The Economics of Recirculation Aquaculture

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Abstract. This paper investigates the financial and economic efficiencies of three scales of recirculation aquaculture production growing Murray Cod (*Maccullochelli peelli peelli*) at tonnages of 25 tonne, 50 tonne and 150 tonne. Best practice industry data is used (growth, FCR, mortality, equipment and running costs) in conjunction with *AQUAFarmer* feasibility software[1] to determine the relationship between key bio-economic variables such as the sale price of the product, FCR, stocking density and growth.

Keywords: Recirculation aquaculture, financial feasibility, farm modelling.

1. INTRODUCTION

Recirculation (intensive) aquaculture systems are a relatively new technology for holding and growing a wide variety of fresh water and marine finfish in Australia. These systems come in an array of capacities and efficiencies. Through the effective management of production variables, recirculation technology offers relatively more independence from the external environment. This translates to an increased level of control, which can provide a basis for improved risk management.

This paper investigates the financial and economic efficiencies of three scales of recirculation aquaculture production growing Murray Cod (*Maccullochelli peelli peelli*) at tonnages of 25 tonne, 50 tonne and 150 tonne. Best practice industry data is used (growth, FCR, mortality, equipment and running costs) in conjunction with *AQUAFarmer* feasibility software to determine the relationship between key bio-economic variables such as the sale price of the product, FCR, stocking density and growth.

2. AQUACULTURE PRODUCTION

2.1 World Production

Within a global context, aquaculture is the primary means by which the shortfall in world fish production will be met. Aquaculture production has grown at an average rate of 10% since 1984 compared with captured fisheries at 1.6% and livestock meat at 3%. Overall global production of aquaculture production (including finfish, shellfish and aquatic plants) is 34 million tonnes (valued at US$46.5 billion) of which the majority is finfish and shellfish (59%) (FAO 1998)

In addition, the tendency that has been observed lately towards healthy nutrition is going to significantly increase demand for seafood since fish is considered one of the healthiest foods. By the end of this year cultured fish is expected to account for 30% of total world fishery. (FAO 1995)

2.2 Australia

Australian aquaculture production is relatively small compared with world production with 32,000 tonnes (worth AUD$602 million) being produced in 1998/99.

Production is largely marine based using extensive aquaculture systems (85% of total production, consisting of Pearl Oysters 30%, Blue Fin Tuna 28%, Atlantic salmon 12%, Edible Oysters 8% and Prawns 7%)(ABARE 1999)

Victoria, like most other states in Australia, is currently experiencing a boom in private aquaculture investment. Investment in freshwater finfish recirculation systems has nearly doubled in the last year. Total investment reached over $16 million in 1999/2000. See figure 1 below for a breakdown of this investment. This increase has partly been encouraged by an increasing government recognition and support for aquaculture development in inland regional areas. There is also a national push to integrate aquaculture (both intensive and extensive) with more traditional land based agriculture that uses irrigated water for production.

More importantly however, the private sector is demonstrating increased aquaculture investment confidence. This confidence is buoyed by global and regional trends that indicate decreasing availability of wild fish stocks, increasing seafood demand and falling prices of traditional farm based commodities.

Type	1998/99	1999/001	%change
Marine	3.8	5.6	47
Freshwater	5.1	9.7	90
Other	.25	1	300
TOTAL	9.15	16.3	78

Fisheries Victoria, 2000

Fig 1: Investment in Victorian Aquaculture ($mill)

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[1] **AQUA*Farmer (V1.1)* is a propriety software developed by Fisheries Victoria. It is specifically designed to analyse recirculation aquaculture efficiency and viability. It is a 10 year accounts simulator that creates farm scenarios based on bio-economic inputs.**

Notwithstanding these important trends, aquaculture investment demands a case by case examination of the opportunities and risks. Successful identification and management of risk and a comprehensive understanding of the many bio-economic variables which affect farm income and performance is more often than not, what separates success from failure.

Private expenditure in aquaculture is all too often characterised by unrealistic business expectations. While enthusiasm for industry development remains high, aquaculture investment is fraught with danger for the uninitiated. Not unlike many other emerging agribusiness sectors, for every successful development in aquaculture, multiple failures are apparent and seemingly re-occurring. Undoubtable, at the heart of most failures is poor business planning.

The realisation that aquaculture is by its nature inherently risky and operating in a competitive high value end food industry market place is often overlooked. A combination of high business expectations and limited technical and business planning skills can result in a lack of appropriate venture capital and/or poor investment decisions.

3. INTENSIVE AQUACULTURE SYSTEMS

3.1 Advantages
Recirculation (intensive) systems represents relatively new technology with a wide variation in system design and quality. Through the effective management of production variables, recirculation technology may offer relative independence from the external environment.

Recirculation aquaculture systems are receiving increasing interest in intensive fish culture operations as technological advances in closed systems technology. Small business ventures in particular are attracted to enclosed and modular recirculation systems. The closed system offers several advantages, including:

- water and heat conservation
- waste management control
- fish health control
- stock management
- site flexibility
- increase stocking density

Improvements in feed formulations, nutrition, water chemistry, disease prevention and treatment, and selection of species with economically desirable traits could well lead to continuous production improvements. The identification of species with economically desirable traits include those which have the following important aspects:

- Established markets
- High value

- Tolerance for poor water quality
- High stocking densities
- Feed on pelleted food
- Efficient food Conversion ratio (FCR)
- Available from local sources (hatcheries or wild)

3.2 Managing Risk
The level of control inherent in recirculation systems can provide a basis for improved risk management. The trade off, of course, is a necessary increase in technology dependence and associated expense and the expertise to manage it. Low cost, small-scale entry into the industry is often recognised as a means of limiting financial exposure while gaining valuable experience. This approach is now widespread and yet it can lead to complex equipment retro-fitting, higher production risk margins and technological shortcuts that may be costly in the medium to long-term.

While there may be a cost incentive to de-construct recirculation systems into component parts by adding or subtract from established designs, in practice this should not be considered lightly. It must be recognised that water re-use systems involve complex water chemistry in a finely tuned balance and that deviation from proven designs increases the fish farmer's risks significantly.

In best practice recirculation systems more than 90% of the water is recirculated through a series of purpose built biological and mechanical filtration systems so that only a fraction of the water is actually consumed. The importance of the biological filtration sub-system cannot be overemphasised. The capacity to efficiently nitrify the bacteria which break down the ammonia and nitrite in the water is critical to the success of the system. A recirculation system in effect grows two organisms – fish and bacterial culture resident in the bio filter. The bio filter must be constantly managed to ensure optimum performance and hence optimum fish growth.

A recent bio-economic simulation of recirculation aquaculture was carried out for Tilapia by Kazmierczak and Caffey (1996). The simulation carried out an optimisation sequence for:

- 7 levels of biological filter efficiency (BE) ranging from 1 to 0.7,
- 4 levels of mechanical efficiency - solid removal efficiency (SRE) ranging from 1 to 0.25,
- 3 levels of dietary protein (20, 30, 40% dietary protein),and
- 4 levels of stocking density ranging from 0.07 g per litre to 0.13 g per litre.

The bio-economic simulation model suggests that movements in biological filtration efficiency (BE) has a

far greater impact on net returns than combinations of the other three variables. As biological filter efficiency falls then:

- time to harvest *increases* at an increasing rate.
- net returns *decreases* at an increasing rate.
- higher stocking levels may lead to economic failure.
- economic trade offs between feed quality (dietary protein) and stocking occur over a narrow range.
- A higher degree of management expertise is required in optimising system to maximise returns.

The simulation model concludes that the efficiency of biological filtration is critical to the success of the venture. Biological filtration efficiency has lower limits whereby alternative management of other parts of the system may not compensate and the system may fail.

One of the greatest problems associated with this technology is that while emerging technical blockages may be overcome technically they may not be *economically* solvable. As producers intensify their aquacultural activities the margin for management error becomes more acute as the more intense bio feedbacks occur. The inevitable link between stocking densities, necessary to cover the higher fixed and variable costs associated with closed systems as compared to open or

semi closed systems, and margins of error suggests that economic success is more allusive.

The quality of investment decision making is related to the degree of pre start up business planning which requires a comprehensive assessment of production costs, markets and a sound identification of risk. The lack of expertise and knowledge of both production and economic variables will increase risk in venture failure. This is particularly relevant where traditional agricultural operators look to diversify into aquaculture without access to the appropriate skills. Intensive recirculation aquaculture systems demands a high degree of technical dependency and the expertise to manage it.

4. THE MURRAY COD PROJECT

4.1 Introduction

Murray Cod (*Maccullochelli peelli peelli*) is becoming a premium species for aquaculture in Australia, especially Victoria. In 1999 trials were carried out by the Marine and Freshwater Resources Institute (MAFRI) which indicated that stocking densities of over 100k/g per cubic metre could be obtained with little mortality and a grow out period to plate size (500-1000gms) in 10 months. This was despite previously held views that the species were territorial and aggressive and therefore unsuitable to high density stocking. See figure 2 below for the growth rates of farmed and wild Murray Cod.
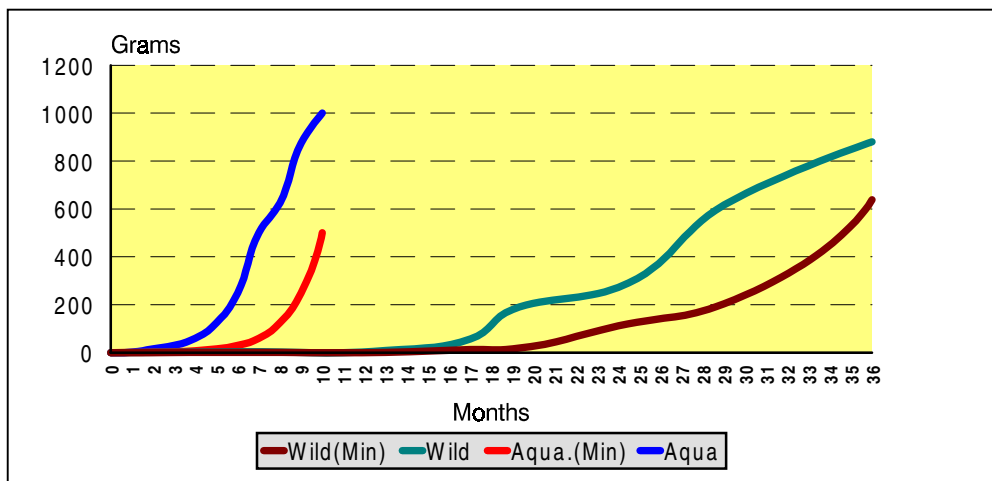
Source: Fisheries Victoria 1999
Figure 2: Murray Cod Growth: Farmed and Wild

Murray cod is one of the largest freshwater fish in the world and is an endemic Murray-Darling river system. It is valued for recreational, commercial and conservation purposes. In the wild they attain maturity

at 4-5 years weighing between 2.5 and 5 kg and can grow up to 113 kg. A female can produce between 14,000 and 30,000 eggs (Kaiola 1994).

It is highly sought after as a table fish (with a high protein content) and up until recently has supported a lucrative but otherwise relatively small commercial fishery for many decades. However, the distribution and abundance of the species have declined markedly since European settlement, and commercial fisheries production is now restricted to small quantities of Murray Cod being landed from within South Australia and Victoria on an irregular basis. New South Wales has recently banned commercial fishing for Murray Cod.

4.2 Stocking

Over the last 10-15 years, techniques have been developed that enable routine, large-scale hatchery production of Murray cod. This technology however, is largely limited to the seasonal production of fry and small fingerlings between 30-50 mm, or 0.5-1.5g. Private and state government fish hatcheries in Victoria, New South Wales and Queensland annually produce fish for stocking public and private waterways for both recreational and conservation purposes. Australian annual production of pond reared juveniles was 645,000 fish in 1995/96.

4.3 Fish Farming

Murray Cod is proving to be a very suitable species to grow in recirculation aquaculture farms. The adoption of European enclosed recirculation systems for on-growing Murray Cod has from the outset produced promising if not outstanding results in recent years.

Preliminary investigations have been completed into nutritional requirements and development of artificial diets for Murray Cod at the Marine and Freshwater Resources Institute and Deakin University. Some private fish farms are beginning to commercially produce market-size Murray cod in tanks and ponds with both natural and artificial diets under a range of intensive/semi-intensive and ambient/controlled environmental conditions.

4.4 Marketing

There is considerable interest in farmed Murray Cod (both plate size and larger). Producers, wholesalers and retailers see Murray Cod as an ideal species to satisfy a significant latent domestic and export demand. Such a demand is in part driven by the premium and associated ongoing demand placed by Asian markets in cultured grouper, and the perception that Murray Cod are a like species which could be equally well marketed throughout Asia (Stoney 2000). A recent preliminary market appraisal of Murray Cod in Taiwan, Hong Kong, Singapore and Japan has indicated positive market response. On product quality

parameters, Murray Cod was considered highly competitive with other premium freshwater finfish present in those export markets.

At the present time, approximately 25% of the annual Australian pond production of Murray Cod fry has been laid down for grow-out purposes, with at least three producers in Victoria and two in NSW having dedicated systems already in place. Both the numbers of fish and actual producers involved is likely to increase significantly over the next five years. Existing strategies involve harvesting pond-reared fry, acclimatising them to tank conditions and then weaning the fry onto artificial diets for the purpose of over winter production in specially designed tanks enclosed in insulated sheds. Current farming methods are producing market size fish (1 kg) in 10 months. This usually takes 3 –4 years in the wild. Figure 2 below shows the minimum and maximum growth rates of Murray Cod in the wild and grown under intensive aquaculture.

5. ECONOMIC ANALYSIS OF RECIRCULATION AQUACULTURE FARMS

5.1 Introduction

Business planning that is attuned to the complex interplay of bio-economic variables will have an overriding influence on the viability of an aquaculture venture. Best practice industry data is used (growth, FCR, mortality, equipment and running costs) in conjunction with *AQUAFarmer* feasibility software to determine the relationship with key bio-economic variables such as the sale price of the product, FCR, stocking density and growth.

In developing *AQUAFarmer*, particular attention was focused on generating feasibility reports that reveal the critical link between key bio-economic variables and financial performance. *AQUAFarmer* provides a model or platform that can be used to run different case studies or scenarios based on the use of different key inputs that can present best case/worse case scenarios. The scale of production is a critical element in determining the costs associated with producing fish. The cost per fish will decline as scale increases.

Recirculation systems come in many shapes, sizes and cost (depending on the quality of the system). AQUAFarmer V1.1 was loaded with three fish farm examples. The examples represent a small (25 tonne), medium (50 tonne) and large (150 tonne) scale operation.

(i) Small Scale Farm

A 25 Tonne Farm small scale diversification venture. This type of venture is best suited to a diversified venture (eg. Land based farmer utilising water resources to supplement main farm operations). Land is assumed to be in place but the cost of specialised buildings are assumed to be part of the capital setup cost. The system consists of 20 final grow tanks. The salary component is $40,000.

(ii) Medium Scale Farm

A 50 Tonne medium scale specialised single venture where fish farming is the only activity of the enterprise. Land is assumed to be in place but the cost of specialised buildings are assumed to be part of the capital setup cost. The system consists of 39 final grow tanks. The salary component covers two staff at a cost of $80,000.

(iii) Large Scale Farm

A 150 Tonne large scale specialised single venture where fish farming is the only activity of the enterprise. Land is assumed to be in place but the cost of specialised

buildings are assumed to be part of the capital setup cost. The system consists of 119 final grow tanks. The salary component covers five staff at a cost of $190,000.

The data used to produce the results have been estimated from industry sources and should be taken as a guide only. The grow out period is 10 months with product ranging from 500g to 1kg (see figure 7 for growth details of the cohort streams). It is assumed that stocking occurs after complete sale of fish, therefore in years 4, 7 and 10 there are two growouts within a financial year. Based on industry data 10% mortality occurs in the first 2 months of growth only and 85% is recovered for HOGG product.

5.2 Common Base Data

In order to compare and contrast the three different scales production farm cost and bio-economic parameters were standardised as much as possible. These common cost items and bio-economic parameters are detailed in 3 below:

Description	Value
Price (HOGG)	$20.00
Cost of fingerlings	$0.50
Cost of Water	$0.65 per kilolitre
Electricity Cost per Kilo of Fish	$0.60
Cost of Weaning Tanks $ per cubic metre	$350
Cost of Grow out Tanks $ per cubic metre	$200
Tank Volume (Weaning)	2 cubic metres
Tank Volume (Grow out)	10 cubic metres
Aquaculture Fees	$2,000
Feed Costs	$1.80 per kilo
Property Tax	$3,000
Biological Parameters	
Stocking Density	100 K/G per cubic metre
FCR	1.2
Mortality (Month 1 and 2)	10%
Recovery rate (fillet)	70%
Recovery rate (HOGG)	85%
Grow out period	10 months
Financial	
Loan Interest [1]	10%
Repayment period [1]	10 years
Discount Rate	8%
Corporate Tax	36%
Stock Insurance (% of turnover)	4%

Figure 3: Common Cost items and bio-economic parameters

1. It is assumed for the sake of comparison that there is no borrowing's and that the feasibility results are based on a debt free venture.

5.3 Scale Specific Running Costs

There are a number of running cost variables that will change as the scale of the farm increases due to the increasing production and accompanying administrative

and maintenance costs etc. These estimates are detailed in Figure 4 below.

Cost Description	25 Tonne	50 Tonne	150 Tonne
Labour	$40,000	$80,000	$190,000
Administration	$1,000	$5,000	$15,000
Office Consumables	$1,000	$5,000	$15,000
Research	$0	$2,000	$10,000
Marketing	$0	$2,000	$15,000
Fuel (Vehicles)	$3,000	$3,000	$10,000
Repairs and Maintenance	$5,000	$10,000	$20,000
Building Insurance	$5,000	$10,000	$20,000
Equipment Insurance	$2,000	$5,000	$20,000

Figure 4: Cost Variables and Farm Scale

5.4 Scale Specific Capital Expenditure

Each scale of farm will require appropriate capital expenditure to meet the pressures of producing increasing tonnages. These costs are one off costs that occur in capital setup. It is assumed that no new capital equipment will be required to be replaced over a 10 year period. Depreciation is calculated on a straight-line basis and shows up in the profit and loss accounts.

In all three examples it is assumed that land does not have to be purchased but is an asset bought into the project by the farmer and that there is no borrowing's. Capital start up costs also includes the initial stock of fingerlings to be grown out and also that there is only one stocking occurring each year in July. However, multiple stockings (up to 12 per year) can be accommodated by the software. Recirculation technology consists of the following capital goods items, however smaller farms may not employ all of the components:

- Mechanical and Biological Filtration Systems
- Fractionator
- Degassing Equipment
- Ozone and Oxygen Equipment
- Ultra violet Equipment
- Pumps
- Monitoring and Control Systems
- Backup Equipment
- Plumbing

The building required to house the fish farm is a purpose built insulated design to ensure that temperatures are kept as stable as possible and that systems maintenance and harvesting are optimally designed into the floor plan.

Each of the farm scale specific capital items required for start up are listed below in Figure 5.

Cost Description	25 Tonne	50 Tonne	150 Tonne
Recirculation Technology	$230,000	$615,000	$1,850,000
Buildings	$100,000	$175,000	$350,000
Vehicles	$30,000	$30,000	$60,000
Tanks	$41,000	$81,000	$240,000
Power Installation	$15,000	$15,000	$25,000
TOTAL	**$416,000**	**$916,000**	**$2,525,000**

Figure 5: Capital Expenditure and Farm Scale

5.6 Growth Parameters

Data from best practice farms reveal that there are 4 cohorts growing from an initial fingerling weight of 1 gram. The revenue stream from the operation assumes that all fish are sold at the end of the grow out period and restocking occurs 1 month later. Therefore over a ten year period there will be 3 years (Years 4,7 and 10) of double production due to the fact that the fish are sold after 10 months and restocking in month 11. The final weights of the fish for sale and their proportion of biomass can be seen in Figure 6 below.

It is also assumed that size grading takes place on a monthly basis to ensure that fish of equal size and weight are placed together in the same tanks. This ensures that the fish grow at their optimum by not being discriminated against in their food requirements.

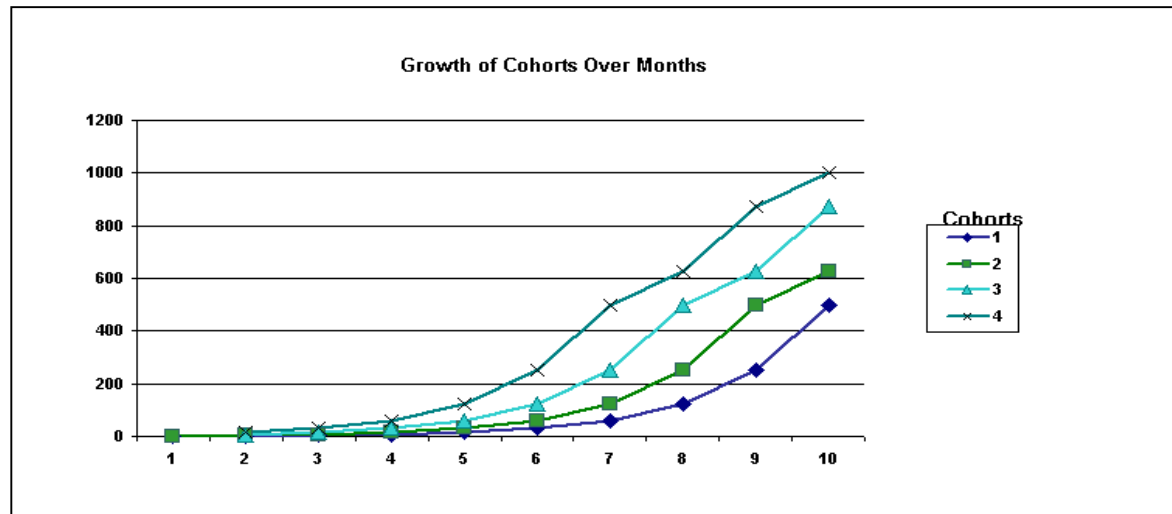| Weight	Proportion
500 g	40%
625 g	30%
875 g	20%
1000 g	10%

Figure 6: Weight distribution on Final Grow out

Figure 7: Growth of Murray Cod under intensive aquaculture through 4 graded cohorts

6. FARM SCALE COMPARISONS

6.1 Key Profitability Indicators
The following key profitability indicators are examined for each of the farms over a range of prices. Currently (June) the wholesale price for Murray Cod is $20.00 per kilo (HOGG). Prices of up to $30.00 to $35.00 are likely to be attained for live export product.

(i) Internal Rate of Return
The Internal Rate of Return (IRR) is the discount rate that equates the present value of net cash flows with the initial outlay. It is the highest rate of interest an investor could afford to pay, without losing money, if all of the funds to finance the investment were borrowed, and the loan was repaid by application of the cash proceeds as they were earned. Conventional projects involve an initial outlay followed by a series of positive cash flows. In this case if the IRR is higher than the required rate of return then the NPV is positive.

The initial capital investment which is used to calculate IRR and NPV includes the following:
- Capital Goods Purchased
- Capital Goods and Land Value bought to the venture by farmer
- Year 1 Running Costs (Working Capital)

(ii) Profit Margin
Profit Margin is the sales return *before* interest. The Profit Margin is equal to the Net Income (NI) before interest {NI + after tax interest expense (ATI)} (averaged over 10 years) *divided* Revenue (averaged over 10 years). This ratio indicates the percentage of sales revenue that ends up as income. It is a useful measure of performance and gives some indication of pricing strategy or competitive intensity.

(iii) Return on Assets
This is the operating return which indicates the company's ability to make a return on its assets *before* interest costs. ROTA equals Profit Margin (PM) times Asset Turnover (AT). Figures 9,10 and 11 below detail each of these indicators for each of the three farm sizes over a range of prices. The current wholesale price of $20.00 is marked on each graph. At this price the indicators reveal a scale of economy impact. Figure 8 shows these indicators at the current wholesale price ($20.00) and the % movement between the small scale and the large scale farms. The indicators show that an improvement in the indicators of around 20%. The bracketed figures in the IRR row are calculated with a risk acknowledgment (Year 1: 50% of production, Year 2: 70% of production, Year 5: 20% of production)

Indicator	Small	Medium	Large	% movement
Profit Margin	23.5	26.9	28	19
IRR	16.5 (13.2)	18 (14.8)	19.7 (16.45)	19
Return on Assets	10.3	11.3	12.5	21

Figure 8: Comparison of key indicators with farm size
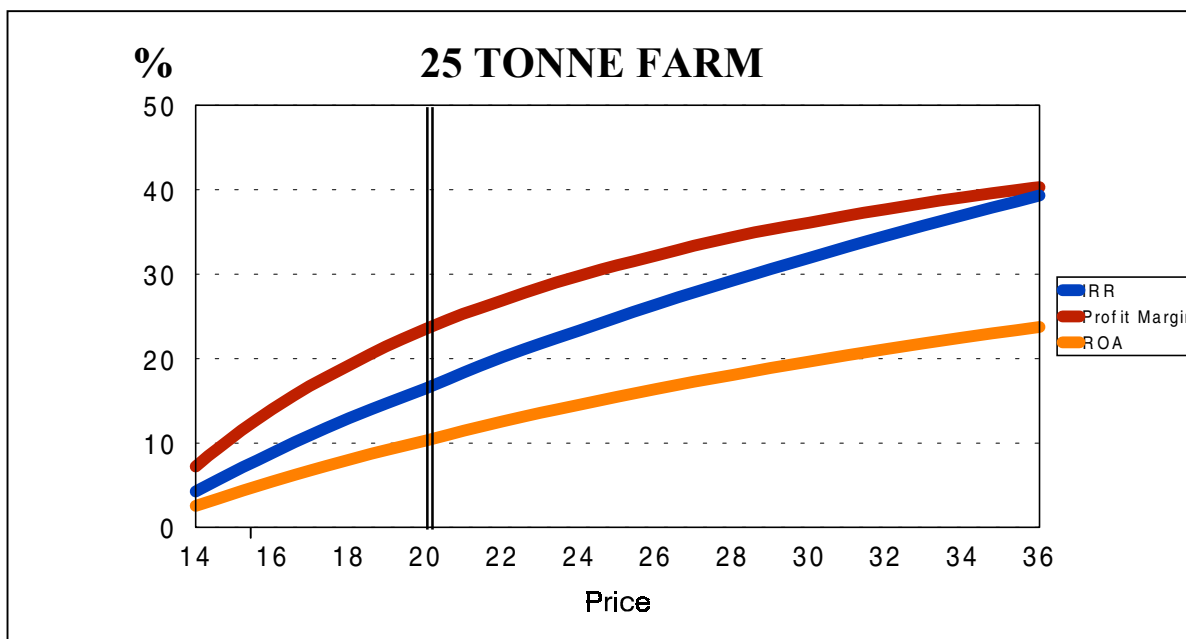

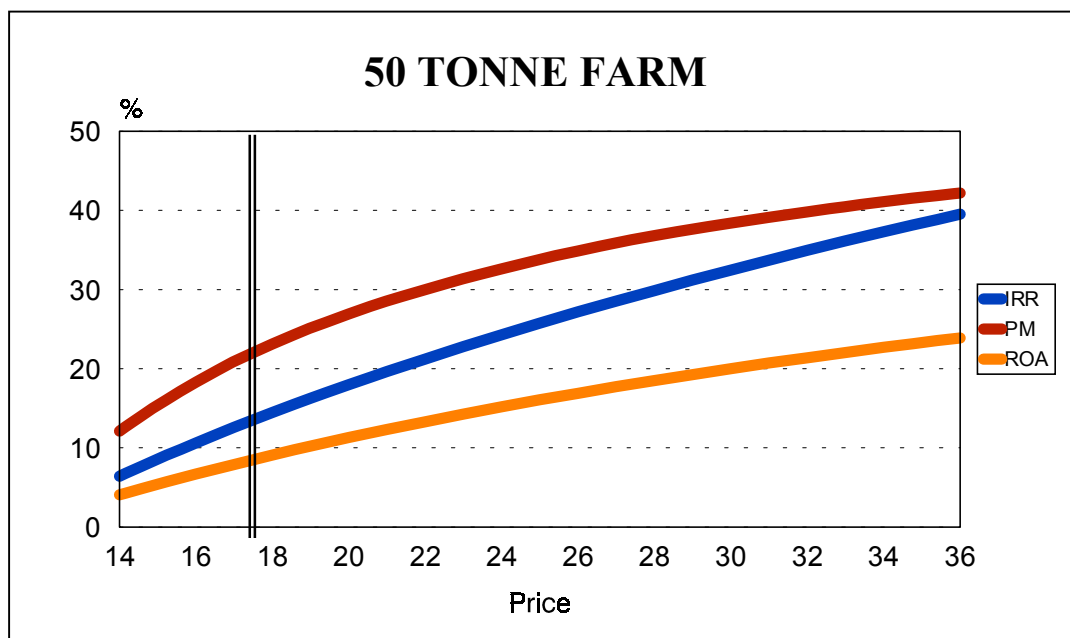Figure 9: Feasibility Indices for 25 tonne Fish Farm

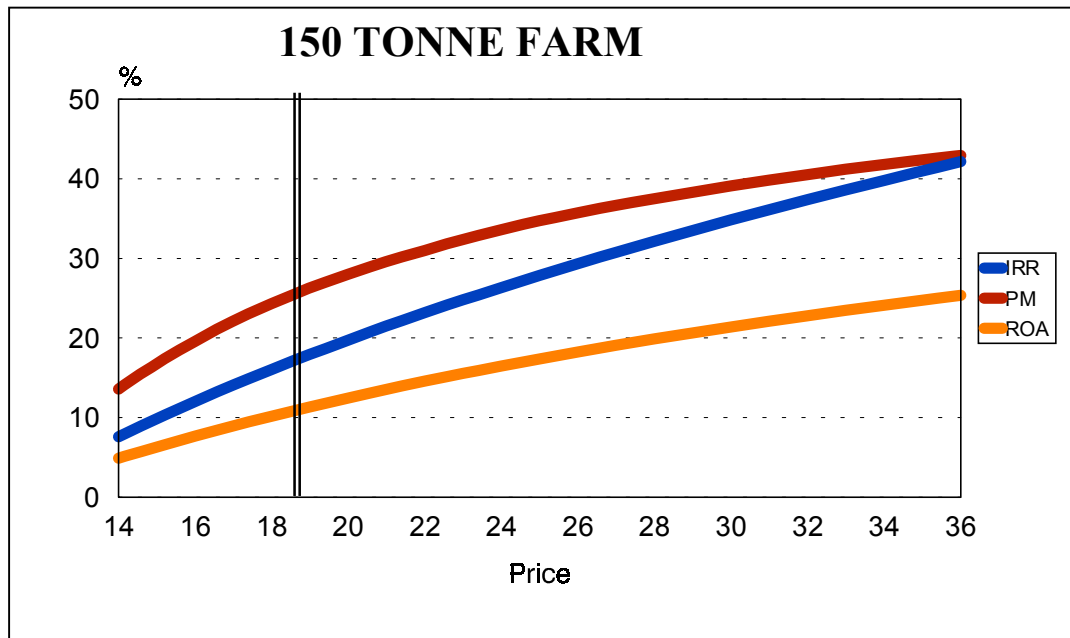Figure 9 : Feasibility Indices for 50 tonne Fish Farm

Figure 10 : Feasibility Indices for 150 tonne Fish Farm

6.2 Hasagawa Index

The Hasegawa index (Hirasawa, 1979) is a convenient way to obtain and indication of profitability of an aquaculture venture. The index compares the *ratio* of the selling price and the price of feed to the *ratio* of the conversion ratio and the ratio of feed cost to total costs.

  a = Feed Conversion Ratio
  b = Cost of Feed to Total Operating Costs

  A = Selling Price per kilo
  B = Feed Price per kilo

$$\frac{a/b}{A/B} \quad < 1$$

In order to decrease the index and make the venture more profitable then either of the following will need to take place (or both at the same time)

(i) Decrease numerator by improving Feed Conversion Ratio [ie decrease (a)]and/or cut costs other than feed costs [ie increase b]

(ii) Increase denominator by increasing Selling Price (A) and/or reduce cost of feed (B)

Figure 11 below shows how changes in the sale price will affect the Hasegawa Index for a 150 tonne farm. The index ranges from 0.6 at $14.00 to 0.25 at $36.00. Japanese open system prawn farming where getting an index of between 0.6 to 1.2.
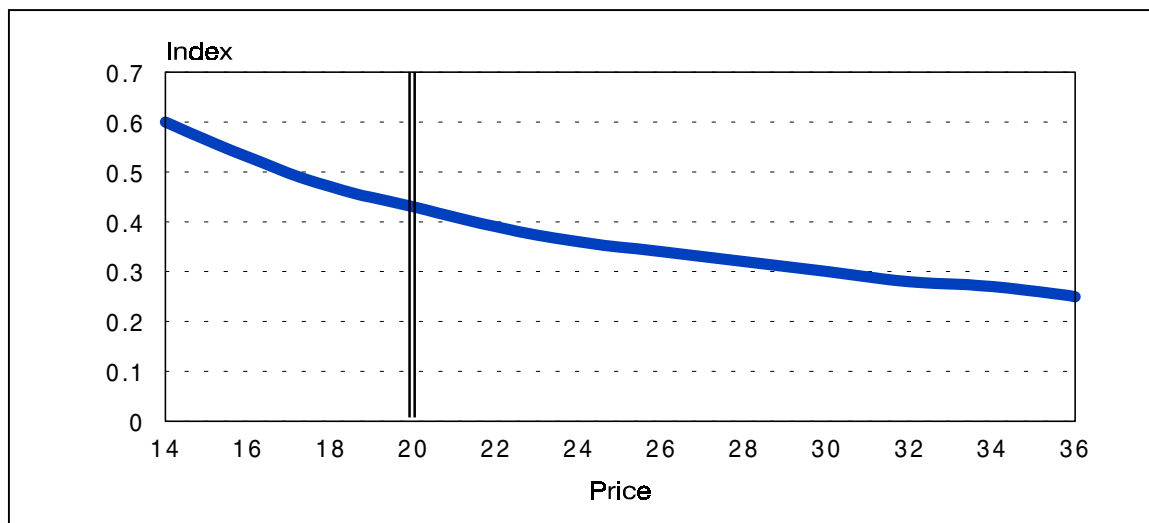
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Figure 11 : Feasibility Indices for 150 tonne Fish Farm

6.3 The FCR and Profitability

The Feed Conversion Ratio (FCR) has an important impact on running costs (feed represents 26% of total running costs at FCR of 1.2) as more food is required to achieve the same weight gain. The increase in FCR could be due to many reasons, including:

- Poor feed quality
- Inappropriate diet mix (protein and fat content of feed)
- Poor feeding regimes

- Poor water quality and oxygenation
- Poor husbandry techniques and fish stress
- Stocking regime

Figure 12 below details the impact of the FCR on key indicators for a 150 tonne farm. The largest effect (through the FCR range of 1.0 to 2.0) is on the IRR which falls from 20.8% to 15.3% or 26%. Profit Margin and Return on Assets both fall by 23%.
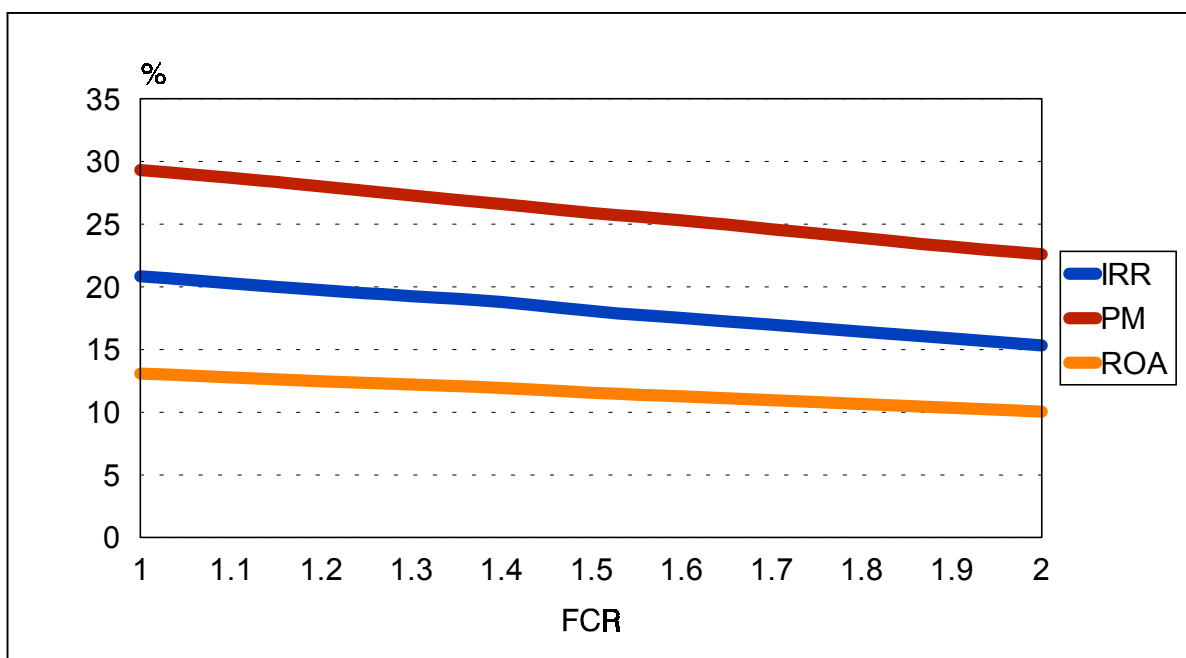

Figure 11 : Feasibility Indices for 150 tonne Fish Farm

6.4 Equity

Equity is defined in the accounting framework as total assets minus liabilities (loan repayments). Assets include the cumulative cash in bank, which increases each year from annual cash surplus and depreciated capital items. It can also be calculated (giving the same amount) as owners investment plus assets not purchased but bought to the enterprise plus cumulative net profit after tax. Double production in years 4,7 and 10 are revealed in Figures 13 and 14 below. Figure 12 below shows the range of equity accumulations after 10 years.

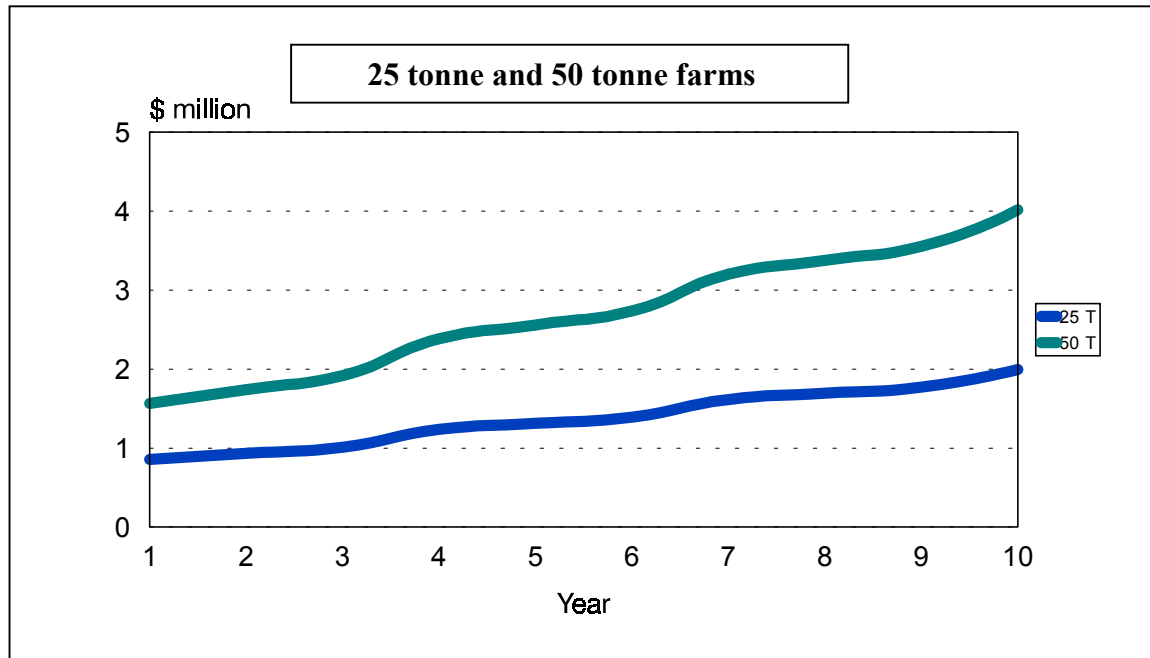| Farm	Equity after 10 years($mill)
25 tonne	1.995
50 tonne	4.018
150 tonne	12.20

Figure 12 Cumulative Equity for various farm scales

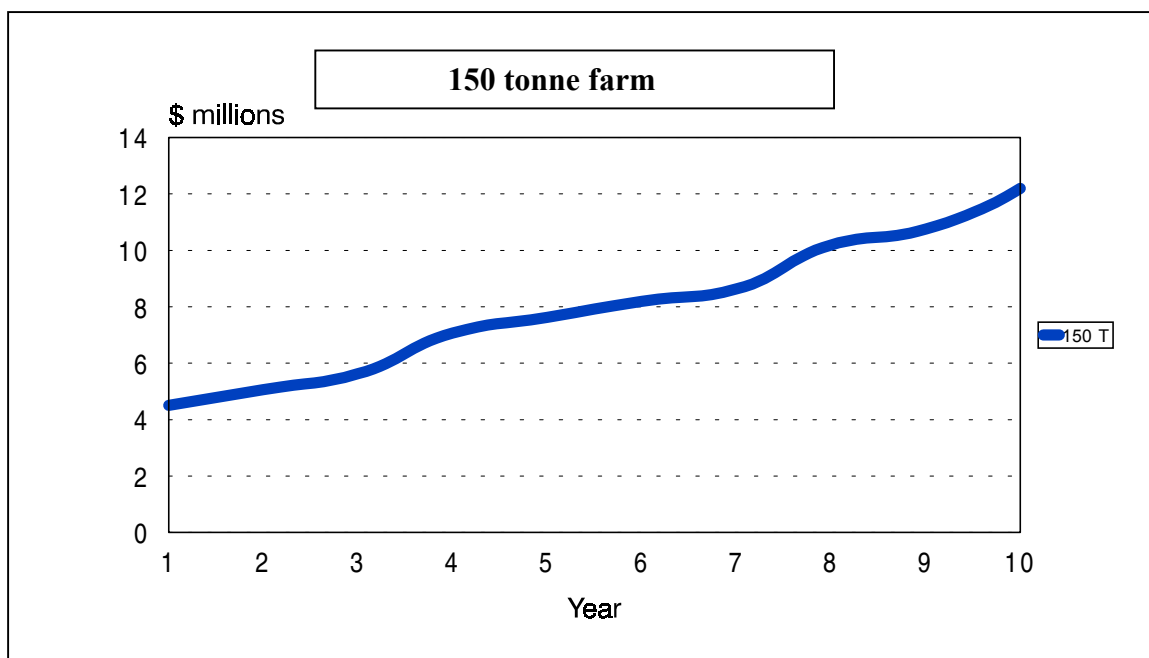Figure 13 Cumulative Equity for 25 tonne and 50 tonne farm

Figure 14 Cumulative Equity for 150 tonne farm

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7. CONCLUSIONS

The main conclusions that can be drawn from this paper include the following:

- ➢ Recirculation systems offer greater control of key production and economic variables and afford improved risk management control.
- ➢ Key bio-economic variables influencing viability include:
  - Scale of the farm
  - Species biological attributes (mortality and growth)
  - Species market attributes (products and price)
  - Feed Conversion Ratio
- ➢ There are significant opportunities for improved risk management in larger systems.
- ➢ Achieving optimal output requires total system control including bacterial growth in bio-filters.

Fisheries Victoria, while a small producer of aquacultured products, is leading Australia in its research of Murray Cod in terms of fish health, feed developments, product and marketing development. The improvement in investment during the last year reveals a promising future for Murray Cod throughout the range of farm scales. Victoria, like the rest o Australia, is searching for ways to improve water utilisation and environmentally friendly systems to produce food products. Recirculation aquaculture provides an manageable solution to farm diversification and stand alone ventures.

Each of the farms analysed reveals very strong indicators of financial success. The profit margins and the return on assets rival the best performing sectors in the economy. However it must be remembered that the data is dependent on best practice husbandry and recirculation technology. It presents a best case scenario that assumes optimal production (100% production through out the ten year project) and sale of all output once fish have completed their grow out period. This may not be the case in reality, as real time data will change from year to year. However, the model farms do give an indication of the inherent viability of growing Murray Cod in recirculation aquaculture systems.

The influence of production scale on the cost of production (per kilo) reveals that 8% fall in the cost from a 25 tonne farm to a 50 tonne farm and a 3% fall from a 50 tonne farm to a 150 tonne farm. Overall the reduction in the cost of production from moving from a 25 tonne farm to a 150 tonne farm is in the order of 8%. The Profit Margins, on the other hand, show an increase of around 20% when moving from a 25 tonne farm to a 150 tonne farm.

These figures are obviously influenced by the configuration of annual running costs, for example feed and labour accounts for between 45% - 50% of total costs. There is no doubt that as more work is done on specialist diets for the Murray Cod and as more farms come on stream then feed prices may well be reduced.

Farm Bio-economic variables	Example 1 25 Tonne Farm (small scale)	Example 2 50 Tonne (medium scale)	Example 3 150 Tonne (large scale)
Number of juvenile fish	36,500	72,000	220,000
Stocking density	100 k/g per cubic metre	100 k/g per cubic metre	100 k/g per cubic metre
Cost per kilo (ex. Dep.)	$9.21	$8.54	$8.50
Cost per kilo (incl. Dep.)	$12.67	$11.60	$11.26
Equipment (ex land)	$416,000	$916,000	$2.53 mill
Operating Outflows Y1	$230,000	$413,435	$1.30 mill
Sales	$333,000	$656,829	$2.007 mill
Net Present Value	$352,873	$838,000	$2.830 mill
Internal Rate of Return	16.7%	18%	20%
Profit Margin	23.5%	27%	28%
Av. Closing Cash balance	$170,300	$360,700	$1.1 mill
Asset Turnover	.44	.42	.45
Return on Assets	10.4%	11.3%	12.5%

Notes

Capital Investment: Includes recirculation technology and tanks, purpose built insulated shed, power installation and initial stock.

Internal Rate of Return: Highest rate of interest a borrower can afford to pay for startup finance

Profit Margin: Net income (before interest) divided by revenue. % of sales that ends up as income

Av. Closing Cash Balance: 10 year annual average of yearly cash balance. This money could be used for capital expansion or faster debt repayment. These funds are in addition to owner salary.

Table 15: Feasibility Results of 3 Farm Scenarios Using *AQUAFarmer (V1.1)*

References

ABARE Australian Fisheries Statistics (1999), p. 33. Commonwealth of Australia 2000

AQUA*Farmer (V1.1)* is a propriety software developed by Fisheries Victoria. It is specifically designed to analyse recirculation aquaculture efficiency and viability. It is a 10 year accounts simulator that creates farm scenarios based on bio-economic inputs.

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