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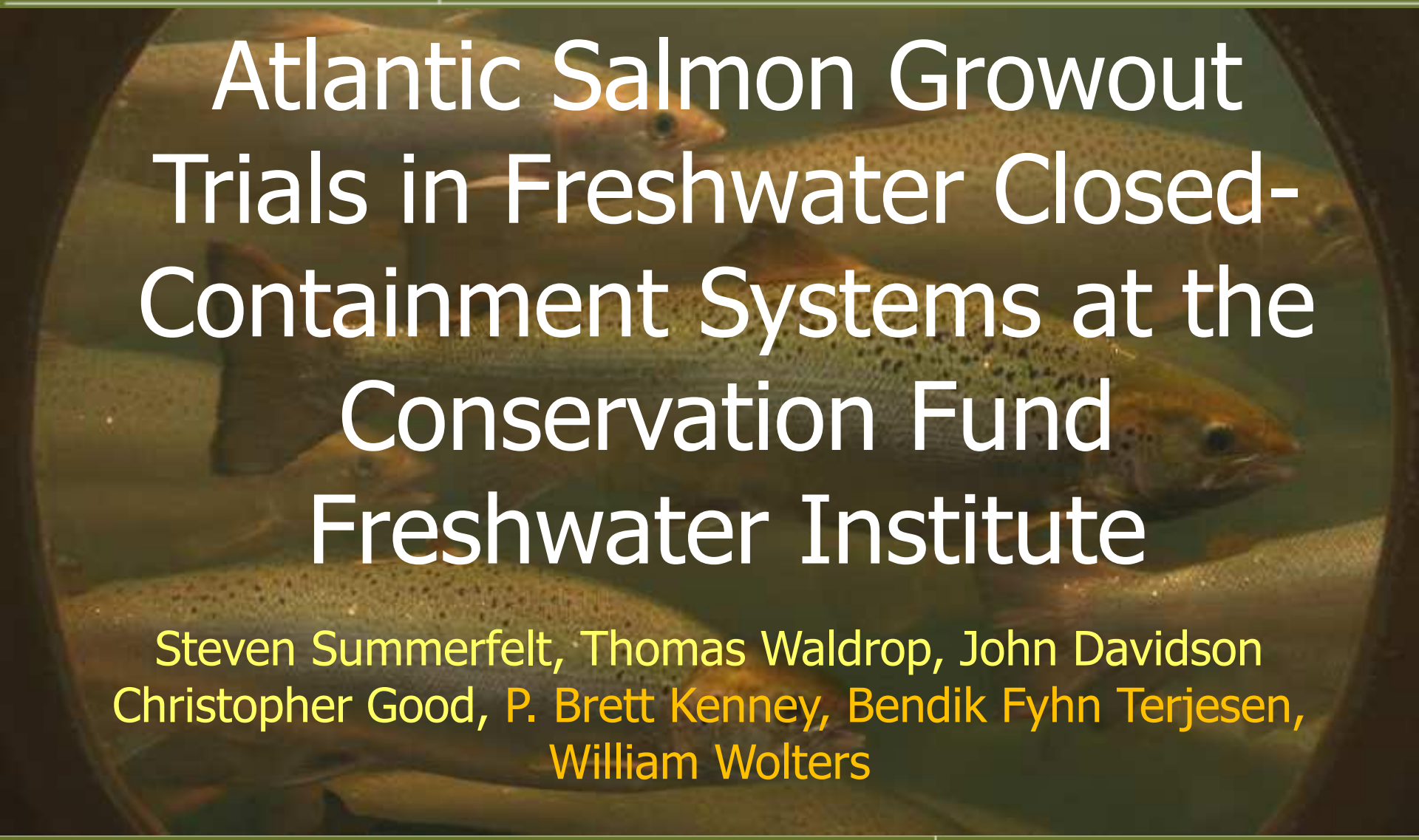

Atlantic Salmon Growout Trials in Freshwater Closed-Containment Systems at the Conservation Fund Freshwater Institute

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Comox, BC, Nov 5-6, 2012

Acknowledgments

- Support for **The Conservation Fund Freshwater Institute**:
  - **U.S. Department of Agriculture, Agricultural Research Service**
    - 1st salmon studies finished in 2011
    - Gaspe and St John River strain
  - **Atlantic Salmon Federation**
    - 2rd Growout Trial finished in 2012
    - St John River strain salmon were harvested at 24-26 months post-hatch
  - **Moore Foundation**
    - 3th Growout Trial
    - Cascade strain salmon now 20 months post-hatch

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$ 0.02-0.06 / KWH

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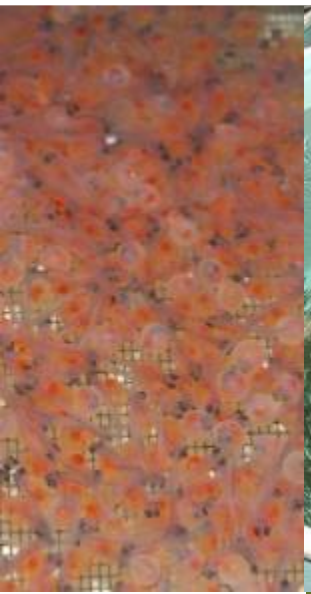
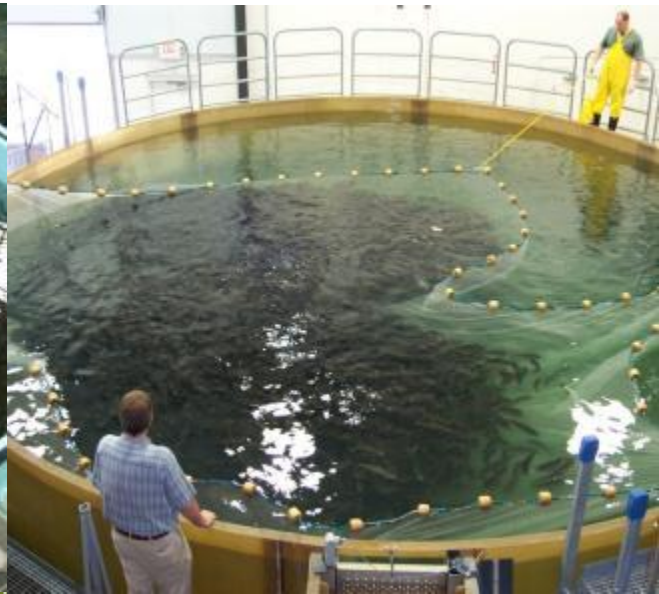
Atlantic Salmon Federation Funded Growout Trial

- Atlantic Salmon, Saint John River strain (Cooke)
- Jan 2010 - Eyed eggs arrive
- March 2010 - First Feeding
- May 1, 2011 Stocked into growout at 340 g
- Feb 27, 2012 – First harvest at 4 kg/fish



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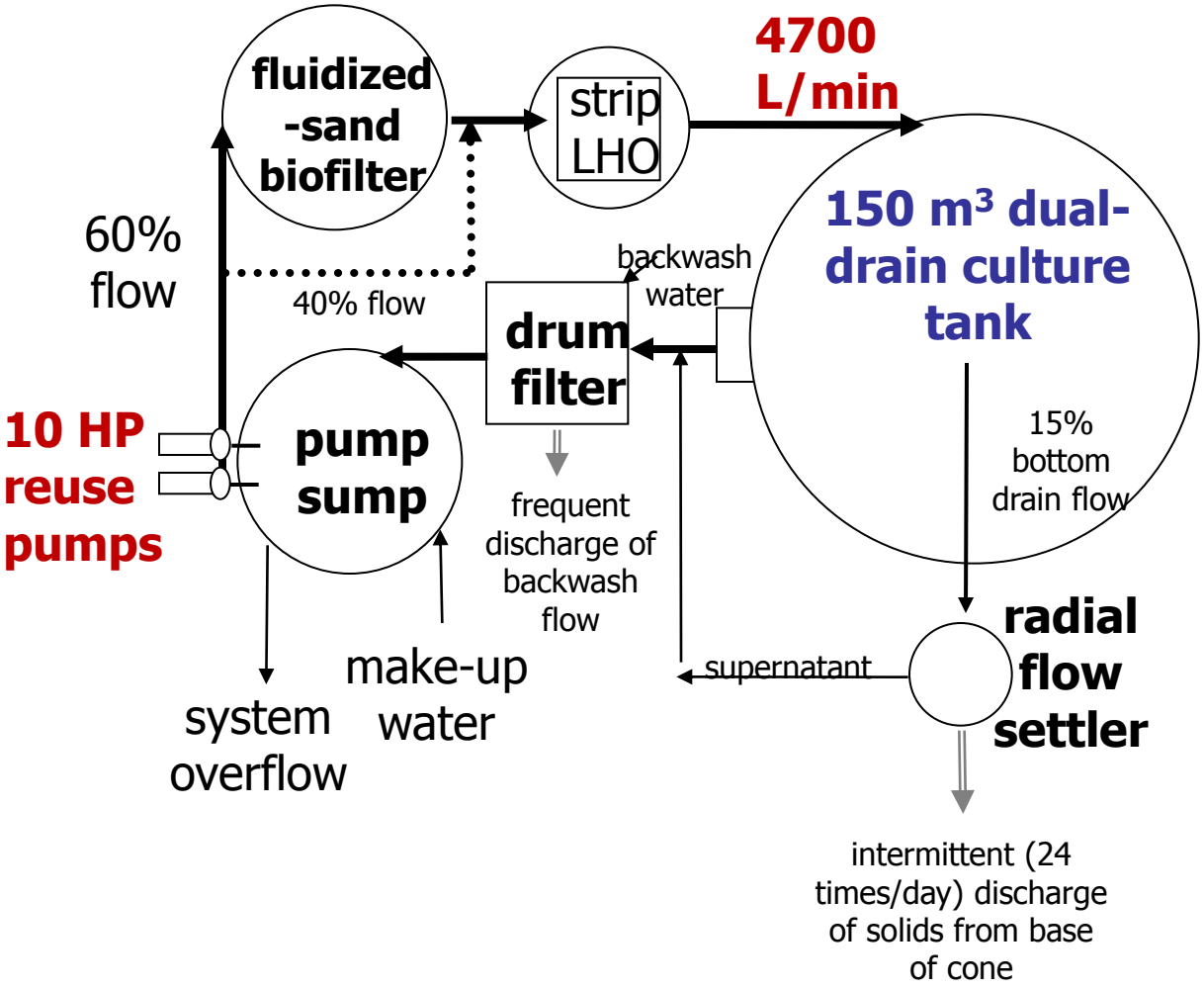
Precocious males (~10%) before start of production trial

Process Flow Drawing of Closed-Containment System

CO2 stripping unit stacked over a LHO & sump tank



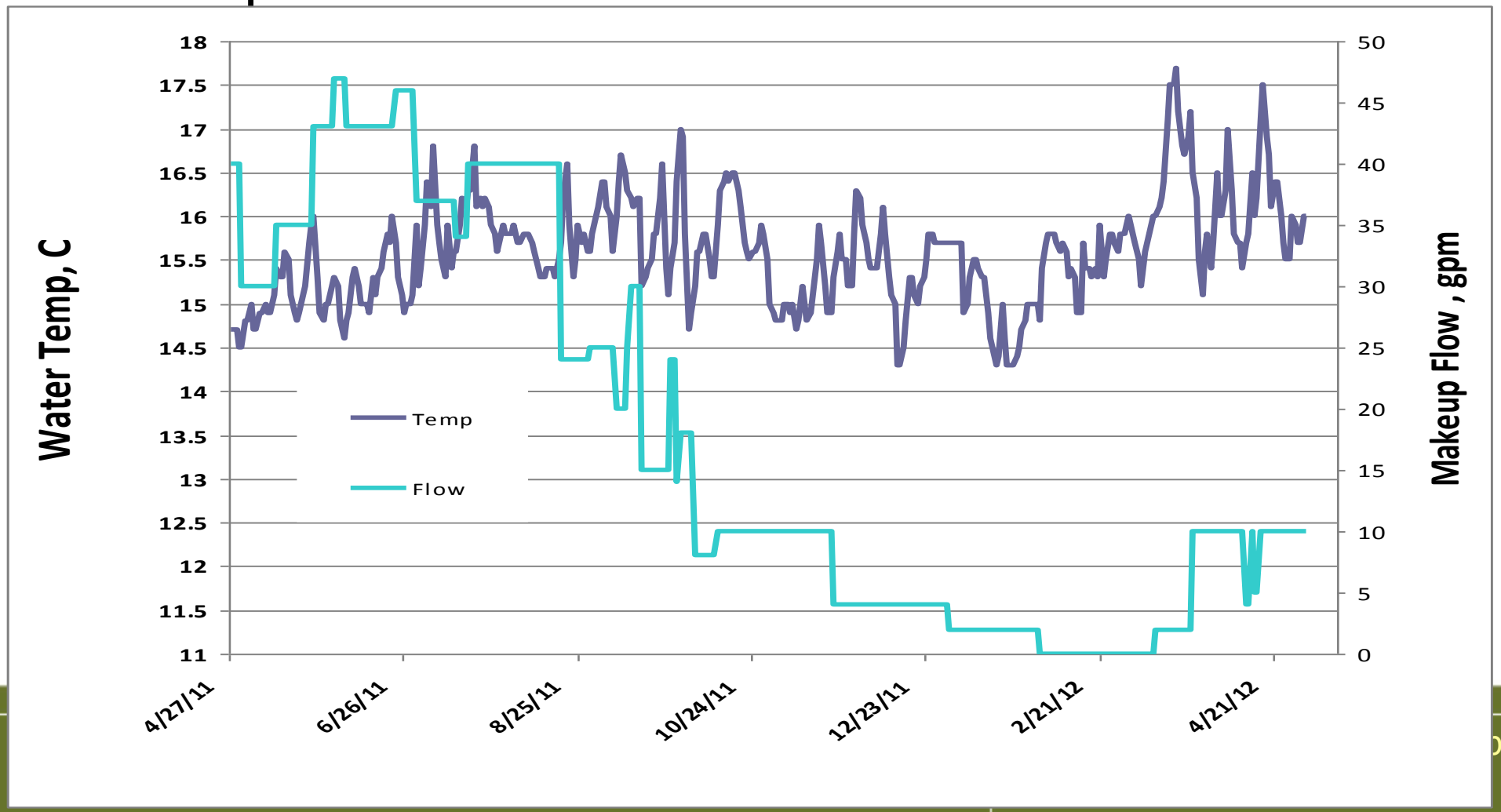
Closed-Containment System

- 150 m^3 Culture Tank Volume
  - 4900 L/min recirc flow
  - 30 min HRT
- 260 m^3 System Volume
  - 12 to 140 L/min make up water flowrate
  - 15 to 1.3 day HRT
  - 99.8 to 97.2% flow reuse

High flushing rate to keep water ≤ 16.5˚C in summer

Water Temperature Control

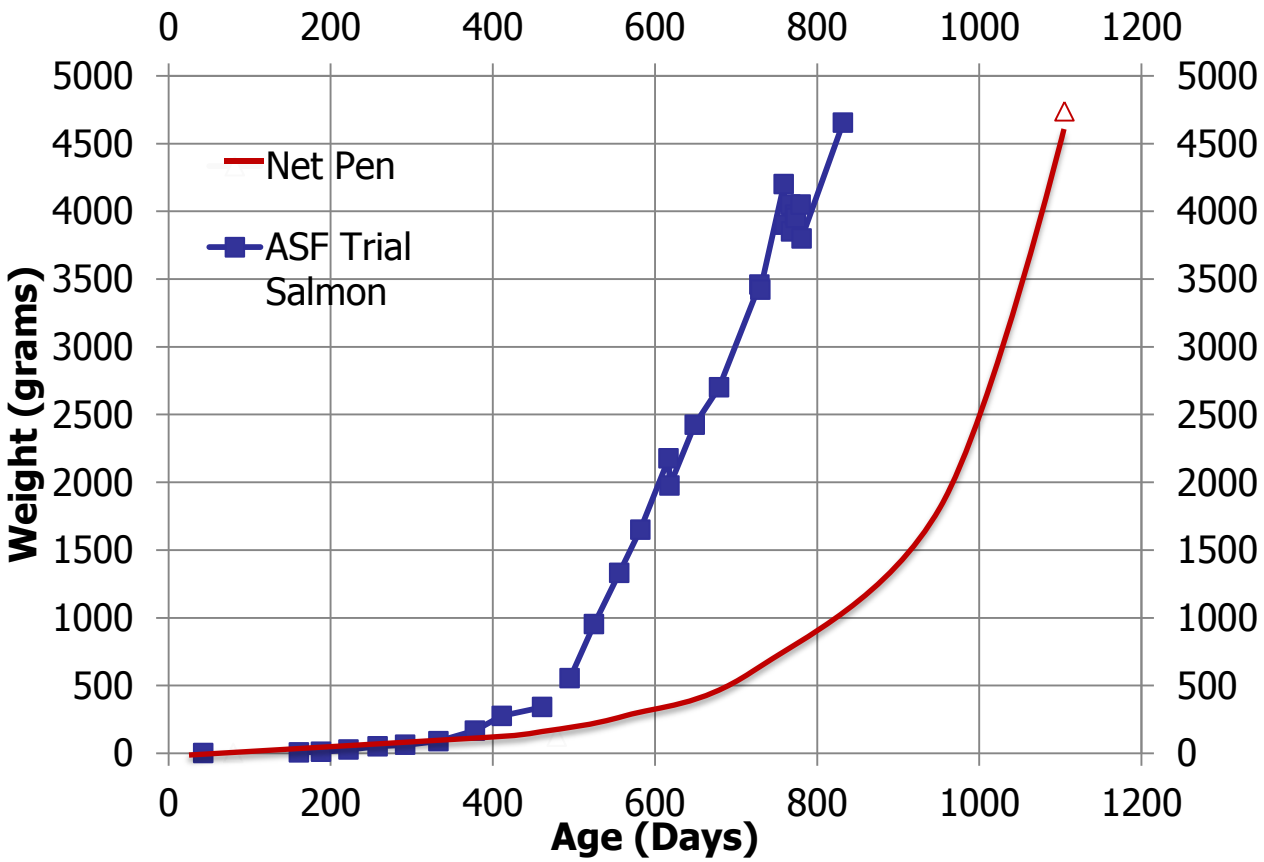
- Makeup water flow adjusted to maintain water temperature at 14.5-16.5°C



Grow-Out Trial Results: Water Quality

- Mean Water Quality in Culture Tank
  - Temperature 15.5°C
  - Dissolved Oxygen 10.8 mg/L
  - Dissolved Carbon Dioxide 9.2 mg/L
  - Total Ammonia Nitrogen 0.11 mg/L
  - Nitrite Nitrogen 0.01 mg/L
  - Nitrate Nitrogen 20 mg/L
  - Total Suspended Solids 1.3 mg/L
  - Total Phosphorus 0.87 mg/L

Atlantic Salmon Growth



Net pens growth data in Maine (Wolters, 2010)

Harvested Males

- 2 kg, Sept 30, 2011
- 3.5 kg, Jan 20, 2012

Primary Harvests

- Harvested Premium Salmon from Feb 20 to May 2, 2012
  - 4 kg mean size
  - ~7 tonne produced = 15,000 pound

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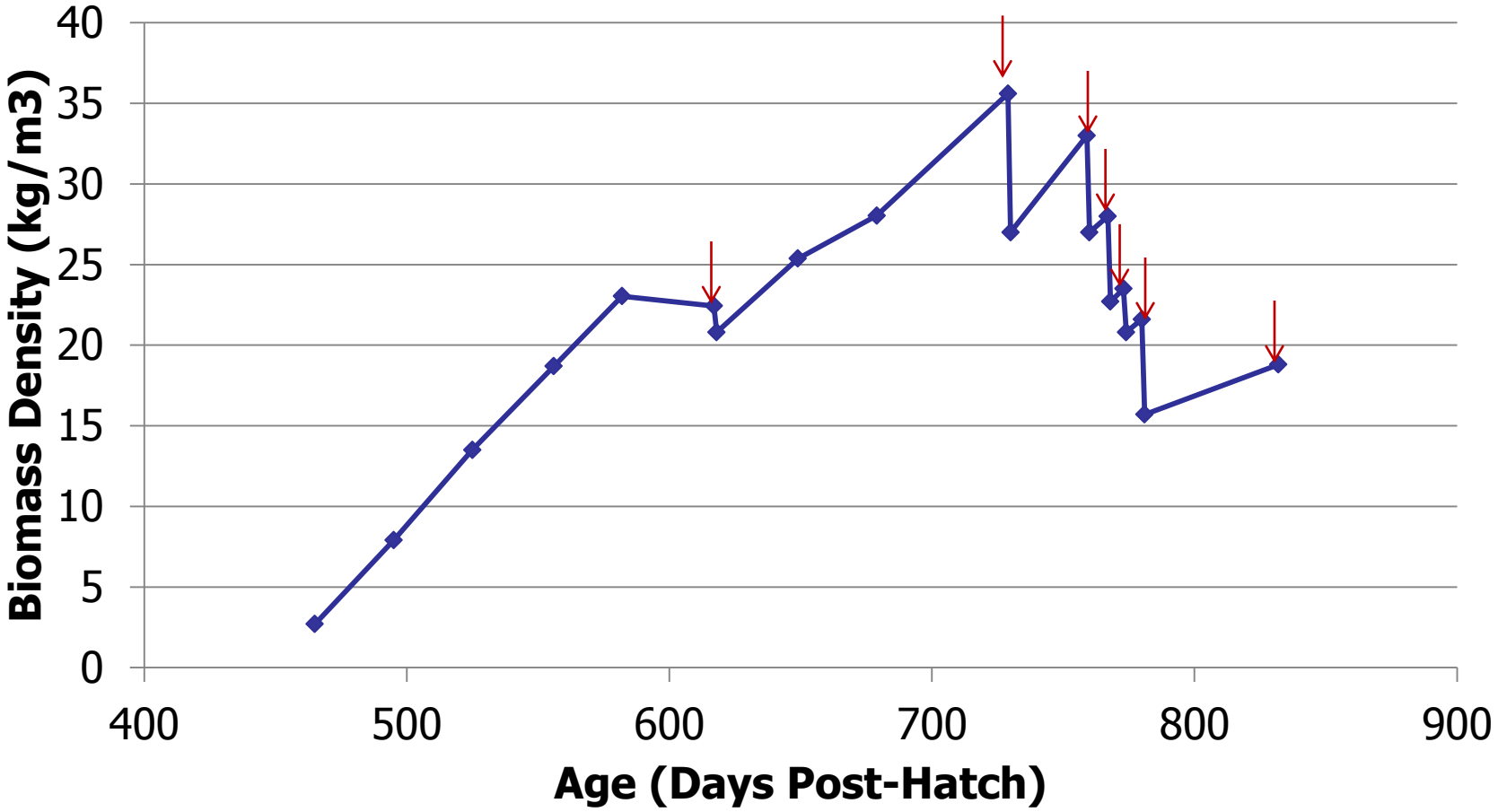
Mortality, Jumpers, and Culls

- Mortality 3.9%
- Culls 5.6%
- Jumpers 1.9%
- Total 11.4%

Salmon Biomass Density



vertical arrows indicate harvest events

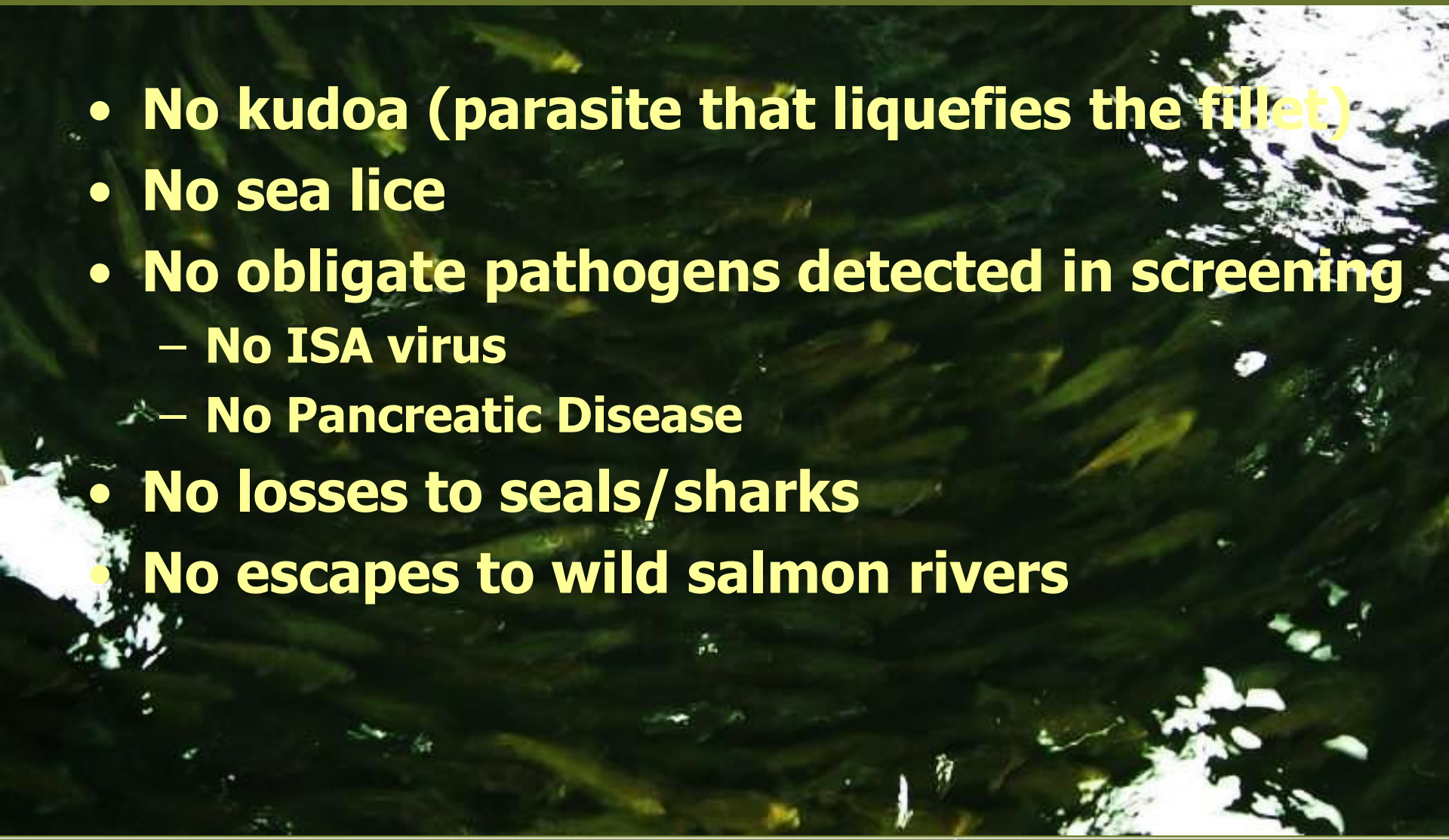
ASF Grow-Out Trial Results
St John River Strain

- **Feed Conversion of 1.09 feed : 1.0 gain**
- Commercial diet with 40:30 protein: fat
- 1.7 condition factor (net pen industry is ~1.3) @ final harvest

Escapees

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

Grow-Out Trial Results
St John River Strain



- **No kudoa (parasite that liquefies the fillet)**
- **No sea lice**
- **No obligate pathogens detected in screening**
  - **No ISA virus**
  - **No Pancreatic Disease**
- **No losses to seals/sharks**
- **No escapes to wild salmon rivers**

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: 14,400 lbs.

Product Quality Results

- MUST DEPURATE salmon for 10 days after removing harvested fish from recycle system
  - Depurate in partial reuse system with little biofilm
  - Purges off-flavors, i.e., geosmin and MIB, produced by bacteria (***actinomycetes***)

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Post-Harvest Slaughter

Rapid & Humane

- Percussive Stunning
  - MODEL SI-7 (Seafood Innovations)

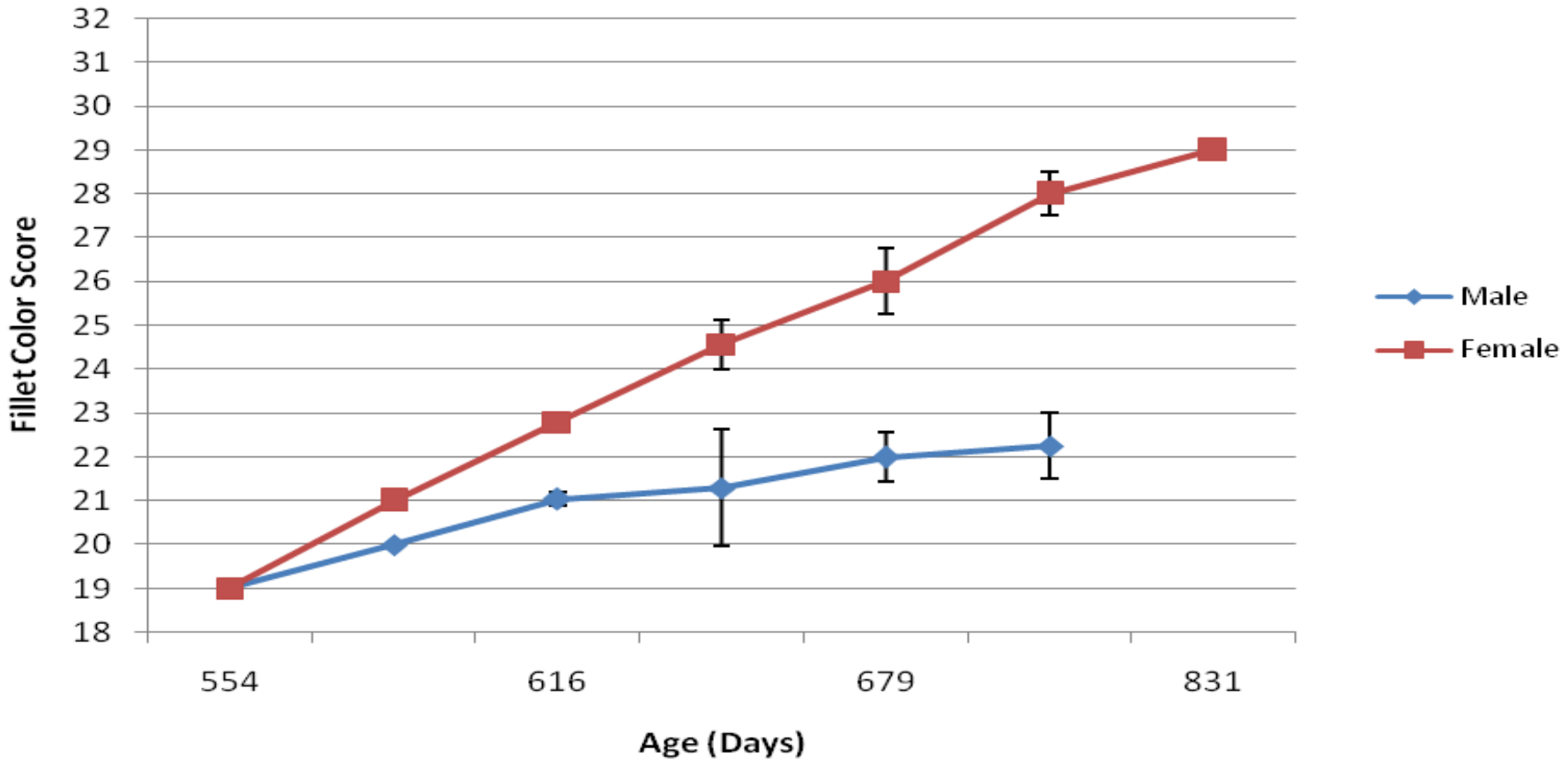
Growout Trial Results: Product Quality

- High condition factor (1.7)
- Good fillet yield (58% skin-off & trimmed)

Growout Trial Results: Product Quality

- Good fillet color (28-30) & lipid content (16%)

Fillet Color Scores based on Salmo fan



Flavor

- Two blind taste test panels of seafood professionals in Seattle indicated preference for Freshwater Institute salmon cultured in RAS and depurated 10 days vs. commercially available ocean-raised A. salmon
  - Cooked flavor
  - Cooked smell
  - Cooked texture

Growout Trial Results: Early Maturing Male

- 80% of male salmon matured early
- 40% of all fish removed as early maturing males
  - approximately half at 2 kg and half at 3.5 kg
- Few sexually mature females

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

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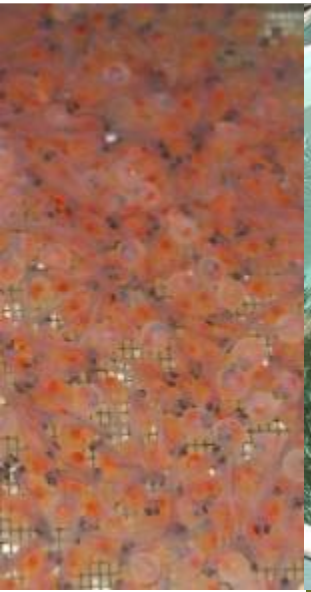
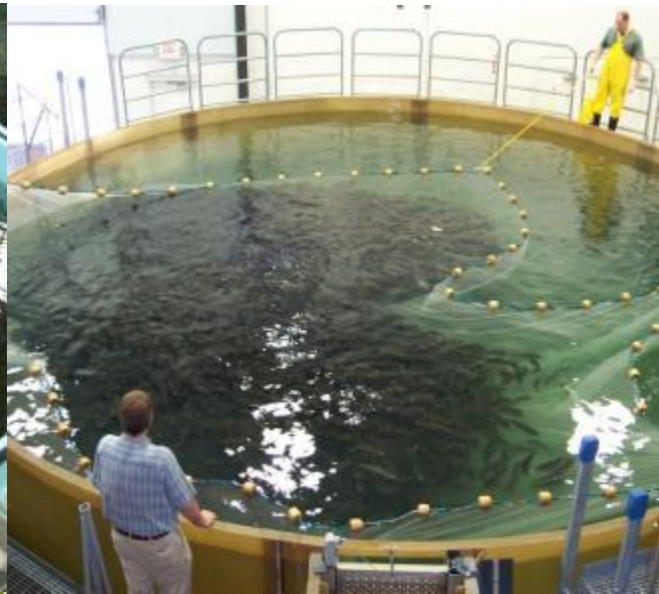
Moore Foundation Funded Growout Trial

- Atlantic salmon - Cascade Strain
  - eggs purchased from American Gold Seafood
- Jan 2011 – Eyed eggs received
- March 2011 - First feeding
- Aug-Sept 2011 – Photoperiod manipulated to S0 smolt
- September 2011 - Moved into advanced nursery system
- March 2012 – Moved into growout system



Moore Foundation Trial Results to Date - Cascade Strain

- **Feed conversion of 1.01 feed : 1.0 gain**
- **Good fin condition**
- **No sea lice**
- **Obligate pathogens screening will be conducted before harvest**

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Moore Foundation Trial Results to Date - Cascade Strain

- Mortality 0.8%
- Culls 1.1%
- Jumpers 0.2%
- Total 2.1%

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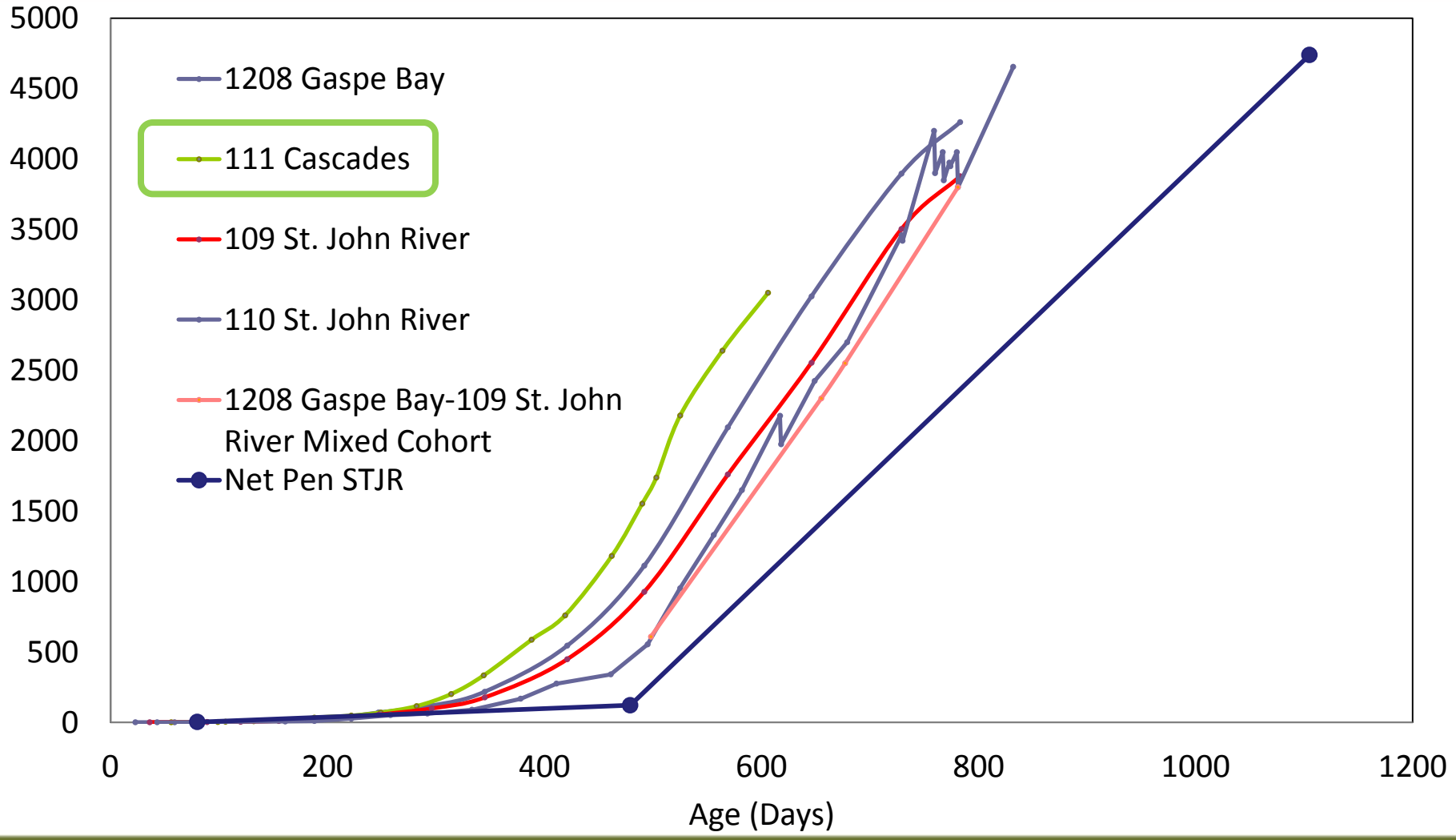
Moore Foundation Trial Results to Date - Cascade Strain



Moore Foundation Trial Results to Date - Cascade Strain

- 37% of the population harvested Sept, 2012
  - biomass at 100 kg/m3
  - mean fish size at 2.64 kg.
  - 5.4 metric tonne (12,000 lb)
  - sold to a local processor for hot smoking.

Moore Foundation Trial Results to Date - Cascade Strain

- Premium salmon:
  - mean size of 4 kg in early December 2012
    - 22 months post-hatch
  - biomass density will be 100 kg/m3
  - harvests begin in December, run through February,
  - produce another 15-18 metric tonne
    - selling to Albion Fisheries
- Total Production Expected: 21-23 tonne

Moore Foundation Trial Results to Date - Cascade Strain

- No vaccination (saves $$ & stress)
- No antibiotics or pesticides used at any time
- No formalin used at any time
- Small amount of hydrogen peroxide (H_2O_2) used in the sac fry and early parr stage to treat fungus.
- Total salt used to treat fungus: 8070 lbs.

CONCLUSIONS: Atlantic Salmon Growout Trial

- Good growth in freshwater
  - Harvest 8-9 months sooner than net pens
- Good survival (90+%) and feed conversion (1.09:1)
- Density can reach 100 kg/m^3
- Should use all female eggs to avoid precocious males

We don't need seawater to farm Atlantic salmon

Additional Research Needs

MINIMIZE EARLY MATURING FISH

- Identify the optimum photoperiod
  - 18 hr light vs. 24 hr light during 1st year (+ S0 winter)
    - ASF & Moore Foundation funded study
    - Cascade salmon are now 60 g in S0 winter
- Identify the best seedstock for land-based closed-containment systems
  - Late maturing & rapid growing Norwegian strains
  - All female eggs & triploids
  - Need funding (eggs to arrive this winter)