A COMPARISON OF BIOFLOC, CLEAR-WATER, AND HYBRID CULTURE SYSTEMS FOR INTENSIVE SHRIMP (*Litopenaeus vannamei*) NURSERY PRODUCTION

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Inland Production of *L. vannamei*

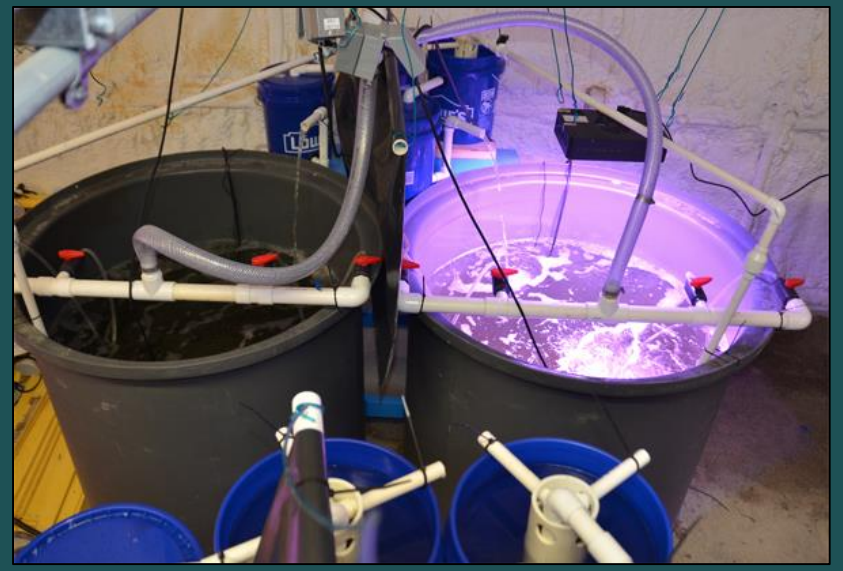
- Shrimp are the #1 seafood product consumed in the U.S.
  - About 4 lbs/person/year
- >85% imported
- Supply markets year round
- Food Safety
  - Hormones, antibiotics, environmental contaminants
- Inland production is sustainable, and provides enhanced biosecurity

Growing Industry

- Shrimp farms throughout the Country
- Unique opportunities
  - Higher quality seafood through controlled inputs
- Educational workshops
- Ziegler Bros Inc. selling feed to ~100 U.S. shrimp farms

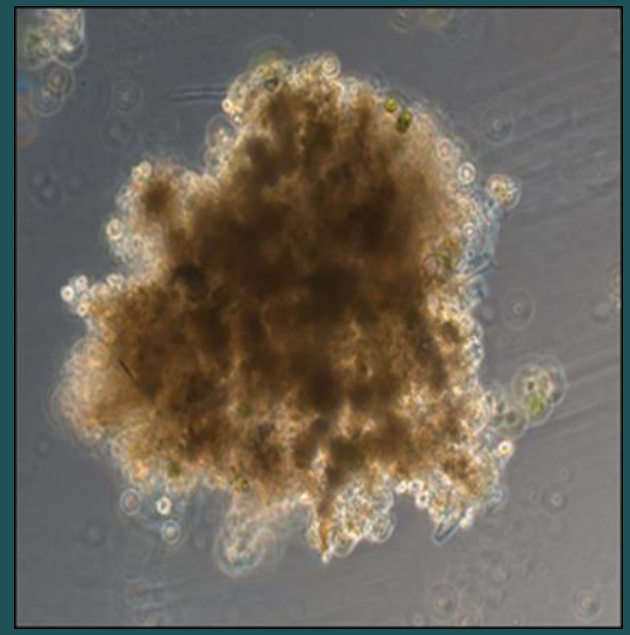
RECIRCULATING AQUACULTURE SYSTEMS (RAS)

- Closed Systems
- Typically indoor systems
- Minimal water exchange
  - < 1%
- Heat & salt conservation
  - Inland marine operation
- Biosecurity
- High stocking density



Biofloc (BF)

- Microbial community suspended in the water column
- Biofloc particles: algae, bacteria, protozoans, uneaten feed, and other organic matter
- Limited external filtration
  - Solids filtration common, but no external biofilter
- Nitrification (ammonia converted to nitrate) & biomass
- Provide supplemental nutrition
  - Lower FCR
- Intensive aeration, more inconsistent water quality

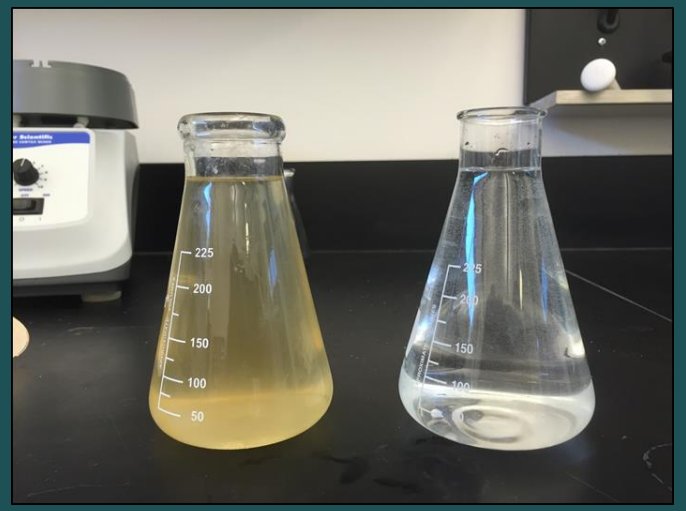


Clear-Water RAS (CW)

- Greater control of water quality, more filtration
  - Thorough solids removal
- Nitrification in external biofilter
- Reduced turbidity (NTU) in water column
- Scale of filtration matched to animal density
- Higher start-up costs

Hybrid RAS (HY)

- Can advantages from both biofloc and clear-water systems be integrated?
- Less solids filtration, but with external biofilter
- May provide nutritional benefits and good water quality
- Cost of system may be more practical

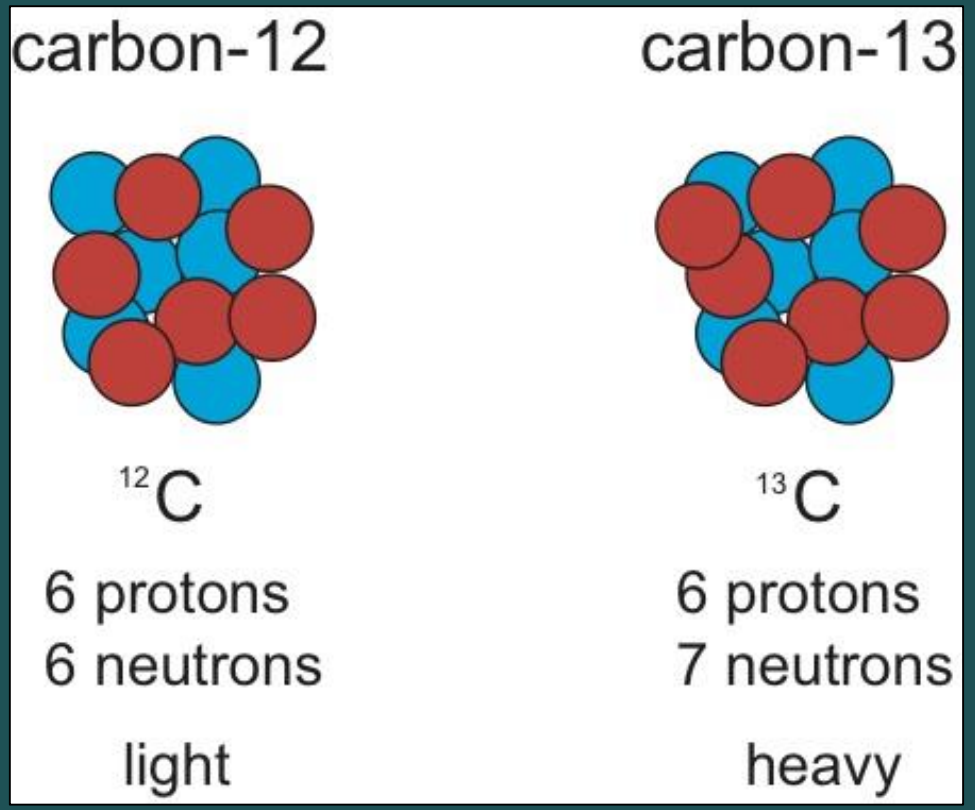


Nursery Production

- Extends culture season/ better yield
- Improve PL inventory
- Maximize space utilization
- Post-larvae (PL) → juvenile
- Biosecurity
- BF and CW systems have been utilized in nursery phase

Stable Isotope Ecology

- Stable isotope analysis → understanding nutritional contribution from biofloc & feed
- Different number of neutrons in the nucleus
- Heavy/light ratio
- Lighter isotopes are excreted
- Heavier isotopes are retained in animal tissue
- Carbon (13C) & Nitrogen (15N)
- Animal tissue vs. potential food sources

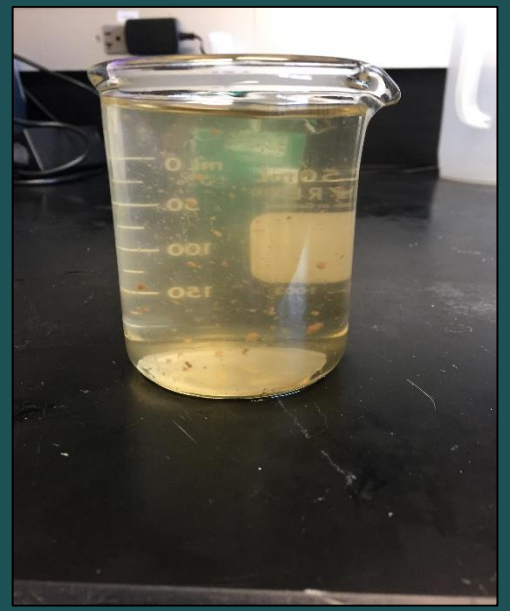


Stable Isotope Ecology

- **Del notation δ**

- **Fractionation Factor**
  - $\Delta = \delta Product - \delta Source$

- **Two-source mixing model:**
  - $f_1 = (\delta sample - \delta source2) / (\delta source1 - \delta source2)$
  - $f_2 = 1 - f_1$



Objectives & Experimental Design

- Examine differences between 3 types of RAS (BF, HY, CW)
  - Water quality
  - Shrimp production
  - Isotope dynamics
- Which system works best for nursery production

3 Treatments

- 1.) BF: settling chamber
- 2.) HY: settling chamber and biofilter (MBBR)
- 3.) CW: settling chamber, foam fractionator (FF), and biofilter (MBBR)
- Twelve 180-L tanks
  - 4 tanks per treatment
- HY included pseudo (FF), BF included pseudo (FF) and pseudo biofilter
  - Match water volume

Statistical Analysis

- Shrimp production
  - One-way ANOVA
- Water quality
  - Repeated Measures
- Final TAN, NO_2-N, NO_3-N
  - One-way ANOVA
- Stable Isotopes
  - One-way ANOVA
- $\alpha = 0.05$

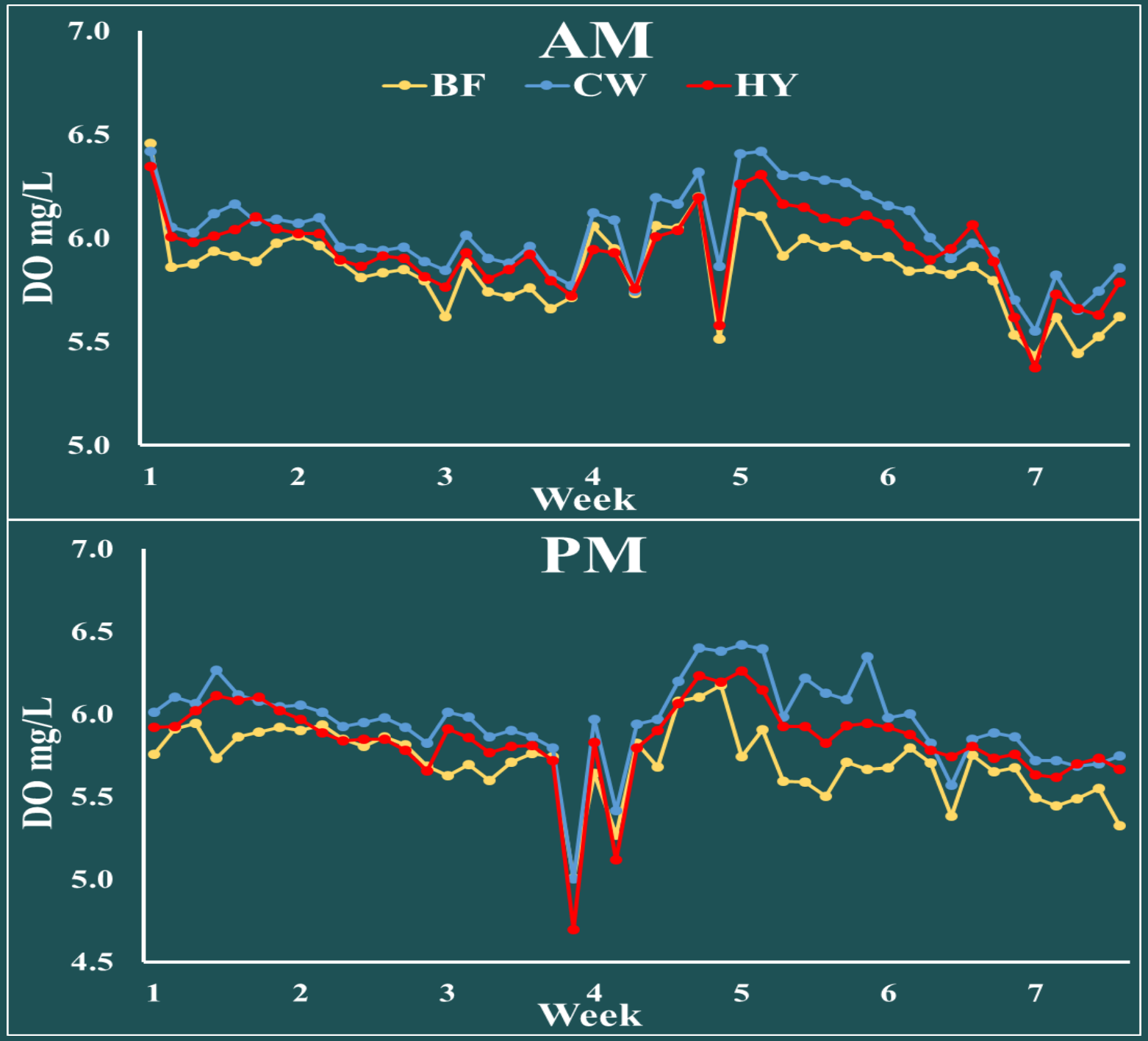
Management

- Duration: 48 days
- Initial weight = 7 mg
- 3,000 PL/m^3 → 480 per tank
- All tanks received equal feed
- ~12% biomass → 3% biomass
- 2x Daily: Temperature, DO, pH, and Salinity
- 1x a week: Total ammonia nitrogen (TAN), Nitrite (NO_2-N), Nitrate (NO_3-N), and turbidity (NTU)

DO

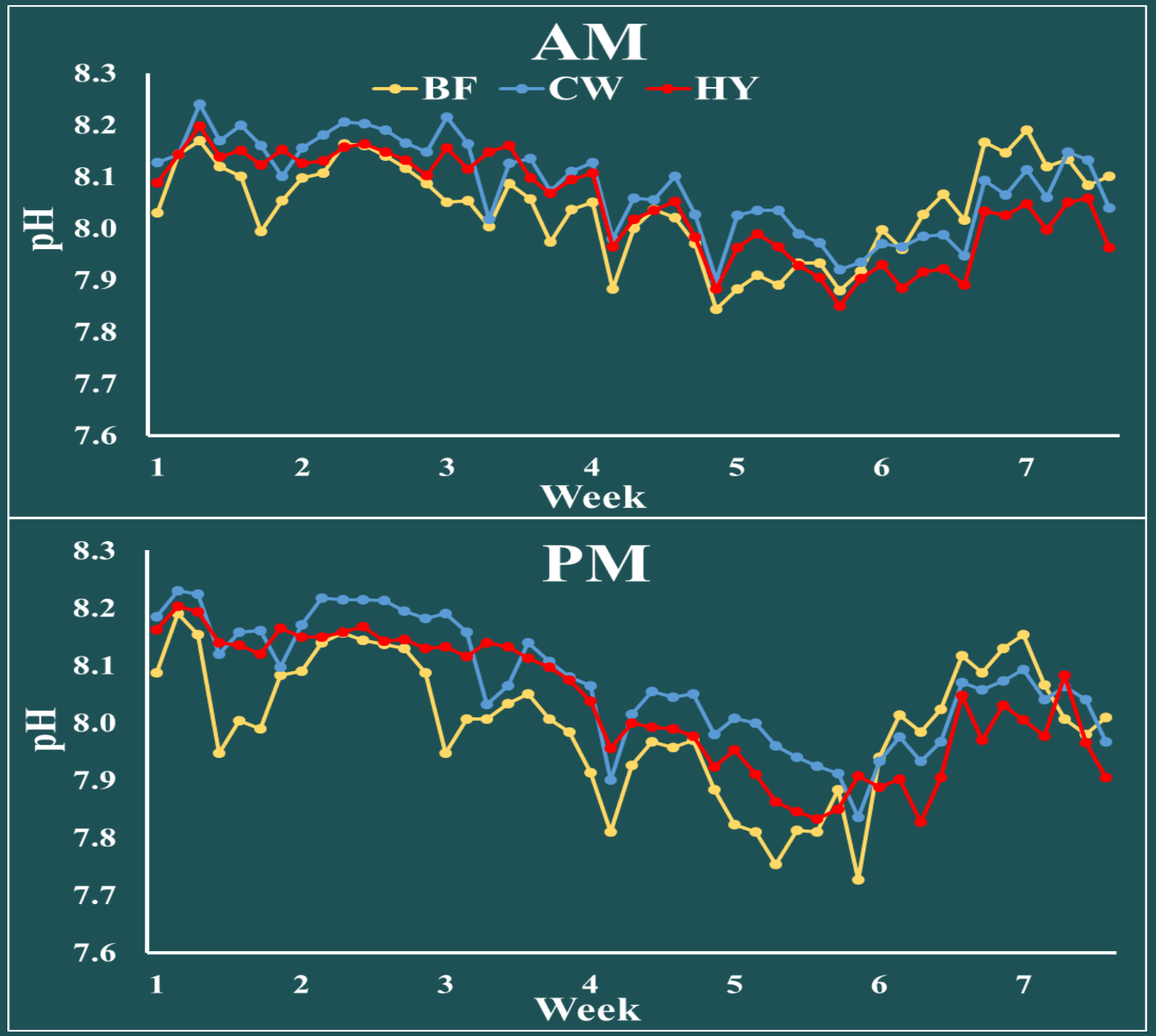
- Significant differences between all treatments

- CW > HY > BF

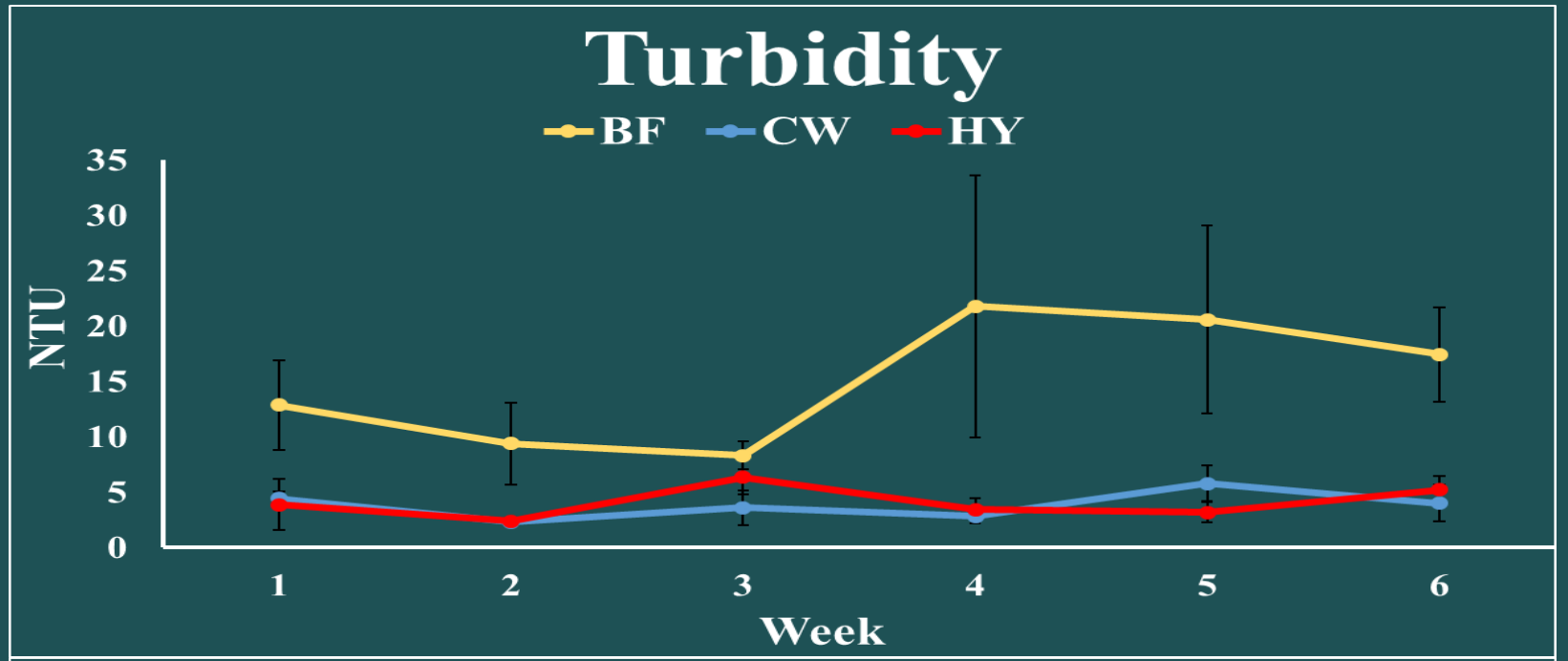


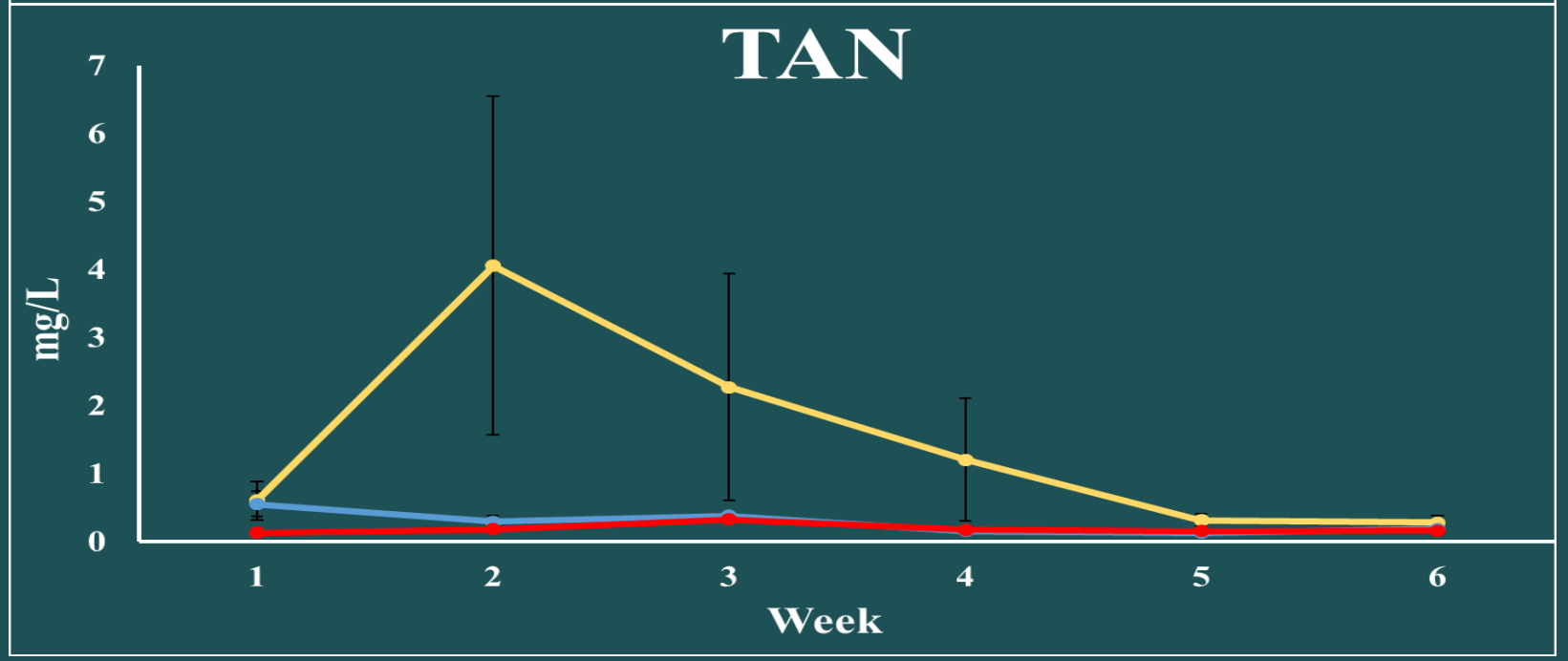
pH

- CW > BF, HY for AM data
- CW > HY > BF for PM data
- Bicarbonate added when pH < 7.8



- **BF significantly higher turbidity than HY, CW**
- **No significant differences found with TAN**





- NO_2 over duration

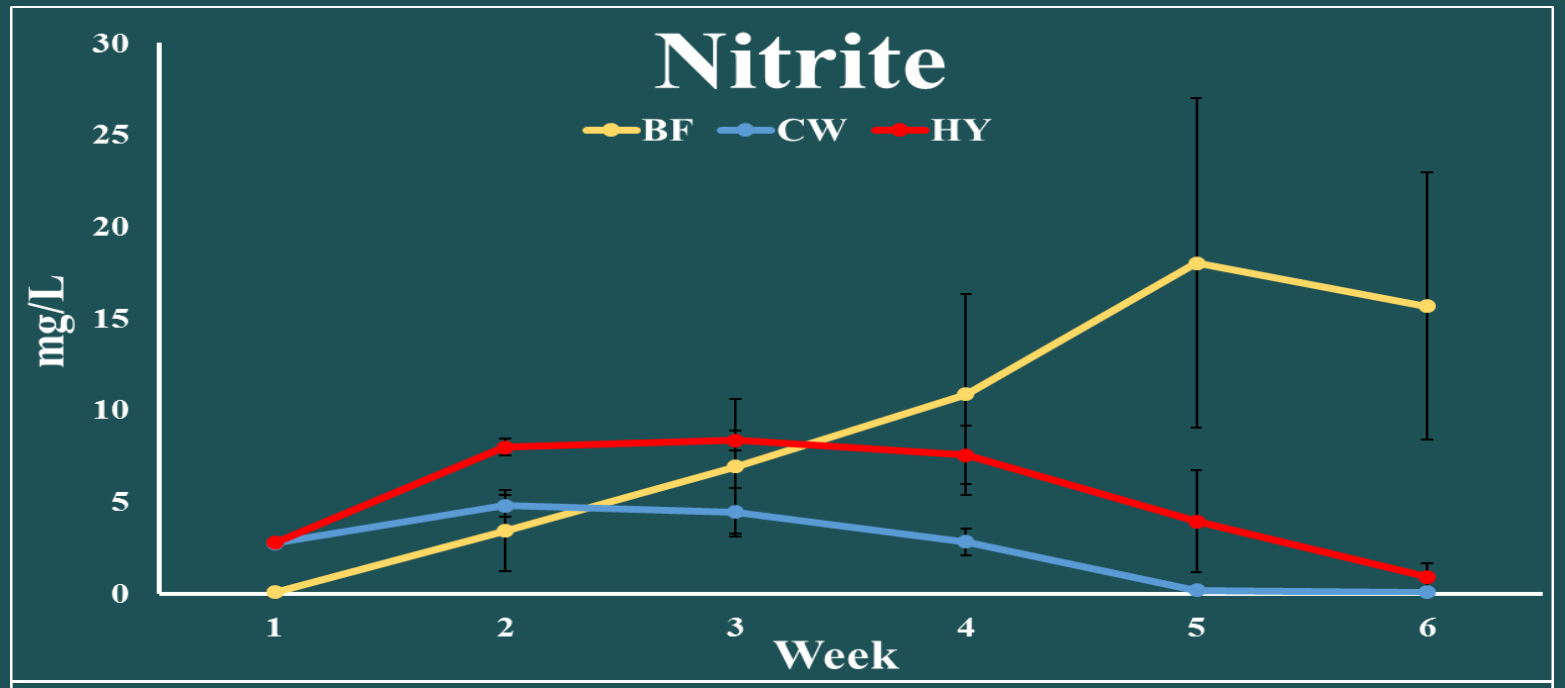
  HY > CW

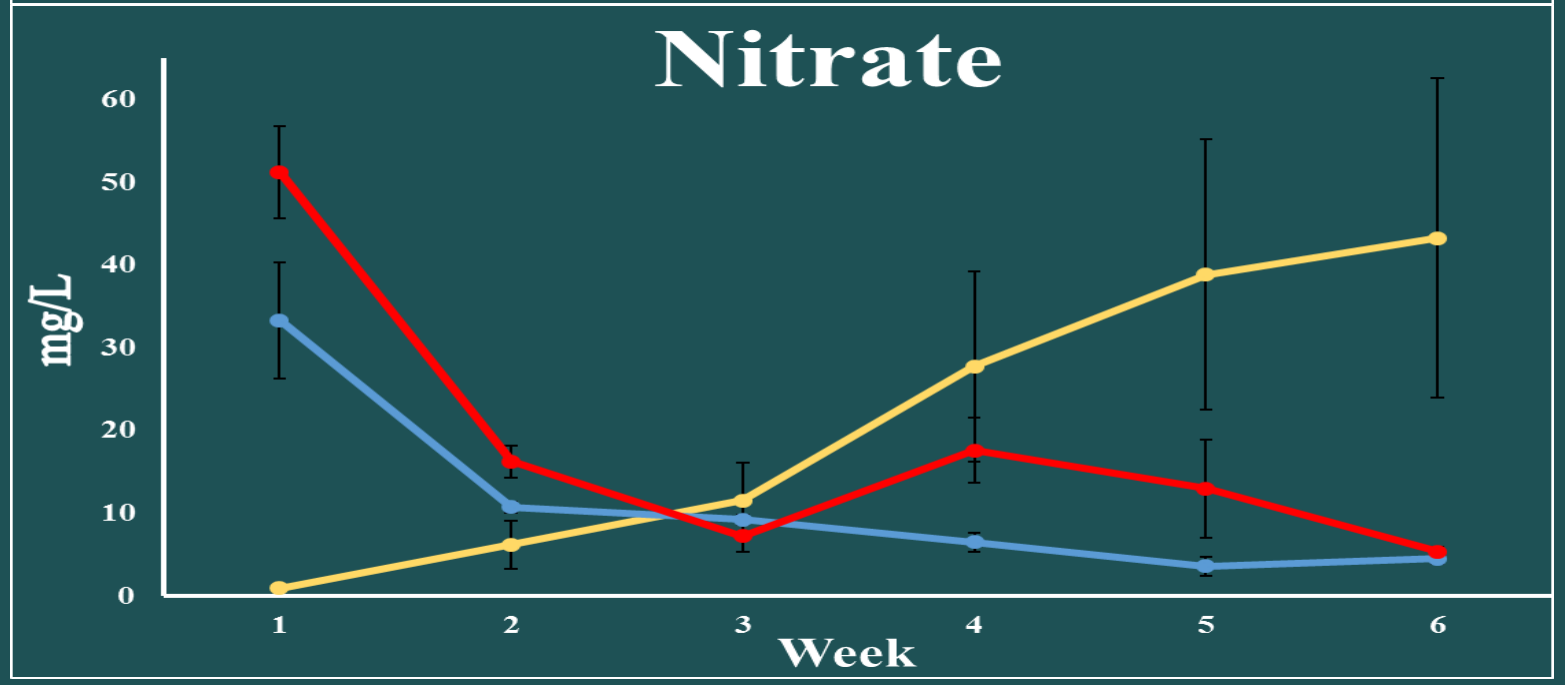
- No differences with NO_3 over time

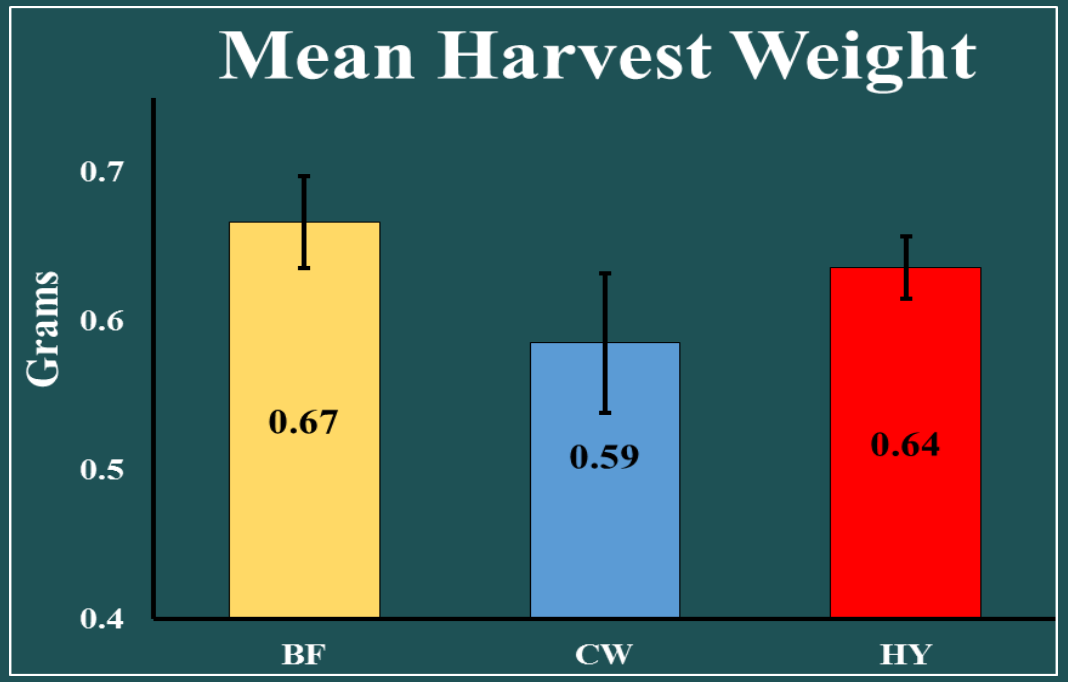
- NO_2 & NO_3 on Final date

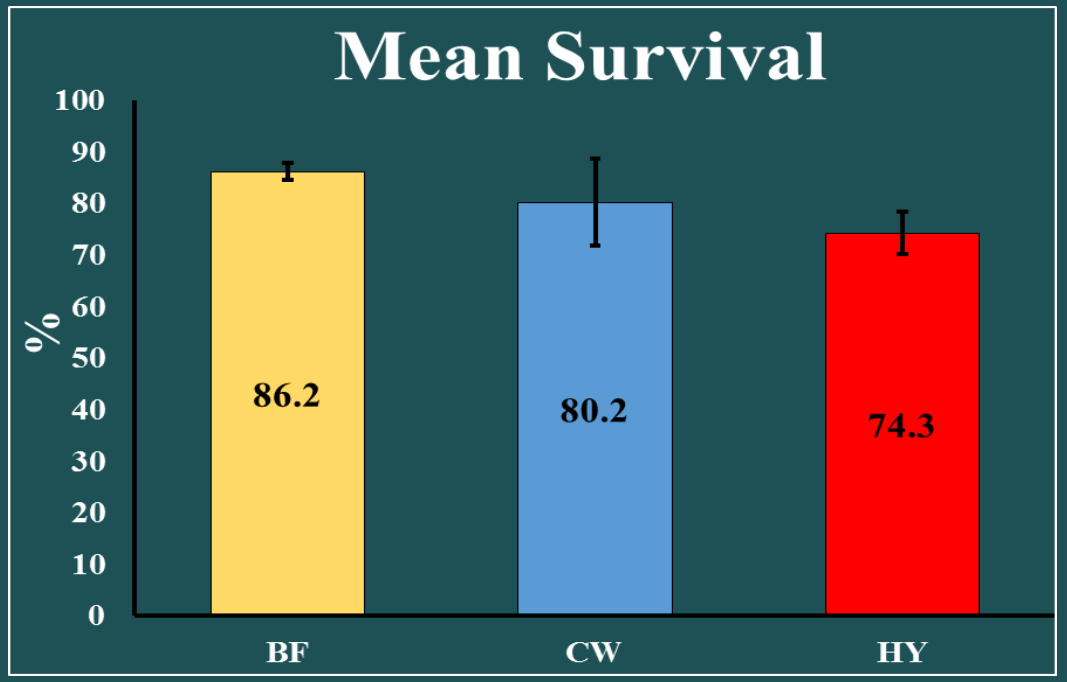
  BF > CW, HY

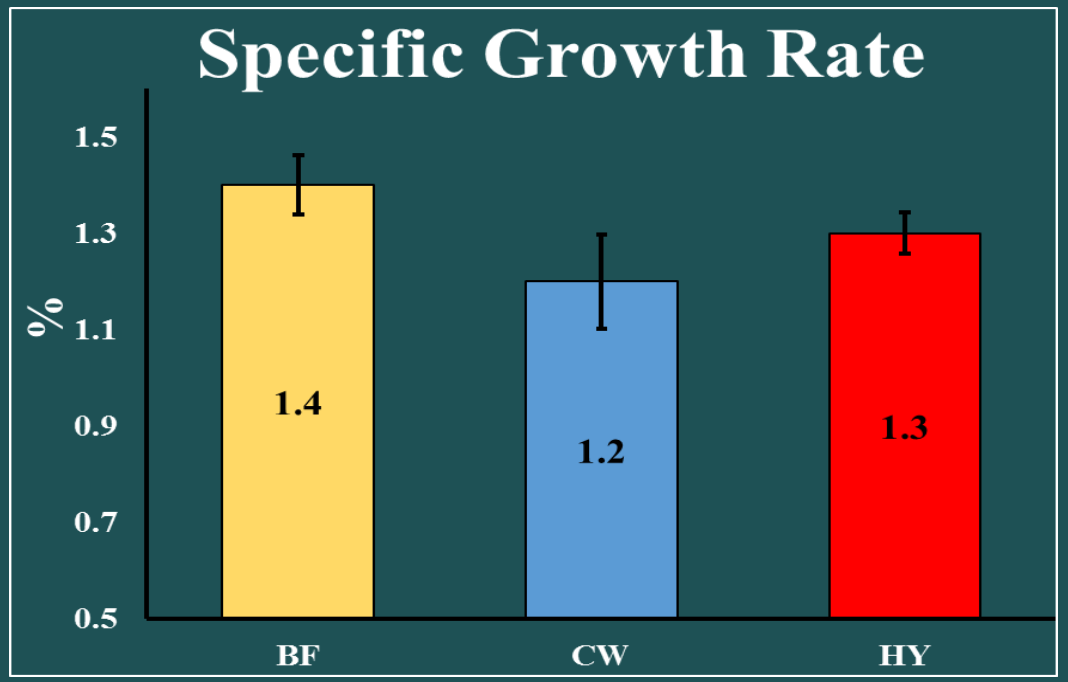
- Possible denitrification in CW and HY?

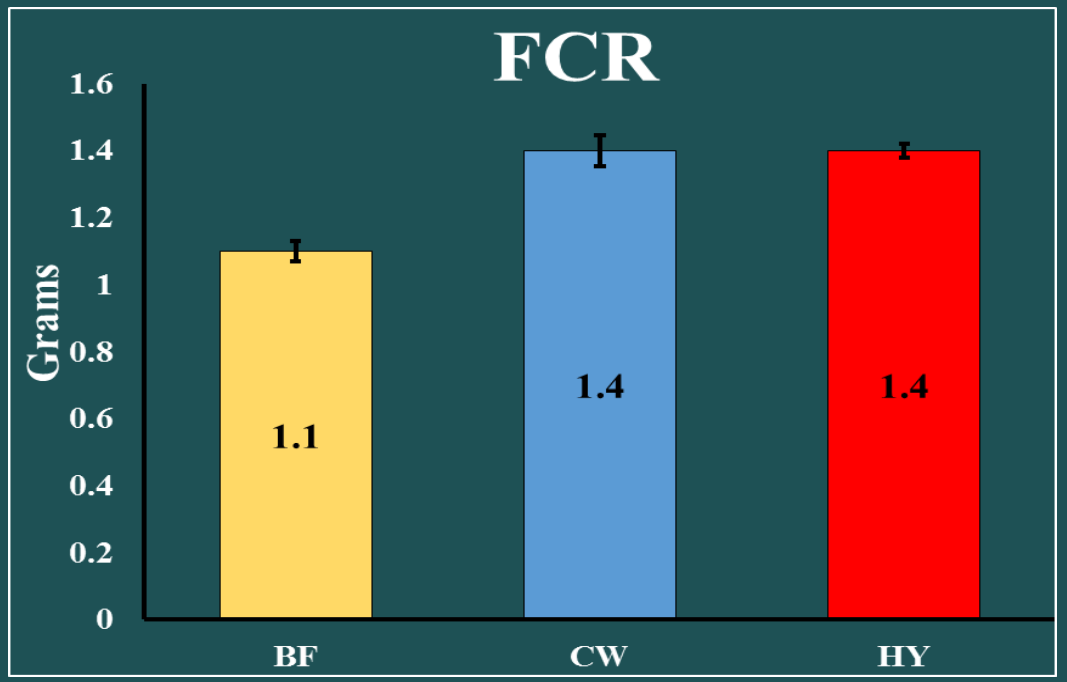





Mean Harvest Weight
Grams
0.7
0.6
0.5
0.4
0.67
0.59
0.64
BF
CW
HY


Mean Survival
%
100
90
80
70
60
50
40
30
20
10
0
86.2
80.2
74.3
BF
CW
HY

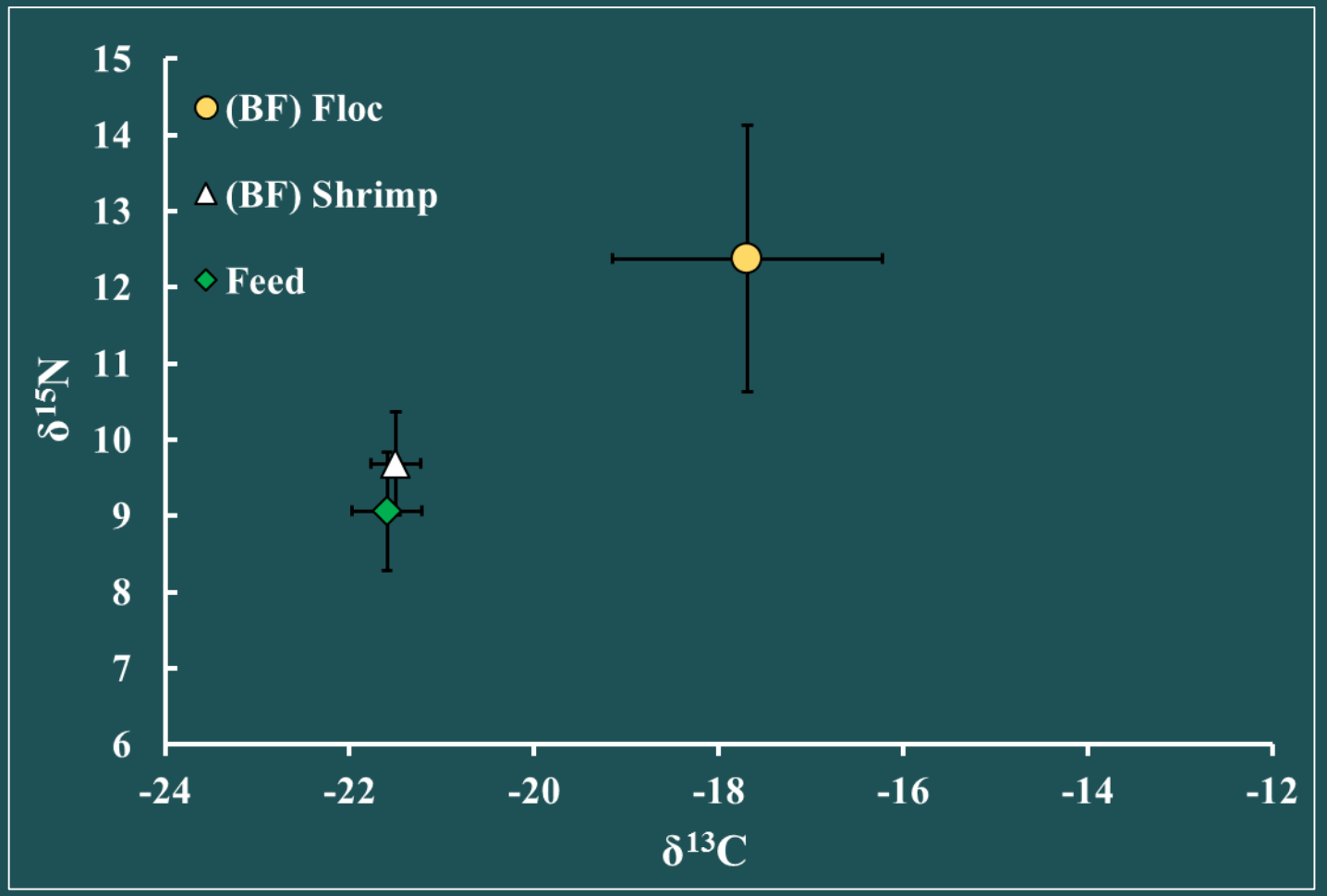

Specific Growth Rate
%
1.5
1.3
1.1
0.9
0.7
0.5
1.4
1.2
1.3
BF
CW
HY


FCR
Grams
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1.1
1.4
1.4
BF
CW
HY

Stable isotope analysis

	$\delta^{13}C$	$\delta^{15}N$
BF Shrimp	-21.7 ± .3	10.1 ± 0.7^{a}
CW Shrimp	-22.2 ± .2	9.1 ± 0.3^{b}
HY Shrimp	-22.2 ± .1	9.3 ± 0.2^{b}

- No differences between treatments in $\delta^{13}C$
- BF > CW, HY in $\delta^{15}N$



	Feed (%)	Floc(%)
Carbon	86.5	13.4
Nitrogen	66.0	33.9

Conclusions

- No significant differences in shrimp production
  - BF was slightly better though
- Significantly lower DO, pH and higher turbidity corresponding to less filtration
- Higher Nitrite in HY vs. CW
- Final date = BF > HY, CW for both NO_2 and NO_3
- Denitrification with HY & CW?
- BF > CW, HY in $\delta\ ^{15}N$

Implications

- All methods are suitable for nursery production

- Similar Production
  - Use biofloc → lower startup costs?

- However, lower DO + pH, nitrogen cycling concerns
  - Carbohydrate and bicarbonate additions?

- Filtration & consistency?

Future Investigations

- Economic analyses between treatments
- Growout production
- How to increase crude protein in the biofloc material
  - Biofloc material used as an alternative feed supplement may reduce feed costs?

Thank You!

- **Funding = USDA-NIFA**
- **Aquaculture Production Sciences Lab**

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