CHAPTER 6 – EGG INCUBATION

Fish eggs can be split into three categories according to whether they float or sink and whether they are sticky or not. Floating and sinking eggs tend to be from species which release eggs into moving water and allow the eggs to be washed away with the water flow. Species that have sticky eggs deposit the eggs on substrates so that the eggs are not lost from the spawning site. Since eggs have different characteristics, the methods for incubation and hatching vary as follows.

6.1 Floating eggs

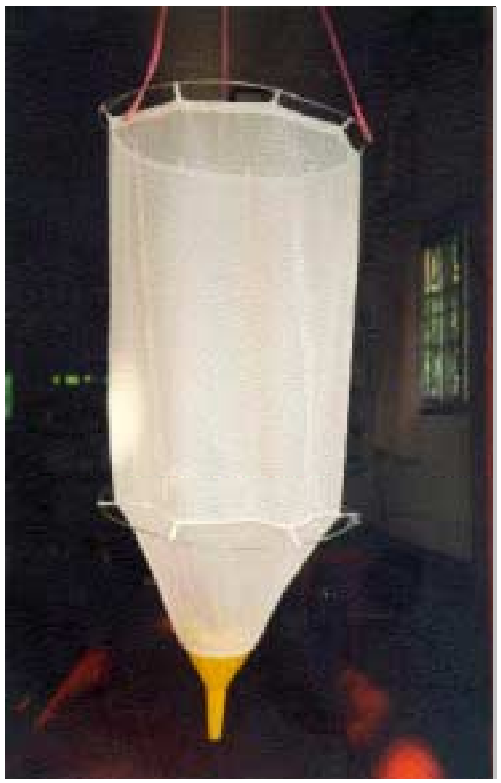
The eggs can be hatched in a pond, concrete tank or 'Orlon' hatching cage. Since the eggs float they will not clump together and suffocate. Some water movement is desirable so that oxygen concentrations are kept at a healthy level. Typically the incubation and hatching tank/cage should be approximately 2 x 1m and 0.5 m deep. The hatching cage is made of 'Orlon' cloth and its shape is maintained by using a wire or plastic frame. The best material to use is blue plastic pipe since water can be passed through the pipe to provide upwelling water from the bottom of the cage (see Diagram 6). If possible aeration should be provided to maintain oxygen levels and also to strip the oil that is released from the eggs from the surface of the water. This oil can foul the water and encourage bacterial colonisation of the eggs. The eggs are incubated until hatching, after which the fry are held for a further 2 -3 days, until the yolk sac is reabsorbed and the fry start feeding. After this point the fry can be transferred to nursery tanks or stocked to a prepared nursery pond. This method can also be used with half-sinking half-floating eggs as well.

Figure 15. 'Orlon' hatching cage with frame (Note: water flows out of the frame through holes in the pipe)

6.2 Half floating - half sinking eggs (e.g. Rohu, silver barb)

For species such as Chinese and Indian carp and the Barb species (*e.g. Puntius spp.*), swelling after fertilisation is completed in about 10 minutes and the eggs can be gently washed and transferred to a hatching container. For these species which have floating or semi-floating eggs, the best hatching container to use is the upwelling hatching cone (Diagram 5, Figure 16).

Figure 16. 'Orlon' hatching cone (Note: water flow enters through the funnel in the bottom



Once the eggs have been placed in the 'Orlon' upwelling hatching cone or the hatching cage, water flow should be provided. This ensures that the eggs do not clump on the bottom of the container and suffocate. The water movement also helps clean the eggs. The water coming into the hatching container should be clean if possible and should be screened to exclude anything that might eat the eggs (*e.g.* insect larvae, tadpoles etc.). 'Orlon' is a suitable material for this. The water flow should be sufficient to keep the eggs moving continuously. If the water flow is too strong the eggs will be damaged, if it is too low then the eggs will not be circulated. The best method for setting the water flow is to observe the eggs in the hatching container and adjust the flow until the desired movement is obtained.

Figure 17. Transfer of Puntius eggs to upwelling 'Orlon' hatching cones

6.3 Sticky eggs

Common carp eggs and the eggs of the catfish species are sticky once they are released and fertilised. These eggs cannot be incubated in the upwelling hatching cone since they would clump together and suffocate. For common carp the technique used is to allow the fish to deposit their eggs naturally on a spawning substrate (see previous chapter). If the eggs are stripped (*e.g.* during artificial fertilisation the eggs must be poured onto a flat surface so that they will attach. Once attached to the surface the eggs must have flowing water past over them continuously. The best method for this is to use the 'Orlon' hatching cage method (see above) and take care to pour the eggs over the cage evenly so that they attach in a thin layer. Water is passed over the eggs by the flow out of the plastic pipe that is in the base of the cage.

Techniques exist for washing eggs to remove the stickiness, however this process is more complicated, and the chemicals required are difficult to obtain in Lao PDR.

6.4 Egg Hatching

From Table 5 , the hatching of *Puntius* eggs occurs between 8 - 12 hours after fertilisation. The hatching time and hatching efficiency depends upon a variety of factors especially temperature, which if high, will shorten the hatching time. The factors that need to be considered for good egg hatching efficiency are listed below

Maintain good water quality

- Water should not be too hot. Water temperatures over 32 ^{o}C are undesirable and will reduce hatching efficiency. Care should be taken not to take water from shallow ponds or stored in metal water tanks. Hatching tanks should be shaded to prevent heating from direct sunlight.
- Water should be clean and not contain high levels of suspended solids
- Water should not appear dark green (indicating high phytoplankton concentration) or have visibly high number of zooplankton (can be observed in a glass held to the light). These will use up oxygen and some zooplankton species can damage eggs
- Predatory water insects should be excluded from the hatching tank since many of these species can be predators of eggs and fry (*e.g.* dragon fly larvae, water boatmen). Blue netting screens around tanks and on the water inlet can be used to avoid their entry.

Figure 18. Spraying water into 'Orlon' cage to increase oxygenation

Maintain high oxygen concentration in the water

- This is very important if water temperatures are high, since the oxygen concentration in the water will be lower.
- Water can be splashed to increase oxygenation before it is introduced to hatching container
- Water can be sprayed into tanks to increase oxygenation (see Figure 18)
- The oxygen level of the water must be high during the time when the eggs are about to hatch.

- Low oxygen concentrations can slow hatching times, but if they become too low egg survival will be low and the number of fry hatched will be reduced.

Minimise waste products

- During the egg swelling period just after fertilisation, mucus is produced that will foul the water. If the water flow is not sufficient, this will allow bacterial numbers to increase and this might infect the eggs. Waste products form the eggs provide food for bacteria and good water exchange is essential for their removal.
- Some of the waste products formed in the water may be directly toxic to the eggs (*e.g.* ammonia).
- Water exchange is very important if the water is cloudy or contains high concentrations of phytoplankton or zooplankton.

Ensure good water circulation

- The eggs must be continuously circulated and washed by the water flow.
- This increases oxygen availability and cleans the eggs
- If water circulation is too strong, the eggs will be damaged due to impact with the container.
- If the circulation is too low then the eggs will not be stirred sufficiently and the eggs will suffocate.
- If water flow cannot be used, small air pumps can be used to provide aeration and water circulation.

Once the eggs have hatched, the fry can be transferred from the upwelling hatching cone to an ‘Orlon ‘ hatching cage. If the eggs have been hatched in a hatching cage, then the newly hatched fry do not need to be transferred. Fry should be maintained in these nursery cages until transferred to nursery ponds. This process is described in the next chapter.

Figure 19. Checking egg hatching by observation in a glass – do this regularly to check the development of eggs and fry.

CHAPTER 7 - FRY NURSING AFTER HATCHING

After the fry have hatched they are transferred to a nursery area. There are many forms of fry nursery - earth ponds, concrete tanks, fibreglass tanks and 'Orlon' cages have all been used successfully to rear fish fry. The decision as to which nursery system to use depends upon the species of fish, materials available and the amount of money that can be invested. Small-scale hatcheries have small budgets for construction therefore low-cost nursery techniques are a priority.

7.1 Earth pond nursery

Earthen pond nurseries are effective for the production of many species of fish. The naturally feed that occurs in a well-prepared nursery pond assists survival and compensates for poor quality supplemental feed. Growth rates are high in earth ponds, but survival rates can vary greatly. This is due to the problems of controlling earth ponds because they are difficult to feed and predators of the fish fry can enter easily. One of the principle problems in Lao PDR is the entry of predatory dragon fly larvae nymphs, tadpoles and carnivorous fish. These prey on the larval fish and can reduce the survival greatly. Correct preparation of the earth pond is essential for good survival of the fish fry. This is often poorly done due to difficulty in draining ponds, lack of fertilisers or rainfall to fill ponds at the required time. Good pond preparation requires the following steps to be observed:

- Empty the water out of the pond (drain or use a pump) and dry the pond.

- If water cannot be drained, predators in the pond can be killed by the addition of rotenone (derris powder) at a rate of 1.5 g per m^3 of pond water. Derris is difficult to obtain in Lao PDR and therefore draining and drying the pond is the most effective method for eliminating predators.

- Add lime to the pond at a rate of 1 kg for every 25 m^2 of pond area. Lime can usually be purchased from building supplies shops. Lime assists soil fertility and reduces the amount of fertiliser required to produce greenwater in the nursery pond.

- Add fertilizer to the pond at the rate of 1.5 kilos per 10 m^2. This is equivalent to one full bucket per 20 m^2 of pond area. Fertilizers that can be used include buffalo, cow, chicken and pig manures. After the manure is applied the pond can be filled to a depth of 5 - 10 cm to allow the breakdown of the manure. After 3 - 5 days, the pond should be filled to a depth of 30 - 50 cm and is then ready for stocking.

- Fry are stocked to the nursery pond at a rate of 125 - 500 individuals/m^2 (see Table 6).

- After stocking the fry to the pond (usually done in the early evening) the water level is maintained for one week. One week after stocking the water level is then increased to 80 cm.

CHAPTER 8 - ECONOMICS OF SMALL-SCALE HATCHERY OPERATION

The types of hatchery appropriate for extension in Lao PDR differ greatly depending upon local conditions. Typically, small farmers are unwilling to invest money in a small-scale hatchery unless they have had evidence of the success of such an operation. This usually means somebody locally who was in a similar situation and was successful. Even with the evidence that such a hatchery would be profitable, many farmers are still unwilling to commit finances to invest in cement tank and pond construction.

Farmers can be introduced to small-scale hatchery techniques gradually, starting with a low cost hapa-based method (*i.e.* ‘Orlon’ and blue net cages suspended in a pond), followed by gradual up-scaling to methods that employ flowing water and possibly even pumping.

The choice of species produced by the farmers should also reflect the type of operation. Typically, hapa-based methods favour species such as Common carp and Tilapia. If spawning hormones are made available, the production of other species is also possible using these simple methods (especially Common silver barb)

The ultimate goal of this is to take farmers beyond simply producing fish fingerlings for their own purposes to actively selling them as a commercial enterprise. Until this happens, the shortage of fry for both pond and rice-fish culture will continue to constrain Lao aquaculture.

The economic breakdowns that are presented in this chapter demonstrate:

- The investment required for different types of hatcheries
- The effect of different survival rates (10 – 50 %) on potential production per crop.
- The effect of fish sale price variation (10 – 50 Kip)
- Breakeven fish production for different types of hatcheries

These economic breakdowns can also serve as an approximate guide to the investment required to establish a fish hatchery depending upon the required production. Economic indicators (*e.g.* Internal Rate of Return, Net Present Value) have not been included since these have little meaning to many small-scale hatchery entrepreneurs. In most cases small hatcheries are constructed on the basis of payback within the first year or two, hence the calculations are presented to reflect this. Most farmers are unwilling to borrow or invest for periods over two years since this presents an unacceptable degree of uncertainty (*i.e.* risk).

At the time of writing , these values are based in Kip and the exchange rate is $1 equivalent to 3,500 Kip.

8.1 Marketing

Important note:

The economic projections provided here assume that the fingerlings produced by a hatchery are marketed soon after they are produced.

A potential problem for some locations is that farmers only purchase a small numbers of fingerlings and thus the hatchery must hold the fingerlings for periods longer than may be economically feasible. In this respect the timing and marketing of fish production must be well established before investment in a hatchery. Most hatcheries will have problems marketing their fry until sufficient numbers of farmers know of their location. This may take more than one year and in this respect credit provision for hatcheries may require longer than one-year payback periods.

Fry price is currently 30 – 50 Kip per piece and this is unlikely to reduce in the near future. As previously mentioned, the constraint of a hatchery producing large numbers of fry is the eventual marketing of the production. In this respect hatcheries should also be located near to an area where demand for fingerlings is high (*e.g.* for rice fish culture or fish ponds). It may be necessary to lower the price of the fish fingerlings in order to sell sufficient quantities.

In interviews with fish farmers in Lao PDR it is often mentioned that they require fry to be delivered to their village – in this respect the transportation by the hatchery may be crucial in ensuring sales. Visiting villages which grow fish and taking orders is one method for selling larger quantities. In areas with good road access, fingerlings are carried along the road and are sold in each village along the route.

8.2 Minimal input small-scale hatcheries

This type of hatchery represents the lowest level of inputs for hatchery, ponds and equipment. It is thus the type of small-scale hatchery that would suit a small farmer operation that was producing fry for sale.

Operations smaller than this are not considered here, since the investment required is below that at which credit would be required to construct the hatchery. Typically, smaller operations would also be unlikely to produce a fry surplus for sale, therefore would not constitute an income generating activity. This type of hatchery would only require the net cage components and self-constructed ponds.

The table below gives the investment and returns expected from three different types of minimal input hatchery : The three hatchery types are distinguished by their different sources of water and electricity. These are:

- Type 1 - The water supply is under gravity and thus represents a site that is fed by a small stream, irrigation canal, or pond/reservoir that is higher than the hatchery site.

- Type 2 - Again, water may be supplied under gravity to the hatchery or flowing water is present nearby. This water is used to power a small generator of the type that is readily available in Lao PDR (Chinese construction). The pump is used to pressurise water in the hatchery, or provide aeration etc . (the cost of these additional components have not been included here).
- Type 3 – This hatchery has an electricity supply that is use to power an electrical pump for the hatchery. This hatchery also has a 5hp petrol water pump for filling and emptying ponds.

All three types of hatchery have the same nursery and broodstock pond areas. The difference between the types is related to investment cost and potential production levels.

From Table 8 the fixed costs of net cages, tanks and equipment for the three types of hatchery range between 243,000 – 1,333,000 Kip. Labour is not included as it is assumed that there is no hired labour on a hatchery of this scale. Pond construction costs are considered separately (Table 9) since in many cases small-scale hatcheries already have ponds. The cost of pond construction is often a considerable deterrent to farmers starting fish fry production, therefore attention for small-scale hatchery development in Lao PDR is initially directed at farmers with existing ponds.

Where water is supplied by gravity there may be no need for pumping since water can be pressurised to the hatchery. Often, hatcheries and fish ponds are not located lower than the water supply and thus some form of pumping is required. In the case of hatcheries relying on rainwater, pumping is always necessary. This type of situation usually requires electricity nearby, or a petrol driven water pump. In this case, the reservoir for water for the hatchery needs to be large.

Table 8. Fixed costs for hatchery construction and equipment

Item	Unit cost	Unit	Type 1 water flow	Type 2 generator	Type 3 electricity
			Number of items		
Orlon' upwelling hatching cone (80 litres)	10,000	each	1	1	1
Orlon' nursery cage (1,000 litres)	40,000	each	1	1	1
Blue net nursery hapas (20 m^2)	35,000	each	2	2	2
Cement tank (3 m^2)	250,000	each	0	0	1
Pipework to tanks or cages	50,000	total	0.5	0.5	1
Fittings (valves)	15,000	total	0	0	1
Roofing - thatch plus wood	50,000	section	1	1	2
Electric pump (small submersible)	150,000	each	0	1	1
5 hp Petrol pump (for emptying/filling ponds)	500,000	each	0	0	1
Hoses for pump	50,000	set	0	0	1
Water powered generator (220V)	120,000	each	0	1	0
Aerator (12 v)	50,000	each	0	0	1
Broodstock feed (3 kg/ kg of fish/year)	1,000	kg	24	24	24
Broodstock females	3,000	kg	4	4	4
Broodstock males	3,000	kg	4	4	4
Total fixed costs			**243,000**	**513,000**	**1,333,000**

Table 9. Pond requirement and construction cost

Pond Type	Pond Area (m^2)	Pond Construction (Kip)
Nursery	378	567,000
Broodstock	200	300,000
	Total	**867,000**

The operational costs listed in Table 10 concern those costs incurred for the preparation and feeding of nursery cages and ponds. These costs are related to the nursery pond area and also to the fuel usage for pond draining and filling.

The greater degree of flexibility in management that could be achieved by the use of pumps will be reflected in higher production rates. This is due to higher survival in the hatchery because of better water quality and aeration and pumping. In many cases the inputs such as rice bran are also derived from rice production activities of the farmer and this can reduce operational costs. In all three cases the cost of manure for fertilisation is not included as it is assumed to be available to the farmers at an opportunity cost of collection. Chemical fertilisers can be used and must be added to the operational cost.

Table 10. Operational costs for minimal input hatcheries (per crop)

Item	Unit cost	Unit	Type 1 water flow	Type 2 generator	Type 3 electricity
			Number of items		
Hormones	3,000	dose	4	4	4
Rice bran	350	kg	18	18	18
Eggs	300	each	3	3	3
Pellet feed	3,000	kg	0	0	0
Pig/Chicken starter feed	1,500	kg	9	9	9
Fuel for pump	800	litre	0	20	20
Lime	1,000	kg	16	16	16
Total operational costs (Kip)			**48,700**	**64,700**	**64,700**

The breakeven production of fry required to cover the fixed costs and one crop of fry is presented in Table 11. This clearly shows that these types of hatcheries can pay back within one to three crops, providing fry price remains higher than 20 Kip per piece and the survival from the nursery pond is greater than 20%. Low survivals in nursery ponds are encountered in Lao PDR as a result of poor pond preparation, poor water quality and inadequate feeding. Using the equipment listed above, survivals higher than 10% should be consistently achieved.

It is important to note that more than one crop is possible within the ideal growing season. The number of crops depends on a variety of factors such as availability of water and seasonal demand for fry, but generally three crops could be produced during the optimal season for fry production. Subsequent crops after the first will only incur operational costs and possible increased broodstock and broodstock feeding costs.

Table 11. The effect of fry selling price on breakeven production of fry (assumed over one year)

	Required Fry Production (not including pond construction)			**Required Fry Production** (including pond construction)		
Selling price (Kip)	**Type 1**	**Type 2**	**Type 3**	**Type 1**	**Type 2**	**Type 3**
20	14,585	28,885	69,885	57,935	72,235	113,235
30	9,723	19,257	46,590	38,623	48,157	75,490
50	5,834	11,554	27,954	23,174	28,894	45,294

Table 12. Potential production per crop (based on area of nursery ponds and hatchery equipment)

Survival from nursery ponds (%)	**All types**
10	**7,560**
20	**15,120**
30	**22,680**
50	**37,800**

The potential production figures listed in Table 12 have been conservatively estimated. Higher production figures are possible if careful attention is paid to pond and hatchery management. These values are however, what might be expected initially from hatcheries of this type. The values in Table 12 represent the production per crop and could be multiplied by 3 to give an estimate of annual production.

8.3 Small-scale hatcheries with increased investment

The hatchery types presented in this section are those types of hatcheries which are capable of relatively high levels of production of fry, but that require significantly increased levels of investment due to increased infrastructure. Principally the increased fixed costs are for the construction of cement tanks, better roofing structures, pumping and aeration.

Table 13. Fixed costs for increased investment small-scale hatcheries.

			Investment level			
			Medium		High	
Item	**Unit cost**	**Unit**	Number of items			
Orlon' upwelling hatching cone (80 litres)	10,000	each	3	5	6	9
Orlon' nursery cage (1,000 litres)	40,000	each	3	4	5	7
Blue net nursery hapas (20 sq. metres)	35,000	each	5	7	9	14
Cement tank (3 sq. metres)	250,000	each	2	3	4	6
Cement tank (12 sq. metres)	600,000	each	0	1	1	1
Pipework to tanks	50,000	total	1	2	4	8
Fittings (valves)	15,000	total	2	4	4	8
Roofing - thatch plus wood	50,000	total	0	0	0	0
Roofing – galvanised (8 sheets + wood)	300,000	total	1	2	2.5	3
Electric pump (small submersible)	150,000	each	1.5	2	2	3
5 hp Petrol pump (for emptying/ filling ponds)	500,000	each	1	1	1	1
Hoses for pump	50,000	set	1	1	1	1
Water powered generator (220V)	120,000	each	0	0	0	0
Aerator (compressor type, 220V)	300,000	each	0	1	1	1
Aerator (12 v)	50,000	each	1	0	0	0
Labour	60,000	w/m	4	12	24	36
Broodstock feed (3 kg/ kg of fish/year)	1,000	kg	96	144	192	288
Broodstock females	3,000	kg	16	24	32	48
Broodstock males	3,000	kg	16	24	32	48
Total fixed costs			**2,462,000**	**4,723,000**	**6,159,000**	**8,416,000**

Labour and broodstock maintenance have been included as fixed costs (Table 13) since they are incurred annually and not on a by-crop basis. For subsequent years these costs should be considered additional to the operational costs, whereas the equipment costs may be depreciated over 1 – 3 years.

Cement tanks can be written off over 3 – 5 years depending upon quality of construction. Earthen ponds will require periodic maintenance every two - three years.

The pond construction costs will vary according to construction method. These ponds have been calculated based on an excavation depth of 0.5 metres. The final depth of the pond would be expected to be 1.5 metres or more.

Table 14. Pond requirement and construction cost of increased investment hatcheries

		Investment level			
	Unit	**Medium**		**High**	
Area of Nursery ponds required	m^2	1512	2268	3024	4536
Area of Broodstock ponds	m^2	800	1200	1600	2400
Nursery pond	Kip	2,268,000	3,402,000	4,536,000	6,804,000
Broodstock pond	Kip	1,200,000	1,800,000	2,400,000	3,600,000
Cost of ponds		**3,468,000**	**5,202,000**	**6,936,000**	**10,404,000**

Table 15. Operational costs per crop for increased investment small-scale hatcheries.

			Investment level			
	Unit cost	**Unit**	**Medium**		**High**	
Hormones	3,000	dose	8	12	16	24
Rice bran	350	kg	69	103	137	205
Eggs	300	each	11	16	21	31
Pellet feed	3,000	kg	36	54	72	108
Pig/Chicken started feed	1,500	kg	35	52	69	103
Fuel for pump	800	litre	40	60	80	120
Lime	1,000	kg	61	91	121	182
Total operational costs			**304,950**	**455,850**	**606,750**	**909,550**

The operational costs per crop in these systems are very much increased due to the larger area of nursery ponds and the increased usage of fuel. If fuel is not used for pumping, then a similar electricity cost for pumping could be expected. Feed prices are over-estimated due to the inclusion of pellet feed. The use of pellet feed may not be necessary, however it has been included since fingerling sales may not be immediate and they may be required to be held for some time in blue net cages until sale. During this time they should be fed pellet feed. The increased size of the fish produced in this way would assure a sale price of over 40 Kip per piece and covers the additional feed cost. Intensive nursing in cages is only successful if water quality does not deteriorate. In this situation it is important to have some form of water flow and preferably additional aeration. It is only suitable for hatcheries with pumps and aeration, or those that are situated where there is a steady supply of flowing water (*e.g.* hillside stream).

Table 16. Break-even production of fry per crop at different fry prices

		Required Fry Production for Investment level			
	Selling price (Kip)	**Medium**		**High**	
Inclusive of pond construction cost (3 crops)	20	**114,081**	**188,209**	**248,588**	**359,144**
	30	**65,889**	**110,278**	**145,500**	**209,111**
	50	**39,533**	**66,167**	**87,300**	**125,467**
Not inclusive of pond construction cost (3 crops)	20	**56,281**	**101,509**	**132,988**	**185,744**
	30	**27,356**	**52,478**	**68,433**	**93,511**
	50	**16,413**	**31,487**	**41,060**	**56,107**

The cost of pond construction is not included in the hatchery fixed costs table and hence is considered separately since in some cases ponds have been previously constructed. For high investment type hatcheries, the nursery ponds and cement tanks are almost certainly not previously constructed and therefore the construction cost of the ponds should be considered in the overall economics of the operation.

The break-even production costs in Table 16 assume that the hatchery can produce and sell fingerlings from three production cycles during the year. Annual production of fingerlings can be obtained by multiplying the values in Table 16 by 3.

The level of investment required for hatcheries of this type would normally require a longer term loan (at least two years). It can be seen that provided survivals are consistently higher than 25 %and selling price remains higher than 30 Kip per piece, these hatcheries would achieve payback within three crops (*i.e*. one year). The annual production from these types of hatchery ranges between 100,000 to 1,400,000.

Since marketing the output from the largest of these hatcheries might be a problem in the short term, it is always advisable to start the farm as a small-scale operation, whilst allowing the potential for expansion should the market develop. Many hatcheries fail in the early stage of operation due to over-investment before the market develops sufficiently to support a hatchery of that size. The construction of too many ponds is a frequent problem therefore the hatchery layout can be planned, but construction may take place over several years.

Table 17. Potential production per crop based on investment level

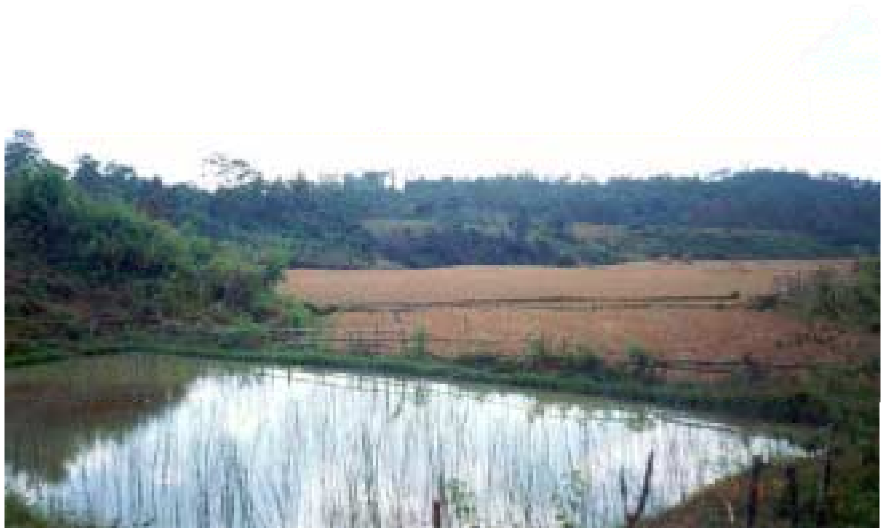
	Expected Production for Investment Level			
Survival from nursery ponds (%)	**Medium**		**High**	
10	30,240	45,360	60,480	90,720
20	60,480	90,720	120,960	181,440
30	90,720	136,080	181,440	272,160
50	151,200	226,800	302,400	453,600

The potential production figures presented in Table 17 may possibly be underestimated in cases where the hatchery has a good supply of water and good management. In other countries, production levels higher than this have been achieved, however the experience of the hatchery manager is a critical factor and skilled hatchery managers are uncommon in Lao PDR.

For annual potential production of fish fingerlings, multiply the values in Table 17 by 3.

Earth pond nurseries typically have an area of 100 - 1600 m^2, and should have a water depth of 1.5 metres. Nursery ponds in Lao PDR are often shallow (70 cm), but they can still be used to produce fish fry.

Figure 20. Earthen pond with clean banks and well fertilized water



7.2 'Orlon' cages

Earth ponds are difficult to keep free of predators, therefore it is sometimes better to keep the predators out using a cage. Holding the newly hatched fry in a cage made of 'Orlon' will prevent predators from eating the fry and also prevent the fry from escaping. The cage is usually 1 x 2 m and 60 cm deep.

Fry cultured in 'Orlon' cages must be fed since the natural food in the pond will be unavailable. Feeding starts approximately 1 -2 days after the fry hatch. After the fry have grown they can be transferred to an earth pond or to a larger cage made of blue netting. Some water exchange may be necessary since the oxygen levels in the cage can become low. Uneaten food in the cage will breakdown releasing toxic products and these must be flushed out using water exchange.

If no water pump or flowing water is available, water exchange can be performed manually before feeding the fry. The water should be screened to prevent the entry of predators from the pond water.

Fry cannot be cultured for longer than one week in the cage because they will suffer from nutritional deficiency and high mortality because of polluted water and oxygen deficiency; unless water can be pumped into the cage from the pond

7.3 Blue net cage

Once fry are large enough not to escape through blue netting (about 2 - 3 weeks after hatching) , they can be cultured in cages made of this material. The advantage of fry culture in cages is that they do not suffer from predation from larger fish, frogs or large water insects. The fish need to be fed more than if they were cultured in the pond, but the high survival will compensate for the extra cost of the feed.

Figure 21. Blue net cage 4 x 5 metres (1 metre deep)

If water can be supplied to the cage this will increase aeration and remove waste products. This will allow higher densities of fry to be cultured than is otherwise possible without water flow.

- Blue net cage (4 x 5 m) without water supply - stock 2,000 fry (>2 weeks old)
- Blue net cage (4 x 5 m) with water supply - stock 5,000 to 10,000 fry (>2 weeks old)

The fish should be fed pig or chicken starter feed mixed with soft rice bran to ensure that they obtain sufficient food and grow well.

7.4 Cement tanks

Cement tanks are easily controlled since they are above ground and can be drained and dried. When cement tanks are filled the water can be screened to exclude unwanted predators. It is important to shade cement tanks from direct sunlight because they will become too hot and this can kill the fish fry.

Cement tanks cost more money to construct but they can be used for many years. Cement tanks also require some form of water delivery system to fill the tanks. If water is held in a reservoir pond higher than the cement tank, then water can be supplied by gravity. If the water supply is at the same level or lower than the cement tank, this means that a water pump is needed to fill the tanks and to exchange water.

It is important that newly constructed cement tanks are soaked for 2 weeks before use so that the new cement is weathered completely. If green algae is seen growing in the cement tank, this is a good indication that the weathering is complete and fry can be nursed in the tank.

Before stocking the fry, fill the tank with clean water to a depth of about 20 - 30 cm. The fry will not need to be fed immediately after stocking since they still have a yolk sac. *Puntius* fry will start feeding after approximately 24 hours and so boiled egg yolk must be prepared beforehand (feeding rates for different species are given in Table 6).

Uneaten feed will decompose in the tank and foul the water quickly, so some form of water exchange is necessary to prevent waste accumulation and subsequent problems with bacteria and ammonia build-up.

The cement tanks also need some form of aeration - either from an aerator, or by spraying water into the tank. Without aeration stocking rates that can be used in cement tanks are usually lower than those that can be used in earth ponds as can be seen for Table 6.

7.5 Stocking rates for fry in nursery systems

The stocking density for fry depends upon the fish species used and the type of nursery system. The table below indicates recommended stocking densities for young fry (approximately 1 week old) of the different species commonly cultured in southeast Asia. The values given for the earth pond assume a depth of more than 80 cm for the nursery pond. Values for the cement tank and net cage assume that the water depth in the tank and cage are greater than 50 cm.

Table 6. Stocking densities for different fish species in two types of nursery system

Species	Earth pond (pieces / m^2)	Cement tank / blue net cage (pieces / m^2)
Common silver barb	500	250
Common carp	190	150
Rohu, Mrigal	250	100
Grass carp Silver carp, Bighead carp	250	100
Tilapia	190	200
Snakeskin gouramy, Giant gouramy	130	50
Snakehead, Climbing perch	190	300
Catfish (all spp.)	310	3,500
Sand goby	63	100

Fish fry can be held at these densities for up to 1 month or until they reach a size of 2 - 3 cm. After this size the densities should be reduced since competition for food and space will increase rapidly and the growth rate and survival of the fry will deteriorate. Once the fry reach 2 - 3 cm then intensive nursing in net cages is an option if flowing water and aeration is available.

7.6 Feeding of fry in nursery ponds and tanks

The types of feed used in nursery culture of fish depends upon the feed available. It is important that the feed given to the fish fry is of a size that can be ingested. If the particle size of the feed is too large the fish fry will starve, even though sufficient feed may be applied.

Boiled egg yolks

A common starter feed for fish fry is boiled egg yolk. This is prepared by boiling eggs and removing the hardened yolk. The yolk is mashed with a small amount of water until it forms a paste. This past is then rubbed through several layers of 'Orlon' cloth to obtain the small particles required for newly feeding fish fry. The resulting suspension will have the appearance of milk. Some more water is added to the egg yolk so that it is easy to handle and the suspension is poured around the tank, cage or pond. In larger ponds care must be taken to get the egg suspension further from the pond bank, in this situation some form of sprayer maybe used.

Rice bran

Soft rice bran is a suitable early feed for young herbivorous feed after they have been nursed for approximately 7 days on egg yolk. Rice bran is readily available, but care must be taken to ensure that the bran is soft bran and does not contain a high proportion of husk. Sieving the bran is advisable so that the particle sizes are small enough for the fish to ingest and a single layer of 'Orlon' cloth is suitable for this.

Chicken and pig starter feed

Starter feed are excellent for fish fry feeding if they are ground to an appropriate size. Usually starter feeds are coarse since they are intended to chicks or piglets and it may be necessary to pound the feed to reduce the particle size. A single layer of 'Orlon' cloth can be used to sieve the particles so they are of the appropriate size. Starter feeds are available in Lao PDR, but are quite expensive, however the amount of feed required is low and its' cost is low when compared to the income from the sale of the fingerlings produced.

Catfish Pellet

This feed is excellent due to its high protein content. It should be ground and sieved as for starter feeds and rice bran. The cost and availability of this feed limits its use in Lao PDR. Other fish feeds could be used as a substitute, but tend to have lower protein contents.

Table 7. Nursery requirements for herbivorous fish using different culture systems.

Age (days)	Tank/cage/pond	Feed		Water exchange	Aeration	Comments
		Type	Amount			
0 – 2	Orlon net cage (2 - 3 m^2) Cement tank (2 - 8 m^2)	Fry do not feed (still using yolk sac)	-	Flow water continuously or change 10 - 20 cm/ day	Use air pump or spray water	Requires a roof to shade from direct sunlight
3 - 6	Orlon net cage (2 - 3 m^2) Cement tank (2 - 8 m^2)	Boiled egg yolk *Moina*, zooplankton	1 egg yolk / 200,000 fry/day Feeding 3-4 times /day	As above	As above	As above
7 - 14	Earth pond (100 - 400 m^2)	Mixed feed, 2:1 ratio. (soft rice bran : pig/chicken starter feed) Catfish feed is excellent if available.	1 kg/ 400,000 fry/ day. Fry are fed 2-3 times/ day	-	-	Water depth in pond should be 50 -80 cm
15 - 25	Earth pond (100 - 400 m^2) Blue net cage (10-20 m^2)	As above	2 kg / day spread around the whole pond (pond 400 m^2). 100 g / day for net cage (1 sardine can/day)	Maintain water level in pond Flowing water into cage will increase survival (clean net regularly)	-	Water depth should be 1 metre. Stocking density in cage 5,000 - 10,000 (20 square metres)
26 - 50	Blue net cage (10-20 m^2) Earth pond (50 - 400 m^2)	As above	1 kg./day per 100,000 fry of size 2 - 3 cm. Fish are fed 2 times per day	Use piped water to spray into cage. This will increase oxygen and keep good water quality.	Use air pump or spray water	Fish fry can be held at high density if water flow is good and feed is supplied.

7.7 Nursery requirements for carnivorous fish species.

Carnivorous fish are cultured rarely in Lao PDR due to their requirement for high protein diets. There are some examples of cage culture of carnivorous fish in reservoirs (Giant snakehead - *Channa micropeltes*), but the fry for this is currently wild caught. Small catfish farms do exist also, but the low price for cultured catfish relative to wild caught catfish currently limits its profitability.

- Carnivorous fish fry are fed *Moina* or *Artemia* at the rate of 12- 15 kg/ rai / day (7 - 10 g/m^2) for the first seven days after stocking. Fry can be cultured in earth ponds or concrete tanks. Supplemental feed can be used and this is usually boiled egg yolks liquidised with water, which are fed at a rate of 10 eggs per rai (1 egg / 160 m^2). The emulsion of egg yolk is sprayed around the edges of the pond.

- Finely mashed fish mixed with water can also be used at a rate of 3 - 5 kg / rai / day (2 - 3 g/m^2 /day) for the first 5 - 7 days. Fry are fed twice a day, morning and evening.

- 7 days after stocking fry are fed finely chopped fish at a rate of 5 kg/rai /day (3 g/m^2 /day) for a further 3 days.

- 10 days after stocking floating catfish starter feed should be used. The feed should be soaked before feeding to soften the pellets.

    - For a 1 rai pond (1600 m^2) containing 500,000 fish fry, feed 3 times a day at a rate of 5 kg / time.
    - For a 100m^2 pond, containing 30,000 fry, feed 3 times daily with 0.3 kg / time
    - This rate should be maintained for 3 weeks.

(Note: 1 rai is equivalent to 1600 m^2, *e.g.* a pond 40 m x 40 m)

CHAPTER 8 - ECONOMICS OF SMALL-SCALE HATCHERY OPERATION

The types of hatchery appropriate for extension in Lao PDR differ greatly depending upon local conditions. Typically, small farmers are unwilling to invest money in a small- scale hatchery unless they have had evidence of the success of such an operation. This usually means somebody locally who was in a similar situation and was successful. Even with the evidence that such a hatchery would be profitable, many farmers are still unwilling to commit finances to invest in cement tank and pond construction.

Farmers can be introduced to small-scale hatchery techniques gradually, starting with a low cost hapa-based method (i.e. 'Orlon' and blue net cages suspended in a pond), followed by gradual up-scaling to methods that employ flowing water and possibly even pumping.

The choice of species produced by the farmers should also reflect the type of operation. Typically, hapa-based methods favour species such as Common carp and Tilapia. If spawning hormones are made available, the production of other species is also possible using these simple methods (especially Common silver barb)

The ultimate goal of this is to take farmers beyond simply producing fish fingerlings for their own purposes to actively selling them as a commercial enterprise. Until this happens, the shortage of fry for both pond and rice-fish culture will continue to constrain Lao aquaculture.

The economic breakdowns that are presented in this chapter demonstrate:

- The investment required for different types of hatcheries
- The effect of different survival rates (10 — 50 %) on potential production per crop.
- The effect of fish sale price variation (10 — 50 Kip)
- Breakeven fish production for different types of hatcheries

These economic breakdowns can also serve as an approximate guide to the investment required to establish a fish hatchery depending upon the required production. Economic indicators (e.g. Internal Rate of Return, Net Present Value) have not been included since these have little meaning to many small-scale hatchery entrepreneurs. In most cases small hatcheries are constructed on the basis of payback within the first year or two, hence the calculations are presented to reflect this. Most farmers are unwilling to borrow or invest for periods over two years since this presents an unacceptable degree of uncertainty (i.e. risk).

At the time of writing , these values are based in Kip and the exchange rate is $1 equivalent to 3,500 Kip.

8.1 Marketing

Important note:

The economic projections provided here assume that the fingerlings produced by a hatchery are marketed soon after they are produced.

A potential problem for some locations is that farmers only purchase a small numbers of fingerlings and thus the hatchery must hold the fingerlings for periods longer than may be economically feasible. In this respect the timing and marketing of fish production must be well established before investment in a hatchery. Most hatcheries will have problems marketing their fry until sufficient numbers of farmers know of their location. This may take more than one year and in this respect credit provision for hatcheries may require longer than one-year payback periods.

Fry price is currently 30 — 50 Kip per piece and this is unlikely to reduce in the near future. As previously mentioned, the constraint of a hatchery producing large numbers of fry is the eventual marketing of the production. In this respect hatcheries should also be located near to an area where demand for fingerlings is high (e.g. for rice fish culture or fish ponds). It may be necessary to lower the price of the fish fingerlings in order to sell sufficient quantities.

In interviews with fish farmers in Lao PDR it is often mentioned that they require fry to be delivered to their village — in this respect the transportation by the hatchery may be crucial in ensuring sales. Visiting villages which grow fish and taking orders is one method for selling larger quantities. In areas with good road access, fingerlings are carried along the road and are sold in each village along the route.

8.2 Minimal input small-scale hatcheries

This type of hatchery represents the lowest level of inputs for hatchery, ponds and equipment. It is thus the type of small-scale hatchery that would suit a small farmer operation that was producing fry for sale.

Operations smaller than this are not considered here, since the investment required is below that at which credit would be required to construct the hatchery. Typically, smaller operations would also be unlikely to produce a fry surplus for sale, therefore would not constitute an income generating activity. This type of hatchery would only require the net cage components and self-constructed ponds.

The table below gives the investment and returns expected from three different types of minimal input hatchery : The three hatchery types are distinguished by their different sources of water and electricity. These are:

- Type 1 - The water supply is under gravity and thus represents a site that is fed by a small stream, irrigation canal, or pond/reservoir that is higher than the hatchery site.
- Type 2 - Again, water may be supplied under gravity to the hatchery or flowing water is present nearby. This water is used to power a small generator of the type that is readily available in Lao PDR (Chinese construction). The pump is used to pressurize water in the hatchery, or provide aeration etc. (the cost of these additional components have not been included here).
- Type 3 — This hatchery has an electricity supply that is use to power an electrical pump for the hatchery. This hatchery also has a 5hp petrol water pump for filling and emptying ponds.

All three types of hatchery have the same nursery and broodstock pond areas. The difference between the types is related to investment cost and potential production levels.

From Table 8 the fixed costs of net cages, tanks and equipment for the three types of hatchery range between 243,000 — 1,333,000 Kip. Labour is not included as it is assumed that there is no hired labour on a hatchery of this scale. Pond construction costs are considered separately (Table 9) since in many cases small-scale hatcheries already have ponds. The cost of pond construction is often a considerable deterrent to farmers starting fish fry production, therefore attention for small-scale hatchery development in Lao PDR is initially directed at farmers with existing ponds.

Where water is supplied by gravity there may be no need for pumping since water can be pressurised to the hatchery. Often, hatcheries and fish ponds are not located lower than the water supply and thus some form of pumping is required. In the case of hatcheries relying on rainwater, pumping is always necessary. This type of situation usually requires electricity nearby, or a petrol driven water pump. In this case, the reservoir for water for the hatchery needs to be large.

Table 8. Fixed costs for hatchery construction and equipment

Item	Unit cost	Unit	Type 1 water flow	Type 2 generator	Type 3 electricity
			Number of items		
Orion upwelling hatching cone (80 litres)	10,000	each	1	1	1
Orion' nursery cage (1,000 litres)	40,000	each	1	1	1
Blue net nursery hapas (20 m	35,000	each	2	2	2
Cement tank (3 m	250,000	each	0	0	1
Pipework to tanks or cages	50,000	total	0.5	0.5	1
Fittings (valves)	15,000	total	0	0	1
Roofing - thatch plus wood	50,000	section	1	1	2
Electric pump (small submersible)	150,000	each	0	1	1
5 hp Petrol pump (for emptying/filling ponds)	500,000	each	0	0	1
Hoses for pump	50,000	set	0	0	1
Water powered generator (220V)	120,000	each	0	1	0
Aerator (12 v)	50,000	each	0	0	1
Broodstock feed (3 kg/ kg of fish/year)	1,000	kg	24	24	24
Broodstock females	3,000	kg	4	4	4
Broodstock males	3,000	kg	4	4	4
Total fixed costs			243,000	513,000	1,333,000

Table 9. Pond requirement and construction cost

Pond Type	Pond Area (m^2)	Pond Construction (Kip)
Nursery	378	567,000
Broodstock	200	300,000
Total		**867,000**

The operational costs listed in Table 10 concern those costs incurred for the preparation and feeding of nursery cages and ponds. These costs are related to the nursery pond area and also to the fuel usage for pond draining and filling.

The greater degree of flexibility in management that could be achieved by the use of pumps will be reflected in higher production rates. This is due to higher survival in the hatchery because of better water quality and aeration and pumping. In many cases the inputs such as rice bran are also derived from rice production activities of the farmer and this can reduce operational costs. In all three cases the cost of manure for fertilisation is not included as it is assumed to be available to the farmers at an opportunity cost of collection. Chemical fertilisers can be used and must be added to the operational cost.

Table 10. Operational costs for minimal input hatcheries (per crop)

	Unit cost	Unit	Type 1 water flow	Type 2 generator	Type 3 electricity
			Number of items		
Hormones	3,000	dose	4	4	4
Rice bran	350	kg	18	18	18
Eggs	300	each	3	3	3
Pellet feed	3,000	kg	0	0	0
Pig/Chicken starter feed	1,500	kg	9	9	9
Fuel for pump	800	litre	0	20	20
Lime	1,000	kg	16	16	16
Total operational costs (Kip)			**48,700**	**64,700**	**64,700**

The breakeven production of fry required to cover the fixed costs and one crop of fry is presented in Table 11. This clearly shows that these types of hatcheries can pay back within one to three crops, providing fry price remains higher than 20 Kip per piece and the survival from the nursery pond is greater than 20%. Low survivals in nursery ponds are encountered in Lao PDR as a result of poor pond preparation, poor water quality and inadequate feeding. Using the equipment listed above, survivals higher than 10% should be consistently achieved.

It is important to note that more than one crop is possible within the ideal growing season. The number of crops depends on a variety of factors such as availability of water and seasonal demand for fry, but generally three crops could be produced during the optimal season for fry production. Subsequent crops after the first will only incur operational costs and possible increased broodstock and broodstock feeding costs.

Table 11. The effect of fry selling price on breakeven production of fry (assumed over one year)

	Required Fry Production (not including pond construction)			**Required Fry Production** (including pond construction)		
Selling price (Kip)	**Type 1**	**Type 2**	**Type 3**	**Type 1**	**Type 2**	**Type 3**
20	14,585	28,885	69,885	57,935	72,235	113,235
30	9,723	19,257	46,590	38,623	48,157	75,490
50	5,834	11,554	27,954	23,174	28,894	45,294

Table 12. Potential production per crop (based on area of nursery ponds and hatchery equipment)

Survival from nursery ponds (%)	**All types**
10	**7,560**
20	**22,680**
30	**15,120**
50	**37,800**

The potential production figures listed in Table 12 have been conservatively estimated. Higher production figures are possible if careful attention is paid to pond and hatchery management. These values are however, what might be expected initially from hatcheries of this type. The values in Table 12 represent the production per crop and could be multiplied by 3 to give an estimate of annual production.

8.3 Small-scale hatcheries with increased investment

The hatchery types presented in this section are those types of hatcheries which are capable of relatively high levels of production of fry, but that require significantly increased levels of investment due to increased infrastructure. Principally the increased fixed costs are for the construction of cement tanks, better roofing structures, pumping and aeration.

Table 13. Fixed costs for increased investment small-scale hatcheries.

	Unit cost	Unit	Investment level			
			Medium		High	
Item			Number of items			
Orion' upwelling hatching cone (80 litres)	10,000	each	3	5	6	9
Orion' nursery cage (1,000 litres)	40,000	each	3	4	5	7
Blue net nursery hapas (20 sq. metres)	35,000	each	5	7	9	14
Cement tank (3 sq. metres)	250,000	each	2	3	4	6
Cement tank (12 sq. metres)	600,000	each	0	1	1	1
Pipework to tanks	50,000	total	1	2	4	8
Fittings (valves)	15,000	total	2	4	4	8
Roofing - thatch plus wood	50,000	total	0	0	0	0
Roofing — galvanised (8 sheets + wood)	300,000	total	1	2	2.5	3
Electric pump (small submersible)	150,000	each	1.5	2	2	3
5 hp Petrol pump (for emptying! filling ponds)	500,000	each	1	1	1	1
Hoses for pump	50,000	set	1	1	1	1
Water powered generator (220V)	120,000	each	0	0	0	0
Aerator (compressor type, 220V)	300,000	each	0	1	1	1
Aerator (12 v)	50,000	each	1	0	0	0
Labour	60,000	wlm	4	12	24	36
Broodstock feed (3 kg! kg c fish/year)	1,000	kg	96	144	192	288
Broodstock females	3,000	kg	16	24	32	48
Broodstock males	3,000	kg	16	24	32	48
Total fixed costs			**2,462,000**	**4,723,000**	**6,159,000**	**8,416,000**

Labour and broodstock maintenance have been included as fixed costs (Table 13) since they are incurred annually and not on a by-crop basis. For subsequent years these costs should be considered additional to the operational costs, whereas the equipment costs may be depreciated over 1 — 3 years.

Cement tanks can be written off over 3 — 5 years depending upon quality of construction. Earthen ponds will require periodic maintenance every two - three years.

The pond construction costs will vary according to construction method. These ponds have been calculated based on an excavation depth of 0.5 metres. The final depth of the pond would be expected to be 1.5 metres or more.

Table 14. Pond requirement and construction cost of increased in vestment hatcheries

		Investment level			
		Medium		High	
Area of Nursery ponds required	m^2	1512	2268	3024	4536
Area of Broodstock ponds	m^2	800	1200	1600	2400
Nursery pond	Kip	2268,000	3,402,000	4,536,000	6,804,000
Broodstock pond	Kip	1,200,000	1,800,000	2,400,000	3,600,000
Cost of ponds		**3,468,000**	**5,202,000**	**6,936,000**	**10,404,000**

Table 15. Operational costs per crop for increased investment small-scale hatcheries. Investment level

			Investment level			
			Medium		High	
Hormones	3,000	dose	8	12	16	24
Rice bran	350	kg	69	103	137	205
Eggs	300	each	11	16	21	31
Pellet feed	3,000	kg	36	54	72	108
Pig/Chicken started feed	1,500	kg	35	52	69	103
Fuel for pump	800	litre	40	60	80	120
Lime	1,000	kg	61	91	121	182
Total operational costs			**304,950**	**455,850**	**606,750**	**909,550**

The operational costs per crop in these systems are very much increased due to the larger area of nursery ponds and the increased usage of fuel. If fuel is not used for pumping, then a similar electricity cost for pumping could be expected. Feed prices are over-estimated due to the inclusion of pellet feed. The use of pellet feed may not be necessary, however it has been included since fingerling sales may not be immediate and they may be required to be held for some time in blue net cages until sale. During this time they should be fed pellet feed. The increased size of the fish produced in this way would assure a sale price of over 40 Kip per piece and covers the additional feed cost. Intensive nursing in cages is only successful if water quality does not deteriorate. In this situation it is important to have some form of water flow and preferably additional aeration. It is only suitable for hatcheries with pumps and aeration, or those that are situated where there is a steady supply of flowing water (e.g. hillside stream).

Table 16. Break-even production of fry per crop at different fry prices

Inclusive of pond construction cost (3 crops)

Required Fry Production for Investment level				
Selling price (Kip)	Medium		High	
20	114,081	188,209	248,588	359,144
30	65,889	110,278	145,500	209,111
50	39,533	66,167	87,300	125,467

Not Inclusive of pond construction cost (3 crops)

Required Fry Production for Investment level				
Selling price (Kip)	Medium		High	
20	56,281	101,509	132,988	185,744
30	27,356	52,478	68,433	93,511
50	16,413	31,487	41,060	56,107

The cost of pond construction is not included in the hatchery fixed costs table and hence is considered separately since in some cases ponds have been previously constructed. For high investment type hatcheries, the nursery ponds and cement tanks are almost certainly not previously constructed and therefore the construction cost of the ponds should be considered in the overall economics of the operation.

The break-even production costs in Table 16 assume that the hatchery can produce and sell fingerlings from three production cycles during the year. Annual production of fingerlings can be obtained by multiplying the values in Table 16 by 3.

The level of investment required for hatcheries of this type would normally require a longer term loan (at least two years). It can be seen that provided survivals are consistently higher than 25 %and selling price remains higher than 30 Kip per piece, these hatcheries would achieve payback within three crops (i.e. one year). The annual production from these types of hatchery ranges between 100,000 to 1,400,000.

Since marketing the output from the largest of these hatcheries might be a problem in the short term, it is always advisable to start the farm as a small-scale operation, whilst allowing the potential for expansion should the market develop. Many hatcheries fail in the early stage of operation due to over-investment before the market develops sufficiently to support a hatchery of that size. The construction of too many ponds is a frequent problem therefore the hatchery layout can be planned, but construction may take place over several years.

Table 17. Potential production per crop based on investment level

Survival from nursery ponds (%)	Expected Production for Investment Level			
	Medium		High	
10	30,240	45,360	60,480	90,720
20	60,480	90,720	120,960	181,440
30	90,720	136,080	181,440	272,160
50	151,200	226,800	302,400	453,600

The potential production figures presented in Table 17 may possibly be underestimated in cases where the hatchery has a good supply of water and good management. In other countries, production levels higher than this have been achieved, however the experience of the hatchery manager is a critical factor and skilled hatchery managers are uncommon in Lao PDR.

For annual potential production of fish fingerlings, multiply the values in Table 17 by 3.

The following documents have been produced by LAO/97/007. STS Field Documents:

No. 1 Mini-Hatchery Development

No. 2 Socio-economics and Gender in Aquaculture (English version)

No. 2L Socio-economics and Gender in Aquaculture (Lao version)

No. 3 Small-Scale Fish Hatcheries for Lao PDR (English version)

No. 3L Small-Scale Fish Hatcheries for Lao PDR (Lao version)

Project Field Documents:

No. 1 Government Fish Fry Production Facilities in Lao P.D.R. (December 1997)

No. 2 Current Production Constraints and Suggested Improvements at Nongteng Fish Seed Station, Vientiane, Lao P.D.R.

No. 3 Timetable of Project Activities 1998

No. 4 Proposed Strategy for Extension of Aquacultiire to Farmers Groups

No. 5 Comments on Proposed Fish Hatchery/Seed Station at Hooay Keeow, Lamam District, Sekong Province

No. 6 Introduction to the Provincial Aquaculture Development Project - Potential for Collaboration and Co-ordination

No. 7 Training Notes for Workshop on Fish Culture Extension (Oudomxay and Savannakhet, March 1998) (English version)

No. 7L Training Notes for Workshop on Fish Culture Extension (Oudomxay and Savannakhet, March 1998) (Lao version)