The Imnaha River Chinook Salmon Supplementation Program after Thirty-one Years: Is Supplementation Working?

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Management Objectives

- Enhance natural production while maintaining long term fitness (productivity) of the natural population.

- Operate the hatchery program:
  - to maintain the genetic and life history characteristics of the natural population and
  - so that hatchery salmon characteristics mimic those of wild salmon, while achieving production objectives.

Broodstock Development History

- Wild adults were collected for broodstock beginning in 1982.
- The majority (62-100%) of broodstock were natural through 1989.
- Natural and hatchery adults were used for broodstock from 1990-2014 (7-71% wild).

- Due to logistical constraints of weir installation, the broodstock generally comes from middle to end of run.
  - Mean weir efficiency has been 67% (13-97%).
  - We were able to collect broodstock from nearly across the entire run (>95% weir efficiency) only in 1989, 2005, and 2007.

Management of Returns and Escapement

- Nearly all wild salmon captured were kept for broodstock from 1982- 1986.
  - Due to very late weir installation
- Percentage of of the wild/natural salmon captured that were retained for broodstock after 1986 was 50% or less, except 1995.
- Few hatchery salmon were released to spawn naturally until 1990.
  - Before 1990, naturally-spawning hatchery salmon were those that passed the weir site prior to weir installation and those that spawned below the weir.

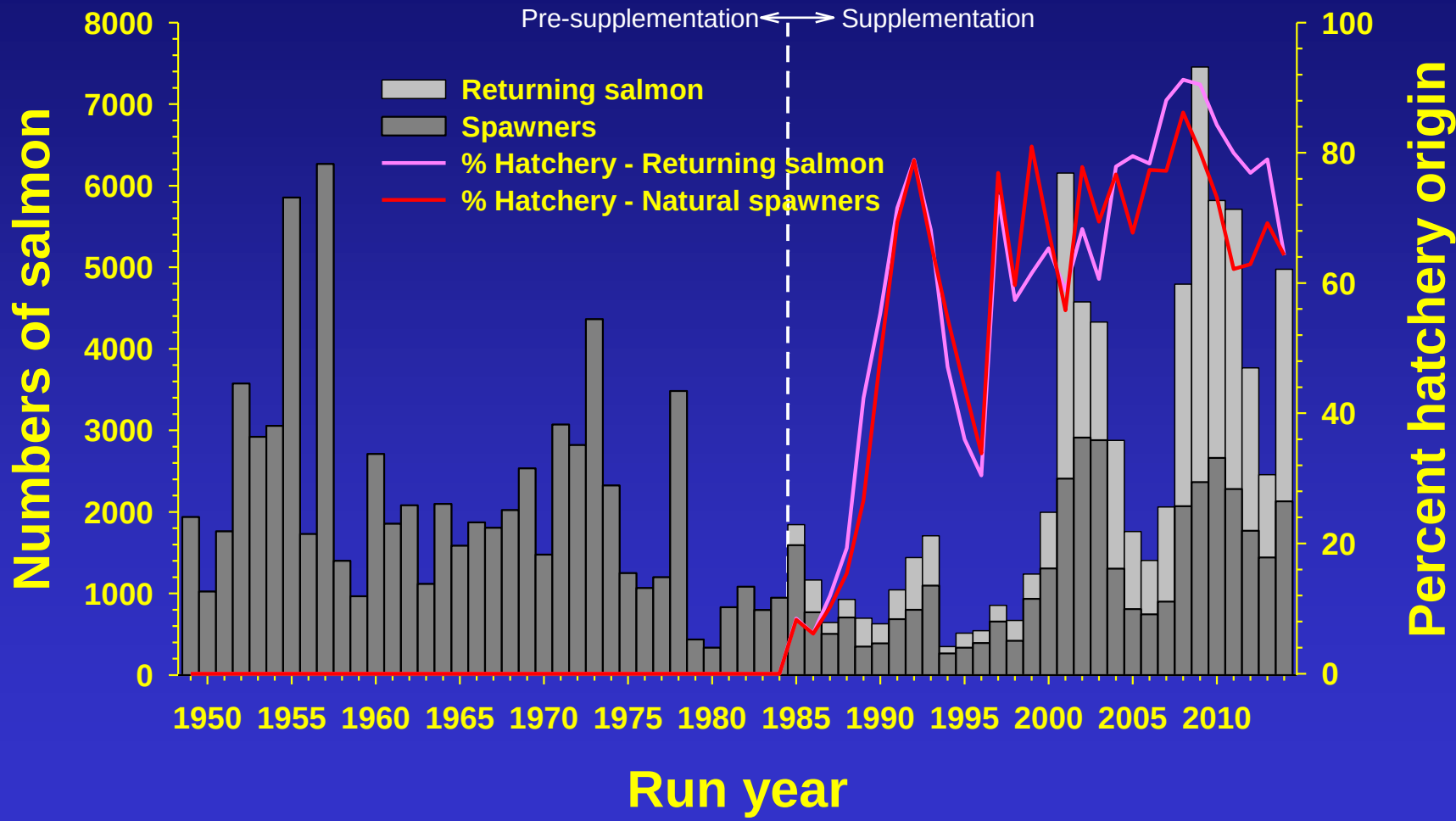
Management of Returns and Escapement

- 27% of the total return to the river spawns below the weir.

- Adult pHOS, pNOB, and PNI since 1990:

	Total River		Above Weir	
	Mean	Range	Mean	Range
pHOS	58%	20-89%	55%	21-89%
pNOB	32%	13-75%		
PNI	0.356	0.152-0.789	0.364	0.167-0.779

Salmon Abundance in Nature
1949 - 2014



Today's Presentation

- Illustrate our approach to assessing success in supplementation programs

- Questions:
  - Are the life history and spawning characteristics of hatchery origin salmon the same as those of natural origin salmon?

  - Has the supplementation program increased the numbers of total spawners and natural origin spawners?

  - Has the hatchery program influenced natural spawner productivity?

Life History and Spawning Comparison Approach

Compiled data from weir collections, spawning ground surveys, and hatchery spawning to examine:

- Age composition – based on tags and scales to determine age
- Run timing – based on time of arrival at the
- Spawning characteristics (age, size, fecundity, egg size, ovosomatic index, spawn timing) – based on females spawned at Lookingglass Hatchery and female carcasses from spawning ground surveys

- **Our objective is for hatchery origin salmon to have the same life history and spawning characteristics as natural origin salmon.**

Life History Comparison Results

Life history and spawning characteristics of hatchery salmon are not matching those of natural salmon.

Nature:

- Run timing
  - Hatchery adults return later than natural adults.
- Spawn timing
  - Hatchery salmon spawn later in nature.
- Spawning distribution
  - Hatchery salmon spawn more downstream, near the smolt release location.
- Age composition
  - Hatchery adults are younger for both sexes.

Life History Comparison Results (cont'd)

Hatchery - spawner characteristics from Lookingglass Hatchery:

- Age
  - Hatchery adults are younger for both sexes.
  - Mean age at maturity is decreasing in hatchery and natural females.
- Size
  - Younger salmon means smaller salmon for both sexes.
- Fecundity
  - Younger females have fewer eggs.
- Egg size
  - Younger females have smaller eggs.
  - Mean egg weight is decreasing in hatchery and natural females.
- Ovosomatic index
  - Hatchery and younger females have more eggs / kg body weight.
- Spawn timing
  - Younger females spawn later.

Abundance and Productivity Comparison Approach

- Compiled spawner and recruit adult abundance and productivity (R/S) time series datasets for Imnaha River and unsupplemented Idaho Salmon River Chinook salmon populations (ICTRT / ODFW / IDFG).

- Determined level of correlation (Pearson's) in abundance and productivity between Idaho and Imnaha populations for the pre-supplementation time period to evaluate adequacy as reference populations.
  - Abundance: 1957-1985 Run Years
  - Productivity: 1957-1981 Brood Years

Abundance/Productivity Comparison Populations

Abundance/Productivity Comparison Approach

- Calculated annual (brood year or run year) ratios of Imnaha-to-unsupplemented (Idaho) populations for spawner abundance (total and natural) and productivity.
  - Ratio = $\frac{\text{Imnaha River}}{\text{Unsupplemented stream}}$
    - Compared ratios between pre- and post-supplementation time periods using a t-test.
  - Abundance:
    - Pre-supplementation: 1957 - 1985 return years
    - Post-supplementation: 1986 - 2013 return years
  - Productivity:
    - Pre-supplementation: 1957 - 1981 brood years
    - Post-supplementation: 1982 - 2008 brood years

Abundance/Productivity Comparison Approach - Hypotheses

If the program is successfully supplementing the natural population, then:

1 - Total abundance should increase.

- Therefore, the post- supplementation total abundance ratio should be higher than during the pre-supplementation period.

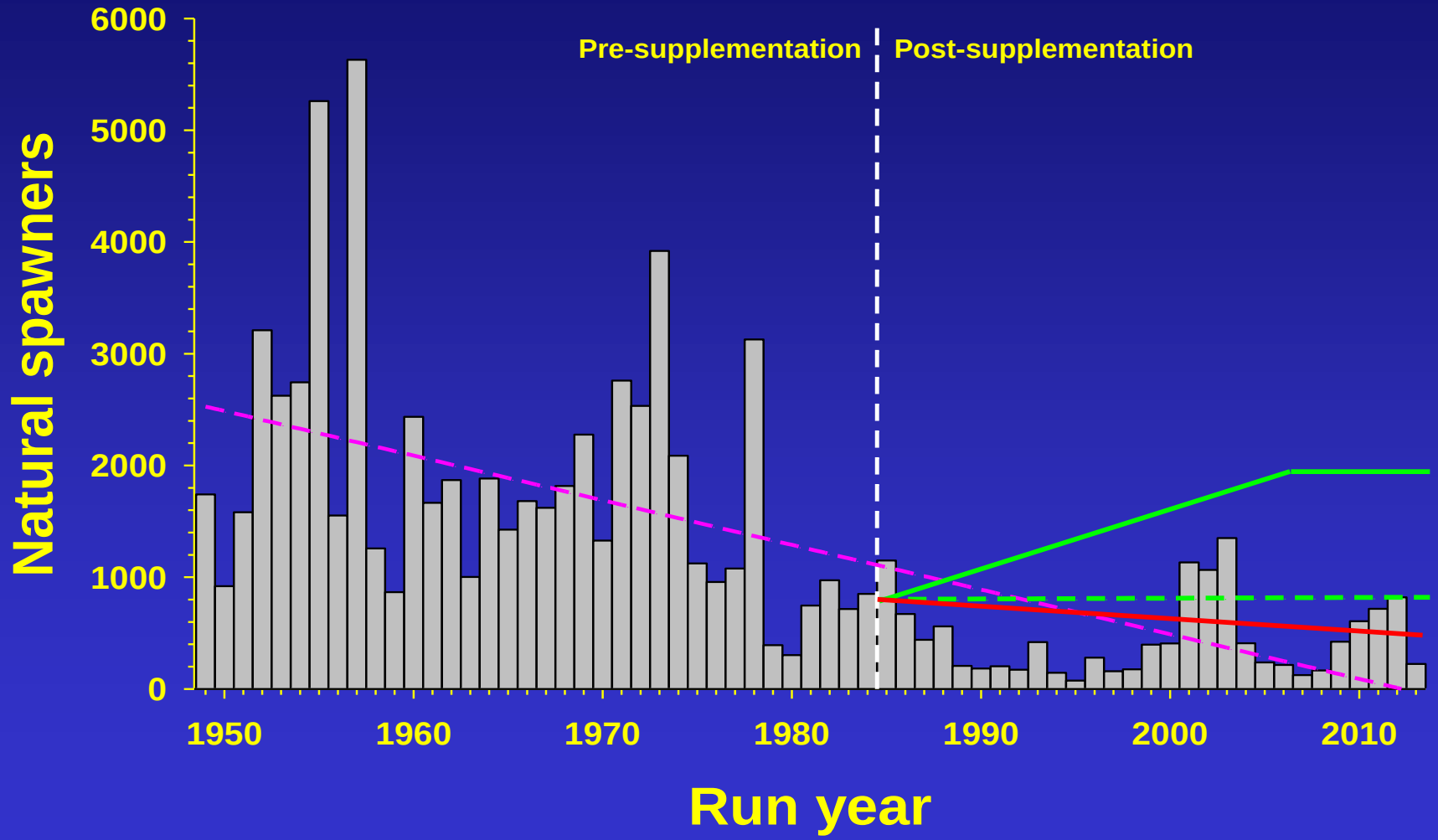
2 - Natural origin abundance should increase.

- Therefore, the post- supplementation natural origin abundance ratio should be higher than during the pre-supplementation period.

3 – Productivity should not change.

- Therefore, the post-supplementation productivity ratio should be equal to or higher than during the pre-supplementation period.

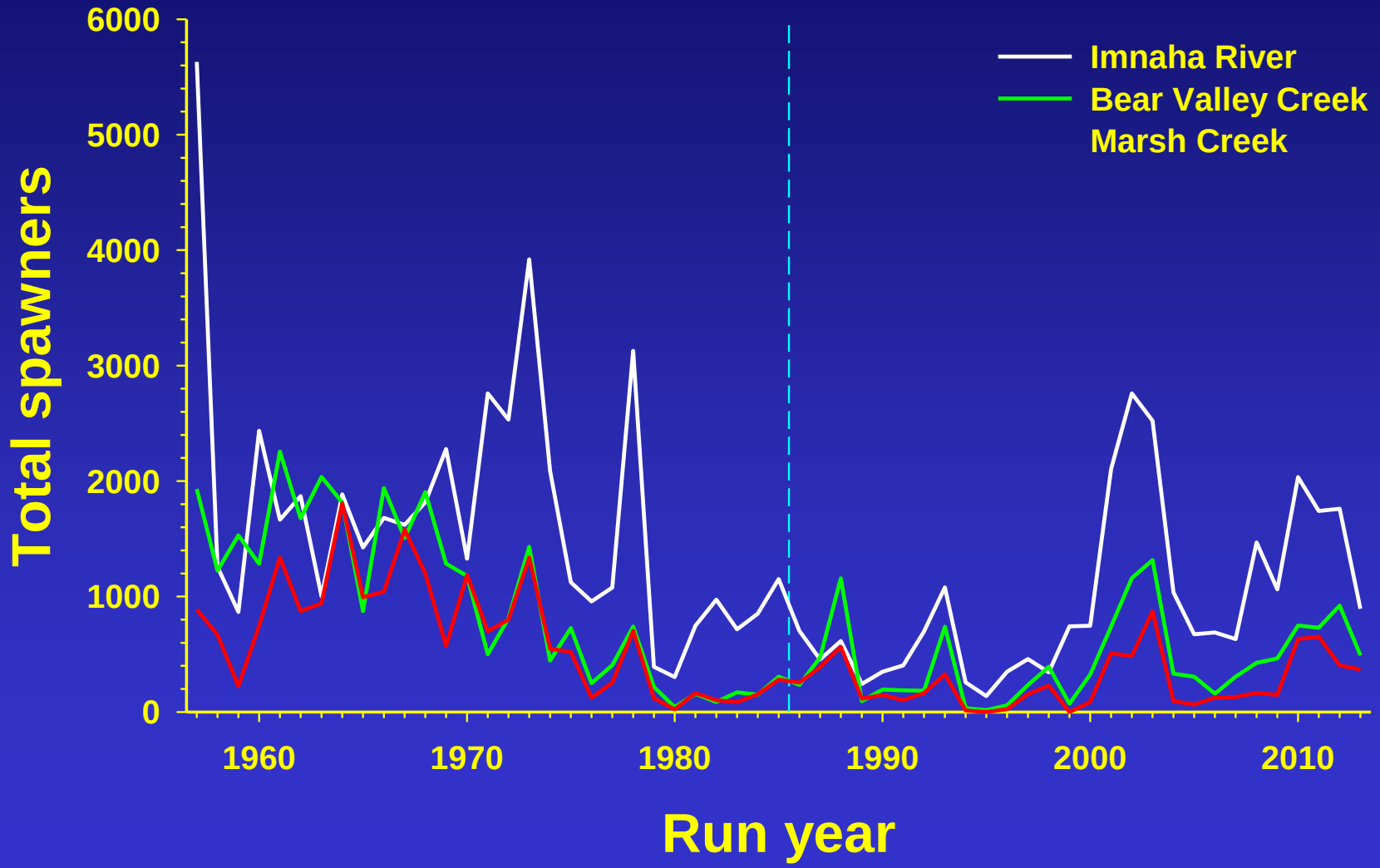
Natural Origin Abundance
Imnaha River



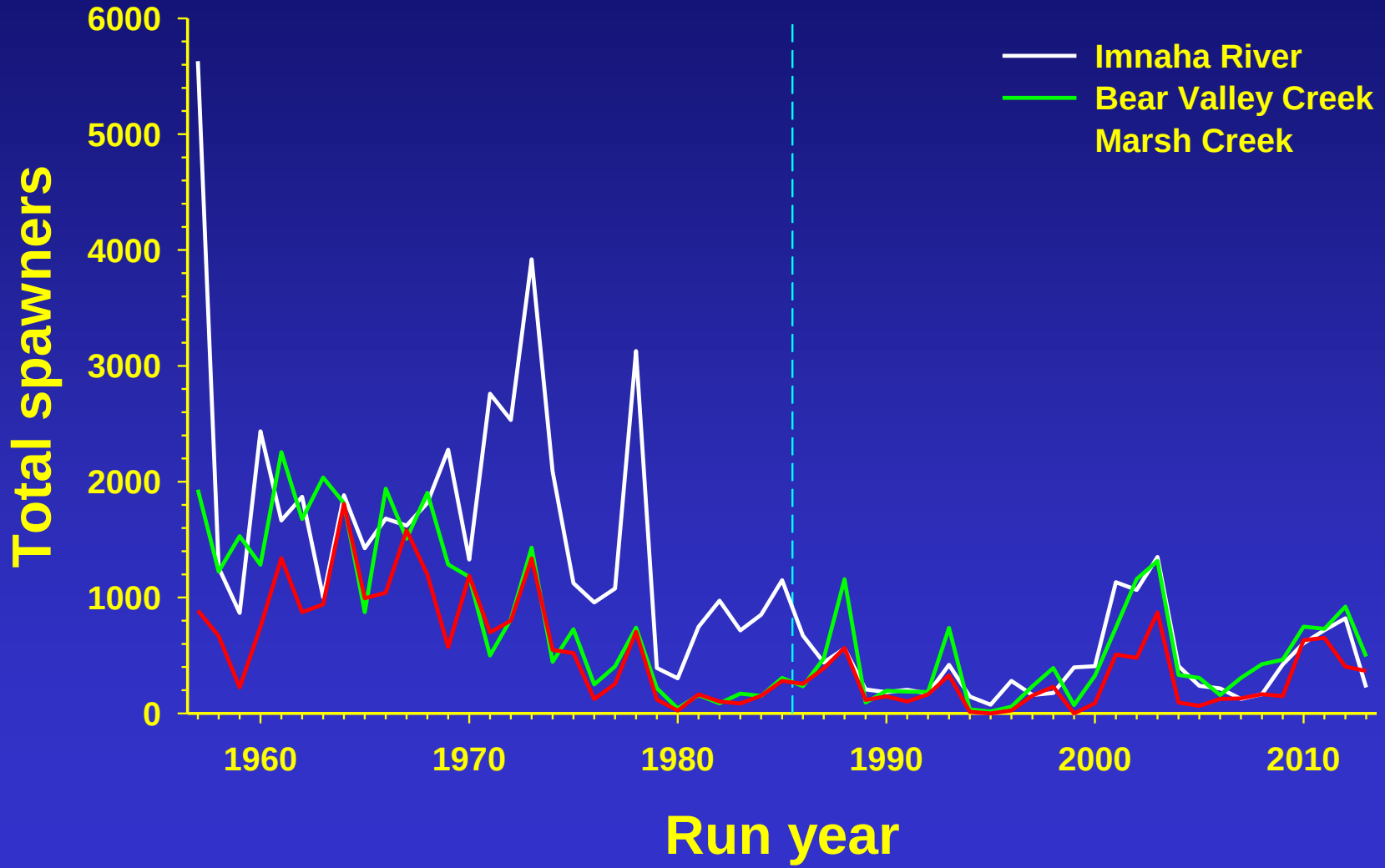
Pre-Supplementation Correlations
Imnaha Population vs. Idaho Populations

	Abundance (Total = Natural origin)		Recruits-per-spawner	
Idaho stream	rho	P-value	rho	P-value
Bear Valley Creek	0.4296	0.0200	0.5740	0.0027
Big Creek	0.4095	0.0274	0.4666	0.0187
Camas Creek	0.4531	0.0136	0.6164	0.0010
Lemhi River	0.3769	0.0496	0.6943	0.0001
Loon Creek	0.5349	0.0028	0.4149	0.0392
Marsh Creek	0.4580	0.0125	0.6497	0.0004
Sulphur Creek	0.5449	0.0022	0.5004	0.0109
Valley Creek	0.6749	<0.0001	0.5124	0.0088

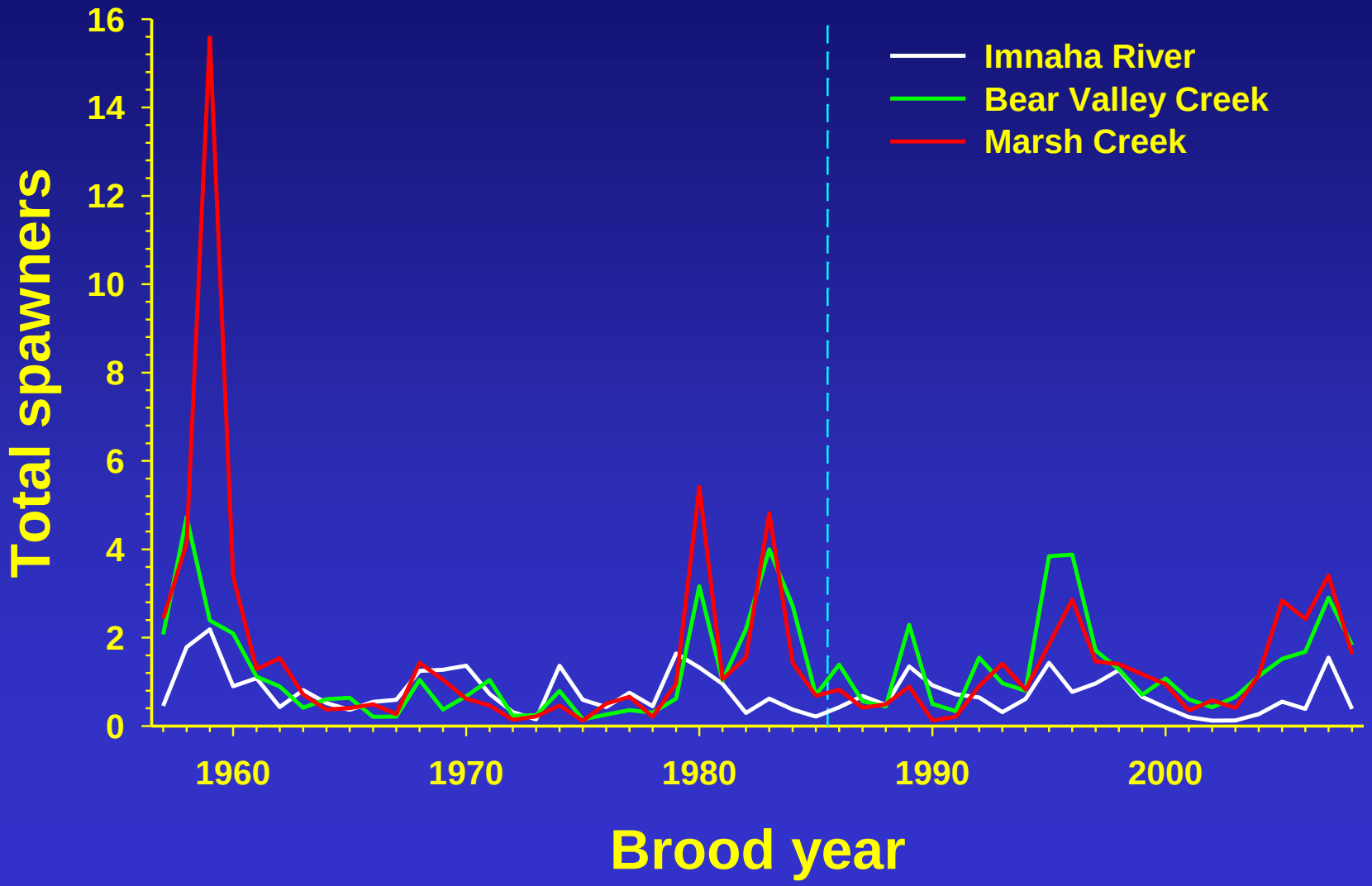
Abundance of Total Spawners



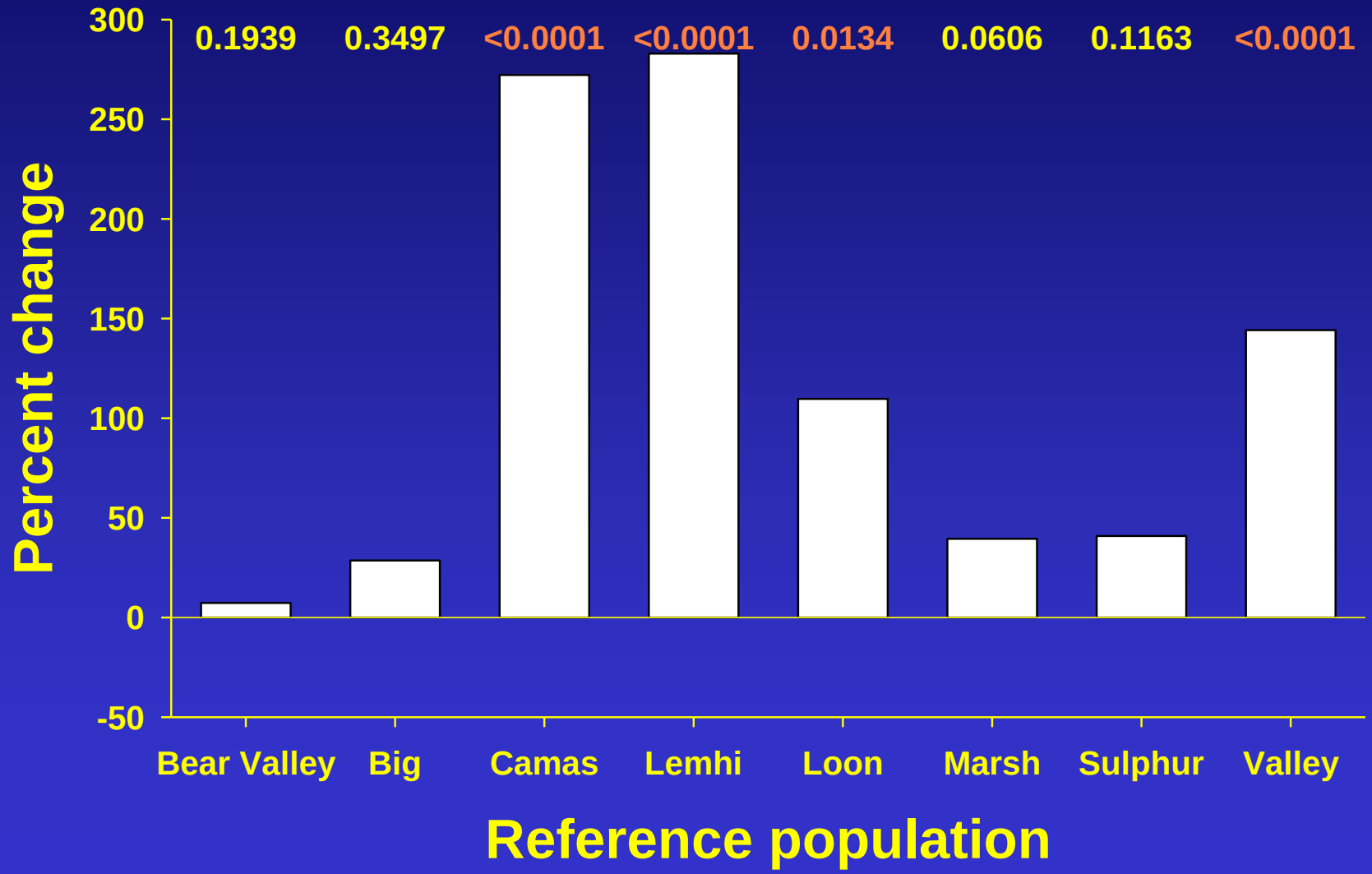
Abundance of Natural Origin Spawners



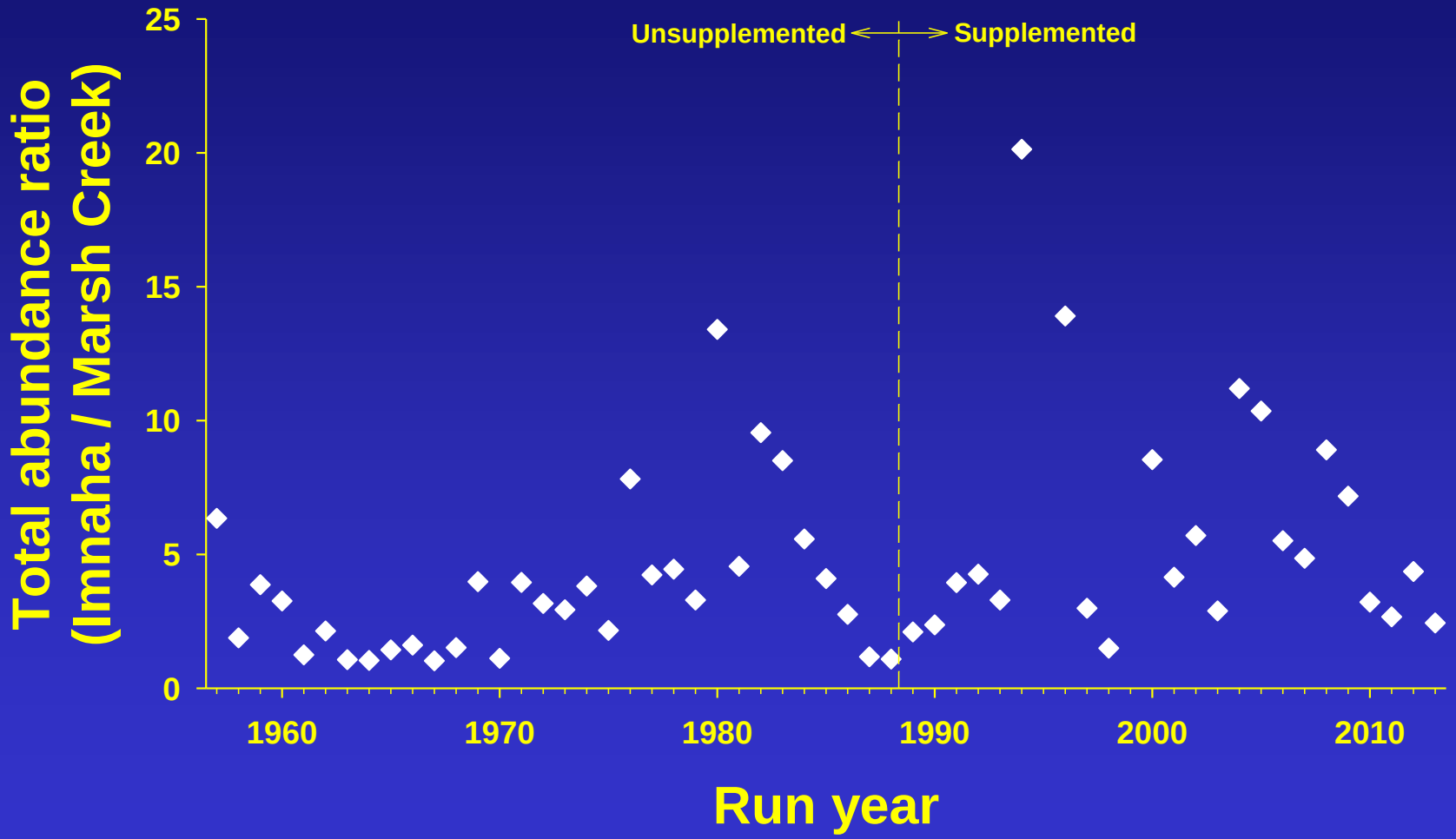
Natural Origin Recruits-per-Spawner



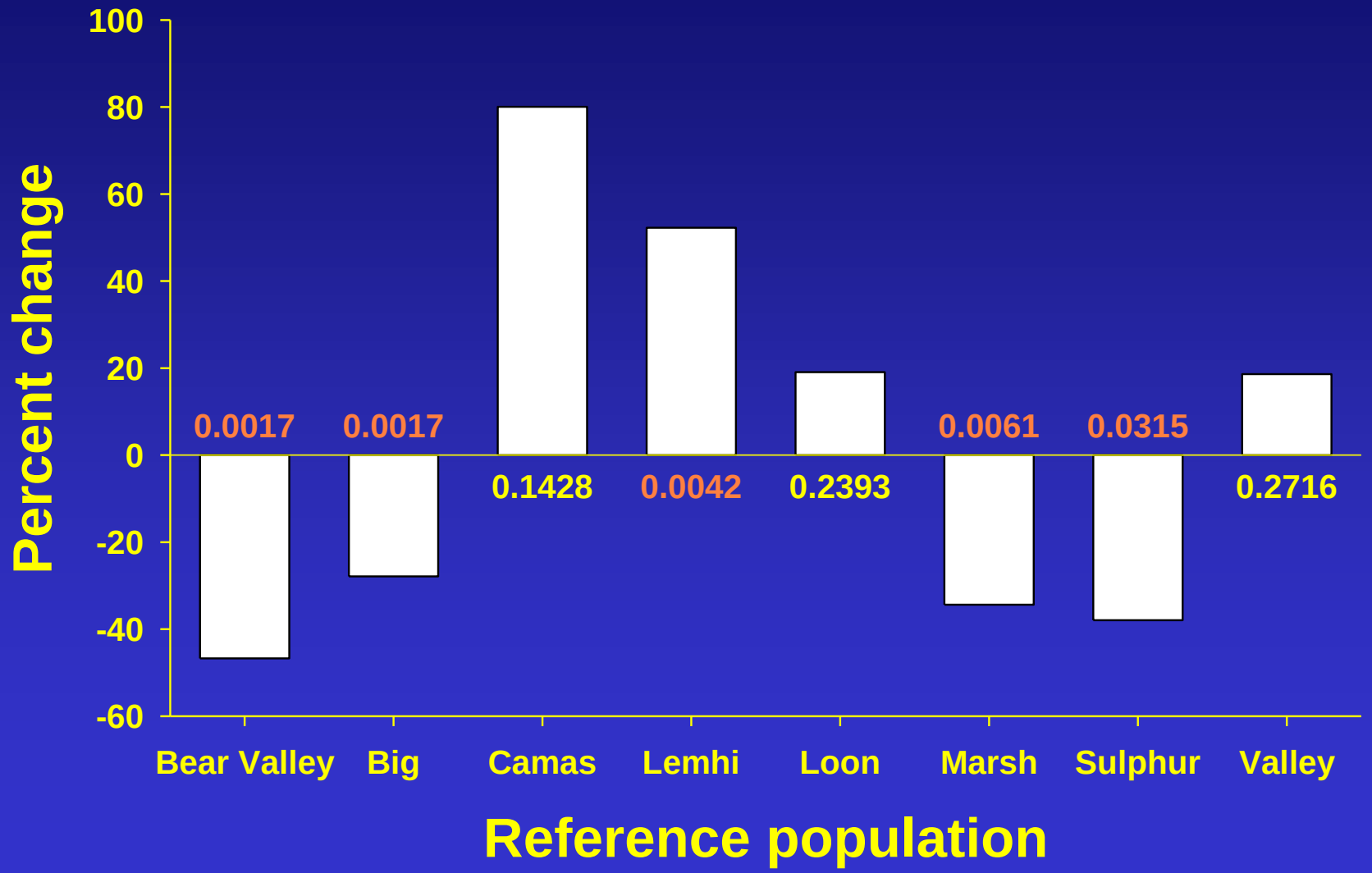
Magnitude and Direction of Pre- vs Post-Supplementation Change in Total Spawner Abundance Ratios



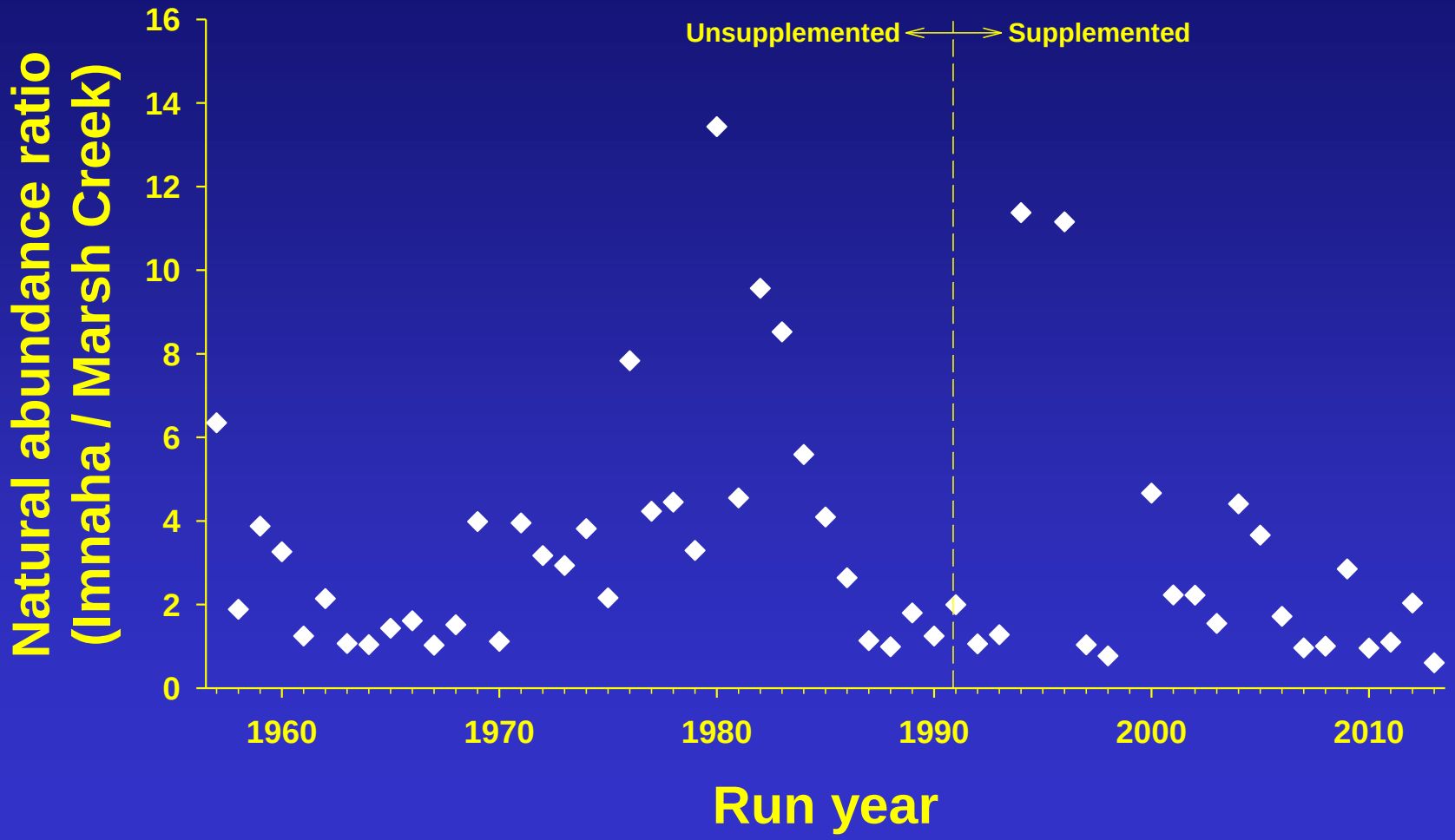
Total Abundance Ratio (Imnaha River / Marsh Creek)



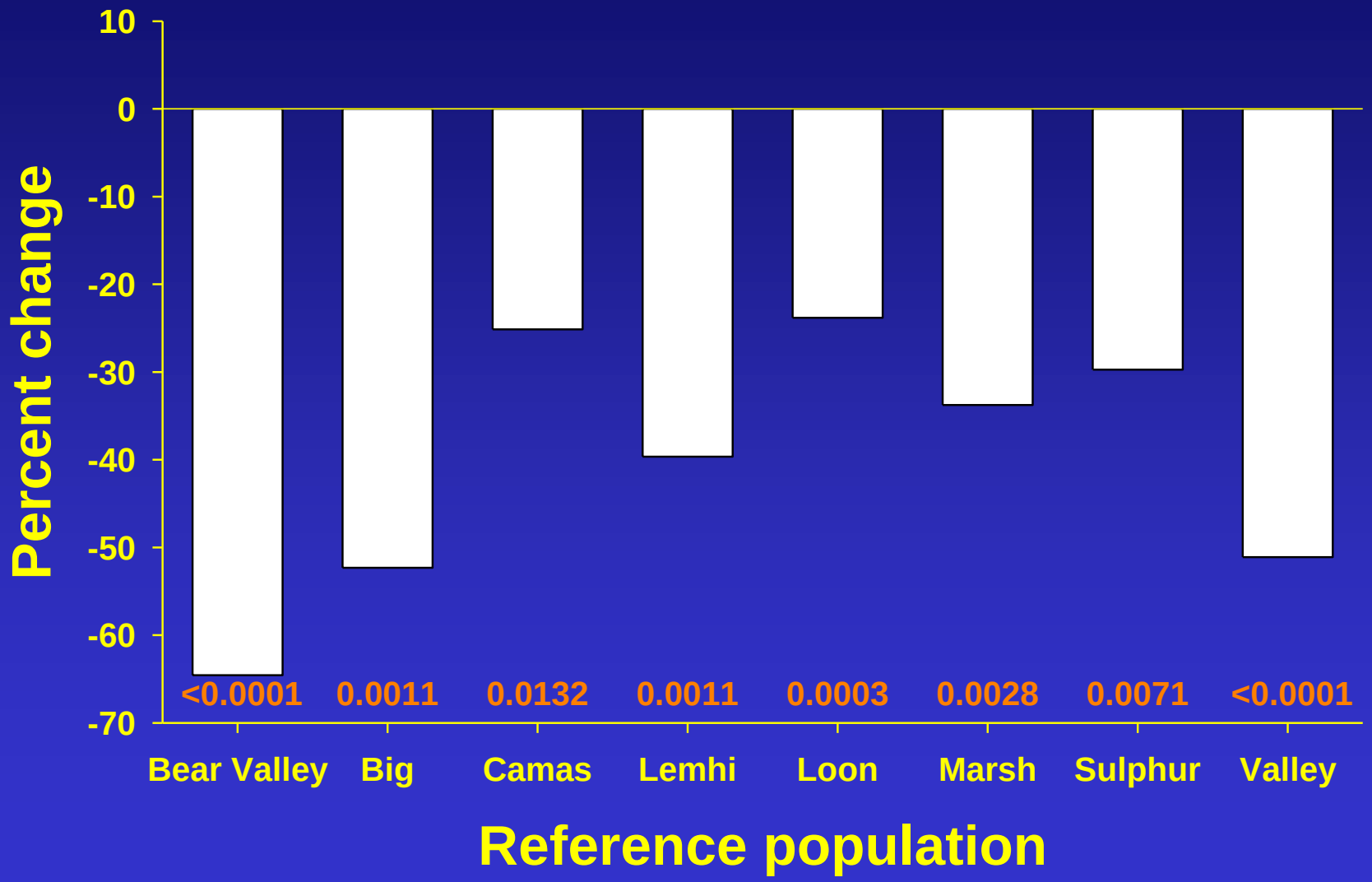
Magnitude and Direction of Pre- vs Post-Supplementation Change in Natural Origin Spawner Abundance Ratios



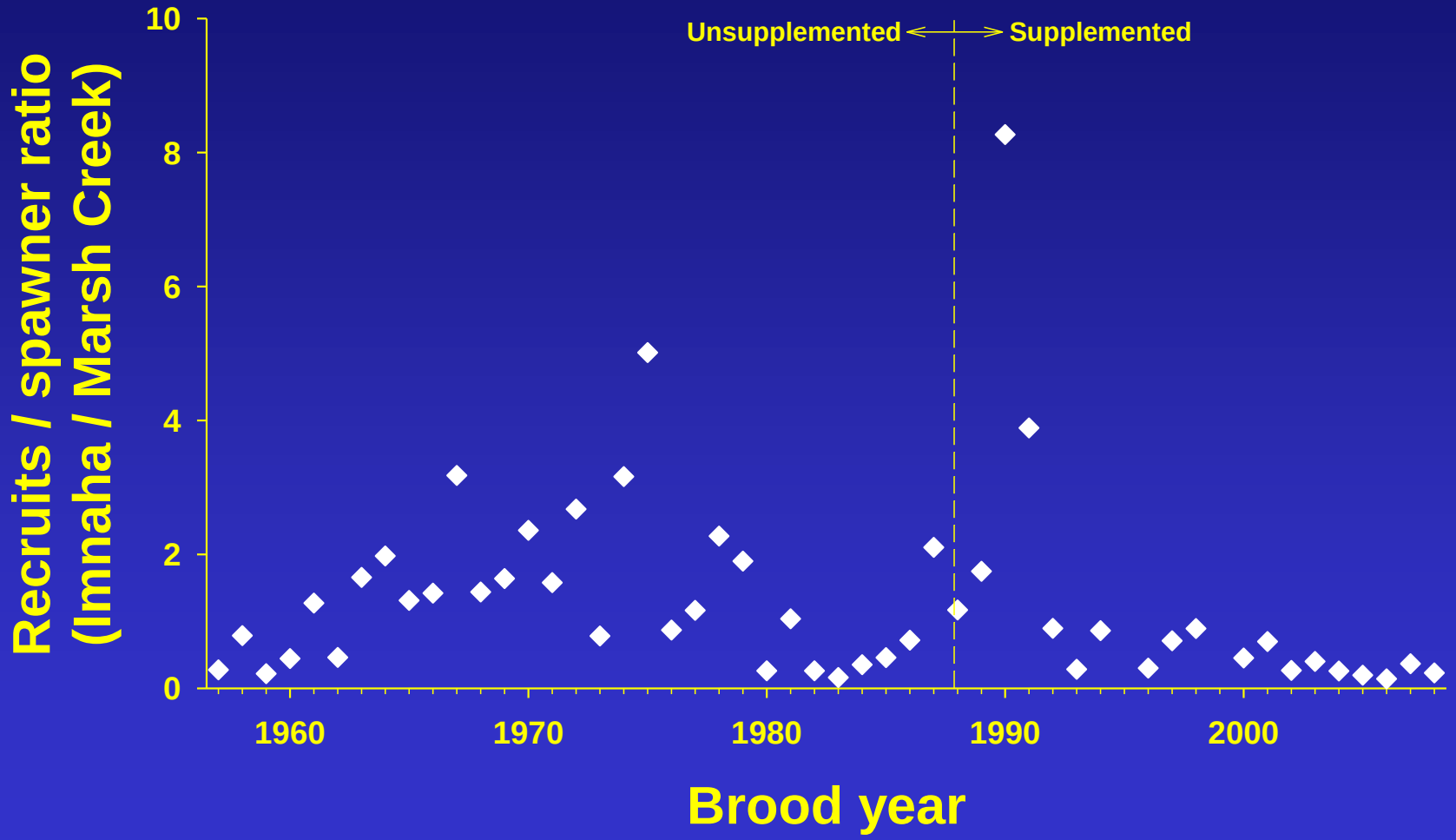
Natural-Origin Abundance Ratio (Imnaha River / Marsh Creek)



Magnitude and Direction of Pre- vs Post-Supplementation Change in Productivity Ratios



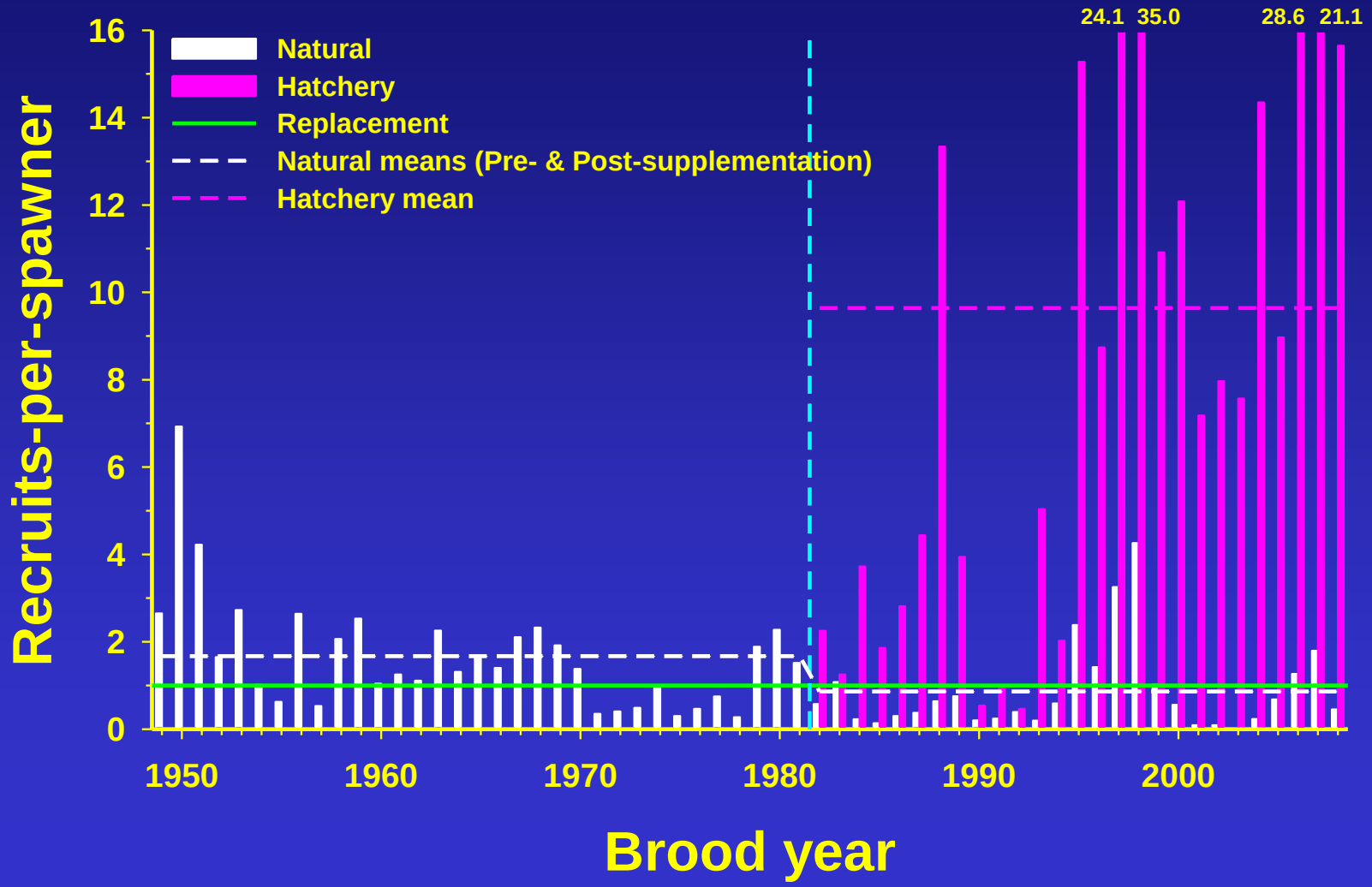
Recruits-per-Spawner Ratio (Imnaha River R:S / Marsh Creek R:S)



Imnaha River Recruits-per-Spawner

Pre-supplementation
23/33 (70%) above replacement

Post-supplementation
8/27 (30%) above replacement
24/27 (89%) above replacement



Abundance and Productivity Summary

- We have not observed a trend of increased number of natural-origin spawners through time since supplementation started.
- We have achieved a significant life cycle survival advantage for hatchery salmon with a recruits-per-spawner advantage of 7:1.
- Recruits-per-spawner for naturally spawning hatchery and natural salmon have averaged less than 1 and have been above replacement for only eight of the 28 supplemented brood years.
- We have not increased natural origin abundance with supplementation even though we have increased the total number of spawners.
- Productivity of natural spawners in the Imnaha population has decreased since supplementation was initiated.

Why Not More Natural Origin Salmon and Why Does Productivity Appear Depressed?
Some Hypotheses:

- **Poor reproductive success of hatchery salmon?**
  - Likely given the relatively low PNI, selective broodstock collection, and resulting life history effects: run timing, spawn timing, younger age (resulting in smaller size - both sexes - and smaller eggs).

- **Competitive and other ecological effects on natural origin juveniles?**
  - Highly uncertain due to lack of information, however the number of hatchery produced smolts far exceeds natural smolt production.

Why Not More Natural Origin Salmon and Why Does Productivity Appear Depressed?
More Hypotheses:

- **Other genetic and ecological effects?**
  - Likely, given selective broodstock collection, high proportion of hatchery origin salmon spawning naturally, differences in run timing, spawn timing and spawning distribution between natural and hatchery origin salmon, unnaturally high proportions of jacks spawning in nature, and potential weir effects on adult spawning distribution.

- **Density dependent effects of increased total spawners?**
  - Likely some influence, however early post-supplementation years (1986-2000) were low spawner abundance in the Imnaha River.

Program Successes

- Imnaha River Chinook salmon are still extant
  - Increased total abundance of Chinook salmon in the Imnaha River
- Fisheries
  - For most years since 2001 and likely for foreseeable future
  - Recreational and tribal
  - Contributes to Columbia River fisheries
- Fish culture
  - "Bigger" is not always better
  - Acclimation may not be necessary/beneficial for Chinook Salmon

What To Do?
Potential Management Actions

1. Improve pre- and in-season run forecasting for natural salmon
   - Underway - This will allow us to determine the appropriate sliding scale criteria for weir management.
2. Install and operate a new weir that will enable capture of broodstock from across the run.
   - Underway - This will help to reduce the difference in run and spawn timing between hatchery and natural salmon.
3. Operate weir and implement pass/keep protocols to ensure sliding scale criteria are achieved.
   - This will reduce pHOS and improve PNI.
4. Examine feasibility and potential benefits and risks of increasing the proportion of broodstock that are natural origin (based on Johnson Creek study results).
   - This will increase pNOB and improve PNI.

What To Do?
Potential Management Actions

5. Continue evaluating alternative rearing and release strategies that improve SAR and reduce early age at maturation so that hatchery origin salmon have similar age structure to natural salmon.
    - Growth modulation
    - Size-at-release
6. Develop and evaluate release strategies that result in a hatchery spawner distribution that mimics natural origin distribution.
    - Direct stream release at weir (underway)
    - Direct stream release at other locations
7. Develop and evaluate hatchery release and harvest strategies that maximize hatchery salmon exploitation opportunity with acceptable impacts to the natural population.
    - This will help us use excess hatchery salmon

Questions?

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