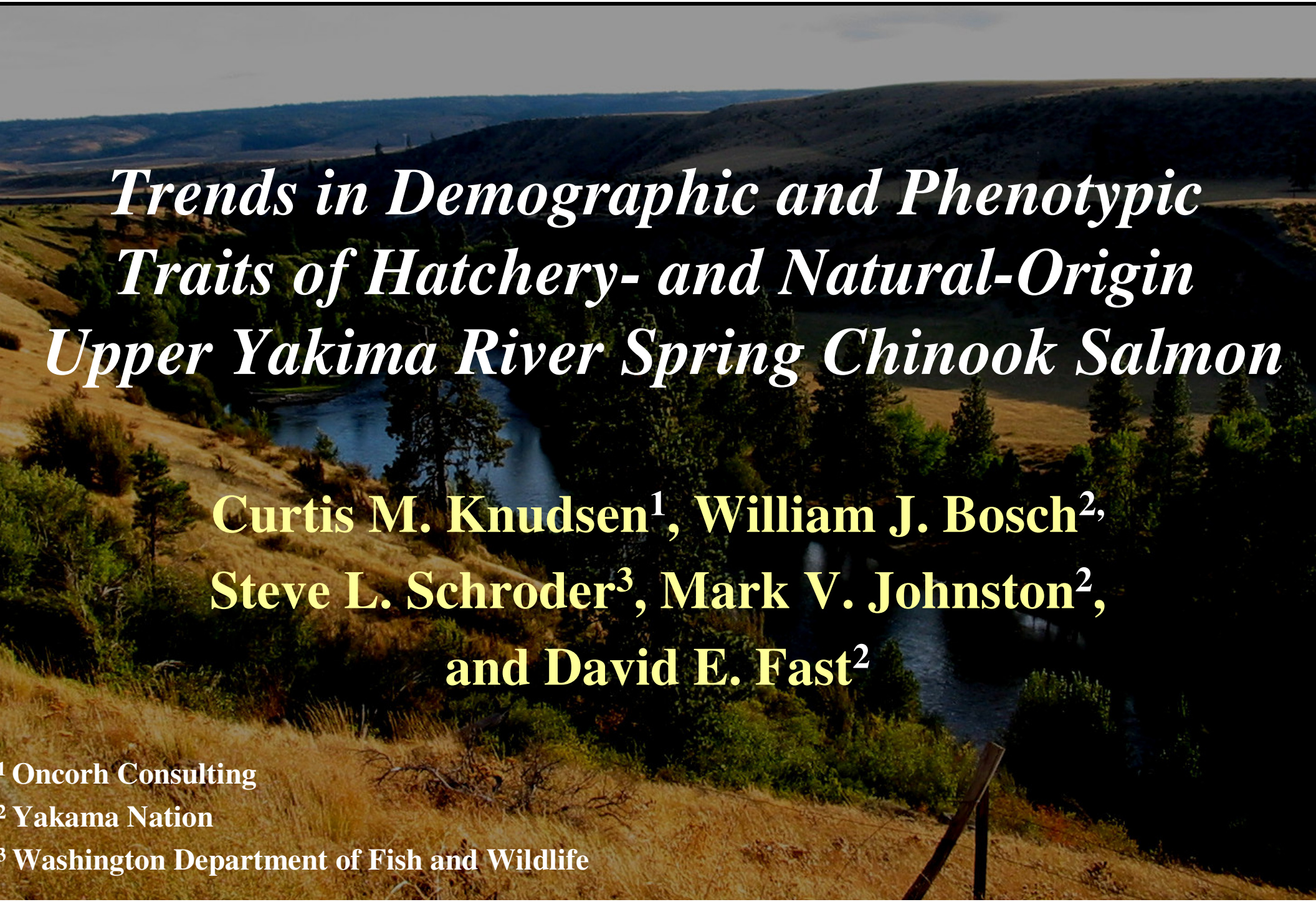

Trends in Demographic and Phenotypic Traits of Hatchery- and Natural-Origin Upper Yakima River Spring Chinook Salmon

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[3] Washington Department of Fish and Wildlife

Suggested Questions

- **Has the mean size-at-maturity for natural and hatchery populations been changing over time?**
- **Has the age and sex composition of natural and hatchery populations been changing over time? (Corollary: Is the proportion of jacks changing over time for wild or hatchery fish?)**
- **Is the mean age and size of fish caught in commercial, recreational, and/or tribal fisheries changing? (not covered here)**

In Addition

- **Does the proportion of jacks allowed on the spawning grounds influence the proportion of jacks produced by a naturally spawning cohort?**
- **Does the proportion of jacks included in broodstock influence the proportion of jacks produced by a hatchery cohort?**

Definitions

- **Natural Origin (NO)– progeny of naturally spawning parents. Parents could be natural or hatchery origin.**

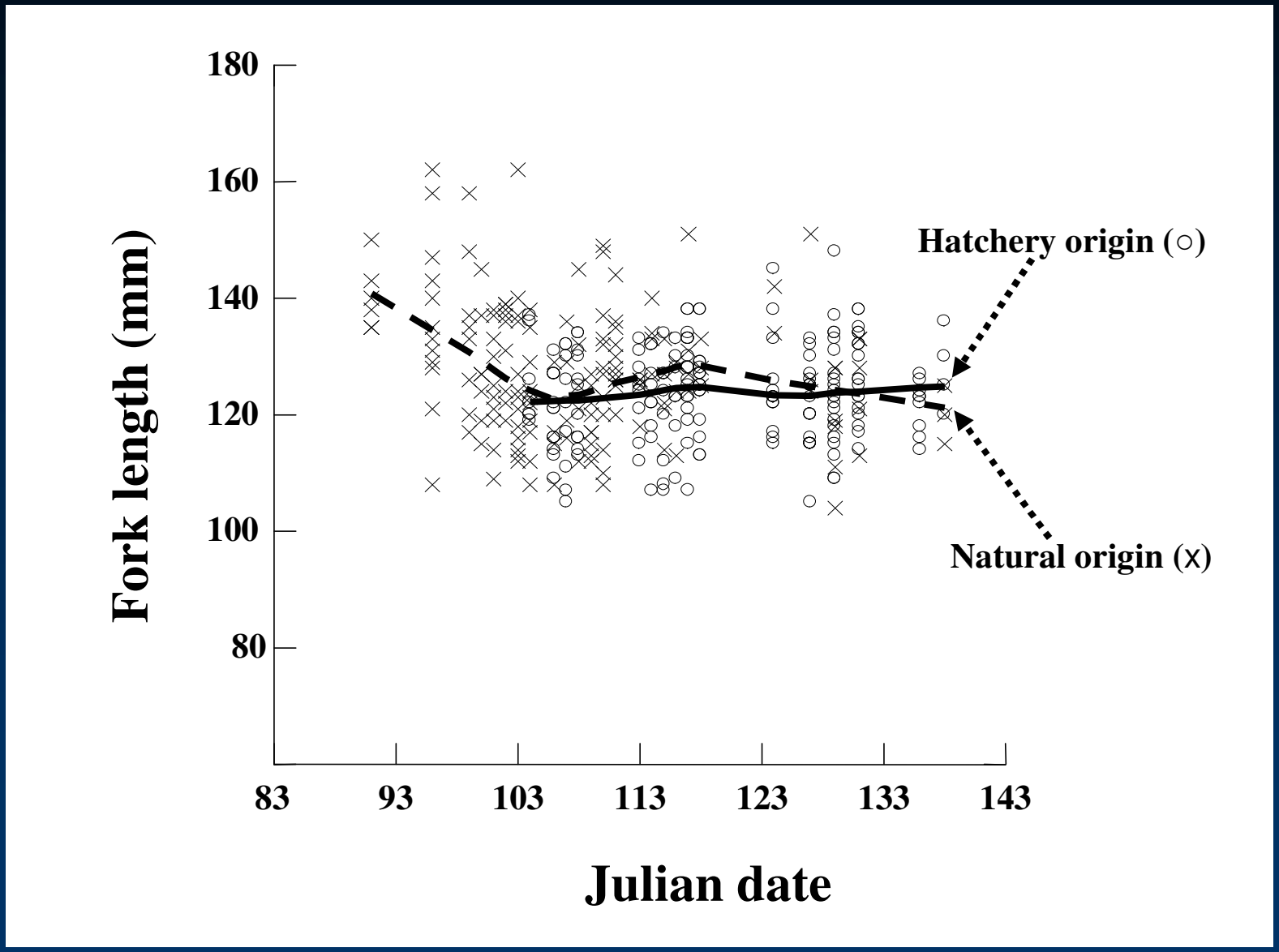
- Hatchery Origin
  - **Supplementation Hatchery (SH) Origin – Parental broodstock of natural origin, artificially spawned. Supplement naturally spawning population, integrated population.**
  - **Hatchery Control (HC) Origin – Parental broodstock of hatchery origin and are not allowed to naturally spawn. Segregated hatchery population.**

The YKFP spring chinook hatchery program was designed to minimize domestication effects

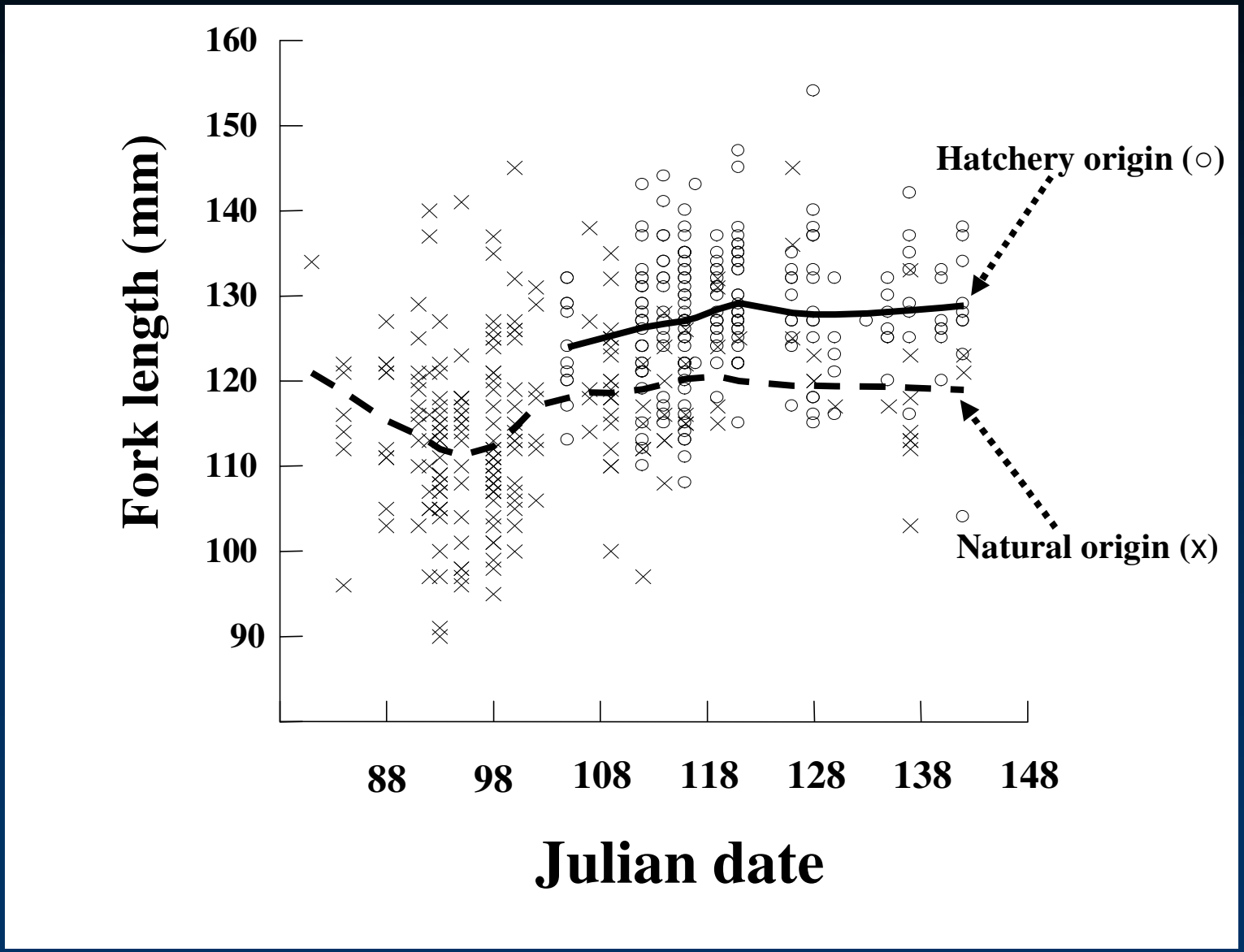
- use only natural-origin broodstock
- take no more than 50% of the NO returns into the hatchery
- PHOS mean=56% (6-76%); PNI mean=65% (57-84)
- utilize factorial crosses during artificial matings
- limit the proportion of NO jacks in the broodstock
  Mean = 12.7% (range 6.0 – 29.2)
- randomly mate individuals
- use "best culture practices" such as low rearing densities
- volitionally release juveniles at sizes larger than, but comparable to, wild-origin smolts

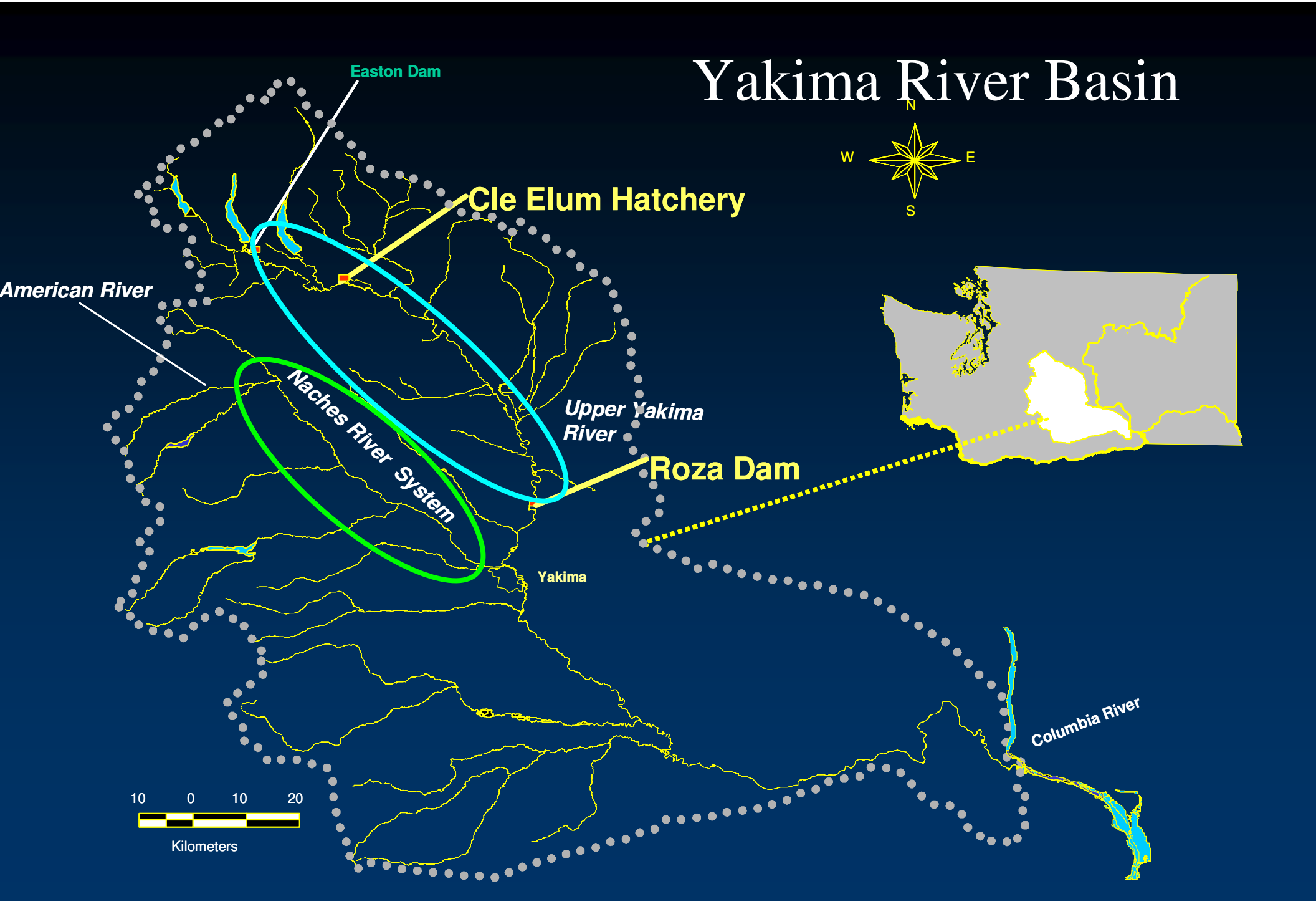
Yearling Smolt Fork Length at Chandler 2006 (BY2004)

(LOWESS trend lines shown)



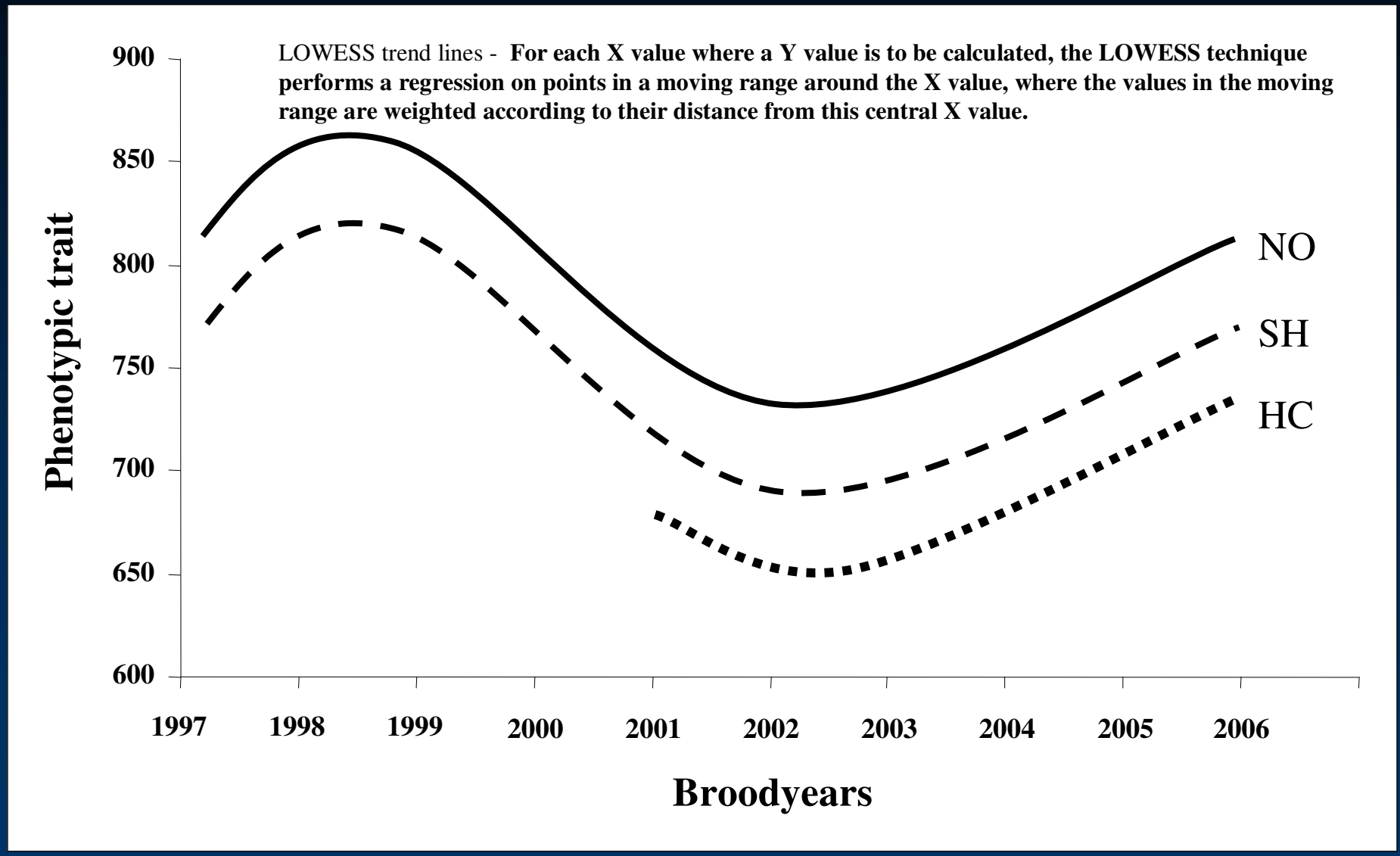
Yearling Smolt Fork Length at Chandler 2007 (BY2005)



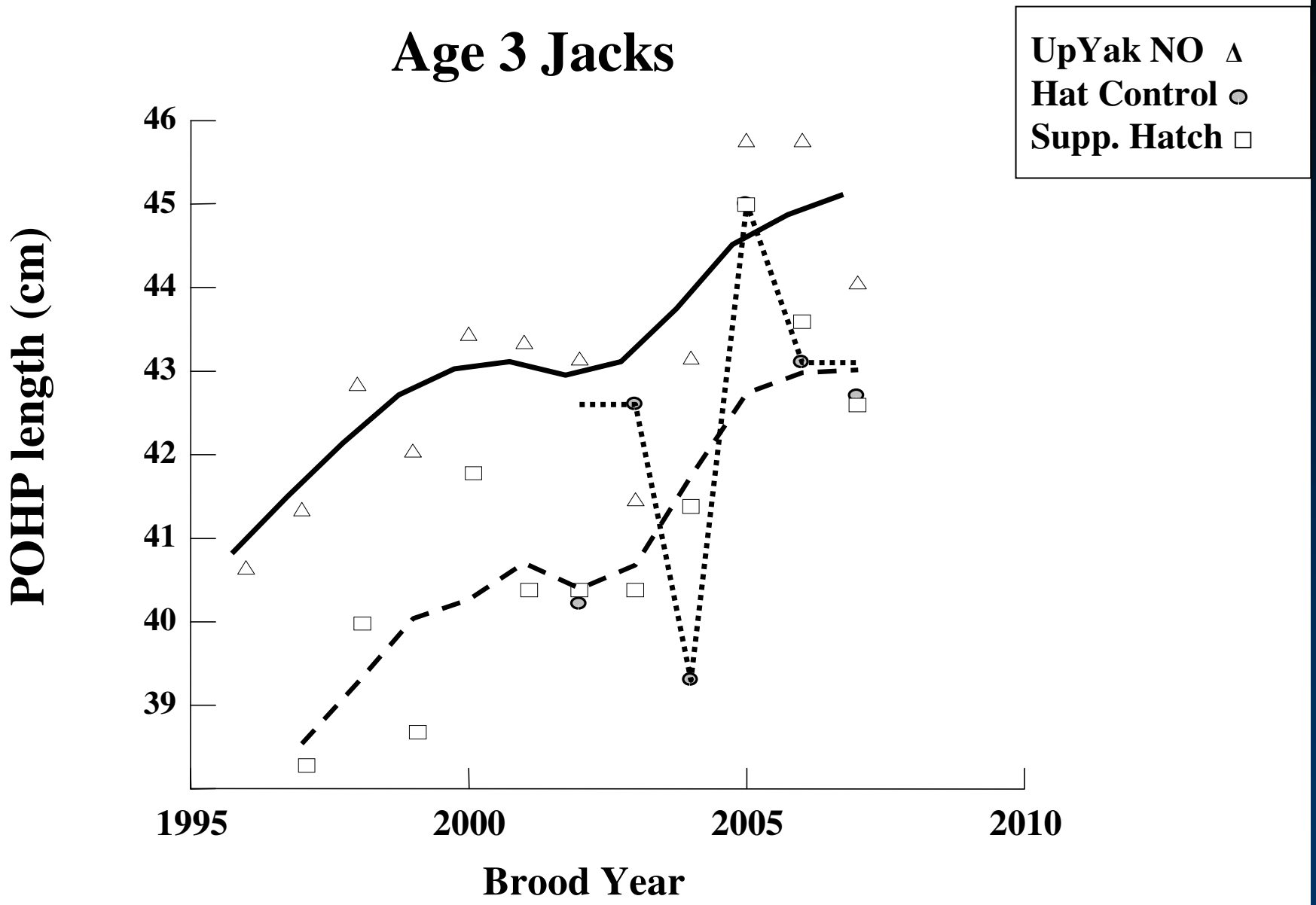

Yakima River Basin
Easton Dam
Cle Elum Hatchery
American River
Naches River System
Upper Yakima River
Roza Dam
Yakima
Columbia River
N
W
E
S
10 0 10 20
Kilometers

Roza Dam Adult Monitoring Facility

Trends In Traits Over Broodyears

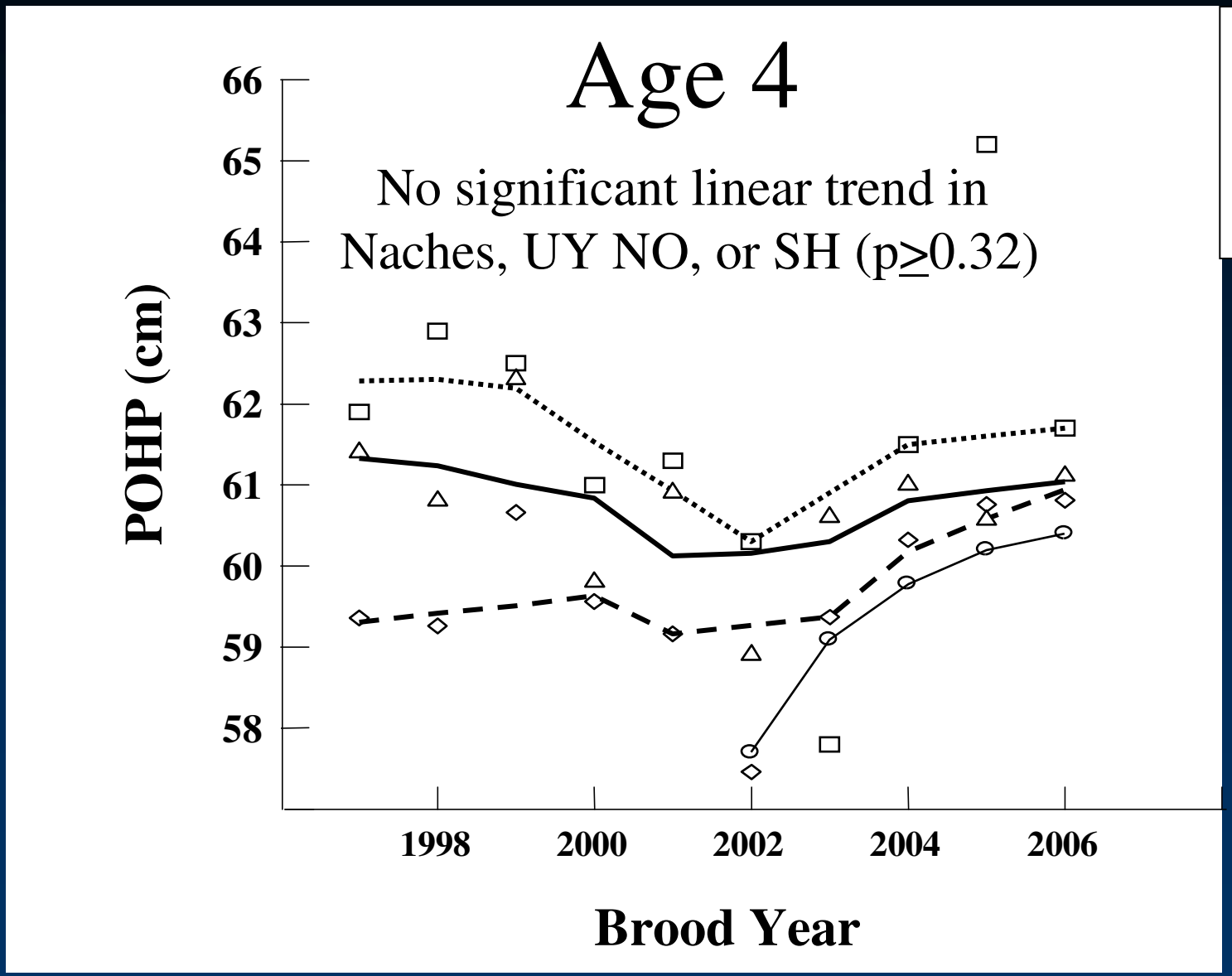



Size-at-Age
STEARNS
MANUFACTURED BY
STEARNS MFG.


Age 3 Jacks
UpYak NO
Hat Control
Supp. Hatch
POHP length (cm)
46
45
44
43
42
41
40
39
1995
2000
2005
2010
Brood Year

Jack Size-at-Age

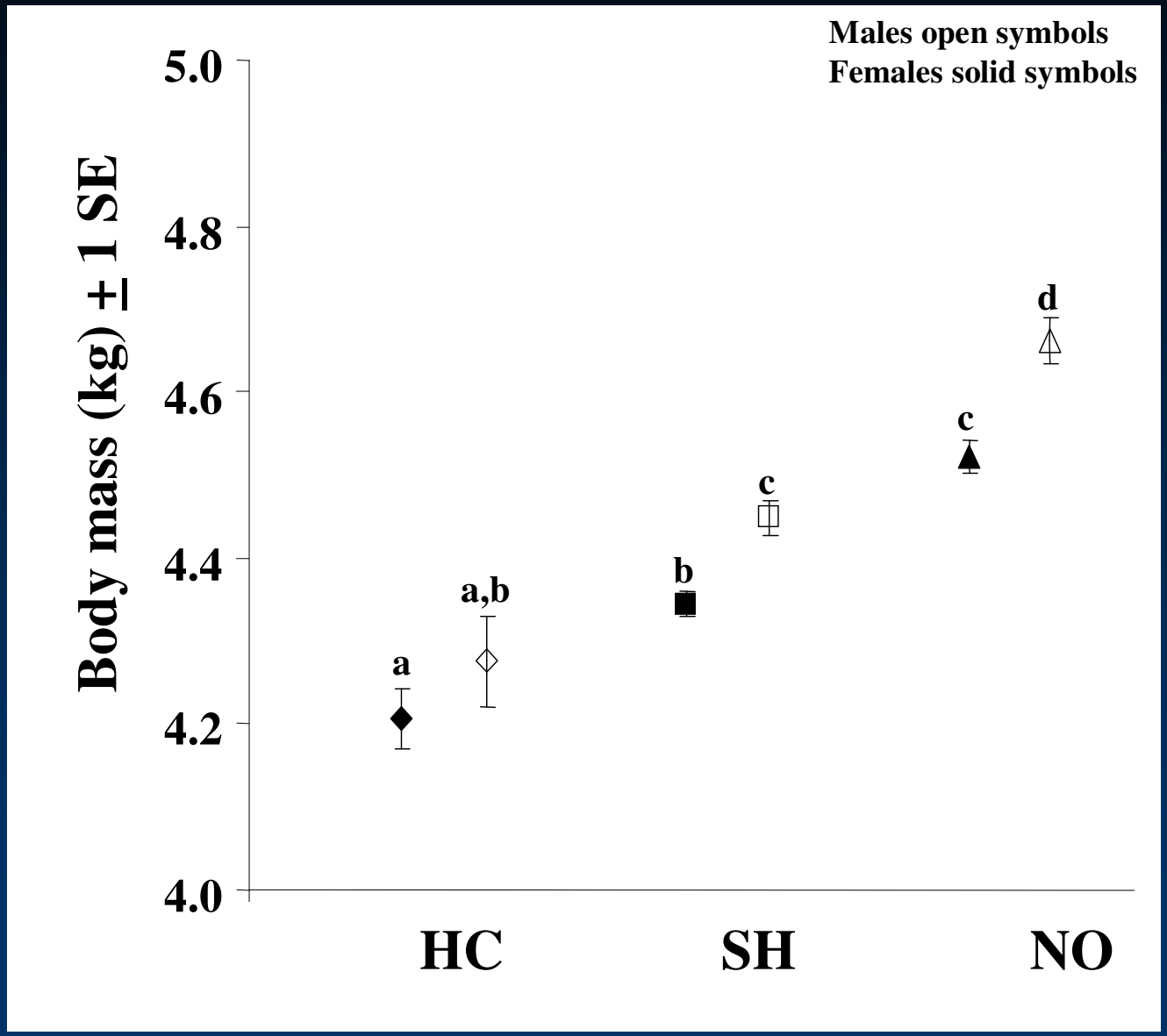
- Age 3 jacks have significantly increased in size over time in both hatchery and natural origin UY populations at the same rate (cm/yr)
- NO jacks are significantly larger than SH jacks and have been since the first generation of hatchery jack production
- Yet, SH smolts are equal to or larger than NO smolts, typically leading to larger adult body size and younger age at maturation (see Hi/Lo Growth Study presentation by Don Larsen, NOAA)


Age 4
No significant linear trend in Naches, UY NO, or SH (p≥0.32)
UpYak NO Δ
Naches NO □
Supp. Hatch ◊
Hat Control ○
POHP (cm)
66
65
64
63
62
61
60
59
58
1998
2000
2002
2004
2006
Brood Year

Age 4 Size-at-Age

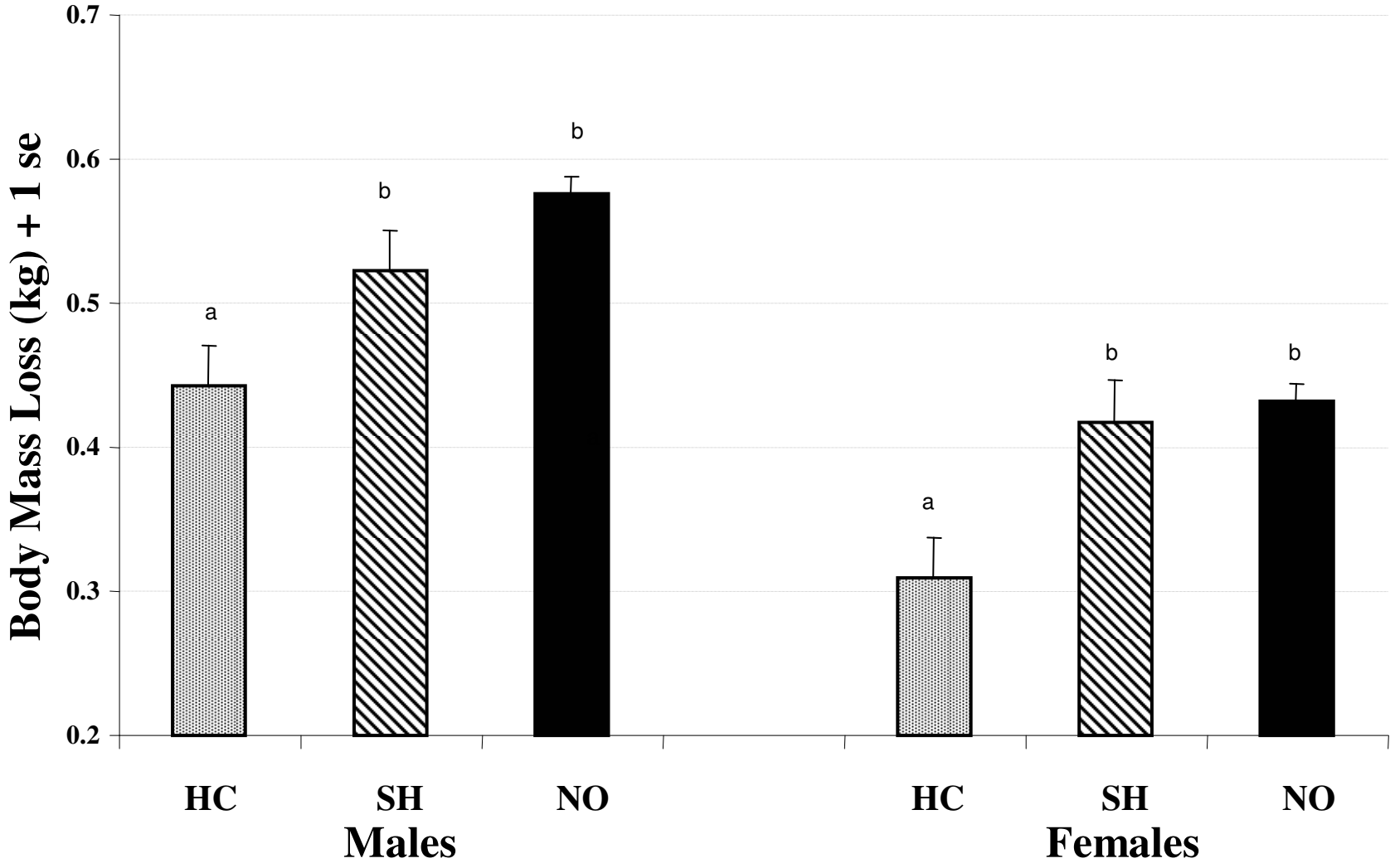
- While differing in mean size, Naches (a true wild control population) and U Yakima NO age 4 fish exhibited the same lack of trend in size over time
- Hatchery origin UY population also showed no significant trend over time, but has converged on the NO population
- No apparent negative effect (decrease in mean size) of naturally spawning hatchery fish on naturally produced fish

2010 Body Mass At RAMF

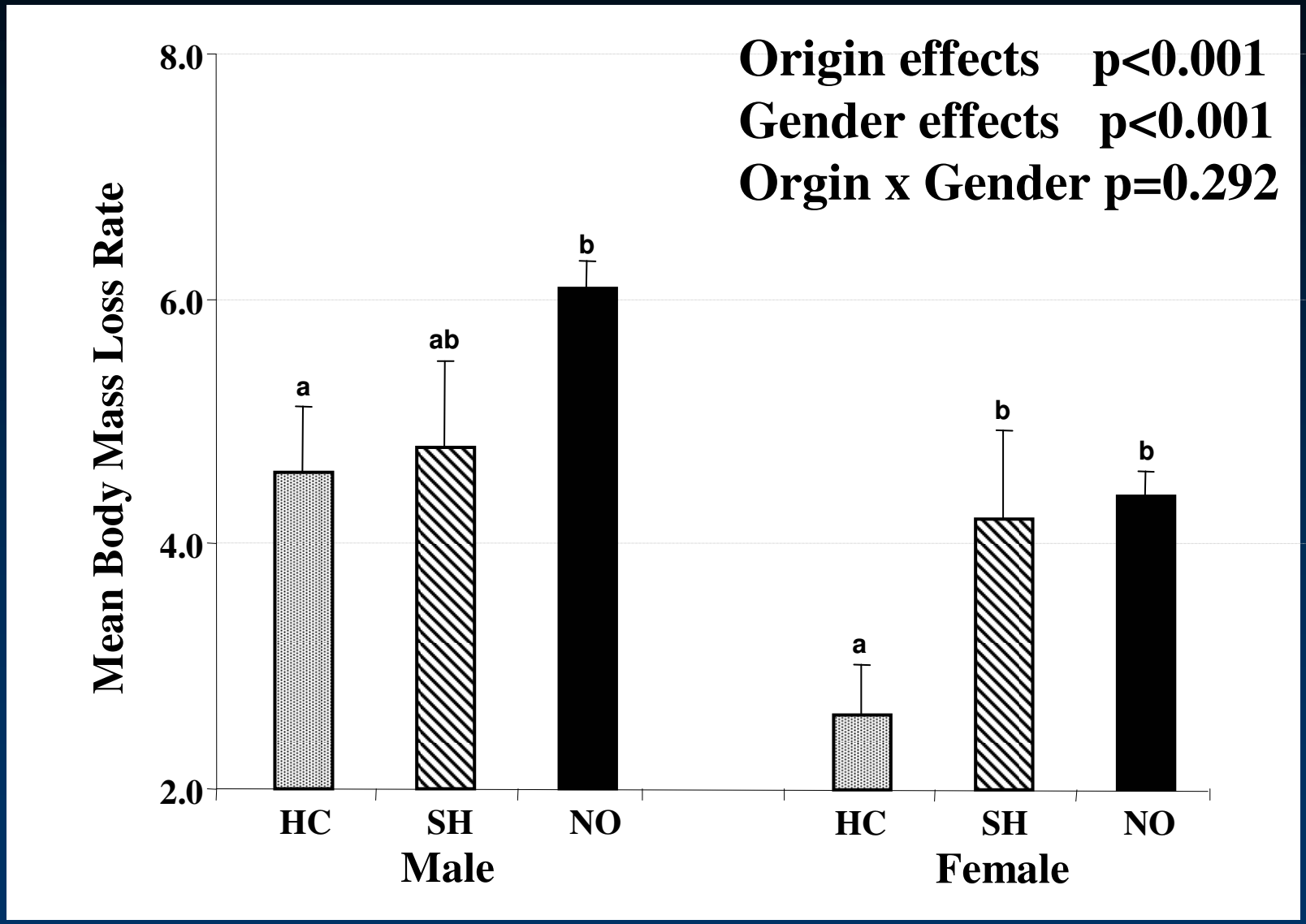


We rarely observe significant differences in body size (dimorphism) between the sexes at full maturity. However, here are body mass means for 2010 for males and females. Significant Origin effects, but also significant Gender effects. The letters indicate means significantly different in a Tukey MCT. The detection of significant differences is likely a function of the increased gender-specific data (over an order of magnitude greater) made possible by an ultra-sound device for gender identification used in 2010.

2010 Body Mass Loss During Captivity



2010 Mean BM Loss Rate (g body mass/day)



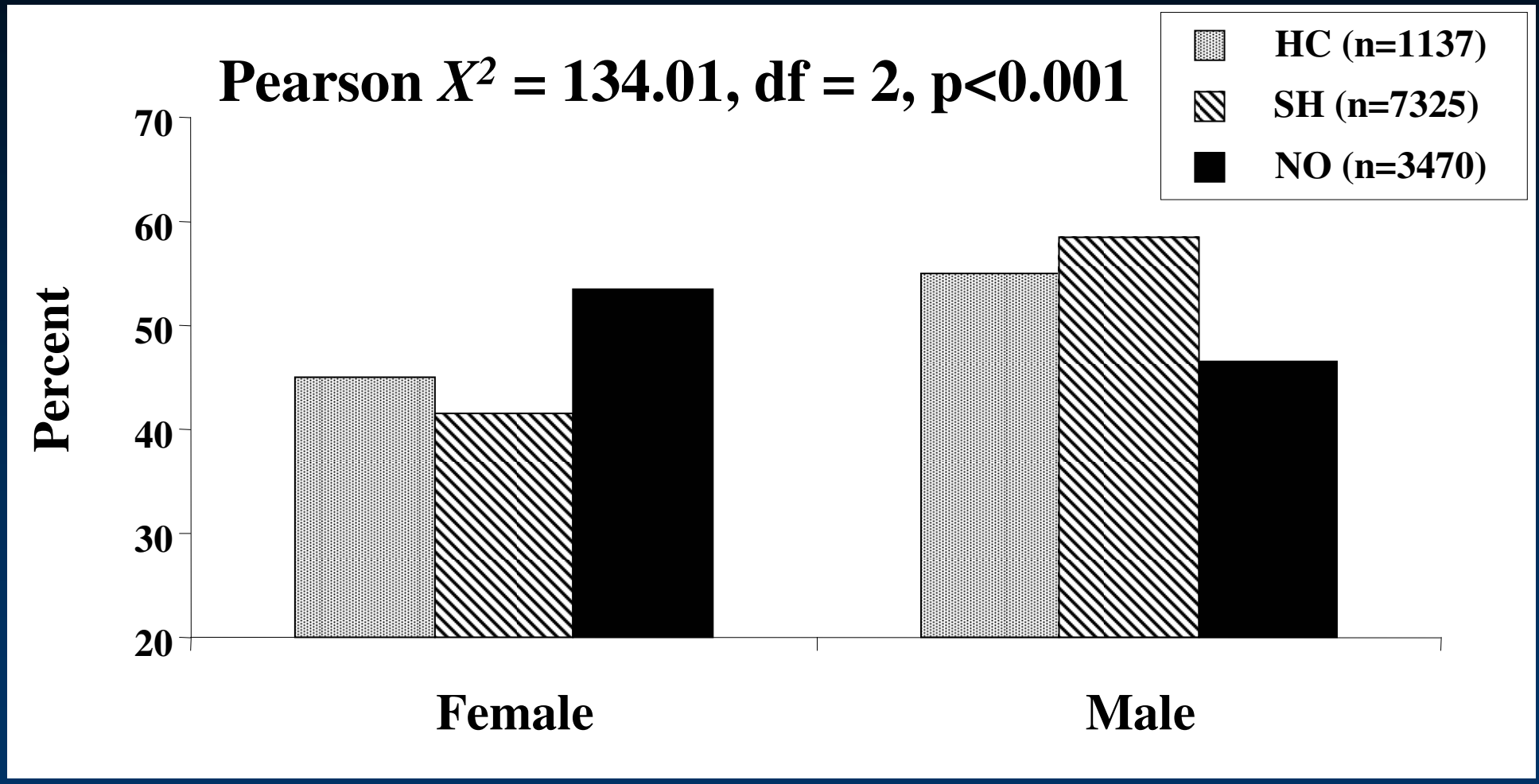
Gender Identification

- **1997 to 2009 we estimated gender ratios from fish collected at RAMF and then taken to CESRF and held to maturity or death**
- **All adipose fin clipped fish were inspected and gender identified visually, but errors were 20-30% for males and 10% for females**
- **We also used DNA-sexing on a random sample of 145 hatchery adults/year**
- **Beginning in 2010, an ultrasound device (Honda HS-101V) was used on all fish passing RAMF increasing gender-specific data by more than an order of magnitude**

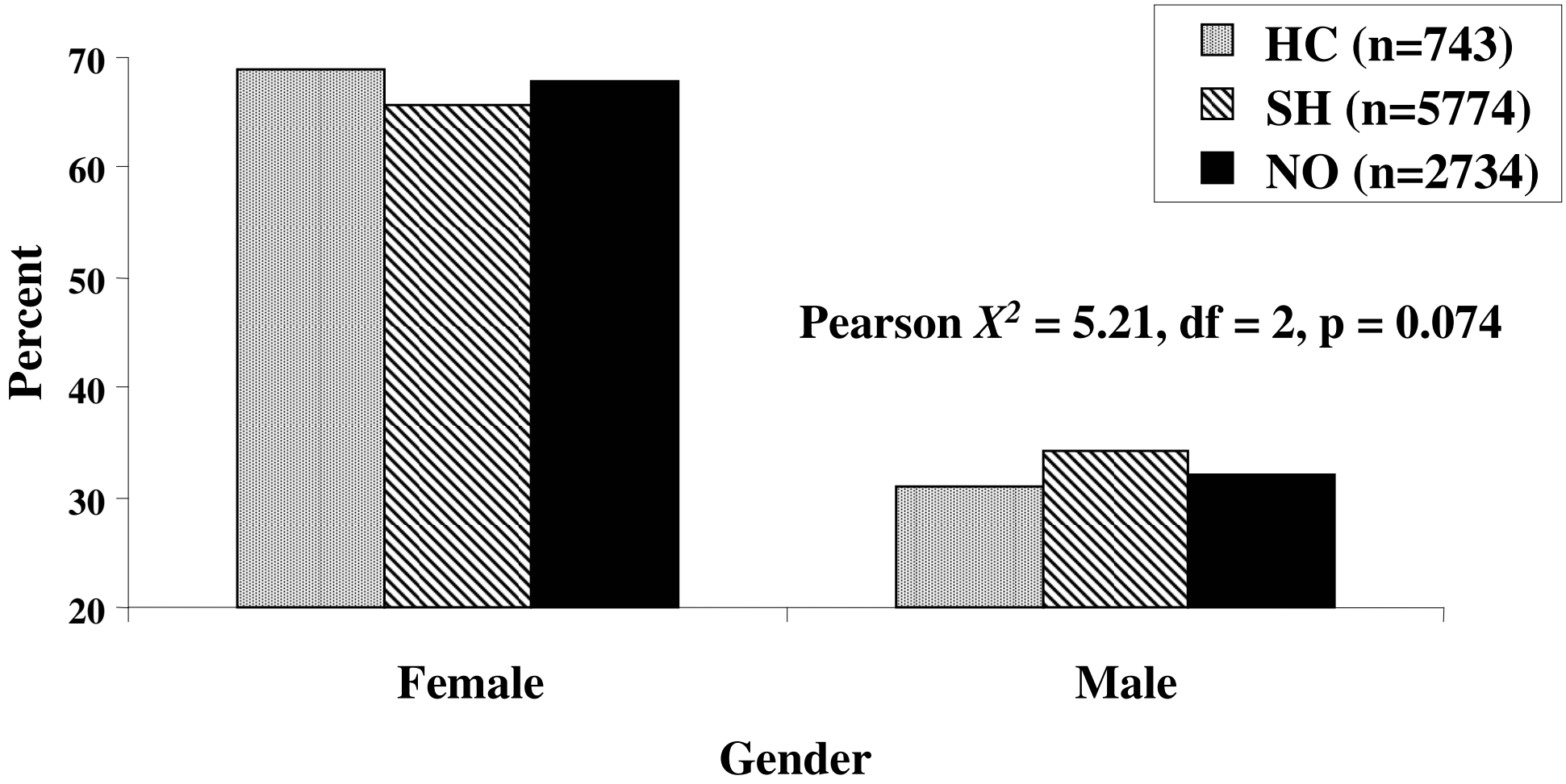
Gender Identification 2010

- **Of a total of 624 fish classified to gender using ultrasound and then held to maturity**
- **621 (99.5%) were corrected classified**
- **All 9,749 fish passing RAMF were classified to gender in 2010**

Gender Comparison BY2006 (Ages 3 and 4)



Gender Comparison BY2006 (Age 4 only)

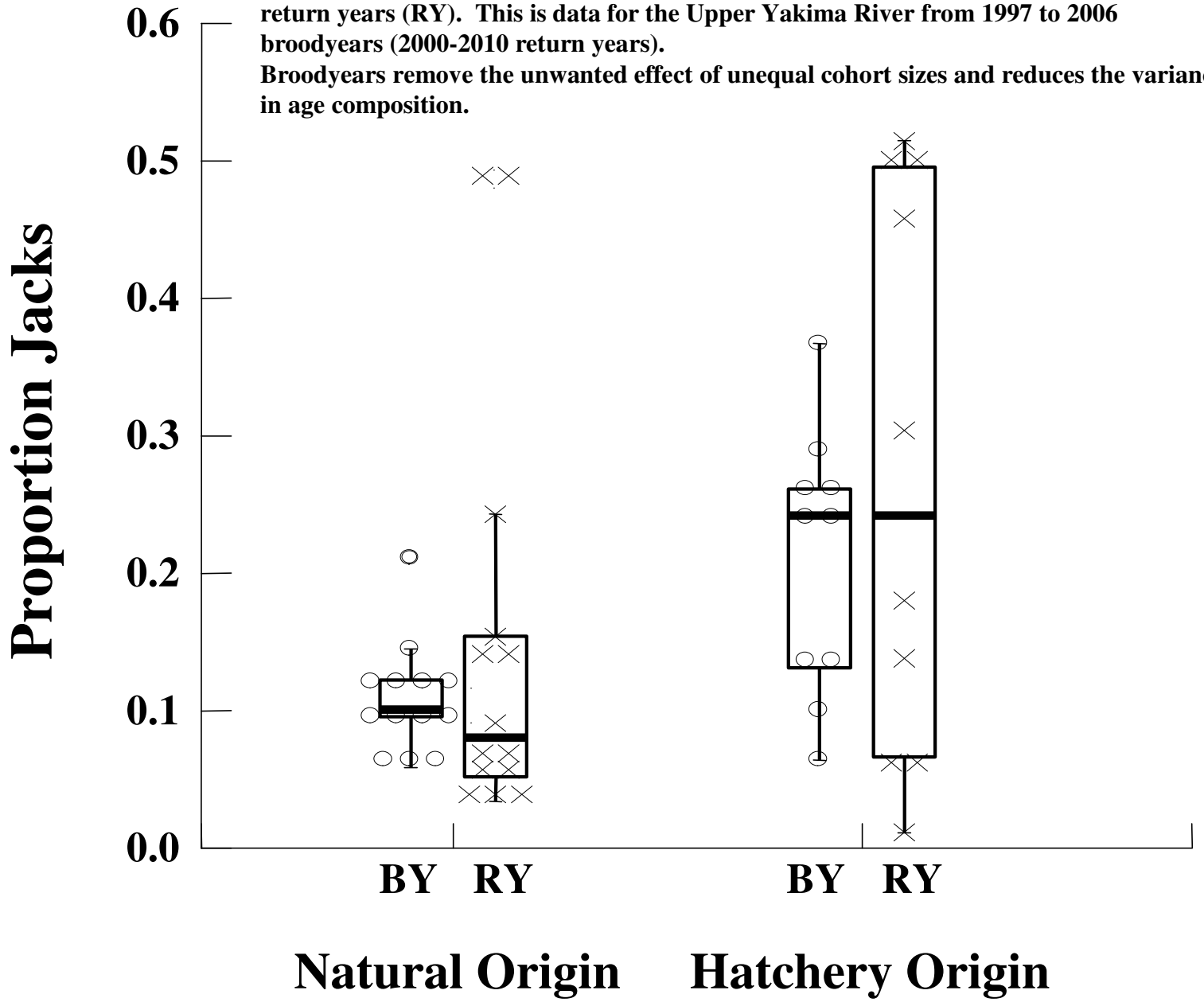


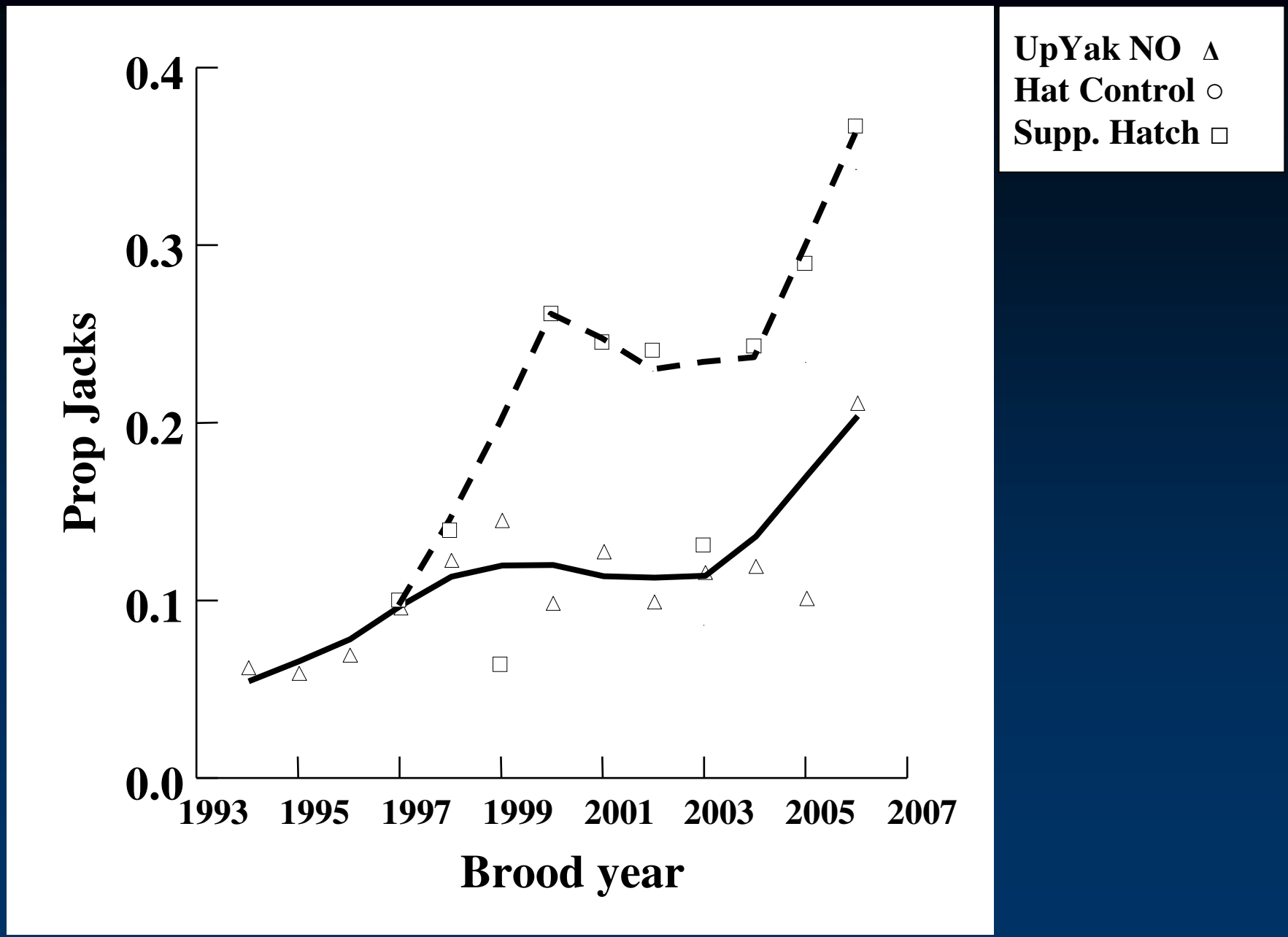
Why aren't the F:M ratios of age 4 UY hatchery fish skewed toward females more than Natural Origin fish?

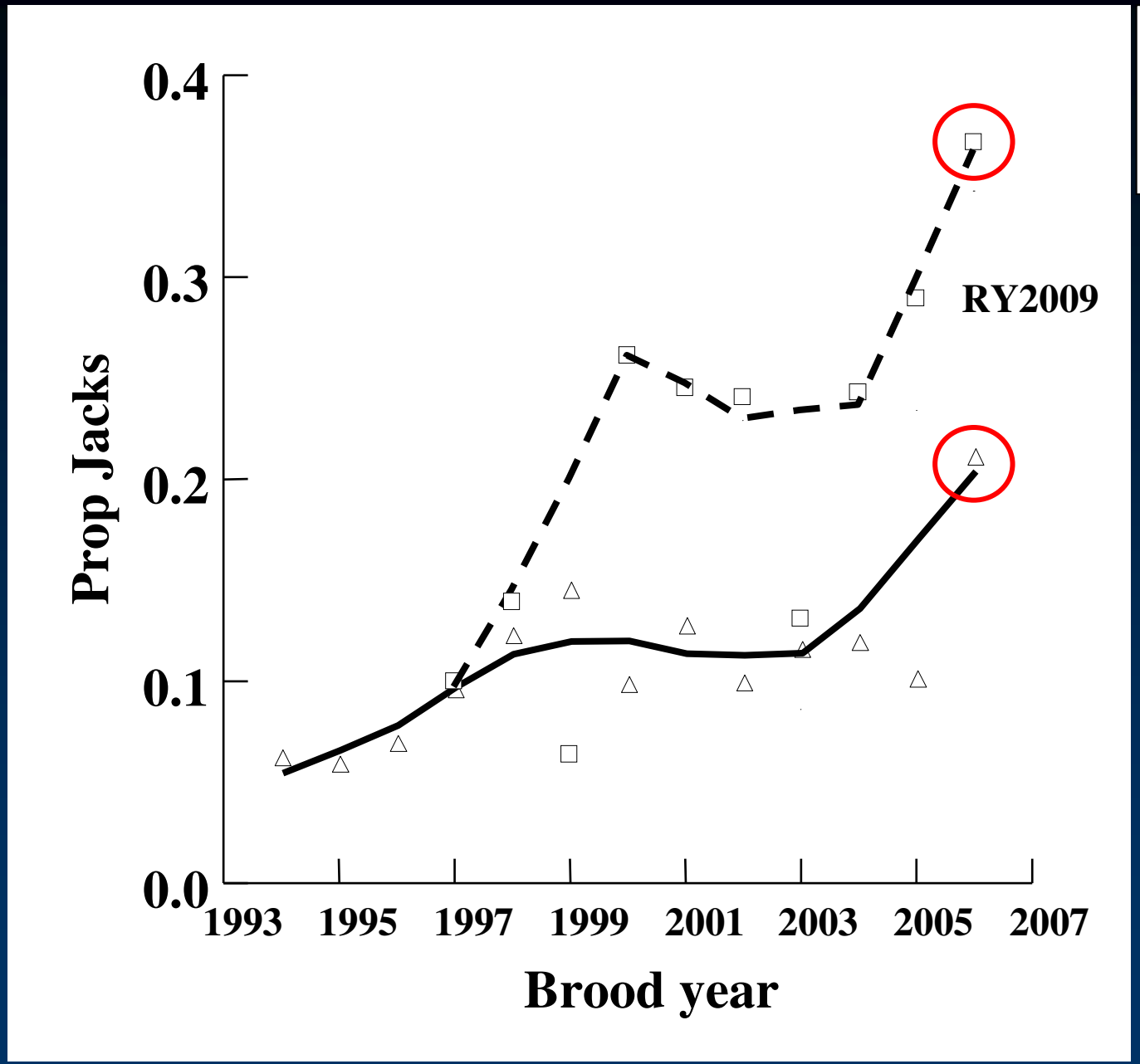
- **BY 2006 – SH and HC males had 40-54% minijack production**
- **BY2006 – SH and HC jack production was ~50% greater than for NO fish**
- **Yet, there is no significant difference in the proportion of adult age 4 females and males even with very large sample sizes**
- **More work is needed on this question**

Trends In Jack BY Proportions

This illustrates why we should focus on broodyear age composition (BY), rather than return years (RY). This is data for the Upper Yakima River from 1997 to 2006 broodyears (2000-2010 return years).
Broodyears remove the unwanted effect of unequal cohort sizes and reduces the variance in age composition.



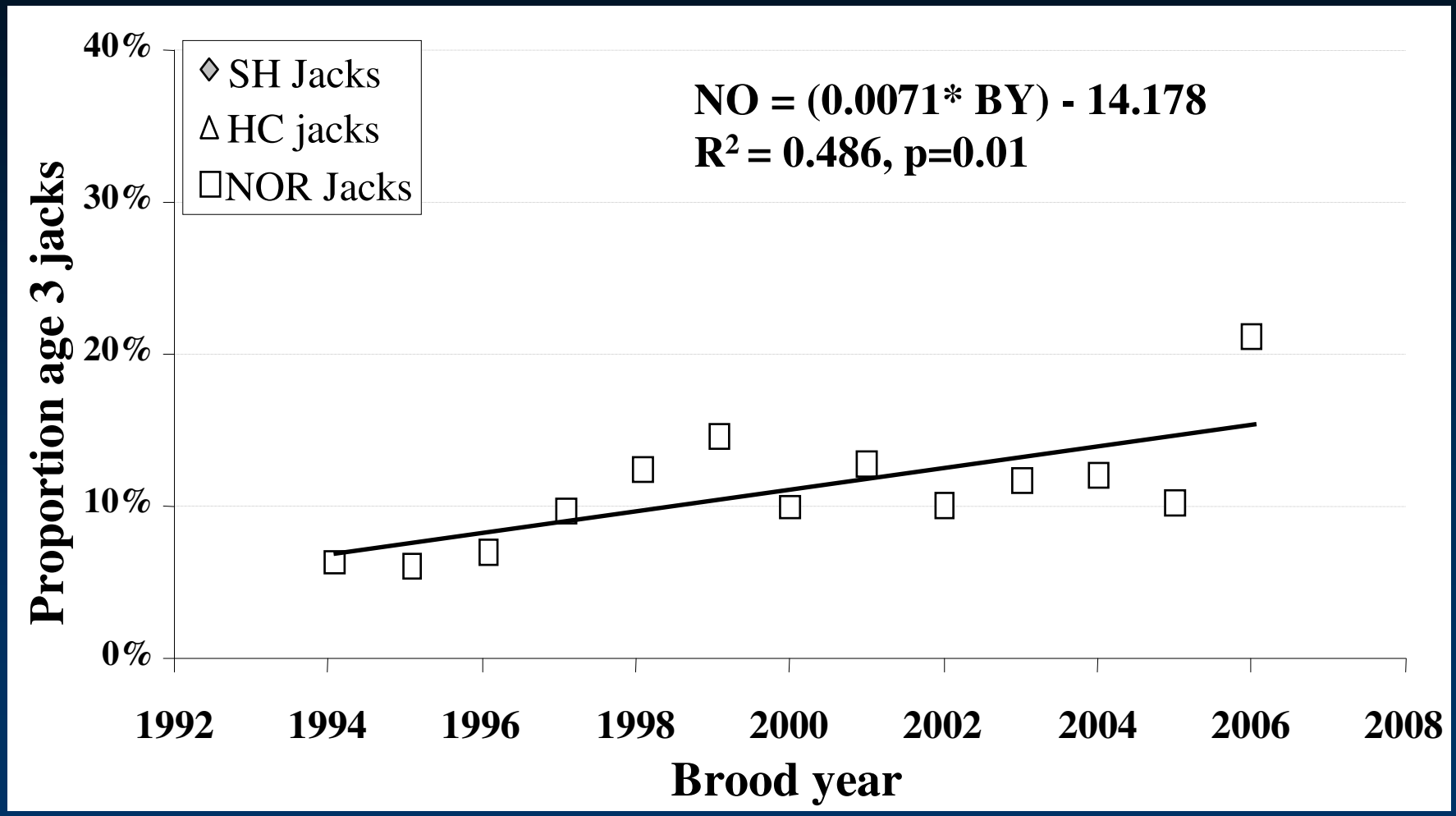

UpYak NO ∆
Hat Control ○
Supp. Hatch □
Prop Jacks
0.4
0.3
0.2
0.1
0.0
1993
1995
1997
1999
2001
2003
2005
2007
Brood year



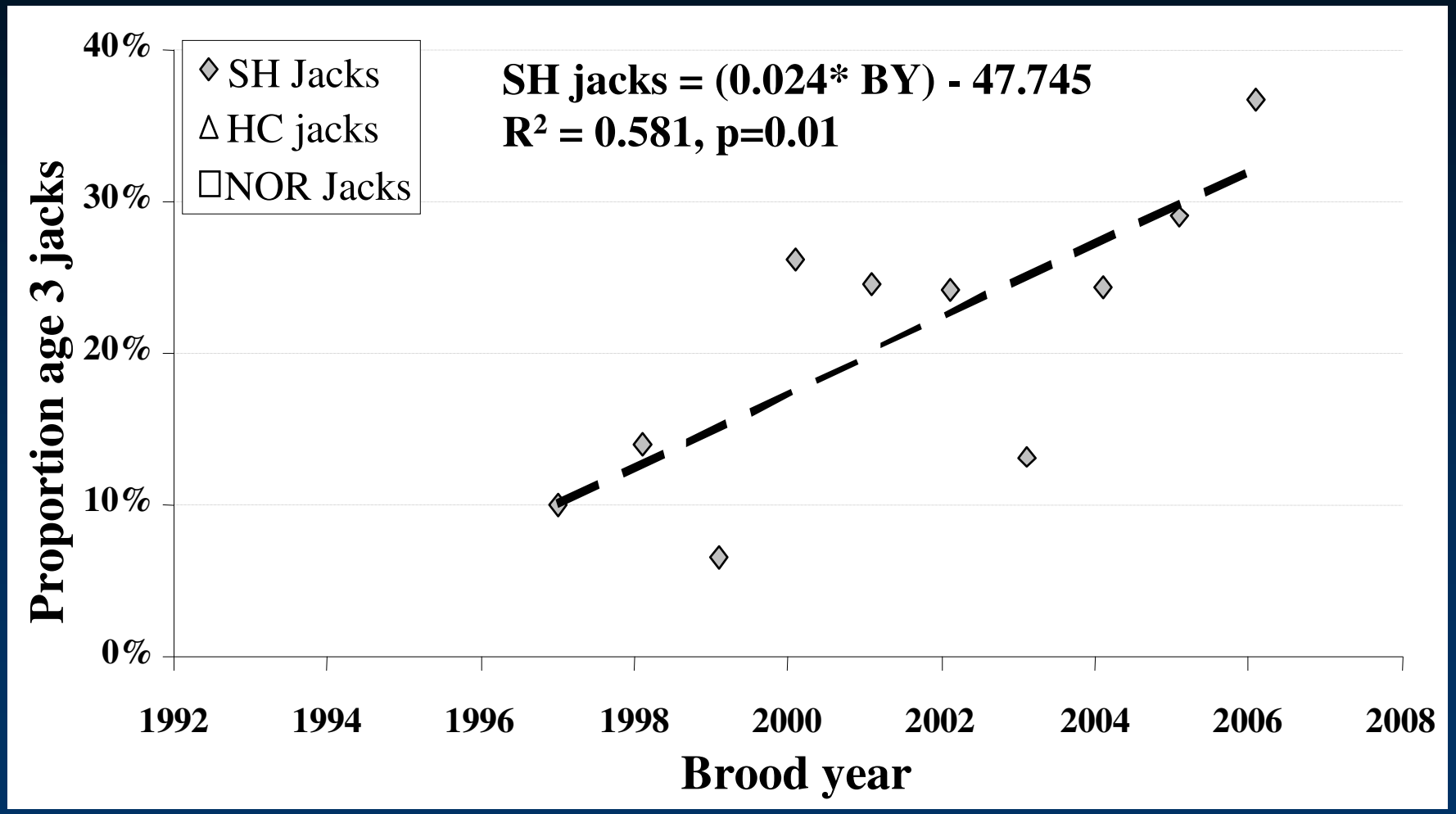
UpYak NO △
Hat Control ○
Supp. Hatch □

Broodyear 2006 (RY 2009) was significantly higher for both NO and SH populations.

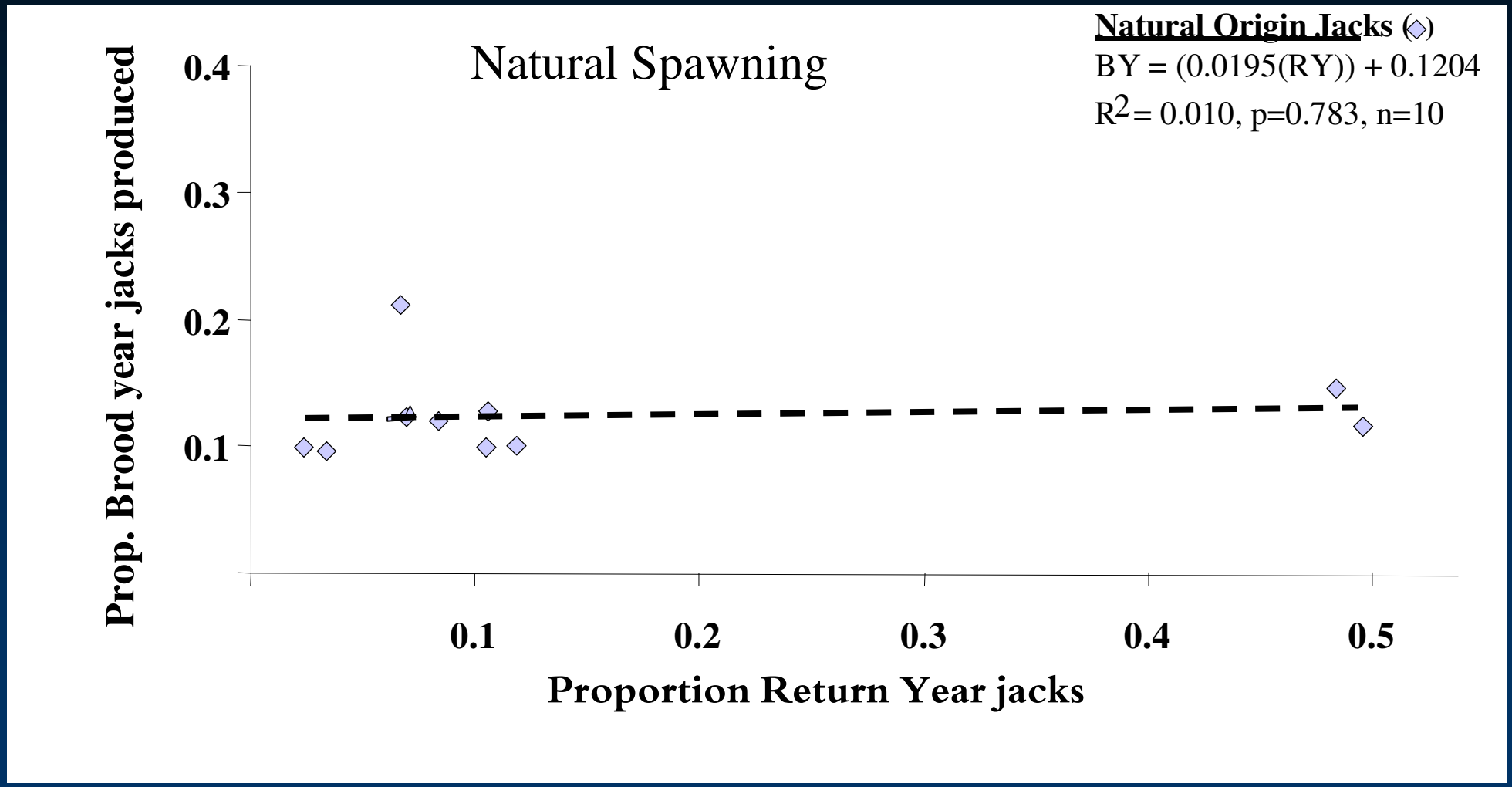
Proportion Age 3 Jacks Over Time



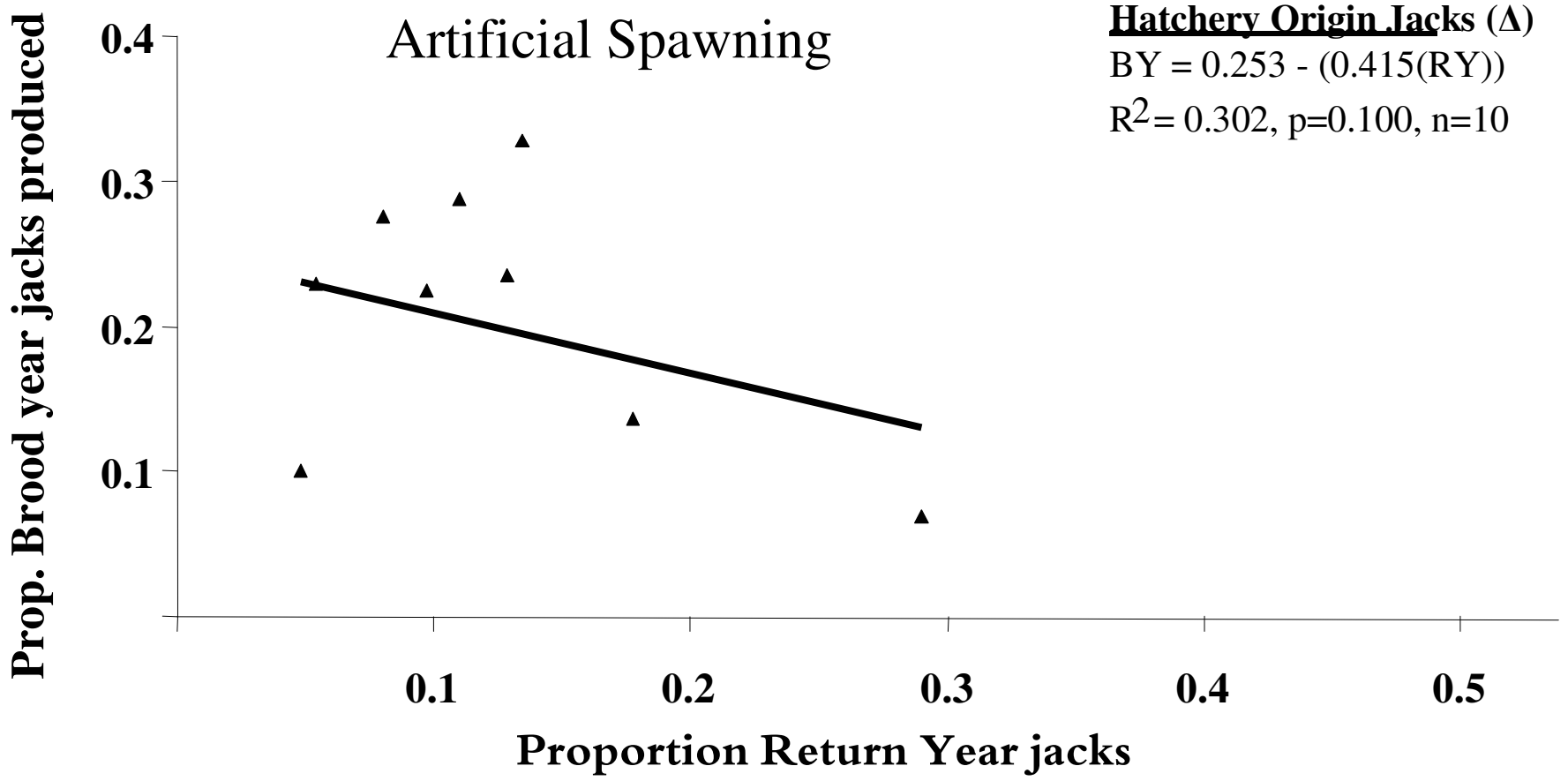
Proportion Age 3 Jacks Over Time



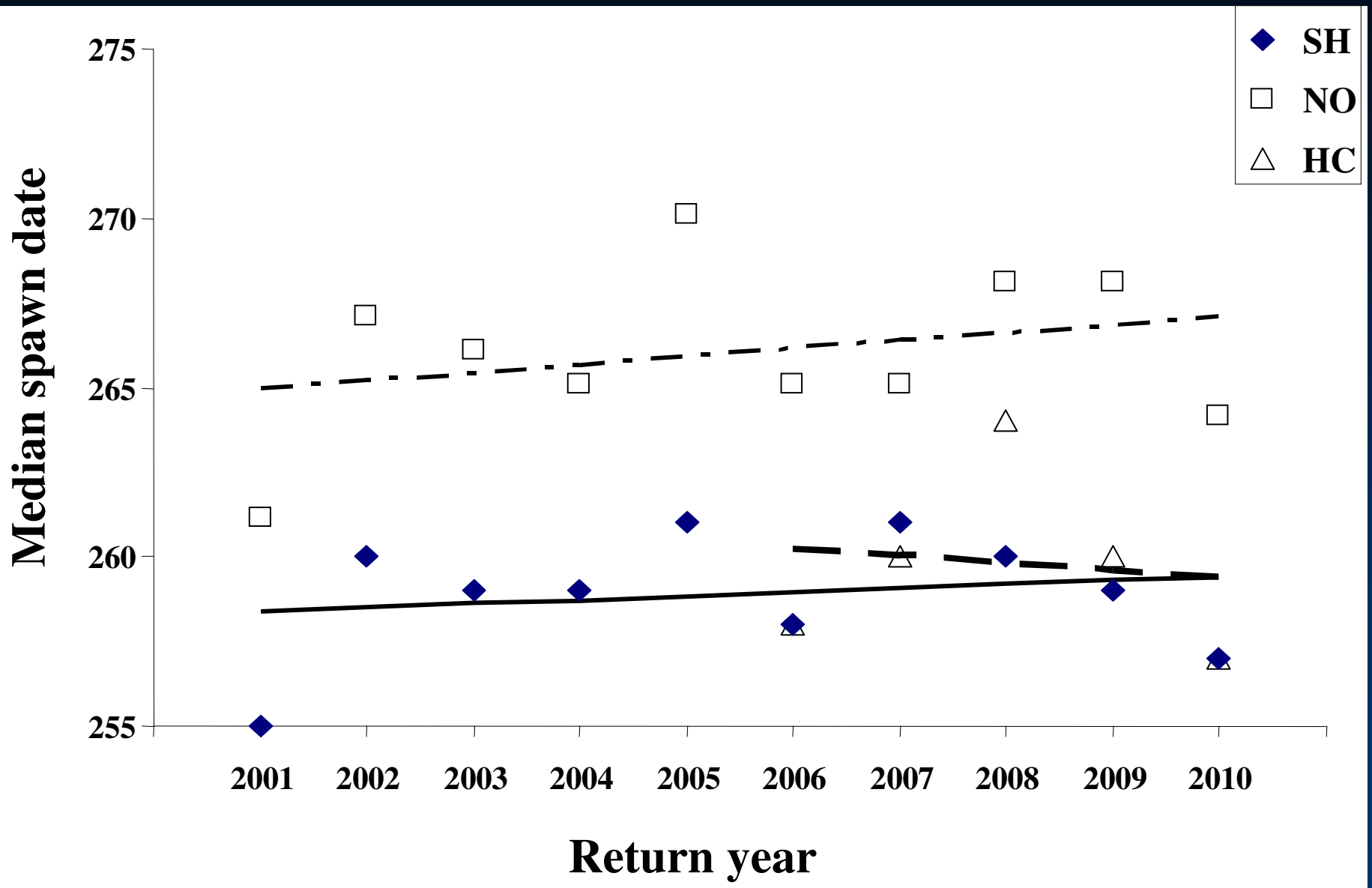
Proportion Jacks Spawned vs Proportion Jacks Produced



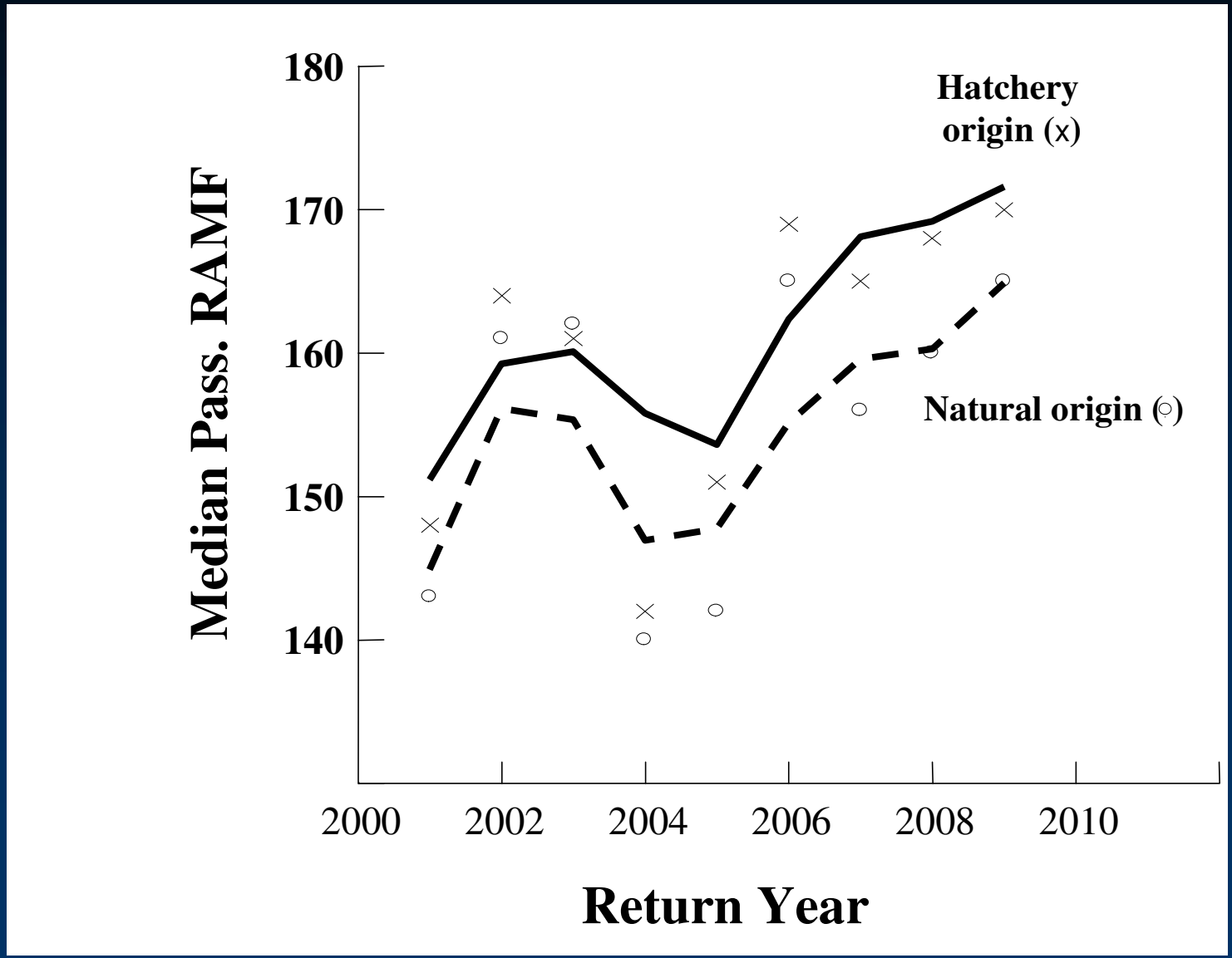
Proportion Jacks Spawned vs Proportion Jacks Produced



Median Spawning Date At CESRF



Median Passage Date At RAMF



Conclusions – Size-at-age

- **Age 3 SH and HC jacks were significantly smaller than NO fish, but all were increasing in size over time at the same rate.**
- **Age 4 have not increased significantly in size over time, but SH and HC fish have reduced the difference between NO fish and are now approximately equal in size.**

Conclusions – Jack Production Trends

- **Hatchery jack production is significantly greater than NO jack production (11% vs 23% before BY2006)**
- **Jack production increased significantly in BY2006 in both SH and NO fish likely due to the increasing size-at-age of jacks which is likely driven by marine environmental conditions**

Conclusions – Gender Differences

- When all ages are analyzed, hatchery origin fish have a significantly higher proportion of males than NO fish
- If just age 4 fish are analyzed (which make up 70-95% of the cohort on average) there is no significant difference between NO, SH and HC gender proportions

Conclusions – Effects of Spawning Jacks

- The proportion of NO males maturing as jacks was not significantly affected by the proportion of jacks naturally spawning (range 3% to 50%)
- The proportion of SH males maturing as jacks was not significantly affected by the proportion of jacks used as broodstock (range 3% to 29%)
- Managing the proportion of naturally spawning jacks or jack in broodstock is not likely to have any significant affect on subsequent jack production in UY spring Chinook salmon

Conclusions – Other

- During captivity in 2010 the Body mass Loss rate (g body mass/day) of NO fish was significantly higher than for SH and HC fish
- Males of all types had significantly higher BM Loss rates during captivity than females
- Spawn timing of hatchery fish at CESRF was significantly earlier than NO fish
- Passage timing at RAMF was later for hatchery fish

Acknowledgements

- Yakama Nation Roza Adult Monitoring Facility Crew
- Cle Elum Supplementation Research Facility Crew
- WDFW Ecological Interactions Crew
- Bonneville Power Administration for providing funding through the Yakima/Klickitat Fishery Project Monitoring and Evaluation Program