Performance of *Litopenaeus vannamei* in Super-Intensive Limited-Discharge Raceways with Foam Fractionation and Dissolved Oxygen Monitoring Systems as Management Tools

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Introduction

- Production of the Pacific White Shrimp, *Litopenaeus vannamei*, in the last few decades has been negatively affected by disease epizootics and environmental issues over effluent water impact on receiving streams
- Traditional shrimp grow-out methods use outdoor ponds and require high water exchange
- These practices can result harmful pathogens introduction to culture stocks and negative environmental impact from releases of nutrient-rich effluent water

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Introduction

- Recirculating aquaculture systems (RAS) are an alternative that can address these issues
- Earlier research showed good shrimp production under low/no water exchange
- Recent advances in biofloc dominated RAS with *Litopenaeus vannamei*, suggest that these systems can be profitable when used to produce live or fresh (never frozen) shrimp for niche markets

Introduction

- Researchers, supported in part by the United States Marine Shrimp Farming Program have been working to improve system efficiency and make this technology economically viable
- Members of the USMSFP recently initiated a study using economic modeling and other metrics to evaluate advances in management practices and culture systems used to produce food shrimp

Introduction

- Participating facilities attempted to standardize certain factors (e.g., salinity, stocking densities, feed, PL source, etc.) to facilitate comparisons
- This presentation describes the results from the trial conducted at the Texas AgriLife Mariculture Lab as part of this comparative study

Objectives

- To study the performance of fast-growth line *Litopenaeus vannamei* juveniles when raised at high density with no water exchange
- To study the changes in selected WQ indicators in tanks stocked with *L. vannamei* at high density with no water exchange
- To study the benefit from using the YSI 5200 DO monitoring system as a management tool for a super-intensive zero exchange shrimp production system

Materials & Methods

- Four 40 m^3 EPDM-lined RWs (Firestone Specialty Products, Indianapolis, IN)
- RWs filled with a mixture of seawater (12 m^3), biofloc-rich water (8.5 m^3) used in an earlier 42-d nursery trial, and 19.5 m^3 of chlorinated municipal freshwater to adjust salinity to 18 ppt
- RWs were stocked (500/m^3) with fast-growth *L. vannamei* juveniles (1.90 g) received from Oceanic Institute

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Materials & Methods

- For comparison, a fifth RW was operated with 30 ppt salinity (21 m^3 biofloc-rich water and 19 m^3 seawater), and stocked (500/m^3) with juveniles (1.40 g) from the same fast-growth breeding population
- Each RW had eighteen 5.1 cm airlifts, six 1 m long air diffusers (AeroTube, Colorite Division, Tekni-Plex, Austin, TX) and a center longitudinal partition over a 5.1 cm PVC pipe with spray nozzles operated by a 2 hp pump and a Venturi injector

Materials & Methods

- RWs were outfitted each with a small commercial FF (VL 65 Aquatic Eco Systems, Apopka, FL) and a settling tank
- Water temperature, salinity, dissolved oxygen and pH were monitored twice daily; ammonia-N, nitrite-N, nitrate-N, alkalinity, settleable solids, turbidity, TSS, VSS, and $cBOD_5$ were monitored once a week
- Alkalinity was adjusted to 150-200 mg/L (as $CaCO_3$) using sodium bicarbonate

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Materials & Methods

- FF were used to control particulate matter and dissolved organics, originally targeting TSS and SS levels in the ranges of 200-300 mg/L and 10-14 mL/L, respectively
- Targeted TSS levels were increased (Day-30) to 400-500 mg/L to minimize algal blooms
- RWs were equipped each with on-line multi-parameter monitoring systems (YSI 5200, YSI Inc., Yellow Springs, OH)

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Materials & Methods

- Shrimp were fed a 35% crude protein feed (Hyper-Intensive 35, Zeigler Bros., Gardners, PA)
- Daily rations were determined based on assumed FCR of 1.2, growth of 2.0 g/wk, and mortality of 0.25%/wk, and were adjusted according to feed consumption and twice a week growth sampling
- Shrimp were fed 2/3 of the daily ration in four equal portions during the day (8:30, 11:30, 14:30, 16:30)
- One third of the ration was fed at night using three belts feeders

Materials & Methods

- Raceways were operated with no water exchange
- Evaporative losses were compensated using chlorinated municipal freshwater
- As a preventative measure oxygen supplementation was initiated on Day 44 when estimated shrimp biomass was 6.5 kg/m^3

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APR 18 2009


EverStart
maxx
marine


Remote Control
Map: Mapping
RW 1
Temp: 29.5°C
DO: 4.96mg/L
RW 2
Temp: 30.1°C
DO: 5.14mg/L
RW 3
Temp: 30.5°C
DO: 4.93mg/L
RW 4
Temp: 30.7°C
DO: 4.67mg/L
DO Calibration
AUG 27 2009

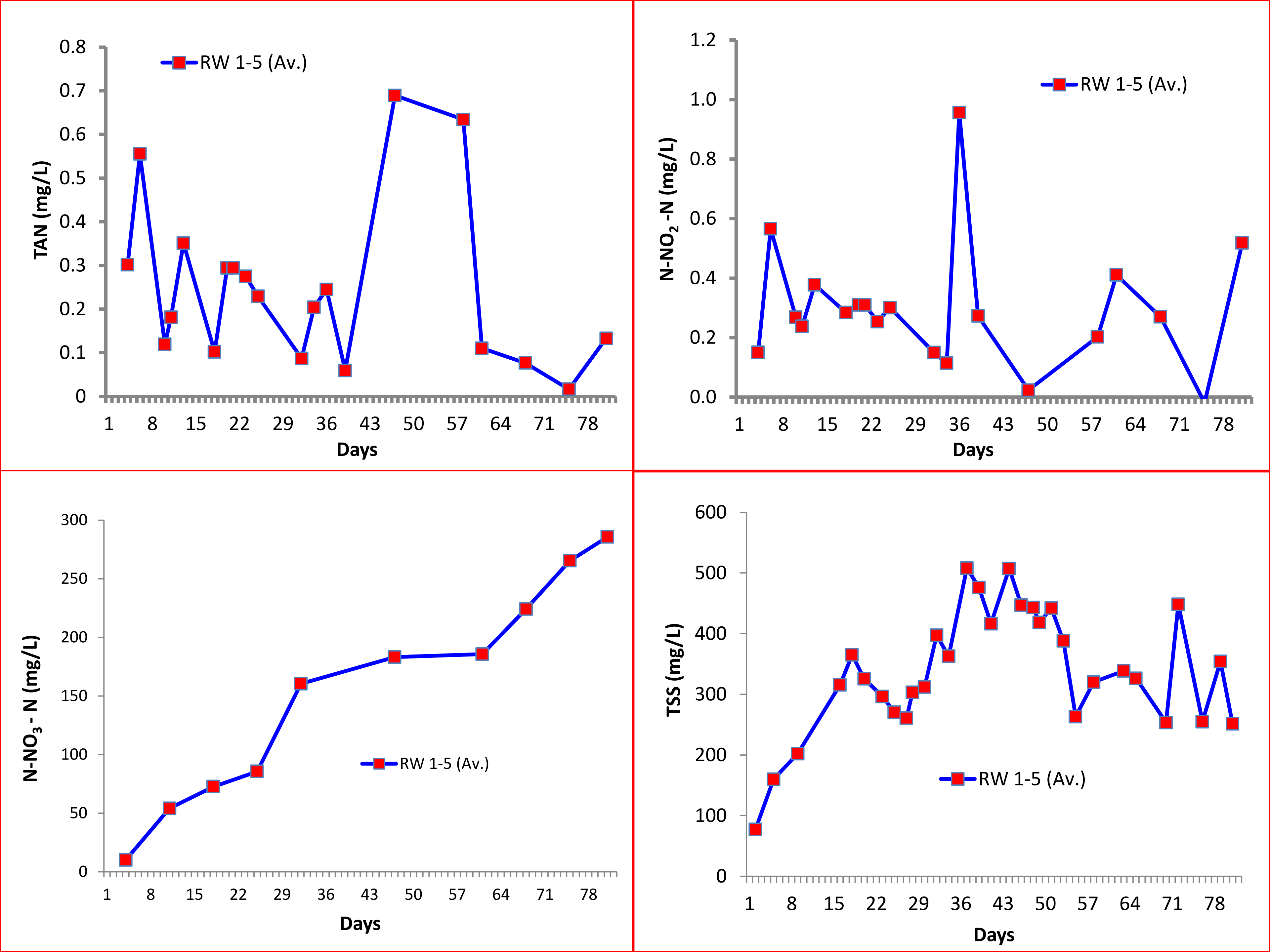

YSI
NOV 6 2009

Results

- When needed, molasses was used to force the change of culture water from autotrophic to heterotrophic
- The YSI DO monitoring probe worked with no problems (e.g., no fouling or loss of calibration) throughout the 85-d study duration
- The use of this monitoring system resulted in better scheduling of feeding and reduction of DO fluctuations in the culture medium

Results

- Ammonia and nitrite levels stayed low in all five raceways throughout the trial
- Nitrate increased from about 10 mg/L at the study initiation to a maximum of 350 mg/L at the end of the trial
- Because targeted TSS and SS in the culture water exceeded preset levels, a settling tank was added to each RW to bring down the concentrations



RW 1-5 (Av.)
TAN (mg/L)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1 8 15 22 29 36 43 50 57 64 71 78
Days
RW 1-5 (Av.)
N-NO$_2$ -N (mg/L)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1 8 15 22 29 36 43 50 57 64 71 78
Days
RW 1-5 (Av.)
N-NO$_3$ - N (mg/L)
300
250
200
150
100
50
0
1 8 15 22 29 36 43 50 57 64 71 78
Days
RW 1-5 (Av.)
TSS (mg/L)
600
500
400
300
200
100
0
1 8 15 22 29 36 43 50 57 64 71 78
Days

Selected WQ Data

RW 1-4	AM Temp. (C)	Sal. (ppt)	DO (mg/L)	pH	NTU	SS (ml/L)	PM Temp. (C)	DO (mg/L)	pH
Av.	29.3	18.5	5.9	7.4	133.7	44.9	30.2	5.6	7.4
SD	0.4	0.1	0.1	0.0	12.8	7.6	0.4	0.1	0.0
Min.	26.4	17.7	4.5	7.0	82.7	6.5	27.8	4.1	7.0
Max.	30.7	19.2	7.6	7.8	242.0	120.0	31.5	7.1	8.0
5									
Av.	29.6	30.4	5.6	7.3	130.5	50.5	30.6	5.4	7.3
SD	1.3	0.7	0.9	0.2	31.5	33.4	1.3	0.8	0.2
Min.	25.2	28.4	4.3	7.0	97.4	13.0	26.2	4.0	6.9
Max.	31.1	31.5	7.8	7.6	193.0	130.0	32.2	8.2	7.9

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Water Management

RW 1-4	Molasses (L)	Bicarbonate (kg)	Seawater (L)	Freshwater (L)	Alkalinity (mg/L)	CO_2 (mg/L)
Av.	14.8	67.2	1,875	19,000	186	18.6
SD	2.6	4.5	750	3,655	6	2.4
Min.					131	6.7
Max.					261	35.5
5						
Av.	17.0	67.4	6,500	12,000	189	22.5
SD					30	11.0
Min.					137	7.6
Max.					248	63.1

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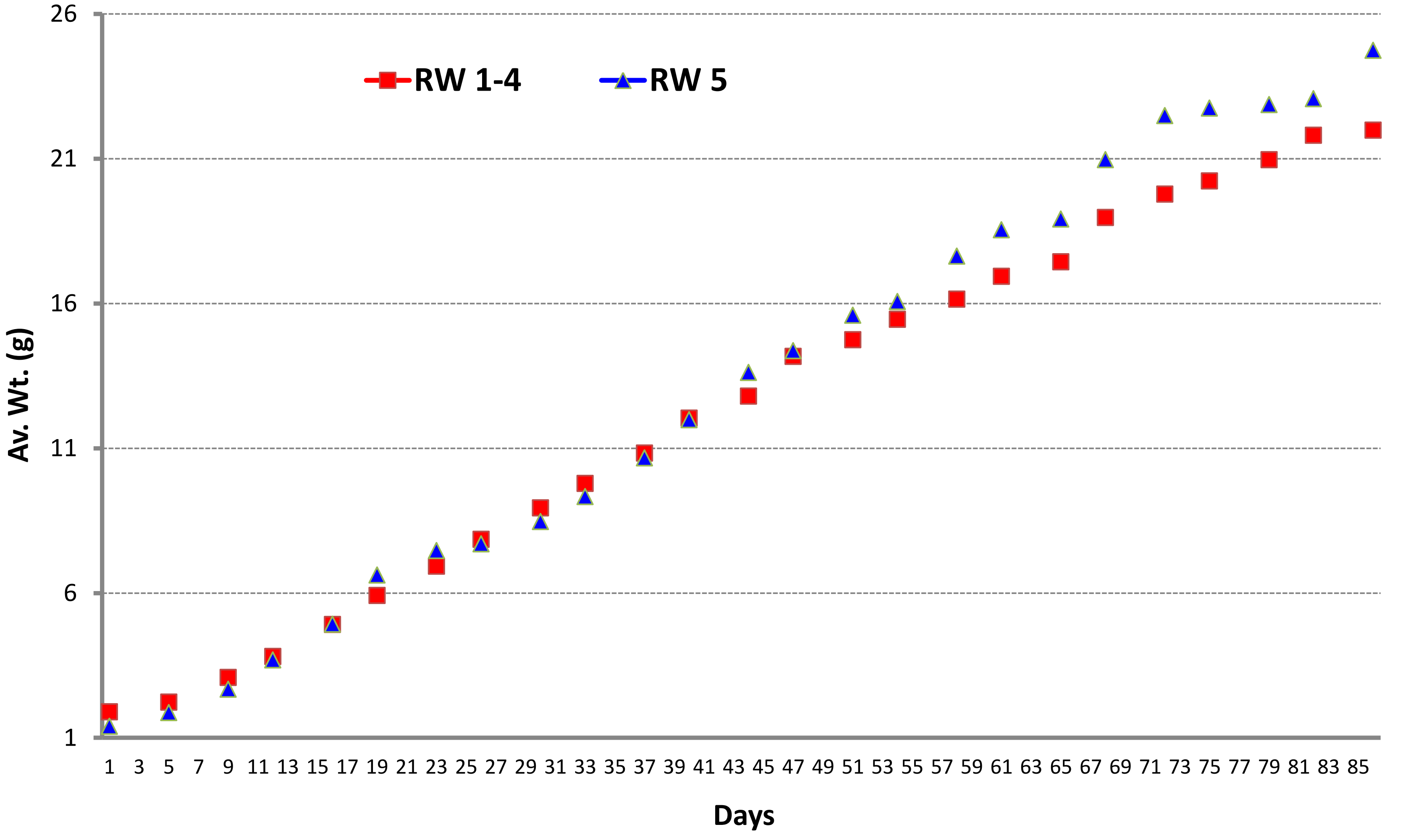
Growth Performance



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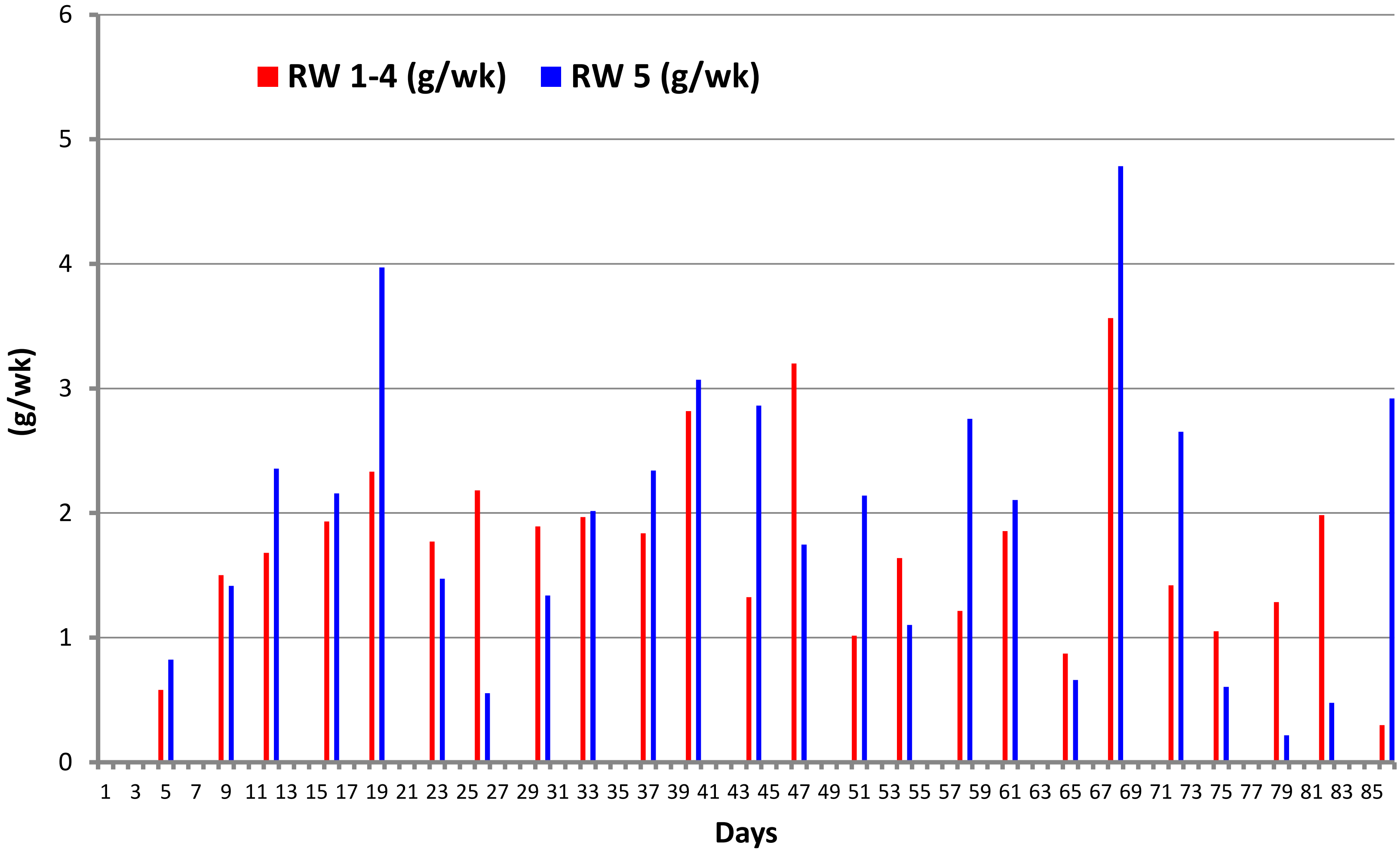
Weekly Growth



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Summary of a high-density grow-out study in five 40 m^3 RWs operated with no exchange

RW	Stocking (Juv/m^3)	Stock (g)	Harvest (g)	Days	Growth (g/wk)	SGR (g/d)	Sur. (%)	Yield (Kg/m^3)	FCR	Water Use L/1 kg	Sal (ppt)
1	500	1.9	22.16	81	1.75	0.25	87.6	9.66	1.39	169.0	18
2	500	1.9	23.63	82	1.86	0.27	81.5	9.59	1.44	160.8	18
3	500	1.9	23.36	82	1.83	0.26	80.7	9.40	1.45	149.0	18
4	500	1.9	23.79	83	1.85	0.26	79.3	9.39	1.45	161.0	18
5	500	1.4	25.12	85	1.95	0.28	78.9	9.87	1.44	148.2	30
Av.			23.61		1.85	0.26	81.6	9.58	1.43	157.6	
SD			0.9 4		0.06	0.01	0.3	0.18	0.02	7.9	

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Table 1. Production results from two experiments (A, B) and expected (C)

Treatment	A	B	C
Stocking density (Juvenile/m^3)	500	390	500
Survival rate (%)	81.6	83.0	83.0
Growth rate (g/wk)	1.85	1.46	1.85
Stocking size (g)	1.8	3.14	1.8
Desired harvest size (g)	23.6	25.3	23.6
FCR	1.43	1.77	1.43
Length of crop period (day/crop)	83	106	83
Production (kg/m^3)	9.58	8.36	9.79

A - Average values from five RWs (current study)
B - Average values from two 100 m^3 RWs operated with special nozzles
C - Hypothetical values

Issues to address in the future

- Operating year round (ionic changes over time)
- Bacterial diseases
- Year round PL Supply
- Marketing
- Feed cost
- FCR
- Growth
- Survival
- Energy & Temp control
- Water treatment (zero exchange vs. recirculating)

Opportunities for the Future

- Improved technology continues to increase growth and production rates while reducing variable costs
- Continued genetic selection should favor higher yields over time
- Financial analyses are focusing research to sharpen competitiveness
- Marketing opportunities
  - Consistent fresh never frozen product
  - Improved image as a domestic producer of healthy food in eco-friendly systems

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- Firestone Specialty Products for the EPDM liner