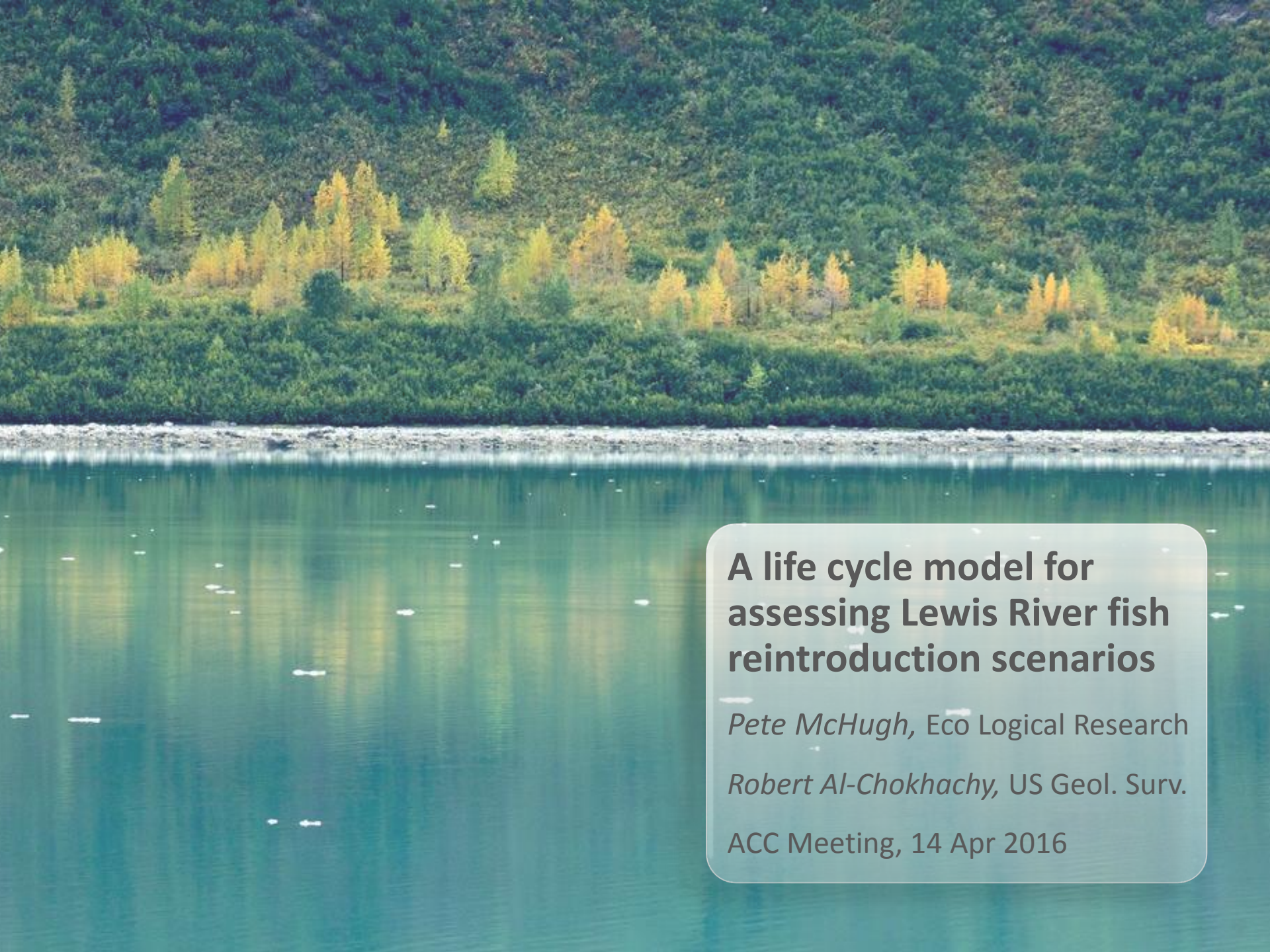

A life cycle model for assessing Lewis River fish reintroduction scenarios

Pete McHugh, Eco Logical Research

Robert Al-Chokhachy, US Geol. Surv.

ACC Meeting, 14 Apr 2016

Presentation outline

- Overview of life cycle model (LCM) framework:
  - Model structure
  - Base parameterization & simplifying assumptions
  - Simulation procedures
- Assessing management scenarios:
  - Juvenile and adult passage
  - Supplementation strategies
  - Criteria for evaluating performance
- Example application (very rough)
  - Juvenile Chinook collection efficiency & adult release
- Where to from here?

Optimal Stock Size and Harvest Rate in Multistage Life History Models

Elie Moussalli and Ray Hilborn[1]

Institute of Animal Resource Ecology, University of British Columbia, Vancouver, B.C. V6T 1W5

The Shiraz model: a tool for incorporating anthropogenic effects and fish–habitat relationships in conservation planning

Mark D. Scheuerell, Ray Hilborn, Mary H. Ruckelshaus, Krista K. Bartz, Kerry M. Lagueux, Andrew D. Haas, and Kit Rawson

A quantitative framework for the analysis of habitat and hatchery practices on Pacific salmon

Rishi Sharma[a,*], Andrew B. Cooper[b,1], Ray Hilborn[c]

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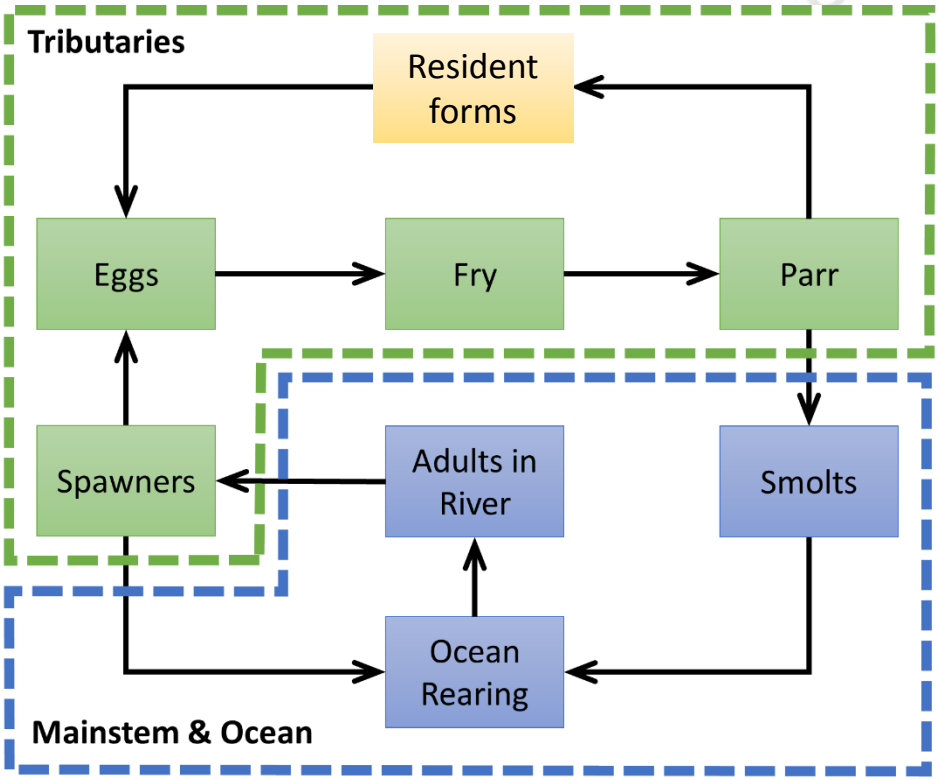
A quantitative framework for the analysis of habitat and hatchery

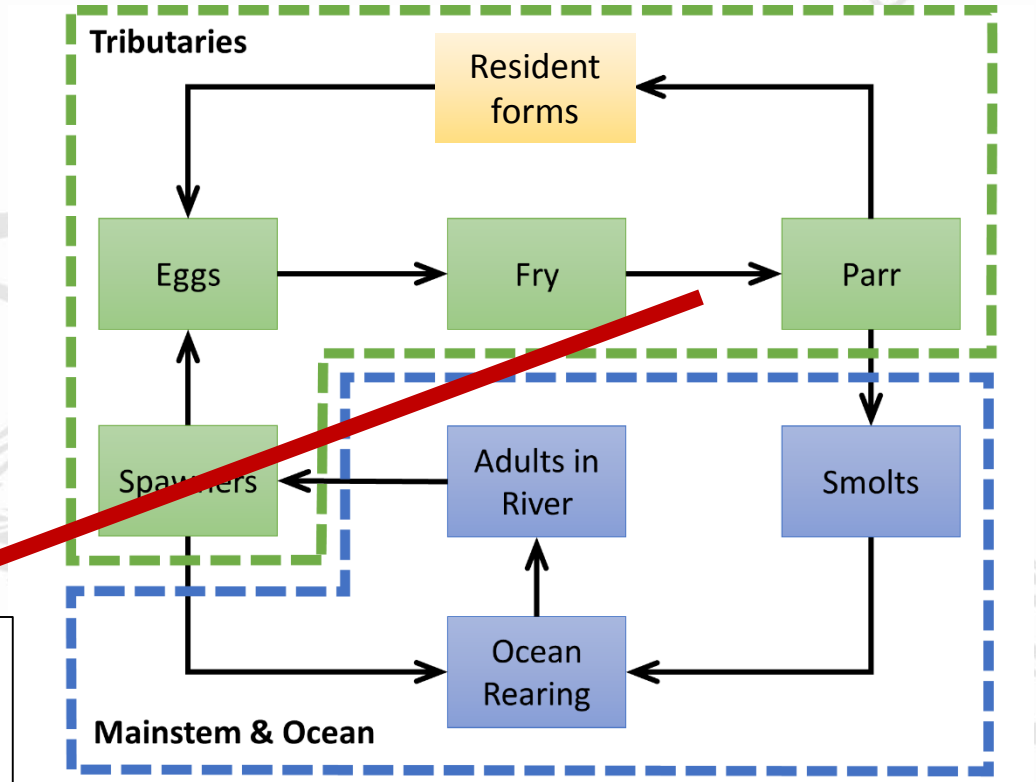
S.P. Cramer & Associates, Inc. **Salmon PopCycle Model Structure**

APPENDIX B: SALMON POPCYCLE MODEL STRUCTURE

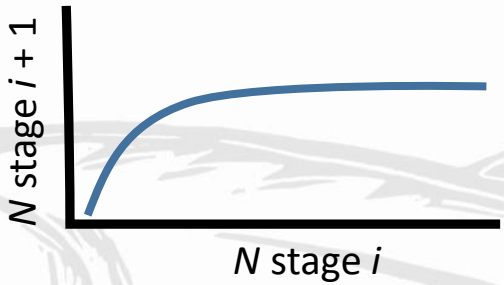


Juvenile *O. mykiss*

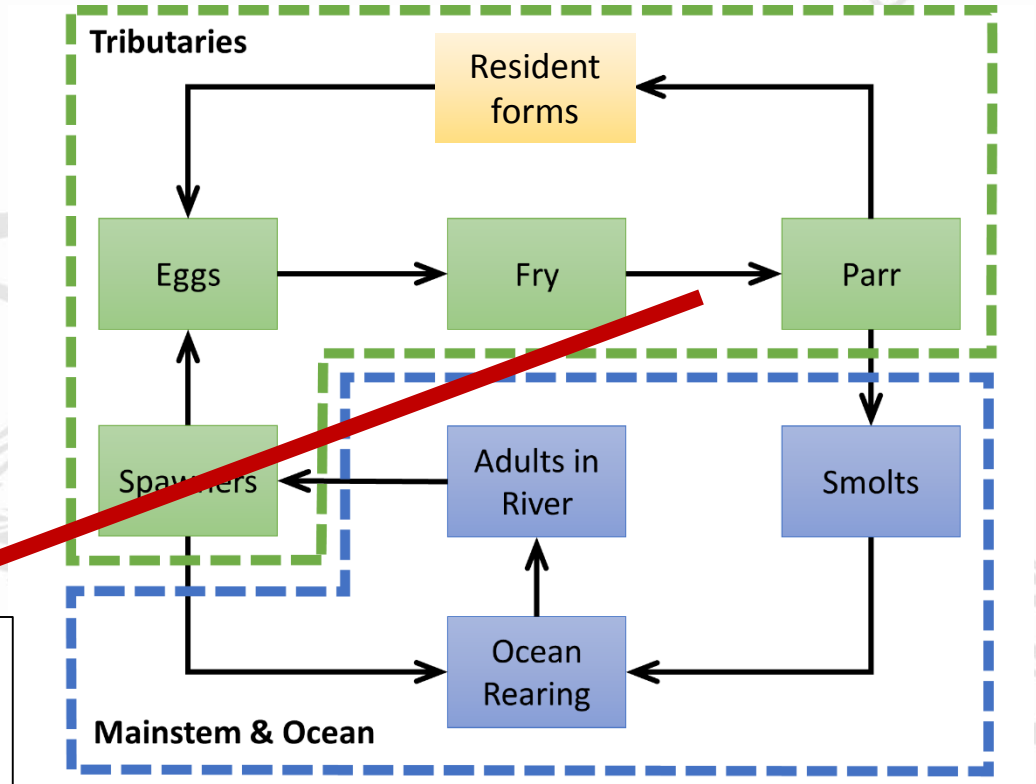
Adult steelhead



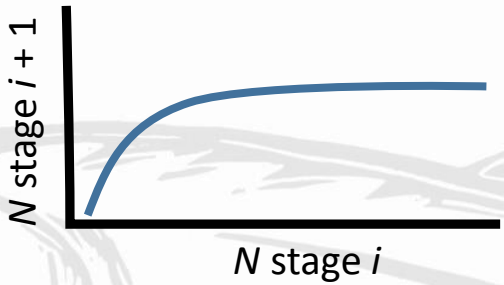
S_i = realized survival, fxn of stage-specific productivity & carrying capacity parameters (Beverton-Holt form)



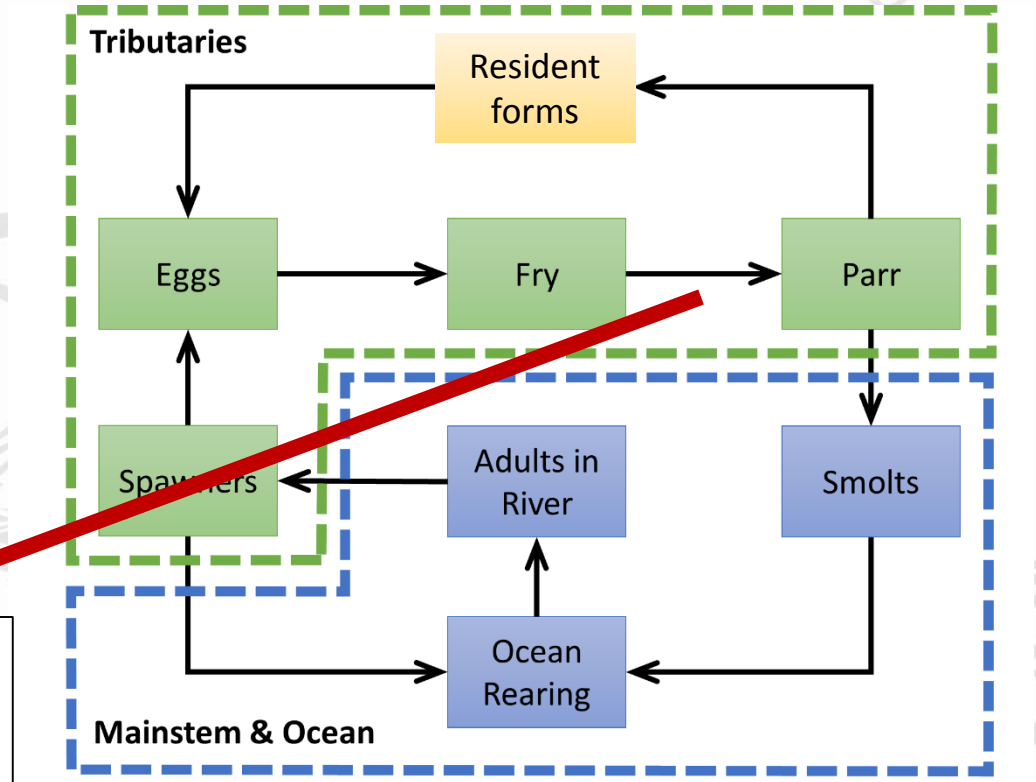
$$N_{i+1} = \frac{N_i}{\frac{1}{prod.} + \frac{1}{capacity} N_i}$$



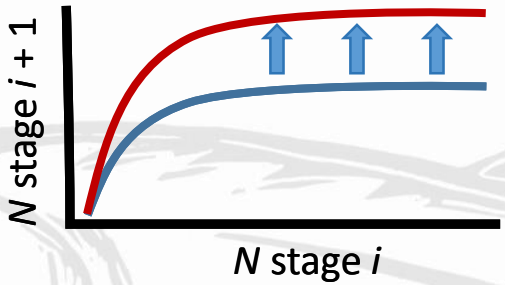
S_i = realized survival, fxn of stage-specific productivity & carrying capacity parameters (Beverton-Holt form)



$$N_{i+1} = \frac{N_i}{\frac{1}{prod.} + \frac{1}{capacity} N_i}$$

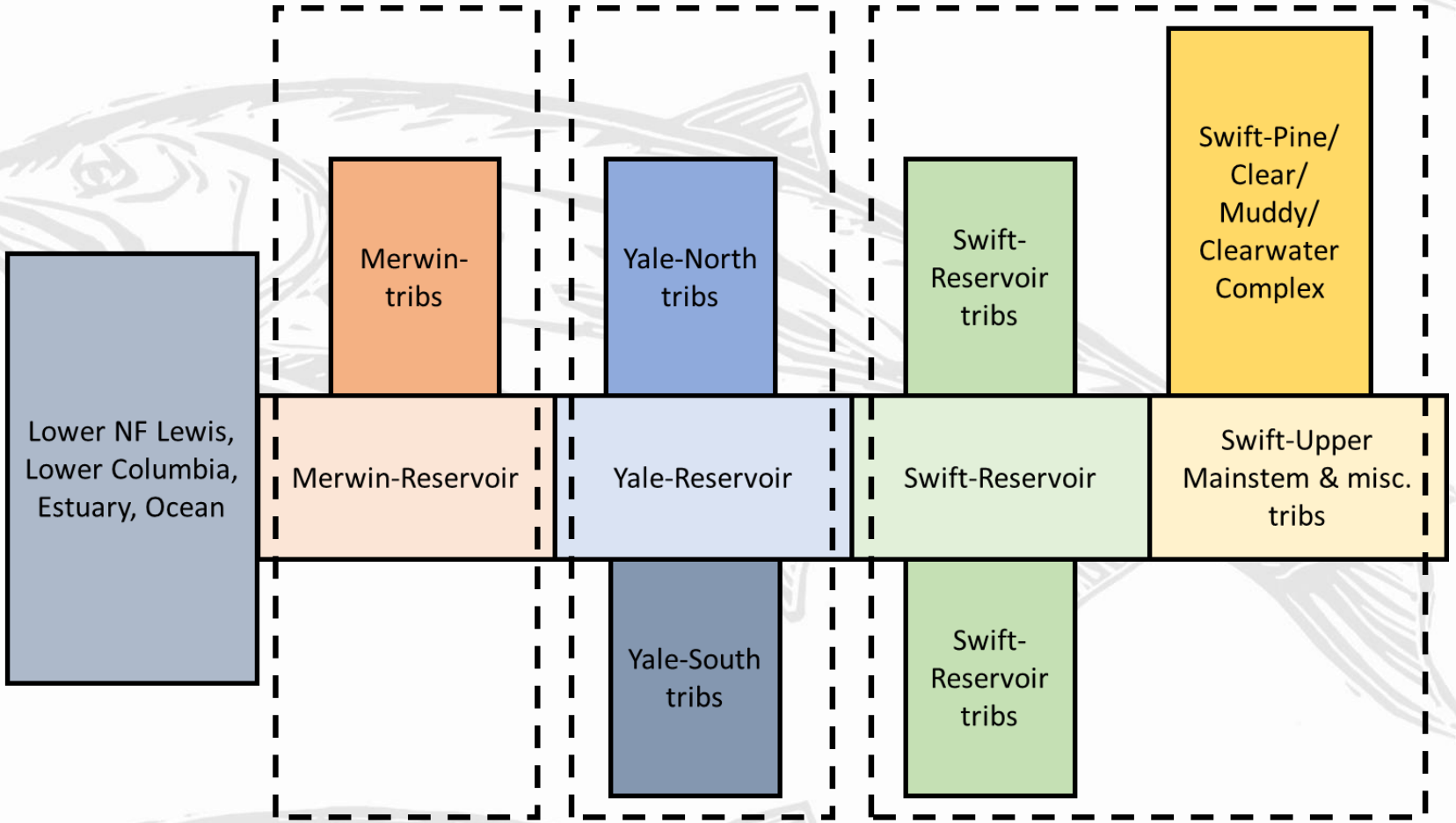


S_i = realized survival, fxn of stage-specific productivity & carrying capacity parameters (Beverton-Holt form)



$$N_{i+1} = \frac{N_i}{\frac{1}{prod.} + \frac{1}{capacity} N_i}$$

Spatial structure for NF Lewis



Other LCM features

- Separately tracks hatchery- and natural-origin fish
  - Model H/N fitness differential (survival, fecundity,…)
  - Model range of supplementation strategies
- Allows for anadromous and resident forms
  - Steelhead & resident *O. mykiss*; landlocked salmon
- Can model gender-specific life history expression
  - Earlier maturation by males, male-biased residency
- Biological realism has a cost -> plausible estimates needed for additional life history parameters
- Parameters vary stochastically & can have time trends

Base model parameterization (draft)

Freshwater survival

- Egg incubation: EDT
- Fry colonization: EDT
- Parr-to-smolt *S*: EDT
- Outmigration survival** (*Reservoir Surv + CE*): performance standards, or hypothetical values

Freshwater capacity

- Spawner/egg: EDT
- Fry: infinite (?)
- Parr: EDT, other reservoir approaches
- Smolt: infinite (?)

Base model parameterization (draft)

Adult prod. & capacity

- SARs: hatchery with N/H adjustment
- Adult CE: performance standards
- Pre- and post-spawn mortality: EDT or lit
- Ocean capacity: taken as infinitely large (?)

Other model parameters

- Emig. & mat. probabilities
- Fecundity
- Fishery impacts
- Prob. of residency
- Inter-pop'n movement
- Supplementation rules
- Fitness differentials
- Level of stochastic noise

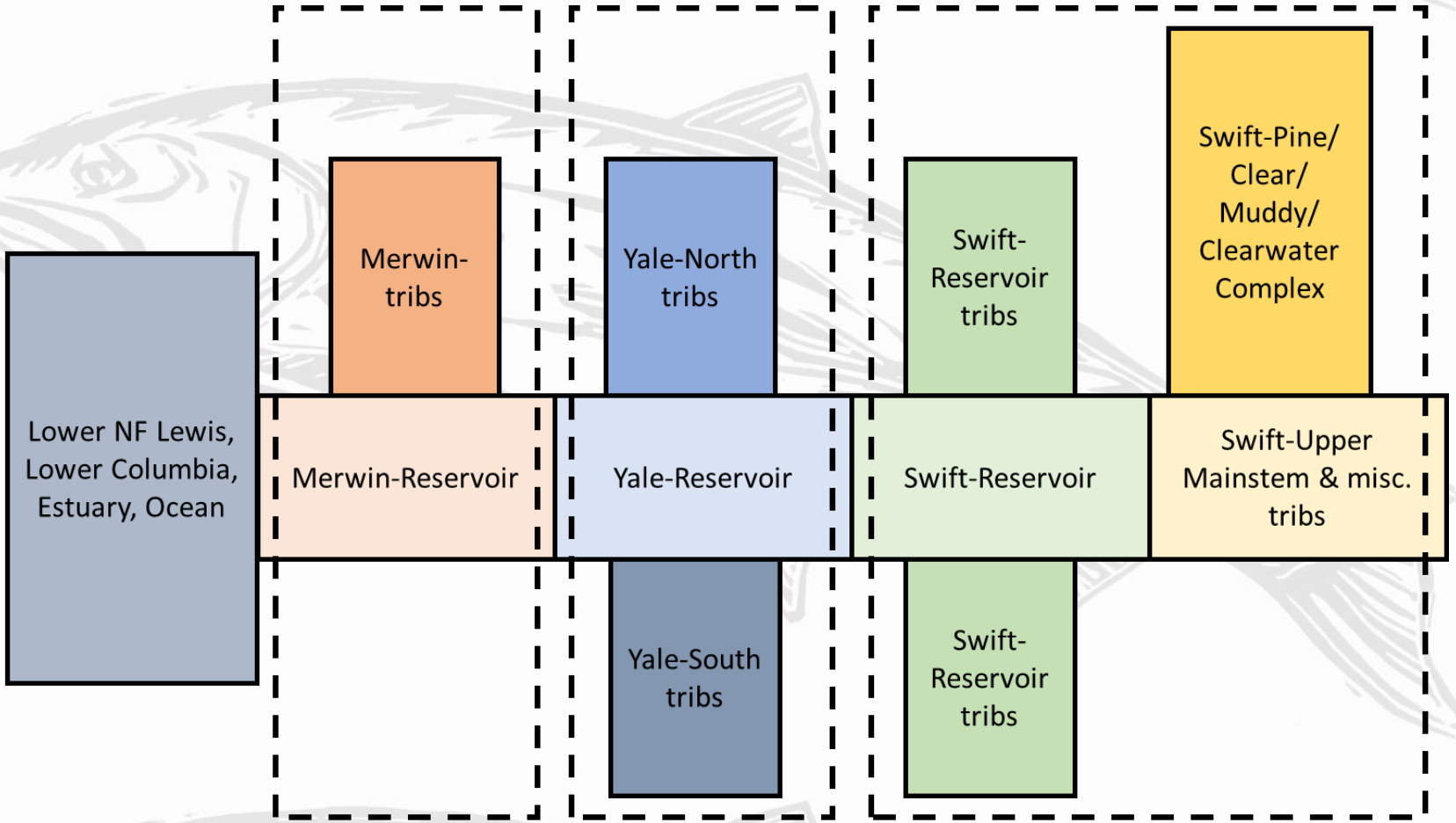
Simulation/implementation specs

- Coded in R and takes inputs that can be prepped in Excel (.csv) templates; produces .csv outputs files:
  - Pros: freely available platform; stats/graphics options
  - Cons: it can be slow for complex runs
- Stochasticity can be added for select parameters:
  - Mostly beta-dist'd random variables
  - Random run-to-run variation (i.e., replicates)
  - Random temporal within-run variation
- User specified N of Monte Carlo reps
- Metrics for summarizing outputs – the sky's the limit

Example application: spring Chinook

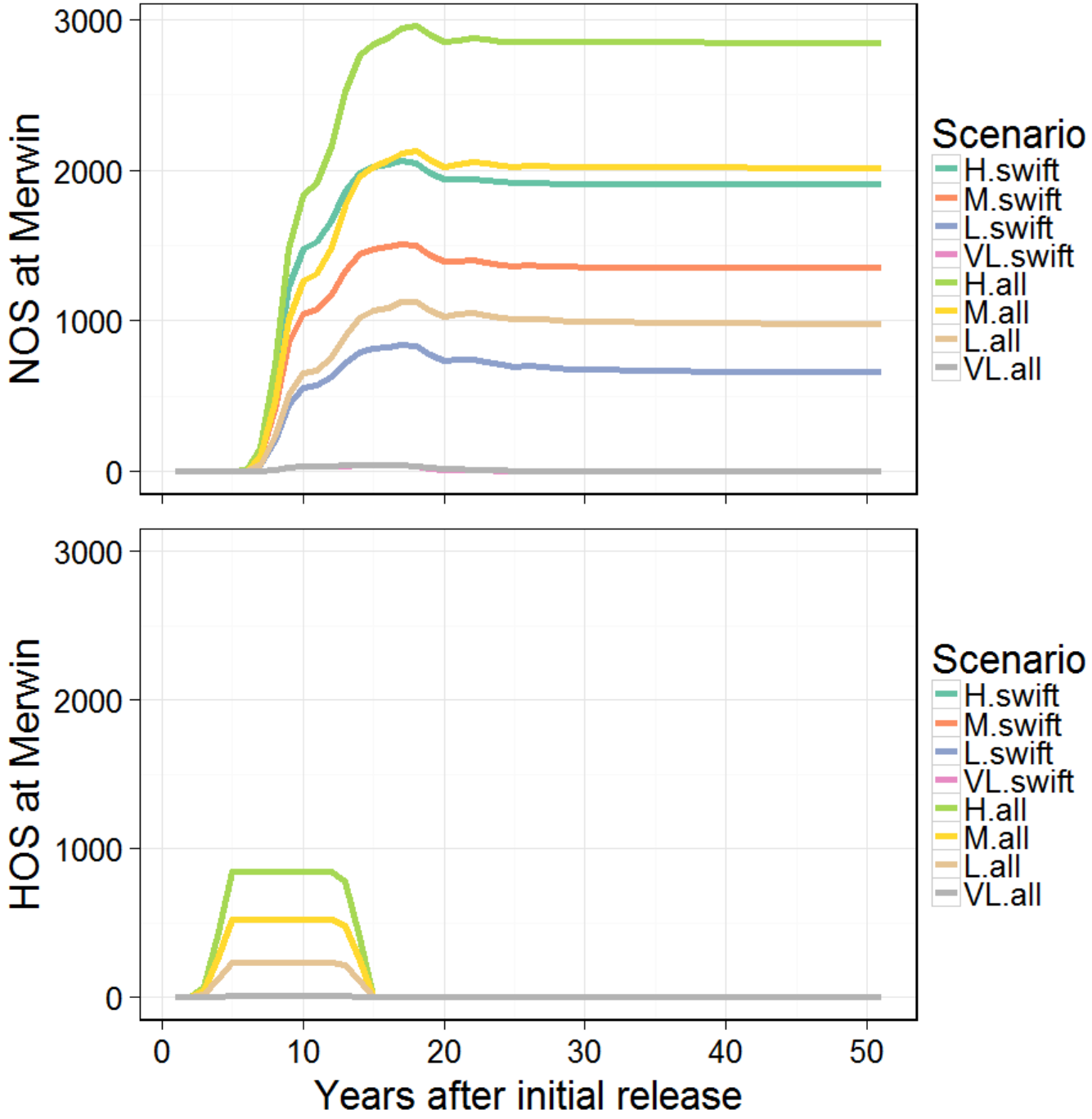
- **Key question:** how do different passage (juvenile) & adult release (destination) strategies affect reintroduction success?
- Modeled scenarios:
  - 100,000 smolts released for 10 years above Swift (67/33)
  - Smolt collection efficiency:
    - Very low (10%), low (50%), moderate (75%) and high (95%)
  - Adult transport strategies (returns from juvenile releases):
    - Release all adults above Swift
    - Release adults into each reservoir in proportion to capacity
- Monitor population performance for 50 years
- Deterministic & stochastic runs (N = 25 replicates)

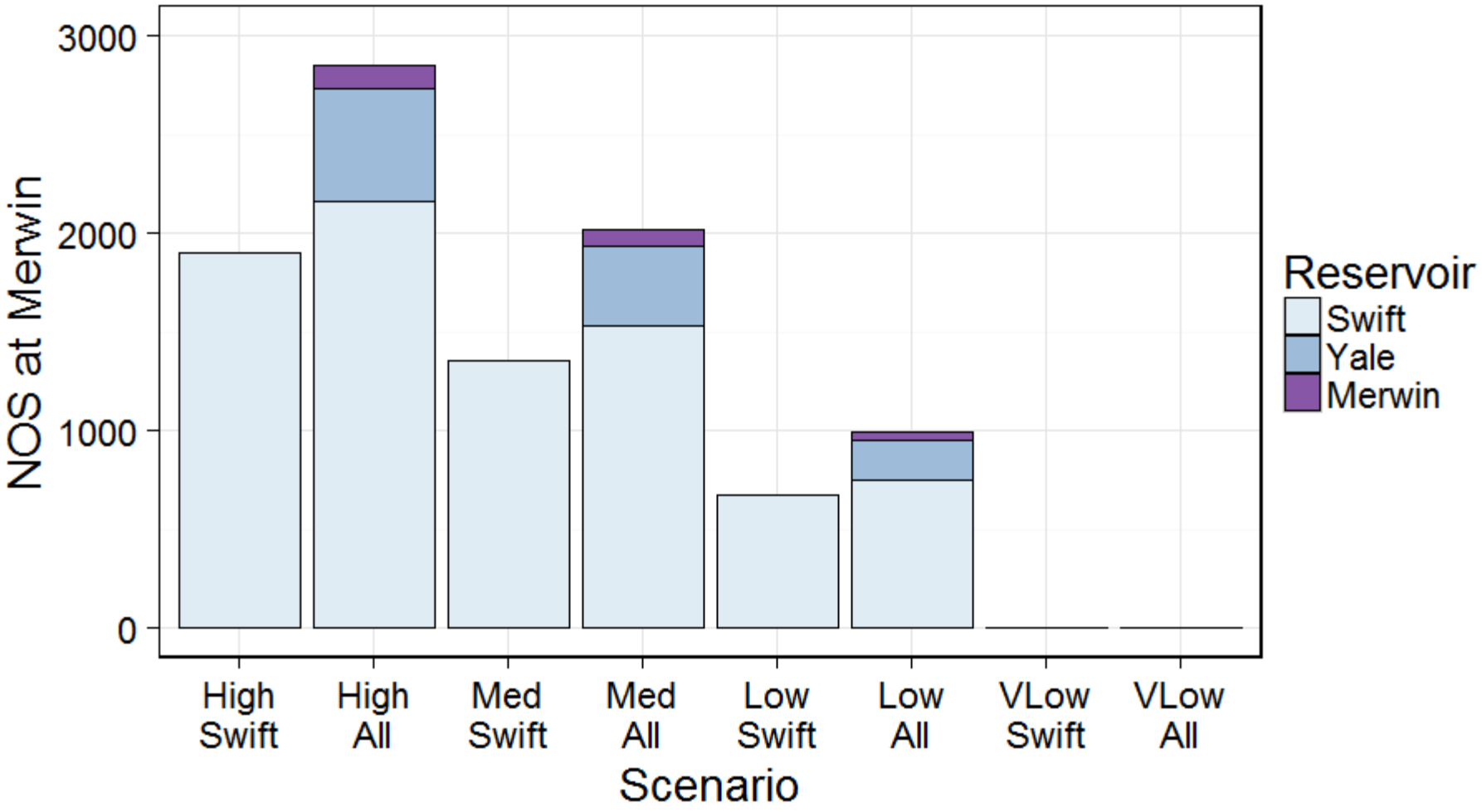
Spatial structure for NF Lewis

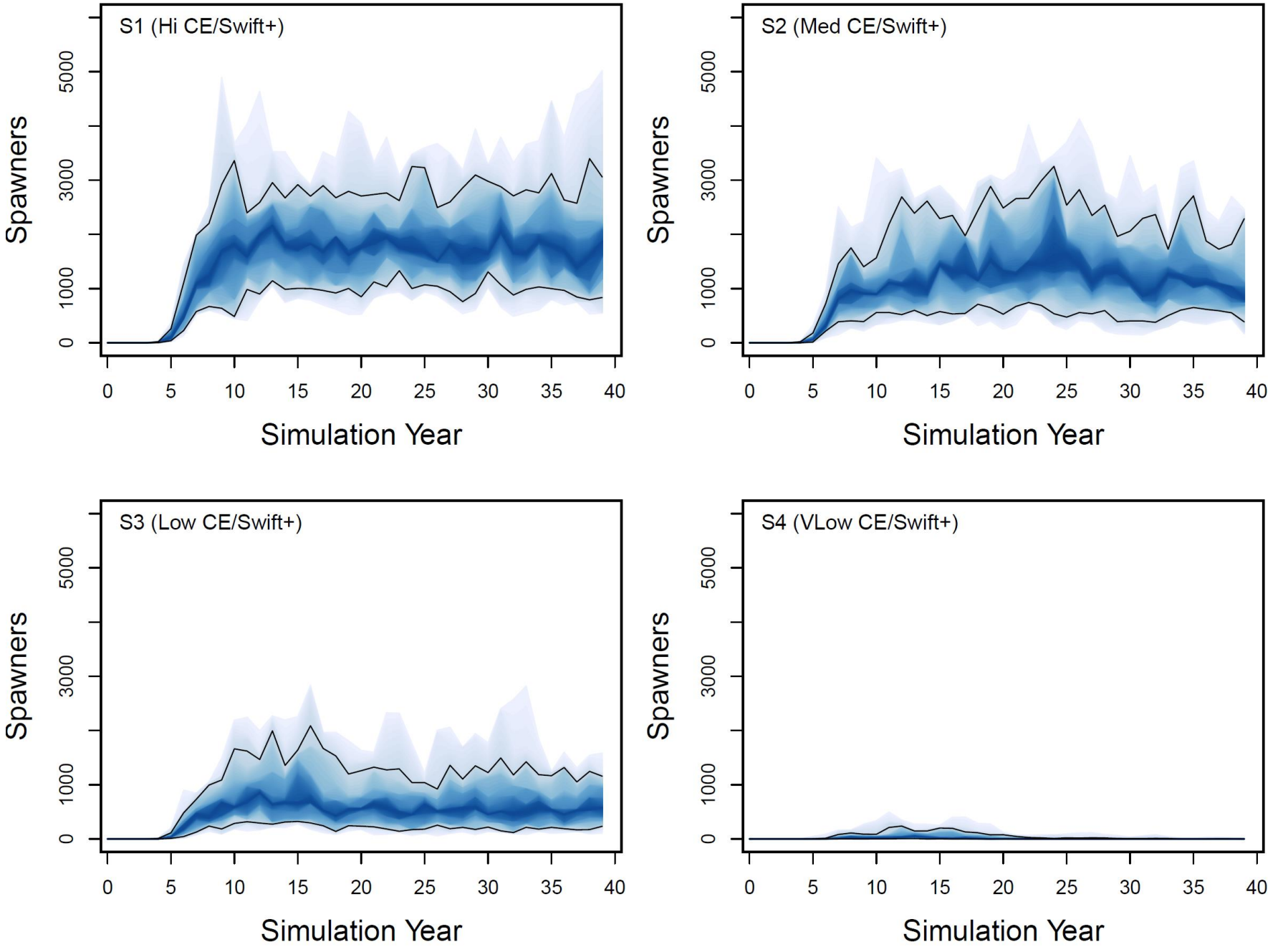


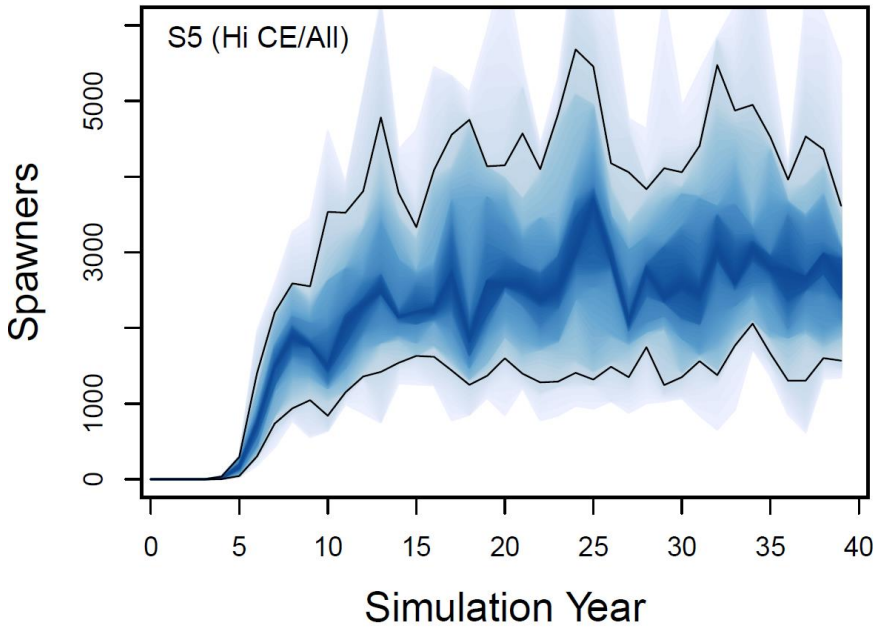
Important parameter assumptions

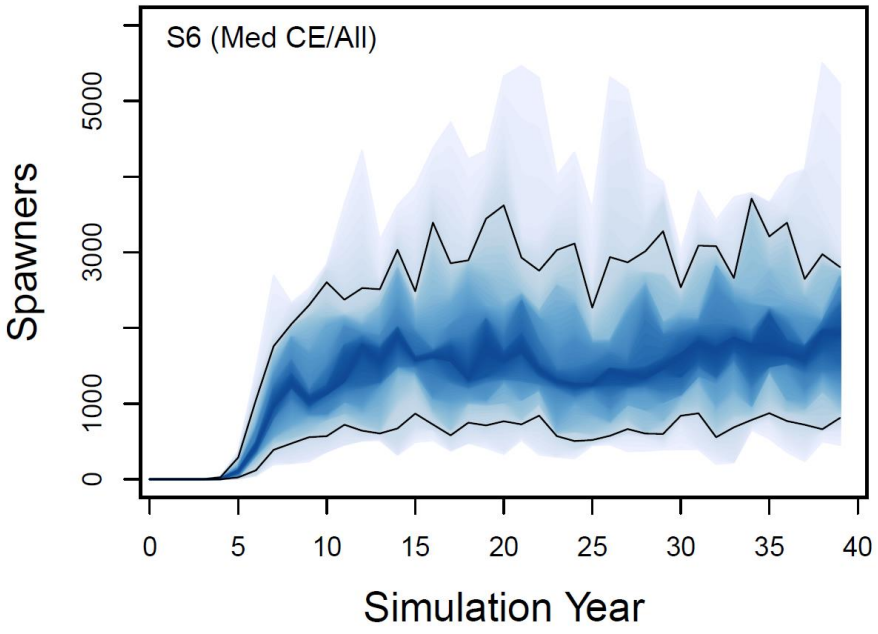
- **Caveat:** these runs are mostly for demonstration, placeholders were used for several parameters
- Freshwater survivals (incl. CE) are spatially uniform & generally optimistic (*this will change*)
- Adult and juvenile capacities are pop'n specific
- Juveniles & adults have 100% fidelity to release sites across life stages (*this will change*)
- Hatchery fitness = natural fitness (*this can change*)
- Contribution of through-dam fish = negligible
- Marine survival is very influential & lower than what's been assumed in past modelling (*this may be real*)

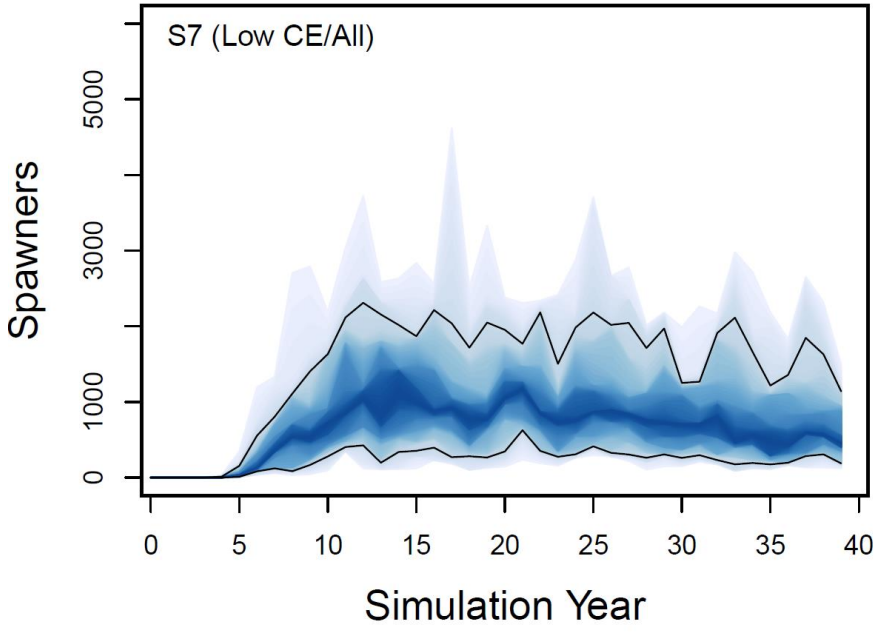

NOS at Merwin
3000
2000
1000
0
Scenario
H.swift
M.swift
L.swift
VL.swift
H.all
M.all
L.all
VL.all
HOS at Merwin
3000
2000
1000
0
Scenario
H.swift
M.swift
L.swift
VL.swift
H.all
M.all
L.all
VL.all
0
10
20
30
40
50
Years after initial release

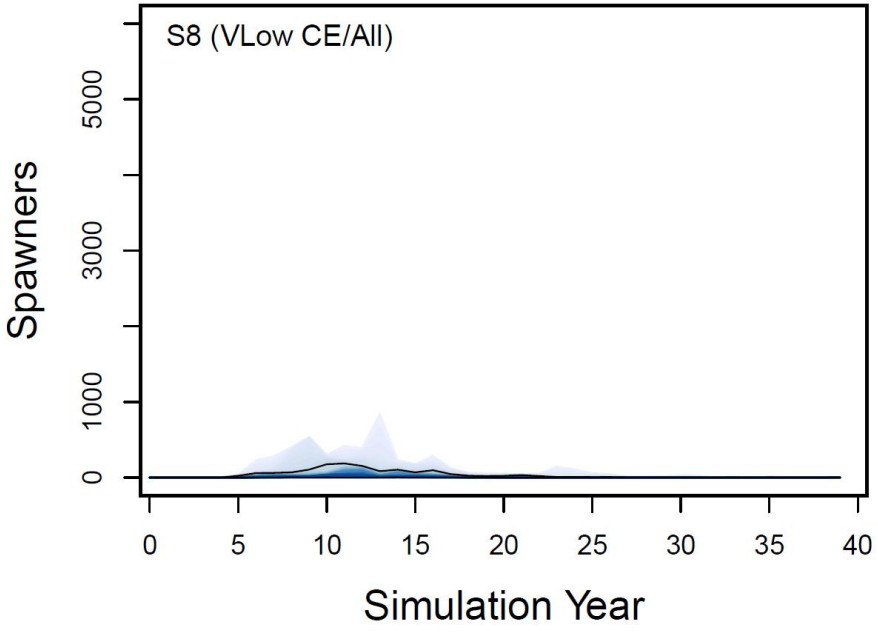

3000
2000
1000
0
NOS at Merwin
High Swift
High All
Med Swift
Med All
Low Swift
Low All
VLow Swift
VLow All
Scenario
Reservoir
Swift
Yale
Merwin

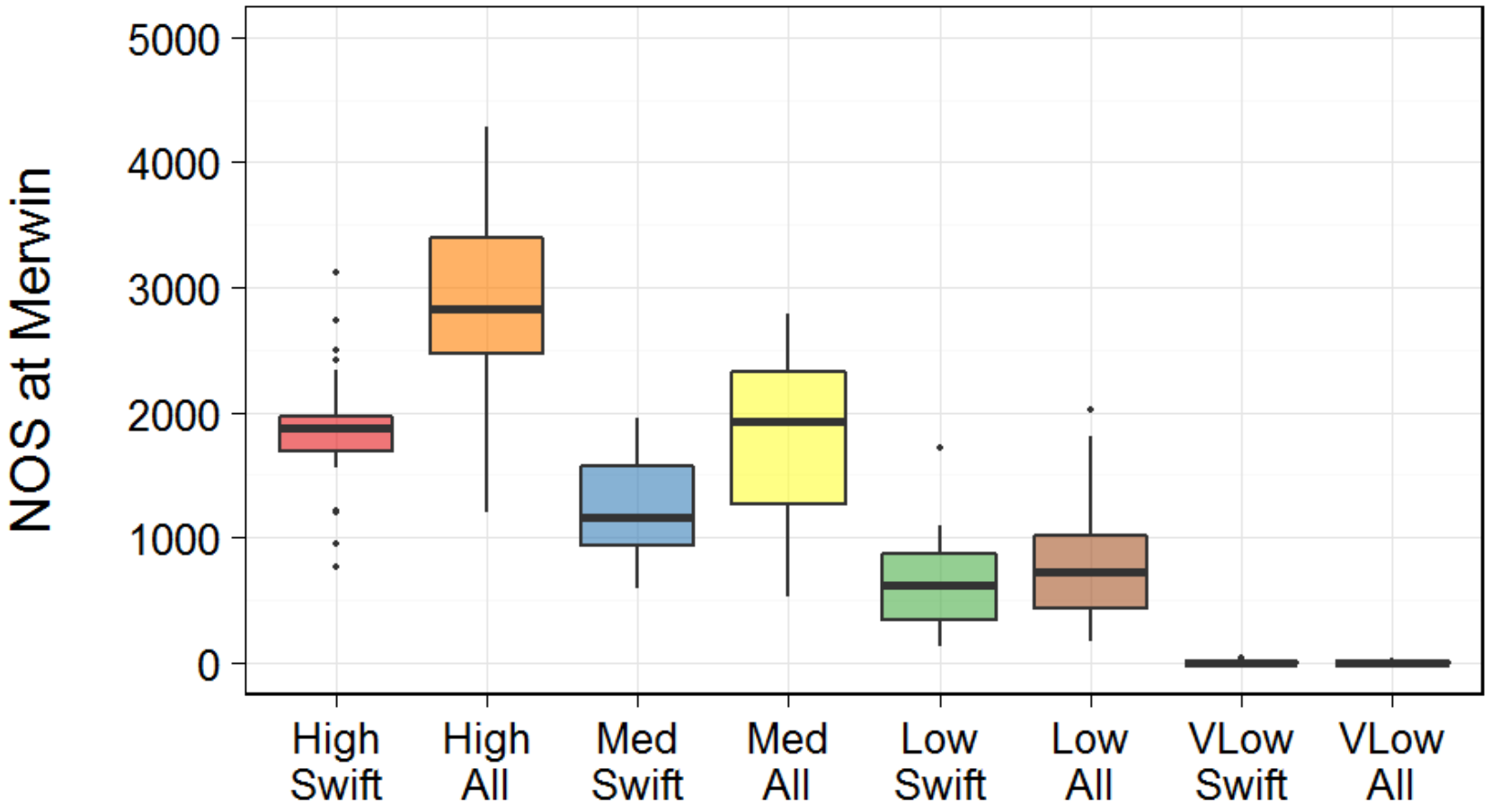

S1 (Hi CE/Swift+)
S2 (Med CE/Swift+)
S3 (Low CE/Swift+)
S4 (VLow CE/Swift+)
Spawners
Simulation Year
0
1000
3000
5000
0
5
10
15
20
25
30
35
40


S5 (Hi CE/All)
Spawners
0
1000
3000
5000
0
5
10
15
20
25
30
35
40
Simulation Year


S6 (Med CE/All)
Spawners
0
1000
3000
5000
0
5
10
15
20
25
30
35
40
Simulation Year


S7 (Low CE/All)
Spawners
0
1000
3000
5000
0
5
10
15
20
25
30
35
40
Simulation Year


S8 (VLow CE/All)
Spawners
0
1000
3000
5000
0
5
10
15
20
25
30
35
40
Simulation Year


NOS at Merwin
5000
4000
3000
2000
1000
0
High Swift
High All
Med Swift
Med All
Low Swift
Low All
VLow Swift
VLow All

Initial insights & next steps

- **Caveat:** these runs are mostly for demonstration, placeholders were used for several parameters
- Optimistic survivals + low CE = no establishment (there's little chance this result will change)
- Multi-reservoir adult releases yields a higher return (to Merwin) and spreads risk…realistic assumptions?
- **Next steps:**
  - Finalize inputs & modelling decisions
  - Set models up for coho and steelhead
  - Construct final list of scenarios of interest to ACC
  - Run all and prepare report