Lower Granite Equivalents, SAR, and TIR in the Presence of Overwintering Behavior of Juvenile Fall Chinook Salmon

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Overview

- Quick review of C_0 , T_0 groups, SAR, TIR, Lower Granite Equivalents
- Complications from overwintering or winter passage during juvenile migration
- Analysis of 2006 PIT-tag data
- Alternative analysis approaches

SAR: C_0 and T_0 Groups

$$\text{SAR} = \frac{\text{Number of Adults}}{\text{Number of Juveniles}}$$

- Estimate for:
  - C_0 group = Juveniles that pass transport dams undetected
  - T_0 group = Juveniles that were transported upon their first detection at transport dam
- Adults: A_{C0}, A_{T0}
  - Observed directly, not estimated
- Juveniles:
  - Measured in terms of Lower Granite Equivalents

Lower Granite Equivalent

- LGE
- Number of juveniles at LGR that were "destined" to pass through hydrosystem with particular detection history, if they had survived

$$\mathrm{LGE}\left(C_0\right) = \frac{m_{LGR}}{\hat{P}_{LGR}} - \left(m_{LGR} + \frac{m_{LGS}}{\hat{S}_{LGS}} + \frac{m_{LMO}}{\hat{S}_{LGS}\hat{S}_{LMO}} + \cdots \right)$$

$$\mathrm{LGE}\left(T_0\right) = X_{LGR} + \frac{X_{LGS}}{\hat{S}_{LGS}} + \frac{X_{LMO}}{\hat{S}_{LGS}\hat{S}_{LMO}} + \frac{X_{MCN}}{\hat{S}_{LGS}\hat{S}_{LMO}\hat{S}_{MCN}}$$

SAR and TIR

- SAR

$$\mathrm{SAR}\left(C_0\right) = \frac{A_{C0}}{\mathrm{LGE}\left(C_0\right)} \qquad \mathrm{SAR}\left(T_0\right) = \frac{A_{T0}}{\mathrm{LGE}\left(T_0\right)}$$

- TIR

$$\mathrm{TIR} = \frac{\mathrm{SAR}\left(T_0\right)}{\mathrm{SAR}\left(C_0\right)}$$

SAR for Fall Chinook: Inriver

- Measure SAR from Lower Granite:

$$\mathrm{SAR} = \frac{A}{\mathrm{LGE}}$$

- Use only subyearling detections for LGE
- Overwintering or winter passage
  - Mismatch between adults and juveniles (LGE)
    - A: Includes adults that migrated as yearlings
    - LGE: Restricted to subyearling migrants
  - SAR: Positively biased
  - TIR: Negatively biased

2006 PIT-Tag Data: Clearwater and Snake River Fall Chinook

- Extended PIT-tag monitoring (to Dec. 16)
- Compare estimates of SAR(C_0) both with and without late fall detections
- Two monitoring periods:
  - Abbreviated Monitoring Period (A): Ended Nov. 1
  - Extended Monitoring Period (E): Ended Dec. 16

2006 Analysis: Release Groups

Three weekly release groups from:

- Clearwater River
  - Released 19 June 2006 – 9 July 2006
  - 98,020 fish total

- Snake River
  - Released 15 May 2006 – 3 June 2006
  - 229,063 fish total

2006 Analysis Methods

For each weekly release group:

- Form two sets of detection histories
  - Abbreviated Monitoring Period
  - Extended Monitoring Period (≈ 6 extra weeks)

- Compare SAR, TIR estimates from the two monitoring periods
  - Fit CJS model to juvenile detections

    → Estimate LGE of C_0 group
  - Use adult detections from 2007-2009

    → Estimate SAR

2006: Results

Estimates	CLR-1	CLR-2	CLR-3	SNK-1	SNK-2	SNK-3
N	32,868	32,822	32,330	59,975	76,944	92,144
$\text{LGE}(C_{0A})$	2,112	1,038	566	15,321	22,153	20,985
$\text{LGE}(C_{0E})$	3,664	1,692	1,337	15,332	22,195	21,163
A_{C0} (Abbrev.)	47	37	72	52	82	48
A_{C0} (Exten.)	33	25	30	52	81	47
$\text{SAR}(C_{0A})$	0.022	0.036	0.127	0.003	0.004	0.002
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Mismatch between Adults and Juveniles: Possible Solutions

- Fix counts of adults
  - Restrict to those that migrated as subyearlings
- Fix counts of juveniles (LGE):
  - Include winter and spring migrants

Fix Adults: Scale Samples

- Indicate age at ocean entry
- Need scale samples from ***every*** adult detected at LGR
  - Practical?
- Reliable?
- Sufficient information?
  - Undetected juvenile entered SW as yearling:
    - When did it pass through the hydrosystem?

Fix Juveniles: C_0

$$\mathrm{LGE}\left(C_{0[\mathrm{Fall}]}\right)+\mathrm{LGE}\left(C_{0[\mathrm{Winter}]}\right)+\mathrm{LGE}\left(C_{0[\mathrm{Spring}]}\right)$$

Fix Juveniles: C_0

$$\text{LGE}\left(C_{0[\text{Fall}]}\right) + \text{LGE}\left(C_{0[\text{Winter}]}\right) + \text{LGE}\left(C_{0[\text{Spring}]}\right)$$

- Current estimate from
  - PIT-tag data
  - Subyearling detections only

Fix Juveniles: C_0

$$\mathrm{LGE}\left(C_{0[\mathrm{Fall}]}\right)+\mathrm{LGE}\left(C_{0[\mathrm{Winter}]}\right)+\mathrm{LGE}\left(C_{0[\mathrm{Spring}]}\right)$$

- Estimate from
  - Long-lived acoustic tags
  - Dual acoustic receive arrays in LGR tailrace

Fix Juveniles: C_0

$$\mathrm{LGE}\left(C_{0[\mathrm{Fall}]}\right)+\mathrm{LGE}\left(C_{0[\mathrm{Winter}]}\right)+\mathrm{LGE}\left(C_{0[\mathrm{Spring}]}\right)$$

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Fix Juveniles: C_0

$$\mathrm{LGE}\left(C_{0[\mathrm{Fall}]}\right)+\mathrm{LGE}\left(C_{0[\mathrm{Winter}]}\right)+\mathrm{LGE}\left(C_{0[\mathrm{Spring}]}\right)$$

- Large release groups
- SAR:
  - Includes fish with no opportunity for transport
  - Should not for transportation assessment

Alternative Approach: SAR from LGR

$$\text{SAR} = \frac{\#\ \text{Adults detected at LGR as subyearlings}}{\#\ \text{Juveniles detected at LGR as subyearlings}}$$

- Restricted to fish that migrated to LGR as subyearlings
- May include fish that held-over downstream
- No inference to C_0 group

Alternative Approach: SAR from Release Point

- Measure SAR from release point:
  - Robust to overwintering
  - Cheap
  - Cannot restrict to C_0 group
  - We know what we are estimating

$$SAR = \frac{A}{N}$$

- Transport effects:
  - Preassigned treatment groups
  - TIR estimate: Ricker Relative Recovery Ratio

Conclusions

- Overwintering or winter passage introduces bias in
  - SAR of C_0 group
  - Transport-Inriver Ratio using the C_0 group
- Adjustment for overwintering requires
  - Much more data (juvenile and/or adult)
  - More modeling assumptions
- Focus on the C_0 group is misguided for Fall Chinook salmon that overwinter
- An unbiased, simple, and robust approach is available for estimating TIR

Acknowledgements

- Billy Connor, U.S. Fish and Wildlife Service
- Doug Marsh, NMFS
- Bonneville Power Administration [Project 2002-032-00]

Extras

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2006 Analysis: For Each Monitoring Period

- Juveniles
  - Fit CJS model with removals to detection data
    - Use detection sites LGR, LGO, LMO, ICH, MCN
    - Pool detections from JD, BON, TWX for “final site”
  - Estimate inriver “survival” and detection probabilities
  - Estimate LGE of C_0 group
- Adults
  - Adult detections from 2007 – 2009
  - Estimate SAR