Northwest Power and Conservation Council

August 30, 2012

MEMORANDUM

TO: Fish and Wildlife Committee Members

FROM: Peter Paquet, Manager, Wildlife and Resident Fish

SUBJECT: Presentation on technical aspects of supplementation and hatchery policies

At the September 2012 Fish and Wildlife Committee meeting, Jay Hesse, (Nez Perce Tribe) and Dave Fast, (Confederated Tribes and Bands of the Yakama Nation), will be presenting on the technical aspects of supplementation and hatchery policies.

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Supportive breeding boosts natural population abundance with minimal negative impacts on fitness of wild Chinook salmon in Johnson Creek

1

Maureen Hess[1]
Craig Rabe[2]
Jason Vogel[2]
Jeff Stephenson[1]
Doug Nelson[2]
Shawn Narum[1]

2

Hess *et al*. 2012, in press, Molecular Ecology

Background/Rationale

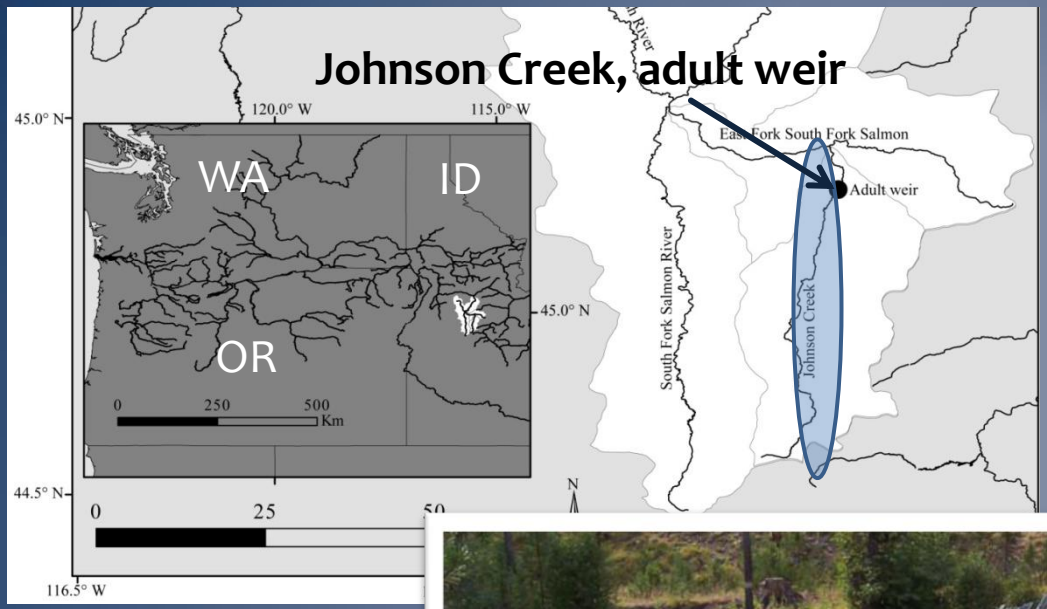
- Main goals of supplementation programs:
  - Prevent extirpation; increase/maintain abundance
  - Minimize negative impacts to wild fish

- Published studies show that hatchery fish can have negative genetic consequences to wild fish when they mate together

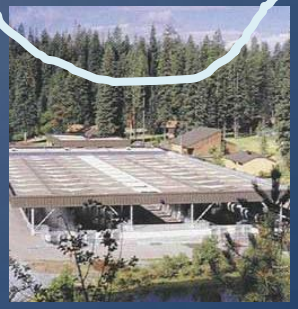
Limitations:

- Largely limited to steelhead
- Re-use of hatchery fish as broodstock
- No studies on lifetime fitness of Chinook salmon in the wild

Study system

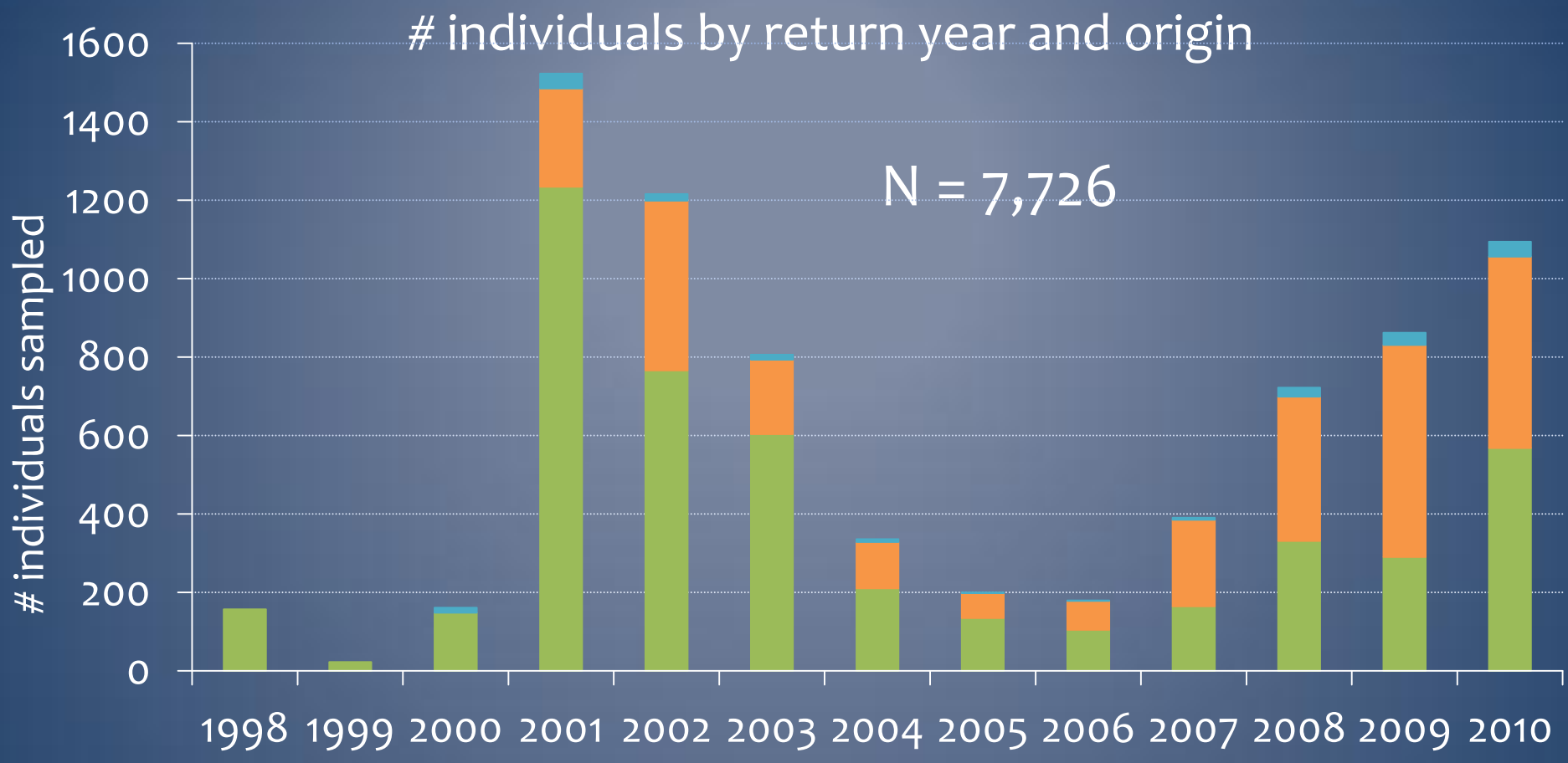


- Nez Perce Tribe initiated supplementation program in 1998
- Only wild-origin returns used for broodstock

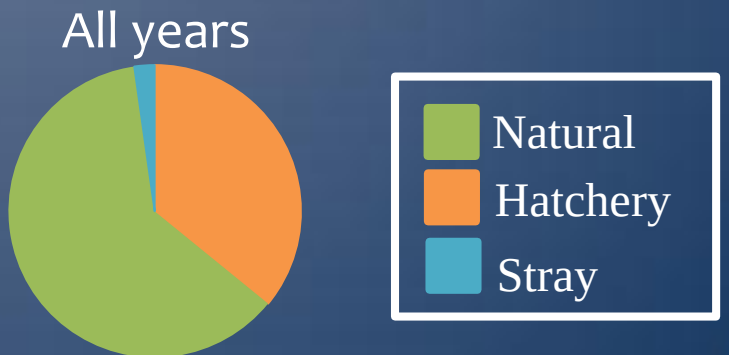


First study to evaluate lifetime reproductive success of Chinook salmon in the wild at the initiation of supportive breeding

Summary of dataset



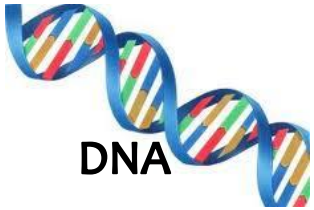
13 years of data = 2 complete generations of adult to adult returns



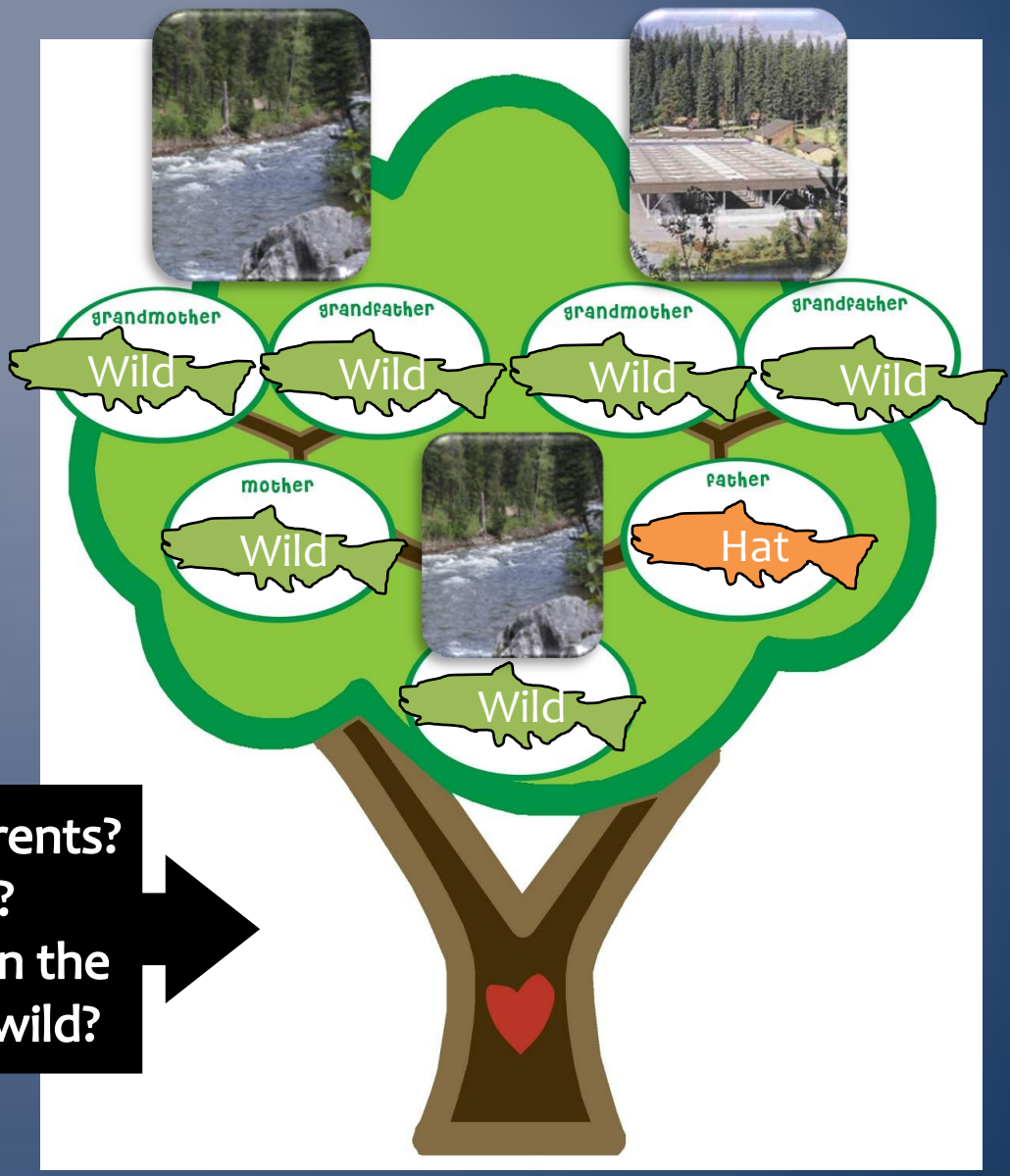
Methods

i.) Use DNA to reconstruct genetic pedigrees

Tissue in ethanol vial



i. Who are your parents?
ii. How old are you?
iii. Were you born in the hatchery or in the wild?



Methods

ii.) Use genetic pedigrees to quantify reproductive success

- Reproductive success = How many offspring did you have?

- Comparison of reproductive success (RS) between hatchery and wild

$$RRS = \frac{\text{Avg \# offspring produced by a hatchery fish}}{\text{Avg \# offspring produced by a wild fish}}$$

Objectives and Results

i.) Demographic boost provided by the hatchery?

Hatchery environment

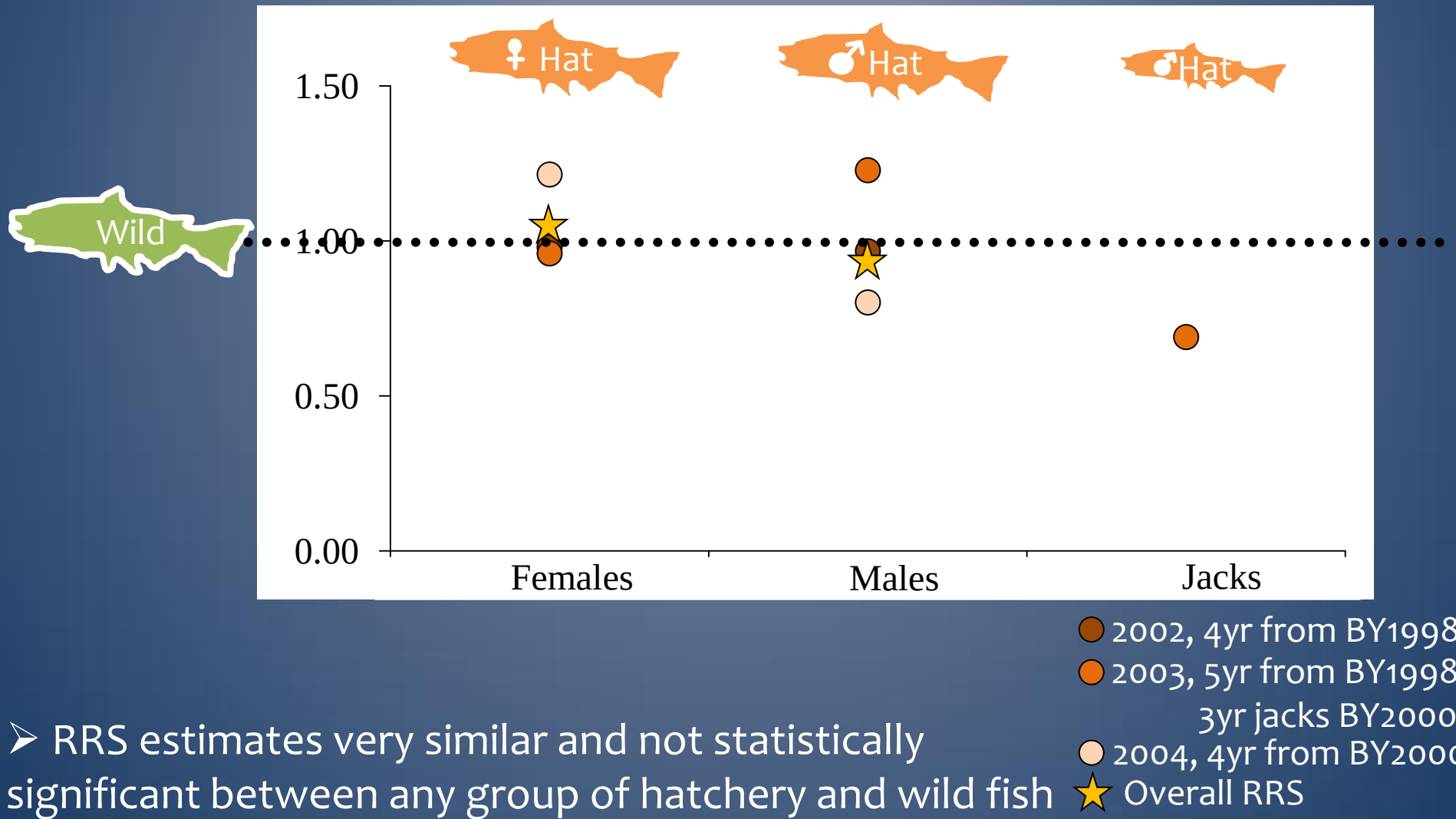
Offspring
Grand-offspring

Wild environment

Brood year	Adult offspring produced relative to wild	Adult grand-offspring produced relative to wild
1998	2.77	1.37
1999	n/a	n/a
2000	1.22	1.28
2001	5.35	tbd
2002	5.48	tbd
2003	8.01	tbd
2004	5.29	tbd
2005	4.70	tbd
Mean	**4.69**	**tbd**

Objectives and Results

ii.) Differences in reproductive success between SUCCESSFUL hatchery-reared and wild-origin fish spawning naturally?



- RRS estimates very similar and not statistically significant between any group of hatchery and wild fish

Objectives

iii.) Do hatchery-reared fish have a negative genetic impact on wild fish when they mate with them?

A theoretical example:

3 types of matings in the wild:

Wild X Wild

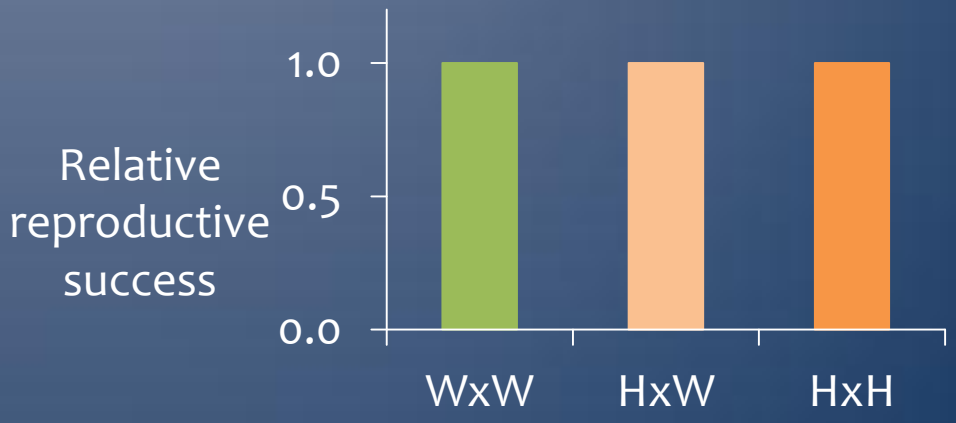
10 offspring

Hat X Hat

10 offspring

Hat X Wild

10 offspring



Result would indicate equal reproductive success - no negative genetic effect

Objectives

iii.) Do hatchery-reared fish have a negative genetic impact on wild fish when they mate with them?

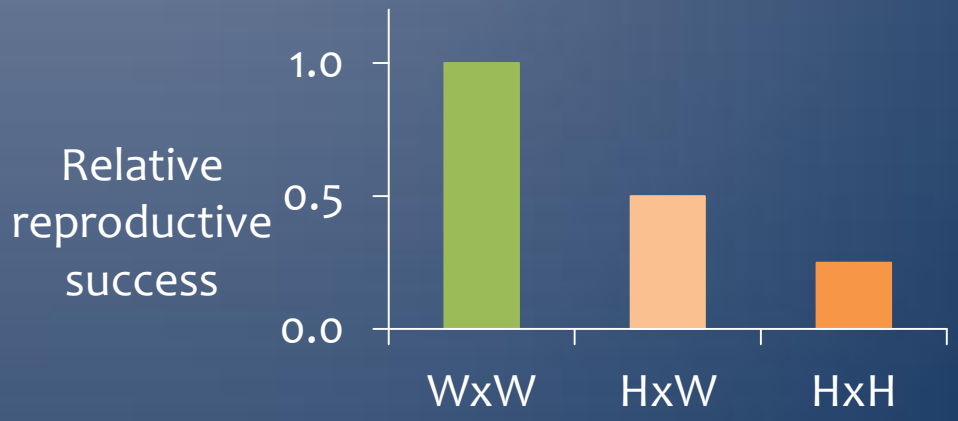
A theoretical example:

3 types of matings in the wild:

Wild X Wild → 10 offspring

Hat X Hat → 2 offspring

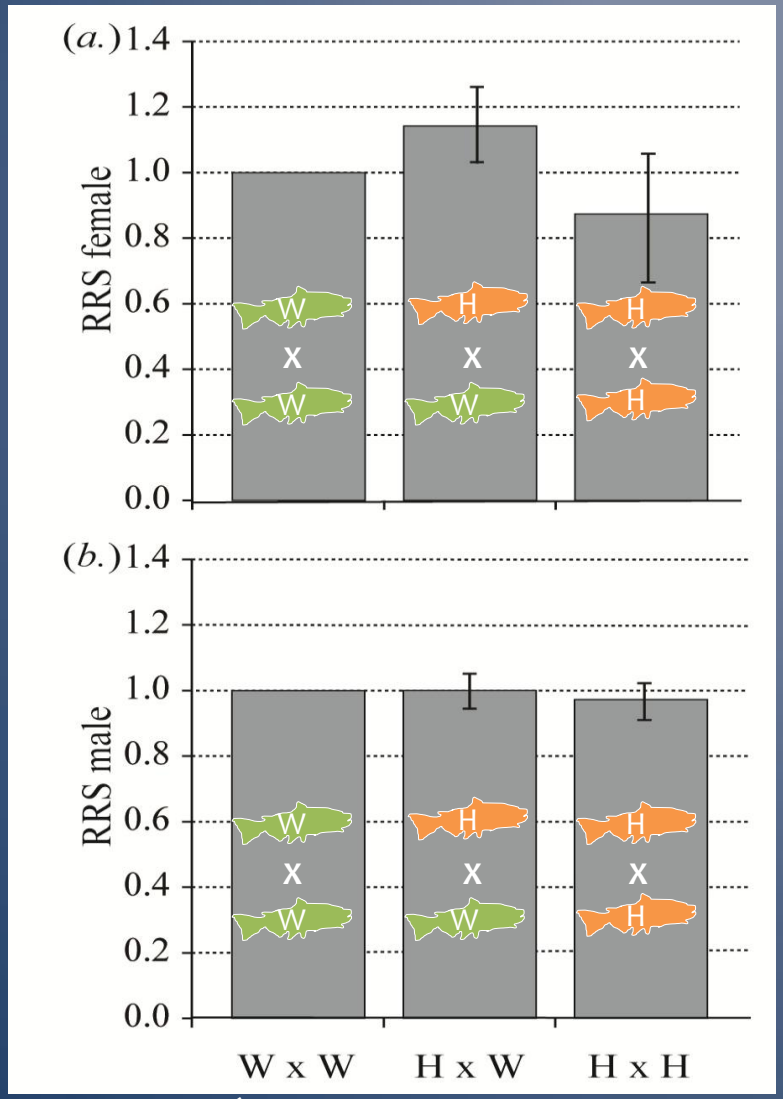
Hat X Wild → 5 offspring



Result would indicate that hatchery fish reduce the fitness of wild fish - negative genetic impact

Objectives and Results

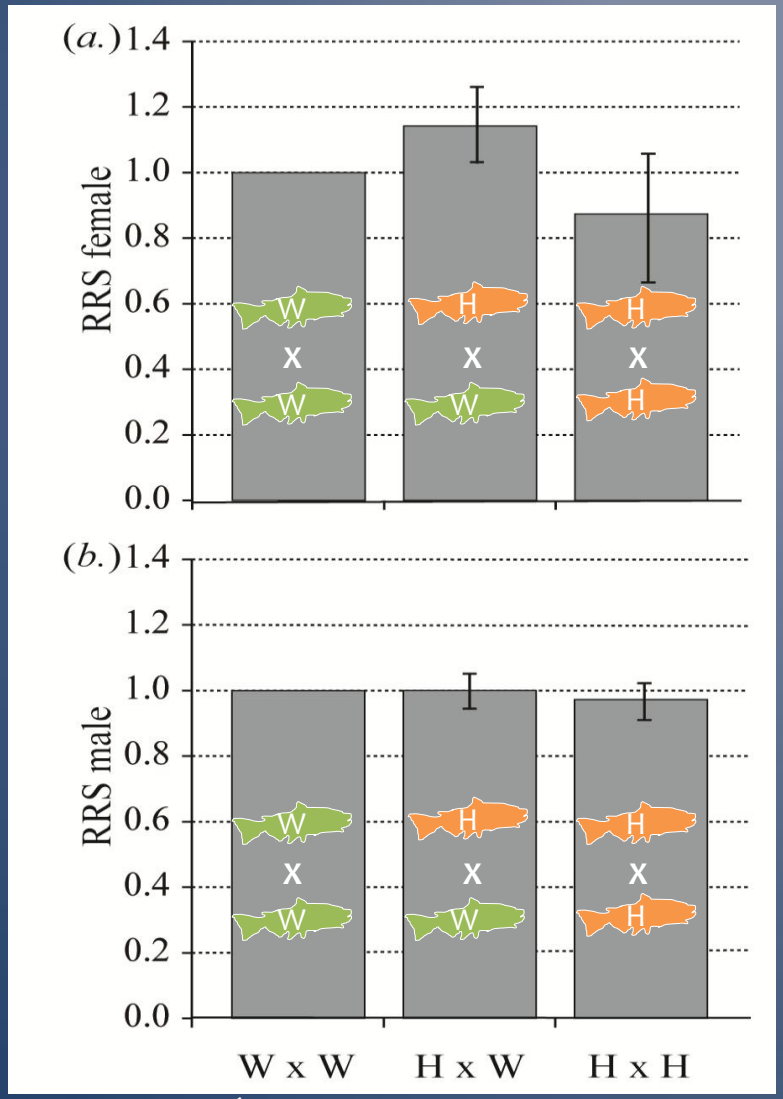
iii.) Do hatchery-reared fish have a negative genetic impact on wild fish when they mate with them?



- No significant difference in RS of mating types
- No evidence of reduction in fitness of wild fish when they mate with hatchery fish

Objectives and Results

iii.) Do hatchery-reared fish have a negative genetic impact on wild fish when they mate with them?



Mating type (spawn in natural environment)

Hood River steelhead RS WxW > HxW > HxH

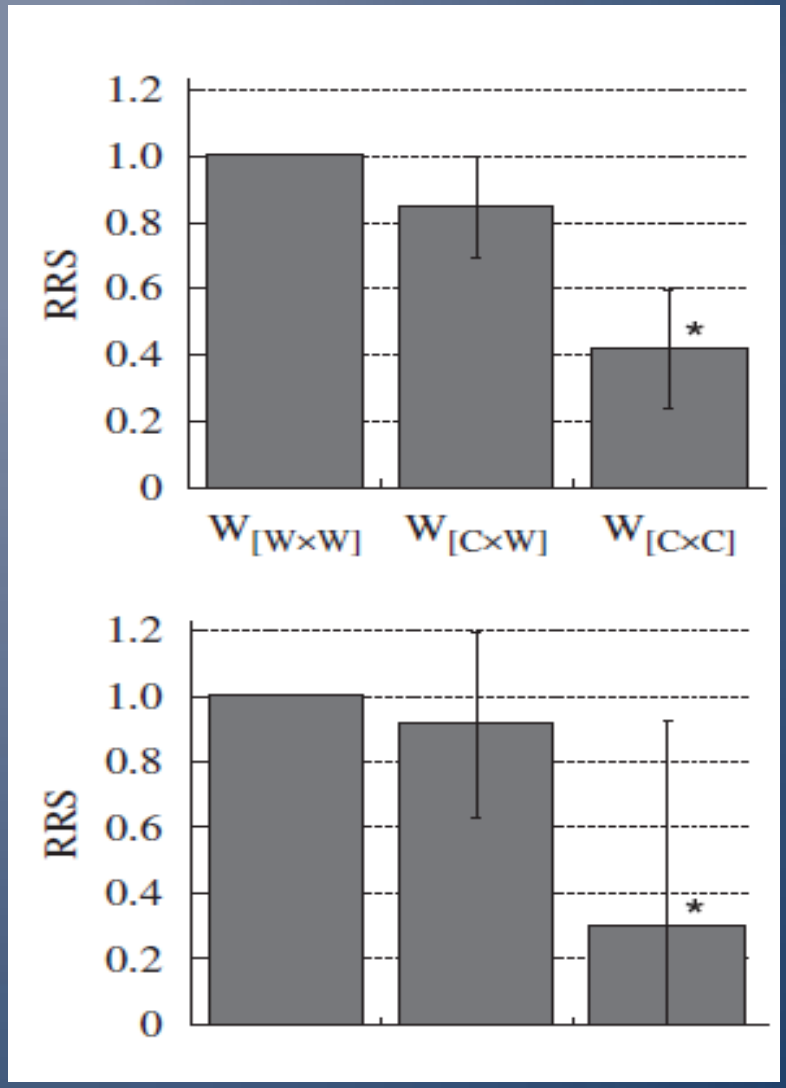


Figure from Araki *et al.* 2009, Biol. Letters

Conclusions

- Demographic Boost: Supplementation program provides a boost to the natural population

- Fitness Differences: Generally, equal reproductive success of H and W fish contributing offspring to the next generation

- Fitness Effects: No significant difference in reproductive success of HxH, HxW, and WxW mating types

  - Suggests Chinook salmon reared for a single generation in the hatchery had a limited and undetectable effect on the fitness of wild-origin fish in Johnson Creek

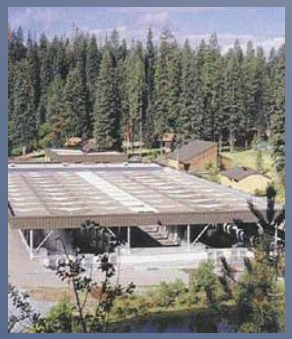
Photo credit: Bill Young

Generalization:

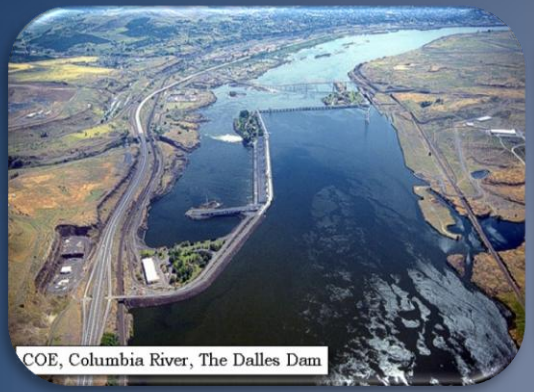
Hatchery-origin fish can decrease fitness in wild populations

Why not in Johnson Creek?

- Broodstock = 100% wild-origin fish



- Differences in hatchery rearing practices between species
  - Chinook salmon ≠ Steelhead



- Supplementation programs are a necessary tool to help recover and/or maintain some populations

- HOW can we better manage programs to minimize potential for negative effects on wild fish

Johnson Creek Chinook salmon, an example of how a supplementation program can be managed to minimize negative effects from hatchery rearing

Acknowledgments

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Bob Lessard

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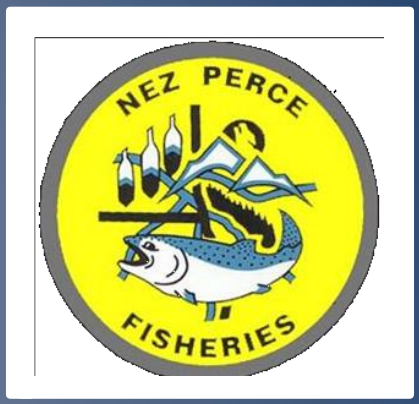


Review:
Jay Hesse
Bill Young

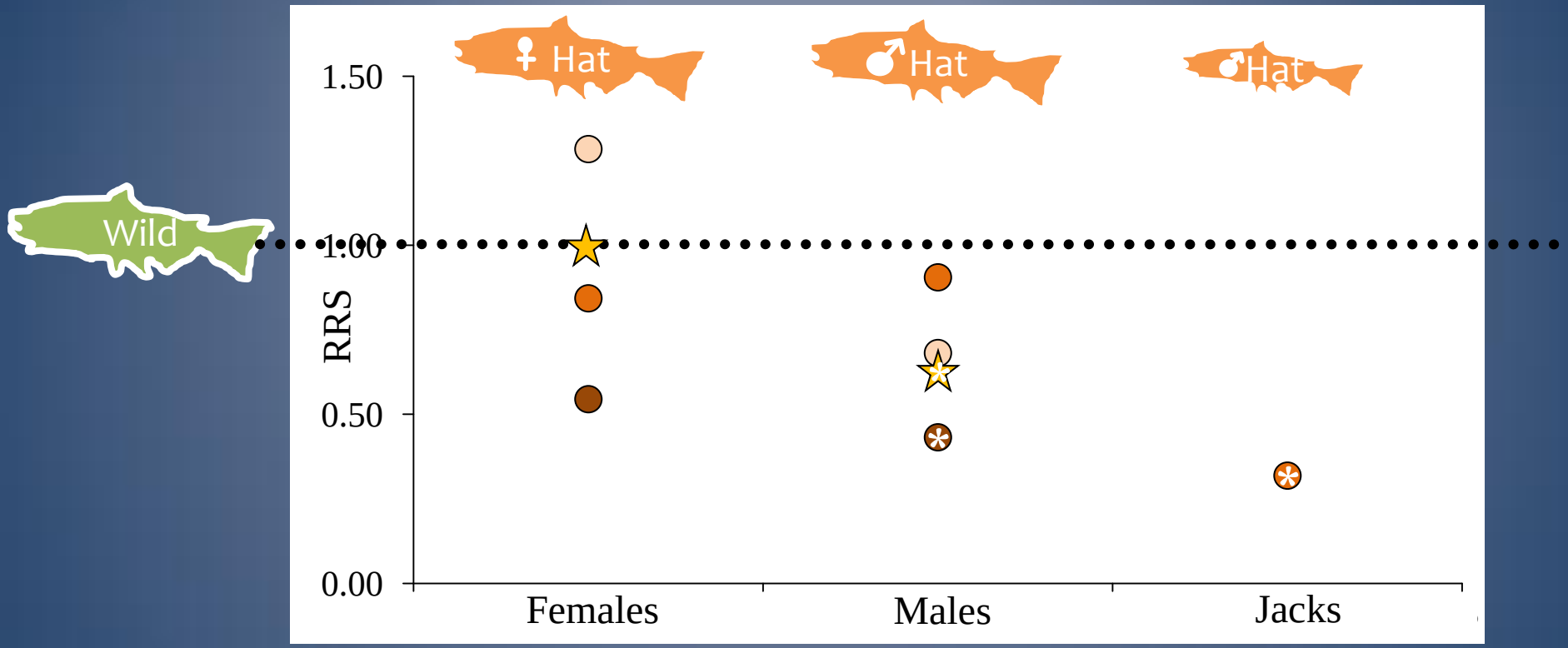
Funding:

Objective 2

Differences in reproductive success between hatchery-reared and wild-origin fish spawning naturally?

Results, Objective 2a

Differences in reproductive success between hatchery-reared and wild-origin fish spawning naturally?



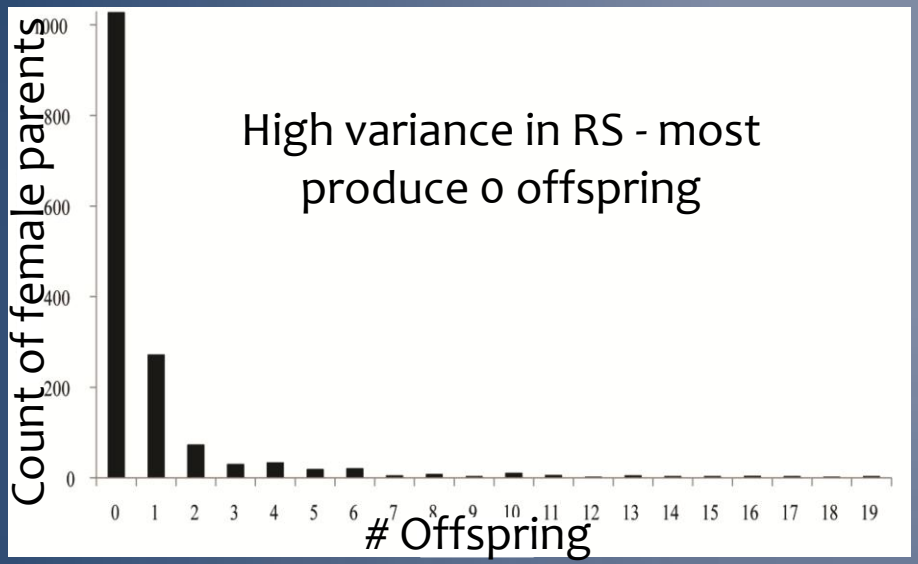
- Significantly lower fitness:
  - Hatchery males in 2002
  - Hatchery jack males in 2003
  - Overall hatchery males

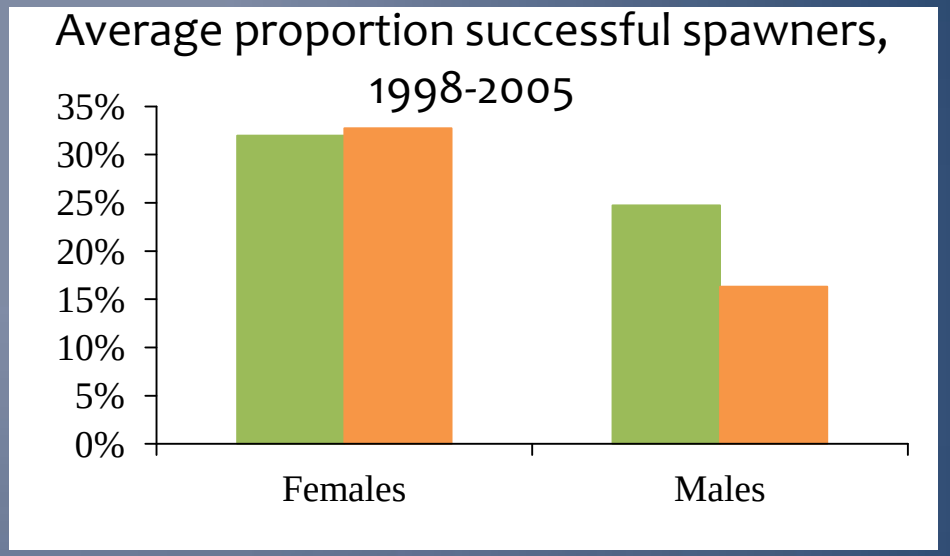
2002, 4yr from BY1998
2003, 5yr from BY1998
3yr jacks BY2000
2004, 4yr from BY2000
Overall RRS

- Possible density-dependence or no mate selection for hatchery males?

Results, Objective 2

Differences in reproductive success between hatchery-reared and wild-origin fish spawning naturally?





- Strong selection during spawning in the natural environment

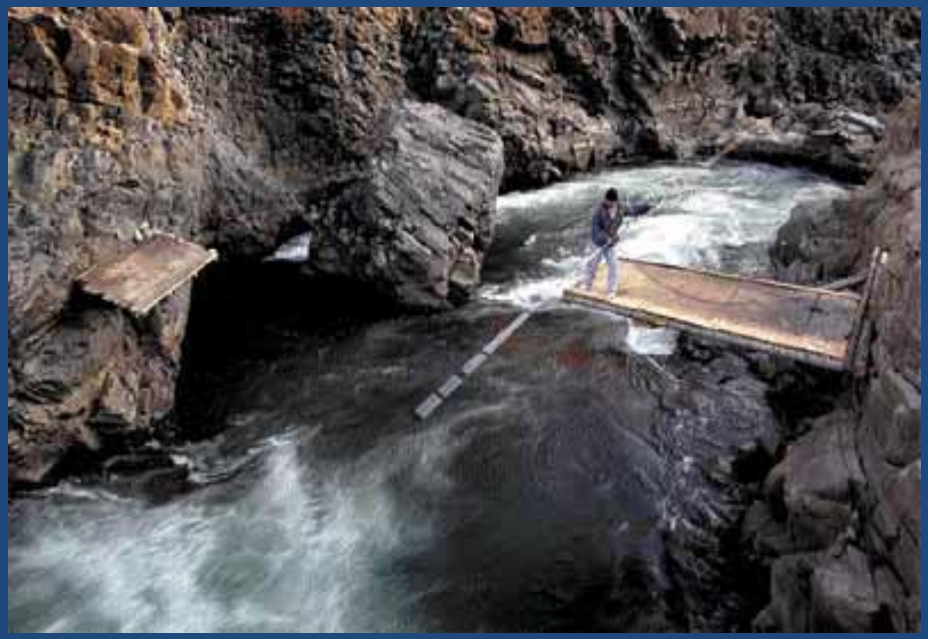
- Hatchery rearing yielded fewer males that reproduced (possible sexual selection in action)

- Some hatchery fish are simply not producing any offspring - no direct genetic effect on fitness of the wild

HATCHERY REFORM AND REINTRODUCTION:
Putting Fish Back in the Rivers and Protecting the Places they live

Yakama Nation Fisheries

Progress Update
NPCC - September 2012



Map by GIS
Yakama Nation

Historic Salmon Runs

Species/Run	Low Estimate	High Estimate	Current Status	Low	Year	High	Year
Spring Chinook	200,000	500,000	Supplemented Population	666	1995	23,265	2001
Fall Chinook	38,000	100,000	Supplemented Population	523	1988	13,000	2002
Summer Chinook	??	??	Extirpated Began Reintroduction	-		250 to Bonneville	2012
Coho	40,000	150,000	Extirpated and reintroduced	-	till 93	10,248	2009
Sockeye	100,000	200,000	Extirpated Begin Reintroduction	-		10,000(+15)	2012
Steelhead	30,000	100,000	Wild Population Kelt Reconditioning	505	1996	6,793	2010
Total	**408,000**	**1,050,000**		**1,700**		**53,000**	
Bull Trout	??	??	Wild Population			2500 to 3000 adults	
Lamprey	??	??	Wild Population			0 to 87 adults	

Restoration Toolkit

- Habitat Protection and Restoration
- Passage and Flow Restoration
- Outplanting Natural- and Hatchery-Origin Adults
- Nutrient Enhancement
- Hatcheries

Habitat Protection

"Rebuilding natural populations will ultimately depend on improving habitat quality and quantity" – ISRP 2011

Accomplishments

- **stream channel, floodplain, and vegetation restoration in several key steelhead producing streams on reservation**
- **protected over 1,800 acres of floodplain habitat**
- **reconnected or screened over 50 miles of tributary habitat**
- **restored over 100 acres of floodplain and side channels**
- **saving water through irrigation improvements**

Roza Dam Fish Monitoring Facilities

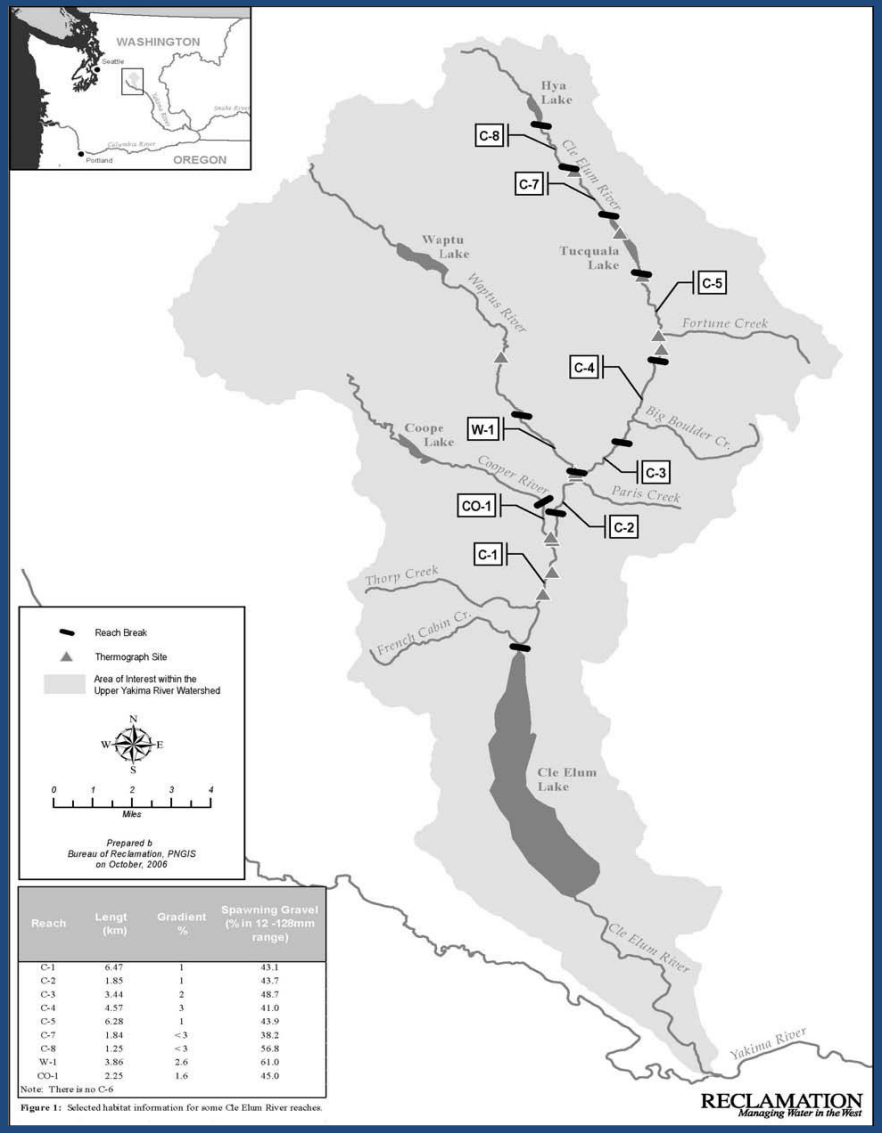
Problem

Solution

L. Cle Elum Sockeye Reintroduction

Year	Adults Transported
2009	1,000
2010	2,500
2011	4,500
2012	10,000

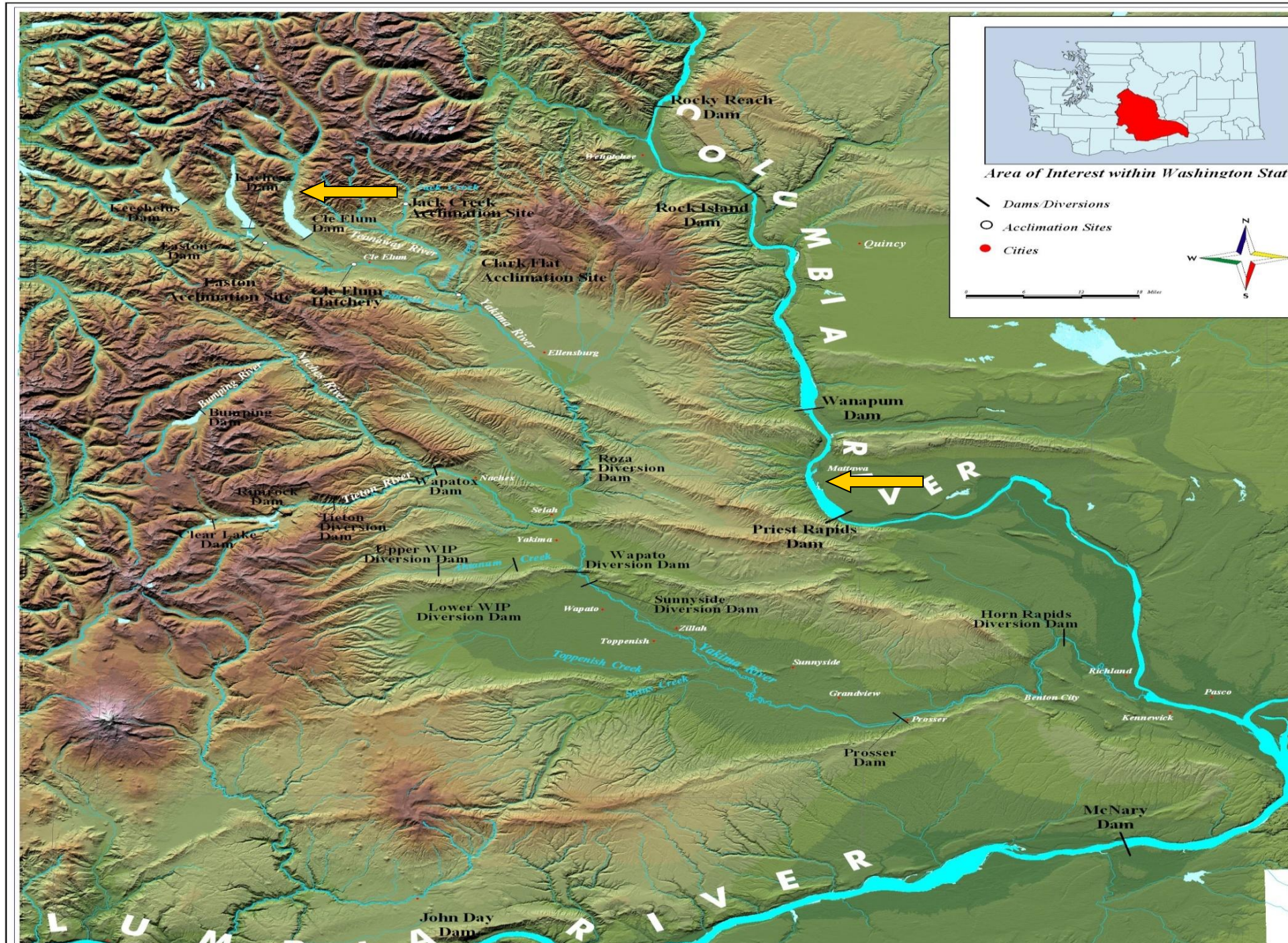
Some of the first sockeye to spawn in upper Cle Elum R. watershed in over 100 years



Reach	Lengt (km)	Gradient %	Spawning Gravel (% in 12 -128mm range)
C-1	6.47	1	43.1
C-2	1.85	1	43.7
C-3	3.44	2	48.7
C-4	4.57	3	41.0
C-5	6.28	1	43.9
C-7	1.84	<3	38.2
C-8	1.25	<3	56.8
W-1	3.86	2.6	61.0
CO-1	2.25	1.6	45.0

Note: There is no C-6

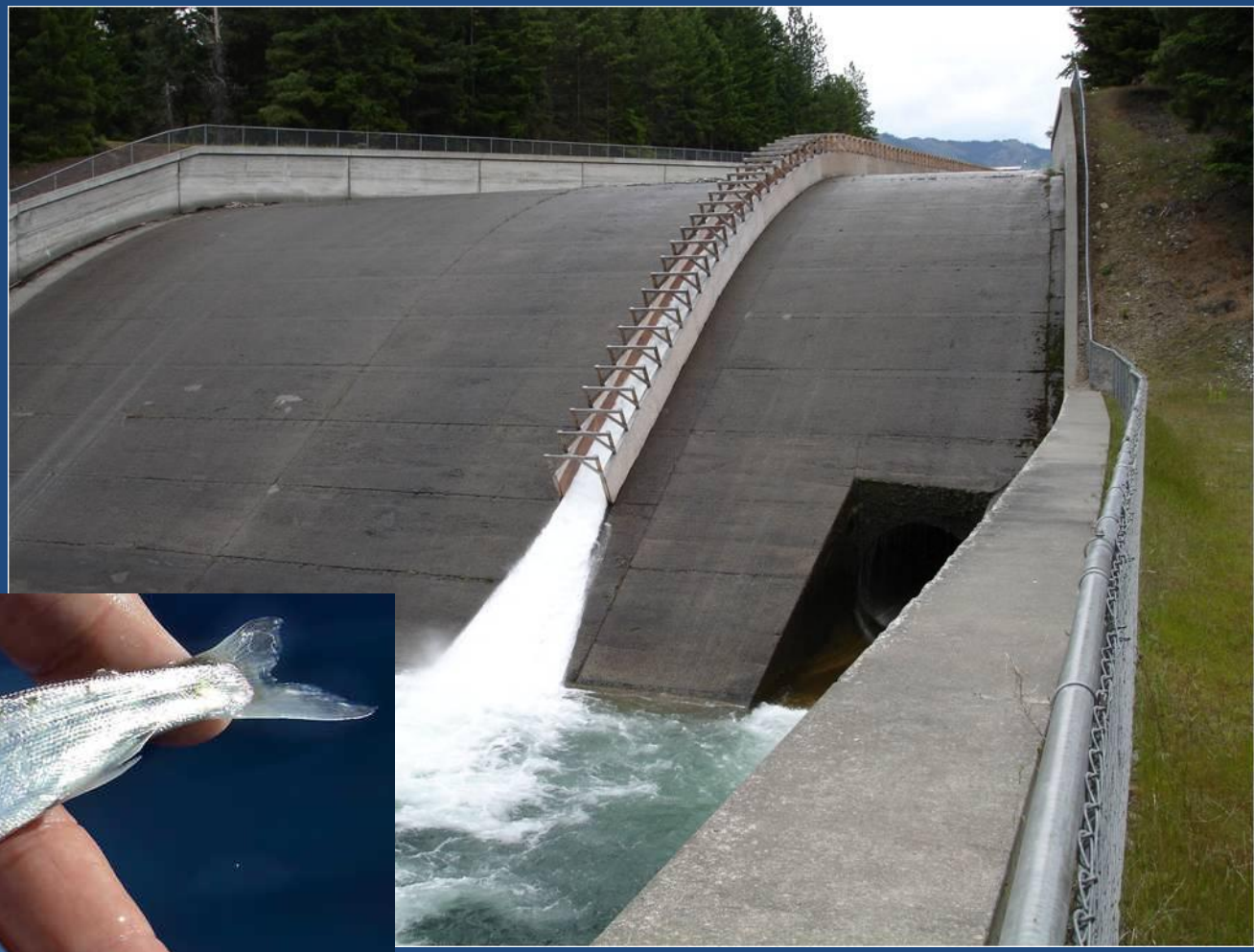
Figure 1: Selected habitat information for some Cle Elum River reaches.


Area of Interest within Washington Stat
Dams/Diversions
Acclimation Sites
Cities
Rocky Reach Dam
Rock Island Dam
Wanapum Dam
Priest Rapids Dam
Roza Diversion Dam
Wapato Diversion Dam
Sunnyside Diversion Dam
Horn Rapids Diversion Dam
Prosser Dam
McNary Dam
John Day Dam
Lower WIP Diversion Dam
Upper WIP Diversion Dam
Tieton Diversion Dam
Wapatox Dam
Rattlesnake Dam
Clear Lake Dam
Bumping Dam
Easton Dam
Easton Acclimation Site
Cle Elum Dam
Cle Elum Hatchery
Jack Creek Acclimation Site
Clark Flat Acclimation Site
Keechelus Dam
Kachess Dam
Columbia River
Yakima River
Cle Elum River
Bumping River
Naches River
Tieton River
Ahtanum Creek
Toppenish Creek
Satus Creek
Ellensburg
Yakima
Selah
Naches
Wapato
Toppenish
Zillah
Sunnyside
Grandview
Prosser
Benton City
Kennewick
Pasco
Richland
Quincy
Mattawa
Wenatchee

Sockeye Reintroduction

L. Cle Elum Sockeye Reintroduction

About 80,000 juveniles (progeny of 2009 adult plants) were estimated to have passed Prosser in 2011.

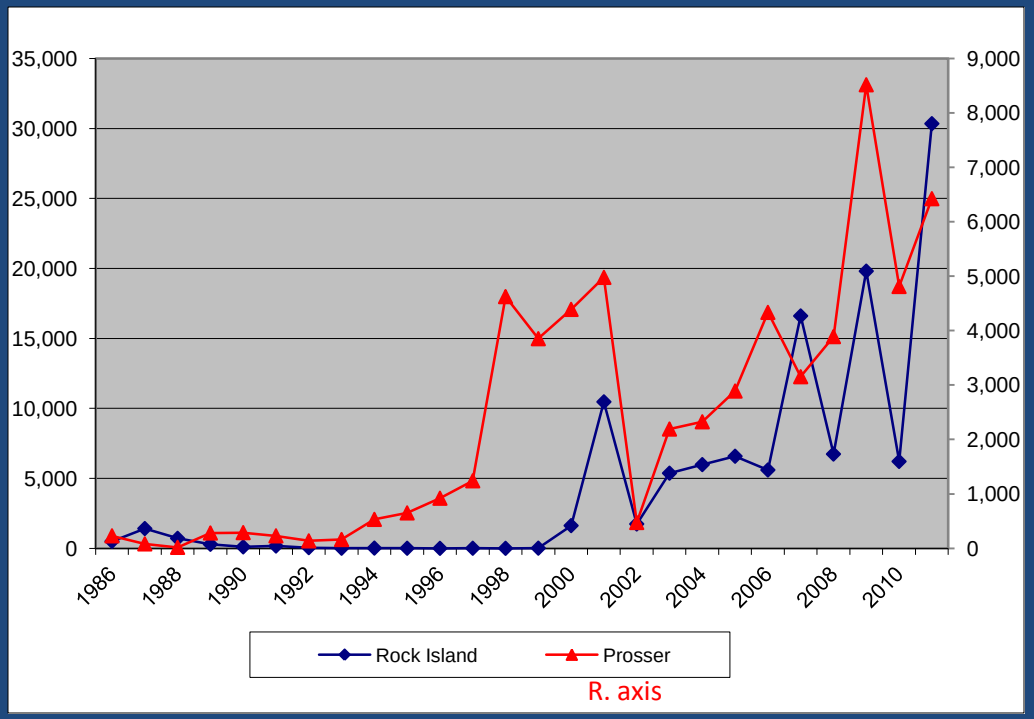


Wild smolt at Roza, 5/10/2011

Yakama Coho Reintroduction Programs

- Virtually extinct in the mid-1980s
- Started with out-of-basin transfers
- Demonstrated ability to reestablish a naturalized population after as few as 3 to 5 generations of outplanting in the wild
- Moving to local brood stocks
- Using combination of fry, smolt, and adult release strategies
- Adult returns are combination of natural- and hatchery-origin fish

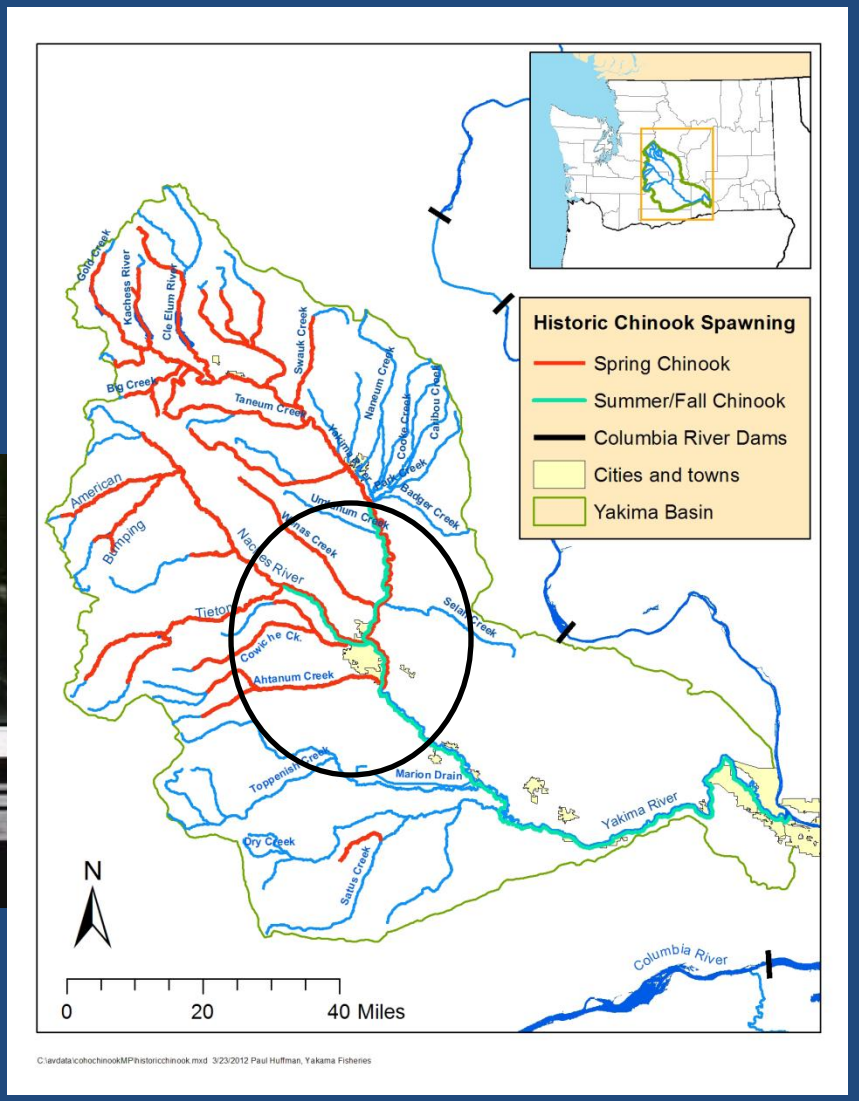
Adult Coho counts at Rock Island and Prosser Dams, 1986- Present



Yakima River Summer Run Chinook Reintroduction – Restoring Diversity

- Extirpated stock
- Started with Wells transfers
- Releasing both yearling and subyearling fish
- Intend to move to local stock once returns and infrastructure in place
- Several hundred adults returning now from three different age classes

3-Ocean Adult Summer at Prosser, 7/1/2012

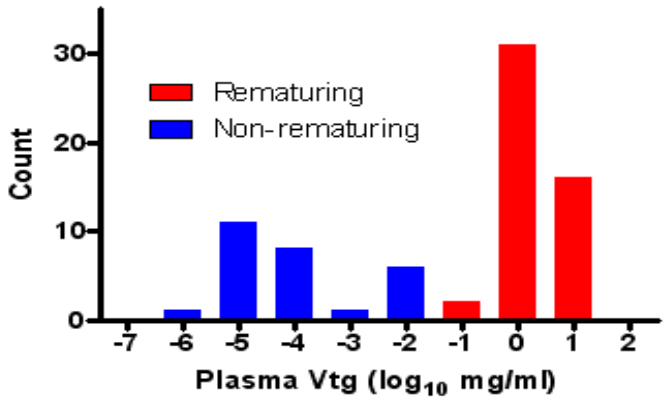


Yakima River Steelhead Kelt Reconditioning

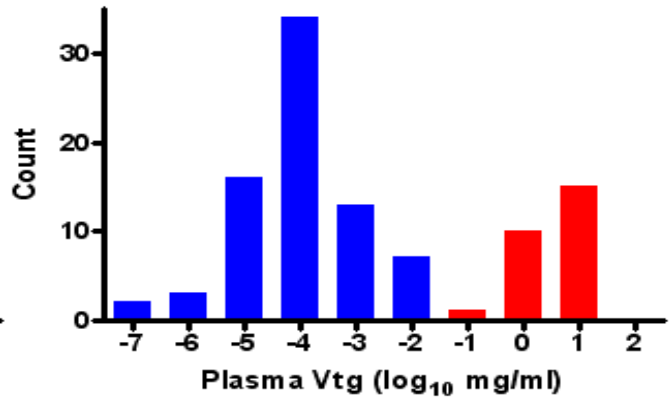
- Capture steelhead returning to ocean after completing first spawning cycle
- Most (>90%) are females
- Held and fed for 6-8 months
- Released in mid-late October (beginning of upstream migration peak)
- Select own mates, where to spawn, when to spawn

EARLY MATURATION VS SKIP SPAWNING

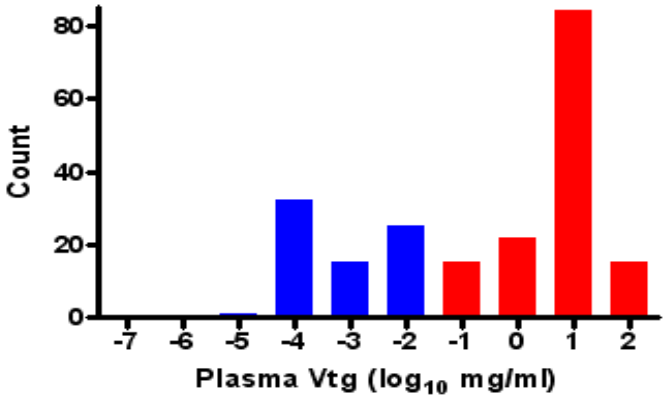
10/29/2009
76 female kelts w/Vitellogenin
128 female kelts total
64% rematuration



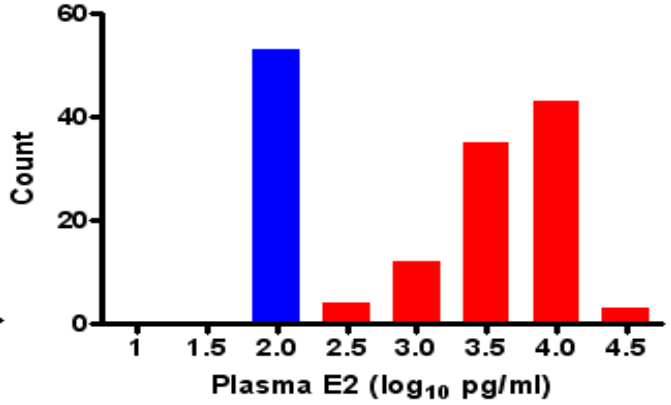
10/13/2010
101 female kelts w/Vitellogenin
381 female kelts total
26% rematuration



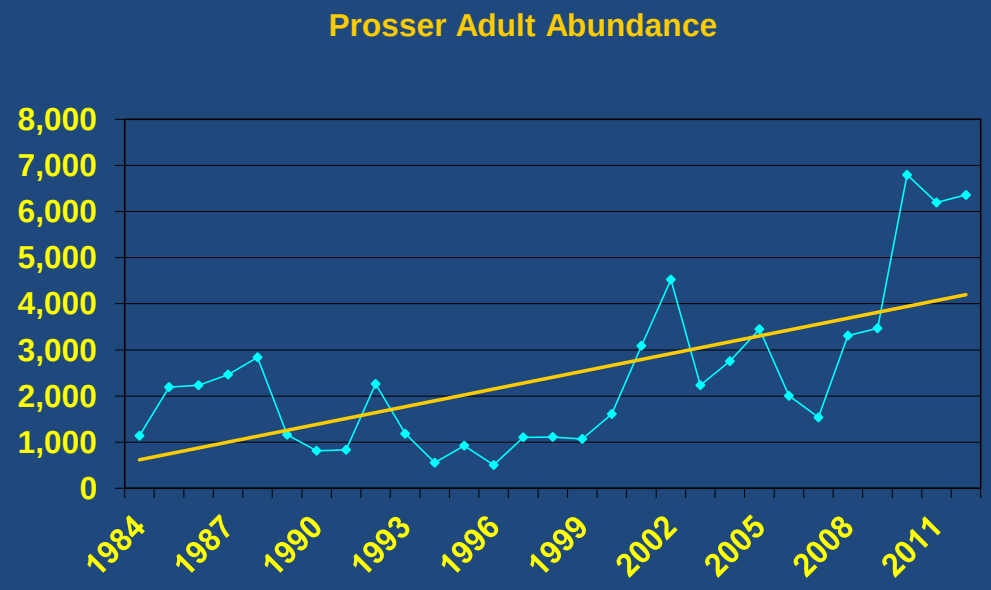
10/13/2011
209 female kelts w/Vitellogenin
212 female kelts total
65% rematuration

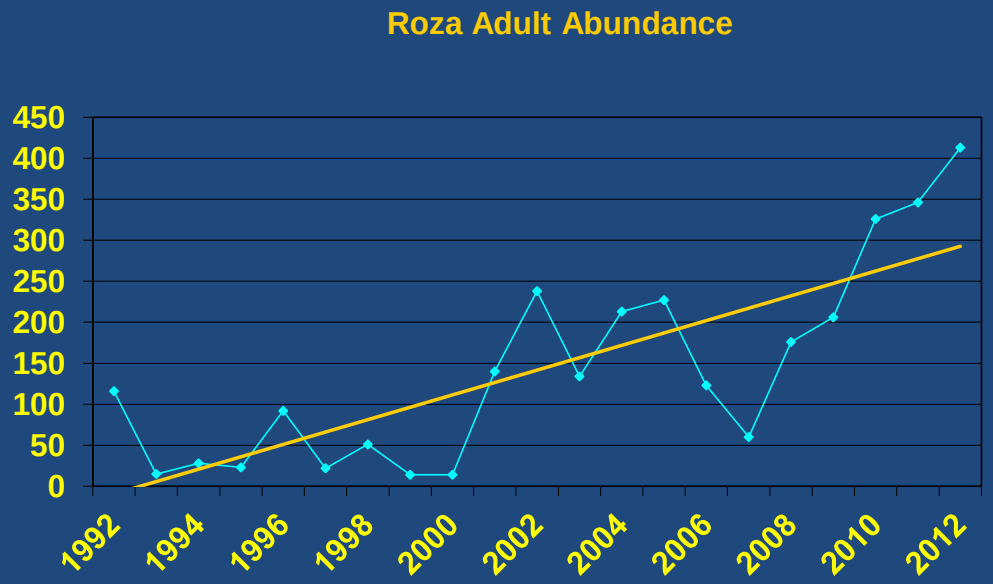


8/16/2012
150 female kelts w/Estradiol
subsample of 2 of 4 tanks
63% rematuration



Steelhead Population Response: Abundance Trends





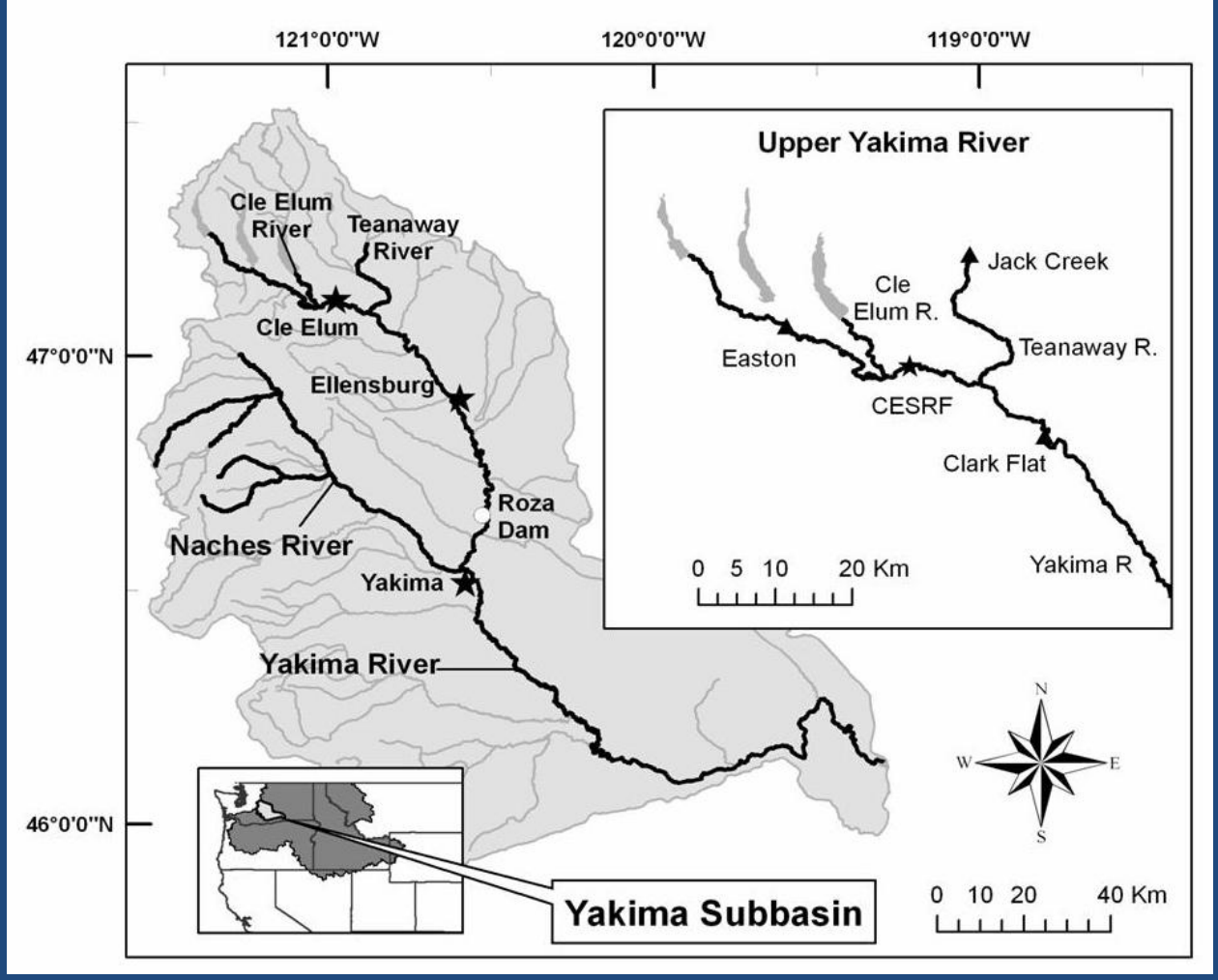
Cle Elum Spring Chinook
Supplementation and Research Facility

Goals

- maintain or increase:
  - Harvest
  - natural production
  - ecosystem function
- use research to:
  - improve hatchery practices
  - address critical uncertainties

CESRF Management Practices
Cuenco et al 1993, Mobrand et al 2005

- random, representative broodstock selection
- local broodstock
- use natural broodstock if possible
- factorial mating to maintain diversity
- low rearing densities
- underwater feeders and cover to encourage natural behavior
- intensive disease monitoring
- acclimation sites in natural spawning areas
- state-of-the-art marking strategies for M&E
- test different rearing/release strategies to increase survival



1st Brood

Integrated HxW spawning in the wild

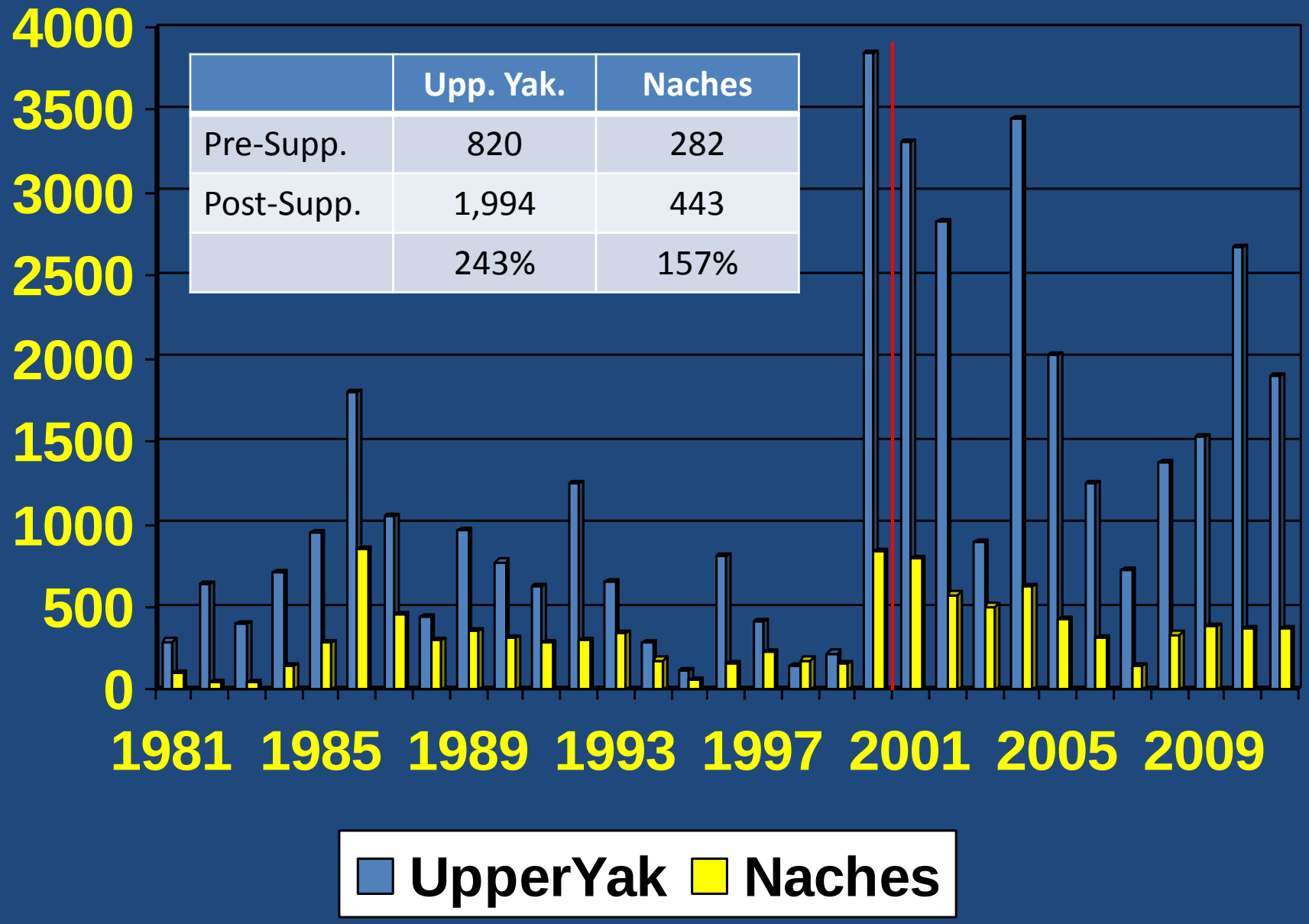
Integrated F1 progeny return

Integrated F2 progeny return

1997 2001 2005 2009 2013

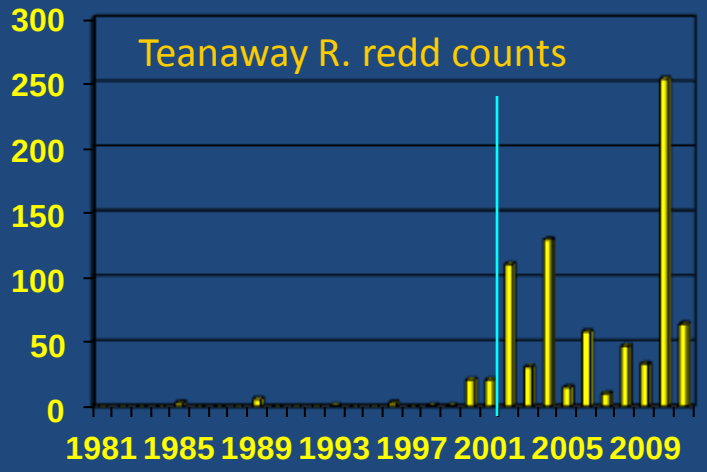

HOMING
FIDELITY
NRS

Upper Yakima vs Naches Redds, 1981-2011



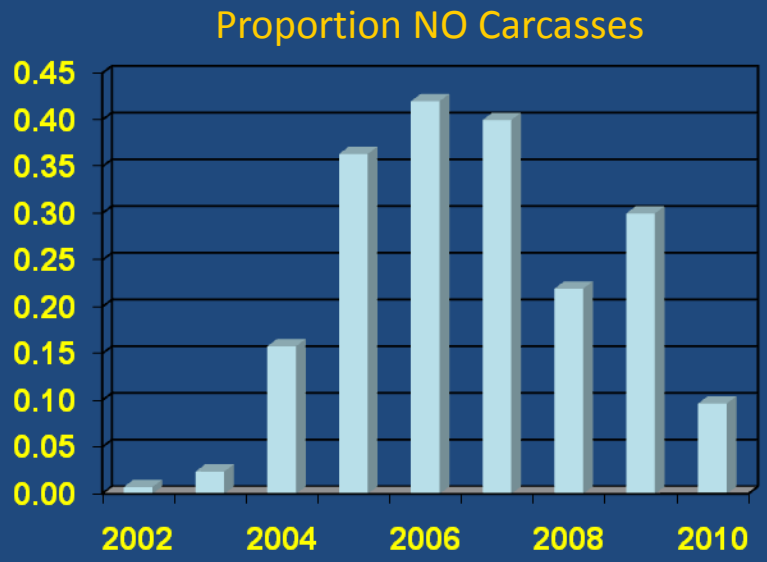
	Upp. Yak.	Naches
Pre-Supp.	820	282
Post-Supp.	1,994	443
	243%	157%

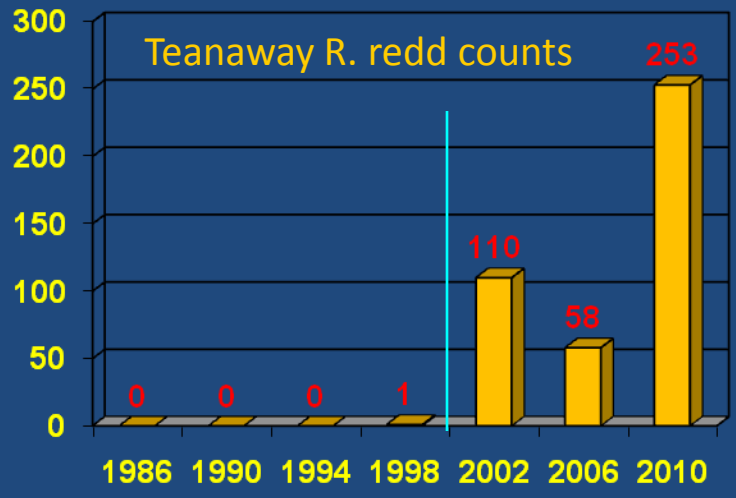
Evidence of Hatchery-Origin Reproductive Success: Teanaway R. Spring Chinook



- pre-supplementation average: 3
- post-supplementation average: 75

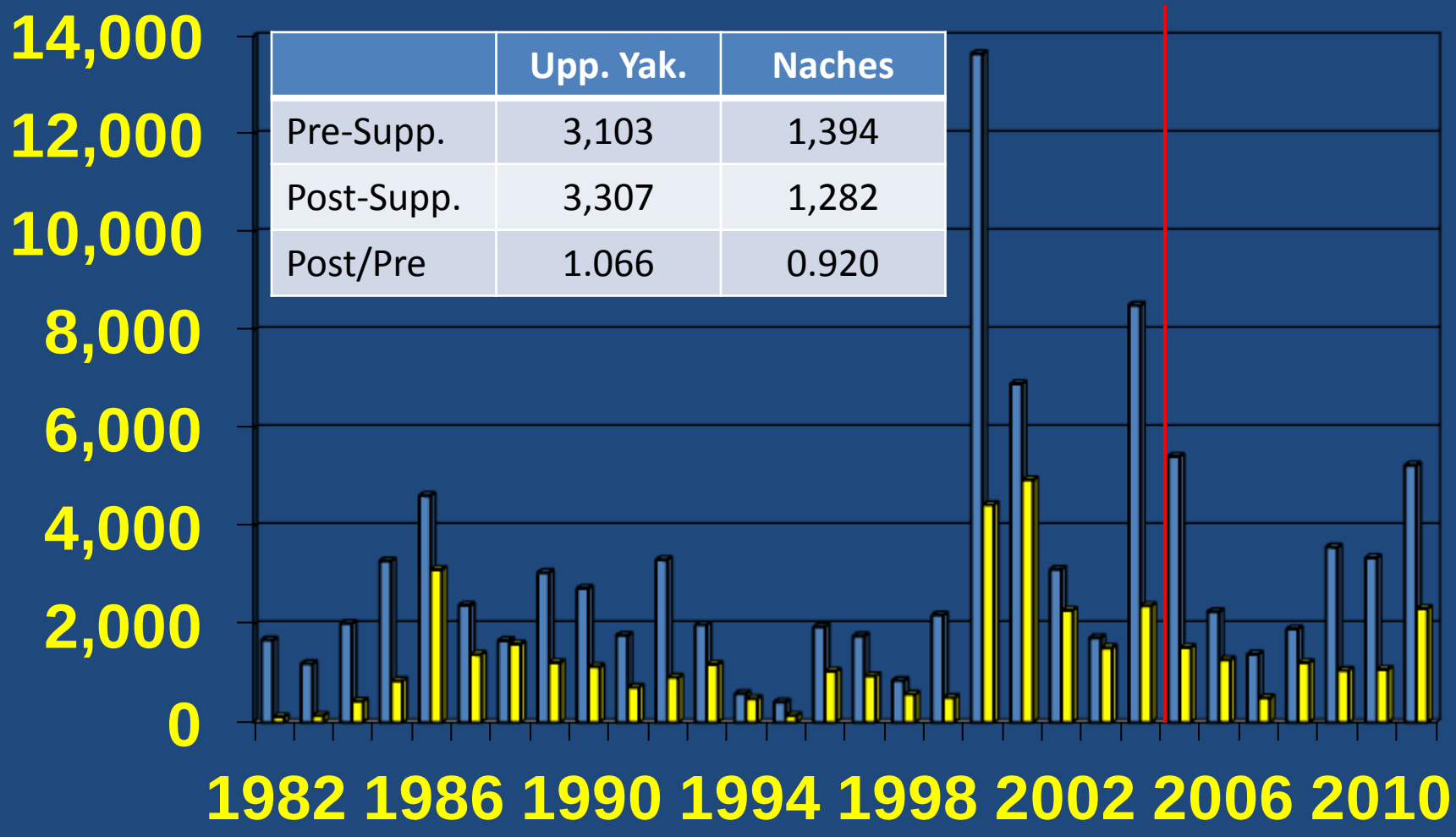
Let's look at one 4-year brood cycle:



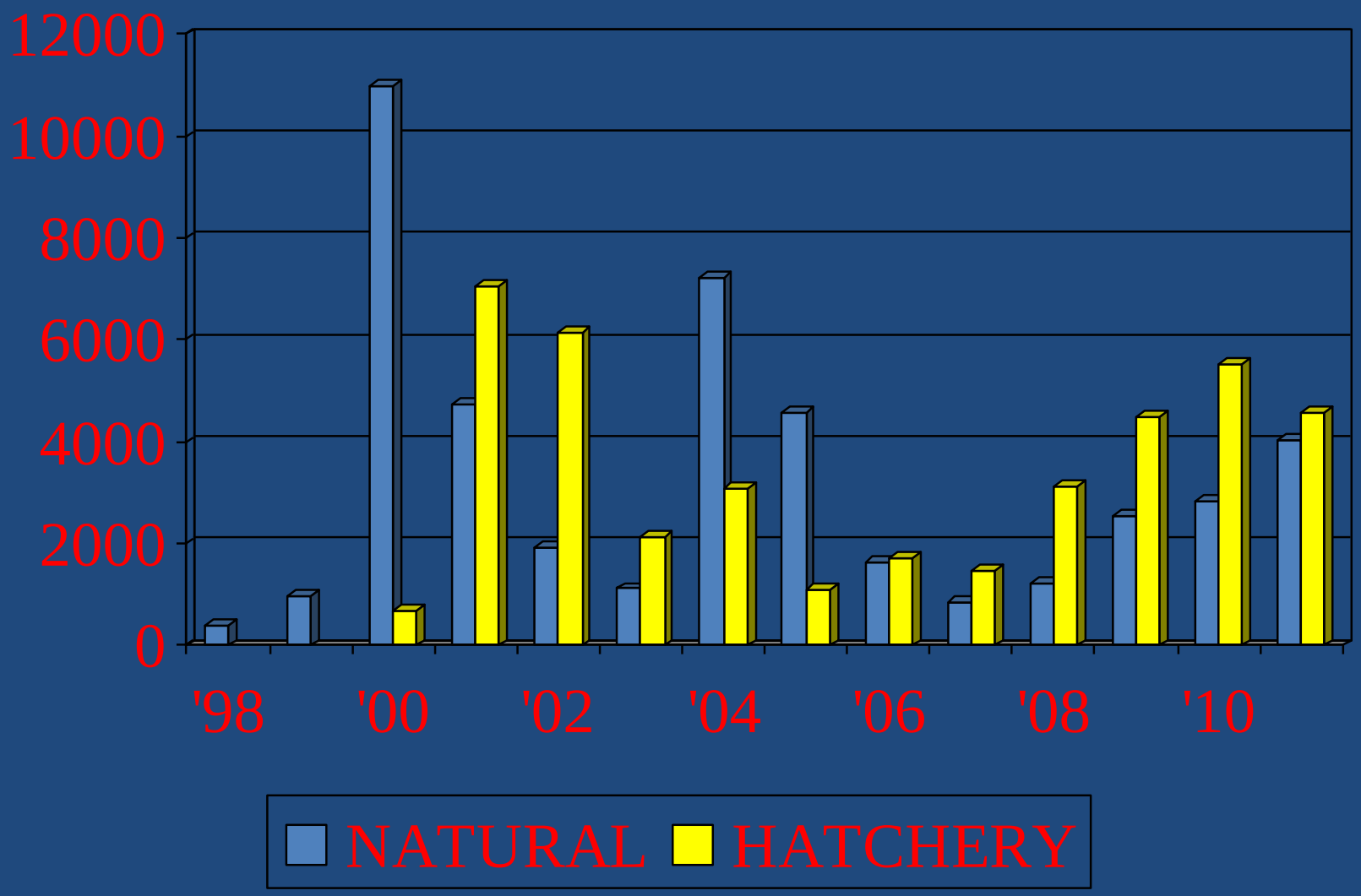


Upper Yakima vs Naches Natural-Origin Returns, 1982-2011

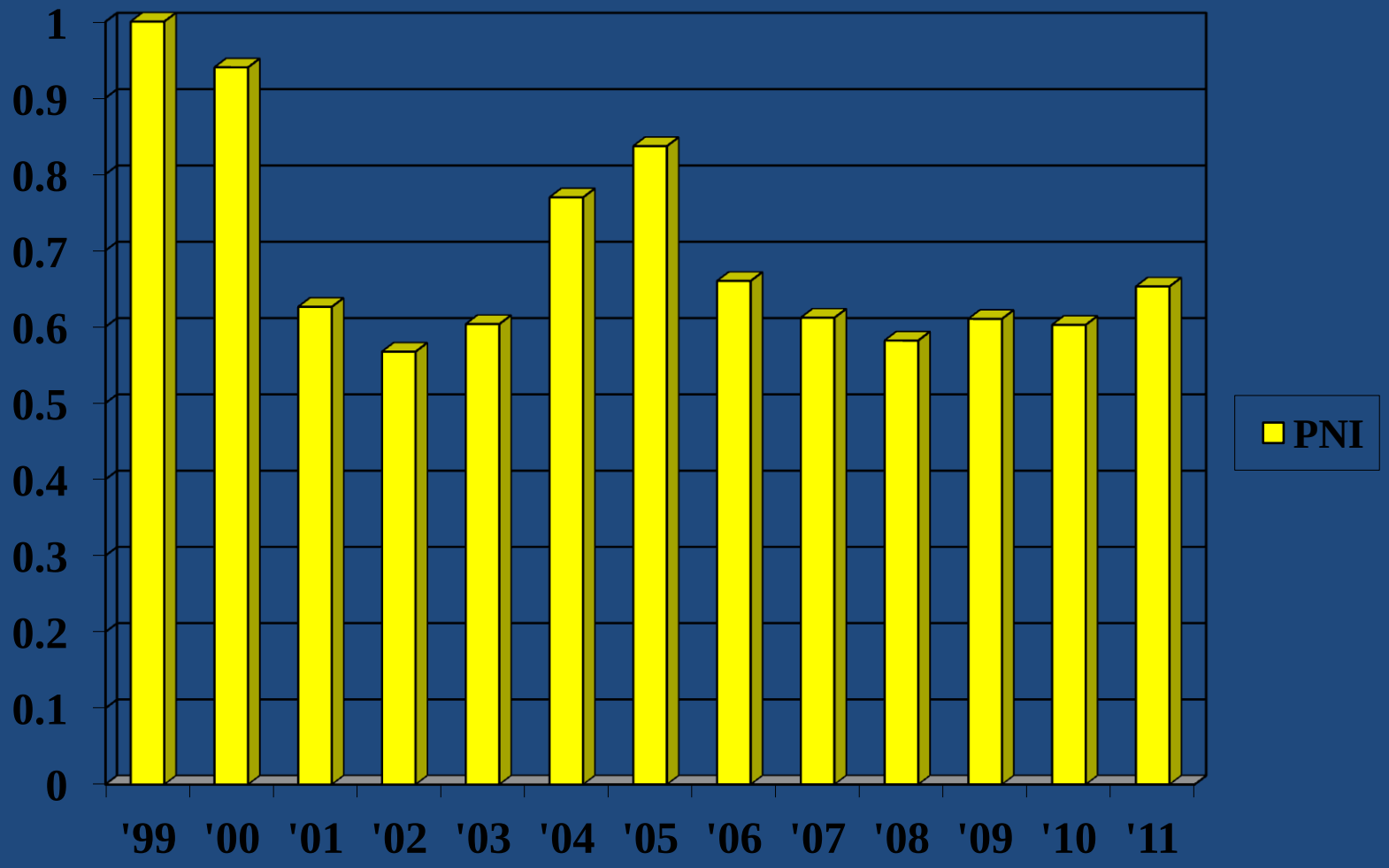
	Upp. Yak.	Naches
Pre-Supp.	3,103	1,394
Post-Supp.	3,307	1,282
Post/Pre	1.066	0.920



Upper Yakima Spring Chinook
Natural and Hatchery Fish on the Spawning Grounds



Annual PNI; Mean 2001-2011 = 0.65




Reproductive Success
Comparative behavioral/reproductive fitness research

Behavior and Breeding Success of Wild and First-Generation Hatchery Male Spring Chinook Salmon Spawning in an Artificial Stream

S.L. Schroder, C.M. Knudsen, T.N. Pearsons, T.W. Kassler, S.F. Young, E.P. Beall and D.E. Fast

Transactions of the American Fisheries Society, 139:989-1003

"Pedigree analyses based on DNA showed that hatchery and wild males had comparable breeding success values."

Breeding Success of Wild and First-Generation Hatchery Female Spring Chinook Salmon Spawning in an Artificial Stream

S.L. Schroder, C.M. Knudsen, T.N. Pearsons, T.W. Kassler, S.F. Young, C.A. Busack, and D.E. Fast

Transactions of the American Fisheries Society, 137:1475-1489

"No differences were detected in the egg deposition rates of wild and hatchery females. Pedigree assignments based on microsatellite DNA, however, showed that the eggs deposited by wild females survived to the fry stage at a 5.6% higher rate than those spawned by hatchery females."

Yakama Nation Lamprey Restoration

- Goal: restore throughout ceded lands
- Regional collaboration
- Habitat surveys – identify limiting factors, key habitats for spawning and rearing
- Document presence and abundance
- Research and develop lamprey culture techniques

Lamprey spawning at Prosser Hatchery, 4/25/2012

Native American Hoop Dance

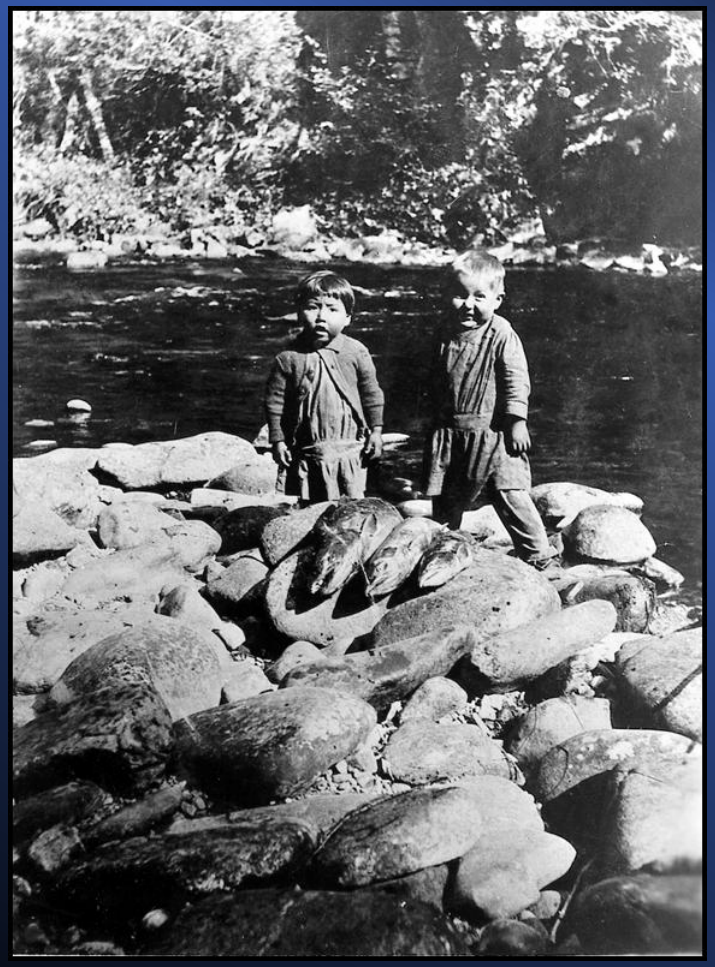
QUESTIONS?

“The vision for this Program is a Columbia River ecosystem that sustains an abundant, productive, and diverse community of fish and wildlife…”

-NPCC Fish and Wildlife Program – Overall Vision

Side Channel Restoration

Nez Perce Tribe Hatchery Perspectives



"Our fate and the fate of the fish are linked."

Dan Landeen and Allen Pinkham, Salmon and His People

Take Home Messages To Date

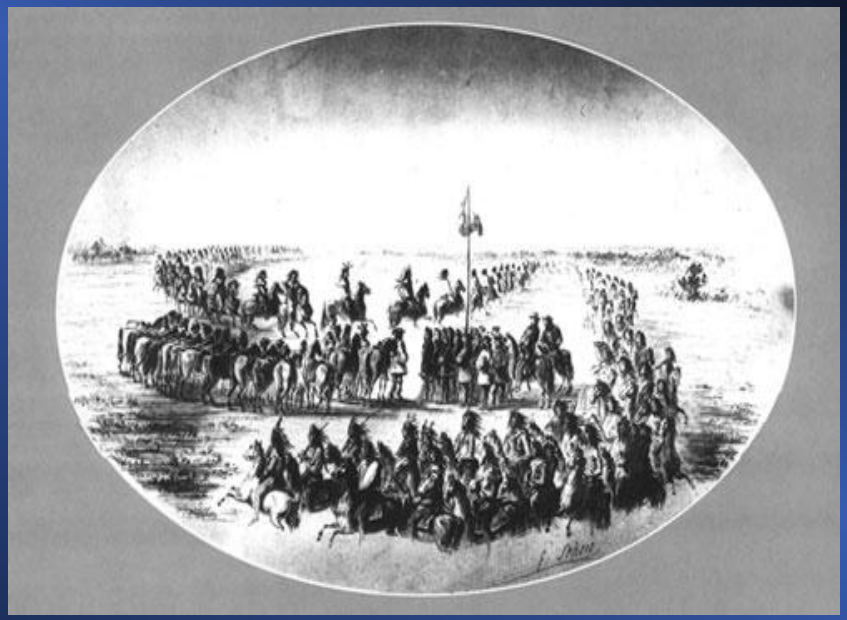
1. The social, cultural, and economic benefits of salmon and steelhead harvest are immense.
2. Hatcheries represent a promise – they are payment on the unfulfilled debt to mitigate for limiting factors (e.g., hydrosystem, habitat destruction).
3. Not all hatchery fish are the same. Most hatchery production occurs for harvest programs. Some (much less) have recently been operated for recovery.
4. Hatchery operations for both harvest and recovery have evolved and continue to be refined/reformed at an accelerated rate. Information from refined and reformed hatchery programs has only recently begun to be included in the published literature.
5. Modern hatchery programs can fulfill multiple objectives of supporting fisheries and re-introduction and recovery efforts (adult disposition management).

Take Home Messages To Date

6. Hatchery actions are just one of many tools being applied to recover and restore populations.
7. Hatchery actions have associated risks to natural production; realized impacts vary by species and population.
8. Almost all hatchery fish in the Columbia Basin are marked in some way. The vast majority are adipose fin clipped.
9. Rigorous and coordinated research, monitoring, and evaluation is ongoing to adaptively manage and minimize risks.
10. Collaborative effort to evaluate hatchery effectiveness at regional scale needed.

Nez Perce Treaty of 1855

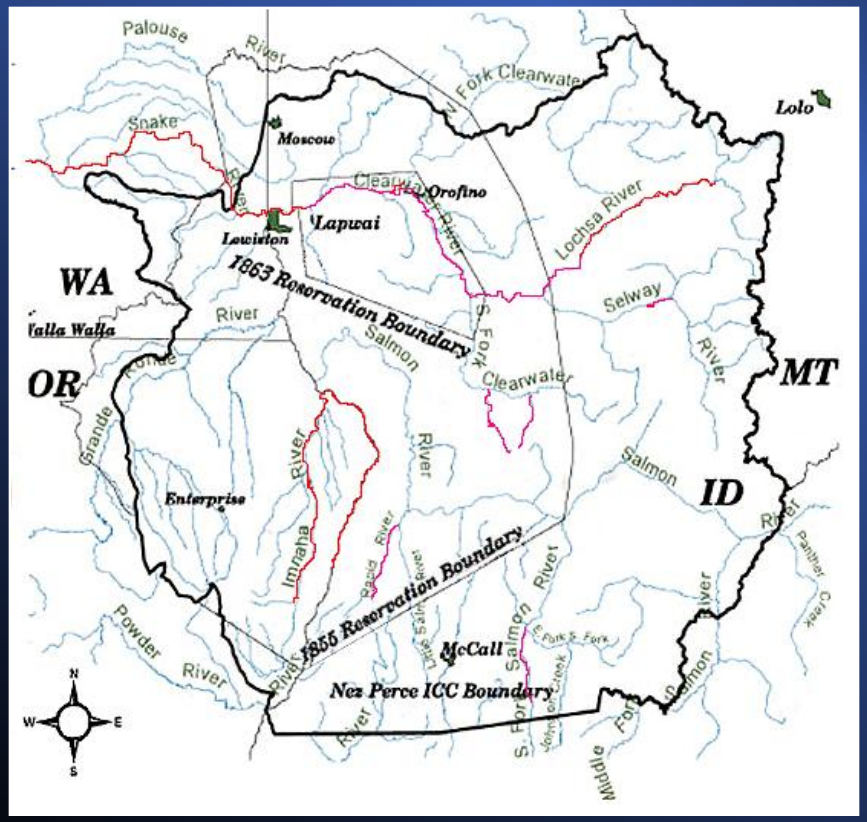
The exclusive right of taking fish in all the streams where running through or bordering said reservation is further secured to said Indians; as also the right of taking fish at all usual and accustomed places in common with citizens of the Territory…(12 Stats. 957, Article 3). Treaty of 1855.



Holistic Management

- ✓Regional Collaboration
- ✓Habitat Protection and Restoration
- ✓Harvest Regulation
- ✓Conservation Enforcement
- ✓Mainstem Passage
- ✓Artificial Propagation

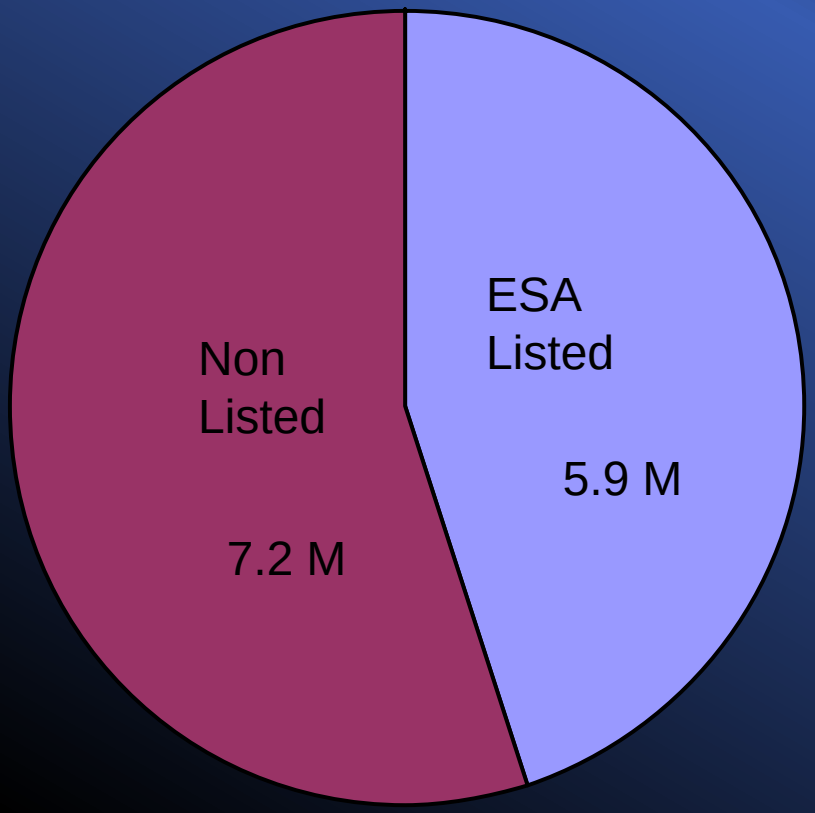
Nez Perce Tribe Treaty Area



- 32 spring/summer Chinook populations (Clearwater extirpated/reintroduced)
- 1 fall Chinook population
- 24 steelhead populations
- 1 sockeye population
- Coho – extirpated/reintroduced
- Lamprey – life support
- Majority of hatchery origin fish are listed

All Snake Salmon and Steelhead populations ESA Listed … or extirpated

BPA FWP Funded Hatchery Programs



13 M juveniles produced for supplementation with FWP funding

ESA listed

- Nez Perce Tribal Hatchery fall Chinook
- Fall Chinook Acclimation Project
- Hood River steelhead
- Northeast Oregon Hatchery Grande Ronde spring Chinook
- Johnson Creek summer Chinook
- Tucannon spring Chinook
- Yankee Fork spring Chinook
- Snake River sockeye

Non listed

- Yakima Klickitat Fisheries Project spring Chinook, fall Chinook, coho
- Umatilla Hatchery spring Chinook, fall Chinook, coho
- Upper Columbia coho
- Nez Perce Tribal Hatchery spring Chinook
- Hood River spring Chinook

Why Evaluate Hatcheries?

- Accountability
- Adaptive Management

Adaptive Management Steps

1) Define desired resource condition
2) Determine resource status
3) Identify limiting factor(s)
4) Develop management options
5) Apply selected management action(s)
6) Monitor and evaluate results
7) Modify/adjust management action or goals
8) Monitor and evaluate results

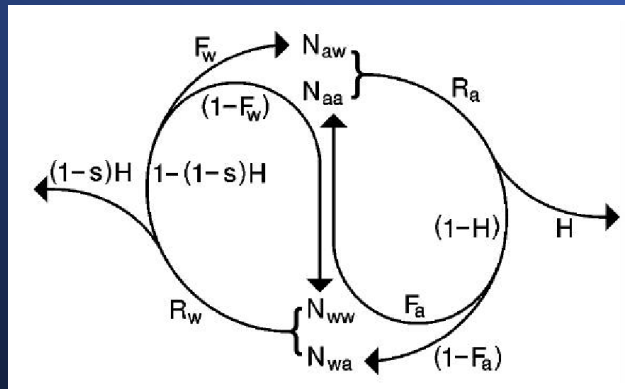
Hatchery Monitoring and Evaluation Study Designs

Local

- NPTH M&E Action Plan (Hesse and Cramer 2000)
- NEOH M&E Plan (Harbeck et al. 2006)
- JCAPE M&E Plan (Vogel et al. 2004)

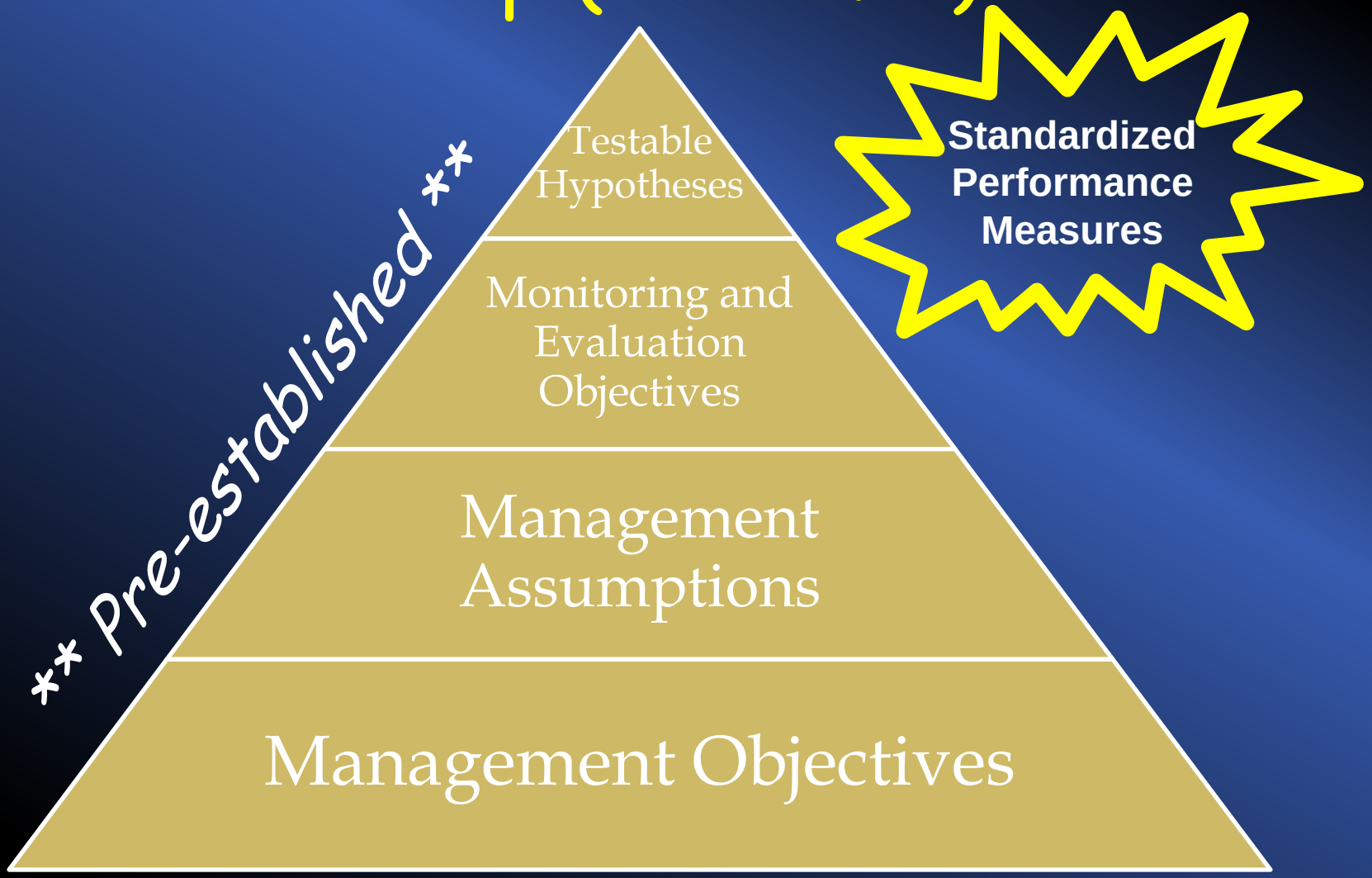
Regional

- Collaborative System-wide Monitoring and Evaluation Project (CSMEP) Hatchery Subgroup
- Ad Hoc Supplementation Work Group (AHSWG)
  - Standardized Performance Measures



How Much Hatchery Evaluation is Enough?

Ad Hoc Supplementation Work Group (AHSWG)



Three Tiered Monitoring Framework

1. Implementation & Compliance Monitoring
2. Hatchery Effectiveness Monitoring
   a) Long-term Trend (BACI, T/C)
   b) Relative Reproductive Success (RSS)
3. Uncertainties Research Monitoring

Implementation and Compliance (All Hatcheries)

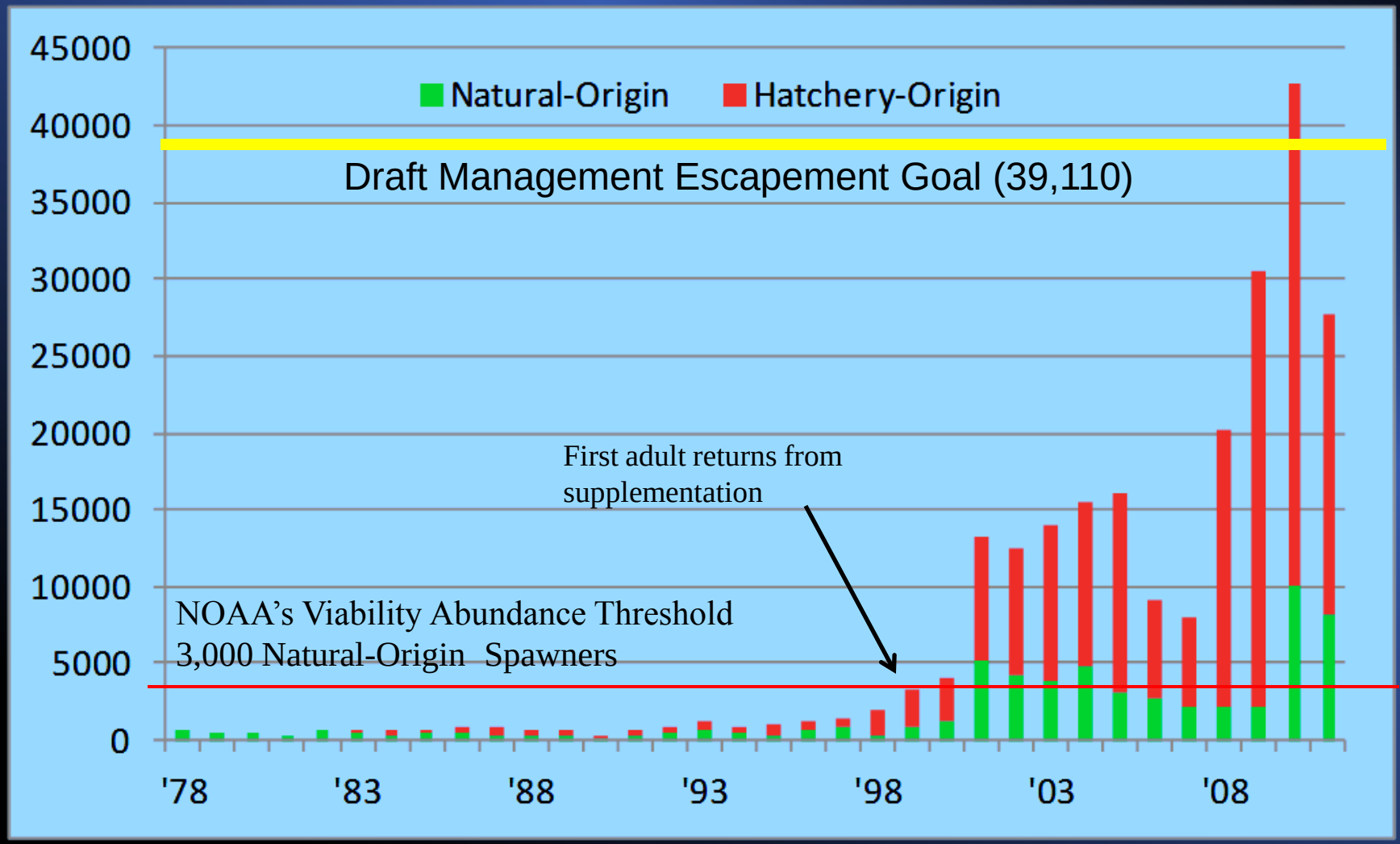
- Hatchery - wild composition
- Rearing density
- Size at release
- Number of fish released
- Post-release survival (supplementation only)
- Release location
- Harvest
- Adult escapement

Implementation and Compliance Example – Release Numbers

Johnson Creek Summer Chinook Salmon

Implementation and Compliance Example – Adult Returns

Snake River Fall Chinook Salmon



Effectiveness Monitoring
(subset of supplementation programs)

- Natural production
- Life history characteristics
- Genetic diversity
- Effects on non-target populations
- Restoring / maintaining fisheries
- Optimize effectiveness
- Status & trends of natural populations
- Communicate M&E findings

Effectiveness Monitoring Example
Snake River Fall Chinook
Program Assessment

Management Assumption (6 of 28)	Status
1a. Adult progeny per parent (P:P) rations for hatchery-produced fish significantly exceed those of natural-origin fish.	
1b. Natural spawning success of hatchery –origin fish must be similar to that of natural origin fish.	Not readily quantifiable
1e. Post-release life stage-specific survival is similar between hatchery and natural-origin population components.	Different size and timing
2a. Adult life history characteristics remain similar to pre-supplementation	Hatchery fish altered..effect on natural unknown
2b. Juvenile life history characteristics remain similar to pre-supplementation.	Natural fish changing
3a. Genetic characteristics of hatchery-origin fish are indistinguishable from natural origin fish.	

Uncertainties Research Example

Lostine River Spring Chinook

Background

Program

- Integrated Harvest Mitigation and Conservation Program
  - Lower Snake River Compensation Plan

- 250,000 smolt release targeting 1,625 adult returns

Approach

- Endemic Broodstock (including H:N parents)
- Out-of-basin rearing
- In-basin acclimation
  - acclimation site capacity limited
  - two release groups
    - 2-4 week acclimation
    - 125,000
    - 125,000

Uncertainties Research Example

Lostine River Spring Chinook

Release Timing

MANAGEMENT OBJECTIVE 1- ACHIEVE OPTIMAL PRODUCTION EFFECTIVENESS WHILE MEETING PRIORITY MANAGEMENT OBJECTIVES FOR NATURAL PRODUCTION

Management Assumption (1c) - We can identify the most effective rearing and release strategies

M & E Objective (1c) - Determine the influence of early and late release strategy on smolt and adult performance

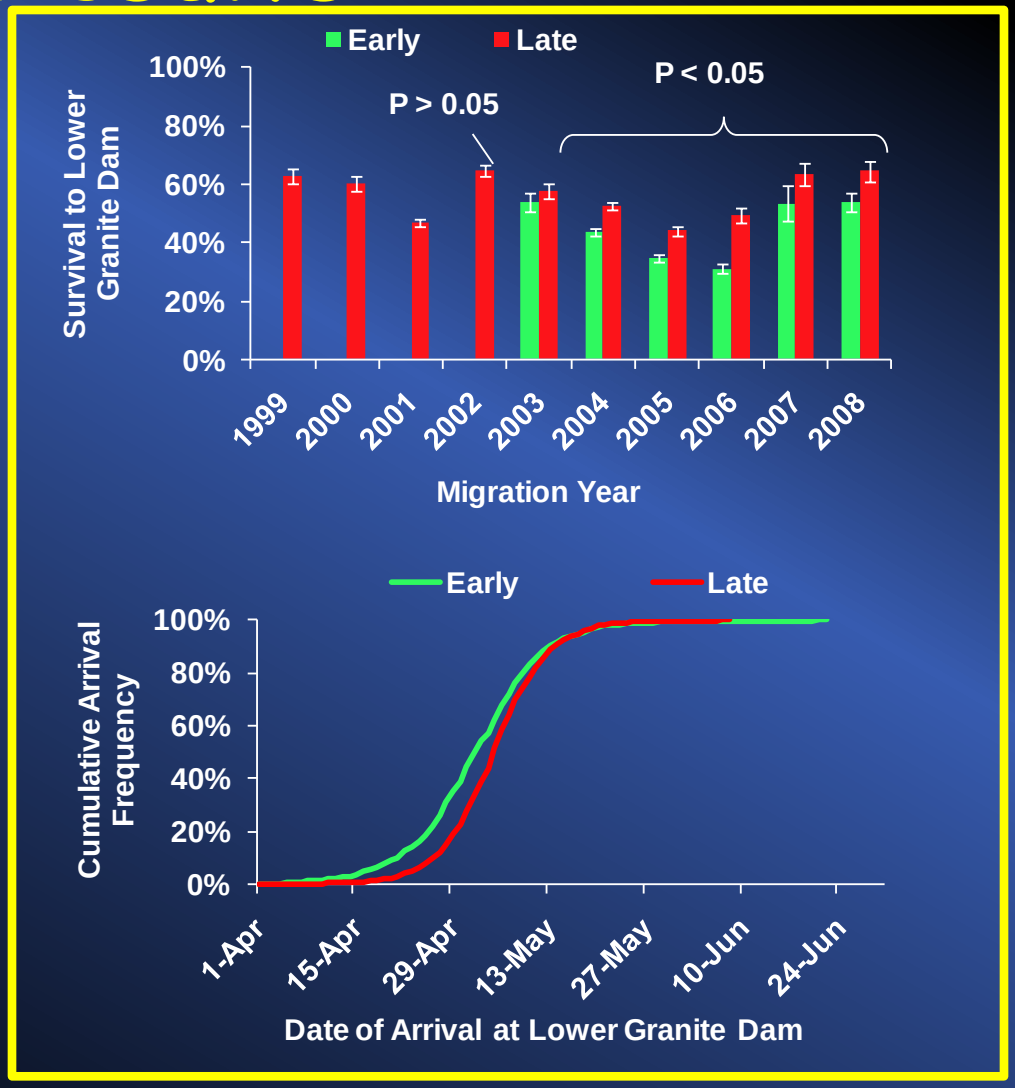
Hypotheses:

Ho1: Survival rate to Lower Granite Dam equal
Ho2: Emigration-timing at Lower Granite Dam equal
Ho3: Smolt to Adult Survival Rates equal

Uncertainties Research Example - Results

Key Findings:

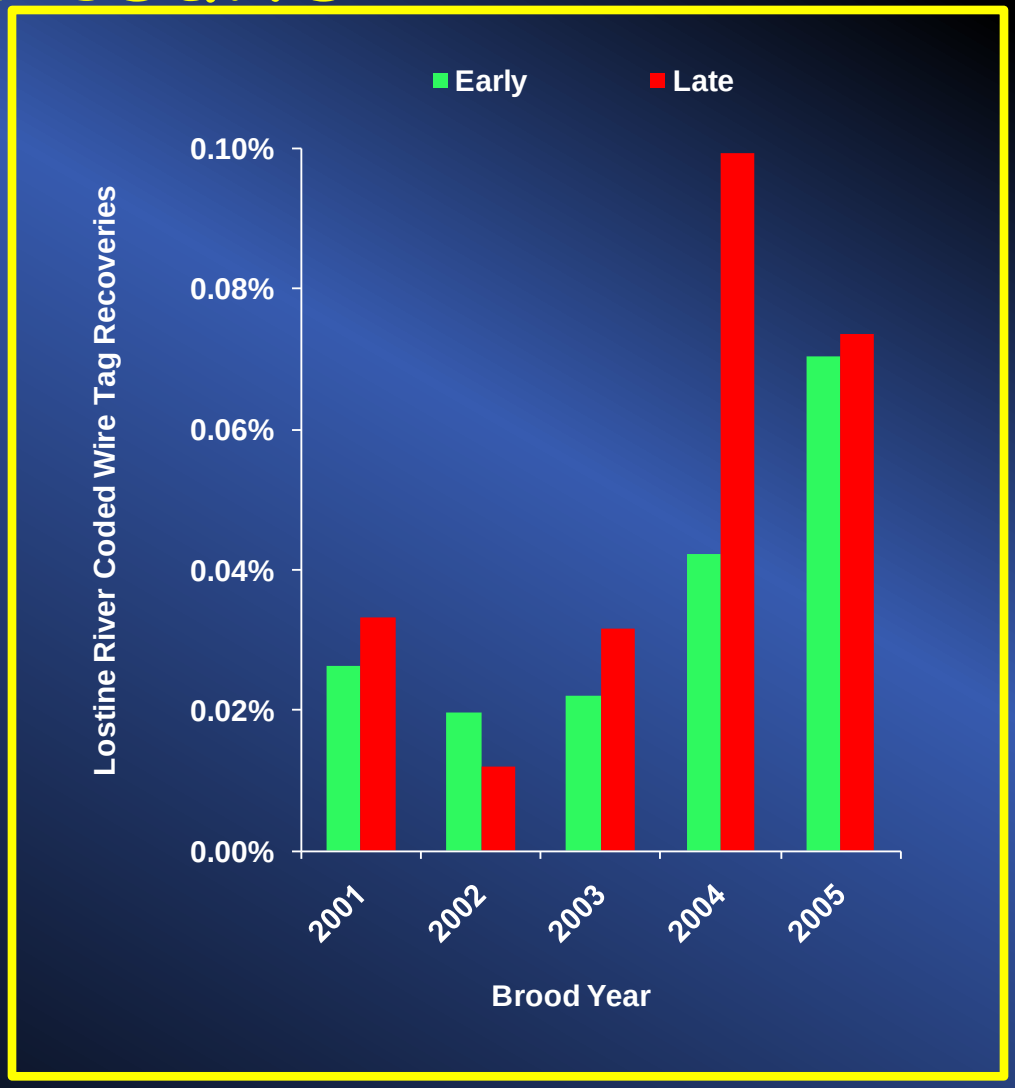
- Later releases had higher survival
- Earlier release had slower travel times



Uncertainties Research Example - Results

Key Findings:

- Later releases returned more adults



Uncertainties Research Example Adaptive Management Response

Options:

- Later release date with shortened acclimation periods
- Direct release
- Single release group

Issues:

- Potential increase in straying
- Variable environmental conditions
- Funding of new facilities

Status:

- Short term – acclimation periods shortened for both groups and first release group delayed 2 weeks
- Long term – pending permanent hatchery funding

Integrated Supplementation

✓In conjunction with other management actions

✓Harvest (Treaty right and/or mitigation)

✓Natural-origin fish inclusion in broodstock (pNOB)

✓Hatchery-origin fish contribution to natural spawning (pHOS)

Future Direction

1) Framework for hatchery monitoring and evaluations exists
   a) Google "Beasley AHSWG"
   b) NEOH M&E Plan (www.nptfisheries.org)

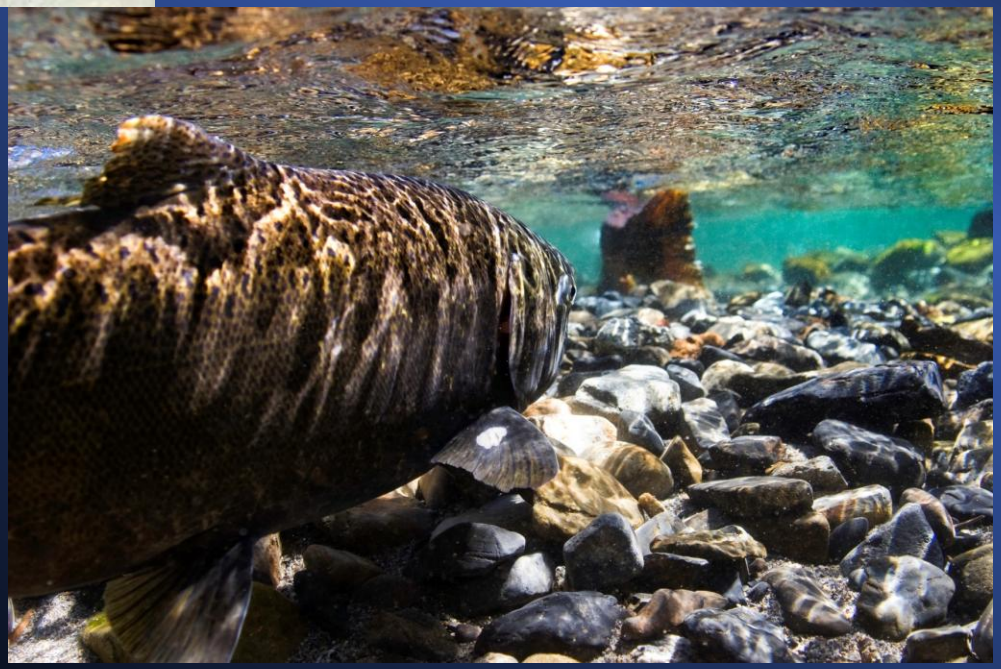
2) Integration of results across multiple programs benefits from standardized performance measures

3) Don't underestimate amount of effort and time required

"Our fate and the fate of the fish are linked."

Dan Landeen and Allen Pinkham,
Salmon and His People

"Knowledge is a tool, and like all tools, its impact is in the hands of the user(s)" - Dan Brown, The Lost Symbol



Future of Our Salmon Conference

A Focus on Hatchery Policy
October 17-18, 2012
Convention Center
Portland, OR

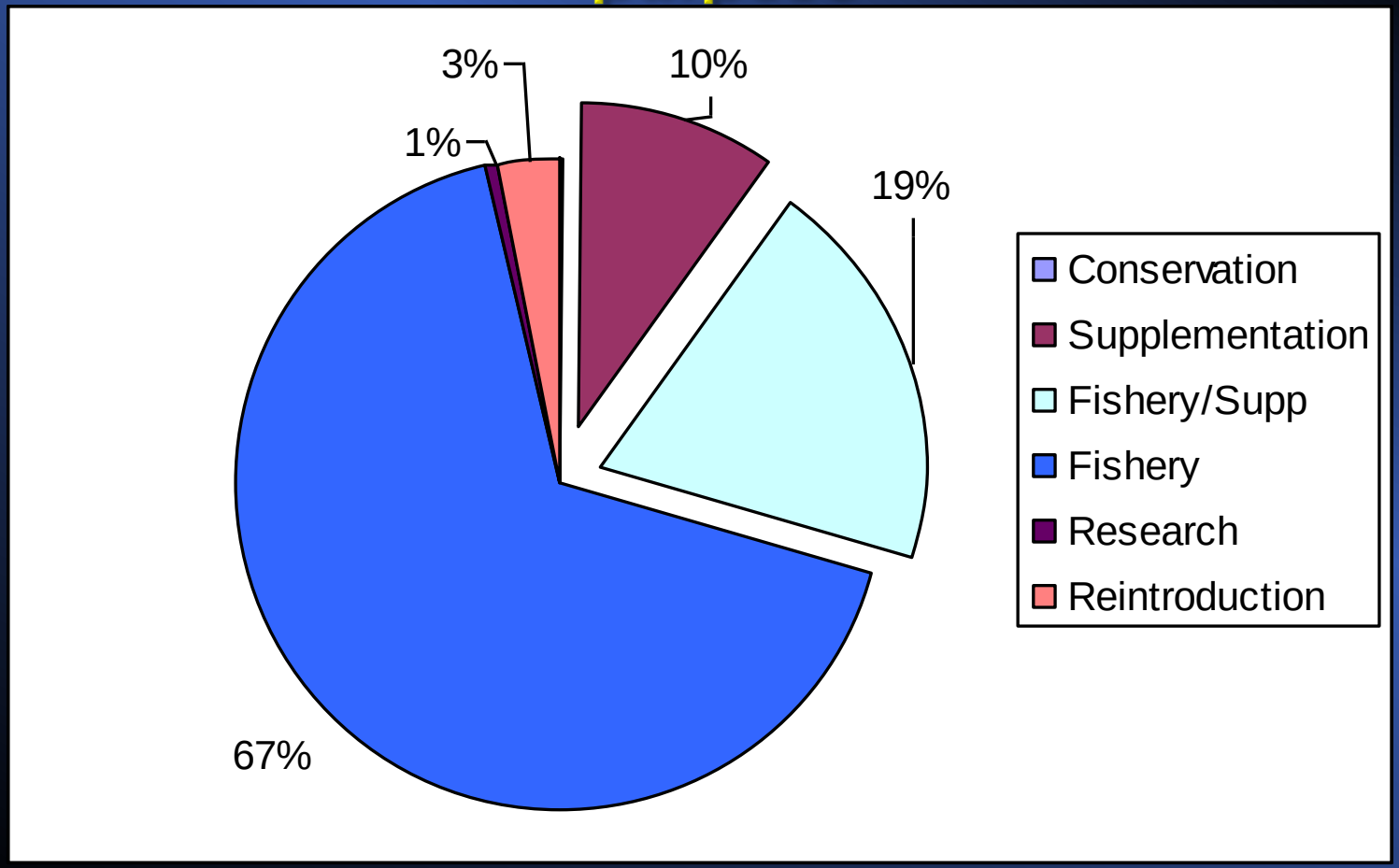
www.critfc.org/future
(registration, agenda)

Common misconception: There's a whole bunch of supplementation programs out there releasing fish that could be negatively impacting ESA listed fish recovery.

The Power and Conservation Council should develop a policy on supplementation

- Of these 13 million juveniles, 6 million are produced to supplement ESA listed stocks. The remaining 7 million are unlisted.
- Many of the ESA listed supplementation programs funded directly or in a funding mix by BPA are called for in the FCRPS BiOp.
- Supplementation programs funded by BPA FWP for ESA listed salmon and steelhead in the Columbia Basin amounts to about 7% of the production above Bonneville Dam.
- Almost all of the artificial production programs funded by BPA FWP are sponsored and operated by Tribes – many of them are in the Accords.

Columbia Basin salmon and steelhead production above Bonneville Dam – by primary purpose



88 million salmon and steelhead

misconception: All hatchery programs are the same

Who funds Columbia Basin Supplementation/Fishery Programs?