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EX POST BENEFIT/COST ANALYSIS

PROJECT NO: 1998/322

Aquaculture Feed Development for Atlantic Salmon

Prepared for the FRDC

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Summary

The project was developed in the context of expected future increases in the costs of marine based protein sources used in salmon feeds such as fishmeal and marine oils, and the need for further research on the suitability of ingredients commonly available in Australia that may have potential use as an alternative protein source.

Tests were conducted to assess the chemical composition and digestibility of 19 alternative protein sources. Dehulled lupins were found to have the greatest potential for fishmeal replacement with best growth response and no adverse impact on the salmon's immune system. Potential cost savings from using a lower protein feed to replace a higher protein feed at the second feeding time each day, and from reducing lysine concentrations in existing feed mixes, were also identified.

The key output from the project has been implemented and lower cost aquaculture feeds using a lupin-meal additive are being commercially manufactured in Australia. Although the initial rationale of the project was to develop new food products that were less reliant on fishmeal, the addition of the lupin meal to the feed has not as yet displaced any of the fishmeal content. Instead, the lupin meal has replaced imported plant-based ingredients – such as soy meal and gluten meal – that were formerly used. Lupins can be sourced domestically at a cheaper price than these imported meals. Feed manufacturers advise that the full benefits of lower raw material costs have been passed on to aquaculture farmers in the form of cheaper feed prices, with the lupin-added feeds estimated at being $30/mt-$40/mt cheaper than feed using the imported plant meals. With annual production of lupin-added feed estimated at around 10,000mt, around 25% of which is exported, the drop in feed price represents a saving to Australian aquaculture producers of $225,000-$300,000/year.

The net present value of the forecast return over the period 2002-2008 to FRDC's investment in the project is estimated at between $630,000-$840,000. This represents a benefit/cost ratio of around 3:1.

This estimate does not include the potential benefits that may arise over the longer term should increased quantities of higher-protein content lupins become available and be used to replace fishmeal or should foreign-based feed manufacturers start to purchase large quantities of Australian-grown lupins.

1. Introduction

This report describes an ex-post cost/benefit analysis undertaken on FRDC project 1998/322, Aquaculture feed development for Atlantic Salmon, implemented by the Tasmanian Aquaculture and Fisheries Institute of the University of Tasmania.

2. Background

Atlantic salmon is a carnivorous species that spawns in freshwater and can undergo growth and maturation in fresh and seawater. The majority of salmon feed is used in the seawater phase where fish are grown from around 70g to market size of 3-4 kg. This period takes about 12-18 months. During this time, salmon are usually fed a pelleted feed high in protein (40-45%) and high in fat.

Atlantic salmon culture in Australia began in Tasmania in the mid-1980s and the industry has continuously expanded over the subsequent years, with an estimated 14,600mt of salmon produced in 2001/02 with a farm gate value of $111m[1]. The industry has grown by more than 30% in both output and value since 1999/00, with around 90% of production is sold domestically.

This project built on the results from two previous FRDC-funded projects:

- Fishmeal Replacement in Aquaculture Feeds for Atlantic Salmon (project 1993/120.5), which found that there was potential to use plant-based protein meals to replace marine-based meals as a food source for Atlantic salmon; and
- Replacement of Fishmeal in Aquaculture Diets: Development of more cost effective salmon feeds for the Tasmanian Altantic Salmon industry (project 1993/126) which developed methods to measure digestibility of plant proteins used in salmon diets.

This project was developed in the context of expected future increases in the costs of marine based salmon feeds such as fishmeal and marine oils. Given that, on average, feed costs comprise about 50% of a salmon farm's operating costs, the likelihood of higher prices for marine-based feeds would have had a significant impact on industry profitability.

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[1] ABARE (2003), Australian Fisheries Statistics 2002

Much of the overseas research on salmon nutrition and feed sources is not directly applicable to Australian conditions, given differences in environmental conditions on Australian farms compared to the other salmon farming countries and differences in the alternative ingredients available to Australian feed manufacturers compared to European and North American feed manufacturers. Alternative ingredients being developed overseas were either unavailable in Australia or not considered appropriate for Australian farms, and the need existed for further research on the suitability of a number of ingredients commonly available in Australia thought to have potential use in salmon feeds.

The project was actively supported by the aquaculture feed manufacturing sector, with the general manager of the leading salmon feed manufacturing company in Australia and New Zealand a co-investigator on the project.

3. Project Objectives

i) Expand the data base for feed intake, digestibility and utilisation of key nutrients and feed ingredients (principally protein and fat sources) to ensure the optimum balance is used to formulate Atlantic salmon feeds;

ii) Determine the lowest level of fishmeal that can be used by combining alternative protein sources and to investigate the factors limiting inclusion of the most promising of these combinations;

iii) Determine whether at low fishmeal inclusion salmon performance is equivalent or better than fishmeal diets;

iv) To use the research results to formulate feeds for testing under commercial type conditions; and

v) To successfully transfer these results to ingredient producers, feed manufacturers, salmon and trout farmers and the scientific community.

4. Research Findings

The primary aim of the research was to identify and then develop new feeds for Atlantic salmon that are less reliant on the use of fishmeal. The research was concentrated into three key areas:

- assessing the suitability of alternative fishmeal substitutes;
- testing the suitability – including developing appropriate feeding practices – of these alternative products; and
- reviewing the lysine requirements of salmon.

Suitability of alternative fishmeal substitutes

The chemical composition of nineteen potential sources of protein that could be used in salmon feeds – 3 fishmeal, 1 blood meal, 3 meat meal, 2 meat and bone meal, 1 poultry meal, 1 feather meal, 2 canola meal, 2 corn meal, 2 lupin meal, 2 soybean meal and 1 wheat meal - were analysed. The feed manufacturing industry was actively involved in selecting the potential protein sources. Results from the analysis were made available to industry.

Feed trials were conducted in which separate test diets using each of the 19 potential protein sources were fed to tanks of Atlantic salmon parr (the freshwater stage of the salmon) over a 28 day period. The protein sources were added at 15% and 30% levels of concentration.

The apparent digestibility of each of the test diets – that is, the extent to which the salmon was able to absorb the nutrient value of each of the diets - was estimated by comparing the chemical composition of the test diets with the chemical composition of faecal samples collected from the tanks after 2 weeks and again at 4 weeks. The estimated digestibility coefficients from each test diet were made available to industry.

The rate of salmon growth obtained from each test diet was compared to the growth rate from a tank of parr fed a standard reference diet. Best results were obtained from the test diet containing dehulled lupins. Further tests were conducted to assess whether the use of lupin meal had any adverse impact on the salmon's immune system. The tests proved negative, indicating that changing the diet had no effect on salmon mortality or vulnerability to disease, and supporting the findings from the growth tests indicating lupins as having the greatest potential for fish-meal replacement.

Developing appropriate feeding practices using these alternative products

A commercial-type diet containing 20% dehulled lupin meal was produced. The feed was used in trials conducted 'under commercial conditions' at the research centre and 'supported excellent growth rates'.

Further experiments tested the effects on growth performance of:

i) using a low (40%) and high (45%) protein diet;

ii) a mixed feeding regime, using one high and one low protein diet for the two daily feeding times; and

iii) replacing 30% of the fishmeal with lupin meal.

It was found that growth performance was poorer on the low protein diet. This was consistent for both the fishmeal and lupin replacement diets.

More importantly, no significant differences in growth were detected between the other diets, suggesting that 30% of the fishmeal could be replaced with lupin meal, and that a lower protein diet could be used to replace a higher protein diet in one of the daily feedings, without adversely impacting on growth rates.

Review of lysine requirements

A number of feed trials were undertaken examining the impacts of feeding regimes, diet formulations and dietary proteins on the lysine utilisation of salmon parr (lysine being a supplement added to the salmon feed). The relationship between lysine utilisation and salmon growth was found to be more dynamic and complex than formerly assumed.

The findings raised the possibility of being able to formulate more effective dietary formulations – with reduced lysine concentrations – at lower cost, without adversely affecting growth rates.

5. Cost/Benefit Analysis

There are two major components of net economic benefit in cost/benefit analysis - producer's surplus and consumer's surplus. In the context of this project, producer's surplus is a measure of net economic benefit generated in the salmon farming and feed manufacturing industries as a result of the manufacturing of new salmon feeds. Although

somewhat simplified, producer's surplus can be thought of as the additional profits generated in these sectors. In addition, if the lower feed costs induce increases in production and employment, then to the extent that previously unemployed labour is hired, the associated wages would also be included as a benefit in producer's surplus.

Consumer's surplus is a measure of net economic benefits to consumers. For example, if lower feed costs result in an increase in product supply that in turn results in a decrease in salmon prices on the domestic market, domestic consumers would be better off. Consumer surplus is a measure of this improvement in consumer well-being.

Cost/benefit analysis involves the calculation of the net economic benefits that are generated from the research investment, which are in turn compared to the initial research investment.

a. Project Costs

Total costs of the project are estimated at $462,000 of which FRDC contributed 44%.

Table 1 Costs of Research Investment for Project 1998/322

FRDC	University of Tasmania	Other sources	Total
$203,109	$106,699	$152,273	$462,081

b. Potential Benefits

The potential benefits associated with the increased use of lupin meal in salmon feed and/or or a change in feeding practices so as to use a lower protein content feed at the second daily feeding are:

i) a reduction in costs of salmon feeds. This could benefit, through reduced production costs, both feed manufacturers and/or salmon farmers;

ii) an increase in net employment in the salmon farming industry if decreased production costs led to an expansion of production on existing salmon farms or an increase in the number of salmon farmers. Net employment might also increase in the plant protein industry and the feed manufacturing industry if salmon aquaculture expanded;

iii) an increase in profits made by feed manufacturers, salmon farmers or lupin farmers as a consequence of the production expansion described in (2); and

iv) benefits gained by domestic consumers through any reduction in the price of salmon as a result of the increased production referred to in (ii).

c. Realised Benefits

Lower costs of salmon feeds

The output from the project has been implemented by the salmon-feed producing sector and lower cost feeds using a lupin-meal additive are being commercially manufactured in Australia. Representatives from the feed manufacturing sector advise that the main salmon feed producing company in Australia has been producing a salmon feed that includes lupin meal for the past 18 months.

Although the overall rationale of the project was to develop new salmon feeds that were less reliant on the use of fishmeal, the addition of the lupin meal to the feed has not displaced any of the fishmeal content. Instead, the lupin meal has replaced imported plant-based ingredients – such as soy meal and gluten meal – that were formerly used.

Despite being contrary to the overall project aim, company representatives advised that the work undertaken during the project assessing the chemical composition and estimating the apparent digestibility of the lupin-meal was of critical importance to the decision to use lupin meal. The full benefits from the use of lupin meal to displace the former imported plant-meals are thus considered as being fully attributable to the project.

Similarly, although the project was focused on salmon feeds, the lupin-enriched feeds are being sold to a variety of aquaculture producers apart from salmon framers. This is not considered important: what is important is that these benefits are directly attributable to the project.

Lupins can be sourced domestically at a cheaper price than these imported meals. The company manufacturing the lupin-added feed advises that the full benefits of these lower raw material costs have been passed on to aquaculture farmers in the form of cheaper feed prices, with the lupin-added feeds estimated at being $30/mt-$40/mt cheaper than feed based on the imported plant meals. With annual production of lupin-added feed estimated at around 10,000mt, around 75% of which is sold to domestic aquaculture farmers, the drop in feed price represents a saving to the aquaculture farming sector of $225,000-$300,000/year (Table 2).

Table 2: Estimated annual cost savings to the domestic farming sector

Annual production of lupin-added feed (mt)	10,000
Proportion of feed sold domestically	75%
Savings/mt	$30-$40
Annual savings to the domestic farming sector	$225,000-$300,000

There has not been any commercial uptake at this stage of the practice of using a lower-protein-content diet in the second daily feeding session. Similarly, there has not been any commercial application of the work relating to lysine utilisation. Consequently, no benefits have as yet been realised from these two aspects of the project.

Increased employment

No employment benefits have been generated from the use of lupin meal as an additive to the feed at this stage. Company officials advise that the 10,000mt of feed containing lupin-meal would have still have been produced in the absence of the project, albeit using imported plant-based meals. Though the source of the raw material has changed, there has been no real increase in total production such that employment levels are largely unchanged.

Additional profits generated by increased production

The use of lupin meal in aquaculture feed is not considered to have had any significant impact on production levels in the feed manufacturing industry, the lupin industry or the salmon farming industry:

- as stated above, there has been no increase in production in the feed manufacturing sector;
- lupin production in Australia is estimated at between 700,000mt-1,000,000mt/year, most of which is used as a stockfeed ingredient. The quantity of lupins required by the aquaculture feed manufacturing sector – currently around 2000mt/year – accounts for at most around 0.3% of total Australian lupin production and would not have had any impact on production, price or profit in the lupin industry.

  This relative importance of the aquaculture sector to lupin farmers may change in the future. Large–scale foreign-based feed manufacturing companies have expressed initial

interest in purchasing significant volumes of Australian-grown lupins for trialling in their overseas processing plants. Discussions are only at an early stage, but should the trials proceed, and should the results prove positive, the aquaculture feed sector has the potential to become a major purchaser of Australian lupins in the medium-term.

d. Net Benefits

In nominal terms, the project is forecast to generate economic benefits of between $1.6m-$2.1m over the period 2000-2008, all accruing to the aquaculture sector as a result of lower feed costs. Using a discount rate of 5%, these benefits have a net present value in 2003 terms of between $1.4m-$1.9m. Project costs, also expressed in 2003 terms, have a net present value of around $530,000.

In calculating the net economic benefits of FRDC's investment in the project, it is assumed that the research would not have proceeded without the financial contribution made by each of the parties. In this situation, the net benefits are allocated to each of the research-funding parties in proportion to their funding contribution.

The net present value of the benefits attributable to the project over the period 2002-2008 is estimated at between $630,000-840,000. Given a net present value of FRDC's investment in the project of $235,000, this represents a benefit/cost ratio of around 3:1 (Table 3).

Table 3: Summary of research costs and benefits

Research costs and benefits	
Net present value of FRDC investment in the project	$235,000
Net present value of benefits attributed to FRDC investment	$630,000-$840,000
Benefit/Cost ratio	2.7:1-3.6:1

This should be viewed as being a conservative estimate:

i) the likelihood that alternative protein sources will be found in the medium-term means that there is too much uncertainty to forecast the level of lupin-based feed production

beyond the next 5 years, such that any benefits attributable to this project beyond 2008 have not been included;

ii) the analysis assumes production of lupin-based feeds will remain constant at around 10,000mt/year. This is based on the views of company representatives who considered that demand for lupin-added meals would remain stable at current levels for the next few years pending the availability of higher protein lupin varieties. Any increase in production of lupin-based feeds above current levels would generate additional benefits not included in the analysis;

iii) the analysis does makes no allowance for benefits accruing to the lupin-growing sector should foreign-based feed manufacturers begin to purchase large quantities of lupins over the medium term;

iv) no allowance has been made for the cost-savings that would arise should industry adopt the practice suggested in the project of using a mixed feeding regime, using a lower-protein diet for one of the two daily feeding sessions. Should industry start using this practice, at least some of the benefits resulting from lower feed costs would be attributable to the project; and

v) no allowance is made for any cost-savings that would arise should the feed manufacturing industry formulate more effective dietary formulations – with reduced lysine concentrations – based on the findings from the project in respect to lysine utilisation.