PRODUCTIVITY DYNAMICS IN SPRING-RUN CHINOOK SALMON IN ADJACENT DAMS

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Background

- It is intuitive to assume that adjacent stocks have similar productivity
- Fall Creek (FC), for example, seems to have a self-sustaining population of Chinook salmon during the past decade compared with (the adjacent) DEX-LOP dam.
- FC has a more effective dam passage and likely more limited migratory groups (e.g., fry and subyearling). While the DEX-LOP dam has more migratory groups but less effective dam passage.

Background

- Juveniles in the FC and DEX-LOP Dam reservoirs reach large sizes, but the reservoir survival seems to be better at FC.

- FC has a lower reach capacity (e.g., spawners or eggs) and high PSM compared with DEX-LOP Dams.

Question/hypothesis

- There are factors that are limiting population increase. The dam passage is an important factor, but there are others too (e.g., smolt-to-adult survival (SAS), and PSM)
- It is important to consider them all to design recovery strategies.
- Is reservoir survival or PSM key to maintaining a self-sustainable wild population?

Approach

- A life-cycle model (LCM) might help understand these questions.

- Typically, simulation models with stochastic parameters (including uncertainty) are used to answer these questions.

- Simulation models might not capture the past/future population dynamics because the future/projected dynamics are conditioned by the input parameters.

Approach

- A different approach is "reconstructing" the population dynamics using the available time series. In fisheries, the "stock assessment" approach.

- This approach not only reconstructs the [past] population dynamics but also provides estimates of key population parameters for recovery and projections.

Approach

- Multistage Beverton-Holt model (msBHM) (Moussalli & Hilborn, 1986). Typically, it is used as a simulation model with stochastic parameters to include uncertainty.

$$N_{s+1} = \frac{N_s}{\frac{1}{p} + \frac{1}{c} N_s}$$

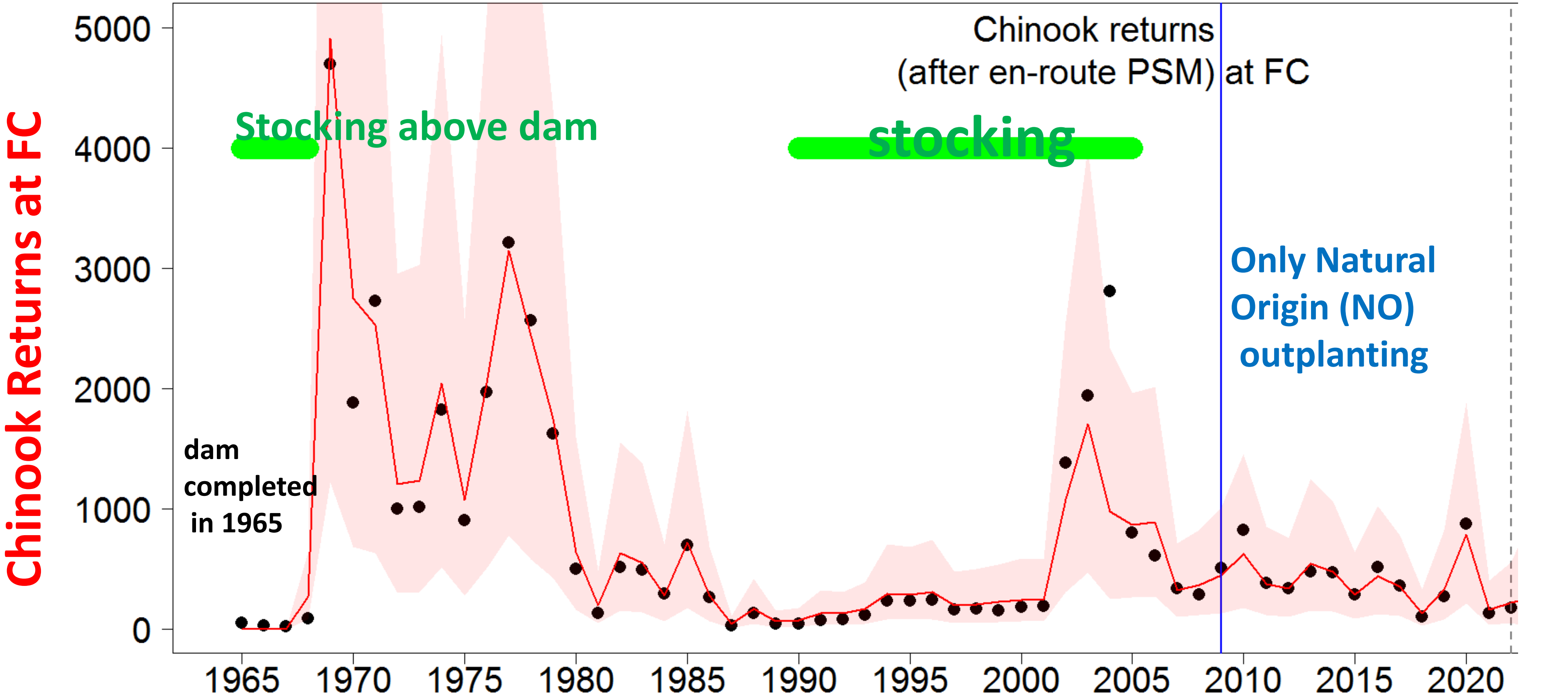
where N_{s+1} are the individuals alive at the life stage *s*, *p* is the productivity or survival rate from *s* to *s* +1, and *c* is the capacity for the life stage *s.*

- The model can include as many stages as required.
- We used the msBHM as a statistical model to predict available time series of data (chinook adults at dam, juvenile stocking above dams, PSM and redd estimates).
- We estimated key population parameters (annual smolt-to-adult survival (SAS), and PSM).

Data

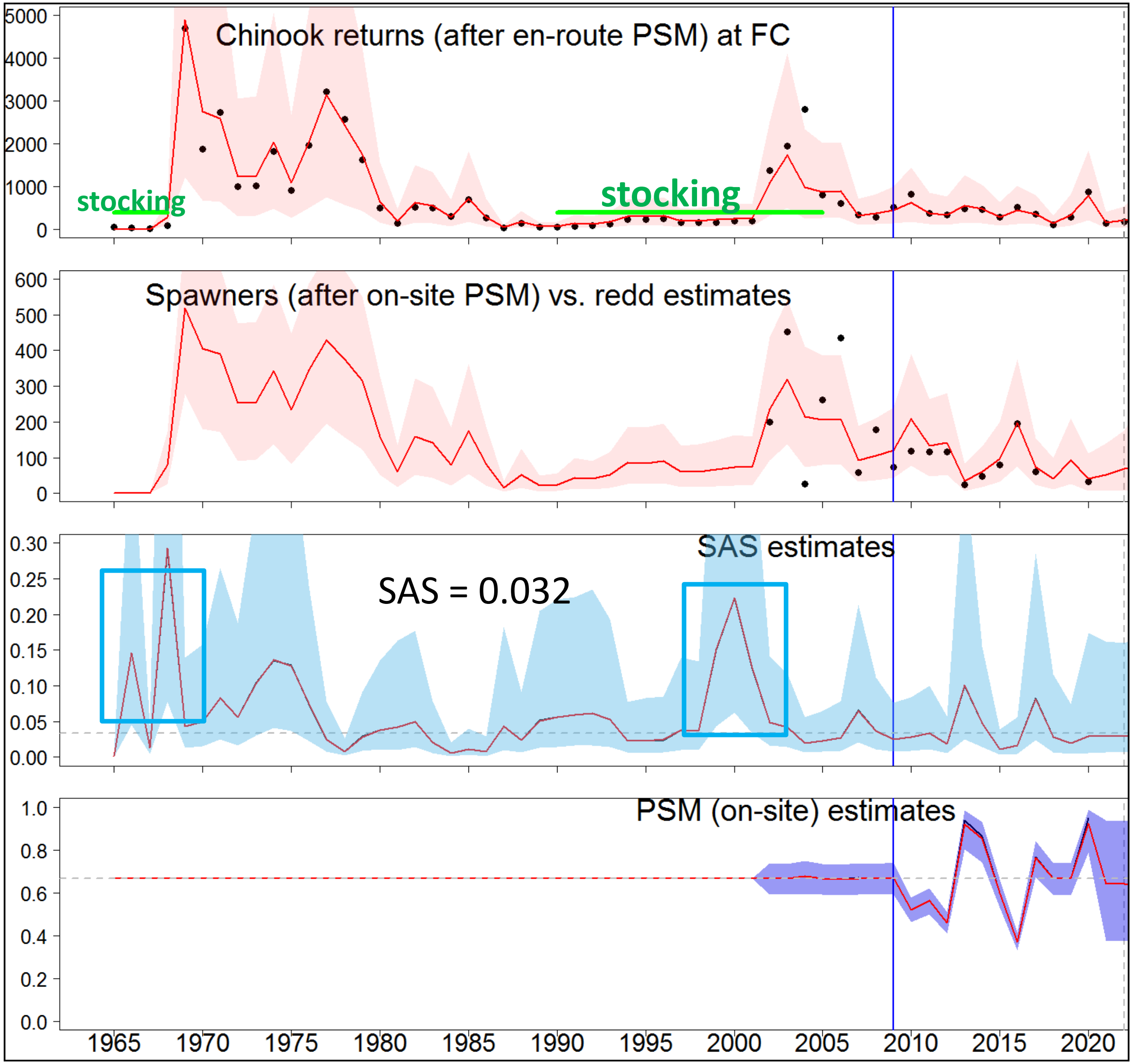
Data	Years
Total adult returns	1965-2022
Redd counts expanded to Fall Creek	2002-2017
Juvenile stocking above Fall Creek	1965-1968; 1990-2005
Adults outplanting	1998-2021
Priors	
Smolt-to-adult survival (SAS) prior distribution	Based on Cormack-Jolly-Seber (CJS) model (for FC)
PSM prior distributions (Above-dam)	Based on Fall Creek data (O'Malley 2017)

Model fit



- After the stocking in 1965, the FC population showed a significant/abrupt increase
- Old reports mentioned drastic drawdowns (1968-1976). But the reservoir evacuation changed in 1977 to a less effective dam passage.
- The stocking program was resumed in 1990, but the population did not respond
- The reservoir evacuation possibly changed around 1999 (no records/reports)
- Stocking shows that the FC reservoir has high reservoir survival.

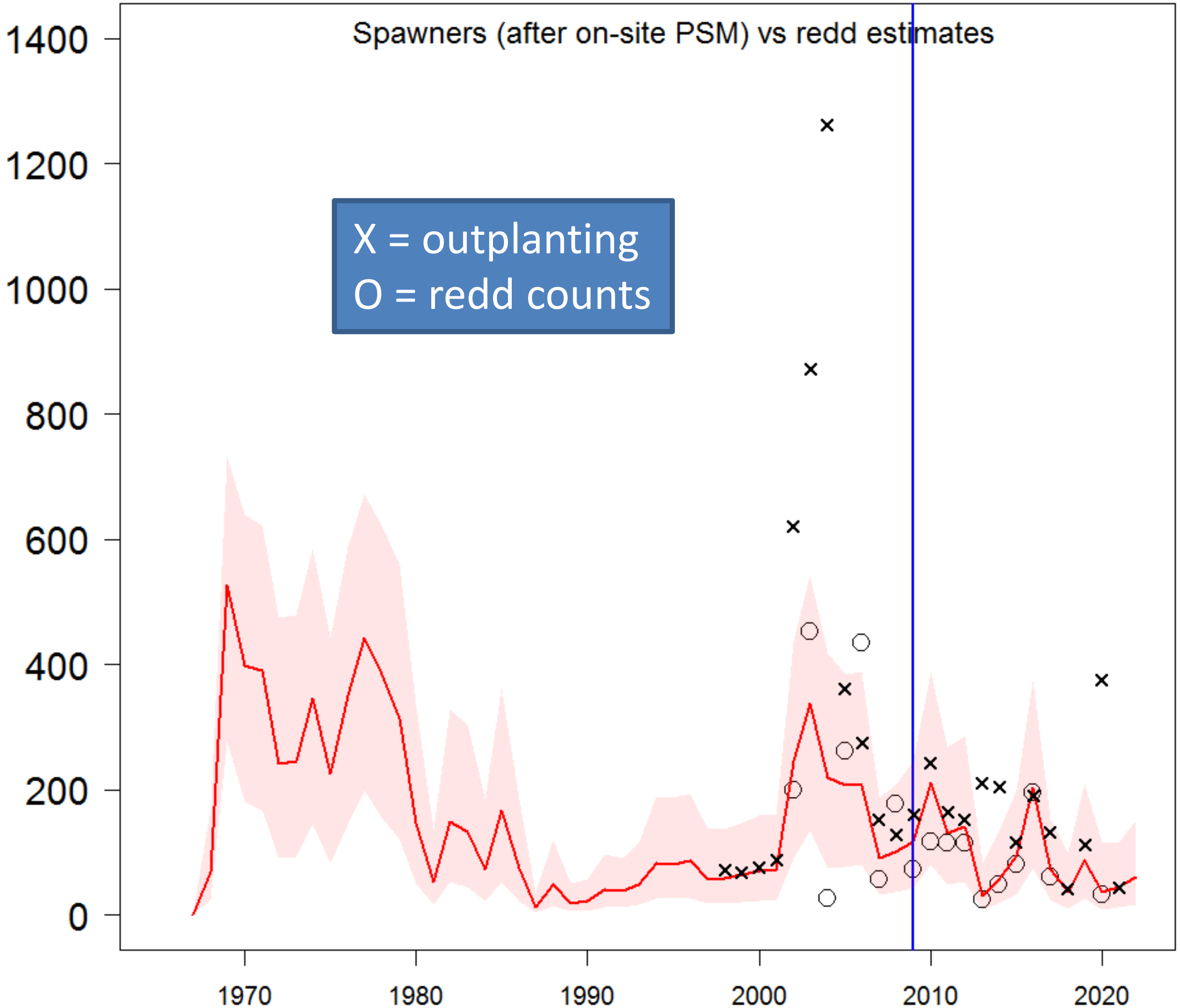
Model fit (in progress)



better fit after 2009

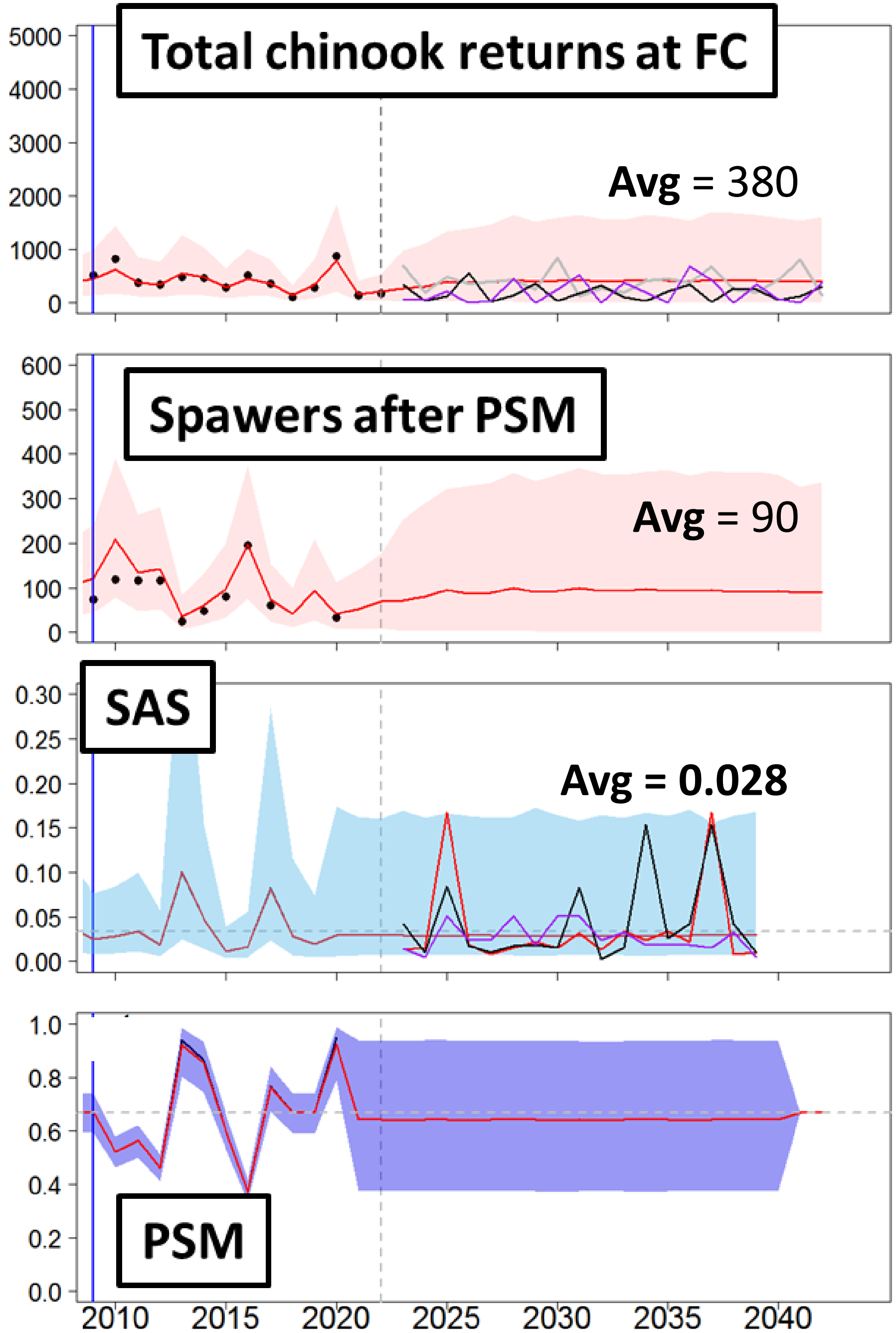
SAS shows period of high values due a combination of stocking and effective dam passage

Model validation?



- In some years, significant differences between outplanting and redd counts, indicating high PSM above dam
- Note: outplantings are not included in the model estimation
- The model predicts outplanting adjusted for PSM

Model projections

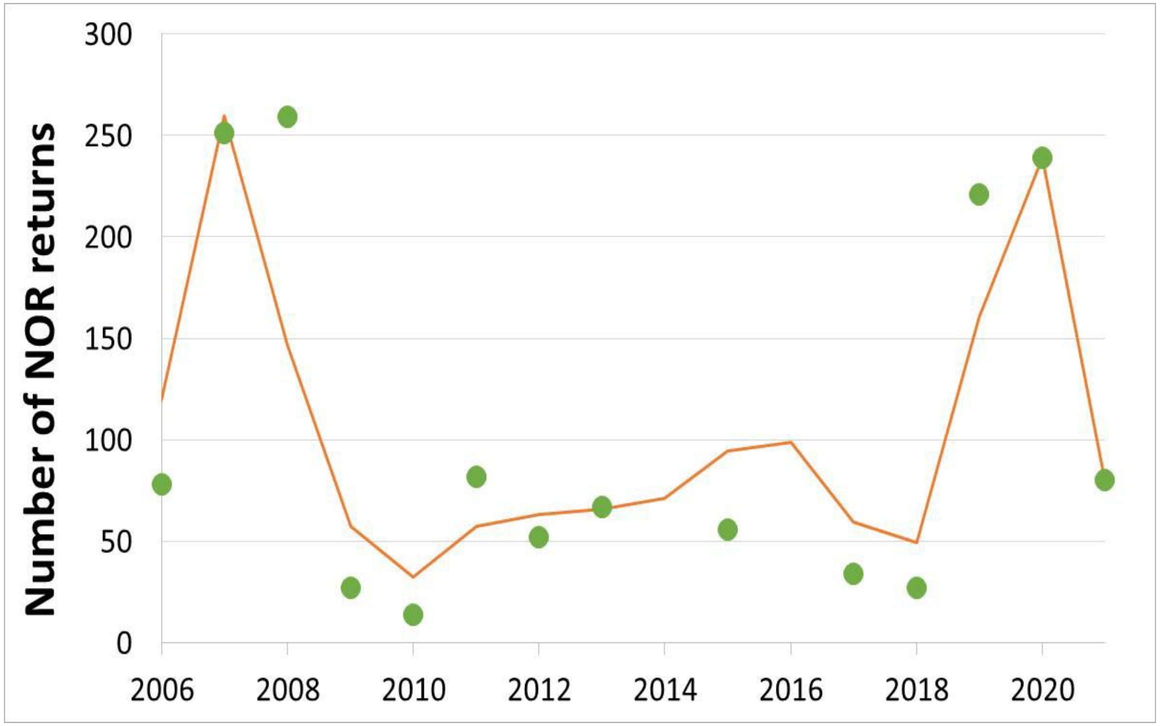


Model reproduces the levels observed in the past years (i.e., after 2009)

Model uses SAS values more consistent with recent years (no stocking and only NO salmon)

PSM is relatively high, but projections suggest a self-sustaining population (under the PSM values observed).

Productivity in adjacent Dam



- Middle Fork has shown very low adult returns over the last two decades (average 94, range 14-259).

- CJSM model indicates very low SAS (<0.01)

- Above LOP dam: Juvenile Chinook grow well in the reservoir.
- Reach is more extensive than in FC (i.e., more adult and juvenile capacity).
- Low reservoir survival, but this could change with more effective dam passage.
- Low PSM (above the dam) (e.g., cooler temperatures).
- 6 migrating groups (this could change with more effective dam passage).

Conclusions

- Model can be used to reconstruct past life stages and key population parameters; e.g., SAS, which are useful for projections.

- Reconstruction of past life stages can be used to define targets (a reference for recovery). e.g. how many spawners are needed to have a self-sustainable wild population based on historical estimates; “we are here, we need to get there.”

- It allows to explain changes in productivity; e.g., based on juvenile stocking; how much SAS can be improved (useful for hatchery practices)

Conclusions

- Model allows for time series of data that usually are not included in LCM (e.g., PSM, redd counts) to calibrate the models.
- Empirical evidence suggests that the population can increase quickly under effective dam passage conditions (and SAS).
- FC might have a high reservoir survival and produce a large number of chinook (e.g., 850) when dam passage is effective (considering it is a relatively small reach).
- PSM (above the dam) seems high, but model projection suggests FC can maintain a wild population (under the current values observed).

Conclusions

- It is important to understand/record the “history” of the dam passage (stocking, outplanting, and dam operations). Data need to be accessible.

- More comprehensive data (e.g., well-designed CJSM) is required to understand dam passage and juvenile and adult survival; e.g., there is only 1 study to estimate SAS and freshwater survival (all effects combined)

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