Conditions that Promote or Inhibit Off-flavor in RAS

THE CONSERVATION FUND
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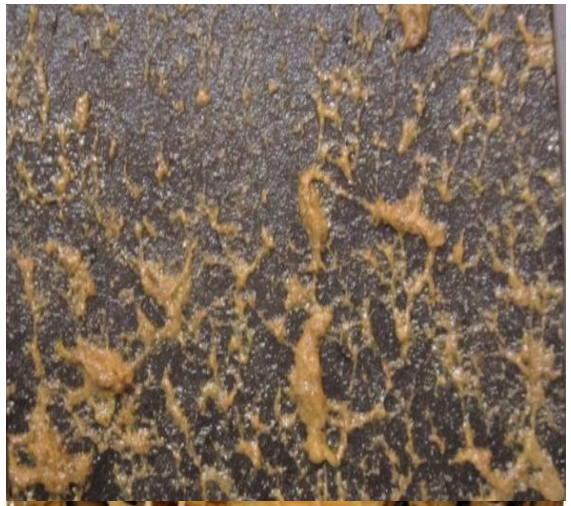
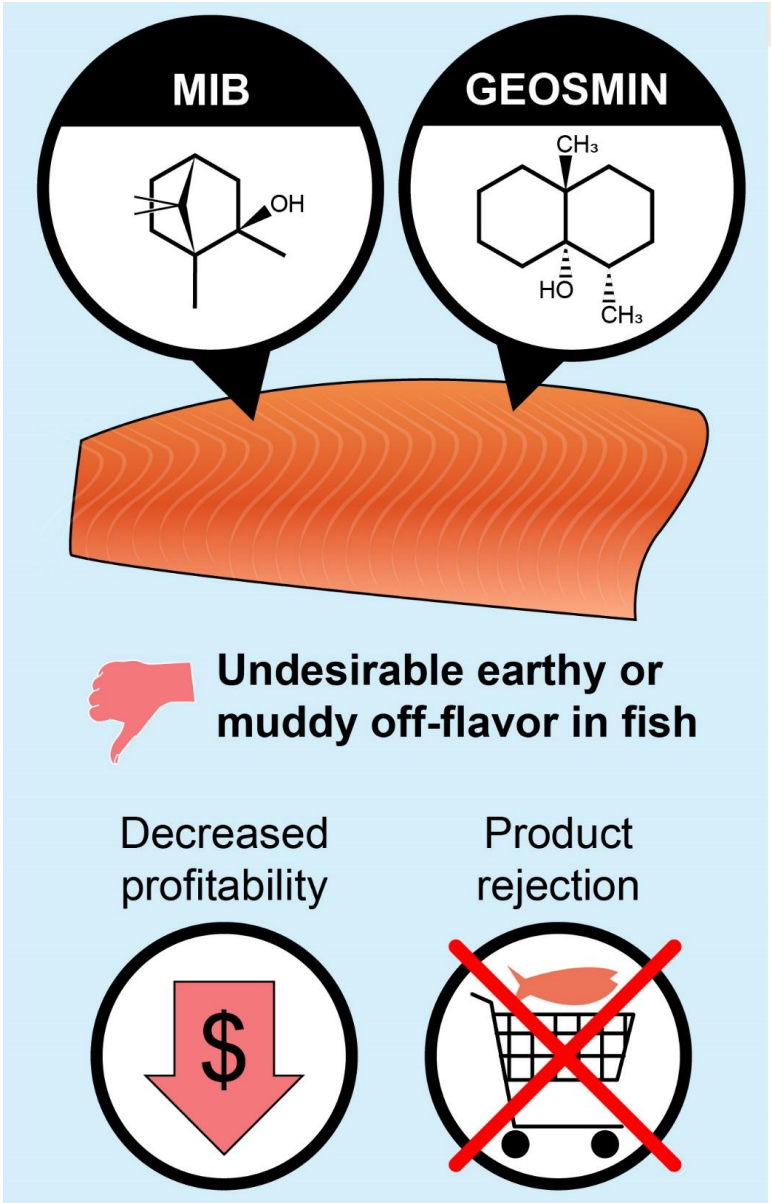
Sustainable Aquaculture Systems Supporting Atlantic Salmon
Baltimore, MD 2025

SAS²

Bacteria produce Geosmin & MIB in RAS.



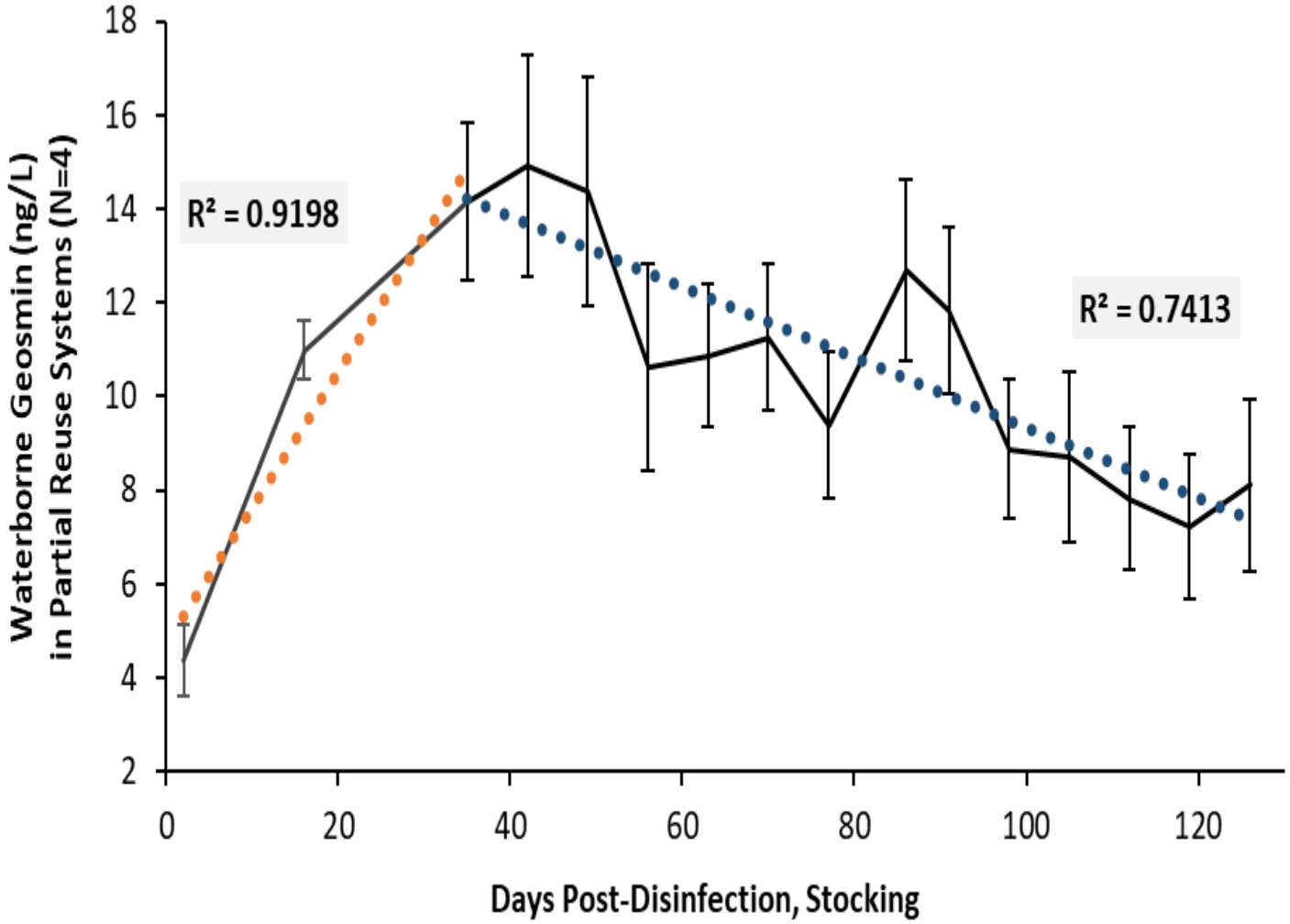


- Depuration is a proven finishing procedure.
  - Fish are moved to separate systems.
  - Water low/void of off-flavor is exchanged.
  - Off-flavor is eliminated by fish across a concentration gradient with the water.

Is Off-Flavor Production Affected by Microbial Maturity?

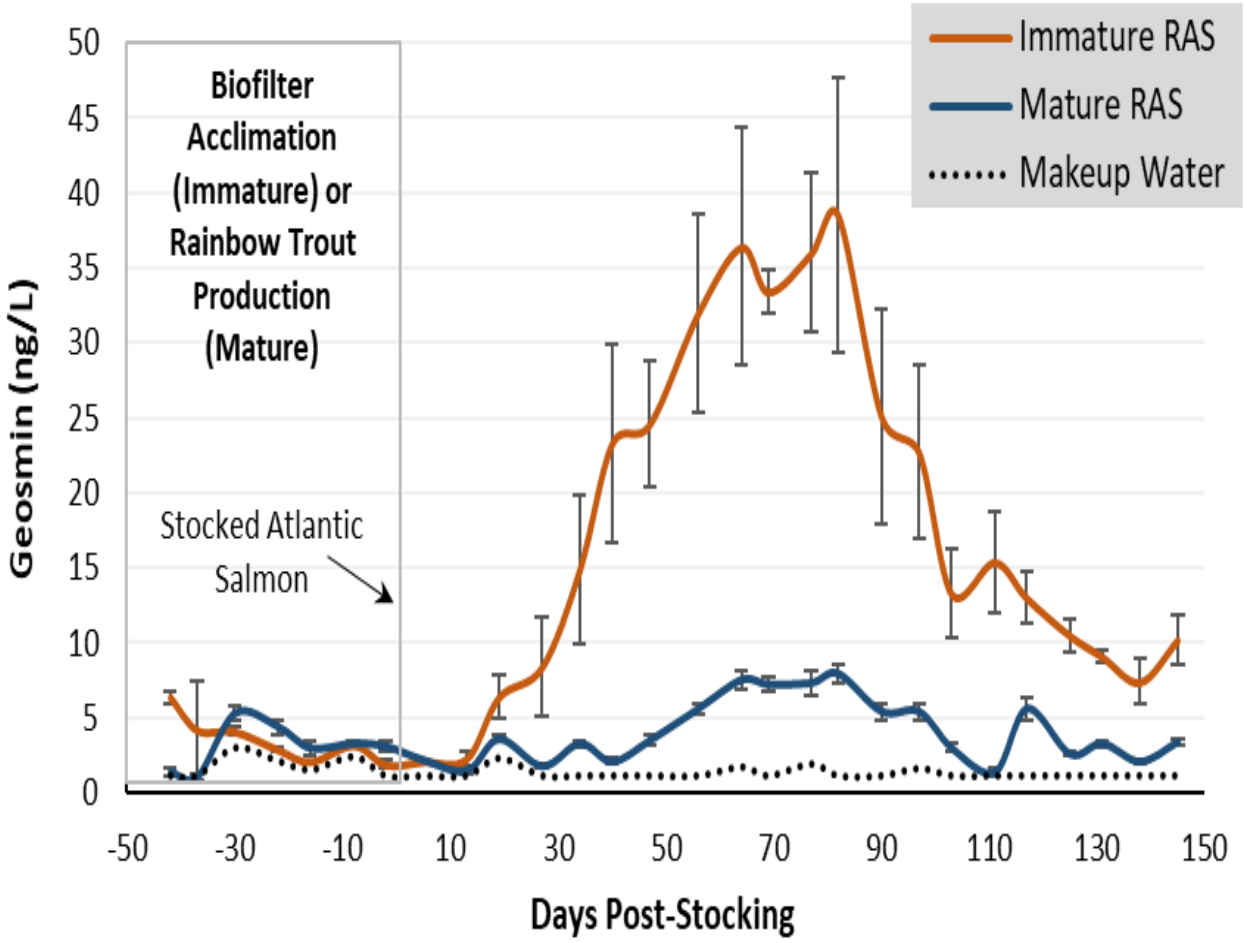
Geosmin production in partial reuse systems ***without a biofilter***.

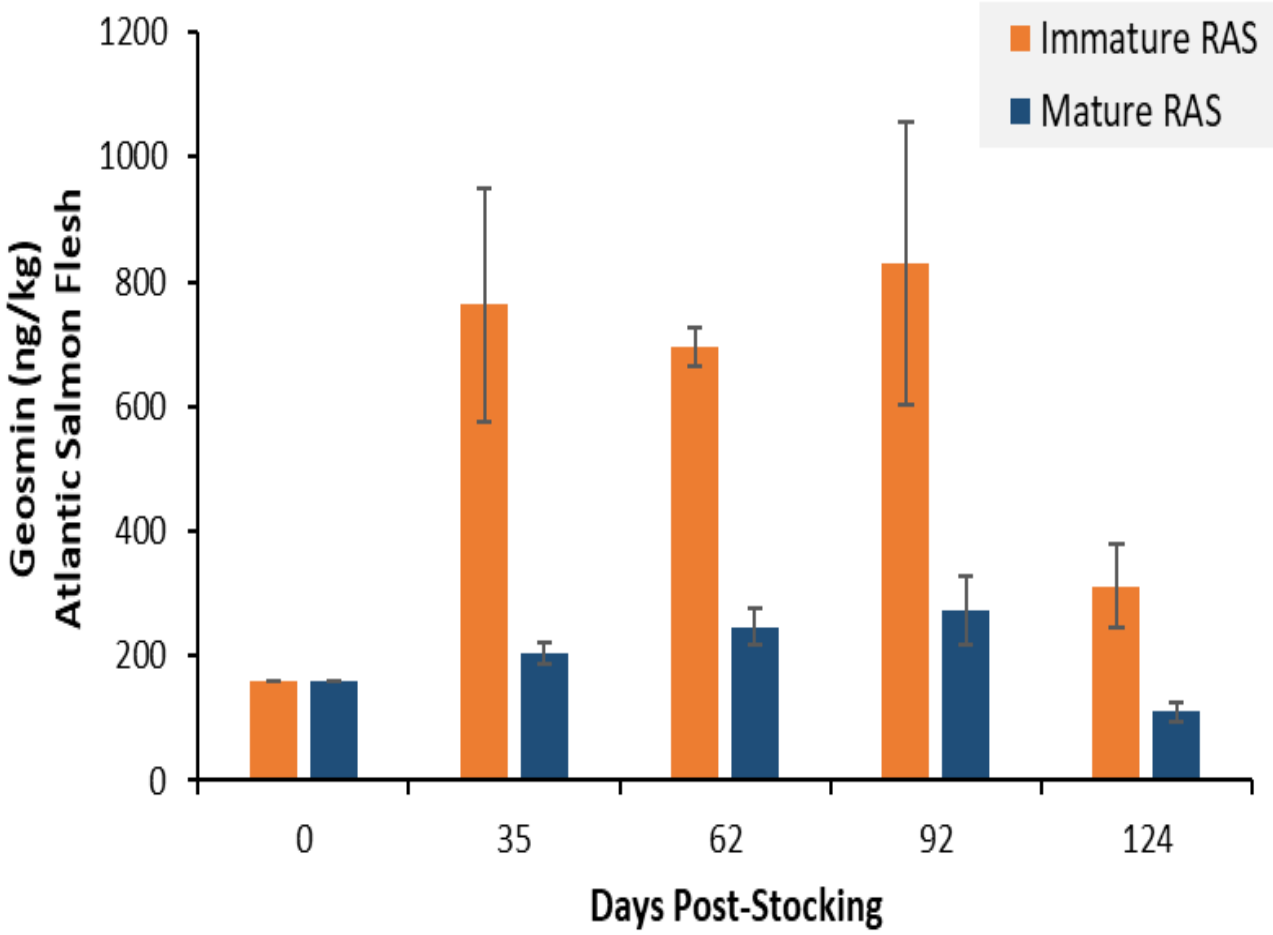
- This data set was the driver for subsequent studies at FI.
- We cleaned and disinfected 4 identical partial reuse systems (PRS), then stocked Atlantic salmon. We did not brush submerged surfaces thereafter.
- A peak and gradual decline in waterborne geosmin was observed across replicate PRS.
- Does a similar response occur in RAS?
  - Is it related to the development of microbial maturity?



Geosmin Levels - Immature vs. Mature RAS

- A similar response was observed in replicated RAS (n=3).
- At its peak, geosmin was 4x higher in water and Atlantic salmon flesh in pre-disinfected RAS where nitrification was re-established (*Immature*) vs. RAS operated for 2.5 years (*Mature*).

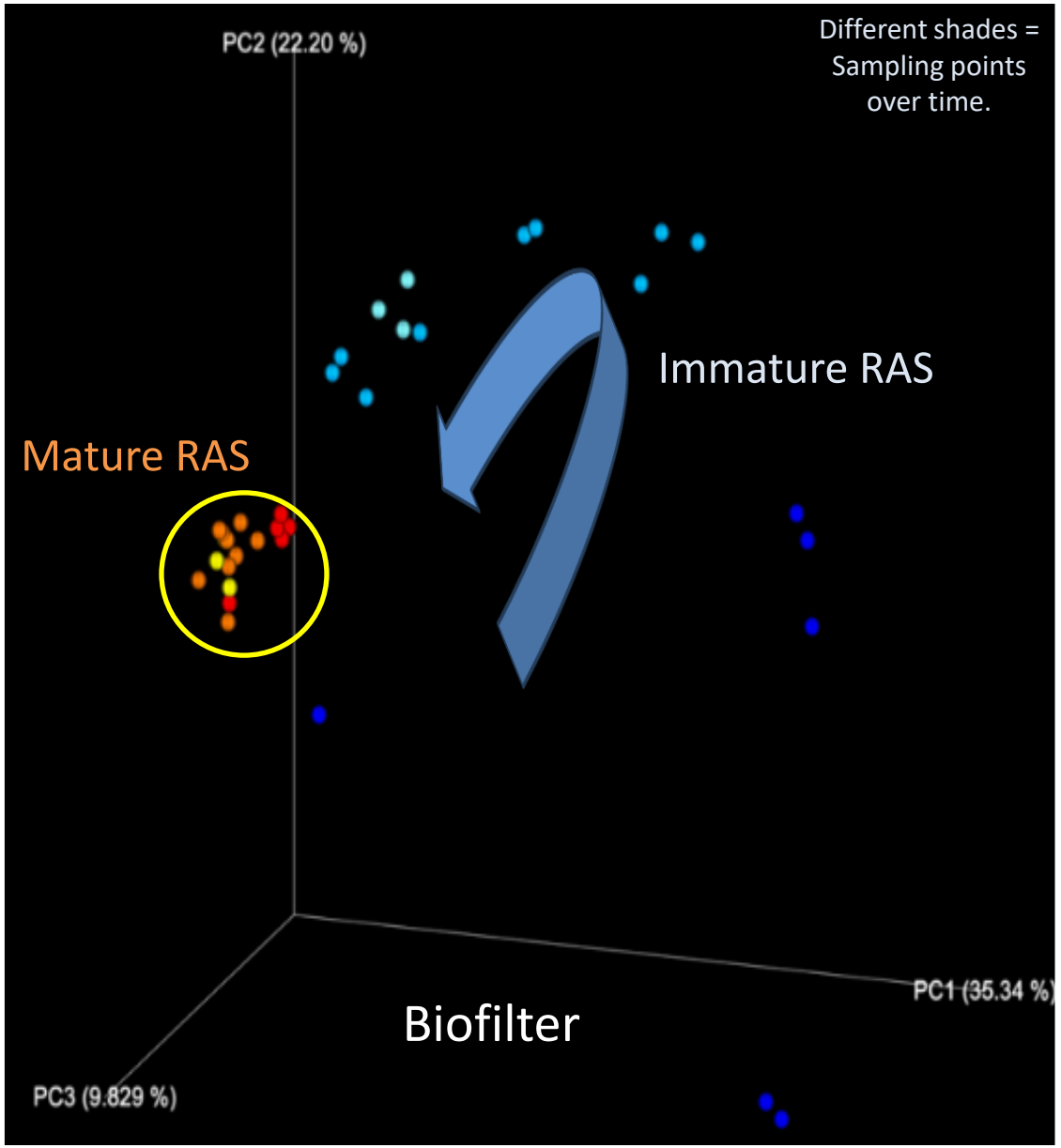




Microbiome Summary

Off-flavor Producing Bacteria	Off-flavor Degrading Bacteria
Odorella benthonica	*Pseudomonas putida*
Calothrix sp. PCC7507	*Stenotrophomonas maltophilia*
Cylindrospermum stagnale	*Pseudomonas fluorescens*
Synechoccus sp. NIES-970	
Sorangium cellulosum	
Aquabacterium commune	

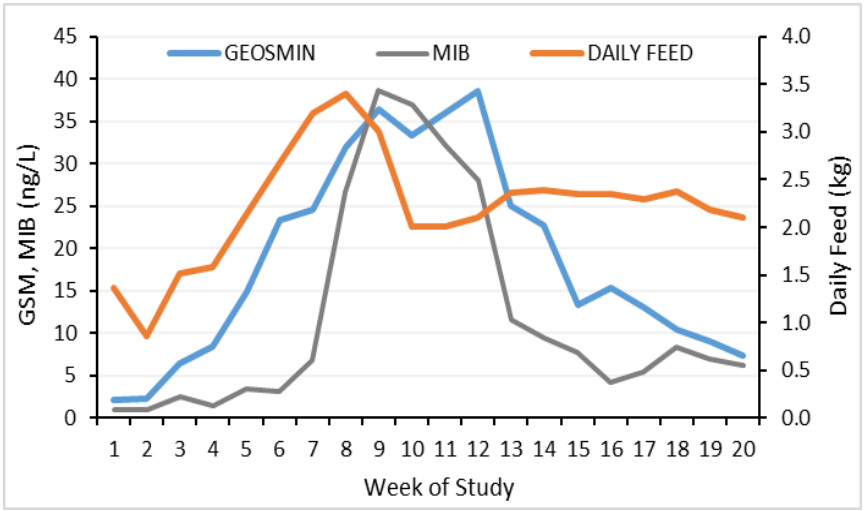
- Four of six off-flavor (OF) producers were Cyanobacteria.
- Most OF producers were found in tank biofilm.
- *OF producer abundance was generally higher in the mature RAS, opposite to the OF levels.*
- The plot at right is a principal coordinates depiction of the entire microbiome over time in biofilters.

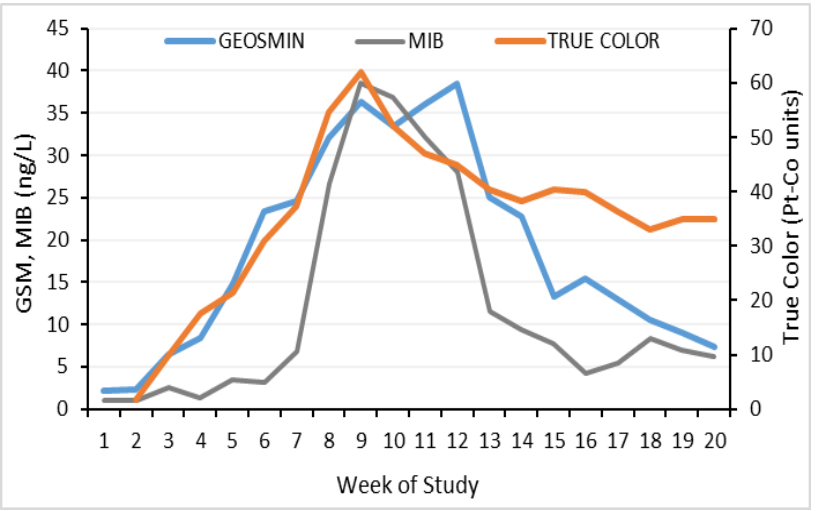


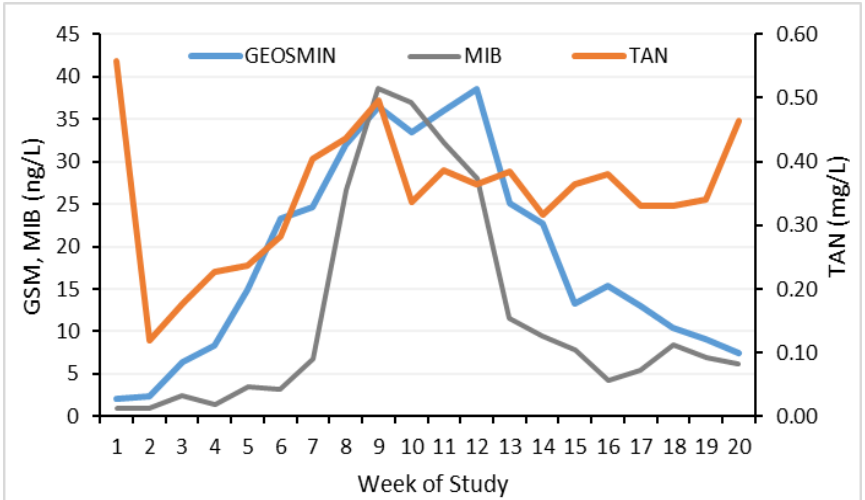
Off-flavor & Water Quality Trends - *Immature RAS*

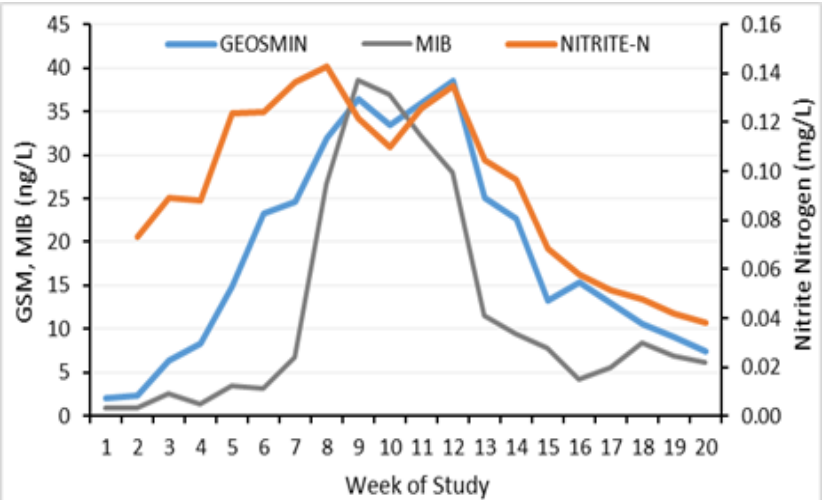
- Despite similar water flushing and feeding, many water quality differences were observed.
  - Two machine learning models separated true color as the most important variable affecting geosmin.
- The decline in OF production coincided with stabilized feeding and nutrient levels, and improved nitrification.

Conditions including Significant WQ Differences Associated with Higher Off-flavor
Recently Disinfected
Immature, Less Stable Microbiome
Higher Total Ammonia Nitrogen
Higher Nitrite Nitrogen
Higher True Color
Higher Total Suspended Solids
Higher Heterotrophic Bacteria Counts
Lower Nitrifier Abundance







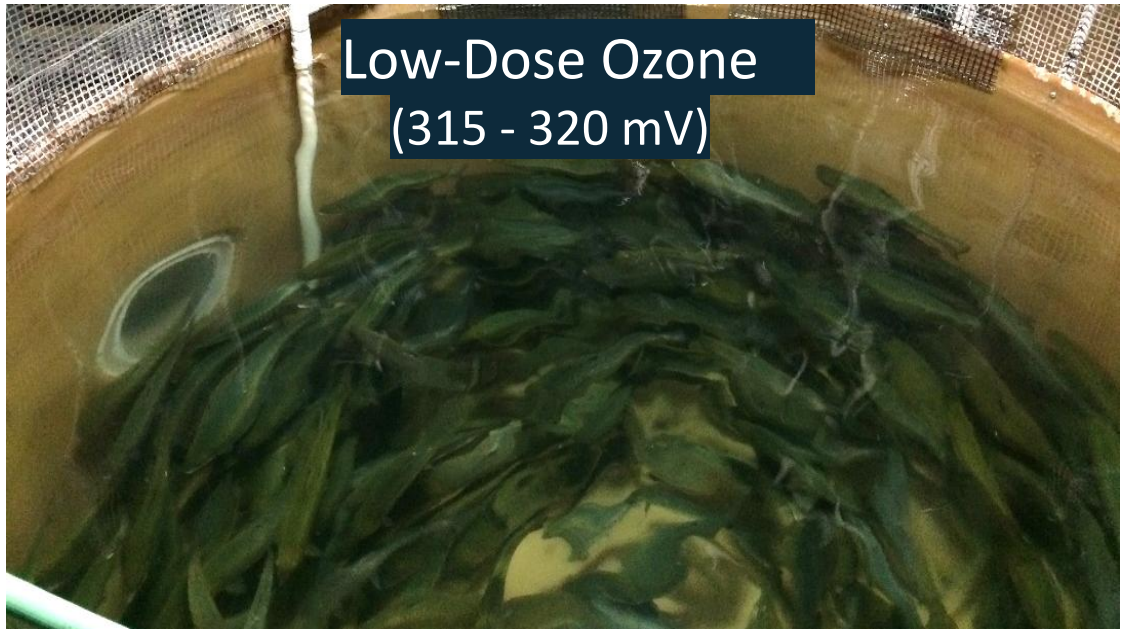


Can Common Oxidants Control Off-flavor?

- Hypothesis 1: Low-dose ozone will create an environment conducive to inhibiting off-flavor production in RAS?

Conditions Associated with Lower Off-flavor	Ozone Control
Longterm RAS Operation	-
Mature & Stable Microbiome	-
Lower Total Ammonia Nitrogen	↘
Lower Nitrite Nitrogen	↓
Lower True Color	↓
Lower Total Suspended Solids	↓
Lower Heterotrophic Bacteria	↓
Higher Nitrifier Abundance	↗↙

- Hypothesis 2: Low-dose ozone with peracetic acid dosing will reduce off-flavor levels through advanced oxidation or combined water quality control and microbial reduction.



Davidson et al. (2021). Aquacultural Engineering

Conclusions

- Operating RAS continuously without shutdown maintains lower off-flavor levels vs. disinfecting and restarting between cohorts.
- Better water quality, including lower true color (dissolved organics), and lower TAN and nitrite resulting from stable and efficient nitrification, aligned with lower off-flavor levels in water and fish.
- We must consider off-flavor production holistically.
  - Geosmin and MIB are produced by specific bacteria *competing for space and nutrients in a complex microbiome*.
- This research is a step forward in establishing a possible "recipe" for maintaining lower geosmin and MIB levels in RAS.
  - Optimizing RAS operation, water treatment efficiencies, and the RAS environment could be a cost-effective solution!

Acknowledgments

- This work was funded by the USDA National Institute of Food and Agriculture through the Agriculture and Food Research Initiative (AFRI), SAS program (award #2021-68012-35922).
- The Conservation Fund and its partners are equal-opportunity employers and providers. All experimental protocols complied with the Animal Welfare Act (9CFR) and were approved by the Freshwater Institute's Animal Care and Use Committee.
- Special thanks to FI team members Megan Murray and Sarah Rice for water chemistry, Shanen Cogan, JC Stanley, and Scott Tsukuda for operations, Curtis Crouse, Kayla Fairfield, Anna Knight, and Travis May for fish production, Christine Lepine for data entry and research support, and Kata Sharrer for photography and schematics.
- Thanks to Bobby Harrington and Mariah Pearson at the University of Maine's Aquaculture Research Institute for off-flavor analysis and Julianna Stangroom, Jordan Poley, Adriana Artiles, and others at the Center of Aquaculture Technologies and Onda for microbial analysis and interpretation.

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