Pond polyculture in the West Sea of South Korea

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The present state of polyculture in Korea

Established polyculture form (1994)

- Southeastern coastal area : sea squirt + sea mustard + sea tangle
- Mid-western coastal area : abalone + sea tangle + seaweed fusiforme
- Southwestern coastal area : manila clam + surf clam + laver
- Southern coastal area : oyster+ sea squirt + blue mussel

Polyculture of land-based tank (MOMAF, 2006)

- Sea cucumber + abalone

Pond polyculture

- Shrimp (fleshy shrimp) + fish (mullet) : 1999
- Shrimp (fleshy shrimp, pacific white shrimp) + fish (river puffer) : 2004~2006
- Shrimp (pacific white shrimp) + shellfish (surf clam) : 2006

Introduction

- To increases productivity by polyculture techniques harmonized with pond environment in the West Sea.
- To increase a growth by its biological complement and efficient use of water surface and to prevent diseases of shrimp.
- To increase the productive yield at polyculture using shrimp and other organisms.
- To affect on the water purification by feeding organic matter (excrements, dregs of feed) of shellfish in shrimp culture farm.

Materials & Methods

- The experiment was conducted in 4 culture ponds at fisheries institute of the SCF in Taean, Chungcheongnando from June to September 2005.

- Preparation of experimental culture pond
  - 4 ponds (pond 1~4) are set up by heavy equipment (e.g.tractor) for removal of bottom materials and improvement of dike (height 1.8~2.0 m) from April.
  - After drying the bottom, the rearing water was used by sea water that collected in May and sprayed chloride to disinfect (validity of chloride concentration 50 ppm)
  - The second disinfection is performed, 2 weeks after the first chloride disinfection.
  - For culturing phytoplankton, organic manure of 50 kg is scattered in each pond before input the seedling into culture pond .
  - For air supplement and stirring water of the ponds, water wheel (2Hp) of paddle type was set up at both side of each pond.

- Rearing organisms and input the seedling into culture pond (table 1)

Abstract of seed input

Table 1. Outline of rearing organisms and input the seedling in culture pond

	Pond 1		Pond 2	pond 3		pond 4
Area (m^2)	1,848		1,616	1,624		1,716
Rearing organisms	pacific white shrimp	river puffer	pacific white shrimp	fleshy shrimp	river puffer	fleshy shrimp
Amount (number)	85,000	400	70,000	40,000	400	52,000
Rearing density (number/m^2)	46.9	0.22	43.4	24.6	0.25	30.3
Weight of individual (g)	0.0013	73	0.0013	0.054	73	0.054
Day of rearing start	Jun. 11	Jul. 24	Jun. 11	Jun. 13	Jul. 24	Jun. 13

- As table 1 the experiment seed was input pacific white shrimp, fleshy shrimp and river puffer into 4 culture ponds from June 11 to July 24.
- River puffer was input one month later than shrimps.

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Investigation of rearing water quality

- Water temperature, pH, DO, Salinity were measured by water measurement equipment (YSI 85 model), twice a day (07:00, 14:00) and Turbidity was measured by Secchi disc, once a day [14:00].

Nutrient analysis of field

- To measure NH_4-N, NO_2-N and alkalinity, handy kit (Merck Co.) was used twice a week. Data of field is used for control culture.

Close analysis of nutrient

- 1L of rearing water collected in every week is analyzed by NH_4-N, NO_2-N, NO_3-N, PO_4-P based on Marine Environment Standard Operation Procedure (MOMAF, 1999).

Investigation of disease in shrimp by parasite

- Parasite was observed in gill, detritus and white spot of carapace. To confirm infection by parasite, 5 shrimps from each pond were performed by optical microscope (Investigation of filamentous bacteria, ciliata, microalgae and melanization, investigation of infection levels in gill, investigation of white spot formation levels on carapace).

Investigation of growth and survival rate

- In a case of river puffer, body length and body weight of all were measured twice, at the time before rearing and at the time after the experiment finished.
- In a case of shrimp, more than 10 individuals from each pond were randomly collected in every week and then total length and total weight were measured. Final growth rate is calculated by more than 100 individuals from each pond.

Results and Discussion

Table 2. Variations of water quality

Division	Pond 1	Pond 2	pond 3	pond 4
W.T (℃)	21.9~34.2 (27.5)	21.3~34.1 (27.5)	20.5~32.1 (27.5)	23.2~31.3 (27.4)
Salinity (‰)	19.0~31.36 (25.7)	17.5~32.0 (25.6)	17.0~31.5 (24.7)	20.0~31.03 (26.8)
DO (ppm)	3.63~11.8 (7.15)	4.14~10.68 (7.03)	3.95~11.23 (7.04)	4.01~11.25 (7.57)
pH	7.7~8.8 (8.1)	7.8~8.7 (8.2)	7.6~8.7 (8.1)	7.6~8.6 (8.2)
Alkalinity (ppm)	100~140 (125.7)	100~150 (129.6)	100~140 (122.7)	105~145 (129.0)
Turbidity (㎝)	20~100 (43)	20~80 (40)	15~50 (30)	20~50 (31)

- The water quality of polyculture is no significantly differences from single culture. And the value of them was a stable to keep the water quality for shrimp and river puffer.

Experiment of pacific white shrimp and river puffer by polyculture

Table 3. Comparison with data of nutrient in pond 1 and 2

Division	NH_4-N		NO_2-N		NO_3-N		PO_4-P	
	pond 1	pond 2	pond 1	pond 2	pond 1	pond 2	pond 1	pond 2
Min.	0.004	0.02	0	0	0.015	0.02	0.006	0.022
Max.	1.462	0.56	0.177	0.075	0.435	0.36	0.43	0.134
Mean	0.37	0.08	0.05	0.02	0.15	0.09	0.15	0.07

- Table 3 showed that change of concentration in nutrient was generally increased at the middle of July, maximum point was at early and middle of August and then decreased gradually. Also concentration of nutrient in pond 1 showed, at least, 2 times higher than that of pond 2 on every data.
- Concentration of nutrient maintained a propriety range without an effect on the growth of shrimp and river puffer.

Experiment of fleshy shrimp and river puffer by polyculture

Table 4. Comparison data of nutrient in pond 3 and pond 4

Division	NH_4-N		NO_2-N		NO_3-N		PO_4-P	
	pond 3	pond 4	pond 3	pond 4	pond 3	pond 4	pond 3	pond 4
Min.	0.003	0.006	0	0	0.019	0.018	0	0.01
Max.	0.741	0.076	0.061	0.009	0.355	0.057	0.071	0.062
Mean	0.14	0.03	0.011	0.003	0.073	0.033	0.020	0.023

- Concentration change of nutrient in pond 3 (polyculture) showed 2~5 times higher than that of pond 4 (single culture), except for PO_4-P.
- General concentration of nutrient showed the high value at polyculture but it didn't give any effect on the growth of river puffer and shrimp.

Health standard investigate of pacific white shrimp and fleshy shrimp

Table 5. Comparison with health standard of gill in shrimp and formation rate of white spot on carapace

Date	Ponds	Bacteria	Melanized lesions	Stalked protozoans	Diatoms /algae	Detritus	White spot on carapace
Jul. 20	pond 1	0	0	1	0	0	0
	pond 2	0	0	3	0	0	0
	pond 3	0	1.0	4.5	0	0	0.2
	pond 4	0	0.2	0	0	0.2	1.2
Aug.17	pond 1	0	0	0	0	0	1.2
	pond 2	0	0	0	0	0	0.4
	pond 3	-(mortality)	-	-	-	-	-
	pond 4	-(mortality)	-	-	-	-	-
Aug.31	pond 1	0	0	0	0	1.0	1.0
	pond 2	0	0	0	0	1.0	0.2

- Infected level of gill: 0=do not exist; 1=1~20%; 2=21~40%; 3=41~60%; 4=61~80%; 5=81~100%
  Detection rate of white spot on carapace: possessed area rate of white spot on carapace (level of infection)

- Jul. 20 : Ciliata in polyculture with fleshy shrimp showed seriously infection that pacific white shrimp (pond 1 and 2) is infected level of 1 and 3, fleshy shrimp (pond 3 and 4) is infected level of 4.5 by Stalked protozoans.

- pacific white shrimp showed better condition than fleshy shrimp (e.g. parasite in gill).

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Result summary of pacific white shrimp polyculture with river puffer and single culture without river puffer

	Pond 1		Pond 2
Rearing organism	pacific white shrimp	river puffer	pacific white shrimp
Amount (number)	85,000	400	70,000
Rearing density (number/㎡)	46.9	0.22	43.4
Weight of individual (g)	0.0013	73.0	0.0013
Weight at harvesting (g)	14.58	129.4	16.51
Total production (kg)	401.5	47.6	210.3
Production per area (kg/㎡)	0.22	0.026	0.13
Survival rate (%)	32.4	92.0	18.2
Date of rearing start	Jun. 11	Jul. 24	Jun. 11
Harvesting date	Sep. 14	Sep. 15	Sep. 14
Rearing period	95 days	53 days	95 days

- Pacific white shrimp of pond 1 showed a double production of single culture.
- Also the survival rate 32.4% which is 14.2% higher than that of single culture.

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Result summary of fleshy shrimp polyculture with river puffer and single culture without river puffer

	pond 3		pond 4
Rearing organism	fleshy shrimp	river puffer	fleshy shrimp
Amount (number)	40,000	400	52,000
Rearing density (number / ㎡)	24.6	0.25	30.3
Weight of individual (g)	0.054	73.0	0.054
Weight at harvesting (g)	4.38	140.5	4.17
Total production (kg)	7	32.88	-
production per area (kg/m^2)	-	0.020	-
Survival rate (%)	4.0	58.5	-
Date of rearing start	Jun. 13	Jul. 24	Jun. 13
Harvesting date	Aug. 9 (mortality)	Sep. 25	Aug. 3 (mortality)
Rearing period	58 days	53 days	52 days

- Compared the survival rates pond 3 was a little higher than pond 4. Even if pond 4 was 0% and the survival rare was also 4.0% on pond 3.

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Result summary of shrimp (pacific white shrimp, fleshy shrimp) polyculture with river puffer and single culture without river puffer

	Pond 1		Pond 2	pond 3		pond 4
Rearing organism	pacific white shrimp	river puffer	pacific white shrimp	fleshy shrimp	river puffer	fleshy shrimp
Body weight at harvesting (g)	14.58	129.4	16.51	4.38	140.5	4.17
Total production (kg)	401.5	47.62	210.3	7	32.88	0
production per area (kg/m^2)	0.22	0.026	0.13	~0	0.020	0
Survival rate (%)	32.4	92	18.2	4.0	58.5	0
Note	A part mortality at middle of August		A part mortality at middle of August	Mass mortality at 58 days		Mass mortality at 52 days

- Total production of pacific white shrimp polyculture, pond 1 was 401.5 kg and the survival rate was 32.4%, which was highest value of other condition ponds.

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Summary

- To examine an effect to reduce viral disease of shrimp by the river puffer in a pond polyculture, rearing experiment was performed to compare single culture using shrimp (pacific white shrimp, fleshy shrimp) with shrimp polyculture with river puffer in 4 ponds from June to September 2005.

- Water quality environment (water temperature, salinity, DO, pH, alkalinity, turbidity) and/or concentration of nutrient (NH_4-N, NO_2-N, NO_3-N, PO_4-P) are maintained a propriety range for the growth of shrimp and river puffer, but the concentration of nutrients in pond polyculture showed 2~5 times higher than single culture. It is important to maintain a quality of rearing water at polyculture.

- Due to white spot viral disease, the whole fleshy shrimps in single culture were died at 52 days after rearing start and polyculture with fleshy shrimp and river puffer showed a high mortality at 58 days after rearing which is indicated that mortality of fleshy shrimp was decreased by restrain of viral disease and that final survival of fleshy shrimp was 4%.

- Final survival of pacific white shrimp in polyculture with river puffer and single culture without river puffer were investigated 32.4% and 18.2% and production per area of shrimp in the polyculture and in the single culture were investigated 0.22㎏/㎡ and 0.13㎏/㎡ respectively so that survival and/or production of shrimp in polyculture showed 14.2% higher than that of single culture.

- A further land pilot experiment of polyculture is necessary to know whether the productivity difference between polyculture and single culture is affected from feeding infected shrimps by river puffer or not.

Culture process and Infected shrimp by disease

Harvesting of shrimp and river puffer in polyculture

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Indoor pilot experiment to confirm polyculture effect of shrimp and river puffer

Do river puffer predate infected shrimp ?

- river puffer *Takifugu obscurus*
  - Distribution: Korea, China
  - Inhabitation: the coast and brackish area of west sea, south sea, downstream of a river
  - Feeding: live on flesh, crustaceans, shrimp, juvenile fish, egg

Investigate of shrimp and river puffer poly-rearing effect

- Experiment period : 2006. 10. 25~11. 1(8 days)
- Experiment group
  - Tank 1 : HHS 1200
  - Tank 2 : river puffer 15, HHS 1200
  - Tank 3 : river puffer 15, HHS 800, VIS 400
  - Tank 4 : HHS 400, VIS 800
- Rearing organism
  - HHS (high health shrimp) : B.W. 0.62±0.32 g, B.L. 3.93±0.70 cm
  - VIS (virus infected shrimp) : used at 3 days after artificiality infection
  - river puffer : B.W. 11.60±2.39 g, B.L. 7.39±0.37 cm (yearling), be domesticated during a week in salinity before experiment (5‰/32‰)

Investigate of shrimp and river puffer poly-rearing effect

- Rearing tank and condition
  - Rearing tank: concrete circle tank (Ø 6 m, 28.26 m^2)
  - Condition: filled the tank with filtered sea water, added rearing water cultured phytoplankton in the tank to maintain similar concentration of pond polyculture (turbidity about 50 cm, water depth 1 m), after dissolved enough oxygen.
  - Water temperature of each tank is maintained by 1KW electricity heater.
- Feeding supply
  - The shrimp was supplied EP (protein 38%) only, which is 8% of shrimp body weight in amount, twice a day.
- Investigation of rearing water quality
  - Water temperature, DO, Salinity, turbidity, pH, alkalinity, NH_3-N, NO_2-N
  - General water quality is measured by YSI, nutrient is measured by handy kit (Merck Co.)

Result and Discussion

Table 6. Size of initial and final in shrimp and puffer

Date	Shrimp (pacific white shrimp)		river puffer	
	B.L.(cm)	B.W.(g)	B.L.(cm)	B.W.(g)
Oct. 24	3.93±0.70	0.62±0.32	7.39±0.37	11.60±2.39
Nov. 1	4.62±0.66	0.99±0.46	7.99±0.47	13.62±1.57

- Table 6 showed both shrimp and river puffer gained a little weight during the experiment.

Table 7. Variations of water quality

Division	Tank 1	Tank 2	Tank 3	Tank 4
Water Temp. (℃)	23.7~25.9	23.2~25.3	23.5~25.3	22.9~24.7
Salinity (‰)	32.8~34.2	32.5~33.2	33.4~34.0	33.0~33.7
DO (mg/L)	6.49±0.28	6.64±0.22	6.59±0.23	6.70±0.19
NO_2-N (mg/L)	0.0±0.0	0.0±0.0	0.01±0.01	0.01±0.01
NH_4-N (mg/L)	0.05±0.10	0.0±0.0	0.18±0.13	0.0±0.0
NH_3-N (mg/L)	0.0±0.01	0.0±0.0	0.01±0.01	0.0±0.0
pH	8.0	8.0	8.0	8.0
Alkalinity (mg/L)	133.8±2.5	132.5±2.9	137.5±2.9	135.0±0.0
Feeds (g)	290	290	290	290

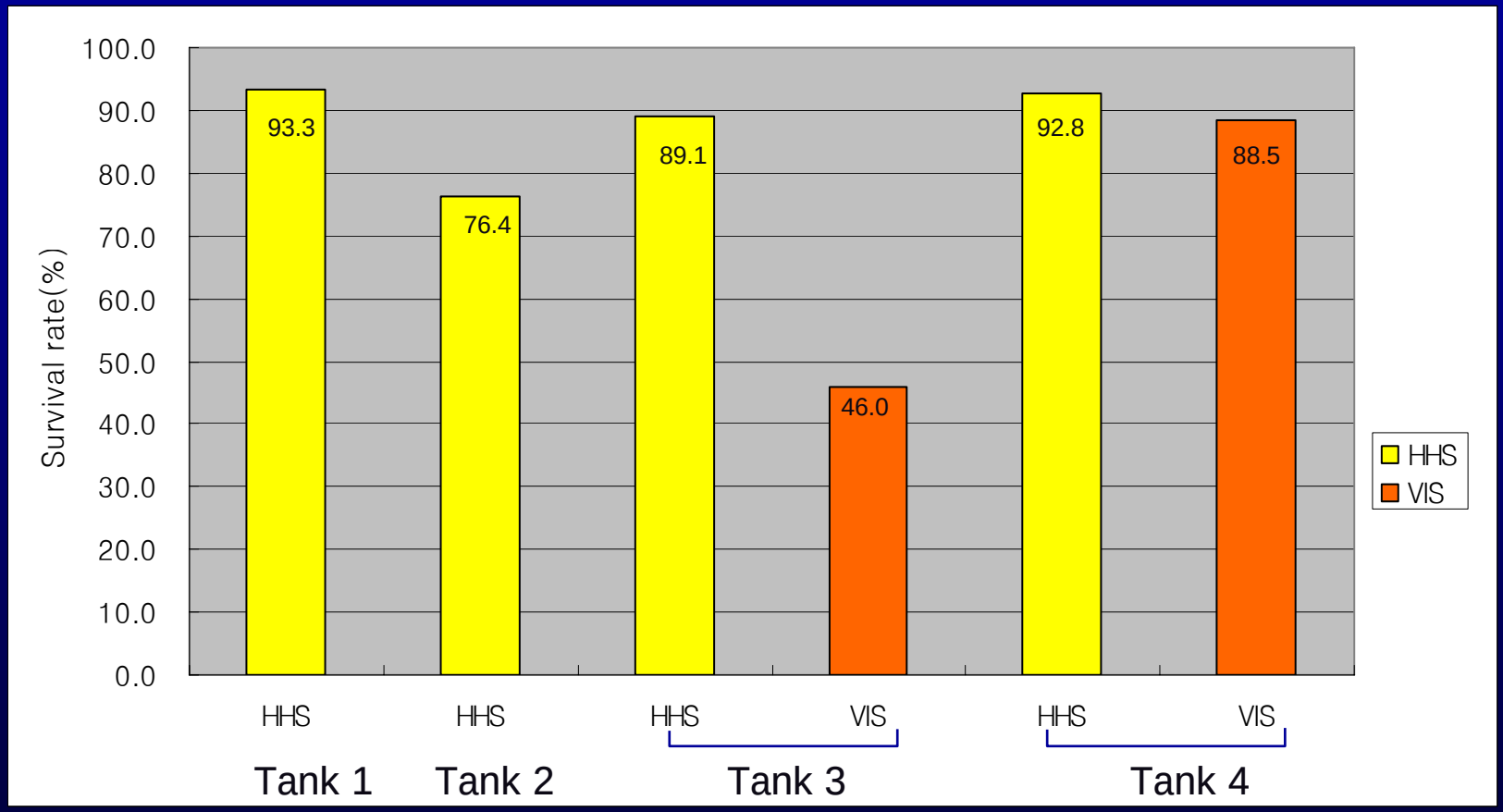
- The water quality and concentration of nutrient of experiment tank were maintained a propriety range for shrimp and puffer.

Table 8. Survival rate of puffer and shrimp

Tank	Organism	Initial No.	Final No.	Survival rate (%)
Tank 1	HHS	1,200	1,119	93.3
Tank 2	Puffer	15	15	100
	HHS	1,200	917	76.4
Tank 3	Puffer	15	15	100
	HHS	800	713	89.1
	VIS	400	184	46.0
Tank 4	HHS	400	371	92.8
	VIS	800	708	88.5

- Survival rate of puffer in tank 2 and tank 3 with shrimp (poly-rearing) was 100%.

Figure 1. Survival rate of HHS and VIS



Tank 1 : HHS
Tank 2 : HHS + puffer
Tank 3 : HHS + VIS + puffer
Tank 4 : HHS + VIS

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Summary

- Rearing water condition (water temperature, DO, salinity, turbidity, pH, alkalinity, NH_3-N, NO_2-N) was maintained a propriety range in growth of shrimp and river puffer.
- Survival rates of river puffer in tank 2 and 3 were 100%.
- Survival rate of healthy shrimp in single culture was 93.3%.
- Survival rate of healthy shrimp in polyculture was 92.8% and the rate of infected shrimp was 88.5%, which was 4.3% lower than that of healthy shrimp.
- In polyculture with river puffer and healthy shrimp, the survival rate of healthy shrimp was 76.4%.
- In polyculture with river puffer, healthy shrimp and infected shrimp, the survival rates of healthy shrimp and infected shrimp were 89.1% and 46.0%.
- Consequently, the experiment indicated that river puffer prefered to feed on infected shrimp rather than healthy shrimp when they are reared with both infected shrimp and healthy shrimp.


Thank You!