



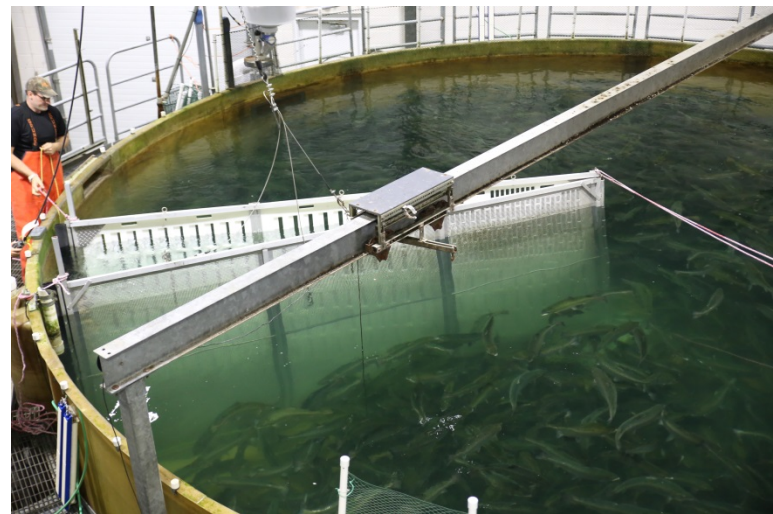
Freshwater Institute RAS Grow-out and Depuration Research Update

Steven Summerfelt, Travis May, John
Davidson, Tom Waldrop, Chris Good,

1. Atlantic salmon growout trials in land-based closed-containment systems
2. Depuration procedures to mitigate off-flavor from harvest-size Atlantic salmon
3. Approaches to minimize early maturing males during Atlantic salmon growout to food-size

Growout Trial Funding

- **USDA ARS**
 - 1st salmon studies finished in 2011
 - Gaspe and St John River strain
- **Atlantic Salmon Federation**
 - 2nd Growout Trial finished in 2012
 - St John River strain salmon @ 40 kg/m³
- **Gordon & Betty Moore Foundation**
 - 3rd Growout Trial finished in 2013
 - Cascade strain salmon @ 100 kg/m³
- **GBMF & ASF**
 - 4th Growout Trial to finish in 2014
 - Cascade strain salmon @ 2 photoperiods and 120 kg/m³ biomass density
- **GBMF & Salmobreed**
 - 5th Growout Trial to finish in 2015
 - Norwegian strain salmon @ 2 feed strategies and 120 kg/m³ density



Closed-Containment System

- 145 m³ Culture Tank Volume
 - 4900 L/min recirc flow
 - 30 min HRT
- 260 m³ System Volume
 - 45 L/min mean makeup
 - 8 to 150 L/min makeup
 - 4 day HRT (1.2-23 day)
 - 99.8 to 96.9% flow reuse

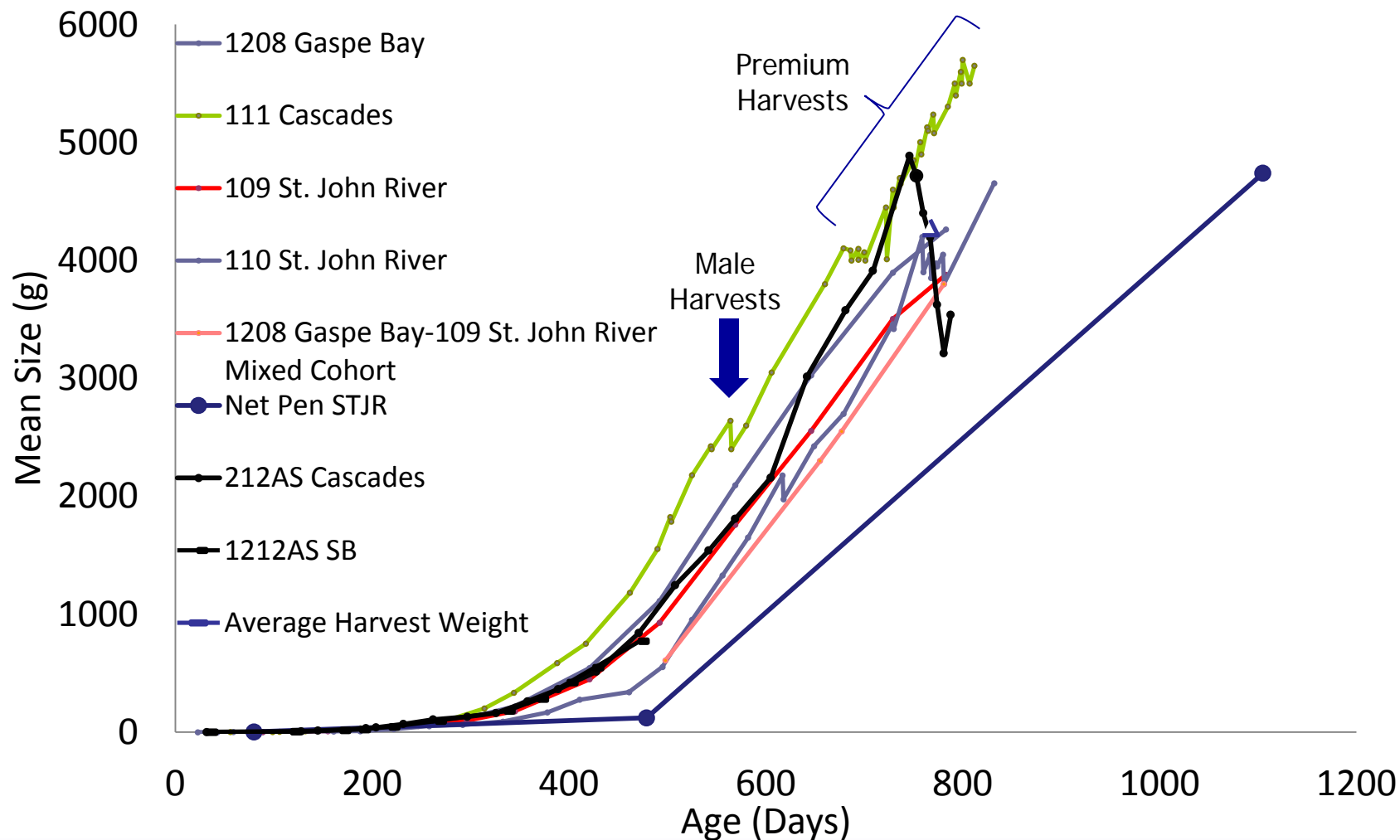
High flushing rate to keep water $\leq 17^{\circ}\text{C}$ in summer



- Growout stocking & harvest size (days in growout/days post hatch)

	Trial #2	Trial #3	Trial #4	Trial #5
Strain	St John River	Cascade	Cascade	SalmoBreed
Stock growout	0.34 kg (0/465d)	0.76 kg (0/417d)	0.51 kg (0/428d)	0.70 kg (0/475d)
1st early male harvest	2.7 kg (151/616)	2.6 kg (147/564)	2.1 kg (189/617)	2.28 kg (127/604)
Last early male harvest	3.7 kg (263/728)	2.6 kg (165/582)	2.0 kg (206/634) ^a	2.19 kg (134/611)
1st premium harvest	4.2 kg (294/759) 25.3 month phatch	4.1 kg (262/679) 22.6 month phatch	4.9 kg (318/746) 24.9 month phatch	tbd
Last premium harvest	4.7 kg (366/831)	5.7 kg (395/812)	3.5 kg (360/788) ^b	tbd

Atlantic Salmon Growout Trials



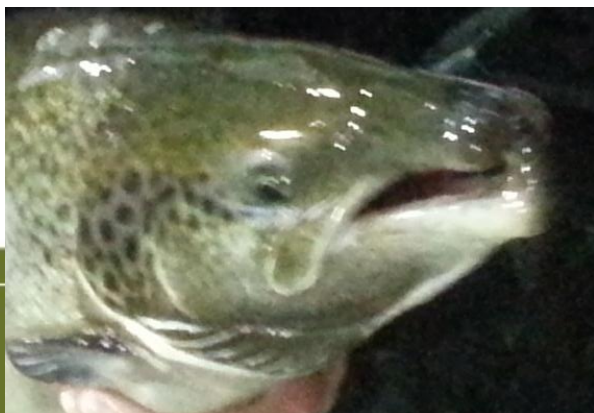
Maximum Growout Density

	Trial #2	Trial #3	Trial #4	Trial #5
Strain	St John River	Cascade	Cascade	SalmoBreed
Max Density	36 kg/m ³	100 kg/m ³	118 kg/m ³	tbd



- Early Maturing Males

	Trial #2	Trial #3	Trial #4	Trial #5
Grilse harvest size, kg	2.7 & 3.7 kg	2.6 kg	2.1 kg	2.2
Prevalence, %	36.6%	38.5%	17.1%	18.0%
Total grilse harvest, kg	1,800 kg	5,442 kg	2,330 kg early 327 kg late	1,400 kg early
Other harvest, kg			2,868 kg early	
Post-harvest use	Hot smoked	Cold smoked	Fresh fillets & smoked	Fresh fillets



Final Salmon Harvests

	Trial #2	Trial #3	Trial #4	Trial #5
Mean harvest size, kg	4.2 to 4.6 kg	4.1 to 5.7 kg	4.9 to 3.5 kg	tbd
Total final harvests, kg	5,200 kg	13,382 kg	<u>12,695 kg</u> Prem: 12,047 kg subPrem: 320 kg grilse: 328 kg	tbd
All harvests, kg	7,000 kg	19,496 kg	19,727 kg	tbd
Post-harvest use	Food-banks	Albion Seafood	JJ McDonnell	tbd



AIW#6
er 27-28, 2014

- Overall feed/gain

	Trial #2	Trial #3	Trial #4	Trial #5
Strain	St John River	Cascade	Cascade	SalmoBreed
FCR	1.09	1.07	1.10	tbd

Trials 2-4, Growout RAS fed Ewos Dynamic Red (~44% protein & ~29% fat)
Trial 5, Growout RAS fed Skretting Optiline RC (varies with size)



Cumulative mortality

	Trial #2	Trial #3	Trial #4	Trial #5
Strain	St John River	Cascade	Cascade	SalmoBreed
Mortality	3.9%	2.7%	2.6%	0.96%
Culls (fungus-unthrifty)	5.6%	3.9%	1.3% in growout 3.6% @ harvest	0.24%
Jumpers	1.9%	0.4%	0.7%	0.32%
Total	11.4%	7.0%	8.2%	1.5%



- **No** major fish health events were noted
 - A little fungus, mostly during incubation & fry culture
- Sixty fish from each cohort were tested for listed salmon pathogens at least once for every cohort
 - **No** sea lice or kudoa
 - **No** ISAV, IPNV, VHSV, OMV, SVCV, *A. salmonicida*, *R. salmoninarum*, *Y. ruckeri*, *M. cerebralis*, *C. Shasta*, or *K. thyrsites*
 - **None**, during any of the salmon growout trials

- No vaccination (saves \$\$ & stress)
- No antibiotics or pesticides used at any time
- No formalin used at any time
- Some hydrogen peroxide (H_2O_2) used in the sac fry and early parr stage to treat fungus.
- Some salt used to treat fungus @ 2-3 ppt

Escapees

- **No escapees – two Atlantic salmon parr removed from the effluent fish exclusion area.**



Test Marketing

- Premium salmon sold to Safeway in Vancouver and Wegmans in DC, Maryland, and Virginia



CONCLUSIONS: Atlantic Salmon Growout Trial

- Good growth in freshwater
 - Harvest sooner than net pens
- Great survival (89-95%) & feed conversion ($\leq 1.1:1$)
- Density can reach 100-120 kg/m³
- Ideally, use all female eggs to avoid precocious males

We don't need seawater to farm Atlantic salmon



Evaluating Standard Operating Procedures to Mitigate Off-flavor from Atlantic Salmon Cultured in a Semi-Commercial Scale Recirculating Aquaculture System

John Davidson, Bruce Swift, Eric Ruan, Jennifer Aalhus, Manuel Juarez, Kevin Schrader, Bill Wolters, Christopher Good, Gary Burr, and Steven Summerfelt

Depuration Trial

- Aeration columns and media can harbor biofilms and off-flavor producing bacteria even within depuration systems



Experimental Design

Trials 1 and 2

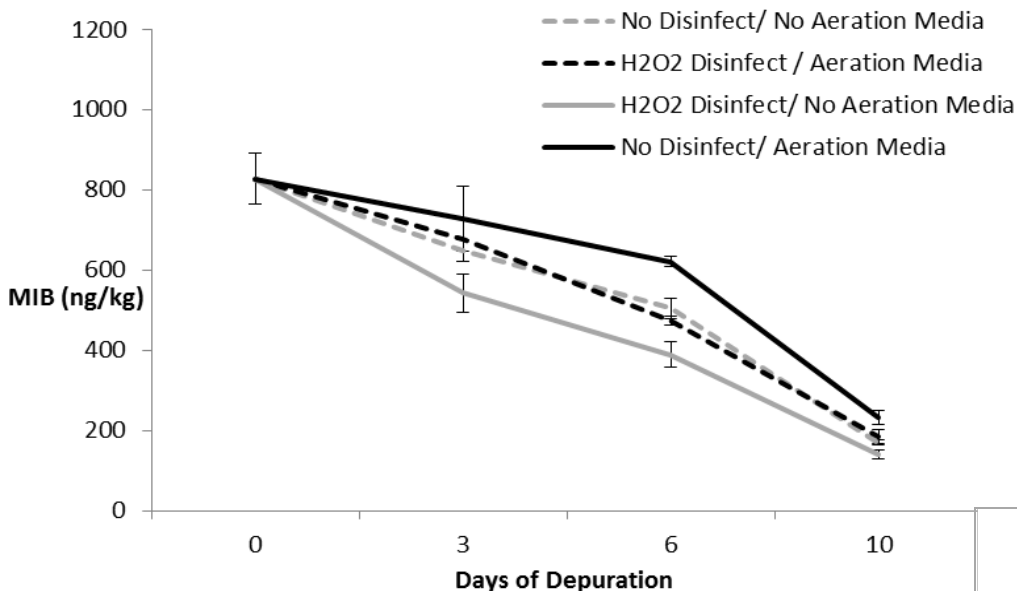
Culture Systems per Treatment	Granular Activated Carbon (GAC)	Hydrogen Peroxide
3	✓	✓
3	✓	
3		✓
3		

Trial 3

Culture Systems per Treatment	Hydrogen Peroxide Disinfection	Water Aeration Media Present
3	✓	✓
3	✓	
3		✓
3		

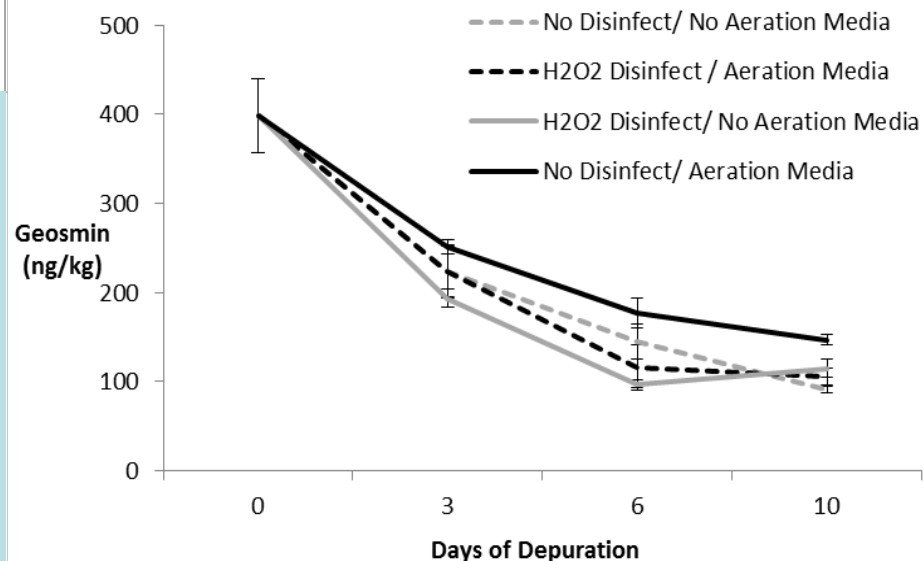
- Prior to the studies, depuration systems were used to culture rainbow trout to create biofilm coated surfaces
- Trout were removed one day prior to each study
- Six systems were disinfected with 250 mg/L hydrogen peroxide as a static treatment for 1 hr
- Atlantic salmon were stocked, approximately 14 per tank
- Salmon (n=3-4) harvested at specified intervals from each depuration system to evaluate off-flavor kinetics
- Fillets were vacuum sealed, frozen, and shipped for analysis

Trail 3 Results




- Disinfect between cohorts
- Use no water aeration media in depuration systems because it provides surface area for biofilm attachment and is difficult to clean and disinfect

- Use simple partial-reuse or flow-through systems and avoid treatment processes with difficult to clean areas



BIOREMEDIATION

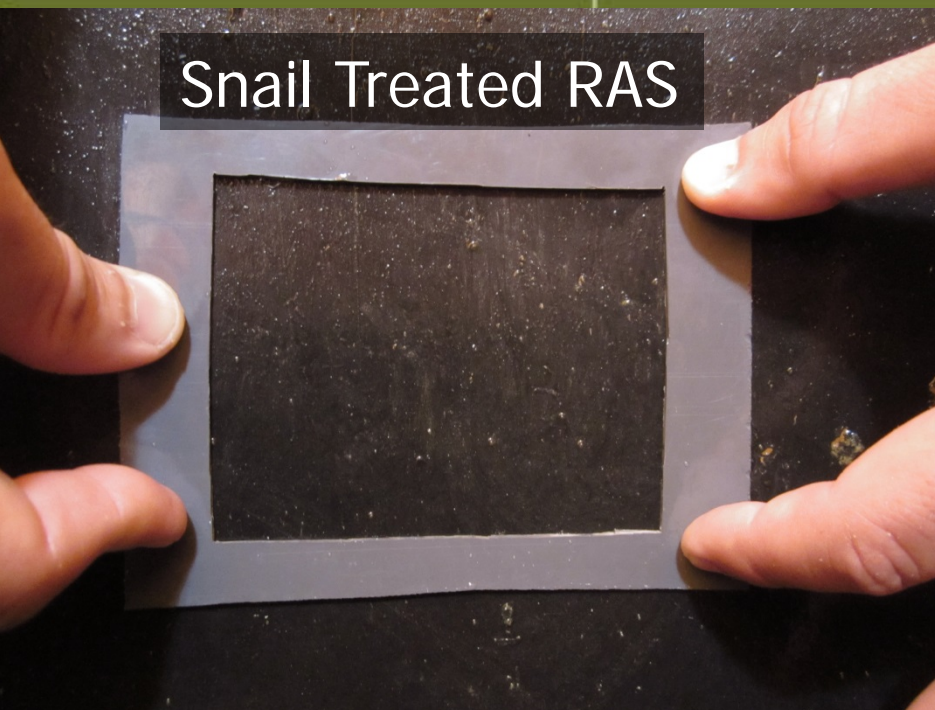
Can Native, Freshwater Snails
Mitigate Off-Flavor in RAS?



John Davidson, Eric Ruan,
Clayton Raines, Carol Plautz,
Christopher Good, Niels
Jørgensen, Jennifer Aalhus,
& Steven Summerfelt

Initial Results

Snail Treated RAS



- 100 snails, *Physa gyrina*, completely grazed the submerged surfaces of 50 gallon tanks within replicated reuse systems (left)
- Systems without snails had substantial biofilm accumulation (below)

No Snail Control RAS



- Total solids (biofilm) per area
 - Snails - $0.03 \pm 0.02 \text{ mg/cm}^2$
 - No Snails - $1.16 \pm 0.16 \text{ mg/cm}^2$
- Off flavor results still pending

Conclusion

- Snails controlled biofilm
- Rapid snail reproduction & distribution
- Waiting for data on geosmin & MIB
- More research necessary in replicated RAS





**Effects of 1st year photo
period (18 hr vs 24 hr
continuous light) and
circulating hormones on
sexually maturing
Atlantic salmon in
freshwater RAS**

**Good C, Davidson J, Weber G, Earley R, Lee E,
& Summerfelt S**

AIW#6
October 27-28, 2014

Background: Atlantic salmon growout trials

Precocious maturation in three earlier growout trials

- 75% of male salmon matured early
- 38% of all fish removed as early maturing males
- approximately half at 2 kg and half at 3.5 kg



Sexual maturation in *S. salar*:

A highly flexible process, influenced by

- Photoperiod
- Water temperature
- Feed intake
- Nutrition
- Lipid reserves
- Growth rate
- Stock genetics
- Etc.

HORMONE ACCUMULATION IN RAS

- **Testosterone** the only measured hormone significantly accumulating in RAS relative to exchange rate
- **11-KT** the only measured hormone to be significantly reduced across the water treatment processes
- **Testosterone, 11-KT, and estradiol** sig. higher in RAS compared to makeup water
(Good et al. 2014. JARD)

Photoperiod effect?

Two treatment groups:

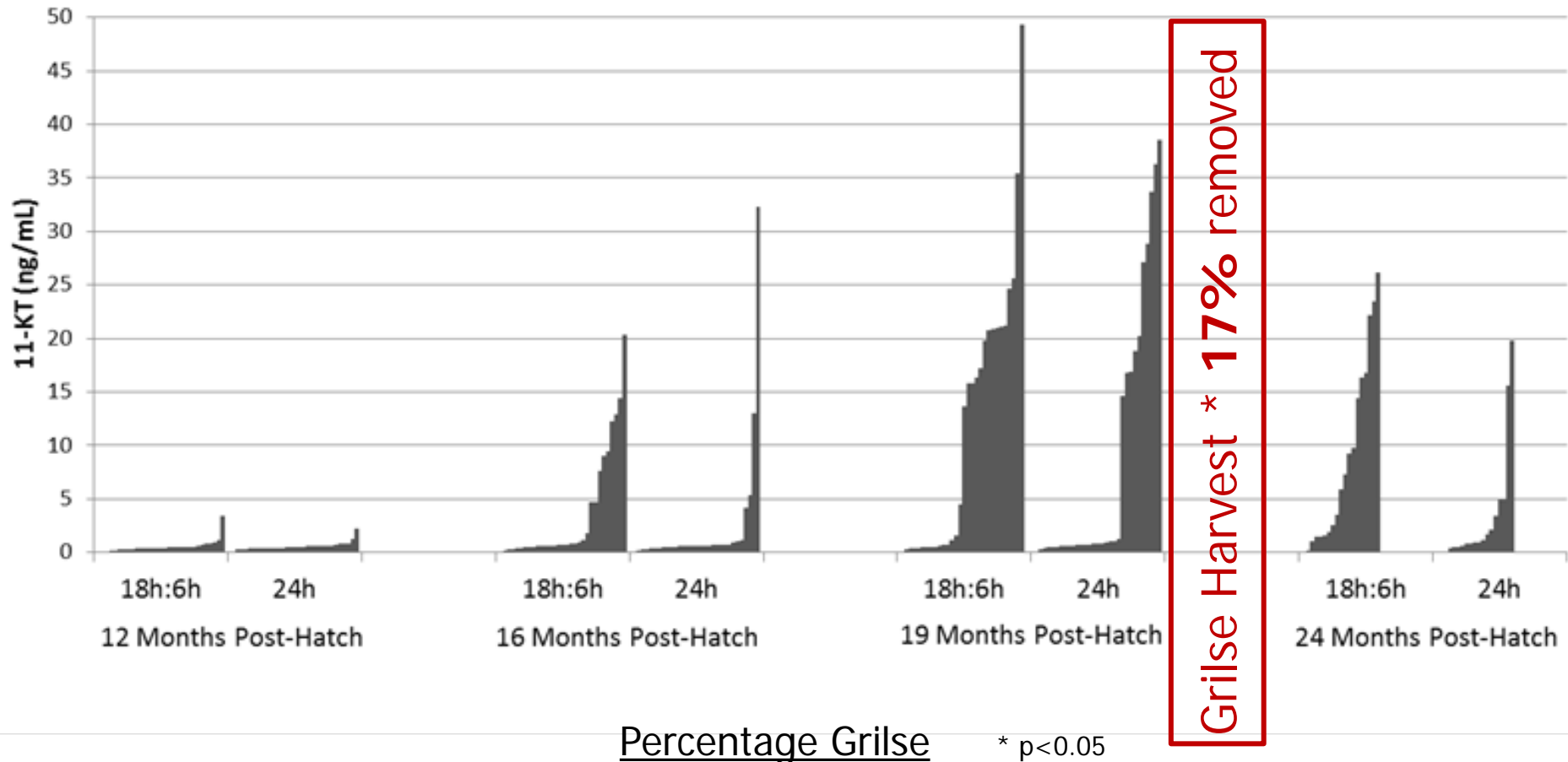
- 24-hour photoperiod
- 18h:6h photoperiod

Reared under different photoperiods for 12 months, then comingled for growout



- Assessments (18-30 males per treatment):
 - Gonadosomatic Indices
 - Plasma 11-KT
- Samplings:
 - 12 months post-hatch
 - 16 months post-hatch
 - 19 months post-hatch (just prior to grilse harvest)
 - 24 months post-hatch

18h:6h vs 24h Photoperiod

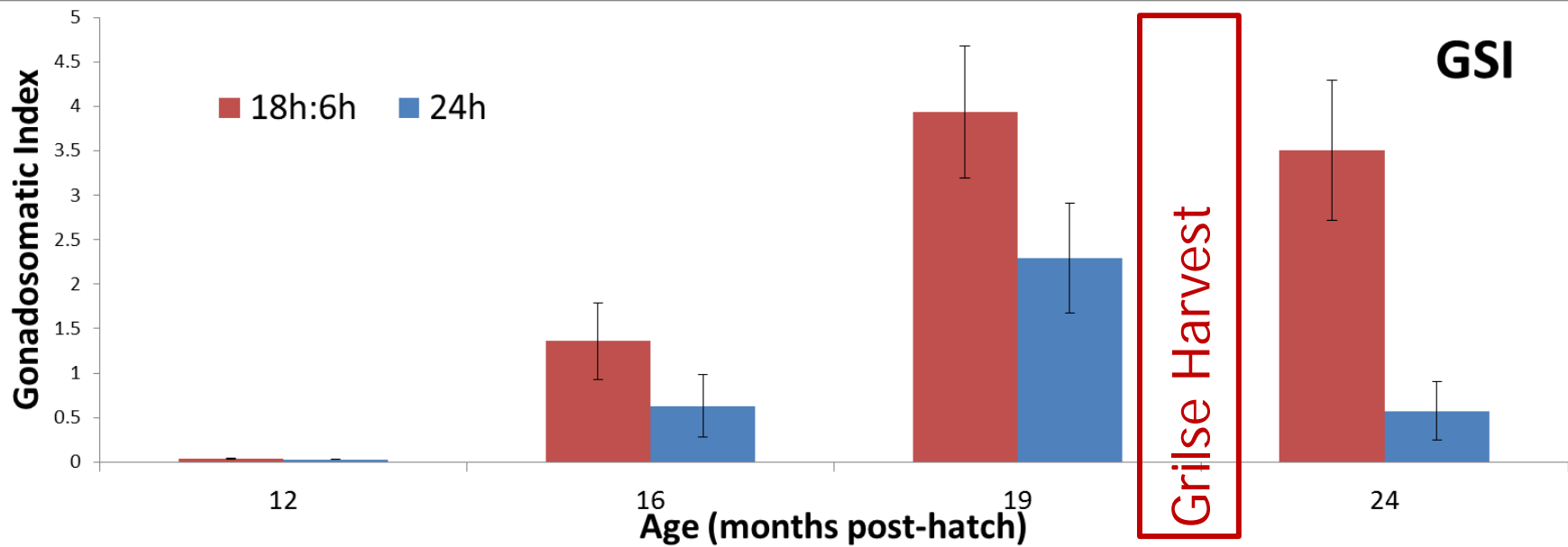


18h:6h – 0.0%
24h – 0.0%

18h:6h – 23.3% *
24h – 6.7%

18h:6h – 53.6%
24h – 30.0%

18h:6h – 61.1% *
24h – 11.1%



<u>Sampling</u>	<u>Treatment</u>	<u>Mean</u>	<u>SE</u>	<u>P-value</u>
12 months	18h:6h	0.037	0.004	0.165
	24h	0.029	0.002	
16 months	18h:6h	1.359	0.429	0.175
	24h	0.632	0.355	
19 months	18h:6h	3.939	0.741	0.029
	24h	2.296	0.618	
24 months	18h:6h	3.510	0.787	0.002
	24h	0.573	0.329	

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- Grilse dropped from 38% to 17% in last two cohorts, i.e., when 600 g post-smolt were not stocked into same RAS as large mature salmon
- No quantifiable advantage for adopting 18h:6h photoperiod during first year:
 - Significantly higher % grilse relative to 24h photoperiod

➤ Research support

