FERM

Fisheries Economics, Research and Management Pty. Ltd.

EX POST BENEFIT/COST ANALYSIS

PROJECT NO: 1991/77

Orange Roughy and Other Marine Oils: Characterization and Commercial Applications

and

PROJECT NO: 1994/115

Marine Oils from Australian fish: characterization and value added products

Prepared for the FRDC

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Summary

This report describes an ex-post cost/benefit analysis on two FRDC projects:

- 1991/77, Orange Roughy and Other Marine Oils: Characterization and Commercial Applications; and
- 1994/115, Marine Oils from Australian Fish: Characterization and Value Added Products.

The initial 1991 project was framed in the context of the boom orange roughy catches of the late 1980s-early 1990s and widespread concern over the amount of wastage that was occurring in terms of the landed orange roughy catch and the deep water sharks that were taken as bycatch by the orange roughy fleet.

Accordingly, project 1991/77 was focused on characterising the oil composition of orange roughy, oreo dories and deep sea sharks, on identifying processing techniques to extract and purify orange roughy and shark liver oils, and on identifying potential commercial products based on orange roughy-type oils and shark liver oils.

Project 1994/115 continued these general themes, though with less focus on the orange roughy-type oils and greater emphasis on the polyunsaturated omega-3 type fish oils. New species were characterised – with particular reference to their omega-3 content – and attention was given to developing processes to purify omega-3 type oils. The shark liver work continued - more species of shark were characterised - and further efforts were made at improving processes to extract and purify shark liver oils.

Both projects were focused on the same three activities:

i) characterising the oil composition of various marine species;

ii) developing improved procedures to extract/purify these oils; and

iii) transferring these results to industry, including an initial assessment of possible commercial opportunities.

Combined costs of the two projects were just under $700,000, of which FRDC contributed $290,930, or around 42%.

Prior to the projects, little information was available on the oil composition of Australian marine species or processing techniques to extract valuable oils from crude marine oil. This was compounded by the nature of the marine oils industry – there being a small number of low-scale companies with little capital investment and

mostly working in isolation from each other – making it unlikely that industry would have been able to produce the same level of information in the absence of the project.

The commissioning of the two projects enabled scientific research on Australian marine oils to be undertaken and technical advice and extension services to be provided to the Australian marine oils and fishing industries. These extension services were in demand – researchers engaged in the two projects prepared in excess of 150 reports for 32 industry clients in the six years 1991-97. The projects also developed four new processing techniques, two relating to shark liver oils and two relating to omega-3 oils, and a protein gel based on a combination of fish oil and dairy products.

In general, the scientific successes of the two projects have not readily been converted into commercially viable outcomes. Although there has been investment in the marine oils industry and production is occurring, most companies are yet to prove their commercial viability:

i) in terms of wax-based ester oils, the company that was operational has incurred losses, has downsized production and its future production levels are uncertain;

ii) in terms of shark liver oils, the projects are likely to have had some positive influence on the leading company in the industry, though these benefits could not be quantified given uncertainties regarding profit levels and the attribution of these profits to the projects. The net benefits generated by the other companies currently operating are considered negligible;

iii) in terms of omega-3 type oils, a company has been established to refine and process tuna-based oils but the company has been experiencing sustained losses.

There is potential for the industry to generate future benefits, though given uncertainty over the commercial viability of those companies most influenced by the projects, these future benefits cannot be estimated with any confidence.

Other potential benefits arising from the two projects but not quantified are the extent to which the projects benefited fishers in the form of increased shark liver prices, the value of the extension services provided to Australian industry, the value of having a greater understanding of the oil characterisation of different Australian fish species, and the value of strengthening Australia's research capabilities and reputation in the marine oils field.

1. Introduction

This report describes an ex-post cost/benefit analysis of two FRDC projects:

- 1991/77, Orange Roughy and Other Marine Oils: Characterization and Commercial Applications; and
- 1994/115, Marine Oils from Australian Fish: Characterization and Value Added Products.

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) implemented both projects.

2. Background

The initial 1991 project was framed in the context of the boom orange roughy catches of the late 1980s-early 1990s, widespread concern over the amount of the orange roughy catch that was being wasted and similar concern that a significant amount of deep water sharks taken as bycatch by the orange roughy fleet was also being wasted.

At the same time, other deepwater species such as the oreos were being landed in Tasmania and the southern ocean fisheries were beginning to be developed.

In addition to there being an increasing – and underutilised - supply of possible raw material, the 1991 project was also set in the context of growing worldwide demand for marine-based oil products. This was primarily being driven by the health foods sector, a result of the increasing awareness of the likely human health benefits from consuming fish-derived oils.

More particularly, there was growing worldwide demand for squalene – a product produced from shark liver oil –and marine-based oils with a high polyunsaturated fatty acid (PUFA) content. There was also growing demand in the aquaculture industry for lower grade marine-based oils to be used as a food supply.

Overall, there was general interest in exploring the potential to use orange roughy, its associated shark bycatch, and other species, in the growing marine oils-based industry. However, little information was available on the oil composition of

Australian marine species and the processing techniques to extract valuable oils from crude marine oil. Further, the marine oils industry was comprised of a small number of low-scale companies operating with little capital, mostly working in isolation from each other, with limited prospects of undertaking the required research themselves.

Given this context, project 1991/77 was designed to identify possible uses for:

i) orange roughy oil – orange roughy was known to have a very high oil content, with around 18% of the weight of the whole fish being oil, with the oil sourced mostly in waste products (the head, swim bladder, frame and skin);

ii) orange roughy pigment as a possible food additive to enhance the colouring of farmed salmon;

iii) orange roughy oil from waste – at the time orange roughy waste was being used as a compost agent with plant waste, to produce a soil fertiliser, and uses were sought for the oil runoff; and

iv) the livers from some species of the deep water shark bycatch which were known to be large in size and high in oil content: small volumes of shark liver oil were being exported, and possibilities for further refining/adding value to the shark liver oil were sought.

The second project (1994/115) continued the general thrust of project 1991/77 though with less reliance on orange roughy. More specifically, project 1994/115 continued the evaluation of different shark species for squalene content and oil composition, the determination of the oil content of underexploited pelagic species, and the improving of methods to refine marine oils.

3. Project Objectives and Descriptions

Project objectives

Project 1991/77: Orange roughy and other marine oils

i) To identify the red pigment material present in orange roughy, determine the yield of the pigment, and examine means to separate the pigment from the orange roughy oil;

ii) To characterise the chemical composition of orange roughy from Australian caught fish and compare the oil composition with that obtained for New Zealand and other regions;

iii) To use the methods developed for (2) to assist in monitoring breakdown of orange roughy oil during composting of orange roughy waste;

iv) Determination of the composition of other marine oils to determine their suitability as sources for polyunsaturated fatty acids and other specialty chemicals;

v) Characterisation of the composition of shark liver oil collected from different fishing areas and an examination of methods for further refining squalene and diacylglyceryl ethers (squalene being a fraction of deep-sea shark liver oil and used as a health tonic in human health foods, diacylglyceryl ethers – also known as DAGE or alkoxy glycerol - being a byproduct from producing squalene and also used as a health supplement).

Project 1994/115: Marine oils from Australian fish

Objective - To assist Australian industry develop new marine oil-based value added products from existing or new fisheries including the bycatch and waste generated by the fishing and related industries.

This was to be achieved by:

i) evaluating squalene content and oil composition of a variety of shark species;

ii) determining the oil composition of a range of underexploited pelagic species and assisting industry to develop products from these oils; and

iii) developing more effective techniques for the refining of marine oils.

Project descriptions

Both projects were based on the same three activities:

i) characterising – that is, identifying and quantifying – the oil composition of various products;

ii) developing improved procedures to extract/purify these oils; and

iii) transferring the results to industry, including an initial assessment of possible commercial opportunities.

Fish samples, fish oils and related materials were obtained from industry and CSIRO sources and analysed for oil and fatty acid content at the CSIRO laboratories.

Project 1991/77 was focused on orange roughy, oreo dories and the deep sea sharks, on identifying processing techniques to extract and purify wax ester-based oils and shark liver oils, and potential industrial-type products utilising oils produced from orange roughy and oreo dories, and health products using squalene and DAGE.

Project 1994/115 continued these general themes, though with less focus on the wax ester type oils and greater emphasis on the omega-3 type oils. The shark liver work continued - more species of shark were characterised - and further efforts were made to improving processes to extract and purify shark liver oils. New species were characterised – with particular reference to their omega-3 content – and attention was given to developing processes to purify omega-3 oils. Project 1994/115 was more focused on potential health-related marine-oil based products rather than industrial products.

4. Project Results

Project 1991/77

Pigment material present in orange roughy

The pigment of orange roughy oil was analysed and its main component identified - an astaxanthin ester. Attempts to produce a purified pigment from orange roughy oil proved unsuccessful.

Characterise and compare chemical composition of Australian orange roughy

The oil present in orange roughy caught in Australia, New Zealand and Britain were found to be similar – rich in monounsaturated constituents and low in PUFA compared to most fish oils.

The report considered that orange roughy oil was suitable for use in the cosmetics and pharmaceutical industries. At the time, crude orange roughy oil was being exported from Australia for subsequent refining in Japan.

Project staff provided analytical support to a Tasmanian-based company - Beku Environmental Products Pty Ltd (Beku) – in the development of biodegradable cleaning products (a degreaser and a hand cleaner) using orange roughy-based marine oils. These products were commercialised during the course of the project.

Monitor breakdown of orange roughy oil during composting

The waste oil that drained off during the composting of orange roughy waste mixed with eucalypt waste was analysed. The results indicated that the composting did not affect the high wax ester content of orange roughy oil and that after appropriate treatment, the oil may be suitable for industrial use.

Determine composition of other marine oils

Muscle samples from seven species of deep-sea oreos were analysed for oil, fatty acid and fatty alcohol content:

i) muscle samples from oreos were found to have high levels of PUFA, in particular eicosapentaenoic acid (EPA) and docosapentaenoic acid (DHA); and

ii) oils produced from oreos were found to be rich in wax ester and monounsaturated components, similar to orange roughy oil. The report

suggested that it would be possible to substitute, or at least blend, the oil produced from oreos with that produced from orange roughy.

The omega-3 PUFA contents of flesh and oils of several other Australian fish species were determined. Results were reported for the flesh from Patagonian toothfish and spiney icefish, and the oil from jack mackerel, red bait (a bycatch in the jack mackerel fishery) and Patagonian toothfish. Results of analyses on zooplankton grown in sewerage treatment ponds, southern ocean krill, salmon farm oil waste, muttonbird oil and two strains of bacteria from Antarctic waters were also reported.

The capsules of a range of imported fish-based health products and a plant-based capsule were analysed to estimate their oil and fatty acid composition.

Composition of shark liver oil and examination of refining methods

The liver oils from 6 deep-sea shark species were analysed. The high squalene content in the oils from four of these species was considered suitable for industrial uses.

A chemical process to separate squalene from shark liver oil, at a lower cost than the conventional distillation techniques, was developed. Laboratory methods were also developed to separate the DAGE fraction from shark liver oil.

Project 1994/115

Evaluating the squalene content and oil composition of a variety of shark species

A collaborative study on deep sea shark species common to Australian and New Zealand waters was undertaken to analyse the effect of water depth, size and other factors on shark liver oil composition. The study found:

i) an inverse relationship between squalene content and DAGE content in shark liver oil;

ii) that squalene content tended to decrease as the shark increased in size; and

iii) that many species had high levels of DAGE;

The oil, fatty acid and vitamin composition of school and gummy shark and white spurdog liver oils were assessed:

i) gummy shark liver yielded oil 30-64% of the liver's wet weight, school shark liver 50-53%;

ii) in contrast to the livers from deep sea sharks, the oils from school and gummy sharks were relatively high in PUFA and low in terms of squalene and DAGE;

iii) the study concluded the oil from school and gummy shark livers may be an attractive source of omega-3 fatty acids;

Three samples of shark liver oil from species landed in the Northern Territory and Western Australia were analysed:

i) oil from one of the Western Australian species contained the highest squalene content of liver oils thus far identified from Australian deep-sea sharks;

ii) the two samples from the Northern Territory contained low levels of squalene but were high in PUFA oils and may be suitable for value-adding;

The properties of DAGE - an oil byproduct from the production of squalene - was analysed to assess its possible commercial use. The report concluded that DAGE oils had commercial potential as a health supplement.

Determining the oil composition of a range of underexploited pelagic species and assisting industry to develop products from these oils and specific oil fractions

The project analysed, often upon request from industry, the omega-3 oil content of a number of Australian species:

i) school, gummy, tiger and other sharks;

ii) banana prawn waste;

iii) oil produced as a byproduct of tuna canning;

iv) ling;

v) atlantic salmon waste;

vi) redbait;

vii) european carp;

viii) spotted wobbegong;

ix) jack mackerel;

x) patagonian toothfish; and

xi) southern ocean krill;

Developing more effective techniques for the refining of marine oils

Wax ester oils

Support was given to a private company – Beku Environmental Products - to develop a new wax ester-based cutting fluid. The product was subsequently commercialised. Further support was given to the same company to develop a process to produce a refined wax ester product. The process produced oil with greater than 99% purity.

Shark liver oils

A process was successfully developed to produce squalane (the saturated component of squalene), with the resultant oil having squalane purity exceeding 99%. Squalane was considered to have industrial application as a cosmetic, perfumery, lubricant and high boiling solvent. The process also generates DAGE as a byproduct which may have future commercial application.

Trials were held with new equipment - hand-held refractometers – to assess the accuracy of the equipment in measuring the squalene content of shark liver oil. The refractometers were considered to provide unreliable estimates for some oils.

PUFA oils

Three processes were successfully developed:

i) a process to refine purified omega-3 oil from crude tuna oil;

ii) a process to produce a highly concentrated omega-3 oil rich in DHA; and

iii) in conjunction with the CSIRO Division of Dairy Research, a protein gel based on milk powder and omega-3 oils.

Provision of technical advice and extension services to industry

Researchers engaged on the two projects provided technical advice and support to more than 30 Australian companies, and in excess of 150 technical reports characterising the oil composition of different marine products, the oil composition of end-products and the status of different oil-refining procedures, were produced during the life of the two projects[1]. A further 9 reports were provided to the New Zealand Crop and Food Research Institute on the oil characterisation of New Zealand species.

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[1] Information on technical reports sourced from Dr Peter Nichols, principal investigator of the projects

5. Cost/Benefit Analysis

There are two major components of net economic benefit in cost/benefit analysis – producer's surplus and consumer's surplus. Producer's surplus is a measure of net economic benefit generated in the Australian marine oils industry from the research project. Although somewhat simplified, producer's surplus can be thought of as additional profits generated. In addition, if the research findings 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 a research project induces an increase in product supply that in turn results in a decrease in price on the domestic market, domestic consumers would be better off. Consumer surplus is simply a measure of the 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.

5.1: Project Costs

Total costs of both projects were just under $700,000, of which FRDC contributed around 42% (Table 1).

Table 1: Cost of Research Investment

Project No.	FRDC	Other	Total
1991/77	$112,930	$0	$112,930
1994/115	$178,000	$409,000	$587,000
TOTAL	**$290,930**	**$409,000**	**$699,930**

5.2: Potential Benefits

There are three potential economic benefits arising from this project:

i) benefits in the form of additional profits earned by Australian-based processors as a result of increased production of marine-based oil products;

ii) benefits in the form of increased prices paid to Australian fishers as a result of increased demand for fish materials to produce fish oils; and

iii) benefits in the form of the wages earned by workers as a result of increased employment in the marine-based oils industry, to the extent that these workers would otherwise have been unemployed.

5.3: Realisation of benefits

There are three sectors of the Australian marine oils processing industry:

- the processing of orange roughy oil into wax ester-based industrial products;
- the processing of shark liver oil, primarily to produce refined squalene oil for sale on both the export and domestic markets for eventual sale as a health supplement. There is also a limited market for DAGE oils produced as a byproduct; and
- the processing of tuna oil into a range of PUFA-based oil products targeted mainly at the neutraceuticals market, with some bulk sales of refined tuna oil, mostly for use in the livestock industries.

The assessment of the economic benefits attributable to the project is based on discussions held with representatives of those companies known to be currently active in the industry and researchers in the marine oils and food processing sectors.

Benefits generated in the industry as a result of the project are assessed in terms of profits, increased prices for Australian crude oils, and increased employment across the three sectors of the industry. Where benefits are identified, the extent to which these benefits can be attributed to the project is assessed.

5.3.1: Wax ester-based products

Company profits

Beku Environmental Products and its successor company, Deep Sea Oils, has been producing industrial products based on orange roughy and oreo dory oils:

- researchers engaged on the projects provided in excess of 20 technical reports on orange roughy/wax-ester based oils to Beku over the period 1991-1996;

Beku commenced production in the early 1990s. No data was available on the company's profit levels in those early years. Deep Sea Oils advise that Beku had accumulated considerable debts during its operations in more recent years.

Deep Sea Oils has continued to trade, despite inheriting Beku's debts, but market acceptance of the oil-based products has been slow to develop and Deep Sea Oils has recently downsized its production of wax-based ester oils and has no immediate plans to expand production of wax-ester based products.

That Beku accumulated losses does not necessarily mean that the projects were inappropriate, as Beku's financial performance is determined by a number of factors outside the influence of the research projects such as:

i) the level of market acceptance of the oil-based products;

ii) the downturn in Australian orange roughy landings; and

iii) the management strategies employed by Beku management.

The losses do indicate, however, that the results have not as yet been used by Beku – or Deep Sea Oils – to generate benefits in the form of profits.

In terms of likely future profits, research is currently underway at the Royal Melbourne Institute of Technology examining the properties of a cutting fluid based on wax ester oils. Initial results from the research are promising, and with Deep Sea Oils having a patent on the cutting fluid, there may be improved market opportunities in the future.

However, with Beku having accumulated losses from past production, Deep Sea Oils recently downsizing production levels, significant reductions in domestic landings of orange roughy, and considerable uncertainty over future demand for wax-ester based

products, the net economic benefits in the form of company profits arising from the processing of wax-ester oils are considered to be negligible.

Increased prices for Australian crude oils

Oil for processing was imported from New Zealand and there is no oil processing of Australian-caught orange roughy or oreo dories. Instead, orange roughy and oreo dory waste is used for small scale fertiliser/composting operations, or otherwise dumped.

There has thus been negligible impact on local crude oil prices.

Employment

The company formerly employed 5 people across its operation - wax ester products being only a part of the company's activities. However, with the suspension in production, all staff have recently been retrenched.

The national average duration of unemployment for people aged between 15 and 34 is 32 weeks (comparable figures for Tasmania are not available). Had Beku not commenced production, it is assumed that it would have taken the 5 people employed by Beku 32 weeks to find an alternative job. Accordingly, the economic benefits from Beku employing the 5 people are represented by the wages paid during those first 32 weeks. Beyond that, Beku's employment generates no net benefits as it is assumed that the 5 people would have found alternative employment.

The 5 people have since been made redundant. It is assumed that it will take them 32 weeks to find new employment. The economic costs of their redundancy are represented by their lost wages during these 32 weeks.

The initial benefits of Beku's employment are thus matched by the costs of Beku's subsequent retrenchments, such that Beku's net employment benefits are negligible.

5.3.2: Shark liver oils

Company profits

One company – Ocean Oils Pty Ltd - is commercially processing significant quantities of shark liver oil in Australia at the present time. The company specialises in the production of squalene refined from domestically produced shark liver oil extracted from the livers of Australian-caught deep-sea sharks. The squalene is sold on both the domestic and export markets for subsequent use in the health foods

market. The company is also developing markets for the DAGE oils produced as a byproduct from the refining process.

The projects appear to have had little direct impact on Ocean Oils:

- Ocean Oils does not use the processing technique developed during the projects:
    - the process developed during the project was used commercially – not by Ocean Oils but by a separate company no longer in the industry. Some squalene was exported but a slump in world squalene price made the operation commercially unattractive;
    - the consultant contracted by Ocean Oils to establish the distillation process considered that the process used by the company was developed independently from the process developed during the two projects;
- the directors of the company were already involved in the industry prior to the project, albeit in separate businesses, consider that the merger of their respective businesses would have occurred irrespective of the project, and feel that the results of the project had little influence on their company's operations.

However, it is likely that the projects had a positive indirect effect on the company:

- one of company directors acknowledged the value of the technical support and encouragement that he had received during the projects:
    - project staff completed 13 separate analyses from 1993-1995 for the director's then company;
    - on three separate occasions from 1993-1995 the director wrote to CSIRO to express support for the work being undertaken under the two projects.
- the director did not consider that the support and advice received during the projects had been essential to his business, and he felt it highly likely that he would have remained in the industry in the absence of the two projects:
    - notwithstanding the director's views, the ready availability of technical expertise is likely to have fast-tracked the director's understanding of the oil contents of different shark species, of squalene processing techniques, and of commercial opportunities in the industry;

- the key issue is the extent to which this improved understanding hastened the development of Ocean Oils sooner than would otherwise have occurred.

Ocean Oils is operating profitably, though the extent of these profits is not known[2]. This, together with the uncertainty regarding the extent to which company profits should be attributed to the projects, make it impossible to quantify with any confidence the benefits generated by Ocean Oils.

There are two other smaller-scale companies processing shark liver oils – Deep Sea Oils and Quotila Trading.

Deep Sea Oils – and its preceding company Beku - has been refining crude shark liver oil into squalene and DAGE oils for sale on the export and domestic markets. The company also produced a small quantity of shark liver oil capsules and squalene capsules for the local health market.

- as with Ocean Oils, Deep Sea Oils is using use the distillation technique and not the chemical extraction technique developed during the project (though researchers involved in the project assisted Deep Sea Oils establish and fine-tune their distillation technique);
- Deep Sea Oils considered the technical support received by project staff during the establishment phase of the processing operation was extremely beneficial:
  - researchers engaged on the two projects prepared at least 13 technical reports relating to shark liver oil/squalene to Beku during 1992-1997;
- Deep Sea Oils emphasised the value of the research analysing the properties of DAGE oils and considered this had created greater awareness of potential uses of DAGE oils. However, market acceptance of DAGE oils has been slower than anticipated such that the real value of the research has not as yet been realised.

Deep Sea Oils is currently downsizing its shark liver processing operation and has curtailed production, citing its major constraints as being the slow market acceptance of DAGE products, problems in securing regular supplies of shark liver oil, and losses

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[2] given the small size and competitive nature of the Australian marine oils processing industry, the company was unwilling to provide any financial details

incurred by Beku in earlier years. Should demand for DAGE products improve, Deep Sea Oils may expand its production.

- It has not been possible to confirm Beku's financial performance in its initial years, though by the late 1990s it had accumulated substantial debts and was downsizing production.
- Beku and Deep Sea Oils has accumulated net losses and given the uncertainty over the company's future level of shark oil production, no attempt has been made to forecast future profit levels.

Quotila Trading processes small quantities of shark liver oil for subsequent value adding for the cosmetics industry. A representative of the company considered that the research has had little positive impact on his business.

Increased prices for Australian crude oil/shark livers

Most shark liver sold in Australia is sold through the Melbourne fish market. Prices range from $2-$6/kg depending upon the species of the shark – squalene content of the liver varies according to species - and the quality of the liver.

Shark liver prices have trended upwards in recent years, generating benefits to fishers. In the absence of a detailed quantitative analysis of the demand for shark liver, it is not possible to estimate how much of this price increase is attributable to greater competition from an increased number of domestic processors – due in part to the technical support provided by project researchers - and how much is attributable to factors independent of the research such as growing worldwide demand for squalene and lower worldwide supplies of shark liver oil.

It is likely that the projects and the support provided by the research team to the processing sector have been a contributing factor to the upward price trend for shark livers. However, there is insufficient information available to quantify this benefit.

Increased employment

Direct employment in the industry is minimal – Ocean Oils is a one-person operation. In any case, the benefits arising from such employment are assumed to have been realised in the absence of the project. The same reasoning applies to Quotila Trading. As discussed previously, employment benefits from Beku are considered negligible.

5.3.3: PUFA oils

Clover Corporation

One company was identified processing PUFA-type marine oils in Australia. The company – Clover Corporation – is a listed company that processes naturally-based oils for the food, health and livestock industries. It processes both marine-based and plant-based oils, though marine-based oils are the company's core business.

The company markets the refined marine oils in several forms:

i) in purified form for subsequent encapsulation for the health market;

ii) in powdered form for use in infant foods, special dietary foods (such as for pregnant and lactating women) and for enriching everyday foods such as breads, breakfast cereals, snack bars and dairy products;

iii) in liquid form for addition to liquid and semi-liquid foods and drinks; and

iv) in capsule form under various brand names for the health food market.

The company also markets capsules and refined products rich in omega-6 type oils based on plant matter – evening primrose and borage – though these represent a relatively small and declining portion of the company's business.

Clover was established as a private company in 1988 and processed imported plant-based oils. The company then became interested in the processing of tuna oils to target the infant milk formula market. Clover received considerable technical support from researchers engaged on the two projects, especially during project 1994/115:

- Between 1994-1997, project staff provided 29 reports to Clover on a range of topics covering analyses of the oil composition of Clover's finished products, the oil composition of Clover's raw materials, and progress reports on the scale-up and plant trials of the new purification process.

In January 1997 Clover entered into a joint venture with HJ Heinz to establish Nu-Mega Lipids Pty Ltd, Clover having 49% equity and Heinz 51% in the joint venture company. The intent was that Nu-Mega would source and refine the tuna oil and Clover would further process and market products using the refined oil. Clover's intent was to transform the refined tuna oil into a powdered form for inclusion in infant milk formulas and other specialty foods.

In October 1999 Clover purchased Heinz's 51% share in Nu-Mega such that Nu-Mega became a fully-owned Clover subsidiary.

Clover was floated in November 1999, with 70 million shares issued at $0.30 each, raising capital of $21 million. Given that there were 80 million Clover shares prior to the float, the market capitalisation of the company in late 1999 was $45 million.

Company profits

Clover had accumulated losses of $1.8m up to the period 30 June 1999 (prior to its take-over of Nu-Mega and its public float). Since then, further losses have been experienced. Thus far the company has been unable to achieve the sales and profit projections as outlined in the 1999 prospectus (Table 2).

Table 2: Comparison of Clover's Projected and Actual Financial Performance (projections cover low, medium and high case scenarios, $m)

	Sales				**Trading Profits**			
	Projected			**Actual**	**Projected**			**Actual**
	low	medium	high		low	medium	high	
1999/00	11	21	33	7.6	0.4	4.9	11	-1.7
2000/01	21	33	49	8.8	5.9	12.1	19.3	-4.7

In its 2001 annual report, Clover's Executive Chairman stated that 2001 and 2002 would 'set the stage for Clover's commercial take-off'. However, the annual report did not contain any profit or sales projections to describe the likely flight path:

- the company is set to record a further loss for 2001/02 - financial information issued in April 2002 indicates an operating cash flow deficit of $2.9m, based on sales of $7.1m, for the first three quarters of 2001/02 (part of this loss is due to a write-down of asset values).

The company is yet to record a profit and no dividends have been distributed. Its share price is currently trading at around $0.19 and market capitalisation is around $28m.

Given that the processing of tuna-based oils are Clover's core business, it is fair to assume that the majority of these trading losses are attributable to its tuna oil-processing operations.

The company has not as yet created any economic benefits in terms of profits.

Likelihood of future benefits

Discussions with company representatives indicated that the future profitability of the company relies on its ability to utilise a new technique - for which it has exclusive marketing and development rights – to transform refined tuna oil into a highly concentrated powder/gel form. Clover has the option of either:

i) licensing the technique to other users – there have already been preliminary discussions with multinational companies in this regard; or

ii) expanding its application of the technique to supply increasing amounts of the gel and/or powder to domestic and overseas clients.

Some positive signs are emerging for Clover's future profitability:

i) use of the gel and/or powder in infant milk formulas and other food products has recently been approved by the United States Food and Drug Authority, possibly creating new market opportunities in the US market;

ii) in July 2002 Tip Top bakeries launched a new bread product in Australia and New Zealand enriched with omega-3 oils using the powder produced by Clover. Consideration is apparently being given to expand production of the enriched bread for the European market;

iii) increasing awareness within the developed world of the importance of personal health and fitness and the need to include omega-3 type oils in the daily diet.

Whether Clover is able to convert these opportunities into commercial profits is yet to be seen. The company has thus far been unable to trade profitably, its latest annual reports do not give any sales or profit projections, and in any case its previous projections proved unattainable:

- the potential for Clover to generate future benefits is recognised, but there is insufficient information and too much uncertainty to estimate Clover's future profit levels.

The extent to which the projects contributed to Clover's development

Current and former Clover staff considered that the informal support and assistance that the project team - and in particular the principal investigator who was

acknowledged as a world authority on marine oils – provided to the company during its early involvement in tuna oils was very beneficial to the company's development:

i) the laboratory analyses of oil profiling undertaken by the project team were used to cross-check the results of other laboratory analyses undertaken by the company;

ii) use of the specialised equipment available at the CSIRO laboratories enabled the company to obtain more detailed information on the oil characterisation; and

iii) having this support available locally was considered very advantageous.

However, current and former Clover staff had different perspectives on whether the support received during the projects was essential to Clover's development:

- some considered that without the support obtained through the projects Clover would not have continued its tuna oil processing activities;
- others considered that the support could have been obtained from overseas sources had the project researchers not been available – though at greater cost/difficulties/delays – such that in the absence of the projects Clover would still have developed along the same path, albeit perhaps at a slower rate.

The technique developed during the project to refine crude tuna oils was found to be unsuitable from a commercial perspective and has not been used by the company. However, the additional information on the properties of tuna oil and of processing techniques would have directly benefited the company's general understanding of tuna oil and tuna oil processing.

With respect to the development of the highly concentrated gel/powder, the technique used by Clover was developed through a research agreement between the company and Food Science Australia, the latter being a joint venture between Australian Food Industries Science Centre and CSIRO:

- under the agreement, Clover and Food Science Australia collaborated to 'conduct research in relation to the development of high fat powders and liquid emulsions containing PUFA's from marine oils as ingredients for functional food/nutraceuticals which have sufficient stability to survive transport, storage and subsequent processing operations' (Clover Prospectus 1 September 1999);

- the Food Science Australia research was undertaken after the FRDC projects, and both Clover and Food Science Australia considered there were no direct links between the Food Science Australia work and the FRDC projects;
- however, the FRDC projects contributed to some extent to the development of processes to transform fish oils into protein gels as in 1994 researchers from the projects, in association with CSIRO's Dairy Division, produced a protein gel based on dairy products and fish oils.

It is not possible to put a value on the analytical support and peer support that the project and project staff provided to Clover during the course of the project. The two most likely scenarios are that in the absence of the projects, either Clover would not have continued processing of tuna oils, or that Clover would have developed along a similar path to that which it has, albeit at a slower rate:

- had the company been operating profitably, at least some of the profits being realised by the company could be attributed to the projects;
- given Clover's past operating performance, no such benefits have as yet been realised; and
- the potential for future benefit is recognised but given the uncertainty over Clover's future profit levels, cannot be quantified.

Increased prices for Australian tuna oils

Most of the oil processed by Clover is sourced from the Heinz cannery in American Samoa. Domestic sources are either unsuitable or unable to provide sufficient volume.

Clover did source oil from the Eden cannery and associated fishmeal plant. The Eden plant closed in July 1999, two and a half years after the formation of the joint venture company. While it was operational, Clover utilised around 60-70% of the oil available from the Eden plant. Despite this, Clover sourced most of its oil requirements from American Samoa and the closure of the Eden plant had little impact on Clover's operations.

Oil from the remaining Australian cannery in Port Lincoln is currently used as a stockfeed for the pig and chicken industries.

Any impact on local tuna oil prices was limited to the time when the Eden cannery was operating. The expected benefits from this are considered negligible.

Increased employment

The company employs 14 people at its processing factory in Melbourne. However, given the uncertainty over the extent to which the projects influenced the development of the company, the accumulated losses, and doubts about the future profitability of the company, there is too much uncertainty to quantify the employment benefits generated by Clover.

5.4: Non-Quantified Benefits

No existence value has been attributed to the new information generated during the course of the two projects with respect to the oil characterisation of various marine species and the new processing techniques.

No value has been assigned to the research and technical extension services available to industry during the two projects:

- aside from Beku and Clover, a further 30 companies received technical assistance – in the form of a formal report - from researchers engaged on the project. Around half of these companies sought technical assistance more than once;
- while these companies have not have progressed to commercial-scale production, this does not mean the reports were of no value to these companies. In fact, the number of repeat customers indicates the value that these companies placed on the technical support available.

The research undertaken in these two projects was used in subsequent FRDC projects such as project 1995/122, 'Nutritional Value of Australian fish: Oil, fatty acid and cholesterol composition of edible species', resulting in publication of the 'Seafood the Good Food' booklets.

A number of papers based on work undertaken during the two projects were presented at a variety of conferences in both Australia and overseas. The value of the international recognition of the Australian work, and the increased expertise of the Australian research community in the marine oils field, have not been quantified.

6. Net Benefits

The economic benefits attributable to the two projects are defined by the extent to which the information generated during the projects led to the successful commercialisation of products that otherwise would not have been marketed.

The principal beneficiaries of the projects have been the two companies that were most directly involved with the research activities – Beku/Deep Sea Oils and Clover Corporation:

- between them, these two companies accounted for 83 of the 153 reports prepared for Australian industry during the course of the two projects. Representatives from both companies considered the support and assistance received from project researchers had been extremely valuable.

Had these companies been operating profitably, some of the benefits associated with these companies realising profits would be attributable to the research. However, at this stage neither of the two companies has generated profits:

- Beku is no longer operational and its successor company Deep Sea Oils has recently downsized production;
- Clover is processing significant volumes of tuna oil and developing new products though the company is yet to demonstrate its commercial viability.

Should either company become profitable in the future, some of these future benefits will be attributable to the projects. The potential for future benefits is recognised, but given the uncertainty over both Deep Sea Oils and Clover's future profitability, any attempt to quantify these potential future benefits is considered premature.

The projects are likely to have contributed, to some extent, to the successful development of Ocean Oils. However, it is not possible to quantify the benefits arising from Ocean Oils with any confidence.

Shark fishers have also benefited, in the form of higher market prices for shark liver. However, other factors have also contributed to the increasing shark liver price, such as increasing world-wide demand for squalene and reduced supplies from other countries, and there is insufficient information available to estimate the relative impacts of these various factors on the price of shark liver oil.