

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_{C_0}, A_{T_0}

- 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

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

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

SAR and TIR

▶ SAR

$$\text{SAR}(C_0) = \frac{A_{C_0}}{\text{LGE}(C_0)}$$

$$\text{SAR}(T_0) = \frac{A_{T_0}}{\text{LGE}(T_0)}$$

▶ TIR

$$\text{TIR} = \frac{\text{SAR}(T_0)}{\text{SAR}(C_0)}$$

SAR for Fall Chinook: Inriver

- ▶ Measure SAR from Lower Granite:

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

- ▶ 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
$LGE(C_{0A})$	2,112	1,038	566	15,321	22,153	20,985
$LGE(C_{0E})$	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
$SAR(C_{0A})$	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

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

Fix Juveniles: C_0

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

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

Fix Juveniles: C_0

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

► Estimate from

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

Fix Juveniles: C_0

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- ▶ Estimate from
 - PIT-tag data
 - Yearling detections only

Fix Juveniles: C_0

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

- ▶ 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