Independent Scientific Review Panel
for the Northwest Power and Conservation Council
851 SW Sixth Avenue, Suite 1100
Portland, Oregon 97204
www.nwcouncil.org/fw/isrp

July 1, 2014

Presentation: Summary of ISRP Reviews of Steelhead and Spring and Fall Chinook Salmon Programs of the Lower Snake River Compensation Plan

ISRP member Steve Schroder and Chair Greg Ruggerone will present findings and answer questions regarding the ISRP's summary review of the Lower Snake River Compensation Plan: www.nwcouncil.org/fw/isrp/isrp2014-6.

Executive Summary

This report summarizes the Independent Scientific Review Panel's (ISRP) review of the Lower Snake River Compensation Plan's (LSRCP) three hatchery programs. The ISRP completed a review of the spring Chinook program in 2011 (ISRP 2011-14), the steelhead program in 2013 (ISRP 2013-3), and the fall Chinook program in 2014 (ISRP 2014-4). The reviews were requested by the Northwest Power and Conservation Council and U.S. Fish and Wildlife Service.

Scientific foundation: The ISRP found that the LSRCP's hatchery programs for steelhead and spring and fall Chinook salmon are largely consistent with the scientific foundation, artificial production strategy, and artificial production principles contained in the Council's Fish and Wildlife Program. Each hatchery program has objectives, including targets for broodstock abundance, egg-to-smolt survival rates, smolt size-at-release, and contributions to fisheries and, in the case of supplementation programs, to natural spawning populations. Adequate monitoring and evaluation programs are in place to ascertain if these objectives and outcomes are realized. Data produced from project experiments are being used to refine how fish are reared, released, and identified. Interactions between hatchery and wild fish are being examined, and methods used to estimate the survival and contribution of project fish to fisheries and natural spawning populations are being employed and refined. Data gaps have been identified, and program activities designed to address these issues are either underway or planned in the future. The hatchery programs have provided substantial fish and wildlife benefits. These have ranged from preventing extinction of natural populations via supplementation and captive broodstock programs to providing valuable recreational and commercial fishery opportunities. Materials presented at symposiums and associated reports

covering LSRCP activities demonstrated that the cooperators are dedicated, innovative, and collaborative. The ISRP compliments them for their fine technical performance.

In-hatchery performance standards for broodstock abundance, pre-spawning survival of broodstock, egg-to-smolt survival, and numbers of released smolts were established for many of the LSRCP hatcheries. Currently, adequate numbers of broodstock are being collected, and mortality prior to spawning has been low. While under artificial culture, fish will experience some mortality during incubation and rearing. Since 1995, egg-to-smolt survival rates in hatcheries have averaged 84% for steelhead and 70 to 80% in Chinook. These high survival rates are indicative of well-run hatchery programs. Goals for smolt size at release have been set, and with some exceptions, the hatchery programs have met these objectives. Each hatchery is programmed to release a fixed number of smolts. Over the past decade, LSRCP hatcheries for spring Chinook, steelhead, and fall Chinook reached their juvenile release goals 36%, 60%, and 70% of the time, respectively. Failure to reach release goals occurred for a variety of reasons, including the desire for reduced rearing densities and greater size at release. In a few instances, water shortages and scarcity of broodstock also limited fish production.

Post-release performance of hatchery fish was evaluated by examining survival of smolts from release to Lower Granite Dam, calculating smolt-to-adult survival prior to removal from fisheries (SAS) and smolt-to-adult return (SAR) to Lower Granite Dam. Additionally, the number of recruits produced per fish spawned (R/S) was estimated along with harvest numbers and frequency of straying. The survival of smolts to Lower Granite Dam varied from one year to the next but typically ranged from 60 to 70%. Standards for SAS and SAR rates were established for the steelhead and Chinook hatchery programs. Considerable annual variation in SAS and SAR values was observed. Substantial differences in these values occurred among hatcheries rearing the same type of fish; however, they tended to increase or decrease in a synchronous fashion. Consequently, survival of smolts to the adult stage appears to be shaped by conditions the fish experience in the mainstem and ocean. To be self-sustaining, a hatchery needs on average to consistently achieve R/S values that are equal to or greater than 1, and this has been accomplished by all the hatcheries in LSRCP program. One of the primary objectives of the LSRCP was to restore fisheries in areas below and above the project area. Harvest goals for the ocean and mainstem Columbia River originally envisioned for the LSRCP have never been reached. Lower than expected SAS values and the need to constrain fisheries to protect Endangered Species Act (ESA)-listed species are largely responsible. Nevertheless, the hatchery programs have significantly increased the total abundance of spring and fall Chinook and steelhead, and thus the programs have contributed to important commercial and recreational fisheries.

Potential demographic, ecological, and genetic impacts of the hatchery programs were assessed. Chinook reared in hatcheries produced more early maturing males and fewer older maturing fish than wild counterparts. Age data were collected over time on hatchery and natural populations of spring Chinook, and no identifiable trend toward an increasing number of younger fish was detected in either group. This result suggests that changes in age observed in hatchery populations were mainly caused by environmental conditions the fish experienced during artificial culture. Nevertheless, naturally spawning hatchery fish influence the age structure of natural populations because they currently represent a high proportion of natural spawners. The ISRP encourages LSRCP cooperators to continue to test and evaluate changes in age structure, including genetic linkages, and its effect on productivity. The migration timing of adult hatchery and natural-origin salmon and steelhead was examined and found to differ in some projects.

New research is examining the spawning distribution of hatchery and natural-origin fish in streams; some hatchery fish formed spawning aggregations adjacent to release locations. Straying of hatchery fish was evaluated annually, and it varied by year and species. In a few cases, straying percentages for project steelhead to out-of-basin watersheds exceeded 20%. After this degree of straying was identified, the LSRCP implemented a number of strategies, including the use of endemic broodstocks and the wide-scale use of acclimation ponds, which reduced the incidence of straying. However, transport of juveniles in barges around the dams remains a key factor contributing to the straying of steelhead. Potential interactions between juvenile hatchery and wild fish were considered and some protocols have been implemented to minimize disease transmission and the possible occurrence of competitive and predaceous interactions.

The effects of supplementation on adult abundance and productivity of natural populations are also being investigated. Results of these studies have been mixed. Spring Chinook supplementation programs have increased the total abundance of spawners in their rivers (hatchery plus wild) but have not produced an increase in natural-origin adults. Fall Chinook supplementation has likely contributed to the recent increases in natural-origin fish abundance in the Snake River Basin, but the productivity of the natural-spawning population remains very low. Clear evidence for density dependence has been observed in supplemented populations, especially in spring Chinook, and this ecological response may inhibit desired increases in abundance and productivity. In fall Chinook, there has been a marked increase in natural-origin fish, and it is reasonable to believe that a number of these represent the progeny of naturally spawning hatchery fish. For logistical reasons, assessing the role of supplementation versus improvements in survival and harvest reductions is not complete. Additional research is needed to understand how genetic and environmental factors, including habitat restoration, affect the consequences of supplementation on natural populations. The LSRCP's supplementation programs offer important opportunities for such work.

Monitoring and evaluation programs established by the LSRCP have allowed its three hatchery programs to make informed changes to hatchery infrastructure, broodstock sources and collection locations, mating protocols, and rearing and release procedures. Ongoing refinements to run reconstruction procedures are helping to quantify harvest numbers and to estimate natural escapements of project fish. Parentage based tagging will be used in the future to identify all the hatchery steelhead and spring and fall Chinook produced by the LSRCP. Accurate identification of hatchery origin fish will allow additional refinements to 1) the contribution rates of hatchery and natural origin fish to harvests and spawning escapements and 2) estimates of natural origin productivity and abundance.

After Snake River spring and fall Chinook and steelhead were listed by the ESA, the LSRCP recognized the need to assist in the recovery of these species in addition to meeting original program objectives. The ISRP encourages the LSRCP to continue collaborative efforts with ESA recovery planning while also providing the harvest opportunities originally sought by the LSRCP. Overall, the hatchery component of the LSRCP is scientifically sound. It has established goals, quantitative targets, and objectives for research, monitoring, and evaluation. Finally, as indicated above, it has demonstrated the ability to be managed adaptively as new challenges develop.

ISRP Retrospective Review
Lower Snake River Compensation Plan

Goal

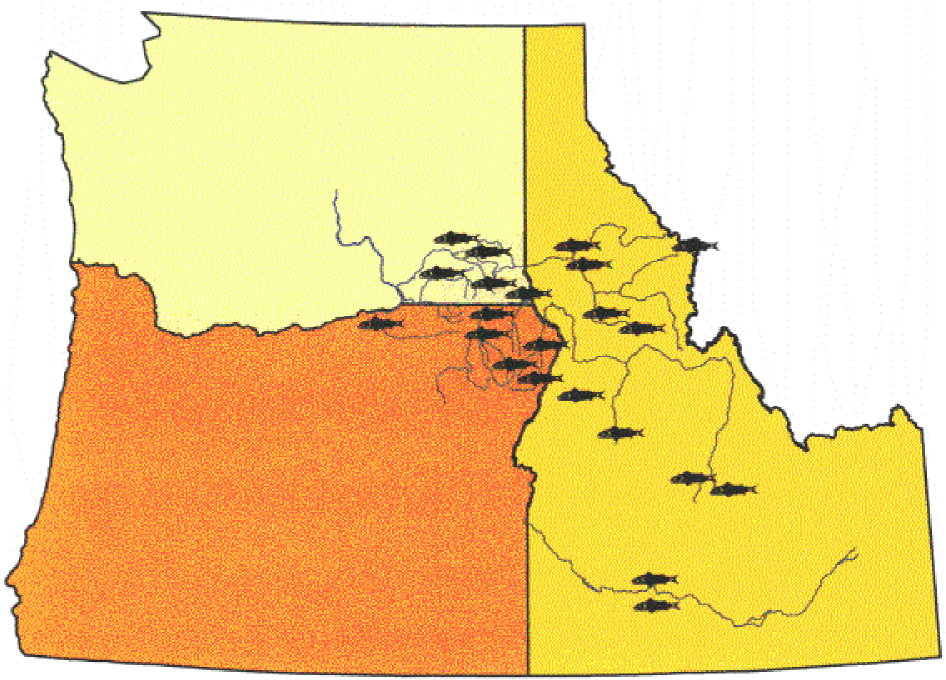
Replace Lost Adult Salmon & Steelhead Caused by the Construction and Operation of the Four Lower Snake River Dams

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)

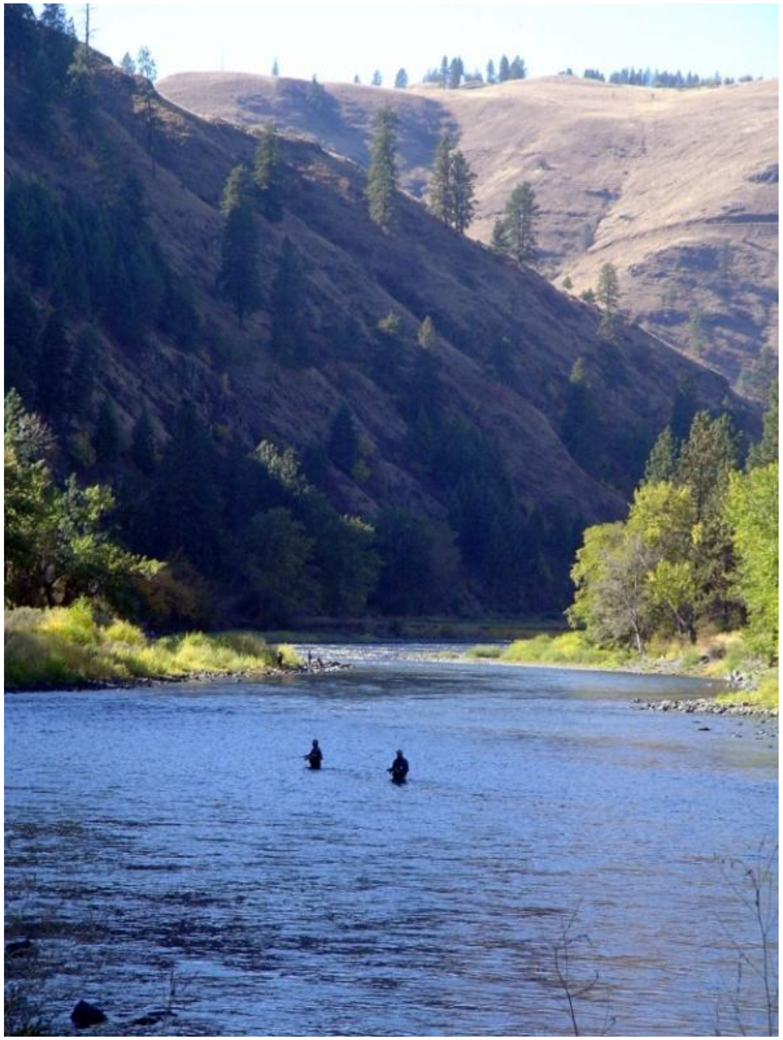
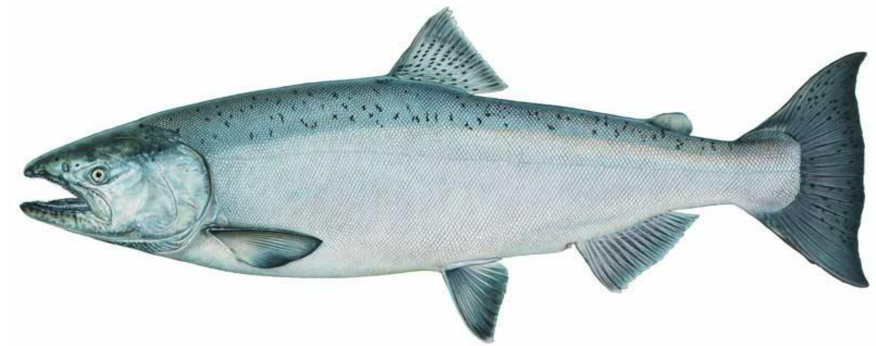


Photo from L. Clarke et al. (2012)

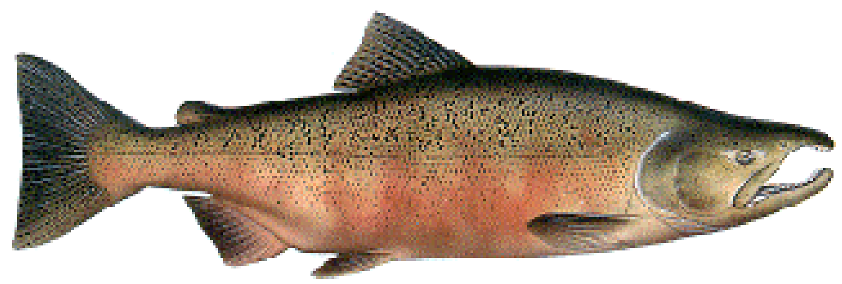
Mitigation Goals

- 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 ≥ 70%
  Yrs Achieved 92%

Steelhead
  Survival Goal 65%-70%
  Yrs Achieved 76%

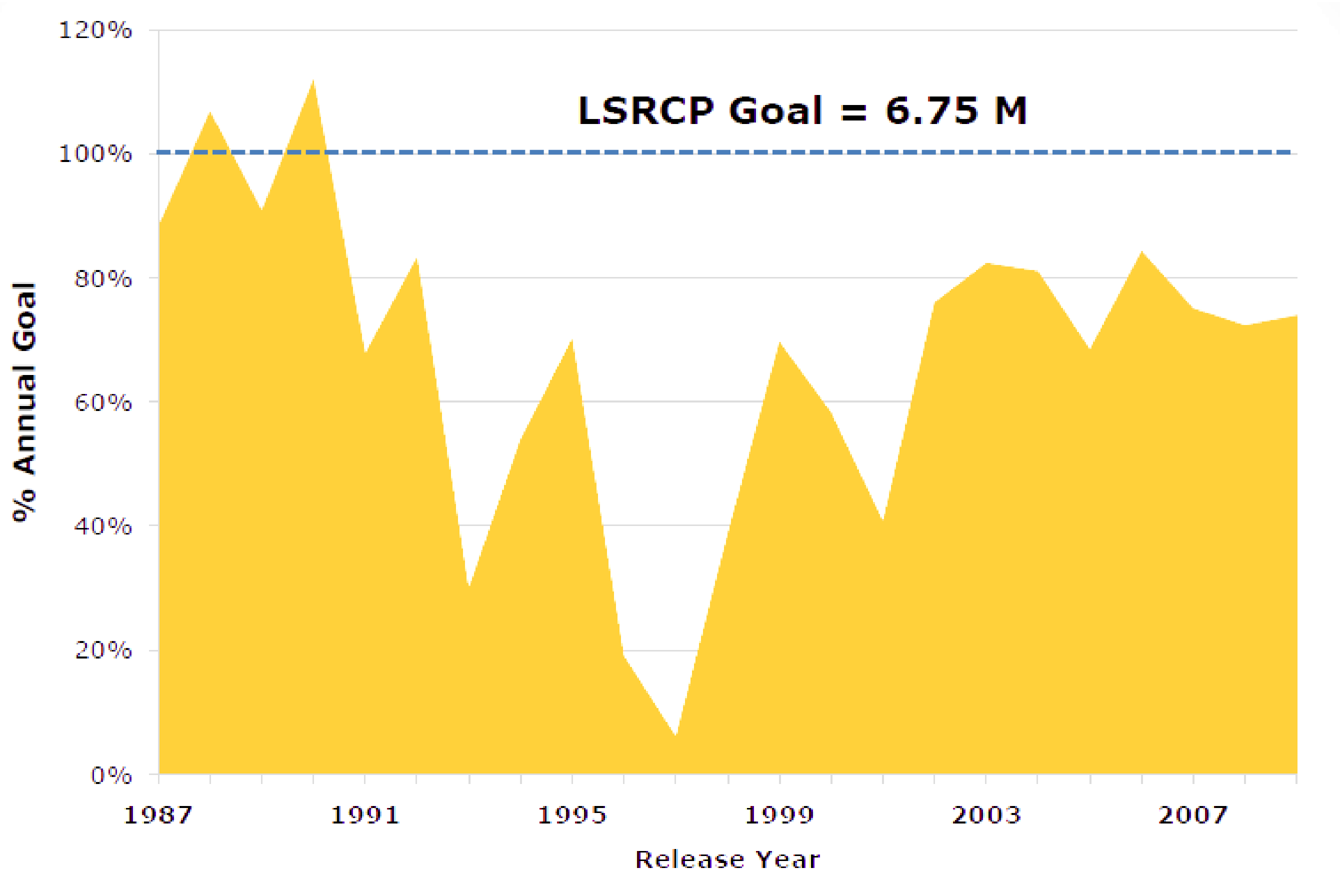
Fall Chinook
  Survival Goal 70% - 80%
  Yrs Achieved 79%

Photo From J. Bumgarner (2012)

Photo from R. Carmichael et al. (2012)

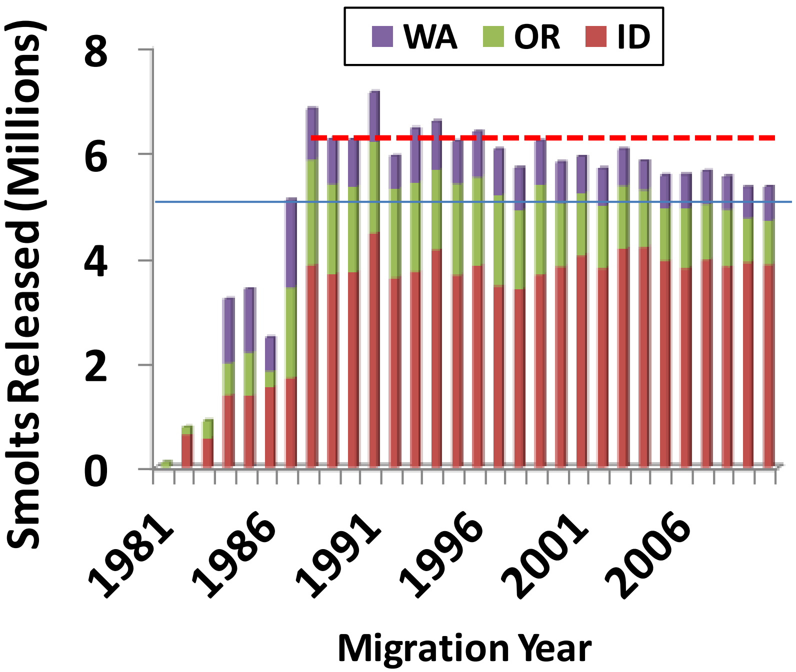
Smolt Release Goal:

Spring Chinook



From Mark Shuck LSRCP Roll-up (2010)

Smolt Release Goal:
Steelhead

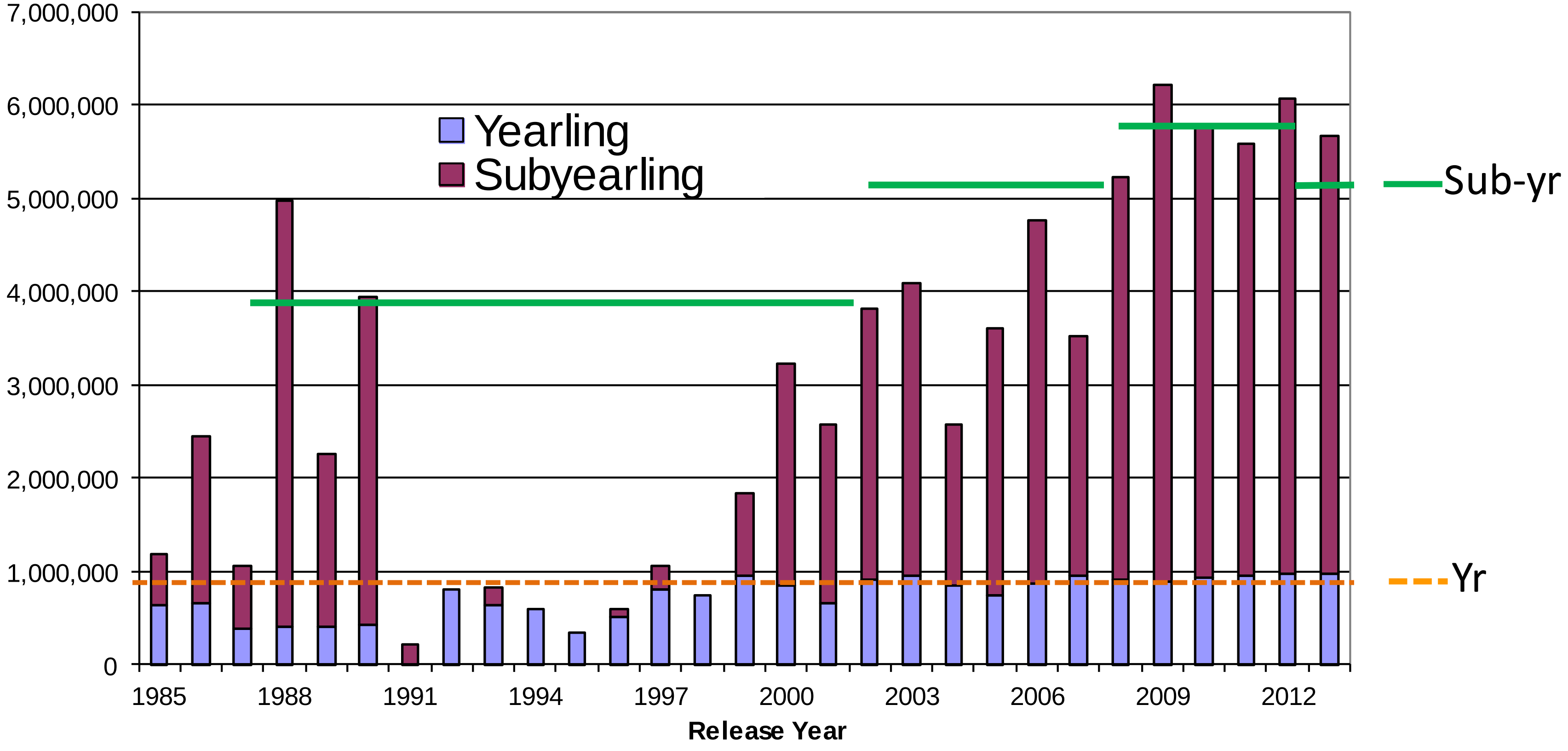


1989- 6.25M
2010- 5.35M

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)

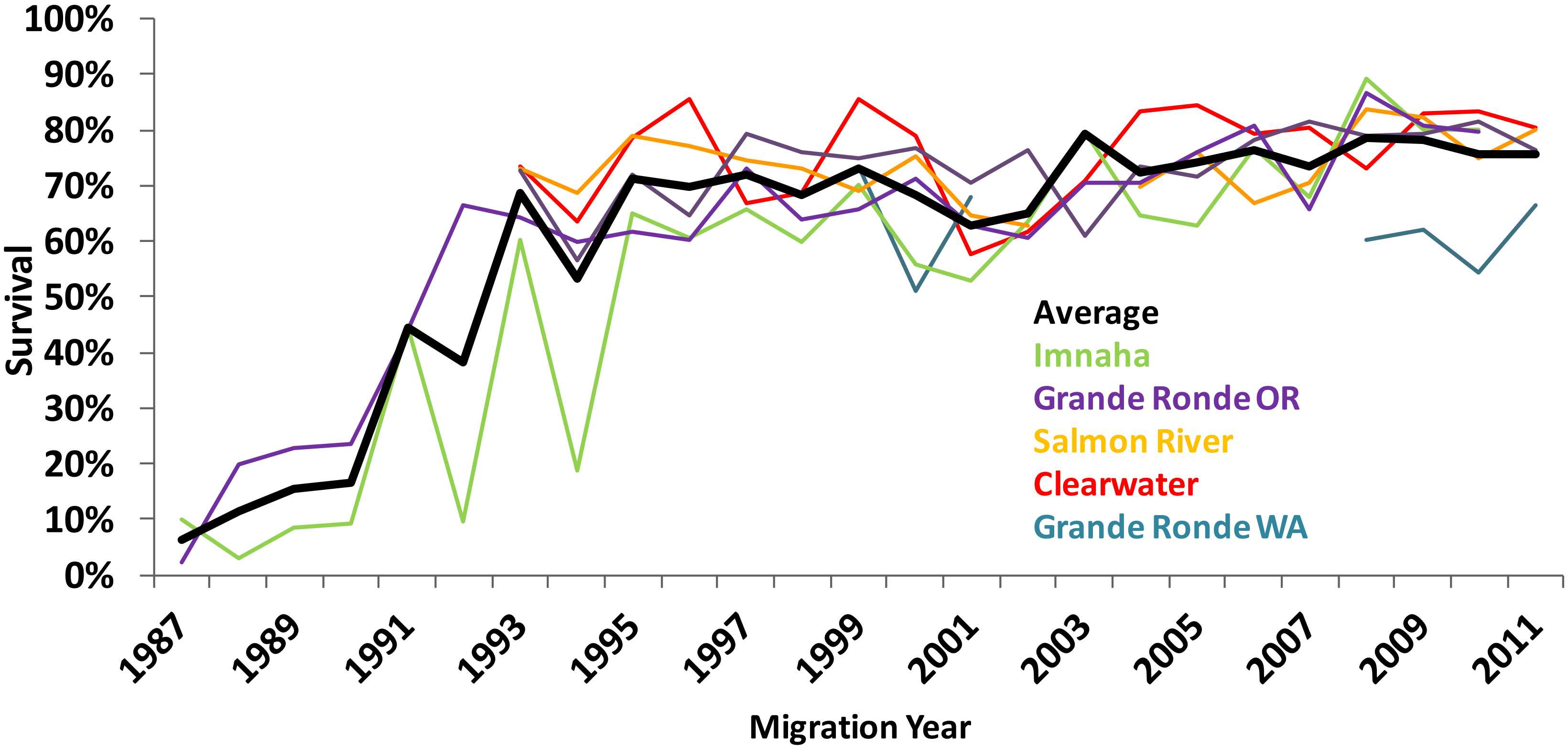
Post Release Metrics

- 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:

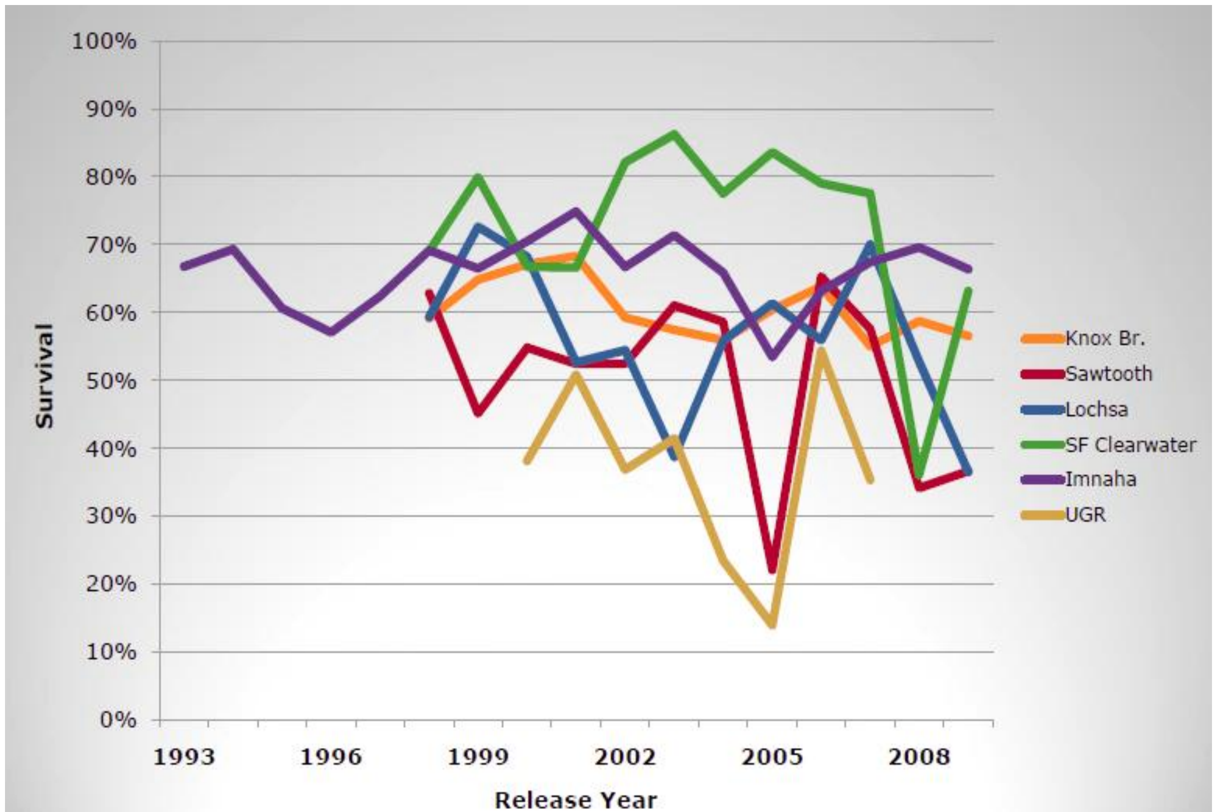
Spring Chinook

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

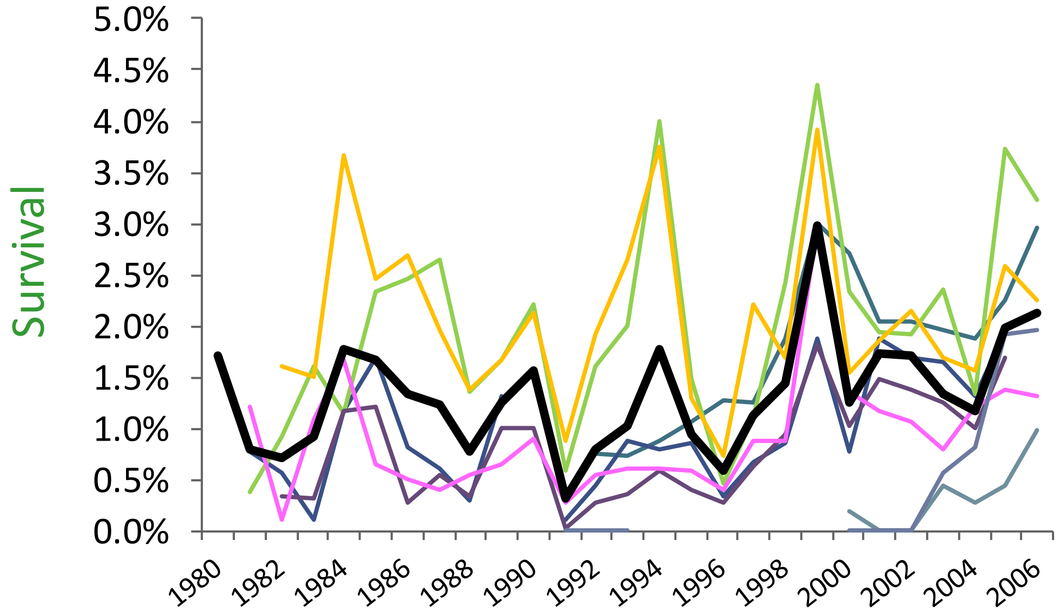
SAS Goal 3.25% - 4.35%
Years Achieved = 0%

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%

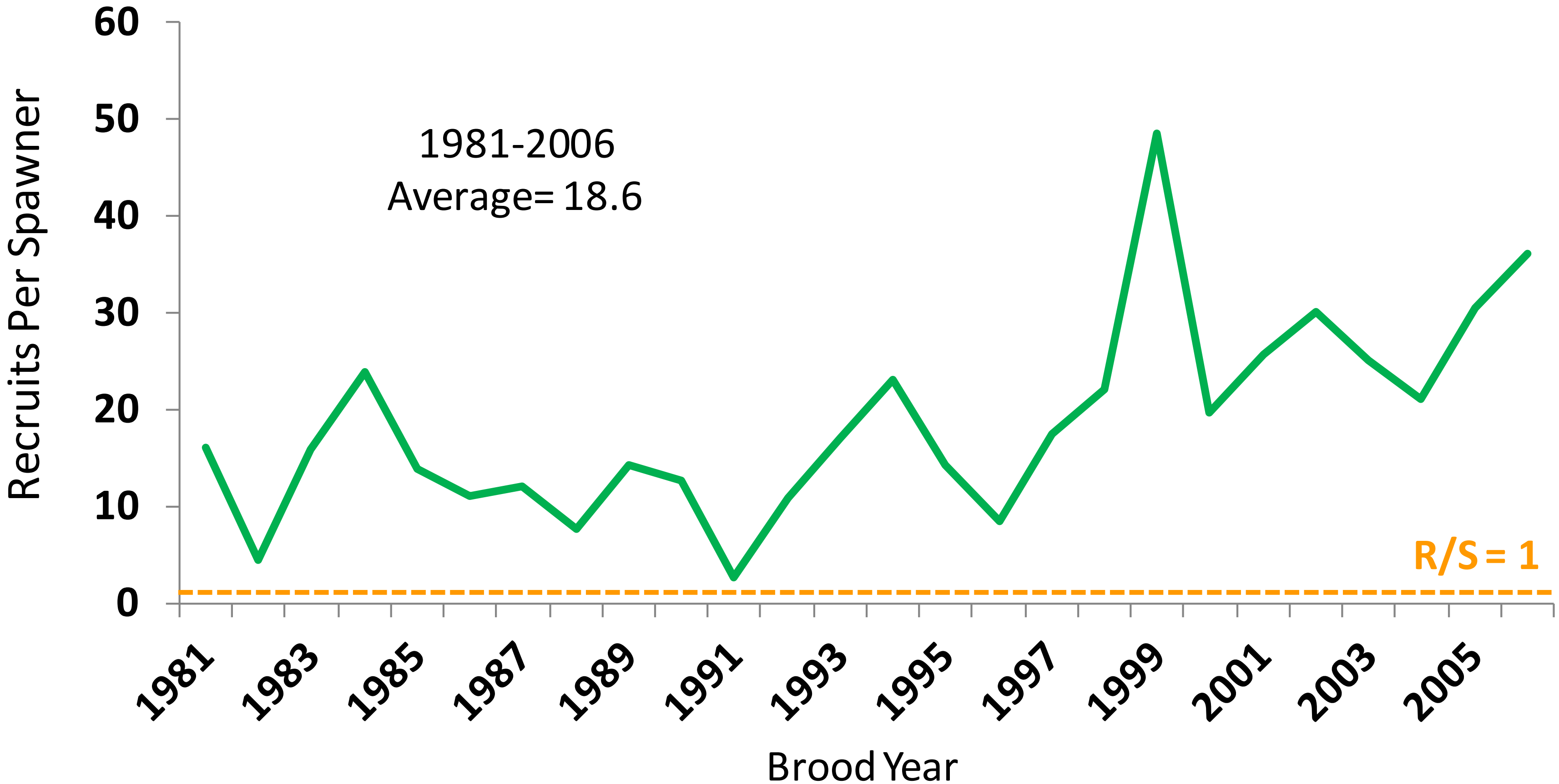


Steelhead SAS By Brood Year

From B. Leth Steelhead Roll-up (2012)

Recruits Per Spawner

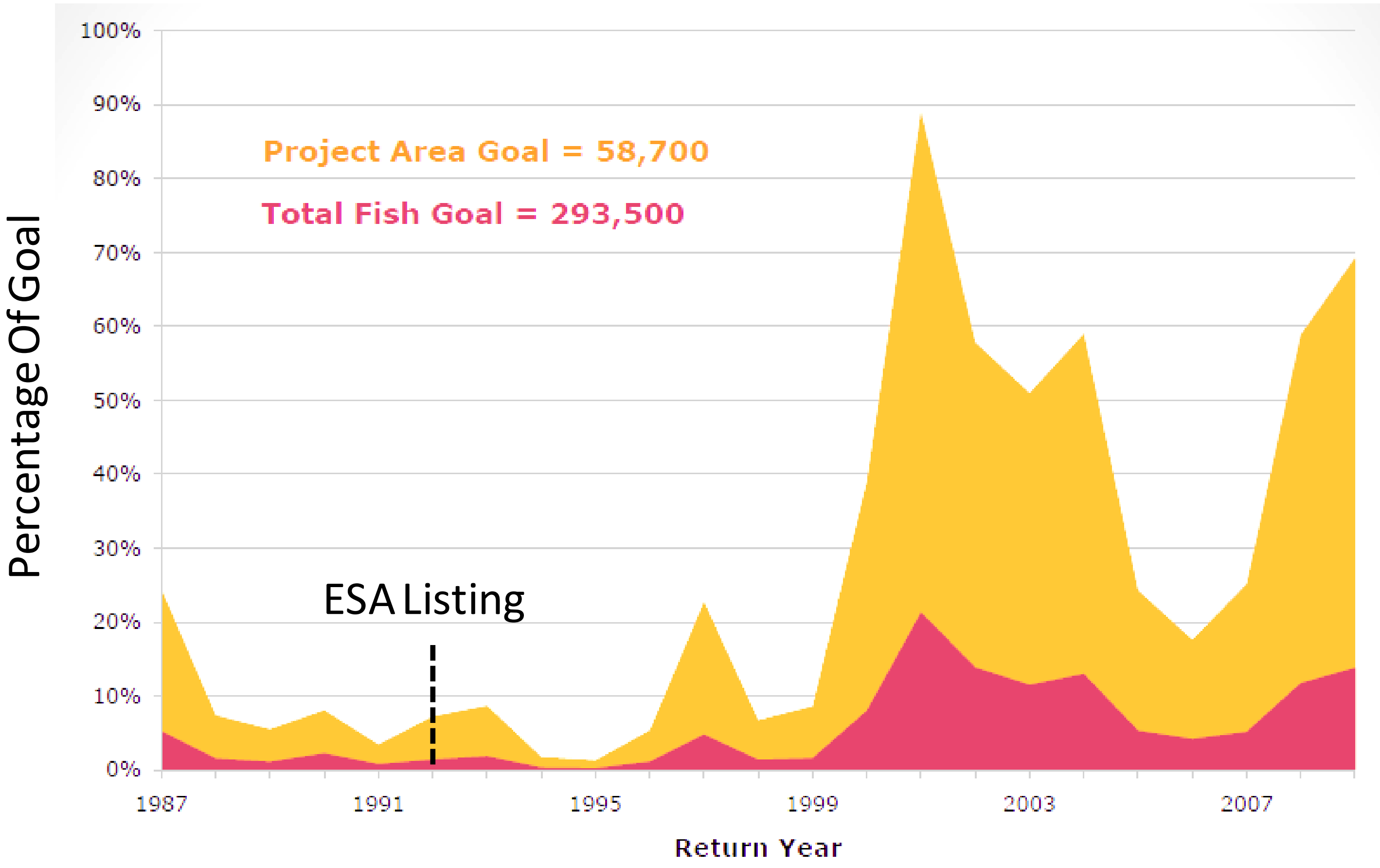
Hatchery Steelhead



From B. Leth steelhead roll-up (2012)

Adult Abundance

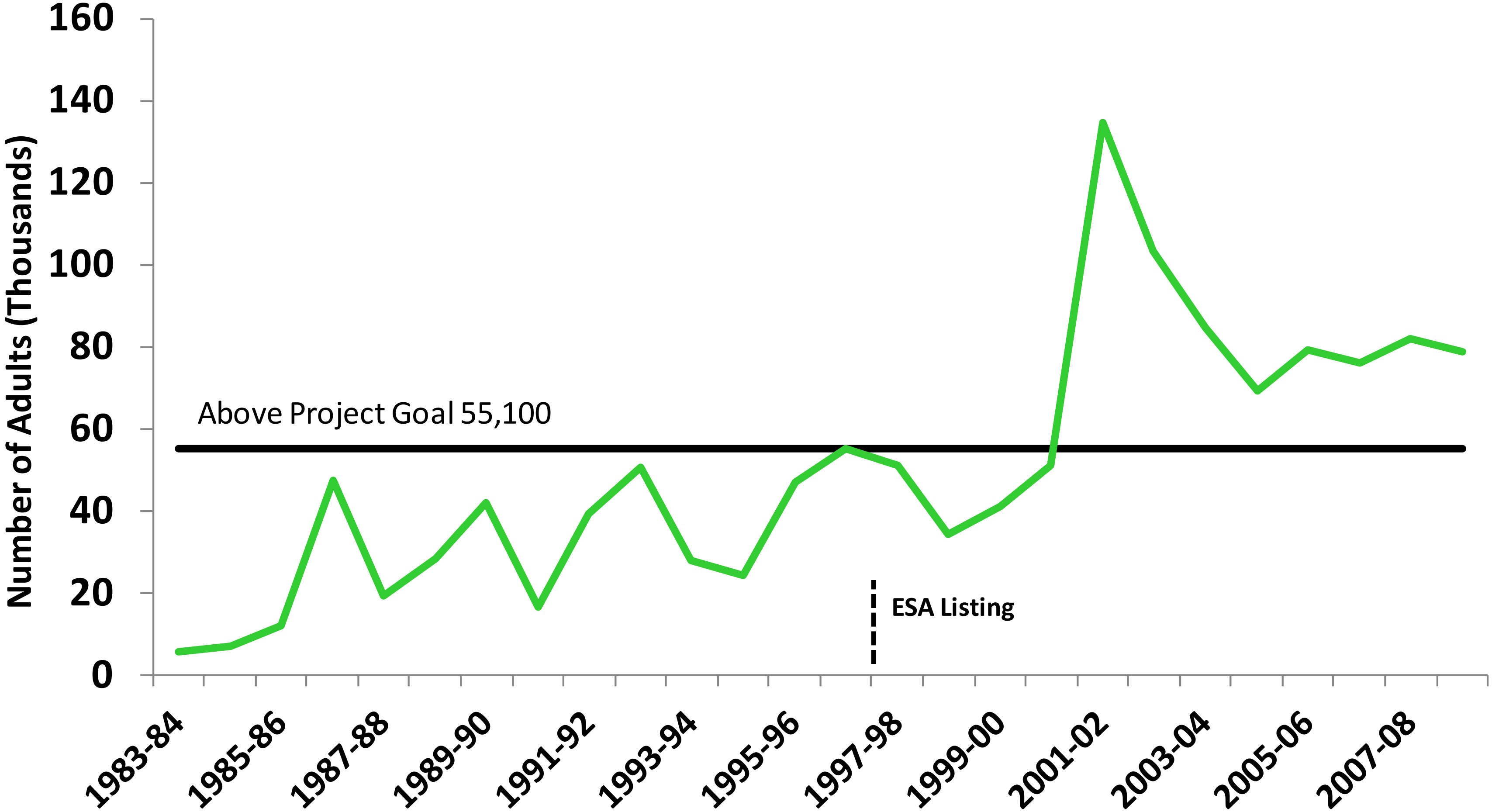
Spring Chinook Salmon



From Mark Shuck roll-up (2010)

Adult Steelhead Abundance

Above Project

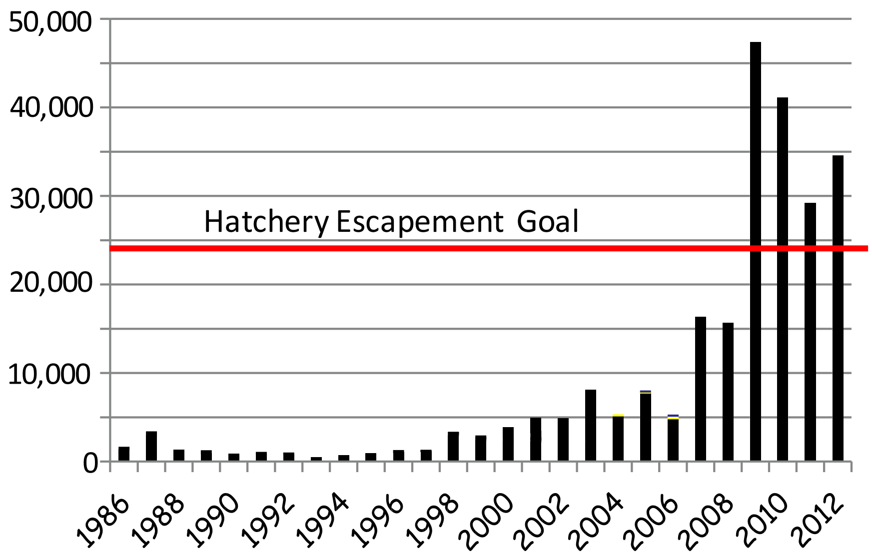


From B. Leth Steelhead Roll-up (2012)

Adult Fall Chinook Abundance

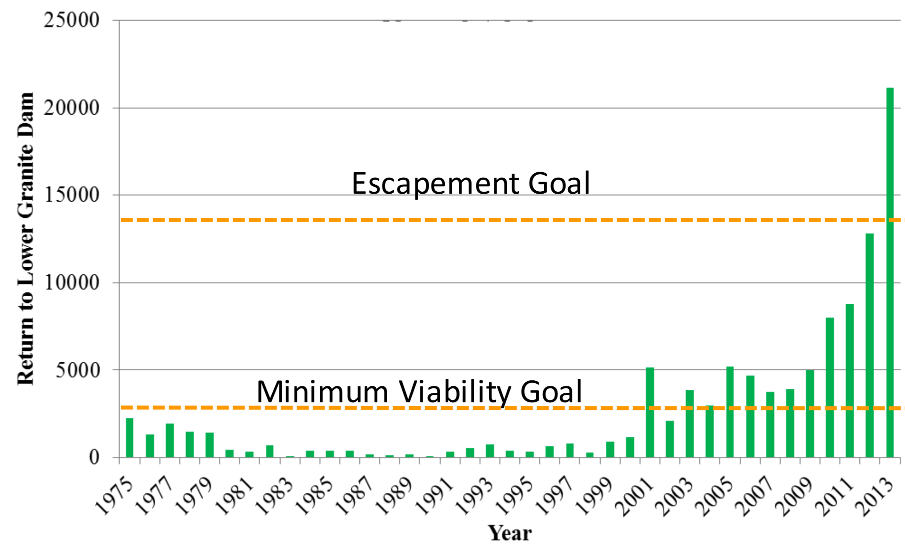
Snake River

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)

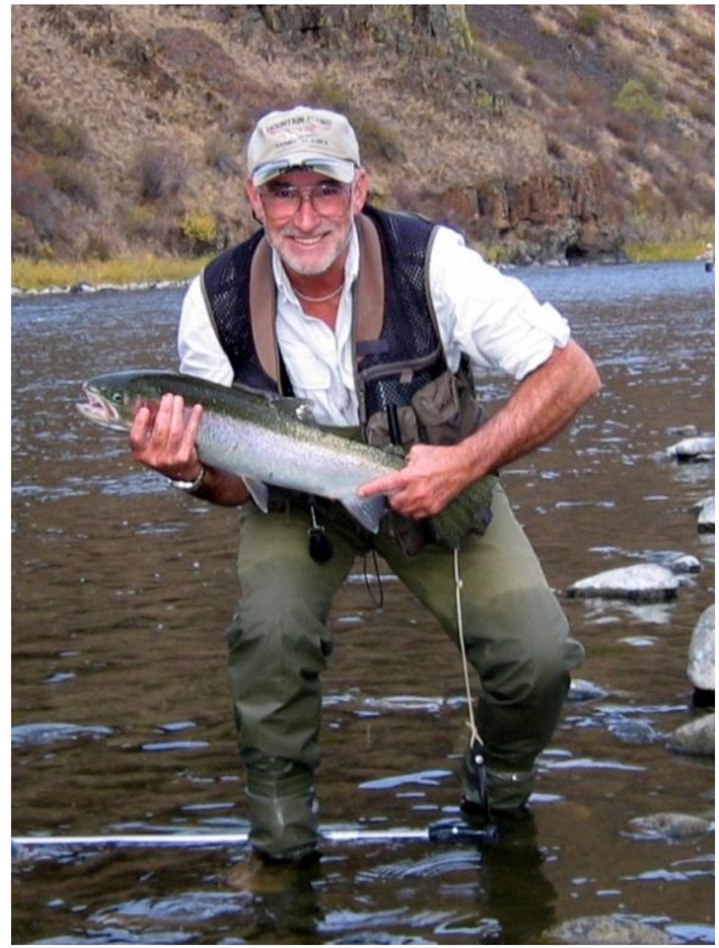


Photo From L. Clarke et al. (2012)

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

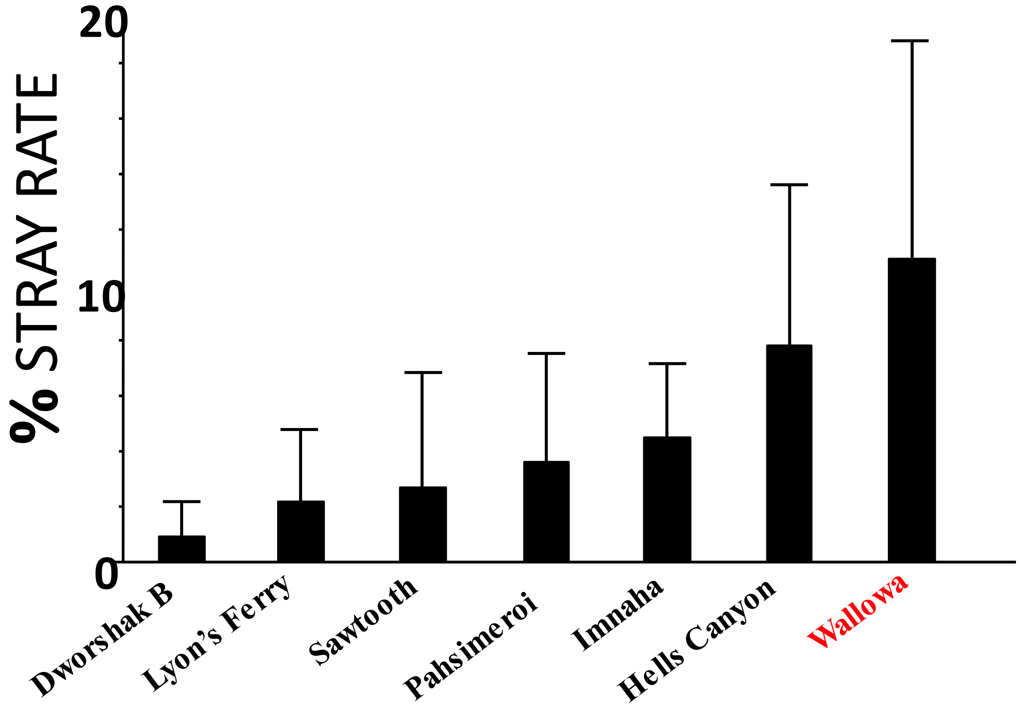


Figure From Clarke et al. 2012

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 **Volitional** 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

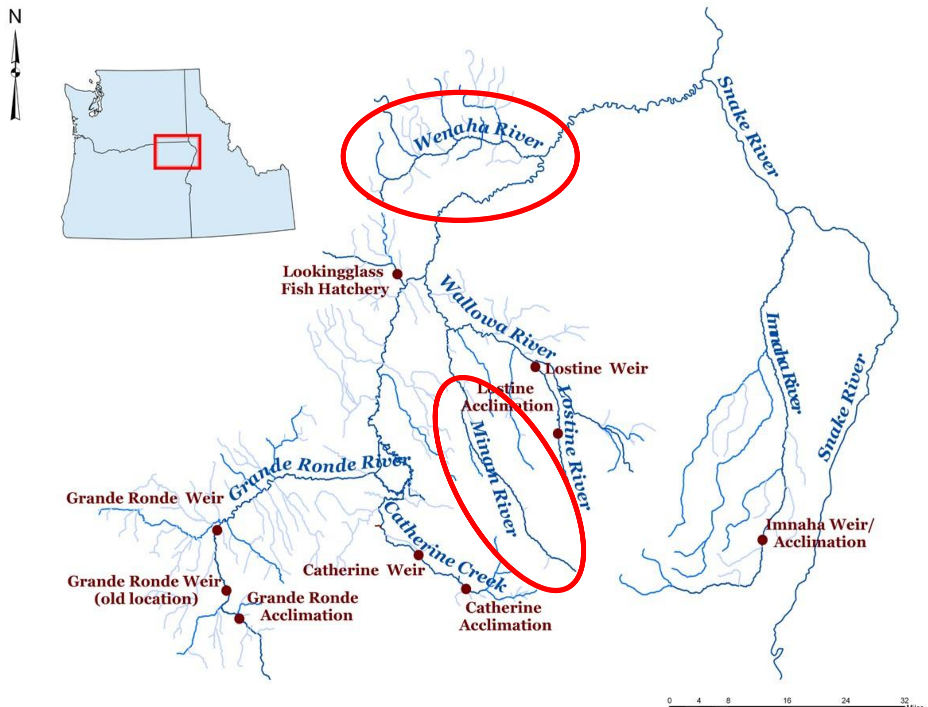
Wild Stock Protection
Grande Ronde Spring Chinook

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

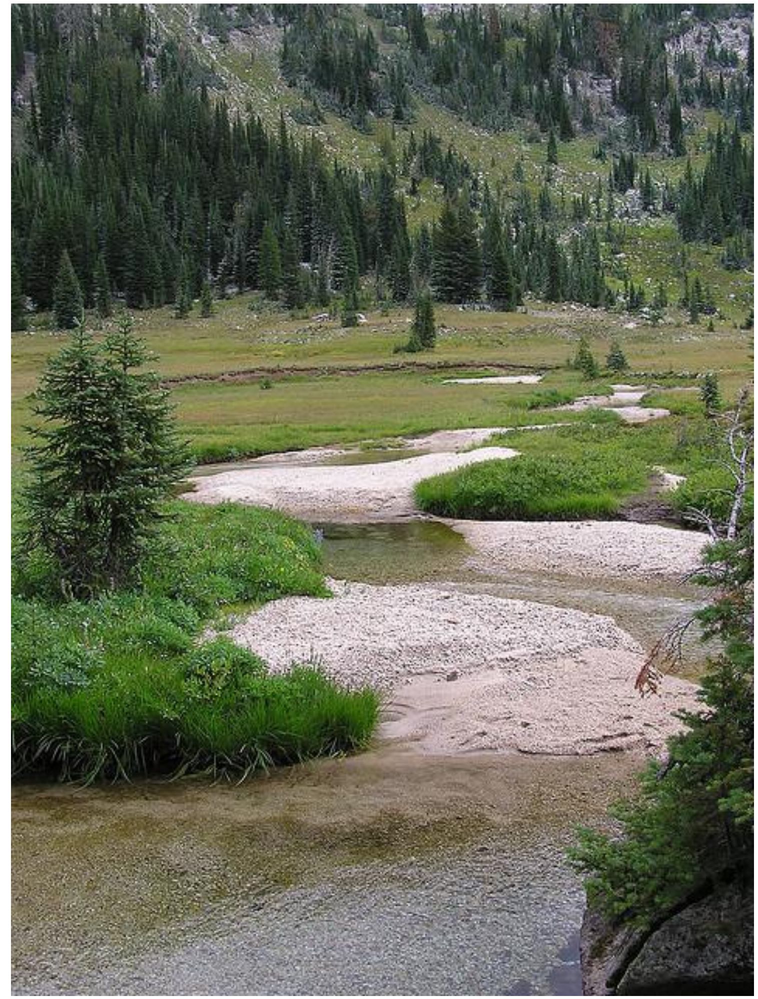
Type	No. Of Parr	No. Adult Females Produced	No. Of F_1 Adults
Captive Brood	500	133	370
Conv. Hatch	500	1.1	18
Natural	500	0.6	2

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

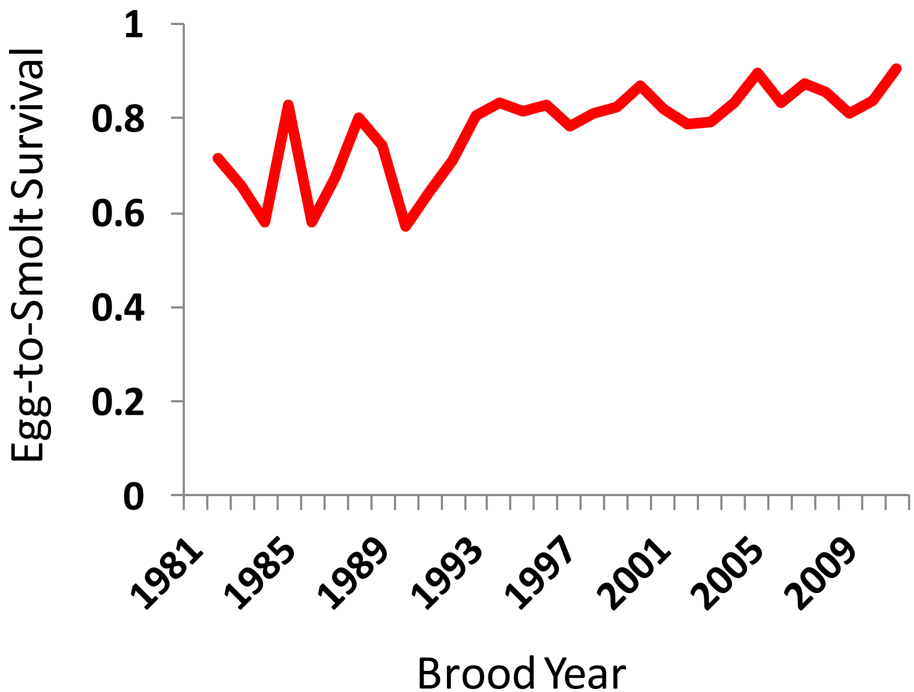
7. Using Artificial Production to Augment Harvest While Simultaneously Implementing Recovery Actions for ESA-Listed Steelhead & Chinook

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%

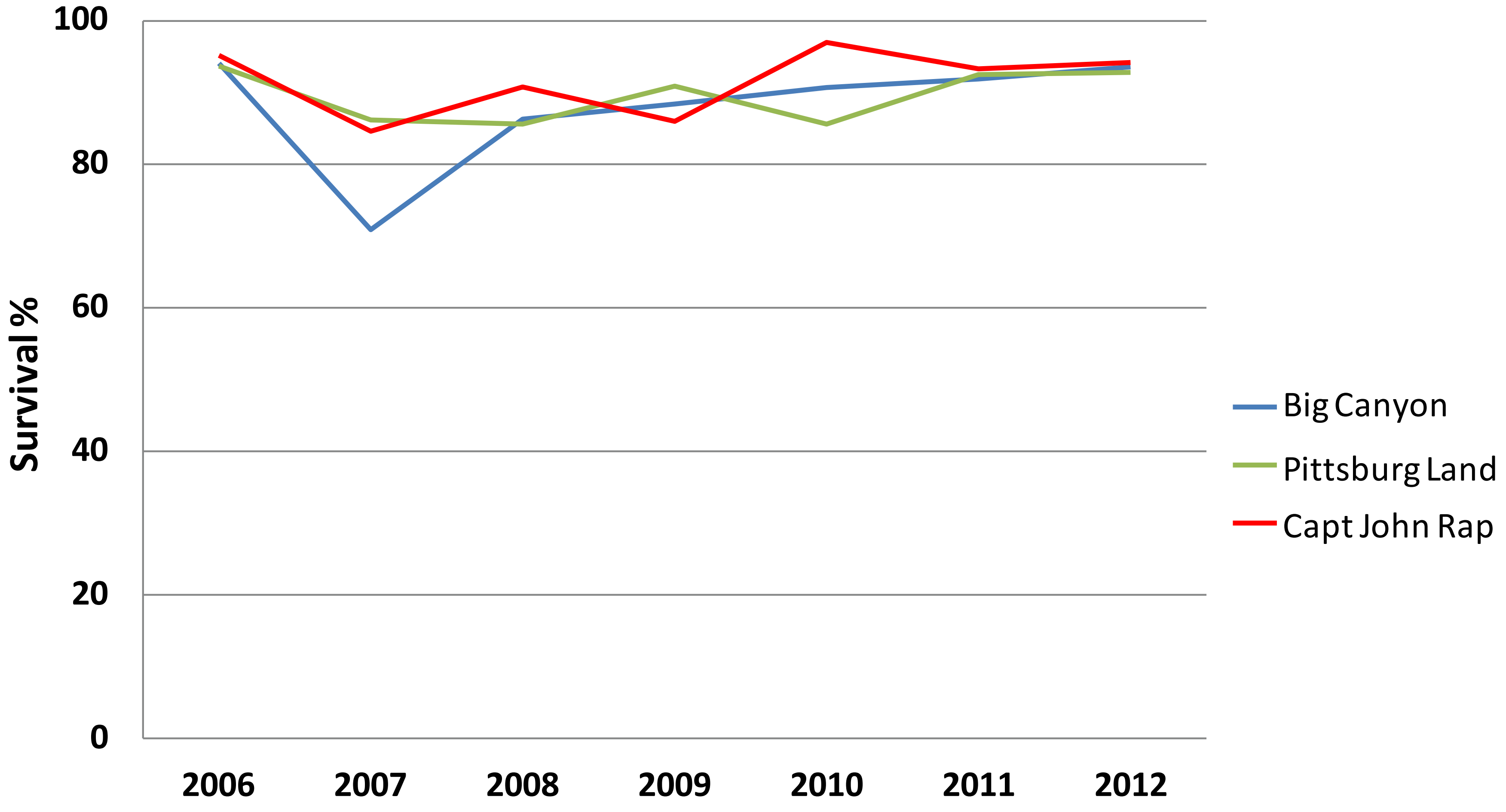
Fall Chinook
0+ Goal = 4.6 Million
Yrs Achieved = 69%

1+ Goal = 0.9 Million
Yrs Achieved = 95%

Spring Chinook smolts
Photo workareaonline.com

Yearling Fall Chinook Survival To Lower Granite Dam

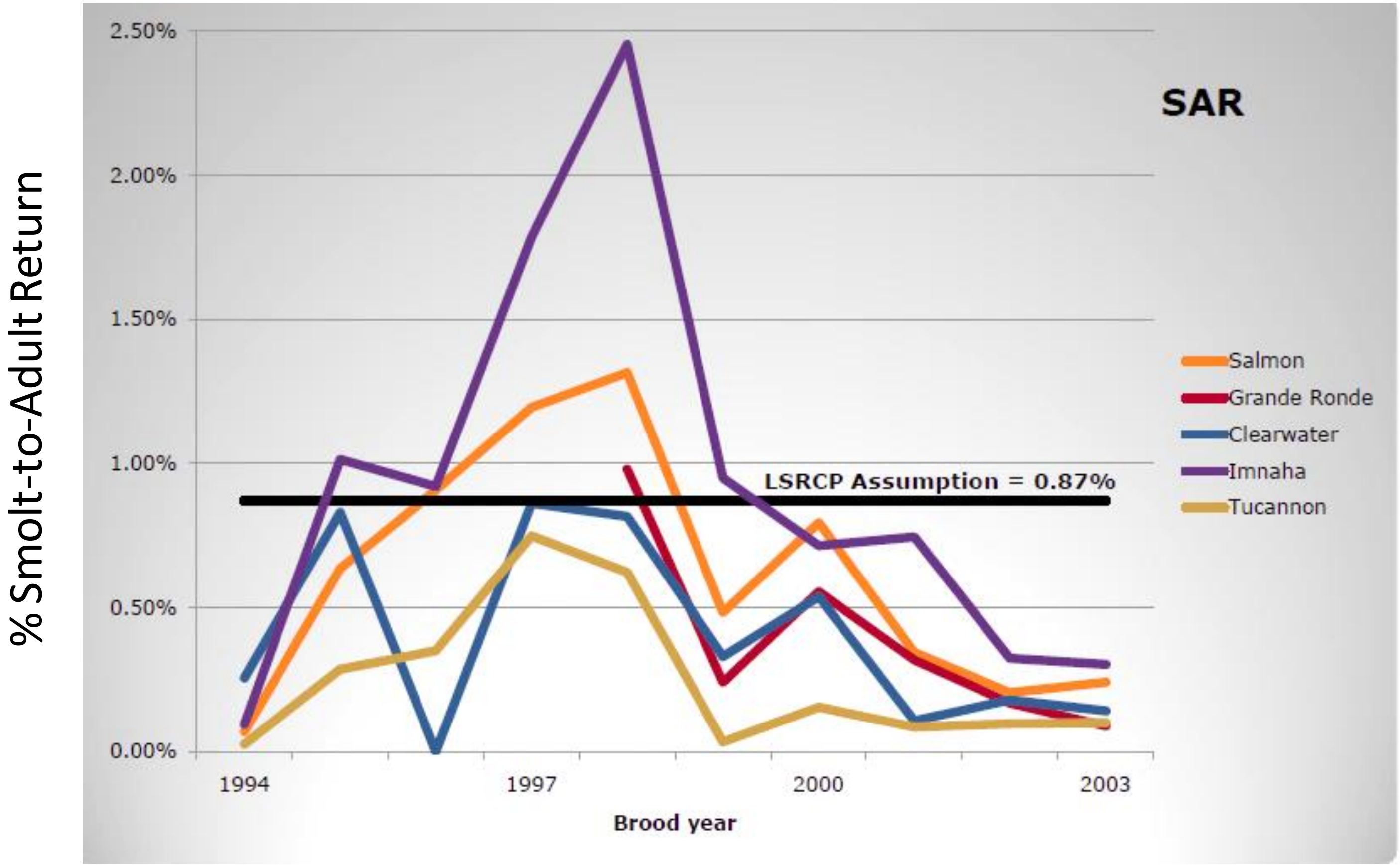
Acclimation Pond Releases



From M. Key (2013)

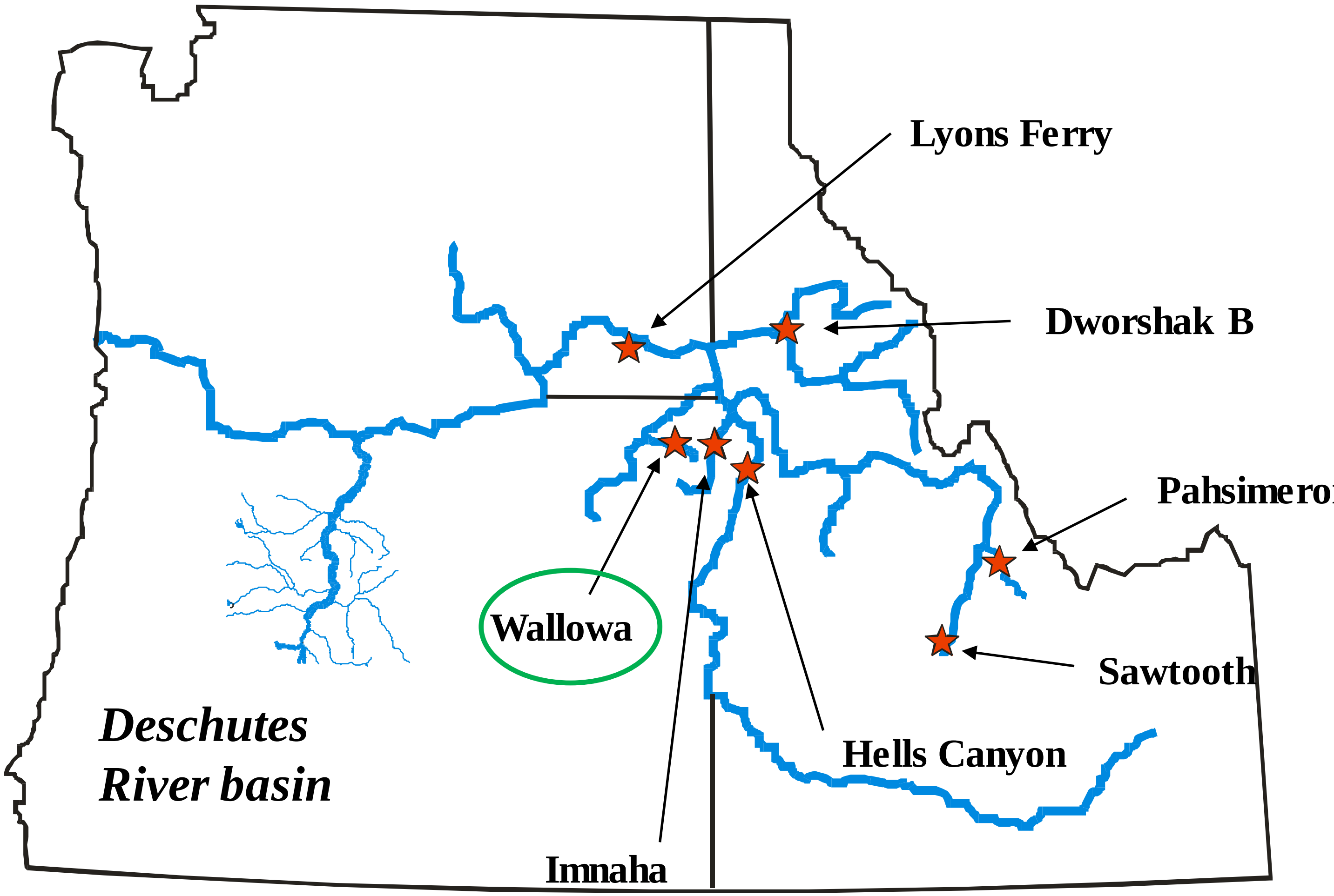
Smolt-to-Adult Returns (SAR)

Spring Chinook



From Mark Shuck roll-up (2010)

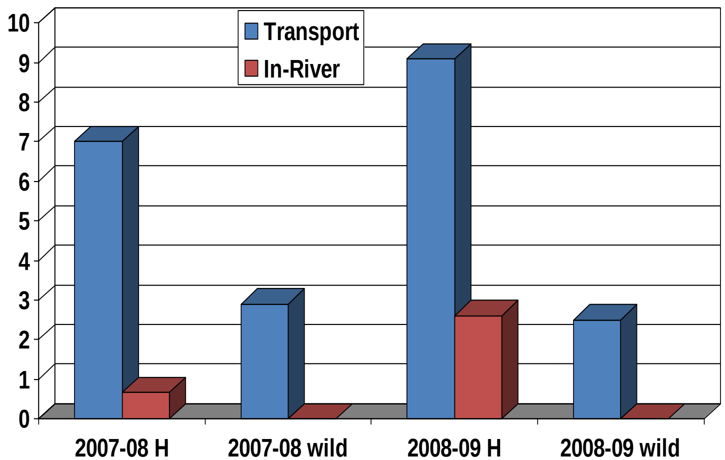
Snake River Hatchery Steelhead Stocks



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

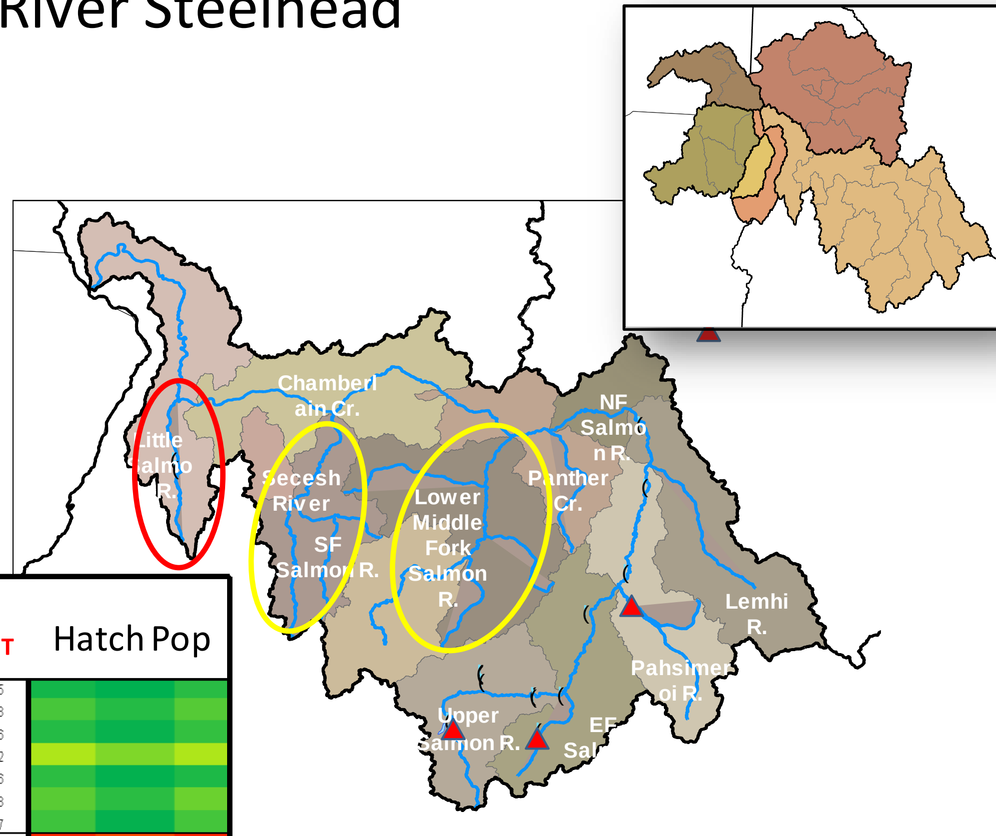
- Hatchery Releases

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	

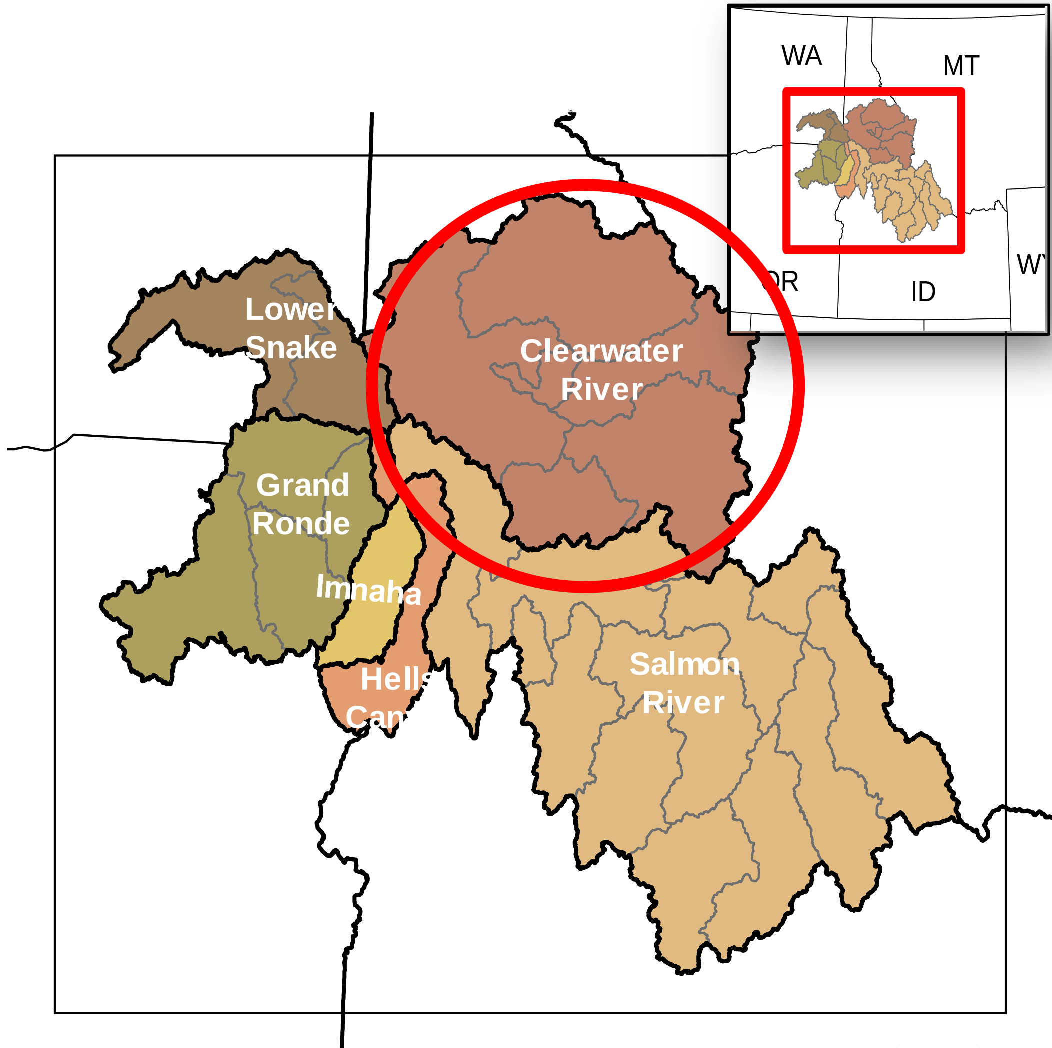


From Brian Leth (2012)

Wild Stock Protection

Clearwater Steelhead

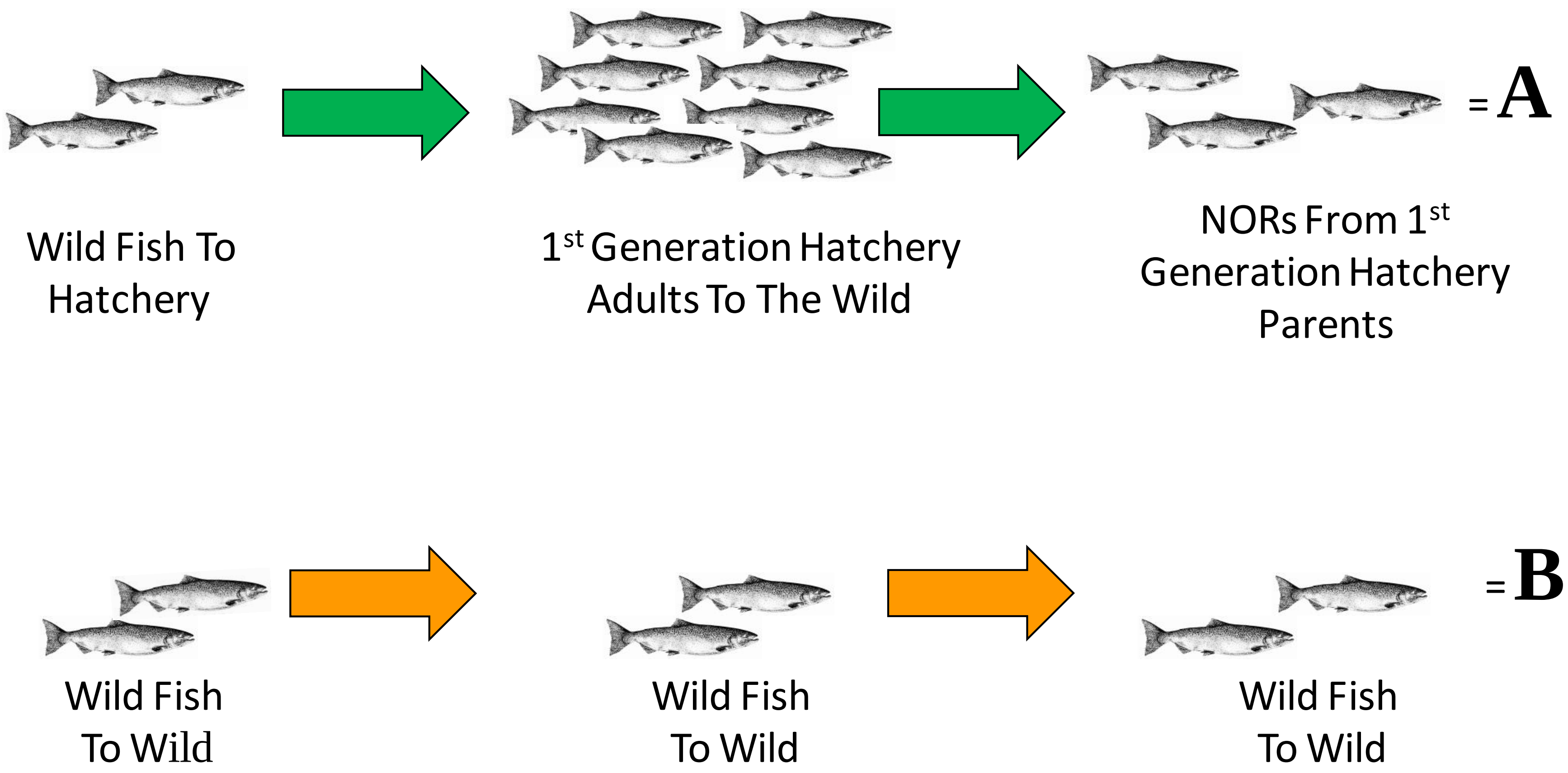
Natural Population	Tributary	Dworshak Avg. Pairwise F_{ST}
Colt Cr	Lochsa R. No Releases	0.023
Storm Cr		0.025
Crooked Fork		0.018
Lake Cr		0.025
Fish Cr		0.018
Canyon Cr		0.013
Selway R	Selway R. No Releases	0.024
Little Clearwater R		0.023
Whitecap Cr		0.024
Bear Cr		0.025
NF Moose Cr		0.018
Three 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



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

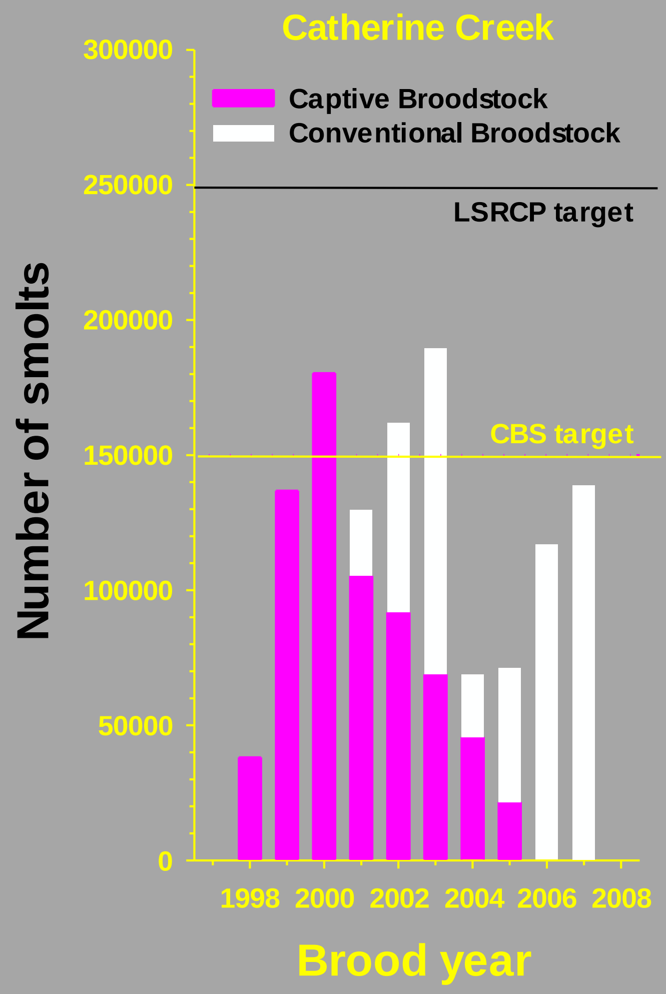
Photo grantpud.org

Key Assumptions of Supplementation

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

Grande Ronde River
Photo commons.wikimedia..org

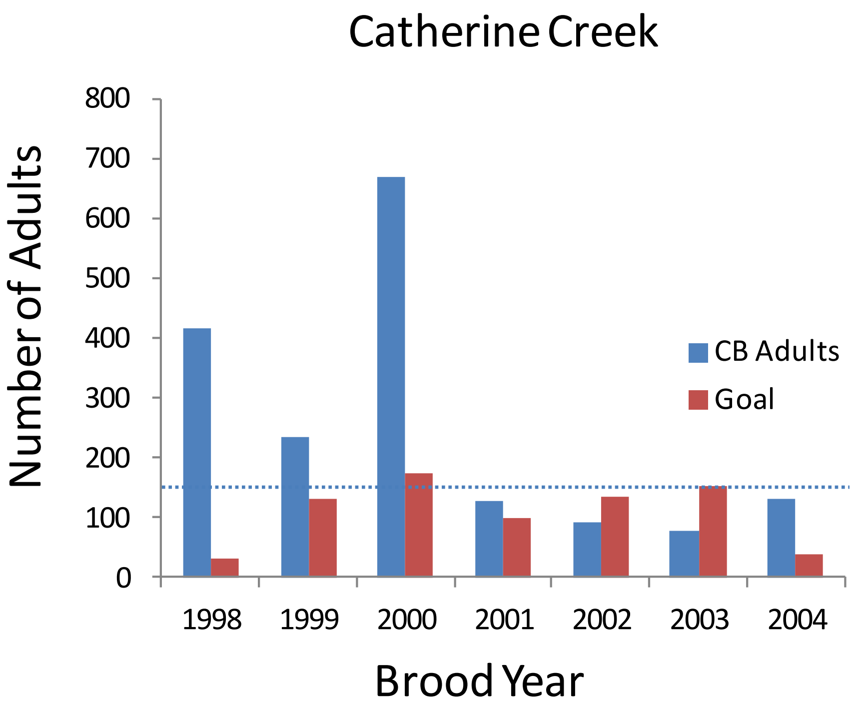
Changes In Smolt Origin



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)

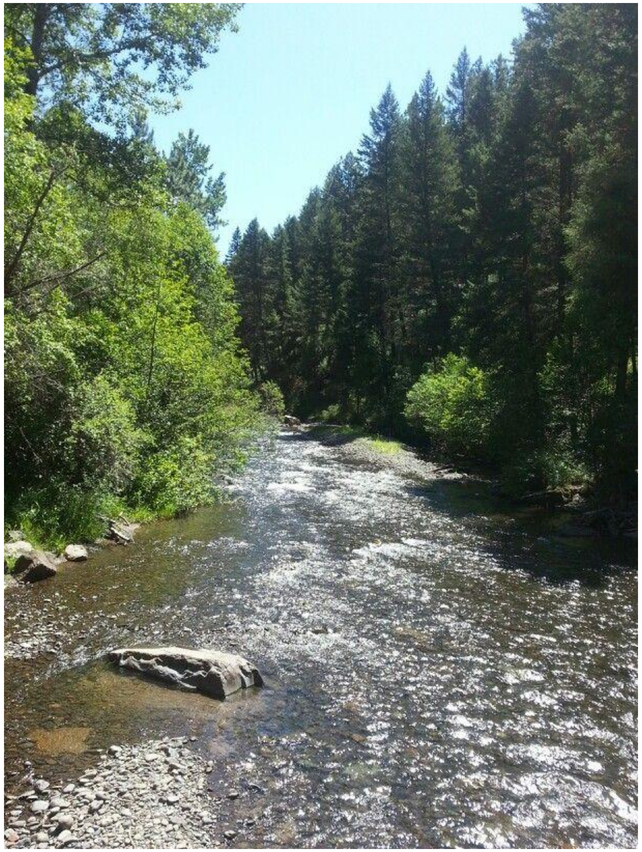


Photo pinterest.com

Results Of Captive Brood Program
Grande Ronde Spring Chinook

Parr Collections: Generally Met

Growth: Slower than Expected

Survival: Wild Parr-to-Smolt > 95%

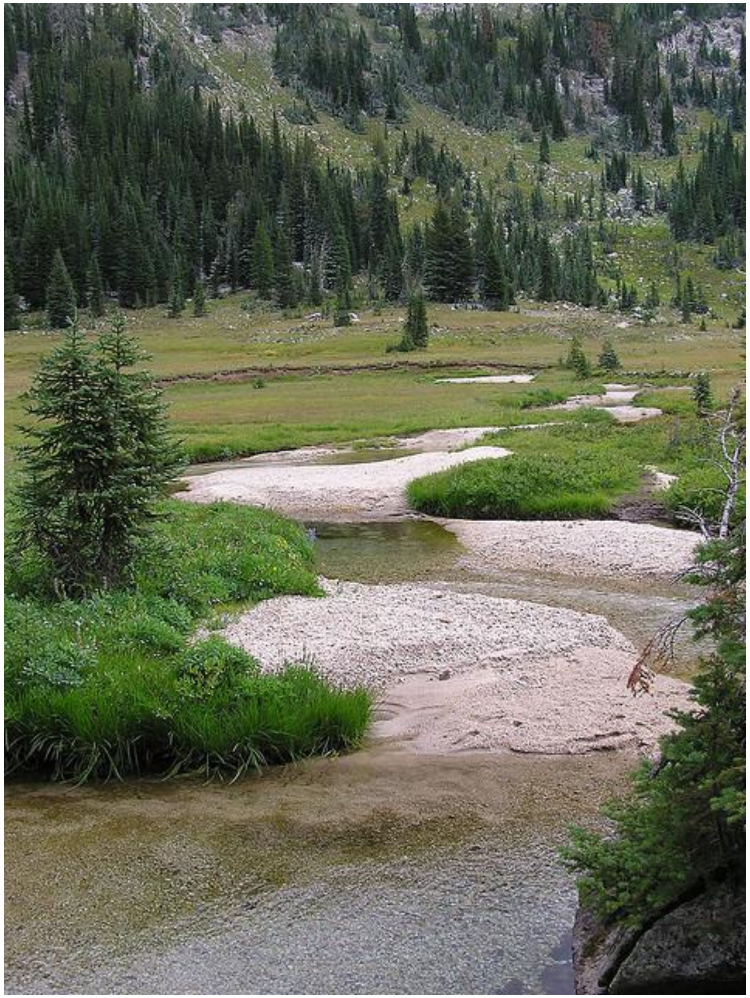
Wild Smolt-to-Adult ~ 55%

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)