PERFORMANCE OF THE PACIFIC WHITE SHRIMP *Litopenaeus vannamei* IN BIOFLOC-DOMINATED ZERO-EXCHANGE RACEWAYS USING A NON-VENTURI AIR INJECTION SYSTEM FOR AERATION, MIXING, AND FOAM FRACTIONATION

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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

Introduction

- Biosecure enclosed systems with advanced engineering

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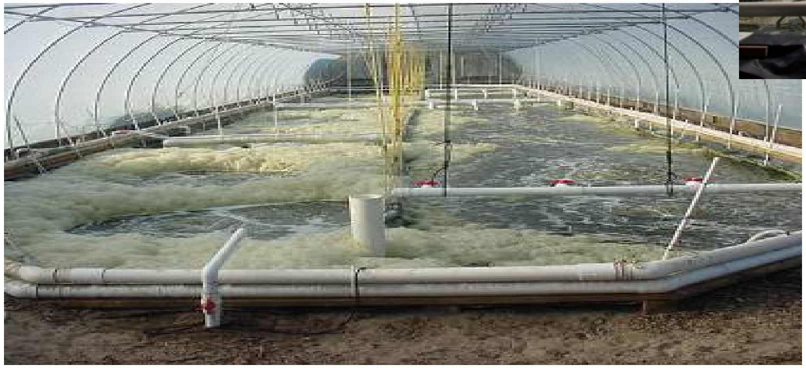
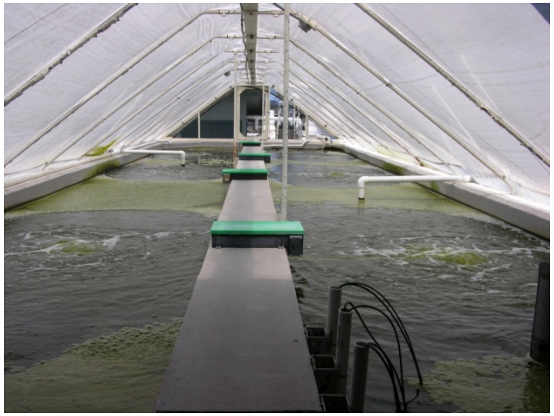
Introduction

Super-Intensive

- Capable of high output per unit area with multiple crops per year

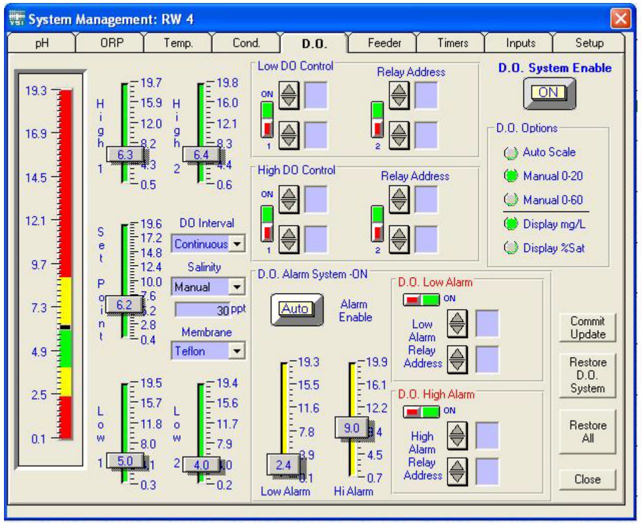


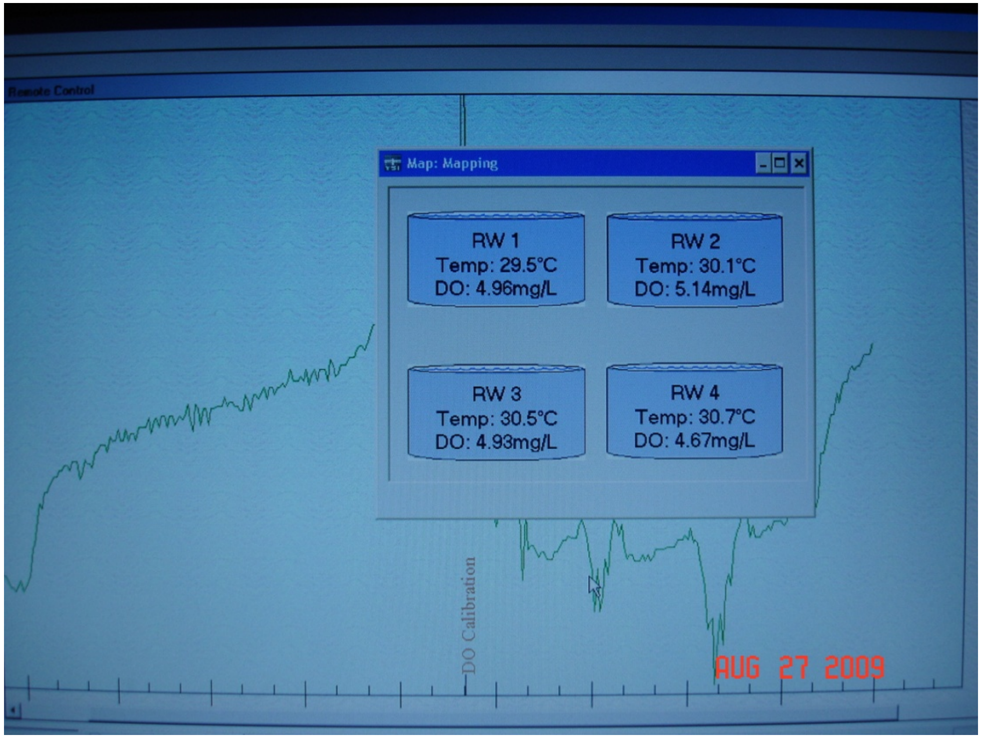


Introduction

Super-Intensive

- Automated systems for environmental and water quality control





Introduction

Super-Intensive

- These systems require substantial inputs to satisfy the high oxygen demand of the shrimp and the microbial communities

Introduction

- Previous studies at the Texas AgriLife Mariculture Lab have utilized a combination of a pump driven Venturi injectors, airlifts & air diffusers to provide adequate DO and mixing
- Recently we began looking into a non-Venturi alternative currently used in several wastewater treatment facilities in Florida
- This technology may be successfully transferred to biofloc systems and other types of aquaculture

Introduction

- According to the manufacturer these pump-driven nozzles are capable of providing a 3:1 air to water ratio

- In contrast, our current Venturi system provides a ratio of < 1:1 and requires injection of supplemental oxygen to maintain adequate DO levels at high biomass loading (>7-8 kg/m^3)

Introduction

- In 2010 we conducted an 87-day test of our two new 100 m^3 raceways (RWs)
- RWs were each filled with 80 m^3 water
- Stocked at 270 shrimp/ m^3
- Home-made foam fractionators (FF) were used to control solids
- The new nozzles provided adequate aeration and mixing throughout the water column; eliminating the need for an air blower, air diffusers, airlifts, and supplemental oxygen

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Summary of 2010 grow-out study with *L. vannamei* stocked at 270/m^3

RW	Volume (m^3)	Yield (kg/m^3)	Av. Wt. (g)	Survival (%)	FCR	(g/wk)
1	80	6.25	25.68	89.5	2.56	1.38
2	80	6.56	26.58	90.8	2.36	1.45

No oxygen supplementation

No water exchange

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Introduction

2011

- With the exception of unusually high FCRs the 2010 results were so encouraging we decided to take it further...
- RW volume was increased from 80 m^3 to 100 m^3
- Stocking density was increased from 270 shrimp/m^3 to 390 shrimp/m^3
- Total available pump horsepower was reduced from 5 hp to 4 hp per RW
- FF size remained the same

Objectives

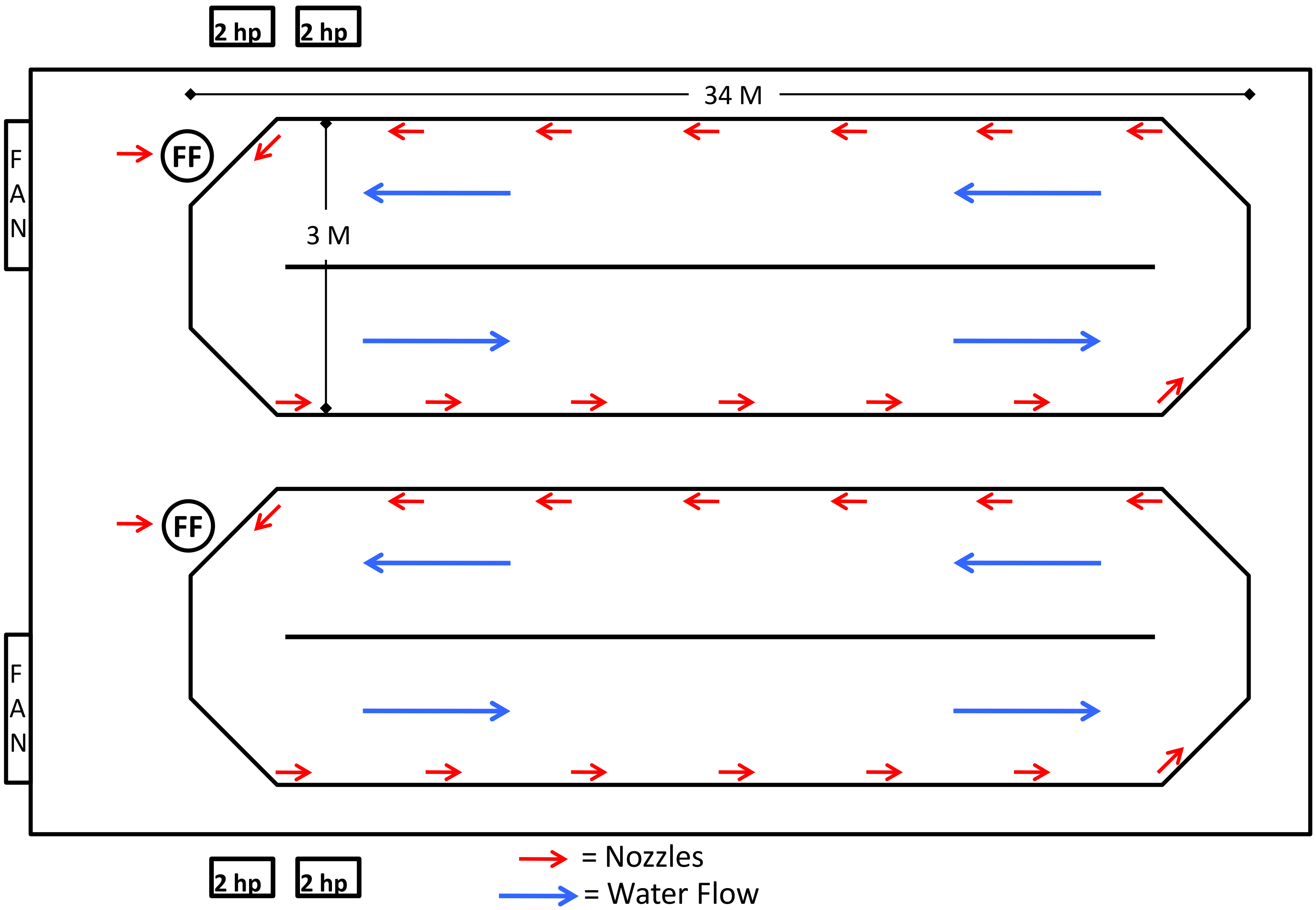
2011

- Evaluate the ability of the nozzles to maintain adequate DO levels and mixing in an intensive RW system without the use of pure oxygen
- Evaluate the effect of the nozzles on shrimp performance
- Determine if the same foam fractionators used in the 2010 study could control particulate matter and dissolved organics in the system despite the anticipated increase in loading (e.g. biomass, feed input)

Materials & Methods

- 14 nozzles were positioned inside each RW
- Each RW had 1 additional nozzle powering a home-made foam fractionator
- Each RW had two 2 hp pumps which could be operated independently or simultaneously depending on loading factors (e.g. biomass, DO concentration)

New 100 m^3 RWs at Texas AgriLife



Foam Fractionator

- One nozzle
- Flow rate ≈ 28 lpm
- Size ≈ 30 cm diameter at base,
  ≈ 2 m tall
- FFs were initially operated to maintain targeted TSS levels between 200-300 mg/L
- Target levels were later raised to 400-500 mg/L to decrease FCRs

Materials and Methods

- RWs were each filled with a mixture of seawater (55 m^3) freshwater (10 m^3) and biofloc-rich water (35m^3) from a previous study
- Juvenile shrimp (3.14 g) were stocked at 390/m^3 (1.2 kg/m^3)
- ½ daily ration was fed in four equal portions 4 times/day (8:30, 11:30, 14:30, and 16:30)
- Remainder of feed was fed by belt feeders overnight
- Shrimp were fed a 35% CP commercial feed (Hyper-Intensive 35 Extra Short-cut, Zeigler Bros., Gardners, PA)
- Freshwater was added to offset losses due to evaporation and solids removal

Materials and Methods

WQ

- Temperature, salinity, dissolved oxygen, and pH were recorded twice daily
- Settleable (SS) were measured daily
- Total suspended solids (TSS) were measured twice/wk
- NH_4-N, NO_2-N, NO_3-N, VSS, turbidity, $cBOD_5$, and RP were monitored weekly
- Alkalinity was adjusted 2x/wk using sodium bicarbonate or agricultural lime to maintain 160 mg/L as $CaCO_3$
- Each RW was equipped with a YSI 5200 monitoring system to provide continuous DO and temperature readings

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Summary of mean twice-daily water quality parameters during the 106-d grow-out study

		Temp (°C)	Salinity (ppt)	DO (% Sat)	DO (mg/L)	pH
AM	Mean	29.9	28.6	88.8	5.8	7.1
	Min	27.3	24.3	76.1	4.9	6.7
	Max	31.6	32.4	109.1	7.3	7.9
PM	Mean	30.4	28.5	88.2	5.7	7.2
	Min	27.6	24.3	70.5	4.4	6.3
	Max	32.0	32.2	104.6	6.9	7.9

Results

- Mean ammonia-N levels were low: 0.5 mg/L
  min: non-detectable   max: 3.8 mg/L

- Mean nitrite-N levels were low: 0.3 mg/L
  min: non-detectable   max: 2.2 mg/L

- Nitrate-N levels increased from 10 mg/L at stocking to about 400 mg/L at harvest




Summary of 2011 grow-out study in two 100 m^3 raceways with *L. vannamei* stocked at 390/m^3

RW	Yield (kg/m^3)	Av. Wt. (g)	Survival (%)	FCR	(g/wk)
1	8.04	25.14	79.7	1.83	1.45
2	8.69	25.39	86.3	1.70	1.47

No water exchange

Results and Conclusions

- Foam fractionators were not able to maintain the TSS within the targeted limits (400-500 mg/L) at the current volume, stocking density, and feed rate
- Significant mortality was observed beginning on Day-62, despite DO levels of 4.7 mg/L
- Settling tanks were constructed and installed on Day-74
- Within 4-5 days of operation TSS decreased from 800 to 200 mg/L

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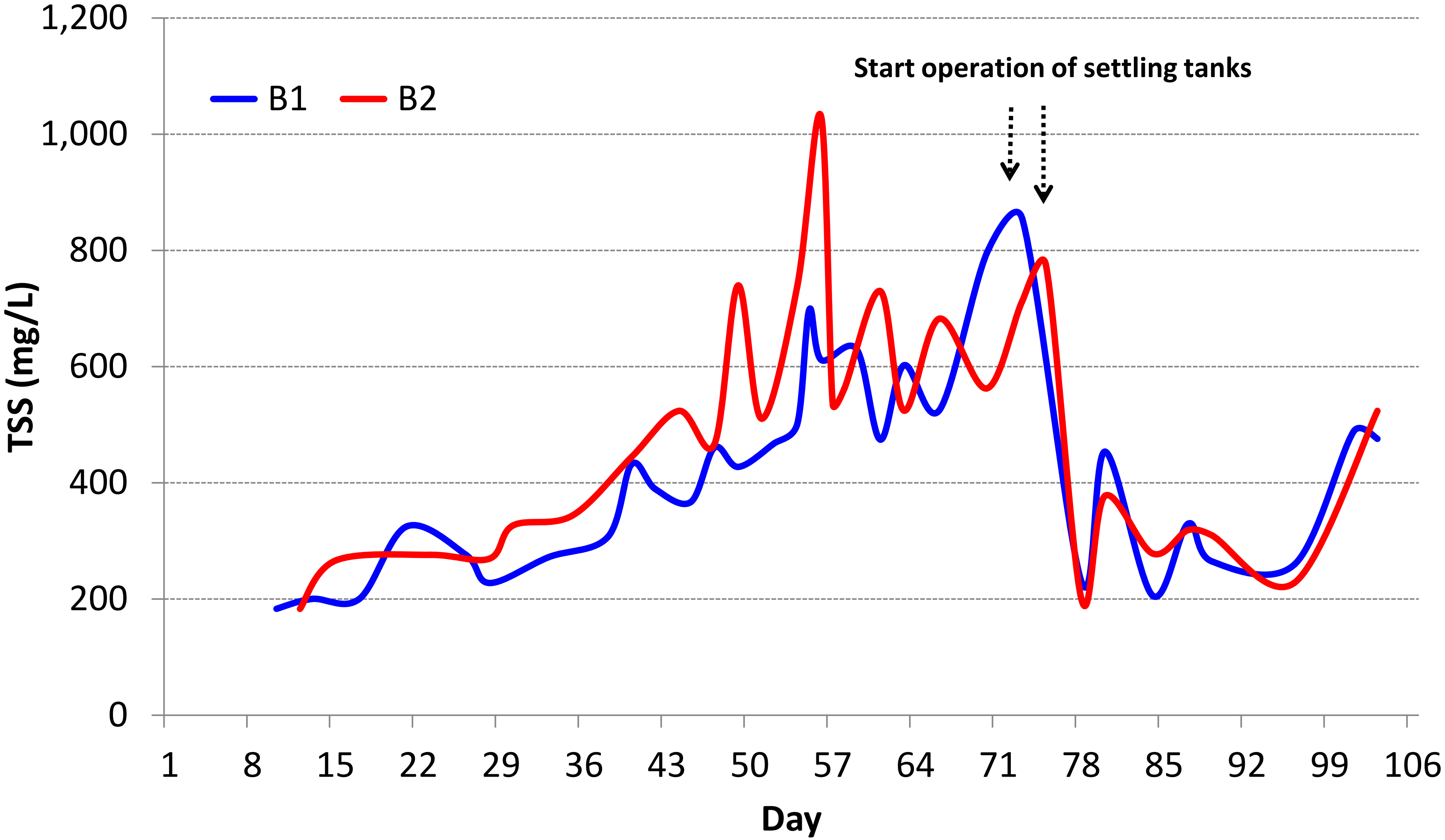
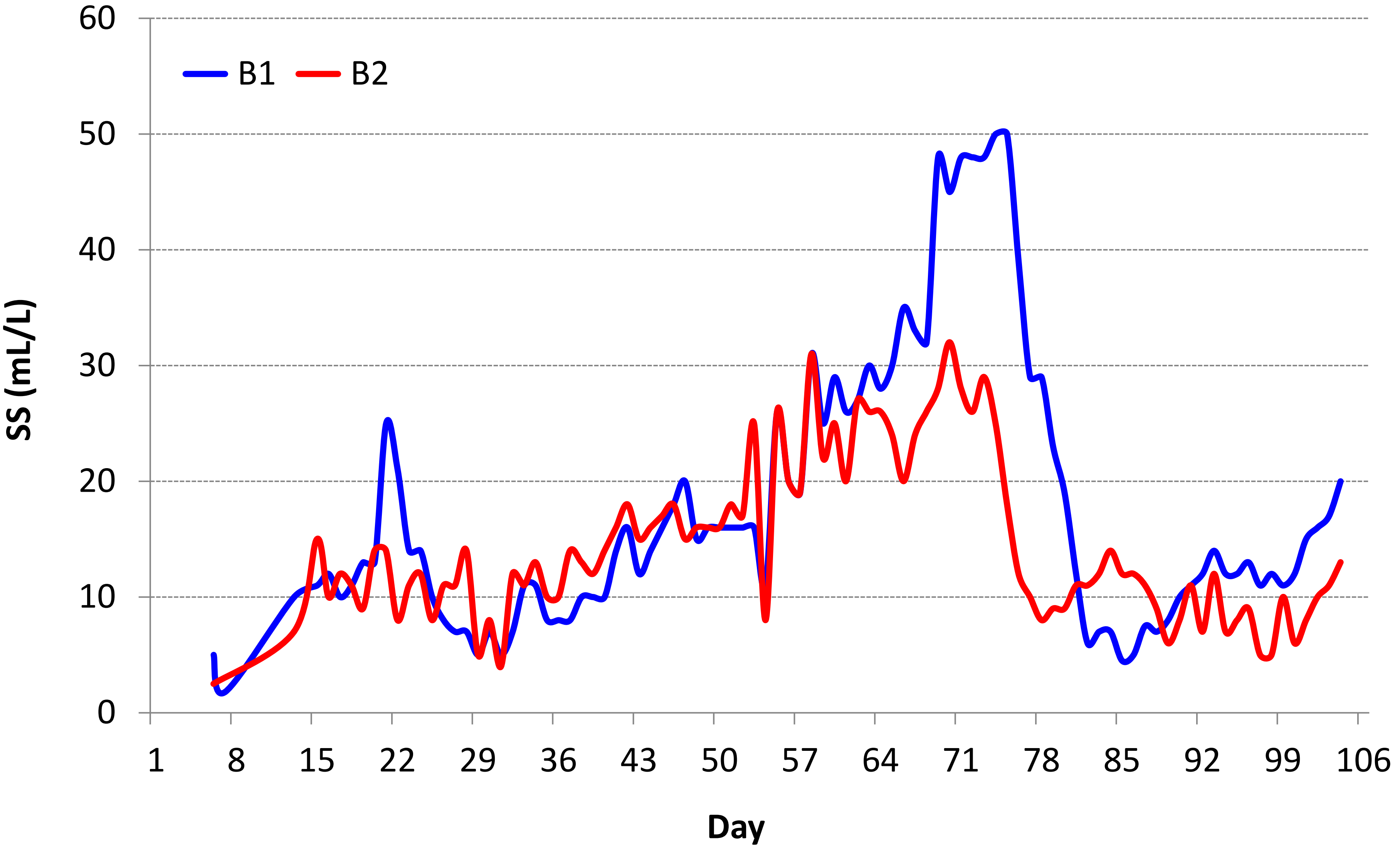
Settling Tanks

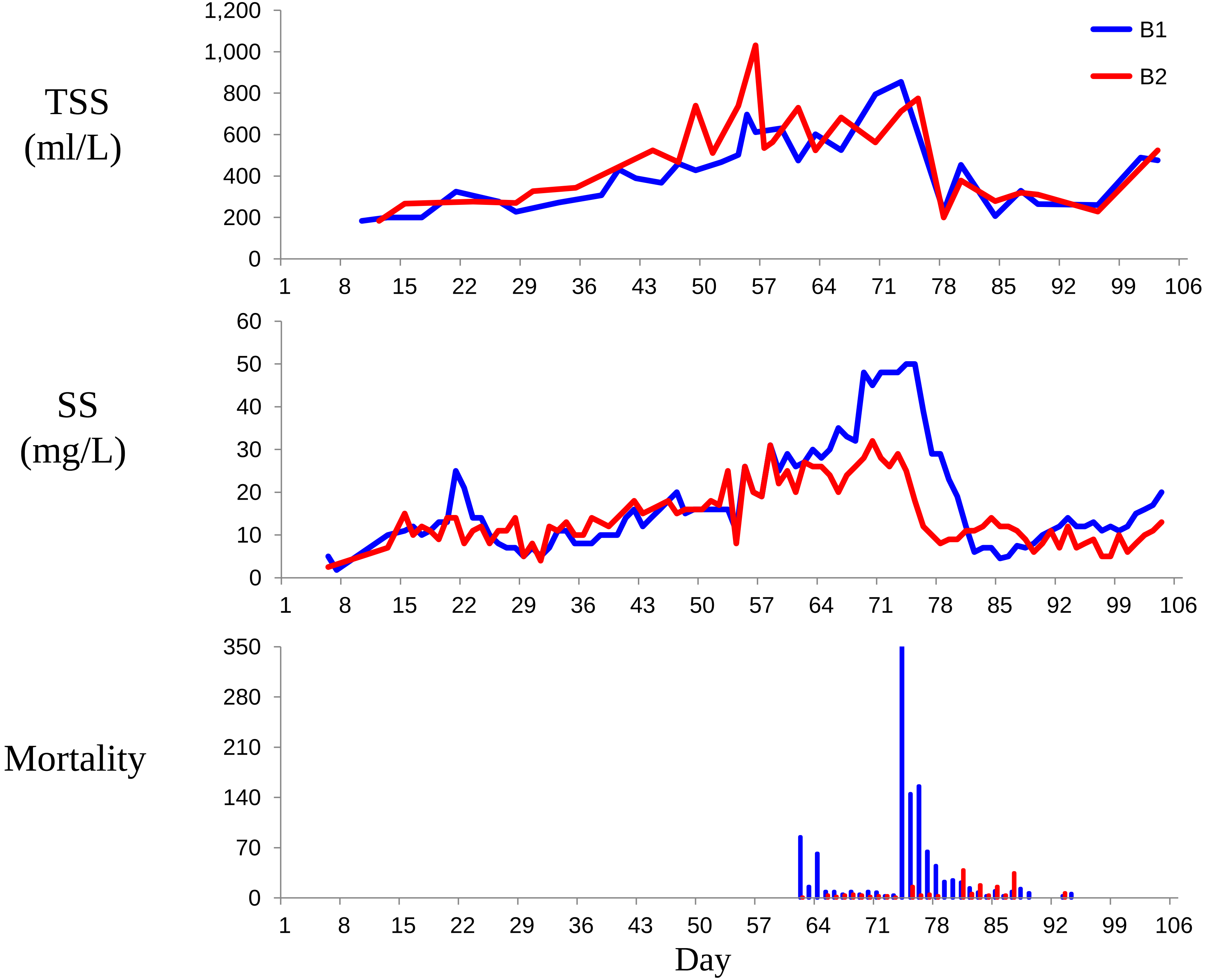
- Conical tank 2 m^3
- Flow rate 7.5 to 12 L/min
- Flow from side-loop off aeration pump
- Land application of sludge

Changes in TSS



Changes in SS





TSS
(ml/L)
SS
(mg/L)
Mortality
B1
B2
1,200
1,000
800
600
400
200
0
60
50
40
30
20
10
350
280
210
140
70
1
8
15
22
29
36
43
50
57
64
71
78
85
92
99
106
Day

Results

Aeration

- One 2 hp pump was able to maintain adequate DO levels (4.7-5.5 mg/L) at 6.5 kg shrimp/m^3 (650 kg) without using supplemental oxygen
- Mixing was sufficient enough to eliminate the need for an air blower, diffusers, or airlifts
- Second 2 hp pump was turned on Day-62 when significant mortality was observed despite DO levels of 4.6-4.7 mg/L
- Supplemental oxygen was provided intermittently from Day-62 until Day-92

Results and Discussion

Shrimp

- FCRs in 2011 improved over the 2010 trial (1.77 vs. 2.46 respectively)
- Survival was fair (83%)
- Observed mortality was due to reduced oxygen uptake due to gill fouling caused by high solids levels rather than low DO
- Supplemental oxygen was provided during this period
- “Magic” DO level to prevent mortality was 5.5 mg/L

Future Considerations

- Determine cause of high FCR
- Use fast growth line
- Explore heating and cooling options
- Study the changes in ionic composition over time
- Denitrification, sludge digestion and disposal
- Integrate automatic feeders with our DO monitoring system

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- Advanced Industrial Aeration for nozzles