Evaluation of passage options for the Middle Fork Willamette River accounting for life history diversity of juvenile spring Chinook salmon

Eric Parkinson, Roberto Licandeo, Oliver Murray, Tom Porteus,
and Murdoch McAllister
Institute for the Oceans and Fisheries,
University of British Columbia, Vancouver, BC

Integrated Passage Assessment

Life History Conservation: Portfolio Effects

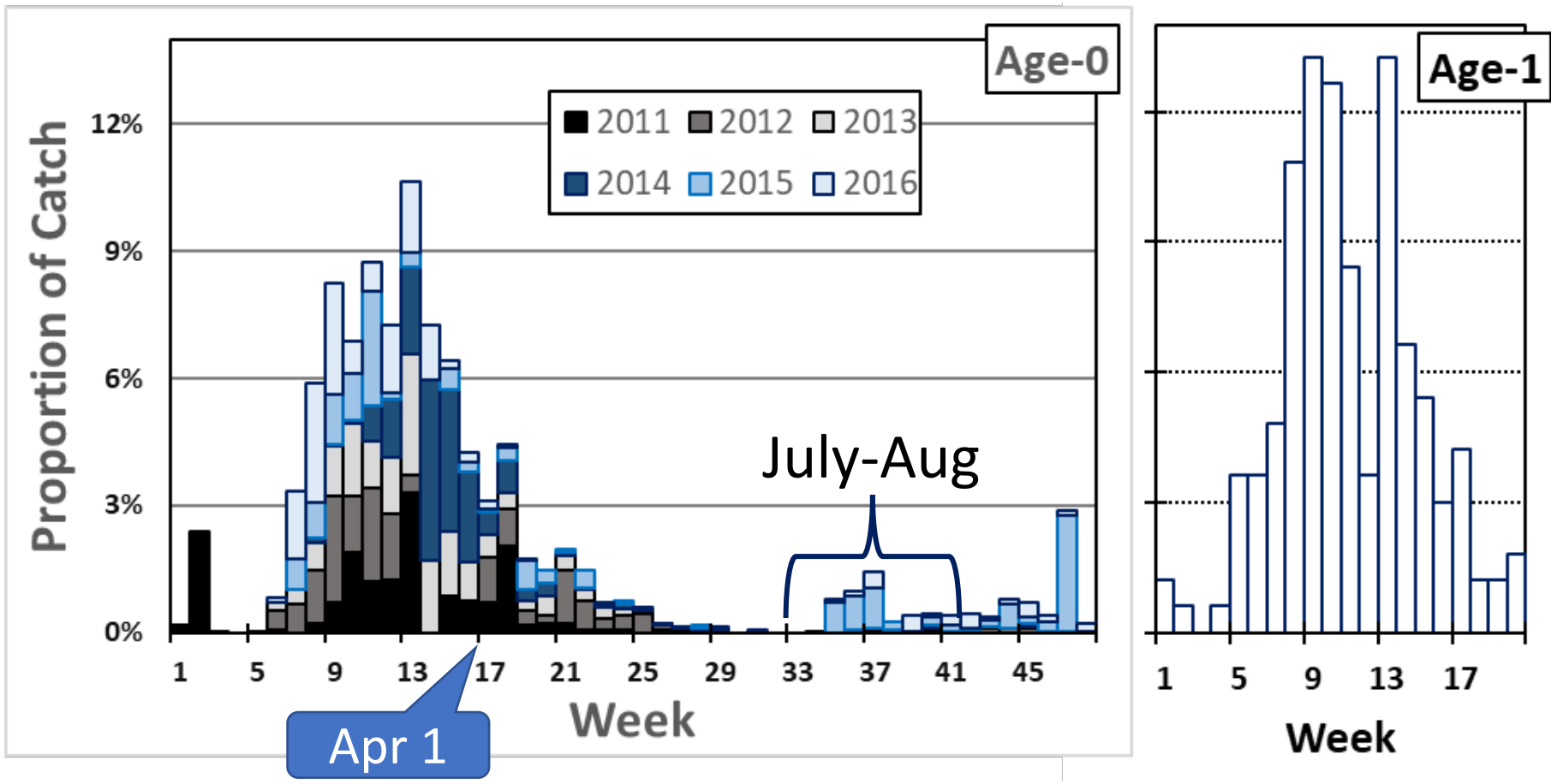
- Life History Type (**LHT**): a group of fish with similar size and time of migration among habitats
- Benefits
  - Utilization of a spatial array of environments
  - Bet hedging – LHTs provides insurance against recruitment failure of any one life history
- Two of common LHTs in Willamette Spring Chinook Salmon:
  - **Stayers** that leave their natal stream at age-1,
  - **Movers**, that leave as age-0

Control over Life History Type (LHTs)

- Behavioral response to high density
  - Fish movement is a density dependent effect driven by territory size (Grant and Cramer 1990, Conner et al. 2013, Apgar et al. 2021)
- Genetic Programmed size and timing
  - Fish migration timing and size is driven by inherited responses to ambient environmental conditions (Clarke et al. 1992, Bourrett et al. 2016)
    - Good evidence in a variety of salmonids that LHTs heritable but can be re-established after long periods of absence (Dodson et al. 2013, Foerster 1947, Godbout et al. 2011, Mills et al. 2012, Pearse et al. 2009, Wood and Foote 1996)

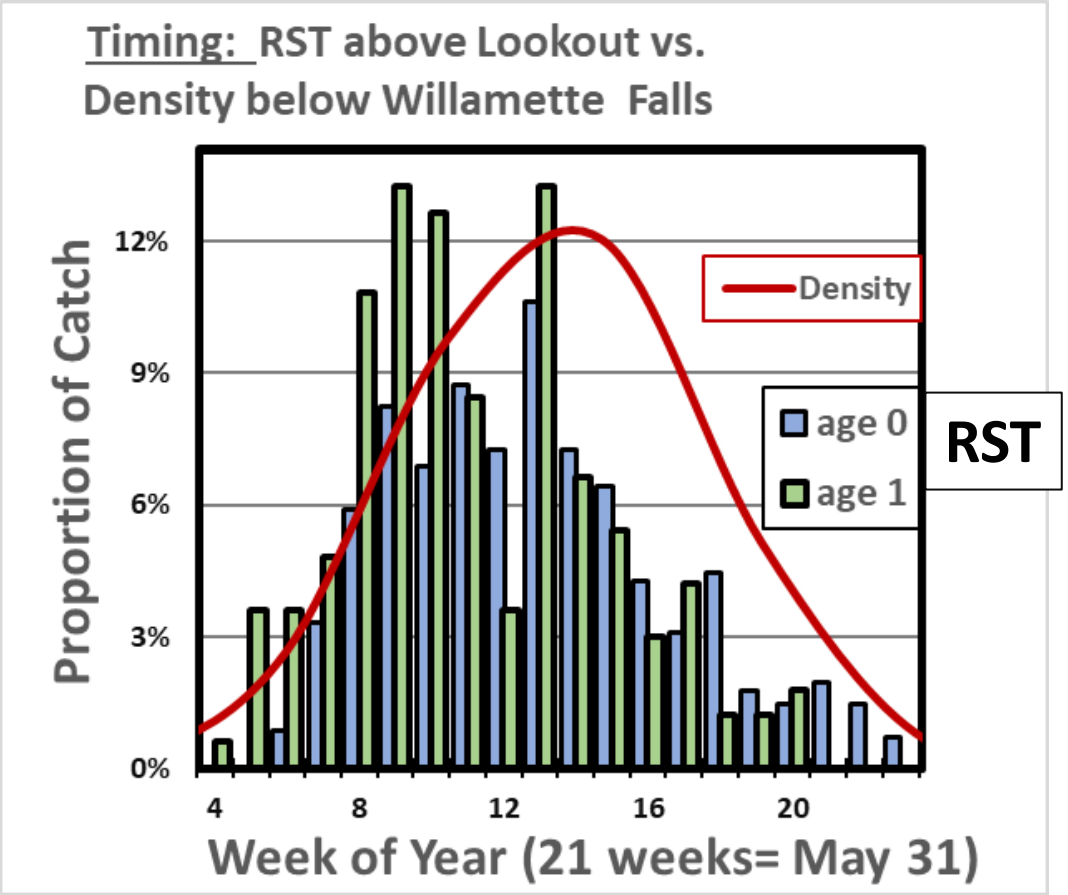
Migration from Middle Fork into Lookout Point Reservoir*

- Spring Migration peaks near April 1 for both Age-0 and Age-1
- Fall migration is much less common in this data set



Romer et al. 2017 : RST catches, Uncorrected for RST efficiency

Timing: Middle Fork *vs.* Willamette Falls (RST vs. CPUE)



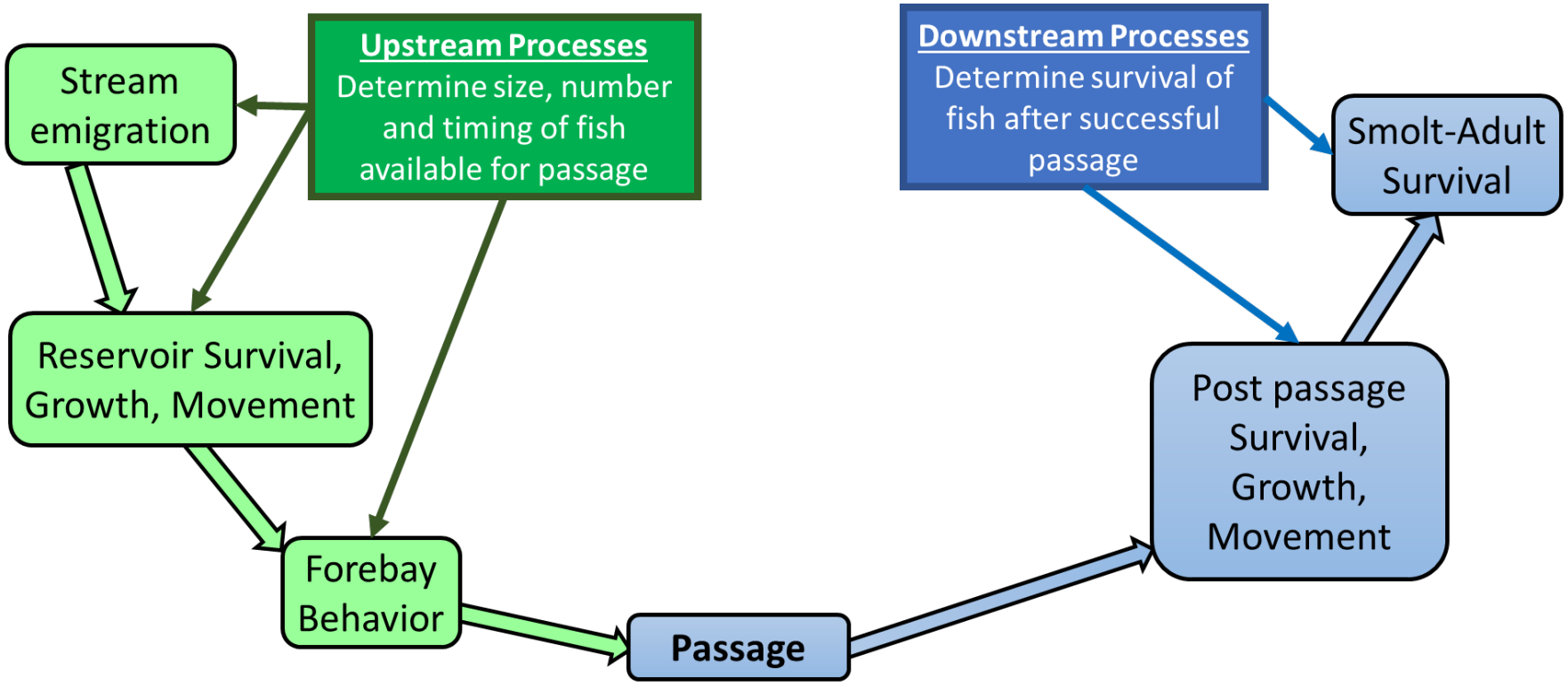
- Movement in Middle Fork peaks in **Week 10-12**
- Density below Willamette Falls peaks in **Week 14** (mid May)*

- Timing implies a 2-3 week transit time
  - **Passage timing is an essential component in this migration process**
  - **Upstream fish must pass LOP by mid-April**

*Friesen 2007, beach seines, electrofishing
The fish below Willamette Falls are from wild Chinook Salmon populations in the Willamette Basin

Passage success depends on the timing of pre- and post-passage processes

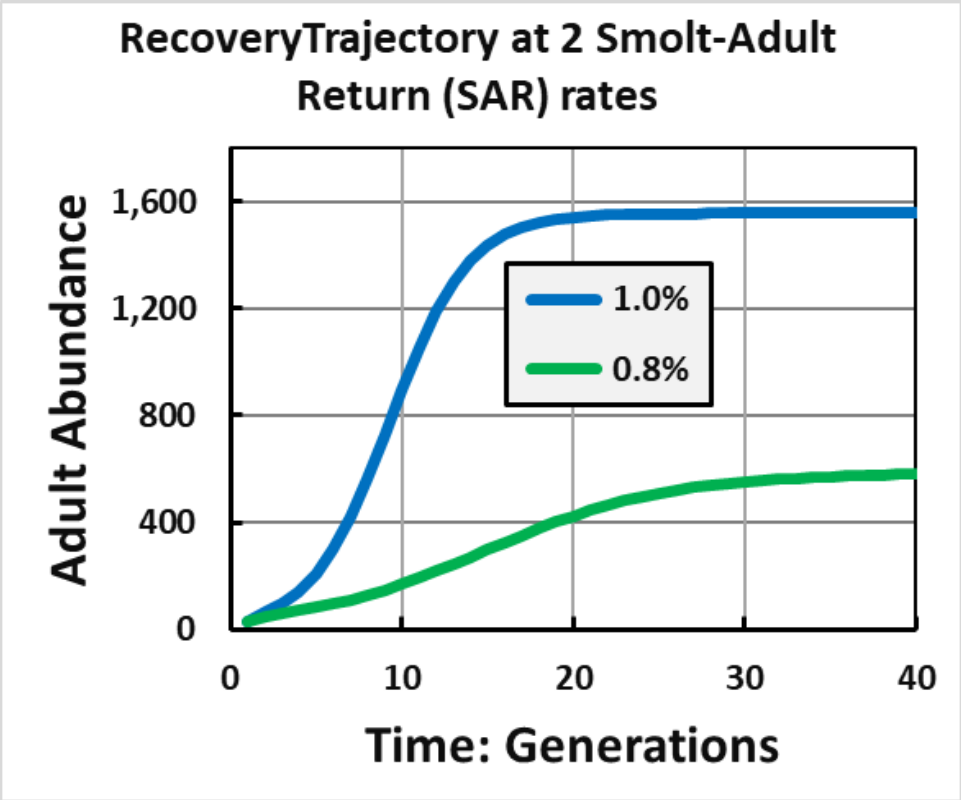
- LHTs differ in (1) the timing of downstream migration and/or (2) the timing of ocean entry
- To maintain a particular LHT, the provision of passage has to match both of these



Single marginally viable LHT: N. Fork MWR

Reservoir-rearing, Fall migration

- Small differences in SAR are important
- Effective passage must pass fish at sizes and times where SAR is higher



Some Details **Max Recruits/Spawner = 1.48**

- Fry per Spawner is a Bev-Holt function
- Later stages are all density independent

Pre-Passage

- Fecundity=2250/adult
- Max egg-Fry survival = 70%
- Maximum fry output 5 million, equivalent to 2000 adults
- Density Independent Reservoir survival 18% (Kock 2019, 2017 results)

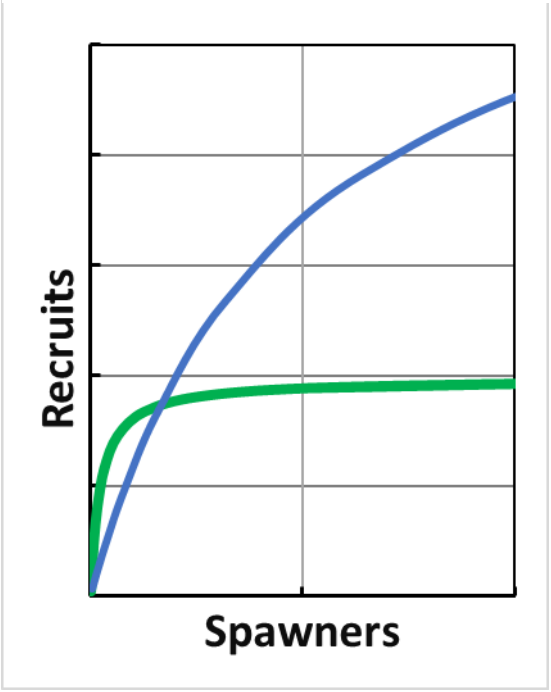
Post-Passage

- Migration to Sullivan = 54% (Beach Seine survival)
- Marine Survival= 0.78%, from Table 4 biostandards
- **PSM=10%**

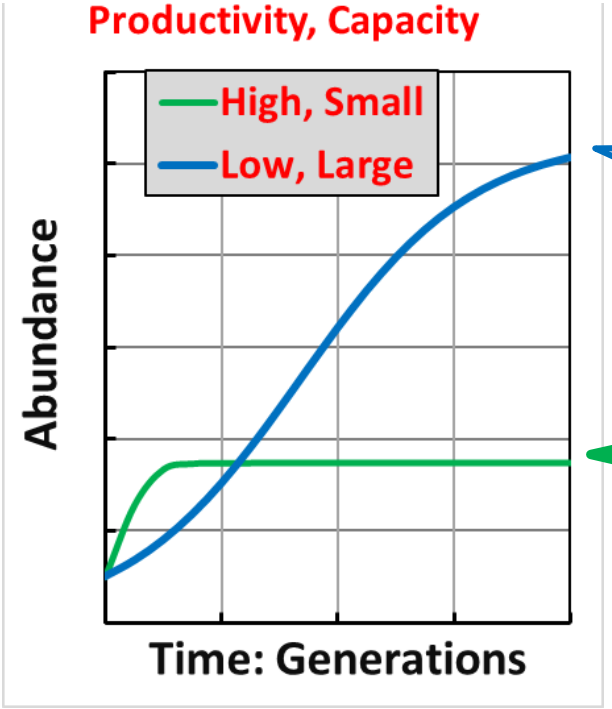
Recovery Trajectories: Two Populations with contrasting demographics:

1) **High Stock Productivity and Low capacity in freshwater**
2) **Low Stock Productivity and High capacity in freshwater**

Stock-Recruit Curves



Recovery Trajectories



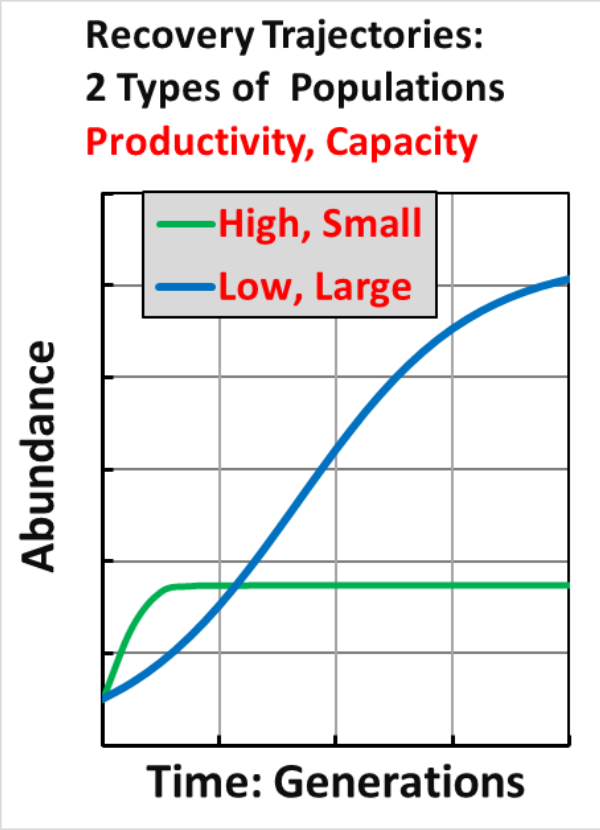
Low survival and large capacity, **e.g. Movers** enter LOP which has low survival combined a large capacity to produce juveniles

High survival and low capacity, **e.g. Stayers** migrate as Age-1 smolts high survival but low juvenile capacity in streams

Recovery Trajectories of a single population, with 2 LHTs

- The **Two LHTs** share egg-fry habitat, i.e. they compete for spawning and incubation habitat

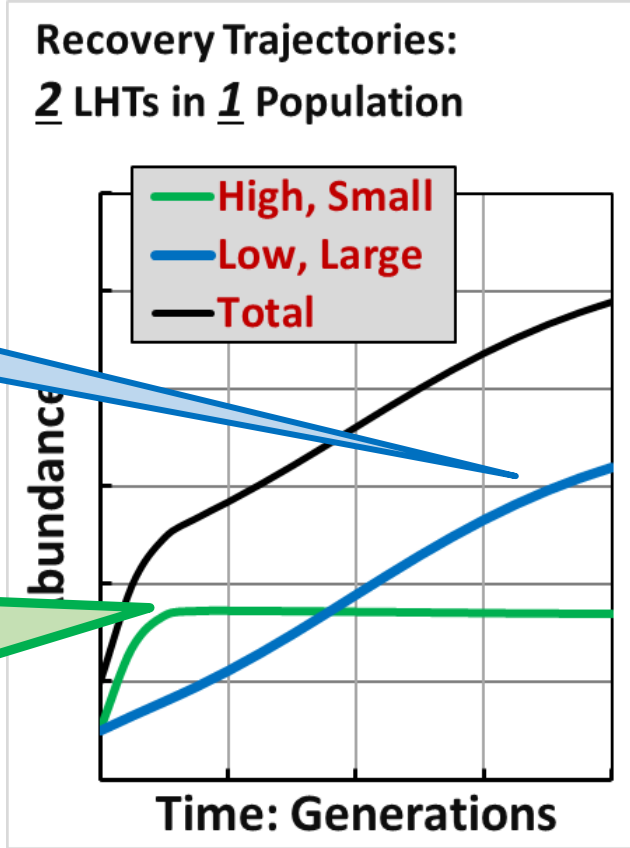
As independent populations



Asymmetric competition among LHTs

Movers recover more slowly to a lower abundance when competing for egg-fry habitat

Stayers rate of recovery and equilibrium abundance is unaffected by the presence of the less productive Movers



Equilibrium Abundance of alternative LHTs

- **Independent Populations do not compete, LHTs compete in shared habitat (egg-fry)**

In both cases, survival has to be high enough that max Recruits /Spawner, r >1.0

2 Types- Movers and Stayers

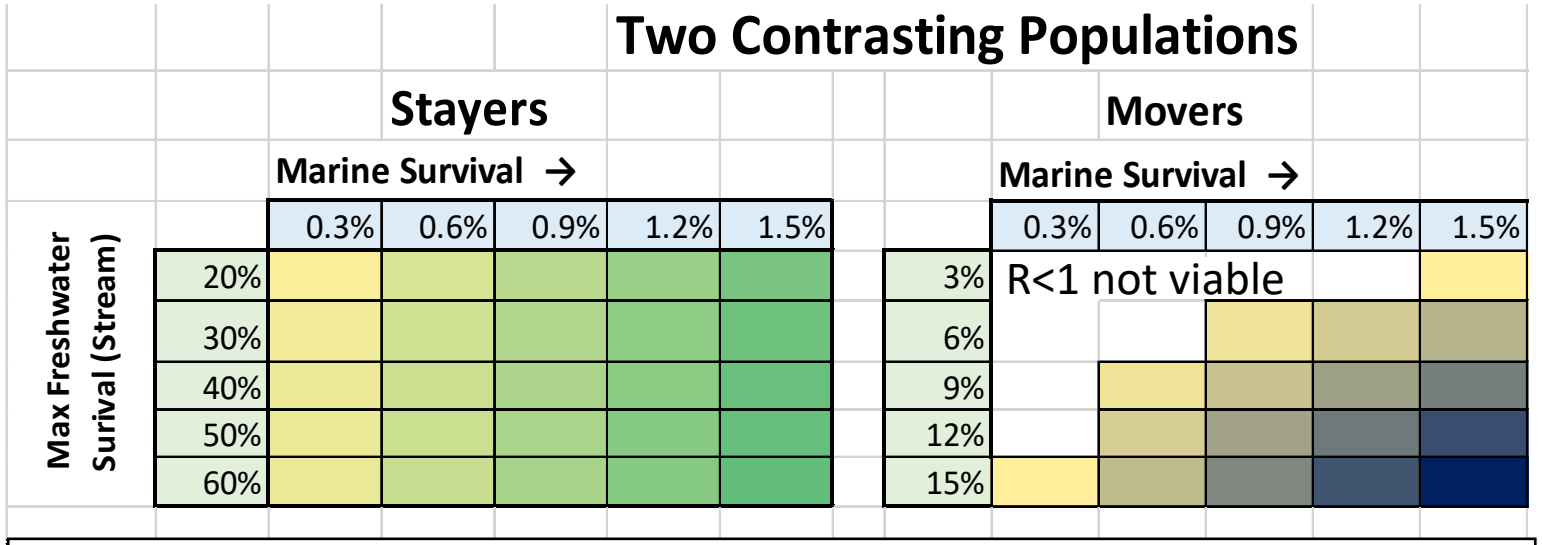
Stayer – High stock productivity, small habitat area

Mover - Low stock productivity, large habitat area

(1) Movers are strongly affected by competition

(2) Stayers are not

Yellow is low abundance,
Green and Blue are high abundance



Stayers are insensitive to freshwater survival because survival is density dependent and high. Habitat saturates

Yellow is low abundance,
Green and Blue are high abundance

Passage Options

Fish Benefits Workbook Options

1. Baseline (Includes temp control/fish passage ops from March 1 to October 15)
2. FSC (floating surface collector - Pumped attraction flow = 220 cfs; no nets)
3. FSS + SWS (SWS for temp control; FSS with attraction flow of 400 cfs to 2,000 cfs)
4. SWS (SWS for temp control; fish pass to turbine or RO from SWS)
5. Drawdown (Reservoir drawn down to El. 754; compare to Min Flood Control Pool El. 825)

Two Life History Types X Two Passage Options

- Model two LHTs:
  - Movers vs Stayers; Behavior is 100% heritable
- Two Passage Options:
  - Baseline: Spring Spillway flow is more likely
  - Drawdown: Fall migration from the reservoir is enhanced
- Model parameters are based on the LHTs on previous slides

This model is Illustrative,
i.e. Plausible but not predictive

Assumed Effects of Options: Migration Timing

Option 1: Baseline

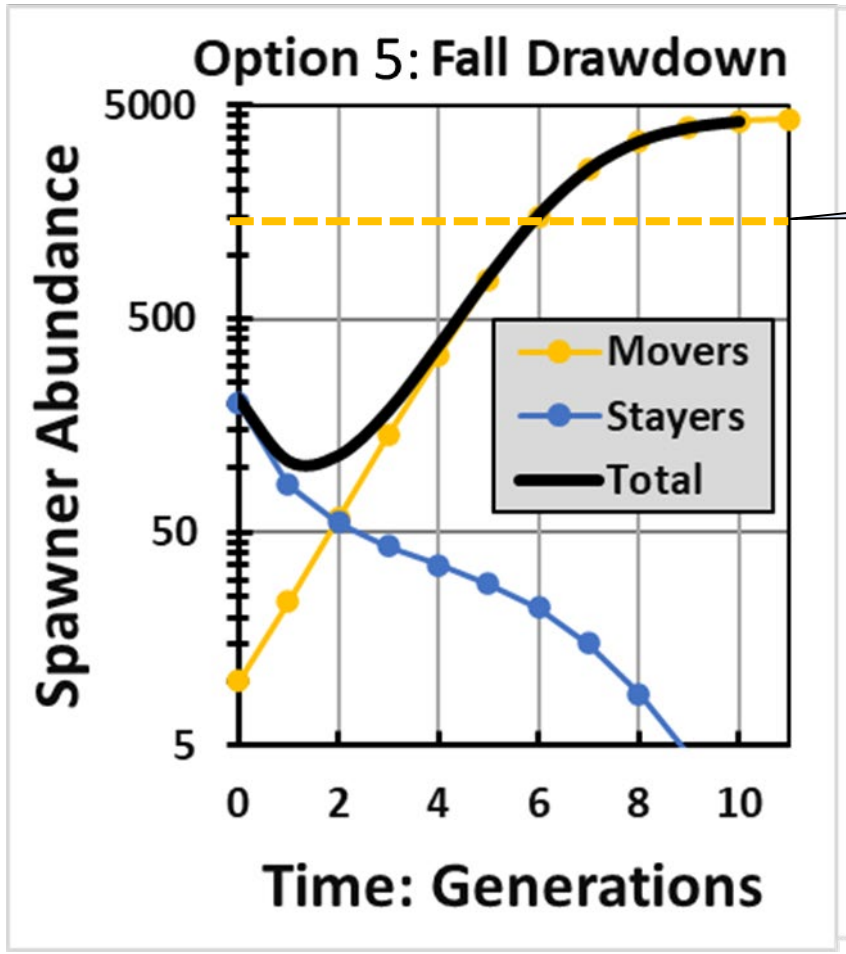
- **Spring** – **90%** passage efficiency
  - Spring spillway can pass stayers (age-1) –
- Summer – No Passage
- **Fall and Winter** – **30%** passage efficiency
  - Exit via Turbines or RO inhibited by water depth

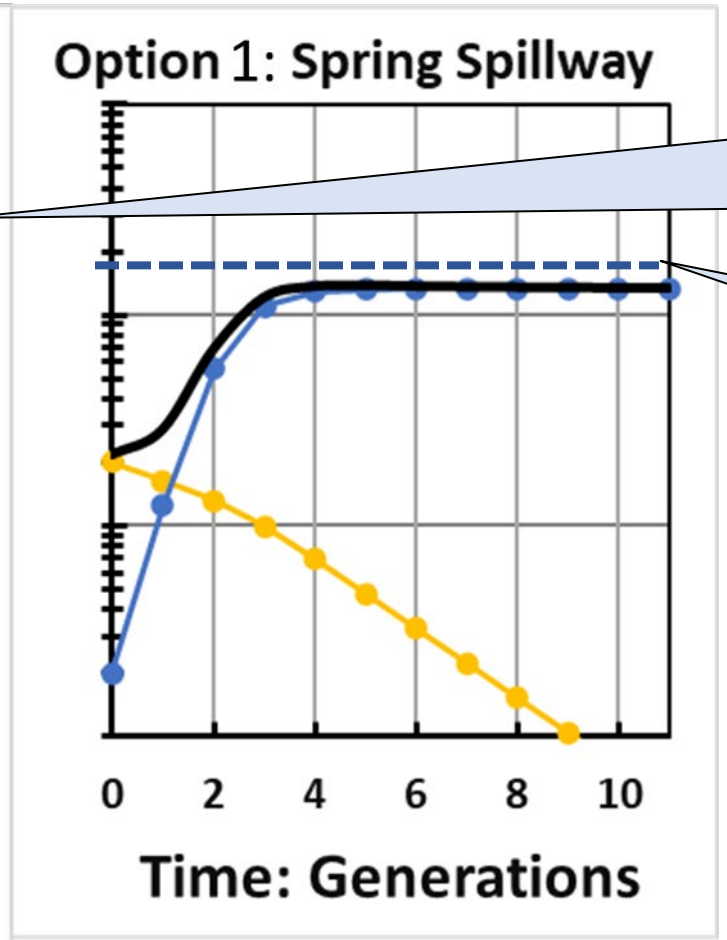
Option 5: Fall Drawdown

- **Spring** –**10%** passage efficiency
  - Low Winter elevations makes spillway use less likely,
- Summer – Reservoir survival may be low
- **Fall** – **90%** passage efficiency
  - Good passage for age-0 movers –

Recovery Trajectories: Two Life History Types X Two Passage Options

- Drawdown favors Movers ---------- (limited by spawning area)
- Spring spillway release favors Stayers - (limited by juvenile rearing area)



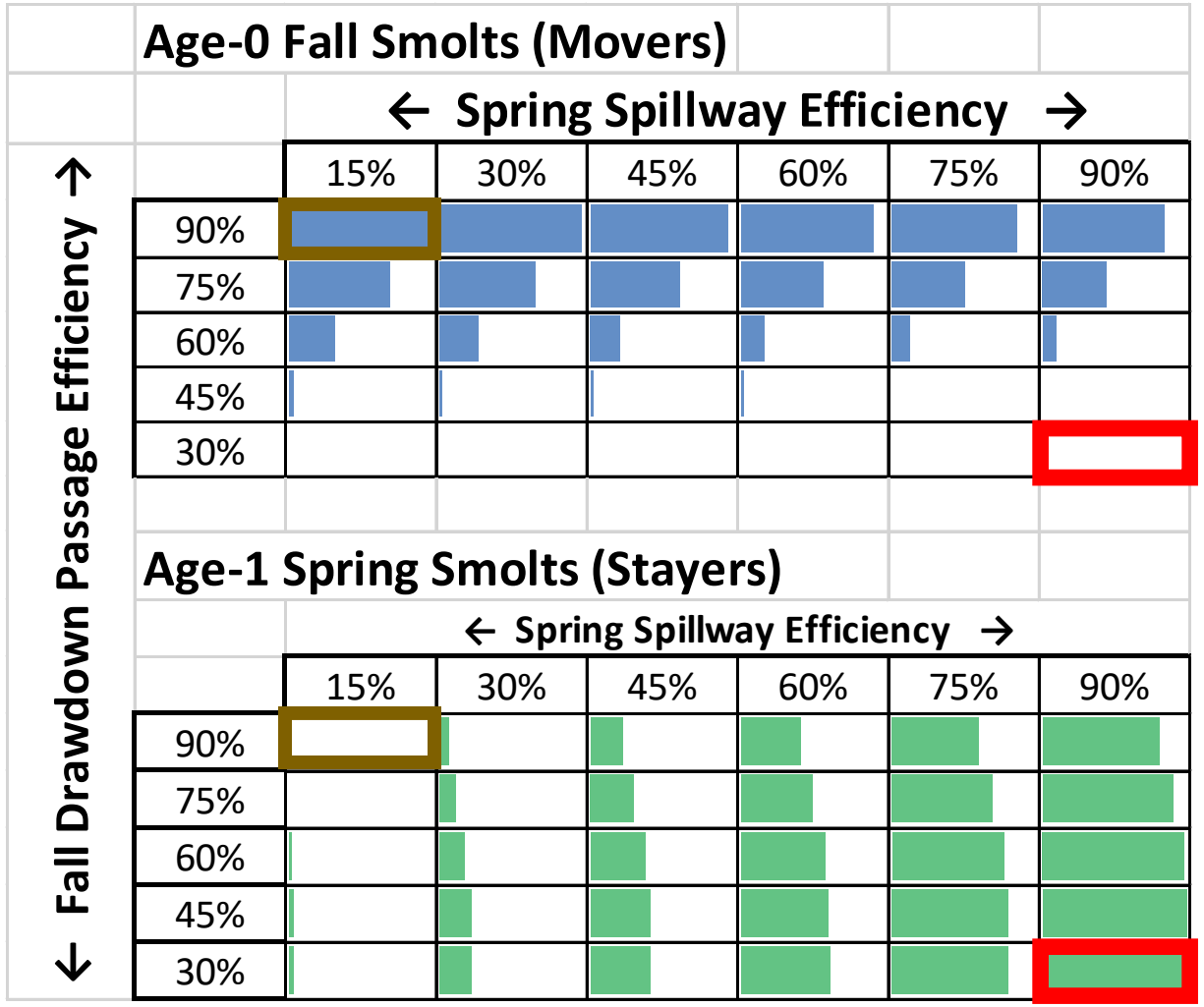


Population limited by a capacity of 2000 successful spawners – (Excess spawners represent a harvestable surplus)

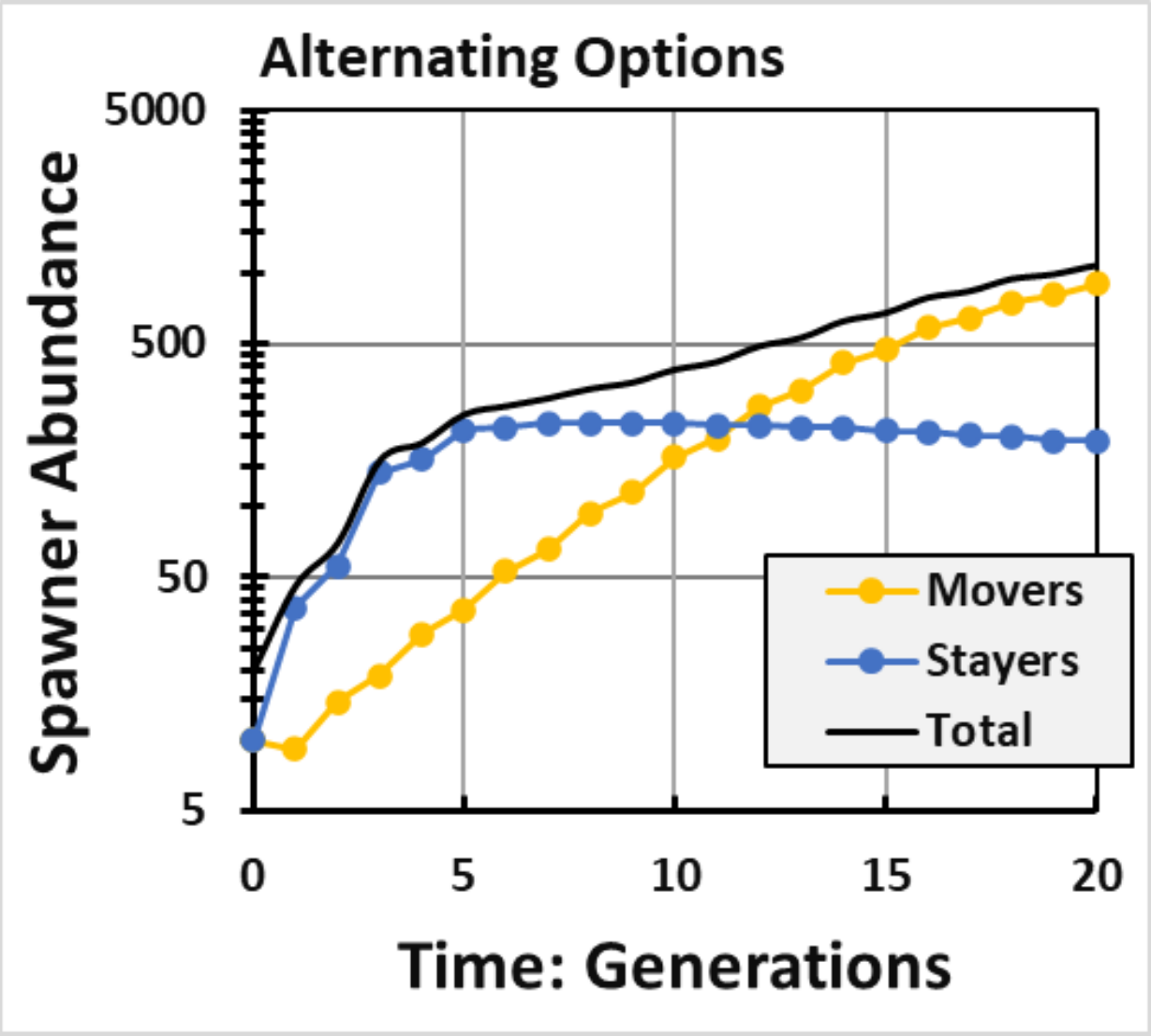
Population limited by a capacity of 100,000 spring migrants (equivalent to 807 spawners)

Two Life History Types X Two Passage Options

- More generally: **Equilibrium spawner abundance** of both LHTs varies with the efficiency of the passage option
- **Option 1: Assumed spring spillway efficiencies that favors Stayers**
- **Option 5: Assumed fall drawdown efficiencies that favors Movers**
- Substantial uncertainty in these passage efficiencies and reservoir survival



Two Life History Types X Two Passage Options



- Option1 and Option 5 in Alternate Years sustain both LHTs
- The more productive LHT builds rapidly but declines as competition for spawning area builds

Summary: Passage and Conservation of LHTs

1. Passage options will often favor certain LHTs
2. More than one passage option may be required to conserve LHTs
3. A variety of uncertainties need to be incorporated into the decision model
4. The Baseline and Drawdown Options are more difficult to evaluate
   - FSS and FSC options can provide data on size, time and numbers of downstream migrants

Source of LHT strategy is important

1. LHTs driven by behavior
   - Permanent loss of LHTs is not an issue if heritability is very low
   - Displacement behavior means that Stayers dominate at low density, Movers at high density
2. LHTs with strong genetic component
   - LHTs present in the source population may be poorly adapted to reservoir passage
   - Selection for fewer LHTs may be inevitable (e.g. Fall Cr. Selects for movers)

Acknowledgments

- Oregon Department Fish and Wildlife
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