A Preliminary Study of the Costs of Operating a Lobster Hatchery in Orkney and the Development of an Economic Model for Future Hatchery Programmes

C A Burton & K Adamson

SUMMARY

The operation and cost structure of the lobster hatchery run in Orkney by the Orkney Fisheries Association has been examined in detail. The facility was constructed and operated on minimal expenditure and probably represented the lowest level of investment possible for such an enterprise. With an output of approximately 30 000 juveniles per year (at stage VIII), the full production cost per juvenile from the hatchery was calculated to be £ 0.64, although the cost based on operating expenditure alone was £ 0.46

The expansion of the hatchery to a production capacity of 100 000 juveniles per annum (at stage VIII) was modelled and costed. To accommodate the extra output, it was found that the larval and on-growing facilities required expansion. With re-organisation and maximal utilisation of the space available, the expansion required very little additional floor area. Assuming that the investment and operating costs could be kept to a minimum the projected cost per juvenile (at stage VIII) decreased to £ 0.30.

Using data from the Orkney hatchery together with that from other sources, a preliminary 'generic' model of a generalised hatchery operation was constructed. In its present form, the resultant model is a useful indicator of lobster hatchery economics, but it does not replace the requirement for detailed project planning and costings for specific developments.

To illustrate the economics of operating a hatchery, the model has been used to derive production costs for different operational or investment scenarios. It suggested that, for a hatchery with a designed output of 100 000 juveniles per year at stage VIII, the 'typical' production cost per juvenile would be approximately £ 0.68, but that this could vary between £ 0.45 - £ 1.02 depending upon whether a 'least cost' or a 'high cost' scenario was used.

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1. INTRODUCTION

As part of the UK Lobster Stock Enhancement programme, the Sea Fish Industry Authority (Seafish) conducted a series of juvenile lobster (*Homarus gammarus*) releases in Scapa Flow, Orkney. Hatchery operations and the results of the different trials have been summarised in several reports and articles (Burton 1992, Beard & Wickins 1992, Bannister *et al* 1994, Burton 1994, Anon 1995, Cook 1995, Burton 1999, Burton *in press*).

The positive results from the scientific trials led an Orkney company, North Isles Shellfish (NISF), to begin their own hatchery experiments at a site on Lambholm in the late 1980s. Gradually, they developed their system and evolved a reliable methodology.

In 1994, the hatchery was expanded with assistance from the Orkney Fisheries Association (OFA), Orkney Islands Council and Orkney Enterprise. A larger-scale stocking programme was begun at this time. The Fisheries Association initially took responsibility for the funding and management of the hatchery whilst NISF continued to provide the physical site, infrastructure and staff. Recently, the Fisheries Association has assumed full control of the operation.

It was acknowledged that the production cost of £1.12 - £1.25 per animal calculated from the scientific trials was too high to be economic, and the long-held view was that reducing the cost of each juvenile lobster released was a key step in the development of stocking programmes. By late 1997, the Orkney hatchery was reporting that its unit cost per juvenile released at stage VIII was £0.30 (Coghill 1997).

A second phase of expansion in Orkney began in 1998 with the proposal to build an additional hatchery in Stromness. As part of this programme, Seafish, in collaboration with OFA and with the co-operation of NISF, began an examination of the cost structure of the hatchery.

The objective was to use the data generated to model the costs associated with a hatchery capable of producing 100 000 juveniles per year for release on a year-round basis. It should be noted that the figures used in this report have been simplified for illustrative purposes and should only be used as a general guide to likely investment and returns.

2. THE ORKNEY FISHERIES ASSOCIATION HATCHERY ON LAMBHOLM

The lobster hatchery on Lambholm is situated in a disused quarry. Seawater is drawn from intakes in Scapa Flow and discharged on the other side of the Churchill Barrier into the North Sea. At the time of the study, the hatchery occupied two buildings; an extension to an existing building and a completely new structure, although this arrangement has since been modified. Also on the site is a facility for the pond storage of shellfish and a large open-air seawater pond.

The hatchery comprised 3 areas; broodstock, larval rearing and on-growing. The layout of the buildings is shown in fig 1.

The facility was staffed by two part-time operatives with others recruited from the NISF workforce, as required, at peak times. At all times, the employee's principle concern was the smooth running of the shellfish merchanting operation; the hatchery work was secondary and had to take place around this requirement. Consequently, the emphasis was on performing the minimum work necessary to produce the maximum number of juveniles of the best possible quality.

Freeze-dried krill, which is available commercially for the aquarist trade, was used as the food source for all hatchery stages. There was no dietary supplementation. The berried females were feed on processing waste (scallop offal, crab legs, fish trimmings etc) produced by the commercial activities.

Broodstock were selected from the locally caught animals held in the commercial ponds.

3. COST STRUCTURES

Costings were assembled by examining records and through interview. For clarity, the different components of the overall cost structure are considered individually.

3.1 Capital expenditure

These outlays were derived from records and include the costs of converting or extending existing buildings or constructing new facilities, together with the associated costs of fitting out which includes direct labour costs.

Category		Broodstock	Hatchery	On-growing	General
		£	£	£	£
Building		4 000	6 000	5 000	
Pipework		1 000	1 200	500	
Electrics		200	300	500	
Stands		300	100	600	
Tanks		576	880	6 000	
Heaters etc		70	140	70	
Filters	Biological	600	1 200	600	
	UV	150	300		
	Canister	25	50	50	
Aerators		250	500		
Containers				5 600	
Covers				100	
Powerwasher					300
Generator					500
pH meter					300
O_2 meter					500
Total		**7 171**	**10 670**	**19 020**	**1 600**

The total capital cost of the hatchery, as described, was £ 38 461.

3.2 Running costs

These are expenses incurred on an annual basis and represent the costs of operating the facility. At the present time, the hatchery has not identified any marketing or other costs associated with the sale of juveniles, consequently none are shown below.

3.2.1 Rent, Rates etc

Apportioning the total site cost by the floor area occupied by the facility provided the cost of rent and rates for the hatchery. This was estimated at 3% of the total, producing an annual cost of approximately £ 3 000.

3.2.2 Repairs and renewals

Each year, it is necessary to maintain the fabric of the buildings and replace or repair items of worn-out equipment. It is also prudent to include an allowance to cover the cost of replacing equipment which may have a life of several years before renewal is necessary. In this case, the charge included was taken as the replacement cost divided by the expected life in years (eg. replacement cost £ 1 000, life expectancy 5 years, charge = 1 000 ÷ 5 = £ 200 per annum).

Category	**Broodstock**	**Hatchery**	**On-growing**	**General**
	£	£	£	£
Buildings	100	300	175	
Equipment	100	200	100	250
Total	**200**	**500**	**275**	**250**

Thus, the total budget for repairs and renewals was £ 1 225.

3.2.3 Consumables

These are items which are used on an annual basis and have been taken to include feed costs in this case.

Category	**Broodstock**	**Hatchery**	**On-growing**	**General**
	£	£	£	£
Food	0	80	1 100	
Filter materials	325	650	450	
Mesh				200
Nets etc				30
Thermometers				50
Cleaning				40
Chemicals etc				300
Miscellaneous				700
Total	**325**	**730**	**1 550**	**1 320**

The total cost of consumables was £ 3 925.

3.2.4 Power

The power usage associated with the different activities in the three main areas and within the general facility was calculated and costed. The figures represent the costs of the electricity supplied to the hatchery at the tariff applied by the electricity company to businesses of that size in Orkney for 1998/99, which was £ 0.07 kWh^{-1}.

Category	**Broodstock**	**Hatchery**	**On-growing**	**General**
	£	£	£	£
Heat	80	800	800	
Light	40	230	80	
Pumps	50	60	130	
Aeration	40	80		
Miscellaneous				400
Total	**210**	**1 170**	**1 010**	**400**

Total power costs were £ 2 790.

3.2.5 Labour

The facility operates year-round, aiming for continuous production and release. However, there is a seasonal peak in production during the summer. Records were kept of the labour input each month throughout the year. However, costs were not allocated by activity at this stage. The figures below have been rounded for clarity. Labour regardless of task has been calculated at £5 per hour gross.

Month	Man-hours	Cost (£)
May	82	410
June	137	680
July	236	1 180
August	170*	850
September	202	1 010
October	151	760
November	102	510
December	65	320
January	72	360
February	53	270
March	53	270
April	107	530
Total	**1 430**	**7 150**

* This figure was lower than expected due to operational constraints. The budgeted figure was 240 man-hours.

Had the labour input been at the budgeted figure of 1500 man-hours, the total cost would have been £ 7 500.

4. JUVENILE PRODUCTION

4.1 Total production

For the year 1998/99 the hatchery produced a total of 30 149 juveniles at stage VIII.

4.2 Release numbers

The numbers of juveniles released in Orkney each year were recorded by the hatchery, together with the number of animals in each batch and the number of sites seeded. The detail of the releases is reproduced below.

Year	N° Releases	N° Sites	N° Released	Stage	Batch size
1996/97		17	11 600	VI - VIII	400 - 1 000
1997/98	16	12	9 260	VIII	650 - 810
1998/99	26	21	20 429	VIII	600 - 950

5. COST PER JUVENILE

The quoted costs per juvenile which have appeared in the press were calculated solely from the annual direct running costs and production figures. Thus, for 1998/99, the reported operating cost was £11 000 and total juvenile production was 30 149, giving a cost per juvenile of £0.36. However, the reported operating cost incorporated income from the sale of juveniles and income from other sources to defray part of the running costs.

For accuracy, the production cost per juvenile should be calculated from the total costs of operating the hatchery without any allowance for income from sales or other sources. Thus, following their example, the cost per juvenile produced can be recalculated using 1998/99 production figures and accumulated direct running costs from the preceding sections:

Juvenile production	30 149
Hatchery costs (£)	13 865
Cost per juvenile (£)	0.46

Closer examination revealed that two items budgeted for had been excluded from the hatchery cost calculations; these were for ‘rent/rates’ and ‘repairs & renewals’. Incorporating those costs increased the overall hatchery operating budget to £ 18 090 and the cost per juvenile to £ 0.60.

There remained one final element to be incorporated into the hatchery cost calculation: the capital cost of the hatchery. At its simplest, the total capital cost can be divided by the expected life of the hatchery to produce a nominal annual charge (depreciation), which can be added to the yearly hatchery operating costs to give a total annual cost. For the purposes of this report, the operational life of the hatchery was taken to be 30 years.

In this example a capital cost of £ 38 461 depreciated over a 30 year period produces an annual charge of £ 1 281. Adding this to the £ 18 090 operating budget produced a total annual cost of operating the hatchery of £ 19 371. In which case, the cost per juvenile produced from the hatchery was £ 0.64.

Based upon the above simplistic calculations, it was apparent that the true cost per juvenile produced lay between £ 0.46 (based on actual spend) and £ 0.64 (fully costed). Both estimates are in line with current analyses (Wickins & Lee, 2002), but the hatchery operators report that they expect to be able to reduce the costs per juvenile further as they gain more experience with greater numbers.

6. MODELLING HATCHERY OPERATIONS FOR ORKNEY

In order to construct a model for the Orkney lobster hatchery, each facet of the hatchery cycle has to be considered in detail.

It is hoped to expand production at the Orkney hatchery from its present level to 100 000 animals for release each year, so the model is based around testing this scenario using the existing facilities and with a view to making recommendations for future development.

Each calculation is aimed at producing the optimum number of eggs, larvae or juveniles at each stage in order that the modelled 'hatchery' can output 100 000 juveniles at stage VIII per annum. Consequently, some elements have been back-calculated from the desired result, whilst others have been projected forward. These have also been tempered with a degree of practicality within a working hatchery environment. Inevitably, rounding errors at various points occur and not every figure will relate accurately to every other.

Fractions of cycles, for things like tubs and troughs etc, have been left in, as each phase will not have a sharp beginning or end. There will be a progressive build up and decline in the number of tanks in production at any one time. However, this serves as an illustration of the minimum requirement for equipment in order for the Orkney hatchery to be expanded.

6.1 Production cycle

This was based upon the experience of both the Ardtoe and Orkney production cycles.

6.1.1 Broodstock

Berried females can be obtained from the wild fishery at almost any time of year. In late August and September, they are newly berried, whilst in June and July the eggs are close to hatch. Consequently, egg-bearing females can be held in the hatchery year-round and larvae can be hatched at anytime by manipulating water temperatures.

Within the hatchery, as females end their hatch they are removed from the system and are replaced by others which are about to liberate their larvae.

The broodstock facility in Orkney contained 96 individual tanks and associated larval collection containers. The females were held on a recirculated water system at approximately 16 ^{o}C.

It was assumed that each female would produce 5 000 larvae and that they are held individually.

N^{o} larvae required	N^{o} larvae per female	N^{o} females required	N^{o} tanks	Stock per tank	N^{o} cycles per tank
730 000	5 000	146	96	1	1.52

Thus with the existing broodstock facility, each tank would be stocked 1.52 times throughout the year. If it were desired to stock each tank once, then 146 containers would be required, which would necessitate expanding the broodstock area. However, the number of tanks required can be reduced if they are restocked more frequently. For instance, if each tank were stocked twice, the number could be reduced to 73.

6.1.2 Hatchery

The Orkney hatchery area contains 16, 80-litre (l) larval rearing tubs.

Two assumptions could be made about hatchery stocking:

a) the hatchery was full all year
b) there would be peaks and troughs during the production cycle.

Each scenario gives a slightly different result.

The production cycle of each larval tub was taken to be 16 days and the stocking density was 2 000 larvae per tub (25 l^{-1}). Average larval survival was taken as 20%.

a) If the hatchery is full year-round

Nº tubs in production	Cycle time	Stocking density	Nº days at that level	Nº cycles per tub	Nº larvae used	% survival	Post-larvae produced
16	16 days	2 000	365	22.81	730 000	20	146 000

Under these circumstances, the 16 larval rearing tubs could accommodate the 730 000 larvae produced by the broodstock, if they were stocked nearly 23 times each. This would produce an estimated 146 000 post-larvae (stage IV) for on-growing.

Unfortunately, it is extremely unlikely that the larval system would be full all year round. It is much more likely that there will be seasonal peaks and troughs of production.

b) If it was assumed that the hatchery would not be full for the entire year

For these calculations it has been assumed there will be 90 days (approximately 3 months) when only 6 tubs will be in full production, 61 days (2 months) when 8 tubs are used, with all 16 tubs in full use for the remainder of the year (approximately 7 months).

Nº tubs in production	Cycle time	Stocking density	Nº days at that level	Nº cycles per tub	Nº larvae used	% survival	Post-larvae produced
6	16 days	2 000	90	5.62	67 500	20 %	13 500
8			61	3.81	61 000		12 200
16			214	13.37	428 000		85 600
Total			**365**		**556 500**		**111 300**

In these circumstances the current facility would only utilise 556 500 larvae and produce 111 300 post-larvae each year. From later calculations, we know this to be too few to produce the desired output of 100 000 juveniles for release.

This suggests that more than 16 larval tubs would be necessary if the goal is to use all 730 000 larvae produced by the broodstock and produce at least 146 000 post-larvae. This model predicts that a maximum of 23 tubs would be required at peak times.

N° tubs in production	Cycle time	Stocking density	N° days at that level	N° cycles per tub	N° larvae used	% survival	Post-larvae produced
6	16 days	2 000	90	5.62	67 500	20 %	13 500
8			61	3.81	61 000		12 200
23			214	13.38	615 250		123 050
Total			**365**		**743 750**		**148 750**

6.1.3 On-growing

The post-larval grow-out period can vary, depending upon the desired size of juvenile for release, in this case stage VIII, and the water temperature. The most likely durations are either 6 or 8 weeks in the hatchery prior to release. It is anticipated that at ‘normal’ operating temperatures (14 – 16 °C) it will take approximately 6 weeks to produce a stage VIII post-larva. However, it is anticipated that, on occasions, operational constraints may necessitate retaining juveniles in the hatchery for longer, up to a maximum of 8 weeks.

Each tank in the on-growing system was assumed to have a capacity of 1 296 individually housed juveniles. Average survival to release size was taken as 70%, which is, perhaps, lower than can be generally expected, but it does produce a conservative estimate of the output.

In addition to the two possible on-growing durations, it can also be assumed either that the grow-out troughs can be kept fully stocked throughout the year or that they undergo similar seasonal fluctuations in stocking to the larval rearing system.

If the facility has the capacity for 12 tanks and can be kept full all year, the productivity prediction for the two on-growing times suggests the following outcomes:

N° Tanks	Grow-out Cycle time	Stock per tank	N° weeks	Cycles per tank	Post-larval input	% Survival	Juvenile output
12	8 weeks	1 296	52	6.50	101 088	70	70 762
12	6 weeks	1 296	52	8.67	134 784	70	94 349

Clearly, these results are below the desired intent to utilise the 146 000 post-larvae produced from the larval system to enable the hatchery to output at least 100 000 juveniles for release. In which case the calculation can be used to predict the number of tanks required.

N° Tanks required	Grow-out Cycle time	Stock per tank	N° weeks	Cycles per tank	Post-larval input	% Survival	Juvenile output
17.33	8 weeks	1 296	52	6.50	146 000	70	102 200
12.99	6 weeks	1 296	52	8.67	146 000	70	102 200

If the on-growing troughs can be kept full year-round, the on-growing facility would, in practical terms, require either 13 or 18 troughs in order to accommodate the post-larvae necessary to produce in excess of 100 000 juveniles for release.

It is, however, far more likely that the hatchery will undergo peaks and troughs in production. In which case further on-growing tanks will be required. The calculations in section 6.1.2 for the post-larval production phase of the model suggested that for 12 weeks of the year 13 500 post-larvae would be in the on-growing system. For 9 weeks the figure was 12 200, but for the bulk of the year (31 weeks) a theoretical maximum of 123 050 post-larvae could require housing. However, the target for post-larval production is 146 000, so the figure of 148 750 post-larvae represents an excess on-growing capacity. Considered practically, it is better to have slightly too much capacity at each stage rather than too little and the calculations have been performed on this basis.

Nº Tanks required	Grow-out Cycle time	Stock per tank	Nº weeks	Cycles per tank	Post-larval input	% Survival	Juvenile output
6.94	8 weeks	1 296	12	1.500	13 500	70	9 450
8.37			9	1.125	12 200		8 540
24.50			31	3.875	123 050		86 135
Total			**52**		**148 750**		**104 125**
5.21	6 weeks	1 296	12	2.000	13 500	70	9 450
6.27			9	1.500	12 200		8 540
18.38			31	5.167	123 050		86 135
Total			**52**		**148 750**		**104 125**

Unless specifically designed smaller tanks are sourced, part-troughs are not practical. Consequently, on an 8 week grow-out cycle 25 tanks would be required, whilst on a 6 week cycle 19 troughs would be needed. This suggests that it will be necessary to approximately double the present Orkney on-growing area, if the total hatchery output is to be increased to 100 000 juveniles at stage VIII per annum.

6.2 Labour

The labour costs are the largest component of the annual hatchery running costs. Consequently, predicting the requirement is central to any model.

In order to predict times of peak labour requirement and forward plan staffing levels, labour input was considered as man-hours per day, analysed by month throughout the year. The total labour cost was set at £ 5 h^{-1}.

	Brood-stock (hrs)	Hatch-ery (hrs)	On-grow (hrs)	Main-tenan-ce (hrs)	Man-age-ment (hrs)	Total hrs per day	Days per month	Total Man-hours	Totals
Jan	1.0	1.0	2.0	4.0	1.0	9.0	31	279.0	
Feb	1.0	1.0	2.0	4.0	1.0	9.0	28	252.0	
Mar	1.0	1.0	2.0	0.0	1.0	5.0	31	155.0	
Apr	1.0	1.0	2.0	0.0	1.0	5.0	30	150.0	
May	1.0	1.5	6.0	0.0	1.0	9.5	31	294.5	
Jun	1.0	6.0	6.0	0.0	1.0	14.0	30	420.0	
Jul	1.0	6.0	6.0	0.0	1.0	14.0	31	434.0	
Aug	1.0	6.0	6.0	0.0	1.0	14.0	31	434.0	
Sep	1.0	1.5	6.0	0.0	1.0	9.5	30	285.0	
Oct	1.0	1.5	6.0	0.0	1.0	9.5	31	294.5	
Nov	1.0	1.0	2.0	0.0	1.0	5.0	30	150.0	
Dec	1.0	1.0	2.0	0.0	1.0	5.0	31	155.0	
Total Man-hrs									**3 303**
Rate £ h^{-1}									**5**
Total Cost (£)									**16 515**

The pattern displayed by these calculations suggest that, assuming a working day of between 7 or 8 hours, 2 people are necessary full-time in the hatchery for 3 months of the year. For 5 months, 1 full-time and 1 part-time person would be sufficient, but for 4 months only 1 person would be required on slightly less than a full-time basis. It also suggests that it might be better to alter the anticipated work schedules at certain times of the year, particularly with regard to maintenance, in order to smooth the times of high demands on staff.

6.3 Expansion of the Orkney hatchery

From the above, it appears that the existing Orkney facility has the theoretical capacity to produce 730 000 larvae from its broodstock and that the 16 larval rearing tubs could accommodate this if they were kept fully stocked throughout the year. However, this is unlikely and it is probable that the tubs would only use 556 500 larvae and produce 111 300 post-larvae for on-growing. The 12 on-growing troughs can accommodate between 101 088 - 134 784 post-larvae, depending on the on-growing cycle, if they are kept fully stocked all year-round. This would result in between 70 762 - 94 349 juveniles for release on either an 8- or 6-week cycle (see section 6.1.3), respectively. Once more, this is an unlikely scenario and it is more likely that the number of troughs in use will rise and fall throughout the production year. Under these circumstances the production capacity of the troughs would be much reduced.

Clearly, the hatchery requires a moderate expansion if it is to meet its production target of 100 000 juveniles (stage VIII) for release each year. The capacity of the larval facility should rise from 16 to 23 tubs (44% increase) and the number of troughs in the on-growing area from 12 to at least 18 or maximally 24 tanks (a 50% or 100% expansion respectively). However, economies of scale will apply and the associated costs of the hatchery will not rise by the same proportions. To increase the larval area capacity a total additional capital cost of approximately £ 500 is projected. Expanding the on-growing area capacity is anticipated to cost between £ 3 000 - £ 5 500 respectively.

Examination of the existing hatchery layout suggested that, with alterations to make more efficient use of the space available, all of the additional tanks could be accommodated within the existing buildings. However, an allowance was made for a small increase in floor area.

Considerable savings in the unit cost of capital items can be made when greater numbers are ordered. This applies particularly to tanks etc, where there is a substantial cost in making the initial mould, but the cost per tank decreases dramatically as the numbers produced from it increase. Savings of up to 50% can be made. Similarly, the cost per unit of electricity can decrease as usage increases.

In the following projection, the costs shown reflect the full amount of capital which would have been invested in the expanded facility had it been built anew, following the previous practices, and the anticipated annual running costs thereafter. The costs are for the maximum projected facility, ie 23 larval tubs and 24 on-growing troughs. In deriving the costs, hatchery suppliers were consulted, full account of any anticipated discounts were included and the figures were discussed fully with the operator in Orkney before inclusion. It is doubtful that they are completely accurate, but these figures probably represent the best estimate of the minimum costs likely to be incurred by a hatchery built with the intention of a production capacity of 100 000 juveniles at stage VIII per year.

		£
Capital cost		45 000
Annual costs		
	Labour	16 600
	Rent & rates	3 100
	Repairs & renewals	1 500
	Consumables	4 500
	Power	3 000
	Total Annual Costs	28 700

6.3.1 Projected cost per juvenile

Assuming the proceeding projections to be valid within the above scenario, it is possible to calculate the cost per juvenile (at stage VIII) on the same basis as before (section 5). Under these circumstances, the projected cost per juvenile produced by the hatchery is calculated to be £ 0.30.

6.4 Conclusions for the Orkney hatchery

To meet a projected target of producing 100 000 juveniles (at stage VIII) per year for release the Orkney hatchery requires expansion. The existing broodstock area is sufficient for its needs, but the number of larval tubs must be increased to 23, and 24 on-growing troughs are required. By re-arranging the internal layout of the tanks this expansion can be accommodated with only a very moderate increase in floor area. The cost per juvenile is predicted to be around £ 0.30. The hatchery team expect to be able to reduce the cost per juvenile further as they increase production efficiency.

7. GENERAL LOBSTER HATCHERY ECONOMIC MODEL

Data derived from studying the Orkney hatchery was combined with data gathered from other sources in order to construct a preliminary ‘generic’ model of the economics of operating a lobster hatchery. In its present form, the model derived is a useful indicator of lobster hatchery economics, but it is not intended to replace the requirement for detailed project planning in any specific location.

For this general model (see CD-ROM), it has been assumed that the hatchery has foreshore access, a target output of 100 000 juveniles per year with size selected by operator, and that it will operate year-round on a partial recirculation basis, with a 10% daily water renewal rate. It has also been assumed that the land is rented; if it is to be purchased, then additional capital would be required. The capital cost of the operation has been depreciated over 15 years rather than the 30 years used in the Orkney example (section 6).

For simplicity of modelling at this stage, certain cost elements, such as services and equipment, have been expressed as a ‘cost per on-growing tank’. The calculations surrounding the assumptions about the design and operation of the hatchery have also been kept basic and simple to reduce the complexity and size of the model.

By making a series of key assumptions about the potential hatchery operation, the model provides an indication of likely annual operating costs and staffing levels as well as the scale (floor area) of facility and capital budget. Ultimately, it displays an indication of the potential cost per juvenile produced (Fig 2).

The ‘default’ values entered in each field are intended to reflect an ‘average’ hatchery located in a ‘typical’ part of the UK. Marked regional and local differences will apply in ‘real-life’ scenarios.

Within the model, useful guidance and hints are concealed behind the red ‘Note’ indicators displayed on screen.

Detailed instructions for using the model are contained in appendix 1 and they are also reproduced on the CD.

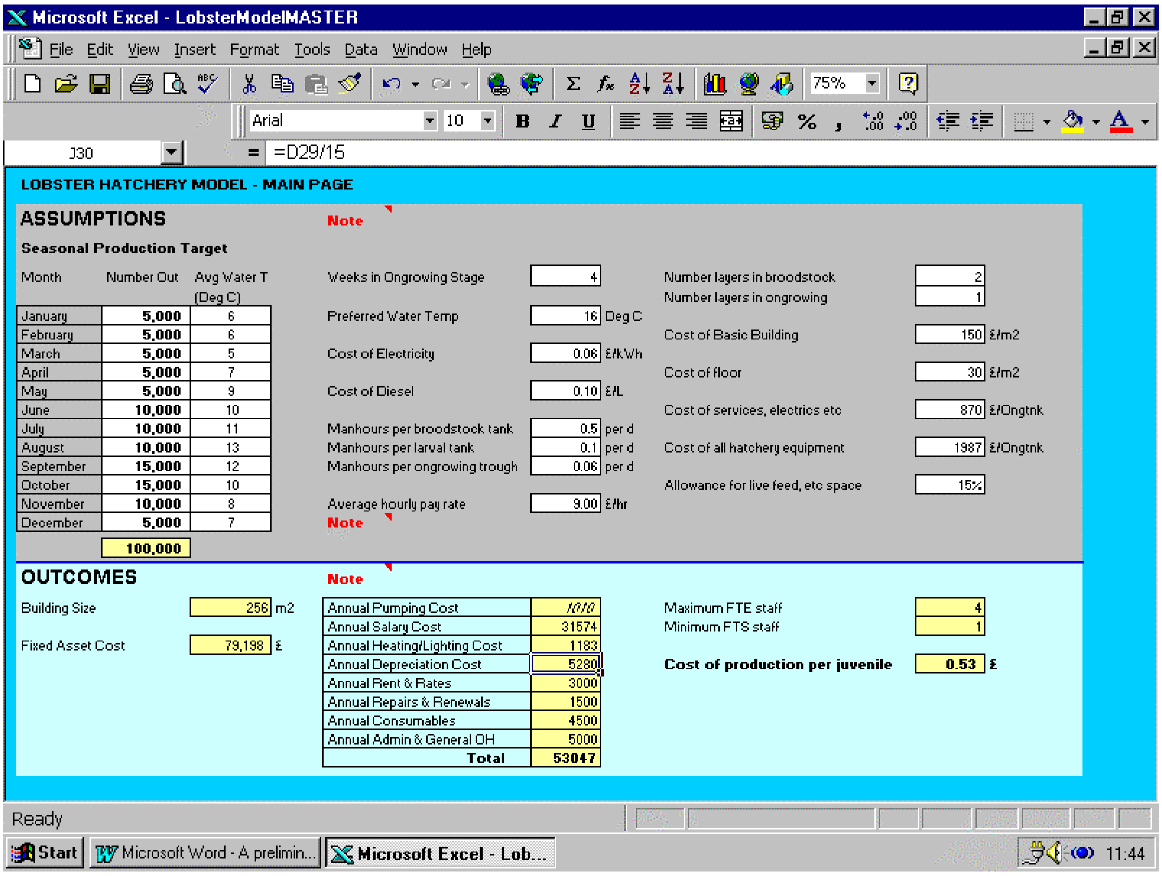

Fig 2 The 'default' lobster hatchery economic model, as it appears on screen

7.1 Using the model

The first stage of the model is to enter monthly production targets and the average ambient seawater temperature each month for the locality. The preferred on-growing (holding) time for the post-larvae before release is entered (in multiples of 4 weeks) together with the target operating seawater temperature. Energy costs are entered as appropriate. The main element of the model is the time (man-hours) allocated to each stage of the hatchery process together with the gross employment costs (wage rates paid plus the associated employment costs – employers National Insurance, pensions etc). The arrangement of the tanks, ie whether to stack or have only a single layer, affects the size (floor area) of the facility. In turn, this, together with the type of building and flooring used, controls the building costs. The cost of fitting out the building to service the tanks etc is entered as a cost per on-growing tank, as is the cost of the other hatchery equipment. These must be calculated separately before input. Space has to be set aside for preparing food, cleaning equipment etc, and, for simplicity, this element is represented as a proportion (%) of the overall facility. Cost estimates for rent & rates, repairs & renewals, consumables and administration & overheads are entered manually. Pumping costs, salary costs, heat & light and depreciation are calculated automatically.

7.2 General guidance for data and costs used in the model

Ambient seawater temperatures vary by month and the monthly averages usually decrease as one moves northwards. In the south, winter minima may be around 8 °C with summer maxima of 16 °C or higher. In the far north, sea temperatures can be as low as 4 °C, in late winter/ early spring and only reach a maximum of 12 °C in early autumn. More detailed guidance for individual locations can usually be obtained by reference to oceanographic literature.

The on-growing period can only be input in multiples of four weeks. As an approximate guide for this model, a 4 week on-growing period equates to a juvenile at approximately stage VI, an 8 week period to approximately stage VIII and 12 weeks to approximately stage X – XI (all at approximately 16 ^{o}C).

Utility and fuel costs vary from supplier to supplier and they also offer many different tariffs and discounts. Consultation with them will provide guideline figures.

The example man-hours allocated to each area of the hatchery have been derived from the calculations in section 6. However, they can be varied to reflect different hatchery regimes and resource deployment. For example, greater use of automation may be planned and this may reduce staff input at that particular stage.

Actual wage rates paid can vary widely around the country. In some areas they will be at or very close to the national minimum wage level set by government. In other locations, it would not be possible to recruit or retain staff unless the rates of pay were considerably higher. Local knowledge and circumstance will guide that decision. In addition, more experienced staff or those with greater responsibility are usually paid proportionately more than other employees. Thus the rate entered should represent an average for the area and employee profile of the facility. To derive the approximate gross employment cost, the actual wage rate can be multiplied by a percentage, which varies according to company structure and current legislation (for NI contributions etc). Typically, this is between 10% - 20%.

The cost of the building can vary greatly. At its simplest, commercial polypropylene covered tunnels can be constructed for as little as £ 10 - £ 20 m^{-2}, whilst a heavier tarpaulin-style cover can increase the cost to £ 20 - £ 30 m^{-2}. Substantial corrugated metal tunnels can be assembled for between £ 50 - £ 60 m^{-2}. A simple rendered block-work facility would cost around £ 150 m^{-2}. At the top end of the scale, purpose designed, architecturally pleasing, conventional-style buildings made from brick or clad block-work can cost over £ 350 m^{-2} to construct.

Similarly, the cost of flooring can vary. A simple gravel chip floor cover can cost £ 1 m^{-2} or less. More substantial stone chip material can be obtained for £ 2 m^{-2} or more, depending on material, size, grade and quality. Poured concrete floors start at around £ 30 m^{-2} whilst heavily insulated ones could cost substantially more (>£50 m^{-2}).

Each tank has to be supplied with water and drainage etc and the cost of the pipework varies depending on the materials used and diameter of pipe. Many recent hatcheries use food preparation grade plastic, high-grade ABS or potable water-supply quality alkathane pipes and fittings on the supply side. However, there are marine hatcheries that report that they operate successfully using less costly u-PVC pipes and fittings. Where funds permit, opt for higher grade materials. Drainage is almost universally achieved using domestic-grade waste pipes and fittings.

Standards of electrical cabling, fittings and fit-out used in conditions where water or heavy condensation is present, as in any hatchery, are controlled by recognised guidelines.

In the example given, £ 870 has been allocated per on-growing tank for the provision of all services in the hatchery.

The quality and quantity of equipment, from the tanks themselves to individual post-larval containers, used in and around the hatchery will be reflected in its cost. For some items, it may be better to purchase less costly, less durable items and replace them frequently; for others, accuracy or durability will dictate greater expenditure. Experience and personal preference are likely to guide the decision. If greater automation is to be used within the hatchery, its higher capital costs will be reflected in this figure. In the default example illustrated, £ 1987 has been allowed per on-growing tank for all equipment.

Some hatcheries have operated using little or no live or fresh feed supplements, in which case the proportion of space allocated for these and associated services could be reduced. However, the space required is unlikely to ever be zero as some area will always be required for servicing equipment etc. Conversely, a facility that wished to use high quantities of live or fresh food supplementation is likely to increase the proportion of space allocated.

7.3 Costs per juvenile derived from the model

Varying individual cost elements within the model demonstrates their influence upon the design, operation and ultimate cost per juvenile produced by the hatchery. For instance, using the model with its 'average costs' (default) settings unchanged and varying the time in the on-growing system, it can be used to mimic releasing juveniles at different stages (sizes) and show the effect on the cost per juvenile (Table I). See section 7.2 for an approximate guide to holding time verses release stage.

Table I. Influence of on-growing period on the cost per juvenile

On-growing period (weeks)	Cost per juvenile (£)
4	0.53
8	0.68
12	0.84

Alternatively, major cost elements, such as the employment costs (£ h^{-1}) can be varied and the effect on the cost per juvenile shown (Table II).

Table II Influence of employment costs on the cost per juvenile held for different on-growing periods

On-growing period (weeks)	Average employment cost (£ h^{-1})	Cost per juvenile (£)
4	5	0.39
	9	0.53
	15	0.74
8	5	0.50
	9	0.68
	15	0.96
12	5	0.60
	9	0.84
	15	1.19

The influence of the cost of constructing the building (£ m^{-2}), whilst proportionately less, mainly because it is amortised over a long period (15 years), on the cost per juvenile can also be examined (Table III).

Table III Influence of building cost on the cost per juvenile held for different on-growing periods

On-growing period (weeks)	Building cost (£ m^{-2})	Cost per juvenile (£)
4	20	0.51
	150	0.53
	350	0.56
8	20	0.65
	150	0.68
	350	0.74
12	20	0.79
	150	0.84
	350	0.91

Finally, multiple elements can be varied at the same time to model different scenarios. Three examples are given below (Table IV):

a) least costs, minimal building investment (£ 20 m^{-2}), low employment cost (£ 5 h^{-1}) etc – ‘least cost’
b) medium costs, medium building investment (£ 150 m^{-2}), medium employment costs (£ 9 h^{-1}) etc – ‘typical’ (model default values)
c) high costs, high building investment (£ 350 m^{-2}), high employment cost (£ 15 h^{-1}) etc – ‘high cost’

Table IV Example costs per juvenile held for three different on-growing periods in three different hatchery investment and operation scenarios.

Hatchery type	On-growing period (weeks)	Cost per juvenile (£)
Least cost	4	0.36
	8	0.45
	12	0.54
Typical	4	0.53
	8	0.68
	12	0.84
High cost	4	0.78
	8	1.02
	12	1.12

7.4 Conclusions for the general model

Based upon the 100 000 capacity default model shown, it is projected to cost £ 0.45 for a juvenile at stage VIII (approximately 8 weeks on-growing) based on a ‘least cost’ scenario. In the ‘typical cost’ situation, which is likely to be realistic for many UK locations, the projected cost is £ 0.68.

The hatchery economic model as constructed is capable of providing indicative capital and production costs for a number of differing scenarios. However, it is important to recognise that a high degree of hatchery expertise and experience is required to determine accurate input values. The inexperienced must seek expert guidance and determine the most appropriate scenarios for the level of output envisaged. For complete evaluation, each and every hatchery proposal requires a detailed project plan and investigation by an experienced hatchery operator if the true operating costs are to be identified.

8. ACKNOWLEDGEMENTS

Richard Slaski of Epsilon Aquaculture Ltd developed and produced the CD-based general hatchery model from the information gathered from the hatchery operators.

Alan Coghill of the Orkney Fisheries Association and staff from North Isles Shellfish working at the Lambholm hatchery provided much useful information, advice and input into the report.

Edwin Derriman and Philip Midgley from the National Lobster Hatchery, Padstow, added additional information based on their recent experience.

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Appendix 1

Guidance notes for using the lobster hatchery model

<u>CAUTION</u>

This model is not intended to replace or obviate the need for detailed planning and evaluation of any lobster hatchery proposal.

The economic model referred to in this publication and the corresponding CD-ROM are for guidance only and should not be regarded as definitive. Seafish recommends that professional advice is sought prior to any investment commitment being undertaken. Seafish can accept no liability arising out of the use of this model or implementation of the outcomes. The CD-ROM has been prepared on a system which is routinely checked for computer viruses and to the best of our knowledge is free from such corruptions.

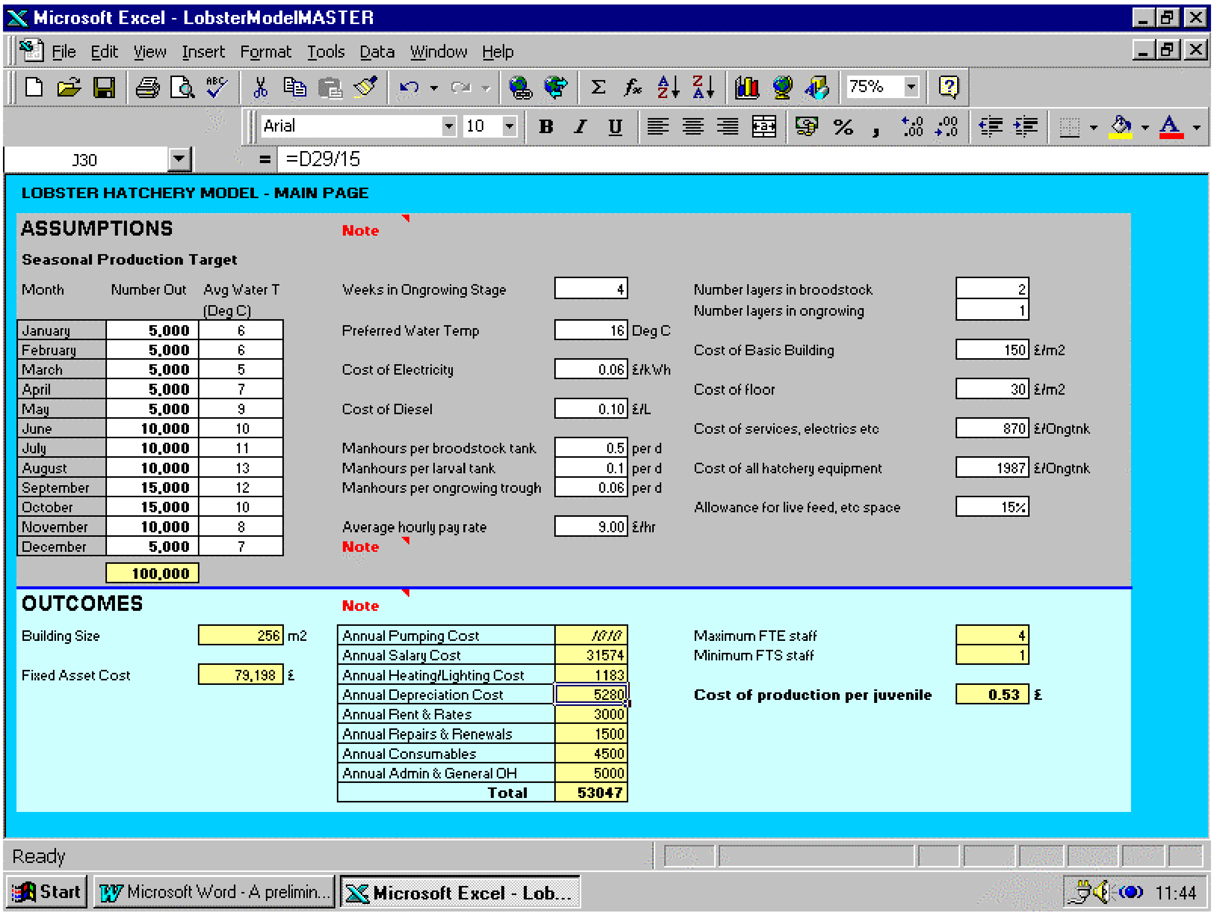
THE MODEL

To run the model you will require a PC with CD drive and Microsoft Excel97 or above.

1. Loading the model

1) Place the CD in your CD drive
2) Locate the model on the CD (My Computer>CD drive [D:]>lobster model) and double click on it.
3) Excel should start automatically. If it does not, start Excel and then load the model in the normal way (File>Open etc)
4) If offered the choice as the model starts, accept the "Enable macros" option. Without this the calculations will not run.

The screen below should appear:



2. Entering Data

Most data is entered in the white boxes (cells) in the grey 'Assumptions' area of the sheet. The exceptions are items 13 – 16, which are entered in the yellow boxes in the light-blue 'Outcomes' area.

Make each entry in the appropriate box of the sheet. Alternatively, you may accept the suggested default values by making no entry.

1) Enter the monthly production targets and the average ambient seawater temperature each month for your locality.
2) Enter the preferred on-growing (holding) time for the post-larvae before release. This has to be in multiples of 4 weeks. Other periods will cause errors.
3) Enter the target operating seawater temperature.
4) Enter the appropriate energy costs, electricity and diesel (or gas), for your locality and supplier(s).
5) Enter the estimated man-hours per day (time) spent for each stage of the hatchery process for your facility.
6) Enter the estimated average gross employment costs (wage rates paid plus the associated employment costs – employers National Insurance, pensions etc) for your facility and locality.
7) Decide whether the tanks in the broodstock and on-growing areas will be arranged in single or double layers (ie stacked) and enter as appropriate.
8) Enter an estimated cost (per square metre of floor area) for constructing (or modifying) the style of building you intend to use.
9) Enter an estimated cost (per square metre of area) for the type of flooring you intend to use.
10) The cost of fitting out the building to service the tanks etc is entered as a ‘cost per on-growing tank’. This must be calculated separately before input.
11) Similarly, the cost of the other hatchery equipment is also entered as a ‘cost per on-growing tank’. It too should be estimated separately before input.
12) Space is required for preparing food, cleaning equipment etc, and this element is represented as a proportion (%) of the overall facility floor area.
13) Enter an estimated cost for the ‘rent & rates’ paid per year for the facility.
14) Enter an estimate for the cost of ‘repairs & renewals’ which may be required by the facility each year.
15) Enter an estimate for the cost of ‘consumable’ items used each year within the facility.
16) Enter an estimate for ‘administration & overhead’ charges incurred each year.

3. Elements calculated automatically

The following fields (boxes) are calculated automatically by the model and do not require user entry:

1) Building size (square metres).
2) Fixed asset cost.
3) Annual pumping costs.
4) Annual salary costs.
5) Annual heat and light costs.
6) Annual depreciation charges.
7) Maximum number of staff required (full-time equivalents).
8) Minimum number of staff required (full-time equivalents).
9) Cost of production per juvenile.

4. Printing the model

The model may be printed automatically on almost any printer by pressing “Ctrl p”. Alternatively, it may be printed manually using the normal Excel print prompts (File>Print etc).

5 Saving the model

You can save a copy of any calculations/changes to the model that you make using the normal Excel ‘File>Save As’ options. Save the new files to a folder on your hard disk (usually C:) or a removable disk. Unless you have a CD-writer, you will not be able to save copies/files to the CD. Take care not to over-write or otherwise corrupt the master file.

General guidance for data and costs used in the model

1. Ambient seawater temperatures vary by month and the monthly averages usually decrease as one moves northwards. In the south, winter minima may be around 8 ^{o}C with summer maxima of 16 ^{o}C or higher. In the far north, sea temperatures can be as low as 4 ^{o}C, in late winter/ early spring and only reach a maximum of 12 ^{o}C in early autumn. More detailed guidance for individual locations can usually be obtained by reference to oceanographic literature.

2. The on-growing period can only be input in multiples of four weeks. As an approximate guide for this model, a 4 week on-growing period equates to a juvenile at approximately stage VI, an 8 week period to approximately stage VIII and 12 weeks to approximately stage X – XI (all at approximately 16 ^{o}C).

3. Utility and fuel costs vary from supplier to supplier and they also offer many different tariffs and discounts. Consultation with them will provide guideline figures.

4. The example man-hours allocated to each area of the hatchery have been derived from the calculations in section 6 of the hatchery report. However, the hours can be varied to reflect different hatchery regimes and resource deployment. For example, greater use of automation may be planned and this may reduce staff input at that particular stage.

5. Actual wage rates paid can vary widely around the country. In some areas they will be at or very close to the national minimum wage level set by government. In other locations, it would not be possible to recruit or retain staff unless the rates of pay were considerably higher. Local knowledge and circumstance will guide that decision. In addition, more experienced staff or those with greater responsibility are usually paid proportionately more than other employees. Thus the rate entered should represent an average for the area and employee profile of the facility. To derive the approximate gross employment cost, the actual wage rate can be multiplied by a percentage, which varies according to company structure and current legislation. Typically, this is between 10% - 20%.

6. The cost of the building can vary greatly. At its simplest, commercial polypropylene covered tunnels can be constructed for as little as £ 10 - £ 20 m^{-2}, whilst a heavier tarpaulin-style cover can increase the cost to £ 20 - £ 30 m^{-2}. Substantial corrugated metal tunnels can be assembled for between £ 50 - £ 60 m^{-2}. A simple rendered block-work facility would cost around £ 150 m^{-2}. At the top end of the scale, purpose designed, architecturally pleasing, conventional-style buildings made from brick or clad block-work can cost over £ 350 m^{-2} to construct.

7. Similarly, the cost of flooring can vary. A simple gravel chip floor cover can cost £ 1 m^{-2} or less. More substantial stone chip material can be obtained for £ 2 m^{-2} or more, depending on material, size, grade and quality. Poured concrete floors start at around £ 30 m^{-2} whilst heavily insulted ones could cost substantially more (>£50 m^{-2}).

8. Each tank has to be supplied with water and drainage etc and the cost of the pipework varies depending on the materials used and diameter of pipe. Many recent hatcheries use food preparation grade plastic, high-grade ABS or potable water-supply quality alkathane pipes and fittings on the supply side. However, there are marine hatcheries that report that they operate successfully using less costly u-PVC pipes and fittings. Where funds permit, opt for higher grade materials. Drainage is almost universally achieved using domestic-grade waste pipes and fittings. Examination of catalogues from pipe and plumbing suppliers will illustrate the price differentials.

   Standards of electrical cabling, fittings and fit-out used in conditions where water or heavy condensation is present, as in any hatchery, are controlled by recognised guidelines. Consequently, similar materials should be used whatever the style or size of hatchery and only inter-supplier and regional cost differences will apply. Again, consult with likely suppliers for guidance as to costs.

   In the example given, £ 870 has been allocated per on-growing tank for the provision of all services in the hatchery.

9. The quality and quantity of equipment, from the tanks themselves to individual post-larval containers, used in and around the hatchery will be reflected in its cost. For some items, it may be better to purchase less costly, less durable items and replace them frequently; for others, accuracy or durability will dictate greater expenditure. Experience and personal preference are likely to guide the decision. If greater automation is to be used within the hatchery, its higher capital costs will be reflected in this figure. In the default example illustrated, £ 1987 has been allowed per on-growing tank for all equipment.

10. Some hatcheries have operated using little or no live or fresh feed supplements, in which case the proportion of space allocated for these and associated services could be reduced. However, the space required is unlikely to ever be zero as some area will always be required for servicing equipment etc. Conversely, a facility that wished to use high quantities of live or fresh food supplementation is likely to increase the proportion of space allocated.

11. Consult your Local Authority and/or landlord for the likely level of rent and rates to be paid on the facility. If possible, it may be advantageous to seek to have the facility classified as an ‘agricultural’ concern.

12. The amount included for the repair and renewal of items each year can either be calculated for each individual area, as in the example above, or, for simplicity, it can be estimated as a percentage of the capital cost. If the latter route is chosen, between 1-5% may be considered appropriate, depending upon circumstance. In all instances, the value is entered in monetary terms.

13. The purchase of all items, including food-stuffs, chemicals and protective clothing etc, used within the hatchery during the course of an operational year is included under the ‘consumable items’ heading. This should be estimated before entry.

14. Yearly charges for office administration, accountancy functions, telephone, fax etc are entered in the ‘Administration & General Overhead’ field. Estimate or enter a value you consider appropriate for your circumstance.

15. Depreciation has been calculated over 15 years on a straight-line basis.

16. Energy costs for pumping water and for heating and lighting are calculated on the basis of the floor area of the facility and guideline costs for ***domestic dwellings***, published by the Department of Trade and Industry each year. As such, they are not entirely accurate for the industrial setting.

17. Staff numbers are calculated from the man-hours per day required to complete each hatchery function for the level of production anticipated. They assume an 8 hour working day and a 40 hour working week.

18. Salary costs are calculated from the total man-hours calculated by the model multiplied by the average hourly pay rate entered.

19. The production cost per juvenile is calculated simply from the total yearly costs divided by the total yearly juvenile production.

Other guidance and assistance

Limited on-screen guidance and suggestions are concealed behind the red “Note” boxes. Place the cursor over the cell to view the information.

In the event of any other difficulties please contact the Aquaculture Development Service at:

Sea Fish Industry Authority
Marine Farming Unit
Ardtoe
Acharacle
Argyll
PH36 4LD

Tel: 01397 875 402 (direct line)
Tel: 01397 875 000 (switch board)
Fax: 01397 875 001
E-mail: c_burton@seafish.co.uk (direct)
E-mail: aquaculture@seafish.co.uk