Intensive production of the Pacific white shrimp, *Litopenaeus vannamei* fed two commercial feeds of differing protein content in a no water exchange, biofloc-dominated system

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Introduction

- Feed accounts for more than 50% of total shrimp productions costs
- Feed also plays an important role in optimizing shrimp growth and can significantly affect the system's water quality and biofloc composition
- Interactions between feed, WQ, and productivity resulted in specially designed feeds being developed for super-intensive biofloc-dominated shrimp production systems
- *Vibrio* infections regularly restrict shrimp performance in intensive culture systems

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Objectives

- To evaluate the use of a commercial (HI-35) and an experimental (EXP-14) feed formulated for super-intensive biofloc-dominated shrimp production systems for *Litopenaeus vannamei* under no water exchange
- To study the changes in selected WQ indicators throughout the trial
- To monitor changes in *Vibrio* populations throughout the trial

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Materials & Methods

- Four 40 m^3 EPDM-lined RWs (*Firestone Specialty Products*, *Indianapolis*, *IN*) were filled with biofloc-rich water (35 m^3) from an earlier nursery trial, and natural seawater (5 m^3)
- Salinity was adjusted to 30 ppt
- RWs were stocked at 457/m^3 with Taura Resistant/Fast-Growth juveniles (5.3 g) raised at the lab from PL (*Shrimp Improvement Systems*, *Islamorada*, *FL*)
- Study duration: 48 d

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Materials & Methods

- Each RW had eighteen 5.1 cm airlifts, six 0.9 m long air diffusers (*AeroTube*, *Colorite Division*, *Tekni-Plex*, *Austin*, *TX*) & a center longitudinal partition over a PVC pipe with spray nozzles fed by a Venturi injector operated by a 2 hp pump
- Chlorinated municipal freshwater was added weekly to compensate for losses to evaporation and particulate matter control
- Raceways were operated with no water exchange

Materials & Methods

Two RWs were fed Shrimp GR Hyper-Intensive (HI-35) feed while the other two received Shrimp EXP-14 (EXP) feed (*Zeigler Bros*., *Gardners*, *PA*)

Component	HI-35	EXP
Crude Protein (%)	35	40
Lipid (%)	7	9
Fiber (%)	2	2
Phosphorus (%)	-	1
VPak™	✓	✓
Price ($/kg)	1.76	2.10

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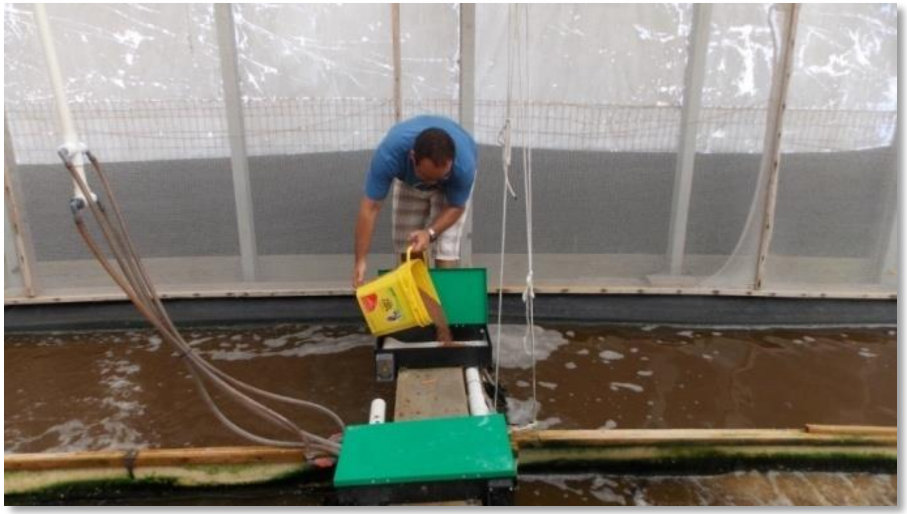
Materials & Methods

- Rations were initially determined using an assumed FCR of 1.2-1.3, growth of 1.5 g/wk, and mortality of 0.5%/wk, and were adjusted according to twice weekly growth samples and observations of mortality
- Feed was distributed continuously 24/7 using belt feeders



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Materials & Methods

Water Quality

Every RW had an optical DO monitoring probe and YSI 5500D monitoring system (*YSI Inc.*, *Yellow Springs*, *OH*)


Monitoring frequency	Parameters
Twice daily	Temp., Salinity, DO, pH
Daily	SS
Every 2nd day	Alkalinity
Twice weekly	TAN, NO_2-N, TSS
Weekly	NO_3-N, PO_4, VSS, Turbidity

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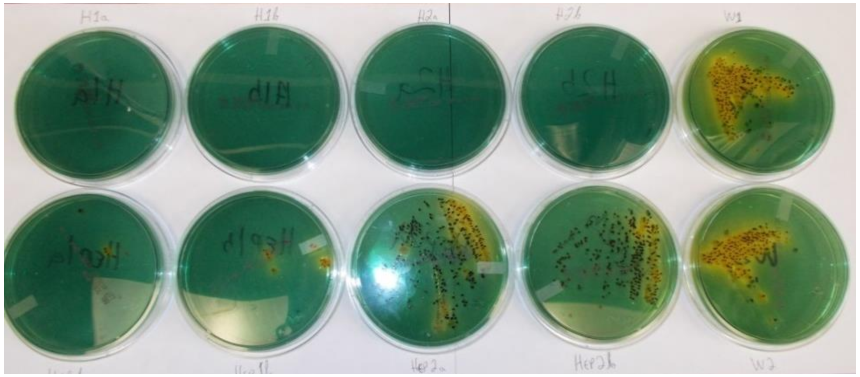
Materials & Methods

- Alkalinity adjusted to 160 mg L^{-1} (as $CaCO_3$) using sodium bicarbonate every 2nd day
- pH adjusted to >7 using NaOH on days 33 – 40
- O_2 supplemented from day 14 onwards
- A probiotic was added every 1-3 days: Ecopro® (*EcoMicrobials, LLC*, *Miami*, *FL*)
- *Vibrio* was monitored 2/wk on TCBS



Materials & Methods

- Each RW was outfitted with a small commercial Foam Fractionator (*VL 65 Aquatic Eco Systems*, *Apopka*, *FL*) and a 450 L Settling Tank
- FFs & STs were used to control particulate matter and dissolved organics, targeting TSS and SS levels in the ranges of 200-300 mg L^{-1} and 10-14 mL L^{-1}, respectively

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Foam Fractionator

Settling tanks

Results

Water Quality

Daily WQ

	HI-35		EXP	
	Mean	Min - Max	Mean	Min - Max
Temperature (^{o}C)	30.0	27.8 - 31.8	29.9	27.8 - 31.9
DO (mg L^{-1})	5.3	3.5 - 6.9	5.3	3.8 - 6.8
pH	7.5	6.8 - 8.0	7.5	6.7 - 8.0
Salinity (ppt)	30.3	29.6 - 31.2	30.4	29.7 - 31.3

Results

Water Quality

- Ammonia (< 6.00 mg L^{-1}) and nitrite (2.24 mg L^{-1}) levels remained low in all raceways throughout the trial
- Nitrate-N increased from 45 mg L^{-1} at the study initiation to a maximum of 232 mg L^{-1} (EXP) & 189 mg L^{-1} (HI-35) at the end of the trial
- Phosphate was significantly higher in EXP
- Although TSS & turbidity levels with the EXP feed were higher, these differences were not significantly different

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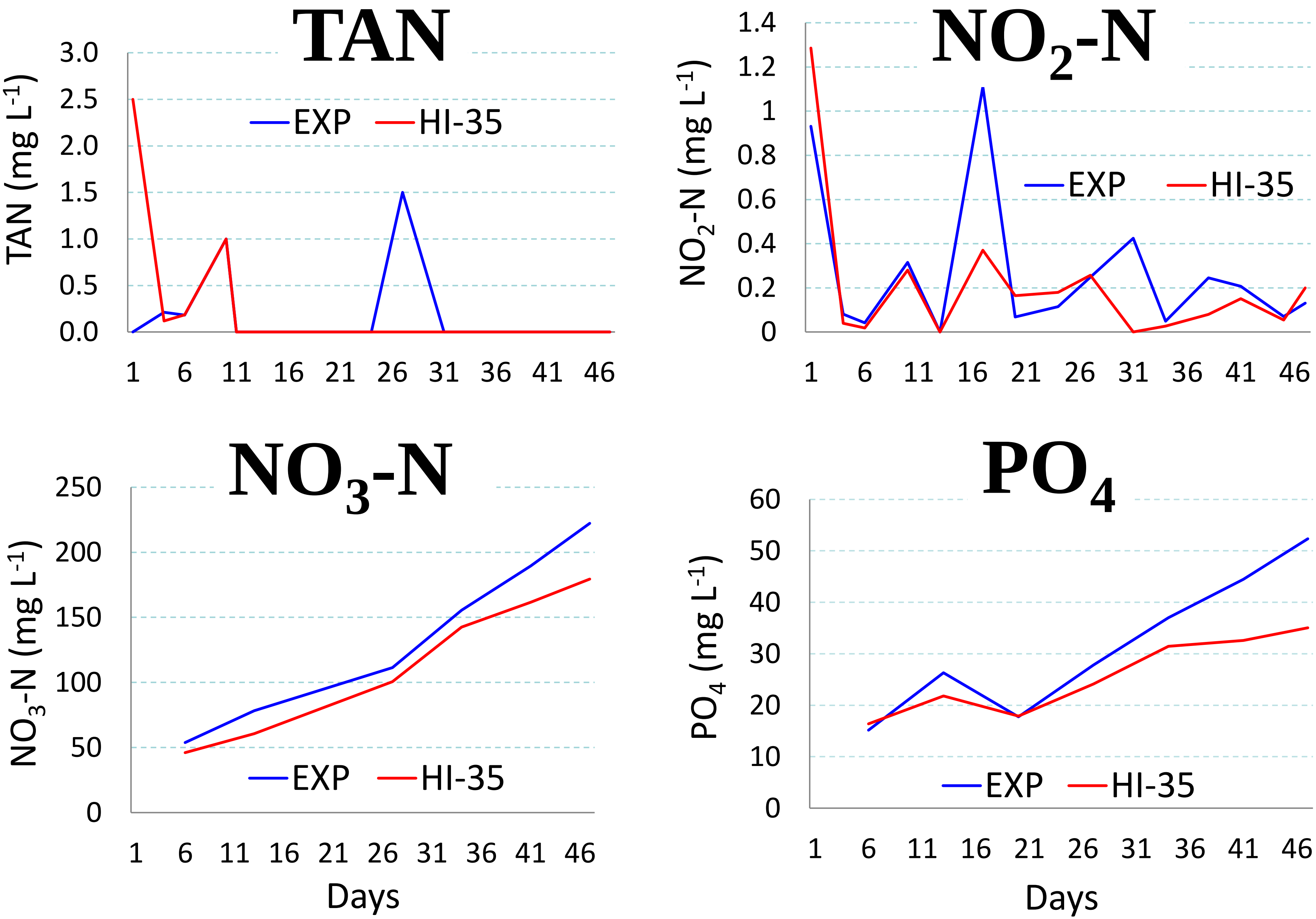

TAN
TAN (mg L-1)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
EXP
HI-35
1
6
11
16
21
26
31
36
41
46
NO2-N
NO2-N (mg L-1)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
EXP
HI-35
NO3-N
NO3-N (mg L-1)
250
200
150
100
50
0
EXP
HI-35
Days
PO4
PO4 (mg L-1)
60
50
40
30
20
10
0
EXP
HI-35
Days

Summary of alkalinity, particulate matter and turbidity data

	HI-35		EXP	
	Mean	Min-Max	Mean	Min-Max
ALK (mg L^{-1})	158	102-199	143	109-189
TSS (mg L^{-1})	348	150-533	364	175-550
VSS (mg L^{-1})	253	142-367	221	117-288
SS (mL L^{-1})	26.7	8-90	11.2	3.5-31
Turbidity (NTU)	147	94-202	161	102-241

Turbidity/TSS r^2 = 0.916; Turbidity/SS r^2 = 0.267

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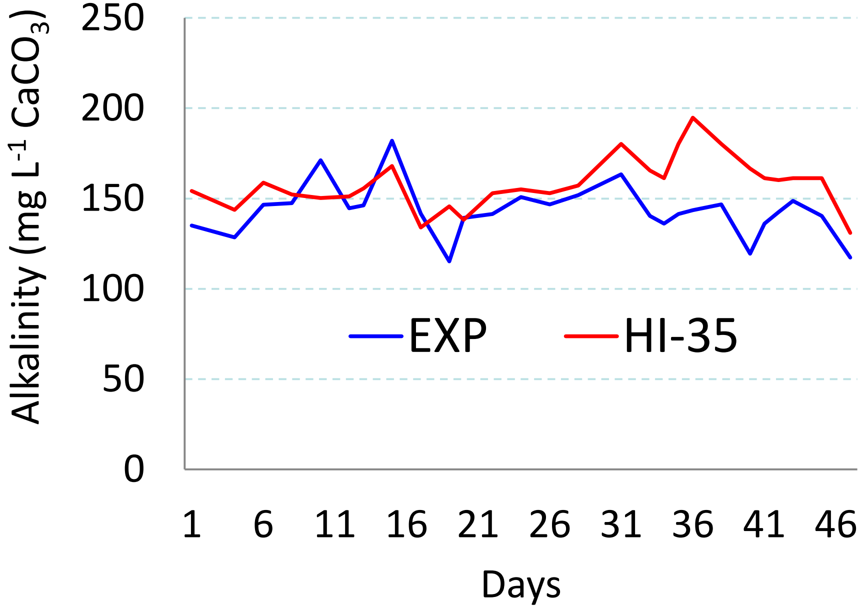
Alkalinity

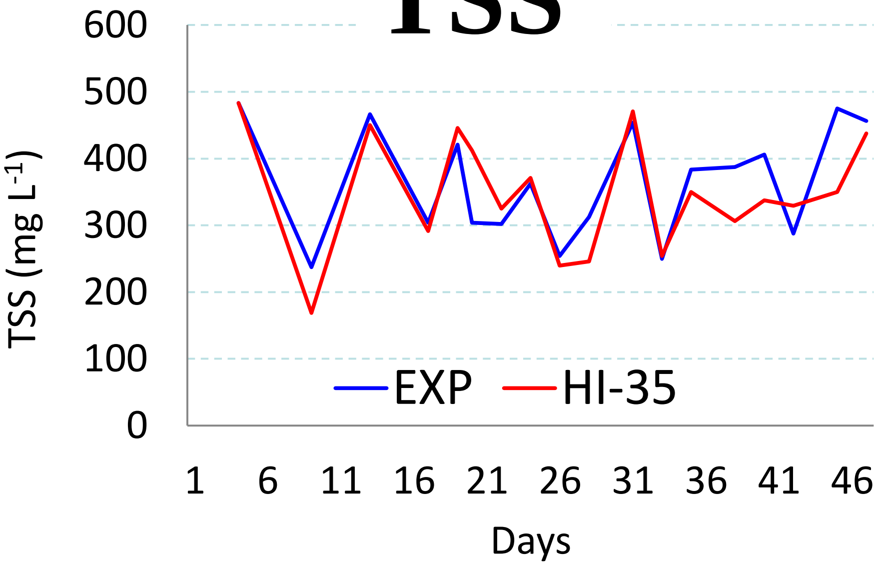


NaHCO$_3$ added/RW:

EXP: 40.8 kg (1.02 kg/m^3)

HI-35: 27.5 kg (0.69 kg/m^3)

TSS



Results

Shrimp Performance

- No statistically significant differences were found in shrimp performance between treatments
- Growth was higher with EXP, while survival was higher with HI-35, resulting in similar final total biomass and yield
- Mortality increased towards the end of the trial due to confirmed *Vibrio* infections

Harvested shrimp with no signs of chitinoclastic bacteria infection

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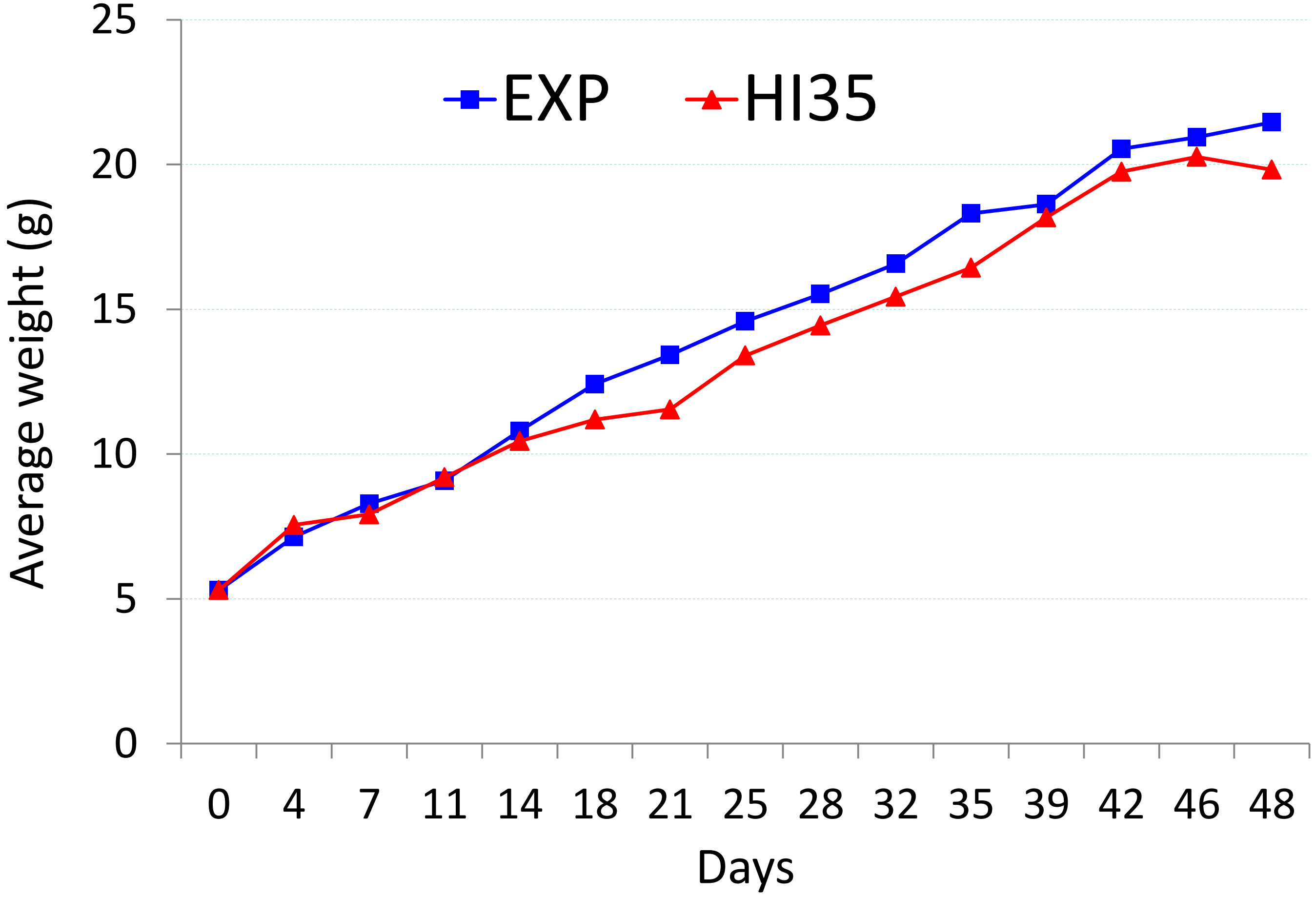
Results

Shrimp Performance



Results

Shrimp Performance

	HI-35	EXP
Final Weight (g)	19.82±0.38	21.46±1.69
Growth (g/wk)	2.10±0.02	2.33±0.21
Total Biomass (kg)	289.5±22.9	294.4±27.9
Yield (kg/m^3)	7.24±0.57	7.36±0.70
FCR	1.68±0.22	1.62±0.22
PER	1.72±0.23	1.55±0.21
Survival (%)	79.86±0.05	75.57±0.13

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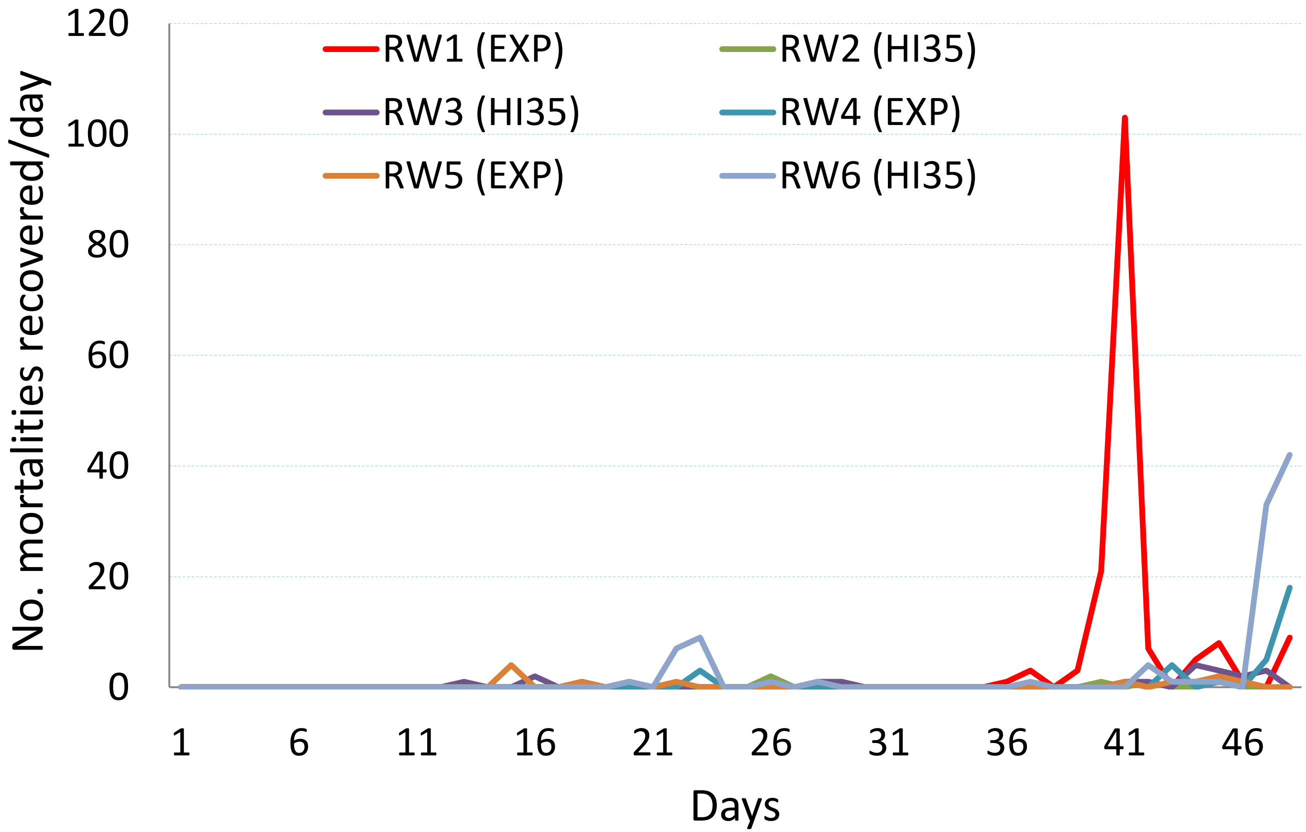
Results

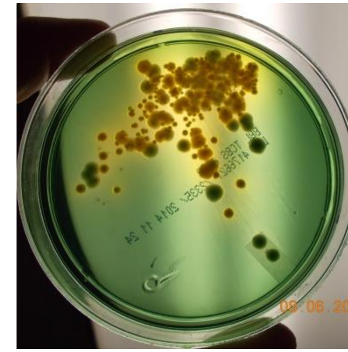
Shrimp Performance

Mortalities recovered per day

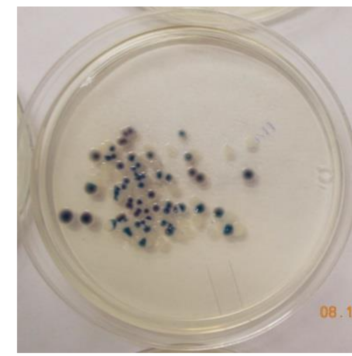


Results

Vibrio



- Green colony-forming *Vibrio* were much more abundant than in the prior nursery study, although vibriosis-related mortality was not observed until late in the trial



- RambaCHROM plating & preliminary API suggest presence of *V. parahaemolyticus*, *V. vulnificus* & *V. alginolyticus* in culture water, & moribund shrimp

- The algae & diatom community may have had a probiotic effect, delaying shrimp mortality

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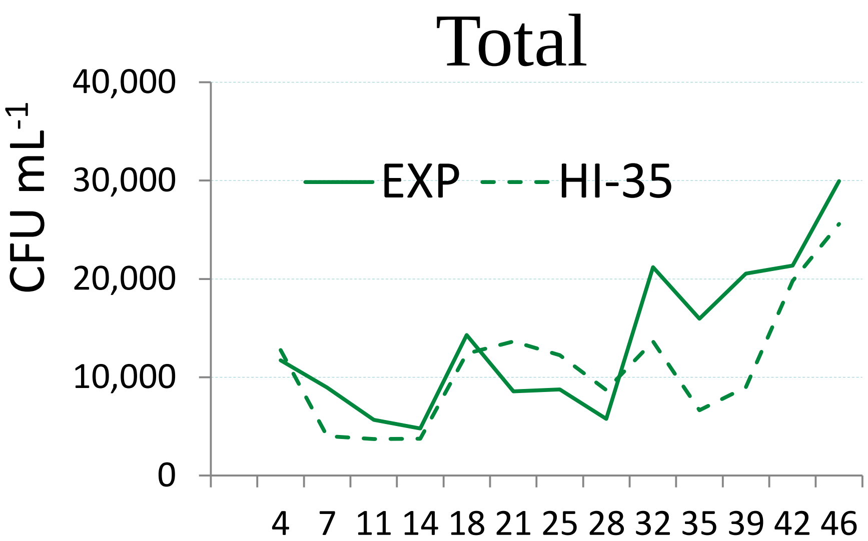
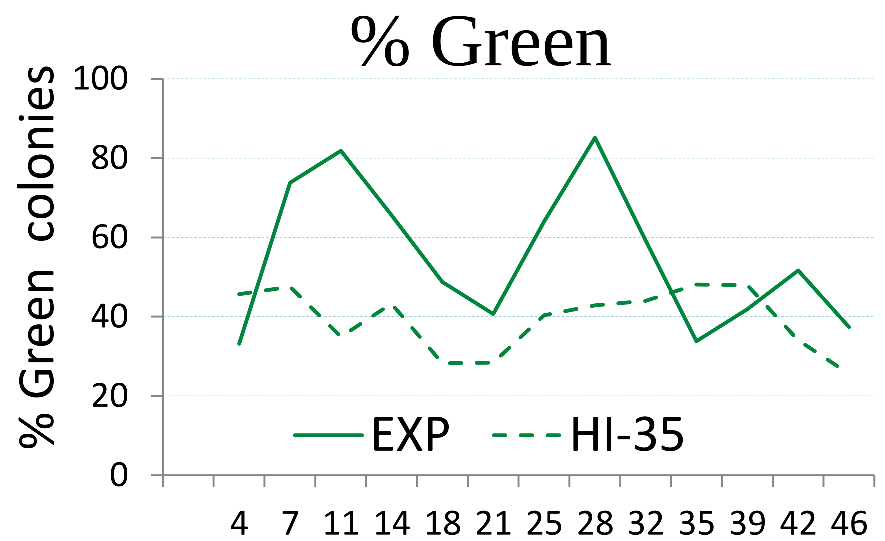
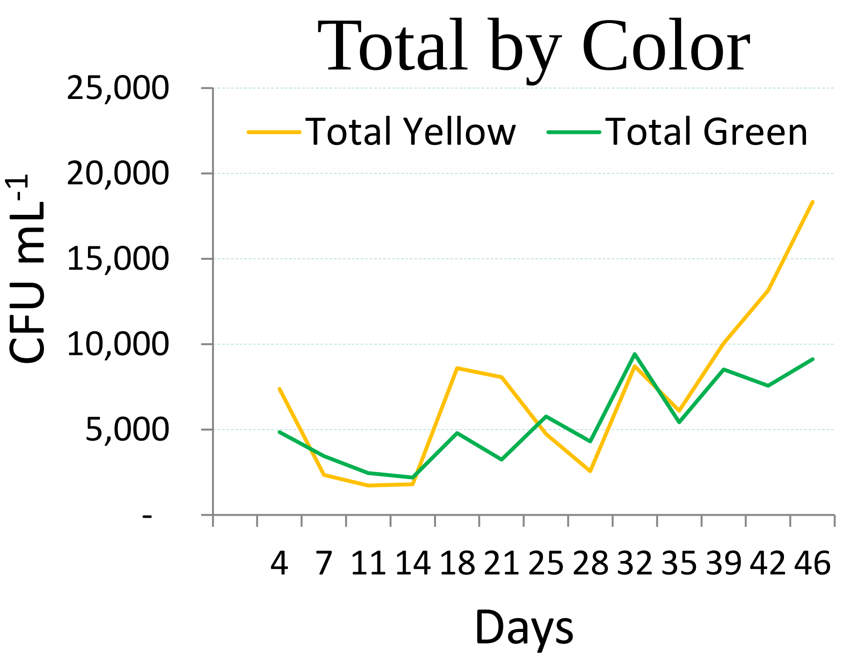
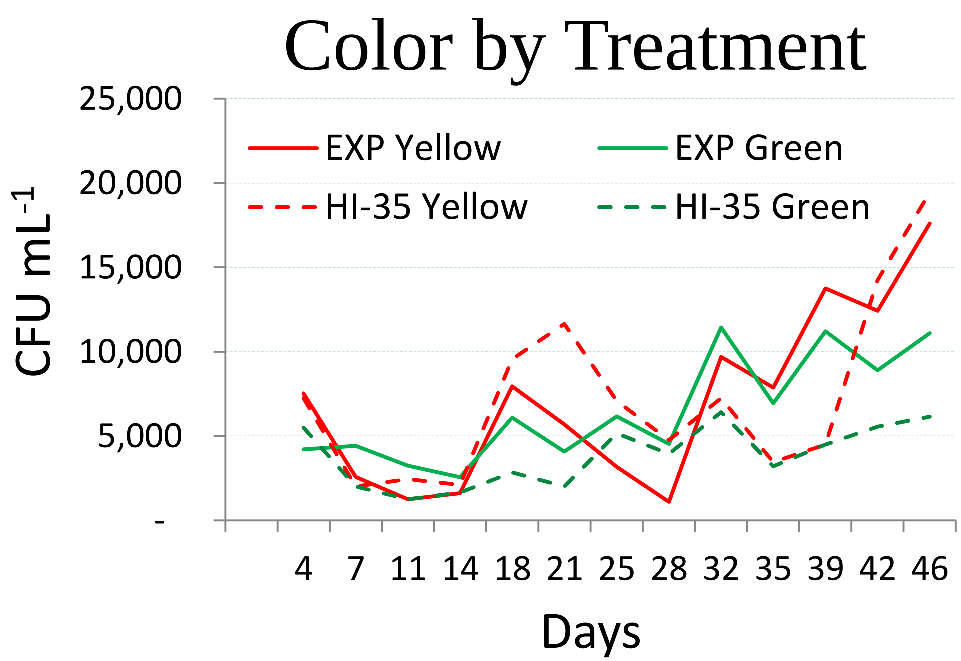
Vibrio colonies in the culture medium









Summary of *Vibrio* counts on TCBS

	HI-35		EXP	
Vibrio col. (CFU mL^{-1})	Mean	Min-Max	Mean	Min-Max
Total	11,221	2,700-30,150	13,652	3,600-35,500
Yellow	7,364	1,600-25,050	6,960	700-20,900
Green	3,858	600-10,600	6,692	1,850-15,900
% Green	39.3	2.9-69.7	55.2	19.5-86.7

Conclusion

- Under these study conditions, a marketable sized product was produced at a biomass of 7.3 kg/m^3
- Increasing the protein content from 35 to 40% increased the bicarbonate requirement and did not significantly improve shrimp performance (although growth and FCR were better with EXP)
- The *Vibrio* infections encountered may have limited the development of significant differences in shrimp performance between feed types

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Acknowledgements

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