Estimating Mark Selective Impacts on Coho and Chinook Salmon

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Special Recognition to Kurt Reidinger

Building on the concepts from the previous talk - the challenge is estimating unmarked mortalities that are not directly observable

$$U^{SF} = M^{SF} \cdot \lambda \cdot sfm$$

Observed | <u>*Changing*</u> | Assumed Known

Size and configuration of fisheries

Different information on M^{SF} and λ

Changes λ

Focus on estimating stock and age specific unmark/mark ratio ($\lambda_{i\,a}$) for large MSF

- Using auxiliary information but examining different aspects of the application
  - Benefits and costs (trade-offs)
- Biases in estimates of exploitation rate using different estimates of λ (e.g., release vs. escapement)

In a NSF or test fishery the stock and age specific mark ratio is

$$\hat{\lambda}_{ia}^{FISHERY} = \frac{CWT_{ia}^{U}}{CWT_{ia}^{M}}$$

Problem: VERY possible that CWT^U or CWT^M for a stock/age will be 0, so that the estimated ratio is not very informative

$$0 \leq \hat{\lambda}_{ia}^{FISHERY} < \infty$$

One possible solution: use GSI (w/ auxiliary age) as a bridge

$$\underbrace{CWT^{U}_{i,a}}_{FISHERY} = \underbrace{GSI^{U}_{i,a}}_{FISHERY} \cdot \underbrace{\frac{U^{CWT}_{i,a}}{U^{RELEASES}_{i,a}}}_{AUXILIARY}$$

$$\underbrace{CWT^{M}_{i,a}}_{FISHERY} = \underbrace{GSI^{M}_{i,a}}_{FISHERY} \cdot \underbrace{\frac{M^{CWT}_{i,a}}{M^{RELEASES}_{i,a}}}_{AUXILIARY}$$

This method is not without tradeoffs. Looking at what needs to happen at the hatchery….

Hatchery Release Groups

Marked CWT	Marked Untagged
Unmarked CWT	Unmarked Untagged

↑ Number Marked ↓

↓ Number Unmarked ↑

Weaker signal; greater MSF opportunity

Stronger signal; reduced MSF opportunity

GSI assumes that the baseline is sufficient to detect a particular indicator stock in the fishery.

- Other indicators, e.g., otolith marks, also require this assumption

- Alternatively, consider using a biased λ rather than a GSI-based bridge and compare bias in unmarked mortalities (U^{SF}) or exploitation rates (ER^{U})

Usually* the mark ratio in a MSF will be bounded by the release and escapement ratios

$$\lambda_{ia}^{REL} < \lambda_{ia}^{SF1} < L < \lambda_{ia}^{ESC}$$

OR

$$\frac{U_{i}^{REL}}{M_{i}^{REL}} < \frac{U_{ia}^{SF1}}{M_{ia}^{SF1}} < L < \frac{U_{ia}^{ESC}}{M_{ia}^{ESC}}$$

With successive MSF – M decreases faster than U

- Several values of λ available (DIT)
  - The release unmarked/mark ratio (λ^{REL})
  - The escapement unmarked/mark ratio (λ^{ESC})
  - A recursive (recalculated) unmarked/mark ratio (λ^{SF})
    - Several versions

- Recursive (recalculated) unmarked/mark ratio (λ^{SF})
  - Using the annual marked exploitation rate (ER) and the mark ratio at age *a-1* the mark rate for age *a* is calculated by

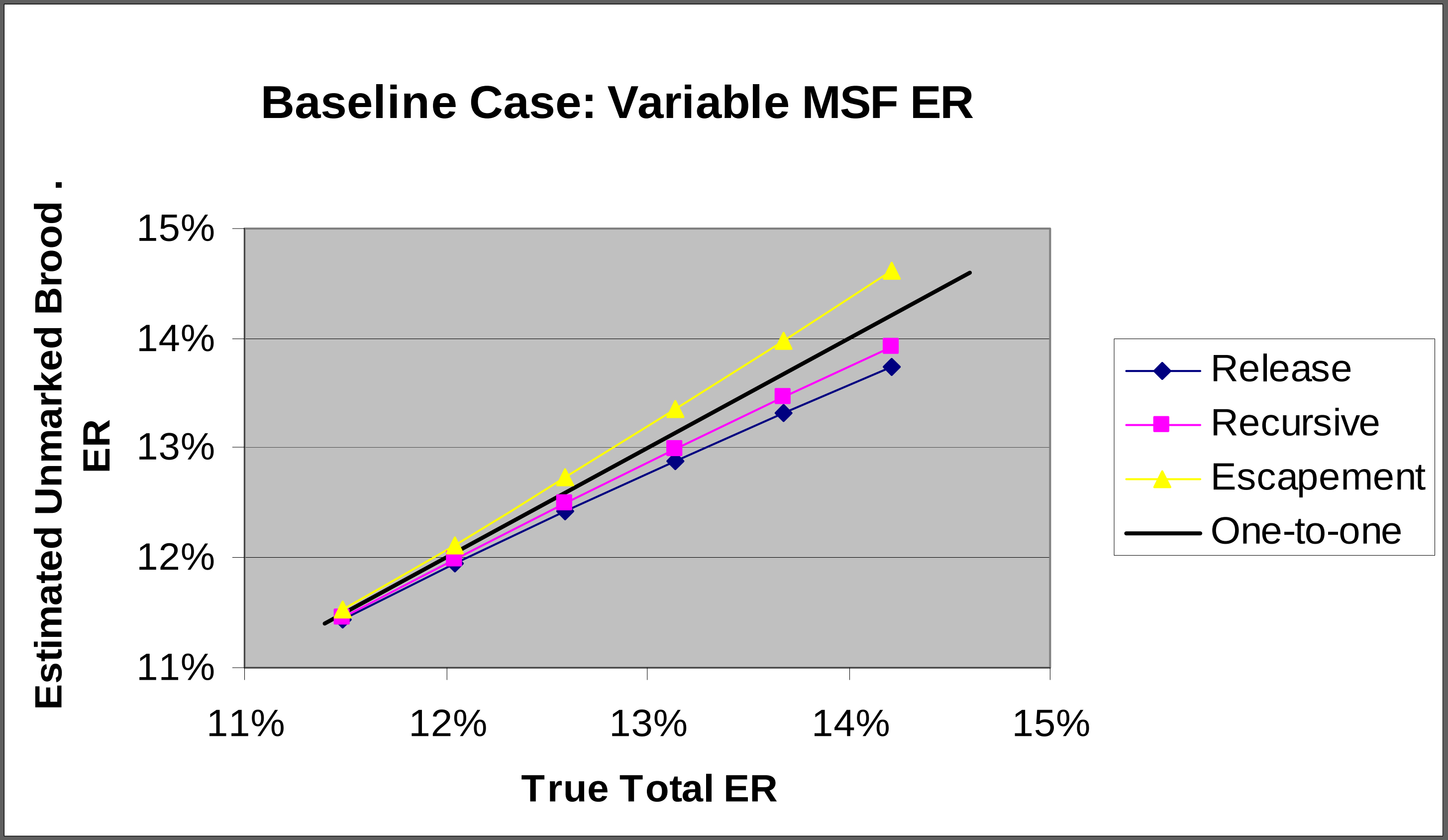
$$\lambda_{ia}^{SF} = \lambda_{i(a-1)}^{SF} * \frac{\left(1 - ER_{i(a-1)} \cdot sfm\right)}{\left(1 - ER_{i(a-1)}\right)}$$

Estimates of ER^U : λ^{REL} vs. λ^{SF} vs. λ^{ESC}

Divide a Chinook population into unknown 2 sub-populations

- Sub-pop 1: 95% of pop., subject only to MSF at variable rates (> λ^{REL})
- Sub-pop 2: 5% of pop., subject only to NSF or no fisheries (~ λ^{REL})
- Under the assumptions of equal maturation, natural survival - compare absolute bias of ER^U using the 3 estimates of λ

Bias in ER^U: λ^{REL} vs. λ^{SF} vs. λ^{ESC}



Biases in ER^U:

- λ^{REL}: Overestimates
- λ^{ESC}: Underestimates
- λ^{SF}: Underestimates – not as much as λ^{ESC} (closest to true)
- In all cases, % bias < 0.25 for ER about 15%

Conclusions:

- Increasing detectability of marked and unmarked fish in a fishery by increasing the number of one portion is not without some cost to the fishery
- Alternatively one can consider a biased method and simulate a worst case scenario to determine if the bias is of a management/conservation concern.