ISRP Retrospective Review
Lower Snake River Compensation Plan

Goal

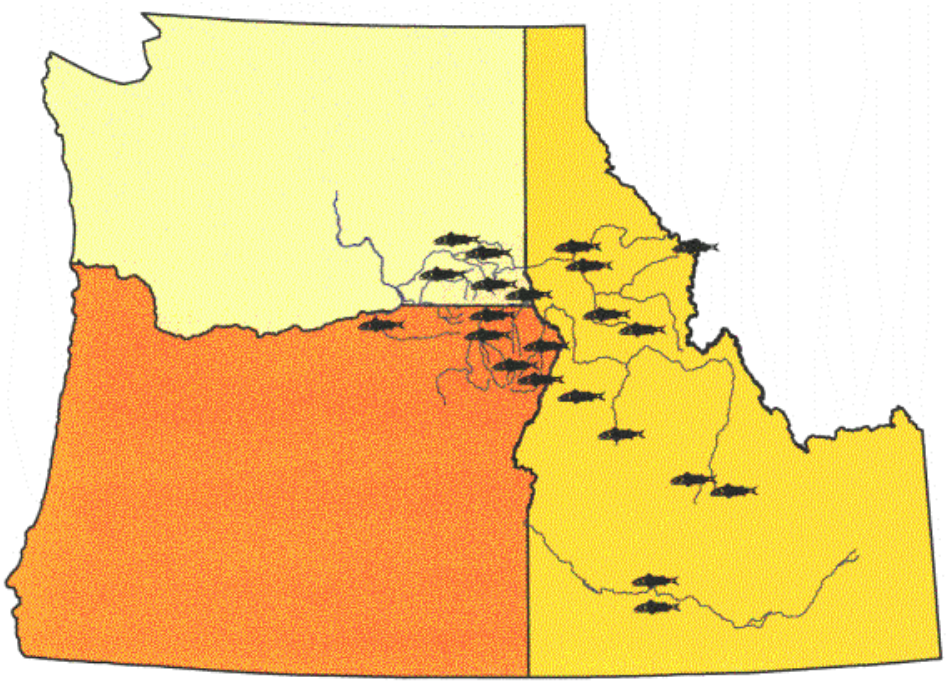
Replace Lost Adult Salmon & Steelhead Caused by the Construction and Operation of the Four Lower Snake River Dams

S.L. Marshall (2010)

Snake River & Lower Granite Dam
Photo by J. Wilson, N.Y. Times

LSRCP Hatcheries

- Oregon
  - Lookingglass
  - Wallowa
  - Irrigon
  - Umatilla
- Washington
  - Lyons Ferry
  - Tucannon
- Idaho
  - Clearwater (CR, Red Powell)
  - Magic Valley
  - Dworshak NFH
  - Hagerman NFH
  - McCall
  - Sawtooth
- Idaho Power Company
  - Oxbow
- Nez Perce Tribe
  - Nez Perce Tribal Hatchery



From BPA Integrated Program Review Fish & Wildlife Program (2014)

Estimating Losses
(Using Steelhead As An Example)

Steps:

1) Estimate Escapement Prior to Dam Construction
   (Steelhead = 114,800 Adults)

2) Estimate Smolt Mortality at Each Dam
   (Steelhead = 15% Loss Per Dam, 48% Total Loss)

3) Estimate Number of Adults Lost Due to Dams
   (114,800 Adults x 48% = 55,100

   55,100 Became the LSRCP Return Goal for Steelhead)

Photo from M. Gallinat (2010)

Estimating Losses
(Using Steelhead As An Example)

Steps:

4) Estimate Smolt to Adult Return to Lower Granite Dam = 0.5%
(No. of smolts needed to produce 55,100
55,100/.005 = 11,020,00)

5) Estimate Egg-to-Smolt Survival
(Assumed 65%, Therefore No. of Eggs Needed = 11.02 M /.65 = 16.95 M)

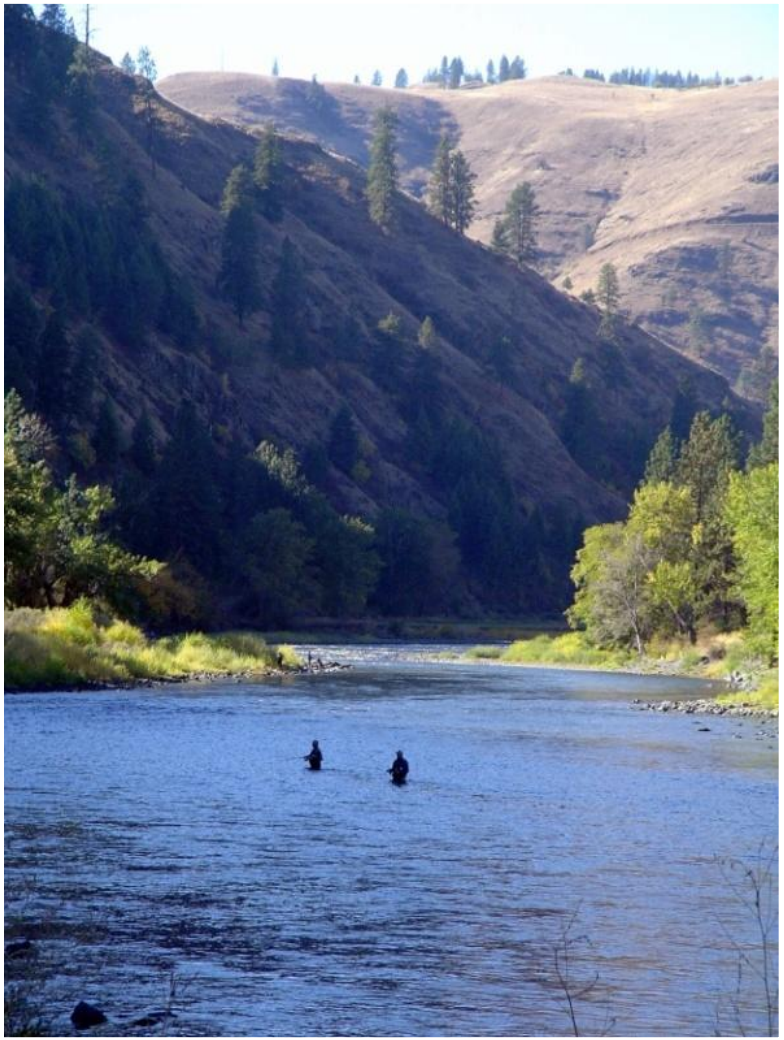
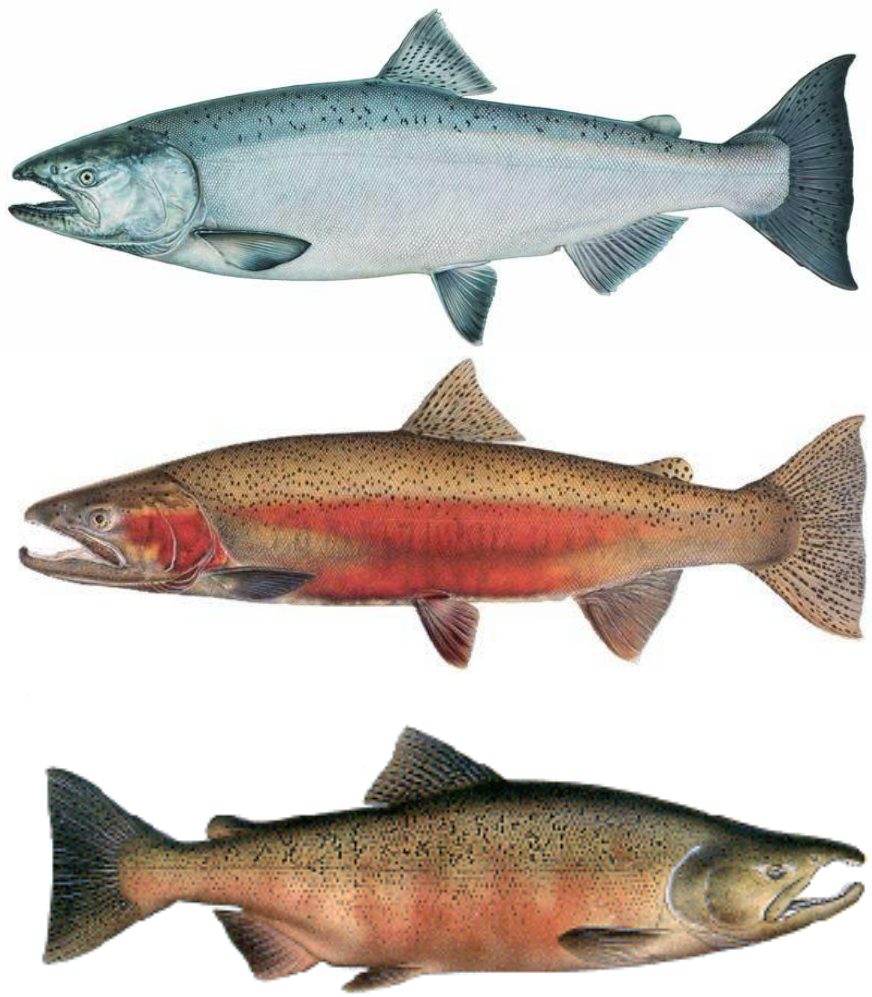


Photo from L. Clarke et al. (2012)

Mitigation Goals

- Spring Chinook
  - **58,700** Adults To Project Area
  - **234,800** Adults To Fisheries
- Steelhead
  - **55,100** Adults To Project Area
  - **110,200** Adults To Fisheries
  - **130,000** Angler Days
- Fall Chinook
  - **18,300** Adults To Project Area
  - **73,200** Adults To Fisheries



Illustrations: Idaho Fish & Game & Bing

Unforeseen Factors Affected LSRCP

- Lower Smolt-to-Adult Survivals
- ESA Listings of:
  - Fall & Spring Chinook (1992)
  - Steelhead (1997)
- Downstream Harvests Curtailed & More Fish Back to Project Area
- US v. Oregon
  - Hatchery Production Set
  - New Stocks & Release Areas
- Harvest Mitigation Project Changed to Harvest & Conservation Project

Photo USFWS

ISRP Retrospective Review
LSRCP Steelhead, Fall & Spring Chinook Programs

Purpose Of Review

1) To determine if the Three Programs are:
   - Based on Sound Science
   - Benefit Fish & Wildlife
   - Have Clearly Defined Objectives
   - Contain M & E Programs

Photo Of Lyons Ferry Hatchery M. Key (2013)

ISRP Retrospective Review
LSRCP Steelhead, Fall & Spring Chinook Programs

Purpose Of Review

2) To Evaluate:
   - In-Hatchery Performance
   - Post-Release Performance
   - Ecological Interactions
   - Program Modifications

3) Consistent With Council's FWP
   - Artificial Production
   - Standards & Strategies

Photo Of Irrigon Hatchery from Carmichael et al. (2012)

In-Hatchery Performance

Metrics:

- Broodstock Collection & Survival
- Egg-to-Smolt Survival
- Number of Smolts

Photo from E. Loudenslager (2011)

Broodstock Collection & Survival

Spring Chinook
- Survival Goal ≥ 80%
- Yrs Achieved 90%

Steelhead
- No Universal Goal
- For Survival

Fall Chinook
- Survival Goal 90%
- Yrs Achieved 86%

Photo From J. Bumgarner (2012)

Egg-to-Smolt Survival Goals

Spring Chinook

Survival Goal $\geq$ 70%

Yrs Achieved 92%

Steelhead

Survival Goal 65%-70%

Yrs Achieved 76%

Fall Chinook

Survival Goal 70% - 80%

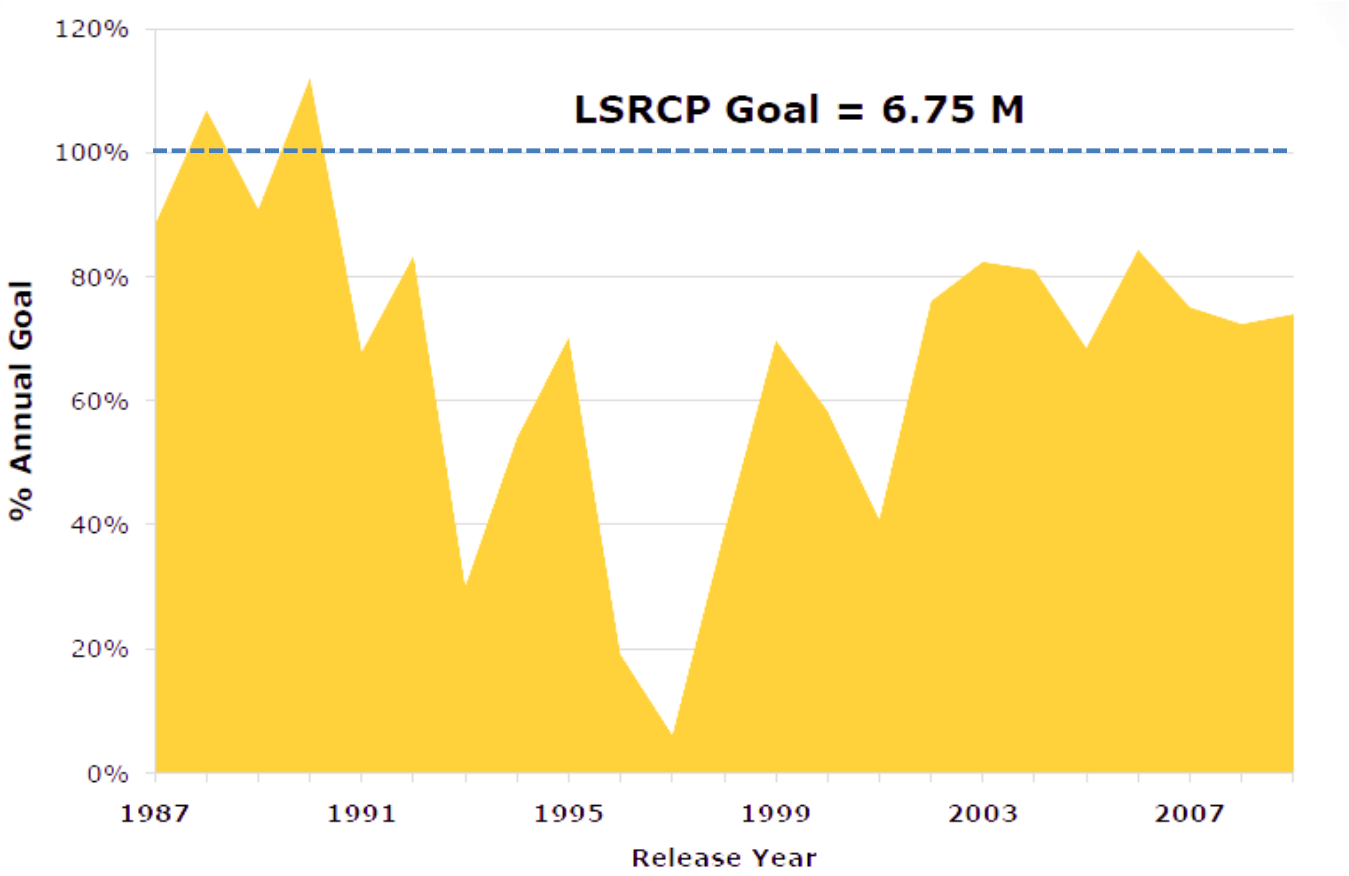
Yrs Achieved 79%

Photo From J. Bumgarner (2012)

Photo from R. Carmichael et al. (2012)

Smolt Release Goal:

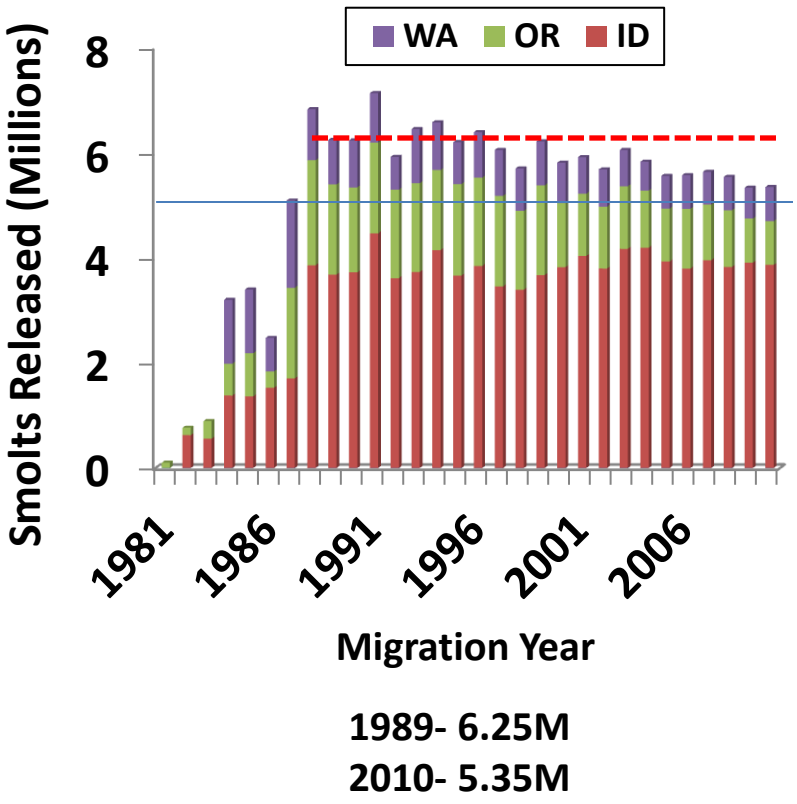
Spring Chinook



From Mark Shuck LSRCP Roll-up (2010)

Smolt Release Goal:

Steelhead

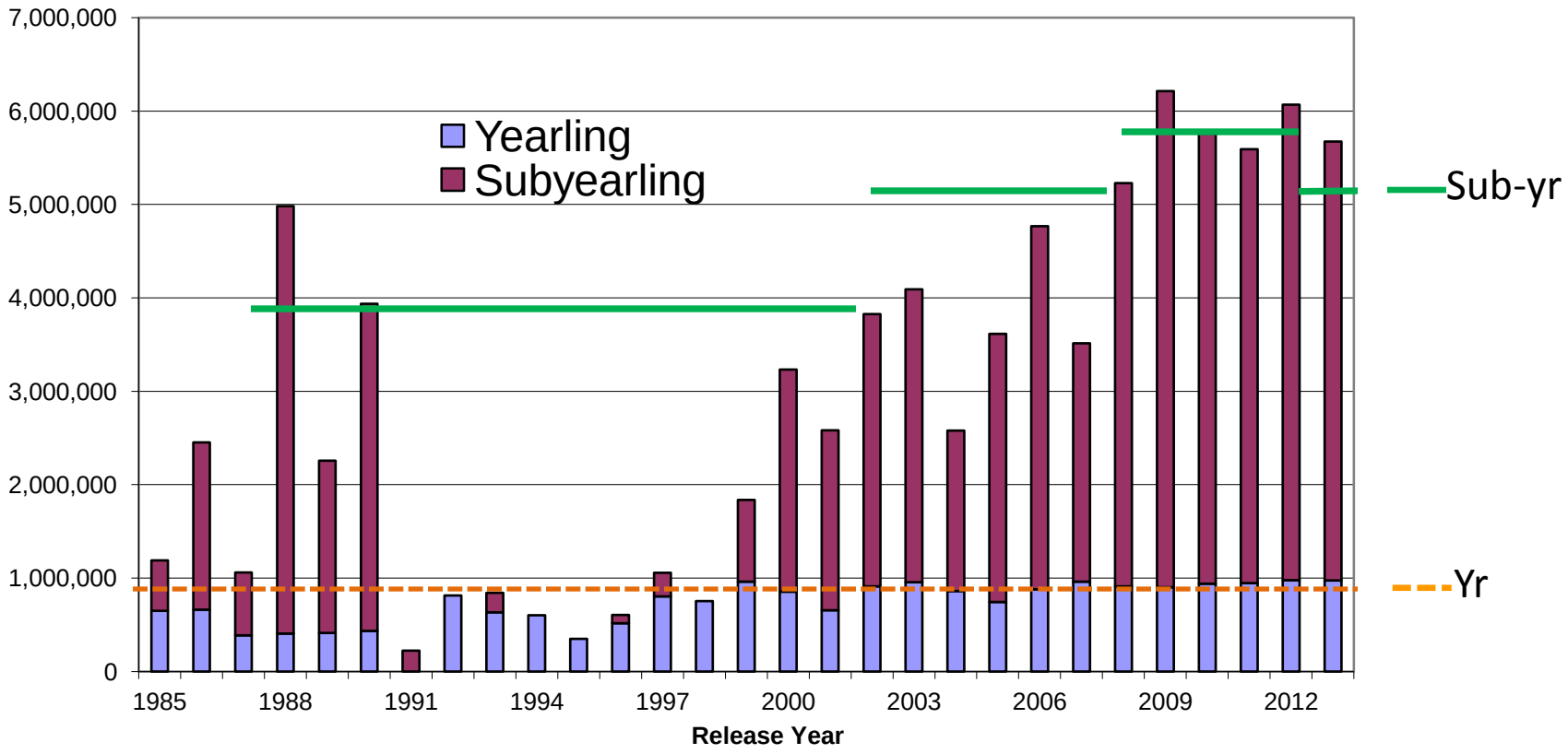


1989- 6.25M
2010- 5.35M

From B. Leth Steelhead Roll-up (2012)

Photo B. Leth Steelhead Roll-up (2012)

Smolt Release Goal
Fall Chinook



From J. Hesse PPT to NPPC Council 2014

Factors Affecting Release Goals

Spring Chinook

- Broodstock Scarcity
- Reductions in Rearing Densities
- Water Shortages at Some Hatcheries

Steelhead

- Greater Smolt Size Goal Set
- Decreases in Water Availability
- Shift in Production to Spring Chinook

Fall Chinook

- Broodstock Scarcity

Lyons Ferry Hatchery
Photo by D. Gloyn (2013)

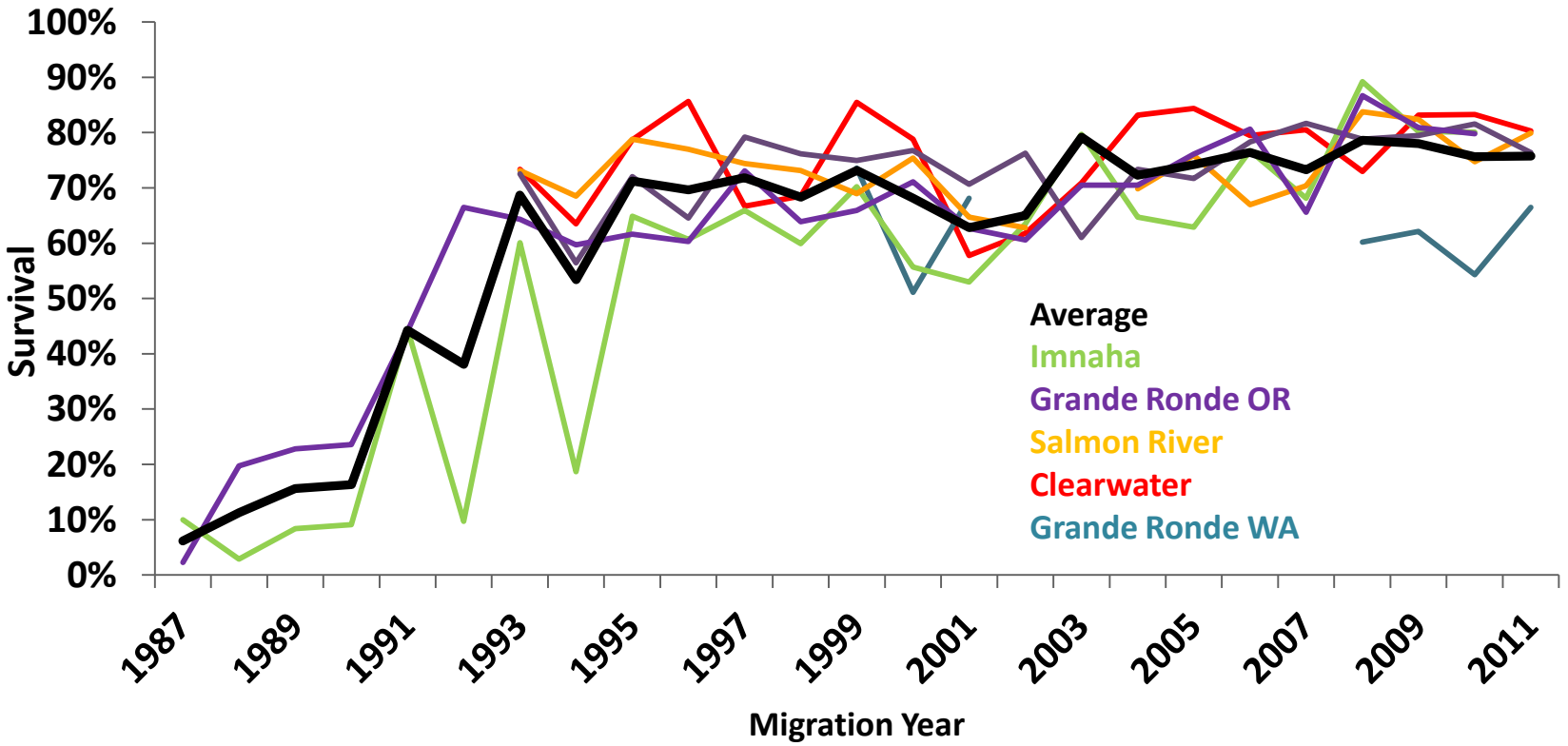
Post Release Metrics

- Survival to Lower Granite Dam
- Smolt-to-adult survival (SAS)
- Smolt-to-adult Return (SAR)
- Recruits per Spawner (R/S)
- Harvest (below and within project area)

Photo from B. Leth steelhead roll-up (2012)

Smolt Survival to Lower Granite Dam:

Steelhead



B. Leth steelhead roll-up (2012)

Smolt Survival to Lower Granite Dam:

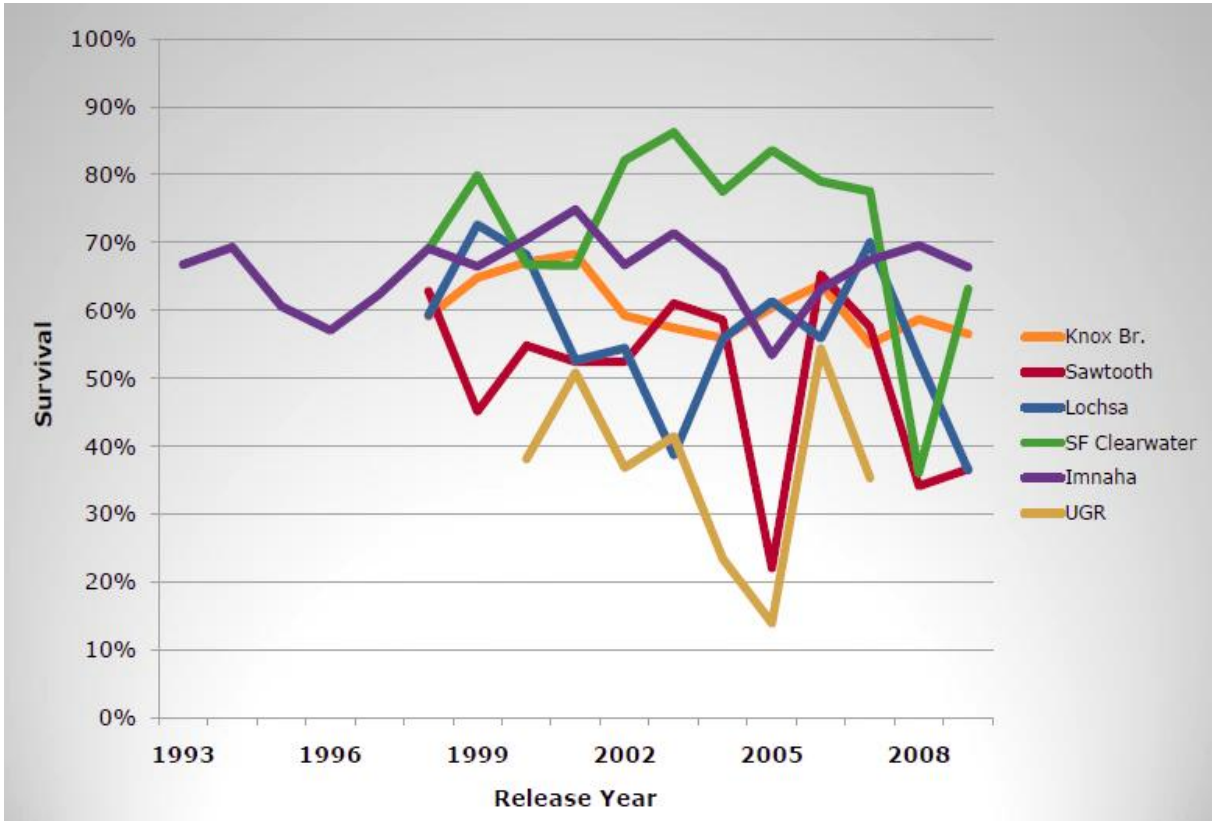
Spring Chinook

Potential Factors Affecting Survival

River Flow
Water Temperature
Turbidity
Travel Distance
Date of Release
Type of Release
- Direct-Release
- Acclimation Pond

Fish Size
- Yearling
- Sub-Yearling

Smoltification Stage
Fish Health
Time Of Release
- Diurnal
- Nocturnal



From Mark Shuck LSRCP Roll-up (2010)

Smolt-to-Adult Survival & Return Rates

Steelhead & Spring Chinook

Spring Chinook

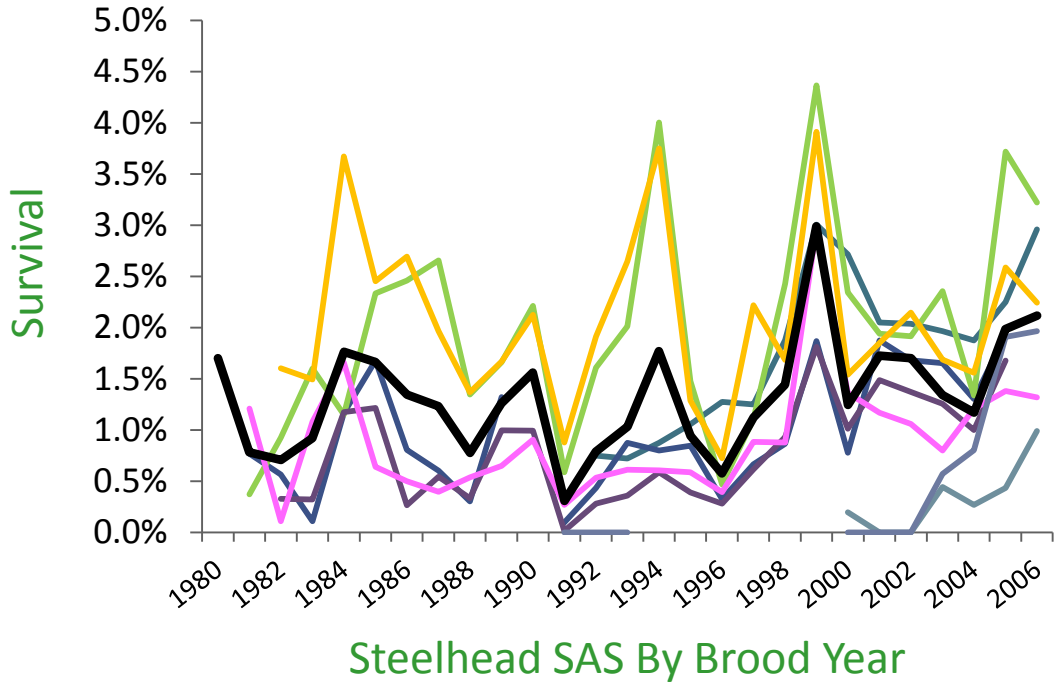
SAS Goal 3.25% - 4.35%
Years Achieved = 0%

SAR Goal 0.1% - 0.87%
Years Achieved = 41%

Steelhead

SAS Goal 1.5% - 2.61%
Years Achieved = 38%

SAR Goal 0.5% - 0.87%
Years Achieved = 83%

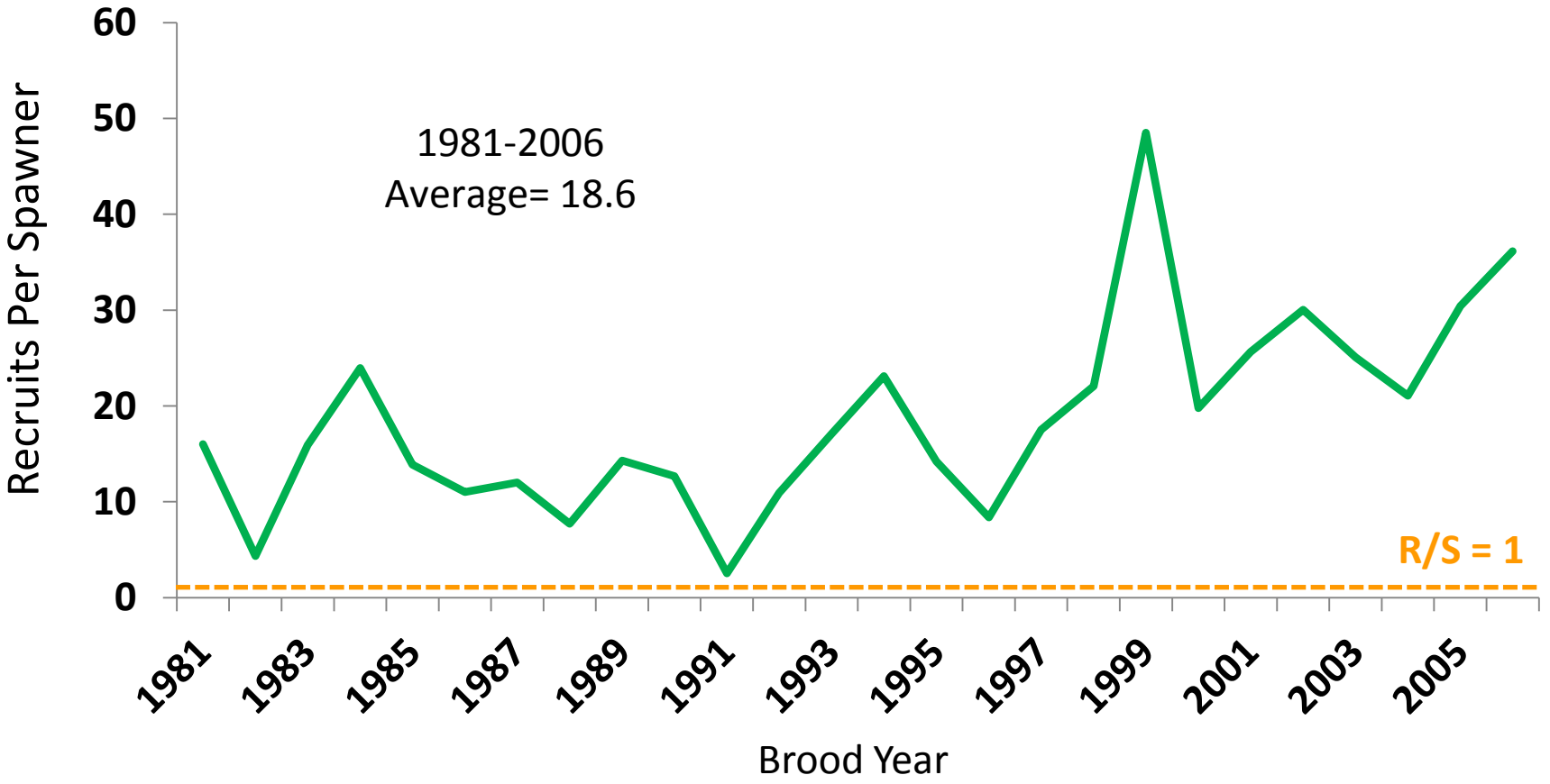


Steelhead SAS By Brood Year

From B. Leth Steelhead Roll-up (2012)

Recruits Per Spawner

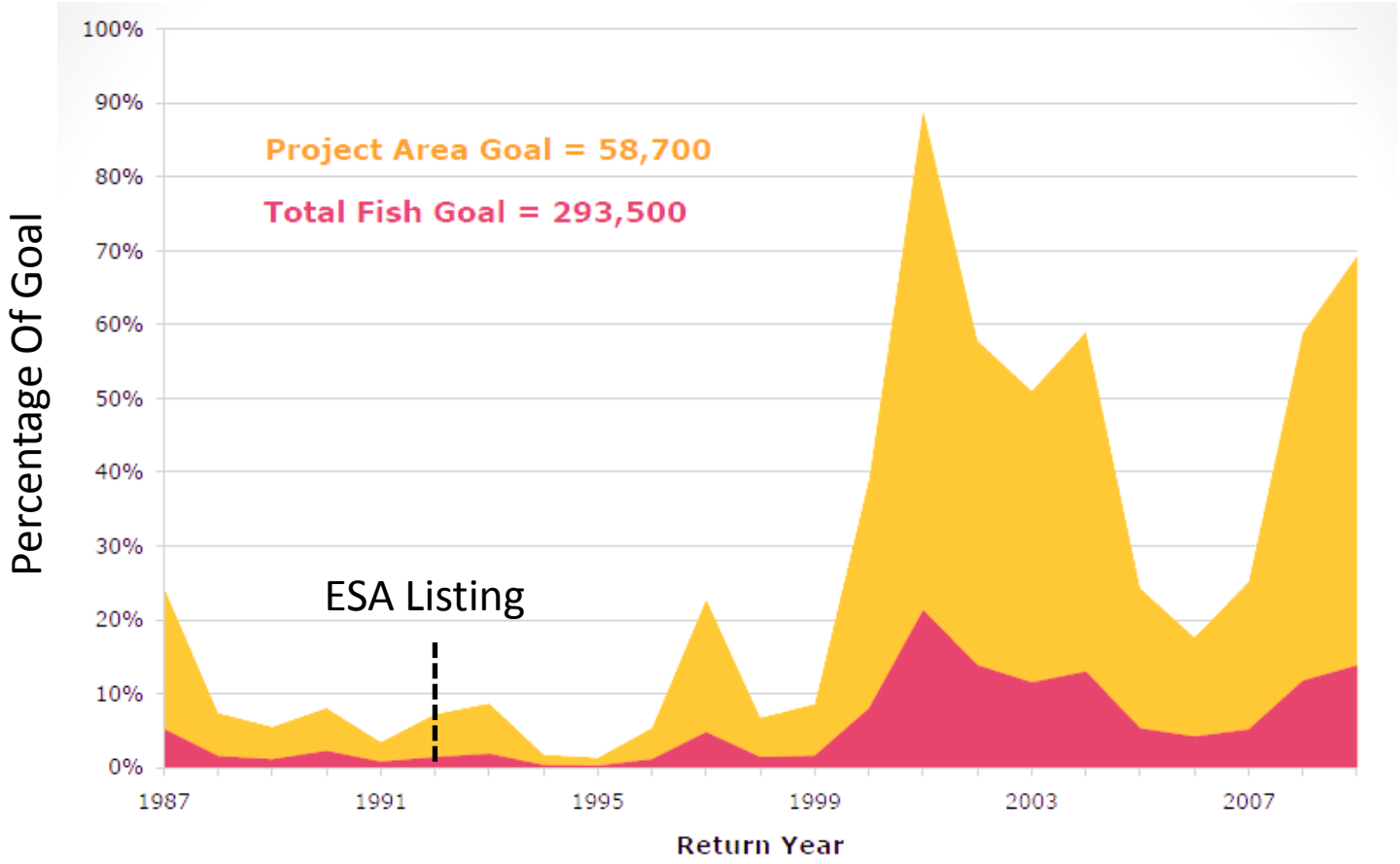
Hatchery Steelhead



From B. Leth steelhead roll-up (2012)

Adult Abundance

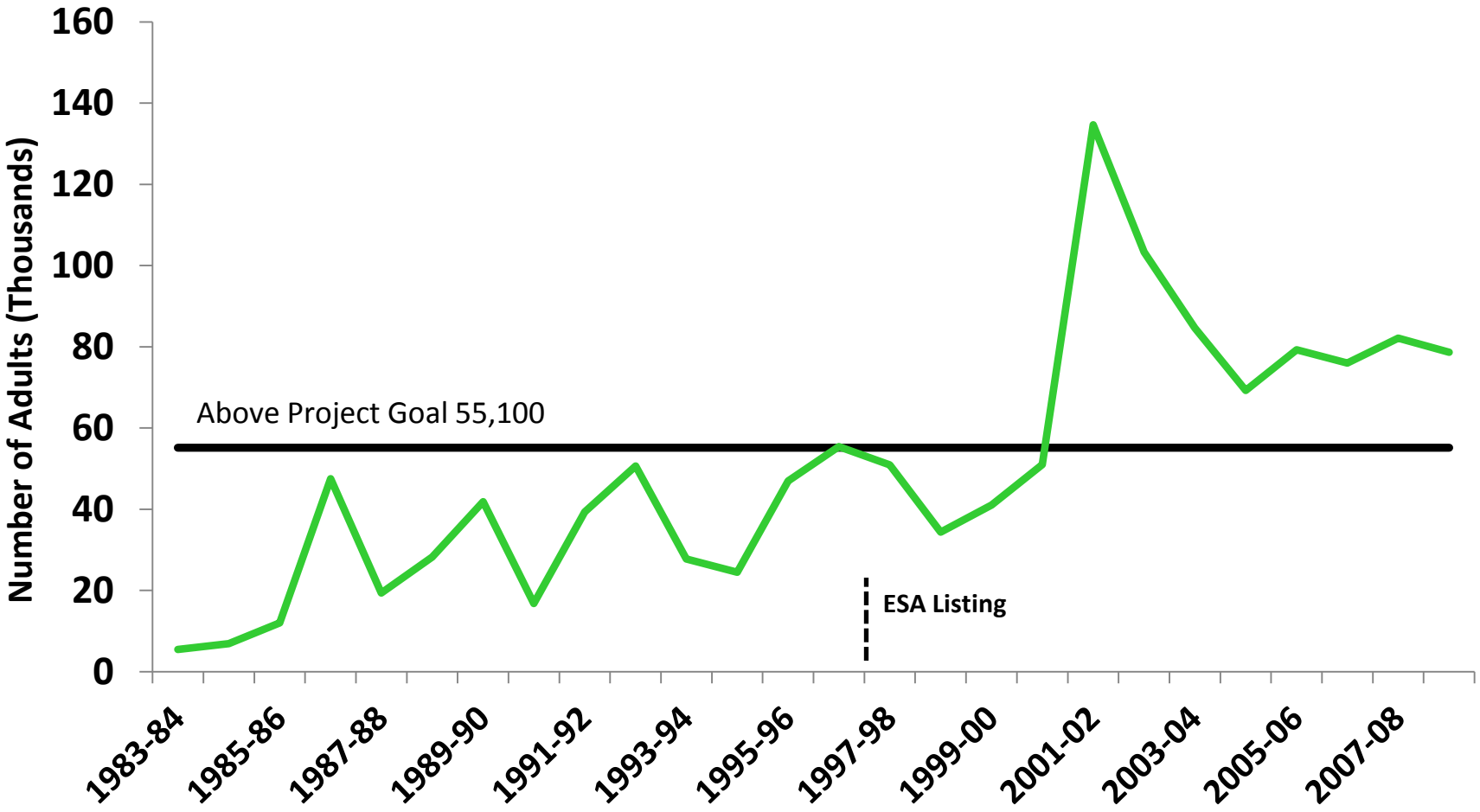
Spring Chinook Salmon



From Mark Shuck roll-up (2010)

Adult Steelhead Abundance

Above Project

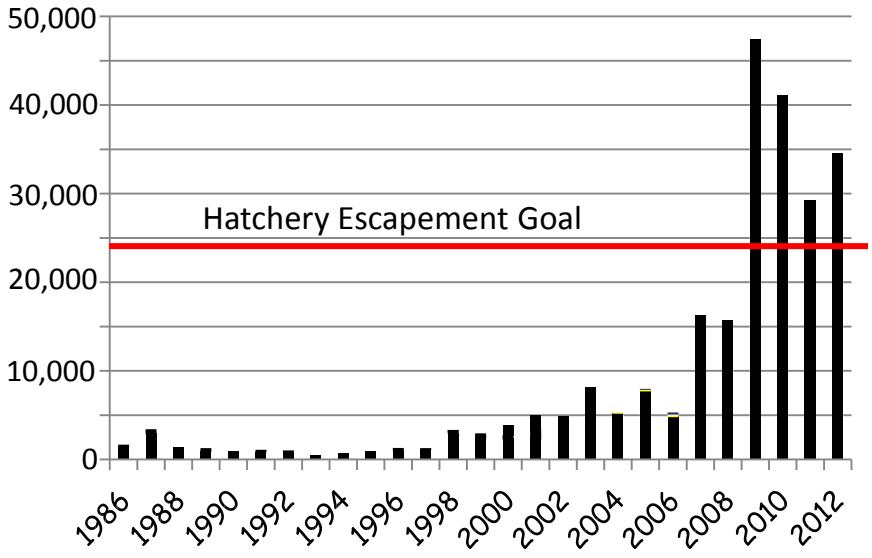


From B. Leth Steelhead Roll-up (2012)

Adult Fall Chinook Abundance

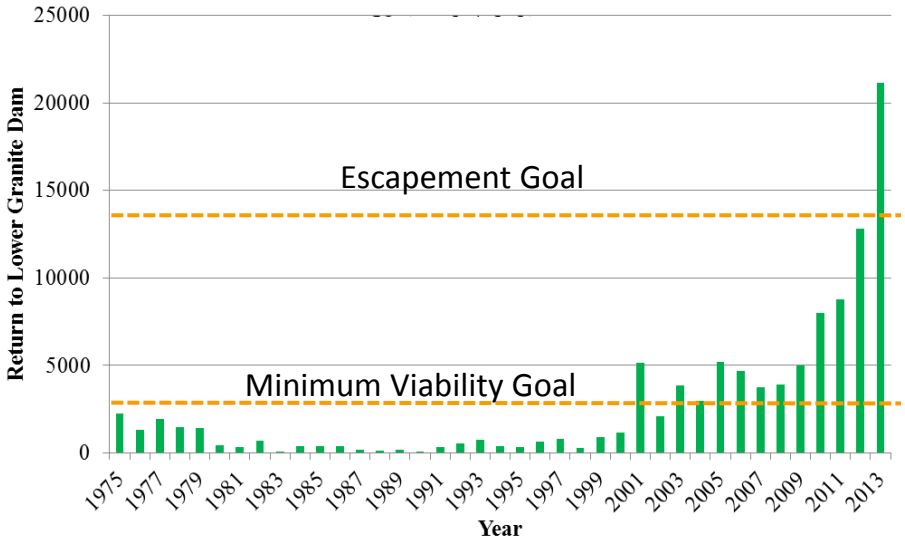
Snake River

Hatchery Fall Chinook Returns



From J. Hesse Fall Chinook Roll-up (2013)

Natural Origin Fall Chinook Returns



From J. Hesse PPT to NPPC Council 2014

Spring Chinook Harvest

Fisheries In Project Area

No Fisheries From 1975 – 1995

In 2010:

- 9 % Of Historical Harvest
- 31% Of Historical Area
- 16% Of Historical Fishing Days

Fishing Opportunities are Growing With Increases in Abundance

M. Shuck spring Chinook Roll-up (2010)

Photo of Spring Chinook Fishing In The Lower Snake River
Photo from Bing

Steelhead Harvest
In Project Area

Pre Project Harvest & Effort

- Average of **26,000** Caught Per Year
- Average Angler Effort 130,000 days

Post Project 1998 – Present

- Average of **62,000** Caught Per Year
- Average Angler Effort 475,000 days

B. Leth Steelhead Roll-up (2012)

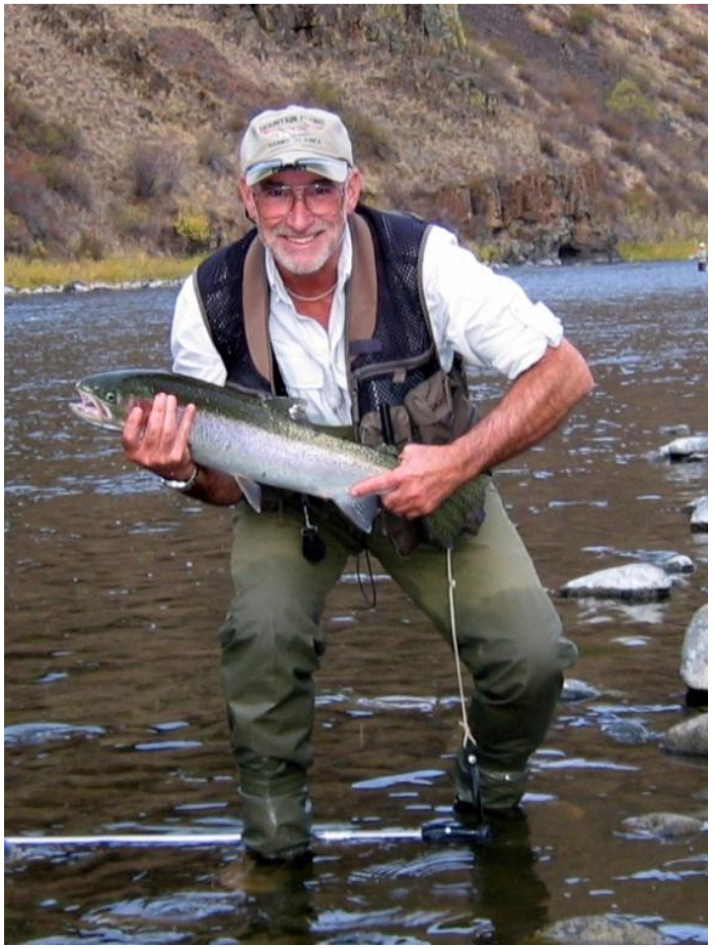


Photo From L. Clarke et al. (2012)

Fall Chinook Harvest

Snake River

Exploitation Rates

Brood Years 1994-2007 (Ad Clipped CWT Fish)

Program	Returns + Harvest	% Col R & Ocean	% Snake River	Total %
IPC	24,791	20	0.1	20
LSRCP	104,684	44	0.3	44
FCAP	45,284	44	0.3	45
NPTH	8,334	26	<0.1	26

From Milks et al. (2013)

Photo: sarasotasalilingsquadron.com

Fish &Wildlife Program

Artificial Production Standards and Strategies

- Operate in an Experimental & Adaptive Manner
- Minimize Adverse Effects on Other Stocks Through Straying & Harvest
- Preserve Natural Populations Where Habitat is Intact
- Restore, Preserve, and Rebuild Natural Populations

Average Annual Deschutes River
Straying By Snake River Hatchery Steelhead

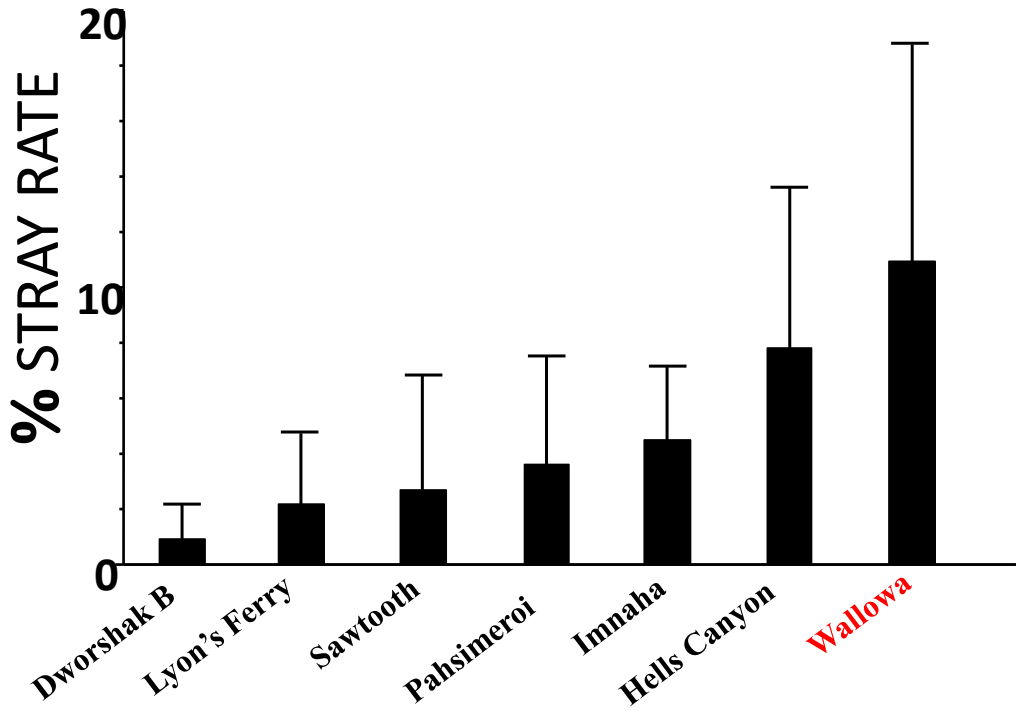


Figure From Clarke et al. 2012

Photo Of Lower Deschutes River From Findfish.com

Potential Factors Affecting
Straying Frequencies

- Incubation, Rearing, and **Release Strategies**
- Release Location
- Stock Origin
- Seaward Migration Pathways (In-river vs. Transported)
- Columbia River and Deschutes Water Temperatures

From R. Carmichael (2012)

John Day River Photo From pinterest.com

Acclimated vs. Direct Release Studies
Steelhead

Wallowa Hatchery Studies

1. **Acclimated vs. Direct Releases**

2. **Volitional vs. Forced Release**

From Clarke et al. (2012)

Results of Acclimated v. Direct Releases

Steelhead

Acclimated vs. Direct Release

1. **Smolt-to-adult Survival**
   (**33.3% higher** survival for acclimated releases p = 0.013)

4. **Stray frequency**
   (**70% higher** stray rates for direct releases p = 0.001)

Photo from J. Bumgarner (2012)

From Clarke et al. 2012

Results of Volitional vs. Forced Releases
Steelhead

Results of Volitional vs. Forced Releases

1. **Smolt-to-adult Survival**
   (**no difference** detected p = 0.658)

2. **Straying frequency**
   (**no difference** detected p = 0.852)

Big Canyon Acclimation Pond
Photo from Clarke et al. (2012)

From Clarke et al. (2012)

Results of Volitional vs. Forced Releases
Steelhead

Results of **Volitiona**l vs. **Forced** Releases

3. Volitional Releases Allow the Removal of "Residual" Males at End of the Release Period

   When 70% of the Fish Remaining in a Pond are Males—They are Trucked and Released Into Local Ponds for Fisheries

Photo by Mike Croxford

From Clarke et al. (2012)

Acclimation Ponds Studies

Spring Chinook

Effects of Duration Of Acclimation Period

1. 4 Months vs. 2 Months

2. Fish Acclimated for 4 Months Had Higher Smolt-to-Adult Survival Rates ($p < 0.005$)

Umatilla River

Photo nwwaterfrontrealestate.com

Protecting Natural Production Areas
Steelhead & Spring Chinook

Natural Spawning & Rearing Areas in Idaho, Oregon, & Washington are Being Protected & Monitored

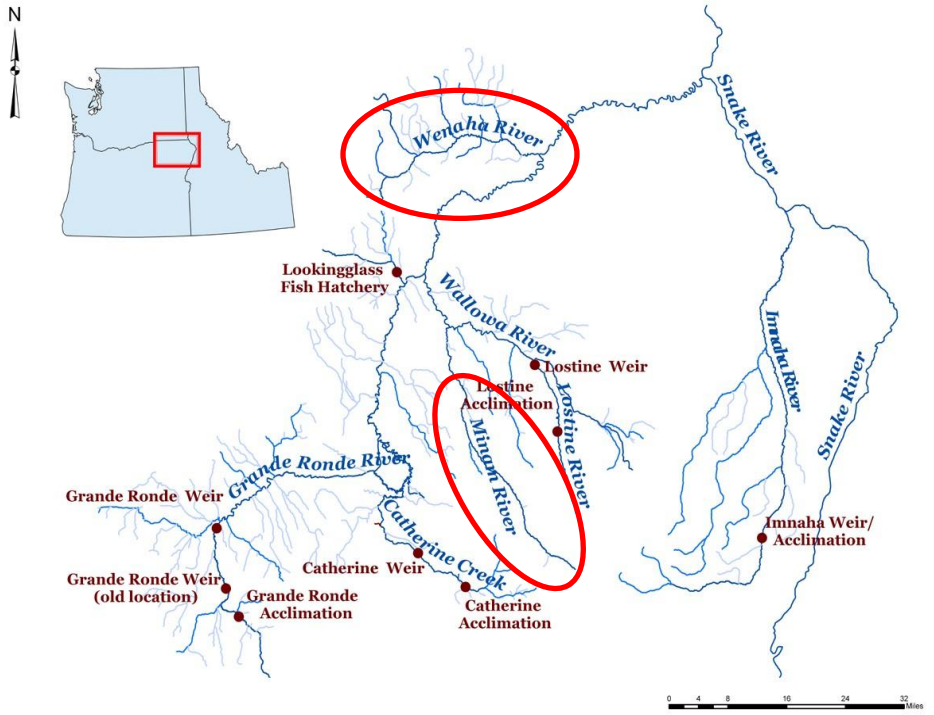
South Fork Salmon River

Photo by panoramio.com

Wild Stock Protection
Grande Ronde Spring Chinook

Incidence Of Strays

1. 1986-1994 ≥ 50%
2. Endemic Broodstock & Acclimation Ponds 2000
3. Present Occurrence of Strays 2002 – Present < 5%



From R. Carmichael (2010)

Conservation via Captive Brood Program

Grande Ronde Spring Chinook

Approach Of Captive Brood Program

1) Collect 500 Parr in the Grande Ronde River, Catherine Creek, & Lostine River

Photo From T. Hoffnagle et al. (2010)

Conservation via Captive Brood Program
Spring Chinook

Approach Of Captive Brood Program

2) Rear Wild Parr to Maturation

Juvenile Chinook Salmon, Tucannon River
From M. Gallinat (2010)

Conservation via Captive Brood Program

Approach Of Captive Brood Program

3) Artificially Spawn Reared Adults

4) Rear Subsequent Progeny to Smolt Stage and Release

5) Allow Resulting F_1 Adults to Spawn in Nature

Tucannon River Captive-reared Adult Spring Chinook—Photo from M. Gallinat (2010)

Comparison of F_1 Adult Production

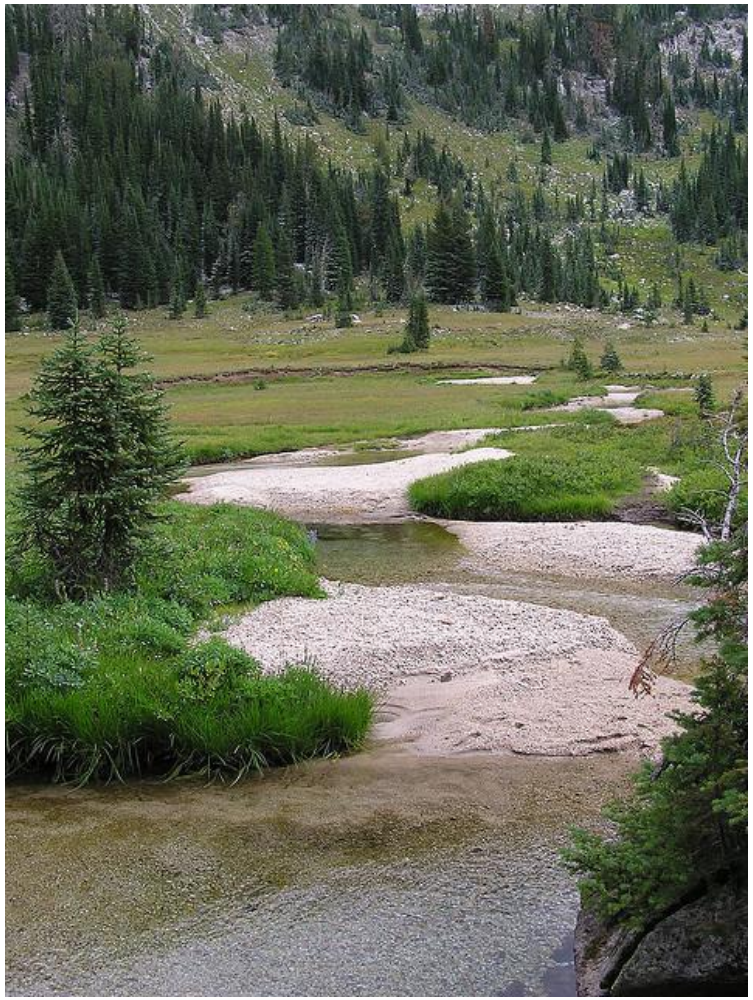
Type	No. Of Parr	No. Adult Females Produced	No. Of F_1 Adults
Captive Brood	500	133	370
Conv. Hatch	500	1.1	18
Natural	500	0.6	2

Data From T. Hoffnagle et al. (2010)

Photo: thewildlifenews. com

Results Of Captive Brood Program
Grande Ronde Spring Chinook

1. Contributed Smolts to Hatchery Releases
2. Increased Adult Abundance in Targeted Streams
3. Reduction in Smolts Per Spawner as Spawner Densities Increased



Lostine River Photo Flickr.com

From T. Hoffnagle et al. (2010)

Regional & LSRCP Challenges

RM&E

1. Identifying Factors Responsible for Density-Dependency in Natural Spawning and Rearing Habitats

2. Assessing & Reducing Stray Rates

3. Regulating Numbers of Hatchery Fish on Spawning Grounds

4. Evaluating the Utility of Supplementation

5. Identification of Project Fish in Fisheries & on Spawning Grounds

Spring Chinook Smolts
Photo from kera-kw.com

LSRCP Challenges

Regional & Basin-Wide Management

6. Integrating & Coordinating LSRCP Programs With on-going Regional Habitat Restoration, Harvest Management, US v. Oregon Agreements & ESA Recovery Efforts

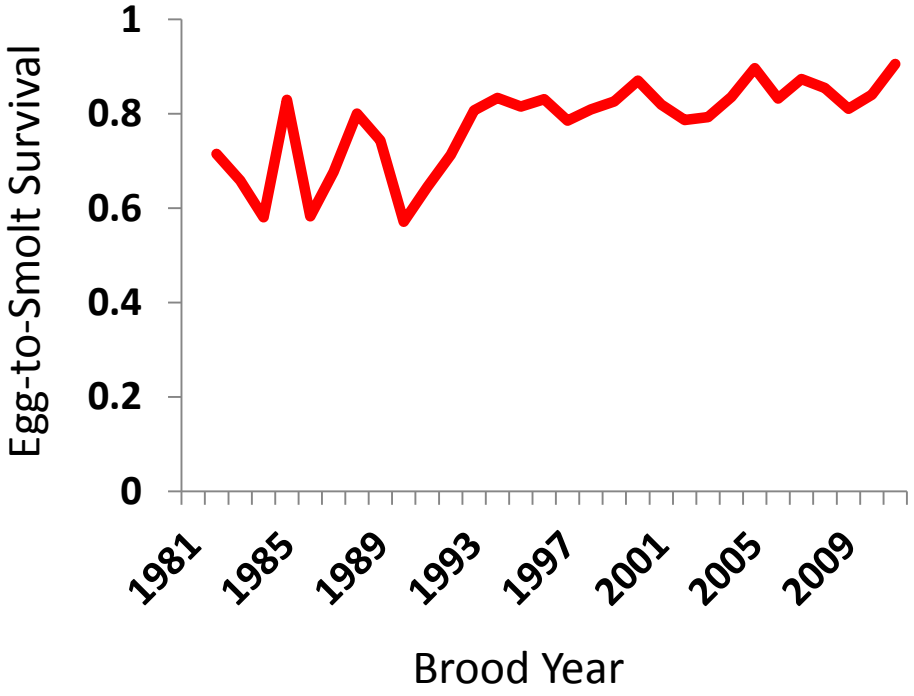
7. Using Artificial Production to Augment Harvest While Simultaneously Implementing Recovery Actions for ESA-Listed Steelhead & Chinook

8. To Achieve Mitigation Goals Will Require Action Beyond the Responsibilities of the LSRCP

Adult Spring Chinook
Photo from businessweek.com

Egg-to-Smolt Survival: Steelhead
Across All Projects

Photo from J. Bumgarner (2012)



From B. Leth steelhead roll-up (2012)

Smolt Release Goals

Spring Chinook

Goal = 6 – 7.5 Million

Yrs Achieved = 42%

Steelhead

Goal = 5.3 – 6.8 Million

Yrs Achieved = 57%

Fall Chinook

0+ Goal = 4.6 Million

Yrs Achieved = 69%

1+ Goal = 0.9 Million

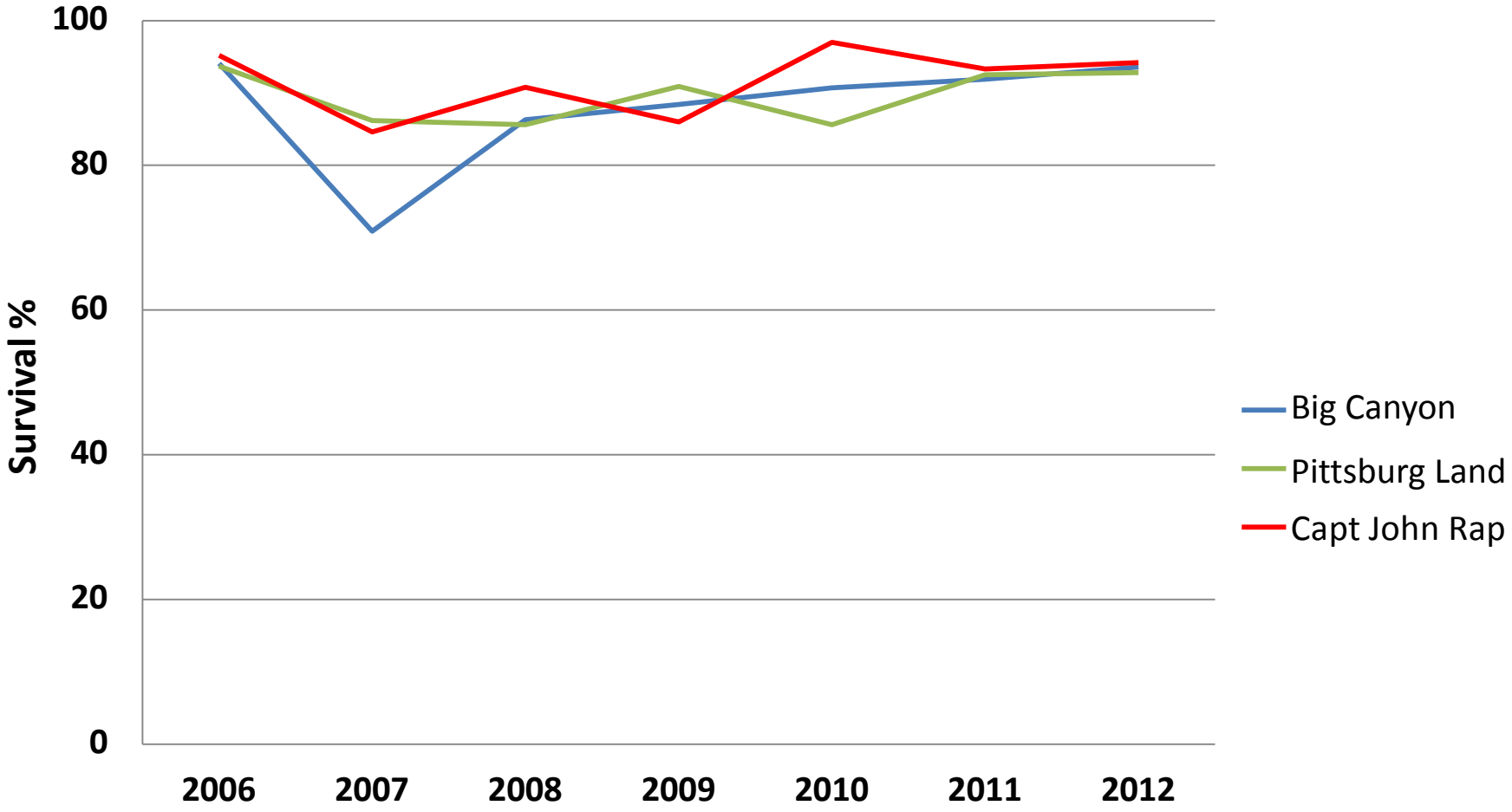
Yrs Achieved = 95%

Spring Chinook smolts

Photo workareaonline.com

Yearling Fall Chinook Survival To Lower Granite Dam

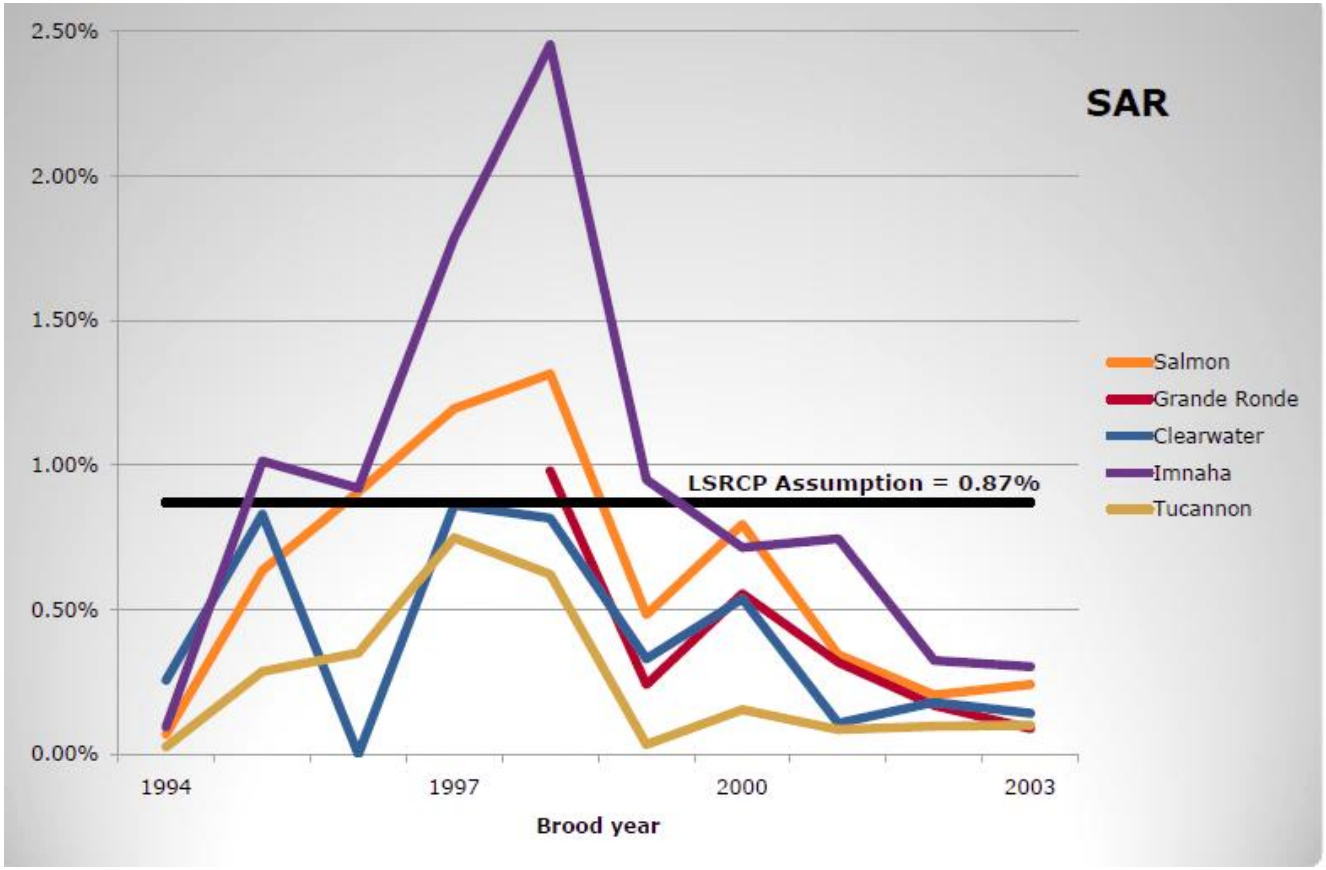
Acclimation Pond Releases



From M. Key (2013)

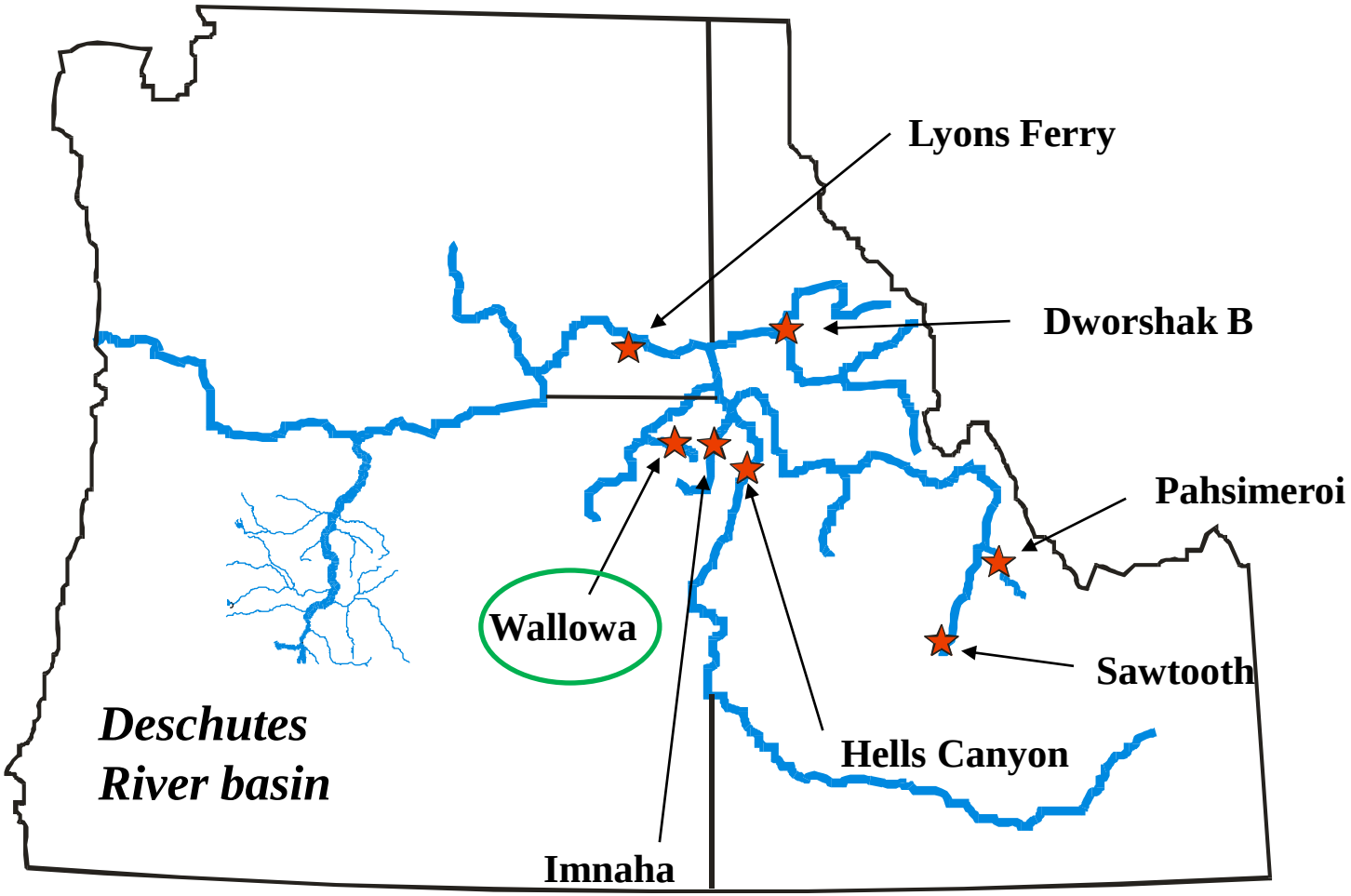
Smolt-to-Adult Returns (SAR)

Spring Chinook



From Mark Shuck roll-up (2010)

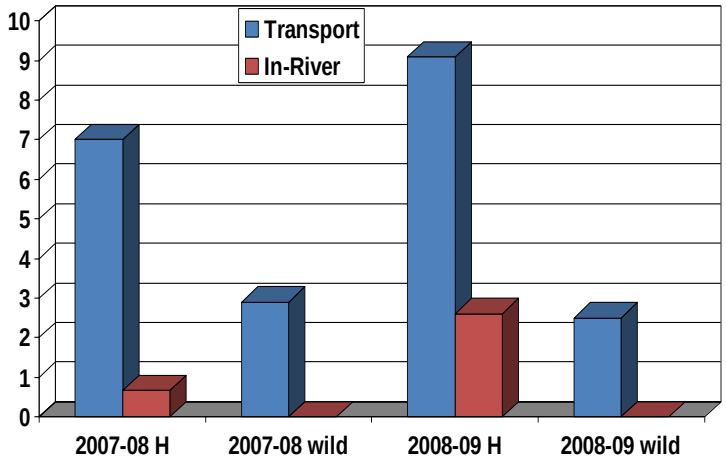
Snake River Hatchery Steelhead Stocks



From Clarke et al. (2012)

Effects of Barging On Straying
Steelhead

Stray rates into the Deschutes



Stray rates were:
Higher for Transported Fish
Within Transported Fish:
Hatchery > Natural

Photo From M.L. Keefer and C. Caudill Tech. Rept. 2012-6 Draft

R. Carmichael & T. Hoffnagle (2012)

Wild Stock Protection

Salmon River Steelhead

- Hatchery Releases

Little Salmon R. and

Upper Salmon R

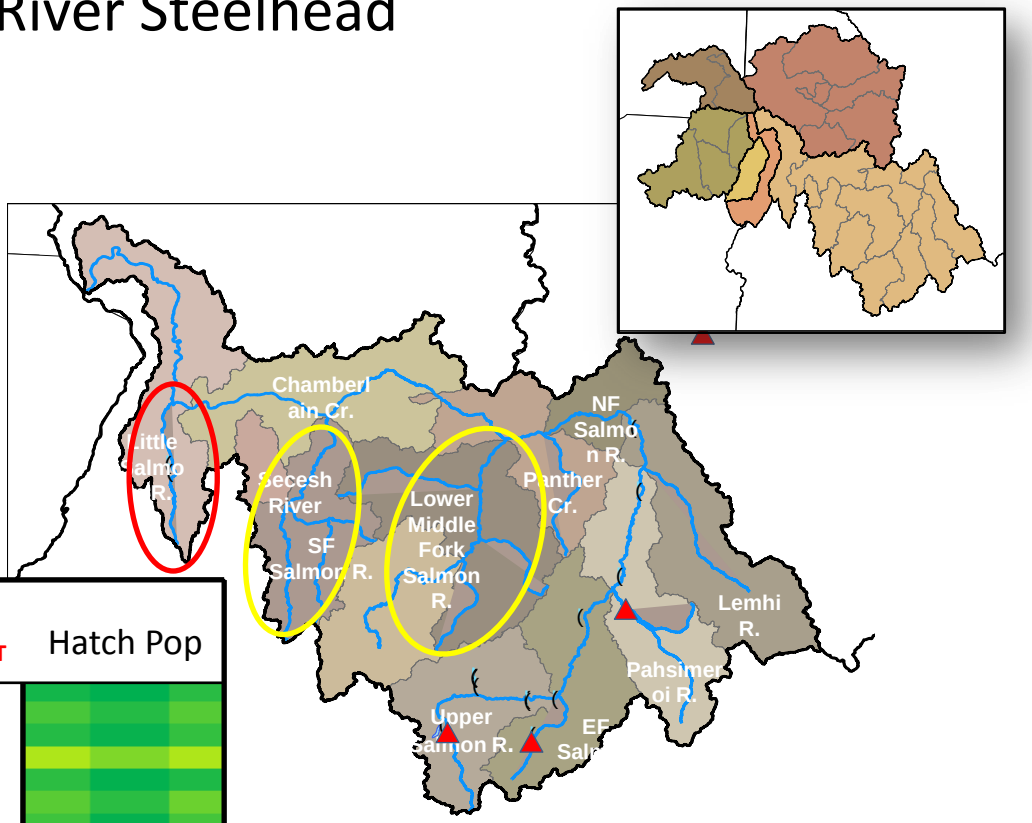
- No Releases

South Fork

Middle Fork

North Fork

Mainstem Salmon downstream of the North Fork



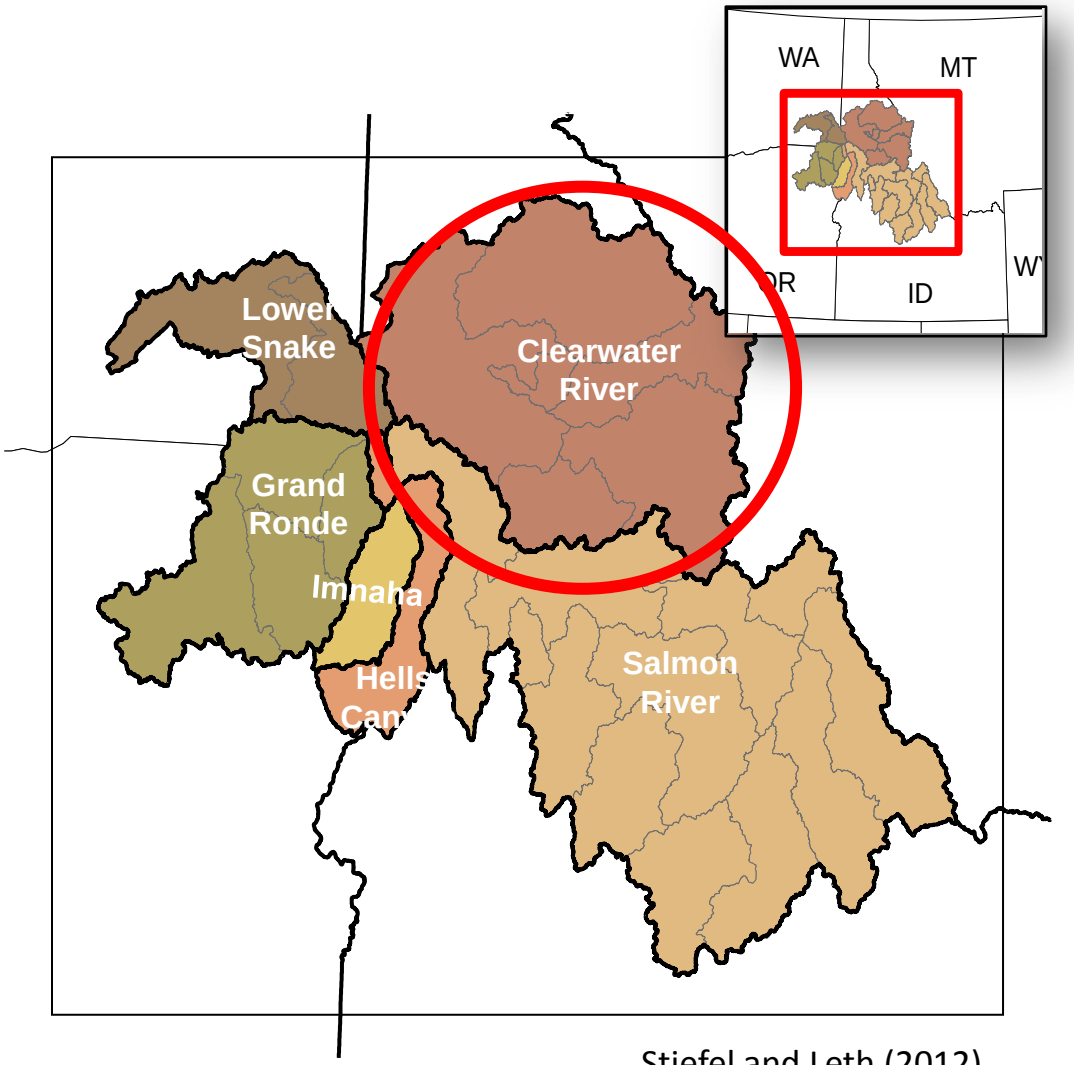
Area	F_{ST}	Hatch Pop
Upper Salmon	0.005 0.008 0.006 0.012 0.006 0.008 0.007	
Middle Salmon	0.032 0.030 0.029 0.034 0.023 0.022 0.030 0.025 0.016 0.017	
South Fork	0.029 0.026 0.026 0.031	
Low Salmon	0.012 0.013 0.012 0.011	

From Brian Leth (2012)

Wild Stock Protection

Clearwater Steelhead

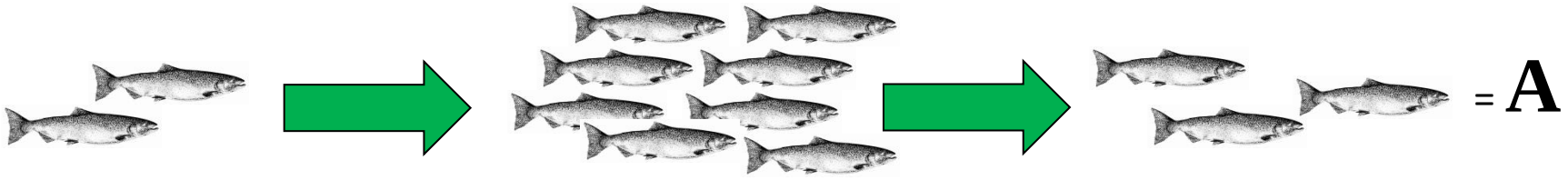
Natural Population	Tributary	Dworshak Avg. Pairwise F_{ST}
Colt Cr	Lochsa R. No Releases	0.023
Storm Cr		0.025
Crooked Fork		0.018
Lake Cr		0.025
Fish Cr		0.018
Canyon Cr		0.013
Selway R	Selway R. No Releases	0.024
Little Clearwater R		0.023
Whitecap Cr		0.024
Bear Cr		0.025
NF Moose Cr		0.018
Three Links Cr		0.026
Gedney Cr		0.016
O'Hara Cr		0.011
Clear Cr	SF Clearwater Releases	0.011
Crooked R		0.004
Tenmile Cr		0.021
John's Cr		0.010



Stiefel and Leth (2012)

Hatcheries, Supplementation & Conservation

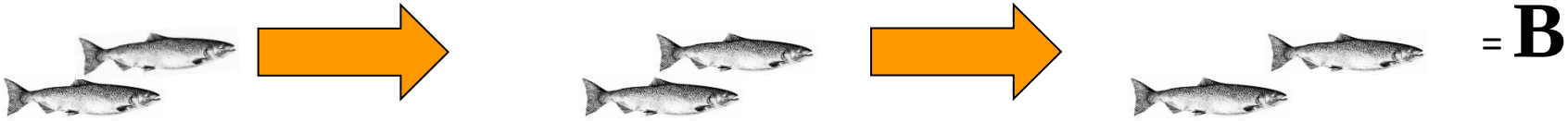
Operational Definition Of Supplementation



Wild Fish To Hatchery

1st Generation Hatchery Adults To The Wild

NORs From 1st Generation Hatchery Parents = **A**



Wild Fish To Wild

Wild Fish To Wild

Wild Fish To Wild = **B**

Is A $\geq$ B ?

Key Assumptions Of Supplementation:

1) Hatchery-Origin Fish Are Reproductively Competent When Allowed To Spawn Under Natural Conditions

Photo: Oceanmdx
www.skyscrapercity.com

Key Assumptions Of Supplementation

2) Progeny Produced
By Hatchery Origin Adults
Can Survive In Nature

Spring Chinook Juvenile

Photo grantpud.org

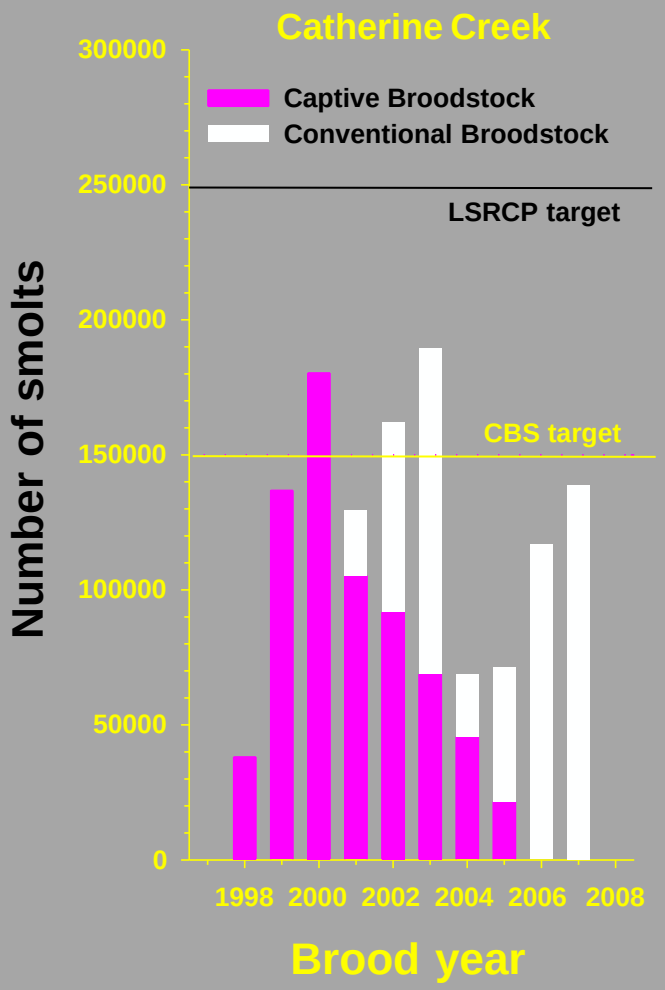
Key Assumptions of Supplementation

3) The Receiving Environments Are Productive & Complex Enough To Accommodate Additional Juveniles

Grande Ronde River

Photo commons.wikimedia..org

Changes In Smolt Origin

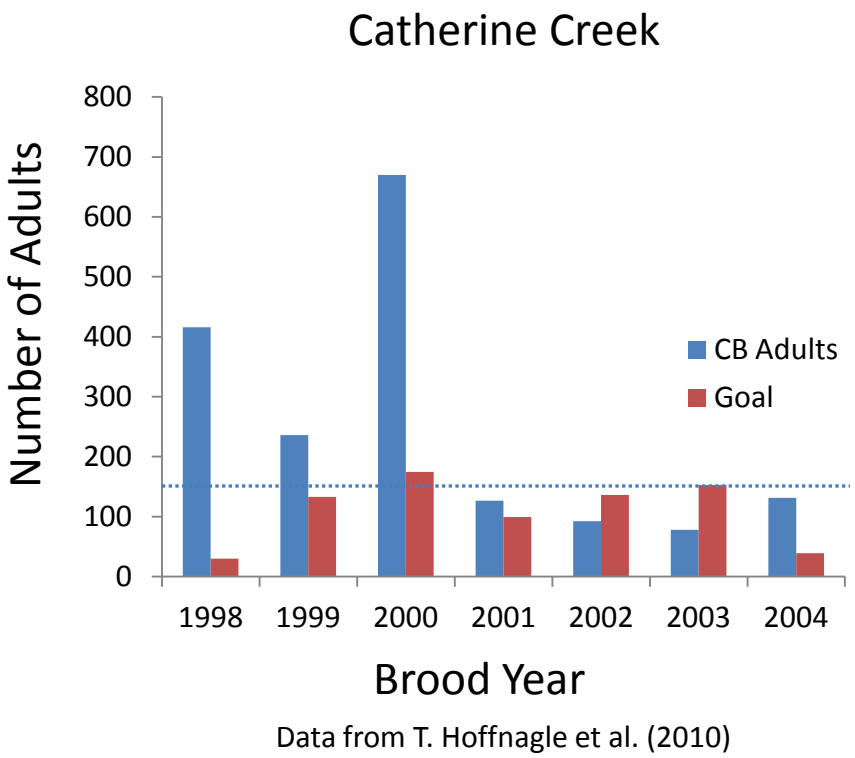


Data From T. Hoffnagle et al. (2010)

Catherine Creek Acclimation Pond

Photo from R. Carmichael (2010)

Captive Brood Adult Returns



Data from T. Hoffnagle et al. (2010)

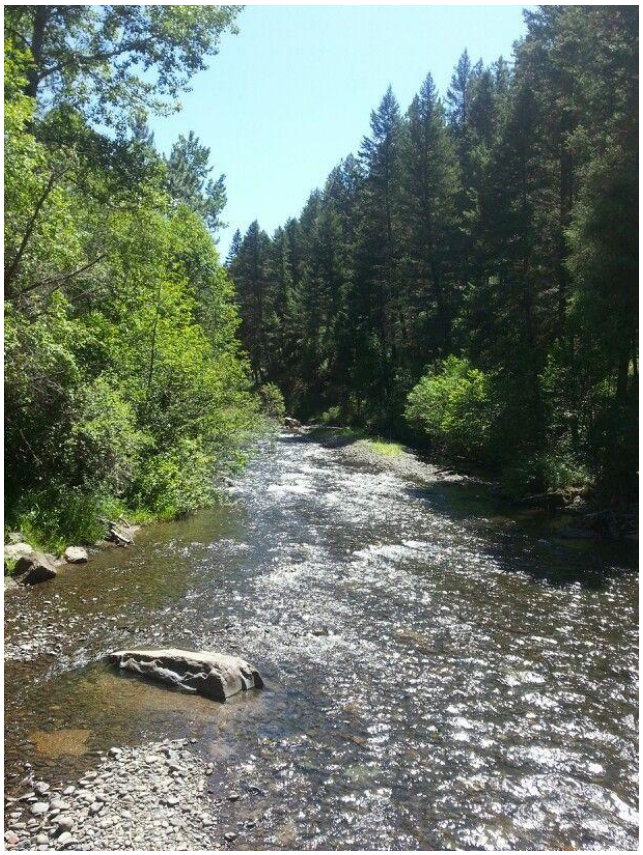


Photo pinterest.com

Results Of Captive Brood Program
Grande Ronde Spring Chinook

Parr Collections: Generally Met

Growth: Slower than Expected

Survival: Wild Parr-to-Smolt > 95%

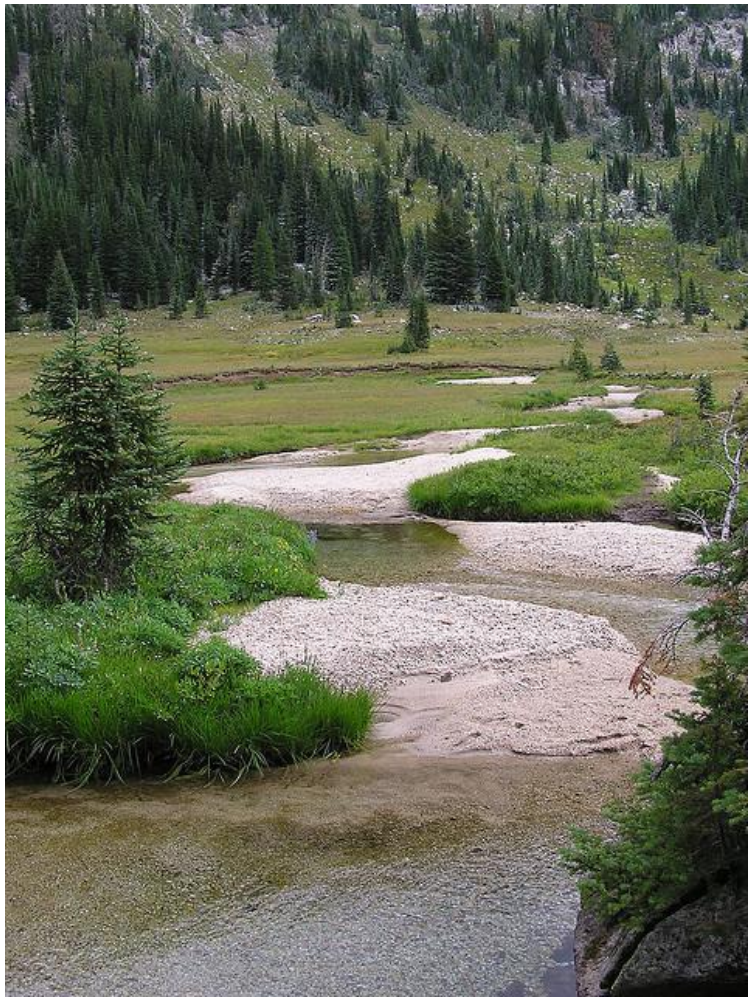
Wild Smolt-to-Adult ~ 55%

Mortality: BKD Largest Cause

Maturity: Male matured earlier than expected – most at age 3

Females matured later, more 5's than expected

Fecundity: 60% Lower than expected



Lostine River Photo Flickr.com

From T. Hoffnagle et al. (2010)

Captive Broodstock Challenges

Recognized Challenges In The Captive Broodstock Program

- F_0 Smolt-to-Adult Growth
- F_0 Fecundity
- Egg Culling & Disease During Rearing
- Hatchery Performance of F_1's
- Potential Gene Amplification

From Hoffnagle et al. (2010)

Photo from Venditti et al. (2005)