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

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Objectives

- How has the mean size-at-maturity of UY natural and hatchery populations changed over time relative to Naches wild control?
- Has the proportion of natural or hatchery origin jacks changed over time?
- Does the proportion of jacks naturally spawning or used as broodstock influence future jack production?
- Does the sex composition of natural and hatchery populations differ?
- Has mean natural and hatchery origin egg size changed over time?
- Do PIT and non-PIT SARs still differ?

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 only, one generation of domestication. Supplement naturally spawning population, integrated population.
  - Hatchery Control (HC) Origin – Parental broodstock of hatchery origin only. Multiple generations of domestication. Are not allowed to naturally spawn, segregated hatchery population.
- Wild Control – Naches population

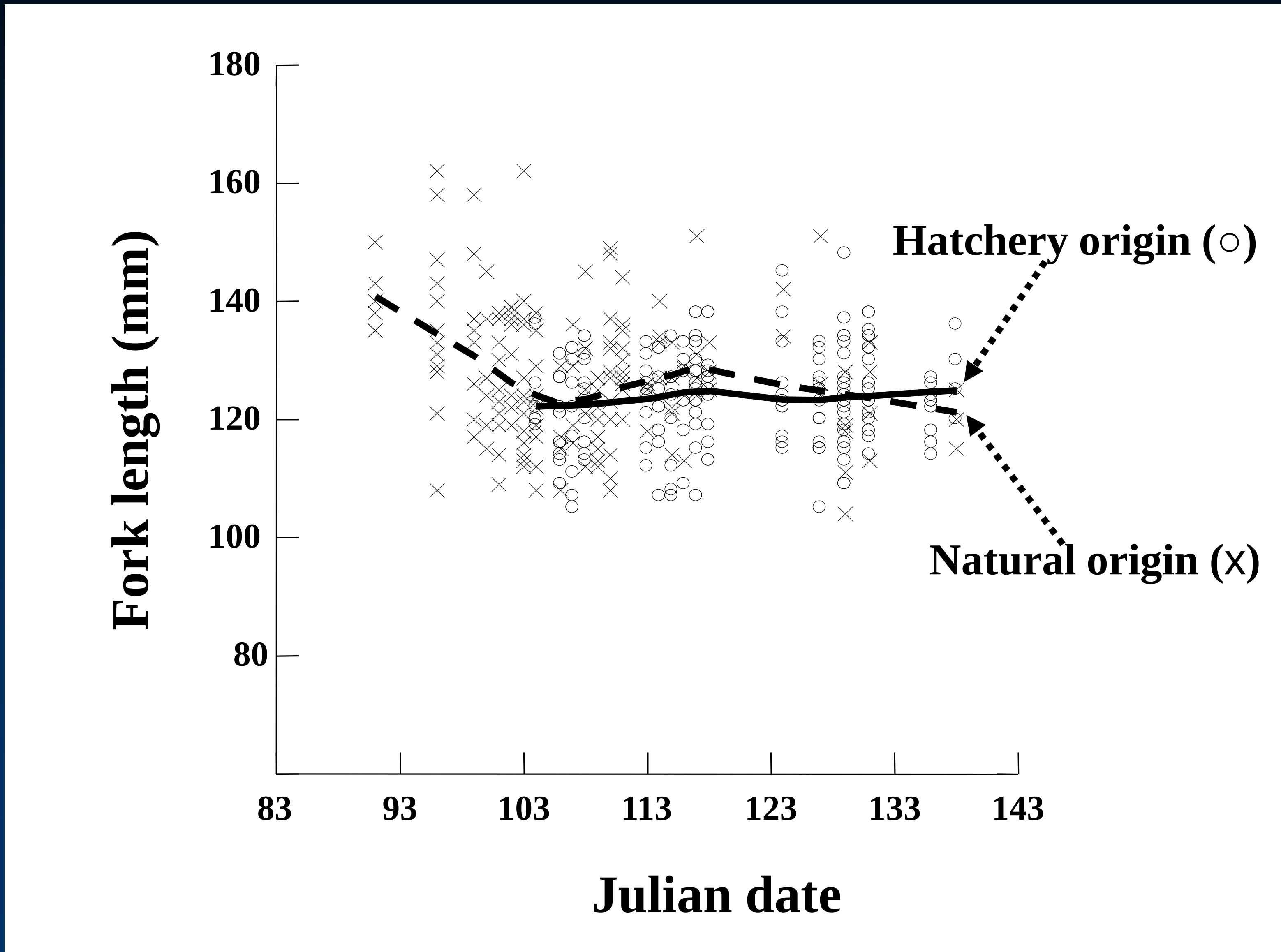
The YKFP spring chinook hatchery program was designed to minimize domestication effects

- use only natural-origin broodstock
- take no more than 50% of the NO returns into the hatchery
- 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)



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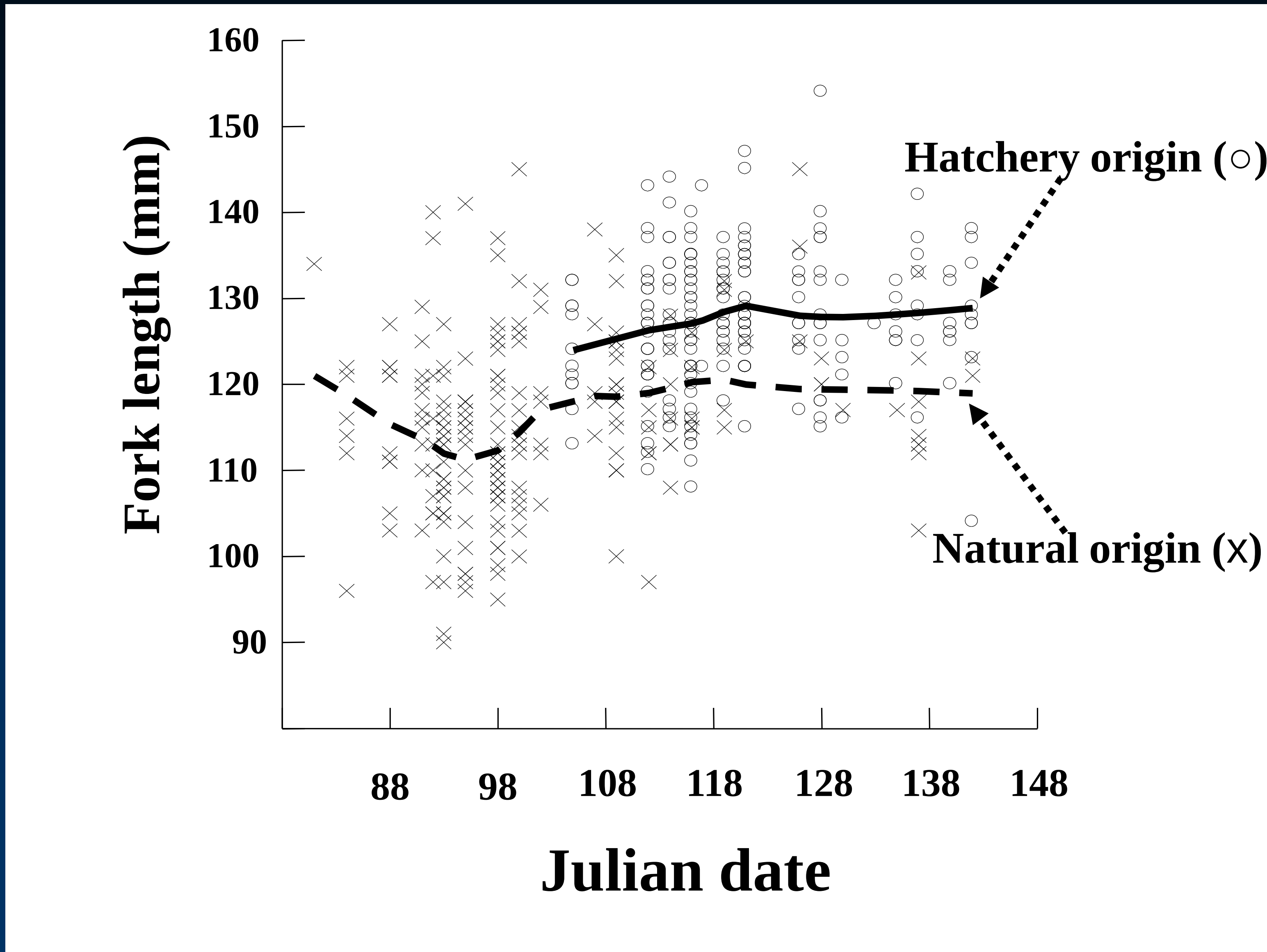
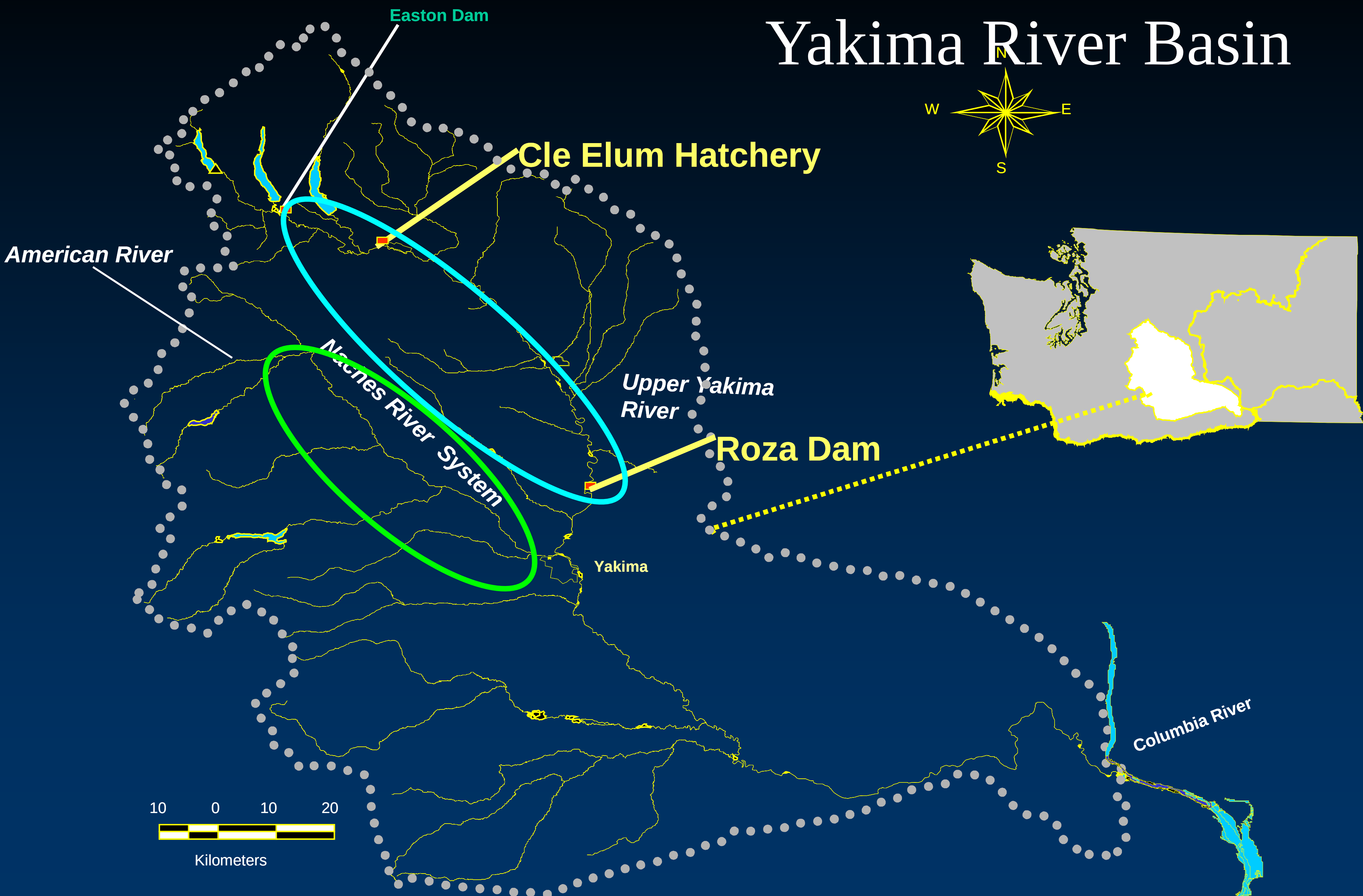
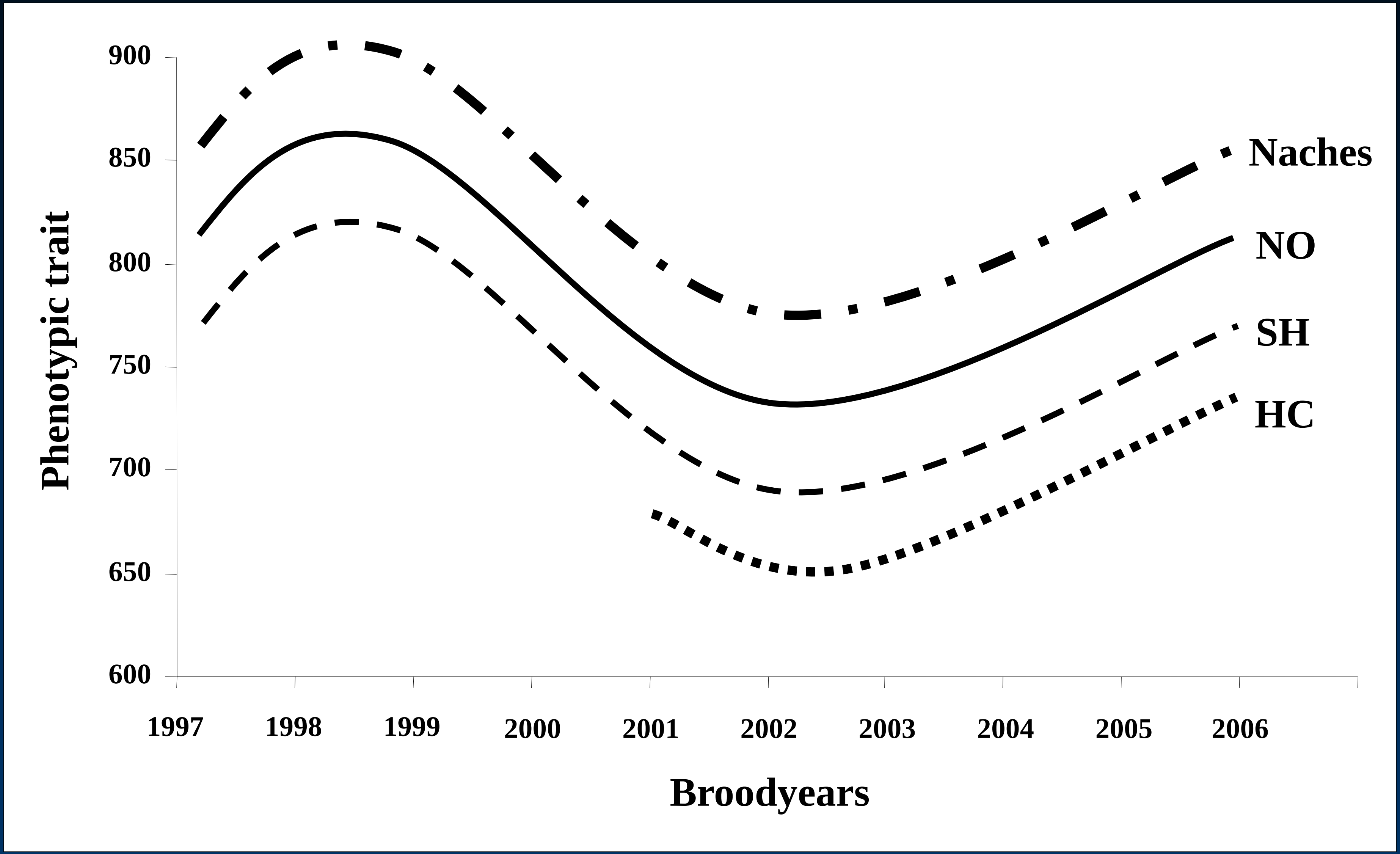


Yakima River Basin

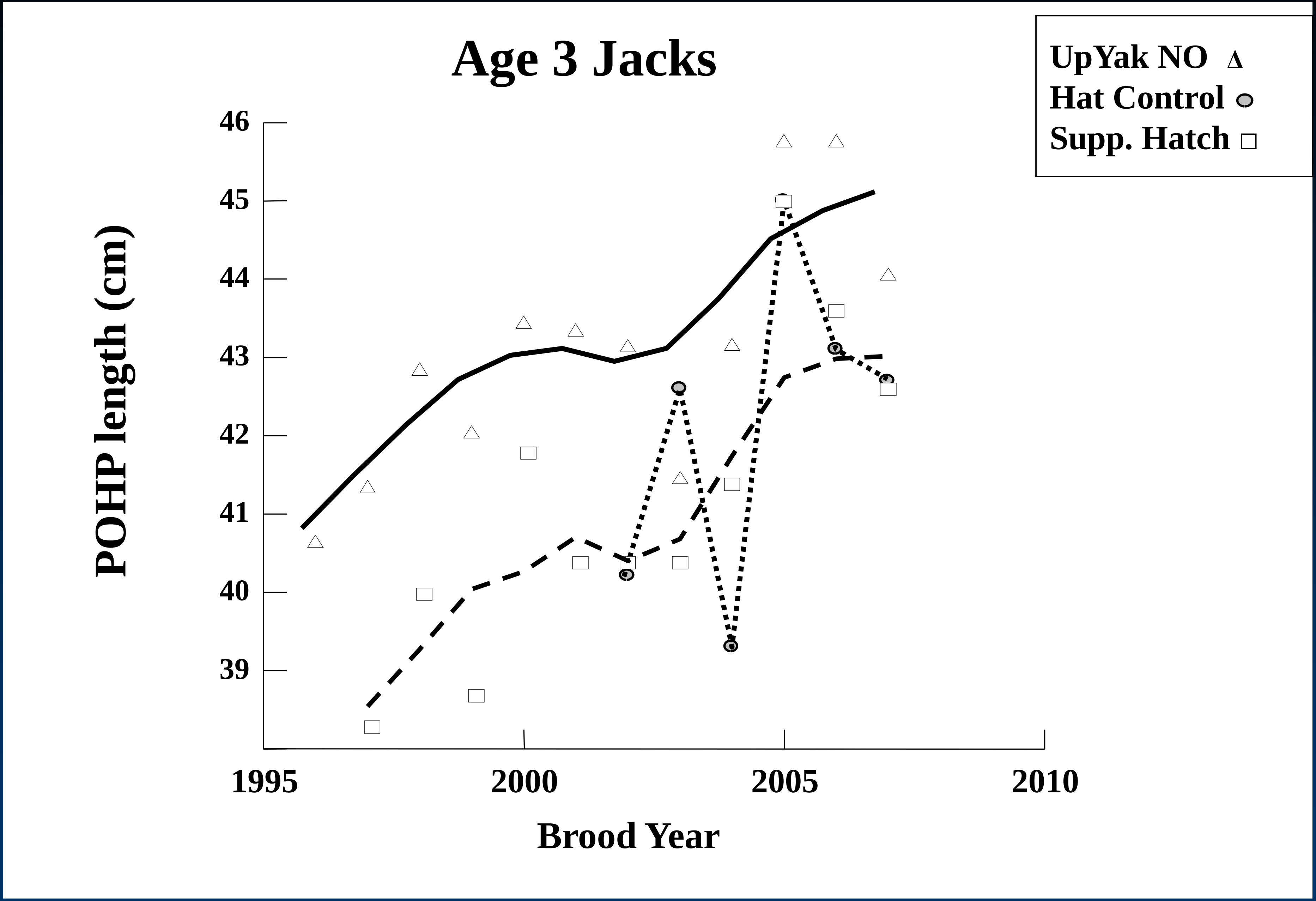


Roza Dam Adult Monitoring Facility

Trends In Traits Over Broodyears

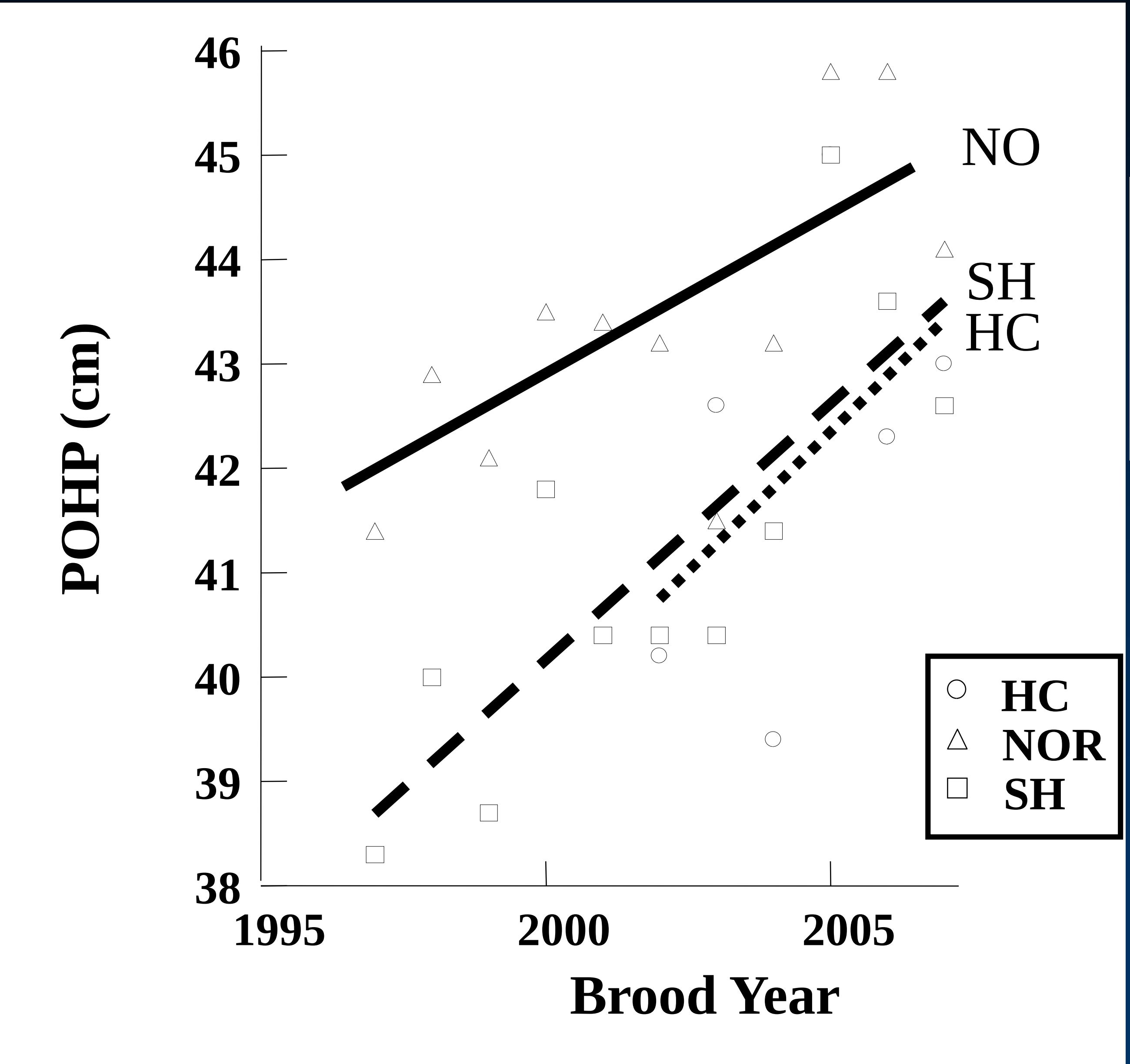


Size-at-Age



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

Linear Trends in Length - Age 3

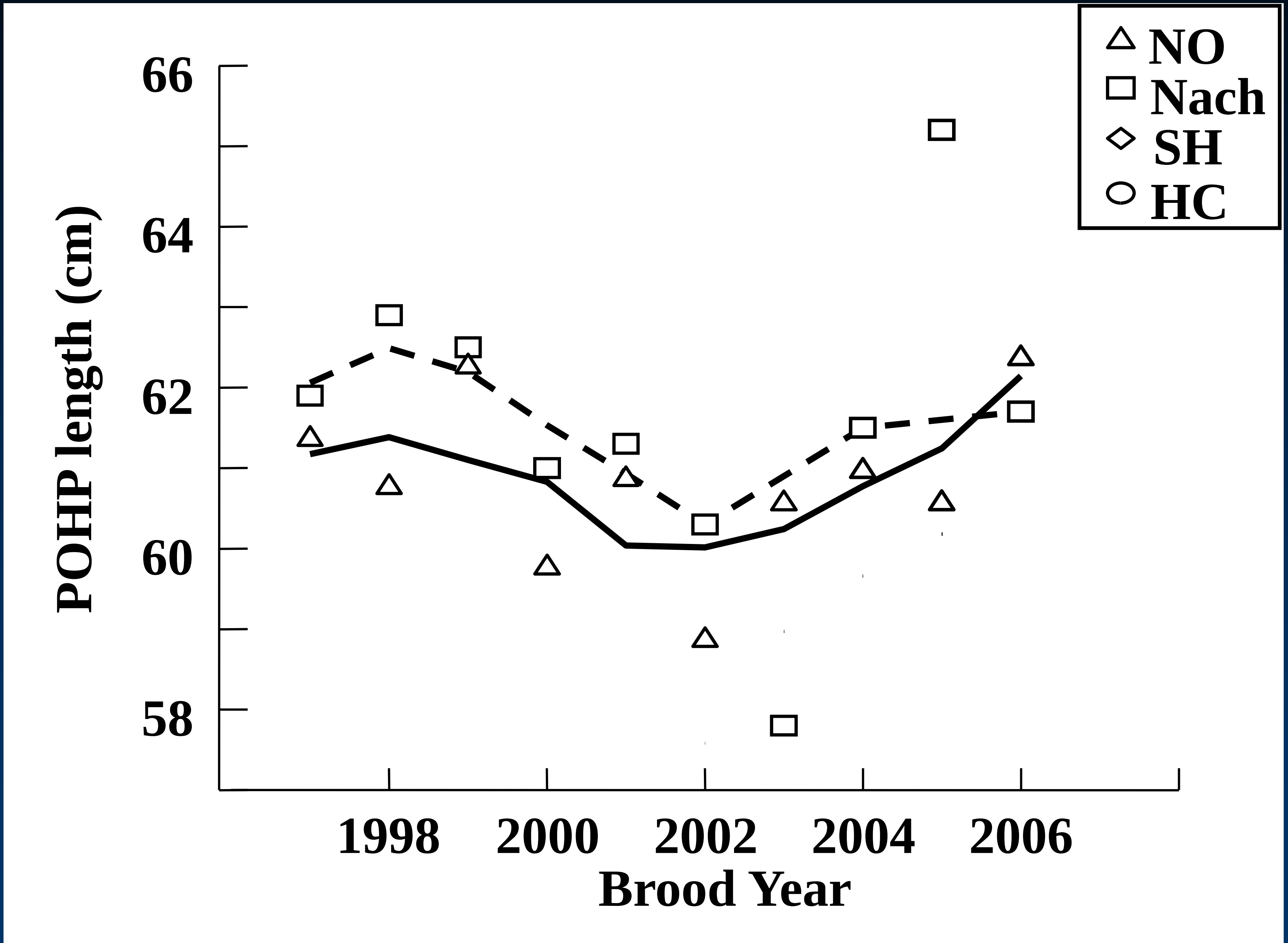


Regression (SH and NO)
$r^2>0.48$, $p<0.02$
ANCOVA
Equal slopes p=0.565

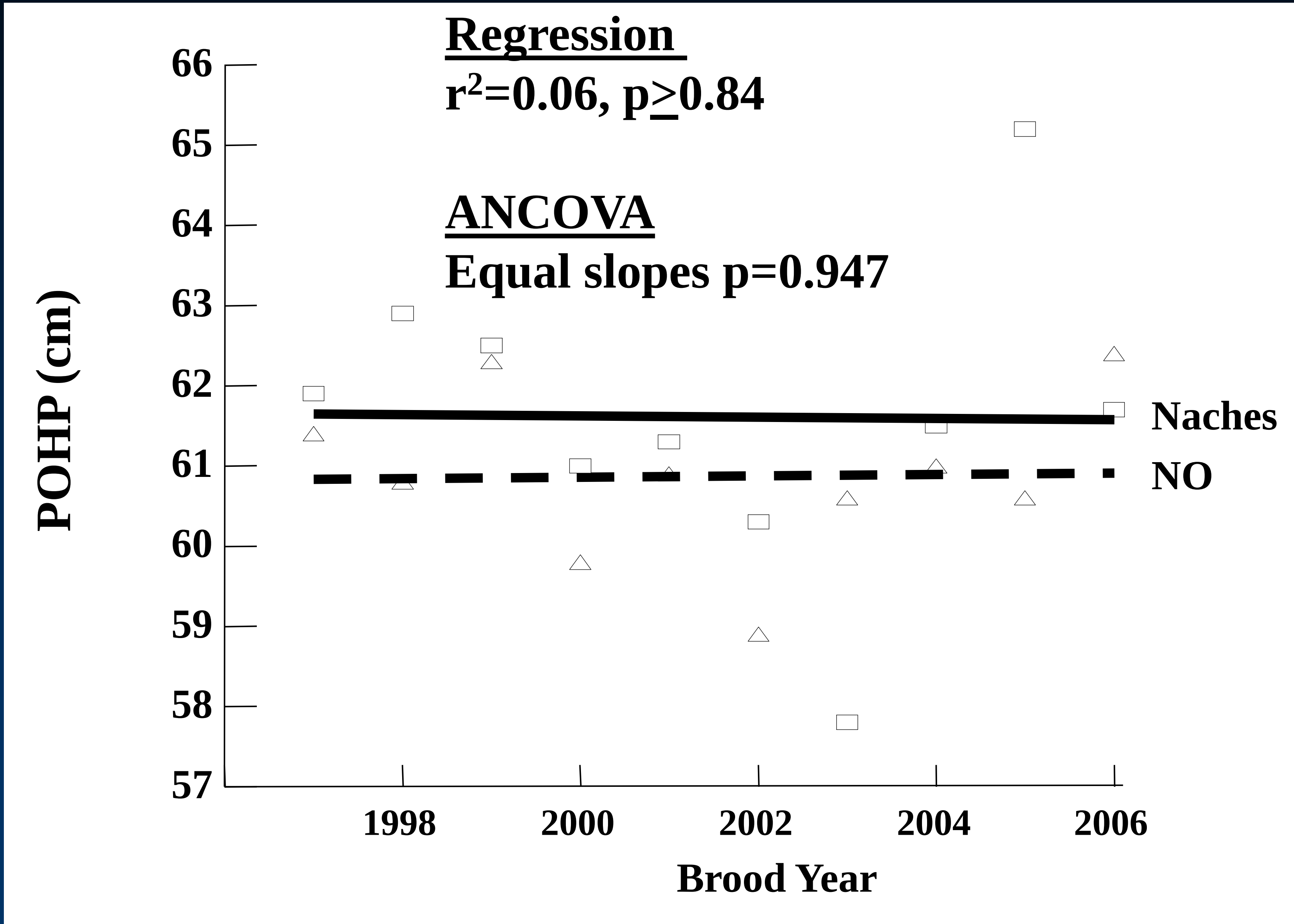
Jack Size-at-Age

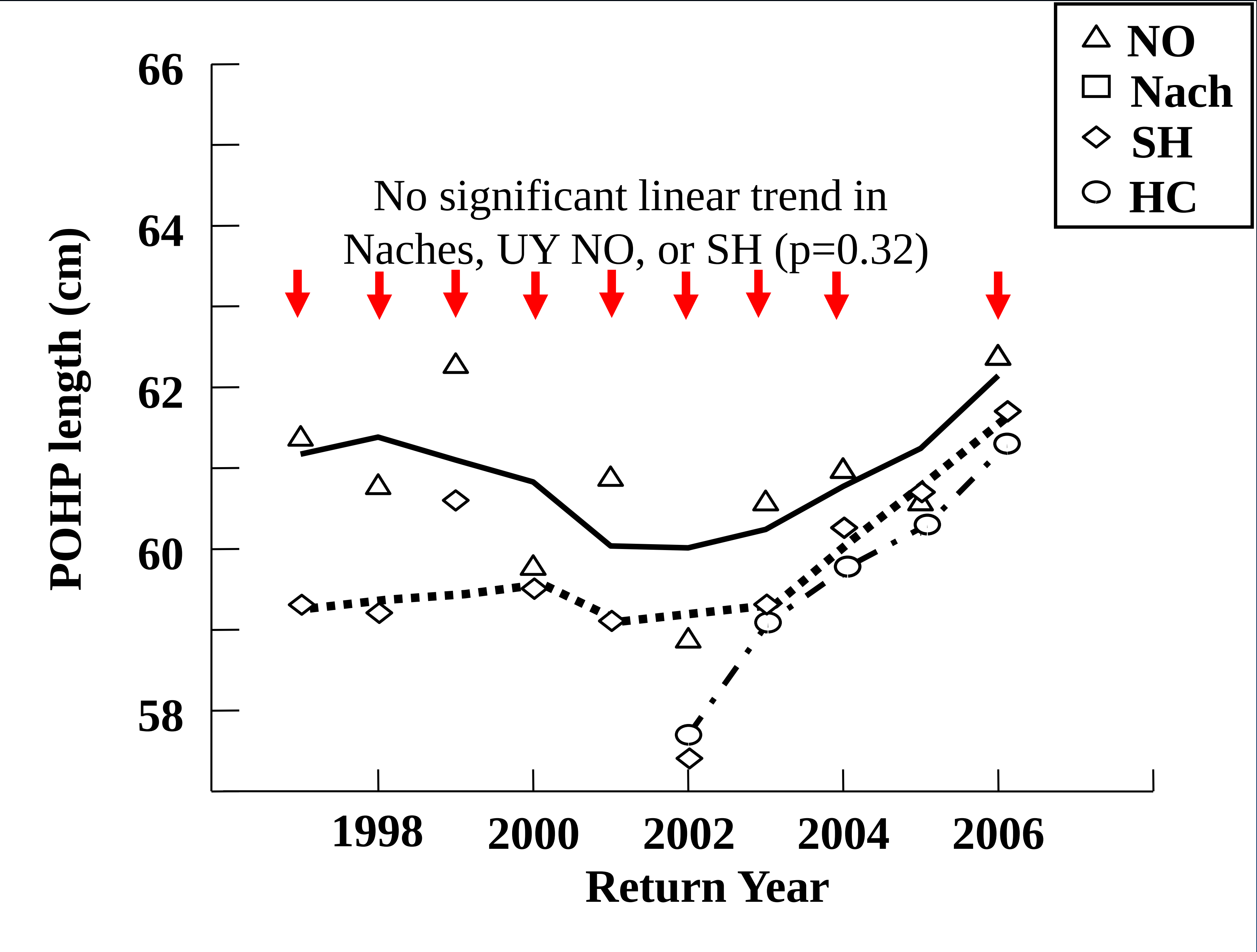
- Age 3 jacks have significantly increased in size over time in both hatchery and natural origin UY populations at the same rate (cm/yr)
- NO jacks are significantly larger than SH jacks and have been since the first generation of hatchery jack production
- Yet, SH smolts are equal to or larger than NO smolts, typically leading to larger size-at-age but younger age-at-maturation

Trends in Length – NO, Naches Age 4



Linear Trends in Length - Age 4





NO
Nach
SH
HC
No significant linear trend in
Naches, UY NO, or SH (p=0.32)
POHP length (cm)
66
64
62
60
58
1998
2000
2002
2004
2006
Return 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
- SH origin population also showed no significant trend over time, but is converging on the NO population
- No apparent negative effect (decrease in mean size) on NO fish despite 56% of naturally spawning fish are hatchery origin on average

Gender Identification

- **From 1997 to 2009 we estimated gender ratios from fish collected at RAMF and then taken to CESRF and held to maturity**
- **All adipose fin clipped fish were inspected and gender identified visually, but errors were approximately 20-30% for males and 10% for females**
- **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**

Sampling At Roza Adult Trap

Video provided by P. Huffman, YN

Sampling At Roza Adult Trap

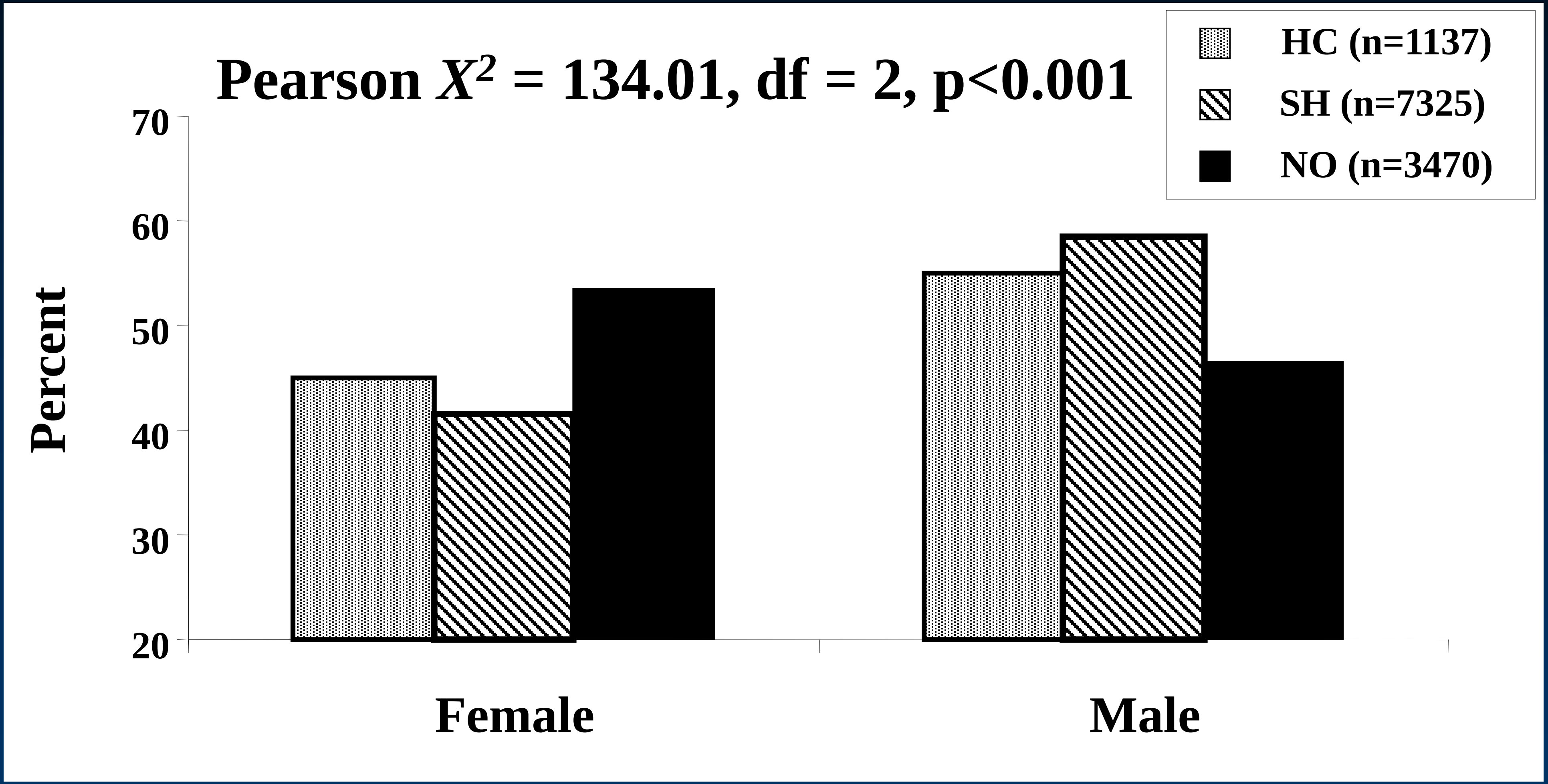
28 seconds total time, ~1 second gender ID

Checked for ad clip, elastomer and CWT tags
Weighed and measured POHP and FL
Identified gender
PIT tagged
DNA sampled

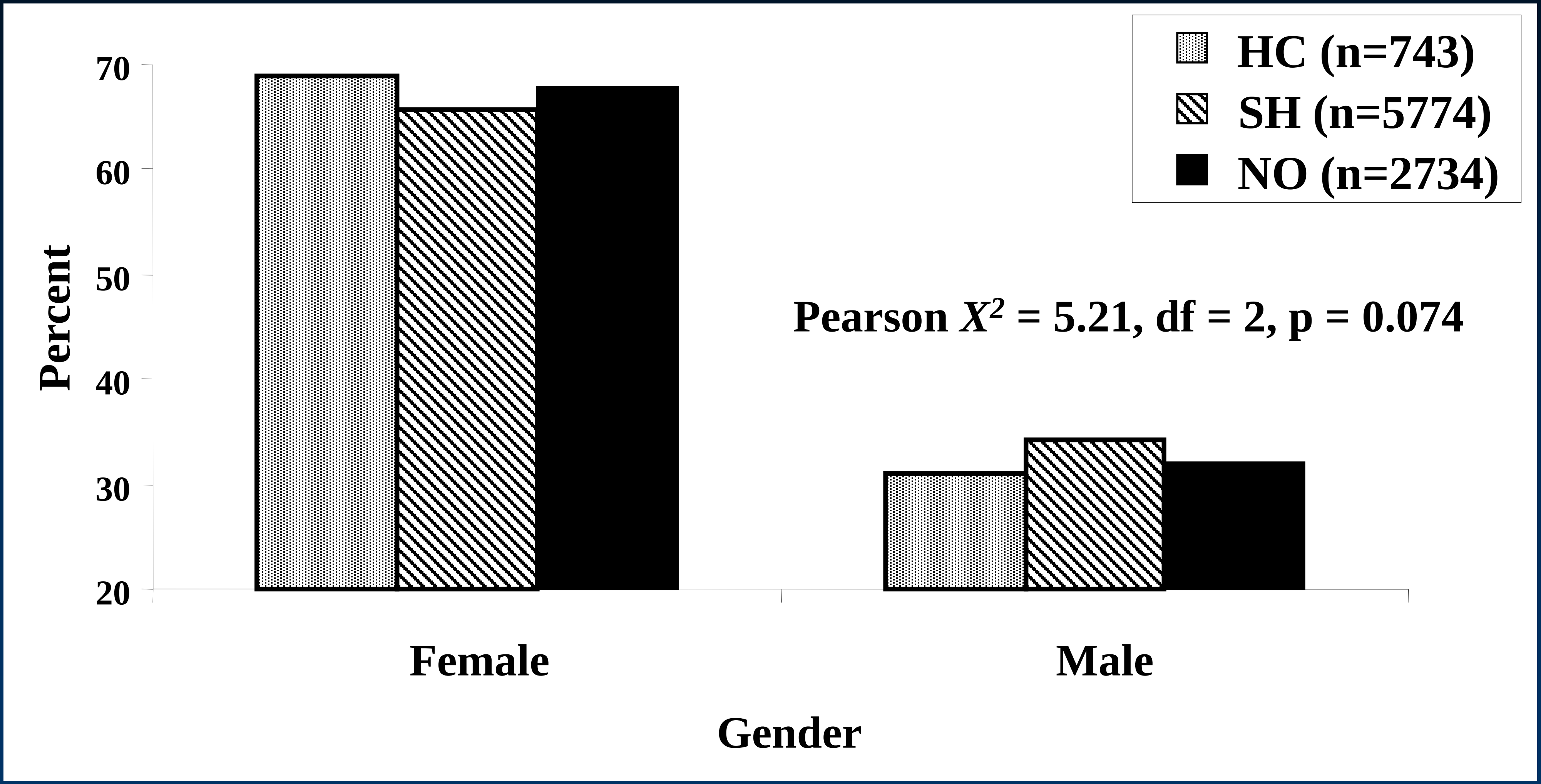
Gender Identification 2010

- **There were a total of 624 fish classified to gender using ultrasound and then held to maturity at CESRF**
- **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)



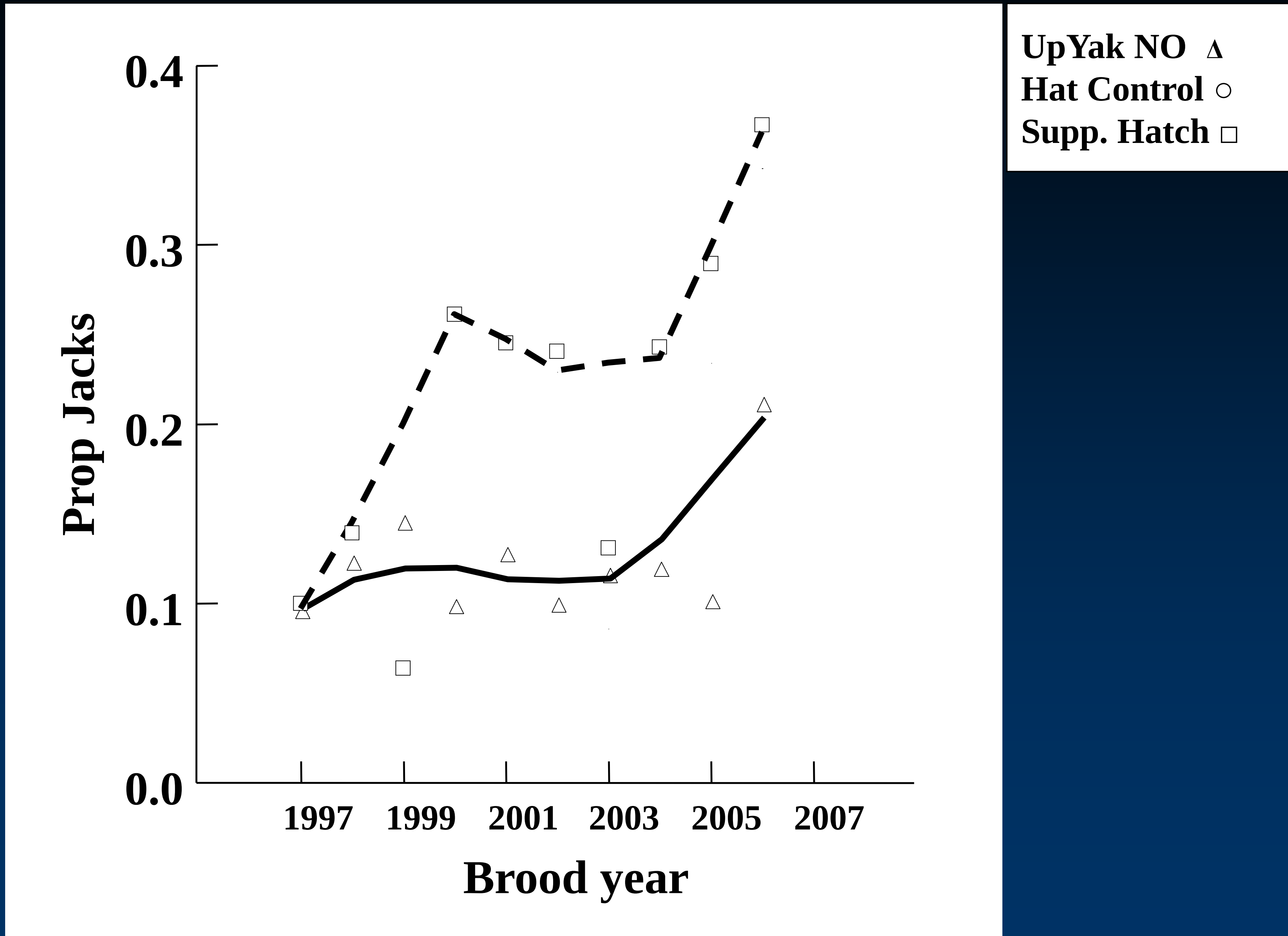
Gender Comparison BY2006 (Age 4 only)



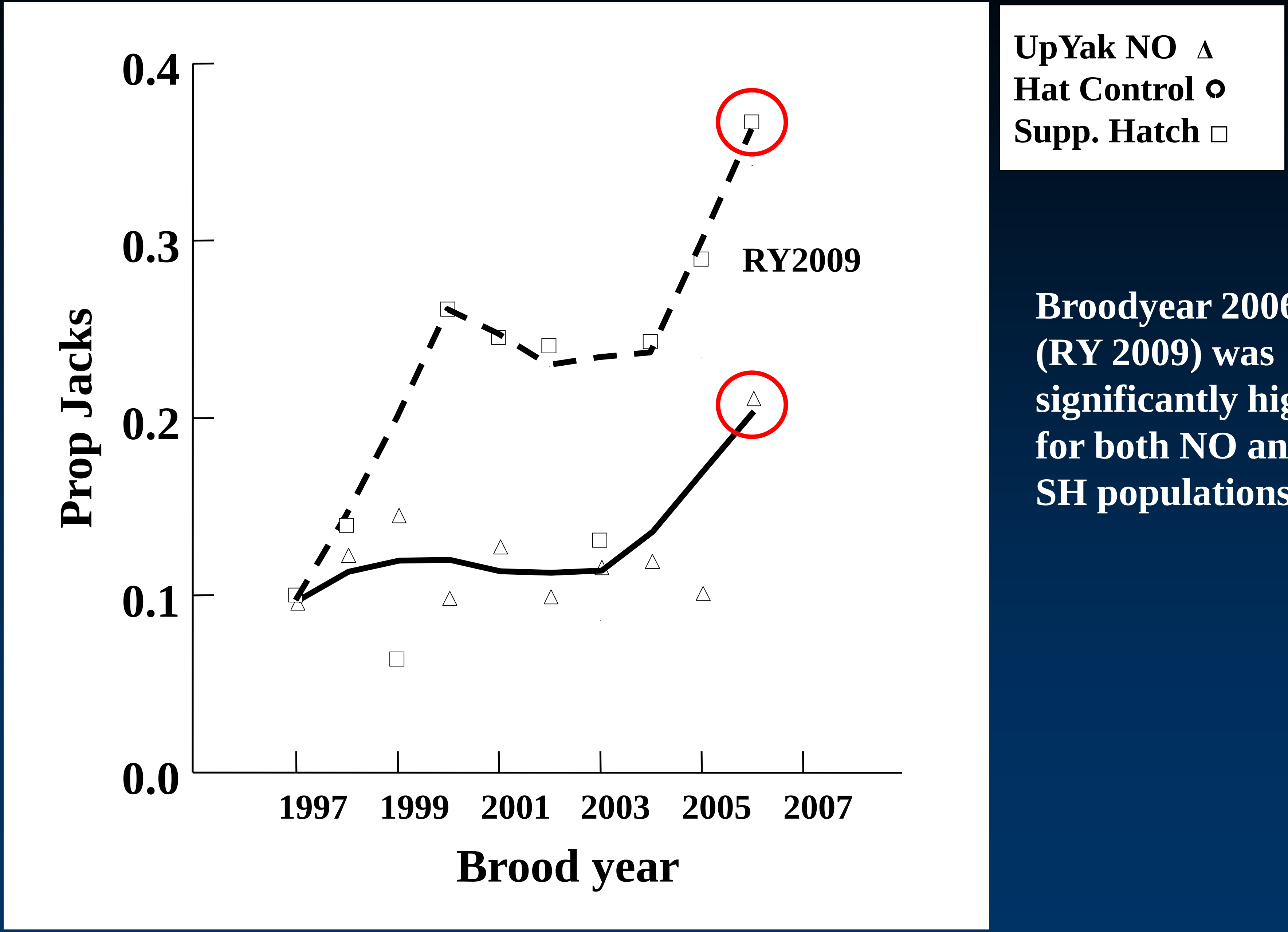
Why aren't the F:M ratios of age 4 hatchery fish skewed toward females more than Natural Origin fish?

- **BY 2006 had 40-54% minijack production in SH and HC males**
- **BY2006 SH and HC jack production was ~50% greater than NO fish (36% vs 22%)**
- **Yet, there was <3% difference in the proportion of adult age 4 females and males and no significant difference even with very large sample sizes**
- **More work is needed to understand this issue**
  - **What are wild precocious male production rates?**
  - **Compare Female recruits/Female spawner rates**

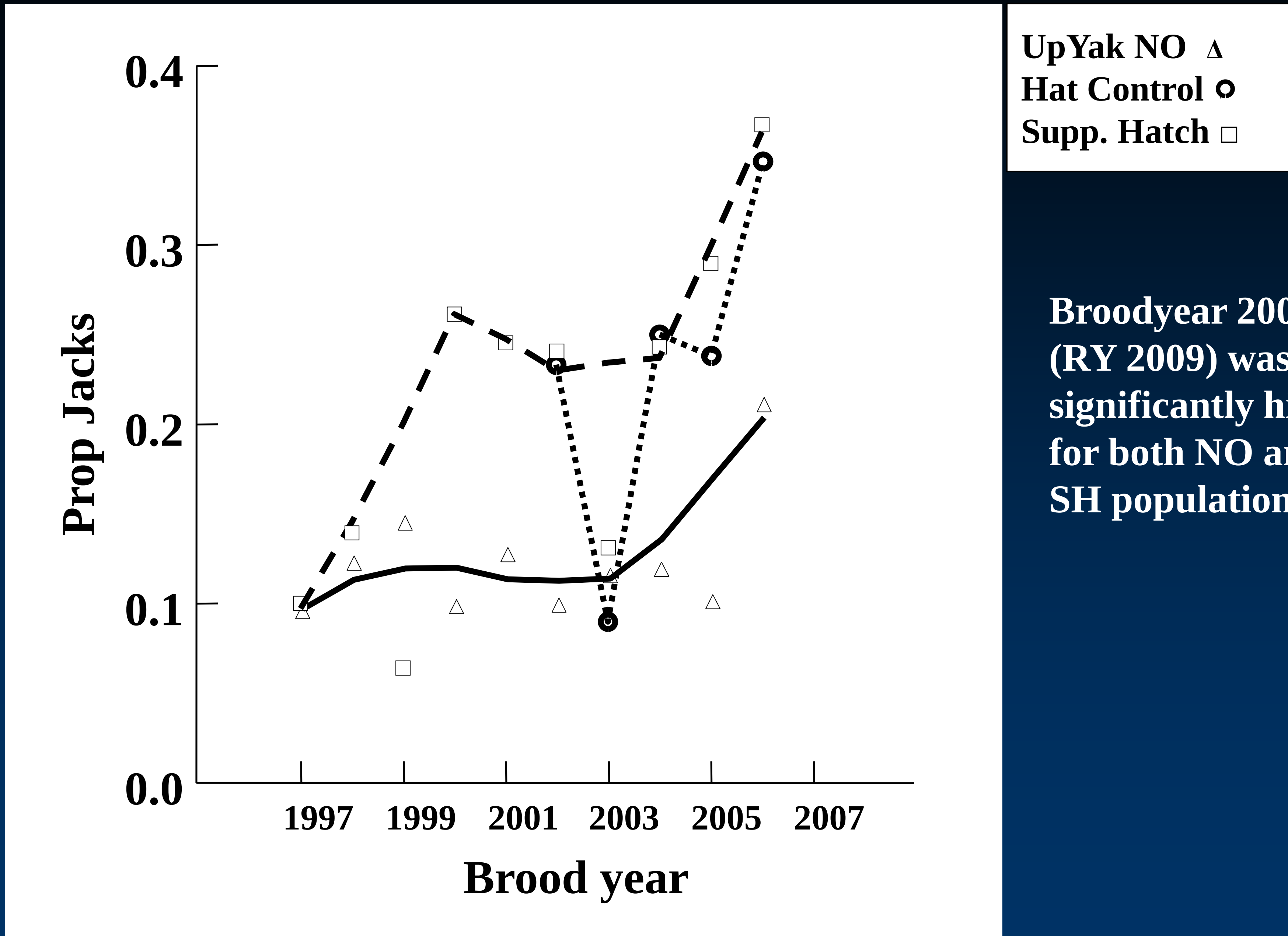
Trends In Jack BY Proportions



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



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



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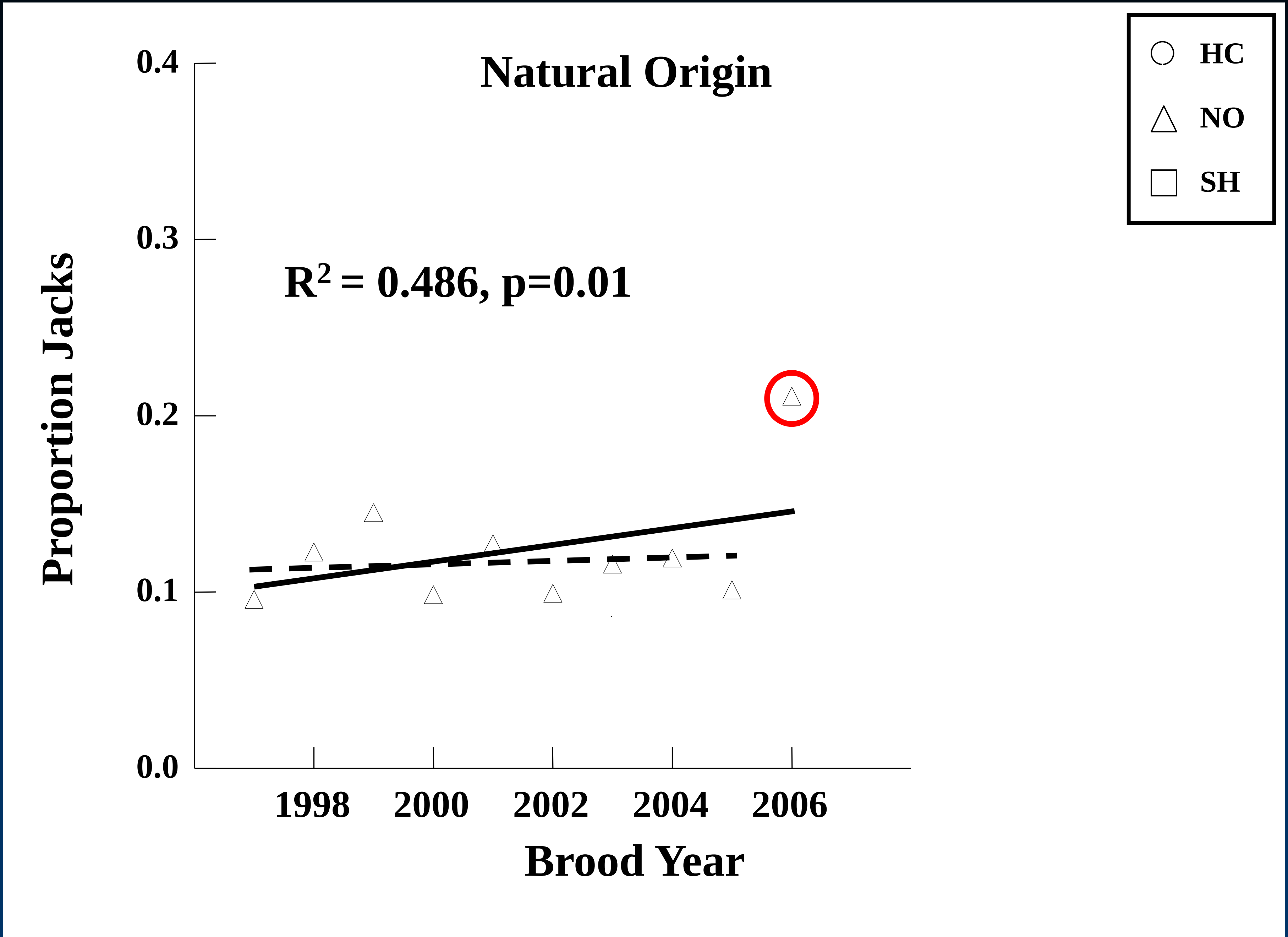
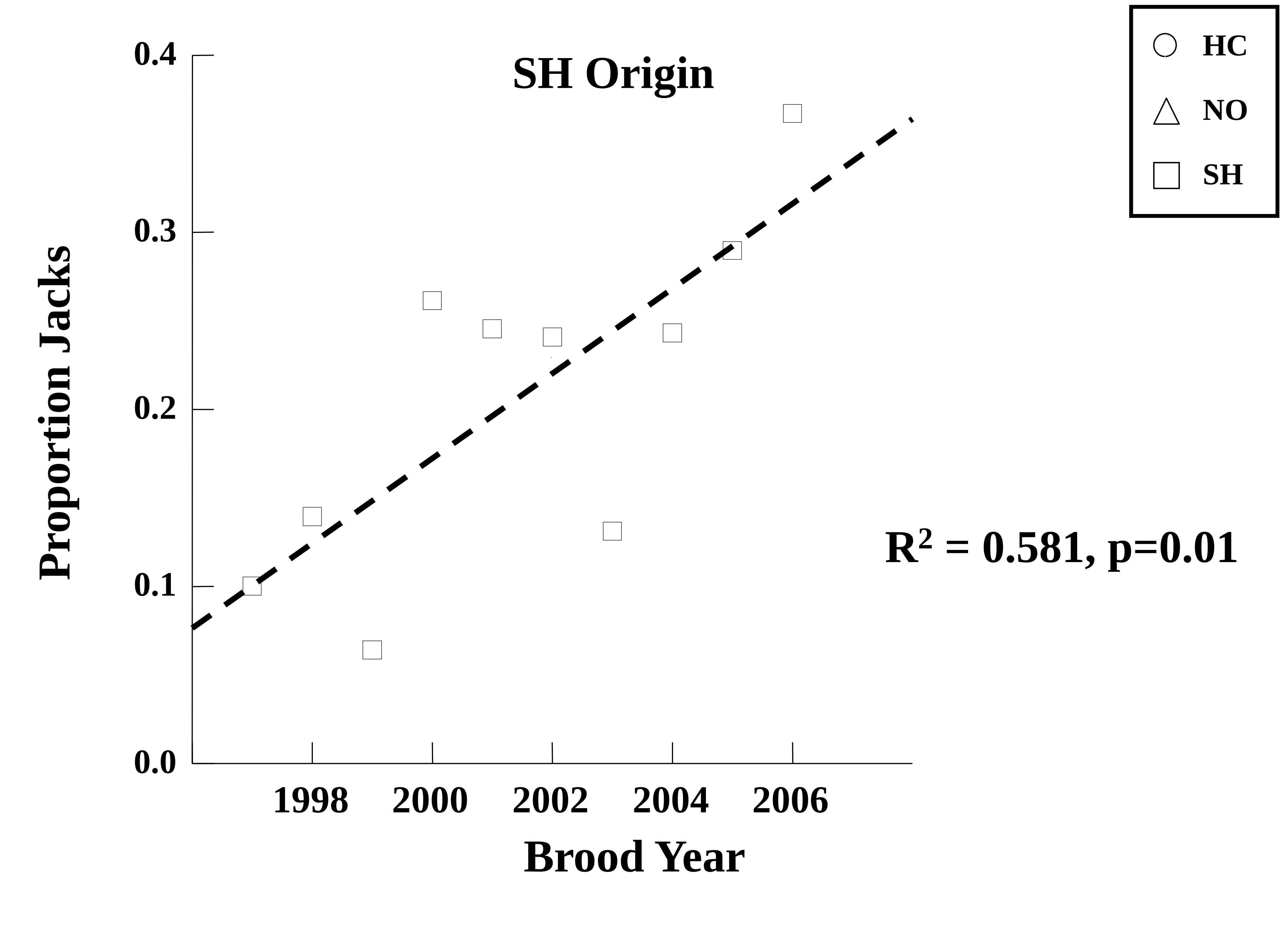
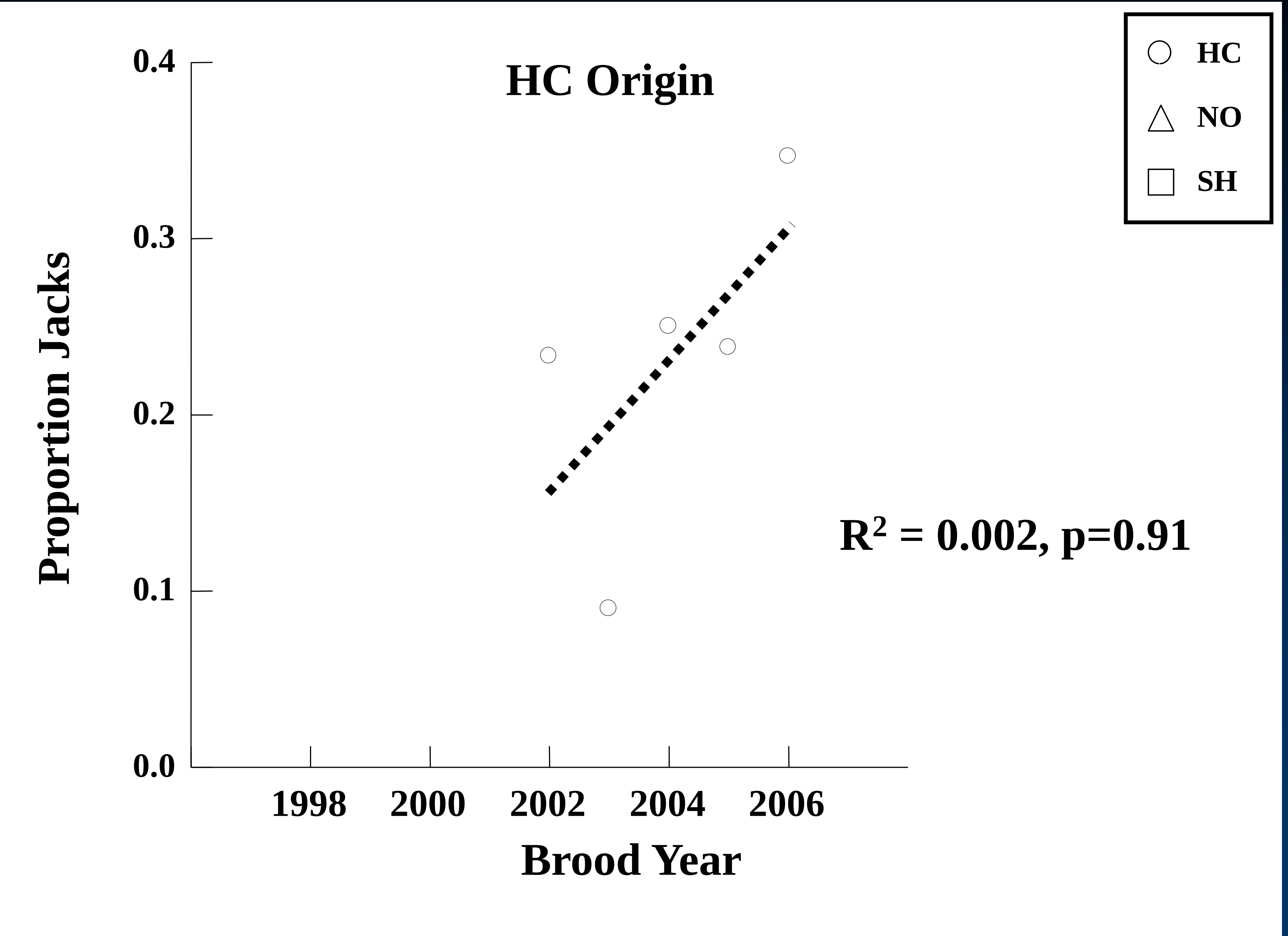
Proportion Age 3 Jacks Over Time



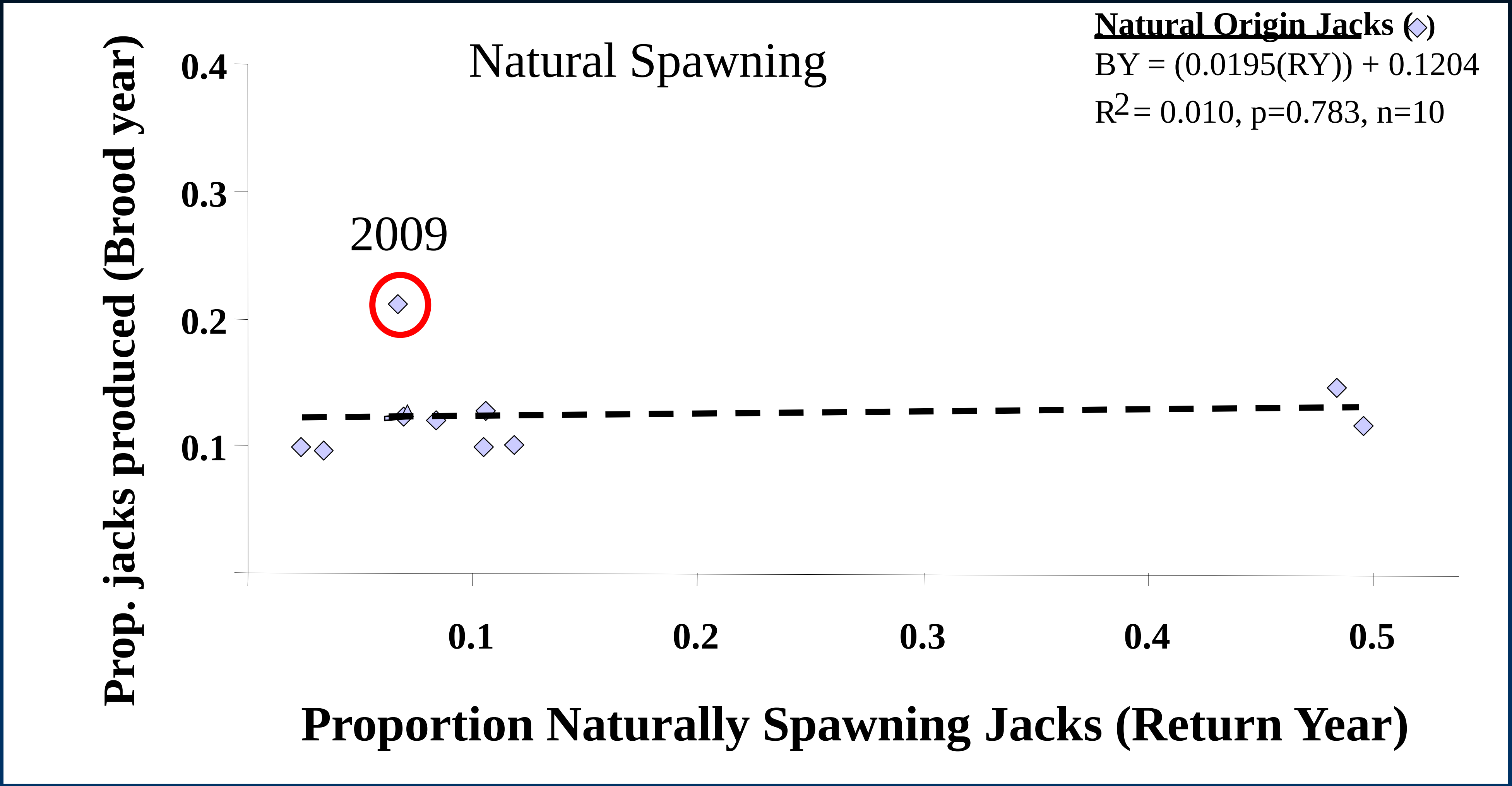
Proportion Age 3 Jacks Over Time



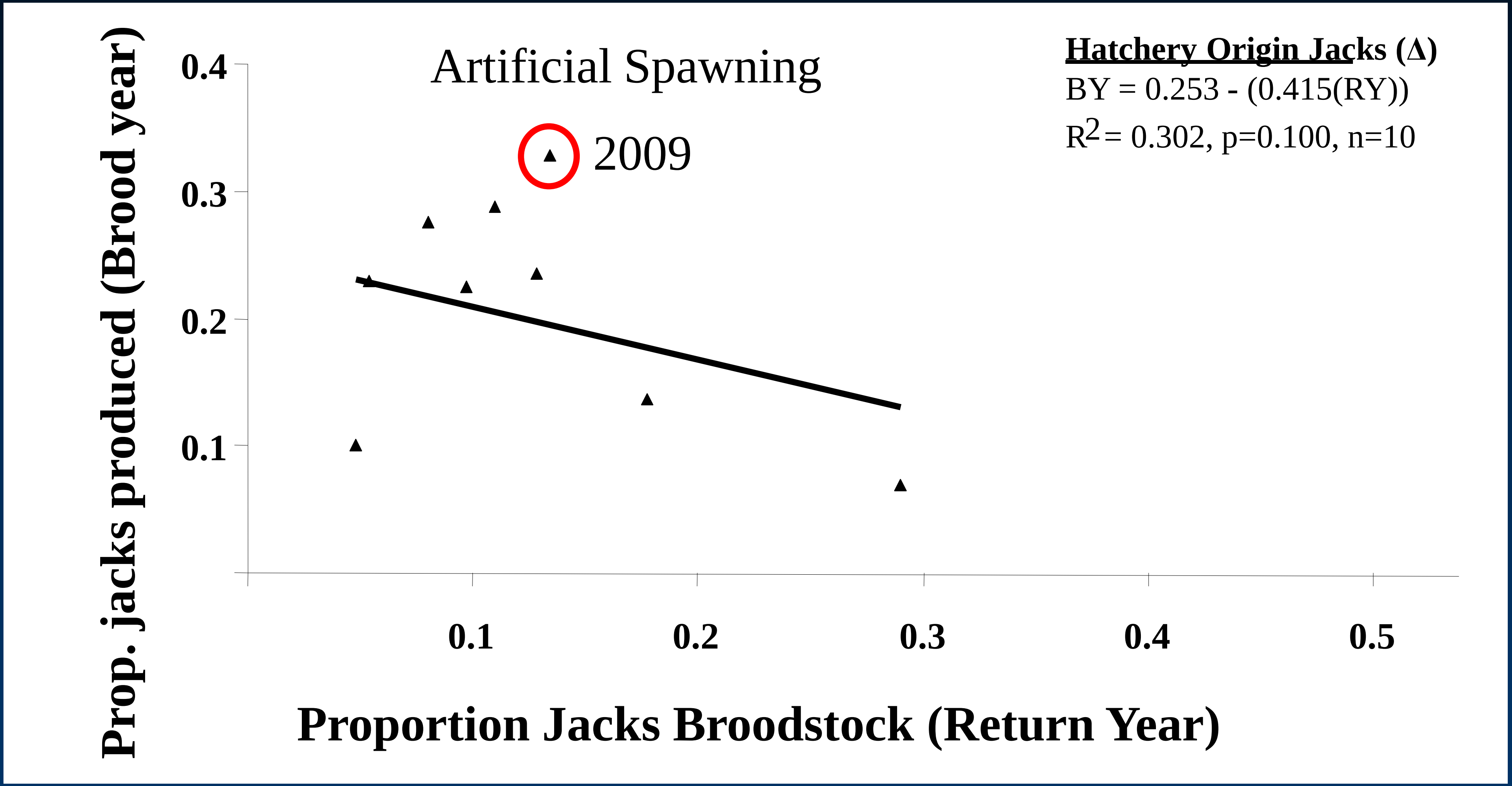
Proportion Age 3 Jacks Over Time



Proportion Jacks Spawned vs Proportion Jacks Produced



Proportion Jacks Spawned vs Proportion Jacks Produced



Linear Trends in Spawn Timing

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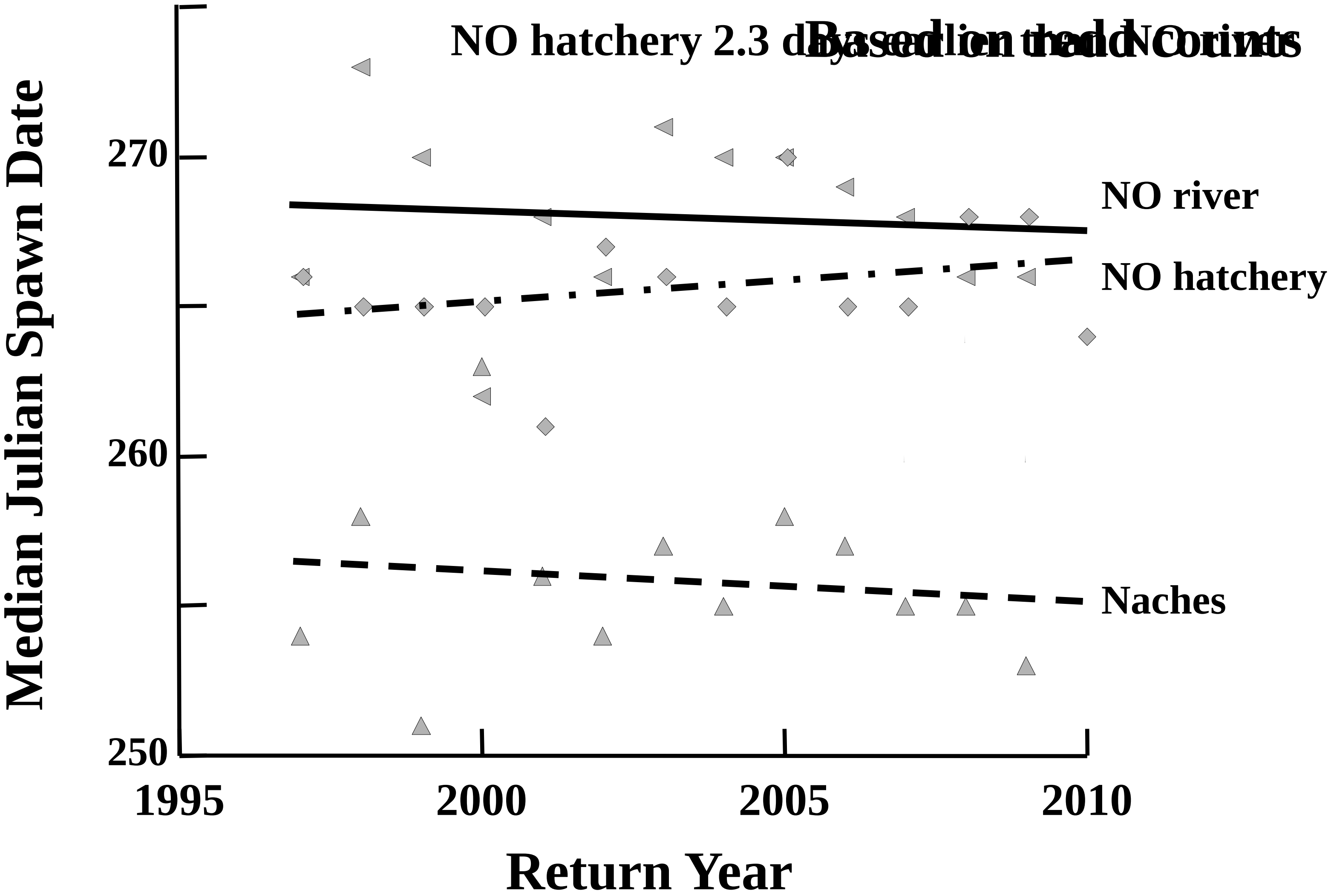


Regression

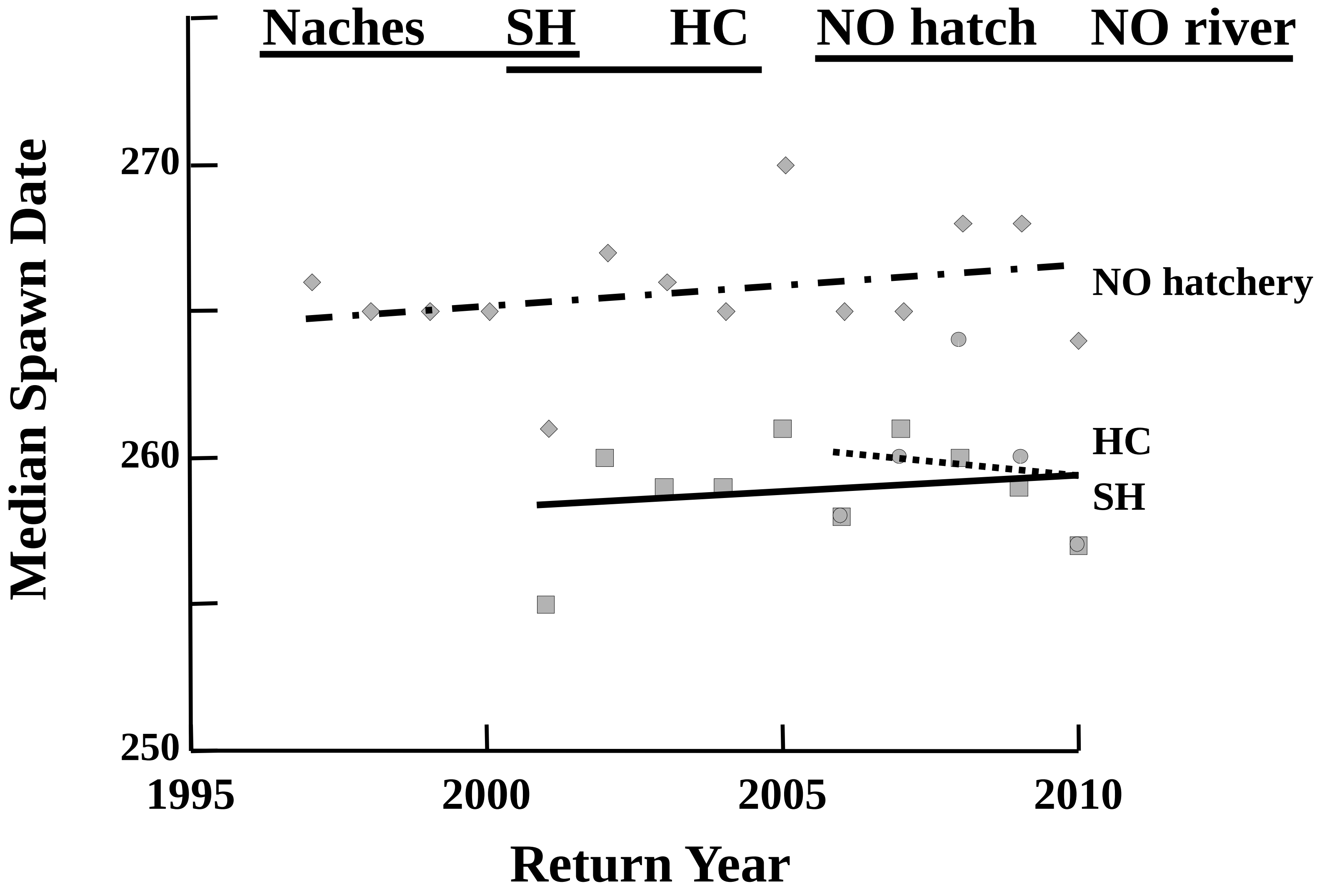
$R^2<0.16$, $p>0.17$

ANCOVA

Equal slopes p=0.872

Nach<NO Hat=NO R

Linear Trends in Spawn Timing



Trends In Egg Size (Mass)

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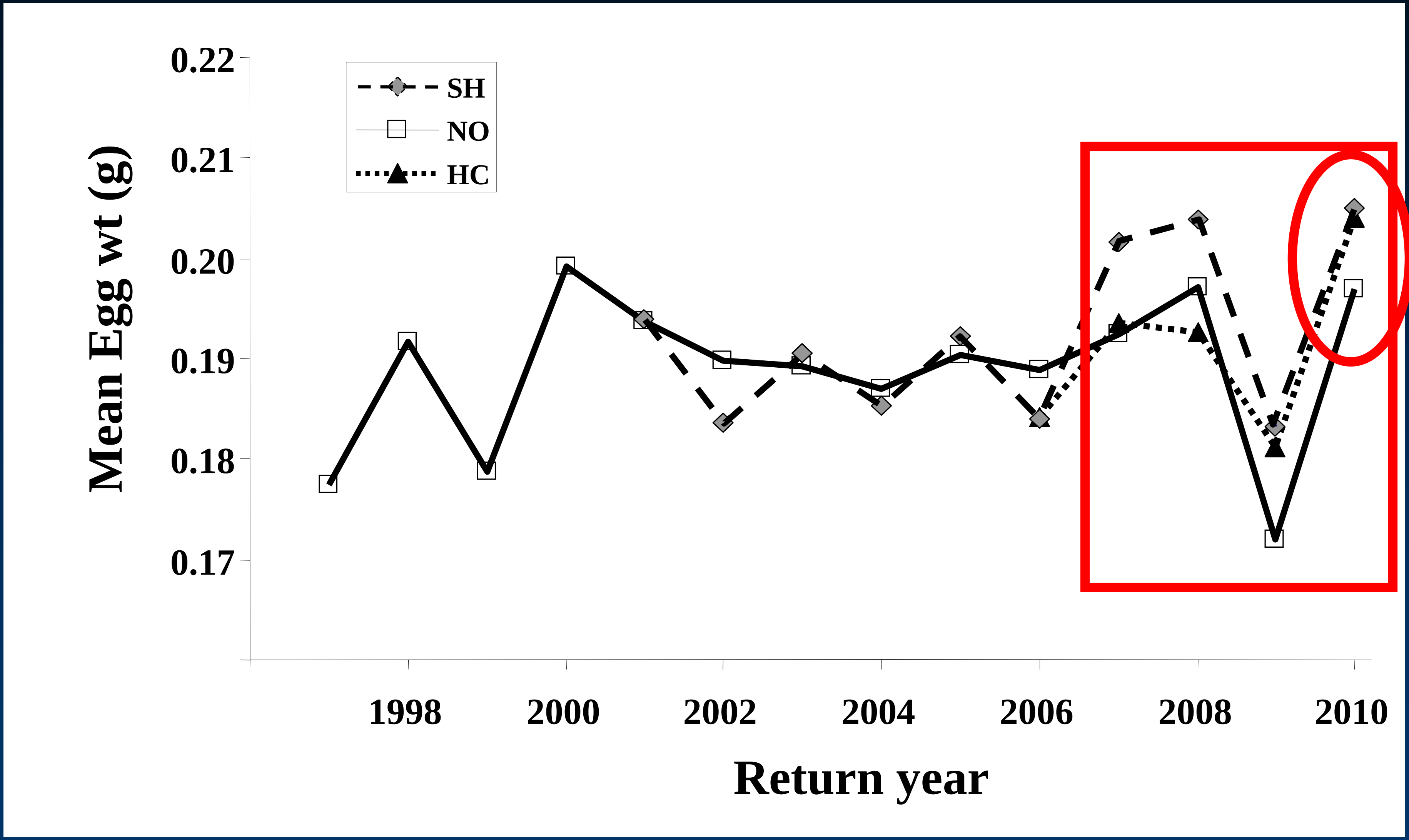
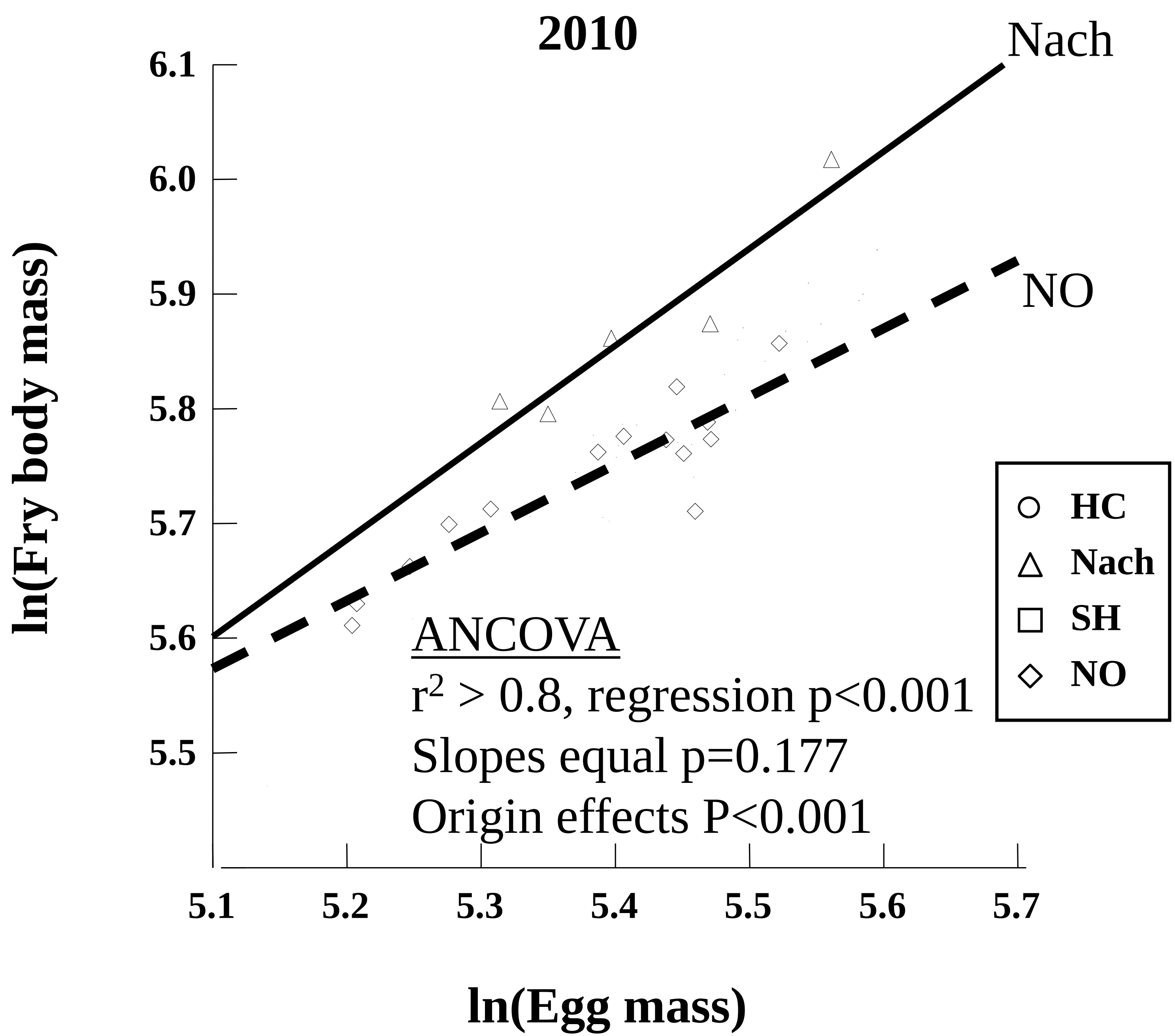
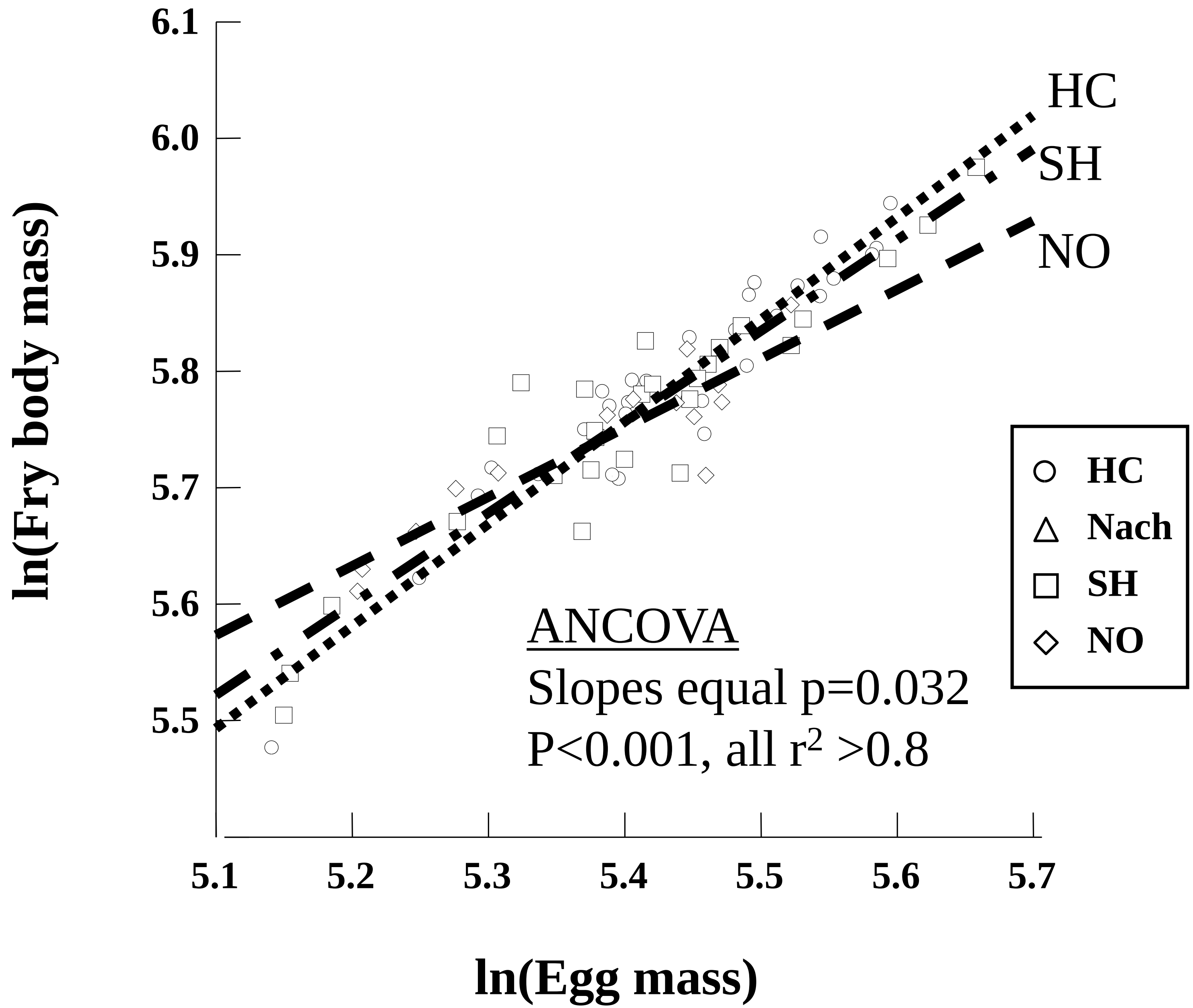
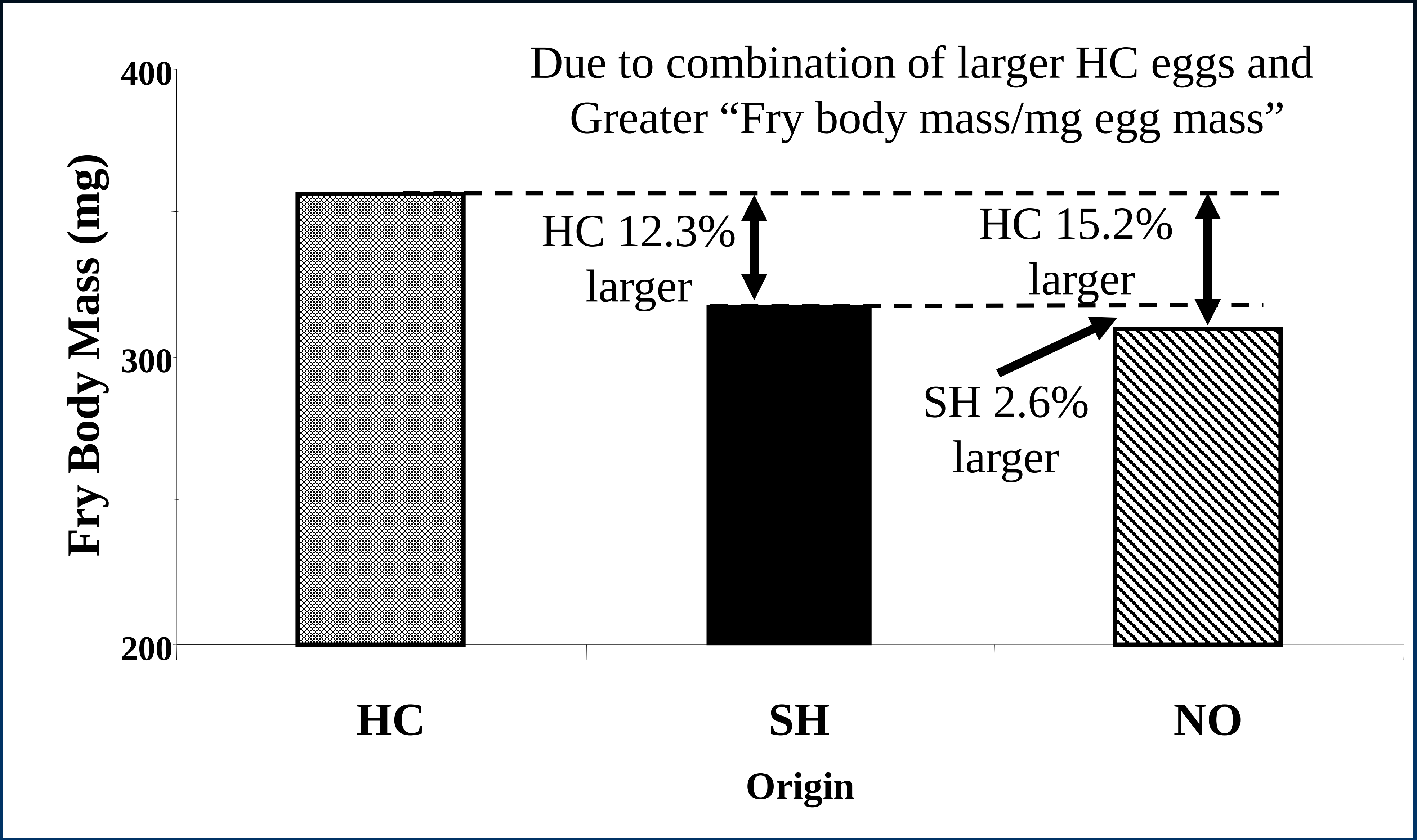



2010
Nach
NO
6.1
6.0
5.9
5.8
5.7
5.6
5.5
ln(Fry body mass)
5.1
5.2
5.3
5.4
5.5
5.6
5.7
ln(Egg mass)
HC
Nach
SH
NO
ANCOVA
r2 > 0.8, regression p<0.001
Slopes equal p=0.177
Origin effects P<0.001



ln(Fry body mass)
6.1
6.0
5.9
5.8
5.7
5.6
5.5
HC
SH
NO
HC
Nach
SH
NO
ANCOVA
Slopes equal p=0.032
P<0.001, all r2 >0.8
5.1
5.2
5.3
5.4
5.5
5.6
5.7
ln(Egg mass)

Estimated Fry Mass 2010



Comparison of PIT vs Non-PIT SARs

- **1997-2001 broods mean PIT tag loss = 18.4% (17.2% -19.5%)**
- **Mean PIT tag induced mortality = 10%**
- **What's happened since then (2002-2006 broods)?**

Comparison of PIT vs Non-PIT SARs

Brood Year	PIT SAR	PIT SAR corrected	Non-PIT SAR	Ratio corrected PIT/Non-PIT SAR
1997	1.50%	1.84%	1.81%	1.015
1998	1.06%	1.30%	1.31%	0.994
1999	0.06%	0.07%	0.11%	0.694
2000	0.40%	0.49%	0.48%	1.027
2001	0.22%	0.27%	0.32%	0.839
2002	0.25%	0.31%	0.28%	1.103
2003	0.08%	0.10%	0.21%	0.456
2004	0.34%	0.42%	0.61%	0.687
2005	0.35%	0.43%	0.79%	0.544
2006	1.16%	1.42%	1.42%	1.001

Conclusions – Size-at-age Jacks

- Age 3 SH and HC jacks were significantly smaller than NO fish, but all populations were increasing in size over time at the same rate.
- SH and HC jacks NS difference in size most years.
- Unable to use age 3 Naches to compare to UY fish to show and compare trends over time due to low sample sizes.

Conclusions – Size-at-age Age 4

- Age 4 Naches and UY NO fish show the same trends over time indicating that naturally spawning SH fish have not impacted NO size-at-age.
- Age 4 populations did not increase significantly in size over time, but SH and HC fish are now closer in size to NO fish, though still significantly smaller.

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
- Perhaps 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 examined (which make up 70-95% of a cohort on average) there is no significant difference between NO, SH and HC gender proportions
- More work needed here

Conclusions – Effects of Spawning Jacks

- **The proportion of SH males maturing as jacks was not significantly effected by the proportion of jacks naturally spawning (range 3% to 50%)**
- **The proportion of NO males maturing as jacks was not significantly effected by the proportion of NO jacks used as broodstock (range 3% to 29%)**
- **Managing the proportion of jacks naturally spawning or in broodstock is not likely to have significant effects on subsequent jack production in UY spring Chinook salmon**
- **These results do not necessarily hold for other spring or fall Chinook populations**

Conclusions – Other

- In recent years HC and SH egg mass has been larger than NO egg mass
- In 2010 HC fry were 15% larger than NO fry due to larger eggs and higher Egg Mass-to-Fry Mass conversion rate
- Spawn timing of hatchery fish at CESRF was significantly earlier than NO fish, but no population showed significant temporal trends
- PIT tagged SARs were significantly lower than Non-PIT tagged SARs in 5 of 10 brood years

Acknowledgements

- Yakama Nation Roza Adult Monitoring Facility Crew
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