Reproductive Development in Reconditioned Female Yakima River Steelhead Kelts: Comparison with Maiden Spawners

Andy Pierce[1, 2], Joe Blodgett[3], Chris Frederiksen[3], Luke Caldwell[1], Tim Cavileer[1], Lea Medeiros[1], Ryan Branstetter[2], Neil Graham[2], Laura Jenkins[1], Bill Bosch[3], Dave Fast[3], Doug Hatch[2], Jim Nagler[1]

[1]University of Idaho, Moscow ID

[2]Columbia River Inter-Tribal Fish Commission, Portland OR

[3]Yakama Nation, Toppenish WA

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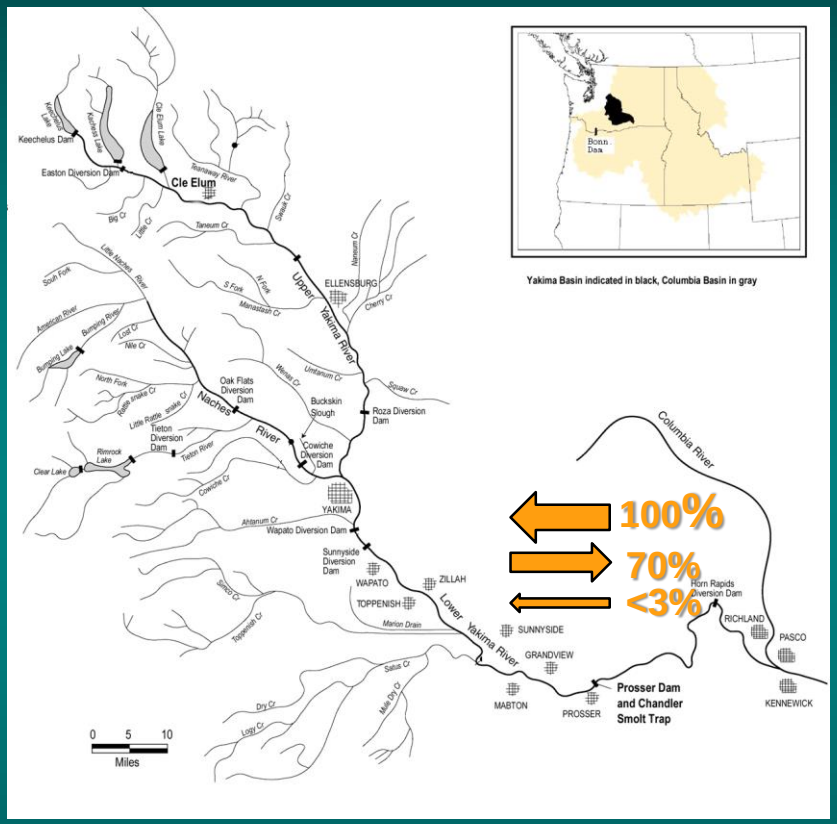
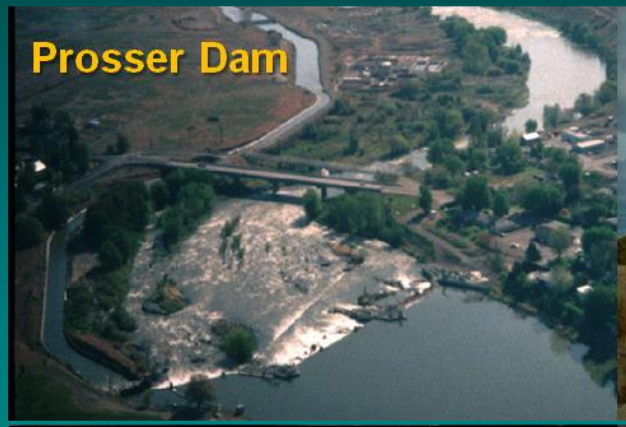
Kelt reconditioning is restoration strategy that takes advantages of the repeat spawning life history of steelhead.

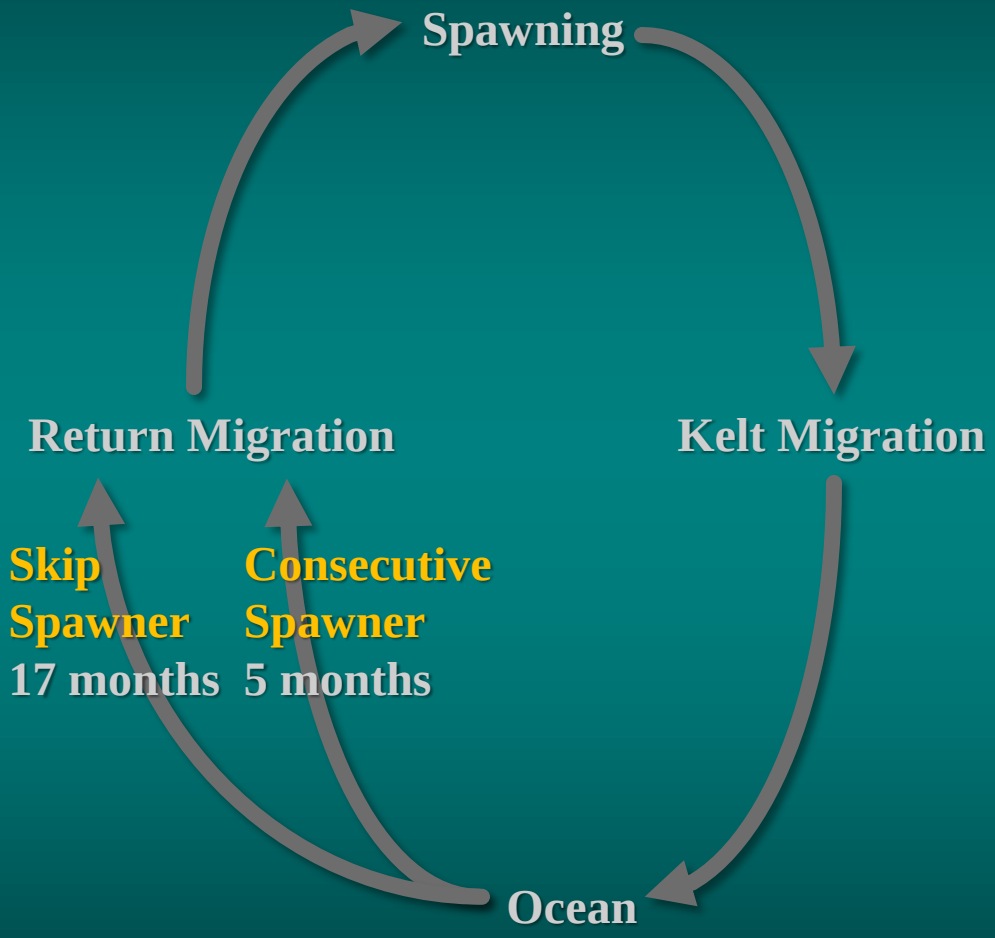




Intake Reconditioning Release

Feb Mar Apr May Jun Jul Aug Sep Oct Nov

Natural repeat spawning female steelhead have two major post-spawning life histories.



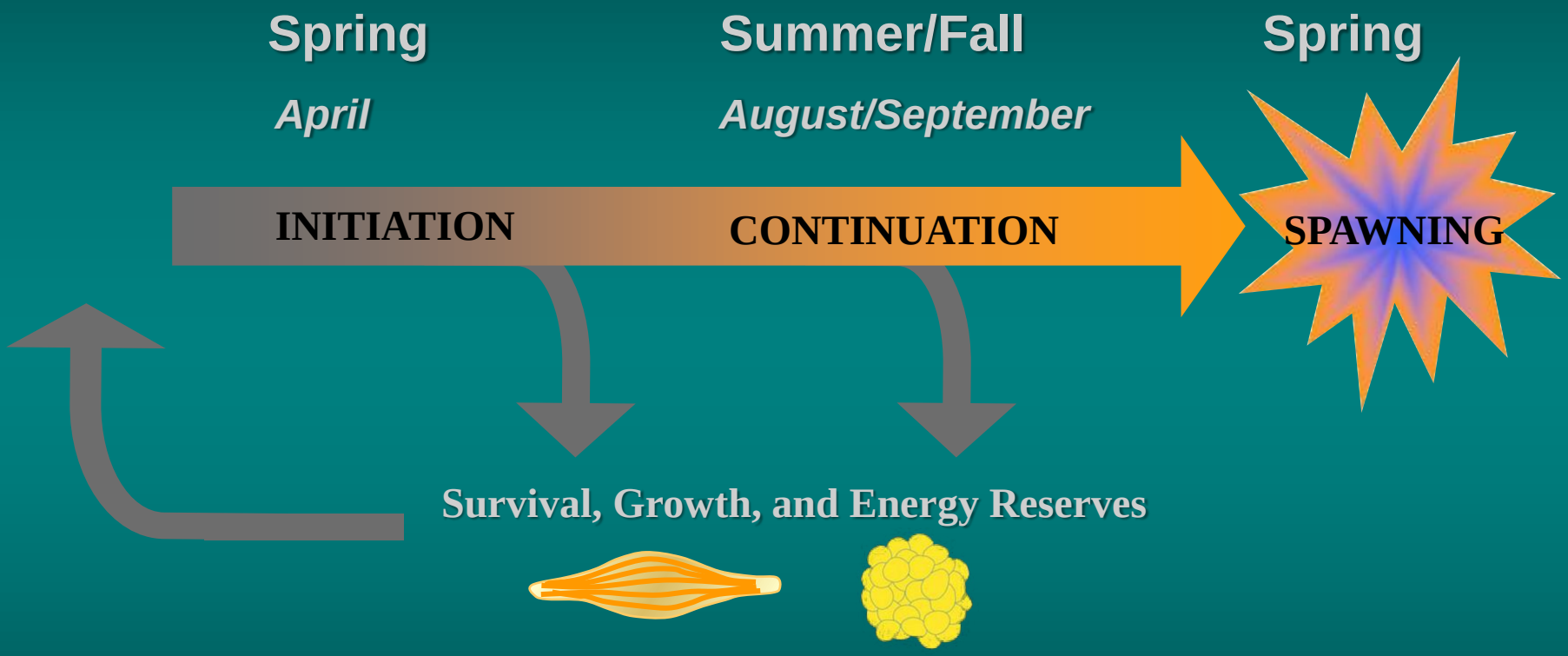
Skip spawning is common in seasonally breeding iteroparous fishes, and is driven by energetics (Rideout 2005).

Repeat spawners tagged at McNary Dam were 47% consecutive spawners/53% skip spawners (Keefer 2008).

Fecundity and egg size are greater in skip spawning than consecutive spawning Atlantic salmon (Reid & Chaput 2012).

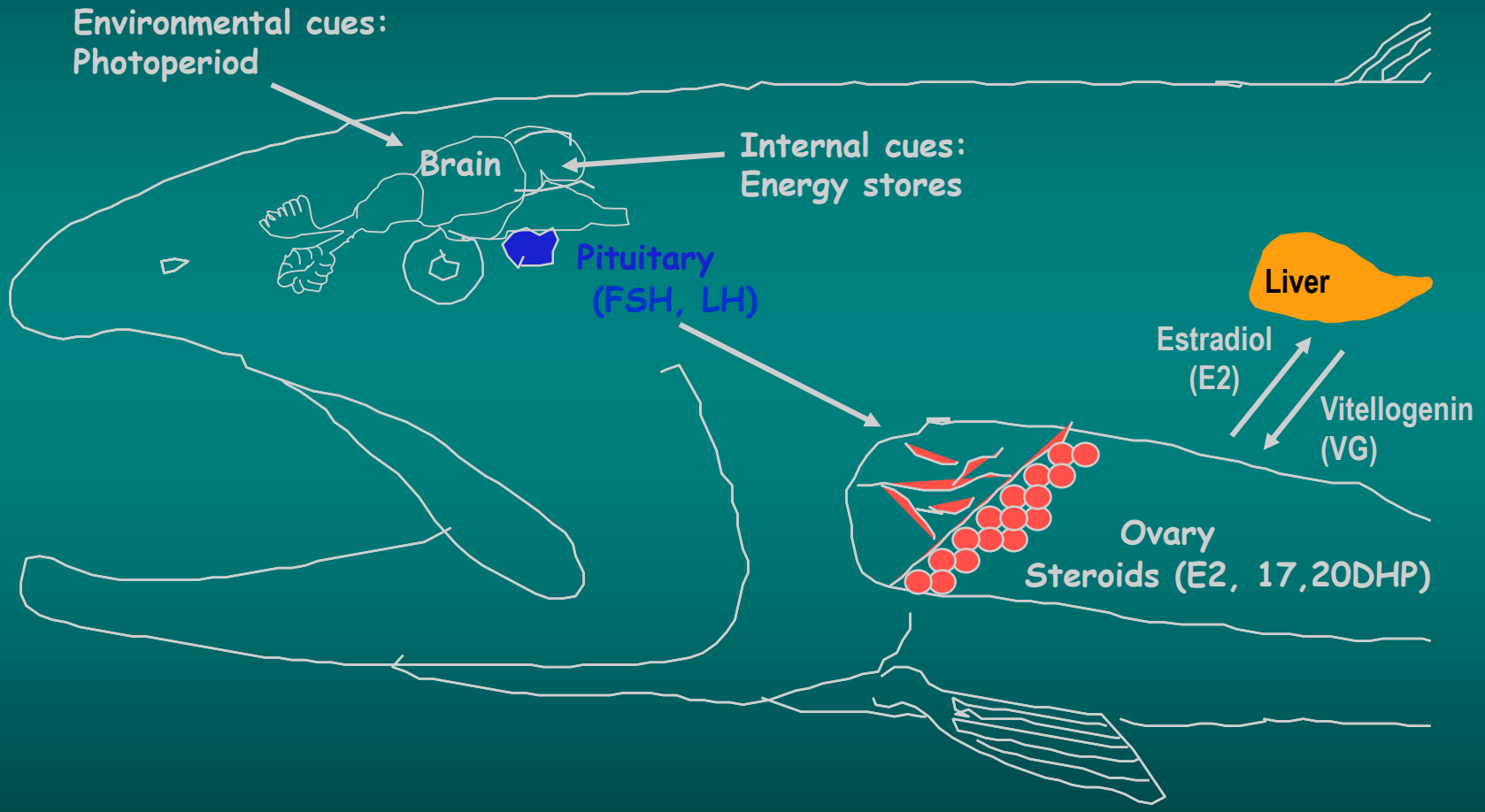
Hypothesis:
Reconditioned female steelhead may be consecutive or skip spawners.

In salmonids, maturation is initiated during a critical period about 1 year before spawning.

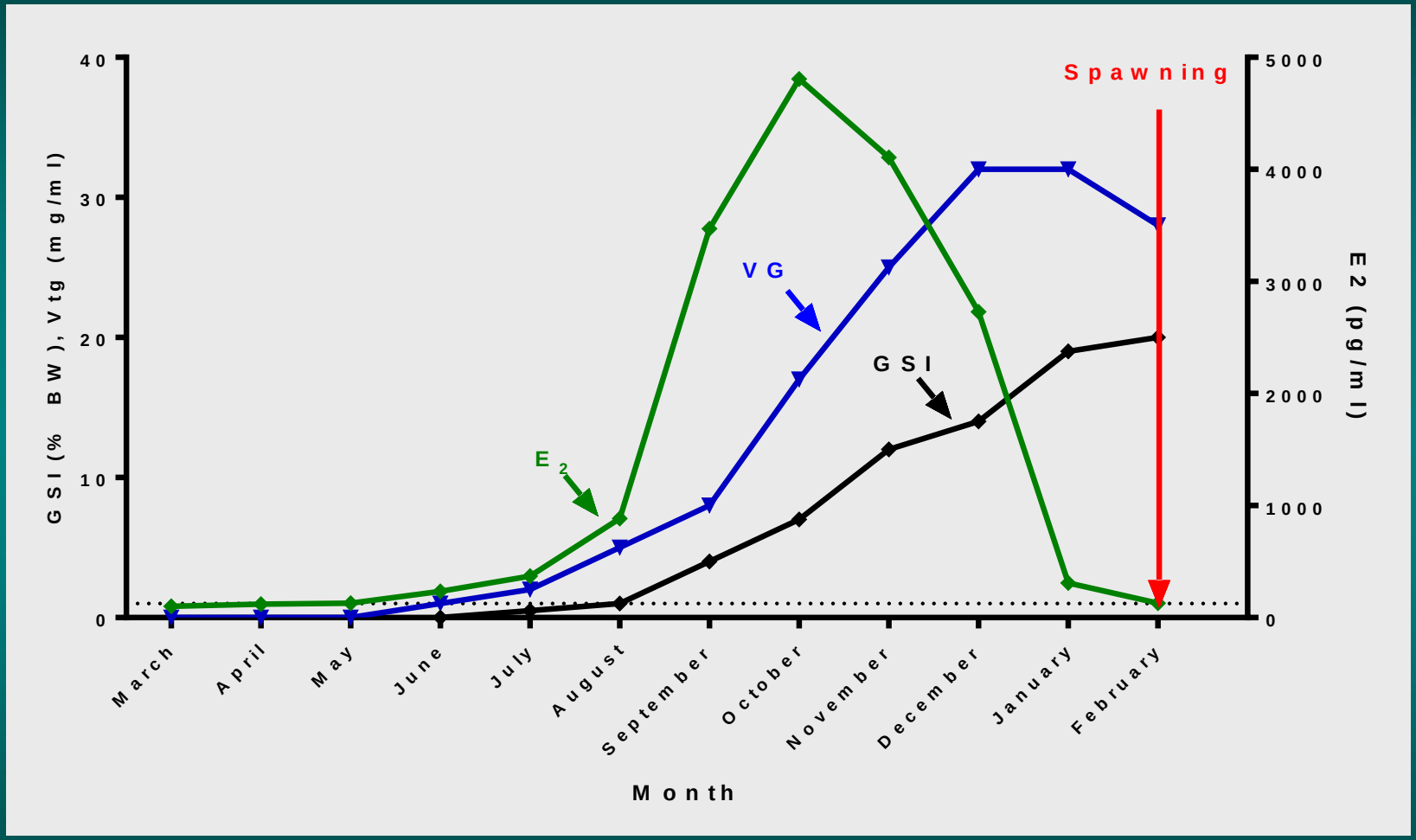


Question: When is rematuration determined in steelhead kelts?

The Reproductive Endocrine Axis regulates reproductive maturation in female salmonids.



In rainbow trout, E2, VG, and Gonadosomatic Index increase beginning 6-9 months before spawning.



Sources: Bromage, Whitehead & Breton 1982 Gen Comp Endocrinol; Whitehead, Bromage & Breton 1983 Gen Comp Endocrinol; Tyler, Sumpter & Witthames 1990 Biol Reprod; Prat, Sumpter & Tyler1996 Biol Reprod

Objectives

Assess the maturation status of reconditioned female kelts at release.

Determine when reproductive trajectory is set.

Establish methods for determining maturation status prior to release.

Compare reproductive development and energy reserves in reconditioned kelts and maiden spawning steelhead.

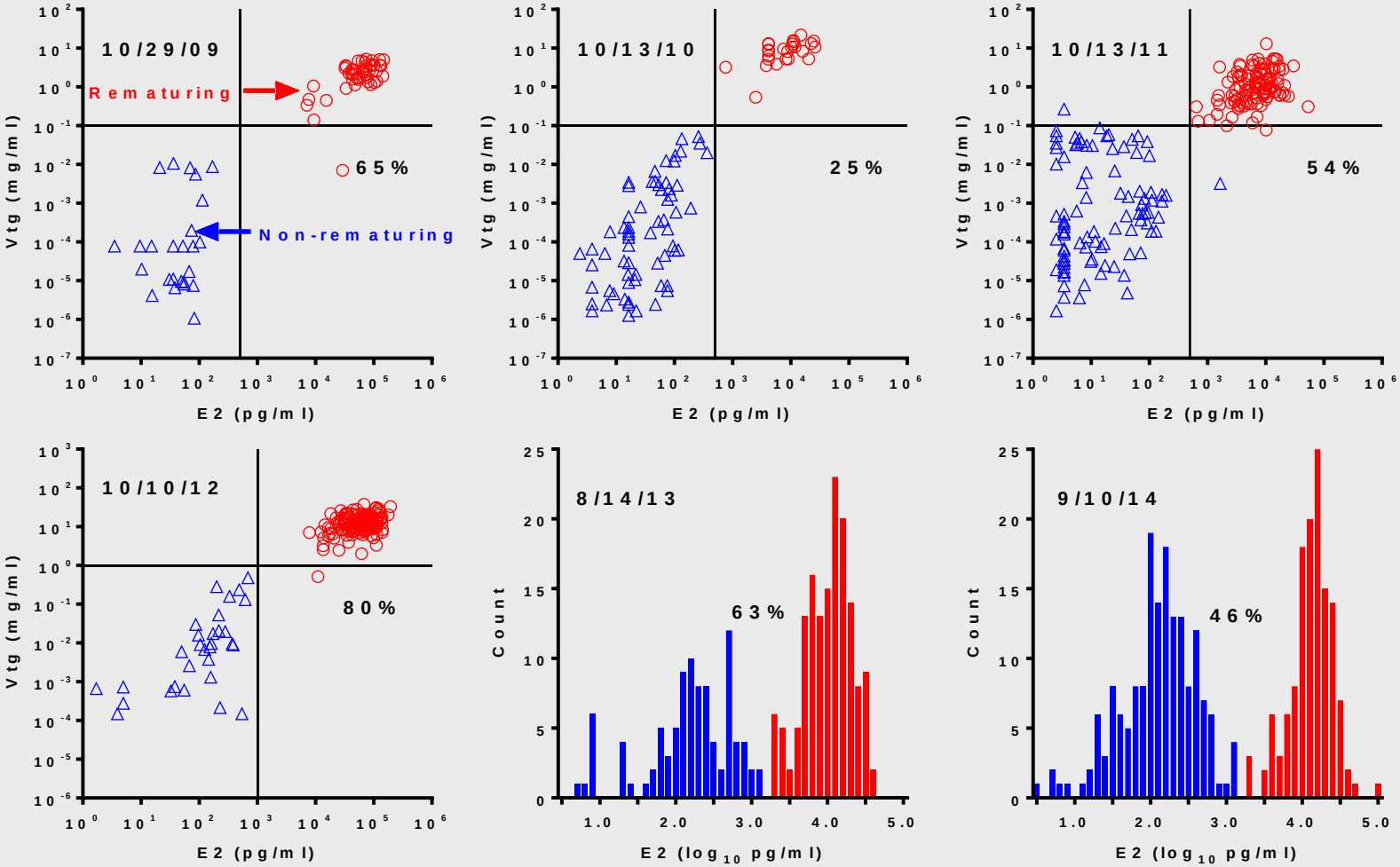
Methods

Kelts were blood sampled.

Maiden steelhead were blood sampled at the Prosser Denil ladder.

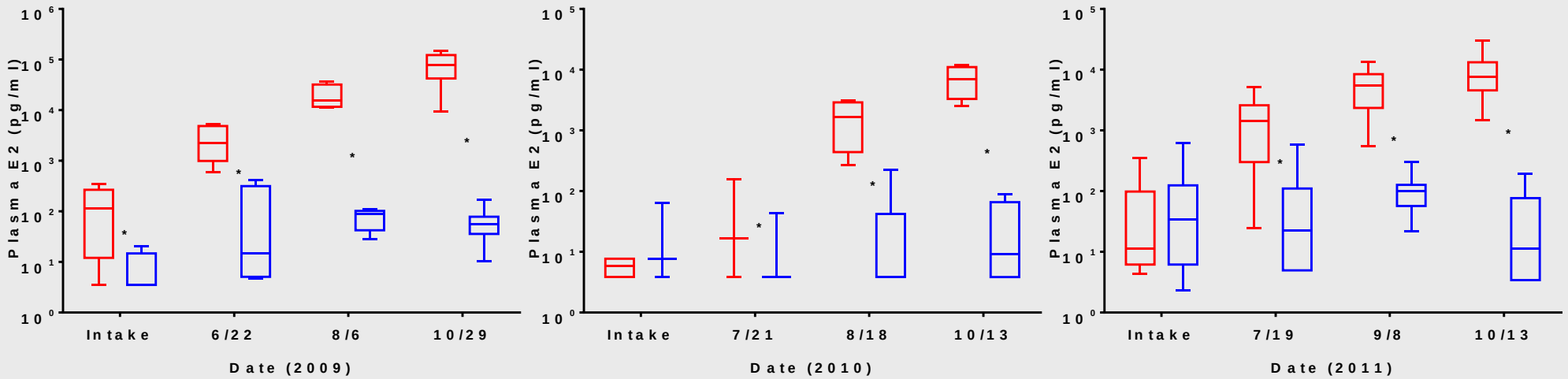
Plasma Estradiol (E2) and Vitellogenin (VG) levels were determined.

Plasma estradiol and vitellogenin levels divided female fish into rematuring and non-rematuring groups.



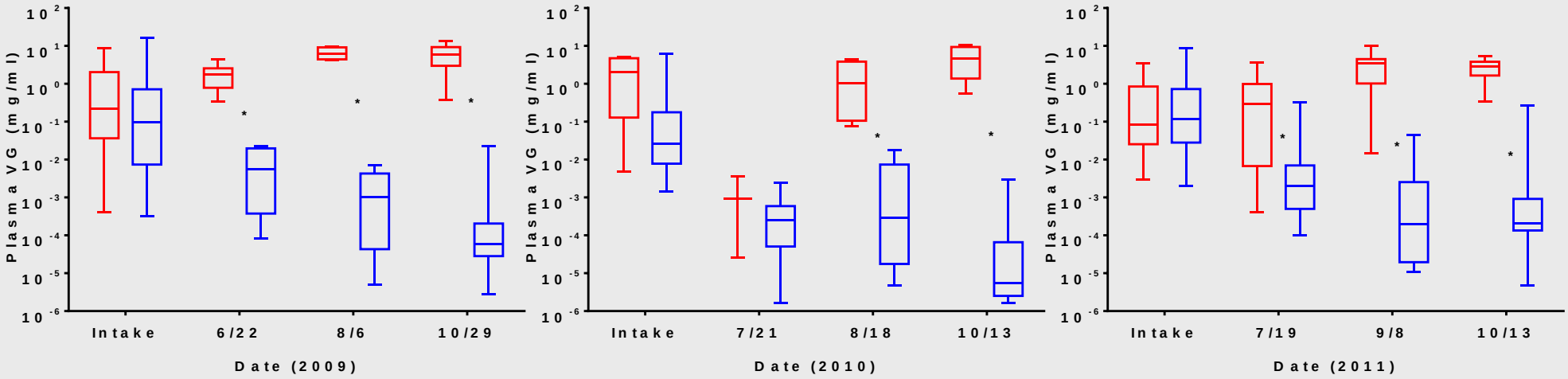
Random subsample of 25-100% of female fish. Groups identified by cluster analysis (hierarchical by Ward linkage, 2 groups, 09-12), or threshold value (13-14).

Plasma E2 levels were low at intake into reconditioning, and increased in rematuring versus non-rematuring fish by mid-July.



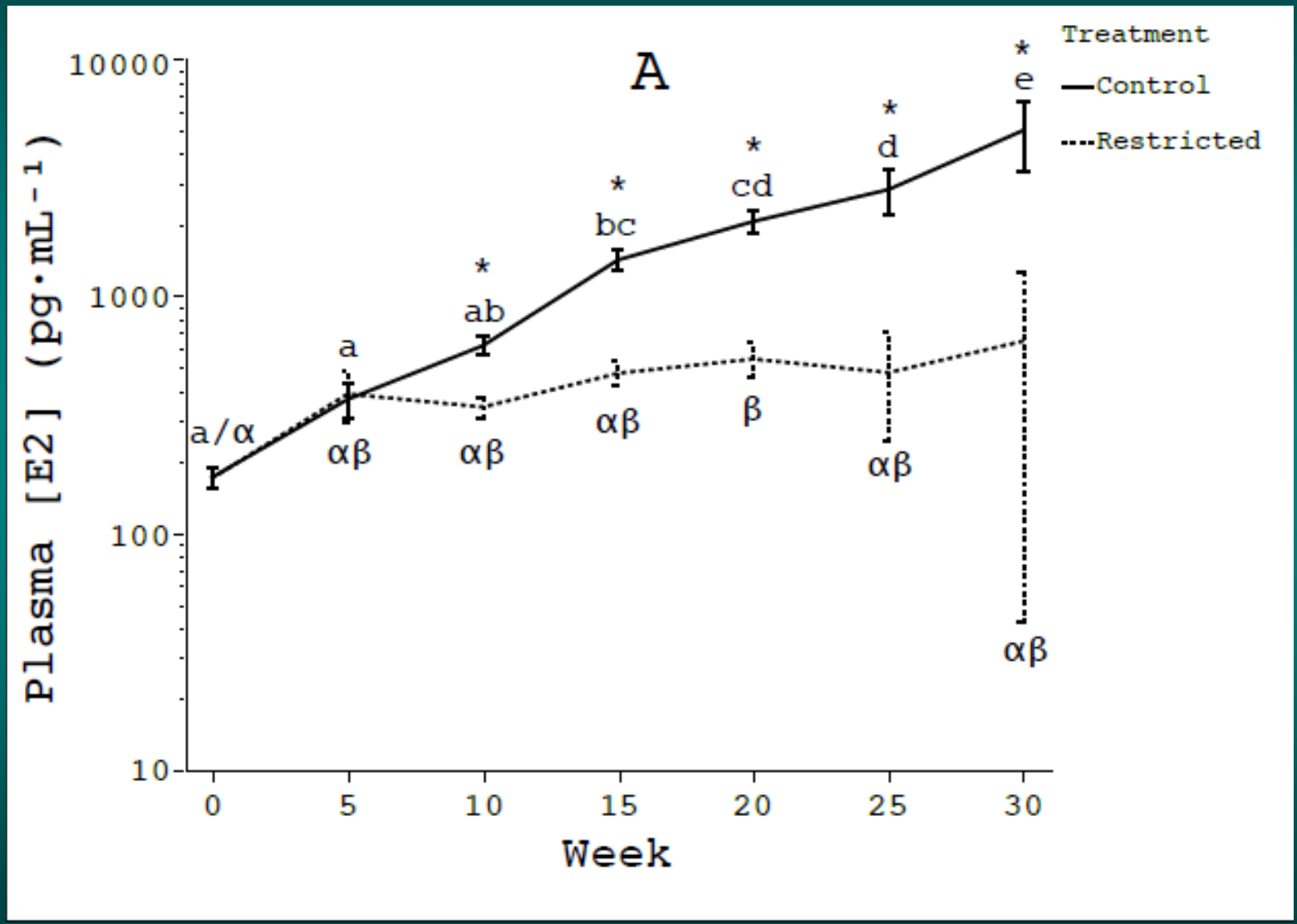
Serially sampled fish. Maturation category assigned by release E2 and VG levels. Significant 2-way ANOVA (maturation, sample date, maturation x sample date) in all years, followed by Tukey's test for the effect of maturation status at each sampling point.

Plasma VG levels were high at intake into reconditioning, and typically decreased in non-rematuring versus rematuring fish by mid-July.



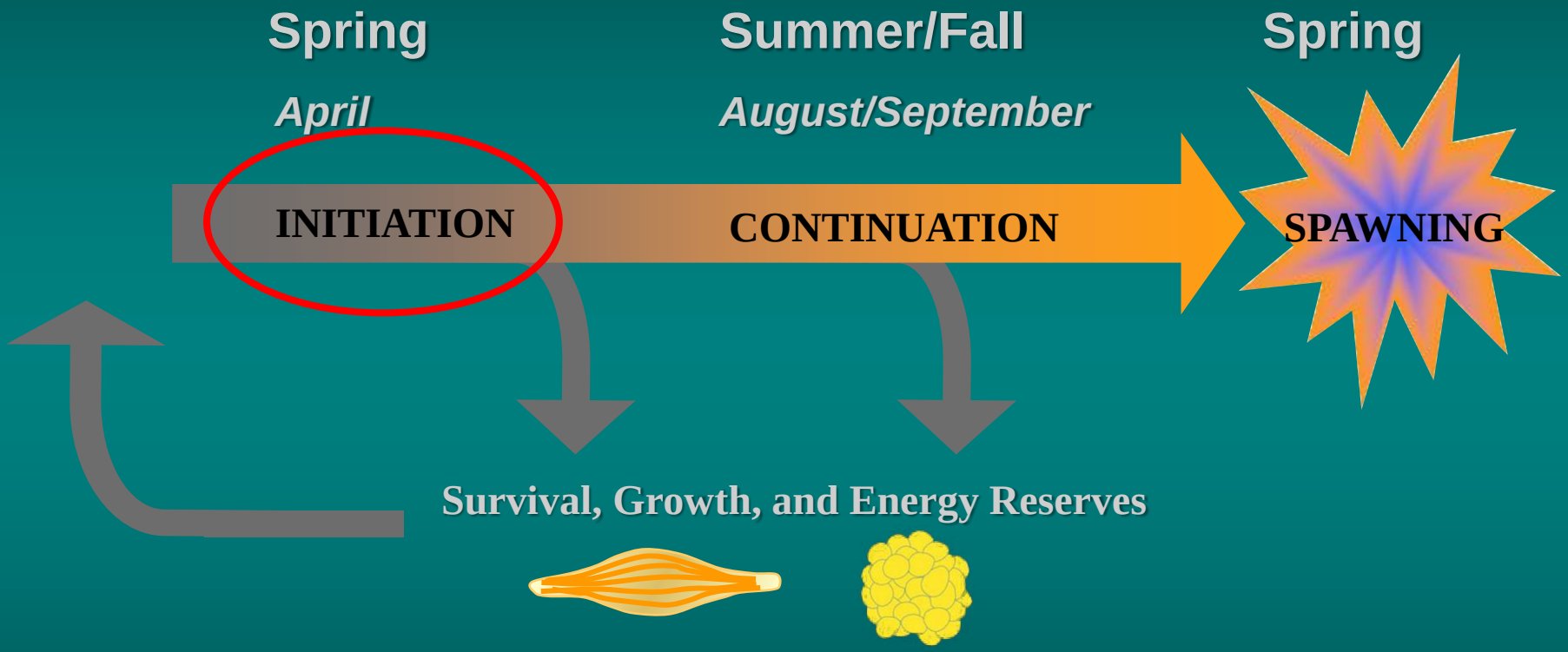
Serially sampled fish. Maturation category assigned by release E2 and VG levels. Significant 2-way ANOVA (maturation, sample date, maturation x sample date) in all years, followed by Tukey's test for the effect of maturation status at each sampling point.

In post-spawning rainbow trout, plasma estradiol was reduced by nutritional restriction within 10 weeks after spawning.



Caldwell et al., PLOS One, 2014.

Rematuration is determined early.



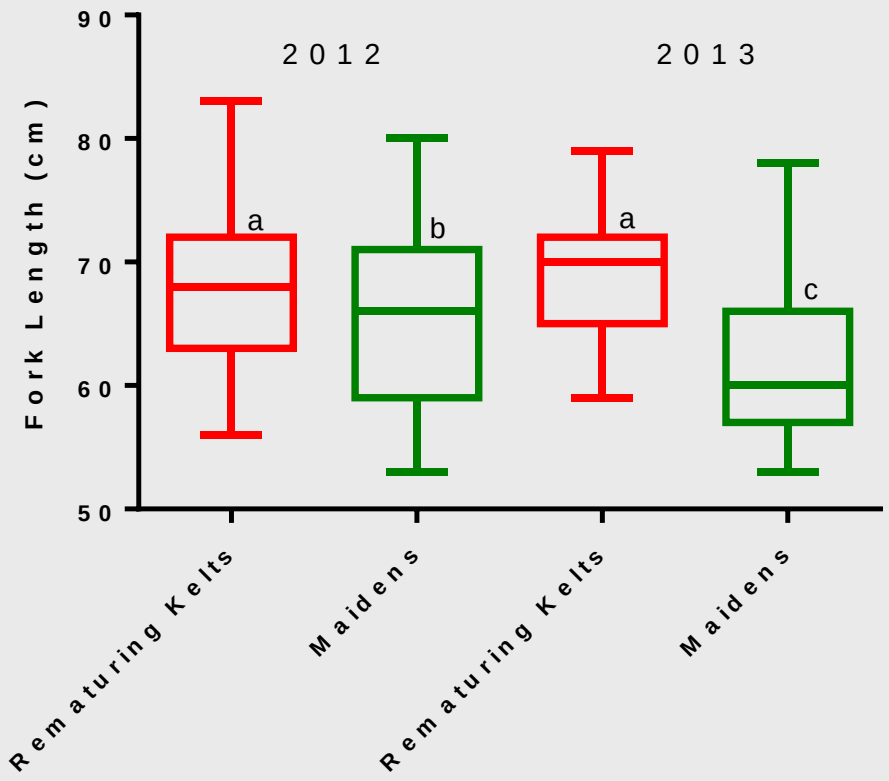
Upriver migrating maiden female steelhead were sampled during October in 2012 and 2013 at Prosser dam, about 1 km upstream from the reconditioned kelt release point.

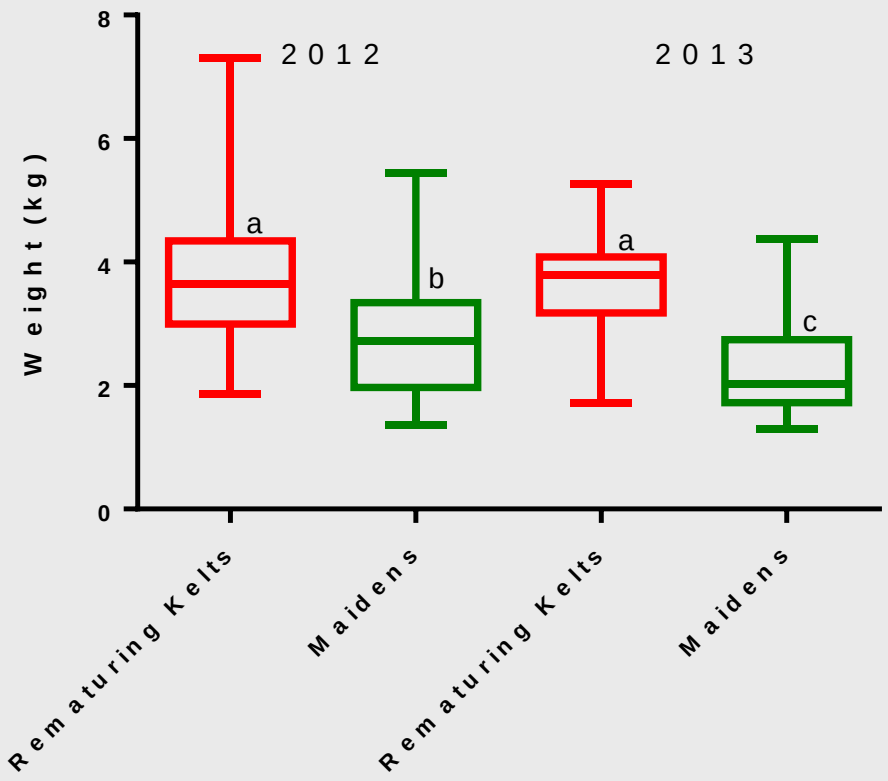
Maiden steelhead sampled at the Denil were compared with rematuring female reconditioned kelts sampled in October.

Response	Effect	P	Partial eta squared
Length	Year	0.0546	0.0093
	Kelt vs Maiden	<.0001	**0.1418**
	Year x Kelt vs Maiden	0.0001	0.0371
Weight	Year	0.0025	0.0230
	Kelt vs Maiden	<.0001	**0.3131**
	Year x Kelt vs Maiden	0.0327	0.0116
Condition Factor	Year	0.0057	0.0193
	Kelt vs Maiden	<.0001	**0.3284**
	Year x Kelt vs Maiden	0.0322	0.0116
Muscle Lipid	Year	<.0001	0.0443
	Kelt vs Maiden	<.0001	0.0545
	Year x Kelt vs Maiden	**<.0001**	0.0746
Plasma E2	Year	**<.0001**	**0.1559**
	Kelt vs Maiden	<.0001	0.0445
	Year x Kelt vs Maiden	<.0001	**0.1867**
Plasma VG	Year	<.0001	**0.1175**
	Kelt vs Maiden	0.9261	0.0000
	Year x Kelt vs Maiden	0.1184	0.0064

Two-way ANOVA. Partial eta squared is a measure of effect size similar to r^2.

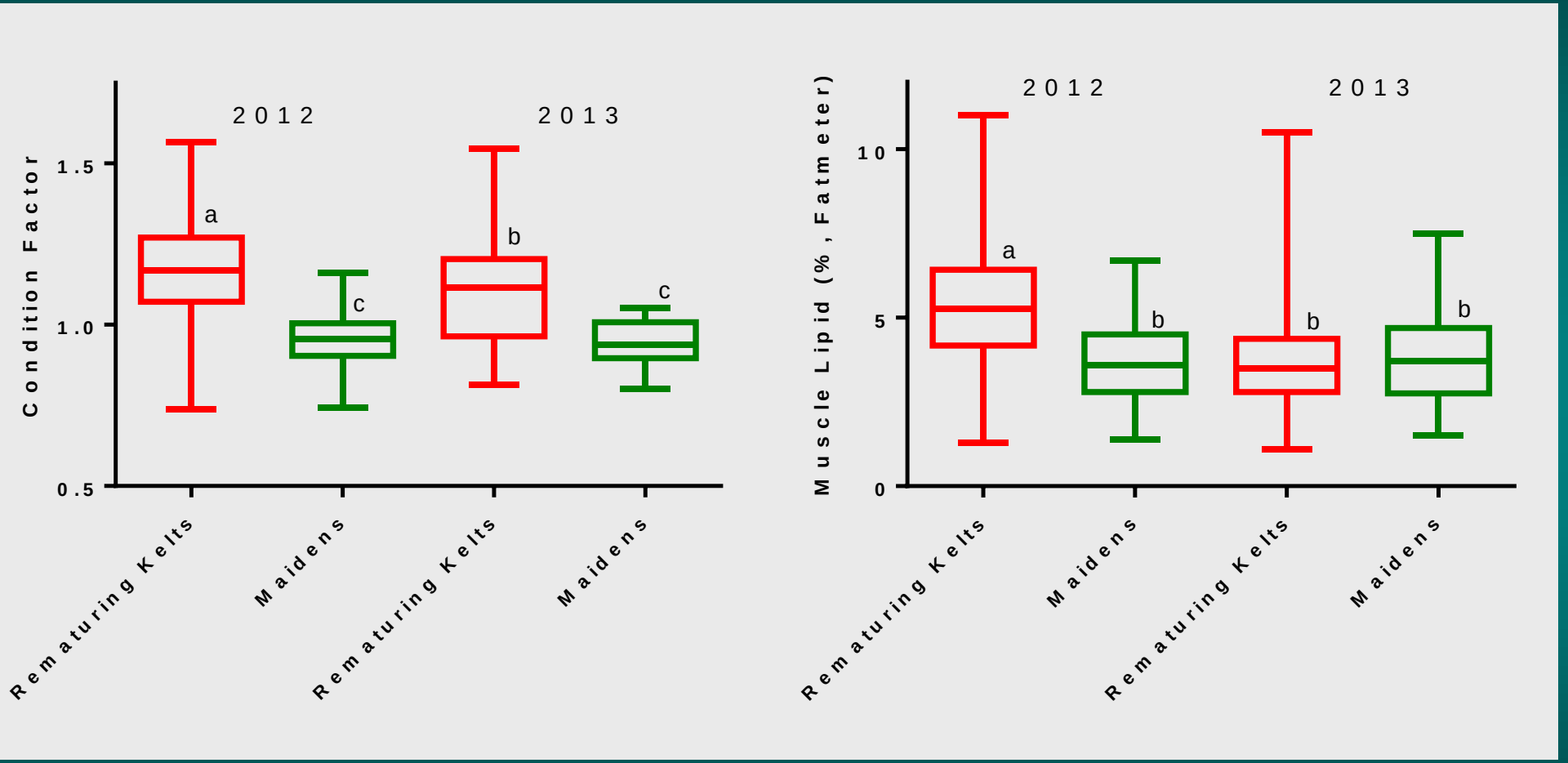
Rematuring reconditioned kelts were larger than maidens.





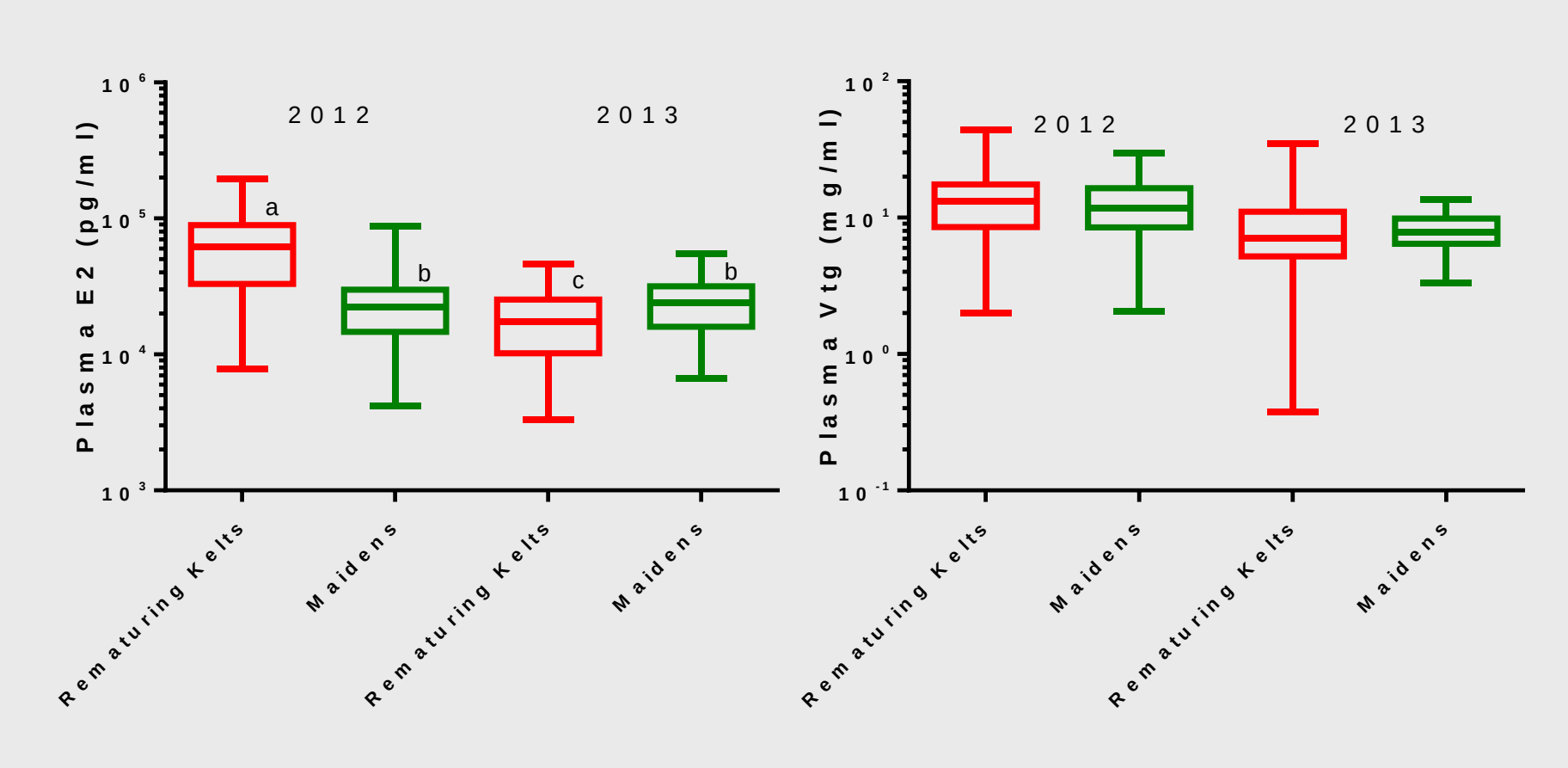
2-way ANOVA followed by Tukey's test.

Rematuring reconditioned kelts had higher condition factors and similar or higher muscle lipid levels versus maidens.



Muscle lipid levels measured were measured with a Fish Fatmeter (Distell, Inc). 2-way ANOVA followed by Tukey's test.

Rematuring reconditioned kelts had similar plasma E2 and VG levels versus maidens.



E2: 2-way ANOVA followed by Tukey's test. VG: only year was significant in 2-way ANOVA.

Conclusions

The kelt reconditioning project at Prosser releases both rematuring and non-rematuring females. Rematuration percentage varies between years.

Reproductive trajectory is determined during the critical period 1 year prior to spawning.

Fish can be screened for maturation status by blood hormone level from mid-August onward.

Rematuring reconditioned kelts are larger and have greater energy reserves than maiden spawners at the same point in migration.

There is no evidence for impairment in reproductive development in rematuring reconditioned kelts versus maidens.

Non-rematuring females rematured at a high rate if held for a second year.

Site	Release Year	Non-rematuring females held	Sampled next Fall	Mature	Survival	Maturation
Prosser	2011	34	13	11	38.2	84.6
Prosser	2012	12	4	2	33.3	50.0
Prosser	2013	42	7	6	16.7	85.7
Prosser	2014	125	No data yet			
Prosser	2011-13	88	24	19	27.3	79.2