Nursery production of the Pacific White Shrimp, *Litopenaeus vannamei*, in a zero-exchange biofloc-dominated system operated with a^3 injectors

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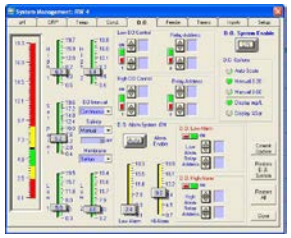
Introduction

Use of greenhouse-enclosed super-intensive limited discharge biofloc systems can potentially:

- Reduce water usage
- Reduce effluent discharge
- Increase biosecurity
- Be constructed close to markets
- Provide economic advantages when used for nursery to stock outdoor ponds

Introduction

Super-Intensive



- The systems are equipped with automated monitoring & control tools & require substantial oxygen inputs to satisfy the high demand by the shrimp & the microbial communities

- Previous studies at the Texas A&M AgriLife Research used a combination of a pump driven Venturi injectors, airlifts pumps, air diffusers and oxygen to provide adequate DO levels & mixing
- For the last few years we have been testing a pump-driven non-Venturi injectors (*a*^{3} *All Aqua Aeration, Orlando, FL*) that may eliminate the need to use pure oxygen in these systems

- According to the manufacturer the injectors are capable of providing a 3:1 air to water ratio

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Objectives

- Evaluate the ability of the a^3 injectors to maintain sufficient DO and mixing levels in nursery RWs operated with no water exchange
- Evaluate if the injectors are safe to use for nursery of very young PL
- To study the effect of the injectors on shrimp growth, survival, and FCR
- To study the changes in selected WQ indicators during the nursery phase

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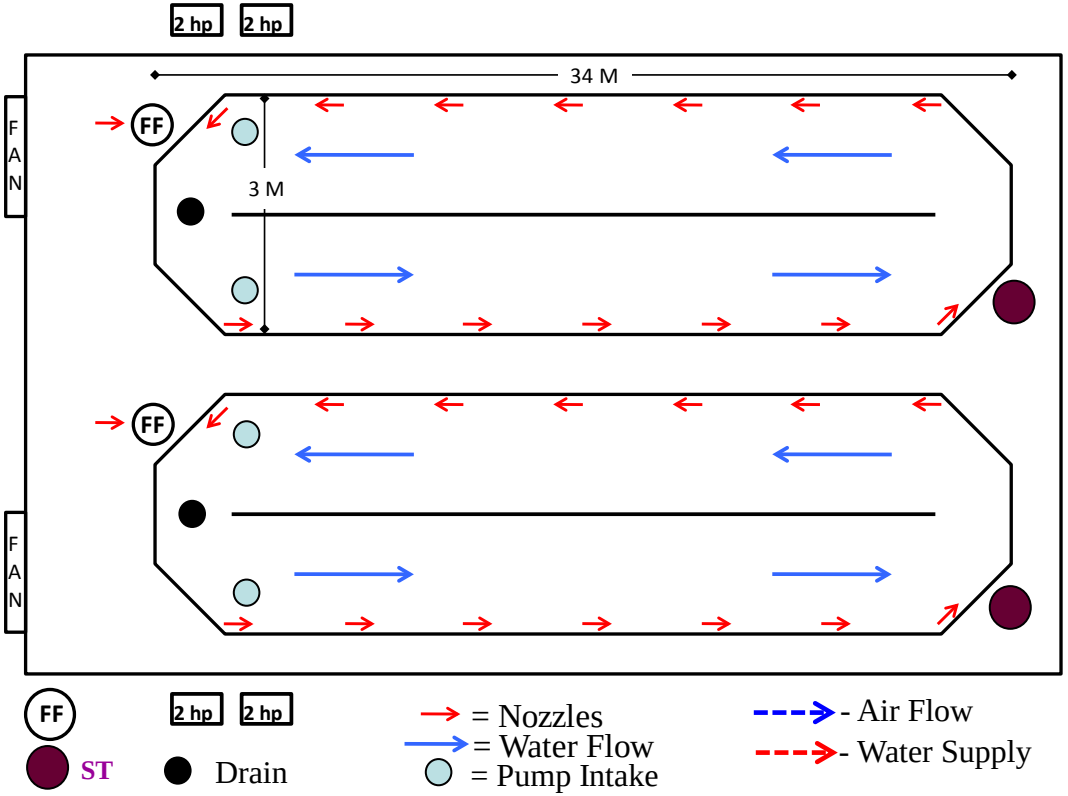
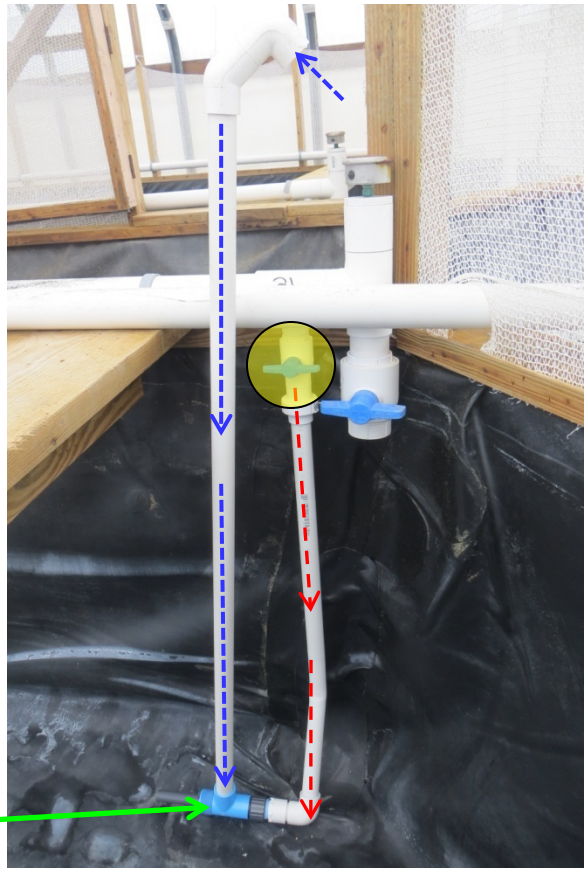
100 m^3 RWs – Greenhouse

Water & Air Flow





- Each RW has 14 a^3 injectors
- One ST & one FF per RW
- Two 2 hp pumps per RW that can be operated independently or simultaneously, depending on loading factors (e.g., biomass, DO concentration)

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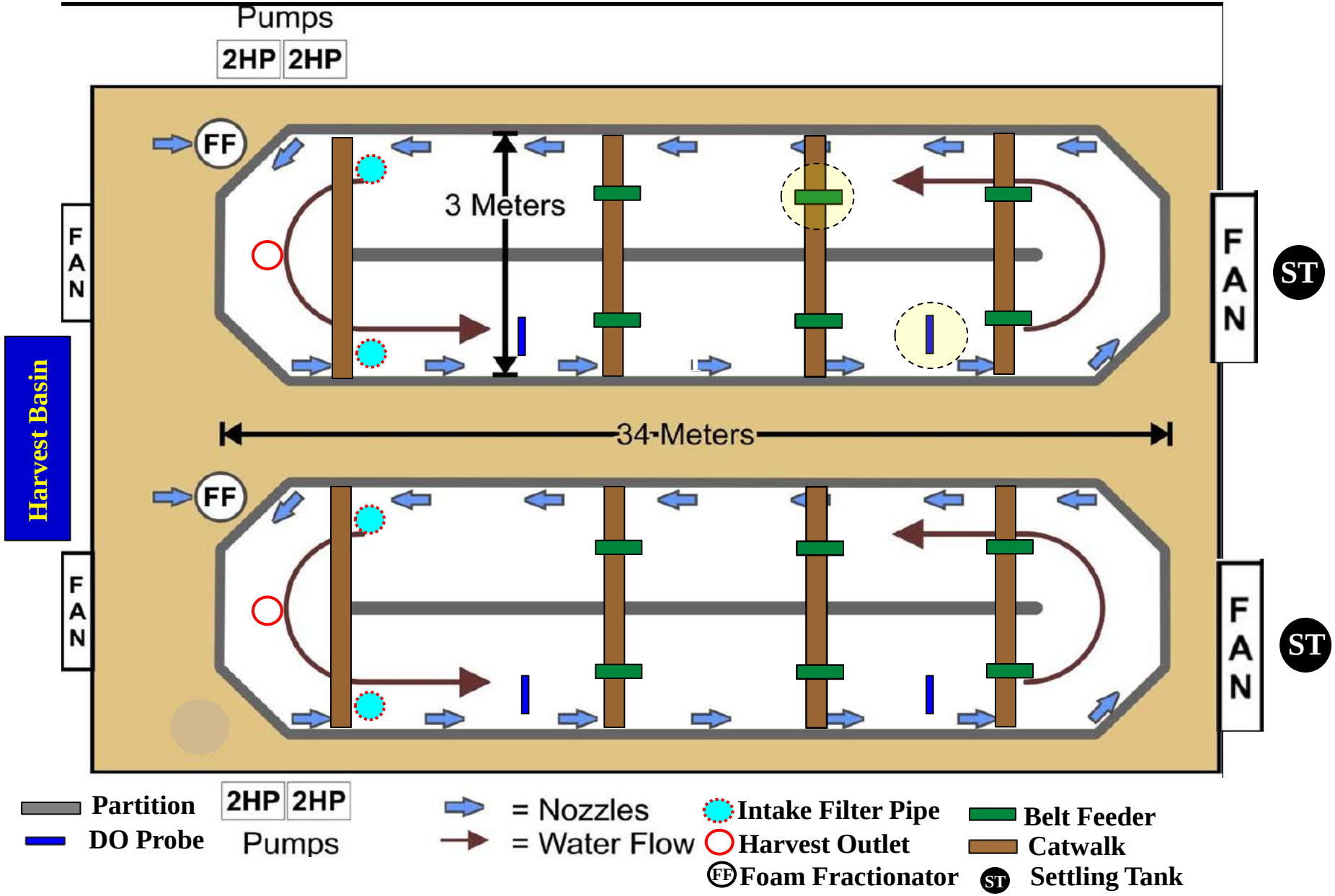
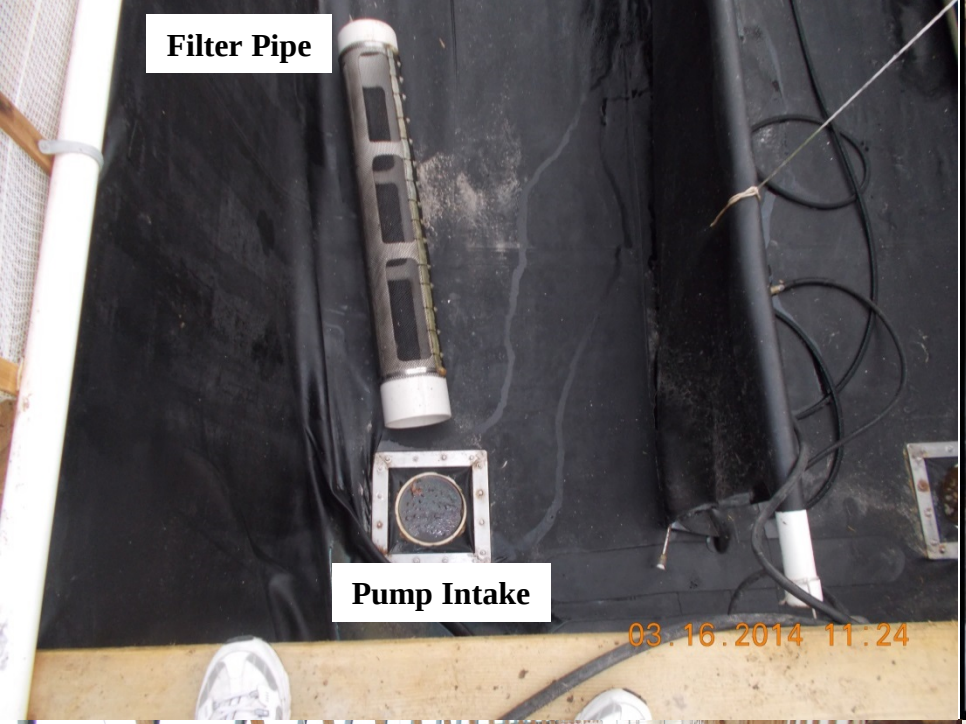
Top View - 100 m^3 RWs at Texas AgriLife




Filter Pipe
Pump Intake
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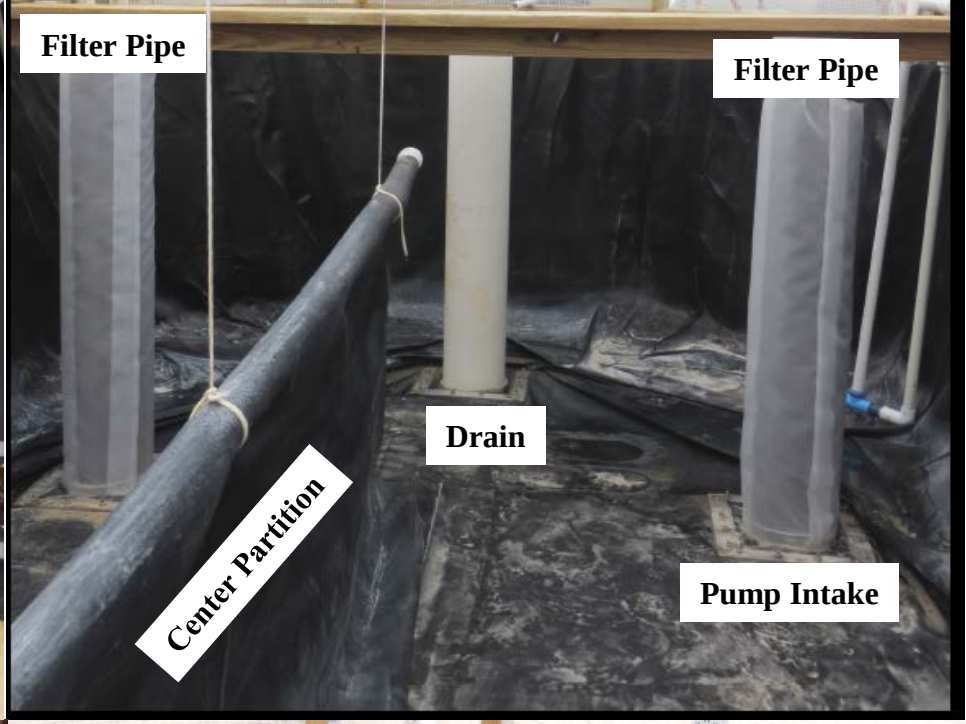
Filter Pipe
Filter Pipe
Drain
Center Partition
Pump Intake


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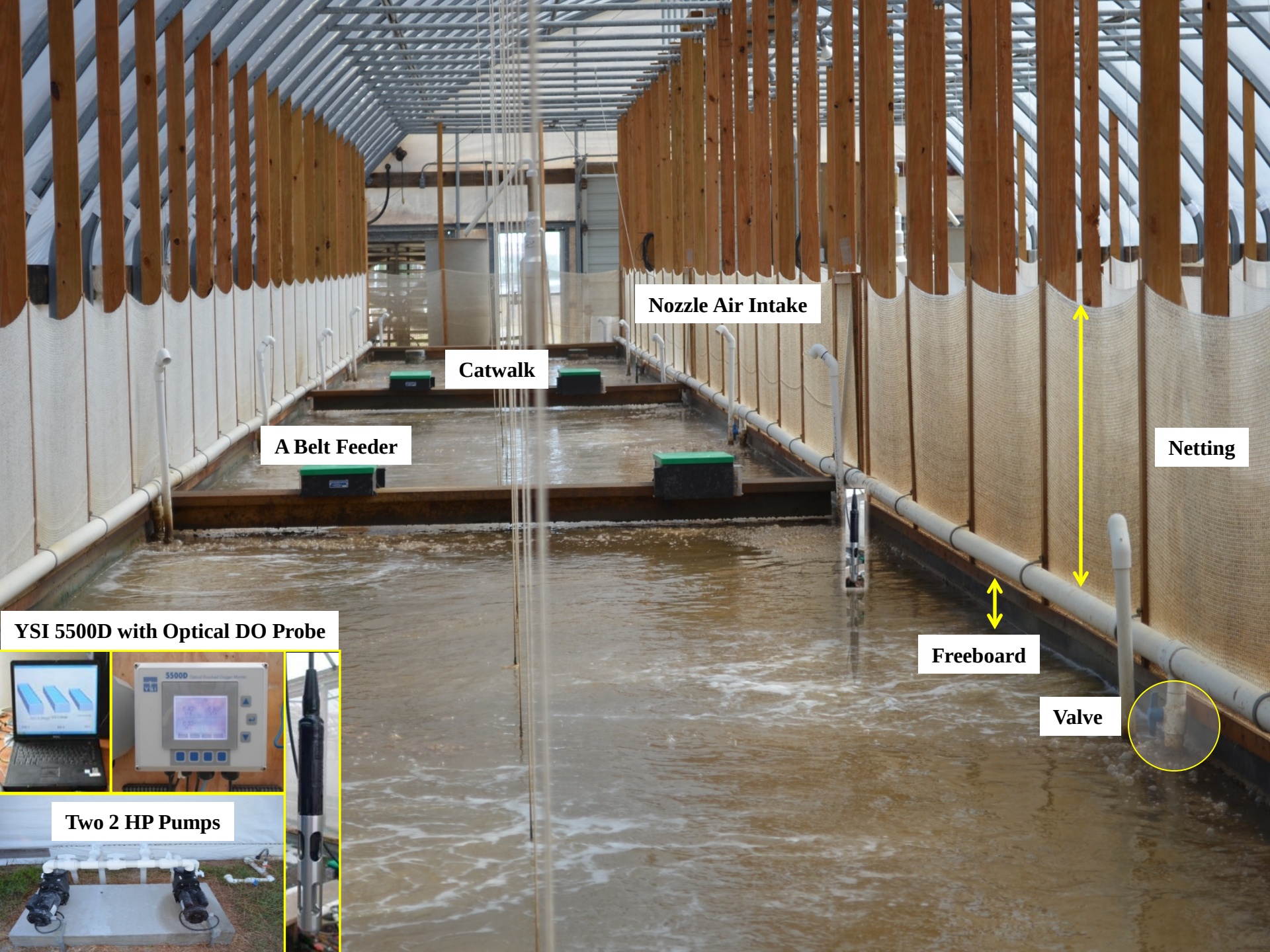
Nozzle Air Intake
Catwalk
A Belt Feeder
Netting
Freeboard
Valve
YSI 5500D with Optical DO Probe
5500D
Two 2 HP Pumps

Foam Fractionator

- Operated with one a^3 injector, flow rate ≈ 28 Lpm, fed from the pump's side loop
- Use of fabric for dewatering and drying of the organic particulate matter

Settling Tanks

- Conical tank 2 m^3, flow rate 20 Lpm, fed from the pump's side loop
- Use of fabric for dewatering and drying of the organic particulate matter

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Materials & Methods

- RWs were filled with NSW adjusted to 30 ppt salinity
- 540 $PL_{5\text{-}10}/m^3$ (0.94±0.56 mg; CV: 59.7%) - hybrid Fast-growth/Taura-resistant
- Continuous feeding from Day 2
- FW to offset losses to evaporation & solids removal
- Filter pipes fitted with 0.5, 0.8 & 1 mm screens
- Temp., Sal., DO, pH: 2/d; SS: 1/d; TSS: ≥1/wk; TAN, NO_2-N, NO_3-N, VSS, turbidity, RP: 1/wk; Alka.,: adjusted 2/wk using $NaHCO_3$ to maintain 160 mg/L as $CaCO_3$
- Remote access YSI 5500 DO monitoring w/ optical DO/RW
- TCBS agar for monitoring yellow and green-colony forming *Vibrio*: 2/wk

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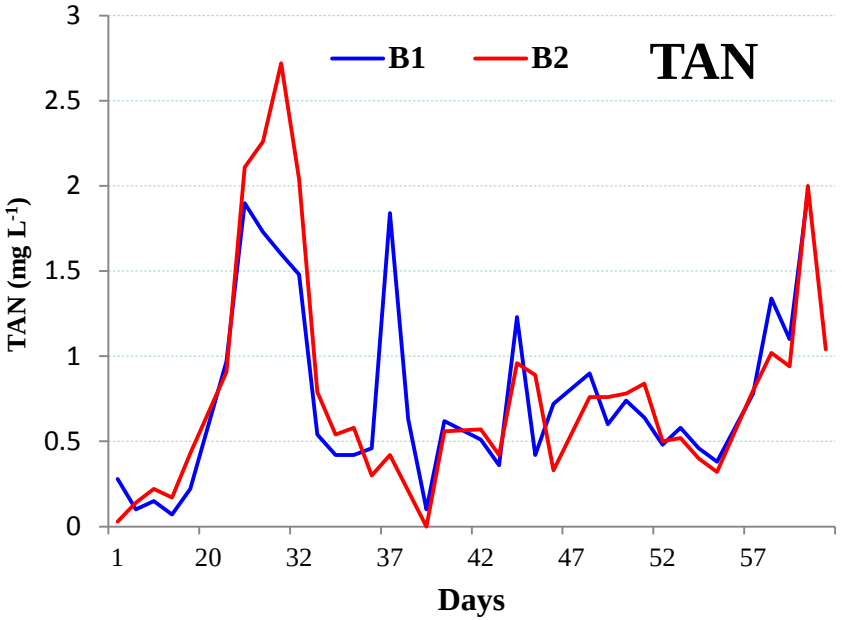
Materials & Methods

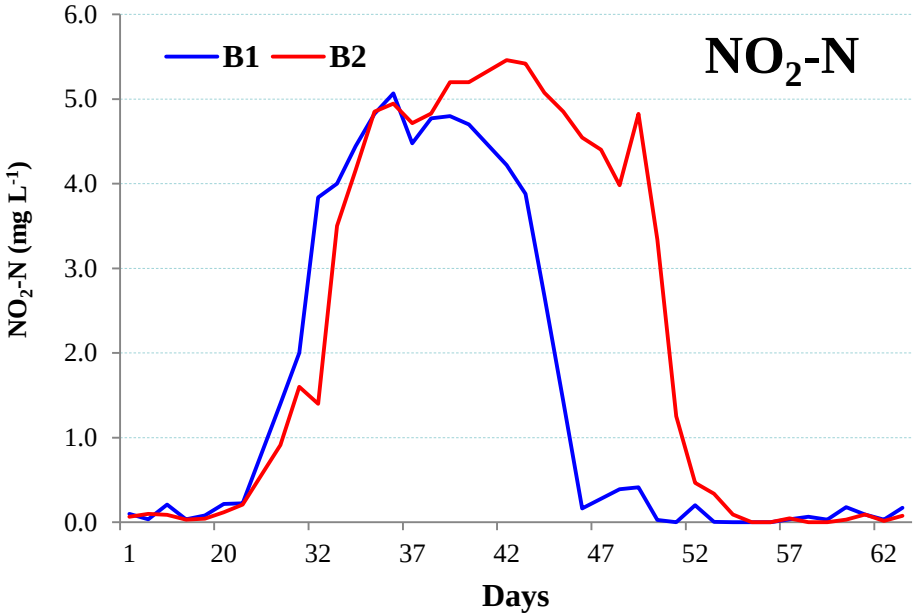
- Biofloc control: FF & ST
- Use of commercial nitrifying bacteria: KI-Nitrifier™ (*Keeton Industries*, *Wellington*, *CO*) and sugar to stimulate nitrification
  - Application: 1 g per 3,785 L or 26.42 g RW^{-1}, on Day 1, 4, 7, 10 & 32
- Use of commercial probiotic, Ecopro (*EcoMicrobials*™, *Miami*, *FL*) every three-days to daily:
  - Routine: every 3 days: 200 mg m^{-3} plus: Day 1: 55 mg m^{-3}, Day 39: 400 mg m^{-3} & Day 42: 300 mg m^{-3}

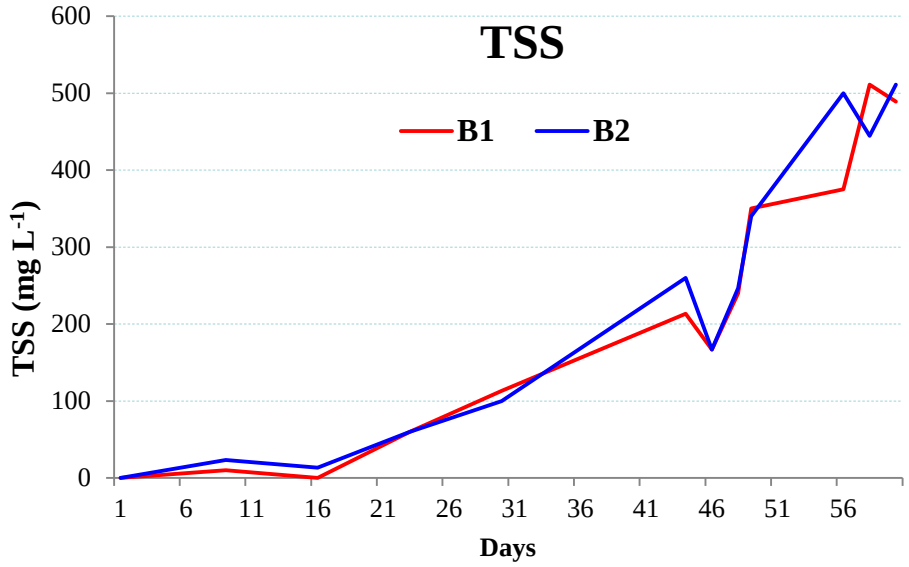
Materials & Methods

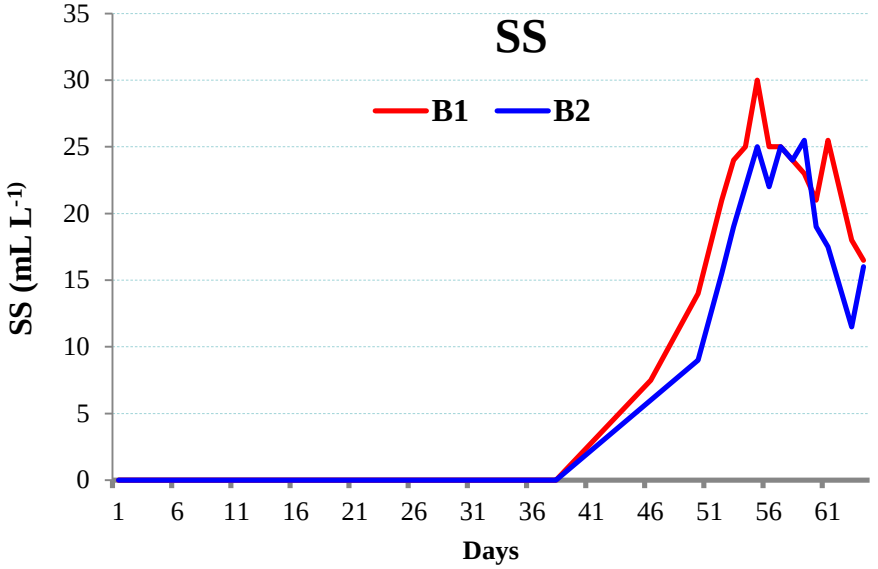
- Shrimp were fed a combination of EZ-*Artemia* & dry feed (Zeigler Raceway Plus <400 µm) for the first 8 days post-stocking & Zeigler Raceway Plus (<400 µm, 400-600 µm, 600-850 µm), & Zeigler Shrimp PL 40-9 with V-pak™ (1 mm, 1.5 mm, 2 mm) for the remainder of the trial
- Feed size & rates were adjusted based on shrimp growth & size variation - continuous delivery by belt feeders

		Temp. (°C)	Sal. (ppt)	DO (mg L^{-1})	pH
AM	Mean	26.4	30.4	6.8	8.1
	Min	22.2	29.7	4.6	7.6
	Max	29.7	31.1	8.5	8.5
PM	Mean	26.8	30.4	6.6	8.1
	Min	22.9	28.6	4.4	7.6
	Max	30.2	31.1	7.9	8.5


TAN
B1
B2
TAN (mg L-1)
Days
0
0.5
1
1.5
2
2.5
3
1
20
32
37
42
47
52
57

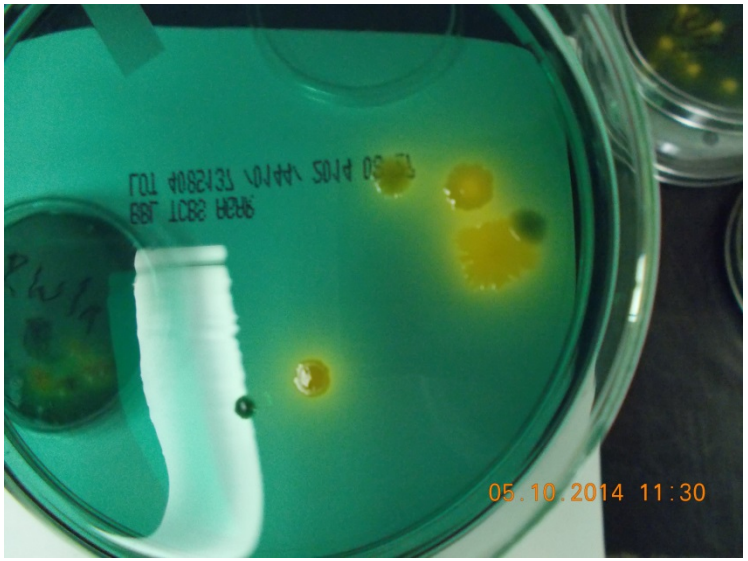

NO2-N
B1
B2
NO2-N (mg L-1)
Days
0.0
1.0
2.0
3.0
4.0
5.0
6.0
1
20
32
37
42
47
52
57
62

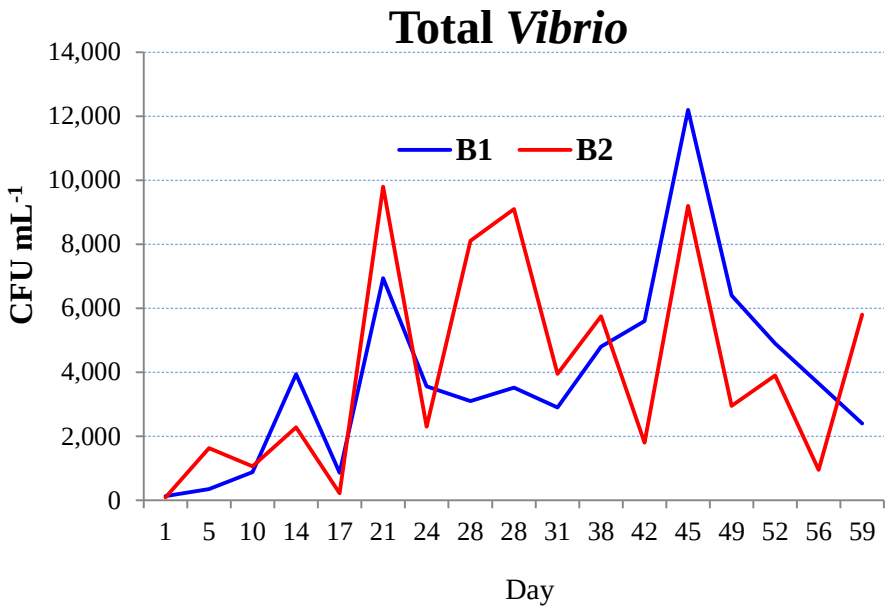

TSS
B1
B2
TSS (mg L-1)
Days
0
100
200
300
400
500
600
1
6
11
16
21
26
31
36
41
46
51
56

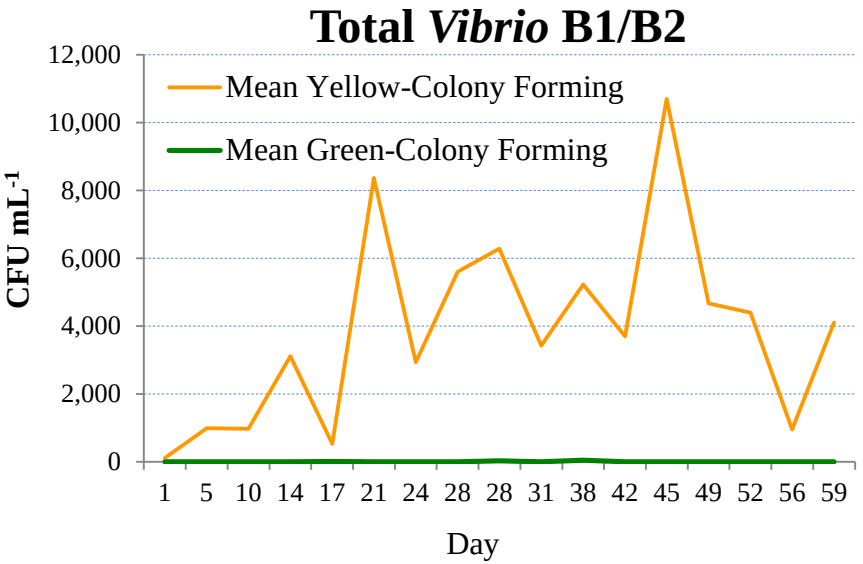

SS
B1
B2
SS (mL L-1)
Days
0
5
10
15
20
25
30
35
1
6
11
16
21
26
31
36
41
46
51
56
61

Results

Green colony-forming *Vibrio* concentrations remained below 50 CFU/mL and less than 2% of the yellow colony-forming concentrations throughout the trial







Summary of 62-d nursery study in two 100 m^3 RWs with *Litopenaeus vannamei* stocked at 540 PL_{5-10} m^{-3}

RW	Yield (kg/m^3)	Av. Wt. (g)	Max (g)	Min (g)	CV (%)	Sur. (%)	g/wk	FCR
B1	3.43	6.49	11.9	0.6	35.6	97.8	0.73	0.81
B2	3.28	6.43	10.5	0.5	31.0	94.6	0.73	0.81

- Low temp. for the 1st three wks resulted a in long trial
- PL high size variation required frequent monitoring of individual weight to determine feed particle size
- The high variation may have prevented full expression of the shrimp growth potential
- High size variation continued throughout the harvest

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Conclusion

- Preparing nitrifying bacteria rich water ahead of stocking prevented PL exposure to high TAN & Nitrite
- The use of probiotic may have contributed to the low FCR. A follow-up controlled study is needed urgently
- Use of TCBS agar plates served as a good tool to monitor non- and pathogenic *Vibrio* in culture medium
- Although the a^3 injectors were used with very small PL, shrimp were not damaged
- One 2 hp pump was sufficient to maintain high DO (4.4-8.5 mg L^{-1}) at biomass load of 3.43 kg shrimp m^{-3} with no need for oxygen supplementation
- a^3 injectors provided adequate mixing of the biofloc

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Acknowledgements

- *The National Sea Grant, Texas A&M AgriLife Research* for funding
- *Zeigler Bros.* for the feed & funding
- *YSI* for the DO monitoring systems
- *Keeton Industries* for the nitrifying bacteria
- *Aquatic Eco-Systems* for the foam fractionators
- *Colorite Plastics* for the air diffusers
- *Firestone Specialty Products* for the EPDM liner
- *Florida Organic Aquaculture* for funding
- *a³ All-Aqua Aeration* for providing the injectors