Physiology and precocious male maturation of Yakima River spring Chinook salmon

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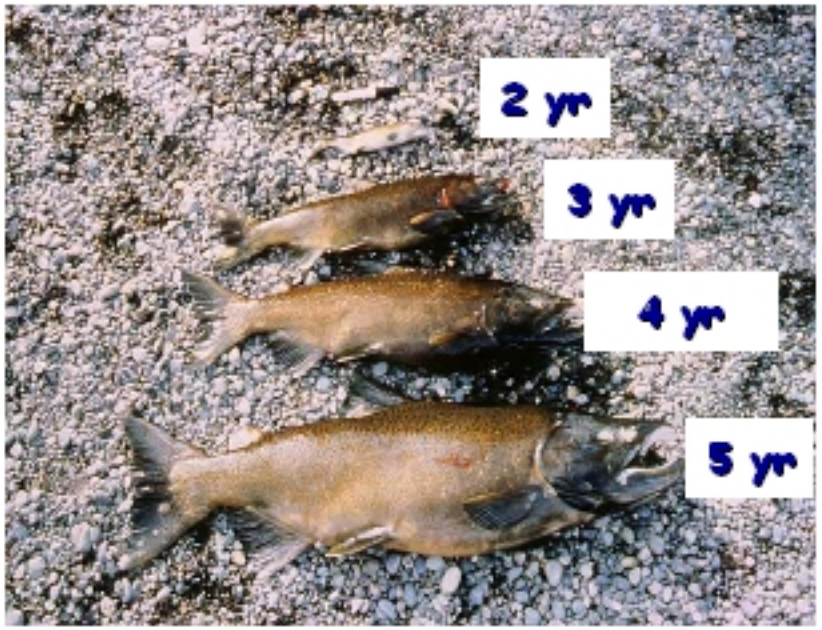
Curt Knudsen	**Oncorh Consulting**
Ray Brunson Joy Evered Chris Paterson Sonia Mumford	**US Fish and Wildlife Service**
Contract #2002-032	**Bonneville Power Administration**

Variation in Age of Male Maturity



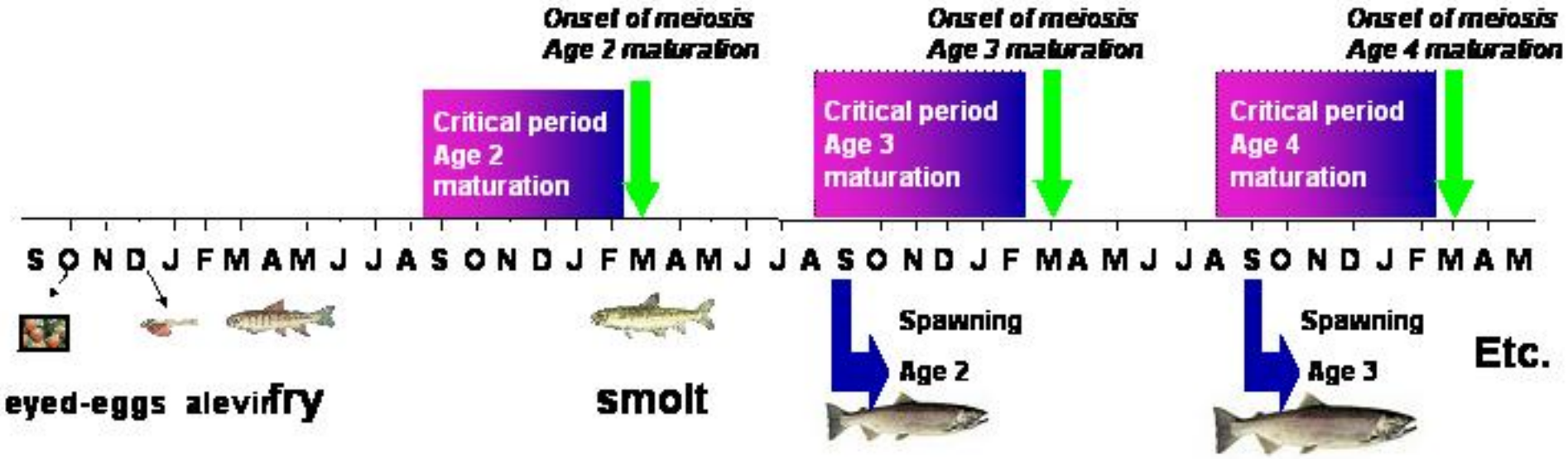
Mature male salmon

Factors Affecting Age of Maturation

- ✓ Genetics
- ✓ Environment
  - temperature
  - food availability
  - food quality

Growth & Body energy stores

Annual Critical Periods When Growth Affects Puberty Onset



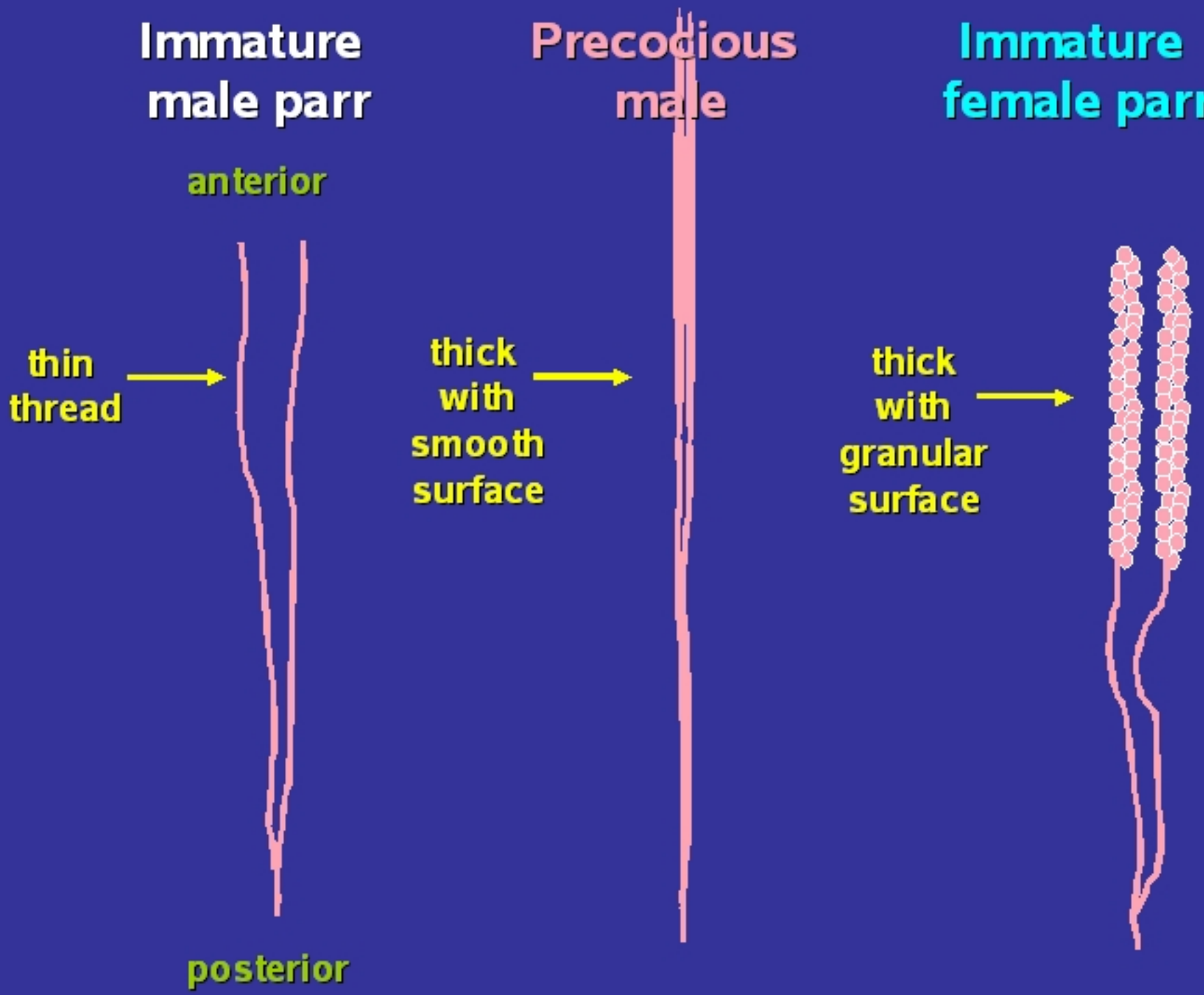
Silverstein et al. 1998, CAFS
Shearer and Swanson 2000, Aqua.
Campbell et al. 2000, Biol. Repr.
Shearer et al. submitted, TAFS

On average 25% of all fish (50% of males) are minijacks in Yakima hatchery spring Chinook

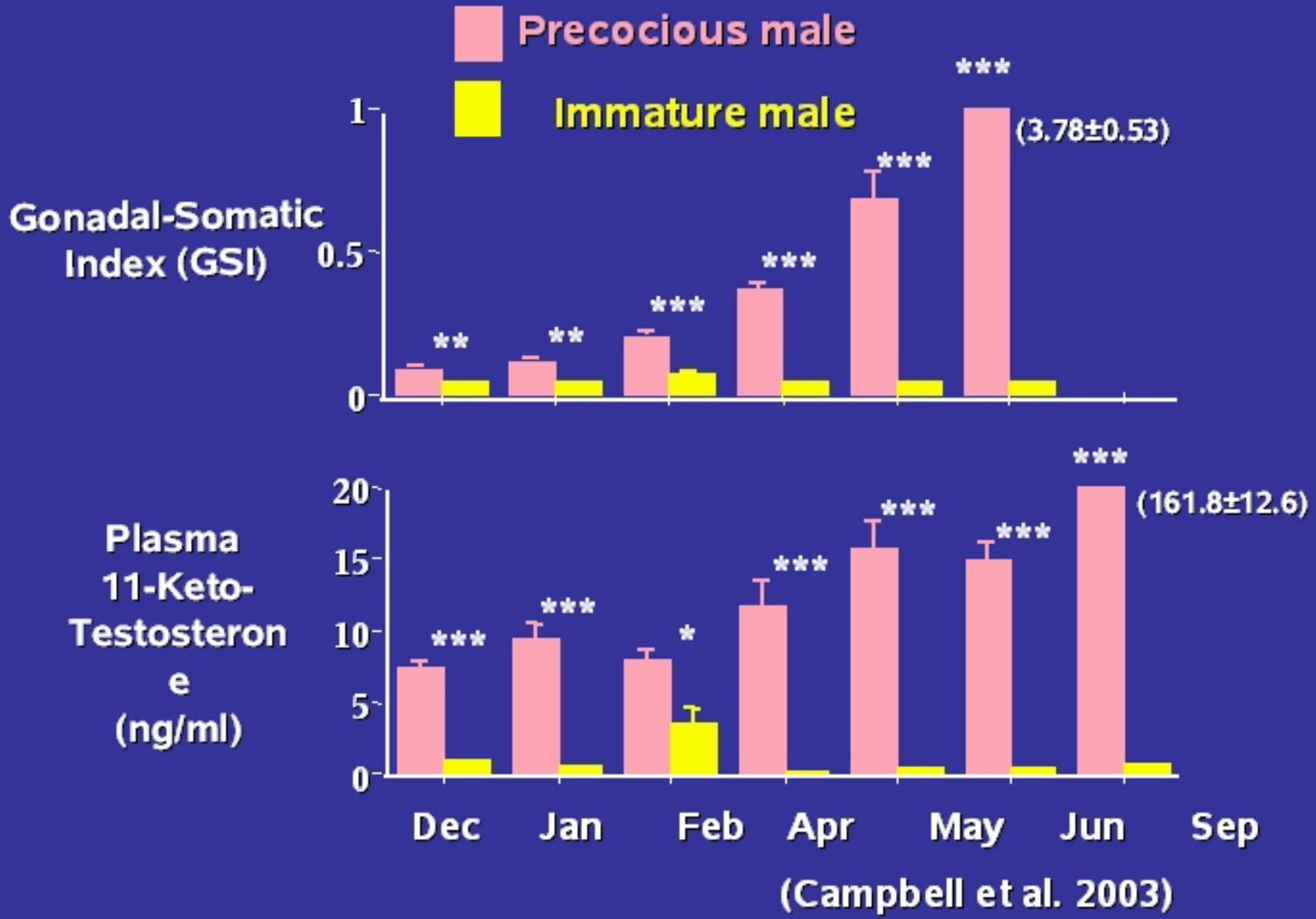
Brood Year	Release #	% of all fish	# Minijacks
97	386,048	22%	84,931
98	589,683	36%	211,107
99	758,789	25%	189,697
00	834,285	18%	153,508
01	370,236	26%	95,520
		Avg. 25%	

Larsen et al.(2004) Trans. Am. Fish. Soc.

Identification of precocious males by gross morphology

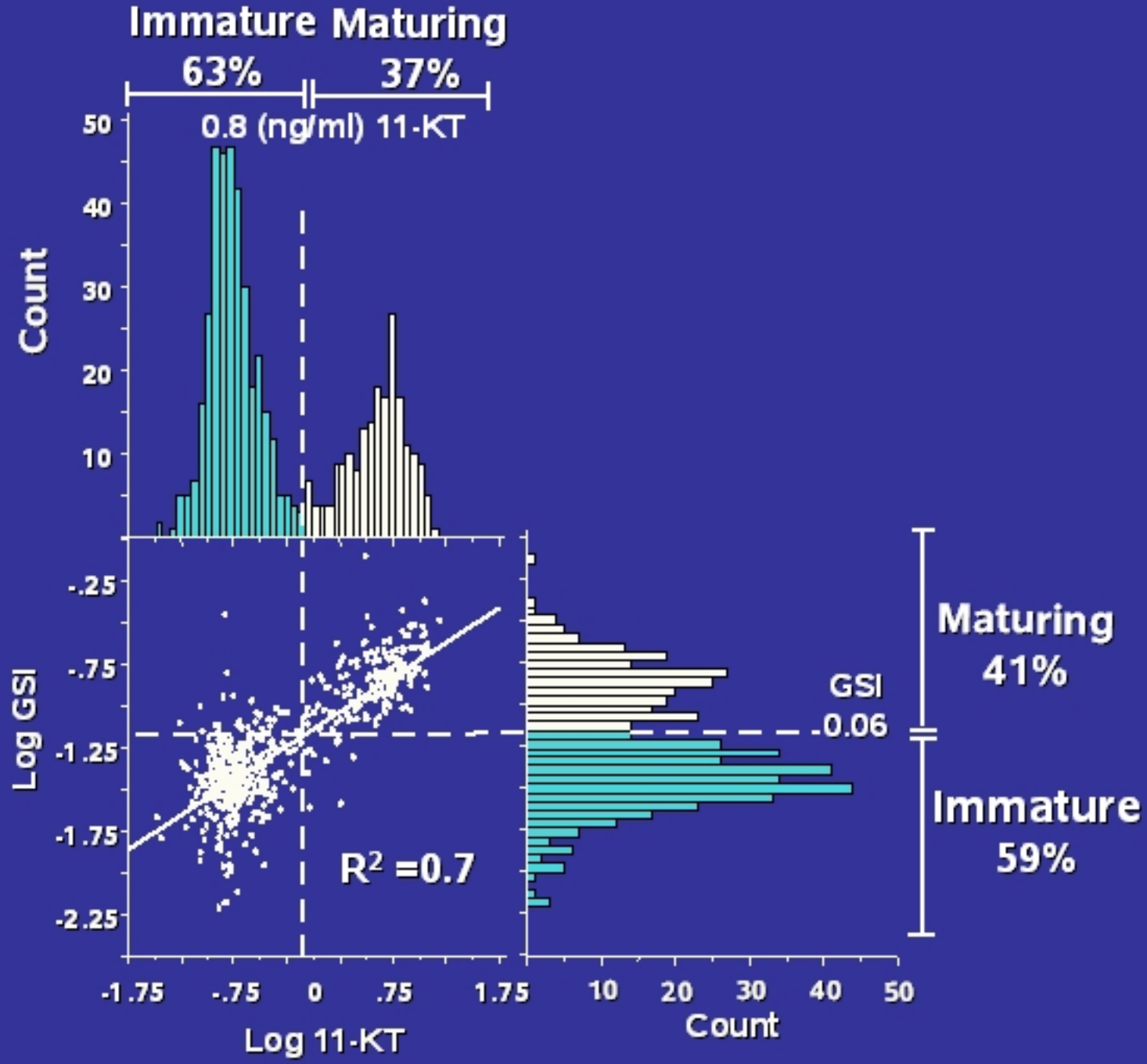


Laboratory based studies have clearly established that both GSI and 11-ketotestosterone (11-KT) are significantly elevated in precocious males approximately 9 months prior to maturation



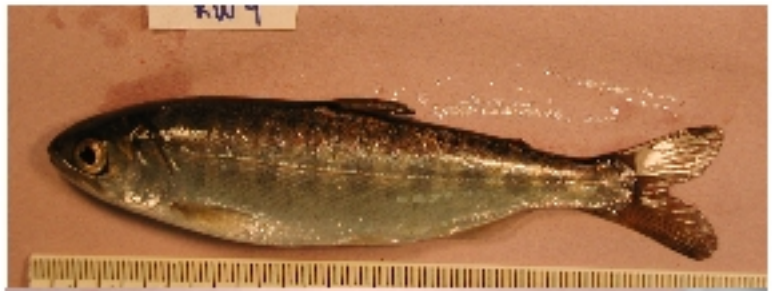
(Campbell et al. 2003)

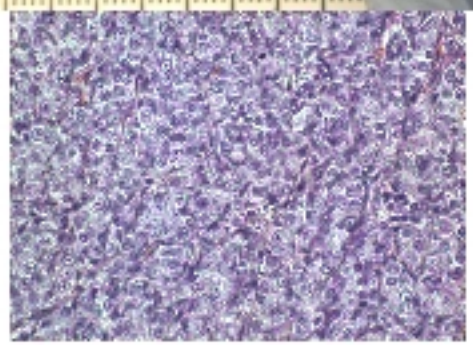
11-ketotestosterone vs. GSI (Brood Yr. 00)



1+ Age Spring Chinook Salmon : April

Non Maturing

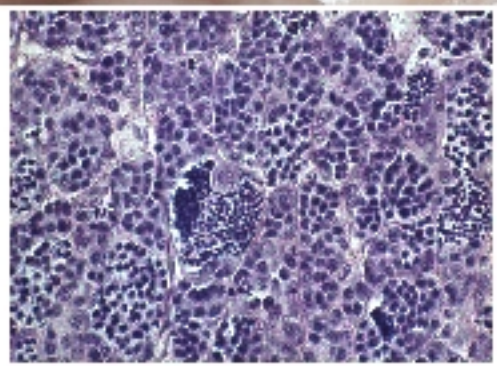




Plasma 11-KT = 0.2 ng/ml

GSI = 0.02%

Maturing



Plasma 11-KT = 7.0 ng/ml

GSI = 0.2%

Consequences of high levels of precocious maturation

- Ecological impacts
- Genetic impacts - leakage of HH Control genes in to supplemented stock (?)
- Increased straying (?)
- Skewed sex ratio (?)
- Loss of adult production

Objectives

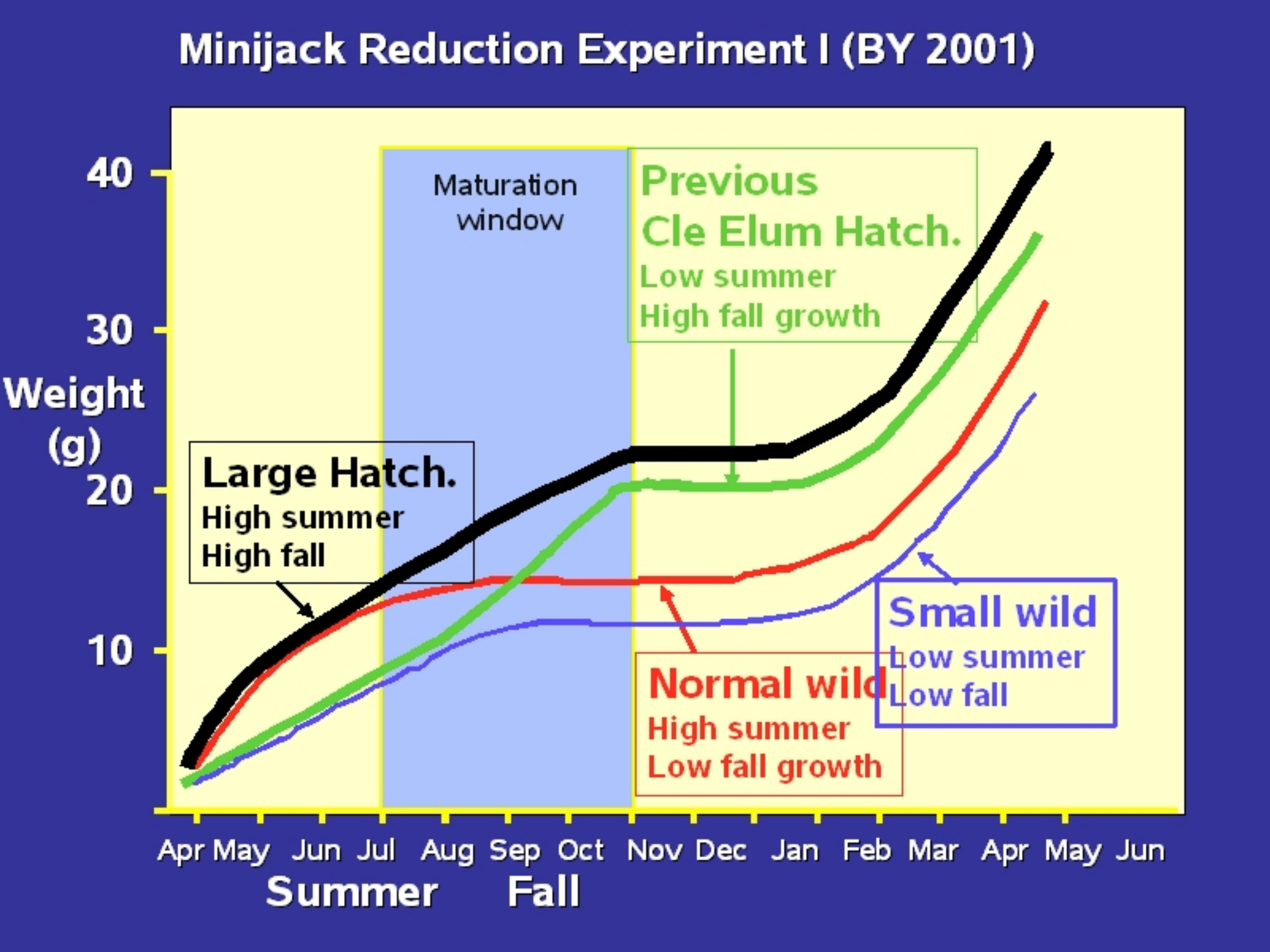
1. Design and conduct experiments aimed at controlling precocious male maturation and improving smolt quality

3. Assist Yakima Program in conducting production scale experiments to control precocious male maturation rates and improve smolt quality

5. Monitor the precocious maturation rate of the Cle Elum Hatchery spring Chinook population

4. Estimate the precocious maturation rate of wild Yakima Spring Chinook

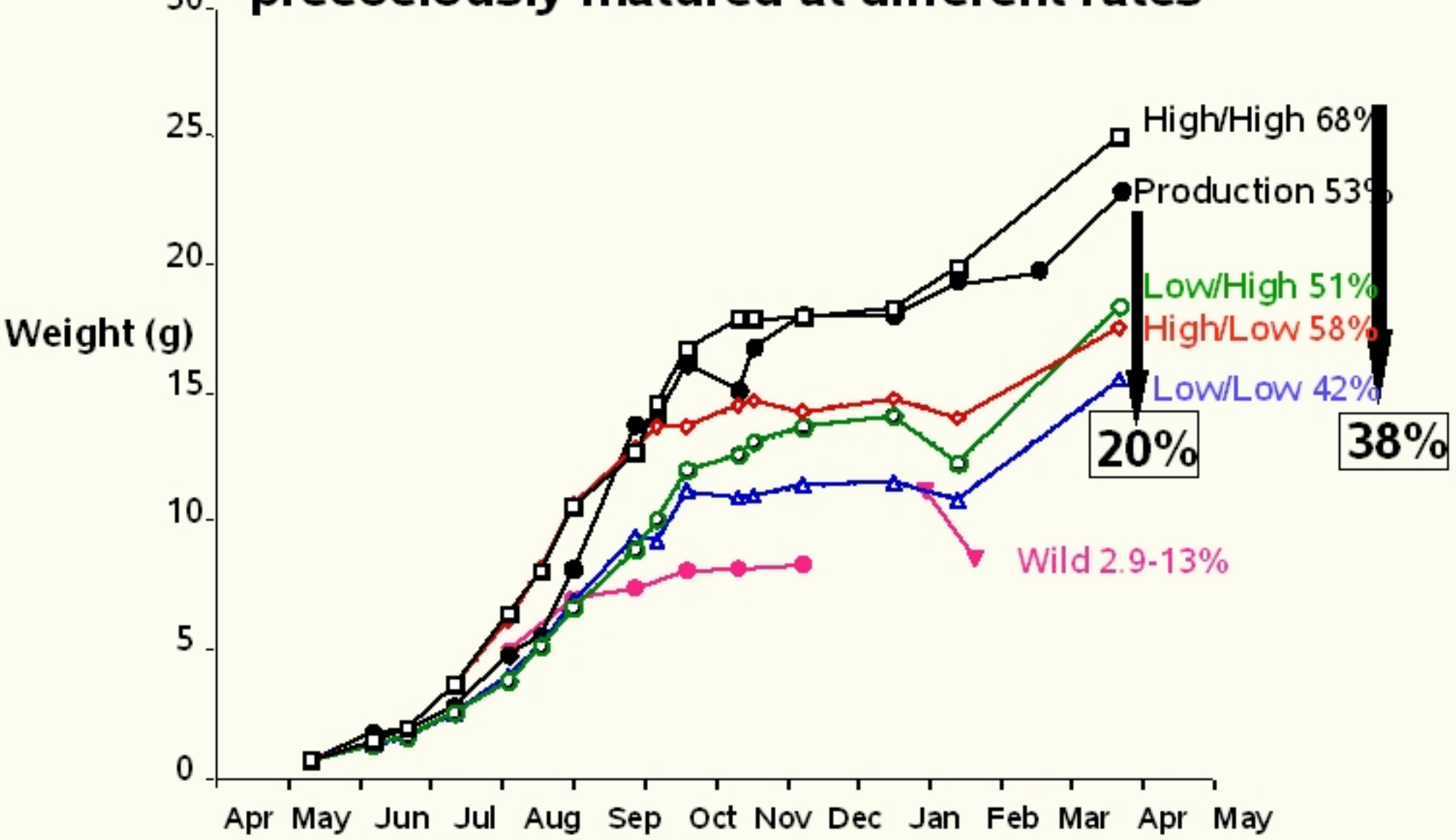
1. Design and conduct experiments aimed at controlling precocious male maturation


Minijack Reduction Experiment I (BY 2001)
40
30
20
10
Weight (g)
Maturation window
Previous Cle Elum Hatch.
Low summer
High fall growth
Large Hatch.
High summer
High fall
Small wild
Low summer
Low fall
Normal wild
High summer
Low fall growth
Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun
Summer
Fall

Monitor

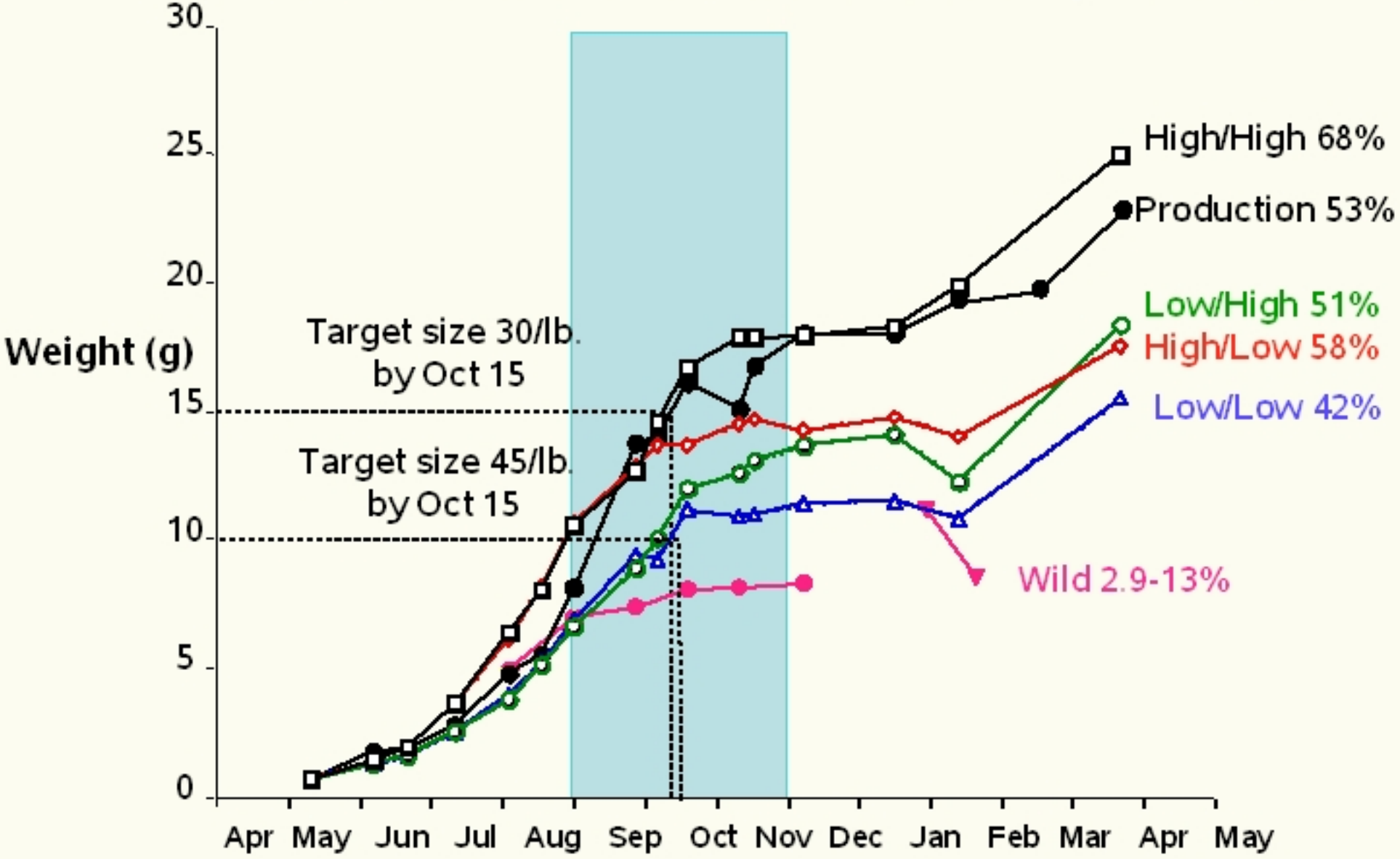
- Size
- Growth rate
- Gill Na+/K+-ATPase (index of smolting)
- Plasma IGF-I (growth regulating hormone)
- Condition Factor
- Whole body lipid

Experimental, production, and wild fish grew and precociously matured at different rates



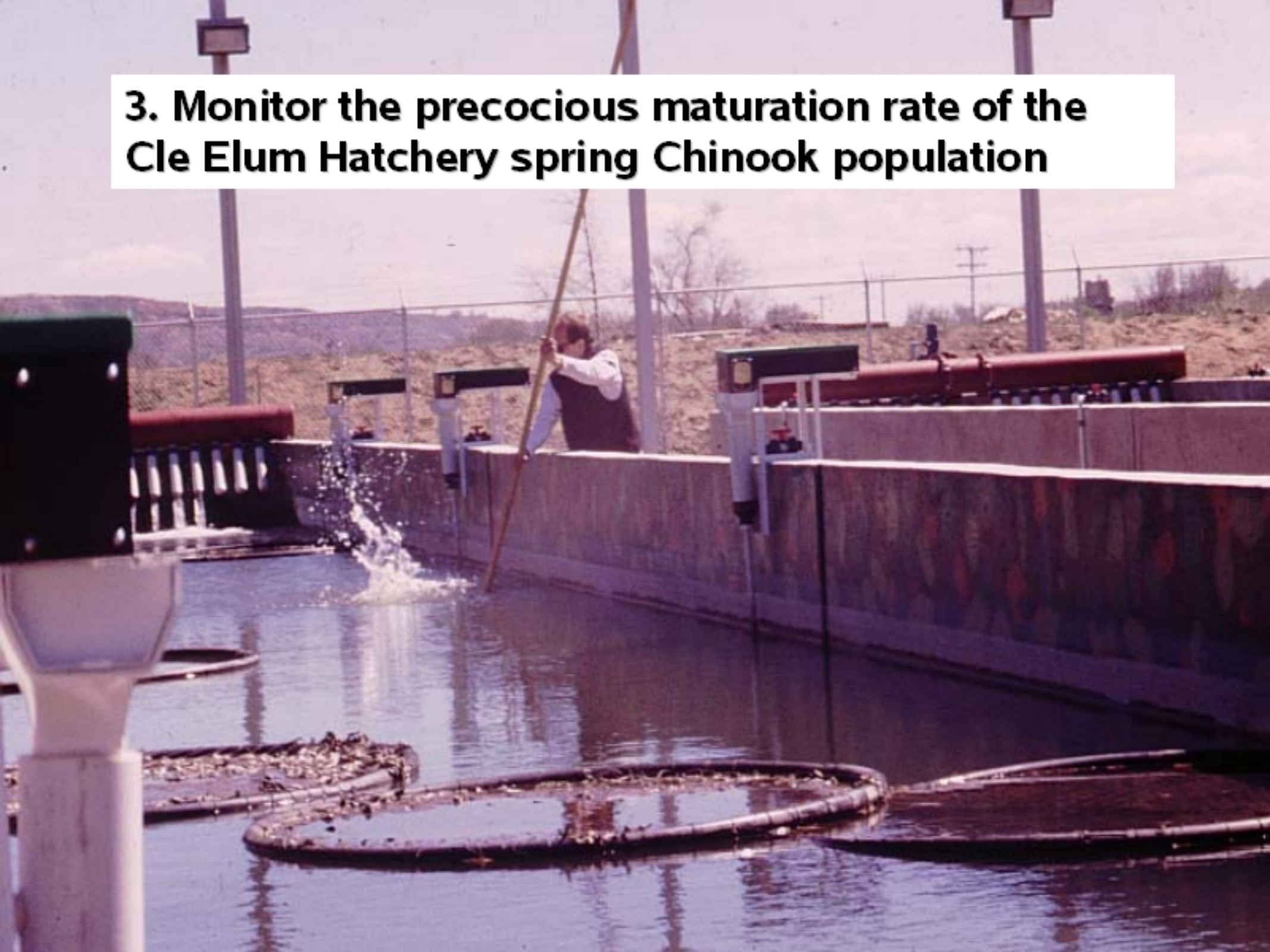
2. Assist Yakima Program in conducting production scale experiments to control precocious male maturation rates and improve smolt quality

BY 2002 Cle Elum Production Experiment



BY 2002 Cle Elum Production Experiment

- Alter ration to produce High (30 fish/lb.) and Low (45 fish/lb.) growth groups by mid-October start of tagging.
- Differentially tag treatment groups to monitor juvenile and adult survival
- In spring feed both groups equivalent ration as % of body weight
- Volitional emigration from acclimation sites starting mid-March

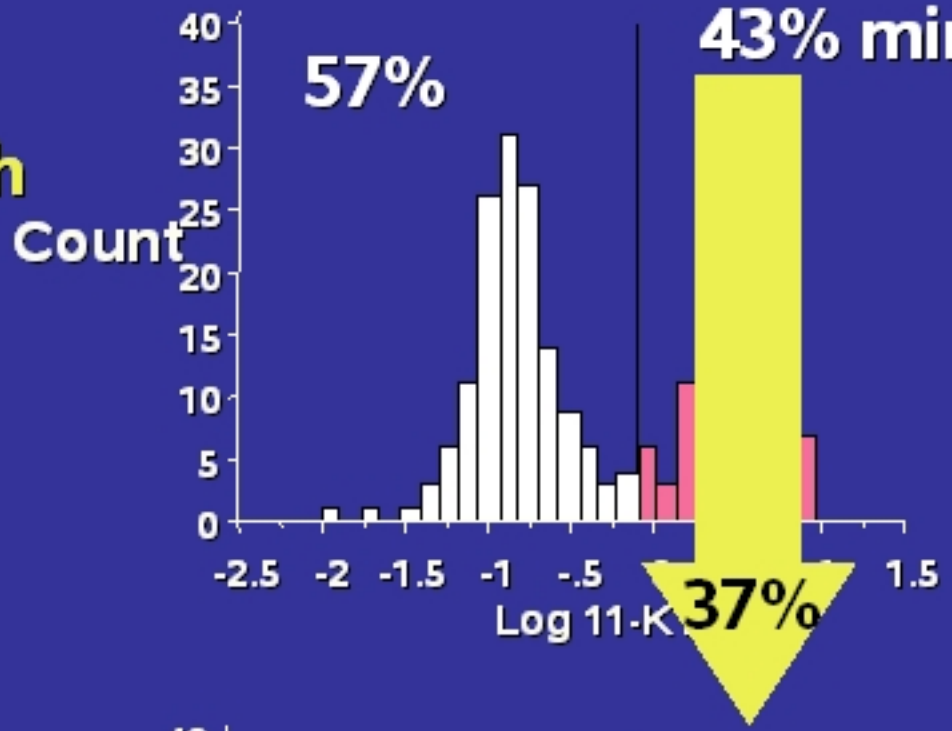


3. Monitor the precocious maturation rate of the Cle Elum Hatchery spring Chinook population


Pathology / Physiology Screening

Minijack Rate Cle Elum Stock BY 2002 (sampled '04)

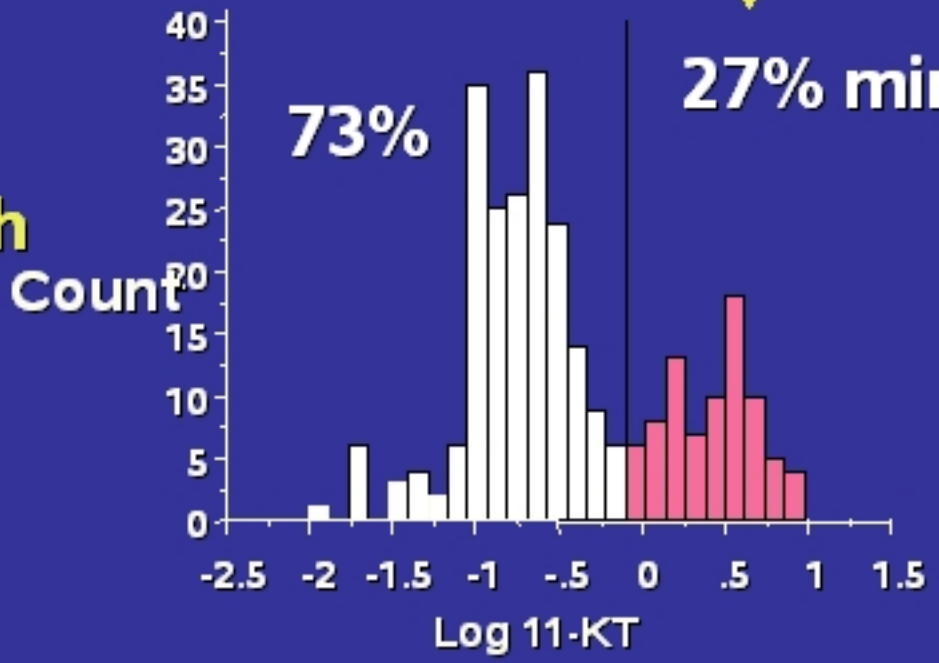
High Growth Treatment



N = 540

Female:Male ratio
53 : 47

Low Growth Treatment

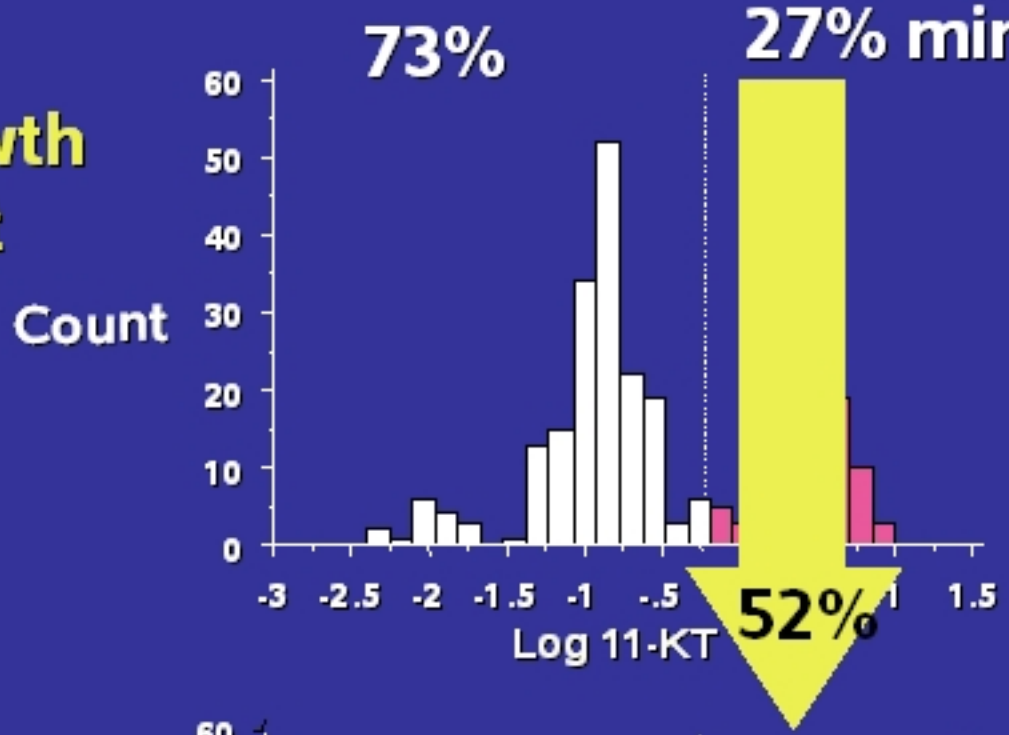


N = 540

Female:Male ratio
49 : 51

Minijack Rate Cle Elum Stock BY 2003 (sampled '05)

High Growth Treatment



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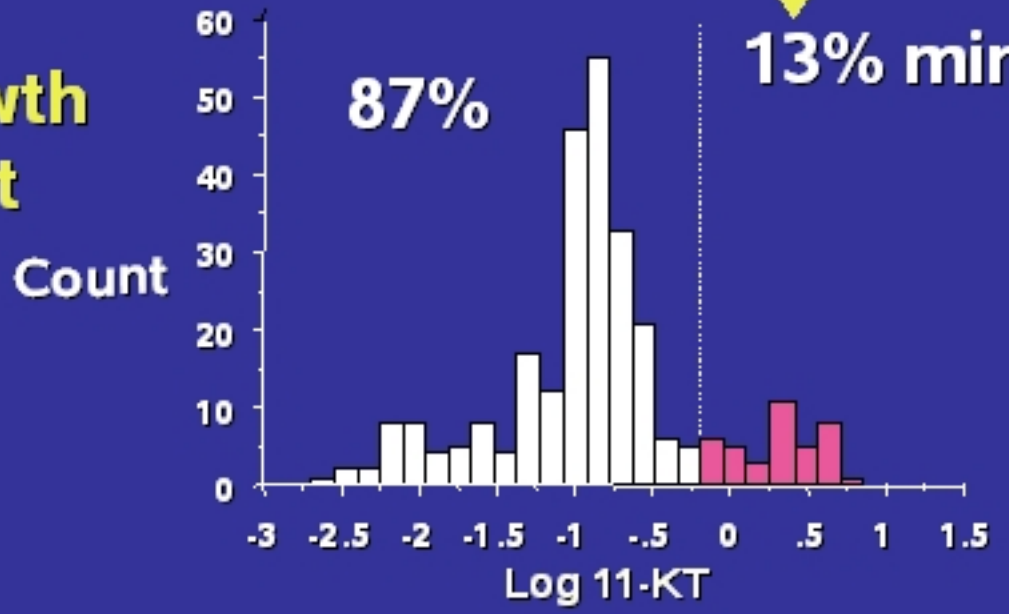


N = 540

Female:Male ratio
49 : 51

Release size of BY '02 and '03 Cle Elum Spring Chinook

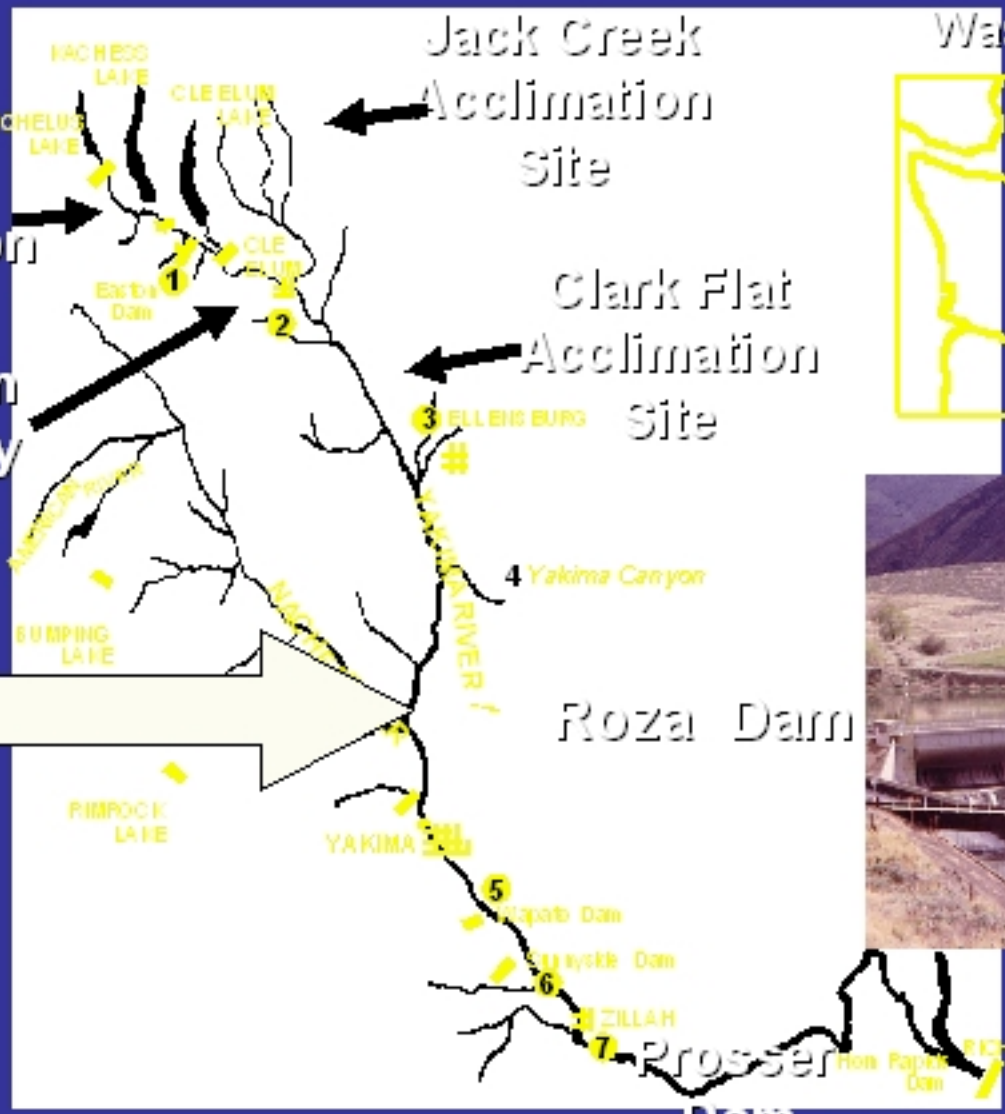
	High Growth Growth	Low
BY '02	15.6 g	11.7 g
BY '03	19.1 g	13.6 g

Potential Explanations:

Sampling error
Year-to-year population variation
Genetic influence

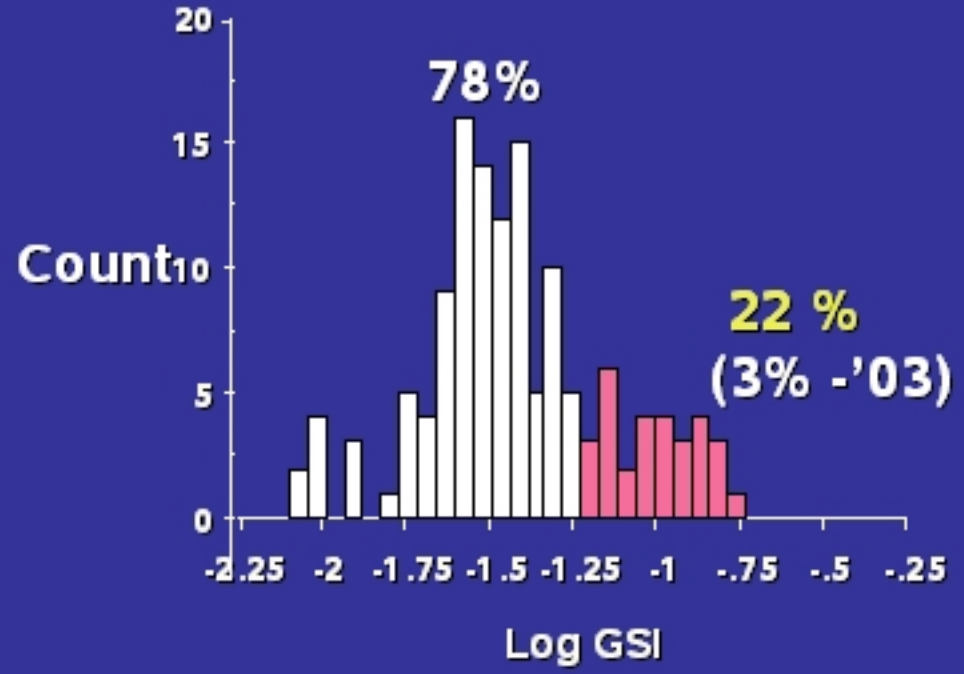
4. Estimate the precocious maturation rate of wild Yakima Spring Chinook

The Yakima River



Wild minijack rates at Roza in 2004 ranged from 11-22% of males

1/28/04

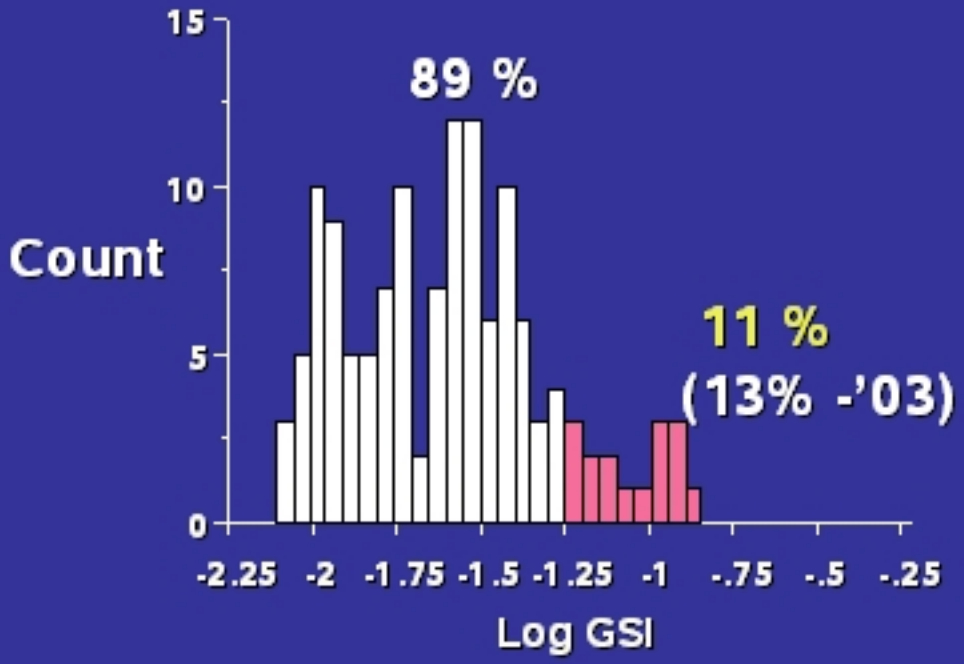


N = 310

F:M ratio
56:44

(50:50 -'03)

2/27/04

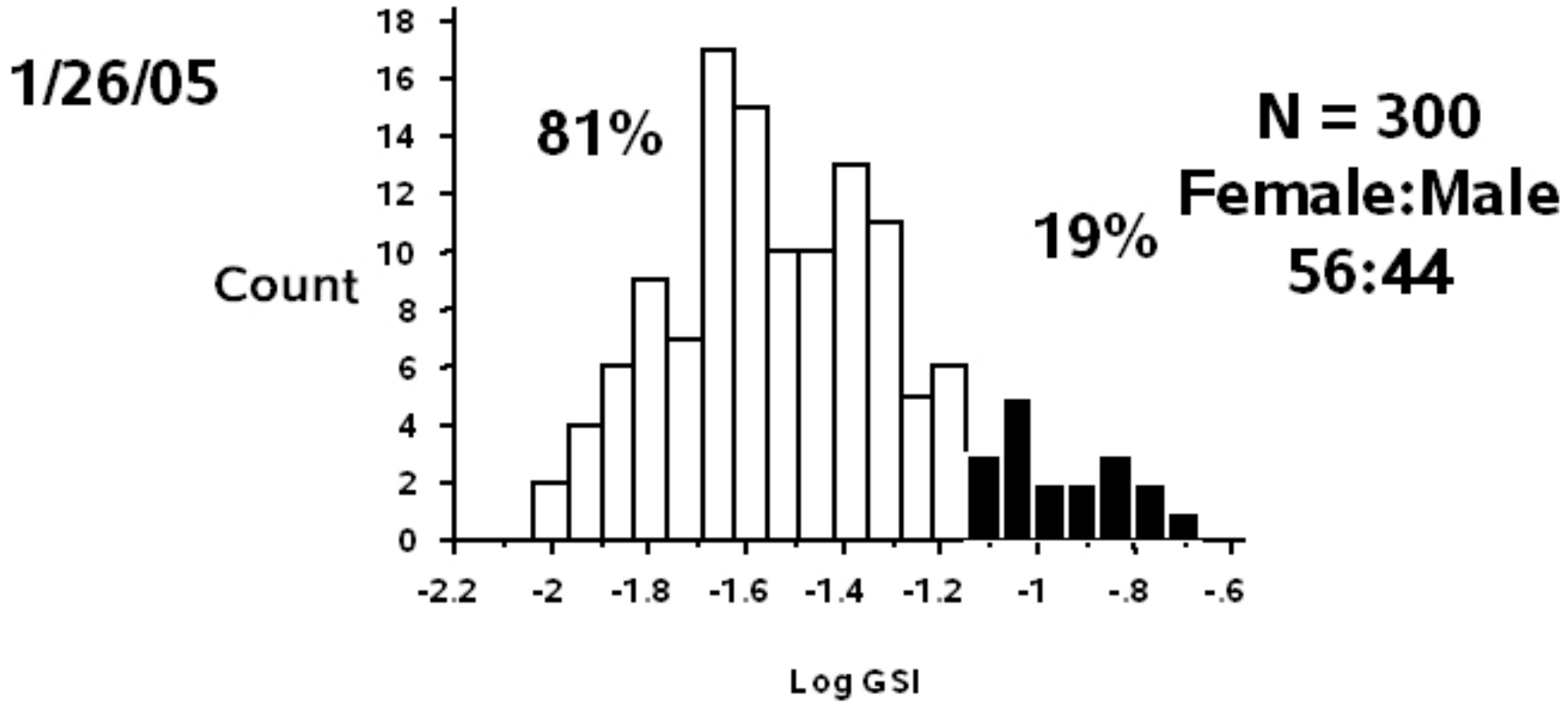


N = 308

F:M ratio
57:43

(49:51 -'03)

Wild Minijack estimates at Roza Dam
BY 2003 (sampled in '05)



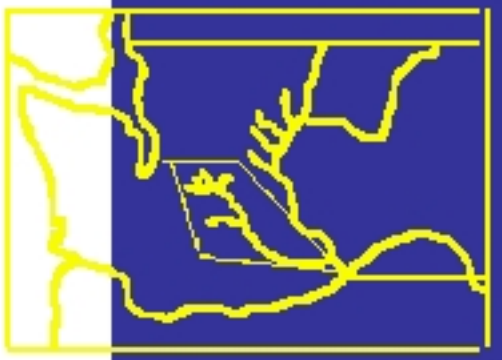
Wild Minijack Estimates BY 01-03

BY 01	3-13%
BY 02	11-22%
BY 03	19%

The Yakima River

Jack Creek Acclimation Site

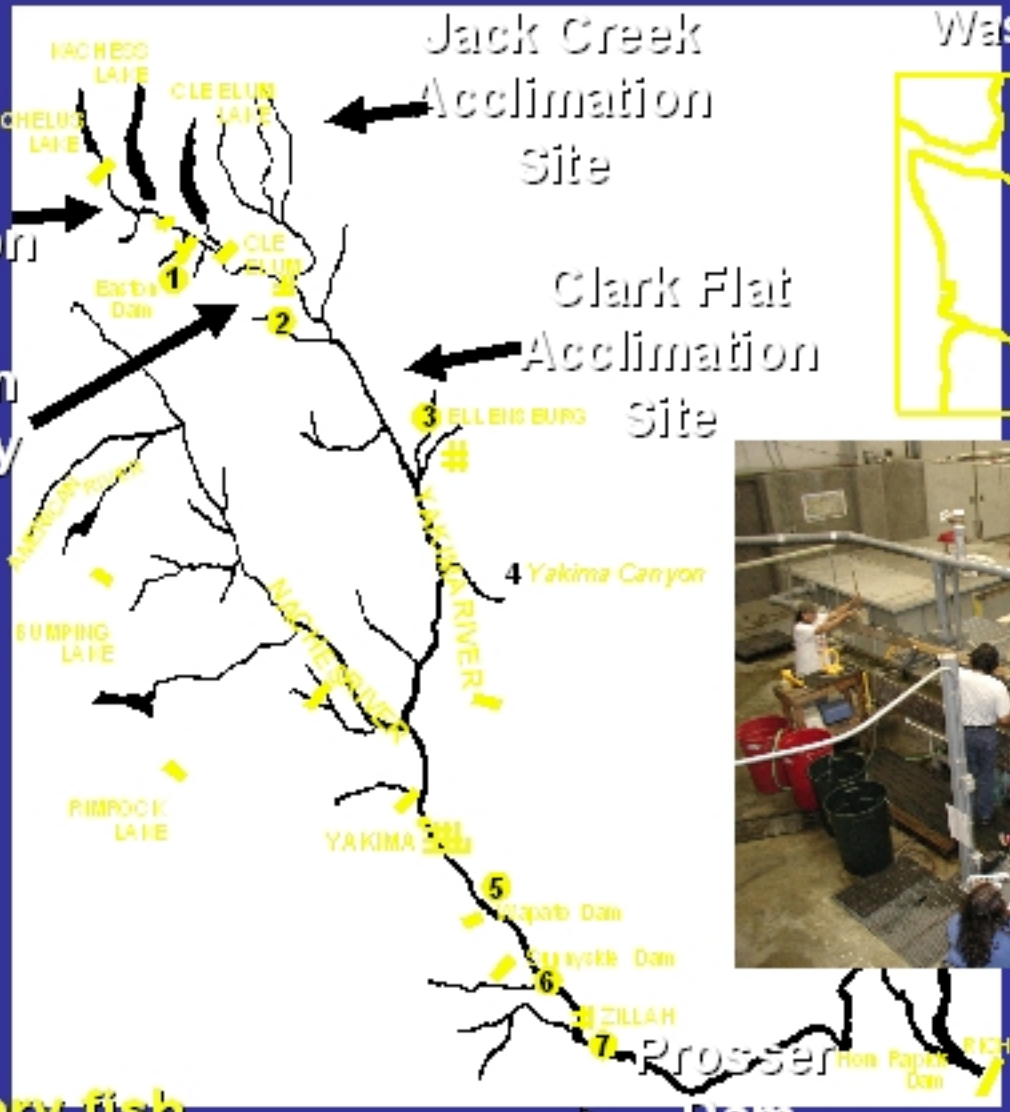
Washington State



Easton Acclimation Site

Cle Elum Hatchery

Clark Flat Acclimation Site

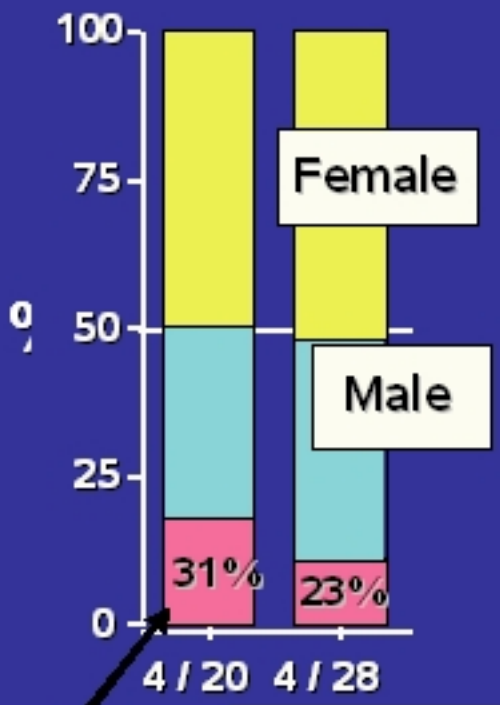


N

Wild / hatchery fish spring smolt migration

BY 03 Hatchery and Wild Fish - Prosser Dam 2005

High Growth

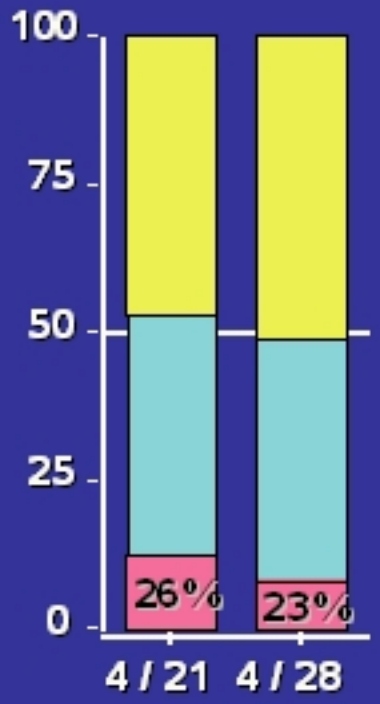


Minijacks

27% of males minijacks (28% - '04)

F:M
51:49 (61:39 - '03)

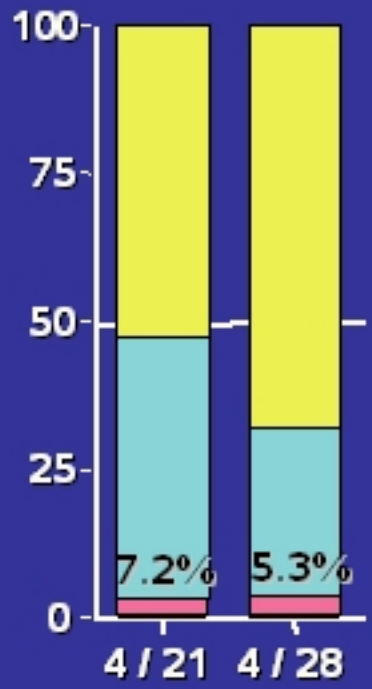
Low Growth



25% of males Minijacks (27% - '04)

F:M
48:52 (52:48 - '03)

Wild



6.3% of males minijacks (11% - '03)

F:M
58:42 (62:38 - '03)

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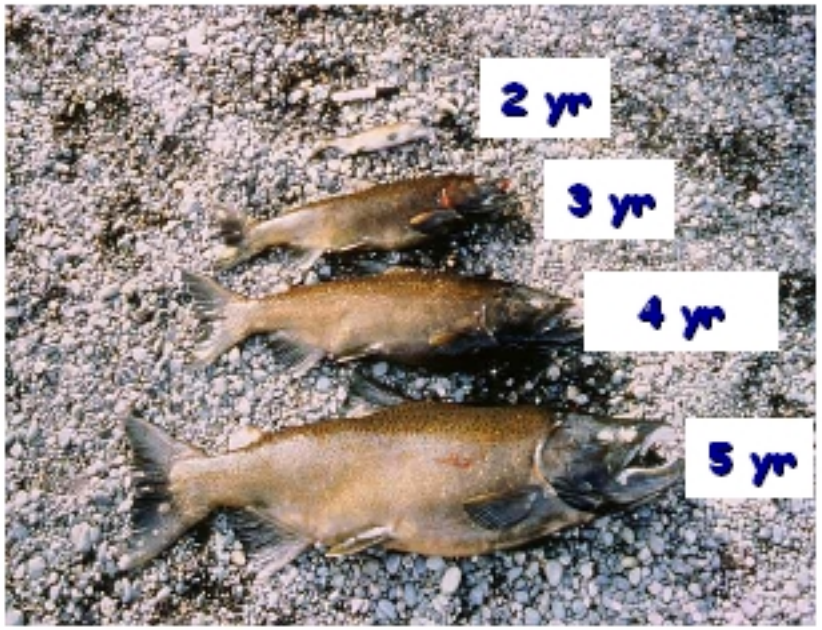
3. Assist Ya… …g production scale exp… …ious male maturatio… …quality

5. Monitor t… …ate of the Cle Elum Hat… …lation

7. Estimate the precocious maturation rate of wild Yakima Spring Chinook

Variation in Age of Male Maturity



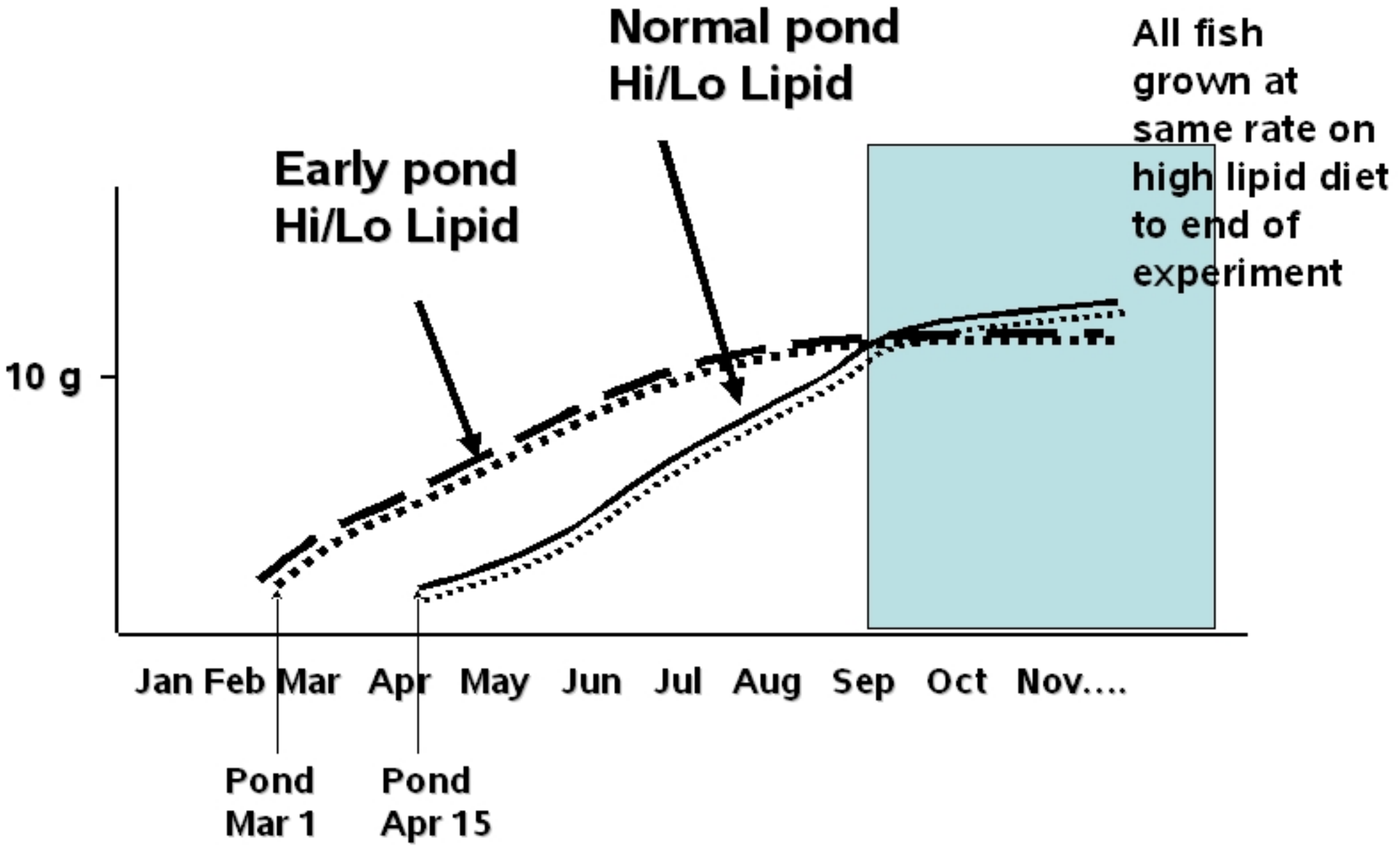
Mature male salmon

Factors Affecting Age of Maturity

- ✓ Genetics
- ✓ Environment
  - temperature
  - food availability
  - food quality

Growth & Body energy stores

Minijack Reduction Experiment II (BY 2003)

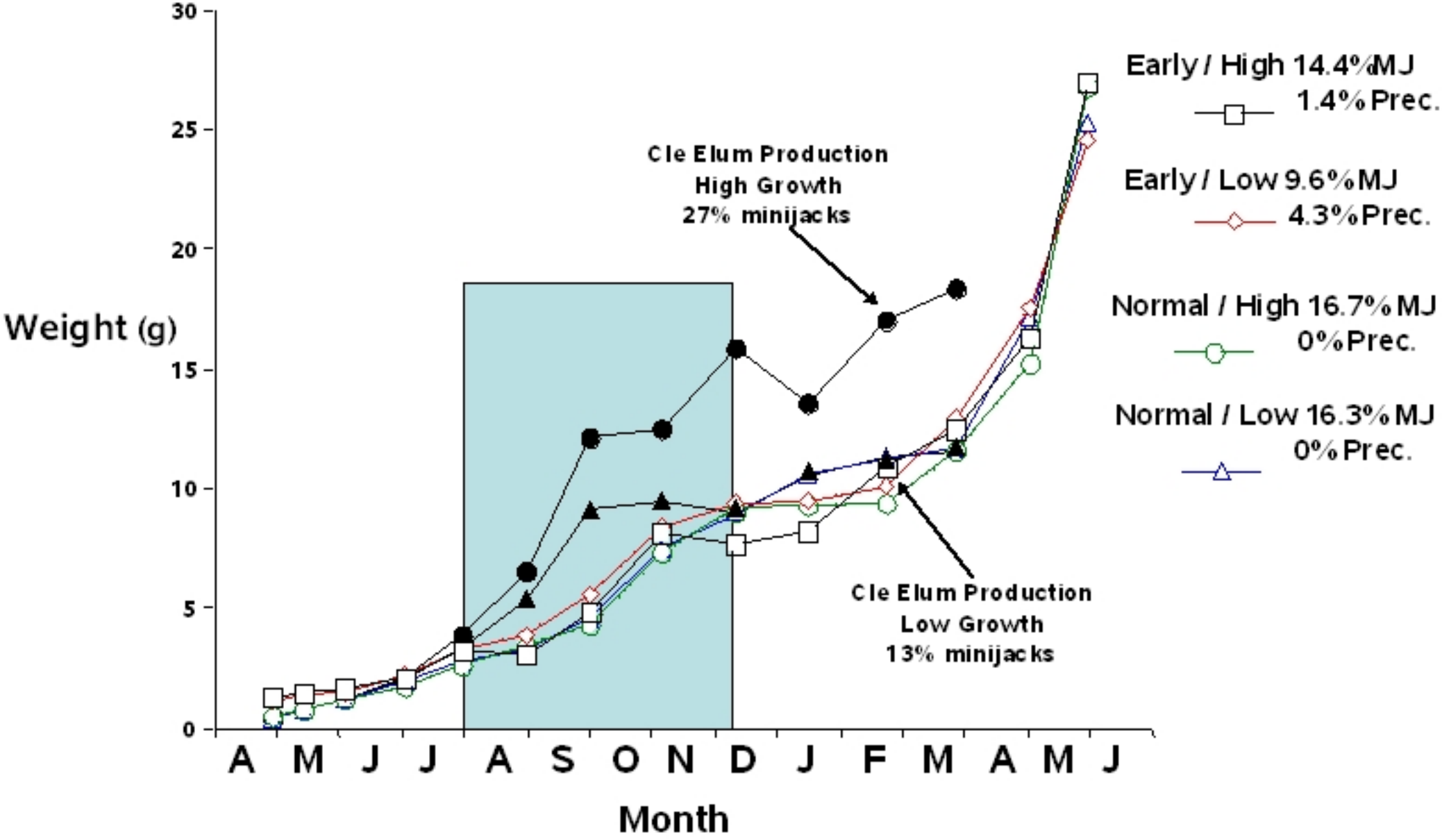


Monitor

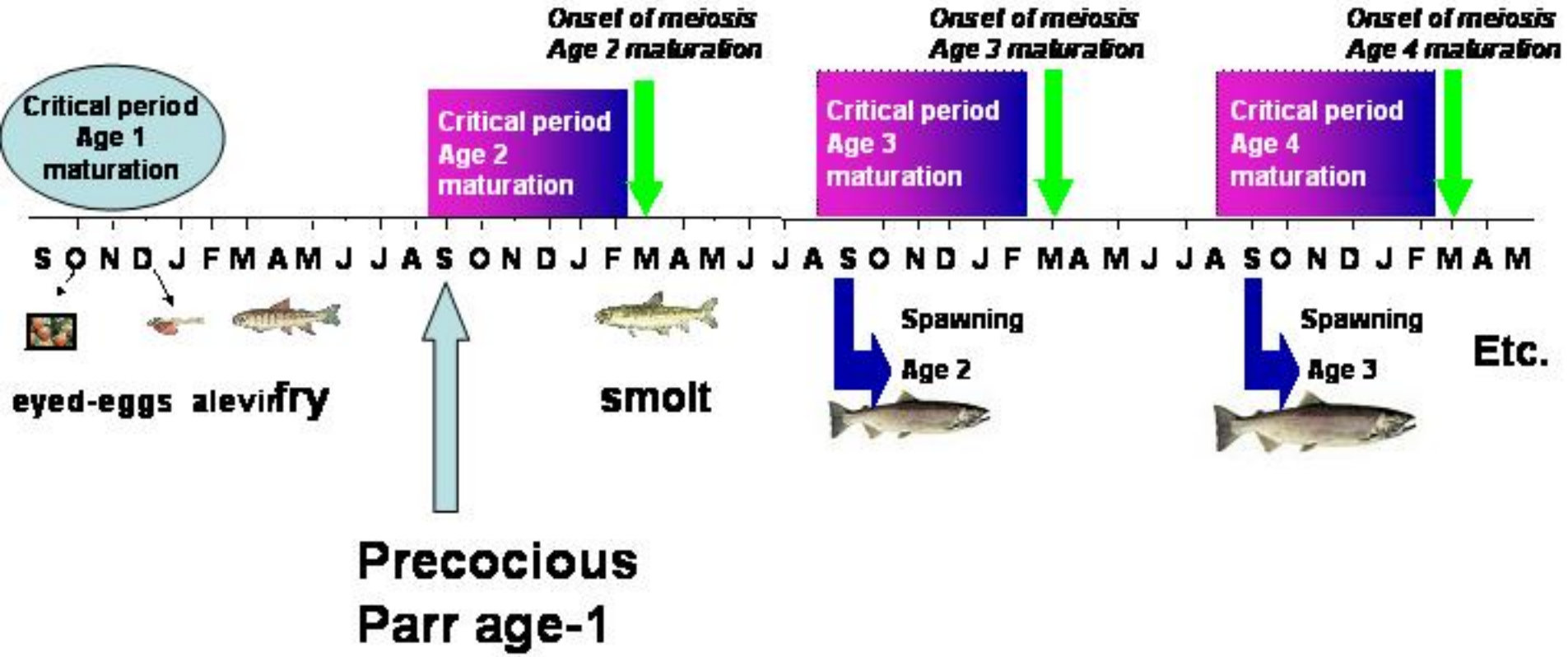
- Size
- Gill Na+/K+-ATPase (index of smolting)
- Plasma IGF-I (growth regulating hormone)
- Condition Factor
- Whole body lipid

Brood Year 2003 Minijack Reduction Experiment

Preliminary results



Annual Critical Periods When Growth Affects Puberty Onset



Future Investigations

How prevalent is precocious male maturation in other Columbia Basin spring Chinook salmon populations?

Thanks to Joy Evered-USFWS, Olympia
Dan Davies-Leavenworth National Fish Hatchery
Bill Edwards-Entiat National Fish Hatchery
Chris Pasley-Winthrop National Fish Hatchery

Preliminary Data 2005

	BY		%minijacks	
Cle Elum Hatchery	97-01	"High growth"	37-53%	
	02	High growth	43%	15.6g
		Low growth	27%	11.7g
	03	High growth	27%	18.3g
		Low growth	13%	11.5g
Carson Stock	03	Leavenworth	9%	26.4g
		Entiat	13%	27.1g
		Winthrop	17%	25.3g

Conclusions

- Rates of precocious male maturation vary annually in both wild and hatchery stocks
- Growth modulation clearly alters maturation rates and life-history composition of populations
- Emergence time and initial growth significantly influences prevalence of precocious parr
- Minijacks are ubiquitous even in stocks cultured for decades
- Localized broodstocks (i.e. wild) may be particularly susceptible to high rates of precocious maturation under optimal growing conditions of the hatchery environment


Questions?

GSI and 11-KT levels indicate maturity onset at least 8 mos. Prior to spawning