“Balancing Marine and Freshwater Survival Rates When Managing Anadromous Fish Passage”

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Or: “The Thinking Fish’s Guide to Where to Spend Life”

Pre-Migration:
- Egg
- Fry
- Pre-Smolt

Migratory Phase:
- Smolt (Freshwater)
- Juvenile (Early Ocean)
- Immature (Ocean Years 2+)
- Returning Adult (Last Few Months)

Reproductive Phase:
- Spawn & Die
The Salmon Life Cycle

Credit: Lakelse Watershed Society
The Salmon Life Cycle

TIME
- FW: 0.5~1.5 yrs
- Ocean: 1.5~4 yrs

GROWTH
- 99% in ocean

SURVIVAL
- “Most” determined in ocean
- (About 6/7ths of migratory survival is determined in the ocean)
The Salmon Life Cycle

TIME

- Age at maturity is fixed (years are integers), so...

- Less time spent in freshwater ➔ More time spent in the Ocean

- Let’s Explore the Implications
“...Put simply, salmon can remain in freshwater and have a comparatively high survival rate... or they can go to sea and have a lower probability of survival [and a higher growth rate]...”

Virtually all salmon conservation efforts in the Columbia River hydrosystem assume that moving smolts out of the hydrosystem and into the ocean faster improves survival:

- Spill
- Barging (Transportation)
- Reservoir Drawdown
- Dam Breach

This makes logical sense only if $S_{\text{Ocean}} > S_{\text{FW}}$

So what is the empirical evidence?
Kintama Acoustic Telemetry Overview
Map of the 2006-09 Array

- Coastal ocean sub-arrays extended offshore to 200 m depth (Edge of Continental Shelf)
- Sub-array added at Astoria in 2008
- Sub-array added at Cascade Head, OR in 2009

LAB= Lake Bryan
LAW= Lake Wallula
LAC= Lake Celilo
MCG=McGowans Channel
AST=Astoria Bridge
WIL=Willapa Bay
LIP=Lippy Point
CAS=Cascade Head
Graves Harbor

Acoustic sub-array
Hatchery origin
Release site
Telemetry array (Vemco equipment) used to measure Snake River Spring Chinook survival in 4 habitats:

- Hydrosystem
- Estuary
- Plume
- Coastal Ocean
2008 & 2009 Juvenile Migration Animation

1st GENERATION ARRAY - 2008

1st GENERATION ARRAY - 2009

- Estimated fish locations
- Interpolated path
- Final known location

18 Apr
IS THE DATA RELIABLE?
Acoustic-Tagged Smolts: Adult Return Rates (SARs)
IS THE DATA RELIABLE?

PIT vs Acoustic-Tagged Smolts: Columbia River Chinook Survival (Freshwater Comparison)
Continental shelf Chinook Survival

Estimated CJS survival ± 95% CI; Coastal survivals assume NWVI sub-array detection efficiencies of 50 & 100%

Continental shelf Chinook Survival

Estimated CJS survival ± 95% CI; Coastal survivals assume NWVI sub-array detection efficiencies of 50 & 100%
SUMMARY

- Reducing freshwater residence time necessarily increases survival in the hydrosystem
  - First, because freshwater observation time is shorter. (!)

- However, only if survival rates are better in the ocean than freshwater does reducing freshwater residence time improve adult returns.

A Decision Rule:

<table>
<thead>
<tr>
<th>RULE</th>
<th>EFFECT OF CURRENT MANAGEMENT APPROACHES</th>
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<tbody>
<tr>
<td>$S_{\text{Ocean}} &gt; S_{\text{FW}}$</td>
<td>Improves adult returns</td>
</tr>
<tr>
<td>$S_{\text{Ocean}} \approx S_{\text{FW}}$</td>
<td>No Effect</td>
</tr>
<tr>
<td>$S_{\text{Ocean}} &lt; S_{\text{FW}}$</td>
<td>Reduces adult returns</td>
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Conclusions

- Management actions reducing smolt residence time in the river increase time spent in the ocean.
- Under the poor ocean conditions predicted in future (similar to what occurred in the 1990s) ocean survival rates could well be lower than in the hydrosystem.
- Current approaches to river conservation should be assessed to see if they are appropriate under such conditions.