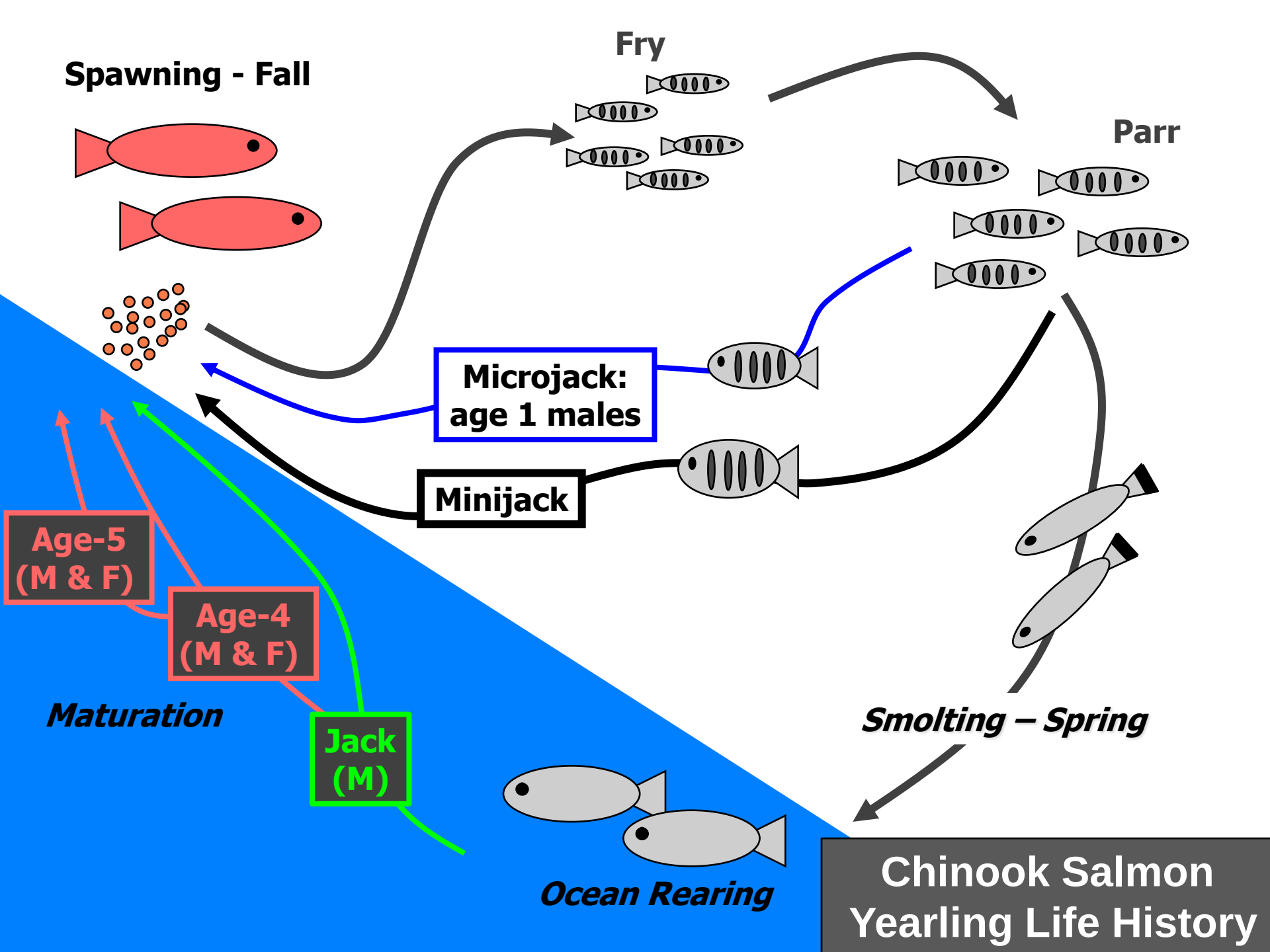
The Mac & Jack study: Size and domestication effects on minijack rates of summer Chinook salmon from McCall Fish Hatchery, Idaho.

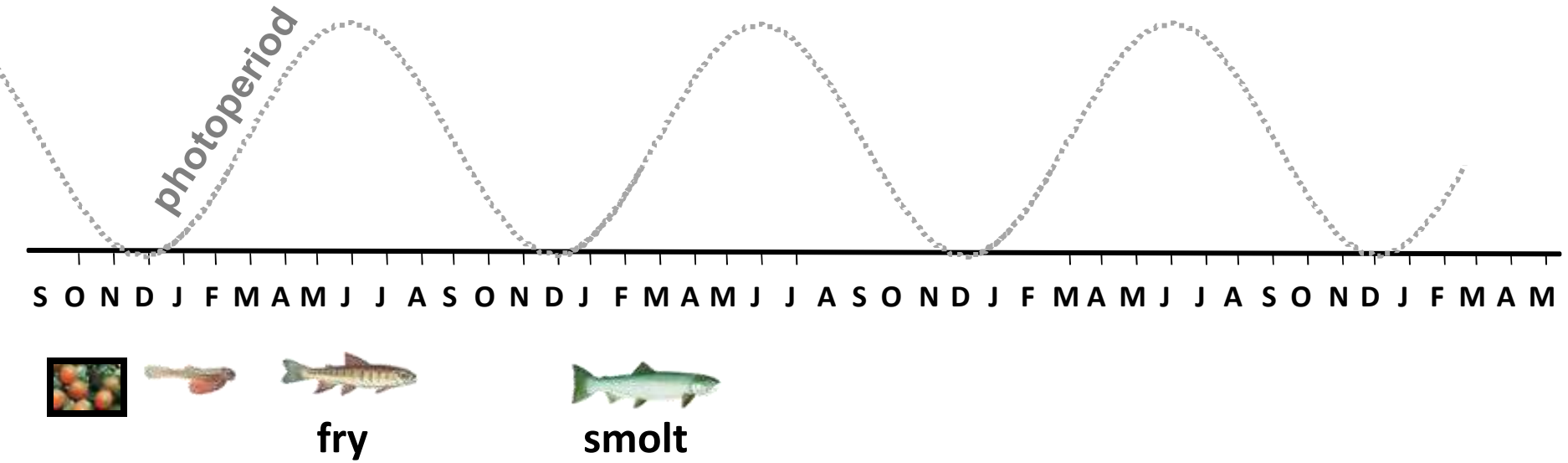
Deb Harstad[1]*, Don Larsen[1], Abby Fuhrman[1], Dina Spangenberg[1], Chris Kozfkay[2], Brian Beckman[1]

1

2


Spawning - Fall
Fry
Parr
Microjack:
age 1 males
Minijack
Age-5
(M & F)
Age-4
(M & F)
Maturation
Jack
(M)
Smolting – Spring
Ocean Rearing
Chinook Salmon
Yearling Life History

Critical Periods in Maturation Decision



Adapted from P. Swanson

- Silverstein et al. 1998, *CJFAS*
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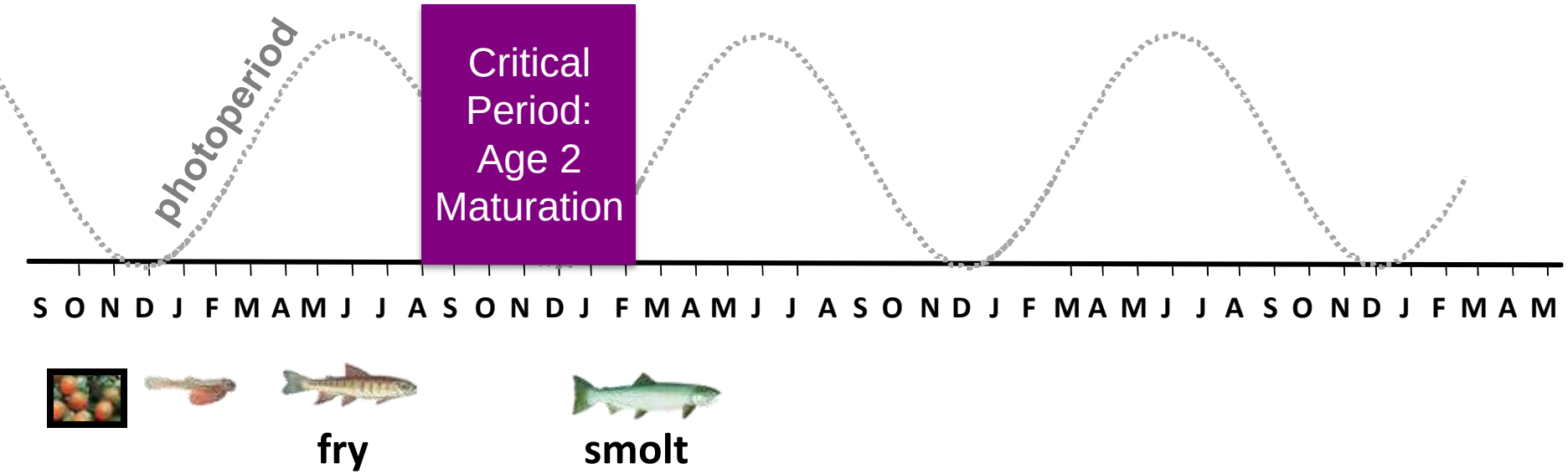

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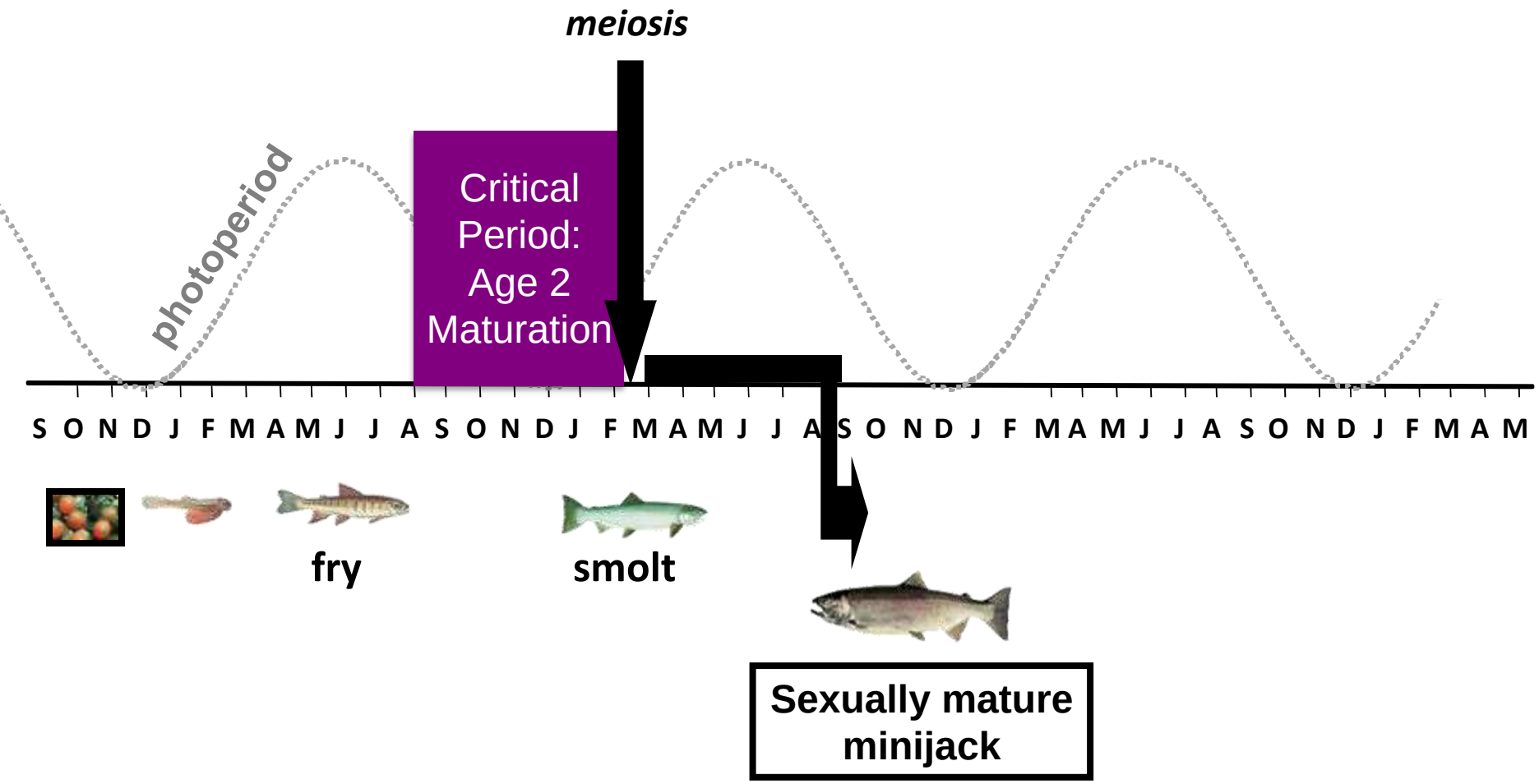

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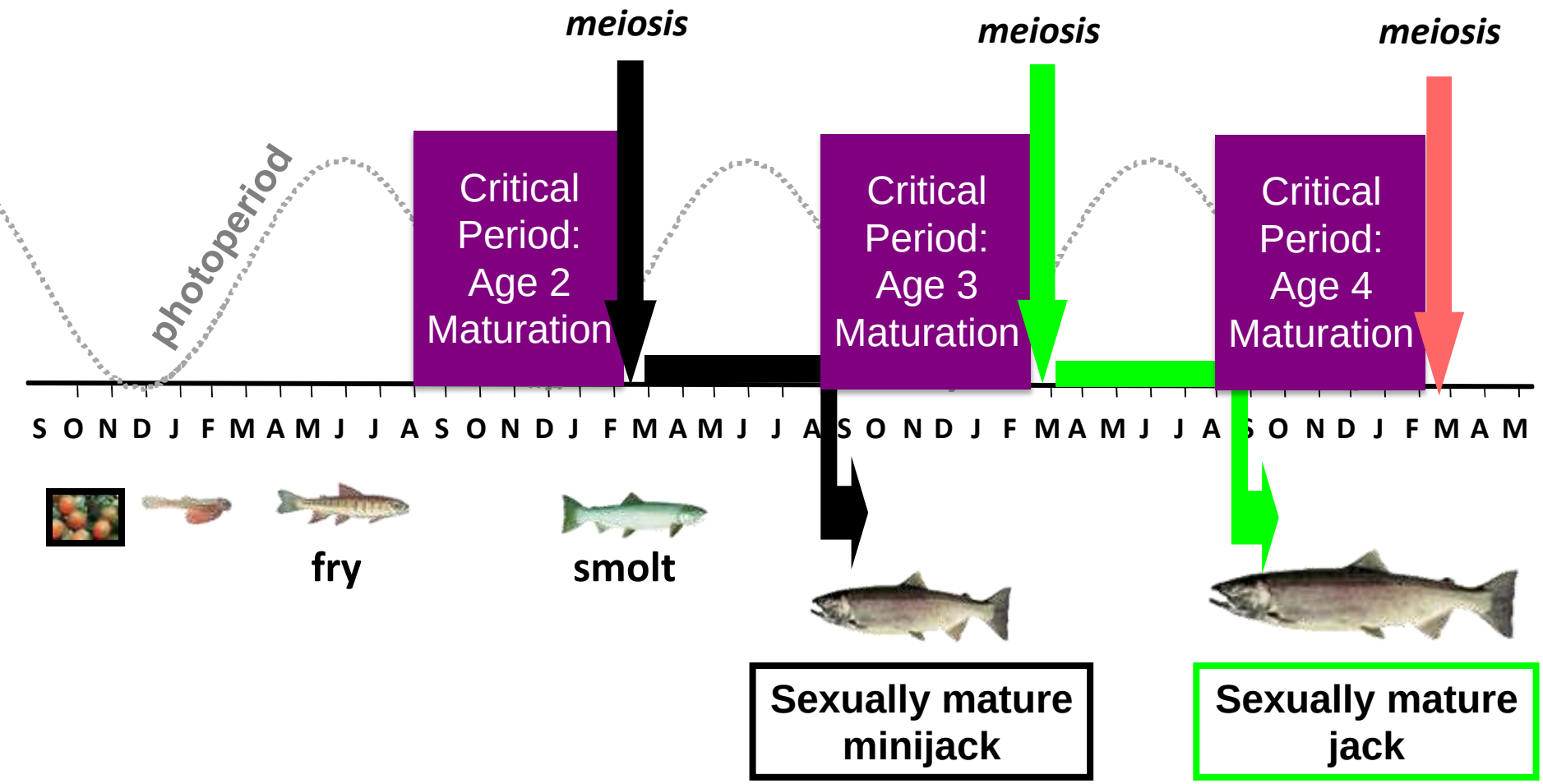

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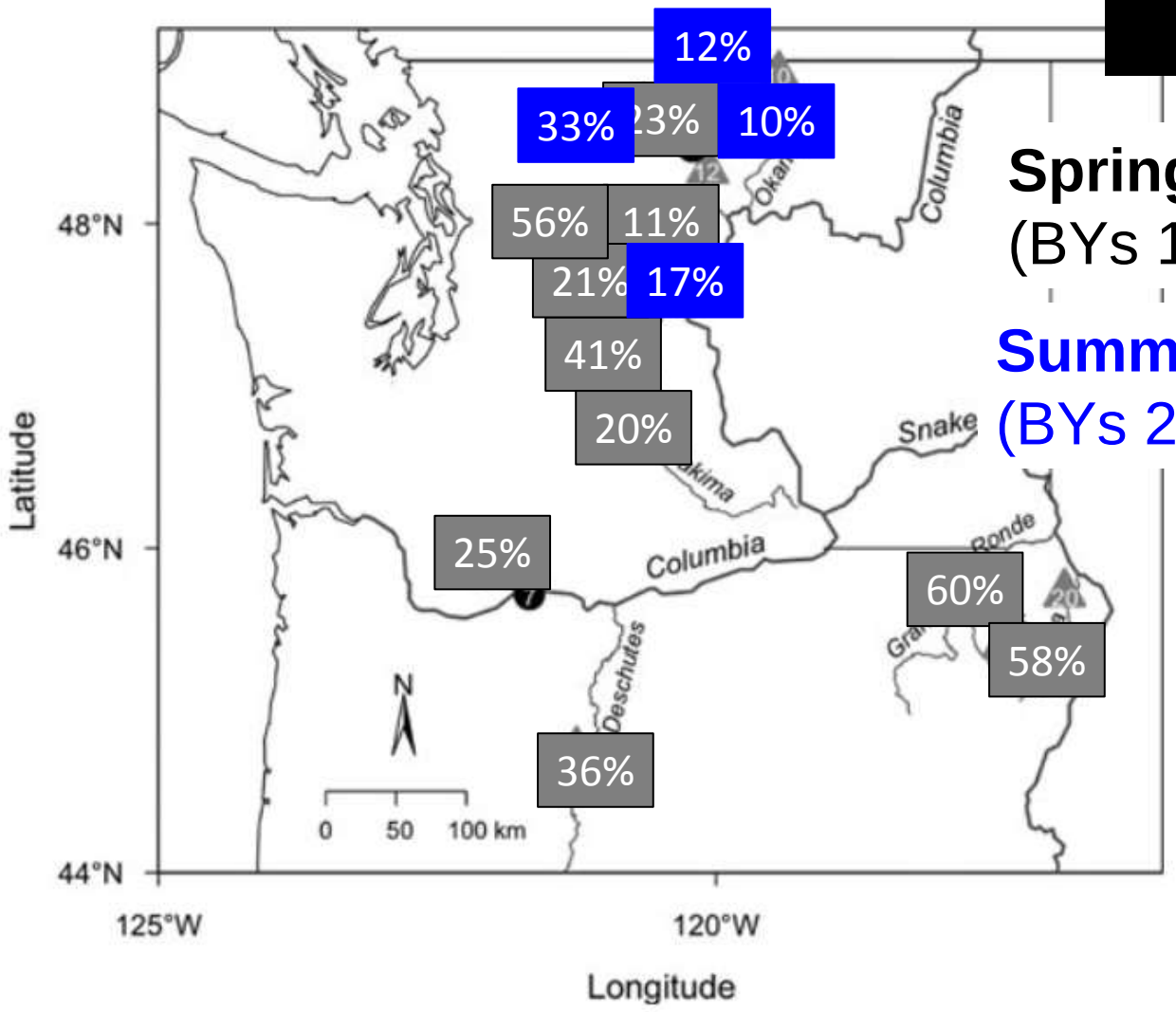
Minijack (MJ) rates from Columbia River and Snake River basins: WA & OR



Mean MJ rates:

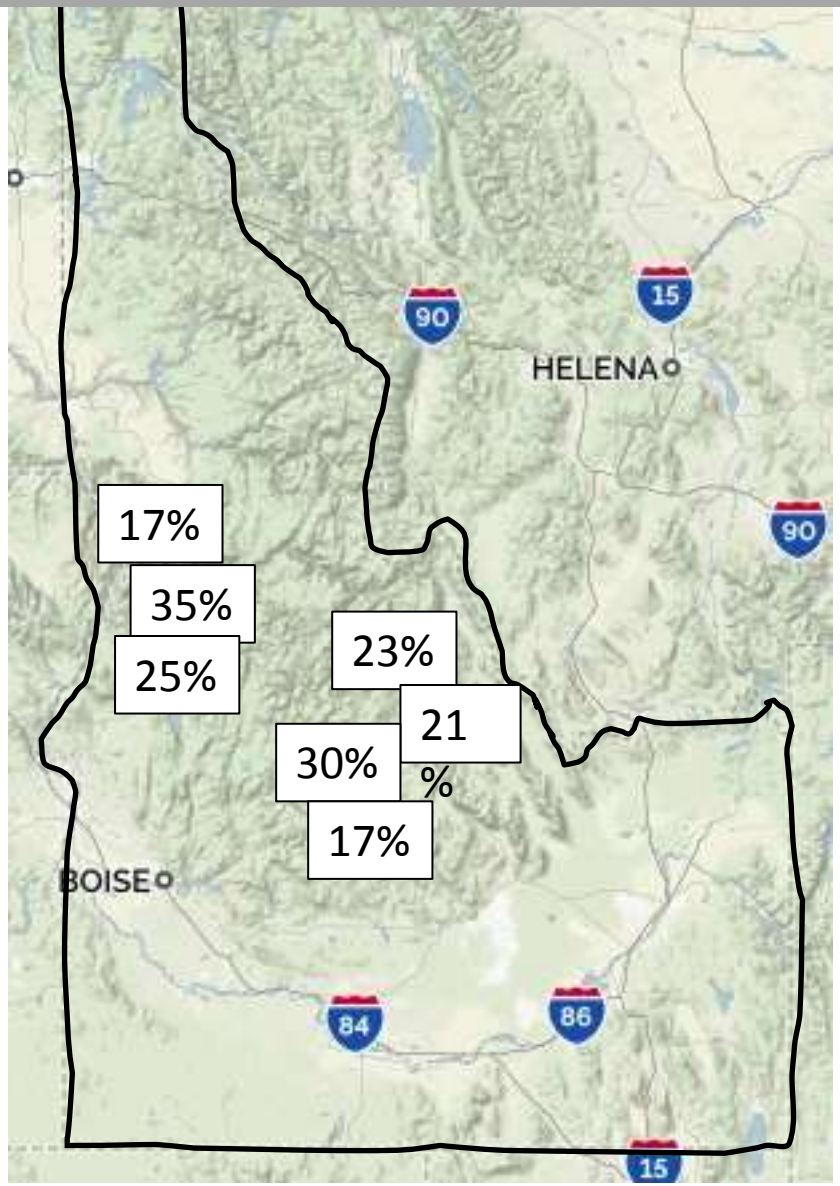
Spring Chinook* = 32%
(BYs 1999-2010)

Summer Chinook* = 19%
(BYs 2006-2009)

*Yearlings

Harstad et al. 2014

MJ rates from Snake River basin: ID



<u>Brood Years 2013-2015</u>:

-Rapid River Hatchery

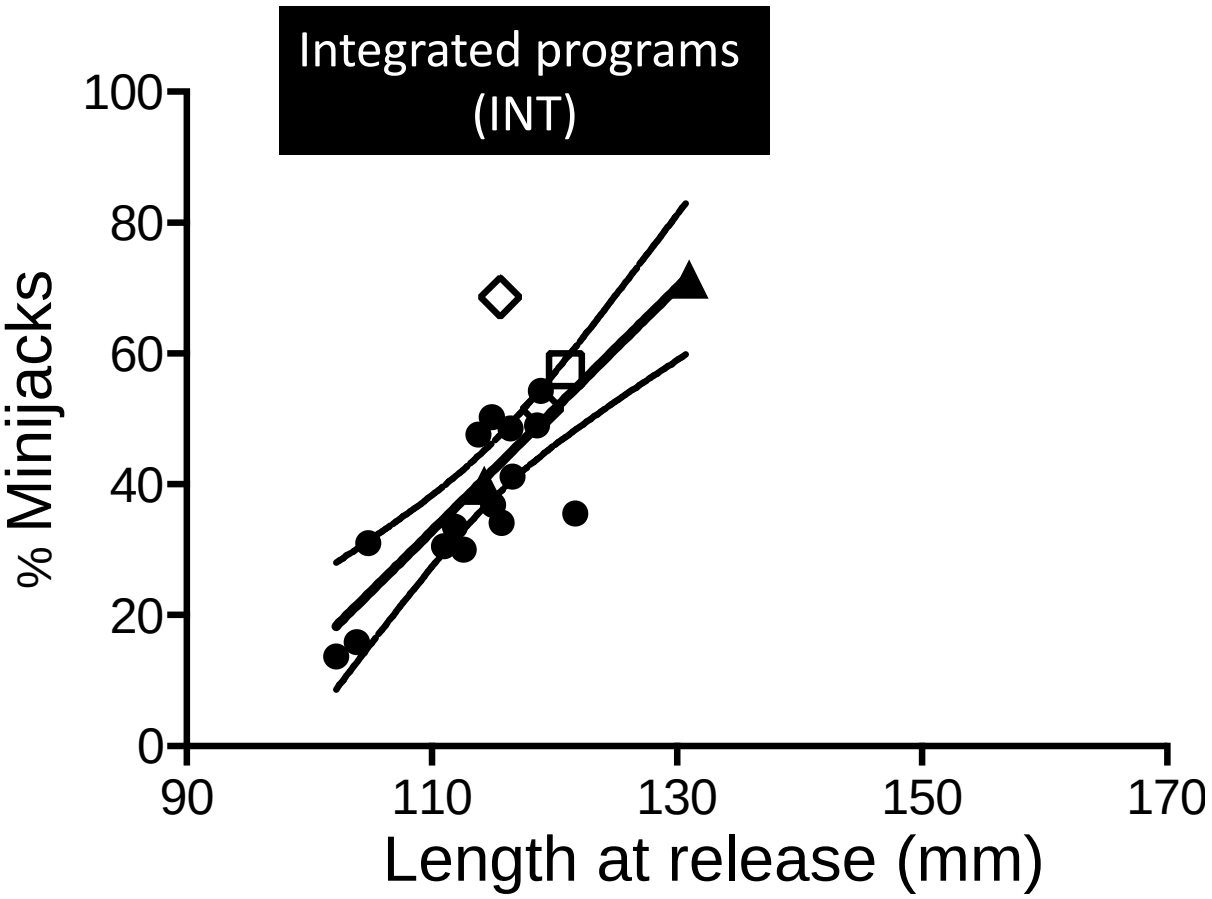
-McCall Hatchery

-Pahsimeroi Hatchery

-Sawtooth Hatchery

Spring/Summer Chinook
Mean MJ rates = 24.6%

Minijack rate is related to growth/size: Integrated vs. Segregated Programs



Harstad et al. 2014

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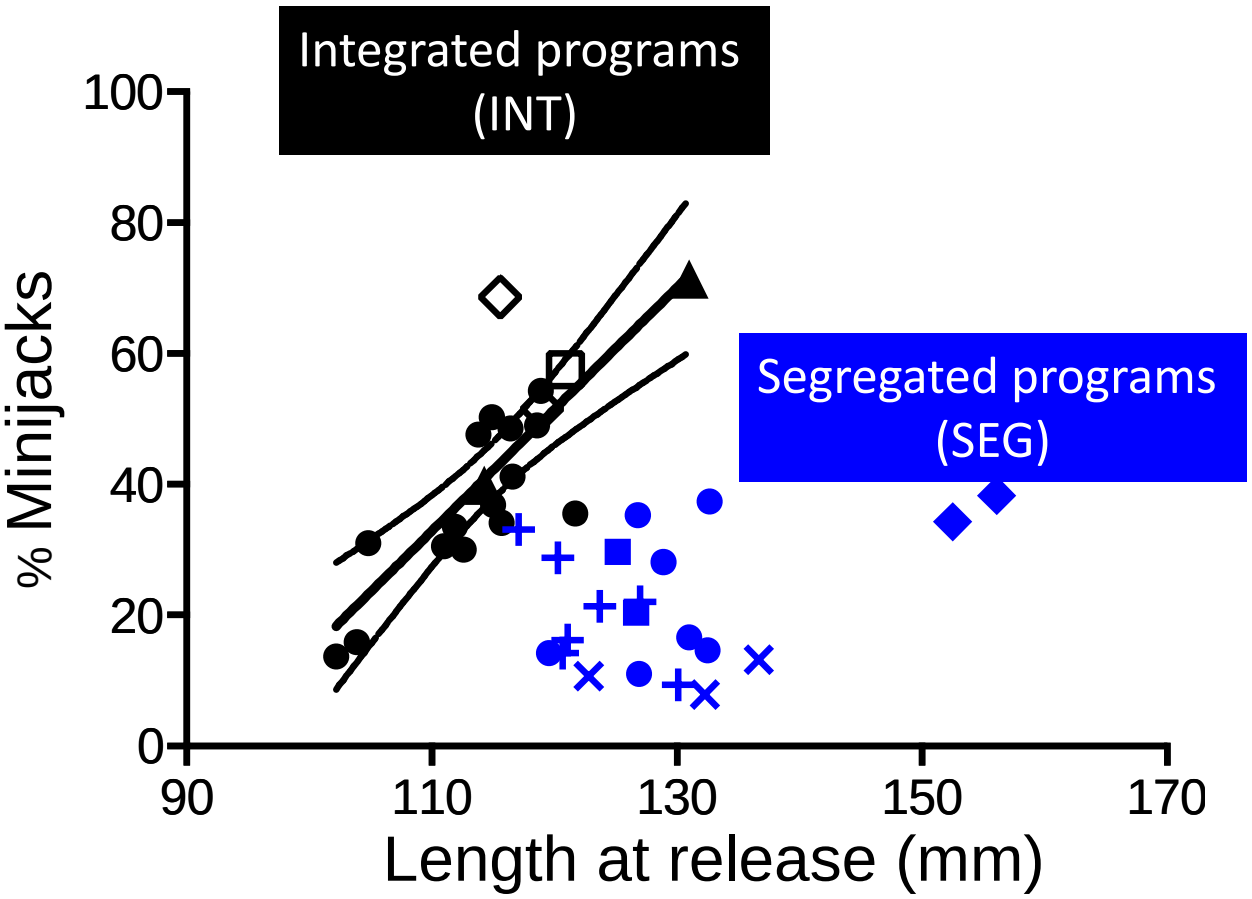

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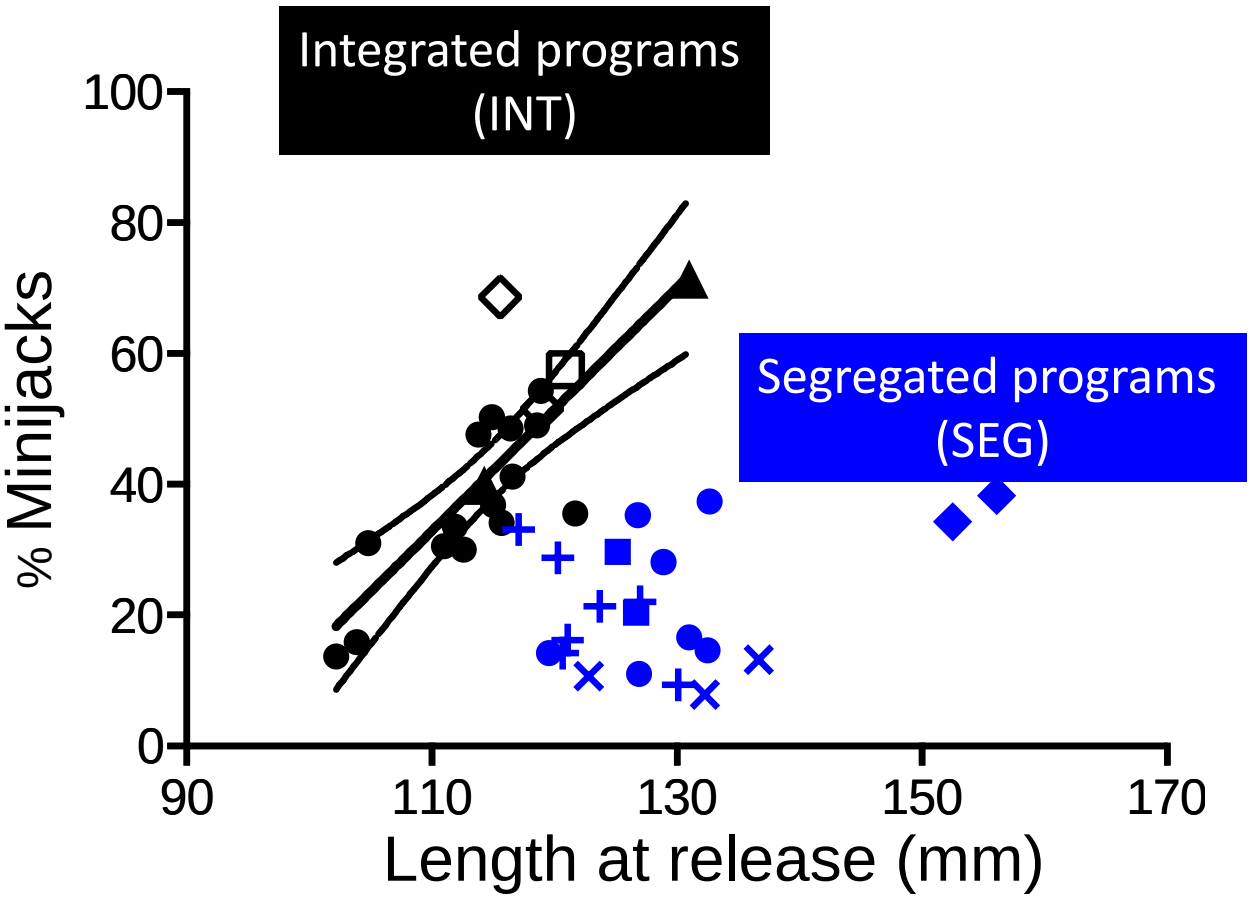
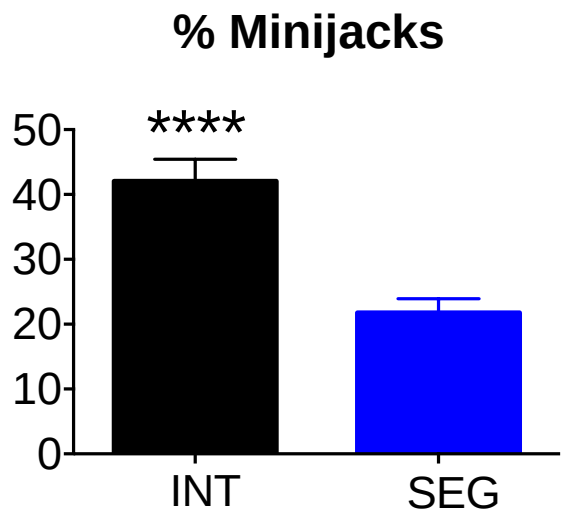
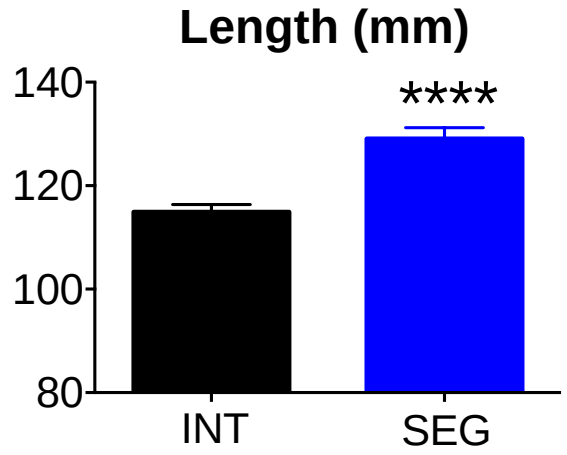


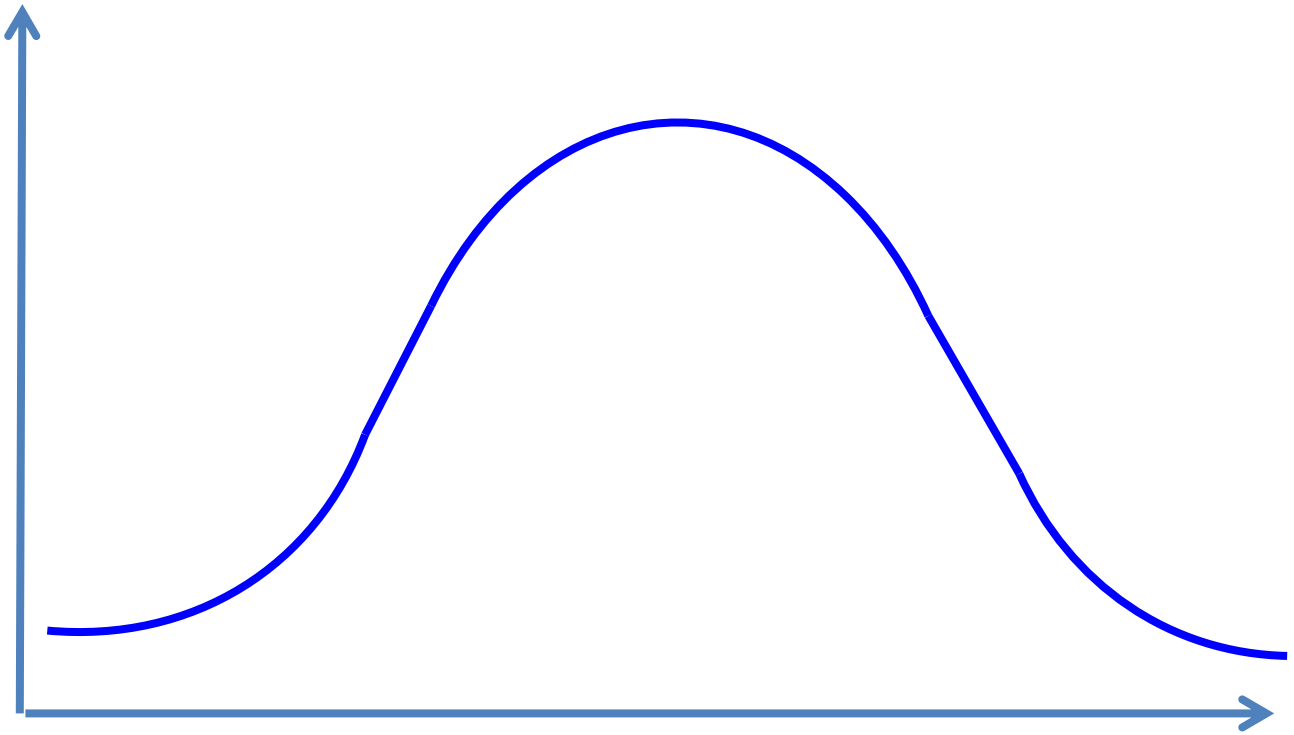




Harstad et al. 2014

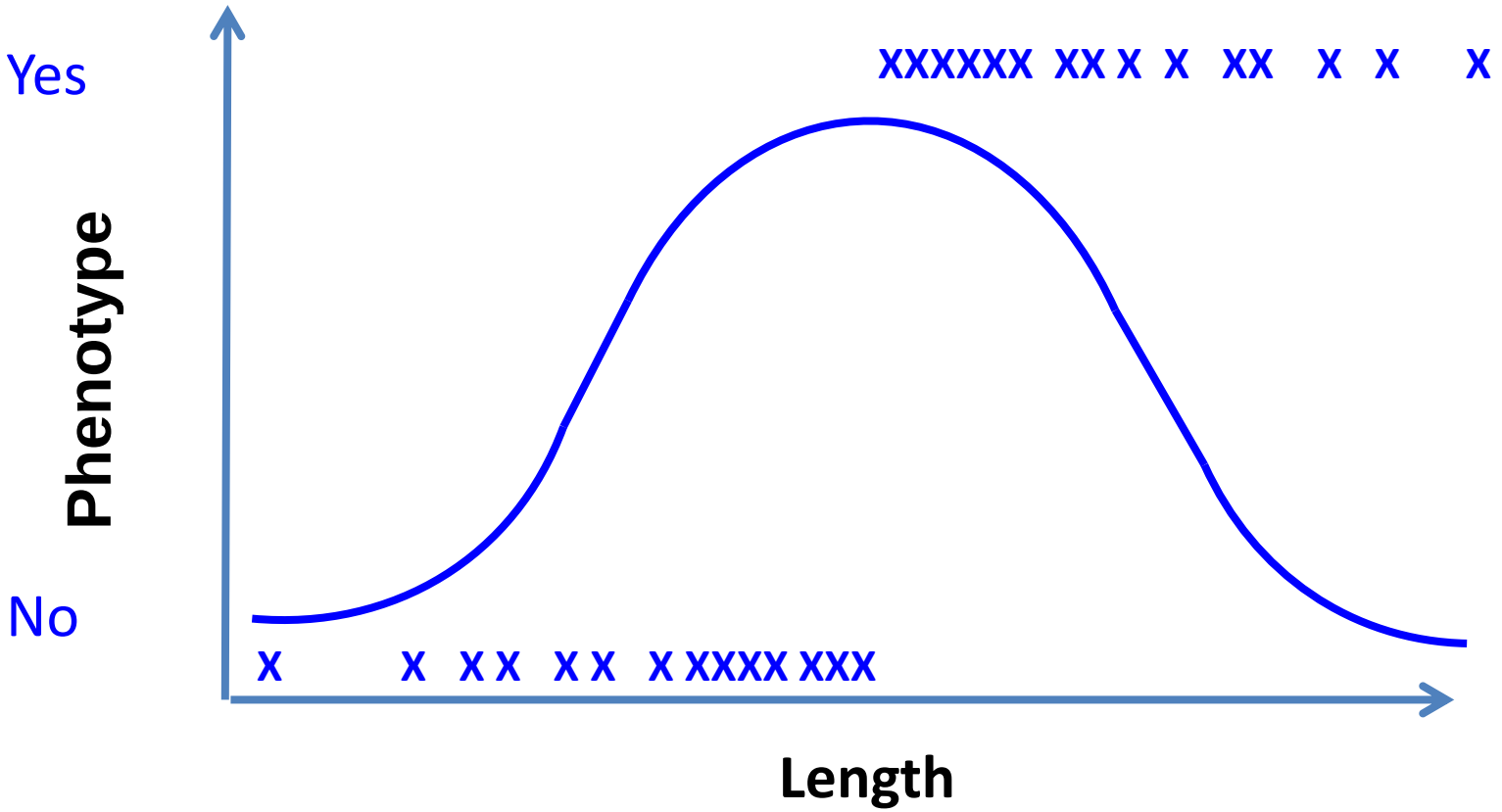
Threshold trait

continuous distribution of factors that contribute to a trait

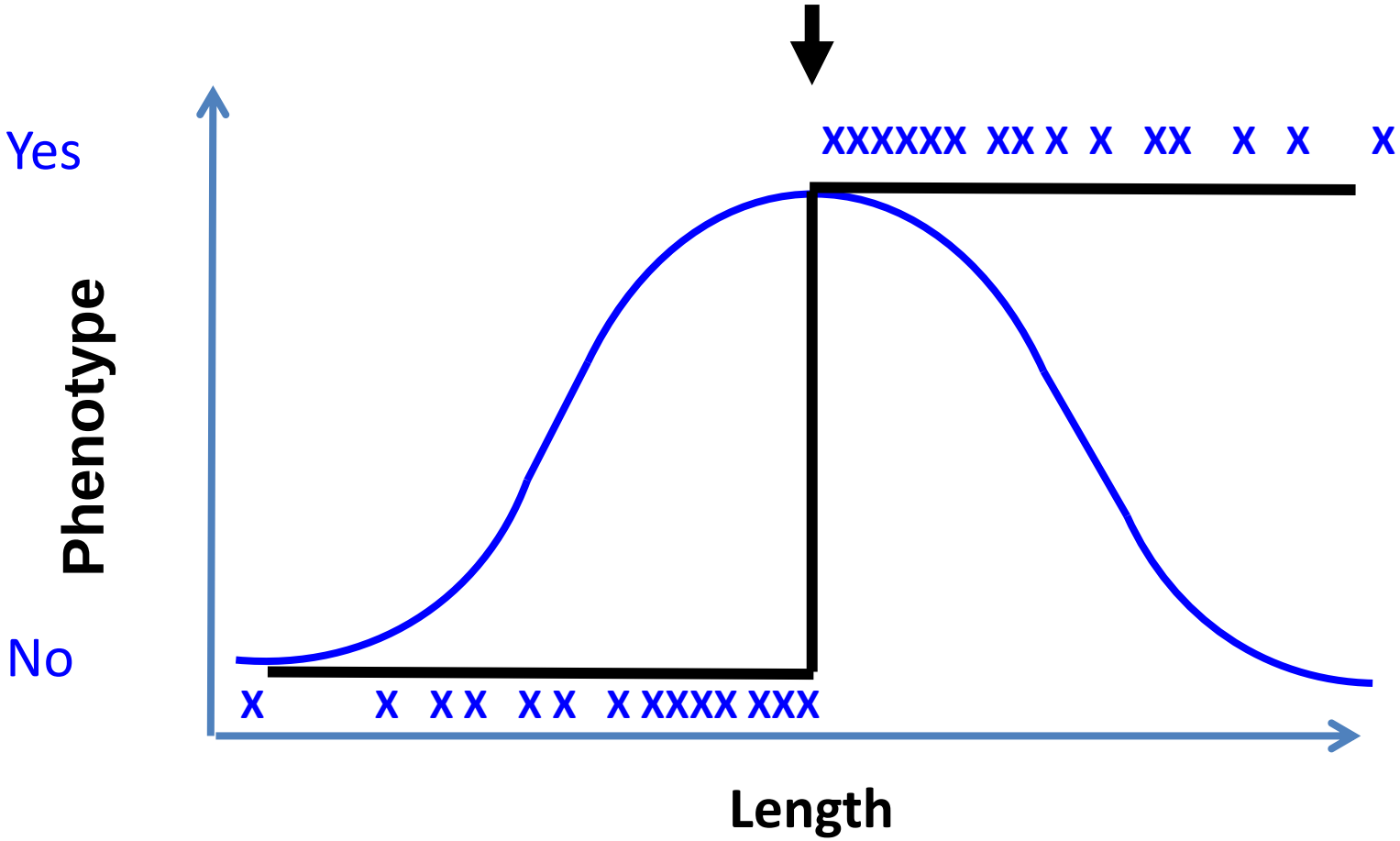


(i.e. size, growth rate, lipid level)

Threshold trait

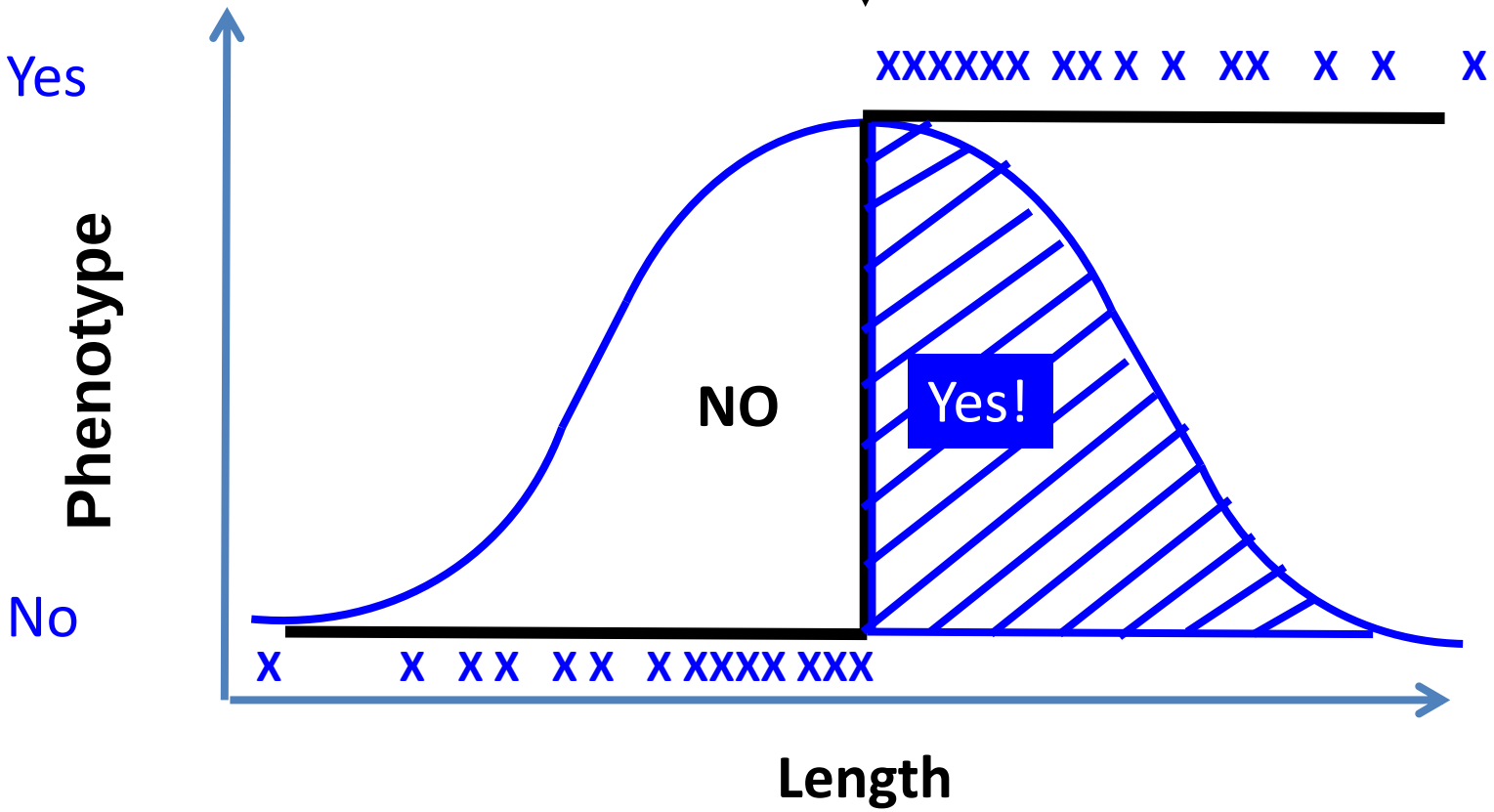


Threshold trait

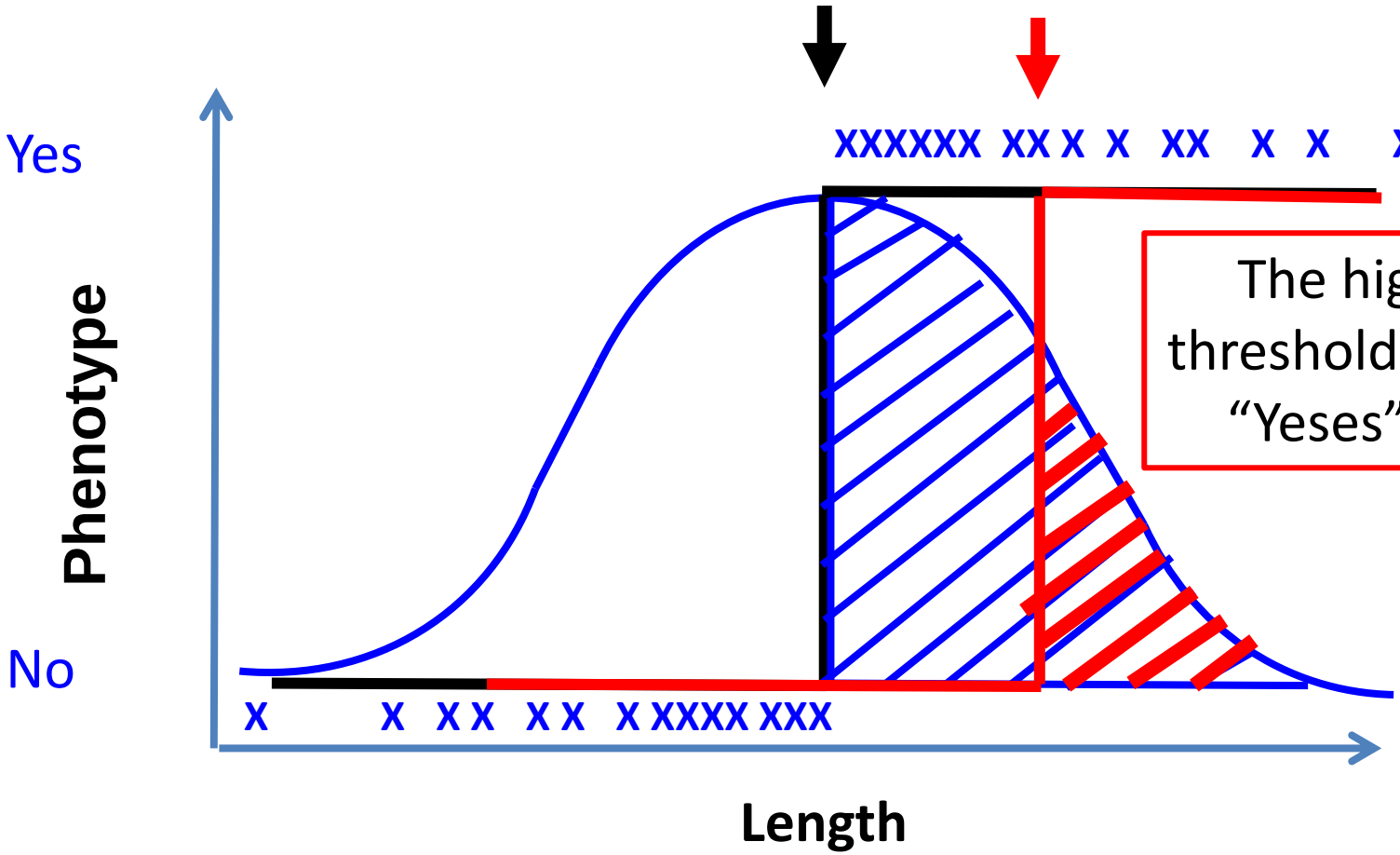


Threshold trait

If you exceed a threshold, than you will develop the trait

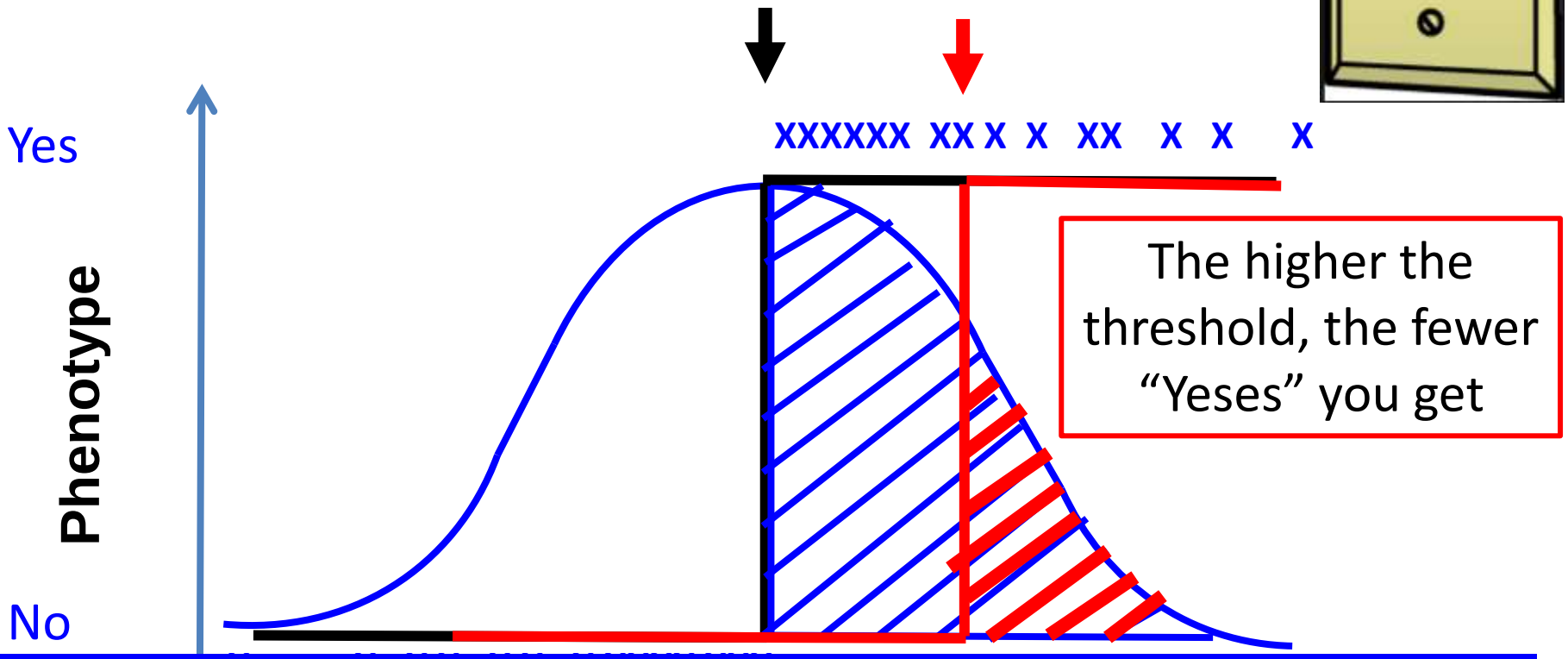


Threshold trait



The higher the threshold, the fewer "Yeses" you get

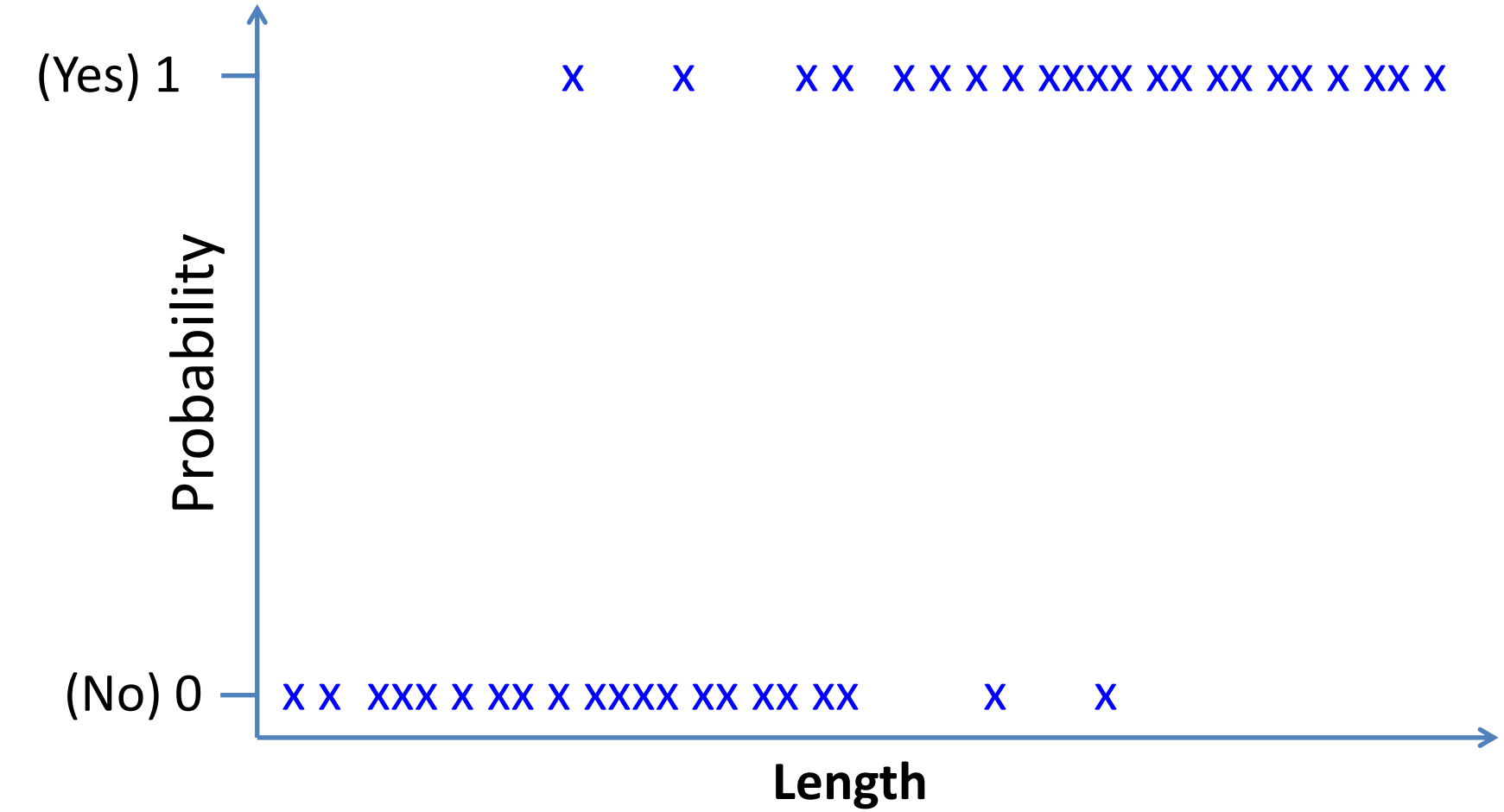
Threshold trait



Both genetics and environment can affect this relationship

Reaction Norm: Often this relationship is not just an on/off switch

Response variable = binomial



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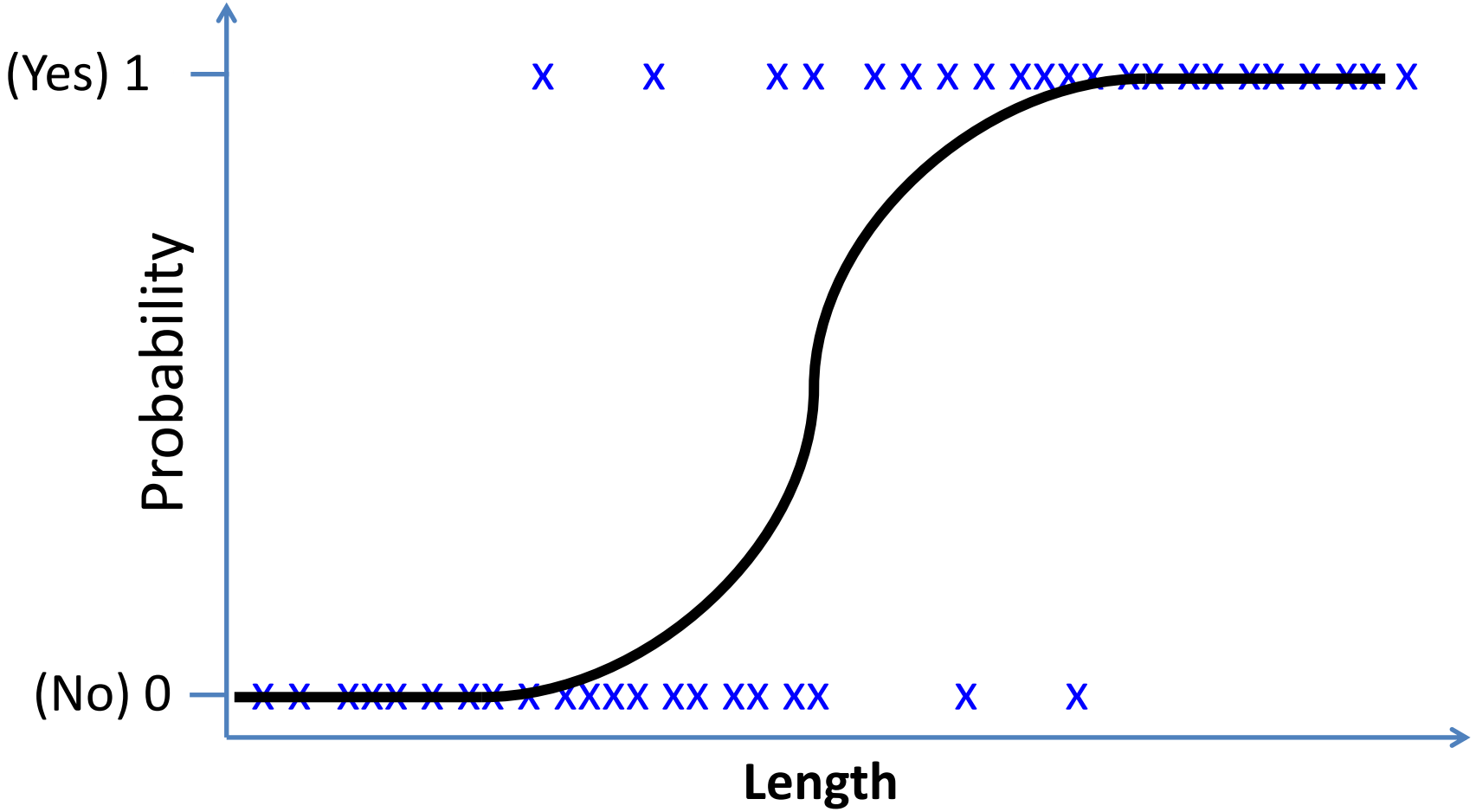

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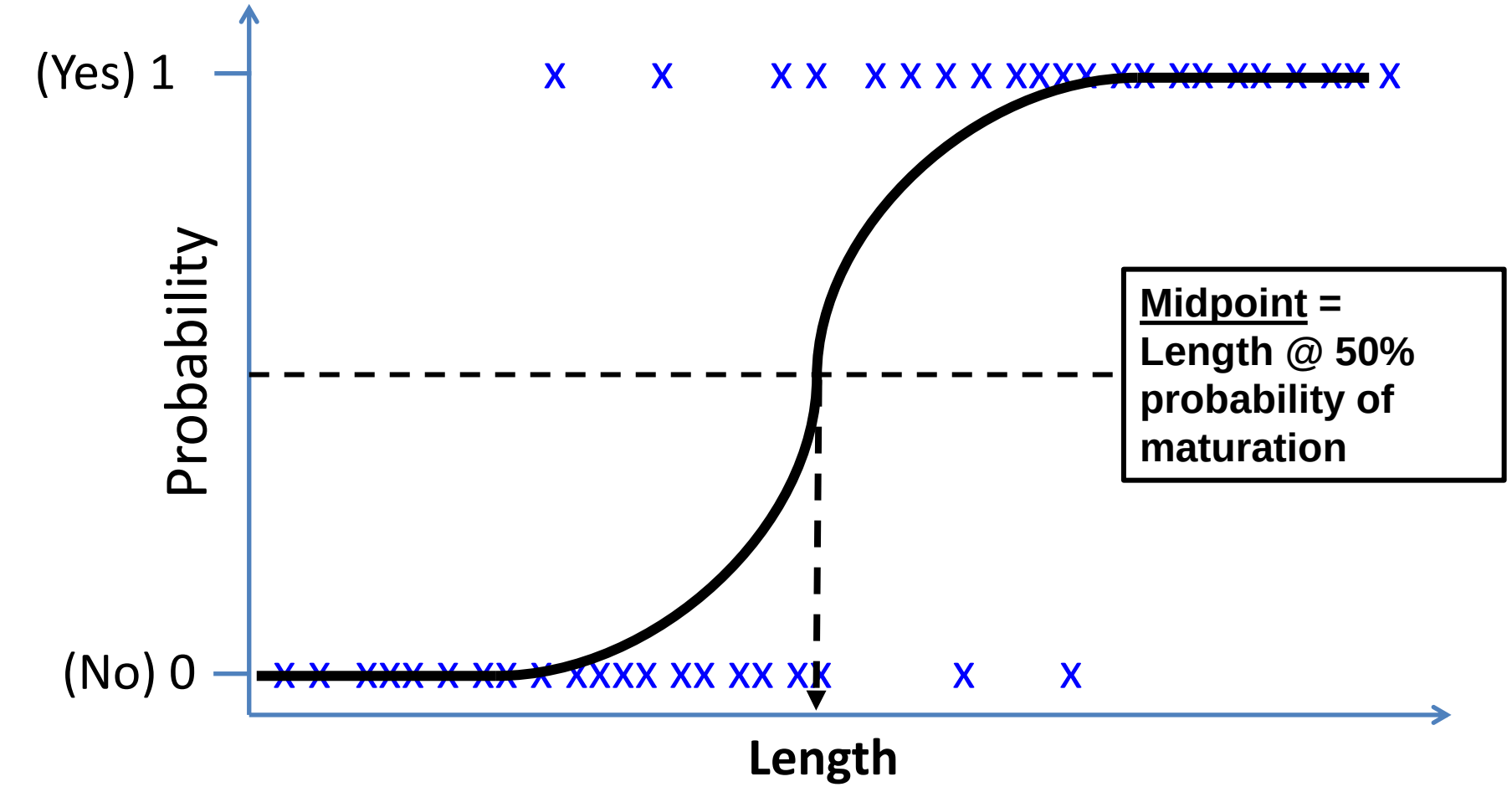

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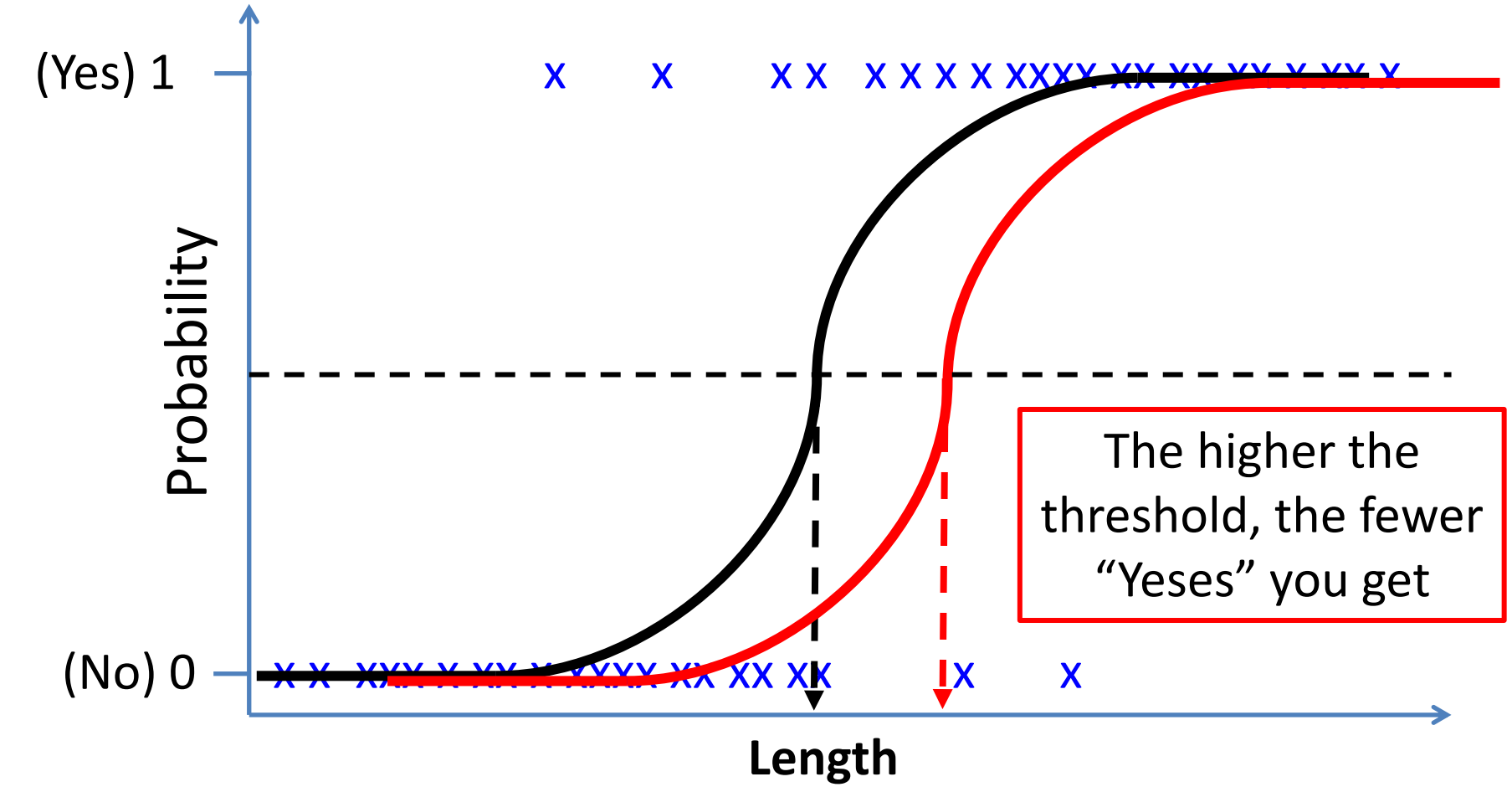

Example: Reaction Norm Approach to Maturation

PROCEEDINGS OF THE ROYAL SOCIETY B

Proc. R. Soc. B (2008) **275**, 1571–1575
doi:10.1098/rspb.2008.0251
Published online 15 April 2008

Genetic variation in threshold reaction norms for alternative reproductive tactics in male Atlantic salmon, *Salmo salar*

Jacinthe Piché[1], Jeffrey A. Hutchings[1,*] and Wade Blanchard[2]

[1]*Department of Biology, and* [2]*Department of Mathematics and Statistics, Dalhousie University, Halifax, NS B3H 4J1, Canada*

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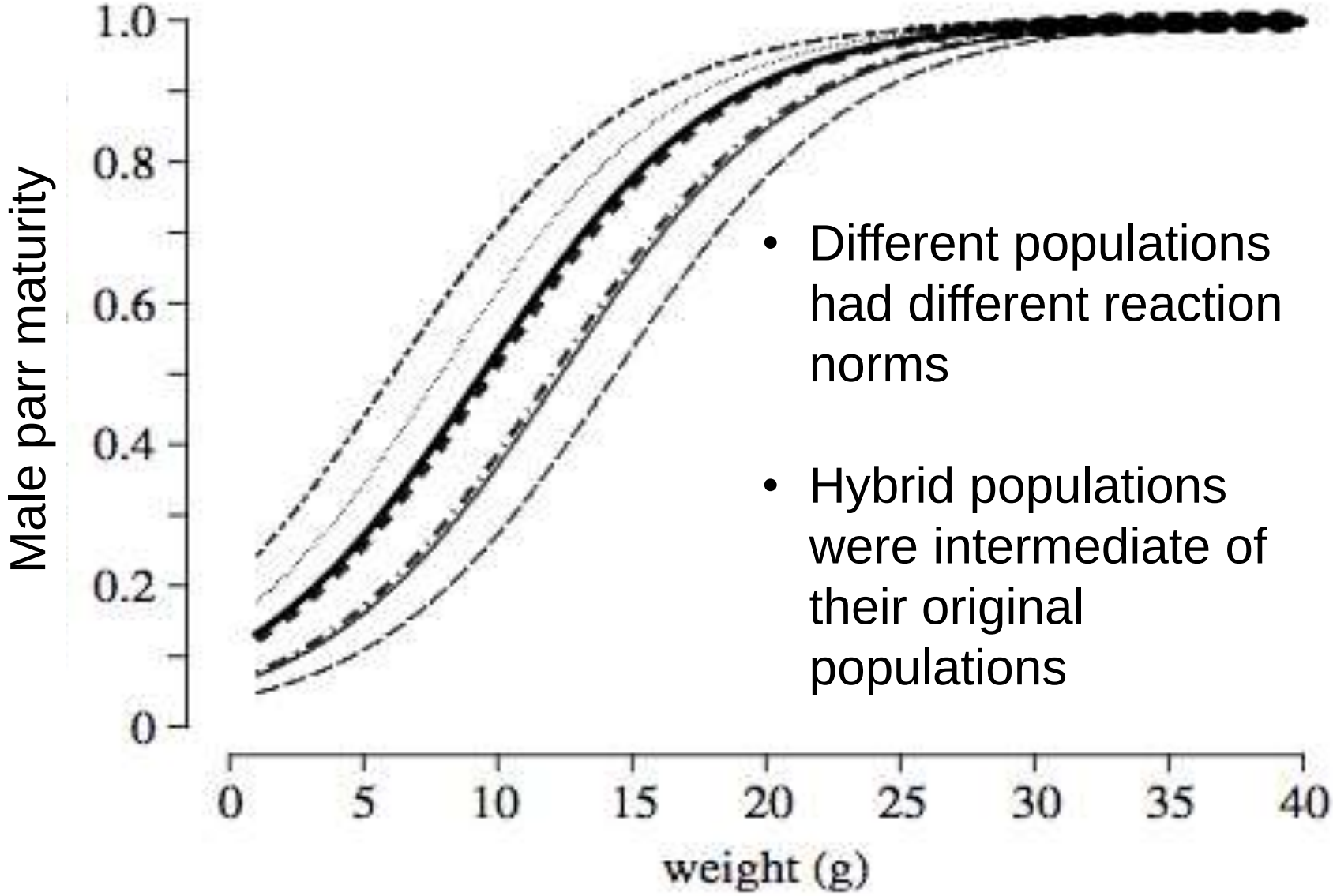
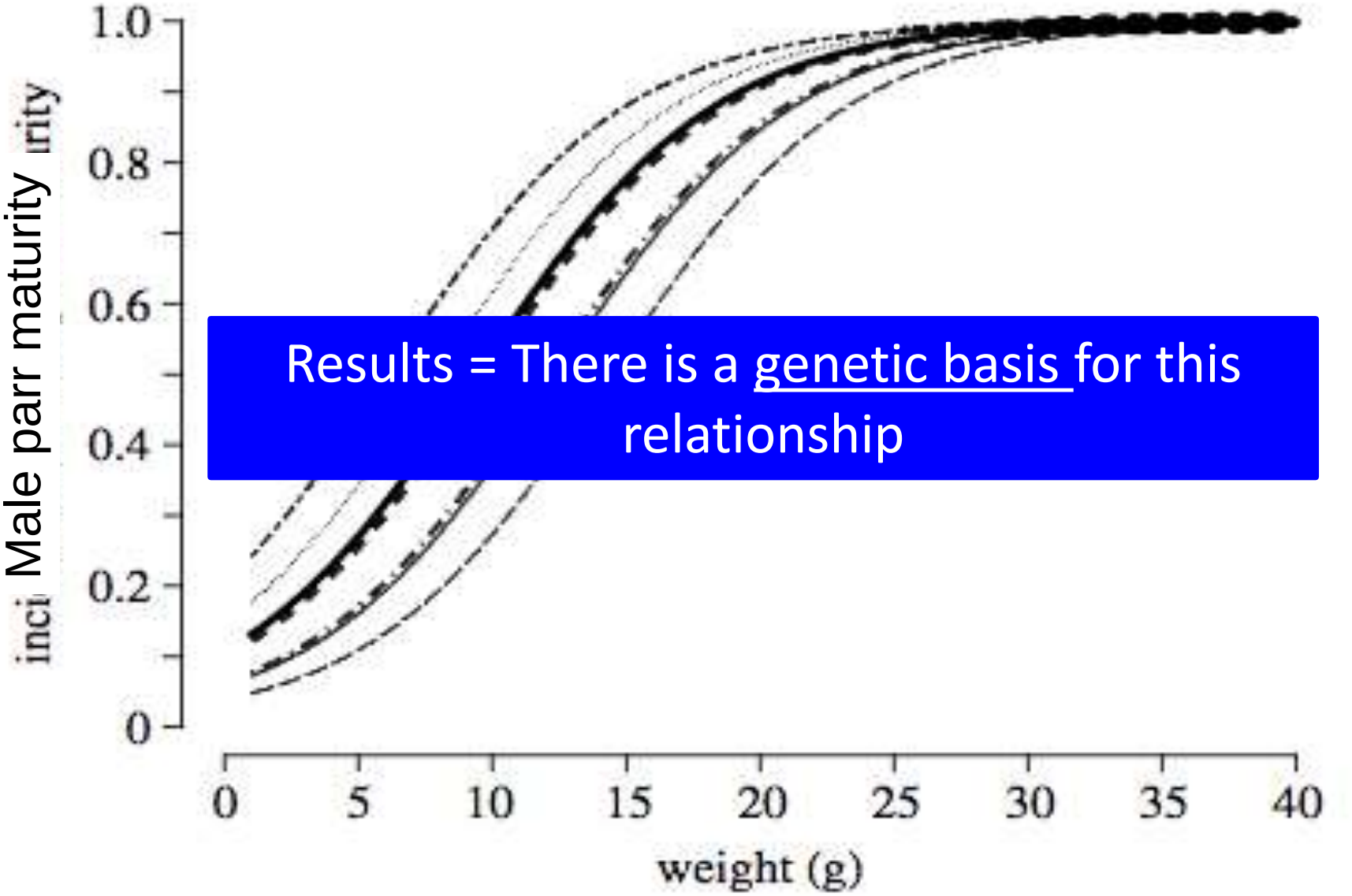
- Atlantic Salmon and early male maturation (parr)
- Common garden experiment (controlled environment)
- 4 populations + hybrid crosses to test population differences in early male maturation

Example: Reaction Norm Approach to Maturation



- Different populations had different reaction norms
- Hybrid populations were intermediate of their original populations

Example: Reaction Norm Approach to Maturation



Results = There is a genetic basis for this relationship

We wanted to apply this technique to studying precocious maturation closer to home

Chinook Salmon: Mature males

- Reaction Norms (via logistic regression analysis) is a tool that we can use to compare thresholds for different populations/genetic groups

Mac & Jack Study Objectives:

1. Can we demonstrate **genetic** difference in early male maturation (INT vs. SEG)

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Bonus: Can we use reaction norms to assess the critical period in maturation decision

McCall Hatchery

Summer Chinook (Yearlings)

- **segregated** [(**SEG**), H x H]

- **integrated** [(**INT**); N x N; H x N]

McCall Hatchery

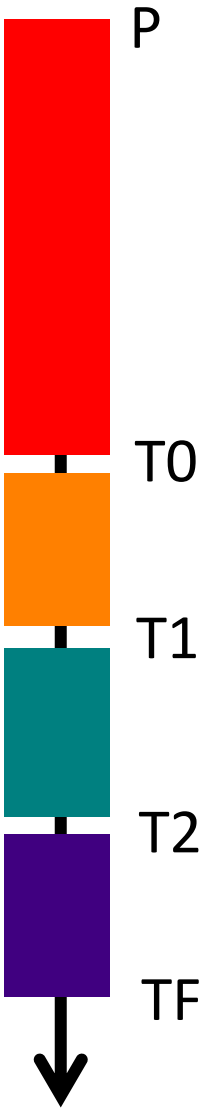
Summer Chinook (Yearlings)

- **segregated** [(**SEG**), H x H]
- **integrated** [(**INT**); N x N; H x N]

- Eyed-eggs were collected Fall 2014
- Transported to Seattle, WA
- Incubated NOAA/NWFSC

Rearing Facilities

Experiment Timeline:



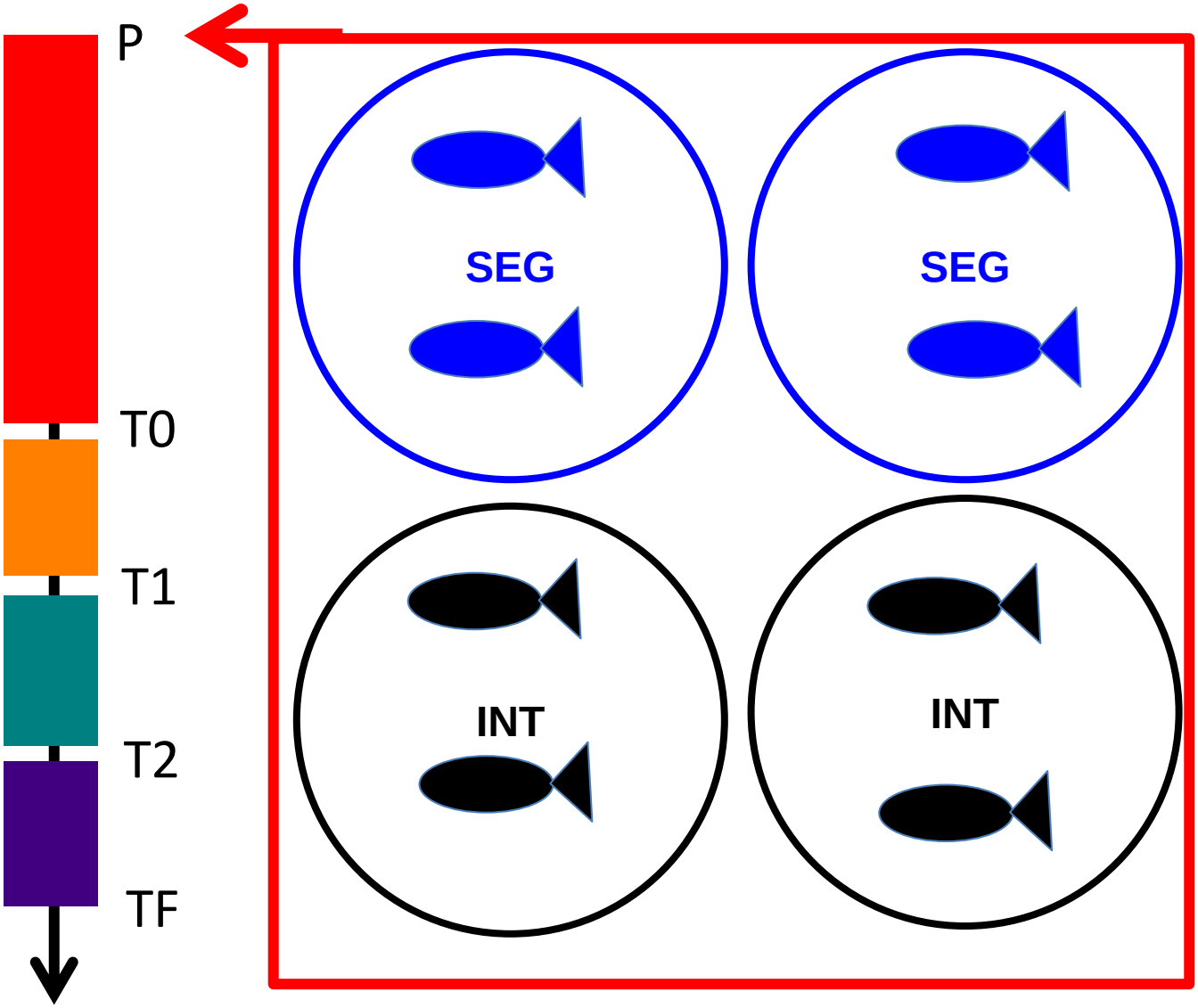
3 March, 2015

Total rearing time from ponding was 14 months

Fish were reared on ambient photoperiod

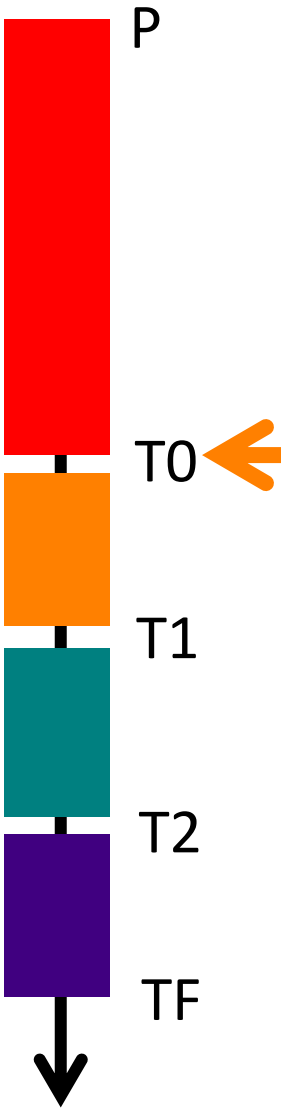
2-5 May, 2016

Ponding (P): 3 March



- 4 8-ft recirculating tanks at 10°C
- 2 replicates/genetic line
- 600+ fish/tank

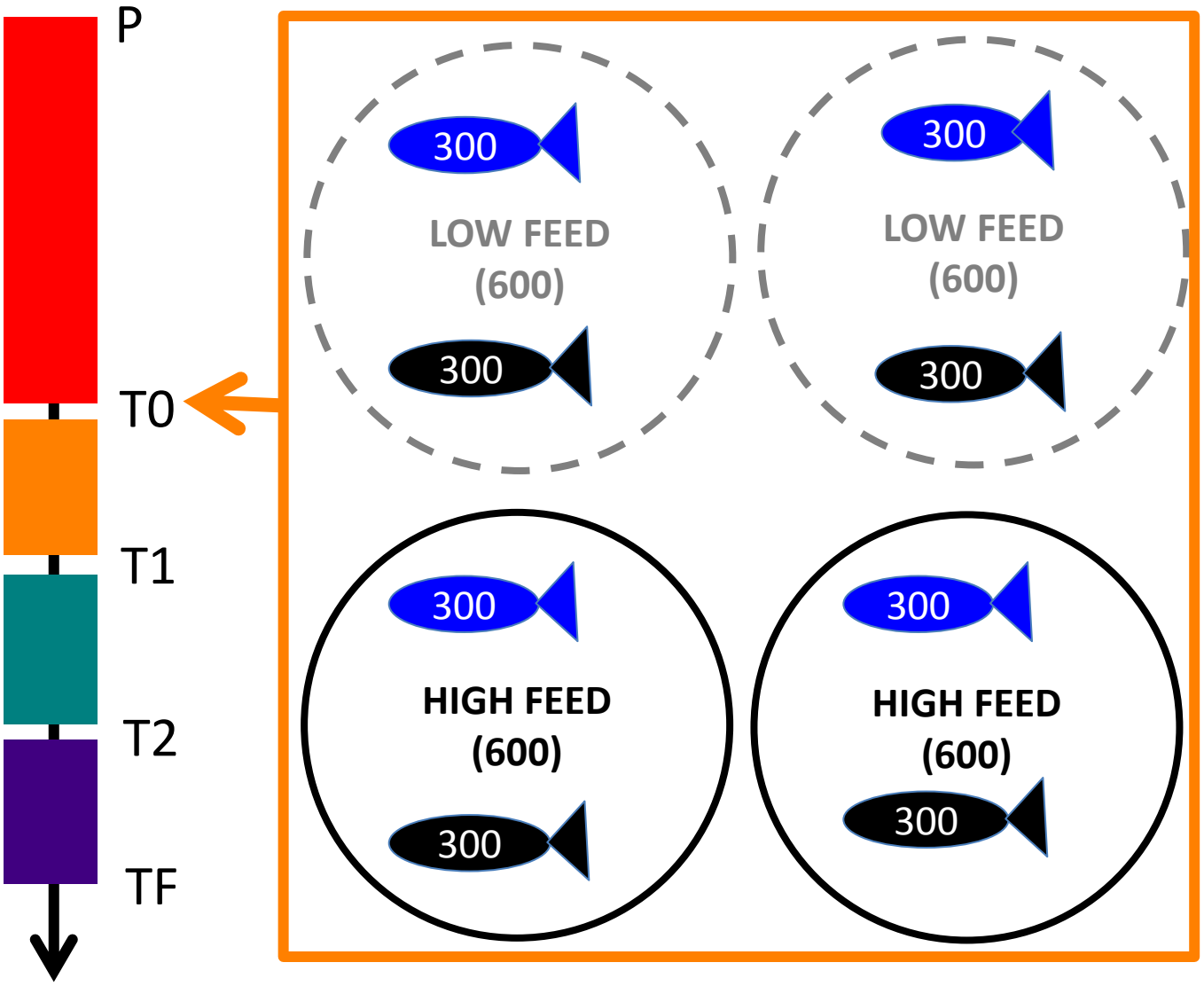
26 August (T0): PIT tagging



- All fish were implanted with a PIT tag
- Length & Weight recorded

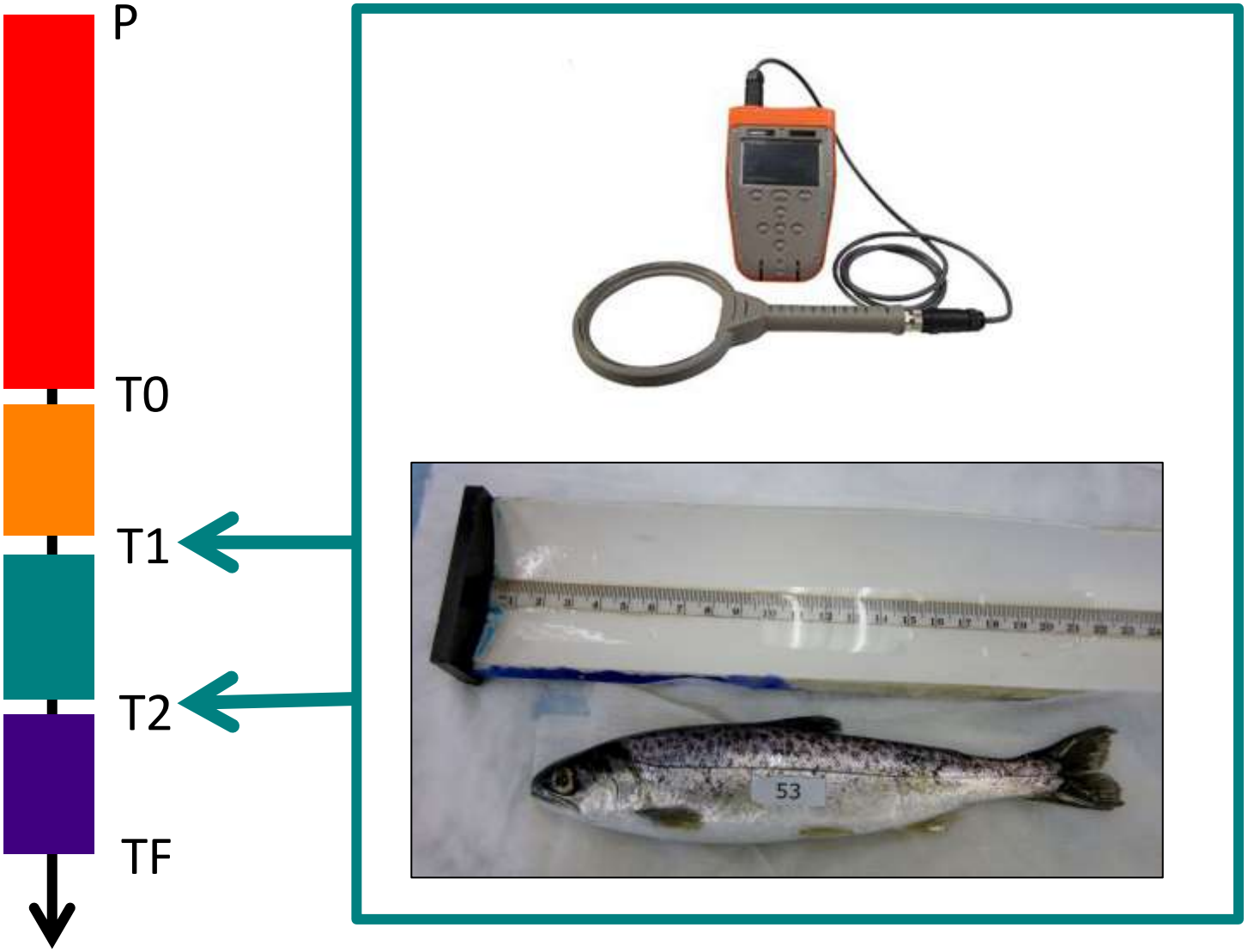
26 August (T0): Feed Treatments Began

Low Feed = 33% of High Feed ration through winter solstice



- 2 replicate tanks/feed treatment
- SEG & INT fish mixed in each tank

9 Nov (T1) & 26 Jan (T2): Individual Size checks



2 -5 May (TF): Assessing minijacks

- Gonads were visually inspected to determine maturation status
- All fish were scanned for PIT
- Individual size recorded

Growth rates of individual fish

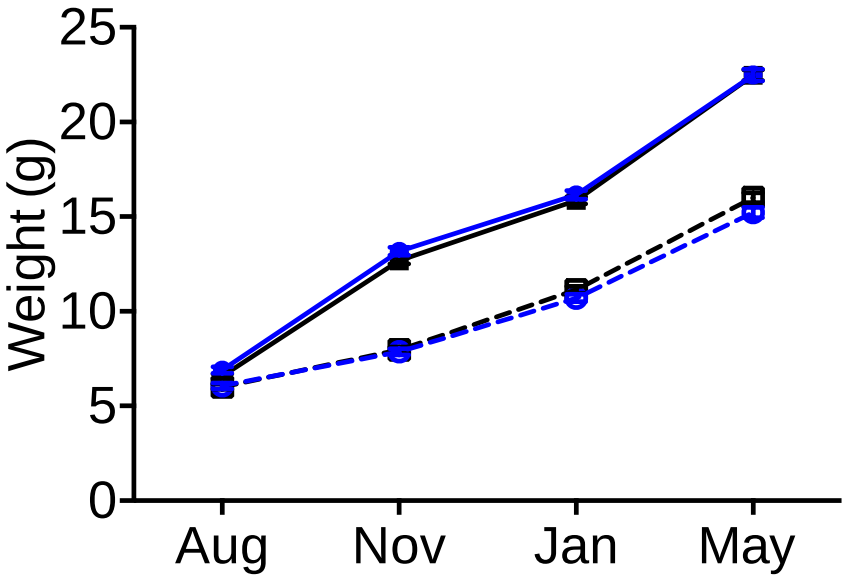
$$\text{Specific Growth Rate} = \ln(WT_2 - WT_1)/(t_2 - t_1)*100$$

1: Aug - Nov

2: Nov - Jan

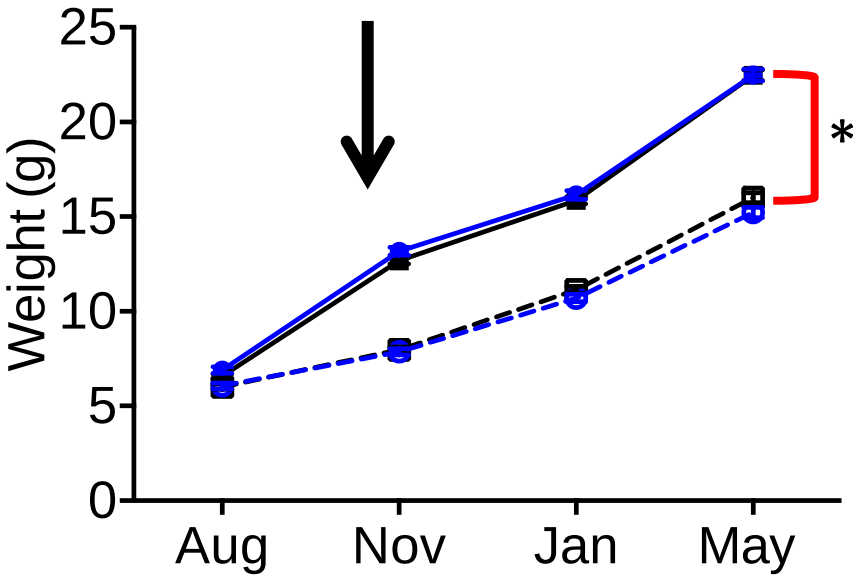
3: Jan - May

Size & Condition Factor



SEG LOW
SEG HIGH
INT LOW
INT HIGH

Size & Condition Factor



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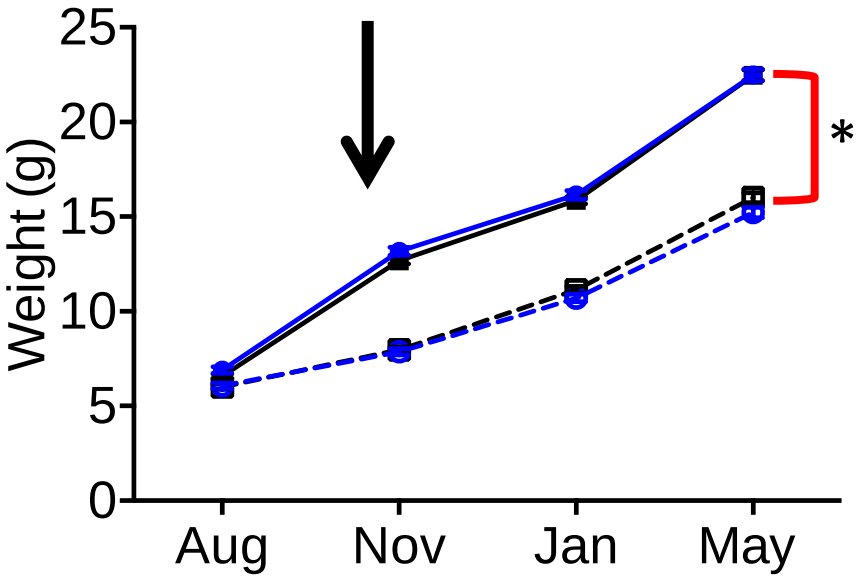

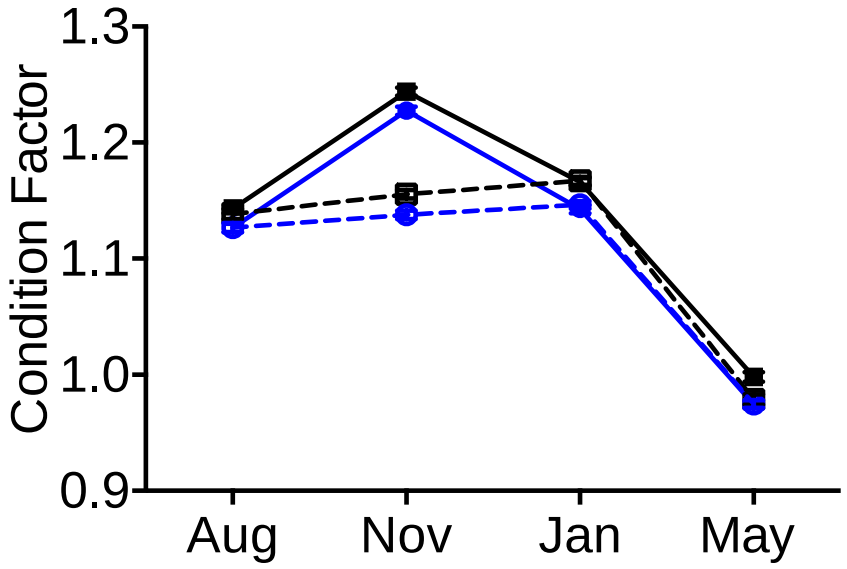

SEG LOW
SEG HIGH
INT LOW
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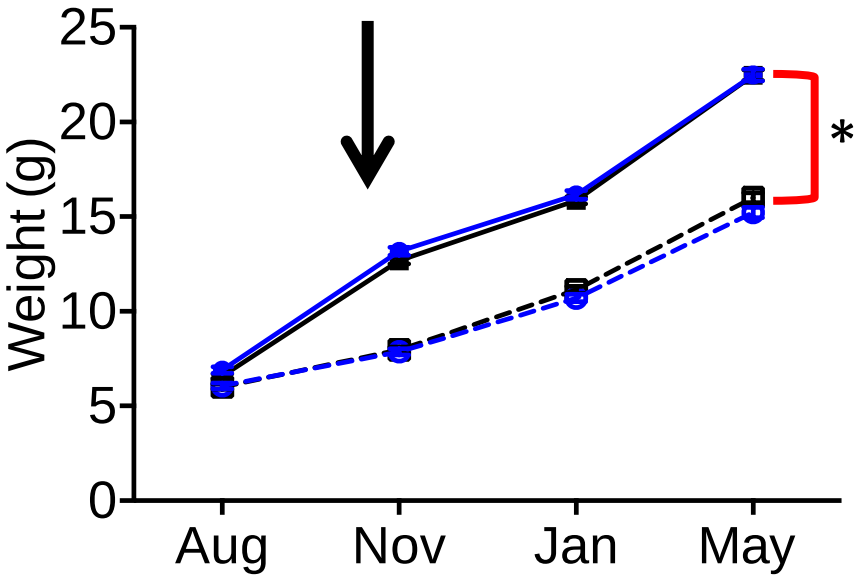
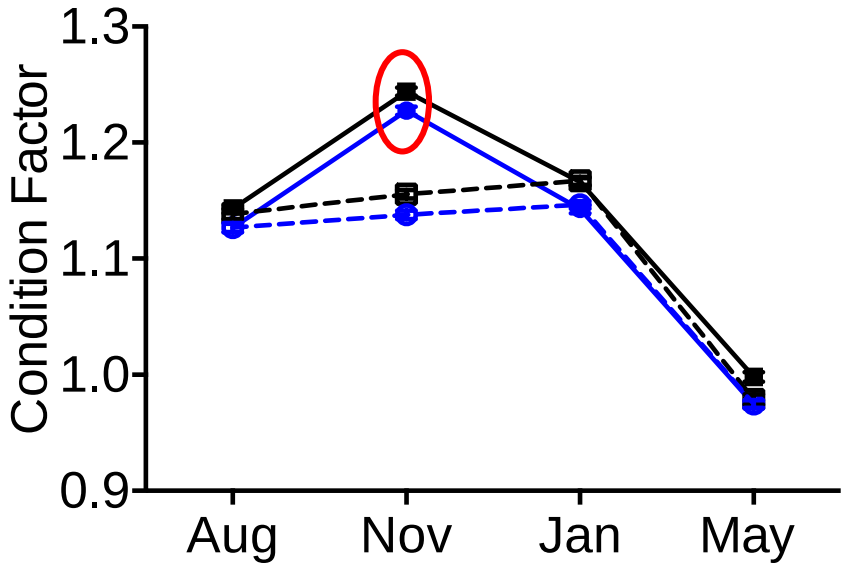
Size & Condition Factor

- **High** feed **>** **Low** feed during the fall

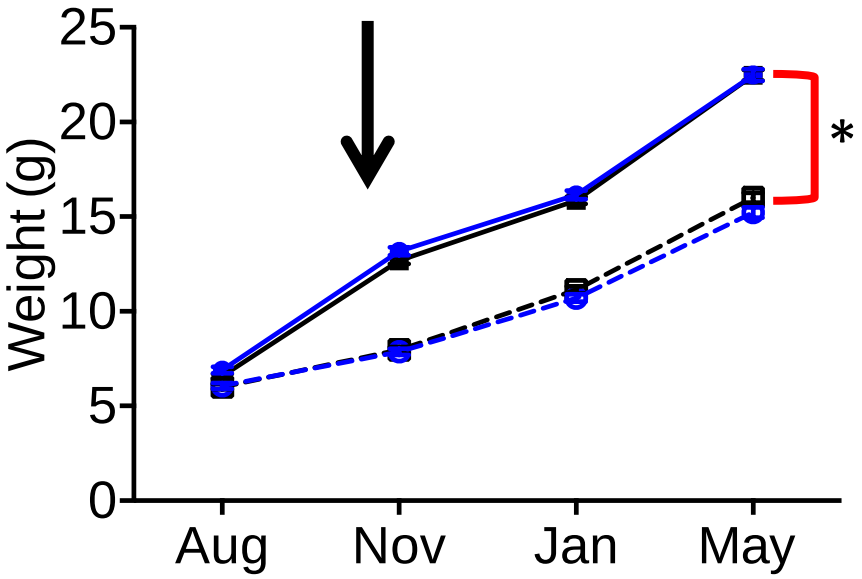


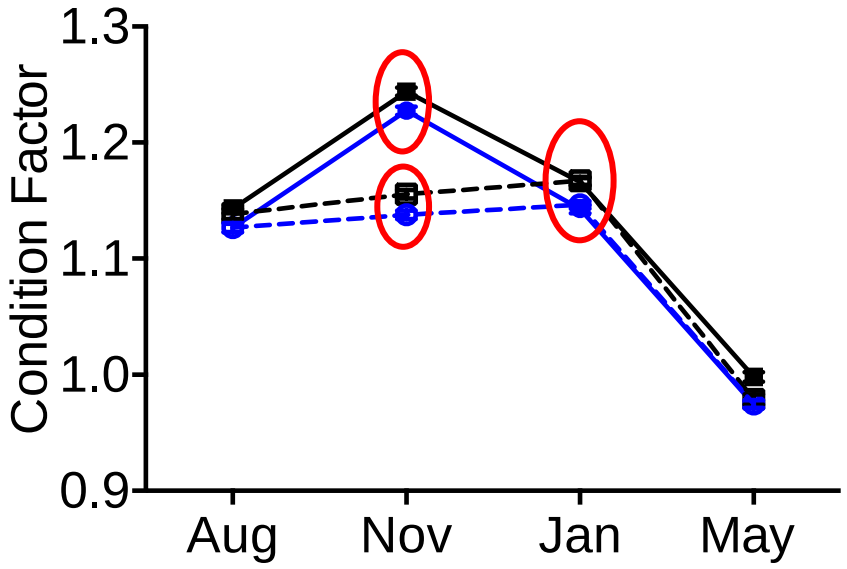


SEG LOW
SEG HIGH
INT LOW
INT HIGH

Size & Condition Factor

- **High** feed **> Low** feed during the fall
- **INT** fish had higher condition





SEG LOW
SEG HIGH
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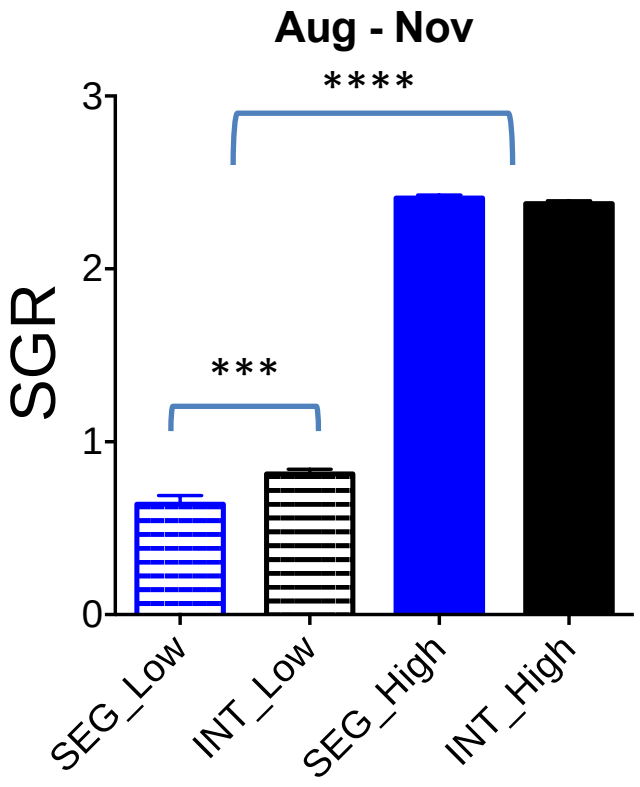
Specific Growth Rate (% change in WT/day)



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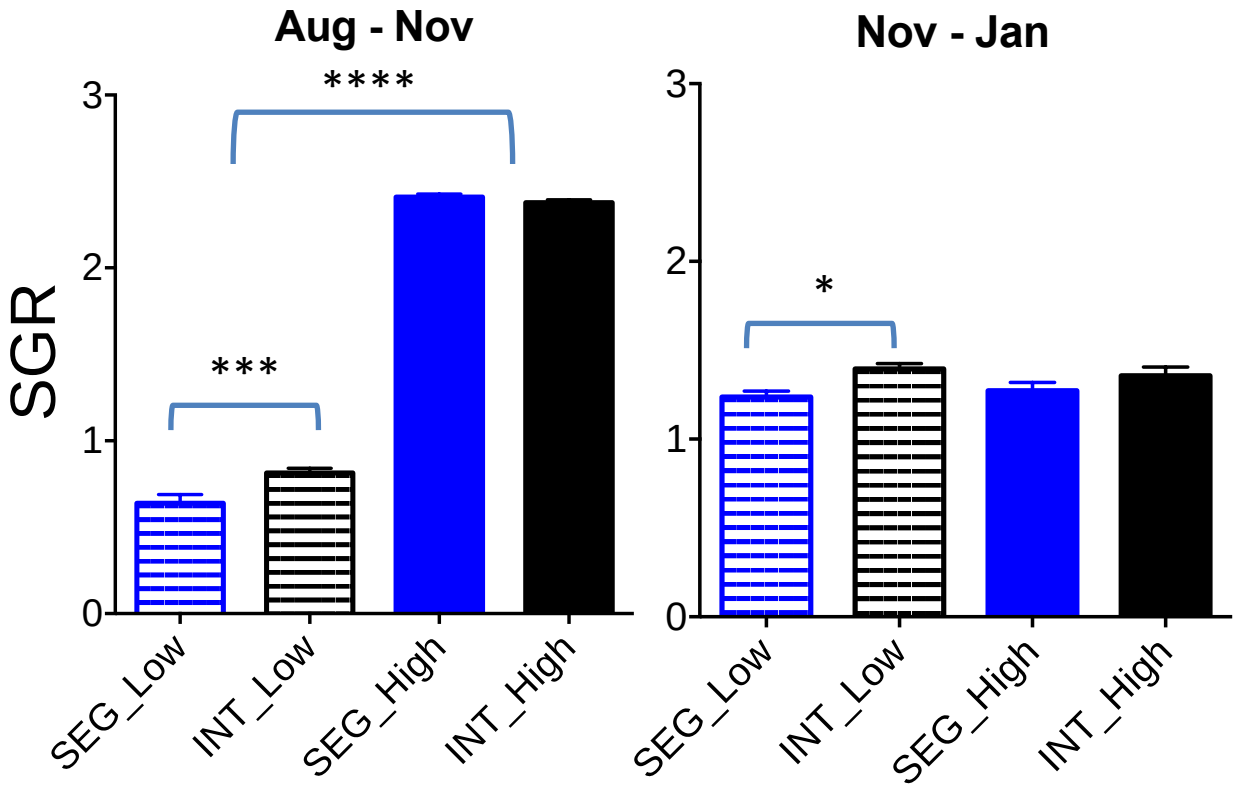

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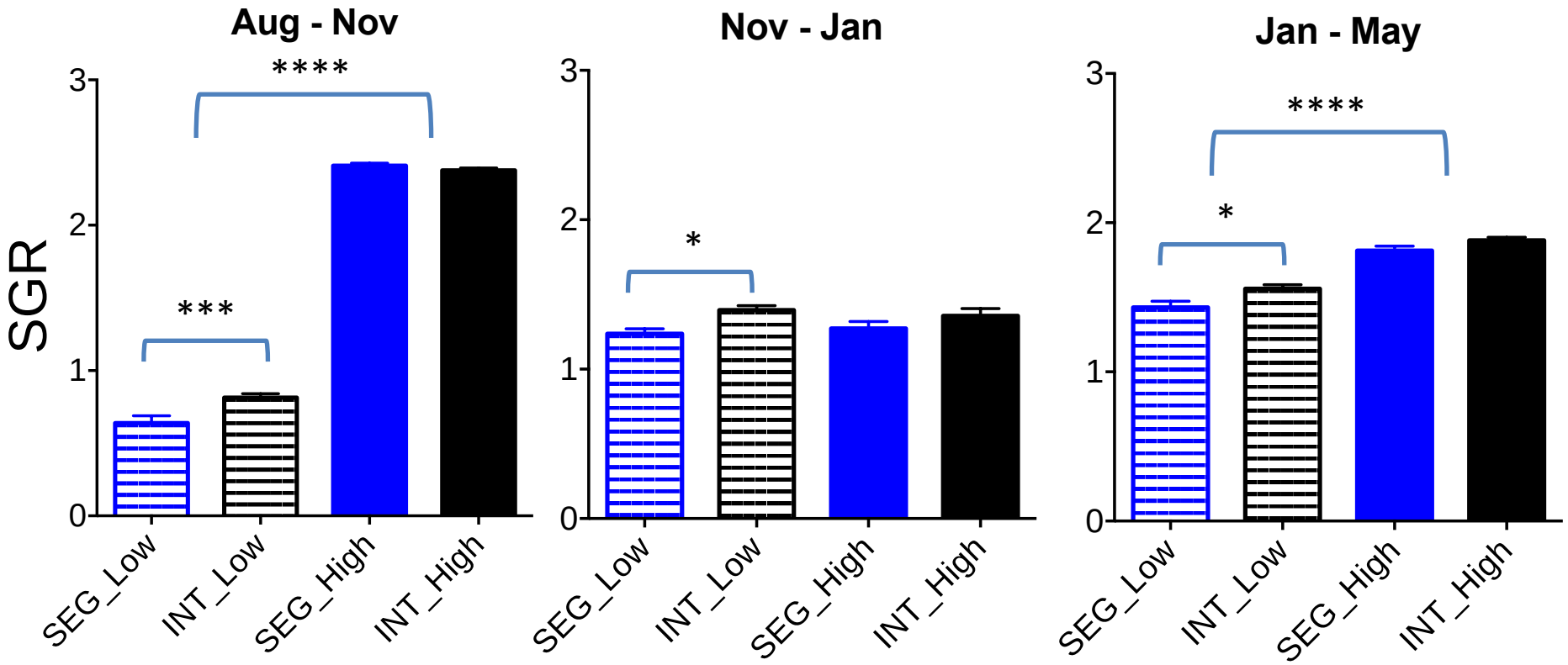
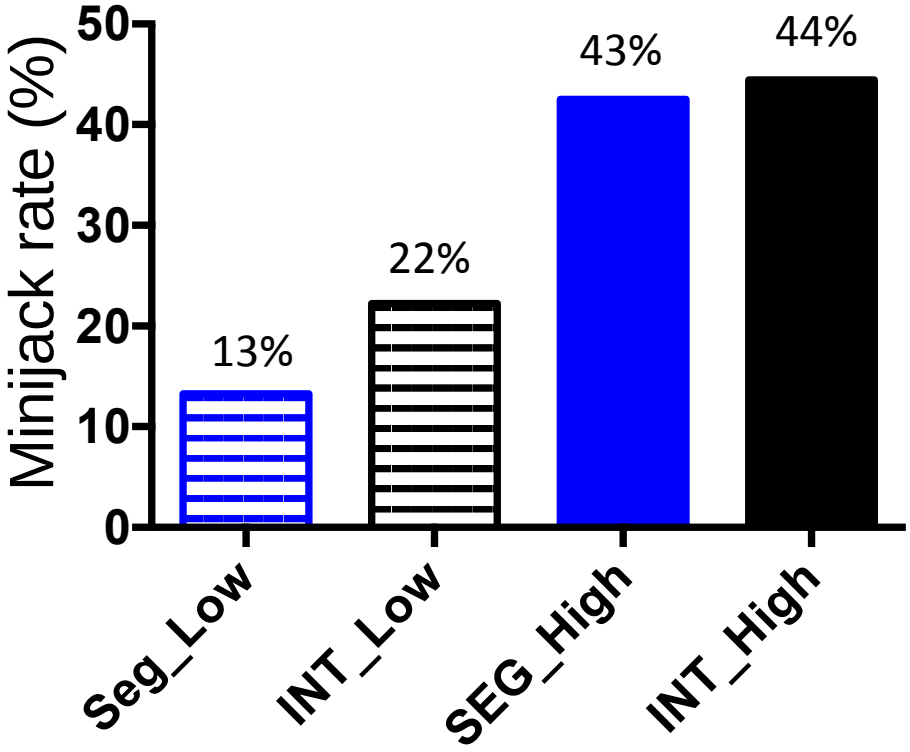
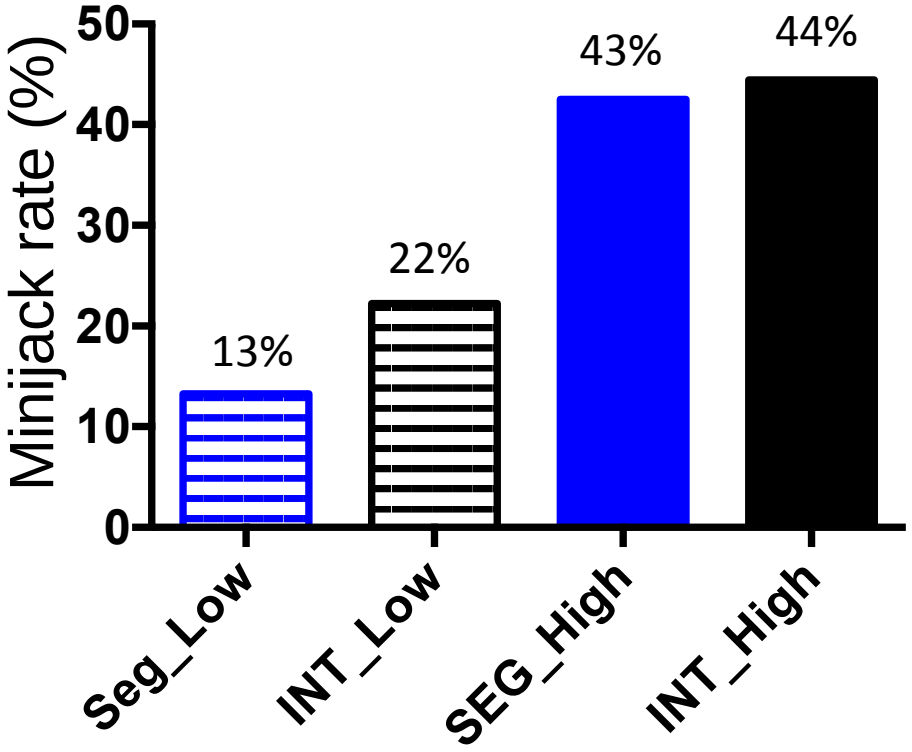


Environmental and genetic influences on early male maturation



Environmental and genetic influences on early male maturation

Logit [MATURITY] = FEED + GENETIC LINE



1. **FEED**
   (Coef. = 1.27, *P* = 0.000)

2. **GENETIC LINE**
   (Coef. = 0.28, *P* = 0.037)

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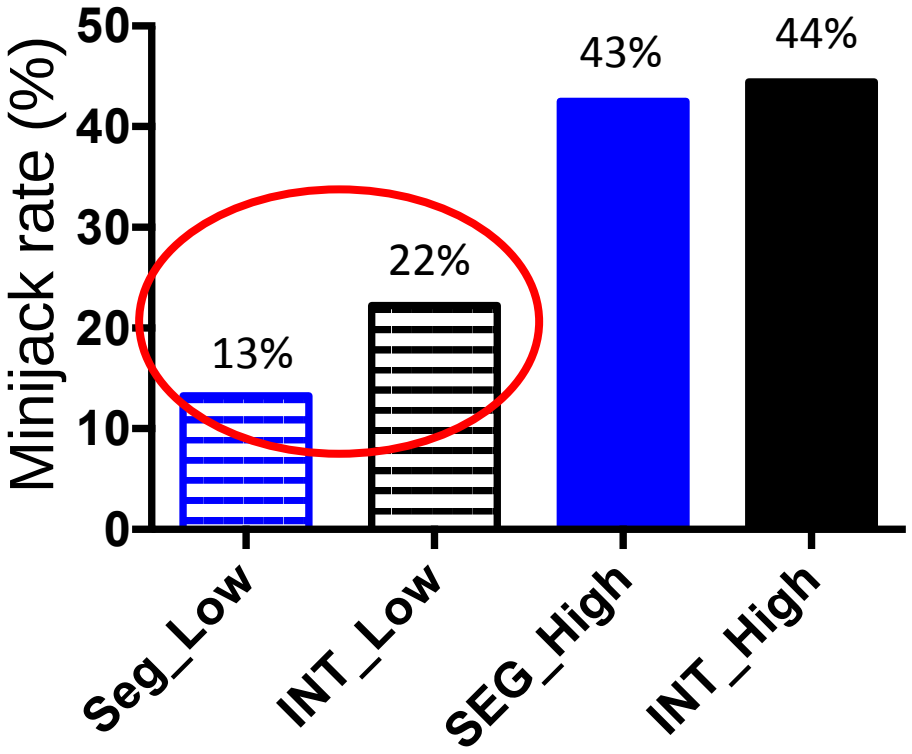


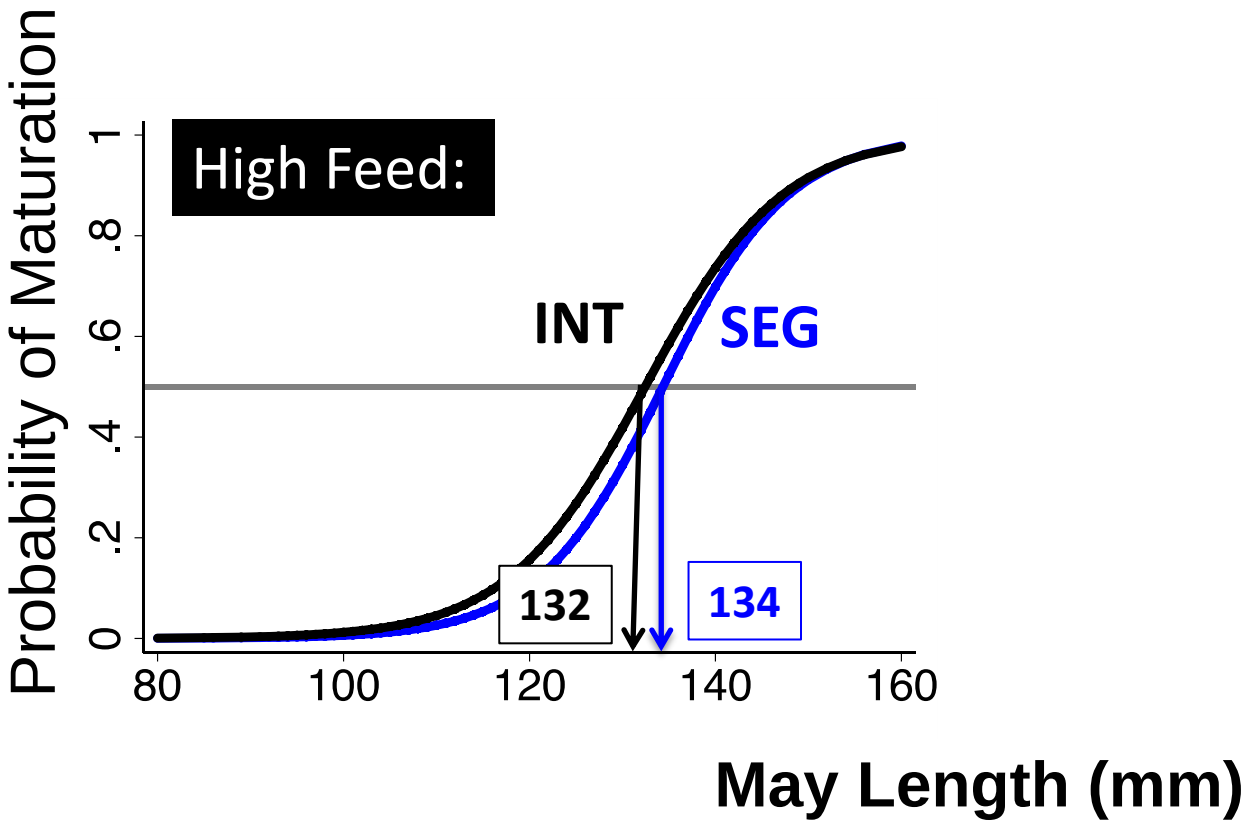
1. **FEED**
   (Coef. = 1.27, *P* = 0.000)

2. **GENETIC LINE**
   (Coef. = 0.28, *P* = 0.037)

FEED X GENETIC LINE is significant (*P* = 0.045)

Genetic effect on threshold?

- **INT**-line fish tended to have slightly lower threshold in both feed groups



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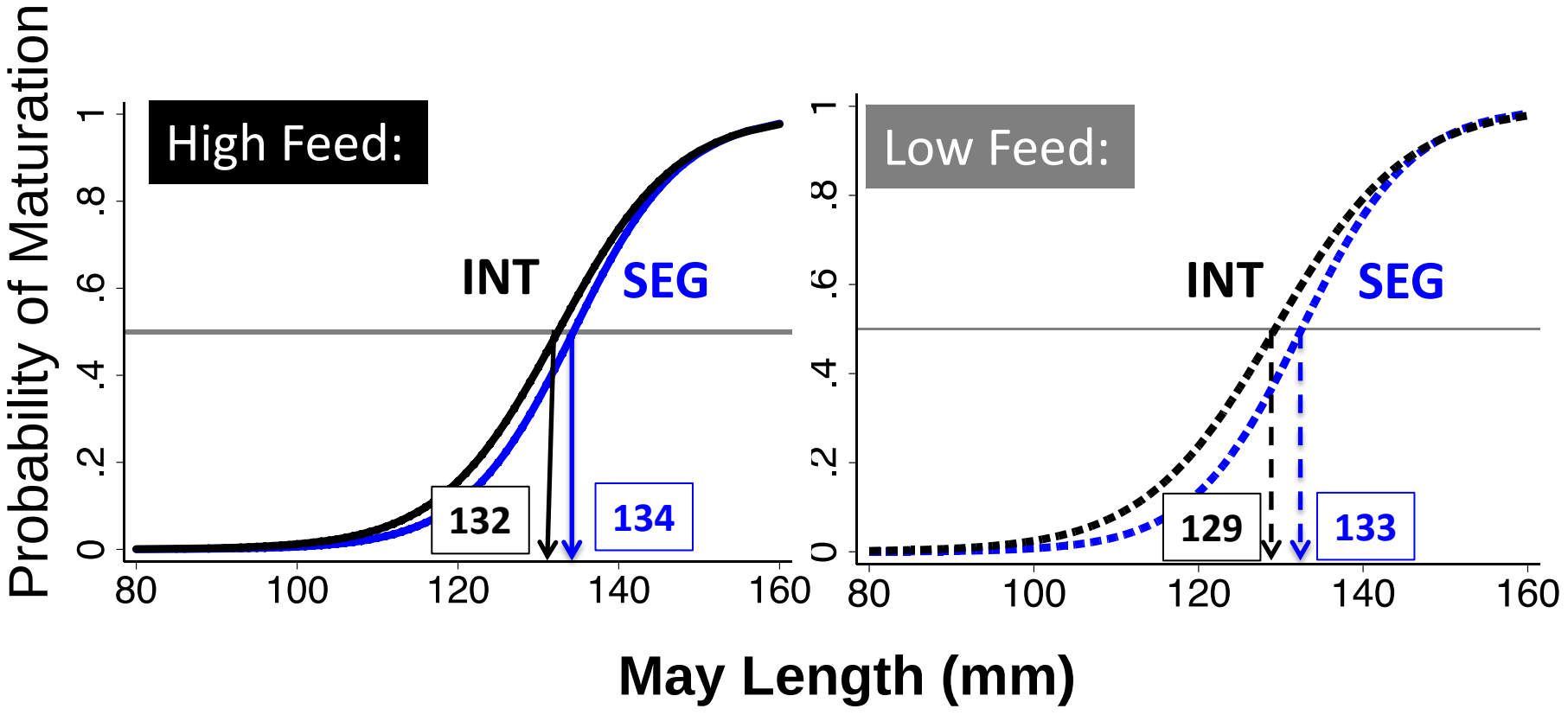
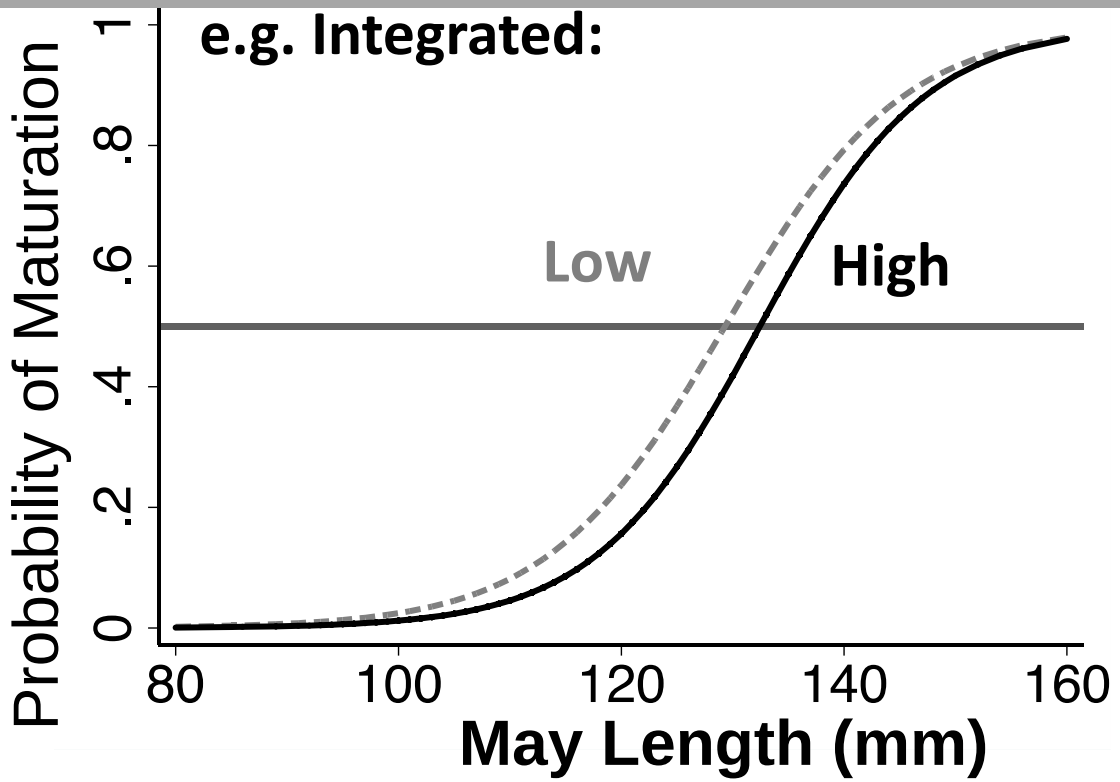


Within brood line comparison: High and Low Feed treatments have the same parents……so why do they look different?



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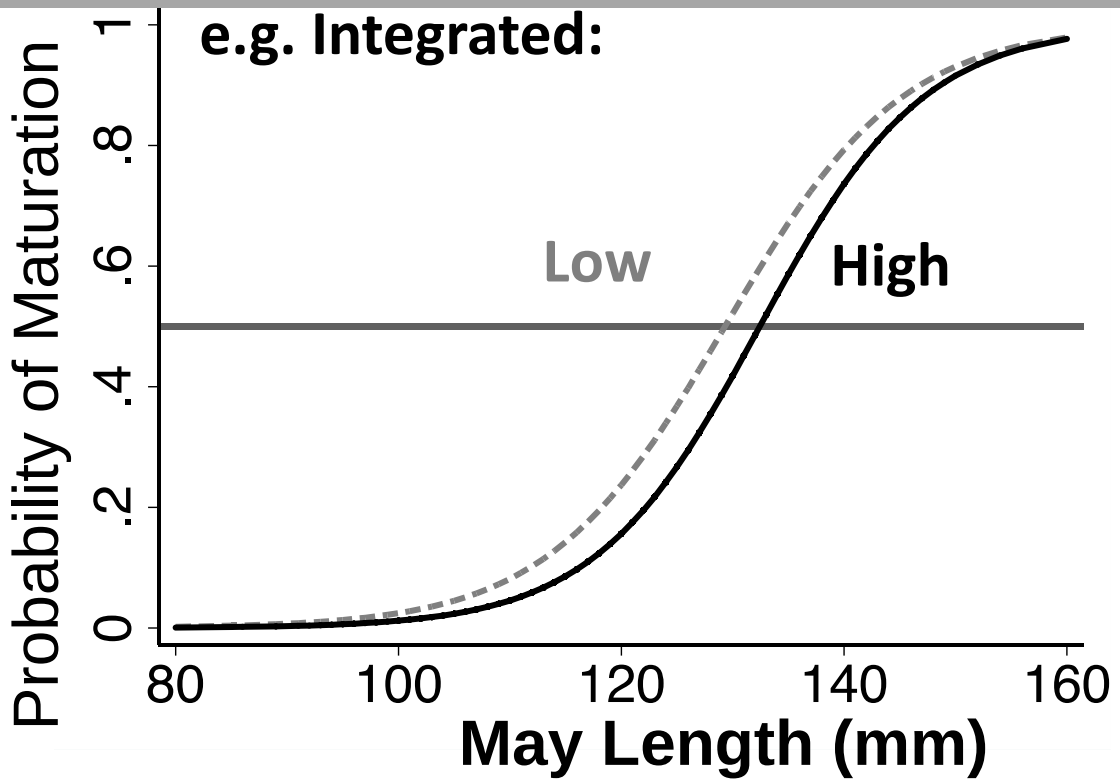
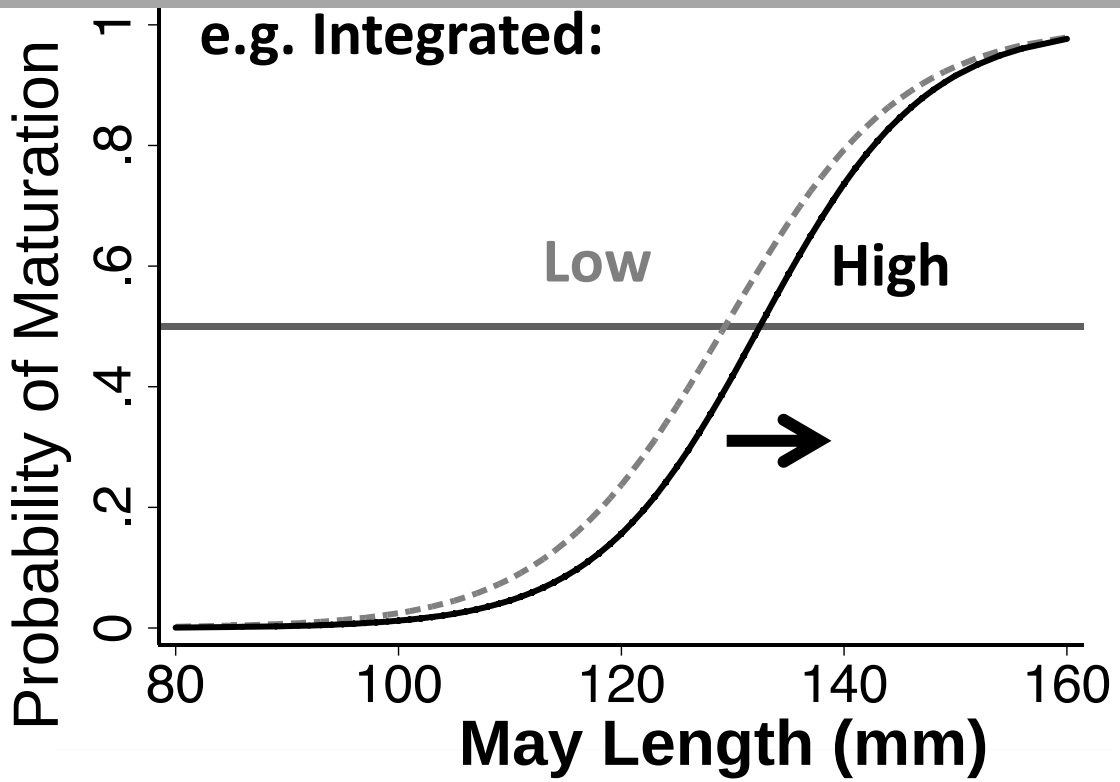


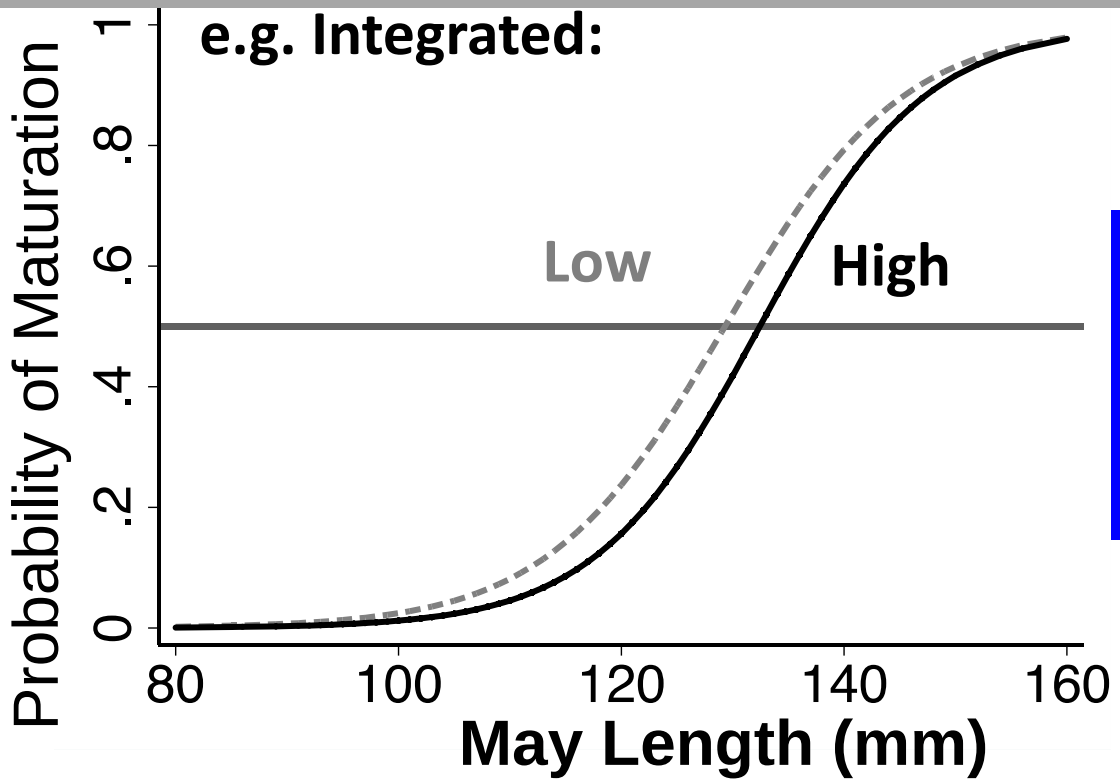
- Differences in growth that happened after the critical window can affect this

Within brood line comparison: High and Low Feed treatments have the same parents……so why do they look different?



Example: High feed fish had higher growth which shifted the apparent threshold to the right

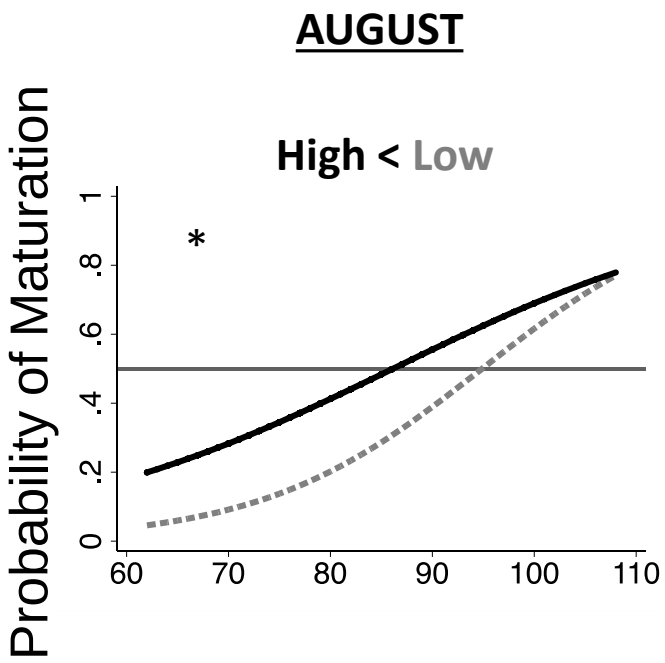
Within brood line comparison: High and Low Feed treatments have the same parents……so why do they look different?



Hypothesis: during the critical decision window, these two reaction norms should appear the same

Timing of critical window for Maturation:
When LP50 High = LP50 Low

e.g. Integrated:



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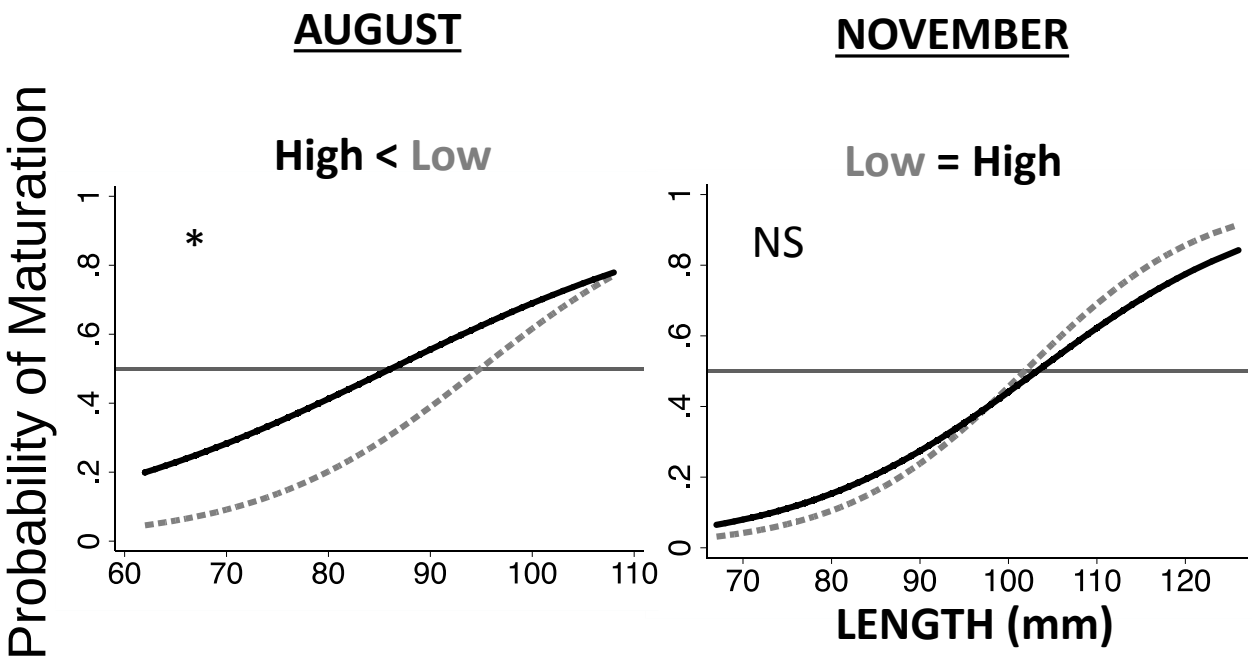

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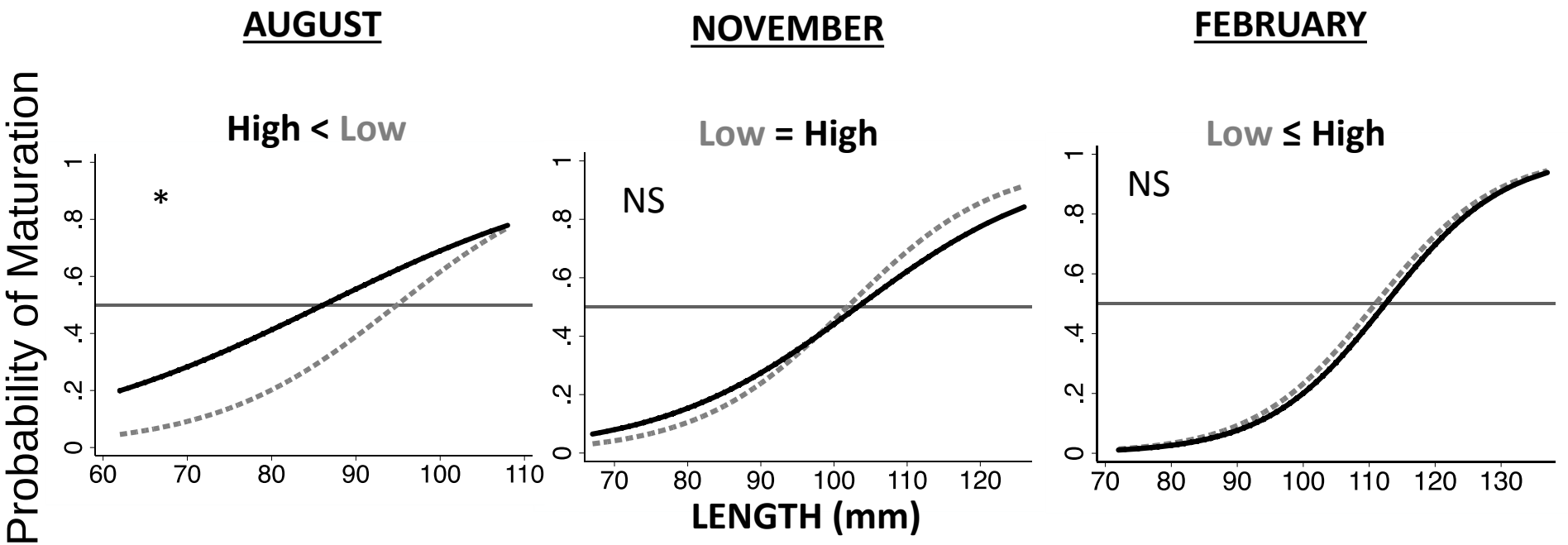

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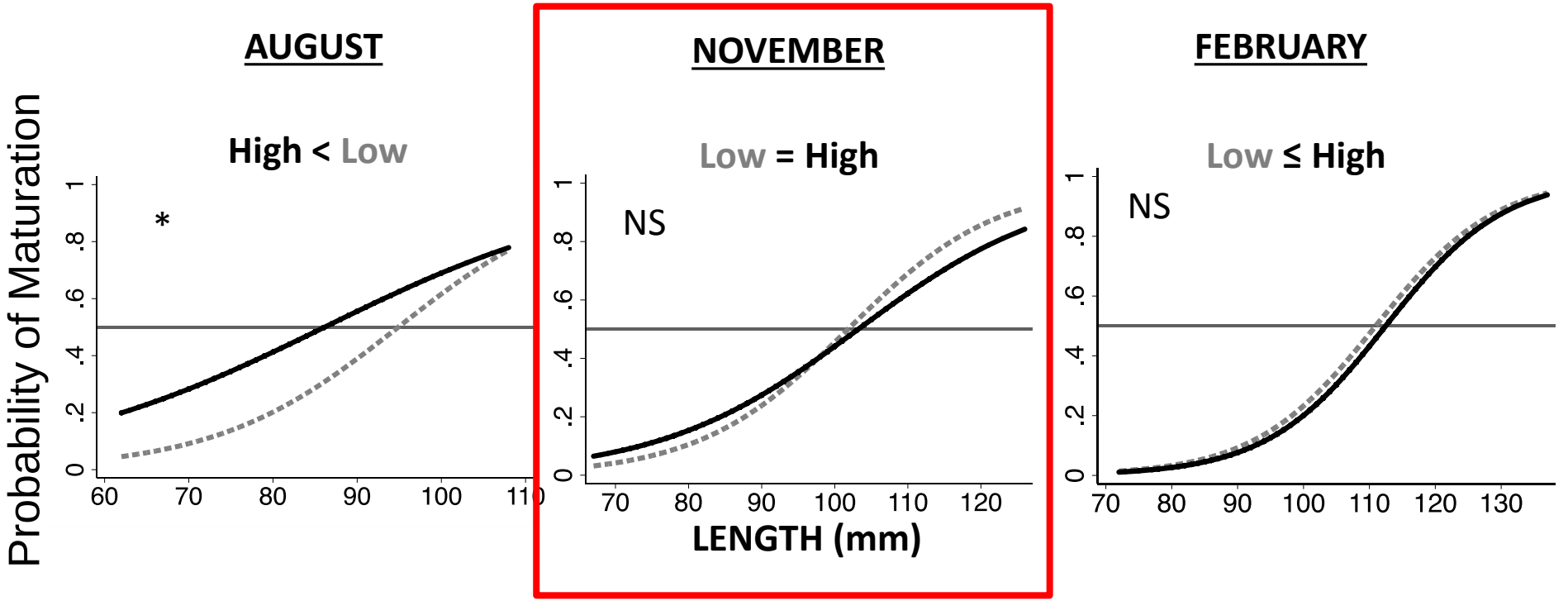
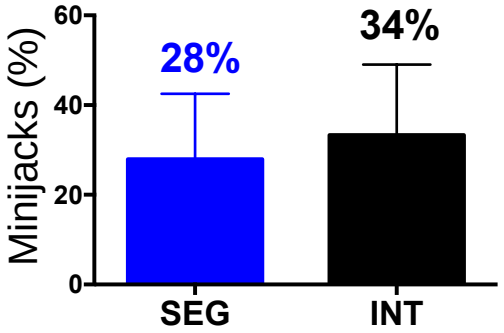


Conclusions

Objective 1:

- The level of domestication had an effect on minijack rate



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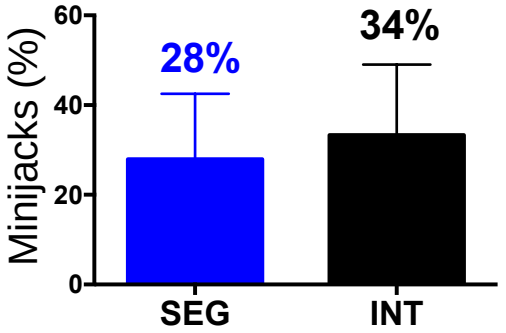
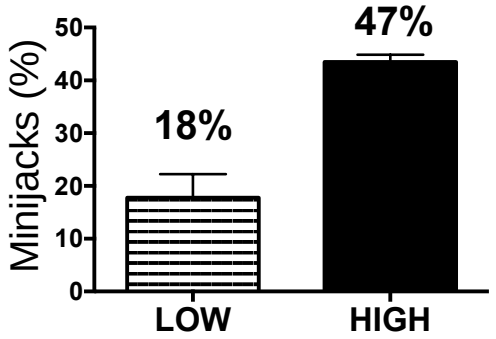
Objective 2:

- Feed treatment had the greatest influence on minijack rate





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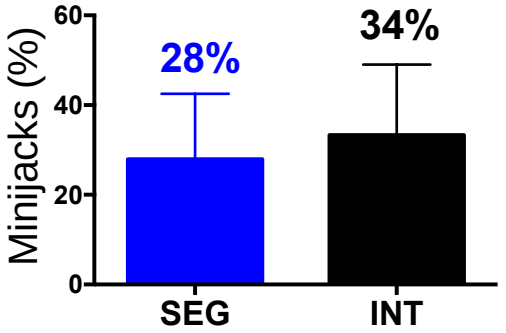

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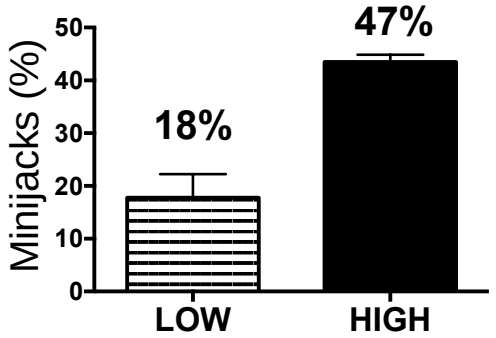

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- The **INT** line had higher growth rates that **SEG** line at **low feed**, suggesting a potential advantage to the **INT** line in competing for resources.

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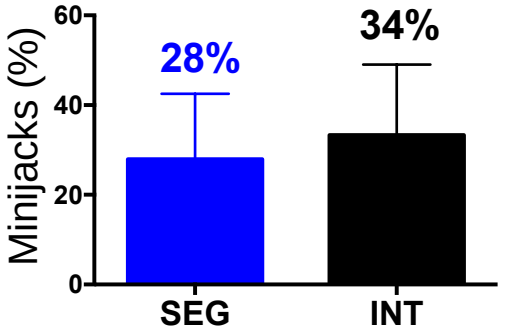

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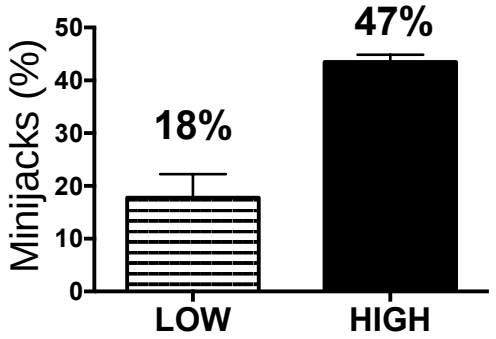

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Bonus:

- Tracking thresholds across time provides further evidence that the fall may be a critical window for initiation of minijack maturation.

Cheers!

<u>Special thanks to</u>:

- Shelly Nance, NOAA
- Meredith Journey, NOAA
- McCall Hatchery for donating eggs