Standard Operating Procedure: Nursery rearing of Indian pompano in RAS

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Introduction

A technological intervention has been the major impetus for the rapid development of recirculating aquaculture system (RAS) for nurery rearing of marine fishes across the world. In spite of the various technologies available for the fulfilment of high production and proper installation of the RAS, it is necessary to optimise many factors periodically and to customize the RAS according to the species, area and scope of application. In this context, developing standard operating protocols for the nursery rearing of Indian pompano in customised RAS is utmost necessary to promote good growth of fishes and to obtain optimal production in a sustainable manner from RAS. A standard operating protocol for nursery rearing of Indian pompano, *Trachinotus mookalee* is provided below. The present SOP was developed on the basis of various experiments in Visakhapatnam Regional Centre of ICAR-CMFRI, Visakhapatnam.

Transition from traditional fish farming to recirculation significantly changes the daily routines and skills necessary for managing the farm. The fish farmer has now become a manager for both fish and water. The task of managing the water and maintaining its quality has become just as important, as the job of looking after the fish if not more so. The traditional pattern for doing the daily job on a traditional flow-through farm has changed into fine tuning a machine that runs constantly 24 hours a day.

RAS system

The present RAS is a customized system, consists of three 5 m^3 capacity FRP tanks. The FRP tanks are circular in shape having a slope of 5^0 towards the center. The tanks are provided with two outlets: one in centre of the tank bottom and the another in the side of the tank top. The three tanks are connected in parallel with PVC pipe through a central bottom drain as well as top drain. The outlet pipe is connected to the sump. The sump is of 2 m^3 capacity having conical bottom with a central drain in the bottom. The sump has an inlet at the middle of the tank and an another outlet in the centre at the top. Outlet of the sump, which is in the middle of the tank top is connected to drum filter through PVC pipe.

Two drum filters containing 60 µm and 40 µm mesh respectively are connected in a series. The outlet of the second drum filter is connected to 1 m^3 tank, from where the water is pumped to two protein skimmers of 500 L capacity each via 2 HP pump. The water falls freely to the biological filter (2 m^3) from the protein skimmer. The biological filter is filled with bivalave shells and bioballs of approximately 1 m^3. Then the water flow back to the culture tank by gravity. In addition, one 3 grammase ozone fixed in the first sump.

Stocking of Indian pompano

Metamorphosed larvae (0.5-0.7 g) of 25-30 days old can be stocked in the tank. The stocking density depend upon the size of the harvest required and also the duration of the culture. The system can be stocked with 2 numbers per L (2000 nos per m^3) and 1 number per L (1000 nos per m^3), if the culture duration is for 2 and 3 months respectively. The grading of the larvae is compulsory for the first month of the culture. The grading should be carried out at forthnightly intervals. It is recommended to give freshwater bath to the larvae when it is getting shifted or after grading before stocking back to the system.

Figure 2. Indian pompano stocked in RAS

Figure 3. Indian pompano manual grading.

Feed and feeding

Fishes should be fed with high quality feed with minimum of 52-40% proteins and 12-10% fats. It is preferable to mix the feed with probiotics fermented soyabean powder.

Feed and feeding schedule for nursery rearing of Indian pompano

Culture duration (Months)	Feed pellet size (mm)	Feeding intervals (hrs)
First	0.3, 0.5 and 0.8	3
Second	1 and 1.2	4
Third	1.5 and 1.8	5

Figure 4. Feeding at floating feed on water surface

Filter in central drain of tank

A filter needs to be kept in the central drain of the tank to avoid fish going to the sump and drum filter. However, the pore size of the filter should be in such a way that the fecal matter and other debris should pass but not the fish. The mesh in the central drain should be changed appropriately as given below so that it should allow free flow of water.

Culture duration	Central drain pore size (mm)
First fortnight	4 mm
Second fortnight	6 mm
Third fortnight	8 mm
Fourth fortnight	grilled

Figure 5. Different filters used for central drain

Figure 6. Tank top drain.

Drum filter mesh maintenance

Drum filter mesh will get clogged eventhough it is getting washed with a nozzole spray. During the first month of the culture, drum filter mesh will work very nicely. However, as the culture progresses, drum filter needs to be cleaned manually with any cleaning agent like hydrogen peroxide or liquid bleach. The first cleaning of the mesh should be after first month of the culture and later at forthnightly intervals.

Sump maintenance

The sump is round shaped with conical bottom and this is appropriate for self cleaning by opening the bottom valve to remove settlement from the tank. The bottom valve needs to be opened daily once in the morning, at least for 10-15 seconds, to remove the settled fecal matter and other debris. Eventhough the sump are structured for self cleaning, there are settelemnts in the sides of the sump tank that needs to be cleaned atleast once in a month. This can be achieved by ozonizing the sumps water for 1-2 hours and then discarding the full water from the sump tank. It should be noted that when the sump and drum filter mesh are getting cleaned, the RAS should be off for 2-3 hrs.

Figure 7. Sensor based drum filter used in RAS

Aeration pipe cleaning

The oxygen is provided through aeration pipe in the tank. The aeration pipe is provided in horizontally, hanging from the top at a level of 20 cm up from the bottom. This is fixed as mentioned above to avoid the creation of dead zone between the aeration pipe and tank wall. If the aeration is kept in the bottom, a dead zone is created in the tank bottom between the tank wall and aeration pipe, where the fecal matter and other debris get accumulated and form aneraobic condition in the bottom. To avoid this problem the aeration pipe was hung 20 cm above the bottom. Eventhough the aeration pipe is releasing air from their pores, it is getting blocked due to settelement of organic load on the pipe. These aeration pipes need to be cleaned once in a week by lifting up from the tank column and to be cleaned manually by using brush.

Figure 8. Aeration pipe line in RAS tank

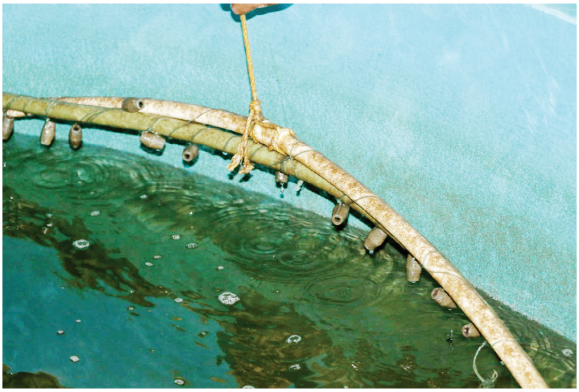


Figure 9. Cleaning of aeration pipe line

Water top-up

There is no water exchange in the RAS. Water reduces in the system due to backwash of drum filter and protein skimming. The loss of water due to subsidiary activites like back wash and skimming needs to be supplemented as a top-up. Generally, top-up is done in the tune of 10-15% of the RAS capacity daily in the present system.

Water quality checking

Once the culture is in progress, the water quality parameters need to be evaluated daily, if not, atleast weekly once. As per the standard operating protocol of the present RAS with the recommended stocking density, water quality is maintained in the system properly for the last 4 cycles with a range of pH: 7.5-8.2; CO_2: < 30 ppm; ammonia: <0.5 ppm; nitritie: <0.1 ppm; DO: >5 ppm.

Oxygen maintanence

The life line of any living animal is oxygen. The oxygen is required not only for the fish but for the microorganisms, to convert toxic ammonia to non-toxic poduct. The oxgen level shold be maintained at optimum levels in the range of 5-6 ppm; extreme levels are dangerous for the fish as well as the system. If the oxygen level is less, the fishes will start dying, and if it is more fishes will show symptoms of gas bubble disease and if it persists the fish start dying. Hence the oxygen levels should be controlled by fixing timer in the oxygen concentrator as per the requirement of the system. Generally, oxygen concentrator runs for 15 minutes ON and OFF mode intitially that changes as the culture progresses towards ON time.

Water circulation

The water circulation pattern in tank will help in driving the fecal matter and debris near the central drain. However, the present system is dealing with the nursery rearing of Indian pompano, where the fry are stocked in very small size of 0.5 to 0.8 g. The fry are generally delicate in nature at this stage, hence we should be careful in providing water circulation during the initial culture period. There should not be any water circulation in the tank during the first month of culture, afterwards the water circulation should be provided in clockwise direction by turning the "L bend" provided in the inlet pipe.

Harvest

The system has been standardized for two way production. The first is for 2 month culture cycle with a stocking of 2 fish per liter, where the fish can be harvested with an average size of 12 g and an average survival rate of more than 90%. The other way is to culture for 3 months, where the fish are stocked at 1/L and harvested at an average size of 27 g with a survival rate of more than 96%.

Figure 10. Harvest from RAS

Routines procedures

The most important routine and working procedures are listed below. Many more details will occur in practice, but the overall pattern are gien below for reference purpose. It is better to make a list with all the routines to be checked each day, and also lists for checking at longer intervals.

Daily or weekly

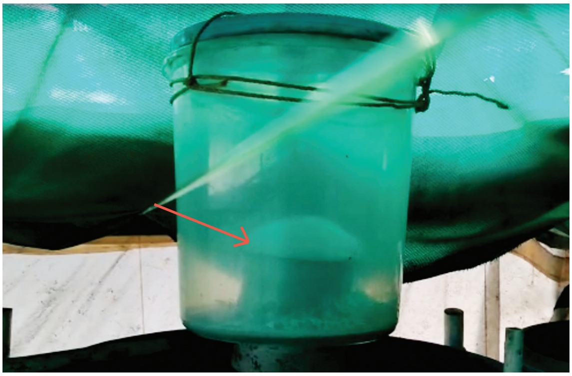
- Visually examine the behaviour of the fish
- Visually examine the water quality (transparency/turbidity)

- Check hydrodynamics (flow) in tanks
- Check, remove and register dead fish
- Observe feeding pattern
- Open the outlet from sump tank
- Check water levels in pump sumps
- Check nozzles spraying on mechanical filters
- Make tests of ammonia, nitrite, nitrate, pH and dissolved oxygen
- Check ozone machine
- Clean aeration pipe
- Check oxygen concentrator
- Check oxygen purity coming from the oxygen concentrator

Some tips

If the fishes are floating on the surface, eventhough they are accepting feed nicely, it shows that the oxygen level in the tank water is supersaturated. It is recommended to control the oxygen concentrator and set appropriately, so that the fish behavior should become optimal.

If the tank water is more turbid, it shows that the protein skimmer might not be working properly. It should be checked regularly and set in such a way that the skimmer should work properly. Another reason might be due to less water in the sump so the pump is taking air while running and hence it didn't allow the protein skimmer to work efficiently.

Economic analysis of Recirculatory Aquaculture System (RAS) for nursery rearing of finfish

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The Recirculatory Aquaculture System (RAS) for marine finfish nursery rearing offers potential scope of more economic returns. From the previous chapters, it could be well comprehended that RAS is a technology where water is recycled and reused after mechanical and biological filtration and removal of suspended matter and metabolites. This method is used for high- density culture of various species of fish, utilizing minimum land area and water. In this context, the economic performance of RAS for nursery rearing was evaluated and presented below.

Financial Feasibility of RAS

The financial feasibility of RAS is an important analytical tool that determines the financial worthiness of the marine finish nursery rearing using RAS. The financial institutions are interested to see the economic viability of any enterprise before advancing loans. The financial feasibility of RAS can be studied through investment evaluation using both discounted and undiscounted cash flow techniques.

A. Undiscounted cash flow techniques

Rate of return to capital (%):
(Average annual benefits over costs / initial investment) * 100

Pay-back period (Years): Initial Investment / Average annual benefits over costs

B.Discounted cash flow techniques

These techniques have a relative advantage since the expected future cash flows are reduced to a single sum at a point of time by incorporating the time value of money.

The different criteria that were employed to evaluate the investment are:

Net Present Value (NPV),

Benefit Cost Ratio (BCR) and

Internal Rate of Return (IRR).

Net Present Value (NPV) / Net Present Worth (NPW)

The Net Present Value (NPV)/ Net Present Worth (NPW) is used to determine the present net worth of the stream of returns over costs.

The streams of benefits should be discounted at the selected interest rate (World Bank suggested rate).

NPW = Total Benefits – Total Costs

For an investment to be feasible, the NPW should be positive.

Benefit Cost Ratio (BCR)

The Benefit Cost Ratio (BCR) is expressed as the ratio of sum total of annual discounted benefits over the annual discounted costs.

Benefit Cost Ratio = Total Benefits/ Total Costs

For an investment to be feasible, the BCR should be equal to or greater than unity (1).

Internal Rate of Return (IRR)

Internal Rate of Return (IRR) is that discount rate which makes the NPW equal to zero. It can be said that, IRR is that discount rate which equates the net benefits during its economic life with initial investment.

IRR = Lower discount rate + Difference between the two rates – NPW at lower discount rate / Absolute difference between the NPW at the two rates.

The calculated IRR should be greater than the investors' required rate of return or Opportunity Cost.

Table 1 presents the annual costs of RAS for marine finfish nursery rearing. The average initial investment accounted to INR 11,40,000/-. The Drum filter and Oxygen generator accounted for the maximum share of investment (52.64%) followed by the tank (15.79%), biological filter (4.39%), electric pump (3.51%), protein skimmer (1.75%) and others (21.92%).

Table 1: Annual costs of RAS for nursery rearing of marine finfish

Particulars	Unit	Quantity	Price per unit (INR*)	Total Value (INR)	Share (%)	Economic Life (In years)
I. Initial Investment						
Tank	Number	3	60,000	1,80,000	15.79	10
Electric Pump	Number	2	20,000	40,000	3.51	4
Oxygen generator	Number	2	1,50,000	3,00,000	26.32	6
Biological Filter	Number	2	25,000	50,000	4.39	10
Protein Skimmer	Number	4	5,000	20,000	1.75	10
Drum Filter	Number	2	1,50,000	3,00,000	26.32	5
Miscellaneous expenditure	INR	1	2,50,000	2,50,000	21.92	5
Total Initial Investment	INR			**11,40,000**	100	
II. Fixed Costs						
Depreciation	INR			1,95,000	70.96	
Interest on investment @7 % per annum	INR			79,800	29.04	
Total Fixed Costs	INR			**2,74,800**	100	
III. Variable Costs						
Labor Charges	Man-days	90	700	63,000	4.11	
Seed	Numbers	1,80,000	5	9,00,000	58.66	
Feed	Kg	2,644	160	4,23,040	27.57	
Electricity	KWH	11,200	5	56,000	3.65	
Rental Value of Land	Sq.m	150	15	2,250	0.15	
Misc. expenditure	INR			90,000	5.87	
Total Variable Costs	INR			**15,34,290**	100	
IV. Total Cost of Production	INR			**18,09,090**		

*INR: Indian Rupees

The annual total cost of production was estimated at INR 18,09,090/-, comprising a fixed cost of INR 2,74,800/-(15.2%) and variable cost of INR 15,34,290/- (84.8%). The annual fixed cost included depreciation on investment, interest on investment @ 7 per cent per annum while variable costs included charges for labor, seed, feed, electricity, rental value of land and miscellaneous items. The cost of production for producing one larva works out to be INR 11.17/-.

The annual gross returns are estimated at INR 32,40,000/-, leading to an annual net income of INR 14,85,090/-. The estimation of gross revenue was with a yield of 1,62,000 larvae per annum and a market price of each larva at INR 20 (Table 2).

Table 2: Annual gross returns of RAS for nursery rearingof marine finfish

Year	Larval Production	Value in INR*
1	1,62,000	32,40,000
2	1,62,000	32,40,000
3	1,62,000	32,40,000
4	1,62,000	32,40,000

*INR: Indian Rupees

The average annual net income for the 4 years using RAS for nursery rearing (INR 14,85,090/-.) is more than the initial investment (INR 11,40,000/-), suggesting a payback period of less than a year (Table 3). The estimated Net Present Value (NPV) at 20% discount rate is INR 25,64,197 (implying an IRR greater than 100%) while the Benefit Cost Ratio (BCR) at 20% discount rate is 1.40. All these indicators provide strong evidence of the economic and financial feasibility of RAS for nursey rearingof marine finfish.

Table 3: Economic and financial indicators of RAS for nursery rearing of marine finfish

Indicators	Unit	Year 1	Year II	Year III	Year IV	Average
Gross Investment	INR	11,40,000	0	0	0	2,85,000
Total Cost of Production	INR	18,09,090	18,09,090	18,09,090	18,09,090	18,09,090
Gross returns	INR	32,40,000	32,40,000	32,40,000	32,40,000	32,40,000
Net income	INR	14,85,090	14,85,090	14,85,090	14,85,090	14,85,090
NPV @ 20% DR	INR					**25,64,197**
BCR @ 20% DR	Ratio					**1.40**
IRR	Per Cent					**>100**
Return on investment	Per cent					**130.27**
Pay Back period	Years					**0.77**

Note:INR: Indian Rupees;

Sensitivity analysis:

Sensitivity analysis is a simple technique to assess the effects of adverse changes on the RAS. It involves changing the value of one or more selected variables and calculating the resulting change in the NPV, BCR and IRR. Cost and benefit stream across the RAS time period anticipated is required. This can be done to ascertain the RAS feasibility at 3 different stages:

Increasing cost of capital

Escalation of cost due to different risks involved

Yield, technological, price, institutional uncertainties etc.

The uncertainties in the RAS for nursery rearing of finfish arise due to yield, technology, climatic conditions, institutions etc. In countering the uncertainties, the production benefit stream can be sensitized by the ex-ante approach of reducing the anticipated project benefit stream at 10%, 20% and 30%, keeping the cost unchanged. The financial analysis can be done using MS Excel. The factors for year-wise discount rates can be arrived at using the formula $1/(1+r)^n$.

The calculated Net Present Value (NPV) and Benefit Cost Ratio (BCR) indicate that the system can withstand risk even to the tune of 30 per cent reduction in the production due to the different uncertainties. The NPV and BCR at 30 per cent reduction in the production in the RAS benefit stream were found to be INR 47,980and 1.008 respectively (Table 4).

Table4: Sensitivity Analysis of RAS for nursery rearing of marine finfish

Year	Cost	Benefit	Discount Factor (20 %)	Discounted cost at 20%	Discounted Benefit at 20%	Reduction in benefit of 10%	Discounted Benefit	Reduction in benefit of 20%	Discounted Benefit	Reduction in benefit of 30%	Discounted Benefit
0	1140000	0	1	1140000	0	0	0	0	0	0	0
1	1809090	3240000	0.8333	1507515	2699892	2916000	2429903	2592000	2159914	2268000	1889924
2	1809090	3240000	0.6944	1256232	2249856	2916000	2024870	2592000	1799885	2268000	1574899
3	1809090	3240000	0.5787	1046920	1874988	2916000	1687489	2592000	1499990	2268000	1312492
4	1809090	3240000	0.4823	872524	1562652	2916000	1406387	2592000	1250122	2268000	1093856
				NPV	2564197	NPV	1725458	NPV	886719	NPV	47980
				BCR	1.440	BCR	1.296	BCR	1.152	BCR	1.008

NPV: Net Present Value BCR: Benefit Cost Ratio

The economic analysis illustrated in this brief write-up can be very helpful in understanding the financial performance of RAS or proposed investment in it, especially for the nursery rearing of marine finfishes. The small-scale fish farmers and entrepreneurs can be encouraged, and also facilitated fish production in areas where land and water are scarce, by promoting this intensive high density fish culture using RAS technology.

References:

1.Narayanakumar, R; Shyam, S Salim and Madan, M.S. (2017). Economics of fishing operations, financial feasibility and sensitivity analysis. In: Methodological tools for socioeconomic and policy analysis in Marine Fisheries. *ICAR-CMFRI special publication* No.127, p.1-15.

2.Ritesh Ranjan, SekarMegarajan, Biji Xavier, S.S.Raju, Shubhadeep Ghosh and A.Gopala Krishnan (2019). Design and performance of recirculating aquaculture system for marine finfish brood stock development. *Aquacultural Engineering*. 85(2019): 90-97.