Assessing limitations to life history diversity to help prioritize actions for restoring steelhead

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U.S. Department of the Interior
U.S. Geological Survey
I. Know thy fish well
(before you mess with their home)

II. Is a moving fish a dead fish?
(not talkin' about their emotional state)
Steelhead, AKA: anadromous rainbow trout
*Oncorhynchus mykiss*

Methow River Watershed
Upper Columbia River ESU, ESA “Threatened”

Freshwater ➞ Saltwater
Adult ➞ Egg ➞ Fry ➞ Parr ➞ Smolt ➞ Adult
Barrier removals in Beaver Creek 2000-2005

Small dams
Culverts
(Reclamation, USFS)
Recolonization by steelhead

and/or

Enhancing expression of steelhead life history from within

Genetic aspects: Focus of Dana Weigel's doctoral work (U. of Idaho)
Number of age-1 *O. mykiss* PIT tagged near rkm 5, and then detected moving downstream past our PIT tag interrogator system at rkm 4.

<table>
<thead>
<tr>
<th>Year</th>
<th>Number PIT tagged</th>
<th>Number detected</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2004</td>
</tr>
<tr>
<td>2004</td>
<td>150</td>
<td>27</td>
</tr>
<tr>
<td>2005</td>
<td>140</td>
<td>--</td>
</tr>
<tr>
<td>2006</td>
<td>104</td>
<td>--</td>
</tr>
<tr>
<td>2007</td>
<td>50</td>
<td>--</td>
</tr>
<tr>
<td>2008</td>
<td>279</td>
<td>--</td>
</tr>
</tbody>
</table>

Emigrating at age 1-3 years old
Pattern of *O. mykiss* downstream movement, Beaver Cr.

Spring: mostly age-2 and age-3 smolts;
Numbers by age of juvenile *O. mykiss* moving out of Beaver Creek in fall, 2004-2007 (weir trap counts).
Numbers by age of juvenile *O. mykiss* moving out of Beaver Creek in fall, 2004-2007 (weir trap counts).
II. Is a moving fish a dead fish?

Upon leaving its natal area, or the area being evaluated, is an assumption of mortality valid?
A comparison of fate:

a) Parr that STAY in natal area (Beaver Creek) until smolting in spring

vs

b) Parr that MOVE downstream (mainstem Methow R) until smolting in spring
Fate of PIT tagged age-1 *O. mykiss* in lower Beaver Creek, 2004-2007: Contribution to smolt production

<table>
<thead>
<tr>
<th>Year</th>
<th>Number PIT tagged</th>
<th>Life history strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Move in fall (age-1 parr)</td>
<td>Stay (until smolting)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Detection probabilities</th>
<th>Move in fall</th>
<th>Stay</th>
</tr>
</thead>
<tbody>
<tr>
<td>At Beaver Cr detector</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>At Beaver Cr weir</td>
<td>0.346</td>
<td>0.346</td>
</tr>
<tr>
<td>At McNary Dam detector</td>
<td>0.176</td>
<td>0.176</td>
</tr>
</tbody>
</table>

Survival from: Beaver Cr to McNary Dam

-57%

Multi-state mark-recapture modeling by: Russell Perry, USGS
Lower Beaver Creek

Age at smolting, as detected in the Columbia River PIT tag interrogation network, for age-1 *O. mykiss* tagged in 2004-2007

Currently the subject of an ongoing foodweb study and a bioenergetic modeling effort

**Movers at age-1 in fall**

- 67% at age 2
- 33% at age 3

**Stayers until smolting in spring**

- 54% at age 2
- 38% at age 3
- 8% at age 4

67% 33% 54% 38% 8%
Modeling inputs to answer:

What is the contribution of age-1 fall movers to total steelhead smolt production from Beaver Creek given:

<table>
<thead>
<tr>
<th></th>
<th>Movers</th>
<th>Stayers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed parr-smolt survival:</td>
<td>23.4%</td>
<td>54.5%</td>
</tr>
<tr>
<td>Smolt age distribution (age 2,3,4):</td>
<td>67%, 33%, 0%</td>
<td>54%, 38%, 8%</td>
</tr>
</tbody>
</table>

Over three levels of percent stayer values: 30%, 50%, 70%

Solving for egg-to-parr survival to stabilize: 6.4%, 3.9%, 2.8%
**Modeling results:** Contribution of age-1 fall movers to total steelhead smolt production from Beaver Creek.

<table>
<thead>
<tr>
<th>Percent age-1 MOVERS</th>
<th>30%</th>
<th>50%</th>
<th>70%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent age-1 STAYERS</td>
<td>70%</td>
<td>50%</td>
<td>30%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Percent contribution of MOVERS to total output of smolts</th>
<th>16%</th>
<th>30%</th>
<th>50%</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Percent smolt “increase” due of MOVERS (those typically not recognized)</th>
<th>18%</th>
<th>43%</th>
<th>100%</th>
</tr>
</thead>
</table>

*Caveat:* Preliminary modeling exercise that needs, and will get, more data.
Revisit:

Limiting factor as a bottleneck (by life-stage and season)

Adapted from: Hall and Baker (1982) “...oversimplification of a complex ecological process.”
Incorporating movement, with a winter pinch.

Trib A
- Spawning
- Summer
- Winter
- (+1yr)

Trib B
- Spawning
- Summer
- Winter
- (+1yr)

Mainstem
- Spawning
- Winter
- Spring
- (+/-)

TO OCEAN

TO OCEAN
Conclusions

First ask:
  “How are fish using the system? (How did, How will?)
Before asking:
  “What is the limiting habitat factor(s)?”

Tracking fate of individual juvenile fish can provide valuable information on existing diversity of life history strategies. ("Who knew?!" moments)

With this kind of information, better able to assess where to focus restoration efforts: Tributary vs Mainstem?
Why would juvenile fish move from their natal area?

Response to:
- Food and space
- Interaction (intra-, interspecific)

Displaced by:
- Flow events
- Disturbance (fire, debris flows, etc)

Smolting vs residualization because:
- Genetic (physiological destiny)
- f (food, temperature, growth, maturation)
  - Thorpe (1994), Hendry et al. (2004), Satherwaite et al. (2008)