Strategies to Control Biofloc Production in Zero to Limited Water Exchange Shallow Water Indoor Nursery Systems

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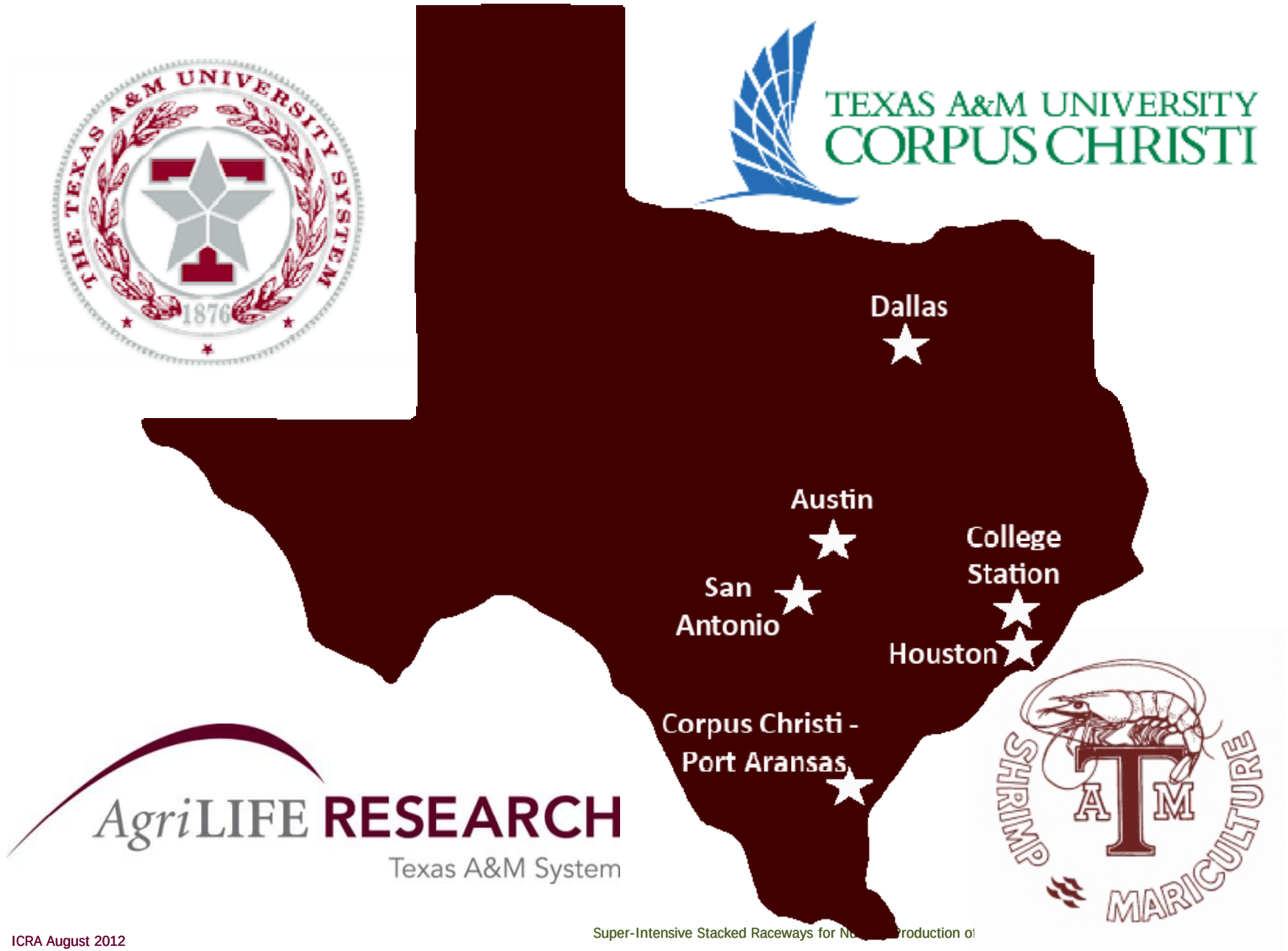
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Production Trial Objectives

- To produce the optimal number of juvenile *Litopenaeus vannamei* in a limited water volume during a four week period.
- Establish a reliable methodology for starting biofloc in clear water.
- Test the dilution of biofloc by limited water exchange.
- Test limiting the production of biofloc in zero water exchange systems by adjusting feed application.

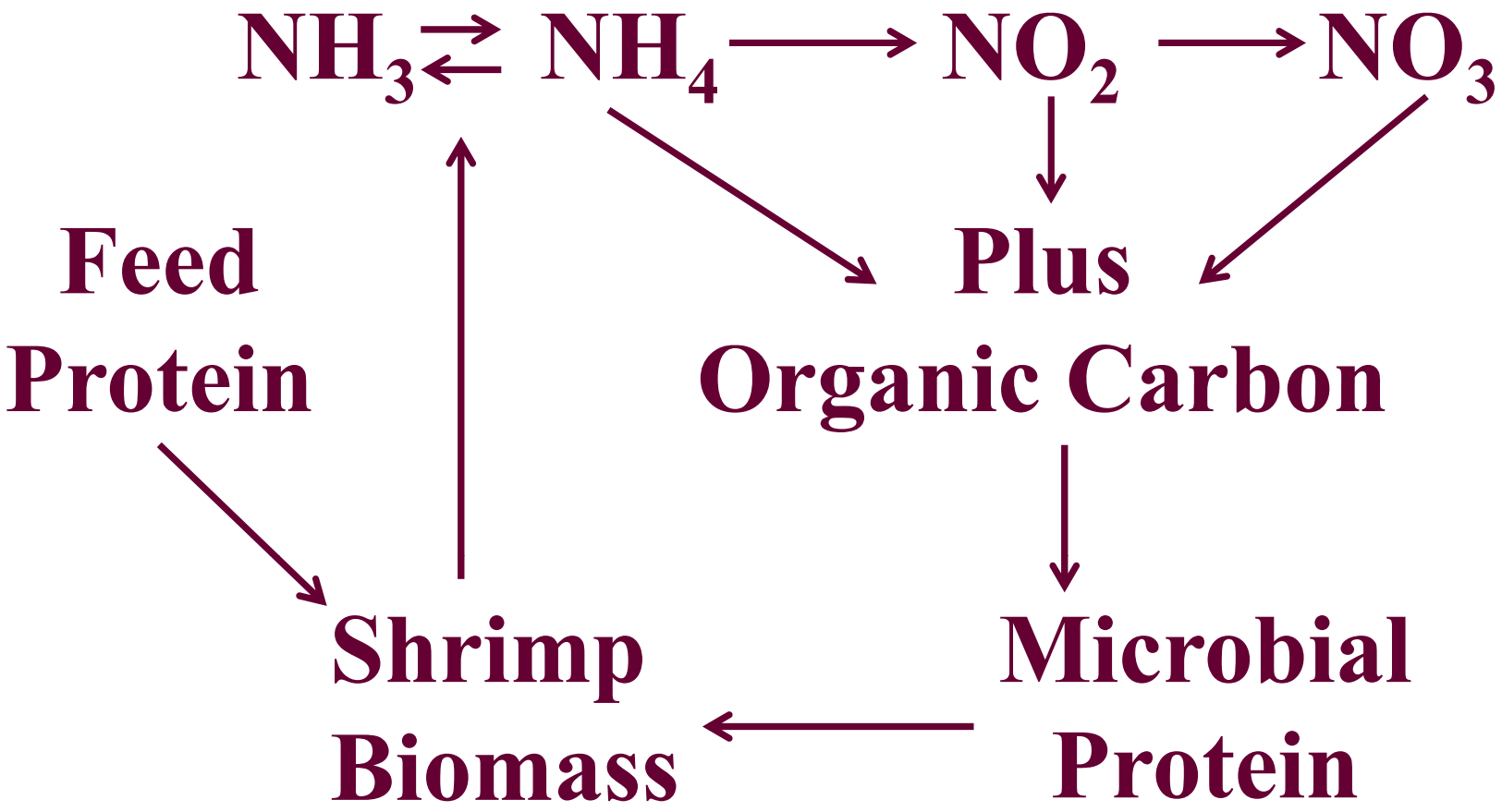
Biofloc Systems:

- Provide a media upon which bacteria colonize.
- Recycle un-utilized feed by microbial heterotrophic processes. (Avnimelech, 2009)
- The retention of nitrogen in shrimp contributed by biofloc can be significant. (Burford, et al, 2004)

Bacterial Dominance

- **There are no totally autotrophic or heterotrophic controlled systems. There is always a mix of the two.** **(Avnimelech, 2009)**
- **Autotrophic bacteria use CO_2 as a carbon source and Heterotrophic bacteria utilize organic carbon.**
- **If Autotrophic bacteria dominate a system the result will be a high level of nitrates.**
- **If heterotrophic bacteria dominate a system, the result will be a high level of biofloc.**
- **Biofloc systems can be managed to promote either type of dominance.**

Nitrogen Pathways Affecting Biofloc



- **Autotrophic bacteria generate energy and produce cell material through the oxidation of NH_4 and NO_2 and the reduction of CO_2. The energy yield of NH_4 or NO_2 oxidation is very low and only about 10-14% is converted to cell material. The generation period for autotrophs is in the order of 12 hours.[1]**

- **Heterotrophic bacteria assimilate inorganic nitrogen to cell material through a process that has a 50% conversion efficiency. The generation period of heterotrophs is about 30 minutes.[1]**

([1] Yoram Avnimelech, *Biofloc Technology, a practical guide book*, 2009)

Biofloc level in a system is important:

- Not enough biofloc in a limited or zero water exchange system will result in poor water quality.
- Too much biofloc in a limited or zero water exchange system will result in a management problem.

Autotrophic Nitrifying Bacteria Were Selected to be Dominant

- **Autotrophic bacteria create less biomass than heterotrophic bacteria.**
- **High biofloc production levels require special equipment for control.**
- **Autotrophic dominant bacteria can be rapidly started up.**

- **Autotrophic bacteria produce nitrates.**
- **At typical seawater salinity NO_3-N up to 100 mg/l has not been proven to be toxic to shrimp.**
- **The nursery cycle has a relatively limited quantity of nitrogen applied to the system.**
- **Autotrophic dominant biofloc can be transformed to heterotrophic dominant biofloc if or when system management requires a change.**

- A steady state of biofloc is achieved within a few weeks if feed input is steady.[1]

- However, changes in feeding will affect the concentration of bioflocs.[1]

([1]Yoram Avnimelech, *Biofloc Technology, a practical guide book*, 2009)

Assumption:

- A steady state of biofloc can be obtained by manipulation of the feed rate.

Production Cycle NRS11-07

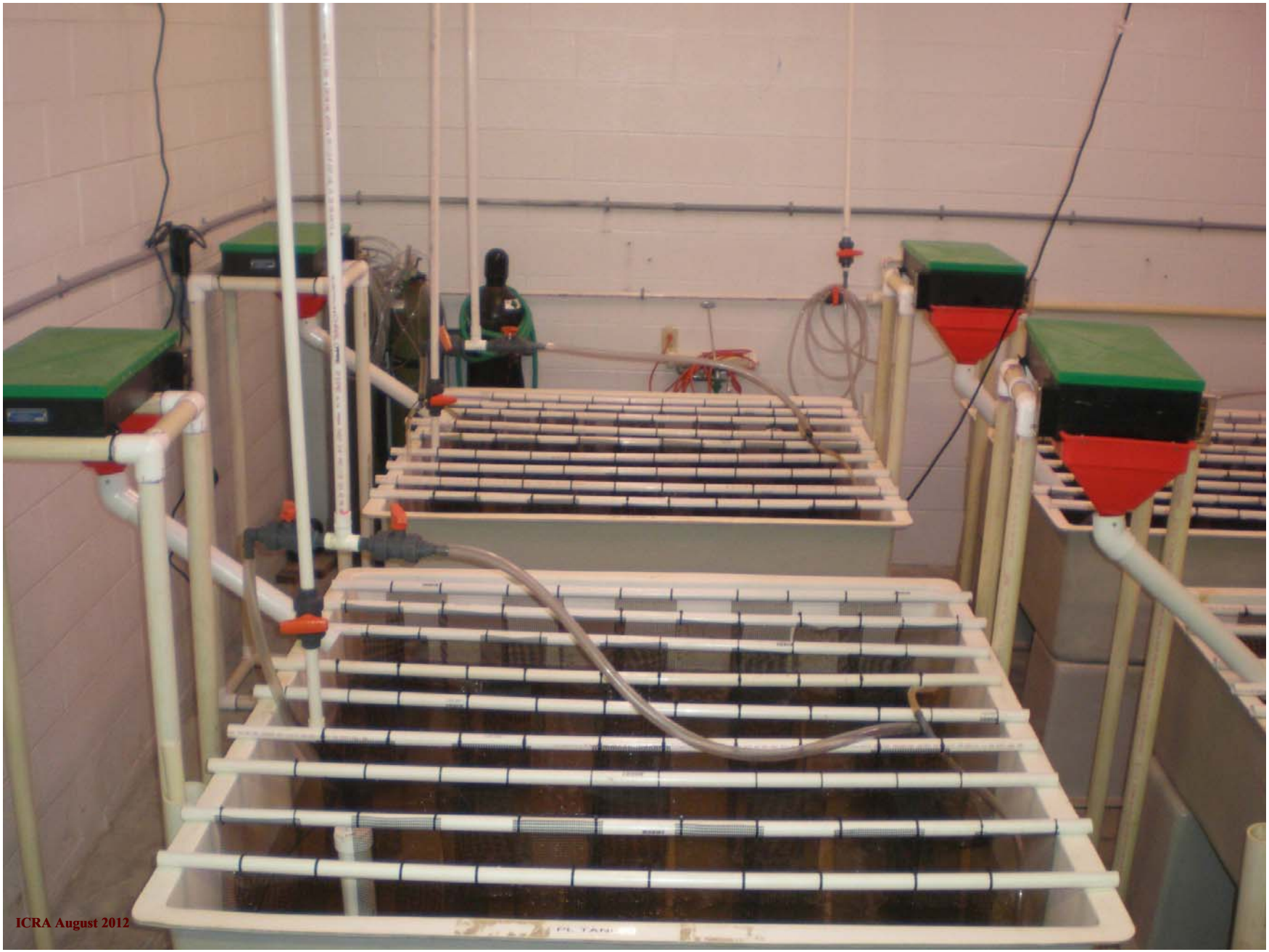
- Four 1.5 M square tanks were filled with 28 ppt seawater to a depth of 20 cm.
- They were stocked with PL_{12} *Litopenaeus vannamei* from SIS.
- Two tanks had a density of 19,445/m^3 (3,889/m^2)
- Two tanks had a density of 38,890/m^3 (7,778/m^2)

Parameters Monitored on a Daily Basis

TAN
NO_2-N
NO_3-N
pH
Dissolved O_2

Temperature
Salinity
Alkalinity
Settleable Solids

- **The tanks were inoculated with autotrophic nitrifying bacteria.**
- **Light level in the room where the tanks are located was maintained between 17 and 20 lux (lumens/m^2).**
- **No additional organic carbon was applied to stimulate the development of heterotrophic bacteria.**
- **The only organic carbon source was from the feed (40% protein with C:N ratio 8.1).**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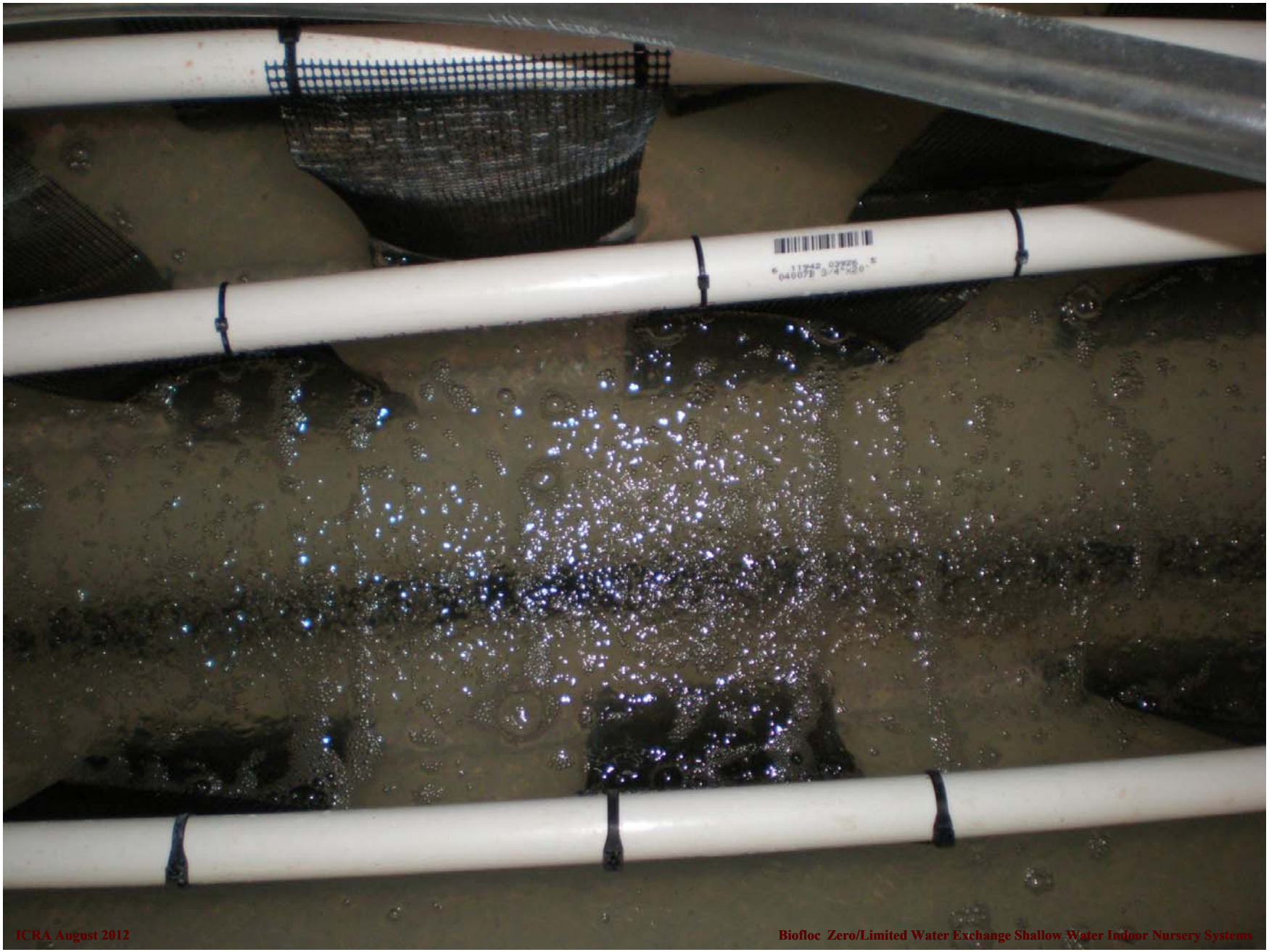

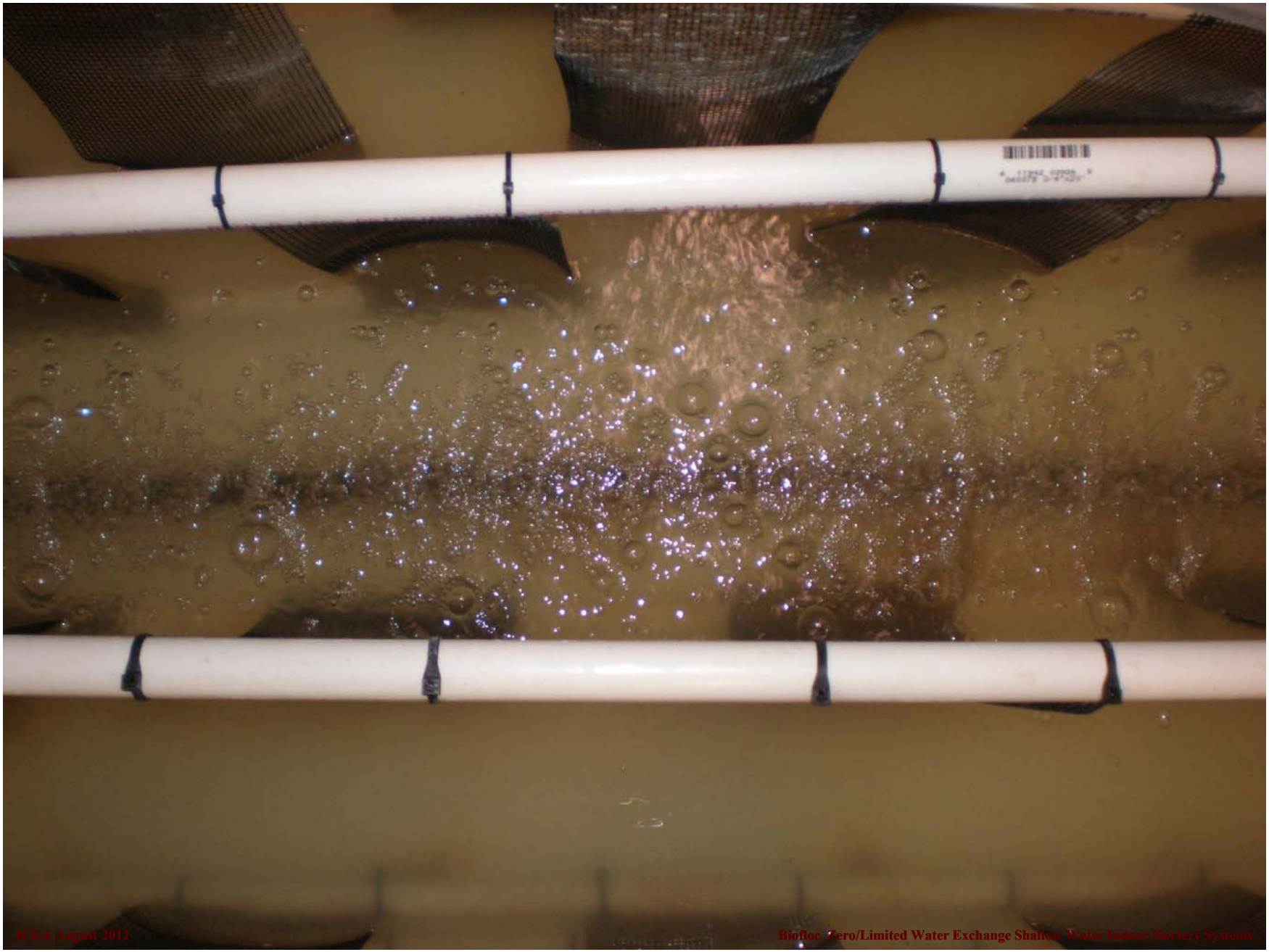

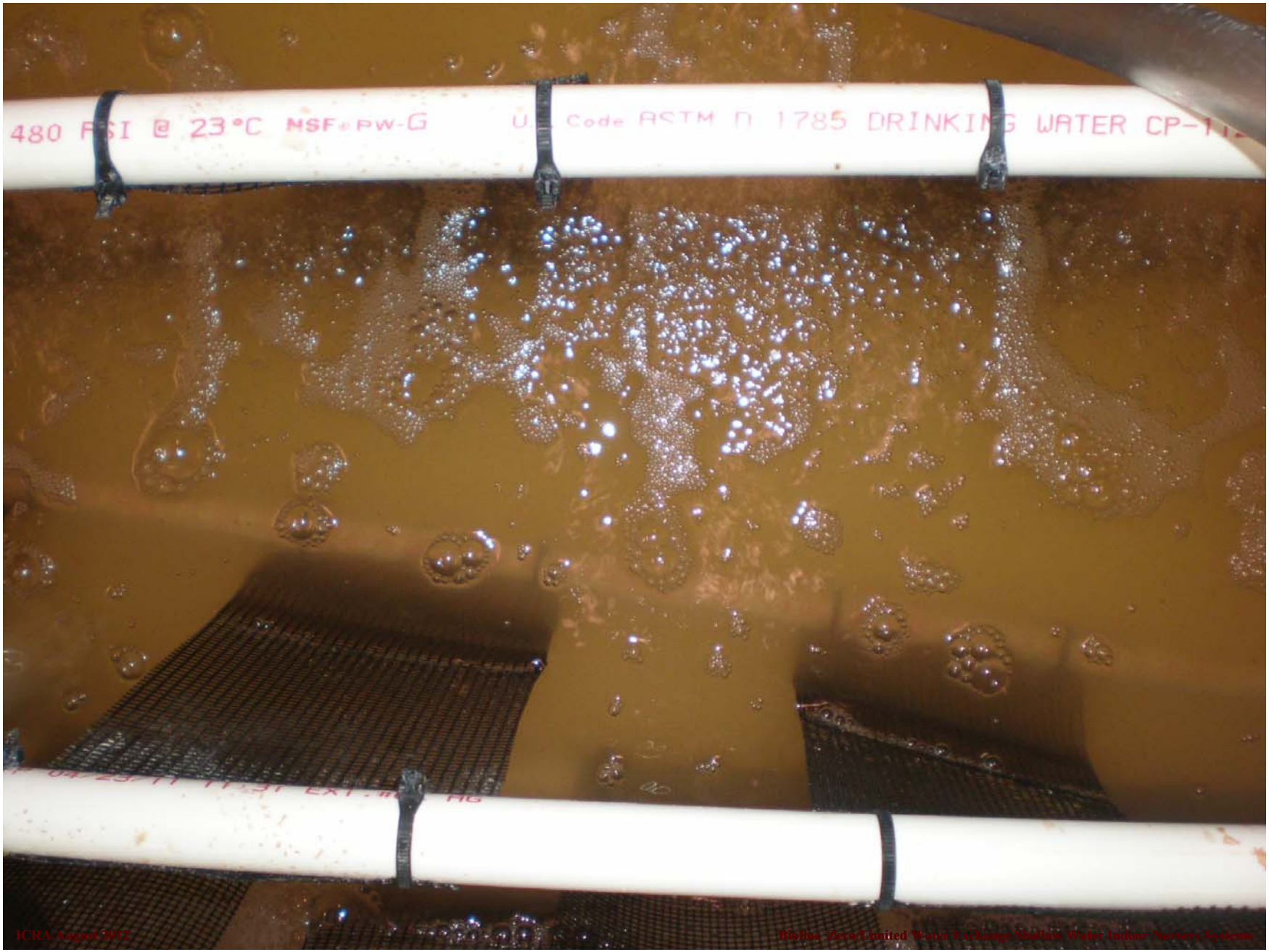
480 PSI @ 23°C NSF-PW-G
Code ASTM D 1785 DRINKING WATER


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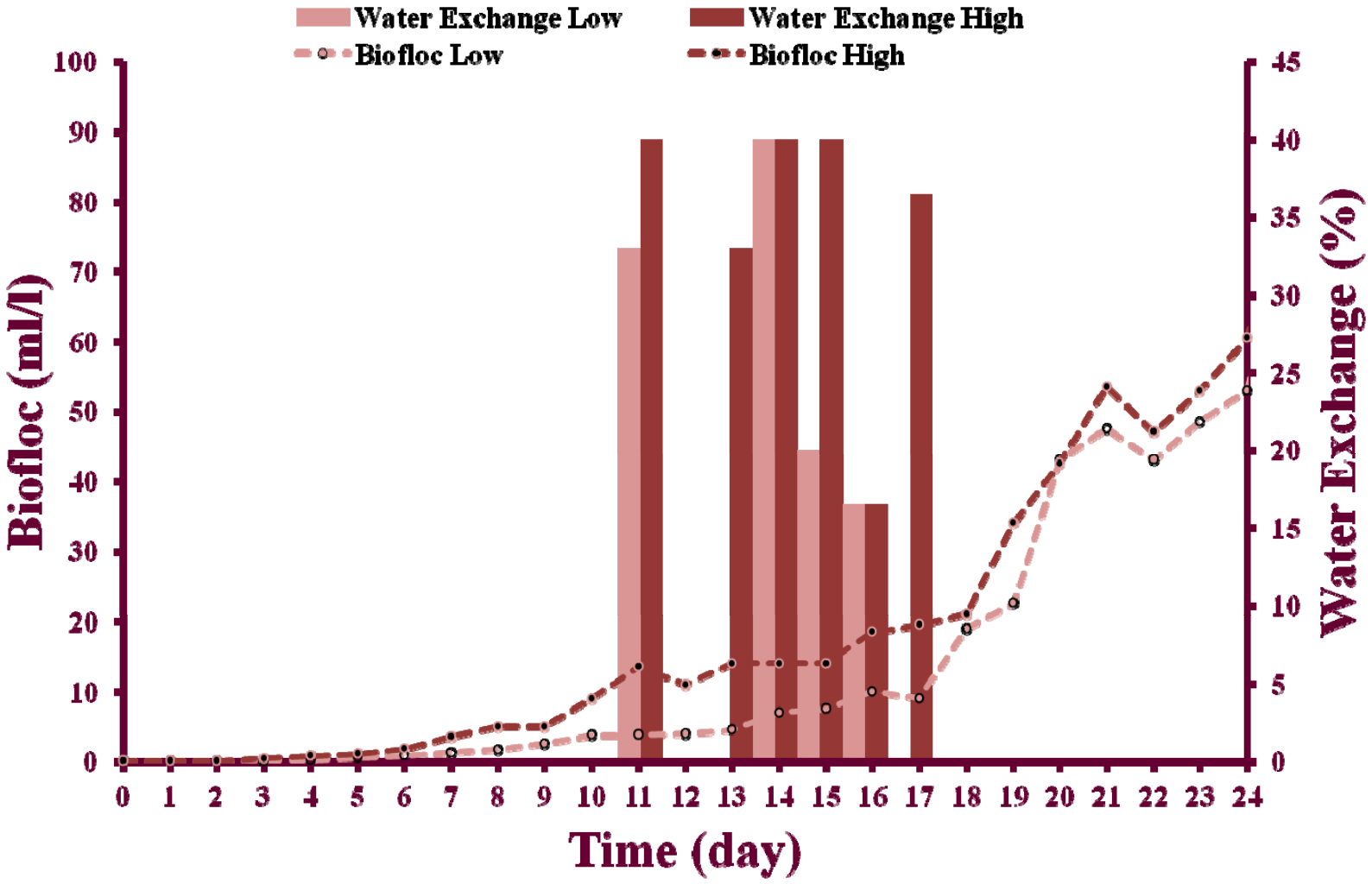
04007B 3/4"x20'
U.P. Code ASTM D 1785 DRINKING WATER CP-112-

Standards for Water Exchange

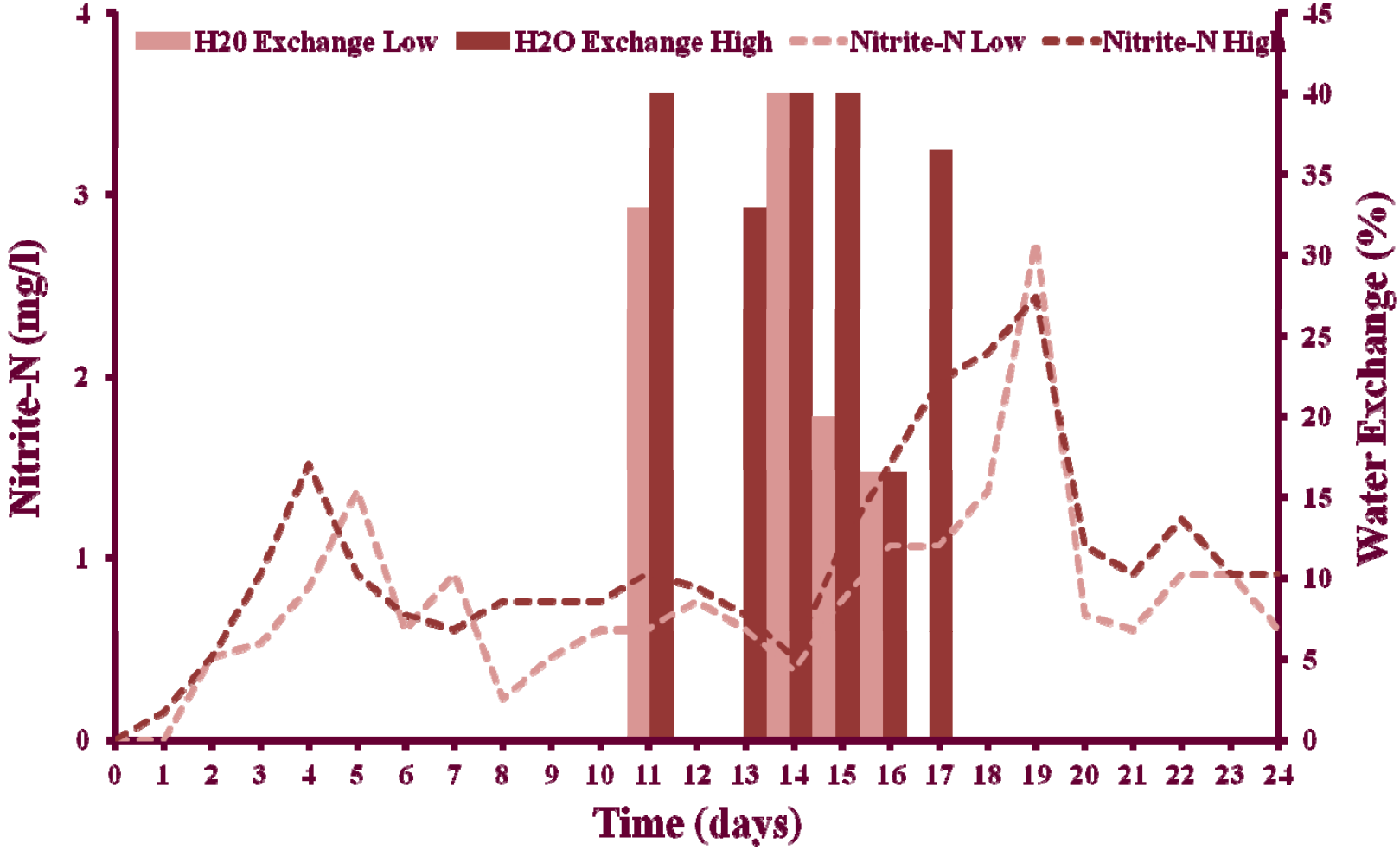
NO_3-N (mg/l)	Daily Batch Water Exchange (%)
18	33
36	40
45	50

Biofloc and Water Exchange VS. Time



Nitrite-N vs. Water Exchange

(means of 2 values)



- **Biofloc in a system being fed with a low C:N ratio (10:1 or less) has a higher level of protein.** (Yoram Avnimelech, Biofloc Technology, a practical guide book, 2009)

- **Biofloc protein does not have an optimal essential amino acid profile.** **(David Kuhn and Addison Lawrence, Biofloc Technology, a practical guidebook, second edition, 2012)**

- **However, biofloc will complement the nutritional value of the feed which is being applied.** **(Cheng-Sheng, L. O'Brien, P. (Eds.)** ***Microbial Approaches to Aquatic Nutrition within Environmentally Sound Aquaculture Production Systems,*** **2002)**

- **Shrimp production systems have been described in which a healthy and diverse microbial community and detritus likely contributed significantly to shrimp growth.**

(Cheng-Sheng, L. O'Brien, P. (Eds.) ***Microbial Approaches to Aquatic Nutrition within Environmentally Sound Aquaculture Production Systems,*** **2002)**

- **Assumption:**

  Biofloc in the juvenile production trial would very likely supplement nutritional requirements.

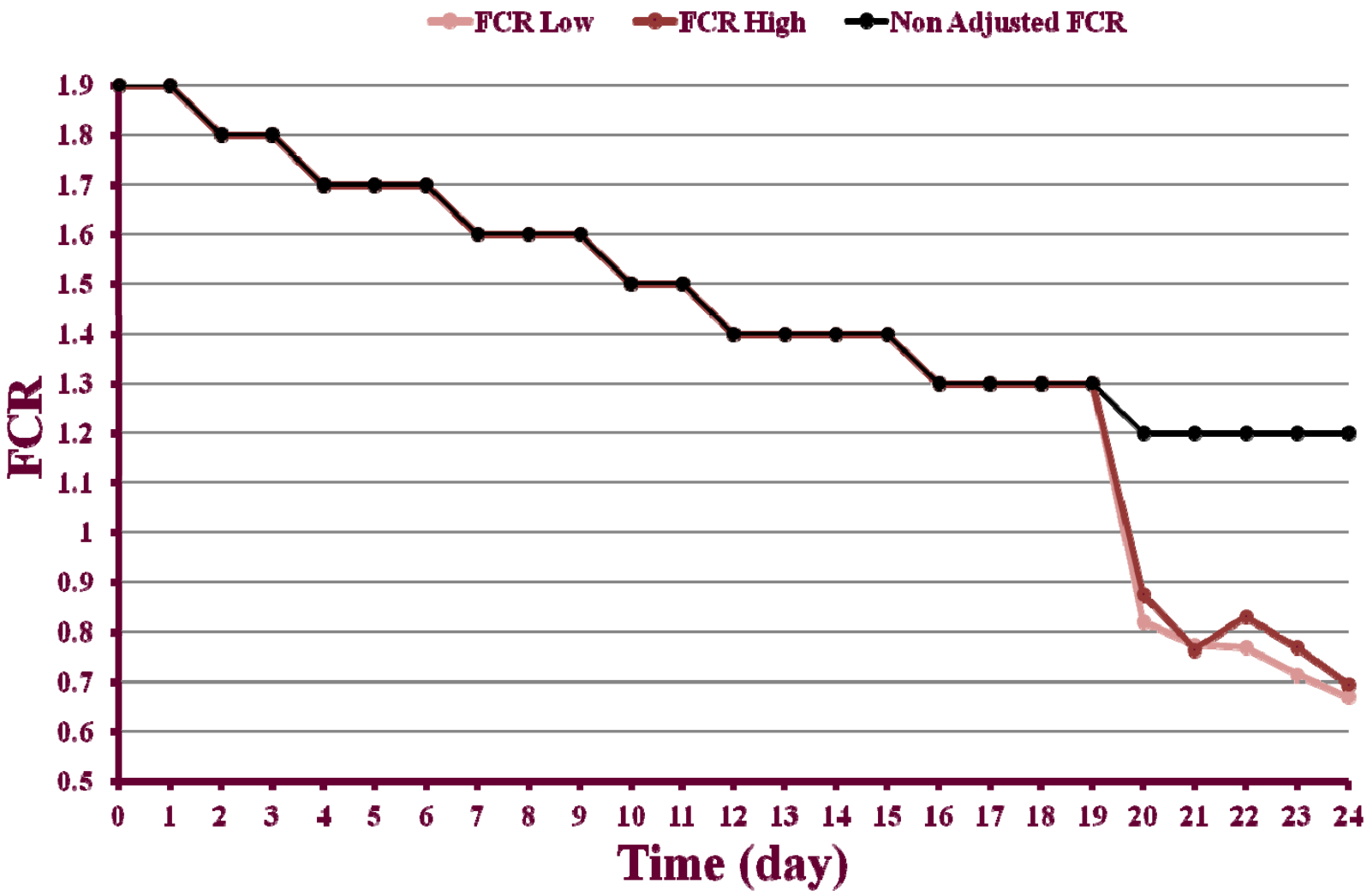
Traditional Feed Curves

- Number of animals adjusted daily, based on expected survival.
- An expected weight gain (EWG) per day taken into consideration.
- A sliding Feed Conversion Ratio (FCR) was decreased from 1.9 to 1.2 over 25 days.
- Amount of feed per day = number of animals X EWG X FCR.

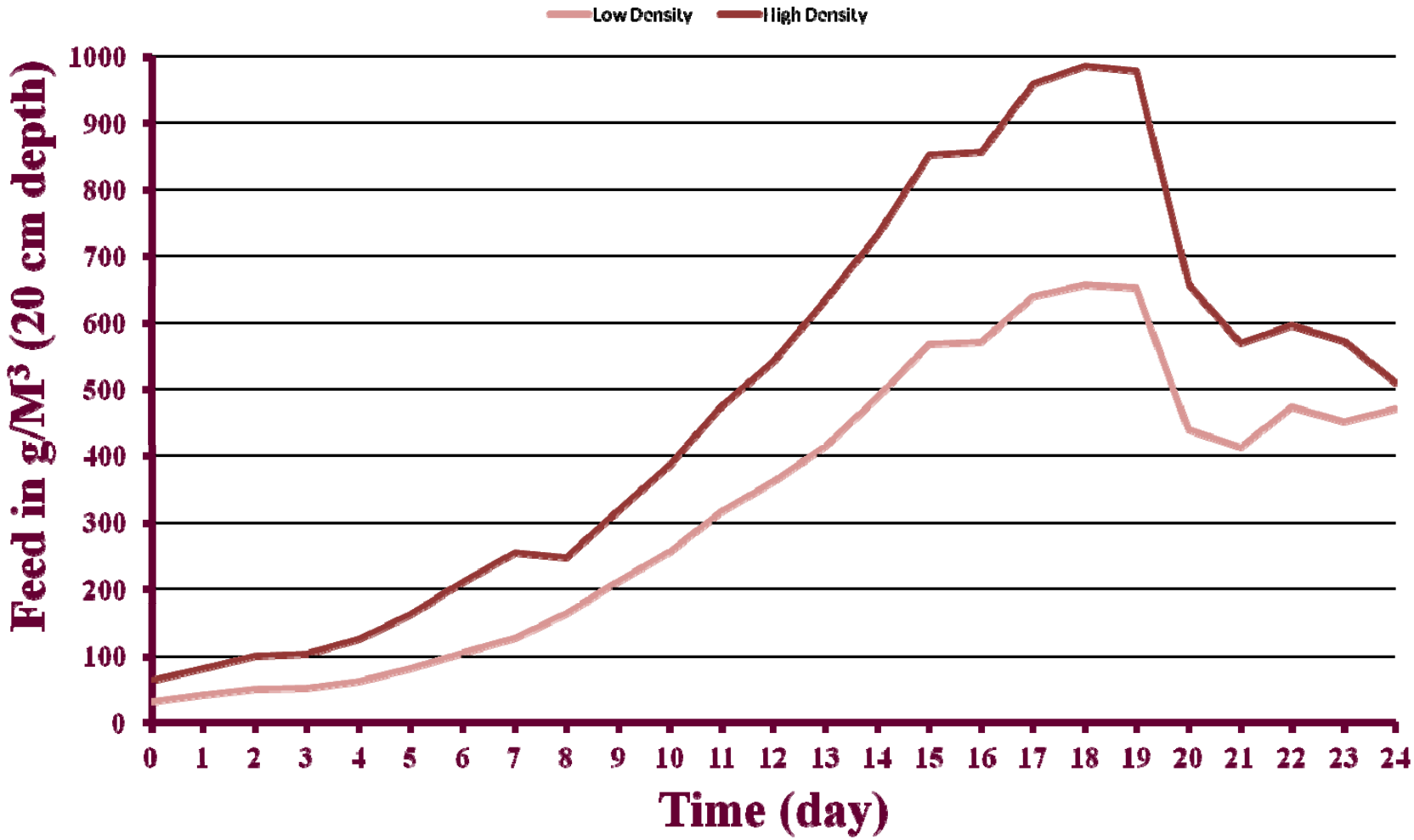
Adjustment of the Feed Curve

- Traditional feed curves were adjusted proportionally to the biofloc level
- The specified FCR was reduced by 0.1 for each 10 ml of biofloc over 40 ml/l
- Objective was to keep settleable solids below 90 ml/l

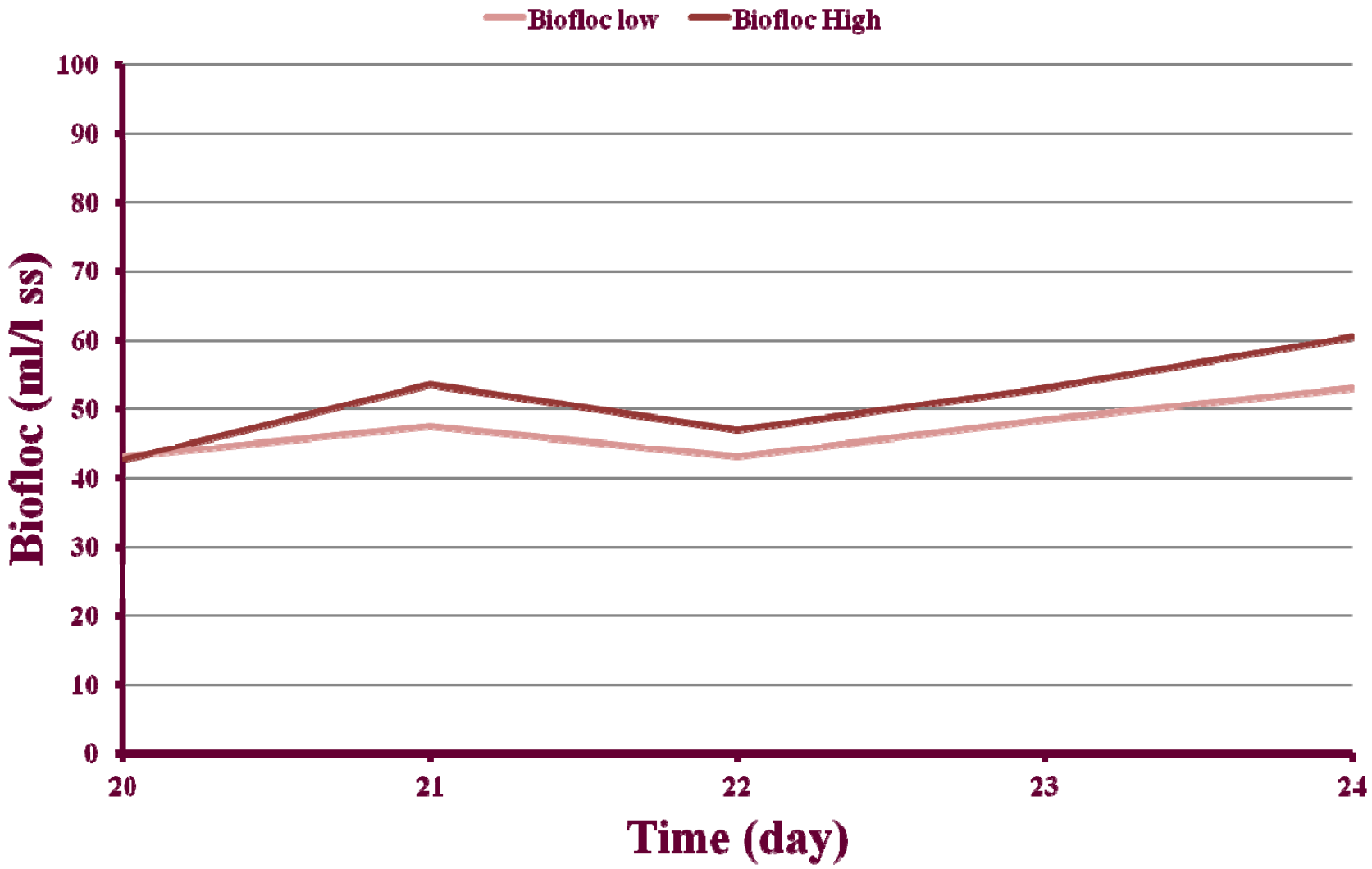
Adjusted FCR's



Feed Application

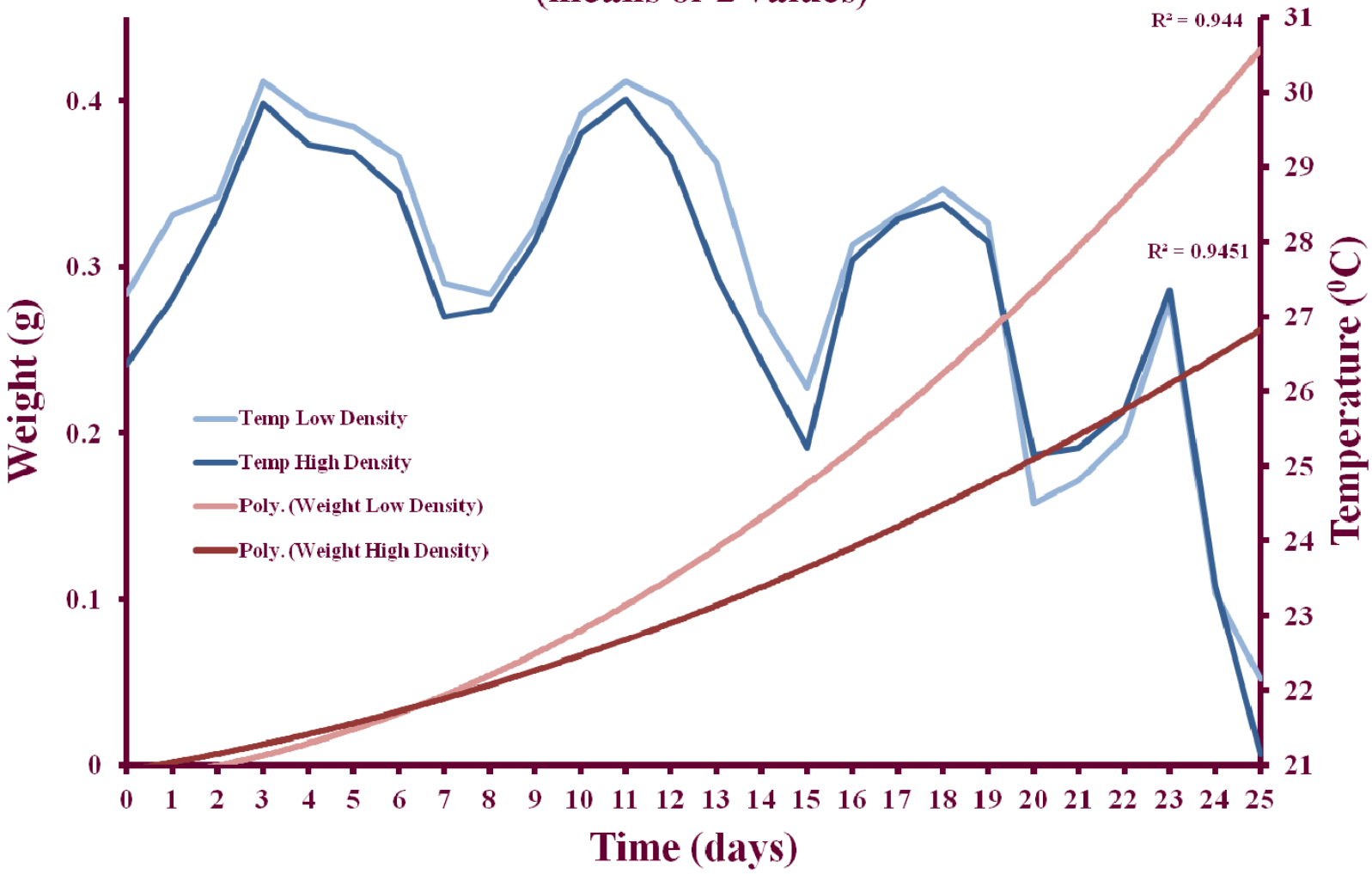


Steady State of Biofloc



Growth and Temperature vs. Time

(means of 2 values)



Mean Temperature, Survival, Biomass and FCR for Two Stocking Densities

# Stocked/m²	3,889	7,778
Size (g)	.3605	.2431
Temperature (°C)	27.6	27.3
Survival (%)	96.5	88.7
Biomass (kg/m²)	1.35	1.68
Biomass (kg/m³)	6.76	8.39
FCR	1.20	1.43

Values are means of two observations for each stocking density over 25 days.

Conclusions

- Juvenile production (>34,000/m^3) in low water depth with good survival was obtained.
- Rapid establishment of biofloc was achieved.
- Changing the FCR's proportionally to biofloc level resulted in a steady state of feed.
- Biofloc was kept at a relatively sustainable level by feed reduction.
- FCR's (1.20 and 1.43) indicate that feed was not limiting growth during this trial.
- Lower than optimal temperature affected shrimp growth.

Practical Observations Concerning Biofloc

- If organic carbon is not limiting, even if the conditions are perfect for autotrophic bacteria, heterotrophic bacteria will dominate.
- A C:N ratio of 8.1 or less is adequate for autotrophic bacterial dominance.
- Autotrophic bacterial dominance can be changed to heterotrophic bacterial dominance by increasing the C:N ratio.
- An indicator of autotrophic bacterial dominance loss, is stable alkalinity without addition of sodium bicarbonate.
- A conservative approach is a minimum FCR of 0.85 regardless of biofloc level.

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From Texas A&M University

Thank You!!!!!

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