Using Large Wood to Increase Salmon Abundance in Pudding Creek: A BACI Experiment
Introduction/Overview

• Why?
  – Others have found some relationship between LWD and salmonid abundance.
  – However, it has not been demonstrated in CA.
Introduction/Overview

• Who?
  – Campbell/Hawthorne
  – CDFW
  – Trout Unlimited
  – The Nature Conservancy
  – Chris Blencowe
  – Ken Smith
Introduction/Overview

• Where?
  – Pudding Creek, Mendocino County, CA (Treatment).
    • 9.9 miles.
  – Caspar Creek, Mendocino County, CA (Control).
    • 7.4 miles.
Introduction/Overview

• When?
  – At least three years of pre-treatment data collection on both streams.
  – Implementation in summer 2015.
  – At least three years of data collection following implementation.
Introduction/Overview

• What?
  – Approximately 7 miles of Pudding Creek will be treated with standard un-anchored LWD structures.
  – Caspar Creek will not receive any treatment.
  – Biological indices will/have been monitored for 3 years before and after treatment.
    • Smolt abundance monitoring.
    • Spawner abundance monitoring.
    • Summer juvenile abundance monitoring.
  – Physical indices will/have been monitored before and after treatment.
    • Habitat monitoring using Columbia Habitat Monitoring Program (CHaMP).
Fish are provided low velocity cover at multiple stage heights.
Beaverton-Holt Recruitment Curve for Pudding Creek

B-H curve starts to asymptote near 20,000 smolt.

Based on 3000 eggs per female = 228 hens or > 400 spawners

Question: Will LWD treatment in Pudding Creek increase egg-to-smolt survival, i.e. carrying capacity?
Beaverton-Holt Recruitment Curves for Pudding Creek

Based on 3000 eggs per female = 228 hens or > 400 spawners

B-H curve starts to asymptote near 20,000 smolt.

Hypothetical curve starts to asymptote near 50,000 smolt.

Based on 3000 eggs per female = 228 hens or > 400 spawners

Question: Will LWD treatment in Pudding Creek increase egg-to-smolt survival, i.e. carrying capacity?
Hypothetical change in smolt ratios between Pudding and Caspar Creeks
Analytical layout of population and habitat metrics for the BACI Experiment.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Data collection period</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Physical Habitat</strong></td>
<td>Pretreatment Years</td>
</tr>
<tr>
<td>Summer and winter</td>
<td>2013-2015</td>
</tr>
<tr>
<td>Habitat number, size, volume, heterogeneity, and geometry</td>
<td></td>
</tr>
<tr>
<td>Winter only</td>
<td>Percent slow water habitat, Percent off channel habitat, floodplan channel length</td>
</tr>
<tr>
<td>Biological</td>
<td></td>
</tr>
<tr>
<td>Coho and Steelhead Survival</td>
<td>2011-2014</td>
</tr>
<tr>
<td>coho and steelhead Survival</td>
<td>2011-2014</td>
</tr>
<tr>
<td>Habitat specific survival and growth</td>
<td>2011-2014</td>
</tr>
</tbody>
</table>

* This will also be related to specific habitat unit types and site fidelity (Bell et al. 2003).
## Salmonid Unit Abundance:

### Coho Parr, Steelhead YOY, Y+, Y++

<table>
<thead>
<tr>
<th>Habitat Unit Type</th>
<th>Percent Fish Cover</th>
<th>Substrate Composition</th>
<th>Measured Unit Variables</th>
<th>Calculated Unit Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cascade*</td>
<td>Aquatic Vegetation</td>
<td>Bedrock</td>
<td>Average Depth</td>
<td>Residual Pool Depth¹</td>
</tr>
<tr>
<td>Dam Pool*</td>
<td>Artificial Structures*</td>
<td>Boulders</td>
<td>Bankfull Width</td>
<td>Residual Pool Volume¹</td>
</tr>
<tr>
<td>Dry Units*</td>
<td>Dead Woody Debris</td>
<td>Cobblest</td>
<td>Length</td>
<td>Unit Surface Area</td>
</tr>
<tr>
<td>Falls*</td>
<td>Live Overhanging Vegetation</td>
<td>Course Gravel</td>
<td>Maximum Depth¹</td>
<td>Unit Volume</td>
</tr>
<tr>
<td>Non-Turbulent</td>
<td>No Cover</td>
<td>Fine Gravel</td>
<td>Pool Tail Crest Depth¹</td>
<td>Dry LWD Abundance</td>
</tr>
<tr>
<td>Off Channel</td>
<td>Undercut Banks</td>
<td>Fines</td>
<td>Width</td>
<td>Wet LWD Abundance</td>
</tr>
<tr>
<td>Plunge Pool</td>
<td></td>
<td>Sand</td>
<td></td>
<td>Dry LWD Density</td>
</tr>
<tr>
<td>Rapid*</td>
<td></td>
<td>Pool Tail Fines &lt; 2mm¹</td>
<td></td>
<td>Wet LWD Density</td>
</tr>
<tr>
<td>Riffle</td>
<td></td>
<td>Pool Tail Fines 2-6mm¹</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scour Pool</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Few or none encountered

¹ Pools only
Coho Three Year Juvenile Life History in Pudding Creek as Response to the Drought (2012-2015)
Spawning Adult

Eggs
Hatch in about 3 months.

Alevin
Feeds off yolk-sac for several weeks.

Fry
5 to 10 weeks old and swimming.

Parr
Several months old. Develops ‘finger’ markings.

Smolt
1-3 years old. Will group and head out to sea.

Adult
Spawn and die within 2 weeks.

1-3 years at sea
Figure 21. Growth of Waddell Creek silver salmon.

From Shapovalov and Taft 1954
Good spawning conditions in early winter 2012/13

Drought begins in spring 2013

Really poor rearing conditions in summer 2013

Rain too late for spawning 2014

Juvenile fish don’t outmigrate
How do we know there was no coho spawning in Pudding Creek in 2014?

1. No adult coho were captured at the dam.
2. No spawners (or redds) were observed during biweekly spawning surveys (100% Census—4 months)
3. No YOY were captured at the rotary screw trap (spring 2014)
4. No YOY were captured during summer eFishing surveys (2X—early summer, late summer, random sampling)
5. No YOY were found in random dive surveys throughout the creek
6. The sandbar did not open until late February
Pudding Creek Coho Spawner vs. Smolt (2005-2015)
Smolt Fork Lengths

Smoothed histogram of coho salmon fork lengths at the outmigrant trapping station in Pudding Creek (2006-2010).
Coho Fork Lengths (2006-2014)
Length of individual coho salmon (*Oncorhynchus kisutch*) in Pudding Creek vs. time. The length of each fish measured in each spring survey is shown as a dot. Line segments join successive recoveries of the same individual PIT tag in spring surveys.
Boxplot of fork lengths for 1 year old smolt (Y+) compared to 2 year old smolt (Y++) at first capture at the RST and recapture at the dam. Grey boxes indicate the Y++ cohort.
Smolt Length vs. Outmigration Time

Time elapsed between original capture at RST and subsequent detection at dam vs. initial measured fork length. Error bars are 95 percent confidence intervals.
Electro-Fishing Summer 2014

Over 8000 in Pudding Creek.
Two-year old “Big Kahuna”
Three Year Life-History Questions:

- Is this a coho survival strategy for drought-prone Northern California?
- Are coho “programmed” to live exactly 3-years?
- If so, will all these fish return as jacks, and is this how most jacks originate?
- And, if this is so, what happens to females? Most jacks are identified as precocious males.
- Will the males return as jacks, but the females as 4-year old spawners?
- Do we need to re-think our present recovery strategy—based on Metapopulation Theory?