Aquaculture Nutrition Subprogram: Technical Review, Project Management and Development Services

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2007/230: Aquaculture Nutrition Subprogram: Technical Review, project management and development services.

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OBJECTIVES:

1. Provide expert guidance and direction for aquaculture nutrition research in Australia through maintenance of a strategic plan, provision of technical review services and inputs into project development.
2. Identify nutrition research priorities that are not being addressed through existing portfolios and initiate research projects in this area.
3. Promote capacity building and human capital development through provision of training and resources in aquaculture nutrition and aquafeed manufacturing.
4. Development risk management strategies as required for various aquaculture sectors in relation to nutrition to assist the research priority setting process.
5. Improve communication of nutrition research outcomes and current nutrition research between scientists, aquaculturalists, ingredient suppliers and feed manufacturers utilizing workshops, planning meetings and conferences.

NON TECHNICAL SUMMARY:

Over recent years, the relevance of the Aquaculture Nutrition Subprogram has waned and as a consequence, activities within this project were terminated prior to achievement of the stated objectives.

A number of factors have contributed to the recommendation to cease this Subprogram by the Subprogram Leader. None of the contributing factors are being viewed with malice nor should they be construed as apportioning blame for failure of the Subprogram to deliver against the stated objectives, but simply represent the changing aquaculture nutrition research environment in Australia. These include:

- Available funding within the FRDC portfolio that can be allocated towards nutrition as a discipline is limited. Fishmeal and fish oil replacement remain a priority as a generic issue, but it is unlikely that advances in public sector research in this area will have as much influence as private sector research to the same end. It appears critical that end-users adopt full ownership of fishmeal replacement initiatives if they are to be successfully implemented into commercial production systems.
- This Subprogram did not have any discretionary funds for the conduct of activities apart from maintenance of the Subprogram Managers time. Hence, any initiatives such as workshops or training courses required separate applications and were hard to justify.
- Species-based Subprograms, and initiatives within the Seafood CRC (such as the Temperate Marine Finfish Aquaculture Network), represent the bulk of the nutrition research being undertaken in the Australian aquaculture sector and do not require coordination under a separate nutrition subprogram.
- ACIAR-funded research programs occupied a significant amount of time of key nutrition researchers making it difficult to secure time for delivery of specific workshops or courses.

- The number of aquaculture nutrition researchers in Australia is decreasing as are the number of active research groups (notable losses include Kevin Williams, David Smith and Meegan Vandepeer).
- Given commercial sensitivities, it is difficult to obtain public disclosure from the two dominant aquafeed suppliers (Ridley and Skretting) despite their willingness to work on public sector projects. The complexities of aquafeed manufacture and the comparative low volumes in Australia also make it difficult for many research outcomes from Australian nutrition research to be implemented on a farm-by-farm basis.
- Changes in the nature of internal funding within organisations like CSIRO (who have traditionally supplied key aquaculture nutrition research expertise) have reduced their reliance on funds from investors like FRDC
- Research groups such as CSIRO have had success with the development of commercial aquaculture nutrition products (such as NOVAQ) and are devoting a significant amount of time and resources to their commercial development and adoption. These activities fall well outside public sector research into aquaculture nutrition.
- Following a review of new and emerging aquaculture species research in Australia (undertaken by the Subprogram Leader), it was clear that most research relevant to the Aquaculture Nutrition Subprogram could be managed under the auspices of an Emerging Species Subprogram. The recommendation to the FRDC Board was as follows:

  .....It should also be recognized that if FRDC adopt these recommendations that potential exists to consolidate investment in some existing Subprograms into this portfolio. For example, the Aquaculture Nutrition Subprogram is primarily focused on the less developed aquaculture sectors, given the more developed sectors have core aquaculture nutrition programs within their portfolio. There is also no indicative allocation of funds to the Aquaculture Nutrition Subprogram which makes it difficult to attract interest or generate momentum.....

With the above in mind, if FRDC were to reinvigorate generic aquaculture nutrition research in Australia, then development of a base resource initiative under the Primary Industries Ministerial Council Research, Development and Extension Strategy may be most appropriate. In addition, in the absence of a species-base for a Subprogram, some discretionary funds that can be used to entice collaboration between scientists, research groups and potential end-users would be advisable.

OUTCOMES ACHIEVED

Despite early termination of this project, some notable outcomes were achieved, including:

- Organisation and delivery of successful aquaculture nutrition sessions at the Australasian Aquaculture 2008 and Australasian Aquaculture 2010 conferences in Brisbane and Hobart, respectively.
- Recommendations were provided for the development of a semi-commercial nutrition research platform for the salmon industry in Tasmania.
- A range of preliminary research proposals pertaining to nutrition were reviewed on behalf of FRDC.
- A limited number of key nutrition related projects were managed and reviewed on behalf of FRDC.

KEYWORDS: Aquaculture, nutrition.

BACKGROUND

Aquaculture nutrition research is a fundamental component in the establishment of new aquaculture industries and in further development of existing aquaculture industries for the following reasons:

Aquaculture nutrition research is a fundamental component in the establishment of new aquaculture industries and in the further development of existing aquaculture industries for the following reasons:

1. Feed costs represent a significant proportion (30-50%) of the production costs in most aquaculture systems. The most effective way to reduce feed costs is to improve the feed conversion efficiency of the target species which can only be accomplished by improving definition of feed ingredients, defining the nutritional requirements for different production phases, improving diet form and feed stability and increasing the range of feed ingredients available for use – all of which require significant research inputs.

2. Development of cost-effective manufactured feeds for aquaculture species is a difficult process because the research has to be conducted underwater. This makes collection of information on fundamental parameters such as feed intake difficult. In addition, most aquaculture diets needs to be extruded which is a research discipline in itself and requires highly specialised equipment.

3. Many aquaculture diets have a heavy reliance on fresh fish, fish meals and fish oils. To provide long term stability to new and established aquaculture industries and to reduce the reliance on these ingredients, there is a need to identify alternative nutrient sources that facilitate maintenance of similar production levels and product quality.

4. Improved nutrition of aquaculture species is one of the most effective ways to reduce any environmental impacts from aquaculture by reducing nutrient loads in effluent.

5. Some aquaculture sectors, such as prawns, still rely heavily on imported feeds due to a lack of alternatives in Australia.

Given the large number of unknowns often associated with the nutrition of new and existing aquaculture species and the difficulties associated with conducting the research, significant improvements in the efficiency of conducting this research can be achieved by developing a coordinated approach to the definition of research priorities and research methods, such as that achieved within a managed subprogram. A review of the aquaculture nutrition literature also reveals that a significant proportion of the aquaculture nutrition research that has been conducted in the past is based on terrestrial nutrition principles, but in many cases not all of the principles have been extended resulting in fundamental errors in the experimental protocols and subsequently the value of the results. As a consequence, continued expert external review is essential to ensure any research investment made by FRDC is effective and consistent with the defined research priorities.

SUBPROGRAM MANAGEMENT OF AQUACULTURE NUTRITION RESEARCH

Fishmeal Replacement Subprogram and Aquaculture Diet Development Subprogram

Prior to 2001, the FRDC invested in two nutrition specific subprograms – 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:

a) Promoted a high level of collaboration between scientists working within a common discipline;
b) Successfully delivered nutrition research expertise to infant aquaculture industries that otherwise would have not had access to this level of nutritional skill;
c) Reduced the level of duplication of research effort towards a common goal;
d) Applied outcomes were delivered to industry improving the profitability and viability of these industries;

e) Facilitated a coordinated delivery of research funding submissions and research reports to the FRDC.
f) Advanced the overall international knowledge base for aquaculture nutrition.

The aquaculture industries benefiting from research conducted within the FMR and ADD Subprograms (ie. barramundi, salmon, prawns, silver perch) suggested they would value the continuation of further coordinated research in the area of aquaculture nutrition. Research providers and researchers operating within the FMR and ADD 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.

Aquaculture Nutrition Subprogram Phase I (2001-2003)

Following the success of the FMR and ADD Subprograms, the FRDC established the Aquaculture Nutrition Subprogram in 2001. The initial phase of the subprogram (2001-2003) focused on four main objectives:

1. Implementation of a core research program based on fundamental, non species-specific nutritional constraints to aquaculture production.
2. Establish basic research standards and preferred methodologies for nutrition research.
3. Facilitate technology transfer in the field of aquaculture nutrition.
4. Develop and provide training for research investors, research providers, and end-users associated with aquaculture nutrition.

In response to these objectives, the ANS undertook the following:

The ANS convened an industry workshop and facilitated a planning meeting to identify and prioritise key nutritional limitations to aquaculture production. The outcomes from these meetings culminated in the publication of the ANS Strategic Directions 2001-2005. The development and production of vegetable protein alternatives to fish meal and alternatives to fish oil still existed as the highest research priority in this field.

In August 2003, the ANS convened a Methodology Forum involving key aquaculture nutrition scientists from across Australia. The forum aimed to develop a standardized approach to a range of nutrition research issues, including:

1. Nutrition and Diet Development for New Aquaculture Species.
2. Basis for use of surrogates in nutrition research
3. Chemical Analysis Methods for Aquaculture Nutrition Research
4. Nutrient Digestibility Measurements in Aquaculture Species
5. Nutrient Availability and Utilisation in Aquaculture Species
6. Nutrient Requirements in Aquaculture Species
7. Measuring transit time
8. Measuring feed intake
9. Palatability/Preference/Attractants
10. Growth correlates
11. Feed preparation and measures of ingredient functionality in feed processing systems
12. Basic evaluation of feed ingredients
13. Growth performance, ingredient evaluation and diet formulation

Outcomes from the forum are being published as a standards manual for use by Australian scientists, the FRDC and aquaculturalists.

Annual themed workshops were to identify priorities for aquaculture nutrition research and to promote collaboration and communication between scientists and stakeholders in the sector. This included the second hatchery feeds workshop in Sydney.

The Australasian Livestock Feed Ingredient Database (ALFI) was developed with co-investment from FRDC and still remains the primary means of collating data arising from FRDC nutrition-related projects. The database is now available for sale via the Grains Research and Development Corporation website.

The ANS collaborated with Food Industry Engineering and the South Australian Research and Development Institute to deliver a short-course in aquafeed extrusion in 2003.

In addition to the above, the ANS acted as a point of contact for aquaculture nutrition in Australia, and actively developed links between research investors, research providers and end-users associated with aquaculture nutrition.

Aquaculture Nutrition Subprogram Phase II (2004-2007)

In 2004, the FRDC scaled the activities of the ANS back to the delivery of technical and review services with some project management where appropriate given the then priority for aquaculture nutrition research relevant to other priorities and the existence of nutrition-related projects managed under the auspices of other subprograms.

The objectives of Phase II of the Subprogram were to:

1. Provide expert guidance and direction for aquaculture nutrition research in Australia through maintenance of a strategic plan, provision of technical review services and inputs into project development.
2. Identify nutrition research priorities that are not being addressed through existing portfolios and initiate research projects in this area.
3. Promote capacity building and human capital development through the provision of training and resources in aquaculture nutrition and aquafeed manufacturing.
4. Develop risk management strategies as required for various aquaculture sectors in relation to nutrition to assist the research priority setting process.
5. Act as an identifiable point of contact for aquaculture nutrition research in Australia and improve the aquaculture nutrition skills base in Australia.
6. Improve communication of nutrition research outcomes and current nutrition research between scientists, aquaculturalists, ingredient suppliers and feed manufacturers utilizing workshops, planning meetings and conferences.

During this Phase, the Subprogram delivered the following:

1. Extensive consultation on projects under development and recommendations to FRDC re project design and relevance.
2. Continued development of a standardized methodology manual for use in aquaculture nutrition research.
3. Preparation of a nutrition manual for the Australian abalone aquaculture sector.
4. Development of feed formulation software (NOMAD) for the Australian abalone aquaculture sector.
5. Development of strategic nutrition research directions for the Australian abalone aquaculture sector and consultation to the Abalone Growers Association and the Abalone Aquaculture Subprogram.
6. Contributions to the development and delivery of the Crawford Fund Masterclass in Thailand with a view to delivering subsections of this class as an aquaculture nutrition short course in Australia.

7. Consultation on aquaculture nutrition research to a range of commercial companies under the auspices of the Aquaculture Nutrition Subprogram.
8. Management of a range of existing aquaculture nutrition research projects and representation on the Steering Committee of the Aquaculture Feed Grains Program co-funded by FRDC and the Grains Research and Development Corporation.
9. Inputs into the nutrition components of species-based FRDC Subprograms.

Prior to completion, the Subprogram has planned a nutrition priority meeting for December, 2006, an aquaculture nutrition short course in February, 2007 and publication of the methodology manual.

There have been significant benefits to FRDC through the maintenance of this subprogram in terms of research efficiency and direction in addition to a range of tangible outcomes. There is a strong case for maintenance of this Subprogram on an ongoing basis to address re-emerging needs in this sector.

NEED

The need for on-going research into aquaculture nutrition and the need for continued inputs to how this research is conducted to ensure it is completed to the highest possible standard is emphasized by the fact that Australian aquaculture industries have a heavy reliance on imported nutrition technologies, feeds and ingredients for the supply of nutrients to target species. This includes feed manufacturing technologies, ingredients such as bait fish, fish meals, crustacean meals and fish oils, and complete feeds such as those utilised by the prawn industry. Not only does this create issues in relation to imported disease risks, continuity of supply and cost, but it means that many local products are being under utilised.

There is currently renewed interest in establishing a dedicated aquaculture nutrition research program due to the increase in cost of fishmeals and oils, their increasingly limited availability and potential contamination with antibiotic residues such as chloramphenicols if the meals are derived from some aquaculture reared products. In addition, pressure from consumers to limit the use of animal proteins in diets and limit interspecies recycling has applied new pressure to feed manufacturers and increased the need to identify and utilise alternative vegetable protein sources in aquafeeds. The increased value of the Australian dollar has also increased competition from imports and the need for the Australian sector to become increasingly efficient to remain internationally competitive with nutrition playing a key role in their capacity to achieve this.

OBJECTIVES

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2. Identify nutrition research priorities that are not being addressed through existing portfolios and initiate research projects in this area.
3. Promote capacity building and human capital development through provision of training and resources in aquaculture nutrition and aquafeed manufacturing.
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5. Improve communication of nutrition research outcomes and current nutrition research between scientists, aquaculturalists, ingredient suppliers and feed manufacturers utilizing workshops, planning meetings and conferences.

GENERAL METHODS

EXPERT GUIDANCE AND DIRECTION

On behalf of the FRDC, the Aquaculture Nutrition Subprogram through the Subprogram Leader will:

1. Maintain a 5 year research and development plan for generic Australian aquaculture nutrition and feeding research priorities.
2. Scrutinise, as required, nutrition research planned within the species based subprograms.
3. Provide advice to the FRDC Board and other Australian research and development investors on aquaculture nutrition research priorities.
4. Act as an identifiable point of contact for expert advice on nutrition for all Australian stakeholders in aquaculture.
5. Provide industry feedback and views to FRDC and research providers.
6. Review existing nutrition research based on contractual obligations when requested by FRDC.
7. Ensure nutrition research outcomes are commercially focused;
8. Identify those research providers and researchers best equipped to address defined research priorities;
9. Commission tendered research to address defined priorities;
10. Facilitate extension and technology transfer of nutrition research outcomes.

STRATEGIC PLANNING AND DEVELOPMENT OF A CORE PROJECT BASE

Using priorities published in the Aquaculture Nutrition Subprogram Strategic Plan, the Subprogram Leader will convene meetings with relevant researchers and research institutions to identify gaps in the existing research program and will assist with the development of new projects where appropriate. The Subprogram Leader will ensure new research proposals are distributed to FRABS and other stakeholders for comment and ratification before submitting the proposals to FRDC on behalf of the lead agencies, or facilitating adjustments to the proposals prior to submission.

IDENTIFICATION AND PROCUREMENT OF ADDITIONAL FUNDING

Utilising the relationship between FRDC and other investors, the Aquaculture Nutrition Subprogram will identify and procure additional funding for the conduct of core aquaculture nutrition projects for the benefit of the Australian aquaculture sectors.

DELIVERY OF AQUACULTURE NUTRITION WORKSHOPS

When appropriate, the Aquaculture Nutrition Subprogram will organise the delivery of aquaculture nutrition workshops to facilitate communication between research providers and stakeholders. The workshops will be funded on a case by case basis through separate submission to FRDC and other investors and will provide a forum for the delivery of research results from all FRDC-funded and other relevant aquaculture nutrition projects. Where possible, invited speakers will be utilised to address issues relevant to nutrition research. The workshops will also provide an opportunity for feed manufacturers and end users to present their views in relation to aquaculture nutrition research priorities.

PROVISION OF SHORT COURSES

As a service to end users, researchers and feed manufacturers, the Aquaculture Nutrition Subprogram will coordinate the delivery a series of Masterclass short courses. These short courses will be a condensed version of the original Masterclass developed as part of the previous FRDC ANS project 2004/235 which were delivered in Bangkok, Vietnam, Indonesia and Papua New Guinea. The 1 day condensed Masterclasses will be directed towards producers/farmers and will be delivered on an as required basis depending on the level of interest. They will be run on a full cost recovery basis. Promotion will detail the cost of attendance, the minimum number of participants required for the

course to proceed and an outline of the course content. If there is insufficient interest, the course will not proceed. It is expected that the first course will be held in Cairns and involve all the original course presenters. Subsequent courses are anticipated to be held in Port Lincoln, Hobart, Grafton and Perth and involve just 2 or 3 presenters.

INDUSTRY CONSULTATION AND COMMUNICATION

The Subprogram Leader will promote the activities of the Aquaculture Nutrition Subprogram through a website, industry newsletters, and direct communication with industry organisations and representatives.

COMMUNICATION WITH OTHER SUBPROGRAMS AND FRABS

Communication with FRAB's and other subprograms will be via distribution of an annual operating plan for the Aquaculture Nutrition Subprogram in December of each year combined with direct communications. The Subprogram Leader will also provide direct inputs at meetings of other subprograms as required.

FEED SUPPLY RISK ASSESSMENT

One of the concerns raised at the ANS priority mapping workshop held in April 2007 was security of feed supply. A formal risk assessment of feed ingredient supply will be conducted particularly in relation to the potential for a culmination of events such as drought and increased bio-diesel and ethanol production. This formal risk assessment will be used to identify on-going research priorities.

INDUSTRY BENCHMARKING EXERCISE

In addition to a risk assessment model as a means of identifying key research areas, it was also deemed necessary at the ANS priority mapping workshop to establish some industry benchmarking. A standardized approach to identifying performance target by species will be developed. This will be used to monitor progress towards performance targets for each species.

NUTRITION X HEALTH REVIEW

Another priority research area identified at the ANS workshop was that of nutrition x health x environment interactions. Information will be collated on relevant projects with proposed research on ingredient composition versus physiology.

RESULTS/DISCUSSION

Provide expert guidance and direction for aquaculture nutrition research in Australia through maintenance of a strategic plan, provision of technical review services and inputs into project development.

NUTRITIONAL ADVICE TO NORTHERN TERRITORY BARRAMUNDI FARMERS

In October, 2009, the Subprogram Leader participated in a workshop and meeting with Northern Territory Barramundi Farmers over two days to assist with identifying nutrition research priorities, and practical approaches to undertaking this research and implementing the outcomes.

Following the meetings, the farmers were provided with a range of information for incorporation into their strategic research plans focusing on:

- Feeding frequency
- Nutrient requirements vs age
- Digesta transit time and influences on satiety
- Consequences of feed interruption
- Potential causes of fatty liver syndrome
- Lipostatic mechanisms and the impact on feed intake and feeding intensity
- Fat sources and the influence of fatty acid ratio
- Negative influences of mycotoxins in fish diets
- Development of basic on-farm research projects and their appropriate conduct
- Addressing nutrition x environment x management x health interactions

PROGRESS REPORT REVIEWS

Recommendations were made to Principals Investigators and FRDC on numerous milestones for the following projects during the reporting period:

2004/237: Aquaculture Nutrition Subprogram: Assessment of fish growth under limiting environmental conditions
2004/258: Development towards commercialisation of marine fish larvae diets – Artemia
2004/258: Development towards commercialisation of marine fish larvae diets – Microdiets

FINAL REPORT REVIEW

A detailed review of a draft and final report for project "2004/237: Aquaculture Nutrition Subprogram: Assessment of fish growth under limiting environmental conditions" was undertaken. Key comments are presented below:

Overall comments

A significant amount of research has been completed within this project and it contributes significantly to the knowledge pool associated with salmon and barramundi nutrition.

The project has addressed all of the original objectives. The investigators are to be commended for the large number of presentations that have arisen from this project and their attempts to communicate outcomes of the research to end users and other scientists.

Specific comments

My main concern with this final report and the research that has been undertaken vests with the diet composition in experiments reported in Chapters 2, 3 and 6.

The diets fed as part of the experiments do not appear to reflect what was intended in the original formulations and this may have compromised the experiments and the subsequent interpretation of the results. The discussion sections have not addressed this issue in detail and I believe it needs to be covered in the report.

In Chapter 2, the differences in energy content and protein content were not evident. The high energy diets did not differ in energy content and the low energy diets did not differ in protein content. In addition, there is a linear growth response between intake and growth and no plateau is evident, so can we assume the reported figures represent an optimum requirement, or just the highest level of growth achieved in the experiment.

In Chapter 3, the differences were more evident between the diets, but similar comments to those made for Chapter 2 apply.

In Chapter 6, the H:L diet ended up with a higher lipid content than the H:H diet despite an extra 60g/kg of fish oil being added to the H:H diet.

Chapter 7 responses are more reflective of what I would have expected from experiments conducted in Chapters 2 and 3.

I suggest some clarifying comments addressing the above points to ensure the data presented is not misinterpreted if in fact the lack of differences in diet composition have compromised the results to any extent.

General comments

A number of layout and presentation corrections are required and have been marked on the report.

REFEREES REPORTS

In my role as Subprogram Leader, I provided a referees report for Sagiv Kolkovski for the 2009 ATSE Clunies Ross Award as follows:

It is my pleasure to act as a referee for Dr Sagiv Kolkovski who has been nominated for the 2009 ATSE Clunies Ross Award.

I am acting as a referee based on my contact with Dr Kolkovski through the Fisheries Research and Development Corporation (FRDC) Aquaculture Nutrition Subprogram, which I lead. In addition to this role, I hold a number of positions that provide me with extensive exposure to scientists in a range of disciplines in Australia and overseas. These roles include being a Specialist Director of Australian Pork Ltd and Chair of the Research and Development Advisory Committee, a Director of the Pork CRC Ltd and a member of the Research and Development Committee, a Subprogram Leader of the FRDC Rock Lobster Propagation Subprogram (in addition to the Aquaculture Nutrition Subprogram), the Leader of Science and Technology for the CHM Alliance Pty Ltd and through adjunct professorships at the University of New England and the University of Queensland. This exposure allows me to rank Dr Kolkovski as one of the best scientists in Australia, and one who possesses the unique skills of being able to link basic science with applied outcomes.

Consistent with the award criteria, I offer the following:

Commitment

Dr Kolkovski is employed by the WA Department of Fisheries. Far from being "institutionalized", his primary focus is the outcome and the net benefit these outcomes can bring the aquaculture sector. His work ethic ensures the outcomes are delivered in a timely manner, and he has managed to translate some basic research areas into commercial deliverables in a short time frame. He has demonstrated this on a number of occasions and in a number of different facets of hatchery management and nutrition.

Dr Kolkovski's success in delivering valuable commercial outcomes is underpinned by high quality science. He has a rare ability to identify key commercial bottlenecks, formulate solutions, provide a sound scientific basis for the development of a commercially viable outcome, and then navigate the commercialization minefield so that these outcomes can be accessed by all.

Contribution

Key deliverables whereby Dr Kolkovski has initiated the research process, secured public sector and commercial investment in a series of projects and delivered commercially valuable outcomes vest with large scale Artemia production in association with Cognis Ltd and the production of automatic feeding systems for use in hatcheries. The success of many existing and emerging aquaculture sectors depends on cost effective hatchery production, and his contributions to the viability of commercial hatcheries worldwide cannot be underestimated. If the aquaculture sector was considered analogous to a bakery, Dr Kolkovski conceived, developed and commercialized the "oven".

Performance

Dr Kolkovski's ability to complete high quality research on time and then champion the commercial delivery is well beyond his peers. As a government employee he is actively engaged by the commercial sector and the timeliness of delivery is admirable given the range of challenges he faces operating from within a public sector institution. I have always found Dr Kolkovski's research reports to be more than comprehensive and his constant focus on the deliverables provides me with a lot of confidence in the value of our research and development investments.

Persistence

Dr Kolkovski has a demonstrated capacity to deliver valuable commercial outcomes to the aquaculture sector over many years and in numerous countries. He is recognized worldwide and has devoted his entire career to ensuring the viability of developing aquaculture industries. His particular area of expertise is one of the few disciplines that will ensure that aquaculture systems worldwide deliver a positive balance of fish protein to the human food chain.

The Extra Mile

Many government employees operate in a very sheltered operational environment with generous working conditions and deadlines. I have never considered that Dr Kolkovski operates under this framework, and have always felt that his primary objective has been to invest his time, effort and considerable expertise in delivering outcomes above all else. He also has a very clear vision that his reason for undertaking research is to deliver outcomes to industry – securing public sector investment and publications are important to him, but do not drive his enthusiasm towards his research discipline.

I would be happy to elaborate on any point further if required. Please do not hesitate to contact me on 0418 802 462 or via email at rob@barneveld.com.au.

PRELIMINARY RESEARCH PROPOSAL REVIEWS

Two preliminary research proposals were reviewed on behalf of FRDC during the reporting period as follows:

Principal Investigator: Giovanni Turchini
Title: Omega-3 enhancement of fish fillets for improved marketability and human nutrition

Significance of Project: National

Replacement of fish oil in aquafeeds is a high priority, but it must be noted that the price differential between fish oils and other sources of edible oils is closing as a result of strong demand for both feed and fuel. It is also well known that diet can influence the fatty acid composition of farmed fish species. In 2002, the FAO published a report that concluded that "*….marked changes in the lipid composition of feeds for carnivorous aquatic species are inevitable in the future. These will be dictated by supply and economic factors and may affect both the source and the total inclusion rates of lipids. Further research is necessary to ensure that the quality and consumer acceptability of the farmed products remain acceptably high as these dietary modifications evolve."*

The need for this project is based on a number of listed factors that are difficult to support:

1. *Production of fish fillets that have a consistently high functional food value and can be certified from a human nutrition perspective is of critical importance to the Australian aquaculture industry* – In fact, two papers published (see attached) on attitudes and intentions towards purchasing novel foods enriched with omega-3 fatty acids and overweight consumers' salient beliefs on omega-3 enriched functional foods revealed that omega-3 content had no influence on choice for those not convinced about the benefits of omega-3's, that omega-3 consumption was a very personal choice and that promoters of omega-3 functional foods should direct their attention towards changing attitudes rather than the specific product. Further to this, participants were aware of a range of potential health benefits of omega-3 fatty acids, but they had reservations about the ability of omega-3 enriched foods to deliver a health benefit.
2. *Feeding reduced levels of fish oil will hinder the lipid profile of the farmed fish* – this is inevitable, but if attention were to be directed towards enhancing omega-3 fatty acid content of farmed fish, the primary focus would be on a fish that has high oil levels and high proportions of EPA and DHA. Murray Cod and Barramundi are low oil fish with fillets containing approximately 0.6-0.8% oil of which 36% is PUFA. In comparison, salmon fillets contain in excess of 2.7% oil of which 47% is PUFA.
3. *Novel ingredients may exist that permit formulation of diets without marine oil that maintain product EPA and DHA levels* – truly novel feed ingredients are few and far between. There is a significant body of research that shows that growth performance can be maintained with use of vegetable oils, and vegetable proteins but lipid profile of the fish does suffer. In reality, the only novel ingredients that are likely to have potential will be microalgaes, and these will need to be sourced and grown.

Track record of the Principal Investigator: Not Known

The investigators claim to lead fish nutrition in Australia. Not only does this pay little regard to the significant other nutrition researchers in Australia, but it is interesting to note that these researchers are yet to participate in any national Aquaculture nutrition research activity such as the Aquaculture Diet Development Subprogram or the Aquaculture Nutrition Subprogram.

Likelihood of achieving objectives: Low

The likelihood of achieving the objectives of this project is low because:

1. Based on published research, the primary way to increase consumption of an omega-3 containing product is to demonstrate a direct link between a health benefit and that specific product. This is not addressed in this application.
2. Novel feed ingredients with commercial potential that have not previously been investigated are unlikely to be identified.

3. Murray Cod and Barramundi are not high oil fish, so enhancements in their lipid profile are unlikely to have a significant impact on their level of consumption, and limited amounts of omega-3's will be required in the diet to maintain their sensory properties.

Value for money: Low

This is a very expensive project over an unnecessarily long time frame even if the potential project benefits could be substantiated.

Comment on Justification for Recommendation:

Replacement of fish meals and oils with alternative ingredients while maintaining product quality is a significant issue that needs to be tackled at a National level with all aquaculture species in mind, and needs to take into account the global pressure on all oils and protein sources as a result of increasing demand for feed and fuel.

Principal Investigator:	Xiao Su
Title:	The effect of feed supplemented with Omega-3 polyunsaturated fatty acids on farmed hybrid abalone in Victoria

Significance of Project: Regional

Abalone have low levels of oil (0.8%) and contain almost no PUFA's. There is also definitive research into the substitution of fish oils in abalone diets and the upper levels of oil inclusion in diets.

Based on existing research:

1. Manipulation of diet is unlikely to have any impact on the PUFA content of abalone given they have next to no PUFA's in their oil.
2. The oil content of abalone diets is very low, so any replacement of this oil with alternative sources is likely to have minimal impact.
3. The cost differential between marine and vegetable oils has diminished and replacement is unlikely to have a significant influence on overall diet cost.

Track record of the Principal Investigator: Not Known

The investigators are not known to the reviewer.

Likelihood of achieving objectives: Low

Diet will not significantly impact on the PUFA content of abalone and subsequent consumption, nor will the research improve the cost-effectiveness of raising abalone in Australia.

Value for money: Low

While inexpensive, this project is protracted and will add little to the pool of scientific knowledge or the cost-effectiveness of raising abalone in Australia.

Comment on Justification for Recommendation:

Represents a repeat of previous research despite the fact it is focussed on adult hybrid abalone, and has little hope of improving the cost-effectiveness of raising abalone in Australia.

Identify nutrition research priorities that are not being addressed through existing portfolios and initiate research projects in this area.

DELIVERY OF AOP AND STRATEGIC DIRECTIONS

Without an indicative budget, with funds in this project only covering operational costs for the Principal Investigator, with other FRDC and Seafood CRC species based subprograms having their own nutrition components, it was hard to justify a separate AOP and strategic plan for this Subprogram.

The activities of this Subprogram may be better served as a component of another where an indicative budget can be justifiably allocated by FRDC.

Promote capacity building and human capital development through provision of training and resources in aquaculture nutrition and aquafeed manufacturing.

AQUACULTURE NUTRITION METHODOLOGY MANUAL

Subsequent to the last Aquaculture Nutrition Subprogram (2004-235), a significant amount of additional work was required to finalise the Aquaculture Nutrition Methodology Manual. This work was primarily undertaken by Dr Meegan Vandepeer with the contribution exceeding 200 hours of work within this Subprogram (2007-230). The draft report was included with the final report for Project 2004-235.

Development risk management strategies as required for various aquaculture sectors in relation to nutrition to assist the research priority setting process.

DEVELOPMENT OF A SEMI-COMMERCIAL NUTRITION RESEARCH PLATFORM FOR THE SALMON INDUSTRY IN TASMANIA

The Principal Investigator participated in two days of meetings in Tasmania in October, 2008 in an attempt to identify a opportunities for FRDC support of a semi-commercial research platform for the salmon industry in Tasmania.

Meetings were convened with Skretting Australia, Tassal, and the University of Tasmania.

The following conclusions and feedback was provided from the meetings to Rhys Hauler from Skretting:

Establishment of Research Infrastructure

Key stakeholders in the salmon industry are looking for support to establish a semi-commercial research facility compromising 15 commercial pens of approximately 1000 salmon/pen (allowing 5 experimental treatments and 3 replicates per treatment). The pens would include an automated feeding system and the facility would be coordinated by TASSAL. Rhys Hauler proposed that Skretting and TASSAL would invest in the infrastructure (base cost upwards of $0.5 million) but would require a return from the grow out of the fish (in the vicinity of $100K per annum based on 15,000 fish over a 12 month period). Further support for a full-time operations manager ($60,000 per annum) plus specific project funds would be required from an organization like FRDC.

Long-standing issue

This requirement is not new to the salmon industry. When the BECAN Consulting Group reviewed Aquaculture Nutrition Research for the FRDC in 2000, the following was concluded:

- 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.

- 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.
- 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.

Since that time, there have been a range of salmon research projects funded through the FRDC Aquaculture Nutrition Subprogram, but none of these have had a requirement for semi-commercial facilities (although arguably the outcomes should now be demonstrated to industry using semi-commercial facilities).

Base Resource Funding vs Project Approach

The initiative proposed is consistent with a "Base Resource Funding Model" (Figure 1). This approach usually starts with an audit of research capacity nationally and then looks at a range of industry research priorities that utilize common resources. By funding the resource, it is possible for a research provider to develop more stable base research capacity and build human capital around the infrastructure rather than a project. This approach also reduces the cost of individual experiments substantially because the overheads are covered across a minimum number of experiments within the infrastructure per annum over at least three years. Once the infrastructure is in place, the industry and research investors spend time identifying research priorities and innovations with any costs above and beyond the base resource cost borne by an individual project or experiment. This means more time is spent delivering outcomes using a "perennial" resource rather than writing individual projects on a cyclical basis in an attempt to keep the resource operational.

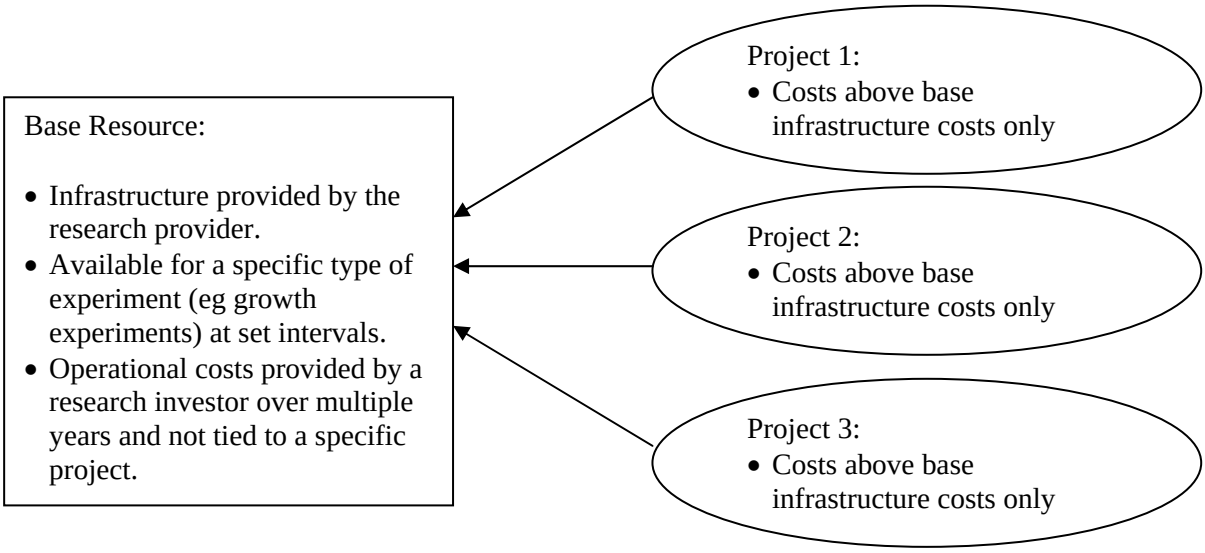

Figure 1. ***Schematic representation of a Base Resource Funding Model***

This concept is being developed as part of a wider Primary Industries Ministerial Council initiative looking at consolidation of research resources across Australia and investments by research and development corporations – this has provided an opportunity to examine other deliberations and filter out concepts that are going to struggle to gain wider acceptance. To date a number of preliminary models have been considered by various industries, but base resource funding models seem to be gaining favour.

To be successful, any new base resource funding initiative will need to deliver the following and posses the following attributes:

1. There must be strong support from all sectors of the industry and the results arising from research within the facility must have wide relevance.
2. There should be a mechanism for multiple inputs into the experiments that are to be undertaken using the infrastructure.
3. There should be a significant cash and in-kind investment from the research providers managing the infrastructure.
4. There must be a nominated minimum number of experiments conducted using the infrastructure each year, with a set time period for the start of a new experiment (eg. 2 experiments per year utilizing 15 pens with 1000 salmon per pen from 200 grams to 0.5kg every 25 weeks).
5. The resource should be unique and should result in consolidation of national facilities.
6. There should be sufficient demand for the facility to utilize more than the available experimental time within the infrastructure.
7. Provision of base resource funding should facilitate the leverage of additional funds and should promote development of human capital.

Current Salmon Research Priorities

During discussions it was highlighted that the current salmon industry bottlenecks continue to be amoebic gill disease and performance during summer, respectively. The Skretting Aquaculture Research Centre is involved in research investigating:

- Nutrient requirements – aimed at reducing dietary nutrient levels or confirming current recommendations;
- Raw material analysis – Optimising use of land animal proteins, the EU return to poultry product use, and fishmeal replacement to 15-25% of the current requirement.
- Focus on large fish (>1kg) – Pigmentation, marine hatchery feeds and recirculation diets
- Health – Functional feed ingredients, screening of natural ingredients that promote digestion and/or immunity.
- Gut health – application of organic acids, manipulation of intestinal microflora, gut integrity and mucous production.
- Skin condition and gill condition.

In Australia, these research priorities have been further refined to include:

- Feeding and nutrition in sub-optimal conditions, with the highest priority being summer feeding;
- Addressing sub-optimal flesh quality;
- Feeding strategies and nutritional requirements;

A need for whole of life experiments within a multi-purpose facility was highlighted. We discussed the facilities available at the University of Tasmania and their research program. While the program was seen as relevant, a big gap existed between these outcomes and the commercial upscaling and adoption. The current UTAS program consists of:

- Ingredient and feed development – fishmeal replacement, fish oil replacement, additives.
- Nutrition and environment interactions – Elevated temperatures, macronutrients, phosphorus, fatty acids and low dissolved oxygen.
- Nutritional physiology – Digestion and gut physiology, gut health, microflora, protein and amino acids, energy and respiration, model fish and molecular tools and endocrinology.

FRDC Support for a Base Resource Funding Model with Salmon

In theory, FRDC support could be offered in one of three ways:

1. Through the current MOU with the Tasmanian Salmon Growers Association (TSGA) – this would require full support from this association and would require an allocation of their current funds research funds towards this initiative. My understanding is that the TSGA has not been supportive of this approach to date, otherwise it is likely it would already be operational.
2. Through the Aquaculture Nutrition Subprogram (ANS) – for this to occur, the ANS would require an indicative funding allocation from the FRDC Board for priority research within this discipline (which currently doesn't exist). I have approached FRDC to investigate the potential for an indicative budget allocation going forward and have suggested that without one, the ANS will struggle to develop a project portfolio and human capital in this research field. Given a range of nutrition initiatives exist within species based portfolios supported by FRDC, and given the increasing use of MOU's with specific industries, FRDC have advised that it would be difficult to allocate indicative funds to nutrition as a discipline and hence, the ANS is an unlikely source of funds for your model.
3. A specific project application to FRDC through the annual submission process – while this is an option, it is unlikely to be successful without the full support of the TSGA or the Salmon Aquaculture Subprogram.

In addition to the limited funding opportunities through FRDC, the base resource funding model for salmon would need to overcome a number of other hurdles to be seen as an acceptable investment:

1. As a commercial entity, TASSAL have indicated that they would participate in a model of this nature to maintain a competitive advantage. This could limit the capacity to disseminate research results more widely.
2. While summer feeding is a significant industry issue for salmon, we would need to clearly demonstrate that there was a sufficient research load to warrant investment in this infrastructure over a whole year and for multiple years.
3. We would need to demonstrate why a $60-80,000 investment in salmon research infrastructure is a higher priority than the many other priorities within FRDC's portfolio.
4. While both TASSAL and Skretting would require a return from the infrastructure through the sale of salmon, we would need to demonstrate that some of those funds were being returned to the research program as discretionary cash for the on-going conduct of research projects.

In addition to FRDC, I have looked into a range of Federal government funding initiatives that may be suited to supporting a model of this type. Few schemes will support production based research (the Federal government has largely deferred this task to the RDC's taking us back to FRDC as the primary option) – the Industry Cooperative Innovation Program held some potential but is currently under review and future rounds are yet to be announced. The one scheme that may be consistent with the objectives of TASSAL and Skretting is the R&D Tax Concession Scheme. I am sure both Skretting and TASSAL already make good use of this scheme, and given the level of investment you would have to make into infrastructure, you would more than recoup the additional funds you are seeking through tax concessions. The downside of the scheme is the cash that must be legitimately expended on research and development before any form of rebate is possibly from the tax office. It will also depend heavily on how your companies are structured in Australia.

Improve communication of nutrition research outcomes and current nutrition research between scientists, aquaculturalists, ingredient suppliers and feed manufacturers utilizing workshops, planning meetings and conferences.

AQUACULTURE NUTRITION SUBPROGRAM COMMUNICATION PLAN

The ANS defined a policy for the distribution of information arising from research conducted within the Subprogram that formed the basis of the communication plan for this project. This project distributes information on behalf of all projects within the Subprogram with the following objectives:

1. To provide direct technical advice to FRDC re the robustness of existing aquaculture nutrition research programs and nutrition-related research.

2. To distribute research outputs (technologies and knowledge) that has a net benefit for the Australian industry and to distribute that information in a timely manner to achieve rapid adoption by industry.
3. To disseminate information about the subprogram's role, activities and achievements to relevant stakeholders.
4. To disseminate information to the general public when it contributes to a positive perception of the sector and/or the FRDC and contributes to the public good.
5. To disseminate information to international partners when there is a two-way flow of information.

It should be noted, however, that in most cases the dissemination of results will be via projects managed within the ANS rather than via the ANS directly.

Target audiences:

1. Fisheries Research and Development Corporation
2. The Australian aquaculture industries, aquafeed manufacturers, infrastructure manufacturers and FRDC stakeholders.
3. General public.

Key messages:

1. Research outputs from the projects managed under the subprogram.
2. Role, activities and achievements of the subprogram.

Communication/Extension methods:

1. Facilitation of workshops aimed at disseminating the latest nutrition research results from Australia and New Zealand and identifying core research priorities for pursuit within the Subprogram.
2. Publication of workshop proceedings from the aquaculture nutrition workshops as they are convened for distribution to workshop participants, industry and educational institutions.
3. Maintenance and annual upgrading of an Aquaculture Nutrition Subprogram strategic plan available via the FRDC web-site for use by research providers, industry, other subprograms and FRAB's.
4. Publication of an annual operating plan for the subprogram for delivery to FRABs in December each year to assist deliberations on projects related to aquaculture nutrition.
5. Coordinated delivery of progress and final reports to FRDC from core projects managed within the aquaculture nutrition subprogram.
6. Collation of standardized nutrition research methodologies and species related nutrition information in practical manuals for use by industry.
7. Where sufficient interest exists, the subprogram will provide short courses to improve the practical nutrition knowledge base that exists in the Australian aquaculture sector.

The ANS communications policy aims to facilitate the orderly release of information produced by research providers managed under the subprogram. This policy covers the publication of final reports and scientific papers and the release of media articles, unsolicited media inquiries/interviews and films. Release of information is based on the following criteria:

1. Distribution of information must have a net benefit for the Australian industry.
2. Dissemination of information to international partners will be approved when there is a two way flow of information.
3. *Ad hoc* requests for results or information will not be accepted.
4. Special cases for the supply of information will have to be approved by the Steering Committee and where appropriate, Memorandums of Understanding will be prepared.

Action Plan

During the project:
Method: Reporting to FRDC as required or at least 6 monthly
Person Responsible: Robert van Barneveld
Completion date: 6 monthly to 31 July 2011

Method: Feedback to Principal Investigators on project progress and new proposals
Person Responsible: Robert van Barneveld
Completion date: As required to 31 July 2011

Method: Development of nutrition sessions at Australasian Aquaculture conferences
Person Responsible: Robert van Barneveld
Completion date: Bi-annually to 31 July 2011

Method: Development of an annual operating plan
Person Responsible: Robert van Barneveld
Completion date: December each year to 31 July 2011

After the project
Nil.

Evaluation

Success of the communication plan will be judged by FRDC – this is a management subprogram undertaken on their behalf.

Intellectual Property

This project does not generate any research results so management of intellectual property arising from the project *per se* is not applicable.

AUSTRALASIAN AQUACULTURE 2008

A session entitled "Feed for Growth" was developed and convened at the Australasian Aquaculture Conference in August 2008. The session was structured as follows:

Rob van Barneveld	Barneveld Nutrition Pty Ltd	Security of feed supply for the Australasian aquaculture sector
Leo Nankervis	Skretting	Health concepts in nutrition
Mike Hall	AIMS	Relationship between nutrition, gut integrity and health in crustaceans: the case of larval lobsters
Joseph Kearns	Wenger Manufacturing Inc	Production of aquatic feeds by extrusion cooking comparing pelleted and extruded prawn feeds
Chris Carter	University of Tasmania	Diet amino acid, fatty acid and energy sources: the value of alternative approaches to assessing their biological value
Chris Carter	University of Tasmania	Elevated water temperature and the biological value of lupin kernel meal compared with soybean and fishmeal to Atlantic salmon

In addition to Chairing and presenting during the Feed for Growth session, the Principal Investigator met with key contributors to the aquaculture nutrition sector including Skretting (Rhys Hauler), Ridley Aquafeeds (Richard Smullen), Proaqua (Nick Kempe), University of Tasmania (Chris Carter) and

NSW Fisheries (Geoff Allan) to discuss possible options for the Aquaculture Nutrition Subprogram going forward. One opportunity was to convene an Aquaculture Nutrition Masterclass in Australia with corporate support (possibly focussed around Barramundi farmers in Cairns) but to date we have been unable to agree on the focus, the contributors or the location and it is unlikely that this will proceed.

Copies of the paper, press release and presentation from this conference are presented in Appendix III.

AUSTRALASIAN AQUACULTURE 2010

Two sessions were convened and Chaired as part of the Australasian Aquaculture 2010 Conference. A full session matrix for each session is presented in Appendix IV.

Feature Papers

- Development Of Land Plants Containing Long-Chain Omega-3 Oils – Future New Sources For Aquafeeds – **Peter Nichols**
- Marine Algae And Plant Proteins In Feeds For Black Tiger Prawns, *Penaeus monodon* – **Louise Ward**

Other papers

- Effect Of Diet On Abalone Meat Quality: A Taste-Active Chemical Component Perspective
- Development Of Passive Acoustic Monitoring As A Feedback Mechanism In Intelligent Feeding Of Vocalizing Species In Aquaculture Including Shrimp (*Penaeus monodon, P. vannamei, P. merguiensis*) And Barramundi (*Lates calcarifer*)
- Feed Additive Screening Using Cell-Based Assays: High-Throughput Assays For Antioxidant Activity, Oxidative Stress And Toxicity In Primary Fish Cell Cultures And Cell Lines
- The Effect Of Dietary Vitamin A During Rotifer Feeding On The Performance And Skeleton Formation Of Striped Trumpeter *Latris lineata* Larvae
- Impact Of Fish Meal Replacement With Poultry Meal On Rainbow Trout *Oncorhynchus mykiss* Nutrition, Physiology And Performance
- Effect Of Feeding Atlantic Salmon *Salmo salar l.* A Diet Enriched With Stearidonic Acid From Parr To Smolt On Growth and N-3 LC-PUFA Biosynthesis.

Posters

- Comparison Growth And Survival In Peneaus Semisulcatus Larvae By Spirulina Feeding
- The CSIRO Microalgae Supply Service: Supplying Quality Microalgae From The Australian National Algae Culture Collection
- Increasing Capacities Of Extruders For Small Diameter Feeds And Review Of Shrimp Feed Production Utilizing Extrusion Production Methods
- Feeding Behaviour Of Yellowfin Seabream Larvae Acanthopagrus Latus Fed On Live Food And Microencapsulated Diet
- Evaluation Of Live Mosquito Fish (Gambusia Holbrooki) As A Partial And Complete Dietary Replacement For Juvenile Barramundi (Lates Calcarifer)
- Determination Of Qulitative And Quantitative Frequency Of Phyto & Zooplanktons In Feeding Of Hilsa Shad Tenualosa Ilisha In The North Of Persian Gulf (Boushehr Province).
- The Effect Of Various Levels Of Silkworm Pupae Meal On Some Growth Parameters In Rainbow Trout Diet (Oncorhynchus Mykiss)
- The Effect Of Various Levels Of Silkworm Pupae On Some Blood Parameters (Red Blood Cells) In Rainbow Trout Diet (Oncorhynchus Mykiss)
- Effect Of Different Protein Level On Growth And Survival Of The Catla Catla (Hamilton) Reared In Glass Aquaria

HEALTH AND NUTRITION

Feature papers

- Diet and Microbial Interactions In Palinurid Lobster Larvae – **Mike Hall**.
- Immunostimulant Use In The Southern Bluefin Tuna Industry: Immune Response, Health, And Performance **– Nicole Kirchhoff**

Posters

- The Effects Of Immunoster as a Prebiotic on Some Growth Parameters Of Great Sturgeon *Huso huso*
- The Effect Of *Bacillus subtilis* and *B. licheniformis* as Probiotic Bacteria And Ferrous Sulfate On Some Specific Blood Parameters Of Rainbow Trout *Oncorhynchus mykiss* Larvae During Incubation Period
- The Study Of Growth Performance Of Rainbow Trout *Oncorhynchus mykiss* Larvae With Different Levels Of Probiotic and Iron In Use Of Supplemented In Diet
- Effect Of Prebiotic Immunoster On Growth Performance, Blood Factors And Body Composition Of Southern Caspian Sea Rutilus *Frisii kutum* Fingerlings

BENEFITS

The presence of this Subprogram delivered some benefits through maintenance of the Subprogram Leaders time to provide expert nutritional advice to FRDC and the Australian aquaculture sector. It also facilitated the involvement of the Subprogram Leader in the Australasian Aquaculture conferences in 2008 and 2010 and resulted in the delivery of three successful nutrition sessions across these two events. Apart from that, the benefits arising from the on-going maintenance of this Subprogram are limited and are a primary driver behind the recommendation to terminate the Subprogram early.

FURTHER DEVELOPMENT

It is recommended that any further thoughts around a Subprogram approach to aquaculture nutrition be considered as part of attempts to establish a portfolio around new and emerging aquaculture species.

CONCLUSION

The Subprogram concept within the FRDC management framework should be applauded, but circumstances change and it is appropriate to reconsider the presence of some Subprograms from time to time. The nature of Australian aquaculture nutrition research and those best qualified to undertake this research has changed in the past 5 years, and in the absence of indicative funding for generic aquaculture research, a Subprogram approach can no longer be justified.

APPENDIX I – INTELLECTUAL PROPERTY

There is no intellectual property requiring protection arising from this project.

APPENDIX II - Staff

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Ms Kylie Franzmann, Barneveld Nutrition Pty Ltd, Level 1, Unit 7 Riverland Central, 16-18 Riverland Drive, Loganholme, Qld, 4129. Ph: 07 3806 0671. Fax: 07 3806 4993. E-mail: kylie@barneveld.com.au.

APPENDIX III –

AUSTRALASIAN AQUACULTURE 2008

- PAPER, PRESENTATION and NEWS ARTICLE

Security of Feed Supply for the Australasian Aquaculture Sector

Robert J van Barneveld

Barneveld Nutrition Pty Ltd, Level 1, Suite 11, Plaza Chambers, 3-15 Dennis Rd, Springwood, Qld 4128.

Despite attempts to identify alternative protein sources for use in aquaculture diets, fishmeal remains a key component. In some cases reliance on fishmeal has increased where performance of fish fed diets containing alternative proteins has been shown to be suboptimal. With this in mind, security of aquafeed supply could be compromised if you consider issues such as the availability of fishmeal and fish oils, concerns over inter-species recycling, access to alternative protein sources in the wake of increases in biodiesel and ethanol production and decreases in supply through drought, and access to alternative protein sources that need to be either GM free or mammalian-protein free to meet the needs of specific markets. Peripheral impacts of biofuel production have also placed increased pressure on feed ingredients such as phosphates, synthetic amino acids and some vitamins and minerals. The objective of this paper is to investigate some of the potential threats to aquafeed supply and cost in Australasia, and strategies that may assist in securing this supply.

Pressure on traditional aquafeed ingredients and cost-effective alternatives can be seen by examining demand for fishmeal and the impacts of biofuel production on protein and energy sources. When coupled with growth in other livestock sectors, where demand for protein and energy has also increased (for example China's consumption of soybean meal has increased 2850% in the past16 years), the risks associated with the security of aquafeed feed supply can be easily seen. For the last 20 years the production of fishmeal has remained fairly constant at around 6 millions tonnes. Aquaculture has taken an increasing share of the global fishmeal production with the estimated percentage rising from 45 % in 2002 to 57 % in 2006 (Jackson, 2007). This growth has been at the expense of the more traditional forms of dietary usage such as pigs and poultry. The FAO (2006) have made estimates of the continuing growth in aquaculture feed production, which they suggest will continue to grow from around 22 million tonnes in 2005 to around 32 million tonnes in 2012. During 2006 fishmeal prices surged from the $US700/tonne to $US1400/tonne (Josupeit, 2007). Given the predicted increase in aquaculture feed production and subsequent pressure on fishmeal supplies, these high prices are likely to continue. In addition to the foreseeable increase in fishmeal prices, the aquafeed industry faces potential increases in the cost of some alternative grains and protein sources due to the rapidly growing biofuel industry. Biofuel production is already well developed in Europe (predominately biodiesel from oilseed crops, but now also boioethanol in France), USA (bioethanol from corn and biodiesel from oilseeds e.g. soybean) and Brazil (bioethanol from sugar cane) and recently China (worlds largest bioethanol plant). The US is currently producing 29.7 billion litres of ethanol (Higgins, 2007) and corn-based ethanol production is growing by about 30 % per year (RIRDC, 2007).

A renewed approach to securing diversity in cost-effective protein and energy supply is a priority for the Australasian aquafeed sector if the industry is to remain profitable and sustainable.

Security of Feed Supply for the Australasian Aquaculture Sector

Dr Robert van Barneveld
Barneveld Nutrition Pty Ltd and the BECAN Consulting Group Pty Ltd
Leader, FRDC Aquaculture Nutrition Subprogram

Key Messages

- Security of aquafeed supply in Australasia is under threat unless we maintain a focus on broadening the ingredient base:
  - Pulses offer strategic opportunities for protein replacement
  - Carbohydrate supplies stable but will be influenced by drought and biofuel production
  - Fat and oil supply critical – alternatives required
  - Minerals and synthetic amino acid supply heavily influenced by biofuel production.

Characteristics of Australian Aquafeeds

- Low volume
- High value
- Limited range of feed ingredients used
- Wide variety of forms and function

The feed industry proposes to increase total feed production to 1.5 billion tonnes over the next 10-15 years – current global production is 650 million tonnes

Weaver (2007) – FEED International

Range in diet forms

Species	Feeding	Sink rate	Stability	Presentation	Production
Prawns	Benthic	Fast	24 h	Dry	Steam-press
Tuna	Pelagic	Slow	Minutes	Semi-moist	Extruded/ Formed
Barramundi	Pelagic	Floating/slow	Minutes	Dry	Extruded/SP
Sea urchins	Benthic	Fast	48 h	Semi-moist	Extruded
Abalone	Benthic	Fast	48 h	Dry	Formed
Lobster	Benthic	Fast	48h	Dry	SP/Extruded
Salmon	Pelagic	Slow	Minutes	Dry	Extruded /Infused
Crocodiles	Pelagic	Floating	72 h	Moist	Formed
Whiting	Pelagic	Floating	Minutes	Dry	Extruded
Snapper	Pelagic	Slow	Minutes	Dry	Steam-press
Silver perch	Pelagic	Slow	Minutes	Dry	Steam-press

Feeding Objectives

- Production
  - Cost-effective – Feed cost, FCR, growth rates
  - Consistent
  - Minimal environmental impacts – FCR, feed intake
  - Product quality – Non-GMO, Non-animal protein
- Consumers
  - Safe
  - Taste
  - Health benefits – Omega 3 and 6.

Meeting all of these objectives will affect the security of feed supply

Ingredient categories

- Protein
- Carbohydrate sources
- Fats and oils
- Additives

Protein

- 25-60% of most diets
- Nutrient supply and functionality
- Heavy reliance on fishmeal
- Alternative protein sources under increasing pressure
- Animal protein sources not accepted by some markets
- Vegetable protein alternatives best opportunity for fishmeal replacement

Fishmeal Security Issues

- Availability
  - Quantity available – Ongoing demand vs supply
  - Transport costs - imported
- Price
- Quality

Fishmeal will remain in demand for use in aquafeeds and other monogastric diets irrespective of the availability of alternative protein sources

Fishmeal in Aquafeeds

- No obligate requirement for fishmeal despite high inclusion in many aquafeeds
- Valuable source of:
  - Amino acids (ideal balance, hydroxyproline)
  - n-3 Fatty acids/energy
  - Vitamins and minerals
  - Attractants/palatants

Comparative Protein Costs

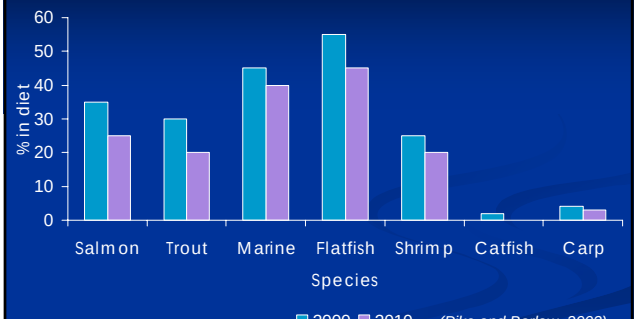
Ingredient	CP (%)	Price ($mt)	Cost/kg CP
Feather meal	83	250	$0.301
DDGS	28-35	85	$0.304
MBM (porcine)	51	170	$0.333
Soybean meal	48	168	$0.356
Poultry by-product meal	60	250	$0.417
Corn gluten meal	60	263	$0.438
Blood meal	89	475	$0.534
Soy protein concentrate	76	1001	$1.317
Fishmeal (Menhaden)	68	930	$1.368
Wheat gluten	80	1166	$1.458

(Feedstuffs, 2006)

Fishmeal in Aquafeeds

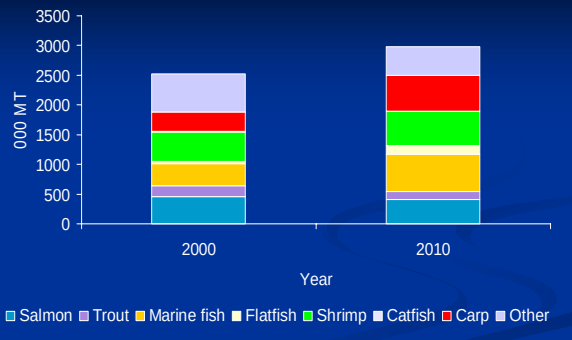
- FAO estimates aquaculture feed production will increase from around 22 million tonnes in 2005 to 32 million tonnes in 2012
- Fishmeal production constant over last 20 years at 6 million tonnes
- Aquaculture requirements up from 45 % in 2002 to 57 % in 2006

Inclusion of Fishmeal in Aquaculture Diets



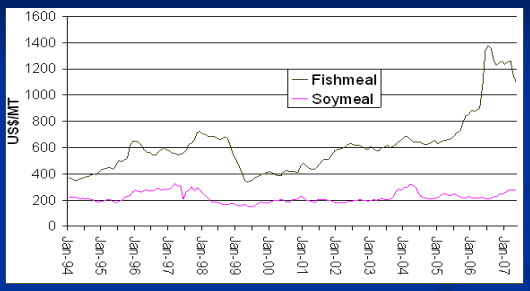
(Pike and Barlow, 2003)

Fishmeal Consumption by Aquaculture Sector



(Pike and Barlow, 2003)

Fishmeal vs Soybean Meal Price



Josupeit (2007)

From a risk management and sustainability perspective there is value in identifying fishmeal alternatives for use in Australian aquafeeds

Fishmeal Replacement

- Consumer perceptions
  - GMO's
  - Mammalian proteins
- Interspecies recycling (tuna)
- Antibiotic residues (?)

Outlook for Global Protein Supply

- VERY complex
- Biofuel demand – influenced by oil price
- Biofuel politics – mandates, production subsidies
- Land use – starch vs edible oil; non-agriculture
- Water availability
- Price signals
- Genetic engineering

Dried Distillers Grains with Solubles

DDGS are the dried residue remaining after the starch fraction of grains are fermented with selected yeasts and enzymes to produce ethanol and carbon dioxide

DDGS – Factors Affecting Use

- Fibre content
- Variable quality
  - Dry matter – 87 to 93%
  - Crude protein – 23 to 29%
  - Crude fat – 3 to 12%
  - Ash – 3 to 6%
  - Lysine – 0.59 to 0.89%
- Transport and export logistics
- Cost-effectiveness in monogastric diets is highly dependent on fat content

DDGS – Factors Affecting Use

- Antibiotic residues from ethanol fermentation?
- Aflatoxins are not destroyed during ethanol production, but are concentrated in the distillers grains by-products where they may be present at levels as high as three times that found in the corn or grain sorghum starting materials
- Most research has been conducted on corn DDGS

DDGS – Factors Affecting Use

- Enzyme technology

The high concentration of fibrous material in DGGS limits its inclusion in monogastric diets. However, there is potential to improve the nutritional value with the use of NSP-degrading enzymes, particularly those with a high affinity for insoluble fibre

Use of DDGS in Fish Diets

- DDGS have been evaluated in diets for
  - Rainbow trout
  - Tilapia
  - Catfish

Use of DDGS in Fish Diets

- Tilapia – up to 20 % DDGS inclusion (Lim *et al*., 2007)
- Catfish – up to 30 % DDGS inclusion (Webster *et al*., 1993)
- Rainbow trout – up to 15 % inclusion (Cheng and Hardy, 2004)

Soybean Meal

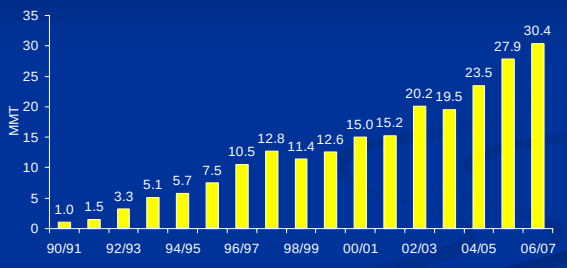
- Widely used in terrestrial livestock diets and aquaculture diets
- Inclusion in young animal diets limited to reduce potential for aberrant “immune” responses
- Known issues with intestinal atrophy in salmon
- Primary issue surrounding quality with increased production outside the US

Oilseed Meals

- Global edible oil production to grow by 5% during 2006/07 (134 vs 128 mmt)
- Global meal production to increase by only 4% this season (231 vs 222 mmt)
- 2007 US soybean crop estimated to be 70.8 mmt, 18% less than last year.

China Soybean Meal Consumption 1990/91 – 2006/07

Consumption up 2,850% in 16 years!



Soybean Meal

- Nutritional value can be enhanced through the use of exogenous phytase
- Dietary additional of mycotoxin binders is an added cost that may have to be factored in when selecting meals
- Development of NIR calibrations for available lysine and proximates will assist incorporation of soybean meal (and DDGS) into livestock and aquaculture diets

Vegetable Protein Alternatives

- Protein content exceeding 53% but less than 60%
- Minimal influences from carbohydrate components (starch and NSP)
- Minimal additional processing required
- Lupins hold the greatest potential at present
- Need to characterise each pulse for each species
- Volume markets exist outside Australia

Vegetable Proteins

- Pulses as a target – Lupins, peas, beans
- Use of phytase enzymes
  - Release phytate bound phosphorus
  - Improve protein and amino acid digestibility
- Use of carbohydrase enzymes (?)

Ingredient Digestibility (%) - Salmon

Glencross et al. 2004

	LKM	LPC	LPI	SBM	SPC	SPI
N	130.4	108.7	96.9	94.4	90.1	97.4
GE	69.6	105.9	104.5	89.0	101.2	117.4
P	26.0	8.1	22.6	8.1	-20.4	24.2
OM	55.3	81.8	95.8	73.4	78.3	97.9

Carbohydrates

- Starch
- Influences extruded pellet quality and characteristics
- Capacity of aquatic species to utilise NSP's often limited

CHO Security Issues

- Domestic supply
- Drought
- Price
- Insoluble NSP content

Fats and oils

- Varying requirements for specific fatty acids
- Omega 3 and 6 requirements often important
- Dietary fat level and source can influence diet quality
- Fish oil alternatives necessary

Fat and Oil Security Issues

- Demand far exceeds supply - Availability
- Alternatives can be used but will affect
  - Product Omega 3 content
  - Taste
- Cost
- Must seek alternatives while maintaining performance levels and product quality

Additives

- Vitamins and minerals
- Enzymes
- Attractants
- Adsorbants/binders
- Anti-oxidants
- Preservatives
- Anti-microbials

Additive Security Issues

- Availability
  - Phosphates
  - Synthetic amino acids (Methionine)
- Cost
  - Phosphates
  - Methionine ($2,500/T in May - $7,000/T in July)
- Quality
  - Lead contamination of zinc oxide

Key Messages

- Security of aquafeed supply in Australasia is under threat unless we maintain a focus on broadening the ingredient base:
  - Pulses offer strategic opportunities for protein replacement
  - Carbohydrate supplies stable but will be influenced by drought and biofuel production
  - Fat and oil supply critical – alternatives required
  - Minerals and synthetic amino acid supply heavily influenced by biofuel production.

The following article was prepared by Melissa Marino and published in FRDC News as a result of the paper presented at Australasian Aquaculture 2008 in Brisbane:

The security of feed supply for the Australasian aquaculture sector will be under threat unless focus is maintained on broadening the ingredient base to shift reliance away from fishmeal.

Consultant research scientist and nutrition specialist Robert van Barneveld told AA08 that global livestock and aquaculture feed production is projected to increase by 1.5 billion tonnes over the next 15 years, but that the quantity of fishmeal available was likely to remain static.

"Obviously, from a risk management or sustainability perspective there's definitely value in identifying fishmeal alternatives for use in aquafeeds," he said.

As well as facing growing demand from the aquaculture sector, fishmeal – a feed source made from fish itself – was also prized by other growth industries for young animal diets, putting further pressure on resources, he said.

On top of that, as aquaculture producers sought alternatives, they would face competition from other industries, such as biofuels, also vying for protein sources other than fishmeal, he said.

With competing interests and higher costs, including in production and transport, prices for fishmeal are expected to rise. While the system could absorb some increased costs, it may not necessarily be the best way to go forward, he said.

Fishmeal is a source of protein as well as amino acids, Omega 3 fatty acids, energy, vitamins and minerals. While it is not an absolute requirement in an aquaculture diet and is more expensive than many other protein sources, it has long been sought after.

"Fish are not koalas or pandas – they don't live on eucalyptus leaves and bamboo shoots and won't live on anything else," Robert van Barneveld says. "It's not an obligate requirement but it's certainly something that confers attractiveness and we know the fish perform well on it."

Despite concerted efforts from some industry sectors to reduce fishmeal consumption, an overall increase in aquaculture production will see demand continue to rise.

But while Robert van Barneveld says the low volume requirement for fishmeal in Australia may be the industry's 'saving grace', he stressed that alternatives must be found.

"We are foolish if we think it's going to be a constant resource that we'll continue to be able to use," he said.

While no one had a crystal ball and the outlook for global protein supply and demand was complex, alternatives being investigated include Dried Distillers Grains with Solubles (DDGS), soybean meal and vegetable proteins, he said.

Of these, he identified pulses as offering strategic opportunities for protein replacement. "Vegetable proteins – specifically pulses rather than oilseed meals -- probably offer our best alternative," he said. Robert van Barneveld said he hoped discussion at AA08 would help reinvigorate R&D into alternative feed sources in Australia. "We shouldn't be complacent in Australia even though we're low volume producers of aquafeeds," he said. "There will be increasing pressures on our raw materials and we need to try to spread that ingredient base."

APPENDIX IV –
AUSTRALASIAN AQUACULTURE 2010 SESSION MATRIX

Feed for the Future: Developments in Aquaculture Nutrition, Feed Technology and Feed Management	
Nutreconomics in aquafeeds	Pedro Encamacao (Proudly supported by Biomin – 40 minute presentation)
Scientific developments in feed processing techniques and functional ingredients as a foundation for a new range of salmonid diets for freshwater hatcheries	Roar Sandvik (proudly supported by Skretting)
Development of land plants containing long-chain omega-3 oils – future new sources for aquafeeds	Peter Nichols
Marine algae and plant proteins in feeds for black tiger prawns, *Penaeus monodon*	Louise Ward
Development of passive acoustic monitoring as a feedback mechanism in intelligent feeding of vocalizing species in aquaculture including shrimp (*Penaeus monodon, P. Vannamei, P. Merguiensis*) and barramundi (*Lates calcarifer*)	Stephen Shotton
Feed additive screening using cell-based assays: high-throughput assays for antioxidant activity, oxidative stress and toxicity in primary fish cell cultures and cell lines	Peter Bain
Predicitive growth models for *Thenus australiensis*: applications for production estimation, feed managment and feed design	Matthew Johnston
Increasing capacities of extruders for small diameter feeds and review of shrimp feed production utilizing extrusion production methods	Joe Kearns
Effect of feeding atlantic salmon *Salmo salar* l. A diet enriched with stearidonic acid from parr to smolt on growth and n-3 LC-PUFA biosynthesis	Baseer Codabaccus

Understanding the Interaction between Health and Nutrition	
Diet and microbial interactions in palinurid lobster larvae	Mike Hall (potential 40 minutes)
Immunostimulant use in the southern bluefin tuna industry: immune response, health, and performance	Nicole Kirchhoff
The effect of dietary vitamin A during rotifer feeding on the performance and skeleton formation of striped trumpeter *Latris lineata* larvae	Reham M. K. Negm
Impact of fish meal replacement with poultry meal on rainbow trout *Oncorhynchus mykiss* nutrition, physiology and performance	Kamil Latif