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Atlantic Salmon Growout on a Zero Fish Meal, Zero FIFO, and Non-GMO Diet in Freshwater Closed-Containment Systems

Steven Summerfelt, Travis May, Curtis Crouse, John Davidson, Chris Good, Rick Barrows, Jason Mann

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Acknowledgements

USDA

Gordon and Betty MOORE FOUNDATION

HERRICK FOUNDATION

CtrlAQUA

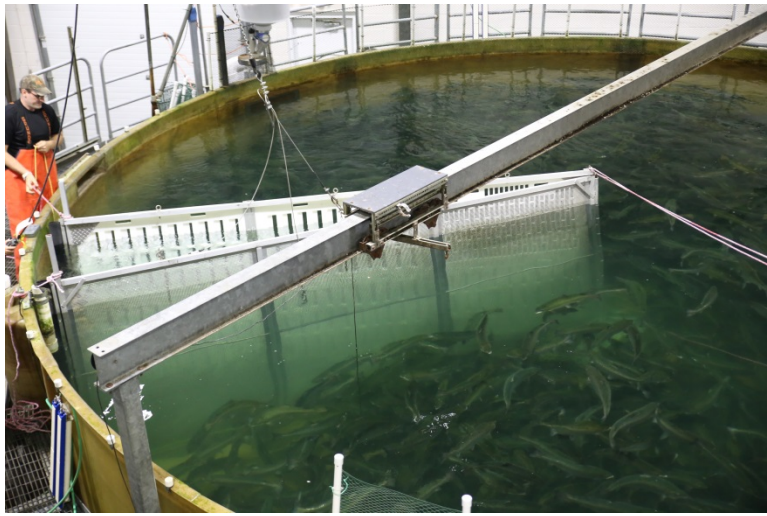
Atlantic Salmon Federation

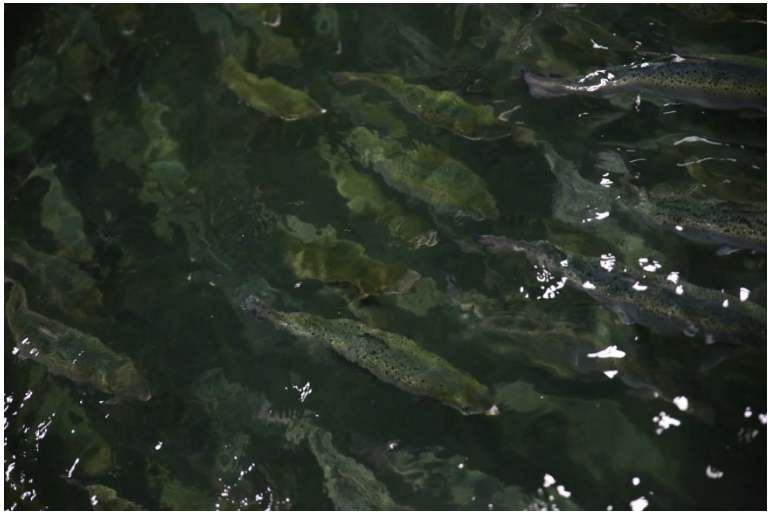
SalmoBreed

Tides Canada

Growout Trials

1. **USDA ARS** (finished 2011)
   - Gaspe and St John River strain
2. **Atlantic Salmon Federation** (finished 2012)
   - St John River strain salmon @ 40 kg/m3
3. **Gordon & Betty Moore Foundation** (finished 2013)
   - Cascade strain salmon @ 100 kg/m3
4. **GBMF & ASF** (finished 2014)
   - Cascade strain salmon @ 2 photoperiods and 120 kg/m3 biomass density
5. **GBMF & Salmobreed** (finished 2015)
   - Norwegian strain salmon @ 2 feed strategies and 95 kg/m3 density
6. **GBMF, ASF, & Salmobreed** (finished 2016)
   - Norwegian strain salmon @ 94 kg/m3 with custom **sustainable feed formulation**





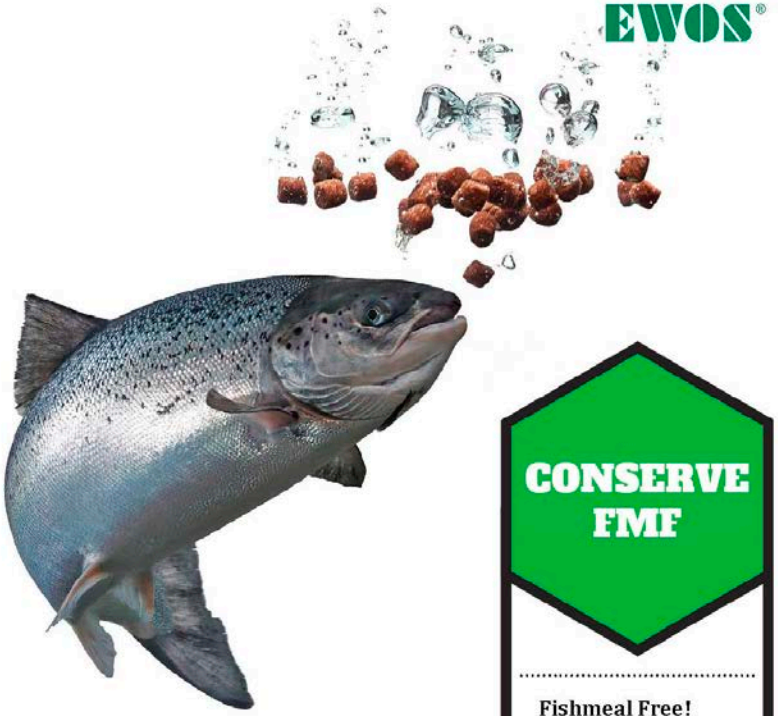
Custom, Practical, & Sustainable Feed

- Fishmeal & GMO free
- Zero Fish in: fish out (by Seafood Watch)
- North America sourced ingredients
- Natural pigment added (non-gmo phaffia yeast)
- Only fish oil (byproduct of processing residuals)
- Formulated by Rick Barrows (USDA) & Jason Mann (Ewos-Cargill)
- 20 MT produced by Ewos-Cargill

Ingredients

- Pea protein concentrate
- Mixed nut meal
- Wheat flour
- Poultry by product meal
- Bloodmeal
- Fish Trimmings oil
- Natural Astaxanthin (80 ppm)

EWOS®



CONSERVE FMF

Fishmeal Free!

A breakthrough feed with high sustainability credentials that will ensure your fish standout in the marketplace.

EWOS Conserve Fishmeal Free (FMF) is formulated by nutritional experts using plant and animal by-products of human food production.

Cargill

EWOS®

EWOS Conserve FMF		
Size	Protein	Fat
L and XL shaped pellet	40	30

EWOS CONSERVE FMF

Fish that Standout in the Market

- **Fishmeal Free** – the only fishmeal free diet that uses commonly sourced ingredients
- **Zero Wild Fish In: Farmed Fish Out Ratio** (as defined by Seafood Watch program) – uses fish oil by-product from human food fish processing
- **Natural Astaxanthin** – 80 ppm from natural sources achieves optimal fillet colour
- **Enhanced Local Sourcing Minimizes Carbon Footprint** – all major ingredients are North American origin
- **Share the Earth** – uses plant and animal by-products from human food production
- **Healthy Omega-3 Fatty Acid Levels** – fish oil levels reflect less marine ingredient reliance but ensure heart and brain-healthy Omega-3 fatty acid levels
- **Available with no Genetically Modified Ingredients**

No Risk Production Results

- **Expert Formulation** – formulated by nutritional experts from the USDA Agricultural Research Service and Cargill Aqua Nutrition Canada to meet requirements set by The Conservation Fund Freshwater Institute
- **Proven Ingredients** – a mixture of well-tested protein sources have established nutrition and are readily sourced
- **Excellent Performance** – semi-commercial production in The Conservation Funds Freshwater Institutes's RAS facility yielded FCR of 1.18 with 97 percent survival during 10-month growout
- **Validated Production Results** – 12 tonnes of Atlantic salmon raised from 600 grams to 4.5-5.0 kg harvest weight
- **High Nutrient Specification** – ensures nutrient requirements are well met, specifically designed for Atlantic salmon from 1.5 kg to harvest

ASC Certification? With no fishmeal and with by-product fish oil only, EWOS CONSERVE FMF will simplify responding to the ASC Salmon standard's feed requirements and will ensure the ability to meet marine ingredient sourcing indicators does not limit certification of sites.

Cargill

Growout System

- 24 hr light & 24/7 feeding
- 145 m^3 Culture Tank Volume
  - 4900 L/min recirc flow
  - 30 min HRT
- 260 m^3 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 in summer keeps water ≤ 16°C

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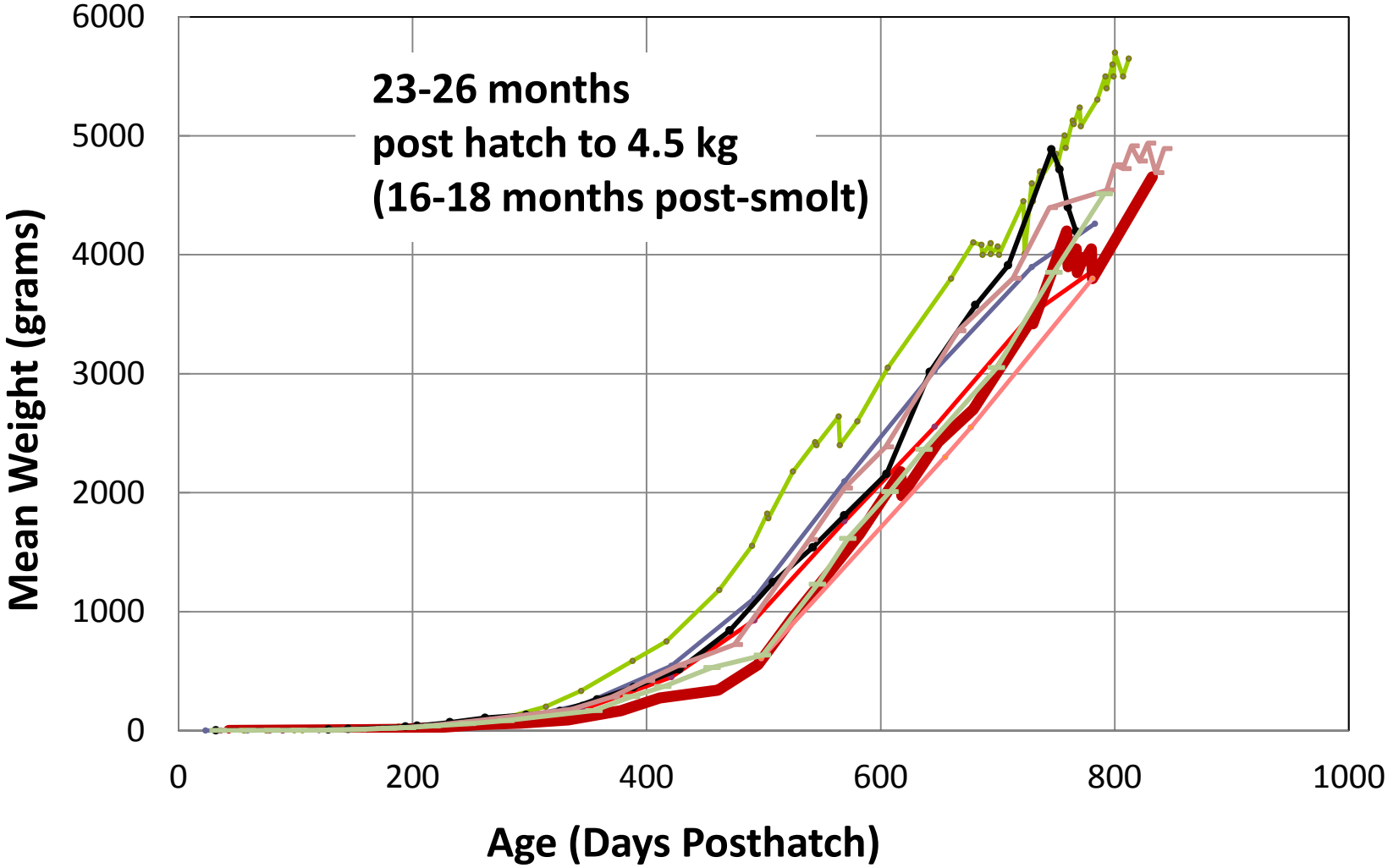
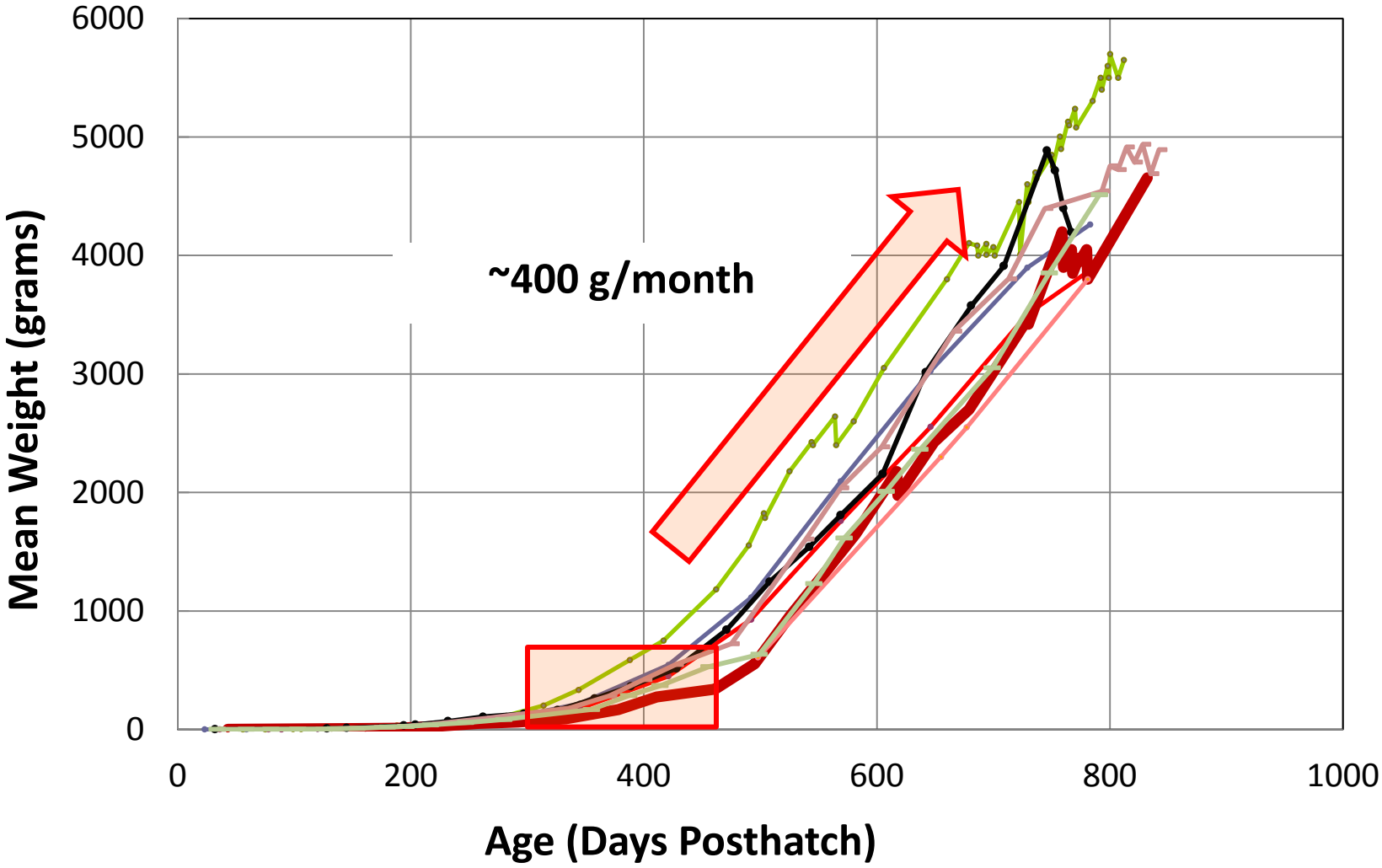
Growth of 8 Cohorts





Similar growth rate after 500-700 g

Fish Health

- **No** major fish health events were noted at TCFFI
  - A little fungus, mostly during incubation & fry culture
- Tested **sixty** fish from each 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*
- **No** vaccination, antibiotics, formalin, or pesticides used at any time in over a decade
- **No** escapees

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- Maximum Growout Density in freshwater

	Trial #3	Trial #4	Trial #5	Trial #6
Strain	**Cascade**	**Cascade**	**SalmoBreed**	**SalmoBreed**
Density	100 kg/m^3	118 kg/m^3	95	94

(Mean CO2 = 14 mg/L; Max CO2 < 20 mg/L at highest density)

Early Maturing Males

	Trial #3 ★	Trial #4	Trial #5	Trial #6
	Cascade	Cascade	SalmoBreed	SalmoBreed
Grilse harvest size, kg	2.6	2.1	2.2	2.5
Prevalence, %	**38.5**	**17.1**	**18.3**	**31.6**
Post-harvest use	**Hot smoked**	**Cold smoked**	**Fresh fillets & smoked**	**Fresh fillets**

★High maturation: Post-smolt initially comingled with previous cohort that were maturing

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Final Salmon Harvests

	Trial #3	Trial #4	Trial #5	Trial #6
Mean harvest size, kg	4.1 to 5.7	4.9 to 3.5	4.5 to 4.7	4.5 to 4.7
Total final harvests	13,382 kg	12,695 kg Prem: 12,047 kg subPrem: 320 kg grilse: 328 kg	12,453 kg Prem: 12,107 kg subPrem: 117 kg grilse: 229 kg	12,374 kg Prem: 10,470kg subPrem: 18kg grilse: 1,886 kg
All harvests	**19,496 kg**	**19,727 kg**	**15,754 kg**	**19,064 kg**
Post-harvest use	**Albion Seafood**	**JJ McDonnell**	**JJ McDonnell**	**JJ McDonnell**

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Feed Conversion (Feed/Gain)

	Trial #3	Trial #4	Trial #5	Trial #6
Strain	**Cascade**	**Cascade**	**SalmoBreed**	**SalmoBreed**
FCR	**1.07**	**1.10**	**1.37**	**1.18**
Feed Type	Ewos Dynamic Red	Ewos Dynamic Red	Skretting Optiline RC	Ewos Conserve FMF

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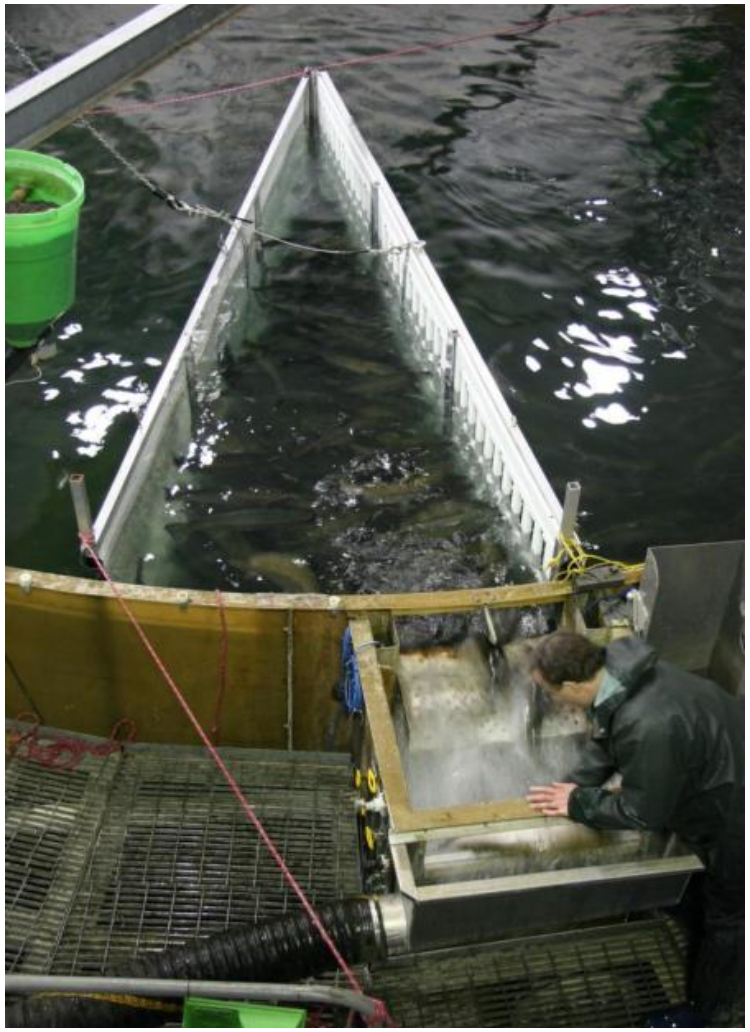
Cumulative Mortality

	Trial #3	Trial #4	Trial #5	Trial #6
Strain	**Cascade**	**Cascade**	**SalmoBreed**	**SalmoBreed**
Mortality	2.7%	2.6%	2.6%	1.43%
Culls (fungus-unthrifty)	3.9%	1.3% in growout 3.6% @ harvest	0.4% in growout 2.4% @ harvest	1.17% growout 0.002% harvest
Jumpers	0.4%	0.7%	0.4%	0.7%
Total	**7.0%**	**8.2%**	**5.8%**	**3.3%**

Conclusions

- Producing salmon in RAS is **biologically** and **technically** viable
  - Rapid growth
  - High survival
  - Good FCR
  - No sealice
  - Good health & welfare
- Requires all-female germplasm
  - **Now Available**



Publications

- Summerfelt, S. May, T., Crouse, C., Davidson, J., Barrows, F., Mann, J., Good, C.(2016). **Fishmeal-free Atlantic salmon feed formulation shows promise - Joint research between TCFFI, USDA and EWOS uses new diet for post-smolt to food-size fish**. *Global Aquaculture Advocate*. April 15. http://advocate.gaalliance.org/fishmeal-free-atlantic-salmon-feed-formulation-shows-promise/
- Davidson, J., May, T., Good, C., Waldrop, T., Kenney, B., Terjesen. B.F., Summerfelt, S.T. (2016). **Production of market-size (4-5 kg) North American strain Atlantic salmon Salmo salar in a commercial scale, land-based recirculation aquaculture system using freshwater**. *Aquacultural Engineering*. 74, 1-16. http://dx.doi.org/doi:10.1016/j.aquaeng.2016.04.007
- Davidson, J., Barrows, F.T., Kenney, P.B., Good, C., Schroyer, K., Summerfelt, S.T. (2016). **Effects of feeding a fishmeal-free versus a fishmeal-based diet on post-smolt Atlantic salmon Salmo salar performance, water quality, and waste production in recirculation aquaculture systems**. *Aquacultural Engineering* 74, 38-51. http://dx.doi.org/10.1016/j.aquaeng.2016.05.004

Acknowledgements

- All experimental protocols were in compliance with Animal Welfare Act (9CFR) and were approved by the Freshwater Institute Animal Care and Use Committee.

- Special thanks to Karen Schroyer, Susan Glenn, Brianna Taylor, Christina Russell, Katelyn Walters, and Natalie Monacelli for water quality analysis, to Clayton Raines, Heather Dailey, Michael “Wells” Larson, Ryan Snader, and Jeremy Ruffner for technical support, and to Kata Sharrer for images and photography.