Growth performance of *Litopenaeus vannamei* in super-intensive mixotrophic raceway culture with zero discharge using Tareation® technology for aeration and extended CO_2 degassing

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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

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

Introduction

- AgriLife Research has been developing cost-effective, sustainable and biosecure super-intensive production of food-size Pacific White Shrimp, *Litopenaeus vannamei*
- Significantly higher weight gain in biofloc water than in clear water with more expensive diet
- However, maintaining adequate dissolved oxygen in intensive raceway culture can be difficult and costly

Super-Intensive Greenhouse Raceway Systems

- Biosecure enclosed systems with advanced engineering

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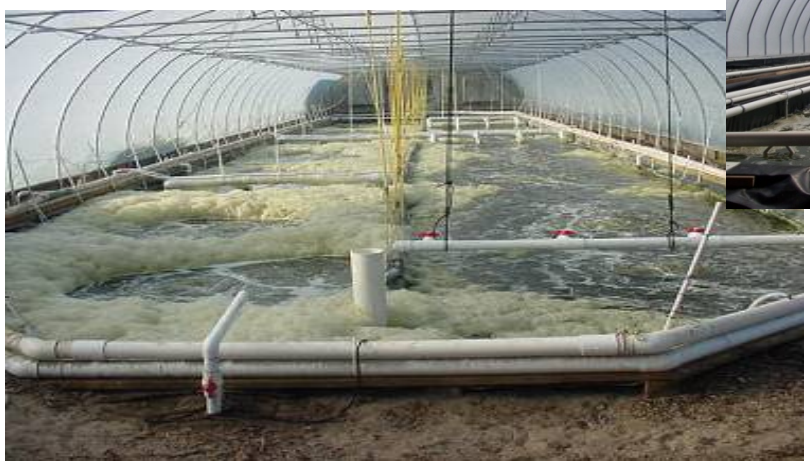
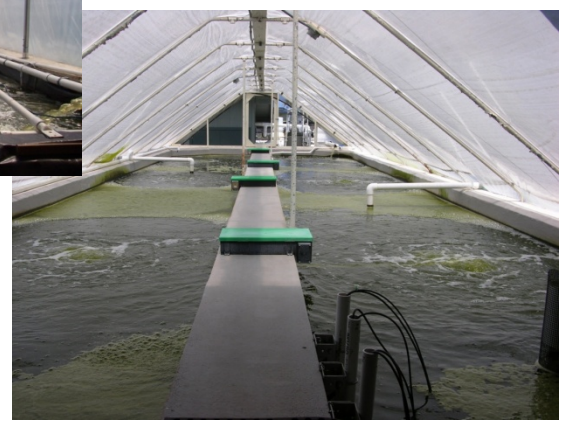
Super-Intensive Greenhouse Raceway Systems

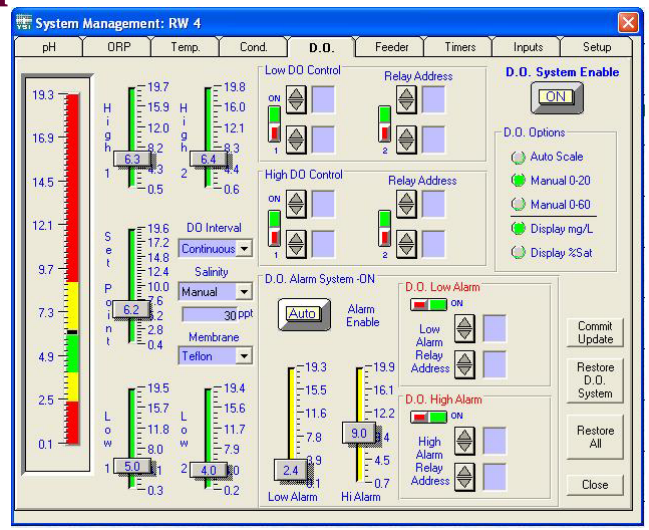
- High output per unit area, nursery phase and multiple crops per year provides for low cost of production per pound

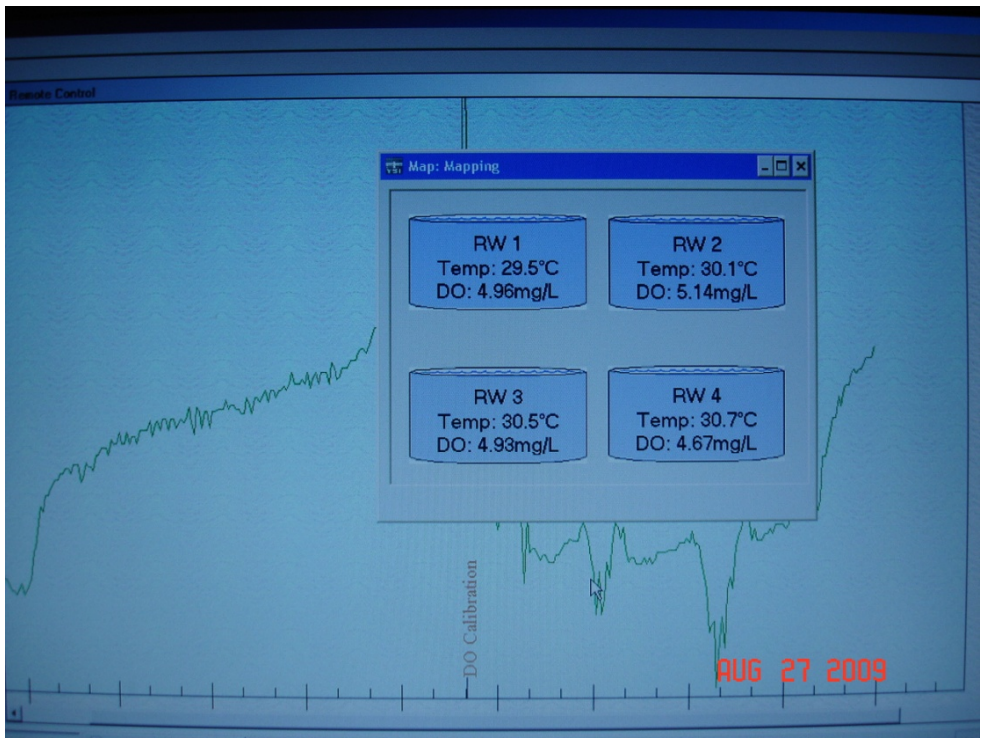




Super-Intensive Greenhouse Raceway Systems continued

- Automated systems for environmental and water quality control





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Super-Intensive Greenhouse Raceway Systems continued

- Aeration and oxygenation

Super-Intensive Greenhouse Raceway Systems continued

- Super-intensive biofloc systems require large amounts of oxygen input ----> expenses
- It can also limit feeding and thus potential growth of the shrimp
- The Taeration® device is currently employed in several wastewater treatment facilities
- This system offers low maintenance solution compared to some other oxygenation alternatives
- This technology may be successfully transferred to biofloc systems and other types of aquaculture systems

Super-Intensive Greenhouse Raceway Systems continued

- According to the manufacturer's specs the Taeration® nozzle provides 3:1 air to water ratio

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

Introduction

- It has been suggested that use of the Taeration® system is successful at degassing CO_2 from water and may be responsible for faster shrimp growth and better overall health
- Although pH and alkalinity monitoring is quite common, the monitoring of CO_2 is less common

Goals

- Evaluate the ability of a new aeration device to maintain adequate levels of DO in a super-intensive culture system (> 8 kg/m^3) without the use of supplemental oxygen
- Determine if CO_2 degassing is possible with this device, thereby relieving pH stress on the shrimp and reducing use of carbonate buffers
- Evaluate shrimp performance during the culture period

Materials & Methods

- Adult shrimp (21.9 g) were stocked (8.8 kg/m^3, 403/m^3) into one 40 m^3 (68.5 m^2) ethylene propylene diene monomer (EPDM) lined raceway filled with water previously used in a 170-d nursery & grow-out trial

- RW had eighteen 5.1-cm airlift pumps, six 1-m long air diffusers, and spray nozzles fed by a Venturi injector powered by a 2 hp pump
- Additionally the RW was equipped with several different sized Taeration® nozzles and protective screen configurations to be tested

Materials and Methods

- YSI 5200 multi-parameter monitoring system provided continuous DO and temperature readings
- Taeration® devices were tested for periods of 8h, 24h, 48h, and one week
- Following Taeration® tests particular attention was given to the physical condition of the shrimp and mortality
- Temperature, salinity, and pH were monitored twice daily
- CO_2 was calculated from pH and degrees of hardness (derived from alkalinity)

Materials and Methods

- Shrimp were fed a 35% CP commercial feed (Hyper-Intensive 35, Zeigler Bros., Gardners, PA)
- Two-third of the daily ration was fed in four equal portions during the day (8:30, 11:30, 14:30, 16:30) with the remaining one third offered 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 mortality rate of 0.5%/wk

Summary of a 38-d post grow-out study with *Litopenaeus vannamei* stocked with adult (21.9 g) at 403/m^3 under no water exchange

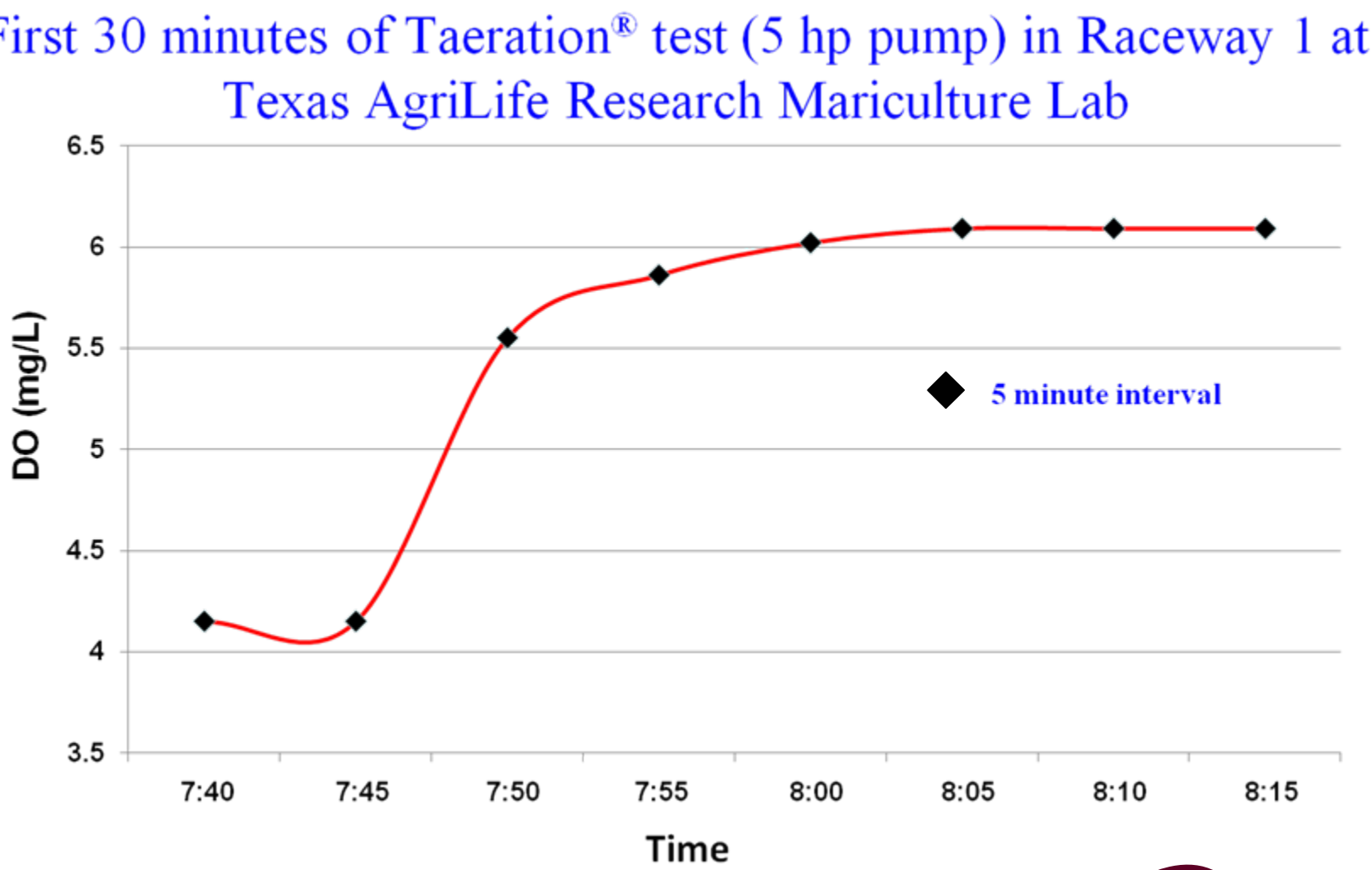
Yield (kg/m^3)	Av. Wt. (g)	Survival (%)	(g/wk)
9.59	25.22	94.4	0.62

Observations

- The initial test of the Taeration® nozzles powered by a 5 hp pump showed that the amount of aeration (DO) provided was greater than the current Venturi system with oxygen supplementation

- During this initial 8h test DO was maintained above 6 mg/L even during feeding

Observations



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YSI
5200
DO 6.06 mg/L
Temp 24.3°C
Recirculating
System
Monitor
ESC


DEC 2 2009

Observations

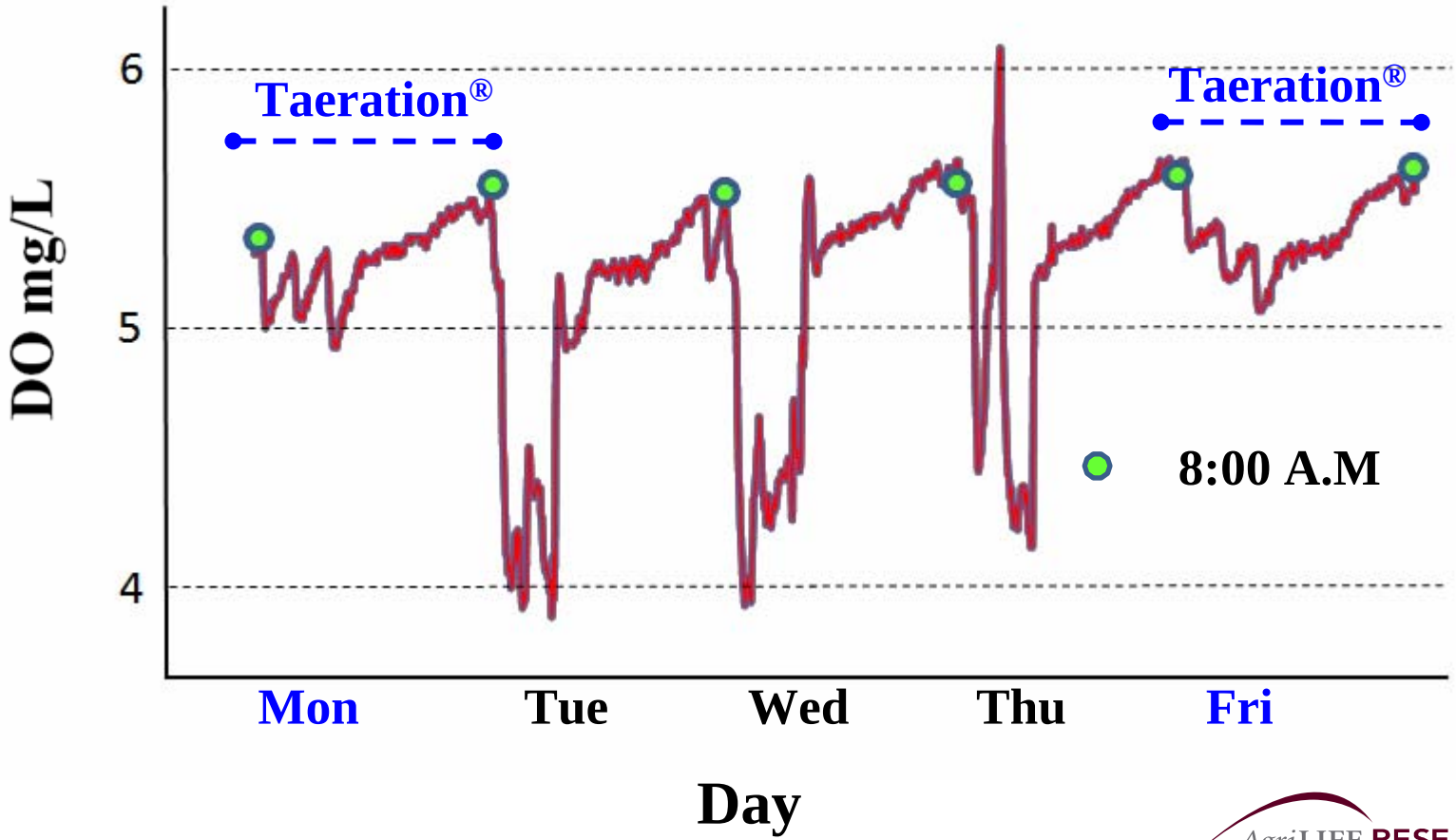
- Following the initial 8h test several dead shrimp were observed
- The “peeled” condition of the dead shrimp and the “boiling” appearance of the water suggested the 5 hp pump created too much disturbance for the shrimp in this raceway
- Subsequent tests were performed using a 2 hp pump and smaller nozzles with no damage to shrimp
- Different screening configurations were tried to reduce contact between the shrimp and the water jet from the nozzles

Observations

- DO was consistently above 5 mg/L while using the Taeration® devices
- DO decreased slightly following each of the three daily feedings
- In contrast the Venturi system with supplemental oxygen (0.5 lpm) was only able to maintain DO at about 4-4.5 during feeding periods
- Both systems maintained a RW flow of 15 cm/sec

Observations

Taeration® (2 hp pump) vs. Venturi with oxygen supplementation)



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Observations

- The system produced fine micro bubbles
- Decreased SS and increased TSS compared with the old setting
- Biofloc particles appeared to be reduced in size over time
- Ammonia and nitrite stayed low

Observations

- Mortality due to the force of the water jet was not as high as expected (survival was 94%)
- However, a number of shrimp died after entering the screens while the pump was off
- Cooler temperatures (24-25 C) resulted in poor growth (0.6 g/wk)

Observations

- CO_2 levels were tested on 3 days when the Taeration® system was operating for 8h
- CO_2 levels increased after feeding and decreased shortly afterward
- pH and alkalinity readings during this period do not suggest a reduction in CO_2
- Following the harvest the system was observed to kill an algae bloom in a raceway containing freshwater and no shrimp

Summary of daily water quality parameters during the 38-d post grow-out study

		Temp. (°C)	Salinity (PSU)	DO (mg/L)	pH
AM	Mean	24.6	30.5	5.8	6.7
	Max	27.9	31.4	6.9	7.0
	Min	21.0	29.2	3.8	6.5
PM	Mean	25.5	30.5	5.4	6.7
	Max	28.8	31.3	7.0	6.9
	Min	20.2	29.5	4.1	6.4

Note: DOs include both Taeration® and Venturi operation

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Conclusion

- Preliminary results showed that the Taeration® system using 3:1 air/water ratio (without oxygen supplementation was able to maintain higher DO levels and mixing than our current Venturi system with oxygen supplementation
- This has the potential to eliminate the need for the Venturi and all air-driven devices (e.g., air blower, air diffusers, airlift pumps) necessary for mixing and circulation
- Preliminary calculations suggest that the system can save over 30% on energy cost, and

The system can potentially reduce oxygen cost - during the previous 108-d GO trial $307 were spent on oxygen per RW

Conclusion

- Eliminating oxygen supplementation and reducing HP requirements will make super-intensive shrimp production more competitive
- Improving technologies along with genetic improvement are increasing growth and production rates while reducing variable costs

Acknowledgements

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- Harlingen Shrimp Farms: PL supply
- YSI: DO monitoring system
- Aquatic Eco System: Foam fractionators
- Colorite Plastics: Air diffusers
- Firestone Specialty Products: EPDM RW liner
- AIAeration: Taertion® test system

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