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RIVO report

Number: C055/03

A bio-economic model for commercial on-growing of pike-perch (*Sander lucioperca*)

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Report produced in the framework of the CRAFT project “LUCIOPERCA: bio-economic feasibility of intensive culture of pike-perch”

Task deliverable no.	11, 12, 13
Project number:	352 12230 03
Contract number:	Q5CR-2001-70594
Approved by:	L.J.W. van Hoof Head of Department Seafood & Aquaculture
Signature:	________________________
Date:	3 November 2003

Number of copies:	6
Number of pages:	27
Number of tables:	8
Number of figures:	1

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Summary

One of the major aims of the project ‘Lucioperca’ is the assessment of economic feasibility of farming of pike-perch. In order to make this assessment, a model was constructed which could process all required input and give the answers necessary.
The model consists of a spreadsheet model of seven linked sheets which cover aspects like, productivity (growth and density), investments, unit prices, cost of production and cash flow. The model covers the on-growing cycle starting with a fingerling of 10 grams up to a variable end-weight.
The input in the model has been generated in different tasks within the project. Data on investments and productivity have been produced in the pilot system and different experimental trials. The total investments for a farm with a capacity of 75 tonnes per year amount to app. 850.000 euro. The maximum negative cash-flow is attained after 22 months and amounts to 1,3 million euro. In a base-case scenario a production size of 75 tonnes per year is used with a sales price of 6 euro per kg, which comes from the market study. The fish reach a market size of 1500 grams after 22 months under a total productivity of 155 kg/m^3.y.

The model shows that on-growing of pike-perch in a recirculation system can be marginally profitable under the assumptions used with an Internal Rate of Return of 8,01% and a production price of 4,74 euro per kg. The profitability is very sensitive for the market price attained. Scale of production and productivity are other factors of major importance.

1. Introduction

One of the major targets of the project 'Lucioperca' is to assess the technical and economical feasibility of intensive farming of pike-perch (*Sander lucioperca*). Currently, there is no commercial farming of pike-perch in Europe. There is only a small production in ponds, which can be considered a by-catch.

Therefore, in order to make an assessment of the feasibility of farming of pike-perch, a bio-economic model has been constructed which can answer questions regarding economic feasibility. An important part of the input in the model has been generated during the project in the pilot-system and in separate experiments. Data on prices and markets for pike-perch are essential and have been collected in task 5 of this project. The production costs for fingerlings are calculated in a separate model and report since this activity can be a stand-alone production for re-stocking or ongrowing on farms.

In this report the structure and calculations of the bio-economic model are explained. The model covers production starting with a fingerling and up to market size. No further processing is incorporated in the activities. Different production scenarios are analysed in a separate paragraph.

2. Model description

2.1 General outline

The model is a spreadsheet (Excel) consisting of seven linked worksheets each covering specific aspects. The first sheet '*Control variables & Output*' shows some of the major variables and gives a summary of the most important output. The next sheet '*Productivity*' gives a calculation of the growth rate, density and productivity. The sheet '*Farm design*' calculates the size of the infrastructure needed for a certain production capacity. The output of this sheet is used in the sheet '*Investments*' to calculate investment costs and depreciation. The prices of the different costs items are given in a separate sheet '*Prices*'. The production costs are calculated in '*Costs*' using input from the sheets 'Farm design' and 'Prices'. In the last sheet '*Cash flow*', the expenses and sales are calculated on a monthly basis for the first three years and on a yearly basis for the remaining 12 years. The cash flow is used to calculate some key-parameters for economic performance.

Each separate sheet is discussed in more detail below. The parameterisation of the model is explained in chapter 3.

2.2 Control variables and output

Table 1 gives an overview of this sheet. In the control variables part the user can define the production situation with respectively production volume, market price (€), market weight (g), growth rate and opportunity costs.

In the output part, the major results like initial investment, cost per kg production, net present value (NPV), internal rate of return (IRR) and break even (years) can be evaluated. The go or no-go decision is based on a comparison of *IRR* and *Opportunity costs* and results in a go decision if this is a positive number.

Table 1. The sheet "Control variables and Output".

THE ONGROWING MODEL

SPECIES: PIKE-PERCH

CONTROL VARIABLES		
Fish production	mt.year^{-1}	75
Market price	euro.kg-1	6,00
Market weight	g	1500
SGR = a*W^b		
a:		6,92
b:		-0,43
Opportunity costs	%	7

OUTPUT	
	Euro
Total initial investment	861.268
Cost per kg production	4,74
NPV (15 year project)	69.699
IRR (15 year project)	8,01
Break even	13,43

GO/ NO-GO?	**GO**

2.3 Productivity

In the productivity sheet (table 2) some formulas are used to calculate the number of months needed to farm market size fish. Data on production size and market weight are taken from the first sheet. Every month a new specific growth rate (SGR) is calculated based on $SGR = a.W^b$ in which a = 6,92 and b = - 0.43. Based on a starting weight of 10 grams average weights can be calculated for each month. The density (D) is based on D = a.ln(W) + b in which a = 15 and b = 4. The daily productivity (Pdaily) can then be calculated based on SGR and D. This can be calculated as: *P (daily) = (SGR/100)*D.* Yearly productivity is calculated as:

$$P\ (year) = \frac{SUMproduct((P(daily)*Weight(g))}{total\ weight\ (g.)} / time\ (months)*365$$

As can be seen this function of yearly productivity is based on an average daily productivity taking into account the difference in productivity for each weight by incorporating the different weights into the formula.

2.4 Farm design

The farm design page is based on the annual production level, growth and productivity (see growth page). Fish production (FP) is calculated on the value given in the control variables and output page (FPin). However, fish production includes depuration loss (SL = 5%) so it is described by the formula *FP = FPin / ((100-SL)/100).* The productivity (P) as calculated in the growth page in combination with fish production (FP) and a production efficiency (PE) determines the tank volume (T) by the formula

*T = (FP*1000)/(P*PE)*

The size of the building and the total area of land needed are calculated using specific ratio's between tank area: building and building: land.

A feed conversion has to be fed to the model and is used to calculate a daily feed load (FL) from fish production.

In order to calculate the size of the biofilter a specific feed capacity per m3 biofilter is used (3). The product of the specific feed capacity and the daily feed load gives the size of the biofilter.

The oxygen input (OI) is calculated by oxygen use and feed load (FL). In this respect oxygen use per kg feed is a constant (OU = 500). The formula is then *OI = (FL*OU)/1000*.

The recirculation flow (RF) is determined by oxygen concentrations in influent and effluent of the tanks and the demand. The oxygen level in (OLI) and oxygen level out (OLO) are constants (20 and 7 respectively) as well as factor for flow incorporated to adjust for different demand during the day (d = 1.2). RF is then calculated by *RF = OI*d*1000/((OLI-OLO)*24)* in which the 24 is the translation from 1 day to 1 hour. Based on the flow the power needed to pump the water around can be calculated. The pressure (Pr) is a constant (0,8). The power (kW) needed to pump this amount of water around is described by *kW = Pr*10*RF*1000*10 / (3600*1000*0.7*). In which 0.7 is the efficiency coefficient of the used pumps. The other constants in the formula are defined to transform pump capacity into necessary pump kW. The total electrical power needed continuously (including biofilter, light etc.) is calculated using a ratio between power needed for recirculation and the rest of the system (0,4).

The water use is calculated from a specific water use per kg feed (400) and the feed used per year.

For heating of water and building, natural gas is used. The amount of gas needed for heating of water is calculated from a temperature difference (25-12), the specific heat capacity of water, the caloric value of the gas and a heating efficiency. The gas needed for heating of the building is calculated from the area of the building and an empirical value giving the specific gas use per m2 building.

The levy for waste discharge is based on the number of Inhabitant Equivalents (IE). A farm with a good system for effluent treatment produces app. 1 IE per ton of fish production per year.

The labour needed is differentiated into three categories (high, medium, low) and calculated according to production capacity. There is a fixed and a variable part for each category.

The fish produced needs to be kept in clean water without feeding for a few days before sale. This depuration causes a loss in fish weight (5%). No further processing is incorporated.

Table 2. An overview of the sheet “Productivity”.

Table 3. An overview of the sheet "Farm design"

Tanks		
Fish production	*mt.year^{-1}*	79
Production efficiency	*%*	85
Max. Productivity	*kg.m^{-3}.d^{-1}*	155
Tank volume	*m^{3}*	599
Tank height	*m*	1,3
Tank area	*m2*	461

Building		
Ratio tanks:building		0,3
Building size	*m2*	1536
Ratio building:land		0,3
Total area	*m2*	5122

Feeding		
Feed conversion		1,1
Max daily feed load	*kg.d^{-1}*	238

Nitrification		
Rel. Feedcapacity	*kg feed/m3 biofilter*	3,0
Volume filters	*m^{3}*	79

Oxygenation		
Oxygen use	*g.kg feed^{-1}*	500
Oxygen input	*kg.day^{-1}*	119

Flows & power		
O2-out	*mg/l=g/m^{3}*	7
O2-in	*mg/l=g/m^{3}*	20
d	*max/avg*	1,2
Water flow	*m^{3}.h^{-1}*	458
Pressure	*bar*	1
Power	*kW*	18,2
Ratio recirc:rest power		0,3
Total power	*kW*	60,5

Water use		
Relative water use	*l kg feed -1*	400
Water use	*m3 y-1*	34737

Heating		
Heating water	*m3 gas/m3*	1
Heating building	*m3 gas/m2.Y*	5
Total heating	*m3 gas*	39261

Effluent	*VE/ton prod.Y*	1

Labour	*Fixed: FTE/ton.Y*	*Variable: FTE/ton.Y*	total
High	0,003	0,004	0,303
Average	0,003	0,004	0,303
Low	0,003	0,005	0,378
			0,984

Processing		
Slaughter	*100*	%
Depuration loss	*5*	%

2.5 Investments

In the investment sheet (table 4) all necessary investments are presented. The number of units needed for each item is taken from the sheet 'Farm design' and multiplied with a price per unit. Most of the investment items have a linear relationship with production size. A few items like connections and some equipment are considered fixed.

The <u>depreciation terms</u> are estimated based on value and expected lifetime. All depreciation is linear over time.

Table 4. An overview of the sheet "Investments".

Description	Number	unit	Price/unit	Subtotal	%	Total	Depreciation Term	5	10	20	30
Land	5.122	m^2	10,00	51.200	6	51.200					
Permits				10.000	1						
Hookup electra				7.000	1						
Hookup phone				454	0						
Hookup gas				4.500	1						
Hookup water				1.000	0						
Hookup sewer				0	0						
Well				6.000	1						
Groundwork	1.536	m2	10	15.365	2	44.319					
Building	1.536	m^2	200	307.293	36	307.293	25	0	0	0	0
Heating	1.536	m^2	15	23.047	3		5	4.609	0	0	0
Ventilation	1.536	m^2	5	7.682	1		5	1.536	0	0	0
Lighting	1.536	m^2	15	23.047	3		5	4.609	0	0	0
Electra	61	kW	400	24.209	3	77.985	5	4.842	0	0	0
Tanks	599	m3	106	63.517	7		10	0	6.352	0	0
Piping	458	m3/h	50	22.877	3		10	0	2.288	0	0
Drum	458	m3/h	100	45.755	5		10	0	4.575	0	0
Pumps	458	m3/h	35	16.014	2		5	3.203	0	0	0
Filtermaterial	79	m^3	150	11.896	1		10	0	1.190	0	0
Oxygenreaktor	458	m3/h	30	13.726	2		10	0	1.373	0	0
Oxygen dose regulator	458	m3/h	10	4.575	1		10	0	458	0	0
Concrete sumps				30.000		208.361					
Other											
De-ironing	34.737	m3/Y	0,3	10.421	1		5	2.084	0	0	0
Emergency power aggregate	61	kW	500	30.261	4		10	0	3.026	0	0
Measurement and control	599	m3	15	8.988	1		5	1.798	0	0	0
Alarm				2.269	0		5	454	0	0	0
Septic tank	79	ton/Y	100	7.895	1		10	0	789	0	0
Feeding equipment	599	m3	30	17.977	2		10	0	1.798	0	0
Weighing equipment				4.000	0		5	800	0	0	0
Sorting equipment				4.000	0		5	800	0	0	0
Cooler/freezer				2.000	0		10	0	200	0	0
High pressure cleaner				1.000	0		5	200	0	0	0
Office				5.000	1	93.811	10	0	500	0	0
Unforeseen	10%			78.300	9	78.300					
								24.935	22.548	0	0
Total initial investment						**861.268**					
Production	**$kg.y^{-1}$**					**75.000**					
Investment per unit prod.	**euro.kg-1**					**11,48**		**Yearly depreciation:**		**47.483**	

2.6 Prices

In the prices sheet (table 5) all prices are given that are needed to calculate cost price. The fingerling price is generated in the model 'Hatchery'.

Table 5. An overview of the sheet "Prices".

Item	*Unit*	amount	remarks
Juvenile price	*euroct.piece* $^{-1}$	40	from hatchery model
Feed price	*euroct.kg* $^{-1}$	91	
Electricity price	*euroct.kWh* $^{-1}$	5,0	
Gas price	*euroct.m3* $^{-1}$	23	
Water	*euroct.m* $^{--3}$	0	
Oxygen	*euroct.kg* $^{-1}$	14	incl rent
Chemicals/medicine	*euroct.kgprod* $^{-1}$	9	
Maintenance	*% of investments*	2,0	
Insurance	*% of investments*	0,3	
Effluent fee	*euro.IE* $^{-1}$	100	
Measuring costs	*euro.y* $^{-1}$	2.000	
General costs	*fixed; euro*	20.000	
Variable	*euroct.kg prod* $^{-1}$	10	
Labour:			
High	*euro.y* $^{-1}$	50.000	
Mid	*euro.y* $^{-1}$	35.000	
Low	*euro.y* $^{-1}$	20.000	
Interest rate	%	6,0	

2.7 Costs summary

In the costs summary cost price is calculated based on all necessary costs. The actual fish production (AFP) is calculated based on fish production (FP), slaughter (S = 100%), depuration loss (SL = 5%) and is as follows *AFP = FP*(S/100)*(100-SL/100)*1000*. The costs for the juveniles (JC) are based on fish production (FP), market weight (MW), survival from sheet 'Productivity' (S = 85%) and juvenile price (JP) and is as follows *JC = FP*(1000/MW)*(100/PE)*(JP/100)*.

Feed costs (FC) are calculated based on fish production (FP), feed conversion (FCR) and feed price (FPr) and is as follows: *FC = (1000*FP*FCR*FPr)/100*.

Electricity cost and other direct inputs are calculated using the data from 'Farm design' and 'Prices'. Medical costs (MC) are based on fish production (FP) and cost of medicine per kg production (MedCost) so the formula looks as follows *MC = FP*1000*(MedCost/100)*.

Maintenance (M) and insurance (I) are percentages of initial investment (II). Thus these are calculated as *MC = (II*M%)/100* and *IC = (II*I%)/100*. Measure costs are a constant (see prices sheet). General costs (GC) are divided into fixed and variable (GF and GV, respectively). Variable general costs depend on fish production level (FP) so the formula is *GC = GF+ (FP*GV/100).*

Labour costs are calculated from the number of people needed ('Farm design') and the price per category. Depreciation is based on totals as calculated in the investment sheet. The numbers presented here are yearly depreciation numbers. Building is presented separately because a term of 30 years is calculated for the building.

Interest cost are based on investment (II), standing fish stock (StaS) and interest rate (IR). The formula for investment is *ICII = 2/3*II*(IR/100)*. For standing fish stock the assumption is made that the fish stock represents a value of subtotal company costs (see sheet) divided by two and of standing fish stock *IstaS = (Subtotal company costs/2)*(IR/100)* The sum of both represents total interest costs.

2.8 Cash-flow

In the cash-flow sheet the economical results are calculated based on monthly sales and monthly costs. The formulas used to calculate net present value and internal rate of return will be discussed. <u>An important assumption is that the third year of production is representative for the rest of the project term</u>. This is because in the third year monthly product sales occur whereas in the first and second year no product is sold (start sales base case in month 23).
<u>Average weight</u> in the production months is taken directly from the growth sheet. The <u>number of fish per square meter</u> is calculated based on density (D) and is *number = (D*1000)*Wt.(g)* this number is then used to calculate <u>square meters per fish</u> by *1/Number*. <u>Mortality</u> is based on the mortality in the sheet “Productivity”. The mortality is integrated over the first four months by *Mortality (%)/4.* The <u>number of juvenile fish</u> that is needed every month is based on cost for juveniles (JC) divided by the price for a juvenile (JP), these are taken from the sheets costs summary and prices respectively. The formula for monthly input of juveniles is then *#Juveniles = (JC/JP*100)/12*.

In order to estimate the number of fish in the system the spreadsheet calculates the monthly number of fish present in any weight class. The average weight is in fact the weight of the fish at the end of the month so no underestimation of necessary <u>farming surface</u> can be made. To calculate the amount of fish that is in the system at any time the <u>total number of fish</u> is calculated after which the sum-product of number times <u>individual weight</u> is calculated. Based on this number necessary <u>farming surface</u> is calculated by the sum-product of <u>number of fish</u> in each weight class times <u>individual fish space</u>.

The <u>number of pumps</u> needed to pump the water around is based on <u>occupied farming surface</u> (OS) in the production facility, <u>farming surface</u> as based on productivity (FS) and the <u>number of pumps available</u> (4). The formula then is *pumps = OS/(FS/4)*. In this formula the assumption is made that 4 pumps should cover the entire production facility.

<u>Initial investments</u> are based on total initial investment minus investments needed for operation costs (see investments sheet). These investments regarding operation are taken into the model in month 11 to have some spread of finance and because of the fact that operation costs slowly start-up.

The <u>cost for the juveniles</u> are *#Juv*(JP/100)* automatically referring to the number of juveniles that is put in monthly. The <u>cost for feed</u> is based on the weight gain of the population e.g. for month 2 it is *sum-weight(month2) – sum-weight(month1)*FCR*FPr/100*. <u>Other input costs</u> are e.g. <u>electricity and gas</u>. The assumption is made here that gas usage in the first year is half of what is used in the second year because of under-exploitation of the system. The formula for month 1 is e.g. *(electricity cost)/12+(gas cost/2)*. All other input costs are divided over the year. The other input costs for month 2 are *(electricity costs/Pumps active/4) - (electricity costs/12)*. This was built in to account for the number of pumps that are working. The reason this was not done in month 1 is start up electricity use. In the other months the total other input costs are added just by dividing them by 12.

The fixed company costs are calculated by *FCC = (Other company costs + labour costs) / 12*. In the costs summary sheet these values are found. In other company costs for instance insurance, maintenance etc are covered.

These above mentioned costs result in a monthly subtotal.

Monthly interest rate is based on interest rate (IR) and cash flow (CF). The formula is *interest = (IR/12/100)*CF*. Monthly expenses (ME) are the total of costs, inclusive investments. At first this is equal to cash flow since in first year no sales are present.

Basically what is mentioned above is also true for the second year however, in the base case fish is sold from month 17 onwards. The formula for monthly sales is based on market weight (MW) market price (MP) and number of fish sold. *Sales = Number of fish*(MW/1000)*MP*. From month 17 onwards this has a positive effect on the cash-flow.

In year 3 monthly sales occur and costs are stable since the standing stock (the amount of fish present at the production facility) is constant. This means that year 3 functions as a model year for year 4 to 15 and is taken into the economical evaluation that summarises this sheet.

In the first year investments have to be done, these are found in the first year investment evaluation and can be summed up. In the first, second and third year juvenile costs, feed costs, other inputs and fixed company costs can be calculated by the sum of the monthly costs. For the interest costs this is also applied. By adding the subtotal of cost and interest the total expenses (incl. interest) are found. This is a negative number indicating expenses. By adding to that number the turnover that is obtained from sales the cash flow is found. Cash flow ex interest is also presented. From year 4 onwards the model refers to year 3 with the only difference that for the year 5 and 10 investments that are depreciated a renewed investment value is presented. The net present value and internal rate of return are based on the cash flow ex interest. The formulas that are used are derived from the financial functions present in Excel. The net present value is based on a rate of discount of 7%.

Interest costs are, as stated above, based on fish stock and initial investment. For the first three years these costs are calculated by summing up the values as calculated per month. However, from the fourth year onwards the interest costs are based on another calculation, in year 5 for instance the interest costs are based on the cash flow year 4 (CF4), turnover year 5 (TY5) and the sum of the costs of year 5 (SC5). The formula is as follows: *Interest costs (year5) = CF4 + ((TY5-SC5)/2))*.

The break-even analysis is based on the number of years it will take to be out of costs. The formula is based on cash flow cumulative and cash flow ex interest and the year of the project. The formula is based on IF and AND functions present in Excel. An example, for year 5 this formula would be:

$$Break\text{-}even = IF(AND(CFC>0;CFC_{last\ year}<0);1;0)*(5-(CFC_{thisyear}/CFexinterest_{lastyear})).$$

Over the entire project the break-even is calculated by summarising these yearly values.

3. Parameterisation of the model

3.1 Introduction

Any model is as good as the input used. Therefore, this chapter will be used to explain the most important data used in the model and indicate sources. The base-case constructed in this way is also shown in the tables and used in the scenario analysis.

3.2 Control variables and output

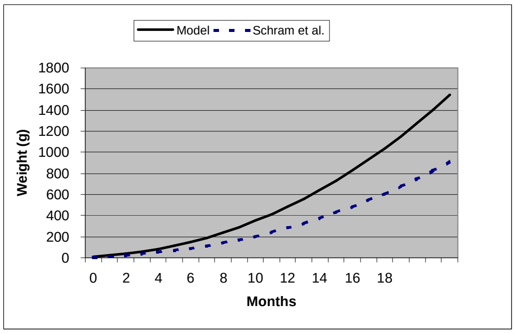
The default production size in the model is 75 tonnes per year. This is a medium-sized farm, which is technically very well feasible to build. The market price used is 6 euro per kg for a fish of 1500 grams. This figure is taken from the market study (de Wilde, 2003), which has shown that good prices can be paid for large pike-perch. It is obvious that the market price is a key-figure for profitability since it determines directly the margin on the sales. The growth rate of the fish is set by the parameters a and b. These are discussed under “Productivity”.
The data generated under output in this sheet will be discussed under results (Ch. 4).

3.3 Productivity

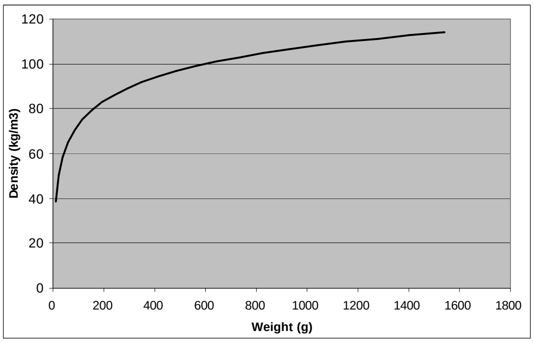
In the sheet Productivity, the growth rate and the densities of different fish sizes are elaborated on.
Every month a new specific growth rate (SGR) is calculated based on SGR = $a.W^b$ in which a and b are set respectively at 6,92 and - 0.43. Based on a starting weight of 10 grams average weights can be calculated for each month and a growth curve can be constructed. Figure 1 shows the growth curve using the data mentioned above and compares it with data generated in the pilot project. Gielen and Mélard (2003) found a relationship between SGR and W with a= 10,253 and b= -0,576. These results would amount to an average weight of 860 grams after 24 months. Wedekind et al. (2003) showed a growth to an average weight of 1,5 kg in 2,5 years of which the last 1,5 years were attained in cages in open water.

Figure 1. The growth curve (a) and density (b) used in the simulations.

a)



b)



The density (D) is based on D = a.ln(W) + b in which a = 15 and b = 4. In figure 2 this relationship is depeicted graphically. Densities vary from 50 kg/m^3 for fish of 20 gram to 114 kg/m^3 for fish with an average weight of 1500 grams.

In the pilot-system densities of 80 kg/ m^3 have been attained with fish of 400 to 900 grams (Schram and Philipsen, 2003). Gielen and Mélard (2003) have worked with densities up to 80 kg/m^3 with fish of a body weight of 120 gram. The calculated productivity expressed as kg of fish produced per year per unit of culture volume is 155 kg/m^3.year according to the model. This can be considered a key-parameter for perfomance. In the pilot system a maximum productivity of 134 kg/m^3.y has been achieved with fish of app. 200 g average weight over a period of half a year. Experimental research over relatively short periods by Gielen and Mélard resulted in maximum productivities of 220 kg/m^3.y.

3.4 Farm design

The actual fish sales are from the first sheet are corrected depuration loss (5%) after production. The maximum productivity calculated in "Productivity" is multiplied with a factor 0,85 to correct for inefficiencies in production. A tank volume of 599 m^3 and a rearing area of 599 m^2 are thus calculated.

An overall feed conversion of 1,1 is used. In the pilot-system conversions around 1.0 were shown to be feasible.

The data on nitrification, oxygenation, flows & power and water use are taken from the actual figures realised in commercial eel farming in recirculation systems.

The labour input into the farm is one of the most difficult to estimate because there is little material for comparison. A linear relationship is assumed between farm production and labour input, which is different for different levels of skill. For a farm producing 75 tonnes per year an equal input of app. 0,3 fte is assumed for respectively a high, medium and low skilled worker resulting in a total input of manpower of 1 fte.

3.5 Investments

In the sheet "Investments" a cost breakdown is given and depreciation is calculated. The amounts used have been calculated in "Design"; experience with the unit costs has been generated during the pilot project. The building is with 36% of the total a very important item. A unit-price of 200 euro/m^2 is used. The total investment costs (including 10% unforeseen costs) amounts to 860.000 euro which corresponds with 11,48 euro per kg production capacity. The yearly depreciation is calculated to be 47.000 euro.

3.6 Prices

The price for a juvenile (40 cts/pc) is derived from the fingerling model. The other prices are based on experience in the pilot system and reflect the price level in The Netherlands.

4. Results

4.1 Costs

Table 6 gives an overview of the costs involved in producing 75 tonnes of pike-perch per year in the base-case. Total costs amount to 355.638 euro per year, which corresponds to 4,74 euro per kg of fish produced. With an anticipated sales price of 6 euro per kg, a margin of 1,26 euro is created (21%). Costs for juveniles are minor with 7%; feed is an important input covering 22% of the cost price. Other direct costs are taking up 16% of the costs price; electricity is an important item here with 7%.

Other company costs like maintenance; insurance and general costs cover roughly 14%. Labour costs amount to 45.755 euro per year, which represents 13% of the total.

Depreciation and interest cover respectively 17 and 12% of the total costs and are a major cost item.

Table 6. A breakdown of the costs for producing 75 tonnes of pike-perch per year.

Production (kg actual product)		74.963 kg		
		[euro]	[euro/kg]	*% costprice*
Juveniles		23.529	0,31	*6,6*
Feed		78.819	1,05	*22,2*
Other inputs				
	Electricity	26.509	0,35	*7,5*
	Gas	8.908	0,23	*4,8*
	water	0,00	0,00	*0,0*
	oxygen	5.910	0,08	*1,7*
	chem., med., etc.	7.170	0,10	*2,0*
	purification fee	7.895	0,11	*2,2*
	subtotal	56.391	0,75	*15,9*
	subtot. dir. costs	158.739	2,12	*44,6*
Other company costs				
	maintenance	17.230	0,23	*4,8*
	insurance	2.580	0,03	*0,7*
	measure costs	2.000	0,03	*0,6*
	general costs	27.500	0,37	*7,7*
	subtotal	49.310	0,66	*13,9*
Labour				
	high	15.150	0,20	*4,3*
	average	10.605	0,14	*3,0*
	low	20.000	0,27	*5,6*
	subtotal	45.755	0,61	*12,9*
Subtotal company costs		253.804	3,39	*71,4*
Depreciation				
	5-year	24.935	0,33	*7,0*
	10-year	22.548	0,30	*6,3*
	20-year	0	0,00	*0,0*
	building	12.290	0,16	*3,5*
	subtotal	59.773	0,80	*16,8*
Interest				
	2/3 investment	34.450	0,46	*9,7*
	fish stock	7.610	0,10	*2,1*
	subtotal	42.060	0,56	*11,8*
Subtotal depreciation and interest:		101.833	1,36	*28,6*
Total costs:		**355.638**	**4,74**	***100,0***

4.2 Cash-flow and return

The first sales start in month 22. At that time a maximum negative cash-flow of 1.329.084 euro is achieved which has to be financed. A positive cumulative cash-flow is only achieved in year 14.

The internal rate of return (IRR) of the farm would be 8.0% and the Net Present Value (NPV) 70.000 euro. The means that an investment in such a farm would be sensible considering opportunity costs of 7%. However, it is obvious that the return is marginal.

Table 7. The cash-flow of a 75-tonnes production of pike-perch.

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4.3 Scenario analysis

The bio-economic model is an excellent tool to study different production scenarios, which give insight in areas for improvement of economic results. Table 8 gives an overview of effects of changes in a number of key-variables on economic performance of a pike-perch farm.

Table 8. Internal Rate of Return (IRR) and cost price under a number of different production scenarios. The base-case is shown in italics.

Production (T/Y)	***75***	**100**	**150**	**200**
IRR (%)	*8,01*	9,74	11,71	12,64
Cost price (e/kg)	*4,74*	4,57	4,40	4,31
Productivity (kg/m^3.Y)	***155***	**170**	**185**	**200**
IRR (%)	*8,01*	9,09	9,32	10,16
Cost price (e/kg)	*4,74*	4,66	4,59	4,53
Market price (e/kg)	**5,50**	***6***	**6,50**	**7**
IRR (%)	3,76	*8,01*	11,71	15,03
Cost price (e/kg)	4,74	*4,74*	4,74	4,74

The scale of production has a significant effect on the returns because fixed costs can be attributed to a large production volume. An increase of the production with 200% to 150 tons per year increases the IRR from a marginal 8,01% to 11,71%.

The productivity is the resultant of growth rate and density and has a considerable bearing on economic results. An increase in productivity from 155 to 200 kg/m^3.y results in a concomitant increase in Return from 8,01 tot 10,16%. Both production capacity and productivity can be expected to increase once experience is gained on production of this new species.

In the base-case a market price of 6 euro per kg is used. It is obvious from table 8 that small changes in this price have a strong effect on profitability.

Other factors, which deserve constant attention, are feed costs (21% of total) and investment costs resulting in a high depreciation.

5. Conclusions

- On-growing of pike-perch in a recirculation system can be considered marginally profitable under the assumptions used in the bio-economic model. In the base-case (75 tons/y; 6 euro market price) an Internal Rate of Return is generated of 8,01% at a cost price of 4,74 euro per kg.

- The fish can reach a market weight of 1,5 kg after 22 months, starting from 10 gram individual weight. The density ranges from 40 kg/m^3 for the smallest fish to 115 kg/m^3 for the largest sizes. This results in a total productivity of the system of 155 kg/m^3.y.

- Total investments costs amount to roughly 850.000 euro which is 11,48 euro per kg production capacity. The maximum negative cash-flow (including investments) is reached after 22 months and amounts to 1.3 million euro.

- The profitability of a farm for pike-perch is very sensitive for the market price attained. Other major factors are scale of production and productivity. Improvements in this field can results in interesting Returns once experience is gained.

6. References

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