Briefing to ISAB on transport/spill, 2010

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Northwest Fisheries Science Center

12 March 2010
Outline
Outline

• 2008 ISAB review
Outline

• 2008 ISAB review
• 2010 environmental conditions
Outline

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• 2010 environmental conditions
• Recent NOAA Transport/spill analysis
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• Straying
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• Lamprey
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• Sockeye
• Lamprey

• Summary
• “Whenever river conditions allow during the late April-May period, a strategy allowing for concurrent transportation and spill is prudent”
ISAB 2008-5

• “Whenever river conditions allow during the late April-May period, a strategy allowing for concurrent transportation and spill is prudent”

• “Spill-transport operations like those of 2006 and 2007 should be continued long enough to determine how much influence such operational changes have on downriver migration and adult returns”
April-September Runoff
(Percent of average)

<table>
<thead>
<tr>
<th></th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010*</th>
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<tbody>
<tr>
<td>Lower Granite</td>
<td>66</td>
<td>116</td>
<td>59</td>
<td>106</td>
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<td>Grand Coulee</td>
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<tr>
<td>The Dalles</td>
<td>74</td>
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<td>86</td>
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<td>85</td>
<td>67</td>
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</tbody>
</table>

* forecast
Ocean Conditions

2009 Sea Surface Temperature Anomalies
Sept 2009 SST Anomaly
2010 SST forecast
2010 Conditions

• Forecast: 2010 flows will be similar to 2007 in the Snake, but lower than 2007 in the Columbia
2010 Conditions

• Forecast: 2010 flows will be similar to 2007 in the Snake, but lower than 2007 in the Columbia

• Ocean conditions will likely be less favorable than in 2007
2010 Conditions

- Forecast: 2010 flows will be similar to 2007 in the Snake, but lower than 2007 in the Columbia
- Ocean conditions will likely be less favorable than in 2007
- Proportion collected and transported < in low flow years (< water through the powerhouse)
Transport/spill analysis
Transport/spill analysis

- Structural and operational changes have reduced travel time through the system

Stream-type Chinook Median Travel Time
Lower Granite to Bonneville (461 km)

Steelhead Median Travel Time
Lower Granite to Bonneville (461 km)
Transport/spill analysis

- Structural and operational changes have improved survival through the system

Snake River Trap to Bonneville

Stream-type Chinook

- Estimated survival
- $\bar{X} = 48.8\%$
- 2004: 53.2%

Steelhead

- Estimated survival
- $\bar{X} = 38.3\%$
- 1996: 69.3%

[Graphs showing survival rates over years]
Fewer smolts have been transported in recent years.
Analyses of Seasonal Patterns in Smolt-to-Adult Return Rates (SARs)

- Have changes in operations, juvenile survival, travel time resulted in changes in SARs?
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  • Changes in absolute SARs?
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  • Changes in SARs for in-river migrant fish relative to SARs for transported fish (T:M)?
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- Have changes in operations, juvenile survival, travel time resulted in changes in SARs?
  
  • Changes in absolute SARs?

  • Changes in SARs for in-river migrant fish relative to SARs for transported fish (T:M)?

- Caveats for analyses to date
Caveats

• Analyses are:
  • Mostly based on available (adventitious) data

• Analyses are not:
  • Based on planned, designed experiments (small exceptions)
Caveats

• Analyses are:
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  • Restricted by dates of adventitious data

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  • Limited by small numbers of adult returns for some years
  • Based on incomplete adult return data for recent migration years

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  • Based on planned, designed experiments (small exceptions)
  • Able to shed much light on transport early in the season, 2006-2008
  • Prescriptive for transport on particular dates or under particular conditions
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Data

- Daily estimates of smolt-to-adult return rates (SARs)
  - Four groups of smolts for each species/rear-type/migration season:
    - Smolts collected and transported from collector dam and smolts bypassed there and returned to the tailrace
    - Smolts tagged upstream from collector dam or at collector dam
  - Count numbers of PIT-tagged smolts at collector dam in each group each day
  - Count numbers of adults that return to LGR from each daily smolt group
  - Estimated SAR for day $i$: $\hat{SAR}_i = \frac{A_i}{J_i}$
Models for SAR Data

- For four groups of a species/rear-type/migration year:
  - Fit family of statistical regression models (Poisson log-linear regression) with SAR (potentially) a function of:
    - Migration group (transported or in-river migrant)
    - Tagging location (upstream of or at collector dam)
    - Date of passage (day of year)
    - Two-way and three-way interactions of above
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    - Date of passage (day of year)
    - Two-way and three-way interactions of above

  • Derive AIC-weighted model-averaged estimates:
    - SAR by day for transported fish
    - SAR by day for in-river migrant fish
    - T:M ratios by day
    - Confidence envelopes
Standards of Comparison for T:M

• Assess daily model-averaged T:M ratio estimates relative to two different standards:
  
  • **Standard of 1.0**
    • Estimated T:M greater than 1.0 indicates that among LGR detected fish, those transported returned at a higher rate than those bypassed
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  - **Alternative Standard**
    - Greater than 1.0; accounts for difference between SARs for non-bypassed and bypassed in-river migrants
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  • **Alternative Standard**
    • Greater than 1.0; accounts for difference between SARs for non-bypassed and bypassed in-river migrants.

• Estimated T:M greater than alternative standard indicates that transported fish in the run at large returned at a higher rate than in-river migrants in the run at large.
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    - Greater than 1.0; accounts for difference between SARs for non-bypassed and bypassed in-river migrants
      - Estimated T:M greater than alternative standard indicates that transported fish in the run at large returned at a higher rate than in-river migrants in the run at large

- Statistical “significance” assessed using confidence envelope
Alternative T:M Standard

- Value depends on
  - Ratio of annual SARs for non-bypassed and bypassed in-river migrants
  - Proportion of smolts non-bypassed
Alternative T:M Standard

- Value depends on
  - Ratio of SARs for non-bypassed and bypassed in-river migrants
  - Proportion of smolts non-bypassed
  - \((\text{SARC0}/\text{SARC1} \times \% \text{NB} + 1 \times \% \text{C1})\)

- For Transport from LGR compared to bypassed in-river migrants:

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<th>WST</th>
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<td>2008</td>
<td>1.02</td>
<td>1.09</td>
<td>1.08</td>
<td>1.28</td>
</tr>
</tbody>
</table>

- For transport from LGO compared to bypassed in-river migrants:

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<tr>
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<th>WCH</th>
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<th>WST</th>
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<td>1.14</td>
<td>1.27</td>
<td>1.21</td>
<td>1.16</td>
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<td>2006</td>
<td>1.08</td>
<td>1.19</td>
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<tr>
<td>2007</td>
<td>1.22</td>
<td>1.39</td>
<td>1.31</td>
<td>1.20</td>
</tr>
<tr>
<td>2008</td>
<td>1.13</td>
<td>1.22</td>
<td>1.23</td>
<td>1.20</td>
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</table>
SAR and T:M Modeling Results
Wild Chinook 1999

Top AIC-weighted model is #12: SAR=D + L + T + D*T

released above LGR

transported

migrant

April 1 May 1 May 15 Jun 1

date at LGR

Released above LGR

Released at LGR

transported

migrant

April 1 April 15 May 1 May 15 Jun 1

date at LGR

fitted T.M ratio

released above LGR (30,150)

released at LGR (177,153)

(same curve)

smolt passage index

April 1 April 15 May 1 May 15 Jun 1

date at LGR
Wild Chinook 1999
Model-Averaged

Released above LGR
- Transported
- Migrant

Released at LGR
- Transported
- Migrant

Fitted T:M Ratio
- Released above LGR (30,150)
- Released at LGR (177,153)
- Smolt Passage Index
Wild Chinook 2002
Top AIC-weighted model is #1: SAR=D

Released above LGR
- Transported
- Migrant

Released at LGR
- Transported
- Migrant

Date at LGR

Fitted T:M Ratio

Released above LGR (26,38)
Released at LGR (62,302)
(same curve)
Smolt Passage Index

Date at LGR
Wild Chinook 2002
Model-Averaged

Released above LGR

Released at LGR

Date at LGR

Fitted T:M Ratio

- Released above LGR (26,38)
- Released at LGR (62,302)
- Smolt Passage Index

Date at LGR
Wild Chinook 2003

Top AIC-weighted model is #11: SAR=D + L + T + D*L

Released above LGR

Released at LGR

Fitted T:M Ratio

Released above LGR (16,17)
Released at LGR (24,62)
(same curve)

Smolt Passage Index
Wild Chinook 2003
Model-Averaged

Released above LGR

Released at LGR

Date at LGR

Fitted T:M Ratio

Date at LGR

Smolt Passage Index
Wild Chinook 2006

Top AIC-weighted model is #18: SAR=D + L + T + D*L + D*T + L*T + D*L*T

Released above LGR

Released at LGR

Date at LGR

Date at LGR

Fitted T:M Ratio

- Released above LGR (36,39)
- Released at LGR (121,64)
- Smolt Passage Index
Wild Chinook 2006
Model-Averaged

Released above LGR

- Transferred
- Migrant

Released at LGR

- Transferred
- Migrant

Date at LGR

Fitted T:M Ratio

- Released above LGR (36,39)
- Released at LGR (121,64)
- Smolt Passage Index

Date at LGR
Wild Chinook 2007

Top AIC-weighted model is #18: SAR = D + L + T + D*L + D*T + L*T + D*L*T

Released above LGR

Released at LGR

Fitted T:M Ratio

Released above LGR (27,54)
Released at LGR (117,75)
Smolt Passage Index
Wild Chinook 2007
Model-Averaged

Released above LGR
- Transported
- Migrant

Released at LGR
- Transported
- Migrant

Fitted T:M Ratio
- Released above LGR (27,54)
- Released at LGR (117,75)
- Smolt Passage Index

Date at LGR
Hatchery Chinook 2007
Model-Averaged

Released above LGR

Date at LGR

Transported
Migrant

Released at LGR

Date at LGR

Transported
Migrant

Fitted T:M Ratio

Released above LGR (231,158)
Released at LGR (115,158)
Smolt Passage Index

Date at LGR
Hatchery Steelhead 2007
Model-Averaged

Released above LGR

Released at LGR

Date at LGR

Date at LGR

Fitted T:M Ratio

Released above LGR (16, 27)
Released at LGR (399, 105)
Smolt Passage Index

Date at LGR
Wild Steelhead 2007
Model-Averaged

Released above LGR
- Transported
- Migrant

Released at LGR
- Transported
- Migrant

Fitted T:M Ratio
- Released above LGR (45,14)
- Released at LGR (179,22)
- Smolt Passage Index

Date at LGR

01234 SAR(%) 01234 SAR(%) 012468 T:M
April 1 May 1 May 15 June 1
April 1 May 1 May 15 June 1
April 1 April 15 May 1 May 15 June 1

Date at LGR

0 2 4 6 8 T:M
April 1 April 15 May 1 May 15 June 1

Date at LGR

0 2 4 6 8 T:M
April 1 April 15 May 1 May 15 June 1

Date at LGR
Geometric Mean Estimated T:M
All Years (Top AIC Models)
Geometric Means of Estimated T:M
(Preliminary Analysis)

Wild Chinook

Hatchery Chinook

Wild Steelhead

Hatchery Steelhead
# Adults Returning

- Total number of adults returning depends on:
  - Number of smolts arriving at LGR
  - Proportion transported
  - SAR for transported smolts
  - SAR for inriver migrant smolts
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- All above vary by day throughout season
# Adults Returning

- Total number of adults returning depends on:
  - Number of smolts arriving at LGR
  - Proportion transported
  - SAR for transported smolts
  - SAR for inriver migrant smolts

- All above vary by day throughout season

- Proportion transported depends
  - Proportion in bypass system (% spill)
  - Proportion of those in bypass system that are transported
  - For steelhead:
    - ~ 30% of LGR arrivals with spill (2007)
    - ~ 85% of LGR arrivals without spill
# Adults Returning

- Scenarios under discussion are the same in April:
  - Differences in adult returns depend on different management choices for May

- Smoothed average passage distribution at LGR for steelhead:
  - Hatchery and Wild Combined: 5M in May (7M seasonal total)
  - ~10% Wild

![Graph showing passage distribution]

- X-axis: May 1 to May 31
- Y-axis: Number of Passages (0 to 300,000)

Graph shows a peak around May 16 with a gradual decline thereafter.
For SARs use model-averaged estimates for Wild Steelhead released above Lower Granite Dam in 2007 (increasing SARm by 11% for C0:C1 adjustment)
# Adults Returning

Overall SARs for May-passing fish based on preceding assumptions:

<table>
<thead>
<tr>
<th>Percent Transported</th>
<th>Resulting SAR</th>
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<tbody>
<tr>
<td>0%</td>
<td>0.47%</td>
</tr>
<tr>
<td>100%</td>
<td>2.08%</td>
</tr>
<tr>
<td>30% with spill (2007)</td>
<td>0.92%</td>
</tr>
<tr>
<td>85% without spill</td>
<td>1.83%</td>
</tr>
</tbody>
</table>

* SARs for run at large (T and M) likely higher than these based on PITs

* SARs in worse ocean would be lower
# Adults Returning

Total adults returning from May-passing fish based on preceding assumptions:

<table>
<thead>
<tr>
<th>Percent Transported</th>
<th>Total Adults From 5M Steelhead smolts</th>
<th>Adults from 500K Wild steelhead smolts</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>23,600</td>
<td>2,360</td>
</tr>
<tr>
<td>100%</td>
<td>105,500</td>
<td>10,550</td>
</tr>
<tr>
<td>30% with spill (2007)</td>
<td>46,600</td>
<td>4,660</td>
</tr>
<tr>
<td>85% without spill</td>
<td>92,900</td>
<td>9,920</td>
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Questions about Analyses of Seasonal Patterns in SARs and T:M
Straying

• All anadromous salmonids stray
Straying

• All anadromous salmonids stray

• Rate of straying varies among hatcheries (Irrigon Hatchery the highest)
Straying

• All anadromous salmonids stray
• Rate of straying varies among hatcheries (Irrigon Hatchery the highest)
• Transported fish stray > migrant fish (3-5%)
Straying

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• Rate of straying varies among hatcheries (Irrigon Hatchery the highest)
• Transported fish stray > migrant fish (3-5%)
• Transported fish have impaired homing ability
Straying

• All anadromous salmonids stray
• Rate of straying varies among hatcheries (Irrigon Hatchery the highest)
• Transported fish stray > migrant fish (3-5%)
• Transported fish have impaired homing ability
• More transports PIT tagged in recent years (>196k steelhead, >107K spring Chinook, 2006-2008 from alternate release site study)
Straying

• Substantially more transported steelhead return than steelhead that migrate inriver
Straying

• Substantially more transported steelhead return than steelhead that migrate inriver
• Is transport the problem or do we have too many hatchery steelhead (>9 million)?
Lamprey passage
Lamprey passage

• Bottom oriented (no swim bladder)
Lamprey passage

- Bottom oriented (no swim bladder)
- Weak swimmers, negatively buoyant
Lamprey passage

- Bottom oriented (no swim bladder)
- Weak swimmers, negatively buoyant
- Very little passage data available
Lamprey passage

• Bottom oriented (no swim bladder)
• Weak swimmers, negatively buoyant
• Very little passage data available
• Occasionally found impinged on bar screens
Lamprey depth distribution
Bonneville Dam, 2002
44 tests

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<td>Total</td>
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Lamprey depth distribution
The Dalles Dam, 1960
14 tests

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<tr>
<td>FN-4</td>
<td>387</td>
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<td>FN-5</td>
<td>460</td>
</tr>
<tr>
<td>FN-6</td>
<td>211</td>
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<tr>
<td>Total</td>
<td>1,679</td>
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Spillway passage?
Less likely to use surface passage structures (Lower Granite RSW)
Lamprey passage

• No injury or mortality data available for juvenile lamprey passing through spillways or turbines
Lamprey passage

- No injury or mortality data available for juvenile lamprey passing through spillways or turbines
- transporting most salmonids would likely increase predation risk for juvenile lamprey passing through turbines
Sockeye passage

• No data available to directly assess effects of Snake River sockeye transport
Sockeye passage

• No data available to directly assess effects of Snake River sockeye transport

• Sockeye are more fragile than other salmonids (> descaling in bypass systems)
Sockeye passage

• No data available to directly assess effects of Snake River sockeye transport
• Sockeye are more fragile than other salmonids (> descaling in bypass systems)
• No data available on sockeye injury rates and mortality for spillway or turbine passage
Comparison of annual Snake River sockeye salmon Index SAR estimates with annual survival estimates of smolts from Lower Granite Dam to McNary Dam, juvenile outmigration years 1998-2006
Percent Snake River transported vs Snake River SAR

\[ R^2 = 0.71, \ P < 0.01 \]
Percent Snake River River transported vs Columbia River SAR

$R^2 = 0.73, P < 0.01$
Comparison of estimated SAR for combined Columbia River sockeye salmon population (smolts at McNary Dam and adults at Bonneville Dam) with Index SAR for Snake River sockeye salmon (smolts and adults at Lower Granite Dam), juvenile outmigration years 1998-2006

\[ y = 0.107x - 0.036 \]

\[ R^2 = 0.872, P < 0.001 \]
Relationship between the proportion of Snake River sockeye salmon juveniles transported and an index of Snake River-specific variation of subsequent Index SARs (residuals of regression of Snake River Index SARs on Columbia River SARs), juvenile outmigration years 1998-2006.
New structures

• LMO surface passage (2008)
New structures

• LMO surface passage (2008)
• LGO surface passage (2009)
New structures

• LMO surface passage (2008)
• LGO surface passage (2009)
• John Day surface passage (2008)
New structures

- LMO surface passage (2008)
- LGO surface passage (2009)
- John Day tailrace bird wires (2010)
New structures

• LMO surface passage (2008)
• LGO surface passage (2009)
• John Day surface passage (2008)
• John Day tailrace bird wires (2010)
• The Dalles Spillway wall (partial 2009, complete 2010)
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• Should result in survival improvement
Summary

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- However, transport still returns more adults for most stocks, especially later in the migration season, so transporting fewer fish in recent years has resulted in substantially fewer adult fish returning.
- Terminating spill in May will greatly reduce survival for fish left in river, but few fish will be affected.
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• Low flow conditions in 2010 will likely offset any survival gains made with additional passage structures
• It would be prudent to demonstrate that passage improvements have reduced the late season transport benefit for wild steelhead under moderate to high flow conditions before testing them during low flow/poor ocean conditions