XIX CONGRESO ECUATORIANO DE ACUICULTURA

Tecnologías para una producción sustentable

ABS
Aquaculture Biosecure Systems

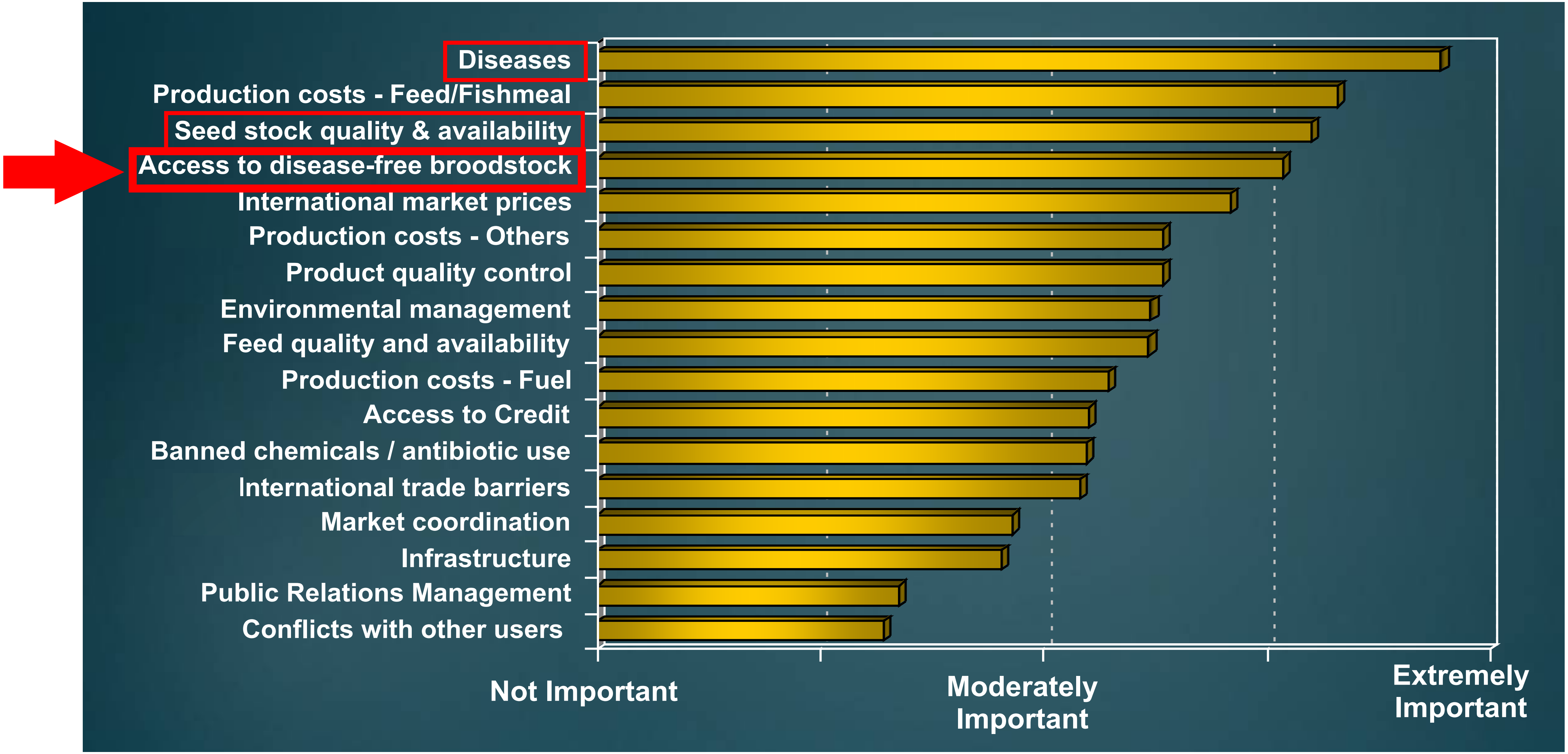
BIOSECURITY IN SHRIMP FARMING

Indoor Biofloc Systems Applied to Biosecure Shrimp Broodstock Production

by Francois Brenta

BIOSECURITY IN SHRIMP FARMING – Indoor Biofloc Systems Applied to Broodstock Production

Source: 2016 Survey from the Global Aquaculture Alliance



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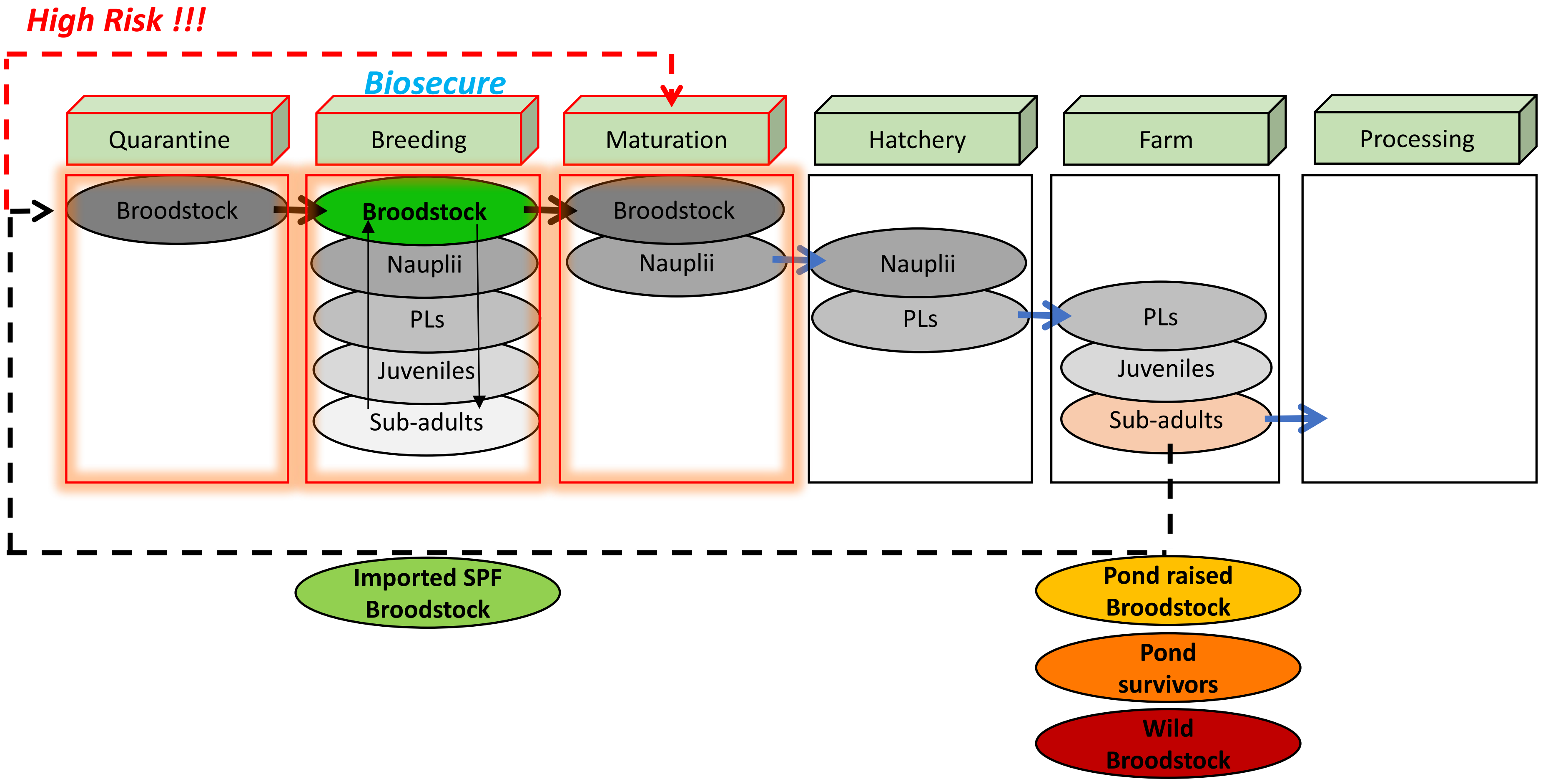
Broodstock Supply Chain



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Reason for Lack of Supply of Disease Free Broodstock

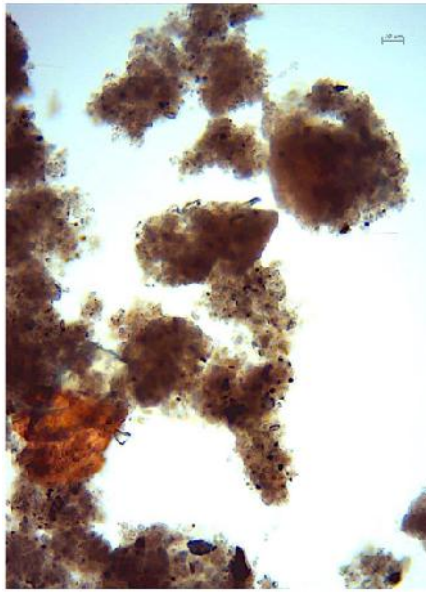
- Wild broodstock!!!! Extremely high biosecurity risk.
- Outdoor broodstock production!!! Very High biosecurity risk.
- Lack of biosecurity in indoor broodstock production facilities!! High biosecurity risk.
  - Inadequate shrimp health monitoring programs. Unable to achieve and maintain health status.
  - Inadequate water treatment. Unable to **bio-remediate** to rationalize water management.
  - Inadequate zoning and insufficient access restriction.
- Insufficient biosecure indoor broodstock production facilities! High business risk.

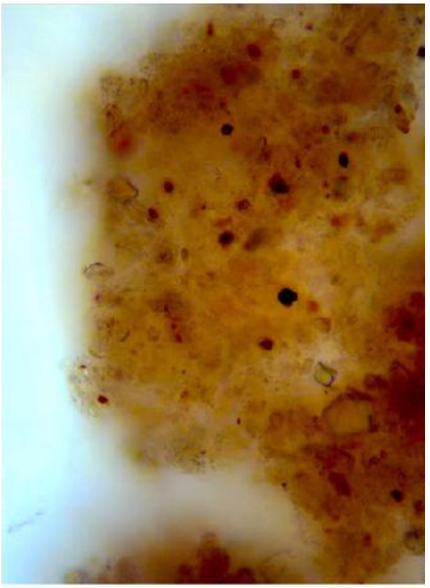
Why Biofloc Technology

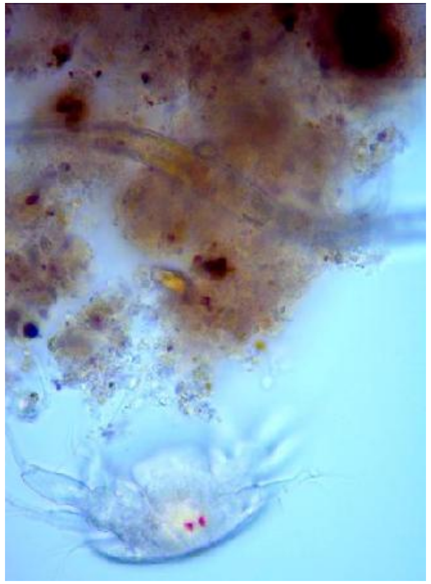
- ❑ Can sustain high carrying capacity.
- ❑ Cost-effective bio-remediation tool.
- ❑ Reduces very significantly water exchange requirements.
- ❑ Low capital expenditure vs. other bio-remediation systems such as RAS.
- ❑ Reduces FCR and wastes in water column.
- ❑ Enhances natural gonadal development in broodstock.
- ❑ Low environmental impact.

Definition of Bioflocs

- Aggregates formed by interaction between particulate organic matter and a large range of microorganisms, such as bacteria, (phytoplankton), rotifers, ciliates flagellates protozoa and copepods.







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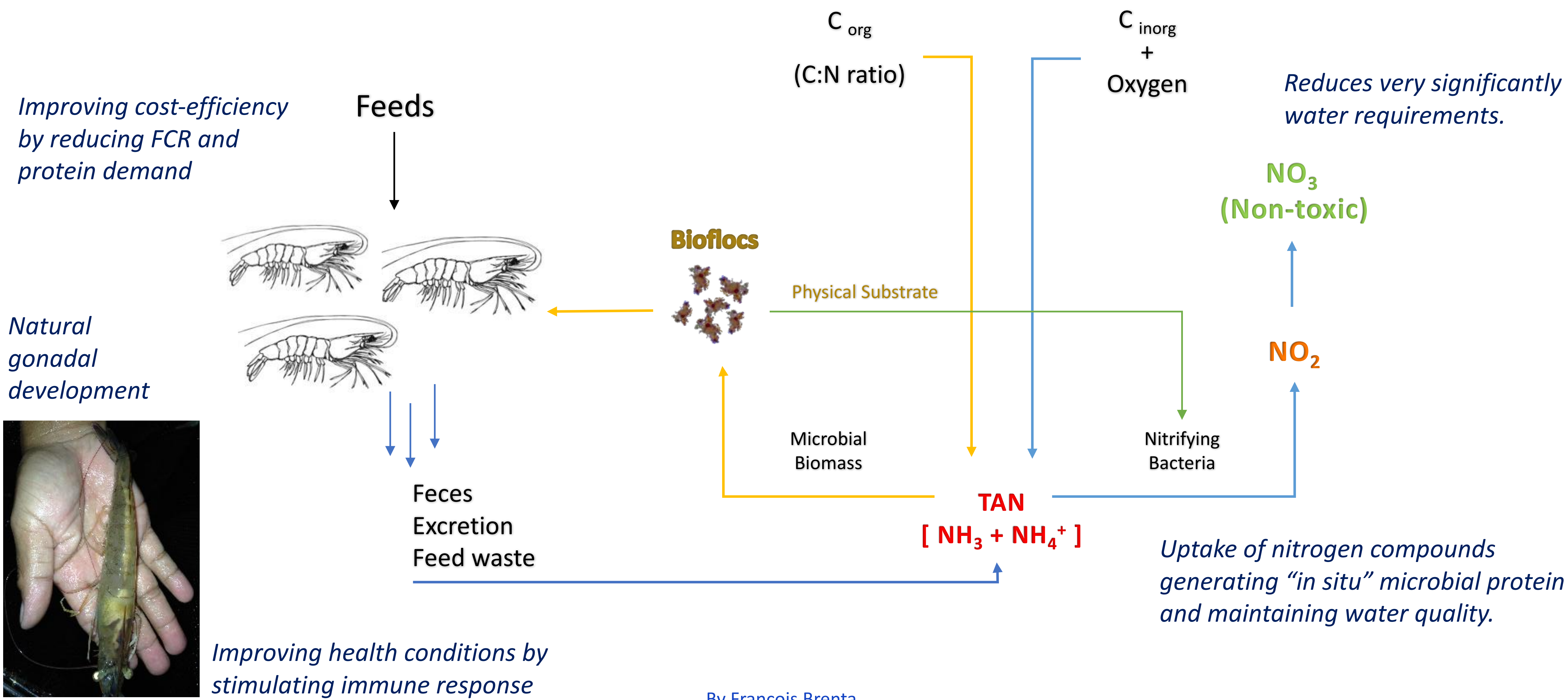
The Biofloc System



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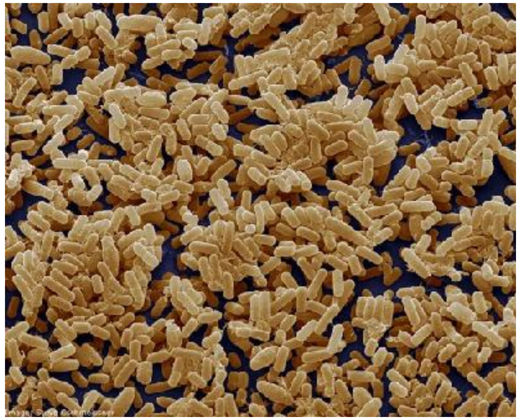
Heterotrophic Bacteria



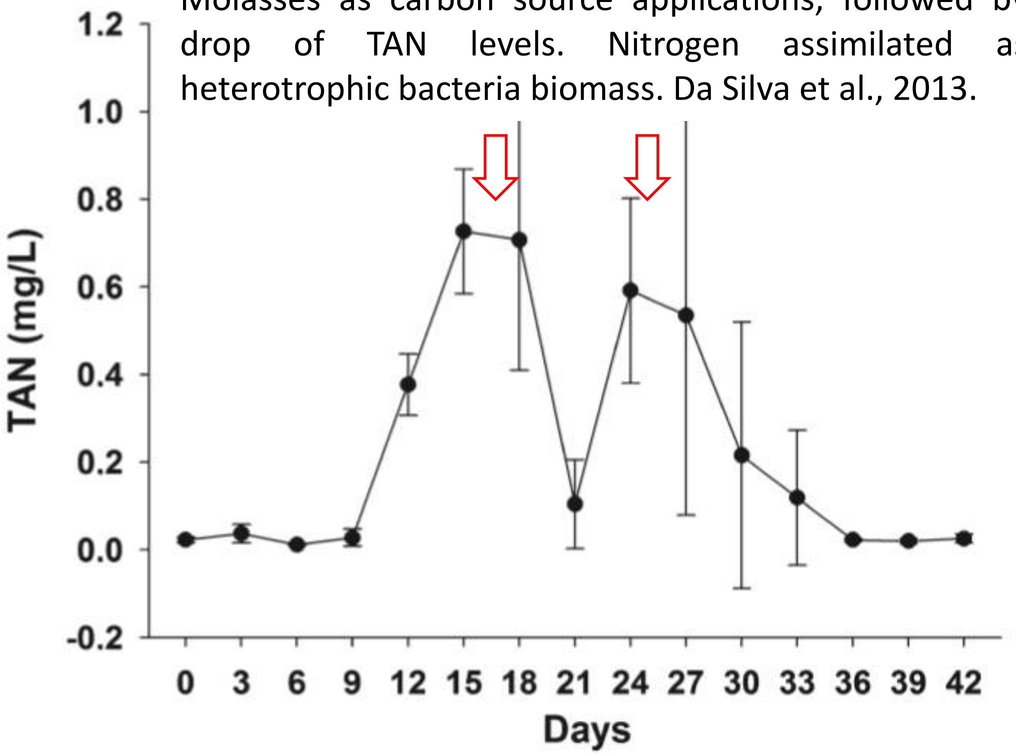
Heterotrophic bacteria
Bacillus spp.

- ✓ Assimilate Ammonia into protein
- ✓ Consume organic carbon
- ✓ Very fast cell duplication
- ✓ Form the biofloc

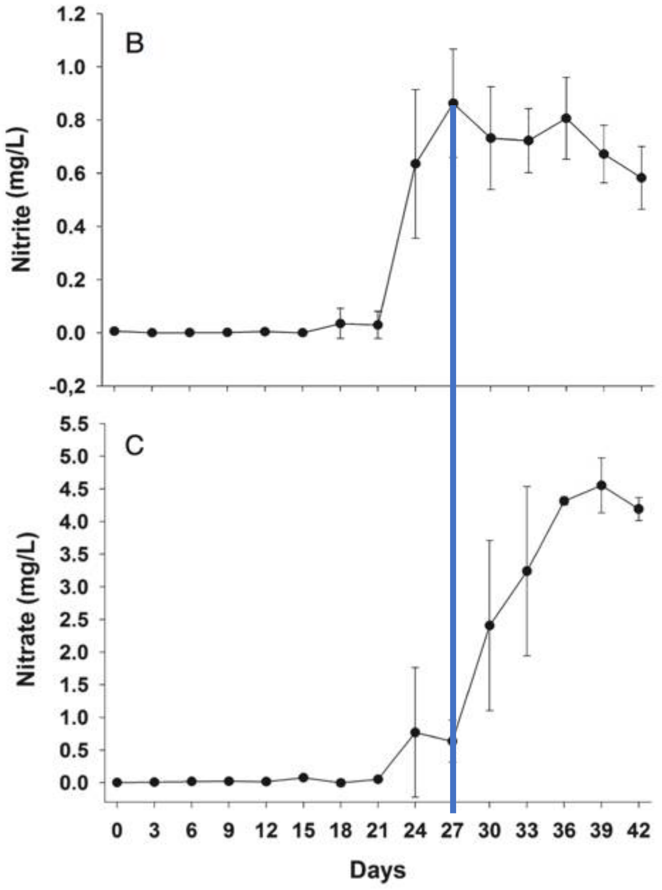
Imhoff cone showing biofloc settled

Floc level will increase with the growth of heterotrophic bacteria

Molasses as carbon source applications, followed by drop of TAN levels. Nitrogen assimilated as heterotrophic bacteria biomass. Da Silva et al., 2013.



Chemo-autotrophic Bacteria



Nitrification process in biofloc system where nitrite is being oxidized into nitrate. Da Silva et al., 2013.

- ✓ Nitrifying Bacteria
- ✓ Late establishment in the system
- ✓ Require to be attached for effective nitrification
- ✓ Consume inorganic carbon (alkalinity)
- ✓ Inoculum and/or Probiotics

- ✓ Ammonia Oxidizer Bacteria (AOB)
  - *Nitrosomonas, Nitrosococcus, Nitrosospira*
  - Oxidize ammonia into nitrite (NO_2)

- ✓ Nitrite Oxidizer Bacteria (NBO)
  - *Nitrobacter, Nitrococcus, Nitrospira*
  - Oxidize NO_2 into nitrate (NO_3) non toxic

Biofloc System Dynamics

❑ Immature System

- ✓ Heterotrophic pathway 100% of N recycling
- ✓ Application of molasses and bicarbonates
- ✓ Increase in bioflocs (surface area)
- ✓ Protein source and boosts immune system

❑ Mature System

- ✓ Nitrification process established
- ✓ Chemo-autotrophic pathway – 65% of N recycling
- ✓ Heterotrophic pathway – 35% of N recycling
- ✓ Carbon provided by feeds (organic) and alkalinity (inorganic)
- ✓ Applications of bicarbonates
- ✓ Occasional applications of molasses

Impact of Bioflocs on Water Quality and Water Consumption

- ✓ Recycling nitrogen into bacterial protein
- ✓ Establishment of microbial food chain (protein-rich)
- ✓ Transfer of N into shrimp biomass
- ✓ Maintenance of N in non-toxic levels
- ✓ Less generation of waste

Water exchange decreases from 50-100% per day to 5%-10% per week.

60% less Nitrogen wastes and 70% less Phosphorus wastes than conventional system.

TABLE 1. *Nitrogen and phosphorus waste compared to shrimp production (tons) for different stocking densities and management systems.*

	Species	Density	Nitrogen (kg/ton)	Phosphorus (kg/ton)	References
BFT	*Litopenaeus vannamei*	Super-intensive	20	4,1	Da Silva et al., (2013)
	Penaeus monodon	Intensive	72	–	Jackson et al. (2003)
	P. monodon	Intensive	81	44	Funge-Smith and Briggs (1998)
	P. monodon	Intensive	112	31	Robertson and Phillips (1995)
	P. monodon	Intensive	72	–	Jackson et al. (2003)
	L. vannamei	Semi-intensive	73	12	Casillas-Hernández et al. (2006)
	L. vannamei	Semi-intensive	36	12	Páez-Osuna et al. (1997)
	L. vannamei	Semi-intensive	29	12	Teichert-Codington et al. (2000)

Da Silva et al., (2013)

Impact of Bioflocs on Feed Consumption

- ✓ Reduce FCR
- ✓ Reduce protein demand in the feeds
- ✓ Consequently reduces feed costs

30% - 40% of shrimp's biomass is obtained by biofloc consumption in BFT system

(Burford et al., 2004; Cardona et al., 2015)

Crude Protein of Bioflocs	Reference
43%	McIntosh et al., 2000
12 - 42%	Soares et al., 2004
26 - 41.9%	Ju et al., 2008
31%	Tacon et al., 2010
38.8 - 40.5%	Kuhn et al., 2010
28 - 43%	Maicá et al., 2012

Impact of Bioflocs on the Health of the Shrimp

Microbial flocs are rich in polysaccharides, taurine and fat soluble vitamins, all of which can contribute to a healthy status of the prawns. The contents of bioflocs can be influenced by inputs and light exposure.

Table 6 Mean bioactive compound content in the dried, ground floc sample collected from outdoor shrimp cylindrical culture tanks

Compounds	Content
Carotenoids (mg kg^{-1})	
Violaxanthin	145.6
Fucoxanthin	2891.2
Diadinoxanthin	463.3
Astaxanthin	237.6
Lutein	69.9
Alloxanthin	46.4
Lycopene	14.3
Zeaxanthin	23.0
Rhodopin	11.4
β-carotene	234.5
Chlorophylls (mg kg^{-1})	
Chlorophyllide a	25.8
Chlorophyll c1 + c2	937.3
Pheophorbide	77.3
Peridinin	97.9
Chlorophyll b	123.6
Chlorophyll allomer	46.4
Chlorophyll a	3785.3
Chlorophyll epimer	345.1
Pheophytin b	20.6
Pheophytin a	10.3
Pyropheophytin b	10.3
Pyropheophytin a	25.8
Bromophenols (μg kg^{-1})	
2-bromophenol	229.9
4-bromophenol	190.9
2,4-dibromophenol	79.9
2,6-dibromophenol	88.1
2,4,6-tribromophenol	234.4
Phytosterols (mg kg^{-1})	
Desmosterol	274.2
Fucosterol	174.6
Cholesterol	133.4
Stigmasterol	93.8
Campesterol	119.1
β-sitosterol	48.6
Amino sugars (mg kg^{-1})	
Glucosamine	736.3
Muramic acid	168.0
Galactosamine	280.8
Fat-soluble vitamins (mg kg^{-1})	
Vitamin A	6.4
Vitamin D	3.0
Vitamin E	3.7
Vitamin K	4.4
Taurine (mg kg^{-1})	191.2
Total free amino acid (mg kg^{-1})	1120.7

- ✓ Biofloc has bioactive compounds that contribute for a healthy status of cultured prawns (Ju et al., 2008b)
- ✓ Expressions of certain haemocytes enzymes related to immune system is enhanced in biofloc reared *L. vannamei* (Jang et al., 2011)
- ✓ Bioflocs have positive effect in the immune response of *L. vannamei* leading to higher resistance against IMNV challenge (Ekasari et al., 2014)
- ✓ Immune system and antioxidants enhanced in *L. vannamei* juveniles reared in biofloc (Xu & Pan, 2013)
- ✓ Prawns show resistance to *Vibrio spp* when reared in BFT (Liu et al., 2017)

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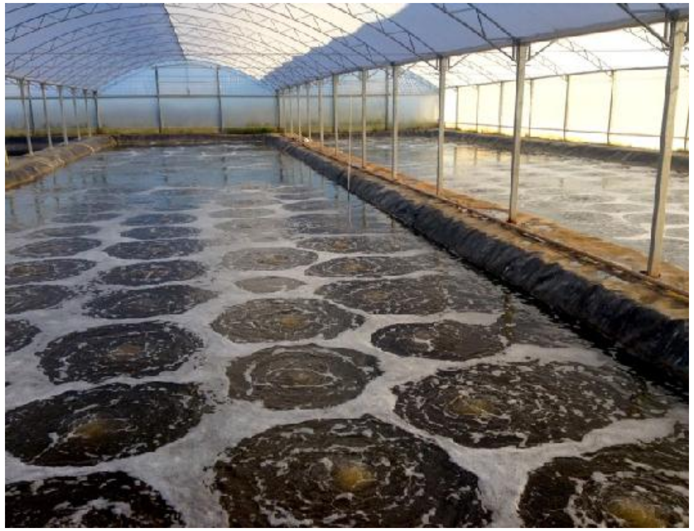
Concrete raceways

Aeration with airlifts

Biofloc Management

- ✓ Full scale production from broodstock to broodstock in 300 DOC.
- ✓ Maturation-larval: 60 DOC.
- ✓ Nursery: 60 DOC from PL to 2g.
- ✓ Grow-out: 120 DOC from 2g to 20g.
- ✓ Pre-conditioning: 60 DOC from 20g to 35g.
- ✓ 100m^2 ~ 100m^3 for producing 1000 broodstock.
- ✓ Cost per broodstock 20-40 USD.

Greenhouse – aeration with porous diffusers



Greenhouse – aeration with paddle-wheels

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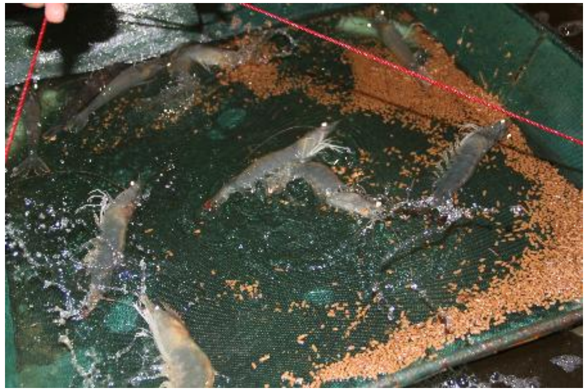
Biofloc Management

- Feeding

Feed trays



Wastes from syphoning

- *Standard grower feeds can be used however in dark biofloc conditions a higher dosage of carotenoids must be added (~150ppm Astaxantin).*
- *Feeding 100% in feed trays, adjustment from feed left over in trays or feeding in tanks based on below reference table, adjusted by check trays, gut fullness observations and from syphoning results.*
- *Reference table also highlights when transfers-culling are required to stay within carrying capacity.*

ABW	Feed Rates	Daily Maximum Feed Load (g/m3) vs. ABW (g) at specific Shrimp Loads (g/m3) - Rule : Keep < 100g Feed per day /m3								
Ave.	Ave.	500	750	1250	1750	2250	2750	3250	3750	4000
0.05	18%	88	131	219	306	394	481	569	656	700
0.55	13%	63	94	156	219	281	344	406	469	500
2.0	9%	45	68	113	158	203	248	293	338	360
4.0	7%	35	53	88	123	158	193	228	263	280
7.5	5%	25	38	63	88	113	138	163	188	200
15	4%	18	26	44	61	79	96	114	131	140
25	3%	13	19	31	44	56	69	81	94	100
30	2%	10	15	25	35	45	55	65	75	80

Biofloc Management

❑ Water quality parameters

- ✓ Oxygen saturation ~ 95%
- ✓ Temperature ~ 28-32°C
- ✓ pH ~ 8.0-8.2
- ✓ Alkalinity ~ 300mg/l
- ✓ TAN < 0.2 ppm
- ✓ Nitrites ~ 0ppm
- ✓ TSS < 200mg/l
- ✓ Biofloc <10ml/l

❑ *Adjustments*

- ➢ *Skip feeding / back-up oxygen*
- ➢ *Adjust water heater / AC*
- ➢ *Addition of carbonates (~15mg/l Bicarb. / 10mg/l Alk.)*
- ➢ *Addition of molasses (6g/1gTAN)**
- ➢ *Pre-maturation with substrates*
- ➢ *Removal of biofloc with clarifier*

**Adding molasses causes dissolved oxygen to decrease!! If quantities are significant they must be applied over a longer period of time.*

Biofloc Management

❑ Biofloc density and TSS

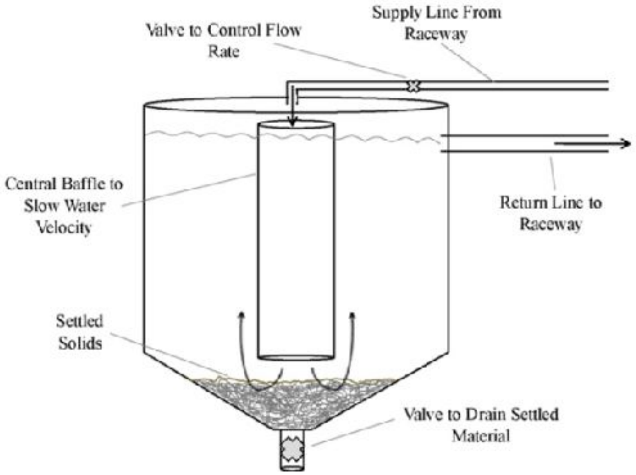
Biofloc reading after 20 minutes

Imhoff cone

If biofloc readings or TSS too high

Biofloc Removal by Sedimentation

Clarifier



Potential Issues of Biofloc Systems

- Bacterial infections (vibrio sp.) causing significant necrosis, melanization and mortalities.
- Low density floc that does not settle in the Imhoff cone.
- Dinoflagellates (if photosynthesis) causing gill fouling, affecting performance and potentially causing mortality.

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Questions ?

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