

PROGRAM AND ABSTRACT BOOK

September 26-29, 2004

Sydney Convention Centre - Sydney, NSW Australia BIENNIAL CONFERENCE & EXPOSITION OF

Asian-Pacific Chapter, WAS



National Aquaculture Council of Australia Tasmanian Aquaculture Council



Fisheries Research and Development Corporatio

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Tumbalong Room #1 & 2 are on the Second Floor All Promenade Rooms are on the Lower Level

Posters – Exhibits Lower Level and 2nd Floor Speaker Prep Room – Promenade 2A (Lower Level)

Day/Time		Tumbalong Auditorium	Tumbalong 1	Tumbalong 2	Promenade	Promenade	Promenade
Mon. 9/27 Break	08:30 - 10:10	Opening & Plenary				3	4
Lunch	10:40 - 12:20	Profitable Sustainability		Mollusc: Innovations in		Crustacean Nutrition -	7-
Break	13:40 - 15:20	Business Planning & Investment	Recirculation & Aquaculture Engineering	Farming & Grading Technology	Indigenous and Pacific Island	Bridging the Gap Between Researcher, Feed Manufacturer and Farmer	
	15:50 - 17:30	Crustacean Post-harvest & Marketing		Mollusc Health	Ilusc Health Aquaculture Finfish Breeding & Genetics		
Tue. 9/28 Break	08:30 - 10:10		Promoting Farm		Indigenous and Pacific Islands	Government Regulations & Policy	Einfich Nutrition
Lunch	12:20		Products	to Commercial	Aquaculture	Crustacean Health	Finish Nutrition
Break	13:40 - 15:20 15:50 - 17:30		Inland Saline & Arid Aquaculture	Competitiveness: Crustaceans	Post-harvest & Marketing - Production & Product Quality	Mollusc Husbandry & Environment	Food Safety
Wed. 9/29 Break Lunch	08:30 - 10:10 10:40 - 12:20		Larval Nutrition and	Crustacean Husbandry & Environment	Finfish Husbandry & Environment	Mollusc Breeding & Genetics	
Break	15:20 15:50 - 17:30 -		Feeds	Extension & Technology Transfer Education & Training	Finfish Health	Mollusc Nutrition	
	18:00		WRAP-U	Session			

TRADESHOW SCHEDULE

MONDAY	TUESDAY	WEDNESDAY	
Sept. 27	Sept. 28	Sept. 29	
10:00 - 18:30	9:30 – 17:30	9:30-15:50	

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AUSTRALASIAN AQUACULTURE 2004



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STEERING COMMITTEE Chair: Geoff Allan

Past President World Aquaculture Society 2003/2004, NSW Department of Primary Industries

Committee Members:

Bruce Zippel	National Aquaculture Council
Patrick Hone	Fisheries Research and Development Corporation
John Cooksey	World Aquaculture Society
Mike Rimmer	President Asian-Pacific Chapter WAS
Tom Lewis	Tasmanian Aquaculture Council
Tim Walker	Austasia Aquaculture
Ian Lyall	NSW Department of Primary Industries
Helen O'Connor	Sydney Fish Market
Simon Bennison	National Aquaculture Council
Glen Hurry	Australian Government Department of Agriculture, Fisheries and Forestry
Leanne Wilson	Media Liaison Officer
Sarah-Jane Day	NSW Department of Primary Industries

PROGRAM COMMITTEE

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Committee Members:

Geoff Allan	Past President World Aquaculture Society 2003/2004, NSW Department of Primary Industries
Tom Lewis	Tasmanian Aquaculture Council
Simon Bennison	National Aquaculture Council
Pheroze Jungalwalla	Tasmanian Salmonid Growers Association
Martin Breen	Australian Prawn Farmers Association
Helen O'Connor	Sydney Fish Market
David Whyte	Skretting
lan Lyall	NSW Department of Primary Industries

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Australia Office Staff

Sarah-Jane Day Alexandra Bagnara Allison Bennison Jacki Knight

Special Thanks To: All of the Associate Sponsors and the many other people who helped out in so many ways

SESSIONS AT A GLANCE BY SCHEDULED TIME

PLENARY SESSION - Monday, September 27

Welcome and Onening Address - Hon, Ian Macdonald	8:30 ·	· 9:10	lumbalong Auditorium
Dianary World Coope Philip Smith	9.10 -	9.50	Tumbalona Auditorium
Plenary - world Scelle - rinnp Sinni	0.50	10.10	Tumbalang Auditorium
Plenary - Australian Scene - Nick Paspaley	9:20 ·	- 10:10	Tompatong Additionom

SESSIONS – Monday, September 27

Profitable Sustainability	10:40 - 12:20	lumbalong Auditorium
Recirculation & Aquaculture Engineering	10:40 - 17:30	Tumbalong 1
Molluse: Innovations in Farming and Latest Grading Technology	13:40 - 15:20	Tumbalong 2
Indigenous and Pacific Island Aquaculture	10:40 - 17:30	Promenade 1
Crustacean Nutrition – Bridging the Gap Between Researcher,		
Feed Manufacturer and Farmer	10:40 - 15:20	Promenade 3
Rusiness Planning & Investment	13:40 - 15:20	Tumbalong Auditorium
Crustacean Post Harvest & Marketina	15:50 - 17:30	Tumbalong Auditorium
Molluse Herith	15:50 - 17:30	Tumbalong 2
Finfish Breeding & Genetics	15:50 - 17:30	Promenade 3
Timish brocking a concise mental		

Tuesday, September 28

Government Regulations & Policy	8:30 - 10:10 Promenade 3
Promoting Farm Products	8:30 - 12:20 Tumbalong 1
Indiaenous and Pacific Island Aquaculture	. 8:15 - 12:20 Promenade1
Contribution of Genetics to Commercial	
Competitiveness: Crustaceans	. 8:30 - 17:30 Tumbalong 2
Finfish – Feed Development, Larval Nutrition & Food Safety	. 8:30 - 12:20 Promenade 4
Crustacean Health	. 10:40 - 12:20 Promenade 3
Food Safety	. 13:40 - 17:10 Promenade 4
Inland Saline and Arid Aquaculture	. 13:40 - 17:30 Tumbalong 1
Post Harvest & Marketing – Production	
and Product Quality	. 13:40 - 17:30 Promenade 1
Mollusc Husbandry & Environment	. 13:40 - 17:30 Promenade 3

Wednesday, September 29

Finfish Husbandry & Environment	. 8:30 - 10:10 Promenade I
Crustacean Husbandry & Environment	. 8:30 - 12:20 Tumbalong 2
Molluse Breeding & Genetics	. 8:30 - 12:20 Promenade 3
Larval Nutrition and Feeds	. 8:30 - 17:30 Tumbalong 1
Cinfich Hoalth	10:40 - 17:30 Promenade 1
Fillisi liculii	13·40 - 17·30 Promenade 3
	13.40 - 15.20 Tumbalong 2
Extension and lechnical transfer	15.50 17.20 Tumbalang 2
Education & Iraining	15.50 - 17.30 Tullibulong Z

POSTERS LOCATED ON 2ND FLOOR AND IN EXHIBITS

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Zippel Enterprises Humpty Doo Barramundi TASEA NSW Department of Primary Industries

Oyster Bob

CONFERENCE SCHEDULE

	Sunday, Sep	tember 26	
Registration Open		•••••	
Welcome Drink			1730 - 1830

Monday, September 27

Monday, September	£/
Registration Open	
Plengry Session	
Refreshment Break	
Saccions	
Trade Show Anen	
Lunch (Provided)	
Socione	
Refrechment Brenk	
Socione	
Hanny Hour & Poster Session	
Tuppy from & roster session	

Tuesday, September 28

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Registration Open	0730 - 1700
Sessions	
Refreshment Break	1010 - 1040
Sessions	
Trade Show Open	
Lunch (Provided)	1220 - 1340
Sessions	1340 - 1520
Refreshment Break	1520 - 1550
Sessions	1550 - 1730
Maritime Museum Exhibits Open Special Viewing	
Conference Reception	

Wednesday, September 29

Veunesuuy, se	
Registration Open	
Sessions	
Refreshment Break	
Sessions	
Trade Show Open	
Lunch (Provided)	
Sessions	
Refreshment Break	
Sessions	
Wran-up Session	

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FUTURE WORLD AQUACULTURE SOCIETY **CONFERENCES & EXPOSITIONS**

2005 **AQUACULTURE AMERICA '05**

New Orleans Marriott New Orleans, Louisiana U.S. National Annual Conference & Exposition of the U.S. Chapter, WAS, National Aquaculture Association, and U.S. Suppliers Association.

2005 WORLD AQUACULTURE '05

Bali Convention Centre Bali, Indonesia International Annual Conference & Exposition of WAS with many other associations, industry and government sponsors.

2005 **AQUAMAR Internacional 2005**

Centro de Convenciones Merida, Yucatan, Mexico Latin America Chapter, WAS meeting with many aquaculture groups in Mexico.

2006 AQUACULTURE AMERICA '06

Riviera Hotel Las Vegas, Nevada U.S. National Annual Conference & Exposition of the U.S. Chapter, WAS, National Aquaculture Association, and U.S. Suppliers Association.

2006 **AQUA 2006**

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Fortezza da Basso

Florence, Italy International Annual Conferences & Expositions of EAS & WAS with many other associations, industry and government sponsors.

2007 AQUACULTURE 2007

San Antonio Convention Center San Antonio, Texas, USA Triennial Int'l Annual Conference & Exposition with National Shellfisheries Association, Fish Culture Section, AFS, National Aquaculture Association and U.S. Suppliers Association.

2008 WORLD AQUACULTURE '08

Busan Convention Center

Busan, Korea International Annual Conference & Exposition of WAS with many other associations, industry and government sponsors.

For information, contact:

Director of Conferences

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Email: worldagua@aol.com

Feb. 26 - March 2

May 19-23

May 9-13

Jan. 17-20

Sept. 12-14

Feb. 13-16

May 9-13



AUSTRALASIAN AQUACULTURE 2006

Winter/Spring 2006

The next meeting of: National Aquaculture Council of Australia Asian-Pacific Chapter, WAS Tasmanian Aquaculture Council

For location and dates and other information on AUSTRALASIAN AQUACULTURE 2006

Watch for the announcement at AUSTRALASIAN AQUACULTURE 2004.

If you miss that announcement, you can contact:

Web: australian-aquacultureportal.com

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MONDAY, September 27

OPENING & PLENARY

Chair: Geoff Allan Monday, September 27 8:30 - 10:10 Tumbalong Auditorium

WELCOME TO COUNTRY

Allen Madden - Metropolitan Local Aboriginal Land Council

INTRODUCTION OF SENATOR MACDONALD

John Jenkin – Chair of NAC

OPENING ADDRESS

Hon. Ian Macdonald Australian Government Minister for Fisheries, Forestry and Conservation

INTRODUCTION OF PLENARY SESSION

Mike Rimmer - President, APC-WAS

PLENARY - WORLD SCENE

Philip Smith - Vice-President, Nutreco

A METICULOUS attention to nutritional quality is the new focus for aquaculture producers, according to the world's largest aquaculture company. Philip Smith, vice chairman of Nutreco, believes this change requires aquaculture in this region to move from being a production-driven industry to one further embracing its responsibility for social and environmental sustainability. Mr Smith will in this context set the scene for aquaculture's enormous opportunity for growth in his keynote address. Specific working examples such as how to target the emerging obesity-conscious consumer market and managing stakeholder interest in aquaculture through a consultative approach are among highlights not to be missed in Philip's authoritative address.

PLENARY - AUSTRALIAN SCENE

The pearling industry is an Australian success story. In a demonstration of the power of innovation, when plastics destroyed the core of the previously valuable pearl shell industry in North West Australia just after World War II, a small number of pioneers arose from the ashes of the pearl shell industry to establish pearl culture. At the head of this development was the Paspaley family, led for much of its history by Nicholas Paspaley. The Paspaley Group now accounts for more than fifty percent of the world's finest pearl production and is a leader in pearl quality and production systems. The farm gate value of white South Sea pearl production in Australia is now around \$200 million and in terms of exports after value adding, would be close to \$400 million. In this sense, the Paspaley Group is the precursor of aquaculture in Australia, with a wealth of experience applicable to an industry where many of its sectors and individual companies are still at the stage of striving to establish their markets and their production systems in what is now a highly competitive global market. Nicholas Paspaley will use his vantage point to describe where he sees aquaculture heading in Australia and what he sees as vital steps needed to take the industry into the future. where he sees aquaculture heading in Australia and what he sees as vital steps needed to take the industry into the future.

	PROFITABLE SUSTAINABILITY
	Monday, September 27 10:40 - 12:20 Tumbalong Auditorium
	Session Chairs: David Whyte & Tom Lewis
10:40	Graham Dear FOOD SAFETY AND THE EU CONSUMERS PERSPECTIVE
11:00	Murray Hogarth LEVERAGING NEW MARKET FORCES TO DRIVE SUSTAINABLE AQUACULTURE
11:20	Ted Loveday PROVE IT OR LOSE IT!
11:40	Rick Fletcher A PRACTICAL FRAMEWORK FOR MANAGING AND ASSESSING AQUACULTURE USING ESD PRINCIPLES
12:00	Col Dyke SUSTAINABILITY CAN BE COST-EFFECTIVE, PRACTICABLE, ENVIRONMENTALLY RESPONSIBLE AND SAFE.
	DECIDCULATION & AQUACULTURE ENGINEERING
	Monday, September 27 10:40 - 17:10 Tumbalong 1 Session Chair: Thomas Losordo
10:40	James F. Muir Environmental challenges faced by the marine aquaculture industry and Potential engineering solutions
11:20	Vincenzo Zonno, Sebastiano Vilella, Jean-Paul Blancheton LAND-BASED FISH FARM EFFLUENT MANAGEMENT: TECHNOLOGICAL, BIOLOGICAL AND ENVIRONMENTAL ASPECTS
12:00	Amir Neori, Muki Shpigel, Max Troell A GREEN BLUE REVOLUTION: ALGAL CULTURE IS KEY TO A SUSTAINABLE EXPLOITATION OF THE SEA
13:40	Kotaro Kikuchi NITROGEN IN THE CLOSED RECIRCULATING AQUACULTURE
14:20	Thomas M. Losordo, Geoff L. Allan, Mark A. Booth, Dennis P. DeLong NITRIFICATION RATES IN MARINE BIOFILTERS
15:00	Gavin J. Partridge OXYGEN USE BY MARINE FISH IN A RECIRCULATING AQUACULTURE SYSTEM
15:50	Robert Bishop MONITORING, CONTROLLING AND RECORDING THROUGH AUTOMATION IT FOR RECIRCULATION LANDBASE FARMS
16:10	Robert O. Collins, Paul L. Jones, Giorgio Palmeri, Paul Dionno, Stephen Ryan CHALLENGES IN ESTABLISHING INTENSIVE R.A.S TO MEET THE NEEDS OF INDUSTRY AND RESEARCH AT DEAKIN UNIVERSITY
16:30	Wayne Knibb, Daniel Willett TOWARDS AUTOTROPHIC RECIRCULATION SYSTEMS FOR PRAWN FARMS
16:50	Paul N. De Ionno, Stephen Ryan, Giorgio Palmeri, Robert Collins, Paul Jones

PRELIMINARY ANALYSIS OF THE GROWTH RATES OF MURRAY COD Maccullochella peelii peelii GROWN IN A COMMERCIAL RECIRCULATING AQUACULTURE SYSTEM

MOLLUSC INNOVATION IN FARMING & LATEST GRADING TECHNOLOGY

Monday, September 27 10:40 - 15:20 Tumbalong 2 Session Chairs: Bruce Zippel & Gary Zippel

Innovation in Shellfish Farming Systems

This is a new style of session on the first day of the conference of direct interest to shellfish farmers. It intends to present an overview of innovations in new farming techniques, and will provide this where possible from a grower's perspective. This will give the audience a candid overview of how this technology is working on the farm, and where it may be improved. This overview will cover Australian, New Zealand and North America technology. The session will be finalised by an interactive panel discussion between the speakers and the audience.

- **Joth Davis** 10:40 INNOVATIONS IN SHELLFISH FARMING SYSTEMS IN NTH AMERICA
- **Dennis Martin** 11:00 DRAG EMBEDMENT ANCHOR LLA - MK II
- **Michael Cameron** 11:10 COMBINING LONG-LINE TECHNOLOGY WITH TOOLTECH TRAY GROWING SYSTEMS
- **Richard Hamlyn-Harris** 11:20 ADAPTING BST ADJUSTABLE LINE GROWING SYSTEMS FOR NEW ENVIRONMENTS
- **Bob Cox** 11:30 USING SEAPA GROWING SYSTEMS FOR MAXIMUM PERFORMANCE
- **Stephen O'Keefe** 11:40 USE OF LONGLINE SYSTEMS FOR THE AUSTRALIAN PEARLING INDUSTRY
- **Gavin Wilton** 11:50 INNOVATIVE USE OF RAFT TECHNOLOGY FOR DEEPWATER GROWING SYSTEMS

Tom Hollins 12:00

INNOVATION IN NEW ZEALAND GROWING SYSTEMS

PANEL DISCUSSION 12:10

Latest Shellfish Grading and Handling Technology

Similar to the innovation in shellfish farming systems, this session intends to provide an overview to the audience on the latest technology in shellfish grading and handling from the growers perspective where possible. There have been significant global developments in these areas over the last 5 years, and this session will bring you up to date where it can.

An interactive approach between the audience and presenters is also planned for this and the shellfish farming technology session to ensure the best information flow for the benefit of all those present.

13:40	Joth Davis INNOVATION IN GRADING AND HANDLING SYSTEMS IN NTH AMERICA
14:00	Jane Clout BENEFITS OF USING THE SED AUTOMATED GRADING SYSTEM
14:10	Gavin Wilton BENEFITS OF USING THE OSYTECH AUTOMATED GRADING SYSTEM
14:20	Kevin Hitchcock USING AN AUTOMATED WEIGHT GRADER FOR SHELLFISH

14:30	Rob Pooley GRADING AND HANDLING SYSTEMS FOR THE NEW ZEALAND MUSSEL INDUSTRY
14:40	Gary Zippel BETTER GRADING TECHNOLOGY FOR JUVENILE OYSTERS
14:50	Bob Cox AUTOMATED LOADING OF BASKETS/GROWING MODULES
15:00	Tom Hollings IMPROVED OYSTER HANDLING SYSTEMS IN NEW ZEALAND
15:10	PANEL DISCUSSION
	INDIGENOUS AND PACIFIC ISLAND AQUACULTURE Monday, September 27 10:40 - 17:30 Promenade 1 Session Chair: Mike Rimmer, Ian Lyall, Yves Harache & Dennis Ah-Kee
10:40	Grant Sarra INTRODUCTION, WORKSHOP OBJECTIVES
11:00	Ben Ponia AQUACULTURE DEVELOPMENT IN THE PACIFIC
11:20	Sheree Rankmore CURRENT STATUS OF THE WOLLONGONG ABORIGINAL AQUACULTURE CORPORATION
11:40	Jacob Wani AQUACULTURE DEVELOPMENT IN PNG
12:00	Filomone Mate INDIGENOUS AQUACULTURE IN THE FIJI ISLANDS
13:40	Shane Willis TRAINING ISSUES ASSOCIATED WITH SNOWY RIVER NATIVE FISH HATCHERY
14:00	Chris Robertson INDIGENOUS AQUACULTURE DEVELOPMENT IN NORTH QUEENSLAND, AUSTRALIA
14:20	Jason Karpany AQUACULTURE ACTIVITIES AT NALTA RUWE
14:40	Graham Haylor STREAM
15:00	Timothy Pickering, Merekeleni Namudu, Bill Johnstone PICKING WINNERS FOR INDIGENOUS AQUACULTURE: RECENT EXPERIENCES AND SOCIO- ECONOMIC TECHNIQUES FROM THE FIJI ISLANDS
15:50	Malwine Lober SAMOA TROCHUS ENHANCEMENT PROJECT
16:10	Robert A. Jimmy COMMUNITY BASED TROCHUS CULTURE INITIATIVE IN VANUATU
16:30	Charla Clements AN OVERVIEW OF THE KIMBERLEY AQUACULTURE ABORIGINAL CORPORATION
16.50	Roore Tieti

DEVELOPMENT TOWARDS A CULTURED PEARL INDUSTRY IN KIRIBATI, CENTRAL PACIFIC

12

Masahiro Ito 17:10

PEARL AQUACULTURE DEVELOPMENT PROJECT IN THE FEDERATED STATES OF MICRONESIA, WESTERN CENTRAL PACIFIC

Session continues Tuesday, September 27 08:30 – 12:20 Promenade 1

CRUSTACEAN NUTRITION - BRIDGING THE GAP BETWEEN RESEARCHER, FEED MANUFACTURER & FARMER

Monday, September 27 10:40 - 15:20 Promenade 3 Session Chairs: David Smith, Kevin Williams & Martin Breen

David M. Smith 10:40

BRIDGING THE GAP: A RESEARCHER'S PERSPECTIVE

Richard Smullen 11:20 BRIDGING THE GAP: AN AUSTRALIAN FEED MANUFACTURER'S PERSPECTIVE

Sergio F. Nates, Thomas R. Zeigler 11:40 A NEW APPROACH TO SYSTEMS FEED AND NUTRITION: THE SHIFT IN THE PARADIGM

12:00 Alistair J. Dick

PRACTICAL CONSIDERATIONS FOR THE NUTRITION OF FARMED PRAWNS IN AUSTRALIA

- Md. Shah Alam, Shin-ichi Teshima, Shunsuke Koshio, Manabu Ishikawa, 13:40 Daisuke Haseaawa UTILIZATION OF COATED CRYSTALLINE AMINO ACIDS BY KURUMA SHRIMP Marsupenaeus japonicus IARVAE AND POST-LARVAE
- Simon J. Tabrett, David M. Smith 14:00 DO CULTIVARS OF LUPIN Lupinus angustifolius DIFFER IN THEIR NUTRITIONAL VALUE FOR BLACK TIGER PRAWNS Penaeus monodon?
- lan M. Ruscoe, Clive M. Jones 14:20 A REVIEW OF FEEDING STRATEGIES AND NUTRITION RESEARCH IN REDCLAW CRAYFISH Cherax quadricarinatus AQUACULTURE
- Kevin C. Williams, David M. Smith, Margaret C. Barclay, Simon J. Irvin 14:40 HIGH PERFORMANCE PELLETED DRY DIETS FOR REARING JUVENILE TROPICAL ROCK LOBSTER Panulirus ornatus
- PANEL DISCUSSION 15:00

BUSINESS PLANNING & INVESTMENT

Monday, September 27 13:40 - 15:20 Tumbalong Auditorium Session Chair: Simon Bennison

- **Russell J. Barnett** 13:40 THE REALITIES OF THE MARKET FOR RISK CAPITAL: THE IMPLICATIONS FOR THE CAPITAL STRATEGIES OF AUSTRALIAN AQUACULTURALISTS
- **Peter Marshall** 14:00 TURNING FISH INTO MONEY

Bill Marmion 14:20

INVESTMENT IN THE ABALONE AQUACULTURE INDUSTRY: STATUS & THE FUTURE

14:40 Chris Hoey

ATTRACTING SUPERANNUATION INVESTMENT TO THE AQUACULTURE INDUSTRY

15:00 Ian Sutton

ATTRACTING INVESTMENT TO THE AUSTRALIAN WINE INDUSTRY: LESSONS FOR AQUACULTURE

CRUSTACEAN POST HARVEST & MARKETING

Monday, September 27 15:50 - 17:30 Tumbalong Auditorium Session Chairs: Martin Breen, Harry Peters

This workshop will explore how locally and imported prawn aquaculture product can co-exist in the Australian seafood market. The recent boom in *Litopenaeus vannamei* production in SE Asia and China, and the increasing strength of the Australian dollar have all been blamed for decreasing the competitiveness of the Australian prawn aquaculture on local markets. But is this case? How can Australian aquaculture product compete with imports? Are Australian aquaculture products in the same market? In this session key players in the aquaculture and import sectors will discuss and debate how to develop a partnership that is a win win for both sectors.

MOLLUSC HEALTH

Monday, September 27 15:50 - 17:30 Tumbalong 2 Session Chairs: Brian Jones & Gary Zippel

15:50 Judith Handlinger, Richard Callinan, John Creeper, Matthew Landos, Richmond Loh, Malcolm Lancaster, Peter Phillips, Stephen Pyecroft, Fran Stephens A NATIONAL SURVEY OF DISEASES OF COMMERCIALLY EXPLOITED ABALONE SPECIES – A MOVE TO ADVANCE BOTH PROFIT AND SUSTAINABILITY

16:10 Serge Corbeil, Mark Crane DEVELOPMENT OF A REAL-TIME PCR ASSAY FOR THE PATHOGEN Bonamia

16:30 M. Josie Lategan, Bill Booth, Ronald Shimmon, Lewis F. Gibson ACTIVITY OF THE PURIFIED INHIBITORY SUBSTANCE PRODUCED BY Aeromonas media A199, A PROBIOTIC BACTERIUM

16:50 J. B. Jones WHY WON'T THE DAMN THINGS GROW? INHIBITORY SUBSTANCES AND MOLLUSC HATCHERIES

17:10 B. Ruth Arkless, Barrie M. Peake CADMIUM BIOACCUMULATION FROM THE DISSOLVED PHASE BY THE GREENSHELL MUSSEL Perna canaliculus

FINFISH BREEDING & GENETICS

Monday, September 27 15:50 - 17:30 Promenade 3 Session Chairs: Nick Elliott, Steven Battaglene & Pheroze Jungalwalla

15:50 Nick Robinson

EFFECTIVE USE OF NEW TECHNOLOGIES FOR GENETIC IMPROVEMENT - THE NORWAY EXPERIENCE

16:10 Graham C. Mair

GENETIC IMPROVEMENT OF FINFISH AND IMPLICATIONS FOR AUSTRALIAN AQUACULTURE DEVELOPMENT

16:30 Abigail Elizur, Kimberley Guyatt, Bryony Dixon, Josephine Nocillado, Phillip Brady, Nick Moody, Tim Holton FISH AND CHIPS – A FUNCTIONAL GENOMICS APPROACH TO THE STUDY OF KEY ISSUES IN FISH AQUACULTURE

TUESDAY

16:50 Brett A. Ingram, Jennifer Lade, Meaghan Rourke, Nick Robinson GENETIC ENHANCEMENT OF AUSTRALIAN FINFISH FOR AQUACULTURE AND CONSERVATION:

MURRAY COD

17:10 Jeffrey A. Guy, Stuart J. Rowland, Charlie Mifsud, Mark Nixon, Nathan Ferrie, Rod Simpson

HETEROSIS FOR GROWTH IN A DIALLEL CROSS BETWEEN TWO STRAINS OF SILVER PERCH Bidyanus bidyanus

TUESDAY, September 28

GOVERNMENT REGULATIONS & POLICY

Tuesday, September 28 8:30 - 10:10 Promenade 3 Session Chairs: Damian Ogburn, Micheal Deering & Brett McCallum

- 8:30 Neil Byron, Phil Hughes, Michael Schuele ENVIRONMENTAL REGULATION OF AQUACULTURE IN AUSTRALIA
- 8:50 Gary L. Jensen, John Colt

UNITED STATES CASE STUDY: INTEGRATING SCIENCE TO DEVELOP NATIONAL DISCHARGE REGULATIONS FOR AQUACULTURE OPERATIONS

9:10 Daryl P. McPhee

NIMBY'S, LULU'S AND AQUACULTURE - ARE WE MEETING THE PLANNING CHALLENGES?

- 9:30 Damian Ogburn, Steve McCorrie, Tim Gippel, Francis Dorman THE NEW SOUTH WALES OYSTER INDUSTRY SUSTAINABLE AQUACULTURE STRATEGY – DEVELOPING A MANAGEMENT FRAMEWORK
- 9:50 Bernard P. Walrut AQUACULTURE – WHAT DOES IT MEAN AT LAW

PROMOTING FARM PRODUCTS

Tuesday, September 28 8:30 - 12:20 Tumbalong 1 Session Chair: Helen O'Connor

- 8:30 Ian Sutton 2,000,000 SUCCESS STORIES PER DAY THE PHENOMENA OF THE MODERN AUSTRALIAN WINE INDUSTRY
- 9:10 Norm Grant FOSTERING A PROFESSIONAL APPROACH TO MARKETING
- 9:30 Danny Loch DOES YOUR BRAND STAND OUT OF THE CROWD?
- 9:50 **Gus Dannoun** MANAGING AND APPRECIATING A CHALLENGING AND COMPETITIVE MARKET
- 10:40 John Jenkin DEVELOPING AN AQUACULTURE BRAND - A NATIONAL AQUACULTURE COUNCIL INITIATIVE
- **11:00** Yu Liu, Felicia Kow, Devinder Grewal CONSUMER PREFERENCES FOR OYSTERS: IMPLICATIONS FOR THE AUSTRALIAN OYSTER INDUSTRY

11:20 John Susman

FROM PLATE TO WATER - THE NEED FOR DESIGNING TO CONSUMER WANTS

11:40 **PANEL DISCUSSION**

INDIGENOUS AND PACIFIC ISLAND AQUACULTURE

Tuesday, September 28 8:15 - 12:20 Promenade 1 Session Chair: Mike Rimmer, Ian Lyall, Yves Harache & Dennis Ah-Kee

Mike Rimmer 8:15

INTRODUCTION TO THE SESSION

8:30 **Cathy Hair**

CAPTURE AND CULTURE OF PRE-SETTLEMENT CORAL REEF FISH FOR THE MARINE AQUARIUM TRADE IN SOLOMON ISLANDS

8:50 **Steven W. Purcell**

RAPID GROWTH AND BIOTURBATION ACTIVITY OF THE SEA CUCUMBER Holothuria scabra IN EARTHEN PONDS

9:10 Ian Middleton

COMMERCIAL BARRAMUNDI Lates calcarifer FARMING WITH RURAL VILLAGERS ALONG THE NORTH COAST OF MADANG, PAPUA NEW GUINEA

9:30 Sheryl Miller, Philip L. Heath, Tiratu Williams DEVELOPING LOW-COST AQUACULTURE SYSTEMS ACCESSIBLE TO COASTAL MÂORI

Bruno Castelain 9:50

EVOLUTION OF SHRIMP FARMING IN NEW CALEDONIA: STRATEGIC CHOICES AND DEVELOPMENT POLICY OF THE NORTHERN PROVINCE

10:40 **Ray Hall** AQUACULTURE IN THE NORTHERN TERRITORY: BAWINANGA ABORIGINAL CORPORATION

11:00 **Cletus Oengpepa**

DEVELOPMENT OF GIANT CLAM AQUACULTURE IN SOLOMON ISLANDS

E. A. Evans-Illidge, C. W. W. Wolff, A. R. Duckworth, C. N. Battershill, R. Bannister, 11:20 S. Whalan, D. Louden, R. DeNys, G. Dobson, D. Steinberg EXPLORING THE POTENTIAL OF SPONGE AQUACULTURE WITH REMOTE COASTAL AUSTRALIAN COMMUNITIES

11:40 **Raymond Newnham** THE MARKETING OF COOK ISLANDS BLACK PEARLS

12:00 **Grant Sarra** WAY FORWARD

CONTRIBUTION OF GENETICS TO COMMERCIAL COMPETITIVENESS: CRUSTACEANS

Tuesday, September 28 8:30 - 17:30 Tumbalong 2 Session Chairs: Nigel Preston, Wayne Knibb & Martin Breen

- Henry C. Clifford, Edward D. Scura 8:30 A REVIEW OF GENETIC IMPROVEMENT OF WHITE SHRIMP Litopenaeus vannamei
- Brian P. Kinghorn, Hein van der Steen, Joao Rocha, Donghuo Jiang, Alok Deoraj 9:00 GENETIC TECHNOLOGIES TO TARGET EFFICIENT PRODUCTION OF QUALITY SHRIMP

TUESDAY

9:30	Emmanuel Goyard, Denis Coatanea, Cyrille Goarant, Jean-Marie Peignon, Jacques Patrois, Dominique Pham, Yves Harache INTEGRATING A GENETIC APPROACH INTO THE NEW-CALEDONIAN SHRIMP INDUSTRY FOR BIOLOGICAL AND ECONOMICAL SUSTAINABILITY: PAST, PRESENT AND FUTURE
9:50	Wayne Knibb, Michael Burke, Jason Bartlett, Michael Macbeth, Cam McPhee, Abigail Elizur, Liz O'Brien, Matt Kenway, Kate Wilson REVIEW OF GENETIC SELECTION PROJECTS AT BRIBIE ISLAND AQUACULTURE RESEARCH CENTRE WITH A FOCUS ON PRAWN GENETICS
10:40	M. Macbeth, Michael Burke, , P. Palmer, C. McPhee, Wayne Knibb ESTIMATION OF HERITABILITIES FOR REPRODUCTION AND GROWTH IN <i>Penaeus monodon</i> (FABRICIUS, 1798)
11:00	Peter Crocos, Greg Coman, Stuart Arnold, Melony Sellars IMPROVING THE REPRODUCTIVE PERFORMANCE OF DOMESTICATED Penaeus monodon
11:20	Nigel Preston GENETIC IMPROVEMENT OF THE KURUMA PRAWN Penaeus japonicus IN AUSTRALIA
12:00	Cameron P. McPhee, Clive Jones, Scott Shanks GENETIC AND ECONOMIC GAINS FROM SELECTION FOR INCREASED HARVEST WEIGHT IN RED CLAW CRAYFISH Cherax quadricarinatus
13:40	Sara L. Davis, Jim Wyban, Scott K. Davis, Wei Guo, Trina Guerra, Lara Robles, Keqin Gregg GENETIC MAPPING OF TAURA SYNDROME VIRUS RESISTANCE THE PACIFIC WHITE SHRIMP Penaus vannamei
14:00	Abigail Elizur, Anna Kuballa, Kimberley Guyatt, Bryony Dixon, Tim Holton, Brian Paterson, Wayne Knibb MICROARRAYS – NEW FACE OF CRUSTACEAN GENETICS?
14:20	Franklin Pérez, Constanza Erazo, Mariuxi Zhinaula, Juan Ortiz, César Gonzabay, Filip Volckaert, Jorge Calderón LINKAGE MAPPING IN THE WHITE SHRIMP Litopenaeus vannamei
14:40	Yutao Li, Russell Lyons, Leanne Dierens USING AFLP MARKERS AND A TWO-STAGE SELECTIVE GENOTYPING STRATEGY TO IDENTIFY GROWTH GENE MARKERS FOR THE KURUMA SHRIMP Penaeus japonicus
15:00	Dean R. Jerry Overcoming the problem of pedigree retention in prawn selective breeding programs – the use of dna markers as biological tags
15:50	Scott K. Davis, Sara L. Davis, Jim Wyban, Wei Guo, Lara Robles, Trina Guerra, Andrew Krystkowiak, Li Cai, Keqin Gregg A MICROSATELLITE LINKAGE MAP FOR THE PACIFIC WHITE SHRIMP Penaus vannamei
16:10	Greg Coman, Dean Jerry, Peter Crocos, Nigel Preston EFFECT OF GENOTYPE AND THE ENVIRONMENT ON THE SURVIVAL AND GROWTH OF THE KURUMA SHRIMP Penaeus japonicus
16:30	Melony J. Sellars, Frank E. Coman, Nigel Preston PROTECTING GENETICALLY IMPROVED SHRIMP VIA INDUCED STERILITY
16:50	Silvie Dumas, Eleonora Puente, Sergio López-Machado THE USE OF POLAR BODY AS AN INDICATOR TO OPTIMIZE THE PRODUCTION OF TRIPLOIDS BY COLD SHOCK IN PACIFIC WHITE SHRIMP Litopenaeus vannamei
17:10	Kevin Healey

Kevin Healey USE OF Bacillus CULTURES AS PROBIOTICS FOR AQUACULTURE

Tuesday, September 28 8:30 - 12:20 Promenade 4 Session Chairs: Robert van Barneveld, Rhys Hauler & Chris Carter

- 8:30 Brett Glencross, Wayne Hawkins, David Evans, Neil Rutherford, Ken Dods, Ross Maas, Peter McCafferty, John Snowden, Sofia Sipsas DEVELOPMENT AND EVALUATION OF VALUE-ADDED GRAIN PROTEIN PRODUCTS FOR THE AQUACULTURE FEEDS SECTOR: PROGRESS IN REPLACING FISH MEAL IN AUSTRALIA 9:10 Robert van Barneveld, David Ellis, Jeffrey Buchanan RECENT ADVANCES IN THE PRACTICAL NUTRITION OF SOUTHERN BLUEFIN TUNA Thunnus maccoyii 9:30 Chris Carter, Robin Katersky, Julia Barnes, Matthew Miller, Keith Irwin, Peter Nichols, **Rhys Hauler** EFFECT OF THE INTERACTION BETWEEN TEMPERATURE AND NUTRITION ON THE GROWTH PERFORMANCE OF FISH 9:50 Mark Booth, Geoff Allan AQUACULTURE DIET DEVELOPMENT: UNDERSTANDING THE RELATIONSHIPS BETWEEN FEED INGREDIENTS AND THE NUTRIENT REQUIREMENTS OF FIN-FISH 10:40 Rhys Hauler, Julia Barnes, Chris Carter, Keith Irwin PERFORMANCE OF ATLANTIC SALMON UNDER SUMMER WATER CONDITIONS 11:00 Shymaa M. M. Shalaby, Asmaa Abd Elmonem, Ashraf Y. El-Dakar, Olfet W. Sedrak IMPROVEMENT OF GROWTH AND FEED UTILIZATION BY USING LICORICE ROOTS (ERKSOUS) AS A FEED ADDITIVE IN DIETS OF NILE TILAPIA Oreochromis niloticus FINGERLINGS 11:20 Mehdy Shamsaie Mehrjan, M. R. Ahmady, G. H. Vosughi, H. Emadi, A. Afsar, K. Nazari RESEARCH OF THE EFFECTS OF 3 DIFFERENT KINDS OF FEED ON GROWTH AND SURVIVAL RATES OF EUROPEAN WHITEFISH Coregonus lavaretus OF KARAJ LAKE IN IRAN 11:40 Ashraf Y. El-Dakar, Shymaa M. M. Shalaby, Asmaa Abd Elmonem ENHANCEMENT OF GROWTH PERFORMANCE AND FEED UTILIZATION USING FENNEL (SHUMER) SEED MEAL AS FEED ADDITIVE IN NILE TILAPIA Oreochromis niloticus FINGERLING DIETS Maria I. Sandoval-Muy, Benjamin Barón-Sevilla 12:00 THE EFFECT OF FOOD ON THE METABOLIC RATE AND NITROGEN EXCRETION OF PACIFIC SEAHORSE Hippocampus ingens **CRUSTACEAN HEALTH** Tuesday, September 28 10:40 - 12:20 Promenade 3 Session Chairs: Dick Callinan, Peter Walker & Martin Breen 10:40 Daniel F. Fegan, T. W. Flegel THE IMPACT OF Litopenaeus vannamei ON THE SHRIMP DISEASE SITUATION IN THAILAND 11:00 Chantal Mugnier, Jacques Patrois, Sophie de Decker, Cyrille Goarant INTERACTION BETWEEN Vibrio INFECTION AND STRESS ON THE BLUE SHRIMP Litopenaeus stylirostris RESPONSE 11:20 Kate J. Wilson, Neil Young, Brian Murphy, K. V. Rajendran, Jeff Cowley
 - THE INFLUENCE OF VIRAL LOAD ON THE SPAWNING EFFICIENCY OF WILD AND DOMESTICATED AUSTRALIAN Peneaus monodon BROODSTOCK
- 11:40 Enrique de la Vega, Bernie Degnan, Mike Hall, Kate Wilson A MOLECULAR APPROACH TO CHARACTERISE ENVIRONMENTAL STRESS RESPONSE AND PATHOGEN INTERACTION OF Penaeus monodon IN AUSTRALIA

TUESDAY

12:00 Jeff A. Cowley, K. V. Rajendran, Russell J. McCulloch, Peter J. Walker

THE DETECTION OF INFECTIOUS HYPODERMAL AND HAEMATOPOIETIC NECROSIS VIRUS (IHHNV) IN AUSTRALIAN Penaeus monodon AND ITS POTENTIAL EVOLUTIONARY ORIGIN

FOOD SAFETY

Tuesday, September 28 13:40 - 17:10 Promenade 4 Session Chairs: Rhys Hauler, Robert van Barneveld & Chris Carter

13:40 Graeme Dear FOOD SAFETY AND THE EU CONSUMERS PERSPECTIVE

- 14:20 Katrina Roper, Jenny Williams HOW DO WE ACHIEVE FOOD SAFETY IN THE AQUACULTURE INDUSTRY IN AUSTRALIA?
- **15:00** D. J. Padula, A. Kiermeier, B. J. Daughtry, T. L. Madigan, A. M. Pointon A THROUGH-CHAIN RISK-BASED ASSESSMENT OF RESIDUES IN SOUTHERN BLUEFIN TUNA *Thunnus maccoyii:* PREDICTIVE MODEL DEVELOPMENT

15:50 Fay Stenhouse

EXPORT FACILITATION - DAFF'S ROLE IN SUPPORTING THE AQUACULTURE INDUSTRY EXPORT PUSH

16:30 Arjen Roem HOW TO ORGANISE FOOD SAFETY IN A GLOBAL AQUACULTURE COMPANY

INLAND SALINE AND ARID AQUACULTURE

Tuesday, September 28 13:40 - 17:30 Tumbalong 1 Session Chair: Stewart Fielder

- 13:40 Kevin Fitzsimmons OVERVIEW OF INLAND – SALINE AQUACULTURE
- 14:00 Claude E. Boyd IONIC SUPPLEMENTATION OF POND WATERS FOR INLAND CULTURE OF MARINE SHRIMP
- 14:20 Adrian Collins, Benjamin Russell EMERGING OPPORTUNITIES FOR PRAWN AQUACULTURE USING SALINE GROUNDWATER
- 14:40 Sudhir Raizada, Javed Hasan, S. Ayyappan, Subhash Mukherjee, Umesh Maheshwari HATCHERY SEED PRODUCTION OF GIANT FRESHWATER PRAWN, Macrobrachium rosenbergi IN GROUND SALINE WATER OF ROHTAK (HARYANA), INDIA
- 15:00 Luke Dutney COMMERCIAL PRODUCTION OF MULLOWAY Argyrosomus japonicus USING SALINE GROUND WATER
- **15:50 Geoff Allan, Simon Bennison** INLAND SALINE AQUACULTURE: NATIONAL COORDINATION OF R&D IN AUSTRALIA
- 16:10 Stewart Fielder, Grant Webster, Mehdi Doroudi & Geoff Allan STATUS OF R&D AT THE INLAND SALINE AQUACULTURE RESEARCH CENTRE, WAKOOL, NSW
- 16:30 Gavin J. Partridge, Gavin A. Sarre, Greg I. Jenkins NEW TECHNOLOGY FOR THE COMMERCIALISATION OF INLAND SALINE AQUACULTURE IN WESTERN AUSTRALIA

TUESDAY

TUESDAY

16:50 Tim Flowers, Wayne Hutchinson

CURRENT RESEARCH IN DEVELOPING AN AQUACULTURE INDUSTRY USING WATER FROM SALT INTERCEPTION SCHEMES IN SOUTH AUSTRALIA

17:10 Geoff J. Gooley, Fiona Gavine

WATER USE SUSTAINABILITY IN AGRICULTURAL LANDSCAPES: A CONCEPTUAL FRAMEWORK FOR INLAND AQUACULTURE DEVELOPMENT IN AUSTRALIA

POST HARVEST & MARKETING - PRODUCTION & PRODUCT QUALITY

Tuesday, September 28 13:40 - 17:30 Promenade 1 Session Chairs: Philip Thomas & Allan Bremner

13:40 Jacques Gabaudan

PIGMENTATION OF SALMONID FEED AND PRODUCT QUALITY

14:00 Alastair Smart

TO KILL A FISH: THE METHODS USED, AND THE LINK BETWEEN QUALITY AND WELFARE AT SLAUGHTER

14:20 Trine Karlsrud, Craig Foster, Jim Smith, Steven Matthews BARRAMUNDI PRODUCT QUALITY CHARACTERISTICS

14:40 T. Lewis MODIFIED ATMOSPHERE PACKAGING (MAP) MICROBIOLOGY AND SEAFOOD

15:00 Alan Travis RETAIL PACKAGING – ADDING VALUE OR JUST WINDOW DRESSING?

15:50 Mark Boulter THE 'QUALITY' ASSESSMENT OF AQUACULTURE PRODUCT TRADED AT SYDNEY FISH MARKET

16:10 Philip Thomas, John Carragher, Allan Bremner, Alistair Douglas, Mark Thomas, Jeff Buchanan, Steven Nottingham TO MARKET TO MARKET TO BUY A FAT TUNA AQUAFIN-CRC TUNA QUALITY PROJECT, SENSORY EVALUATION WORKSHOP

MOLLUSC HUSBANDRY & ENVIRONMENT

Tuesday, September 28 13:40 - 17:30 Promenade 3 Session Chairs: Mike Heasman & Gary Zippel

13:40 Mark Gibbs ESTIMATING CARRYING CAPACITY – A DIFFICULT BUT ESSENTIAL PREREQUISITE TO SUSTAINABLE BIVALVE AQUACULTURE

14:20 Ana M. Rubio

CARRYING CAPACITIES OF NSW ESTUARIES FOR SUSTAINABLE OYSTER Saccostrea glomerata PRODUCTION

14:40 Kevin Heasman, Mark T. Gibbs, Lance Searle, John Wilson, Nigel Keeley OPEN OCEAN SHELLFISH AQUACULTURE IN NEW ZEALAND

15:00 Mike Dredge

NEW AQUACULTURE INDUSTRIES IN AUSTRALIA – SCOPING STUDIES, DEVELOPMENT AND REALITY

- 15:50 Scott P. Gifford, R. Hugh Dunstan, Wayne A. O'Connor, Geoff R. Macfarlane ARE ENVIRONMENTAL MONITORING PROGRAMS NECCESSARY FOR BIVALVE AQUACULTURE? THE PORT STEPHENS, AUSTRALIA, EXPERIENCE
- 16:10 Laurent Girault, Marie-Lyne Larrivée, Benoît Thomas, Fabrice Pernet COMPARISON OF FIVE REARING TECHNIQUES FOR THE GIANT SCALLOP Placopecten magellanicus IN THE GASPE BAY, QUEBEC, CANADA
- 16:30 Mike Heasman POTENTIAL FOR ENHANCING THE NSW BLACKLIP ABALONE Haliotis rubra FISHERY USING HATCHERY PRODUCED SEED
- 16:50 Justin D. Ho, Stephen Edwards, Peter A. Thompson LAND BASED ABALONE FARMING: HOW CLEANING AND SEASON AFFECT ENVIRONMENTAL PERFORMANCE
- 17:10 Robert Bishop REPLACEMENT OF THE BIOFILTER FOR LAND BASE AQUACULTURE SEAWATER RECIRCULATION SYSTEM

WEDNESDAY, September 29

FINFISH HUSBANDRY & ENVIRONMENT

Wednesday, September 29 8:30 - 10:10 Promenade 1 Session Chairs: John Volkman, Brett Glencross & Pheroze Jungalwalla

- 8:30 Tony Rumbold INDUSTRIAL LAND-BASED FISH FARMING – IS THIS THE WAY OF THE FUTURE?
- 8:50 Brett A. Ingram, Sena S. de Silva, Geoff J. Gooley INDUSTRY DEVELOPMENT: A CASE STUDY FEATURING MURRAY COD
- 9:10 Stephen C. Battaglene, David T. Morehead, Ross M. Goldsmid IMPROVEMENTS AND LONG-TERM TRENDS IN STRIPED TRUMPETER Latris lineata CAPTIVE SPAWNING
- 9:30 Susan Forbes, Catriona MacLeod, Christine Crawford, John Volkman, Daniel Holdsworth, Andrew Revill, Chris Burke, Andrew Bissett A SIMPLE AND EFFECTIVE METHOD FOR FARM-BASED ENVIRONMENTAL MONITORING OF CAGED MARINE FINFISH
- 9:50 Peter Lauer, Melena Fernandes, Jason Tanner, Peter Fairweather, Anthony Cheshire TUNA FARMING AND THE SEAFLOOR

CRUSTACEAN HUSBANDRY & ENVIRONMENT

Wednesday, September 29 8:30 - 12:20 Tumbalong 2 Session Chairs: Chris Robertson, Chris Jackson & Martin Breen

- 8:30 Daniel F. Fegan CULTURE METHODS FOR Litopenaeus vannamei IN THAILAND
- 8:50 Paul J. Palmer, Dirk Erler, Michael Burke, Ross Lobegeiger, Catriona Morrison, Gwen Bell, Wayne Knibb GROWING BANANA PRAWNS *Penaeus merguiensis* (de Man) IN PRAWN FARM SETTLEMENT

GROWING BANANA PRAWNS *Penaeus merguiensis* (de Man) IN PRAWN FARM SETTLEMENT PONDS TO UTILISE AND HELP REMOVE WASTE NUTRIENTS

	9:10	Gil Penha-Lopes, Andrew Rhyne, Junda Lin, Luis Narciso MARINE ORNAMENTAL DECAPODS – AQUACULTURE OF EMERGING SPECIES
	9:30	Greg B. Maguire, John N. Heine, George Cassells, Craig S. Lawrence, Tony Church EFFECTS OF STOCKING DENSITY FOR YEAR 1 AND GRADING STRATEGY IN YEAR 2 ON GROWTH, SURVIVAL AND PROFITABILITY FOR MARRON <i>Cherax tenuimanus</i> STOCKED INTO AND HARVESTED FROM MODEL FARMING PONDS IN SUMMER
	9:50	Kavita Gosavi, Jes Sammut, Jerzy Jankowski REMEDIATION AND MANAGEMENT OF ACID SULFATE SOILS IN COASTAL AQUACULTURE PONDS
	10:40	Brian D. Paterson, David Mann DEVELOPMENTS IN PORTUNID CRAB AQUACULTURE IN QUEENSLAND – ADDRESSING CANNIBALISM
	11:00	David Mann, Tom Asakawa, Beverley Kelly, Trent Lindsay, Brian Paterson PRODUCTIVITY IN INTENSIVE NURSERY SYSTEMS FOR MUD CRABS Scylla serrata
	11:20	Sarah Groves, Jesmond Sammut, Jerzy Jankowski GEOCHEMICAL RELATIONSHIPS AT THE SEDIMENT-WATER INTERFACE WITH EMPHASIS ON NUTRIENTS, AT A MARINE PRAWN AQUACULTURE FARM, SOUTH-EAST QUEENSLAND, AUSTRALIA
DAY	11:40	Frank Coman, Stuart Arnold, Chris Jackson DEVELOPMENT OF A TANK SYSTEM TO INVESTIGATE THE HIGH DENSITY CULTURE OF <i>Penaeus</i> <i>monodon</i> AND <i>P. merguiensis</i> USING REDUCED PROTEIN FEEDS AND CARBON ADDITION PROTOCOLS
EDNES	12:00	Stuart Arnold, Melony Sellars, Greg Coman, Peter Crocos ULTRA-HIGH-DENSITY PRODUCTION OF JUVENILE <i>Penaeus esculentus</i> AND <i>P. monodon</i> IN A TANK SYSTEM USING ARTIFICIAL SUBSTRATES
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		Session Chairs: Wayne O'Connor & Gary Zippel
	8:30	Robert D. Ward, Peter A. Thompson PROGRESS IN A GENETIC IMPROVEMENT PROGRAM FOR PACIFIC OYSTERS Crassostrea gigas IN AUSTRALIA
	8:30 8:50	 Wednesday, September 29 8:30 - 12:20 Promenade 3 Session Chairs: Wayne O'Connor & Gary Zippel Robert D. Ward, Peter A. Thompson PROGRESS IN A GENETIC IMPROVEMENT PROGRAM FOR PACIFIC OYSTERS Crassostrea gigas IN AUSTRALIA John A. Nell BREEDING SYDNEY ROCK OYSTERS Saccostrea glomerata FOR FAST GROWTH AND DISEASE RESISTANCE
	8:30 8:50 9:10	 Wednesday, September 29 8:30 - 12:20 Promenade 3 Session Chairs: Wayne O'Connor & Gary Zippel Robert D. Ward, Peter A. Thompson PROGRESS IN A GENETIC IMPROVEMENT PROGRAM FOR PACIFIC OYSTERS Crassostrea gigas IN AUSTRALIA John A. Nell BREEDING SYDNEY ROCK OYSTERS Saccostrea glomerata FOR FAST GROWTH AND DISEASE RESISTANCE Joth Davis TETRAPLOID INDUCED TRIPLOID OYSTER PRODUCTION IN NORTH AMERICA.
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	8:30 8:50 9:10 9:30 9:50 10:40	 Wednesday, September 29 8:30 - 12:20 Promenade 3 Session Chairs: Wayne O'Connor & Gary Zippel Robert D. Ward, Peter A. Thompson PROGRESS IN A GENETIC IMPROVEMENT PROGRAM FOR PACIFIC OYSTERS <i>Crassostrea gigas</i> IN AUSTRALIA John A. Nell BREEDING SYDNEY ROCK OYSTERS <i>Saccostrea glomerata</i> FOR FAST GROWTH AND DISEASE RESISTANCE Joth Davis TETRAPLOID INDUCED TRIPLOID OYSTER PRODUCTION IN NORTH AMERICA. Scott A. Parkinson FATTER, FASTER, BETTER – A SUCCESS STORY IN SELECTIVE BREEDING FOR PROFIT IN THE AUSTRALIA PACIFIC OYSTER INDUSTRY David Raftos, Britt Bezemer, Daniel Butt, Kathryn Newton THE GENETICS OF GX DISEASE RESISTANCE IN SYDNEY ROCK OYSTERS David Hurwood, Mike Heasman, Peter Mather GENETIC STOCK STRUCTURE OF THE AUSTRALIAN FLAT OYSTER <i>Ostrea angasi</i> IN NEW SOUTH WALES: IMPLICATIONS FOR AQUACULTURE
	8:30 8:50 9:10 9:30 9:50 10:40 11:00	 Wednesday, September 29 8:30 - 12:20 Promenade 3 Session Chairs: Wayne O'Connor & Gary Zippel Robert D. Ward, Peter A. Thompson PROGRESS IN A GENETIC IMPROVEMENT PROGRAM FOR PACIFIC OYSTERS Crassostrea gigas IN AUSTRALIA John A. Nell BREEDING SYDNEY ROCK OYSTERS Saccostrea glomerata FOR FAST GROWTH AND DISEASE RESISTANCE Joth Davis TETRAPLOID INDUCED TRIPLOID OYSTER PRODUCTION IN NORTH AMERICA. Scott A. Parkinson FATTER, FASTER, BETTER – A SUCCESS STORY IN SELECTIVE BREEDING FOR PROFIT IN THE AUSTRALIA PACIFIC OYSTER INDUSTRY David Raftos, Britt Bezemer, Daniel Butt, Kathryn Newton THE GENETICS OF QX DISEASE RESISTANCE IN SYDNEY ROCK OYSTERS David Hurwood, Mike Heasman, Peter Mather GENETIC STOCK STRUCTURE OF THE AUSTRALIAN FLAT OYSTER Ostrea angasi IN NEW SOUTH WALES: IMPLICATIONS FOR AQUACULTURE Rodney Roberts, John Smith, Serean Adams, Achim Janke, Nick King, Henry Kaspar
	8:30 8:50 9:10 9:30 9:50 10:40 11:00	 Wednesday, September 29 8:30 - 12:20 Promenade 3 Session Chairs: Wayne O'Connor & Gary Zippel Robert D. Ward, Peter A. Thompson PROGRESS IN A GENETIC IMPROVEMENT PROGRAM FOR PACIFIC OYSTERS Crassostrea gigas IN AUSTRALIA John A. Nell BREEDING SYDNEY ROCK OYSTERS Saccostrea glomerata FOR FAST GROWTH AND DISEASE RESISTANCE Joth Davis TETRAPLOID INDUCED TRIPLOID OYSTER PRODUCTION IN NORTH AMERICA. Scott A. Parkinson FATTER, FASTER, BETTER – A SUCCESS STORY IN SELECTIVE BREEDING FOR PROFIT IN THE AUSTRALIA PACIFIC OYSTER INDUSTRY David Raftos, Britt Bezemer, Daniel Butt, Kathryn Newton THE GENETICS OF GX DISEASE RESISTANCE IN SYDNEY ROCK OYSTERS David Hurwood, Mike Heasman, Peter Mather GENETIC STOCK STRUCTURE OF THE AUSTRALIAN FLAT OYSTER Ostrea angasi IN NEW SOUTH WALES: IMPLICATIONS FOR AQUACULTURE Rodney Roberts, John Smith, Serean Adams, Achim Janke, Nick King, Henry Kaspar, Robin Tervit, Steve Webb CRYOPRESERVATION AND COOL STORAGE OF PACIFIC OYSTER SPERM FOR SELECTIVE BREEDING AND COMMEPCIAL SPAT EPODUCTION

11:20 Michael Dove, Wayne A. O'Connor, Ben Finn, Michael P. Heasman

PROGRESS IN OVERCOMING CONSTRAINTS TO COMMERCIAL SCALE HATCHERY AND NURSERY PRODUCTION OF SYDNEY ROCK OYSTERS Saccostrea glomerata

11:40 Wenshan Liv, Mike Heasman

INDUCTION AND EVALUATION OF TRIPLOIDS IN THE BLACKLIP ABALONE Haliotis rubra FOR FARMING AND FISHERIES ENHANCEMENT

12:00 Elizabeth O'Brien, Jason Bartlett, Bryony Dixon, Peter Duncan, Wayne Knibb SAUCER SCALLOP RANCHING – GENETIC CONSIDERATIONS

LARVAL NUTRITION AND FEEDS

Wednesday, September 29 8:30 - 17:30 Tumbalong 1 Session Chairs: Sagiv Kolkovski, Robert van Barneveld & Stephen Battaglene

- 8:30 Marisol Izquierdo NUTRITIONAL REQUIREMENTS FOR FINFISH LARVAE
- 9:10 Matthew P. Bransden, Stephen C. Battaglene, Jennifer M. Cobcroft, Graeme A.Dunstan, David T. Morehead, Peter D. Nichols INVESTIGATING THE DIETARY DHA REQUIREMENT OF LARVAL STRIPED TRUMPETER Latris lineata USING DOSE-RESPONSE TECHNIQUES
- 9:30 Atsushi Hagiwara, Hiroshi Kuwada CURRENT STATUS OF LIVE FOOD CULTURE IN JAPAN
- **10:40** Richard M. Knuckey, Gale L. Semmens, Damien C. McKeering, Michael A. Rimmer PRODUCTION OF COPEPODS Acartia sinjensis FOR MARINE FINFISH LARVAE
- 11:00 Arjen Roem GEMMA MICRO – A DECISIVE REPLACEMENT
- **11:20** Sagiv Kolkovski, John Curnow, Justin King, Gavin Partridge, Paul Southgate FISH LARVAE DIETS REPLACING IMPORTED Artemia – FRDC RESEARCH PROJECT
- 11:40 Alireza Asem, Nasrullah Rastegar Pouyani, Naser Agh BIOMETRICAL VARIATION OF Artemia urmiana CYSTS HARVESTED NORTH PART OF THE LAKE URMIA, IRAN
- 12:00 John Curnow, Justin King, Gavin Partridge, Jerome Bosmans, Trine Karlsrud, Sagiv Kolkovski THE EFFECT OF VARIOUS CO-FEEDING AND WEANING REGIMES ON GROWTH AND SURVIVAL IN BARRAMUNDI Lates calcarifer LARVAE
- 13:40 John Sweetman EUROPEAN AQUACULTURE: RECENT DEVELOPMENTS IN MARINE HATCHERY PRODUCTION METHODOLOGIES AND SPECIES DIVERSIFICATION
- 14:20 Shin-ichi Teshima, Manabu Ishikawa, Yohko Fudo, Md. Shah Alam, Luis Hector Hernandez Hernandez, Shunsuke Koshio, Fady Raafat Michael EFFECTS OF THE FORMULATION, SINKING SPEED, AND FEEDING METHOD OF DIETS ON SURVIVAL AND GROWTH OF LARVAL JAPANESE FLOUNDER Paralichthys olivaceus AND RED SEA BREAM Pagrus major FED MICROPARTICULATE DIETS
- 14:40 Justin King, Sagiv Kolkovski, John Curnow INTENSIVE CULTURE OF Artemia BIOMASS
- 15:50 Jan A. Olafsen

ASPECTS OF HOST-MICROFLORA INTERACTIONS IN MARINE AQUACULTURE: FROM DISEASE PROBLEMS TO MICROFLORA MANAGEMENT?

16:30	Ketut Sugama, Adi Hanafi and Mike Rimmer NATURAL SPAWNING AND LARVAL REARING OF BARRAMUNDI COD Cromileptes altivelis
17:10	Ben Nan Chen, Jian G. Qin MORPHOLOGICAL AND HISTOLOGICAL DEVELOPMENT OF THE DIGESTIVE SYSTEM IN YELLOWTAIL KINGFISH <i>Seriola lalandi</i> LARVAE
	FINFISH HEALTH
	Wednesday, September 29 10:40 - 17:10 Promenade 1 Session Chairs: Barbara Nowak, Mark Crane & Pheroze Jungalwalla
10:40	Michael Horne THE FUTURE OF AQUACULTURE VACCINES
11:40	Jeremy Carson, Toni Wagner, Georgina Mann, Melanie Ansell BACTERIAL VACCINES FOR FINFISH AQUACULTURE IN AUSTRALIA: THE ART, THE POSSIBLE AND THE CHALLENGE
13:40	Barbara Nowak AQUAFIN CRC HEALTH PROGRAM
14:00	Mark D. Powell DEVELOPMENT OF SEAWATER TREATMENTS FOR AMOEBIC GILL DISEASE
14:20	Mathew T. Cook, Jawahar G. Patil, Nick G. Elliott, Chris Prideaux DEVELOPMENT OF A VACCINE FOR AMOEBIC GILL DISEASE (AGD) IN ATLANTIC SALMON Salmo salar: A DNA APPROACH
14:40	Richard N. Morrison, Barbara F. Nowak STIMULATING THE FISH IMMUNE SYSTEM
15:00	Kenneth A. McColl CYTOKINES IN FINFISH – A REVIEW
15:50	Serge Corbeil, Mark Crane RNA INTERFERENCE AND FISH
16:10	lain J. East, Eva-Maria Bernoth BENEFITS TO INDUSTRY ARISING FROM THE FISHERIES RESEARCH AND DEVELOPMENT CORPORATION'S AQUATIC ANIMAL HEALTH SUBPROGRAM
16:30	Karina Scott "DISEASE WATCH – PLAY YOUR PART": AN AQUATIC ANIMAL HEALTH AWARENESS KIT
16:50	Mark St. J. Crane FUTURE DIRECTIONS FOR AQUATIC ANIMAL HEALTH RESEARCH IN AUSTRALIA
	MOLLUSC NUTRITION
	Wednesday, September 29 13:40 - 17:10 Promenade 3 Session Chairs: Malcolm Brown & Gary Zippel
13:40	Meegan Vandepeer THE NUTRITIONAL REQUIREMENTS OF ABALONE – WHAT WE CURRENTLY KNOW
14:00	R. Mohan, R. Gimin, L. V. Thinh, S. Renaud, A. D. Griffiths EVALUATION OF LIVE MICROALGAE AS DIETS FOR MANGROVE CLAM <i>Polimesoda erosa:</i> EFFECTS ON FILTRATION, INGESTION, ASSIMILATION AND ENERGY ACQUISITION

WEDNESDAY

14:20 Malcolm R. Brown

MICROALGAE AND THEIR ROLE IN BIVALVE HATCHERY NUTRITION

14:40 W. Lindsey Zemke-White, C. Templeton SOLUBILITY OF PROTEIN AND STARCH IN ARTIFICIAL AQUACULTURE FEEDS: HOW MUCH OF YOUR MONEY IS GOING DOWN THE DRAIN?

15:00 Mike Heasman

AN ALTERNATIVE HIGH DENSITY NURSERY REARING SYSTEM FOR LARGE SCALE, YEAR-ROUND, LOW COST PRODUCTION OF BLACKLIP ABALONE Haliotis rubra SEED FOR FISHERIES ENHANCEMENT OR ON-FARMING

15:50 Susan Blackburn, Dion Frampton, Majed Mansour, Stefano Gallori, Mario Tredici, Malcolm Brown

PHOTOBIOREACTOR TECHNOLOGY FOR MASS-PRODUCTION OF MICROALGAE FOR AUSTRALIAN AQUACULTURE

16:10 Rodney P. Grove-Jones, John C. Bayes PRACTICAL CONTINUOUS ALGAE CULTURE IN A COMMERCIAL HATCHERY

16:30 Michael A. Borowitzka

MICROALGAE PRODUCTION FOR MOLLUSK AQUACULTURE: CULTURE SYSTEMS, NUTRITIONAL QUALITY AND ECONOMICS

16:50 Yan Li, Jian G. Qin

EFFECT OF ILLUMINATION, TEMPERATURE AND SALINITY ON THE GROWTH OF A HYDROCARBON-RICH ALGA Botryococcus braunii

EXTENSION AND TECHNICAL TRANSFER

Wednesday, September 29 13:40 - 15:20 Tumbalong 2 Session Chairs: Tim Walker, Stuart Rowland & Dos O'Sullivan

13:40 Michael P. Masser ROLE OF EXTENSION IN THE DEVELOPMENT OF THE CHANNEL CATFISH AND OTHER AQUACULTURAL INDUSTRIES IN THE USA

14:00 Tony Leaney The Aquaculture Compendium – A review of the development of this innovative Multimedia knowledge resource and a demonstration of the compendium Technology in Action

14:20 Derek Foster EXTENSION – THE PROCESS OF NESTING SCIENTIFIC RESEARCH INTO BROAD SOCIAL SYSTEMS

14:40 Dan Machin THE E-MYTH IN AUSTRALIAN AQUACULTURE DEVELOPMENT

15:00 Brendan Larkin

INFORMATION TRANSFER WITHIN RAS IN AUSTRALIA

EDUCATION & TRAINING

Wednesday, September 29 15:50 - 17:30 Tumbalong 2 Session Chairs: Jo-Anne Ruscoe, Ross Ord & Chris Carter

- 15:50 Steven Webster "PEARLS OF WISDOM" ESTABLISHING TRAINING IN AN EMERGING INDUSTRY
- 16:10
 Cheryl Phillips, Martin Smallridge

 A NEW MODEL OF LEADERSHIP DEVELOPMENT IN RURAL INDUSTRIES

16:30 Roy Palmer A SHORT JOURNEY INTO DIGITAL STORY TELLING (DST) – A RESOURCE FOR TRAINING

- 16:50 Paul McShane MAKING THE MOST OF EDUCATION TRAINING AND WORKPLACE OPPORTUNITIES FOR THE AUSTRALIAN AQUACULTURE INDUSTRY
- 17:10 John Roach TBA

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FINFISH POSTERS

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101	Fatemeh Abbassi, Shahrbano Oryan, Abbas Matinfar REVERSAL SEX CHANGE IN THE PROTOGYNOUS FISH <i>Epinephelus coioides</i> IN THE PERSIAN GULF
102	Hamish Aiken, Craig Hayward, Marty Deveney, Barbara Nowak PARASITE SURVEY IN CULTURED SOUTHERN BLUEFIN TUNA
103	Ahmed Al-Marzouk, Rosylene Duremdez, Jafar Qasem, Ahmed Al-Harbi, Hashem Al-Gharabally
	IN KUWAIT
104	Sungchul Bai, Kyungmin Han EVALUATION OF SEVERAL DIFFERENT LIVE FOODS IN GLASS EEL Anguialla japonica
105	Matthew P. Bransden, Stephen C. Battaglene, Philippe Esnault, Ross M. Goldsmid, Jennifer M. Cobcroft, Peter D. Nichols TEMPORAL TRENDS IN BROODSTOCK CONDITION AND EGG LIPID OF CAPTIVELY-HELD STRIPED TRUMPETER Latris lineate
106	J. G. Buchanan, P. M. Thomas COATING PILCHARDS WITH DIETARY ANTI-OXIDANTS TO IMPROVE THE SHELF LIFE OF SOUTHERN BLUEFIN TUNA <i>Thunnus maccoyii</i>
107	Jennifer M. Cobcroft, Stephen C. Battaglene, David T. Morehead, Matthew P. Bransden, Judith Handlinger
	HISTOPATHOLOGY OF THE INTESTINE OF LARVAL STRIPED TRUMPETER Latris lineata CULTURED IN TASMANIA
108	Mathew T. Cook, James W. Wynne, Barbara F. Nowak, Nick G. Elliott POLYMORPHISMS WITHIN MHC GENES ASSOCIATED WITH RESISTANCE AND SUSCEPTABILITY TO AMOEBIC GILL DISEASE (AGD) IN ATLANTIC SALMON Salmo salar

- 109 Elizabeth S. Cox, Peter A. Fry, Anjanette C. Johnston, Michael A. Rimmer LIGHT INTENSITY INFLUENCES MORPHOLOGICAL DEVELOPMENT OF PRE-FEEDING GROUPER LARVAE
- 110 S. J. Davies, R. D. Serwata

DIGESTIBILITY ASSESSMENT OF SELECTED PLANT PROTEIN CONCENTRATES (PEA, MAIZE, WHEAT) FOR RAINBOW TROUT *O. mykiss*

111 S. J. Davies, R. D. Serwata, A. Gouveia

DIGESTIBILITY EVALUATION OF SELECTED COMMERCIAL ANIMAL BY-PRODUCTS FOR APPLICATIONS IN DIETS FOR SEABASS Dicentrachus labrax

112 Silvie Dumas, Hugo Pliego-Cortés, Juan Pablo Alcántar-Vázquez, Martín Rosales-Velazquez, Pablo Pintos

THE EFFECT OF LHRH- α ON THE REPRODUCTIVE PERFORMANCE OF THE SPOTTED SAND BASS Paralabrax maculatofasciatus

113 Brett Glencross

INFLUENCE OF FISH SIZE AND WATER TEMPERATURE ON METABOLIC DEMAND FOR OXYGEN BY BARRAMUNDI Lates calcarifer: IMPLICATIONS FOR DIETARY ENERGY DEMAND

114 Sridevi Gopinath, Barbara Nowak, Rick Butler

EFFECTS OF BACTERIA ON PROGRESSION AND SEVERITY OF AMOEBIC GILL DISEASE IN ATLANTIC SALMON

115 Kally A. Gross, Richard N. Morrison, Barbara F. Nowak

THE IMMUNE RESPONSE OF AMOEBIC GILL DISEASE (AGD) AFFECTED ATLANTIC SALMON Salmo salar L.

116 Kyungmin Han, Jin Hyung Yoo, Xiaojie Wang, Sungchul C. Bai, Sungbum Hur EFFECT OF DIETARY ESSENTIAL FATTY ACIDS ON BODY COMPOSITION OF JAPANESE EEL Anguilla japonica

117 Judith Handlinger, Kevin Ellard IDENTIFICATION OF A RICKETTSIA-LIKE ORGANISM CAUSING DISEASE IN TASMANIAN FARMED ATLANTIC SALMON

- 118 Brett W. Herbert, Peter A. Graham EFFECT OF GRADING ON POND GROW OUT OF GOLDEN PERCH Macquaria ambigua
- 119 Greg I. Jenkins, Tony Bart

ENVIRONMENTAL MANAGEMENT OF MARINE FINFISH GROWOUT OPERATIONS

- 120 Michael B. Kearney, Andrew Jeffs, John Montgomery, Mere Roberts, Guy Carton ACCLIMATION AND GROWTH RATES OF THE GLASS EEL STAGE OF Anguilla australis AND Anguilla dieffenbachii IN SALTWATER CULTURE
- 121 Sagiv Kolkovski, John Curnow, Justin King INTENSIVE REARING SYSTEMS FOR FINFISH LARVAE RESEARCH
- 122 Melanie J. Leef, James O. Harris, Mark D. Powell THE CARDIOVASCULAR EFFECTS OF AMOEBIC GILL DISEASE (AGD): A COMPARATIVE STUDY OF THREE SALMONID SPECIES
- 123 Christian Lückstädt, Andreas Groth, Ulfert Focken OBSERVATIONS ON DAILY FEEDING RHYTHM OF JUVENILE MILKFISH Chanos chanos IN BRACKISHWATER PONDS

124 Peter Mellor, Ravi Fotedar

BLOOD OSMOLALITY AND BODY MOISTURE OF MURRAY COD Maccullochella peelii peelii (MITCHELL 1839) JUVENILES REARED IN INLAND SALINE WATERS (MITCHELL 1839) JUVENILES REARED IN INLAND SALINE WATERS

125	Leo Nankervis, P. Southgate, R. DeNys THE NUTRITIONAL INFLUENCE OF DIETARY PROTEIN AND ENERGY ON GROWTH INDICES AND THYROID HORMONE CONCENTRATION IN BARRAMUNDI Lates calcarifer LARVAE
126	Giorgio Palmeri, Nigel Abery, Paul De Ionno, Stephen Ryan, Robert Collins,
	EFFECTS OF COVER AND REFUGE ON THE PERFORMANCE OF MURRAY COD Macculochella peelii peelii FINGERLINGS REARED IN A RECIRCULATING SYSTEM
127	Renato Peña, Silvie Dumas, Ana Trasviña, Gerardo García, Hugo Pliego-Cortés, Dora
	Hernandez-Ceballos EFFECT OF LIGHT INTENSITY, REARING TANK COLOUR AND PREY DENSITY ON FEEDING EFFICIENCY AT FIRST FEEDING OF THE SPOTTED SAND BASS Paralabrax maculatofasciatus LARVAE
128	Konda P. Reddy, B. Sivaloganathan, Juan Walford POTENTIAL FOR USING FROZEN/DRY FEEDS TO REPLACE LIVE FEEDS IN THE CULTURE OF SEAHORSES
129	Shane D. Roberts, Mark D. Powell
	PROPHYLACTIC ORAL ADMINISTRATION OF L-CYSTEINE ETHYL ESTER DELAYS THE ONSET OF AMOEBIC GILL DISEASE IN ATLANTIC SALMON Salmo salar
130	Jerome M. P. Bosmans*, Glenn R. Schipp, Damon J. Gore, Ben Jones,
	EARLY WEANING OF BARRAMUNDI, Lates calcarifer (BLOCH), IN A COMMERCIAL, INTENSIVE, SEMI-AUTOMATED, RECIRCULATED LARVAL REARING SYSTEM
131	Ashely Roberts-Thomson, Stewart Fielder, Andrew Barnes, Robert J. G. Lester, Robert Adlard MANAGING VELVET DISEASE IN MARINE FISH HATCHERIES
132	Kirsten M. Rough, Barbara Nowak, Ruth Reuter HAEMATOLOGY OF SOUTHERN BLUEFIN TUNA <i>Thunnus maccoyii</i>
133	Kirsten M. Rough, John Gunn, Toby Paterson, Jason Hartog EFFECT OF FEEDING FREQUENCY ON THE GROWTH OF SOUTHERN BLUEFIN TUNA <i>Thunnus</i> <i>maccoyii</i>
134	Meaghan Rourke, Nick Robinson, Andrea Taylor, J. Lade, Brett A. Ingram USE OF MICROSATELLITE TESTS TO EVALUATE GENETIC DIVERSITY IN WILD AND CAPTIVE MURRAY COD <i>Maccullochella peelii peelii</i>
135	Stuart J. Rowland, Tully Pat HATCHERY QUALITY ASSURANCE PROGRAM FOR MURRAY COD Maccullochella peelii peelii, GOLDEN PERCH Macquaria ambigua AND SILVER PERCH Bidyanus bidyanus
136	Hassan Salehi ECONOMICS ANALYSIS OF KUTUM <i>Rutilus frisii kutum</i> FINGERLING PRODUCTION AND RELEASING IN IRAN
137	Gavin W. Shaw, Stephen C. Battaglene, Patricia M. Pankhurst THE EFFECT OF WATER TURBULENCE AND TURBIDITY ON FEEDING, GROWTH AND SURVIVAL OF STRIPED TRUMPETER <i>Latris lineata</i> LARVAE
138	Gavin W. Shaw, Patricia M. Pankhurst, Stephen C. Battaglene THE EFFECT OF TURBIDITY AND PREY DENSITY ON THE FEEDING, DISTRIBUTION AND GROWTH OF GREENBACK FLOUNDER <i>Rhombosolea tapirina</i> LARVAE
139	Maria I. Sandoval-Muy, Benjamin Barón-Sevilla EXTRA-POUCH TERMINAL EMBRYONIC DEVELOPMENT OF Hippocampus ingens IN LABORATORY CONDITIONS

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140	B. Sivaloganathan, Juan Walford, Konda Reddy SELECTION OF SUITABLE SITES FOR RESTOCKING SEAHORSES IN SINGAPORE COASTAL WATERS BY MONITORING HATCHERY REARED SEAHORSE JUVENILES KEPT IN CAGES
141	Benita Vincent, Richard Morrison, Barbara Nowak IMMUNOMODULATION IN THE CONTROL OF AMOEBIC GILL DISEASE IN ATLANTIC SALMON
	MOLLUSCS & OTHER INVERTEBRATES POSTERS
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201	Felipe Ascencio, Erick Nuñez, Angel I. Campa SUPEROXIDE DISMUTASE ACTIVITY IN HEPATOPANCREAS AND MUSCLE OF Nodipecten subnodosus EXPOSED TO THE TOXIC MICROALGAE Prorocentrum lima
202	Susan Blackburn, Stanley Robert, James Petrie, Xue-Rong Zhou, Peter Mansour, Bronwyn Innes, Dion Frampton, Mina Augerinos, Peter Nichols, Surinder Singh, Allan Green
	NEW SOURCES OF OMEGA-3 OILS: CLONING GENES FOR SYNTHESIS AND ASSEMBLY OF LONG CHAIN OMEGA-3 FATTY ACID PATHWAYS IN PLANTS
203	Jorge Cáceres-Martínez, José G. González-Avilés, Rebeca Vásquez-Yeomans DEGRADATION OF ABALONE Haliotis fulgens IN NATURAL AND CULTURE CONDITIONS, ELEMENTS FOR FORENSIC ANALYSIS
204	Jorge Cáceres-Martínez BURROWING WORMS IN MOLLUSK AQUACULTURE, A GENERAL SCOPE FOR CONTROL
206	Nicholas Elliott, Graeme A. Dunstan, Natalie Conod, Sharon Appleyard, Bronward Innes
	IS THERE A COMMERCIAL ADVANTAGE WITH TRIPLOID GREENLIP ABALONE H. laevigata?
207	Dion Frampton, Peter Mansour, Stefano Gallori, Mario Tredici, Susan Blackburn CUSTOMIZED MICROALGAE MASS-PRODUCTION FOR USE IN AUSTRALIAN AQUACULTURE
208	Robert W. Hickman, Philip L. Heath, Graeme A. Moss BETTER CONTROL IMPROVES SEED PRODUCTION FOR NEW ZEALAND PAUA (ABALONE) Haliotis iris
209	Greg N. Kent, Christopher J. Bolch, Robert D. Ward, John A. Nell MEIOGEN AND MITOGEN DEVELOPMENT IN THE PACIFIC OYSTER Crassostrea gigas GAMETE IRRADIATION
210	Yan Li, Xiaoxu Li INDUCTION OF TRIPLOIDY IN AUSTRALIAN GREENLIP ABALONE Haliotis laevigata WITH CYTOCHALASIN B
211	Sabine Daume, Mark Davidson, Tahryn Mackill, Rick Lambert, Peter Cook EVALUATION OF ENRICHED FORMULATED CONDITIONING DIET ON SPAWNING SUCCESS AND OFFSPRING PERFORMANCE OF THE GREENLIP ABALONE Haliotis laevigata
212	Bridget Tangney, Paul McNabb, Patrick Holland, Andrew Selwood, Melissa Glastone LIQUID CHROMATOGRAPHY MASS SPECTROMETRY (LCMS) TO DETERMINE BIOTOXINS IN SHELLFISH FOR MANAGEMENT OF HARVESTING AND PROTECTION OF PUBLIC HEALTH
213	Erica A. Vidal, Dominique P. Ibbotson, Edward J. Buskey, Phillip G. Lee FACTORS AFFECTING THE ENCOUNTER AND CAPTURE RATES IN SQUID PARALARVAE
214	Aiguo Yang, Liu Zhihong, Wang Qingyin CROSS FERTILIZATION OF SCALLOP Chlamys farreri WITH Patinopecten yessoensis AND THE CHARACTER INHERITANCE OF THE HYBRID

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301	Greg Coman, Silvio Peixoto, Nigel Preston, Peter Crocos, Stuart Arnold FINAL OOCYTE MATURATION IN WILD AND DOMESTICATED Penaeus monodon BROODSTOCK
302	Rolando B. Cerezo PRODUCTION TRIALS ON THE ECONOMICS OF RICE CUM PRAWN FARMING IN KALINGA PROVINCE, PHILIPPINES
303	Francis Coman, Roberta Soares, Christopher Jackson, Nigel Preston NUTRITIONAL COMPOSITION OF FLOCCULATED MATERIAL IN EXPERIMENTAL ZERO-EXCHANGE SYSTEM FOR Penaeus monodon
304	Edilmar Cortés, Humberto Villarreal, Maricela Rendón EFFECT OF FEEDING FREQUENCY ON GROWTH OF JUVENILE REDCLAW CRAYFISH <i>Cherax</i> quadricarinatus (VON MARTENS)
305	Edilmar Cortés, Tania Zenteno, Juan P. Vázquez EFFECT OF DIFFERENT DIETARY PROTEIN/LIPID LEVELS ON OXIDATIVE STRESS OF JUVENILE REDCLAW CRAYFISH Cherax quadricarinatus
307	Saleem Mustafa, Jim Luong-Van PRODUCTION OF ORGANIC SHRIMP: SUSTAINABILITY OF GROWTH ADVANTAGE PRODUCED BY "CELL SALT" TREATMENT
308	Laura A. Muzinic, Kenneth R. Thompson, Carl D. Webster EVALUATION OF PRACTICAL DIETS CONTAINING THREE DIFFERENT PROTEIN LEVELS, WITH OR WITHOUT FISH MEAL, FOR JUVENILE AUSTRALIAN RED CLAW CRAYFISH Cherax quadricarinatus
309	Laura A. Muzinic, Kenneth R. Thompson, Carl D. Webster EFFECTS OF FEEDING PRACTICAL DIETS CONTAINING VARIOUS PROTEIN LEVELS ON GROWTH, SURVIVAL, BODY COMPOSITION, AND PROCESSING TRAITS OF AUSTRALIAN RED CLAW CRAYFISH Cherax quadricarinatus AND ON POND WATER QUALITY
310	Laura A. Muzinic, Kenneth R. Thompson, Carl D. Webster TOTAL REPLACEMENT OF FISH MEAL WITH SOYBEAN MEAL AND BREWER'S GRAINS WITH YEAST IN PRACTICAL DIETS FOR JUVENILE AUSTRALIAN RED CLAW CRAYFISH Cherax quadricarinatus
311	Laura A. Muzinic, Kenneth R. Thompson, Carl D. Webster GROWTH AND PROCESSING TRAITS OF MALE AND FEMALE AUSTRALIAN RED CLAW CRAYFISH Cherax quadricarinatus STOCKED INTO EARTHEN PONDS
312	Hector Nolasco, Dulce-Rocio Flores, Fernando Vega-Villasante, Alberto del Monte, Olimpia Carrillo-Farnes CHARACTERIZATION OF DIGESTIVE ESTERASE-LIPASE ACTIVITY OF WHITE SHRIMP Litopenaeus vannamei
313	Brian D. Paterson, David Mann, Matteo Barchiesi, Beverley Kelly ESTIMATING WEIGHT OF NURSERY-STAGE MUD CRABS <i>Scylla serrata</i> USING DIGITAL IMAGE ANALYSIS
314	Brian D. Paterson, David Mann, Beverley Kelly, Matteo Barchiesi LIMB-LOSS IN POND-REARED BLUE SWIMMER CRABS Portunus pelagicus: MOULTING PERIOD AND INCREMENT IN AN INDOOR SHEDDING SYSTEM
315	Jacques Patrois, Jean-Marie Peignon, Sophie De Decker, Emmanuel Goyard TECHNIQUES AND MATERIALS USED FOR SHRIMP SIZE GRADING: EVOLUTION AND PERSPECTIVES

THE MICROBIAL COMMUNITY ASSOCIATED WITH THE WATER COLUMN OF AN ORNATE ROCK LOBSTER Panulirus ornatus LARVAL REARING SYSTEM

317 Vania V. Serrano-Pinto, Igor Landais, Marie-Helene Ogliastro, Meliza Gutiérrez-Ayala, Humberto Mejía-Ruíz, Humberto Villarreal-Colmenares, Alejandra García-Gasca, Celia Vázquez-Boucard

DETERMINATION SITE OF mRNA EXPRESSION OF VITELLOGENIN SECONDARY-VITELLOGENIC AT FIRST MATURATION FEMALE OF Cherax quadricarinatus

- **318** Steve L. Slattery, David J. Williams TREATING PRAWNS WITH AN EXTENDED DIP IN EVERFRESH TO PREVENT BLACKSPOT
- **319 M. Tokhmafshan, M. Shariff, M. D. Hassan** THE STUDY OF SUSCEPTIBLE LARVAL AND POSTLARVAL STAGES OF Penaeus Semisulcatus TO Penaeus monodon Baculovirus (MBV)
- 320 Nelly Wabete, Dominique Pham, Liet Chim, Pierrette Lemaire, Jean-René Maillez, Francis Broutoi, Jean-Charles Massabuau CHARACTERISATION OF PHYSIOLOGICAL DISTURBANCES IN SHRIMP Litopenaeus stylirostris INDUCED BY HANDLING STRESS. APPLICATION IN SURVIVAL IMPROVEMENT AND REPRODUCTION ACHIEVEMENT OF BREEDERS DURING WINTER IN NEW CALEDONIA
- **321** Daniel Ancieta, Marielle van Hulten, Simon Tabrett, Ian Andrew, Andrew C. Barnes PRELIMINARY INVESTIGATION OF EFFECT OF DIETARY NUCLEOTIDE ON GROWTH AND IMMUNITY IN BLACK TIGER PRAWNS Penaeus monodon

GENERAL TOPICS POSTERS

This section of posters is located in the 2nd Floor Tumbalong Foyer

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- **401 Paul Armstrong, Christopher Bolch, Peter Thompson, Sue Blackburn** NUTRIENT DYNAMICS AND PHYTOPLANKTON BLOOMS IN THE HUON ESTUARY
- 402 Jean Cannon MAKING AQUACULTURE POLITICALLY SUSTAINABLE
- **404** Julie L. Delabbio, Brian R. Murphy, Gerald R. Johnson MANAGING BIOSECURITY AT THE FARM LEVEL
- 405 Nelson F. Díaz STATUS OF THE CHILEAN AQUACULTURE AND USE OF GENETIC MARKERS
- **406** Fiona M. Gavine, Geoff J. Gooley USE OF RECLAIMED WATER FOR AQUACULTURE – AN ASSESSMENT OF OPPORTUNITES AND RISKS FOR THE AUSTRALIAN AQUACULTURE INDUSTRY
- **407 Jan Holland, Robert Campbell, Ben Divett** HUMAN FOOD SAFETY EVALUATION OF AQUI-S: AN AQUATIC ANAESTHETIC
- **408** Jérôme M. E. Hussenot, François Paticat, Philippe Blachier COASTAL POND AQUACULTURE IN FRANCE
- 409 Sagiv Kolkovski, John Curnow, Justin King, Boyd King COMMERCIAL PRODUCTION OF Artemia CYSTS IN WESTERN AUSTRALIA
- 410 Sagiv Kolkovski, Brett Glencross, Malene Felsing, Gideon Gal, Jose Romero, Ingrid Lupatsch INTERNET-BASED, INPUT – OUTPUT WASTE MODEL FOR AQUACULTURE VENTURES

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411	G. Michael Macbeth, Ross Lobegeiger, Michael Burke INCREASED PRODUCTION AND RETURNS FOR Penaeus sp. USING SELECTIVE BREEDING
412	Peter D. Nichols, Peter Mansour, Stanley Robert, Bronwyn Innes, Surinder Singh, Dion Frampton, Susan Blackburn, Allan Green NEW SINGLE-CELL AND CROP PLANT SOURCES OF LONG-CHAIN OMEGA-3 OILS
413	Oladayo Oyelakin Gbolagunte ECONOMIC VIABILITY OF PRIVATE FISH FARMERS IN SOUTHERN NIGERIA
414	David Prangnell, Ravi Fotedar ACCLIMATISATION OF WESTERN KING PRAWNS Penaeus latisulcatus TO INLAND SALINE WATER
415	Hassan Salehi, Abbas Mokhtari-Abkenari ATTITUDES TOWARDS SUSTAINABLE AQUACULTURE AMONG THE IRANIAN FISHERIES OFFICERS
416	Jesmond Sammut, David McKinnon ASSESSMENT AND CLASSIFICATION OF TROPICAL COASTAL ENVIRONMENTS FOR SUSTAINABLE AQUACULTURE SYSTEMS
417	Mehdy Shamsaie Mehrjan, Mandana Mohseni Masuleh TESTING A NEW INVENTION AS A NEW INTENSIVE FISH CULTURE SYSTEM TO NAME OF "IN CHANNEL RACEWAY" (I.C.R)
418	Mainui Tanetoa, Sandra Langy, Anne-Sandrine Talfer MANAGEMENT OF THE FRENCH POLYNESIAN PEARLING INDUSTRY
419	Uras Tantulo, Ravi Fotedar CAN INLAND SALINE WATER BE USED TO REAR POST LARVAE OF BLACK TIGER PRAWN <i>Penaeus</i> monodon Fabricius?
420	Dean Thomson, John Volkman, Chris Burke, John Purser SEDIMENTARY BIOGEOCHEMISTRY OF THE HUON ESTUARY
421	Bernard P. Walrut OWNERSHIP OF FISH – SOME LEGAL CONSEQUENCES
422	Graham Woods, Colin Shepherd, Eric Brain, Ray Murphy BENTHIC ENVIRONMENTAL MONITORING OF SALMONID FARMING IN TASMANIA 1997 – 2003
423	Yi Yang Managing Aquaculture wastes through integrated approaches to minimize Environmental impacts
424	Dale A. Young, James Udy, Simon Albert, Deborah L. Ramage PROFIT FROM WASTEWATER – COMPARING THE USE OF DIFFERENT SEAWEED SPECIES TO TREAT AQUACULTURE WASTEWATER

AUSTRALASIAN AQUACULTURE 2006 Winter/Spring 2006

For Location and More Information: Web: australian-aquacultureportal.com

AUSTRALASIAN AQUACULTURE 2004

EXHIBIT FLOOR PLAN



AUSTRALASIAN AQUACULTURE 2004 EXHIBITORS

Booth

Company

1	Department of Primary Industries
2, 3	Jevco Mooring & Rigging
4	VoR Environmental Australia Ptv I td
5	Inter Aqua Advance Aps
6-11	Aquasonic Pty Ltd
12, 13	Alltech
14, 15	McRobert Aquaculture Systems
16	Department of Primary Industries & Fisheries
17, 18	Oystek Pty Ltd
19	Tooltech - Ploma Pty Ltd
20	Allied Industries Pty. Limited
20	. Wenger Manufacturing, Inc.
21, 22	. National Food Industry Strategy Ltd
23	Aquaculture Association of Queensland Inc.
24, 25	. Australian Blue Yabby Aquaculture
20	Cadeng Pty Ltd
28	Australian Institute of Marine Osienes
20 30	Adultation Institute of Marine Science
29,30	South Australian Research & Development Institute
29 30	Tasmanian Aquaculture & Eichorice Institute
31	Cumminscorp
32	Environmental Products (Australia) Ptv Ltd
33. 34	AGK Technology
35	Ketchum Manufacturing Inc.
36, 37	Plastic Plumbing Supplies
38	.KW Automation
39, 40, 55, 56	. INVE ASIA SERVICES Ltd.
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Australian Government Department of Agriculture, Fisheries & Forestry

GPO Box 858 Canberra, ACT 2601 AUSTRALIA

Tel: +61 02 6272 4647 *Fax:* +61 02 6272 4875 *Email:* andrew.buckley@daff.gov.au *Web:* www.daff.gov.au

The Australian Government Department of Agriculture, Fisheries and Forestry (DAFF) is proud to be working with the aquaculture industry, our nation's fastest growing primary industry.

Australian Institute of Marine Science

PMB 3 Townsville, QLD 4810 AUSTRALIA

Tel: +61 07 4753 4462 *Fax:* +61 07 4772 5852 *Email:* k.wilson@aims.gov.au *Web:* www.aims.gov.au

The Australian Institute of Marine Science carries out research & development into the sustainable use & protection of the marine environment. The Tropical Aquaculture team works closely with industry and community partners to develop technologies to improve profitability & sustainability of existing tropical aquaculture industries, & to develop new candidate aquaculture species. This includes work on species that are suitable for production in remote communities with limited infrastructure.

Australian Primary Super Fund

Level 15, 190 Queen Street Melbourne, VIC 3000 AUSTRALIA

Tel: +61 03 8622 9370 *Fax:* +61 03 8622 9380 *Email:* administration@australianprimary.com.au *Web:* www.australianprimary.com.au

Australian Primary Superannuation Fund exists primarily as an industry super fund for sponsoring employers operating in agriculture, horticulture, timber, seafood and other rural and regional enterprises. The fund is nominated on a number of industrial relations awards. However, the fund can also accept participating employers from any other industry that needs to comply with superannuation guarantee or award obligations.

Bioremedy c/o Unit 1/75 Kremzow Rd Brendale, QLD 4500 AUSTRALIA

Tel: +61 07 3881 2770 *Fax:* +61 07 3881 2780

Integrated Aquaculture Solutions.

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Tel: +61 07 3881 2770 *Fax:* +61 07 3881 2780

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BST Oyster Supplies Pty Ltd

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Challenger TAFE – Aquaculture Development Unit

WA Maritime Training Centre 1 Fleet Street Fremantle, WA 6160 AUSTRALIA

Tel: +61 08 9239 8030 Fax: +61 08 9239 8081 Email: greg.jenkins@challengertafe.wa.edu.au Web: www.challengertafe.wa.edu.au

The Aquaculture Development Unit (ADU) is located at the WA Maritime Training Centre, a campus of Challenger TAFE in Fremantle, which is managed by the Western Australian Department of Education and Training. The ADU is one of Australia's leading aquaculture research and training organisations, specialising in applied research and the provision of training services for establishing and sustaining a competitive aquaculture industry. The ADU also provides an aquaculture consultancy service to the Australian aquaculture industry.

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Cittadini spa

Via Trento 35/45 Paderno F.C. (BS) 25050 ITALY

Tel: +39 030 6857565 *Fax:* +39 030 657148 *Email:* sales@cittadini.it *Web:* www.cittadini.it

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CSIRO is Australia's Commonwealth Scientific and Industrial Research Organisation. CSIRO scientists work with commercial partners, research and funding agencies to realise the potential of Australian aquaculture.

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Department of Fisheries, Western Australia

Level 3, The Atrium 168 St George's Terrace Perth, WA 6000 AUSTRALIA

Tel: +61 08 9482 7333 Fax: +61 08 9482 7390 Email: aquaculturemanager@fish.wa.gov.au Web: www.fish.wa.gov.au

The Department of Fisheries is the State Government Department that principally assists the Minister responsible for the conservation, development, and sharing of fish and other living aquatic resources, including aquaculture, within Western Australia for the benefit of present and future generations.

Department of Primary Industries

Fisheries Victoria

GPO Box 4440 Melbourne, VIC 3001 AUSTRALIA

Tel: +61 03 9658 4000 *Fax:* +61 03 9658 4380 *Email:* customer.service@dpi.vic.gov.au *Web:* www.dpi.vic.gov.au

State Government Department

Department of Primary Industries and Fisheries

c/o Dr. Colin Shelley GPO Box 46 Brisbane, QLD 4001 AUSTRALIA

Tel: +61 07 3224 2257 *Fax:* +61 07 3239 0439 *Email:* colin.shelley@dpi.qld.gov.au *Web:* www.dpi.qld.gov.au/fishweb

The Queensland Government manages aquaculture policy, facilitates aquaculture industry development, and undertakes research throughout Queensland. Recently some major changes have been made to the way government does business, with the aim of maximising the growth and profitability of aquaculture. New and improved services are being offered to promote investment in profitable aquaculture for Queensland.

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The publication *Fish Farming International* was established in 1973 and today boasts of a circulation to farmers, manufacturers, researchers and aquaculture administrators in over 120 countries worldwide. The latest issue will be available from our stand at the show along with copies of our other projects including worldwide aquaculture farms guides. Sister papers *Seafood International, Seafood Processor & Fishing News International* will also be presented. Information will also be available on our exhibitions; Fishing 2005, Scotland; Seafood Russia 2005, Russia; Aquaculture Africa 2005, and Fish Africa 2005, Africa.

Fisheries Research & Development Corporation

PO Box 222 Deakin West, ACT 2600 AUSTRALIA

Tel: +61 02 6285 0412 *Fax:* +61 02 6285 4421

The Fisheries Research and Development Corporation (FRDC) is a statutory authority within the portfolio of the federal Minister for Agriculture, Fisheries and Forestry, jointly funded by the Australian Government and the fishing industry. It is responsible to its stakeholders to:

• plan, invest in and manage fisheries R&D throughout Australia; and

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John Holder is a registered professional biologist in the Province of British Columbia and he graduated from the University of Guelph in 1973. He started his aquaculture career in that same year. He has had extensive experience with fresh water systems dealing with Salmonids, Cichlids and more recently with salt-water species including shrimp and he can be considered an expert in this field. He has worked and consulted for aquaculture companies on six continents.

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The National Aquaculture Council is Australia's peak industry representative body.

National Fishing Industry Education Centre TAFE North Coast Institute

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National Food Industry Strategy Ltd

Locked Bag 4911 Kingston, ACT 2604 AUSTRALIA

Tel: +61 02 6270 8800 *Fax:* +61 02 6270 8888 *Email:* nfis@nfis.com.au *Web:* www.nfis.com.au

The National Food Industry Strategy is an industry-based, Australian Government backed organisation established to be a catalyst for change in the Australian food industry. Our key programs and activities include increasing investment in innovation, improving supply chain competitiveness, increasing sustainability, improving workforce skills and achieving export market growth. For further information, visit Bess at our stand or our website at www.nfis.com.au

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NSW Department of Primary Industries is the State Government's key management, research, and technical advisory body covering aquaculture in NSW.

NSW Department of State and Regional Development

PO Box N818 Grosvenor Place NSW 1220 AUSTRALIA

Tel: +61 02 93386984 *Fax:* +61 02 93386676 *Email:* food@business.nsw.gov.au *Web:* www.business.nsw.gov.au

The Department of State and Regional Development is the first point of contact for companies wishing to do business in New South Wales. It provides assistance in the areas of investment, export, import replacement, regional development and enterprise improvement.

OneSteel

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Panaquatic Health Solutions Pty Ltd offers innovative and cost effective strategies in the area of fish health management, production biosecurity, risk reduction and husbandry management to ensure sustainable and profitable production. The principal, Dr Paul Hardy-Smith, is a veterinarian with over 12 years of experience working in the Australian and North American aquaculture industries. Dr Hardy-Smith is also a member of the Australian Institute of Company Directors.

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Trestle 2

Located on 2nd Floor by Escalator

Pisces Engineering Ltd

Easter Poldar Thornhill, Stirling FK83QT SCOTLAND, UK

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Seafood Services Australia

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ABSTRACTS

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CHAIRS' FOREWORD

The Australian aquaculture industry is the most promising and exciting primary industry today.

Delivering on the promise of aquaculture calls for a strong commitment to sustainability, innovation, learning and forging partnerships throughout the Australasian region. The cornerstone is a learning culture based on excellence in science. To that end, one of the goals that the organisers have set themselves is to bring together industry, managers and scientists to exchange information, forge partnerships and inspire new developments.

Not since WAS 99 in Sydney, where Australia showed that it had emerged as a significant contributor to world aquaculture development, has there been such a comprehensive array of presentations on "the best of the best". During three days, we will see more than 200 presenters and interact with more than 100 tradeshow people. With the emphasis on profitable sustainability, we will learn how Australia has developed its enviable reputation for environmental stewardship that makes good business sense.

Thank you!

This conference springs from a partnership between the National Aquaculture Council of Australia and the Asian-Pacific Chapter of the World Aquaculture Society, with help from the Tasmanian Aquaculture Council, that enables us to reach all sectors and bring together high-quality presenters.

Putting the conference together has required a special effort from a dedicated team led by Dr Geoff Allan. NSW DPI has shown why it has a reputation for excellence in aquaculture. The unflappable Sarah-Jane Day and the can-do Ian Lyall have been busy in the "engine room", organising everything imaginable. The conference could not have occurred without the guidance and behind-the-scenes efforts by John and Mary Cooksey from the World Aquaculture Society and the commitment and hard work by staff from the National Aquaculture Council. Jacki Knight, Alexandra Bagnara and Allison Bennison worked above and beyond the call of duty. The program itself has been a "ride on the wild side"! Contributors are from the "who's who" of Australian aquaculture — industry people and scientists who are passionate about their ideas and about the desire to share and learn.

It has been our pleasure to Chair the Program Committee and the members of this committee, Geoff Allan, David Whyte, Helen O'Connor, Pheroze Jungalwalla, Martin Breen, Tom Lewis, Simon Bennison and Ian Lyall, have helped to ensure a program relevant to today's industry and the business environment they work in.

Finally, a warm "thank you" to our many sponsors, from the large to the small. Without your contributions, this conference would not have come into being!

This conference is the first step in creating an institution in the calendar for Australasian aquaculture — something that brings value to the industry, showcases innovative technologies, and ensures that the industry is supported by a knowledge and learning culture. And the long-lasting legacy will be understanding, partnerships and friendships.

We hope you enjoy the experience. We can never have enough knowledge, so let's soak it up — and use it wisely!

Patrick Hone and Bruce Zippel Program Chairs

REVERSAL SEX CHANGE IN THE PROTOGYNOUS FISH Epinephelus coioides IN THE PERSIAN GULF WATER

F. Abbassi[#], S. Oryan and A. Matinfar

Alzahra University Vanak Ave, Tehran Iran fabbassi_2000@yahoo.com

Epinephelus coioides (family serranidae) is protogynous. This species is one of the most important fishes in persian Gulf. Protogynous hermaphroditism, or female-to-male sex change, is known for many reef fishes including orange spotted *Epinephelus coioides* (family serranidae).

Gonads at all stages of development in this species were examined in the persian Gulf from may 2001 to september 2002.

Demographic data and gonad histology show that *E.coioides* is a protogynous hermaphrodite that follows a monandric pathway in sexual development. Females exhibited synchronous ovarian development. The sexual transition was found to occure in individuals of 51.2-105 cm in standard length (SL) and then maturation of the testis tissue begins. Sex reversal to 3 different stages was classified. Transitional *E.coioides* gonads were characterized by the concurrent degeneration of all oocytes and the proliferation of spermatocysts. The results indicated that female and male tissues are not separated by connective tissue and the two tissue types are intermixed during the course of sex reversal.

Regarding to the results of this research, it seems that the period of spawning in *Epinephelus coioides* is in May-Jun and sex reversal begins in the transitionals after spawning in the functional females.

PARASITE SURVEY IN CULTURED SOUTHERN BLUEFIN TUNA

Hamish Aiken, Craig Hayward, Marty Deveney and Barbara Nowak

School of Aquaculture University of Tasmania and Aquafin CRC Locked Bag 1370 Launceston 7250, Tasmania Australia

Southern bluefin tuna aquaculture started in 1991 and has grown into the largest finfish aquaculture industry in Australia, with an export value of \$290 million. It is based on fattening of wild caught fish in sea-cages over a period of 3-6 months. Continuous husbandry improvements ensure very low mortality. A tuna health risk assessment completed last year recommended a health surveillance and monitoring program. This parasite survey is the first part of this program, funded by the Aquafin CRC as FRDC project 2003/225. The aim of this survey is to investigate the presence of parasites in harvest tuna to provide background information for health surveillance and other tuna health projects.

Seven companies are providing samples during harvest. Gills and internal organs (excluding kidneys) are collected at harvest and put on ice. Within a few hours of sampling these organs are examined for parasite presence and any abnormalities. Some hearts are flushed with PBS to determine the presence of *Cardicola forsteri*. Fish with swimmer syndrome and morts are sampled for the presence of *Uronema nigricans*. Last year a total of 167 healthy fish were sampled at harvest and 31 morts and 2 fish showing swimmer syndrome were examined.

A wide range of parasites was found in screened fish. *Cardicola forsteri* was found in hearts of 13 fish out of 43 fish screened at harvest. The intensity of infection ranged from 1-7 flukes per heart. The epidemiology of the infection with blood flukes, and the changes in prevalence and intensity of infection over holding time, are now being investigated. Implications of the presence of blood flukes will be discussed.

None of the harvest fish screened for *Uronema nigricans* presence were positive, whereas fish showing swimmer syndrome were both positive and 18 out of 31 morts were positive. This test lacks sensitivity which may result in false negative results. As it only detects the parasite with fish already showing the syndrome, or which died due to infection, it has limited practical value.

UTILIZATION OF COATED CRYSTALLINE AMINO ACIDS BY KURUMA SHRIMP MARSUPENAEUS JAPONICUS LARVAE AND POST-LARVAE

Md. Shah Alam*, Shin-ichi Teshima, Shunsuke Koshio, Manabu Ishikawa, and Daisuke Hasegawa

Lab of Aquatic Animal Nutritio Faculty of Fisheries Kagoshima University Shimoarata-4-50-20 Kagoshima-890-0056, Japan alam1@rocketmail.com

Supplementation of crystalline amino acids (CAA) to shrimp diet was not successful due to the lack of knowledge of utilization of CAA by shrimp species. Therefore, the utilization of CAA by kuruma shrimp larvae and post-larvae were examined by feeding six microbound diets (MBD) containing either *k*-carrageenan or agar as binder. To reduce the leaching losses of CAA in water from the MBD, CAA were pre-coated using carboxymethylcellulose. The test MBD were formulated to prepare agar-MBD and *k*-carrageenan-MBD supplemented with three levels (control, 15% and 30%) of coated-CAA. Diets containing mainly intact protein sources (casein and gelatin) and 1.96% of coated-arginine supplement were regarded as control diets. CAA were supplemented to correspond to the amino acid pattern found in the whole body protein of the kuruma shrimp larvae. Each test MBD was fed to triplicate groups of shrimp larvae (zoea 1 ; experiment 1) for 10 days and post-larvae (PL-15; experiment 2) for 30 days.

In experiment 1, the larvae received 15% and 30% of CAA with agar-MBD improved its nutritional value providing high survival as comparable to larvae received control diets either agar or *k*-carrageenan MBD. The larvae received agar-MBD with high amount of CAA showed significantly higher metamorphosis rate (%) of zoea-1 to PL than those fed the *k*-carrageenan MBD which contained same amount of coated CAA. In experiment 2, PL received MBD that contained coated CAA (either 15 or 30%) gave body weight gain indices equal to or higher than the control groups those receiving mostly intact protein sources, irrespective of the binders. The survivals of PL did not show any differences among the dietary treatments. After the feeding trial, total whole body amino acid contents of the larvae and post-larvae were few differences among the dietary groups. This study indicates that kuruma shrimp larvae and post-larvae are able to utilize coated CAA, and agar seems to be an efficient binder for shrimp larvae when MBD contain high amount of CAA.

INLAND SALINE AQUACULTURE: NATIONAL COORDINATION OF R&D IN AUSTRALIA

Geoff Allan and Simon Bennison

NSW Department of Primary Industries Port Stephens Fisheries Centre Taylors Beach, NSW 2316, Australia geoff.allan@fisheries.nsw.gov.au

In Australia, seafood consumption is growing and is being increasingly met by imports. The volume of imports increased by 52% from 19919/92 to 2001/02. Capture fisheries production is static and although aquaculture is increasing, expansion of coastal aquaculture is limited by a shortage of suitable sites. In inland Australia, rising saline groundwater is currently reducing agricultural productivity from over 2.5 million ha of land. One of the key methods to ameliorate the effects of salinisation is to pump the saline groundwater into large ponds for disposal by evaporation. Inland saline aquaculture (ISA) may offer a partial solution to the shortage of coastal sites for aquaculture while incorporating aquaculture into saline groundwater interception and evaporation schemes may provide an economic return to the costly business of building and operating these schemes.

Technology is being developed and evaluated by researchers in SA, NSW, WA, Qld & Victoria but needs to be coordinated and backed up by other information required by investors before a large-scale commercial industry can develop. A national network between State Departments in Australia has been established under the National Aquaculture Council, with support from the Australian Government Department of Agriculture, Fisheries and Forestry and the Fisheries Research and Development Corporation. Specific Objectives of this project are to help commercialisation of inland saline aquaculture in different regions, manage communication and technology transfer, identify and review national priorities, and help ensure "best-practice" science.

Commercialisation will be assisted by: 1) supporting four demonstration facilities in NSW, Qld, SA and WA, 2) producing a specific ISA investment directory (including inventory of available resources of water and land and a risk assessment framework), 3) developing comprehensive economic models for inland saline aquaculture, 4) producing a market analysis for ISA inland saline aquaculture products (including a case study for commercial production of inland saline trout from WA), and 5) developing an interactive temperature model to help investors understand the relationship between ambient weather conditions in inland Australia and pond water temperature.

The progress with each of these specific components will be discussed. Potential investors in inland saline aquaculture in Australia will be provided with advice on how to access information to assist with investment decisions. More details are available from www.australian-aquacultureportal.com.

FIRST INCIDENCE OF Streptococcus agalactiae IN CULTURED SILVER POMFRET Pampus argenteus IN KUWAIT

A. Al-Marzouk*, R. Duremdez, J. A. Qasem, A. Al-Harbi and H. Gharabally

Aquaculture Fisheries and Marine Environmental Department Kuwait Institute for Scientific Research P.O.Box 1638 Salmiya, 20017 Kuwait amarzouk@mfd.kisr.edu.kw

The aquaculture of silver pomfret *Pampus argenteus* (Euphrasen) is a new research endeavor in Kuwait because of its high economic value among local consumers. In August until September 2000, serious mortalities among cultured silver pomfret were occurred. More than 90% of the infected fish showed distinctive belly enlargement without skin hemorrhages and lesions. A few fish also exhibited slight eye haemorrhages and corneal opacity. Internal organs showed enlarged liver and congestion in the kidney and spleen.

The bacterium was isolated in tryptic soy agar supplemented with 2.0% NaCl and brain heart infusion agar also supplemented with 2.0% NaCl and incubated at 35°C for 24 h. The isolates were Gram- positive cocci/ovoid cells in pairs or short chains of about 0.6-0.8 µm, non-motile, oxidase and catalase negative. These isolates were further characterized using the API 20 Strep (Table 1). Using a commercial streptococcal grouping kit (Oxoid) based on Lancefield grouping; all isolates reacted serologically with the group B antisera. All isolates were - haemolytic. Based on these, the isolates were identified as Streptococcus agalactiae. All isolates were able to grow at 20° to 42°C but were not at 5°, 10°, 15° and 45°C. They grow at different NaCl concentrations from 0.5, 3.0, 4.0, 4.5, 5.0, 5.5 and 6.0%, but not in 6.5% NaCl.

Six of the isolates that phenotypically identified as *S. agalactiae* were tested for polymerase chain reaction (PCR) and RAPD. In the amplification of bacterial DNA using the (PCR), two sets of Table 1. Physiological and biochemical characterization of S.agalactias

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oligonucleotide primers capable of detecting organisms of genus Streptococcus and species agalactiae targeting a specific sequence of the 16sRNA gene were obtained. The sequence of primers is: F1: 5'-GAGTTTGATCATGGCTCAG-3' and IMOD: 5'- ACCAACATGTGTTAATTACTC -3' which were expected to give an amplicon of the size 220 bp. The PCR products were resolved by agarose gel electrophoresis and photographed under UV light using a standard procedure. As a result, a specific DNA fragment (length 220 bp) was amplified from template DNA purified by the standard procedure using primer set F1/IMOD. This band was detected in all the DNA templates and the ATCC18813 reference strain of *Streptococcus agalactiae*. All the six isolates were identified as *S. agalactiae* based on their phenotypic characteristics; however, the PCR amplified the genus and species-specific primer for the *S. agalactiae* for the six *S. agalactiae* isolates.

This study used two methods for identifying *S. agalactiae* isolated from infected silver pomfret. The rapid biochemical method using API 20 Strep clearly identified eight of the isolates as belonging to *S. agalactiae*. Six of the eight isolates of *S. agalactiae* were subjected to further identification by PCR and RAPD and were confirmed to be *S. agalactiae*. This is the first report of *S. agalactiae* in this fish species in Kuwait and in the Arabian Gulf.

CADMIUM BIOACCUMULATION FROM THE DISSOLVED PHASE BY THE GREENSHELL MUSSEL Perna canaliculus

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New Zealand GreenshellTM mussels (*Perna canaliculus*) comprise 75% of New Zealand's aquaculture industry and 85% of the harvested mussels are destined for the export market. The present food safety limit for Cadmium (Cd) in GreenshellTM mussels, as set by the New Zealand and Australian Food Board is 2 g/g or 2 mg/kg (Metal Content Food Standards 2002). However there is a proposal presently before the International CODEX committee on food additives and contaminants to reduce this limit to 1 mg/kg (35th session, 17-21 March 2003). To understand the impact of this reduction on the industry, knowledge of the process of accumulation of Cd by *P. canaliculus* is required. This study has been designed to look at dissolved Cd uptake by *P. canaliculus* to determine whether Cd is being accumulated directly from the water.

Mussels were collected from a local wild population and tested in the laboratory for the bioaccumulation of Cd at two different elevated concentrations of Cd (100 μ g l⁻¹ and 50 μ g l⁻¹) over a period of 10 days. The Cd levels in these mussels were then analysed using Flame Atomic Absorption Spectrometry to determine the level of Cd bioaccumulation.

An increase in the mussel soft tissue Cd content with exposure time and external Cd concentration (Figure 1), confirmed the bioaccumulation of Cd from water by *P. canaliculus*. This in-crease suggests that Cd in the plankton food source is not the only source of bio-accumulated Cd for this mussel species and so dissolved Cd has to be accounted for in further research. Figure 1. Plot of the regression lines for the bioacumulation of dissolved cadmium by *P. canaliculus*





NUTRIENT DYNAMICS AND PHYTOPLANKTON BLOOMS IN THE HUON ESTUARY

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The Huon Estuary has been the subject of intensive environmental studies since 1996 as part of a program to ensure the sustainability of aquaculture in the estuary. One of the key topics being addressed is the link between nutrients and phytoplankton blooms in the estuary. The Huon Estuary Study (HES, 1996-1999) suggested that phytoplankton growth is limited primarily by nitrogen (N). The main objective of our present work is to determine which nitrogen sources: nitrate (NO_3) , ammonia (NH_4) and/or urea are important for supporting phytoplankton growth in the Huon Estuary. We are investigating through field and laboratory experiments the nitrogen uptake capabilities and strategies of the main dinoflagellate species Gymnodinium catenatum that has bloomed in the estuary in recent years. This species is toxic and at bloom densities it has caused shell fish farms to close for significant periods of time in this area. In the laboratory, we have shown that G. catenatum is capable of using NH_4 as a sole nitrogen source for growth. Physiological differences between G. catenatum grown on NO₃ or NH₄ were also examined. It is still not known why this toxic species blooms in some years and not others and when it does why it reaches a far greater biomass than any other species in the Huon. We have completed 4 field trips (28-29 May 2003, 23-24 September 2003, 18-19 November 2003, and 24-25 February 2004. On these field trips a ¹⁵N dilution technique was used to measure uptake of NO_3 , NH_4 and urea at 5 m and 20 m depths during the day and night. Results from the first field trip indicate that NH₄ is the preferred nitrogen source at both depths and during the day and night. Our aim is to link the N uptake data with the changes that occur in the phytoplankton assemblage throughout the year. In late March of 2004, a G. catenatum bloom took place in Southport not far from the Huon Estuary. We repeated the ¹⁵N dilution technique to measure N uptake in the field with a vertically migrating phytoplankton assemblage dominated by G. catenatum. The results from this field work will give an understanding of the N uptake strategies of G. catenatum in the environment and provide a strong link between the field and laboratory components of this project. Greater understanding of how G. catenatum sequesters sufficient nitrogen to dominate this ecosystem will allow us to both better predict and manage the ecosystem to reduce the impact of toxic phytoplankton blooms.

ULTRA-HIGH-DENSITY PRODUCTION OF JUVENILE Penaeus esculentus AND P. monodon IN A TANK SYSTEM USING ARTIFICIAL SUBSTRATES

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Juvenile brown tiger prawns *Penaeus esculentus* were grown from PL17 (seventeen-day-old postlarvae), to approximately 1 g at ultra-high densities, with initial stocking densities of up to 11,430 m⁻³, in a novel tank system to ascertain the optimal density for culture of juveniles to 1 g. Artificial substrates were used to enable utilization of the whole water column and enhance the growth of natural biota for supplementary nutrition.

P. esculentus postlarvae were stocked in tank systems (1,750 L) at densities of 2,860 m⁻³, 5,720 m⁻³ and 11,430 m⁻³ and grown to a mean weight of 1 g. Three different artificial substrate systems were evaluated. These substrates increased the surface area in the tanks by between 120% and 340%. Comparative growth and survival of the prawns at each stocking density and with each artificial substrate was assessed. The tanks were set up two weeks prior to the prawns being stocked to promote the colonisation of natural biota on the artificial substrates.

Prawns grew to a mean weight of 1g in 6.5, 7 and 8 weeks at stocking densities of 2,860 m⁻³, 5,720 m⁻³ and 11,430 m⁻³, respectively. Mean survival ranged from 21.23% at the highest density to 50.85% at the lowest density. The final mean biomass at harvest was very similar across all densities, ranging between 1.5 kg m⁻³ and 1.7 kg m⁻³. Mean harvest density ranged from 1,215 prawns m⁻³ at the lowest density to 2,427 prawns m⁻³ at the highest density. The type of substrate system had no effect on prawn performance. An optimal stocking density was estimated to be between 3,300 and 3,700 prawns m⁻³. This optimal density was based on the results of prawn performance (growth, survival, biomass, harvest density and size variation), labour input requirements and risk associated with the different stocking densities.

In a separate experiment *P. monodon* postlarvae were stocked into the same tank systems at densities of 1,000 m⁻³ and 2,000 m⁻³ and grown for 8 weeks. Comparative growth and survival of the prawns at each stocking density, with and without artificial substrate, was assessed. After 8 weeks the mean weights were highest at a stocking density of 1,000 m⁻³. Prawns provided with substrates grew to a mean weight of 1.2 g compared to 1.0 g where no substrate was provided. Survival was highest in tanks with substrates, with 88% and 82% recorded at a stocking density of 1,000 m⁻³ and 2,000 m⁻³ respectively. With substrates, the final mean biomass at harvest was 1.3 kg m⁻³ and 1.0 kg m⁻³ at stocking densities of 2,000 m⁻³ and 1,000 m⁻³ respectively. Without substrates, the biomass was 0.9 kg m⁻³ and 0.8 kg m⁻³ at stocking densities of 2,000 m⁻³ and 1,000 m⁻³ respectively.

The results of this study have positive implications for the development and application of high intensity nursery systems for *P. esculentus* and *P. monodon*.

SUPEROXIDE DISMUTASE ACTIVITY IN HEPATOPANCREAS AND MUSCLE OF Nodipecten subnodosus EXPOSED TO THE TOXIC MICROALGAE Prorocentrum lima

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Okadaic acid (OA)is an algae toxin produced by certain species of marine dinoflagellates. The toxin accumulates in the digestive organs of filter-feeding shellfish and is the cause of diarrhetic shellfish poisoning (DSP) in humans. Dinoflagellates implicated as DSP toxin producers include several planktonic Dinophysis spp. And a few benthic/epi-benthic species of Prorocentrum. It seems possible that organisms naturally exposed to toxic algae have mechanisms to avoid harmful effects of OA in host cells. Aerobic organisms have therefore developed a complex antioxidant system which, apart from counteracting the negative effects of ROS also to plays a key role in protecting cells from oxidative stress and constitutes a potential indicator of oxidative stress in marine organisms. Superoxide dismutases (SODs) catalyze the reaction of superoxide ions and two protons to form hydrogen, peroxide and 0_2 . This enzyme has been shown to play an important role in modulating oxidative responses.

Juvenile of *N. subnodosus* were immersed for 48 h in three different densities of live *P. lima* (500, 2000, and 5000 cel/ml). SOD activity, in hepatopancreas and muscle was quantified to evaluate whether the dinoflagellate induce any immunostimulatory activity. Groups of three random clams per treatment were sampled after the immersion test at 6, 12, 24, and 48 h.

The toxicity of *P. lima* was evaluated in vivo in terms of SOD activity by exposing juveniles of *N. subnodosus* to three different doses of the toxic microalgae. In hepatopancreas, dosis of 500 cel/ml induced an increase in SOD activity at 24 h post-challenge, and dosis of 1000 cel/ml induced an antioxidant increase at 12 h (fig 1). Clams exposed to 5000 cel/ml registered 100% mortality at 48 h. Exposure of Juvenile clams to *P. lima* did not increase SOD activity in muscle (data not shown). In this study, 500 cel/ml of *P. lima* was enough to trigger antioxidant activity in *N. subnodosus*.



Fig. 1. Relative SOD activity (SODA) in hepatopancreas of juvenile *N. subnodosus* exposed to *P. lima* for 48 h at three different doses. Dosis 1 (500 cel/ml); dosis II (2000 cel/ml); dosis III (5000 cel/ml).



Fig. 2. Relative SOD activity (SODA) in muscle of juvenile *N. subnodosus* exposed to *P. lima* for 48 h at three different doses. Dosis 1 (500 cel/ml); dosis II (2000 cel/ml); dosis III (5000 cel/ml).

BIOMETRICAL VARIATION OF Artemia urmiana CYSTS HARVESTED NORTH PART OF THE LAKE URMIA (IRAN)

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Artemia is a small crustacea from class branchiopoda, phylum arthropoa. Artemia urmiana is a unique species of Artemia reported from Lake Urmia. The objectives of this study were to determine the diameter of untreated and decapsulated cysts and its chorion thickness in cysts harvested from 11 harvesting sites in north part of the Lake. Tukey Test was used, for comparison of data. Means of only 2 pair untreated cyst samples were significantly different, but analyzing decapsulated cysts showed presence of vast differences among the samples harvested from different sites and as well as among the cysts harvested from the same site (19 pair decapsulated cyst samples). Consequently no variations were observed amongst the diameters of untreated cysts but high variation amongst the diameters of decapsulated ones. In order to differentiate the cyst samples, Hierarchical Cluster Analysis was used. As diameters of decapsulated cysts showed high variations, mean of diameters of decapsulated cysts and C.V in each station was used in Hierarchical Cluster Analysis. According to results obtained from this analysis, the cyst samples were grouped in 4 collections (Fig.1). Largest untreated cysts were found in S_{3-1} station (259.34±2.25 micrometer) and smallest size in S_2 station (249.79±5.14 micrometer). Largest decapsulated cysts were found in S_{64} (251.6±2.23 micrometer) and smallest size in S_{41} (238.75±2.23 micrometer) sire. Thickest chorions were observed in S_{4-1} (9.38 micrometer) and thinnest chorions belong to the cysts harvested from S_{6-4} (2.04 micrometer). Results obtained indicate that diameter of decapsulated cyst is a natural character for the population and environmental factors do not influence it considerably, but it seems that environmental factors do considerably influence the diameter of untreated cysts that include chorion layer too. Therefore it could be finally concluded that biometrical studies of decapsulated cysts could probably be used as a tool for differentiating different Artemia populations within the same biotope.



Fig.1 - Classification 11 harvesting sites in north part of the Lake by Cluster Analysis

MOLECULAR GENETICS IN FRESHWATER CRAYFISH AQUACULTURE

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Freshwater crayfish, as with many groups of commercially important aquatic organisms, has been benefiting from the increasing application of molecular genetic techniques over the last decade. While this commercially and ecologically important group has not seen the same level of molecular study as higher profile aquaculture organisms, especially in relation to genome projects, functional genomics and transgenic technologies, our understanding of genetic variation within and between species of freshwater crayfish has been significantly increased.

Thus, most of the increase in genetic knowledge in relation to freshwater crayfish has been derived from the application of a number of molecular marker systems including, allozyme electrophoresis, restriction fragment analysis (RFLPs), amplified fragment length polmorphisms (AFLPs), randomly amplified polymorphic DNA (RAPDs), microsatellite loci and direct sequencing. As a consequence, a diversity of genetic information is now available for an increasing range of freshwater crayfish species, including the major Australian commercial species. This enhanced knowledge of genetic variation and the increasing access to molecular genetic information has a number of significant implications for the sustainable exploitation of freshwater crayfish and for the efficient development of genetically improved freshwater crayfish lines.

This presentation will review our knowledge of freshwater crayfish molecular genetics and outline how this genetic information can be used to inform management decisions in relation to the sustainable exploitation and conservation of exploited freshwater crayfish stocks and in relation to the design of efficient and effective genetic improvement research, mainly in relation to Australian species. The need to find a balance between the enhancing of commercial production using genetically improved lines of freshwater crayfish and the conservation of wild freshwater crayfish populations will be highlighted.

EVALUATION OF SEVERAL DIFFERENT LIVE FOODS IN GLASS EEL, Anguialla japonica

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The present study examines nutrients composition and identifies suitability and availability of live food in glass eel. Also, it evaluates the effect of supplementing various live foods on growth, survival rate, and biochemical composition in glass eel during a 6-week culture period. Three different phyto-plankton, *Isochrysis galbana*, *Tetraselmis suecica* and *chrollela spp.*, and three zooplankton, *Moina spp.*, rotifer, and *Artemia franciscana* were evaluated for their nutrient composition and for their nutritional values as the live food sources in glass eel, *Anguilla japonica* in experimental feeds with three different level for this experiment. 2) For the evaluation of the five different live foods, the proximate composition, amino acids and fatty acids contents will be compared, and feeding trials will be carried out to evaluate the effects of the live foods supplementation on growth, survival rate, and body proximate composition.

THE REALITIES OF THE MARKET FOR RISK CAPITAL: THE IMPLICATIONS FOR THE CAPITAL STRATEGIES OF AUSTRALIAN AQUACULTURALISTS

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Many aquaculture projects in Australia require financial resources that are beyond the immediate means of the project proponents. Because many of these projects are characterised by protracted negative cash flows during the early years of operation and an absence of collateral, bank financing is often not an option. As a result, the only viable source of financial capital is often the equity markets.

This would not represent such a challenge if equity financing was a simple concept, aquaculture projects always presented attractive risk-reward propositions and all people were commercially rational beings. Unfortunately, the equity markets (particularly the markets for risk capital) are complex and highly varied, aquaculture projects compete for risk capital with a range of other, often far more attractive, investment opportunities and not all investors act from transparent commercial motivators.

Russell Barnett has over 12 years experience in financing seed, start-up and expansion venture opportunities, in both the public and private equity markets. He has acted as an adviser, investor and manager to a range of early stage businesses in the Asian Pacific Region that have relied on external equity capital to fund their growth. Russell has a bachelor of commerce degree from the University of Western Australia, a Graduate Certificate in Mineral Economics from Curtin University of Technology and a Master of Business Administration from University of Western Australia. He is the Principal of Australian Venture Consultants and an Independent Director of Kirke Securities. He is a Master Stockbroker with the Securities and Derivatives Industry Association, the State Convenor for the Western Australian Chapter of the Australian Venture Capital Association and is a member of the Western Australian Aquaculture Development Council. He has also authored a number of papers on venture capital.

Russell will discuss the characteristics of the various sources of risk equity investment that can be contemplated by proponents of aquaculture projects and the various pros and cons of those sources as far as they may relate to aquaculture. He will go on to discuss strategies for sourcing appropriate equity financing as well as some of the strategies that can be deployed to manage engagements and ongoing relationships with investors.
IMPROVEMENTS AND LONG-TERM TRENDS IN STRIPED TRUMPETER Latris lineata CAPTIVE SPAWNING

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A ten-year captive breeding program for wild-caught striped trumpeter Latris lineata has demonstrated that they are an excellent aquaculture species. Wild-fish are caught at depth but do not rupture their swim bladders and are extremely hardy and easy to transport. They are easily acclimated and held in captivity in 25,000 L tanks, spawning within 6 months of capture at ambient temperatures of 12 to 16 °C. Hormone induced ovulation using slow release LHRHa pellets in mature fish caught during the spawning season (August to November) is no longer necessary. Striped trumpeter are multiple spawners with group synchronous oocyte development, producing eggs on a three to four day cycle over 3 months. Broodstock of 3 to 6 kg are now held under controlled photoperiod and temperature. They can be entrained to spawn out of season and compression of the spawning cycle can be achieved within six months. Unlike some tropical species they do not undergo sex inversion. The stress and reproduction response of captive striped trumpeter is unlike that of other marine species under investigation in Australia, for which similar data is available, such as snapper or barramundi. For example, striped trumpeter can be hand-stripped daily for weeks without inducing ovarian atresia. Regular hand-stripping increases the volume of eggs produced by females over a season. It also facilitates experimentation and increases genetic diversity by allowing fertilisation of females using stripped sperm from up to 6 males. Natural spawning has increased in recent years with better husbandry practises and changes to sex ratios. Total egg production for spawning groups has increased with time in captivity (Fig.1), although, poor performing fish are culled and replacement policies confound interpretation. The life cycle for striped trumpeter has been closed and F1 generation broodstock spawn in their fourth year. Broodstock have traditionally been fed pelleted, formulated feeds and fresh fish with a recent change to a composite moist diet. Egg biochemical composition changes in response to different broodstock diets and other aspects of egg "quality" are being assessed. The performance of tagged fish has shown differences among seasonal groups and between individual broodstock. Individual females show repetitive spawning traits with some reliably spawning early, others with increased fecundity or poor fertilisation and larval hatch histories. Out of season broodstock performance is similar to ambient season fish.



MONITORING, CONTROLLING AND RECORDING THROUGH AUTOMATION IT FOR RECIRCULATION LANDBASE FARMS

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In a aquaculture recirculation system, fresh or seawater water, there many parameters to be taken into account over a 24 hours period. It's impossible for trained staff to keep a check on these water parameters and maintain water quality in a typical recirculation system unless the aquaculture operation is 24/7. The normal means of testing water parameters, observations work, controlling can only be done when staff is on the aquaculture farm site and when everyone is always this is offend the time when parameters go out of balance. Many species like abalone, crayfish etc are night feeders so parameters during the night are more important then during the day when the animals are resting. The BOD, CO_2 , pH, NH₃, parameters etc can increase or decrease during this time with animals feeding and in the mean time you are sleeping. Over a prolong period of time this can result in mortalities, slow growth rate, poor qualities product and therefore cost the company bottom line profits.

On July 22nd 1969 Neil Armstrong walked on the moon. What does this have to do with aquaculture? EVERTHING. The technology to monitor, control and record has been around that long and the aquaculture industry has been very slow to take this automation IT on board.

Through companies like Honeywell, Siemens, Rockwell, Bosch etc automation IT system for any aquaculture farm to control and maintain the correct parameters 24/7 for your aquatic species are readily available.

This paper will work through the process of designing, controlling, maintaining, and recording in automation IT environment and the economical cost benefits to the aquaculture industry.

REPLACEMENT OF THE BIOFILTER FOR LANDBASE AQUACULTURE SEAWATER RECIRCULATION SYSTEM

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The aim of this project is to develop a natural engineering process to replace the typical bio filtration systems used for seawater recirculating waste treatment in landbased aquaculture. This development came about due to the nature of managing of both the normal production of aquaculture species and the bio filtration system equipment of waste matter for marine production. The long term benefits to the whole aquaculture industry would be to have a new system that does not reply on the complicated relationship between production waste and bio filtration requirements.

The development of an alternative more robust water treatment system will lessen the need to site the aquaculture farm near the seaside, since it is less likely that large make-up volumes of fresh seawater will be required. By removing the constraint of location near the seaside, farm location will be more flexible, and should provide for more cost-effective operation when all cost inputs are considered and minimised (land, installation, labour, electricity and regulatory compliance costs).

The underpin research development is to achieve an alternative systems for the removal of ammonia and dissolved organics. Current technologies are based upon biological filtrations (known as a bio system or bio filter) which are constrained by temperature, poor stocking space, feed waste and susceptibility to chemical disturbances. In the case of dissolved organics removal, current processes rely upon adsorption media, for example activated carbon, which can incur significant regeneration/ replacement costs. Technology developed would provide a new lower capital cost alternative to this existing technology and would be more robust. Thermodynamic assessment and experimental confirmation of ammonia gas solubility in seawater as a function of pH.

Design and costing assessment of possible separation process which could be adapted for ammonia removal from marine systems (these include gas stripping, membrane per evaporation, other membrane technologies, Centrifugal High Gravity Enhanced Extraction (HIGEE), flash vaporization and spraying, vacuum stripping).

This 3 year project is using both *Haliotis iris & Haliotis australis* as the test and control species with a total of 2000 kg for a real production loading.

NEW SOURCES OF OMEGA-3 OILS: CLONING GENES FOR SYNTHESIS AND ASSEMBLY OF LONG CHAIN OMEGA-3 FATTY ACID PATHWAYS IN PLANTS

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Long-chain omega-3 fatty acids (LC-PUFA) are essential for human health and key components of aquafeeds. Inadequate human consumption of LC-PUFA is common and leads to elevated levels of cardiovascular disease and cancer in adults and delayed or impaired neurological and cognitive development in infants. As well, LC-PUFA are necessary not only for the development and health of aquaculture species but also for producing seafood with favourable oil profiles. The main source of LC-PUFA in human diets is fish and seafood, both wild-caught and cultivated. Wild fisheries will not be able to supply the increasing demands for LC-PUFA – many are unsustainable – and aquaculture is a net user as LC-PUFA from wild fish are processed and fed to farmed fish. Marine microalgae and other microorganisms are the primary producers of LC-PUFA in the food web. By isolating the genes involved in LC-PUFA biosynthesis from these organisms and transferring them to oilseed crop plants, we expect to be able to create novel, sustainable sources of LC-PUFA. These oilseed-based LC-PUFA could be incorporated into human foods directly as processed oils and oil products or incorporated into aquaculture feeds, and then to humans.

We will describe our progress in isolating genes in the aerobic LC-PUFA pathway (desturases and elongases) as well as the anaerobic pathway (polyketide synthases) from Australian isolates of terrestrial plants, marine microalgae, bacteria and thraustochytrids.

PHOTOBIOREACTOR TECHNOLOGY FOR MASS-PRODUCTION OF MICROALGAE FOR AUSTRALIAN AQUACULTURE

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Microalgae are essential live feeds for many hatchery-produced aquaculture animals. They are normally grown in low concentrations in bags, tanks and ponds. This is both costly in terms of dollars and space. Photobioreactor technology has been developed for efficient, high biomass production of microalgae usually for biotechnology applications. The number of different microalgae produced using these technologies is very few, and include *Chlorella* and *Spirulina*, with *Nannochloropsis* being one of few aquaculture species.

As part of a collaboration with the University of Florence, world leaders in photobioreactor technology, we have undertaken growth trials of Australian microalgae in a range of different photobioreactors. While the project targeted production of bioactives and nutritionally important compounds with broad-based biotechnology applications, production of some aquaculture feed species was also tested. For example, using Italian-designed annular column reactors *Skeletonema* sp. has been tested in laboratory and field-based reactors, and further assessed as feed for juvenile Pacific oysters.

With an increasing trend in aquaculture for high intensity animal production there is a need for production of efficient, high biomass algal feedstocks. Proposed research involves matching a range of key microalgal species used as feeds in Australian hatcheries with photobioreactor technology, to demonstrate proof-of-concept of efficient, cost-effective microalgal feeds at a "model" hatchery scale.

AQUACULTURE DIET DEVELOPMENT: UNDERSTANDING THE RELATIONSHIPS BETWEEN FEED INGREDIENTS AND THE NUTRIENT REQUIREMENTS OF FIN-FISH

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The primary aim of our nutritional research has been to reduce feeding costs to improve profit. We have been researching the freshwater silver perch (*Bidyanus bidyanus*), the marine Australian snapper (*Pagrus auratus*) and are starting research with the estuarine and marine mulloway (*Argyrosomus japonicus*) and yellowtail kingfish (*Seriola lalandii*). The nutritional requirements of rapidly growing fish must be met by the diets they consume. Our research approach includes 1) determining the digestibility of a range of feed ingredients, 2) determining requirements for major digestible nutrients and energy 3) investigating the dietary limitations of different feed ingredients, 4) on-farm validation of new diets, and 5) determining optimum feeding strategies.

Australia imports most fishmeal used in aqua-feeds. As fishmeal is usually the most expensive component of omnivorous and carnivorous fish diets, the identification of alternative, locally available feed ingredients offers opportunities to reduce feed cost. Determination of digestibility values, especially digestible energy and protein, is the first step. Because different fish excrete different types of faeces, different methods of collecting faeces are sometimes required. For species with structurally intact faecal pellets, collection by settlement through the water column is adequate while for species that excrete loosely bound faeces, collection by stripping is often required. Digestible nutrient values can be affected, among other things, by dietary inclusion level and ingredient processing and production techniques. Once digestibility coefficients are available, digestible protein and energy requirements can be determined. Several methods can be employed ranging from simple empirical approaches such as dose-response studies to factorial modeling (mass balance, bioenergetics). Both approaches have individual advantages/disadvantages depending on how they are applied. Although ingredients may be highly digestible and provide high levels of digestible nutrients, such things as palatability, imbalanced amino acid profile, and the presence of anti-nutrients or high levels of non-starch polysaccharides may limit their use in aqua-feeds. The interaction between some ingredients may preclude or enhance their use. This requires investigation of ingredient utilization; usually indicated by growth responses, carcass composition, feed intake and feed conversion efficiency. New diets need to be manufactured using current technology (e.g. extrusion) and validated in controlled experiments and on-farm. As a large portion of feeding costs are associated with labour involved with feed delivery, determining the minimal number of feeds, and the best times to feed for different species under different growth stages and environmental conditions (especially temperature) is critical.

The digestibility coefficients of up to 60 Australian based ingredients were determined for silver perch. Application of these data and those from nutrient requirement and utilisation trials, has led to production of new diets for silver perch that contain no fish-meal, very low levels of fish-oil and are based entirely on Australian agricultural ingredients. Ingredient costs have been reduced by approximately 50%. Data for silver perch and other species will be used to illustrate the research methods described above.

MICROALGAE PRODUCTION FOR MOLLUSK AQUACULTURE: CULTURE SYSTEMS, NUTRITIONAL QUALITY AND ECONOMICS

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The culture of mollusks presents some particular problems in the area of algal culture for the nutrition of these animals. Filter feeding mollusks such as oysters and scallops require planktonic microalgae species whereas gastropods such as abalone require unialgal species which grow attached to surfaces as well as multicultural algal species later during their growth. The production of microalgae for aquaculture feed represents a major cost for the aquaculturalist and the main focus of research in this area has been on planktonic microalgae with less effort on attached species.

A wide range of culture systems are used for the large-scale culture of microalgae with large bags and tanks being the most common. Batch culture is the most common mode of culture, although semi-continuous culture is also used. These culture systems are rather inefficient due to poor mixing and poor light availability due to a long light path and the cell densities reached generally are quite low at 0.1 g.L^{-1} dry weight or less. Newer culture systems such as the tubular photobioreactors and plate reactors have been developed and should allow many hatcheries to improve the efficiency and economics of algae production.

The range of algae species used in mollusk aquaculture is very small. The chemical composition and nutritional value of these algae is a function of the species and the culture conditions. For example diatom lipids are generally high in eicosapentaenoic acid and the cell content of this fatty acid can be manipulated by changing growth conditions. Similarly the ratio of carbohydrate to lipid can be manipulated and can the protein content.

Effective and economical aquaculture of mollusks, as other aquaculture species, requires the production of low cost feed with high nutritional value. This paper will describe new developments in algal culture systems, the optimization of the nutritional value of the algae and the potential for the isolation of new species.

THE 'QUALITY' ASSESSMENT OF AQUACULTURE PRODUCT TRADED AT SYDNEY FISH MARKET

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In recent years aquaculture produce has become an important component of the product mix that is traded by Sydney Fish Market Pty Ltd (SFM) and has seen a growth in volume that supports worldwide trends.

This presentation will outline the most popular aquaculture product types that are traded by SFM and will highlight their importance to Sydney Fish Market and to its wholesale/retail buyers.

SFM's management practices in assessing and grading the product prior to sale will be discussed in generic terms, with emphasis on the 'quality' differences that are commonly found between wild caught and aquaculture product, especially in terms of size, freshness, temperature, and labelling. Reliability of these product characteristics, as well as regular product supply leads to product consistency, which in turn strengthens buyers' trust and maximises the chance of on-going repeat sales.

The presentation will then summarise the on-going research being undertaken by SFM and its partners through an FRDC funded project to develop a freshness assessment 'Quality Index' for Australian seafood. This pilot project that commenced in July 2003 is addressing six species including two nominated aquaculture products, tiger prawns and Atlantic salmon. The potential commercial uses for this tool in fish wholesaling will also be discussed.

IONIC SUPPLEMENTATION OF POND WATERS FOR INLAND CULTURE OF MARINE SHRIMP

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Saline well waters are used for inland, pond culture of marine shrimp and fish. Although these waters may have adequate salinity, they often are deficient in one or more major ions and potassium and magnesium in particular. Inland shrimp producers in Alabama (USA) treated pond waters with potassium chloride to increase potassium concentration from 2 to 6 mg/L to about 35 mg/L and maintain it at this level. One or two treatments of 1,000 to 1,500 kg/ha of fertilizer grade potassium chloride were adequate to provide the target potassium concentration. There was substantial improvement in shrimp survival following potassium supplementation. A study was conducted at one farm where salinity in ponds ranged from 2 to 4 mg/L and potassium concentrations naturally are below 5 mg/L. In 2001, no potassium salt was applied until near the end of the growing season, and survival and production were 19% and 595 kg/ha, respectively. In 2002, shrimp were stocked at the same density as in 2001, potassium was applied before stocking shrimp, and the concentration of this ion did not fall below 30 mg/L in any of the nine ponds. Survival improved to 67% and production averaged 4,068 kg/ha. Magnesium supplementation also was provided, but there was no increase in magnesium concentrations in pond waters. Thus, improvement in survival and production was attributed mainly to potassium.

Any major ion may be at relatively low concentration in saline well waters. It seems logical to assume that seawater has the proper proportions of major ions for marine organisms. The diluted seawater equivalent for ionic concentrations in culture water may be obtained by multiplying salinity of culture water by the following factors: calcium, 11.6; magnesium, 39.1; potassium, 10.7; sodium, 304.5; chloride, 551; sulfate, 78.3. However, potassium, magnesium, and calcium concentrations probably are more critical than other ionic concentrations provided salinity is adequate for the species being cultured. Some salts for use in inland, low-salinity culture of marine organisms are provided in Table 1.

TADEE 1, Dummary of properties of minietal bank for all magnetiments					
Formula	Common or trade name	Typical composition			
CaSO ₄ ·2H ₂ O	Gypsum	22% Ca; 53% SO ₄ ; 55% hardness			
KCl	Muriate of potash	50% K; 45% Cl			
K ₂ SO ₄ ·2MgSO ₄	K-Mag	17.8% K; 10.5% Mg; 63.6% SO ₄			
K ₂ SO ₄		41.5% K; 50.9% SO₄			
MgSO₄·7H ₂ 0	Epsom salt	10% Mg; 39% SO₄			
NaCl	Rock salt, mine-run salt	39% Na; 61% Cl; 98% salinity			
	$Formula$ $CaSO_4 \cdot 2H_2O$ KCl $K_2SO_4 \cdot 2MgSO_4$ K_2SO_4 $MgSO_4 \cdot 7H_20$ $NaCl$	FormulaCommon or trade nameCaSO ₄ ·2H ₂ OGypsumKClMuriate of potashK $_2$ SO ₄ ·2MgSO ₄ K-MagK $_2$ SO ₄ MgSO ₄ ·7H ₂ OEpsom saltNaClRock salt, mine-run salt			

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EMPORAL TRENDS IN BROODSTOCK CONDITION AND EGG LIPID OF CAPTIVELY-HELD STRIPED **TRUMPETER** Latris lineata

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Striped trumpeter is an Australian, marine finfish with aquaculture potential. Striped trumpeter broodstock 4-6 kg are held in 25000 L indoor tanks under ambient light and temperature regimes. They are fed pelleted, formulated feeds and fresh fish. Striped trumpeter broodstock are multiple spawners with group synchronous oocyte development, producing eggs on a three to four day cycle over 3 months. Over an ambient spawning season (July-November, 2003), we monitored the weights and dorsal muscle fat of female broodstock (n=15). Muscle fat was recorded using a non-invasive microwave technique (Torry fat meter). Females were strip-spawned under standard conditions, and the resultant eggs were measured for lipid diameter under a dissecting microscope.

Our results show that female broodstock initially increase in weight at the commencement of the spawning season, possibly as a time of 'conditioning', after which weight gradually decreases (Figure 1). Muscle fat content decreases linearly during the spawning season, probably as lipid is redirected from the muscle to the liver for vitellogensis.

Similarly, temporal trends in egg lipid diameter show a linear decrease during the season (Figure 2), suggestive of a gradual reduction in available lipid reserves.

-0.0027x + 202.91x - 4E+06 $r^2 = 0.48; P < 0.01$ 95 X of Initial Noid D 60 ò • Weight ۰. 🗆 Muscle fat 65 v = -0.4137x + 15769 r² = 0.84; /² < 0.001 50 28-Ju 6-Sep 16-Oct 25-N Figure 1. Temporal changes in female striped trumpeter broodstock weight and muscle fat. Values are exp ressed as percentage of the initial weight or fat. Line 106 y = -0.1087x + 4252.5 r² = 0.58; P < 0.001 100 퉡 95 K of intial 90 28-Jul 27-Aud 26-Sep 26-00 25-No Date Figure 2. Temporal changes in the lipid diameter of striped trumpeter eggs during a spawning season. Values are expressed as percentage of the initial weight or fat. A Interrogression has been filted. Average of 16 londes. spawning season. Values

There is no apparent effect of decreased egg lipid on larval quality. Larvae reared from late season spawnings have similar growth and survival to early and mid season spawnings. Egg quality is now being assessed through larval activity tests.

INVESTIGATING THE DIETARY DHA REQUIREMENT OF LARVAL STRIPED TRUMPETER Latris lineata USING DOSE-RESPONSE TECHNIQUES

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Striped trumpeter is an Australian, marine finfish with aquaculture potential. Our research has recently focused on determining nutritional requirements during the larval phase when low and inconsistent survival is a common problem. Determining fatty acid requirements in larval fish supplied live feeds is difficult; doseresponse designs frequently used in larger fish are often overlooked due to inherent problems in manipulating multiple batches of live feeds with desired essential fatty acids profiles. We aimed to determine the 22:6n-3 (docosahexaenoic acid, DHA) requirement of striped trumpeter larvae using dose-response designs during rotifer and *Artemia* feeding using seven and five graded concentrations of DHA, respectively.

During the rotifer feeding experiment (5-18 days posthatch, dph), no relationship was identified between growth or survival to dietary DHA. A relationship was observed between dietary DHA and the severity of 'grey-gut syndrome' (Figure 1), a condition observed in striped trumpeter larvae associated with bacterial proliferation in the gut. Left untreated, the condition progresses and can ultimately result in larval mortality. Data therefore suggests dietary DHA during early stages stimulates the larval immune response.

During the *Artemia* feeding experiment (16-36 dph) a positive, linear relationship was identified between larval growth and dietary DHA. With time, the disparity in growth between larvae fed low or high DHA was found to widen (Figure 2).



The experiments highlighted the importance of DHA on different physiological processes at different stages of development. While technically difficult, costly and labour intensive, dose-response designs with adequate replication are an excellent method for assessing nutrient requirements of larval fishes.

MICROALGAE AND THEIR ROLE IN BIVALVE HATCHERY NUTRITION

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Over the last five decades, several hundred microalgae have been tested as food for bivalve molluscs in hatcheries, but less than twenty have gained widespread use. Those proven successful are of an appropriate size for ingestion, eg. from 3 to 10 μ m for larvae and juveniles, are readily digested and have good nutritional value based on feeding experiments. These strains generally have rapid growth rates, are amenable to mass culture, and stable in culture to environmental fluctuations. Data from the CSIRO Collection for Living Microalgae (C. Johnston, pers. comm.) shows that *Isochrysis* sp. (T.ISO), *Pavlova lutheri, Chaetoceros calcitrans* and *C. muelleri* are the most common species used in Australian hatcheries, with *Thalassiosira pseudonana, Skeletonema costatum* and *Tetraselmis suecica* also popular. For larvae, a mixture of *Isochrysis* sp. (T.ISO), *P. lutheri* and *C. calcitrans* is popular – both within Australia and overseas.

Since the early reports that demonstrated biochemical composition differences in microalgae, many studies have attempted to correlate their nutritional value with their biochemical profile. However, results from experiments that have tested microalgae differing in a specific nutrient are often difficult to interpret because of the confounding effects of other nutrients. Nevertheless, from examining all the literature data, including experiments where algal diets have been supplemented with compounded diets or emulsions, some general conclusions can be reached.

The proximate composition of microalgae (% of carbohydrate, protein, lipid and ash) can vary substantially. In general, this is not always a strong predictor of nutritional value, and where correlations have been found the results may be specific to the target animal species. For example, algae with higher concentrations of protein have performed better with juvenile *Crassostrea gigas*, whereas higher carbohydrate improved the growth of juvenile *Ostrea edulis*.

With respect to the quality of nutrient fractions, the essential amino acid composition of microalgae is very similar. Algae have significant differences in their proportions of the fatty acids designated 20:5n-3 (EPA) and 22:6n-3 (DHA), and the presence of one or both of these is considered essential for bivalves. However, requirements for these fatty acids may be lower than previously thought and, at least for *C. gigas* larvae, saturated fatty acids in the algal diet may be more critical as higher proportions of these improve larval growth. Concentrations of vitamins and types of sterols also differ between algal species, and may be influenced by the culture environment. However, as yet there is no rigorous data that an alga's composition of these contributes significantly to their nutritional value for bivalves.

This paper will review the current state of knowledge of larval and juvenile bivalve nutrition, and how appropriate feed microalgae may be chosen and cultured to meet the animals' needs.

COATING PILCHARDS WITH DIETARY ANTI-OXIDANTS TO IMPROVE THE SHELF LIFE OF SOUTHERN **BLUEFIN TUNA** Thunnus maccoyii

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The bright red colour and shelf life of tuna meat are important quality characteristics for the high value sashimi market for farmed Southern Bluefin Tuna (SBT). This experiment is the third in a series examining the use of dietary antioxidants to extend the shelf life of farmed SBT flesh. We have previously demonstrated that feeding pellets with boosted levels of vitamin C & E and selenium can increase tissue levels of these anti-oxidants and increase the subsequent of tuna flesh (Buchanan and Thomas, 2001, Thomas and Buchanan 2002). However, as only a small proportion of farmed SBT are raised on pellets there was a need to apply the dietary antioxidant technique to the commercial practice of feeding frozen baitfish. The current study examined the effectiveness of applying dietary antioxidant to the frozen bait fish most commonly fed to SBT.

Materials and methods

For a period of 55 days farmed SBT were fed either mixed bait fish (Control), or mixed baitfish with a vitamin powder coating containing vitamin E and vitamin C (High vitamin). As a reference point, a group of ten fish (initial) were also sampled at the beginning of the experiment. Tuna were sampled at 27, 42 and 55 days after vitamin coatings were introduced. After day 55 the coating was withdrawn and SBT were again sampled after a further 21 days. At each harvest core flesh samples were then taken from the bleed cut and analysed for vitamins E and C. Over a period of 8 days, flesh sample shelf life was estimated by assessing the rate of colour change for flesh samples. Samples were held at 4 C and trained panellists scored the colour of each sample daily.

Results

The tissue levels of vitamin C was significantly higher in the High vitamin group than the Control group and initial sample (Figure 1). Tissue vitamin E levels were not significantly different between treatments. The shelf life of tuna flesh was significantly increased by the high vitamin treatment. Tissue samples taken at day 27 and 55 showed significantly slower rates of browning for the High vitamin group than the Control group. Differences in shelf life at other harvest times were not significant.

Conclusions

These preliminary results indicate that coating baitfish with high levels of vitamin powders can raise vitamin C levels within four weeks and increase the shelf life of tuna where tissue vitamin C levels exceeded 35mg/kg.

Acknowledgments

This work formed part of a project of Aquafin CRC, and received funds from the Australian Government's CRCs Program, the Fisheries R&D Corporation and other CRC Participants. The authors wish to thank Roche Vitamins Australia Pty Ltd for contributing the vitamins for the diets used in this research. Also thanks to the SARDI and Flinders technicians the care of the fish and for their efforts and assistance with sample collection, data collation and sample analysis.

ESTIMATION OF HERITABILITIES FOR REPRODUCTION AND GROWTH IN Penaeus monodon (FABRICIUS, 1798)

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The capital investment and costs required to run large scale selection programs in aquaculture can be large, and accurate estimates for heritabilities of and genetic correlations between selection criteria and breeding objectives are needed to ensure success. Analysis of 3 generations of black tiger prawn pedigree data has produced estimations of genetic parameters (heritabilities and genetic correlations) for a range of reproduction and growth traits in Australian *P. monodon*. The estimates can be used to predict future response to selection. One example of response to selection is illustrated in Fig. 1. Simulations indicate that a selection program can improve reproductive success of black tiger prawns and that commencement of a selection program in Australia is viable with current technology. This is the first report of heritabilities for reproductive and "domestication" traits in *P. monodon*. Data will also be presented from a recent analysis of Australian pedigree information for *P.merguiensis* indicating high heritability estimates for harvest weight in banana prawns.



Fig. 1. Response to selection for more nauplii and eggs and for an increase in percentage hatch rate (assuming spawns from the best 11% are selected each generation).

ENVIRONMENTAL REGULATION OF AQUACULTURE IN AUSTRALIA

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In Australia, there is increasing demand for access to public land and water resources for aquaculture production. A major challenge for regulatory agencies is how to satisfy this increasing demand while managing potential conflicts with other resource users. A related challenge is how to manage potential environmental impacts without unnecessarily restricting the development of the aquaculture industry. This paper assesses environmental regulatory arrangements for aquaculture, identifies potential constraints on the aquaculture industry, and opportunities for improving the efficiency and effectiveness of the regulatory arrangements.

Aquaculture production is subject to regulatory arrangements covering aquaculture production, environmental protection, land use planning, marine and coastal management, land tenure, and quarantine and translocation. The arrangements reflect the diversity of aquaculture production and the use of public and private resources. Since some aquaculture operations have potential for significant environmental impacts, some environmental regulation is required. However, aquaculture production is subject to an unnecessarily complex array of regulation administered by different agencies. This can impose unnecessary costs on aquaculture producers, consumers and the community, and adversely affect competitiveness and the environment.

Various aquaculture leases and licences, environmental permits and development approvals may be required for aquaculture production, depending on the location, species and production system. Prospective aquaculture operators can experience significant costs and uncertainties from dealing with multiple agencies with different regulatory responsibilities for aquaculture management. More complex aquaculture proposals may take more than four years to be approved where extensive consultation and many different approvals are required.

There is potential for greater use of innovative policy instruments to complement (or in some cases replace) existing regulatory and administrative controls. For example, the use of auctions for marine lease allocation, and the use of tradeable discharge permits to manage discharges of effluent, may have merit. However, the costs and benefits of innovative policy instruments, including implementation and monitoring costs, will need to be assessed.

Several state governments are reviewing aspects of their aquaculture regulatory arrangements to improve administrative arrangements and approval processes. There is an opportunity to learn from successful reforms in other jurisdictions, both in Australia and overseas, to improve environmental regulatory arrangements for aquaculture.

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BURROWING WORMS IN MOLLUSK AQUACULTURE, A GENERAL SCOPE FOR CONTROL

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Everywhere mollusk aquaculture is established, late or early, small holes in the shell of mollusks start to appear. The analysis of the inner shells reveals blisters and channels inhabited by boring worms. These annelids are in fact epibionts; although they are not considered as parasites, their effect could be of great importance in mollusk health and for marketing, therefore sometimes they are considered as pests. Suggestions for the control of this pest are: air-drying during certain periods of time, baths of fresh and warm water, chemicals, etc. These control measures are focused to kill adult stages or recently settled larvae and juveniles. If we take into account the reproductive biology and behavior of these worms, additional control measures could be implemented.

Due to the sexual and asexual (Architomy) reproduction of some of these worms, aquaculture practices, such as shell brushing, and cleaning in or near by the aquaculture facilities, may favor colonization and dispersion of them. A review on the control of these pests is presented, and new recommendations for their control based on its reproductive strategy and behavior are presented.

DEGRADATION OF ABALONE *Haliotis fulgens* IN NATURAL AND CULTURE CONDITIONS, ELEMENTS FOR FORENSIC ANALYSIS

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Unusual mortality episodes of abalone frequently are recorded in natural wild stocks and culture facilities around the world. Producers detect these events when they found dead abalone on the ocean floor or culture tanks. These organisms could be recently dead or had several days of dead or even months. This information turns crucial to explain these mortality and to take corrective actions. However, up to date, no information on degradation conditions of abalone tissues or shell occurring through the time, is available to make a retrospective (-forensic-) analysis. Adults, blue abalone *Haliotis fulgens*, were killed using anesthesia and exposed to a degradation in cages on the ocean floor and culture tanks. The experiment was performed by triplicate. Each 24 h degradation estimators such as odor, color, flesh consistency, histology, flora and fauna associated and environmental conditions were evaluated for the soft during a period of five days. For shells, degradation estimators such as epibionts, shell thickness, nacre bright and flora and fauna associated were recorded every 15 days for 3 months. Moreover, a photographic record during the study was done. Results showed a degradation process that is characterized by a succession of organisms and deterioration of the shell, which is very useful as a practical tool for forensic analysis by producers and pathologists.

NUTRITION, DIGESTION AND DEVELOPMENT IN FISH LARVAE

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Since two decades, studies have been conducted in laboratories to formulate compound diets sustaining larval growth. But these formulations, incorporating the same ingredients than those used for growing fish, failed to sustain larval development. Diets with convenient sizes were effectively ingested by fish larvae, but not digested. Recent studies focussed on digestive enzyme ontogenesis during larval development, in order to understand specificities in larval digestion, and consequently, specificities in larval nutritional requirements.

Experiments conducted on European sea bass (*Dicentrarchus labrax*), sole (*Solea senegalensis*), red drum (*Scianops ocellatus*) and more recently on yellow croaker (*Pseudociana crocea*) showed that ontogenesis of digestive enzymes exhibits similar patterns in different marine fish species. Pancreatic enzymes, such as trypsin and amylase, are synthesized from very early stages and can be assayed in developing embryos. Their synthesis is not induced by diet but can be modulated by diet composition. Both mRNA and activity of phospholipase A2 increase with phospholipid dietary content. This suggests a good digestion of phospholipid by fish larvae, and this hypothesis was reinforced by an improved growth in larvae fed high phospholipid. At the opposite, mRNA and activity of lipase are not correlated with lipid concentration in diet, revealing a poor digestion of triglycerides. Cytosolic enzymes of intestine, which are mainly peptidases, are highly expressed in early stages, then suddenly decrease around day 25. This could indicate that young larvae are adapted to digest peptides. Indeed, growth of young larvae was enhanced by dietary incorporation of hydrolysed protein, which can replace up to 20% of total dietary protein. At the opposite, the enzymes of the intestinal brush border, such as alkaline phosphatase, N aminopeptidase, maltase, are poorly expressed in early stages and abruptly increase, concurrently to the cytosolic enzyme decrease. This phenomenon has been already described in mammals and corresponds to a shift from a larval mode of digestion to an adult mode of digestion.

New knowledge in digestive specificities of fish larvae has allowed a better determination of nutritional requirements and convenient microdiets are now formulated for marine fish larvae. These microdiets are used in studies aimed to improve larvae quality. Indeed, skeletal malformations, such as spinal malformation - scoliosis, lordosis, coiled vertebral column-, bending opercle or jaw malformations are the major problem in fish hatchery. Recent results showed that some nutrients, such as vitamin A (retinol) and highly unsaturated fatty acids directly act on genes involved in development, such as *RAR* (Retinoic Acid receptor), *RXR* (Retinoid X Receptor), *BMP4* (Bone Morphogenetic Protein). The change in the expression of these genes, induced by inadequate vitamin A or HUFA dietary levels was associated with jaw deformities and variable numbers of vertebra. The study of the gene regulation by nutrients will be helpful to improve the compound diets formulated for fish early stages.

MAKING AQUACULTURE POLITICALLY SUSTAINABLE

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It is fashionable in some very vocal circles to complain about Aquaculture – there is a worldwide movement to do this. There are people in this debate who oppose all fish farming, particularly sea-farming. There are many people who do not trust industry to manage their operations in an environmentally sustainable manner While there may be some irresponsible fish farmers who damage the credibility of the rest of the industry, most fish farmers, like the rest of the community, want all forms of industry on and off shore to be managed in an environmentally responsible way. Fish farmers know that they cannot grow healthy fish and run sustainable businesses unless they look after the environment. However this informal principle is not sufficient to convince politicians and senior bureaucrats to provide unreserved support for the aquaculture industry.

Implementing auditable environmental management systems that are internationally recognised is increasingly important to provide credibility to markets, to concerned community groups and to politicians and regulators. Having an environmental management system (EMS) that is externally audited to ISO 14001 gives businesses the independently accredited endorsement they need to counter some of the misinformation that is publicly available.

ISO 14001 is an important marketing tool for both selling and for rasing their public image. In particular we have found that consumers in the international market want to be able to use the web to reassure themselves that the food they are eating is free from pollutants and is sustainably produced.

BACTERIAL VACCINES FOR FINFISH AQUACULTURE IN AUSTRALIA: THE ART, THE POSSIBLE AND THE CHALLENGE

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Worldwide, vaccines as an aid in the control and management of bacterial disease in finfish, have gained growing importance as a key strategy of sustainable fish farming. In Australia, however, use of vaccines is still largely limited and is a reflection of the relatively small scale production of finfish, the diversity of finfish farmed and the generally low incidence of major and continuing disease episodes.

Of the species farmed in Australia, only the salmonid industry in Tasmania uses vaccination consistently as a disease control strategy. In 1985 when sea farming of Atlantic salmon and rainbow trout commenced in Tasmania, it was forecast that vibriosis was likely to be a significant disease. In that same year, outbreaks of disease, caused by *Vibrio anguillarum* serotype O1, occurred in rainbow trout and to a lesser extent Atlantic salmon. By 1989 an immersion vaccine for the disease had been developed by the Fish Health Unit and registered for use as Anguillvac-C[®] with the Veterinary Medicines Board in Tasmania and later with Australian Pesticide and Veterinary Medicines Authority (APVMA). Anguillvac-C[®] is the only registered fish vaccine in Australia. Production of the vaccine is undertaken by the Fish Health Unit in a GMP licensed facility and all salmonids farmed in seawater in Tasmania are vaccinated with Anguillvac-C[®]. In Australia, Atlantic salmon are susceptible to infection with *Yersinia ruckeri* serotype O1b. Production losses due to Yersiniosis are significantly high and persistent to warrant vaccination. The Fish Health Unit have developed a second immersion vaccine, Yersinivac-B[®], for use in hatcheries. The vaccine is currently undergoing efficacy trials in the field in preparation for registration with the APVMA.

Development of vaccines for other fish species has been limited, a reflection of industry size and disease occurrence. Of the major fish species farmed other than salmonids, significant episodes of disease have been reported in barramundi (*Lates calcarifer*) due to *Vibrio harveyi* and *Streptococcus iniae*. While no commercially available vaccines are available, experimental trials with killed whole cells for both pathogens show some promise.

Vaccine use in Australia is controlled by the APVMA. For a vaccine to be used commercially, it must be registered with the APVMA and its efficacy in the field demonstrated. Autogenous vaccines may be used with approval but strains must have been isolated within a period of two years and the vaccine can only be used at the originating farm. Use of commercial vaccines manufactured overseas poses special problems because of Australia's unique position of being free of inajor diseases that occur in the northern hemisphere. Imported vaccines, particularly those based on exotic strains, will need to satisfy quarantine requirements at a national and state level and such products will also need to be registered with the APVMA and able to demonstrate efficacy in an Australian context.

EFFECT OF THE INTERACTION BETWEEN TEMPERATURE AND NUTRITION ON THE GROWTH PERFORMANCE OF FISH

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Understanding the interaction between fish nutrition and environmental parameters has an extremely high priority in several sectors of the Australian finfish aquaculture industry. Climate change appears to be causing high summer water temperatures in salmon growing regions. Barramundi are being farmed under an increasingly diverse range of systems. Generally, fish growth performance is being pushed harder. Although aquafeeds have changed dramatically there is a real need to match formulations more accurately to environmental conditions, particularly temperature. This is because aquafeeds are being formulated to more closely meet the actual nutritional requirements and therefore have lower "margins for error"; they now contain a diverse range of ingredient sources that introduce different sets of positive and negative characteristics; they are a major production cost and major sources of environmental loading. Limiting environmental conditions, particularly those imposed by extreme temperatures that are outside of the optimum range, will test the adequacy of nutrient supply and the efficiency of growth. It is important to note that research into aquaculture nutrition often accumulates data under optimum experimental conditions that maximise growth performance. This paper will discuss temperature in relation to fish growth and present a summary of current research being conducted at TAFI on Atlantic salmon and on barramundi.

EVOLUTION OF SHRIMP FARMING IN NEW CALEDONIA: STRATEGIC CHOICES AND DEVELOPMENT POLICY OF THE NORTHERN PROVINCE

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The first attempts to develop shrimp farming in New Caledonia where made just 30 years ago in 1973, through a FAO-PNUD project, with the support of the local communities. A screening of the aquaculture potential of various species of local or imported shrimps led to the selection of *Litopenaeus stylirostris*, which appeared very well suited to the New Caledonian coastal environment. After initial introductions in the late 70's, under sanitary control by IFREMER from the laboratory of Tahiti (French Polynesia), no other introductions of live material was done after 1983. New Caledonia thus became one of the first cases of development of an activity, with a domesticated non-indigenous species. Shrimp farming developed steadily after the first commercial farms were established in 1983, to reach an overall production of 1900 t (metric tons) in 2003. The development plan of new farms should lead to a production of 5000 t by 2007. It represents an important economic activity for New Caledonia, and became the leading food-export item during the 90's.

The main characteristics of this production, in regards of the historical steps of its development which will be described as follows:

Choice of technology and environment preservation

- Monospecific production of the blue shrimp, with moderate intensification,
- A sanitary sanctuary, remaining free of the main virus affecting shrimp farming over the world, due to a strict sanitary control by the Animal Health services of New Caledonia, and prohibition of live or frozen shrimps imports.
- Specific constraints applied to site development, preserving mangrove destruction.

Organization of the production

- A combination of artisanal and semi-industrial farms, organized, through a federation of producers including farms, integrating hatcheries and process plants.
- Small to intermediate size of production sites and minimum distance required between sites to avoid farm concentration.
- A permanent effort to ensure high quality standards, through certified procedures and a strict control of production and export policy, supported by a constant research effort.

Illustration of the Development policy of the Northern Province: The Webuihoone shrimp farm

- In 1991, the Northern Province, the Sofinor and the council of Voh, met populations of the village and surrounding tribes to approach the idea of a shrimp farm.
- In this time shrimp farming was a new activity for the newly created Northern Province.
- This pioneer project was attempted to show the way to other industrial or artisanal farms.
- In a customary ceremony, clanic land owners gave the land to the project. This area was included in an indigenous protected area.
- A limited liability company named Webuihoone was set up in 1992 including individual shareholders from tribes and village and the Partnership of Gatope's tribe where the farm is located. Other shareholders were a company held by public collectivities, the SOFINOR, and ICAP, a venture capital body.
- From 1993 to 2004 Webuihoone farm increased investments, area of ponds and today production is more than 220 t / year. It is a major actor of the SOPAC alliance which exports New Caledonian shrimps – 12% of this product comes from Webuihoone.
- Today, other farms have followed the way to develop aquaculture in the Northern Province. SOPAC is building a new processing plant in Kone (30 km from Voh). Webuihoone is about to invest in a hatchery and in a bigger farm a few kilometres north, to continue to develop this export industry and stimulate local economy and employment, still associating local populations.

PRODUCTION TRIALS ON THE ECONOMICS OF RICE CUM PRAWN FARMING IN KALINGA PROVINCE, PHILIPPINES

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The study was conducted to determine the production and economics of rice cum prawn farming in rice paddies of Kalinga Province, Philippines. The municipalities of Tabuk, Pasil and Rizal, all in Kalinga Province were identified as experimental sites. A 1,000 m2 paddy was used in each site. Four successive croppings were used as replicates.

Results showed no significant difference (P > 0.05) in the total production of prawn among treatments, however, significant difference (P < 0.05) appeared in the total production of rice. Treatment 1 (Tabuk) has a total rice production of 560 kg, which is significantly higher than Treatment 2 (Pasil) with 493.75 kg, but not significantly different with Treatment 3 (Rizal) with 520 kg (Table 1).

Production cost was PhP 6,264.20 for all Treatments (US\$ 1.00= PhP 56.00).

Analysis of variance on the mean net income and mean return on investment resulted to a significant difference (P < 0.05) between Treatments (Table 1). Treatment 1 has a significantly different net income and return on investment than Treatment 2, however, it is not significantly different with Treatment 3 (Rizal).

Results indicated adaptability and viability of rice cum prawn farming in the Province of Kalinga, Philippines due to its high production and income. It is recommended that the technology be also tested in other municipalities of the province and the whole of the Cordillera Administrative Region (CAR).

Treatment	Total Production (kg)		Production	Net Income	ROI
	Prawn	Rice	Cost (PhP)	(PhP)	(%)
1 (Tabuk)	26.95 ^a	560 ^a	6,264.20 ^a	3,885.80 ^a	62.03 ^a
2 (Pasil)	25.9 ^a	493.75 ^b	6,264.20 ^a	3,112.68 ^b	49.69 ^b
3 (Rizal)	27.3 ^a	520 ^{ab}	6,264.20 ^a	3,660.80 ^{ab}	58.43 ^{ab}

Table 1. Mean total production of rice and prawn production cost, net income and return on investment of rice cum prawn farming in three municipalities of Kalinga Province, Philippines.

MORPHOLOGICAL AND HISTOLOGICAL DEVELOPMENT OF THE DIGESTIVE SYSTEM IN YELLOWTAIL KINGFISH Seriola lalandi LARVAE

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With a growing interest in yellowtail kingfish (*Seriola lalandi*) farming, a better understanding of its larval digestive physiology, nutritional requirements and dietary formulation is required. As a first step towards understanding the digestive physiology of this species, the structural development of the digestive system has been studied using light microscope through the entire period of larval development till metamorphosis.

Larval rearing was conducted in a recirculating system at a initial density of 60 individuals per litre. Larvae were fed with rotifers from the mouth opening (i.e., 3 DAH) until 12 DAH. Then *Artemia* nauplii were introduced into larval rearing tanks from 12 DAH to 30 DAH. Finally, larvae were weaned onto commercial pellet feed until the end of the experiment. Samples were taken randomly from the rearing tanks in triplicates once every day from the first day of hatching to 5 DAH and once every 3-5 days after 5 DAH to the end.

After hatching, the digestive tract was a simple undifferentiated tube with an opening at the anus. The mouth opens on 2 DAH. The liver and pancreas appeared on 1 DAH and 2 DAH, respectively. Significant change occurred between 3 DAH and 4 DAH when exogenous feeding started, showing significant differentiation along the larval fish digestive tract. When the digestive tract was segmented into buccopharynx, oesophagus, presumptive stomach, anterior intestine, posterior intestine and rectum on 5 DAH (Fig. 1) fish was histologically ready to process external food. Intestinal absorption occurred quickly after exogenous feeding, evidenced by the digestive vacuoles in the anterior intestine (Fig 1. shown by the arrows) and eosinophilic granules in the rectum on 5 DAH. Mucous cells increased numerically on 7 DAH and the brush border of the intestine appeared on 10 DAH. The absorption area moved to the posterior part of the intestine on 10 DAH after the brush border formed. A large number of digestive vacuoles could be observed in this region. The last major morphological change occurred around 30 DAH with the development of pyloric caeca.

The results of this study suggest that the digestive system of yellowtail kingfish developed much faster than some other species, indicating that yellowtail kingfish could be weaned in an earlier time.



Figure 1. Sagittal section of a 5 DAH larva (H-E stain) showing the presumptive stomach (PS), anterior intestine (AI), food particles (FD), kidney (K), liver (LI), notochord (NO), oesophagus (OE), oil granule (OG), pancreas (P), swim bladder (SB). The arrows show digestive vacuoles.

ORGANIC AQUACULTURE – THE AUSTRALASIAN COMPETITIVE EDGE

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Background

Globally, organic aquaculture is still largely embryonic. However, trend data from a number of larger seafood markets points towards strong growth in demand for organic seafood.

The paper will explore current global food trends and in particular changing consumer demands for foods that are free of residues and low in environmental impact. Chief amongst these trends is the fast growing organics market and increasing consumer concerns regarding fish grown in intensive conditions.

Issues to be covered

The cost effectiveness of moving towards organic aquaculture solutions will increasingly provide the Australasian industry with competitive pricing and wider market acceptance.

The over-reliance on expensive nutrition solutions has already reduced the capacity of many aquaculture businesses to trade profitably. The need for a more integrated system approach will provide the industry with the extra advantage it will need to meet growth projections.

Organic certification and regulation is currently dominated by the agri-business sector. The aquaculture sector must develop appropriate controls to match worldwide consumer demand for organic products.

Farm methodologies for organic farming will require changes to feed constitution and regimes whilst stocking densities, fish welfare and environmental monitoring to a great extent will need to be over and above existing standards.

Simplicity, sustainability and greater efficiencies are key outputs for a 'sea-change' in aquaculture principles and raising levels of organic aquaculture standardisation. The move towards organic solutions will require leadership and practical demonstration of the benefits.

The new Omega operations in New South Wales are an early example of this sea-change.

AN OVERVIEW OF THE KIMBERLEY AQUACULTURE ABORIGINAL CORPORATION

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The Kimberley Aquaculture Aboriginal Corporation (KAAC) is the peak representative body for indigenous aquaculture in the Kimberley. KAAC was formed in 1995 with membership open to Indigenous people (16 years old and over), who permanently reside in the Kimberley. The steering committee consists of ten elected members.

KAAC applied for funding from federal and state departments to construct a Multi Species Hatchery. In 1998/99 KAAC received \$2.2 million to build the hatchery plus an additional \$1.0 million to do a three-year trochus shell re-seeding project involving 19 communities across the Kimberley. Further funding was received to employ a Community Aquaculture Project Officer to assist communities and individuals who are interested in developing an aquaculture project. Aside from the Project Officer, KAAC now employs six full time staff and five trainees, it is an active member on various committees, and produces a quarterly newsletter.

Today, KAAC is the proud owner of "Manbana", a Multi Species Hatchery and world class discovery centre designed to give visitors an insight in to the relationship Indigenous people have with the seas and waterways of the Kimberley. As well as this, KAAC is the commissioned organisation for the following projects: ACIAR funded trochus shell re-seeding project involving Australia, Vanuatu and Samoa; the Kimberley Sustainable Regions Programme, "Commercialisation of Black Tiger Prawn Farming in the Kimberley" project and; development of the "Indigenous Aquaculture Pack."

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A REVIEW OF GENETIC IMPROVEMENT OF WHITE SHRIMP Litopenaeus vannamei

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In the past 25 years, a combination of improved culture technologies, and increases in farming area have produced dramatic worldwide increases in the volume of farmed shrimp. Culture systems are approaching maximum carrying capacities, and the rapid global expansion of new farming areas is likely to decelerate. With the focus now on profitability through sustainability, advances in genetic improvement are expected to provide the major impetus for future increases in productivity. Important advances have been accomplished in genetic improvement strategies for *L. vannamei* since the inception of the first breeding and selection programs developed in the early 1980's. Rudimentary efforts to enhance growth and disease resistance using mass or individual selection have led the way for more advanced techniques that rely on family based selection, marker assisted selection, and quantitative molecular genetic selection. Significant gains in resistance to specific pathogens (SPR) have been attained in relatively short periods of time (Figure 1).

An industry consensus does not yet exist on which genetic improvement strategies offer the greatest potential for gains in productivity. Some producers continue to select pond survivors, which may produce measurable gains in disease resistance, but may also encourage the spread of disease via pathogen-infected broodstock. Others contend that marker assisted selection (MAS) may offer greater potential for fast gains than traditional

family based selection methods, yet successful breeding programs for shrimp based on MAS are not yet a commercial reality. Enhanced growth and disease resistance are generally the selection traits of preference in most genetic improvement programs, however, there is also interest in selecting for low salinity and temperature tolerance, reproductive performance, and commercial attributes such as meat texture and head:tail ratio. The debate also continues on the relative merits of SPF vs. SPR strategies, although conventional wisdom suggests that SPF stocks possessing disease resistant characteristics represent the ideal combination for most culture environments. This paper will review these issues as they pertain to progress in the genetic improvement of white shrimp (*L. vannamei*).



Figure 1. Progress in selecting for resistance to Belize TSV using family selection.

HISTOPATHOLOGY OF THE INTESTINE OF LARVAL STRIPED TRUMPETER Latris lineata CULTURED IN TASMANIA

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Striped trumpeter *Latris lineata* is being investigated in Tasmania for its aquaculture potential. Survival of striped trumpeter larvae can often be low and the time of mortality variable between batches. Changes in the intestine of larvae have been identified in some batches undergoing mortality events. Pathology has included severe decay of the posterior intestine, grossly associated with a loss of convolutions in the gut lining, swelling of the anterior region of the mid gut and degeneration of the hindgut to the extent that the passage of material through the gut was blocked. Histological examination of larvae identified bacterial enteritis characterised by sloughing of gut epithelial cells associated with bacteria.

A different intestinal disorder, suggestive of bacterial infection, was identified in trials examining larval nutrition. This was grossly identified as a grey section in the mid gut of the larvae (Fig 1a) referred to as "greygut syndrome". The appearance of grey-gut syndrome was often associated with larval mortality events. Experiments were conducted to examine the effect of antibiotics on grey-gut and larval performance. Larvae were stocked into a replicated system of 24 x 300L tanks and fed rotifers (5mL-1) twice daily from 5 days posthatching (dph). Oxytetracycline (OTC) was added at 25 ppm daily to half of the tanks. Grey-gut syndrome was not observed in OTC treated larvae, but was seen in untreated larvae. Both larval growth and survival were significantly higher in treatments receiving OTC than in tanks without antibiotic. Histologically, grey-gut was associated with highly vacuolated enterocytes in the mid gut (Fig 1b,d) compared to enterocytes in larvae without grey-gut (Fig 1c,e).



FIGURE 1. Photomicrographs of the intestine of larval striped trumpeter (18dph) demonstrating the gross appearance of grey-gut syndrome (a), a section through the mid gut of a larva with (b) and without (c) grey gut and differences in enterocyte vacuolation in larvae with (d) and without (e) grey gut syndrome. Scale bars a, 1mm; b & c, 100_m; d & e 40_m.

It remains to be demonstrated whether this histopathology results from a single cause or is the result of an interaction between the bacterial flora of the gut and the digestive function of the intestine.

EMERGING OPPORTUNITIES FOR PRAWN AQUACULTURE USING SALINE GROUNDWATER

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In Australia land clearing and irrigation have contributed to raised groundwater levels and soil salinity in many regions. To remain productive on salt affected land many farmers have invested in a range of management strategies including the development of salt-tolerant farming practices and crops. Aquaculture is one industry that can potentially utilize saline groundwater for profit in an environmentally responsible manner. In Queensland, the best candidate for inland saline aquaculture is the black tiger prawn, *Penaeus monodon*. The tolerance of this species to a range of salinities, an established coastal prawn farming industry in the states and global examples of successful inland prawn farming are reasons for this favorable status. In Queensland the irrigation industry uses almost 65% of the states water. Of this, almost half is groundwater. Salt levels in groundwater are relatively high with a third of the states irrigation bores yielding water in excess of 1.8ppt. Unfortunately this water is usually deficient in potassium (K⁺), an ion that is tightly regulated in the hemolymph of prawns. An absolute lack of K⁺ in groundwater will result in acute and significant mortality. Potassium levels can be readily addressed through the addition of potash (KCL). At lower salinities (1-2ppt) these treatments are relatively cheap, provide immediate survival and growth benefits and are simple to administer. If acclimated properly, in water with favorable salinities and chemistry, the survival and growth of black tiger prawns in groundwater is equal to animals raised in seawater. The results of trials using water from several regions will be presented. The implications of this work for future research, industry growth and policy development, including environmental management, will also be discussed.

CHALLENGES IN ESTABLISHING INTENSIVE R.A.S TO MEET THE NEEDS OF INDUSTRY AND RESEARCH AT DEAKIN UNIVERSITY

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In Oct 2002 Deakin University won a \$2.02 million dollar competitive grant from the Victorian State Government under the Science and Technical Infrastructure program to advance endeavors in Recirculating Aquaculture Systems (RAS) and to increase capacity for training and education in the field. This was to be achieved by developing partnerships with the existing farming industry government instrumentalities and other research organizations. The initial target species being Murray Cod, *Maccullochella pelii pelii*, Mitchell.

The grant has provided infrastructure assistance to a local farm operation in the form of a 20 ton RAS fit out and on campus 3 * 6 ton units, a hatchery nursery and a 20 ton unit, all under the one roof. It has initially employed three extra staff, two PhD's and an Honours program. The thrust of the initial research effort is aimed at shedding light on, out of season breeding, species specific diets and system comparison for growth, focusing on Murray Cod.

This paper will discuss the structure and aims of the venture, the challenges in designing the system to meet industry and research needs, achievements so far and projections post the grant period.



Fig 1. Warrnambool Trout Farm

Fig 2. Deakin University facility

NUTRITIONAL COMPOSITION OF FLOCCULATED MATERIAL IN EXPERIMENTAL ZERO-EXCHANGE SYSTEM FOR Penaeus monodon

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The use of a zero water exchange system in shrimp production significantly reduces the releasing of effluents and sediments to the environment. Therefore, nutrients could be recycled by the pond biota instead of being flushed. In this system, the characteristic autotrophic phytoplankton community is shifted by a more stable heterotrophic community of bacteria. The development of flocs composed by microorganisms and inorganic particles add surface area to the pond increasing assimilation of dissolved organics and recycling of inorganic nutrients. Further the flocs can be consumed directly by shrimps contributing to the recycle of nutrients into shrimp biomass. The present study analyses the nutritional composition of flocculated material in a experimental zero-exchange system for *Penaeus monodon*.

Three 2000 L outdoor fibre glass tanks stocked with 425 PLs/m² (tank 1) and 64 PLs/m² (tanks 2 and 3) were used Shrimp were fed with pelleted feed (41% protein) 3 times per day. Floc development were promoted by routine addition of organic materials as carbon sources (tapioca starch and sago). Artificial food and shrimp excretion products also contribute as nitrogen sources Water was continually mixed and aerated. Samples were collect weekly by filtering known volumes of water through a 90 Im nylon mesh. Samples were dried and analysed for crude protein, total lipids and ash.

Percentage of crude protein and total lipids tended to increase with time reducing the ash values. Crude protein ranged from 17 to 42 % (Fig. 1a), total lipids from 2 to 8 % (Fig. 1b) and ash from 22 to 46 % (Fig. 1c). These results suggested that the flocculated material has potential to contribute to the shrimp nutrition. Additionally, shrimp were observed feeding on flocs during the experiment. However, further studies are necessary to evaluate if *P. monodon* are able to retain the nutrients from this flocculated material.



Figure 1. (a) Percentage of crude protein (%CP); (b) percentage of total lipids (%TL) and (c) percentage of ash in the flocculated material on shrimp tanks (1, 2, 3) during sampling period.

DEVELOPMENT OF A TANK SYSTEM TO INVESTIGATE THE HIGH DENSITY CULTURE OF Penaeus monodon AND P. merguiensis USING REDUCED PROTEIN FEEDS AND CARBON ADDITION PROTOCOLS

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The essential characteristics of the highly intensive, zero exchange shrimp culture system originally pioneered at industrial scale in Belize, are now widely known in the global shrimp farming community. This system, or some derivative, is now becoming adopted in other parts of the world. In this system a heterotrophic bacterial community is promoted by management practices such as the addition of grain-based feed and sugar products. Under appropriate conditions the bacteria and other microorganisms accumulate in larger particles (flocs) that are ingested by shrimp. The bacterial growth helps limit toxic ammonia levels in the pond water.

Responding to pressures from environmental regulators, and decreasing profit margins due to price competition from imported cultured shrimp, Australian shrimp farmers are strongly motivated to evaluate new shrimp farming technologies that have potential to address these problems. Compared to traditional intensive culture, the Belize shrimp farming system offers substantial environmental benefits through reduced water usage, better nitrogen conversion, and a waste stream that is well-suited to simple and effective nutrient-removal strategies. In addition this system has the potential to be more profitable due to the increased production per hectare and better protein conversion.

To introduce this system to Australia will require a detailed understanding of the way Australian shrimp species perform under these very different culture conditions. To enable such investigations a replicated tank system has been developed. For space and economic reasons fibreglass tanks of approximately 2500 Litre capacity were chosen. A major design consideration was that the water body within the tanks needed to be continuously circulated, to keep the flocs in suspension. The circulation needed to be strong enough to keep floc particles in suspension, but not so vigorous that it would break up the flocs. Furthermore the circulation had to be such that dead spots did not develop where the flocs could settle out and become anaerobic. A further consideration was that the circulation system should not interfere with the feeding or other behaviours of the shrimp in the tanks. A novel system driven by low pressure air, which achieves the desired water circulation and also contributes to the aeration of the tanks, has been developed. External heat exchangers will be used on each tank, and along with the positioning of the tanks in a hothouse, this will allow experiments to be conducted throughout the year. The system which has been developed will be described, and some preliminary results will be presented and studies planned for the future will be discussed.

FINAL OOCYTE MATURATION IN WILD AND DOMESTICATED Penaeus monodon BROODSTOCK

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The reproductive performance of penaeid prawns is affected by broodstock source. For many penaeid species is often assumed that wild prawns provide superior performance in terms of fecundity, egg quality and larval survival. Histological analysis has been used to evaluate the ovarian condition and quality of broodstock from different sources. The present study compares the ovarian histology of mature ovaries from wild and domesticated *Penaeus monodon* broodstock.

Wild-caught broodstock (100g) from the east coast of Australia and two lines (DL1 and DL2) of 12-monthold domesticated prawns (80-100g) were compared in a reproductive trial conducted as per standard protocols in tanks at CSIRO Marine Research. Histological analysis of mature ovaries was performed using readyto-spawn (stage 5) females from each treatment after eyestalk-ablation. After dissection of the ovary, gonadosomatic index (GSI) was calculated as a percentage of the ovarian weight relative to the body weight. Middle portions of the gonadal tissue were removed for histology. Digitized images from each ovary section were used to record the frequency and diameter of different oocyte types.

Final maturation stage was attained in all groups, as indicated by the GSI values and the presence of mature oocytes with cortical rods (CO) in the ovaries However, domesticated females presented some significant differences (P<0.05) compared to wild ones, such as, larger immature oocyte types (primary and yolky oocytes), smaller CO and higher frequency of atretic oocytes under reabsorption (Table 1; Fig. 1) These results suggested that final ovarian maturation was less advanced in domesticated *P. monodon*, which could affect their capability to produce reliable supplies of healthy seedstock for commercial culture.

Table 1. Means (\pm SD) of gonadosomatic index (GSI %) and diameter (μ m) of primary oocytes (PO), yolky oocytes (YO) and cortical oocytes (CO) for wild (W) and domesticated (DL1 and DL2) *P. monodon* broodstock. Sample size is between parenthesis. Different letters within rows indicate significant differences (ANOVA, P<0.05).

	W (6)	DL1 (8)	DL2 (4)
PO	43.3 ± 19.2 ^b	47.5 ± 20.7 ^a	50.6 ± 19.3 ª
YO	176.2 ± 26.5 °	193.1 ± 25.7 ª	184.5 ± 23.8 ^b
CO	242.1 ± 28.1 ^a	232.1 ± 30.1 ^b	231.6 ± 32.8 ^b
GSI	5.83 ± 0.83	6.54 ± 1.05	6.86 ± 0.86
100 90]		iii Wild



Figure 1. Percentage (mean + SE) of primary oocytes (PO), yolky oocytes (YO), cortical oocytes (CO) and atretic oocytes (AO) in the images captured from wild and domesticated (L1 and L2) *P. monodon* broodstock. Different letters within oocyte types indicate significant differences (ANOVA, P<0.05).

EFFECT OF GENOTYPE AND THE ENVIRONMENT ON THE SURVIVAL AND GROWTH OF THE KURUMA SHRIMP *Penaeus japonicus*

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With the continued development of selective breeding programs in shrimp farming, there is an increasing need to improve our knowledge of factors affecting the efficiency of genetic selection. Variations in the performance of different genotypes when reared across different environmental conditions can result in genotype x environment (GxE) interaction. GxE interaction occurs when a change in the environment does not have the same effect on all genotypes, and can affect the efficiency of genetic selection if stocks produced from breeding programs are to supply a range of farming environments.

In this paper we summarize results from both controlled laboratory and on-farm experiments examining survival and growth of different *Penaeus japonicus* families reared across different environments. Interactions between family and environment (GxE interactions) were quantified to determine whether the family performance was consistent across different rearing environments in three laboratory experiments. In these experiments, growth and survival of juveniles from six families were examined across a range of constant temperatures (experiment 1; 24°C, 27°C, 30°C; experiment 2; 27.5°C, 29.2°C, 31.2°C) and densities (experiment 3; 48 and 144 shrimp m⁻²). Additionally, an experiment conducted on a commercial farm assessed the growth of males and females from 30 families reared in four commercial ponds. Variations in growth of the families across the different ponds were determined by correlating the family ranking between the ponds.

In the laboratory experiments, a significant interaction between family and temperature was found for survival and growth of the *P. japonicus* families when reared over a wider temperature range (24° C to 30° C experiment 1) indicating variations in the response of the families at the different temperatures. This effect was more pronounced for survival than for growth. However, no interaction was found for either survival or growth of the families when reared over a narrower temperature range (27.5° C to 31.2° C experiment 2). A small interaction between family and density was also found for growth of different *P. japonicus* families when reared at the two densities, but not for survival (experiment 3). In the on-farm experiment, correlations in the family rankings were not consistent between ponds, indicating that the relative growth of the families was similar between some ponds, but not between other ponds.

Results of both laboratory and on-farm experiments identified a small degree of variation in the relative performance of the *P. japonicus* families when reared in the different test environments. Implications of these results for development of shrimp breeding programs will be discussed.

IMPROVING THE REPRODUCTIVE PERFORMANCE OF DOMESTICATED Penaeus monodon

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The giant tiger prawn *Penaeus monodon* has been the predominant farmed prawn in the Eastern hemisphere for several decades. The reasons for the dominance of this species include the rapid growth and large final size of *P. monodon* compared to other farmed prawns. However, the capacity to maintain sustainable production of farmed *P. monodon* in the future is constrained by the current dependency of the industry on wild broodstock, which can be of variable quantity and quality and are a known source of several viral pathogens. Furthermore, dependency on wild stocks precludes genetic selection for desirable traits such as rapid maturation, growth rates and disease resistance.

In Australia, a research consortium comprising the Australian Prawn Farmers Association, three research agencies and three commercial farms was formed in 2002 to address the issue "Understanding and removing the barriers to *P. monodom* domestication". One objective of this study was to determine the optimal rearing conditions for the production of healthy broodstock with high reproductive performance. In this paper we present the assessment of the growth and reproductive output of 1st generation domesticated *P. monodon* broodstock reared in two production environments, raceways and tanks. These two production environments were chosen in preference to ponds as they allow greater control over the rearing conditions and are more amenable to biosecurity broodstock production.

P. monodon broodstock from two sibling families were grown successfully in raceways and tanks, with females reaching a mean size of 118 g over a 12 month period. Reproductive performance of the broodstock was assessed for two moult period after ablation in a standardised assessment. A higher percentage of the tank-reared females (57%) spawned than the raceway-reared females (39%). Averaged for all ablated females, tank-reared females spawned an average of 1.2 times and raceway females 0.8 times over the two moult periods. Tank-reared females produced a mean of 145 000 (\pm 17 000) eggs per spawning and raceway females 100 000 (\pm 16 000) eggs per spawning. Including all spawnings (hatching and non-hatching), mean hatch rates per spawnings were 22.5% (\pm 4.3%) from tank-reared and 18.2% (\pm 4.9%) from raceway females. Large differences in the growth and reproductive performance of the two families were found.

Our results indicate that *P. monodon* broodstock can be successfully domesticated in tanks and raceways. Improving hatch rates of spawnings from the domesticated stocks has been identified as a research priority. Future experiments focussed on improving hatch rates from domesticated stocks, and the current status of the 2^{nd} generation stocks, will be discussed.

POLYMORPHISMS WITHIN MHC GENES ASSOCIATED WITH RESISTANCE AND SUSCEPTABILITY TO AMOEBIC GILL DISEASE (AGD) IN ATLANTIC SALMON Salmo salar

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Amoebic gill disease (AGD) of sea-caged Atlantic salmon, and to a lesser extent ocean trout, is considered the main health problem affecting salmonid culture in Tasmania. Currently AGD treatment and related lost productivity are responsible for significant financial losses to the industry Prophylaxis, through selection of resistant individuals, offers a novel and environmentally sustainable approach to combat AGD. This theory is based on anecdotal reports suggesting that variation in AGD resistance exists within the Tasmanian Atlantic salmon population. AGD resistance may have a genetic basis and therefore could be commercially exploited with a future selective breeding program. However to maximise the efficacy of a selective breeding program for AGD resistance, molecular makers associated with resistance must be identified. Considering their important role in the immune system, namely antigen presentation, genes of the major histocompatibility complex (MHC) were considered possible candidates for the development of an AGD resistance marker.

Polymorphisms within four exons encoding the peptide-binding clefts of the MHC class I and class II molecules were compared between individuals within known levels of AGD resistance and susceptibility. To segregate resistant and susceptible individuals, 107 Atlantic salmon were challenged with experimental AGD. Genomic DNA was extracted and the four MHC domains amplified using specific primers and the polymerase chain reaction (PCR). Restriction fragment length polymorphism (RFLP) using a range of enzymes was performed on each PCR product for each MHC domain. The restriction digest was electrophoresed and RFLPs visualised on 8% non-denaturing polyacryimide gels. The frequencies of RFLP variants for each gene were compared between individuals resistant and susceptible to AGD.

Of the four exons examined only one, MHC class II,, showed any variation in RFLP haplotype frequencies between resistant and susceptible fish. Indeed, two different class II, RFLPs were significantly more frequent in individuals resistant and susceptible to AGD respectively. It is postulated that polymorphisms within the resistant individuals may be causing more efficient presentation of *Neoparamobea* antigens and therefore stimulating an immune response against AGD possibly improving resistance. Conversely polymorphism within susceptible individuals perhaps decreased antigen binding and presentation efficacy and thus a less effective immune response was developed. Results of the present study suggest AGD resistance may be genetically influenced and a molecular marker, perhaps within the MHC locus can be developed to assist in a selective breeding program.

DEVELOPMENT OF A VACCINE FOR AMOEBIC GILL DISEASE (AGD) IN ATLANTIC SALMON Salmo salar: A DNA APPROACH

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Amoebic gill disease (AGD) caused by the amoebae, *Neoparamoeba pemaquidensis*, is currently considered to be the most significant health problem for farmed Atlantic salmon in Tasmania, costing the industry an estimated 10% of the gross value of production. Current efforts for control are centred on bathing treatments of the fish. However, this is both costly and not sustainable in the long term. Logically a vaccine against AGD would be a valuable tool to aid in controlling the disease. However, previous attempts to inoculate fish with attenuated *N. pemaquidensis* have failed to result in any significant protection. This immunisation with crude, whole parasite preparations was ineffective despite the production of antibodies in the serum of treated fish.

Despite the lack of protection gained by whole cell immunization it has been shown that when grown in culture N. *pemaquidensis* loses virulence. This suggests that during an active infection the 'wild type' amoeba express a set of virulence factors that are not produced during replication in the lab. This is a common phenomenon in pathogens and these *in vivo* expressed virulence factors have proven to be important vaccine antigens in other veterinary pathogens. Therefore to ascertain the possible identity of these virulence factors we have utilized a suppressive subtractive DNA approach to produce a library enriched for genes expressed at a higher level or only in wild type 'infective' amoeba and have performed limited sequencing analysis of clones obtained from the library. Furthermore, in order to perform an expression library immunisation (ELI) regime we have created a full length cDNA library which has been cloned into the delivery vector, pCI- β -actin-Cat which contains the Atlantic salmon β -actin promoter.

Of the clones sequenced so far, 25% share significant homology with possible cell surface/antigens, 13% with enzymes, 2% with proteins involved in cell division and 35% with hypothetical or unnamed proteins. Approximately 15% of the clones share homology with known housekeeping proteins and about 10% are either undescribed or share no homology with any known proteins. Future work involves more extended bioinformatic analysis of the subtractive library and the use of 3' and 5' RACE to obtain full length clones of 'interesting' ESTs. We will also commence the ELI using sub-fractions of the full length library to determine which of the cDNA clones may provide protection against AGD.

DEVELOPMENT OF A REAL-TIME PCR ASSAY FOR THE PATHOGEN Bonamia

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Australian flat oysters (Ostrea angasi) are known to harbour Bonamia sp., a pathogenic protistan causing bonamiosis. Bonamia sp. has caused mortalities in Ostrea angasi in NSW, Victoria, Tasmania and Western Australia. In order to avoid spread of the pathogen, to protect the Australian oyster industry, better surveillance of infected stocks is required. Furthermore, Australia has limited diagnostic capability for the exotic species Bonamia ostreae and Bonamia exitiosa that are listed by the Office Internationales des Epizooties (O.I.E.). Such limited diagnostic capability and in the uncertainty about the identity of the species of Bonamia encountered in Australia have the potential to impede overseas market access for product that could harbour these pathogens.

This project aimed at developing molecular-based diagnostic assays that allow rapid, reliable and sensitive detection of *Bonamia* spp. A real-time PCR assay capable of detecting *Bonamia* isolates from Australia, New Zealand, and Europe was developed. In addition, conventional PCR, Restriction Fragment Length Polymorphism and sequencing allowed differentiation of the different isolates. It is anticipated that, with the development of these diagnostic tools, improved surveillance will be achieved providing better management of oyster stocks and leading to identification of disease-free stocks with potential for export.

RNA INTERFERENCE AND FISH

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A gene-specific silencing mechanism, mediated by small double-stranded RNA molecules, referred to as RNA interference (RNAi), has recently been described in a number of plant and animal species (Fire *et al.*, 1998; Hannon, 2002). It is believed that RNAi has an essential role in cells by mediating responses to exogenous RNAs, such as viruses, and in stabilising the genome by sequestering repetitive sequences such as transposons (Hannon, 2002). Considerable interest is focusing on the putative therapeutic applications of small interfering RNA molecules (siRNAs), particularly for fighting viral infections (Andino, 2003). Several studies have shown that specific siRNAs can selectively suppress the replication of infectious viruses including hepatitis B virus (McCaffrey *et al.*, 2003), human immunodeficiency virus type 1 (Capodici *et al.*, 2002) and dengue-2 virus (Adelman *et al.*, 2002).

A recent study by Boonanuntanasarn *et al.* (2003) showed that siRNAs can specifically and efficiently suppress the expression of transgenes as well as endogenous genes in rainbow trout embryos. It is hoped that RNAi technology will facilitate the development of new nucleic acid therapies for viral diseases by enabling specific viral gene knockdown in commercially valuable fish species.

EFFECT OF DIFFERENT DIETARY PROTEIN/LIPID LEVELS ON OXIDATIVE STRESS OF JUVENILE REDCLAW CRAYFISH Cherax quadricarinatus

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The experiment was conducted to investigate the effect of dietary protein/lipid levels on basal oxidative stress indicators in juvenile redclaw crayfish *Cherax quadricarinatus*, having an average initial weight of 0.71 ± 0.13 g Nine practical test diets were formulated to contain a combination of three crude protein (26, 31 and 36%) and three crude lipid levels (4, 8 and 12%). Crayfish were fed for 60 days to quadruplicate groups, stocked in 36 tanks (401 freshwater, $28 \pm 0.29^{\circ}$ C).

Differences were found in superoxide radical (O_2^-) production and lipid peroxidation (TBARS) levels among tissues, even in those crayfish fed the control diet. There was no effect of dietary protein or lipid levels on O_2^- production in crayfish digestive gland, muscle and gills. However, dietary protein levels significantly affected TBARS levels in crayfish gills (P<0.05). The results suggest tissue-specific effects of dietary protein and lipid levels on oxidative stress indicators in *C*. *quadricarinatus*.

EFFECT OF FEEDING FREQUENCY ON GROWTH OF JUVENILE REDCLAW CRAYFISH Cherax quadricarinatus (VON MARTENS)

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The effect of feeding frequency on the growth and survival of juvenile redclaw crayfish *Cherax quadricarinatus* with initial mean weight of 0.89 ± 0.06 g was evaluated in a 60-day study. Juveniles were fed with four different feeding frequencies: every 24 h (C1), 12 h (C2), 6 h (C3) and 4 h (C4), with a 35% crude protein diet. Specific Growth Rates (SGR) of 3.02 and 2.80%/day showed that feeding frequency treatments C3 and C4 maximize growth of juvenile redclaw, reaching final mean weights of 4.7 and 5.4 g, biomasses of 253.2 and 311.8/m², and Feed Conversion Ratios (FCR's) of 1.8 and 1.2, respectively. Treatments, C1 and C2 showed significantly higher FCR's.

Survival ranged from 86.7 to 98.3%, and was different statistically among the experimental treatments, except for organisms fed with C1 and C2. Final weights of juvenile redclaw showed that a feeding frequency of at least three times a day (C3) was significantly better. However, in terms of biomass, treatment C4 was better.



Figure 1: Effect of feeding frequency on weight gain of juvenile *C. quadricarinatus.*

Feeding	Final	Biomass	SGR	Survival	ECD
frequency	weight (g)	(g/m)	(%/dav)	(%)	FUR
C1	3.57±1.1 ^b	176.91±10.9 °	2.31 ± 0.04 b	86.7 ± 0.05 b	$32 + 0.04^{d}$
C2	3.84±1.1⁵	190.80±11.2 °	2.44 ± 0.06 ^b	86.7 ± 0.07 ^b	2 1 + 0 15 °
C3	4.74±0.7ª	253.20±12.2 ^b	2.80 ± 0.07 ª	93.3 ± 0.05^{ab}	1.8 ± 0.18^{b}
C4	5.45±1.0 ^ª	311.80±14.8 ª	3.02 ± 0.11 ª	98.3 ± 0.03^{a}	$1.2 \pm 0.10^{\circ}$
THE DETECTION OF INFECTIOUS HYPODERMAL AND HAEMATOPOIETIC NECROSIS VIRUS (IHHNV) IN AUSTRALIAN *Penaeus monodon* AND ITS POTENTIAL EVOLUTIONARY ORIGIN

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Infectious hypodermal and haematopoietic necrosis virus (IHHNV) is a shrimp parvovirus that can cause acute disease and mass mortalities in *Penaeus stylirostris*. In *P. vannamei*, the virus typically causes a chronic 'runt deformity syndrome' disease characterised by growth retardation and by rostrum and other curricular deformities. IHHNV is widely distributed in prawn species in the Pacific coast of the Americas and in the Indo Pacific and Asia region but remains listed by the OIE as exotic to Australia. However, the occurrence of ~20 nm dia. parvovirus-like particles, which were associated with characteristic IHHNV histopathological lesions but were not reactive to an IHHNV DNA probe, was reported in 1992 in experimental hybrids of *P. monodon* and *P. esculentus*.

Recently, virus screening of the progeny of *P. monodon* collected from Weipa in the Gulf of Carpentaria (GoC) using a TaqManTM-probe based real-time PCR test detected IHHNV DNA in the gills of 8 out of 10 prawns sampled. The real-time PCR primers were designed to sequences conserved among known isolates from East Africa, Madagascar, Thailand and the Americas and agarose gel analysis confirmed the amplification of a PCR product (104 bp) of the expected length. However, all 10 samples were tested PCR negative using primers (ie. 77012F and 77353R) recommended by OIE for the diagnosis of IHHNV (OIE Manual of Diagnostic Tests for Aquatic Animals 199x) and designed from sequence information on an isolate from the Americas. To validate the real-time PCR results, new PCR primers were designed to the same IHHNV genome region that avoided sequence changes among the different isolates predicted to critically affect the performance of the OIE PCR with some isolates. PCR using the revised primers confirmed the presence of IHHNV in 7 out of the 10 *P. monodon* gill DNA samples. Sequencing of the PCR amplicons generated in the 2 tests showed the IHHNV isolate in the GoC *P. monodon* to be most closely related genetically to the isolate from Madagascar (98.9% nucleotide identity) and most distantly from isolates from the Americas/Hawaii (86.0/86.2 % identity) and Thailand (84.6 % identity).

Subsequently, the real-time PCR primers were used in a conventional PCR format to assess the prevalence of IHHNV in 49 wild (G0) and progeny (G1) *P. monodon* from GoC and in 41 commercial *P. monodon* broodstock sourced from the region between Innisfail and Cairns between 2000 and 2003. The PCR detected IHHNV at high prevalence in prawns originating from GoC (80-100%) and northeast Queensland (60-100%), and in the latter location little variation occurred over the past 4 years. Sequence comparisons detected 100% identity between IHHNV isolates present in the GoC and east coast prawns. The close genetic relationship between IHHNV isolates infecting *P. monodon* from Australia, Madagascar and East Africa suggests that the virus, and possibly their prawn host, have evolved from a common genetic linage. As the IHHNV genotypes detected in *P. monodon*, the mechanism by which the virus is perpetuated and accommodated as an unapparent infection is of some interest. Moreover, from our sequence data we hypothesise that the Australian IHHNV genotype may have co-evolved with ancestral *P. monodon* that existed on the Gondwanaland super-continent and that co-segregated with Africa, Madagascar, India and Australia.

LIGHT INTENSITY INFLUENCES MORPHOLOGICAL DEVELOPMENT OF PRE-FEEDING GROUPER LARVAE

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With increasing interest in grouper species for aquaculture production, low and inconsistent survival during the early larval rearing phase continues to present the major bottleneck. At the QDPI Northern Fisheries Centre, Cairns, research is focussed on the larval rearing of two grouper species, the flowery cod *Epinephelus fuscoguttatus* and the estuary cod *Epinephelus coioides*. Spawning of estuary cod held under a simulated photo-thermal regime has produced a consistent supply of larvae over the past 12 months. However larval survival has been consistently poor. The timing of mortalities, at the pre- and first feeding larval stages, suggests that early survival is likely to be influenced by factors other than feeding. This study examined the effect of light intensity on survival, growth and utilisation of endogenous nutritional reserves.

Estuary cod larvae were obtained from three larval cohorts. Three light intensities were randomly assigned to thirty static, experimental chambers with illumination provided by two fluorescent lights suspended above the chambers. Blackout cloth and shade-cloth were used to achieve light intensities of 0 (dark); 1 - 1.5 (low); and 12 - 17 (high) µmol. s⁻¹.m⁻². Larvae were left undisturbed until the morning of Day 3 when the numbers of live and dead larvae were counted and live larvae were preserved for measuring. Standard length, body depth and oil globule volume were measured using a microscope and ocular micrometer.

Whilst survival did not differ significantly, the results indicate that light intensity does influence growth of pre-feeding larvae (Fig. 1). This experiment also identified significant cohort variation, which has implications for experimental outcomes based on single rather than multiple cohorts.



Figure 1. Standard length of estuary cod (*Epinephelus coioides*) larvae from three cohorts held under dark, low, and high light intensities from D1 to D3 post hatching. Means within each experiment sharing a common superscript are not significantly different.

FUTURE DIRECTIONS FOR THE FISHERIES RESEARCH AND DEVELOPMENT CORPORATION'S AQUATIC ANIMAL HEALTH SUBPROGRAM

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The FRDC Aquatic Animal Health Subprogram was established in 2001 and over the past three years has managed over forty projects covered by three programs, supported through the Federal Government's Budget Initiative *Building a National Approach to Animal and Plant Health*:

- Diagnostics Program
- Manuals and Planning Program
- Training Program

As part of its operation, the subprogram undertakes an annual review of its strategic plan and invites comments from major stakeholders. Stakeholder comments have shown that a key strength of the AAH Subprogram is its strategic focus and the establishment of a network of aquatic animal health experts and research providers. The scientific output directed at aquatic animal health, from the 40+ Subprogram projects over the Subprogram's existence, is unprecedented in Australia. Coordination of the R&D program by a steering committee comprising of industry and government representatives and guided by good scientific advice has advanced significantly Australia's capability in the management of aquatic animal disease outbreaks. Further, the AAH Subprogram has provided an industry-based structure through which to develop and maintain strategic direction for investment in aquatic animal health R&D.

The Subprogram strategic R&D plan lists key research areas as:

- Nature of disease and host-pathogen interaction
- · Aquatic animal health management
- Endemic and exotic aquatic animal disease diagnostics
- Surveillance and monitoring
- · Best practice/national and international quality assurance
- Training and capacity building

As in the past, the success of the subprogram will rely on continued support from governments and industries and, to achieve its goals, the subprogram will depend on the development and implementation of projects involving cooperation and collaboration among researchers in the growing network of aquatic animal health specialists within Australia.

THE EFFECT OF VARIOUS CO-FEEDING AND WEANING REGIMES ON GROWTH AND SURVIVAL IN BARRAMUNDI Lates calcarifer LARVAE

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Larval nutrition is a key element in the successful culture of marine fish. Live feed such as rotifers and *Artemia* are considered obligatory for successful culture. However, viable alternatives are needed due to high costs, increased risk, unreliability and variability in nutritional value of the live feed organisms. In order to reduce live feed requirements, it is of major benefit to wean larvae onto formulated diets as early as possible. In the past, early weaning has led to reduced growth and inferior quality larvae with an increased risk of skeletal deformities. Factors such as the type and nutritional quality of live and dry feeds, timing of first introduction of microdiets (MD), and the duration and method of weaning can all affect larval performance.

'Co-feeding' weaning protocols (MD and live feeds) have been developed to allow a fast and efficient change over period onto MD, which achieve better growth and survival than feeding either live feeds or MD's on their own. It has been shown that early co-feeding of acceptable MD can improve larval nutrition and condition them to accept MD more readily. The standard weaning protocol for barramundi larvae usually starts when the larvae reach an average total length of 12-16mm following first feeding of rotifers and then *Artemia* nauplii and continues for 10-15 days. However, it may be possible to cofeed larvae on rotifers and a larvae specific MD from initial exogenous feeding, without loss of growth or survival, which could minimize or eliminate the use of *Artemia*. Commercial hatcheries usually develop 'in house' protocols that are rarely tested within statistically rigorous experimental designs. This study evaluates current and available formulations for commercial marine finfish hatcheries within a statistically rigorous framework in order to develop MD specific weaning procedures.

Two commercial weaning MD's were compared for barramundi (*Lates calcarifer*) using larval growth and survival data for three weaning protocols. At mouth opening rotifers were used as an initial live feed for larvae in all treatments. Then at 13 days post hatch (dph) *Artemia* were introduced to two weaning treatments and continued into a period of co-feeding with MD for 8 days starting on 16 dph or on 20 dph (control). The third weaning treatment used rotifers as sole feed until 13 dph when co-feeding with MD was started.

Types of MD (manufacture) were shown to significantly affect growth survival and rate of cannibalism of barramundi larvae. Each MD performed better using different weaning strategies, but both benefited from the inclusion of *Artemia* nauplii. Barramundi larvae were able to complete metamorphosis successfully with high survival rates when co-fed algaeenriched rotifers and MD. Survival and rates of cannibalism did not differ between weaning protocols within each MD treatment.

MANAGING AND APPRECIATING A CHALLENGING AND COMPETITIVE MARKET

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- The biggest myths:
- The best product will win.... This is not always so!
- I'll be able to sell it because I know it like the back of my hand.. Not so!
- · You need to know the market place.
- Everyone loves it. I'll have no problem selling it Not so!
- · What people tell you and what they actually do often don't match up
- Local / Australian demand.
- Market floor case study (the Hiramasa story).
- Lessons to be learnt.

EVALUATION OF ENRICHED FORMULATED CONDITIONING DIET ON SPAWNING SUCCESS AND OFFSPRING PERFORMANCE OF THE GREENLIP ABALONE *Haliotis laevigata*

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It has been reported that farm-grown female abalone, that were fed with commercial formulated feed, spawn less readily and produce eggs of poorer quality than animals collected from the wild. There is growing evidence that specific dietary lipids play an important role in gonadogenesis of abalone. In an earlier conditioning trial, eggs derived from newly caught wild greenlip abalone broodstock contained about twice as much arachidonic acid (ARA) as eggs spawned from conditioned broodstock feeding on formulated feed. The present study was conducted to determine if low ARA levels affect abalone reproduction. Two levels of ARA enrichment were tested and compared to a formulated diet without the enrichment (negative control) and a diet of red seaweeds (positive control). All animals were spawned out and induced to spawn again after a conditioning period of 16 weeks. Egg size and colour, fatty acid composition of unfertilised eggs, fertilisation and hatch rate, larval survival, settlement success and post-larval survival were determined and compared between batches (1 Female x 1 Male) using replicated groups of abalone.

In total 49% of all females spawned successfully (Table 1). Abalone feeding on red seaweed showed the highest spawning success rate (64%), followed by the high ARA treatment (53%). A total of 83 x 10^6 eggs were spawned from the 71 females with an average batch size of 1.4×10^6 . More eggs were spawned from the females feeding on the high ARA diet.

Fertilisation was highest in batches derived from animals feeding on red seaweed and lowest in batches derived from females feeding on the high ARA diet. Hatch rate was equally good in batches derived from animals feeding on red seaweed and the control diet and lowest in the high ARA treatment. Percentage settlement was highest in the red seaweed treatment. Settlement was lowest in the high ARA treatment. These results indicate that ARA may influence spawning but may not be linked to performance of the offspring. Even though the high

	Total	No. eggs	Average		
	Spawnings	x 10 ⁶	Batch size x 10 ⁶		
Red seaweed	23 (36)	12.18	0.67		
Control	15 (36)	23.09	1.91		
Low ARA	14 (36)	18.43	1.31		
High ARA	19 (36)	29.38	1.69		
Total	71 (144)	83.08	1.40		

TABLE 1: Total number of female spawnings, total number of eggs produced and average batch sizes for the four diet treatments.

ARA treatment showed an improvement in spawning success compared to the control diet, batches derived from females feeding on the red seaweed diet outperformed in offspring performance.

DIGESTIBILITY EVALUATION OF SELECTED COMMERCIAL ANIMAL BY-PRODUCTS FOR APPLICATIONS IN DIETS FOR SEABASS Dicentrachus labrax

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A series of experimental diets were formulated designed to evaluate coefficients of digestibility for major nutrients i.e. protein, energy and lipid with respect to refined animal by-products for prospective inclusion in European sea bass.

Diets were based on a fishmeal reference diet with 30% substitution of standard hydrolysed feather meal, enzyme treated feathermeal (Allzyme[®]), poultry meat meal, and a spray dried haem protein (APC 301[®]) as test ingredients. The complete diet mixtures were balanced with fish oil to maintain similar energy levels and supplemented with equal amounts of vitamins and minerals. All diets contained Chromic Oxide ($Cr_2 O_3$) as the inert marker.

Sea bass fingerlings (25g) were first acclimated to a commercial diet in an experimental system with tanks conforming to the Guelph faecal collection protocol, and subsequently fed experimental diets for at least four weeks to satiation prior to the faecal collection period.

Fish were held in full strength sea water 32ppt and a temperature of 22°C for the trial.

Pooled faecal material was collected from each tank and nutrients analysed together with chromic oxide to allow for digestibility calculations. Protein digestibility was determined for each protein source based their respective contribution to the total protein concentration in the mixed test diets.

Results showed that protein digestibility was particularly favourable for poultry meat meal (>80%) compared to (93%) for the fishmeal within the reference diet. However both feathermeal and enzyme treated feathermeals did not show an appreciable difference in there digestibility for protein (75%). The latter was significantly lower than fishmeal (P<0.05). The spray dried haem assessed as a single ingredient source produced a high digestibility of 90% compared to the other sources. Various blends were also tested and the enzyme feathermeal/spray dried haem combination resulted in a digestibility of over 80%.

Digestible energy values for the combined diets ranged for 53% to 82% and these proved significant.



DIGESTIBILITY ASSESSMENT OF SELECTED PLANT PROTEIN CONCENTRATES (pea, maize, wheat) FOR RAINBOW TROUT *O. mykiss*

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A digestibility study was undertaken to establish the potential of three high quality plant protein concentrates for the substitution of a high quality low temperature fishmeal source (LT-94 Norwegian).

50% of the protein was replaced from the reference fishmeal diet with each of the three test plant sources i.e. pea protein concentrate, maize gluten (Glutalys[®]) and wheat gluten (Viten[®]). All diets were produced using a commercial pilot extruder and a target protein level of 46% crude protein and 20% lipid was maintained for each diet, Yttrium oxide was added as the inert marker.

All female rainbow trout (mean weight 120g) were randomly assigned to each diet (36 fish per tank) in triplicate groups. Fish were acclimated to the experimental diets for four weeks prior to the collection of the faecal material and fed to satiation twice daily. Digestibility was determined by the faecal stripping method. This was performed on three separate occasions, (once every five days) and samples pooled from each collection.

Pea protein and Viten[®] clearly show significantly better (P<0.05) digestibility values (92%) and (91%) respectively compared to fishmeal (88%).

Glutalys[®] however was significantly inferior at 80% (P<0.05). The ingredient essential amino acid digestibility mirrored the protein digestibility results showing similar significance. Energy ingredient digestibility values were very favourable for the pea protein source (87%) when compared to the fishmeal reference (87%); however the Glutalys[®] energy availability (69%) and Viten[®](66%) did not perform as well, and these values were significant (P<0.05).







GENETIC MAPPING OF TAURA SYNDROME VIRUS RESISTANCE THE PACIFIC WHITE SHRIMP Penaus vannamei

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Susceptibility to disease and the associated losses are one of the primary risk factors in shrimp farming. The fall and rise of shrimp production by country worldwide can be tracked by disease outbreaks and subsequent control measures, such as the introduction of SPF broodstock. Development of shrimp lines that are disease resistant will be a primary driver for adoption of genetic stock as the industry matures and expands

ViaGen has developed a number of genetic tools for Marker Assisted Selection in Peneaid shrimp. For *P. vannamei*, these tools include 410 polymorphic microsatellite markers and a genome linkage map of 44 linkage groups with 140 markers. Using these tools, we identified multiple loci associated with resistance to one or more strains of *Taura* Syndrome Virus (TSV).

The four families used to construct the ViaGen linkage map were selected for resistance to TSV over multiple generations. Each family was challenged with TSV strains from Hawaii, Mexico and Belize. Genotypic frequencies of survivors and control (unchallenged) animals within a family were compared to detect markers showing significant distortion of allele frequencies in the survivors. Eleven markers showed strong evidence of linkage to TSV resistance, as evidenced by significant (p<0.05) genotype frequency distortion in more than one family, or highly significant distortion (p<0.01) distortion in one family.

Results show that there are multiple genes contributing to TSV resistance in *P. vannamei* The genetic data also confirm what has been shown by disease challenge; resistance to one strain of TSV does not necessarily infer resistance to a different strain. Several markers exhibit evidence of linkage to one strain in one family and a different strain in other families, suggesting different alleles at the resistance loci may exist. It also appears that resistance alleles and marker alleles are not in linkage disequilibrium, necessitating that the markers be used within families, rather than ad hoc.

The results of this project indicate that MAS in shrimp is now achievable. In order to obtain maximum resistance within and across TSV strains, it will be necessary to pyramid multiple resistance genes. MAS is the only practical way to select broodstock with favorable alleles at multiple loci simultaneously. Using our existing map and marker resources, we can begin selection in within families from any genetic stock of *P. vannamei*.

A MICROSATELLITE LINKAGE MAP FOR THE PACIFIC WHITE SHRIMP Penaus vannamei

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Marker Assisted Selection (MAS) is valuable for genetic improvement, but requires the existence of several key genomics tools, such as genetic markers, a genetic linkage map and reference populations. Currently, the body of public genomic knowledge is not sufficient to perform MAS in shrimp. The construction of linkage maps in Peneaids has been historically hampered by difficulties in each step of the mapping process.

Because approximately 17% of random shrimp DNA sequences contain microsatellites, we were able to use direct sequencing of *P. vannamei* shrimp genomic libraries for microsatellite discovery. Thus far, we have identified 410 polymorphic microsatellites from 3,000 sequences. One hundred eighty-six of these markers segregate in the four full-sib families used to construct the linkage map.

We use four techniques to increase efficiency in genotyping and map development. ViaGen has developed a universal-PCR primer methodology which eliminates the need to fluorescently label primers for markers prior to determining their suitability for a particular population, allowing us to eliminate dye-labeling of markers that do not produce a scorable product, or are monomorphic.

Highly selected aquaculture populations can be inbred, resulting in a loss of genetic diversity. Consequently, markers that are polymorphic in one family or population may not be polymorphic in another. In order to rapidly identify the subset of markers most useful in new populations, we pool the DNA of individuals in the target population and genotype the pool.

We have also developed a one-step shrimp DNA template preparation system that allows genotyping directly from shrimp tissue lysate and provides sufficient DNA for MAS from a single pleopod.

Finally, we developed a robust multiplexing technique that allows eight markers to be genotyped in a single reaction, reducing the genotyping cost, labor and machine time by 50%.

Using these proprietary techniques, we have developed a genome-wide linkage map in our four families comprising 44 linkage groups and 140 markers. We now have the tools to make feasible the application of MAS to the shrimp breeding industry.

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PRELIMINARY ANALYSIS OF THE GROWTH RATES OF MURRAY COD, *Maccullochella peelii peelii* GROWN IN A COMMERCIAL RECIRCULATING AQUACULTURE SYSTEM

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Water re-use or recirculating aquaculture systems (RAS), are widely believed to be one of the future growth sectors within the Australian aquaculture industry. The Deakin University Sustainable Aquaculture Systems (SAS) program located in Warmambool, Victoria, is aimed at undertaking industry scale research in RAS. The program, now in its second year, is well underway with a 20 tonne RAS system nearing full production and a further four systems (1 x 20 tonne and 3 x 6 tonne), currently in the final stages of construction.

Murray cod were cultured in a 20 tonne RAS since June, 2003. The system has been managed in accordance with standard RAS management guidelines and weekly production has been established. All water quality parameters were maintained within the acceptable guidelines for RAS culture of Murray cod, and initial results have been obtained from 3 generations of growth data.

Results to date indicate that the feed conversion ratio (FCR), ranges from 0.75 to 1.26 (Figure 1), and the specific growth rate (SGR), ranges from 1.02 to 3.3 (Figure 1), throughout the culture cycle of Murray cod. Results also highlight that Murray cod naturally develop into a minimum of 3 size classes (cohorts), throughout a culture cycle (Figure 2), with 1.5g fingerlings reaching a market size of 800g-1kg, from 365 days. The cohort development has proven to be a key management tool, especially in regards to regular market supply over a period of time.



Figure 1. FCR & SGR vs. growth



Figure 2. Growth variations of Murray cod in RAS

A MOLECULAR APPROACH TO CHARACTERISE ENVIRONMENTAL STRESS RESPONSE AND PATHOGEN INTERACTION OF *Penaeus monodon* IN AUSTRALIA

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The health of aquatic species is dependent on interactions between the environment, pathogens and the host organism. In prawn farming production systems, cultured animals can generally coexist with potential pathogens in a chronic infection stage with little or no impact to production. However, environmental or anthropogenic pressures can often generate stress and decrease the immune response capacity in chronically infected populations. The resultant induced stress response is believed to be the trigger in the transition between chronic to acute infections, and hence disease outbreaks.

In Australia, most cultured and wild caught *Penaeus monodon* are chronically infected with Gill Associated Virus (GAV). This subclinical GAV infection is restricted primarily to spheroid bodies within the lymphoid organ causing no major impact on prawn production. An acute infection state involves other tissue types and has been associated with morbidity and mortalities. Recent evidence using in-situ hybridization and quantitative real time Reverse Transcription Polymerase Chain Reaction (qRT-PCR) suggests that this transition from a chronic to acute infection can be the result of rapid viral replication, which can be triggered by environmental, and/or anthropogenic stress.

To further understand the environmental stress response and its effect on host-pathogen interaction in *Penaeus monodon*, we have challenged juvenile prawns to thermal, hypoxic and osmotic stress. Western Blotting, qRT-PCR, and Suppression Subtractive Hybridization were used to measure changes in protein, gene, and GAV levels in experimental prawns. Preliminary results have shown significant changes in protein and gene expression patterns associated with particular types of stress, making them potential biomarkers of stress response. The relationship between environmental stress, expression patterns of these candidate biomarkers, GAV replication and disease outbreaks will be discussed.

FOOD SAFETY AND THE EU CONSUMERS PERSPECTIVE

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Why are EU Consumers concerned about food safety? Well, they have every reason to be - or do they? The paper will review the reasons behind the high profile given to food safety issues in the EU. It will chart the history from the issue which is widely credited as the start point, BSE, followed by Salmonella in eggs in the UK, dioxins in feedstuffs in Europe, GMO's globally and, more relevant to aquaculture, the recent Science article.

With an incite as a food producer, scientist and EU consumer the author will examine the role that the media, NGO's, Governments, retailers and food producers have played in establishing what can be a highly charged and emotive issue, but which can also have serious social and economic impacts.

The internet and media revolutions have helped to 'fuel the fire' of food scares and anti-aquaculturists have sought to use them to frighten consumers as a means of furthering their aims. In both cases the author considers they have, through a combination of fact, misinformation and fiction which, particularly in the UK, is sometimes unclear as to whether the aim is genuinely to inform, or to create a story. But, there is also a recognition that the consumer is, quite rightly, more aware of food issues and food producers would be advised not to dismiss the 'noise' as being unimportant or, in some cases, not without substance.

Ultimately, legislation will set the standards, based on consumer safety, that food producers have to meet and the future role of such legislation will be examined. However, with ever increasing costs of meeting these standards will the consumer be willing to pay, or will they, as some commentators state, become ever more tired of 'yet another food scare in the press' and continue to demand cheap food.

Food safety should be the single most important issue for food producers and some analysis of the actions taken by businesses to address these concerns through the development of traceability systems such as Nutrace, product certification schemes, independent audits, retailer audits and ISO certification will be made.

But, in many cases, it may just come down to price!

MANAGING BIOSECURITY AT THE FARM LEVEL

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A mail survey was conducted in fall 2001 among finfish recirculation operators in the United States and Canada to assess the frequency of use of different biosecurity measures and to identify factors affecting biosecurity practice. The response rate to the survey was 86 % (United States n=93, Canada n=38). The data indicate that biosecurity utilization was not homogenous within the finfish aquaculture industry of the United States and Canada. Patterns of biosecurity utilization were related to a variety of factors, some of which were social in nature. Biosecurity measures that were considered inexpensive and practical were the ones most frequently used. However, perceptions of effectiveness also influenced the use of biosecurity measures. Government policies or regulations advocating or mandating certain biosecurity practices were not viewed as the most important inducements to practicing biosecurity. Rather, the most significant reason for using biosecurity was the effect good biosecurity has on an operation's business image.

A follow-up series of in-depth interviews was conducted in spring 2002 with farm personnel working in finfish recirculating facilities in the United States and Canada to further examine factors affecting biosecurity utilization. Among farm personnel, there was an interaction of several factors that influenced and supported the practice of biosecurity. Contrary to popular opinion, knowledge about biosecurity is not the most significant factor in biosecurity utilization. Information from this study should assist facility managers, educators, and animal health specialists to develop strategies for the improvement of biosecurity utilization at the farm level.

STATUS OF THE CHILEAN AQUACULTURE AND USE OF GENETIC MARKERS

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The aquaculture production in Chile has increased from less than 10.000 tons in 1992 to more than 500.000 tons in 2002. Several species are been used for such us production, including 6 species of fish, 7 species of mollusc and 1 species of algae; more than 50% of these species are introduced to the country.

At the University of Chile, genetic characterization or studies to apply genetics to the enhancement of production, were initiated at the end of the decade of 1980, including areas like citogenetic, genetic improvement and molecular genetics.

At present, genetic improvement programs are being developed for coho salmon, Atlantic salmon, rainbow trout, chilean scallop and abalone. Some of them are being initiated in relation to research grants to develop genetic selection, or evaluation of genetic markers like RAPD and microsatellites, or mitocondrial markers.

PRACTICAL CONSIDERATIONS FOR THE NUTRITION OF FARMED PRAWNS IN AUSTRALIA

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As an aquaculture species prawns are relatively poor converters of feed with an Australian industry average of around 2.1:1 . This compares well with other crustacea such as redclaw crayfish (2.5:1), but poorly with a tropical finfish species such as barramundi, where the FCR has continued to improve from greater than 2:1 to approach 1:1 in some cases. There are many reasons for this inefficiency in feeding, not the least of which relates to the way prawns actually feed and the fact they are not visible during the feeding process. Since feed cost represents around 35% of the overall production costs of prawns as well as being the major contributor to the nutrients found in prawn farm effluent, there is great scope for a reduction in FCR and an increase in the retention efficiency of the feeds used. Currently under the intensive farming conditions used in Australia and the current protein levels commonly used of between 35-40% the nitrogen retention efficiency is about 22%.

Traditionally nutritionists have measured the protein requirements of prawns without giving much consideration to intrinsic protein sources within the culture system. More recently it has been shown that nitrogen retention efficiency within the culture environment can be greatly improved by manipulating the natural biota present, this can be done in a number of ways. This allows feeds of lower protein levels (<35%) to be utilized with no apparent loss of growth or increase in FCR and providing some significant environmental outcomes in the process. In terms of reaching the niche markets that many Australian prawn farms are now attempting to break in to, strong environmental credentials and prawns fed with non GMO feeds are seen as strong marketing advantages.

There is scope to further increase the efficiency of compound feeds used in prawn ponds, by considering the ways in which prawns are fed and when. And also by the methods used to monitor feed consumption.

PROGRESS IN OVERCOMING CONSTRAINTS TO COMMERCIAL SCALE HATCHERY AND NURSERY PRODUCTION OF SYDNEY ROCK OYSTERS, Saccostrea glomerata

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The 120 year old Sydney rock oyster (SRO) industry directly employs about 800 people, more than any other form of aquaculture in NSW. But it has suffered a 40% decline from peak production during the 1970's. There are several reasons for this decline including disease, lack of profitability and competition from other oyster species, which are forcing many farmers to abandon the industry. To overcome this decline, economic analyses show that profitability will be greatly improved if SRO farmers can grow hatchery-produced oysters that have been selected for faster growth and disease resistance.

Several million dollars have been spent over the last decade to develop selected lines of SRO that can reach market size up to 11 months earlier and survive outbreaks of the oyster disease "QX" 50% better than the oysters currently farmed. Unfortunately, while large batches of several million SROs have been produced in hatcheries in NSW, the techniques have not been sufficiently reliable to be adopted commercially to make these specially selected oysters available to industry.

Two distinct problems have plagued hatchery production. 1) Larval anorexia or starvation has affected many hatchery production runs and occurs when the oysters are between 2 to 8 days old. 2) Spat mortality occurs later when the oysters are approximately 1 - 1.5 months old and are being held in nursery systems outside the hatchery.

To overcome this high mortality of young oysters, several complementary strategies have been developed. NSW Fisheries has begun to make simple but potentially significant changes to existing hatchery facilities, rearing equipment and operating protocols that are designed to prevent larval anorexia. In a second strategy, a private hatchery in Queensland has been commissioned to attempt to produce SRO larvae. Thirdly, a research program, funded in part by the Fisheries Research and Development Corporation, has begun to systematically address factors that might be involved with the two mortality problems.

Progress to date has been encouraging. Both the hatchery in Queensland and the NSW Fisheries hatchery have now succeeded in conducting three successive, successful commercial scale larval runs, a benchmark not previously achieved. Among the oysters produced in these runs have been the 12 million progeny from the fifth generation of oysters selected specifically for faster growth that have been passed to oyster farmers in New South Wales and Queensland for their evaluation.

NEW AQUACULTURE INDUSTRIES IN AUSTRALIA – SCOPING STUDIES, DEVELOPMENT AND REALITY

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Scallop culture is a major aquaculture industry, with global production now being in the order of 2 million tonnes each year. While scallop culture hasn't developed into a viable industry in this country, one Australian species (*Amusium balloti*) has growth and market characteristics that offer promise for scallop aquaculture.

A detailed feasibility study on scallop aquaculture, incorporating biological, marketing and economic reviews and modelling was funded by FRDC and completed by a diverse and experienced technical working work. The economic models predicted profit under almost all scenarios.

Two Australian companies have attempted to develop scallop culture based on *A. balloti* within the last 5 years. One of these companies was set up as a direct response to the feasibility study's output and the other is using procedures very similar to those described in the feasibility study.

Both companies have struggled to develop their operations into viable businesses thus far. The delays can be attributed to both technical and organisational limitations. One company has fully developed infrastructure and authorisation, but has had problems with consistent spat supply, perhaps as a consequence of water quality issues in a harbour-based hatchery. The second has experienced a series of delays due to authorisation processes. Some of these delays can be attributed to the company's failure to understand government process and legislation. Under-capitalisation and delay in establishing an appropriate organisational structure have compounded the company's problems.

There is a great deal to be learnt from this case study. Key points include over-optimism about dealing with technical uncertainty, assumption that private enterprise can develop efficient management, budgeting and financing requirements (including realistic capitalisation), and communication failure between government agencies responsible for licensing and private companies seeking to use publicly owned resources.

Companies undertaken new aquaculture operations need to understand government process, need to be sufficiently capitalised to withstand delay, and above all must have a management structure that understands and supports the technicalities and risks of the industry in question.

Scallop culture based on A. balloti still has considerable potential for profitability. Only time will tell if it is the current generation of entrepreneurs who realise this profit.

THE EFFECT OF LHRH-a ON THE REPRODUCTIVE PERFORMANCE OF THE SPOTTED SAND BASS Paralabrax maculatofasciatus

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The spotted sand bass is a spontaneous spawner in captivity. However, the use of genetic manipulation such as triploidization needs the synchronization of spawning. Three experiments were made to induce final maturation and spermiation in spotted sand bass by LRRH-a injection. Broodstock were collected in the field and brought to the laboratory. Fish were maintained in a closed circulation system (23 °C, 35ppm and 13:11 L:N). In a first experiment, females showing oocytes with 400 mm diameter were injected (8 per concentration) with half-doses followed by the second injection 24 hours later (25, 50, 100 μ g and 0.7% saline solution). Females were biopsied every twelve hours to check for oocyte maturation. Spawned eggs were collected and the volume of dead and alive eggs was measured. 2) In a second experiment, males (16 per concentration) were injected with 12.5, 25, 50 μ g kg⁻¹ and saline solution. The dose was administered only once.

Eight males per concentration were sacrificed after 12 hours and the remainder after 24 hours. Sperm motility and density were evaluated. These were also evaluated in fish recently brought from the field and 15 days later just before the treatment. In a third experiment, 4 groups of 5 males and 5 females were maintained separately in a closed recirculating system equipped with eggs collectors. Females of each group were injected with LHRH-a with one of the following concentration (12.5, 25, 50 μ g kg⁻¹ and saline soln) whereas males were only injected with the 25 μ g kg⁻¹ dose. The treatment was administered in one dose.

In the first experiment, spawning females were obtained after 36 hours following the second injection. No significant difference was observed between doses but a trend towards better results (percentage of spawned females and volume of viable eggs) was observed with the lower dosage (Table 1). In the second experiment, wild males showed a significant total longer motility duration. The total duration was also significantly longer in the fish injected with the 12.5 μ g kg⁻¹ y 25 μ g kg⁻¹ doses compared to the laboratory control and the 100 μ g kg⁻¹ and the saline-injected fish. No difference in the sperm density was observed. In the third experiment, the maximum spawn was obtained with the saline injection and the 12.5 μ g kg⁻¹, 48 hours after the injection, However the 12.5 μ g kg⁻¹ dose showed the larger proportion of viable fertilized eggs, hatching percentage, and number of live larvae

THE USE OF POLAR BODY AS AN INDICATOR TO OPTIMIZE THE PRODUCTION OF TRIPLOIDS BY COLD SHOCK IN PACIFIC WHITE SHRIMP *Litopenaeus vannamei*

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The aim of this study was to establish a repeatable protocol for triploid induction in Litopenaeus vannamei by improving manipulation techniques and by using and individual-basis observation of the kinetics of polar body extrusion to determine the time application and the duration of treatment. We resolved manipulation problems and obtained no-damaged eggs when the use of sieve was afforded. First we tried to assess the variability of polar body extrusion by following the eggs development in 30 individual spawns. A great variability indicating the difficulty to apply the shock a fixed post-fecundation time. The first polar body was completely extruded within a range of 7-19 min while it was 13-37 min for the second polar body. The triploidy induction experiments were then conducted with a simultaneous checking of polar body extrusion at incubation temperature (28 °C) Three cold shock temperature were applied 5, 7 and 10 °C in 4 spawns per temperature (3 replicates by combination of treatment). Cold shock was applied by adding chilled water to the induction recipients. Two application times were selected: 50 % and 100 % of the eggs had extruded the first polar body. Three treatments duration were applied: 25, 50 and 100 % of the eggs showing the second polar body extruded. Two controls were used 1) fertilized eggs collected directly from the spawning tank; 2) eggs that pass through all the manipulations except the cold shock. Treated eggs and controls were incubated at 28 °C until hatching. Triploidy was evaluated in nauplii by flow cytometry. Triploids were obtained only when the treatment was applied at 50% of the first polar body extruded. Triploids were observed at all temperatures. No significant differences were observed between the treatment duration. However, the average percentage was significantly higher at 5 °C (80%) compared to 10 °C (60%). The results at 7 °C were intermediate. However, more 100% triploids were observed at this temperature. Survival ranged between 60-80% of the control. We concluded that it is possible to produce triploids in a repeatable way using a simultaneous observation of polar body extrusion. The better treatment is to apply a 5-7 °C cold shock when 50% of the eggs showed the first polar body out of the fertilization membrane. The treatment may be stopped at any time (25, 50 or 100) but the 50% is recommended to make sure that tetraploids won't be produced.

COMMERCIAL PRODUCTION OF MULLOWAY <u>Argyrosomus japonicus</u> USING SALINE GROUND WATER

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O'Donohue Sand and Gravel is Australia's first commercial, saline ground water, aquaculture operation. After initial experiments, the operation has focused on hatchery production of mulloway (*Argyrosomus japonicus*) and Australian bass (*Macquaria novemaculeata*). Recently a shift was made to the grow-out of mulloway, marketed as Clearwater Mulloway‰.

The groundwater used is formerly oceanic water that is trapped in a sub-terrainian gravel bed. The water chemistry varies slightly to that of estuarine and oceanic water. The variations in chemistry were problematic initially, however simple management techniques have been devised to allow the production of commercial quantities of fingerlings and market size fish.

Located in the lower Hunter Valley, the farm is ideally located for easy access to markets in Newcastle and the Hunter, the Central Coast and Sydney. All water is reused by incorporating complementary production strategies, to create a profitable and environmentally sustainable enterprise.

BENEFITS TO INDUSTRY ARISING FROM THE FISHERIES RESEARCH AND DEVELOPMENT CORPORATION'S AQUATIC ANIMAL HEALTH SUBPROGRAM

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The overall outcome of the Aquatic Animal Health (AAH) Subprogram was an increased ability to manage aquatic animal disease in the commercial, recreational and traditional fishing industry sectors. The AAH Subprogram thus helped Australia's aquaculture and fisheries industries become more competitive, profitable and sustainable, as well as assist in ensuring that R&D investments would focus on priorities identified by industries and governments.

The AAH Subprogram has delivered improved diagnostic capability for pilchard herpesvirus and an additional ten Standard Diagnostic Techniques for priority aquatic animal diseases; twenty-one AQUAVETPLAN aquatic animal disease emergency management manuals or other training resources; and ten training exercises to enhance the disease emergency management capability of industry and government personnel. Other resources such as the *Aquatic Animal Health Subprogram: exotic disease training manual*, the *Australian Aquatic Animal Disease Identification Field Guide (2nd edition)*, and the *Aquatic Animal Disease Emergencies Video And Training Kit "Disease Watch – Play your Part*" have all been completed.

The series of disease simulation exercises culminated in *Exercise Tethys*, the world-first multi-jurisdictional disease simulation exercise in the aquatic area. The subsequent report included a set of broad recommendations that aim to improve preexisting frameworks and resources in order to develop more robust communication systems and procedures for an aquatic animal disease emergency response. The report includes recommendations specific to the operating systems and procedures within individual jurisdictions. *Exercise Tethys* also highlighted other concerns including the need to address compensation cost sharing issues within the aquaculture industry.

Other courses supported through Subprogram projects were a training course on exotic diseases of aquatic animals, education and training on the Consultative Committee on Emergency Animal Diseases process, and the AAH Subprogram Scientific Conference *Emergency Disease Response Planning and Management*.

Through further projects, the AAH Subprogram facilitated the establishment of the Aquatic Animal Health Committee as the primary industry-government interface for aquatic animal health in Australia and also identified the most suitable mechanism to compensate aquaculture farmers for financial losses associated with government-ordered compulsory destruction of stock due to an outbreak of an emergency disease.

The AAH Subprogram has proved successful in its aim to provide an industry-based structure through which to develop and maintain strategic direction for investment in aquatic animal health.

ENHANCEMENT OF GROWTH PERFORMANCE AND FEED UTILIZATION USING FENNEL (SHUMER) SEED MEAL AS FEED ADDITIVE IN NILE TILAPIA Oreochromis niloticus FINGERLINGS DIETS

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A feeding trail was conducted to study the effect of graded levels of Fennel seeds meal on growth performance, feed and nutrient utilization, body composition, glucose, total plasma lipid (TPL) and total plasma protein (TPP), liver enzymes, liver and gonads histology and cost-benefit analysis of Nile tilapia fry. Ten glass aquaria with the dimensions of 70 x 30 x 40 cm, were used to stock 10 fish averaging 0.37 g/fish. Five experimental diets were formulated to contain 0, 0.5, 1.0, 1.5 and 2 % of FSM as feed additive in Nile tilapia. All the diets were isonitrogenous (31% protein) and isocaloric (450 Kcal/10 g diet). The feed amount was given three times daily, six days a week for 98 days. Fish were weighed biweekly and feed amounts were adjusted on the basis of the new fish weight. Body weight of fish fed the control diet was relatively lower than all diets containing FSM. Final body weight, weight gain and specific growth rate (SGR) of fish fed 0.5% FSM was significantly higher (P<0.05) than other test levels. Feed conversion ratio (FCR) showed no significant differences among all treatments, however the FCR of diets supplemented with FSM were better than the control diet. No significant differences (P>0.05%) were found in moisture, protein, fat, ash and energy percentage. Incidence cost than decreased by 20, 38, 86 and 87% than the control for diets containing 0.5, 1.0, 1.5 and 2%, respectively.

FISH AND CHIPS – A FUNCTIONAL GENOMICS APPROACH TO THE STUDY OF KEY ISSUES IN FISH AQUACULTURE

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The study of functional genomics has changed profoundly since the development of microarray (DNA chip) technology, which enables the investigation of thousands of genes simultaneously. At the Bribie Island Aquaculture Research Centre we are developing a fish microarray (chip) that contains 5000 cDNA clones, derived primarily from brains isolated from barramundi larva that were infected with nodavirus. The main aim of the DNA chip is to investigate the molecular response of barramundi larva to Viral Nervous Necrosis, VNN.

VNN is a disease of the central nervous system of teleost fish, resulting from nodavirus infection. VNN has been reported in 30 species of fish worldwide, and is considered a major limiting factor in the successful culture of several important marine species, including barramundi *Lates calcarifer*. In barramundi, *encephalitis virus* (LcEV) is the major cause of VNN, where it can cause 50-100 % larval mortality per month during culture.

Changes in gene expression occur in a host in response to infection and often represent key events in the disease process. In this study, we aim to identify and isolate genes differentially expressed between isogenic nodavirus-susceptible and resistant barramundi cell lines, susceptible and resistant barramundi larvae/juveniles and healthy and nodavirus-infected barramundi larvae and cell-lines. If successful, this approach will be a step towards developing a faster, more direct route to the identification of beneficial trait genes for enhancement of selective breeding programs of high-value fish species, than that currently provided by the traditional methods of marker assisted selection involving mapping of quantitative trait loci.

In addition to the 5000 cDNA clones discussed above, we have also spotted on the chip 120 previously characterised cDNA clones that have a key role in the process of puberty and reproduction. These include the sequences coding for the three GnRHs, brain and gonadal aromatase, GH, LH, FSH, IGF I &II, IGF-R. We aim to use the chip to characterise the up and down regulation of these genes in response to various physiological situations.

MICROARRAYS - NEW FACE OF CRUSTACEAN GENETICS?

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Microarray technology is gaining popularity as a new powerful tool to show those genes that are switched on or turned off (differentially expressed), either within the same individual in response to different environmental conditions, or between individuals under the same environment. Microarrays are also used to identify novel genes associated with traits of interest (gene discovery).

At the Bribie Island Aquaculture Research Centre we have developed a DNA chip that contains 5000 cDNA clones, isolated from the Australian blue swimmer crab *Portunus pelagicus*. These clones represent transcripts isolated from young whole crabs and from adult endocrine organs, all at defined stages of the moult cycle. In this case, the array allows us to investigate simultaneously the many molecular changes associated with moulting and reproduction. This differs from the traditional approach to molecular studies where individual or single genes are isolated and studied.

The development of arrays, from concept to reality and their relevance to genetic programs will be presented.

IS THERE A COMMERCIAL ADVANTAGE WITH TRIPLOID GREENLIP ABALONE H. laevigata?

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The production of triploid individuals in aquaculture is undertaken for perceived advantages in growth and/or maturation characteristics. Triploid induction has been widely reported in a number of abalone species using various shock treatments and with varying degrees of success, but few studies have reported on the commercial advantages of such lines. In this study we have compared the performance over 36 months of triploid greenlip (*H. laevigata*) abalone grown under commercial conditions with diploids from the same cohort.

Triploidy was induced using the chemical 6-DMAP and aimed at suppressing meiosis II (preventing the extrusion of the second polar body). Induction rates of over 90% as measured by flow cytometry were recorded in trochophore larvae, with a reduction to ca. 80% triploid at veliger larval stage prior to settlement. After settlement the proportion of triploids in the sub-sample analysed was 53%. Tagged and untagged triploids and diploids (identified by flow cytometry on cephalic tentacle tissue) have been on-grown under semi-commercial conditions in the same tank. Growth measurements (length and weight), maturation status and samples for ploidy validation have been taken periodically over the past 42 months.

No individuals for which cephalic tentacles were re-sampled had reverted from a triploid to diploid status. Flow cytometry of five main tissue types (tentacle, gill, muscle, mantle and digestive tissue) verified triploid status in all cells at 32 months of age. To date the triploid abalone have grown at a lower absolute growth rate, however, when expressed as specific growth rate (relative to initial size) there was no difference observed between triploids and diploids during the second and third years of growth. The observed difference between absolute and specific growth rates is due to the triploids being smaller at the first size measurement at 13 months of age. The smaller initial size and possible lower survival rate at settlement may be a consequence of reduce nutritional reserves during the short (non-feeding) larval phase.

This paper will expand on the results discussed above and present our latest results on the effects of triploidy on maturation, and the use of microsatellite markers in the identification of meiosis I and meiosis II triploids.

REALITY BITES

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There is much to celebrate about Australian produce, but complacency is dangerous and there is much to improve.

For the past two decades Australians have talked up the state of our ingredients until "world-class produce" has become a cliché. The big question however, isn't whether we have some excellent produce, because we do, but just how does it compare, as a whole, with the best anywhere?

There is some amazing produce in this country, particularly seafood. We have a lot to be proud of, but we must keep improving so our produce compares with the world's best at every level. Sadly, in some areas we still have a long, long way to go.

We need to get more passionate about the produce than we already are.

I've been to fish markets in other countries where every single item for sale is gone by midday. I've seen people cycling across a harbour foreshore to intercept a fishing boat as it docks, just to get the freshest calamari. Visit a co-op in Tassie, in contrast, and often all you will see are frozen fish fillets.

There has been a huge increase in respect for produce over the past 20 years. But more farmers need to care about what happens to the produce after it leaves the farm gate.

EXPLORING THE POTENTIAL OF SPONGE AQUACULTURE WITH REMOTE COASTAL AUSTRALIAN COMMUNITIES

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The commercial demand for Dictyoceratid sponges in cosmetic, bath, or industrial use has grown consistently since early Grecian times and currently far exceeds supply from wild harvest. In 2002, global sponge production was a meagre 460 metric tonnes compared to a global trade that year of 2589 metric tonnes (FAO statistics). Supply from wild fisheries in several areas including the Mediterranean and Caribbean has suffered from overharvesting, and periodic political instability and disease. Experimental culture trials conducted by AIMS between 1999 and 2001 at Davies Reef (central Great Barrier Reef) indicate that local Australian sponges suitable for the global market can be grown by aquaculture, returning up to 1000% growth per annum.

Sponge aquaculture is currently being explored as a sustainable new sponge production method in a collaborative research project with coastal indigenous communities in three regions of Northern Australia: Palm Islands (Great Barrier Reef), Torres Strait (Far North Queensland), and Western Arnhem Land (Northern Territory). In each of these three areas, the project commenced with extensive community consultation to establish a community based collaboration, and a survey of local Dictyoceratid species to select candidates for experimental aquaculture trials. These trials seek to adapt and modify methods used elsewhere to local species and conditions, and provide the data to allow the community collaborator to assess the commercial potential through appropriate business planning and enterprise development activities. The projects also seek to establish a knowledge base in each region to underpin the sustainable environmental management of this potential new industry, with guidelines for impact prediction, site selection, sustainable harvest of wild seed stock, and translocation.

Critical to the success of these projects is effective knowledge, skills and technology transfer to the community partners. This is being sought through extension, and opportunities for participation, employment and training within the projects.

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THE IMPACT OF Litopenaeus vannamei ON THE SHRIMP DISEASE SITUATION IN THAILAND

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Since the widespread introduction of *L. vannamei* into Asia, it has transformed the commercial shrimp culture industry. Farmers, used to dealing with the problems associated with traditional *Penaeus monodon* culture, were quick to grasp the opportunities associated with cultivation of this new species. With relatively minor changes in culture technique, farmers have been able to stock *L. vannamei* at densities exceeding 200 per sq.m. High survival and fast growth rates as well as lower feed costs and shorter production cycles have resulted in harvest yields exceeding 20 MT/Ha per crop and higher profit levels. The relative ease of production of broodstock from pond-reared shrimp also held the promise that not only could supply of broodstock be maintained from domestically reared shrimp but that stocks could be further selected to suit local culture conditions.

These initial introductions took place with little concern for the possibility of pathogen transfer despite these concerns having been raised in previous years. Fortunately, many of the early introductions were made using Specific Pathogen Free (SPF) stocks, thereby avoiding many of the risks of pathogen transfers. However, many of these stocks were held in conditions of poor biosecurity and an increasing incidence of IHHN virus, endemic in Asian *P. monodon*, was noted in farmed *L. vannamei*. Also, continued introductions of *L. vannamei* were made from stocks that were not free of some major pathogens, resulting in the introduction of Taura Syndrome Virus into Asia.

In the last two years, *P. monodon* has been stricken with a condition resulting in abnormally slow growth rates in ponds. From a normal average daily growth (ADG) of around 0.2g/day, farmers have reported growth rates as low as 0.09 g/day. The precise cause for this is still under investigation but it is strongly suspected that it is due to a virus, tentatively named "Monodon Slow Growth Syndrome Virus" and it has been speculated that this may have been introduced unintentionally with apparently healthy *L. vannamei* although the evidence for this is highly circumstantial.

One likely unintended consequence of the success of *L. vannamei* culture has been the recognition by Thai farmers of the benefits of working with domesticated, selected stocks free of major pathogens. This has led to a renewed interest in the domestication of *P. monodon* in order to improve the quality and performance of this species in culture.

CULTURE METHODS FOR Litopenaeus vannamei IN THAILAND

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Since its introduction into Thailand, the Pacific white shrimp, *L. vannamei*, has become the dominant species in commercial production. The species has proved to be highly amenable to culture in Thai conditions with relatively minor modifications to existing techniques. With increasing success and experience, farmers have been able to increase stocking densities to exceed 200 per sq.m. and harvest yields in excess of 20 MT/Ha per crop have been reported.

The spectacular performance of Pacific white shrimp in Thai culture conditions, together with the problems that continue to be faced by *P. monodon* producers, have resulted in a dramatic shift to production of the introduced species. From its initial introduction in 2001, production of *L. vannamei* now represents as much as 60% of total shrimp production in Thailand.

This paper will provide a brief review of the main culture methods and production strategies for *L. vannamei* and explore some of the issues surrounding the shrimp industry in the wake of its introduction

STATUS OF R&D AT THE INLAND SALINE AQUACULTURE RESEARCH CENTRE, WAKOOL, NSW

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Opportunities exist to develop aquaculture using saline groundwater associated with sub-surface drainage schemes and evaporation ponds in inland Australia. However, in order to develop aquaculture as a business initiative in saline affected inland areas, it was essential to initiate a research program to evaluate the suitability of inland saline groundwater for aquaculture and to produce information for bioeconomic analyses.

For this purpose, a new research and demonstration facility, the Inland Saline Aquaculture Research Centre (ISARC) was constructed at the Wakool-Tullakool Sub-Surface Drainage Scheme (WTSSDS), the largest evaporation scheme in Australia with over 1,600 ha of evaporation ponds, near Wakool in southern New South Wales. The Centre includes 6 0.05 ha plastic-lined earthen ponds, supplied with freshwater and saline groundwater from a dam and two evaporation ponds (each have different salinities), respectively, a small-scale experimental tank facility and a temperature controlled laboratory.

The research strategy adopted includes initial replicated bioassays in tanks with environmental control to determine the suitability of the saline groundwater, especially the need for adjustment of potassium concentration, for the selected species. The bioassays are followed by controlled, small-scale growth experiments in 500-L tanks and finally semi-commercial production is done in ponds to determine suitable pond management protocols. Saline groundwater from the WTSSDS has approximately 95% less potassium than similar salinity oceanic seawater, and consequently is not suitable for survival and growth of marine species. However, the potassium concentration of groundwater can be fortified easily and cheaply by adding KCl (potash) and provided potassium levels are adjusted to above 40% of those concentrations present in seawater at the same salinity, snapper (*Pagrus auratus*), mulloway (*Argyrosomus japonicus*), black tiger prawns (*Penaeus monodon*), kuruma prawns (*Penaeus japonicus*) and Sydney rock oysters (*Saccostrea glomerata*) held in tanks survived and grew at similar rates as they grew in seawater. Unfortified saline groundwater is suitable for the salt-tolerant freshwater silver perch (*Bidyanus*) and rainbow trout (*Oncorhynchus mykiss*) at salinities tested to date of 10ppt and 5-20ppt, respectively.

Pilot production of black tiger prawns in greenhouse-covered and uncovered ponds has demonstrated that ambient summer pond temperature range (15-28°C) is limiting to prawn growth, whereas growth in covered ponds was the same as coastal ponds. Cheap methods to heat ponds are being investigated. Semi-commercial production of rainbow trout is being done and results will be discussed.

OVERVIEW OF INLAND – SALINE AQUACULTURE

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With increasing demands on coastal lands and concerns over environmental impact; shrimp farmers, and producers of other marine species, have looked for inland locations in which to farm. Several techniques have been tested with commercial applications now becoming viable. Penaied shrimps have been the first crop, but other euryhaline species including striped bass, barramundi, steelhead trout and certain seaweeds have been tested.

The first applications of inland saline farming were probably in Thailand, where brines were brought inland to create brackish water ponds for shrimp production. In Israel and locations in the United States, complete recirculation systems with transported and artificial seawater, have been operated. Also in the US and Israel, saline aquifers have been tapped to utilize brackish waters for fish and shrimp. In Australia, saline groundwater, due to over-irrigation has been recovered and used to support production of several species.

The commercial success of these operations currently depends on niche markets and continued research support. Specialized diets and mineral amendments to the water may be necessary. Most importantly, the resources available to support the expansion of these techniques are vast. Huge saline aquifers underlie portions of Israel and the Middle East, southern portions of the United States and parts of Australia. Rising groundwater with increasing salinities, are a problem in South and Central Asia, Australia, Brazil, and the Western United States. Utilizing these saline waters could not only turn an environmental problem into a productive resource, but it could also be an important development strategy in several developing countries that need sustainable production technologies.

Integrated farming systems are described that provide food for local markets as well as products for international trade. Production of seaweeds, olives, dates, and certain halophytic plants are needed to remove nutrients from effluent waters generated by the aquatic animals. Salts may be recovered by certain plants, be concentrated for industrial uses, or may be land applied and allowed to re-mineralize in the vadose zone.

A PRACTICAL FRAMEWORK FOR MANAGING AND ASSESSING AQUACULTURE USING ESD PRINCIPLES

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A potential impediment to the continued growth of the aquaculture is meeting the growing community expectations that this industry can demonstrate that they are operating within the principles of Ecologically Sustainable Development (ESD). ESD requires the integration of short and long-term economic, social and environmental effects in all assessments and decision-making. To help achieve this, a series of National ESD frameworks has been developed to enable all Australian fisheries and aquaculture sectors to demonstrate that they are operating utilising ESD principles.

An ESD framework for aquaculture has now been developed that can help to identify the relevant environmental, social/ economic and governance issues. It also assists with determining the appropriate level of management response using risk assessment techniques, and provides a reporting structure that, where relevant, can document outcomes.

One of the main elements of this system is that the environmental components are structured into three different spatial levels - (1) Whole of industry issues, (2) Catchment/Regional issues and (3) Within facility. This hierarchical approach is designed to determine if there are appropriate linkages between the requirements at the operator level and the outcomes expected by government/community at the regional and whole of industry scales.

A '*How to*' guide has now been written that specifies how this framework can be implemented by both government and industry participants. This can assist with the development of reports/assessments at a whole of industry, a regional level, or be used as the basis for an EMS at the facility level.

CURRENT RESEARCH IN DEVELOPING AN AQUACULTURE INDUSTRY USING WATER FROM SALT INTERCEPTION SCHEMES IN SOUTH AUSTRALIA

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In South Australia a number of salinity interception schemes (SIS's) have been constructed to help control the flow of salt into the River Murray. In the Waikerie region there are 93 bores that intercept saline groundwater that would otherwise enter the River Murray. Once the water has been intercepted, it is pumped to an arid area now know as the Stockyard Plains Disposal Basin (SPDB), located 12 kilometres south-west of Waikerie. This water is at a constant temperature of 22-24°C and has a salinity of 16-17ppt. The objective of the research being undertaken is to develop a managed aquaculture system that can best utilise this saline water resource for commercial production purposes.

In 2003 a trial was undertaken at the Cooke Plains Inland Saline Aquaculture Research Centre comparing the growth of a euryhaline species, mulloway (*Argyrosomus japonicus*), in water transported from SPDB outfall with that achieved in salinity adjusted oceanic water (West Beach (WB)).

Growth of mulloway in both water types was virtually identical for the first 3 months of the trial (Figure 1). At the November weight check (92 days) a difference between the treatments was observed. At this time the average weight for the WB treatment was 11.7% greater than the average weight for the SPDB treatment. The difference in growth between the two treatments continued until the experiment was terminated on the 30th December. The food conversion ratio (FCR) of the fish in the SPDB treatment was nearly double the FCR for the fish in the WB treatment. When the trial was finished the SPDB treatment had an FCR of 0.9.

Our results for mulloway in the SPDB treatment indicate that negative impacts on growth rate and FCR took longer in time to occur than for snapper in water with similar potassium concentrations. Future research will examine the effects of supplementing feeds with potassium to maintain optimal growth rates and FCR's.

Currently in SA another SIS is being constructed near Loxton, 100km east of Waikerie. This SIS will be known as the Bookpurnong/Loxton scheme and is expected to intercept 100ML/day for disposal into the Noora basin. It is proposed to establish aquaculture parks aligned to major SIS's providing the research can be undertaken to demonstrate commercial potential.



Figure 1: Average monthly weights for mulloway grown in SPDB water and salinity adjusted oceanic water.

A SIMPLE AND EFFECTIVE METHOD FOR FARM-BASED ENVIRONMENTAL MONITORING OF CAGED MARINE FINFISH

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We have conducted a 3 year multidisciplinary study to assess the potential for progressive degeneration of sediments underlying and adjacent to cage aquaculture operations. We aimed to adapt and develop novel combinations of monitoring techniques to facilitate evaluation of sediment degradation and recovery and incorporate these techniques into farm management protocols. We report here the production of a simple field guide describing recommended approaches for on-site monitoring and a database package for analysis and interpretation of the results tailored to the needs of fish farmers.

Our initial research evaluated several approaches for monitoring sediment condition with regard to both their reliability and usefulness on farms. Some traditional sediment assessment approaches were not particularly useful for monitoring (e.g. organic carbon levels and measures of stable isotopes), whilst others were limited in their application range (e.g. redox potential, sediment sulphide concentrations). However, two visual assessment techniques gave very encouraging results. These approaches characterise the environmental conditions either by evaluation of benthic faunal samples based on photographs or by assessment of video footage. The techniques are relatively inexpensive and can be undertaken by farm personnel after some initial training. The results provide fish farmers with important information regarding their sediment condition, as they identify not only impacted and unimpacted sediments, but also transitional stages and can distinguish degrading and recovering conditions. They can also provide a predictive capacity when analysed in combination with farm production information.

A database has been designed to assist farmers to analyse and interpret the results of the recommended techniques. It comprises a series of data entry and report forms designed to automate the processes of converting and calibrating the results. Summary data reports enable managers to rapidly assess sediment condition within their lease areas. Although developed for the Tasmanian salmonid industry, the field guide and database clearly could be applied in other areas.

STUDIES ON IMPROVED MUD CRAB Scylla serrata Forskål CULTURE SYSTEMS IN THE PHILIPPINES

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Improvement of techniques for the production of larvae, juveniles and market-size mud crab was attempted. Phase I carried out five runs of larval mass rearing to determine the effects on larval production of (1) feeding with microencapsulated diet; treating rearing water with antibiotics (2) furan and (3) oxytetracyline; (4) krill as supplemental feed; and (5) use of F_2 juveniles from hatchery-produced parents. Phase II tested various techniques of nursing zoea (Z) and megalopa (M) to crab stage (C) including feed and other factors. Phase III determined the effect of shelters in the grow-out phase to produce market-size mud crab in ponds and mangrove enclosures.

Phase I. Larvae fed microencapsulated diet did not improve growth and survival. Larvae collected 1 hr after hatching had higher survival (60 %) compared to those collected after 3 hours. Adding *Artemia* at either Z_2 or Z_3 stage did not improve production of *M*. Treating rearing water with 2 ppm Furan did not arrest mortality of Z_1 but use of oxytetracyline resulted to better survival of larvae. Supplementing krill in feeds did not improve megalopa production. The second generation larvae (F_2) from hatchery-produced parents (F1) were observed to be equally robust as those caught from the wild.

Phase II. The 125 M/m^2 density had significantly higher (P<0.01) M survival than the 250 M/m^2 in 23 days but were not different (P<0.05) in terms of mean weight gain and SGR. Using lower densities of 25, 50, 75 and 100 M/m^2 , best survival was 32% at 25 M/m^2 . Survival of M to C after 10 days of rearing was highest at 1M/l and lowest at 8M/l. Molting to C was advanced by 1 day at densities 0.5M/li and 8M/l. Highest percentage of M molting to C was at 1M/l. The range of pH 5 to pH 9 had 100% survival; molting to C started at day 5 between pH 5 and pH9 and highest at pH7. At pH 4, molting failed but those that molted had exhibited certain abnormalities. Desirable protein levels in feeds for mud crab is between 30 and 45%. These were significantly demonstrated in length increment and survival (P<0.05). Mussel meat appears to be the best natural food for mud crab

Phase III. The use of coconut frond base as shelters for mud crab reared in mangrove enclosures and bamboos in brackishwater ponds appeared to have no effect on survival. It is probable that more shelters and other materials are needed to significantly improve survival. Furthermore, the shelters at the densities and ratios used may not be sufficient making it appear that the shelters used did not improve survival of the mud crab in the grow out phase.

EXTENSION - THE PROCESS OF NESTING SCIENTIFIC RESEARCH INTO BROAD SOCIAL SYSTEMS

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There are several 'paradigms' of extension as defined by Coutts (1994). One of these is the commonly called 'technology transfer' paradigm. This paradigm is useful in a restricted number of applications. The contemporary extension professional will use a framework for developing an extension program. This framework will typically use a comprehensive systems analysis to identify what might be the most effective array of extension paradigms to use in a particular situation and what processes will be used within these paradigms.

This paper will describe a framework for designing extension programs. Through this framework a process can be designed with an array of extension paradigms. The paper will discuss the processes typically used for each extension paradigm.

These processes have been used in the development of the ACIAR project 'Development and delivery of practical disease control programs for small scale shrimp farmers in Thailand, Indonesia and Australia'. The paper will use this as a case study to illustrate how an array of paradigms can be put together to effectively nest scientific research outcomes into a broad social system. It will also describe the forms of systems analysis used at the start of the project and will describe the processes designed for each of the countries involved in the project.



Figure 1. Framework for designing and extension program

CUSTOMIZED MICROALGAE MASS-PRODUCTION FOR USE IN AUSTRALIAN AQUACULTURE

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Microalgae are essential live feeds for many aquaculture animals. Along with their nutritional value they are also a rich source of bioactive molecules potentially important for agrifood, human health and other applications. In the aquaculture industry a very small proportion (tens) of the estimated thousands of extant microalgae species are used as live feeds, with whole classes being omitted or rarely used. New microalgae would be beneficial both for nutritional optimization and also for specific animal needs. As well, use of endemic species adapted to local conditions is important when considering the most appropriate strains for both new and established industries and also due to recent concerns of exotic species' introductions.

Traditional methods of microalgae mass cultivation for use as live feeds involve simple but inefficient culture technology, such as bags or tanks with capacities of hundreds or thousands of litres. With an objective being to enable superior quality optimization and cost-effective microalgae production in aquaculture situations, we have investigated the high density cultivation potential of new Australian microalgae strains using several different laboratory scale photobioreactor designs. Strain suitability and biomass production have been evaluated for the different reactor designs (Table 1) and the effect of irradiance, temperature and cell density on lipid class and PUFA profiles has been considered. With careful species and strain selection of microalgae combined with further culturing optimization using high biomass photobioreactor technologies, we believe there is potential for more diverse and efficient production of aquaculture live feeds and omega-3 PUFA.

TABLE 1. Summary of photobioreactor trials ($n\geq 2$) using *Skeletonema* sp. CS-252. VAP = Vertical alveolar panel; VGP = Vertical glass panel; VAC = Vertical annular column. Biomass concentration values represent mean pre-harvest culture biomass. Areal productivity calculated using illuminated surface area.

Photobioreactor design	Capacity (L)	Maximum trial duration (days)	Light path length (cm)	Biomass concentration (g.L ⁻¹)	Volumetric productivity (g.L ⁻¹ .d ⁻¹)	Areal productivity (g.m ⁻² .d ⁻¹)
VAP	4.5	34	1.2	0.81	0.11	1.32
VGP	5	23	2.5	1.40	0.25	6.25
VAC	13	60	2.0	1.36	0.26	4.05

PIGMENTATION OF SALMONID FEED AND PRODUCT QUALITY

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Product quality, especially flesh colour is one of the most important selection criteria of salmonid buyers. Consumers equate 'colour' with product health and quality.

Colour in salmonid flesh is determined by carotenoid source and concentration in the feed. Carotenoid pigmentation regimes implemented in salmonid production are adapted for different species, feeding durations, deposition rates and required target colour. Consequently there are many pigmentation regimes employed worldwide to obtain optimal flesh colour. Commercial experience has shown that one of the most efficient pigmentation regimes is to feed continuously approximately 60mg/kg of astaxanthin for optimal pigment retention in Atlantic salmon. (Torrissen et al, 1995), while in freshwater rainbow trout the level has been reported to range from 50-70mg/kg.

Reduced product quality by excessive colour variation at the time of marketing can be minimized by implementing the most efficient pigmentation regime.

Processing of salmonid flesh can lead to pigment loss and it is important that this loss is taken into consideration when planning pigmentation regimes and the required target flesh pigment level for any one stock of fish. In particular the affect on product quality of freezing and storage is significantly influenced by the pigmentation regime implemented during production.

In order to maximize product quality through colour it is critical for regular monitoring of pigmentation levels throughout the production cycle no matter what pigmentation regime is implemented.

USE OF RECLAIMED WATER FOR AQUACULTURE – AN ASSESSMENT OF OPPORTUNITES AND RISKS FOR THE AUSTRALIAN AQUACULTURE INDUSTRY

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Wastewater is increasingly being recognised as a valuable resource that can be reclaimed for further use, rather than a waste disposal problem. The recycling or re-use of treated wastewater has a key role in the long-term sustainable management of Australian water resources. Only a small proportion of treated wastewater is currently recycled although the Victorian Government has a target of recycling 20% of water from Government owned water businesses in Melbourne by 2010. It is envisaged that increasing wastewater recycling will reduce waste and provide triple bottom line (environmental, social and economic) benefits to the community.

Water Authorities are under increasing pressure to identify options for productive use of reclaimed water and many are actively considering aquaculture as both a value-added use and ecologically-based, low cost alternative to conventional engineered treatment systems. Although this potentially presents a number of opportunities for the inland aquaculture industry in Australia, there are also a number of risk factors which must be considered prior to investment.

Recent research in Victoria has investigated the technical and economic feasibility of culturing fish in domestic and industrial effluent (Gooley, *et al.* 1999; Gooley, *et al.* 2000) and has clearly demonstrated that aquaculture is technically feasible in such wastewaters in Australia. The research has shown that fish culture could make a positive contribution to offsetting effluent treatment costs through the revenue generated by the sale of fish and, to a lesser extent, the removal of nutrients from the effluent flow. Major constraints to commercialisation include the high variability in the quality and quantity of the effluent due to diurnal and/or seasonal variations. Water temperatures and associated ambient climatic variables are additional constraints to integrated wastewater aquaculture in some parts of Australia.

This paper will provide an analysis of the species and production systems that can potentially be used for aquaculture in wastewaters and the management systems that may be employed to ensure optimal growth and survival. Ultimately the intended market for the cultured product will be the key to determining the scale and configuration of the operation and the means by which risks involved in production and marketing can best be managed.

ESTIMATING CARRYING CAPACITY – A DIFFICULT BUT ESSENTIAL PREREQUISITE TO SUSTAINABLE BIVALVE AQUACULTURE

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Sooner or later, all existing and proposed bivalve aquaculture growing areas must consider carrying capacity or sustainability issues. However, determining the carrying capacity limits can be particularly problematic, even for the more straightforward case of production carrying capacity (defined here as the carrying capacity of the area for supporting bivalve culture-at the expense of other ecological processes and communities). It is even more difficult to answer the question: how much bivalve culture can be supported without having undue adverse effects to other parts of the marine system?

The New Zealand legislation only allows the introduction of bivalve culture as long as it does not have major effects to other marine communities and processes, hence New Zealand farmers must demonstrate that existing and proposed activities fit into the existing natural system. Therefore, a considerable level of knowledge on interactions between bivalve culture and the surrounding environment has been developed to help address these issues A number of approaches have been trialled in New Zealand including extensive field studies and the development of the development of food web (trophic interaction) models, and complex coupled and decoupled hydrodynamic/NPZ models. Whilst these technically complex techniques have helped to gain an understanding of these systems, non-scientist stakeholders have had considerable difficulty in understanding and dealing with these methods and their accuracy is certainly questionable. By contrast, the establishment of more practical environmental performance indicators has in many cases proved more effective in managing many growing areas. These methods, and their costs and benefits, will be discussed here.

ARE ENVIRONMENTAL MONITORING PROGRAMS NECESSARY FOR BIVALVE AQUACULTURE? THE PORT STEPHENS, AUSTRALIA, EXPERIENCE

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Shellfish aquaculture is one of the most environmentally benign forms of aquaculture, and recently the value of intensive environmental monitoring programs for this type of aquaculture has been questioned. Indeed, while the scientific literature outlines several cases of negative environmental impacts associated predominantly with mussel farming, it is highly likely that these effects can be overcome through appropriate management and lease controls tied to farm licence approvals. The two most important controls that are likely to lessen any negative environmental impacts associated with bivalve aquaculture are appropriate site selection incorporating good tidal flushing, and controls on stocking density and stock losses If mitigation of environmental impacts can then be incorporated into the planning process, what then is the value of environmental monitoring programs for shellfish aquaculture?

A trial pearl oyster farm has operated in Port Stephens, Australia since February 2000. There has been a very vocal opposition to the pearl farm within the Port Stephens community, and the recent 110th anniversary of the local newspaper nominated the farm as the #1 story in the newspaper's history. The main opposition to the farm centred on the assertion that pearl aquaculture would pollute the "pristine" waterways of Port Stephens, and this assertion received much local media attention. A condition set on this farm was an ongoing environmental monitoring program. Since Feb 2000, sediments have been monitored below the farm site for organic carbon, nitrogen, and phosphorus and compared to multiple control sites four times a year within Port Stephens. Investigations of the impacts on benthic fauna and nearby seagrass beds have also been conducted (Roberts 2002) and more recently, monitoring has also included quantification of a range of nutrients and pollutants in the tissue and shell of harvested oysters.

The environmental monitoring programs found no evidence that the pearl farm had significantly negatively affected the surrounding environment. Rather, it was discovered that the pearl farm was in fact a net bioremediator of the Port Stephens estuary, removing 8 kg heavy metals, 84 kg nitrogen and 6 kg phosphorus in the year 2003. Following public release of these results, opposition to the pearl farm on environmental grounds was reduced, an editorial in the local newspaper supported the farm, and the farm operators had firm scientific data which they were able to refer to in community discussions. This case study outlines the value of environmental monitoring studies in easing the fears of local residents towards molluscan aquaculture, giving farm proponents hard scientific data with which to reassure opponents and allowing decision makers the ability to rationalize use of coastal resources. Further, such data allows decision makers to revise monitoring requirements as well as providing direct means of assessing the impact of a variety of other anthropogenic impacts on waterways

COMPARISON OF FIVE REARING TECHNIQUES FOR THE GIANT SCALLOP Placopecten magellanicus IN THE GASPÉ BAY, QUEBEC, CANADA.

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The giant scallop is an indigenous species of the Gaspé Peninsula, which represents high commercial value; therefore it is potentially interesting. Several rearing techniques are available and it is preferable to determine which is the most adapted to the particular conditions of the Gaspé Bay before undertaking commercial culture.

Juveniles were therefore imported from Magdalene Islands in spring and autumn of 2001 in order to carry out this evaluation. They were immersed into the Gaspé Bay at three different depths into five kinds of devices: earrings (ER), pearl nets (PN), Wang-Joncas lanterns (WJ), Savoury cages (SC) and oyster tables (OT). Growth rates, mortalities and several environmental variables are being followed for each depth, each device and each season of transfer until 2004. Biochemical analyses will supplement field measurements.

Mortalities were high for the scallops transferred during spring, varying, according to device, from 59 to 82% (Figure 1). These losses are mainly ascribable to the combined stresses of transfer and spawning. Mortalities approached normal values after the autumnal transfer. Growth rates are comparable with those observed elsewhere in Quebec (Figure 2). They are similar for ER, PN and SC, but they are lower for OT and WJ. The effect of depth is more noticeable on the meat yield, which is higher near the surface, than on the shell growth rate. These results will be presented with the very last follow-ups carried out in 2003 and 2004.

As Gaspé Bay presents significant interannual variations of the environmental parameters, the follow-ups over the four years (2001-2004) will be useful to determine the average and extreme conditions in order to consequently optimize the rearing strategy. In addition, it is increasingly evident that the meat yield, which can only be determined at the end of the growth cycle, is the important factor in the determination of economic feasibility of each method.







Figure 2. Evolution of scallops average sizes according to the rearing device.

DEVELOPMENT AND EVALUATION OF VALUE-ADDED GRAIN PROTEIN PRODUCTS FOR THE AQUACULTURE FEEDS SECTOR: PROGRESS IN REPLACING FISH MEAL IN AUSTRALIA

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Considerable progress has been made in recent years in replacing fish meal in commercial extruded aquaculture diets with meals from the grain of lupins (Lupinus sp.). Western Australia is the world's largest producer of lupins, with annual production around 1 million tonnes. Presently the majority of the lupin products used is that from kernel meals of the lupin species Lupinus angustifolius and some from Lupinus luteus. Research is presently refining the quality assurance criteria to maximise the successful use of these products in aquaculture feeds. In addition, further research is examining the potential of producing grain based protein concentrates to further reduce fish meal use in aquaculture and increase the diversity of the ingredients available to this feed sector. In a series of studies we examined the laboratory-based development of lupin protein concentrates (LPC) and their evaluation when fed to rainbow trout. Protein concentrate products were developed from both Lupinus angustifolius and L. luteus kernel meals with an increase in protein of 415 g/kg DM to 690 g/kg DM for L. angustifolius and 545 g/kg DM to 750 g/kg DM for L. luteus respectively. A three phase approach to evaluating the nutritional value of the products was undertaken. Digestibility of energy, nitrogen, phosphorus and organic matter was determined using the diet substitution approach, with ingredient inclusion at 30% of the test diets. Apparent digestibility of the energy from the L. angustifolius LPC was 84.2%, apparent protein digestibility was 98.4%, apparent phosphorus digestibility was 138.5% and organic matter was 70.7%. L. luteus LPC apparent energy digestibility was 94.4%, apparent protein digestibility was 102.1, apparent phosphorus digestibility was 131.5% and organic matter was 92.8%. Serial inclusion of either LPC at 0%, 10%, 20%, 30% and 40% into a typical salmonid diet specification allowed an examination of the palatability of each product. Additional negative-controls, based on the 0% diets with inclusion of sulfamerazine sodium, were included in the experiment to demonstrate the capacity of the experiment to detect significant palatability issues. No significant effects of inclusion of either LPC on any fish performance criteria, such as feed intake or growth, were identified. In contrast, significant reductions in feed intake and consequently growth were observed from fish fed either of the negative controls. This experiment demonstrated that each LPC was highly palatable at inclusion levels up to and including 40% of the diet. Using a protein-limited-restrictively-fed experimental approach, the discrete nutritional utilisation of each LPC was defined. Growth of fish fed the LPC treatments was not significantly different to that of the 0% reference diet. Two control diets with substitutions of cellulose to an equivalent inclusion level to that of the LPC's provided an indication of the net benefit of the test ingredients. This experiment demonstrated that each LPC provided equivalent nutritional value to the fish at either of the two inclusion levels (20% and 40%) evaluated. Together, these studies clearly show that the prototype LPC's have substantial potential as a prospective feed ingredient for the aquaculture sector.

INFLUENCE OF FISH SIZE AND WATER TEMPERATURE ON METABOLIC DEMAND FOR OXYGEN BY BARRAMUNDI, Lates calcarifer: IMPLICATIONS FOR DIETARY ENERGY DEMAND

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Oxygen demand by all animals is driven primarily by their needs for sustaining metabolism. Typically larger animals require more oxygen and cellular fuel to carry out respiration than smaller animals. This relationship however, is not linear and is usually described by a coefficient and exponent (eg. ax^b). The exponent b showing the relationship between liveweight and energy/oxygen demand and is often termed the metabolic body weight (MBW) exponent, while the coefficient (a) tends to be temperature specific and describes the relationship between MBW and maintenance metabolic energy and oxygen demand at that specific temperature. In addition to examining the use of cellular fuel (protein, fat and some glycogen) for respiration and maintenance metabolism, it is also possible to examine this relationship based on oxygen consumption. Therefore it is expected that a similar weight specific relationship between oxygen consumption and maintenance metabolism energy demand will also be evident in barramundi. It is well known that food intake affects oxygen demand, therefore the evaluation of oxygen consumption rate by fish that had been starved in excess of 24 hrs was undertaken to provide an assessment of the standard metabolic rate (SMR). The relationship between fish live-weight (x; g) and relative oxygen consumption as SMR (y; mg $O_2/kg/hr$) at 28.6 ± 0.1 °C (mean ± SD) was described by the exponential curve; y=1166x^{-0.434}. $R^2 = 0.985$. Fish, being poikilothermic animals, are thermal conformers and as such their metabolic rate is also strictly dependent on the temperature of their environment. Examination of the pooled data for gross oxygen consumption (mg O₂/ hr) from all experiments (n= 242 assessments) and all temperatures (27.2 to 32.0) showed a relationship between liveweight (x; g) and gross oxygen consumption (y; mg O_y/hr) that was described by the exponential curve: $y = 0.687x^{0.680}$, R^2 = 0.919. The metabolic weight exponent of 0.680 determined in this study was partially consistent with other studies undertaken on barramundi, but differed from data collected overseas. In essence it implies that maintenance energy demands are perhaps higher for smaller fish and lower for larger fish than initially thought. The examination of the relative oxygen consumption data (mg $O_{\gamma}/kg/hr$) as influenced by water temperature showed clear relationships for fish of both 60 g (y = 30.2x - 667, $R^2 = 0.698$) and fish of 410 g (y = 12.1x - 257, $R^2 = 0.634$). The combined relationship between fish live-weight (y: g) and water temperature (x: °C) on gross oxygen consumption rate (z: mg O_2/hr) was described by the equation: z = $3.792 - 0.643x - 0.031y + 0.025x^2 + 0.004xy - 1.397E^{-5}y^2$. Based on nutritional modelling using this data the implications of the findings suggest that diets for barramundi at larger fish sizes (>1000 g) would benefit from being more energy dense and clear changes in energetic demand with fish live-weight also provide an indication of where diet energy density changes should be introduced to optimise production.
WATER USE SUSTAINABILITY IN AGRICULTURAL LANDSCAPES: A CONCEPTUAL FRAMEWORK FOR INLAND AQUACULTURE DEVELOPMENT IN AUSTRALIA

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Inland aquaculture in Australia is a relatively small commercial fisheries sector dominated historically by intensive, flowthrough pond culture of rainbow trout in Victoria, and more recently semi-intensive, cage culture of barramundi in Queensland. Many other species and production systems have been developed and commercialised to varying degrees and with equally varying success over the last 10-20 years, including several species of freshwater crayfish, eels, ornamentals and native finfish. However to date none have become established as significant (> 500 tonnes annual production), stand-alone sectors other than perhaps on a regionally specific basis. Indeed in the absence of a coordinated and strategic approach, the development of inland aquaculture in Australia continues to be somewhat ad hoc and fragmented, and the potential for sustainable, high value, industrial scale production remains largely unfulfilled despite ongoing investment in related R&D and new commercial enterprise.

In this paper a conceptual framework for inland aquaculture development in Australia is proposed based on contemporary water use sustainability imperatives within agricultural landscapes. These imperatives dictate the need for more innovative, higher value, multiple use of valuable irrigation water in agrifood production systems and increased conjunctive use of wastewater through application of cost-effective bioremediation technologies. In short these are the key drivers providing the opportunity for inland aquaculture in Australia to progress to the next level, thereby delivering significant soci-economic benefits to regional Australia. This level will be characterised by the production of clean/green, healthy/safe seafood and other commercially valuable aquatic (by)products, using innovative integrated aquaculture systems which impose a significantly smaller ecological footprint on the natural landscape. More specifically, the role of Integrated Agri-Aquaculture Systems (IAAS) and complementary 'green economics-based' resource management policy, is elucidated in this context. Recent R&D in this area is summarised and reviewed and a long term industry development strategy and vision outlined.

This work forms the basis of a major new study being undertaken by Primary Industries Research Victoria as part of a Victorian state government funded initiative entitled 'Our Rural Landscape', designed to promote and facilitate long term ecologically sustainable agribusiness development within regional Victoria.

EFFECTS OF BACTERIA ON PROGRESSION AND SEVERITY OF AMOEBIC GILL DISEASE IN ATLANTIC SALMON

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Neoparamoeba pemaquidensis is an amphizoic protozoan presumed to be the causative organism of amoebic gill disease in Atlantic salmon. However, Koch's postulates have not been fulfilled and it is possible that whilst presence of *N. pemaquidensis* is required for the disease to occur, presence of additional factors is also necessary. The exact environmental conditions or health status of the fish that allow *N. pemaquidensis* to proliferate on fish gills are unknown. One possibility is that the free living amoebae only colonize the gills of individuals showing an existing bacterial infection that may provide a food source. Therefore, through a series of *in vitro* and *in vivo* trials the effects of salmon gill bacteria on amoeba nutrition, growth and reproduction will be determined.

The first infection experiment included 5 groups of Atlantic salmon. Groups 1-4 were treated with potassium permangante (20 mg/L for 30 min bath), group 5 was bathed in seawater as a control for the same time. Two days later fish were exposed to bacterial suspensions; group 1, no bacteria; group 2, *Staphylococcus* sp.; group 3, *Psychroserpens* sp.; and group 5, no bacteria. After a further 2 days all groups, with the exception of group 5 were infected with *Neoparamoeba* sp. (300 cells/L). Gill and kidney swabs for bacterial recovery, and gills for gross pathology assessment and histology were sampled on days 4, 8 and 12 post amoebae challenge.

The results obtained on day 12 post infection suggest that bacteria enhance the ability of *Neoparamoeba* to cause AGD infection but it was also observed that *Neoparamoeba* is able infect bacterially sterile gills (group 1). However the infection without bacteria was less severe compared to the groups (2, 3 and 4) infected with both bacteria and amoebae. The average lesion size on gill filaments in groups 2, 3, and 4 were significantly greater than group 1 (Figure 1). The AGD severity in groups 2 and 3 was less severe compared to group 4 but group 1 had the lowest AGD lesion severity. Therefore, considering the preliminary results, further work will investigate the dynamics of amoebae infections on both sterile and non-sterile gills to highlight the differences that might have important implications for management of this disease.



Figure 1: Average lesion size on filaments at day 12 post infection (n=2). Values are \pm SE. Different letters indicate values that are significantly different.

REMEDIATION AND MANAGEMENT OF ACID SULFATE SOILS IN COASTAL AQUACULTURE PONDS

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Throughout Southeast Asia, acid sulfate soils (ASS) are considered one of the main constraints on the shrimp aquaculture industry. Chronically low yields in ponds impacted by ASS could be attributed to several causes including, decreasing pH and increased toxic metal concentrations in pond waters, or increased toxicity of reduced pond bottom sediments. There are few published scientific studies on ASS in coastal aquaculture, of which most have focused on the management of ASS. Majority of these studies, however, lack the rigorous experimental work on soil chemical and mineralogical processes required to underpin effective management recommendations.

The most common management practices include liming, seawater neutralisation, submergence, and a combination of forced oxidation and extensive leaching. The effectiveness of these methods in ASS aquaculture environments has been variable, and where successful have offered only short-term solutions. Long-term amelioration of these soils has not been adequately addressed, largely because pond soil influences on pond water quality have not been fully investigated. As such most so called remediated ASS ponds continue to suffer from low production, disease and mass mortalities.

These apparently unsuccessful but widely recommended management practices are based on several assumptions on the sources and rates of acidity being generated within these ponds. Recommended management practices often neglect to consider the complex chemical and physical interactions within pond environments, which greatly influence the behaviour of ASS. In many instances farmers are not even aware that the pond soils are likely to continue generating acidity and mobilised toxic metals during the growth period when ponds are filled. As such, there is a severe underestimation of the acid producing and metal releasing potential of pyritic pond soils.

Detailed investigations on the interactions between dyke soils, accumulated sediment, and water quality were conducted in order to identify major factors potentially contributing to lowered production in ASS ponds. These investigations revealed complex interactions between biological, chemical and physical parameters, which affected the production of acidity within ponds. The results of these investigations formed the basis of several recommendations for the improved management of ASS-affected farms. Remediation trials utilising these new management practices, undertaken in Indonesia, have demonstrated dramatic improvements in pond water quality and production yields.

INTEGRATING A GENETIC APPROACH INTO THE NEW-CALEDONIAN SHRIMP INDUSTRY FOR BIOLOGICAL AND ECONOMICAL SUSTAINABILITY: PAST, PRESENT AND FUTURE

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The New Caledonian shrimp industry represents the largest agriculture export production of this country and has strong social benefits. Though limited compared to the world landings, New Caledonian production continues to increase in terms of tonnage, pond area and number of farms. This activity is based on the culture of the blue shrimp *Litopenaeus stylirostris* which was introduced from Panama and Mexico *via* Tahiti in 1978, tested and then hatchery-propagated for more than 25 generations in research laboratories and private companies. The progressive domestication which occurred during the first generations resulted in a strain of *L. stylirostris* genetically resistant to IHHNV, well adapted to the local environment, and this allowed New Caledonia to become a world leader of this high quality species benefiting from a high priced product. As in most human activities, this industry is now facing the challenge of staying ahead of the international competition, and this challenge has a genetic component.

A structured program in genetics emerged in 1992 and aimed at the assessment of the potential to improve the rearing performances through a breeding program. This potential depends structurally (i) on some biological factors (the genetic component of the desired traits and the available variability among the cultivated population) and (ii) on the capacity of the industry to turn these biological factors into technical advantages. The scientific program demonstrated the feasibility of mass selection for growth (despite a relatively low response to selection), the positive correlation between heterozygosity and growth rate, and the low level of genetic variability of the New Caledonian population in comparison with a wild population from South America. In addition, the genetic variability of a Hawaiian line of *L. stylirostris* (the only one in the world to be Specific Pathogen Free) was assessed. These results led the New-Caledonian shrimp farmers to consider the necessity of additional genetic management even though the performance of the New Caledonian strain still appears good. A risk analysis was developed to allow industry to chose between several options: no importation, importation of wild animals, importation of the Hawaiian SPF domesticated line.

In order to promote a common strategy in shrimp genetics, the farmers created an association which chose to introduce the Hawaiian SPF line through a quarantine procedure. Several actions are now under development in collaboration between the public institutions and this association:

- pilot scale experimental early selection for growth;
- management of inbreeding in the New Caledonian line;
- introduction of the Hawaiian SPF line of *L. stylirostris*; this line will be compared to the New Caledonian line and the reciprocal hybrids in experimental facilities before its exploitation at a production scale.

FOSTERING A PROFESSIONAL APPROACH TO MARKETING

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As aquaculture emerges around Australia, companies are discovering, often through costly experience, that Marketing is not just 'window-dressing' but an integral component of the operation. One that is as vital to the business as the entire production process. If you can't sell it for the right profit, why grow it? And it is Marketing that drives a successful sales program.

Marketing involves cost; it involves people; and it involves skills - some of which are complex and require specific training and experience.

In an era of intense global competition, good marketing can't guarantee success. But the absence of good marketing WILL guarantee failure.

Why is it that in a country where seafood is the most expensive, and most sought-after primary protein, many seafood producers struggle to survive?

Aquaculture investors should be asking that question long before they risk their money and, if they proceed, should be fostering a resource of marketing skills long before they have product ready to go. Only then they can capitalise on the strengths of aquaculture in a world where consumer awareness is increasingly directing market share.

Being forced to meet some of the world's toughest environmental sustainability requirements ought to offer Australian aquaculture a significant competitive advantage. But with the absence of a strong marketing culture within the industry, the opportunity for successful 'cause branding' has diminished and the industry's negatives have now emerged as a serious threat. It will take a strong and sophisticated approach to marketing to halt the increasingly negative local consumer perception of aquaculture that is now apparent in Europe and North America.



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Amoebic gill disease (AGD) is the only significant health problem affecting commercial Atlantic salmon (*Salmo salar* L.) production in Tasmania, Australia. The putative causative agent is *Neoparamoeba pemaquidensis*. Fish with AGD have raised, white mucoid patches on their gills (Figure 1) and hyperplastic gill lesions (Figure 2) with associated *Neoparamoeba* sp. attached. Currently the only efficacious method for treating AGD is with a freshwater bath, a time consuming and expensive process. Little is known about the immunological host-pathogen interactions that occur in Atlantic salmon during infection with *Neoparamoeba* sp. The current studies aimed to identify the *in vitro* and *in vivo* interactions of *Neoparamoeba* sp. and innate immune cells.

Studies have demonstrated the presence of an acquired immune response following *Neoparamoeba* sp. exposure. However, the effect of AGD on the innate immune system is relatively undescribed.

In vitro studies have demonstrated a significant priming effect of *Neoparamoeba* sp. sonicates on the chemiluminescence response of salmonid phagocytes. *In vivo* studies have also identified a significant effect of *Neoparamoeba* sp. exposure and resulting AGD on systemic innate immune cell function.

Mechanisms by which attachment to the gill epithelium and interactions with localised immune cells translate to systemic responses are yet to be elucidated, however it is expected that characterisation of gill leukocyte lineages during infection will significantly enhance our overall understanding of amoebic gill disease.



Figure 1: AGD gross pathology. Gross gill patches associated with AGD, note the white, raised mucoid patch (MP).



Figure 2: AGD histology. Hyperplastic lesions (HPL) and associated *Neoparamoeba* sp. (NP).

PRACTICAL CONTINOUS ALGAE CULTURE IN A COMMERCIAL HATCHERY

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This talk describes the general operating principles of a continuous algal production system developed at Seasalter Shellfish (UK). Some recent developments in the field will be highlighted and discussed in relation to the direction our research and development is taking.

Based on research conducted by Michael Droop in the UK during the 1960's, the system described is the result of 35 years work by one of us (JB) in adapting the original concept to supply the algal needs of a commercial mollusc hatchery in an efficient manner.

The primary goal was to produce the required amount of *quality* microalgae *reliably* and *consistently*. The secondary goal was to minimise production costs and eliminate unnecessary labour. These initial goals have now been substantially realised and production for most of the major species is a reliable, relatively straightforward and cost effective procedure.

Pasteurisation has proven to be the most reliable way to remove unwanted pathogens from the culture water prior to its inoculation with algae. The Pasteurian principal of destroying microorganisms with heat and then reducing the opportunity for reinfection is highly effective in circumventing chance contamination of the culture.

By harvesting algae continuously from the culture bag and replacing it with fresh nutrient enriched and pasteurised medium the culture can be maintained in a steady state of relatively constant cell density. This reduces the likelihood of cultures "crashing" and most species of interest in the hatchery can be reliably harvested for around ten weeks before there are visible signs of deterioration.

Production costs have been reduced by always investigating low energy or low labour alternatives to our prevailing methods. Current energy requirements for a 7000 litre per day production unit are approximately 4kw per hour and the labour requirement is approximately 15 hours per week.

GEOCHEMICAL RELATIONSHIPS AT THE SEDIMENT-WATER INTERFACE WITH EMPHASIS ON NUTRIENTS, AT A MARINE PRAWN AQUACULTURE FARM, SOUTH-EAST QUEENSLAND, AUSTRALIA

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In prawn aquaculture ponds the accumulation of nutrients such as phosphate, nitrate and ammonia at the sediment-water interface deteriorates water quality and affects the health of aquaculture species. Sediment dwelling commercial prawn species such as the Karuma Prawn (Penaeus japonicus) are especially affected by the build up of nutrients at this interface. Elevated nutrient concentrations $(NH_4^+, NO_3^- \text{ and } PO_4^{-3-})$ can lead to algal blooms which in the absence of sufficient aeration can deplete oxygen. This can cause the deterioration of prawn health, lead to prawn mortality, and reduced pond productivity.

Two acid sulfate soil affected ponds at a marine prawn aquaculture farm situated in coastal south-east Queensland were selected as the basis for this hydrochemical study. Water samples were collected during multiple field trips between November 2001 and June 2002. Samples were taken from the water column and underlying sediments using transects of nested piezometers. These provide vertical and lateral sampling points for the collection of water samples that assist in understanding the chemical evolution of the ponds. Phosphate (PO₄³⁻) and oxygen concentrations were found to be variable from the pond surface, through the water column, and into the underlying sediments as seen below:

There is depletion of oxygen with depth. This is due to oxidation reactions and the respiration of organisms which leads to a variety of redox reactions. The oxygen concentrations at the sediment-water interface are below concentrations (<3mg/L) that are lethal to the prawns in two of the three sampling periods in Pond 7 and all four sampling periods in Pond 10. Phosphate concentrations in the water column are around 10 times, and sediments 100 times, that of the adjacent estuary which provides intake water. It is inferred that phosphate concentrations in the shallower samples are lower due to the photosynthetic activity of algae. The elevated concentrations at the base of the pond may be due to: lower light intensity; soil water interaction; fertiliser addition to stimulate algal growth; prawn waste accumulation; or excess feed accumulation.



HETEROSIS FOR GROWTH IN A DIALLEL CROSS BETWEEN TWO STRAINS OF SILVER PERCH Bidyanus bidyanus

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Silver Perch is a developing aquaculture industry in Australia, producing around 400 tonnes valued at \$3 million annually. A genetic improvement program, aimed at improving growth rates and involving cross-breeding, mass selection and heritability studies commenced in January 2004. Three experiments were run at the Grafton Aquaculture Centre to determine if crosses between two wild strains of silver perch from the Murray River (M) and Cataract Dam (C) result in hybrid vigour during the larval rearing and fingerling phases of production.

In the first experiment, larvae (overall mean = 5.8mmTL) from 9 pairs of broodfish (0.65-2.8kg) of each cross were stocked at a density of $54/m^2$ in 8, 0.1ha earthen ponds and cultured for 82 days. There were two replicate ponds for each cross. Water temperatures ranged from $21.2 - 29.7^{\circ}$ C. Ponds were fertilized weekly (7kg DAP, 200g potash and 35kg lucerne chaff) for 5 weeks and weaning began 31 days after stocking. Post-larvae were fed a diet containing 50% crude protein and 19MJ/kg energy. A total of 349,735 fry were harvested from the 8 ponds. Survival ranged from 63.9-94.0%. C x M grew faster (specific growth rate, SGR, 8.5%/day) and had the highest size variation (COV, 41.8%) compared to M \bar{x} C ($\bar{8}.2\%/day$, 32.3%), M x M (8.3%/day, 37.1%) and C x C (8.2%/day, 36.5%). Heterosis was positive for body weight (20.4%) and total length (7.7%).

In the remaining experiments, fry (2.2-3.5g) were stocked in 12 x 1m³ floating cages at 200 fish/m³ and 8 x 0.1ha earthen ponds at 80,000 fish /ha for 106 days. Cages were attached to a walkway in a 0.32ha aerated, earthen pond. Fish were fed twice daily a diet containing 50% crude protein and 19MJ/kg energy for 42 days, and a diet with 37% crude protein 13.5MJ/ kg energy thereafter. These two experiments are currently in progress and will terminate in April 2004.

CURRENT STATUS OF LIVE FOOD CULTURE IN JAPAN

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Euryhaline rotifer *Brachionus plicatilis* complex has been used as a first live food for rearing marine fish larvae. Even under identical environmental conditions, genetically similar rotifer strains have variable size, thus, selection of appropriate size of rotifer strains is useful for feeding fish larvae whose mouth size differ among species and growth stages. Rotifer life history parameters such as reproductive characteristics and lorica size can be regulated artificially using chemicals such as neurotransmitters and hormones. In vivo enzyme activity test is useful for detecting instability of rotifer cultures.

Culturists generally feed rotifers several times a day. In this condition, however, rotifers suffer periodical starvation, which results in low quality rotifers that live long and spawn less. Recent development of continuous culture system for rotifer mass production has enabled the aquaculturists in Japanese public hatcheries to carry out stable rotifer production of higher quality live food. This system utilizes large tanks (e.g. 25 m^3) used in conventional rotifer cultures. With continuous culture water inflow, feeding and harvest, L-type *B*. *plicatilis* can be produced at $0.2-1x10^8$ rotifers/day/m³ for 40-220 days. Rotifer population growth rates of this system are higher than those of conventional batch culture or semi-continuous culture methods, while the production costs are the same.

Live rotifers can be stored under low temperature such as 4-12°C. Resting eggs are appropriate for long-term preservation of rotifers. By using a continuous culture system in 25 m³ tanks, 5.2 to 5.9 x 10^9 resting eggs can be produced in 15 days, which are about 40 % higher than those produced in batch culture method.

CAPTURE AND CULTURE OF PRE-SETTLEMENT CORAL REEF FISH FOR THE MARINE AQUARIUM TRADE IN SOLOMON ISLANDS

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Between 1999 and 2003, the WorldFish Center in Solomon Islands conducted research into the feasibility of a new fishery based on the capture and culture of pre-settlement (or post-larval) coral reef fish for the live fish trades. Harvest at settlement could form the basis of a sustainable fishery because of the high mortalities associated with the transition from a pelagic to a benthic lifestyle. If feasible, the fishery could provide a much-needed source of cash income for rural communities in the Asia-Pacific region. The work was funded by the Australian Centre for International Agricultural Research and carried out in two phases: a research phase from 1999 to 2002; and a "fine-tuning" phase in 2003.

During the research phase, light traps and crest nets were used to sample pre-settlement fish communities over a period of two years. Light traps (n=3) were deployed for six nights per month and caught a total of almost 93,000 fish belonging to 50 families. Catches were dominated by Apogonidae (72% of the total) and Pomacentridae (16%). Crest nets (n=2) were set for 14 nights per month and caught around 150,000 fish belonging to 85 families. Net catches were more diverse and dominated by Labridae (27% of the total), Gobiidae (22%) and Apogonidae (11%). With the exception of lobster, which recruited in greater numbers between June and September each year, no other taxa or groups showed any seasonality. Very few live reef food fish species were recorded but marine aquarium species were present in catches. Light traps caught highest numbers of aquarium fish, predominantly pomacentrids. However, crest nets caught a greater diversity of high-value species, specifically banded cleaner shrimp and tropical spiny lobster. Overall, they accounted for more than 80% of the total farmgate value, mostly due to cleaner shrimp. Crest nets were selected as the best harvest method for development of an artisanal fishery because they were also reliable, easy to operate and cost effective. Over 120 species of pre-settlement fish were transferred to raceways and floating sea-cages during the research phase. Cleaner shrimp and lobster could not be reared in floating cages and were reared in mesh cages on the seafloor. Most species were ready for export within three months of capture.

The fine-tuning phase was primarily concerned with increasing survival of pre-settlers caught using crest nets and improving the growth and survival of target species during rearing. The development of increased survival and improved condition of live fish during capture. Survival of teleosts, cleaner shrimp and lobster was 64%, 97% and 97%, respectively. Another method to catch lobster pueruli was developed, using drilled coconut logs as artificial settlement habitat. Grow-out techniques for shrimp were improved by rearing them separately in jars that were painted black to prevent aggression and to protect the shrimp from sunlight.

An economic model using real data indicates that a fishery based on shrimp supplemented with small numbers of lobster and fish is economically feasible. The next phase of the project is technology transfer with the establishment of a village demonstration farm in the Solomon Islands.

EFFECT OF DIETARY ESSENCITIAL FATTY ACIDS ON BODY COMPOSITION OF JAPANESE EEL, Anguilla japonica

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The present study evaluates the dietary supplementing with essential fatty acids (EFAs) such as docosahexaenoic acid (DHA, 22:6n-3), eicosapentaenoic acid (EPA, 20:5n-3) or arachidonic acid (ARA, 20:4n-6) of these HUFA on growth, survival rate, and biochemical composition in juvenile Japanese eel during a 10-week culture period. Three different essential fatty acids were evaluated the differences in fatty acid incorporation in juvenile eel, *Anguilla japonica* in experimental feeds with different level for this experiment. For the evaluation of the essential fatty acids, feeding trials will be carried out to evaluate the effects of the essential fatty acids supplementation on growth, survival rate, specific growth rate and body proximate composition.

A NATIONAL SURVEY OF DISEASES OF COMMERCIALLY EXPLOITED ABALONE SPECIES – A MOVE TO ADVANCE BOTH PROFIT AND SUSTAINABILITY

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This reports on a FRDC Abalone Aquaculture Subprogram project to survey the diseases of wild and farmed abalone in each of the States with commercial abalone industries. The purpose of the project was to provide knowledge of disease status to support both trade and translocation, and to facilitate the development of health monitoring programs for both industries. The need for such a project reflects the lack of disease surveys in wild aquatic animals generally, and the relatively undeveloped state of mollusc pathology. An understanding of disease processes is most important for abalone farming because of the intensive nature of abalone farming, with both environment and feed being man-made. Building diagnostic expertise is therefore seen as important as increasing and confirming knowledge of Australian abalone diseases and regional disease status.

The survey strategy is to undertake a single-round health survey of statistically relevant numbers of abalone from all abalone farms and reseeding operations and from representative wild groups of commercial abalone species throughout their natural range. Examination is being undertaken in the major aquatic animal diagnostic laboratory in each of the 5 states, to build a broad diagnostic expertise base. The survey is linked to *Perkinsus* studies where appropriate, to increase the understanding of any disease interactions, though specific *Perkinsus* findings will be presented separately. To maintain this, project outputs will emphasise presentation of findings as a specialist training resource.

Findings from the survey will be presented, including bacterial, fungal and parasitic diseases. However perhaps the major finding to date is tissue damage in farmed and recently collected wild stock reflecting non-infectious stress processes, which have the potential to significantly limit productivity. Understanding such changes is essential for the diagnostic process to progress to determining precipitating causes and possible corrective procedures.

The project commenced with a commitment of growers in each State to develop an on-going health monitoring programs for farms, plus considerable interest to have this available also for the wild fisheries sector. Farms see such programs as putting them in a unique position to enable them to prevent disease in their stock and of meeting future market expectations in relation to health accreditation. The project findings to date support this outlook, with a growing awareness that stressful conditions on farms can precipitate disease outbreaks and allow the build-up of minor pathogens to potentially important levels. Increasingly, therefore, such programs are being seen within the context of Environment Management Systems. Onfarm disease monitoring geared to minimising production losses would provide considerable surveillance information of internationally significant diseases to meet market requirements.

IDENTIFICATION OF A RICKETTSIA-LIKE ORGANISM CAUSING DISEASE IN TASMANIAN FARMED ATLANTIC SALMON

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Extensive investigations into unexplained clinical disease noted in farmed Atlantic salmon in the south-east of Tasmania resulted in identification of a previously undescribed rickettsial-like organism. This finding was part of the Tasmanian Fish Health Surveillance Program, which is conducted as a joint initiative between the Department of Primary Industry Water & Environment and the Tasmanian Salmonid Growers Association.

Clinical expression and pathological changes were similar to those previously described elsewhere for piscirickettsiosis in salmonids, however the low mortality rate, lack of associated skin lesions and difficulty in visualising the organism suggested a different organism might be involved. A causative agent was not identified in tissues during early stages of the disease, instead characteristic riskettsia-like organisms were only noted in samples collected 10-14 days after the onset of clinical signs. Clinical outbreaks were generally associated with known stress episodes or concurrent infection with Tasmanian reovirus.

Isolated outbreaks of the disease in the three years subsequent to the first event have been characterised by generalised congestion in peracute cases, anaemia and ascites in subacute stages and finally pathognomonic doughnut shaped hepatitic lesions (Fig 1). Histopathologic findings include a generalised vasculitis and characteristic spleen and kidney haematopoietic changes as well as necrosis of affected cells within a wide range of tissues. Rickettsia like organisms were most commonly seen in liver, blood vessels, macrophages and occasionally pancreatic acinar cells, spleen, kidney and brain.

Attempts to culture the rickettsial-like organism on cell lines, as recommended by the OIE, were unsuccessful but there was weak cross reactivity with immunoperoxidase when using an antisera raised against a reference strain *Piscirickettsia salmonis*. When the OIE PCR for piscirickettsia was conducted on nucleic acid extracted from pooled tissues of affected fish, a specific product of the correct size was obtained, indicating this test is useful for detecting the organism. The sequence of this PCR product was consistent with a "rickettsia-like organism", though overall evidence is that this differs from *P. salmonis*.



PERFORMANCE OF ATLANTIC SALMON UNDER SUMMER WATER CONDITIONS

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Overcoming compromised Atlantic salmon performance during summer remains an industry priority. Recent studies by Skretting and School of Aquaculture have focused on the influence of diet formulation on post-smolt performance at high water temperature and low dissolved oxygen. The primary response considered has been growth and food conversion – but other biological measures are being investigated. An intake-response approach has enabled modeling performance at a range of protein and energy intakes - allowing differentiation of diets from intermediate feed intake (ration level) up to satiation feed intake (ration maximum). Focus has been on formulations common Tasmanian industry, namely Atlantic HE (400 g.kg⁻¹ protein, 300g.kg⁻¹ fat with 20.4 MJ DE.kg⁻¹), Atlantic HP (450 g.kg⁻¹ protein, 250g.kg⁻¹ fat with 20.6 MJ DE.kg⁻¹) and Atlantic HT (500 g.kg⁻¹ protein, 200g.kg⁻¹ fat with 19.1 MJ DE.kg⁻¹). But non-commercial formulations have been included to compare to these industry standards. The results presented further our understanding of maintenance and the intake-growth response relationship of Atlantic salmon under summer water conditions.

USE OF Bacillus CULTURES AS PROBIOTICS FOR AQUACULTURE

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Probiotics are live microbial cultures that promote good animal health. The use of probiotics for terrestrial animals is welldeveloped and is attracting more attention, particularly as the use of antibiotics in farming has come under increasing pressure. Probiotics are also of great benefit in aquaculture and allow the use of chemicals to be greatly reduced or eliminated.

The bacterial species used for aquaculture overlap to some degree with probiotics for terrestrial animals; however the properties required of aquaculture probiotics are quite different. This arises especially because effective aquaculture probiotics play an important role in maintenance of good water quality as a means of promoting good health and reducing the incidence of disease.

Bacillus cultures in particular are widely used as probiotics for aquaculture for a number of sound reasons. However the selection of strains for commercial use has a large impact on the effectiveness of the probiotic products in the field. Apart from being safe and well-characterised in the laboratory, good probiotic strains for aquaculture need to be well-proven under actual field conditions.

OPEN OCEAN SHELLFISH AQUACULTURE IN NEW ZEALAND

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Open ocean shellfish aquaculture is a new development in New Zealand. A >2000ha submerged farm is presently under development off the east coast of the North Island, New Zealand. The development is being undertaken by a partnership program involving industry and indigenous Maori in a joint venture company (OTD, Offshore Technology Developments), and a research provider (Cawthron Institute).

The project has been split into three stages:

- 1. Planning and consent
- 2. Experimental and trials
- 3. Commercial development

The first stage of the project is now complete following an inclusive management approach and consultation with local stakeholders. The second stage of development, which commenced in July 2003, is presently underway. This research will help develop the knowledge required to make structural, economic, environmental and logistical decisions for the commercialisation process. The third stage of the project is due to start in the latter part of 2004.

Various aspects of the project will be discussed.

AN ALTERNATIVE HIGH DENSITY NURSERY REARING SYSTEM FOR LARGE SCALE, YEAR-ROUND, LOW COST PRODUCTION OF BLACKLIP ABALONE *Haliotis rubra* SEED FOR FISHERIES ENHANCEMENT OR ON-FARMING

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Very large improvements have been made to the reliability, efficiency and cost of large scale seed production of black-lip abalone for fisheries enhancement or on-farming. The first step in achieving these improvements was year-round access to and induced spawning of ripe ready-to-spawn broodstock maintained in energy efficient holding facilities that combine high turnover water reuse with a low daily net exchange of new seawater. This in turn enabled routine generation of multiple annual batches of high quality eggs and larvae. This attribute was then coupled with gregarious settlement induced by stocking competent larvae at high density of $1-2/cm^2$ onto conventional diatom nursery plates. Gregarious settlement has the added advantage of circumventing the need of alternative settlement inducers such as exposure to neuroactive compounds such as GABA or pre-inoculation of the plates with *Ulvella lens* or crustose coralline algae. Survival of resultant post-larvae consistently stabilizes at 20-30% after about 4 weeks resulting in yields of about 0.2 to 0.4 /cm² (700 – 1500 per standard 300x600mm diatom plate). By ensuring that the post-larvae are harvested as soon as they attain a mean size of about 1mm after 5 weeks (summer) to 10 weeks (winter), they are prevented from overgrazing plates thereby maintaining exponential growth and good general health and vigor. This in turn facilitates high survival and rapid weaning onto formulated diets following their transfer into shallow raceways.

POTENTIAL FOR ENHANCING THE NSW BLACKLIP ABALONE Haliotis rubra FISHERY USING HATCHERY PRODUCED SEED

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NSW Fisheries is attempting to reverse a long-term decline in the state's sustainable catch of blacklip abalone. As the fishery appears to be recruitment limited, it is likely that its decline could be reversed by stocking depleted reef with hatchery produced seed. Research started in July 1998 to explore this possibility has achieved a number of important advances including reliability, versatility and cost of seed production. About 30 million larvae and almost a million juveniles, mainly button size (5-15mm), were experimentally seeded. These were mainly deployed by SCUBA divers in clusters of 700 to 2,500, pre-stocked into predator protective release devices. Although more than 40 reef sites at 6 locations along the NSW coast were seeded, survival rates a year or so after release were low, ranging from 0-3.5%. These compare poorly with typical rates for wild stock of 12-40%.

These disappointing results prompted a search of published information on the ecology of black-lip abalone that found that while densities of recently settled wild post-larvae commonly vary greatly from less than 10 to several 1000 /m_ of reef surface, surviving juveniles converge to a narrow density range of $1-3/m_$ as 1+ year olds. Results of laboratory experiments with larvae and week-old post-larvae seeded onto simulated juvenile habitats showed that these low densities were probably due to food limited carrying capacity of the coralline algae encrusted rock habitats more than to predation or other factors.

The poor seeding results also prompted development of an economic model for enhancing abalone fisheries based on size and age related mortality data of wild abalone. The model predicts that seeding of larvae will be cost prohibitive and that button size juveniles will be the most cost effective seed. These findings in turn prompted a final experiment to test whether low survival could be overcome by dispersed low density seeding of juveniles matching the low carrying capacity of natural habitats. Two treatments were used at 3 sites. In the first, juveniles were released as 10 clusters of 100 and in the second as single clusters of 1000. A year later, a mean survival rate of 12.5% for dispersed seeding was within the range of wild stock while that of juveniles released as a single large cluster was again a low 3.8%.

Beginning in April 2004, a one year extension to experimental seeding research will follow-up this encouraging result of dispersed low density seeding. A range of deployment strategies and issues to be assessed include: comparison of clustered vs dispersed seeding at different densities; evaluation of urchin shadows for reducing post-release mortality; evaluation of multiple low density seeding of sites vs single higher density seeding events; effects of natural and artificial diets on survival and relative performance of sibling diploid and triploid juveniles when seeded onto depleted reef.



INDUCTION AND EVALUATION OF TRIPLOIDS IN THE BLACKLIP ABALONE Haliotis rubra FOR FARMING AND FISHERIES ENHANCEMENT

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This study, conducted in collaboration with NSW Fisheries, aimed to optimise chemical induction of triploidy in the blacklip abalone *Haliotis rubra*. It is also continuing to investigate the relative reproductive and growth performance of resultant sibling triploid and diploid stock. A purpose designed experimental system enabled complex experimental designs with adequate replication involving three triploidy induction treatment factors in factorial combination to be applied to a common batch of fertilised eggs. The factors were chemical dosage, starting time of chemical exposure and duration of exposure. This provided information on both the individual and interactive effects of the factors on triploidy yield. This study contrasts with previous studies of triploidy induction in molluscs that have either used different batches of eggs to create replicates, thereby introducing the confounding effect of batch, or have failed to apply replication.

Results up to 19 months after fertilization showed that diploids and triploids performed equally (P > 0.05). At 22 months, a significant difference in mean live-weight (8.91 vs. 8.18 g) had emerged, but not in mean shell length (37.0 vs. 36.2 mm). Sexually matured individuals (mainly males, as indicated by general appearance and color of the gonad) were recently observed amongst both ploidy classes. To date, the testes of adult triploid males appear more developed than those of their diploid counterparts.

EFFECTS OF STOCKING DENSITY FOR YEAR 1 AND GRADING STRATEGY IN YEAR 2 ON GROWTH, SURVIVAL AND PROFITABILITY FOR MARRON *Cherax tenuimanus* STOCKED INTO AND HARVESTED FROM MODEL FARMING PONDS IN SUMMER

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Marron are often farmed in Western Australia by stocking juveniles into semi-intensive ponds in winter about 6 months after maternal care ceases in summer, selling sufficiently large marron in the first 12 months, and growing the remainder for up to a further 12 months. Efficient harvesting/restocking in cooler months is achieved by draining the pond, removing all marron by hand, washing out accumulated organic matter, and refilling and restocking winter juveniles. In warmer months, less efficient partial harvest methods are used by farmers i.e. using baited traps or "hide harvesting" i.e. displacing marron from hides (folded bundles of fine plastic mesh netting with a float and weight at opposite ends) into a framed net. Summer harvesting is important for providing continuity of marketing and, to improve the efficiency of this strategy, summer drain harvesting is being evaluated in this research. Harvesting in summer would also necessitate restocking with very small juveniles eg 1-2 months old, and re-use of water as water supply is limiting in summer at many commercial sites. Marron are typically sold live to domestic and export markets and hence efficient handling is needed, particularly under summer conditions.

This research in twenty 150 m² ponds is aimed at answering the following questions:

- For 2 year production cycles, should year 1 be run at a high density (13.5 juveniles/m²) instead of a low density (5.0/m²), followed by a low density (3.1/m²) in year 2? Initial analyses favour the high density strategy for Year 1.
- In year 2, after harvesting of all stock at the end of year 1, should marron be restocked without any grading, or as two size grades or as two sex groups? Initial analyses indicate that stocking ponds with all males depresses survival.
- Can a stocking, drain harvest, restocking and final drain harvest cycle, with each of these steps carried out in summer, yield good survival at final harvest and during post harvest handling? At the lower density survival exceeded 80% in year 1 and 75% in year 2.
- Can the 150 m² ponds be operated successfully using only reused water (after passing through settlement and macrophyte ponds)? While survival in year 2 was lower than anticipated, the water reuse strategy was successful and has the potential to reduce a major limiting factor for freshwater pond culture i.e. inadequate water supplies for pond exchange.

EFFECT OF GRADING ON POND GROW OUT OF GOLDEN PERCH Macquaria ambigua

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Golden perch (*Macquaria ambigua*) is recognised as one of Australia's premier freshwater table fish. Until recently aquaculture development of this species was stifled due to the perception that they would not take artificial food. Following development of weaning techniques and use of a nursery phase, grow out of golden perch was trialed in experimental aquaculture ponds. After a pond nursery phase, fish were graded into large and small groups (arbitrarily selected 50% of pond populations for each pond) and restocked into separate ponds at a lower density (14 060 fish/ha). Ungraded fish were left in nursery ponds at 37 500 fish/ha.

Comparison of average growth after nine months of grow out demonstrated that the large fish exhibited good growth rates, attaining an average weight of 250g After that size they are capable of growing at 100g per month and quickly reach the required market size of 400-700g. The largest 50% of the ungraded fish in the higher density had similar growth rates to the graded large fish. In contrast, there was no increase in growth rate of small, graded fish after they were moved. The smaller 50% of fish in the ungraded populations had similar growth rates to the small, graded fish.

The implications of this for culture of golden perch are that early grading of about 50% of smallest fish will remove the proportion of fish that did not to grow in the experimental conditions trialed. The mechanisms of lack of growth in a proportion of fish are poorly understood, and require research into effects grading, behaviour, and environmental conditions on growth. In particular, pond size, water depth and turbidity may have major impacts on growth patterns of golden perch. Golden perch are very tolerant of high pH (feeding up to pH 10.3), ammonia up to 5 mg/L, and temperatures between 14 and 33°C. As such, they are well adapted to conditions of aquaculture ponds when water availability is restricted.

BETTER CONTROL IMPROVES SEED PRODUCTION FOR NEW ZEALAND PAUA (ABALONE) Haliotis iris

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Production of seed, or juveniles, is the most technically demanding part of abalone farming. In the New Zealand paua farming industry it is an activity that small enterprises have generally been unsuccessful in undertaking, and they have needed to purchase seed to stock their farms from other companies. The National Institute for Water and Atmospheric Research set up a paua seed production unit in 2001. NIWA's seed production is assisting the development of the industry by supplying paua farmers with seed, and also with ready-to-settle larvae, and it has recently contributed to the sustainability of paua fishing by providing seed for reseeding in the Marlborough Sounds to replenish the wild population.

The seed production unit uses paua spawning and larval rearing methods developed by NIWA in the 1980's to obtain larvae for settlement and initial growth in V-tanks. Seed of 3-5 mm length are transferred from the V-tanks to a nursery rearing system of stacked trays, in which they are reared to 10-12 mm for sale to commercial paua farmers for on-growing to market size.

The unit has progressed from outdoor V-tanks, individually covered to protect them from sun, wind and rain, to a twin skinned plastic greenhouse, providing weather protection, which, together with partial recirculation of the seawater, allows much greater control over light levels, water temperature and flow rates within the V-tanks. Light level can be manipulated to optimise diatom production and water temperature elevated to increase paua growth. We have experimented with the type (corrugated v flat plates) and configuration (close v widely spaced plates) of the substrate provided for larval settlement, and with the water movement (pumped v aerated) within the tanks. Better control over all these factors has resulted in increased yields of seed from the V-tanks, from the original 1-2,000 to the current 10-12,000 seed per tank.

The tray rearing system has recently been adapted from its original operating mode on ambient temperature, flow-through seawater, under indoor diurnal lighting conditions, to run as a constant water temperature (18°C), recirculation system (with about 10%/day make-up of new seawater), incorporating mechanical and biological filtration and foam fractionation, and maintained in a darkened, insulated room.

By improving our control over the rearing conditions in the V-tank system, we have increased the through-put of seed and maximised the number of spawnings and settlements we can achieve each year. Better control over the rearing tray system will enable optimum growth of high quality seed, and facilitate the supply of seed for paua farming and stock enhancement.

LAND BASED ABALONE FARMING: HOW CLEANING AND SEASON AFFECT ENVIRONMENTAL PERFORMANCE

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As the Australian aquaculture industry grows there is an emerging need for farming operations to be proactive to ensure their long term environmental viability. Current environmental monitoring of land based abalone farming in Victoria and Tasmania consists of a monthly or bi-monthly sampling of nutrients and Total Particulate Matter (TPM) of the intake and outflow water. Commonly the nutrients tested include nitrate, nitrite, ammonia, phosphate and silicate whilst TPM refers to the suspended solids in the water column. The difference between the intake and outflow nutrient and particulate concentration potentially gives a snapshot of the farms 'environmental performance'. However this information must be complemented with other farm information to give a reliable picture. Previous trials have shown that the net nutrient outputs of the study site, Abalone Farms Australia (AFA), vary according to farm practices. Hence monitoring during a steady-state operation (i.e. where no cleaning is occurring) produces a different environmental performance to a cleaning-state where cleaning practices generate short pulses of nutrients. Subsequently it is evident that the 'state' of the farm needs to be considered when reviewing environmental monitoring results of a farm. In addition to the state of the farm many other factors need to be considered when trying to determine a farm's environmental performance. Other such factors include season, feed rates and biomass. These factors change drastically between the summer and winter periods; primarily driven by water temperatures which in turn drive metabolic requirements of the abalone and hence feeding and growth rates/biomass.

This study determined the differences between the cleaning and steady states of AFA during a winter and summer period. In addition to the monitoring program described above, samples were taken between compartments (i.e. intake, tank, settlement pond and outflow). Substantial differences were found in all nutrients when cleaning and steady states were compared for the summer and winter periods. TPM was less varied, primarily due to the presence of settlement ponds. The findings of this study indicate that season is likely to affect the environmental performance of AFA through the on farm cleaning and feeding practices associated with those periods. The effects of net nutrient outputs are currently being assessed in an environmental impact study of the farm coastal foreshore. This study is important for future related work which is developing means to utilise excess nutrients generated within the farm.

HUMAN FOOD SAFETY EVALUATION OF AQUI-S: AN AQUATIC ANAESTHETIC

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Isoeugenol is the active ingredient in the aquatic anaesthetic AQUI-S. Isoeugenol was chosen as the active ingredient for its efficacy, consistency of anaesthetic action and because the existing toxicology data indicate that isoeugenol is safer than either eugenol or clove oil. Isoeugenol was therefore more likely to be approved as an aquatic anaesthetic for use with food fish with no withdrawal time.

Clove oil is a natural oil that is extracted from the bud, leaf or stem of the clove plant (*Eugenia caryophyllata*). The composition of clove oil changes depending on geographical location, stage of maturity, part of the plant that has been used to obtain the extract and the method of extraction. The major components of clove oil are eugenol, caryophyllene and acetyl eugenol. Clove oil does not contain significant quantities of isoeugenol. Eugenol, the main component of clove oil, is manufactured by distillation of the raw extract from the clove tree. Isoeugenol is synthesised from eugenol.

Eugenol, the main active ingredient in clove oil, is an allylbenzene. Allylbenzenes have a double bond between the second and third carbon on the hydrocarbon side chain. Other allylbenzenes include estragole, safrole and methyleugenol, all of which are carcinogenic. Eugenol has been found to have "equivocal evidence of carcinogenicity".

Allylbenzenes become carcinogenic by a two stage metabolic process. Firstly there is hydroxylation of the first side chain carbon to form the 1'-hydroxy metabolite. The second step is sulfation and the formation of electrophilic sulphuric acid esters. Studies in humans have determined that eugenol is also metabolised by this pathway. However the carcinogenic activity of eugenol is less than that of carcinogenic allylbenzenes due to eugenol having a free phenolic hydroxyl group on the benzene ring. This means that eugenol has a short residence time in the body as it can be directly conjugated to form water-soluble compounds which are rapidly eliminated. Carcinogenic allylbenzenes do not have a free hydroxyl group and therefore need metabolic transformation prior to elimination.

Isoeugenol is the propenylbenzene isomer of eugenol. Propenylbenzenes have a double bond between the first and second side chain carbons. This makes the first side chain carbon less reactive, preventing the formation of the 1'-hydroxy metabolite and thus blocking the carcinogenic pathway. Therefore isosafrole (the propenylbenzene isomer of safrole) and anethole (the propenylbenzene isomer of estragole) have less carcinogenic activity than the allylbenzene isomer, in fact anethol has been determined not to be carcinogenic. Accordingly isoeugenol as the propenylbenzene isomer has less potential than eugenol to become carcinogenic.

Like eugenol, isoeugenol also has a free phenolic hydroxyl group on the benzene ring enabling direct conjugation to form water soluble substances that are rapidly eliminated from the body. Therefore isoeugenol has less potential than other propenylbenzenes to become carcinogenic.

Clove oil has an uncontrolled and variable manufacturing process giving inconsistent composition and quality. This results in inconsistent anaesthetic action and the oil containing varying amounts of toxic compounds.

Eugenol is manufactured under a controlled process resulting in a consistent composition and anaesthetic action. However eugenol has been shown to have equivocal evidence of carcinogenicity and therefore the potential carcinogenic properties of the allylbenzene must be considered.

Isoeugenol is manufactured under a controlled process resulting in a consistent composition and anaesthetic action. The chemical properties of the propenylbenzene indicate that isoeugenol has less potential for carcinogenic activity than eugenol and therefore must be considered safer than eugenol. These conclusions lead to isoeugenol becoming the preferred active ingredient for AQUI-S based on efficacy and safety.

THE FUTURE OF AQUACULTURE VACCINES

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In 1942 Duff showed formally that fish could be protected from disease by the use of vaccines and the first full marketing authorisations for fish vaccines were issued in the United States in 1975. Since that time they have become an indispensable tool in intensive, commercial aquaculture and studies in fish immunology have shown the close similarities, as well as the important differences, between fish and higher vertebrates. The early vaccines were prepared against bacterial diseases and were of the simplest kind in the form of killed strains of the disease organism. However, as more diseases came to prominence in aquaculture, especially the viral diseases, these simple methods were frequently found to be ineffective. Fortunately, the same period of time that saw aquaculture develop into a major industry and important contributor to the world's food supply, also saw rapid changes in the technologies available to create effective vaccines. There are now available commercially killed viral preparations, live attenuated vaccines, xenotypes and standard genetic recombinants. These newer techniques, mostly derived from human medicine have maintained the position of vaccines as an integral part of fish husbandry. Even so many significant disease problems remain for which no vaccines are yet truly effective and the rapid intensification of aquaculture in the Pacific countries continually brings to prominence previously unknown disease organisms in fish species which have themselves been little studied immunologically. Aquaculture also faces new challenges in finding the means to protect valuable species such as shrimp and even shellfish, which do not possess the type of immune system normally associated with the application of vaccines.

This presentation will describe the commercial application and data requirements of some of the newer types of vaccine now becoming available and will address the extent to which some of these novel technologies, especially those being developed in genetic research, might be applied to aquaculture, disease problems. Examples will be given of the use in fish of alternative hosts for recombinant genes, viral vector vaccines, plasmid (DNA) vaccines, single-chain antibodies and the possible future uses of gene silencing techniques for the control disease in invertebrates.

GENETIC STOCK STRUCTURE OF THE AUSTRALIAN FLAT OYSTER Ostrea angasi IN NEW SOUTH WALES: IMPLICATIONS FOR AQUACULTURE

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Where possible, it is desirable to develop an understanding of the population structure of any new species being targeted for aquaculture. The application of population genetic techniques has proven particularly useful in achieving this goal. The benefits are twofold. Firstly where wild stocks show structure, informed management decisions can be made regarding where to source broodstock and also about the extent to which hatchery juveniles should be translocated for the purposes of growout or wild stock enhancement. This approach can help reduce negative impacts on the genetic integrity of natural populations. Secondly, an assay of the genetic structure provides an indication of the genetic diversity available for the improvement of cultured stocks. The present study is an investigation into the population structure of *O. angasi* collected from five estuaries in NSW. This species is seen as an ideal candidate for aquaculture due to its relatively rapid growth and high export value. Unlike the cultured Sydney rock oyster (*Saccostrea glomerata*) *O. angasi* brood their larvae, greatly reducing the time spent in the water column and thereby limiting dispersal capability. Therefore, it is expected that *O. angasi* will display a relatively high degree of structuring across the range of the species. Here we discuss the results of the study in terms of their consequences for the future culture of the species.

MARINE POND CULTURE IN FRANCE

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The West coast of France along the Atlantic Ocean has numerous marine wetlands, where earthen ponds were constructed by embankment to cultivate from centuries diverse marine products. Salt production and extensive fish polyculture were the first traditional activities. After a period of decline, the rehabilitation of salt works is increasing today with product diversification (salt flower: the fine surface crystallisation and saltwort: *Salicornia* spp.). But extensive fish polyculture in ponds (eels, mullet, sea bass, sea bream) is today a marginal activity, due to a low economic return, used as spare time activity only. A great part of salt- and fish polyculture ponds were converted in oyster ponds and after a glory period with the flat oyster (*Ostrea edulis*), and the cupped Portuguese oyster (*Crassostrea angulata*), epizootic diseases endangered the production. Today the only species reared on the sea-shore and fattenned in ponds (ii) "fines de claires" oysters (FCO) and (ii) "spéciales de claires" oysters (SCO) fattened in 1-2 months with 10-20 oysters per m, (iii) and "pousse en claires" (PCO) with a true growth in ponds during 6-8 months with 1-2 oysters per m. A diversification of the aquacultural production in ponds was stimulated between 1970's and 1990's with other shellfish species: Manila clam (*Ruditapes philippinarum*), Kuruma shrimp (*Metapenaeus japonicus*), and some hatcheries and intensive growing out marine fish farms of turbot (*Scophthalmus maximus*), sea bass (*Dicentrarchus labrax*), and sea bream (*Sparus aurata*). The production and the pond

Table 1: The marine aquaculture products (mt), the fish fry from hatcheries (millions of units) and the used pond surfaces (ha) coming from French West coast ponds

Year	Salt	Salt flower	Saltwort	Oyster CO-SCO	Oyster PCO	Man. Clam	Shrimp M.jap.	Sea bass	Turbot	Fish fry	Bivalve spat
2003	20000	1000	> 50*		100		35				
2000								630	560	21	
1995				1		35	20	200	465	4.8	300
surfaces	2000	2000		1800	158				<u> </u>		

* including 5mt by farming on pond dykes

Scientific experiments, pilot modules in Regional farms, tests with pond farmers were carried out to develop pond-monoculture techniques in semi-intensive or intensive systems for Manila clam and Kuruma shrimp. For the Kuruma shrimp production an adapted semi-extensive system including a first ongrowing pond (60 PL.m⁻²) during 40 days and a growout pond starting with a 1g-shrmp (1-2 ind. per m) was developed. Due to the small shrimp density a feed strategy (Hussenot et al., 1993) using two feed formulations with low and high protein level (LPLF and HPLF) was developed with success and adopted by shrimp farmers. The LPLF was used as fertiliser to stimulate and feed natural preys (polychaetes in mud) and the HPLF in the second rearing period when natural preys became rare. Today new systems are experimented to develop a sustainable pond integrated aquaculture with the help of European funds ("Genesis project").

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INDUSTRY DEVELOPMENT: A CASE STUDY FEATURING MURRAY COD

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Murray cod (*Maccullochella peelii peelii*) aquaculture is a relatively new industry in Australia. This species is highly valued for recreational, commercial and conservation purposes, and is sought after as a table fish. During the 1970's and 1980's techniques were developed that enable routine, mass production of Murray cod fingerlings primarily for stock enhancement purposes. Since the mid-1990's there has been considerable research and industry activity in developing methods for production of table fish, in particular grow-out in intensive recirculation systems (RAS) where most production is now occurring. Features of Murray cod that are attractive to aquaculture include, easiness to breed in captivity, robust larval stages, easiness to wean on to artificial feeds, hardiness and adaptability to crowding in confined spaces, high rate of growth and production under culture conditions, good feed conversion efficiencies and late maturity. Murray cod is already well accepted and in demand by consumers, and fetches premium price at the market compared to other farmed fish.

Murray cod performs well in RAS, as indicated by excellent growth rates, survival rates and FCR's at high stocking densities, and bio-economic indicators. Key production information for the grow-out of Murray cod to a minimum market-size (700 g) is described and includes information on growth, survival, fish condition, feeding, food conversion ratios. Based on these data, in a commercial operation, for every 1,000 fingerlings (1g/fish) stocked into a RAS, operating at a temperature between 22-26°C, between 413 and 616 kg (median 500 kg) of Murray cod (at 700 g/fish) are expected to be harvested from 36 weeks to 108 weeks after stocking.

The Murray cod aquaculture industry has quickly established itself as a relatively small but viable industry that produces a range of relative high-valued products. Farmed Murray cod have now replaced wild caught Murray cod in the market. A vertically integrated Murray cod aquaculture industry is envisaged, with some elements, already in place. The industry is expected to expand as new operators enter the industry and production methods and operations are continuously improved. Individual owner-operator farms are common across the Murray cod industry. While, this type of industry model is attractive, providing regional/rural socio-economic values, this approach may be inconsistent if the goal is a modern, large-scale market-driven industry. Production using RAS is a capital-intensive endeavour and for the most part requires corporate investment. Nevertheless, there is still a place for owner-operator farms, particularly in rural areas, which are in a position to supply local and/or specialised niche markets. Integration of existing production systems with agricultural practices, "integrated agri-aquaculture systems" (IAAS), will provide options and opportunities for improving production efficiencies, achieving economies of scale and increasing market access.

GENETIC ENHANCEMENT OF AUSTRALIAN FINFISH FOR AQUACULTURE AND CONSERVATION: MURRAY COD

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Use of biotechnology in the aquaculture industry is growing rapidly, as indicated by increasing R&D activity and investment in this field. Well-managed breeding programs incorporating selection of favourable traits (growth, survival, disease resistance, food conversion efficiency etc.), have resulted in tremendous gains in production performance and reliability, and increased profitability of culture animals.

Production of Australian freshwater finfish species for aquaculture purposes has a short history. Key species include barramundi which developed during the 1980's, silver perch, Jade perch and eels which developed during the early 1990's and Murray cod which developed during the late 1990's. To date however, these industries have developed without genetic selection.

Murray cod (*Maccullochella peelii peelii*) aquaculture is a relatively small but highly valued industry within Australia, which has the potential to expand both domestically and internationally. To date there has been no active selection of fish for aquaculture purposes with the majority of seedstock being derived from essentially wild broodstock held in captivity. Despite this, the species appears to be highly suited to large-scale production especially in intensive recirculating aquaculture systems (RAS), with promising performance statistics in terms of growth, survival and feeding efficiencies at high densities. Because the Murray cod aquaculture industry is still in the early stages of development, there is considerable potential to increase production and profitability through instigation of a large-scale genetic selective breeding program.

A genetic selective breeding program for Murray cod has been initiated by the Department of Primary Industries, Primary Industries Research Victoria with funding from the Our Rural Landscapes Initiative. Principal drivers for this program are to apply innovative genetic and production methods to enhance profitability and sustainability of inland aquaculture species and to conserve the biodiversity of wild stocks. Technologies and guidelines for selective breeding for aquaculture purposes and associated risk analysis to ensure long term genetic integrity and biosecurity and improvement in performance of farmed Murray cod stocks will be developed. A microsatellite library will be developed and DNA markers will be used to discover desirable traits and assist selection. The library will also be used to determine wild population genetic structure and will assist in preparing guidelines for managing the breeding and stock enhancement programs to ensure biodiversity in wild populations is maintained and enhanced. Application of other biotechnology options for enhancing production and associated performance of fish in selective breeding programs, including controlled reproduction, chromosome manipulation, sex manipulation, hybridisation and cryopreservation will also be investigated.

PEARL AQUACULTURE DEVELOPMENT PROJECT IN THE FEDERATED STATES OF MICRONESIA, WESTERN CENTRAL PACIFIC

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Micronesians are far behind the South Pacific island and Australasian nations in the development of its pearl industry. One of the reasons for this is the fact that there is not sufficient number of the wild-caught spat of the blacklip pearl oyster to supply pearl farms on regular basis. In 2001, the College of Micronesia Land Grant Program (COM) embarked on a search for technology for production of pearl oyster spat to overcome this lack of naturally occurring wild spat supply in Micronesian region. Funding was provided by the United States Department of Agriculture (USDA) and Department of Interior's Office of Insular Affairs (DOI) in support of this search for the pearl technology under a project called: "Development of Pearl Aquaculture and Expertise in Micronesia" (the Project). The purposes of this Project are to provide training programs for: a) development of the pearl industry in Micronesia, and b) development of local human resources for supporting and maintaining the pearl industry once it is established.

The funding support enabled the Project to commence its Phase-1 activity from the first quarter of 2001 to third quarter of 2003. All Phase-1's objectives were accomplished: an Australian expert in pearl oyster hatchery technology was hired; a small hatchery was established in an abandoned dock warehouse at Nett Point, Pohnpei; and the pearl expert and his Micronesian trainees successfully conducted hatchery and ocean nursery events during the Phase-1 resulting in tens of thousands of blacklip pearl oyster at the three demonstration farms, also established by the Project. Three Micronesian staffs were trained as trainers in spat production and four local people became trainers in farm grow-out technology with participation of more than 50 trainees from local communities, schools and colleges. In September 2003, a trial round-pearl seeding was also commenced by using the hatchery-produced hosts and donors to implement the pearl quality improvement research.

The Project entered to the Phase-2 in the fourth quarter of 2003, proceeding to complete the necessary evaluations and demonstrations to the critical issues in the pearl industry development including actual pearl production and business development. The Phase-2 activities are currently carried out for: a) expansion of training of hatchery and grow-out farm techniques into the other state (Yap) and into the job training program with the Pohnpei State Government; b) implementation of pearl production trials and evaluation of pearl production techniques; and c) collaboration with institutions in the region (e.g. Univ. of Guam, Palau Community College, College of Marshall Islands), government agencies, outer island communities and private sector in developing business models.

NUTRITIONAL REQUIREMENTS FOR FINFISH LARVAE

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From on-start feeding, fish larvae nutritional reserves are very limited and their survival dramatically depends on exogenous feed. Hence, complete and balanced nutrition is critical of rearing success during early life stage. But most fish larvae, particularly marine ones, despite on the wild fed on a wide range of live preys, under culture conditions are forced to fed on a very limited number of preys (two or three) which frequently are not part of their natural food and hence their nutritional composition is not always the most suitable for maximum growth, development and survival of the larvae. Moreover, along larval development the fish will undertake several morphological and physiological changes which in nature are simultaneous with changes in behaviour and even habitat and type of prey fed. All these changes will affect to nutrient availability and feed utilization by the larvae in order to match their nutritional requirements. In practice, most of these problems will be simplified by the proper development of inert diets, which are able to cover nutritional requirements at different moments of larval development. In order to achieve those diets we need, among many other important things, to have a complete knowledge of nutrient requirements for the different fish species.

Whereas protein composition of live preys is genetically determined, lipid qualitative and quantitative composition is greatly affected by their diet and significantly varies among batches of the same type of prey, as well as among different species. Early studies on the 80's had determined that lipids are the most important factor affecting the nutritional quality of live preys and since then a vast amount of the research conducted on larval nutrition have focussed on these nutrients. Essential long chain polyunsaturated fatty acids, as key components of bio-membranes play many important roles in their functioning and are particularly indispensable for larval development. Their presence and quantity in the diet are determining to the efficiency of digestion, absorption, and transport of some nutrients, and to the capacity of dietary energy deposition and utilization. They markedly affect eye and brain development as well as larval behaviour. Finally, as sources of eicosanoids they regulate several physiological functions including some related with larval development, immune function and stress resistance, globally affecting larval growth and survival and rearing success. Recently, molecular studies have denote the presence and activation by the fatty acid composition of the diet of a delta-6 desaturase like gene, involved in long chain polyunsaturated fatty acids synthesis. Besides, the different essential fatty acids compete among them at many different points of fish physiology, dietary unbalances among them leading to detrimental consequences for the larvae. To complicate the picture a bit more, the molecular form in which they are administered is determinant of the utilization efficiency of the dietary essential fatty acids. Other lipids such as phospholipids are considered indispensable for fish larvae, since they distinctly promote the limited ability of larvae to absorb, to re-acylate and to transport triglycerides and provide additional sources of nutrients. Fat-soluble vitamins and pigments have also prove to play important roles along larval development and their inadequate dietary levels either by shortage or excess are negative for the larvae. In a similar manner to what is found in juveniles, dietary protein utilization has been found to be affected by the dietary source, particularly during early larval stages and playing a central role in the development and maturation of the larval gut. Besides, certain free amino acids also constitute a very important source of energy, act as attractants and play a significant role in gut function and development. Finally, despite their importance, only a very limited number of studies have focused other nutritional aspects of larval development such as water-soluble vitamin and mineral requirements and energy utilization by fish larvae.

ENVIRONMENTAL MANAGEMENT OF MARINE FISH GROWOUT OPERATIONS

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The emerging Western Australian aquaculture industry and the community are acutely aware that ecological impacts of marine fish farming must be managed and minimised if the growout of marine finfish is to proceed in WA.

This Challenger TAFE 'Science and Technology Innovation Strategy' project identified and documented sustainable national and international aquaculture technologies and procedures for marine fish farming. The project developed a VET course titled 'Environmental Management of Marine Finfish Growout Operations' and set guidelines for the development of the industry in WA. The course is the first of its type in Australia for marine aquaculture. The expectation is that the course and the associated 'Guidelines for Sustainable Marine Finfish Farming', established in consultation with the industry, conservation groups and the community, will encourage this valuable new industry to become established in Western Australia in an ecologically sustainable manner.

The VET course 'Environmental Management of Marine Finfish Growout Operations' resulting from this project was developed for Western Australia but has direct relevance to the interstate marine aquaculture industry. The course is based on world best-practice to cater for the training needs of this industry, and will be incorporated into the Diploma of Aquaculture in WA, a nationally recognised qualification. Students who complete the course will have an understanding of sustainable finfish farming practices and have some skills and knowledge to provide direct assistance to their potential employers. An example of the training schedule includes the carrying out of small-scale baseline surveys of the environment before a trial seacage is put into position, and the monitoring of the water quality and the documentation of changes in the benthic sea floor after the location of the seacage.

UNITED STATES CASE STUDY: INTEGRATING SCIENCE TO DEVELOP NATIONAL DISCHARGE REGULATIONS FOR AQUACULTURE OPERATIONS

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Under a federal court-ordered consent decree settlement, the United States Environmental Protection Agency (EPA) decided in 2000 to promulgate national effluent limitations guidelines and standards for aquaculture operations in the United States to include both public and commercial facilities. Aquaculture in the United States is extremely diverse and the scope of the new regulations initially included all facilities considered to be aquaculture. The federal government has invested millions of dollars in effluents characterization studies and management research, and expertise on a myriad of effluent topics is scattered across the Nation. Because of the national scope and importance of this new rule, the federal interagency Joint Subcommittee on Aquaculture, with concurrence by EPA, created the Aquaculture Effluents Task Force (AETF). The AETF provided a national forum and coordinated effort to engage the scientific community and diverse stakeholders in this public policy process. The role and responsibilities of participants were clearly defined in addition to AETF objectives.

For the first time several professional societies joined this type of activity, in addition to every national aquaculture association, numerous other organizations, and several environmental NGOs. The formation of the AETF was a proactive response to a complex, critical national issue and need to create a diverse stakeholder coalition supportive of a science-based approach of consulting and interacting with EPA. The AETF produced several technical documents and participants were primary contributors for developing a Best Management Practices (BMP) technical guidance document for consideration by EPA. The AETF is guided by the collective knowledge, experience and expertise of participants and their willingness to voluntarily contribute resources for the public good of aquaculture development. The AETF has provided an outreach education function to interested parties with encouragement for others to provide input as opportunities arose. EPA finalizes the national effluent regulation in June 2004 after four years of public debate and analysis on effluent issues associated with drugs and chemicals, aquatic animal pathogens, and non-native species in additional to treatment technologies, BMPs, and more. This paper presents the lessons learned and significant outcomes employing this participatory stakeholder model and an assessment of effectiveness in addressing a complex, controversial national issue.

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The last decade has seen a worldwide increase in the instigation of selective breeding programs for many aquaculture species. Most of this targeted breeding effort has been focused on improving productivity traits in finfish species such as Atlantic salmon, rainbow trout and Nile tilapia, with increases in growth rate of $\sim 14\%$ /generation being achieved through directional selection in these fishes. The instigation of selective breeding programs when applied to penaeids, however, has been slower forthcoming.

One of the major impediments to large-scale penaeid commercial breeding programs is an inability to reliably retain pedigrees when large numbers of families are involved. The ability to assign progeny with high confidence to their family of origin is considered imperative for these highly fecund crustaceans to reduce the incidence of inbreeding and associated reductions in genetic response to directional selection. Traditionally, research and pilot selection programs have relied on protocols where families are individually reared in tanks, or where a small number of progeny/family were marked with a coloured elastomer dye coded for their family of origin. Both these approaches have shortcomings for large-scale breeding programs including a reduction in the number of families and their progeny that can be evaluated, possible introduction of confounding environmental effects that complicate analyses, tag loss through moulting and a reduction in the selection intensity practiced.

The use of a DNA based pedigree system offers several advantages over the traditional approaches outlined above. Firstly, the gene markers utilised naturally occur in every individual and when viewed in conjunction with other similar genes provide a unique identifying "fingerprint" of the animal. DNA markers are effectively a biological tag and are retained throughout the animal's lifetime. This means that theoretically progeny from a large number of families can be communally stocked from hatching and reared in a common environment without having to physically tag individuals, or invest in large amounts of hatchery infrastructure. Secondly, because every individual has a biological tag, entire families (i.e. 100, 000's of progeny) can be simultaneously evaluated increasing the selection intensity that can be practiced. Genetic response is linked to the intensity of selection; therefore the rate of genetic progress achieved through targeted breeding may increase with the use of this technology.

This presentation will introduce the theory behind DNA pedigreeing and will highlight the significant advantages this approach can offer large-scale penaeid selective breeding programs.

COMMUNITY BASED TROCHUS CULTURE INITIATIVE IN VANUATU

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Top shell, *Trochus niloticus*, is one of the most important valuable resources for Vanuatu. The flesh provides a unique protein source for the village communities while the shells are sold locally to the blank button factories for AUD3 to 4 per Kilogram (kg). Local button industry valued at US\$350,000 in foreign exchange per year. Since late 90s, trochus production has drastically fallen and it was highly likely that this was due to excessive fishing pressure on the natural stock. The involvement of communities is vital in ensuring a continuous supply of trochus to the local market industry. In a country such as Vanuatu where land is traditionally owned and is passed on through generation by blood-line, involvement of communities on village-based aquaculture development and or management is of paramount importance.

Caging of adult trochus on the reefs to allow them to breed under natural conditions was carried out in three communities in April 2003. Prior to the caging period, Fisheries Department put forward a request through the radio encouraging interested communities to apply through their respective Provincial Governments to the National Government represented by the Fisheries Department. Three Provinces were then short-listed. Proposed sites within each of the 3 Provinces were surveyed to determine areas having ideal conditions for the experiment. Factors such as reef structure, reef ownership customary marine tenure (CMT), availability of trochus stock in certain areas so as to minimize movement of stock from one island to another were taken into account.

Preliminary results indicated an effect on recruitment on the stock on the treatment sites. Participation of the communities have also improved which is apparent on the establishment of the marine protected areas (MPAs) set up recently in all trial sites as a result of this work. The current work is also creating huge interests among communities, and other Provincial authorities have already pledged their willingness for the current activity to be carried out in their respective areas. The current work is funded under the auspices of the Australian Center for International Agriculture Research (ACIAR).

WHY WON'T THE DAMN THINGS GROW? - INHIBITORY SUBSTANCES AND MOLLUSC HATCHERIES

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Molluscs are known to be seriously affected by trace amounts of environmental pollutants. It was the observation of imposex in gastropod molluscs that first alerted people to the environmental dangers posed by TBT antifouling at concentrations in seawater that were below the level of detection by all but the most sensitive chemical analytical techniques. This extreme sensitivity by molluscs has led to the use of both adults and larvae as biomonitors for environmental pollution.

Aquaculture of molluscs has led to increasing demand for commercial hatcheries to supply seed stock, including selected genetic lines of spat. It is becoming apparent that many of the unexplained "crashes", ill thrift or failures of spat to metamorphose in such hatcheries are primarily due to spat being compromised for a range of reasons including traces of inhibitory or toxic substances in the water supply (and these are not just "heavy metals"). Because dead and dying larvae are ideal substrate for bacterial and ciliate growth, such invaders are often assumed to be the primary cause of the problem and this hinders finding a solution. In addition, many of the toxins which may be implicated in crashes are sporadic in occurrence and are both difficult to detect and hard to remove from the water supply. This paper reviews evidence for these toxic effects and suggests ways of reducing the problems.

BARRAMUNDI PRODUCT QUALITY CHARACTERISTICS

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In 2000 Skretting (then Pivot Aquaculture) started a pilot project farming barramundi in sea cages of Bathurst Island, Northern Territory. The farm is now part of Marine Harvest, which is owned by Nutreco, and is a sister company of Skretting.

Most farmed barramundi are sold as plate size and there has been little focus on flesh quality. A project was undertaken with the aim to create a baseline for farmed barramundi flesh quality. The project started in October 2001 and finished in April 2003. A total of 88 fish were sampled during the project period. The parameters studied in detail were fillet fat, gutting loss, liver index and condition factor.

The results showed that in common with salmon, trout, European sea bream and European sea bass there is a tendency (r = 0.59) towards higher fillet fat content in larger barramundi. The highest average fillet fat level in fish from Marine Harvest is 8.2 ± 1.1 % (weight group 3 - 4 kg). Fillet fat level in other farmed 4 kg fish (Bluewater Barramundi) is reported to be 10 % (FRDC Project 1999/331). Fillet fat levels in wild-caught barramundi ranges from 0.4 % (saltwater) to 0.9 % (freshwater) (FRDC Project 1999/331). These results are based on data from three fish from each group with an average weight of 2.48 \pm 0.03 kg (saltwater) and 3.83 \pm 1.79 kg (fresh water).

There is a weak correlation (r = 0.28) between gutting loss (%) and fish weight (g) for fish sampled at Marine Harvest. This indicates that fish size (g) explains little of the variation in gutting loss (%). The data also indicate that gutting loss (%) does not vary significantly with season.

Many marine species store energy in the liver. Therefore, we calculated liver index (liver weight/whole weight of fish*100) to monitor any trends in energy deposition and/or mobilization. There was a very weak correlation (r = 0.14) between liver index and fish weight for fish sampled at Marine Harvest. This indicates that the weight of the fish explains very little of the variation in liver index for the fish sampled. There is a tendency for the liver index to increase during the "winter months" (February - June) in the fish sampled at Marine Harvest.

Condition factor (K-value) is a ratio between weight and length of the fish (i.e. sardines have a low K-value and gold fish have a high K-value). There are no significant correlations (r = 0.05) between K-value and fish weight (g). This indicates that variation in K-value cannot be explained by the fish weight. K-value does not appear to vary significantly with season for fish sampled at Marine Harvest.

Further work is needed to examine seasonal patterns of fat deposition and condition factor to better understand these critical aspects of product quality.

ACCLIMATION AND GROWTH RATES OF THE GLASS EEL STAGE OF Anguilla australis AND Anguilla dieffenbachii IN SALTWATER CULTURE.

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The New Zealand shortfin eel Anguilla australis and longfin eel Anguilla dieffenbachii are potential candidates for intensive aquaculture. This study was undertaken to investigate growth of glass eels (transparent, post larval stage) of A. australis and A. dieffenbachii held in 801 seawater tanks at 25°C. Results demonstrate successful acclimation of shortfin and longfin eels from 12 - 15 ∞ C freshwater to 25 ∞ C saltwater (35 ppt) over a 24-hour period. This rapid acclimation period had minimal effect on the initial survival of glass eels, with the resultant mortality being less than 3%.

Glass eels were fed a commercial eel diet three times per day (0900, 1300 and 1700 hours) with feed rates calculated at 10% of total eel wet weight for each tank per day. There was no significant difference (P < 0.05) between the daily SGRs for shortfin and longfin eels when averaged over the entire experiment. Calculated daily SGRs for shortfin eels ranged from 2.01% to 3.02% per day (mean 2.39 % \pm 0.32 S.E.) and 1.46 % to 1.62 % per day for longfin (1.53 % \pm 0.05; Refer Table 1).

Mortality differed significantly (P < 0.05) between shortfin and longfin eels with shortfin mortality on completion of the trial ranging from 18 % to 32 % (mean 24.0 % \pm 14.4) and longfin from 60 % to 82 % (mean 71.3 % \pm 22.0; Refer Table 1). Observations of emaciated eels with empty stomachs suggested mortality was due to starvation. No mortalities from parasites or pathogens were observed during the trials.

	Shortfin	Longfin
Wet weight per eel	· · · · · · · · · · · · · · · · · · ·	
Initial (mean \pm s.e.)	$0.13 \text{ g} \pm 0.00$	0.12 g <u>+</u> 0.01
Final (mean \pm s.e.)	$0.52 \text{ g} \pm 0.04$	$0.42 \mathrm{g} \pm 0.03$
Total mortality (% total \pm s.e.)	24.0 % <u>+</u> 4.16	71.33 % <u>+</u> 6.36
Daily specific growth rate $(\%/day \pm s.e.)$		
Days 0-14	5.22 % <u>+</u> 1.08	3.12 % <u>+</u> 0.32
Days 15-28	3.63 % ± 0.28	1.50 % ± 1.05
Days 29-42	0.99 % <u>+</u> 0.19	1.67 % ± 0.83
Days 43-56	$0.82\% \pm 0.37$	$2.29\% \pm 0.82$
Days 56-70	$1.86\% \pm 0.17$	$1.03\% \pm 0.65$
Days 70-84	$1.80\% \pm 1.57$	-0.44 % <u>+</u> 0.75

Table 1: Initial and final mean wet weight, survival and SGR of shortfin and longfin glass eels after 84 days (mean \pm standard error).

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MEIOGEN AND MITOGEN DEVELOPMENT IN THE PACIFIC OYSTER Crassostrea gigas GAMETE IRRADIATION

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The efficacy of UV intensity and duration on sperm for the production of meiotic and mitotic gynogen *C.gigas* was investigated. Three exposure times; 60, 180 and 300 seconds, and two radiation intensities; 600 and 1200uW.cm⁻² were initially evaluated for their potential to produce haploid zygotes. UV radiation doses on 5ml sperm aliquots of between 180 and 300 seconds (@ 1200uW.cm⁻² were effective in producing primarily haploid zygotes as assayed by flow cytometry. In subsequent trials using this protocol, the diploid state was restored in some larvae by suppression of first or second polar body or first cleavage through exposure to the fungal metabolite cytochalisin B or the puromycin analog 6-Dimethylaminopurine, although survival through to settlement was low.

In another experiment, *C.gigas* eggs were exposed to UV radiation for 300, 600 or 1200 seconds at a single intensity of 1200uW.cm^{-2} . Exposures of between 600 and 1200 seconds proved effective in producing haploid zygotes, although in a subsequent trial, egg cohesion was adversely affected by the longer exposure time.

NITROGEN IN THE CLOSED RECIRCULATING AQUACULTURE

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In the closed recirculating aquaculture, excretory substances from fish which accumulate in the culture water should be treated effectively so as not to make negative effects on the growth of fish. Because ammonia is the major excretory substance and is considered to be harmful to fish, removal of ammonia is one of the most important parts to design the closed system.

In this paper, nitrogenous excretion of fish, especially ammonia, was estimated quantitatively in terms of fish size, feeding rate, water temperature and fish species. In case of Japanese flounder, nitrogen excretion per fish after feeding increased with increasing body weight. However, there seems to be upper limit of about 25mg-N/100g fish/day at 20°C independent of feeding rate for commercial size fish. Ammonia and feces nitrogen accounted for 75% and 10% of total nitrogen excretion, respectively. Nutritional approaches to reduce nitrogen excretion of the flounder were conducted in terms of increasing dietary fat and carbohydrate, however, we could not obtain any favorable results.

Ammonia oxidation rate of submerged biological filter was examined with several types of filter media, and that with net filter medium was estimated to be 260g-N/m³ filter/day, equal to 0.55g-N/m² surface area/day at 20°C.

In aerobic condition, nitrate concentration in the culture water increased linearly through the nitrification process, and showed adverse effects on the growth of Japanese flounder when it exceeded 800mgN/L.

Nitrate was reduced successfully by bacterial denitrification and algal assimilation. The denitrification rate of submerged biofillter with fiber type filter media was about 30g-N/m³ filter/day at 20°C. Nitrate assimilation activity of *Ulva pertusa* was estimated to be 0.3mg-N/g wet weight/day at 20°C. Algal production was 2 to 3 times higher than that of fish on the wet basis.

Based on the above and other available information, we designed the closed recirculating aquaculture system for Japanese flounder and Tiger puffer, popular marine finfish with high market price in Japan.

INTENSIVE CULTURE OF Artemia BIOMASS

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Brine shrimp (Artemia) is one of the most commonly used live feed organisms for fish and crustacean in aquaculture. Adult Artemia referred to as 'biomass', is one of the predominant forms of Artemia used by commercial fish and shrimp hatcheries. Adult Artemia biomass is sold as live, frozen or dried product. Over 95% of more than 3000 tonnes of adult Artemia required for the aquaculture and aquarium trade are harvested from a restricted number of natural sources. The global demand for Artemia biomass constantly increasing while supply is discouraging. Therefore, culture as opposed to harvesting from natural populations has potential for improving Artemia biomass supply and availability. Numerous companies in Australia, as well as overseas, require Artemia biomass including aAquaculture ventures (hatcheries), public and private aquaria and R&D institutes. These companies would benefit from intensively cultivating their own Artemia biomass or having a local supply.

Intensive tank-culture of Artemia biomass is generally regarded as being expensive although the benefits are well appreciated;

- Year-round availability of Artemia biomass, independent of climate or season
- Specific stages (juveniles, pre adult, adults) with uniform size.
- Higher and better controlled Artemia quality (based on nutritional, pathogen and contaminants criteria)

High quality feeds such as micro-algae like Dunaliella salina or Tetraselnus suecica are often used for tank-produced Artemia biomass. Production of micro-algae is expensive so inexpensive inert feeds such as soybean meal and rice bran are more commonly being used. These products are generally of low nutritional value. It is suggested that these feeds act as a substrate for bacteria that provides nutritional benefits to the Artemia. Varying strains of bacteria may have positive or negative effects on the Artemia culture. As various feeds promote growth of different bacterial strains, further work is required to determine the effects associated with these feeds and the associated bacteria.

The Department of Fisheries WA has set up an experimental 18 x 165 l heated tank system, that can be operated as static or semi flow-through. The system is currently being used to compare inexpensive, locally-available, inert feeds. A series of experiments, to be completed in mid 2004, will be used to further determine the types and effects of bacteria associated with culture techniques (static or semi flow-through culture) and feeds (micro-alga, inert diets).

GENETIC TECHNOLOGIES TO TARGET EFFICIENT PRODUCTION OF QUALITY SHRIMP

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Progressive operations in the world's major domestic animal industries are now exploiting quantitative genetics and animal breeding theory to make fast and sustainable genetic gains. These efforts target product quality, disease resistance, animal welfare, productivity, and costs of production. Molecular genetic technologies have an increasing role to play within this framework. In the aquacultural industries, we can also exploit this position if we take proper account of the biological and environmental constraints that face us. The SyAqua division of Sygen aims to make a major contribution to improving shrimp production, partly through leverage of experience in other species. R&D activities include:

Sampling and testing of diverse shrimp genotypes. An inventory of genetic resources for an aquacultural breeding program will help exploit variation between wild strains and boost sustainable gains. Genetic marker data can be used to help balance short-term genetic gains with maintenance of diversity when choosing foundation stocks for a breeding program.

Trait recording and use of pedigree information. Traits of key interest relate to growth, product quality, disease resistance and survival in a range of production environments. Investments in physical and/or genetic tagging has pay-offs in genetic gains, genetic connection, management of inbreeding, estimation of genetic parameters, and gene detection.

Detection and exploitation of favourable genetic markers. Attention to program design and genotyping strategy can improve power to detect genes that influence traits of importance. The resulting genetic markers are most useful for traits that are difficult to measure on individuals, such as carcass traits, disease resistance, and survival.

Use of optimal contributions theory: This is implemented at the level of family contributions, in addition to individual selections. The strategy includes control of genetic gains, effective population size and progeny inbreeding to manage genetic diversity and to target sustainable genetic gains.

Modeling of shrimp growth and environment. This program aims to help identify selection criteria and to help manage all aspects of robust genetic change. Classic statistical parameters that describe observed relationships amongst shrimp traits

are constrained by the specific ages, weights, and other conditions of data capture, and do not infer or exploit information about the underlying biology. This program aims to develop understanding of shrimp growth, modeled in a manner that can be used to predict optimum management regimes, designed for more accurate genetic evaluation, and to help avoid otherwise

Control of reproductive biology. This program aims to provide further opportunities in genetic change and stock dissemination. Gamete and embryo preservation provides opportunity to compare lines in different locations with minimal health risks. There are also opportunities for faster genetic gains, especially when combined with good genetic marker information. Success in the ploidy-manipulation program, together with appropriate crossing strategies, could bring considerable industry benefits in trait performance and product uniformity.
TOWARDS AUTOTROPHIC RECIRCULATION SYSTEMS FOR PRAWN FARMS

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From 1999-2003, BIARC researchers considered the role biotic interactions could play in future recirculation systems. Specifically, we determined the influence of grazers (mullets, siganids, etc) on algal and specific bacterial growth, on nitrification and denitrification rates, on bio-perturbation of the sediment.

In 2004, we are assessing whether these new learnings of biotic interactions are relevant to pilot scale recirculation systems. Specifically, we have designed and built a system of four independent 70,000-litre production ponds, each with its own 20,000-litre concrete treatment raceway. This system is unique, as it allows replicate trails under pilot scale conditions.

While some previous knowledge has relevance under recirculation conditions (sludge and amphipod control with mullet), the operation at pilot scale has introduced new issues to be solved (eg. temporal variance in Ulva growth, instability of phytoplankton/ macrophyte ratios). Potential approaches to these new issues will be discussed.

REVIEW OF GENETIC SELECTIOIN PROJECTS AT BRIBIE ISLAND AQUACULTURE RESEARCH CENTRE WITH A FOCUS ON PRAWN GENETICS

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The following will be discussed:

- How to rationalise genetic investment across species
- Genetic and breeding programs for different tropical and subtropical aquaculture species (with a focus on banana and tiger prawns)
- · Results to date from selection
- Future directions, including;
 - options for a combined AIMS-CSIRO-DPI genetic selection program for black tiger prawns
 - options for faster selection response including higher selection intensity with greater infrastructure, better selection criteria using levels of gene expression.

PRODUCTION OF COPEPODS Acartia sinjiensis FOR MARINE FINFISH LARVAE

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At present marine finfish larval culture in Australia and around the world is dependent on two main food organisms: 1. the rotifer *Brachionus (B. plicatilis* and *B. rotundiformis)*

2. and the brine shrimp Artemia.

Although easy to culture, these organisms can present problems such as unsuitable size, inadequate or inconsistent nutritional content and poor digestibility.

There is increasing evidence of a benefit of including copepod nauplii in the larval diet of high-value marine finfish such as snappers and groupers. Their advantage as a first-feed species is their small size ($<110 \,\mu m$) and excellent nutritional profile. However, their adoption into finfish aquaculture is currently restricted by the lack of suitable culture methods to reliably supply sufficient copepod numbers.

To develop culture methods for *Acartia* five microalgae were compared as monoalgal diets for growth of copepod nauplii. Newly hatched (30 x N1) nauplii were fed an algal diet at a minimum of 8 feed densities. Culture volume was replaced daily and fresh algae added. After 72h, surviving copepods were isolated and their development stage determined. Results were averaged for 3 consecutive replicates and a level of development (development index) assigned to each feed concentration of each algal species. Copepod development was significantly faster for those fed either *Rhodomonas* or *Cryptomonad* (CS-412). Using either of these species, a maximal copepod development rate was achieved at a feed density of 1.12 µg AFDW/ mL (Figure 1).

With our current production system of 400 L hemispherical tanks a maximal production rate of 1500 nauplii/L/day is possible. Four tanks can produce up to 2.4 million nauplii per day. Scaling up production cultures to 1200 L resulted in an approximate 13% drop in maximal nauplii production. However, this relatively small drop in production could likely be overcome with some minor modifications to tank dynamics.

This presentation will focus on our advances made in the culture of copepods and ability to provide greater numbers of nauplii for first feeding marine finfish larvae.



0 Increasing algal density (Ash Free Dry Weight)

Figure 1. The relationship between copepod development and increasing feed concentration. Initial copepods (N1 nauplii) were fed *Rhodomonas* for 72 h. Asymptote occurs where copepod development is limited by time and not feed concentration.

FISH LARVAE DIETS REPLACING IMPORTED Artemia – FRDC RESEARCH PROJECT

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A major problem in intensive culture of fish is nutrition during the early life stages and inadequate food supply (quantity or quality) is a major cause of mortality. Live food is currently obligatory for successful culture up to metamorphosis when fish are weaned onto dry formulated diets. The main organism used as 'live food' in the aquaculture industry is the brine shrimp *Artemia* sp. Eighty percent of the world brine shrimp production originates from the Great Salt Lake, Utah, U.S.A. In recent years the production of cysts from the lake strongly varied, causing pricing and availability problems.

On this basis, any decrease in the use of imported *Artemia* in fish hatcheries, would be economically advantageous. Three potential alternatives to using imported *Artemia* are: (1) microdiets (i.e. dry, semi-dry or suspended micro-particles) which can represent a considerable saving in production costs and infrastructure as well as offering nutritional consistency and off-the-shelf convenience; (2) 'local' *Artemia* that may present an Australian source of *Artemia* cysts; and (3) optimizing the use of imported *Artemia* through better hatching and enrichment methods.

Based on the recommendations from the 'Hatchery Feeds' workshop held in Cairns, Qld (March 2000), a research project was funded by the FRDC. The project was set as collaboration between east coast (James Cook University) and west coast (Department of Fisheries and Challenger TAFE, WA), international linkages (Spain, Portugal and New Zealand) and industry partners (Cognis Pty Ltd, Batavia Coast Fisheries, WA). The project has also drawn in several Australian R&D institutes, international and industry collaborations.

The project objectives were:

- (1) To develop a standard testing system for evaluating live and artificial feeds for fish larvae
- (2) To test currently available artificial (commercial) larval diets
- (3) To formulate artificial larvae diets
- (4) To assess the use of 'local' Artemia and improve their nutritional value
- (5) To develop the use of co-feeding live and dry diets for partial or full replacement of Artemia nauplii

An automated experimental larvae rearing system was developed as the first step of the project. The system includes complete environmental control (lights, temperature, food supply) and an adjunct Artemia hatching / enriching system.

Several commercial diets were assessed for their nutritional value for the larvae of several marine fish species and cofeeding and weaning protocols were developed in collaboration with commercial hatcheries and feed manufacturers. In parallel, a prototype - experimental larvae diet was developed which matched the performances of the commercially available diets.

Commercial-scale production of Artemia cysts was assessed in collaboration with an industry partner. Project outcomes will be presented and future research directions discussed.

COMMERCIAL PRODUCTION OF Artemia CYSTS IN WESTERN AUSTRALIA

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Brine shrimp (*Artemia*) has been intensively used as a live food in aquaculture since the 1960's. Live *Artemia* nauplii and/ or adults are currently used in virtually all commercial prawn and marine finfish hatcheries. Over 85% of all marine animals now cultured utilise *Artemia* as a partial or sole diet during their larval phase. The availability of the *Artemia* cysts combined with long shelf life and easy procedures for hatching made them a convenient live food for larvae of marine organisms. The biggest disadvantages, however, are reliability of supply, product quality variation between sources and variable cost.

Over 80% of the world production of *Artemia* cysts is harvested in the Great Salt Lake (GSL), Utah, USA. Some 7000 hatcheries, around the world (in 1997), required over 1500 metric tons of dry cysts annually, or 7500 tonnes of raw, wet cysts. The majority of the cyst consumption is by the prawn industry (80%-85%), while other mariculture industries use 15-20% of total world consumption. However, the mariculture industry is, at the moment, almost totally dependent on *Artemia* cysts as a secondary food organism after the rotifer.

The GSL production of cysts is vulnerable due to the geological structure of the lake and global weather changes (El nino). The 1997 El nino phenomenon changed the salinity levels within the south and north arms of the lake, making them inappropriate for cysts production. As a result, the harvest from the lake dropped sharply in the following years. This situation led to a dramatic increase of cysts prices.

It was clear that diversification of *Artemia* sources is needed. However, large-scale production of *Artemia* cysts is, in most cases, limited by the availability of a food source i.e. microalgae. Small-scale production of *Artemia* cysts is possible in salt field, however, the salt production and quality may be influenced by the organic matter in the water (algae-*Artemia*) and in many cases salt field operators are reluctant to initiate *Artemia* cyst production.

Therefore, as part of an FRDC project, an initial assessment of commercial production of Artemia cysts was carried out in Western Australia.

Hut Lagoon at Port Gregory, north of Geraldton in WA, is a natural saline lake where microalgae *Dunaliella salina* grows naturally. At high salinity the algae starts to produce beta-carotene. Besides *Dunaliella*, *Artemia* also grows in the lake. The combination of high salinity and an abundance of food is an ideal situation for *Artemia* production.

During the last two years the Department of Fisheries, WA and Cognis Australia, a company based at Port Gregory which harvests and processes the *Dunaliella* for the food and the pharmaceutical industry, have commenced an assessment of the potential for commercial scale production of *Artemia* cysts.

A pilot scale grow out experiment was carried out using six 22 m³ plastic-lined ponds. A specific 'in-line' filtration system was developed to separate adult *Artemia*, nauplii and cysts for population control and cyst harvesting. *Dunalliela* harvested from the main algae ponds was used as a food source for the *Artemia*.

The project, grow out system, results and future direction will be presented.

INTENSIVE REARING SYSTEMS FOR FINFISH LARVAE RESEARCH

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I. Marine finfish larvae rearing system

Larvae culture in general and specifically larvae nutrition are considered to be the 'bottle necks' for marine finfish culture. Fish larvae rearing experiments are carried out in various systems, from small beakers to very large commercial tanks, making it difficult to compare data across systems.

A continuous supply of live or dry feeds and a controlled environment i.e. temperature, filtration, photoperiod, oxygen and pH, are essential for any experimental or commercial system. These environmental factors are best controlled automatically in order to minimize variation between tanks. However, only a few automatic systems have been developed for marine finfish hatcheries.

One of the high priority recommendations of the 'Hatchery Feeds' workshop (Cairns, Qld, March 2000) was the development of a reliable experimental system for marine finfish larvae rearing that minimizes variability between the tanks and enhances control of environmental parameters while reducing the workload. Therefore, as part of an FRDC project, an experimental larval rearing system was developed.

The system includes 24 270 l conical tanks with up-welling or bottom draining flow through water delivery system. The inlet water passes through a gas exchange column that saturates the water with dissolved oxygen and stabilizes the pH. The system was originally designed for nutritional experiments using formulated feeds and the use of an up-welling water inlet method extends the suspension time of inert particles in the water column. The system enables the operator to change the water flow direction from up-welling to bottom draining as the larvae grow and pass the metamorphosis stage. A unique outlet filter was developed that eases the daily routine of replacing screens when enriched live food is used.

The system is fully controlled by a single programmable logic controller (PLC). Light intensity, photoperiod, dimming time, live food and algae pumping intervals are all automated, substantially reducing labor requirements. An innovative, PLC controlled, microdiet feeder system was developed. The system delivers 20 to 80 mg shots of a diet at any required time intervals to individual tank.

II. Artemia hatching and enriching system

Live food such as *Artemia* is considered to be an essential part of any marine finfish hatchery. Standard methods were developed for hatching and enhancing the nutritional value of the *Artemia* nauplii by using different enrichment products. Although there are a variety of commercially available products on the market, further research on more specific enrichments for meeting specific nutritional deficiencies in finfish larvae is still required. A simple, compact experimental system was developed in order to provide a reliable array of live food organisms for these nutritional experiments. The system was built as a compact, all-in-one system with eight 50 l conical tanks in a water bath. The system reduces variation between the replicates (tanks) resulting from individual heaters and aeration. It reduces the manpower time through simple procedures for harvesting, washing and refilling all of the tanks synchronously and allows automated addition of enrichments. The system has been used for a variety of experiments, comparing commercial and experimental enrichments, bacterial monitoring and evaluation of different *Artemia* procedures.

INTERNET-BASED, INPUT – OUTPUT WASTE MODEL FOR AQUACULTURE VENTURES

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To ensure that aquaculture is developed in an ecologically sustainable manner, due consideration needs to be given to the potential environmental impact of sea-cage and pond farming systems. At present, very little information is publicly available on the waste impacts of most sea-cage and land-based aquaculture industries in Australia and especially in Western Australia. Although a number of models, predicting the waste outputs mainly from salmonid aquaculture operations, have been developed in Europe and Canada, no easy-to-use model is presently available for use by individuals, companies or agencies from the aquaculture industry in Australia, dealing with locally farmed species and feeds. This information is urgently needed for the sustainable development of the aquaculture industry. Moreover, in many cases, the environmental protection authorities require that any new aquaculture project will provide an assessment of the potential waste and/or excretion output from any proposed venture.

An input-output waste model was developed as an internet-based interactive program that enables the user to estimate the waste outputs from aquaculture ventures for a variety of aquaculture species. These include, barramundi (Lates calcarifer), pink snapper (Pagrus auratus) and rainbow trout (*Oncorhynchs mykiss*). The model is based on a biological/nutritional approach and the information collated included bioenergetic parameters for the selected species, feed types and rates and excretory outputs. The databases were designed so that additional species and feed types can be readily incorporated and linked to the model in the future. The web-based model provides aquaculture proponents, governmental agencies and communities with a useful tool to quantify the waste produced by aquaculture activities. An inherent part of the model is the feed rate schedule for a species, based on the bioenergetic demands of the species and the energy content of the selected feed.

The model, funded by The Aquaculture Development Fund (WA) was developed in a collaborative effort of three research groups: Department of Fisheries, Western Australia, The National Centre for Mariculture of the Israel Oceanographic and Limnological Research Ltd. and The Centre for Water Research at The University of Western Australia.

Model Web Address: http://www.wa.gov.au/westfish/aqua/broc/output

INFORMATION TRANSFER WITHIN RAS IN AUSTRALIA

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Information and technology transfer is an essential ingredient if the rapidly evolving world of RAS (recirculating aquaculture systems) is to develop profitably and be sustainable in the long term. There is still massive interest in RAS and the question of how to provide reliable up to date information to the various parts of the RAS community is still largely unanswered.

In most states of Australia networks have been established to facilitate the transfer of information for the RAS community. These networks generate interest on formation, however substantial commitment is required by all parties to continue the momentum gained in this formative period.

Regional networks are also a vehicle for information flow back to RAS researchers and developers as they provide essential information regarding real world requirements of producers and to raise issues or problems. It is then the role of Government and researchers to appropriately disseminate and prioritize these issues for action.

If the research-extension-government-industry links are viewed as a continuum, where each entity learns from the other, the research programs and other Government decisions should be directly influenced by the farmers' needs. This continuum is threatened in some states, as the support for extension services has been actively reduced, and researchers and regulators risk making decisions based on poor information, or information based on the opinions of a few influential individuals.

Conversely, the most effective method of disseminating information to an industry, and also between industry members, particularly in its formative period, is with a well-resourced and energetic extension service. This involves regular workshops and field visits. Farmer knowledge transfer through group learning and decisions may be facilitated by a knowledgeable extension service. As RAS are essentially attempting to control an indoor culture environment much of the information found to work in one part of the country would also work in another part, even though ambient climatic conditions are very different.

Facilitation of information flow by extension services at a national level would not only permit the rapid and effective communication of information, but also avoid poor practices spreading from state to state.

ACTIVITY OF THE PURIFIED INHIBITORY SUBSTANCE PRODUCED BY Aeromonas media A199, A PROBIOTIC BACTERIUM

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Aeromonas media strain A199 is a bacterium that produces an extracellular substance *in vitro* with inhibitory activity against a variety of bacterial and fungal fish pathogens. *In vivo*, the organism has been shown to: enhance the survival of the Pacific and Sydney rock oyster larvae after challenge with a bacterial pathogen; and contribute to the recovery of fish affected with saprolegniosis. *Aeromonas media* A199 is thus a potential probiotic for the management of bacterial and fungal disease in the aquaculture industry.

The probiotic properties of A199 are thought to derive from an inhibitory substance that is produced during growth. In this study, an extracellular substance identified as fraction T1 was isolated from broth cultures of A199. The purified fraction T1 when reconstituted in aqueous medium exhibited both antibacterial and antifungal activity *in vitro*. Fraction T1 inhibited the growth of *Vibrio tubiashii*, *Cytophagae columnaris*, *Aeromonas salmonicida*, *Edwardsiella tarda*, *Vibrio anguillarum* (figure 1) and *Yersinia ruckerii*. One bacterial indicator, *Lactococcus garviae*, demonstrated a degree of resistance to the fraction. Growth of this indicator was generally delayed by 40- 50 hours when loss of inhibitory activity occurred and the organism resumed growth (figure 2). Fraction T1 inhibited also the vegetative growth and the germination of cysts of *Saprolegnia parasitica*. Inhibitory activity against indicators was found to be both concentration dependent and limiting over time due to the natural degradation of the fraction's component.

Gas Chromatography Mass Spectrometry (GCMS) and Nuclear Magnetic Resonance (NMR) analysis were used to identify the chemical composition of the fraction. Identification of this antimicrobial agent has the potential to be an important tool for the management of disease in the aquaculture industry.



Figure 1: Inhibition of growth of *Vibrio anguillarum* in the presence fraction T1.



Figure 2: Fraction T1 delays rather than completely inhibits the growth than completely inhibits the growth

TUNA FARMING AND THE SEAFLOOR

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The effect of farming fish at sea on the surrounding environment has been investigated for several fish species, particularly salmon. Environmental research in southern bluefin tuna (SBT, *Thunnus maccoyii*) aquaculture near Port Lincoln, South Australia, currently seeks to better understand ecosystem processes and the environmental effects of the SBT industry on a regional as well as on a farm-site basis. Our research involves developing protocols to measure the amount of oxygen consumed by organisms in bottom sediments and then evaluating whether there is a difference in oxygen consumption at the seafloor at sites near to SBT farms and those further away. Oxygen consumption normally arises from consumption of naturally occurring organic matter, such as phytoplankton/algae that sink to the seafloor, by bacteria and other infauna. The result of this aerobic decomposition of organic matter includes , nutrient regeneration into the water column above, conversion of organic matter by benthic organisms and accumulation of refractory material on seafloor sediments.

The data collected so far suggest there is a naturally occurring gradient in carbon and nitrogen content of the sediments across the region where SBT farms have been located. The nature of this gradient gives rise to three distinct geographical zones of sediments that share common characteristics. Upon this background and over seasons, there was no significant difference in sediment oxygen consumption between fallowed SBT farm sites (4 – 10 months after the farm fish had been harvested and the site left empty) and control sites. Compared with Australian and international literature sources, the sediment system around the SBT farming area has average conditions typical of natural muddy sand sediments in subtidal coastal marine waters of temperate latitudes. This conclusion contrasts with research on salmonid farms in northern European countries, where elevated levels of wastes and uneaten food have been detected in the close vicinity to pontoons many months after fish have been removed. The difference is probably due to the more wave-exposed locations of the South Australian tuna farms, higher abundance of mobile scavengers (a number of macroscopic species of fish and crustaceans rapidly consume uneaten feed), the seasonal nature of tuna farming (normally 3-7 months per annum), and low tuna stocking densities.

THE AQUACULTURE COMPENDIUM – A REVIEW OF THE DEVELOPMENT OF THIS INNOVATIVE MULTIMEDIA KNOWLEDGE RESOURCE AND A DEMONSTRATION OF THE COMPENDIUM TECHNOLOGY IN ACTION

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CAB International (CABI) and its partners worldwide have developed an innovative series of multimedia knowledge resources called Compendia. A Compendium is a comprehensive and versatile electronic reference and problem-solving resource that brings together a wide range of encyclopaedic and multimedia tools into a continually updated scientific overview of the topic. To date CABI has compiled Compendia on Crop Protection, Forestry and Animal Health & Production. Compendia are delivered on CD-ROM and on the Internet.

Practitioners in aquaculture have voiced a pressing need for an improved, consolidated knowledge resource. In response, the *Aquaculture Compendium* has been designed to bring together existing respected sources of knowledge with newly commissioned structured texts, integrated using CABI's unique Compendium technology and resourced by a Development Consortium. Publication of the Compendium is planned for 2005.

The *Aquaculture Compendium* will encompass the commonly cultured species and their biology, health and diseases; culture technology of production systems; marketing and economics; policy; environment; sustainability; and education and training. It will help users:

- Understand aquaculture natural resources and environment, biodiversity, trade, food production and safety.
- Find information about finfish, crustaceans, molluscs and other cultured aquatic species.
- Diagnose, solve and prevent health problems including detailed coverage of pests and diseases.
- Recognize patterns in aquaculture trade and commerce for decision making in business.
- Identify trends in aquaculture worldwide.
- Recognize good practice through detailed case studies from around the world.
- Promote the sustainable development of aquatic resources.

The Aquaculture Compendium will be a unique source of key information for specialists and non-specialists. The content will include: Datasheets on hundreds of topics, prepared by specialists and peer-reviewed; A relational database structure, plus softlinking - a dynamic connecting system between topics; Maps, and a GIS to present geographic data visually and dynamically; Production statistics, with dynamic visual presentation of chosen subsets; Illustrations, which (like the text and graphics) are available for copying and use; A dynamic biosystematic infrastructure; A bibliographic database; A virtual library of full-text documents; A glossary; A system of personal and shared Notepads, to allow additions by the user.

Compendia are in use throughout the developed and developing world. We aim to ensure that all those who need them, know about them, and all those who want them can afford them under a flexible pricing structure. Further details at www.cabicompendium.org

THE CARDIOVASCULAR EFFECTS OF AMOEBIC GILL DISEASE (AGD): A COMPARATIVE STUDY OF THREE SALMONID SPECIES

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Amoebic gill disease (AGD) is the most significant health issue affecting Tasmanian salmonid production; however, the actual mechanism by which AGD causes mortality in fish is still unknown. Previous investigations into the pathophysiology of AGD have provided evidence to suggest that AGD appears to be associated with both hypertension and abnormal cardiac morphology, which possibly suggest an AGD-associated cardiac dysfunction. This study was therefore conducted to ascertain specific cardiovascular responses associated with AGD in three commercially important salmonid species, Atlantic salmon, *Salmo salar*, brown trout, *Salmo trutta*, and rainbow trout, *Oncorhynchus mykiss*

Experimental fish in this study were infected by co-habitation in a *Neoparamoeba sp.*, (the assumed causative agent of AGD), stock infection tank for 3 days. Following the surgical placement of a dorsal aortic catheter and a cardiac flow probe, cardiovascular parameters including dorsal aortic pressure ($P_{\rm DA}$) and cardiac output (Q), were recorded over a post-surgical recovery period of 6 h. AGD-affected Atlantic salmon displayed significantly elevated systemic vascular resistance ($R_{\rm s}$), calculated as $P_{\rm DA} / Q$, at 4 and 6 h post surgery and also a consistently reduced Q that was significant at 4 h (Fig. 1). Comparatively, brown trout appear to be less susceptible to AGD in terms of cardiovascular effects as no major significant effects attributable to AGD were found within the trout group. Results for rainbow trout are yet to be completed.

In agreement with previous studies, results from the present investigation suggest that AGD-associated mortality, specifically in Atlantic salmon, is related to cardiovascular dysfunction. During chronic, field-based infections it is possible that increased R_s and consistent reductions in Q will lead to a decrease in both cardiac scope and function. AGD-affected fish may therefore not have the cardiovascular capacity to cope during stressful periods and mortality, may occur following cardiac collapse and failure.



Fig. 1. Q (ml/min/kg) and R_s (cmH₂O/ml/min/kg) in Atlantic salmon. * Indicates a significant difference between treatments at the same time point (P<0.05).

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MODIFIED ATMOSPHERE PACKAGING (MAP) MICROBIOLOGY AND SEAFOOD

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Fish is generally perceived to have a short shelf life relative to other foods, its deterioration being due to lipid oxidation, self-degradation by autolytic enzymes, and microbiological processes. Although the former processes may cause sensory changes leading to quality loss, microbial growth and activity are the main reason for the development of off odours and flavours in refrigerated fresh fish. By inhibiting the growth of bacteria responsible for spoilage, it is possible to extend the shelf life of fish.

One way to slow the growth of spoilage bacteria is to store and distribute foods in an environment in which oxygen has been removed, or enriched in carbon dioxide or other mixtures of gases. The latter approach is termed "Modified Atmosphere Packaging (MAP)". The shelf life extension achieved by MAP depends on the type of fish, the type of bacteria on the fish at the time of packaging, and the effect of the gas mixture on the specific bacteria present. Complications arise in the case of tuna, for example, in which it is be desirable to include high levels of oxygen in the gas mixture to preserve the appearance of the flesh but which could lead to increased lipid oxidation and development of rancid taints.

In this presentation the basis of MAP and its effect on microbial growth will be described, benefits and limitations discussed, and examples of its effect demonstrated using actual samples.

INDUCTION OF TRIPLOIDY IN AUSTRALIAN GREENLIP ABALONE Haliotis laevigata WITH CYTOCHALASIN B

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Induction of triploidy by Cytochalasin B (0.25mg/L, 0.5mg/L and 0.75mg/L) was conducted to block the formation of polar body 2 (PB2) in the Australian greenlip abalone *Haliotis laevigata* In the treatment of 0.5mg/L CB for 15min duration, 20 min between releasing of polar bodies was divided into four trial groups. At the forth day, group 4 was usually suffering mass mortality. As showed in table 1, 2 and 3 groups were significant differently from 1 and 4 groups (P<0.01), resulted in 15min past fertilisation (PF) was the optimal commencement time of treatment. Based on this, the zygotes of greenlip abalone were treated for 10min, 15min and 20min, individually. Significant differences in triploid induction (P<0.01) were found both among concentrations of CB and among durations of treatment (See figure 1). The polyploidy was determined in abalone larval stage with flow cytometry. The most effective treatment for triploid induction was 0.5mg/L of CB for a treatment period of 15min, resulting in hatch rate (HR) of $46.1 \pm 2.4\%$, survival rate (SR) of $52.0 \pm 2.3\%$ and triploid percentage (N3) of $61.1\pm3.6\%$.



Figure 1. Effect of triploid induction

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	6 h	24 h	72 h	3N
Group	FR (%)	HR (%)	SR (%)	(%)
1	$86.0 \pm 2.6$	$36.7 \pm 2.0$	$35.8 \pm 2.3$	33.6±3.0
2	88.7±3.5	$46.7 \pm 1.7$	$44.8 \pm 3.5$	57.9±3.8
3	$91.6 \pm 2.1$	$54.0 \pm 5.0$	$43.4 \pm 2.4$	52.8±3.4
4	$88.0 \pm 2.6$	$45.4 \pm 1.5$	$29.1 \pm 4.1$	31.1±5.0
Control	$90.0 \pm 2.0$	$67.4 \pm 2.5$	$66.9 \pm 2.3$	

Table 1. The effects of commencement times with 0.5mg/L CB on fertilization, hatch and survival rate and triploid inductions in Greenlip abalone (15min duration).

#### EFFECT OF ILLUMINATION, TEMPERATURE AND SALINITY ON THE GROWTH OF A HYDROCARBON-RICH ALGA *Botryococcus braunii*

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*Botryococcus braunii* is an autotrophic green alga (Chlorophyceae) that occurs in lakes and reservoirs in Australia and other parts of the world. This microalgal species has the ability to produce unusually high levels of hydrocarbons ranging from 15% to 76% of dry weight and has been proposed as a renewable source of biofuel for future energy supply. Previous studies have shown that the hydrocarbon production kinetics depends on the algal growth phase, however, the optimal conditions to maximize biomass production are yet not defined. In this study, we tested the response of the population growth of this alga under various light, temperature and salinity conditions.

In the illumination experiment, we set daily photoperiods at 4, 8, 12 and 24 hours, and light intensities at 8, 12, 18 and 26 W m⁻². In the temperature experiment, we selected 20, 23, 25, 27 and 30°C to test the algal growth under the photoperiod of 12 h light and 12 h dark. The population abundance was measured twice a week with spectrophotometry. With three replicates, the data were analyzed by one-way ANOVA to detect the optimal culture condition. The results indicate that the algal abundance at 12 h or 24 h illumination was greater than that at 4 h or 8 h illumination, but there was no significant difference between the 12 h and 24 h light conditions (Figure 1, P>0.05).

Considering there is a large area of land and brackish water in Australia available to cultivate this alga for fuel, the salinity tolerance of five *Botryococcus braunii* strains obtained from China, UK and Japan was tested in 0.2, 0.4, 0.6, 0.8 and 1.0 M NaCl solutions under the optimal light and temperature condition. This alga could adapt to a large range of salinity variation. We identified the salt tolerance range of each *Botryococcus braunii* strain and determined the relationship between the oil content in algae and the salinity level. The best strain will be selected for further research for hydrocarbon production.



Figure 1. Photoperiod experiment

### CONSUMER PREFERENCES FOR OYSTERS: IMPLICATIONS FOR THE AUSTRALIAN OYSTER INDUSTRY

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Due to the availability of advanced oyster culture technologies and the dramatic increase in oyster production, better understanding of oyster consumption patterns has become an anecdotal issue for the Australian oyster industry and marketers today. This paper seeks to provide a holistic perspective of the factors influencing the way people construct the process of choosing to consume oysters. It will also examine the relevant importance of these factors on the consumer choice of oysters and provide some insights into its potential consumption growth in the future. The focus group study was first utilised to help with the consumer survey questionnaire design. The method of face-to-face interviews with consumers at randomly selected seafood retail shops in several Australian capital cities was used to collect the data in this study. Some variables of consumer attitudes towards oysters, such as quality, safety and psychological aspects, were identified by 'Principal Component Factor Analysis'. A logistic regression approach predicts the consumer choice of oysters using those factors and the demographic factors in the binary choice model. The results suggest that consumers require more information on the traceability of served oysters. Age and gender seem to affect the consumer choices of oysters, with males generally preferring oysters more than females and young Australians aged between 15-19 rarely enjoying eating oysters. Dislike of the taste is the main reason given why people do not eat oysters (Figure 1). In addition, consumer preferences for the other attributes associated with oyster purchase were identified. Further, consumer attitudes towards oysters have been clarified and ranked. The information in this study would be very useful in organising retailing of seafood as well as in advertising and publicity campaigns to encourage the marketing of oysters.





Figure 1: Factors influencing negative choice of oysters as food.

### SAMOA TROCHUS ENHANCEMENT PROJECT

Malwine Lober

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Samoa participated in the ACIAR Regional Trochus Project as a result of the ACIAR Aquaculture Workshop in Noumea, New Caledonia in July 2001. Trochus is not endemic to the reefs of Samoa and was introduced for seeding purposes to provide an alternative resource for coastal fishers. The Community-based Fisheries Management Program established under the AusAID funded Fisheries Extension and Training Project provided a platform for community consultation and participation in the trochus enhancement work. Three communities participating in the Fisheries Program were selected as seeding sites for imported broodstock from Fiji and Vanuatu. Hatchery production of trochus juvenile seedlings at the Fisheries Division hatchery, Toloa was also initiated under the trochus project.

### DOES YOUR BRAND STAND OUT OF THE CROWD?

Danny Loch

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Whether you're trying to broaden your product's appeal, lift your market share or just cut through the clutter of a saturated marketplace, a strong brand could prove to be your most valuable asset.

Danny Loch, director of branding agency Gasoline, will talk about how to identify your branding objectives and develop cohesive strategies for its implementation utilising the Sydney Fish Market re-branding as an example.

#### NITRIFICATION RATES IN MARINE BIOFILTERS

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Production of finfish in land based recirculating systems is widespread with most commercial applications in freshwater. However, use of this technology in fully marine aquaculture production systems is also increasing. In using recirculating technology in marine applications, designers need to take into account differences in biological reaction rates within the biological filters. As early as 1990, Nijhof and Bovendeur (Aquaculture, 87) described a 59% reduction in the rate of nitrification in fixed film biological filters in seawater vs. freshwater. Implications of their work would suggest that marine biological filters would need to be much larger than those used in freshwater systems. This presentation will describe a study conducted over an 18 month period at the Port Stephens Fisheries Centre in NSW Australia. The study measured the nitrification rate of three moving bed biological filters (also referred to as mixed bed filters) (BF1-3) at two different times; 4 months (Dec 01) and 12 months (Sept 02) from the start of fish farming activities.

Three reactors, each containing 1 m³ of commercially available moving bed media (marketed as Bee Cell by Water Management Technology, Baton Rouge, Louisiana, USA) were included as part of a two tank recirculating fish culture system. The system water was treated by removing waste solids with particle traps and drum screen filters before being introduced in parallel to the three test filters. The filters were operated over a one year period while fish of two different species were cultured at fully marine (28 - 32 ppt) salinity.

Results from this study support the findings of Nijhof and Bovendeur, in that nitrification rates were not stable until well after day 100 initial and even at 400 days after startup, the filters exhibited nitrification rates that were less than 20% of rates expected within a similar freshwater filter. Figure 1 shows volumetric nitrification rates in all three filters as a function of reactor inflow ammonia-nitrogen concentration at the two different study times. The presentation will compare these results with those of Nijhof and Bovendeur and other more recent studies on this topic. Additionally the presentation will review the implications of these findings on marine recirculating systems biological filter design criteria.



#### OBSERVATIONS ON DAILY FEEDING RHYTHM OF JUVENILE MILKFISH Chanos chanos IN BRACKISHWATER PONDS

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Milkfish (*Chanos chanos*) production is widely spread in the Asian-Pacific region. The importance of milkfish to the livelihood and nutrition of the Asia-Pacific population is evidenced by the enourmous amounts of land, water and human resources involved in milkfish culture. In the Philippines, milkfish is the most important cultured finfish species in terms of quantity. In 2001 more than 225,000 t were produced here, over 93% of this in brackishwater ponds. Milkfish is often described as daytime feeder, and feeding schemes are often based on this assumption. Previous studies however showed doubts about that. The present study was conducted to determine the voluntary feeding rhythm of commercially cultured milkfish in brackishwater ponds.

Eight ponds (area between 1 and 9 ha, depth between 0.2 and 0.4 m) of two commercial milkfish farms on Panay Island, Philippines were monitored between March and August 1998. Water parameters like temperature and dissolved oxygen (DO) were regularly monitored. Samples of up to 3 fishes were caught with a cast net every even hour on the first day and every odd hour on the second day of sampling, so that every hour of the day was covered after 48 hours. This sampling regime minimized the disturbance to the fish in the pond. In total, 267 fishes, ranging from 54 g to 173 g mean body weight, were sampled. After collection, fish were measured and weighed. The stomach was removed, preserved in 70% ethanol, and the content analysed microscopically (qualitative) and gravimetrically (quantitative). Start and duration of the feeding period was calculated for each pond by considering changes of stomach contents.

Results are shown in Table 1. During the monitored period, milkfish started feeding as early as midnight or shortly after, and feeding period on natural food alone was extended up to 21 hours if dissolved oxygen levels in the water were above  $1.5 \text{ mg } l^{-1}$ .

Date	31.03.	04.06.	07.06.	30.07.
Min. DO in mg l ⁻¹ during night	3.0	0.1	2.1	0.4
Number of fish [n]	71	53	72	71
Mean weight [g]	92.1	173.0	54.4	156.5
Feed begin [time]	03:00	08:00	00:00	05:00
Feeding period [h]	21	14	21	14

TABLE 1: Feeding parameters of juvenile milkfish from two commercial milkfish farms between March and August 1998.

It can be concluded, that milkfish is not a strict daytime feeder, but feeds during the whole day, if water parameters (e. g. dissolved oxygen level) are suitable.

## USING AFLP MARKERS AND A TWO-STAGE SELECTIVE GENOTYPING STRATEGY TO IDENTIFY GROWTH GENE MARKERS FOR THE KURUMA SHRIMP Penaeus japonicus

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The Kuruma shrimp, *Penaeus japonicus*, is an important farmed species in Southeast Asia and Australia. Its domestication and genetic improvement of farmed prawns has been relatively slow compared to other aquaculture species and most terrestrial livestock. The principal barriers have been the ready availability of wild prawn broodstock and postlarvae, a lack of understanding of prawn reproductive biology and perceptions of low potential for genetic improvement. The rapid development of genetic maps with DNA markers in numerous biological species offers much promise in the quest to resolve more fully cellular, developmental and evolutionary processes.

To identify QTLs in Kuruma prawns that affect growth, we had employed a mapping strategy that involved crosses between the extreme high and low ends of the size distribution in a group of farmed prawns. One intermediate F2 family, F1 from HH x LL and F2 from HL x LH, was chosen to generate the genetic maps. A two-stage selective genetic mapping strategy was applied in the study. An initial mapping of 46 extreme progeny from two tails (top and bottom 6%) using 54 pairs of AFLP primer combinations had resulted in nearly 70% genome coverage. The preliminary QTL analysis indicated the potential existence of QTL for the growth traits. In order to verify the results, a second stage of linkage mapping on the additional 56 progeny (top and bottom 8%) of the same family with the same 54 primer combinations was conducted. A total of 401 markers following the Mendelian segregation ratio of 1:1 were generated from the population of 102 progeny. Forty-three linkage groups were obtained for male map and thirty-one for female map, in comparison to the haploid number of 44 chromosomes of P. japonicus. The QTL analyses identified two chromosome regions on the male map that had significant effects on the growth traits. Bulk Segregation Analysis (BSA) was applied to saturate the QTL regions and one additional AFLP marker was mapped to the QTL region and confirmed the QTL LOD profile (LOD=3.7). One sex-linked marker was also confirmed on female map. Efforts were underway to identify the allelic variants responsible for the marker segregation, and to isolate and characterise the regions surrounding the QTL and sex marker. A number of strategies were employed, including library production, inverse PCR and genomic DNA walking techniques and two alleles of the AFLP marker associated with the large QTL region were identified.

## INCREASED PRODUCTION AND RETURNS FOR Penaeus sp. USING SELECTIVE BREEDING.

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Based on heritability estimates it may be possible for growth rate to increase 20% each generation, through management of inbreeding, and by applying a high selection intensity for growth. This translates to a doubling of growth in 5 years. The total annual cost of running a basic selective breeding program adjoining existing facilities is approximately A\$0.5m. This is made up of infrastructure costs of A\$4m (annual interest A\$0.3m) and ongoing running costs of around A\$0.2m.

Doubling growth may allow twice the amount of product to be produced for the same hectares of ponds. If the wholesale value of prawns averages A\$12/kg then doubling growth is worth an extra A\$12/kg, less additional costs. These additional costs are largely attributed to additional feed, and additional costs of post larvae (PL). Assuming a feed conversion ratio of 1.8 and feed costs of A\$1.50/kg, the additional feed costs are A\$2.70/kg.

Pond reared spawners, essential for a breeding program, may require  $15^{a}$  times more broodstock to produce the same number of zoea than wild broodstock. For hatcheries this means additional maturation facilities to produce the same quantities of nauplii. Assuming maturation costs are 30% of the A\$5.6m^b in annual sales of Australian PL's, additional costs may be up to \$5.6m(15*30%-1)=A\$19.6m.

Based on an annual production of  $3m \text{ kg}^a$ , the annual increase in profit margin from doubling growth is worth approximately: (3m kg *(\$12/kg-\$2.70/kg)-\$19.6m)=A\$8.3m to the Australian industry which is equivalent to an additional margin of A\$2.75/kg of production. The result of 5 years of selective breeding, may compare very favourably to the elimination of disease as an alternative investment. If the total loss of production from disease was 5%, then the cost of disease to industry is \$12/kg*5%=A\$0.6/kg of production.

Just how prawns, with the genetic ability to grow twice as fast, will impact on individual farm returns will depend on how their growth is realised. Additional crops per year will require some additional harvesting costs, whereas growing animals to a larger size will result in higher oxygen demand and perhaps reduce growth rate and or survival. Selection for growth at high densities will be preferred in a selection program but the initial priority will be to provide the environment to grow healthy mature animals capable of breeding, an essential component in any breeding program.

It appears that industry would benefit from a selective breeding program using existing technology. The cost effectiveness of pond-reared broodstock for PL production should improve as selection pressure for reproductive performance is expected to increase PL numbers.

a Aquaculture 116:191-198.

b estimated from: (Value of PLs sold )(No stocked)/(No sold) Report to farmers, Department of Primary Industries and Fisheries, Information Series QI 04027

### THE E-MYTH IN AUSTRALIAN AQUACULTURE DEVELOPMENT

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Key words: extension, practice change, research, development, technology transfer, outputs and outcomes, Strategic extension campaign, J Greber, technican, manager, and entrepreneur, ERDE wrap.

## GENETIC IMPROVEMENT OF FINFISH AND IMPLICATIONS FOR AUSTRALIAN AQUACUTLURE DEVELOPMENT

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Aquaculture genetics is just about past its embryonic stage of development relative to the application of genetics in crops and livestock. This paper briefly reviews progress in aquaculture genetics over the past two decades, from an applied perspective, charting the experimentation with various forms of "rapid response" approaches based on hybridization, chromosome set manipulations and more recently transgenesis. The uptake and impact of much of this research in aquaculture has perhaps been disappointing and there would appear to be a consensus that some form of selective breeding should be at the core of most applied genetic improvement programmes. The current emphasis of research is on modern molecular techniques, particularly the application of genetic markers as genetic tags, and for marker assisted selection. These tools are now starting to be used in applied and commercial breeding programmes and are increasingly likely to be adopted to enhance the efficiency of traditional approaches to selective breeding. The major focus of genetics research has been on salmonid species, not reflecting the relative and growing importance of non-salmonid species in global aquaculture production but rather the sources of funding and geographic location of most aquaculture genetics research.

Molecular tools are still rarely used in Asia, where the majority of aquaculture production takes place. Emphasis of aquaculture genetics research in Asia has been on the characterisation of cultured stocks, most of which have been domesticated for 3-4 decades. There is evidence, in many species, that domestication and poor genetic management is leading to deterioration in culture performance and remedial actions are now being taken to counter the negative impacts of inbreeding, genetic drift and hybrid introgression. With the majority of non-salmonid aquaculture species in Australia yet to be domesticated, there are important lessons to be learned from past experiences and opportunities exist to avoid common pitfalls.



Figure 1. Chart illustrating trends in genetics research derived from the subject topics of papers and posters presented at the triennial International Symposia in Genetics in Aquaculture

## PRODUCTIVITY IN INTENSIVE NURSERY SYSTEMS FOR MUD CRABS Scylla serrata

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Nursery systems are considered as a necessary intermediate phase in the mud crab production chain between hatchery and growout, to take the post-larvae to a size that is robust and suitable for long distance dry transport (>24h). To minimise both operating costs and area required for commercial nursery systems production densities need to be maximised while not severely compromising survival rate. An experiment was conducted to assess the influence of stocking density and addition of habitat structure on the productivity of a simple nursery system design, using post-larvae produced in 6000L tanks.

Culture units were mesh cages (hapa nets) suspended within an outdoor plastic lined pond. The hapa nets were 2m(L)x1m(W)x0.8m(H) suspended from a PVC float and held to the correct form by a weighted PVC frame. The habitat was constructed from cantilevered 20mm woven mesh. A single layer of this covered 95% of the bottom surface area.

In the first stage of the nursery experiment, megalopa to C2 (= crab instar 2), stocking density in the range 625 to 2300 per  $m^2$  did not significantly influence survival rate, however it was apparent that loss of crabs accelerated when the crabs were continued beyond C2 at these high densities.

From the C2 instar the addition of habitat improved survival at all crab densities. Mean survival with and without additional habitat was 84% and 45% respectively in the C2 to C5 stage and 63% and 37% in the C5 to C8 stage. This indicates that even short nursery cycles for early crablet stages greatly benefit from the inclusion of a simple habitat system. Growth, as measured by frequency of moulting, was not significantly influenced by stocking density or inclusion of habitat. This may indicate that within the range of experimental parameters, density dependant factors such as the degree of intra-specific interaction, either did not change or does not impact on growth as it does on survival. Incidence of limb loss was not correlated with density and was consistent among treatments. The highest productivity obtained from the nursery experiment is detailed in Table 1.

Table 1: Production statistics of the best performing treatment at the end of each stage of nursery culture. Figures are the mean of duplicate culture units.

Nursery stage	Duration (days)	Crab instar	Crab size (g / mm CW)	Productivity (crabs/m ² )	Survival (%)
Meg to C2	7	1.7	0.03 / 5	1024	81.2
C2 to C5	19	4.8	0.37 / <i>13</i>	203	81.0
C5 to C8	16	7.9	4.8 / 35	70	56.2

Nursery DurationCrab instarCrab sizeProductivitySurvivalstage(days)(g / mm CW)(crabs/m²)(%)Meg to C271.70.03 / 5102481.2C2 to C5194.80.37 / 1320381.0C5 to C8167.94.8 / 357056.2This information is being used to formulate a production and economic model that optimises the production system for mud crabs. Further development of intensive nursery systems for crabs is continuing at the Bribie Island Aquaculture Research Centre.

## ROLE OF EXTENSION IN THE DEVELOPMENT OF THE CHANNEL CATFISH AND OTHER AQUACULTURAL INDUSTRIES IN THE USA

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Extension has served a critical role in the development and sustainability of the channel catfish and other aquaculture industries in the USA. Since early research into aquaculture, the Extension Service has developed programs to meet the needs of prospective producers and educated existing producers on new research and infrastructure needs pertinent to the industry.

New fish producers face many problems in developing aquaculture enterprises. Some of these problems include infrastructure development, management assistance, and market development. Infrastructure development includes manufacturers of equipment (e.g. aerators, feed bins, seines, etc.), feed, hauling, and processing. Infrastructure development also includes banking services, pond construction, road/bridges, and proactive political involvement. New producers may lack essential management skills and therefore need direct management assistance. Management assistance can include region specific publications, workshops/seminars, demonstrations, and on-site consultations provided by Extension Aquaculture Specialists. Market development is always problematic with successful niche market development essential to new culturists and/or new species.

Existing aquaculturists need to be kept abreast of new research developments that effect production efficiency, profitability, and offer liaison support for potential regulatory changes. The Extension Service programming efforts support the experienced producer through newsletters, conferences, diagnostic and/or problems solving assistance, and interactions with commodity associations and regulatory agencies.

This talk will discuss these challenges and address insights into possible solutions or strategies of Extension or outreach programming.

#### INDIGENOUS AQUACULTURE IN THE FIJI ISLANDS

Filimone Mate

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The Fiji Islands have among the most diverse aquaculture sector in the Pacific. The main target commodities include GIFT tilapia, macrobrachium shrimp, penaeus prawn, kappaphycus seaweed, giant clam, live rock, carp and black pearl. The government plays a central role both in policy and development and has an underlying policy and legislative framework to promote the socio-economic development of its indigenous population. In support of this policy the focus of the Ministry of Fisheries aquaculture program is to facilitate the expansion of farming, transfer technology and best husbandry practices, and to concentrate on priority species to subsistence or commercial level. Increasingly, assistance is being directed towards small-scale aquaculture and domestic consumption. The opportunity to provide employment to rural people, for example as an alternative to Fiji's displaced farmers from the ailing sugar industry, is recognised. This presentation will present the status of indigenous aquaculture and the support provided by government in the Fiji Islands. It will examine the challenges (such as land disputes and profit sharing) faced by rural, indigenous people through a case study of tribally owned (Mataqali) fish farm in Deuba Village and Driti Village women's fish farm.

### **CYTOKINES IN FINFISH – A REVIEW**

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Cytokines are polypeptides or glycoproteins that have a pivotal role in initiating, and regulating, both the inflammatory process and the immune response in vertebrates. Generally they act in an autocrine or paracrine fashion (i.e., they act locally), and their effect is usually only exerted transiently. A cytokine may act alone, or synergistically with other cytokines.

The fish counterparts of many mammalian cytokines have now been recognized. These have been identified using a variety of approaches, and, in recent years, a number of fish cytokines have been well-characterized. The first reports on the use of fish cytokines as vaccine adjuvants, or immunomodulators, have also begun to appear.

This review paper aims to:

- Briefly discuss the phylogenetic diversity of fish as a reminder of the difficulties encountered in comparative studies on vertebrates.
- Make some general comments about the function and characteristics of cytokines.
- Review the state of knowledge of selected finfish cytokines, particularly those involved in antiviral immune responses.
- Demonstrate how the innate and adaptive immune responses to viral infections are integrated with each other, and the role of cytokines in this process.

### GENETIC AND ECONOMIC GAINS FROM SELECTION FOR INCREASED HARVEST WEIGHT IN RED CLAW CRAYFISH Cherax quadricarinatus

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The aim of the project reported here was to develop a cost effective genetic improvement program for increasing growth rate of Red Claw. Two lines were established from Queensland river stocks. One line was selected for increased weight at 9 months, and the other maintained as an unselected control. Fifteen females and 10 males of heaviest harvest weight in each of 21 selected line cohorts, and of average weight in each of 7 control line cohorts, were chosen as parents in each of four generations of selection. Matings were devised to minimise inbreeding and took place in separate indoor tanks where the water temperature and lighting were controlled. Seven females at the same stage of egg development from each cohort were transferred to one of 28 random pens in a pond. Three months later, females were discarded and 100 of their offspring around their pen mean size were grown to 9 months at which time 15 females and 10 males were selected as parents. This process was continued for 4 generations.

Genetic changes in economically important traits after four generations of selection for increased harvest weight are given in Table 1. In the analysis weight was corrected for number harvested per pen and tail length for weight. An economic model of a typical Red Claw farm in Queensland was used to compare the profitability of farms with either unselected or selected stock. All fixed and variable costs were included. Returns took account of the difference in harvest weight (quantity) of the two stocks and were calculated using prices listed at the Sydney Fish Market which include premiums for larger size and for females without eggs attached (quality). The net present value (NPV) of the stock substitution was calculated by accumulating annual profits using a 20 yr time horizon and a 6% discount factor and is given in Table2.

Selection increased weight at harvest by 25% and reduced egg bearing females by 17.5% and slightly increased tail length. The increased quantity of crayfish at harvest and their improved quality gave increases in NPV of 111% and 47% respectively.

	Harvest weight	Females with eggs	Tail length (mm)
Selected line	61.6	9.7	73.2
Control line	49.3	18.1	70.2
s.e. of diff.	2.32	3.91	1.14

TABLE 1. Growth, reproduction and morphometric traits at generation 4

Value of unimproved	Improvement v	Total NPV	
stock (\$A)	Quantity	Quality	
28,380	31,616	13,301	73,297

TABLE 2. Net Present Value (NPV) of substituting the unimproved for selected stock on a typical Red Claw farm. 20 yr time horizon and 6% annual discount rate.

### NIMBY'S, LULU'S AND AQUACULTURE - ARE WE MEETING THE PLANNING CHALLENGES?

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The community generally views the concept of aquaculture as a production technique with considerable enthusiasm. However, when specific new aquaculture developments are proposed they are increasingly being met with vocal and often effective local opposition. This is particularly the case for proposals along the coastal zone and those in marine waters which may be viewed by the community as NIMBY (not-in-my-backyard) type developments or as a LULU (locally-unwanted-land-use). There is a significant risk that aquaculture growth in Australia will be substantially constrained by a lack of site access due to community opposition to aquaculture proposals.

In recent years, several proposed new aquaculture projects have come under intense public criticism including a proposed Akoya pearl (*Pinctada imbricata*) farm at Port Stephens (NSW) and the sea cage culture of snapper (*Pagrus australis*) and yellowtail kingfish (*Seriola lalandi*) in Moreton Bay (Queensland). Further, successful citizen initiated legal action in NSW against development consent for a prawn farm on the Clarence River resulted in the proposal being abandoned by the proponent.

The above examples highlight several important considerations for industry, governments and consultants when proposing and assessing new aquaculture projects. The considerations include:

- How a strategic planning framework at a regional level is necessary, but recognition that even if a proposal is consistent with such a framework, it does not guarantee that conflict over the proposal will be minimal.
- Greater awareness of how the community perceives environmental risk.
- The challenge gentrification and migration by retirees to the coastal zone poses to 'non-traditional' aquaculture developments.
- The use of charismatic species such as dolphins and dugongs by opponents of developments to engender significant public opposition to a development.
- The perception of local communities that the majority, or all, of the farm production is to be exported and thus, benefits to the local community for those not employed by the projects is low.

If these issues are not considered, and where necessary addressed, growth forecasts for the Australian aquaculture industry appear overly optimistic. Some approaches to addressing these considerations are proposed and discussed.

## MAKING THE MOST OF EDUCATION TRAINING AND WORKPLACE OPPORTUNITIES FOR THE AUSTRALIAN AQUACULTURE INDUSTRY

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Responsive to the Aquaculture Industry Action Agenda, an assessment of current and projected needs to support growth in the Australian aquaculture industry was undertaken by: surveying training providers, conducting a focus group of Aquaculture Industry participants, using the findings from the focus group to conduct a follow up survey of other Aquaculture industries including emerging sectors, and consolidating existing information, case studies and discussions with other stakeholders. The assessment revealed that the Australian Aquaculture industry is expected to double by 2010. However, the workforce composition is expected to change to accommodate greater application of technology to improve efficiency of production. Although government, industry, and training provider plans are well developed in relation to servicing the needs of the Australian aquaculture industry there is relatively little intersection between these three key groups. Gaps identified in relation to current and projected training needs include: entrepreneurship (including marketing and supply chain management) and aquaculture engineering technology. Recommendations arising from the assessment of education and training needs include: harnessing and developing the social capital in the Aquaculture industry by focus group engagement. This will also assist in aligning plans of government, industry and training providers.

## BLOOD OSMOLALITY AND BODY MOISTURE OF MURRAY COD Maccullochella peelii peelii (MITCHELL 1839) JUVENILES REARED IN INLAND SALINE WATERS

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Murray cod, family Percichthyidae is Australia's largest freshwater teleost, inhabiting a large area of the Murray-Darling River system of south-eastern Australia. Murray cod are a potamodromous species migrating wholly within freshwater. The effects of increased salinity on life stages of native fish are largely unknown. Freshwater fish when transferred to saline water initially loose water as the body alters osmoregulatory mechanisms before returning to normal levels. The time taken for the fish to switch mechanisms shows the fish's ability to osmoregulate in that particular environment.

The experimental system consisted of 15 aquaria, (300 mm (L)x 150 mm (W)x 100 mm (H)) containing 30 l of water. Each tank had a preconditioned biological foam airlift filter run by one outlet of an aerator. All tanks were arranged in a random block design so that each block contained four test (2.5, 5, 7.5 and 10 ppt) salinities and one control (0 ppt) in replicates of three, one replicate in each block. One randomly selected juvenile from each tank was anaesthetised using AQUI-s[®] at 25 ml per 1000 l for 30 min. The blood from each juvenile cod was sampled after 2, 24 and 120 hours by severing the vein in the caudal peduncle and collecting the free-flowing blood into a pre-cooled (at 10^oC), pre-weighed, 1ml sodium heparinised syringe using a 23-gauge hypodermic needle. The blood osmolality of the heparin and blood mix was measured using Osmomat 030TM freezing-point osmometer. The sampled cod was dissected to remove the liver and muscle tissues in the form of a fillet from the left side of the fish. The liver and the muscle were weighed and dried at 110^oC till constant weight was achieved.

Survival of juveniles was not affected during the trial by directly transferring larvae to any salinity. Mean blood osmotic concentrations increased steadily with increase in salinity (Figure 1) showing a direct relationship with medium salinity ( $r^2$ =0.96) irrespective of the hours following transfer (2 to 120 hours). Juveniles were found to be weak hyper-osmotic regulators with an isosmotic point of 5.8 ppt. There was no significant difference (P>0.05) in body moisture levels of cod juveniles following 24 hours of transfer to any test salinity. However, after 120 hours of transfer there was a significant decrease in body moisture levels of juveniles at 0 ppt compared to body moisture levels of juveniles at 10 ppt. Muscle moisture levels of juveniles were not significantly different when reared at any salinities following 24 and 120 hours of transfer. After 2 hours of transfer, muscle moisture levels of juveniles at 0 ppt were significantly lower than muscle moisture levels of juveniles at 5 and 7.5 ppt. Liver moisture levels in juveniles ranged from 67.4 ± 0.9 to 74.5 ± 2.8 but showed no significant differences.



Figure 1: Relationship between blood osmolality and medium osmolality of Murray cod juveniles.

## COMMERCIAL BARRAMUNDI Lates calcarifer FARMING WITH RURAL VILLAGERS ALONG THE NORTH COAST OF MADANG, PAPUA NEW GUINEA

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Although small-scale aquaculture and ranching has been practiced in Papua New Guinea since the mid 1900's the commercial aquaculture industry is still very much in its infancy. Located 65 km up the scenic North Coast of Madang Province, Bismark Barramundi (PNG) Ltd is the countries only fully integrated intensive finfish mariculture facility. Although there is a semi intensive rainbow trout farm in the Highlands the only other registered commercial facility is a pearl hatchery and growout farm off the east coast of PNG in Milne Bay.

Bismark Barramundi began operations in 1999, building a Hatchery, Grow out and processing facilities before successfully spawning PNG's first ever crop of barramundi in November 2000. Production has since grown to over 100,000 fish per annum with current plans for a further 200,000 fish by the end of this year compliments of a European Union rural coastal fisheries program.

All barramundi are grown out within floating pontoons and cages in the pristine waters of the Bismark Sea. Each pontoon is designed specifically to accommodate rural family groups under the Companies "Family Farmer" program. This has provided an invaluable small business opportunity for the costal people of Madang Province and a realistic chance to better their respective livelihoods. The interest in the program from donor agencies, Government bodies (local and foreign), the private sector and of course the rural people has been astounding and allowed the concept to expand significantly faster than it otherwise would have.

Bismark Barramundi no longer owns any of the grow out pontoons. The Company supplies the fingerlings and feed to the "Family Farmers" then buys back all fish produced for both local (primarily hotels and resorts) and Australian export markets.

Bismark Barramundi has also made recent advances in penaeid prawn farming with a successful banana prawn trial in 2003 and is currently researching opportunities for large-scale cobia farming in 2005.

### DEVELOPING LOW-COST AQUACULTURE SYSTEMS ACCESSIBLE TO COASTAL M¬ORI

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The ocean plays an important cultural, spiritual and economic role in Mãori society. Mãori involvement in the aquaculture industry is considerably less than their participation in traditional and commercial wild fisheries. This is due in part to high capital costs, unsuitable seawater supply and conventional and established aquaculture activities that are not readily available to coastal Mãori. Coastal Mãori have expressed interest in utilising polyculture (the culture of several species in a single system) as a means of providing sustainable employment and as a source of customary foods. The aim of this project is to develop new water recycling and polyculture technologies alongside appropriate husbandry techniques in order to develop an economically sustainable aquaculture system accessible to Mãori. These systems will be modular, and scaleable to meet the requirements of individual applications whilst establishing techniques for existing and new high-value species that can be cultured economically in small volumes

## EVALUATION OF LIVE MICROALGAE AS DIETS FOR MANGROVE CLAM, *Polimesoda erosa*: EFFECTS ON FILTRATION, INGESTION, ASSIMILATION AND ENERGY ACQUISITION

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The mangrove clam *Polymesoda erosa* (Bivalvia: Corbiculoidae) is a large, fleshy bivalve presently exploited as an important food and subsistence resource for indigenous communities inhabiting coastal areas and islands in tropical Northern Australia and as well as other Indo-Pacific island nations. Currently there have been attempts to commercially exploit and culture this species as a self-sustaining project for indigenous communities. As there is no research on nutrition, this study was aimed to evaluate a range of locally available tropical microalgae as suitable diet for mangrove clam. The good diets in the present study, *a priori*, are those microalgae that provide high absorbed energy. Five locally isolated microalgal species *Isochrysis sp* (NT14) *Chaetoceros sp* (CS256) *Rhodomonas sp* (NT15), *Cryptomonas sp* (CRFI01), *Tetraselmis sp* (NT18) from tropical Australia were tested and compared with popular microalgae Tahitian *Isochrysis* (T-ISO) and *Tetraselmis suecica* (TETRA).

By dietary energy, T-ISO (294.70 J h⁻¹), NT15 (274.51 J h⁻¹) and CS256 (272.79 J h⁻¹) provided the highest amount of energy for clams. Fairly high energetic values were also gained by clams fed on CRFI01 (242.68 J h⁻¹) and TETRA (204.23 J h⁻¹). Being consumed in significantly low rates, NT14 and NT18 contributed the smallest amount of energy for clams. Absorbed energy differed significantly in clams fed with different algal diets ( $F_{6,28}$ =103.824, P<0.05). The highest amount of energy was acquired by clams fed on T-ISO (217.14 J h⁻¹); this value was similar to CS256 (182.31 J h⁻¹). NT15 (145.90 J h⁻¹), CRFI01 (161.79 J h⁻¹) and TETRA (144.65 J h⁻¹) provided comparable amount of energy for clams. The lowest energy acquisition was recorded on groups of clams supplied with NT14 (28.95 J h⁻¹) and NT18 (3.00 J h⁻¹). The preliminary experiments indicated that three locally isolated tropical microalage CS256, NT15 and CRFI01 are potential diets for the mangrove clam. Further research is needed to investigate the long-term effects of these microalgae on the chemical composition of the mangrove clam to obtain greater understanding of the relationship between energy acquisition and utilization in *P. erosa*.

### REPLACEMENT OF FISH MEAL BY ANDEAN LUPIN IN DIET FOR SHRIMP Litopenaeus vannamei

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The limited world supply of fish meal (6-7 million tons per year) and constant growth of global aquaculture production (16% per year) has resulted in a continuing high prices for fish meal with future forecasts suggesting prices will continue to rise. This uncertain availability has led to seek for more sustainable protein sources for aquaculture feeds. Hence, this study evaluated the nutritive value of andean lupin (*Lupinus mutabilis* Sweet) as an ingredient for shrimp, *Litopenaeus vannamei*, in practical diets.

Experimental diets providing 35% protein and 11% lipid were prepared, where 0, 25, 50, 75 and 100% of protein from fish meal (FM) were substituted by lupin meal protein (LM). All diets contained 10% squid to provide an attractant source. Before grinding lupin seeds, alkaloids, hull and fat were removed by specific treatments. Only the corn starch (30.6 to 36.0%) and fish oil (5.3 to 7.0%) contents of the diets were varied to keep the protein and lipid content of the diets constant across treatments. Shrimp weighting  $1.23\pm0.22g$  were stocked at 8 per 50L tank, with 6 replicate tanks assigned to each treatment in a fully randomised design.

At the end of the 57-day feeding trial, the average survival of shrimp was >80% and did not vary (P>0.05) when FM was replaced partial and totally with LM. Results of this study showed that LM can substitute 50% of FM protein without depressing growth significantly (P>0.05) (Table 1). The inclusion of LM at any of levels tested decreased statistically (P<0.05) the apparent dry matter digestibility (ADMD) and apparent protein digestibility (APD) of feed (Table 1). Replacements levels of 50, 75 and 100% of FM by LM showed a significant lower (P<0.05) ADMD with respect to the diets with 25% LM. The gradual increases of LM in diets produced a significant decrease (P<0.05) in ingestion rate (IR) (Table 1). The amount of food consumed by shrimp given the diets containing 25 and 50% LM were higher than those with 75 and 100% of LM but lower than shrimp fed diet 0% LM.

Table 1. Physiological response of *L. vannamei* fed experimental diets containing various substitution levels of fish meal by lupin. Means in a column with different letters were significantly different (P<0.05).

Percent replacement	Weight gain (%)	IR (% biomass)	ADMD (%)	APD (%)
0	476.1±84.4a	7.82±1.19a	77.85±2.90a	80.47±2.95a
25	463.0±89.2a	4.88±0.80b	72.67±1.73b	77.57±1.62b
50	449.0±26.7a	4.48±0.67b	67.75±1.78c	75.48±2.54b
75	325.5±60.0b	3.4±0.64c	66.04±1.88c	76.76±1.57b
100	295.2±39.3b	3.53±0.64c	66.54±6.9c	75.96±3.24b

These findings show that LM has very good potential as protein source up to 50% of protein from FM which is equivalent to one third of the total protein in the diet. The cost benefit of including this ingredient needs to be assessed.

### STIMULATING THE FISH IMMUNE SYSTEM

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Intensive research in recent years has seen an enormous expansion in our understanding of the fish immune response. Contentious issues have now been resolved using elegant studies, most notably those using molecular biological techniques. Beyond this, collaborative projects such as those run by genome and expressed sequence tag (EST) gene sequencing consortiums have provided immense knowledge about what the fish immune system contains and how it works. We now know that the fish immune system contains all the basic components similar to that of higher vertebrates such as mammals. Armed with this knowledge, fish health specialists have been able to produce a number of vaccines to prevent both bacterial and viral diseases. Without these vaccines, many finfish aquaculture ventures would fail. Many more vaccines, particularly anti-viral and anti-parasitic vaccines still need to be developed. While successful production and commercialisation of these vaccines is probably medium to long term, we can potentially fill this void by titillating the immune system with immunostimulants. Unlike vaccines where enhanced resistance is typically species or even strain specific, immunostimulation is the administration of components of microbes that enhance the immune system non-specifically. These components are generally basic features of all microbes such as cell walls, repetitive structures and even DNA. Recent experimental work, including that in our laboratory has shown that immunostimulants stimulate the immune system of fish both *in vitro* and *in vitro*. The challenge for us as fish health specialists is to convert this laboratory success to success in the field.

## INTERACTION BETWEEN Vibrio INFECTION AND STRESS ON THE BLUE SHRIMP Litopenaeus stylirostris RESPONSE

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Aquaculture of the blue shrimp *Litopenaeus stylirostris* is a developing industry in New Caledonia. However, it is facing seasonal episodes of mortality due to bacteria of the genus Vibrio. Variations in environmental factors seem to have an impact on the mortalities observed. It is known that environmental factors may induce a stress response in shrimp and increase susceptibility to pathogens. An experimental study was conducted in order to evaluate the potential interaction between stress and *Vibrio* infection. The effect of stress, infection and the combination of both on the response of shrimps in terms of mortality and physiology was studied

Shrimps (average weight  $10.2 \pm 0.1$ g) were acclimated for 5 days to indoor aerated tanks. They were not fed 12h and during the experiment. They were either submitted to a sub-lethal concentration of 3575 mg/l total ammonia-N (1.99 mg/l NH₃) for 24 hours (treatment A) and/or infected (treatment Vn) by immersion for two hours before (Vn+A)/after (A+Vn) with a pathogenic strain of *V nigripulchritudo* (3000 CFU/ml), which is the main bacteria found during the Summer mortalities. Average temperature was 28°C, mean pH 7.9 and salinity 37 ‰. Haemolymph from animals in intermolt (stage C) was sampled the day after for all treatments and several parameters were measured. Mortality was recorded. Osmotic pressure, pH, temperature, salinity and total ammonia-N were measured in the tank water.

No mortality was recorded for ammonia treatment. Infection killed 16% of the shrimps. If the stress was applied after the infection, it increased the mortality up to 33% (figure 1). It was not the case if the stress was applied before. Treatments had different effects on the physiological response of the shrimps (ANOVA, p<0.05). Increase in Mg ions and glucose concentration in haemolymph of shrimps stressed before infection (figure 1) could indicate that those animals were more stressed than the others.

In conclusion, blue shrimps infected with a pathogenic *Vibrio* seem to be less resistant to ammonia stress, while ammonia stress does not seem to increase susceptibility to *Vibrio*.



FIGURE 1: Mortality and Mean ( $\pm$  S.E.) osmoregulatory capacity (OC), Glucose and Mg ion concentrations in the haemolymph of *L. stylirostris* (stage C). C = control; A = ammonia treatment; Vn = infection with Vibrio See text for explanation.

## ENVIRONMENTAL CHALLENGES FACED BY THE MARINE AQUACULTURE INDUSTRY AND POTENTIAL ENGINEERING SOLUTIONS

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The development of marine aquaculture, particularly in its more intensive forms, also been one of the most remarkable growth phenomena in the global food sector. With rising demand for seafood and major public and private investment, marine aquaculture is moving a small-scale presence, incidental in natural resource and production to becoming a major element in many coastal environments. This great expansion has not been without consequence however, and there have been rising if not always well-founded concerns for environmental impacts, whether through nutrient intensification, pathogen stimulation, treatment chemical disposal, stock escapes and genetic contamination, or scenic challenge.

A range of responses has been required of the aquaculture industry, from complete cessation of production, to radically changed management practices, movement of production units, or technical change. Based on examples from an international perspective, covering a number of different production systems, this paper aims to set out the elements of the last of these, summarising recent developments, considering the comparative impacts and the driving forces for further development, and outlining potential future directions.

## PRODUCTION OF ORGANIC SHRIMP: SUSTAINABILITY OF GROWTH ADVANTAGE PRODUCED BY 'CELL SALT' TREATMENT

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Occurrence of antibiotics and chemicals in shrimps that are hazardous to health of human consumers has generated interest in sustainable production of farm shrimp free of these harmful substances. Fear of disease outbreak and resulting economic losses, and the desire to maximize production within a short period of time have been the main reasons behind the widespread use of drugs and chemicals in aquaculture. Producing organic shrimp without the use of banned chemicals and drugs by cost-effective methods is a major challenge facing the shrimp industry. New approaches are being considered to fulfill the organic criteria. Use of cell salts is a permitted treatment under the guidelines of Naturland, the International Federation of Organic Agriculture Movements (IFOAM)-accredited body. Because treatments require cost inputs, they should produce long lasting effects to be economical. This study was aimed at determining how far is the growth advantage that accrues to shrimp by cell salt treatment is sustainable.

Experiments were designed in the hatchery to rear juveniles of predetermined size and weight and expose them to Calcarea phosphoricum cell salt for two weeks. The treatment involved a 30-minute bath in salt water containing the cell salt in a concentration of 0.2 mg/L on alternate days for two weeks. A control set was maintained with no cell salt treatment of the shrimp. All the specimens were provided a pellet diet at the rate of 5% body weight on a daily basis. At the start of the trial, untreated shrimp (representing the control set of the preceding trial) measured 605 - 741 g weight whereas those representing the treated batch weighed 1000-1200g. After two weeks of rearing under conditions similar to those in the earlier experiment the specimens were measured for their weight for calculation of body specific growth. Thereafter, the shrimps from both the sets were reared under identical conditions, with none receiving cell salt treatment. After a fortnight they were taken out and measured for quantitative evaluation of body specific growth. The total range of the specimens examined was 50 - 55mm in the untreated stock and 67 - 70 mm in the treated one.

Analysis of the data suggested that the body specific growth advantage produced by the cell salt treatment in the late juvenile phase persisted in the early adolescent stage. The cell salt treated shrimp maintained their higher body specific growth even when the treatment was discontinued for two weeks.

Shrimp batch	Body specific growth (%)	Weight/length ratio
Untreated	30.48±1.80	17
Treated	45.70±2.41	45

Further investigations extending over all stages of their life cycle and specified periods of time within each stage are required. A close examination of the cell salt advantage at maturity stage is particularly important so that the supply of these mineral complexes to the broodstock could be resumed, if necessary, to boost their health and fertility.

## EVALUATION OF PRACTICAL DIETS CONTAINING THREE DIFFERENT PROTEIN LEVELS, WITH OR WITHOUT FISH MEAL, FOR JUVENILE AUSTRALIAN RED CLAW CRAYFISH Cherax quadricarinatus

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The Australian red claw crayfish is being considered as an aquaculture species in the United States. The objective of this study was to evaluate the effects of growth, feed conversion ratio, survival, and amino acid composition of tail muscle meat of juvenile red claw when fed six practical diets containing increasing percentages of crude protein (CP) (30, 35, and 40%) with or without anchovy fish meal (FM). An 8-week feeding trial was conducted in a recirculating system with juvenile (mean individual weight, 1.1 g) red claw, each randomly stocked in individual plastic mesh culture units containing its own individual water line. Water was recirculated through biological and mechanical filters. Practical diets were formulated to contain the same protein:added lipid ratio (5.7) and marine fish oil:corn oil ratio (2.5), respectively. Diet 1 contained 30% CP, 0% FM, and 42.5% SBM; Diet 2 contained 30% CP, 15% FM, and 20% SBM; Diets 3 contained 35% CP, 0% FM, and 56.5% SBM; Diet 4 contained 35% CP, 17.5% FM, and 30.5% SBM; Diets 5 contained 40% CP, 0% FM, and 71% SBM; and Diet 6 contained 40% CP, 20% FM, and 40.5% SBM.

After eight weeks, there were no significant differences (P > 0.05) in specific growth rate (SGR) or percentage survival among treatments, which averaged 3.91%/day and 80.7%, overall. The final mean weight of red claw fed Diet 6 (containing 20% FM, and formulated as 40% protein) was significantly higher (13.1 g) compared to red claw fed Diet 1 (0% FM, and 30% protein), Diet 2 (15% FM, and 30% protein), Diet 3 (0% FM, and 35% protein), Diet 4 (17.5% FM, and 35% protein), but not different from red claw fed Diet 5 (10.9 g) containing (0% FM, and 40% protein). The percentage weight gain of red claw fed Diet 6 was significantly higher (1352%) compared to red claw fed Diet 1 (828%), but not different from red claw fed Diet 3 had significantly higher FCR (5.73) compared to red claw fed Diet 6 (3.03), but not different from red claw fed the other four diets.

Results from this study indicate that juvenile red claw (1.12 g) can be fed a diet containing 35% CP with 0% FM if a combination of less expensive plant protein ingredients (SBM, wheat, BGY, and milo) is added. Reducing diet costs for red claw producers will help reduce operating cost and thereby increase profits.

#### EFFECTS OF FEEDING PRACTICAL DIETS CONTAINING VARIOUS PROTEIN LEVELS ON GROWTH, SURVIVAL, BODY COMPOSITION, AND PROCESSING TRAITS OF AUSTRALIAN RED CLAW CRAYFISH Cherax quadricarinatus AND ON POND WATER QUALITY

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A 117-day feeding trial was conducted in ponds with juvenile Australian red claw crayfish to evaluate the effects on growth, survival, body composition, and processing traits when fed diets containing three different protein levels (22, 32, and 42%), and the effects of feeding these diets on pond water quality. Juvenile crayfish (mean weight of 4.6 " 2.2 g) were randomly stocked into nine 0.02-ha ponds at a rate of 500/pond (25,000/ha), and each diet was fed to three ponds. There were two feedings per day, each consisting of one-half of the total daily ration. At harvest, there were no significant differences (P C 0.05) in the individual weight, percentage weight gain, or specific growth rate among treatments, which averaged 75.3 g, 1535%, and 2.38%/day, respectively. Red claw fed the 42% crude protein diet had significantly higher (P < 0.05) FCR (7.34) compared to crayfish fed diets containing 22% (5.18) or 32% (5.13) crude protein, and had significantly lower percentage survival (46.1%) compared to red claw fed the 42% protein diet (640 kg/ha) compared to red claw fed diets containing 22% (920 kg/ha) or 32% (904 kg/ha) protein.

Mean total ammonia nitrogen (TAN) levels were significantly higher (P C 0.05) in ponds with red claw fed the 42% protein diet (0.55 mg/l) compared to ponds with red claw fed diets containing 22% (0.32 mg/l) or 32% (0.38 mg/l) protein. Mean total nitrite concentrations in ponds with red claw fed the 42% protein diet was significantly higher (0.05 mg/l) compared to red claw fed diets containing 22% (0.01 mg/l) or 32% (0.02 mg/l) protein.

These results indicate that a practical diet containing 22% (as fed basis) protein may be adequate for pond production of red claw when stocked at the density used in this study, and that a diet containing 42% protein adversely affected levels of TAN and nitrite, possibly reducing overall survival of red claw. Use of a diet with 22% protein may allow red claw producers to reduce diet costs and thereby increase profits.
## TOTAL REPLACEMENT OF FISH MEAL WITH SOYBEAN MEAL AND BREWER'S GRAINS WITH YEAST IN PRACTICAL DIETS FOR JUVENILE AUSTRALIAN RED CLAW CRAYFISH Cherax quadricarinatus

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Two, eight-week, feeding trials were conducted within indoor recirculating systems to evaluate the effects on growth and survival of two separate strains of juvenile Australian red claw crayfish when fed diets where fish meal was completely replaced with a combination of soybean meal (SBM) and brewer=s grains with yeast (BGY-35). Four practical diets were formulated to be isonitrogenous (40% protein) and isocaloric (4kcal available energy/g of diet) containing 24% or 0% fish meal (FM). Diet 1 was formulated similar to a commercial marine shrimp diet, containing 24% FM, 23% SBM, and 0% BGY-35. A variable percentage of SBM (56.75, 47.75, and 40.75%, respectively) and BGY-35 (10, 20, and 30%, respectively) replaced the FM in the remaining three diets.

Ecuadorian-strain red claw (average weight of 1.2 g) were stocked into individual plastic mesh rearing units, with 25 replicates per treatment. After eight weeks, juveniles fed all four diets had no significant differences ( $\underline{P} > 0.05$ ) in final weight, percentage weight gain, and specific growth rate which averaged 11.46 g, 977.2%, and 3.08%/day, respectively. Percentage survival of red claw fed the control diet (Diet 1) was 76% and was 80% for red claw fed Diets 2-4.

In the second feeding study, Australian-strain red claw (average weight of 3.1 g) were stocked into individual plastic mesh rearing units, with 30 replicates per treatment. After eight weeks, juvenile red claw fed all four diets had no significant differences ( $\underline{P} > 0.05$ ) in final weight, percentage weight gain, and specific growth rate and averaged 16.22 g, 457.4%, and 2.34%/day, respectively. Percentage survival was 93% for red claw fed Diet 1 and 100% for red claw fed Diets 2-4.

These results indicate that fish meal could be totally replaced with soybean meal and BGY-35 in diets, containing 40% protein, for juvenile red claw crayfish. Total replacement of fish meal in red claw diets may also reduce operating expenses to increase profitability for producers.

### GROWTH AND PROCESSING TRAITS OF MALE AND FEMALE AUSTRALIAN RED CLAW CRAYFISH Cherax quadricarinatus STOCKED INTO EARTHEN PONDS

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Small (0.7 g) juvenile red claw were stocked in earthen ponds (0.04 ha) in Kentucky and grown for 86 days so that measurements of growth, survival, processing characteristics, and proximate composition of tail muscle in male and female Australian red claw crayfish could be obtained. A commercial marine shrimp diet was fed to all red claw in two separate feedings, each consisting of one-half of the total daily ration between 0800-0830 and between 1530-1600 hours for the duration of the culture period. Total weight and number of red claw from each pond were recorded at time of harvest.

Forty (40) red claw from each sex were randomly sampled, chill-killed by lowering the body temperature in an ice-bath, and frozen (-20NC) for processing measurements and proximate composition. Red claw were removed from the freezer, thawed, individually weighed to the nearest 0.01 g, and were then hand-processed so that weights of chelae, tail, and tail muscle were obtained to the nearest 0.01 g. After 86 days, red claw had a final average individual weight of 59.6 g, percentage weight gain of 8413%, survival of 64%, yield of 903 kg/ha, and feed conversion ratio (FCR) of 4.63. When analyzed by sex, males had significantly (P < 0.05) higher final individual weight (71.1 g) compared to females (53.7 g); significantly higher chelae weight (13.1 g for males compared to 6.8 g for females); significantly higher tail weight (25.5 g for males compared to 20.4 g for females); significantly higher tail muscle weight (19.0 g for males compared to 14.9 g for females); and significantly higher cephalothorax weight (32.4 g for males compared to 26.4 g for females). There were no significant differences (P > 0.05) in the percentage moisture, protein, lipid, fiber, and ash in the tail muscle of male and female red claw when analyzed on a wet-weight basis and averaged 81.0%, 16.5%, 0.2%, 0.1%, and 1.4%, respectively.

Results from the present study indicate that red claw can be grown as a commercial aquaculture species in locations with limited growing seasons, and that male red claw grow larger, have larger chelae, and higher tail muscle weights compared to females. Thus, it might be economically advantageous to stock all-male populations of red claw in ponds to achieve maximum production. Further research on growth and processing yields of red claw should be conducted to assist the industry.

### THE NUTRITIONAL INFLUENCE OF DIETARY PROTEIN AND ENERGY ON GROWTH INDICES AND THYROID HORMONE CONCENTRATION IN BARRAMUNDI Lates calcarifer LARVAE

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Formulated 'artificial' diets have the potential to overcome the innate nutritional and financial drawbacks associated with live feeds. Artificial formulations also provide a vehicle for accurate manipulation of nutritional constituents, enabling further investigation into the nutrient requirements of fish larvae.

Thyroid hormones (triiodothyronine, T3 and L-thyroxine, T4) have been associated with nutritional quality and quantity in juvenile fish in numerous studies. While there is a strong association between thyroid hormones (predominantly T4) and growth, survival, development and metamorphosis in fish larvae, data is lacking on an endocrine-nutrition link at the larval stage. By applying an endocrinal approach to the nutritional control of growth, we can achieve a better understanding of the underlying processes governing the physiological status of fish.

The present studies therefore attempted to clarify the quantitative and qualitative protein requirement, and to investigate possible nutritional links to thyroid hormone concentration, in barramundi larvae.

Initially the effect of dietary protein and energy were investigated to arrive at baseline macronutrient inclusion levels. Barramundi larvae (14 DAH) were fed microbound diets (MBD), varying in gross dietary protein (45, 50 and 55%) and energy (18 and 21MJ/kg) for a period of 14 days. All fish were then sacrificed, measured for total length and a sub-sample taken for dry weight analysis. Carcass T3 and T4 were measured by radioimmunoassay, after chloroform/NH₃OH extraction.

Marine animal meals (fish meal, squid powder, *Artemia* meal, mussel meal, prawn meal and krill meal) were evaluated for their suitability for inclusion into MBD for barramundi larvae. Each of these meals was included in dietary formulations to a total of 50% gross protein.

An optimal diet was found to contain at least 21MJ/kg dietary energy and derived its protein from a combination of fishmeal and squid powder. Thyroid hormone levels had no direct correlation to dietary ingredient type or inclusion level, though it appeared that depressed T4 levels may be an accurate indication of decreased nutritional status of barramundi larvae.

## A NEW APPROACH TO SYSTEMS FEED AND NUTRITION: THE SHIFT IN THE PARADIGM

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Growing shrimp forage *in situ* is somewhat analogous to feedlot production of cattle wherein rumen populations of bacteria and protozoa give immediate nutrient complements derived from simpler feeds than those required by isolated monogastric animals. Currently-available feeds or microbiota as forage alone cannot support shrimp growth equaling that from both nutrient sources combined: Feeds lack specific trace nutrients and primary production rates of forage cannot support high shrimp yields of intensive culture. Under current systems, shrimp production is optimised when both exogenous and endogenous feeds are present – if either of these is absent, productivity is dramatically reduced.

However, technologies in feed supplements now being commercialized offer improvements beyond satisfying animals' nutrient requirements. Indeed, new aquaculture feed ingredients and processes are figuring more and more prominently in the production of more nutritious and better balanced "specialty feeds". Increasing consumer demand for specialty feeds has spurred the growth of specialty ingredients, and new technologies offers the prospect for novel ingredients with fatty acid and amino acid profiles tailored to shrimp species specific nutritional needs. These ingredients reportedly enhance the quality of the feed, and the largest share of sales and fastest growth in this segment is expected to be amongst those ingredients that serve some special purpose or function, and/or provide some particular advantage, such as cost savings. Of these ingredients, fish meal replacers are expected to have the largest share and be the fastest growing, because they provide feed manufacturers with cost and functional advantages and have wide applicability.

On the other hand, an increased understanding of those physiological and endocrinological processes that control the growth and development of shrimp (and particularly under conditions of maximal attainable growth and high diseases challenges) is paramount if the industry is to continue to grow and become truly sustainable - we need to better tailor our diets to our shrimp and culture environments. For example, in shrimp, a significant portion of this optimization is not only related to the selection of the right diet, but also to the inherent behavioral and functional morphology of feeding and grooming of the species under cultivation. Furthermore, understanding the basis for diet selection for shrimp is clearly complex, and the relationship between "forms" (morphology) and "function" (nutrient extraction and diet selection) in shrimp has been the focus of many research projects.

Ultimately, the success of the culture of the different species of shrimp will depend greatly on a good nutrition and good management of the feeding. With this in mind, this paper attempts to present some of the new and exciting specialty aspects of feeds and feeding techniques currently being considered for use within shrimp aquaculture operations.

## BREEDING SYDNEY ROCK OYSTERS Saccostrea glomerata FOR FAST GROWTH AND DISEASE RESISTANCE

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NSW Fisheries established a breeding program for the Sydney rock oyster, *Saccostrea glomerata*, in 1990. Four breeding lines selected for fast growth were maintained in Port Stephens, NSW. Four breeding lines were also maintained in the Georges River, NSW, to select for fast growth and resistance to winter mortality caused by the protistan parasite *Bonamia roughleyi*. Winter mortality was first observed in Georges River in the early 1920's.

#### Disease

Progress in Georges River was severely interrupted when QX disease first occurred in 1994. This disease is caused by the prototistan parasite *Marteilia sydneyi* and has such a devastating effect that 85% of all oysters died at two out of three experimental sites in Georges River in 1995. In January 1997, the program was re-established and modified to incorporate one line to be selected for resistance to winter mortality, one for resistance to QX disease and one for resistance to both winter mortality and QX disease. The breeding lines were re-organised in this way as the site in the upper reaches of the estuary (Lime Kiln Bar) is severely affected by QX disease every year, the site in the middle reaches of the estuary (Woolooware Bay) is regularly affected by both QX disease and winter mortality and the one at the lower reaches, near the mouth of the estuary (Quibray Bay) is annually affected by winter mortality but rarely affected by QX disease.

In June 2004, after two successive years of heavy exposure to QX disease at Lime Kiln Bar in Georges River NSW, mortality from QX disease was reduced from 92% in controls to 45% for the most improved QX disease resistance line. This is a 47% reduction in mortality after only three generations of selection. Resistance to QX disease does not appear to confer resistance to winter mortality. However, the breeding line selected at Woolooware Bay has some resistance to both QX disease and winter mortality whereas, the one at Quibray Bay only appears to have some resistance to winter mortality.

#### Growth rates

Selection for faster growing oysters has also been successful. In April 2003, the progeny of the fifth generation of the most improved line had reached market size (50 g whole weight) in 26 months, which was more than 11 months earlier than controls. Although oysters are selected for fast growth, the percentage shell weight and meat yield of the oysters has not changed.

# A GREEN BLUE REVOLUTION: ALGAL CULTURE IS KEY TO A SUSTAINABLE EXPLOITATION OF THE SEA

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FAO and other authoritative sources expect a huge expansion in mariculture production. For this to occur, however, sustainable technological approaches must be developed and adhered to. To expand freely, the mariculture industry should be not only financially profitable in the short term, but also beneficial in the long term, i.e., benign to natural ecosystems and to the social fabric of the countries in which it takes place.

Today, algal-based integrated mariculture, both on shore and in coastal waters, provides perhaps the only suitable technologies for the necessary expansion of the industry. The uniqueness of these approaches is in the merging in single location of existing commercial monoculture technologies of organisms, belonging to the two opposing metabolic forms - heterotrophs and photoautotrophs. An integrated farm is a simplified version of a balanced natural ecosystem, where sunlight drives the recycling of heterotrophic metabolites and the purifying of water. Auxiliary benefits of the algae to the farm are the removal excess microelements and the restoration of DO and pH balance in the culture water, all in one step. Additional important benefits of such a farm are the reduction in regulatory limitations and in "polluter pays" charges levied on the farm.

Plant production of course outweighs animal production by several folds. Sales of seaweeds and shellfish profitably recover the additional costs in investment and operation involved with sustainable mariculture. With seaweed and shellfish already the largest mariculture sectors in the world, marketing of these "by-products" is easy. A culture system that diversifies its products by integrating the fed culture of fish/shrimp with an extractive algal culture, and with herbivores that feed on these algae, makes therefore much sense, not only ecologically but also economically. The simple integrated mariculture farm cultures fish and seaweed. Additional crops of heterotrophic herbivorous macroalgivores (abalone, sea urchin), filter feeders (e.g., shellfish and brine shrimp) and detritivores (e.g., sea cucumbers and gray mullets) improve the versatility, profitability and environmental friendliness of an integrated mariculture farm. The integrated farm of Seaor Marine Enterprises on the Mediterranean coast of Israel cultures seabream, *Ulva* and Abalone, while the PGP 1994 farm in Southern Israel cultures seabream, microalgae, oysters, clams and brine shrimp. Fed heterotrophs -fish and shrimp - typically excrete over half of their ingested nutrients.

Because they integrate existing profitable culture technologies of highly marketable and highly valuable marine organisms (intensive cultures of fish, shellfish, shrimp and algae are proven commercial technologies world wide), integrated mariculture farms are able to be profitable, and are therefore destined to comprise much of the inevitable expansion of mariculture.

### THE MARKETING OF COOK ISLANDS BLACK PEARLS

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The development of the Cook Islands Black Pearl Industry has been turbulent. The early stages were marked by a struggle by the indigenous farmers to assert their right to farm independently. A period of growth through the 1990s was affected by a cyclone in 1997 and then by bacterial problems in the main producing lagoon in 2000.

Present production levels are approximately 200,000 pearls a year mainly from the Manihiki lagoon. Export values for 2003 were recorded at approximately NZD 3,000,000. The small production levels of the majority of the farms, along with the relationship with the seeding technician influence how the farmers market their pearls. Some farmers opt to market their own crops. Others may utilise a broker.

A crop is normally broken down by size into 1mm gradations. Each pearl is classified using a combination of five individual grades (A/B/C/D/Low Quality) and four shapes (Round/Near-Round, Semi-Baroque, Baroque, Circle). Weights by shape and grade are also provided.

There are limited markets for whole crops as prices have fallen and profit margins have been squeezed. Farmers now have to evaluate how much risk they want to bear in marketing their crops. Some have moved into wholesale of jewellery in order to sell their pearls.

### NEW SINGLE-CELL AND CROP PLANT SOURCES OF LONG-CHAIN OMEGA-3 OILS

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Long-chain omega-3 polyunsaturated fatty acids [LC-PUFA, e.g. EPA, 20:5(n-3) and DHA, 22:6(n-3)] are essential for infant nutrition (e.g. brain and retina development) and have health benefits against coronary heart disease, inflammatory diseases such as rheumatoid arthritis, hypertension and may have beneficial effects against some cancers as well as various mental disorders such as schizophrenia, ADHD and Alzheimer's disease.

Fish oil is the main commercial source of these LC-PUFA. However, global fisheries have been reported to be unsustainable, indicating a need for new sustainable and commercially viable sources of omega-3 oils. In addition, fish do not synthesis these oils, rather microalgae and other marine microorganisms (e.g. thraustochytrids and some bacteria) are the primary source of omega-3 LC-PUFA which are incorporated in higher marine animals, and ultimately in humans through consumption of seafoods.

Microalgae and heterotrophic organisms are a renewable 'clean and green' resource which is amenable to high density culturing using photobioreactors and fermentors for biomass production and optimization of omega-3 LC-PUFA-rich oils. They are also a source of novel genes for PUFA biosynthesis which can be transferred to terrestrial crop and oil-seed plants.

The aim of our research is to target microalgae and other microorganisms with high levels of LC-PUFA. We also aim to identify, isolate and characterise omega-3 LC-PUFA biosynthesis genes (desaturases and elongases from microalgae; PKS genes from thraustochytrids and bacteria) and transfer these to oil-seed crop plants (e.g. Canola, flaxseed). Omega-3 LC-PUFA oils from these plants will be used in human nutrition and aquaculture feeds.

Other research includes isolating novel lipases from insects and other sources to determine and optimize regiospecificity of current omega-3 oils and those being designed, and to perform laboratory and farm-based feeding trials with animals using these oils.

# CHARACTERIZATION OF DIGESTIVE ESTERASE-LIPASE ACTIVITY OF WHITE SHRIMP Litopenaeus vannamei

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Lipases have been found in many species (Berner and Hammond, 1970), but few works have reported lipases in decapod crustaceans. The presence in crustaceans of a true lipase (glycerol-ester hydrolase E.C.3.1.1.3) has been demonstrated only in *Homarus americanus* (Brockerhoff *et al.* 1970, Biesiot and Capuzzo 1990a & 1990b), *Litopenaeus schmitti* (González *et al.* (1994). Artemia (Bowen and Sterling, 1978), *Macrobrachium borellii* (Gonzalez-Baró *et al.*, 2000), and aquatic isopods (Sévilla *et al.*, 1975), Cherax quadricarinatus (López-López, et al., 2003). This study identifies some properties of esterase-lipase activity in the digestive tract of white shrimp *Litopenaeus vannamei*.

#### Materials and methods

Juvenile white shrimp were randomly obtained from the culture pond of CIBNOR. A total of 20 specimens, in intermolting stage, were sacrificed by freezing, and stored at -40°C up to the moment of dissection to obtain the digestive tract segments (stomach, digestive gland, and intestine). The pool of 20 digestive tract segments was separately homogenized with four volumes of buffer solution (Tris-HCl, 50 mM, pH 7.5). The homogenized material was centrifuged (23000g, 5°C, 15min.). The aqueous supernatant was used as crude extract (CE) for the protein (Bradford, 1976) and esterase-lipase enzyme analysis (Versaw, et al., 1989) using b-naphthyl-and p-nitrophenyl-derived compounds.

#### Results

Esterase and lipase specific activity was found similar in stomach, intestine and digestive gland of *Litopenaeus vannamei*, however esterase activity decreased as the length of fatty acid in synthetic substrates increase Table 1. Lipase activity was optimum at pH 9, 45°C, and 1-500 mM NaCl.

Esterase and lipase activity in digestive tract of *Litopenaeus vannamei* was demonstrated as occurs in other marine decapods, indicating a true capability to hydrolyse dietary lipids from the diet.

	Esterase-Li	pase activity U/	mg protein
Substrate	Stomach Dig	estive Gland	Intestine
Acetate	3.671922	15.96335168	19.92092207
Propionate	11.07421	5.480652911	8.49026686
Butyrate	17.89075	18.24839439	10.19765249
Valerate	5.919144	5.587382976	8.624257225
Caprylate	1.560775	2.451070891	5.106324102
Nonanoate	4.52316	4.347062025	0.408566132
Laurate	0	0.225686155	0.124545535
Palmitate	0	0.321219039	0.349568862

### TABLE 1

Hydrolysis of dietary lipids (animal and vegetable oils) indicates a real lipase activity in digestive gland of *Litopenaeus vannamei*.

#### AQUAFIN CRC HEALTH PROGRAM

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Cooperative Research Centre for Sustainable Aquaculture of Finfish (Aquafin CRC) was established in 2001. Aquafin CRC contributes to the growth and competitiveness of aquaculture industry, develops effective research collaborations, provides education and training. It also allows for harmonisation between industry sectors. Aquafin CRC focuses on southern bluefin tuna (62%) and Atlantic salmon (32%) aquaculture, additionally snapper and striped trumpeter are investigated as future commercial aquaculture species. The main objectives of Health Program are to reduce economic impact of disease in farmed finfish, improve industry and government responsiveness to disease outbreaks and to develop environmentally friendly approaches to disease management. The Program consists of two subprograms - Diagnostics and Risk Assessment and Management and Control of Amoebic Gill Disease in Atlantic salmon. Two projects within Diagnostics and Risk Assessment have already been completed. These included Tuna health risk assessment and Development of diagnostics for bacterial pathogens. The continuing projects are on development of tuna cell lines and on the effects of farming practices on tuna health. This July a new project started investigating detection of SBT parasites in the environmental samples. The subprogram on Control of Amoebic Gill Disease includes four projects: Treatment and control of AGD, Host-pathogen interaction in AGD, Epidemiology of AGD and AGD vaccine development. These projects will be completed late this year. New projects in the AGD subprogram focus on AGD treatment, effects of husbandry on AGD, potential for immunomodulation in AGD, vaccine development, AGD challenge and molecular markers for resistance to AGD. Aquaculture industry needs in the area of training and human capital development is recognised and addressed within Health Program.

#### SAUCER SCALLOP RANCHING - GENETIC CONSIDERATIONS

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The saucer scallop, *Amusium balloti*, is commercially harvested from wild fisheries off the coast of Queensland and Western Australia. To reduce the high annual variation in catch from the wild, sea ranching is considered to be a viable solution and is being undertaken by companies in both states. As this relies on hatchery production rather than wild caught seed, the genetic structure of the populations is being investigated as well as their taxonomic relationship to other Australian scallop species.

### DEVELOPMENT OF GIANT CLAM AQUACULTURE IN SOLOMON ISLANDS

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Against a background of high human population growth, unsustainable exploitation of marine resources and few income earning opportunities, aquaculture of giant clams in Solomon Islands is a tool for sustainable development. In addition, farmers were asked to retain a number of clams for reseeding.

The culture of giant clams is restricted to six *Tridacna* species (*T. gigas*, *T. derasa*, *T. squamosa*, *T. crocea* and *T. maxima*) and one species of Hippopus (*H. hippopus*) native to Solomon Islands. Initial research began in 1987 and, by 1995, 42 farms were established throughout the country and supplying overseas aquarium markets by 1997. Giant clams grown for the aquarium trade grew relatively fast with grow-out period for all species less than a year (Table 1).

TABLE 1.	Growth of giant	clams farmed	for ac	uarium trade.
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Species	Market size (mm)	Grow-out (months)	Mean survival (% ± SD)
T.gigas	75	10	54.0 ± 18.6
T. denasa	75	7	92.2±9.1
T.squamosa	50	6	66.6±18.3
T. maximu	50	9	38.9±16.6
T. croces	35	11	39.0 <u>+</u> 22.6

Revenue collected by the farmers for the sale of cultured giant clams to the aquarium trade were high compared to traditional commodities such as copra and cocoa and were able to sustain rural livelihoods, i.e. meeting school fees, medical fees and other domestic needs. Some farmers were able to venture into other business activities, for instance, retail store and furniture making, by capitalising on income generated from the sale of clams and knowledge gained from simple book-keeping courses provided to the farmers (Table 2).

TABLE 2.	Revenues	(US\$) to	growers of	giant	clams (	per 200	"seed")
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		Revenue		and a second			
Species	Clams	Price per	Total	Seed clams	Cages	Total	Net Revenue (\$)
_	survived (n)	clam			U		
T.gigas	108	\$1.20	\$130	\$60	\$28	\$88	\$42
T.derasa	190	\$0.75	\$142	\$50	\$28	\$78	\$92
T.squamosa	134	\$1.10	\$147	\$60	\$14	\$74	\$73
T.maxima	134	\$1.10	\$176	\$60	\$14	\$74	\$102
T.crosea	84	\$2.00	\$118	\$60	\$14	\$14	\$94

Although there is a great potential to increase the production of cultured giant clams, constraints exist. These include limited domestic markets, transport problems, limited infrastructure, capital and skilled labour force, fragile habitats, cyclones and lack of aquaculture experience.

# THE NEW SOUTH WALES OYSTER INDUSTRY SUSTAINABLE AQUACULTURE STRATEGY – DEVELOPING A MANAGEMENT FRAMEWORK

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The Sydney rock oyster industry has existed for many thousands of years along the south east of Australia. Since European arrival the oyster reefs present in these estuaries have disappeared. . The industry has faced substantial issues due to overfishing, translocation of pest and disease, environmental degradation such as pollution from acid sulfate soils, new food safety measures and demand driven lease allocation and has been in decline for the last 25 years. Historically, potential impacts on the NSW Oyster Industry from adjacent coastal development and activities have not been assessed. Without security of tenure, recognition and protection of oyster growing areas and improvements in institutional arrangements, little incentive exists for further investment. Without soundly based recognition and planning protection of oyster growing areas, little incentive exists for further investment in the oyster industry by farmers or financial institutions. The Oyster Industry Sustainable Aquaculture Strategy (OISAS) is statutory framework established under an inter-agency-industry partnership. OISAS will identify priority areas for oyster farming in estuaries and enable the water quality needs of the oyster industry to be protected, through the establishment of water quality objectives for oyster growing areas. OISAS will also set management parameters for oyster farming within the estuary. The planning and legislative framework aims to achieve long-term maintenance of high water quality in estuaries. In particular, it will target specific planning controls around estuaries that relate to industrial, urban, rural and recreational development around and on estuaries.

# ASPECTS OF HOST-MICROFLORA INTERACTIONS IN MARINE AQUACULTURE: FROM DISEASE PROBLEMS TO MICROFLORA MANAGEMENT?

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Aquaculture will depend on extensive understanding of the complex interactions between the cultured organisms and bacterial communities, which develop on mucosal surfaces and in the rearing systems. The various cultured fish and invertebrate hosts share ecosystem, and hosts become easily colonized by bacteria. This intimate relationship may result in disease epizootics or commensal relationships. Our research has been aimed at factors involved in interactions between marine hosts and their microflora, and includes studies of the normal and pathogenic microflora, selected pathogens and aspects of non-specific defense reactions. Microbial colonization of fish larvae is a consequence of the bacterial flora of the water, the egg epiflora and the microflora of feed and on other resident organisms in the facility. We have demonstrated that in herring (*Clupea harengus*) larvae the indigenous gut microflora was completely altered by the use of antibiotics. Various forms of interactions between bacteria and biological surfaces occur at egg and larval stages, and may result in the formation of an indigenous microflora - or be the first step in an infective process.

In aquaculture eggs are kept in incubators with a microflora that differs in numbers and characteristics from that in the sea, and the eggs become heavily overgrown with bacteria shortly after fertilization. The adherent microflora on eggs may cause damage, whereas we do not know whether the egg epiflora may bestow some protection. Marine fish larvae ingest bacteria, and are thus primed with antigens before active feeding commences. Sequestering of intact bacterial antigens by newly hatched larvae may result in tolerance, but as yet we have little information about acquired tolerance of fish larvae to the microflora. Most marine bacteria adhere well to fish mucus. Fish pathogenic vibrios colonize the gastrointestinal brush border of cod (Gadus morhua) larvae by first adhering to the mucus coat, and result in extensive damage to the microvilli. Little is known about adhesion, receptors or colonization factors, but agglutination studies demonstrated that lipopolysaccharides (LPS) might be involved in adhesion. In halibut (Hippoglossus hipoglossus) an increase in the number of mucous cells of the epidermis, as well as qualitative changes of the mucus composition from predominantly neutral to a mixture of neutral and sulphated glycoproteins occurred during development from a pelagic larva to bottom-dwelling flatfish. The numbers of saccular cells increased following addition of bacteria to incubators. These findings may help to understand the protective role of the mucus layer of halibut during development. The use of probiotics, and further on microbial management may also have a potential in aquaculture. Addition of commensal apathogenic bacterial strains affected survival of the halibut larvae, and the best result was obtained with a commensal, apathogenic Vibrio salmonicida strain. Thus the use of microflora manipulation, competition, or antagonism may increase larval survival, depending on the strains used.

Marine invertebrates may harbour bacteria that are pathogenic to other organisms, and thus serve as vectors for spreading of fish-pathogens. A better understanding of such interactions is also essential to comprehend disease epizootics. Invertebrates and fish (including eggs) possess ligand-binding lectins that may act in defense reactions such as opsonisation of phagocytosis. We have demonstrated that shellfish lectins may bind to LPS of marine bacteria, and that parts of complex lectin molecules may harbour antibacterial activity. Lectins are phylogenetically conserved, multifunctional proteins that appears to carry out a variety of receptor-binding and signal functions in various defense-related systems. They are constitutive in invertebrates and fish, whereas "lectin-like" pentraxins act as "acute phase" proteins in early defenses reactions of mammals, but there is little evidence of acute-phase reactions involving pentraxins, in fish.

# ECONOMIC VIABILITY OF PRIVATE FISH FARMERS IN SOUTHERN NIGERIA

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This study demonstrates a comprehensive economic appraisal and analysis of fish production in private fish farms in rural and urban communities of Southern Nigeria. Structured questionnaires on socio-economic cost, net returns and production constraints in terms of growth and expansion completed by respondents revealed the potentials of fish farming in bridging the gap between fish demand and supply. The socio-economic and cultural factors analysis due to intensification (through water management, fertilization and stocking in fingerlings) technically shows greater fish production per hectare in managed ponds compared with unmanaged ponds. Financial and economic analysis of smale scale aquaculture demonstrated that income from fish farming represented a significant proportion of total cash income in addition to its food value for the household. Results obtained from the study showed that the major problems militating against fish farming are lack of credit facilities, inadequate land area, shortage of fingerlings as well as poaching. Results from budgetary anlysis further revealed that fish farming is not only viable but profitable despite all it's shortcomings.a

## A THROUGH-CHAIN RISK-BASED ASSESSMENT OF RESIDUES IN SOUTHERN BLUEFIN TUNA Thunnus maccoyii: PREDICTIVE MODEL DEVELOPMENT

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Southern Bluefin Tuna (SBT) (*Thunnus maccoyii*) is an important aquaculture-produced species in South Australia. The major focus for export product is the premium Japanese sushi and sashimi markets. As a post-BSE outcome, Japan is demanding greater accountability from those countries wishing to export product into the Japanese market. An important component of the accountability equation is chemical residues, especially mercury and persistent organic pollutants.

This paper presents the development of a through-chain risk-based approach for aquaculture-produced SBT to demonstrate the traceability of chemical residues. The process includes investigation of potential pathways (eg benthic and feed sources) for residues to enter the SBT during aquaculture production and the potential for bioaccumulation in tuna during growout. We will present examples of how results of this process were taken up and used for market promotion and standards setting processes by Australian and International regulatory agencies. This has demonstrated through-chain traceability of chemical residues in a trade context.

Results of the risk-based approach highlighted the need by Industry to understand the relationship between the initial residue levels of the wild-caught SBT and baitfish fed during aquaculture growout to final harvest levels. The second part of the presentation discusses the development of predictive residue models for mercury and persistent organic pollutants, such as dioxins. The purpose of the predictive residue models is to aid the SBT aquaculture Industry to make informed decisions when purchasing baitfish. Greater understanding of residues in harvested SBT will ensure the current low levels are maintained.

# GROWING BANANA PRAWNS *Penaeus merguiensis* (de Man) IN PRAWN FARM SETTLEMENT PONDS TO UTILISE AND HELP REMOVE WASTE NUTRIENTS

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To assess their utility for profitable wastewater bioremediation, banana prawns (*Penaeus merguiensis*, de Man) were stocked at low densities  $(1 - 5 \text{ m}^{-2})$  and grown without supplemental feeding in five commercial-prawn-farm settlement ponds (0.3 to 6.0 ha). The prawns free-ranged in the variously designed ponds for 160 to 212 days after stocking as PL15. Survival estimates ranged from 12 % to 60 % with production of  $50 - 528 \text{ kg ha}^{-1}$ . Over 1150 kg of marketable product was produced in the study. Exceptional growth was monitored at one farm where prawns reached an average size of 17 g in 80 days (Figure 1).



Figure 1. Growth of banana prawns in settlement ponds of 5 commercial prawn farms (A-E).

Only small differences in water qualities were detected between waters running into and out of the settlement pond that supported the most rapid prawn growth (Farm A). Total nitrogen levels gradually increased from  $1 - 1.5 \text{ mg L}^{-1}$  early in the season to over 3 mg L⁻¹ towards the end of the season. Total phosphorous levels similarly rose from  $0.1 - 0.2 \text{ mg L}^{-1}$  to  $0.3 - 0.4 \text{ mg L}^{-1}$  in the middle of the season, but fell to  $0.2 - 0.3 \text{ mg L}^{-1}$  towards the end when approximately 12,000 prawns were harvested with a total weight of 175 kg. No significant differences (P > 0.05) were detected in the overall acceptability of prawns harvested from each of the 5 settlement ponds in small-scale consumer sensory analyses. The prawns from settlement ponds were rated similarly to banana prawns grown with commercial diets at two other establishments. Microbiological analyses of prawns from all farms showed bacterial levels to be well within food-grade standards and lower than prawns produced in a normal grow-out pond. These results demonstrate that high quality food grade banana prawns can be produced in these wastewater treatment systems.

# A SHORT JOURNEY INTO DIGITAL STORY TELLING (DST) - A RESOURCE FOR TRAINING

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What started out as an embryo of an idea when I heard the end of a conversation on a radio program has ended up in being an exciting new venture that may assist the Seafood Industry with training resources as well as creating lots of other opportunities.

I followed through on the conversation, threw caution to the wind, exposed myself to a whole new world and ended up with some additional skills, some new friends and a new area to be involved with.

Along the way I was invited to join a TAFE frontiers Project 'Digital Storytelling for VET' where this whole experience will be expanded and shared. One of the project focuses is on 'teachers/trainers creating and using innovative and flexible strategies involving the use of digital story tools to capture the learning journey'.

You will see my first attempt at DST which is 'My Life – it's a FishyBusiness' and the DST I am doing under the TAFE frontiers Project "Seafood at WorldSkills'. As part of the Project TAFE frontiers, completion date is November 2004, will be delivering a Facilitator Guide and Developer Guide which will assist trainers with the concept.

## EFFECTS OF COVER AND REFUGE ON THE PERFORMANCE OF MURRAY COD Macculochella peelii peelii FINGERLINGS REARED IN A RECIRCULATING SYSTEM

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This study was undertaken as part of the Deakin Sustainable Aquaculture System (SAS) initiatives to develop and provide the industry with the best husbandry techniques for Murray cod.

Some Murray cod farmers believe that added cover and/or refuge result in higher survival rates and better growth. For this reason the effects of cover and refuge on growth, survival and food conversion of Murray cod (*Macculochella peelii peelii*) were investigated during a 6 week trial. Murray cod fingerlings with a mean initial weight of  $1.05 \pm 0.02g$  were divided into four treatments, control (C), cover (Cov), refuge (Ref), and a combination of refuge and cover (Ref-Cov) and stocked at 5 fish l⁻¹ in triplicate in a recirculating system comprising of twelve 100 litre fibreglass tanks. Photoperiod was set at 12L:12D regime. All treatments were hand fed to satiation twice daily with a commercially available 2mm crumbed diet during the first three weeks of the experiment and a 2mm pelleted diet during the last three weeks (50% protein, 23% lipid). There were no significant differences (<0.05) in growth and food conversion amongst the four treatments. However mortality was significantly lower (<0.05) in C (5.1 %) compared to Cov (10.3 %) and Ref-Cov (11.2 %) while Ref had a mortality rate of 8 % which did not differ from the other treatments (>0.05).

Values across columns with different superscript are significantly different (p< 0.05)

	Treatment						
Parameters	Control	Cover	Refuge-Cover	Refuge			
Initial mean wt (g)	$1.05 \pm 0.02$	$1.05\pm0.02$	$1.04\pm0.02$	$1.05\pm0.08$			
Final mean wt (g)	$4.10\pm0.05$	$4.39 \pm 0.13$	$4.41\pm0.09$	$4.17\pm0.09$			
SGR (% day ⁻¹ )	$3.11 \pm 0.03$	$3.20 \pm 0.07$	$3.19\pm0.08$	$3.12\pm0.02$			
ADG (% day $^{-1}$ )	$6.52\pm0.12$	$6.89 \pm 0.30$	$6.83\pm0.31$	$6.58\pm0.09$			
FCR	$0.75\pm0.02$	$0.77 \pm 0.01$	$0.84 \pm 0.05$	$0.72\pm0.02$			
Feed consumption (mg ⁻¹ fish ⁻¹ day ⁻¹ )	$53.9 \pm 1.53$	$60.9\pm2.02$	$66.4 \pm 3.43$	$53.2 \pm 1.35$			
Mortality (%)	$5.1 \pm 0.8$ ^a	10.3 ± 1.4 ^b	$11.2 \pm 2.1$ ^b	$8.0 \pm 1.1$ ^{ab}			

# FATTER, FASTER, BETTER - A SUCCESS STORY IN SELECTIVE BREEDING FOR PROFIT IN THE AUSTRALIAN PACIFIC OYSTER INDUSTRY

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Pacific Oyster are produced in three states in Australia with the total production exceeding 7 million dozen oysters in 2001/ 02. Virtually all production is based on hatchery produced seed and therefore amenable to improvement by selective breeding. The task of Australian Seafood Industries P/L (ASI) is to exploit this by commercialising outcomes from the Fisheries Research and Development Corporation (FRDC) funded project "Sustainable Genetic Improvement of Pacific Oysters in Tasmania and South Australia.

ASI was established in December 2000 and is a company controlled and owned by the Tasmanian and South Australian Oyster Industries. Its shareholders are the Tasmanian Oyster Research Council (TORC), the South Australian Oyster Research Council (SAORC) and the South Australian Oyster Growers Association (SAOGA). ASI has a formal licence agreement with the three research collaborators; FRDC, University of Tasmanian and the CSIRO (Marine Research) to exploit the project technology with an eventual option to purchase it. In November 2003 ASI took over the responsibility of commercialising the selective breeding program and has just completed the production of the 6th generation of thoroughbred oyster lines.

ASI has four main objectives;

- 1. Implementation and ongoing development of the breeding plan.
- 2. Production and promotion of thoroughbred oyster lines to meet the needs of the Pacific oyster industry throughout Australia.
- 3. Becoming financially self reliant through the commercial sale of Thoroughbred Oysters lines.
- 4. Provision of an important link between the Australian oyster industry, industry associations and research agencies, particularly in relation to genetic research.

The Company aims to encourage the use of genetically improved (thoroughbred) oysters throughout all of Australia. As a non-profit, industry owned organization ASI makes thoroughbred broodstock available on request to hatcheries, who supply the resulting seed to growers at commercial rates. A small premium is added which reverts to ASI to cover its costs.

Over 35 million thoroughbred oysters have been sold in the past three years and orders for this season currently exceed 20 million seed – approximately10% of the market. Results from ongoing research and positive responses from industry leaders have resulted in this increase in production with lines such as 118 from our F4 generation demonstrating considerable commercial advantages including shape, consistency in growth, growth rates and shell colour.

ASI is anticipating that with the release of the  $5^{th}$  and  $6^{th}$  generation of thoroughbred oysters over coming years we will see hatcheries producing approximately 50% of seed originating from ASI thoroughbred broodstock equating to 100 million seed per year.

# NEW TECHNOLOGY FOR THE COMMERCIALISATION OF INLAND SALINE AQUACULTURE IN WESTERN AUSTRALIA

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Over the past few years, a keen interest has been expressed by various groups in Western Australia regarding the commercial culture of marine and/or estuarine finfish using inland saline water. Such culture has the potential to boost rural economies through farm diversification and would be an effective means of offsetting the costs associated with engineering practises linked to salinity management. In response to this interest, our research group has implemented a structured R&D approach to determine the biological, technical and economic feasibility and environmental sustainability of such culture. This presentation will focus on our research into the second aspect of this approach.

The techniques currently used to produce fish in inland saline groundwater in WA are typically not commercially viable, with yields limited by water quality issues. These water quality issues stem from the low water exchanges imposed by factors including ionic composition adjustment and disposal of saline waste-water. A technology capable of overcoming these issues is therefore required before a commercially viable industry can develop.

In response to these limitations, the "Semi-Intensive Floating Tank System (SIFTS)" was developed by our research group specifically for inland saline conditions. This technology offers significant advantages in the areas of fish harvesting and management, waste removal and a substantial increase in potential yield, compared with conventional pond-based systems and is thus ideally suited to the many natural and man-made saline water bodies that exist throughout the state. Testing of this new culture technology is currently underway on a semi-commercial scale on a demonstration farm in the WA Wheatbelt. A detailed discussion on the specifications of the system and its performance will be presented.

## OXYGEN USE BY MARINE FISH IN A RECIRCULATING AQUACULTURE SYSTEM

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Due to the high capital and operating costs associated with intensive recirculating aquaculture systems, it is imperative that the highest possible sustainable yield of product be obtained to ensure the profitability of the enterprise. The use of pure oxygen is critical in this regard, as it allows for greater stocking densities of fish to be cultured compared to systems that use only aeration.

The sizing of oxygen dissolution systems and oxygen generation and/or supply systems requires data on the amount of oxygen that the fish will consume. As the commercial scale culture of marine fish in recirculating systems is still a fairly recent practise, these data are lacking for most marine species. This presentation describes a study in which the oxygen consumption by yellowtail kingfish (*Seriola lalandi*) and pink snapper (*Pagrus auratus*) were measured in a demonstration McRobert recirculating aquaculture system, stocked at commercial densities. Each 10 m³ tank was fitted with a BOC Turbolox dissolver to which oxygen gas was supplied via a solenoid valve controlled by a PLC. Oxygen use was compared at water turnover rates of 0.83 and 0.56 exchanges/hour.

The average daily oxygen consumption of the 1.4 kg yellowtail kingfish was  $209 \pm 5 \text{ mg O}_2/\text{kg/hour}$  (Fig. 1), whilst that of the 790 gram pink snapper was  $125 \pm 2 \text{ mg O}_2/\text{kg/hour}$ . Data was also obtained on the change in oxygen consumption rate throughout the day and these data will be compared between the two species.

In addition to oxygen consumption, ammonia and carbon dioxide excretion were similarly measured, both as rates of excretion and as peak-concentrations, and these results will be discussed in relation to the various water turnover rates investigated.



# DEVELOPMENTS IN PORTUNID CRAB AQUACULTURE IN QUEENSLAND – ADDRESSING CANNIBALISM

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Crabs are attractive species for aquaculture because of their rapid growth rates. Depending upon the market targeted, crabs reach commercial size in 4-8months. However, this rapid growth comes at the cost of reduced survival due to cannibalism. Now that commercial hatchery methods are available for the promising crab species, the low yield from pond systems is a major impediment to the commercial viability of crab farming in Australia and this, coupled with the increasing scarcity of good pond sites, means that the industry is evolving toward closed-cycle recirculation from the very outset.

In addition to ongoing hatchery and nursery development for mud crabs, *Scylla serrata*, in Queensland, a partnership of State Government and pioneering industry partners has seen the successful transfer of blue swimmer crab, *Portumus pelagicus*, hatchery methods to the commercial sector, has conducted both pond and indoor grow-out and marketing of soft-shelled product. As expected, the pond grow-out trials have returned low productivity- most likely due to cannibalism. The options for addressing this in the short term are adding more shelters to ponds. An alternative is to rear the crabs individually in an array of compartments, which while capital-intensive completely eliminates cannibalism. Another strategy for the long term is to consider incorporating communal survivability of families into a selective breeding program for each species.

Since crabs seek out refuges prior to moulting, survival can be improved to some extent by adding structures to the ponds. Pond-reared crabs are most likely to die in post-moult. A trial in a small pond suggested that shelters could be used to mitigate mortality at high-density grow-out but it proved difficult to repeat this in larger ponds. In practical terms, there is probably a limit to how much shelter can be added to a pond without greatly complicating pond management.

Containing the crabs individually within a recirculating raceway system allows them to moult and grow in safety. The capital cost is higher, but automating procedures to cut labour costs can help offset this. Individually reared crabs gain nutrition solely from pelleted feeds- and until tailored crab feeds are developed, shrimp feeds must be used. Intensive aquaculture inevitably requires keener attention to maintenance and hygiene but without the need to discharge, recirculation technology is also more site-friendly and more amenable to the evolving regulatory framework than traditional methods of pond production. However, the yield of crablets from nursery systems needs to be increased to reduce the demand for more ponded sites and is an area where there is room for more innovative approaches.

Broodstock are currently sourced from the sea, but portunid crabs mate so readily in captivity that domestication is an obvious next step. Given their fast growth to maturity and precendents from other crustacean selection programs, rapid and significant gains in production are expected from an organised selection program. Of course, apart from selecting for growth, we can also pursue the possibility that some lines may show better communal survival than others- giving the tantalising prospect that all the walls might come down at some point in the future.

# ESTIMATING WEIGHT OF NURSERY-STAGE MUD CRABS Scylla serrata USING DIGITAL IMAGE ANALYSIS

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When harvesting early instar crabs, traditional methods of weighing and measuring are labour-intensive and time-consuming when the main objective is timely handling of the product. Image analysis has been used successfully elsewhere to achieve rapid, efficient measurement of large numbers of fish, abalone, and even prawns, but is only recently being applied to crabs. To assess the ability of image analysis to efficiently and accurately measure large numbers, nursery stage crabs, (<9g wet weight) were photographed using a simple light-box and a 2 megapixel digital camera. The bit-map files were analysed using public domain software (Scion Image for Windows) and the area of each crab was related to its recorded wet weight using regression techniques to prepare a calibration curve.

A robust relationship was found between crab weight and area ( $r^2=0.973$ ). Image analysis appears to be a convenient method for obtaining weight/ frequency data from crab populations with minimal handling. The photographs provide a permanent record that allows further quantification of limb or chela loss. The crablets were immobilized by pre-chilling to allow them to be distributed inside the light box. Repeated chilling may of course be undesirable in long-term growth studies.

Image analysis may be particularly useful for collecting growth data from domestication/selection programs with crabs and other farmed species. Methods for batch handling of many images are needed to fully exploit the efficiencies of the method, as are routines for rejecting suspicious objects (eg. agglomerations of individuals, crabs in the corners that are haloed by shadow). There may also be scope to use this technology to record crab posture and automatically register activity/behavioural data from crabs in intensive rearing systems.



Figure 1: Regression of image area versus crab wet weight for early insar mud crabs *Scylia serrata*.

### LIMB-LOSS IN POND-REARED BLUE SWIMMER CRABS Portunus pelagicus: MOULTING PERIOD AND INCREMENT IN AN INDOOR SHEDDING SYSTEM

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There is interest in developing a soft-shell crab industry in Australia based on pond-reared blue swimmer crab *P. pelagicus* It is clear that growing crabs in ponds leads to high mortality and steps need to be taken to improve the yield. But apart from outright cannibalism and mortality, frequent crab encounters are expected to lead to increasing limb-loss. It is important to know the magnitude and outcome of this injury because limb-loss in crustaceans is reported to reduce moult increment and can also delay or advance the timing of moulting, particularly if many limbs are removed- both aspects that are likely to impact upon soft-shell crab production.

For this study, we harvested crabs from a pond, recorded numbers of absent limbs and then placed them in an indoorcompartmentalised growing/shedding system supplied with flowing seawater and fed them pelleted shrimp feed. This process was repeated on two further occasions as larger crab instars became available in the pond. The culture system was switched from flow-through to partial recirculation (with heating) as ambient temperature dropped toward the end of the season. The wet weight, carapace width and limb complement was assessed on arrival and after each captive moult.

The results show that up to half of the crabs were missing limbs when harvested. Mostly this involved one or two limbs however chelipeds figured highly in the statistics. With regard to moult period, the effect of limb loss on the timing of moult was apparently influenced by the stage of the moult cycle at harvest, probably because of the need to fit limb regeneration into the moult cycle. But in terms of moult increment, the results hinged upon the fact that, not surprisingly, harvested crabs missing even a couple of limbs weighed significantly less at the start of the trial and consequently they weighed less at the end. Pre-moult weight was a strong covariate in an analysis of moult increment- and this factored in the expected weight difference due to missing limbs.

In an animal that roughly doubles its weight each time it moults, how much *P. pelagicus* weighed before it moulted can clearly bear heavily upon how big it will become, even several instars into the future. And any differences between crabs also tended to double. In this fashion, the occasional loss of limbs could easily explain much of the spread in size-frequency distribution seen in pond-reared crabs. The relative interplay between genes and environment in driving crab growth remains to be demonstrated. However, in immediate practical terms, the moult increment or yield from a given kg of crab received for shedding was not actually altered by limbloss. This outcome may be surprising but crab growth literature focuses upon changes in carapace width rather than sale-able weight. Carapace width may mean much to fishery managers but its increment suffers following moulting precisely because limb regeneration has priority and the weight increment is thus conserved. However limb-loss is clearly a burden on the harvestable yield of hard-shelled crabs from a pond and is a reason to either rear crabs individually as soon as practical or perhaps to try to reduce its incidence through selective breeding.

### TECHNIQUES AND MATERIALS USED FOR SHRIMP SIZE GRADING: EVOLUTION AND PERSPECTIVES

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Selection of the largest animals in a given population has always been a target to improve productivity either directly by producing larger animals, or, indirectly, by improving the growth rate: empirically the largest animals have often been chosen for reproduction in most domestication programs; and when size differences appear in a rearing, for example with freshwater prawn, selective harvest is practiced to facilitate growth expression of the smaller individuals of the population.

Individual body weight in healthy cultivated shrimp populations generally have a Gaussian distribution with a slight shift between males and females. Pioneer works on size started with domestication and the availability of captive breeders populations. They were based on individual weight and size measurements of late juveniles and adults. With the growing concern for genetic selection, it appeared that numerous animals had to be graded to maximize selection and that individual measurements could no longer be used. A first application was the use of selective calibrated traps placed in grow out ponds to catch the largest shrimps and raise them further until breeding size The drawbacks were essentially the induced mortality and the relatively small number of animals that were sorted. In addition, grown shrimps could already have suffered mortality and not represent the initial population diversity The size at which sorting was realized was then progressively lowered by using adapted small mesh sieves and fish graders with bars. Grow out results with larvae obtained from ponds seeded with sorted post larvae (20 days old) confirmed that early selection was an efficient zootechnical process A simulation computer program was written to forecast the theoretical results of an early grading. Problems encountered were mainly due to the inaccuracy of the gap size between the bars, the slowness of the active sorting through a mesh and the limited size of the sorted populations within a short time.

New graders with different gap sizes were designed and precisely engineered using a thick PVC plate and a computerized milling machine. Preliminary trials allowed confirming the precision of the grader and its ability to handle large quantities of post larvae without harming the animals. Full scale sortings were then realized in commercial hatcheries at the time of harvesting of their nurseries.

These graders, associated with very early selection of size, make way for new applications both at experimental and production level: quality criteria of post larvae batches, homogenous post larvae for specific growth trials, experimental breeding programs based on early selection.



Fig 1: Relation between individual shripm weights and retention percentage for 2 bar graders.

## THE MICROBAL COMMUNITY ASSOCIATED WITH THE WATER COLUMN OF AN ORNATE ROCK LOBSTER Panulirus ornatus LARVAL REARING SYSTEM

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To date, few studies have successfully reared Palinurid lobsters through their entire larval lifecycle. This is largely due to the extremely long larval development that is associated with the animals, ranging from approximately 160 days in *Panulirus ornatus* to 340 days in *Panulirus cygnus*. Where larvae have been reared through their entire larval development, survival has been extremely low, typically around 1% of the original stocking density. A lack of suitable feeds may be responsible for larval mortalities during the rearing process, as at present the natural food source of wild phyllosoma larvae is unknown. It has also been suggested that a pathogen or pathogens within larval rearing systems may be responsible for larval mortalities.

*P. ornatus* has been identified as a potential candidate for commercial aquaculture in Australia. This species has the shortest larval lifecycle of all of the Palinurid lobsters, is fast growing, and is has a high market value. At present, the commercial scale larval rearing of *P. ornatus* has not progressed beyond the fourth (of eleven) phyllosoma stage. This is largely due to the occurrence of mass larval mortalities early in the larval rearing phase (*Figure 1*). Due to larval mortalities occurring en masse, and not over an extended period of time, it has been suggested that one or more pathogens may be responsible.

In hatcheries larvae are cultivated in an environment with a bacterial flora that differs both qualitatively and quantitatively from that found in their natural environment. This bacterial flora can inflict various detrimental effects on larvae, including, fouling, disease and antagonistic competition for potential beneficial bacterial populations. Here we present a holistic approach for determining the microbial community associated with the water column of a *P. ornatus* larval rearing system using traditional culture-based and molecular analyses.

Preliminary results indicate that *Vibrio* and *Bacillus* are the dominant bacterial genera of the culturable microbial community of the *P. ornatus* larval rearing system water column.



Figure 1 - Survival of P. ornatus phyllosoma larvae during larval rearing attempts

### EFFECT OF LIGHT INTENSITY, REARING TANK COLOUR AND PREY DENSITY ON FEEDING EFFICIENCY AT FIRST FEEDING OF THE SPOTTED SAND BASS Paralabrax maculatofasciatus LARVAE

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The feeding incidence and prey consumption at first feeding of spotted sand bass larvae (*Paralabrax maculatofasciatus* Steindachner), using four light intensity treatments (0, 100, 400 and 700 lux), three tank colours (black, grey and white) and three prey densities (5, 10 and 15 prey/ml) were evaluated in two experiments. Specimens were fed the rotifer *Brachionus plicatilis* One hour after the addition of prey,  $30 \pm 3$  (mean  $\pm$  SEM) larvae were sampled from each treatment aquarium. Feeding incidence was evaluated as the percentage of larvae with prey in the digestive tract. Feeding intensity was measured as the number of prey in the digestive tract of the larvae. Histological analysis was carried out to describe the eye structure at the time of first feeding.

Larvae fed in darkness (0 lux) had a significantly lower (P < 0.05) feeding incidence ( $1.2 \pm 2.2 \%$ ) and intensity ( $0.4 \pm 0.7$  rotifers/larva) than those larvae fed at 100 ( $28 \pm 11 \%$ ,  $1.8 \pm 0.2$  rotifers/larva), 400 ( $48 \pm 10 \%$ ,  $2.4 \pm 0.3$  rotifers/larva), and 700 lux ( $52 \pm 4 \%$ ,  $2.4 \pm 0.1$  rotifers/ larva). Feeding incidence of the spotted sand bass larvae increased with light intensity while the feeding intensity showed no significant difference (P > 0.05) between light treatments.

The tank color had no significant effect (P > 0.05) on the feeding incidence of the spotted sand bass larvae. The larvae fed with 5 rotifers/ml had a significantly lower feeding incidence  $(52.3 \pm 10.1 \%)$  than those larvae fed at  $10 (74.8 \pm 8.7 \%)$  and 15 rotifers/ml ( $71.0 \pm 6.8 \%$ ). Both, the tank colour and prey density significantly affected (P < 0.05) the number of prey ingested by larvae. The highest feeding intensity was recorded in black tanks at 15 rotifers/ml ( $4.3 \pm 1.6$  rotifers/larva), while the lowest was registered in the white tanks at 5 rotifers/ml ( $1.9 \pm 0.9$  rotifers/larva).

Histological analysis of the eye structure showed that first feeding larvae had well-formed lens along with a retina composed of pure single cones as photoreceptors.

### MARINE ORNAMENTAL DECAPODS – AQUACULTURE OF EMERGING SPECIES

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Over the last years, the growing demand for marine ornamentals has contributed to increase the anthropogenic pressure on the coral reefs ecosystem. The fact the majority of the marine organisms marketed in the aquarium trade industry are still collected from the wild, particularly from coral reef ecosystems, combined with the destructive harvesting techniques, such as use of cyanide and explosives, lead to dramatic impacts on the health and biodiversity of coral reef ecosystems.

The implementation of sustainable collection practices combined with proper aquaculture technologies for marine ornamental species will preserve the ecosystem as well as guarantee a sustainable supply for the aquarium industry.

While several species of shrimps are highly studied, little research is being address to the rearing of anomuran and brachyuran crabs, considered the second and third group most traded. The low unit price seams to explain the existence of such "research bias". Although, the reduce number of larval stages, and consequent short larval duration, should be an appealing aspect for the commercial culture of these organism.

In this study, an overview of the ornamental aquaculture research is given and the larval rearing of two species of the genus *Mithraculus* is analysed.

#### LINKAGE MAPPING IN THE WHITE SHRIMP Litopenaeus vannamei

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*Litopenaeus vannamei* is the principal shrimp species produced in America. By 2000 around 100000 tons of this species was produced by cultivation. Selective breeding of the species is underway in USA, Colombia, Panama and Ecuador. Breeding programs might benefit from the availability of linkage maps in order to carry out characterization of quantitative trait loci (QTLs), mass assisted selection (MAS) and evolutionary studies by synteny comparisons.

We report the advances in the construction of sex-specific linkage maps in the white shrimp *Litopenaeus vannamei*. Linkage information was generated using AFLP markers in a mapping panel consisting of 42 individuals derived from a commercial cross. We used 103 primer combinations that produced 741 segregating bands from which 477 segregated in a 1:1 model, 181 in a 3:1 model, 62 fitted both models and 21 fitted neither model. A total of 394 loci with a 1:1 segregation ratio were mapped to unique positions in the male and female maps using a pseudo-test cross strategy. A total of 51 and 47 linkage groups were detected for the male and female maps respectively, instead of the expected 44 haploid groups expected from the karyotype. The female map (Figure 1) covered 2,771 cM and was 24% longer than the male map (2,116 cM long). The distribution of the markers showed that both maps have low saturation and clustering at short linkage distances. Markers with a distorted segregation were observed as previously reported in other shrimp species. The estimated genomic length indicates that the *L*, *vannamei* genome has higher recombination rates than closely related species.

Development of gene tagged markers by data mining of ESTs publicly available sequences will generate anchoring markers. An initial screening of 5832 ESTs gave 284 microsatellite containing sequences. From 224 designed primer pairs, 109 gave PCR products. In *L. vannamei* polymorphism was detected for 61 sequences. Thirty one out of 109 markers showed evidence of intron presence. This type of markers might be highly transferable between different shrimp species as shown by 79 *L. vannamei* markers that amplified in a closely related species, *L. stylirostris*.

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FE-36 (e275-0 (e304-22	FE-39	FE-40 N285 21	FE-41 N131 20	FE-42 fe187 fe187 fe187	FE-43 1+111-0 1+314-11	FE-44 fe165 fe434	FE-45 16243 16243 160170 160170	FE-46	FE-47 (e207 (e252 15

Fig. 1: L. vannamei female map based on AFLP markers.

### A NEW MODEL OF LEADERSHIP DEVELOPMENT IN RURAL INDUSTRIES

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Leadership theory has changed many times during recent decades through behavioural traits to charismatic, transformational and visionary leadership models. Each of these has focused on the leader and explaining leadership in terms of defining the leader. Our work in rural Australia has lead us to question this approach to leadership and to develop a more holistic model of "industry leadership" rather than "individual leadership". Industries which will have greater leadership capacity are those that develop general awareness among their members, have skilled, knowledgeable and networked participants at all levels and individuals who can represent them at a local, state and national level. Those industries which value the passing on of knowledge through mentoring and which are prepared to review their own practices in order to ensure organisational support structures will enhance their sustainability. This paper presents the results of applying this concept to the Australian Seafood and Dairy industries and discusses its applications to the aquaculture industry by presenting results from our range of industry leadership development programs.

### PICKING WINNERS FOR INDIGENOUS AQUACULTURE: RECENT EXPERIENCES AND SOCIO-ECONOMIC TECHNIQUES FROM THE FIJI ISLANDS

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Serious efforts to develop aquaculture industries in Fiji Islands began in the 1970's, and this sector continues to attract a high level of support from government, regional, and international institutions. Government's objectives for aquaculture in Fiji are to (1) improve food security for rural low-income communities, (2) provide alternative livelihoods, especially in rural areas with few other economic opportunities, (3) allow import substitution of commodities needed for Fiji's tourism industry, and (4) generate national income through exports. Aquaculture projects that have been or are being tried include *Kappaphycus* seaweed, *Tridacna* giant clam, blacklip pearl *Pinctada margeritifera*, tilapia *Oreochromis niloticus*, freshwater prawn *Macrobrachium rosenbergii*, shrimp *Penaeus monodon*, corals e.g. *Acropora* spp., Asian carps, and goldfish. Success has been mixed, and has not fully met the expectations that might be warranted by the amounts of public money so far spent. The issues nowadays tend to be socio-economic rather than technical, and the focus of research and project management has shifted to development of socio-economic tools that can better predict the locations and community characteristics where aquaculture projects have the best chance of success. This paper describes some tools developed recently in Fiji, and uses Fiji case studies to illustrate the application of such tools.

### AQUACULTURE DEVELOPMENT IN THE PACIFIC

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Modern day aquaculture in the Pacific began in the early 1950's. Today the sector has emerged as one that is tailored towards the regions unique socio-economic and environmental features. The estimated value of annual production is in the order of USD130-180 dollars. Most of the revenue is concentrated in capital and technology intensive farming of black pearls and marine prawns. On the other hand, it is low input and extensive farming of commodities such as kappaphycus seaweed, tilapia fish and freshwater shrimp which offers the most readily available opportunities for the Pacific's rural population to benefit from the economic gain and food security of aquaculture. Most governments have made a relatively significant investment in aquaculture. A common priority is to promote the opportunities for small scale, rural based farming. Some challenges include policy and legislation, institutional capacity building, environmental management, applied research, integrated approaches and marketing. A growing network of regional and international organisations is supporting development efforts among the Pacific island countries.

### DEVELOPMENT OF SEAWATER TREATMENTS FOR AMOEBIC GILL DISEASE

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The control of amoebic gill disease (AGD) of salmonids in Tasmania is a significant cost to the aquaculture industry. Current treatments using freshwater to bath cages of salmon have become less effective at AGD control in recent years. However, advances in understanding water chemistry have identified ways in which the efficacy of freshwater bathing (primarily related to water chemistry) can be enhanced. Nevertheless the cost of freshwater bathing remains high. The development of a treatment that can be administered in seawater either as a bath or in feed is desirable so as to reduce the reliance upon freshwater, and reduce the costs of AGD control. Recent investigations using the disinfectant chloramine-T added to both fresh and seawater in experimental tank trials have shown that rates of removal of gill amoebae and gill recolonisation by amoebae were comparable to that provided by conventional freshwater bathing. Moreover, the treatment duration was reduced from 3-4 hours for conventional freshwater to 1 hour for seawater chloramine-T under commercial conditions where oxygenation can be carefully controlled, the use of oxidative disinfectants may offer an alternative to conventional freshwater bathing for AGD.

## ACCLIMATISATION OF WESTERN KING PRAWNS Penaeus latisulcatus TO INLAND SALINE WATER

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Inland saline water is abundant in Western Australia, occurring naturally and as a result of agricultural activities. The ionic composition of much of this water is similar to that of marine water, which presents an opportunity to investigate whether marine animals can be reared in this water. A candidate species for culture in inland saline water is the western king prawn (*Penaeus latisulcatus*). The broad rearing parameters of this species are established. No research has been conducted to date on the impact of acclimatisation period on the survival and physiological state of prawns. The present study was conducted to standardise the acclimatisation period to inland saline water for western king prawns and to investigate the effect of the acclimatisation process on their survival and osmoregulatory capacity.

A 10-day trial was conducted in seven 125L tanks, each with an external bio-filter and protein skimmer. Out of 56 juvenile prawns (mean weight of  $7.02 \pm 0.42$ g) 8 were placed into each of the tanks, 6 of which contained marine water (MW) and one containing inland saline water (ISW) from Wannamal WA (31°15''S, 116°05''E). Prawns were acclimatised from MW to ISW by gradually replacing MW with ISW over a period of 1, 3 or 6 hours. Each of these acclimatisation periods had a control, where MW was replaced by more MW. The ISW from the seventh tank was replaced by more ISW, representing direct transfer of prawns into ISW without any acclimatisation. Survival and ingestion rate were then monitored for 10 days. Prawns were fed daily on green mussels (*Perna canaliculatus*). Haemolymph was withdrawn from 5 pre-acclimatised prawns, from 3 post-acclimatised prawns per tank and from all remaining prawns after 10 days. Haemolymph was mixed with anticoagulant solution (0.1% glutaraldehyde in 0.2M sodium cacodylate, pH 7.0). The haemolymph and medium osmotic pressure was then measured using a cryoscopic osmometer – Osmomet 030.

After 10 days prawn survival was 100% in all tanks except the tank with no acclimatisation, which had 1 mortality. Prawns that were directly transferred to ISW without acclimatisation had a lower ingestion rate than all other prawns. Prawn ingestion rate was higher in MW than in ISW at each acclimatisation period. Prawn final osmoregulatory capacity was significantly (P<0.05) higher in MW than in ISW at each time period. These results indicate that acclimatisation to inland saline water is required but that acclimatisation period, between 1 and 6 hours, has no impact on the survival, ingestion rate or osmoregulatory capacity of prawns. The lower osmoregulatory capacity of prawns in inland saline water indicates that the different ionic composition of inland saline water can have an impact on prawns.





Figure 1. Mean final osmoregulatory capacity of *P. latisulcatus* acclimatised to ISW for 0, 1, 3 or 6 hr.

Figure 2. Mean daily ingestion rate of *P. latisulcatus* 10 days following different acclimatisation periods.

# GENETIC IMPROVEMENT OF THE KURUMA PRAWN Penaeus japonicus IN AUSTRALIA

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Farming Kuruma prawns (Penaeus japonicus) for live export to Japan commenced in Australia in 1991. The profitability of this export industry is closely linked to variations in the relative value of the Australian and Japanese currencies. In the mid to late 1990's favorable market prices resulted in a peak in the volume and value of the industry. The success of the industry during this period stimulated progressive developments in production techniques, including domestication and selective breeding for improved growth. A mass selection program resulted in significant improvements in the growth rates of farm stocks. The largest 10% of individuals from equal-aged population in farm ponds were selected as broodstock. Compared to the progeny of wild stocks, there was a 9.3 % increase in the mean weight at first harvest of second generation farm stocks and a 14% increase in the mean weight of fourth generation stocks. Significantly, stocks of P. japonicus, initially selected for high growth in farm ponds and then reared from egg to adult for three generations under controlled conditions in tanks, retained their capacity for superior growth when returned to farm ponds. This indicates that selected lines, maintained in bio-secure conditions, could provide reserve stocks for re-establishing superior lines of farm stocks. Sub-sets of Specific Pathogen Free (SPF) lines of selected stocks, maintained in biosecure conditions, could provide a valuable and sustainable genetic resource for stocking farms or re-establishing farm populations in the event of stock losses due to disease outbreaks or other factors. The potential benefits of this approach have been highlighted by recent observations on the relative growth rates, survival and health status of farm reared stocks and tanks reared siblings. In parallel with gains achieved via mass selection, the development and application of genetic markers has enhanced progress in the selective breeding of P. japonicus. This has included establishing pedigrees, linkage mapping and identifying Quantitative Trait Loci for growth. Many of these research advances may also be of value for other shrimp species.



# RAPID GROWTH AND BIOTURBATION ACTIVITY OF THE SEA CUCUMBER Holothuria scabra IN EARTHEN PONDS

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Sea cucumbers are valuable export products. Technology on their culture is expanding rapidly to help meet market demand in China, and to help relieve exploited fisheries. The sandfish, *Holothuria scabra*, is the most valued of tropical species. It is the focus of a restocking research project in New Caledonia, funded by ACIAR, provincial governments and the government of France. Sandfish are deposit-feeding detritivores of shallow muddy/sandy habitats, thus earthen ponds provide suitable conditions. Pond grow-out could reduce the costs involved in producing juveniles for restocking and provide a valuable and novel crop.

Hatchery-produced juveniles and wild-caught broodstock sandfish grew rapidly in earthen ponds in New Caledonia (Table 1). No additional feed was given, so animals had only the existing organic matter in the sediments, averaging 4.0 to 6.2 % by wt., and autochthonous production. Densities were 78 to 128 g m⁻², under the reported growth-limiting threshold of 225 g m⁻².

One kg is an appropriate size for processing for exportation. Therefore, the culture cycle in ponds could be 1.5 to 2 years.

In-situ measurements showed that the bioturbation of pond sediments, particularly by burrowing, is substantial. Sandfish averaging 919 g (n = 4) displace 1087 (± 296) cm³ of sediment by burrowing, which is a natural diurnal behaviour (Fig. 1). Burrows are shallow in ponds due to hard underlying sediments. Feeding was periodic and variable but, as a guide, animals averaging 1.0 kg excreted 1.6 g (± 1.3 g) sediment h⁻¹.

Pond grow-out of sandfish appears technically feasible. Sandfish could act as bio-remediators for pond aquaculture by eating unused organic deposits, but conversion to soluble nitrogenous excreta should be considered. Bioturbation by sandfish could benefit shrimp culture. An experiment rearing juvenile sandfish with shrimp showed promise for successful co-culture. However, co-culture is not a likely panacea for reduced pond management, since ponds with sandfish can also become eutrophic with anoxic sediments. Future research should examine inter-specific interactions, verify bio-remediation effects, and determine optimal management of co-culture systems.

Av. Start wt. (g)	n	Duration (months)	Growth rate (g ind ⁻¹ month ⁻¹ )
1375	43	12	8.2
702	132	5	69.8
378	37	7.5	71.6
262	31	11.5	46.2
22 *	55	1	35.0
26 *	62	1	30.1

FIGURE 1. An adult sandfish burrowing into the upper layer of pond sediments.



TABLE 1. Growth of sandfish broodstock and hatchery-produced juveniles (asterisks) in ponds.

## THE GENETICS OF QX DISEASE RESISTANCE IN SYDNEY ROCK OYSTERS

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QX is a fatal infectious disease of Sydney rock oysters (*Saccostrea glomerata*) mediated by the protistan parasite *Marteilia sydneyi*. QX outbreaks have marginalized rock oyster farming in some areas of NSW and Queensland. Since 1997, NSW Fisheries have bred *S. glomerata* for QX disease resistance. This breeding program has substantially decreased QX-associated mortality among selected oysters. Our study is testing whether the defensive enzyme, phenoloxidase (PO), plays a role in the QX disease resistance being generated by selective breeding.

Third and fourth generation oysters bred for QX resistance (QXR₃ and QXR₄ oysters) were compared to non-selected *S. glomerata* (wild type oysters). Microplate assays showed that PO enzyme activities were significantly higher in QXR oysters when compared to wild type oysters (Fig. 1).



d

Figure 2. The four distinct forms of PO in rock oysters (a-d) revealed by native PAGE.

а

С

Population genetic analysis indicated that the two forms of PO common among QXR oysters are variant alleles of normal PO proteins. The data suggest that these alleles are responsible for enhanced PO



Figure 1. Phenoloxidase activities of  $QXR_3$  and wild type oysters. N = 61, bars = SEM

activity, and that they protect oysters from QX disease.

Native polyacrylamide gel electrophoresis (native PAGE) revealed four distinct forms of PO (Fig. 2). Genotypes containing two of these PO proteins (bands *b* and *c* in Fig. 2) were found far more often in  $QXR_4$  oysters than in wild type oysters (Fig 3).

### **Conclusions:**

b

- 1. Distinct forms of PO are responsible for QX disease resistance.
- 2. Breeding programs that actively select for those PO alleles could rapidly generate QX resistant oyster strains.



Figure 3. Comparison of the PO genotypes found in wild type (WT) and  $QXR_4$  oysters.

# HATCHERY SEED PRODUCTION OF GIANT FRESHWATER PRAWN, Macrobrachium rosenbergi IN GROUND SALINE WATER OF ROHTAK (HARYANA), INDIA

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The suitability of inland ground saline water (IGSW) of Lahli-Baniyani Fish Farm Rohtak was assessed for larval rearing of Giant Freshwater Prawn, Macrobrachium rosenbergii and necessary ionic amendments carried out for enabling the process. A total of four experiments were conducted to standardize the procedure. In experiment-I, high level of total hardness of 3650 mg l⁻¹ (salinity 12 g l⁻¹) of IGSW was reduced to different grades of hardness 900,1200,1500,1800,2200,2800 and 3200 mg l⁻¹ and raw ground saline water of equivalent salinity was used as control. In all the seven sets comprising of 4-6 larval cycles, the larvae did not survive beyond stages II and III and total mortality was observed within 3-5 days of hatching. No significant difference in mortality rate was noticed between control set and graded waters. The IGSW was analyzed for cations and deficiencies in levels of potassium, calcium and magnesium were identified as possible cause for problems in larval rearing. In experiment-II, low level of potassium ions (10.9 mg l-1 at salinity 12g l-1) in IGSW were amended to a level 118.5 mg l⁻¹ through addition of KCl so as to maintain K⁺ approximately equivalent to coastal seawater (120 mg  $l^{-1}$  at salinity 12g  $l^{-1}$ ). The larvae survived in test water (T₁) in all five cycles up to stages IV-V with total mortality however seen after 11-15 days. In experiment-III, the levels of both potassium (K⁺) and magnesium (Mg²⁺) ions were amended by addition of KCl and MgCl₂. The levels of K⁺ ions were maintained at 118.0 mg l⁻¹ whereas; Mg²⁺ was increased to maintain a Mg²⁺/Ca²⁺ ratio of 1.9. The larvae survived in this medium up to stages IV-V, total mortality was seen within 11-15 days in all the cycles. In experiment-IV, higher level of Ca2+ in IGSW (440 mg l-1, 3.18 times more than the CSW at 12 g l⁻¹ salinity) was reduced (148-160 mg l⁻¹, 12 g l⁻¹) to similar levels of Ca²⁺ as in CSW and subsequently fortified with K⁺  $(117-122 \text{ mg } l^{-1})$  and Mg²⁺ (275-304 mg l⁻¹) to maintain Mg²⁺/Ca²⁺ ratio of 1.9. The larvae reared in this water completed 11stage life cycle and metamorphosed to post larvae in all the seven cycles with survival levels of 2-11%. The study thus demonstrated that IGSW with ionic amendments could be used for larval rearing of Macrobrachium rosenbergii, accounting for the first report of complete larval rearing of giant freshwater prawn in IGSW. Such water medium, apart from abundance, will be free from pollution, pathogens and much cheaper than the artificial seawater and the other saltpan residues in remote inland sites. The scaled-up technology would enable utilization of large reserves of IGSW available in northwestern parts of India as also in several other countries for quality seed production of freshwater prawn. This will also provide for easy and cost effective availability of quality prawn seed in inland region where farming of freshwater prawn has received increased attention in recent years.

# CURRENT STATUS OF THE WOLLONGONG ABORIGINAL AQUACULTURE CORPORATION

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The Wollongong Aboriginal Aquaculture Corporation (WAAC) was formed in March 2004 from a voluntary group called the Illawarra Indigenous Aquaculture Development Committee. A group of Indigenous community and departmental members who saw the need for sustainable Indigenous enterprise to alleviate ever growing employment issues in the Illawarra region. With our Project Manager and Board Members coming from a social background, WAAC seeks to develop sustainable aquaculture ventures to address issues such as cultural identity, cultural preservation, mentoring, employment, education and training. In regions such as the Illawarra, the concerns for ocean rights almost outweigh those of land right, as this directly affects traditional practices and cultural expression of coastal Indigenous peoples.

WAAC has received support from NSW Fisheries, the Department of Agriculture Fisheries and Forestry and other government agencies to continue the work they have commenced over the past months. This work focuses on marine hatchery and grow-out facilities. The opportunities available to Indigenous communities through such a venture are immeasurable, increasing the social and economical portfolio of a hugely disadvantaged group. WAAC has sought joint venture partnerships with key corporate bodies as well as government agencies to assist this project further, while maintaining majority Indigenous community ownership of the project.

# POTENTIAL FOR USING FROZEN/DRY FEEDS TO REPLACE LIVE FEEDS IN THE CULTURE OF SEAHORSES

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Current success of seahorse aquaculture is dependent on the supply of suitable live feeds, either wild caught or cultured. However, the production of large quantities of live feeds is expensive and the supply is unreliable. In the present study, we examined the possibility of replacing live artemia with frozen artemia or commercial pellets for feeding juveniles of *Hippocampus spinosissimus* over a period of six weeks. During the first week of the experiment, juveniles were gradually weaned from live artemia onto frozen artemia or dry pellets. By the end of fourth week, all the juveniles fed with dry feed had died. There was no mortality for the juveniles fed live artemia or frozen artemia up to the end of the experiment. However, the juveniles fed with frozen artemia ( $420 \pm 20$  mg) were significantly smaller compared with those fed with live artemia ( $610 \pm 30$  mg).

In a second feeding trial, live artemia was partially replaced with freeze- dried copepods (Cyclop-eeze[®]) for feeding juveniles of *H. spinosissimus* over a period of four weeks. In the first week, 50% of the live artemia was replaced with freeze-dried copepods followed by 75% in the second week and 90% from the third week onwards. The juveniles in the control tanks were fed with live artemia throughout the experimental period. There was 100% survival for both the treatments at the end of the experiment. There was no significant difference in wet weight between the two treatments at the end of first week when 50% of live artemia was replaced with freeze-dried copepods. From the second week onwards, the juvenile seahorses fed dried copepods were significantly smaller compared to those fed live artemia.

These results demonstrated that although live artemia could be replaced with frozen artemia to feed seahorse juveniles, their growth was not as rapid compared to feeding live artemia. Similarly, freeze-dried copepods could be used to replace live artemia for feeding juvenile seahorses; however, when more than 50% of live artemia was replaced, seahorse growth was significantly lower compared to feeding live artemia. More work is needed to identify frozen/formulated feeds, which can effectively replace live artemia in seahorse culture.

## CRYOPRESERVATION AND COOL STORAGE OF PACIFIC OYSTER SPERM FOR SELECTIVE BREEDING AND COMMERCIAL SPAT PRODUCTION

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Several studies have demonstrated fertilisation with cryopreserved shellfish sperm in small laboratory trials. However, the reduction in fertility caused by cryopreservation can generate difficulties in converting this research success into commercial application. This paper outlines the results of research into practical, commercial scale methods for the storage of Pacific oyster (*Crassostrea gigas*) sperm for use in selective breeding and spat production.

Method development led to the following protocol. Dry-stripped sperm ( $\sim 2 \times 10^{10} \text{ ml}^{-1}$ ) was mixed stepwise with 10 parts of diluent (final concentration of 0.45M trehalose + 5% DMSO in distilled water). Sperm mixture was loaded into 4.5 ml cryovials, mounted on canes, cooled for 10 min in a dry-ice/alcohol bath, and transferred to liquid nitrogen for storage. Vials were subsequently thawed in room temperature water. One large male provided sufficient sperm to load 10 to 20 cryovials, with the contents of each vial sufficient to fertilise a few million eggs. To demonstrate commercial applicability, 30 million eggs were fertilised with 31 ml of cryopreserved sperm, yielding 81% fertilisation. Larval rearing by normal commercial practices yielded 3.7 million settled spat, which was comparable to 2.5 million spat obtained from a parallel batch using the same egg pool fertilised with unfrozen sperm.

Many breeding programmes rely on family lines from single pair crosses. Fertility may vary markedly among male/female combinations, and loss of fertility during cryopreservation compounds this issue. To provide a robust tool for breeding, sperm cryopreservation needs to be effective for the majority of single pair crosses. We conducted 20 random, single pair crosses, fertilising 1 million eggs from a single female with cryopreserved sperm from a single male, at 2000 sperm per egg. Fertilisation ranged from 12 to 89%, and exceeded 25% for all but two of the 20 crosses. In one of those cases, the poor result was explained by low fertility before freezing, and in the other, by atypical loss of fertility during cryopreservation. Doubling the sperm to egg ratio would increase fertilisation rates, allowing more margin for losses during larval rearing of individual families.

Short term (hours to days) storage of gametes gives flexibility in the timing of crosses during intensive breeding runs. This is particularly important for complex mating designs. We examined the longevity of fertility in sperm and eggs held at high density at  $\sim$ 5°C. Sperm fertility did not decline for 8 days, and cryopreservation success was not compromised by storing sperm for up to 5 days before freezing. Egg fertility began to decline after 2 to 7 days at 5°C.

These results are being used in our Pacific oyster selective breeding programme.



### Sperm maintained fertility for 8 d at 5°C

### PROPHYLACTIC ORAL ADMINISTRATION OF L-CYSTEINE ETHYL ESTER DELAYS THE ONSET OF AMEOBIC GILL DISEASE IN ATLANTIC SALMON Salmo salar

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The current treatment for amoebic gill disease (AGD) in Tasmanian farmed Atlantic salmon (*Salmo salar*) is to bath fish in freshwater. Bathing duration is only short-term (3 h) and holds no significant physiological consequences. However, bathing is a time-consuming, resource intensive and stressful procedure. Additionally, commercial bathing frequency has increased over the last decade. In this study we aimed to assess the effects of the mucolytic drug L-cysteine ethyl ester (LCEE) as an in-feed additive to retard the development of pathological gill lesions characteristic of AGD. Blood parameters were also assessed to document any physiological consequences.

Seawater acclimated fish of mean ( $\pm$  SE) weight 151  $\pm$  8 g were divided into 3 tanks per treatment. The experimental trial involved an initial 2-week feeding period followed by an AGD challenge, where tanks of fish were inoculated with isolated gill amoebae from a confirmed AGD infection. Treatments included control fed fish and prophylactic LCEE fed fish (dosage: 35-45 mg LCEE kg⁻¹ fish day⁻¹). Feeding was maintained throughout the experiment. Medicated feed was prepared by top dressing salmon pellets with LCEE and cod liver oil. Control pellets were coated with cod liver oil only. Fish were sampled throughout the experiment for gills and blood. The results showed that LCEE administered as a prophylactic treatment significantly delayed the infection rate, approximately 50% less AGD-affected gill filaments, compared to the controls (Fig. 1). Blood pH, plasma total ammonia, protein, chloride concentrations and plasma osmolality did not significantly differ between treatments throughout the experiment. These results demonstrate the potential of LCEE as an in-feed additive to delay the onset of AGD and subsequently allow for a reduced bathing frequency. Furthermore, results suggest that administration of LCEE holds no physiological consequences. In a previous study, LCEE was successfully tested as an infeed additive to protect coho salmon (*Oncorhynchus kisutch*) against a harmful phytoplankton. In-feed treatments are easily administered without the need for stressful husbandry practices.



Fig. 1 - Percent of gill filaments with a histological AGD lesion in Atlantic salmon (mean  $\pm$  SE) (n=72). ANOVA showed that cumulative means for treatments are significantly different, P<0.05

# EFFECTS OF L-CYSTEINE ETHYL ESTER ON ATLANTIC SALMON Salmo salar MUCUS AND GILL ISOLATED AMOEBAE IN VITRO

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The development of improved therapeutic treatments for amoebic gill disease (AGD) would be an valuable tool in the management of this production disease in the Tasmanian Atlantic salmon industry. In a previous study, the mucolytic drug L-cysteine ethyl ester (LCEE) was successfully tested as an in-feed additive to protect coho salmon (*Oncorhynchus kisutch*) against a harmful phytoplankton. Recently, in two separate experiments, we found that LCEE administered orally (approximately 50 mg LCEE kg⁻¹ fish day⁻¹) significantly delayed the onset of AGD in Atlantic salmon (*Salmo salar*). In this study we aimed to assess the mechanism of action of LCEE, which would subsequently allow us to assess other similar drugs for potential use. In order to test its mucolytic and amoebicidal properties, LCEE was incubated *in vitro* with Atlantic salmon mucus and isolated gill amoebae associated with AGD.

Body mucus was non-lethally collected from sea-caged Atlantic salmon, and amoebae were isolated from the gills of fish from an ongoing AGD laboratory infection. 2 ml mucus samples had 20ul of either deionised water or LCEE stock solution added to achieve final concentrations of 0, 8, 12, 100 and 200 ug LCEE ml⁻¹ mucus (ppm). Solutions were incubated at  $17\infty$ C for 2 h before measuring their viscosity. Isolated amoebae were incubated at  $18\infty$ C for 24 h with LCEE (at 0, 5, 50 and 200 mg LCEE L⁻¹) (ppm) in 200ul aliquots. Amoebae numbers were counted at 0, 6 and 24 h. The results showed that LCEE has a significant mucolytic effect after 2 h incubation on Atlantic salmon mucus with increasing concentration (Fig. 1). LCEE also showed a significant amoebicidal effect after 6 h incubation at 200 ppm only. Our results suggest that the main mechanism of action of LCEE is mucolytic, observed as significant thinning of fish mucus. A reduced mucus viscosity, and possibly altered mucus biochemistry, may create a less favourable environment on the gills for amoebae attachment. At higher concentrations LCEE may also be amoebicidal, although oral administration *in vivo* is generally much lower than 200ppm. This study has demonstrated adequate techniques to assess other cysteine based mucolytic compounds for their use as gill disease treatments in cultured fish.



Fig. 1 – Viscosity of mucus (at shear rate 11.5 sec⁻¹) as a proportion of controls is negatively correlated to LCEE concentration (mean  $\pm$  SE) (n=26). Asterisks indicate significant differences from controls, P<0.05
#### INDIGENOUS AQUACULTURE DEVELOPMENT IN NORTH QUEENSLAND, AUSTRALIA

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Indigenous communities and individuals in North Queensland have shown a significant interest in aquaculture opportunities in recent years. This has ranged from an overall desire to increase regional economic opportunities for indigenous people, to individuals wanting to establish their own small-scale ventures in remote communities. The more remote parts of North Queensland have vast areas of environmentally diverse aquatic resources, many of which are indigenous lands in DOGIT, freehold in trust or community tenure. Some of these areas may have significant potential for aquaculture in various forms, but can only be developed within the requirements of existing regulations and only through the support of government and indigenous community leadership.

The AFFA/ATSIC funded National Aquaculture Development Strategy for Indigenous Communities was completed in 2001 after a wide range of consultations and investigations, and provided a long list of recommendations that could be used to progress indigenous aquaculture opportunities in North Queensland. It is clear that the National Strategy does provide a framework for appropriate development that should greatly improve development of viable indigenous aquaculture enterprises.

In response to the increasing number of aquaculture extension enquiries from indigenous people in North Queensland, two separate workshops were conducted in 2002 to provide information and increase awareness about the various issues relating to aquaculture development in indigenous communities. An important outcome from these workshops was the formation of a working group to enable indigenous leadership in the facilitation of aquaculture ventures. The membership of the North Queensland Indigenous Aquaculture Working Group includes indigenous representatives from the Gulf region, Cape York, Torres Straits and the east coast of Queensland down to Bowen, as well as State and Commonwealth representatives.

A significant outcome from the efforts of the indigenous working group has been the funding of a scoping study to provide a report and investigation of strategic needs and opportunities for indigenous aquaculture in North Queensland: "Realising aquaculture development in North Queensland Indigenous Communities". The study has been completed and provides a range of recommendations and advice to government as well as indigenous communities on issues such as training needs, potential for joint venture arrangements with existing aquaculture sectors, a project assessment tool to select and support viable projects, and the biogeographical assessment of different aquaculture technologies for the diverse regions of North Queensland. The development of barramundi and prawn farming ventures are now under consideration, as well as the potential for sponge farming and the restocking of sea cucumbers. Issues relating to the recommendations in the scoping study and the future development of indigenous aquaculture in North Queensland will be discussed further.

#### MANAGING VELVET DISEASE IN MARINE FISH HATCHERIES

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The project objective is to reduce the impact of the parasitic marine dinoflagellate, *Amyloodinium ocellatum*, cause of "Velvet Disease," in marine aquaculture. Cultured snapper (*Pagrus auratus*), mulloway (*Agryosomus japonicus*) and Australian bass (*Macquaria novemaculeata*) at NSW Fisheries, Port Stephens Fisheries Centre (PSFC) hatchery facility have been significantly affected by this parasite during growout.

A. ocellatum is a significant problem in marine finfish aquaculture worldwide due to its lack of host specificity, broad environmental tolerances and potential to cause large-scale mortality of fish in hatcheries. Molecular characterisation of the Port Stephens strain of A. ocellatum has been undertaken. This has provided the means to develop a specific PCR diagnostic test, making initial identification of velvet disease rapid and precise. Dissemination methods employed by Amyloodinium ocellatum have also been investigated with particular attention to aerosol dispersal strategies. Techniques developed for management of parasites at the PSFC will be applicable to other marine fish hatcheries in Australia.

#### EFFECTIVE USE OF NEW TECHNOLOGIES FOR GENETIC IMPROVEMENT - THE NORWAY EXPERIENCE

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The human genomic revolution has resulted in the development of numerous new technologies such as gene markers and microarrays. The application of these tools to aquaculture species has been limited and in particular there has been very little research on how they can be most efficiently utilized with selective breeding to maximise genetic gain and profit. There have been some investigations of this topic for livestock species, however transferring the results directly to aquaculture species will not take advantage of unique features such as very high fecundity and genome peculiarities such as the absence of recombination that has been observed in the male Atlantic salmon genome. Perhaps the greatest potential for the application of genomic information occurs when it is combined with advanced reproductive and selection technologies, such as cryopreservation of gametes and optimum contribution selection.

This paper will summarise the challenges that are faced with making effective use of this information and highlight some of the applications of new technology with the most potential in terms of impact on the aquaculture industry. By way of example, the paper will focus on the use of gene expression profiles as a possible tool for selective breeding of salmon. Changes or differences in the level of expression of these genes under particular experimental conditions and/or at different stages of development can be determined by comparing the quantities of sampled mRNA hybridising to the cDNA samples in the microarray.

There is potential to use microarray experiments to find characteristic expression patterns that are indicative of, for example, fish with inherent disease resistance, or fish with particular meat quality traits such as texture, taste or colour etc. Clustering algorithms are commonly used to identify patterns of gene expression that are characteristic of particular states. However, nobody has yet modelled how these characteristic patterns could be used to selectively breed animals for disease resistance, meat quality or other economic traits.

Akvaforsk is planning to undertake a number of new projects which will model the effect of scenarios for the use of new technologies with various breeding program designs on the rate of improvement of economically important traits in salmon to determine which have the most potential and how they should be most effectively and profitably utilised. Key technologies will be those that can be effectively incorporated into selective breeding programs in order to reduce the costs associated with genetic improvement and increase the rate of improvement in production and product quality.

#### HOW TO ORGANISE FOOD SAFETY IN A GLOBAL AQUACULTURE COMPANY

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Nutreco is an international food company with a widespread portfolio of activities in aquaculture: fish feed production, farming of salmon and other fish species, marketing & sales of farmed fish; and agriculture: animal breeding, animal feed and premix production, poultry & pork integrations. A number of food related crises in Europe such as dioxins in poultry meat in Belgium emphasised the need for a food safety program in these operating companies.

A corporate food safety team became responsible for the food safety strategy and built a standard food safety and quality network. The food safety program became known as Nutrace – Nutreco's passion for food quality. Making no distinction between fish feed and fish, Nutrace sets clear global food safety and quality standards for operating companies in the areas of certification schemes, residue monitoring, risk management. Moreover, tracking and tracing solutions are integrated throughout the supply chain. Any food safety program needs to be dynamic as new food safety issues will emerge and companies need to be prepared to respond, while being flexible so that global quality standards still meet additional local or regional requirements for maximal market penetration. The Nutrace approach will be illustrated with clear examples from the fish feed as well as the fish farming sector.

#### **GEMMA MICRO – A DECISIVE REPLACEMENT**

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The purpose of a good hatchery feed is efficient and fast production of healthy juveniles and this is the fundamental objective of Skretting's continuous starter feed development work. Gemma Micro is a revolutionary pre-starter diet that is designed to replace Artemia in the first feeding of marine fish larvae. Gemma Micro is the result of very specific research conducted in order to formulate a complete diet, corresponding closely to the nutritional requirements of marine fish larvae. The INRA/ IFREMER nutritional team studied digestive enzyme activity onset during seabass larvae development. Gemma Micro is formulated in accordance with nutritional requirements determined in marine fish larvae before metamorphosis which enables it to replace live feed, in particular Artemia, from an early larval stage.

Each species of marine fish larvae requires a specific procedure or protocol of feeding in order to have successful survival and growth. When using live-feed replacement diets, feed allotment and distribution in larval tanks must be managed differently from live feed. Specialized micro-feeding systems have been developed to pre-suspend and introduce the feed below the surface of the water - dispersing the feed evenly in the water column. Nutreco Aquaculture Research Centre is co-ordinating and undertaking research projects aimed at improving the nutritional and physical quality of Skretting starter feeds. This presentation will illustrate latest farming application of Gemma Micro in a number of species including European sea bass, sea bream, turbot, Atlantic cod and Barramundi.

#### HAEMATOLOGY OF SOUTHERN BLUEFIN TUNA Thunnus maccoyii

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Haematology is the study of blood and involves attributes of the red cells, the white cells and the plasma. Haematology tests can give either a direct or inferential indication of a fishes' functional status and is used for studies of health, physiology and nutritional status. Red blood cells (erythrocytes) are responsible for respiratory gas transport, and carry oxygen from the gills to the organs and tissues; these are the predominant cell type in circulation. White blood cells (leucocytes) are involved in blood clotting and immune responses. The cell types and numbers making up the leucocyte population of fishes vary substantially between species. For this reason it is important that research is conducted for any particular fish to establish what is normal for that species. Situations with tuna farming where haematology is useful include assessing the adequacy and quality of the diet, the impact of blood and gill parasites, assessing stress and particularly when assessing fish for dehydration and anaemia. This poster and abstract illustrate and detail the findings of some of the research undertaken with farmed and wild southern bluefin tuna between the years 1994 and 2004.

To establish a reference range of haematology parameters for the southern bluefin tuna stocked into the farms at Port Lincoln; tuna of the same age class were captured and tested on the fishing grounds in 1995, 1996, 1997 and 1999. Observations on haematological characteristics were made on blood samples collected from specimens immediately at the time of capture. Cytology and cytochemistry revealed the blood in peripheral circulation of wild tuna is comprised of erythrocytes, reticulocytes, ghost cells, lymphocytes, thrombocytes, eosinophilic granulocytes, neutrophilic granulocytes and monocytes. Erythrocyte indices, leucocyte types and cytochemistry were comparable to other species of scombrid fish.

Specific studies undertaken in the initial years of the project demonstrated that packed cell volume (PCV) was particularly sensitive to the physiological state of the fish and also to sample handling technique. Research into the effect that stress at the time of capture has on PCV was undertaken in 1995. During a single harvest, tuna were sampled immediately after capture by handline, and after being net crowded for 30 and 120 minutes. Increasing stress, determined through analysing blood lactate levels resulted in significantly elevated PCV. To determine the effect in-vitro artefact such as sample storage temperature has on PCV, repeated measures were made on samples collected and stored at two temperature regimes in 1996. Results of this research demonstrated that a significant elevation of PCV occurred after only 15 minutes of storage if the sample is not handled appropriately. To determine the effect that captivity had on fish health, haematology and leucocyte profiles were determined for tuna at the time of capture on the fishing grounds and tuna from a pontoon after 3 and 7 months time in captivity. After analysing all husbandry and some environmental factors that can lead to this blood picture, nutrition was found to be the most likely cause. With the improved diet quality in subsequent years, this scenario has not been repeated. This research clearly demonstrates that both the fish and the sample handling history are critical factors to consider in the interpretation of results.

### EFFECT OF FEEDING FREQUENCY ON THE GROWTH OF SOUTHERN BLUEFIN TUNA Thunnus maccoyii

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The sea cage culture of the southern bluefin tuna is a novel means of enhancing the profitability in a quota restricted wild fishery. Typically 3-4 year old tuna are captured by purse-seine net at the fishing grounds, transferred into specially designed sea cages then towed to Port Lincoln for fattening. At the time this project was initiated, 1997, the industry was relatively new and therefore required research to determine optimum feeding strategies. This project is ongoing, and aims to evaluate feeding strategies by examining energetics using internal data logging tags.

By tracking visceral temperature we are able to determine if and when a tuna has fed (figures 1 & 2). This allows us to answer key questions such as: do fish eat at every feeding opportunity, and is growth related to the number of feeds?

The frequency that tuna ate was negatively correlated with the number of opportunities to feed. Tuna growth showed a weak positive trend, tending to be higher with increasing feeding opportunities.



Figure 1: Change in visceral temperature of a southern bluefin tuna due to feeding.



Figure 2: Visceral temperature of 3 fish within the same cage, the tuna (AT4621) did not feed on the  $4^{th}$  or  $5^{th}$  despite food being offered, as verified by the feeding activity of the other 2 tuna.

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## USE OF MICROSATELLITE TESTS TO EVALUATE GENETIC DIVERSITY IN WILD AND CAPTIVE MURRAY COD Maccullochella peelii peelii

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Murray cod are valued in Australia as both a cultural icon and an excellent eating fish. Environmental degradation of waterways and pressure from over fishing has resulted in Murray cod being listed as a threatened species. Stocking programs have been in place for many years to help ensure the long-term survival of the species and to meet the demands of recreational fishermen. Fingerlings released into the wild for restocking purposes are produced from stock derived from a diverse range of wild populations. Therefore, restocking programs to date may not truly conserve local population genetic types, but instead may homogenise the genetic types from a number of different populations. In addition, current stock enhancement practices may inadvertently promote inbreeding and loss of genetic variation, potentially resulting in impaired reproduction, survival and disease resistance and increased abnormalities.

Advanced genetic technologies will be applied to evaluate historic and current genetic structure of wild populations, identify individual management units for conservation purposes and develop genetically sound management strategies for captive breeding and stock enhancement programs. A Murray cod microsatellite library has been developed and from this approximately 30 polymorphic microsatellites will be selected and used to determine wild population genetic structure. Historical population structure and effective population sizes will be assessed through obtaining museum specimens, extracting DNA and running a number of microsatellite markers across these samples.

Computer simulations of Murray cod breeding programs, with and without the application of microsatellite assisted selection, will be used to determine the best strategy to avoid inbreeding. For example, a small number of microsatellite tests could be utilised to select broodstock based on pedigree information to avoid mating close relatives and therefore maximise genetic diversity.

This project will form the basis of a PhD study supported by Monash University and the Department of Primary Industries, Primary Industries Research Victoria with funding from the Our Rural Landscapes Initiative.

### HATCHERY QUALITY ASSURANCE PROGRAM FOR MURRAY COD Maccullochella peelii peelii, GOLDEN PERCH Macquaria ambigua AND SILVER PERCH Bidyanus bidyanus

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Techniques for the large-scale hatchery production of Murray cod, golden perch and silver perch were developed at the Narrandera Fisheries Centre in the early 1980's, and commercial hatcheries began to produce and sell fingerlings in 1982/83. Around 30 hatcheries in NSW, Queensland and Victoria produce between 5 and 8 million fish annually. They are sold to stocking groups, State and Territory Governments, farm dam owners, commercial fish farms, and a small number to the aquarium trade. In addition, around 2.5 million fish are produced by Government hatcheries for conservation and stock enhancement. Over the last 25 years, the regular stocking of native fish into impoundments and some rivers has established large, popular recreational fisheries and contributed significantly to the conservation of these species.

In recent years, there have been concerns about some aspects of the hatchery industry, in particular genetics, diseases and trash fish. Research has found closely related species and sub-species of Murray cod, golden perch and silver perch in other drainages, and discrete populations within the Murray-Darling River System. Populations (or strains) are genetically distinct and usually differ in other biological attributes. These differences reflect natural selection and adaptation to local environments, and so mixing of populations through inappropriate stockings may have serious, long-term effects and reduce the "fitness" of the endemic, wild populations. Pathogens and diseases that are transferred on hatchery fish, may reduce survival and introduce new diseases to regions and farms. Native fish hatcheries have been implicated in the translocation of non-endemic fish such as the banded grunter which is now found as far south as the Clarence River in NSW. Continuation of poor practices may have serious long-term biological consequences for populations and species, and hinder the development of sustainable and economically-viable aquaculture industries.

To address these concerns, NSW Fisheries has developed a Hatchery Quality Assurance Program (HQAP) for use by Government and commercial hatcheries. The HQAP describes key features of native fish hatcheries and identifies *Essential Criteria* and *Recommended Criteria* for site selection, design and operation, and the management of broodstock, breeding programs, water quality and fish health. *Essential Criteria* are the basis for accreditation and auditing, and hatcheries in NSW that produce and sell Murray cod, golden perch and silver perch for stock enhancement, conservation and commercial grow-out will be required to be accredited in accordance with the HQAP.

# CARRYING CAPACITIES OF NSW ESTUARIES FOR SUSTAINABLE OYSTER Saccostrea glomerata PRODUCTION

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Australian oyster production reached 4,916 tonnes in 2001-02 (ABARE data). The majority (~60%) was made up of the Sydney Rock Oyster (SRO) from 41 estuaries of New South Wales. Over the last 20 years, SRO and State wide average production (oysters/ha/yr) has declined significantly despite the introduction of new technologies. Over the same period the number of permit holders has fallen, oyster growth rates have reduced, and the size of oysters going to market has decreased. This has led to economic pressures that have forced many oyster farmers with low levels of production to leave the industry. A number of factors might have caused this decline in production. These include oyster diseases and altered water quality triggered by coastal development. Economic pressures have also been exacerbated by competition with the growing Pacific oyster industry in South Australia and Tasmania. However, other environmental factors, in particular limited food (seston) supplies, might have a major and crucial impact on production levels. Based on evidence that shows that the growth of individuals in oyster populations may be phytoplankton limited as a result of their massive filtration capacity, we aim to investigate the importance of food dynamics on oyster development in conjunction with physical and environmental aspects of the system.

Spatial and temporal variation in the quantity and quality of seston could limit cultured oyster growth. Determining the spatial distribution and the dynamics of seston, monitoring stocking densities, growth and mortality rates and movement of oyster stock, especially during poor water quality events, will assist with the development of the oyster industry. The Clyde River is a relatively pristine estuary making it a good area to investigate the importance of food supplies without the added complication of anthropogenic stresses. Samples have been taken at various locations, corresponding to 'growing areas' (e.g. nursery, fattening) where farmers have traditionally located their oysters at different times in their life cycles. We will present data on nutrient distribution and associated primary production levels and its effect on oyster growth rates. On the whole, we find that primary production is internally driven (i.e. not set by ocean end-member concentrations but by conditions within the estuary). We therefore assess regions where primary production is the greatest and investigate how estuarine hydrology effects its redistribution.

Ultimately this information will be used in conjunction with a verified quantitative ecological model to investigate local carrying capacities and optimal stocking densities for sustainable oyster production. This will combine primary production and other seston components taking into account nutrient loads and tidal changes in addition to the known physiological response of oysters.

### INDUSTRIAL LAND-BASED FISH FARMING – IS THIS THE WAY OF THE FUTURE?

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Modern fish farming is heavily reliant on engineering technology to improve the efficiency of production operations. Industrial scale equipment to move, grade and count fish has allowed substantial improvement to the efficiency of husbandry operations throughout the world. In this presentation the use of some of these and other technologies will be discussed in their application to a new large-scale land-based finfish farm in New Zealand.

# A REVIEW OF FEEDING STRATEGIES AND NUTRITION RESEARCH IN REDCLAW CRAYFISH Cherax quadricarinatus AQUACULTURE

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One of the critical factors limiting the growth of the redclaw aquaculture industry is the animals' poorly defined nutritional requirements. To date, all successful redclaw aquaculture in Australia is, to some extent, reliant upon the natural productivity of culture ponds. Farmers are using low nutrient-density feeds as a medium to accomplish the dual role of supplemental feeding and organic fertilisation of the sediments, in order to boost productivity in the pond benthos.

This strategy of establishing a rich benthic community through detrital processing has proven to be a cheap and effective method of growing redclaw crayfish at moderate densities of up to 10 animals per m⁻². However, husbandry, feeding methodology and feed efficiencies could be improved markedly with the formulation of a diet that reduces the reliance on natural food organisms, which become limiting at high biomass densities during the growout period. It would also improve sediment and water quality by reducing waste loads, and perhaps improve growth rates. Growth at high densities would not be limited by a reliance on natural food organisms from the benthos, and stocking rates of up to 15m⁻², which do not impact on redclaw survival may be practiced.

Early redclaw nutrition experiments involved the feeding of diets designed for other species, such as native fish feeds, salmon feeds and penaeid feeds. Generally the low nutrient-density feeds resulted in better growth. More recently, the macro-nutrient requirements have been researched, mainly in the United States and Mexico, with very similar results. Currently, these diets are being refined by investigating fishmeal substitution, and specific fatty acid and amino acid requirements. Other areas of research include carotenoid, phospholipid and cholesterol requirements. Physiological research on digestive processes is also being undertaken and endogenous cellulase production has been confirmed, for the first time in any crustacean. Broodstock nutrition is also receiving some attention.

At present the most appropriate complete diet for growout stages of redclaw crayfish seems to have approximately 28-32 % crude protein, around 6-8 % lipid, 18-20 kJ g⁻¹ gross energy, 0.5 % cholesterol, <0.5 % lecithin, with standard aquatic animal vitamin and mineral mixes. It is generally recommended that at least 15 % of the protein should come from high quality animal sources (fishmeal) and that a combination of fish and vegetable oils be used.

Enzymic evidence and standard nutritional experiments suggest that higher protein levels of up to 40 % may benefit very early stage juveniles (<1 g). Carotenoid inclusion (50 mg/kg) may also improve growth and survival, and improve marketability. Careful economic analysis will be required to determine if these diets can be used profitably, as provision of extra hides will be necessary to maintain greater crayfish densities.

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### ATTITUDES TOWARDS SUSTAINABLE AQUACULTURE AMONG THE IRANIAN FISHERIES OFFICERS

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Fisheries, including aquaculture, provide a vital source of food, employment, recreation, trade and economic well-being for people throughout the world, both for the present and future generations and should therefore be conducted in a responsible manner (FAO, 1995). As the fastest growing food production sector in the world, modern aquaculture is maturing, with emphasis shifting from the development of production technologies to assurance of longer term economic and environmental ability. Therefore, there is a growing public interest in aquaculture sustainability and aquatic source conservation. This growing public concern implies the need for focusing fisheries programs on *sustainable aquaculture* (SA).*Fisheries Officers* (FO) in various sectors of aquaculture are the first line of manpower of aquatic productions, must be the guide and executive of manpower to observe SA procedures, principles and regulations. However, the question is whether FO has been prepared to carry out these tasks for their stakeholders or have the positive perception regarding SA. The main purpose of this study was to asses the FO's attitudes in respect to SA and determine its relation with the FO's professional characteristics; and ascertain how much of the variance FO' attitudes could be explained by independent variables of the study.

This study used a descriptive and correlation survey method and the FO of 28 provincial departments of aquaculture in Iran (N=550) made up the population of the staff were selected sample, 226 of the FO were selected for the study. Likert-type scales were used to measure attitudes related to knowledge level of SA Content validity of the perception questionnaire was done by collective of aquaculture experts in the central department and needed modification made. A pilot study was conducted to determine the reliability of questionnaires for this study, also a response rate of 87% was attained.

The result of the study indicated that the term of SA as a concept was somewhat ambiguous to many FO. Besides, the respondent had positive attitude towards SA. These positive attitudes vary with the respondents' age, gender, level of education and experience.

# ECONOMICS ANALYSIS OF KUTUM Rutilus frisii kutum FINGERLING PRODUCTION AND RELEASING IN IRAN

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In 2001, to determine the costs of production of a single kutum fingerling in Iran, a questionnaire was prepared. An expert team comprising of economist, statistician and aquaculturist completed the questionnaire, while reffering all kutum centers. For more accuracy, they reffered to documents available in different sections of Shilat, specially, accounting, budgeting and stock enhancement offices. Among various expenditures, cost of labour with 50% and costs of feed and fertiliser with 20% have the greatest share, maintenance with 10% and harvesting, handling and releasing 6% were the important factors. Results shaw, an average cost of production of a single kutum fingerling in Iran, was Rls. 37, in 2001. The cost of labour had a great share in total expenditures, it could be justify by unactivity of centers during almost 6 months off season, which could be reduced by adopting extra activities in such hatcheries.Over the 2004-2005, with the average of 8.3% rate of fingerling return and the average wieght of 815 grammes and 3.7 fish ages, the number of 19,257,494 kutum fish with the total of 16,000 tonnes might be harvested.The value of whole sale price of these catches with the price index of the year 2001, is interesting and might be estimated Rls. 345 billion.

### ASSESSMENT AND CLASSIFICATION OF TROPICAL COASTAL ENVIRONMENTS FOR SUSTAINABLE AQUACULTURE SYSTEMS

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The expansion of coastal aquaculture in the tropics has outstripped available management tools, particularly in East Asia. Two parallel ACIAR projects will collect and synthesize environmental information from aquaculture farms in Australia and Indonesia and use this to develop management tools and farming protocols to underpin ecologically sustainable industry development.

A land-based aquaculture project will address the rapid expansion of pond-based aquaculture systems in Indonesia, where earthen ponds are often constructed in unsuitable environments because of a lack of comprehensive site selection criteria and land capability assessment. Many extensive farming systems have been constructed in strongly acidic coastal soils leading to recurrent production losses and low pond yields. Areas more suited to low intensity polyculture have been developed, unsuccessfully, for highly intensive monoculture. The Indonesian study will assess land suitability for seaweed, shrimp and fish production as well as suitability for polyculture. The Australian component of this work will concentrate on intensive prawn farms in North Queensland and will apply multivariate analysis of production, environmental and management data to investigate pond productivity issues not addressed by existing site selection and mapping criteria.

The research output will include GIS and Remote Sensing-based mapping protocols and a land classification scheme that will be used to generate regional-scale land suitability maps for intensive shrimp farming in Australia and a range of landbased culture systems in Indonesia. Farm-level site selection criteria will also be developed to improve farm design, planning and pond management. The land classification schemes and site selection criteria will address factors that could potentially reduce pond productivity, and identify areas that are well suited to aquaculture development. Similar approaches will be applied to fish cage farming, which is at least as productive as pond culture of shrimp in South East Asia and is growing rapidly. Best practice guidelines will be developed for the location and management of tropical sea cages, in both northern Australian (macrotidal) and Indonesian (microtidal) environments. The Australian component of the work will focus on the Marine Harvest barramundi farm at Bathurst Island, NT, and the Indonesian component at Maros, in South Sulawesi. The two projects are a collaborative effort between the University of New South Wales, the Australian Institute of Marine Science, the Research Centre for Coastal Aquaculture (Maros, Indonesia) and Gadjah Mada University (Indonesia) funded under the ACIAR Fisheries Program.

# THE EFFECT OF FOOD ON THE METABOLIC RATE AND NITROGEN EXCRETION OF PACIFIC SEAHORSE *Hippocampus ingens*

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*Hippocampus ingens* is a seahorse species that is distributed from Northern Peru to San Diego, California, including Galapagos Island and Gulf of California. Adults of *H. ingens* are larger than other seahorse species. These interesting organisms reach a high economic value in the Ornamental fish market and specifically in Asian countries, where they are used as an ingredient in the Traditional Chinese Medicine. Nevertheless, the information on this group of organisms is still scarce, since concentrates on the important economic species.

The routine metabolism of the Pacific seahorse was measured in individuals with an average weight of  $34.9 \pm 1.64$  g. The organisms were fed with two diets commonly supplied to these species. The O:N relation was calculated to know how metabolic substrates are catabolized under controlled environmental conditions.

The organism were distributed in two groups, one group was fed with frozen Artemia franciscana and the other with frozen Mysis relicta (Table 1). To measure metabolic rate and ammonia production, each seahorse remained in respirometric chambers for 24 hours fasting The water temperature was 22°C and salinity 35â.

Oxygen consumption and ammonia excretion of both experimental groups were not significantly different (P > 0.05). Nevertheless, the group feed with A. franciscana have high oxygen consumption (Table 2). This results were compared with other obtained for tropical fish species.

The O:N relationship was similar for both groups (P>0.05), that suggests a mixture of lipids and proteins are utilized like metabolic substrates.

	Mysis relicta (%)	Artemia franciscana (%)		
Proteins	13.97	5.02		
Lipids	10.94	1.71		
Carbohydrates	0	3.42		
Humidity	75.59	87.21		
Ashes	1.65	2.64		

Table 1. Biochemical composition of frozen foods.

Food	Oxygen consumption	Nitrogen excretion		
Mysis	0.036 ± 0.0159	0.0016 ± 0.0008		
relicta	n=24	n=21		
Artemia	$0.046 \pm 0.0234$	0.0019 ± 0.0009		
franciscana	n=35	n=35		

Table 2. Oxygen consumption rate (mg  $O_2 g^{-1} h^{-1}$ ) and nitrogen excretion (mg  $NH_3$ -N g⁻¹ h⁻¹) in *Hippocampus ingens* fed with two frozen foods. n=sample size

# EXTRA-POUCH TERMINAL EMBRYONIC DEVELOPMENT OF *Hippocampus ingens* IN LABORATORY CONDITIONS

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The members of the family Syngnathidae are characterized by three different reproduction strategies. In all cases males incubate the eggs and hatch early juveniles: 1) eggs are transferred from the female to the ventral region where they remain until they hatch; 2) male develop a spongy tissue where eggs are embedded and they are partial or totally protected by skin folds; 3) males possessed brood pouch, where eggs are deposited and fertilized, embryos are then incubated until expelled as a totally developed juveniles through the brood pouch pore. The information related to the functions of the brood pouch is scare, several studies suggest that the male is capable of providing adequate osmotic environment and gas transfer, food and metabolic waste exchange; and all this processes are probably hormonally regulated.

The objective of this work was to provide preliminary information of the brood size and the extra pouch development of the Pacific seahorse *Hippocampus ingens* embryos during the final stages of embryonic development.

In laboratory we observed frequently the expulsion of eggs or the embryos at different development stages. A group of 18 prematurely expelled embryos (Fig. 1), three in pre-hatched stage and 15 hatched were incubated to  $24 \,^{\circ}$ C and  $35 \,\%_{o}$  salinity until reached a total length of 7.0 mm and swim freely. Juveniles that develop and born normally have a range length of 5.3 to 7.04 mm with an average of 6.9 mm (EE  $\pm$  0.09 mm). The maximum number of newborn juveniles was 3521. Once the seahorse began to swim they were transferred to 2900 ml glass flasks and were fed with Fry Feed Kyowa B diet, the juveniles died to the day 5 after the transfer, since the type of food and the water quality were poor, though was accomplished a partial change water.

At the moment it is not possible to certainty associate the occurrence of these abortive events with a particular stressor, since simultaneously in the same reservoir and in other similar tanks, are maintained pregnant males that normally brood and hatch healthy juveniles.



Figure 1. Pre hatched *Hipocampus ingens* embryos prematurely expelled.

### "DISEASE WATCH – PLAY YOUR PART": AN AQUATIC ANIMAL HEALTH AWARENESS KIT

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Australia earns over \$2.4 billion per annum from fish and aquaculture production, and the market is growing each year. In addition, recreational and sport fishing is a pastime for 3 million Australians who spend \$3.5 billion annually in pursuit of their fishing. The value of our commercial and recreational fisheries is enhanced by our freedom from many fish diseases that cause problems overseas. Education is one of the most important tools we can use to continue to protect our fishing and aquaculture sectors.

"Disease Watch – Play Your Part" is a two part awareness kit designed to provide the aquaculture, wild catch and recreational fishing industries with up to date information on the importance of aquatic animal health management.

While some information is mostly focused on aquaculture, both the CD-ROM and Web Sit components of the kit highlight the important role played by recreational and wild catch fisheries in the continued development of a profitable and sustainable Australian fisheries and aquaculture industry.

The CD-ROM component contains over 90 minutes of video footage and interviews with key industry and government representatives, relating to one of four categories: Overview, Prevention, What to do, and Education. The interviews are supported by fact sheets and additional resources such as AQUAPLAN and AQUAVETPLAN manuals.

The CD-ROM also includes four case studies that detail responses to aquatic animal disease in both Australia and overseas. These case studies highlight the importance of health management and cooperation at all levels of industry and government.

The Disease Watch Web Site contains the supporting fact sheets and resources, but can and will be updated on a regular basis. In addition, the Web Site includes a "Discussion Forum" where information, questions and answers can be posted by anyone interested in aquatic animal health.

The preparation of this awareness kit was made possible by a grant from the Australian Government's Budget Initiative *"Building a National Approach to Animal and Plant Health"*, administered by the Fisheries Research and Development Corporation.

#### PROTECTING GENETICALLY IMPROVED SHRIMP VIA INDUCED STERILITY

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Worldwide shrimp farming industries are heavily investing in genetic improvement for improved growth and specific pathogen free or pathogen resistance characteristics. Such investments are rapidly moving the industry towards developing genetically superior stocks, a resource which needs to be protected to prevent unauthorised breeding. This has created demand for a method to induce sterility in live shrimp, that can be readily applied on a commercial scale, has no impact on growth or survival and is acceptable to the consumer.

Several techniques have been used to induce sterility in marine invertebrates with polyploidy and irradiation having considerable potential in shrimp farming. Polyploidy has been trialed in several shrimp species with varying levels of success. CSIRO Marine Research has demonstrated successful production of triploid female *P. japonicus* using chemical shock to prevent the extrusion of the second polar body. Furthermore from over 22 spawning inductions, 6 triploid families have been reared through to reproductive age. We found that all triploid shrimp were female, sterile and had comparable survival and growth rates to their female diploid counterparts (Fig.1). Despite the potential benefits of triploid progeny. We are currently focusing on producing tetraploids which will enable the production 100% triploid progeny through the crossing of tetraploid and diploid parents. To date no viable tetraploid shrimp have been reported despite numerous attempts by researchers around the world.

Irradiation has also been proven successful to varying degrees at inducing sterility in various marine invertebrates. Preliminary research completed at CSIRO Marine Research has shown that when adult *P. japonicus* are exposed to low levels of ionising irradiation (between 10 to 20 gray), their ability to produce viable offspring is severely impaired (Fig. 2). Exposure of *P. japonicus* to levels greater than 25 gray proved lethal. We are currently carrying out further investigations into the effectiveness of irradiation to induce sterility in farmed shrimp and its suitability for commercial application



Fig. 1. Growth rates of female *P. japonicus* 





## DETERMINATION SITE OF mRNA EXPRESSION OF VITELLOGENIN SECONDARY-VITELLOGENIC AT FIRST MATURATION FEMALE OF *Cherax quadricarinatus*

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One of the main characteristics in invertebrate reproduction is the accumulation of reserves made in the ovocites of the vitellogenic females. Such nutritive substances will be transferred to the eggs and larvae to allow their well development. With a lipo-glyco-carotene-proteinic moiety, it contains the most important chemical constituents needed for the embryogenesis and survival of eggs until they can feed independently. Vitellogenin (Vg) is precursor of vitellin (Vt), mayor components of egg yolk protein in many oviparous invertebrate animals, including Crustacean.

A controversy exists studing the extraovarian or intraovarian sources of vitellogenin synthesis in different species of invertebrates. Vitellogenin synthesis, both endogenous (ovaries) and exogenous (hepatopancreas, adipose tissue) has been proposed for several marine and freshwater crustacean species. In freshwater species the hepatopancreas seems to be the synthesis site of Vg. The objective of the present study was to determine the site(s) of mRNA expression of vitellogenin in the freshwater crayfish *Cherax quadricarinatus* based on the nucletidic sequence of the Vg molecule.

The genomic DNA was prepared from the muscles tissue and was amplified by PCR amplification, cloned and sequenced. Total RNA isolated from ovaries and hepatopancreas of secondary-vitellogenic at first maturation female was subjected to reverse transcription and transferred to a positive charged nylon membrane by the Northern blot analysis.

A PCR product size of 1.1 Kb was obtained using the par of oligonucleotids primers designed from Vg cDNA and the genomic DNA as a template. Results of RT-PCR analysis showed that mRNA enconding the 3' end cDNA vitellogenin was present simultaneously in the hepatopancreas and the ovary. The bands were aproximatly 900 bp for both tissues. The hybridazed signals analyzed by Northern blot, were thus detected in the ovary and the hepatopancreas from secondary-vitellogenic at first maturation female, but was not detected in male hepatopancreas. The hybridized band was aproximatly 8 kb in each tissue.

# IMPROVEMENT OF GROWTH AND FEED UTILIZATION BY USING LICORICE ROOTS (ERKSOUS) AS A FEED ADDITIVE IN DIETS OF NILE TILAPIA Oreochromis niloticus FINGERLINGS

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A feeding trail was carried out to study the effect of inclusion different levels of Licorice Roots (LR) on growth performance, feed and nutrient utilization, glucose, total plasma lipid (TPL) and total plasma protein (TPP), body composition, liver enzymes, liver and gonads histology and cost-benefit analysis of Nile tilapia, *Oreochromis niloticus*, fry. Ten glass aquaria with the dimensions of 70 x 30 x 40 cm, were used to stock 10 fish averaging 2.6 g/fish. Four experimental diets were formulated to contain 0, 1, 2, 3 and 4% of Licorice Roots. All the diets were isonitrogenous (36 % protein) and isocaloric (484-489 Kcal/100 g diet). The feed amount was given three times daily, six days a week for 70 days. Fish were weighed biweekly and feed amounts were adjusted on the basis of the new fish weight.

Results indicated that final weight and gain were higher significantly (P<0.05) with diets containing Licorice Roots when compared with fish fed control diet. Supplementing diets of Nile tilapia with graded levels of LR resulted in an improvement of body weight, gain, specific growth rate upon 2-3 % thereafter they decreased to the 4% level of diet. Feed conversion ratio improved by using Licorice Roots in the tilapia diets until 3 % level. The best inclusion level achieved maximum feed utilization was 2 %. Fish fed 2 % LR had higher significant (P<0.05) in protein efficiency ratio, productive protein value and energy retention than other test levels. Inclusion of LR resulted in an increase in glucose plasma, however TPP and TLP were not affected. The activities of liver enzymes glutamate oxaloacetate transaminase (GOT) and glutamate pyruvate transaminas (GPT) were strongly decreased in fish fed diets containing LR than those fed LR free diet.

# RESEARCH OF THE EFFECTS OF 3 DIFFERENT KINDS OF FEED ON GROWTH AND SURVIVAL RATE OF EUROPEAN WHITEFISH *Coregonus lavaretus* OF KARAJ LAKE IN IRAN

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For stoking restoration of European whitefish (*Coregonus lavaretus*) in the only living area of this species in IRAN (Karaj Lake), the artificial propagation of 9 spawners was achieved in February 2002.In order to evaluating the best food for growth of the juveniles,1350 pieces of 4 days old with .009g individual average weight, were fed with 3 different kind of feed(rotifer as live food, trout commercial food, mixture of equal rate of live and commercial feed) for a 3 mounts period. The daily ration was 270% of juveniles wet weight. At the end of the experiment a clear difference was observed between the wet weights of 3 groups of juveniles fed on 3 different kinds of feed. The best average weight belonged to juveniles fed on live food (.8<). The average of water temperature during the experiment period was 13 degree centigrade. There was a very good correlation between total length and weight in all juveniles fed on 3 different kinds of feed (90%<). There was a good correlation between specific growth rate of the juveniles and their daily ration in the group that fed on live food, but such correlation was not observed in 2 other groups which were fed on with commercial and mixture feed. There was a clear difference between survival rate of juveniles fed on commercial food and the other juveniles group which were fed on live food and mixture feed.

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## TESTING A NEW INVENTION AS A NEW INTENSIVE FISH CULTURE SYSTEM TO NAME OF "IN CHANNEL RACEWAY" (I.C.R)

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In order to applying fast current waters of agricultural channel in freshwater aquaculture activities, a new fish rearing system was designed, built, and used in agricultural water channel in Khoozestan province of IRAN. This new system which was named "In Cannel Raceway", was classed as a new invention in aquaculture industry in IRAN and registered under no.3827

In May 2003, 3 units were employed. Each unit dimensions were 14m length, 2m applied width, and 1.5m depth. The water speed in channel was 1.5m/s. After regulating water velocity on 5cm, 7000 of 15g trout were introduced to each unit that were left to grow up for a 3 mounts period. The commercial trout feed were used during the period culture. The average of water temperature during the said period was 19 degree centigrade and water dissolved oxygen concentration in all over the period time was 11ml/l. At the end of experiment time, the average weight of harvested fishes was 230g. Fish weight range varied 190-330g. Total harvested crop from each unit neared 45kg/cubic meter. This was noticeably higher than the ordinary harvested crop from land trout farms (10-20kg/cubic meter). This study showed some advantages of this new system like lower capital costs and high density of production in comparison land trout farms in area.

# THE EFFECT OF WATER TURBULENCE AND TURBIDITY ON FEEDING, GROWTH AND SURVIVAL OF STRIPED TRUMPETER Latris lineata LARVAE

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Striped trumpeter, Latris lineata, is under investigation for its aquaculture potential. Current investigations are focusing on the early larval period when temporally variable mortality often occurs resulting in low survival to flexion. Successful feeding on live prey organisms is essential during this early larval period, especially during first exogenous feeding when larvae are poor predators and have a limited time to initiate feeding or die of starvation. This study investigated two factors, turbulence and turbidity, which have the potential to increase predatorprey encounter rates and therefore prey consumption. Increasing turbulence within a tank is known to increase the encounter rate between larva and prey due to an increase in relative velocities between predator and prey. However, increasing turbulence also affects the ability of larvae to successfully pursue and capture prey. This arises because as turbulence increases the live prey may be removed from the larva's reactive zone faster than the larva is able to initiate a successful feeding event. Hence, the optimal level of turbulence occurs where there is a



Fig. 1 – Mean rotifer consumption by striped trumpeter larvae 8 days post-hatching fed *B. plicatilis* at a density of 5 ml⁻¹.

compromise between increasing encounter rate and decreasing pursuit success. One of the mechanisms proposed to explain how green water improves the larval rearing of many larval species is that algal cells improve the visual contrast between prey and background thus facilitating greater reaction distances, increased prey encounter and therefore prey consumption. Experiments were conducted to investigate both short-term feed intake and overall growth and survival of striped trumpeter reared in clear or green water environments with varying levels of turbulence. Results indicate improved growth, survival and feed intake (Fig 1) when reared in a low turbulence environment in comparison with a static or more turbulent environment. Furthermore, the turbulence level resulting in highest feed intake increased with larval development.

## THE EFFECT OF TURBIDITY AND PREY DENSITY ON THE FEEDING, DISTRIBUTION AND GROWTH OF GREENBACK FLOUNDER Rhombosolea tapirina LARVAE

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Improved feeding, growth and survival has been reported for many fish larvae cultured in a "green water" environment; however the underlying mechanism remains unclear. Greenback flounder, *Rhombosolea tapirina* (Günther) larvae, were reared in clear water tanks, with and without the addition of *Tetraselmis suecica* (green water). Short duration feeding trials were conducted in 3-l aquaria from 9 to 38 days post-hatching (dph) to investigate the effect of larval culture history (green or clear water), live prey density, and turbidity level on feeding performance. In addition, larval behaviour and distribution in culture tanks were monitored. Flounder fed at a prey density of 1 prey ml⁻¹ fed equally well across all turbidity levels irrespective of prior culture environment. However, at a lower prey density of 0.1 prey ml⁻¹ feeding was significantly increased at low and moderate turbidity levels (5 - 20 NTU) and corresponded with both an increase in the time larvae spent searching for prey and a decrease in the percentage of larvae "walling" in green water (Fig. 1). At low prey density larvae from a green water environment fed better than those from a clear water environment suggesting that green water reared larvae adapted better to feeding in a low prey density environment. Larvae reared in green water therefore had an increased potential to feed during periods of low prey density, which may in part explain the increased size of the larvae reared in a green water environment.



Fig. 1 – Mean consumption of *B. plicatilis* by larvae (18 dph) fed at a density of 0.1 rotifers  $ml^{-1}$ . A) Mean consumption for all larvae from clear water or green water. B) Mean consumption for all larvae at each turbidity level.

#### SELECTION OF SUITABLE SITES FOR RESTOCKING SEAHORSES IN SINGAPORE COASTAL WATERS BY MONITORING HATCHERY REARED SEAHORSE JUVENILES KEPT IN CAGES

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In areas of the Indo-Pacific region, seahorse populations are under pressure due to the demand from Traditional Chinese Medicine (TCM) trade for dried seahorses as well as some demand from the aquarium trade for live seahorses. In other areas such as Singapore, habitat degradation due to industrial development has led to reductions in local seahorse populations. There is a need for conservation and stock enhancement of seahorse species through reef and coastal habitat reseeding in order to ensure viable seahorse populations.

During our survey in Singapore coastal waters, two species *Hippocampus comes* and *H. spinosissimus* were found but their numbers were low. As a step towards stock enhancement of seahorse habitats in Singapore, we developed hatchery technology for production of juveniles of these two species. Selection of suitable areas for restocking with seahorse juveniles is being carried out. Cages with juveniles of *H. comes* and *H. spinosissimus* were placed in selected sites on the East and West coasts of Singapore and their growth and survival were monitored over a period of six months. Weekly data were collected for changes in water quality parameters at each site and the weight and length of seahorse juveniles were recorded. The reproductive status of the groups of seahorses in each of the cages was monitored in terms of maturity, sex ratio and the percentage of pregnant males at every sampling. At one of the sites tested, the juveniles of both the species grew to sexual maturity and started reproducing on a regular basis within four months. There was a good correlation between the changes in environmental parameters at each site and the pattern of growth of the seahorses placed in cages at that location.

#### TREATING PRAWNS WITH AN EXTENDED DIP IN EVERFRESH TO PREVENT BLACKSPOT

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For years now the seafood industry has been searching for alternatives to sulphiting agents for the prevention of blackspot. Because sulphites cause allergic reactions in some sensitized individuals, consumers and food authorities would like to see a reduction in the amount of sulphite present in food. The new alternative treatment 4-hexylresorcinol (available commercially as Everfresh®) can prevent blackspot for longer without the use of sulphites (Otwell et al.,1992; Slattery et al, 1995). There a number reasons why the Australian seafood industry has not adopted this treatment wholeheartedly. The main one is that the supplier has only one type of application that it recommends, a once off dip in a solution of Everfresh (equivalent to 50mg/kg 4-hexlyresorcinol). A survey conducted by the authors in 1988 found that over 20% of fishers applied their blackspot treatment to refrigerated seawater tanks or ice slurries rather than a once off dip (Slattery, 1988 & 1989). They used chemicals in this way because it was convenient and disregarded warnings about the risk of excessive residues. A method was found that gave better protection than the conventional dip. When investigating concerns about the effectiveness of Everfresh, this researcher has found that the Everfresh was not used by industry as recommended and that the handling after the dip had a major impact on the residues present or that the standard dip was not as convenient to use as long term immersion. These experiments will assist both wild capture and aquaculture industries in using chemicals in a more efficient manner, they will reduce the cost of using them and encourage adoption of a treatment that is safer for consumers.

## TO KILL A FISH: THE METHODS USED, AND THE LINK BETWEEN QUALITY AND WELFARE AT SLAUGHTER

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#### Introduction

Food quality is increasingly becoming a global concept as suppliers and retailers become larger and fewer. Food should be safe and traceable to the farm. In addition, the ethical aspects concerning food production, such as protection of the environment and animal welfare, have been identified as important issues to consumers. Most countries have legislation covering the welfare of mammals and birds, however few have legislation applying to fish, although this is rapidly changing. Fish welfare at slaughter is of special importance as this has potential to cause significant, stress, 'pain and suffering'. A slaughter method is considered to be humane when unconsciousness is induced immediately by stunning and is irrecoverable. The slaughter of wild fish is not covered in this paper but it represents an area of growing concern. Most wild fish die by anoxia in air followed by chilling without exsanguination (bleeding).

#### **Farmed Fish Slaughter Methods**

There are a wide variety of slaughter techniques used between and within farmed fish species, as follows:

- Exposure to air (suffocation, anoxia, asphyxia)
- Ice slurry (live chilling, hypothermia)
- · Bleeding to death
- Gutting
- Anaesthesia (terminal)
- Carbon dioxide (anaesthesia, asphyxia, anoxia)
- Electrostunning
- Ike Jime (brain spiking)
- Percussive stunning

#### **Humane Slaughter Methods**

In regard to welfare, the majority of the commercial methods listed above are unsatisfactory as fishes are not rendered unconscious immediately. Furthermore, animals exhibit aversive behaviour such as vigorous escape attempts. Electrical stunning, percussive stunning and ike jime have been found to be humane if applied properly. However, specific precautions are necessary for each method. For electrical stunning, minimal currents need to be defined for each species in order to achieve an immediate loss of consciousness. Currently, despite many attempts, there is no commercial application of electrostunning by industry. Spiking of the brain requires a high level of precision and expertise. Moreover, it is possible that parts of the brains which are not destroyed continue to function after the shot. Spiking is therefore probably not feasible for humane slaughter in industry and apart from individual manual application with tuna it has not been successfully mechanised. As to percussive stunning, a pneumatic automated device is preferred to a manually applied club, since the latter generates fatigue and can lead to imprecise or insufficiently strong blows. Substantial progress has been made in the development of mechanised pneumatic stunning machines.

#### **Mechanised Percussive Stunning**

The first commercially operated mechanised percussive stunner, the MT4, introduced this methodology on an industrywide scale, and was successful in winning the prestigious RSPCA Alastair Mews Award in 2002 – a UK wide competition encompassing all animal agriculture. The technology has evolved further and the SI~5 machine incorporates a flow-through design so that no human intervention is required. The system utilises directional water currents which encourage fish to swim into a flow of water leading them into the SI~5's, where they are stunned, and then they pass down the line to be bled or gutted.

Good welfare leads to good quality and this relationship is now better understood. The major benefits of good welfare and reduced stress at slaughter are seen in improved flesh texture and appearance, i.e. reduced gaping and softness, reduced bloodspotting, improved colour, and water holding capacity. There are also other potential benefits such as improved market perception and a reduction in free oil. Pneumatic slaughter systems are being implemented throughout all the major fish farming nations, i.e. Scotland, Chile, Canada and Australia, etc. Stunners are also currently used for trout and arctic char, and systems are being developed to suit other species such as yellowtail (*Seriola* spp.), Atlantic cod and halibut.

#### Conclusion

The forces in the marketplace are dictating a move to low-stress, welfare friendly harvest practices. A proactive approach by fish farmers to utilise these slaughter systems leads to increased market acceptance and selling price, and it will also increase quality and yields.

#### **BRIDGING THE GAP: A RESEARCHER'S PERSPECTIVE**

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To ensure its relevance, crustacean nutrition research must be closely linked to the needs and objectives of both the feed manufacturing industry and the crustacean farmers – bridging the gap to apply the science. The key issues in nutrition research are to understand the nutritional requirements of the species of interest and the interaction of nutrients within the diet. Other important issues facing the researchers are: (a) the identification and characterization of alternative ingredients that can be used to reduce feed manufacturer's reliance on fishmeal and fish oil in crustacean feeds; and (b) reducing the environmental impact of crustacean farming by optimizing feed formulations and feeding strategies for the specific culture system that the farmer is using.

The nutrient requirements for maximum growth in a species are generally determined by researchers under laboratory conditions. However, nutrient specifications for feeds are set by feed manufacturers recognizing the diminishing returns of attempting to meet the requirements for maximum growth and the increased cost of the feed. Under commercial culture conditions, crustaceans obtain varying amounts of nutrients from the pond or tank environment through consumption of benthic organisms and microbial particulate matter. Hence, the specifications of a feed may be changed to take into account the nutrient input from the environment, with a potential reduction in the ingredient cost of the feed. To gain this benefit, the researcher and feed manufacturer need to work together to ensure that the nutrient specification of the feed is appropriate for the culture system being used. Researchers can also provide information about the digestibility or availability of nutrients in ingredients that may be used by the feed manufacturer, and the response of the species to different inclusion levels of those ingredients in the feed. It is important that the feed manufacturers and the researchers interact to understand the advantages and constraints that the manufacture has in using particular ingredients. In this way research effort will focus on ingredients that are likely to be used by the feed manufacturers or on new ingredients that have significant potential to be used in the future.

Crustacean farmers have additional considerations to meeting the nutrient requirements of the species in the culture system that they use. Interaction with both the feed manufacturer and the researcher are needed to identify the priority of issues such as cost of the feed, its stability in water, feed management and feeding strategies, and formulations that can help reduce the amount of nitrogenous waste being discharged from the system and hence the environmental impact of the culture system. This three-way interaction between researcher, feed manufacturer and farmer will ensure that the needs and priorities of each group can be aligned for the benefit of all.

#### BRIDGING THE GAP: AN AUSTRALIAN FEED MANUFACTURER'S PERSPECTIVE

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The farmer has very specific requirements of the feed that their stock eat. It must be cost effective, be of excellent physical quality, and give the best performance possible, while supporting an excellent finished quality of fish or prawn. The farmer is under pressure by the end user – often the supermarkets, to supply a product that they feel should meet the requirements of the target market – be those real or perceived.

The feed manufacturer is required to provide this to the farmer and as part of the service be able to supply information on various issues. The manufacturer is expected to have information about the latest R&D, nutritional performance data of the specific species being farmed, to be able to supply information or diets for unexpected events (disease, low DO etc.) and have an understanding of the market to which the farmers stock is being sold.

The researcher is under pressure to gain grant funding and publish data in peer review journals. Often the funding can come partly from industry and as such the feed manufacturer is seen as an obvious R&D partner; although more recently the farmer too is becoming more involved in this process. To be simplistic there are two types of research. The first is fundamental, investigating cellular, biochemical or physiological mechanisms – which are often far, or perceived to be far from market. The second is applied research, where focus is on subjects such as growth performance, raw material evaluation, disease or water quality. Publication of research can, on occasion, be contentious.

All too often with applied research the work is good, but the focus on the application is lacking. Much research is conducted that does not give the answers that the feed manufacturer and ultimately the farmer are looking for. Likewise, the end user can force research or diet changes that are at times only driven by market perception.

A feed manufacturer has to look at the current market and predict possible future developments, before investing funds into R&D. Closer links between research establishments, farmers and ultimately the end user will result in a more informed study and therefore better targeting of funds. Australia is no different to anywhere else, but researcher, feed company and farmer can learn a great deal from looking historically at what has happened elsewhere.

### EXPORT FACILITATION - DAFF'S ROLE IN SUPPORTING THE AQUACULTURE INDUSTRY EXPORT PUSH

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The real value of aquaculture production more than doubled in the 10-year period from 1992-3 to 2002-3 from \$331 million (in 2002-3 dollars) to \$743 million in 2002-3. Aquaculture's share of total fisheries gross value of production increased from 17% in 1992-3 to 32% in 2002-3. *ABARE Australian Fisheries statistics 2003*. Unfortunately it is not easy to obtain the exact percentage of aquaculture products (distinct from total fisheries product) exported. However, there is a strong trend in Australia to export high value seafood and as the value per unit weight of edible aquaculture products is nearly twice that of wild caught, therefore it is logical to assume that aquaculture is export focussed.

What is the Government role in facilitating export of aquaculture products?

Domestic market activity is the responsibility of States and Territories; but the export of fisheries products comes under Commonwealth jurisdiction. The major legal instrument for Government involvement in exporting primary products is the Export Control Act (1982). The Act and subsidiary Regulations and Orders allows AQIS the power to prohibit the export of seafood and other prescribed products, unless conditions and restrictions are met. The Act gives the AQIS the powers to conduct export inspection, provide export certification and charge industry for its services. AQIS is responsible for meeting Australia's international obligations and the import requirements of overseas countries in relation to exported agricultural commodities.

All exporters of aquaculture products must register with AQIS and have a quality assurance system in place before exporting. These are known as Food Processing Accreditation (FPA) and Approved Quality Assurance (AQA) and are HACCP based. These QA systems and a national monitoring program for contaminants and residues underpin the AQIS export certification system. The purpose of the National Residue Survey is to monitor and report on the level of contaminants and residues in foods.

AQIS can be seen as policing exports, and the Market Access group in DAFF can be viewed as having a salesman role for Australian seafood. The Market Access group actively seeks to support and improve market access opportunities for Australian seafood and to seek new markets including increases in seafood/fish trade with major partners through participating in international fisheries fora, such as the Asia Pacific Economic Cooperation (APEC) forum's Fisheries Working Group, and by addressing fish trade issues in the context of reducing or removing tariff and non tariff barriers to export of fisheries products to such markets as the EU, US and Taiwan.

The aim of regulators and exporters is to meet the needs of overseas customers. In a world where food scares (both real and imagined) make great copy, attacks on integrity of foods are commonplace. Not only must food be safe, it must be seen to be safe. The following quote from the EU website illustrates,

Food safety has emerged as a "new" issue. Major food safety scares, such as dioxin contamination and BSE ("mad cow disease"), as well as concerns about genetically modified foods and the use of growth promoting hormones in beef have increased consumer anxiety, particularly in Europe, about domestic food safety systems.

It is AQIS and the aquacultures industry's challenge to meet these market demands.

### FROM PLATE TO WATER - THE NEED FOR DESIGNING TO CONSUMER WANTS

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The term "water to plate" is not only hackneyed marketing jargon but more often merely an oxymoron for producers wishing to force the product they want to produce on an unwilling market.

In a market that is spoilt for quality, choice and value from every other food group, the seafood industry and specifically the Aquaculture industry has an obligation to consider the end user/consumer *first*.

What exactly is the contemporary chef - professional and amateur, looking for in their seafood.

Aquaculture projects demand intensive investigation and analysis of the site selection, the hatching, growing and harvesting of the fish but how often is the same level of forensic investigation undertaken in regards what the market really wants.

In this presentation, we review the contemporary food trends, listen to the consumers, the chefs, the distributors and the wholesalers and try to unravel the mystery of designing a product from the plate back to the water.

## 2,000,000 SUCCESS STORIES PER DAY THE PHENOMENA OF THE MODERN AUSTRALIAN WINE INDUSTRY

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In the mid 1980's the Australian Wine Industry was anything but a success story. It was fragmented, seen as a cottage/sunset industry, lacked strategic direction and little market place cooperation. Less than 35% of the annual vintage was premium fruit and exports were less than \$100 million and concentrated in the United Kingdom.

The story today is a story of a new wine industry. Since 1990 the Industry has unified around the Board table of the Winemakers Federation of Australia (WFA), providing the authority, policy and strategic engine-room for the industry to close ranks, pool its collective wisdom and resources and drive towards clearly established industry goals. This collaboration has allowed WFA to develop strategic plans that have shifted attention from today to the future.

Australian winemakers have become world leaders in identifying the needs of its customers and producing a product to meet these needs; including style, flavour, packaging, image and at specific price points. The Australian Wine Industry produces over 10,000 brands, but doesn't have an over-arching holistic brand. Branding and brand strength is pivotal to success, but not necessarily in the form that some may think. The collective respect, reputation, quality, value and image, along with the industry's status and role in managing its affairs have created a brand image, which distils into a "Brand Proposition".

If industries have sufficient self-determination and self-reliance their global potential is practically unlimited.

# EUROPEAN AQUACULTURE: RECENT DEVELOPMENTS IN MARINE HATCHERY PRODUCTION METHODOLOGIES AND SPECIES DIVERSIFICATION

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European marine finfish hatcheries have developed to be amongst the most intensive and productive units in the world. This presentation looks at many of the factors that have helped this development.

Examined are the infrastructures and technological advances that have combined to provide the basis for a diverse range of species to be successful cultured. A variety of diverse environmental conditions from above the artic circle to the subtropical Mediterranean region have required the development of species-specific larval rearing methodologies.

Recent developments in reproductive technologies, live food production methodologies and nutritional advances, combined with improved hatchery design features and management strategies have resulted in cost effective mass production of juveniles and the reduction in juvenile deformities.

### DO CULTIVARS OF LUPIN Lupinus angustifolius DIFFER IN THEIR NUTRITIONAL VALUE FOR BLACK TIGER PRAWNS Penaeus monodon?

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Lupins have been identified as an alternative protein source for inclusion in compound feeds for aquaculture. Australia supplies approximately 80% of the global lupin production and has an active breeding program to improve the cultivars of several lupin species. Most of the commercial production is of the Australian sweet lupin *Lupinus angustifolius*. Previous work demonstrated that the growth response of black tiger prawns *Penaeus monodon* was compromised when lupin kernel meal (*L. angustifolius* cv. Gungarru) was included in the feed at levels above 30%. The results of a more recent experiment suggested that the growth response of the prawns was not adversely affected when given feed containing ~50% kernel meal prepared from recently acquired samples of lupins.

A 50 day experiment was carried out to investigate the effect of current lupin cultivars on the growth of prawns when included in a feed at an inclusion level of approximately 50%. Four commercially produced cultivars (Belara, Tanjil, Kalya and Myallie) and two developmental cultivars (currently named Walan 2141 and Walan 2173) were tested. The test feeds were based on a control feed containing 35.6% fishmeal. Each of the test feeds contained 14% fishmeal and varying inclusion levels of the kernel meal such that each contained the same amount of lupin protein. Wheat flour and soybean oil was adjusted in each feed to balance the formulations so that all feeds contained 40% CP and 9.5% total lipid. The experiment was conducted in a flow-through seawater system of 48 circular 100 L tanks maintaining temperatures at  $28.7 \pm 0.6$ °C. Each tank was stocked with 5 juvenile prawns (6.93 ± 0.46 g). The prawns were fed to satiety twice a day with rations adjusted daily. Waste was siphoned from the tanks each morning before feeding.

After 50 days survival across all treatments was above 93% and growth rates were similar to the fishmeal based control feed (Table 1). The cultivar Kalya performed the best sustaining a daily growth coefficient (DGC) of 0.94 %/day, while the developmental cultivars also performed well. There was no sign of a marked depression in prawn growth rates due to any of the lupin cultivars, even though the inclusion levels were much higher than the 30% limit seen previously. These results suggest that current lupin cultivars may have lost the trait that depressed growth at high inclusions and could be used confidently in commercial feeds.

						,	
<u> </u>	Feed						
	Control	Belara	Tanjil	Kalya	Myallie	W 2141	W 2173
Final Weight (g)	12.54	12.40	12.02	13.61	12.14	13.24	13.44
Weight gain (g)	5.72	5.55	5.13	6.60	5.20	6.19	6.47
DGC (%/day)	0.85	0.83	0.77	0.94	0.78	0.89	0.93

TABLE 1. Final weight, weight gain and daily growth coefficient (DGC) of black tiger prawns fed a control feed based on fishmeal or feeds with ~50% lupin kernel meal from different cultivars.

#### MANAGEMENT OF THE FRENCH POLYNESIAN PEARLING INDUSTRY

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The french polynesian south sea pearling industry produces pearls from the black lipped oyster *Pinctada margaritifera*, principally from broodstock artificially captured oysters.

Highest export production of rough pearls was valued at \$US 211 million for 11.4 tonnes in 2000, representing \$US 18.5/gr. Since 1998, the average gram price of Tahitian black pearl continuously declined from \$US 31.5 to finally reached \$US 13.8 in 2002.

In order to stabilize and to increase pearl's gram price, serious quality control measures and management of the Ministry of Pearl Culture of French Polynesia are undertaken such as:

- Tight control of exported pearls
  - Seizure
  - destruction of low grade pearls
  - X-ray control of pearl layer thickness
- Professional accreditation
- Closure of marine concessions
- Environment preservation
- Environment monitoring

In 1998, the pearl industry directly and indirectly employs approximately 7000 people in French Polynesia. Recent marine concessions controls have found a total number of 1132 producers in which 794 pearls producers and 869 wild oyster spats capturers. A public hatchery gives the opportunity to validate research experiments.

The pearling program of the Ministry of Pearl Culture of French Polynesia is also responsible for the implementation of professional licences; the formation and technical advice of producers; the research on disease management, pearl's quality improvement; and to ensure a sustainable catch from the wild.

This paper summarizes the principal measures and issues taken by the Ministry of Pearl Culture of French Polynesia facing the global decline in pearl prices.

# LIQUID CHROMATOGRAPHY MASS SPECTROMETRY (LCMS) TO DETERMINE BIOTOXINS IN SHELLFISH FOR MANAGEMENT OF HARVESTING AND PROTECTION OF PUBLIC HEALTH

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The New Zealand and Australian commercial and public health biotoxin monitoring programmes combine phytoplankton monitoring and shellfish flesh testing and to successfully manage commercial shellfish harvesting and protect consumers from the effects of marine biotoxins. The introduction of liquid chromatography mass spectrometry (LCMS) to determine ASP and DSP toxins, including pectenotoxins (PTXs) and yessotoxins (YTXs), in shellfish has greatly enhanced these programmes. Benefits over mouse-based testing include speed, sensitivity (no false negatives), specificity (no false positives) and sustainability (ethical testing).

It is important that new test methods are carefully validated and accepted by international markets. Cawthron has carried out a wide range of within- and inter-laboratory tests to prove the accuracy and precision of the LCMS methods for a wide range of toxins. Cawthron has IANZ/ISO17025 accreditation and NZ Food Safety Authority approval for these methods.

Examples are provided from blooms of *Dinophysis spp*. and *Protoceratium reticulatum* around Port Lincoln South Australia and in the Marlborough Sounds (NZ). LCMS provided test results for shellfish samples that allowed the public to be protected from the effects of Toxic Shellfish Poisoning and facilitated management of commercial harvesting of Greenshellô mussel and other shellfish species. LCMS testing provided results quickly to enable timely decision making, gave accurate data that allowed toxin levels in shellfish to be closely monitored and revealed much about the accumulation and depuration of toxins from hazardous algal bloom events.

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# CAN INLAND SALINE WATER BE USED TO REAR POST LARVAE OF BLACK TIGER PRAWN Penaeus monodon Fabricius?

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Inland saline water has affected approximately 1.8 million hectare of agricultural land in Western Australia (ANRA 2002). However, inland saline water can be used as a potential resource for culturing marine species. This will enhance economic opportunity and diversifying option for farming community. There has been several attempts to use inland saline water to culture black tiger prawn (Penaeus monodon). P. monodon can survive only for 3 weeks in inland saline water at 10 ppt (Ingram et al, 1996).

Two trials were conducted for 96 hour and 336 hour (14 days) respectively to investigate the possibility of rearing postlarvae of P. monodon in different concentrations of inland saline water (ISW). Rearing medium at 26 ppt was prepared by mixing different concentrations of ISW (100, 75, 50, 25, 0%) with ocean water. Post-larval mortality was recorded at 6, 12, 24, 48 and 96 h in first trial and growth was recorded weekly for period of 14 days in second trial. The lethal effect of ISW (LC₅₀), specific growth rate (SGR) and food conversion ratio (FCR), was statistically analysed by probit analysis and ANOVA using SPSS10 computer software.



In the first trial, post-larvae mortality increased linearly with increase in proportion of ISW. Within 7 days, 100% postlarvae died when reared in 100% of ISW. The probit analyses estimated LC50 values for ISW at 76 and 61% (at 48 and 96 hours, respectively)(Fig.1). In the second trial, survival rate was significantly lower (P < 0.05) at 75% of ISW. Further, postlarvae showed significantly lower specific growth rates and significantly higher (P < 0.05) food conversion ratio when reared in a medium having more than 50% proportion of ISW (Fig. 2). The trial indicated that post-larvae could be successfully reared up to 50% of ISW.

#### EFFECTS OF THE FORMULATION, SINKING SPEED, AND FEEDING METHOD OF DIETS ON SURVIVAL AND GROWTH OF LARVAL JAPANESE FLOUNDER *Paralichthys olivaceus* AND RED SEA BREAM *Pagrus major* FED MICROPARTICULATE DIETS

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Inferior dietary values of artificial microdiets to live food for larval marine fish are possibly due to not only nutritive value but also other factors like water-stability, palatability, etc. In the present study, effects of diet composition and feeding method on sinking speed and ingestion of diet and growth performance were investigated using the larval Japanese flounder Paralichthys olivaceus and the red sea bream Pagrus major. The increase in proportions of carbohydrate and lipid contents in diet reduced the sinking speed of zein-microbound diets (MBD). In the red sea bream and Japanese flounder (15 days old), diet intake (mg dry diet/fish/h) was significantly (P<0.05) or tended to be higher, respectively, in the MBD with 20% additional lipid (fish oil calcium salt) (diet L20) than that without additional lipids (diet L0). In both the fish, the diet intake was not significantly different with two feeding methods (water-suspension and spray methods). The increase in feeding frequency in the spray method significantly increased the diet intake of diets L0 and L20.

The feeding experiment on the flounder (5 days old) showed that group 4 receiving diet L20 by the spray method had a significantly (P<0.05) higher survival rate than groups 1, 2, and 3 that fed diets L0 and L20 by the suspension method and diet L20 by the spray method, respectively.Å@Regarding the body length (BL) and body weight (BW), a marked difference was not found among the above 4 groups, except for that group 1 had a trend to give lower weight gain. Group 4 gave high BW and BL comparable to the live food control (rotifer) when supplied by the spray method. Good performance of group 4 could be partly due to the higher diet intake compared with the other groups in addition to the nutritional superiority of diet L20. Thus, the growth and survival rate of the Japanese flounder are possible to be affected by the sinking speed of diets besides nutritive values of diet.

## TO MARKET TO MARKET TO BUY A FAT TUNA AQUAFIN-CRC TUNA QUALITY PROJECT, SENSORY EVALUATION WORKSHOP

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The southern bluefin tuna (SBT) farming industry, reliant on a wild fishery and constrained by a catch quota, is now turning it's focus to product quality and value adding to increase returns and meet market requirements. The Aquafin CRC Tuna Quality Project has been supporting this industry focus by investigating issues in production and processing that affect the qualities of the product.

The research team took commercially produced tuna from Port Lincoln, examined the SBT supply chain and finally, examined the end product in Japan. The flesh was sampled and analysed, and sensory evaluation of it, in the form of sashimi, was done by the professional taste panel of a Japanese seafood processing organisation.

This complex exercise has never been attempted before.

This presentation will provide a colourful exposition of events and will comprise the following:-

- Introduction to techniques of sensory evaluation
- Explanation of why and where sensory evaluation is useful
- Explanation of the logistic and statistical constraints involved in applying sensory evaluation techniques to SBT production experiments

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- Presentation of a graphic, step-by-step illustration of the events, logistics and preparation of the carcasses and sashimi portions for evaluation
- Provision of preliminary results of two SBT flesh quality experiments, one of which examined the effect of harvest stress and the other the feeding of a diet fortified with vitamin E and C, culminating in
- A skilled demonstration of cutting of a real tuna, and
- Participatory tasting and evaluation of the portions by the attendees using the score sheets.

In addition to the authors the information provided in this workshop is a result of the efforts of the following people. From Australia: Mr Trent D'Antignana; Mr Robb McArthur, Blaslov Fishing management and staff, and the SARDI Tuna Research Farm team.

From Japan:Dr Tetsu Mori and his research team at NISSUI; Professors Etsuo Watanabe and Toshiaki Ohshima and their hard working researchers at Tokyo University of Fisheries.

In addition, all those people from the Tsukiji Fish Market, are gratefully acknowledged.

### SEDIMENTARY BIOGEOCHEMISTRY OF THE HUON ESTUARY

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As part of the Aquafin CRC research, 3D ecosystem-wide models of the Huon estuary and D'Entrecasteaux Channel are being developed by CSIRO to understand the sources of nutrients in these waters and their link to phytoplankton blooms. Such models will assist with the environmental management of the estuary by providing predictions on the contribution of fish farms to deleterious effects such as eutrophication.

Currently the models lack data on the role of sediments in nutrient cycling. A proportion of organic matter produced in the water column is transported to the sediments where it can be remineralised releasing nutrients back into the water column making the estuary more vulnerable to an increase in nutrient loads. Thus a study aimed at quantifying the role sediments play in nutrient release and oxygen consumption in the Huon estuary is vital.

This study will use sediment reactors to make measurements of oxygen uptake,  $CO_2$  evolution and nutrient release (nitrate, nitrite, ammonia, phosphate, silicate and total dissolved nitrogen). The same system will also be used to measure denitrification by measuring N₂ gas evolution. Denitrification is of particular interest as it leads to a loss of nutrients from aquatic systems due to nitrogen gas formation. Oxygen microelectrodes will be employed to measure oxygen profiles in sediments and to calculate diffusive oxygen fluxes. Pore water profiles will also be studied at selected sites to determine down-core variations in nutrient concentrations and from these we will infer fluxes from the sediment to the overlying water column.

Some important regulating factors of sedimentary biogeochemistry will also be studied in conjunction with measuring nutrient fluxes and benthic metabolism. Carbon reactivity, critical to metabolic processes, will be studied both in the field and experimentally by loading cores with different types of organic carbon and measuring oxygen consumption and nutrient release. Temporal and spatial variability will also be studied by sampling various sites within the estuary overtime (i.e. Spring, Summer, Autumn and Winter). The role of benthic macrofauna will also be assessed. At the completion of the sediment reactor experiments the sediment will be sieved (500mm) for benthic macrofauna and then enumerated and identified to at least group level (bivalve, polychaete etc) and dominant species will be identified to species or genus level. Their activity will be determined by comparing diffusive oxygen fluxes (obtained from microelectrodes) and total oxygen fluxes (obtained from sediment reactors) and relating it to faunal densities and species type. From field studies, nutrient release and oxygen consumption will be related to sediment characteristics such as grain size and density.

### DEVELOPMENT TOWARDS A CULTURED PEARL INDUSTRY IN KIRIBATI, CENTRAL PACIFIC

Beero Tioti

Project Manager Blacklip Pearl Oyster Project MFNDR Republic of Kiribati

In 1993, the Ministry of natural Resource Development (MNRD) in Kiribati began a collaborative research project towards the development of a cultured pearl industry in Kiribati. The Project is funded by the Australian Centre for International Agricultural Research (ACIAR). The major impetus for this project was a lack of export opportunities for Kiribati and the well-documented success of cultured pearl production in eastern Polynesia.

Initial survey work in the Gilbert Islands of Kiribati showed very low numbers of Blacklip pearl oysters (*Pinctada margaritifera*). This together with low numbers recruitment of spat to collectors, indicated that any development towards a cultured pearl industry in Kiribati would have to be based on hatchery production. A hatchery was established on the island of Tarawa in 1995 and a nursery culture area established at the neighbouring island of Abaiang. Both facilities have developed considerably over the past few years. The hatchery routinely produces large numbers of *P. margaritifera* spat. The main nursery and grow-out facility contains around 80,000 juvenile and adult pearl oysters and functions as a 'demonstration farm' for training Fisheries personnel and local people. A trial pearl seeding was conducted at Abaiang in 2001 and the first pearls were harvested in 2003. A second seeding of 5,000 oysters was undertaken in 2003. Project activities have recently extended to other sites within Abaiang lagoon and to other islands within the Gilbert group (Abemama, Butaritari and Onotoa). Development of a cultured pearl industry in Kiribati will be facilitated through formulation of a Development Plan and establishment of a Pearl Oyster Coordinating Committee (POCC). The Plan provides a framework for industry development with broad community involvement. It addresses both technical and political issues and will be amended on the basis of Project findings. The POCC brings together representatives of relevant government ministries and other agencies and advises the government on industry development.

# THE STUDY OF SUSCEPTIBAL LARVAL AND POSTLARVAL STAGES OF Penaeus Semisulcatus TO Penaeus monodon Baculovirus (MBV)

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The susceptibility of the different larval and postlarval stages of *P. semisulcatus* to MBV investigated by waterborne inoculation methods using zoea, mysis, and postlarval stages PL1-PL12. The rate of infection (ROI), severity of infection (SOI), accumulative mortality and growth rates were the variable determined among MBV-infected and control test shrimp. The zoea and mysis-1 did not show the diagnosable MBV infection after 5 days and three days, respectively. The mysis-2 and PL-1 showed the diagnosable of MBV after six days and two days on post-inoculation, respectively. The ROI and SOI among the older PL (PL7-PL12) was higher than the younger PL. The accumulative mortality was not statistically significant (P>0.05) between zoea and mysis 1 and the control group but was statistically significantly (P<0.05) between the infected mysis 2, 3 and PL,s and the control groups. The general growth rate showed no significant difference (P>0.05) between larval stage.

#### **RETAIL PACKAGING – ADDING VALUE OR JUST WINDOW DRESSING?**

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Increased focus on merchandising, communication and labelling has placed pressure on the successful promotion of most fresh chilled protein based foods in the retail market. Product integrity, tamper evidence and, in the case of national distribution, extended shelf life are key considerations for the aquaculture processors intending to promote products through supermarkets, foodservice markets and in some cases specialised commercial channels.

This presentation will provide a snapshot of the trends and developments in Australia and around the world to assist with getting fresh, value added and further processed products through the rigors of the retail distribution channels while retaining aesthetics and functionality of packaging such as tamper evidence, abuse resistance and enhanced shelf life.

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#### **RECENT ADVANCES IN THE PRACTICAL NUTRITION OF SOUTHERN BLUEFIN TUNA** Thunnus maccoyii

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With the tuna market yielding lower returns in recent years, greater emphasis has to be placed upon production efficiency if tuna farming is to remain profitable. The single most effective way of improving production efficiency in any intensive animal production system is to reduce the proportion of feed-related production costs. This can be achieved by reducing the absolute cost of the feed and/or improving the feed conversion efficiency of the farmed tuna. Recent nutrition research advances that will contribute to reductions in feed-related production costs for tuna include:

Weaning and feeding strategies: Initiation of feeding early in the production season and the capacity to change from one diet to another during the season has always presented challenges. Attractants do not appear to influence intake, however, a flat pellet 30mm in length has been shown to promote intake compared with round pellets. Following initiation of feeding, further research is also required to establish the most effective feeding strategy for manufactured feeds and baitfish. Frequent feeding of reduced quantities of feed may significantly improve utilization (which is currently poor) and reduce nutrient outflows, but will increase overall production costs. In contrast, less frequent feeding may suit tuna as on opportunistic obligate carnivore, but improvements would be required in feed stability and further research would be required to ensure overall growth rates were not compromised.

*Development of FORMU-BAIT*: While a significant amount of effort has been invested into the development of manufactured diets for SBT, baitfish are still the predominant source of nutrients. Anecdotal evidence suggests that farmers have been blending baitfish supplies for some time in an attempt to improve the growth of their fish and the resulting product quality. "FORMU-BAIT" is a computer program that accepts information on potential supplies of baitfish including cost and nutrient composition and using simple linear algorithms it relates this information to a stated requirement by the tuna. This approach will hopefully improve nutrient utilization, ensure cost-effective use of baitfish, and ensure the most appropriate baitfish are sourced over the course of the season.

*Surrogate research*: Research has been undertaken to demonstrate that blue mackerel (*Scomber australasicus*) is physiologically and digestively similar to southern bluefin tuna and may hold potential as a surrogate species for use in nutrition research. The size, value and holding requirements of tuna make practical nutrition research difficult, and a surrogate represents the best opportunity to undertake some more detailed nutrition research (for example, it is unclear how tuna respond to protein and energy supply over the course of a season during which their intake varies markedly). Preliminary capture, holding and feeding experiments are underway to define the potential for use of blue mackerel as a surrogate.

*Semi-moist pellet development*: Semi-moist pellets still represent the most suitable manufactured feed alternative for the supply of nutrients to tuna. Research is ongoing to enhance the durability of pellets, increase the stability and shelf life, and increase the range of ingredients that can be used in the manufactured feeds.
#### THE NUTRITIONAL REQUIREMENTS OF ABALONE – WHAT WE CURRENTLY KNOW

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Currently two species of abalone are being cultured in Australia, the blacklip abalone (*Haliotis rubra*) and the greenlip abalone (*Haliotis laevigata*). The greenlip species is cultured in South Australia, Victoria, Tasmania and more recently Western Australia, whilst the blacklip species is only cultured in Victoria and Tasmania. A hybrid of the two species, known as the Tiger abalone, is also being produced in Victoria and Tasmania. The majority of abalone culture in Australia occurs in land based tanks, although seacages are also used in Victoria and Tasmania. The Australian production of cultured abalone for 2003 was estimated at approximately 180 tonnes.

Due to the lack of support for and logistical difficulties with harvesting algae, abalone's natural diet, the farms in Australia feed their abalone a manufactured diet (excluding a couple of sea cage farms). As a result of the industry's dependence upon a manufactured diet considerable research has been conducted over the last 10 years in Australia to determine the nutritional requirements of abalone. At present information exists on the optimal amount and type of oil and omega 3 to 6 ratio for growth. In addition, the protein and energy digestibility of a range of ingredients for use in diets and the optimum digestible protein to energy ratio for growth has been determined for both blacklip and greenlip abalone. Nutrition research that has been conducted overseas on other abalone species includes the determination of vitamin and mineral requirements, the optimal protein level and protein to energy ratios for growth, digestive enzyme activity and ingredient evaluation.

This talk will present an overview of the abalone nutrition research that has been conducted in Australia and overseas, providing comparisons of nutritional requirements between species where possible. In addition, suggestions for the direction of future research will be provided.

#### FACTORS AFFECTING THE ENCOUNTER AND CAPTURE RATES IN SQUID PARALARVAE

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The theoretical foundation of predator-prey interactions derives largely from ecological analogues and laboratory studies are the primary source of insight, helping to predict prey vulnerability and to explain feeding patterns and rates in mariculture. In this context, a more accurate estimate of food availability during culture can be obtained by measuring the encounter rate between predator and prey. Therefore, this study evaluated the role of predator-prey encounter rate in influencing the predation pattern in paralarvae of the squid *Loligo opalescens*. We combined motion and frame-by-frame analysis of paralarvae-prey interactions. Mean swimming speeds of paralarvae were obtained (Table 1) to calculate expected encounter rates from Gerritsen & Strickler's mathematical model. Observed encounter, attack and capture rates were calculated by counting the number of encounters, attacks and captures between paralarvae and prey during filming sequences. Prey species supplied were mysids, copepods and *Artemia* nauplii, with speeds from 0.4-10 mm s-¹

ML	Age	<b>Reactive Distance</b>	Swimming Speed	Encounters	Attacks	Captures
(mm)	(days)	(mm)	$(mm \ s^{-1})^{-1}$	$(enc. s^{-1})$	$(enc. s^{-1})$	$(enc. s^{-1})$
2-4	0 – 20	8.41± 4.3	$6.31 \pm 1.45$	0.030	0.022	0.009
4 – 6	30 - 40	$14.58 \pm 5.6$	$8.83 \pm 1.57$	0.040	0.030	0.008
> 6	60	17.34± 5.1	11.16 ± 2.98	0.032	0.002	0.004

When mean swimming speeds of paralarvae and prey were different, the larger of the two had the greatest effect on the encounter rate. Thus, paralarvae with speeds  $<15 \text{ mm s}^{-1}$  had their encounter rate affected by prey speeds, but when paralarvae speed was  $>30 \text{ mm s}^{-1}$ , prey speed did not influence the encounter rates. The distance at which a paralarva perceived its prey were called reactive distance (RD), which increased linearly with size (Table 1). This increase produced a much greater effect on encounter, attack and capture rates than that caused by the swimming speed of paralarvae.

Observed encounter rate of paralarvae obtained by image analysis was compared to the expected encounter rate obtained by the mathematical model. Observed and expected encounter rates overlapped for the 2-4 mm ML size class. But, the math model overestimated the encounter rate in larger and faster paralarvae (>4 mm ML), while the image analysis underestimated it in the same size classes. In summary, the mathematical model did not take into consideration a maximal number of encounters per unit of time or space, and the time spent by paralarvae in activities like pursuit, attack, ingestion and digestion. On the other hand, image analysis underestimated the encounter rate because an encounter was accounted for only after a positioning movement of a paralarva towards a prey, thus not all prey that entered the paralarvae's field of vision were considered. Then, it is reasonable to suppose that the real encounter rates of paralarvae lay between the expected (maximum, 0.10-0.20 enc. s⁻¹) and the observed (minimum, 0.03 enc. s⁻¹) in this study.

# THE EFFECT OF IONS ON MOTILITY AND FERTILIZATION ABILITY IN THE SPERM OF THE PISMO CLAM Tivela stultorum

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The sperm of the pismo clam *Tivela stultorum* becomes motile once it gets in contact with seawater. As in many other bivalves, this contact triggers in the sperm an increase of the  $O_2$  consumption, reflecting the activation of a cyanide-sensitive respiration mechanism of cellular origin. This mechanisms are sensitive to low pH, and requires the presence of ions; such as K⁺, Na⁺ and Ca⁺.

The goal of this study was to determine if different concentrations of  $K^+$ ,  $Na^+$  and  $Ca^+$  affects the motility and the ability of the pismo sperm to fertilize eggs.

Pismo clams, 2 or 3 years old were obtained in the bay of Ensenada Baja California, México. Clams were acclimated for 1 week under controlled conditions, and constant temperature (17°C), and were fed daily with the microalgae *Isochrysis galbana T-Iso* and *Tetraselmis suesica* at a cell density of 50,000 cells per mL..

Aliquots of 0.5 ml were taken directly from the gonad and were suspended in 4 different treatments: artificial seawater (ASW), artificial seawater with high concentration of K⁺ (ASWK⁺), artificial seawater calcium free (ASWCa⁺-free), artificial seawater potassium free (ASWK⁺-free). All solutions were adjusted at pH 8.5 and the concentration of sperm was standarized at  $3x10^6$  sperm/ mL.

Samples were refrigerated at 4°C and motility was evaluated daily for 7 days by taking aliquots of 1 mL.

Females were stimulated to spawn by thermal shock. Refrigerated sperm was used to fertilize the eggs at days 1, 3 and 7 of storage. Fertilization ability was evaluated until the first polar body was formed

The Solution ASWK⁺ significantly reduced sperm motility.(Figure 1) Suspension into ASWK⁺-free increase the motility and the fertilization capability of sperm .(TableI)

The suspension of the sperm into ASWK⁺-free and ASWCa⁺-free can lengthen refrigeration storage time of pismo spermatozoa up to 12 days without affecting the fertilization ability of the sperm.

Day	1	3	7
Treatment			
ASW	50	40	0
ASWK ⁺	50	30	0
ASWCa ⁺ -free	50	45	0
ASWK ⁺ -free	50	45	25

TableI Fertilizing ability (%) with the different treatment.

### IMMUNOMODULATION IN THE CONTROL OF AMOEBIC GILL DISEASE IN ATLANTIC SALMON

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In Tasmania, amoebic gill disease (AGD) is the major health concern to the local Atlantic salmon industry. *Neoparamoeba pemaquidensis* is the presumptive causative agent of AGD in Atlantic salmon, this parasite is found in seawater and on surrounding infrastructure of salmon farms. *N. pemaquidensis* affects the gill tissue, white mucoid patches can be seen on the gill surface.

Histologically hyperplastic lesions are seen in close proximity to the causative agent, *Neoparamoeba* sp. Currently, disease control is limited to freshwater bathing. Frequent treatment is required during summer months, posing high costs to industry (~ 14% of total production costs). Development of a more effective treatment is essential for growth of the Tasmanian salmon industry.

Immunostimulants increase disease resistance by stimulating both the innate, and acquired immune response. Atlantic salmon injected with CpG oligodeoxynucleotides had significantly increased survival when exposed to *Neoparamoeba* sp.

Results from a recent *Neoparamoeba* sp. exposure of Atlantic salmon suggest that upon prolonged exposure, fish may develop resistance. Survival of these fish while persistently affected with AGD may be due to the presence of systemic antibody.

Current research is focused on developing disease resistance in Atlantic salmon. The presence and level of serum antibody, and the use of environmental manipulation to favor the host will be investigated.

#### CARACTERISATION OF PHYSIOLOGICAL DISTURBANCES IN SHRIMP Litopenaeus stylirostris INDUCED BY HANDLING STRESS. APPLICATION IN SURVIVAL IMPROVEMENT AND REPRODUCTION ACHIEVEMENT OF BREEDERS DURING WINTER IN NEW-CALEDONIA

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Excessive fragility of the broodstock is a severe problem in shrimp farming during winter in New-Caledonia. A typical consequence of this problem is high mortalities (up to 70%) of breeders following transfer from pond to hatchery. We first documented some aspects of the physiological disturbance and time constant involved, following standard catching test and quick transfer of shrimp from pond to experimental tanks. We then applied our observations to improve breeder's survival. We report here on some observed physiological troubles and putative prophylactic regimes.

In the first experiments, shrimp (38.5 0.6 g) were caught in an earthen pond ( $T = 23-25^{\circ}C$ ) of an experimental shrimp farm using standard procedures and transferred within 10 minutes in either outdoor or indoor experimental tanks. Osmoregulatory Capacity (OC), and whole body water content were measured. Results were compared to reference data from Tahiti (IFREMER) where temperature stays constant all year round (28 °C). The major trouble associated to shrimp catch, either in New-Caledonia or Tahiti, was a large change in OC associated to an outward water shift.

Both phenomena occurred within the 1st hour of handling. The drop of osmotic capacity (60 mosm/kg) was independent of temperature change, which strongly suggests that a major drive was the initial stress itself. However, the time course of OC recovery was T dependent and remark-ably long: 24 h at 28°C and 6-7 days at 20°C.

In the second step, various prophylactic protocols were studied on shrimps weighting 20 to 50-70 g (i.e. juvenile to breeders). The effect of different transfer regimes (at various temperature, salinity and/or feeding rate) to counterbalance the OC disturbances and the mortality was tested. In breeders, the reproductive achievement (spawning, fecundity and hatching rates) was characterized. Fig. 1 shows that the usual transfer of broodstock (T = 20 °C, Salinity = 35 ‰, fed shrimp) in winter led, after 48 hours, to the usual high mortality. However, survival, as well as spawning rate, was dramatically improved when shrimps were transferred in warmed isosmotic water (26 °C and 26 ‰) and unfed for 3 days. Thus, well managed stocking conditions during the first days after transfer may dramatically improve hatchery performance in New-Caledonia.



Fig 1. Survival rate of 20 g shrimp following transfer according treatments (T°C, S‰ and feeding regime).

#### AQUACULTURE - WHAT DOES IT MEAN AT LAW

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The expression aquaculture is usually used and associated with fish farming, shell fish culture and the farming of micro and macro algae. The term is commonly used to refer to both fresh and marine water culture of aquatic animals and plants. One of the more commonly used definitions is that of the Food and Agricultural Organisation of the United Nations. It defines aquaculture in much the same terms as already described, however it adds that farming implies some form of intervention in the rearing process and involves individual or corporate ownership.

So far the courts in the English common law countries have only been called on to consider the meaning of aquaculture on a few occasions. There are a few Australian decisions that have considered the meaning of aquaculture. In one it was held that aquaculture was agriculture in modern Australian usage. However, on appeal the decision was reversed, as it was said not all farming is necessarily agriculture. Another decision held that the stocking of fish out ponds, without any breading, rearing and cultivation of fish for sale constituted aquaculture. Under a couple of statutory definitions, operating storage facilities for live aquatic animals have been held to be within the statutory definition of aquaculture.

A recent Canadian decision regarded aquaculture in a broad sense to be farming, but the analogy stopped there. In the particular case the applicant was undertaking marine fish farming, an activity that was said not to be drawn from or nourished by nature's sustenance in the freehold. In a United States decision aquaculture was, in the particular context, regarded as a contemporary method of farming shellfish. It concluded that it is not incidental to or reasonably related to or a natural derivative of the public's right to fish. So, subject to any legislative intervention, aquaculture is not fishing nor a proper or natural derivative of it.

Aquaculture or fish farming is now extensively defined in Australia by various state and territory legislation. It is defined differently in each state and territory and sometimes differently in different statutes of the same state or territory. An example of the scope of a statutory definition can be found in the *Aquaculture Act 2001* of South Australia. The definition in that Act extends to the farming of aquatic organisms for the purposes of trade or business or research. The definition is so wide it has the potential to apply to aquariums, zoos, pet shops, some universities, some restaurants, some fish processors and wholesalers, some fish shops, some fishers, some government research institutes and some local government authorities. There is a power to exempt a person from the application of this wide definition. It does not appear to apply to sea ranchers once their fish are at sea.

The meaning of the expression "aquaculture" is likely to be decisive in determining the rights and obligations of an aquaculturist in many situations. Licensing is only one example.

#### **OWNERSHIP OF FISH – SOME LEGAL CONSEQUENCES**

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The English common law has for the purpose of describing the nature of the rights of ownership of animals divided them into two classes, those the subject of absolute ownership (*domitae naturae*) and those the subject of a qualified or limited property right (*ferae naturae*). Whilst fish have long been regarded as the subject of a qualified property right (an interest that is usually dependent on possession), it is now possible to assert that some fish and molluscs may be the subject of absolute ownership. The recognition of the ownership of fish and molluscs (whether absolute or qualified) raises a number of legal issues for an aquaculturist. Some of these and incidental issues are considered.

Of those issues, possibly the most significant is what is the right of the aquaculturist to recover fish that have escaped or are released as part of a sea ranching undertaking. If the fish are regarded as *domitae naturae* then they remain the property of the aquaculturist wherever they may go, unless abandoned. If *ferae naturae*, then the property right is much more limited and in most cases is lost on the escape or release. Even if the aquaculturist is at common law entitled to recover his escaped fish, does that recovery constitute fishing in contravention of the various fisheries legislation?

Associated with the recognition of a property right is usually the recognition of the right to exclude third parties from interfering with that property. Once again, at common law, issues may arise for an aquaculturist, depending on the nature of the interest and the method of containment (if any). In many marine situations, legislation now provides for statutory offences for those interfering with those sites or the aquaculture stock. Notwithstanding that, there may remain some situations that are not covered.

Historically, the recognition of absolute ownership of an animal brought with it certain responsibilities or obligations. At common law the owner of most *domitae naturae* (there were no exceptions if *domitae naturae* were limited to *averia* (simply described, as those animals usually kept about a farm), however if extended to dogs and cats there were exceptions) was liable for the trespass committed by the *domitae naturae* owned by that person. As to whether these principles have any application to fish, now regarded as *domitae naturae*, is far less clear. In any event, in many jurisdictions the remedies under those old rules and the tort of negligence are both applicable. In some jurisdictions the old rules have been abolished by statute and replaced by other rules or by negligence. Negligence now has a far wider import and may render the aquaculturist liable for any damage caused by his animals (whether *domitae naturae* or *ferae naturae*) not simply by reason of their trespass.

In addition an aquaculturist may have various responsibilities imposed by statute; some of these statutes are less concerned about the ownership status of the animals concerned. An infringement of these statutes may involve statutory and civil consequences for an aquaculturist.

## PROGRESS IN A GENETIC IMPROVEMENT PROGRAM FOR PACIFIC OYSTERS Crassostrea gigas IN AUSTRALIA

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Pacific oysters were deliberately introduced to Australia in the late 1940s and early 1950s. The intention was to establish a new industry based upon natural spat-fall. However, recruitment proved to be unreliable and in 1979 the first commercial hatchery was established in Tasmania. Now there are four commercial oyster hatcheries in the major Pacific-oyster producing states of Tasmania and South Australia and virtually all Australian production is hatchery based.

In 1996/97 we commenced the first generation of mass selection for growth rate, and in 1997/98 we began family and individual selection for growth rate and some other traits. In 2002/03 we spawned the fifth generation of both our mass selection and family lines. Progeny from all generations have been grown out on one subtidal and two intertidal farms in Tasmania and two intertidal farms in South Australia. Generally, ranked performances were similar across sites, although a few families appeared to have site-specific performance. The small but significant genotype (family) by environment interactions in the first two generations were reduced in the third and fourth generations. Substantial gains in growth rate have been made.

Commercialization of the improved lines is being undertaken by a new company, Australian Seafood Industries Pty Ltd (ASI), in cooperation with the research partners. ASI recently spawned the sixth generation.

#### "PEARLS OF WISDOM" ESTABLISHING TRAINING IN AN EMERGING INDUSTRY

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Central West TAFE is a regional Western Australian College utilising a network of campuses, Telecentres and regional centres to service a geographical area as large as the state of New South Wales.

The main campus is located in Geraldton, a city on the coast approximately 400km north of Perth and the centre of a very strong fishing industry.

Fishermen, like many in primary industries are investigating income diversification and a focus in the region around Geraldton has been the culturing of the local black lipped pearl oyster *Pinctada margaritifera* to produce "black" pearls. However, as with most emerging industries, there are a number of hurdles to overcome on the road to success.

The Black Pearl training program is an excellent example of local industry and TAFE working together to provide high quality training to support a fledgling industry.

This session will outline:

- What and how was consultation undertaken?
- How was the training identified?
- What nationally recognised course will be delivered?
- How is training provided to industry standards?
- Where did funding come from to support this program?

### HOW DO WE ACHIEVE FOOD SAFETY IN THE AQUACULTURE INDUSTRY IN AUSTRALIA?

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How is food safety in the aquaculture industry achieved from the water to plate in Australia? The broad regulatory framework within which this is achieved will be outlined. Contemporary issues around standard setting will be explored together with the principles behind the current approaches to food safety management in Australia.

New food safety legislation affecting the seafood industry, including aquaculture production is currently under development. The new draft requirements will be discussed in the context of existing seafood regulation and State and Territory seafood schemes. The roles of industry, state governments and Food Standards Australia New Zealand within the new food regulatory framework will also be discussed.

Australian industry has a reputation for producing safe food – and the new food regulatory system aims to ensure that this reputation continues through the development of national standards that cover the food supply chain from production through to the consumer. These standards provide consumers with confidence about the safety of food they consume, whilst giving industry flexibility in the way they meet the food safety requirements.

## HIGH PERFORMANCE PELLETED DRY DIETS FOR REARING JUVENILE TROPICAL ROCK LOBSTER Panulirus ornatus

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The Australian Fisheries Research and Development Corporation is supporting nationally-coordinated research to assist the establishment of marine rock lobster aquaculture in Australia. The aim is to develop commercially viable and environmentally sustainable technologies for the hatchery production and subsequent rearing of lobsters. Until hatchery production is successful, one way of value adding to the wild catch is to collect settling juvenile lobsters and on-grow them under aquaculture conditions. In Vietnam and other parts of SE Asia, significant lobster aquaculture industries have established by collecting wild juveniles and feeding them on fishery bycatch until a marketable size of about 1 kg is attained in 15-18 months. The feasibility of harvesting and on-growing wild juvenile lobsters in Australian waters is under investigation but before this can become a commercial reality research is needed to develop a cost-effective and eco-friendly pelleted dry feed.

We found that juvenile *Panulirus ornatus* readily ate laboratory-made and commercial dry shrimp feeds but growth rates were less than half that of lobsters of a similar size in the wild. This sub-optimal growth was attributed to the lobsters loosing interest in the pelleted feed within one to two hours of it being immersed in water. We examined the nature and rate at which nitrogenous compounds leached from pieces of fresh green lip mussel *Perna canaliculus* (GM), an extruded kuruma shrimp *Penaeus japonicus* pelleted feed and five laboratory-made pelleted feeds that contained homogenates of fresh GM, prawn *Metapenaeus bennettae*, bloodworm *Marphysa sanguinea* or squid *Sepioteuthis* spp. In the first hour of immersion, loss of Kjeldahl N, trichloroacetic acid-soluble protein (TCA-P) and total free amino acids from green lip mussel was 2.5 to 6-fold greater than from pelleted dry feeds. These differences persisted but lessened with increased immersion time up to 7.5 h. Regression analysis identified TCA-P, glycine and taurine as the principal components influencing the lobster's preference for these feeds. This finding suggested that the lobster's acceptance of the pelleted feeds might be enhanced by adding peptide-rich ingredients such as protein hydrolysates into the dietary formulation and prolonging the rate at which feeding stimulatory substances leached from the feed.

Two growth assay studies confirmed the benefit of including 8% krill hydrolysate in pelleted diets for juvenile *P. ornatus*. In an 8-week study where dietary crude protein (CP) was serially increased from 33 to 61% DM, growth rate of juveniles initially 2.5 g increased linearly from 0.36 to 0.91 g/week. By comparison, lobster fed fresh GM grew only 0.42 g/week. In a 12-week study with 18 g lobsters, supplementing a 30 mg/kg carotenoid basal diet with 25 mg/kg astaxanthin increments from 0 to 75 mg/kg resulted in no clear growth dose response. However, growth rates of lobsters fed either fresh GM or fresh blue mussel *Mytilus edulis* were inferior to those fed pelleted feeds (2.54 and 1.74 cf 2.81-3.26 g/week, respectively).

## THE INFLUENCE OF VIRAL LOAD ON THE SPAWNING EFFICIENCY OF WILD AND DOMESTICATED AUSTRALIAN Peneaus monodon BROODSTOCK

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Viral disease is widely regarded as being an impediment to successful commercial production of domesticated broodstock for aquaculture in penaeid prawn species. To date, the most successful closed life cycle breeding systems for penaeid prawns have relied on the use of Specific Pathogen Free (SPF) broodstock. However, the exact means by which viral disease impairs reproductive capacity in wild broodstock is not known. It is clear that viral disease has a severe impact where it causes serious mortalities among captive reared broodstock. However, viral disease is also believed to be a factor in the reduced performance of captive-reared broodstock compared to wild-caught broodstock in the black tiger shrimp, *Penaeus monodon*.

We have recently developed quantitative PCR assays for gill-associated virus (GAV) and for Mourilyan virus (MoV), two viruses which are endemic in *P. monodon* broodstock sourced from the East cost of Australia, and which are believed to be associated with production losses due to disease. This affords the opportunity to quantitatively examine the relationship between viral load, and spawning efficiency in *P. monodon* broodstock, to look in detail at the influence of viral load on spawning efficiency.

The relationship between viral load and spawning efficiency was examined in wild-caught broodstock that were spawned either at a commercial hatchery or at a research facility in 2002. The animals spawned at the research facility were subject to artificial insemination affording the opportunity to determine viral load in both male and female broodstock. The broodstock examined ranged from highly efficient spawners (nauplii production in excess of 250,000 per spawning) to very poor performing spawners (less than 100,000 nauplii to 0% hatch). Among these spawnings (99 examined in total), no correlation could be found between the load of either GAV or MoV and spawning efficiency as determined by nauplii production.

These data are confounded by the extreme variability in age and life history observed in wild-caught broodstock. Further analyses are being conducted on domesticated G1 broodstock that were of a common age and were raised in a common environment. This work will examine not only viral load in animals that do spawn, but also in animals that fail to spawn, to examine whether viral load is a predictor of the likelihood of spawning success.

#### BENTHIC ENVIRONMENTAL MONITORING OF SALMONID FARMING IN TASMANIA 1997-2003

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In 1995 the Tasmanian government recognising the need for an integrated approach to sustainable development of the State's valuable marine resources proclaimed the Marine Farming Planning Act (MFPA) and the Living Marine Resources Management Act (LMRMA).

Under the MFPA 1995 a series of marine farming development plans have been prepared for fourteen areas around Tasmania. Each plan must contain management controls to manage and mitigate potential negative effects of marine farming activities. These controls include a regulatory mandate for the regular collection of physical, chemical and biological data from predetermined locations such that ecological changes attributable to salmonid aquaculture waste at the farm scale can be quantified and evaluated.

In addition under the LMRMA 1995 each lease holder is issued annual licence conditions, which include monitoring requirements and standards can be assessed to ensure that salmonid marine farming operations are operating in a sustainable manner. In order to achieve sustainable management the use of State waters by the salmonid industry must be with the knowledge that any potential environmental effect is localised, reversible and short-term. For all salmonid farms the legislative framework clearly prescribes that "there must be no unacceptable environmental impact to the satisfaction of the Secretary of DPIWE, 35 metres outside the boundary of the marine farming lease. Unacceptable impacts include but are not limited to the presence of gas bubbling, feed pellets and mats of *Beggiotoa* sp.

As the program has been running since early 1997 DPIWE now has as a minimum of four years of data for the majority of salmonid farms currently operating within the State. This equates to a baseline survey, eight video surveys and two biennial surveys. The majority of salmonid production is derived from waters in the south east of the State there has been a considerable increase in production from the west coast of Tasmania in the last two years. The net result is that the data captured by the salmonid environmental monitoring program is now probably the most comprehensive temporal and spatial marine data set that has been collected in recent years within Tasmania. This presentation will provide details of the different survey techniques employed through the program and a summary of the results of the monitoring that has been conducted over the last six years. The current program is presently being reviewed as part of the governments commitment to adaptive management and as such an outline of future directions for salmonid monitoring within Tasmania will also be presented.

### CROSS FERTILIZATION OF SCALLOP Chlamys farreri WITH Patinopecten yessoensis AND THE CHARACTER INHERITANCE OF THE HYBRID

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Abstract: Intercross and inbreeding of Chlamys farreri and Patinopecten yessoensis were produced in this study, the fertilized eggs of the reciprocal crossing stained with DAPI were observed by fluorescent microscope. The result showed that the sperm could incorporate oocyte, the fertilized eggs of the reciprocal crossing could finish the first and the second meiotic division and release the first and the second polar body, the chromosomes from sperm and oocyte associated together and then the diploid zygotes nucleus formed£"it could divided normally, and the hybrid embryo could develop the same as inbred embryo of the maternal scallops. In the process of intercross, the egg could be fertilized normally by heterogenous sperms, the fertilization rate could reach more than 90% without significant difference comparing to contrast.

Hybrids of intercrosses Chlamys farreri (Q)**x**Patinopecten yessoensis ( $\sigma$ ), Chlamys farreri( $\sigma$ )**x**Patinopecten yessoensis (Q), and the inbreeding offspring were derived and were breeding in the same sea area. The results indicated that: I. The external shape of hybrid was similar to female parent, the hybrid derived from Chlamys farreri (Q)**x**Patinopecten yessoensis ( $\sigma$ ) had a survival rate of 95% and the growth rate was improved by 23%, while there was large scale death of Chlamys farreri in high water temperature season. II. The survival rate of the hybrid derived from Chlamys farreri( $\sigma$ )**x**Patinopecten yessoensis (Q) was improved by 16%, but there was no significant differences in growth rate comparing with female parents; III. Gonad of the hybrid could develop normally, and mature hybrids were able to spawn naturally. It was concluded that the cross offspring of Chlamys farreri and Patinopecten yessoensis had a high production trait as well as the strong disease resistance ability.

# MANAGING AQUACULTURE WASTES THROUGH INTEGRATED APPROACHES TO MINIMIZE ENVIRONMENTAL IMPACTS

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Nutrient enrichment of pond waters is an essential management practice in aquaculture. The discharge of nutrient-rich wastes, resulting in the deteriorated quality of receiving waters, has become a worldwide environmental concern. Effective means to minimize the environmental impacts of aquaculture are environmental-oriented integrated culture systems, where wastes from intensive aquaculture ponds are reused, recycled and reduced while secondary crops of filter-feeding/herbivorous aquatic animals or terrestrial/aquatic plants are produced.

The principles of the environmental-oriented integrated culture systems are utilizing planktons and suspended solids by filter-feeding species, utilizing detritus by bottom feeder species, stripping nutrients from water by marcoalgae, and extracting nutrients from water and sediment by terrestrial/aquatic plants. The environmental-oriented integrated culture systems have various settings from simple polyculture to complicated recirculation systems, however, all of the integrated systems use different combinations of above species to treat wastes derived from intensive aquaculture.

Integrated aquaculture has been extended from traditional on-farm closed systems to reuse of wastes from intensive aquaculture based on off-farm resources. The development of recycling of wastes from intensive aquaculture to semi- intensive culture or other agriculture crops is still in artisanal stage. Systems approach is needed for further development of the environmental-oriented integrated culture systems, which require proper engineering design, quantitative information on physical conditions, nutrient budgets and biological comparability among cultured species and systems.

### COMPARISON OF DIFFERENT SEAWEED SPECIES FOR USE IN AQUACULTURE (PRAWN FARM) WASTEWATER TREATMENT

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One of the key environmental issues preventing further growth of the aquaculture industry in Australia is the adverse impact of contaminated wastewater discharged to surrounding water bodies. The use of marine macroalgae (seaweed) is an emerging technology for the control of nutrient loadings in wastewater released to the environment. However, little is known regarding the best seaweed species to use for this application. The current study aimed to generate quantitative data to compare different seaweed species for the treatment of prawn farm wastewater (Moreton Bay, Queensland, Australia).

Five common seaweed species were selected for this study; *Gracilaria arcuata*, *Gracilaria edulis*, *Gracilaria purpurasiens*, *Hypnea pannosa* and *Ulva australis*. Each species was grown in laboratory tanks using prawn pond water and pre-filtered ( $50 \mu m$ ) seawater. In addition, each species was grown on floating rafts in a prawn production pond located in Moreton Bay, Queensland, Australia. The success of each species was characterised by determining growth rates, tissue composition and overall health. The efficiency of nitrogen removal was established by combining the tissue nitrogen content and the specific growth rate (SGR), allowing calculation of g N removed day⁻¹ kg⁻¹.

The key results from this study are illustrated in Figures 1 and 2. In the field, *U. australis* recorded a significantly higher average growth rate (P<0.05) and a lower tissue nitrogen content compared to all other species. The major health and performance limitation to species such as *G. edulis* and *H. pannosa* was silt attachment to thalli caused by high turbidity and TSS. It can be concluded that both *U. australis* and *G. arcuata* are more suitable than *G. edulis*, *G. purpurasiens* and *H. pannosa* for the bioremediation of prawn farm effluent under field conditions.

This study provided convincing evidence that seaweed cropping is a potential solution for the treatment of nitrogen-containing wastewater associated with prawn aquaculture prior to discharge. The ability to grow seaweed crops in settling ponds may allow retrofit to existing farms for minimal capital cost. The field results for *G. arcuata* were particularly promising, as this species has the added benefit of potential commercial application in agar production.



Figure 1: SGR for the evaluated macroalgae species for laboratory and pond experiments.



Figure 2: Macroalgae species bioremediation potential in laboratory and field conditions.

### SOLUBILITY OF PROTEIN AND STARCH IN ARTIFICIAL AQUACULTURE FEEDS: HOW MUCH OF YOUR MONEY IS GOING DOWN THE DRAIN?

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If artificial aquaculture feeds are not immediately consumed by the cultured animals, much of the nutrients may become solubilised and lost in the seawater. This is a particular problem in the culture of abalone (paua) where the food may sit for several hours before the animals encounter it. Culture of Paua (Haliotis iris) in New Zealand has grown considerably in the past decade. The feed used in most farms is an artificial formulation of small (~4mm square) chips which may be ground into a fine powder for feeding juveniles. This grinding increases the surface area with a possible increase in the loss of nutrients to the surrounding water. In this study we assessed the loss of protein and carbohydrate in several types of commercially available artificial feeds used in the culture of paua over a 48 hour period. Both protein and starch was solubilised very quickly with up to 30% loss within 2 hours of immersion. Possible remedies are discussed.

### LAND-BASED FISH FARM EFFLUENT MANAGEMENT: TECHNOLOGICAL, BIOLOGICAL AND ENVIRONMENTAL ASPECTS

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Global aquaculture production has increased very significantly in the last 25 years, primarily due to increased demand for fish and stagnant or declining fisheries landings. This rapid development has also increased the potential environmental impact of the activity. The management of waste is one of the most important sustainability-related issues in aquaculture today, due to the potential negative effects of discharge materials into the rivers, lakes or the sea, and ground water. European countries are adopting increasingly restrictive environmental and regulatory constraints. These new regulations underscore the importance of studying these wastes and their treatment, in order to avoid detrimental impacts and potential conflicts. To understand the ways in which these impacts may be reduced and propose mitigation methods, it is first and foremost necessary to understand the biological functions involved in these production systems and the nature of the wastes created by them. In this presentation, land-based marine production systems, flow-through and recirculating tanks, will be analysed as standard systems. Further, potential solutions to minimising the waste production of intensive marine fish farms will be investigated. This will include a description of the major metabolic functions involved in the soluble and particulate waste productions.

Major trends in protein and energy utilisation by fish at experimental and practical levels will be analysed, with particular attention being paid to species characteristics. Based on the production systems being investigated, technologies and best management practices to reduce organic and inorganic releases from the systems will be presented. Expected improvements and future developments will be also discussed.

Processes to optimise the use of water and to valorise by-products (sludge) are today under development in EU. The first treatment operation generally consists of a separation of the suspended solids through a mechanical filtration and a thickening / dewatering of the sludge using various chemicals to provide a coagulation-flocculation process. The characteristics of the sludge, its stabilisation and possible reuse, in different fields, will be presented, with special attention to its marine origin. Algal based processes are a useful tool to treat the liquid effluent of marine aquaculture system before its reuse in the rearing system or release into the environment. The effect of the treated water on fish and the optimal algae growing conditions will be discussed.

Integrated systems are probably the best solution to optimise the use of natural resources in the fish production processes. A combined approach integrating research at the individual fish, species and system level is the most promising way to simultaneously improve the economic, technical and environmental efficiency of fish farming sector.

### **ABSTRACT ADDENDUM**

#### INNOVATION IN SHELLFISH FARMING SYSTEMS IN NORTH AMERICA

#### Joth Davis

Shellfish farming in North America has evolved to take advantage of improvements in gear and other technologies as they are developed. Increasing costs associated with labor and permitting continue to drive the shellfish aquaculture sector towards mechanization, and increased recognition of ecological effects of shellfish culture on growing waters is focusing the industry on more intensive growout systems for oyster, mussel, clam and geoducks. As the oyster industry moves to increased half-shell production in North America, innovations have been made for increasing grading and handling efficiencies. For oysters grown in intertidal regions, growers have moved towards lower cost cage-on-bottom and cage-off-bottom systems with increased focus on more frequent grading and product quality. Clam culture in North America is based on hard clam culture in the US southeast and manila clam culture in the US northwest. Innovations in mechanical systems for laying down predator netting, planting and harvesting have the potential for greatly increasing clam production.

Geoduck culture in the Pacific Northwest has similarly been the focus of innovations in recent years, as development of this sector has grown significantly. Systems for seed handling, planting, predator protection and harvesting technologies have been the subject of much research and development as this new sector continues to grow very rapidly with farmed geoduck production poised to significantly increase over the next year or two. Geoduck farming is an example for the recent trend in North America to focus on the development of culture techniques for species not currently in commercial production.

#### INNOVATION IN GRADING AND HANDLING SYSTEMS IN NORTH AMERICA

Joth Davis

Grading and handling of shellfish in North America has received more attention in recent years as the focus of production has increasingly relied on hatcheries for seed. Handling systems for size grading oyster and clam seed have become increasingly important. The use of mechanical graders for sizing and grading market ready oysters and clams has similarly received attention as costs associated with handling shellfish continue to increase. Innovations in the United States have mainly focused on retooling existing equipment from the agricultural sector for use in specific installations, or designing and building equipment for site-specific use. Larger companies have tended to invest in grading and handling systems as volumes and processing needs have increased. Taylor Shellfish Farms form Washington State, USA has invested significantly in handling and grading systems for manila clam and pacific oyster seed and market ready product. Wet storage handling of shellfish is an increasingly important activity that has required new approaches to water and materials management that has been a focus of interest. New approaches to handling and grading shellfish will be discussed with a focus on systems in use on the US and Canadian west coast.

#### **EMS – IT MAKES GOOD BUSINESS SENSE**

Ted Loveday

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Significant private and public investments are being directed to ensuring a sustainable internationally competitive aquaculture industry in Australia. As well as the normal challenges faced by all businesses, aquaculture operators and investors often face the additional challenge of securing access to suitable aquaculture resources and sites.

One of the keys to overcoming this challenge is to build public confidence in the industry and in particular that it is conducting sustainable and responsible practices. Media debates about the impacts of the fishing and aquaculture industries are often short on facts and characterised by ill-informed comment.

In response, governments are increasingly requiring operators themselves to demonstrate that their operations are sustainable and responsible. Failing to take these matters seriously has resulted in some operators being forced to spend huge amounts of time and money on rear-guard actions.

Seafood Services Australia (SSA) is helping fishing and aquaculture industry groups to meet these challenges by implementing environmental management systems, and harnessing and directing the energy of operators themselves towards demonstrating sustainable and responsible practices, and to having external impacts on the industry addressed. And there have been some exciting results.

Many operators are already proactively adopting environmentally responsible practices and meeting standards that most reasonable people would expect of them. However, very can demonstrate this, leaving them virtually defenceless against ill-informed campaigns.

Increasing community support will be forthcoming when the community at large is confident that the industry is responsible, sustainable and is actually doing what it says it is doing. Industry needs to direct investments towards demonstrating that it is.

Identifying environmental and other risks to your business is not just the right thing to do - it makes damn good business sense. SSA's Seafood EMS Resources have been developed with industry, for industry, and are especially customised to help seafood business to integrate the management of these risks into their day-to-day business activities.

EMS, its not another thing for businesses to do - its what smart businesses do!

#### LEVERAGING NEW MARKET FORCES TO DRIVE SUSTAINABLE AQUACULTURE

**Rick Humphries** 

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Sustainability is emerging as a significant business growth strategy. The global economy and specific sectors are being shaped by a range of environmental and social trends that need to be better understood by industry in order to reduce risk but more importantly identify opportunities to grow.

Australian aquaculture is no different. As wild fish stocks are being run down by an apparently insatiable demand for seafood from a growing and increasingly affluent global population, what steps need to be taken to satisfy the twin necessities of protecting marine biodiversity and providing the world's protein needs? Aquaculture would appear to be a big part of the answer.

Sustainability can potentially assist the Australian aquaculture industry redefine its business strategy by injecting new insights into the equation by posing and answering a new set of questions such as:

How can the industry leverage unsustainable fishing practices to differentiate itself in the market and attract new consumers?

Just how sustainable is the Australian industry and what's the role of accreditation? What has been the experience elsewhere?

What is the prospect of environmental organizations supporting aquaculture in Australia and how could this impact Government and investment policy and consumer preferences?

What's the role of aquaculture in future regional economic development in Australia given that the cane industry appears to be in decline? How can this be leveraged?

With socially responsible investment funds now counted in the billions, what opportunities are there to access new sources of capital investment?

Sustainability is all about new ways of doing business. Rick Humphries from Ecos Corporation, Australia's leading sustainability consultancy will discuss the potential of sustainability to assist the Australian aquaculture industry reach its potential.

#### TETRAPLOID INDUCED TRIPLOID OYSTER PRODUCTION IN NORTH AMERICA

#### Joth Davis

Mated triploid production for Pacific oysters has rapidly increased over the last five years in the northwest US as consumers have recognized the superior quality of 100% triploid yield. Approximately 40-50% of all Pacific oyster production is currently mated triploids. As the Pacific oyster industry continues to move towards half-shell production, the trend for using mated triploids is likely to increase. Other oyster sectors in North America have not embraced triploidy to this degree however as the market advantages to polyploidy for both eastern oysters and Kumamoto oysters are not as evident. In the Pacific Northwest, it is increasingly clear that not all growing environments are conducive to triploid production. Triploid oysters remain susceptible to reduced product quality, growth and survivorship when grown in sub-optimal environments. Because tetraploidy as a technology is patent protected in North America, its use in production for other species of oysters has been constrained.

Development of the capability for producing mated triploids of Crassostrea *ariakensis* for use in restocking parts of Chesapeake Bay is a current focus as is the production of tetraploid *C. sikamea* broodstocks. The development of new markets utilizing sterile, mated triploids would significantly add to the oyster production capability in North America and potentially help to rehabilitate portions of the Chesapeake Bay and other areas where oyster production is no longer possible due to water quality and disease problems. Tetraploid induced triploids may not provide the sterility insurance that the introduction of non-native species demands however, and there is continued research on the question of reversion and sterility in mated triploids. The development of improved tetraploid lines is also an area of current genetic research as to date it has not been possible to take full advantage of genetic improvement programs for oysters that have been in place over the last decade.

# SUSTAINABILITY CAN BE COST-EFFECTIVE, PRACTICABLE, ENVIRONMENTALLY RESPONSIBLE AND SAFE

#### THE LITTLE SWANPORT ESTUARY ENVIRONMENTAL MANAGEMENT SYSTEM (EMS): ONE OF SIX PILOT PROJECTS WITHIN THE SEAFOOD INDUSTRY AS PART OF THE AUSTRALIAN GOVERNMENT EMS NATIONAL PILOT PROGRAM COVERING A RANGE OF PRIMARY INDUSTRIES

Colin Dyke

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For environmental, economic and social reasons, Tasmania's Little Swanport Estuary is a vital natural resource asset. Within this region, water quality and quantity are the critical assets that must not be degraded or lost.

Several years ago the oyster growers within the estuary recognised the need to develop management strategies for maintaining natural resource condition, to ensure sustainability and profitability. In conjunction with various industries, community and all levels of government, the oyster industry has pioneered and led the development of an EMS for the estuary. Utilising resources developed by Seafood Services Australia (SSA), this innovative and dynamic system integrates the principles of the *National ESD Framework For Aquaculture*.

Investment in this EMS has already generated measurable outcomes (not necessarily measured in dollar terms alone) including attitudinal and behavioural changes towards natural resource management

Returns include the development of practicable management and monitoring controls; a water management plan; world's best practice for rice grass management and an integrated water quality monitoring program. Other outcomes include the establishment of vegetation buffer zones, innovative energy saving systems and an improved community attitude towards the aquaculture industry.

#### DEVELOPING AN AQUACULTURE BRAND - A NATIONAL AQUACULTURE COUNCIL INITIATIVE

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In partnership with the Federal Government, the National Aquaculture Council is implementing a significant industry development initiative as part of the government's Action Agenda program. The Aquaculture Action Agenda process is designed to lift overall aquaculture output from the current figure of around \$800 million to \$2.5 billion by the year 2010.

Many of the Action Agenda initiatives are really about developing a comprehensive industry strategy, taking into account factors such as research, education, environmental issues and the regulatory framework. However, if such an ambitious production target is to be achieved, the industry must vigorously take its products to the market. To this end a generic brand approach is being developed, aimed at building awareness of key attributes of Australian aquaculture amongst consumers, wholesalers and retailers at a national and international level.

John Jenkin will outline how this project is being approached, its key features and what might be expected of it.

More details are available from www.australian-aquacultureportal.com

### AN OVERVIEW OF SUCCESSES AND FAILURES FOR TRAINING AND BUSINESS DEVELOPMENT FOR SNOWY RIVER NATIVE FISH HATCHERY

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Snowy River Native Fish Hatchery has grown from a small backyard operation eight years ago to a commercial facility located in Orbost in the East Gippsland Victoria. The hatchery specialises in production of a range on native fish including Silver Perch, Golden Perch, Murray Cod and Australian Bass. More recently, the operation has also begun producing a range of ornamental fish for import replacement in the Australian market.

After initial problems with training delivery, FarmBis organised a new training company, the National Aquaculture Training Institute to deliver more meaningful and customised aquaculture training in the seafood industry training package at Certificate III to Diploma levels. The training delivered by National Aquaculture Training Institute has been successful due to a range of factors including: a customised, flexible training approach delivered by industry experts, training delivered on site, a culturally sensitive approach to training, and Farmbis and ILC funding for training.

The training has resulted in a range of positive outcomes. Not only have staff completed training but also have shown a growing self-confidence and initiative. It is suggested that these changes are just as important for Indigenous people for their developing career pathways.

#### PRELIMINARY INVESTIGATION OF EFFECT OF DIETARY NUCLEOTIDE ON GROWTH AND IMMUNITY IN BLACK TIGER PRAWNS Penaeus monodon

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The growth and survival of aquacultured organisms can be enhanced through better nutrition that may improve both growth and immunocompetence. Recently, research on mammals and fish demonstrated potential benefit of nucleotide supplements in diets to enhance immune function. This preliminary study investigates the effect of a commercial dietary nucleotide supplement (Vannagen, Chemoforma AG, Switzerland) on the growth and immune response of black tiger prawn, *P. monodon*.

Juvenile *P. monodon* were obtained from Gold Coast Marine Aquaculture Pty, Woongoolba, Qld., via CSIRO Marine Research, Cleveland, Qld. Prawns were patted dry and individually weighed. Prawns were blocked into groups of large (weight range 7.2-9.6g) or small (weight range 4.1-6.3g) animals before allocation to tanks. Water (salinity 20-25ppt,  $25\infty$ C) was changed daily (30%). Prawns were maintained in blocked groups of ten prawns per group according to size as described above, with 6 replicates per treatment. Prawns were fed to approximate satiation twice daily for 6 weeks.

Low protein (~30% total protein) diet was prepared from commercial prawn diet mash (Ridley Aquafeeds Pty, Australia). Control diets consisted of mash reconstituted with minimal water and pelleted using a Hobart mixer/mincer. Supplemented diets were prepared in an identical manner except that Vannagen (Chemoforma AG, Switzerland) was incorporated at 0.1% (w/w) during the reconstitution process.

At termination, prawns were patted dry and individual weights recorded. Haemolymph was removed into anticoagulant. Total haemocyte counts (THC) were determined in 80µl haemolymph within one hour of sample collection using a Coulter Counter. Counts and cell sizes determined by Coulter counter were validated by microscopy.

Statistical analysis was performed by the Queensland Centre for Clinical Trial Design, Princess Alexandra Hospital, Brisbane. As there was a slight imbalance in the data with respect to large and small groups of prawns, a generalized linear model analysis of variance (GLM Anova) was applied. There was a consistent significant increase in THC determined by Coulter counter across all Vannagen-fed treatment groups regardless of prawn size, when compared to control groups (Fig. 1). Vannagen also appeared to have some positive effect on growth rates in prawns, but the variance between and within tanks was such that this difference was not significant.



Fig 1. Effect of Vannagen supplement (test) on total haemocyte count (THC)

### INDIGENOUS AQUACULTURE IN THE NORTHERN TERRITORY – BAWINANGA ABORIGINAL CORPORATION

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To be successful in both financial and social terms, an Indigenous aquaculture industry must be adapted to fit with the local culture rather than requiring the local culture to fit with it, and business ethos and marketing strategies must be redefined in a way that makes them acceptable and achievable by Indigenous groups.

The majority of the Indigenous people in the Northern Territory live for most of their time in remote communities where unemployment runs at very high levels, virtually all income is derived from government sources. There is an urgent need for employment and income generating projects within these communities.

Aquaculture could form the basis for such projects, however despite there being several excellent sites for aquaculture near Indigenous communities, there is currently no significant Indigenous involvement in the aquaculture industry. This is largely due to the following factors: isolation, generally poor literacy and numeracy skills, social problems, cultural obligations, and highly mobile populations. These conditions mean that there is very little prospect at the present time for high technology, high cost industry to become established as inclusive industries within remote communities. There is, therefore, a need to develop industries of a nature and at a level of technology that will allow Indigenous participation.

Difficulties and constraints are often offset by the Traditional Owners intimate knowledge of their environment, unparalleled pristine resources and a genuine determination to achieve a degree of independence. In the Northern Territory we are working with the Aboriginal people toward establishing several Indigenous aquaculture ventures that will produce both financial and social benefits to our remote communities.

#### EARLY WEANING OF BARRAMUNDI, *Lates calcarifer* (BLOCH), IN A COMMERCIAL, INTENSIVE, SEMI-AUTOMATED, RECIRCULATED LARVAL REARING SYSTEM

Jerome M. P. Bosmans*, Glenn R. Schipp, Damon J. Gore, Ben Jones, Francois-Eric Vauchez and Keith K. Newman

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The production of live food for feeding to larvae of barramundi (Asian sea bass), *Lates calcarifer*, constitutes a major operational cost and bottleneck in a commercial hatchery. We present a commercial system that tackles these issues by using two of the latest products available in larvi culture.

We have developed an intensive, greenwater, recirculated larval system and a continuous, high density, recirculated rotifer system using the HUFA enriched chlorella paste produced by Pacific Trading Co. Ltd, Japan. The larval system consists of two 6,000 l tanks in parallel and the rotifer system has two 1,000 l tanks. Both systems include classic water treatment system. The chlorella is fed automatically and continuously to both systems 24 hours a day and offers tremendous advantages. Rotifers can be produced at high density (1,000 - 1,500/ml) and the paste is already enriched with essential fatty acids. Bacteriological studies showed that the recirculating system carries a stable bacterial population and there is an almost total absence of harmful *Vibrio* spp. The rotifers are continuously and automatically pumped directly (no rinsing) from the rotifer tanks to the larval tanks and 40-60% of the cultures are harvested per day (over 1 billion rotifers).

The other major improvement to the system is the use of the microdiet, Gemma Micro (GM), from Skretting (Nutreco) for early weaning. The latest batch of barramundi was produced without the use of any *Artemia*. The larval tanks were stocked at 100 larvae per litre (a total of 1.2 million larvae). The larvae were co-fed with rotifers for 7 days and were completely weaned by D16 with only 5% weaning mortality. Over 700,000 fry were produced from this batch with a survival of 60%. In previous batches only 1 to 2 kg of *Artemia* per million weaned larvae (Day 18-20) were used with less than 0.5% weaning mortality, which represented a 95% reduction in *Artemia* use. For economic reasons, once the larvae are weaned, GM is slowly replaced by the microdiet, Proton (INVE). Using this system we have routinely achieved a survival rate of 40-60% from 2 day old larvae through to 23 day old weaned fry (15 mm). The deformity rate of the fingerlings assessed at 100 mm was less than 1% and was not greater than previous batches reared using *Artemia*. The latest batches of larvae weaned quickly with GM and grew to 100 mm 15-25% faster (9-10 weeks from hatching) than previous batches with less size variation. This is a great advantage since barramundi are very cannibalistic and need frequent grading on reaching 3-4 weeks old. Once transferred to the nursery, the fish are much healthier and seem less susceptible to stress. The labour requirement has been significantly reduced to one person dealing with both the larval system and the live feed system. The capital cost of constructing both systems was minimal as the system was mainly built in-house using PVC and assembled using plastic welding.

More than three million barramundi fry have been produced using this system at the Darwin Aquaculture Centre over the last 12 months (5 batches). We will be producing technical and scientific papers early in 2005 describing the larval and the rotifers systems. We are now doing collaborative work with Dr. Sagiv Kolkovski, Department of Fisheries of Western Australia.

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