United States Department of Agriculture
National Institute of Food and Agriculture

USMSFP

PRODUCTION AND ECONOMIC COMPARISON OF *L. vannamei* RAISED IN BIOFLOC UNDER A FULL LIGHT GREENHOUSE ENVIRONMENT VERSUS INDOOR, LOW-LIGHT CONDITIONS IN AN INSULATED BUILDING.

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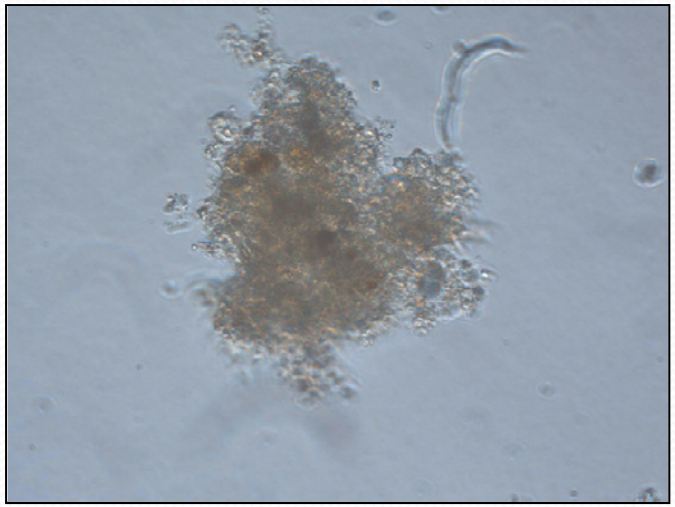
Potential Benefits of Biofloc

- Reduced water use
- Greater biosecurity
- Reduced capitalization cost
- Flexibility in site selection



Potential Benefits of Indoor Production

- Reduced heating costs
  - Nov 11-Feb 5, 3142 gallons of propane-> $6619
  - 29% of cost of production
- Greater control over photoautotrophic microbial community

Experimental System

Greenhouse System

- Steel framed, polyethylene film covering
- 30.5 m^2, EPDM lined raceways, 72 cm water depth
- Full natural lighting

Indoor System

- Steel "quonset" style building, insulated, unheated
- 6.1 m diameter, 29.2 m^2 fiberglass tanks, 75 cm depth
- Two 500 W halogen lights

Experimental System

- Both systems:
  - Zero exchange, no solids removal
  - Culture tanks seeded with established biofloc water
  - Air supplied by regenerative blowers and aluminum oxide airstones
  - Heat supplied by 6000 watt immersion heaters

Stocking

- Stocking date January 11, 2011
- Initial size, 1.87 g
- Stocked by weight
- 7120 shrimp/tank ⟶ 324 shrimp/m^3

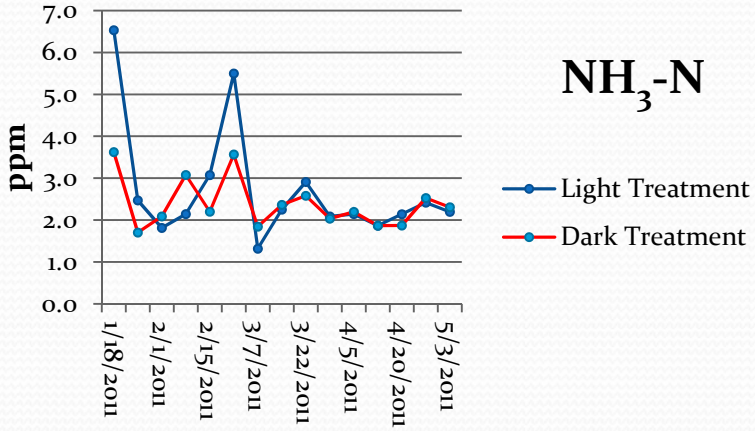
Husbandry

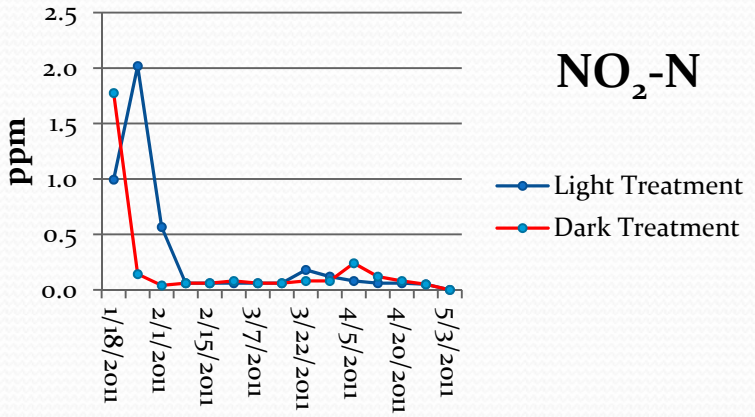
- Fed Zeigler Shrimp Grower HI 35%, 3 times daily
- DO, temperature, salinity and pH measured twice daily
- NH_3-N, NO_2-N, NO_3-N, PO_4, alkalinity, turbidity, TSS, VSS, total chlorophyll and chlorophyll *a* weekly
- Sampled weekly up to week 5, and then biweekly thereafter.

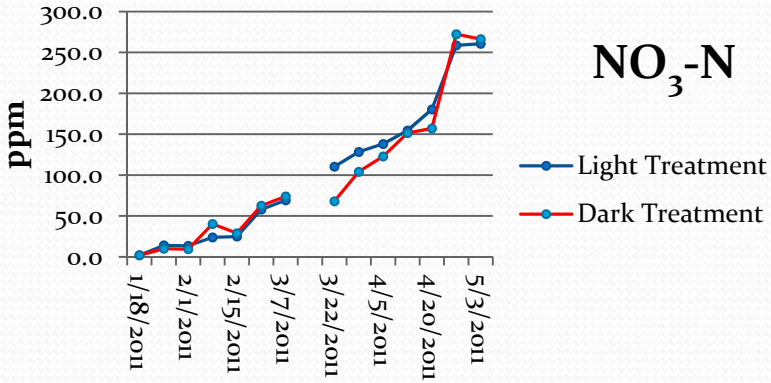
Daily Water Quality

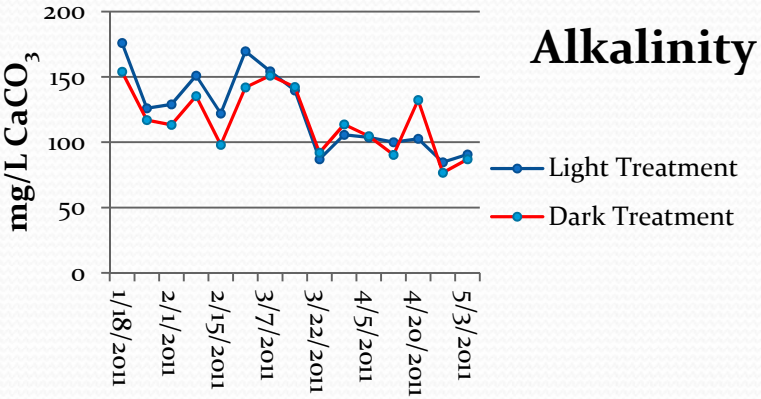
	T (^{o}C)	DO (mg/L)	pH	Salinity (ppt)
Light Treatment Min	24.46	3.59	6.54	25.36
Max	31.46	6.76	7.99	32.91
Mean	**28.23**	**4.90**	**7.36**	**27.44**
Dark Treatment Min	25.2	3.36	6.54	24.81
Max	29.65	6.61	7.99	32.75
Mean	**28.33**	**4.97**	**7.35**	**27.09**

Nitrogen Cycling

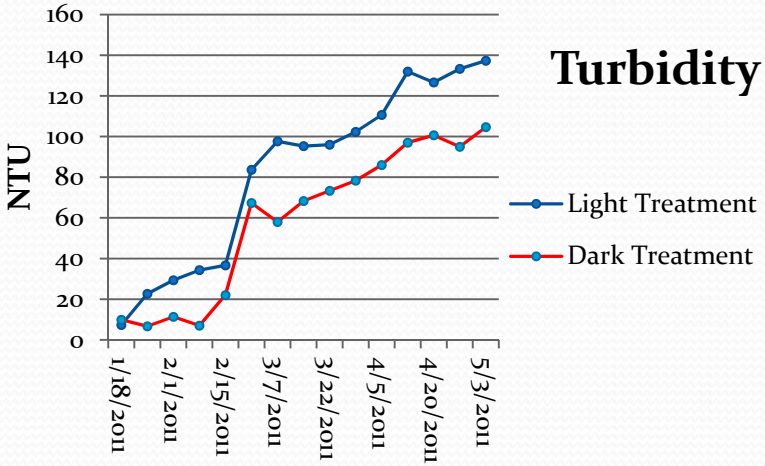








Solids


NTU
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120
100
80
60
40
20
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1/18/2011
2/1/2011
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4/5/2011
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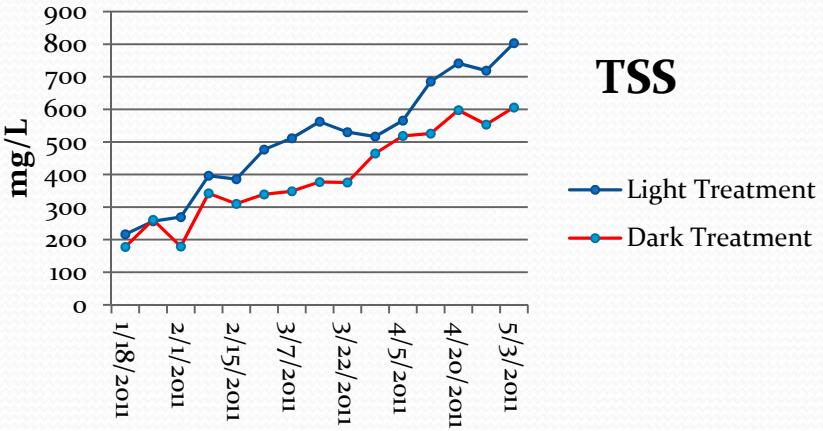
5/3/2011
Turbidity
Light Treatment
Dark Treatment


mg/L
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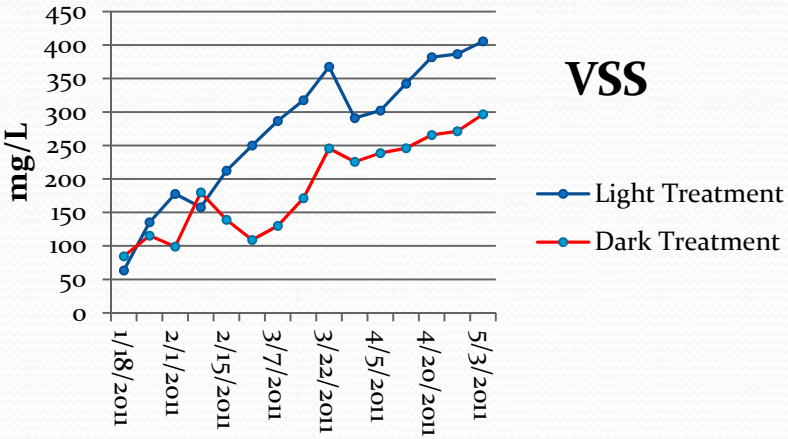
4/5/2011
4/20/2011
5/3/2011
TSS
Light Treatment
Dark Treatment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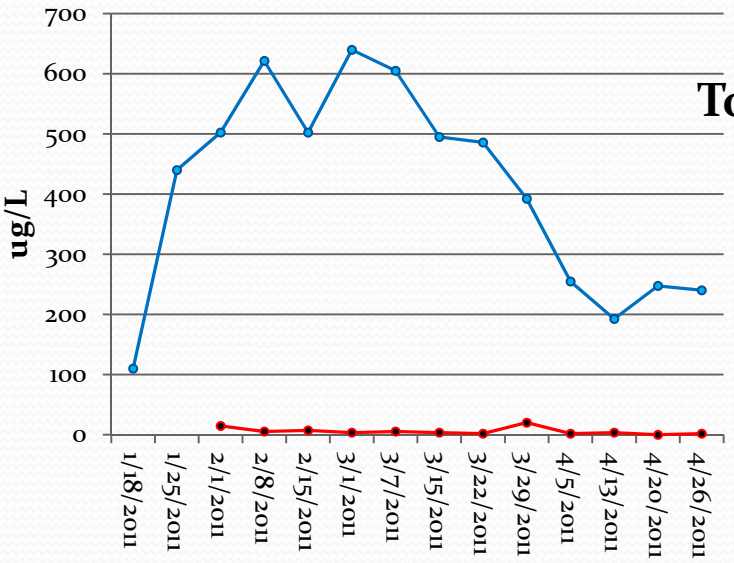
4/5/2011
4/20/2011
5/3/2011
VSS
Light Treatment
Dark Treatment

Photosynthetically Active Radiation (PAR) 400-700 nm

		Surface		66-cm depth	
Light	RW3	64.1 ± 9.5		0.00046 ± 0.00027	
	RW4	67.7 ± 7.8		0.00052 ± 0.00022	
	RW5	73.8 ± 7.8		0.00081 ± 0.00045	
	Mean		**68.6 ± 8.7**		**0.00060 ± 0.00034**
Dark	Tank 1	0.0132 ±.0037		0.00052 ± 0.00035	
	Tank 2	0.0199 ± .0048		0.00030 ± 0.00010	
	Tank 3	0.0025 ± .0004		0.00030 ± 0.00030	
	Mean		**0.0119 ± 0.0081**		**0.00040 ± 0.00030**

in µmol s^{-1} m^{-2}

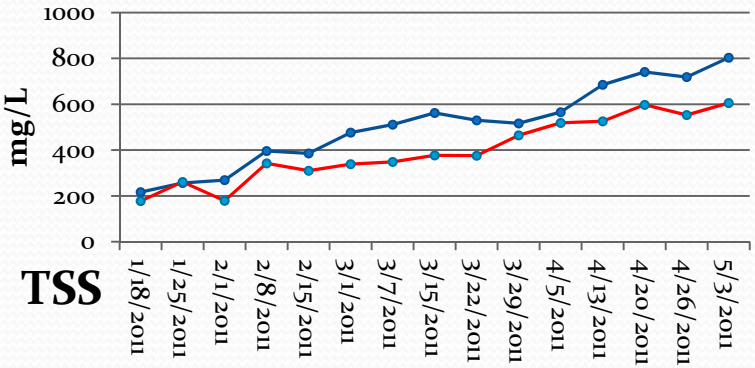
Chlorophyll



Total Chlorophyll

light treatment (mean)

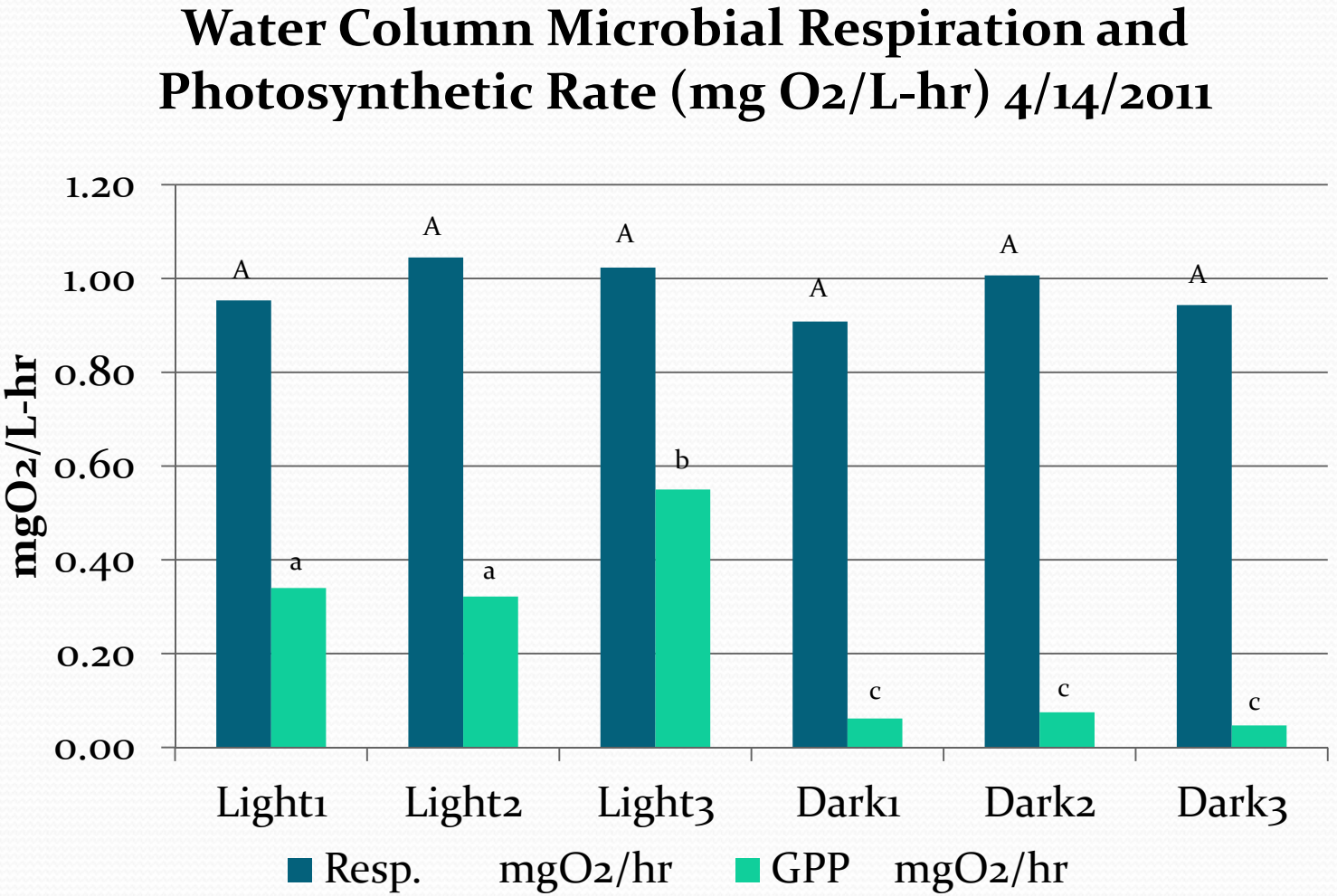
dark treatment (mean)



TSS

Light Tank

Respiration and GPP



Production Parameters

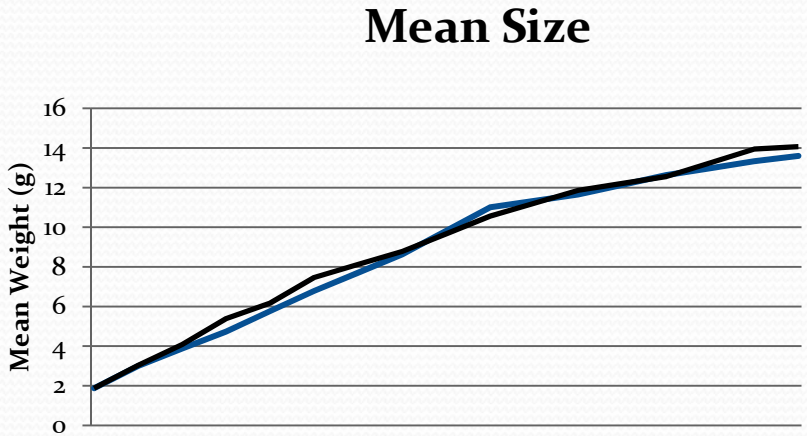
	Survival	Mean Weight (g)	Production (kg/m^3)	FCR
Light	77.0 ± 10.9^a	14.1 ± 0.3^b	3.33 ± 0.14^c	1.93 ± 0.1^d
Dark	73.2 ± 1.5^a	13.6 ± 1.2^b	3.36 ± 0.25^c	1.91 ± 0.17^d
Range	68.7 – 89.4	12.6 – 14.9	3.15 - 3.64	1.73 – 2.07

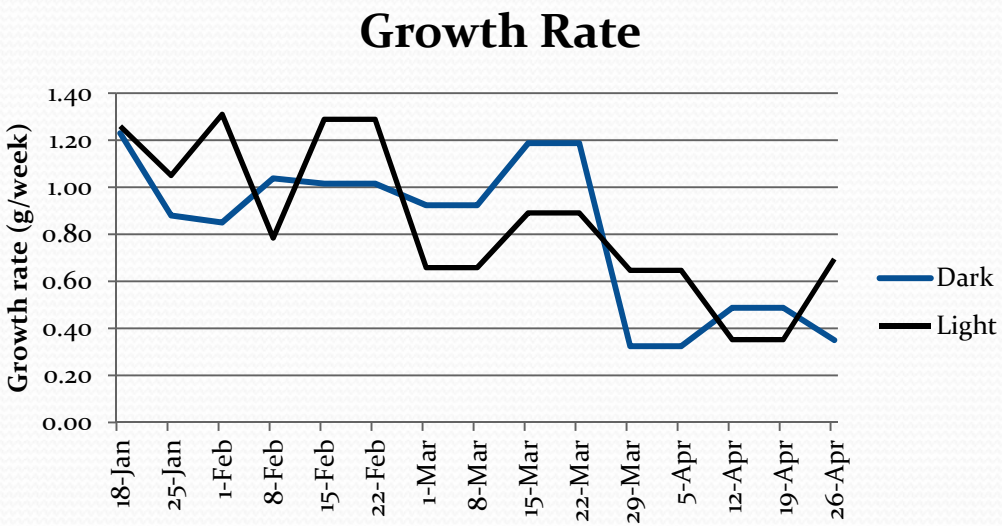
Mean ± SD

No significant differences in mean survival, harvest weight, production or FCR at $P<0.05$.

Survival was significantly more variable in the dark treatment ($P=0.019$).

Shrimp Growth





Growth Rate (g/week)

Light= 0.76 ± 0.02[a]

Dark=0.73 ± 0.07[a]

(mean ± SD)

Ranged from 1.3 to 0.35 g/week

Heating Costs

	Total kW-h	Heating expense per tank	kW-h $(m^3)^{-1}$	Heating expense $(m^3)^{-1}$	Heating expense $(m^3)^{-1}$ day^{-1}
Light	8758.6	$942	398.1	$42.82	$0.404
Dark	7977.8	$858	362.6	$39.00	$0.368
Savings	780.8	$84	35.5	$3.82	$0.036

(Electricity at $0.1075/kW-h)

8.9% reduction in heating costs

Scaling Up

Commercial scale 235 m^3 raceway (1400-1880 kg of production)

	Construction cost	Cost of 10 year loan at 7%
Steel building (insulated)	$38,601	$53,783
Greenhouse	$20,014	$27,866
Difference	**$18,587**	**$25,917**

Heating savings in 235 m^3 raceway 210 days X 0.036 = $1777

Years to recoup extra owner investment $18,587/$1777=10.5 years

Years to recoup extra investment with loan $25,917/$1777= 14.6 years

Additional Considerations

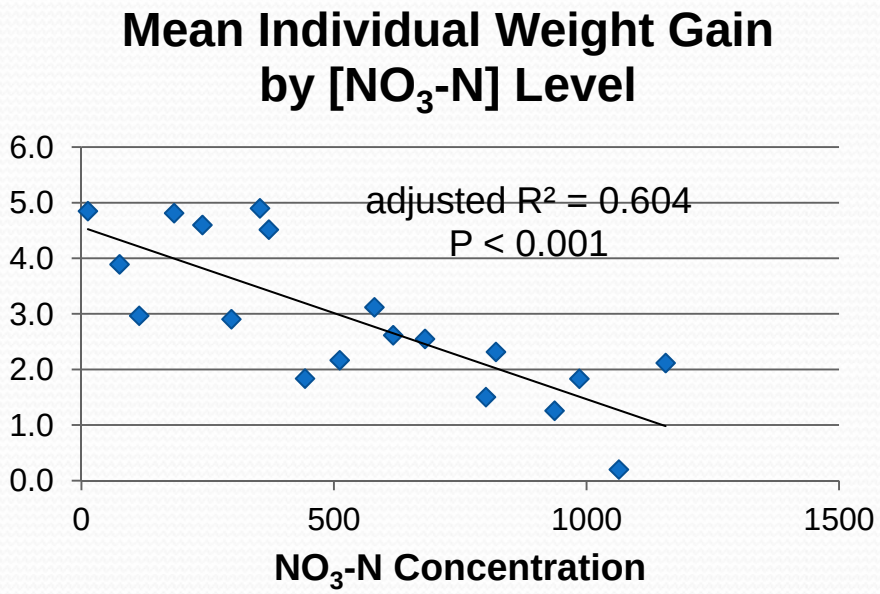
- Space may need to be conditioned to remove moisture
- Cooling in the summer
- Improved oxygen delivery
- Greater lighting efficiency to reduce cost and improve working conditions
- Greenhouse plastic must be replaced

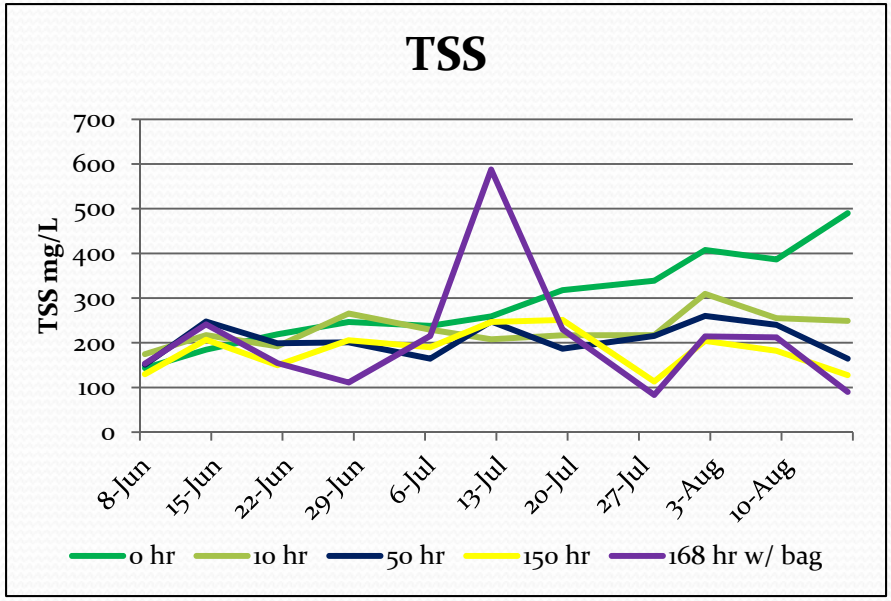
Conclusion

- Water quality parameters were remarkably similar among all tanks from both treatments.
- No differences in suspended microbial respiration rates among all six tanks, but photosynthetic rates were significantly higher in the "light" systems than in the "dark" tanks.
- No differences between the greenhouse-based "light" systems and the building-based "dark" systems with regard to mean growth rate, harvest size, total production, survival, or FCR, although survival was significantly more variable in the dark treatment.
- Production , with respect to survival, did not appear to be more stable, or consistent, in the absence of algae.
- Heating costs were reduced by 8.9% with production in an insulated building.
- Improved engineering could further reduce heating costs. This will be necessary to offset increased cost of construction.

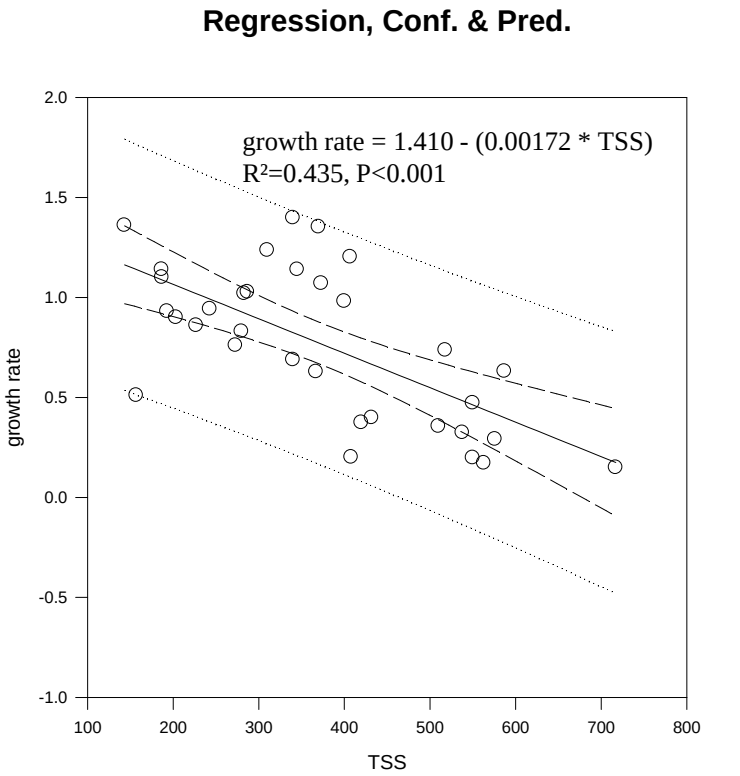
Thank You

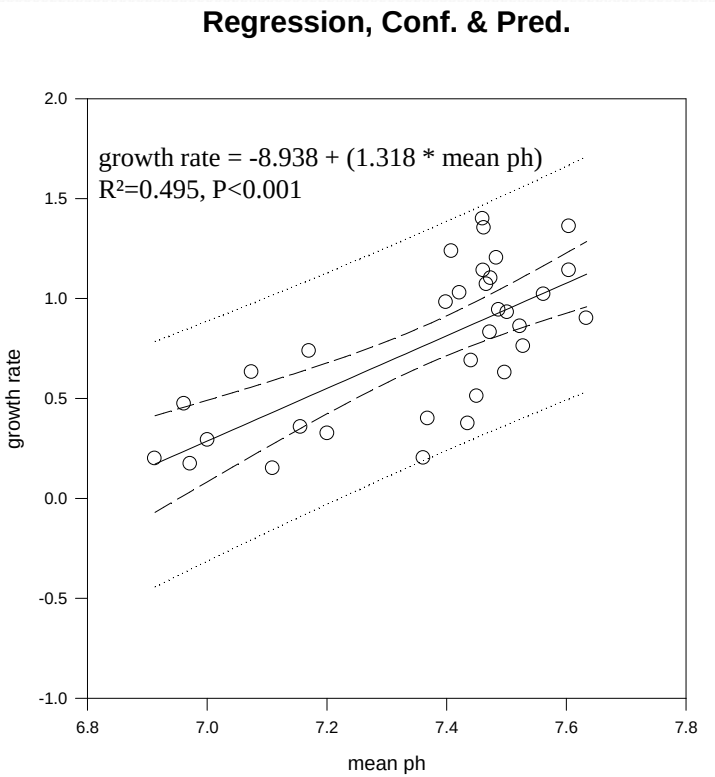
Why such poor growth?





Growth in Dark Tanks





Multiple Linear Regression

growth rate = -6.372 + (0.996 * mean ph) - (0.000518 * TSS)

Adj R^2 = 0.471, P<0.001