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Nutrition Subprogram Reviews

A Review of Research and Directions for the Fisheries Research and Development Corporation's Fishmeal Replacement Subprogram and Aquaculture Diet Development Subprogram

A report prepared by the

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for the

Fisheries Research and Development Corporation

FISHERIES RESEARCH & DEVELOPMENT CORPORATION

BECAN CONSULTING GROUP

Subprogram Reviews

Report Organisation

This report is divided into two parts.

Part A contains individual reviews of component projects within the Fishmeal Replacement and Aquaculture Diet Development Subprograms and will remain in the confidence of FRDC. Part A will also contain specific comments relating to the benefit cost analysis completed for the FRDC on the Fishmeal Replacement Subprogram and will remain in the confidence of FRDC. Part A will therefore independently address terms of reference items 1 and 8.

Part B of the report is a stand alone document that addresses all terms of reference accept items 1 and 8. Following approval by FRDC and the Subprogram Leader, Dr Geoff Allan, Part B will be suitable for wider distribution as required.

Acknowledgments

The BECAN Consulting Group wish to acknowledge all contributors to this report, particularly the industry representatives who took time to provide thoughts on the value of research completed to date and the potential future directions for a subprogram of this nature. A full list of participants in this review is presented at the end of this report.

The BECAN Consulting Group would also like to thank the scientists involved in the subprograms who made time to discuss their results and their potential application in the aquaculture industries. The vast amount of data generated as part of the Fishmeal Replacement and Aquaculture Diet Development Subprograms demonstrates the commitment of these scientists to the future of the aquaculture industries.

All information contained within this report is distributed at the discretion of the Fisheries Research and Development Corporation.

Summary and recommendations

This review identified the following positive outcomes from the establishment and conduct of the Fishmeal Replacement (FMR) and Aquaculture Diet Development (ADD) Subprograms:

- The FMR and ADD Subprograms were successful in meeting the objectives of managed subprograms on the basis that they:
    - Promoted a high level of collaboration between scientists working within a common discipline;
    - Successfully delivered nutrition research expertise to infant aquaculture industries that otherwise would have not had access to this level of nutritional skill;
    - Reduced the level of duplication of research effort towards a common goal;
    - Applied outcomes were delivered to industry improving the profitability and viability of these industries;
    - Facilitated a coordinated delivery of research funding submissions and research reports to the FRDC.
    - Advanced the overall international knowledge base for aquaculture nutrition.

- The aquaculture industries benefiting from research conducted within these subprograms (barramundi, salmon, prawns, silver perch) would value the continuation of further coordinated research in the area of aquaculture nutrition. Industries such as the barramundi industry rate nutrition as the highest research priority above all other disciplines, and believe that nutrition research on behalf of their industry would be severely compromised in the absence of the FMR or ADD Subprograms.

- Research providers and researchers operating within the Subprograms valued their involvement as the Subprograms through the Subprogram Leader managed to breakdown many institutional boundaries that previously existed. The Subprogram workshops also represented a valuable form of peer review for research results.

- Research providers and researchers conducting nutrition research projects within species-based subprograms found the FMR and ADD to be a valuable resource. Workshops conducted as part of

these subprograms provided an outlet for related research results and a valuable forum for critical review of the research. Many researchers operating outside the FMR and ADD used these subprograms as their reporting vehicles to FRDC.

- All individuals involved with, or benefiting from, the FMR and ADD Subprograms were highly complimentary of the efforts of the Subprogram Leader, Dr Geoff Allan. His efforts were largely responsible for the initiation of the subprogram, initiation of collaborations between research groups, involvement of other funding agencies and promotion of the results. Dr Allan's performance serves to emphasise the important role a Subprogram Leader plays in the success of a subprogram. All parties without exception would be keen to see Dr Allan continue as the leader of any future subprogram.

- The infrastructure (ie collaborations, industry contacts, mailing lists etc) developed as part of the FMR and ADD represents a valuable resource to the Australian aquaculture industries.

A number of areas that could be improved in the event of a continuing aquaculture nutrition subprogram were identified during the course of this review. These included:

- While the Subprograms were successful in capturing funding from a variety of sources, there is scope for a future subprogram to take a lead role in the coordination of aquaculture nutrition research on behalf of other research investors. Other research investors have indicated that if FRDC and an aquaculture nutrition subprogram initiated liaisons, they would be keen to capitalise on the existing infrastructure and in many cases would request that FRDC manage research funds for aquaculture nutrition projects on their behalf.

- Submission of aquaculture nutrition projects to other funding agencies after they have been rejected by the Subprogram and/or the FRDC Board is a cause for concern by other research and development corporations. Agencies other than FRDC are not as well equipped to scrutinise aquaculture nutrition priorities and are keen to establish mechanism that ensures a coordinated approach to priority setting and informed decision making.

- End-user industries felt the FMR Subprogram had a highly defined research goal that was best addressed through a collaborative research program. This common goal was diluted during the establishment of the ADD Subprogram, and the funding and Subprogram momentum was accordingly diminished. The establishment of the ADD Subprogram suffered because of a lack of

well defined research priorities. In contrast, researchers felt the ADD Subprogram was a substantial improvement over the FMR Subprogram in terms of research direction.

- A major limitation identified by end-users of technology developed as part of the Subprograms was the process for commercial adoption of the research. Part of this problem stemmed from inappropriate adoption techniques of the end-users themselves. Within the Subprogram and at least one affiliated project, lack of attention to commercialisation of the research resulted in disastrous semi-commercial trials resulting in a loss of industry confidence in the research and a major setback to the research process.

- While Scientific Committee meetings were valuable for the review of research completed to date, they were not used successfully to critically evaluate research prior to commencement, and they were not an effective means of delivering results to the primary beneficiaries of the research (ie the aquaculture industries). In addition, progress reports to research investors cannot be distributed to a wider audience. Outcomes from scientific meetings need to summarised and distributed to participants exclusive of progress reports.

- Despite some review during Scientific Committee meetings, some research providers were not sufficiently responsive to critical comments of their research approach. Over time, this diminished the value of some research results. Despite a significant planning process for many of the experiments, but further changes could have improved the standard of the work. Examples of this are evident when examining comments made in Part A of this report.

- The process for the establishment of core species within the FMR Subprogram was adequate at the time of establishment of the subprogram, but did attract criticism from other groups.

- Many issues remain unresolved in relation to the most appropriate methods for the distribution of intellectual property arising from research conducted within the Subprograms, or the protection of intellectual property during the conduct of the research. A number of end-users expressed concern over the handling of IP and this should represent a key area for attention in any future subprogram.

- Some of the early projects conducted within the FMR Subprogram in particular demonstrate the infancy of the research area and the lack of experience of a number of the researchers at the time of the Subprograms commencement. Significant savings could have been made through the involvement of a broader Steering Committee in the priority setting process.

- The standard of some of the research conducted within the FMR and ADD Subprograms was less than optimal. Specific confidential comments have been made on individual research projects for consideration by FRDC. These comments will be distributed to the researchers in question at the discretion of FRDC and the Subprogram Leader.

- The bulk of projects within both the FMR and ADD Subprogram had the same duration and consumed all funds available to the Subprogram. From a management perspective, this makes it difficult for the Subprogram to maintain momentum.

- The current FRDC submission on national coordination of a new ADD Subprogram is not adequate to meet the needs of a future ADD Subprogram

Recommendations

- Based on the outcomes of this review, it is recommended that an aquaculture nutrition subprogram be maintained by FRDC with due consideration for the following:

- A Subprogram coordination project (1-3 years) should be funded by FRDC with a number of immediate tasks including:
    - Establish what the fundamental non species specific nutritional constraints are to aquaculture production (eg. is it diet form, nutritional requirements, feeding strategies, feed evaluation or a combination of several factors) and how they could be best addressed through a collaborative research program. Outcomes from this process would form the basis for new projects within the subprogram. To define these priorities some strategic research in addition to comprehensive reviews of existing literature may be required to identify nutritional limits.
    - A risk management strategy should be developed for all aquaculture industries in relation to nutrition. This will assist the research priority setting process.
    - A SWOT analysis of nutrition research priorities should be completed for all major Australian aquaculture species.

- An agreement should be forged between the FRDC and other relevant RDC's and research providers for the management of research relating to aquaculture nutrition under the auspices of an aquaculture nutrition subprogram. This should account for variation in priorities between agencies. This mechanism should be for providing information to other RDC's rather than making decisions.

- Existing nutrition research conducted within species based subprograms should continue within these subprograms, but formal links must be maintained with a future aquaculture nutrition subprogram.

- The new subprogram should establish a skills-based Steering Committee to operate within the following terms of reference:

    - Develop a 5 year research and development plan for generic Australian aquaculture nutrition research priorities.
    - Scrutinise nutrition research planned within the species based subprograms.
    - Provide advice to the FRDC Board and other Australian research and development investors on aquaculture nutrition research priorities.
    - Act as an identifiable point of contact as an "expert working group on nutrition" for all Australian stakeholders in aquaculture.
    - Provide industry feedback and views.
    - Review existing nutrition research based on FRDC contractual obligations.
    - Ensure outcomes are commercially focussed;
    - Coordinate industry and research provider involvement in research programs to ensure optimum use of resources;
    - Identify those research providers and researchers best equipped to address defined research priorities;
    - Commission tendered research to address defined priorities;
    - Define an appropriate basis for the distribution of intellectual property on a case by case basis.
    - Facilitate extension and technology transfer.

- Membership of the Steering Committee should be based on skills and should attempt to include expertise in the areas of food technology, economics and commodities and extrusion process control. Where possible, representation on the Steering Committee should not include scientists actively involved in the research programs underway within the subprogram, however, given the specialised skills suggested above, this may not always be possible. It would also be desirable to appoint an independent chair in the event the Subprogram Leader is an active researcher in the subprogram. Appointment of the Steering Committee should vest with the FRDC in consultation with the Subprogram Leader.

- While a Subprogram Leader may have individual research priorities that can be appropriately completed within the subprogram they manage, the role of Subprogram Leader must be completed imparially. If a new aquaculture nutrition subprogram is established, the Subprogram Leader will need the full support of their organisation to:
  - Coordinate research activities that directly address industry needs (established by the Steering Committee);
  - Actively lobby other research investors on behalf of all research organisations involved with the Subprogram;
  - Commit an adequate amount of time for the management of the Subprogram (or utilise a proxy for at least an equivalent amount of time).
  - Coordinate research activities in which they may have no direct involvement.
  - Coordinate research activities that may be in direct conflict with the priorities established in the State in which they live.
  - Host Steering Committee and Scientific Committee meetings and industry workshops.
  - Promote the Subprogram without reference to their host organisation.

- In the event that NSW Fisheries offer full support to the above activities, FRDC should approach Dr Geoff Allan to lead a new aquaculture nutrition subprogram.

- The infrastructure (ie collaborations, industry contacts, mailing lists etc) developed as part of the FMR and ADD must be maintained as part of a future aquaculture nutrition subprogram.

- Under no circumstances should a future aquaculture nutrition subprogram become simply a collection of nutrition research projects. All projects within the subprogram must have a common focus and a common definable goal within a specified timeframe.

- The subprogram operational environment should consist of:
  - Steering Committee meetings (members only) to address the terms of reference detailed above.
  - Scientific Committee meetings (Principal Investigators of core research projects and other aquaculture nutrition projects plus interested observers) for the scrutiny of future research projects and coordination of existing research projects (progress reports, submissions etc).
  - Target industry workshops for a wide audience.

- A number of reporting levels must be established within the new subprogram. Reporting should reflect the above operating environment with separate communications arising from each operating activity. Newsletters should be maintained as a general means of distributing information.

- A dilemma is faced when making recommendations on how a 'discipline-based' subprogram can be integrated with species-based subprograms that contain the respective discipline as a component. As the primary coordinator of all subprograms, FRDC must ensure that the species-based subprograms recognise the role of any future aquaculture nutrition subprogram.

- Budgets for the new subprogram coordination project should support a Subprogram Leader in addition to the Steering Committee for the management of information distribution, Steering and Scientific Committee meetings and target industry workshops.

- The new subprogram should define a mechanism for lead agencies for the commercialisation of all nutrition research arising from FRDC funded projects based on recommendations in this review. All nutrition projects should devote a significant proportion of their budget to commercial upscaling of research results following guidelines defined by the ADD Subprogram Steering Committee in consultation with the major aquafeed manufacturers in Australia.

- Intellectual property issues need to be negotiated on a case by case basis. Unless a potential end-user is involved in the project from the outset, commercialisation is a far more difficult process. Commercial investments should deal with a very specific area of the research only, so that a discrete component of the IP can be apportioned. Commercial groups must recognise the need for some core research in the public arena and the need for most researchers to publish research results as a condition of their employment.

- If appropriate, the new subprogram should consist of core projects that vary in duration and/or starting/finishing dates. This will ensure the subprogram maintains momentum and is not restricted by the need to renew all core projects at the end of a three year period.

- The new Subprogram Steering Committee should take an active and lead role in the establishment of linkages and priorities for any future CRC proposals.

- A new subprogram should endeavour, where possible, to ensure the maintenance of some core research facilities, and should promote the screening of new feed ingredients and/or feeding strategies using a standardised protocol as a core service to industry.

- This review alone has identified a number of research priorities that could form the basis of core projects within a new subprogram. These include:

    - Definition of nutrient partitioning within key aquaculture species (ie defining the proportion of nutrients directed towards energy or protein metabolism).
    - Value adding alternative protein sources for use in aquaculture diets.
    - Development of diet manufacturing technologies for the production of highly flexible aquaculture diets.
    - Development of aquaculture feeds that have a minimal environmental impact.
    - Improved techniques for the measurement of feed intake.
    - Development of a wider database on the nutritional quality of feed ingredients, to facilitate fishmeal replacement.

Obviously a much wider list of priorities exist, but this list can be used as a starting point and does represent some of the information compiled as part of this review.

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Terms of reference

This report has been prepared by Dr Robert van Barneveld, a Consulting Partner with the BECAN Consulting Group.

The Barneveld, Edwards, Choct Animal Nutrition (BECAN) Consulting Group were commissioned by the Fisheries Research and Development Corporation to review the completed Fishmeal Replacement Subprogram and the current Aquaculture Diet Development Subprogram with the following primary objective:

"To provide a recommendation to the Fisheries Research and Development Corporation Board on a potential basis and structure of an Aquaculture Diet Development (or similar) Subprogram considering research completed to date (within the Fishmeal Replacement Subprogram and the Aquaculture Diet development Subprogram) and nutrition research being completed as part of other FRDC research programs".

To date some 10 projects have been funded directly or as part of either the Fishmeal Replacement Subprogram or the Aquaculture Diet Development Subprogram. In addition, FRDC has invested in a wide range of species specific nutrition projects (abalone, tuna, etc). Interest in nutrition ranges from all aspects of the life history of farmed species – from live feeds to finishing diets. The review considers the broader nutrition perspectives and makes recommendations on how these can be incorporated into a subprogram (or similar) structure.

The base terms of reference for this review were to:

1. Review scientific aspects of all projects completed within the Fishmeal Replacement and Aquaculture Diet development Subprograms to ensure that objectives were met, research was robust and to identify gaps in our knowledge.

2. Collect and establish viewpoints of Australian research providers and reearchers who could potentially contribute to a future subprogram.

3. Collect and establish viewpoints of potential end-users of research results from past and future subprograms.

4. Review current FRDC applications relevant to the subprogram.

5. Develop a strategy for the integration of a new subprogram with other non-discipline based subprograms that contain a nutrition or aquaculture diet development component.

6. Define what role, if any, the subprogram would have for other nutritional questions – eg. live feeds, broodstock conditioning, filter feeders etc.

7. Define the potential for investment in aquaculture diet development by other research and development organisations (eg. GRDC, MLC, PRDC) and funding sources.

8. Consider the benefit-cost of investing in nutrition and recommend broad principals that would guide project development. This should consider the question of investing in species specific diet development versus generic technology that may have a broader application. To achieve this, the review team will need to consult with FERM who undertook the benefit cost analysis of the Fishmeal Replacement Subprogram.

9. Recommend a strategy(s) for commercialisation of intellectual property arising from diet development research.

10. Provide a research and development direction plan for nutrition that provides direction for future nutrition research.

11. Provide a written and/or verbal report to the FRDC Board detailing the above.

Part B

Review and future directions for an aquaculture nutrition subprogram

Perspectives of the Fishmeal Replacement and Aquaculture Diet Development Subprograms – Industry and End-Users

A range of industry personnel representing aquaculture feed manufacturers and key aquaculture industries were interviewed face to face or over the phone to establish the value of research completed to date, and priorities for future research.

A summary of the outcomes of these interviews is presented below:

1. Salmon Industry

Research content/priorities:	Applicable/valuable
Research providers:	Excellent
Communication of results:	Poor
Adoption of results:	Moderate to high
Value of the FMR and ADD Subprograms:	High

a) Value of completed research

The salmon industry believes it has benefited significantly from research completed within existing subprograms. The results have contributed to a significant change in the form of salmon diets over the past 5-6 years with diet form shifting from steam pellets to a total use of extruded pellets in that period. In addition to a change in form there has been a significant change in the composition of diets. particularly in relation to dietary fat levels (17% maximum with steam pelleting to 22% minimum with extrusion).

One consequence of the shift from steam pellets to extruded pellets is the relevance of research results derived from experiments utilising steam pellets. Due to the many changes in ingredient conformation that occur with extrusion, it is unlikely that the majority of research completed with steam pellets will have any application.

Industry view Dr Chris Carter and his team at the University of Tasmania as the primary providers of salmon nutrition research. They are particularly impressed with the standard of research conduct, but recognise some limitations to the predominantly laboratory based facilities. There is an urgent need to improve the applicability and commercial validation of results generated under laboratory conditions.

The industry representatives interviewed felt that there was significant room for improvement in the extension of results derived from within the FMR and ADD Subprograms. While results summaries presented in the Subprogram newsletters were seen as very useful and informative, there was a general feeling that the level of direct extension of results through workshops and seminars was distinctly lacking in the past 5 years. While local aquafeed manufacturers such as Pivot Ltd have sponsored some seminars in recent years, the primary focus was on flesh quality rather than nutrition results arising from the FMR and ADD Subprograms.

b) Priorities for future research

The industry representatives had many views on priorities for future research in salmon nutrition. Despite the number of issues raised, they were surprisingly consistent. Priority areas of nutrition research that were nominated are listed below:

- The production levels maintained and the nutritional requirements are unique for the strains of salmon predominantly farmed in Australia. For this reason, industry believe it is important to conduct salmon research locally as overseas data lacks relevance given the differences in conditions under which the salmon are grown. For example, there is currently an emphasis in the salmon industry to move to lower protein, higher fat diets based on recent developments in the northern hemisphere. This coincides with a change in the protein:energy ratio of commercially available diets. There is a strong feeling from industry representatives that the potential and suitability of these low protein, high energy diets under Australian salmon farming conditions has not been adequately assessed and there is an urgent need to pursue this research locally. This is supported by the fact that many overseas research results adopted commercially in Australia yield different results. In particular, industry are concerned about the influence of high oil diets on growth, flesh quality and post-harvest quality when applied under Australian conditions and the lack of information available on appropriate dietary protein:energy ratios for different levels or stages of production.

- Salmon producers are concerned about the lack of control they have over inputs into salmon diets. While they recognise the difficulties associated with producing extruded salmon feeds, they would

prefer to have the capacity to nominate ingredients included in their diets, and the nutritional composition of the diets they purchase. At present, a set range of diets (varying predominantly in size only) are available for purchase from commercial manufacturers. The only factor that can really be altered in these diets is the carotenoid level apart from some specific additives. Salmon producers would value research that could facilitate the variation of ingredients in diets at their request (based on relative nutritional value which will vary with purchase price) without compromising production levels. Due to the lack of existing information, producers were concerned with the basis for current changes in salmon diets and the lack of independent assessment of these changes on a commercial scale.

- Given the lack of assessment of new diets introduced by commercial manufacturers, industry would value access to rapid screening facilities for the routine evaluation of feeds and feeding strategies on a user pays basis.

- A strong preference was placed on nutrition research that would facilitate feeding strategies that had minimal environmental impacts while maintaining feed conversion efficiency and product quality.

- Research on methods for the determination of the nutritive value of feed ingredients (completed by Percival and Lees) was seen as adequate but there was a need for wider application of the research results.

- Further research is required on the source of dietary energy (protein, carbohydrate or fat) and the influence of dietary oil type and fatty acid composition on salmon production.

- More information is required on the interaction between feeding strategy and feeding efficiency (eg the influence of different feeding frequencies).

c) Preferred approaches within a future nutrition subprogram

- As feeding and nutrition represents such a high proportion of salmon production costs, only small improvements in feeding efficiency are required to have a major impact on productivity. For this reason, the salmon industry would value the continuation of research in salmon nutrition under a subprogram structure providing they address many of the issues described above.

- The salmon industry would place a high value on the establishment of an independent marine research facility that could be used for "bridging" experiments for validating laboratory derived results, thus improving commercial adoption rates and industry confidence in the results.

- The potential emphasis on salmon research within an ADD or similar subprogram would depend on the existence of a FRDC funded Salmon Subprogram, but regardless of these developments salmon producers would value a continued involvement in a nutrition subprogram.

- The salmon industry would value the opportunity to contribute to and scrutinise research directed towards the development of salmon feeds rather than researchers relying solely on inputs from commercial feed manufacturers.

- Improved access to information on routine analysis methodology and accredited analysis laboratories would be valued by industry.

d) Summary

The salmon industry were supportive of the FMR and ADD subprogram and the continuation of a nutrition-based subprogram in some form. A major issue identified was the need to improve the mechanism for commercial uptake of research results and the communication of research results to industry. A large number of nutrition research priorities were identified.

2. Barramundi Industry

Research content/priorities:	Highly applicable
Research providers:	Excellent
Communication of results:	Excellent
Adoption of results:	Poor but improving
Value of the FMR and ADD Subprograms:	High

a) Value of completed research

- The barramundi industry places nutrition research as the highest priority research area above all others, and for this reason highly values the research that has been completed within the FMR and ADD Subprograms.

- Numerous comments were made in relation to the use of results achieved to date. In general it was felt that not enough has been done with the data already available in terms of progressing the nutritional status of the barramundi industry. Commercial uptake of research results was seen as an area requiring specific attention to improve the process.

- Research completed into the use of meatmeal as an alternative to fishmeal in barramundi diets was perceived as a significant advance for the industry, however, there was concern over the way the technology was initially commercialised. Due to problems with the commercial manufacture of the feed, some respondents concluded that meat meal was not a viable commercial alternative to fishmeal, but conceded a willingness to reassess these diets if the manufacturing issues are rectified.

- The industry was very comfortable with the level of industry focus and applied outcomes associated with the FMR and ADD Subprograms.

- In the absence of the FMR and ADD Subprograms the barramundi industry felt that they had limited capacity to conduct their own nutrition research. This would restrict their avenues for nutritional information to that provided by the commercial aquafeed manufacturers which was seen as undesirable.

b) Priorities for future research

- Barramundi farmers expressed concern over the limited number of barramundi diets currently available from commercial manufacturers. Additional information of the composition of ingredients and the inclusion of these ingredients into extruded diets was seen as a priority.

- The commercial production of barramundi is completed with fish well within the linear phase of growth. As a consequence, phase feeding of growing fish is unlikely to be necessary. In addition, it is unlikely that farmers would be prepared to change the diet during the course of a season.

- Barramundi production has advanced to a stage where producers are more interested in identifying diets that will promote the best performance in their fish rather than diets that are just cheaper.

- The balance between the need for basic and applied nutrition research was seen as equal.

Research priorities nominated for barramundi nutrition include:

- Barramundi farmers would like to have a wider choice of ingredients available for use in commercial diets. This would mean a reduced reliance on any single ingredient.
- Improvements on overall nutrition of barramundi to improve growth rate and feed conversion efficiency. A rough estimate places current industry production rates at between 40 and 50 tonnes per hectare with a belief that production rates in the vicinity of 50-70 tonnes per hectare being achievable. Improvements in growth rates are sought to improve overall system turnover.
- Nutrition x husbandry interactions. Do different feeding regimes necessitate concurrent changes in management ?
- The relationship between nutritional status and barramundi health.
- Influence of diet type on water quality. There is a requirement for any discharge water from barramundi farms to be of the highest quality and this is always a consideration when assessing new diets.
- Influence of diet type on feeding strategies.
- Assessment of seasonal nutritional requirements (ie is there potential for different diets during summer and winter). The basis for this priority vests with the fact that barramundi have different summer and winter FCR's with higher energy density diets maintaining FCR's over the winter period.
- Influence of higher energy diets on barramundi body composition. Past experience suggests that higher energy diets promote a higher level of gut fat which is not desirable.
- Influence of nutrition on stocking density and pond capacity.
- Potential for larval and starter diets in barramundi farming systems. To date there has been limited commercial interest in these diets due to the very low tonnages involved. Despite this, the nutrition of the larval and early juvenile phases are seen as a production bottleneck with little improvement in production rates in recent years. Scope may exist for the production of these diets using the Australasian Experimental Stockfeed Extrusion Centre.
- Influence of nutrition on egg quality and the reproductive capacity of broodstock.
- The potential to screen new diets rapidly was seen as a potential asset to the industry.

c) Preferred approaches within a future nutrition subprogram

- While a large proportion of the research completed within the FMR and ADD Subprograms was perceived as valuable, there were concerns over the ability to apply this information commercially. Some farmers indicated a willingness to lease ponds for experimental research to assist with the upscaling and adoption process.

- The current Queensland Department of Primary Industries barramundi research framework was highly regarded and was seem as a major asset to the industry. There was strong support to maintain this framework and the individuals involved together with the ongoing support of the ADD Subprogram.

- Barramundi producers would like to see the ADD Subprogram or equivalent take a lead role in the procedures associated with commercialisation of technology derived from research within the Subprogram. This could involve a staged upscaling of research utilising both small-scale and large-scale production experiments.

- The transfer of research results via Subprogram newsletters, industry newsletters and industry workshops was seen as adequate. Of greater issue is the ability to ensure that the research information is being adequately adopted by commercial aquafeed manufacturers.

- Dr Kevin Williams, Mr Chris Barlow and Dr Leong Wee were well known and respected by respondents.

- Some respondents indicated that there was capacity to generate direct cash contributions to a future research program if necessary.

3. Prawn Industry

Research content/priorities:	Some application
Research providers:	Undecided
Communication of results:	Moderate
Value of the FMR and ADD Subprograms:	Gaps in knowledge still exist

a) Value of completed research

- Apart from feed manufacturers, few industry members were available for comment on the value of research from both the FMR and ADD Subprograms. The industry members interviewed had participated in some of the research associated with these Subprograms, but had little knowledge of the outcomes of the research and the extent of their application in the prawn industry.

- Despite the fact that the bulk of the research completed with prawns appears to be of the highest standard, feed manufacturers are still seeking ways to significantly reduce the cost of Australian prawn diets while maintaining or improving production levels. There is a general feeling that this cannot be achieved utilising existing expertise within Australia.

b) Priorities for future research

The key priorities for future research are:

- To reduce the costs of Australian prawn diets,
- Increase production levels through nutritional manipulation while minimising the impact of feed waste on water quality.
- The use of heterotrophic (bacterial) rather than autotrophic (algal) prawn pond production systems.

While the current research program appears to be a logical way to achieve the above aims (with the exception of the final priority), it was generally felt that the rate of progress with this approach is too slow to meet the current industry needs.

c) Preferred approaches within a future nutrition subprogram

- The prawn industry would like any new aquaculture nutrition Subprogram to have a more applied focus in relation to prawn nutrition with closer links to both prawn producers and aquafeed manufacturers.

4. Silver Perch Industry

Research content/priorities:	Applied and relevant
Research providers:	Excellent
Communication of results:	Room for improvement
Value of the FMR and ADD Subprograms:	A valuable resource to the industry

a) Value of completed research

- Research completed within the FMR and ADD Subprograms to date have been effective in reducing diets costs from an average of $1000/tonne to $800/tonne and hence have helped producers maintain profit margins.

- The outcomes from the research completed within the FMR Subprogram in relation to Silver Perch were the only outcomes from the Subprogram deemed to have a net benefit accordingly to an ex-post economic review of the research commissioned by FRDC.

- The FMR and ADD Subprograms have allowed feeding costs to be reduced through a net reduction in diet costs coupled with improvements in daily gain and feed conversion efficiency.

- The Silver Perch industry currently places a high priority on nutrition research (together with a number of other priorities) and would be keen to see research in this field maintained.

b) Priorities for future research

A number of future research priorities were identified including:

- Continued research to increase the number of feed ingredients available for use in Silver Perch diets and further reduce diet costs while maintaining or improving production levels.
- Influence of water quality on nutritional requirements.
- Research with fish at varying water temperatures.
- Use of clove oil in feeds as an anaesthetic.
- Investigation into nutrition x genotype interactions for silver perch.
- Conduct of research with larger fish to assess digestibility of ingredients and nutrient requirements.
- Influence of nutrition on Silver Perch diseases during winter months.

c) Preferred approaches within a future nutrition subprogram

- The Silver Perch industry would like to have more inputs into the priority setting processes for future nutrition research. They would value the development of a five year plan but accept that the plan would have to be reviewed year to ensure the recommendations were still relevant.

- Improved identification of key industry contacts was deemed desirable to ensure the research program was well targeted.

- The Silver Perch industry would be happy to consider financial or in-kind contributions to future nutrition research. Approach's for such funding would have to be made via Silver Perch grower's meetings.

- The Silver Perch industry would be keen to receive intermittent research updates containing nutrition research results that look positive.

- Industry workshops could add extra value to the dissemination of results from any future Subprogram, but they would have to be linked to existing grower meetings.

5. Other Aquaculture Industries

Other aquaculture industries that have had indirect benefits from the FMR and ADD Subprograms have been the abalone, tuna and rock lobster aquaculture industries.

Benefits to these industries have primarily been derived from the involvement of key nutrition researchers in FMR and ADD workshops. This has allowed researchers to present results for scrutiny by other nutrition researchers, undoubtedly improving the standard and relevance of the research conducted and ensuring that any overlaps in research approaches were standardised or consolidated.

As the majority of members of these aquaculture industries had no direct or peripheral involvement in either the FMR or ADD Subprograms it was deemed inappropriate to include their views in this review.

Perspectives of the Fishmeal Replacement and Aquaculture Diet Development Subprograms – Research providers

Tasmanian Aquaculture and Fisheries Institute

The Tasmanian Aquaculture and Fisheries Institute has a wide range of nutrition related projects including:

- Nutrition of rock lobster juveniles and adults;
- Nutrition of rock lobster phyllosoma;
- Striped trumpeter larval rearing
- Live food enrichment and larval feed development for a variety of species.
- Fishmeal replacement and the nutritional requirements of Atlantic Salmon including lysine requirements research (funded by Pivot Aquaculture), and protein:energy requirements for post-moult spat prior to introduction to salt water.
- Fish oil replacement in Atlantic Salmon.
- Feeding behaviour in salmon, flounder, lobster and seahorses.
- Algal research with molluscs.
- Squid and cuttlefish research.
- Nutrition of eels.
- Nutrition of rainbow trout.
- Fundamentals of crustacean digestion.

Despite the wide involvement in nutrition research related projects, this group has only had limited involvement in either the FMR or ADD Subprograms, with the exception of Chris Carter.

Comments on the FMR and ADD Subprograms:

- TAFI generally supports Subprograms and enjoys the cohesiveness they bring to research programs. If a Subprogram is being developed, they would prefer to see the development of a species based Subprogram because these can address a wider range of concurrent issues. Having said this, topics such as larval rearing tend to lend themselves to discipline based Subprograms.

- The general feeling of those interviewed was that the FMR Subprogram had a specific and generic goal and hence was worth pursuing. In contrast, the ADD Subprogram appears to have lost focus and relevance and could be considered as just a collection of projects.

- It was felt that industry was not driving the ADD Subprogram and hence there was a lack of focus for the research and development priorities. In contrast, discipline-based Subprograms are more coherent in their direction.

- The current operation of the Subprogram has resulted in the emphasis of the research being placed upon the aquaculture species the core researchers are most closely associated with.

Priorities for future research:

- Even though more funding opportunities may exist for an ADD Subprogram, TAFI have little desire to separate existing projects into a future discipline based Subprogram.

- If the ADD Subprogram was to be continued, then TAFI would prioritise the following components:
  - Feeding behaviour (activity, location in the water column, training, influence of light).
  - Larval nutrition and enrichment.
  - Live feed development for larvae (to address the lack of enrichment diets currently produced in Australia).

- The future of the ADD Subprogram may best be directed to the nutrition of emerging aquaculture species that cannot justifiably by investigated through a species-based Subprogram.

- In the short term, the establishment of an expert working group and the facilitation of an annual workshop may be the only core functions of the ADD Subprogram.

Queensland Department of Primary Industries (Walkamin)

Comments on FMR and ADD Subprograms

In the absence of local nutrition expertise in North Queensland, the FMR and ADD Subprograms have provided the QDPI with invaluable assistance within their barramundi research program. In particular, the networking associated with Subprogram workshops has been a great asset.

In the absence of an nutrition related Subprogram, the QDPI would find it difficult to maintain an ongoing nutrition research program. To date, the QDPI have obtained a lot of internal departmental benefits through their involvement in the Subprogram. On this basis alone, continuation of the Subprogram was seen as beneficial.

Dr Geoff Allan was seen as a good Subprogram Leader and the QDPI were keen for him to maintain his position. Further to this, the QDPI were happy with the progressive thinking of FRDC in relation to Subprograms and the level of follow-up associated with milestone reports etc.

There was a general feeling that the extension of results from nutrition research could be further enhanced.

Priorities for future research.

The following research areas were seen as a priority for a future Subprogram:

- Storage of aquafeed in tropical environments. Commercial manufacturers currently suggest their products have a six-month useable life, however, this appears to be restricted to good storage conditions in a temperate environment. Under tropical conditions, barramundi feeds appear to begin deteriorating after only 10-12 weeks.
- Fish performance in relation to diet age and storage conditions (while a clear priority, the logistics associated with conducting this type of research to produce meaningful results are such that it is unlikely to proceed).
- The seasonal nutritional requirements of barramundi.
- Interactions between nutrition, feeding efficiency and fish husbandry.
- Nutritional strategies to improve feed conversion efficiency.
- Improved strategies for the commercial uptake of nutrition research results.

Queensland Department of Primary Industries (Bribie Island)

Mr Zafer Sarac was initially involved in the FMR and ADD Subprograms prior to being seconded to another department within the QDPI. Mr Sarac's departure has resulted in significant changes in

relations to the QDPI's involvement in the ADD Subprogram and its potential for involvement in the future.

Comments on FMR and ADD Subprograms

- Concern was raised over the way the QDPI (Bribie Island) component of the ADD Subprogram was terminated following changes in staffing at the institution. QDPI did not feel they were adequately consulted during the process.

- QDPI suggested that FMR and ADD Subprogram meetings spent an excessive amount of time focussing on previous research results rather than scrutinising planned research.

- As an indication of the value of the FMR and ADD Subprograms, the cessation of involvement of the QDPI in the ADD Subprogram has resulted in re-allocation of the experimental facilities (to research with crabs, bugs and mullet). In addition, there is now no nutrition or prawn research group in existence or any defined research priorities in this field.

Priorities for future research

- QDPI felt they had limited potential to re-enter the aquaculture nutrition research field unless there was a strategic research appointment within the institution and any involvement would have to be initiated from outside the QDPI with a strategic vision to utilising the Bribie Island facilities.

- It was felt that industry and feed companies should have greater inputs into the commercial up-scaling of the research.

Western Australia (Fisheries WA, Murdoch University, Agriculture WA, TAFE, Private Organisations)

Viewpoints from Western Australia were gathered during a review specific meeting convened by Fisheries WA.

A number of aquaculture nutrition projects are currently underway in Western Australia including:

- Nutrition of the Western Australian Dhu fish (FRDC)
- Snapper nutrition (GRDC).

- Rock lobster nutrition (through the FRDC Rock Lobster Enhancement and Aquaculture Subprogram).
- Bream nutrition (FRDC).
- Abalone (Roei) nutrition.

Despite a number of FRDC-funded nutrition projects, none of these projects were considered to be part of the FMR or ADD Subprograms.

Comments on FMR and ADD Subprograms.

- To date, Western Australian researchers have felt that they have had limited access to the FMR and ADD Subprograms and limited funds to attend meetings associated with these Subprograms.

- Low volumes and market dominance by a limited number of aquafeed manufacturers have limited the interest of local feed manufacturers in any nutrition research being conducted.

- Due to limited involvement in the FMR and ADD Subprograms, WA researchers established their own research review group and excellent working relationships between research institutions including Fisheries WA, TAFE, Murdoch University and Agriculture WA.

- WA researchers felt that cessation of the ADD Subprogram would have little influence on their current or future conduct. With the exception of the reports generated by the FMR and ADD Subprograms, they saw few other benefits arising from the research conducted within the Subprograms to their aquaculture industries.

Priorities for future research

Researchers in WA identified the following research priorities:

- Development of a nutritional database for aquaculture species.
- Rapid screening of diets and ingredients for use in aquaculture diets and the potential to rapidly assess alternative feeding strategies.
- Fate of dietary protein and energy in target aquaculture species.
- Carbohydrate tolerances of new and existing aquaculture species.
- Waste management in aquaculture systems.
- Nutrient requirements of target aquaculture species – feeding for profit strategies.

- Alternative plant protein sources for crustacea.
- Communication between investors and end-users of the technology could be improved.

NSW Fisheries

As the lead agency for the coordination of the both the FMR and ADD Subprograms, the research associated with these Subprograms represents a core area of research for this institution. The administration component of the Subprogram that is managed through the Port Stephens Research Centre has established a strong network of contacts and should clearly be maintained regardless of whether the Subprogram continues or not.

Comments on FMR and ADD Subprograms

- At the time of commencement of the FMR Subprogram there was no coordinated research towards a common goal. As the first FRDC Subprogram, the FMR Subprogram represented a significant step forward for FRDC in relation to research project management. As the first Subprogram, the FMR Subprogram has also acted as a model for all other Subprograms.

- NSW Fisheries are comfortable with the procedures that were followed to establish research priorities, core research species and involvement in both the FMR and ADD Subprograms. As a consequence, they accept that any criticism in relation to aspects of the research and those who provided the research largely originate from those who were not directly associated with the Subprogram.

- After the success of the FMR Subprogram from a research outcome perspective, the ADD Subprogram represented somewhat of a dilution of momentum. FRDC reduced available funding and encouraged a move to discipline-based nutrition projects rather than species-based projects. External funds had to be obtained from other sources to maintain the level of research that had been maintained as part of the FRMR Subprogram.

- The Subprogram approach has proved useful in ensuring available funds were used for the highest priority research areas. For example, project savings were used to fund additional barramundi research and to extend some prawn research.

- The conversion of technical reports into more end-user friendly formats prior to distribution may improve uptake of the research results by industry.

- NSW Fisheries are very keen to maintain a lead role in any continuing Subprogram. They see a "Centre of Excellence" for nutrition as a major asset for Australian aquaculture industries.

Priorities for future research

NSW Fisheries would support a new aquaculture Subprogram aimed at developing coordinated nutrition research strategies, reviewing existing research project progress and reviewing proposed experimental methodology.

Priority areas for nutrition research included:

- Identification of fish oil alternatives and the potential for blending oils of differing origin.
- Feeding behaviour.
- Interactions between nutrition and fish husbandry.
- Feed delivery strategies.
- Protein:energy requirements of target species.
- The fate of dietary energy sources.
- Influence of nutrition on environmental loads and waste.
- Formulated larval feeds.
- Bioeconomic analysis of feeds and feed costs.
- Target research species should include salmon, prawns, rock lobster, tuna and snapper. Limited potential was seen for continued research with silver perch and barramundi (however this view is unlikely to be supported by the barramundi industry).

- While nutritional of live feeds was seen as a critical research issue, it was not deemed to be a candidate component any future nutrition Subprogram.

- Despite significant outcomes from the FMR Subprogram, fishmeal still represents 30-40% of the 40-50 000 tonnes of aquafeed produced in Australia per year.

- It was felt that research and development should not be directed solely towards established aquaculture industries, but should focus on all industries where nutrition represents a significant production bottleneck.

CSIRO Marine Research (Cleveland)

CSIRO Marine Research have a primary objective to conduct research on plant and animal physiology to develop better foods and feeding practices for aquaculture.

The current CSIRO Marine Research program includes the following project work:

- Identification and quantification of the nutritional requirements for growth and nutrition of aquaculture species for the development of improved and more cost-effective feeds.
- Assessing the utility of supplemental feeding with fresh and preserved unicellular algae as a method of increasing and stabilising the growth of juvenile oysters.
- Evaluating microalgal concentrates (pastes) against live algae for culture of penaeid and oyster larvae.
- Developing environmentally friendly diets and feeding practices for tiger prawns.
- Improving the efficacy of plant proteins as fishmeal replacements in aquaculture diets for prawns.

Comments on FMR and ADD Subprograms

- The FMR and ADD Subprograms were good models that should be maintained. CSIRO Marine Research expressed every confidence in Dr Geoff Allan as Subprogram Leader and enjoyed the personalities involved in the research programs.

- CSIRO Marine Research felt they received unrestrained support in their own research program through the sharing of existing expertise from other research groups. Prior to the commencement of the FMR Subprogram, this level of cooperation was unknown and there were very strong institutional boundaries. Reductions in these barriers really assisted the progression of the research.

- In comparison to the FMR and ADD Subprograms, it was felt that the Aquaculture CRC was not as effective in delivering nutrition research outcomes because it had to meet a wider range of organisational and political agendas rather than scientific agendas.

- CSIRO Marine Research have a number of additional nutrition projects that are not necessarily being captured by the ADD Subprogram. These include research into the nutrition of grouper and the potential for lupins in prawn diets. Arguably, projects that are not captured by a Subprogram

diminish the value of the Subprogram. Further to this, direct requests to other funding agencies without the support of the Subprogram diminish the power of the united approach.

- It was suggested that a new Subprogram could be more pro-active in the capture of SPIRT and ARC grants through participating universities.

- CSIRO Marine Research confirmed that their infrastructure for nutrition research had expanded as a result of their participation in the FMR and ADD Subprograms. They also indicated that their ability to maintain this level of infrastructure would be dependent on the demand for resources generated through a new Subprogram.

Priorities for future research

- CSIRO Marine Research expressed support for an expert working group in aquaculture nutrition with qualifications that the group needs to have an outcome oriented function in the form of research and development plans and the development of new subprograms. The process for the establishment of such a group must be open and transparent.

- An expert working group in nutrition should have inputs into PRP and full submission development as well as preschedules prepared prior to the conduct of the research.

Current research priorities identified through CSIRO Marine Research include:

- Definition of protein:energy requirements for target species.
- Determination of the apparent digestibility of energy, crude protein and essential amino acids for more commonly used ingredients in prawn feeds.
- Larger-scale pond experiments to validate apparent cholesterol requirements of prawns.
- Definition of the physiological responses to prawns to increasing dietary carbohydrates (eg. starch). Further to this, it would be desirable to establish whether observed reductions in food intake in prawns are a response to hyperglycaemia.

CSIRO Marine Research (Hobart)

CSIRO Marine Research in Hobart primarily provides analytical support for a wide range of existing nutrition projects including a number within the ADD Subprogram. Involvement in the ADD

Subprogram is primarily through projects undertaken through CSIRO Marine Research in Queensland or projects requiring fatty acid analysis.

Comments on the FMR and ADD Subprogram.

- This division of CSIRO Marine Research has benefited from their association with a group of discipline specific personnel and would value the maintenance of such a group in the future.

- This group found the basis for selection of some of the target species within the FMR and ADD Subprograms difficult to justify.

Priorities for future research:

If an ADD Subprogram was to continue in the future, this group would prioritise the following research areas:

- Fatty acid requirements of various species and the impact on product quality and human health.
- Effects of increased omega-3 fatty acid concentrations on storage properties.
- Influence of increased product fat on product quality.
- Fish oil replacement in aquaculture nutrition.

University of Queensland

The University of Queensland became involved in aquaculture nutrition research following cutbacks in wool and meat nutrition research. A University Research Grant was used to establish a freshwater re-circulation system for work initially with silver perch.

Comments on FMR and ADD Subprograms

- Without the advent of the ADD Subprogram, it is unlikely the University of Queensland would have secured funds independently for the conduct of nutrition research with silver perch. As a consequence, the ADD Subprogram was perceived as being a highly beneficial initiative.

- The research and teaching expertise developed through involvement in the ADD Subprogram will now be used by the University of Queensland in future research and teaching programs. At

present there is no undergraduate teaching in aquaculture, but a Certificate level course is planned with a view to developing an undergraduate course.

- To date, SPIRT grants have been considered as an option for supplementary funding to that received from within the Subprogram, however, the QDPI alone is no longer seen as a suitable industry partner by the research investors.

- Significant efficiencies are perceived by running projects through Subprograms. Subprograms also provide a mechanism for new entrants into the research field to gain experience and funds for research.

- Subprograms represent an effective means of eliminating state and institutional boundaries.

Priorities for future research

- Future research into the digestibility of diet ingredients for barramundi appear to be exhausted.

- Interested in options for research into the potential of farming Yellow Belly in saline bore water.

- Would like to base future research programs on post-graduate student projects.

- The University of Queensland do not believe that a future ADD structure necessarily needs to be in the form of a Subprogram, but should focus on "capacity building".

Queensland University of Technology

The core role of the Queensland University of Technology in the FMR and ADD Subprograms has been in relation to biochemical aspects of nutrition research and fish physiology.

Comments on FMR and ADD Subprograms

- The FMR and ADD species were selected on the basis that they covered a wide range of species and growing environments and hence the research could be considered as generic for a wide range of other species. QUT felt that this has not been emphasised sufficiently and that there has been

no identification of the small fine-tuning factors that may be required to adopt research to a new species.

- QUT have benefited from their involvement in the FMR and ADD Subprograms by gaining an appreciation of nutrition research and an appreciation of the variety of inputs that are required to derive a pool of knowledge.

- QUT were complementary of the efforts of Dr Geoff Allan as Subprogram Leader in the development of networks between research institutions.

- Fundamental research was undertaken by QUT to support some of the more applied aspects of the Subprogram research. This was seen as a good synergy.

- Within QUT, a lack of aquaculture infrastructure makes it difficult to support the wider range of projects undertaken within the FMR and ADD Subprograms, and hence they saw the links with the Subprograms as invaluable.

- Infrastructure within QUT for aquaculture nutrition related research has expanded as a result of their involvement with the FMR and ADD Subprograms.

Priorities for future research

The Queensland University of Technology highlighted the following as important potential components of any future research program:

- Development of procedures for the initial assessment of potential of new aquaculture species.
- Fundamental physiological research to support more applied research.
- Determination of fundamental constraints to digestion and absorption in target aquaculture species.

Perspectives of the Fishmeal Replacement and Aquaculture Diet Development Subprograms – Feed manufacturers

Pivot Aquaculture

Comments on the FMR and ADD Subprograms:

- The overall view of this organisation was that the Subprograms lack sufficient industry focus and they should not be run by scientists. Having said this, it was felt that continued funding is required to maintain what has obviously established itself as a "Centre of Excellence".

- Future Subprograms should operate on the basis of established objectives derived by industry and end-users and then formal tendering or subcontracting for the conduct of the research.

- It was felt that the FMR Subprogram was worth pursuing but it failed to collect and utilise existing information from overseas. The FMR Subprogram was useful in establishing some key research facilities, but the focus of the research on silver perch and barramundi was not of immediate interest to Pivot. Salmon research had to be self-funded through Pivot. Pivot could not nominate any changes in their operation that had occurred as a result of the FMR Subprogram.

- Pivot has enjoyed useful associations with two groups involved with the Subprogram including TAFI (Chris Carter) and the QDPI (Walkamin facilities through Chris Barlow). Self-funded research with barramundi using higher fat and higher meat meal diets through the Walkamin facilities was a very valuable project to the company. Contract research through UTAS into salmon nutrition has also produced beneficial results.

- As a commercial organisation, Pivot must protect its intellectual property to maintain market share and commercial advantage. As a consequence, it is easier to focus on self-funded contract research than to become involved in FRDC funded research programs.

- Pivot currently have a preference for low-cost, short term research and see little value in pursuing long term research.

- Pivot have a preference for species-based, industry driven Subprograms.

- Any future nutrition-based Subprogram should be accompanied by an international competitive review.

Priorities for future research:

A large number of issues affecting the progress of aquaculture industries could be identified as being nutritionally related but not nutritionally specific.

Pivot nominated the following potential research areas within ongoing Subprograms:

- Assessment of the value of high energy salmon diets in Australia.
- Techniques for enhancing the nutritional value of meat and bone meals for use in aquaculture diets.
- Fish oil replacement in aquaculture diets.
- Improvement in the nutritional value of coproducts for use in aquaculture diets.

An additional gap that was identified in terms of infrastructure was the need for large scale research facilities with full size fish and scale-up research facilities. Pivot indicated a willingness to consider half-funding of such a facility up to $500,000.

Pivot saw the maintenance and efficient use of existing nutrition research facilities as a priority for future nutrition Subprograms.

Ridley Aquafeeds

Comments on the FMR and ADD Subprograms:

- Primary benefits derived from research within the Subprograms has been in the form of barramundi diets. Ridley have been very happy with their association with Chris Barlow and the QDPI and have found the information derived from this research on-farm to be beneficial and useful.

- Ridley's would like to see the Subprogram take more of a lead role in commercialisation of research and to consider issues associated with commercialisation earlier in the research process. In addition, intellectual property issues associated with the research outcomes could be addressed by compartmentalising aspects of the research program.

- The delivery of the research results to the end-user could be in a more user friendly form.

- Ridley's felt that there should be support for industry membership on the Subprogram Steering Committee and that industry should have more involvement in the priority setting process. The Steering Committee of the ADD Subprogram could benefit from restructure.

Priorities for future research:

Ridley's nominated the following priority areas for future research:

- Replacement of fishmeal in aquaculture diets – despite the FMR Subprogram, there is still considerable scope for research in this area.
- Development of environmentally friendly diets.
- Characterisation of extrusion techniques for pellet integrity and stability.

Select Nutrition Pty Ltd

To date, select nutrition have had limited involvement with either the FMR or ADD Subprograms. They believe that research of this nature is of vital importance to the success of their business and their ability to compete in a highly sought after market. They rate research into the nutritional requirements of target aquaculture species and improved definition of the nutritional value of various raw materials as the highest research priorities. They also expressed some frustration associated with gaining entry into research programs that already involved the larger Australian aquafeed manufacturers.

Potential for coordinated co-investment in future aquaculture nutrition research programs

Australian Centre for International Agricultural Research

Potential for co-investment:	Very high
Potential for co-management:	Very high
Mechanism for coordination:	Expert working group in aquaculture nutrition

- ACIAR have been involved with the FMR and ADD Subprograms and have benefited from their participation. The principal involvement was through projects examining feed development for Silver Perch and walking catfish. The primary aim of these projects was to provide advice to farmers on how to reduce their reliance on fishmeal.

- ACIAR have an ongoing research program with CSIRO Marine Research involving grouper and related marine species, but this project is not seen as a core project within the current ADD Subprogram.

- ACIAR currently make use of a regional (Asia Pacific) research and development network for grouper and related species. A part-time position is located at NARCA is used to coordinate this network. Dr Mike Rimmer is the Technical Coordinator and Dr Kevin Williams coordinates the nutrition components of the research.

- ACIAR is funded through the Federal governments overseas aid portfolio. Projects supported by ACIAR must be mutual interest projects and ownership of this research must involve both Australia and the participating countries.

- ACIAR research priorities in relation to fisheries research are currently established using a variety of routes but largely based on three-yearly consultations with major neighbouring countries. All projects must be outcome oriented. A full outline of the Fisheries Research Program Strategic Plan is presented in Appendix II. Key research objectives relating to aquaculture nutrition include:
  1. The evolution of more productive, environmentally responsible aquatic farming systems that increase food supplies and provide income opportunities for small producers.

2. Enhanced research capacity and more effective management extension linkages in partner countries and in Australia.

- Based on the above core objectives, the following priority research areas exist within ACIAR's research program:
  1. Increased sustainability of aquaculture production through improved site selection, farm management, reduced reliance on fishmeal.
  2. Nutritional manipulation of disease threats through reduction of wastes and improvements in the efficiency of utilisation.
  3. Investigations into novel feeds for aquaculture species.

- ACIAR would place a high value on the establishment of an expert working group that could be used as a point of reference in Australia for the development of aquaculture nutrition research priorities. ACIAR would also be keen for the development of a synergistic funding strategy between research investors such as FRDC and GRDC and viewed this research review as a potential starting point for this synergy.

- Formal discussions between ACIAR and FRDC should be pursued as soon as possible to initiate a coordinated funding strategy. An expert working group established as part of a new Subprogram could be used to facilitate meetings between FRDC and ACIAR.

Grains Research and Development Corporation

Potential for co-investment:	Very high
Potential for co-management:	Very high
Mechanism for coordination:	Agreement between FRDC and GRDC.

- The GRDC do not have a defined aquaculture research program nor any defined aquaculture research objectives. If any research projects are proposed to GRDC that relate to aquaculture nutrition, they are assessed and if necessary subsequently managed through Program 1.4.1 which focuses on Premium Livestock Grain Quality.

- GRDC ultimately wants to improve markets and returns to Australian grain growers. In the event that aspects of aquaculture nutrition were defined as an important research priority to achieve this, the GRDC would approach FRDC to refine these priorities and to manage any research investment on their behalf.

- GRDC would view a Memorandum of Understanding with FRDC as a good starting point for the establishment of co-management and co-investment procedures relating to aquaculture nutrition research. GRDC would also view a national expert working group in aquaculture nutrition as a valuable resource.

- Existing GRDC research priorities relating to aquaculture nutrition involve:
  1. Identification of potential overseas markets (particularly South East Asia) for complete aquaculture feeds containing Australian grains or oilseed meals, or markets for Australian grains or oilseed meals for use in aquafeeds.
  2. Potential for canola oil and canola meal in aquaculture diets.

Pig Research and Development Corporation

Potential for co-investment:	Moderate
Potential for co-management:	Moderate
Mechanism for coordination:	Expert working group in aquaculture nutrition

- PRDC would value a single point of contact for the review of aquaculture related projects or for the assessment of research priorities involving aquaculture and the Australian pig industry.

- Research priorities relating to both the pig industry and Australian aquaculture include:
  1. Utilisation of saline water arising from piggeries.
  2. Potential for fish waste products to be incorporated into pig diets and techniques for the preservation of fish wastes that will facilitate storage and continuity of supply.
  3. Use of piggery waste for the production of live feeds is a past priority with little future potential.
  4. Use of scavenging fish to utilise piggery waste is a past priority with a limited future.

Meat and Livestock Australia

Potential for co-investment:	Undefined
Potential for co-management:	Undefined
Mechanism for coordination:	Undefined

- At the time of preparation of this review, Meat and Livestock Australia were undergoing a period of restructure and consilidation and hence limited information could be derived on the potential for co-investment and co-management of aquaculture nutrition projects.

- MLA have prepared a draft strategy for aquaculture-related research but it is likely that the bulk of this research will be undertaken through an invited tender process.

Rural Industries Research and Development Corporation

Potential for co-investment:	Limited
Potential for co-management:	Moderate
Mechanism for coordination:	Undefined

- Limited potential exists for aquaculture nutrition research in relation to the poultry industries.

- Some potential exists for the ADD Subprogram to take a lead management role in relation to nutrition research associated with crocodiles, and it is clear that researchers involved with this program would benefit from involvement in ADD Subprogram meetings.

Benefit-costs of investment into aquaculture nutrition research

The benefit-costs associated with nutrition research are clearly identifiable when dealing with a single target aquaculture species. To this end, research associated with defining the nutritional requirements of individual species or improving the definition of nutritional value of various feed ingredients for individual aquaculture species should only proceed with the full support of these industries (or within species-based subprograms). This would of course include significant financial support for the research. The exception to this suggestion is when the nutrition of an emerging aquaculture species represents a bottleneck or impediment to the establishment of this industry.

Aquaculture nutrition is a difficult research field. There are aspects of nutrition research that cannot be completed within a single organisation or using a single aquaculture species. In this instance, the benefit-costs of the research are more difficult to define. A pro-active approach to the research is required and it is best approached using large, collaborative programs. The establishment of this type of research program should be based on long term benefits to the aquaculture industries, but given the lack of specificity, it should not be subject to ex-post benefit cost analysis (such as the one undertaken for the FMR Subprogram) as this type of analysis provides little valuable information and is generally counter-productive.

Specific comments on the ex-post benefit cost analysis of the FMR Subprogram

- The following comments were not supported by the organisation that conducted this ex-post analysis of the FMR Subprogram. However, after careful consideration of their comments we have chosen to maintain our view. The following comments do not cast negative aspersions on the reviewers, but suggest more an error of judgement on the part of FRDC.

- Based on the highly negative nature of this ex-post benefit cost analysis, the limited information on which it was based, and the limited usefulness of the results, the FRDC should not have released the results to the FMR Subprogram in any form. It is our opinion that the results do not reflect the value of the Subprogram and that the report has been more than counter-productive.

- An ex-post benefit-cost analysis may not have been the most appropriate basis for the assessment of a nutrition subprogram dealing primarily with feed evaluation and the definition of nutrient

requirements. Subsequent discussions with those who completed this review reveal that an ex-ante benefit cost analysis may have been more appropriate. For this reason, while the benefit-cost analysis prepared for FRDC addresses the terms of reference for the exercise, it is of little value to FRDC as an indication of the relative benefits of the FMR Subprogram.

- The benefit-cost analysis conducted should have included benefits and costs arising from the ADD Subprogram in addition to the FMR Subprogram. It is difficult to separate the two Subprograms.

- The basis for assessing benefits from the FMR Subprogram research appears superficial. Assessment of nutrition research projects would be improved through the inclusion of parametric programming exercises to assess the relative change in the value of a feed ingredient resulting from the research in the event that it is utilised in a diet. It has been suggested that the cost of this type of analysis exceeds the benefits. If this is the case, then it suggested that a benefit-cost analysis should not be undertaken at all as only half the story is told. A number of scenarios must be created based on the level of use of the ingredient, the primary species being fed and the relative cost of other ingredients available for use, or being used at the time. This can only be completed in consultation with an experienced nutritionist. Simulation modelling is also required for an adequate assessment of the impact of research into nutritional requirements.

- An inappropriate basis for the conduct of this benefit-cost assessment has caused a significant amount of unnecessary angst amongst researchers and end-users.

- The new ADD Subprogram Steering Committee should establish a uniform basis for the assessment of new and existing nutrition research projects.

Short-term recommendations for the development of a new aquaculture nutrition subprogram

- Based on the outcomes of this review, it is recommended that an aquaculture nutrition subprogram be maintained by FRDC with due consideration for the following:

- A Subprogram coordination project (1-3 years) should be funded by FRDC with a number of immediate tasks including:
  - Establish what the fundamental non species specific nutritional constraints are to aquaculture production (eg. is it diet form, nutritional requirements, feeding strategies, feed evaluation or a combination of several factors) and how they could be best addressed through a collaborative research program. Outcomes from this process would form the basis for new projects within the subprogram. To define these priorities some strategic research in addition to comprehensive reviews of existing literature may be required to identify nutritional limits.
  - A risk management strategy should be developed for all aquaculture industries in relation to nutrition. This will assist the research priority setting process.
  - A SWOT analysis of nutrition research priorities should be completed for all major Australian aquaculture species.

- An agreement should be forged between the FRDC and other relevant RDC's and research providers for the management of research relating to aquaculture nutrition under the auspices of an aquaculture nutrition subprogram. This should account for variation in priorities between agencies. This mechanism should be for providing information to other RDC's rather than making decisions.

- Existing nutrition research conducted within species based subprograms should continue within these subprograms, but formal links must be maintained with a future aquaculture nutrition subprogram.

- The new subprogram should establish a skills-based Steering Committee to operate within the following terms of reference:

- Develop a 5 year research and development plan for generic Australian aquaculture nutrition research priorities.
- Scrutinise nutrition research planned within the species based subprograms.
- Provide advice to the FRDC Board and other Australian research and development investors on aquaculture nutrition research priorities.
- Act as an identifiable point of contact as an "expert working group on nutrition" for all Australian stakeholders in aquaculture.
- Provide industry feedback and views.
- Review existing nutrition research based on FRDC contractual obligations.
- Ensure outcomes are commercially focussed;
- Coordinate industry and research provider involvement in research programs to ensure optimum use of resources;
- Identify those research providers and researchers best equipped to address defined research priorities;
- Commission tendered research to address defined priorities;
- Define an appropriate basis for the distribution of intellectual property on a case by case basis.
- Facilitate extension and technology transfer.

- Membership of the Steering Committee should be based on skills and should attempt to include expertise in the areas of food technology, economics and commodities and extrusion process control. Where possible, representation on the Steering Committee should not include scientists actively involved in the research programs underway within the subprogram, however, given the specialised skills suggested above, this may not always be possible. It would also be desirable to appoint an independent chair in the event the Subprogram Leader is an active researcher in the subprogram. Appointment of the Steering Committee should vest with the FRDC in consultation with the Subprogram Leader.

- While a Subprogram Leader may have individual research priorities that can be appropriately completed within the subprogram they manage, the role of Subprogram Leader must be completed impartially. If a new aquaculture nutrition subprogram is established, the Subprogram Leader will need the full support of their organisation to:
  - Coordinate research activities that directly address industry needs (established by the Steering Committee);
  - Actively lobby other research investors on behalf of all research organisations involved with the Subprogram;

- Commit an adequate amount of time for the management of the Subprogram (or utilise a proxy for at least an equivalent amount of time).
- Coordinate research activities in which they may have no direct involvement.
- Coordinate research activities that may be in direct conflict with the priorities established in the State in which they live.
- Host Steering Committee and Scientific Committee meetings and industry workshops.
- Promote the Subprogram without reference to their host organisation.

- In the event that NSW Fisheries offer full support to the above activities, FRDC should approach Dr Geoff Allan to lead a new aquaculture nutrition subprogram.

- The infrastructure (ie collaborations, industry contacts, mailing lists etc) developed as part of the FMR and ADD must be maintained as part of a future aquaculture nutrition subprogram.

- Under no circumstances should a future aquaculture nutrition subprogram become simply a collection of nutrition research projects. All projects within the subprogram must have a common focus and a common definable goal within a specified timeframe.

- The subprogram operational environment should consist of:
  - Steering Committee meetings (members only) to address the terms of reference detailed above.
  - Scientific Committee meetings (Principal Investigators of core research projects and other aquaculture nutrition projects plus interested observers) for the scrutiny of future research projects and coordination of existing research projects (progress reports, submissions etc).
  - Target industry workshops for a wide audience.

- A number of reporting levels must be established within the new subprogram. Reporting should reflect the above operating environment with separate communications arising from each operating activity. Newsletters should be maintained as a general means of distributing information.

- A dilemma is faced when making recommendations on how a 'discipline-based' subprogram can be integrated with species-based subprograms that contain the respective discipline as a component. As the primary coordinator of all subprograms, FRDC must ensure that the species-based subprograms recognise the role of any future aquaculture nutrition subprogram.

- Budgets for the new subprogram coordination project should support a Subprogram Leader in addition to the Steering Committee for the management of information distribution, Steering and Scientific Committee meetings and target industry workshops.

- The new subprogram should define a mechanism for lead agencies for the commercialisation of all nutrition research arising from FRDC funded projects based on recommendations in this review. All nutrition projects should devote a significant proportion of their budget to commercial upscaling of research results following guidelines defined by the ADD Subprogram Steering Committee in consultation with the major aquafeed manufacturers in Australia.

- Intellectual property issues need to be negotiated on a case by case basis. Unless a potential end-user is involved in the project from the outset, commercialisation is a far more difficult process. Commercial investments should deal with a very specific area of the research only, so that a discrete component of the IP can be apportioned. Commercial groups must recognise the need for some core research in the public arena and the need for most researchers to publish research results as a condition of their employment.

- If appropriate, the new subprogram should consist of core projects that vary in duration and/or starting/finishing dates. This will ensure the subprogram maintains momentum and is not restricted by the need to renew all core projects at the end of a three year period.

- The new Subprogram Steering Committee should take an active and lead role in the establishment of linkages and priorities for any future CRC proposals.

- A new subprogram should endeavour, where possible, to ensure the maintenance of some core research facilities, and should promote the screening of new feed ingredients and/or feeding strategies using a standardised protocol as a core service to industry.

Based on the above recommendations, Dr Geoff Allan has proposed the following basis to a new submission to FRDC:

Planned Outcome

Aquaculture nutrition research in Australia is recognised nationally and internationally for scientific excellence, effective coordination and achievements in developing better, more cost-effective aquaculture diets which contain increased amounts of Australian agricultural ingredients.

Objectives

1. To identify R & D priorities for reducing the real cost of aquaculture diets and feeding and increasing the use of Australian agricultural ingredients in aquaculture diets.
2. To coordinate and manage aquaculture nutrition R & D to improve the quality of the science and to reduce the time taken for research to be adopted by commercial feed manufacturers.
3. To improve communication on diet development among scientists, aquaculturists, ingredient suppliers and feed manufacturers.

Methods

1. Identifying priorities through consultation with aquaculturists, feed manufacturers, ingredient suppliers and scientists. Initially, the communication with stakeholders conducted during the review of the Aquaculture Diet Development Subprogram will be used to develop a Strategic Plan and this will be widely circulated and discussed. Each year, strategic R & D priorities will be reviewed and a plan published. This plan will be circulated in May each year together with a call for Expressions of Interest in developing research to address these issues.

2. There are two distinct groups of research that will be improved by this Aquaculture Nutrition (AN) Subprogram. Firstly, projects which address key identified priorities will be actively merged as "core" Subprogram projects. Such projects would include specific nutrition projects for species not covered by other Subprograms and nutrition research which is species-independent e.g. development of feed ingredient data base, research on methods to measure feed intake, etc. Applications for these projects will be reviewed by the Subprogram Steering Committee and objectives, methodology and outputs, milestones etc. examined prior to approval by the FRDC. These projects would be assessed against the R&D priorities identified by the AN Subprogram. All milestone reports for these projects would need to be submitted to the Steering Committee prior to approval and the Steering Committee would also advise on specific research direction (to deliver on agreed objectives) and technology transfer.

Detailed experimental plans would also be "peer reviewed" by the Steering Committee to help ensure excellence in scientific methodology.

Secondly, nutrition projects managed under a species oriented Subprogram (e.g. tuna, lobster and abalone) would be improved by this Subprogram primarily through active review of methodology. For those "non-core" projects, research priorities would have been set through other mechanisms and the Aquaculture Nutrition (AN) Subprogram's role would be to help ensure that the highest quality nutritional science is used. This would be achieved by the AN Subprogram Steering Committee's "peer review" of detailed experimental methodology. The AN Subprogram would also assist with rapid commercial uptake of research results. The Subprogram would be the first point of contact for many of the feed manufacturers (a role played in the past by the ADD Subprogram). Early dissemination of results through the annual workshops, newsletters and reports will help ensure that feed manufacturers are well aware of research being conducted. Most importantly, the Subprogram workshop and priority review process will provide feed manufacturers with the opportunity to identify problems they are facing in manufacturing aquaculture diets and to become involved at the planning stage so that these impediments can be quickly overcome.

Opportunities to increase the use of Australian agricultural ingredients will be identified through the R & D planning process, especially through consultation with commodity R & D corporations such as Grains Research and Development Corporation (GRDC), Meat and Livestock Australia (MLA) and the Australian Wheat Board (AWB). Where appropriate, applications to these agencies for research on aquaculture diet development will be submitted through the AN Subprogram and these projects will be managed as core or non-core projects, depending on the requirements of the other R & D agency. The key element here is to provide a focal point to allow other stakeholders such as ingredient suppliers to fund aquaculture nutrition research that will have generic application and help them sell their ingredients for use in aquaculture diets generally. This concept of providing a "focal point" has also been identified as important for feed manufacturers and other agencies such as Australian Centre for International Agriculture Research. Where projects funded by other agencies are managed by the Subprogram, a contribution towards overal Subprogram administration would be sought. These would be remitted to FRDC.

The Subprogram will actively encourage excellence in the nutritional science being conducted. Methods to achieve this will involve active review of methods to be used and provision of direction (core projects) or advice (non-core projects) to Principal Investigators

(with a copy to other Subprograms if applicable). Applications for projects will be reviewed and this service will be offered to other R & D Corporations and feed companies for any aquaculture nutrition related research. In addition, for each new and on-going project, experimental methodology will be reviewed before research commences. A detailed proforma seeking information on experimental design, statistical analysis, biochemical analyses and planned scientific publications has been developed and this will be sent to each core project (and be a condition of on-going funding) and non-core project (copy to Subprogram if applicable). Specific workshops on methodology will be held where needs are identified.

Each year an Aquaculture Nutrition Workshop will be held and results of research presented on the future plans and directions of each project (core and non-core) discussed. At this meeting, the Strategic R & D Plan will be reviewed and then call for pre-proposals to address priority issues. This workshop will be inclusive for all stakeholders and will be held in the period April-June to ensure that project development fits into the FRDC, FRAB and Subprogram cycle.

The Steering Committee may also possibly meet at one other time later in the year to review aquaculture nutrition applications to provide advice to Principal Investigators, FRDC, FRABs and Subprograms. Other interaction with the Steering Committee will take place electronically.

3. The communication strategy will include the following outputs: milestone reports, newsletter, progress reports, final reports, scientific papers, conference presentations and proceedings, articles for popular or trade magazines, website and press reports. Other specific outputs will include extension advice to aquaculturists, assistance with commercial diet formulation, technical advice and use of ingredients in aquaculture diets to assist with marketing Australian agricultural ingredients within Australian and overseas.

Strategies for the management of intellectual property associated with aquaculture nutrition research

The management of intellectual property associated with nutrition research includes difficulties that are common to most aspects of modern research. The fundamental difference is that the specificity of aquaculture diets (in terms of species specificity and the influence of ingredient type and source on the extrusion properties of the feed) makes them tangible commodities that are often perceived as marketable.

The potential for the sale of intellectual property from aquaculture nutrition research has traditionally been perceived as high. As a consequence, the communication of basic information to industry has not always been as free as possible, and communication between scientists has in some cases been limited. This has obvious implications in relation to the scrutiny of the research, the standard of the results and the rate of uptake by industry.

In many cases, there is a need for a close working relationship between research providers and aquafeed manufacturers to ensure the research is sufficiently applied and that uptake potential is maximised. For good reason aquafeed manufacturers will protect as much internal information as possible when part of this type of working relationship. As a consequence, the relationships are generally tenuous and difficult to maintain.

Based on the above, the following strategies are suggested for the management of intellectual property related to aquaculture nutrition research. Of course, management of intellectual property is a very complex subject and it is unreasonable to expect a single report to solve all issues. Hence the following is a compilation of recommendations based on information gathered as part of this review:

- Unless a market for any intellectual property arising from the research can be established PRIOR to the completion of the research then it should be considered as public sector research. In general, aquafeed manufacturers have indicated that they would prefer to repeat the research on a contract basis rather than enter into royalty or license agreements for use of the results.

- A useful way of managing intellectual property involves an end-user commitment to purchase the technology if the research program is successful. The end-user is involved in defining the project

outcomes and the methods associated with achieving the outcomes, but only pays if the program is successful. This allows a preliminary agreement to be established in relation to intellectual property and assures the research provider of a return for the outcome. In turn, the end-user does not have to bear any risk associated with the research and only pays if the outcome is delivered as stated in the research contract.

- In general there appears to be a poor understanding of the key issues associated with management of intellectual property by both researchers and end-users. In many cases, employment of an IP manager that is independent of both the end-user and research provider can have significant benefits.

- In the event that intellectual property associated with a research project can be clearly identified and quantified, then the following strategies should be applied as soon as the intellectual property is identified:

- FRDC should reserve the right to facilitate intellectual property negotiations associated with projects it has funded.

- If a number of research providers are involved in the generation of the intellectual property, then agreement should be reached for a single owner of the IP with an agreed financial return to each contributor in the event that the IP is commercialised. The IP owner should be either FRDC or the lead agency associated with the project.

- It is vital that an up-front agreement is reached in relation to background IP and how it will be used as part of the research program.

- Within Subprograms, an IP register must be initiated and maintained by the Subprogram Leader.

- Intellectual property agreements should be maintained on an annual basis.

- All intellectual property agreements must be considered on a case by case basis, but in all cases negotiations should commence as soon as the IP is identified rather than when the research ends.

- While some aspects of the FMR and ADD Subprograms represent highly significant contributions to the nutrition of aquaculture species, the likely returns from commercialisation of any

identifiable IP are likely to be exceeded by the costs associated with commercialisation and protection of the information.

Report contributors

The following individuals were interviewed during the course of preparing this report:

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Nutrition Subprogram Reviews

A Review of Research and Directions for the Fisheries Research and Development Corporation's Fishmeal Replacement Subprogram and Aquaculture Diet Development Subprogram

Summaries from a report prepared by the

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BECAN CONSULTING GROUP

Subprogram Reviews

B E C A N

Terms of reference

The Barneveld, Edwards, Choct Animal Nutrition (BECAN) Consulting Group were commissioned by the Fisheries Research and Development Corporation to review the completed Fishmeal Replacement Subprogram and the current Aquaculture Diet Development Subprogram with the following primary objective:

"To provide a recommendation to the Fisheries Research and Development Corporation Board on a potential basis and structure of an Aquaculture Diet Development (or similar) Subprogram considering research completed to date (within the Fishmeal Replacement Subprogram and the Aquaculture Diet development Subprogram) and nutrition research being completed as part of other FRDC research programs".

To date some 10 projects have been funded directly or as part of either the Fishmeal Replacement Subprogram or the Aquaculture Diet Development Subprogram. In addition, FRDC has invested in a wide range of species specific nutrition projects (abalone, tuna, etc). Interest in nutrition ranges from all aspects of the life history of farmed species – from live feeds to finishing diets. The review considers the broader nutrition perspectives and makes recommendations on how these can be incorporated into a subprogram (or similar) structure.

The base terms of reference for this review were to:

1. Review scientific aspects of all projects completed within the Fishmeal Replacement and Aquaculture Diet development Subprograms to ensure that objectives were met, research was robust and to identify gaps in our knowledge.

2. Collect and establish viewpoints of Australian research providers and reearchers who could potentially contribute to a future subprogram.

3. Collect and establish viewpoints of potential end-users of research results from past and future subprograms.

4. Review current FRDC applications relevant to the subprogram.

5. Develop a strategy for the integration of a new subprogram with other non-discipline based subprograms that contain a nutrition or aquaculture diet development component.

6. Define what role, if any, the subprogram would have for other nutritional questions – eg. live feeds, broodstock conditioning, filter feeders etc.

7. Define the potential for investment in aquaculture diet development by other research and development organisations (eg. GRDC, MLC, PRDC) and funding sources.

8. Consider the benefit-cost of investing in nutrition and recommend broad principals that would guide project development. This should consider the question of investing in species specific diet development versus generic technology that may have a broader application. To achieve this, the review team will need to consult with FERM who undertook the benefit cost analysis of the Fishmeal Replacement Subprogram.

9. Recommend a strategy(s) for commercialisation of intellectual property arising from diet development research.

10. Provide a research and development direction plan for nutrition that provides direction for future nutrition research.

11. Provide a written and/or verbal report to the FRDC Board detailing the above.

Report Organisation

Based on the above terms of reference, this report will be divided into two parts.

Part A will contain individual reviews of component projects within the Fishmeal Replacement and Aquaculture Diet Development Subprogram and will remain in the confidence of FRDC. Part A will also contain specific comments relating to the benefit cost analysis completed by FERM on the Fishmeal Replacement Subprogram and will remain in the confidence of FRDC. Part A will therefore independently address terms of reference items 1 and 8.

Part B of the report is a stand alone document that addresses all terms of reference accept items 1 and 8. Following approval by FRDC and the Subprogram Leader, Dr Geoff Allan, Part B is suitable for wider distribution as required.

Summary and recommendations

The following represents a summary of a preliminary report and recommendations based on the status of the preliminary report at the time of the final Aquaculture Diet Development Subprogram Scientific Committee meeting held in Port Stephens on December 16-17, 1999. The views presented may change following discussion at this meeting or following further development of the report prior to delivery to FRDC in January, 2000.

This review identified the following positive outcomes from the establishment and conduct of the Fishmeal Replacement (FMR) and Aquaculture Diet Development (ADD) Subprograms:

- The FMR and ADD Subprograms were successful in meeting the objectives of managed subprograms on the basis that they:

    - Promoted a high level of collaboration between scientists working within a common discipline;
    - Successfully delivered nutrition research expertise to infant aquaculture industries that otherwise would have not had access to this level of nutritional skill;
    - Reduced the level of duplication of research effort towards a common goal;
    - Applied outcomes were delivered to industry improving the profitability and viability of these industries;
    - Facilitated a coordinated delivery of research funding submissions and research reports to the FRDC.

- The aquaculture industries benefiting from research conducted within these subprograms (barramundi, salmon, prawns, silver perch) would value the continuation of further coordinated research in the area of aquaculture nutrition. Industries such as the barramundi industry rate nutrition as the highest research priority above all other disciplines, and believe that nutrition research on behalf of their industry would be severely compromised in the absence of the FMR or ADD Subprograms.

- Research providers and researchers operating within the Subprograms valued their involvement as the Subprograms through the Subprogram Leader managed to breakdown many institutional

boundaries that previously existed. The Subprogram workshops also represented a valuable form of peer review for research results.

- Research providers and researchers conducting nutrition research projects within species-based subprograms found the FMR and ADD to be a valuable resource. Workshops conducted as part of these subprograms provided an outlet for related research results and a valuable forum for critical review of the research. Many researchers operating outside the FMR and ADD used these subprograms as their reporting vehicles to FRDC.

- All individuals involved with, or benefiting from, the FMR and ADD Subprograms were highly complimentary of the efforts of the Subprogram Leader, Dr Geoff Allan. His efforts were largely responsible for the initiation of the subprogram, initiation of collaborations between research groups, involvement of other funding agencies and promotion of the results. Dr Allan's performance serves to emphasise the important role a Subprogram Leader plays in the success of a subprogram. All parties without exception would be keen to see Dr Allan continue as the leader of any future subprogram.

- The infrastructure (ie collaborations, industry contacts, mailing lists etc) developed as part of the FMR and ADD represents a valuable resource to the Australian aquaculture industries.

A number of deficiencies were identified during the course of this review. These included:

- While the Subprograms were successful in capturing funding from a variety of sources, there is scope for a future subprogram to take a lead role in the coordination of aquaculture nutrition research on behalf of other research investors. Other research investors have indicated that if FRDC and an aquaculture nutrition subprogram initiated liaisons, they would be keen to capitalise on the existing infrastructure and in many cases would request that FRDC manage research funds for aquaculture nutrition projects on their behalf.

- Submission of aquaculture nutrition projects to other funding agencies after they have been rejected by the Subprogram and/or the FRDC Board is not acceptable. The review identified at least two occasions on which this has occurred during the life of the Subprograms. Other research investors are keen to establish mechanism that prevents this in the future and ensures a coordinated approach to priority setting.

- The FMR Subprogram had a highly defined research goal that was best addressed through a collaborative research program. This common goal was diluted during the establishment of the ADD Subprogram, and the funding and Subprogram momentum was accordingly diminished. The establishment of the ADD Subprogram suffered because of a lack of well defined research priorities.

- A major limitation identified by end-users of technology developed as part of the Subprograms was the process for commercial adoption of the research. Within the Subprogram and at least one affiliated project, lack of attention to commercialisation of the research resulted in disastrous semi-commercial trials resulting in a loss of industry confidence in the research and a major setback to the research process.

- Due to the restrictions associated with experimental facilities, a large amount of the research conducted within the FMR and ADD Subprograms was completed with small/juvenile fish. There is concern from a number of end-users that a large amount of research may not be relevant to the bulk of the production cycle of most commercial aquaculture species.

- While Scientific Committee meetings were valuable for the review of research completed to date, they were not used successfully to critically evaluate research prior to commencement, and they were not an effective means of delivering results to the primary beneficiaries of the research (ie the aquaculture industries). In addition, progress reports to research investors cannot be distributed to a wider audience. Outcomes from scientific meetings need to summarised and distributed to participants exclusive of progress reports.

- Despite some review during Scientific Committee meetings, the research providers were not sufficiently responsive to critical comments of their research approach. Over time, this diminished the value of some research results.

- The process for the establishment of core species within the FMR Subprogram was inadequate. A Steering Committee representing the wider views of all aquaculture industries should have established the core species rather than a Scientific Committee consisting predominantly of the scientists conducting the proposed research.

- Too many of the Subprogram priorities relate to the State in which the project Principal Investigator resides or works. While these may well be justifiable priorities, a discipline-based

subprogram must be independent of state boundaries and must capitalise on expertise regardless of the state of origin.

- The Subprograms failed to involve all States and research institutions with aquaculture nutrition research priorities. Despite the fact that this impression may simply be due to a lack of funding for related research in these States, it did appear that there were limited mechanisms for the capture of opinions from research groups not actively involved in, but capable of conducting, nutrition research.

- Nutrition research projects not involving the Subprogram Leader are not necessarily linked to the existing ADD Subprogram.

- Many issues remain unresolved in relation to the most appropriate methods for the distribution of intellectual property arising from research conducted within the Subprograms, or the protection of intellectual property during the conduct of the research. A number of end-users expressed concern over the handling of IP and this should represent a key area for attention in any future subprogram.

- Some of the early projects conducted within the FMR Subprogram in particular demonstrate the infancy of the research area and the lack of experience of a number of the researchers at the time of the Subprograms commencement. Significant savings could have been made through the involvement of a broader Steering Committee in the priority setting process.

- The standard of conduct of all research undertaken within the FMR and ADD Subprograms was high, however, there were instances where misinterpretation of methodologies influenced the conclusions drawn from the results. There were also numerous cases where a wider range of inputs into the research could have improved the interpretation of the results. Specific confidential comments have been made on individual research projects for consideration by FRDC. These comments will be distributed to the researchers in question at the discretion of FRDC and the Subprogram Leader.

- The bulk of projects within both the FMR and ADD Subprogram had the same duration and consumed all funds available to the Subprogram. From a management perspective, this makes it difficult for the Subprogram to maintain momentum.

- The current FRDC submission on national coordination of a new ADD Subprogram is not adequate to meet the needs of a future ADD Subprogram

Recommendations

To address the above deficiencies and to capitalise on the positive attributes of the FMR and ADD Subprograms, the following is recommended:

- An aquaculture nutrition-focussed subprogram (named the Aquaculture Diet Development Subprogram for consistency or if this is not perceived as a priority, the Aquaculture Nutrition Subprogram) should be maintained by the FRDC with due consideration of the following recommendations.

- The primary beneficiaries of any future subprogram must be the aquaculture industries rather than aquafeed manufacturers or commodity suppliers. This should be borne in mind whenever a future research submission is prepared. The aquafeed manufacturers have the capacity to utilise the infrastructure established as part of an aquaculture nutrition subprogram for their own gain, and should be encouraged to initiate their own research within the subprogram framework.

- As a discipline based subprogram with arguable relevance to all aquaculture industries, the level of aquaculture industry involvement and drive is significantly less focussed than that experienced within species based subprograms. With this in mind and for this subprogram to regain momentum and relevance there is an urgent need to:

    - Establish what the fundamental non-species specific nutritional constraints are to aquaculture production (eg. is it diet form, nutritional requirements, feeding strategies, feed evaluation or a combination of several factors) and how they could be best addressed through a collaborative research program. Outcomes from this process would form the basis for new projects within the subprogram. To define these priorities some strategic research in addition to comprehensive reviews of existing literature may be required to identify nutritional limits.
    - A risk management strategy should be developed for all aquaculture industries in relation to nutrition. This will assist the research priority setting process.
    - A SWOT analysis of nutrition research priorities should be completed for all major Australian aquaculture species.

- A formal agreement should be forged between the FRDC and other relevant RDC's and research providers for the management of research relating to aquaculture nutrition under the auspices of an aquaculture nutrition subprogram.

- Existing nutrition research conducted within species based subprograms should continue within these subprograms, but formal links must be maintained with a future aquaculture nutrition subprogram.

- Establish a skills-based subprogram Steering Committee to operate within the following terms of reference:

    - Develop a 5 year research and development plan for generic Australian aquaculture nutrition research priorities.
    - Scrutinise nutrition research planned within the species based subprograms.
    - Provide advice to the FRDC Board and other Australian research and development investors on aquaculture nutrition research priorities.
    - Act as an identifiable point of contact as an "expert working group on nutrition" for all Australian stakeholders in aquaculture.
    - Provide industry feedback and views.
    - Review existing nutrition research based on FRDC contractual obligations.
    - Ensure outcomes are commercially focussed;
    - Coordinate industry and research provider involvement in research programs to ensure optimum use of resources;
    - Identify those research providers and researchers best equipped to address defined research priorities;
    - Commission tendered research to address defined priorities;
    - Define an appropriate basis for the distribution of intellectual property on a case by case basis.
    - Facilitate extension and technology transfer.

A base level of skills required within the subprogram Steering Committee would include:

- Food technologist;
- Finfish nutritionist;
- Crustacean/mollusc nutritionist;
- Monogastric/terrestrial nutritionist;
- Commercial nutritionist;
- Process technologist;
- Economist/commodity expert.

- Subprogram Leader.
- FRDC/RDC Representation

- Where possible, representation on the Steering Committee should not include scientists actively involved in the research programs underway within the subprogram, however, given the specialised skills suggested above, this may not always be possible. It would also be desirable to appoint an independent chair. Appointment of the Steering Committee should vest with the FRDC following a call for expressions of interest Australia wide.

- While a Subprogram Leader may have individual research priorities that can be appropriately completed within the subprogram they manage, the role of Subprogram Leader must be completed with complete independence. If a new aquaculture nutrition subprogram is established, the Subprogram Leader will need the full support of their organisation to:

  - Coordinate research activities that directly address industry needs (established by the Steering Committee);
  - Actively lobby other research investors on behalf of all research organisations involved with the Subprogram;
  - Commit at least 37.5 hours per month to the management of the Subprogram (or via a proxy for at least an equivalent amount of time).
  - Coordinate research activities in which they may have no direct involvement.
  - Coordinate research activities that may be in direct conflict with the priorities established in the State in which they live.
  - Host Steering Committee and Scientific Committee meetings and industry workshops.
  - Promote the Subprogram without reference to their host organisation.

- In the event that NSW Fisheries offer full support to the above activities, FRDC should approach Dr Geoff Allan to lead a new aquaculture nutrition subprogram.

- The infrastructure (ie collaborations, industry contacts, mailing lists etc) developed as part of the FMR and ADD must be maintained as part of a future aquaculture nutrition subprogram.

- Under no circumstances should a future aquaculture nutrition subprogram become simply a collection of nutrition research projects. All projects within the subprogram must have a common focus and a common definable goal within a specified timeframe. On this basis, the recently

approved "Rapid development of diets for Australian Snapper" should not be viewed as a core project of the new subprogram unless it addresses key priorities identified by the Steering Committee following their formation.

- The subprogram operational environment should consist of:

  - Steering Committee meetings (members only) to address the terms of reference detailed above.
  - Scientific Committee meetings (Principal Investigators of core research projects and other aquaculture nutrition projects plus interested observers) for the scrutiny of future research projects and coordination of existing research projects (progress reports, submissions etc). The Scientific Committee should, where possible, include representation from each State involved in aquaculture nutrition research
  - Target industry workshops for a wide audience.

- A number of reporting levels must be established within the new subprogram. Reporting should reflect the above operating environment with separate communications arising from each operating activity. Newsletters should be maintained as a general means of distributing information.

- A dilemma is faced when making recommendations on how a 'discipline-based' subprogram can be integrated with species-based subprograms that contain the respective discipline as a component. As the primary coordinator of all subprograms, FRDC must ensure that the species-based subprograms recognise the role of any future aquaculture nutrition subprogram.

- A one year project should be funded to facilitate the formation of a Steering Committee and to deliver the following as a basis for future aquaculture nutrition research delivered through a managed subprogram:

  - A 5 year research and development plan defining the fundamental non-species specific nutritional constraints to aquaculture production and appropriate strategies to address these constraints
  - A risk management strategy for all aquaculture industries in relation to nutrition.
  - A SWOT analysis of nutrition research priorities for all major Australian aquaculture species.
  - Inputs to all existing aquaculture nutrition research projects.

- The proposed one year project will need to support a Subprogram Leader in addition to the Steering Committee for the management of information distribution, Steering and Scientific Committee meetings and target industry workshops. The existing FRDC application for national coordination may form a base for this proposal, but it is likely to be as easy rewriting the proposal from scratch.

- Assuming the approval of an initial one year project, the Aquaculture Diet Development Subprogram will consist of only one other core project in 2000-2001 – "Inclusion of data on the nutritional value of ingredients used in aquaculture feeds in the Australasian Livestock Feed Ingredient (ALFI) Database".

- A revised research program should ensure that experimentation is completed with both juvenile and mature fish to ensure the research is relevant to all stages of the production cycle.

- The new ADD Subprogram should take responsibility for the commecialisation of all nutrition research arising from FRDC funded projects. All nutrition projects should devote a significant proportion of their budget to commercial upscaling of research results following guidelines defined by the ADD Subprogram Steering Committee in consultation with the major aquafeed manufacturers in Australia.

- If appropriate, the new subprogram should consist of core projects that vary in duration and/or starting/finishing dates. This will ensure the subprogram maintains momentum and is not restricted by the need to renew all core projects at the end of a three year period.

- The new Subprogram Steering Committee should take an active and lead role in the establishment of linkages and priorities for any future CRC proposals.

- Intellectual property issues need to be negotiated on a case by case basis. Unless a potential end-user is involved in the project from the outset, commercialisation is unlikely. Commercial investments should deal with a very specific area of the research only, so that a discrete component of the IP can be approportioned. Commercial groups must recognise the need for some core research in the public arena and the need for most researchers to publish research results as a condition of their employment.

- A new ADD subprogram should endeavour, where possible, to ensure the maintenance of some core research facilities, and should promote the screening of new feed ingredients and/or feeding strategies using a standardised protocol as a core service to industry.

- This review alone has identified a number of research priorities that could form the basis of core projects within a new subprogram. These include:

    - Definition of nutrient partioning within key aquaculture species (ie defining the proportion of nutrients directed towards energy or protein metabolism).
    - Value adding alternative protein sources for use in aquaculture diets.
    - Development of diet manufacturing technologies for the production of highly flexible aquaculture diets.
    - Development of aquaculture feeds that have a minimal environmental impact.
    - Improved techniques for the measurement of feed intake.
    - Development of a wider database on the nutritional quality of feed ingredients, to facilitate fishmeal replacement.

Specific comments on the ex-post benefit cost analysis of the FMR Subprogram

- An ex-post benefit-cost analysis is not an appropriate basis for the assessment of a nutrition subprogram dealing primarily with feed evaluation and the definition of nutrient requirements. Subsequent discussions with FERM, who completed the review, indicate that an ex-ante benefit cost analysis may have been more appropriate. For this reason, while the benefit-cost analysis prepared for FRDC addresses the terms of reference for the exercise, it is of little value to FRDC as an indication of the relative benefits of the FMR Subprogram.

- The benefit-cost analysis conducted should have included benefits and costs arising from the ADD Subprogram in addition to the FMR Subprogram. It is difficult to separate the two Subprograms.

- The basis for assessing benefits from the research conducted was inappropriate and superficial. Any assessment of nutrition research projects must include parametric programming to assess the relative change in value of a feed ingredient resulting from the research in the event that it is utilised in a diet. A number of scenarios must be created based on the level of use of the ingredient, the primary species being fed and the relative cost of other ingredients available for use, or being used at the time. This can only be completed in consultation with an experienced

nutritionist. Simulation modelling is also required for an adequate assessment of the impact of research into nutritional requirements.

- An inappropriate basis for the conduct of this benefit-cost assessment has caused a significant amount of unnecessary angst amongst researchers and end-users.

- The new ADD Subprogram Steering Committee should establish a uniform basis for the assessment of new and existing nutrition research projects.

- The above comments in no way represent a criticism of the conduct of Fisheries Economics Research and Management Pty Ltd. They completed an ex-post benefit cost analysis of the FMR Subprogram as requested and within the terms of reference provided.


B E C A N

Perspectives of the Fishmeal Replacement and Aquaculture Diet Development Subprograms – Industry and End-Users

A range of industry personnel representing aquaculture feed manufacturers and key aquaculture industries were interviewed face to face or over the phone to establish the value of research completed to date, and priorities for future research.

A summary of the outcomes of these interviews is presented below:

1. Salmon Industry

Research content/priorities:	Applicable/valuable
Research providers:	Excellent
Communication of results:	Poor
Adoption of results:	Moderate to high
Value of the FMR and ADD Subprograms:	High

a) Value of completed research

The salmon industry believes it has benefited significantly from research completed within existing subprograms. The results have contributed to a significant change in the form of salmon diets over the past 5-6 years with diet form shifting from steam pellets to a total use of extruded pellets in that period. In addition to a change in form there has been a significant change in the composition of diets. particularly in relation to dietary fat levels (17% maximum with steam pelleting to 22% minimum with extrusion).

One consequence of the shift from steam pellets to extruded pellets is the relevance of research results derived from experiments utilising steam pellets. Due to the many changes in ingredient conformation that occur with extrusion, it is unlikely that the majority of research completed with steam pellets will have any application.

Industry view Dr Chris Carter and his team at the University of Tasmania as the primary providers of salmon nutrition research. They are particularly impressed with the standard of research conduct, but recognise some limitations to the predominantly laboratory based facilities. There is an urgent need to improve the applicability and commercial validation of results generated under laboratory conditions.

The industry representatives interviewed felt that there was significant room for improvement in the extension of results derived from within the FMR and ADD Subprograms. While results summaries presented in the Subprogram newsletters were seen as very useful and informative, there was a general feeling that the level of direct extension of results through workshops and seminars was distinctly lacking in the past 5 years. While local aquafeed manufacturers such as Pivot Ltd have sponsored some seminars in recent years, the primary focus was on flesh quality rather than nutrition results arising from the FMR and ADD Subprograms.

b) Priorities for future research

The industry representatives had many views on priorities for future research in salmon nutrition. Despite the number of issues raised, they were surprisingly consistent. Priority areas of nutrition research that were nominated are listed below:

- The production levels maintained and the nutritional requirements are unique for the strains of salmon predominantly farmed in Australia. For this reason, industry believe it is important to conduct salmon research locally as overseas data lacks relevance given the differences in conditions under which the salmon are grown. For example, there is currently an emphasis in the salmon industry to move to lower protein, higher fat diets based on recent developments in the northern hemisphere. This coincides with a change in the protein:energy ratio of commercially available diets. There is a strong feeling from industry representatives that the potential and suitability of these low protein, high energy diets under Australian salmon farming conditions has not been adequately assessed and there is an urgent need to pursue this research locally. This is supported by the fact that many overseas research results adopted commercially in Australia yield different results. In particular, industry are concerned about the influence of high oil diets on growth, flesh quality and post-harvest quality when applied under Australian conditions and the lack of information available on appropriate dietary protein:energy ratios for different levels or stages of production.

- Salmon producers are concerned about the lack of control they have over inputs into salmon diets. While they recognise the difficulties associated with producing extruded salmon feeds, they would

prefer to have the capacity to nominate ingredients included in their diets, and the nutritional composition of the diets they purchase. At present, a set range of diets (varying predominantly in size only) are available for purchase from commercial manufacturers. The only factor that can really be altered in these diets is the carotenoid level apart from some specific additives. Salmon producers would value research that could facilitate the variation of ingredients in diets at their request (based on relative nutritional value which will vary with purchase price) without compromising production levels. Due to the lack of existing information, producers were concerned with the basis for current changes in salmon diets and the lack of independent assessment of these changes on a commercial scale.

- Given the lack of assessment of new diets introduced by commercial manufacturers, industry would value access to rapid screening facilities for the routine evaluation of feeds and feeding strategies on a user pays basis.

- A strong preference was placed on nutrition research that would facilitate feeding strategies that had minimal environmental impacts while maintaining feed conversion efficiency and product quality.

- Research on methods for the determination of the nutritive value of feed ingredients (completed by Percival and Lees) was seen as adequate but there was a need for wider application of the research results.

- Further research is required on the source of dietary energy (protein, carbohydrate or fat) and the influence of dietary oil type and fatty acid composition on salmon production.

- More information is required on the interaction between feeding strategy and feeding efficiency (eg the influence of different feeding frequencies).

c) Preferred approaches within a future nutrition subprogram

- As feeding and nutrition represents such a high proportion of salmon production costs, only small improvements in feeding efficiency are required to have a major impact on productivity. For this reason, the salmon industry would value the continuation of research in salmon nutrition under a subprogram structure providing they address many of the issues described above.

- The salmon industry would place a high value on the establishment of an independent marine research facility that could be used for "bridging" experiments for validating laboratory derived results, thus improving commercial adoption rates and industry confidence in the results.

- The potential emphasis on salmon research within an ADD or similar subprogram would depend on the existence of a FRDC funded Salmon Subprogram, but regardless of these developments salmon producers would value a continued involvement in a nutrition subprogram.

- The salmon industry would value the opportunity to contribute to and scrutinise research directed towards the development of salmon feeds rather than researchers relying solely on inputs from commercial feed manufacturers.

- Improved access to information on routine analysis methodology and accredited analysis laboratories would be valued by industry.

d) Summary

The salmon industry were supportive of the FMR and ADD subprogram and the continuation of a nutrition-based subprogram in some form. A major issue identified was the need to improve the mechanism for commercial uptake of research results and the communication of research results to industry. A large number of nutrition research priorities were identified.

5th Scientific Committee Meeting
Aquaculture Diet Development Sub-program
16-17 December 1999

Notes on Review of FMR & ADD Subprograms: A Discussion

Present: Rob van Barneveld, Patrick Hone, Mike Taverner, Geoff Allan, David Stone, Mark Booth, Rebecca Warner-Smith, John Nell, David Smith, Kevin Williams, Peter Rothlisberg, Alex Anderson, Neil McMeniman, Chris Carter, Chris Barlow, Belinda Hunter, Kevin Warburton, Anthony Dyer, Brett Glencross, Tom Lewis. (Helena Heasman took notes).

Patrick chaired the discussion and introduced Rob.

Everyone was given a copy and Rob went through the Terms of Reference, Report Organisation, Summary and Recommendations.

Patrick:
FRDC have changed how they look at subprograms - our goal is to establish more subprograms not less but they should be directed to specific industries. We have a wide range of nutrition projects - this will not change. FRDC is currently funding 15-20 species specific projects at present - some are connected to sub-programs, some connected to strategies. The level of service that the subprogram provides is an important component and needs discussing today. Level of service can change markedly depending on the needs of industry. In terms of Rob's review - it is still in draft form. Discussion today may be incorporated in the review. Rob is to be commended on his review. This was a complex task to undertake, crossing many boundaries, jurisdictions and outcomes. Not a simple issue. We support the review outcomes that the subprogram must continue but in a changed form. The link to CRC for Aquaculture has not been addressed in the review. [Rob replied that there was not a clear perception of a link. CRC chose not to involve itself in the nutrition areas initially - quite separate. Now linkages more established (e.g. Brett's work).] Firstly, I'd like to open the floor to specific positive outcomes that haven't been adequately addressed in the review?

Unanimous support for the positives listed on pp. 5-6.

Patrick:
What about negatives?

Kevin Williams:
(p. 7, first point). Further clarification needed on statement that "dilution" has occurred from FMR to ADD.

Rob:
I concede wording may be wrong. FMR happened because it was clear it had to be done. When ADD came along you were riding on a big high after success of FMR and it appeared not as concisely defined as FMR.

Geoff:
Industry, scientists, feed manufacturers came up with species list for ADD subprogram. FRDC then said go back to the drawing board and come up with topic-based rather than species-based projects.

Rob:
One danger with subprograms is the expectation that once funded that it will continue to be re-funded.

Geoff:
For ADD, FRDC board wanted clearly defined start and finish times.

Kevin Williams:
(2nd last point and last point on p. 7). Blunt wording does not reflect the issue adequately. There were some state priorities but these were taken into consideration when listening to industry reps for listing core species.

Peter Rothlisberg:
Re. the species vs. topic debate. I support the topic format of the ADD subprogram.

Patrick:
I agree with the sentiment Rob is expressing - e.g. Nutrient Requirements got hi-jacked by species-driven interests instead of core goal of generic issues. We are very keen to see this information nationally applied not State applied. National focus essential.

Kevin Williams:
It is impossible for researchers not to take into consideration state-based issues.

Rob:
I concede wording too strong. "Concerns" should replace "deficiencies" and "did not" should replace "failed".

Peter:
(2nd point p. 7). Commercial adoption. This seems fairly damning.

Rob:
This group can learn from these failures. In particular the tuna and barramundi experience. All research was rigid and produced good results. Lab scale results should not be released directly to industry. Needs to be taken to a commercial scale before releasing to industry. Otherwise industry will lose faith completely.

David Smith:
We had similar experience with *Penaeus esculentus* with a diet that worked in tanks. Industry stocked ponds in readiness for commercial trial. Problems with manufacture meant that diets did not perform as they should have done.

Patrick:
There should be a transition phase before total commercialisation of results. Should be much more control of results before commercialisation.

Geoff:
Feed manufacturers were sometimes "reluctant partners" for example with silver perch research.

Chris Carter:
Different story in Tasmania for salmon work. Pivot are happy for all information to be publicly available except for specific recipes.

Recommendations (p.9):

Kevin Williams:
As an overview the recommendations address aspects well. How can the work be best captured by the industry and who is the research serving? How do we get the industry to take up the research? Aquafeed manufacturers jealously guard info. Stockfeed manufacturers are not so secretive. How do we get the work through to the industry if we keep the manufacturers at a distance?

Rob:
Primary beneficiaries should be the end-user. Aquafeed manufacturers should not be excluded but they should not be featured prominently in proposal. They should be "an active partner" rather than a beneficiary. They know how to reap benefits.

Kevin Williams:
Manufacturers are reluctant to capture the results of research.

Patrick:
This is an important point. The smaller feed manufacturer is a better partner in research than the larger ones.

Kevin Williams:
Market dominated by 2 large players. Smaller companies keen to gain competitive advantage by being cooperative.

Geoff:
We're not doing research to benefit a particular feed company. Core beneficiaries are our farmers. But to deliver the results to farmers we must make research attractive to feed companies.

Chris Carter:
Salmon industry is different. Continually facing competition from abroad. So work under different set of circumstances.

Mike Taverner:
In order to attract funding from GRDC there should be a targeted outcome to benefit the grain industry.

Define Outcomes/Priorities for the Basis of Core Project within a New Sub-program:

1. Ingredients: Value-adding in terms of protein sources; alternative oil (vegetable/animal) sources in aquaculture diets (GRDC priority). Screening, promotion, marketing. Evaluate product quality - composition, shelf-life etc.
2. Weaning diets for barramundi (Chris Barlow priority)
3. Eco-friendly feeds and feeding practices - low P, N & C (Patrick priority). Contaminants - heavy meals, antibiotics, pesticides. Chris Carter said high nutritive value should still be top priority. Patrick said should look at specific requirements for recirc. systems, cage culture and inland saline aquaculture. Always waste, but what type of waste? Alex said requirements of regulatory authorities and public perception are two separate issues. Peter said farmer makes more money by wasting less feed.

4. Processing effects on ingredient and nutrient composition on factors influencing pellet form.
5. Storage of diets and shelf-life (Chris Barlow priority)
6. Diets, Feeding and Management for Species X - booklet suggested by Chris Barlow (This is an extension outcome). Expand Newsletter. Establish Website.
7. Breeding program and nutrition. Peter asked if we can select for food conversion efficiency? Patrick says this is an issue for all species.
8. Nutritional pathology. David raised the issue of relationship between nutrition and diets and impact on health (immuno-response) of species.

[Rob questioned whether we should we be doing this exercise here? A nominated skill-based Steering Committee should be deciding these issues.]

Patrick:
What do we need to incorporate in this subprogram to make it more attractive to other R & D Corporations?

Mike Taverner:
Specifically No. 1 is a key priority for GRDC. It might be more appropriate for GRDC to liaise with FRDC before investing. Are the outcomes deliverable to the grains and fish industry?

Peter:
Are the Australian aquaculture and aquafeed industries big enough to rate with GRDC or do we need to lift our profile significantly and increase use of feed grains in aquafeeds?

Rob:
The sub-program needs to ask how much attention do they want to pay to all these issues, what criteria is used to select priorities and what spread of research methods can be managed.

Patrick:
Let's look at the establishment of Steering Committee and what qualities are needed (p. 10). Perhaps establish a Working Group first.

Chris Carter:
Why are there no reps from the aquaculture industry on the proposed Steering Committee?

Rob:
This is a discipline-based ["expertise-based" according to Patrick] sub-program. Cannot have reps. from specific aquaculture associations.

Patrick:
I think we DO need a rep from an all-inclusive (National Aquaculture Association?) aquaculture association.

Geoff:
No such thing as an unbiased industry rep. Does not need to be on Steering Committee. Liaise with individual associations to elicit comments and direction. Each person should be responsible for their industry sector.

Peter:
Industry Advisory Group could be gathered from time to time to listen for industry and generic issues.

Chris Barlow:
Public Service mentality? Is a Steering C'tee really essential? A more informal and friendly gathering works better.

Rob:
I hate bureaucracy with a passion. But this new Steering C'tee is essential. Perhaps "Working Group" better terminology.

Patrick:
I like this group being independent of PI's. The FRDC Board will not be evaluating projects in 5 years time - sub-programs will do this.

Rob:
This Steering C'tee will be like a mini Board whose expertise would be respected by funding organisations.

Geoff:
How much would FRDC be prepared to spend on this C'tee and the new subprogram?

Mike:
Comparable budget for GRDC is $90,000 - $100,000 per year.

Patrick:
Budget for abalone $70,000. Ballpark figure between $70-$90,000. We will talk to ACIAR, MLA and GRDC to contribute. Training courses being developed for Sub-programs.

Composition of Working Group to develop new application (after Review has been accepted):

Geoff Allan
Kevin Williams
Chris Barlow
Chris Carter
Brett Glencross
Rob van B.
Patrick Hone

Patrick:
Need for critical data to present to the Board to demonstrate economic benefits that accrue.

Rob:
More than just putting an application together. None of this will take effect until the Review has been accepted by Board - not until the end of January. Inputs and feedback to draft are greatly appreciated.

[9 January closing date for comments on Rob's draft. Helena to email Rob's documents to all present at this discussion.]

Kevin:
I would like to acknowledge Rob's efforts – he's done a difficult job well. On behalf of collaborators in the subprogram I'd like to express our appreciation and congratulate Geoff on his "stewardship" of the subprogram. [A spontaneous round of applause!]

Time-frame
1. Rob finishes Review in January
2. Working Group established to implement recommendations by end of March to get approved in April Board meeting. If Steering C'tee is way to go then Workshop to be planned.
3. 1st Steering Committee meeting in May.
4. Workshop in July/August to develop and promote new nutrition sub-program.