Current Configuration of Biosecure Superintensive Raceway System for Production of *Litopenaeus vannamei*

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Rationale and Interest in Design Development

Evolution of system designs for:

High output **–** Intensification for efficient use of land and labor, multiple crops per year, lower cost per pound

Biosecurity – assuring the health of the target crop by blocking introduction of excludable pathogens

Reduced water use – limited addition and discharge; water recovery

Microbial community management – recycling of waste within the system and enhancement of contributions of natural productivity to shrimp growth

Waste treatment – Filtration, aerobic and anaerobic sludge digestion and dewatering system

Historical Perspective

- Research efforts toward producing more efficient, environmentally friendly shrimp production systems have a 30 year history
- Research toward commercialization of intensive production systems has been conducted at the WMC since the facility opened in 1984
- Efforts have intensified during the last 10 years with support from the USMSFP
- Continued low prices for domestic shrimp require reducing costs of production and development of better marketing strategies to remain competitive
- Coordination of these research efforts and addressing the needs of US shrimp producers is critical to keeping domestic shrimp production a viable industry

Preliminary design

1999

- First raceway systems operated were 55 m^2 pilot-scale raceways
- HDPE lined
- Aeration by 5hp regenerative blower augmented by two Aire-O_2 propeller aspirators in each
- Water temperature maintained through 1.6 m^2 heat exchange tubing attached to a single propane fueled boiler
- Vertical substrate consisted of suspended AquaMat™ ~1m^2 /m^3 water

Preliminary data

System	Stocking Density	Days in Production	Harvest Wt. (g)	Survival (%)	FCR	Production (kg/m^2)
Trial 1						
RW2	$200/m^2$	70	10.2	57.0	2.2	2.4
Trial 2						
RW1	$200/m^2$	140*	19.3	60.9	2.3	2.3
RW2	$200/m^2$	140*	18.9	63.1	2.4	2.4
Trial 4						
RW1	$300/m^2$	112*	14.6	70.5	1.8	3.1
RW2	$300/m^2$	112*	15.4	71.5	2.0	3.3

* Reused the water from the previous trial

Harvest

Next generation

2004

- 55 m^2 pilot-scale raceways
- HDPE lined
- Zero-exchange
- Aeration by 5hp regenerative blower augmented by portable Air Sep oxygen generator
- Water temperature was maintained by two L-shaped removable 3000W heaters
- Vertical substrate decreased to ~0.2 m^2 AquaMat™/m3 water

Next generation

2005

- $55\ m^2$ pilot-scale raceways
- HDPE lined
- Zero-exchange
- Aeration by 5hp regenerative blower augmented by portable Air Sep oxygen generator
- Water temperature maintained by two L-shaped removable 3000 W heaters
- Vertical substrate decreased to $\sim 0.2\ m^2$ AquaMat™/m^3 water



Commercial Scale Raceway

2001

- 282 m^2 commercial scale system
- 1 m mean depth sloped to 6” drain
- HDPE lined with welded central baffle
- Aeration by 5hp regenerative blower through airlifts augmented by a 1 hp AGL Oxygun propeller-aspirator unit in the deep end and a 1-hp paddlewheel aerator
- Water temperature maintained through heat exchanger attached to a 1.4 billion BTU propane fueled boiler
- Vertical substrate consisted of free standing AquaMat™ ~1m^2 /m^3 water

Harvest

Production Data With This Construction

Stock Date	Stocking Density	Stocked As:	Days in Production	Survival (%)	Mean Ind. Wt. (g)	FCR	Harvest (kg/m^3)
Nursery Production							
April 2001	1,950/m^2		97	98	1.01		
April 2002	1,950/m^2		28	97	0.55		
Growout							
Sept. 2001	300/m^2	PL5	140	55.2	17.1	1.9	2.8

Commercial Scale Raceway

2004

- 282 m^2 commercial scale system
- 1 m mean depth sloped to 6” drain
- HDPE lined with welded central baffle
- Aeration by 5hp regenerative blower through airlifts augmented by an Air Products 150 L/min oxygen generator plumbed to single manifold
- Water temperature maintained through heat exchanger attached to a 1.4 billion BTU propane fueled boiler
- Vertical substrate consisted of free standing AquaMat™ ~1m^2 /m^3 water



Production Data With This Construction

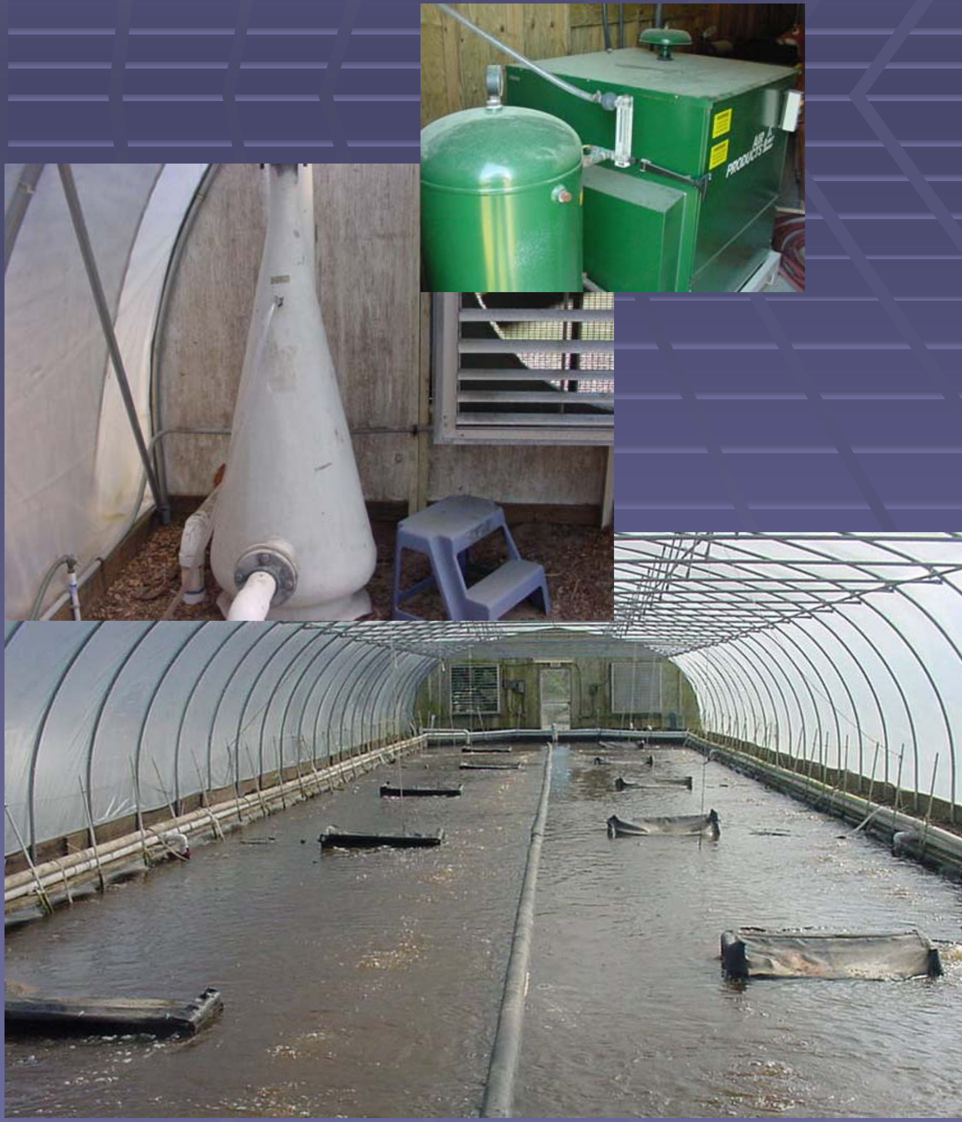
Stock Date	Stocking Density	Stocked As:	Days in Production	Survival (%)	Mean Ind. Wt. (g)	FCR	Harvest (kg/m^3)
			Nursery Production				
June 2002	1,240/m^2		38	97	0.31		
April 2003	3,456/m^2		42	0*	1.0	1.54	
			Growout				
Jan. 2003	300/m^2	1 g juv.	76	91	16.6	1.5	4.5
July 2003	420/m^2	PL25	113	80	20.4	1.9	6.8

* Killed by power outage 5/18/03

Commercial Scale Raceway

2004

- 282 m^2 commercial scale system
- 1 m mean depth sloped to 6” drain
- HDPE lined with welded central baffle
- Aeration by 5hp regenerative blower through airlifts
- Oxygenation by an Air Products 40 L/min oxygen generator plumbed through single jet manifold
- Water temperature maintained through heat exchanger attached to a 1.4 billion BTU propane fueled boiler
- Vertical substrate consisted of free standing AquaMat™ ~1m^2 /m^3 water

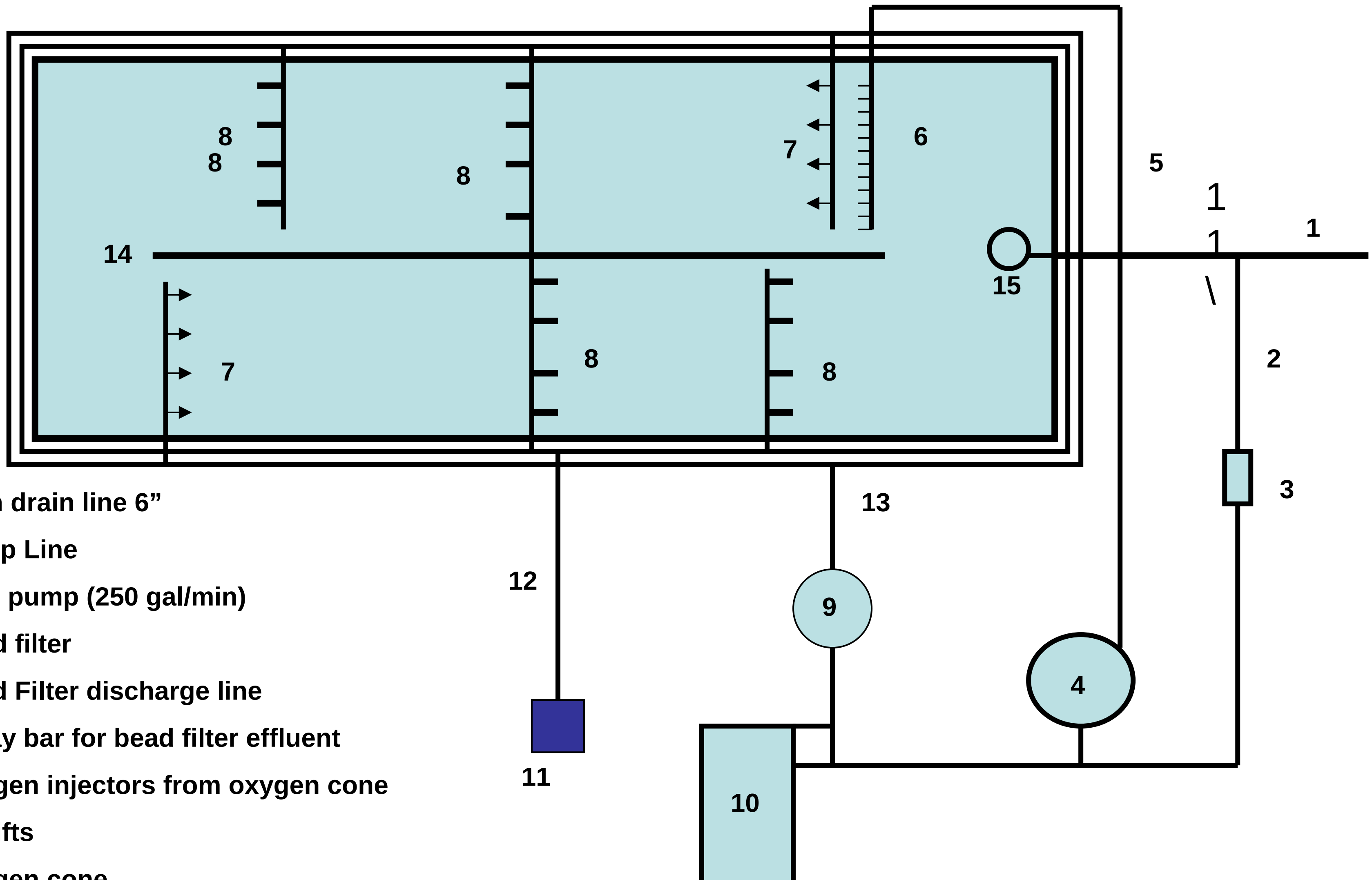


Commercial Scale Raceway

2005

- 282 m² commercial scale system
- 1 m mean depth sloped to 6” drain
- HDPE lined with welded central baffle
- Aeration by 5hp regenerative blower through airlifts
- Oxygenation by an Air Products 40 L/min oxygen generator plumbed into two manifolds
- Water temperature maintained through heat exchanger attached to a 1.4 billion BTU propane fueled boiler
- Vertical substrate consisted of free standing AquaMat™ ~1m² /m³ water

Waddell Mariculture Center Greenhouse Shrimp Production System



1. Main drain line 6”
2. Pump Line
3. 5 Hp pump (250 gal/min)
4. Bead filter
5. Bead Filter discharge line
6. Spray bar for bead filter effluent
7. Oxygen injectors from oxygen cone
8. Air lifts
9. Oxygen cone
10. Propane furnace and heat exchanger
11. 5 Hp air blower
12. Airline to main air line
13. Line from oxygen cone to main water line
14. Center wall (HDPE)
15. Drain structure

Water return and oxygen injection site

Oxygen monitoring system

Solids settling / aerobic and anaerobic waste water treatment

Filtration Optimization

- 25 ft^2 propeller washed bead filter backwash frequency:
  - Summer 2005 – every 1-3 days
  - Winter 2005 – every other day
- Monitored turbidity daily and total suspended solids at least weekly
  - Sampled water in and out of the filter to evaluate efficiency
- Adjusted flow to maintain bead filter pressure <10 psi
- Overfiltration counterproductive to development of large biofloc
- Calculated g solids/kg harvested shrimp
  - Summer 2003 – 242 g/kg (backwash effectiveness reduced, no solids management)
  - Winter 2005 – 195 g/kg (backwash frequency reduced, solids management)


Raceway harvest and temporary water storage

Production Data With This Construction

Stock Date	Stocking Density	Stocked as:	Growout Days	Survival (%)	Mean shrimp Wt. (g)	FCR	Harvest (kg/m^3)
Nursery Production							
April 2004	2,532/m^2	PL_{10}	55	92	0.8	1.1	1.9
March 2005	4,085/m^2	PL_{10}	67	80	1.2	1.0	4.3
Growout							
July 2004	450/m^2	1 g juv.	123	54	25.6	2.6	6.3
June 2005	499/m^2	4 g juv.	59	84	16.4	1.4	6.7
Nov. 2005	370/m^2	2.4 g juv.	140	74	21.5	0.96	5.4*

*Partial harvests prior to final harvest

Future directions

- Alternative filtration methods – more intensive management of the microbial community
- Alternative oxygenation – more flexible, more effective, less energy intensive
- Faster harvest – improved product, less manpower intensive
- More efficient transition from nursery phase to growout phase – reduced stress, less manpower intensive
- Increased production
- Eco-friendly technology

Future of Super-Intensive, Biosecure Systems

- Coordinated research is continuing at WMC, TAES, GCRL, NSU, MSU and OI
- The future of US farmed shrimp production is in biosecure, enclosed facilities which maximize water reuse, minimize labor and energy use, and control risk with efficient process management and redundancy
- Management of all aspects of production is critical
  - shrimp stock genetics
  - feeds and feeding
  - microbial communities and water quality
  - waste management
- Implementation of multi-raceway commercial scale systems will provide new opportunities for refinement and standardization of production operations

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