A photograph of several Atlantic salmon swimming in a circular tank, viewed through a glass barrier. The fish are silvery with a hint of orange on their sides. The background is a solid olive green.

# Progress Update on Two Atlantic Salmon Growout Trials in Freshwater Closed- Containment Systems at the Freshwater Institute

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# Acknowledgments

- Support for **The Conservation Fund Freshwater Institute:**
  - **Atlantic Salmon Federation**
    - CURRENT TRIAL
    - Salmon now 19 months from 1<sup>st</sup> feeding
  - **Moore Foundation**
    - NEXT GROWOUT TRIAL
    - Salmon now 7 months from 1<sup>st</sup> feeding
  - **U.S. Department of Agriculture, Agricultural Research Service**
    - Finished first salmon studies winter 2011
    - Chris Good reported these findings



# Containment is Necessary for Sustainable Aquaculture

- Land-based, closed-containment systems:
  - Exclude chemicals & obligate pathogens
    - No pesticides, antibiotics, & chemotherapeutics in closed-containments systems w/ over 10 yrs operation at TCFFI
  - Prevent escapees & disease interaction between wild & farmed fish
  - Minimize water use & release of pollution
  - Optimize water temperature & photoperiod
  - Locate farm where electric & land are cheap
    - US\$ 0.02-0.03 / KWH



# Current Growout Trial

- Atlantic Salmon, Saint John River strain
  - Purchased from Cooke Aquaculture
- Jan 2010 - Eyed eggs arrive
- March 2010 - First Feeding
- May 1, 2011 Stocked into RAS at 340 gr



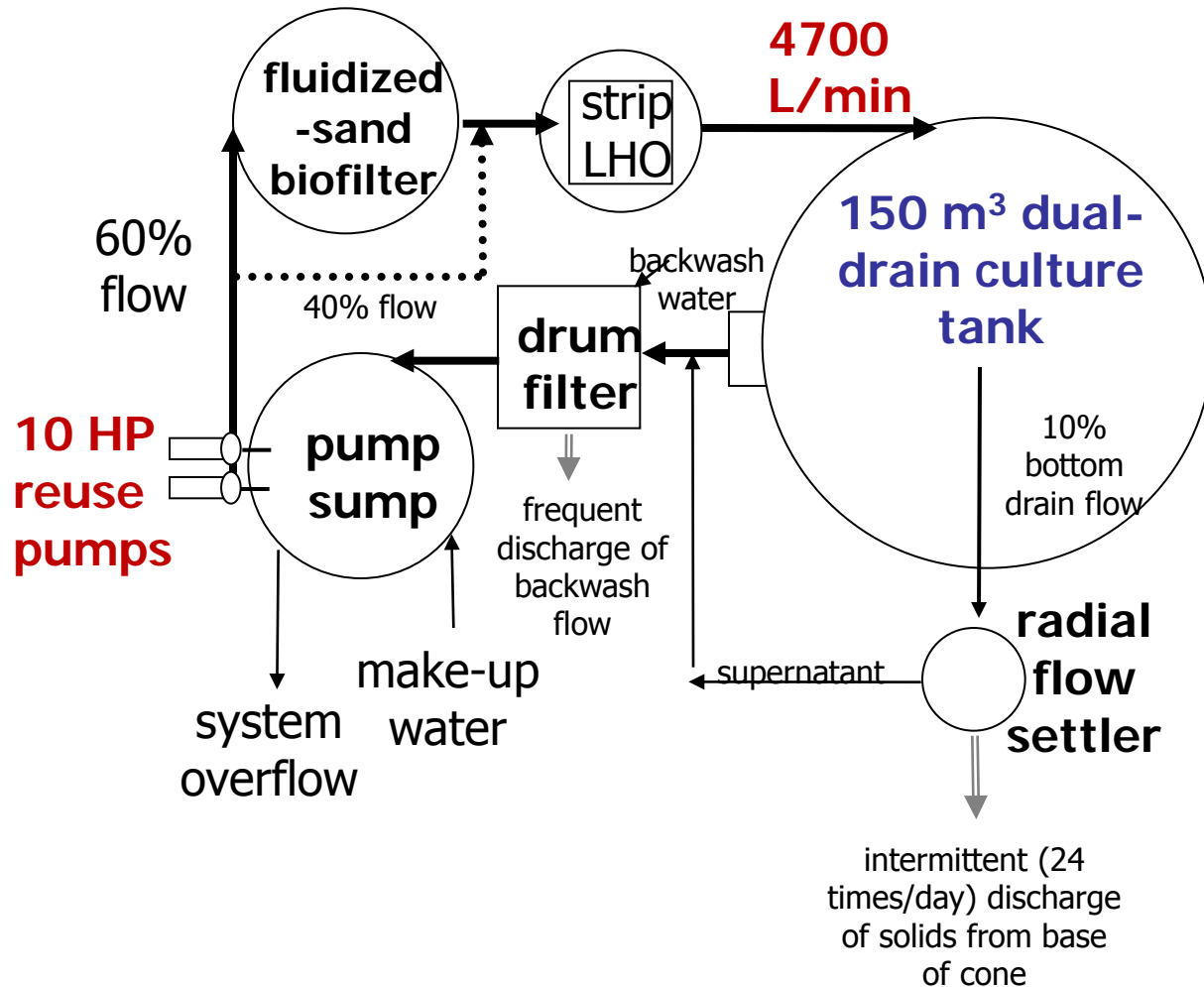
# Closed-Containment System



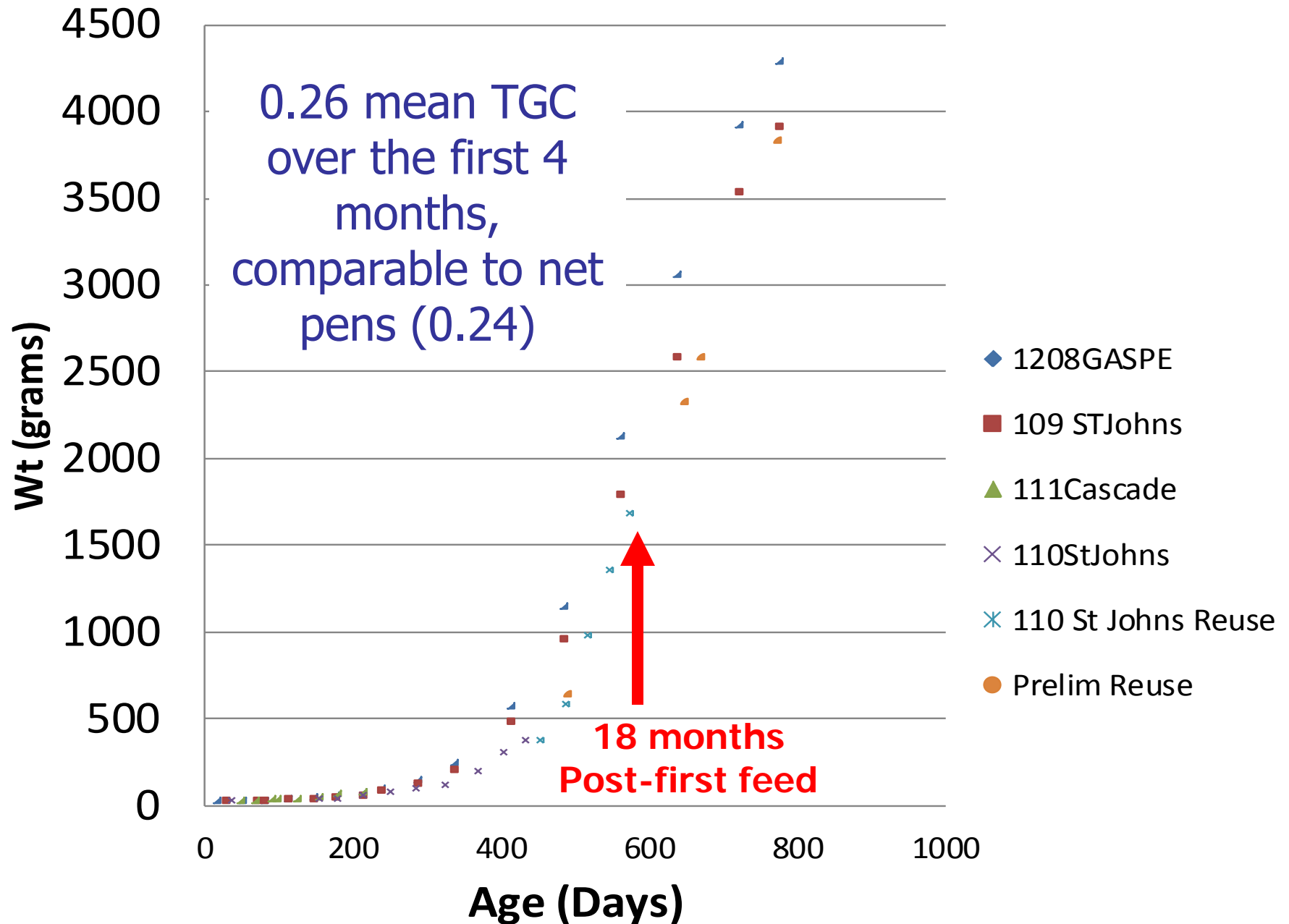
- 150 m<sup>3</sup> Culture Tank Volume
  - 4900 L/min recirc flow
  - 30 min HRT
- 260 m<sup>3</sup> System Volume
  - 140 L/min Mean make up water flowrate
  - 1.3 day HRT
  - 97.2% flow reuse

High flushing rate to keep water  $\leq 16.5^{\circ}\text{C}$  in summer

# Process Flow Drawing of Closed-Containment System



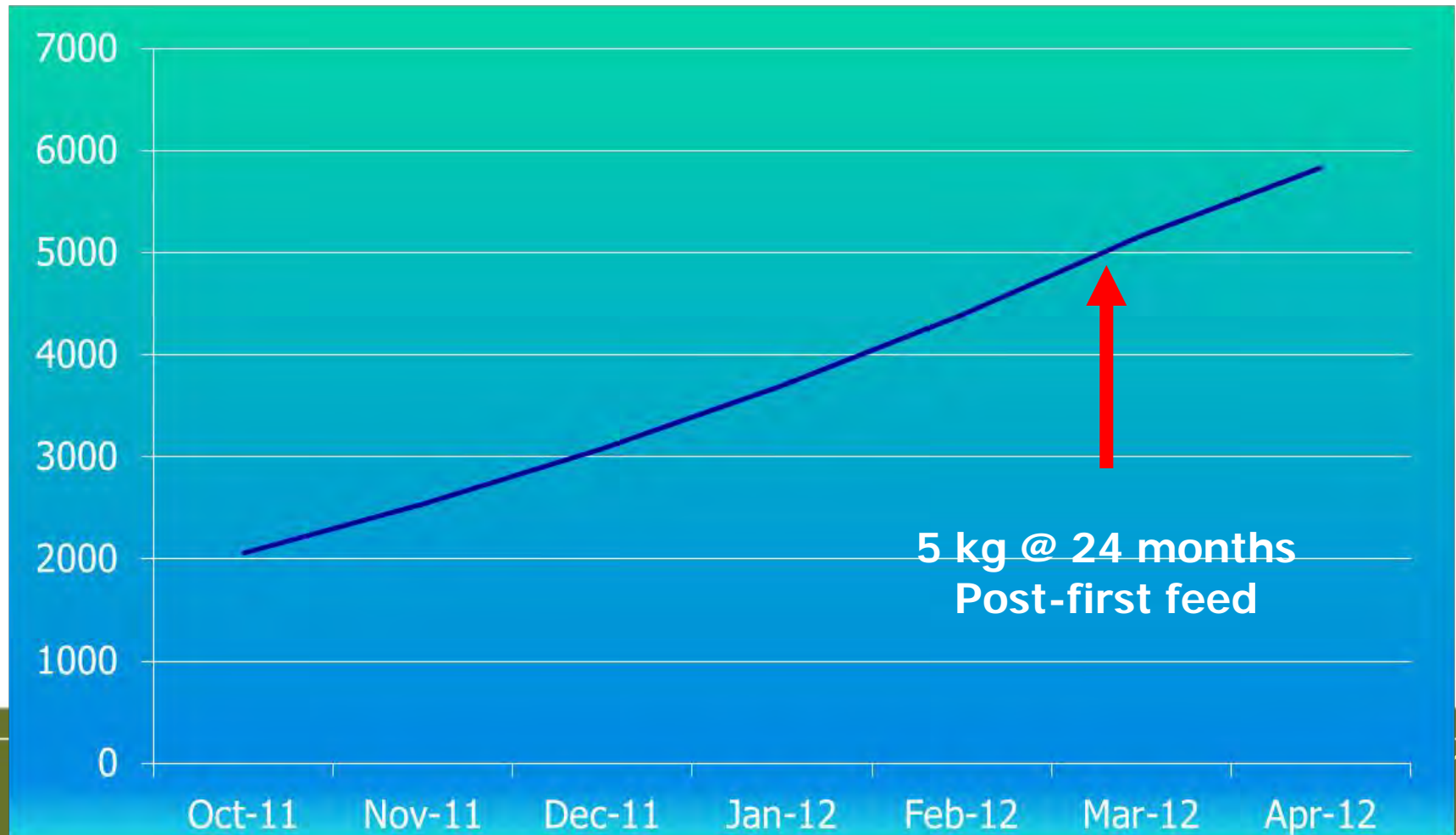
# Atlantic Salmon Growth Comparison





# Predicted Growth

Assumes TGC will average 0.19 over next 7 months, as fish approach 24-month post-hatch.



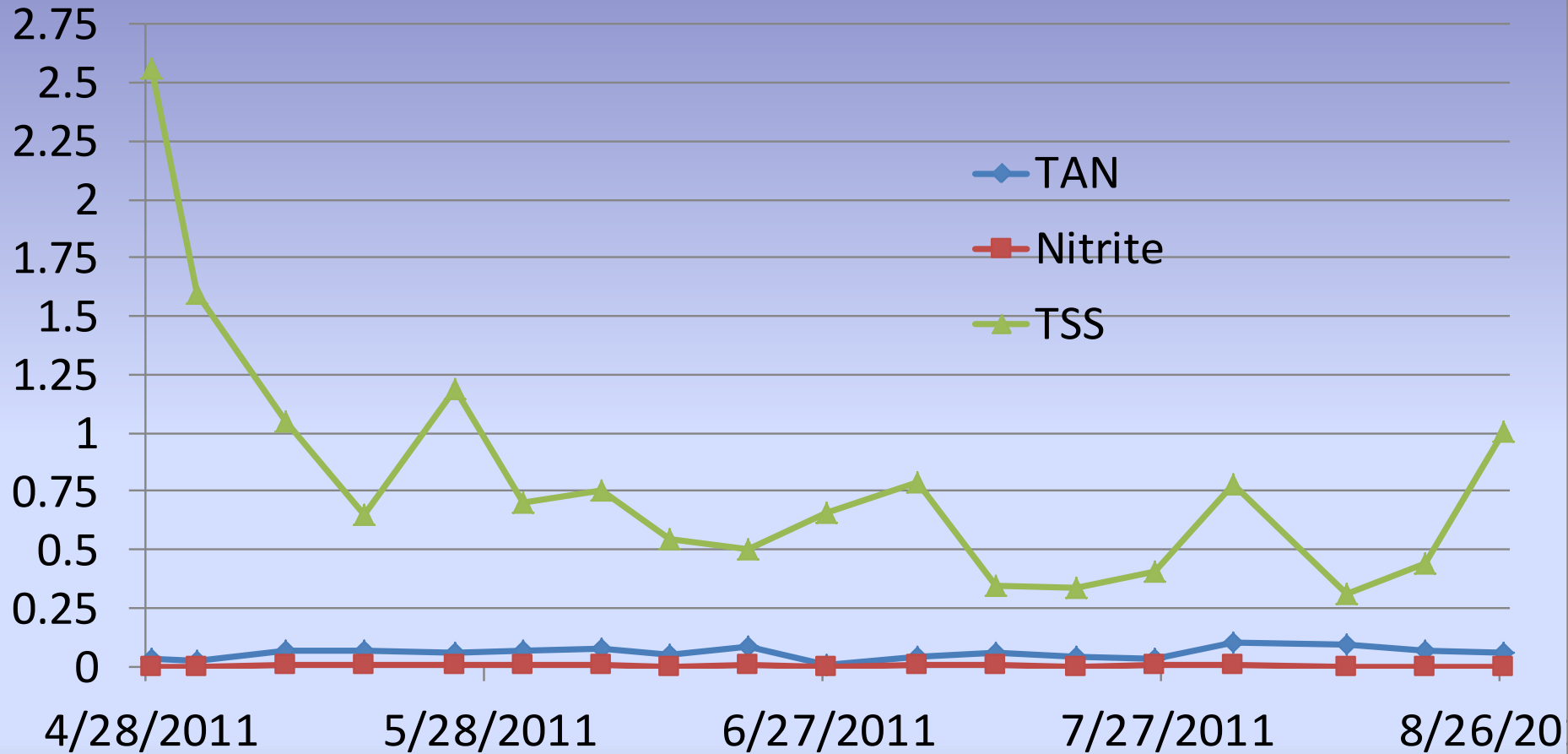




- Ewos 40:30 protein:fat.
- Feed 24/7, 6 times per day for 1.5 kg salmon.
- 1.0 mean FCR from 340 g to 1650 g

# Excellent Water Quality

**TAN, NO2-N, and TSS, mg/L**



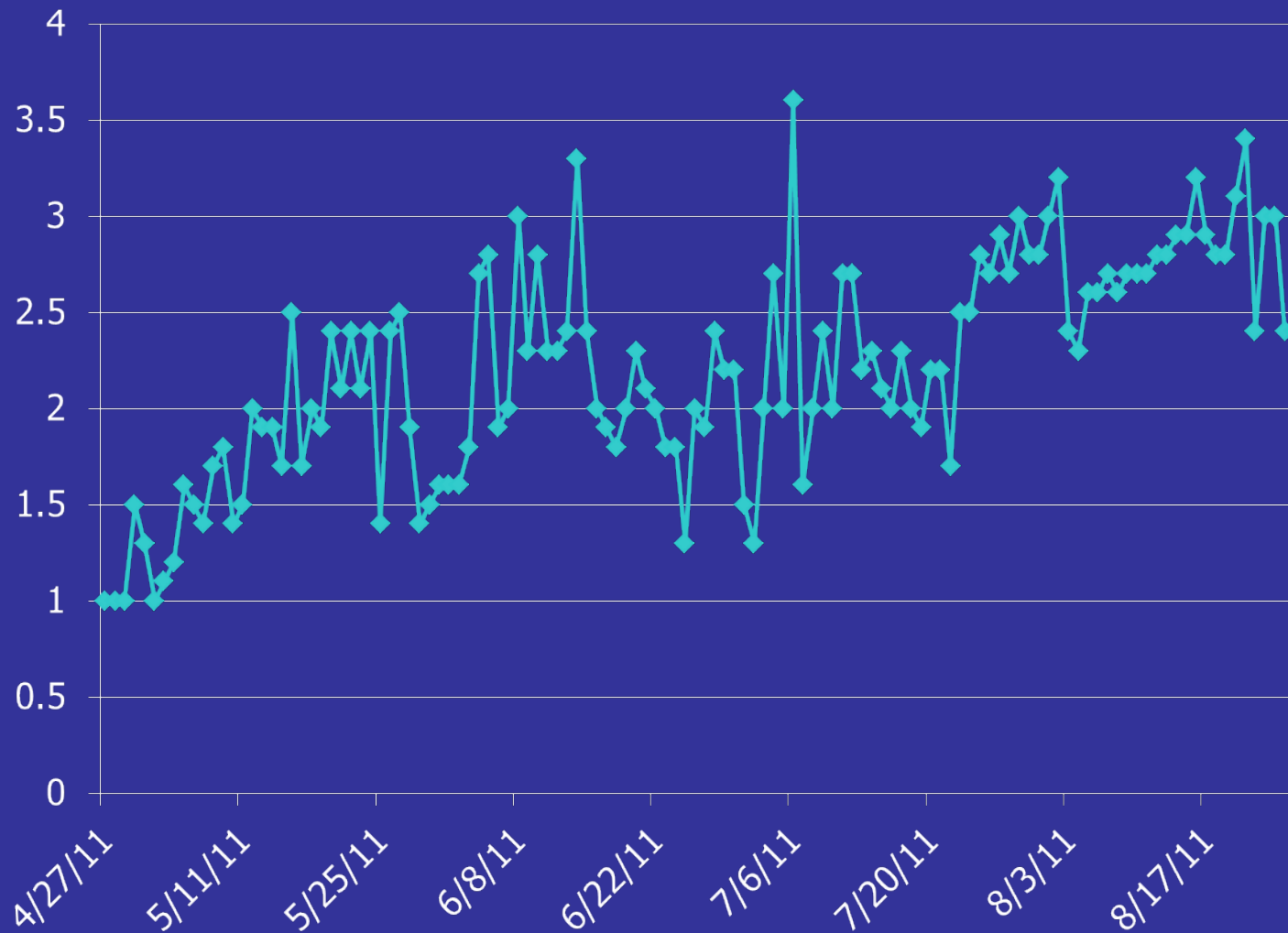
# Excellent Water Quality

Water Quality Parameter	Mean Value, mg/l
Carbon Dioxide	9
Temperature (Celsius)	15.5
Total Suspended Solids	0.8
Total Ammonia Nitrogen	0.06
Nitrite Nitrogen	0.003
Alkalinity	252
Dissolved Oxygen, Influent	12.9
Dissolved Oxygen, Effluent	10.7



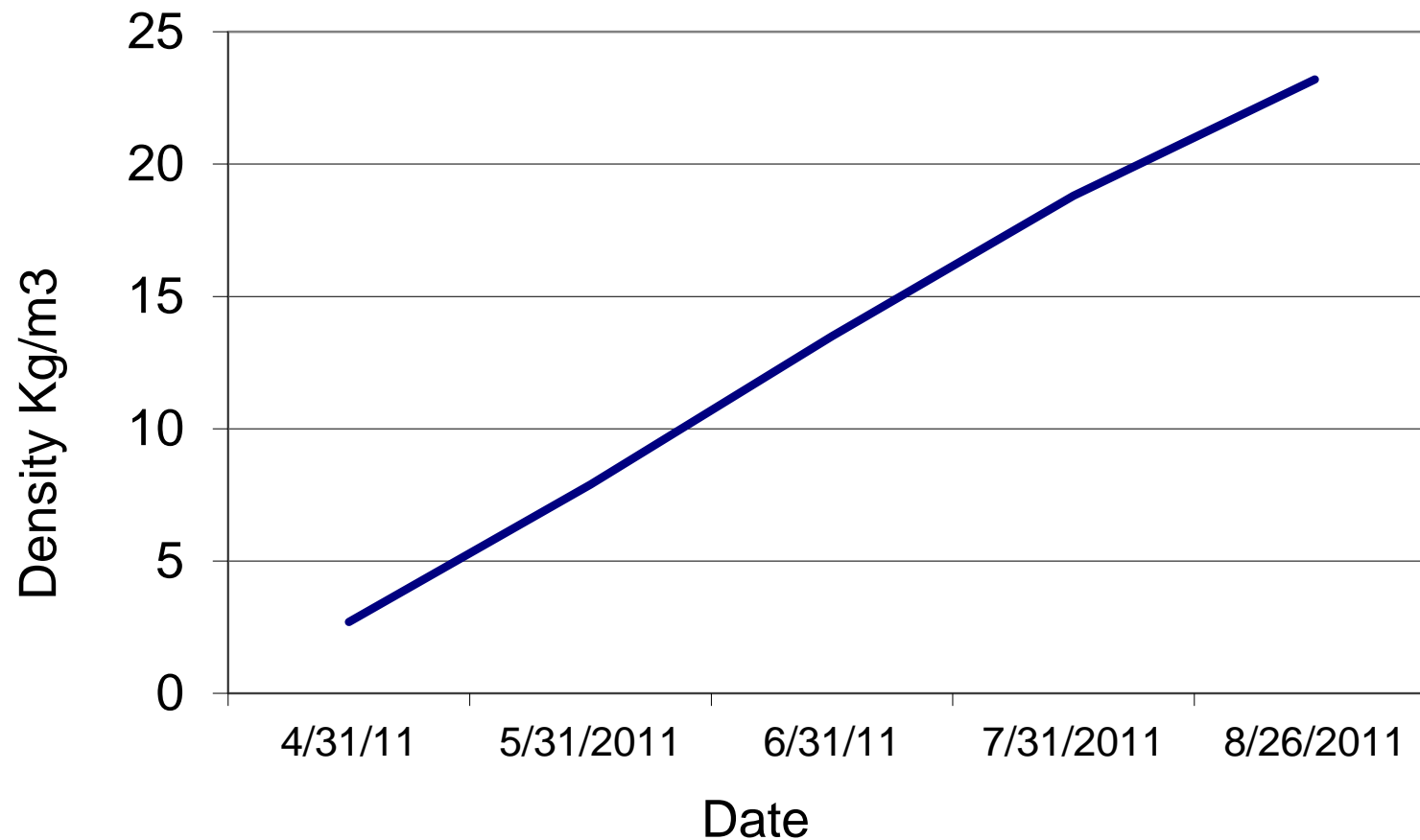
# Modest Feed Loading & Oxygen Demand

**Delta Dissolved Oxygen**





# Biomass Density



# Fish Health Status

- **94.9% overall survival since stocking**
  - One fungal outbreak after fish transfer
  - Many jumpers, a few culls.
- **No sea lice observed**
- **No kudoa expected**
- **No obligate pathogens detected**

# Chemotherapeutics Used in Salmon Growout Trial

- No vaccination (saves \$\$ & stress)
- No antibiotics or pesticides used at any time
- No formalin used at any time
- Small amount of hydrogen peroxide used in the sac fry and early parr stage for fungus.
- Total salt used to treat fungus: 6100 lbs. during three treatments

# Escapees

- **No fish have been observed in the effluent fish exclusion area.**





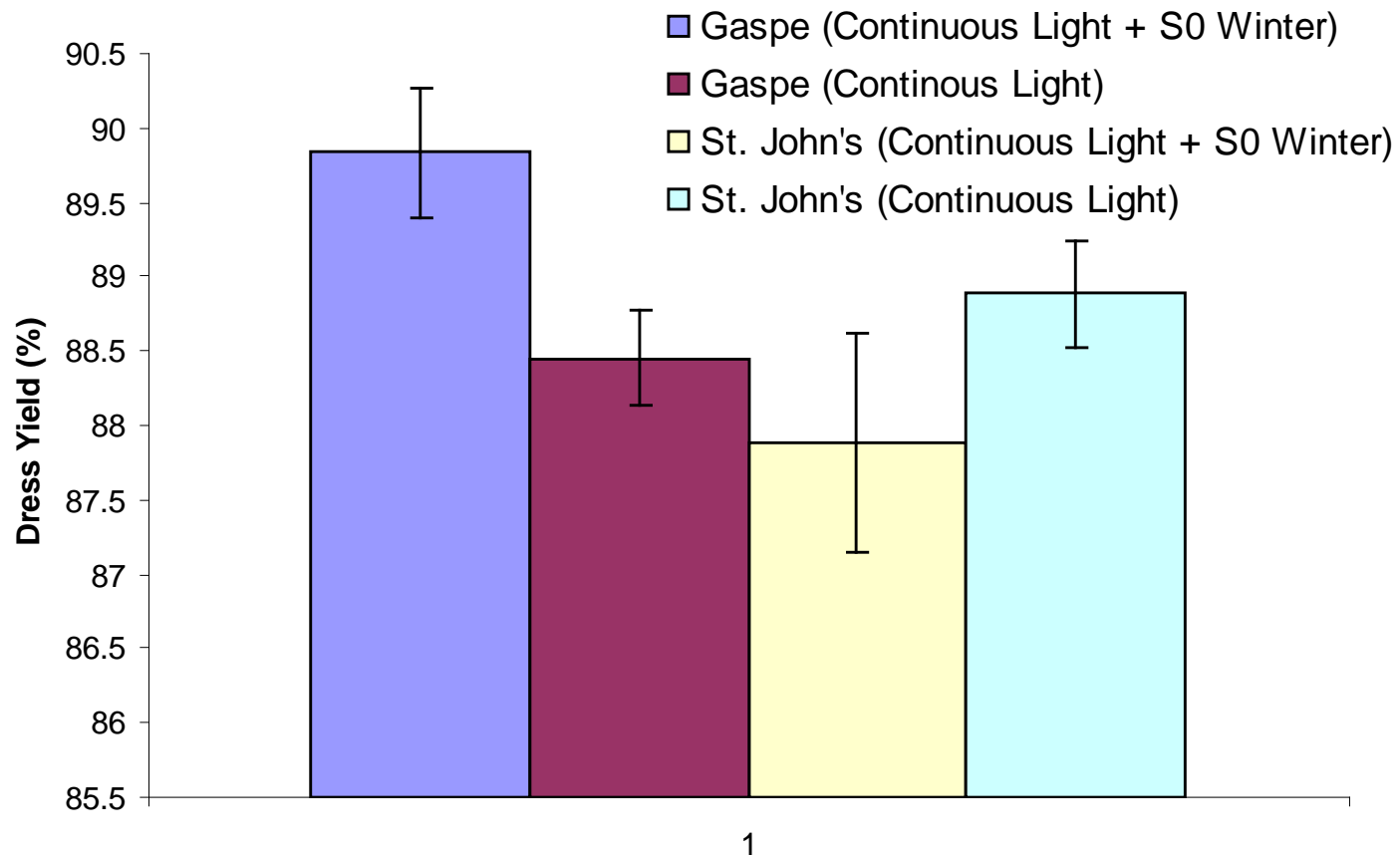
# Product Quality

- Good fillet color, lipid content, and flavor
- **MUST DEPURATE SALMON 10 DAYS OUT OF RAS**
  - System with little biofilm



# Head on, gutted yield (%) (mature males removed)

**Condition Factor averaged 1.7**  
**Net pen fish condition factor ~1.3**



# Previous Atlantic Salmon Study

- Gaspe strain had higher fillet color & lipid content:

	<b>Gaspe Strain S0 Winter</b>	<b>Gaspe Strain Constant Light</b>	<b>St John River Strain S0 Winter</b>	<b>St John River Strain Constant Light</b>
<b>Color</b>	<b>24.2±0.9</b>	<b>25.3±0.7</b>	<b>21.1±2.1</b>	<b>21.3±1.7</b>
<b>Lipid (%)</b>	<b>17.2±0.8</b>	<b>17.8±0.9</b>	<b>11.7±0.8</b>	<b>14.4±0.8</b>

# Precocious Male Atlantic Salmon During Our Last Study

- St John River strain males: 71% mature with constant light; 54% mature with S0 winter
- No sexually mature females sampled, neither
  - Gaspe strain, all females, and St John River strain

Suggests use of an all female salmon or late maturing strain for freshwater growout





**Will Harvest Males at 1.5-2 kg  
(late Sept. 2011)**



# NEXT GROWOUT TRIAL

- Atlantic salmon - Cascade Strain
  - eggs purchased from American Gold Seafood
- Jan 2011 – Eyed eggs received
- March 2011 - First feeding
- Late September 2011 - Salmon currently 60 grams and have just concluded smoltification in 12 fry tanks.

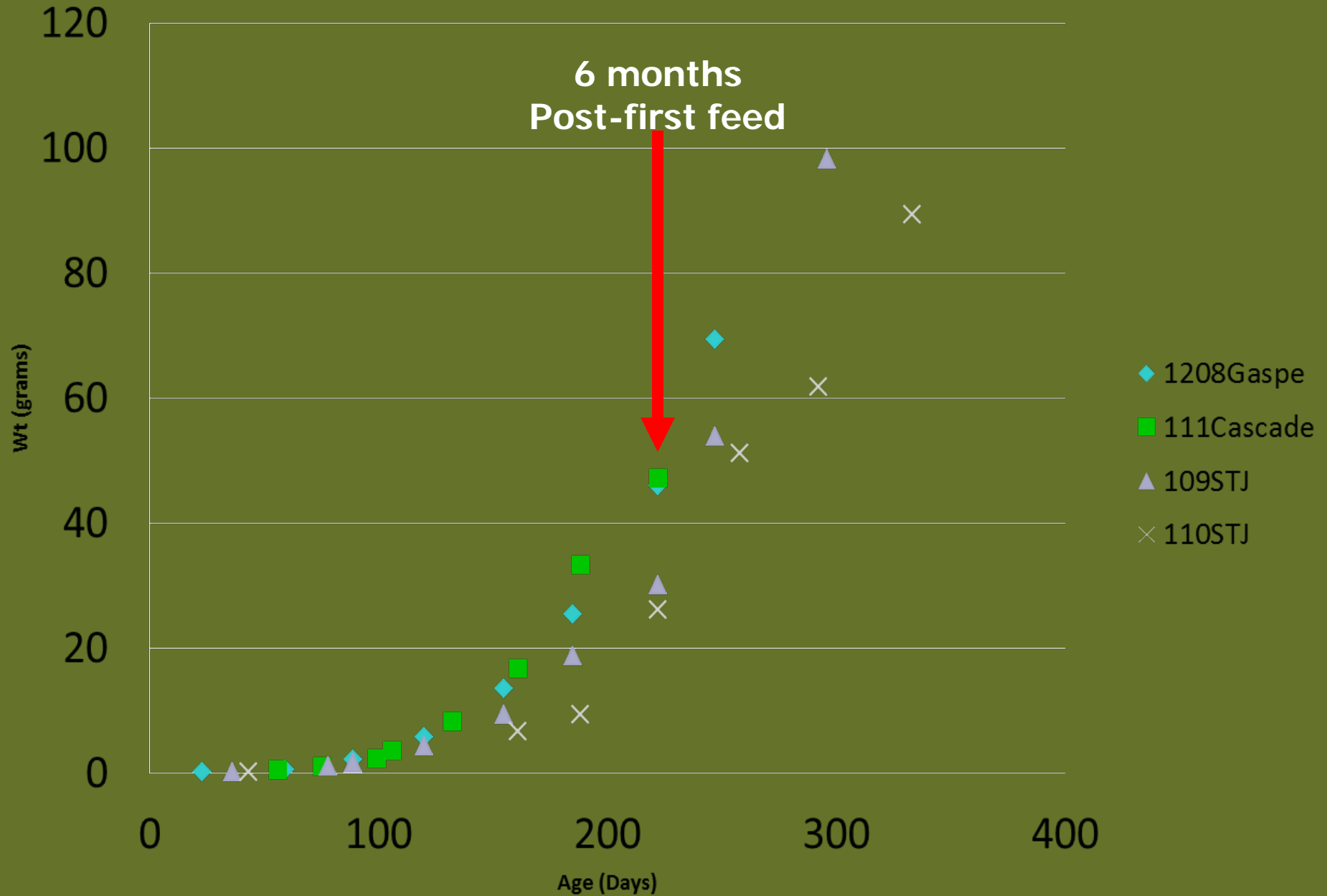


# Performance Metrics to 50 g, Through SO Winter

- Overall FCR 0.995 (.125 gr to 48 grams)
- Overall TGC 1.02
- Average Temperature 13.5°C
- Survival through August 2011, approximately 70-80%.
- Excellent water quality



# Early Salmon Growth Comparison





# Conclusions

- Good growth in freshwater
- Atlantic salmon appear to handle 80 kg/m<sup>3</sup> density better than rainbow trout
- Minor fungus in 'hard' freshwater
- Use of all female eggs avoids precocious males

You don't need the ocean to farm Atlantic salmon!



# Conclusions

- Closed-Containment Systems
  - Confidence in technology is increasing
  - Scale of investment has increased to \$5-25 million/project
  - Current N. American projects being built or planned with projected capital investment of \$50-100 million
    - Atlantic salmon, Coho salmon
    - sea bream, yellow perch, sturgeon, cobia
    - Arctic char, walleye, sablefish

# Conclusions

- Closed-Containment Systems

- N. America, I expect production to increase by 10,000 to 50,000 ton during next 5-yrs, including several species
- Worldwide, a number of 1000-10,000 ton/yr farms for Atlantic & Coho salmon are being built or planned,
  - China (3), Denmark (1), USA (3), Chile (1), Canada (1)
  - Many smaller projects

# Questions and Challenges Related to Upscaling

- Flushing & mixing in 2000-5000 m<sup>3</sup> tanks
- Develop & prove efficacy of depuration SOP's
- Minimizing system energy consumption without sacrificing water quality
- Denitrification without supplementing carbon
  - NO<sub>3</sub> control in low flushing systems
- Pathogen free 'All female' Atlantic salmon eggs commercially available at least twice annually