Development of a Multi-Trophic, Biofloc-based, Polyculture System for Production of Marine Shrimp, Red Drum, and Oysters

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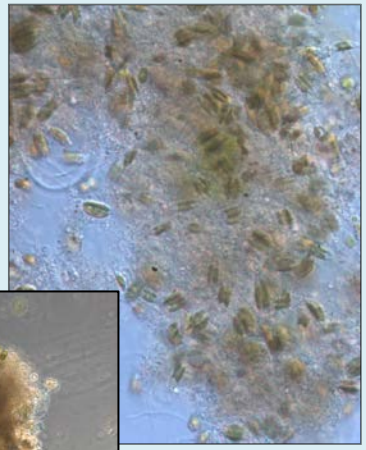
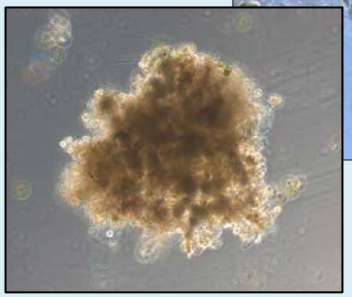
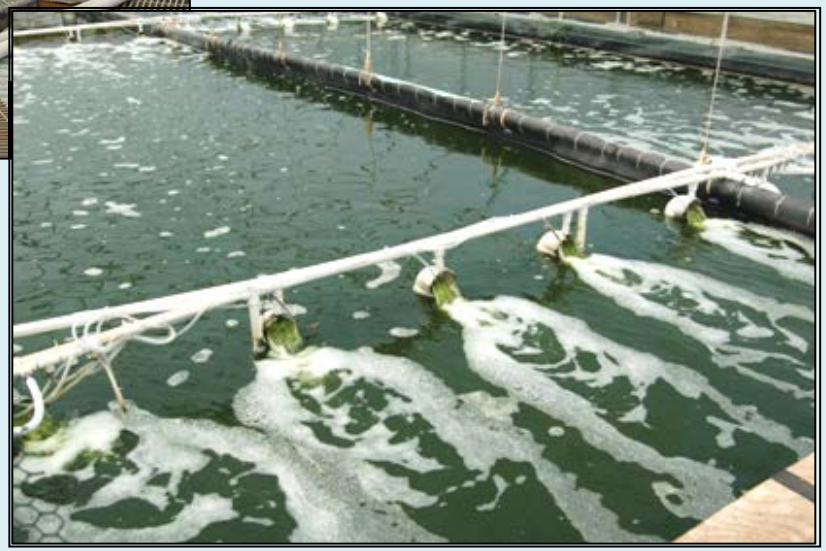
Sea Grant
S.C. Sea Grant Consortium

SOUTH CAROLINA DEPARTMENT OF NATURAL RESOURCES
DNR

Superintensive, Indoor, Minimal-exchange, Biofloc Shrimp Systems

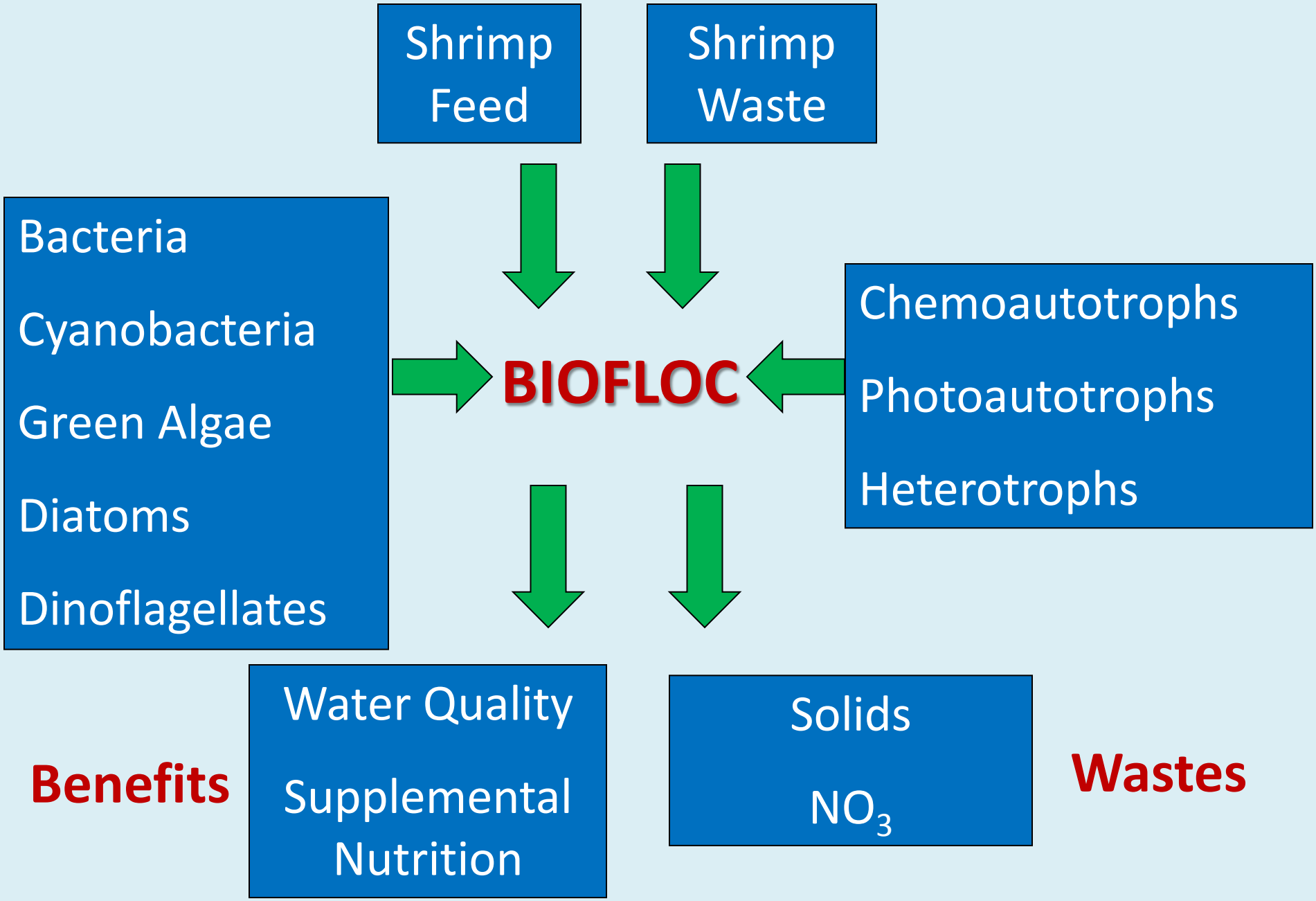






Advantages:

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


Shrimp Feed
Shrimp Waste
Bacteria
Cyanobacteria
Green Algae
Diatoms
Dinoflagellates
BIOFLOC
Chemoautotrophs
Photoautotrophs
Heterotrophs
Benefits
Water Quality
Supplemental Nutrition
Solids
NO_3
Wastes

In an indoor, minimal-exchange, superintensive shrimp biofloc culture:

- Could the biofloc community of the shrimp culture expand to also process wastes generated by fish in the same system?
- Could shellfish utilize the biofloc as a food source?
- Could shellfish reduce the suspended solids to produce relatively clean water for fish production?
- Could shrimp, fish, and shellfish be grown at commercially viable rates?

Greenhouse-based, recirculating biofloc system for the simultaneous culture of

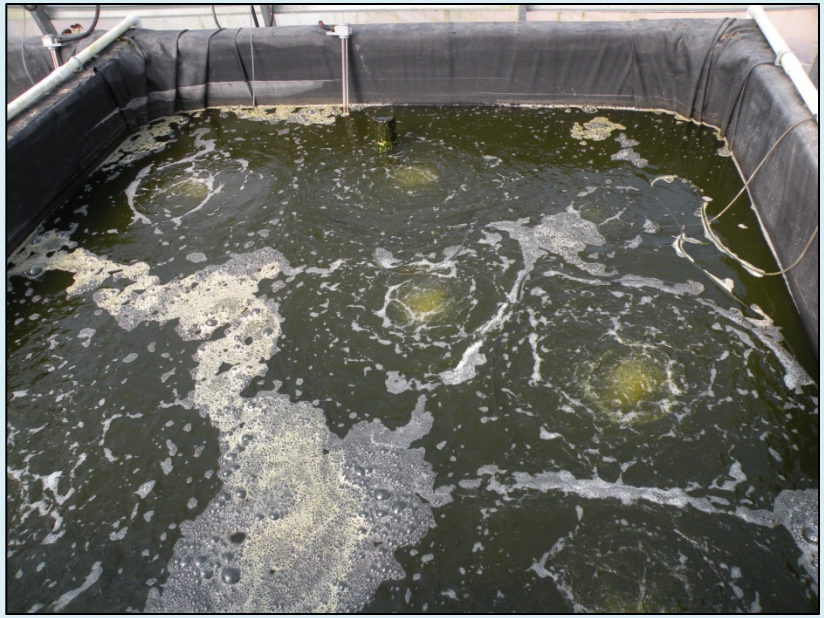
Pacific white shrimp (*Litopenaeus vannamei*)

Red Drum (*Sciaenops ocellatus*)

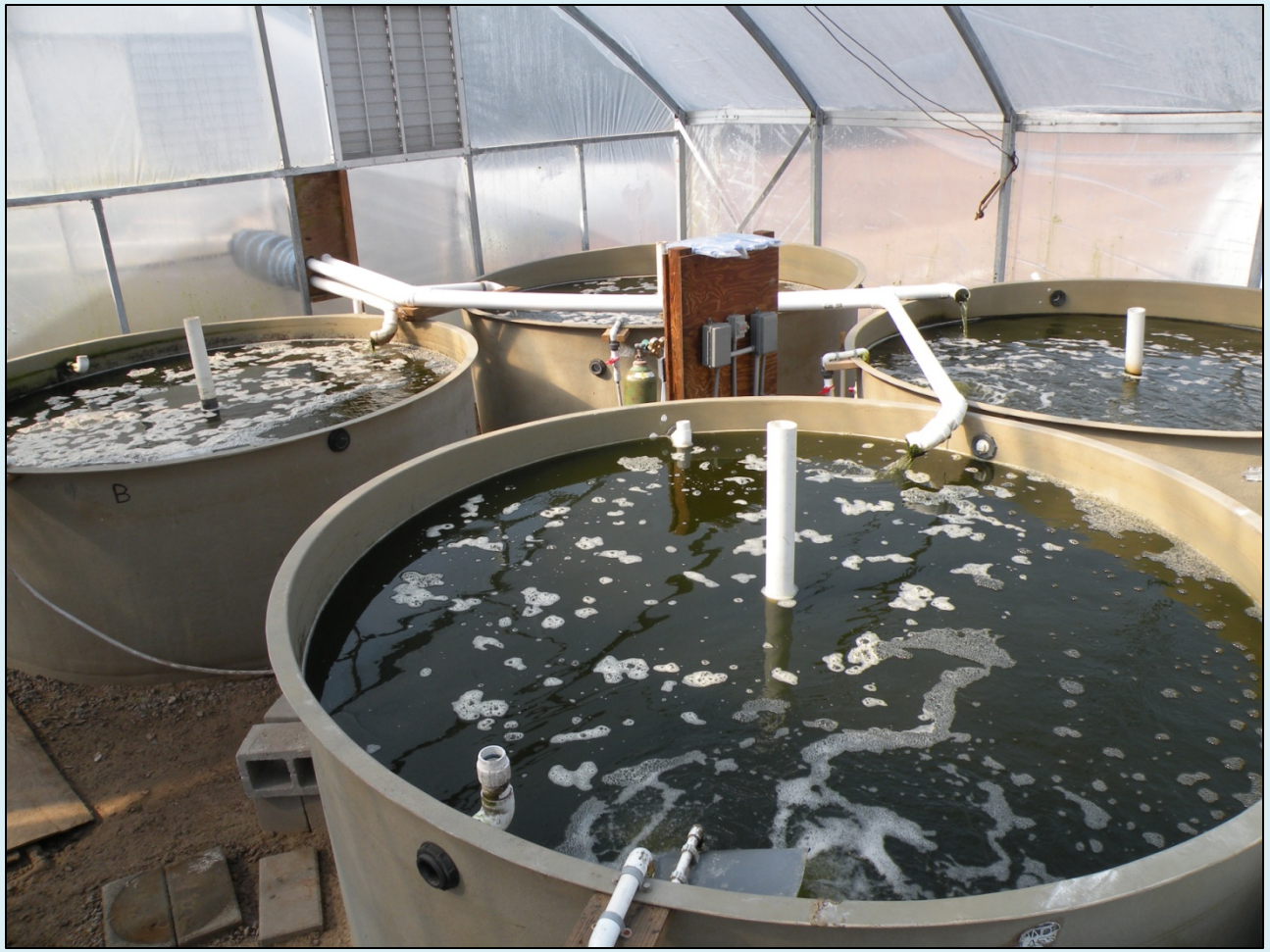
Eastern oyster (*Crassostrea virginica*)

Photos: Courtesy of SC Dept. of Natural Resources

- Constructed four replicate polyculture systems each with total volume of 31 m^3.
- Shrimp held in 30 m^3 tanks filled to 22 m^3.
- Provided main biofloc reservoir.



Fish were held in 7 m^3 circular tanks with center drains.

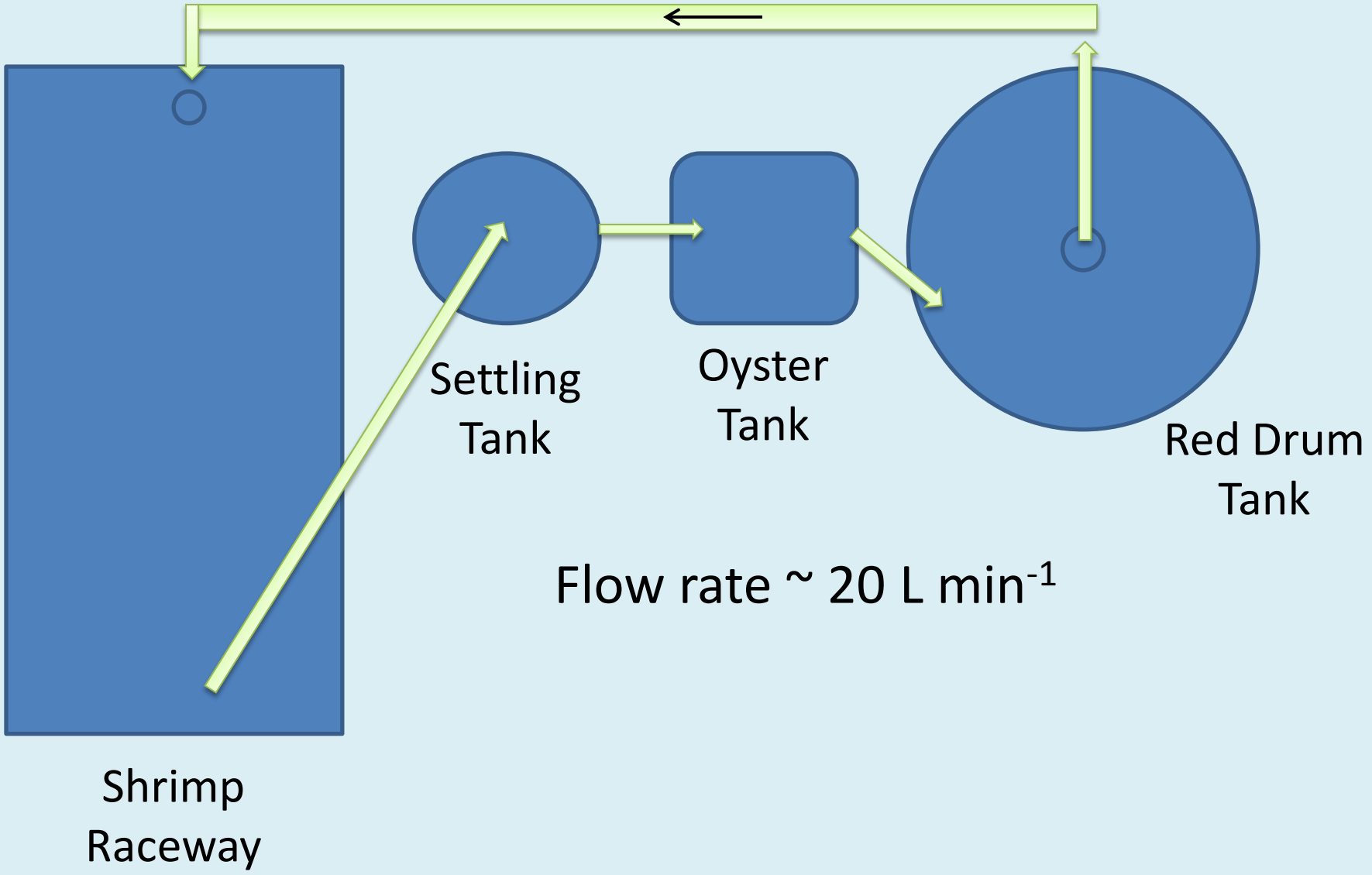


Oysters held in 1 m^3 rectangular troughs.

Oysters in plastic mesh bags suspended from floats.

Included in each system was a 1 m^3 settling tank to manage settleable solids.

Trials 1 and 2

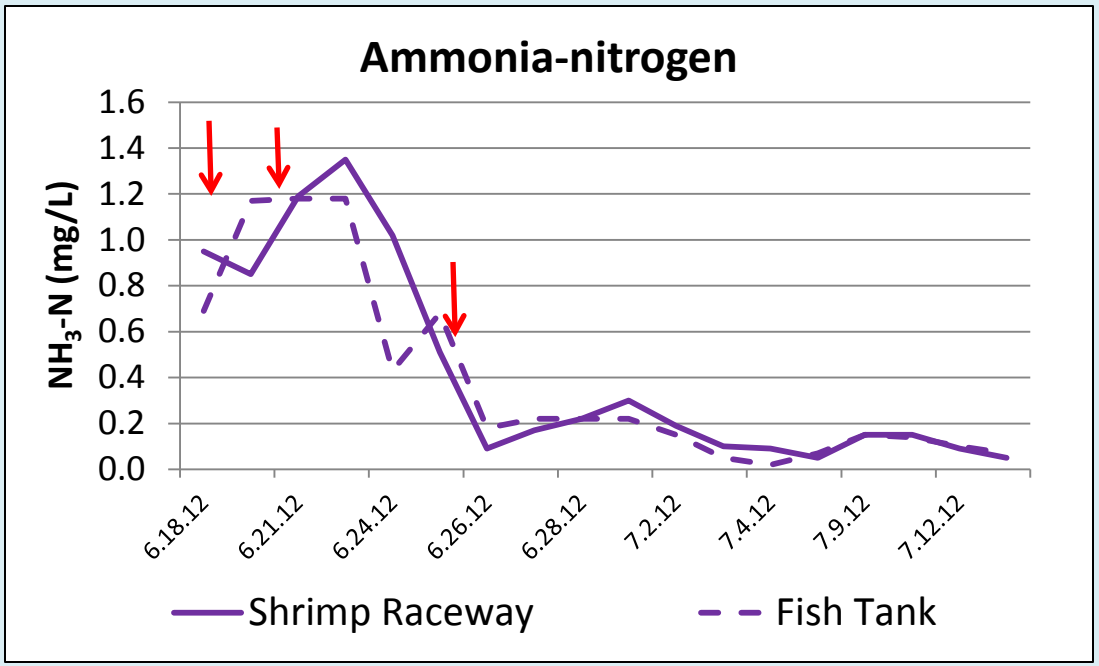


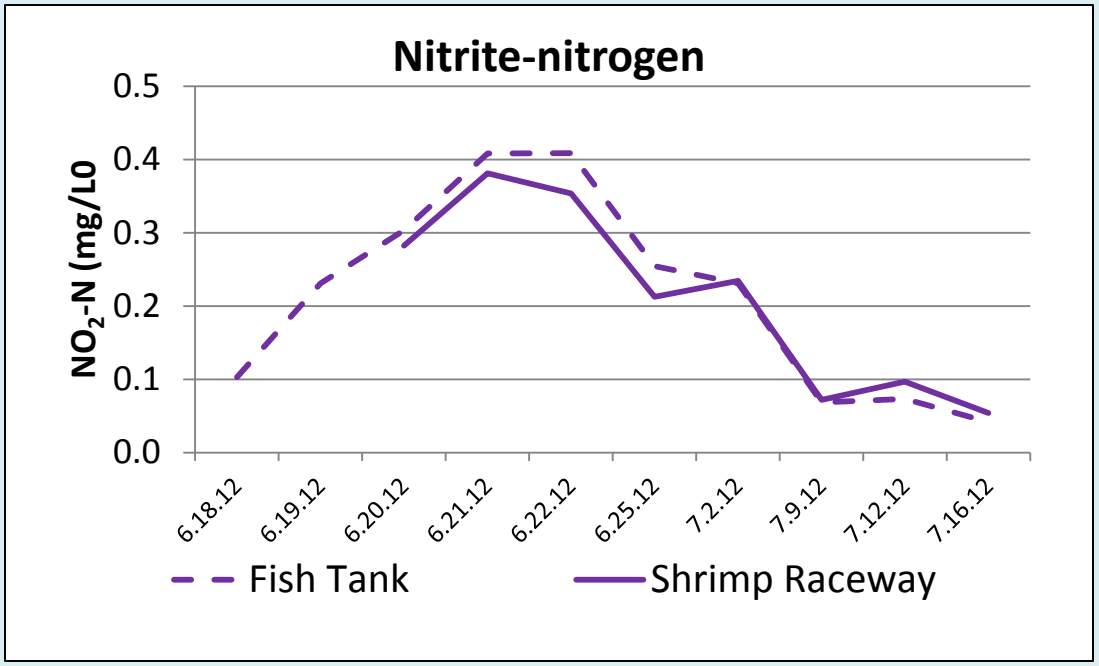
Flow rate ~ 20 L min^{-1}

Early Trials:
Will shrimp system accommodate addition of fish?

	Shrimp	Red Drum	Oysters
Stocking size	4.4 ± 0.3 g	300 ± 92 g	7-10 cm
Stocking density	250 m^{-1}	14.3 m^{-1}	50 m^{-1}
Length of trial	107 d	107 d	10 d
Survival	88%	90%	0%
Growth rate	1.0 g wk^{-1}	7.4 g wk^{-1}	0.0 g wk^{-1}

- Final biomass supported = 134 kg; 4.3 kg m^{-3}
- Shrimp: Fish biomass ratio = 2:1
- Shrimp and red drum found to be compatible in polyculture system.





When red drum were added, the Biofloc increased to process the additional nitrogen input.

NH_3-N < 1.4 mg L^{-1}

NO_2-N ≤ 0.4 mg L^{-1}

Trial 3 Objectives

- System modifications to improve movement of biofloc particles through all tanks
- Evaluate replicability of simultaneous systems in terms of water quality and production.

Diffuser manifolds for oxygen transfer and circular flow.

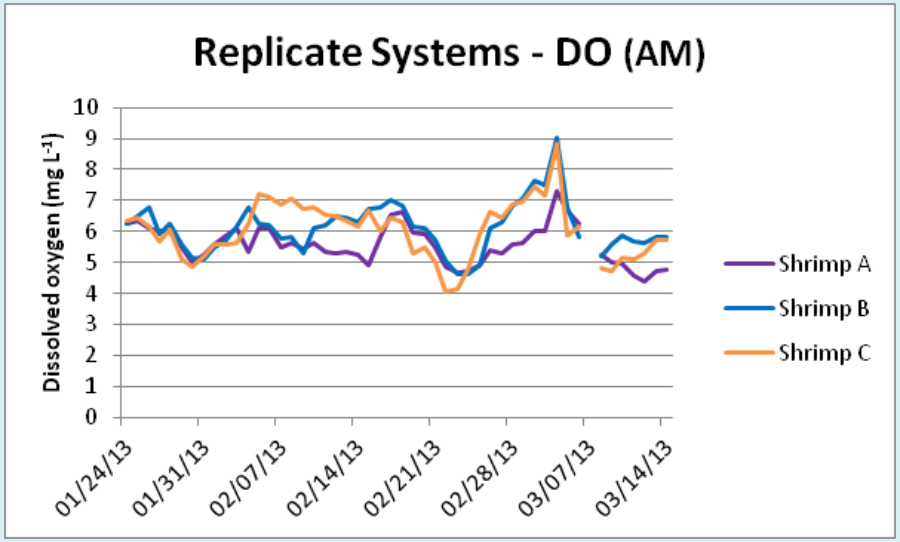
External standpipes removed daily to flush solids to shrimp tanks.

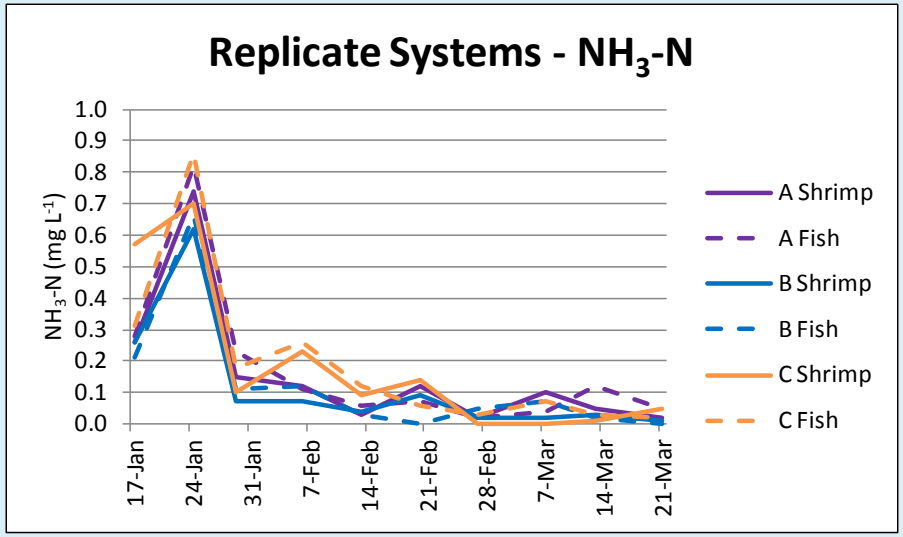
Trial 3 Initial Stocking

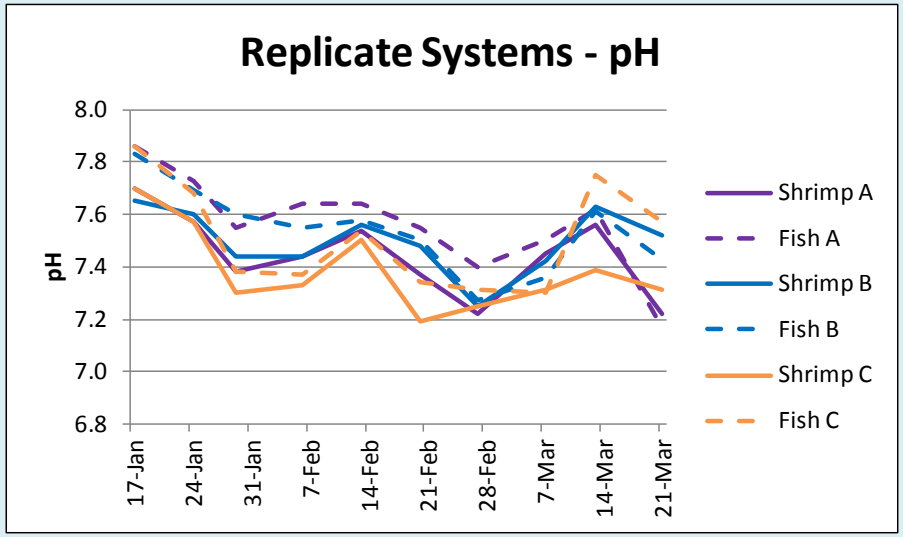
	System A	System B	System C
Shrimp mean weight ± SD (g)	11.6 ± 2.6	10.9 ± 3.2	12.6 ± 3.3
Fish mean weight ± SD (g)	559 ± 178	568 ± 163	562 ± 172
Oyster length ± SD (mm)	41 ± 7	38 ± 8	36 ± 9
Shrimp density (m^{-3})	275	275	275
Fish density (m^{-3})	14.3	14.3	14.3
Oyster density (m^{-3})	30	30	30

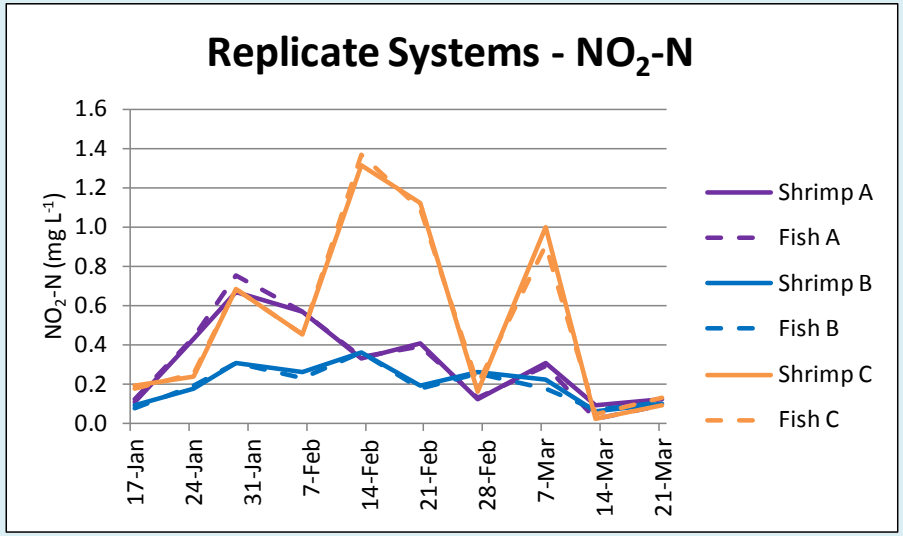
- Shrimp fed Zeigler High Intensive 35 at 400 g d^{-1} per tank.
- Red drum were fed Zeigler Finfish Gold 42-16 slow sinking feed at 280 g d^{-1} per tank.

Replicability among Systems

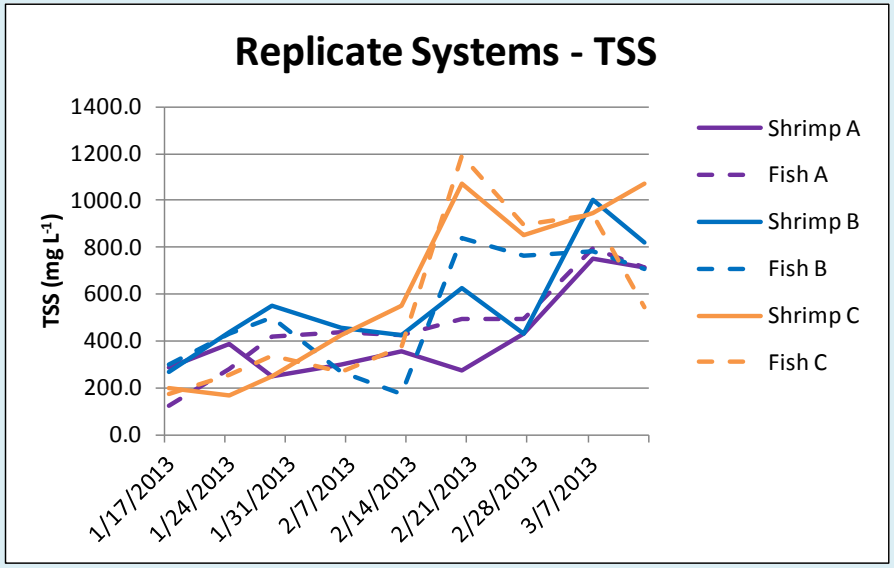


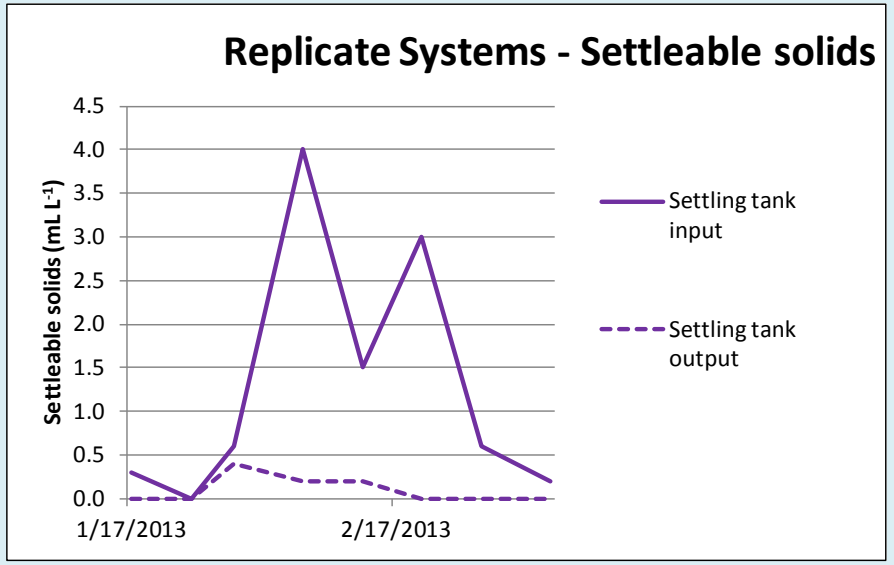






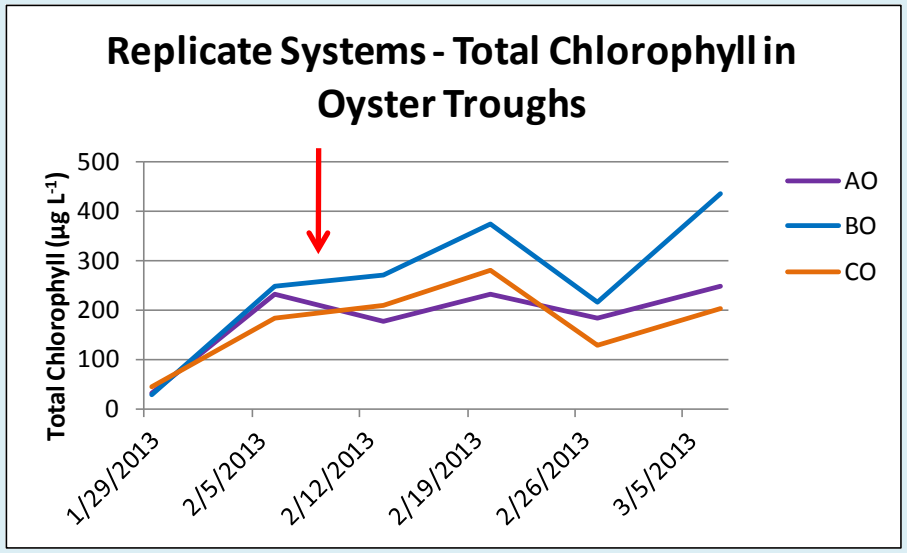
Replicability among Systems - Solids





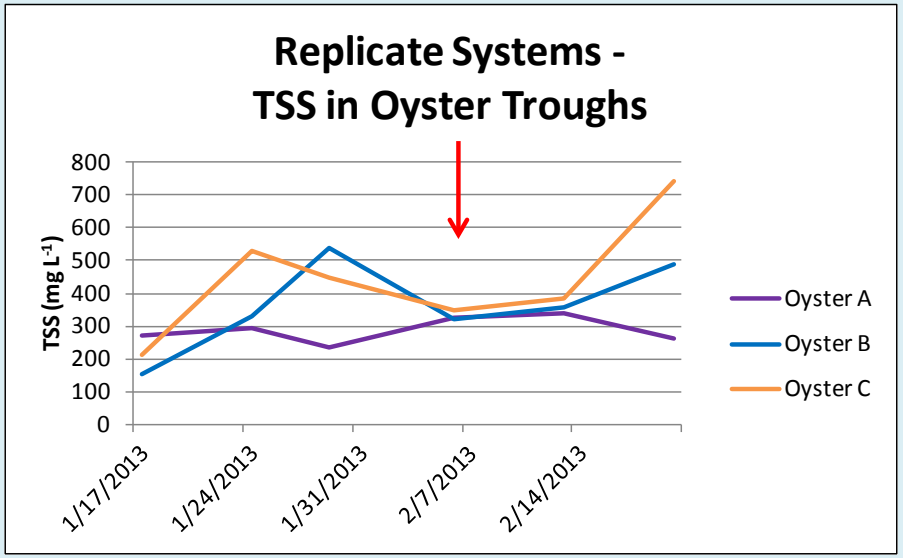
Replicability among Systems - Oysters

Oysters suffered **100% mortality** within 10 days of stocking.



Inadequate food ?

High solids load ?



Trial 4 Objective: Permit Oyster Survival

- Halted Trial 3 and Altered Shrimp & Fish Biomass to Create Different Biofloc Communities

System	Shrimp Biomass (kg)	Fish Biomass (kg)	System Total (kg)	Microbial Community
A	63.5	48.8	112.3	cyanobacterium *Synechococcus*
B	88.9	63.2	152.1	few unicellular algae & diatoms, filamentous bacteria, dinoflage-lates, many rotifers
C	33.4	26.6	60.0	unicellular algae, more diatoms, dinoflagellates, many rotifers
D	Filtered seawater & fertilized; no biomass			unicellular green algae

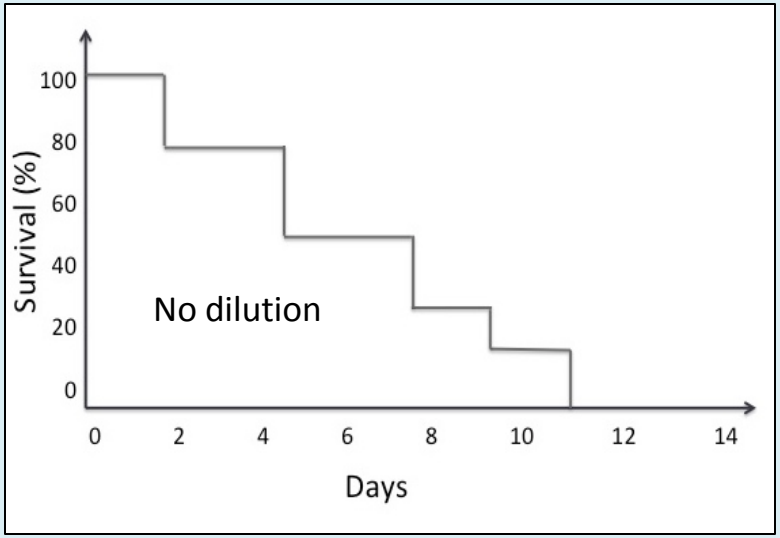
Trial 4 Oyster Survival?

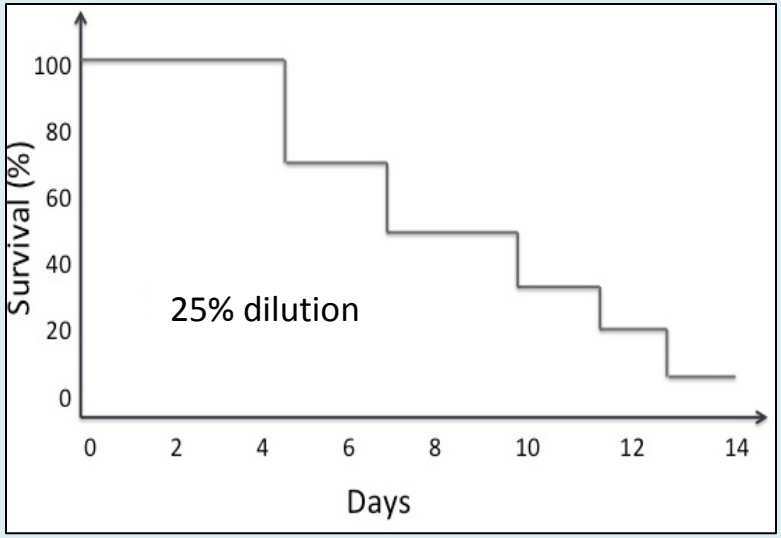
- 25 oysters stocked in each trough for 10 days

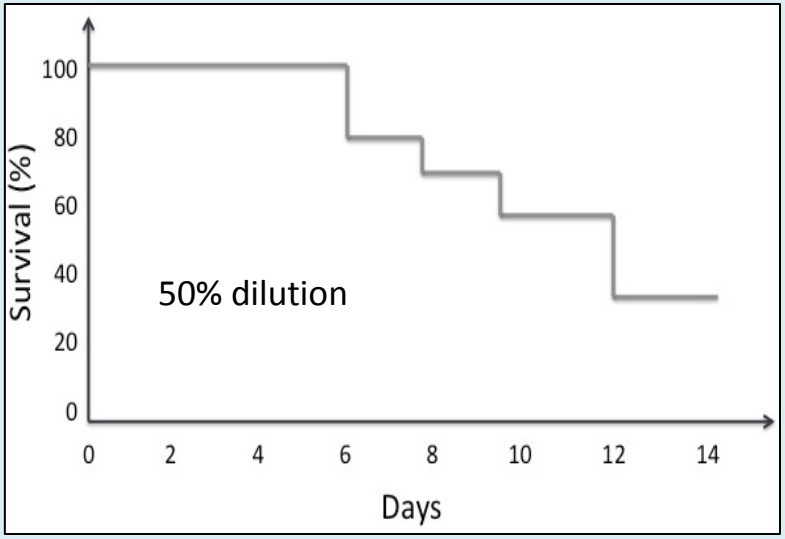
System	% Survival	Density
A	20	Medium
B	68	High
C	80	Low
D	88	No shrimp or fish

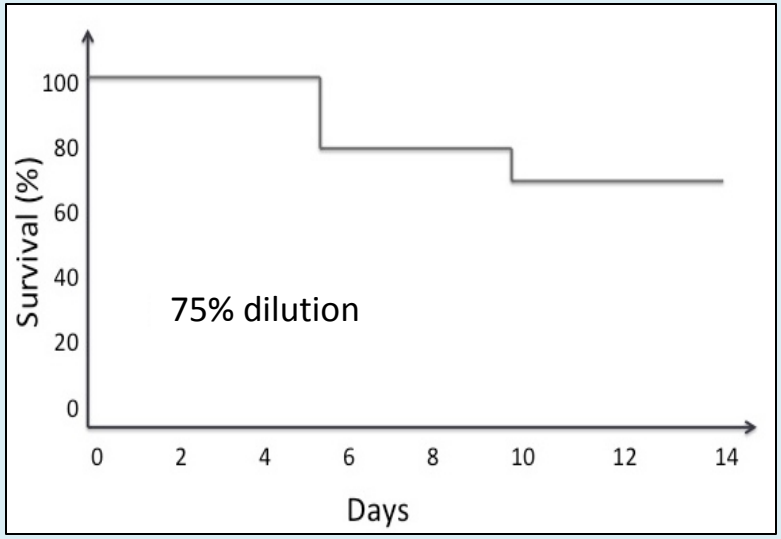
A - Dominated by cyanobacterium *Synechococcus*
B - Filamentous bacteria, hetero. dinoflagellates
C - No filamentous bacteria, hetero. dinoflagellates, more diatoms
D - Unicellular green algae

Survival of Oysters in Serial Dilutions of *Synechococcus* sp. Bloom Water

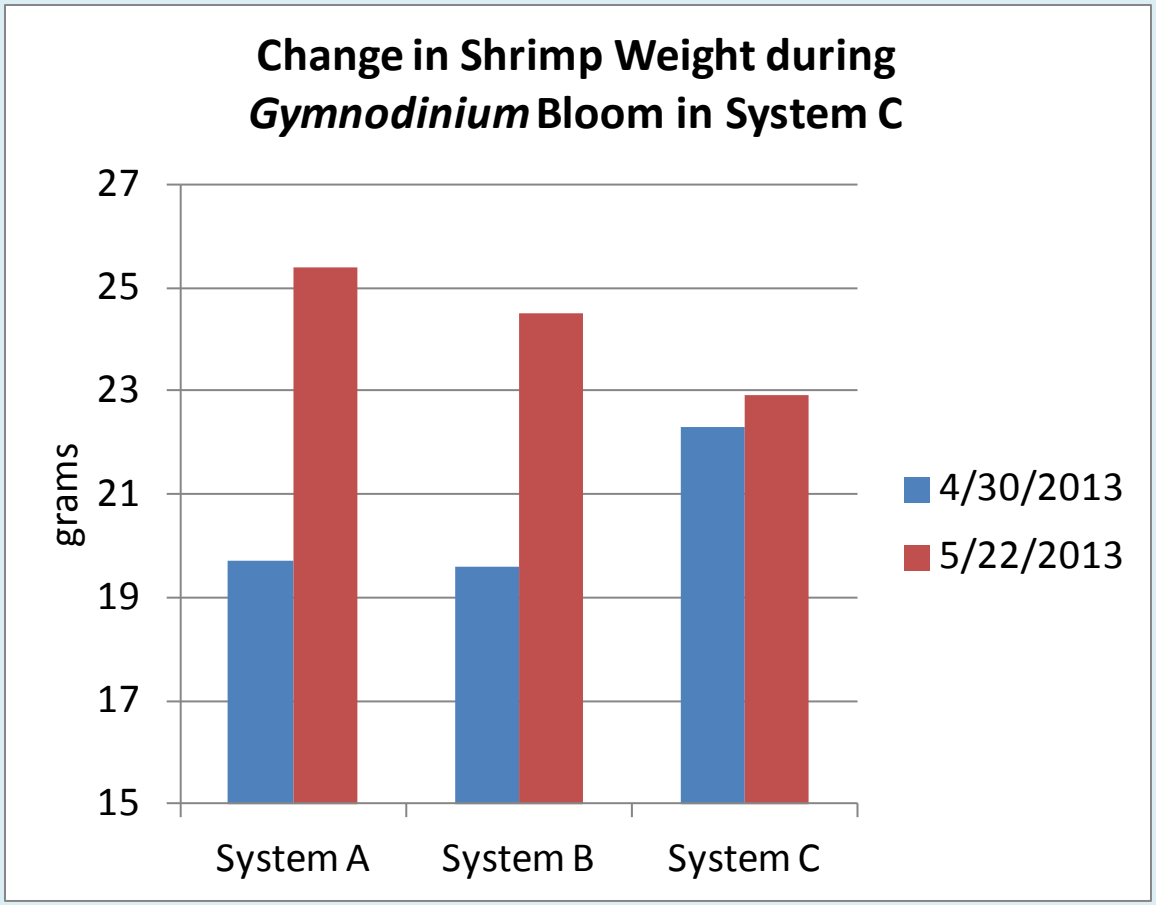


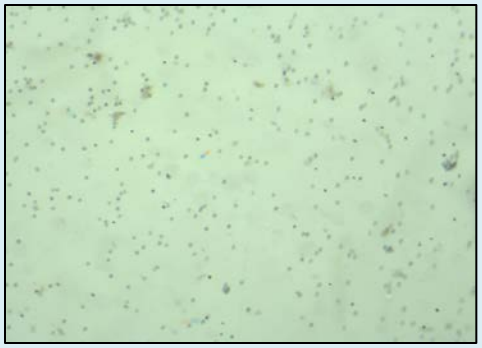


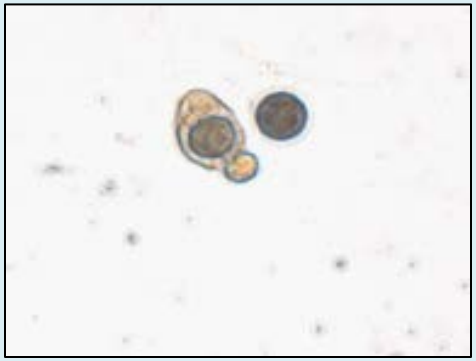




Impact of a *Gymnodinium* sp Bloom

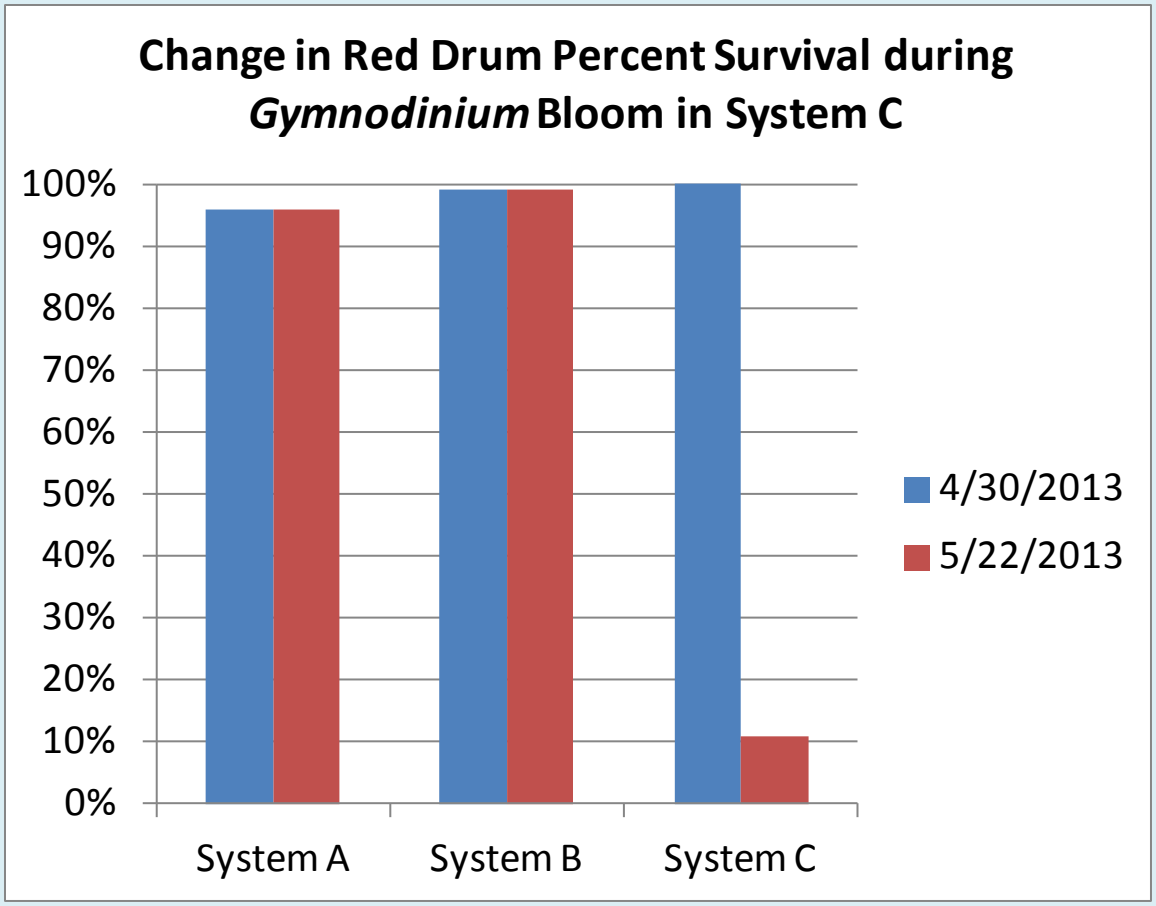


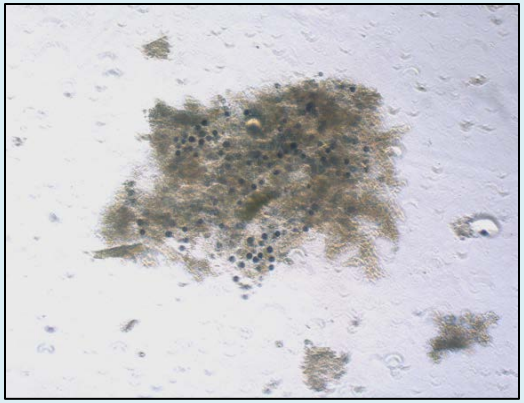


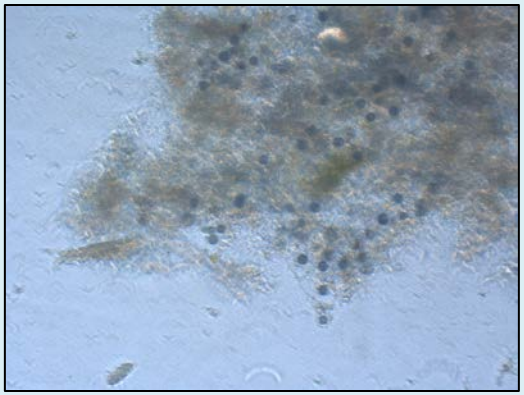


Cysts so abundant that water was gray; Cysts settled into 1-2 mm layer in a 500 mL flask.

Impact of a *Gymnodinium* sp Bloom







Cysts very abundant on gills. Toxins probably killed the fish.

Preliminary Conclusions – BioFloc Polyculture System

- Shrimp and red drum compatible.
- Biofloc will process wastes of combined shrimp-fish biomass.
- Oysters highly problematic.
- Biomass loading influences biofloc community composition.
- Outbreaks of cyanobacteria and heterotrophic dinoflagellates have significant negative impacts on growth and survival.

- Can oysters survive and prosper?
- Can the biofloc community be made more stable?
- Could such a system approach profitability?

Please return for Biofloc Polyculture – Part 2

Trials 5 and 6!

presented by our next speaker:

Dr. Luis Poersch

Thank you!

Acknowledgements

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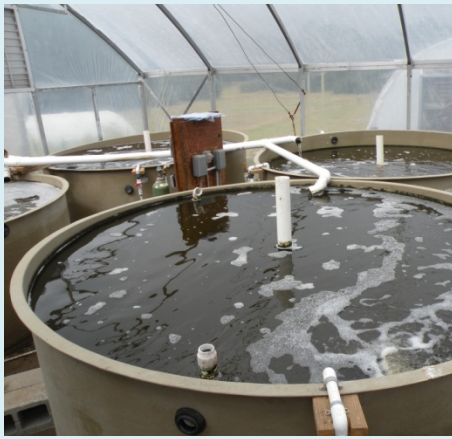


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CONVERSE