Study Designs and Preliminary Steelhead Responses to Hemlock Dam Removal in Southwest Washington

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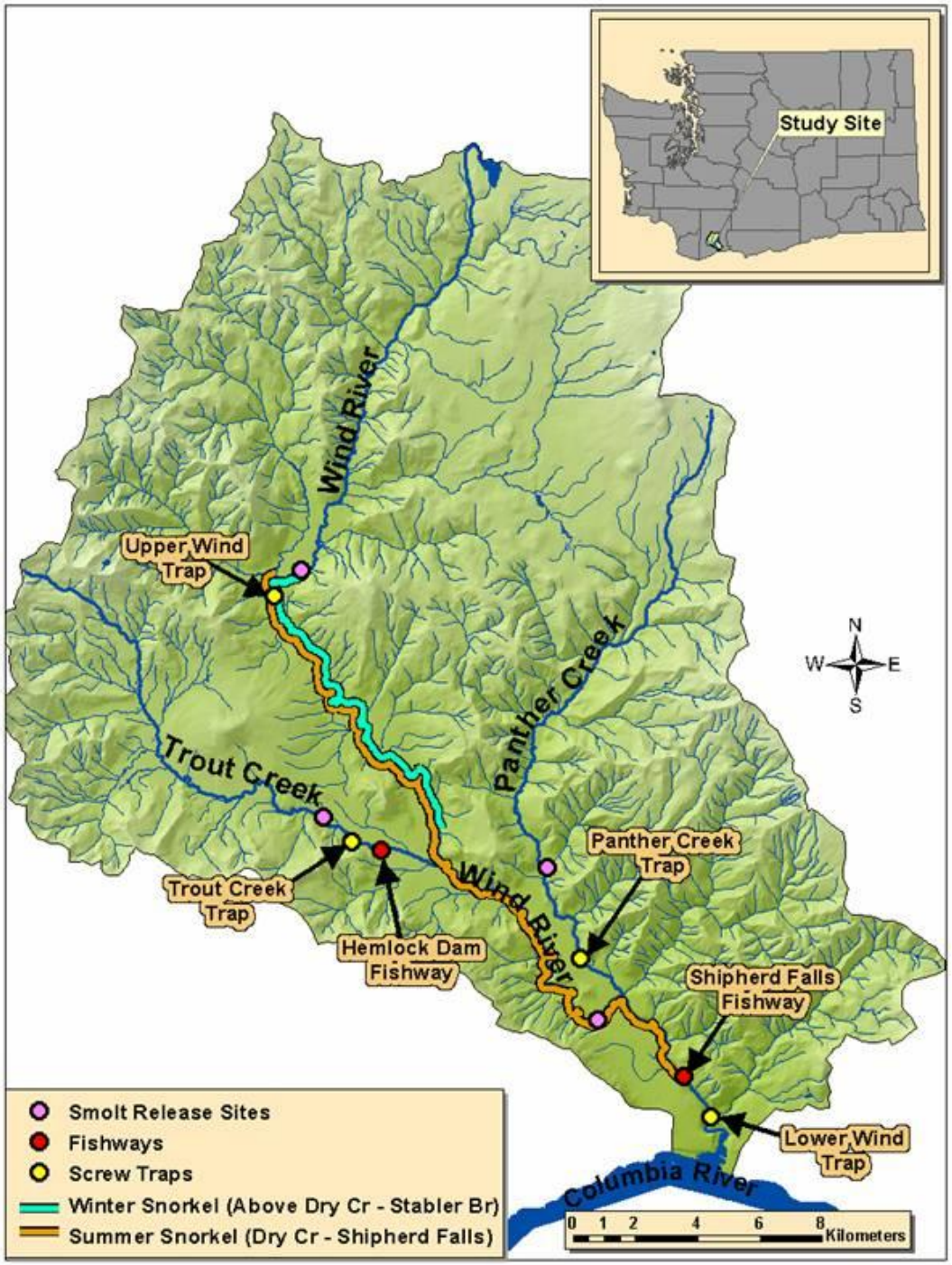
Outline

- Review Wind River salmonid monitoring
- Potential study design
- Hemlock Dam removal
- Testable hypothesis
- Preliminary Results
- Power Analysis



Drainage area - 225 sq. miles

Land Ownership & Use

77% USFS multi-purpose

23% timber, rural residential

Location

- River Mile 155
- 55 miles >Portland

Shipherd Falls

Drops 44 ft. in ¼ mile

Barrier to salmon

Wild Steelhead Sanctuary

Anadromous Species

Chinook & Coho Salmon

Steelhead & Coastal Cutts

Steelhead Hat. Frac.=1%

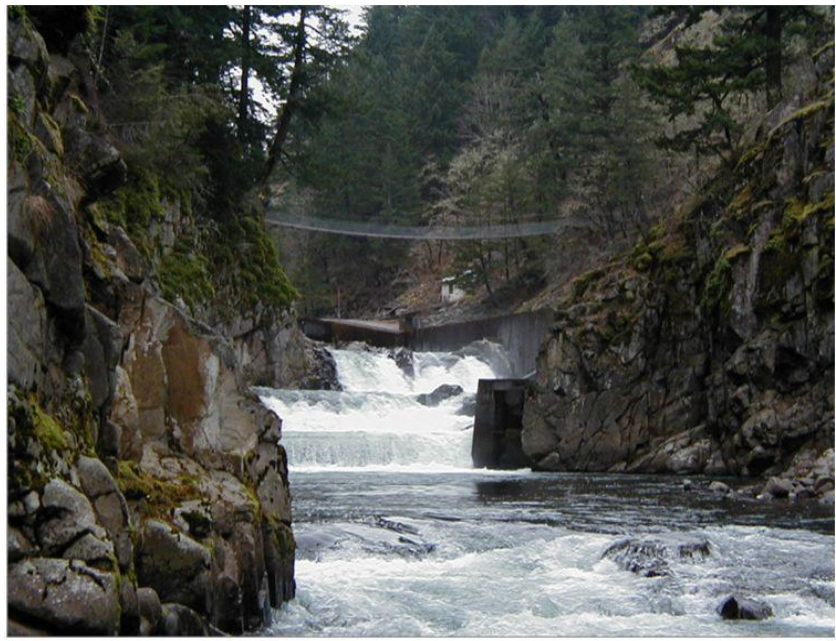
Hemlock Dam

Fish passage facilities

Removed in 2009

Adult Monitoring

- Abundance
  - Wind River mark-resight (2000-2011)
  - Hemlock Dam census (1992-2009)
  - Hemlock PIT tag detection efficiency and mark-resight (2010-2011)
- Bio-Samples
  - Scales(age), length, sex, origin, & tags at Wind
  - Sex & tags at Hemlock



Juvenile Monitoring

- 4 site –Trout Cr. (TC), Upper Wind (UW), Panther Cr. (PC), and Lower Wind (LW)
  - Smolt abundance
  - Parr index of abundance
  - Bio-Samples
    - Lengths, 100 scales per trap per years

Passive Integrated Transponder (PIT) Tagging

- PIT tagging smolts since 2003
- PIT tagging all adults at Hemlock and Shipherd Falls since 2008.
- Detection locations include BON for adults and juveniles, Shipherd Falls for adults, and all smolt trap sites, & instream site at Trout Creek (2007).

Before_After (BA) Designs

- Compare data from multiple years collected from before and after dam removal for a difference typically with ANOVA or T-test.
  - Has temporal replication but lacks spatial replication.
  - Difference in the impact area is **attributed** to the actions but may be due to fish response to natural variations or cycles (marine survival, water temperatures, flooding, etc) or other activities.
  - Cannot disentangle response from natural variation and cycles in the impact area.

Before_After_Control_Impact (BACI) Design

- Measurements are taken at both the treatment (impact) and control site before and after the action and typically analyzed with ANOVA or T-test.
  - $D_{ik} = X_i C_j - X_i I_k = \mu + \eta_i + \varepsilon_{ik}$, μ=mean difference between control and impact, η_i = change in difference control and impact, and ε_{ik}= error associated with the differences.
  - To account for the problem with natural variation in the B_A design the impact area is paired to control area.
  - Has temporal replication but lacks spatial replication due to single control. The solution is to add another control site.

BACI Design Concerns

- Dam placement/removal (impact area) is not random, and neither are control areas.
- Control areas are difficult to maintain because people want to restore habitat in their stream or it is difficult to make a long-term commitment to status quo land management

Hemlock Dam Removal

- Hemlock was the site of a splash dam in 1900's
  - changed to a concrete dam in 1930's w/fish ladder
  - w/trap (1992) & modified trap in 1998
  - outmigrants (juveniles & kelts) used ladder or more often spillway.
- Total dam removal cost estimated at $2.7 million
- The goal of the dam removal project is to increase the viability and productivity of Lower Columbia River Steelhead in the Wind River.
- Objectives:
  - Improve passage for adult and juvenile steelhead passage
  - Reduce peak stream temperatures in lower Trout Creek.
  - Restore substrate transport in lower Trout Creek
  - Increase habitat complexity in lower Trout Creek

Where and What is Measured!

- Adult monitoring is at the dam site and juvenile monitoring is at the head of the reservoir.
- Adult monitoring will detect changes above the dam site & juvenile monitoring will changes above the upstream end of the reservoir.
- This means that changes in steelhead juvenile rearing reservoir site & newly restored channel are not accounted for.

Dam Removal Biological Response

- Objective 1 was to improve passage.
  - May result an increase in the # of spawners and smolts if the habitat was not at capacity due to passage problems. Also a possible change in the # of parr emigrating to downstream areas as capacity of habitat for rearing is filled. Survival of all life stages may be impacted by dam.
- Testable hypothesis for steelhead response
  - Ho: there is no change in smolt, adult, and index of parr abundance.
  - Ho: there is no change in smolt, kelt, and repeat spawner survival.
  - Ho: There is no change in the adult length (repeat spawners are longer) or percentage of repeat spawners.

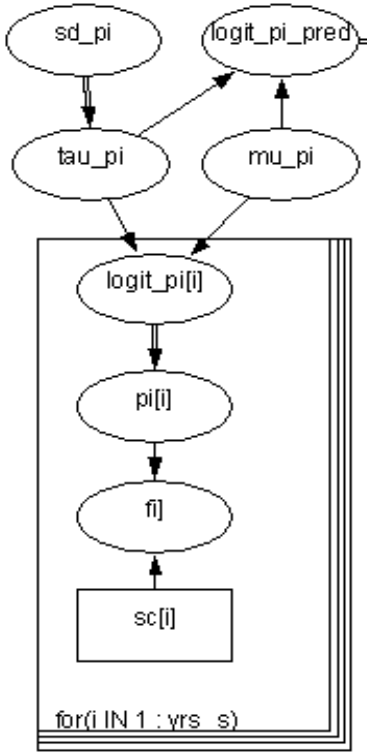
Preliminary results

- Dam was removed in summer 2009
  - Preliminary results available for adults for 2010 & 2011 spawners
  - Create new method to monitor adults in since dam count is not available
  - Average smolt age in Trout Creek is 2.25, so this data not available until spring 2012 & 2013

Trout Cr. Esc. Estimate using a DAG, 2010 & 11

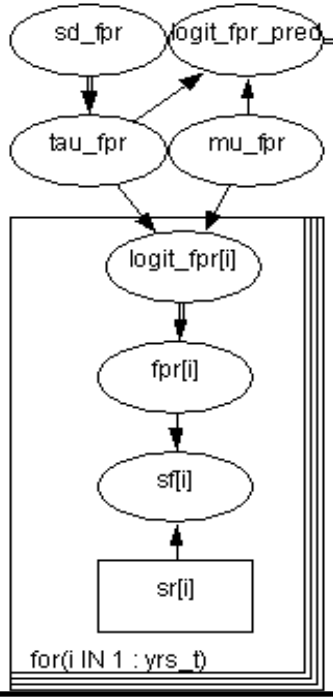
1992-2008

Estimate % females(pi) from females (f) & count (sc) from Trout Cr. trap w/ hierarchical model.



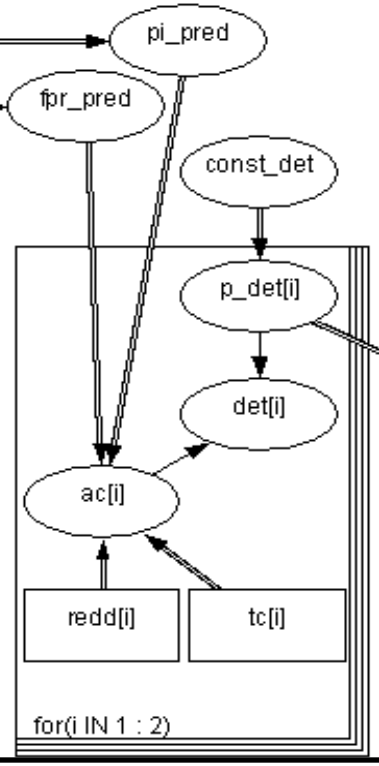
1977-1984

Estimate females per redd (fpr) from Snow Cr. redds (sr), females (sf) w/ hierarchical model.



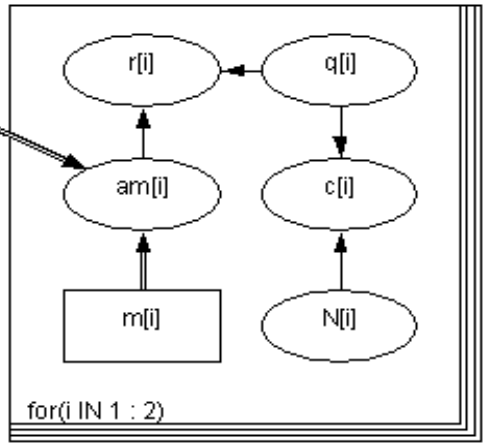
2008-2009

Estimate prob. of detection (p_det) from Trout Cr dam count (tc), adult count(ac) above detector,and detections (det).



2010-2011

All fish at Shipherd Falls are Floy & PIT tagged. Adjusted marks (am) = Floy & PIT tags/prob of detection (m) / (p_det). Petersen mark-resight estimator (N =c *am / r), N=Abundance, am=adj. marks,c=captures, r=recaptures, & q = snorkel efficiency.



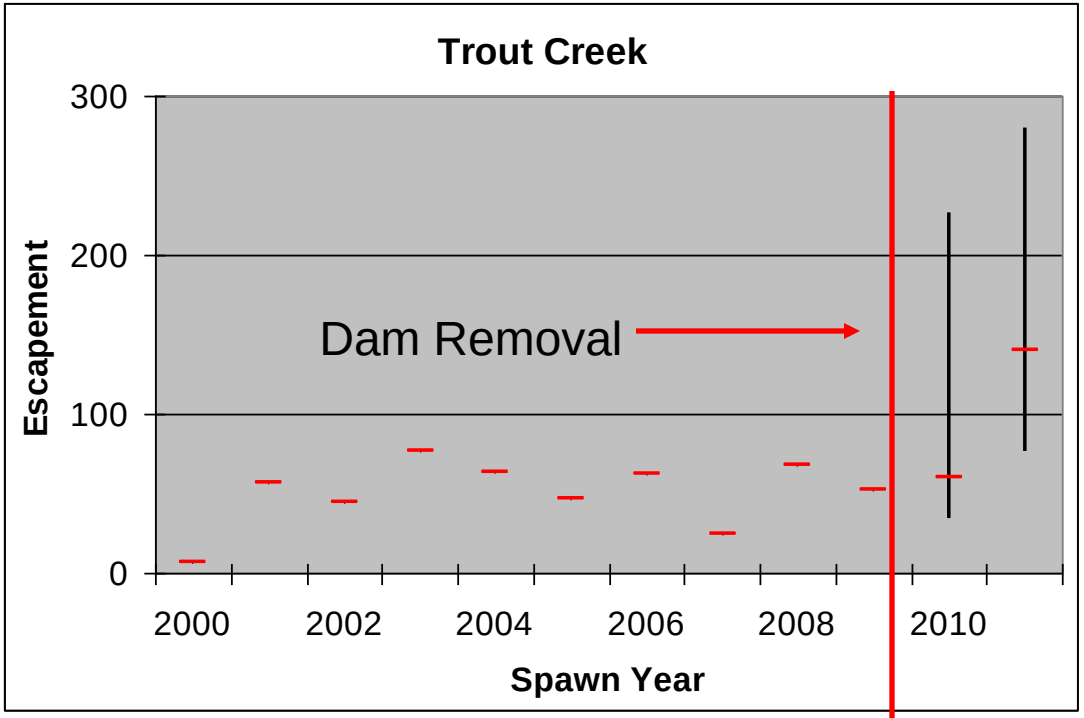
Trout Creek Results

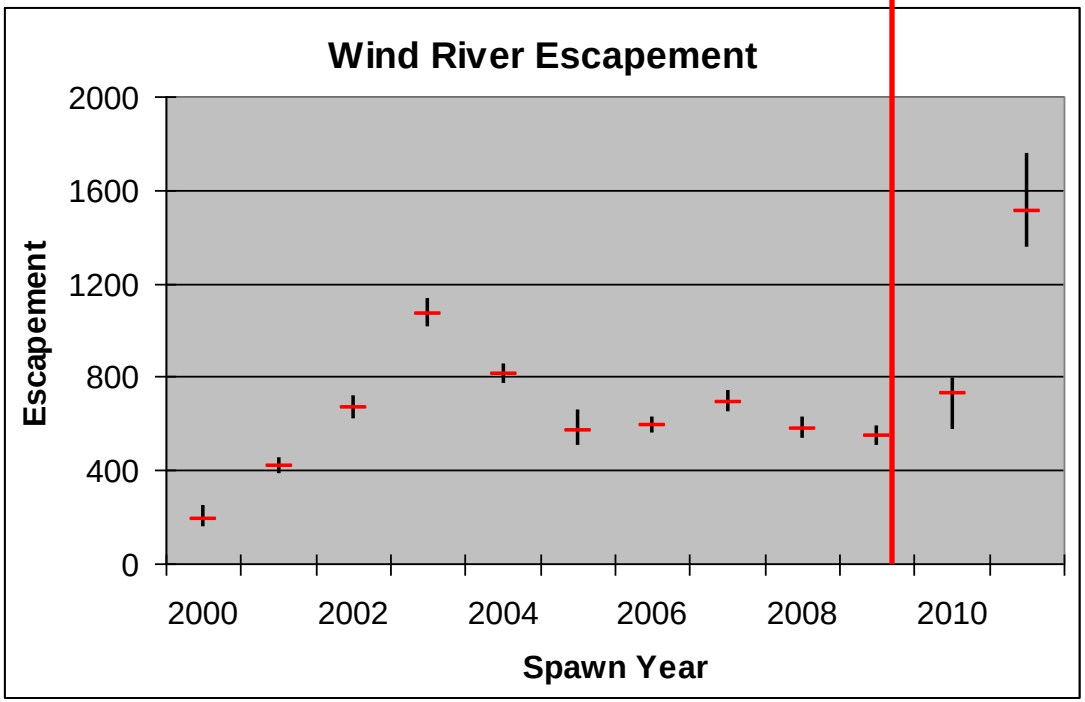
Probability of Detection
p_det = 0.604
95% CI = 0.512-0.692

Trout Cr. Abundance
N[2010] = 57
95% CI = 34-227

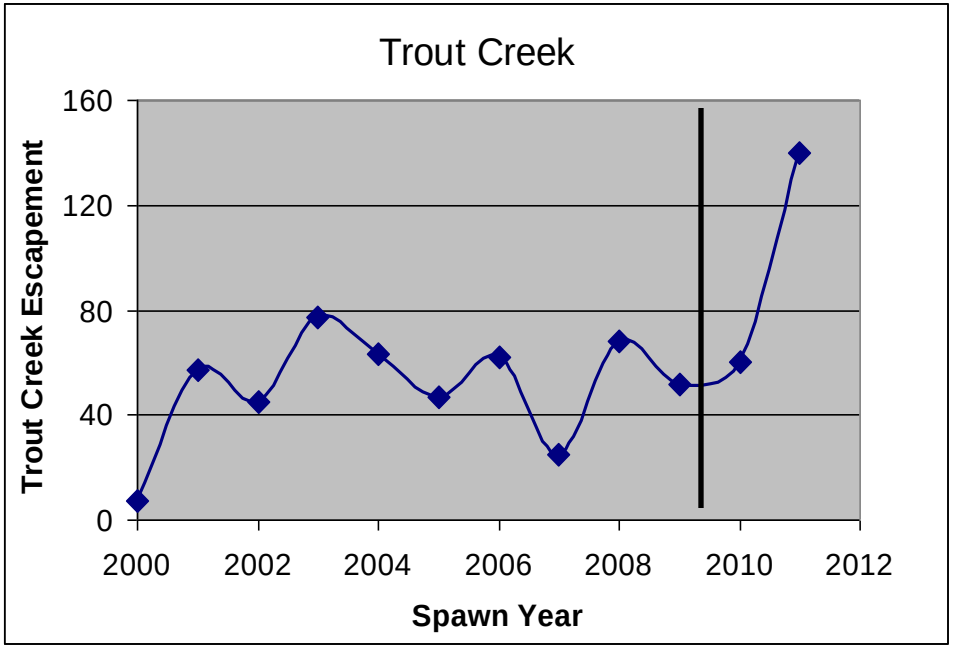
N[2011] = 137
95% CI = 77-280

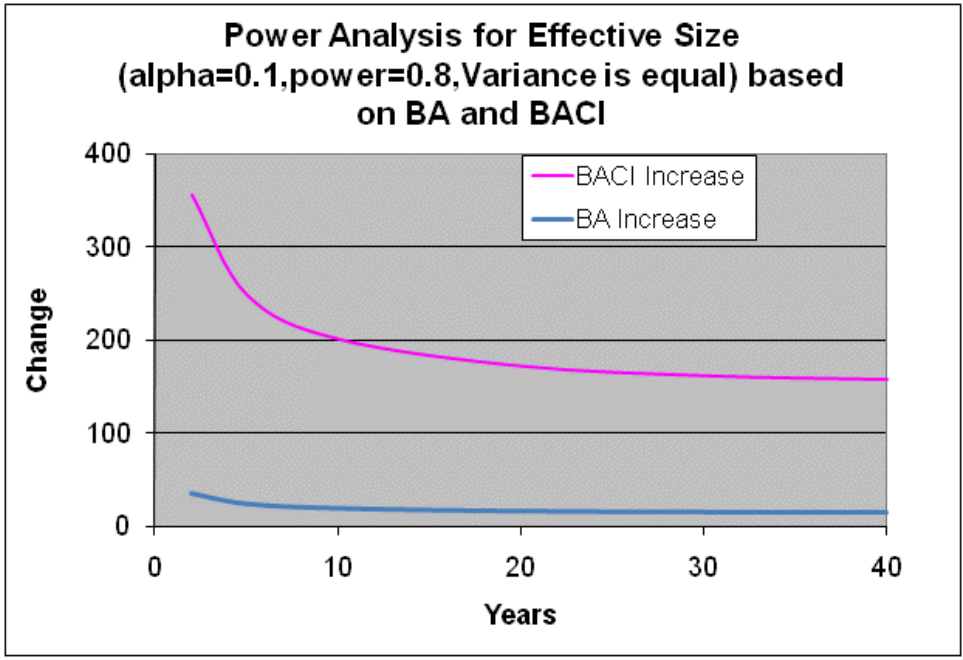
Recommendations
If more precise estimates are desired either improve detection efficiency w/additional interrogators, snorkel efficiency w/additional surveys, or both.

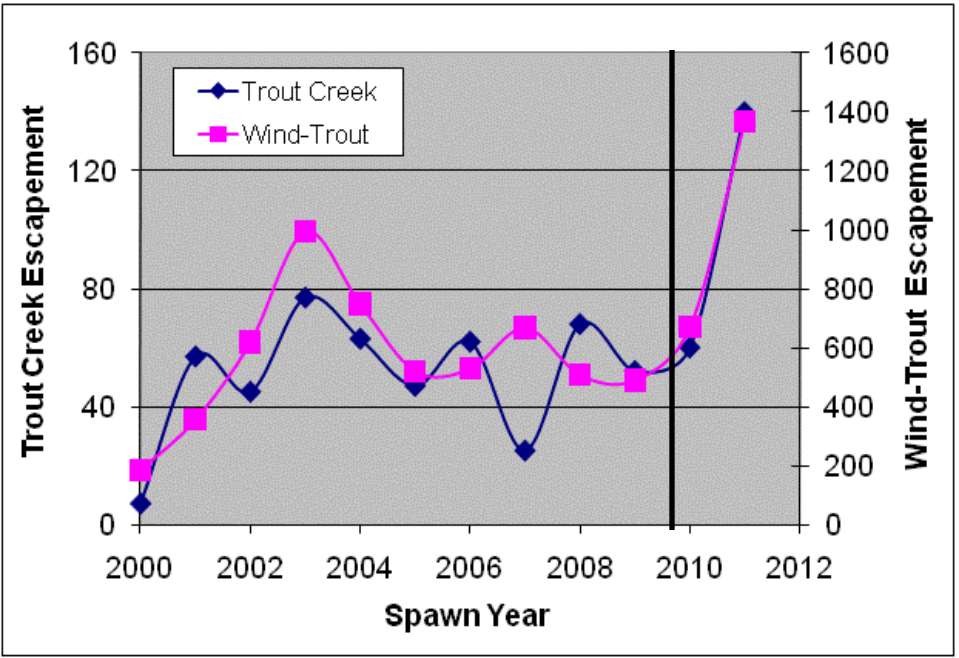




Adults T test & Power





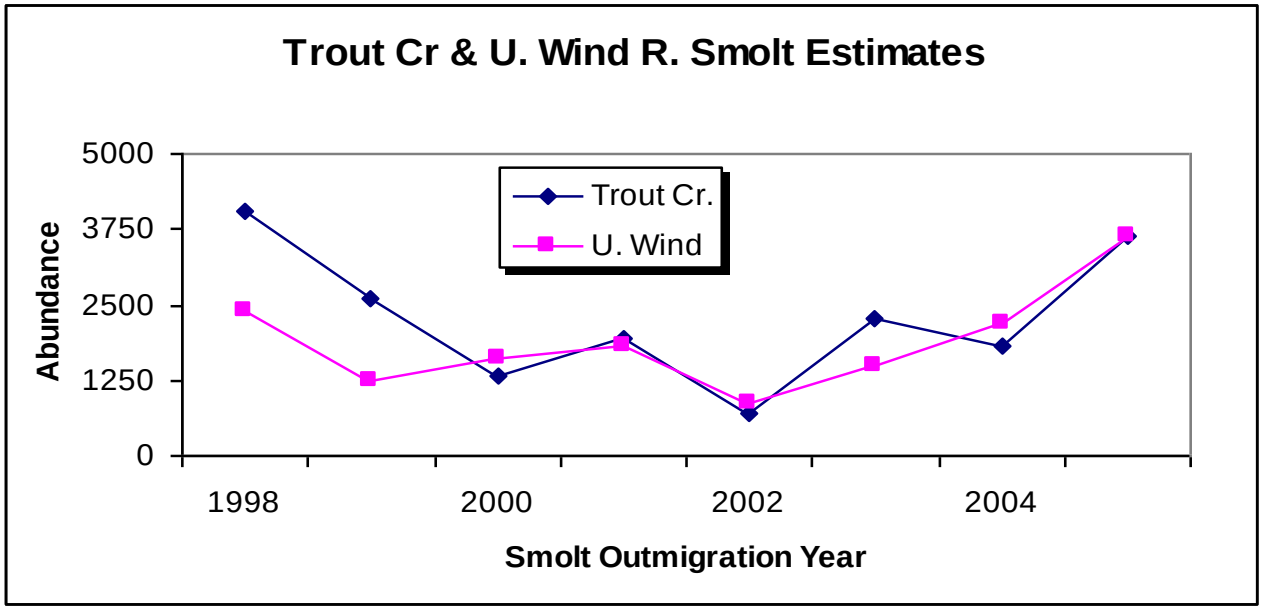


BA design power analysis suggest an effect size from 15 to 34 adults in Trout Creek from 2 to 40 years, respectively.

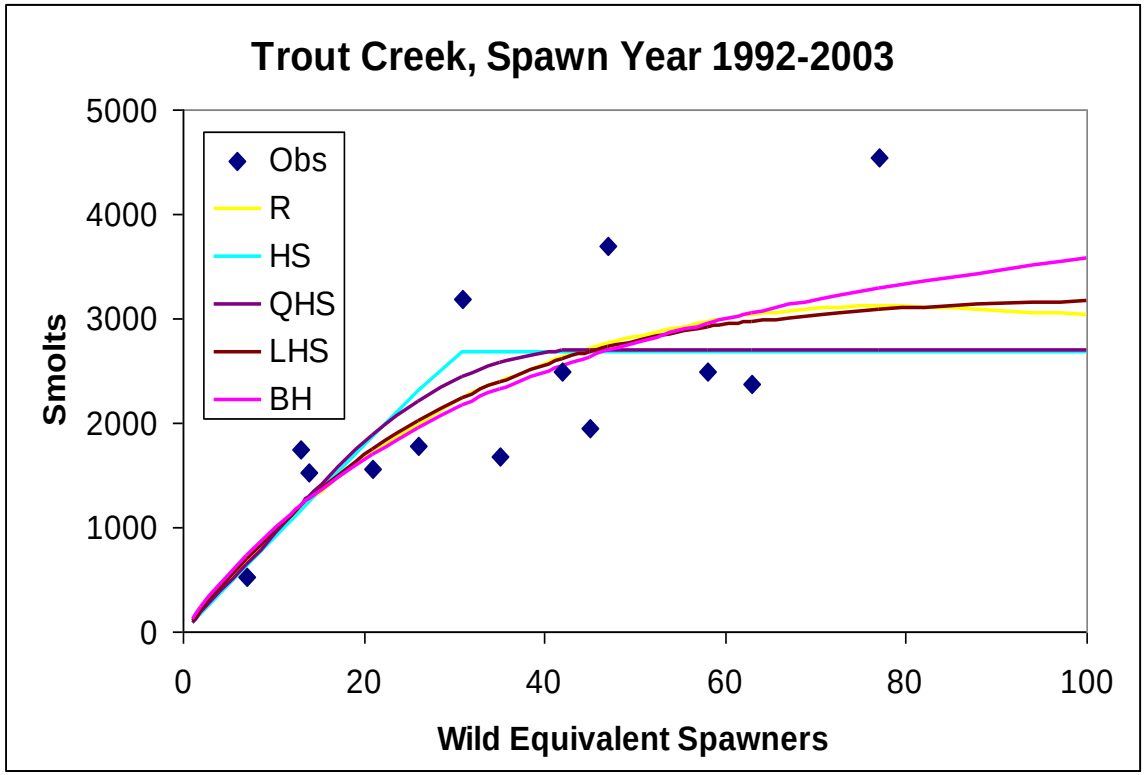
BACI design power analysis suggest an Effect size increase from 156 to 357 adults in Trout Creek.

Greater change for BACI than BA because it accounts for annual variation between the two sites.

- Ho: There is no change in the mean difference in smolt production between impact site(Trout Creek) and the control site (possibly Upper Wind) before and after dam removal using a BACI design.
- The mean difference between the two sites was 43 smolts for the 8 year period, and the standard deviation of the difference was equal to 394 smolts.
- A net increase in smolt production of at least 431 smolts in 8 years (24%) from Trout Creek would yield significant results using a t-test, assuming a significance level = 0.10, and power = 0.80.



- Ho: There is no change in productivity and/or capacity estimate from spawner-recruit analysis before and after dam removal using a BA design by comparison of confidence intervals.
- Bradford, M.J., J. Korman, and P.S. Higgins. 2005. Using confidence intervals to estimate the response if salmon populations (Oncorhynchus spp.) to experimental habitat alterations. CJFAS 62:2716-2762



Choice of models & alpha values influences detectable differences

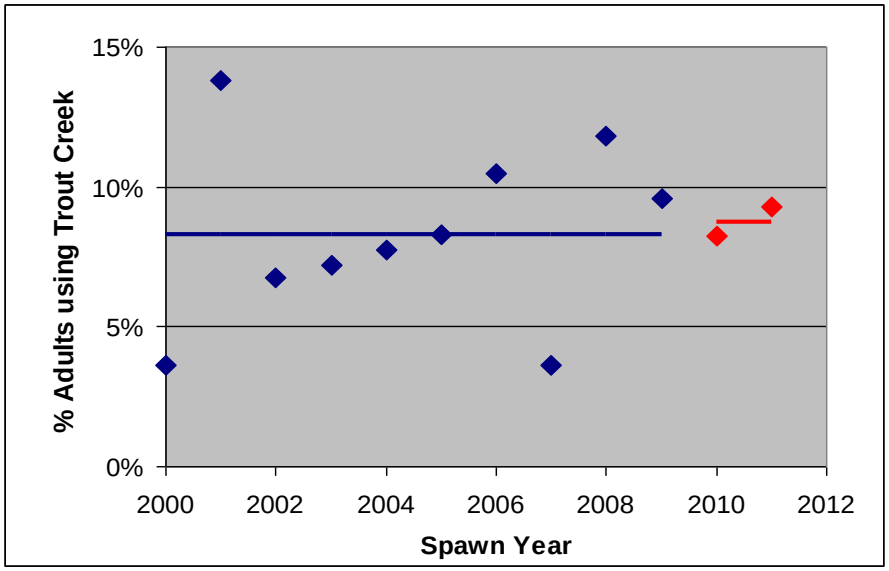
SRR analysis suggests change of 50% in Trout Creek over a 12 year period would lead to detectable success with HS model but only partial success with BH model with alpha = 0.20.

Summary

- ANOVA assumptions (random sampling, normality, equal variance, independent observations, etc) need to be assessed. Difficulty in maintain control site due to spatially scatter approach for salmon restoration.
- BACI w/multiple controls > BACI w/single control > BA. BA measuring adult salmon or steelhead response is problematic under variable marine survival conditions.
- BA using spawner recruit analysis may be a more reliable design when density dependence occurs and eliminates marine survival concern with adult BA designs.

Summary-continued

- BACI-Difference design results show no significant increase in adult returns post dam removal (P = 0.20).
- BACI-Proportion design using % of Trout Cr. adults may be better alternative(P= 0.69).



- Assumed the probability of detection at the PIT tag interrogator was the same for the 2008-09 and 2010-11 periods. **Could use the three arrays of the interrogator to estimate the annual probability of detection but this assumes detection at each array is independent, which may not hold during high water events.**
- All PIT tag data is available at PTAGIS, and adult and smolt estimates are in WDFW annual BPA reports.

Acknowledgements

- Brian Bair & Bengt Coffin (USFS) photos & information on dam removal.
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