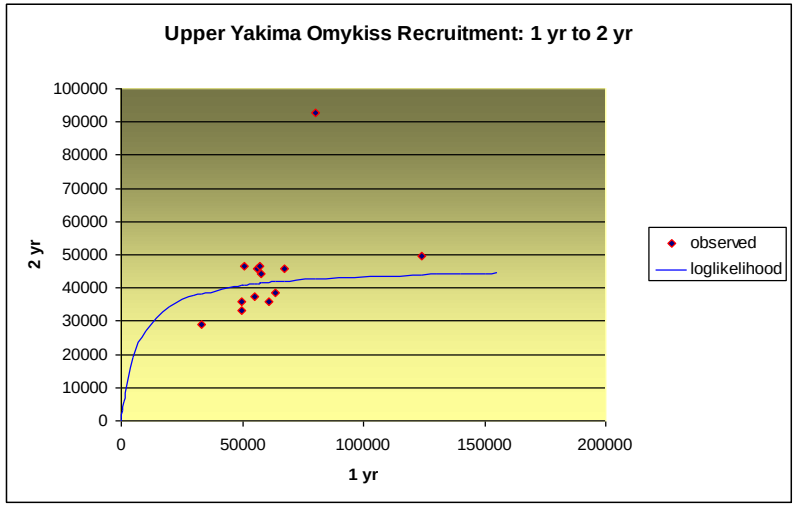
1) <u>Upper Yakima age class abundance estimates</u>

- WDFW data set (1991-2004)
- Index reaches (fish/km) expanded



2) <u>Recruitment curves</u>

- 4 age class recruitment curves constructed
- Capture density dependent effects



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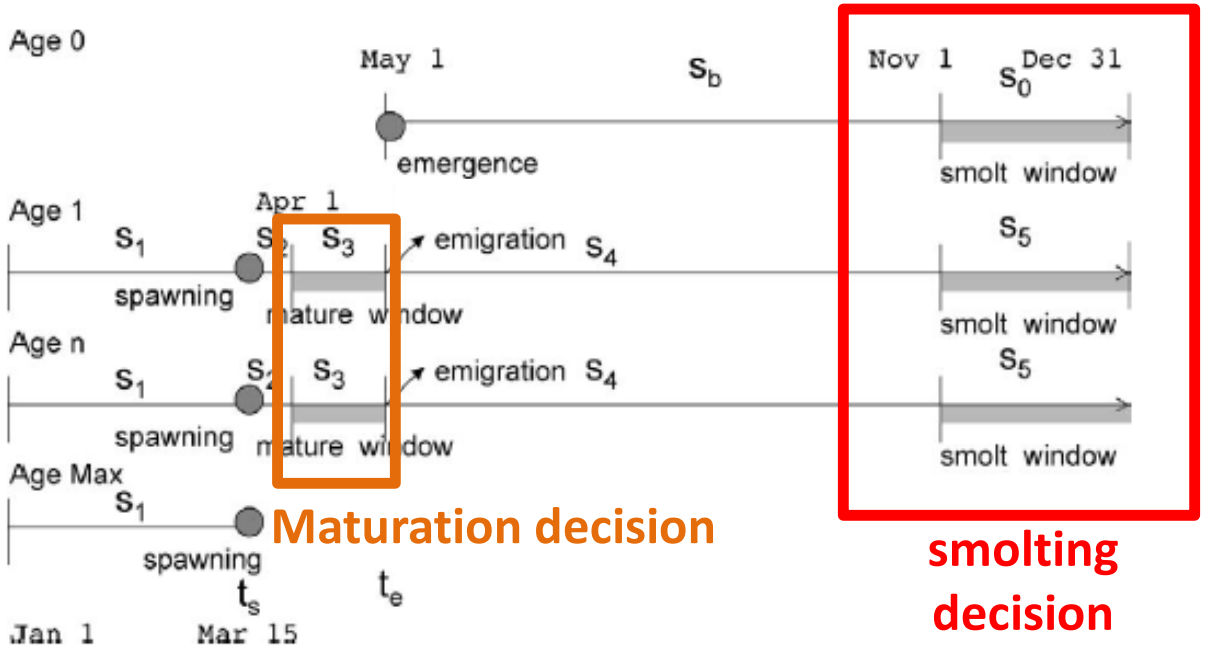
2. Anadromy/residency and smolt age decision for *O. mykiss* (developed for California populations based on fish condition; Satterthwaite et al. 2009, 2010)

Fish condition life-cycle model

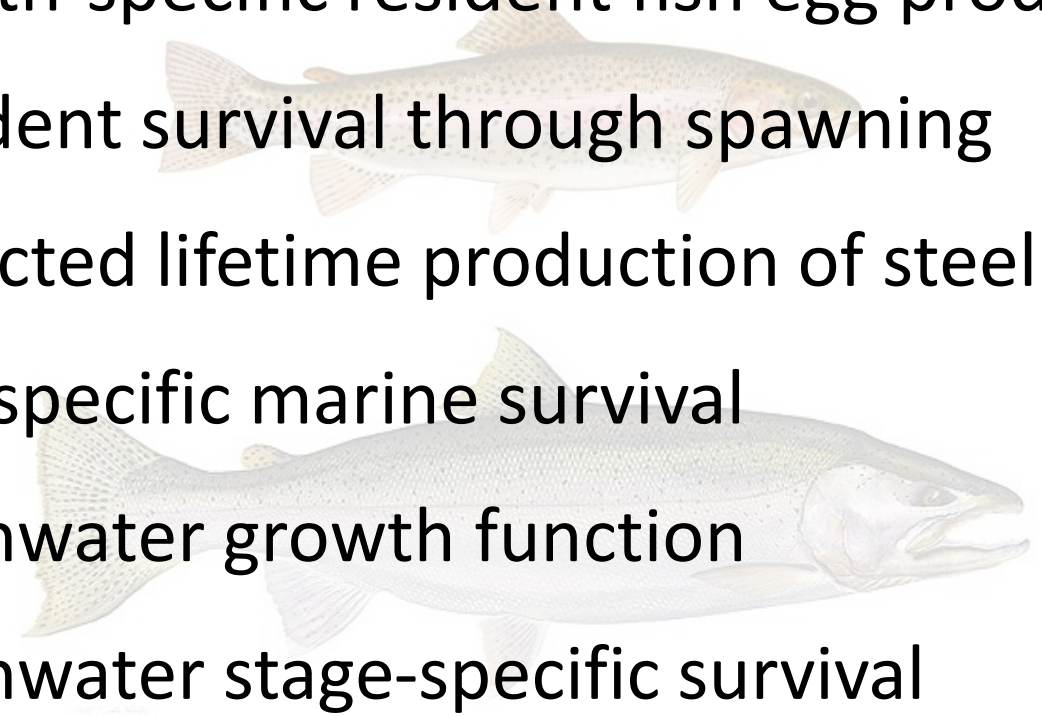
- Based on fish emergence date, freshwater growth, survival and fecundity (affecting its “condition” at a given time) along with predicted overall fitness
- Predict maturation/residency and smolt age decision

Satterthwaite et al. 2009, 2010



Input data

- Date of emergence, resident spawning, emigration, smolt and maturation windows
- Length-specific resident fish egg production
- Resident survival through spawning
- Expected lifetime production of steelhead
- Size-specific marine survival
- Freshwater growth function
- Freshwater stage-specific survival

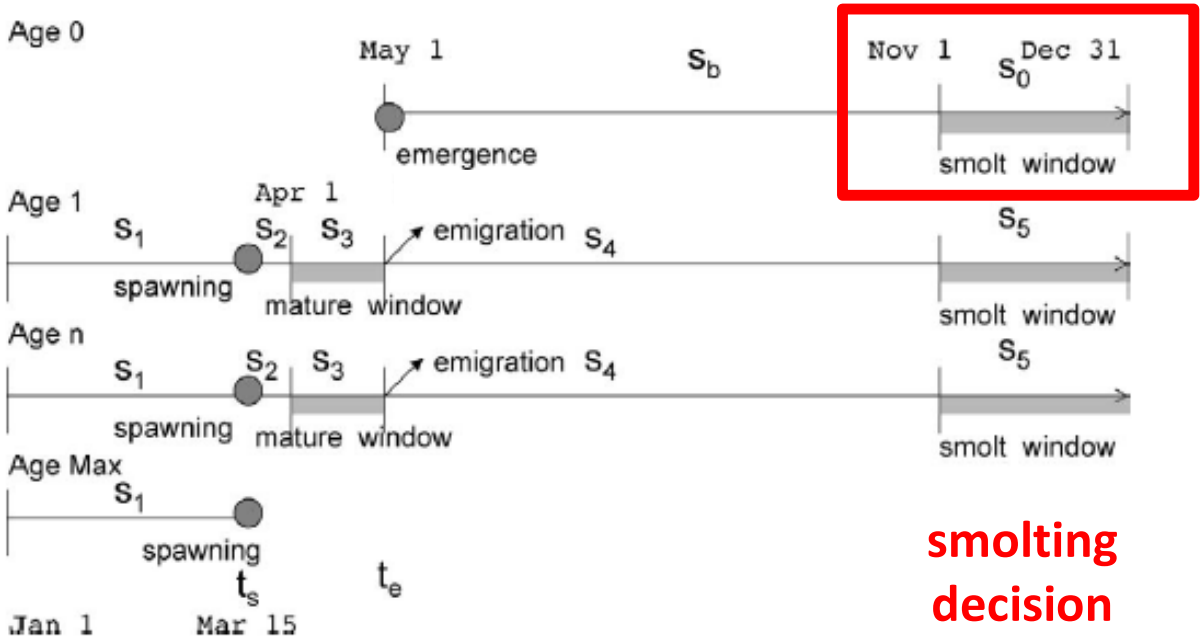


Modeling steps

- Parameterize the model with as much known data as possible
- Adjust inputs, especially uncertain values, to simulate observed patterns of resident maturation age and smolt age
- Call this parameterization “baseline”
- Modify baseline parameters based on scenarios of interest to understand potential life history

Preliminary results: age-0 smolting decision

					15% of fish smolt at age 1							
length (mm) at age-0 smolting decision window (so will smolt the following year at age 1)	40	50	60	70	80	90	100	110	120	130	140	150
baseline												



smolting decision

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baseline												
decrease fw survival 15%												
decrease SAR												
increase fw growth 5%												
increase fw growth 10%												
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decrease fw growth 10%												
spawn and emigrate 10 days earlier												

Preliminary results: age-1, 2, and 3 smolting decision

							73% of fish smolt at age 2										11% of fish smolt at age 3										
length (mm) at age 1+ smolting decision window (so will smolt the following year at age 2+)	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300	310	320	330	340	350
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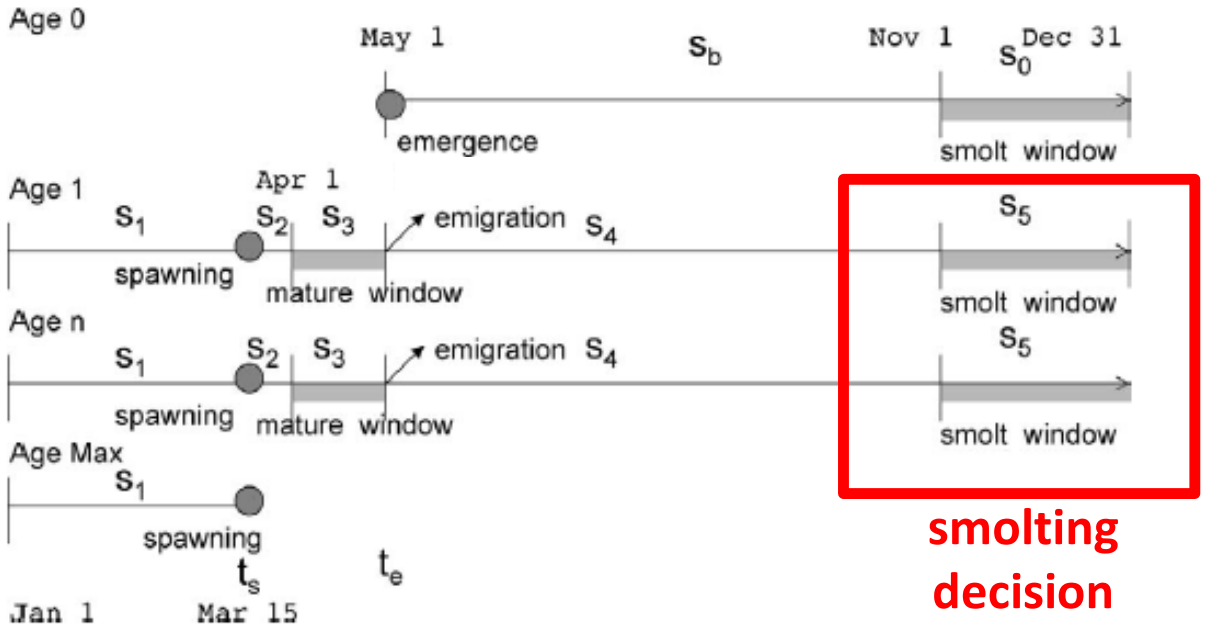

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Preliminary results: age-1, 2, and 3 maturation decision

	15% of fish are mature by age 2							40% of fish are mature by									80% of fish are mature by age 4							
length (mm) at age 1+ maturation decision window (so will mature as a rainbow trout the following year at age 2+)	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300	310	320	330	340	350
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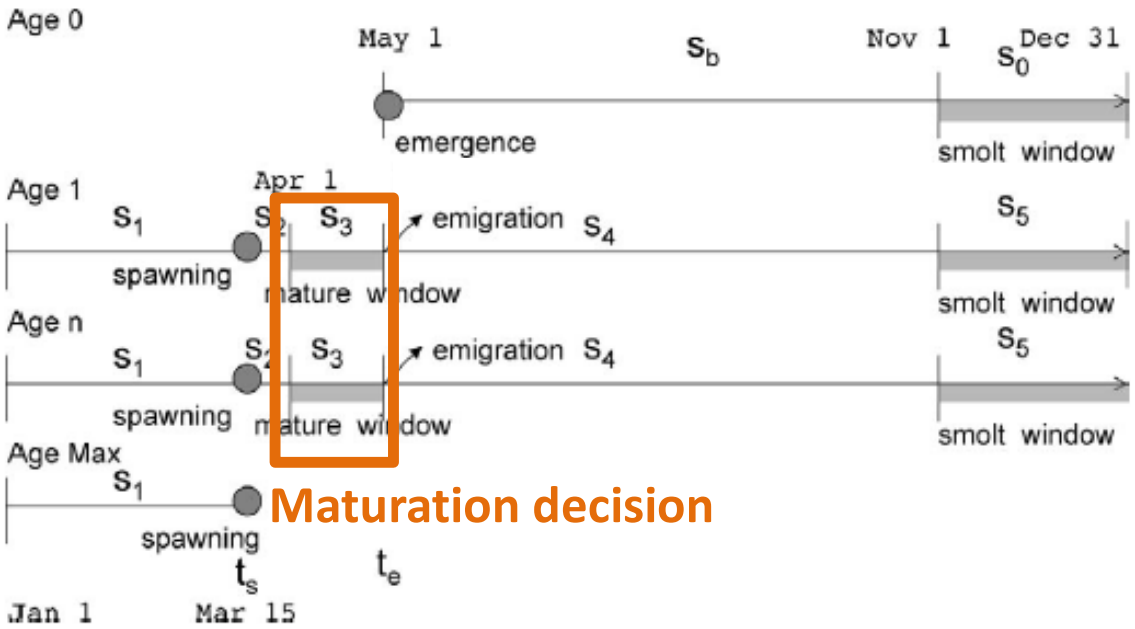

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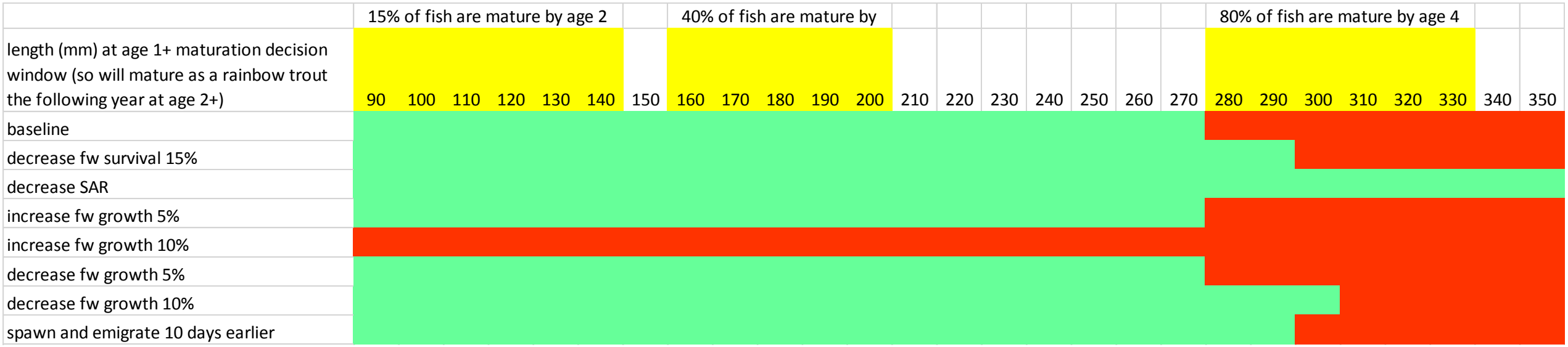

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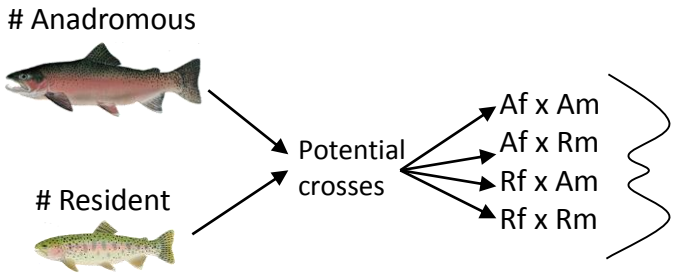

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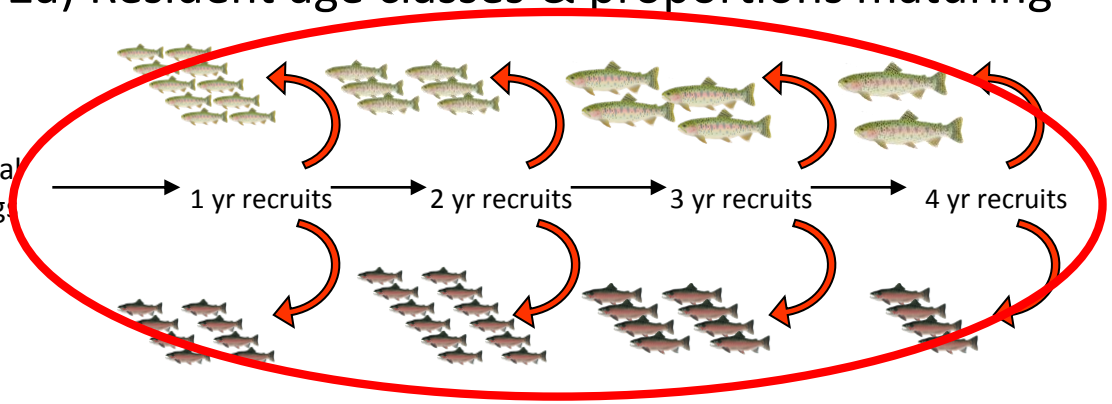

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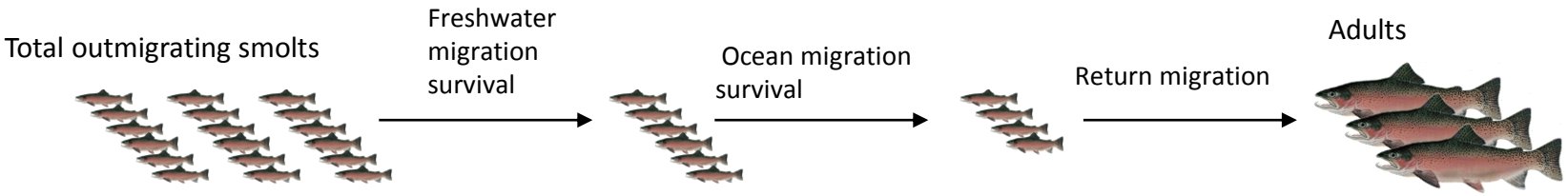

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2. Anadromy/residency and smolt age decision for *O. mykiss* (developed for California populations based on fish condition; Satterthwaite et al. 2009, 2010)
3. Chinook and steelhead life-cycle matrix models (developed for Interior Columbia River Basin; Zabel et al. 2006; ICTRT and Zabel 2007)

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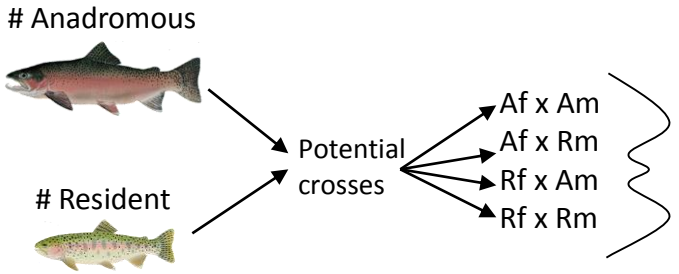

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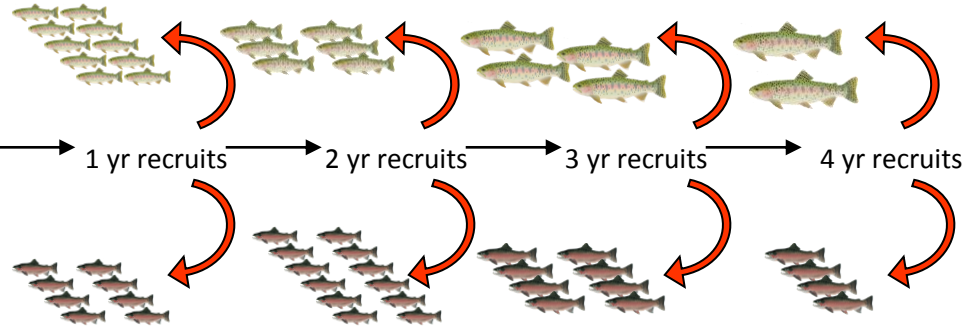

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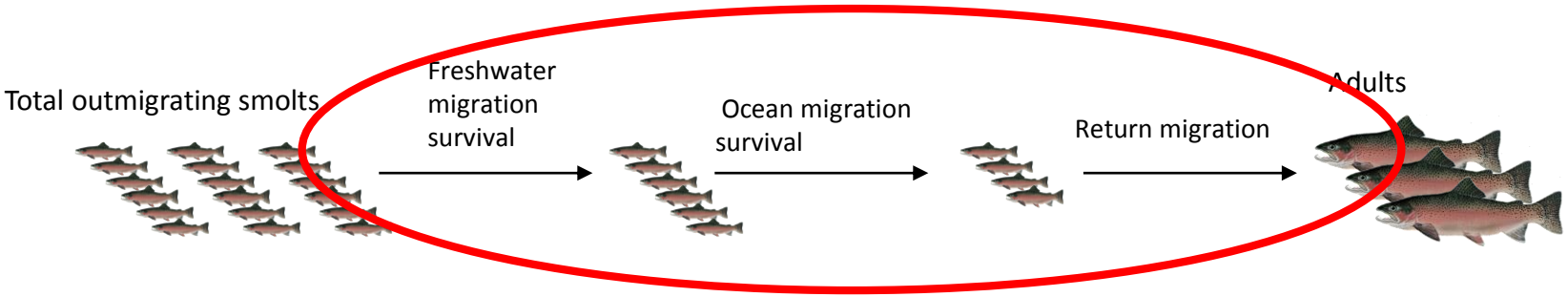

Acknowledgements

- Yakama Nation for funding
- WDFW
- Tom Cooney, Rich Zabel, Jeff Jorgensen, and AMIP Life-Cycle Modeling Group
- Will Satterthwaite

Parts of basin are very flow regulated

- Reservoirs, water delivery for agriculture
- Strong rainbow trout population
- Flow regulation favors rainbows?