

A photograph of several Atlantic salmon swimming in a circular tank, viewed through a glass barrier. The fish are silvery with dark spots and are positioned at different depths within the tank.

# Depuration and Slaughter Techniques to Optimize Atlantic Salmon Product Quality from Land- Based Closed Containment Systems

John Davidson, Thomas Waldrop, Kevin  
Schrader, Brett Kenney, Gary Burr, William  
Wolters, and Steven Summerfelt

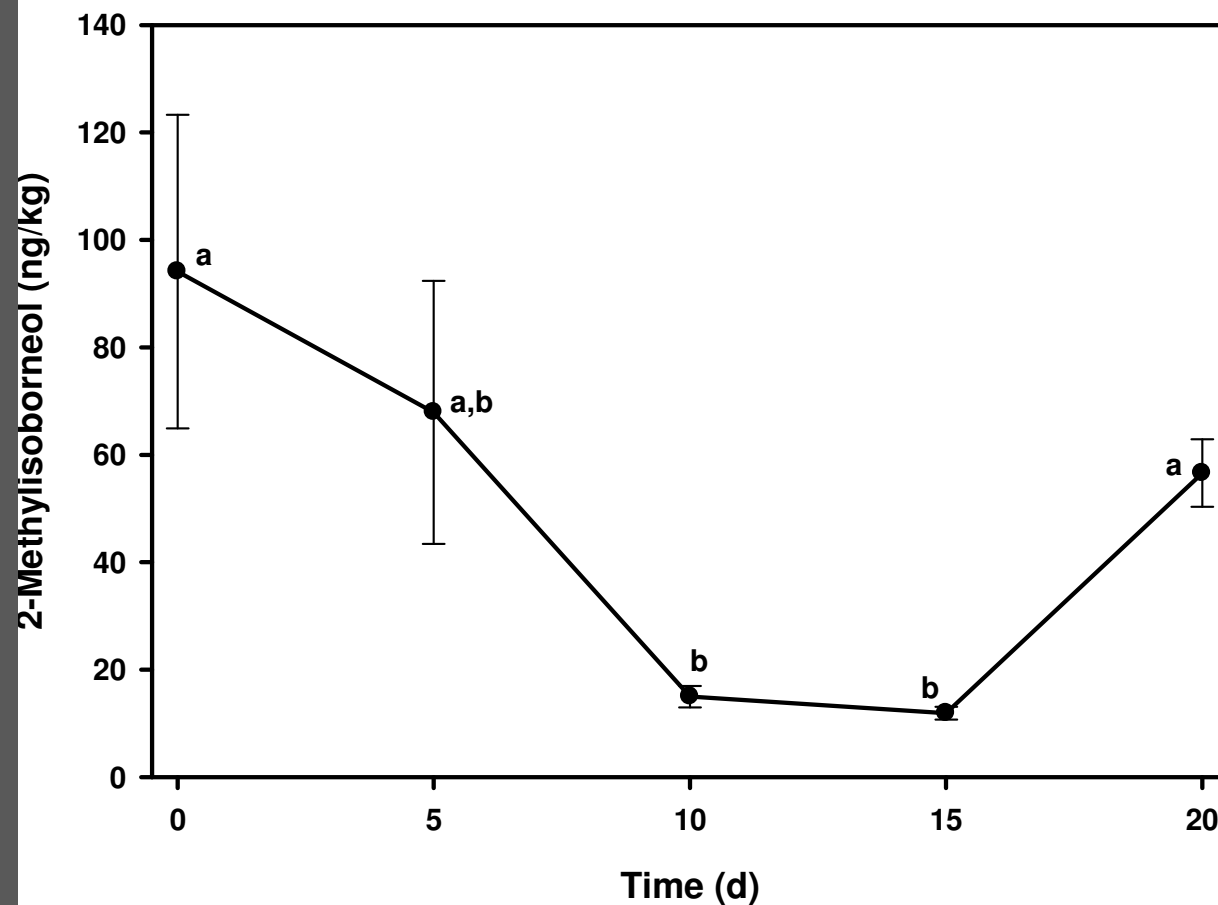
- Increased use of recirculating aquaculture systems (RAS) to culture aquatic species
- Many advantages of RAS, but one drawback
  - Bioaccumulation of off-flavor compounds within fish flesh
  - Create an earthy or musty taste
- Caused by microbial metabolites produced by actinomycetes and cyanobacteria
  - Methylisoborneol (MIB)
  - Geosmin

- Off-flavor not reported for A. salmon cultured in ocean net pens but reported in A. salmon caught in freshwater rivers
- For RAS to be a viable technology methods for off-flavor removal are necessary
- Can be effectively accomplished using a depuration process
  - Fish off feed
  - Clean/ biofilm-free system water
  - Flow Through or Partial Reuse System
- Ozone used at non-disinfecting dose did not remove off-flavor from trout from low exchange RAS

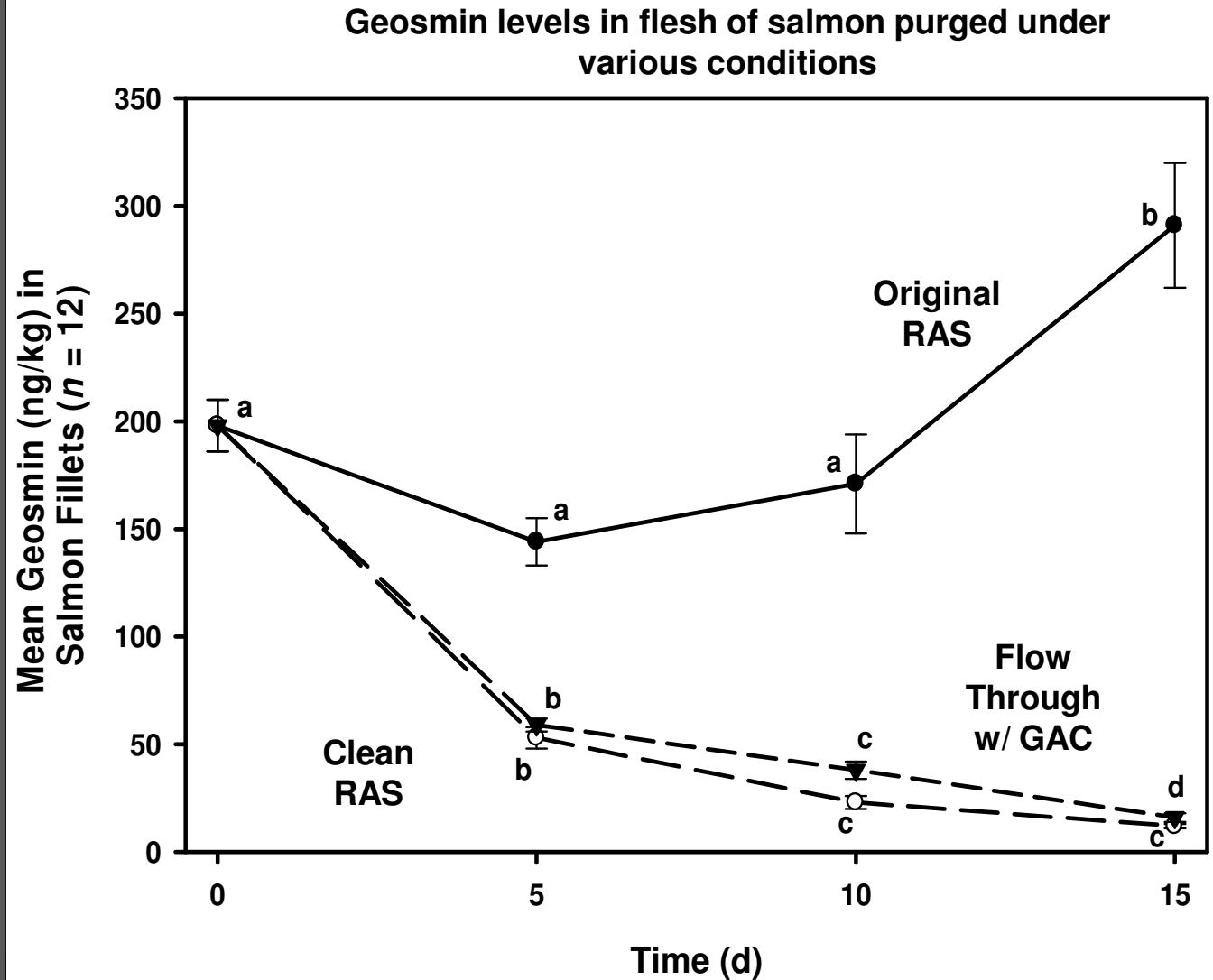
- Burr et al. 2012. Impact of depuration of earthy-musty off-flavors on fillet quality of Atlantic salmon cultured in a recirculating aquaculture system. *Aquacultural Engineering*.
- Determined approximate amount of time and conditions for optimal depuration of A. salmon cultured in RAS
- Salmon cultured in RAS with 97% recycle rate (flow basis)
- Fed a commercial 44/29 diet

- Cited from Wolters et al., 2011. Weight Loss and Fillet Quality Characteristics of Atlantic Salmon after Purging for 5, 10, 15 or 20 days. Aquaculture Innovation Workshop I, Shepherdstown, WV.
- Optimal purge time = 10-15 days

### 2-Methylisoborneol Levels in the Flesh of Salmon from a Flow-through System during Depuration Study



- Cited from Wolters et al., 2011.
- Salmon purged more effectively in geosmin/MIB-free RAS and flow through system



## Burr et al. 2012 Conclusions

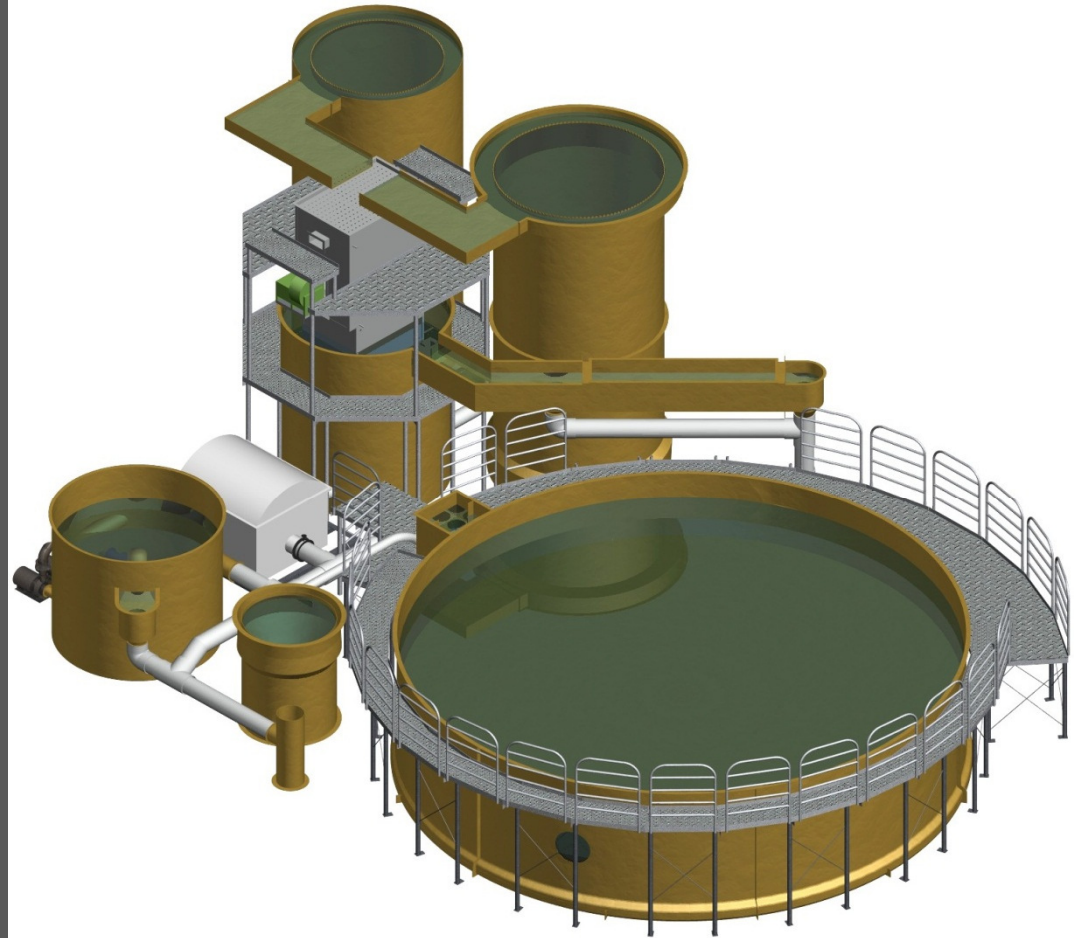
- 10-15 days optimal depuration time
- Taking salmon off feed prior to harvest shouldn't be only method
- Recommend fish relocation to biofilm-free depuration system
- Fillet color not impacted during depuration
- Use of granular activated carbon to treat influent of depuration system appears to be beneficial





## 150 m<sup>3</sup> Commercial Scale Grow-out RAS

- A. salmon used for depuration and fillet quality studies harvested from commercial scale RAS
- Recycle Flow
  - 99.75% (flow basis)
  - 1500 gpm recycle
- Makeup Flow
  - < 5 gpm
- Fish Density - 50-60 kg/m<sup>3</sup>
- Feed Loading Rate –
  - 6-7 kg feed/ m<sup>3</sup> makeup flow/day





- Twelve 0.5 m<sup>3</sup> circular single drain tanks
- Prior to stocking salmon for depuration - equal numbers of rainbow trout cultured in tanks to establish biofilm
- Partial reuse systems operated at appx. 92% recycle
  - 26 gpm recycle flow
  - 2 gpm makeup flow
  - Hydraulic Retention Time > 1 Hr
- Recycle water pumped from within tank through CO<sub>2</sub> stripping column

## 0.5 m<sup>3</sup> Experimental Partial Reuse Systems





## Salmon Depuration Experimental Design

| Experimental Tanks<br>per Treatment | Granular Activated<br>Carbon (GAC) | Hydrogen<br>Peroxide |
|-------------------------------------|------------------------------------|----------------------|
| 3                                   | ✓                                  | ✓                    |
| 3                                   | ✓                                  |                      |
| 3                                   |                                    | ✓                    |
| 3                                   |                                    |                      |

- Rainbow trout removed 1 day prior to stocking salmon
- Six tanks treated with 1 hr static hydrogen peroxide
  - Target – 250 mg/L
- GAC turned on
- Systems allowed to flush 24 hrs
- Appx. 15 salmon stocked per tank next day
  - Trial 1 used 1-2 kg salmon (1 yr. old)
  - Trial 2 and 3 used 4-5 kg salmon
- Salmon remain off feed for study period

## Granular Activated Carbon Filtration

- All makeup water entering six tanks assigned GAC treatment passed through GAC filter



- Fillet samples - Days 0, 2, 6, and 10
- Water and biofilm samples - Days 0, 2, 4, 6, 8, and 10
- All samples to be tested by Kevin Schrader, Microbiologist at University of Mississippi for off-flavor compounds – geosmin and MIB



- Results from Freshwater Institute study pending
- However, marketing research indicates success!
- Blind taste tests of 2 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

## Promising News



“It was the first closed contained fish which we’ve sampled that not only tasted great and entirely lacked any muddy, earthy, plastic, or metallic taste whatsoever. So whatever Steve S. and his team are doing with respect to recirculation systems, feed formulae, depuration, etc., the rest of the closed contained fish farming community should take note because he appears to have nailed the recipe.”

-Dane Chauvel, Organic Ocean

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# Evaluation of Humane Slaughter Techniques



Aquaculture Innovation Workshop #3  
Seattle, WA



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# SI-2 Stunner Technology



Aquaculture Innovation Workshop #3  
Seattle, WA



## SI-2 Stunner Technology

### Pneumatic Piston Design



Fish Automatically Triggers Piston



# Humane Slaughter Techniques Study Methods

- Four techniques compared:
  1. Humane Stunner Technology with bleeding
  2. Humane Stunner Technology without bleeding
  3. Carbon Dioxide and Ice Slurry with bleeding
  4. Carbon Dioxide and Ice Slurry without bleeding
  
- Six salmon randomly selected and euthanized using each slaughter technique
  - Males and obviously mature fish excluded
  - 4-5 kg fish targeted
  
- For groups assigned bleeding, gills manually cut just after euthanasia

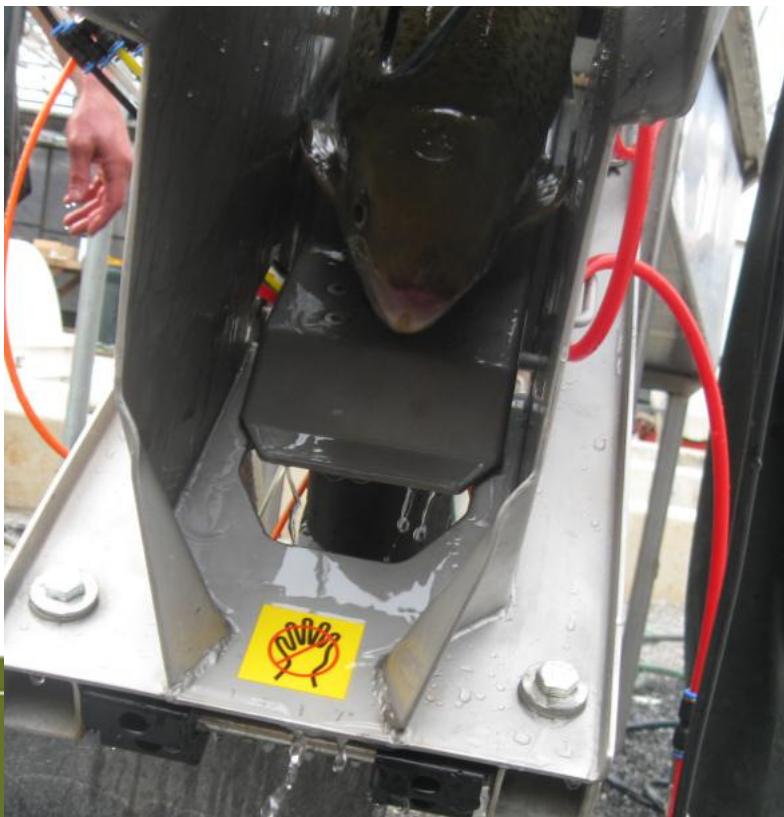


- Length/ whole Body Weight
- Fillet weights and yields
- Gonadosomatic Index
- Fillet temperature, pH
- Fillet texture and color
- Proximate analysis results pending

# Post-Harvest Slaughter

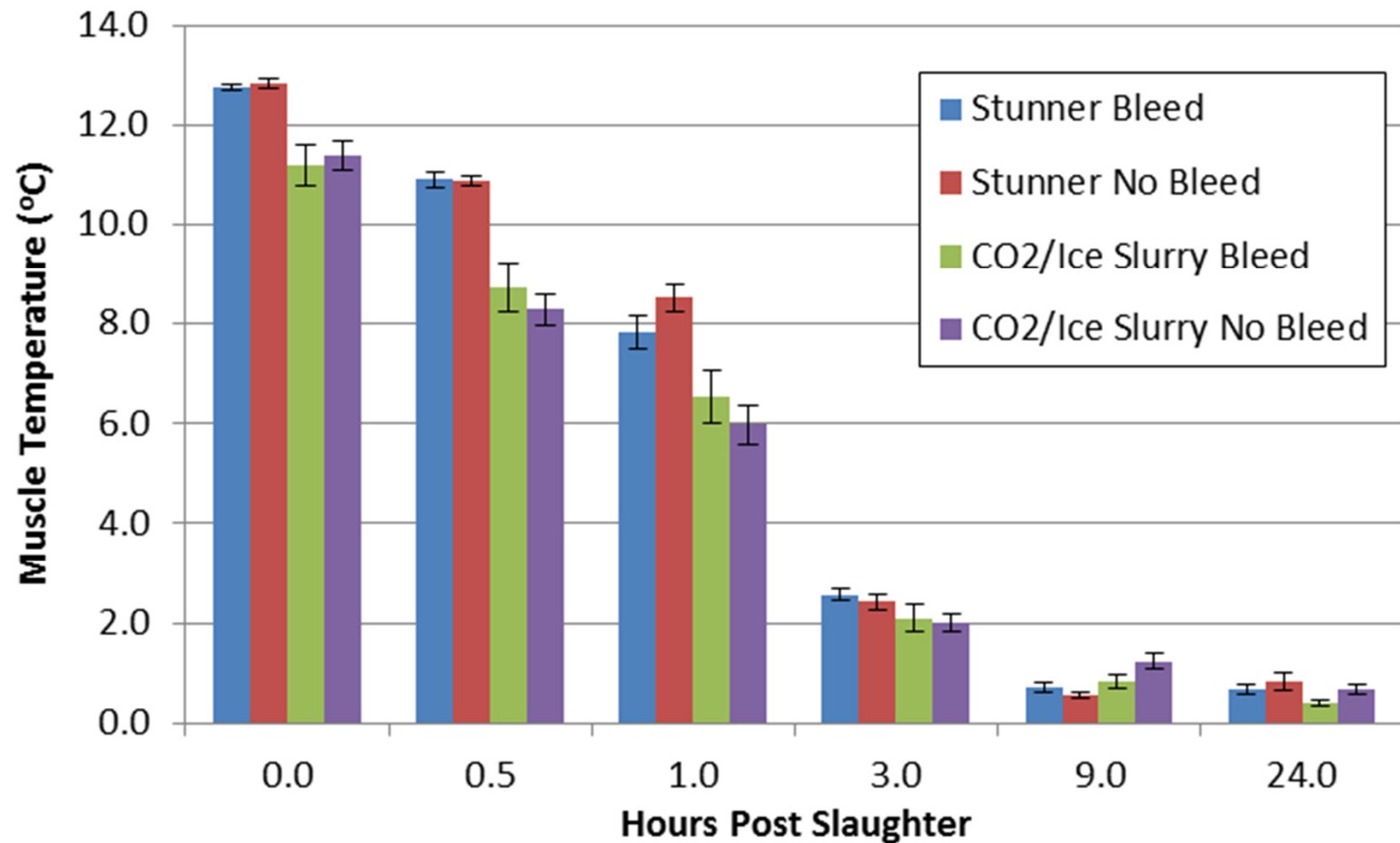
Rapid & Humane

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



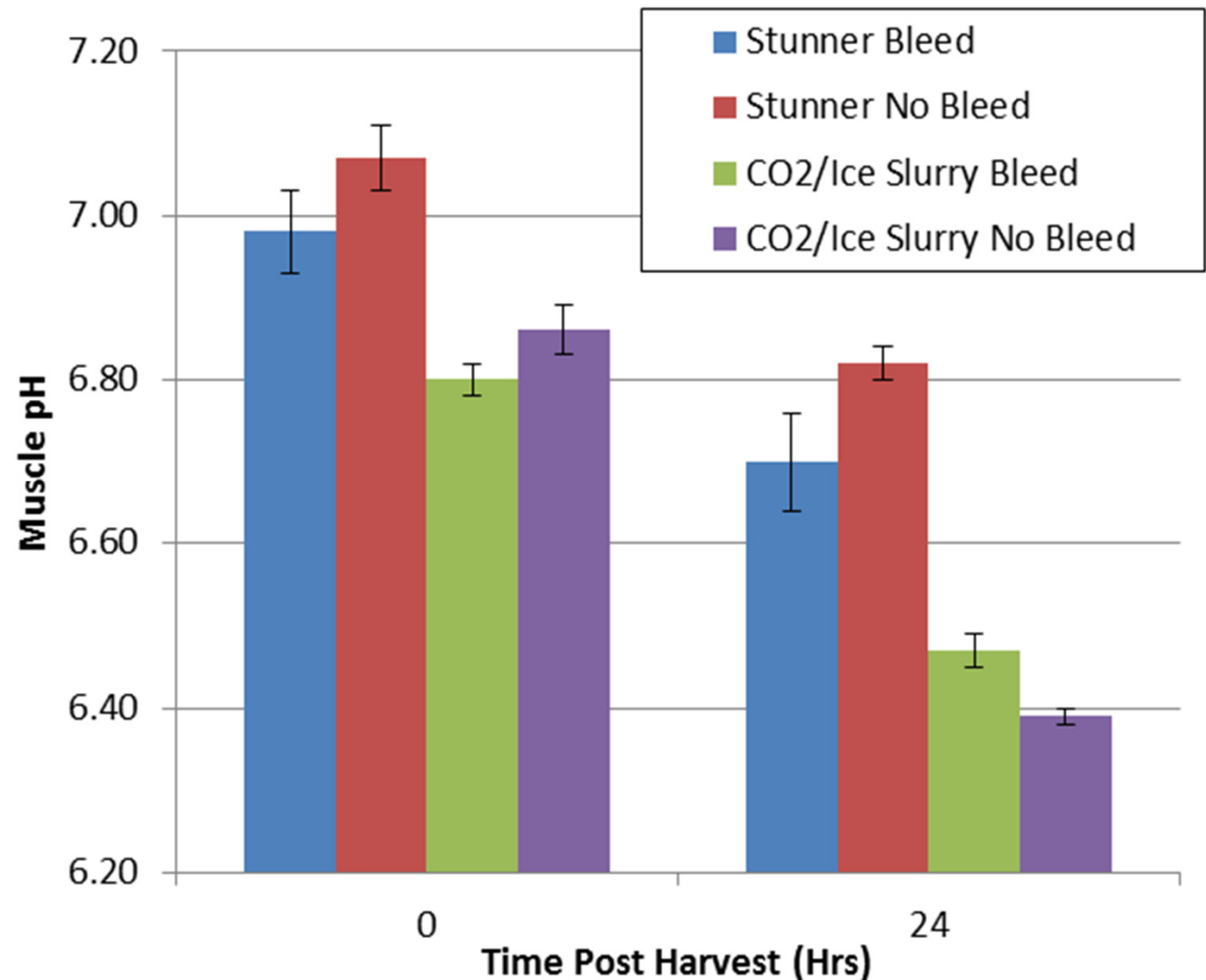
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# Fillet Quality - Temperature



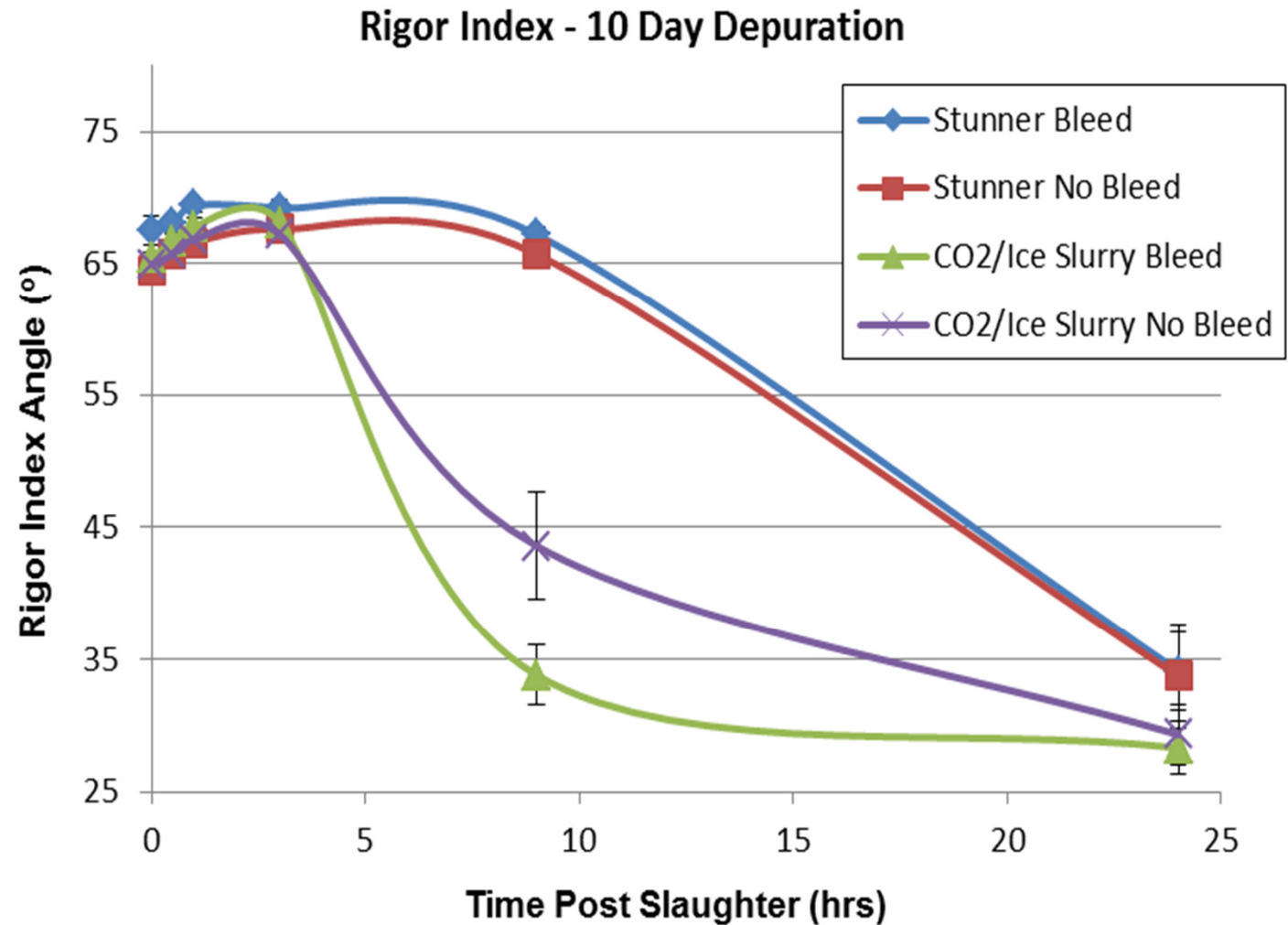
## Fillet Quality - pH

- Salmon euthanized using humane stunner technology had greater and less fluctuating fillet pH levels ( $P < 0.05$ )
- Indicative of less struggle and stress during slaughter
- Generally leads to improved fillet quality



# Fillet Quality – Rigor Onset

- Rigor onset significantly slower for salmon euthanized using humane slaughter technology
- Slower rigor onset generally correlated with improved fillet quality





# Fillet Quality - Color

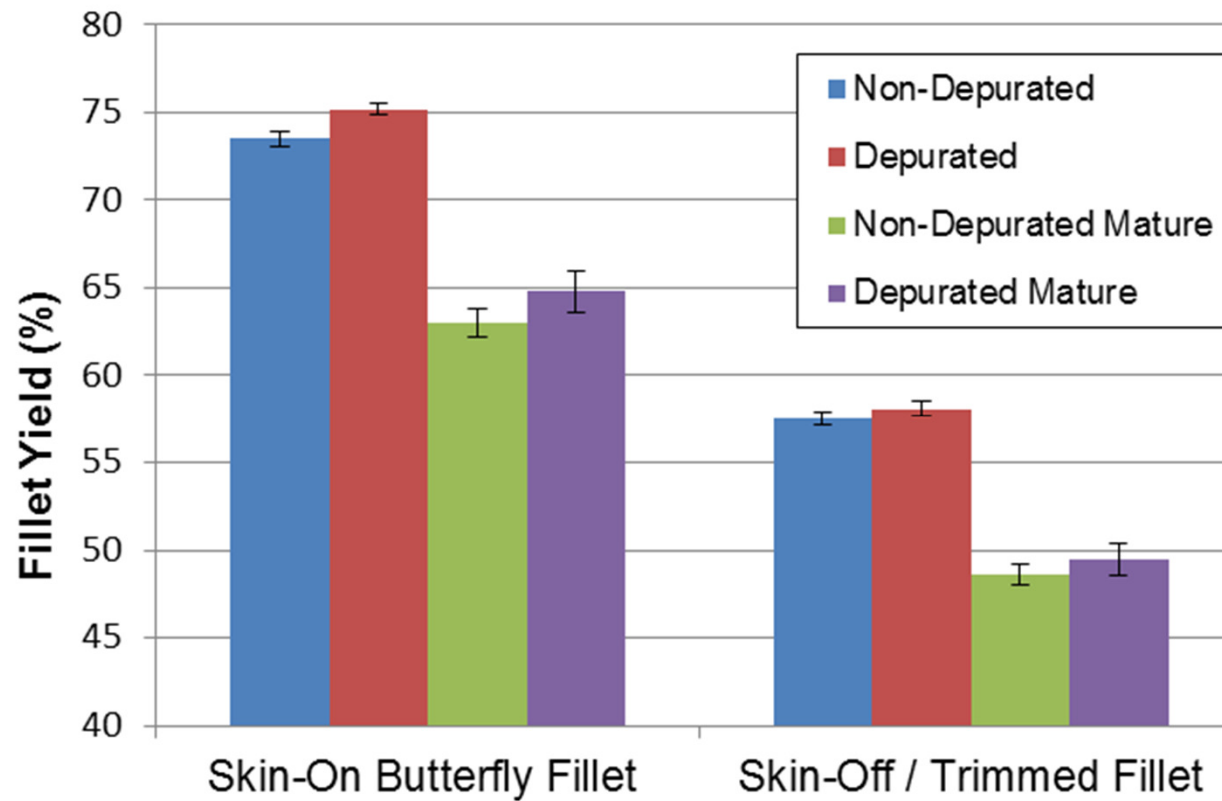
## Color Score on Salmon Fan 28-30

- No significant difference in fillet color between non-depurated and 10-day depurated salmon
- No color loss
- Same result as Burr et al. after 10 days





# Atlantic Salmon Fillet Yield



- Humane stunning technology improves fillet attributes
  - Less struggle = lower ATP use and less lactic acid
  - Less fluctuation of flesh pH
  - Slower onset to rigor
- Fillet color is unaffected after 10 days depuration
- Fillet yield is unaffected after 10 days depuration
- Maturing fish have significantly reduced fillet yield
- Technology is commercially available and is being used by industry

- Research supported by Tides Canada.
- All experimental protocols were in compliance with Animal Welfare Act (9CFR) and have been approved by the Freshwater Institute Animal Care and Use Committee.
- Special thanks to Justin Sabrio, Tre Kidwell, Phil Backover for technical assistance, to Vera Anthony for help with processing, and to Karen Schroyer and Susan Glenn for water quality analysis.