

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

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 m³ EPDM-lined RWs (Firestone Specialty Products, Indianapolis, IN)
- RWs filled with a mixture of seawater (12 m³), biofloc-rich water (8.5 m³) used in an earlier 42-d nursery trial, and 19.5 m³ of chlorinated municipal freshwater to adjust salinity to 18 ppt
- RWs were stocked (500/m³) with fast-growth *L. vannamei* juveniles (1.90 g) received from Oceanic Institute

Materials & Methods

- For comparison, a fifth RW was operated with 30 ppt salinity (21 m³ biofloc-rich water and 19 m³ seawater), and stocked (500/m³) 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 cBOD₅ were monitored once a week
- Alkalinity was adjusted to 150-200 mg/L (as CaCO₃) using sodium bicarbonate

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)

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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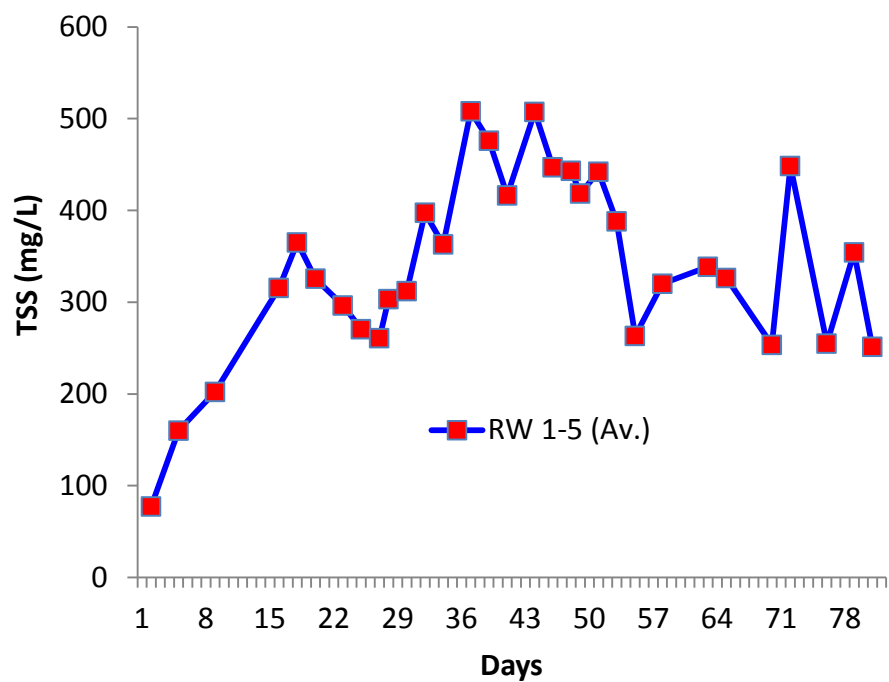
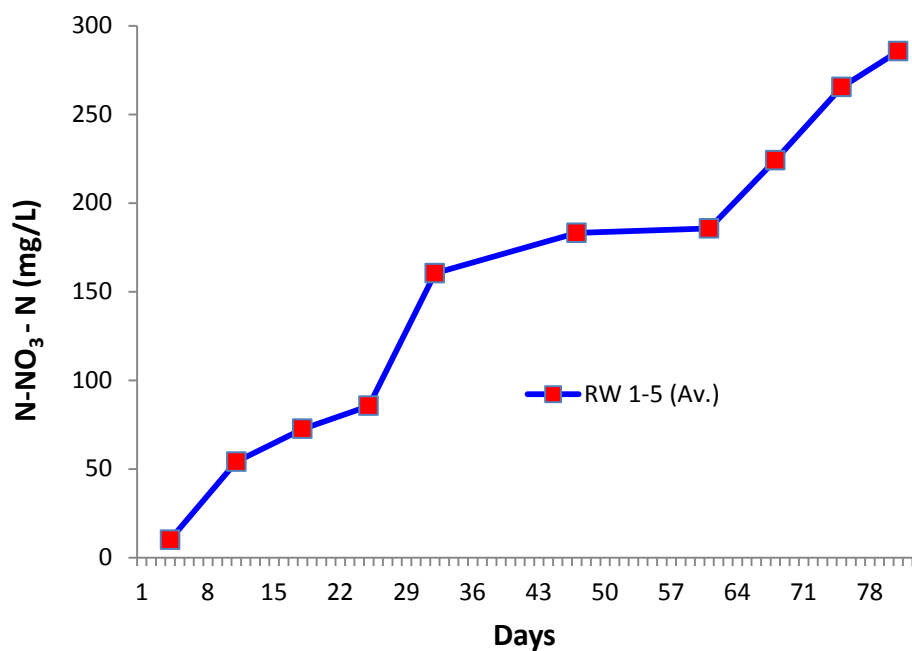
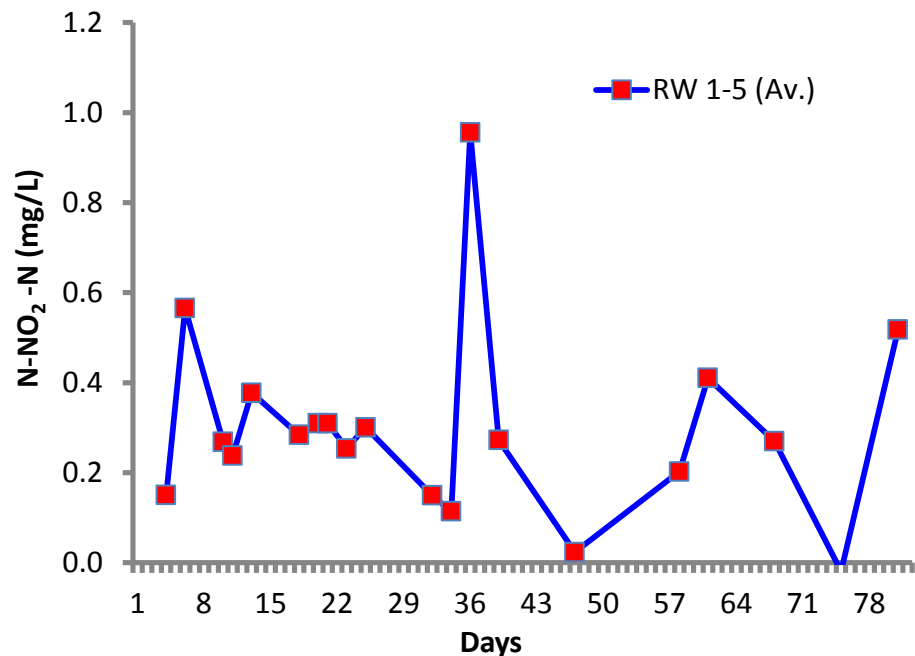
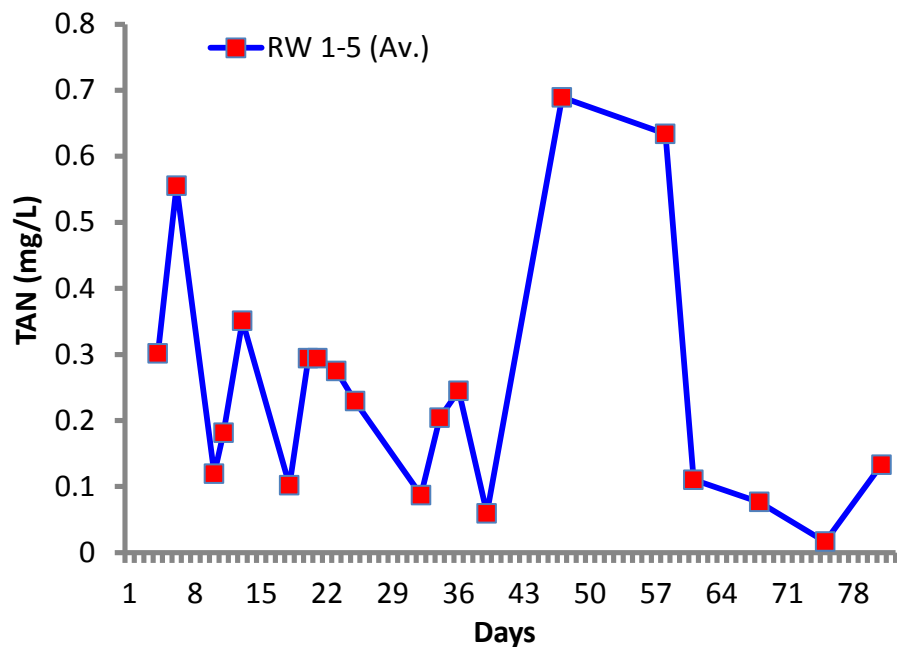
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Results

- 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



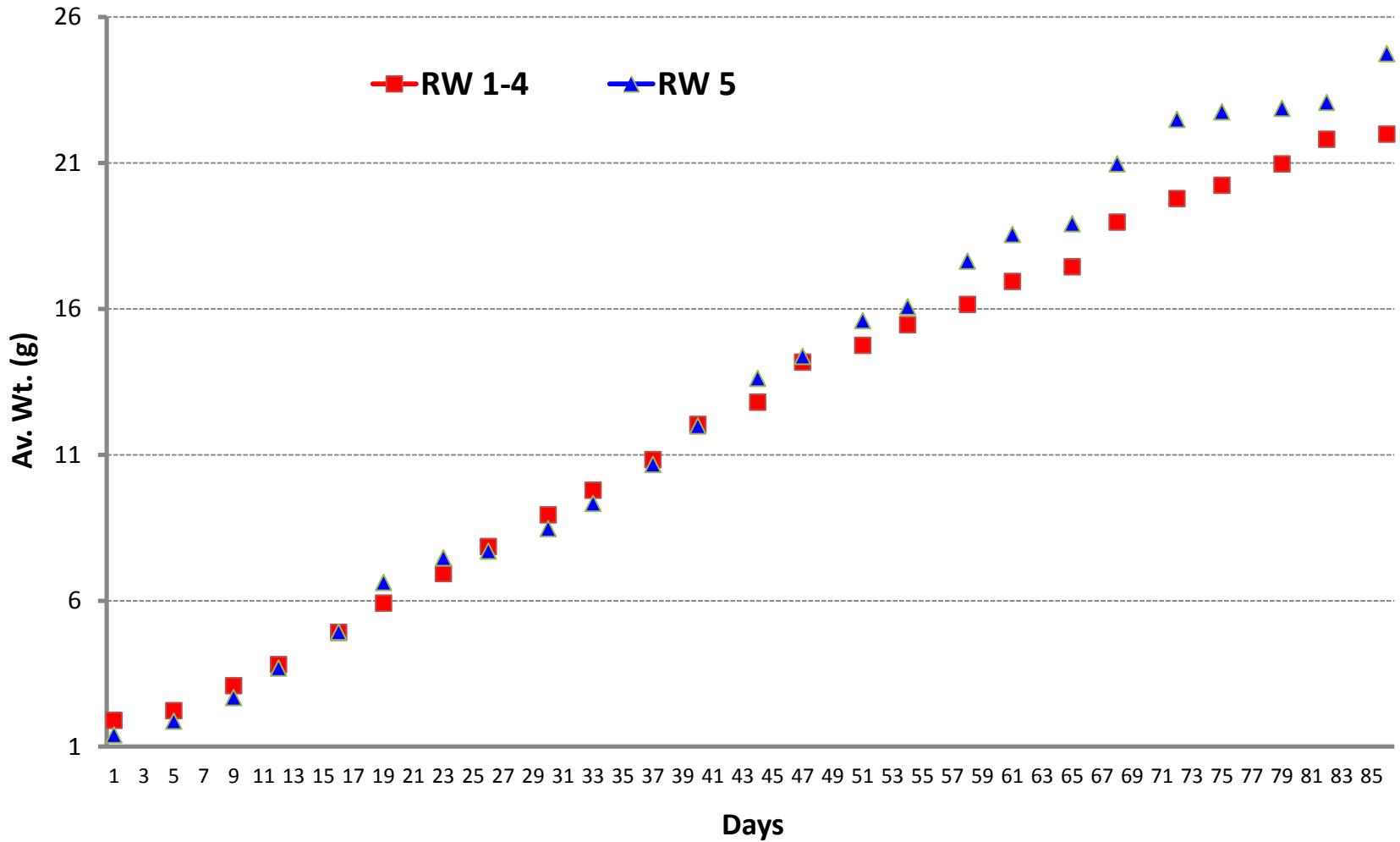
Selected WQ Data

RW	<u>AM</u> Temp.	Sal.	DO	pH	NTU	SS	<u>PM</u> Temp.	DO	pH
1-4	(C)	(ppt)	(mg/L)			(ml/L)	(C)	(mg/L)	
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

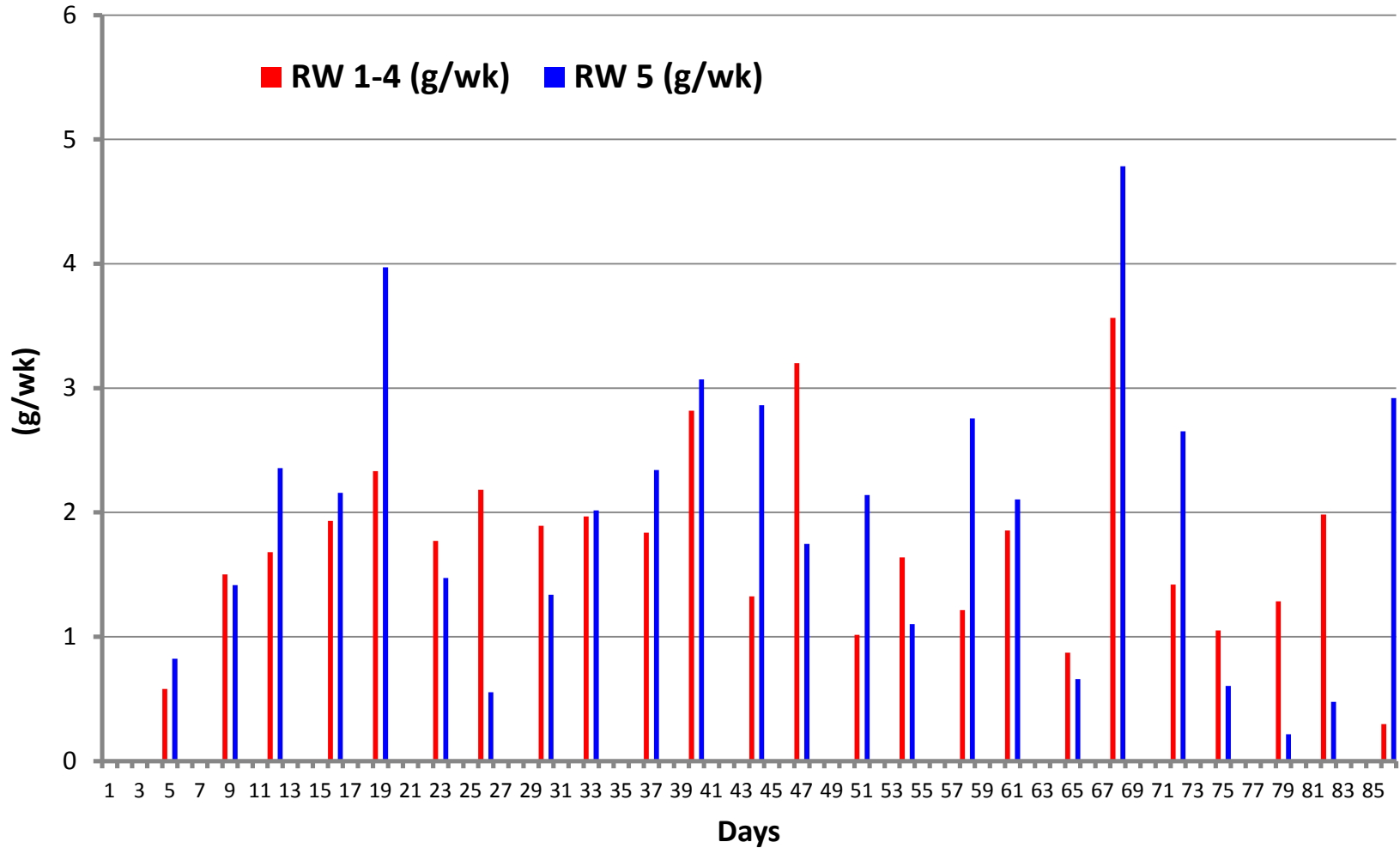
Water Management

RW	Molasses	Bicarbonate	Seawater	Freshwater	Alkalinity	CO₂
1-4	(L)	(kg)	(L)	(L)	(mg/L)	(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

Growth Performance



Weekly Growth



Summary of a high-density grow-out study in five 40 m³ 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			0.94		0.06	0.01	0.3	0.18	0.02	7.9	

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 m³ 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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