IMPACT OF REUSED WATER FROM SUPERINTENSIVE, MINIMAL-EXCHANGE, BIOFLOC SYSTEMS ON THE PRODUCTION OF PACIFIC WHITE SHRIMP (*L. vannamei*)

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USDA
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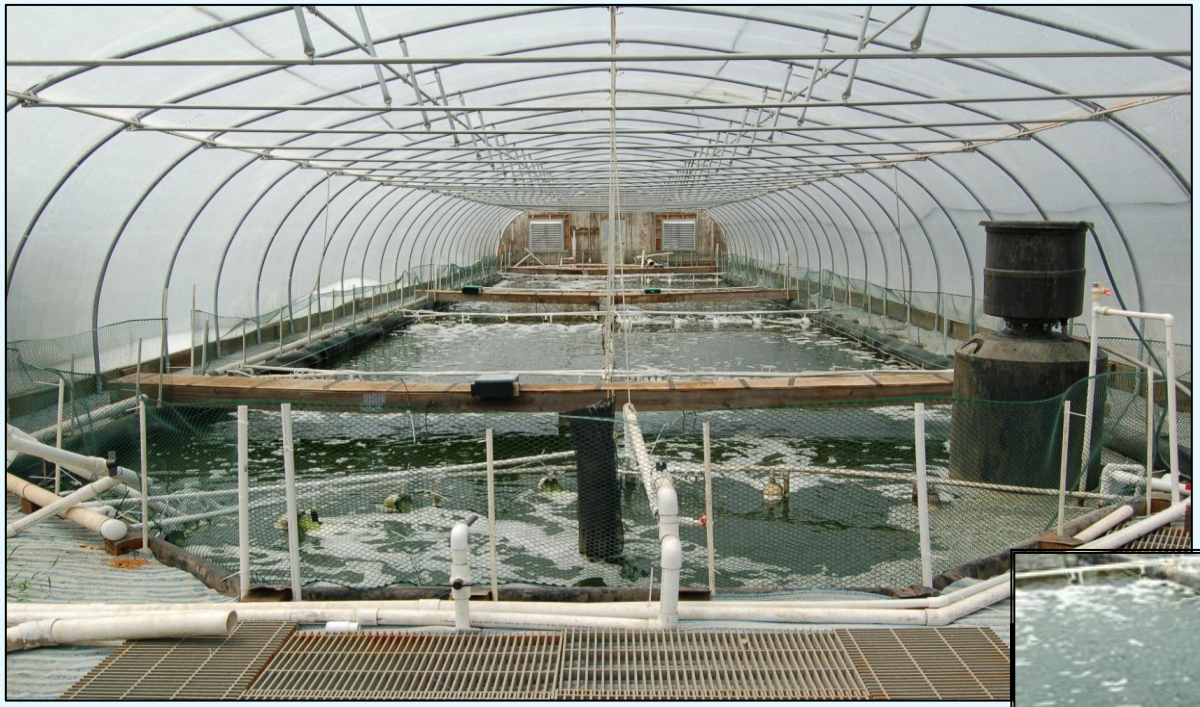
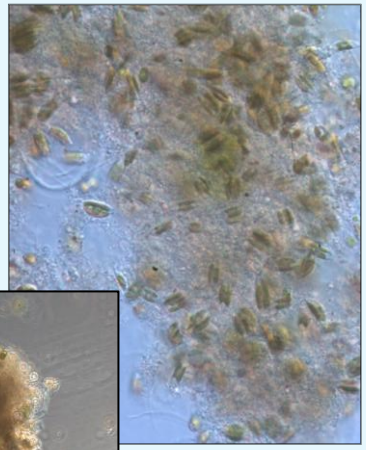
National Institute of Food and Agriculture

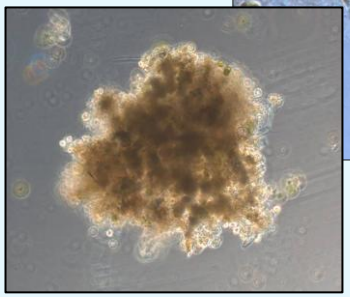
USMSFP

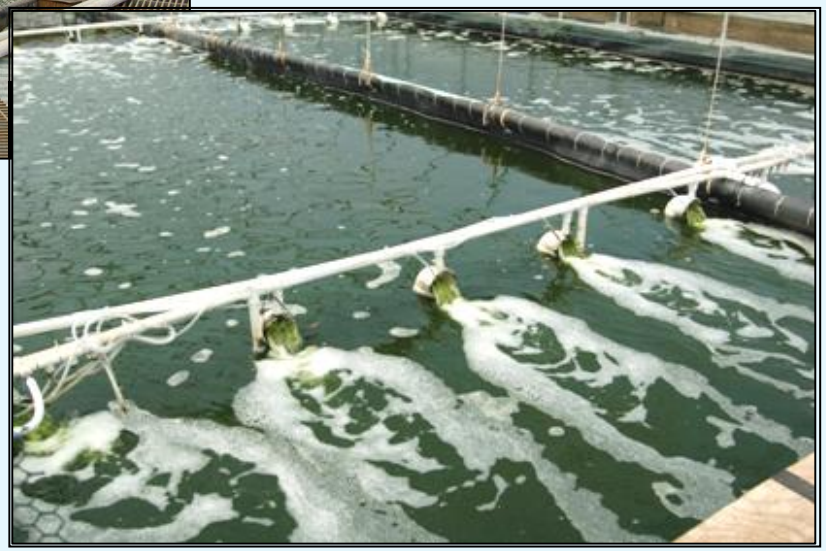
SOUTH CAROLINA DEPARTMENT OF NATURAL RESOURCES
DNR

Superintensive, Indoor, Minimal-exchange, Biofloc Shrimp Systems









Advantages:

- Biosecurity
- High productivity
- Efficient & economical nitrogen control
- Supplemental food/nutrient recycling

Advantages of Water Reuse

- Retain established biofloc community for nitrification
- Reduce expense of replacing sea salts

Can substances accumulate in reused water that might inhibit shrimp production?

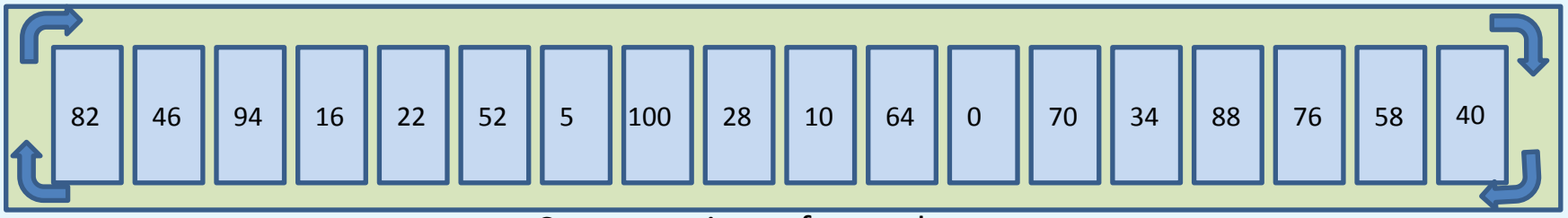
Changes in Water Chemistry during a Growout Trial

- Stocked at 414 m^{-3}
- 128 d growout

Chemical Accumulation throughout Trial 17						
	Water (mg/L)		BioFloc (µg/g)		Shrimp (µg/g)	
Element	Week 0	Week 18	Week 0	Week 18	Week 0	Week 18
Al	0.008	0.005	306	519	**27.4**	**10.1**
As	**0.001**	**0.029**	**0.5**	**8.3**	**0.0**	**2.3**
B	1.62	1.55	63.1	47.6	5.9	4.8
Cd	0.003	0.004	0.6	0.9	**0.0**	**0.3**
Ca	137	137	46,985	34,146	34,449	24,312
Cr	0.001	0.001	3.2	5.3	1.0	0.6
Cu	**0.032**	**0.104**	118	90	167	96
Fe	**0.002**	**0.038**	**503**	**1,486**	35.5	26.6
Pb	0.001	0.000	**0.0**	**1.8**	**0.0**	**2.0**
Mg	651	655	**16,726**	**8,153**	3,033	2,747
Mn	**0.013**	**0.189**	**402**	**137**	6.4	9.6
Mo	**0.003**	**0.020**	1.9	3.0	**0.0**	**0.4**
N	**35**	**427**	**53,000**	**116,000**	61,000	76,700
Ni	0.005	0.008	5.5	7.2	**1.5**	**0.3**
P	**15**	**670**	38,763	21,700	12,085	11,713
K	302	289	9,296	10,650	13,077	14,601
Se	**0.002**	**0.008**	4.0	6.3	**0.0**	**1.6**
Na	4,607	4,972	31,086	27,064	8,193	7,566
S	393	446	9,459	11,018	7,627	7,645
Zn	**0.008**	**0.136**	**260**	**662**	67.4	67.5

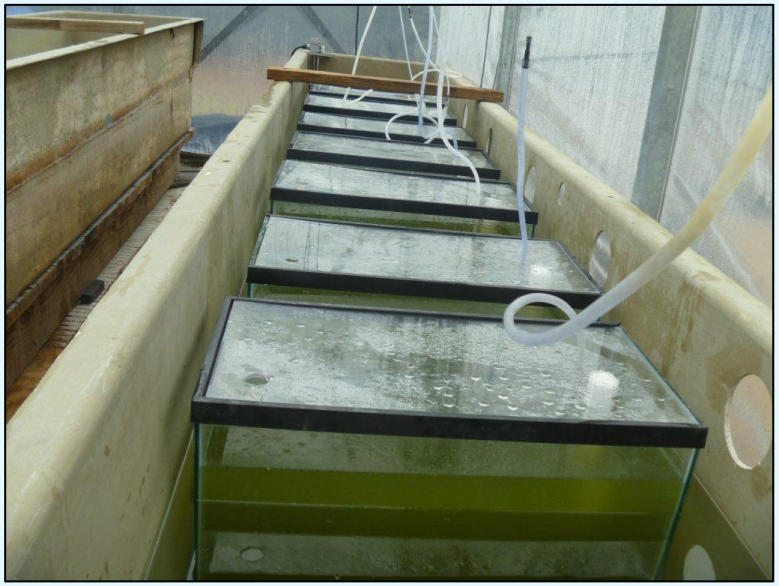
Experimental Design

- 206 day-old water from a biofloc, growout production raceway
- Diluted with fresh filtered seawater
- 18 concentrations from 100% to 0% reused biofloc water

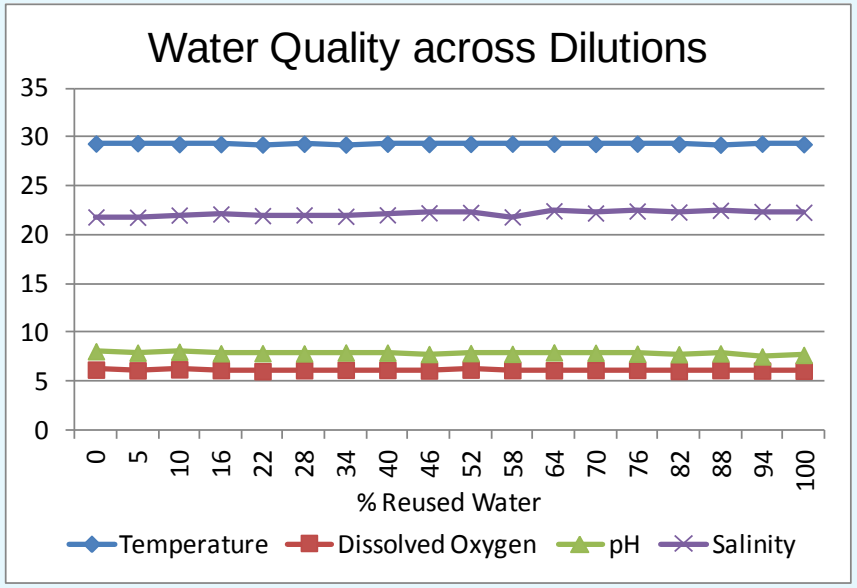


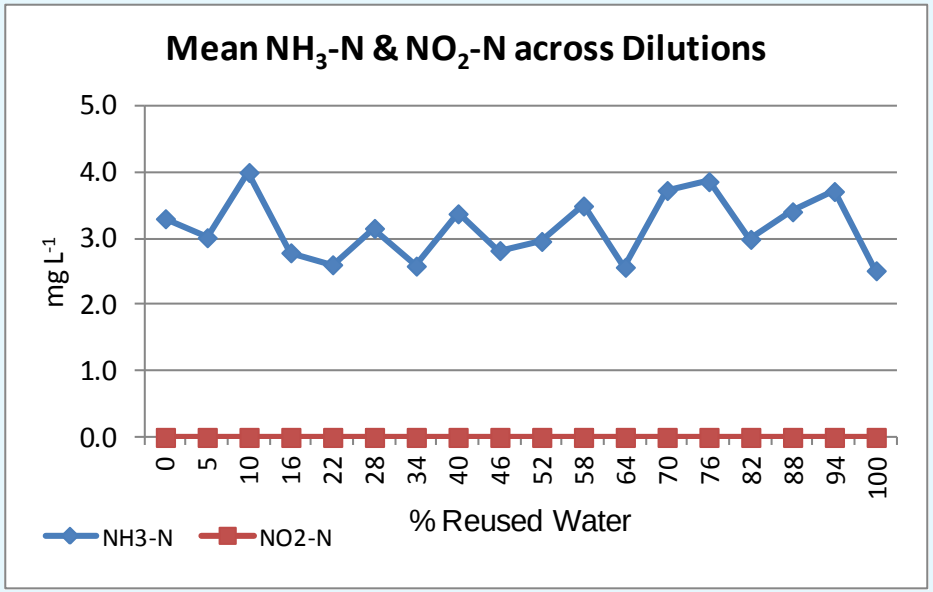
Concentrations of reused water

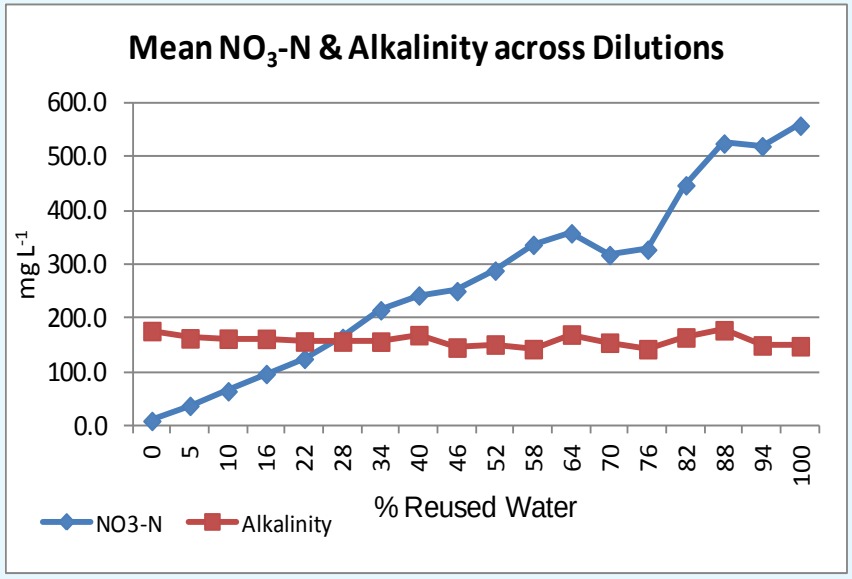
- 60 L aquaria/circulating water bath
- 10 shrimp (~1.98 g) per tank
- Fed 3x daily
- $NaHCO_3$ daily & as needed:
  alkalinity ≈ 150 mg $CaCO_3$-L^{-1}
- Mortalities not removed
- 36 days

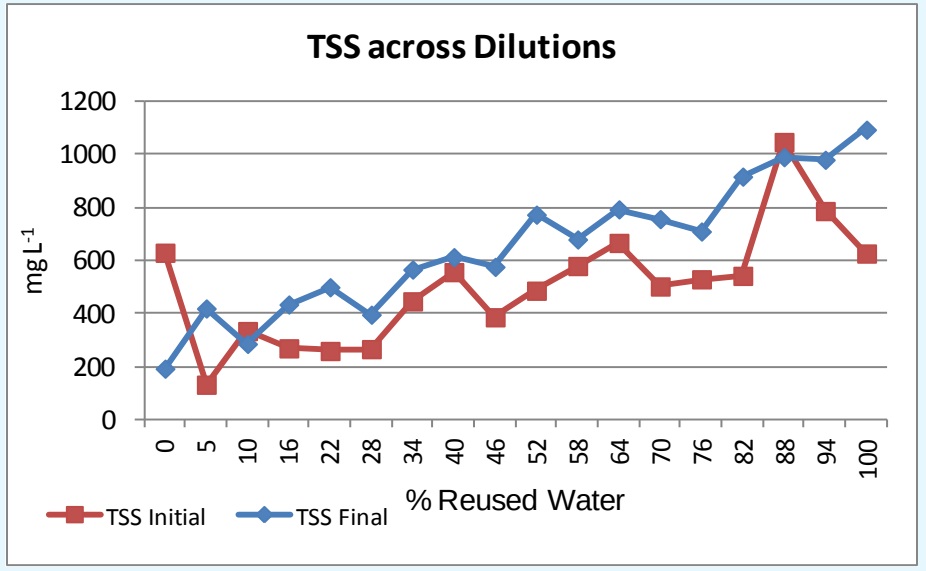


Results: Water Quality





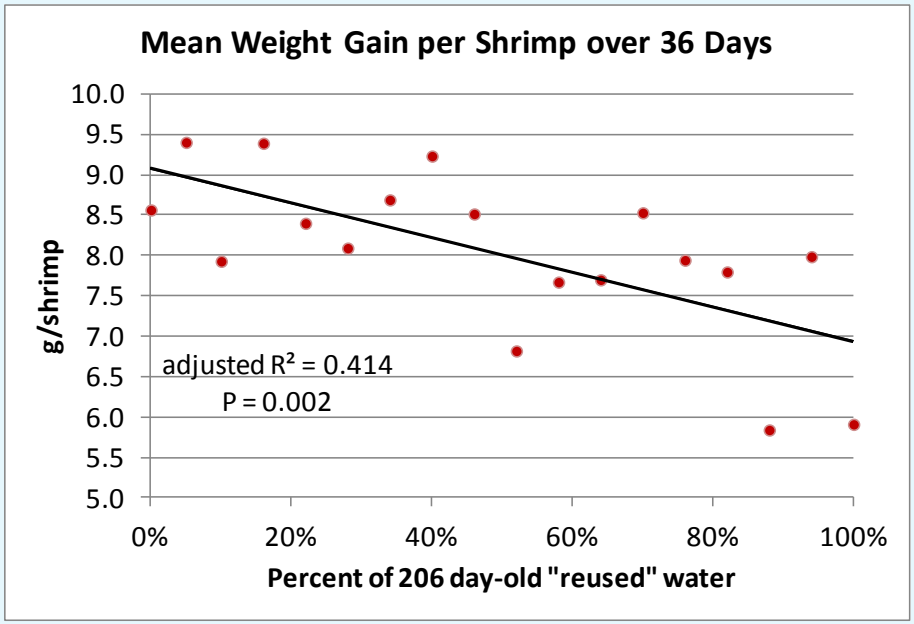


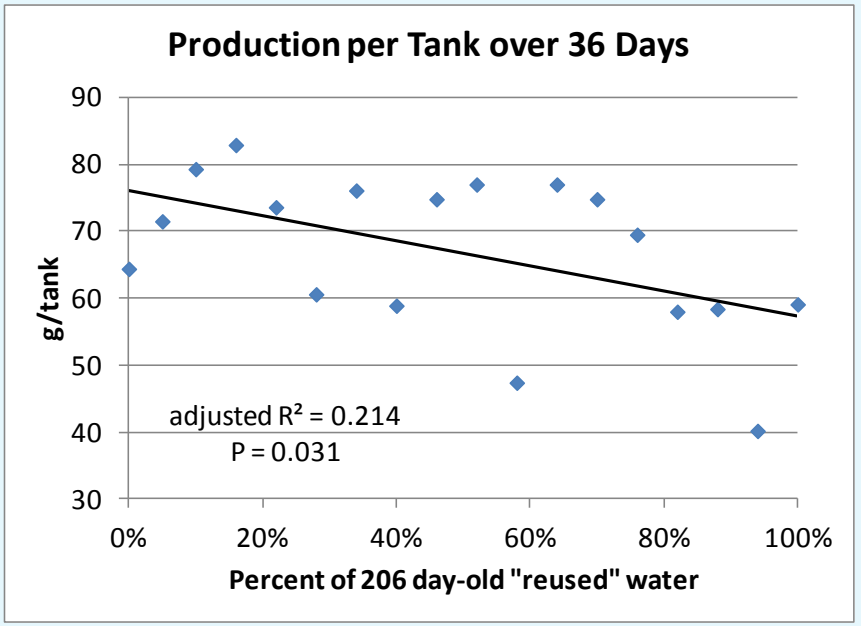


Results:

Decreasing amounts of "Reused Water:

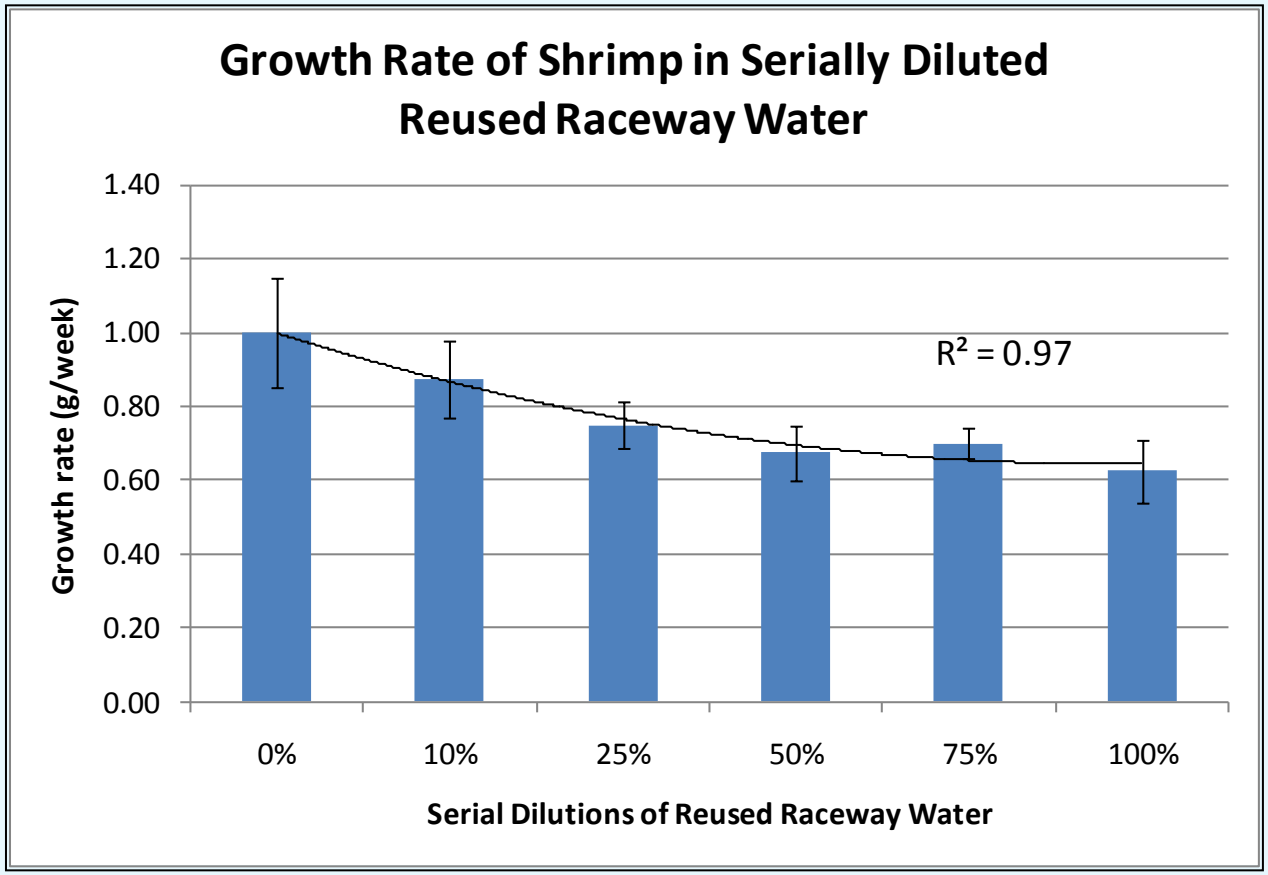
- No effect on Survival (adj. $R^2 = 0.000$, $P = 0.922$)
- Increased Growth Rate (adj. $R^2 = 0.414$, $P = 0.002$)
- Increased Overall Production (adj. $R^2 = 0.214$, $P = 0.031$)



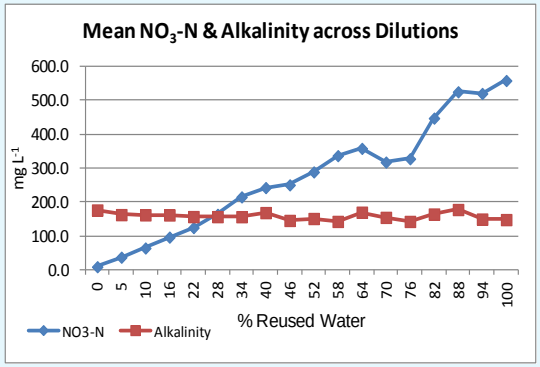


Conclusion: Reused biofloc water depresses shrimp growth!

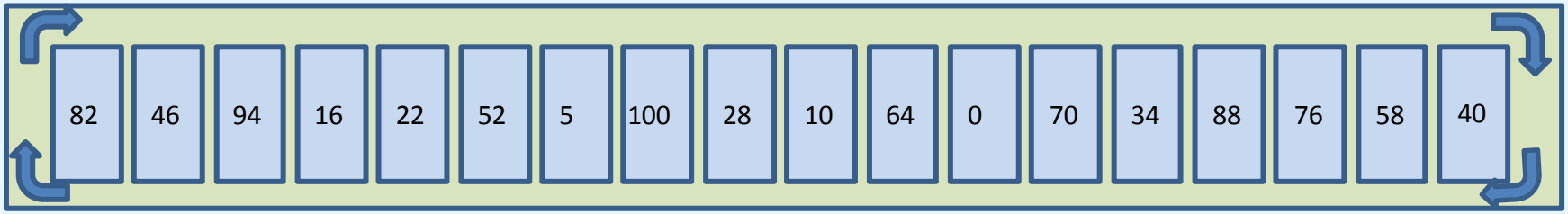
Confirmed a previous, smaller, dilution experiment which also found that reused biofloc water depressed shrimp growth.

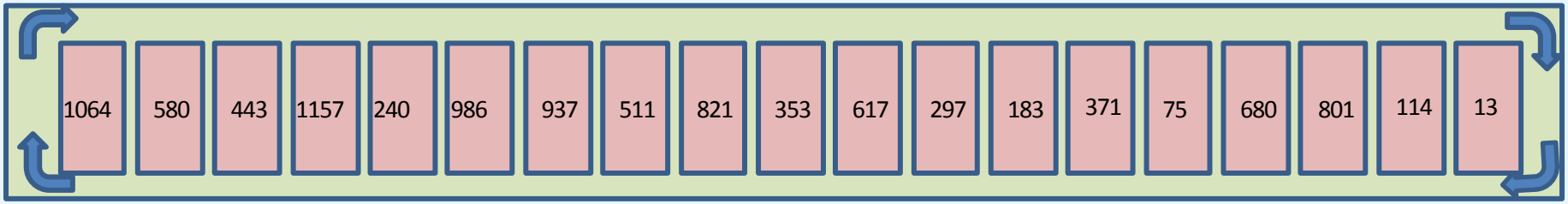


Is the depressed growth associated with reused water due to high accumulated NO_3-N levels?



Concentrations of reused water



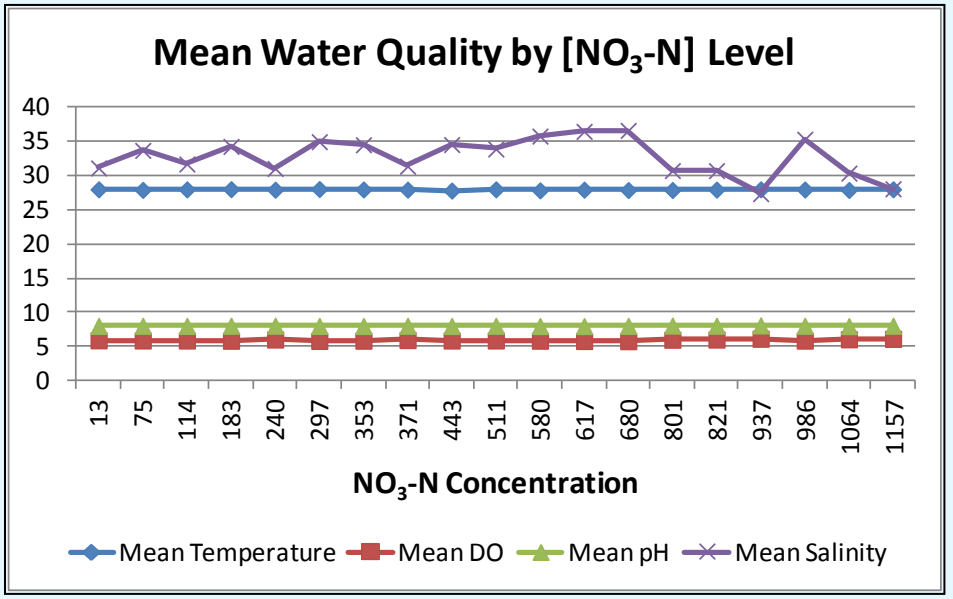


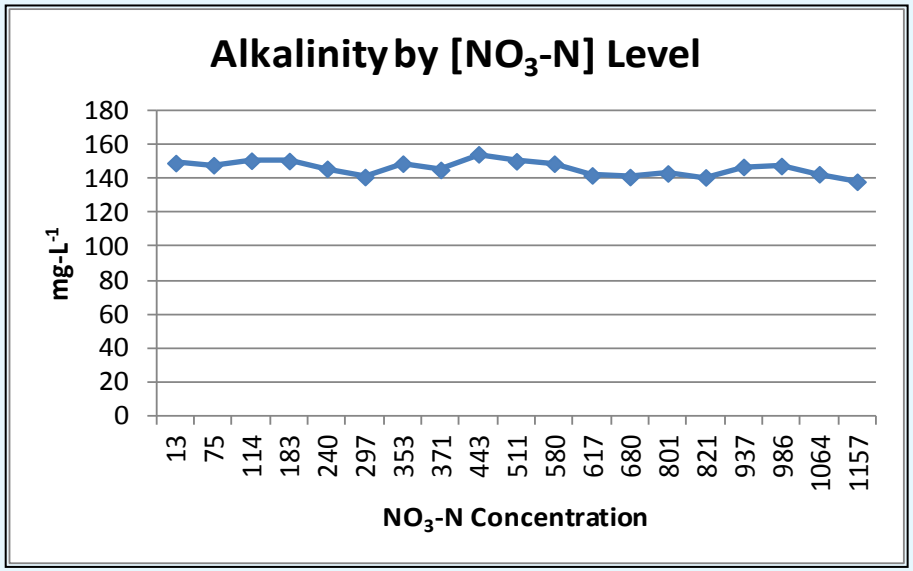
Concentrations of nitrate

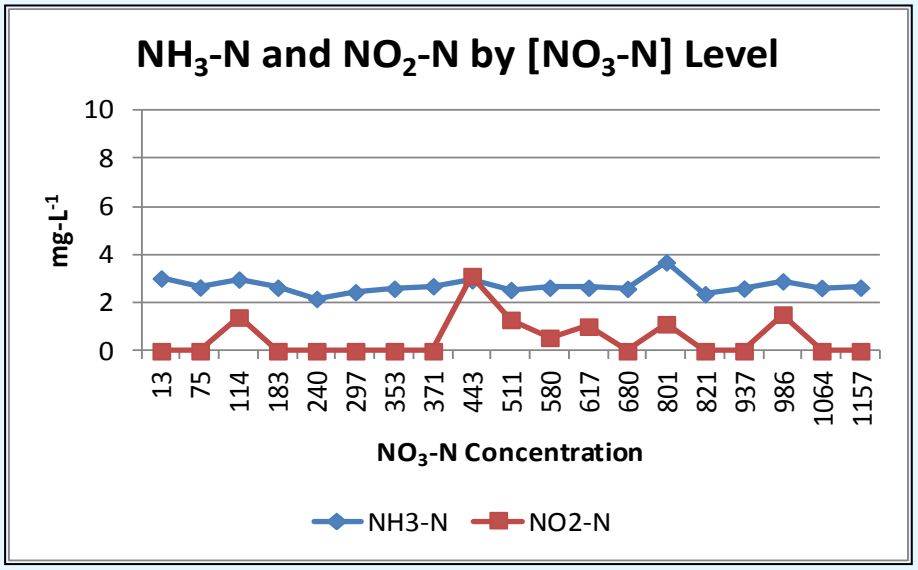
- $NaNO_3$ in fresh filtered seawater
- 19 NO_3-N concentrations: 13 to 1157 mg-L^{-1}
- 11 shrimp (mean weight = 4.23±0.23 g) per tank
- 32 days

Results:
Mean Water Quality throughout Trial

* Salinity ranged from 27.4 g-kg^{-1} to 36.6 g-kg^{-1} among the tanks.

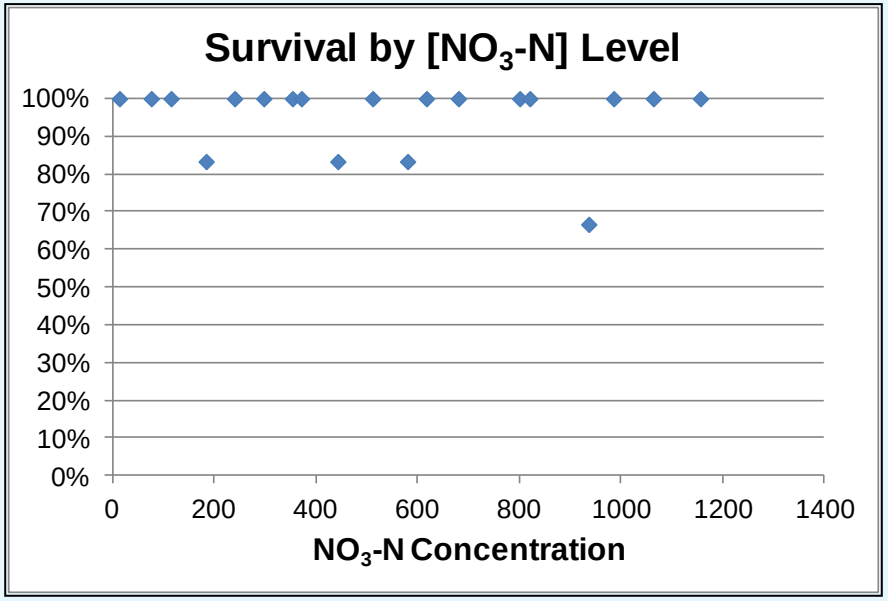


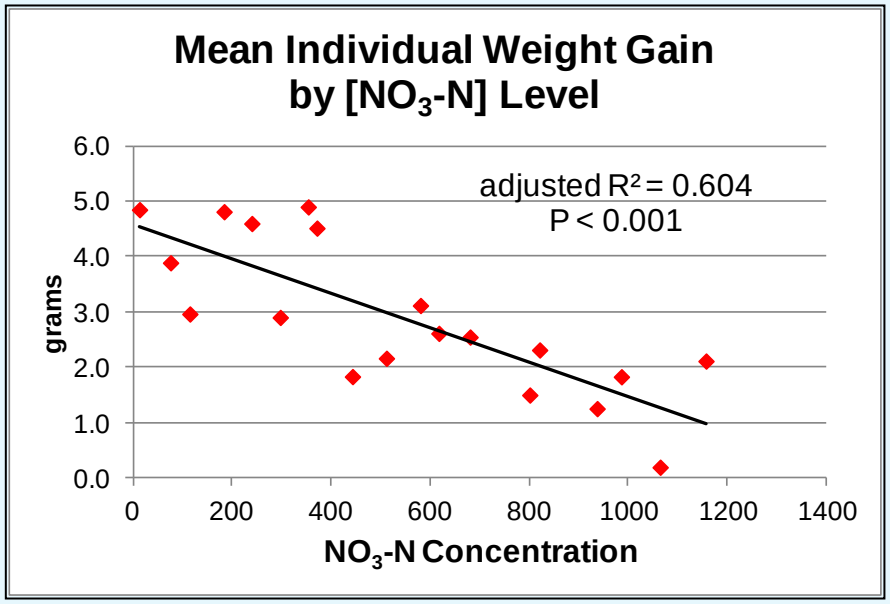


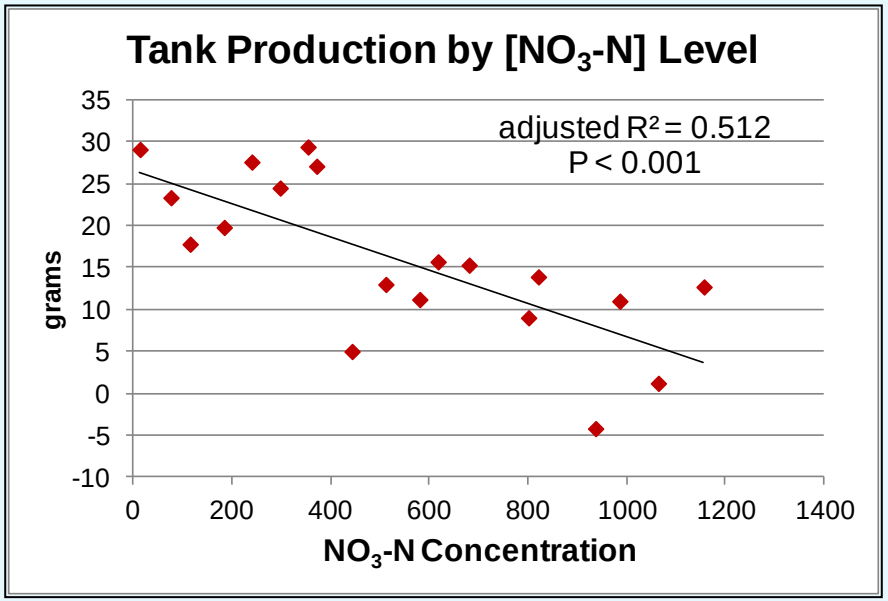


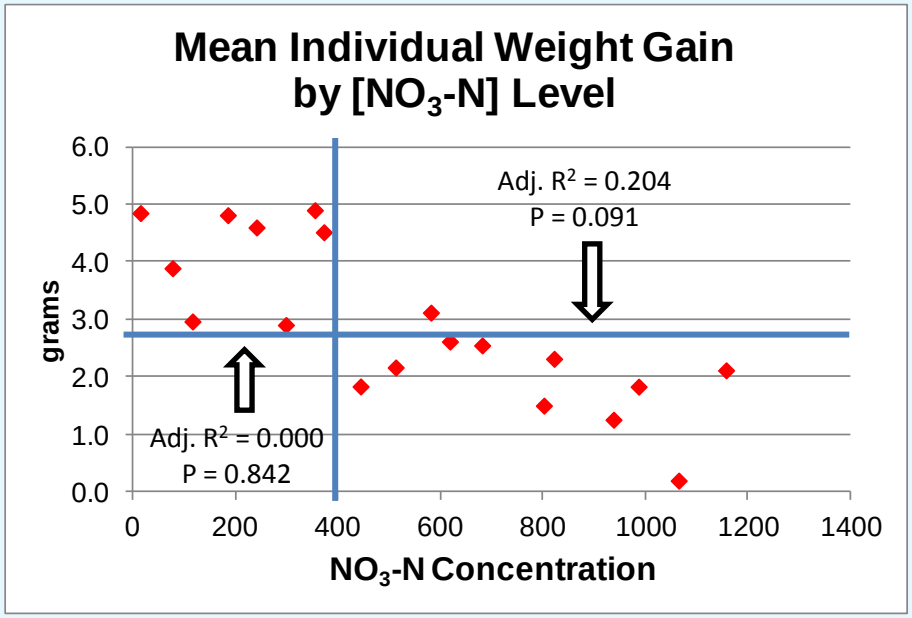
Results:

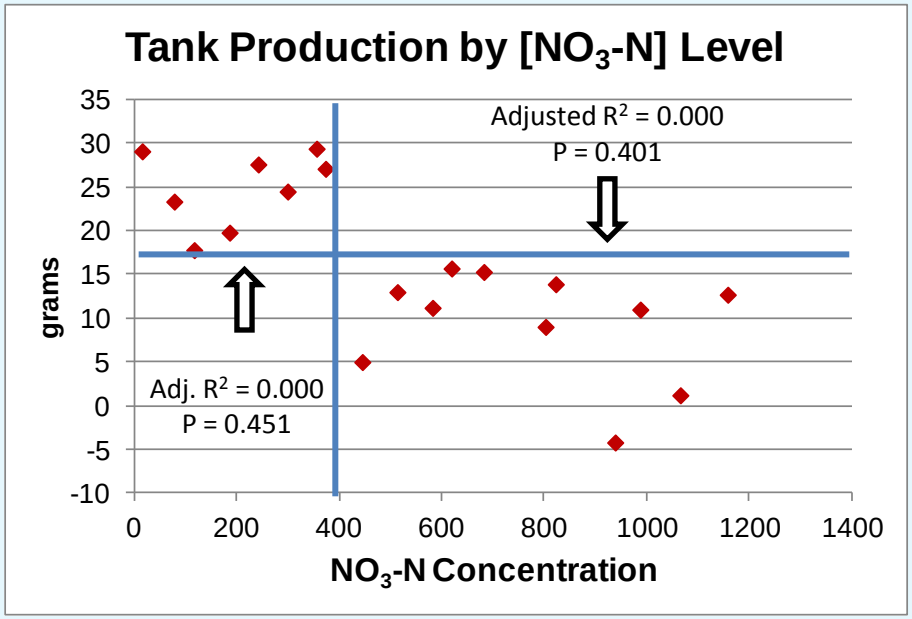
- No effect on Survival.
- Significant negative relationship between $[NO_3\text{-}N]$ and Growth Rate and Total Production.











- 400 mg-L^{-1} : a threshold?
  (Kuhn, et al 2010: 440 mg-L^{-1} had negative effects at all salinity levels)
- Either above or below, no relationship between [NO_3-N] and Growth Rate or Production.
- Growth Rate below 400 mg-L^{-1} is significantly greater than above ($P < 0.001$).
- Production below 400 mg-L^{-1} is significantly greater than above ($P < 0.001$).

Conclusion:

- **Reused biofloc water decreases shrimp growth and production.**

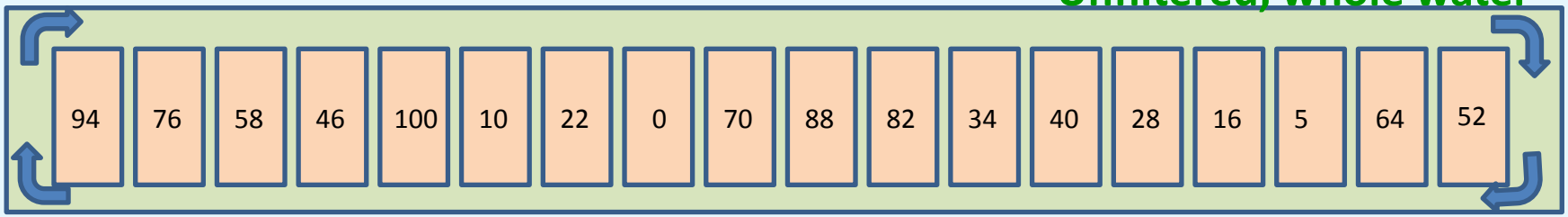
- **NO_3-N levels above 400 mg-L^{-1} limit shrimp growth and production.**

Thank you!

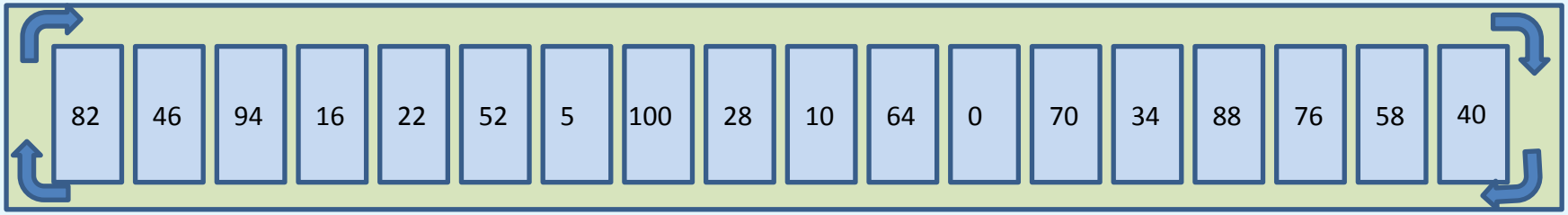
Acknowledgements:
- USDA - U.S. Marine Shrimp Farming Program
- SCDNR – Waddell Mariculture Center
- Al Stokes
- Robert Shumate

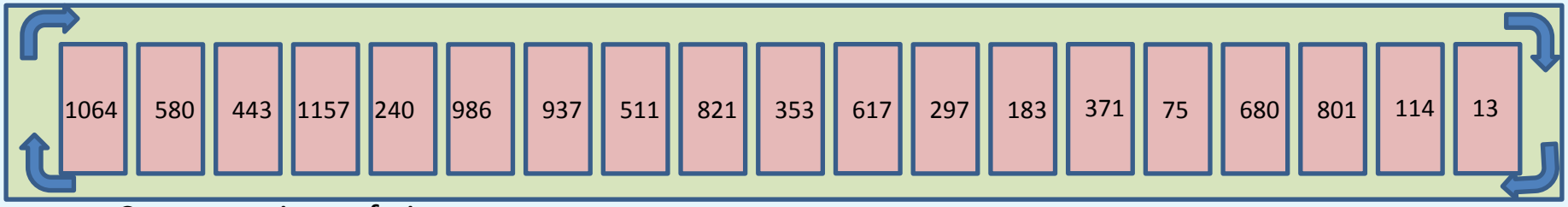
Filtered water only

Unfiltered, whole water

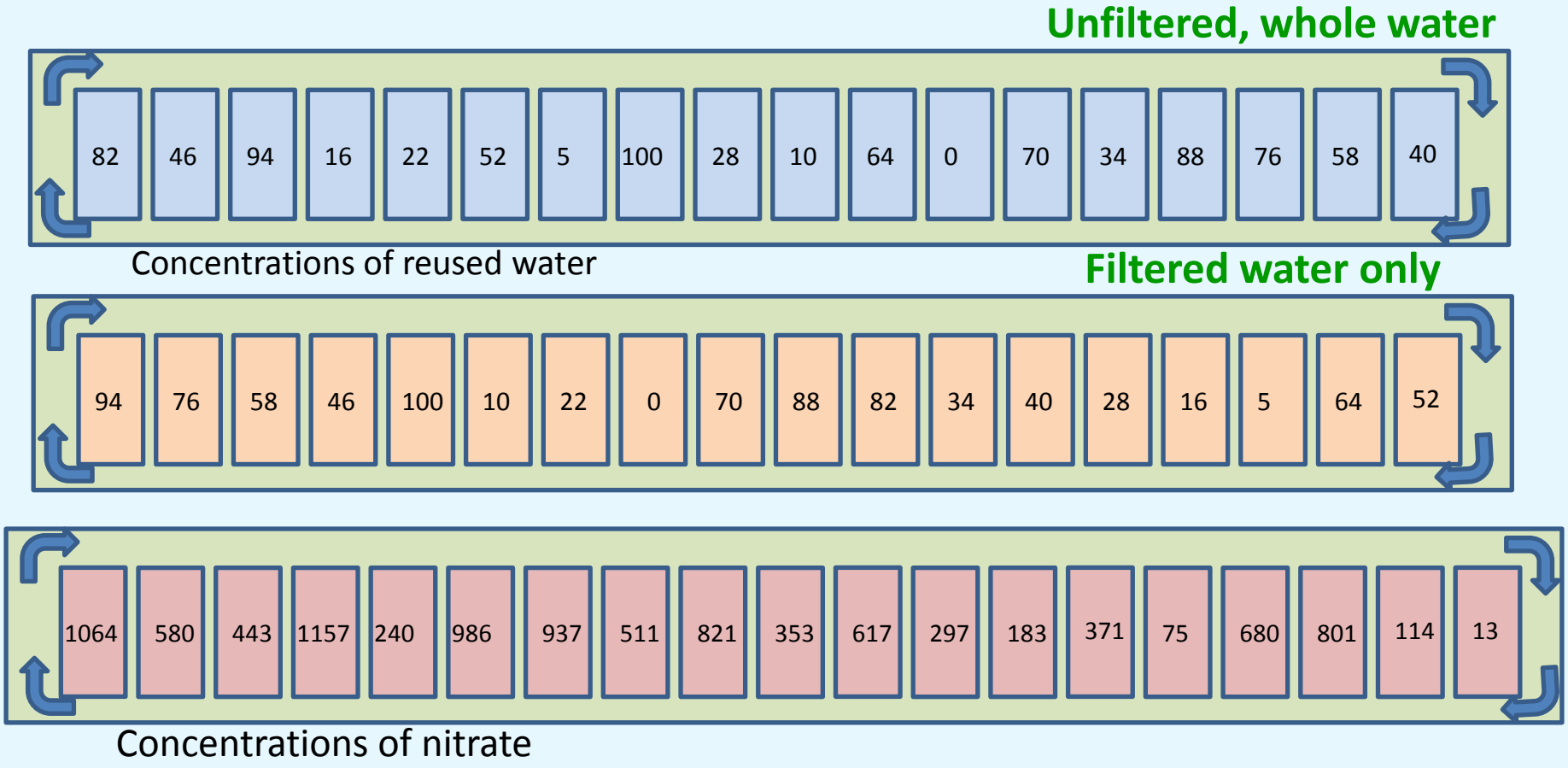


Concentrations of reused water



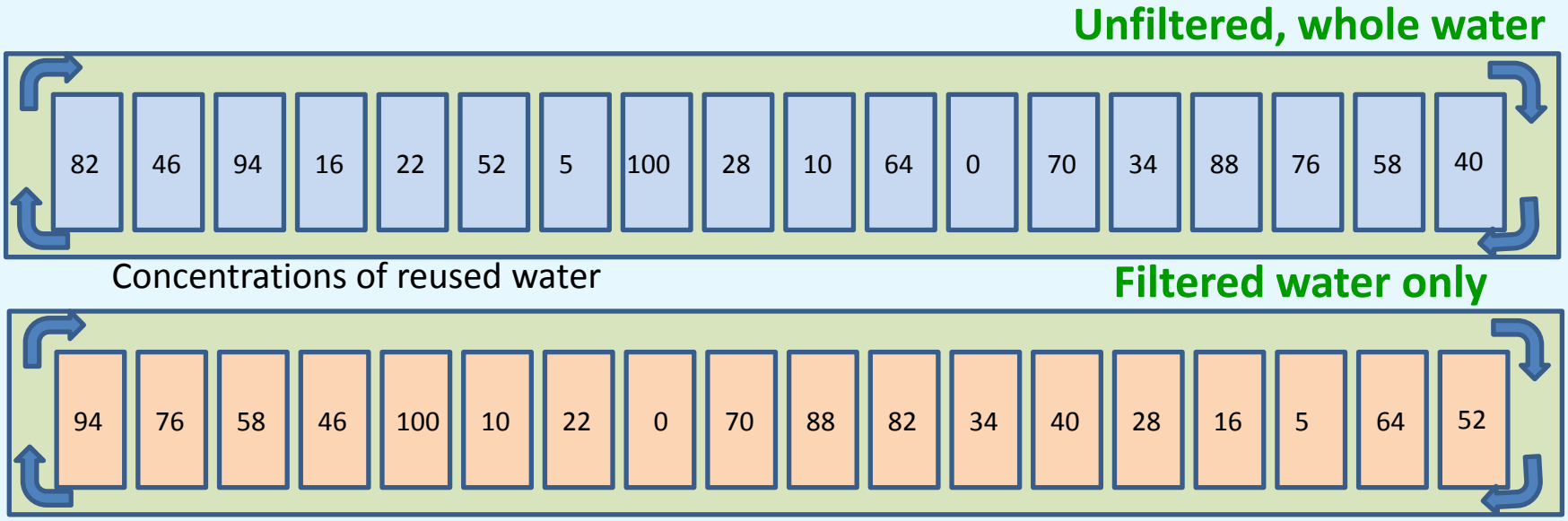


Concentrations of nitrate

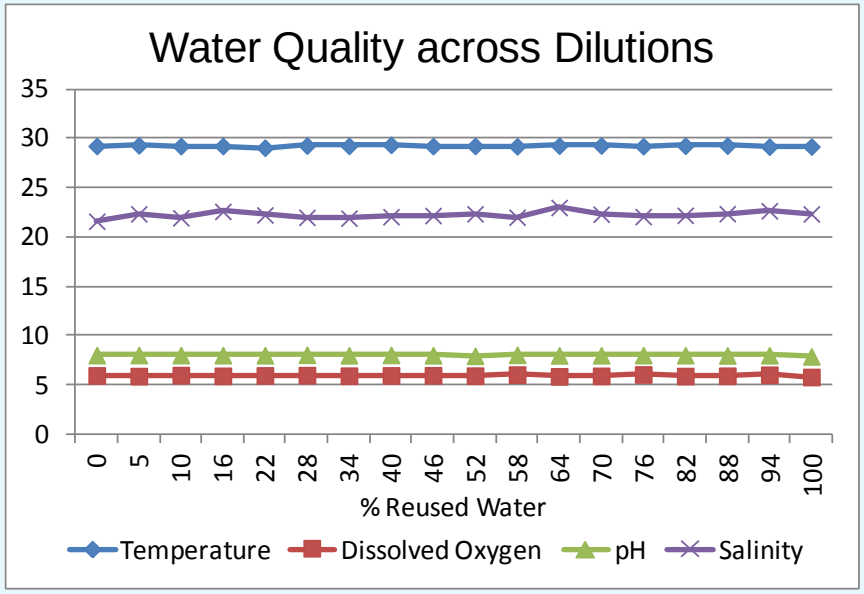

Unfiltered, whole water
82 46 94 16 22 52 5 100 28 10 64 0 70 34 88 76 58 40
Concentrations of reused water
Filtered water only
94 76 58 46 100 10 22 0 70 88 82 34 40 28 16 5 64 52
1064 580 443 1157 240 986 937 511 821 353 617 297 183 371 75 680 801 114 13
Concentrations of nitrate

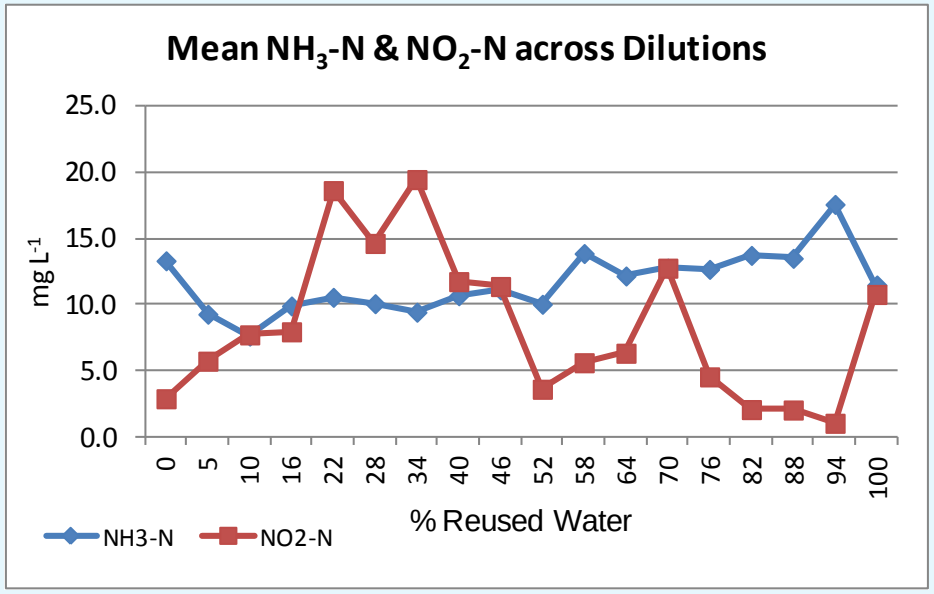
Is the agent causing growth depression dissolved in the water or associated with the biofloc particles?

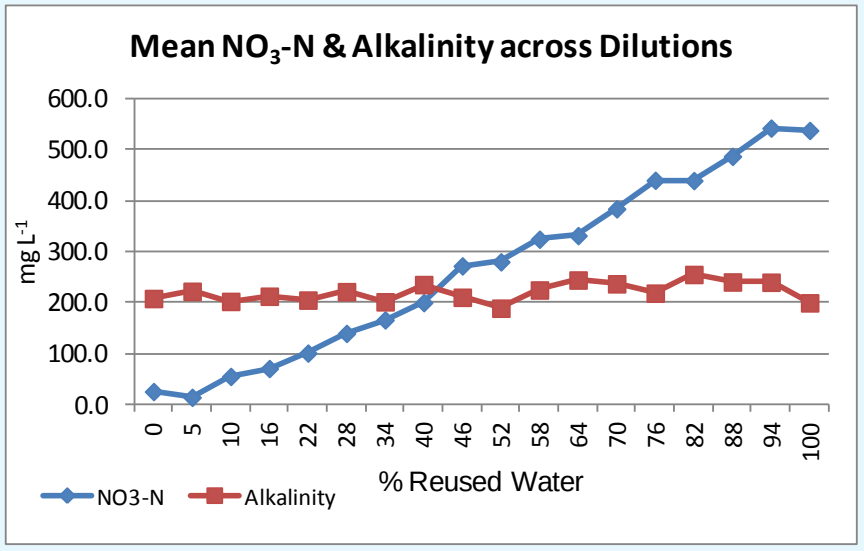
Ran an identical, simultaneous study in which all of the particulates > 1 µm were removed from the reused water prior to dilutions and filling of tanks.

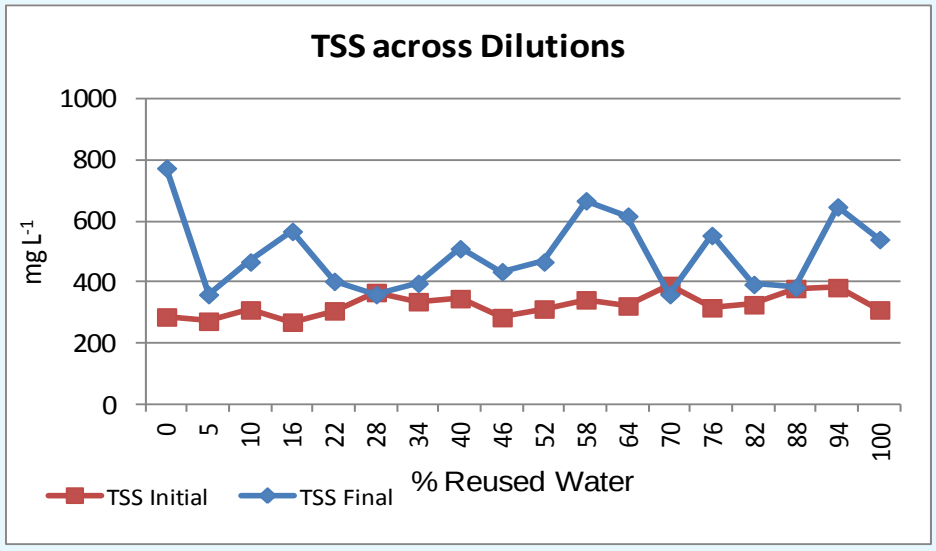


Results: Water Quality in Tanks without Biofloc



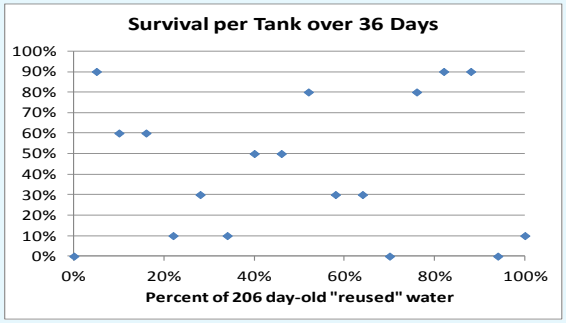


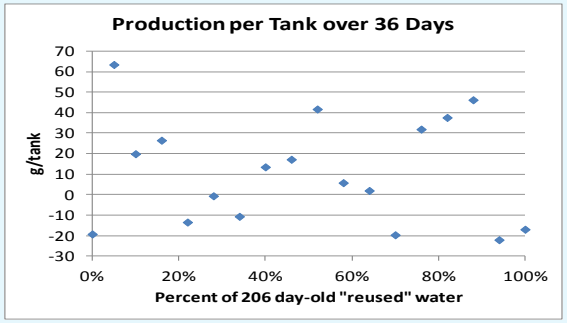


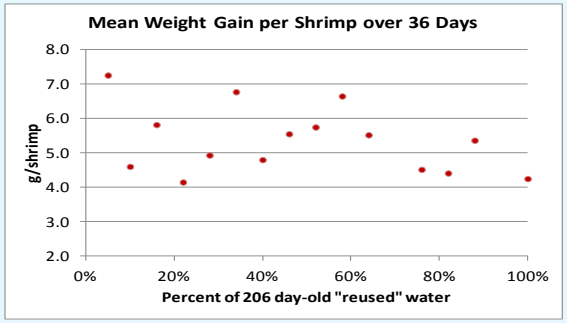


Results:

- Without biofloc, could not control NH_3-N and NO_2-N.
  (NH_3-N reached 25 mg-L^{-1} & NO_2-N reached 68 mg-L^{-1})
- No relationships between survival, growth rate, or production and the percent dilution of reused water.
- Random spikes of NH_3-N and NO_2-N caused apparently random mortality and depressed growth.







Conclusion:

- **Could not determine whether the cause of depressed growth is in the water or the biofloc particles.**
- **Nitrification occurs on biofloc particles.**

Compared production parameters for the same dilutions in the tanks with biofloc particles and the tanks without biofloc particles.

- Paired t-tests
- Survival is significantly higher in the biofloc tanks ($P < 0.001$).
- Weight gain per shrimp is higher in the biofloc tanks ($P < 0.001$).
- Production per tank is higher in the biofloc tanks ($P < 0.001$).

Conclusion:

Biofloc is important for system health.