

HATCHERY OPERATION AND MANAGEMENT PLAN

For 2012-2014

---- 31 July 2012 ----

Project for Promotion of the Grace of the Sea in Coastal Villages (Phase II)

Introduction

This plan is prepared for the Vanuatu-JICA Jointed Project for the Promotion of the Grace of the Sea in Coastal Villages (Phase II). Although this plan is particularly designed based on the current hatchery condition at Vanuatu Fisheries Department (VFD), Port Vila as of July, 2012, this aims to provide a general idea of shellfish hatchery operation and management. This plan does not make reference to staffing and finance in detail (including the number of staff as well as the availability of staff, and the budgeted required for the project), as the primary focus of this plan is to provide technical and practical analysis. Those factors which were excluded from the scope of this plan could be important aspects in the planning. Therefore, the hatchery must be strictly operated in accordance with the VFD's whole activity plan covering the technical and practical aspects as well as the staffing and finance aspects.

Quick summary

1. Hatchery facilities will be partially renovated in July and August 2012.
2. Some cracked concrete raceways (CRWs) will be repaired in September 2012.
3. Spawning trials for 2012 will be conducted on green snail *Turbo marmoratus* and giant clam *Tridacna squamosa*.
4. Spawning trials for 2013 will be conducted on trochus *Trochus niloticus*, green snail *T. marmoratus* and giant clam *T.squamosa*.
5. Spawning trials for 2014 will be conducted on trochus *Trochus niloticus*, green snail *T. marmoratus* and giant clams *T.maxima* and *T.squamosa*. This is a full scale schedule for the hatchery.
6. Farming trial will be restarted with *T.maxima* in 2012.
7. Giant clam *T.squamosa* for aquarium pet shipment will be restarted in 2013.
8. Spawning induction on *T.gigas* will be tried in 2014, if condition allows.

--- Hatchery management planning ---

Procedure regarding the hatchery management planning is shown in Fig.1. This figure indicates the general idea for planning. We discuss about the detail of each article in the following sections.

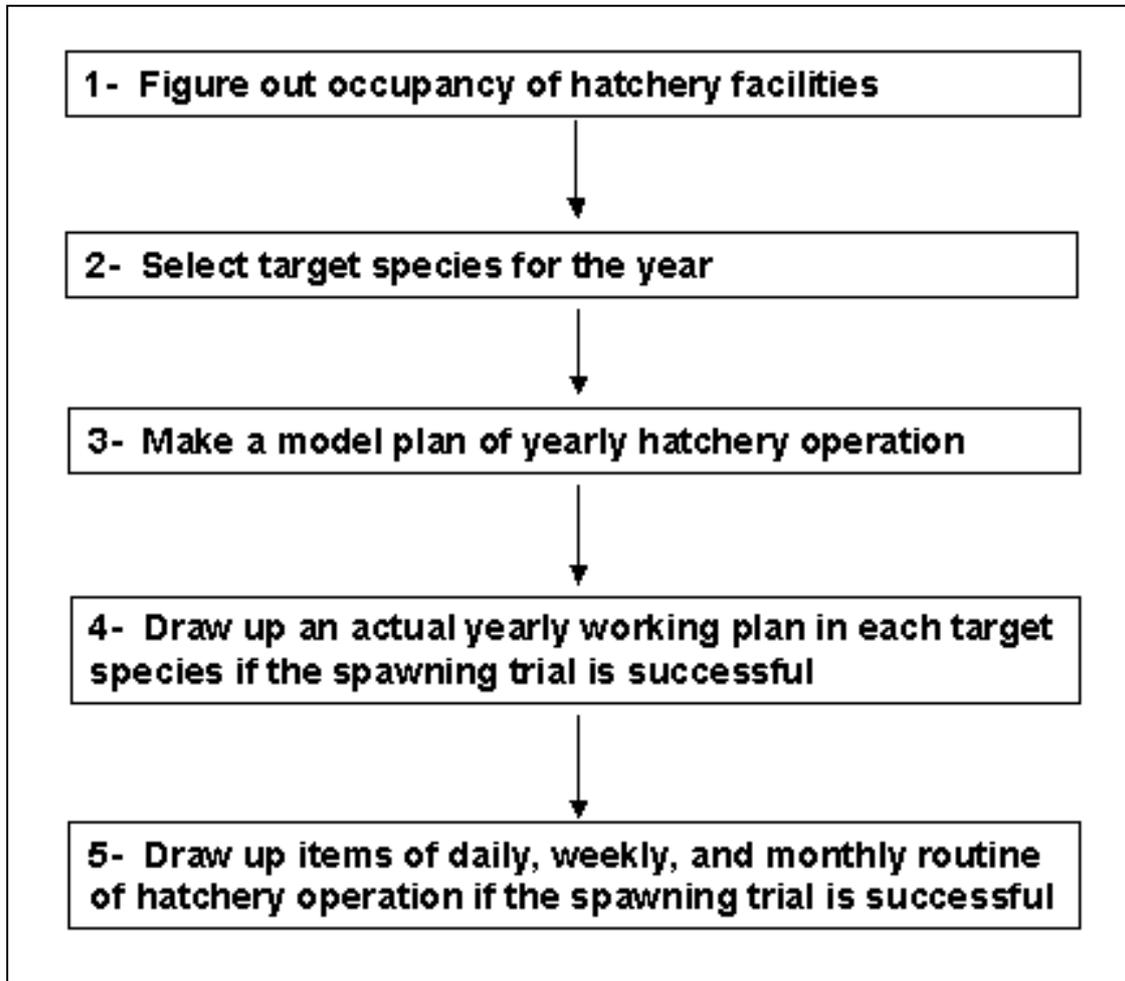


Fig.1. Procedure regarding the hatchery management planning

1. Figure out occupancy of hatchery facilities

At the beginning, access an inventory of shellfish stock by tank to keep the record of exact number held at the hatchery. An example from June 2012 assessment is shown in Fig.2. In this assessment, all the stocked animals were counted. It is recommended that the inventory assessment should be done on a monthly basis. This is the most essential part in the management of hatchery. The arrangement and measurements of each tank is shown in Appendix 1.

Hatchery Inventory Form by Rearing Tank					
Date: 21,22 June 2012			Counted by SONE		
ID #	MAIN		SUB		Remarks
	Species	Number	Species	Number	
FRW-1	TM10	102	TR	78	TM07-1, BTC-2, BTM-2, BTN-3
FRW-2	TS07	50	TR	88	TS09-1, BTM-1 4, BTN-3
FRW-3	TM11	2,632	TR	57	on 47 bricks, 3347 on 090512
FRW-4	TM11	2,688	TR	90	on 48 bricks, 3210 on 300412, +4plates
FRW-5	BMR	250			FRESHWATER
FRW-6					TAP WATER DEPOSIT
CRW-1	TM11	5,000	TR	27	
CRW-2			TR	17	For trochus temporarily stocking before release
CRW-3	TS07	18	TR	37	TM11-200
CRW-4					DRY UP for REPAIR
CRW-5	TM12	5,000	TR	48	
CRW-6	TM11	800	TR	49	Direct on bottom rearing
CRW-7	TM11	1,500	TR	50	On Brick rearing
CRW-8					GREEN SNAIL FEED ALGAE
CRW-9	MR-4MOS	300			
CRW-10	MR-4MOS	700			
CRW-11					DRY UP
CRW-12	MR-4MOS	200			
CRW-13	TILAPIA	30			
CRW-14	GS07	333	TR	21	in 4 CAGES count on 070612
R-1					DRY UP
R-2			TR	64	SOME FISH
R-3			TR	73	
VRW-0					DRY UP
VRW-1	TS07	4	TR	14	WLD-BTS-1, NIMO
VRW-2					DRY UP
VRW-3	MR-4MOS	600			
FC1	TILAPIA	10			Temporal, JUVENILES
FC2	TILAPIA	3	PRAWN	1	Temporal
FC3	TILAPIA	200			Temporal, FINGERLINGS

Fig.2. Assessment of hatchery inventory as of 22 June 2012

The inventory kept at each tank should be separately segregated by species. Refer to Fig.3 for further detail. This Fig. 3 simply shows that the number of animals reared in the hatchery by species as well as by batch. This information is also fundamental to the hatchery management.

Hatchery Inventory Form by Batch								
Date:	22-Jun-12							
Species	Batch ID	Year	Month	Age	E/A	Number	Size	Remarks
Greensnail	GR07	2007	Sep	4.7	A	333	4-7cm SH	Less growth
Trochus	TRM				A	713	1-7cm SD	Mixed up
Maxima	TM07	2007	Dec	4.5	A	1	8inch SL	Specimen only
	TM10	2010	Feb	2.3	A	102	2-4inch SL	Grow-out
	TM11	2011	Dec	6mos	E	12,820	1-2cm SL	Left over from IRD Experiment
	TM12	2012	Mar	3mos	E	5,000	1-3mm SL	Left over from IRD Experiment
Squamosa	TS07-2	2007	Sep	4.7	A	72	20cm SL	Grow-out
	TS09	2009	Sep	2.7	A	1	10cm SL	Specimen only
Crocea	Wild	B-stock			A	2		
Squamosa	Wild	B-stock			A	1		
Teardrop	Wild	B-stock			A	6		
Maxima	Wild	B-stock			A	16		
E/A: Estimate / Actual								

Fig.3. Example of segregated inventory of hatchery as of 22 June 2012

Above Fig. 3 represents followings. The batches (TM11 and TM12) of *T. maxima* became dominant in the hatchery (as of 22 June 2012). TM11 batch must be transferred to ocean as soon as possible, because it occupies many tanks at the moment. Unfortunately VFD has no ocean culture facilities or ocean nurseries. Therefore, admitting that it might be a challenging attempt, as a solution to the current situation, we launched a village farming trial program of *T. maxima*. The species, *T. maxima* is a slow grower and has high mobility that it is not suitable for farming. It is important to keep in mind that this *T. maxima* farming is in the experimental stage. We observed prolonged intermediate culture for green snail batch (GS07) and *T. squamosa* batch (TS07-2) in the hatchery. These long kept batches must be transferred or released into ocean if there are no proper reasons for holding. The GS07 green snails may suffer some internal troubles due to careless rearing for a long period of time. We observed high mortality and inferior growth in this GS07 batch. The older trochus batches also show slower growth due to shortage of food algae. The trochus population should be thinned out in order to maintain a proper stock size as tank cleaners. These removed trochus can be released into wild under VFD's trochus restocking program.

2. Select target species for the year

2.1. Target species

Possible target shellfish species for seed production are listed in Table 1. Production of giant clams is mainly aimed to sell as aquarium pet, while commercial gastropods, such as green snail and trochus, are cultured for the purpose of restocking of the depleted resources. Pearl oysters and edible oysters have not been examined. Other locally edible bivalves and gastropods seem to have no necessity for artificial breeding in Vanuatu. Target species for the year should be selected by based on the VFD's development strategy.

Table1. Possible target shellfish species for seed production in Vanuatu

Species	Stock status	Purposes of production
<i>Tridacna maxima</i>	Abundant	Aquarium trade
<i>T. noea (teardrop)</i>	Abundant	Aquarium trade
<i>T. crocea</i>	Abundant	Aquarium trade
<i>T. squamosa</i>	Over-fished	Aquarium trade, Tourist attraction, Shell, Restocking
<i>T. gigas</i>	Extinct-reintroduced	Tourist attraction, Aquarium trade, Shell, Food
<i>Hippopus hippopus</i>	Over-fished	Restocking, Food
<i>Turbo marmoratus</i>	Heavily depleted	Restocking
<i>Trochus niloticus</i>	Depleted	Restocking, Hatchery tank cleaner

VFD plans to produce 5,000 green snails, 5,000 trochus and 5,000 giant clams in its Research Work Plan for 2012, however giant clam species is not mentioned in this Plan. At the moment, gastropods production area of the hatchery is under the renovation of its roof. It is scheduled to be completed by the end of August 2012. Therefore, we reached the conclusion that it is impossible to produce two species of gastropods in this year. Considering the inventories' situation, green snail will be a main concern for the 2012 seed production. Our recommendation for giant clam seed production is that *T.squamosa*, which has high market value, should be given priority over other giant clam species. In 2013, *T.niloticus* might be added to the target species list to raise the stock in the hatchery, if its natural recruitment is not sufficient. For 2014 spawning trials, *T.maxima* will be added to diversify the output of aquarium pet species (not for farming). Proposed target species for seed production are listed in Table 2. If VFD has enough time to deal with other species, the first spawning induction of *T.gigas* is recommended to try in 2014.

Table 2. Proposed target species for seed production in 2012-2014

Year	Proposed target species	Starting time
2012	Giant clams: <i>Tridacna squamosa</i>	October
	Gastropods: <i>Turbo marmoratus</i>	October - November
2013	Giant clams: <i>T.squamosa</i>	October
	Gastropods: <i>T.marmoratus, Trochus niloticus</i>	September
2014	Giant clams: <i>T.squamosa, Tridacna maxima</i>	October
	Gastropods: <i>T.marmoratus, T.niloticus</i>	September

2.2. Set a target number of the production in each species

VFD’s target numbers of shellfish for seed production seem to be too large for green snail and trochus, considering the capacity of hatchery. On the other hand, its target number for giant clams is considered to be too small. The present hatchery was originally designed to accommodate 3,000 green snails of 2 years old, or 4-5 cm shell height and 3,000 trochus yearlings at once. Meanwhile, the hatchery can accommodate up to 10,000 giant clam juveniles of 6 month old from single spawning (see Fig.4). In order to fully utilize the tank capacity, the target numbers of 3,000 for green snail yearlings (using VRW-1) and 20,000 for 1cm *T.squamosa* clams (using 2x CRW tanks) will be recommended for the spawning trial of 2012. Further target number for 2013 and 2014 can not be estimated at this moment, because it is highly depends on the results of 2012 spawning.

Name #	Gross Vol. (t)	Net Vol. (t)	Btm Area (m2)	Proper Stock Density per Tank
FRW-1	5.2	4.5	7.5	50000 giant clam spats @ first harvest 20000 giant clam juveniles of 1 cm SL 5000 giant clam spats of 2cm SL
FRW-2				
FRW-3				
FRW-4				
FRW-5				
FRW-6				
CRW-1	2.2	1.8	3.6	20000 giant clam spats @ first harvest 10000 giant clam juveniles of 1 cm SL 2000 giant clam spats of 2 cm SL
CRW-2				
CRW-3				
CRW-4				
CRW-5				
CRW-6				
CRW-7				
CRW-8				
R-1	6.2	5.8	9.0	10000 green snail spats @ first harvest
R-2				5000 greensnail juveniles @ 1/2 year old
R-3				
CRW-13	5.6	4.5	7.5	2000 greensnail juveniles @ 2 years old
CRW-14				
VRW-1	2.1	1.8	3.0	3000 greensnail juveniles @ 1 year old
VRW-2				
VRW-3				

Fig.4. Hatchery production capacity by the present rearing tanks

3. Make a model plan of yearly hatchery operation

3.1. Standard schedule for shellfish seed production in Vanuatu

Seed production of marine shellfish must be set as a seasonal activity with a yearly cycle. This cycle consists of three phases, namely preparation phase, spawning trial phase and intermediate culture phase. Spawning trials should be conducted in a spawning season from September to March in the following year, when animals are naturally active in reproduction. Further gonadal studies must be required.

3.1.1. Preparation phase

Prior to the seed production, prepare spawning tanks, larval settlement/culture tanks and other hatchery equipment for the season. If these tanks still hold animals, move all the animals out to other tanks, then empty tanks need to be dried up for a while. Enough number of broodstock are also accumulated and conditioned for spawning induction in this phase.

3.1.2. Spawning trial phase

Start with the spawning induction, followed by the larval and post-larval culture. The post-larval culture will end when spat become visible and can be counted as a first harvest.

3.1.3. Intermediate culture (land culture) phase

The juvenile intermediate culture will usually start after the first count. This phase finishes at harvest as seeds for releasing or farming are taken. In case of giant clams, this phase is a transition phase to the ocean culture. Since VFD has no ocean culture facilities, it must be careful about the prolonged intermediate culture in the hatchery. Harvest from larval settlement tanks should be given priority and completed before the next spawning season, otherwise the following seed production cannot be started. Giant clams can be also harvested for selling to aquarium fish exporters during this period.

3.1.4. Grow-out culture

Over-aged and broodstock specimens (artificially bred or wild) may be held for demonstration. However, such long-term land based cultures sometimes become very hazardous to animals. Number of them must be kept at the minimum for the purposes.

3.2. Proposed yearly hatchery operation plan for 2012-2014

Yearly schedule of hatchery work in 2012, 2013 and 2014 are proposed in Fig.5, 6 and 7, respectively. These work schedules are prepared by species and by batches. Red cells in each schedule indicate the timing of spawning trial.

YEARLY SCHEDULE OF HATCHERY WORK	2012											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
STANDARD SEASONAL WORK	SPAWNING			INTERMEDIATE CULTURE				SPAWNING				
1. GIANT CLAMS												
1-1. TRIDACNA MAXIMA (TM11)	POST-LARVAL		INTERMEDIATE CULTURE - FOR FARMING & SALE									
1-2. TRIDACNA MAXIMA (TM12)				LAVAL POST-LARVAL			INTERMEDIATE CULTURE - FOR SALE					
1-3. TRIDACNA SQUAMOSA (TS07-2)	INTERMEDIATE CULTURE						TRANSFER TO OCEAN FOR GROWOUT					
1-4. TRIDACNA SQUAMOSA (TS12)*											LARVAL	
2. GREEN SNAIL												
2-1. TURBO MARMDRATUS (GR07)	INTERMEDIATE CULTURE						RELEASE TO WILD					
2-2. TURBO MARMDRATUS (GR12)*											POST-LARVAL	
3. TROCHUS												
3-1. TROCHUS NILOTICUS (TR11+TR12)	INTERMEDIATE CULTURE											
4. GROW OUT EXPERIMENT: DEMONSTRATION BATCH												
4-1. TRIDACNA MAXIMA (TMD7+TM10)	100 PCS IN FRW-1											
4-2. TRIDACNA SQUAMOSA (TS07)	4 PCS IN VRW-2											
4-3. TRIDACNA SQUAMOSA (TS09)	1 PCS IN VRW-2											
4-4. TURBO MARMDRATUS (GR07)	25 PCS IN CRW-8											
4-5. TROCHUS NILOTICUS (TRM ADULT)	GROWOUT EXPERIMENT						RELEASE TO WILD					
* Batches seed production proposed												

Fig.5. Proposed yearly schedule of hatchery work in 2012 (spawning trials on 2 species).

YEARLY SCHEDULE OF HATCHERY WORK	2013											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
STANDARD SEASONAL WORK	SPAWNING			INTERMEDIATE CULTURE				SPAWNING				
1. GIANT CLAMS												
1-1. TRIDACNA MAXIMA (TM11)	INTERMEDIATE CULTURE - FOR SALE											
1-2. TRIDACNA MAXIMA (TM12)	INTERMEDIATE CULTURE - FOR SALE											
1-3. TRIDACNA SQUAMOSA (TS12)*	INTERMEDIATE CULTURE - FOR FARMING						INTERMEDIATE CULTURE - FOR SALE					
1-4. TRIDACNA SQUAMOSA (TS13)*											LARVAL	
2. GREEN SNAIL												
2-1. TURBO MARMDRATUS (GR12)*	INTERMEDIATE CULTURE											
2-2. TURBO MARMDRATUS (GR13)*											POST-LARVAL	
3. TROCHUS												
3-1. TROCHUS NILOTICUS (TR11+TR12)	INTERMEDIATE CULTURE											
3-2. TROCHUS NILOTICUS (TR13)* IN CASE											POST-LARVAL	
4. GROW OUT EXPERIMENT: DEMONSTRATION BATCH												
4-1. TRIDACNA MAXIMA (TMD7+TM10+TM11)	IN FRW-1											
4-2. TRIDACNA SQUAMOSA (TS07+TS09)	IN FRW-1											
4-3. TURBO MARMDRATUS (GR07)	RELEASE INTO WILD											
* Batches seed production proposed												

Fig.6. Proposed yearly schedule of hatchery work in 2013 (spawning trials on 3 species)

YEARLY SCHEDULE OF HATCHERY WORK	2014											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
STANDARD SEASONAL WORK	SPAWNING			INTERMEDIATE CULTURE				SPAWNING				
1. GIANT CLAMS												
1-1. TRIDACNA MAXIMA (TM14)*												LARVAL
1-2. TRIDACNA SQUAMOSA (TS12)*	INTERMEDIATE CULTURE - FOR SALE											
1-3. TRIDACNA SQUAMOSA (TS13)*	INTERMEDIATE CULTURE - FOR FARMING						INTERMEDIATE CULTURE - FOR SALE					
1-4. TRIDACNA SQUAMOSA (TS14)*												LARVAL
2. GREEN SNAIL												
2-1. TURBO MARMORATUS (GR12)*	INTERMEDIATE CULTURE FOR RELEASE											
2-2. TURBO MARMORATUS (GR13)*	INTERMEDIATE CULTURE											
2-3. TURBO MARMORATUS (GR14)*												LARVAL/POST-LARVAL
3. TROCHUS												
3-1. TROCHUS NILOTICUS (TR13)*	INTERMEDIATE CULTURE FOR RELEASE											
3-2. TROCHUS NILOTICUS (TR14)* IN CASE												LARVAL/POST-LARVAL
4. GROW OUT EXPERIMENT: DEMONSTRATION BATCH												
4-1. TRIDACNA MAXIMA (TM07+TM10+TM11)							100 PCS IN FRW-1					
4-2. TRIDACNA SQUAMOSA (TS07+TS09+TS12)							20 PCS IN FRW-1					
4-4. TROCHUS NILOTICUS (TR11+TR12)	FOR RELEASE/BLOODSTOCK											
* Batches seed production proposed												

Fig.7. Proposed early schedule of hatchery work in 2014 (spawning trials on 4 species)

3.3. Rearing tank reservation

According to the inventories, rearing tank booking list is prepared as shown in Fig.8. For the spawning trial 2012, the red marked tanks must be reserved for this period.

BOOKING LIST FOR REARING TANKS	2012													
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC		
FRW-1	DEMONSTRATION/GROWOUT TANK TM10 & BROODSTOCK CLAMS													
FRW-2	GROWOUT TANK TS07-2						TROCHUS			GIANT CLAM SETTLEMENT TANK				
FRW-3	GIANT CLAM SETTLEMENT TANK TEMPORAL													
FRW-4	GIANT CLAM SETTLEMENT TANK TEMPORAL													
FRW-5	FRESHWATER SHRIMP CULTURE													
FRW-6	FRESHWATER DEPOSIT													
CRW-1	TM11 STOCK FOR SALE													
CRW-2	GIANT CLAM LARVAL/POST LARVAL						TROCHUS			DRY UP			GIANT CLAM LARVAL	
CRW-3	GROWOUT TANK TS07-2						TROCHUS			DRY UP			GIANT CLAM LARVAL	
CRW-4	GIANT CLAM LARVAL/POST LARVAL						DRY UP FOR REPAIR						GIANT CLAM SPAWNING	
CRW-5	TM12 POST LARVAL						TM12 STOCK FOR SALE							
CRW-6	TM11 STOCK FOR SALE													
CRW-7	GIANT CLAM SETTLEMENT TANK TEMPORAL													
CRW-8	GREEN SNAIL FOOD ALGAE STOCK													
CRW-13	TILAPIA CULTURE													
CRW-14	GREEN SNAIL GROW-OUT						DRY UP FOR CONSTRUCTION							
R-1	DEMONSTRATION						DRY UP FOR CONSTRUCTION							
R-2	DRY UP						GREEN SNAIL LARVAL							
R-3	TROCHUS GROW-OUT						DRY UP FOR CONSTRUCTION							
VRW-0	FRESHWATER SHRIMP						DRY UP							
VRW-1	DEMONSTRATION/HOSPITAL TANK													
VRW-2	DRY UP						GREEN SNAIL GROW-OUT/BROODSTOCK							
VRW-3	FRESHWATER SHRIMP CULTURE													
	LONG-TERM OCCUPATION													
	TEMPORAL OCCUPATION													
	RESERVATION													

Fig.8. Proposed yearly schedule of hatchery work in 2012

4. Draw up an actual yearly working plan in each target species

If the spawning trial is successfully completed, it is time to draw up an actual yearly working plan for each species. The plan for each species must be summarized on the same time table to balance each workload. These can be prepared by referring to a series of seed production manuals prepared during the phase I of the present project or other donor's project (see Table 3).

Table 3. List of seed production manuals prepared for the VFD hatchery

Species	Title of Manual
Giant clams	Giant Clam Seed Production Manual; Targeting for the Aquarium Pets Market, Second Edition, October 2008
Green snail	Seed Production Manual of Green Snail, <i>Turbo marmoratus</i>
Trochus	Trochus Hatchery Seeding Techniques, - A Practical Manual, ACIAR 2002

5. Draw up items of daily, weekly, and monthly routine for hatchery operation

This procedure is almost same as above. If the spawning trial is successfully completed, it is time to draw up contents of daily, weekly and monthly routine for hatchery operation. Most important thing here is not to draw up routine activities itself, but to practice working operational procedures. It is required to decide who is taking responsibility for routine activities. Major routine activities are presented as follows:

--- *Monthly* ---

- *Inventory
- *Measurement and count of each batch
- *Maintenance of water supply system (see Appendix 2 & 3)

--- *Weekly* ---

- *Change of Filter bags during larval/post-larval culture period

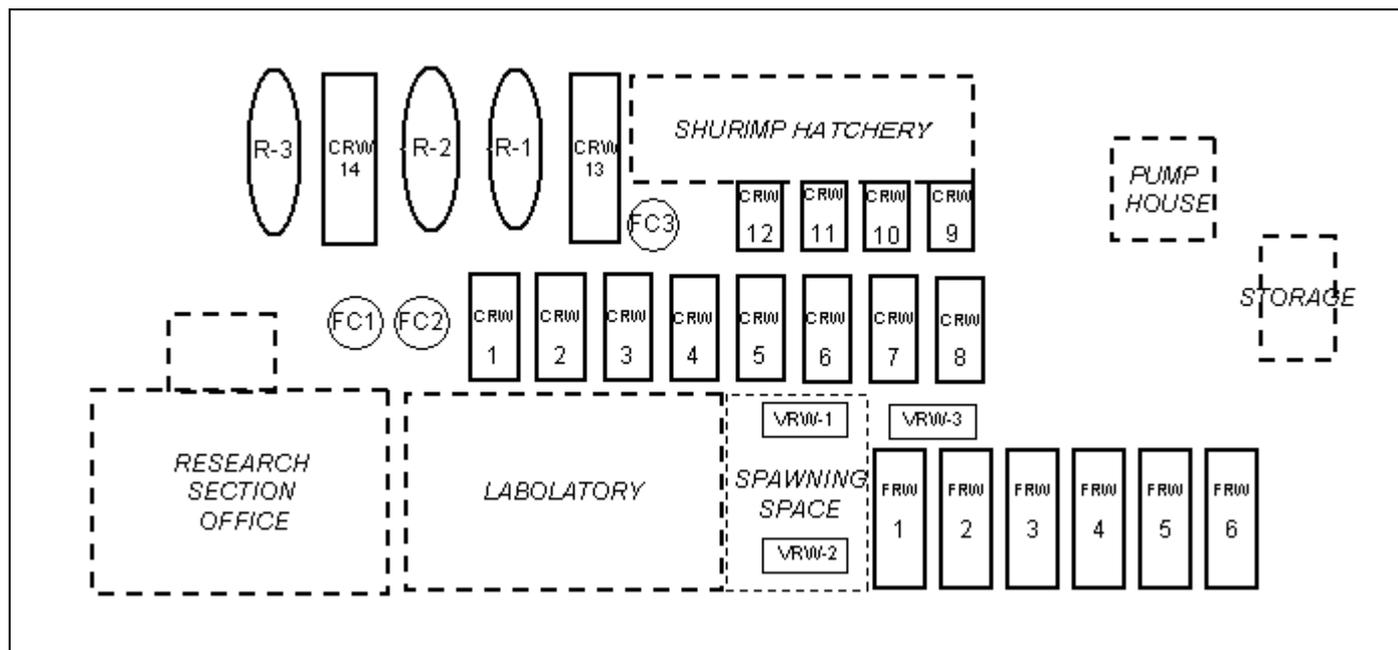
--- *Daily* ---

- *Record of temperature and observation of animal health
- *Check of level, flow rate and quality of rearing water also aeration.
- *Feeding (in case)

--- *Emergency Measures* ---

Refer to Appendix 4.

Appendix 1. Rearing tank arrangement and measurements

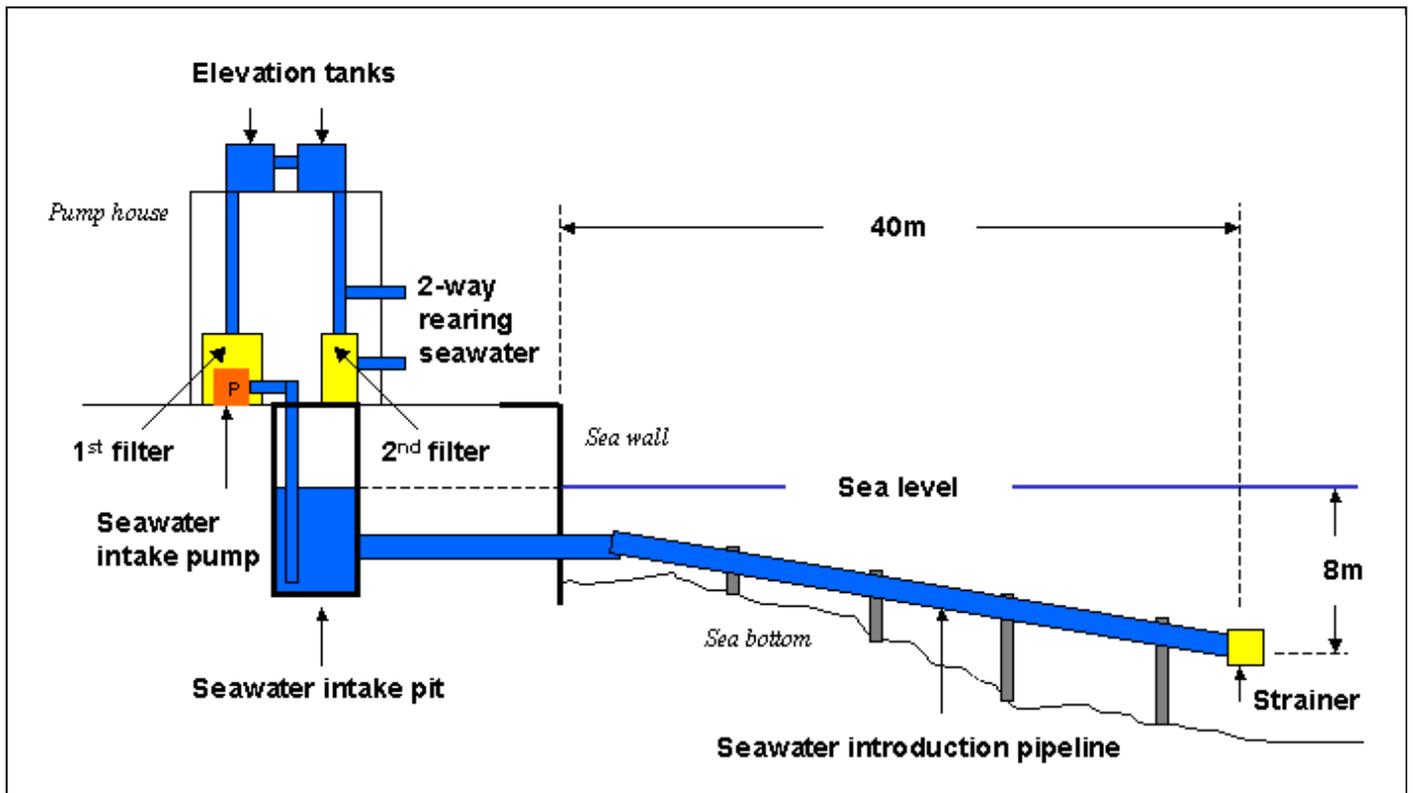


1-1. Layout of rearing tanks and facilities at the VFD's hatchery

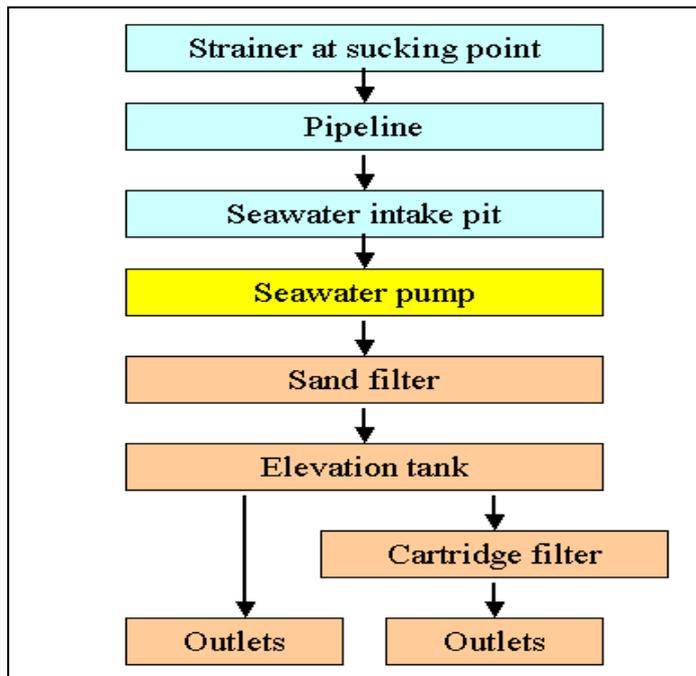
Hatchery Tank Measurements								
Name #	Made	Type	Gross Vol. (t)	Net Vol. (t)	Length (m)	Width (m)	Depth (m)	Installer
FRW-1	FRP	EKT-5.2/Earth-Japan Raceway	5.2	4.5	5.0	1.5	0.7	JICA 2006
FRW-2								
FRW-3								
FRW-4								
FRW-5								
FRW-6								
CRW-1	Concrete	Raceway	2.2	1.8	3.0	1.2	0.6	ACIAR 2000's
CRW-2								
CRW-3								
CRW-4								
CRW-5								
CRW-6								
CRW-7								
CRW-8								
CRW-9	Concrete	Raceway	1.2	1.0	2.0	1.0	0.6	VFD 2002
CRW-10								
CRW-11								
CRW-12								
CRW-13	Concrete	Raceway	5.6	4.5	5.0	1.5	0.7	1980's
CRW-14								
R-1	FRP	ERT-6.2/Earth-Japan Circular	6.2	5.8	5.0	2.0	0.7	JICA 2006
R-2								FAO 1989
R-3								
VRW-0	FRP	FGV-Local Raceway	2.1	1.8	3.0	1.0	0.7	JICA 2007
VRW-1								
VRW-2								
VRW-3								
Total			91.8	79.0				

1-2. Measurements of the present hatchery tanks

Appendix 2. Seawater supply system



2-1 Lateral view of water intake system of VFD's hatchery



2-2 Diagram of seawater intake system

Appendix 3. Maintenance of water intake and supply system

Monthly maintenance

- *Alternate seawater pump with backup pump
- *Wash up seawater pumps with tap water
- *Check generator for oil and fuel
- *Start generator and test electrical supply
- *Inspect and test float switches
- *Wash filter cartridges with tap water
- *Check back pressure on rapid sand filter and back wash if required
- *Check for corrosion of equipment and control box

Bi annually maintenance

- *Check seawater intake pipeline strainers
- *Check sedimentation on the bottom of water intake pit
- *Check sedimentation on the bottom of water preserver tanks

Note:

As of 30 July 2012, a backup intake pump which is under repairing is not yet plumbed.

Appendix 4. Emergency measures against natural disaster

On the alert for cyclone

- *Fill all tanks up to maximum level with full strength seawater.
- *Clear the hatchery place
- *Check fuel for generator.
- *Prepare refuge tanks at the roofed area.

Under affection of cyclone

- *Cover all larval culture tanks with wavy panel and tie up with rope and a heavy load.
- *Stop aeration of flow-through tanks at open area.
- *Check salinity of rearing water frequently.
- *If the salinity drops less than 30ppt, move the animals to refuge tanks