

CURRENT STATUS AND PROSPECT OF INDOOR BIOFLOC-BASED SHRIMP FARMS IN KOREA

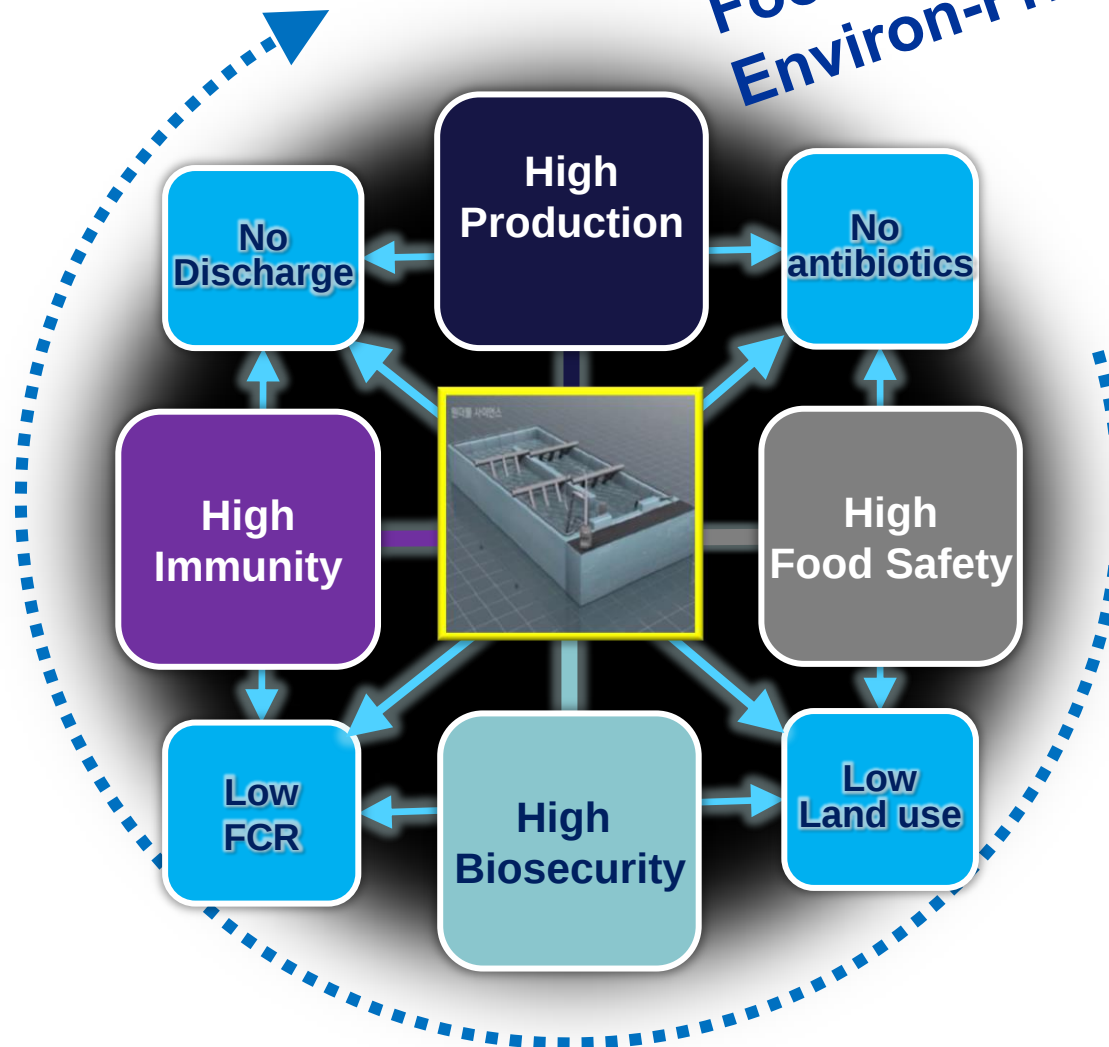


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BFT shrimp production

Economically Profitable
Food Safety
Environ-Friendly



4H-4L features of BFT

- High Production: 10 to 30 times higher than pond method
- High Biosecurity: control pathogen transmission
- High Food safety: no use of antibiotics/chemicals
- High Immunity (health of shrimp): up to 300% in PO activity
- Low/No water discharge: reducing up to 98%
- Low/No antibiotics
- Low FCR: reducing up to 20 – 40%
- Low Land use: up to 50-100 times smaller

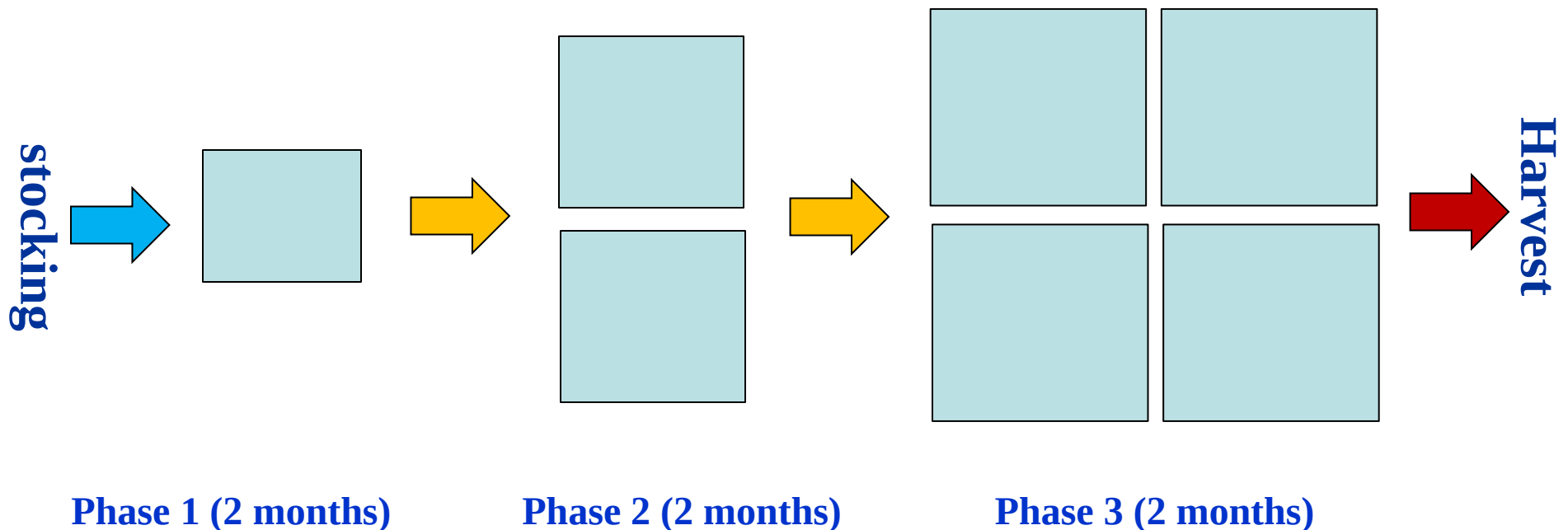
Data based on performance in commercial scale greenhouse-enclosed BFT production system of NFRDI (2009-2014)

- Many works in indoor BFT production system were conducted in the Waddell Mariculture Center (Browdy *et al.*, 2001; Hopkins *et al.* 1993; Ray *et al.* , 2009; Wasielesky *et al.*, 2006)
 - Developed WMC pilot model system of 55 m² in 1999, and a prototype of commercial scale system of 282 m² in 2001
 - Stocking density 300-500/m², Production 3-6.8 kg/m²
- The highest production in greenhouse enclosed BFT system were achieved from Texas AgriLife Res. Lab. (Samocha *et al.* 2002, 2012)
 - Pilot 68.5 m² and semi-commercial 100- m² raceway system
 - Stocking 400-500/m², production 8-9 kg/m³
- A prototype of greenhouse-enclosed shrimp production system in commercial scale was constructed in NFRDI in 2008
 - Two raceway tanks of 300 m²
 - During 2009-2011, shrimp were produced four times
 - Production was 2,754 kg (4.83 kg/ m²)/crop, stocking density 404-500 PL/m²
 - Used for demonstration and training for shrimp farmers

- More than ten farms are currently producing shrimp from indoor systems in Korea.
 - Culturing areas of farm range from 1,000 to 6,600 m² and average raceway sizes of the farms are 300-600 m²
 - Not all farms can make profit although the economic analysis is feasible
- HBOI set up a prototype of greenhouse RAS production system with 3-phase raceway tank in 1998 (van Wyk, 1999)
 - 70.7 m² (10% for nursery, 30% for intermediate culture, 60% for grow-out)
 - Single phase system 2.07 kg/m²/crop, 4.14 kg/m²/year (two crops)
 - Three-phase system 2.0 kg/m²/crop, 7.2 kg/m²/year (2 x 6 crops x 60%)
- A commercial scale three-phase BFT system constructed in NFRDI
 - Shrimp harvested two times in 2014-2015
 - Compared between single- and three-phase BFT system

Three-phase BFT system

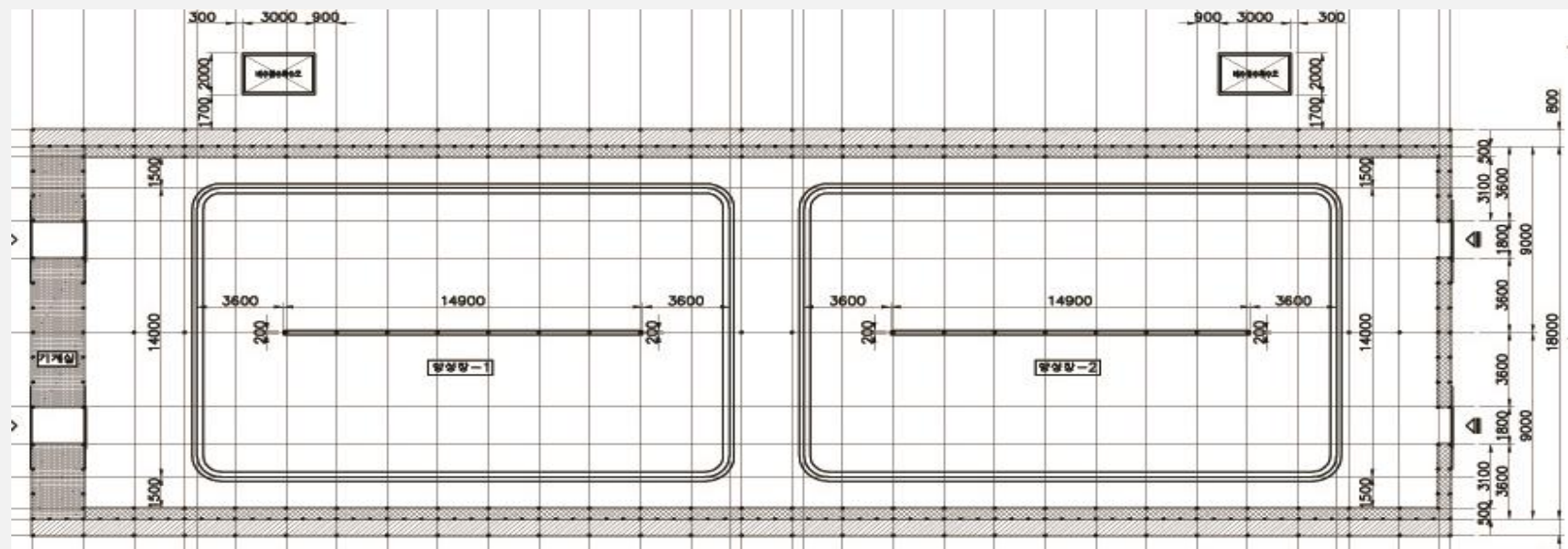
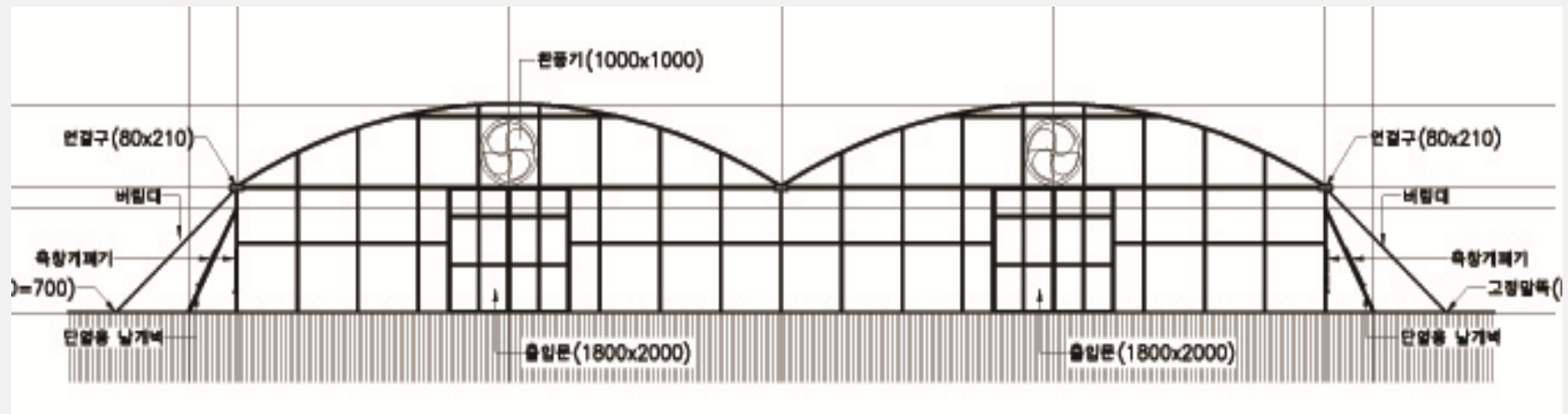
- 3-phase (nursery, intermediate and growout): 2 months each phase
- Stocking and harvest at six times a year
 - (single phase) $5 \text{ kg} \times 2 \text{ crops} = 10 \text{ kg/m}^2/\text{year}$: $10 \text{ mt}/1,000\text{m}^2/\text{year}$
 - (three phase) $5 \text{ kg} \times 6 \text{ crops} = 30 \text{ kg/m}^2/\text{year}$: $30 \text{ mt}/1,000\text{m}^2/\text{year}$
- Suitable to large-scale shrimp farms



Single phase BFT super-intensive shrimp production system (NFRDI)

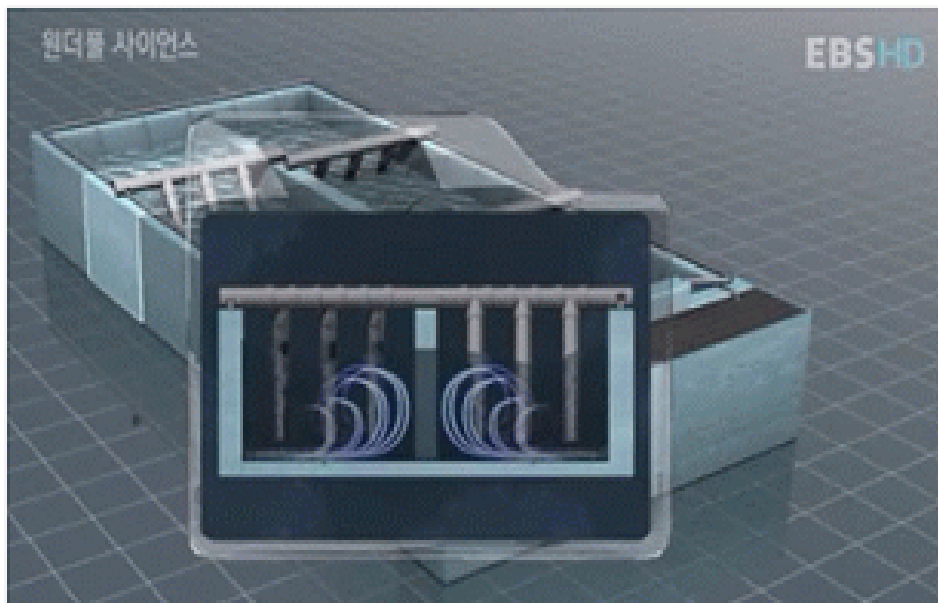


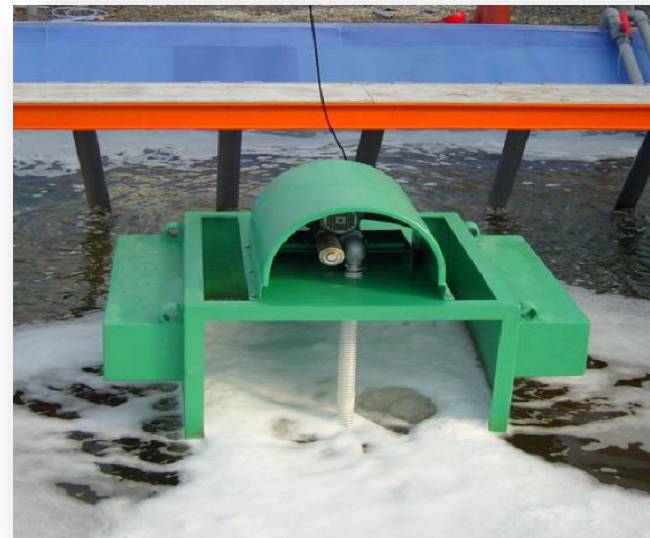
- West Sea Mariculture Research Center, NFRDI
- Two tanks (300 m²) in three-layered greenhouse (1,000 m²)
- Oxygen generator, venturi system, air blower and air lift etc.
- Water was heated by heat-exchanger using underground water



Single-phase growout system (300 m² x 2 tanks)

Basic design of BFT raceway prototype





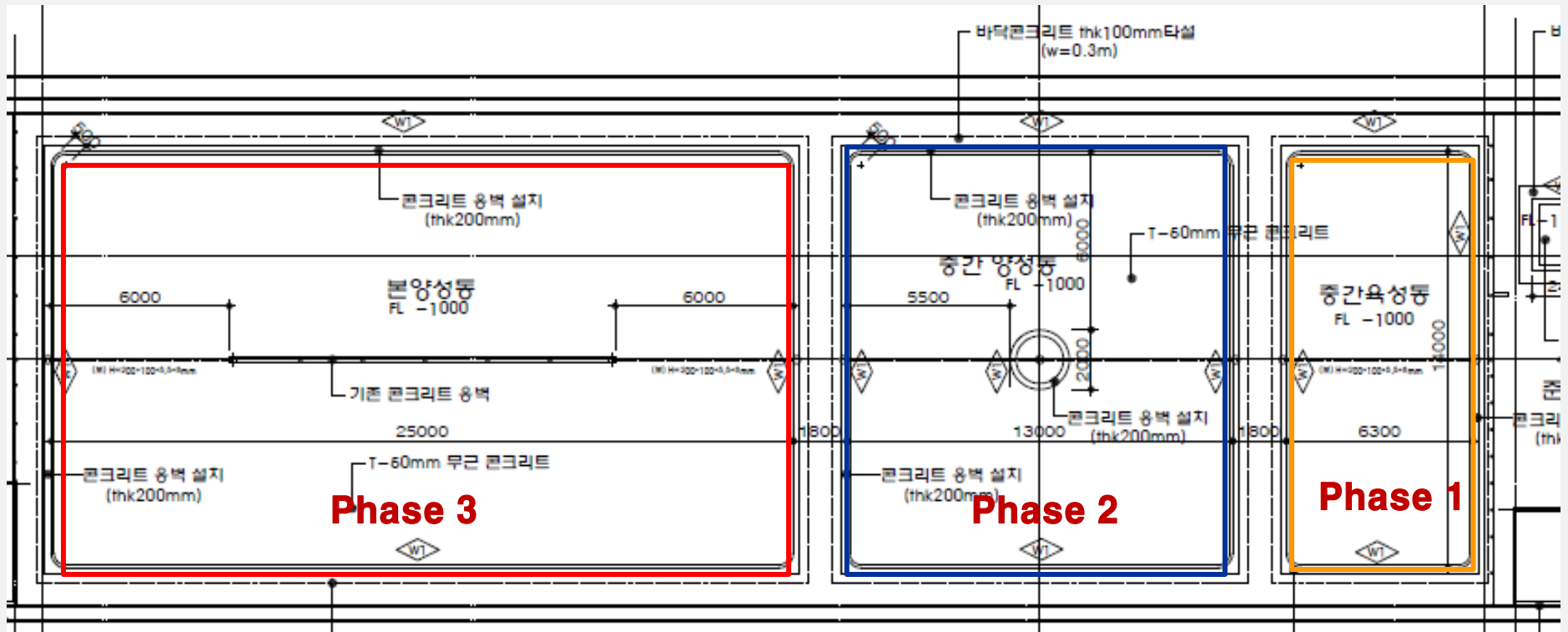


Summary of shrimp production

- four times trials in two 300m² tanks(2009 – 2011)

	Initial B.W. (g)	Stocking Density (/m ²)	Days	Final B.W. (g)	Yield (kg/m ²)	Total Harvest (kg)	Survival rate(%)	FCR
Mean	0.13	465.5	145	16.7	4.83	2,754	64.5	1.91
Min	0.038	404	112	13.6	3.37	2,020	33.7	1.19
Max	0.26	500	177	19.9	6.40	3,280	88.3	2.91

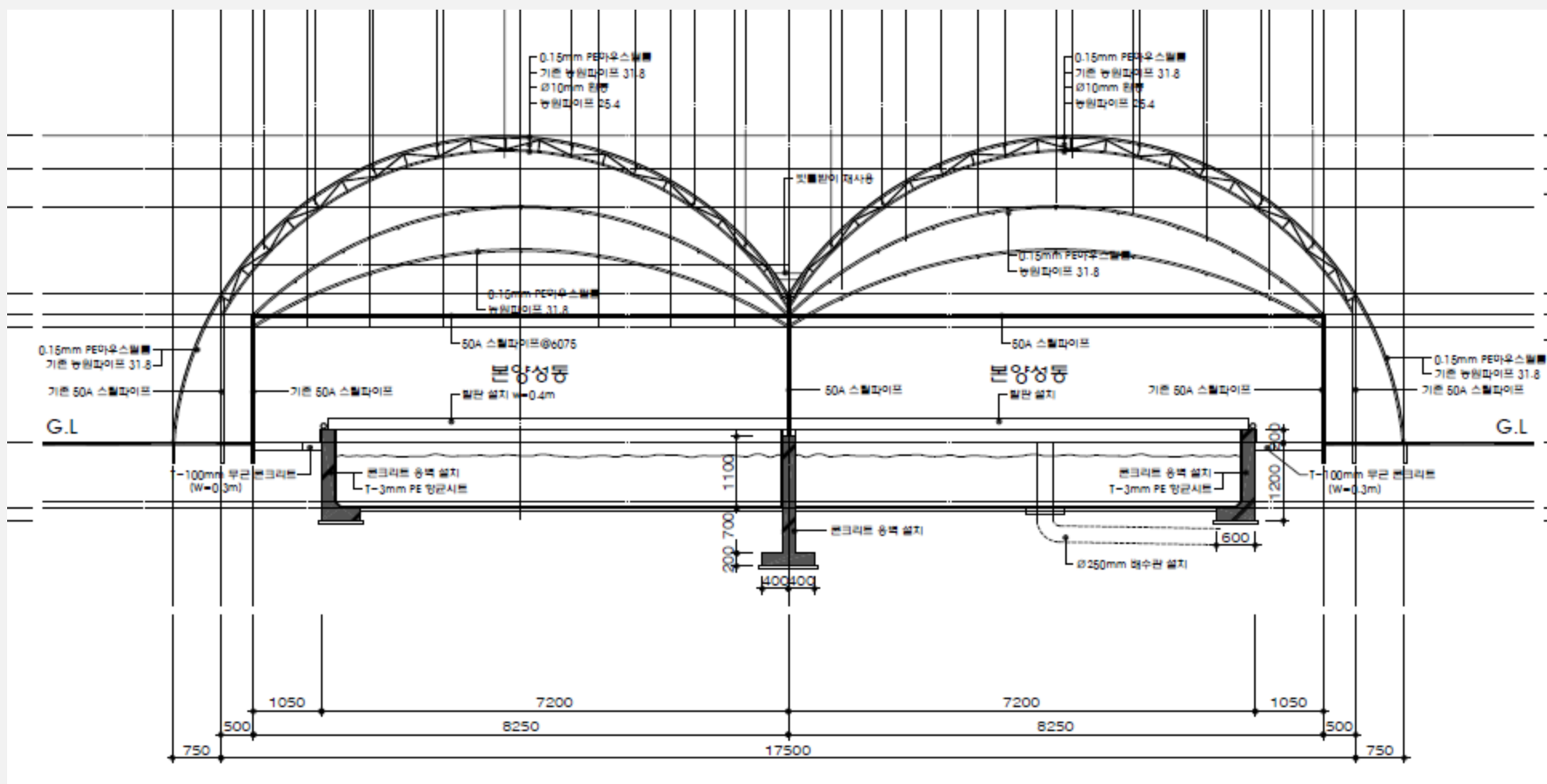
Three-phase BFT production system (2014)

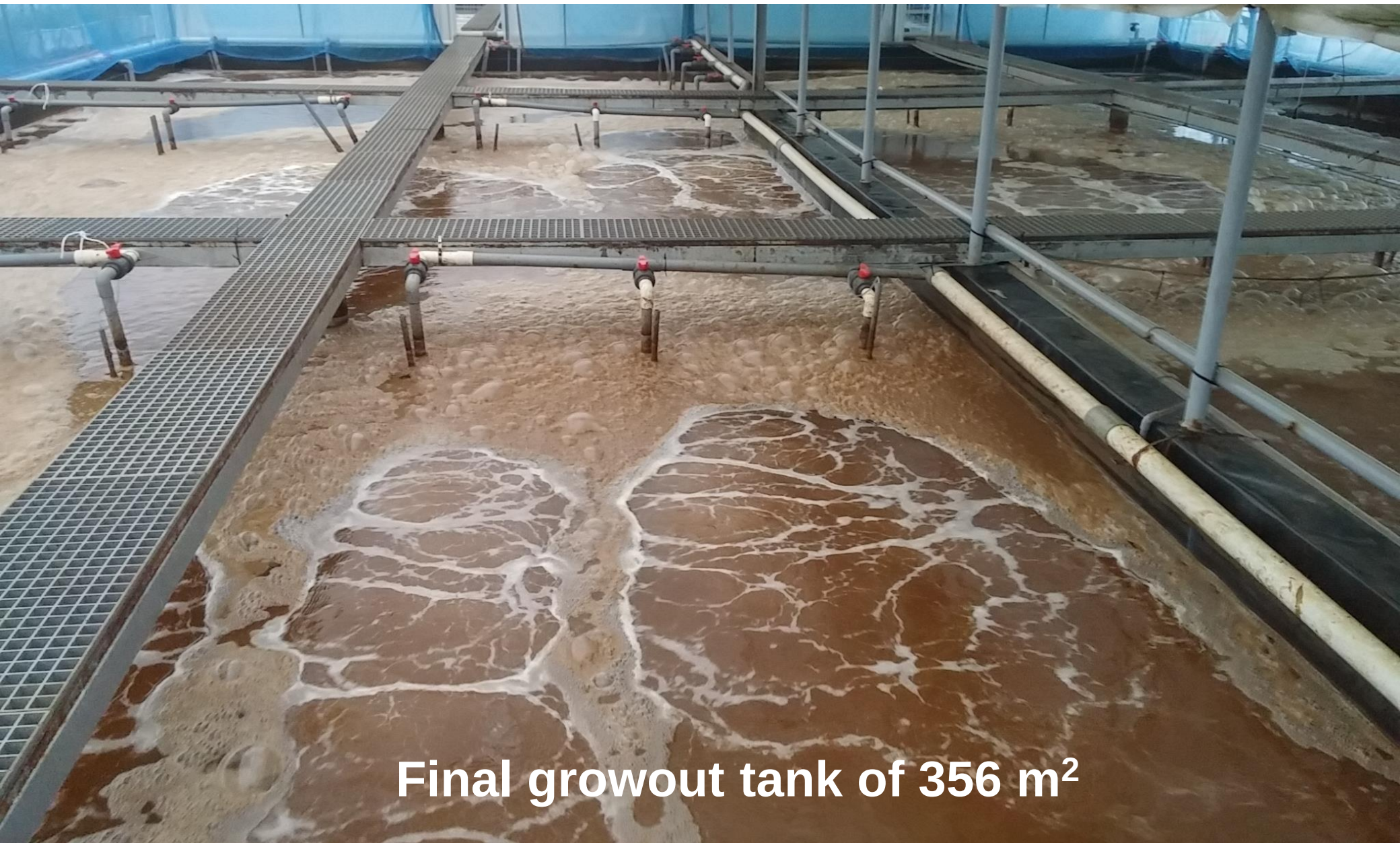


356 m²

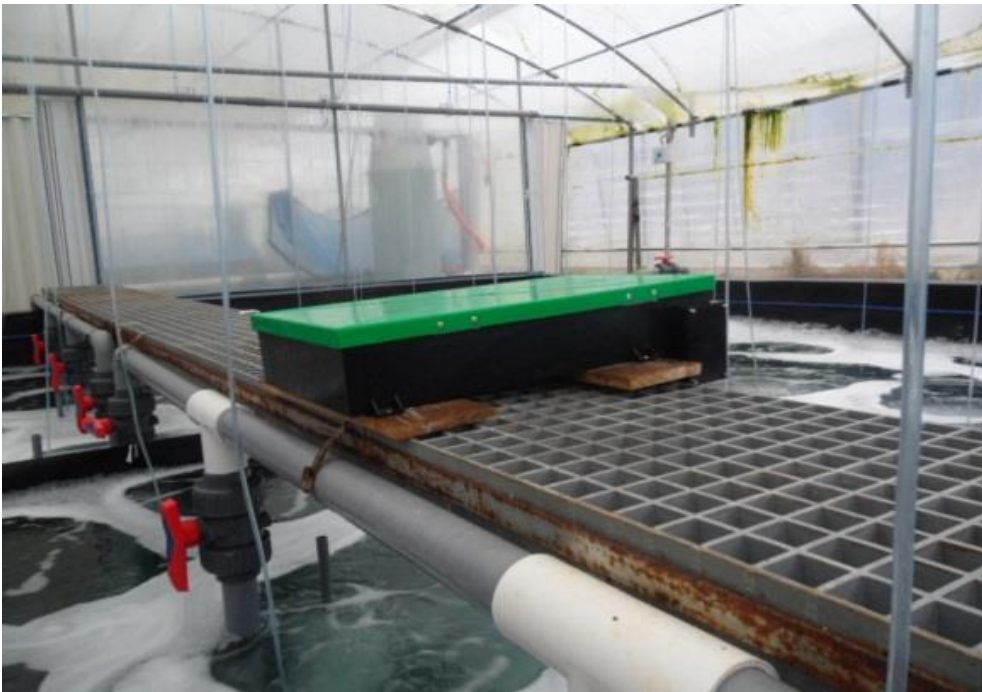
187 m²

90 m²





Final growout tank of 356 m²

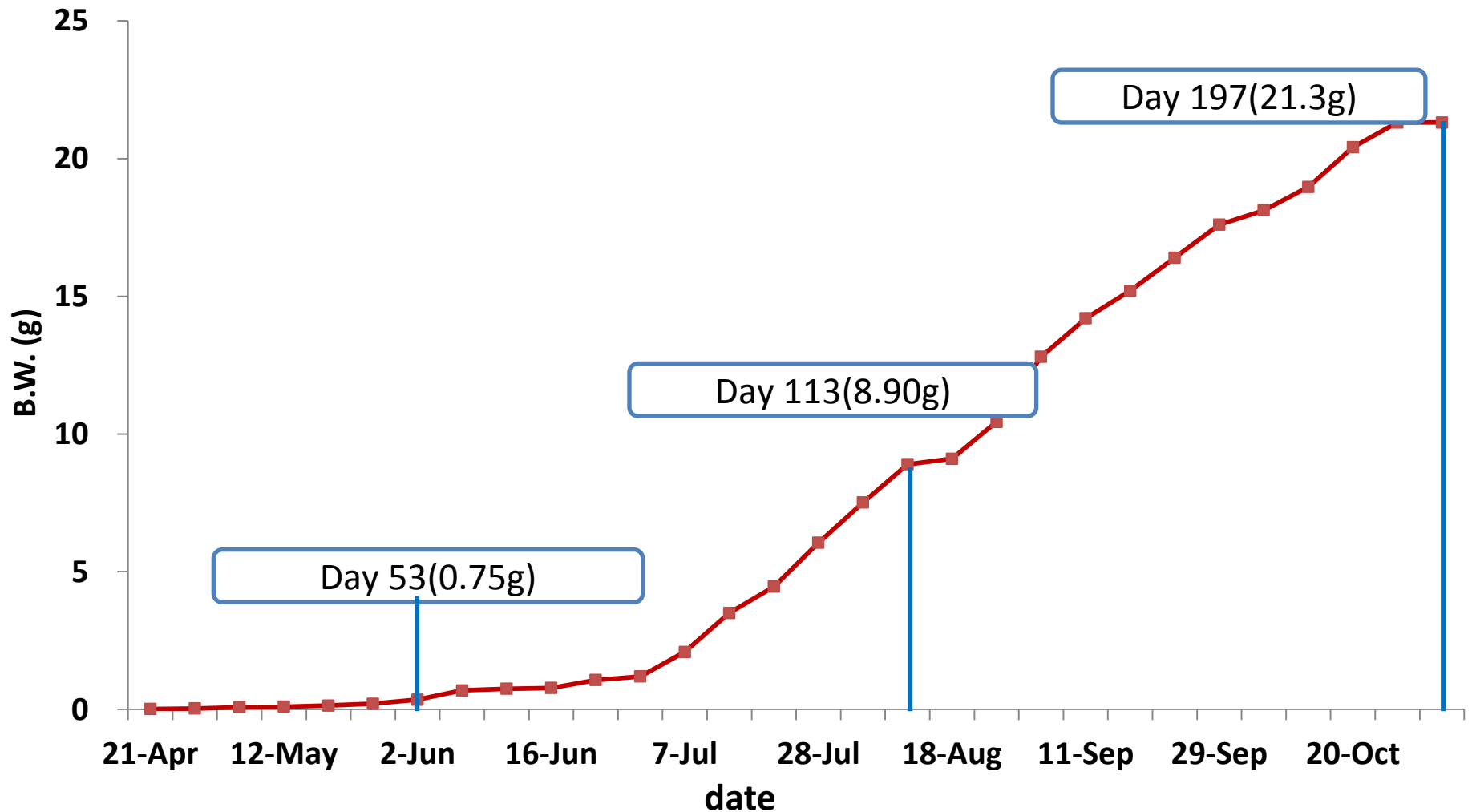








Growth rate of the 1st trial (2014) in 3-phase BFT system



Summary of Production in the 1st trial (2014) of 3-phase BFT system

- The 1st trial: 197 days from Apr. 4 to Nov. 3, 2014
 - Total harvest 1.56 MT from 359 m² raceway (5.41 kg/m³)
 - Expected production (359m²) 9.36 MT/yr (1.56 MT x 6 times)

		Initial B. W (g)	Stocking density (/m ²)	Days	Final B. W (g)	Yield (kg/m ²)	Yield (kg/m ³)	Total prod uction (kg)	Survival rate(%)	FCR
	phase 1	0.013	6056	53	0.75	2.346	2.93	211.1	64.5	0.6
1 st	phase 2	0.75	800	60	8.90	5.873	7.34	1098.2	82.4	1.33
	phase 3	8.9	344	84	21.3	4.331	5.41	1555.0	59.1	2.61

Summary of Production in the 2nd trial (2015) of 3-phase BFT system

- The 2nd trial: 210 days from Jun. 18, 2014 through Jan. 15, 2015
 - Total harvest 1.50 MT from 359 m² raceway (5.21 kg/m³)
 - Expected production (359m²) 9.0 MT/yr (1.50 MT x 6 times)

		Initial B. W (g)	Stocking density (/m ²)	Days	Final B. W (g)	Yield (kg/m ²)	Yield (kg/m ³)	Total prod uction (kg)	Surviva l rate(%)	FCR
	phase 1	0.008	3333	57	2.30	4.444	5.56	400.0	57.9	1.02
2 nd	phase 2	2.30	800	88	12.4	5.730	7.16	1071.5	57.8	1.88
	phase 3	12.40	241	65	23.0	4.169	5.21	1496.8	75.3	3.42

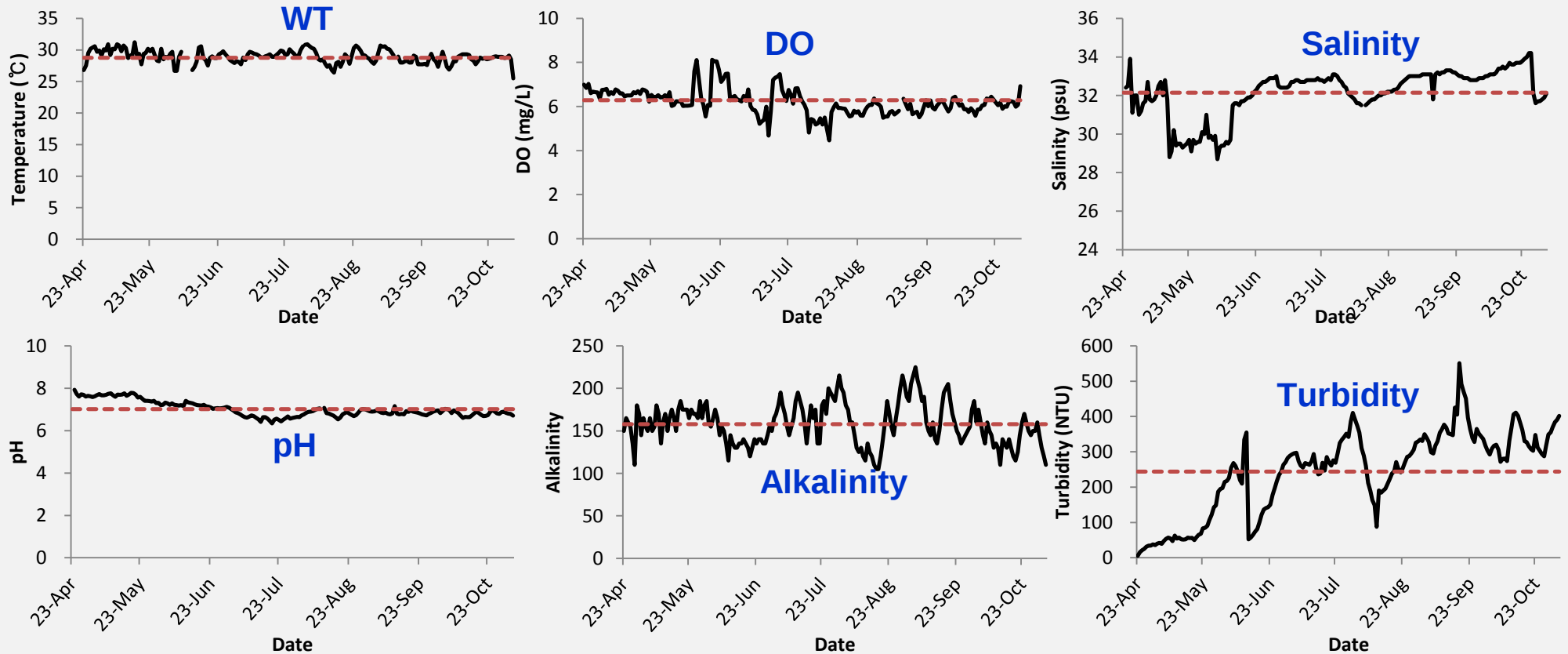
Summary of water quality of the 1st trial (2014) in 3-phase BFT system

	WT (°C)	DO (mg/L)	Sal (psu)	pH	TAN (mg/L)	NO2 (mg/L)	NO3 (mg/L)	TSS (mg/L)	VSS (mg/L)	Alk (mg/L)	Tur (NTU)
1 st trial	phase 1 (Apr. 21 – Jun. 12, 2014)										
	29	6.7	30.5	7.5	0.5	2.9	24.1	214.3	162.4	160.3	108.4
	phase 2 (Jun. 21 – Aug. 11, 2014)										
	29	6.4	32.4	6.9	0.2	0.3	113.5	530	399	158.8	243.2
	phase 3 (Aug. 11 – Nov. 3, 2014)										
	28.4	6.0	32.9	6.8	0.1	0.2	111.2	563.5	318	154.8	322.4

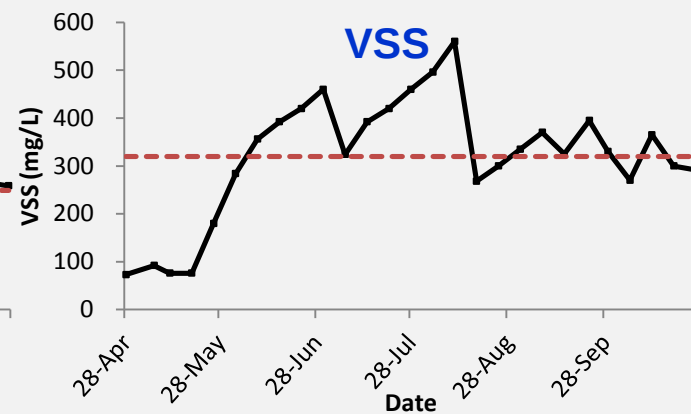
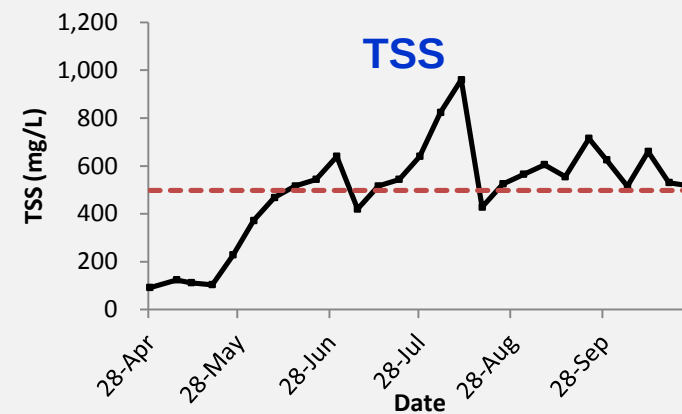
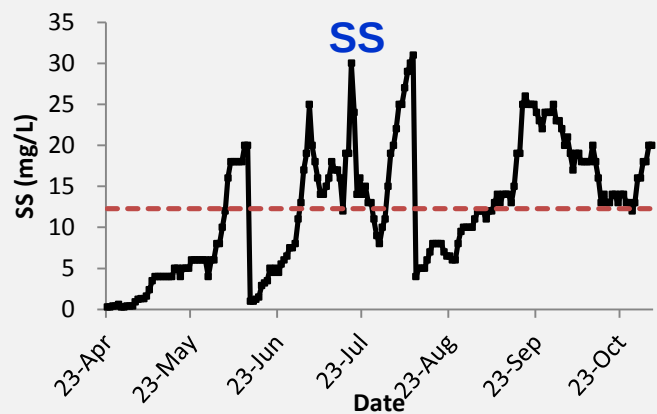
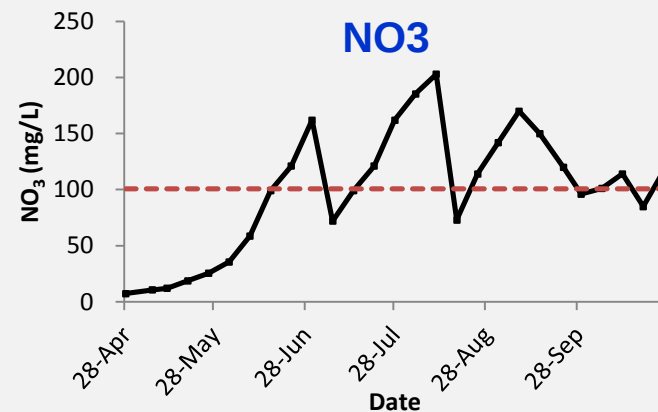
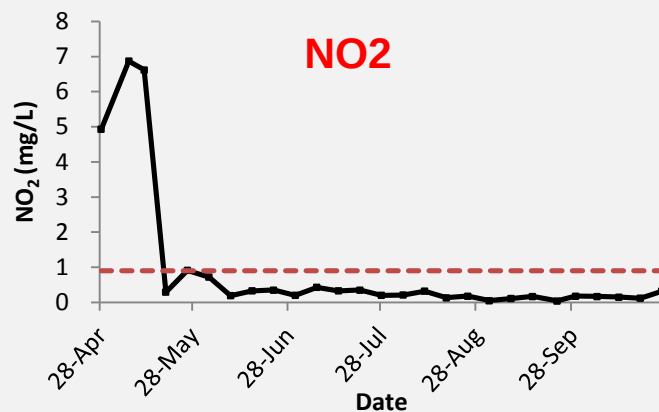
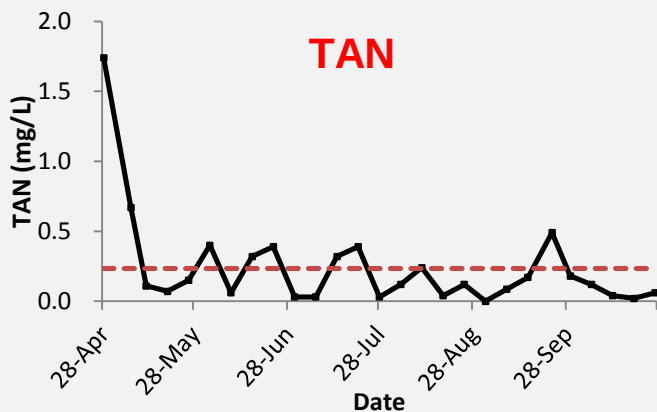
Summary of water quality of the 2nd trial (2014) in 3-phase BFT system

	WT (°C)	DO (mg/L)	Sal (psu)	pH	TAN (mg/L)	NO2 (mg/L)	NO3 (mg/L)	TSS (mg/L)	VSS (mg/L)	Alk (mg/L)	Tur (NTU)
	phase 1 (Jun. 18 to Aug. 14, 2014)										
	28	5.9	30.7	7.2	0.3	0.4	53.4	590	471	143.5	222.2
2 nd	phase 2 (Aug. 14 to Nov. 3, 2014)										
trial	28.1	6.8	32.7	7.1	0.2	0.3	76.3	519.9	318.8	159	312
	Phase 3(Nov. 3, 2014 to Jan. 15, 2015)										
	28.7	6.7	32.8	7.0	0.2	0.6	96.0	376	246	155	307

Change of water quality of the 1st trial (2014) in 3-phase BFT system



Change of water quality of the 1st trial (2014) in 3-phase BFT system



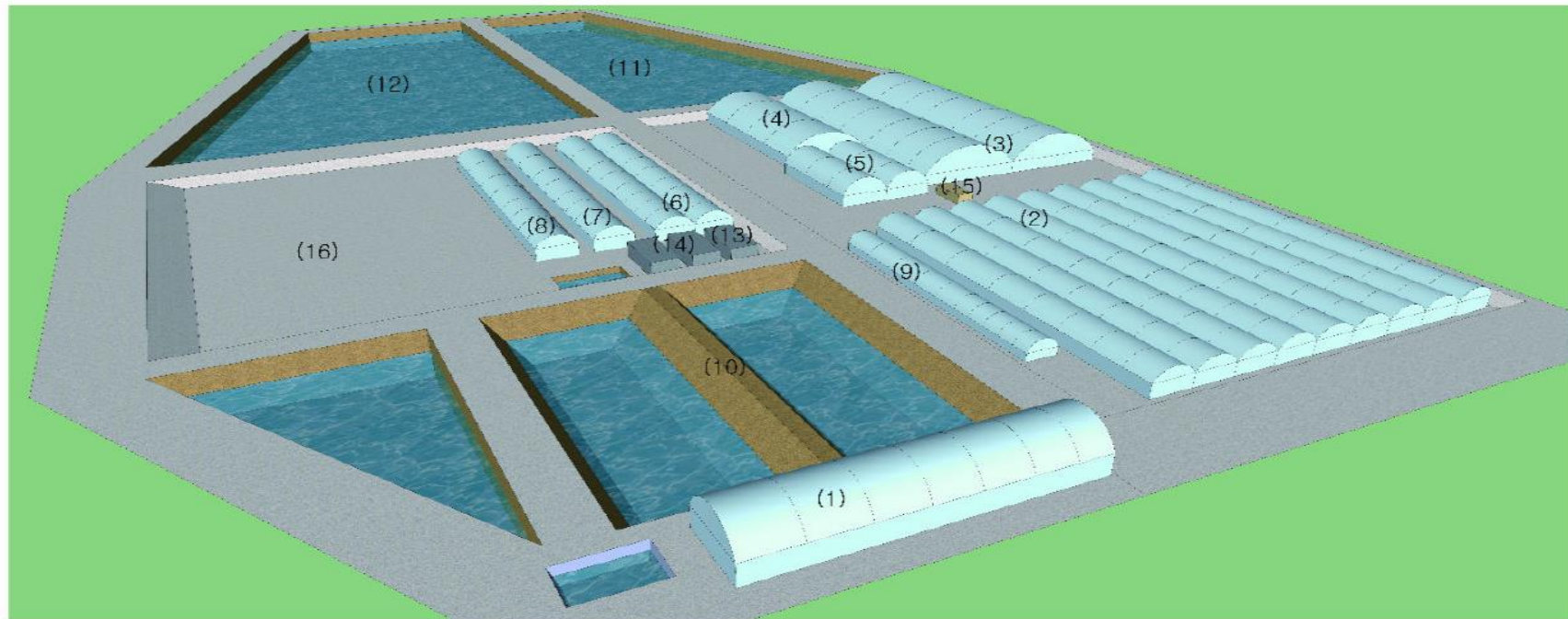
Comparison of performance between single- and three-phase systems

	Single-phase	Three-phase
Percentage of grow-out area	90%	60%
Days to harvest (grow-out)	145	70
Total days (nursery to harvest)	160-200	203
Average shrimp weight (g)	16.7	22.5
Yield (kg/m ² /crop)	4.83	4.30
Crops (/year)	2-2.5	6
Yield (kg/m ² /year)	9.7	25.8
Net yield (kg/m ² /year)	8.73	15.83

- **Data of single-phase based on productions in 300m² tank (2009-2011)**
- **Data of three-phase based on productions in 359m² tank (2014)**

Extension and Implementation

NeoEnBiz Aquafarm, Dangjin (5,500 m²)





Yejin Aquafarm







Safe Food Aquafarm



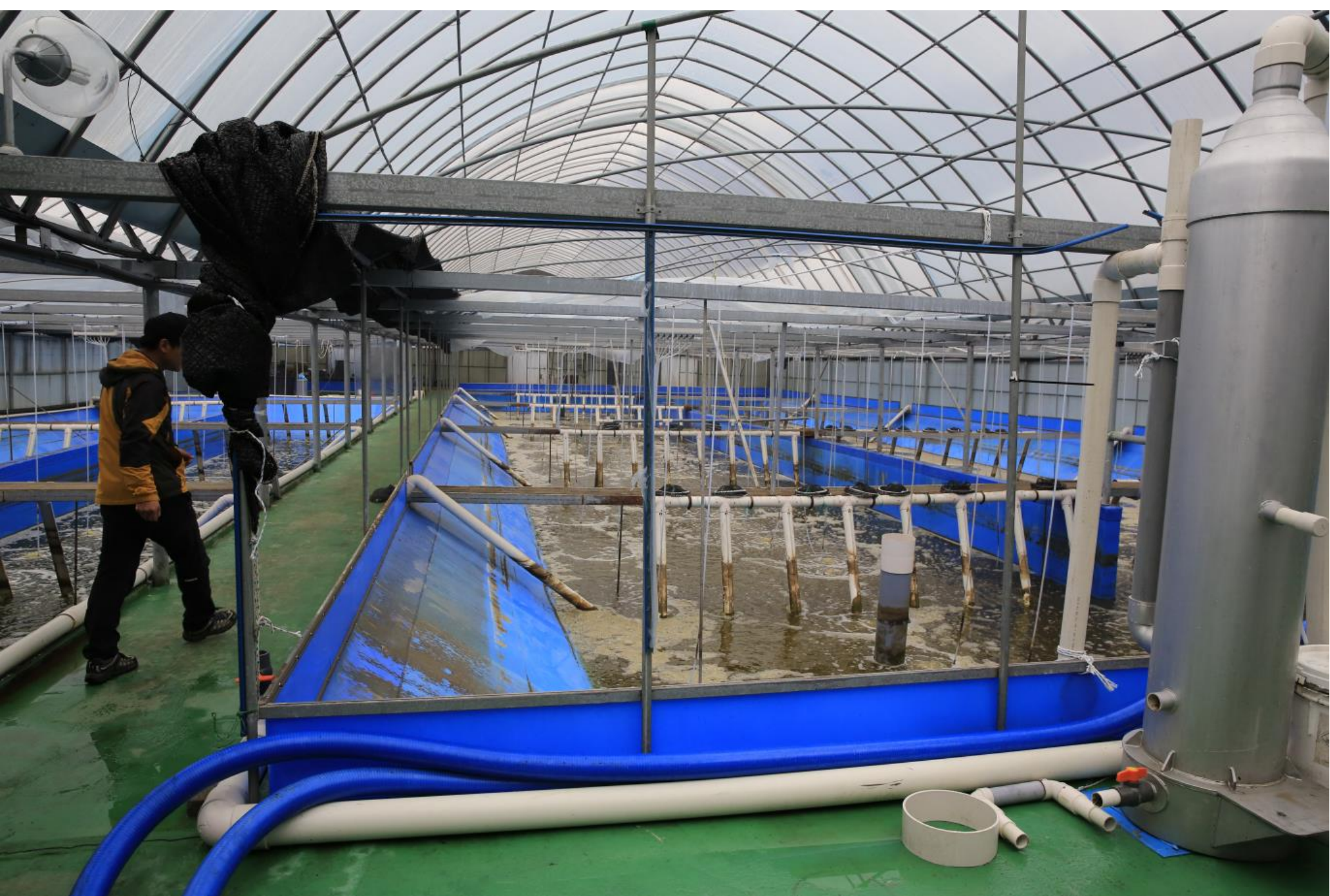


Gumho Fishereis





Mineodo-farm



Application of biofloc technology

- BFT-based Building Aquaculture system, NFRDI -

폐쇄순환양식시스템 Biofloc + Aquaponic



제어시스템



수질환경 모니터링 시스템



산소 / 공기 공급시스템



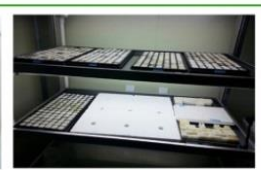
냉·난방시스템



바이오플록 / 아쿠아포닉 여과시스템



식물 발아기



종자식물 배양 시스템



바이오플록시스템



아쿠아포닉



예비수조 / 예비자수조



광어



돌돔



흰다리새우



뱀장어



황복



shrimp

bullhead

catfish



Sahara desert shrimp farming project (2011-2015)



Summary

- A prototype of single-phase greenhouse-enclosed BFT shrimp production system in commercial-scale (two tanks of 300 m²) was constructed in 2009
- Three-phase system (tanks of 90, 187 and 356 m²) was constructed in 2014 and compared with performance of single phase
- Single-phase system produced 4.83 kg/m²/crop of 16.7 g *L. vannamei*, and three-phase produced 4.30 kg/m²/crop of 22.5 g shrimp
- Compared with net production based on percentage of final growout area, three-phase (15.83 kg/m²/year) is twice higher than single phase system (8.73 kg/m²/year)
- More than ten farms are currently producing shrimp from indoor systems in Korea.
- Biofloc technology is recently applied to BFT-building aquaculture system and Sahara Desert shrimp farming project by NFRDI