


Applications and Advancements in Biofloc Technology

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Biofloc Aquaculture Systems

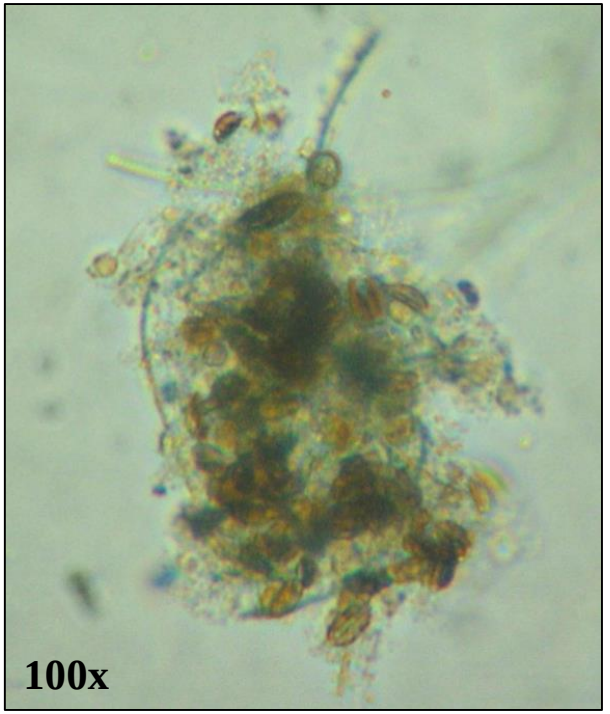
- Low Water Exchange
  - Biosecurity
  - Temperature Control
  - Salt Conservation = Inland Brackish Operation
- High Animal Density
  - (Intensive → Superintensive)
  - Indoor Operation
    - Climate Control
    - Diverse Regions

Biofloc Systems

- No External Biological Filtration
  - Solids Filtration Common
- Typically No Soil Interaction
  - Tanks, Lined Ponds, Concrete Vessels, Raceways
- Primarily Used for Shrimp and Tilapia
  - Other Candidate Taxa and Life Stages (ex. Catfishes, Marine Fishes, Bait Fish)

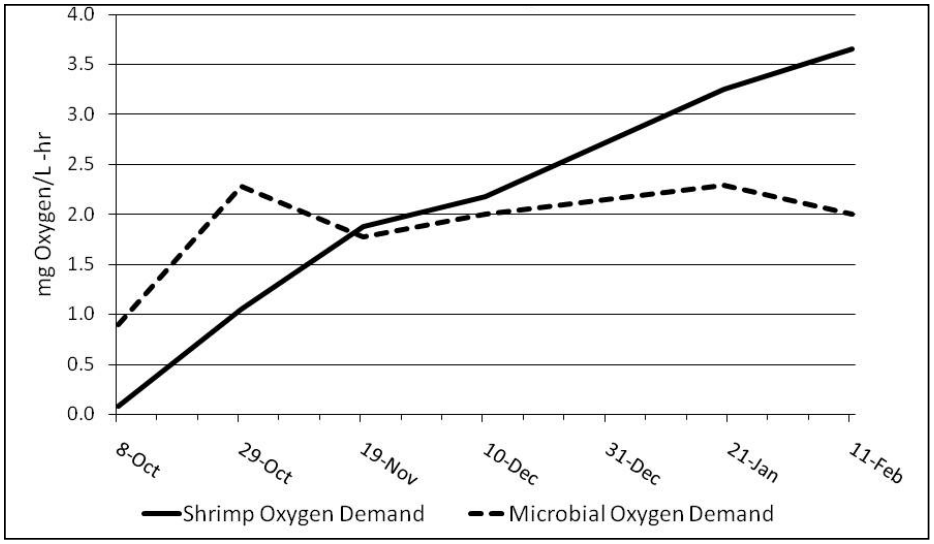
Biofloc Particles

- Natural (Similar to Marine Snow)
- Aggregations of
  - Microbes, Algae (in light), Protists, Zooplankton, Feed Particles, Feces, Detritus (eg. Exoskeletons), Exopolymeric Substances
- Responsible for Cycling Wastes
  - Nutrients (N, C, P)
  - Metals?



Biofloc Particles

- Potentially Nutritious
  - Recycling of Nutrients!
  - Protein, Lipids, Minerals, Vitamins
- Vary in Size (< 1µm – 200 µm)
- Free Living and Surface Dwelling Organisms as Well



Key Functional Variations... Nitrogen Cycling

- Photoautotrophic assimilation: N → protein
- Heterotrophic assimilation: N → protein
- Chemoautotrophic Nitrification: NH_3 → NO_2 → NO_3

- <u>Mixed</u>
  - Most Often
  - Can Manage Function

Biofloc System Management

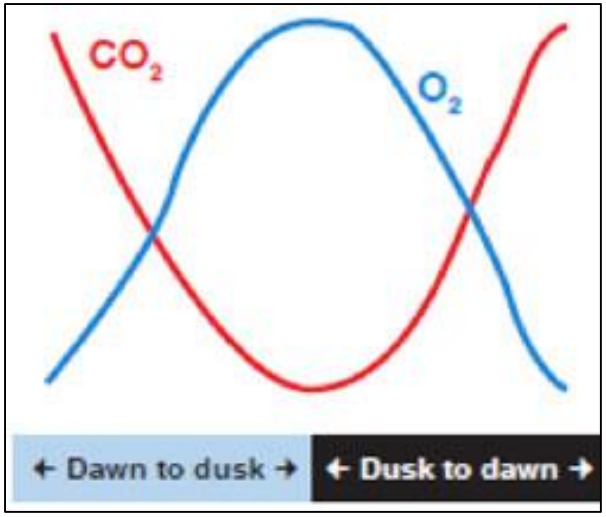
- Key Management Factors
  - Animal Density = Nutrient Load
  - Feed = Types of Nutrients... C/N Ratio
  - Carbohydrate Additions = C/N Ratio
  - Solids Removal = Light Penetration, Nutrient Cycling, and More
  - Lighting = Photosynthesis

Photoautotrophic Function (Green)

- Most Common Commercially
- Lower Density (< ~200 shrimp m^{-3})
  - Lower Maintenance, Cost
- Ponds mostly, greenhouses, possibly indoor
- Algae
  - Nutritious
    - Lipids, Protein
  - N Assimilation, Must be Cropped
    - Filters, Fishes, Shrimp, Zooplankton
  - <u>Light</u> and <u>Dark</u>

Light	Dark
↑ Oxygen	↓ Oxygen
↓ CO_2	↑ CO_2
↑ pH	↓ pH

Photoautotrophic Function (Green)



- Ample Light
  - Natural Light
    - Cheap
    - Inconsistent... Algae Bloom/Crash
  - Artificial Light Possibly Appropriate
    - Supplemental Lighting?
    - Fluorescent (red/blue) = mid-price/energy
    - LED = high price, low energy
    - Incandescent, white fluorescent = potentially harmful organisms
  - Poor Lighting, Solids Shading = Cell Death, Cyanobacteria
    - Must crop solids (biofloc) or self-shading

Heterotrophic Function (Brown)

- Mid-level Density (~150 – 350 shrimp m^{-3})
- High C:N Ratio (> ~12:1)
  - Carbon = Energy
  - Nitrogen = Protein
- Low Protein Feeds
    - Less Expensive
    - Sustainability?
- Additional Carbon Sources
  - Added Cost
- Select For Beneficial Microbes?
  - Against Harmful Microbes?
  - Ex. Vibrio sp. Versus Bacillus sp....
  - Protection from EMS???

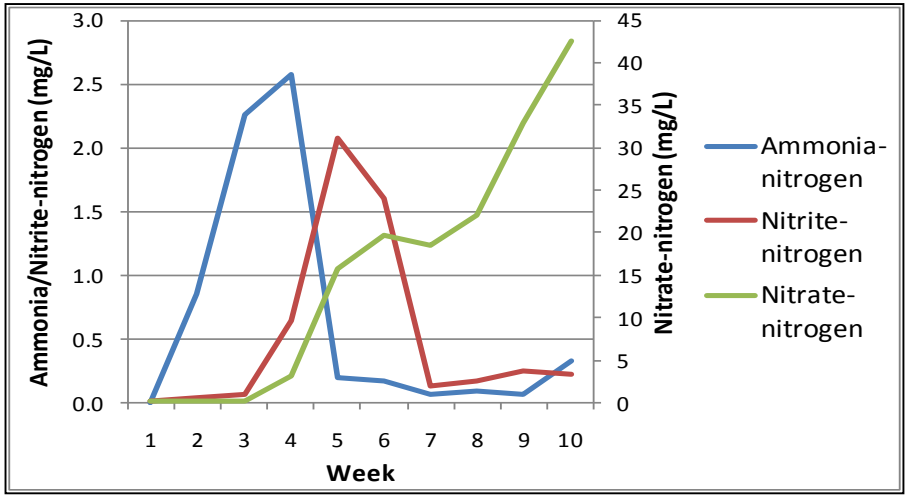
Heterotrophic Systems (Brown)

- Assimilation of N Into Biofloc (heterotrophs)
  - Microbial Protein
    - Nutritious
    - ↓ FCR
    - ↑ Growth Rate
  - No Nitrate

- Increase of Biomass
  - Must be Removed = More Solid Waste
    - Need Remediation (Preferably Recycling) Techniques
- Relatively High Oxygen Demand, CO_2 Production
  - Evaluating Innovative Oxygenation Systems
  - Timing of Feeding, C Additions

Chemoautotrophic Systems

- High Density (> ~350 shrimp m^{-3})
  - Typically greatest production, investment, time, risk...
- Lower C:N Ratio (< ~9:1)
  - Higher Protein Feeds
- Microbial N Oxidation
  - Ammonia to Nitrite to Nitrate
  - Often Reliable Once Established
    - Some glitches... Can be confounded by other organisms
    - Long Establishment Time



Chemoautotrophic Systems

- Less Solids Production and Oxygen Consumption Compared to Heterotrophic
- Generally Mixed Systems
  - Some Heterotrophic and Photoautotrophic Function
  - Less Microbial Management?
- Build up of Nitrate
  - Need Water Reuse (biosecurity, salt conservation, etc...)
  - Denitrification = Filtration Systems, Batch Reactors, Settling Basins

Summary

- Unique Opportunities
  - Biosecurity, Indoor Culture, Reduced Feed Costs, Intensive Production, Nurseries to Support Ponds...
- Some Commercial Application, but Plenty of Room for Refinement = Opportunity to Customize
- System Management = Microbial Management
  - Dictates System Function
  - Focus on Goals
    - Location, Production Goals, Climate, Market, Control...

Thank You

United States Department of Agriculture
National Institute of Food and Agriculture

AES Biofloc Webpage:
http://www.aesweb.org/biofloc.php