Comparative Survival Study Annual Meeting

Presenter: Jack Tuomikoski

CSS Annual Meeting Apr 7th 2011
Background

- Study initiated in 1996 by states, tribes & USFWS to estimate survival rates at various life stages
  - Designed to assess hydrosystem operations on state, tribal, and federal fish hatcheries and LSRCP
  - PATH - “can transportation . . . compensate for the effect of the hydrosystem?”
  - NOAA biological opinions require research, monitoring and evaluation
  - NPCC has established the need to collect annual migration characteristics including survival

- Management-oriented large scale monitoring
  - Observational study
  - Aligned with basin wide monitoring needs (RME)
Background

**GOALS**

1. Quantify the efficacy of transportation
   - Develop a more representative control group
2. Compare survival rates within and across species
3. *Establish long term data set*
Background

CSS data is derived from PIT tags

- Tagged specifically for CSS
- Cooperative marking between CSS and other research studies
  - reduce costs/handling, eliminate duplication
- Groups marked for other studies
Background

- Collaborative scientific process was implemented for study design and to perform analyses

- CSS project independently reviewed and modified a number of times
  - ISAB, ISRP and other entities
  - Early years focused on CIs about parameter estimates
History of ISAB/ISRP Reviews of CSS

1997 – **ISAB** First review of CSS

1998 – **ISAB** Add steelhead, begin nonparametric bootstrap approach

2002 – **ISRP** *Further Evaluate bootstrap*, compare with likelihood methods, Monte Carlo simulator evaluation
History of ISAB/ISRP Reviews of CSS

2003 – **ISAB** Review of flow augmentation
   “understanding of the relation between reach survival, instantaneous mortality, migration speed, and flow”

2006 – **ISAB** Review of 2005 CSS report
   1) “finer scale analyses of the relationships between survival and specific operational actions or environmental features”
   2) Develop a ten year summary report
History of ISAB/ISRP Reviews of CSS

2007 – **ISAB/ISRP** Review CSS “10-year” report
   1) continue coordination to affect cost savings and avoid redundancy
   2) Address: Are PIT tag SARs < run reconstruction SARs and conduct a comprehensive study to determine why

2009 – **ISAB** Tagging Report
   Compare CSS SARs with Run Reconstruction SARs

2009 – **ISAB** annually reviews CSS reports
The CSS is a joint project of the state, tribal fishery managers and the US Fish and Wildlife Service.

**Design**
WDFW, CRITFC, USFWS, ODFW, IDFG

**Review**
Regional review, ISAB, ISRP, FPAC, NMFS

**Implementation and Tagging**
FPC - logistics, coordination, e.g. PITAGIS - data management

**Data Preparation**
Fish Passage Center

**Analysis**
CSS Oversight Committee, FPC - coordinates

**Review**
Regional Review public review
Drafts posted on FPC and BPA websites

**Final Report**
Posted on BPA and FPC websites
CSS hatchery Chinook
CSS Snake River hatchery steelhead
CSS wild Chinook and steelhead
Smolt Survival

Freshwater

- Lower Granite
- Little Goose
- Lower Monumental
- Ice Harbor
- McNary
- John Day
- The Dalles
- Bonneville

Estuary

Ocean

Rearing Habitat Actions

Hydro-system Actions
Adult Success

Freshwater

Bonneville

Lower Granite

Estuary

Harvest Management

Adults

Hatchery

Wild

Hydro-system Actions

Estuary Habitat Actions

Ocean
Post BON Survival

Freshwater

Smolts

Lower Granite

Bonneville

Estuary

Ocean

Transportation Or Bypass effects

Adults Hatchery

Wild
What does the CSS project provide?

- Long term consistent information collaboratively designed and implemented
- Information easily accessible and transparent
  - CSS PIT-tags accessed by any PTAGIS users, including fisheries managers, researchers, and academics.
- Long term indices (identify bottlenecks):
  - Travel Times
  - In-river Survival Rates
  - In-river SARs by route of passage
  - Transport SARs
  - Adult success, conversion
- Comparisons of SARs
  - Transport to In-River
  - Interim NPCC SAR goal
  - By geographic location
  - By hatchery group
  - Hatchery to Wild
  - Chinook to Steelhead

Management questions: hydropower operations, hatchery evaluations, habitat evaluations
2010 Report

- 11th complete brood year for Snake River PIT tagged fish

**Snake River (SARs)**
- Hatchery sp/su Chinook (1997-2008)
- Wild Chinook (1994-2008)
- Aggregate wild steelhead (1997-2007)
- Aggregate hatchery steelhead (1997-2007)

**Snake River Hatchery Sockeye (1998-2009)**
- Juvenile metrics

**Upper Columbia River (SARs)**
- Hatchery Chinook (2000-2008)
  - Leavenworth

**Middle Columbia River (SARs)**
- Hatchery Chinook (2000-2008)
  - Carson, Cle Elum
- Wild Chinook, wild steelhead (2000-2008)
  - John Day, Deschutes
Introduction

Patterns in Overall Smolt to Adult Return Rates (SARs)

Components of Overall SARs, TIR & D: Patterns and Significance

Bypass Effects on SARs and Fish Travel Time

**Break 15 minutes**

Juvenile survival, travel time and the in-river environment

Upstream Passage Success Rates and Straying of Returning Adults

SARs and Juvenile Metrics of Upper and Mid-Columbia Stocks

2011 work planned, new operations, and wrap up

**Questions / Discussion**
Patterns in Overall Smolt to Adult Return Rates (SAR)

Presenter: Howard Schaller

CSS Annual Meeting April 7, 2011
Overview

- Annual SARs for hatchery & wild groups of smolts with different hydrosystem experiences (T, C₀, C₁)
- Overall SAR - survival of all outmigrating smolts weighted across their different in-river and transport route experiences- entire brood of smolts
- Compare SARs from the Snake River, Upper Columbia and Mid Columbia for wild and hatchery spring/summer chinook and steelhead
- Contrast SARs for the various populations relative to NPCC 2-6% SAR objectives
- Estimate So₁ to evaluate ocean conditions and FCRPS smolt migration conditions that may influence post-river survival
Survival rate time series

Freshwater

Eggs → Upper Dam → Direct survival through Dams

Tributary habitat

Smolts-per-spawner

Direct survival transported Fish

Bonneville Dam

Upper Dam

Mainstem Hydro

Estuary

Ocean

First year estuary/ocean survival (S01)

Smolt to Adult Return rates
Smolt to Adult Return

- **Smolts** - categories
  - Snake -
    - Run recon - LGR or upper most dam
    - PIT - LGR
  - Upper Col - McNary dam
  - Mid Col. - 1st dam encountered (JD or Bon)

- **Adult** - categories
  - Snake -
    - Run recon - Columbia River mouth
    - PIT - LGR
  - Upper Col - Bon dam
  - Mid Col. - Bon. Dam

- **SAR = Adult/ Smolt**
  - LGR smolts ~ mark-recapture (CJS) estimate
  - LGR adults ~ count data
  - Bootstrap 90% CI

- **NPCC SAR objective** - 4% average (2-6%)
Study Categories

- **C₀**: Pass all Snake River collector/transport dams (LGR, LGS, LMN) via combination of spill and turbine routes

- **C₁**: Pass one or more transport dams via bypass system

- **T**: Transported fish collected at LGR, LGS or LMN
Weighting of Study Categories

\[ \text{SAR}_{\text{Annual}} = w(T') \times \text{SAR}(T') + w(C_0) \times \text{SAR}(C_0) + w(C_1) \times \text{SAR}(C_1) \]

and where:

\[ w(T) = \frac{T}{T + C_0 + C_1} \]
SARs from smolts at uppermost Snake River dam to Columbia River returns for Snake River wild Chinook

SAR (LGR smolts to LGR adults) and CIs for Snake River wild and hatchery Chinook groups

Wild Snake River Chinook

Rapid River hatchery Chinook
SARs from smolts at uppermost Snake River dam to Columbia River returns for Snake River wild steelhead

SARs based on run reconstruction (1964-1996 solid line) and CSS PIT-tags (1997-2007, dots and solid line).
SARs (LGR smolts to LGR adults) and CIs for Snake River wild and hatchery Snake River steelhead

Wild Snake River Steelhead

Hatchery Snake River Steelhead
SARs and CIs for wild and hatchery Chinook from mid-Columbia region

Smolts are estimated at upper most dam; adults are enumerated at BOA
SAR and CIs for wild steelhead from mid-Columbia region

Smolts are estimated at upper dam; adults are enumerated at BOA
SAR and CIs for Leavenworth hatchery Chinook from Upper Columbia region
IDFG run reconstruction SARs and CSS PIT-tag SARs and 90% CI

Run reconstruction v PIT SARs

Migration year

% SAR (LGR-LGA)

1st year ocean survival rates are calculated by partitioning of SARs using the parameter estimates in CSS, including in-river survival, transport proportions and D.

SARs and So1 survival rates evaluate ocean environmental variables and smolt migration conditions within the FCRPS that influence survival of late life stages.
Gulf of Alaska

California Current brings cold polar water from the north keeping coastal temperatures cool
Candidate Ocean Variables (N = 37)

Broad scale:
• Pacific Decadal Oscillation

Near shore:
• Coastal Upwelling
• Spring Transition
• Near shore Temp.

“Good Ocean”
• Cool phase PDO
• April Upwelling
Candidate River Variables (N = 5)

• **Water velocity** - Water Travel Time - Average days it takes water to travel from Lewiston to BON:
  - pre-dam ~ 2 days
  - 4 dams ~ 7 days (5 - 8)
  - 8 dams ~ 19 days (10 - 40)

• **Powerhouse passages** - Number of powerhouse passages by in-river migrants - 1.3 to 7.8

• **Proportion smolts transported** - Calculated as LGR equivalents
  Chinook & Steelhead 0 to 0.99

• **Mean daily maximum temperature** - Snake River mean maximum temperature entering FCRPS at Lewiston 9.9 to 13.2°C
First Year Ocean Survival (So1)

Partition SARs to account for hydrosystem survival and transportation

First Year Ocean Survival

- Chinook
- Steelhead
**So1**

**Top models**

Best fit, simplest models: Lower Chinook & Steelhead So1

- Warm PDO (Spring)
- Reduced Upwelling (April) – Chinook
- Increased WTT (slower velocity)

![Graph](image)

**So1 Chinook**

- Ocean alone
- River alone
- Ocean and River

Top models

Petrosky & Schaller 2010
Evidence of Delayed Hydrosystem Mortality

• >3 fold decline for Chinook is similar to estimate of delayed mortality using upriver and downriver population comparisons (Schaller and Petrosky 2007)

• River conditions during seaward migration have strong influence on survival rates at later life stages
Snake River wild spring/summer Chinook

\[ \text{SAR} \rightarrow \text{Partition} - \text{Sr, pT, D} \rightarrow \text{So1} \]

\[ \text{SAR (lgr - Col. R. mouth)} \]

\[ \text{In-river survival (SR)} \]

\[ \text{Proportion transported (pT)} \]

\[ \text{So1} \]
Summary

- Snake River wild Chinook & steelhead SARs <= NPCC 2-6% SAR objective

- PIT-tag SARs of Snake River hatchery spring/summer Chinook
  - varied by hatchery and year
  - were highly correlated with those of wild spring/summer Chinook
  - general lack of correlation between hatchery and wild steelhead SARs

- SARs for John Day wild spring Chinook and John Day and Deschutes wild steelhead generally fell within the 2-6% range of the NPCC SAR objectives

- SARs for upper Col. hatchery spring Chinook were highly correlated with wild and hatchery Chinook stocks from both the Snake and Mid-Col.
Run reconstruction SARs were greater than and highly correlated with PIT-tag SARs of Snake Chinook
  • Both survival rate estimates fell well short of the NPCC 2-6% SAR objective
  • Potential for bias in SAR estimates exists in both the run reconstruction and PIT-tag methodologies

Variation in SARs and So1 are influenced by ocean conditions and FCRPS smolt migration conditions

Improve understanding for the role of hydropower management on overall survival in the face of variable ocean and climate conditions
Snake River Spring/Summer Chinook and Steelhead Components of SAR - Transport, In-River, TIR & D: Patterns and Significance

Presenter: Charlie Petrosky

CSS Annual Meeting Apr 7th 2011
Overview

• Snake River spring/summer Chinook & steelhead

• Estimate & compare annual SARs for hatchery & wild groups of smolts with different hydrosystem experiences (T, C₀, C₁)

• Evaluate effectiveness of transportation relative to in-river migration – annual SAR ratios between T & C₀ fish (TIR)

• Estimate differential delayed mortality (D) between transported (T) and in-river (C₀) fish

• Evaluate TIR patterns relative to in-river survival (Sᵣ)
Smolt transportation

- Pre-2006: transported most collected smolts at LGR, LGS, LMN
- 2006-2010: bypassed early, transported mid- & late season
- 1994-2010: wide range of in-river conditions (flow & spill)
Study Categories

• $C_0$ – Pass all Snake River collector/transport dams (LGR, LGS, LMN) via combination of spill and turbine routes
  – i.e., $C_0$ fish not detected at any transport dam
  – Pass primarily via spill when spill provided
  – Represent in-river migrants from run-at-large (most years)

• $C_1$ – Pass one or more transport dams via bypass system
  – 2006-2010 management – early migrants
  – Bypass needed to estimate in-river survival ($S_R$)

• T – Transported from LGR, LGS or LMN
  – Represent transport management strategy
SAR Ratios

- \[ TIR = \frac{SAR(T)}{SAR(C_0)} \]
  - Evaluate relative efficacy of transportation vs. in-river passage
  - Based on LGR smolts and LGR adults

- \[ D = \frac{SAR(T) \div S_T}{SAR(C_0) \div S_R} \]
  - Evaluate relative post-Bonneville survival of transport vs. in-river
  - Based on BON smolts and LGR adults
  - Requires estimate of in-river survival \( S_R \) from LGR to BON and direct survival of transported smolts \( S_T \)

- Bootstrapped 90% CI for all annual SAR ratios
**Wild Chinook, 1994-2008**

In-river SARs (C₀ group) exceeded 2% in 4 out of 15 yrs*

Transport SARs (T group) exceeded 2% in 2/15 yrs

Bypassed SARs (C₁ group) exceeded 2% in 1/15 yrs

*Significance test, lower 90%CI > 2%SAR (Delayed start of transport)
**Chinook SAR patterns:**

- **SAR(C₀):** Wild > Hatchery

- **SAR(C₁):** Wild > Hatchery

- **SAR(T):** (MCCA, RAPH, IMNA) > Wild > DNFH
**TIRs - Wild and Hatchery Chinook, 1994-2008**

Wild Chinook — TIR > 1 in 2/15 yrs; TIR < 1 in 2/15 yrs*

Rapid River and McCall H Chinook — TIR > 1 in 9/12 & 10/12 yrs

Imnaha and Catherine Cr H Chinook — TIR > 1 in 6/12 & 3/8 yrs

Dworshak H Chinook — TIR > 1 in 3/12 yrs; TIR < 1 in 1/12 yrs

---

*Two-tailed significance tests at p<0.10*
**Wild Steelhead, 1997-2007**

In-river SARs (C₀ group) did not exceed 2% in 11 years*

Transport SARs exceeded 2% in 5/11 years

Bypassed SARs (C₁ group) did not exceed 2%

*Significance tests, lower 90% CI > 2%SAR
**TIRs - Wild and Hatchery Steelhead, 1997-2007**

**W Steelhead** – Higher TIRs than for W Chinook

**W Steelhead** – TIR > 1 in 7/11 years; TIR < 1 in 1/11 years*

**H Steelhead** – TIR > 1 in 5/11 years

**W & H Steelhead** – decrease in TIRs in 2006 & 2007

---

*Two-tailed significance tests at p<0.10*
2006-2008 management changes affected SARs of in-river and transported Chinook and Steelhead:

Operational and environmental factors:

• Early migrants passed via in-river routes (not transported)
• Increased spill compared to earlier years
• Increased % in-river migrants
• Decreased % transported
• Faster migration, higher in-river survival in years of higher discharge & spill
• 2006 average flow (Apr 15–Jun 15) - highest since late 1990s
**Differential Delayed Mortality, \(D\)**

\(D = \) ratio of Transport SAR to In-river SAR, smolts below Bonneville & adults returning to Lower Granite Dam

\(D\) < 1 indicates delayed mortality of transported smolts relative to mortality of in-river migrants after smolts pass BON

Evidence of substantial differential delayed mortality of transported wild and Dworshak Hatchery Chinook (\(D\)<1)

\(D\) is a relative measure, it does not provide information about delayed mortality of in-river migrants

<table>
<thead>
<tr>
<th>Population</th>
<th>Geomean (D)</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wild Chinook</td>
<td>0.60</td>
<td>0.32-2.16</td>
</tr>
<tr>
<td>Dworshak Hatchery Chinook</td>
<td><strong>0.75</strong></td>
<td>0.37-2.21</td>
</tr>
<tr>
<td>Rapid River Hatchery Chinook</td>
<td>1.04</td>
<td>0.57-7.33</td>
</tr>
<tr>
<td>Catherine Cr AP Hatchery Chinook</td>
<td>0.88</td>
<td>0.26-1.38</td>
</tr>
<tr>
<td>McCall Hatchery Chinook</td>
<td>1.17</td>
<td>0.64-8.95</td>
</tr>
<tr>
<td>Imnaha Hatchery Chinook</td>
<td>0.91</td>
<td>0.36-4.15</td>
</tr>
<tr>
<td>Wild Steelhead</td>
<td>0.99</td>
<td>0.11-2.69</td>
</tr>
<tr>
<td>Hatchery Steelhead</td>
<td>0.99</td>
<td>0.39-3.19</td>
</tr>
</tbody>
</table>
**Why have W steelhead TIRs > W Chinook TIRs?**

Some of relative transport benefit for steelhead was due to poor in-river survival ($S_R$)

W steelhead $S_R > 55\%$ in 2/11 years

W Chinook $S_R > 55\%$ in 6/15 years

Relation between $\log_e(TIR)$ and $S_R$ suggests transport is detrimental when $S_R$ is above ~ 55%
Summary

• Annual SARs << NPCC 2-6% SAR goal
  • Snake River wild Chinook & steelhead
  • All passage routes: $T$, $C_0$ and $C_1$
• TIRs of both wild Chinook and steelhead variable across years and associated with in-river survival
• Relative effectiveness of transportation declines as in-river survival ($S_R$) increases
  • TIR steelhead $>$ TIR Chinook
  • $S_R$ Steelhead $<$ $S_R$ Chinook
  • $S_R$ is function of in-river conditions (WTT and spill)
• Key management questions: What is scope for improving in-river survival and SARs of in-river migrants?
Bypass effects on SARs and fish travel time

Presenter: Steve Haeseker
Smolt bypass system:

Generally consists of screens, gatewells, orifices, collection channels, and river return pipe/flume

Located at 7 of 8 dams (exception TDA)

Two primary purposes: 1) collection for transportation (LGR, LGS, LMN) 2) reduce turbine passage

All bypass systems have PIT detection
Research on effects of bypass systems:

Generally high route-specific survival (95% JBS v. 98% spillway at JDA in 2010)

Reduced SARs for bypassed or multiply bypassed fish:
  Sandford and Smith (2002)
  Williams et al. (2005)
  Budy et al. (2002)
  Buchanan et al. (2010)
  Tuomikoski et al. (2009)

Reduced post-BON survival for bypassed fish:
  Budy et al. (2002)
  Scheuerell and Zabel (2006)
  McMichael et al. (2010)

Migration delays for bypass system:
  Beeman and Maule (2001)
CSS bypass evaluations

1) Meta-analysis of SAR(C1) v. SAR(C0)

2) Bypass effects on post-BON survival

3) Bypass effects of fish travel time
Synthesizing multi-year data

- Information from multiple studies is combined using “meta-analysis”

- Goal is to increase power to detect effects, by estimating “summary effect” from individual effect size estimates

- Treat each migration year as a “study” and use meta-analysis techniques
Data for analysis

- Wild Chinook 1994-2006 M.Y.s
- Wild steelhead: 1997-2006 M.Y.s
- SAR(C0) and SAR(C1)
SAR(C0) was 52% higher than SAR(C1)
Forest plot of $\text{SAR}(C_1)/\text{SAR}(C_0)$ for wild steelhead

<table>
<thead>
<tr>
<th>Year</th>
<th>C1/C0</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>0.36</td>
</tr>
<tr>
<td>1998</td>
<td>0.19</td>
</tr>
<tr>
<td>1999</td>
<td>0.51</td>
</tr>
<tr>
<td>2000</td>
<td>0.92</td>
</tr>
<tr>
<td>2002</td>
<td>1.45</td>
</tr>
<tr>
<td>2003</td>
<td>1.10</td>
</tr>
<tr>
<td>2005</td>
<td>0.10</td>
</tr>
<tr>
<td>2006</td>
<td>0.41</td>
</tr>
</tbody>
</table>

Summary $0.523$

SAR(C0) was 91% higher than SAR(C1)
Bypass effects on post-BON survival

- Logistic regression
- Yearling Chinook and steelhead, MYs 2000-2008
- Analyzed hatchery and wild, accounted for differences

<table>
<thead>
<tr>
<th>Smolt</th>
<th>JDA</th>
<th>MCN</th>
<th>IHR</th>
<th>LMN</th>
<th>LGS</th>
<th>LGR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smolt 1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Smolt 2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Smolt 3</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Results

Wild Chinook

Each bypass event reduced post-BON SARs by 11%

Wild steelhead

Each Snake bypass event reduced post-BON SARs by 8%

Each Columbia bypass event reduced post-BON SARs by 18%
Bypass effects on travel time

- Linear regression, accounting for seasonal effects
- Project-specific estimates of delay for detected (bypassed) versus non-detected
- Yearling Chinook and steelhead
- Analyzed hatchery and wild separately

<table>
<thead>
<tr>
<th></th>
<th>BON</th>
<th>TDA</th>
<th>J DA</th>
<th>MCN</th>
<th>I HR</th>
<th>LMN</th>
<th>LGS</th>
<th>LGR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smolt 1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Smolt 2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Smolt 3</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Hatchery Chinook in 2008

Day at LGR

LGR-BON
FTT (d)
Hatchery Chinook in 2008

Day at LGR

LGR-BON
FTT (d)
Results

- Similar patterns in delay between hatchery and wild
- Similar patterns in delay among the various dams

**Chinook**

- 67% of cases indicated significant delay for bypassed fish
- Average delay was 17 h

**steelhead**

- 28% of cases indicated significant delay for bypassed fish
- Average delay was 18 h
Conclusions

Transport dam bypass systems reduce LGR-LGR SARs

Bypass events at upriver dams reduce post-BON SARs

Bypass systems increase fish travel time
Management implications

Direct and route-specific survival estimates unlikely to reflect full impacts of passage routes

Most smolts are bypassed at least once: 83% STH, 77% CHN

Actions that reduce powerhouse passage (bypass + turbine) would increase SARs (both from LGR and post-BON)

Reducing powerhouse passage especially important downriver of LMN

Actions that reduce powerhouse passage would reduce FTT
Juvenile survival, travel time and the in-river environment

Presenter: Steve Haesekeker
Juvenile migration

- Two simultaneous processes: migration and mortality

- If we can predict migration rates and mortality rates, then we can predict survival rates
Objectives:

• Measure and monitor juvenile Chinook and steelhead travel time and mortality rates through the hydrosystem

• Examine associations between environmental factors and travel time and mortality rates

• Develop models that explain variation in travel time and mortality rates through the hydrosystem
Monitoring methods:

- Two reaches: LGR-MCN (CHN-W, CHN-H, STH-HW, SOX)
  MCN-BON (CHN-HW, STH-HW)

- Weekly release cohorts of PIT-tagged fish

- Estimated mean fish travel times (FTT), mortality rates and survival rates
Environmental and Management Factors:

• Seasonality (Julian Day)
• Temperature
• Turbidity
• Average percent spill
• Surface passage structures (TSW, RSW)
• Water travel time (WTT, days)
• Hatchery composition
Water Transit Time (WTT)

Estimate of the number of days required for average water particle to transit a reservoir (volume/flow)

- 3 days
- 2.5 days
- 2.5 days
- 8 days
- 3 days
- 8 days
Long-term changes in LGR-BON WTT

WTT

Migration Year


~2 days

~20 days
Yearling Chinook mean travel times

LGR-MCN

MCN-BON
Yearling Chinook mean travel times

LGR-MCN

86%

MCN-BON

96%
Yearling Chinook mean travel times

LGR-MCN

86%

MCN-BON

96%

Environmental and management factors: WTT, percent spill, Julian day
Steelhead mean travel times

LGR-MCN

MCN-BON
Steelhead mean travel times

LGR-MCN

94%

MCN-BON

92%
Steelhead mean travel times

Environmental and management factors: WTT, percent spill, Julian day, surface passage structures (TSW, RSW)
sockeye mean travel times

LGR-MCN
sockeye mean travel times

LGR-MCN

65%
sockeye mean travel times

LGR-MCN

65%

Environmental and management factors: spill
yearling Chinook mortality rates

LGR-MCN

MCN-BON
yearling Chinook mortality rates

LGR-MCN
43%

MCN-BON
8%
yearling Chinook mortality rates

Factors: WTT, Julian day, surface passage

Factors: WTT, Julian day
steelhead mortality rates

LGR-MCN

MCN-BON
steelhead mortality rates

LGR-MCN

52%

MCN-BON

53%
steelhead mortality rates

LGR-MCN

52%

Factors: WTT, Julian day, spill, surface passage

MCN-BON

53%

Factors: temperature
sockeye mortality rates
LGR-MCN
sockeye mortality rates

LGR-MCN

35%
sockeye mortality rates

LGR-MCN

35%

Environmental and management factors: WTT
Yearling Chinook survival

Outmigration year

LGR-MCN

MCN-BON
Yearling Chinook survival

LGR-MCN

55%

MCN-BON

26%

Outmigration year
steelhead survival

Outmigration year

LGR-MCN

MCN-BON
steelhead survival

LGR-MCN

79%

MCN-BON

72%

Outmigration year
sockeye survival

LGR-MCN

![Graph showing sockeye survival from 1997 to 2009 with error bars for each year. The x-axis represents the years 1997 to 2009, and the y-axis represents survival rate from 0.00 to 1.00. The data points are marked with black dots and error bars indicate the variability of survival rates.]
sockeye survival

LGR-MCN

68%
### Summary of factors (FTT):

<table>
<thead>
<tr>
<th></th>
<th>LGR-MCN</th>
<th></th>
<th></th>
<th></th>
<th>MCN-BON</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CHN-W</td>
<td>CHN-H</td>
<td>STH-HW</td>
<td>SOX</td>
<td>CHN-HW</td>
<td>STH-HW</td>
<td></td>
</tr>
<tr>
<td>Julian Day</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
</tr>
<tr>
<td>Temperature</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turbidity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average percent spill</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
</tr>
<tr>
<td>Surface passage</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water travel time</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
</tr>
<tr>
<td>Hatchery composition</td>
<td>↑</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Summary of factors (mortality rates):

<table>
<thead>
<tr>
<th></th>
<th>LGR-MCN</th>
<th>MCN-BON</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CHN-W</td>
<td>CHN-H</td>
</tr>
<tr>
<td>Julian Day</td>
<td></td>
<td>↑</td>
</tr>
<tr>
<td>Temperature</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turbidity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average percent spill</td>
<td>^</td>
<td>↓</td>
</tr>
<tr>
<td>Surface passage</td>
<td></td>
<td>↓</td>
</tr>
<tr>
<td>Water travel time</td>
<td></td>
<td>↑</td>
</tr>
<tr>
<td>Hatchery composition</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Conclusions

Juvenile travel times, mortality rates and survival rates through the hydrosystem are strongly influenced by managed river conditions (water transit time and spill levels).

Improvements in in-river survival and travel times can be achieved through reductions in water transit time or increased spill.
Upstream passage success rates and straying of returning adults

Presenter: Jack Tuomikoski

CSS Annual Meeting Apr 7th 2011
Background

- Early 1990’s - Research results were not conclusive regarding the ability of transportation to improve returns to the spawning grounds or hatcheries (Mundy et al. 1994)

- Delayed survival effects (of transportation) likely extend into the adult life stage as well. (Keefer et al. 2008)
  - Impaired homing, straying, mortality, and longer travel times/greater exposure to harvest

- Out of DPS steelhead strays may be a limiting factor for recovery of distinct steelhead populations in the Deschutes and John Day rivers (Middle Columbia Steelhead ESA Recovery Plan - National Marine Fisheries Service)

- The current mixture of spawning steelhead in the John Day River may have a lower productivity as a result of out-of-basin hatchery strays (Ruzycki and Carmichael 2010 DRAFT)
Background

- Even if transportation provides an apparent survival improvement relative to outmigration through the hydrosystem, the benefit may not carry through to natal areas if transported fish were more likely to stray or die before spawning.

- Potential detrimental impact of out-of-DPS strays on natural spawning areas (McClure et al. 2008 – hatchery strays)
  - genetic traits
  - Productivity

- ICTRT – Viability Criteria Report, draft
  risk to natural patterns of gene flow
  - out of ESU < 5% = low risk
  - 10% > out of ESU > 5% = moderate risk
  - out of ESU > 10% = high risk
PIT tag success and stray rates

- Success = Adult migrates from Bonneville Dam to Lower Granite Dam

\[ \sim 100\% \]
PIT tag success and stray rates

- Success = Adult migrates from Bonneville Dam to Lower Granite Dam
- Stray
PIT tag success and stray rates

- **Success** = Adult migrates from Bonneville Dam to Lower Granite Dam
- **Stray** = Adult last detected outside of FCRPS and does not migrate successfully to Lower Granite Dam
Analyses

- Logistic modeling exercise:
  - Format for testing hypotheses about variable importance
    - Which is more important to success, transportation history or in-river migration conditions?

- Differential Success rates
  (transported vs. in-river)
  - Is there a significant difference?

- Compare stray rates
  (transported vs. in-river)
  - Is there a significant difference?
Logistic Model

Success = Flow + Temperature + Spill + Trans + Location

Success < – Successful from BON to LGR?
Flow, Temp., Spill < – BON, TDA, JDA, MCN
Trans. < – Transported as juvenile?
Location < – Marked at LGR or above?

- Include NOAA marking at LGR for wild fish
  - increase sample size
  - Added as variable to account for any difference in marking programs

- 11 *a priori* models compared when not using location
  - Top model selected
  - Report relative variable importance (Burnham and Anderson 2002)
Chinook Adult Success

**WILD**

Top Model = (-) Transport  (+) Flow

**HATCHERY**

Top Model = (-) Transport  (+) Temp.  (+) Flow
Chinook Adult Success

**WILD**

Top Model = (-)Transport  (+)Flow

**HATCHERY**

Top Model = (-)Transport  (+)Temp.  (+) Flow

**RELATIVE VARIABLE IMPORTANCE ACROSS ALL MODELS**

Wild Chinook

Hatchery Chinook

<table>
<thead>
<tr>
<th>Variable</th>
<th>Wild Chinook</th>
<th>Hatchery Chinook</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transport</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Flow</td>
<td>0.75</td>
<td>1</td>
</tr>
<tr>
<td>Temperature</td>
<td>0.25</td>
<td>0.75</td>
</tr>
<tr>
<td>Spill</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Location</td>
<td>0</td>
<td>N/A</td>
</tr>
</tbody>
</table>
Steelhead Adult Success

**WILD**

Top Model = (-)Transport (-)Spill
(+ )Temp.

**HATCHERY**

Top Model = (-)Transport
Steelhead Adult Success

**WILD**

Top Model = (-)Transport (-)Spill (+)Temp.

**HATCHERY**

Top Model = (-)Transport

**RELATIVE VARIABLE IMPORTANCE ACROSS ALL MODELS**

---

### Wild Steelhead

<table>
<thead>
<tr>
<th>Variable</th>
<th>Importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transport</td>
<td>1.0</td>
</tr>
<tr>
<td>Temperature</td>
<td>1.0</td>
</tr>
<tr>
<td>Spill</td>
<td>1.0</td>
</tr>
<tr>
<td>Location</td>
<td>0.5</td>
</tr>
</tbody>
</table>

### Hatchery Steelhead

<table>
<thead>
<tr>
<th>Variable</th>
<th>Importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transport</td>
<td>1.0</td>
</tr>
<tr>
<td>Temperature</td>
<td>0.75</td>
</tr>
<tr>
<td>Spill</td>
<td>0.5</td>
</tr>
<tr>
<td>Location</td>
<td>0.25</td>
</tr>
</tbody>
</table>

N/A
Chinook success rates compared (transport/in-river)
Chinook success rates compared (transport/in-river)

- 38 of 53 estimates show a lower success for transported fish
Chinook success rates compared (transport/ in-river)

- 12 estimates significantly lower for transported

12 estimates significantly lower for transported
Steelhead success rates compared (transport/in-river)

- 14 of 16 estimates show lower success for transported fish
- Two significant estimates. One higher and one lower for transported hatchery steelhead
Straying

- Adult Success rate reflects a combination:
  - Natural Mortality
  - Fishing Mortality
  - Losses attributed to **Straying**

- A comparison of transport and in-river relieves concerns about:
  - PIT tag bias
  - Efficiency of detection arrays
  - Lack of detection arrays (somewhat)

- Older sites
  - Priest Rapids (2003)
  - Rock Island (2003)
  - Well’s Dam (2002)
New additions since 2005

- Wind River (2007, 2009)
- Little White Salmon River (2009)
- Deschutes River (2007)*
- John Day River (2007)*
- Tucannon River (2005)
Straying of Snake River CSS fish

- Total fish
  - 71 Adult strays from wild and hatchery Chinook (with jacks), wild and hatchery steelhead

- Steelhead mostly strayed into the John Day and Deschutes (61%) Hatchery Chinook mostly strayed into the Columbia River above the SR confluence (76%)
20%

61% of steelhead strays
Deschutes and John Day

76% of hatchery Chinook strays, turn into mid/upper Columbia River
Compared Straying Rates

Transported straying rates are higher:

Transported Chinook straying rate was 0.7% higher than in-river (0.1-6.9% Keefer et al. 2008)

Transported steelhead straying rate was 4.1% higher than in-river (2.6-5.3% Keefer et al. 2008)
Hatch. & Wild steelhead stray rates

- Proportion of the John Day & Deschutes basin spawning population comprised of transported strays is unknown
  - 27-35% of live steelhead on John Day spawning ground were out-of-basin hatchery fish
    - 2004, 2007 EMAP surveys, Ruzycki and Carmichael 2010 DRAFT

- Abundance of John Day + Deschutes ~ 7,131
  - Middle Columbia Steelhead ESA Recovery Plan - National Marine Fisheries Service
    - Abundance = number of adult spawners in natural production areas
    - Based on geomean of expanded redd counts from 1996-2005

- Rough estimate of transported stray steelhead into John Day + Deschutes ~ 2,450
  - Assume 50% of adults at BON were transported
  - TAC estimates of Hatchery + Wild steelhead adults at LGR (2008-2009)
  - Incorporate CSS straying rates for transported fish and proportion that enter Deschutes/John Day
Conclusions

- Transportation was a more consistent predictor of adult success than environmental variables.
- Transportation negatively affects adult success rate for:
  - Wild and hatchery Chinook
  - Wild and hatchery steelhead
- Transported steelhead strayed about 4.5% and in-river strayed at 0.4% (11:1)
  - Deschutes and John Day
  - This a large out-of-basin population as compared to total natural spawner abundance
- Transported hatchery Chinook strayed about 0.7% and in-river strayed 0.03% (23:1)
  - Columbia above SR confluence
SARs and Juvenile Metrics of Upper and Mid-Columbia Stocks

Presenter: Eric Tinus

CSS Annual Meeting Apr 7th 2011
Metrics for Other PIT Tag Groups

- Smolt to Adult Return
- Emigration Rates of Juveniles through the Hydrosystem
- Arrival Time at Bonneville Dam
Other Mark Groups to Include in CSS Analyses

- Upper Columbia Region
  - Leavenworth Hatchery spring Chinook

- Mid- Columbia Region
  - Hatchery Spring Chinook – Cle Elum and Carson hatcheries
  - Wild Spring Chinook – John Day River
  - Wild Steelhead – John Day and Deschutes rivers
SAR and CIs for Leavenworth hatchery spring Chinook from Upper Columbia region
SARs and CIs for wild and hatchery Chinook from Mid-Columbia region.

Smolts are estimated at upper dam; adults are enumerated at BOA.
SAR and CIs for wild steelhead from Mid-Columbia region

Smolts are estimated at upper dam; adults are enumerated at BOA
Median fish migration rate for wild steelhead in the JDA to BON reach

John Day wild Steelhead

Migration rate (km/d)

Migration year

2004 2005 2006 2007 2008 2009
Migration rates of steelhead and Chinook groups downstream of McNary Dam

![Graph showing migration rates of different groups over years]

- **John Day wild Steelhead**
- **John Day wild Chinook**
- **Leavenworth Hatchery Chinook**
- **Cle Elum Hatchery**

Migration year:
- 2004
- 2005
- 2006
- 2007
- 2008
- 2009

Migration rate (km/d)
- 0
- 20
- 40
- 60
- 80
- 100
Juvenile migration rates for Mid- and Upper Columbia spring Chinook stocks, 2000 - 2009
Passage timing at Bonneville Dam for Mid- and Upper Columbia hatchery spring Chinook

Cumulative passage

Julian date

- Carson 8 yr avg
- Cle Elum 8 yr avg
- Leavenworth 8 yr avg
Passage timing at Bonneville Dam for Mid- and Upper Columbia hatchery spring Chinook

Passage timing at Bonneville Dam for Mid- and Upper Columbia hatchery spring Chinook

Graph showing cumulative passage of Chinook salmon at different locations and years.

Key:
- **Carson 2009**
- **Cle Elum 2009**
- **Leavenworth 2009**
Passage timing at Bonneville Dam for juvenile John Day wild spring Chinook
Passage timing at Bonneville Dam for juvenile Mid- and Upper Columbia spring Chinook

Cumulative passage

Julian date

John Day 2008
John Day 2009
John Day 8 yr avg
Juvenile average passage timing for wild John Day and Deschutes River steelhead groups at Bonneville Dam, 2006 - 2009
To Conclude . . .

- Adding mark groups representative of other ESUs to CSS analyses adds valuable monitoring information to the region and the original study sponsors.

- Collaboration and Coordination with other specific marking efforts increases cost effectiveness and the benefits to the region.

- Monitoring the effect of hydrosystem passage on these population groups from existing marking is value added for managers.
2011 Work Planned and
2010 Summary

Presenter: Robin Ehlke

CSS Annual Meeting Apr 7th 2011
2011 - Work Planned

- Continue building long-term database
  - Monitoring SARs, passage characteristics and demographics
- Continue coordination/cost saving efforts
- Snake River sockeye adults
- Snake River Chinook tag groups build
- Snake River Steelhead A run/B run adults
- Upper Columbia wild steelhead & Chinook work continues
- Request to investigate CHF passage/survival
Snake River Sockeye

- 2009 first year for large tag group
- 2010 report 1st year for juvenile metrics
- 2011 and future reports to include adult and juvenile metrics
- Contingent on continued marking
Snake R. Hatchery Chinook

- Spring/summer covered upstream of LGR
  - Eight major hatcheries now represented
    - Clearwater, Pahsimeroi and Sawtooth since 2009
  - Hatchery specific metrics possible
    - Future reports include adult data on all groups
- Nearly all sp/su hatchery Chinook upstream of LGR are represented
Snake R. Hatchery Steelhead

- 1997-2007 no funding for CSS tags
  - Aggregate of existing tags groups (10-25K)
  - Limited to metrics for this aggregate
- 2008 secured funding from multi sources
- 2010 report first year for juvenile metrics
  - (by hatchery, A run vs. B run)
- 2011 will report on both adults and juve A/B
Upper Columbia Stocks

- Wild Chinook and Steelhead

- Wenatchee and Methow basins
  - SAR for aggregate

- Juvenile data available in 2011 report
Presentation Summaries
Summary – Patterns in Overall SARs

- SARs for Snake R. wild Chinook & steelhead less than NPCC 2%-6% objective

- SARs for John Day wild spring Chinook and John Day and Deschutes wild steelhead generally within 2%-6%

- SARs for upper Col. hatchery spring Chinook were correlated with Chinook from both the Snake and Mid-Col.
Summary - Patterns in Overall SARs

- Variation in SARs and first-year ocean survival are influenced by river conditions during out-migration as well as ocean conditions

- Work to improve understanding of how hydropower management affects overall survival in the face of variable ocean and climate conditions
Summary - Continued evaluation of PIT tag effects

- Continue to investigate run-reconstruction SARs and PIT tag SARs

- Pilot study of PIT tag effects implemented at Carson Hatchery

- Explore opportunities to expand PIT tag effect studies within the basin
Summary - Snake River

- Annual SARs << NPCC 2-6% SAR goal
  - Snake River wild Chinook & steelhead
  - All passage routes

- TIRs of both wild Chinook and steelhead variable across years and associated with in-river survival

- The relative effectiveness of transportation decreases as in-river survival increases
Effects of Juvenile Bypass Systems

- Bypass increases travel time
- Bypass increases delayed mortality
- Bypass decreases SARs
Summary - Snake River

- Travel time and survival rates are strongly influenced by managed river conditions including spill and flow.

- Survival rates can be improved through increased water velocity and spill.

- True for Chinook, steelhead, and sockeye.
Summary - Snake River

Transportation negatively affects adult success rates for steelhead and Chinook

Transported adults strayed at a significantly higher rate than their in-river counterparts

- Hatch. + wild steelhead, hatch. Chinook
- Chinook tend to stray to upper Columbia
- Steelhead tend to stray into JD and Deschutes
Summary

Mid/Upper Columbia River stocks

- Monitor some populations outside the Snake River
- Apply CSS metrics to these stocks
- SARs and arrival timing can be easily generated
- Other applications complicated due to fewer detection opportunities
Question and Discussion Period