High-density production of the Pacific White Shrimp, *Litopenaeus vannamei*, in recycled culture water under zero-exchange conditions using settling tanks, foam fractionators and dissolved oxygen monitoring systems as management tools

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USMSFP

USDA

United States Department of Agriculture

National Institute of Food and Agriculture

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Introduction

- In the last few decades, production of the Pacific White Shrimp, *Litopenaeus vannamei*, has been negatively affected by disease epizootics and environmental concerns over effluent impact on receiving streams
- Traditional shrimp grow-out methods use outdoor ponds and require high water exchange
- The possible introduction of harmful pathogens with the incoming water and the release of nutrient-rich effluent into receiving streams are issues of concern

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Introduction

- For the last few years research conducted by members of the US Marine Shrimp Farming Program has been aimed at the development of cost-effective, sustainable and biosecure super-intensive production of food size Pacific White Shrimp, *Litopenaeus vannamei*
- Although genetic selection of viral-pathogen-free fast-growing and specific-viral-free/resistant lines is an important part of the USMSF program, this presentation will focus on the production aspects only

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Introduction

- Limited discharge recirculating aquaculture systems (RAS) are an alternative that can reduce disease introduction and the negative environmental impact created by traditional pond culture
- Previous research has indicated that good shrimp production can be achieved under low water exchange

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Objectives of current activities

- Evaluate shrimp performance and changes in selected WQ indicators in four raceways stocked at high density under no water exchange using settling tanks and foam fractionators as biofloc management tools
- Perform economic analysis based on the results obtained from this year's study
- Improve our understanding and management of a biofloc dominated super-intensive shrimp production system

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Materials & Methods

- Juveniles (0.99±0.17 g) were stocked (450/m^3) into four 40 m^3 (68.5 m^2) ethylene propylene diene monomer (EPDM) lined raceways filled with water previously used in a 62-d nursery trial
- Each RW had eighteen 5.1-cm airlifts, six 1-m long air diffusers, and a center longitudinal partition over a 5.1-cm PVC pipe with spray nozzles fed by a Venturi injector powered by a 2 hp pump
- Two RWs were outfitted each with a small commercial FF while the other two were each equipped with 8.6 m^3 conical bottom settling tank (4.9 m^3 working volume)

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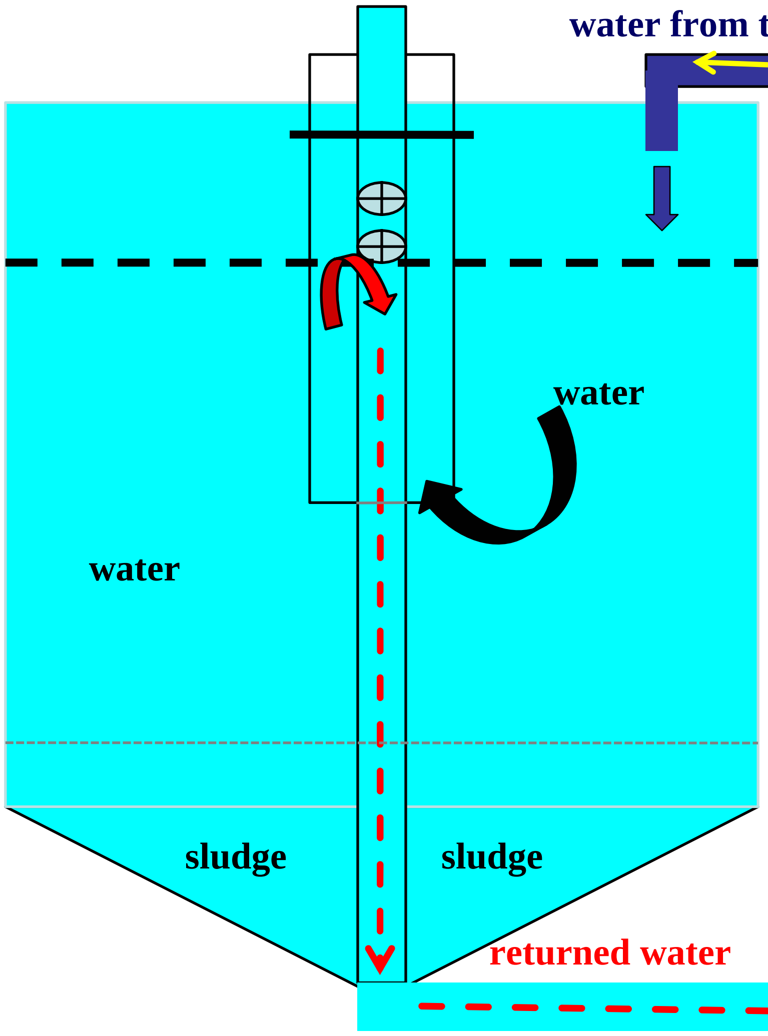
Materials & Methods

- Settling tanks and the FF were operated intermittently from Day 23 targeting culture water TSS concentrations between 400 and 600 mg/L
- Flow into the settling tanks was maintained between 2 to 8 LPM
- Raceways were operated with no water exchange
- Evaporation was compensated by adding chlorinated municipal water
- Alkalinity was monitored at least twice weekly and was adjusted to 160 mg/L using sodium bicarbonate


APR 18 2009

Settling Tank Setup



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Materials and Methods

- Temperature, salinity, dissolved oxygen, and pH were recorded twice daily
- Turbidity, algal counts, TSS, VSS, $cBOD_5$, NO_2-N, NO_3-N, and RP were monitored weekly
- Settleable solids were checked three times a week
- Microbial communities were sampled weekly
- Each raceway was equipped with a YSI 5200 multi-parameter monitoring system to provide continuous DO and temperature readings


EverStart
maxx
marine

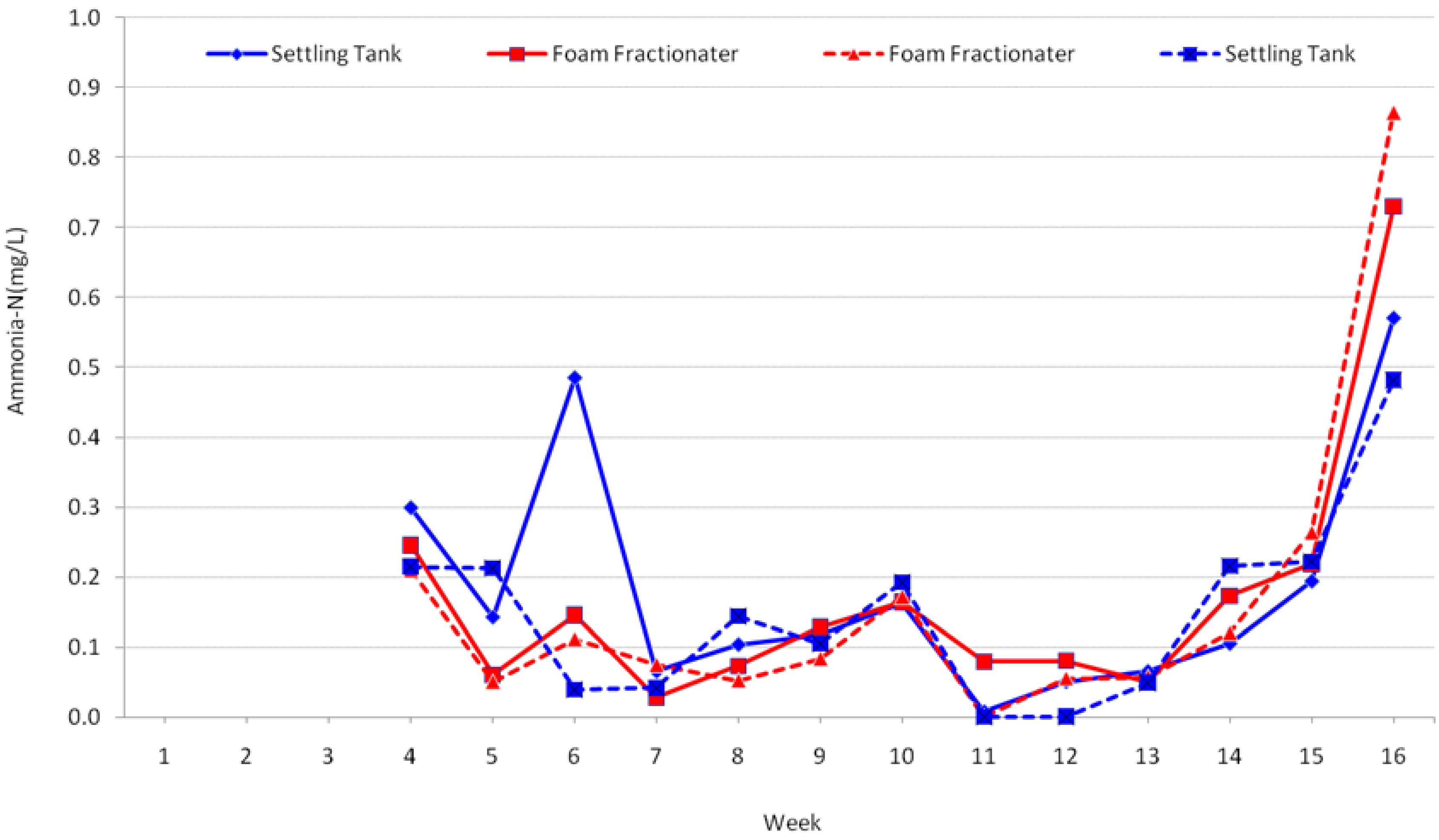

Map: Mapping
RW 1
Temp: 29.5°C
DO: 4.96mg/L
RW 2
Temp: 30.1°C
DO: 5.14mg/L
RW 3
Temp: 30.5°C
DO: 4.93mg/L
RW 4
Temp: 30.7°C
DO: 4.67mg/L
DO Calibration
AUG 27 2009


YSI
NOV 6 2009

Materials and Methods

- Shrimp were fed a 35% CP commercial feed (Hyper-Intensive 35, Zeigler Bros., Gardners, PA)
- 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
- Daily rations were adjusted based on assumed FCR of 1:1.4, growth of 1.4 g/wk and a mortality rate of 0.5%/wk

Weekly changes in TAN



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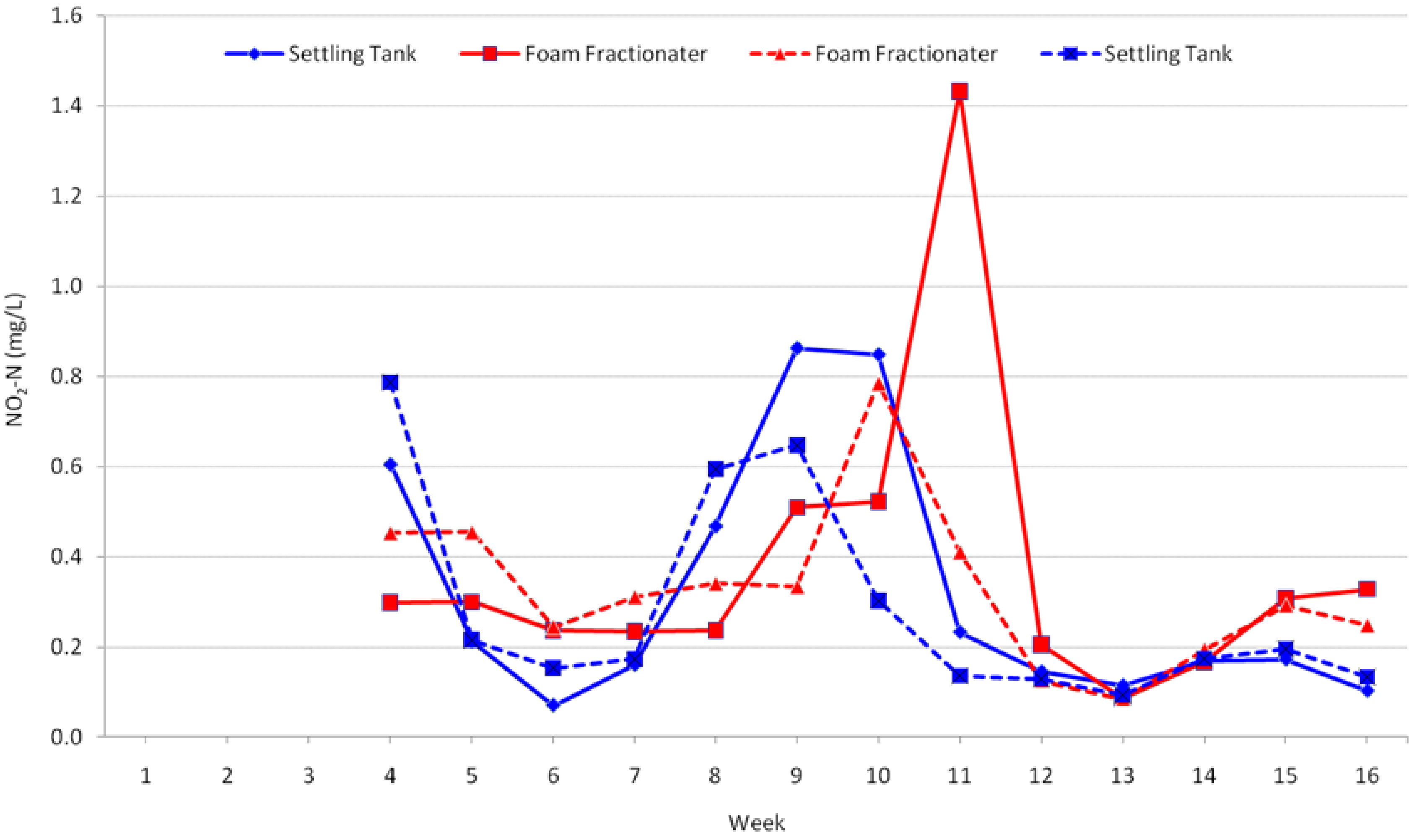
Weekly changes in NO_2-N



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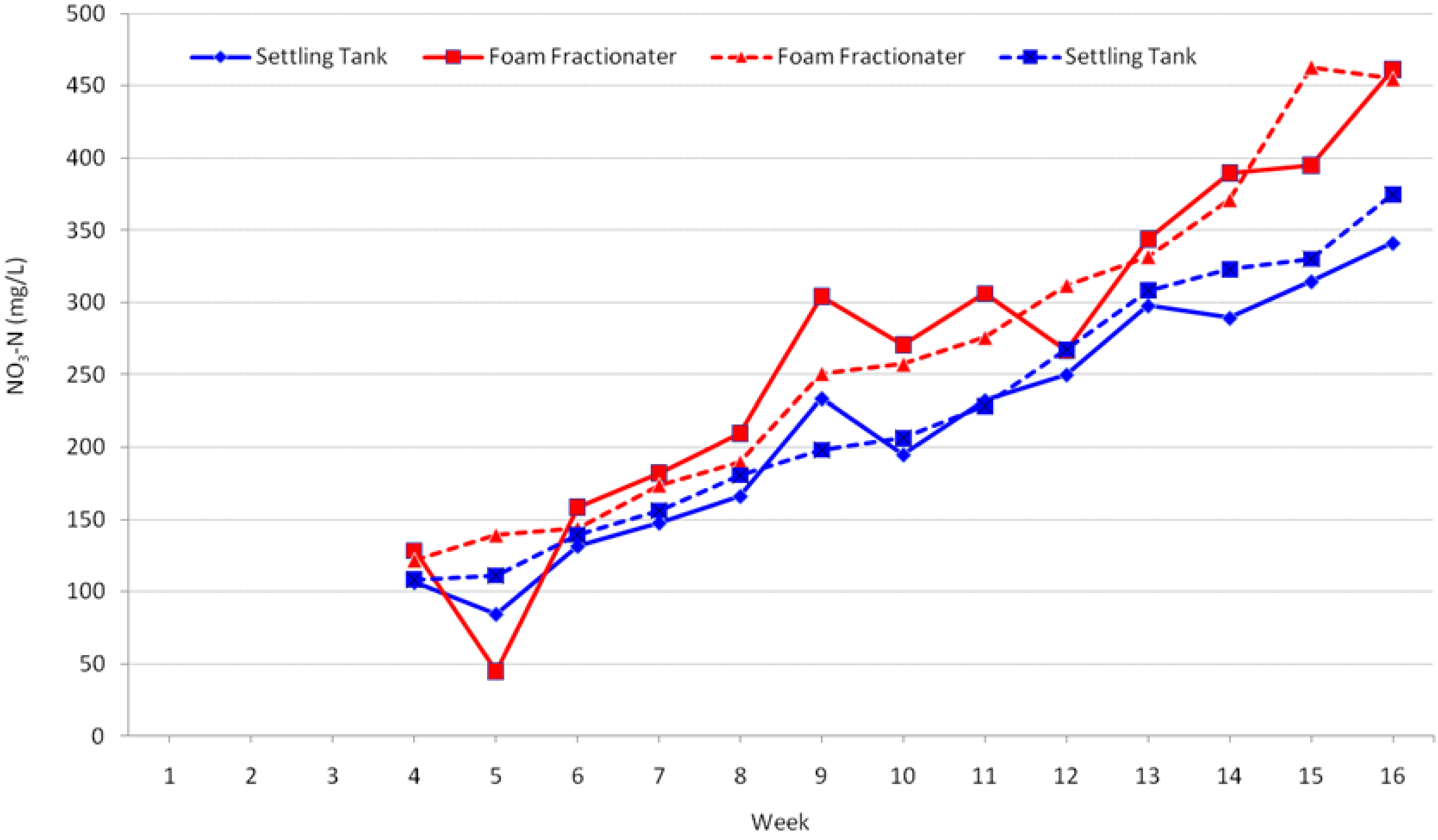
Weekly changes in NO_3-N



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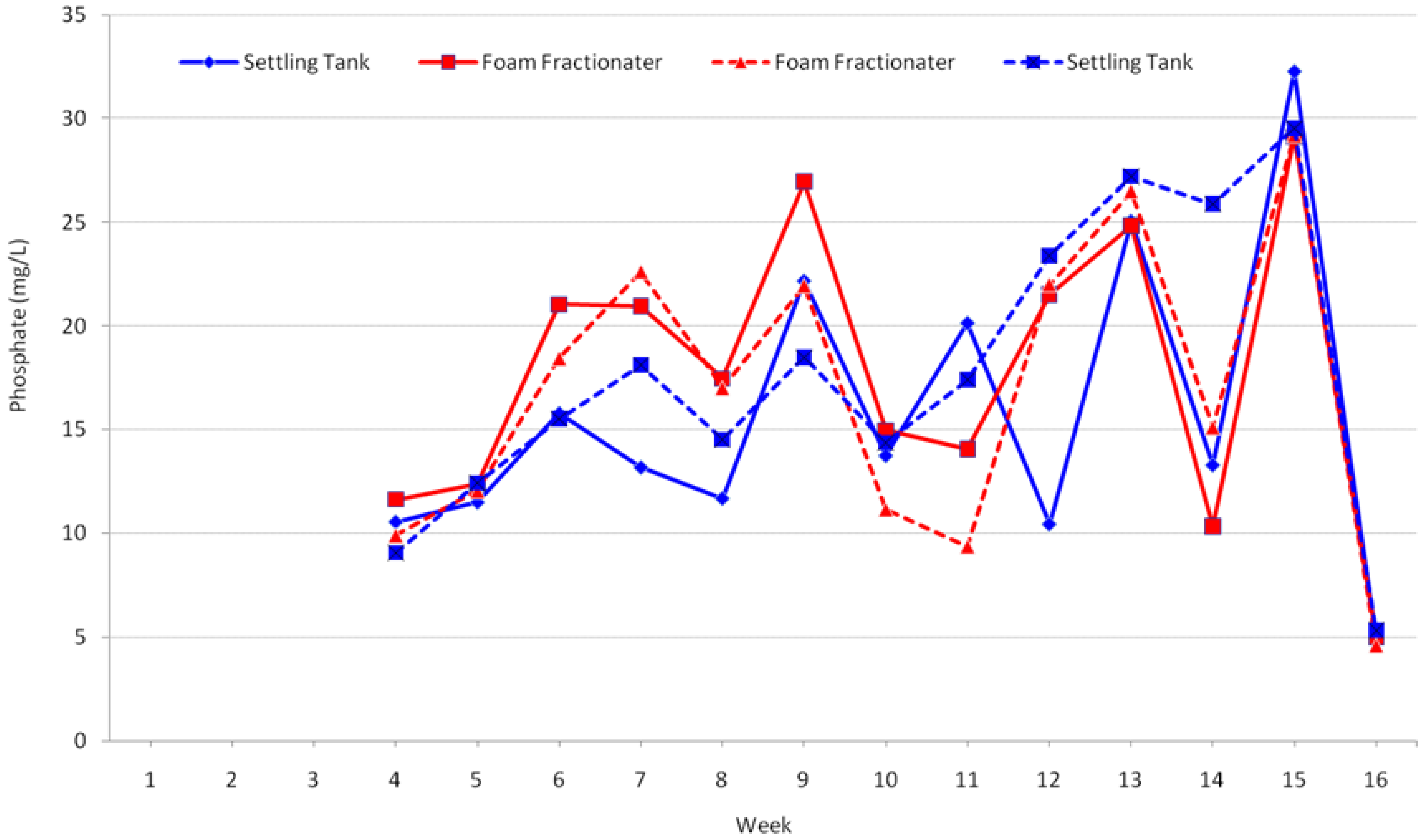
Weekly changes in PO_4



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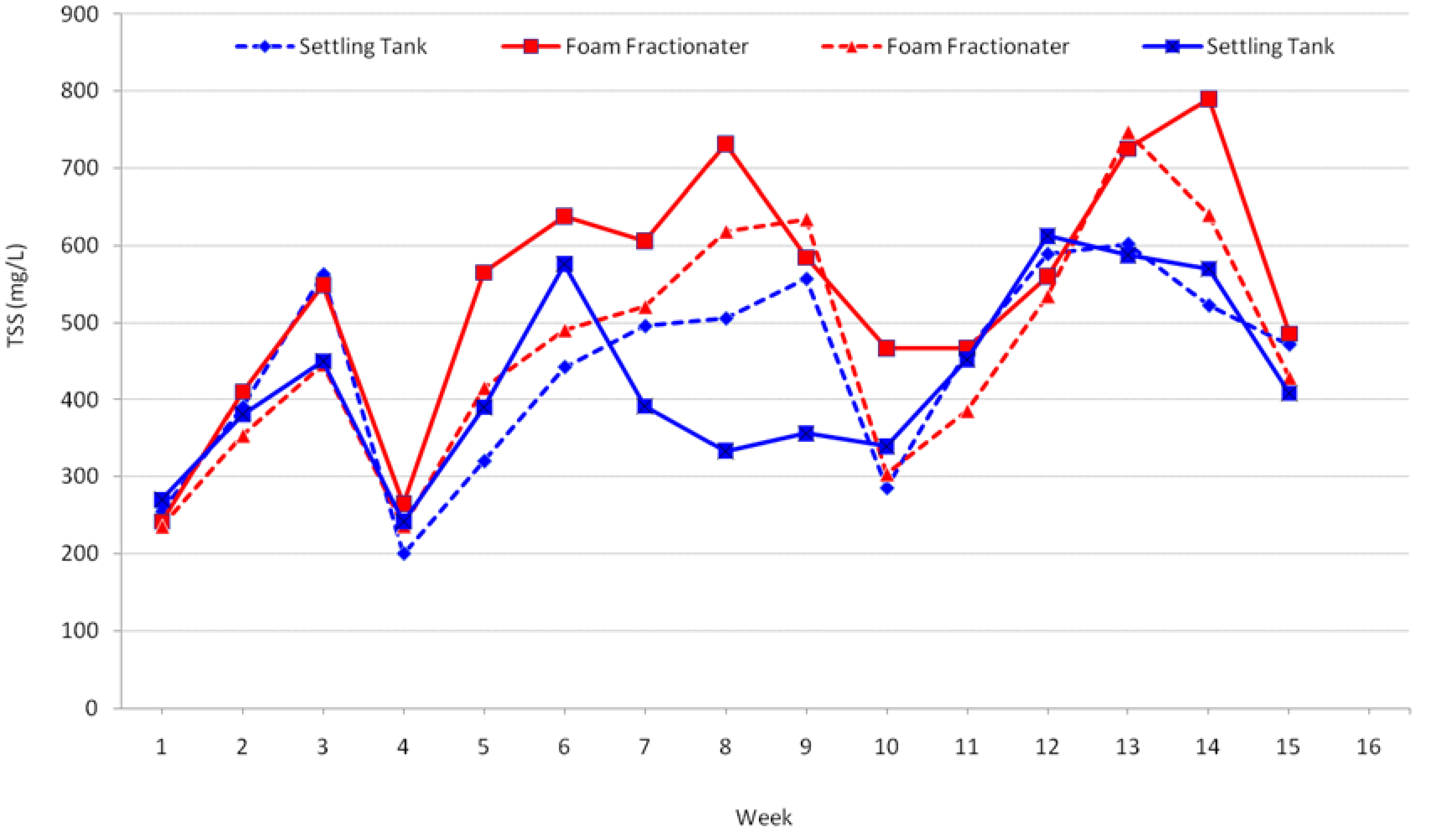
Weekly changes in TSS



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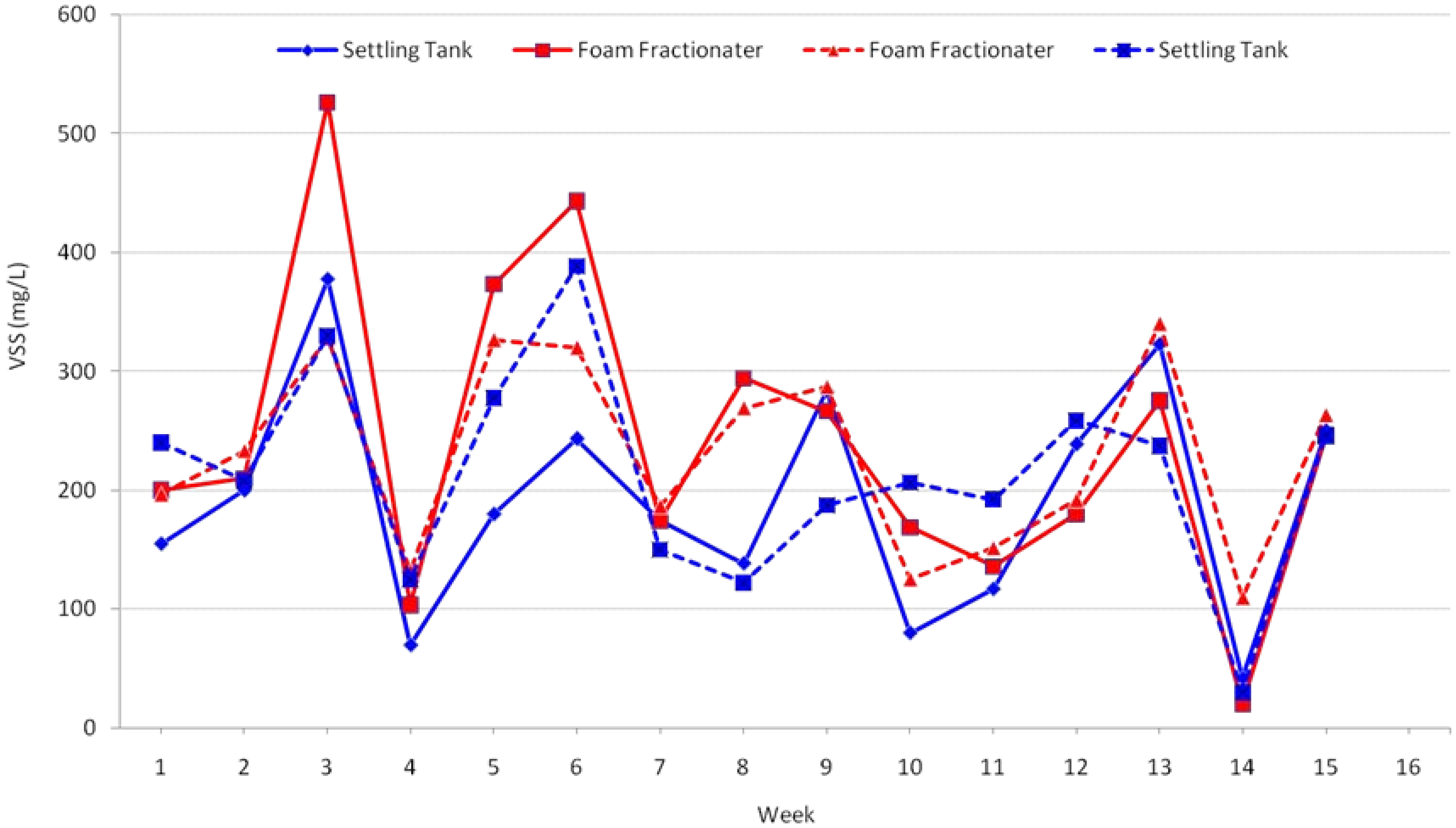
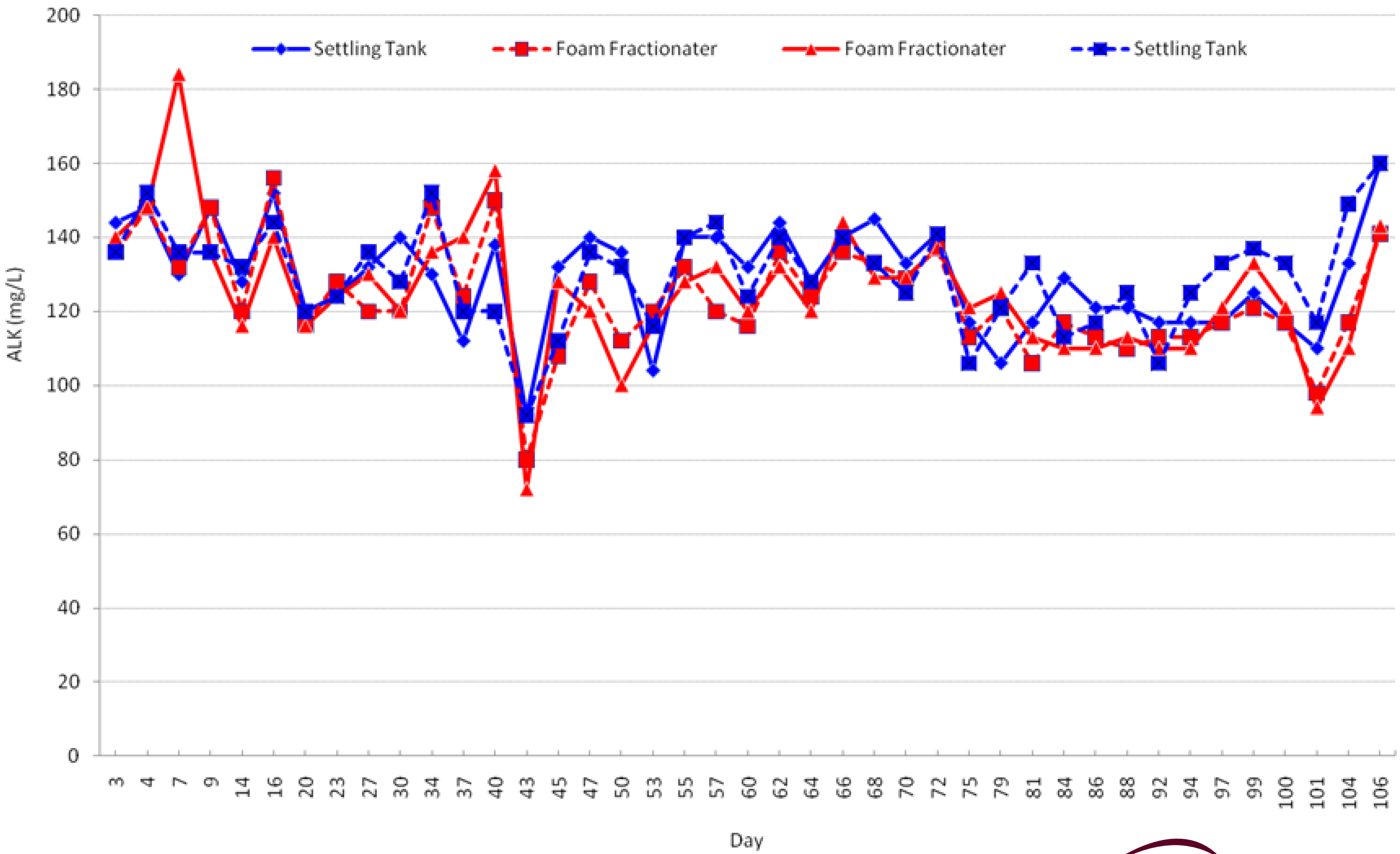
Weekly changes in VSS



Changes in Alkalinity



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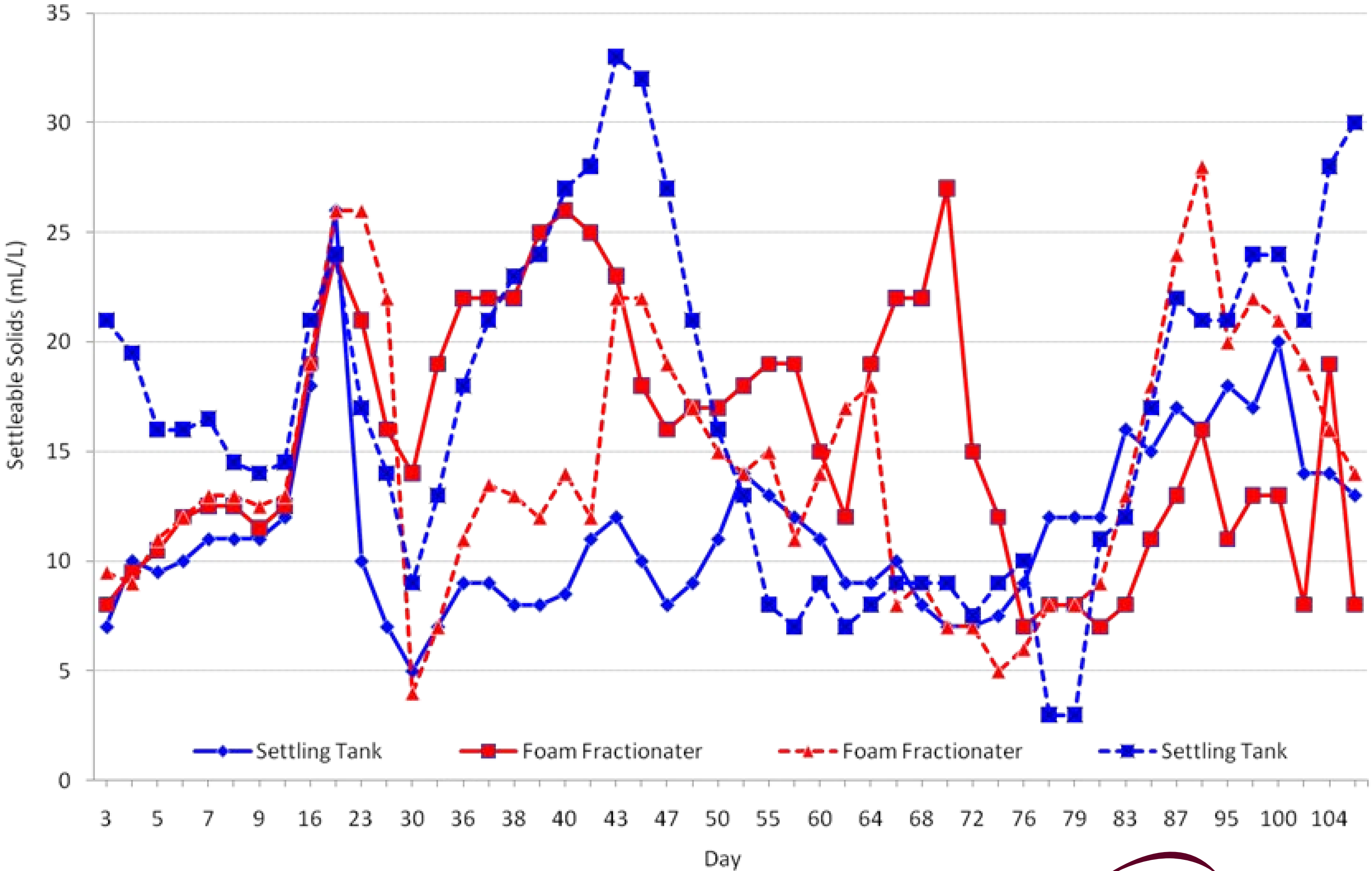
Changes in SS



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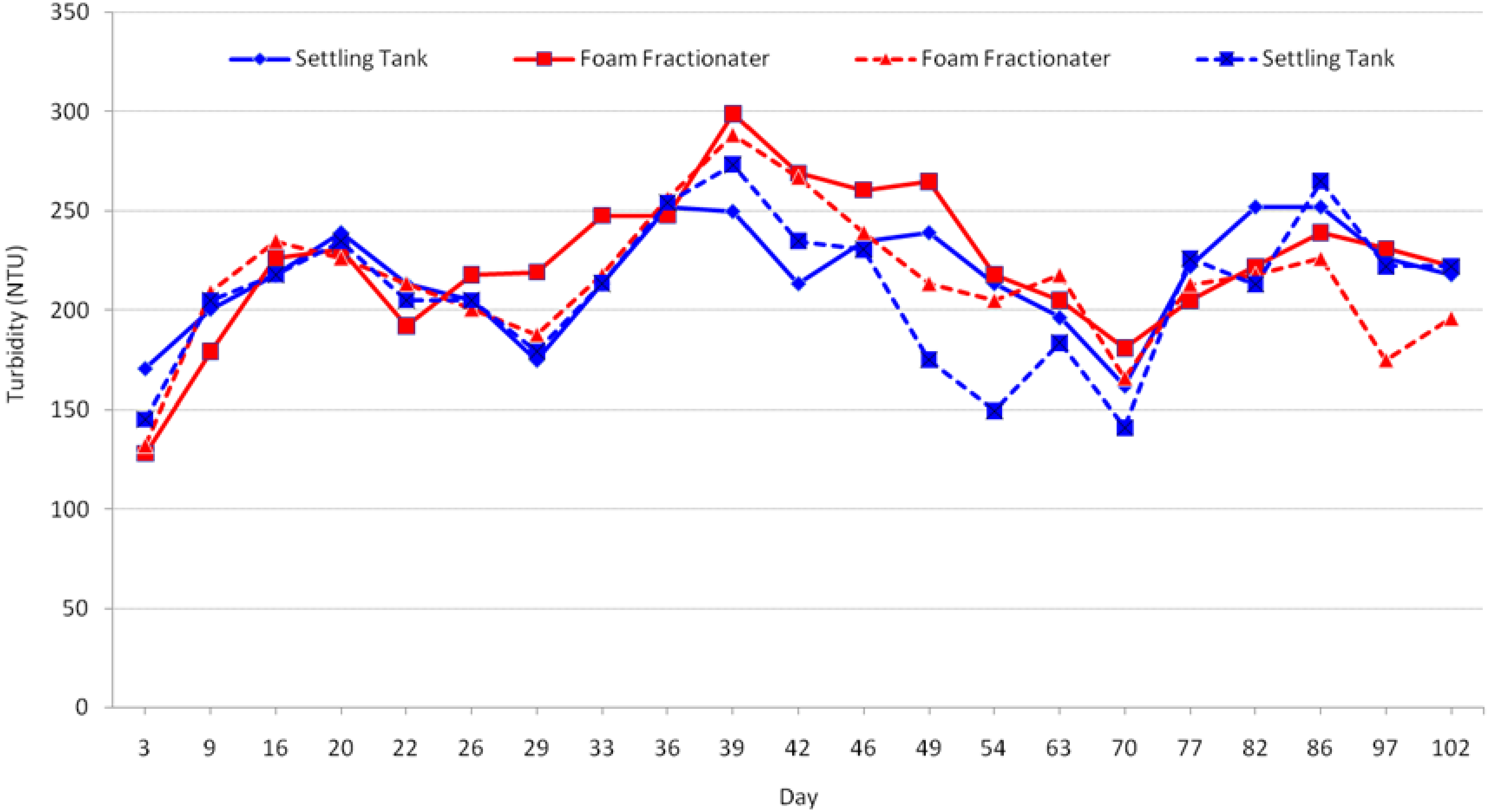
Changes in Turbidity



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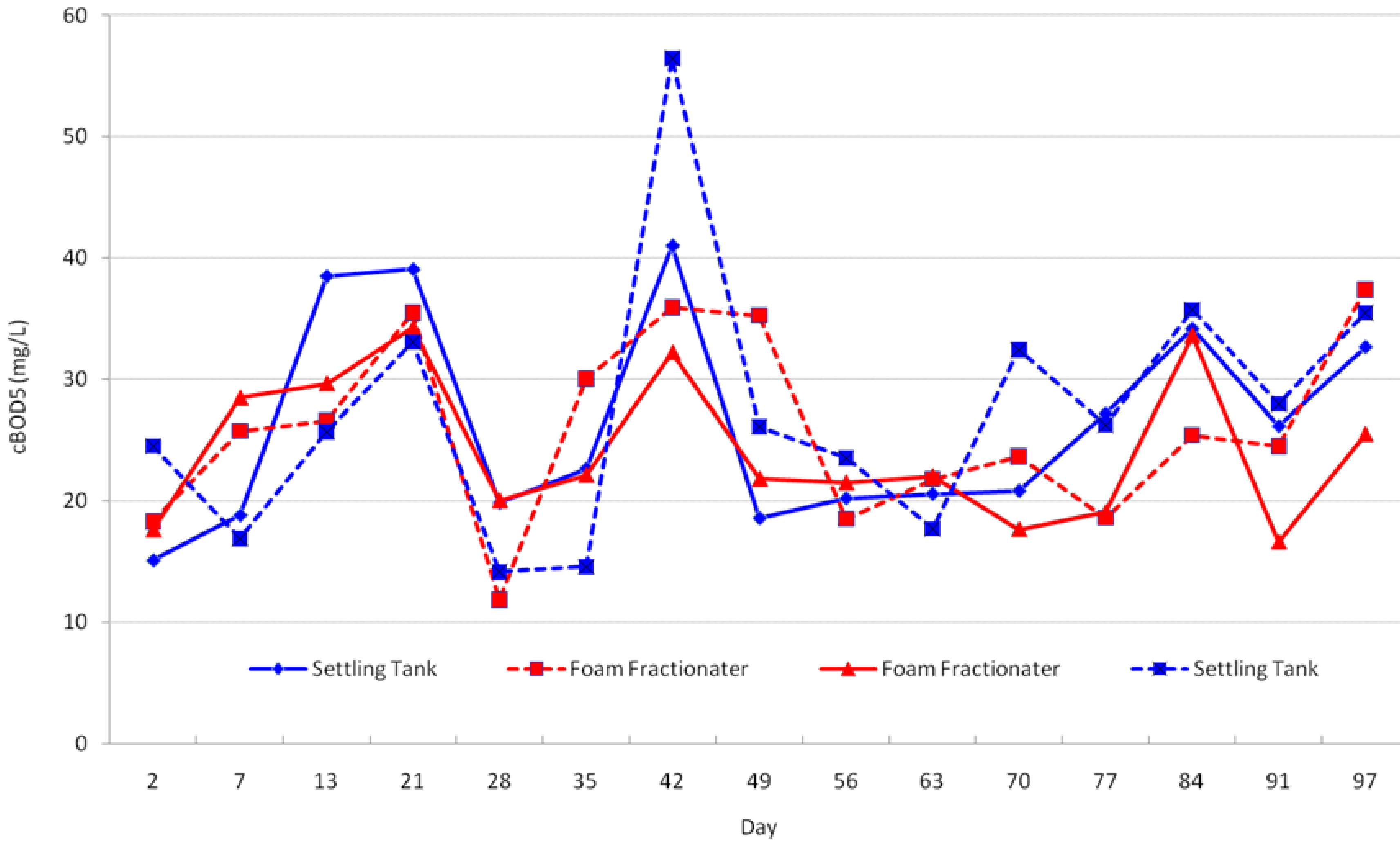
Weekly changes in $cBOD_5$



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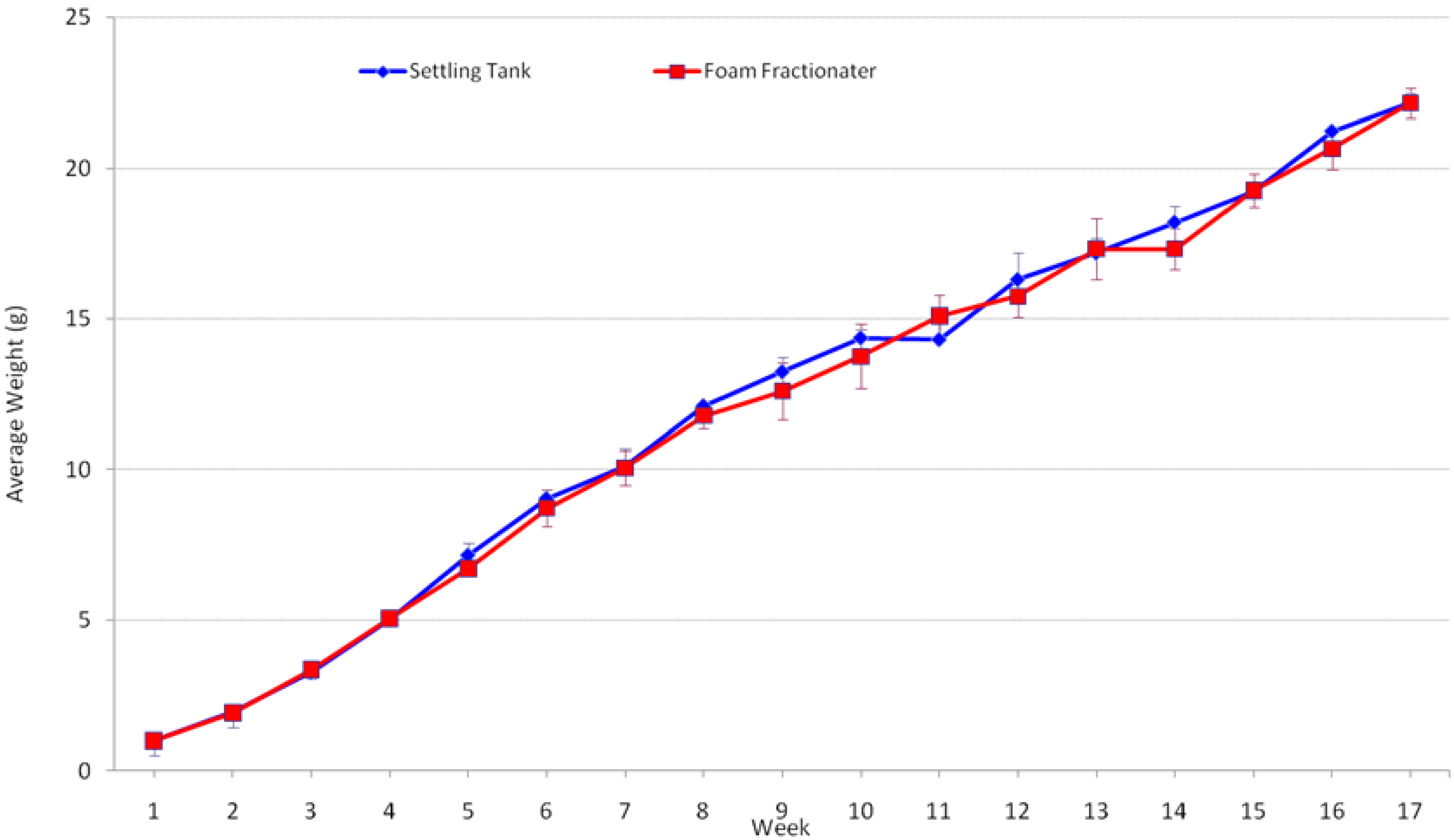
Weekly growth changes



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Summary of the current 108-d grow-out study with *Litopenaeus vannamei* stocked with juveniles (0.99 g) at 450/m^3 under no water exchange

ID	Yield (kg/m^3)	Av. Wt. (g)	Sur. (%)	FCR	(g/wk)	Freshwater (%/day)	L/kg Shrimp	O_2: last 7 d (L/min)
ST1	9.34	21.96	94.5	1.60	1.36	0.28	126	0.19
ST2	9.52	21.81	94.5	1.57	1.39	0.27	107	0.16
FF1	9.51	22.51	96.9	1.53	1.35	0.24	108	0.36
FF2	9.75	22.40	96.3	1.57	1.39	0.22	98	0.19

Power use: 15.4 KW/kg shrimp produced

Economic Analysis - Assumptions

- Based on average 2009 production performance of the two treatments an extrapolation was made to a commercial scale with one greenhouse structure housing:
  - Eight grow-out tanks and two nursery tanks
  - Tank size: 500 m^2 (500 m^3) in a raceway shape
  - 3.7 crops per year
- Initial investment - $ 992,000
  - Includes greenhouse, raceways, machinery, equipment

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Enterprise Budget & Cash Flow Summary 07 vs. 09

Value/Cost, $/kg	2007 Settling	2007 Foam Fractionation	2009 Settling & FF
1. Gross Receipts,	$7.20	$7.20	$7.20
2. Variable Costs	$4.90	$5.50	$4.82
3. Income Above Variable Cost	$2.30	$1.70	$2.38
4. Fixed Cost	$0.77	$0.89	$0.70
5. Total of All Specified Expenses	$5.67	$6.39	$5.52
6. Net Returns Above All Specified Expenses	$1.54	$0.82	$1.68
Net Returns, $/kg, Per Greenhouse:			
Above variable costs	$2.30	$1.70	$2.38
Above total costs	$1.54	$0.82	$1.68
Breakeven Price to Cover:			
Variable costs	$4.90	$5.50	$4.82
Total costs	$5.67	$6.39	$5.52

Over a 10-year period , using a 10% discount rate:			
Pay back period, yr	3.1	4.7	2.8
Net present value, $	840,231	242,108	1,081,001
Internal Rate of Return, %	28.06	15.58	32.78

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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

Acknowledgements

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- Harlingen Shrimp Farms for the PL
- YSI for the DO monitoring systems
- Aquatic Eco-Systems for the foam fractionators
- Colorite Plastics for the air diffusers
- Firestone Specialty Products for the EPDM liner


END!?
OCT 26 2009

Litopenaeus vannamei performance in a 108 d grow-out trial in greenhouse-enclosed RW's stocked with juveniles (0.99 g) at a density of 450/m^3 & operated with no water exchange

Average Treatment Data Used in the Economic Analysis

Treatment	Wt (g)	Growth (g/wk)	Yield (kg/m^3)	Yield (kg/m^2)	Sur. (%)	FCR	Water Use (L/kg Shrimp)
2009 Ave. for ST & FF	22.17	1.37	9.53	5.56	95.5	1.57	110

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Economic Analysis - Assumptions

- Prices/Costs used in analysis
  - Shrimp (21-25 count, head-on)
    - Sell price $3.27/lb
  - Grow-out feed (2007)
    - $0.4965/lb or $993/ton
  - Post larvae, 42 day old
    - Production cost: $19.52/1,000
  - Interest rate for loans
    - 8%

Economic Analysis - Methods

- Performed 10-year cash flow analysis to estimate:
  - Cost of production
  - Net returns to land
  - Net present value
  - Internal rate of return
  - Payback period

Litopenaeus vannamei **performance in a 94-d grow-out trial in greenhouse-enclosed RW's stocked with juveniles (1.25 g) at a density of 530/m^3 & operated with no water exchange - 2007**

ID	Wt_f (g)	Growth (g/wk)	Yield* (kg/m^3)	Yield** (kg/m^2)	Sur. (%)	FCR	Water Use (L/kg Shrimp)
ST1	18.4[a]	1.32	9.29	5.02	88.3	1.21	155
ST2	18.5[a]	1.23	8.63	4.50	80.5	1.36	142
FF1	17.4[b]	1.22	8.57	4.38	80.5	1.40	152
FF2	17.3[b]	1.30	7.92	4.66	80.0	1.30	147

* **Based on RW water volume at harvest (37 m^3)**

** **Based on RW bottom area of 68.5 m^2**