Biological Treatment of Fish Wastewater to Generate Microbial Flocs (Biomass) for Shrimp Culture

D.D. Kuhn, G.D. Boardman, S.R. Craig, E. McLean and G.J. Flick Jr.

Presented by:

David D. Kuhn, Ph.D. Student

Civil and Environmental Engineering

Virginia Tech

Blacksburg, VA

Purpose Statement

The overall purpose of this study is to determine if freshwater tilapia effluent can be used to culture the marine shrimp, *L. vannamei.*

Justification

This project could offer a sustainable option for the culture of marine shrimp through the recycling of nutrients and maximizing water reuse using suspended growth biological processes (e.g. SBRs)

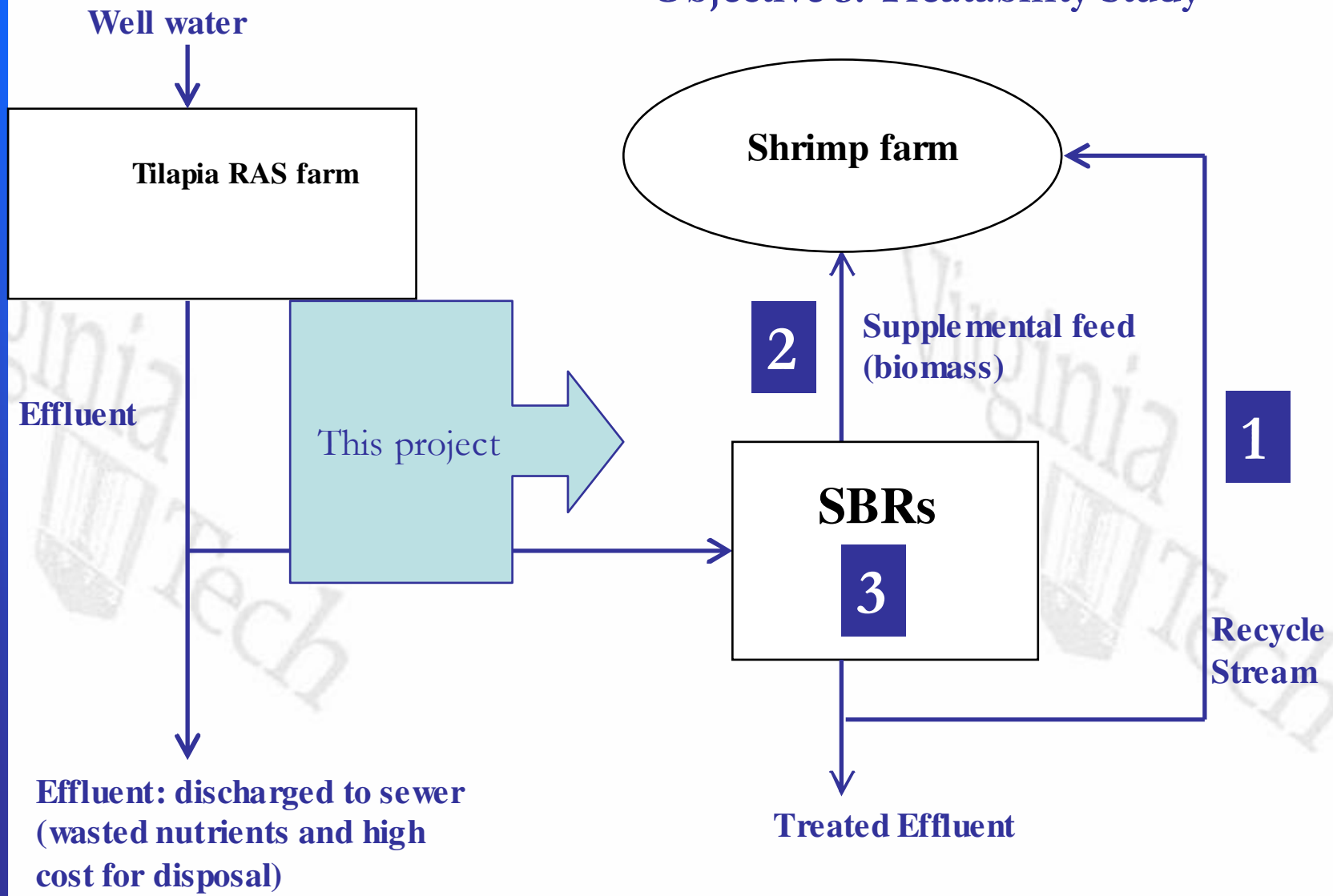
Background

- Traditional heterotrophic shrimp systems have proven to be largely successful (e.g., considering shrimp health, growth rates, nitrogen assimilation)
- Despite these successes, several drawbacks are often observed:
  1. Extremely high oxygen demands
  2. Unstable culture conditions

Objective 1: Ion Study

Objective 2: Nutrition Study

Objective 3: Treatability Study



Background: Sequencing batch reactors (SBRs), a suspended biological growth process

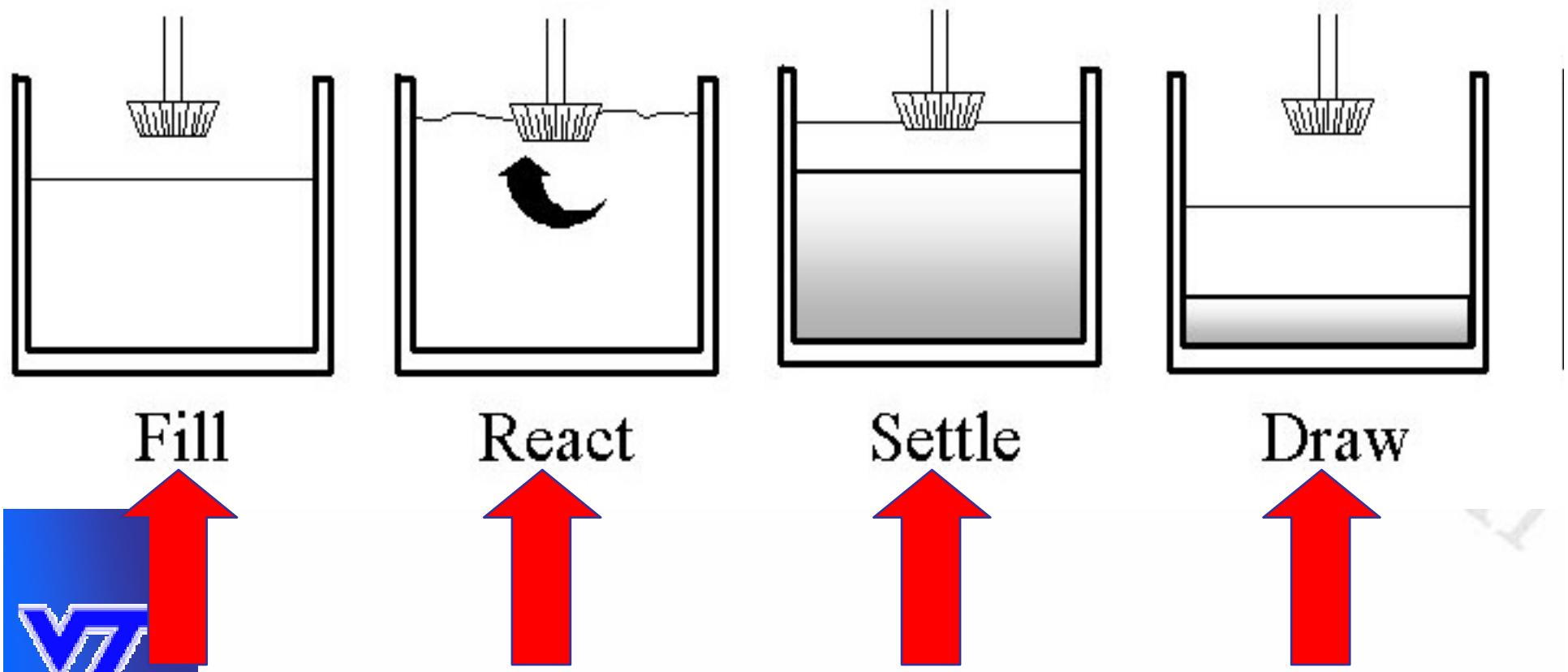


Photo source: http://www.lifesciences.napier.ac.uk/

Objective 2 - evaluate whether or not microbial flocs generated from biologically treating fish effluent can be a viable supplemental feed for shrimp

Objective 2: Nutrition Study

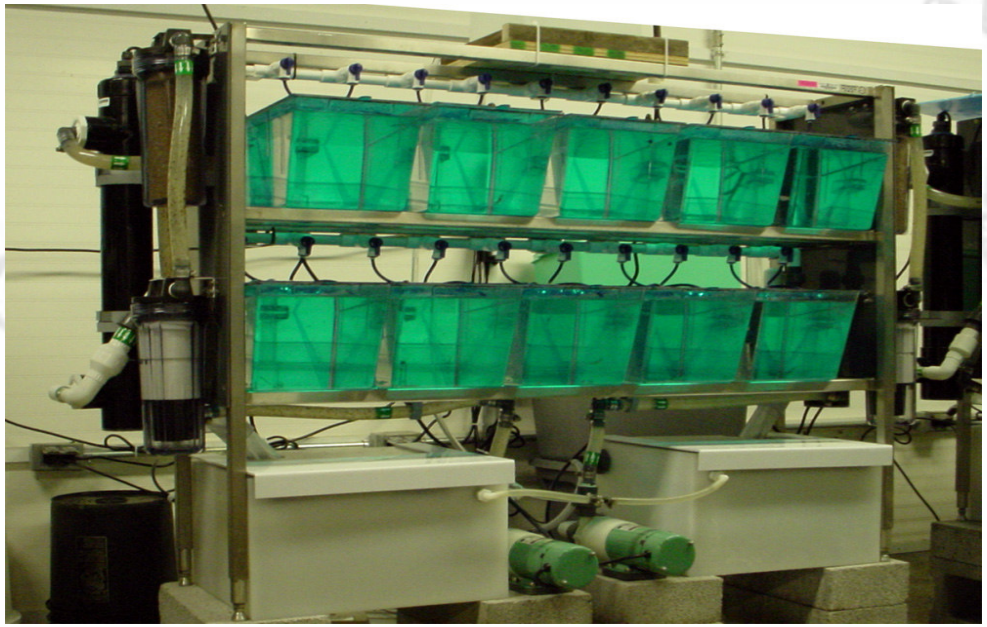
General Methods

- Tilapia effluent collected from a commercial scale tilapia farm
- Untreated solids collected after 30-45 min. settling period
- Microbial flocs generated as soluble COD was consumed (> 80%)
    - Effluent aerated in 10 gallon aquaria
    - Microbial flocs harvested after 30-45 min. settling period

Objective 2: Nutrition Study

Trial 1 of 2

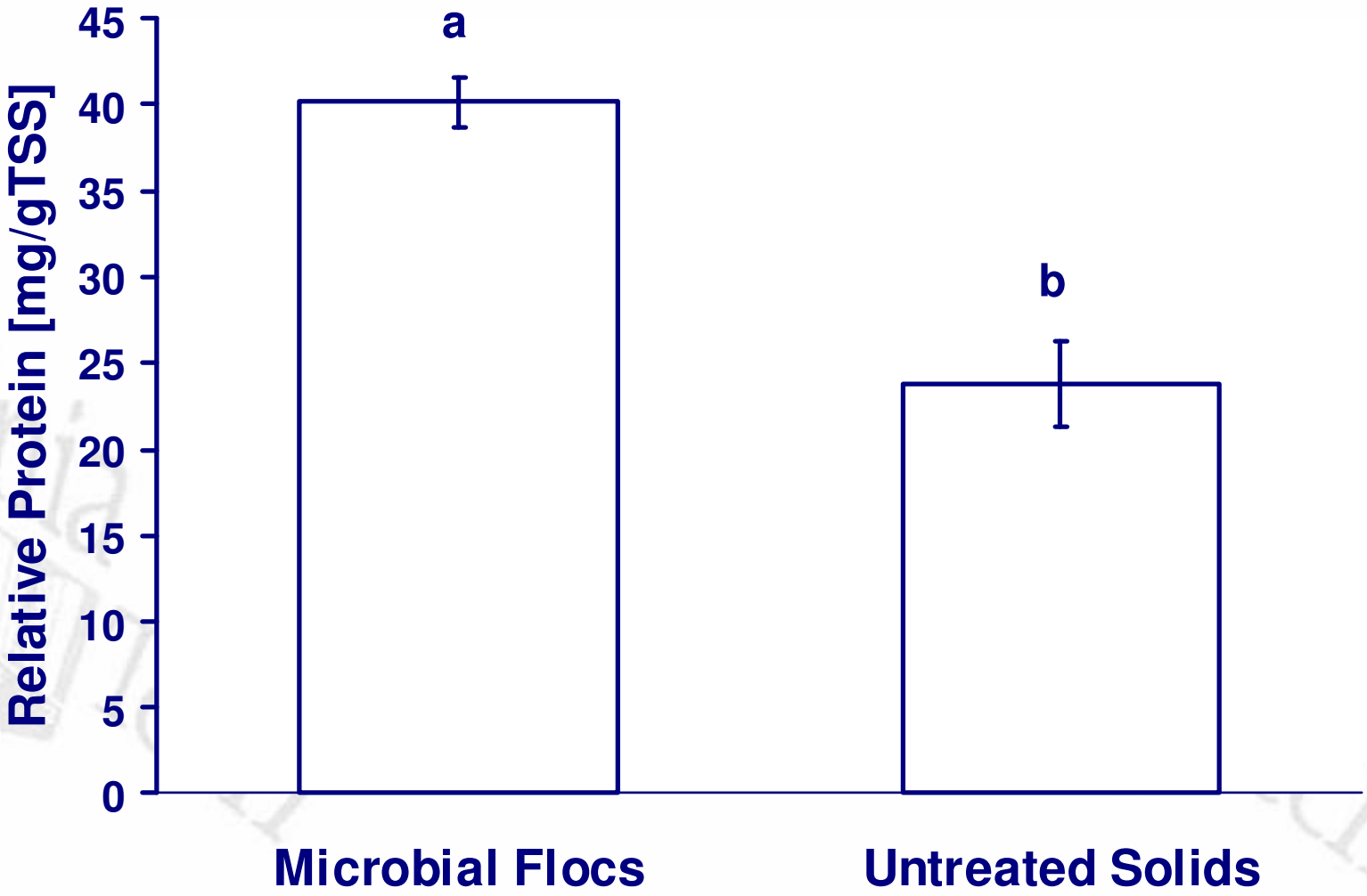
- Four dietary treatments distributed randomly on 6 AHAB™ systems
- Each treatment performed in sextuplicate
- Five shrimp per aquaria
  - Initial mass: 26.3 ± 1.3 mg
- 40 day feeding trial



Objective 2: Nutrition Study

Diet	Day 1	Day 2	Day 3	Day 4	…
Diet one: 100% shrimp feed	Shrimp feed	Shrimp feed	Shrimp feed	Shrimp feed	…
Diet two: 50% shrimp feed 50% microbial flocs	Shrimp feed	Microbial flocs	Shrimp feed	Microbial flocs	…
Diet three: 50% shrimp feed 50% untreated solids	Shrimp feed	Untreated solids	Shrimp feed	Untreated solids	…
Diet four: 50% shrimp feed	Shrimp feed	No feed	Shrimp feed	No feed	…

Objective 2: Nutrition Study



Objective 2: Nutrition Study

Final mass, SGR, and survival of shrimp as determined on day 40, alphas denote significant differences.

Diet	Final mass [mg]	SGR [1/d]	Survival [%]
Diet one: 100% shrimp feed	385.0[a]	6.68	73
Diet two: 50% shrimp feed, 50% microbial flocs	259.1[b]	5.71	93
Diet three: 50% shrimp feed, 50% untreated solids	225.7[b,c]	5.35	87
Diet four: 50% shrimp feed	180.2[c]	4.80	93
Pooled error	39.03		15.06
P > F	<0.0001		0.1027

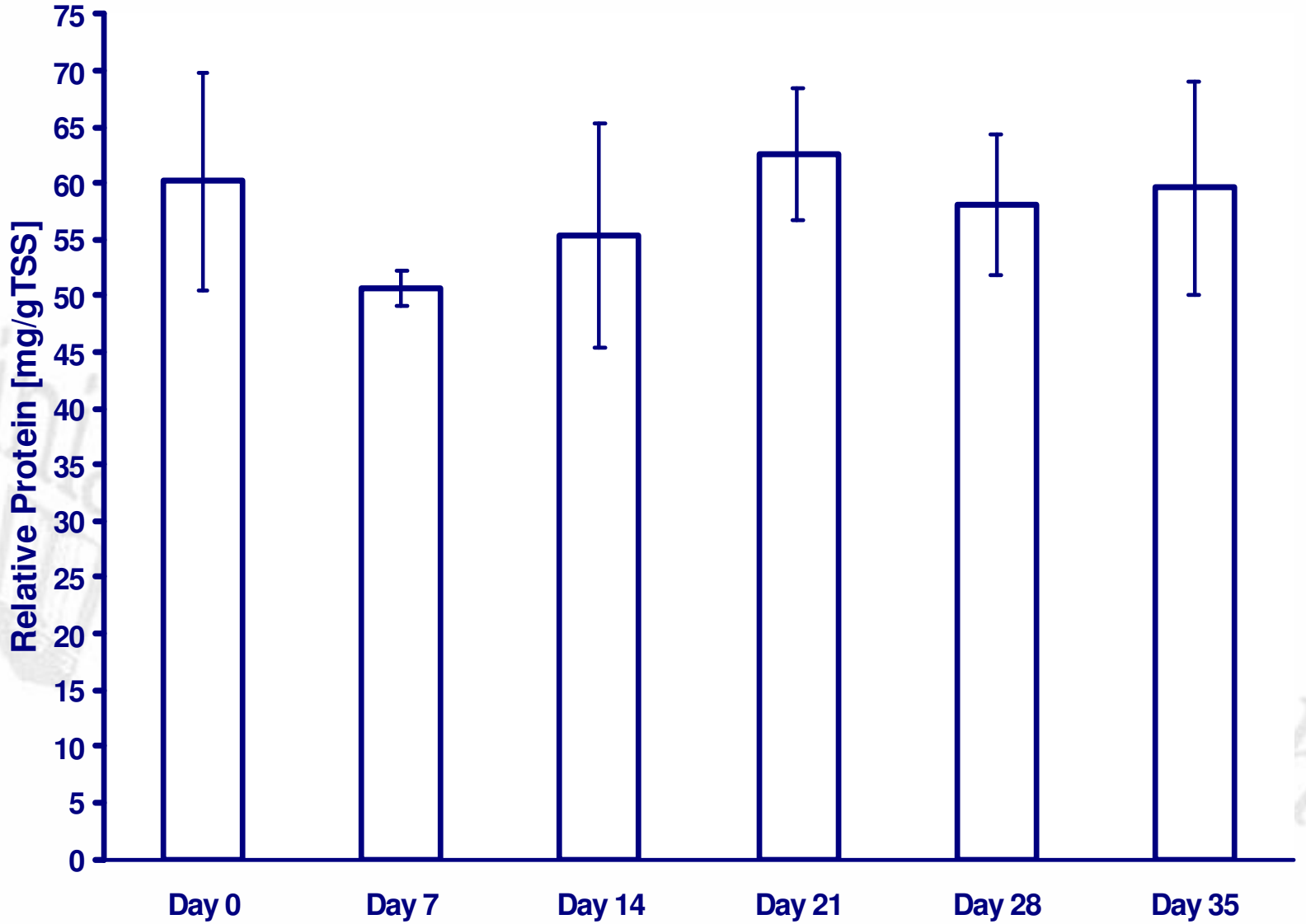
Objective 2: Nutrition Study

Trial 2 of 2

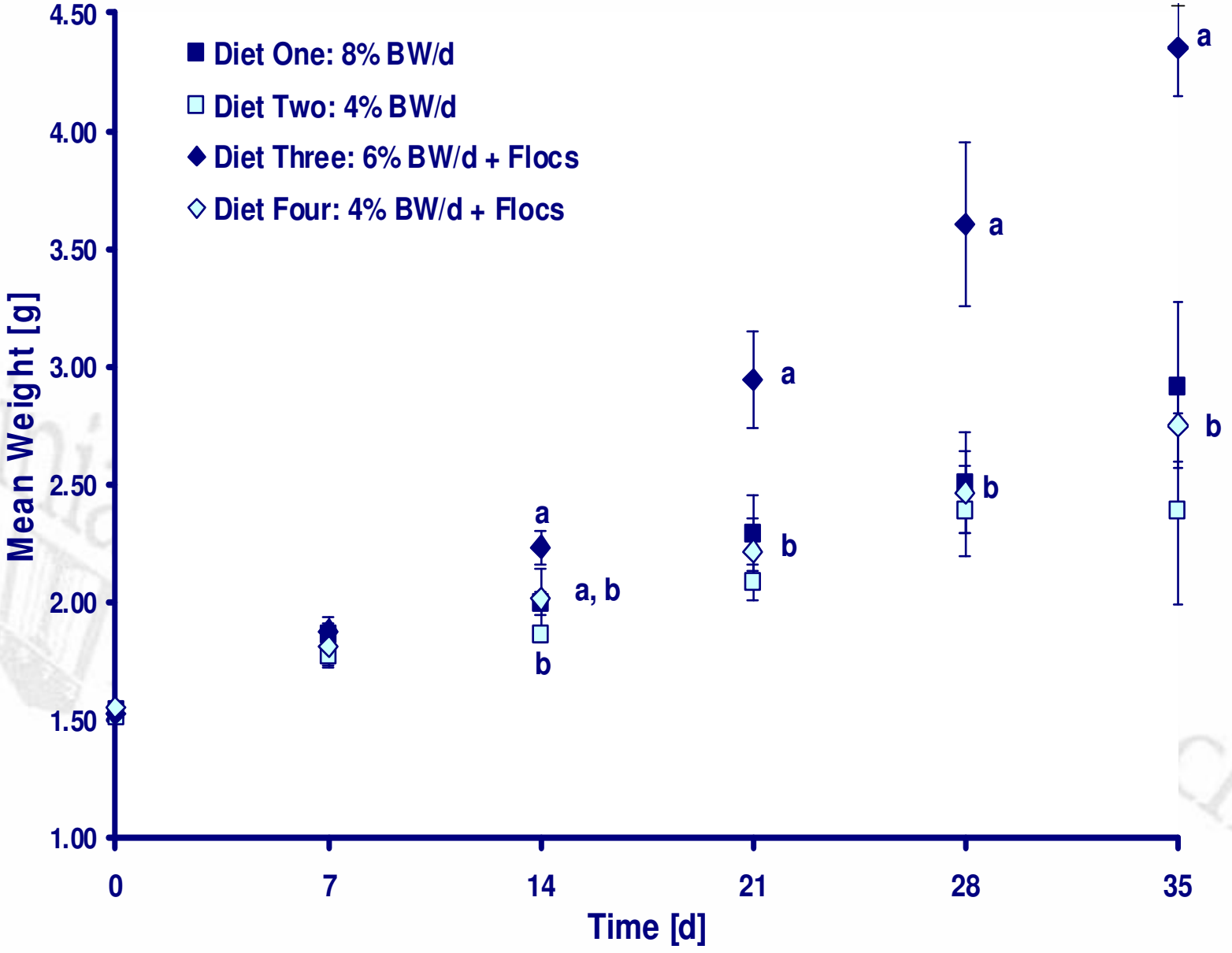
- Four dietary treatments distributed randomly on 3 AHAB™ systems
  - **Diet one:** 8% BW/d
  - **Diet two:** 4% BW/d
  - **Diet three:** 6% BW/d + microbial flocs
  - **Diet four:** 4% BW/d + microbial flocs
- Each treatment performed in triplicate
- Four shrimp per aquaria
  - Initial mass: 1.54 ± 0.01 g
- 35 day feeding trial

Aquaculture

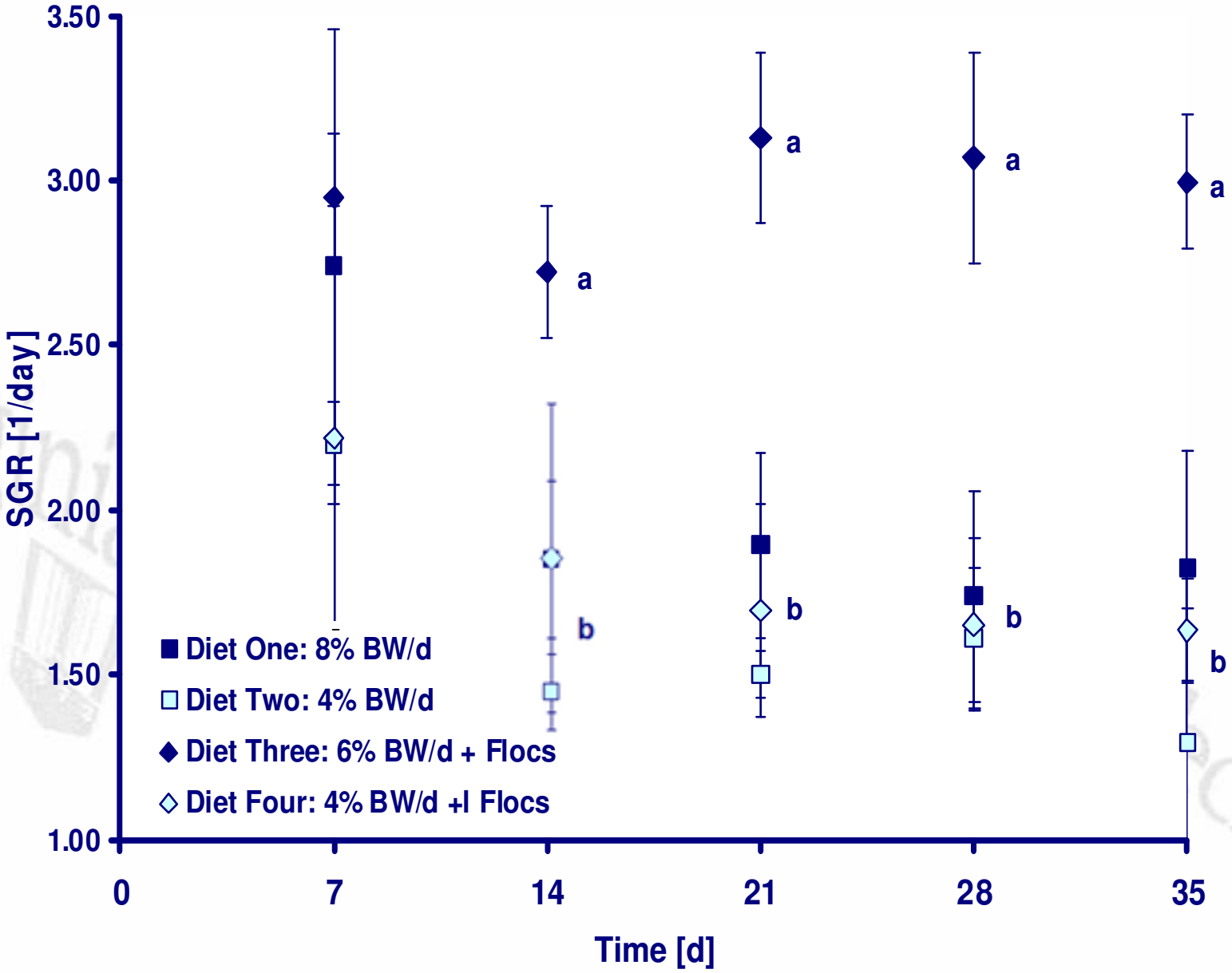
Objective 2: Nutrition Study



Objective 2: Nutrition Study

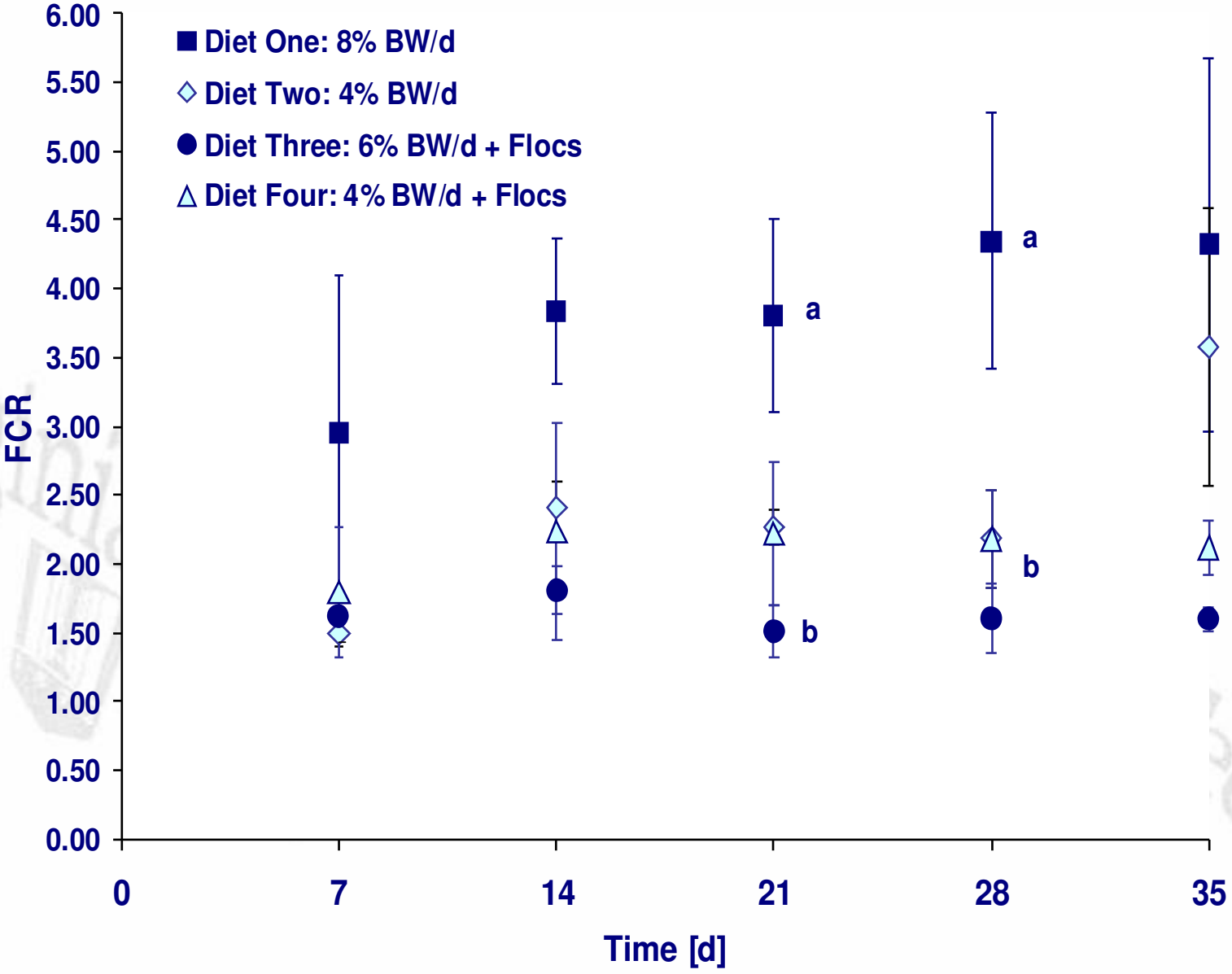


Objective 2: Nutrition Study



Aquaculture

Objective 2: Nutrition Study



Objective 2: Nutrition Study

Results

- Microbial flocs had higher protein levels than untreated solids
- Microbial flocs are a viable supplemental feed for shrimp culture

Future work

- Pilot and full scale studies will be performed

Objective 3 - evaluate the treatability of the tilapia effluent and determine the nutritional characteristics of the biomass generated

Objective 3: Treatability Study

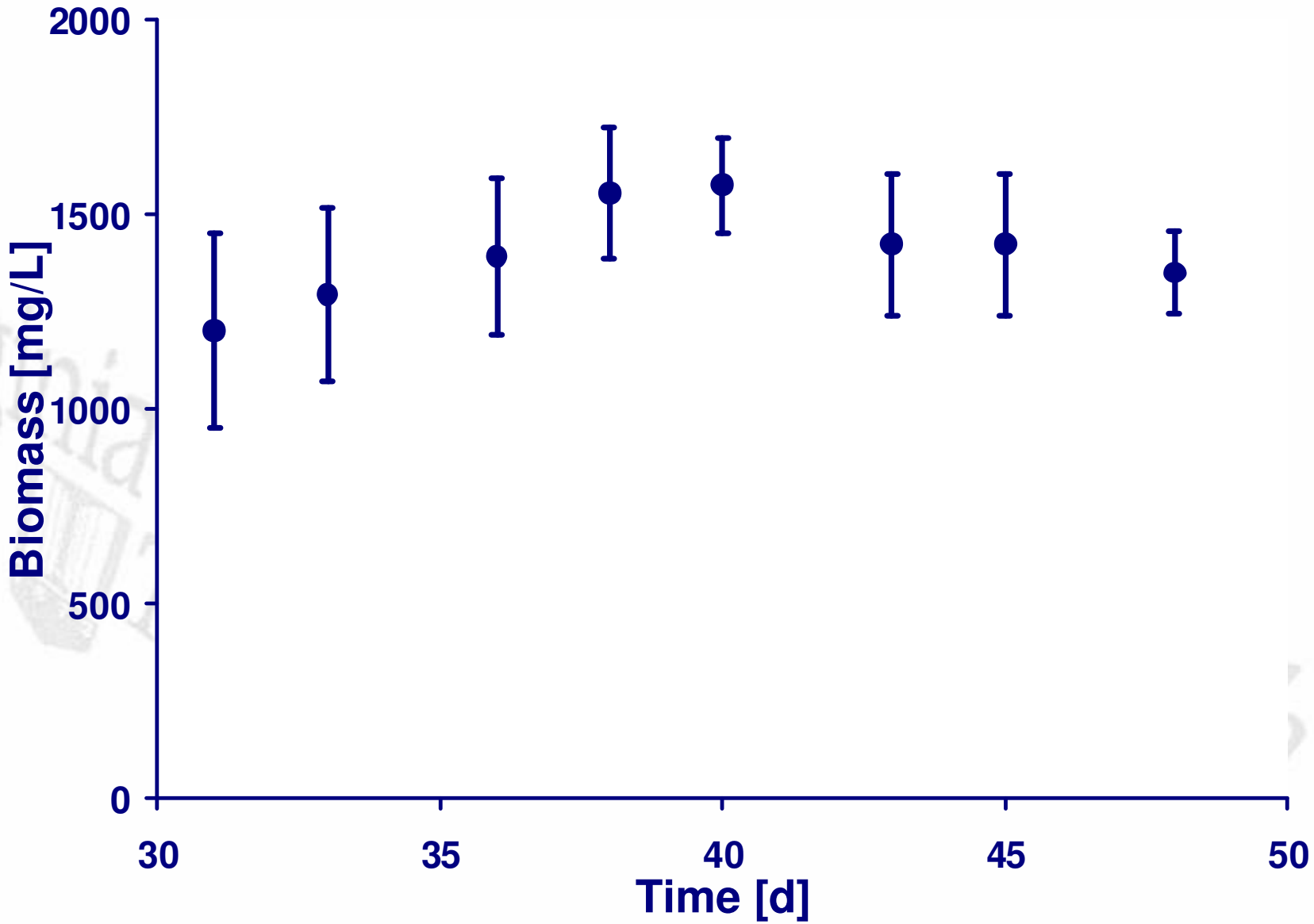
General methods

- Three 5L SBRs are being operated at 28° C
  - HRT = 6 hr
  - SRT = 10 d
- Target biomass concentration 1,500 ± 300 mg/L
- Treatment evaluated with and without carbon supplementation (sugar)

Aquaculture

Objective 3: Treatability Study

Representative data set demonstrating stable biomass concentrations in SBRs operated in triplicate



Preliminary findings (sugar)

Observed yields:

- 1.60 ± 0.07 (g biomass)/(g carbon)

Observed normalized rates:

- Carbon uptake: 0.17 ± 0.01 (g carbon)/(g biomass*h)
- Biomass growth: 0.27 ± 0.03 (1/h)

Crude Protein (Kjeldahl nitrogen):

- CP = 54.4 ± 0.2 % on dry matter basis

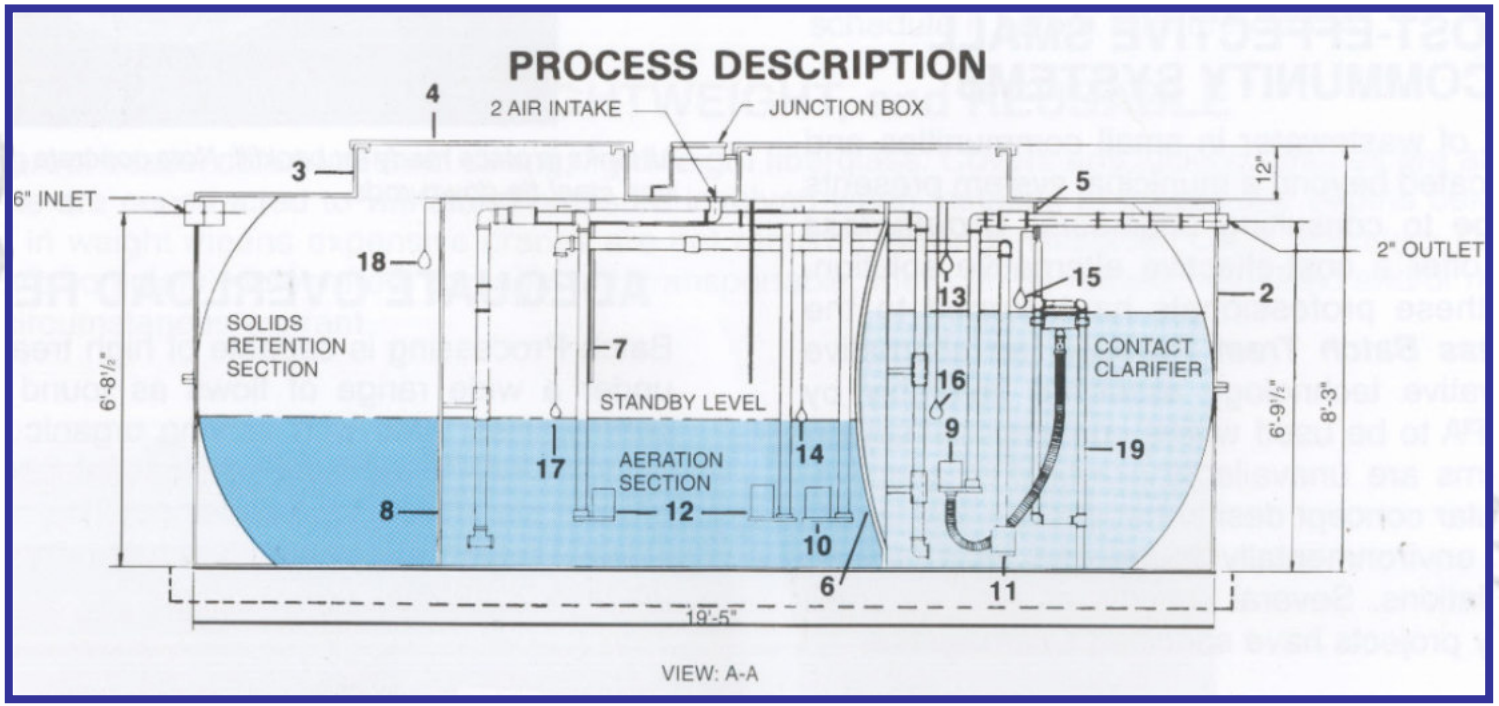
Objective 3: Treatability Study

Preliminary findings

- Treatment of effluent without carbon supplementation not efficient
- Carbon supplementation:
  - Increased amount of biomass produced
  - Improved stability of reactors
  - Increased oxidation (recovery) of reduced nitrogen constituents in the waste stream
  - Increased overall performance and treatment
- Some issues with filamentous growth

Future work

- Continue lab-scale studies
- Scale-up significantly and install SBRs onsite at the commercial tilapia facility



Install three 1,400 gallon Cromaglass SBRs (Cromaglass Co., Williamsport, PA, USA)

Conclusion

- Results from this overall project could potentially:
  - Reduce water demand needed for shrimp farming
  - Increase effluent handling and its reuse
  - Help a local fish farm expand into polyculture, while creating job opportunities for local people
  - Offer a sustainable option for the culture of shrimp

Acknowledgements

- This project was funded by USDA-CSREES
- The authors wish to thank Blue Ridge Aquaculture (Martinsville, VA) for their cooperation and support.