Comparing Chemoautotrophic-Based Systems and the Use of Three Carbohydrates to Promote Heterotrophic-Based Biofloc Shrimp (*Litopenaeus vannamei*) Culture Systems

THE UNIVERSITY OF SOUTHERN MISSISSIPPI
GULF COAST RESEARCH LABORATORY

The National Shellfisheries Association

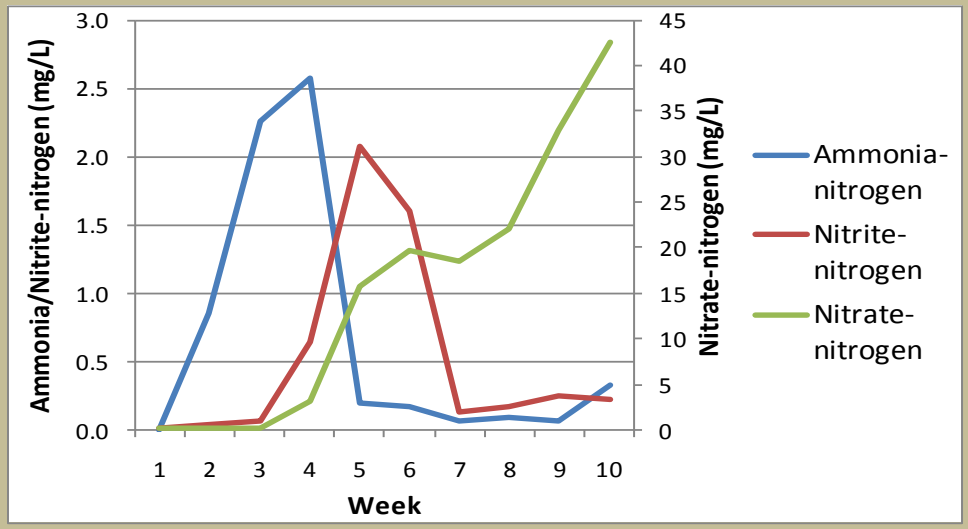
USDA
United States Department of Agriculture
National Institute of Food and Agriculture

Andrew J. Ray*, Verlee M. Breland, Christopher C. Farno, Kevin S. Dillon, and Jeffrey M. Lotz

Gulf Coast Research Laboratory
The University of Southern Mississippi, Ocean Springs, MS USA
AndrewJRay@gmail.com

Biofloc Bacteria

- Chemoautotrophic
  - $NH_3 \rightarrow NO_2^- \rightarrow NO_3^-$
    - Establishment
    - Toxic compounds
    - Reliable once established?
    - $\downarrow O_2$ consumption
- Heterotrophic
  - N assimilation → Protein
    - $\uparrow O_2$ consumption
    - Solids generation
    - Carbohydrate addition (C:N)
      - Carbohydrate source?
- This Project
  - Autotrophic versus heterotrophic
  - Evaluate carbohydrate sources



Materials and Methods

- 16, 500-L round tanks under a greenhouse
  - Water from established raceway
  - 16‰ salinity

- Four Treatments
  - 1.) Autotrophic (T-A) = no additional carbohydrate
  - 2.) Heterotrophic Sucrose (T-HS)
  - 3.) Heterotrophic Molasses (T-HM)
  - 4.) Heterotrophic Glycerol (T-HG)
  - Four randomly assigned replicate tanks each

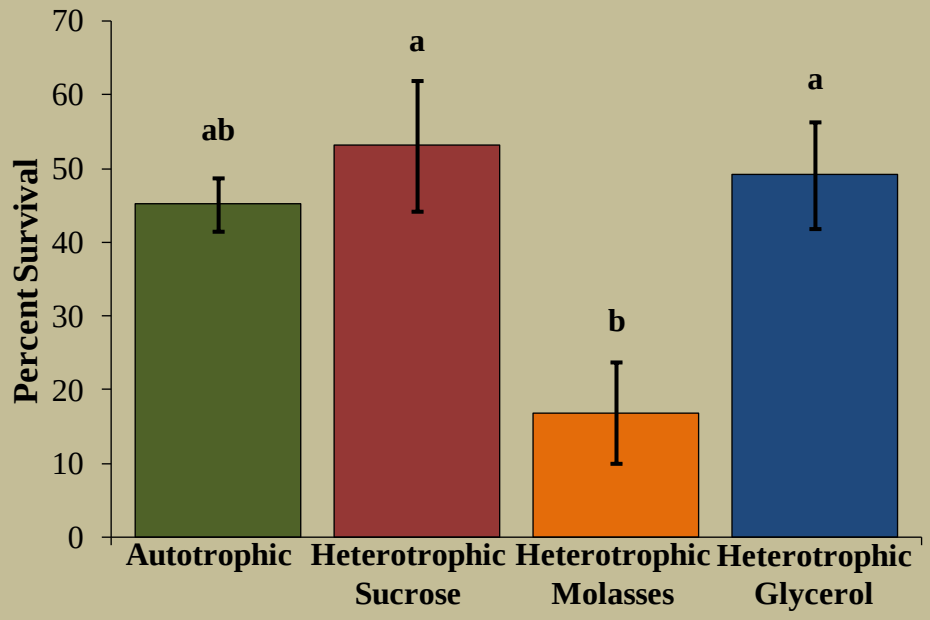
Materials and Methods

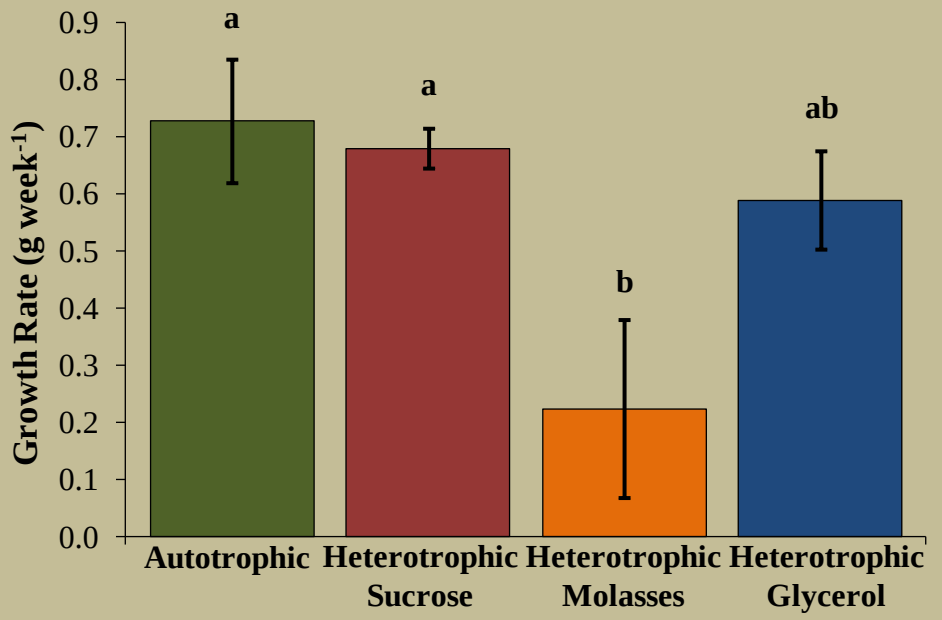
- C:N of inputs (feed + carbohydrate) = 25:1
  - Added twice daily
  - Reduced by 25% during week 5
- Shrimp stocked at 300 m^{-3}
  - 6.8 g mean stocking weight
  - Grown for 8 weeks
- Particle removal
  - Turbidity measured daily beginning week 2
    - 15-L settling chambers
    - > 150 NTU, run all day
    - > 225 NTU, run all day and night (week 4)

Results

	Treatment			
	Autotrophic	Heterotrophic Sucrose	Heterotrophic Molasses	Heterotrophic Glycerol
Temperature (°C)				
AM	24.2 ± 0.3 (14.6-31.2)	25.0 ± 0.3 (15.8-30.1)	24.4 ± 0.3 (15.7-30.5)	24.5 ± 0.3 (15.8-29.7)
PM	26.9 ± 0.2 (19.1-31.9)	27.3 ± 0.2 (20.2-31.3)	27.1 ± 0.2 (20.0-31.7)	27.2 ± 0.2 (20.1-31.2)
Dissolved Oxygen (mg L^{-1})				
AM	8.9 ± 0.1 (6.8-13.1)	8.4 ± 0.1 (6.7-11.6)	8.7 ± 0.1 (6.8-12.3	8.3 ± 0.1 (6.4-11.5)
PM	7.9 ± 0.1 (6.5-11.8)	7.3 ± 0.1 (5.0-11.8)	7.6 ± 0.1 (5.5-13.2)	6.7 ± 0.1 (3.3-12.6)
pH				
AM	8.1 ± 0.0 (7.8-8.5)	8.3 ± 0.0 (7.6-8.6)	8.4 ± 0.0 (8.0-8.7)	8.2 ± 0.0 (7.9-8.5)
PM	8.3 ± 0.0 (7.8-8.6)	8.1 ± 0.0 (7.8-8.6)	8.3 ± 0.0 (7.8-8.6)	8.1 ± 0.0 (7.7-8.5)
Salinity (g L^{-1})	16.4 ± 0.0 (15.4-17.5)	16.3 ± 0.0 (15.4-17.7)	16.4 ± 0.0 (15.6-17.6)	16.3 ± 0.0 (15.5-17.5)

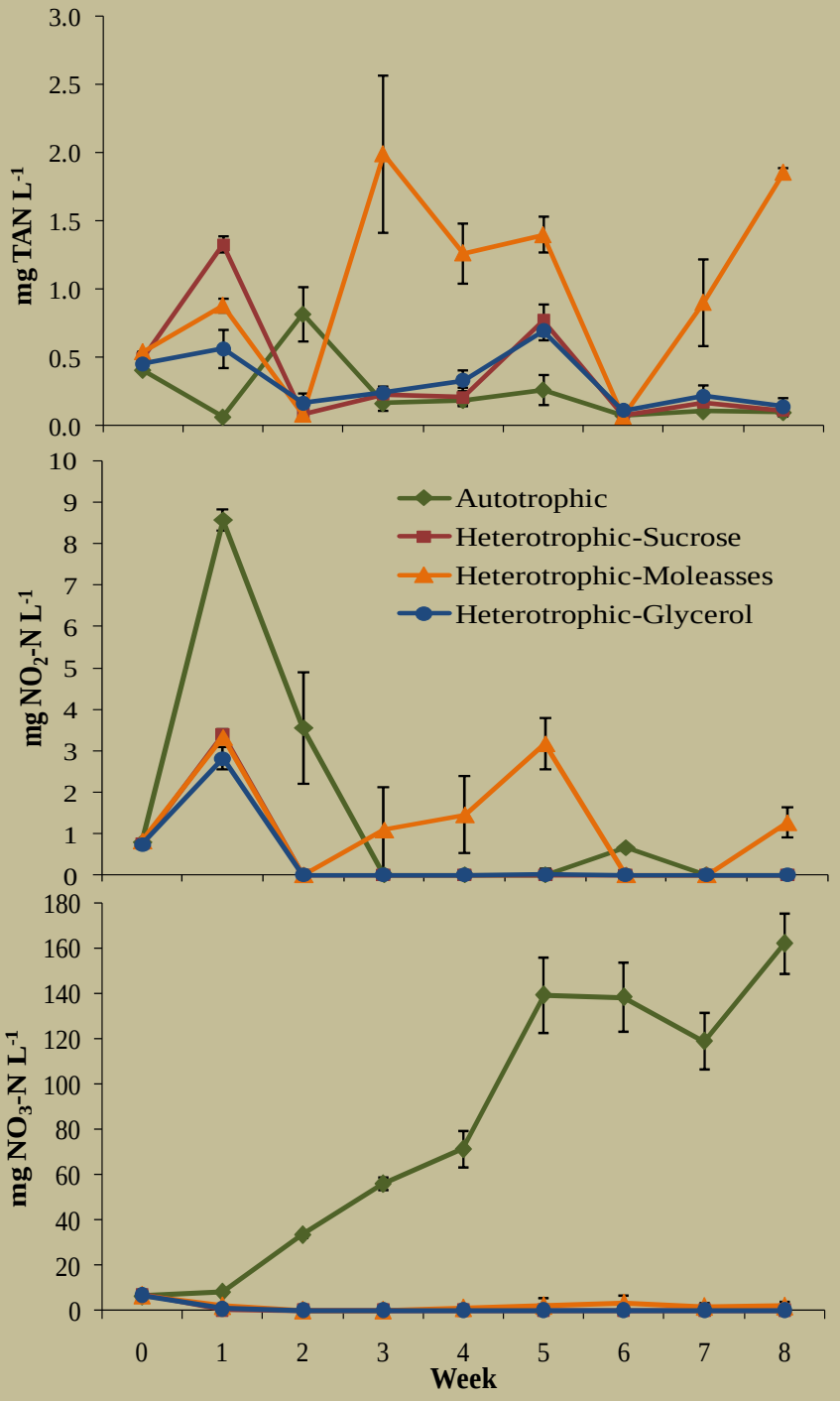
Data are reported as mean ± SE (range)





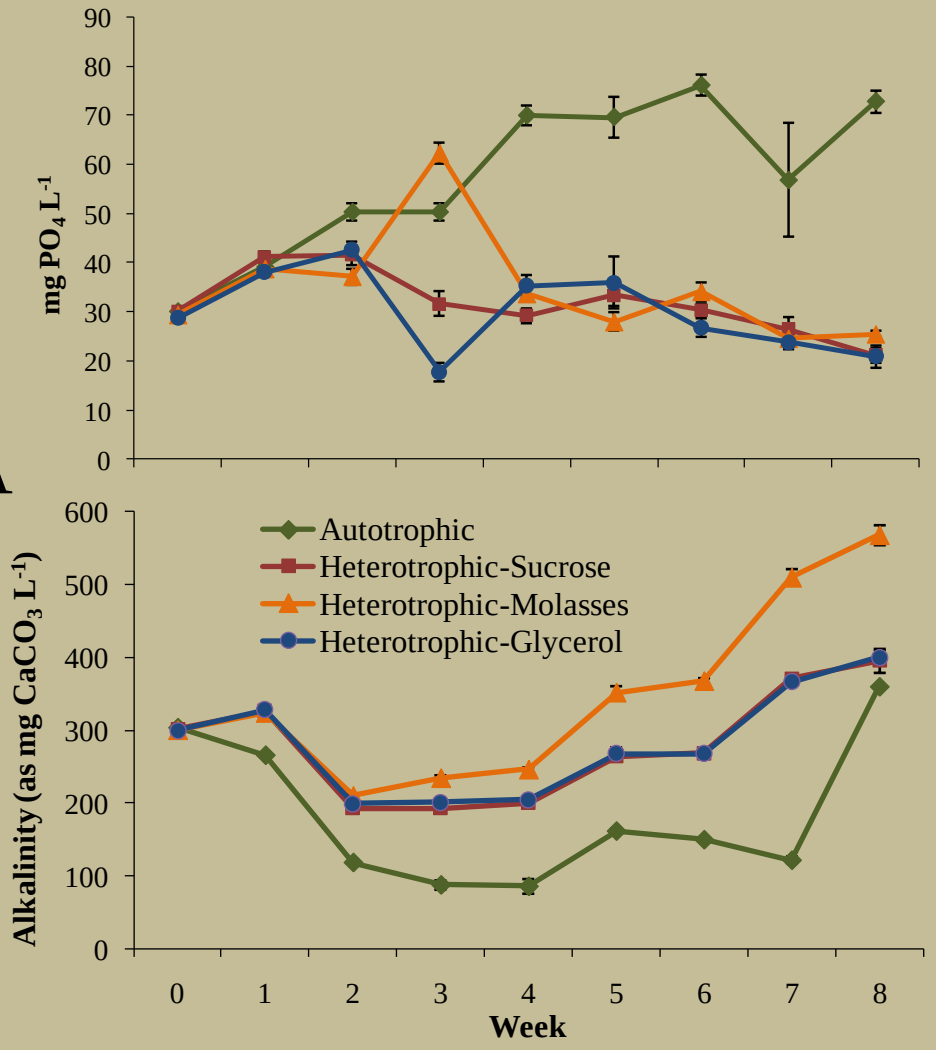
Results

- TAN
  - ↑ in T-HM ($P \leq 0.03$)
- NO_2-N
  - T-A > T-HG ($P = 0.05$)
- NO_3-N
  - Final Sample Date
  - ↑ T-A ($P \leq 0.01$)

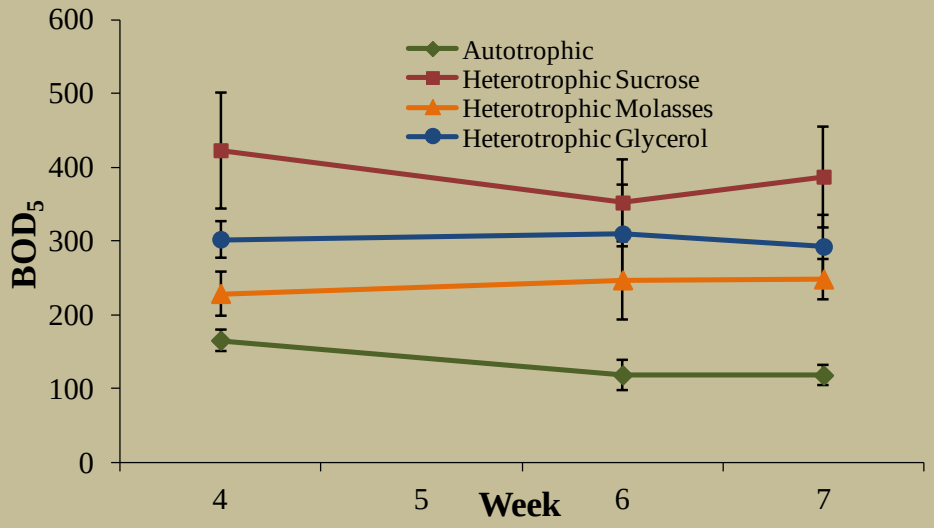


Results

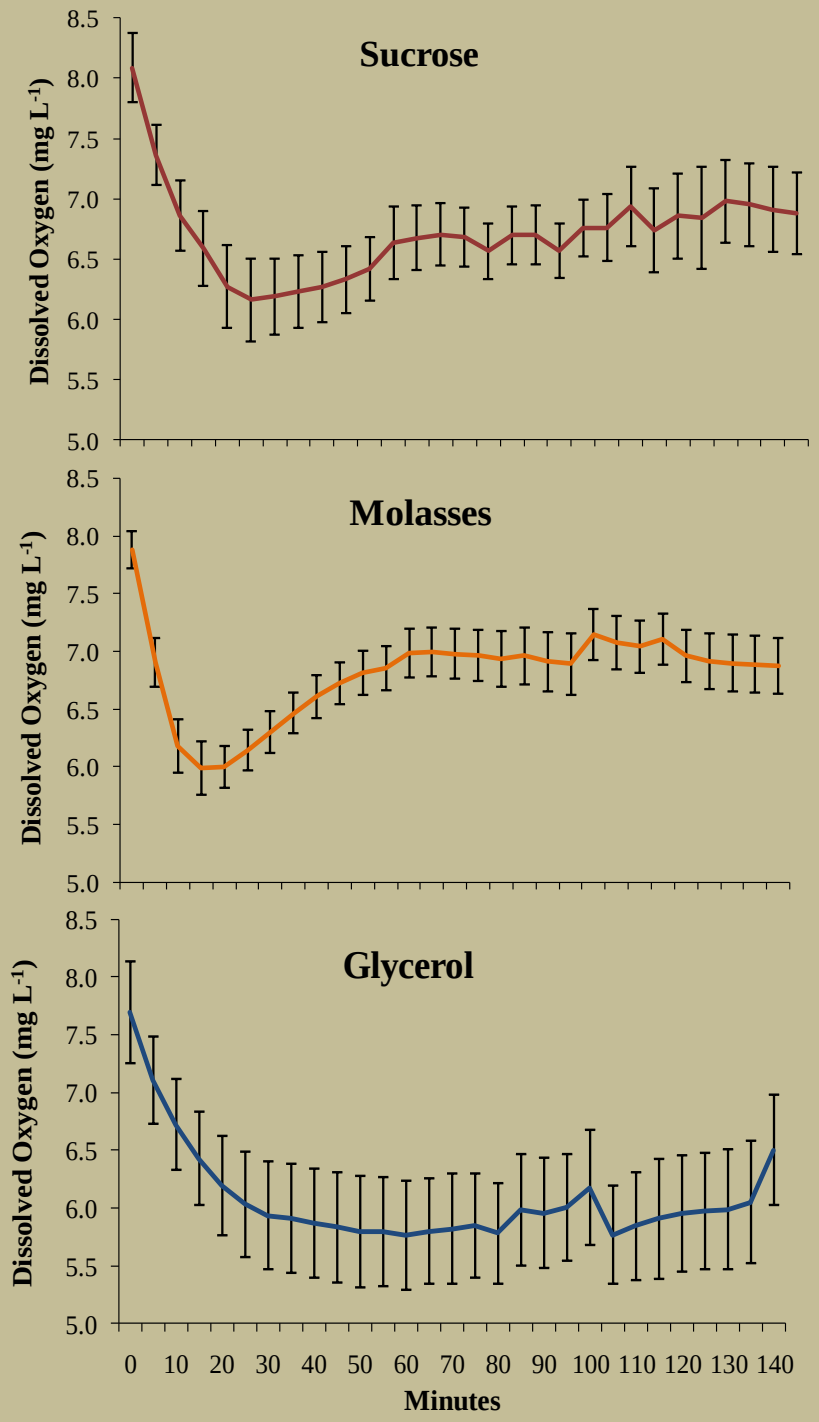
- PO_4 (dissolved, reactive)
  - ↑ in T-A ($P \leq 0.01$)
- Alkalinity
  - T-HM > T-HS, THG > T-A ($P \leq 0.01$)



Oxygen

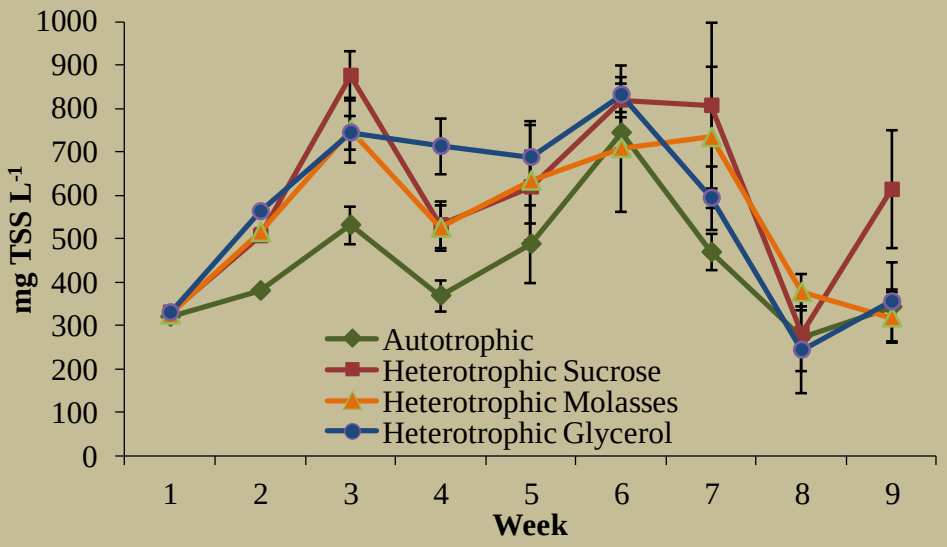


- BOD_5 (biochemical oxygen demand)
  - T-HS, T-HG > T-HM > T-A ($P \leq 0.04$)
- Oxygen Depletion ($N \geq 6$)
  - T-HS = 24% in 25 min.
  - T-HM = 24% in 15 min.
  - T-HG = 25% in 60 min.

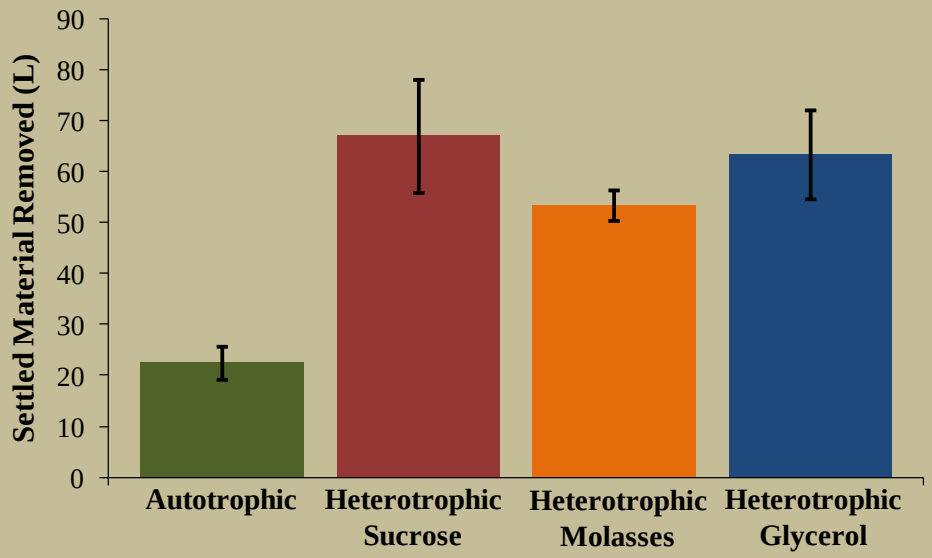


Solids

- Total suspended solids (TSS)
  - ↓ in T-A ($P \leq 0.02$)

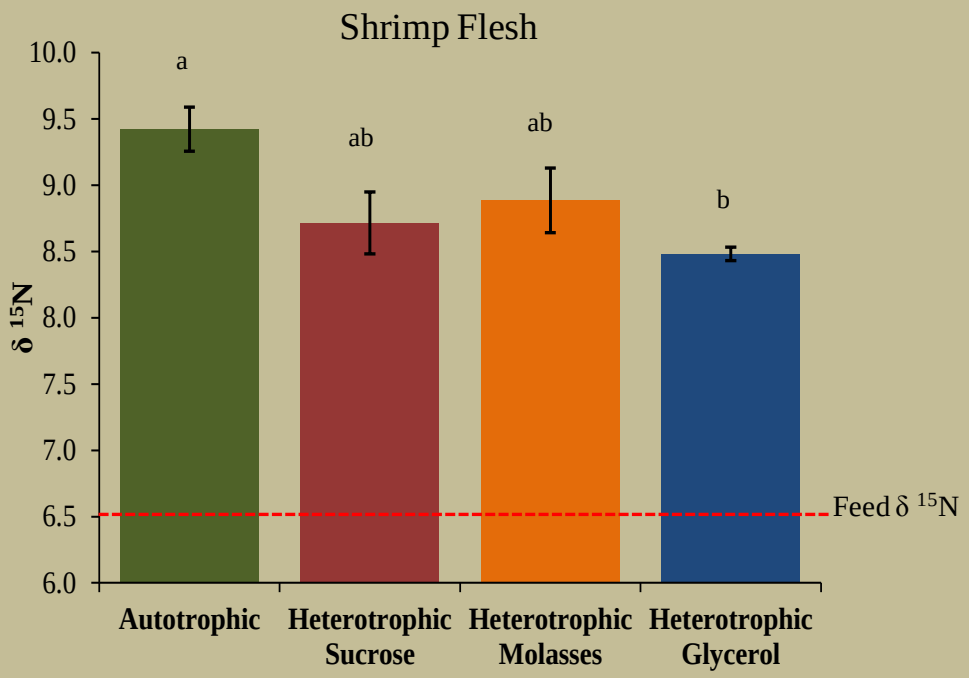


- Removed Solids
  - T-HS, T-HG > T-A, T-HM ($P \leq 0.01$)



Stable Isotope Values

- Apparent direct nitrogen enrichment from feed in T-A shrimp
- Lower δ ^{15}N values in heterotrophic treatments
  - Different N sources?



Summary

- Shrimp Production
  - No significant differences between autotrophic and heterotrophic
  - Very poor in molasses treatment
- Inorganic N
  - Carbohydrate stimulated N uptake
  - NH_3 spike in T-HM, NO_2 spike in T-A, NO_3 accumulation in T-A
- PO_4 ↑, Alkalinity ↓ in autotrophic treatment
- Oxygen
  - BOD ↓ in T-A, highest in T-HG, T-HS
  - DO drops quickly, recovers in T-HS, T-HM; gradual in T-HG
- Solids
  - Significantly less in T-A
- Stable Isotopes
  - Interesting, need further exploration

Thank You

Heterotrophic Glycerol | **Heterotrophic Molasses** | **Heterotrophic Sucrose** | **Autotrophic**

- This work was funded by The National Shellfisheries Association's Michael Castagna Student Grant for Applied Research and the United States Department of Agriculture's US Marine Shrimp Farming Program