



## Aquaculture Nutrition



**Report on the Aquaculture Nutrition Master Class held  
at Asian Institute of Technology, Bangkok, Thailand  
7-19 August 2006**

**Geoff Allan, Helena Heasman and Paul Ferrar**



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Aquaculture Nutrition: Report on the Aquaculture Nutrition Master Class held at Asian Institute of Technology, Bangkok Thailand 7-19 August 2006

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**Authors:** Geoff Allan, Helena Heasman, Paul Ferrar

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## 1. EXECUTIVE SUMMARY

The ATSE Crawford Fund Aquaculture Nutrition Master Class was held at the Asian Institute of Technology, Bangkok, from 7-19 August 2006. The two week live-in intensive course for 27 invited participants from 10 south-east Asia and Pacific Island countries offered comprehensive training in all aspects of grow-out aquaculture nutrition. Fourteen guest lecturers (seven from Australia and seven from other countries), delivered lectures and conducted practical laboratory tutorials followed by discussion and revision sessions and enhanced by field trips to farms and feed mills. All participants had their travel, accommodation and other expenses paid for by the Master Class and in addition students were provided with extensive reading material, T-shirts and satchels. Student feedback from the course evaluation survey was very complimentary and most found the standard of content and delivery to be outstanding.

This intensive two-week course will be condensed and repackaged as short 3-day workshops providing a summary of topics covered at the longer Master Class or cover a selection of key topics of particular interest to target audiences. For example, the first of these mini-workshops will be delivered in Papua New Guinea in November this year by two students and two lecturers from the inaugural Master Class and will focus on small-scale feed manufacture.

The success of the Aquaculture Nutrition Master Class can be attributed to a number of factors including the close working relationship and good humoured camaraderie of lecturers that resulted in the compilation of a well-rounded and comprehensive program; the mutual respect and admiration that developed between lecturers and students from vastly different backgrounds resulting in friendships being forged; the cooperative and collegiate attitude of organizations like NACA, AIT and ACIAR working together to ensure the Master Class achieved its primary aim:

IN ACKNOWLEDGING THAT SMALL SCALE AQUACULTURE IN SOME DEVELOPING COUNTRIES IS AN IMPORTANT SOURCE OF PROTEIN TO SUPPLEMENT OTHERWISE MEAGER DIETS, THE MASTER CLASS AIMS TO EQUIP STUDENTS WITH THE BASIC UNDERSTANDING AND IMPORTANCE OF FISH NUTRITION AND HOW TO PRODUCE COST-EFFECTIVE AQUAFEDS BY UTILIZING LOCALLY AVAILABLE AGRICULTURAL INGREDIENTS.



## 2. SPONSORS AND CONTRIBUTORS

|   |  |   |  |
|---|--|---|--|
|                | <br>Australian Government<br>Australian Centre for<br>International Agricultural Research |    |   |
|                | <br>NSW DEPARTMENT OF<br>PRIMARY INDUSTRIES   | <br>Australian Government<br>Fisheries Research and<br>Development Corporation |   |
| <br>Thai Luxe |    |   |  |
|   | <br><i>Aquaculture without Frontiers</i>  |   |  |



### 3. MASTER CLASS BROCHURE



**Announcing...**

# AQUACULTURE NUTRITION MASTERCLASS

An initiative of  
**THE ATSE CRAWFORD FUND**  
 SUPPORTING INTERNATIONAL AGRICULTURAL RESEARCH

to be held at  
**ASIAN INSTITUTE OF TECHNOLOGY**  
 Klong Luang, Pathumthani 12120  
**BANGKOK**  
 7-20 August 2006

*Proudly sponsored by...*

**ATSE CRAWFORD FUND**  
**AUSTRALIAN CENTRE FOR INTERNATIONAL AGRICULTURAL RESEARCH**  
**FISHERIES RESEARCH AND DEVELOPMENT CORPORATION**  
**FAO**  
**ASIAN INSTITUTE OF TECHNOLOGY**  
**AQUACULTURE WITHOUT FRONTIERS**

Small scale aquaculture in some developing countries is providing an important source of protein to supplement otherwise meager diets. It is therefore important to have an understanding of fish nutrition and how to produce cost-effective aquafeeds by utilising locally available agricultural products. This live-in 2 week intensive course for invited participants from south-east Asia and Pacific Island countries will offer comprehensive training in the following aspects of grow-out aquaculture nutrition:

- PRINCIPLES OF AQUACULTURE NUTRITION
- INTRODUCTION TO DIET FORMULATION
- PELLETING & EXTRUSION OF COMMERCIAL FEEDS
- NATURAL FEEDS & INTEGRATED AQUACULTURE
- ANALYTICAL TECHNIQUES
- POTENTIAL FEED INGREDIENTS
- FARM MADE & LABORATORY FEEDS
- FEED MANAGEMENT - STORAGE
- FEEDING STRATEGIES
- RESEARCH METHODS

TOPICS TO BE PRESENTED AS LECTURES, PRACTICAL LABORATORY TUTORIALS, DISCUSSION & REVISION SESSIONS, FIELD TRIPS TO FARMS & FEED MILLS. COURSE MATERIAL WILL INCLUDE LECTURE NOTES, TEXT BOOK & BIBLIOGRAPHIC LITERATURE.

GUEST LECTURERS, PRE-EMINENT IN THE AQUACULTURE NUTRITION FIELD, INCLUDE:

|   |  |
|---|--|
| DR GEOFF ALLAN, NSW DPI                   | DR BRETT GLENCROSS, WA FISHERIES         |
| DR MALI BOONYARATPALIN, THAILAND MOF      | DR SENA DE SILVA, DEAKIN UNIVERSITY      |
| DR MARK BOOTH, NSW DPI                    | MR DAVID SMITH, CSIRO MARINE RESEARCH    |
| DR ROB VAN BARNEVELD, BARNEVELD NUTRITION | DR KEVIN WILLIAMS, CSIRO MARINE RESEARCH |
| DR PETER EDWARDS, EMERITUS PROFESSOR      | DR AMARATNE YAKUPITTIYAGE, AIT           |

**Logos:** CSIRO, FAO, MAC, CPF, Australian Government, Department of Fisheries, NSW DEPARTMENT OF PRIMARY INDUSTRIES

**Images:** A collage of images on the right side of the brochure showing various aquaculture activities, including people working in ponds, feeding fish, and displaying various feed ingredients.

**REPORT ON**  
**INTERNATIONAL MASTER CLASS**  
**ON**  
**AQUACULTURE NUTRITION**  
**ASIAN INSTITUTE OF TECHNOLOGY, BANGKOK, THAILAND**  
**7-19 AUGUST 2006**

**4. INTRODUCTION**

Aquaculture remains one of the fastest growing food production industries with growth rates of 7.9% over the ten years to 2004 (R. Subasinghe [FAO], presentation to AQUA2006, Florence, May 2006). Aquaculture now accounts for almost 50% of the total food fish consumed in the world with total production in 2004 estimated to be 59.4 million tonnes (includes animals and plants), worth US\$70.3 billion (Subasinghe, 2006).

Demands for aquatic protein (food fish) are increasing due to increasing global population as well as increasing per capita consumption (occurring both regionally and globally). Aquaculture is recognized as the only way these increasing demands for seafood will be met (Allan, 2004 – Fish for feed vs fish for food).

One of the reasons for the phenomenal growth of aquaculture is the progressive intensification of many production systems. The key driver for intensification is the use of increasingly sophisticated diets that meet nutritional requirements of target species. For many species, particularly in Asia, these diets have been based on the use of “trash fish” (low value fish species) fed either as a single ingredient or in combination with other ingredients (e.g. rice bran). Unfortunately, supplies of trash fish are not adequate to support the current rate of expansion of aquaculture. There are also other problems or potential problems with the use of “trash fish” including reliability and consistency of supply and cost. For example, the price of “trash fish” in Vietnam has doubled over recent years (Edwards *et al.*, 2004). The environmental impacts of aquaculture, particularly cage aquaculture, are also usually greater when “trash fish” is used.

The alternative to feeding with “trash fish” is to use formulated diets. The use of formulated diets for aquaculture species has been a rapidly developing industry and now it is estimated that the global market for formulated aquaculture feeds (aquafeeds) is about 15 million tonnes (Tacon 2003). For most carnivorous and omnivorous species, the protein and lipid sources of choice for formulated diets have been fishmeal (usually made from dried and ground whole fish) and fishoil. Globally, approximately 6 million tonnes of fishmeal and 1 million tonnes of fish oil are produced annually and while production has been relatively stable over several decades, the proportion of these ingredients being used in aquafeeds has increased rapidly (34 and 47% of total global supplies in 2002; Tacon, 2003) and cannot continue to support the aquaculture growth rate that will be needed to meet demand.

For these reasons, there is an urgent need to better understand nutritional requirements of aquaculture species and to evaluate a wide range of alternative ingredients. Feeds and feeding are key priorities for aquaculture generally, including for many countries in south-east Asia and the Pacific.



The aim of the Aquaculture Nutrition Master Class is to share information on aquaculture nutrition and train participants in nutritional requirements, ingredient evaluation, feed formulation and manufacture, research methods and how to interpret analytical results.

## **5. ADMINISTRATIVE ORGANISATION**

The Director of the Master Class was Dr Geoff Allan.

Initial planning of the structure and class program was undertaken by a committee comprising:

Geoff Allan and Mark Booth (NSW Department of Primary Industries)  
Kevin Williams and David Smith (CSIRO Marine Research)  
Brett Glencross (WA Fisheries)  
Amararatne Yakupitiyage (Asian Institute of Technology)  
with assistance from Helena Heasman (NSW DPI) and Paul Ferrar (Crawford Fund)

The venue for the Master Class (accommodation and lectures) was the Conference Centre of the Asian Institute of Technology (AIT). Practical classes were held in a nearby computer laboratory of AIT, and feed preparation facilities in the Aquaculture & Aquatic Resources and Development department of the School of Environment, Resources & Development at AIT. Local arrangements for all of this were made by Dr Amararatne Yakupitiyage and his staff at AIT.

The Network of Aquaculture Centres in Asia-Pacific (NACA) was engaged to arrange participants' travel, issuing of meals/incidentals allowances and reimbursement of participants' expenses for visas, taxis and other miscellaneous expenses. Funds for this were transferred in advance by the Crawford Fund, and the arrangement worked out very well.

Two key people ran the majority of planning work involved with the Master Class. In Australia, Mrs Helena Heasman arranged all planning meetings (teleconferences) and circulated minutes, arranged purchase of all course materials, Master Class shirts, satchels and gifts, was responsible for liaising with NACA staff, AIT and AIT convention centre staff and all lecturers. She also arranged travel for lecturers. In Thailand, Mrs Wella arranged the travel arrangements and managed the financial arrangements (e.g. the per diems and reimbursements for taxis, etc) for all participants, a difficult task because of poor communication facilities in several countries.

The Class also owes great thanks to Dr Amararatne Yakupitiyage and his staff at AIT, who made all the arrangements at the Master Class venue and for the field trips, and also managed the importation and customs clearance of a number of shipments of class materials sent from Australia. Mr Apiyut Siyapan, Laboratory/Field Supervisor at AIT, gave significant help during the field trips and practical classes.



*Drs Geoff Allan & Paul Ferrar  
welcome Master Class participants*



## **6. LIST OF PARTICIPANTS**

A full list of participants from the following countries is presented in Appendix 1

|               |  |
|---------------|--|
| Thailand      | 7  |
| Vietnam       | 5  |
| PNG           | 3  |
| Indonesia     | 3  |
| Cambodia      | 2  |
| Laos PDR      | 2  |
| Philippines   | 2  |
| India         | 1  |
| Bangladesh    | 1  |
| New Caledonia | 1  |
| Fiji          | 1 (travel approval was not granted at the last minute and this student did not attend) |

## **7. LIST OF LECTURERS**

Brief bionotes of all lecturers with contact details are presented in Appendix 2.

### ***From Australia***

Dr Geoff Allan (NSW Department of Primary Industries, ACIAR and Aquaculture without Frontiers)

Dr Mark Booth (NSW Department of Primary Industries)

Mr Igor Pirozzi (NSW Department of Primary Industries)

Dr Kevin Williams (CSIRO Marine Research)

Mr David Smith (CSIRO Marine Research)

Dr Brett Glencross (WA Department of Fisheries)

Dr Rob van Barneveld (Barneveld Nutrition and Fisheries R&D Corporation)

### ***From other countries***

Dr Amararatne Yakupitiyage (Asian Institute of Technology)

Dr Thomas Wilson (Thai Luxe Enterprises Public Co Ltd)

Dr Mali Boonyaratpalin (Ministry of Fisheries, Thailand)

Dr Peter Edwards (Emeritus Professor, Asian Institute of Technology)

Dr Nguyen Thanh Phuong (Can Tho University)

Mr Le Anh Tuan (Nha Trang University of Fisheries)

Mr Satya Nandlal (Secretariat of the Pacific Community Aquaculture Officer)



***Lecturers and students of the ATSE Crawford Master Class***

***Front row L-R:*** Kevin Williams, Brett Glencross, Igor Pirozzi, Paul Ferrar, Geoff Allan, David Smith, Amararatne Yakupitiyage, Peter Edwards, Thomas Wilson.

***Back row L-R:*** Montakan Tamtin, Khamson Sisaath, Ajaya Bhaskar, Josy Joseph, Hopa Simon, Jutamas Chomphunich, Nuchnaree Tongsri, Satya Nandlal, Somphouthone Phimmachak, Suphol Phantumaophas, Sophia Lasma Sagala, Rosabella Valencia, Nerafe Muyalde, Reza Samsudin, Le Anh Tuan, Usman, Chea Mong, Holl Tharine, Peter Minimulu, Irene Gubag, Ubonrat Limtipsuntorn, Dinh Van Trung

***Absent:*** Mark Booth, Nguyen Thanh Phuong, Rob Van Barneveld, Somnuek Wisuttipongтарworn

## 8. FUNDING

Major funding was provided by the Australian Centre for International Agricultural Research (AUD 50,000), the ATSE Crawford Fund (AUD 25,000) and the Australian Fisheries Research and Development Corporation (AUD 13,200).

Charoen Pokphand Foods PLC (2 participants), Thai Luxe Enterprises Public Co Ltd (1 participant) and the Secretariat of the Pacific Community (1 participant) all sponsored members of their staff to attend the Master Class.

FAO provided valuable course material for participants. The various other organizations involved made generous in-kind contributions of the time of their staff involved. Much of Dr Allan's time was contributed as a donation to the Charity Aquaculture without Frontiers.



*Dr Brett Glencross, one of the lecturers from WA Fisheries*

9. MASTER CLASS PROGRAM (SEE APPENDIX 3 FOR FULL PROGRAM & APPENDIX 4 FOR NOTES ON FIELD TRIPS)

| Time      | Monday 7th August  | Tuesday 8th August  | Wednesday 9th August   | Thursday 10th August  | Friday 11th August                               | Saturday 12th August  | Sunday 13th August       | Monday 14th August   | Tuesday 15th August   | Wednesday 16th August   | Thursday 17th August   | Friday 18th August   | Saturday 19th August   |  |
|-----------|--|---|--|---|--|---|--------------------------|--|---|---|--|--|--|--|
| 0900-0940 | Welcome & intros. <b>Geoff Allan &amp; Paul Ferrar</b>               | Recap #1 Intro to Aquaculture Nutrition <b>Kevin Williams</b> | Recap #2 Nutritional requirements <b>Kevin Williams</b>                      | FIELD TRIP 1: CP Feed Mill in Ban Pai; snakehead/catfish/giant catfish farm; macrobrachium farm | FIELD TRIP 2: Shrimp farms; DoF grouper hatchery | 5.1 Analytical techniques <b>David Smith</b>                | FREE DAY - PRIVATE STUDY | 6.1 Natural feeds & integrate aquaculture <b>Peter Edwards</b> | 7. Cont'd: Diet formulation - introduction to feed formulation. 8 x 45 minute laboratory and practical sessions <b>Mark Booth, Igor Prozzi, David Smith, Rob van Barneveld &amp; Amara Yakupitiyage</b> | 8.1 Feed manufacture (farm made & lab feeds) <b>Mark Booth</b>        | 11. Farm made and laboratory feeds. 8 x 45 minute laboratory and practical sessions <b>Rob van Barneveld &amp; Thomas Wilson</b> | Recap #8, #9, #10 & #11 <b>Geoff Allan &amp; Rob van Barneveld</b> | Recap #12 Research Methods <b>Kevin Williams</b>   |  |
| 0945-1025 | 1.1 Introduction to Aquaculture Nutrition <b>Kevin Williams</b>      | 2.1 Nutritional requirements <b>Geoff Allan</b>               | 3.1 Assessment of potential feed ingredients <b>Le Anh Tuan</b>              |   |  | 5.2 Analytical techniques <b>Mark Booth</b>                 |                          | 6.2 Natural feeds & integrate aquaculture <b>Peter Edwards</b> |   | 8.2 Feed manufacture (farm made & lab feeds) <b>Kevin Williams</b>    |  | 12.1 Research methods <b>Kevin Williams</b>                        | Review topics identified for further discussion during course.                                 |  |
| 1030-1100 | Morning Tea  |   |  |   |  | Morning Tea   |                          | Morning Tea  |   | Morning Tea   |  | Morning Tea  |  |  |
| 1100-1140 | 1.2 Introduction to Aquaculture Nutrition <b>Mali Boonyaratpalin</b> | 2.2 Nutritional requirements <b>Amara Yakupitiyage</b>        | 3.2 Assessment of potential feed ingredients <b>Brett Glencross</b>          |   |  | 5.3 Analytical techniques <b>David Smith</b>                |                          | 6.3 Natural feeds & integrate aquaculture <b>Peter Edwards</b> |   | 9.1 Commercial feeds - pelleting & extrusion <b>Rob van Barneveld</b> |  | 12.2 Research methods <b>David Smith</b>                           | Review topics identified for further discussion during course; Course assessment/questionnaire |  |
| 1145-1225 | 1.3 Introduction to Aquaculture Nutrition <b>Mark Booth</b>          | 2.3 Nutritional requirements <b>Brett Glencross</b>           | 3.3 Assessment of potential feed ingredients <b>Mark Booth</b>               |   |  | 5.4 Analytical techniques <b>Brett Glencross</b>            |                          | 7.1 Introduction to feed formulation <b>David Smith</b>        |   | 9.2 Commercial feeds - pelleting & extrusion <b>Rob van Barneveld</b> |  | 12.3 Research methods <b>Kevin Williams</b>                        | PRESENTATION OF CERTIFICATES & PHOTOS; OFFICIAL LUNCHEON                                       |  |
| 1230-1345 | Lunch  |   |  |   |  | Lunch   |                          | Lunch  |   | Lunch   |  | Lunch  |  |  |
| 1345-1425 | 1.4 Introduction to Aquaculture Nutrition <b>Geoff Allan</b>         | 2.4 Nutritional requirements <b>Geoff Allan</b>               | 3.4 Assessment of potential feed ingredients <b>Geoff Allan</b>              |   |  | 5.5 Analytical techniques <b>David Smith</b>                |                          | 7.2 Introduction to feed formulation <b>Amara Yakupitiyage</b> |   | 9.3 Commercial feeds - pelleting & extrusion <b>Thomas Wilson</b>     |  | 12.4 Research methods <b>Brett Glencross</b>                       | FLY HOME   |  |
| 1430-1510 | 1.5 Introduction to Aquaculture Nutrition <b>Brett Glencross</b>     | 2.5 Nutritional requirements <b>David Smith</b>               | 4.1 Feeding strategies <b>Brett Glencross</b>                                |   |  | 5.6 Analytical techniques <b>David Smith</b>                |                          | 7.3 Introduction to feed formulation <b>Rob van Barneveld</b>  |   | 9.4 Commercial feeds - pelleting & extrusion <b>Thai DoF</b>          |  | 12.5 Research methods <b>David Smith</b>                           |  |  |
| 1515-1545 | Afternoon Tea  |   |  |   |  | Afternoon Tea   |                          | Afternoon Tea  |   | Afternoon Tea   |  | Afternoon Tea  |  |  |
| 1545-1625 | 1.6 Introduction to Aquaculture Nutrition <b>Brett Glencross</b>     | 2.6 Nutritional requirements <b>Nguyen Thanh Phuong</b>       | 4.2 Feeding strategies <b>David Smith (shrimp)</b> <b>Geoff Allan (fish)</b> |   |  | Recap #5 Analytical techniques <b>David Smith</b>           |                          | Recap #6 & #7 <b>Peter Edwards &amp; David Smith</b>           |   | 10.1 Feed management - storage <b>Igor Prozzi</b>                     |  | 12.6 Research methods <b>Geoff Allan</b>                           |  |  |
| 1630-1715 |  | 2.7 Nutritional requirements <b>Satya Nandlal</b>             | Recap #3 & #4 <b>Geoff Allan</b>   |   |  | Tour of AIT laboratory facilities <b>Amara Yakupitiyage</b> |                          |  |   | 10.2 Feed management - storage <b>Thomas Wilson</b>                   |  | 12.7 Research methods <b>Kevin Williams</b>                        |  |  |



## **10. RESOURCE MATERIAL PROVIDED FOR STUDENTS**

Please see Appendix 5 for full bibliography of all resource and reference material provided to students.

## **11. FUTURE THREE DAY MINI-WORKSHOPS (AQUACULTURE NUTRITION MASTER CLASS SHORT COURSES) AND OTHER SPIN-OFFS FROM THE MASTER CLASS**

Developing the material for the Master Class involved many hundred of hours of work and a very comprehensive set of lecture notes (as PowerPoint presentations) was generated. To help ensure these outputs can benefit as many people as possible, a series of Aquaculture Nutrition Master Class Short Courses will be designed to be delivered in different languages in different countries. These will usually be three-day workshops and provide either a summary of topics presented during the two-week Master Class or a selection of key topics of particular interest to a target audience. Participants from the two-week Master Class will play a key role in delivery of the Short Courses. They will assist with development and condensation of the material to be presented and where required, with translation into other languages. They will also assist with identifying the target audience and arranging logistics of the course.

The development of an Aquaculture Nutrition Master Class Short Course for Australia was a key reason the Australian Fisheries Research and Development Corporation supported the Master Class and a Short Course will be developed for presentation in Australia in 2007. In addition, the following Aquaculture Nutrition Master Class Short Courses are or will be developed and delivered:

- a) Short Course with focus on small-scale feed manufacture (for PNG, to be presented in English in November 2006). Geoff Allan and Mark Booth (NSW DPI) will develop and deliver the course with assistance from Peter Minimulu (PNG NDAL) and Hopa Simon (PNG EHP/ACIAR)
- b) Short Course with focus on use of alternative ingredients and small-scale feed manufacture (for Northeastern Thailand, to be presented in Thai in early 2007). Geoff Allan (on behalf of Aquaculture without Frontiers) will help develop the English version and translation and delivery will be done with assistance from Dr Mali Boonyaratpalin (formally with Thailand Department of Fisheries) and staff from World Vision Foundation Thailand. This particular Short Course is being developed specifically for World Vision Foundation Thailand to assist them expand results from the successful ACIAR/World Vision “low-cost fish feeding” project throughout Northeastern Thailand.
- c) Short Course with focus on bioenergetic modeling and ingredient assessment for *Pangasius* catfish (for Can Tho University to be presented in Vietnamese in early to mid 2007). Dr Brett Glencross (WA Fisheries) and Dr Nguyen Thanh Phuong (Can Tho University) will develop and deliver the course with translation and assistance from Dr Thi Thanh Hien (Can Tho University).

Other Short Courses will also be developed and delivered, particularly in association with ACIAR projects that have an aquaculture nutrition component.

## 12. PRESENTATION OF MASTER CLASS CERTIFICATES

At the conclusion of the Master Class, both participants and lecturers were presented with certificates of completion or appreciation. Lecturers and key people who assisted with the Master Class were also presented with a small gift. Examples of both certificates are presented below:





A selection of photos showing students and lecturers receiving certificates of appreciation from Geoff Allan.

### 13. AUSTRALIAN JOURNALIST AT MASTER CLASS

The ATSE Crawford Fund Public Awareness Program (Ms Cathy Reade) supported an Australian journalist to attend the Master Class for three days during the first week. The journalist was Mr Brydon Coverdale of the Rural Press in Melbourne. He attended the first day of the Master Class and the two days of field trips, and was also able to talk individually to participants and teaching staff outside formal Class teaching. On the other days he attended various meetings organized by the ACIAR Bangkok office to meet with representatives of a number of ACIAR projects in the region and learn more about ACIAR's work and its benefits.

Brydon expressed himself as pleased with the visits and the contacts at the end of his mission, and the results will be seen later as he publishes stories relating to the Master Class and Australian work in the region. He took many photographs, especially during the aquaculture field trips, which should add an extra useful dimension to his articles.

### 14. FEEDBACK FROM PARTICIPANTS

An evaluation form was designed so participants could provide feedback on the course. The evaluation form was anonymous, mainly multiple choice but with sections for comment. A copy of the questionnaire is presented as Appendix 6.

#### *Summary of participants' feedback surveys*

A total of 24 sheets were returned. (Not all respondents filled in all questions).

| Question  | V. helpful | Good | Fair | Not helpful |
|---|------------|------|------|-------------|
| 1.1 Lectures  | 21         | 3    |      |             |
| 1.2 Computer tutorial (Winfeed)                         | 12         | 10   | 2    |             |
| 1.3 Feed formulation practical session                  | 11         | 10   | 3    |             |
| 1.4 Field trips   | 7          | 16   | 1    |             |
|   |            |      |      |             |
| 2.1 Introduction to aquaculture nutrition               | 14         | 9    | 1    |             |
| 2.2 Nutritional requirements of aqua-culture species    | 17         | 7    |      |             |
| 2.3 Assessment of potential feed ingredients            | 16         | 8    |      |             |
| 2.4 Analytical techniques                               | 16         | 6    | 1    |             |
| 2.5 Natural feeds and integrated aquaculture            | 15         | 7    | 2    |             |
| 2.6 Diet Formulation – Introduction to feed formulation | 17         | 7    |      |             |
| 2.7 Feed manufacture                                    | 12         | 11   | 1    |             |
| 2.8 Commercial feeds – pelleting and extrusion          | 15         | 9    |      |             |
| 2.9 Feed management – storage                           | 20         | 2    | 2    |             |
| 2.10 Farm made and laboratory feeds                     | 12         | 11   | 1    |             |
| 2.11 Research methods                                   | 16         | 6    | 1    |             |
| 2.12 Course revision                                    | 16         | 5    | 1    |             |



**1. What was your opinion of the Class materials (e.g. books, CDs, presentations, etc)?**

- Very good; very helpful; well prepared; informative; excellent; satisfactory; very complete; very useful.
- We will transfer to students and people who work in related aquafeed areas. Materials supported presentations of lectures, especially the references, as further readings helps participants to better understand the content.
- Most materials are very useful although some are only applicable to marine species.
- 90% of the content was well prepared and presented. It was easy to understand and follow. Some material was too technical to understand. The best part is we have more downloaded materials to take home and utilise.
- The class materials (hand-outs of printed presentations) should be given in the morning instead of later in the day.

**2. Did you have any language problems? If so, please give details.**

Most people said no problems. Six respondents said people should have spoken more slowly. One said that at first they had trouble but then they got used to people's way of speaking. Two said that the Australians were OK but some of the other participants (including those who lectured) were harder to understand. One said they had a bit of trouble understanding what was spoken, but the Powerpoints and printouts were fine to read.

**3. How has your view of aquaculture nutrition changed as a result of the Class?**

- The main comments were that participants had come to realise that aquaculture nutrition is a broader subject with more facets than they had realised. Several mentioned the importance of environmental considerations that they hadn't realised before, and one also said cost, people and sources of fish ingredients were also important.
- Two said their work will become more systematic, and several said they have become more motivated.
- One said: 'Aquaculture nutrition is very interesting and useful. It is main factor to success in culture of any species... it is art.'
- Another said: 'There are many species of aquatic animals that we didn't know all of their nutritional requirements so from this class we know more data to apply.'
- A third wrote: 'I believed that knowledge gained in the course will certainly make me a specialised aquatic nutrition biologist. The course is well suited to my present job and will be fruitful also to my future work plan.'

**4. Has the range of your professional contacts changed as a result of this Class? If so, please describe what has happened.**

- Most said it had improved a lot. One person said 'No' and one said their range of contacts had improved a bit. They mentioned future networking with other participants, and also being in future contact with the teaching staff (especially if they have any problems).
- One said: 'Yes, because all of the lecturers are the world's predominant aquaculture nutritionists, and they are ready to be contacted any time.'

**5. Were the accommodation, meals and general arrangements appropriate? If not, could you provide details?**

- Comments ranged from satisfactory to good to excellent. One said 'It has some problem with meals'. [Possibly a vegetarian? There was less vegetarian food available except in the buffets.] One said the food was delicious.

- One said that the location in Thailand was good – it is a convenient regional centre for people to get to.
- One said: ‘A group of people who will act as a Secretariat will be appreciated in future Master Class trainings.’
- One person said: ‘Good. I got more than I deserve.’
- A number of people also included comments here on how the Master Class structure and content could have been better. Several said that more field trips would have been good, including to other types of aquaculture – mariculture and brackish water were mentioned. Some also said that more laboratory work would have been good – one person wanted a lot more. One wanted more on Research Methods, and a practical on Statistics.
- One person asked for ‘Field trip for souvenir and tourism resort.’

#### **6. What should be done now to reinforce the activities of this Class?**

- Several people suggested that short follow-up training would be valuable. One suggested that that lecturers/course organisers visit the participants to evaluate how they were getting on, if time and funds were available.
- Several people mentioned that Class participants should keep in touch with each other, partly so that they can keep up with progress in aquaculture, and new developments in the subject. One person suggested a relatively formal network of regional laboratories/scientists (nutritionists) should be set up.
- One person wrote at the end: ‘Thank you for a valuable class.’

#### **15. COMMENT BY DIRECTOR OF MASTER CLASS PROGRAM (PAUL FERRAR)**

I believe that this was an extremely successful Master Class, on a subject of great importance and topicality. The need for more attention to the subject was well described at the annual Crawford Seminar at Australia’s Parliament House two years earlier, at which meeting the idea for this Master Class was born.

The participants were of particularly high calibre, with very good English, and all appeared to gain a great deal from the Master Class.

The program was a good mixture of classroom lectures, laboratory and computer practical sessions and field trips. A large amount of material was presented in the two weeks. As participants were unlikely to be able to absorb all of the material at the time, the teaching team made a great effort to provide Xeroxed copies of every lecture, and also held regular recap sessions. At the end of the Class, a CD was burned for each candidate containing all the presented material plus contact details for all participants and other useful information.

The Master Class was also noteworthy for the amount of valuable background material that was provided to candidates, including key publications on aquaculture, a feed formulation software package, etc. This material is listed in (7) above. I consider this to be a particularly valuable form of assistance because this material will go back to participants’ home departments and will be used by many additional people.

By all appearances the Master Class was also valuable for networking. Most of the participants had not met each other previously, and they interacted very well together during the two weeks of the Class. It is likely that contacts will continue in the region – and with Australia – well after the Class, which will be to the benefit of all.

The Master Class was based at the AIT Conference Centre, which proved a good and very convenient venue. The centre has accommodation (2-3 star rooms) at a reasonable price, plus dining room and

other catering, and a good lecture room with some facilities. Equipment can be hired from AIT if not available from the centre. There are banks, a post office and small shops nearby.

The idea of using NACA as a local agency for organizing travel and other administrative arrangements worked very well. There are many activities that cannot be done easily in advance from Australia, and it was good to arrive and find that all that work had been done. We paid NACA 12% of the total monies handled for the service, which proved excellent value. NACA has indicated that it would be prepared to do the same for any other aquaculture Master Classes held in Thailand in the future. They see it as part of their network function for encouraging and assisting aquaculture in the region.

Two people involved with the organization deserve special mention and thanks. Mrs Helena Heasman undertook the critical task of organizing the logistics before the course and negotiating with everyone involved. Her close attention to detail, extreme efficiency and cheerful persistence were fundamental to the success of the Master Class and made the whole exercise a highly enjoyable experience. The second person who really shouldered a large and critical burden in organization was Ms Wella from NACA. Communicating with some of the participants was very difficult. In many areas, email wasn't available to participants (e.g. parts of PNG) and in others participants could not receive attachments. Mrs Wella still managed to organize all the travel arrangements, apart from visa problems over which she had no control (these are discussed below), none of the participants experience difficulty with travel. Mrs Wella also organized all the *per diems* and reimbursements for participants.

### ***Problems that arose***

The Master Class was generally free of problems, except in relation to visas. Participants had been advised before the Master Class to check whether or not visas were required, and they generally did this. However, two separate problems (affecting four participants) were encountered.

Mr Satya Nandlal, Aquaculture Officer of SPC, travels on a Fijian passport. He had visited Bangkok on many previous occasions and had not required a visa on any occasion. However, the rules regarding Fijian passports had changed since his last visit, and visas are now required. Satya arrived in Bangkok and was refused entry. He was held at the airport by immigration authorities for two days and then put on a plane back to Auckland.

The problem caused a significant distraction at the start of the Master Class to Drs Geoff Allan and Amararatne Yakupitiyage. They spent much time interceding with immigration authorities to explain Satya's position and legitimate status, including obtaining official letters from AIT. They were given conflicting stories by different people in immigration, which added to the confusion and the work to try to get Satya released.

Satya's initial ticket had been bought by SPC as part of their assistance to the Master Class. As he was a lecturer as well as a key participant in the Class, I agreed that Master Class funds should be used to purchase another ticket, and he arrived (with a visa) a week late. However, he worked hard to catch up on the backlog of lecture material, and his contributions to the remainder of the Master Class were such that it was certainly the right decision to support his return.

His initial flight to Bangkok was with Emirates, and that airline was at fault in allowing him to board the aircraft without an appropriate visa. Had he been refused initial boarding, the total delay to his arrival would have been much less.

A different visa problem was encountered by the three participants from Papua New Guinea. They had ascertained that they needed Thai visas and had obtained these. Their flights were from Port Moresby to Brisbane to Sydney to Bangkok, and they had assumed that they would be in transit in

Australia. However, they were not warned by the airline that the flight between Brisbane and Sydney was a domestic Australian flight, for which they needed an Australian transit visa.

In this case it was Qantas that could be regarded as being at fault for not indicating the additional visa requirement. The participants were refused boarding in Port Moresby, and had to wait there an extra day to obtain the necessary Australian visas. This meant extra cost for an unscheduled overnight stay each in Port Moresby. They arrived a day late, which was also unfortunate in that the first day of the Master Class was a key session with much information presented. However, these participants also worked hard to catch up, with extra tuition and assistance kindly provided by Dr Geoff Allan.

The participant from Fiji, Ms Shalini Singh, employed by the Fijian Ministry of Agriculture Fisheries and Forestry, was unable to attend at the last minute when her travel approval was declined. This decision was based on departmental policy relating to her status as a temporary staff member. Shalini will nevertheless receive a copy of all course material and merchandise.



## **16. APPENDICES**

*16.1 List of participants and contact details*

*16.2 Bionotes of lecturers*

*16.3 Full program*

*16.4 Notes on field trips*

*16.5 Resource and reference material*

*16.6 Questionnaire*

## 16.1 LIST OF PARTICIPANTS AND CONTACT DETAILS

| TITLE                   | FIRST NAME | MIDDLE NAME | SURNAME  | ADDRESS 1   | TELEPHONE                        | MOBILE           | FAX                         | EMAIL  |
|-------------------------|------------|-------------|----------|---|----------------------------------|------------------|-----------------------------|--|
| <b>CAMBODIA</b>         |            |             |          |   |                                  |                  |                             |  |
| Mr                      | Chea       |             | Mong     | Royal University of Agriculture, Dangkor District, Phnom Penh, CAMBODIA   | (023) 219 829/219 753            | (855) 12 523 107 | (855) 23 219 690/23 219 753 | <a href="mailto:C_M_mong@yahoo.com">C_M_mong@yahoo.com</a>   |
| Mrs                     | Holl       |             | Tharine  | Royal University of Agriculture, Dangkor District, Phnom Penh, CAMBODIA   | (023) 219 829/219 753            | (855) 11 871 187 | (855) 23 219 690/23 219 753 | <a href="mailto:Tharine_holl@yahoo.com">Tharine_holl@yahoo.com</a>   |
| <b>PAPUA NEW GUINEA</b> |            |             |          |   |                                  |                  |                             |  |
| Ms                      | Irene      |             | Gubag    | Ok Tedi Development Foundation, Ok Tedi Mining Limited, PO Box 1, Tabubil, WP, PAPUA NEW GUINEA                                 | 675 548 3848/675 548 3283        |                  | 675 548 3895/675 548 9348   | <a href="mailto:irene.gubag@oktedi.com">irene.gubag@oktedi.com</a>   |
| Mr                      | Peter      |             | Minimulu | Department of Agriculture & Livestock, Highlands Regional Office, P.O. Box 1075, Goroka 441, EHP, PAPUA NEW GUINEA              | (675) 732 1579 or (675) 732 1627 |                  | (675) 732 3600              | <a href="mailto:c/-jwani@fisheries.gov.pg">c/-jwani@fisheries.gov.pg</a>   |
| Ms                      | Hopa       |             | Simon    | Highlands Aquaculture Development Centre, PO Box 280, Ukarumpa, EHP, PAPUA NEW GUINEA   | (675) 737 3513                   |                  | (675) 737 3526              | <a href="mailto:c/-jwani@fisheries.gov.pg">c/-jwani@fisheries.gov.pg</a>   |
| <b>VIETNAM</b>          |            |             |          |   |                                  |                  |                             |  |
| Mr                      | Trung      | Van         | Dinh     | Research Institute for Aquaculture No. 1, Ding Bang, Tu Son, Bac Ninh   | 0487 80408                       | 0903 411 525     | 0487 85751                  | <a href="mailto:trungria1@yahoo.com">trungria1@yahoo.com</a>   |
| Mr                      | Vinh       |             | Le       | RIA No. 3, 33 Dang Tat Street, Nha Trang City, Khanh Hoa Province, VIETNAM  | (058) 833710                     | 0905 128 665     | (58) 831846                 | <a href="mailto:Levinhtt3@yahoo.com">Levinhtt3@yahoo.com</a>   |
| Dr                      | Hien       | Thi Thanh   | Tran     | College of Aquaculture & Fisheries, Can Tho University, Campus 2, 3/2 Street, Can Tho City, VIETNAM                             | (84-71) 830931                   | (84-91) 8391916  | (84-71) 830323              | <a href="mailto:ttthien@ctu.edu.vn">ttthien@ctu.edu.vn</a>   |
| Mr                      | Tuan       | Anh         | Le       | University of Fisheries, Faculty of Aquaculture, 2 Nguyen Dinh Chieu, Nah Trang, Khanh Hoa, VIETNAM<br><b>STUDENT/PRESENTER</b> | (84-58) 875474                   | (84) 913429198   | (84-58) 831147              | <a href="mailto:leantuan@dng.vnn.vn">leantuan@dng.vnn.vn</a> ,<br><a href="mailto:leanhtuandhts@gmail.com">leanhtuandhts@gmail.com</a> |

|    |                  |          |               |   |                                |                   |                 |  |
|----|------------------|----------|---------------|---|--------------------------------|-------------------|-----------------|--|
| Ms | Ngoc             | Thi Bich | Nguyen        | RIA No. 3, 33 Dang Tat Street, Nha Trang, Khanh Hoa Province, VIETNAM   | (84-58) 833710                 | 0983 747133       | (58) 831846     | <a href="mailto:ntbngoc@dng.vnn.vn">ntbngoc@dng.vnn.vn</a>       |
|    | <b>INDONESIA</b> |          |               |   |                                |                   |                 |  |
| Ms | Sophia           |          | Lasma Sagala  | Research Insitite for Mariculture-Gondol, Bali Ds. Penyabangan, Kec. Grokgak, PO Box 140 Singaraja - Bali 81101, INDONESIA  | (62) 362 92278                 | (62) 812 157 3553 | (62) 362 92272  | <a href="mailto:sophie_id81@yahoo.com">sophie_id81@yahoo.com</a> |
| Mr |                  |          | Usman         | Research Institute for Coastal Aquaculture, Jl. Makmur Dg. Sitakka No. 129, Maros, Sulawesi, Selatan 90511, INDONESIA   | (62 411) 371544                |                   | (62 411) 371545 | <a href="mailto:rsyah@indosat.net.id">rsyah@indosat.net.id</a>   |
| Mr | Reza             |          | Samsudin      | Jl. Semphur No. 1, Bogor, West Java, INDONESIA P.O. Box 150 16154   | 62-251-313200                  | 62-81310969139    | 62-251-327890   | <a href="mailto:jap_oedino@yahoo.com">jap_oedino@yahoo.com</a>   |
|    | <b>INDIA</b>     |          |               |   |                                |                   |                 |  |
| Mr | Josy             |          | Joseph        | Don Bosco Centre, St Xavier's Vocational Training Centre, Bishramganj - 799103, West Tripura District, Tripura, INDIA (to courier use: C/- Mr Samir Saha, STD/XEROX Centre, Surjya Road, Agartala - 799001, Tripura, India Ph: 91-381-2380848; 91-381-2380822 | 91-381-2867555; 91-381-2867594 | 91-9436123473     | 91-381-2865291  | <a href="mailto:mcnrju@yahoo.com">mcnrju@yahoo.com</a>           |
|    | <b>THAILAND</b>  |          |               |   |                                |                   |                 |  |
| Ms | Ubonrat          |          | Limtipsuntorn | c/- AIT (Amara's student)   |                                |                   |                 | <a href="mailto:St103363@ait.ac.th">St103363@ait.ac.th</a>       |
| Mr | Suphol           |          | Phantumaophas | Pokphand Aquatech Co Ltd, 99 Moo 9 banbueng-Klang Rd., T. Nong-i-roon, A. Banbueng, Chonburi THAILAND <b>SPONSORED BY CP</b>  | 034-839622                     | 01-8424670        | 034-839622      | <a href="mailto:anrclab@loxinfo.co.th">anrclab@loxinfo.co.th</a> |

|   |                   |  |                    |  |                             |                  |                    |  |
|---|-------------------|--|--------------------|--|-----------------------------|------------------|--------------------|--|
| Mr  | Somnuek           |  | Wisuttipongtarworn | Bangkok Aquaculture Farm Co, Ltd 313 CP Tower, Silom Road, Bangrak, Bangkok THAILAND 10500<br><b>SPONSORED BY CP</b> | 035-314113                  | 01-9386084       | 035-314113         | nuekw@yahoo.com  |
| Dr  | Dasari            |  | Ajaya Bhaskar      | 69/5 Moo 5 Rama R Road, T. Bangkhantaek. A. Muang, Samutsongkhram 7500, THAILAND <b>SPONSORED BY THAILUXE</b>        | (66) 034 771401             |                  | (66) 034 771406    | ajaya@thailuxe.com, dasariajay@rediffmail.com                      |
| Mrs   | Nuchnaree         |  | Tongsri            | Inland Feed Research Institute, Department of Fisheries, Bangkok 10900, THAILAND                                     | 0-2940-6130-45 EXT. 4512    | 0-1692-7460      | 0-2562-0513        | nuchnareet@fisheries.go.th<br>nuchnareet@hotmail.com               |
| Ms  | Juthamas          |  | Chomphunich        | Inland Feed Research Institute, Department of Fisheries, Bangkok 10900, THAILAND                                     | 0-2940-6130-45 ext. 4512    | 0-1692-7460      | 0-2562-0513        | Porpla_jtm@yahoo.com   |
| Ms  | Montakan          |  | Tamtin             | Coastal Aquatic Feed Research Unit, 122 Moo 1 Laem-pakbia, Amphoe Ban-Laem, Petch Buri, 76100, THAILAND              | 00-66-(0)32-478211 (478210) | 00-66-(1)8618118 | 00-66-(0)32-478211 | mtamtin@hotmail.com  |
| <b>LAO PDR</b>                                      |                   |  |                    |  |                             |                  |                    |  |
| Mr  | Khamsone          |  | Sisaath            | Phonethenh   | 856-21-215014               | 856-20-599-3825  | 856-21-215014      | <a href="mailto:Khamsone13@yahoo.co.uk">Khamsone13@yahoo.co.uk</a> |
| Ms  | Somphouthone      |  | Phimmachak         | Living Aquatic Resource Research Center, Khounta Village, Sikhottabong District, Vientiane Capital, LAO PDR          | (856-21)-215015             | (856-20)76162221 | (856-21)-241855    | phouthavy_00@yahoo.com<br>larrec.aqua@laopdr.com                   |
| <b>PHILIPPINES</b>                                  |                   |  |                    |  |                             |                  |                    |  |
| Mrs   | Rosabella Jumarán |  | Valencia           | Bureau of Fisheries & Aquatic Resources National Inland Fisheries Technology Center 1980 Tanay, Rizal PHILLIPINES    | (02)693-13-89               |                  | (02)693-13-89      | bfarniftc_tanay@yahoo.com.ph                                       |
| Mrs   | Nerafe            |  | Muyalde            | PNR Site San Miguel Calasiao, Pangasinan, PHILLIPINES  | (075) 524-19-04             |                  | (075) 523-03-85    | nerafe12@yahoo.com   |
| <b>FIJI (Student did not attend at last minute)</b> |                   |  |                    |  |                             |                  |                    |  |
| Ms  | Shalini           |  | Singh              | 137 Ragg Avenue, Namadi Heights, Suva, FIJI ISLANDS  | 3321049                     | 9308989          | 3479406            | pete25@connect.com.fj  |



|                      |         |  |        |  |                      |  |  |
|----------------------|---------|--|--------|--|----------------------|--|--|
| <b>NEW CALEDONIA</b> |         |  |        |  |                      |  |  |
| Mr                   | Nandlal |  | Satya  | SPC, B.P. D5 - 98848<br>Noumea CEDEX NEW<br>CALEDONIA<br><b>SPONSORED BY SPC</b> | 687 26 2000 ext. 265 |  | 687 263818<br><a href="mailto:satyaN@spc.int">satyaN@spc.int</a> |
| <b>BANGLADESH</b>    |         |  |        |  |                      |  |  |
| Ms                   | Muslima |  | Khatun | c/- AIT (Amara's student)  |                      |  | <a href="mailto:St103809@ait.ac.th">St103809@ait.ac.th</a>       |

## 16.2 BIONOTES OF LECTURERS



**DR GEOFF ALLAN**  
**NSW DEPARTMENT OF PRIMARY INDUSTRIES**  
**PORT STEPHENS FISHERIES CENTRE**  
**PRIVATE BAG 1**  
**NELSON BAY NSW 2315**  
**Tel: +61-249-163816**  
**Fax: +61-249-821107**  
**Email: [Geoff.Allan@dpi.nsw.gov.au](mailto:Geoff.Allan@dpi.nsw.gov.au)**

Dr Geoff Allan is employed by NSW Department of Primary Industries as the Research Leader, Aquaculture, and he is Centre Director of the Port Stephens Fisheries Centre, NSW, Australia. He conducts and supervises aquaculture research on freshwater and marine fish, molluscs and crustaceans at PSFC as well as two other research centres. He has coordinated major national and international projects on aquaculture feeds and feeding with a particular emphasis on replacing fishmeal. He is currently a project leader for the Australian Aquafin Cooperative Research Centre for a project on developing feeding technology for temperate marine fish. Geoff is also coordinating a national program to help develop commercial aquaculture industries using inland saline water. Geoff has published over 150 scientific manuscripts and reports and presented more than 50 papers at National and International Conferences over the last eight years.

Geoff is also a Program Consultant on Aquaculture for the Australian Centre for International Agricultural Research (ACIAR) and helps that agency develop collaborative research projects to benefit Australia and developing countries. In this capacity, he has worked in Southeast Asian and Pacific countries, particularly with projects on aquaculture nutrition. Geoff is a founding member and Trustee of the charity, Aquaculture without Frontiers (AwF). He is a Past-President of the World Aquaculture Society (2003/04) and the Asian Pacific Chapter of the World Aquaculture Society. Geoff serves on the editorial board of Aquaculture Research, Asian Fisheries Science, International Aquafeed and the Korean Journal of Aquaculture.



**DR. MALI BOONYARATPALIN**  
**FISHERIES ADVISOR**  
**DEPARTMENT OF FISHERIES**  
**CHATUCHAK, BANGKOK 10900**  
**THAILAND**  
**Tel: +66-2 562 0557**  
**Fax: +66-2 562 0561**  
**Mobile: +66-9892 1417**  
**Email: [boonyaratpalin@yahoo.com](mailto:boonyaratpalin@yahoo.com)**

Dr. Mali Boonyaratpalin is a retired fish nutritionist with over 35 years of experience in Thailand and overseas. She graduated with B. Sc. in Fisheries from Kasetsart University in Bangkok and was awarded USAID Scholarships to pursue her higher degrees at Auburn University. She received her Ph. D. in 1978, with Swingle Award and a few others for excellence in academic and research achievement. Since then, she worked with the Department of Fisheries where she published in excess of 75 papers. The spectacular success in research career has made her one of the best known fish nutritionist in Asia and the Pacific. She chairs countless number of governmental as well as international projects in aquaculture with particular focus on aquatic feed development. She has contributed her research expertise in performing academic role in several tertiary educational institutions in Thailand. More recently she has dedicated to the implementation of technical advancement for more sustainable aquaculture development through alternative candidates for farming such as seaweeds and abalone. She also cares for the livelihood of local inhabitants in remote areas where raw fishery materials are available for processing into value-added products.



**DR MARK BOOTH**  
**NSW DEPARTMENT OF PRIMARY INDUSTRIES**  
**PORT STEPHENS FISHERIES CENTRE**  
**PRIVATE BAG 1**  
**NELSON BAY NSW 2315**  
**Tel: +61-249-163816**  
**Fax: +61-249-821107**  
**Email: [Mark.booth@dpi.nsw.gov.au](mailto:Mark.booth@dpi.nsw.gov.au)**

Dr Mark Booth has been employed by NSW DPI Fisheries (PSFC) for approximately 11 years. He was awarded his doctorate for studies on the nutritional requirements of Australian snapper *Pagrus auratus* (= red sea bream) and has authored or co-authored approximately 20 manuscripts in peer reviewed journals and several extensive project reports on the nutrition of the omnivorous silver perch *Bidyanus bidyanus*. Prior to this he completed a BSc (Hons 1<sup>st</sup> Class) in Aquatic Science at Deakin University Warrnambool. Most recently Mark has been involved in collaborative research between NSW DPI Fisheries and the Aquafin CRC for the Sustainable Aquaculture of Finfish studying the nutrition of temperate marine species including Australian snapper and mullet. Before this, Mark was involved with collaborative research between NSW DPI Fisheries and the Thailand Department of Fisheries funded by the Australian Centre for International Agricultural Research (ACIAR). In addition he has been involved in the applied and theoretical aspects of both the Fishmeal Replacement and Aquaculture Diet Development sub programs (silver perch) funded predominantly by the Australian Fisheries Research and Development Corporation (FRDC). He has also conducted aquaculture research on *P. monodon* and Atlantic salmon for commercial feed companies. He has co-supervised the projects of several students studying for their honours or PhD qualifications on a range of topics including fatty acid requirements, skin colour, utilization of carbohydrates, feed attractants, impacts of environmental variables on feed intake and the factorial modeling of nutrient requirements. Mark is interested in all aspects of fish nutrition, particularly the use of alternative feed ingredients.



**PROFESSOR PETER EDWARDS**  
**EMERITUS PROFESSOR**  
**ASIAN INSTITUTE OF TECHNOLOGY**  
**HOME ADDRESS: 593 LAT PRAO SOI 64,**  
**BANGKOK 10310, THAILAND**  
**Tel: +66-2-5386551**  
**Fax: +66-2-5300660**  
**Fax: +61-249-821107**  
**Email: [pedwards@ait.ac.th](mailto:pedwards@ait.ac.th)**

Professor Edwards has experience in education, research and development in the aquatic environment with emphasis on aquaculture. He studied and held university posts in UK and USA but for the past 30 years has been based at the Asian Institute of Technology (AIT) where he established the aquaculture program in 1981 and currently holds the post of Emeritus Professor. Following an early career in seaweed ecology he became involved in environmental engineering at AIT before specializing in aquaculture. Research into wastewater treatment through aquaculture progressed to treatment of livestock manures, integrated farming systems and systems approaches with emphasis on small-scale farming and poverty alleviation. He continues to be involved in curriculum development and teaching at AIT and with national universities in the region through the Outreach program. He supervised 6 Doctoral and over 30 Master's students and was awarded over 20 research grants. He has published over 100 papers, half in refereed international journals, several reviews, and 2 authored and 3 edited books. Major consultancies include a UNDP/FAO assignment on integrated farming in China in 1981; consultant to UNDP / World Bank to produce state-of-the-art reviews of wastewater-fed aquaculture in 1982 and 1986/7; Chair of Working Group on Research Needs in Aquaculture in Developing Countries through the World Bank executed Study on International Fisheries Research in Paris in 1989; Aquaculture Specialist for the Danida funded Mekong River Commission Fishery Sector Policy Review of the Lower Mekong Basin in 1991/2; consultant to the FAO/APFIC Ad Hoc Working Group of Experts on Rural Aquaculture in Bangkok in 1999; review of research needs in feeds and feeding fish in Mekong River countries for ACIAR in 2001 and trash fish in Vietnam in 2003; Aquaculture Development Specialist for the ADB study 'An Evaluation of Small-scale Freshwater Rural Aquaculture Development for Poverty Reduction' in 2004; and member of the working group to revise the WHO Guidelines for the Safe Use of Wastewater and Excreta in Aquaculture in 2005.





**DR PAUL FERRAR**  
**DIRECTOR, MASTER CLASS PROGRAM**  
**THE ATSE CRAWFORD FUND**  
**C/- PO BOX 216, CURTIN ACT 2605**  
**AUSTRALIA**  
**Mobile phone: +61-418-252546**  
**Fax: +61-2-6161-4843**  
**Email: [pferrar@netspeed.com.au](mailto:pferrar@netspeed.com.au)**

Dr Paul Ferrar is a graduate of Cambridge University, UK. He is currently the Director of the Master Class Program of the ATSE Crawford Fund. He retired from the Australian Centre for International Agricultural Research (ACIAR) in 2004, after a number of years as Research Program Manager for Crop Protection. In that role he acquired an interest in quarantine and biosecurity, including in relation to aquaculture and animal health as well as plant pests and diseases. However, he knows nothing else about aquaculture except as a keen consumer of its products. He is looking forward to learning more through this Master Class.

Before joining ACIAR he worked for the Australian research organization CSIRO on biological control of dung-breeding flies, and then on termites as recyclers of dead cellulose material in African savannas. He has written a number of entomological papers, including a two-volume reference work on fly larvae – all you ever wanted to know about maggots but didn't like to ask....



**DR BRETT GLENCROSS**  
**W.A. DEPARTMENT OF FISHERIES**  
**PO BOX 20**  
**NORTH BEACH WA 6920**  
**Tel: +61-8920-30224**  
**Fax: +61-8920-30199**  
**Email: [bglencross@fish.wa.gov.au](mailto:bglencross@fish.wa.gov.au)**

Dr Brett Glencross has been employed by WA Department of Fisheries (WADF) for approximately 7 years. Prior to this he worked for the South Australian Research and Development Institute (SARDI). He was awarded his doctorate for studies on the essential fatty acid requirements of Black tiger prawns *Penaeus monodon* while working at the CSIRO. He has authored or co-authored approximately 40 manuscripts in peer reviewed journals and several extensive project reports on the nutrition of a range of fish, crustacean and mollusk species. His experience includes working with Prawns, Rocklobster, Abalone, Yellowtail kingfish, Asian seabass, Atlantic salmon, Rainbow trout, Red seabream, Silver perch, Tilapia, Pangasius catfish and Tuna among others. Prior to his PhD he also completed an MSc in Agricultural Biochemistry and he also has a BSc (Hons 1<sup>st</sup> Class) in Biochemistry. In recent years he has been the Program Manager for the Australian Aquaculture Feed Grains Program, which coordinates the national research on grain use in aquaculture feeds. In this role he has also been undertaking research projects on the application of lupin and canola products in aquaculture diets for the replacement of fishmeals and oils. He is also managing research projects examining the development of feeds and feeding management, nutritional models, flesh quality assessment and disease management for Asian seabass. He is presently also involved in research in Vietnam and Cambodia on ingredient assessment and diet development for Tilapia and Pangasius catfish. He has also conducted aquaculture research on Prawns, Asian seabass, Rainbow trout and Atlantic salmon for commercial feed companies. He has supervised the projects of several students studying for their honours or PhD qualifications on a range of topics including ingredient assessment, diet development, environmental impact assessment and utilization of carbohydrates. Brett is interested in all aspects of fish nutrition, particularly the nutritional and processing aspects of the use feed grain ingredients, bioenergetics and the development of models and molecular tools for use in nutrition research.



**MR LE ANH TUAN**  
**DEPARTMENT OF FISH NUTRITION AND**  
**AQUAFEEDS FACULTY OF AQUACULTURE**  
**UNIVERSITY OF FISHERIES**  
**2 NGUYEN DINH CHIEU STR., NHA TRANG,**  
**VIETNAM.**

**Tel: +84-(0) 58-831149-173**

**Fax: +84-(0) 58-831147**

**Email: [leanhtuan@dng.vnn.vn](mailto:leanhtuan@dng.vnn.vn)**

After completing his BSc in Aquaculture in 1993 at the University of Fisheries, Tuan was appointed as a lecturer in the Department of Coastal Aquaculture specializing in seaweed cultivation. Between 1997 and 1998 he completed an MSc in aquaculture at the Asian Institute of Technology (AIT), Thailand. On returning to the university in 1998, Tuan led the Vietnamese components of several international aquaculture research projects including two DFID projects on marine cage aquaculture and on estimation and allocation of environmental capacity for aquaculture (Tropeca project), an AusAID CARD project on building aquafeed R&D capacity in Vietnam and the nutrition component of a Norad project. Currently, he leads the nutrition research being carried out by University of Fisheries in an ACIAR spiny rock aquaculture lobster project. Tuan has almost completed his PhD research on malabar grouper nutrition at the University of Fisheries under the supervision of Drs Kevin Williams (CSIRO) and Nguyen Huu Dung (UoF).



**MR SATYA NANDLAL**  
**AQUACULTURE OFFICER**  
**SPC-SECRETARIAT OF THE PACIFIC**  
**COMMUNITY**  
**BP D5-98848 NOUMEA CEDEX**  
**NEW CALEDONIA**  
**Tel: +687 262000 ext.265**  
**Fax: + 687 263818**  
**Email: [SatyaN@spc.int](mailto:SatyaN@spc.int)**  
**Web: [www.spc.int/aquaculture](http://www.spc.int/aquaculture)**

Satya Nandlal is employed by Secretariat of the Pacific Community, Noumea, New Caledonia as the Aquaculture Officer. His main role is to advise and assist Pacific island government department and private sector operators in the establishment of environmentally and economically sustainable aquaculture. His other duties involve developing aquaculture extension services with a particular focus on the capacity of human resources, providing practical hands-on support to aquaculture ventures and also assisting Pacific island governments and private sector to assess aquaculture investment proposals and projects and draw up practical plans, policies or regulations governing aquaculture.

Prior to joining SPC in 2003, Satya worked for 2 years at the Institute of Marine Resources of the University of the South Pacific, Suva, Fiji as a Research Fellow, carrying out consultancies in aquaculture, training and some teaching.

Satya worked for Fisheries Division, Ministry of Fisheries and Forest of Fiji from 1981 to 2001 carrying out various activities, managing programs and projects in aquaculture research, extension, development and training.

Satya is presently studying part-time to finish his PhD studies too.



**DR NGUYỄN THANH PHUONG**  
**ASSOCIATE PROFESSOR OF AQUACULTURE**  
**DEAN, COLLEGE OF AQUACULTURE &**  
**FISHERIES,**  
**CAN THO UNIVERSITY**  
**3/2 STREET, NINH KIEU DIST., CAN THO CITY,**  
**VIET NAM**  
**Tel: +84-71-835701**  
**Fax: +84-71-830323**  
**Email: [ntphuong@ctu.edu.vn](mailto:ntphuong@ctu.edu.vn)**

Dr. Nguyen Thanh Phuong has been employed by Can Tho University in 1986 when he finished his Bsc. degree in aquaculture in this University. He started his career by teaching and doing researches on marine shrimp hatchery and farming. He then completed his Msc. in Aquaculture in Asian Institute of Technology in 1992. In 1995, Mr. Phuong began his Ph.D program and started new research subject on catfish nutrition, and he successfully defended his Ph.D thesis on the nutritional requirements and feed development for *Pangasius* catfish in 1998 in Institut Nationale Polytechnique de Toulouse, France. He is one of pioneer scientists working on nutrition and feeding of *Pangasius* catfish. Dr. Phuong is involving in several research projects on aquatic organism nutrition and feed development such as climbing perch (*Anabas testudineus*); giant freshwater prawn (*Macrobrachium rosenbergii*); snakehead (*Channa micropeltes*) and Tilapia (*Oreochromis niloticus*) in his College. He is recently leading an ACIAR-funded project studying on feeds and feeding for small scale aquaculture systems focusing on catfishes and Tilapia. Dr. Phuong is also leading and involving some research projects on biology, induced breeding and culture of marine finfish, shrimps and prawns. Dr. Phuong has authored and co-authored of more than 10 peer review papers and conference proceedings; and approximately 20 papers in Vietnamese journals and workshop proceedings. Dr. Nguyen Thanh Phuong is teaching courses on coastal aquaculture systems and scientific research methodologies for bachelor and master students; and supervising theses of bachelor, master and doctoral students.





**MR IGOR PIROZZI**  
**NSW DEPARTMENT OF PRIMARY INDUSTRIES**  
**PORT STEPHENS FISHERIES CENTRE**  
**PRIVATE BAG 1**  
**NELSON BAY NSW 2315**  
**Tel: +61-249-163916**  
**Fax: +61-249-821107**  
**Email: [Igor.Pirozzi@dpi.nsw.gov.au](mailto:Igor.Pirozzi@dpi.nsw.gov.au)**

Igor commenced his PhD in March 2005 through James Cook University and is currently based at NSW Department of Primary Industries Fisheries at Port Stephens. His current research involves establishing the protein and energy requirements of mullocky, *Argyrosomus japonicus*, to develop quantitative models that predict optimal feed composition and waste output. Igor graduated with a BSc (Hons) from the University of Newcastle in 2004 researching the ecology of the abalone *Haliotis coccoradiata*. He also has a Diploma in Applied Science.

Prior to commencing his PhD studies, Igor was employed by NSW DPI in Aquaculture Research working with abalone, sea urchins and flat oysters. He has previously worked in Conservation Research for NSW DPI on introduced marine pests. Igor has also worked as a technician for the University of Newcastle in Medicine & Health Science, Geoscience and also for Sydney University in Veterinary Anatomy.



**DAVID M. SMITH** BAppSc  
**PRINCIPAL RESEARCH SCIENTIST**  
**(AQUACULTURE NUTRITION)**  
**CSIRO MARINE & ATMOSPHERIC RESEARCH**  
**PO BOX 120**  
**CLEVELAND QLD 4163, AUSTRALIA**  
**Tel: +61-7 3826 7239**  
**Fax: +61-7 3826 7281**  
**Email: [david.m.smith@csiro.au](mailto:david.m.smith@csiro.au)**

David Smith has worked for CSIRO studying crustacean physiology and nutrition for 35 years, and has led the crustacean nutrition research at CSIRO Marine Research since 1991. He has been Principal Investigator of projects studying nutrient requirements, feeding strategies, developing new diets, and investigating replacement of fishmeal with terrestrial ingredients. This research has mainly involved working with prawns, particularly the brown tiger prawn (*Penaeus esculentus*) and the black tiger prawn (*P. monodon*). More recently he has been involved in research studying the nutrition of finfish – silver perch (*Bidyanus bidyanus*) and barramundi cod (*Cromileptes altivelis*), and larval and juvenile tropical rock lobsters (*Panulirus ornatus*).

He led the broodstock nutrition research in a 3-year, Fisheries Research and Development Corporation Project (Project 92/51) investigating factors affecting the reproductive performance of captive and wild broodstock prawns. Since 1993, David successfully initiated or co-led 15 aquaculture nutrition research projects which together have attracted external earnings of AUD\$4.9M. Seven of these projects involved multi-agency collaboration with the aquafeed industry, other Divisions of CSIRO, universities and state government agencies.

Over the last ten years, David has been senior author of 10 papers published in peer-reviewed scientific publications, co-author of an additional 24 papers and author of a further 20 technical reports of a significant nature. He has been part of and provided scientific support to trade missions to Indonesia, Thailand and Taiwan promoting the use of Australian-produced feed ingredients for use in aquaculture feeds.

David has a demonstrated commitment to collaboration with Universities, having supervised or co-supervised 2 PhD students, (Ausa Chandumpai, 1988-1990, University of New England, NSW; Brett Glencross, 1995-1998, University of Queensland), a Masters Student (Daniel King, 2004, University of Tasmania); and having contributed to the review of project proposals and guidance for many students over the last 10 years.



**DR ROBERT VAN BARNEVELD**  
**BARNEVELD NUTRITION PTY LTD**  
**LEVEL 1, SUITE 11, PLAZA CHAMBERS**  
**3-15 DENNIS RD**  
**SPRINGWOOD QLD 4127**  
**Tel: +61-7-3290-6600**  
**Fax: +61-7-3290-6900**  
**Email: [rob@barneveld.com.au](mailto:rob@barneveld.com.au)**

Dr Robert van Barneveld has specialised in feed evaluation research for monogastrics for the past 15 years. He completed his PhD in 1992 on the effects of heating proteins on the digestibility, availability and utilisation of amino acids for pigs. Subsequently, he has studied the function of non-starch polysaccharides in pig nutrition in his role as a Senior Research Scientist with the South Australian Research and Development Institute.

Robert has operated as a Consultant Research Scientist with Barneveld Nutrition Pty Ltd and as a Consulting Partner with the BECAN Consulting Group since 1998. During that time he has developed many facets of these businesses with some of his current roles including:

- Specialist Director, Australian Pork Ltd
- Director, Pork CRC Ltd
- General Manager, CHM Alliance Pty Ltd (the CHM Alliance is a partnership representing more than 14,000 sows in Australia that also owns PIC Australia and PIC New Zealand);
- Manager, CHM Alliance Science and Technology Program;
- Leader, Fisheries Research and Development Corporation Aquaculture Nutrition Subprogram
- Leader, Fisheries Research and Development Corporation Rock Lobster Enhancement and Aquaculture Subprogram.

Apart from the Rock Lobster Enhancement and Aquaculture Subprogram and the Aquaculture Nutrition Subprogram, Robert has been actively involved with tuna nutrition research since 1994 and currently provides nutrition consultancy services to the abalone, barramundi, prawn, sea urchin and crocodile industries. He was also responsible for the development and construction of the Australasian Experimental Stockfeed Extrusion Centre.

Dr van Barneveld has secured research funding exceeding \$20 million since 1993 and recently led the bid to secure the \$81.4 million Cooperative Research Centre for an Internationally Competitive Pork Industry.

Robert received the Australian Society of Animal Production Young Scientist Award in 1992 and was recipient of the inaugural Batterham Memorial Award from the Australasian Pig Science Association in 1995 for his contributions to pig science. Robert was awarded the 1998 Nutrition Society of Australia Research Award for his research into feed evaluation for monogastrics.

Dr van Barneveld currently holds adjunct Associate Professor positions at the University of Queensland (Faculty of Natural Resources, Agriculture and Veterinary Science) and the University of New England (School of Rural Science and Agriculture).



**DR KEVIN C WILLIAMS**  
**CSIRO MARINE & ATMOSPHERIC RESEARCH PO**  
**BOX 120**  
**CLEVELAND QLD 4163 AUSTRALIA**  
**Tel: +61-7-38267284**  
**Fax: +61-7-38267222**  
**Email: [kevin.williams@csiro.au](mailto:kevin.williams@csiro.au)**

Dr Williams is a veterinary graduate of the University of Queensland and has a PhD from Melbourne University for studies on amino acid metabolism in pigs. For the first 25 years of his career, he was employed by the Queensland Department of Primary Industries where he conducted or managed nutritional research for the Australian intensive pig and poultry industries. This work entailed detailed nutrient requirement studies, particularly amino acid to energy relationships for all classes of pigs, assessment of the nutritive value of alternative protein and energy feed ingredients for pigs and poultry and mould and mycotoxin toxicity studies with pigs and poultry.

Since 1992, Kevin has applied the nutritional skills honed in the intensive pig and poultry industries to the rapidly expanding aquaculture industry. In 1995, he joined CSIRO's Division of Fisheries (now Marine & Atmospheric Research) to lead the aquaculture nutrition group with research management responsibilities for laboratories in Brisbane and Hobart. He has been the leader or co-leader of multi-organization national and international aquaculture research projects in Vietnam, Indonesia, Thailand and the Philippines. His current international research projects involve work with groupers (Indonesia and Vietnam) and spiny lobsters (Vietnam). He has presented his research results widely at international conferences and has been actively involved in the organization of national and international aquaculture conferences. He is a scientific advisor for several international research funding agencies and a regular reviewer of scientific papers submitted to journals such as *Aquaculture*, *Aquaculture Nutrition*, *Aquaculture Research* etc. His recent research interests include nutritional requirement determination and feed's development for farmed barramundi (Asian seabass, *Lates calcarifer*), groupers (*Cromileptes* and *Epinephelus*) marine shrimp (predominantly *Penaeus monodon*) and spiny lobsters (*Panulirus* and *Jasus*). He has authored more than 100 scientific publications in international journals and proceedings with 53 of these reporting the results of his research with aquaculture species.



**DR THOMAS WILSON**  
**THAI LUXE ENTERPRISES PUBLIC**  
**COMPANY LIMITED,**  
**69/5 MOO 5, RAMA 2 ROAD, T.**  
**BANGKHANTA EK, A. MUANG,**  
**SAMUTSONGKHRAM, THAILAND 75000**  
**Tel: +66-34-771-444 (auto)**  
**Fax: +66-34-771-406**  
**Email : [thomas@thailuxe.com](mailto:thomas@thailuxe.com)**

Dr. Thomas Wilson has been employed by Thai Luxe Enterprises for 9 years out of the 14+ years he has lived in Thailand. Thai Luxe started shrimp feed production in 1987, and now has one shrimp feed factory and two fish feed factories in Thailand and a joint-venture shrimp feed factory in Vietnam. At the moment, in addition to being the nutritionist and formulator of both fish and shrimp feeds, he is also a Vice President, Chief Technical Officer, head of fish and shrimp feed production, QA/QC and R&D and a member of the Board of Directors.

Thomas grew up far away from the ocean in the Yukon Territory, Canada, but decided to pursue a career growing food in the ocean after watching Jacques Cousteau on television in the 1960's. After obtaining his B.Sc. in Marine Biology (1978) at the University of Victoria, British Columbia, Thomas worked for the Department of Fisheries and Oceans, Govt. of Canada, first as a technician in a marine geology laboratory, and later as a technologist in a Japanese-style chum salmon hatchery on Vancouver Island, British Columbia. In 1982, Thomas moved to attend the School of Fisheries, University of Washington, Seattle, USA, where he completed his MSc. in aquaculture related to Oregon salmon ranching (1986) and his Ph.D (1992) for research on the successful use of full fat soybean meal in diets for Chinook salmon (*Oncorhynchus tshawytscha*), under the supervision of Dr. John E. Halver and Dr. Ronald Hardy, with funding and cooperation from Ewos Canada.

During his time at the UW, he served 9 years as teaching assistant for Dr. Halver, and was happiest when teaching the FAO-sponsored "Fish Feed Technology" classes for international students and researchers in 1984, 1986 and 1989. Thomas first came to Thailand to work in 1991 as an expert in feed technology for the FAO/UNDP on a project at the Department of Fisheries, teaching researchers how to make extruded feed. Being practically minded and service oriented, Thomas chose to seek employment in the feed industry, and opportunities were greater in Thailand than in Canada.



**DR. AMARARATNE YAKUPITIYAGE**  
**ASSOCIATE PROFESSOR & COORDINATOR**  
**AQUACULTURE AND AQUATIC RESOURCES**  
**MANAGEMENT FIELD OF STUDY**  
**ASIAN INSTITUTE OF TECHNOLOGY**  
**GPO BOX 4, PATHUMTHANI 12120**  
**THAILAND**

**Tel: +66-2 524 5456**

**Fax: +66-2 524 6200**

**Email: [amara@ait.ac.th](mailto:amara@ait.ac.th)**

**<http://www.agri-aqua.ait.ac.th>**

Dr. Yakupitiyage obtained B.SC from Kelaniya University, Sri Lanka in 1979, M.Sc. from AIT in 1984 and Ph. D (Aquaculture) from University of Sterling, Scotland in 1989. Since then he has been teaching at the Asian Institute of Technology, Pathumthani, Thailand on aquaculture nutrition, aquatic resource management and research methods for aquaculture and aquatic resources management, and analytical techniques for Aquaculture research. He conducts research on aquaculture nutrition, aquaculture systems and sustainable management of wild aquatic resources. He closely works with AIT's Aqua Outreach Programme to conduct field research and engage in capacity building activities related to aquaculture and aquatic resource management. In his research and capacity building activities, he emphasizes on the role of aquaculture and wild aquatic resources as an entry point for community development and alleviating poverty. He has supervised over 95 Master's and 15 Doctoral students at the Asian Institute of Technology.



### 16.3 FULL PROGRAM

**ASIAN INSTITUTE OF TECHNOLOGY**  
**KONG LUANG, PATHUMTHANI 12120**  
**BANGKOK**



7-20 AUGUST 2006



Australian Government  
Australian Centre for  
International Agricultural Research

### PROGRAM

#### *Duties of Session Chairs*

1. Decide on presenters for each module.
2. Collate/write workshop “notes” for each session (can get presenters of modules to help). Include key references (to be provided to students) and bibliography (not to be provided).
3. Prepare powerpoint presentations (using course template).
4. “Chair” session.
5. Lead discussion for revision/recap module.
6. All powerpoint presentations (or draft versions) to be forwarded to Geoff/Helena prior to Master Class.

N.B. Modules are now 40 minutes each with a break of 5 minutes. However, lecturers with consecutive modules may wish to reduce their modules further to 35 minutes with a break of 10 minutes. This is entirely a matter of personal preference.

## MONDAY 7<sup>TH</sup> AUGUST

### 1. Introduction to Aquaculture Nutrition

**Duration:** #1: 6 x 45 min modules

**Session coordinator:** Kevin Williams

**Trainers:** Mali Boonyaratpalin, Brett Glencross, Mark Booth, Geoff Allan & Kevin Williams

| TITLE   | LECTURER                  | TIME        |
|---|---------------------------|-------------|
| Welcome and introductions   | GEOFF ALLAN & PAUL FERRAR | 9:00-9:40   |
| 1.1 Type & function of nutrients: protein/amino acids; lipid/essential lipids           | KEVIN WILLIAMS            | 9:45–10:25  |
| <b>MORNING TEA</b>  |                           |             |
| 1.2 Type & function of nutrients: carbohydrate/fibre/macro & trace minerals; vitamins   | MALI BOONYARATPALIN       | 11:00–11:40 |
| 1.3 Physiology of digestion: Structure of gastrointestinal tract and passage of digesta | MARK BOOTH                | 11:45–12:25 |
| <b>LUNCH</b>  |                           |             |
| 1.4 Physiology of digestion: Enzymic digestion of carbohydrate, protein and lipid       | GEOFF ALLAN               | 13:45–14:25 |
| 1.5 Nutritional biochemistry 1 (protein metabolism, lipid metabolism)                   | BRETT GLENCROSS           | 14:30–15:10 |
| <b>AFTERNOON TEA</b>  |                           |             |
| 1.6 Nutritional biochemistry 2 (carbohydrate metabolism, energy metabolism)             | BRETT GLENCROSS           | 15:45–16:30 |

## TUESDAY 8<sup>TH</sup> AUGUST

### 2. Nutritional requirements of aquaculture species

**Duration:** #1: 1 x 45 min revision/recap  
#2: 6 x 45 min modules

**Session Coordinator:** Kevin Williams  
**Trainers:** Geoff Allan, Igor Birozzi, Brett Glencross, Phuong Thanh Nguyen, David Smith & Amara Yakupititage

| TITLE  | LECTURER                | TIME        |
|--|-------------------------|-------------|
| #1 Recap   | KEVIN WILLIAMS          | 9:00-9:45   |
| 2.1 Nutritional requirements 1 (essential <i>vis a vis</i> non-essential nutrient; gross vs digestible nutrient; animal requirement <i>vis a vis</i> diet specification) | GEOFF ALLAN             | 9:45–10:25  |
| <b>MORNING TEA</b>   |                         |             |
| 2.2 Nutritional requirements 2 (Nutritional requirements of Asian herbivorous and omnivorous finfish – carp, tilapia and milkfish)                                       | AMARARATNE YAKUPITIYAGE | 11:00–11:40 |
| 2.3 Nutritional requirements 3 (Nutritional requirements of carnivorous finfish – Asian seabass, trout and grouper)  | BRETT GLENCROSS         | 11:45–12:25 |
| <b>LUNCH</b>   |                         |             |
| 2.4 Nutritional requirements 4 (Nutritional requirements of Australian silver perch and snapper)   | GEOFF ALLAN             | 14:15–14:55 |
| 2.5 Nutritional requirements 5 (Nutritional requirements of marine shrimp)   | DAVID SMITH             | 15:00–15:40 |
| <b>AFTERNOON TEA</b>   |                         |             |
| 2.6 Development of feeds & feeding systems for catfish culture in Vietnam  | NGUYEN THANH PHUONG     | 16:15–16:55 |
| 2.7 Feeding aquaculture species in the Pacific   | SATYA NANDLAL           | 17:00-17:30 |

**Proposed Lab/Field work:** Nil

**WEDNESDAY 9<sup>TH</sup> AUGUST****3. Assessment of potential feed ingredients****4. Feeding strategies**

**Duration:** #2: 1 x 45 min revision/recap  
 #3: 4 x 45 min modules  
 #4: 2 x 45 min modules  
 #3 & #4: 1 x 45 min revision/recap

**Session Coordinator:** #3: Geoff Allan; #4 Brett Glencross

**Trainers:** Geoff Allan, Mark Booth, Brett Glencross, Le Anh Tuan, David Smith

| TITLE  | LECTURER                                      | TIME        |
|--|---|-------------|
| #2 Recap   | KEVIN WILLIAMS                                | 9:00-9:40   |
| 3.1 Status of use and efforts to reduce use of trash fish in aquaculture   | LE ANH TUAN                                   | 9:45–10:25  |
| <b>MORNING TEA</b>   |   |             |
| 3.2 Nutritive value of feed ingredients (gross, digestible, utilizable; energy balance tree; compositional differences between ingredients; effects of processing) | MARK BOOTH                                    | 11:00–11:40 |
| 3.3 Feed ingredient restrictions (attractants, anti-nutritional/growth inhibitor factors)  | BRETT GLENCROSS                               | 11:45–12:25 |
| <b>LUNCH</b>   |   |             |
| 3.4 Fish meal replacement (need for; problems in interpreting reported work; impact on marketability/product quality; examples for fish and shellfish)             | GEOFF ALLAN                                   | 13:45–14:25 |
| 4.1 Introduction to feeding strategies – why important (feeding preference of animal, rate of passage, leaching, improving FCR, timing of feeding)                 | BRETT GLENCROSS                               | 14:30-15:10 |
| <b>AFTERNOON TEA</b>   |   |             |
| 4.2 Feeding practices for fish and shrimp  | DAVID SMITH<br>(shrimp) GEOFF<br>ALLAN (fish) | 15:45–16:25 |
| #3 & #4 Recap  | GEOFF ALLAN                                   | 16:30-17:15 |

**Proposed Lab/Field work: Nil**

## THURSDAY 10<sup>TH</sup> AUGUST

### Field Trip 1

Field trip to CP Feed Mill in Ban Pai; snakehead/catfish/giant catfish farm; macrobrachium farm: 9:00-17:00

## FRIDAY 11<sup>TH</sup> AUGUST

### Field Trip 2

Field trip to shrimp farms; DoF grouper hatchery:  
9:00-17:00

## SATURDAY 12<sup>TH</sup> AUGUST

### 5. Analytical techniques

**Duration:** #5: 6 x 45 min modules  
#5: 1 x 45 min revision/recap  
**Session Coordinator:** David Smith  
**Trainers:** Mark Booth, Brett Glencross, David Smith

| TITLE  | LECTURER        | TIME        |
|--|-----------------|-------------|
| 5.1 Introduction to nutritional analysis (sample preparation, laboratory safe working, quality control; replication)         | DAVID SMITH     | 9:00-9:40   |
| 5.2 Methods & interpretation (DM, ash & N)   | MARK BOOTH      | 9:45–10:25  |
| MORNING TEA  |                 |             |
| 5.3 Methods & interpretation (amino acids and other N forms)   | DAVID SMITH     | 11:00–11:40 |
| 5.4 Methods & interpretation (crude fat, total lipid & neutral & polar lipids)   | BRETT GLENCROSS | 11:45–12:25 |
| LUNCH  |                 |             |
| 5.5 Methods & interpretation (lipid class – fatty acids, cholesterol & phospholipids)  | DAVID SMITH     | 13:45–14:25 |
| 5.6 Methods & interpretation (other common nutritional analyses – chromium, acid insoluble ash) incl. Carbohydrate & Starch. | DAVID SMITH     | 14:30–15:10 |
| AFTERNOON TEA  |                 |             |
| #5 Recap   | DAVID SMITH     | 15:45–16:30 |
| <b>Proposed Lab/Field work: Tour of AIT laboratory facilities – Amara to lead.</b>   |                 |             |

**SUNDAY 13<sup>TH</sup> AUGUST**

**Free day – private study**



## MONDAY 14<sup>TH</sup> AUGUST

### 6. Natural feeds & integrated aquaculture

### 7. Diet formulation – introduction to feed formulation

**Duration:** #6: 3 x 45 min modules; **Plus** shared 1 x 45 min revision/recap; **Plus** Field trips previous Thursday & Friday  
#7: 3 x 45 min modules; **Plus** shared 1 x 45 min revision/recap  
**Plus** lab tutorial/practice on Tuesday 15<sup>th</sup> August

**Session Coordinator:** #6: Peter Edwards; #7: David Smith

**Trainers:** Peter Edwards, David Smith, Amararatne Yakupitiyage, Rob van Barneveld

| TITLE  | LECTURER                    | TIME        |
|--|-----------------------------|-------------|
| 6.1 Nutrient dynamics in ponds (feeding the animal or the pond; nutrient pathways; stocking intensity; species selection; shrimp pond fertilization practices; minimizing environmental impacts)   | PETER EDWARDS               | 9:00-9:40   |
| 6.2 Integrated livestock-fish farming (history; types of farming systems (livestock type and aqua species); rice-shrimp culture; nutrient value of animal manures; managing water quality; human health aspects)   | PETER EDWARDS               | 9:45-10:25  |
| <b>MORNING TEA</b>   |                             |             |
| 6.3 Economic and marketing aspects of integrated farming (polyculture (species feeding at different tropic levels); economics of alternative farm systems; marketing issues)   | PETER EDWARDS               | 11:00-11:40 |
| 7.1 Science and art of diet formulation (matching animal's requirements to feed ingredient availability and nutrient supply; physical characteristics of feed; animal's acceptance; particle size and mixing uniformity), introduction to least-cost formulation | DAVID SMITH                 | 11:45-12:25 |
| <b>LUNCH</b>   |                             |             |
| 7.2 Methods of formulating diets (manual and software applications) 1  | AMARARATNE YAKUPITIYAGE     | 13:45-14:25 |
| 7.3 Methods of formulating diets (manual and software applications) 2  | ROB VAN BARNEVELD           | 14:30-15:10 |
| <b>AFTERNOON TEA</b>   |                             |             |
| #6, #7 Recap   | PETER EDWARDS & DAVID SMITH | 15:45-16:30 |

**Proposed Lab/Field work:** Field trip to be integrated with other field activities

## **TUESDAY 15<sup>TH</sup> AUGUST**

### **7. Diet formulation – introduction to feed formulation Cont'd – Lab tutorial and practical session**

**Duration:** #7: 8 x 45 min lab tutorial/practice

**Trainers:** Mark Booth, Igor Pirozzi, David Smith, Rob van Barneveld, Amararatne Yakupitiyage

**Proposed Lab/Field work:** Hands-on computer experience with formulating feeds for various template species from a selection of feed ingredients – 9:00-17:00.

Computer will be available from 7:30-17:30 in Room 107A, ground floor, AIT Extension.

**WEDNESDAY 16<sup>TH</sup> AUGUST****8. Feed manufacture – Farm made & Laboratory feeds****9. Commercial feeds – pelleting and extrusion****10. Feed management – storage**

**Duration:** #8: 2 x 45 min modules **Plus** 8 x 45 min practical **Plus** Field trips previous Thursday & Friday  
 #9: 4 x 45 min modules **Plus** Field trips previous Thursday & Friday  
 #10: 2 x 45 min modules

**Session Coordinator:** #8: Mark Booth; #9: Rob van Barneveld; #10 Mark Booth

**Trainers:** Mark Booth, Kevin Williams, Rob van Barneveld, Thom Wilson, Mali Boonyaratpalin (or nominee), Igor Pirozzi

| TITLE  | LECTURER          | TIME        |
|--|-------------------|-------------|
| 8.1 Fundamentals of making pelleted dry diets (ingredient preparation; ingredient selection/suitability; binding procedures; post-manufacture handling & storage)  | MARK BOOTH        | 9:00-9:40   |
| 8.2 Fundamentals of making moist diets (doughs/alginate bound driest, etc) (ingredient preparation, choice of binders; conditioning of mix; pelleting; physical characteristics/water stability; hot/cold set)                       | KEVIN WILLIAMS    | 9:45-10:25  |
| <b>MORNING TEA</b>   |                   |             |
| 9.1 Industrial pelleting and extrusion (differences in formulation and end product; degree of gelatinization, end-product physical characteristics (sink rate, hydration/expansion, handling resilience); conditioning; fat content) | ROB VAN BARNEVELD | 11:00-11:40 |
| 9.2 Industrial pelleting and extrusion continued   | ROB VAN BARNEVELD | 11:45-12:25 |
| <b>LUNCH</b>   |                   |             |
| 9.3 Industry perspective - The real world of industrial fish nutrition   | THOMAS WILSON     | 13:45-14:25 |
| 9.4 Regulatory perspective   | THAI DOF          | 14:30-15:10 |

#10 Cont'd over page

| AFTERNOON TEA   |                  |             |
|---|------------------|-------------|
| 10.1 Best practices for feed storage (cause of deterioration in storage; storage guidelines; rotation and shelf life; protecting nutrients; vermin control) | IGOR PIROZZI     | 15:45–16:25 |
| 10.2 Quality control – a commercial feed manufacturer’s perspective.  | THOMAS<br>WILSON | 16:30–17:15 |

**Proposed Lab/Field work:** Field trip to see farm made feed in use previous Thursday & Friday plus practical session #8.

## THURSDAY 17<sup>TH</sup> AUGUST

### 11. Farm made & Laboratory feeds – Practical session

**Duration:** #11: 8 x 45 min modules

**Session Coordinator:** Rob van Barneveld

**Trainers:** Rob van Barneveld, Thomas Wilson, Mark Booth, Kevin Williams

**Proposed Lab/Field work:** Hands-on experience with making laboratory feeds for various species from a selection of feed ingredients: 9:00-17:00.

Directions to find lab.

## FRIDAY 18<sup>TH</sup> AUGUST

### 12. Research methods

**Duration:** #8, #9, #10, #11: 1 x 45 min revision/recap  
#12: 7 x 45 min modules  
**Session Coordinator:** Kevin Williams  
**Trainers:** Brett Glencross, David Smith, Kevin Williams

| TITLE  | LECTURER                             | TIME        |
|--|--------------------------------------|-------------|
| #8, #9, #10, #11 Recap   | GEOFF ALLAN,<br>ROB VAN<br>BARNEVELD | 9:00-9:40   |
| 12.1 Introduction to experimental design and statistical analysis (Research approach, assumptions of ANOVA, data transformation, statistical interpretation, pseudo-replication)                                   | KEVIN WILLIAMS                       | 9:45-10:25  |
| <b>MORNING TEA</b>   |                                      |             |
| 12.2 Statistical rigor and Power analysis  | DAVID SMITH                          | 11:00-11:40 |
| 12.3 Determining nutrient requirements using empirical methods (alternative experimental designs, 1-factor vs dose-response vs factorial vs kinetic saturation vs D-optimal)                                       | KEVIN WILLIAMS                       | 11:45-12:25 |
| <b>LUNCH</b>   |                                      |             |
| 12.4 Determining nutrient requirements using a factorial approach (nutrient/energy retention, efficiency of utilization, maintenance and growth requirements)  | BRETT<br>GLENCROSS                   | 13:45-14:25 |
| 12.5 Experimental system (size and stocking of experimental unit; uniformity of animals; allocation to treatments; positional effects; monitoring/handling of animals; data collection, anaesthetics)              | DAVID SMITH                          | 14:30-15:10 |
| <b>AFTERNOON TEA</b>   |                                      |             |
| 12.6 Methods for ingredient evaluation ( <i>in vitro</i> or <i>in vivo</i> ; apparent or true digestibility; gravimetric or marker; marker type; substitution procedures and calculation; fecal collection issues) | GEOFF ALLAN                          | 15:45-16:25 |
| 12.7 Experimental protocol (need for and level of detail)  | KEVIN WILLIAMS                       | 16:30-17:15 |

**Proposed Lab/Field work:** Nil



## SATURDAY 19<sup>TH</sup> AUGUST

### 13. Course Revision

**Duration:** #12: 1 x 45 min revision/recap  
#13: 2 x 45 min modules

**Trainers:** All

| TITLE   | LECTURER       | TIME        |
|---|----------------|-------------|
| #12 Recap   | KEVIN WILLIAMS | 9:00-9:45   |
| Review topics identified for further discussion during course                                   | ALL            | 9:45-10:30  |
| MORNING TEA   |                |             |
| Review topics identified for further discussion during course. Course assessment/questionnaire. | ALL            | 11:00-11:45 |
| PRESENTATION OF CERTIFICATES WITH PHOTOS - OFFICIAL LUNCHEON 12:00-14:00                        |                |             |

## 16.4 NOTES ON FIELD TRIPS

### Full Day Field Trip Thursday 10<sup>th</sup> August

#### Farm Visit 1

Mr Chamnien (head of Golden Carp Team – Co-op of >100 farmers)  
Klong 13, Nong Sue District  
Pathumthani

- Farmers used to use water from main irrigation canal to farm tangerines. This industry collapsed.
- Tilapia farming is replacement activity.
- >2000 cages (average ~6x6x2.5 m) in ~20 km stretch of canal.
- Producing sex-reversal red tilapia in 2-phase process; nursery from 45 d, growout phase 120 d. Fingerlings cost 60 Baht for 100 fingerlings @ 0.6 g/fish.
- Produce fish from 300 g – 1 kg/fish @ 50 Baht/kg for fish >550 g/fish and 30-50 Baht/kg for <550 g/fish.
- Feed with FCR of around 1.2:1. Two types small pellets @ 400 Baht/20 kg bag (20 Baht/kg); large pellets @ 380 Baht/20 kg bag (19 Baht/kg). (For both types minimum crude protein was 30%, large pellets had maximum crude fibre 8%, lipid 3%, smaller pellets had maximum crude fibre 6%, lipid 5%.
- Fed to satiation
- Average production ~3 tonnes fish/cage @ 1000 cages ~ 3,000 t.
- Feed cost = 24 Baht/kg return 30-50 Baht/kg.



*Mr Chamnien hand feeding tilapia*

## Farm Visit 2

Mr Thana  
Klong 12  
Nong Sue District  
Pathumthani

- Hybrid walking catfish *C. macrolephalus* female; *C. gariepinus* male.
- 20 ponds @ 0.32 ha (=2 rai) each.
- ~ 15 tonnes fish/pond/6 months = ~45 tonnes/ha production; total fish ~ 600 tonnes/year.
- 28-30 Baht/kg for fish ~ 140-160 g/fish (preferred size).
- Fed chicken waste: entrails give FCR ~ 3:1; skeleton ~ 7:1; bones ~ 8:1 @ cost of 6 Baht/kg entrails; 4 Baht/kg skeleton; 2 Baht/kg bones.
- Fed 400-800 kg/day/pond (depending on fish size) for 5 months.
- Purchase 4 tonnes chicken processing waste/day from factory type of material (entrails/bones & skeleton) depends on factory.
- Fingerlings from hatchery cost 2 Baht for 100 fish (0.02 Baht/fish) very small <5 cm/fish.
- Must get >30% survival to break even: last year had 50%.
- White egrets are predators – string lines and hooks across ponds.



*Poultry waste is used to feed walking catfish at this farm*

### Farm Visit 3

Mrs Maew  
Testhong Farm (Catfish hatchery)  
Klong 13  
Nong Sue District  
Pathumthani

- Hatchery produces  $2 \times 10^6$  fingerlings/day over 8 months of production period from March to October ( $\sim 500 \times 10^6$  fingerlings/year).
- Fingerlings sell for 0.015 Baht each – 15 Baht/ $10^6$
- Farm had 28 tanks, 10 x 5 x 0.5 m for production of *Chlorella* (green algae), *Moina* (live feed) and larval rearing.
- Fertilizers used included inorganics, monosodium glutamate (MSG) plus lime.
- Fish are sold 3 days after hatch.
- Hybrids are female *Clarias macrocephalus* and male *Clarias gariepinus*. Females are native to Thailand and taste good but are slow growing. Males are native to Africa, not popular for the taste but very fast growing. Male broodstock just over a year old weight  $\sim 3\text{-}5$  kg/fish while female broodstock weigh  $\sim 250$  g/fish.
- Males are killed to recover milt; females induced to spawn using carp pituitary extract.
- 40 kg of female fish used to produce  $1 \times 10^6$  fingerlings.



*Left: Egg baskets. Right: Male broodstock catfish Clarias gariepinus*



#### **Farm Visit 4**

Mr Chairwut  
Suanprikthai Muang District  
Pathumthani

- Catfish farm – mixed hybrid and giant catfish
- Ponds are leased. 3 “family” groups lease a total of 30 rai of ponds (1 rai = 0.15 ha).
- Keeps pigs as well as fish. Effluent from pigs washed into pond to keep water green. No significant source of food for fish.
- Has contract with canteen from factory – feeds all kitchen wastes to fish. Some he ferments (by leaving overnight) and this is preferable.
- In 2 large ponds (~ 1-2 ha each) he produced 100 tonnes fish/year. (Takes ~ 1 year to reach market size).
- Stocks 200-300 x 10<sup>3</sup> fingerlings.
- Sale price fish 19-20 Baht/kg depending on size and demand. Giant catfish prices more stable than hybrid catfish.
- Pigs – 4- Baht/kg to farmer; middleman gets 80 Baht/kg; retails butchered at ~ 120 Baht/kg.



*Left: Pigs housed above catfish ponds. Right: Fermenting kitchen/restaurant waste used to feed catfish*

## **Full Day Field Trip Friday 11<sup>th</sup> August**

### **Farm Visit 1**

Amon Luengnaruemitchai  
Managing Director  
Manit Farm, Mono-sex tilapia hatchery  
No Official Host at this site.

- Mono-sex tilapia hatchery facility. Extremely neat and tidy with staff of 10-15 persons.
- Technology for sex reversal and hatchery production learned at AIT (ex student of Dr Amararatne).
- Combined hatchery production of approximately 200 million pieces in 2005.
- Each piece (fingerling) is sold for about 0.3 baht.
- Hatchery for 5-7 days and fry are sold when reach about 3 weeks old.
- Approximately 99% of hatchery production is sold to other tilapia farmers. The remaining is kept for stocking into Manit export tilapia farm.
- Sex reversal using hormone (female to male tilapia) although this hatchery is investigating ways to induce sex reversal without using hormone.
- Management is also investigating improvement of offspring through a brood-stock breeding program (e.g. monthly rotation of brood-stock, selection for growth, shape and fertility). Brood-stock usually about 150-170 g each.
- Male tilapia is produced because they grow faster and are 20% larger at harvest.

*Top: Amon  
Luengnaruemitchai,  
Managing Director of  
Manit Farm with his  
former teacher Dr  
Amararatne.  
Below: In the lecture  
theatre at Manit Farm*



## Farm Visit 2

Amon Luengnaruemitchai  
Managing Director  
Manit Farm, export tilapia farm

- All vehicles passed through an infection control dip located at the entrance to the farm.
- A very warm welcome, with all participants etc. offered cold bottled water and a toilet stop. Lunch also provided with compliments of Manit Farm.
- The group was ushered into an air-conditioned training facility adjacent to the main house for introductions followed by a comprehensive 10-15 minute power point presentation on the Manit Farm Operation by the farms Managing Director, Mr Amon Luengnaruemitchai.
- Topics of his presentation included the historical importance of “Gift” tilapia to Thailand ( The King of Thailand decreed that the “Gift” should be propagated and an industry be developed in Thailand) and the role of AIT in the development of the technology used on their farm (sex reversal, higher meat recovery of small headed strain etc.).
- Farm was originally used to grow shrimp (*P. vanamai*) but shifted to tilapia culture some 20 years ago by the current owner’s father. Remains a family owned business.
- Staff of 110 people including 10 technicians.
- Farm approximately 250ha. Predominantly used for tilapia culture although some hybrid catfish are being grown. Farm producing about 700 tonnes of tilapia per year in brackish water ponds. Automated feeding and aeration returning FCR’s between 1.2 to 1.5. Tilapia grown for approximately 10 months to reach 1.2kg. Harvest by seine.
- Farm has an exclusive arrangement with a feed company for the supply of manufactured feeds (25-31 baht kg feed) and a processing plant for the export of tilapia products. Processor demands tilapia of 500-1.2kg with no off-flavour, no antibiotic residue and free from pathogenic bacteria. Fish transported on ice to processing plant.
- Major problems include streptococcal infection (survival some times < 40%), proximity to coast causes increases in salinity of rearing ponds > 15 ppt, off-flavour problems associated with pond dynamics, high summer water temperatures.
- Conclude with group photograph and presentation of gifts.



*Tilapia and walking catfish are grown at Manit Farm*



### Thailuxe Feed Plant

Mr Thomas Wilson

69/5 Moo 5, Rama 2 Road, T. Bangkhantaek

A. Muang, Samutsongkhram, Thailand 75000

- Group was offered refreshments on arrival. No photographs inside mills permitted.
- Power point presentation by Tom Wilson covering background and structure of Thailuxe operation. Shrimp mill commissioned in 1987, fish mill in 2004.
- First company in Thailand to obtain ISO 9000 for shrimp feed.
- Thailuxe now has AJA01# + HACCP DLD-TISI + GMP-DLD certification.
- All participants then signed in, dressed in overcoats and hair nets and taken on tour of shrimp and fish feed mills (bulk storage, ingredient preparation and receival, manufacturing and warehousing).
- Producing about 35,000 tonnes of shrimp feed per year (much smaller than CP). Shrimp mill used exclusively for the production of shrimp feeds.
- Manufacturing feeds for catfish and tilapia (catfish formula). Formulate to gross nutrient values rather than digestible nutrient values.
- Thailuxe deal directly with the farmer and do not use “middle men”.
- Tour of laboratory facility (Leco analyzer, halogen moisture analyzer, Buchi fat analyzer, muffle furnaces, drying ovens etc.). Feed stability tests demonstrated.
- Conclude with presentation of gifts and group photograph.
- Return to AIT.



*Group photo outside Thailuxe Feed Plant*

## 16.5 RESOURCE AND REFERENCE MATERIAL

### List of Resource Material and References from ATSE Crawford Fund Aquaculture Nutrition Master Class, AIT, Bangkok, 7-19 August 2006.

List of Resource Material and References from ATSE Crawford Fund Aquaculture Nutrition Master Class, AIT, Bangkok, 7-19 August 2006.

1. AAFCO. (2002). Feed safety program design audit protocol. Association of American Feed Control Officials.
2. AAFCO. Model feed safety program development guide AAFCO, FDA, EU.
3. Acasio, U. A. Handling and storage of soybeans and soybean meal Kansas State University.
4. AFIA. (2004). Feed Mill of the Year 2004 Application Form American Feed Industry Association.
5. Alarcon, F. J., Diaz, M., & Moyano, F. J. (1997). Studies on digestive enzymes in fish: characterization and practical applications CIHEAM - Options Mediterraneennes.
6. Allan, G. L. (2006). Aquaculture Nutrition Master Class: 1. Introduction to Aquaculture Nutrition. 1.4. Physiology of digestion - enzymatic processes.  
Notes: PowerPoint presentation
7. Allan, G. L. (2006). Aquaculture Nutrition Master Class: 2. Nutritional Requirements of Aquaculture Species. 2.1. Introduction.  
Notes: PowerPoint presentation
8. Allan, G. L. (2006). Aquaculture Nutrition Master Class: 3. Assessment of Feed Ingredients. 3.4. Fish meal replacement.  
Notes: PowerPoint presentation
9. Allan, G. L. (2006). Aquaculture Nutrition Master Class: Welcome and Introduction.  
Notes: PowerPoint presentation
10. Allan, G. L. (2004). Fish for Feed vs Fish for Food. In: Fish, Aquaculture and Food Security: Sustaining Fish as a Food Supply. Record of a conference conducted by the ATSE Crawford Fund, Parliament House, Canberra, 11 August 2004 edited by A.G. Brown (pp. 20-26).
11. Allan, G. L. & Booth, M. A. (2006). Aquaculture Nutrition Master Class: 2. Nutritional Requirements of Aquaculture Species. 2.4 Silver perch and snapper.  
Notes: PowerPoint presentation
12. Allan, G. L. & Booth, M. A. (2004). The effects of dietary digestible protein and digestible energy on protein retention efficiency of juvenile silver perch *Bidyanus bidyanus* (Mitchell). Aquaculture Research, 35, 970-980.
13. Allan, G. L. & Booth, M. A. (2004). Effects of extrusion processing on digestibility of peas, lupins, canola meal and soybean meal in silver perch *Bidyanus bidyanus* (Mitchell) diets. Aquaculture Research, 35, 981-991.
14. Allan, G. L., Booth, M. A., Stone, D. A. J. & Anderson, A. J. (2003). Aquaculture Diet Development Subprogram: Ingredient Evaluation. Final Report to FRDC Project no. 1996/391. (NSW Fisheries Report Report Series No. 58) NSW Fisheries.
15. Allan, G. L. & Dall, W. (1992). Proceedings of Aquaculture Nutrition Workshop, Salamander Bay, 15-17 April 1991. NSW Fisheries.
16. Allan, G. L., Jantrarotai, W., Rowland, S., Kosuturak, P. & Booth, M. (2000). Replacing Fishmeal in Aquaculture Diets: Final Report to ACIAR Project No. 9207. (NSW Fisheries Final Report Series

17. Allan, G. L., Johnson, R. J., Booth, M. A. & Stone, D. A. J. (2001). Estimating digestible protein requirements of silver perch, *Bidyanus bidyanus* Mitchell. Aquaculture Research, **32**, 337-347.
18. Allan, G. L., Parkinson, S., Booth, M. A., Stone, D. A. J., Rowland, S. J., Frances, J. & Warner-Smith, R. (2000). Replacement of fish meal in diets for Australian silver perch, *Bidyanus bidyanus*: I. Digestibility of alternative ingredients. Aquaculture, **186**, 293-310.
19. Allan, G. L., & Rowland, S. J. (2002). Silver Perch, *Bidyanus bidyanus*. In: Nutrient Requirements and Feeding of Finfish in Aquaculture edited by C.D. Webster & C. Lim (pp. 358-373). CAB International.
20. Allan, G. L., Rowland, S. J., Mifsud, C., Glendenning, D., Stone, D. A. J. & Ford, A. (2000). Replacement of fish meal in diets for Australian silver perch, *Bidyanus bidyanus* V. Least-cost formulation of practical diets. Aquaculture, **186**, 327-340.
21. Allan, G. L., Rowland, S. J., Parkinson, S., Stone, D. A. J. & Jantrarotai, W. (1999). Nutrient digestibility for juvenile silver perch *Bidyanus bidyanus*: development of methods. Aquaculture, **170**, 131-145.
22. Alvarado, J. L. (1997). Aquafeeds and the environment CIHEAM - Options Mediterraneenes.
23. ANON (Ed.). (1998). FDA Veterinarian (Vols. XIII).
24. AOAC. (1997). Caviezel extraction: peer-verified method PVM 4:1997 AOAC.
25. AOFPP. Focus on food safety: Information for Ontario Food Processors: Sanitation Programs (Fact Sheet No. 4) Alliance of Ontario Food Processors.
26. Autin, M. (1997). Commercial aquafeed manufacturer and production CIHEAM - Options Mediterraneennes.
27. Barlow, C. G., Allan, G. L., Williams, K. C., Rowland, S. J. & Smith, D. M. (2003). Aquaculture Diet Development Subprogram: Diet Validation and Feeding Strategies. (NSW Fisheries Final Report Series No. 60) NSW Fisheries.
28. Belal, I. E. H. (2005). A review of some fish nutrition methodologies. Bioresource Technology, **96**, 395-402.
29. Berger, L. L. (1996). Selenium: the controversial nutrient. Salt & Trace Minerals, **28**(2).
30. Bergleiter, S. (2004). Reply to G. Hubendick, SSNC Report (2004) deceiving consumers and jeopardising the environment - Coop Konsum Sweden's launch of Naturland's shrimp brand (Information to Consumers Naturland e.V.
31. Bergleiter, S. (2003). Shrimps from certified organic aquaculture. (Information to Consumers Naturland e.V.
32. Black, J. L. Principles behind feed formulation. In: Feed evaluation principles and practice edited by P.J. Moughan, M.W.A. Verstegen & M.I. Visser-Reyneveld . Wageningen Pers .
33. Boonyaratpalin, M. (2006). Aquaculture Nutrition Master Class. 1. Introduction to Aquaculture Nutrition. 1.2. Carbohydrate, vitamins and minerals.  
Notes: PowerPoint presentation
34. Boonyaratpalin, M. & Williams, K. (2002). Asian Sea Bass, *Lates calcarifer*. In: Nutrient Requirements and Feeding of Finfish for Aquaculture edited by C.D. Webster and C. Lim (pp. 40-50). CAB International.
35. Booth, M. A. (2006). Aquaculture Nutrition Master Class: 1. Introduction to Nutrition. 1.3. Digestive tract.  
Notes: PowerPoint presentation
36. Booth, M. A. (2006). Aquaculture Nutrition Master Class: 3. Assessment of Feed Ingredients. 3.3. Nutritive value.

Notes: PowerPoint presentation

37. Booth, M. A. (2006). Aquaculture Nutrition Master Class: 5. Analytical Techniques. 5.2. Dry matter, ash and total N.  
Notes: PowerPoint presentation
38. Booth, M. A. (2006). Aquaculture Nutrition Master Class: 8. Dry Feed Manufacture 8.1. Laboratory and farm feeds.  
Notes: PowerPoint presentation
39. Booth, M. A. & Allan, G. L. (2006). Aquaculture Nutrition Master Class: 12. Research Methods 12.6. Digestibility studies.  
Notes: PowerPoint presentation
40. Booth, M. A. & Allan, G. L. (2003). Utilization of digestible nitrogen and energy from four agricultural ingredients by juvenile silver perch *Bidyanus bidyanus*. Aquaculture Nutrition, **9**, 317-326.
41. Booth, M. A., Allan, G. L. & Anderson, A. J. (2005). Investigation of the nutritional requirements of Australian snapper *Pagrus auratus* (Bloch & Schneider, 1801): apparent digestibility of protein and energy sources. Aquaculture Research, 1-13.
42. Booth, M. A., Allan, G. L., Evans, A. J. & Gleeson, V. P. (2002). Effects of steam pelleting or extrusion on digestibility and performance of silver perch *Bidyanus bidyanus*. Aquaculture Research, **33**, 1163-1173.
43. Booth, M. A., Allan, G. L., Frances, J. & Parkinson, S. (2001). Replacement of fish meal in diets for Australian silver perch, *Bidyanus bidyanus* IV. Effects of dehulling and protein concentration on digestibility of grain legumes. Aquaculture, **196**, 67-85.
44. Booth, M. A., Allan, G. L. & Warner-Smith, R. (2000). Effects of grinding, steam conditioning and extrusion of a practical diet on digestibility and weight gain of silver perch, *Bidyanus bidyanus* . Aquaculture, **182**, 287-299.
45. BUCHI. (2002). Reference Methods (Information Bulletin No. 23) BUCHI.
46. BUCHI. What is fat? BUCHI.  
Notes: PowerPoint presentation
47. Bureau, D. P. & Hua, K. (2006). Letter to the Editor of Aquaculture (re Cho & Slinger's 1979 equation to calculate ADCs of feed ingredients). Aquaculture, **252**, 103-105.
48. Bury, N. R., Walker, P. A. & Glover, C. N. (2003). Nutritive metal uptake in teleost fish: a review. Journal of Experimental Biology, **206**, 11-23.
49. Butcher, G. D. & Miles, R. D. (2003). Minimizing microbial contamination in feed mills producing poultry feed. University of Florida IFAS Extension, VM93.
50. Codex Alimentarius Commission. (2005). Joint FAO/WHO Food Standards Programme: Codex Alimentarius Commission 28th Session, Rome, 4-9 July 2005.; Report of the 27th Session of the Codex Committee on Fish and Fishery Products, Cape Town, 28 February to 4 March 2005. (ALINORM No. 05/28/18) FAO/WHO.
51. Committee on the Implications of Dioxin in the Food Supply, N. R. C. (2003). Dioxins and Dioxin-like Compounds in the Food Supply: Strategies to Decrease Exposure National Academies Press.
52. Deguara, S. (1997). Evaluation of different pressed and extruded fish meal based diets on the growth of gilthead sea bream, *Sparus aurata* L. CIHEAM - Options Méditerranéennes.
53. Devresse, B., Dehasque, M., Van Assche, J. & Merchie, G. (1997). Nutrition and health CIHEAM - Options Méditerranéennes.
54. Diana, J. S., Lin, D. K. & Yi, Y. (1996). Timing of supplemental feeding for tilapia production. Journal of the

World Aquaculture Society, 27(4), 410-419.

55. Directorate General for Health and Consumer Protection. (2004). Guidance note on the application to animal by-products of community legislation regarding animal and public health and waste EU.
56. Divakaran, S. (2005). Errors in the analysis of aqua feeds and feed ingredients. Aqua Feeds: Formulation & Beyond, 2(1), 21-23.
57. Divakaran, S., Obaldo, L. G. & Forster, I. P. (2002). Note on the methods for determination of chromic oxide in shrimp feeds. Journal of Agricultural and Food Chemistry, 50(464-467).
58. Dominguez, L. M., Calero, G. L., Martin, J. M. V., Robaina, L. R. & Fernandez-Palacios, H. (1997). Retention and discharge of nutrients from a marine cage farm in the Canary Islands. Preliminary results. CIHEAM - Options Mediterraneennes.
59. Dosdat, A. Environmental impact of aquaculture in the mediterranean: nutritional and feeding aspects .
61. Dunnavan, G. (1998). Guidance for Industry: Questions and answers BSE feed regulation: 21 Code of Federal Regulations (CFR) 589,2000US Department of Health and Human Services, Food and Drug Administration.
62. Edwards, P. (2006). Aquaculture Nutrition Master Class: 6. Natural Feeds and Integrated Aquaculture 6.1. Part 1.  
Notes: PowerPoint presentation
63. Edwards, P. (2006). Aquaculture Nutrition Master Class: 6. Natural Feeds and Integrated Aquaculture 6.2. Part 2.  
Notes: PowerPoint presentation
64. Datasheet for CABI Aquaculture Compendium Key Topics.: Integrated agriculture aquaculture systems . (2006). P. Edwards.: CAB International.
65. Edwards, P. & Allan, G. L. (2004). Feeds and Feeding for Inland Aquaculture in Mekong Region Countries (ACIAR Technical Reports No. 56) ACIAR.
66. Edwards, P., Demaine, H., Innes-Taylor, N. & Turongruang, D. (1996). Sustainable aquaculture for small-scale farmers: need for a balanced model. Outlook on Agriculture, 25(1), 19-26.
67. Edwards, P., Lin, C. K., & Yakupitiyage, A. (2000). Semi-intensive pond aquaculture. M. C. M. Beveridge, & B. J. e. McAndrew Tilapias: Biology and Exploitation (pp. 377-403). Kluwer Academic Publishers.
68. Edwards, P., Tuan, L. A. & Allan, G. L. (2004). A survey of marine trash fish and fish meal as aquaculture feed ingredients in Vietnam (ACIAR Working Paper No. 57) ACIAR.
69. EFSA. (2003). Workshop on Acrylamide Formation in Food 17 November 2003, Brussels. Report of the WorkshopEuropean Food Safety Authority.
70. El-Sayed, A. & Tacon, A. G. J. (1997). Fishmeal replacers for tilapia: a review CIHEAM - Options Mediterraneennes.
71. EUREPGAP. (2005). Benchmarking cross reference checklist: integrated aquaculture assurance Version 2.1 Eurepgap .
72. EUREPGAP. (2005). EUREPGAP Global Report 2005 Eurepgap.
73. European Parliament. (2002). Directives on undesirable substances in animal feed. Official Journal of the European Communities.
74. European Union. (2004). Questions and answers on animal by-products (Memo No. 04/107) European Union.
75. Eyhorn, F., Heeb, M. & Weidmann, G. (2002). IFOAM Training Manual for Organic Agriculture in the Tropics: theory, transparencies, didactic approachInternational Federation of Organic Agriculture

Movements.

76. Faergemand, J. & Crowley, A.-M. (2005). State of affairs. The ISO Standard 22000. International Food Safety Conference - Managing the Food Safety Cycle ISO.  
Notes: PowerPoint presentation
77. Fairfield, D. A. (2005). Quality and safety systems for the feed industry - what's ahead? Feed and Feeding Digest, 56(1).
78. FEAP. (2000). A code of conduct for European Aquaculture Federation of European Aquaculture Producers.
79. Fei, C. S. Ensuring optimum feed mixability in feed manufacturing American Soybean Association .
80. Garrido-Varo, A. (1997). Current and future applications of NIRS technology in the feed industry CIHEAM - Options Mediterraneenes.
81. Glencross, B. (2006). Aquaculture Nutrition Master Class: 1. Introduction to Aquaculture Nutrition. 1.5. Nutritional biochemistry - Energy metabolism.  
Notes: PowerPoint presentation
82. Glencross, B. (2006). Aquaculture Nutrition Master Class: 1. Introduction to Aquaculture Nutrition. 1.5. Nutritional biochemistry - protein metabolism.  
Notes: PowerPoint presentation
83. Glencross, B. (2006). Aquaculture Nutrition Master Class: 1. Introduction to Aquaculture Nutrition. 1.6. Nutritional biochemistry - carbohydrate metabolism.  
Notes: PowerPoint presentation
84. Glencross, B. Aquaculture Nutrition Master Class: 1. Introduction to Aquaculture Nutrition. 1.6. Nutritional biochemistry - lipid metabolism2006.  
Notes: PowerPoint presentation
85. Glencross, B. (2006). Aquaculture Nutrition Master Class: 12. Research Methods 12.4. Factorial modelling.  
Notes: PowerPoint presentation
86. Glencross, B. (2006). Aquaculture Nutrition Master Class: 2. Nutritional Requirements of Aquaculture Species. 2.3. Carnivorous finfish.  
Notes: PowerPoint presentation
87. Glencross, B. (2006). Aquaculture Nutrition Master Class; 3. Assessment of Feed Ingredients. 3.3. Feed ingredient restrictions.  
Notes: PowerPoint presentation
88. Glencross, B. (2006). Aquaculture Nutrition Master Class: 4. Feeding Strategies. 4.1. General feeding issues.  
Notes: PowerPoint presentation
89. Glencross, B. (2006). Aquaculture Nutrition Master Class: 4. Feeding Strategies. 4.2. Feeding practices for finfish.  
Notes: PowerPoint presentation
90. Glencross, B. (2006). Aquaculture Nutrition Master Class: 5. Analytical Chemistry. 5.4. Total lipids and lipid classes.  
Notes: PowerPoint presentation
91. Glencross, B. (2006). The nutritional management of barramundi, *Lates calcarifer* - a review. Aquaculture Nutrition, 12, 291-309.
92. Glencross, B. (2005). Pilot assessment of the potential for canola meal and oil use in aquaculture feeds. Final Report for the Grains Research and Development Corporation (Fisheries Research Contract Report No. 5)W.A. Department of Fisheries.
93. Glencross, B., Curnow, J. & Hawkins, W. (2003). Assessment of the nutritional variability of lupins as an

aquaculture feed ingredient. Final Report for the Grains Research Committee of WA project  
(Fisheries Research Contract Report No. 6) WA Department of Fisheries.

94. Glencross, B., Evans, D., Rutherford, N., Hawkins, W., McCafferty, P., Dods, K., Jones, B., Harris, D., Morton, L., Sweetingham, M. & Sipsas, S. (2006). The influence of the dietary inclusion of the alkaloid gramine, on rainbow trout (*Oncorhynchus mykiss*) growth, feed utilisation and gastrointestinal histology. Aquaculture, 253, 512-522.
95. Glencross, B. D., Booth, M. & Allan, G. L. (2006). A feed is only as good as its ingredients - a review of ingredient evaluation strategies for aquaculture feeds. Aquaculture Nutrition, 12, 1-18.
96. Glencross, B. D., Boujard, T. & Kaushik, S. J. (2003). Influence of oligosaccharides on the digestibility of lupin meal when fed to rainbow trout, *Oncorhynchus mykiss*. Aquaculture, 219, 703-713.
97. Glencross, B. D. & Felsing, M. (2006). Influence of fish size and water temperature on the metabolic demand for oxygen by barramundi, *Lates calcarifer* (Bloch), in freshwater. Aquaculture Research, 37, 1055-1062.
98. Glencross, G., Evans, D., Dods, K., McCafferty, P., Hawkins, W., Maas, R. & Sisas, S. (2005). Evaluation of the digestible value of lupin and soybean protein concentrates and isolates when fed to rainbow trout, *Oncorhynchus mykiss*, using either stripping or settlement faecal collection methods. Aquaculture, 245, 211-220.
99. Greenpeace. (2003). The European Union's new labelling rules for genetically engineered food and feed: implications for the market of GMO and non-GMO products Greenpeace.
100. Hartog, J. D. (2003). Feed for food: HACCP in the animal feed industry. Food Control, 14, 95-99.
101. Health and Consumer Protection Directorate-General . Report on animal by-products European Commission.
102. Health & Consumer Protection Directorate-General. (2004). Rapid alert system for food and feed (RASFF). Annual Report on the functioning of the RASFF European Commission.
103. Heidenreich, E. (1997). Addition of feed additives and the danger of carry-over CIHEAM - Options Mediterraneennes.
104. Herrman, T. & Behnke, K. Testing mixer performance Kansas State University.
105. IFOAM. (2003). Rules of Procedure of the IFOAM Aquaculture Group International Federation of Organic Agriculture Movements.
106. Jongbloed, A. W. & Lenis, N. P. (1997). Nutrition as a tool to reduce the impact on the environment CIHEAM - Options Mediterraneennes.
107. Kang, D.-H. Enterobacter sakazakii Washington State University.  
Notes: PowerPoint presentation
108. Kaushik, S. J. (2003). Aquaculture Feeds: the future (research perspective) INRA, France.  
Notes: PowerPoint presentation
109. Kaushik, S. J. (1997). Feed formulation, diet development and feed technology CIHEAM - Options Mediterraneennes.
110. Kaushik, S. J. (1995). Nutrient requirements, supply and utilization in the context of carp culture. Aquaculture, 129, 225-241.
111. Kaushik, S. J. (2000). Some recent research on fish meal and fish oil replacement INRA, France.  
Notes: PowerPoint presentation
112. Knud-Hansen, C. F., Hopkins, K. D. & Guttman, H. (2003). A comparative analysis of the fixed-input, computer modeling, and algal bioassay approaches for identifying pond fertilization requirements for



- semi-intensive aquaculture. Aquaculture, 228, 189-214.
113. Lawrence, J. M. (2004). Catch of the day: choosing the right seafood in a world of scaremongers, fishmongers and scientists trolling for credible answers. Eating Well, Spring, 22-28.
  114. Lem, A. (2005). Aquaculture - world trends, opportunities for developing countries, technical and financial constraints UNCTAD, Geneva.  
Notes: PowerPoint presentation
  115. LGC Promochem. (2000). Certificate Matrix Meat Reference Material SMRD 2000 LGC Promochem.
  116. Liebert, F. & Portz, L. (2005). Nutrient utilization of Nile tilapia *Oreochromis niloticus* fed plant based low phosphorus diets supplemented with graded levels of different sources of microbial lphytase. Aquaculture, 248, 111-119.
  117. Limestone and Plastic Pellets. (2002). Mixer testing calculations Limestone & Plastic Pellets.  
Notes: Table of data
  118. Lin, Y.-H. & Shiau, S.-Y. (2005). Dietary selenium requirements of juvenile grouper, *Epinephelus malabaricus*. Aquaculture, 250, 356-363.
  119. Luo, Z., Liu, Y., Mai, K., Tian, L., Yang, H., Tan, X. & Liu, D. (2005). Dietary L-methionine requirement of juvenile grouper *Epinephelus coioides* at a constant dietary cystine level. Aquaculture, 249, 409-418.
  120. Lupatsch, I. & Kissil, G. W. (2005). Feed formulations based on energy and protein demands in white grouper (*Epinephelus aeneus*). Aquaculture, 248, 83-95.
  121. Martin, A. (1997). Aquaculture feed manufacturing practice in EU Mediterranean countries CIHEAM - Options Mediterraneennes.
  122. McIlroy, S. G. (1997). Biosecurity programmes for salmonella control CIHEAM - Options Mediterraneennes.
  123. Melcion, J. P., & Riou, Y. (1997). "On line" quality control in feed manufacturing CIHEAM - Options Mediterraneennes.
  124. Mille, Y., Beney, L. & Gervais, P. (2002). Viability of *Escherichia coli* after combined osmotic and thermal treatment: a plasma membrane implication. Biochimica Et Biophysica Acta, 1567, 41-48.
  125. Nandlal, S. (2006). Aquaculture Nutrition Master Class: 2. Nutritional Requirements of Aquaculture Species. 2.1. Aquaculture in the Pacific.  
Notes: PowerPoint presentation
  126. Olvera-Novoa, M. A., Martinez-Palacios, C. A. & Leon, E. R. D. (1994). Nutrition of fish and crustaceans: A laboratory manual FAO.
  127. Petro-Turza, M. (2003). Food safety management systems: a new international standard under development will help improve food safety. ISO Bulletin, 1-15.
  128. Petterson, D. S., Harris, D. J., Rayner, C. J., Blakeney, A. B. & Choct, M. (1999). Methods for the analysis of premium livestock grains. Australian Journal of Agricultural Research, 50, 775-787.
  129. Phuong, N. T. & Hien, T. T. (2006). Aquaculture Nutrition Master Class: 2. Nutritional Requirements of Aquaculture Species. 2.6. Development of feeds and feeding systems for catfish culture in Vietnam.  
Notes: PowerPoint presentation
  130. Pirozzi, I. (2006). Aquaculture Nutrition Master Class: 10. Feed Management 10.1. Storage.  
Notes: PowerPoint presentation
  131. Product Board Animal Feed. (2004). Evaluation of salmonella in feedingstuff 2003 (Quality Series No. 98) Product Board Animal Feed.
  132. Product Board Animal Feed. (2005). Evaluation of the measures to control salmonella in the animal feed

sector 2004 (Quality Series No. 107) Product Board Animal Feed.

133. Product Board Animal Feed. (2004). Guidelines and acceptance criteria for analysis methods Mycotoxins (DON, ZEN and OTA) in raw materials(s) for animal feed: Report of the Group of Experts (Quality Series No. 96) Product Board Animal Feed.
134. Product Board Animal Feed. (2004). Monitoring of undesirable substances and products animal feed sector (Quality Series No. 97) Product Board Animal Feed.
135. Product Board Animal Feed. (2002). Programme monitoring salmonella in the animal feed sector 2002 Product Board Animal Feed.
136. Product Board Animal Feed. (2002). Requirements for foreign suppliers of feed ingredients (Quality Series No. 78) Product Board Animal Feed.
137. Product Board Animal Feed. (2004). Study into drying processes for animal feed materials and HACCP (Quality Series No. 101) Product Board Animal Feed.
138. Product Board Animal Feed. (2002). Tracking & Tracing Compound Feed (Quality Series No. 82) Product Board Animal Feed.
139. Product Board Animal Feed. (2002). Tracking & Tracing Feed Materials (Quality Series No. 83) Product Board Animal Feed.
140. Robaina, L. & Izquierdo, M. (1997). Methodological strategies for the determination of nutrient requirements in finfish CIHEAM - Options Mediterraneennes.
141. Robinson, E. H., Li, M. H. & Manning, B. B. (2001). A Practical Guide to Nutrition, Feeds, and Feeding of Catfish (Second Revision) (No. Bulletin 1113) Mississippi Agricultural & Forestry Experiment Station.
142. Rowland, S. J., Allan, G. L., Mifsud, C., Nixon, M., Boyd, P. & Glendenning, D. (2005). Development of a feeding strategy for silver perch, *Bidyanus bidyanus* (Mitchell), based on restricted rations. Aquaculture Research, 36, 1429-1441.
143. Ruohonen, K. & Kettunen, J. (2004). Effective experimental designs for optimizing fish feeds. Aquaculture Nutrition, 10, 145-151.
144. Salt Institute. (1993). Chromium - an essential nutrient? Salt & Trace Minerals, 25(1).
145. Saunders, D. S., Meredith, F. L. & Voss, K. A. (2001). Control of Fumonisin: effects of processing. Environmental Health Perspectives, 109, 333-337.
146. Scott, J., & Weddig, L. (1998). Principles of integrated time-temperature processing. Presented at the 1008 Meat Industry Research Conference.
147. Seafood HACCP Alliance. Seafood HACCP Encore Course Seafood HACCP Alliance.
148. Shearer, K. D. (2000). Experimental design, statistical analysis and modelling of dietary nutrient requirement studies for fish: a critical review. Aquaculture Nutrition, 6, 91-102.
149. Shiau, S.-Y. & Yu, Y.-P. (1998). Chitin but not chitosan supplementation enhances growth of grass shrimp, *Penaeus monodon*. Journal of Nutrition, 128, 908-912.
150. Sim, S.-Y., Rimmer, M., Williams, K., Toledo, J. E., Sugama, K., Rumengan, I. & Phillips, M. J. (2005). A practical guide to feeds and feed management for cultured groupersNACA.
151. Slmith, D. M. & Tabrett, S. J. (2004). Accurate measurement of in vivo digestibility of shrimp feeds. Aquaculture, 232, 563-580.
152. Sloth, J. J., Julshamn, K. & Lundebye, A.-K. (2005). Total arsenic and inorganic arsenic content in Norwegian

fish feed products, 61-66.

153. Smith, D. M. (2006). Aquaculture Nutrition Master Class: 12. Research Methods 12.2. Statistical rigor and power analysis.  
Notes: PowerPoint presentation
154. Smith, D. M. (2006). Aquaculture Nutrition Master Class: 12. Research Methods 12.5. Experimental system.  
Notes: PowerPoint presentation
155. Smith, D. M. (2006). Aquaculture Nutrition Master Class: 2. Nutritional Requirements of Aquaculture Species. 2.5 Shrimp.  
Notes: PowerPoint presentation
156. Smith, D. M. (2006). Aquaculture Nutrition Master Class: 4. Feeding Strategies. 4.2. Feeding practices for shrimp.  
Notes: PowerPoint presentation
157. Smith, D. M. (2006). Aquaculture Nutrition Master Class: 5. Analytical Techniques. 5.1. Introduction.  
Notes: PowerPoint presentation
158. Smith, D. M. (2006). Aquaculture Nutrition Master Class: 5. Analytical Techniques. 5.3 Amino acids and other N forms.  
Notes: PowerPoint presentation
159. Smith, D. M. (2006). Aquaculture Nutrition Master Class: 5. Analytical Techniques. 5.5. Fatty acids, lipid classes, sterols.  
Notes: Powerpoint presentation
160. Smith, D. M. (2006). Aquaculture Nutrition Master Class: 5. Analytical Techniques 5.6. Chromic oxide, acid insoluble ash, starch, fibre.  
Notes: PowerPoint presentation
161. Smith, D. M. (2006). Aquaculture Nutrition Master Class: 7. Feed Formulation. 7.1. Science and art of feed formulation.  
Notes: PowerPoint presentation
162. Smith, D. M., Allan, G. L. & Booth, M. A. (2003). Aquaculture Diet Development Subprogram: Nutrient Requirements of Aquaculture Species. Final Report to FRDC Project No. 1996/392. (NSW Fisheries Final Report Series No. 59) NSW Fisheries.
163. Smith, D. M., Hunter, B. J., Allan, G. L., Roberts, D. C. K., Booth, M. A. & Glencross, B. D. (2004). Essential fatty acids in the diet of silver perch (*Bidyanus bidyanus*): effect of linolenic and linoleic acid on growth and survival. Aquaculture, 236, 377-390.
164. Stephen-Hassard, Q. D. (1997). Draft technical guidelines for good aquaculture feed manufacturing practice - A shortened working paper for discussion CIHEAM - Options Mediterraneenes.
165. Subcommittee on Fish Nutrition National Research Council. (1993). Nutrient Requirements of Fish National Academies Press.
166. Subcommittee on Selenium. (1983). Selenium in Nutrition, Revised Edition National Academies Press.
167. Surak, J. G. HACCP and ISO Development of a Food Safety Management Standard ISO.
168. Tacon, A. & Basurco, B. (1997). Feeding tomorrow's fish: proceedings of the workshop of the CIHEAM Network TECAM, Mazorron, Spain, 24-26 June 1996. ( Options Mediterraneennes, Series Cahiers No. 22) CIHEAM/FAO/IEO.
169. Tacon, A. G. J. (1997). Feeding tomorrow's fish: keys for sustainability CIHEAM - Options Mediterraneenes.
170. Tacon, A. G. J. (1987). The Nutrition and Feeding of Farmed Fish and Shrimp - A Training Manual in 3

Volumes. FAO.

171. Tacon, A. G. J. (2004). State of information on salmon aquaculture feed and the environment WWF.
172. Tacon, A. G. J. (2002). Thematic review of feeds and feed management practices in shrimp aquaculture World Bank/NACA/WWF/FAO.
173. Tuan, L. A. (2006). Aquaculture Nutrition Master Class: 2. Assessment of Feed Ingredients. 3.1. Status of trash fish usage in aquaculture.  
Notes: PowerPoint presentation
174. Tuan, L. A. & Williams, K. C. (2006). Optimum dietary protein and lipid specifications for juvenile malabar grouper (*Epinephelus malabaricus*).
175. Tucker, B. J., Booth, M. A., Allan, G. L., Booth, D. & Fielder, D. S. (2006). Effects of photoperiod and feeding frequency on performance of newly weaned Australian snapper *Pagrus auratus*. Aquaculture, 258, 514-520.
176. Van Barneveld, R. (2006). Aquaculture Nutrition Master Class: 7. Feed Formulation. 7.3. Methods of formulating diets - tailoring diet specifications to productivity goals and cost.  
Notes: PowerPoint presentation.
177. Van Barneveld, R. (2006). Aquaculture Nutrition Master Class: 9. Industrial Pelleting and Extrusion 9.1. Industrial pelleting and extrusion con't.  
Notes: PowerPoint presentation
178. Van Barneveld, R. (2006). Aquaculture Nutritional Master Class: 9. Industrial Pelleting and Extrusion 9.1. Extrusion basics - formulation requirements, end-product considerations, conditioning, fat content.  
Notes: PowerPoint presentation
179. Van Barneveld, R. (2006). Feed Manufacturing Practical Session: table of 5 feed mixes.  
Notes: Handout for Aquaculture Nutrition Master Class
180. Van Barneveld, R. (2006). Session 9: Industrial pelleting and extrusion: course notes.  
Notes: Handout for Aquaculture Nutrition Master Class
181. Van Barneveld, R. & Ellis, D. (2005). Formu-Bait: Bait fish feeding optimisation software (Version 1.20) Aquafin CRC.
182. Verlhac, V. & Kiron, V. (2004). Nutrition and immune modulation in aquatic animals. Aqua Feeds: Formulation & Beyond, 1(4), 5-9.
183. Weber, M. L. What price farmed fish: a review of the environmental and social costs of farming carnivorous fish SeaWeb Aquaculture Clearinghouse.
184. Willer, H. & Yussefi, M. (2004). The World of Organic Agriculture: Statistics and emerging trends 2004 BioFach, FIBL, SOL.
185. Williams, K. (2006). Aquaculture Nutrition Master Class: 1. Introduction to aquaculture nutrition: 1.1. Function of protein and lipids.  
Notes: PowerPoint presentation
186. Williams, K. (2006). Aquaculture Nutrition Master Class: 12. Research Methods 12.1. Introduction to experimental design and statistics.  
Notes: PowerPoint presentation
187. Williams, K. (2006). Aquaculture Nutrition Master Class: 12. Research Methods 12.3. Empirical methods for nutrient requirement studies.  
Notes: PowerPoint presentation
188. Williams, K. (2006). Aquaculture Nutrition Master Class: 12. Research Methods 12.7. Experimental protocols.

Notes: PowerPoint presentation

189. Williams, K. (2006). Aquaculture Nutrition Master Class: 8. Farm and Laboratory Feed Manufacture 8.2. Moist diets.  
Notes: PowerPoint presentation
190. Williams, K. (2006). Protocol: Cholesterol requirements of lobsters - Example of a NOT so good protocol.  
Protocol: Cholesterol requirements of sub-adult spiny lobsters (*Panulirus ornatus*) - Example of a better protocol.  
Notes: Handout for Aquaculture Nutrition Master Class
191. Wilson, T. (2006). Aquaculture Nutrition Master Class: 10. Feed Management 10.2 The pursuit of quality in the modern feed industry.  
Notes: PowerPoint presentation
192. Wilson, T. (2006). Aquaculture Nutrition Master Class 9.3. The Real World of Industrial Fish Nutrition.  
Notes: PowerPoint presentation
193. Yakupitiyage, A. (2006). Aquaculture Nutrition Master Class: 2. Nutritional Requirements of Aquaculture Species. 2.2. Herbivorous/omnivorous fish.  
Notes: PowerPoint presentation
194. Yakupitiyage, A. (2006). Aquaculture Nutrition Master Class: 7. Feed Formulation. 7.2. Methods of formulating diets.  
Notes: PowerPoint presentation
195. Ye, C.-L., Liu, Y.-J., Tian, L.-X., Mai, K.-S., Du, Z.-Y., Yang, H.-J. & Niu J. (2006). Effect of dietary calcium and phosphorus on growth, feed efficiency, mineral content and body composition of juvenile grouper, *Epinephelus coioides*. Aquaculture, 255, 263-271.
196. Zinn, R. A. A guide to feed mixing.

## 16.6 QUESTIONNAIRE (OVERLEAF)

## AQUACULTURE NUTRITION MASTERCLASS

### QUESTIONNAIRE

This questionnaire is anonymous - you do not have to sign your name if you do not wish to. Your answers will assist in improving future Master Classes.

1. Please indicate how useful you felt the various components of the Master Class were by ticking the relevant boxes below:

▪ Lectures

|                          |                          |                          |                          |
|--------------------------|--------------------------|--------------------------|--------------------------|
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <i>very helpful</i>      | <i>good</i>              | <i>fair</i>              | <i>not helpful</i>       |

▪ Computer tutorial (Winfeed)

|                          |                          |                          |                          |
|--------------------------|--------------------------|--------------------------|--------------------------|
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <i>very helpful</i>      | <i>good</i>              | <i>fair</i>              | <i>not helpful</i>       |

▪ Feed formulation practical session

|                          |                          |                          |                          |
|--------------------------|--------------------------|--------------------------|--------------------------|
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <i>very helpful</i>      | <i>good</i>              | <i>fair</i>              | <i>not helpful</i>       |

▪ Field trips

|                          |                          |                          |                          |
|--------------------------|--------------------------|--------------------------|--------------------------|
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <i>very helpful</i>      | <i>good</i>              | <i>fair</i>              | <i>not helpful</i>       |

2. Please indicate how useful you found the individual sessions by ticking the relevant boxes below:

▪ Introduction to Aquaculture Nutrition

|                          |                          |                          |                          |
|--------------------------|--------------------------|--------------------------|--------------------------|
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <i>very helpful</i>      | <i>good</i>              | <i>fair</i>              | <i>not helpful</i>       |

▪ Nutritional Requirements of Aquaculture Species

|                          |                          |                          |                          |
|--------------------------|--------------------------|--------------------------|--------------------------|
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <i>very helpful</i>      | <i>good</i>              | <i>fair</i>              | <i>not helpful</i>       |

▪ Assessment of Potential Feed Ingredients

|                          |                          |                          |                          |
|--------------------------|--------------------------|--------------------------|--------------------------|
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <i>very helpful</i>      | <i>good</i>              | <i>fair</i>              | <i>not helpful</i>       |

▪ Analytical Techniques

|                          |                          |                          |                          |
|--------------------------|--------------------------|--------------------------|--------------------------|
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <i>very helpful</i>      | <i>good</i>              | <i>fair</i>              | <i>not helpful</i>       |

▪ Natural Feeds & Integrated Aquaculture

|                          |                          |                          |                          |
|--------------------------|--------------------------|--------------------------|--------------------------|
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <i>very helpful</i>      | <i>good</i>              | <i>fair</i>              | <i>not helpful</i>       |

▪ Diet Formulation - Introduction to Feed Formulation

|                          |                          |                          |                          |
|--------------------------|--------------------------|--------------------------|--------------------------|
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <i>very helpful</i>      | <i>good</i>              | <i>fair</i>              | <i>not helpful</i>       |

▪ Feed Manufacture

|                          |                          |                          |                          |
|--------------------------|--------------------------|--------------------------|--------------------------|
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <i>very helpful</i>      | <i>good</i>              | <i>fair</i>              | <i>not helpful</i>       |

▪ Commercial Feeds - Pelleting & Extrusion

|                          |                          |                          |                          |
|--------------------------|--------------------------|--------------------------|--------------------------|
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <i>very helpful</i>      | <i>good</i>              | <i>fair</i>              | <i>not helpful</i>       |

▪ Feed Management - Storage

|                          |                          |                          |                          |
|--------------------------|--------------------------|--------------------------|--------------------------|
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <i>very helpful</i>      | <i>good</i>              | <i>fair</i>              | <i>not helpful</i>       |

▪ Farm Made & Laboratory Feeds

|                          |                          |                          |                          |
|--------------------------|--------------------------|--------------------------|--------------------------|
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <i>very helpful</i>      | <i>good</i>              | <i>fair</i>              | <i>not helpful</i>       |

▪ Research Methods

|                          |                          |                          |                          |
|--------------------------|--------------------------|--------------------------|--------------------------|
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <i>very helpful</i>      | <i>good</i>              | <i>fair</i>              | <i>not helpful</i>       |

▪ Course Revision

|                          |                          |                          |                          |
|--------------------------|--------------------------|--------------------------|--------------------------|
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <i>very helpful</i>      | <i>good</i>              | <i>fair</i>              | <i>not helpful</i>       |

**3. What was your opinion of the Class materials (e.g. books, CDs, presentations etc.)?**

**4. Did you have any language problems? If so, please give details.**

**5. How has your view of aquaculture nutrition changed as a result of the Class?**

**6. Has the range of your professional contacts changed as a result of this Class?  
If so, please describe what has happened.**

**7. Were the accommodation, meals and general arrangements appropriate?  
If not, could you provide details?**

**8. What should be done now to reinforce the activities of this Class?**

**MANY THANKS FOR YOUR TIME.**