Development of industrial-scale inland saline aquaculture: Coordination and communication of R&D in Australia

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This project involved stakeholders across Australia. We are most grateful to all members of the Steering Committee who contributed to the direction of the project and to discussions. These included Patrick Hone (FRDC), Greg Jenkins (Challenger TAFE, WA), Adrian Collins (QDPI&F), Steven Clarke (SARDI), Andrew Buckley or nominated representative (DAFF), Geoff Gooley (MAFRI, Victoria), George Warne (Murray Irrigation Limited) and Tony Smith (Industry Representative, WA).The scientists and technicians who operated the “demonstration facilities” at each of the four centres were pivotal to this project. Each of the “demonstration facilities” was also the site for other linked R&D, funded by sources external to the current project. The willingness of all officers to share information was exemplary. Specifically we would like to thank Adrian Collins, Ben Russell and Michael Burke (QDPI&F), Stewart Fielder, Grant Webster and Dianne Brettschneider (NSW DPI), Wayne Hutchinson and Tim Flowers (SARDI), Greg Jenkins, Gavin Partridge, and Gavin Sarre (WA) and Geoff Gooley and Fiona Gavine (Victoria). The contribution from industry partners in various states is also gratefully acknowledged. In particular, Stan Malinowski and Ian McRobert from WA, George Warne (MIL) from NSW, and Paul McVeigh (pioneering aquaculture in saline water extracted from coal seam gas mining) from Dalby, Qld. We would also like to thank Jasper Trendall and staff from farms we visited in WA, including Bouverie Trout and Marron Farm (Mt Barker) and Saltlands Trout Farm (Dumbleyung). We are grateful to all members of the Saltwater Trout Alliance in WA and Brett Brenchley and Shane Hartney from the Blackwood Basin Group in WA.

The coordination project developed a number of defined outputs. We thank Carl Young for preparing the investment directory, Nick Ruello for the market analysis, Jasper Trendall for the case study with trout, Bill Johnston for the economic models and Tom Losordo for the temperature model. At the start of the project Alexandra Bagnara (NAC) developed the communication plan and initiated the web site. Finally, we thank all those people who have assisted with the development of commercial ISA in Australia.

NON-TECHNICAL SUMMARY

2004/241	Development of industrial-scale ISA: Coordination and communication of R&D in Australia

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OBJECTIVES:

1. Facilitate rapid commercialisation of regionally appropriate ISA technology.
2. Manage communication and technology transfer among research providers, funding agencies, salinity managers (federal, state and local government, MDBC), industry and the National Action Plan for Salinity & Water Quality.
3. Identify and review national priorities for research, development and extension on ISA.
4. Help ensure scientific methodology is "world-best-practice" and consistent with the National R&D Plan for ISA.
5. Produce an investment directory.
6. Produce Economic Feasibility studies on the selected state projects.
7. Present the project at Australasian Aquaculture 2004.
8. Establish demonstration facilities at key locations.

NON TECHNICAL SUMMARY:

Outcomes Achieved

The project *'Development of industrial-scale ISA: Coordination and communication of R&D in Australia'* ran from March 2004 until July 2007. The project was funded by the FRDC and the Australian Government, Department of Agriculture, Fisheries & Forestry (DAFF). The National Aquaculture Council (NAC) was the applicant and Dr Geoff Allan from NSW Department of Primary Industries (NSW DPI) (ex NSW Fisheries) was the Principal Investigator. Mrs Helena Heasman (NSW DPI) acted as Executive Officer for the project.

Objectives and summary of progress against objectives are:

1. Facilitate rapid commercialisation of regionally appropriate inland saline aquaculture technology

This project helped commercial development of ISA in Australia by managing communication and technology transfer and developing a central point for potential investors where they can access regularly updated information to assist with making informed business decisions about investment in ISA.

2. Manage communication and technology transfer

A communications plan was developed with the project team and key stakeholders (through the project steering committee). Communications were managed through the web site, annual meetings of the steering committee and key stakeholders, organisation and participation at ISA sessions at the Australasian Aquaculture Conferences in 2004 and 2006 and through direct telephone and email communication with stakeholders and potential investors.

3. Identify and review national priorities for research, development and extension

R&D priorities were finally reviewed by the Steering Committee and selected stakeholders at the first (April 2004) and last (June 2007) coordination meetings. A review and updated R&D Plan has been produced.

4. Help ensure scientific methodology is "world best-practice"

This objective was achieved by sharing and discussing proposed methodology, dissecting research plans among the Steering Committee, reviewing progress and reports, preparing and presenting results at international conferences and publishing results in international journals.

5. Produce an investment directory

The investment directory provided a single point source for information on ISA. This contained contact details of researchers, salinity managers, government policy makers and those involved with farming. The R&D plan was highlighted and a comprehensive risk analysis framework developed. All technical information was presented within the investment directory as well as relevant regulations affecting development.

6. Produce economic feasibility studies on the selected state projects

In NSW, biological information for trout was supplied to Lonsec Ltd who completed an investment analysis that demonstrated that a 200 t/yr trout farm could be an attractive investment opportunity if operated in conjunction with a saline groundwater interception and evaporation scheme like the one near Wakool operated by Murray Irrigation Limited. The research at Waikerie in SA was delayed as facilities were completed after the project commenced. Technical information obtained and has been used in economic models and these will be available from PIRSA. In WA, initial modelling using the inland saline recirculation culture model looked attractive though difficulty with managing pond algal blooms and water quality remain a challenge to economically viable ISA using Semi-intensive Floating Tank System (SIFTS) in the saline water bodies in WA. The Saltwater Trout Alliance is a cooperative of small farmers in southwestern WA. This alliance is being maintained and there is potential for modest expansion (in the order of ~10 t/yr). In Qld, QDPI&F have refined economic models for a range of species and systems, including ISA. QDPI&F offer investors the opportunity to discuss potential for investment on a one-for-one basis.

7. Present the project at Australasian Aquaculture 2004

Special sessions on ISA were arranged for Australasian Aquaculture 2004 and Australasian Aquaculture 2006. The sessions included papers from collaborators associated with this project as well as international experts in the field and other scientists working on ISA in Australia. Both sessions were well attended and discussion periods were very useful.

8. Establish demonstration facilities at key locations

Demonstration facilities were established and maintained in NSW, Qld, SA & WA. At all locations, demonstration facilities were used to hold open days and to provide a source of biological and technical information to potential investors, salinity managers, government officials and members of the public.

KEYWORDS:

ISA, Trout, Silver perch, Prawns, Mulloway, Barramundi

1. BACKGROUND

Research providers in Australia have been investigating the potential for using inland saline groundwater for aquaculture for several years. The Victoria Department of Agriculture and Fisheries completed the first scoping studies in a small pond in northern Victoria. Following this, NSW Fisheries conducted early research in collaboration with the CRC for Aquaculture and Murray Irrigation Limited in a small pond located within the Wakool/Tullakool Sub-Surface Drainage Scheme (WTSSDS) near Wakool in south-western NSW. The results indicated that, provided minor adjustments in the chemistry of saline groundwater were made, snapper could survive winter temperatures down to 8^{o}C and they grew rapidly in summer when temperatures ranged up to 31^{o}C. Saline groundwater from many areas in the Murray Darling Basin in NSW is deficient in potassium, in comparison to levels found in coastal seawater of similar salinity. However, potash fertiliser can be used easily and economically to solve the problem.

Rising salinity is the biggest environmental problem facing inland Australia with millions of hectares of land becoming unproductive because of rising salt. Hundreds of millions of dollars have already been spent within the Murray-Darling Basin and at least $100 million more are planned to be spent over the next ten years to construct saline groundwater interception and evaporation schemes to prevent saltwater rising to the plant root zone. These schemes are effective but are very expensive and leave a large “foot print”. If commercially viable aquaculture can be developed in association with these schemes, it may mitigate the costs of establishment and maintenance of both the schemes and aquaculture. In other parts of Australia, e.g., WA and Qld, saline groundwater or saline lakes also offer the potential for aquaculture. Provided effluent can be managed and salty water does not leak into freshwater drainage systems, these resources may offer exciting opportunities for commercial aquaculture.

Incorporation of aquaculture into existing and planned groundwater interception schemes was highlighted in the R&D Plan for ISA that was released by the Fisheries Research & Development Corporation (FRDC). A companion Resource Assessment that lists major sources of inland saltwater in groundwater interception schemes, saline lakes, underground saline aquifers and other sources was released by FRDC at the same time. The two Reports are now available from FRDC, PO Box 222, Deakin West, ACT, 2600 or NSW DPI, Port Stephens Fisheries Centre, Private Bag 1, Nelson Bay, NSW, 2315.

The successful early results with snapper and the positive recommendation from the FRDC R&D Plan stimulated further development of research facilities to thoroughly evaluate the potential for using inland saline groundwater for aquaculture. In response, NSW Fisheries and Murray Irrigation Limited planned and constructed the ISA Research Centre (ISARC) near Wakool in southwest NSW. This facility includes a 36-tank bioassay facility, 16 x 500-L tank grow-out facility, 5 x 500 m^2 plastic-lined ponds and office facility.

There have also been significant investments in ISA in Victoria, South Australia, Western Australia and Queensland. All these states have current active research programs in this area but there is no formal collaboration and limited communication between the different groups.

The recent FRDC publication *‘Modelling Australia’s Fisheries to 2050: Policy and Management Implications’* states that aquaculture, particularly ISA presents exciting opportunities to bridge the supply-demand gap for seafood in Australia over the next 50 years. Investigating ISA is a specific priority under initiative 4 (growing aquaculture within an ecologically sustainable framework) of the Aquaculture Industry Action Agenda.

Provided appropriate technology to culture marine or salt tolerant freshwater species using saline groundwater can be adapted or developed, ISA could become a significant new rural industry. In contrast to coastal Australia, especially the east coast, land adjacent to supplies of saline groundwater is very inexpensive and widely available. Increasing rural economic activities through aquaculture will stimulate regional economic development and employment. As production expands, the emerging ISA industry will also assist meet increasing national demand for seafood and stem rapidly increasing seafood imports.

There are several examples of large-scale “commercial” aquaculture of marine or estuarine species in inland areas overseas. In Arizona, USA a new prawn farming industry is emerging that is totally dependent on saline groundwater. Salinity of the groundwater ranges from 2 – 6 mg/l, between 80 and 100 ha of ponds have been constructed and in 2001, 120 tonnes of prawns were produced. Prawn farming in provinces in Thailand is another example. Here the salt water, in a very concentrated form, is transported inland to raise salt levels in freshwater ponds so farmers can produce estuarine prawns. Governments have regulated against expansion of this activity in Thailand, not because it doesn’t work, but because of problems with salt transport inland. In areas where salt and salt water already exist inland, this is not a concern. In Israel, there are a number of successful commercial pond and tank-based operations utilising inland saline water (Forsberg *et al.*, 1996; Samocha *et al.*, 1998).

References:

Forsberg, J.A., Dorsett, P.W. and Neill, W.H., 1996. Survival and growth of red drum *Sciaenops ocellatus* in inland saline groundwaters of west Texas, USA. Journal of the World Aquaculture Society 27(4): 462–474.

Samocha, T.M., Lawrence, A.L. and Pooser, D., 1998. Growth and survival of juvenile *Penaeus vannamei* in low salinity water in a semi-closed recirculating system. Israeli Journal of Aquaculture-Bamidgeh 50(2): 55–59.

2. NEED

Demand for seafood throughout the world is increasing while landings from capture fisheries are static. In Australia, the growing seafood consumption is being increasingly met by importation (imports of fisheries products have increased by 52%, over the period 1991/92 to 2001/02; ABARE 2002). In Australia, the value of aquaculture production has trebled since 1991/92 representing an annual growth of 14% in nominal terms and 11% in real terms. The Federal Government has committed to an Aquaculture Industry Action Agenda that plans to triple the value of aquaculture production to $2.5 billion by 2010 and create 29,000 new jobs. However, expansion of coastal aquaculture is limited by a shortage of suitable sites with the necessary water quality, depth and proximity to land-based infrastructure that are not either being used or considered for urban and tourist related development or judged to be of too high environmental value for aquaculture. Investigating ISA is a specific priority in this agenda.

Rising saline groundwater is the biggest environmental problem in Australia and currently affects over 2.5 million ha of land. It is estimated that within the next 30 – 40 years, the affected area will grow more than fourfold. One of the key methods to ameliorate the effects of salinisation is to pump the saline groundwater into large ponds for disposal by evaporation.

ISA (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. In other areas, e.g., Qld and WA, opportunities exist to exploit existing saline groundwater (e.g., from bores in Qld and in saline lakes in WA) without having any negative environmental impact.

Preliminary research had indicated that provided potassium is added to saline groundwater from the Murray-Darling Basin it is suitable for farming marine fish and crustaceans. In order to generate enough accurate data to allow the economics of ISA to be evaluated, the ISA Research Centre (ISARC) at Wakool-Tullakool Sub-Surface Drainage Scheme was constructed. A research program has been initiated in NSW to evaluate the suitability of saline groundwater for marine and salt-tolerant species. However, other enterprises in other states are also exploring the commercial viability of ISA. In Qld, scientists from BIARC are working with farmers to develop methods for production of black tiger prawns using saline groundwater in ponds where no water is released into the environment. This is leading edge technology which is economically viable and will have enormous potential in low saline inland areas as well as on the coast. In WA, scientists from Challenger TAFE are developing methods to intensify production in saline lakes through the use of in-pond partial recirculation floating tanks in which the majority of suspended solids and uneaten foods are removed. South Australia is also developing technology for ISA that is specific to the region. A key requirement for development of ISA is the expansion of existing facilities to allow them to be used as demonstration centres. The aim is to develop a growout protocol for commercially viable aquaculture in the region and to transfer the technology to the industry and government bodies involved with new salinity control schemes.

Initial studies at ISARC have been completed successfully with mulloway, snapper, silver perch, trout and black tiger prawns. The ISARC at Wakool is the only research centre mainly focused on proving the commercial viability of ISA associated with groundwater interception and evaporation schemes.

A national network between various State Departments in Australia is needed to improve the quality of research, prevent unnecessary repetition of the research programs, help ensure efficient technology transfer and finally, if the commercial validity is proven, develop an aquaculture industry based on saline water in inland Australia. Several agencies (ACIAR, AFFA, National Aquaculture Action Agenda, Implementation Committee) have committed to or are considering projects to be undertaken at ISARC. The ISARC could act as a focal point for this R&D and communicate progress to stakeholders. This view has been supported by the Aquaculture Committee of the Australian Fisheries Management Forum.

The fragmented nature of inland saline research has also made it difficult for those interested in the field to easily access the collective information available. This will continue and get worse unless there is some coordination of R&D and report production/extension. The ISARC can play a key role here.

3. OBJECTIVES

1. Facilitate rapid commercialisation of regionally appropriate ISA technology.
2. Manage communication and technology transfer among research providers, funding agencies, salinity managers (federal, state and local government, MDBC), industry and the National Action Plan for Salinity & Water Quality.
3. Identify and review national priorities for research, development and extension on ISA.
4. Help ensure scientific methodology is "world-best-practice" and consistent with the National R&D Plan for ISA.
5. Production of an investment directory.
6. Production of Economic Feasibility studies on the selected state projects.
7. Present the project at Australasian Aquaculture 2004.
8. Establishment of demonstration facilities at key locations.

4. METHODS

1. Investment in ISA is constrained by inherent risks in unproven technology. Scientists in NSW, SA, WA and Qld are rapidly developing environmentally sustainable technology for ISA of a range of fish and crustaceans. As this research progresses, the economical viability will be assessed. The next step will be to transfer this technology to the commercial sector. Experience has shown that new farmers are most likely to be influenced by other farmers or the first-hand demonstration of practical farming methodology. One of the most cost-effective ways to achieve this is through establishment and maintenance of demonstration facilities. This must be supported by farming manuals, economic models and peer-reviewed publications. This project established practical demonstration facilities at ISARC in NSW, in Qld, WA and SA In each region, funds were directed to ensuring new potential investors were able to view first-hand successful farming technology. Region-specific investor briefs were developed. Comprehensive farming manuals on different farming techniques for aquaculture using saline groundwater in different regions were produced. Demonstration centres and preparation/dissemination of this material will be coordinated by a Steering Committee comprising representatives from each region, the Murray Darling Basin Commission, Murray Irrigation Limited, FRDC and agencies providing significant support. The following interim Steering Committee was appointed:

S. Bennison (Interim Chair)
G. Allan (NSW)
P. Hone (FRDC)
G. Jenkins (WA)
A. Collins (Qld)
S. Clarke (SA)
A. Buckley or nominated representative (DAFF)
G. Gooley (Vic)
P. Pfeiffer (MDBC)
G. Warne (MIL – industry)
T. Smith (WA – industry)

The Steering Committee (SC) formulated criteria for establishing demonstration facilities in each state and reviewed the use of these facilities on an annual basis. The SC met for the first time in June 2004 then August 2005, January 2006, June 2007 with teleconferences in December 2005 and October 2006.

One of the key activities to facilitate rapid commercialisation of appropriate technology was the "Investment Directory". This is a comprehensive directory for potential investors that includes:

(i) Information on regional (i.e., state and local government) planning and approval processes for aquaculture;

(ii) Available resources for ISA (including location and characteristics of saline groundwater, interception schemes, saline lakes, evaporative ponds and other infrastructure);

(iii) R&D projects, personnel and results;

(iv) Government assistance schemes.

The Investment Directory was prepared by collaborators and consultants (coordinated by the CEO of the National Aquaculture Council).

At the June 2004 ISA workshop held in Sydney the following were listed as key issues that needed to be addressed to assist commercialisation:

(i) *Resource allocation.* A substantial description of available resources for ISA is available from the FRDC (Allan, Banens & Fielder, 2001) and information was updated and where appropriate entered into the "Investment Directory" described above.

(ii) *Economic feasibility study.* A primary aim of each R&D project that underpins activities at the demonstration facilities is to assess economic viability. This was coordinated by the SC and three specific economic decision-making interactive models prepared. A small consultancy was commissioned to achieve this.

(iii) *Market research.* The market will drive the success of ISA. Most species currently being considered for farming are high value species with established market potential. However, markets will change in relation to demand and supply for other domestic and overseas aquaculture industries. Up-to-date information on markets and market potential is crucial data for potential investors. The national Aquaculture Action Agenda Implementation Committee has commissioned a major consultancy on aquaculture markets and this project on ISA linked into that consultancy through the project Steering Committee and the Implementation Committee. A specific Market and Supply Chain development was commissioned as well as a separate supply chain case study for inland saltwater trout in Western Australia.

(iv) *Temperature modelling.* One of the fundamental differences between inland and coastal aquaculture of marine species is the very different climate (especially temperature) in inland areas. For example, at Wakool, water temperatures in shallow ponds can vary diurnally by 10°C while seasonal variations of 25 – 30°C have been recorded. A reliable model that relates water temperatures to air temperatures will be a key tool for investors seeking to find the best location for culture of different species. The temperature model was commissioned through the University of North Carolina after no Australian engineering firms indicated interest or capacity in developing a model.

2. At each of the two Australasian Aquaculture Conferences (2004 & 2006), a special session on ISA was organised. This session sought contributions from Australian and international scientists involved with R&D on ISA and from salinity managers and aquaculturists who have invested in ISA. The session included presentations and a discussion aimed at identifying constraints to commercial development. Following this session, and on-going communication among stakeholders in Australia and practitioners of ISA overseas, the National R&D Plan for ISA was revised.

3. An annual workshop was held to discuss and improve scientific methods proposed for R&D on ISA in Australia. This workshop involved those scientists involved in R&D within Australia. The objectives were to ensure research was carefully designed to minimise the cost and maximise the benefits of the results. A guide to generic research methodology was a component of the proceedings of the first workshop.

4. "Technology briefing workshops" were designed to inform salinity managers about ISA and how this might be incorporated into groundwater interception and evaporation schemes. These workshops were held at the ISA Research Centre at Wakool, during ISA sessions at the Australasian Aquaculture conferences and directly with salinity managers. Specifically designed briefings were delivered to the MDBC, private operators of groundwater interception and evaporation schemes and local council representatives.

5. Publications from collaborating scientists were discussed and reviewed. A bi-annual research summary was produced and posted on the web to keep all stakeholders informed of progress. An internal review process for scientific publications will be developed and managed to improve the quality of scientific manuscripts and final research reports. Non-technical reports will be written. A website will be established and maintained. Content will be updated at least every 3 months and all reports (research summaries, non-technical articles, workshop proceedings etc.) will be posted on the web. Links with other suitable websites will be maintained where appropriate.

Reference:

Allan, G.L., Banens, B. & Fielder, S. (2001) Developing Commercial ISA in Australia: Part 2. Resource Inventory and Assessment. Final Report to FRDC Project No. 93/335. NSW Fisheries Final Report Series No. 31.

5. RESULTS

5.1. Demonstration facilities

5.1.1. Introduction

The following demonstration facility description template was designed and applicants (TAFE WA Challenger; SARDI Aquatic Sciences; QDPI&F & NSW DPI) were invited to submit their bids by 15 April 2004:

DEVELOPMENT OF INDUSTRIAL-SCALE INLAND SALINE AQUACULTURE (ISA): COORDINATION & COMMUNICATION OF R&D IN AUSTRALIA

APPLICATION FOR FUNDING TO ASSIST ISA DEMONSTRATION FACILITIES

APPLICANT:

CONTACT OFFICER:

FACILITY:

Description of facility:

Ownership and approvals:

Purpose of facility:

Summary of progress:

Estimated potential for aquaculture industry growth:

Commitment to ongoing R&D:

Plan for demonstration activities for 2004-2007:

Plan for expenditure from project to facilitate demonstration activities:

2003/04:
TOTAL $30,000

2004/05:
TOTAL $15,000

2005/06
TOTAL $15,000

Sections 5.1.2 to 5.1.5 comprise completed templates together with a final report on progress at each demonstration facility.

5.1.2. Challenger TAFE, WA – Application for Demonstration Facility and summary of R&D progress

APPLICATION

CONTACT OFFICERS

Mr Greg Jenkins, Aquaculture Development Unit, WA Maritime Training Centre

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Secondary:

Dr Gavin Sarre, CY O'Connor College of TAFE, PO Box 498, Northam, WA.
sarreg@northam.training.wa.gov.au

FACILITY:

Springfield Waters Aquaculture (SWA) Inland Saline Research Facility, Northam WA

Description of facility:

SWA is located on freehold land in the Wheatbelt town of Northam, *ca*.100km from Perth. SWA was first utilised as an R&D site for a collaborative, FRDC funded project in 1997 by Murdoch University and the Aquaculture Development Unit (ADU) of Challenger TAFE.

The SWA facility includes:

- 175m^2 insulated nursery shed with office and work area.
- 55m^2 storage shed.
- 12 x 0.01 ha netted, earthen research ponds.
- 2 ML water storage reservoir.
- 2 x 0.2 ha commercial grow-out ponds.
- 4 x 0.02 ha clay ponds.
- 1.5 ha recreational fishing pond.
- 4 x 5000l polyethylene tanks.
- 10,000l quarantine RAS.
- 22,000l rainwater tank.
- Saline water bore supplying 300,000l/day @ 14ppt & 22^{o}C.
- On-site 2 phase power.
- Assorted demonstration aquaria.
- 15 floating net pens.

Ownership and approvals:

SWA is the industry partner of CY O'Connor College TAFEWA (CYCOT). A formal arrangement is in place through a memorandum of understanding (MOU). SWA holds an aquaculture license (#1709) for pink snapper, black bream, and rainbow trout and has R&D permits for Mulloway, barramundi and King George whiting.

Purpose of facility:

The facilities main purpose is to conduct research on species suitability for culture in inland saline groundwater and evaluate potential cost-effective, commercial production technologies. SWA also functions as a training facility for VET students and as an extension site for R&D activities.

Summary of progress prior to the commencement of the current project:

A collaborative project between Murdoch University and the ADU of Challenger TAFE utilised SWA as the R&D field site for FRDC project 1999/320 titled "Factors required for the successful aquaculture of black bream in inland water bodies". A series of replicated, pond-based research trials were carried out between 1997 and 1999 to address issues such as avian predation, cage *vs* free range pond culture, the efficiency of different commercial feeds and application rates and the potential for polyculture of black bream and crustaceans (*Cherax destructor albidus)*. The end result of this work was the development of guidelines for farmers to assist in maximising the survival and growth of black bream cultured in inland saline water bodies. These guidelines were incorporated into a series of short information brochures published by the WA Department of Fisheries and a one-day training workshop delivered through CY O'Connor TAFEWA.

Murdoch University, CYCOT and the ADU have also conducted a series of field trials at the SWA site to evaluate the aquaculture potential of several marine/estuarine species e.g., pink snapper, King George whiting, trout and barramundi in inland saline groundwater. This work has identified that barramundi and trout possess the required survival and growth characteristics to be viable Wheatbelt aquaculture species for grow-out during the summer and winter periods respectively. An industry funded commercial grow-out trial of saltwater trout was completed in 2002 which resulted in a cost-production model for use by farmers in the region.

Current research is now focused on the development and evaluation of production technologies to enable cost-effective, commercial aquaculture production using saline groundwater. A project funded by the Department or Education and Training through their Science and Technology Innovation program commenced in 2004 and involves evaluating a new production technology for the culture of mulloway, pink snapper, barramundi and trout. Termed the SIFTS (semi-intensive floating tank system) the technology has the potential to significantly increase fish yields from open ponds and overcome many of the obstacles relating to the management of wastes and bird predation, harvesting and handling. The SIFTS technology is background IP for this project.

Estimated potential for aquaculture industry growth:

One of the major limiting factors for ISA industry development in WA is the current inability to have intensive production of marine or estuarine fish in earthen ponds. The SIFTS technology has the potential to both intensify production in water bodies of limited capacity and to maintain sustainable production levels through the limiting of solids from entering the pond system. If this R&D is successful then any farmer with a reasonable sized body of saline water could enter the industry. Beyond that, this technology could be applied to fish production in freshwater and in near-shore oceanic sites around the world, particularly where current production technologies leads to eutrophication of local waters.

Commitment to ongoing R&D:

The partners comprising the ISAARG (ISA applied research group), which includes CY O'Connor TAFEWA, the ADU of Challenger TAFE, Springfield Waters Aquaculture and Murdoch University, have been involved in collaborative ISA R&D for over 10 years and are committed to ongoing R&D in this field. CY O'Connor TAFE have committed a 0.5FTE R&D manager (Dr Gavin Sarre) to the demonstration/research role of SWA. Furthermore, SWA's owner has provided significant in-kind time and substantial infrastructure to ensure the suitability of the SWA site for the project.

Plan for demonstration activities for 2004-2006:

- Two open days and information seminars in second half of 2004 for industry, stakeholders, government agencies and the general public.
- Local media releases and regional information seminars.
- Tours by participants of Farmbis approved aquaculture workshops that are being conducted throughout south-western Australia.
- 2 x scientific manuscripts/yr.
- At least 2 non-technical articles.
- Presentations at relevant conferences/meetings.
- Provision of TAFEWA copyright information for web site.
- Three monthly updates to NAC officer.

Plan for expenditure from project to facilitate demonstration activities:

Date	Item	Amount
31 May 04	Purchase and installation of equipment associated with demonstration facilities (e.g., predator protection device, plumbing associated with water and effluent movement).	$10,000
31 May 04	Operating costs – staff and consumables associated with installation of equipment.	$5,000
30 June 04	Purchase and installation of equipment associated with demonstration facilities (e.g., aeration equipment, solids removal devices and plumbing associated with water movement).	$10,000
	Operating costs – staff and consumables associated with installation of equipment.	$5,000
31 December 04	Maintenance and upgrade of demonstration facilities.	$10,000
30 June 05	Maintenance and upgrade of demonstration facilities.	$5,000
31 December 05	Maintenance and upgrade of demonstration facilities.	$5,000
30 June 06	Maintenance and upgrade of demonstration facilities.	$5,000
31 December 06	Maintenance and upgrade of demonstration facilities.	$5,000
TOTAL		**$60,000**

NOTE: All demonstration facilities will remain under control of Challenger TAFE at the conclusion of this project.

5.1.2.1. General summary of R&D progress in WA during the course of the project

Information provided to potential investors

Our advice to potential investors remains to approach commercial scale ISA with caution. The demonstration facility has proven invaluable for local farmers affected by salinity to see first hand what is involved in farming fish. A common misconception by such farmers after seeing the small SIFTS demonstration facility at Northam is that “you guys must be making a packet”. Explaining that a system would need to be at least 5 times bigger than the demonstration farm to be profitable effectively demonstrates the commitment and infrastructure required for a commercial scale farm. Therefore, as a result of visiting the demonstration farm, many dryland farmers have realised that intensive fish farming is not for them.

Completed economic analysis

Economic analysis will be completed at the end of our current FRDC project. A comparison of the economic viability of heterotrophic systems (which are more costly to operate) enabling 13 tonnes/ha/ 3.5 month crop will be compared against industry standard cropping rates of 5 tonnes/ha to determine whether heterotrophic pond management is economically viable.

Commercial adoption/development

We have had considerable interest from commercial companies using SIFTS technology for protected ocean environments and very large freshwater lakes. The SIFTS have proved to be a very viable production platform provided that water quality in the surrounding environment is not limiting. We have not encouraged commercial interest in the use of SIFTS for ISA in Western Australia due to the ongoing constraints discussed below.

Remaining constraints and recommendations for the future

If static water pond culture is to become a viable production system for growing fish, further research is required to optimise the bioremediation processes described in the summary below. Although heterotrophic pond management has been demonstrated to enable successful yields of 13 tonnes/3.5 month crop further research is required to optimise this management strategy. For example, it is now well established that periodic removal of such flocs is essential for exporting nutrients. Without the capability for such removal, the management strategy used in our current trials is unlikely to be sustainable over the longer term. A research need therefore exists to identify viable removal processes. This need is not ISA specific and would benefit other aquaculture industries using heterotrophic pond management.

Although there is an increased cost associated with heterotrophic pond management, it also creates the opportunity for polyculture with prawns, which are capable of utilising flocs as a feed source. Such polyculture could not only offset the increased costs associated with heterotrophic pond management, but would also provide a viable mechanism for removing flocs and exporting nutrients.

We have also been discussing alternative bioremediation strategies with the CSIRO and a private company, Phoslock. As previously mentioned, biofiltration was shown to be ineffective in static ponds due to the inability of nitrifying bacteria to compete with microalgae and heterotrophic bacteria for available nutrients. As both microalgae and heterotrophic bacteria have a requirement for phosphorus, the removal of this nutrient using Phoslock has the potential to minimise microalgal and heterotrophic bacterial blooms, thereby enabling nitrifying bacteria to convert ammonia into nitrate. Representatives from Phoslock having indicated their interest in testing this concept and collaborating with our group if the opportunity arises.

Summary – is there still potential?

It is our belief that potential for inland mariculture still exists in Western Australia, however, we believe the number of locations where commercial-scale culture is technically and economically viable are limited. The following is taken from the concluding paragraph of a review paper currently in press and summarises our belief on the potential for ISA:

> *"The greatest technical constraints identified in this review are the temperate location of the majority of water sources and issues relating to water quality, including ionic composition, potential for contamination and consistency of yield. These constraints will limit where viable enterprises can exist and will also dictate the species and culture*

methods appropriate for these areas. The challenge in developing successful enterprises therefore lies in identifying complementary combinations of these three parameters. That is, species and production systems must be appropriately matched to the physical and chemical characteristics of the selected water source or, conversely, an appropriate water source and production platform selected for the target species. Various technically viable permutations of these three variables will exist, for example rainbow trout could be cultured in ponds or tanks in areas of adequately cool climate using high-yielding groundwater sources or barramundi could be produced in controlled recirculating aquaculture systems using low-yielding groundwater or in water from disused mine voids in the North West of Australia. A further example is the alternate cropping of warm and cool water species in the temperate regions to overcome the issue of large seasonal temperature variations. Economic and market factors will be important in determining which of the various permutations are most viable. For example, without the capability for continuous production, a detailed market analyses would be required to determine if the "batch culture" strategy of seasonal production would be viable or to determine whether fish production in inland recirculating systems would be competitive with similar systems located close to the niche city markets."

Our R&D has focused on utilising innovative technologies and methods to increase yields from static ponds to a level where commercially viable, stand-alone enterprises can exist. This focus is important for Western Australia, where groundwater yields are typically only low to moderate and no large-scale interception schemes exist. Based on previous economic studies we consider the minimum level of production required for a stand-alone farm to be approximately 50 tonnes per annum. Using typical pond production figures of 5 tonnes per hectare per year, most groundwater bores in Western Australia would not provide enough water to even account for evaporation over the 10 hectares of pond area required for a commercial scale farm. Increasing yields is therefore critical to allow commercial scale culture to occur.

Our research has demonstrated that removal of solid wastes via SIFTS waste collectors was insufficient to allow yields of 25 tonnes/ha/year (9 tonnes/crop) to be achieved. Additional bioremediation techniques have been and are in the process of being tested to achieve these yields. Biofiltration was demonstrated to be ineffective due to the inability of nitrifying bacteria to compete with microalgae and heterotrophic bacteria for available nutrients. Heterotrophic pond management techniques, however, enabled a successful crop of 13 tonnes/ha to be achieved. Such techniques stabilise microalgal populations and provide more stable pH and dissolved oxygen levels. Our research demonstrated that phosphorus limitation can impede the development of bioflocs and research into optimising bioflocs is continuing.

Laboratory testing has demonstrated the potential of *Artemia* and NyPa forage to remove nutrients and ongoing trials aim to test their effectiveness in the field on a semi-commercial scale.

<u>Overview of ISA research activities on the demonstration site</u>

During the course of the NAC ISA coordination project, from 2004 to 2007, Challenger TAFE and CY O'Connor College of TAFE have conducted two projects utilising the SIFTS technology at the ISA Demonstration site at Northam.

The first project was run during 2004 and was funded by the WA State Government's Science and Technology Innovation Strategy (STIS) Fund. This project tested a 40 Tonne water capacity prototype SIFTS in a 0.13 Ha earthen pond at Springfield Waters in Northam. The second project was funded by the two Colleges, the FRDC, the Wheatbelt Development Commission and by Springfield Waters over a three year period (we are currently commencing the final year of this study) to trial a commercial model of the SIFTS in purpose built ponds. Both studies grew rainbow trout during the winter months and barramundi during summer while the 2004 trial also included mulloway.

<u>*STIS Project 2004*</u>

The collaborative TAFEWA, Science and Technology Innovation project titled *'ISA – A new marine industry for the WA wheatbelt'* was completed in April 2005. During the 14 month project, three small-scale, commercial crops of fish which included saltwater trout, mulloway and barramundi were grown-out using the SIFTS. The project (and demonstration facility) received significant media coverage which assisted in increasing the profile of ISA in the WA Wheatbelt.

The major outcomes achieved through this highly successful project included:

- The construction of a prototype, semi-commercial scale Semi-Intensive Floating Tank System, SIFTS^{TM} located at the ISA Research and Demonstration Farm in Northam.
- Results demonstrating that the innovative SIFTS technology can facilitate significantly greater levels of production (up to an estimated 27 tonnes/ha/year) at low running costs while minimising the impact of waste on the environment.
- The production, using the SIFTS, of small commercial quantities of high quality salt water trout and barramundi which exhibited fast growth rates, low mortality and exceptional feed conversion.
- Results that demonstrate that optimal dissolved oxygen can be maintained within the SIFTS, essentially independent of that in the production pond even in the presence of initially, a high coverage of macro-algae and later, a heavy micro-algae bloom in the production pond.
- Demonstration of the highly efficient, SIFTS waste removal technology which prevents up to 95% of the solid wastes produced (comprising nitrogen and phosphorous) from entering the production pond and contributing to potentially harmful pond bottom sludge.
- The generation of current and on-going opportunities for VET staff and students to experience a new and innovative aquaculture production technology.
- Significant promotion of TAFEWA and industry partners for their leading roles in the field of applied inland aquaculture research and development.
- Assistance in the leverage of additional state and commonwealth funds for further SIFTS related research, development and demonstration work.

The full project report (PDF format) as submitted to the Department of Education and Training has been provided for inclusion on the NAC aquaculture portal.

Figure 1. The 2004 pilot SIFTS.

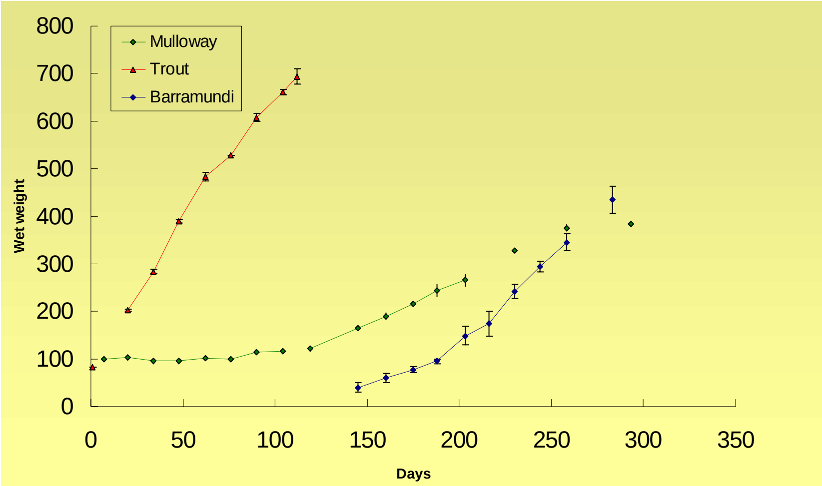

Figure 2. Growth curves of saltwater trout (upper line) and mulloway (lower line) stocked in the SIFTS between June and September 2004.

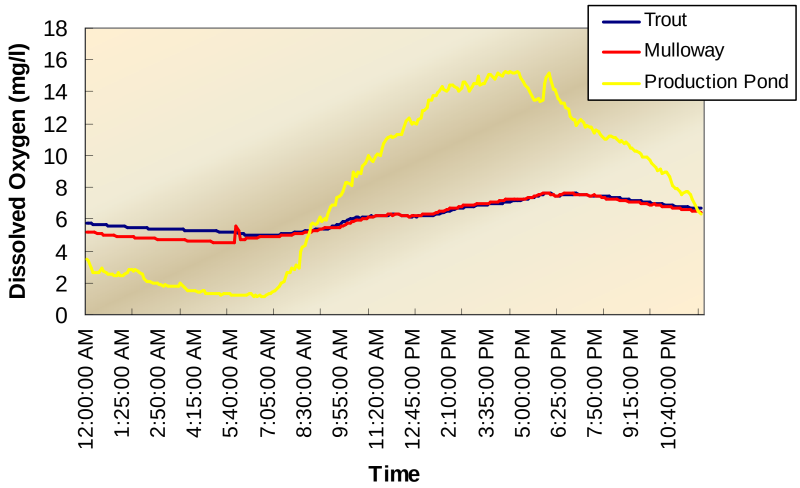

Figure 3. Diurnal variation in dissolved oxygen (mg/l) over a 24 h period in the SIFTS tanks and production pond between June and September 2004.

FRDC Project 2005 – 2008

Summary of SIFTS Trial 1 – Summer 2005 – 2006

The first of four fish grow-out trials using the SIFTS technology was completed in April 2006. The target species was barramundi with the aim of the trial being to assess the McRoberts Aquaculture System (MAS) waste removal system to minimise pond sediment and microalgal blooms.

This experiment showed that the reduction in nutrients to the ponds by the MAS waste removal system was insufficient to prevent microalgal blooms. The data collected highlighted the importance of controlling such microalgal blooms and work commenced to investigate the cropping of microalgae with *Artemia* and through the use of artificial substrates to convert ammonia into nitrate.

A shorter and significantly cooler summer resulted in lower water temperatures than previously recorded at the facility. This resulted in a lower final barramundi weight of 330g (from initial stocking weight of 65g) than in previous grow-out trials using SIFTS. Final stocking densities ranged from $26kg/m^3$ to $53kg/m^3$ in low and high density tanks, respectively.

Summary of SIFTS Trial 2 – Winter 2006

The 9,600 juvenile rainbow trout stocked into the ponds for this trial in early June 2006 died within two weeks of stocking, when all measured water quality parameters were optimal. Microtox analyses of the pond waters were positive, indicating a toxin was present. As the farm is located adjacent to a golf course, a turf club, farming land and a small airport, spray drift was considered the likely origin of the toxin.

Due to the loss of the trout, increasing quantities of inorganic nutrients were added to both ponds to mimic the excretion of nitrogen and phosphorus by fish. This approach allowed the assessment of the effectiveness of the vertical artificial substrates and of changing the SIFTS' air-lift orientation to overcome the stratification we experienced in our previous barramundi crop. During this trial the concentration of ammonia in the outflow differed by no more than 2% of the inflow concentration, highlighting that no ammonia was being oxidised by the mats.

Air-lift intakes on the four SIFTS in each pond were placed close to the bottom of the ponds to determine if this arrangement minimised or prevented temperature and dissolved oxygen stratification experienced during Experiment 2. Although the degree of stratification in this trial was significantly less than experienced in the previous trial, it cannot be attributed alone to the change in orientation of the airlifts, as during this trial blooms of *Heterocapsa* did not occur.

At the conclusion of the Aquamat® trial, molasses was added to one pond to assess whether the pH and ammonia in the ponds could be more effectively managed by heterotrophic means. The data collected suggested that the molasses addition used was insufficient to reduce TAN to a low level and that the circulation and aeration of the entire pond volume by the SIFTS air-lifts was insufficient to maintain the heterotrophic flocs in suspension. Based on these data and observations, we designed and ran the trial in the summer of 2006 – 2007.

Summary of SIFTS fish culture trial 3 – Summer 2006 – 2007

In this trial Pond 1 acted as an autotrophic control. For the first half of this trial, no in-pond bioremediation techniques were employed, however, the destratification techniques described above were tested again to determine if the pond remained destratified during *Heterocapsa* blooms.

During the second half of the trial, *Artemia* were stocked into 2 additional SIFTS (modified to retain *Artemia*) within this pond. The concentration of microalgae in 24-hour composite samples from the inlet and outlet of the duplicate SIFTS were routinely measured to determine the consumption rate of the microalgal cells by the *Artemia*. The number of *Artemia* stocked was determined after detailed analysis of the consumption with temperature data obtained from laboratory trials. Pond 2 was managed throughout the trial as a heterotrophic pond, with daily additions of molasses made as a function of the daily feed rate as described above.

Water quality, bottom sludge analysis and nutrient budgets for these two ponds were made according to previous experiments and growth of the barramundi was monitored and compared between ponds as described in previous milestones.

Figure 4. Harvested barramundi (right) from one of the production SIFTS with liner partly inflated (left).

This trial commenced on the 8th December 2006 with 1200 juvenile barramundi (106 gram average) stocked into each of 4 SIFTS within each of the two ponds. One pond was managed as a heterotrophic system utilising molasses as the carbon source and using aerators to maintain the resultant flocs in suspension. The successful trial concluded on 21st March with 3.75 tonnes of barramundi harvested. The results of this experiment will be reported once the milestone report to the FRDC has been accepted.

<u>*Other related ISA trials*</u>

The determination of microalgal filtration rates by Artemia in inland saline water bodies

We investigated the use of *Artemia* to crop microalgae from static inland saline ponds in order to control the microalgae blooms and resultant crashes. A preliminary study showed that *Artemia* survive equally well at a salinity of 15 ppt compared with 30 ppt and grow at a faster rate.

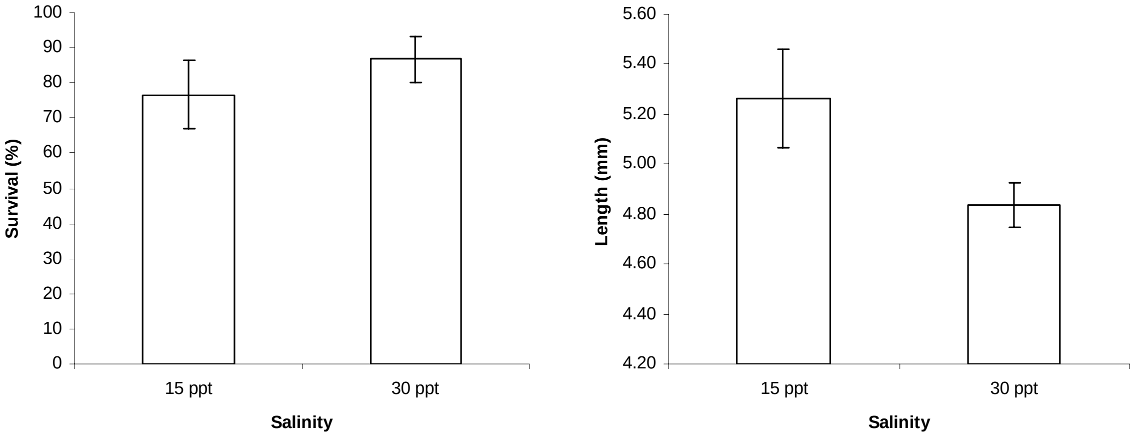

Figure 5. Survival and growth of Artemia in 15 and 30 ppt salinity.

A more detailed study has been completed investigating the growth and filtration rate of *Chaetoceros muelleri* by *Artemia* at 15 ppt salinity (i.e., the salinity of the SIFTS ponds) across the range of temperatures experienced in saline aquaculture ponds in the Wheatbelt of WA.

The collected data show that *Artemia* can effectively crop microalgae at the salinity of the SIFTS ponds and to temperatures down to 20°C. Despite a great deal of literature on the culture of *Artemia* in saline and hypersaline water sources, this appears to be the first demonstrating their ability to grow in low salinity water. We will use these ingestion data with comparative data on the size and energetic content of *Muelleri* compared with *Heterocapsa*, to determine the number and frequency of *Artemia* stockings into the modified SIFTS in order to maintain *Heterocapsa* blooms at safe and stable densities. Further laboratory studies are also underway on the efficiency at which *Artemia* retain nitrogen from microalgae to determine the impact such cropping will have on the overall nutrient budget of the static ponds.

Field assessment of nutrient and salt uptake from aquaculture effluent by Distichlis NyPa Forage cultivars

In this trial the growth and yield of NyPa irrigated with nutrient-rich saline water from the SIFTS ponds was compared against those irrigated with nutrient-free saline bore water.

Four $100 m^2$ field plots (duplicate plots per treatment) have recently been established adjacent to the ponds containing the SIFTS. The plots have been reticulated and fenced (Figure 7). NyPa Forage shoots were planted at 0.5 m spacing in November. It appears at this stage that establishment of the shoots has been poor. Although Northam has recently experienced a plague of locusts, we hypothesise that the poor performance of the shoots is primarily due to their inability to establish when irrigated with saline groundwater. We aim to conduct laboratory trials to test this hypothesis and provide comparative data on the salinity tolerance of shoots versus established plants. New shoots are being obtained for this purpose and as a source for established plants to replant into the field plots if required.

Figure 6. Four irrigated and fenced 100 m^2 NyPa field plots adjacent to SIFTS ponds.

Promotional activities

2004

During the course of this NAC project there have been numerous site visits from a range of people and groups. These include: Mr Peter Rogers (CEO Fisheries), Hon Max Trenorden (Leader of the Parliamentary National Party), Mr Ian Fischer (Chair of the Regional Investment Group), Mr Russell Barnett , Mr Peter Armanasco (Water Corporation), Ms Suzanna Carter (Wheatbelt Area Consultative Committee), Mr Peter Mahler (MD of CYO'C TAFE) and Mr Malcolm Goff (MD of Challenger TAFE).

Two open days were held in the second week in October 2004. The Minister for Agriculture and Fisheries, Hon Kim Chance opened the ISA Demo Farm on October 12 for invited quests with the following day open for the public.

The ADU hosted an Industry breakfast on August 6th that featured the SIFTS project. This breakfast was attended by 50 government and industry persons and extremely positive feedback of the project was forthcoming.

There has been good media coverage in recent months (newspaper articles follow). The SIFTS project also featured on the ABC Stateline show on August 13, 2004. This media segment can be viewed by following the instructions included below.

To download the video click on this link:
ftp://ftp.cityoflights.com.au@ftp.arach.net.au/CLIENT%20access/

A window will pop up asking for User Name (should automatically insert ftp.cityoflights.com.au) and then you type the password 12345 into the relevant field. The browser window will display the folder McRobert_Aquaculture_Systems. Double-Click it. > You will see the files:

'(Full) Mobile Grader.wmv'
'(Short) Mobile Grader.wmv'
'MAS (ABC).wmv'

RIGHT-click on your choice and select 'Copy to folder...' > (Netscape Users select 'Save Link As...')
The normal 'Save' window will pop up and you can choose where you want to save the file (e.g., Desktop). >
Double-click the file when the download has completed and the video will play in the WindowsMedia player.
(Download can occur 'in the background' while you do other work on the computer).

This SIFTS project has received substantial industry exposure through its presentation at the Australasia Aquaculture Conference in Sydney (September 2004) and recently through the official and public open days (October 12 and 13) during which over 150 people attended. A series of multi-media presentations provided the attendees with a history of the collaborative R&D work undertaken by the project partners leading to the launch of the SIFTS technology. The Springfield Waters ISA Demonstration Facility was formally opened by the Minister for Fisheries, Forestry and Agriculture Kim Chance MLC.

Figure 7. Tour of the ISA demonstration farm and the SIFTS.

The TAFEWA partnership and SIFTS project (CYOCT and Challenger TAFE) were finalists in the StateWest Achievement Awards for excellence provided to the Western Australian community by workers throughout the public sector.

The award dinner was held at Government House on November 24th where we were judged runners up and awarded a “Special Merit” for development of sustainable inland aquaculture.

2005

- CY O’Connor and Challenger TAFE hosted the annual meeting of the National ISA Steering Committee in January. The members and invited guests were provided a tour of the Northam facility prior to a two day workshop at the CY O’Connor and Challenger TAFE campuses.
- Dr Gavin Sarre was an invited guest to the WA government cabinet luncheon held in Northam in February. Dr Sarre took this opportunity to brief the Minister for Fisheries, The Hon. Jon Ford, on the progress of the ISA project and general issues associated with aquaculture development in the Wheatbelt region.
- Dr Sarre has delivered two ISA information seminars to prospective aquaculturists and landowners in the Wheatbelt region.
- Gavin Partridge and Ian McRobert were selected from 48 episode winners to appear on the grand final of the ABC’s The New Inventors in December 2005.

2006 – July 2007

The investigators of this project have been collaborating with members of the Rural Town's Program on investigations into the potential of using the 600 kL/day of saline groundwater being pumped from beneath the town of Merredin for fish production. Gavin Partridge has worked closely with Dr Jo Pluske from the School of Agricultural and Resource Economics at The University of Western Australia in populating Bill Johnston's ISA model for mulloway production in SIFTS in this water source. This model will form part of a report by Dr Pluske on the economic viability of various water-use options for the town of Merredin. Members of this group from the Rural Towns Program will be visiting Northam Demonstration Farm in the coming months, once the trout have been stocked for the final trial.

The McRobert Aquaculture Group continues to make progress on the commercialisation of SIFTS. The 50 tonne SIFTS farm in Fremantle Harbour has been approved by the Department of Environmental Protection, Fisheries WA and the Fremantle Port Authority and has now been completed. This farm will demonstrate the applicability of SIFTS in a protected ocean environment and will act as a showcase for potential investors and joint venture partners. The SIFTS will be stocked with ocean trout in July 2007. An article featuring the launch of the first of these 50 m^3 units appeared in the Fremantle Herald on 5th December 2006.

Figure 8. Newly installed, 6 x 50m^3 SIFTS in Fremantle Harbour.

Local media releases and regional information seminars

- A media release detailing the provision of FRDC funds to Challenger TAFE for an ISA project was released on May 11, 2005.
- Numerous local newspaper reports on the ISA activities of the CY O'Connor and Challenger TAFE College's activities have been collated and their titles are at attachment B.
- *'More National Exposure for Fish Farm'*, Avon Advocate, November 30, 2006.
- *'Award for Fish Farm System'*. Fremantle Herald.

Tours

- Hon. Max Trenorden MLA. Leader of the Parliamentary National Party.
- The Hon. John Bowler, Minister for Local Government and Regional Development.
- Iraqi Ministry of Agriculture (+3).
- Dr Mark Hardy (+3) from Department of Agriculture (Western Cape, South Africa).
- John Talbot, DAFF.
- Dennis Ah-Kee, Indigenous Aquaculture Unit, DAFF.
- Richard Stevens, WAFIC.
- Patrick Hone, FRDC.
- Simon Bennison, NAC.
- Challenger TAFE, Industry Advisory Group.
- David Singe, Director, Wheatbelt Development Commission.
- 39 farmers and local industry representatives.
- The Wheatbelt Development Commission (partnership organisation on FRDC project) full board of management toured the ISA facility on 14 December 2005.
- Visit by an Elders Farm improvement group from Victoria (18 participants) November 2005.
- Apex (55 delegates attending WA state convention).
- Australian Grains Institute (38 board and member delegates).
- WA Regional Development Council (25 Reps – Tour).
- Beverley District High School (Tour and seminar).
- Wongan Hills Farm Improvement Group (15 Reps – Tour and seminar).
- WA Department of Fisheries (3 Reps – Tour).
- Department of Environment and Conservation (2 Reps).

Scientific manuscripts

- Partridge G.J., Sarre G.A., Ginbey, B.M., Kay, G.D., Jenkins, G.I. 2006. Finfish production in a static, inland saline water body using a Semi-Intensive Floating Tank System (SIFTS). Aquacultural Engineering, **35**: 109–121. This publication featured in Science Direct's Top 25 most downloaded papers in the last two quarters to date.
- Partridge, G.J., Lymbery, A.J., George, R.J. In Press. Finfish mariculture in inland Australia: A review of potential water sources, species and production platforms. Journal of the World Aquaculture Society.
- Partridge, G.J., Lymbery, A.J. The effect of salinity on the requirement for potassium by barramundi (*Lates calcarifer* (Bloch)) in saline groundwater. Submitted.
- Partridge, G.J., Lymbery, A.J., Bourke, D.K., Larval rearing of barramundi, *Lates calcarifer* (Bloch) in saline groundwater. Submitted.

Non-technical articles

- *'Paving the way for a viable ISA industry'* AUSTASIA Aquaculture, Volume 19, No 1 – February/March – 2005.
- Wilson, G. (2005). *'SIFTS increases Queensland's fish farming potential'*. AAQ Newsletter, October 2005.
- *'New Inventors program awards WA Aquaculture innovators'*. ProWest July – August 2005.
- *'SIFTS Aquaponics Research Awarded $1.4 million'*. Aquaponics Journal. Issue 38. 3rd Quarter 2005.
- 'McRobert Aquaculture Systems – Developers of a Radical New System Called SIFTS'. Fish Information Services. 30 August, 2005.
- *'Challenger TAFE + Industry = Innovative Solutions'*. Quest Magazine. Vol 4 (1). June 2005.
- *'Hopes high for Shift to SIFTS'*. FRDC R&D News. July 2005.
- *'Challenger TAFE wins on The New Inventors'*. 7 Waves Magazine. June 2005.
- *'Award for Fish Farm System'* West Australian Newspaper May 2005.
- '*Saltwater fish farm grabs TV spotlight'* West Australian Newspaper, May 12, 2005.
- *'The New Inventors'* Sunday Times May 15, 2005.
- *'1.4M development could revolutionise aquaculture'* WA Business News June 2 – 8, 2005.
- *'SIFTS'* Aquaculture Association of Queensland Newsletter December 2004.
- Farm Weekly. January 2006. *'Commercial Fish Farming Study'*.
- Project collaborators Dr Dirk Erler from RMIT and Mr Dan Willett from QDPI visited the Northam demonstration farm from 4th to 8th November 2006 to advise on the setup and management of the heterotrophic pond system and to assist in formulating the experimental design for Experiment 6. An article on their visit was published in the February 2007 edition of the Queensland Aquaculture News.

Presentations at relevant conferences/meetings

- Greg Jenkins, Gavin Partridge and Gavin Sarre delivered a presentation titled *'TAFEWA and Sustainable ISA'* at the WA Innovation Festival at the Maritime Museum on 7 May 2005.
- Gavin Partridge delivered a presentation titled *'Innovative systems and novel applications of these and conventional systems to inland aquaculture development in Australia in "the Arid" lands, saline soils and highland aquaculture'* session at the World Aquaculture Society Biennial Conference in Bali Indonesia, 9 – 13 May 2005.
- Gavin Sarre and Gavin Partridge delivered a presentation titled *'Semi Intensive Floating Tank System (SIFTS) – new technology for the commercialisation of ISA in Western Australia'* at the Australasian Aquaculture Conference in Sydney September 2004.
- Gavin Partridge delivered a presentation titled *'The development of the Semi-Intensive Floating Tank System (SIFTS)'*, which included details of ISA related research in WA at the Aquaculture Association of Queensland's Annual General Meeting and Conference in Hervey Bay Queensland 27th – 28th September 2005.
- Gavin Partridge delivered a presentation titled *'Semi Intensive Floating Tank System (SIFTS) – new technology for the commercialisation of ISA in Western Australia'* to government ministers and industry in the Cook Islands in December 2005.
- Gavin Sarre delivered a presentation entitled "ISA" in the *'Opportunities and challenges in agriculture'* session at the WA Regional Outlook conference in Toodyay, 24 August 2005.
- TAFEWA inland saline aquaculture in Western Australia, the semi-intensive floating tank system (SIFTS) and further associated research opportunities.
- CY O'Connor ERADE Village presentation by Greg Jenkins regarding the potential use of by-products of production from the Northam FRDC project March 10, 2006.
- ISA Research Update, Gavin Partridge, Dr Gavin Sarre, Greg Jenkins. Presentation at the 3rd Steering Committee Workshop, Perth Feb 1, 2006.

- *‘The Semi-Intensive Floating Tank System (SIFTS) A new technology for commercial finfish production*’ Presentation to the World Aquaculture Society Conference in Florence by Greg Jenkins, May 10, 2006.
- Gavin Partridge presented an over-view of the SIFTS technology to aquaculture staff from the Environmental Division at Stirling University in Scotland on June 22, 2006.
- In July 2006, Greg Jenkins gave a presentation at the World Aquaculture Society Conference in Florence titled *‘The Semi-Intensive Floating Tank System (SIFTS) a new technology for commercial finfish production’*.
- During the Australasian Aquaculture Conference in Adelaide in August 2006 Dr Gavin Sarre gave an overview of the current FRDC project during the ISA session in a presentation titled *‘Semi-intensive Floating Tank System (SIFTS) – Application in saline water bodies in Western Australia’*.
- Also during the Australasian Aquaculture Conference in 2006 Greg Jenkins gave an overview of Inland saline water resources in Western Australia – with reference to its potential use for aquaculture (on behalf of Dr Richard George, Greg Jenkins and Gavin Partridge).
- Gavin Partridge also gave a presentation in the engineering session of this conference discussing the engineering aspects of the technology and its application to areas other than ISA. Details of Gavin’s presentation featured in an article in FRDC’s R&D news in November 2006 titled *‘”SIFTS” Harbour Showroom”*.

Provision of TAFEWA copyright information for web site

- A TAFEWA report for a project funded by the WA Science & Technology Innovation Strategy *‘ISA – a new marine industry for the wheatbelt’* has been made available to be linked to the NAC ISA website.
- Regular updates have been provided to the NAC ISA Communications Manager, Alexandra Bagnara.

Figure 9. ISA demonstration farm, Northam, WA.

5.1.3. SARDI – Application for Demonstration Facility and Summary of R&D Progress

APPLICATION

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FACILITY:

Waikerie Aquaculture Park, Waikerie, SA.

Description of facility:

SARDI has applied for National Action Plan for Salinity (NAP) funding through the Centre of Natural Resource Management (CNRM) to commence research to develop commercial aquaculture aligned to salinity interception schemes (SIS's) in South Australia. This funding will be used to provide R&D, demonstration and training facilities as part of a commercial Aquaculture Park to be developed near Waikerie (WAP). In May 2004 the CNRM Investment Advisory Board advised that this project has been approved and is with the relevant Minister awaiting his signature.

It is envisaged that this facility will incorporate a number of elements including:

- Saline groundwater supply from trunk main to SPDB (salinity 16/17ppt, temp. 20 – 24^{o}C).
- Power and freshwater supply.
- Laboratory, offices, car parking and amenities.
- System of 16 x 500L tanks with separate biological filters for bioassay of groundwater sources and species evaluation.
- 6 x 50m x 10m polytunnels covering lined ponds for winter production trials.
- 4 x 50m x 20m (0.1 ha) lined ponds for summer production trials.
- 1 x 100m x 30m effluent treatment pond.
- Back-up power supply.
- Air blowers.
- Pumps.
- Fencing.

SARDI has previously conducted similar R&D and demonstration activities at the Cooke Plains ISA Research Centre (CPISARC), an initiative of the Coorong District Council (CDC). This facility has established poly-tunnel covered lined ponds for pilot scale integrated production of fish and other saline species. It is intended that this facility will be used to continue demonstration activities until the WAP facility is operational. It is anticipated that this will take a minimum of 12 months at which time all project related demonstration and other activities will transfer from CPISARC. However, SARDI has proposed to the CDC that they should promote the CPISARC for on-going R&D, training and small scale commercial production activities.

Ownerships and approvals:

Land developed for the R&D component of the WAP will be owned by the Waikerie District Council. SARDI will own the infrastructure on the site. Planning, zoning and aquaculture planning issues will be undertaken by Primary Industries & Resources SA (PIRSA). All the necessary approvals to conduct research at WAP will be obtained by SARDI. The CPISARC is owned by the CDC and is presently leased by SARDI.

Purpose of facility:

The aim of the WAP is to identify suitable species, production technologies; and wastewater treatment methods on a research scale then pilot-commercial scale, to promote the development of a sustainable aquaculture industry aligned to salt interception schemes (SIS) in the Riverland region of South Australia.

This research has commenced with an initial evaluation of saline groundwater from the Waikerie/Woolpunda/Qualco SIS. This SIS discharges 30 ML per day into the Stockyard Plains Disposal Basin (SPDB). CNRM/NAP funding will allow establishment of R&D facilities during 2004/05 to development viable production methods and systems that will be commercialised within the WAP. From 2006 the facility will also provide technology transfer when the nearby (100km) larger (approx. 100ML/day) Loxton/Bookpurnong SIS is completed.

Summary of progress prior to the commencement of the current project:

The CPISARC has been developed over the past five years. Experiments have included the growth of King George whiting, black bream, snapper, brine shrimp and microalgae (*Dunaliella salina*), using tanks and ponds housed inside plastic lined polytunnels. The results from these experiments resulted in an up-grade of the facility in 2002, to explore the potential of growing fish, brine shrimp, oysters and seaweed in an integrated system housed inside polytunnels to enhance winter productivity. To date a 6 month trial has been completed.

In 2003, a six month growth trial was also conducted at CPISARC to examine the aquaculture potential of saline groundwater discharged into SPDB. This water has a salinity of 16 – 17ppt, elevated water temperature of 20 – 24^{o}C, and a potassium concentration of 80mg/L. Mulloway were used in this growth trial and results indicate that some additional potassium supplementation may be required to maximise fish growth. No mortality was attributed to this deficiency, but a reduction in growth and higher FCR occurred during one month indicating that some adaptation might have been necessary to the SIS water.

Currently there are limited funding opportunities for aquaculture research aligned to dryland salinity. This situation has dictated that current ISA research in South Australia should be aligned to the productive use of saline groundwater from SIS's. When the WAP commences operation SARDI and the Coorong District Council will encourage the use of the CPISARC by tertiary and secondary education and indigenous groups for research and training, and for pilot scale investigations by commercial users. This would be greatly facilitated by the development of extension material targeted at summarising the research results to date in a form suitable for investment attraction.

These events have lead to the decision to establish a new aquaculture R&D facility aligned to the Woolpunda/Qualco SIS. This SIS discharges 30 million litres per day of intercepted water into SPDB that would otherwise enter the River Murray. R&D activities will concentrate on finding a commercially viable use for this water by maximising the advantages provided by the flow and water temperature of this otherwise wasted resource.

Estimated potential for aquaculture industry growth:

By 2006/07, SARDI aim to retract their involvement in the WAP and focus their attention to developing the larger Loxton/Bookpurnong Aquaculture Park (LAP). Further research will be required at the LAP, as the quality of the water won't be known until this SIS is fully operational. The South Australian Government via the CNRM are highly interested in developing an aquaculture industry aligned to SIS's, as these are seen as permanent features required to combat salinity in the Murray River and where the development of "Aquaculture Technology Parks" can facilitate orderly and ecologically sustainable development. It is predicted that water discharged into SPDB could be used to produce a minimum of 250-300 tonnes of fish per annum using a single pass flow through system. Production could be further increased if multiple water reuse or recirculating systems were incorporated.

Provided the water is suitable from the Bookpurnong/Loxton SIS, it is estimated that 100 million litres of water will be intercepted daily and be available for use in a managed aquaculture production system. Combining the production from both SIS's, it is predicted that the aquaculture industry in the SA Riverland region could be worth $20 million by 2013.

Commitment to ongoing R&D:

SARDI is committed to R&D at WAP utilising saline groundwater derived from SIS and is currently employing Tim Flowers as an ISA Research Scientist. SARDI has submitted an application to NAP for a three year project to fund future SIS related aquaculture research in SA. At a meeting in May the CNRM Investment Advisory Board advised that the NAP project has been approved and is with the relevant Minister awaiting his signature.

This funding will be used to develop the R&D facility at WAP to promote commercial investment once suitable species and production systems have been identified. The WAP is being established as an R&D, demonstration and training facility with the aim of attracting interest from the local industry, external investors, TAFE and indigenous communities. Until this is completed SARDI intends to continue these activities at a reduced capacity at CPISARC and transfer all effort to WAP when it has been completed (mid-late 2005).

Plan for demonstration activities for 2004 – 2007:

- Workshop (2 days) to present outcomes of research completed at CPISARC to stakeholders and to commence planning process for future R&D and demonstration activities at WAP. The target audience will be local aquaculturalists, industry Associations, representatives of Government Departments with planning, regulatory or operational involvement in the use of the SIS resource for aquaculture; NAC and FRDC representatives, CNRM and NAP representatives and others.
- The CPISARC will be operational for the workshop with the installation of cooling and monitoring systems. Production systems will be stocked and demonstrated at the workshop. Modifications will be tested during the upcoming summer production period and information will be incorporated into design and planning for WAP.
- Presentation at Australasian Aquaculture Conference (AAC) 2004.
- Progress of the project will be reported in local/state print media and industry publications to maximise exposure and information exchange.
- Encourage collaboration with local TAFE and indigenous groups for training and extension work.
- A dedicated demonstration nursery culture system will be installed at WAP (2005).
- Presentation at AAC 06.
- Provide information for web sites (SARDI and PIRSA Aquaculture) and updates to NAC communications officer every 3 months (NAC portal).
- A dedicated demonstration pond system will be installed at WAP (2006).
- Prepare a business prospectus and seek commercial investment based upon R&D outcomes.
- Conduct a workshop to summarise progress of R&D and demonstrate operation of production systems developed.

Plan for expenditure from project to facilitate demonstration activities:

Date	Item	Amount
2003/04	Install temperature control and monitoring equipment to a 10 x 44 m polytunnel at CPISARC and undertake other system modifications required to allow operation during a workshop (late June 2004) and for a summer (2004/05) production demonstration.	
	Hold a workshop in late June 2004 to present findings of research conducted at CPISARC and initiate planning to establish a R&D, demonstration and training facility aligned to saline water intercepted by the Woolpunda/Qualco/Waikerie SIS and discharged to the Stockyard Plains Disposal Basin near Waikerie. This workshop will bring together R&D, State government aquaculture and water use regulators and planners, industry, local government and investment stakeholders.	
	Compile fact sheets for the workshop to summarise outcomes of research conducted to date at CPISARC. These fact sheets will also be available for investors, potential R&D users and training groups. These will summarise research reports; provide current system specifications; identify opportunities and problems and include recommendations for future research to develop integrated systems suitable for areas affected by dryland salinity. These fact sheets will be available as free downloads from the SARDI website and the NAC portal.	
	Prepare an initial feasibility plan for a commercial aquaculture facility at WAP to identify costs, production targets, likely products and income, and information gaps that will need to be provided through research scale and pilot scale trials.	$30,000
2004/05	Install a dedicated facility to demonstrate winter nursery production methods being developed through research conducted at WAP.	$15,000
2005/06	Install a dedicated facility to demonstrate summer pond production methods being developed through research conducted at WAP.	$15,000
TOTAL:		**$60,000**

5.1.3.1. General summary of R&D progress in SA during the course of the project

Since 1997 the South Australian Research and Development Institute (SARDI) has undertaken R&D and demonstration activities to investigate the commercial potential of inland aquaculture utilising sources of saline groundwater. Initial projects focused on the use of saline groundwater from shallow aquifers (1 – 2m) that are an increasing problem in dryland farming areas of South Australia. These investigations were conducted at the Cooke Plains ISA Research Centre (CPISARC) at Cooke Plains from 1997 – 2003. More recently investigations have focused upon the use of saline groundwater available from Salt Interception Schemes (SIS) in the Riverland region of South Australia. These SIS's have been constructed to improve water quality within the Murray River and provide a supply of relatively high volumes of saline groundwater at a constant elevated temperature (20 – 22^{o}C). Since 2004, SARDI has undertaken a NAP funded project that has provided funding to construct and operate the Waikerie ISA Centre (WISAC) that began operation in May 2006.

At the commencement of the FRDC funded NAC National Inland Aquaculture R&D Coordination Project a number of areas where identified that would benefit from further funding to enhance demonstration activities aligned to the ISA R&D projects being conducted by SARDI. At this time the activities supported included:

- Hold a workshop to present outcomes of research completed at CPISARC to stakeholders and to commence planning process for future R&D and demonstration activities at Waikerie. A tour of CPISARC was included as part of the workshop. *Completed.*
- Install temperature control and monitoring equipment to a 10 x 44m polytunnel at CPISARC and undertake other system modifications required to allow operation to be evaluated and demonstrated. *Completed.*
- Provide a presentation at Australasian Aquaculture Conference 2004. *Completed.*
- Report progress of the project in local/state print media and industry publications to maximise exposure and information exchange. *Completed.*
- Encourage collaboration with local TAFE and indigenous groups for training and extension work.
- Install a demonstration nursery culture system at WISAC (2005). *Completed.*
- Provide a presentation at Australasian Aquaculture Conference 2006. *Completed.*
- Provide information for web sites (SARDI and PIRSA Aquaculture) and updates to NAC. *Completed.*
- Install a dedicated demonstration pond system WISAC (2006). *Completed.*
- Prepare a business prospectus and seek commercial investment based upon R&D outcomes. *Completed.*
- Conduct a workshop to summarise progress of R&D and demonstrate operation of production systems developed. *Planned for 1st half of 2008.*

Economic analysis

A preliminary business plan was completed to assess the viability of ISA operation at three production scales using, in part, the services of a postgraduate aquaculture student undertaking the Flinders University postgraduate course in “Bachelor of Innovation and Enterprise (Science and Technology)”. Economic viability was found to be very sensitive to facility capital cost, finfish growth, market price and operating costs, with the largest production level (500 tonnes/annum) achieving a substantially better result than the smallest (100 tonnes/annum). A more comprehensive economic analysis of saline groundwater aquaculture in semi-intensive and intensive systems is currently being undertaken as a separate project commissioned by Primary Industries & Resources South Australia (PIRSA), Aquaculture Division. This analysis will be available from April 2008 and will allow investors to develop business prospectus to assess options for investment.

Commercial adoption/development

To date there has been general interest from commercial companies in the seafood industry that wish to increase the supply of fish for processing and distribution. The NAP funded project at WISAC has provided a catalyst for local Government to examine and make changes to the local planning regulations to accommodate commercial aquaculture. The project has also prompted PIRSA Aquaculture to commence development of policies and regulations required to allow commercial aquaculture developments for inland locations. It has been identified that a range of issues need to be addressed in advance of commercial development such as changes to local land use plans, formulation of appropriate terms and conditions for aquaculture licenses, clarification of ownership of SIS water and development of a system for allocation of the water resource to provide security for investors. These industry development issues are being undertaken by PIRSA Aquaculture in consultation with other State and local government stakeholders.

Remaining constraints and recommendations for the future

There remains a need for continuation of R&D activities at WISAC to identify and demonstrate methods to improve growth rate and reduce costs of production of mulloway cultured in SIS groundwater. Investigations to date have demonstrated that high survival is achieved but growth rate is slower than expected given the favourable water temperature range and composition of the water available. The original project included installation and evaluation of an intensive aquaculture system. It is likely that the water treatment components used in these more intensive systems would allow significant reduction of the current elevated levels of dissolved carbon dioxide that are suspected to be reducing the achievable growth rate of mulloway in the semi-intensive system that is currently being operated at WISAC, while optimising water temperature.

The current project has prompted local government to commence work on amending existing regional planning regulations to accommodate commercial aquaculture developments. State government aquaculture licensing policy and regulations are also being refined by Primary Industries & Resources South Australia (PIRSA) Aquaculture Division to allow planned development of inland aquaculture using groundwater from SIS's in the Riverland. This process involves identification of suitable sites, issuing of aquaculture licenses, agreement of acceptable waste water conditions, clarification of ownership of water and development of a system to allocate access to water that provides security for investors and is acceptable to water management agencies and the public.

SARDI has sold over three tonnes of mulloway produced at WISAC to local seafood distributors primarily for sale in the Riverland and Adelaide. Fish produced in SIS groundwater have also been provided for a range of promotional events and for evaluation of consumer acceptance. In all but one instance, the response from consumers, processors and chefs has been strongly supportive of the taste and potential of the product. The composition, water temperature and volume of groundwater available from SIS are all favourable to support a significant aquaculture industry provided that the growth rate of mulloway can be further improved. This will require further development and demonstration of available productions systems. In particular, the evaluation of a cost effective intensive aquaculture system originally intend at the start of this project remains to be undertaken.

Overview of ISA demonstration activities and related R&D

Workshop

At the start of the ISA demonstration project SARDI organised an ISA workshop that was held on the 24th and 25th June 2004. This workshop incorporated presentations of the findings of Natural Heritage Trust and National Action Plan (NAP) funded research that SARDI had previously conducted on ISA at CPISARC. This workshop also included was a selection of presentations from a range of industry, regulatory and planning agencies involved with the range of issues that would influence the development of commercial Aquaculture Parks aligned to Salt Interception Schemes. These presentations were followed by discussion of issues identified to influence planning for the R&D and demonstration facility and subsequent commercial development based around an Aquaculture Park concept. A trip to inspect aquaculture R&D and demonstration activities at CPISARC was conducted on the second day of the workshop.

Activities at CPISARC

CPISARC was established by the Coorong District Council to investigate the potential for aquaculture to utilise saline groundwater from shallow aquifers that cause dryland salinity that affects over 250,000 ha in the Upper South East region of South Australia. At CPISARC approximately 60,000L of saline groundwater with salinity greater than seawater (38g/L) could be pumped each day from a trench excavated to reveal the shallow aquifer 1 – 2 below the soil surface (Figure 1). A system was designed and constructed to investigate the ability of this water supply to supply a nil-discharge integrated semi-intensive aquaculture system producing finfish, atremia, oysters and seaweed. The concept was to reuse water within a system in which nutrient input was from feed provided to mulloway (*Argyrosomus japonicus*).

Figure 1. Excavated pit used to supply saline groundwater for use within aquaculture systems at CPISARC.

Artemia and oysters (*Crassostrea gigas*) were included to provide removal of suspended organic material (i.e., fine suspended solids and phytoplankton) with wastewater then flowing to a seaweed (*Ulva* sp) culture pond for removal of dissolved nutrients from the water. Water was then returned to the lined fish culture ponds. All water discharged from the system was directed into clay lined evaporation ponds.

Water temperature of the saline water used at CPISARC varied seasonally as it was drawn from the shallow subsurface aquifer and was influenced by soil temperature and exposure to ambient conditions prior to pumping from the supply pit. To address this all components of the system were housed within polytunnels to increase water temperature during the winter period. However high air and water temperature in polytunnels resulted during summer when conditions were experienced that were adverse for culture of finfish and could also be hazardous for the operator. In response to this problem demonstration activities supported at CPISARC involved installation and testing the effectiveness of air extraction fans to achieve improved temperature control within polytunnels during summer. A single air extraction fan (Munters^{TM} EM50) was fitted to a small (20m x 10m x 3.5m high) polytunnel covering lined ponds used to culture mulloway. Two extraction fans were fitted to a large polytunnel (46m x 10m x 3.5m high) used to culture oysters and seaweed (Figure 2). Fans were controlled via a thermostatic switch that turned them on when air temperature inside the tunnel exceeded 26^{o}C with the intention being to maintain inside air temperature at approximately 30^{o}C. Data was collected during operation of these fans during the summer period from 12 Dec 2004 – 11 March 2005.

Operation of the air extraction fans was demonstrated during the tour of CPISARC by delegates of the ISA workshop (June 2004). Extraction fans in the polytunnels at CPISARC maintained average inside air temperatures below 33°C and average water temperatures below 30°C (Figure 3). The average water temperature range in the large polytunnel was 4.34°C (SD ± 1.38) and in the smaller polytunnel 3.65°C (SD ± 1.38). It was concluded that air extraction fans provide capacity to maintain water temperature of culture systems housed within polytunnels.

Ultimately projects at CPISARC were terminated due to a lack of ongoing funding. Operation of the system revealed that the major management issue was control of microalgal populations that rapidly increased within the integrated water reuse system. If the system had continued to operate it was expected that R&D would have focussed upon better defining the role of the populations of filter feeding organisms required to manage the microalgal population within the system and incorporating methods to promote selected microalgal species that can be utilised by Artemia and oysters to ultimately increase nutrient removal from the system. It is likely that this R&D would have required a partial redesign of the system to allow greater capacity to exchange water within the finfish production component of the system with brine shrimp, oysters and seaweeds only being used to treat water prior to discharge to the evaporation ponds. A major lesson learned from this exercise was that integrated systems require much greater R&D to achieve the desired balance of elements within the system and provide the operator with the knowledge to manage all of the species being used, as compared to a single species production system.

Figure 2. Air extraction fans (Munters™ EM50) installed in large polytunnel at CPISARC.

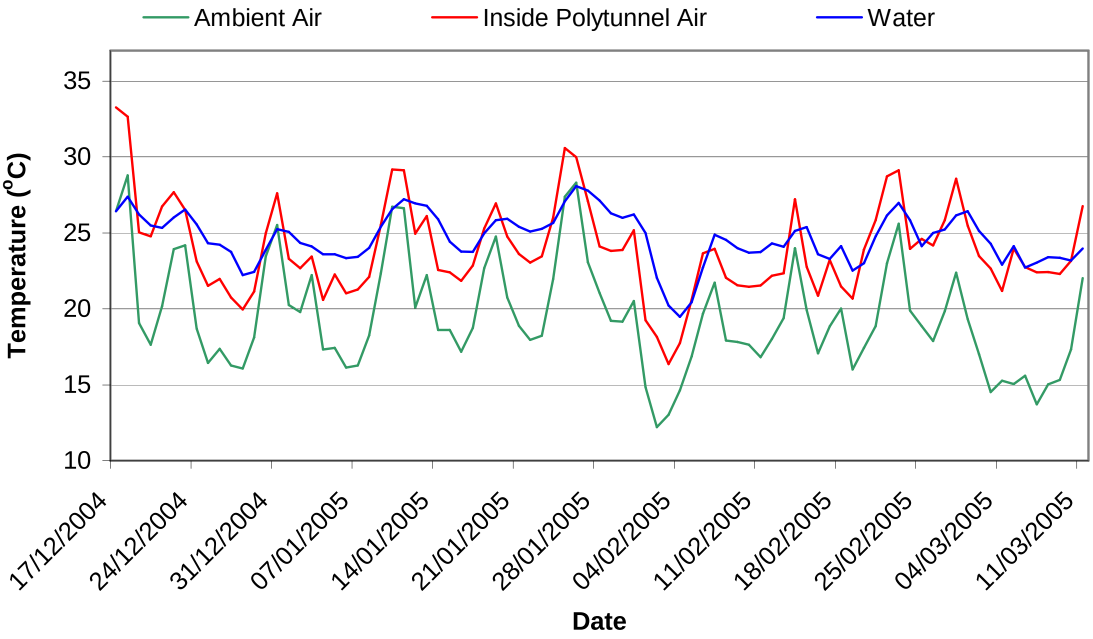

Figure 3. Average daily temperatures for ambient air, air inside the polytunnel and water temperature within a large polytunnel (46m x 10m) during the summer period (12 Dec 2004 – 11 March 2005).

Demonstration and research activities at WISAC

The National Action Plan for Salinity & Water Quality (NAP) provided funding through the Centre for Natural Resource Management (CNRM) to develop and trial a research aquaculture pilot plant to develop and demonstrate productive use for saline groundwater from salinity interception schemes. In the Waikerie region of the Riverland, there are 93 bores that comprise the Woolpunda/Waikerie/Qualco SIS. This SIS diverts approximately 30 million litres per day of saline groundwater to the Stockyard Plains Disposal Basin (SPDB) located approximately 12 kilometres south-west of Waikerie.

The saline groundwater available from SIS has an annual water temperature of 20 – 22°C and a salinity of 19 – 20 g/L. The constant elevated water temperature is viewed as a benefit for aquaculture if it can be used to maintain optimal growth of fish during the cooler months resulting in a shorter time to market.

At the start of the SIS aquaculture project SARDI scientists conducted a study tour through USA and Israel where saline groundwater is used for a range of aquaculture enterprises. Information gathered and previous experience was then used to identify semi-intensive and intensive approaches to the culture of finfish that would be suitable to utilise the saline groundwater available from SIS. This information was used to design and construct the Waikerie ISA Centre (WISAC) to demonstrate pilot commercial scale culture of selected species. WISAC commenced operations in May 2006 near the South Australian River Murray township of Waikerie. Currently only semi-intensive production system is in operation following difficulties encountered in purchasing the preferred Israeli intensive aquaculture system within the allocated time limits.

The aim of initial research was to assess potential finfish species that may be suitable for culture using the saline groundwater available at WISAC. Trials have been completed to assess the suitability of mulloway and snapper (*Pagrus auratus*) for culture in the available saline groundwater from SIS, and preliminary investigations are also being conducted on yellowtail kingfish *(Seriola lalandi*). These trials suggest that growth of mulloway is not adversely affected by culture in the SIS groundwater compared to growth in equivalent salinity seawater. Results for snapper suggest that there is reduced growth in SIS groundwater at this site and no further investigations are being followed for this species. R&D has been conducted to compare the metabolism of each species (i.e., mulloway, snapper and yellowtail kingfish) maintained in SIS groundwater from SPDB and equivalent salinity seawater. These investigations will be presented by the former project Scientist, Tim Flowers for fulfilment of a Master of Applied Science (Aquaculture) qualification.

Culture operations conducted at WISAC are design to assess and demonstrate productive uses fro SIS groundwater at a proof of concept scale to facilitate development of a new regional industry. At WISAC fish culture is conducted in 3 x 70,000L (9.5m diameter x 1.1m deep) tanks whereas a commercial enterprise may utilise a greater number of tanks of comparable size. This approach allows collection of data that is more transferable to a commercial enterprise than data generated in small scale replicated R&D systems that have a primary function to generate scientifically valid data to discriminate between experimental treatments.

To date operation of water supply, fish culture and waste water treatment systems at WISAC have identified a number of key issues that confront commercial exploitation of saline groundwater available from SIS's. These issues are currently the focus of ongoing investigations to provide a better understanding of them and develop approaches to manage their effects on fish and system performance.

Growth rate

To date the growth rate of mulloway cultured in SIS groundwater has been steady but not as fast as would be expected in the conditions in which they are cultured. Although survival is high the growth curve for fish cultured in demonstration pilot-commercial scale production systems at WISAC is linear (Figure 4) rather than exponential as would be expected for fish being cultured at an early stage of growth at elevated water temperature. Investigations are being conducted to determine the likely factors that may be affecting the growth rate of mulloway in SIS groundwater at WISAC. Possible factors include elevated dissolved carbon dioxide in production tanks, the composition of the SIS groundwater at this site and the feeding strategy used.

Dissolved carbon dioxide

When saline groundwater was used directly from the SIS pipeline it was immediately apparent that it contained very high levels of dissolved carbon dioxide (CO_2). Initially measurements were determined by titration that recorded readings in excess of 100 mg/L. From August 2007 a carbon dioxide meter (Oxyguard CO_2 portable) has been used to measure dissolved CO_2 and levels recorded are inline with what is expected. Measurement by CO_2 meter shows that passage of SIS groundwater through the degasser (Figure 5) constructed removes an average of 82.7% of dissolved CO_2 (Figure 6). Average CO_2 content of raw SIS groundwater is 62.8 mg/L (SD ± 8.9 mg/L) and this level is reduced to an average of 10.7 mg/L (SD ± 1.8 mg/L) by degassing prior to entry into 250KL storage tanks. The degasser uses high volume fans to blow a stream of air through a bed of Tellerette® degassing media with incoming water evenly distributed over the bed using five Twister® configuration nozzles. Falling water is constantly broken up by the media promoting gas exchange from the surface of the water film and droplets formed. Recently SARDI has completed a replicated trial comparing growth and survival of mulloway cultured at target dissolved carbon dioxide treatment levels of 5, 10, 20, 40, 60 80 mg/L. Results of this trial are being analysed and will be presented in the final project report.

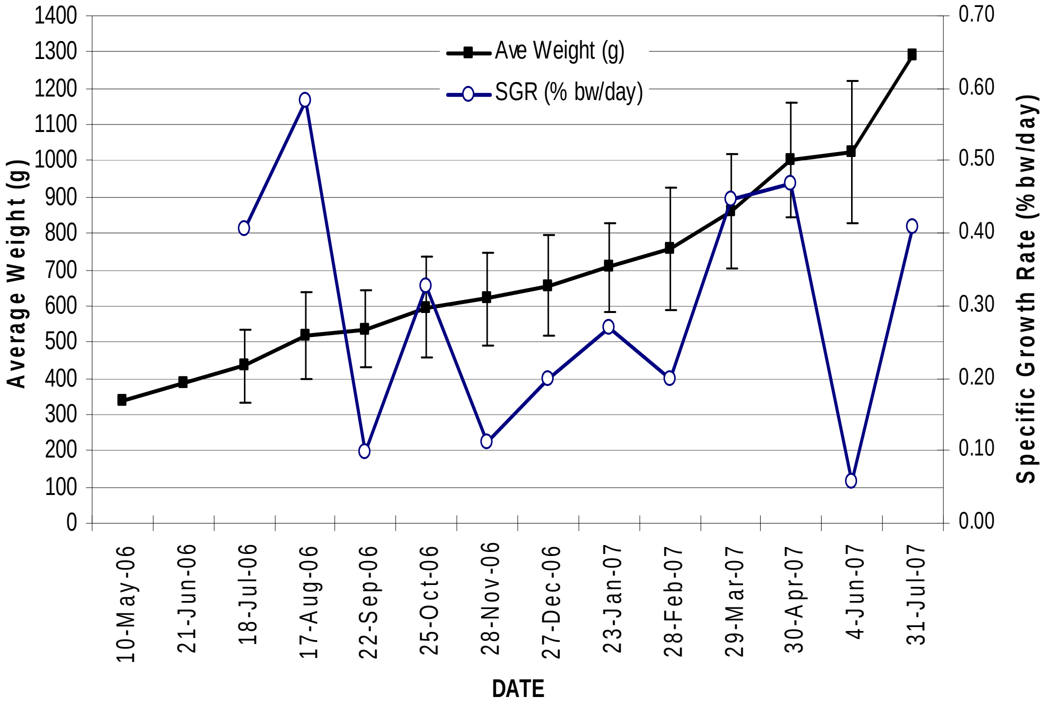

Figure 4. Average growth (± SD) and monthly specific growth rate (SGR) of mulloway in a pilot commercial scale (70KL) production tank supplied with SIS groundwater at WISAC (10 May 2006 – 30 July 2007).

Figure 5. Packed column degasser installed to reduce dissolved carbon dioxide content of SIS groundwater used at WISAC.

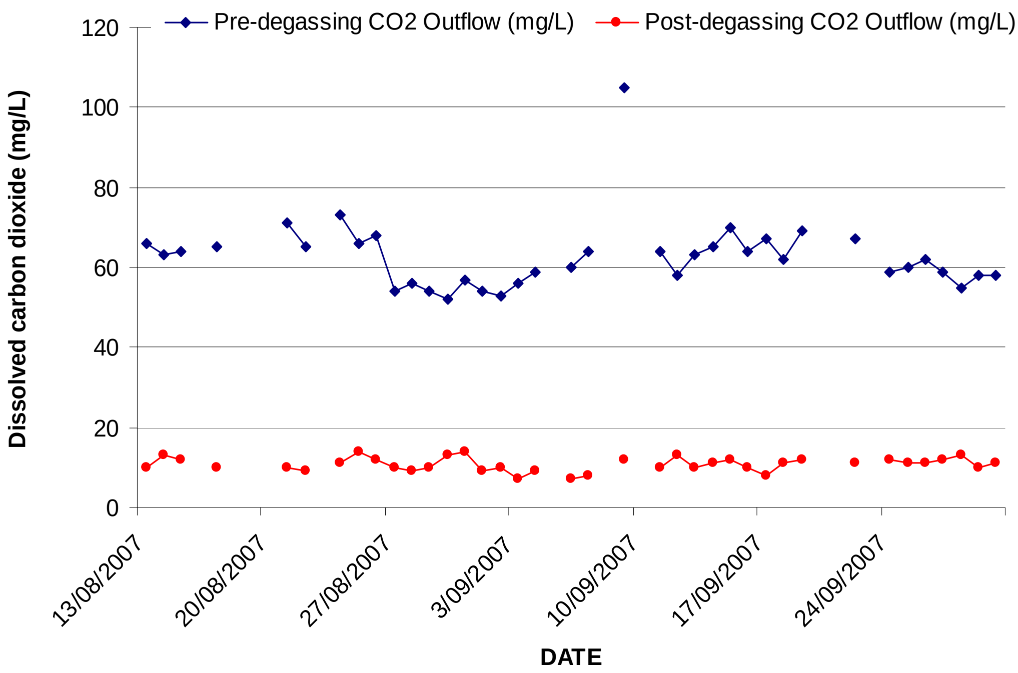

Figure 6. Level of dissolved carbon dioxide (mg/L) in SIS groundwater before and after passing through a packed column degasser at WISAC (Aug – Sept 2007).

Feed management

Mulloway are not aggressive feeders and water clarity in 70KL culture tanks fitted with black plastic liners does not allow accurate observation of feeding behaviour. This limitation necessitates feeding to be calculated from monthly growth checks and records of stock numbers to determine the standing biomass. The amount of daily feed is then predicted from the tank biomass and the targeted feeding rates (percentage of biomass per day). Currently feed consumption is monitored by observation of fish behaviour and excess feed pellets that enter swirl separators fitted to each tank. It is expected that further improvements to feeding can be made to better manage the timing, duration and frequency of feed delivery to increase feed use efficiency and growth performance.

Wastewater treatment

In order to be economically viable the commercial use of SIS groundwater for commercial aquaculture will require the operation of systems capable of producing hundreds of tonnes of product per annum. Regardless of the system used this level of production will generate significant waste in the form of suspended solids and dissolved nutrients that will need to be managed. SARDI has initiated preliminary trials to evaluate growth of local halophyte species (*Halosarcia sp.*, *Sarcocornia sp.*) irrigated with SIS groundwater discharged from aquaculture production tanks with the view to conducting future investigation of their potential for removal of suspended solids and dissolved nutrients.

Promotional activities

The official opening of WISAC on 13 September 2006 was attended by over 60 stakeholders from funding agencies, local and State Government agencies and industry representatives. The opening included presentations by relevant State Government Ministers followed by a facility tour and luncheon with the Chef serving mulloway prepared in a number of ways.

As an event during the Science Outside the Square promotion (September 2006), SARDI and SA Water organised for two buses to transport 100 interested people on a tour demonstrating the operation of SIS's and the aquaculture R&D being undertaken at WISAC (Figure 7A). SARDI provided an introductory talk, tour of the facility and a free tasting of mulloway and chips. The event concluded with a tour of the Stockyard Plains Disposal Basin. SARDI has also conducted demonstrations of scientific investigations and tours of the facility for 100 – 160 local school students each year as part of National Science Week in 2006 and 2007 (Figure 7B).

Figure 7. **A.** Local visitors at WISAC for the *'Science Outside the Square'* event 17 September 2006. **B.** Local school students at WISAC for activities and tour as part of '*National Science Week'* 23 August 2007.

SARDI have also conducted tours of WISAC for local Agricultural Bureaus from Loxton, Berri and Renmark, and presented promotional material and discussed project activities at the 2006 Riverland Field Days attended by over 10,000 people.

SARDI has hosted a number of visits to WISAC for prospective investors from the seafood processing and aquaculture industry sectors. These visits have provided an opportunity to demonstrate the activities being undertaken at WISAC and transfer information and experiences gained in a direct and informal manner. SARDI has also provided visits to WISAC for staff of Government Departments involved in development of policies and regulations for inland aquaculture.

SARDI has supplied promotional material (Figure 8A) and quantities of mulloway to support taste-testing events (Figure 8B) conducted by a marketing group undertaking a consultancy for PIRSA Aquaculture.

Figure 8. **A.** Postcard (front) prepared for promotion of “Murray Mulloway” cultured in SIS groundwater at WISAC. **B.** Taste testing and consumer survey conducted at Adelaide Central Market in collaboration with Samtass Bros. Seafood and a marketing group contracted by PIRSA Aquaculture.

Commercial development of ISA in SA

The South Australian Government has initiated a project to facilitate an innovative use of wastewater from Salt Interception Schemes (SIS) for aquaculture development in the Riverland Region of the state.

The aquaculture division of Primary Industry’s and Resources South Australia in conjunction with the Department of Water Land Biodiversity and Conservation commissioned three projects which provide relevant information to those parties interested in the commercial development of aquaculture operations using the SIS water.

- The market research provides a better understanding of buyer behaviour in key markets (Sydney, Melbourne, and Adelaide) and market acceptance of finfish product produced using water from SIS.
- A GIS mapping exercise was undertaken to identify possible locations for aquaculture zones in the region and in addition to geographic features, current infrastructure and other potential impediments to the development of aquaculture using SIS.
- An economic and sensitivity analysis project was commissioned to estimate likely production volume and value if SIS was to be fully exploited for aquaculture development and to develop a sensitivity analysis model that could be used to check or validate the various assumptions.

A number of commercial parties have already expressed their interest in the opportunity of utilising SIS in the Riverland. At the time of writing, these reports are still in draft form but it is anticipated it will be available in the short term from PIRSA (http://www.pir.sa.gov.au/aquaculture). When finalised a copy of the reports should also be available at http://www.australian-aquacultureportal.com/saline/saline.html

Local media releases and regional information seminars

- The project has been widely promoted by SARDI. To date there have been 16 radio and 11 television segments presented by regional and metropolitan networks and 23 newspaper articles published.
- In May 2006 a television segment titled *'Inland seafood'* was filmed by Dr Rob Morrison for the ABC Australia Network's Nexus program. This program follows the transfer of juvenile mulloway from the SA Aquatic Science Centre, West Beach to WISAC and discusses the objectives of the R&D being undertaken to develop the use of SIS groundwater for aquaculture.

Reports

- Flowers, T.J and Hutchinson, W.G **(**2004) Preliminary studies towards the development of an aquaculture system to exploit saline groundwater from salt interception schemes in the Murray Darling Basin CNRM Final Report 2002/15 South Australian Research and Development Institute (Aquatic Sciences). 27pp.
- Flowers, T.J. and Hutchinson, W.G. (2004) Productive uses for saline groundwater using semi-intensive integrated aquaculture. CNRM Final Report 2002/16. South Australian Research and Development Institute (Aquatic Sciences), Adelaide. 82 pp.
- Flowers, T.J and Hutchinson, W.G (2005) Characterisation of the effects of air extraction fans to ventilate aquaculture polytunnels at the Cooke Plains ISA Centre, South Australia. National inland aquaculture coordination project milestone report, 19pp.
- Flowers, T.J and Hutchinson, W.G (2005) Overseas travel report: Inland aquaculture study tour USA and Israel, October 2004. South Australian Research and Development Institute (Aquatic Sciences). 60pp.

Presentations at relevant conferences/meetings

- During the Australasian Aquaculture Conference, Sydney, September 2004 Tim Flowers gave a presentation titled *'Current research in developing an aquaculture industry using water from salt interception schemes in South Australia'*.
- Wayne Hutchinson provided presentations updating progress of ISA R&D activities in South Australia at annual ISA R&D Coordination meetings as part of this project.
- During the ISA session at the Australasian Aquaculture Conference, Adelaide, August 2006 Wayne Hutchinson gave a presentation titled *'Aquaculture systems for utilising saline water from interception schemes in South Australia'*.

Provision of project information for NAC ISA web site

All reports prepared for CNRM and NHT during the period of this demonstration project have been provided to NAC.

5.1.4. QDPI&F – Application for demonstration facility and summary of R&D progress

APPLICATION

Queensland Government
Department of Primary Industries and Fisheries

CONTACT OFFICER:

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FACILITY:

W&D Hellmuth Aquaculture Facility, Bauple, Qld.

Description of facility:

In 2002, QDPI&F commenced the establishment of Australia's first commercial inland saline prawn production facility in collaboration with industry partners W&D Hellmuth. Subsequent to the production of two successful trial crops of black tiger prawns (*Penaeus monodon*), the owners have recently expanded their production capacity with the construction of four (4) x 2500m^2 earthen production ponds, one (1) buffer pond and one (1) effluent water treatment pond. This system has been designed to operate as a recirculating, zero discharge production facility.

Delivery of saline (5710uS/cm) groundwater to this site has been recently enhanced through the construction of two additional bores that access the site's saline sub-artesian aquifer.

Additional to its prawn production facilities, other assets of this site includes:

- 24 hour on-site staff.
- Feed and equipment storage shed.
- Fully equipped workshop.
- Freshwater storage dam.
- Office and laboratory facilities.
- Four 330m2 trial ponds with recirculation capacity, treatment pond and buffer storage.
- Fifteen (15) x 1000m2 earthen ponds.

Ownership and approvals:

W&D Hellmuth own the land and permanent infrastructure. All licences to produce black tiger prawns at this facility have been approved. A contract enabling access to all facilities for the purposes of demonstration and research activity will be entered into on approval of this proposal.

Purpose of facility:

The primary focus of QDPI&F's initial activity on this site was to demonstrate the potential for black tiger prawn production using low salinity groundwater in inland regions.

The next phase of this project involves using this facilities expanded capability to assess various production technologies and management strategies specific to commercial scale intensive zero-discharge prawn production. This information will be used to assist the development of inland prawn farming in all regions suited to open pond prawn production.

Summary of progress prior to commencement of the current project:

Commencing with a series of laboratory based survival trials, the saline water delivered by this site's aquifer was observed to be highly suitable for the production of black tiger prawns.

With the construction of a 0.26 hectare recirculating prawn production facility in 2002, this pilot site replicated the success of the laboratory trials through the exceptional production performance of the black tiger prawns stocked within it. In 2003-04 this performance was further improved with growth rates as high as 28.2 grams within 87 days, and commanding higher than standard market prices, the suitability for prawn production at this site appears absolute.

Although the growth performance of black tiger prawns in low salinity has been demonstrated at a small scale, the commercialisation of inland prawn production systems and management strategies remain as key issues in determining the economic viability of the activity.

W&D Hellmuth have already initiated activities towards full commercialisation of inland prawn farming with the further expansion of their production capacity. However, the capital demands of this development have dictated that they stage this development from initially extensive production towards intensive production over a period of several years. In view of recent developments pertaining to the cost competitiveness of domestic prawn production (competition with imports), semi-intensive and intensive '3rd generation' production facilities may appear to be most appropriate for new entrants in Australia. This project would therefore fast track the Hellmuth's site development with the benefit of enabling immediate industry scale research into semi-intensive and intensive farming practices to occur.

Estimated potential for aquaculture industry growth:

The described activities will provide a significant opportunity for both Australia's aquaculture industry as well as terrestrial farming sectors that are affected by saline groundwater. Competition for coastal resources, increasingly regulated environmental controls, and greater market pressures have forced Australian prawn growers to increase their production capacity in order to become more competitive with imports while reducing the environmental impacts of such activities.

Addressing the environmental and economic consequences of salinity through exploration of alternative and sustainable uses for saline groundwater is a major priority for Australia. Inland production of marine prawns presents an attractive solution to the economic and environmental challenges faced within the prawn industry as well as the likes of the sugar, cotton and grains industries.

The capacity for growth in this sector is dependent on cost of production. However, if a total of 200ha of inland prawn farm were established, producing a minimum of 4t/ha annually, this would add at least 800t to Australia's present prawn production. If this was sold at the present Sydney auction floor price of between $12 and 14/kg this would represent a turn over in excess of $10 million dollars. The focus on improving the competitiveness of prawn farming methods will also benefit the existing prawn industry in Australia.

Commitment to ongoing R&D:

The support of ISA research is a priority of DPI&F. As such DPI&F will provide the necessary technical input and support for the duration of this project.

Plan for demonstration activities for 2004 – 2007:

- Ad hoc visitation by interstate collaborating research colleagues, existing and potential aquaculture industry members.
- Presentation at DPIF prawn aquaculture workshops and industry conferences.
- Production of technical production manual focussing on production technologies, management strategies, environmental impacts and economic modelling of intensive and semi-intensive inland prawn culture.
- Scientific manuscripts pertaining to inland prawn production.
- Facilitate commercialisation of other inland prawn production sites.

Plan for expenditure from project to facilitate demonstration activities:

Date	Item	Amount
2003/04	HDPE lining of pond walls.	$17,500
	Paddlewheels.	$5,600
	C-macs remote data loggers and alarm, water quality probes and interface.	$8,000
	Power infrastructure.	$2,500
	Probiotics.	$1,000
	Labour to supervise and coordinate construction of semi-intensive, zero exchange system.	$5,400
	Recirculating pump and other misc equipment.	$5,000
2004/05		N/A
2005/06	Labour to maintain/upgrade demonstration activities.	$10,000
	Contribution to vehicle lease.	$5,000
TOTAL:		**$60,000**

5.1.4.1. General summary of R&D progress during the course of the project

In 2002, the Queensland Department of Primary Industries & Fisheries (QDPI&F) commenced the establishment of Australia's first commercial inland saline prawn production facility in collaboration with industry partners W&D Hellmuth and the Fisheries Research & Development Corporation (FRDC). The primary focus of QDPI&F's initial activity on this site was to demonstrate the potential for *Penaeus monodon* (black tiger prawn) and *Penaeus (Fenneropenaeus) merguiensis* (banana prawn) production using low salinity groundwater in inland regions.

With a reputation for high quality produce and strong local demand, prawn farming is one of Australia's most successful aquaculture industries. Inland prawn farming (IPF) has been successfully practiced in many countries including the United States, Thailand, China, Ecuador and India. These countries provide ready examples of how IPF can be successfully implemented in Queensland. The driving forces behind inland production have been the prevention of disease, increasingly stringent effluent conditions for coastal farms and opportunity for low cost production. The benefits of inland prawn culture are "multi-fold" and include the opportunity to diversify land use options, limit impacts of prawn farming on the environment, reduce incidence of disease, simplify farm logistics and improve control over water supply and use.

Successful implementation of IPF in Queensland will be dependent on the availability and suitability of groundwater, appropriate environmental regulation and the overall profitability of the activity. This DPI&F study identified the types of water suitable for IPF, regions with potential for development, the types of systems that would need to be developed and the likely performance of those systems. The results of this work demonstrated that the use of Queensland's groundwater resources could be carefully managed to provide regional communities with a sustainable and productive new industry opportunity.

There are however several biophysical, economic and environmental constraints to such development that must be addressed. Primarily, the availability and suitability of water in regions favourable for open pond prawn production must be determined. This requires not only determination of the size of resource, but also involves testing the effectiveness of mineral supplementations, water quality management techniques, and effluent treatment systems on the growth and survival of black tiger and banana prawns. Secondly, the economic case for the development of inland prawn farms must also be balanced against its technical and operational challenges.

The objectives of the study were to address the primary technical issues associated with the use of groundwater for inland prawn production. Specifically the objectives of this project included:

1. A review of data concerning groundwater use, suitability and availability in key regions in Queensland.

2. Establishment of methods to permit the rapid acclimation and transfer of marine prawns to fresh and low salinity groundwater for grow-out.

3. Ascertaining the mineral supplementation required to enable individual groundwater sources to be used for prawn culture.

4. Comparing the growth of black tiger and banana prawns in marine and inland saline waters.

5. Conducting inland pond trials to investigate the technical issues concerning semi-intensive production of the black tiger and banana prawns using groundwater.

Groundwater resource survey

Of the almost 8,500 individual bores considered in this study, 33% had conductivities in excess of 3,000µS/cm (1.9 ppm). A further 27% had conductivities above 1,500µS/cm (0.95 ppm) but less than 3,000µS/cm. The black tiger prawn has been grown successfully in water considered fresh enough to meet potable freshwater standards (800µS/cm). Bores with salinities greater than 800µS/cm (0.51 ppm) represent over 81% of those considered here. These data indicates that the conductivity of groundwater from existing bores in many regions of Queensland is sufficiently salty for inland production of black tiger prawns. Additional factors such as yields from each bore and water chemistry will also have to be assessed before deeming a bore “suitable” for this type of aquaculture.

Acclimation trials (2002/03)

Results from a number of acclimation trials demonstrated that appropriate care must be taken when acclimatising black tiger and banana prawns to low salinity groundwater. Important factors such as the age of PL, the salinity at the start of acclimation, the final target salinity, and the conditions under which acclimation occurs, must all be considered when devising an acclimation strategy. Typically, survival during acclimation and post acclimation was increased when the acclimation rate was decreased. E.g., Cumulative mortality (%) of *P. monodon* postlarvae at 3, 5 and 7 day acclimation rates from 34ppt to 1.7ppt showed no significant differences during acclimation, however, post-acclimation mortality was significantly higher in 3 and 5 day treatments. An optimised acclimation rate was calculated for diluting seawater with groundwater from 34 ppt to 1 ppt at 0.19ppt/hr. Similar rates are noted in the scientific literature

Bioassay trials (2002/04)

Results of numerous bioassay trials demonstrated that not only are some groundwater types more suitable than others, but that in most cases the addition of potassium chloride (KCl) will improve survival significantly. The data also demonstrates that individual bores, even those considered close in regional terms, can have quite different prospects with respect to their suitability for prawn survival and therefore aquaculture.

Bioassays of this type provide an indication of the suitability of groundwater for aquaculture of marine crustaceans. They are a simple biological means of assessing the potential suitability of an individual groundwater type for prawn culture. The results provide further evidence that, once corrected for potassium deficiencies, groundwater from inland regions of Queensland can provide a favourable medium for the growth of black tiger and banana prawns.

While imbalances in major ions can potentially be corrected, the economics of such modifications must be carefully considered with respect to farm design, water use and operational constraints. Although the results generated provided effective comparisons between seawater and treated groundwater, the rate of growth and survival of PL in all experimental units was generally poor compared to commercial pond data. For this reason, the next phase of this study involved assessing the performance of black tiger and banana prawns in earthen ponds using saline groundwater.

Production trials (2002/04)

The demonstration pond trial site, a redclaw farm located at Bauple in the Tiaro shire approximately two hours North of Brisbane, was selected because of its favourable local climate, the quality and availability of its groundwater supply, the existing infrastructure and its status as an operational aquaculture facility. Groundwater sampled from this site had been included in previous investigations. Site soil analysis indicated high clay content (>70%) suitable for earthen pond construction and water holding characteristics.

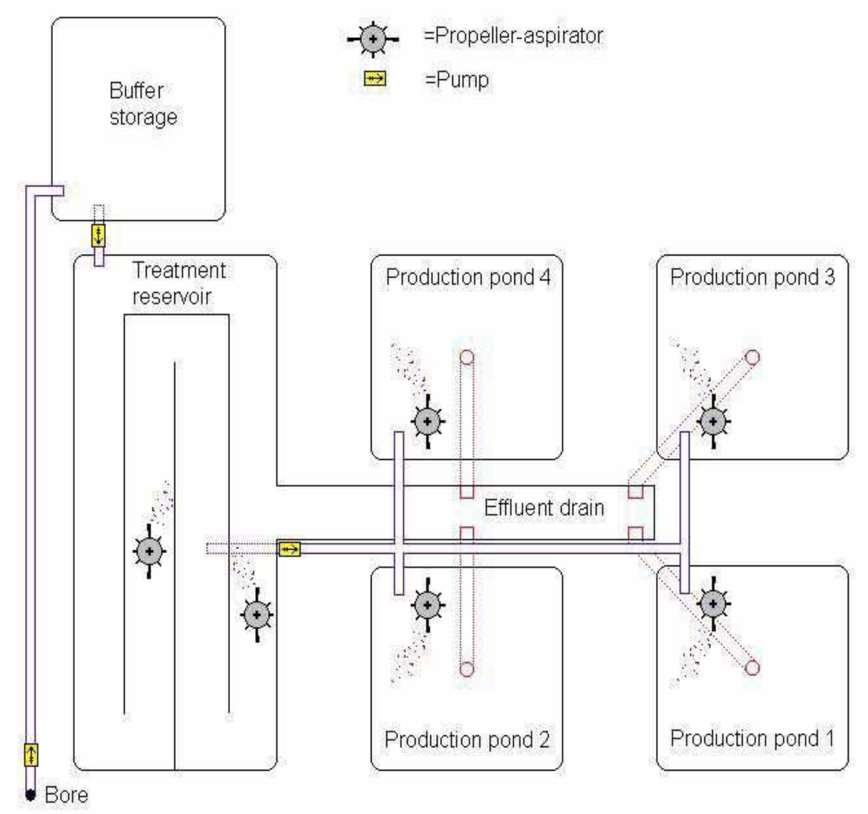

Figure 1. ISA Demonstration Site at Bauple, Qld.

For the trials, four square-shaped earthen ponds (average size of 330m^2 each), a 300m^2 treatment reservoir, and a 400m^2 buffer storage were constructed (Fig.1). The ponds were bird netted to prevent predation and a 400mm barrier fence erected to prevent redclaw from neighbouring ponds from colonising the system. Groundwater drawn from a depth of 10m was pumped to the buffer storage, where it was de-gassed and balanced with the addition of potash (KCl) prior to stocking. The treatment reservoir was used to recycle effluent water back to the production ponds while providing a store for discharge waters during harvest. A 1.5 hp Force 7 propeller-aspirator provided aeration and circulation in each of the ponds, the treatment reservoir, and the buffer storage. The treatment and production ponds had an average depth of 1.5m, while the buffer storage had an average depth of 3m when full.

Despite seasonal differences, changes in production strategies, disparate stocking rates and differences in survival rates, production figures for 2002/03 and 2003/04 were similar across all ponds averaging 4.22 t/ha with the average growth rate at an encouraging 1.8 g per week.

<u>Zero exchange/high density trials (2004/05)</u>

In 2004/05, we compared production protocols and assessed water quality and nutrient dynamics in two replicated high-density production systems. Both systems were intended to operate on a zero or limited discharge basis, following a management regime that encouraged a bacterial floc formation (lined ponds, high aeration, high C:N ratios) similar to “active suspension pond” models.

Production System One (PS1) encouraged floc formation/water treatment within the production pond. Production System Two (PS2) operated as a modified active suspension system, recycling production pond water through an earthen duckweed-based water treatment (DWT) pond to manage water quality.

This study tested high density bacterial floc systems (otherwise known as active suspension ponds) where water treatment is based upon developing heterotrophic bacteria and planktonic algae as sinks for excess nutrients, limiting the need for environmental discharge. The bacterial flocs in turn provide an additional protein source to the prawns. In PS1, we encouraged bacterial flocs within the prawn culture pond, while in PS2 we modified the design to consist of two compartments – one for prawn culture and the second to moderate and control the excess build-up of bacterial and algal biomass with the system. Using DWT in this second pond was designed to better control turbidity and oxygen availability.

A high BOD is a known characteristic of active suspension ponds, so additional aeration was provided to counter this demand in the production ponds of both systems. However, with the high prawn stocking density (equivalent of 10 tonnes/ha) and the evident accidental over-feeding, both systems were unsustainable for the duration of the grow-out period in terms of being able to meet oxygen demands. The fact that both production systems performed similarly (no significant differences in nutrient levels), despite quite different management strategies, is further evidence that the systems were generally overloaded.

Prawn production without water exchange has been studied with *P. setiferus* in the USA. Whilst a different species to the current trial, the results make a useful comparison. The US study found that without water exchange, the best production that could be achieved was 3,169 kg/ha – far below the anticipated 10,000kg/ha yield of this trial. The US study also experienced substantial water quality problems when trialling stocking densities (66/m2) similar to this trial.

Production trials (2005/06)

In 2005/06, the year's activities were focused primarily on successful production of a commercial crop of black tiger prawns. The previous year's failure to produce a commercial end product was due to water quality issues with dissolved oxygen and ammonia (TAN) caused by high stocking densities and overfeeding. Rather than applying experimental techniques which push the biological limits of the system that inevitably have a higher risk and rate of failure, staff concentrated on ensuring a commercial outcome to guarantee regular customer supply. Two trials were initiated at the Bauple demonstration site – the first was focused on applying industry best practice to producing a commercial crop of tiger prawns using inland saline water, while the second involved using existing additional redclaw culture ponds to produce tiger prawns at low density. Other trials to assess the potential of organically farming banana prawns using inland saline water occurred in separate ponds at Bauple during the same period.

If all ponds had been harvested at the appropriate time, it is likely that the production would have met expectations of 160+ kg/pond, the equivalent to 4.2 t/ha. However, in an attempt to guarantee continued supply to a valued, high profile customer, partial harvesting began in March and continued right through into the autumn (May 2006). In hindsight, prawns were kept far longer than was ideal, and the final harvest results were variable, and less than half the predicted harvest with an average of 65.72 kg/pond or 1.7 t/ha.

Simultaneously, in adjacent ponds, a trial was performed to assess the performance of *P. monodon* in standard, soil lined redclaw crayfish production ponds. A rectangular 650m^2 earthen redclaw pond was stocked with the acclimated *P. monodon* PL at a rate of 14.4/m^2. No aeration was applied until Day 63 when the 1.5 hp aspirator was switched on to increase dissolved oxygen to acceptable levels. The average weight of prawns in this pond reached 24.9g after 133 days of production. The results of this trial indicate that standard soil lined redclaw ponds could be used for lower density *P. monodon* production provided adequate aeration is provided.

Organic production trials (2005/06)

There is an increasing demand world wide for organic foods. Over the last decade, organic foods have been one of the most dynamic of the international food markets. Many countries have shown remarkable growth rates for organic foods. Denmark and Sweden, for example, have exhibited growth rates ranging from 30 – 40% and Switzerland and the United Kingdom, 20 – 30%. The international market for organic food was worth approximately US$20 billion in 2000. The largest single market was the USA with sales of around US$10 billion, followed by Europe with US$9 billion, and Japan with US$1.5 billion. Although worth only a fraction of the global conventional food market, the organic market sector is nevertheless considered an important, rapidly growing niche market, not to be ignored by marketers.

An additional benefit of inland groundwater culture of marine crustaceans is the innate biosecurity advantage of such culture systems. Groundwater free of marine pathogens has been used by American producers to develop certified "organic", "chemical free" or "antibiotic free" farms. Its use has enabled growers to source and maintain specific pathogen free (SPF) stock and in some cases initiate the establishment of inland biosecure or "high health" hatcheries.

Figure 2. Black tiger prawns from demonstration site ready to eat.

General discussion

The objectives of these investigations was to review data concerning groundwater use, suitability and availability in key regions; establish methods to permit the rapid acclimation and transfer of marine prawns to fresh and low salinity groundwater for grow-out; ascertain the mineral supplementation required to enable individual groundwater sources to be used for prawn culture; and compare the growth of black tiger and banana prawns in marine and inland saline waters. The findings of these investigations can be summarised as follows:

1. The comparative abundance of fresh, low salinity, brackish and saline water suitable for prawn culture in several regions in Queensland is high.

2. Of the 8,500 bore records studied 81% have conductivities recognised as being suitable for black tiger prawn (*P. monodon*) production (800µS/cm or greater).

3. 33% of all bores studied have conductivities in excess of 3,000µS/cm.

4. Regions like the Burdekin delta and the Darling Downs generally possess good quality groundwater with chemistries favourable for the production of marine prawns.

5. Acclimation of prawn postlarvae to low salinity environments should be conducted slowly (0.19 ppt/hr) and with minimal disturbance so as to maximise survival.

6. Acclimation procedures and target salinities will be species and salinity dependent with *P. monodon* being more tolerant of lower salinities than *P. merguiensis*.

7. Some groundwater types are more suitable than others but most are deficient in potassium (K^+).

8. In most cases, the addition of potassium chloride (KCl) will improve survival significantly in groundwater deficient in K^+.

9. Laboratory trials at salinities greater than 2,800µS/cm show that acclimated *P. monodon and P. merguiensis* postlarvae will grow equally well in groundwater regardless of salinity at salinities as low as 3,000µS/cm.

10. Pond trials show that *P. monodon* and *P. merguiensis* grow at favourable rates in low salinity groundwater (>3,870µS/cm) under semi-intensive conditions.

11. Fully recirculated semi-intensive farming is technically feasible using low salinity groundwater.

12. The efficacy of highly intensive systems for *P. monodon* and *P. merguiensis* production must be further investigated before the comparatively large investment required for their establishment and operation can be justified for this species.

13. Further research on closed “zero-discharge” and “zero-exchange” systems is required for *P. monodon* and *P. merguiensis* at a range of intensification levels.

This series of investigations demonstrate that inland production of marine prawns using groundwater in Queensland could be undertaken in a number of regions using available infrastructure and groundwater resources. The ability to exploit this opportunity will be largely contingent on industry’s adherence to principles of sustainable development and management. The level of intensity, investment and risk will be highly dependent on the location in which the activity is being conducted, its water supply, chemistry, and very importantly the skill of the operator.

Publications/presentations/posters

- Burke, M.J. (2006). Evaluation of the potential for aquaculture in cotton catchments. ISA: Resources and Investment. Skretting Australasian Aquaculture 2006, Adelaide, Australia.
- Collins, A., Russell, B., Walls, A., and Hoang, T., 2005. Inland Prawn Farming – Studies into the potential for inland marine prawn farming in Queensland. Queensland Department of Primary Industries & Fisheries. ISSN 0727-6273 79pp. www.dpi.qld.gov.au/extra/pdf/far/inlandprawnfarming.pdf
- Collins, A. L. (2004). Integrated aquaculture research: water, fish, prawns, crops and more fish. Aquaculture Association of Queensland Annual Conference and Workshop, Harvey Bay, Queensland, 27 – 28th August 2004.
- Collins, A. L. and Russell, B. J. (2004). Emerging opportunities for prawn aquaculture using saline groundwater. World Aquaculture Society. Australian Aquaculture Conference, Sydney Australia.

Information provided to potential investors

N/A

Economic analysis

The Queensland DPI&F have developed an economic decision tool for inland prawn farming as well as many other aquaculture operations (Figure 3). Whilst it may be theoretically possible to populate these models with production figures and hence determine the viability of any possible venture, it is the QDPI&F’s position that these are economic decision-making tools to assist potential industry entrants and it may be unwise to populate even with hypothetical values.

DPI&F Queensland, having developed these models and having significant biological experience in these areas, remain keen and willing to help prospective entrants into the aquaculture industry populate these models but feel this should be on a case by case basis dealing specifically with a set of circumstances besetting the intended customer/investor.

In aquaculture, as in all other operations, there are bound to be economies of scale. There will always be a point at which the size, or lack of, limits the viability or profitability of the business venture. This is especially true in aquaculture. Typically, high capital investment costs together with increasing competition from overseas imports means to remain viable, an aquaculture operation must run with the highest degree of efficiency possible. This is rarely possible in small demonstration facilities such as the Bauple site. Economic decision tools, such as that developed for this project, will assist the customer to determine at what scale a particular operation becomes viable. Potential benefits or incentives for the development of inland prawn farming are numerous:

1. Price differential between coastal property prices and inland areas.
2. Water extraction/disposal costs (existing bores compared to seawater intake infrastructure on environmentally sensitive coastlines).
3. Prevention/absence of disease.
4. Increasingly stringent effluent conditions for coastal farms.
5. Opportunity to diversify land use options (effluent can be used for irrigation in some cases) and low cost production.
6. Limit impacts of prawn farming on the environment.
7. Simplify farm logistics.
8. Improve control over water supply and use.

Commercial adoption/development

N/A

Remaining constraints and recommendations for the future (R,D&E)

There is no strategic plan evident for the development/identification of policy drivers/blockers critical to industry investment and development into ISA.

1. Key Performance Indicators (KPI) for industry growth should include some production based measures and new development approvals.
2. Policy support that exists for inland aquaculture needs to be documented as does the existing regulatory framework. It is important to understand in Queensland what regulatory hurdles will have to be overcome in establishing new operations (i.e., how will the issue of culturing marine or other freshwater species west of the divide be handled (disease and translocation issues etc).
3. Similarly policy issues for other government departments (NRW & EPA) also need to be identified and resolved.
4. Industry development for inland aquaculture should involve the further identification of suitable resources (land, water, infrastructure) that can be developed or utilised.

Summary – is there still potential?

The potential for aquaculture in Australia is still large but is facing the increasing threat of cheap imported product that the Australian palate does not differentiate. Given the diminishing value of wild caught fisheries and the increasing demand for marine based protein, aquaculture stands at the precipice of world-wide protein production technology.

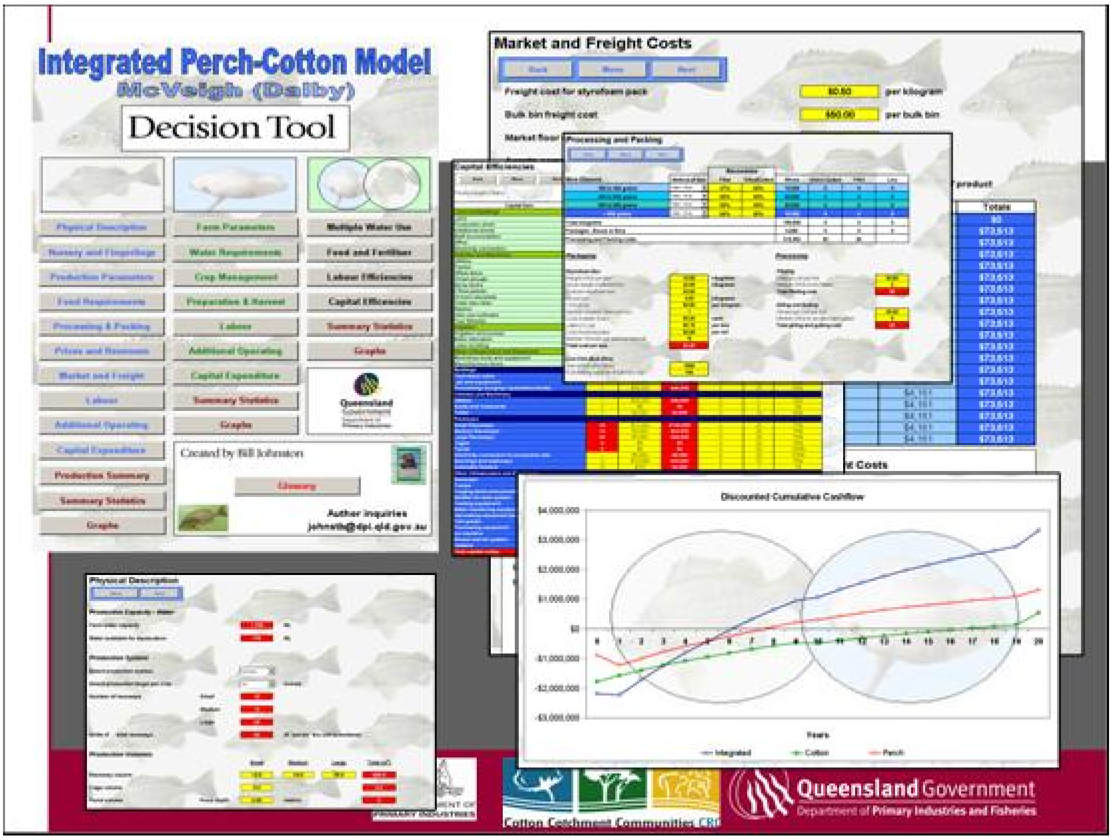

Figure 3. Example of economic decision tools available through the DPI&F and ISA.

Figure 4. W&D Hellmuth Aquaculture Facility, Bauple, Tiaro Shire, Qld.

5.1.5. *NSW DPI – Application for demonstration facility and summary of R&D progress*

APPLICATION

NSW DEPARTMENT OF
PRIMARY INDUSTRIES

CONTACT OFFICER:

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FACILITY:

ISA Research Centre, Wakool, NSW.

Description of facility

In May 2002, NSW Fisheries opened the ISA Research Centre (ISARC) adjacent to the Wakool/Tullakool Sub-Surface Drainage Scheme that is the largest groundwater interception and evaporation scheme in Australia. The ISARC is approximately 30 km from Wakool, NSW. This project has been co-funded by the owners and operators of the Drainage Scheme, Murray Irrigation Limited (MIL). The NSW Department of State and Regional Development and Murray Land and Water Management Plan have also invested in the project.

The ISARC includes:

- Five, 500 m^2 plastic-lined earthen ponds.
- One, 600 m^2 plastic-lined reservoir pond (all ponds are netted to fully protected them from bird predation).
- Temperature-controlled bioassay system with 54, 60L tanks.
- 16, 500L polyethylene tanks.
- 3, 2000L polyethylene tanks.
- Saline water supply (from either a low salinity basin [5 – 20 ppt] or a high salinity basin [>35 ppt]).
- Freshwater storage dam.
- Office-laboratory.

Ownership and approvals:

MIL own the land and permanent infrastructure. All necessary approvals to conduct research at ISARC have or will be obtained by NSW DPI (includes permits to transfer animals for farming experiments and animal care and ethics approvals).

Purpose of facility:

The major purpose of the project run at this facility is to determine if a number of marine or salt-tolerant freshwater species can be cultured 'economically' in inland areas and if groundwater interception and evaporation schemes are suitable for aquaculture.

Summary of progress prior to the commencement of the current project:

In the two years since research at the new ISARC commenced (2002-2004), survival and growth trials were conducted with silver perch (a salt-tolerant, native freshwater fish), mulloway (an estuarine fish), black tiger prawns (a marine prawn tolerant of a wide range of salt concentrations) and rainbow trout. Silver perch survived and grew in water of salinity at or below 10 mg/L without potassium adjustment, trout grew at salinities up to those equivalent to full strength sea water and provided potassium was added for mulloway and prawns, survival and growth in tanks was similar to that in water with salinity adjusted using ocean salts.

Trout survival and growth over the period April to November was excellent and equivalent to that recorded in freshwater raceway systems. A pilot-scale trout production trial was run during the winter of 2004. A pilot-scale prawn production trial (aiming for approximately 300kg/0.05 ha pond; equivalent to 6 t/ha) was also completed. This trial included a comparison between ambient ponds and one passively heated using a greenhouse-type cover. Overall results for prawns in the ambient pond were unsatisfactory – high survival, low growth. However, growth in covered ponds was excellent.

In 2004 there were still key technical issues that needed to be addressed before ISA technology could be transferred to the private sector. Temperature management for prawn culture and marketing and economics for trout needed to be investigated. Occasional mortality of fish (silver perch, mulloway and snapper but not prawns) had been recorded in ponds, even where potassium has been adjusted. This may have been due to unusual pond sediments or other ecological processes within the ponds not experienced in coastal ponds. The solutions are likely to be simple but required focused experimental research. The composition and taste of fish and prawns grown is inland saline water needed to be confirmed and economic modelling was needed to ensure that any ventures can stand-alone financially.

Estimated potential for aquaculture industry growth:

In 2004, it was recognised that there is enormous potential for establishment of large-scale industrial aquaculture in the Murray Darling Basin and other saline affected areas in Australia. Coastal and inshore systems in Australia are limited or inaccessible and industry development in these areas will be slow. In contrast, 2.6 x 10^6 ha of land in Australia is affected by salinity and there are 11 groundwater interception schemes operating in the Murray Darling Basin alone (total pond surface area of these schemes exceeds 6,300 ha, they cost more than $108 million to construct and $3 million annually to operate and dispose of more than 50,000 million litres of water/yr). Another 8 schemes are being constructed or operated with many more likely on the future. 74 rural towns in WA, NSW, Vic and SA are threatened by rising saline groundwater and groundwater interception schemes and evaporation ponds are probably the only viable engineering solution to that problem.

Provided the water is 'suitable', and all preliminary studies' suggests it is, incorporating aquaculture ponds into these evaporation schemes will not only provide an economic return to the extremely costly business of building and operating groundwater interruption schemes and evaporation ponds but greatly reduce costs of establishing aquaculture ponds.

Commitment to ongoing R&D:

NSW Fisheries and Murray Irrigation Limited are committed to R&D at ISARC on ISA. NSW Fisheries have secured a grant from the Australian Centre for International Agricultural Research (ACIAR) to conduct collaborative research with The Central Institute for Fisheries Education at the Rohtak Centre, India. This project is poised to start as soon as the agreement is signed by the Indian Government and is for a three-year period (2004-2007).

Plan for demonstration activities for 2004 – 2007:

- Two open days. Target 100 people for each day. Local and state advertising. Talks, displays, tour.
- Two training workshops (one on trout production and one on prawn and research methodology).

- Production of technical production (culture) manual – focus on acclimation, fortification of potassium and "unique" aspects of ISA culture (will collaborate with WA on trout and Qld on prawns if possible).
- 2 Scientific manuscripts/yr (2004 will be on mulloway and silver perch; 2005 will be on trout and prawns; 2006 will be on economics & marketing).
- Non-technical articles (at least 2 projects).
- Organise ISA session and present at AA04.
- Present at AA06.
- Coordinate data and inputs to generic ISA economic analyses and business planning models.
- Provide information for web site (update to NAC communications officer every 3 months).
- Facilitate commercialization (partnership) of industrial scale ISA (with MIL), firstly on trout and later on other species (e.g., prawns if economic analysis looks favourable).

Plan for expenditure from project to facilitate demonstration activities:

Date	**Item**	**Amount**
2003/04	Water supply for trout (pump + 200 m x 100 mm pipe)	$8,000
	Nursery recirculating holding tanks	$15,000
	Greenhouse covers	$5,000
	Cheap raceways (earthen ponds; $2,000 for plumbing & pipes; assume Murray Irrigation Limited co-invest for construction)	$2,000
2004/05	Replacement pumps, pipes and consumables associated with large-scale validation experiments	$15,000
2005/06	Replacement pumps, pipes and consumables associated with large-scale validation experiments	$15,000
TOTAL:		**$60,000**

5.1.5.1. General summary of R&D progress during the course of the project

Information provided to potential investors

The demonstration farm has provided an excellent platform for information dissemination and education and first-hand observation of salinity and its remediation through subsurface drainage and especially ISA (ISA) activities in NSW. In addition to potential investors in ISA, the ISARC was visited by interstate and international researchers, local farmers and interested community members and school groups. Many local farmers with salt-affected land have been interested to explore opportunities for commercial use of their saline groundwater; however after observing at the demonstration farm the activities and understanding the necessary labour and capital input for a large-scale ISA venture, many farmers realised that there was limited opportunity for them. The best opportunity for commercial development of ISA in southern NSW is large-scale culture of rainbow trout using saline groundwater and disposal, evaporation basins from subsurface drainage schemes.

Completed economic analysis

Economic analyses of rainbow trout culture in raceways has been done using the QDPI (Bill Johnson) model, developed originally for silver perch and barramundi (Barraprofit). A commercial economic model for a 200t/y rainbow trout farm has also been developed by Lonsec and Aquatic Solutions Australia Enterprises (ASAE).

Commercial adoption/development

Development of a 200t/y commercial, demonstration rainbow trout farm with partners Murray Irrigation Limited, Lonsec, ASAE, NSW DPI and Seafood CRC has been approved and construction details are being finalised. It is anticipated that the farm will be operating by mid 2008; however water supply issues (discussed below) may prevent start-up of full-scale operation.

Remaining constraints and recommendations for the future

The biggest constraint to commercial development if ISA in southern NSW currently is the deficit of saline groundwater as a consequence of severe, long-term drought. The extended drought has meant that little or no fresh, irrigation water has been available for irrigated cropping and significant rain has not fallen in the Murray-Darling basin for many years in succession. As a consequence, the groundwater table has not been recharged and the saline groundwater table is very deep. Pumping of saline groundwater is therefore not necessary and even if pumping occurs, it is expensive. The volume of saline groundwater at the WTSSDS has decreased from an average of approximately 35 ML/d in "normal" years to 4 – 5 ML/d in "drought" years. Development of a 200t/y rainbow trout farm using standard, flow-through, raceway methods was based on availability of in excess 20 ML/d of saline groundwater.

The limited availability of saline groundwater has highlighted the need for ongoing research to identify viable, commercial methods for reuse of saline groundwater in rainbow trout production as well as effluent disposal from evaporation basins. This research will be addressed as part of the Seafood CRC project where commercial techniques developed will be demonstrated to farm operators, scientists, groundwater managers and potential new investors.

There is also a need to determine if high density culture of advanced trout fingerlings in indoor tanks during summer would improve production, especially by allowing a larger fish to be produced by the end of winter. Larger fish may be more valuable as there are more options for value-adding the harvested fish compared with small fish.

In the past three years we have also done research to identify the suitability of inland saline groundwater and the environment for culture of tiger prawns (*Penaeus monodon*), kuruma prawns (*P. japonicus*), and mulloway (*Argyrosomus japonicus*). Unlike trout, for each of these species, potassium in the saline groundwater is deficient and must be added (as potash fertiliser) in order for the prawns and fish to survive and grow. Potassium fortification is easy to do, but is an added cost and process during culture. The biggest constraint however for culture of the tropical and semi-tropical species is the volatile climatic environment in southern NSW. Cold weather is generally experienced for 7 months/y and the short summer periods, necessary for optimal growth, are also subject to hot days but cold nights. These conditions caused slow growth compared with that experienced on coastal farms and viability of culturing prawns/mulloway in ambient ponds is questionable. We investigated the efficacy of floating solar covers to increase pond water temperature for mulloway culture. The covers increased winter and summer pond temperature and growth of mulloway was 20% greater in covered ponds compared with ambient, uncovered ponds, however the covers were difficult to manage and were destroyed on two occasions by strong winds. Further development is needed to improve the design and operation of pond covers and must then be assessed for economic viability.

Culture of larval fish and prawns has not been attempted at ISARC, but significant opportunity exists to investigate the suitability of saline groundwater for hatchery production. A major advantage for development of an inland, saline hatchery is the site is likely to be biosecure. The ISARC is approximately 400k from the nearest coastline and all saline water is sourced from groundwater reserves which are likely disease-free. Hatcheries also use small volumes of water compared with growout operations and large numbers of fish/prawns can be produced from a small surface area.

We believe that rainbow trout farming in association with saline groundwater subsurface drainage schemes has the best opportunities for industry development in the Murray-Darling Basin. However, in order for development to occur it will be necessary to demonstrate the viability at a commercial farm, to effectively train new industry participants and to encourage operators of saline groundwater subsurface drainage schemes to become involved with trout farming.

Overview of ISA research activities on the demonstration site

Inland Saline Aquaculture Research Centre (ISARC)

In 2002, the ISA Research Centre (ISARC) was established to evaluate the potential of various species of salt tolerant finfish and crustacean species for ISA. The facility comprises 6 x 500m^2 plastic-lined ponds, an experimental tank system and a temperature controlled room for replicated bioassay research. Fresh and saline waters of different salinity are available. ISARC is located at the Wakool-Tullakool Sub-Surface Drainage Scheme (WTSSDS), the largest subsurface drainage scheme in Australia which disposes 35,000ML of saline groundwater each year. The WTSSDS consists of 60 bore pumps for salt interception and 1600ha of ponds for evaporation and disposal of the saline groundwater. It is estimated that the WTSSDS has helped return 60,000 hectares of unproductive salt-degraded land back to productive farming.

Preliminary research

Preliminary research at ISARC indicated that the inland saline ground water from the WTSSDS has 95% less potassium than marine water of the same salinity and as such was not suitable for survival and growth of marine species. However, addition of potassium in the form of potash fertiliser increased potassium concentration in the saline groundwater and small-scale experiments demonstrated marine species survived and grew in potassium fortified inland saline groundwater at similar growth rates reported for the species in marine water.

A list of potential candidate species was established which included snapper, black tiger prawn, mulloway and silver perch. These species were selected for research as they all had established culture technology, closed lifecycles, ready access to juveniles, high market value, were present in the market place and were salinity tolerant. Early trials focused on determining optimal salinity and potassium concentrations for snapper, silver perch, mulloway and black tiger prawn. A temperature-controlled room was used to run replicated, multi-factor bioassays with each species. The key finding was marine species required potassium to be fortified in saline groundwater to above 50% of the concentration found in marine water of the same salinity. Growth rates of snapper, mulloway and black tiger prawn during bioassays were comparable to published rates in marine water. Silver perch, a salt-tolerant freshwater species, grew well in raw groundwater and did not require potassium adjustment.

Upon completion of the bioassays, pilot-scale commercial production of black tiger prawns, snapper, mulloway, and silver perch was undertaken in plastic lined ponds at ISARC. Cool winters and fluctuating daily water temperatures up to 0 – 5^{o}C limited the growth of snapper and black tiger prawns. Mulloway grew well in the summer, but growth was slow in the winter.

Rainbow trout and kuruma prawns were then selected for evaluation at ISARC as they are temperate species and were possibly more suited to the local climatic conditions. An initial bioassay and pond trial with rainbow trout showed that growth and survival was high when pond water quality was high, however build up of organic matter in static ponds (minimal water exchange) reduced growth.

Other species

Other species evaluated at ISARC in short-term bioassays include brown trout, Atlantic salmon, and Sydney rock oysters. Further research is needed to determine commercial viability of these species.

ACIAR research 2004 – 2007

Temperature fluctuation was identified as a major constraint to the development of ISA. It was evident that the cold winter and fluctuating water temperatures were depressing the growth of marine species in inland saline groundwater at ISARC and that a solution was required if viable culture of tropical prawns and temperate fish was to occur. Research was required to identify either an engineering solution or identify a species well suited to the cold winters and fluctuating temperatures. Various engineering solutions were considered including filling the ponds to maximum to increase volume and reduce fluctuation, changing aeration to a less vigorous type and reduce influence of air temperature on pond water temperature, higher pond walls to reduce the influence of wind, fences, deeper ponds, heaters or insulation. We chose to evaluate the efficacy of pond insulation using floating covers on growth and survival of kuruma prawn, mulloway and rainbow trout.

Summary of Kuruma prawn research

Kuruma prawns are a high value product, almost exclusively exported to Japan, and are also more tolerant of lower water temperatures than black tiger prawns.

The aim of the experiment was to assess the efficacy of polyhouse covers on tanks for growth and survival of Kuruma prawns.

A tank trial to assess the performance of Kuruma prawns commenced in December 2004. The trial was done in six sand-lined 2000L tanks situated outdoors. Three tanks were covered with a plastic sheet (polyhouse), while the remaining three tanks were left uncovered and exposed to ambient conditions.

Kuruma postlarvae (PL15) were stocked in all tanks on the 14/12/04 at commercial densities. The trial was completed on the 17/05/05. Final weight of the Kuruma prawns in the covered tank was significantly larger (7.27g average) than those grown in the uncovered tanks (3.83g average). During the last 14 days of the trial, all prawns began to lose weight as water temperatures decreased. Survival in all tanks was 100%.

The trial showed survival of Kuruma prawns in tanks at ISARC was excellent, although growth was relatively poor. This may be attributed to several factors. There appeared to be a large build up of sulphurous compounds in the tank sediment as well as relatively large fluctuations in water temperature compared to a typical pond. Furthermore, a tank system has less natural food production compared with that experienced in large ponds. Small-scale tanks trials demonstrated that growth of prawns in tanks exposed to ambient conditions was slow compared with that of prawns grown in greenhouse covered tanks. Culture of prawns in saline groundwater in southern NSW will not be possible unless cost-effective management of water temperature is possible.

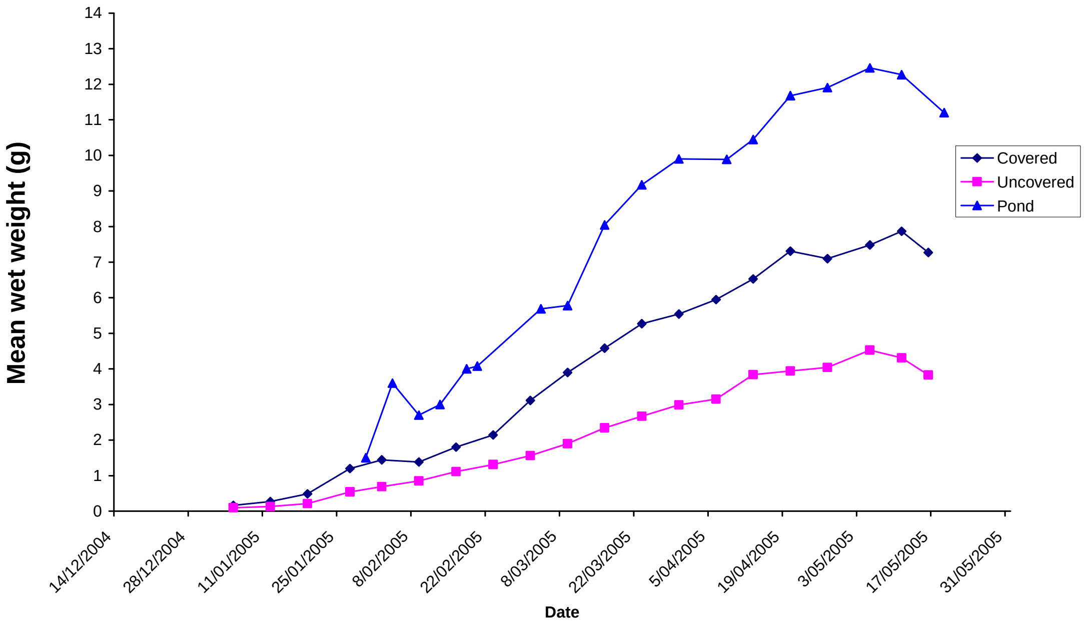

Figure 1. Wet weight of Kuruma prawns in covered and uncovered tanks and a pond at ISARC. Data are means (n = 10).

Figure 2. Cooked Kuruma prawns harvested from polyhouse-covered tanks.

Summary of mulloway research

Pilot scale commercial production of mulloway at ISARC showed that mulloway grew well when water temperature exceeded 16^{o}C. Average pond water temperature was generally greater than 16^{o}C during the period of November – May at ISARC. Mulloway appeared stressed when water temperature was less than 12^{o}C, and when water temperature was less than 10^{o}C (typically June and July) some fish died.

Application of floating solar covers was identified as a potentially suitable method to increase pond water temperatures and subsequently growth of mulloway. Floating covers were likely cheaper to install and could be retrofitted to ponds more easily than traditional, framed polyhouses. Darling Downs Tarpaulins and Gale Pacific Pty Ltd collaboratively developed modular floating transparent pond covers constructed from Solarweave (Figure 3). Three separate covers, each with dimensions of 100% pond length x 33% pond width, were positioned on a pond in order to completely cover the pond surface. Each cover could be moved independently to provide a range of pond coverage (0 – 100%) according to ambient weather conditions.

The trial commenced in February 2006 when 750 mulloway were stocked (96g) into each of 4, 0.05ha ponds. Two ponds were covered with floating solar sheet, and two ponds remained uncovered (control ponds). All ponds were managed similarly to maintain water quality. Temperature loggers were installed in each pond to monitor continually water temperature. Fish were fed twice each day using belt feeders. The feeding regime was 3% estimated biomass/day from February to end April when water temperature and fish feeding activity were high. When water temperatures decreased after April, the amount of food fed was reduced gradually to 1.5% estimated biomass/day. The trial was finalised in October 2006.

The floating solar covers were effective at increasing pond water temperature and in general water temperature in covered ponds was 3.0^{o}C and 1.5^{o}C greater in summer and winter, respectively than in uncovered ponds (Figure 4). Survival of fish in covered ponds (99.3%) was greater than uncovered ponds (90.6%). Mulloway grown in covered ponds were also 20% heavier (321g) than fish grown in uncovered ponds (268g) (Figure 4). Despite the solar covers providing an effective barrier against the air/water interface, DO_2, TAN and CO_2 concentrations were similar to those of uncovered ponds (Table 1)

Figure 3. Three, floating solar covers positioned on a 0.05 ha experiment pond.

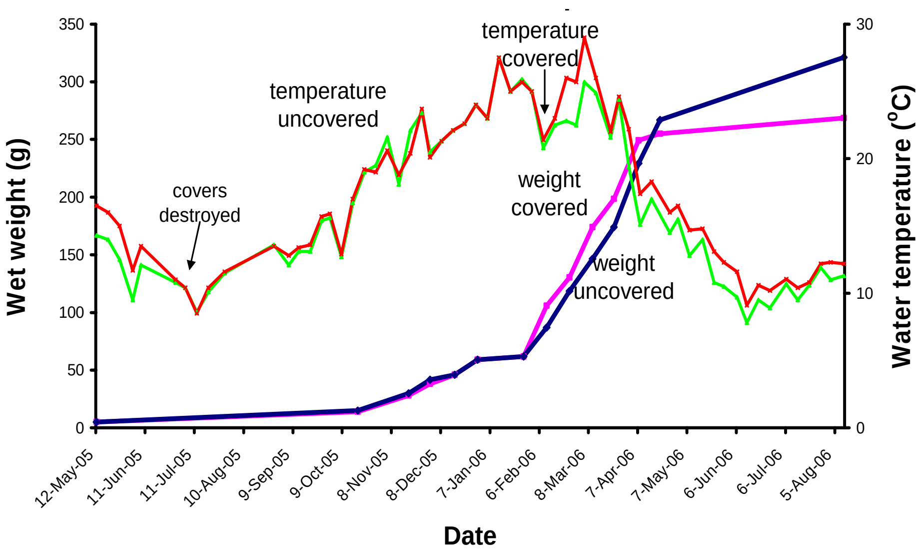

Figure 4. Water temperature and wet weight of mulloway in uncovered and covered ponds at Wakool.

Table 1. Water quality of uncovered and covered ponds during experiment.

	Covered pond	Uncovered pond
CO2 (mg/l)	0 – 15	0 – 5
NH4 (mg/l)	0 – 0.4	0 – 0.2
pH	7.3 – 8.5	7.4 – 8.6
DO (mg/l)	> 5.0	> 5.0
Salinity (ppt)	17 – 28	17 – 29

Although effective in raising pond water temperature, we encountered several problems during the experiment.

- A biofilm grew on the underside of the covers which possibly reduced solar radiation transfer and subsequently reduced the capacity to heat pond water. The biofilm was difficult to remove from the covers and would likely represent a significant labour input on a commercial-scale operation.
- The covers were fragile and susceptible to wind damage. On several occasions the covers were torn and eventually were lifted from the ponds and destroyed in a serious wind storm.
- The covers proved difficult to handle without mechanical winches or alike and any large-scale application would require significant mechanisation. Any future development will require complete cost/benefit analysis to determine the viability of floating solar covers. Alternative designs for pond solar heating including dome-type covers which may provide greater heating capacity than floating covers may be more suitable.

The mulloway from this trial were grown to 500g+ in late 2006 and 1kg+ in late 2007 in uncovered ponds. In excess of 1500 mulloway were sold in the local region for $10kg wholesale to retailers. The fish were highly regarded by consumers and were sold as whole and filleted product. Consumer preference was for filleted mulloway.

Mulloway at ISARC are capable of rapid growth when temperatures exceed 16^{o}C. When temperatures were suitable, fish of 50 – 200g grew at rates of up to 2g/day with FCR of 1.6:1. However, for extended periods during winter, growth was slow and fish were stressed.

<u>Rainbow trout</u>

Pond trials

Preliminary bioassay and short-term tank experiments in 2002/03 demonstrated that rainbow trout survived and grew well to market-size in raw saline groundwater at ISARC. The fortification of groundwater with potassium was unnecessary. Ambient pond water temperatures at ISARC were found to be potentially suitable for salmonid production for at least 7 months of the year from April to October.

A pilot-scale commercial production trial commenced in July 2005. The aim of the trial was to evaluate the performance of rainbow trout in plastic-lined ponds at ISARC, to provide production data to populate bio-economic models and to obtain feedback on market acceptance of harvested trout.

Approximately 1500, 37g rainbow trout were sourced from Triton Trout Farm (Tumut, NSW), and stocked at ISARC on the 06/07/05. The culture pond was operated on a constant flow-through basis to exchange up to 60% of the pond volume each day in order to optimise water quality by dilution of suspended solids and to reduce fluctuation in water temperature. Temperature of water when discharged from the subsurface drainage scheme at ISARC ranges from 16.5^{o}C in winter to 18.0^{o}c in summer, therefore continual exchange of groundwater could potentially provide pond conditions suitable for year-round trout survival and growth. Trout were fed by hand to satiation twice daily.

Growth performance of the trout was outstanding and after 3 months had an average wet weight of 298g and the largest fish were suitable for harvest (Figure 5). Survival was near to 100% during winter but began to decrease as pond temperatures exceeded 21^{o}C in summer, indicating that 60% exchange of pond water each day was inadequate to reduce heating of ponds during summer. Average FCR during the production period was 1.1:1. Despite increasing pond water temperatures market-size fish were continually harvested until late December.

Murray Irrigation Ltd (MIL) with the assistance of NSW DPI sold the rainbow trout to local retailers at Wakool, Barham, Deniliquin and Finley. By the end of 2005, a total of 1100 fish had been sold at $8/kg farm-gate. All proceeds from the fish sales were directed back to the project. The rainbow trout cultured in saline groundwater were very popular with consumers due to the fresh, salty flavour compared with freshwater cultured rainbow trout and consequently returned up to two dollars per kg more than freshwater trout as they were considered a superior product. Promotional and educational material was provided at each sales outlet (Appendix 10.3).

Production trials were repeated in winters of 2006 and 2007 with similar production of high quality rainbow trout. More than 1700kg of rainbow trout averaging 600g/fish have been sold fresh and smoked through local butchers, cafes and supermarkets.

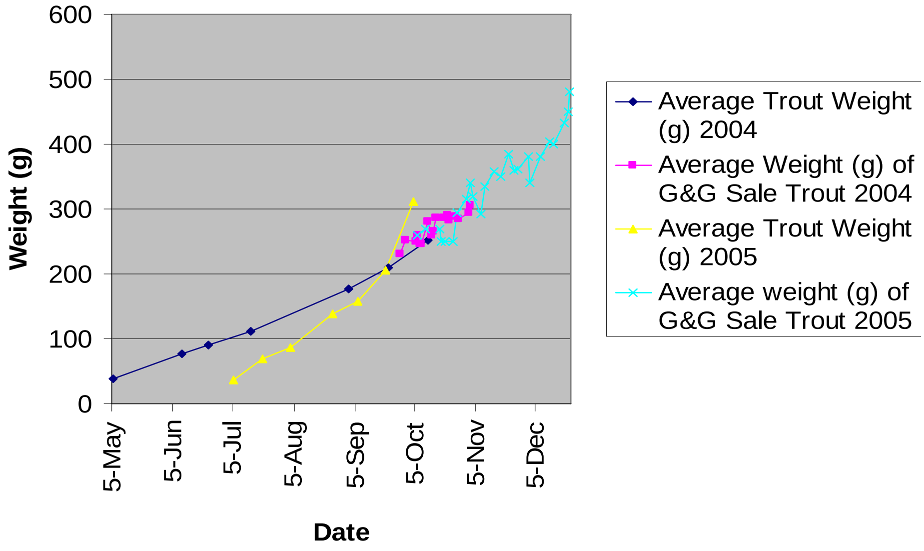

Figure 5. Growth of rainbow trout in saline groundwater ponds at ISARC (2005 & 2005).

Our trials demonstrated the potential feasibility for commercial rainbow trout production in a flow-through pond system using saline groundwater from the Wakool-Tullakool Sub-Surface Drainage Scheme (WTSSDS). The flow-through, raceway-type system reduces suspended organic matter and microalgal concentrations and moderates to some degree extremes in pond temperature. Production of rainbow trout however was not successful during summer as pond water temperature was too high (>24^{o}C), despite constant exchange of water. Feed intake and growth of rainbow trout declined and significant mortality was experienced at high temperatures. Clearly, exchange of up to 60% water volume/day was not adequate to maintain suitable water temperatures for trout during summer, however higher flows are likely to be satisfactory, but this remains to be investigated. Optimal production of rainbow trout at the WTSSDS can be expected between mid April to mid November.

Tank trial

Water quality of saline groundwater pumped directly from the subsurface drainage pipeline differs from that of saline groundwater following settlement in ponds. Typically, the pipeline saline groundwater has a pH of 7 and a CO_2 concentration of 30 – 75ppm while saline groundwater in ponds has a pH of 7.8 – 9 and a CO_2 concentration of 0 – 5ppm. The pond trials described above, established the performance of rainbow trout in small ponds (0.05ha) which were supplied with saline groundwater at a constant but low flow rate. The mixing and aeration of influent water with pond water allowed discharge of CO_2 and subsequent stabilisation of pH. However, in order to determine the feasibility of high-flow, raceway culture of rainbow trout it was necessary to evaluate the suitability of saline groundwater supplied directly from the pipeline for production of trout.

An experiment was conducted to determine the growth and survival of rainbow trout in saline groundwater supplied directly from the subsurface drainage pipeline. Two 2000L tanks were each supplied with raw groundwater which was siphoned from the WTSSDS pipeline outlet to provide a flow rate of 8000L/h (400% exchange/h).

On 01/07/06 each tank was stocked with 103 rainbow trout (mean wt. 126.3g) which were fed twice daily at 5%BWT/d. Water quality was monitored daily. For the duration of the experiment pH range was 6.9 – 7.3, CO_2 range was 30 – 75ppm, O_2 was saturated, temperature range was 15.5 – 18°C and salinity range was 10 – 18ppt. The experiment was terminated in December 2006.

Growth of rainbow was excellent and after 5 months, the fish had a mean wet weight of 455g and survival was 83%; fish died due to jumping from the tanks. The FCR was 1.65:1. Nephrocalcinosis, a renal condition which has been observed in other fish when exposed to high CO_2, was observed in some rainbow trout during the experiment. However, based on growth performance it appears unlikely that nephrocalcinosis caused any problems with the trout.

Other activities

ISARC is involved in a co-ordination project with NAC to promote and address the fragmented nature of ISA research in Australia. The aims are to develop ISA and associated economic models, develop an interactive temperature model and manage communication and technology transfer. ISARC has been actively involved in gathering bio-economic data and long-term temperature logging to develop models. In addition, the staff at ISARC have produced posters, flyers and scientific articles as well as the distribution of promotional items including pens, bags and assorted handouts.

ISARC hosted an Indian scientist, Dr Atul Jain, as part of a capacity building component of the ACIAR project *'Developing aquaculture in degraded inland areas of India and Australia'*. Dr Jain conducted a two week experiment to assess the suitability of saline groundwater from ISARC for culture of Sydney rock oyster.

Currently, Grant Webster is completing an Honours Degree (University of Tasmania) and is investigating the ability of small (1 – 25g) rainbow trout to acclimatise to inland saline groundwater.

ISARC is co-ordinating a trial to monitor the quality and quantity of groundwater delivered by the WTSSDS. This data is required to complete an economic model as the water volume will determine the carrying capacity and therefore the potential profitability of any commercialisation. The trial also investigates the feasibility and cost of modifying the operation of the scheme to deliver increased water volumes during the trout production season.

Commercialisation

Following results of the experiments described above and development of an economic model for trout farming, we are now at a stage where commercial development of a rainbow trout farm using saline groundwater from the WTSSDS will occur. Industry partners including Lonsec, Aquatic Solutions Australia, Murray Irrigation Limited, the Seafood CRC and NSW DPI are commencing a 5 year project to construct and operate a demonstration farm to produce 200t/y of rainbow trout. The main objectives of the farm are to:

- Produce 200t of trout each year.
- Provide a platform for demonstration of commercial ISA activities.
- Provide education for potential stakeholders including subsurface drainage scheme managers, new fish farmers and technicians, salt-affected landholders, university and school students, general public.
- Conduct research to identify optimal strategies for saline water use (e.g., recirculation) and effluent disposal; identification of new species or culture methods for expansion of ISA.

Promotional activities

Open day

ISARC held its 2nd annual Open Day on the 9th November 2004. The day featured several presentations from MIL and NSW DPI staff, poster boards, giveaways, handouts, live fish displays, farm tours, trout tasting and culminated in a BBQ lunch. The attendance for the day was outstanding with in excess of 160 people including landholders/farmers, salinity mitigation scheme managers, MDBC managers, government representatives. The public was very enthusiastic and interested in the project and favourable comment on the eating qualities of the rainbow trout was received.

Media

The research at ISARC has been featured on ABC radio at least 4 times in the past 3 years. ABC Television Sydney flew to the site in a helicopter to film a nightly news segment on ISARC. The research has been detailed on two occasions in the popular trade magazine Austasia Aquaculture as well as in Farming Small Areas magazine. Local and regional print media have published in excess of 16 news articles detailing the various research trials (Appendix 2). ISARC has hosted countless tours involving people from the aquaculture industry, international and local scientists, farmers, school children and members of the general public.

Publications

Scientific papers

- Fielder, D.S., Bardsley, W.J., Allan, G.L., 2001. Survival and growth of Australian snapper, *Pagrus auratus*, in saline groundwater from inland New South Wales, Australia. Aquaculture 201, 73–90.
- Doroudi, M.S., Fielder, D.S., Allan, G.L., Webster, G.K., 2006. Combined effects of salinity and potassium concentration on juvenile mulloway (*Argyrosomus japonicus*, Temminick and Schlegel) in inland saline groundwater. Aquaculture Research 37, 1034–1039.
- Doroudi, M.S., Fielder, D.S., Allan, G.L., Webster, G.K., 2007. Survival and growth of silver perch, *Bidyanus bidyanus*, a salt-tolerant freshwater species, in inland saline groundwater from Southwestern New South Wales, Australia. Journal of the World Aquaculture Society 38, 314–317.
- Fielder, D.S., G.L. Allan and P.M. Pankhurst, (submitted 2007). The effects of potassium concentration in saline groundwater on osmoregulation and chloride cell morphology of juvenile Australian snapper, *Pagrus auratus.* Journal of the World Aquaculture Society.

Conference proceedings

- Fielder, D.S., 2005. Status of ISA R&D at the ISA Research Centre, Wakool. Murray Land and Water Management Plan Conference, Deniliquin, NSW, Australia, 15 February.
- Fielder, D.S., 2005. ISA in India. Proceedings of the Australian Centre for International Agricultural Research Fisheries Program Meeting, CSIRO Marine Research Laboratories, Cleveland, Queensland, Australia, 24 – 25 May.
- Fielder, D.S., M.S. Doroudi, M.S., and G.L. Allan. 2003. Culture of marine and salt tolerant species using inland saline groundwater in Australia. Proceedings of the Asian-Pacific Aquaculture 2003 Conference, Bangkok, Thailand, 22 – 25 September 2003.
- Fielder, D.S., M. Doroudi and G. Allan, 2003. ISA in Australia: status and challenges. Proceedings of World Aquaculture Society Conference, Salvador, Brazil, May 19 – 23.

- Fielder, D.S., G. Webster, M. Doroudi and G. Allan, 2004. Status of R&D at the ISA Research Centre, Wakool, NSW. Proceedings of the Australasian Aquaculture 2004 Conference, Sydney, Australia, September 26 – 29.
- Fielder, D.S., G. Allan, P. Pankhurst and D. Pepperall, 2003. Effects of low potassium concentration in inland saline groundwater on osmoregulation of Australian snapper, *Pagrus auratus*. Proceedings of World Aquaculture Society Conference, Salvador, Brazil, May 19 – 23.
- Gavine F., G. Gooley, G.J. Partridge, A. Collins, W.G. Hutchinson, G.I. Jenkins, and D.S. Fielder, 2005. Key drivers for the future development of inland aquaculture in Australia. Proceedings of World Aquaculture Society Conference, Bali, Indonesia, May 10 – 12.
- Partridge G.J., G.A. Sarre, R.G. Doupé, F. Gavine, G. Gooley, A. Collins, G.I. Jenkins, A.J. Lymbery, S. Fielder, and G. Allan, 2005. ISA in Australia – a synopsis of key species, production systems and approaches to environmental sustainability. Proceedings of World Aquaculture Society Conference, Bali, Indonesia, May 10 – 12.
- Fielder, D.S. 2005. NSW Fisheries ISA Research Centre, Wakool, NSW: Progress with R&D, demonstration and commercialisation. ISA Steering Committee Meeting, Melbourne, 3 – 5 August.
- Fielder, D.S. 2006. ISA at the Wakool-Tullakool Sub-Surface Drainage Scheme. Roundtable discussion on climate change. Charles Sturt University, Wagga Wagga, Australia, November 8. Invited speaker.
- Fielder, D.S. and S. Raizada, 2006. Production of giant freshwater prawns in saline groundwater in inland northwestern India. Australasian Aquaculture 2006, Adelaide, Australia, August 28 – 30. Invited speaker.
- Fielder, D.S., G. Allan and G. Webster, 2006. Development of saline aquaculture in inland New South Wales, Australia. World Aquaculture Society Conference, Firenze, Italy, May 9 – 13.
- Fielder, D.S., G. Allan and G. Webster, 2006. Going outside the loop – a need for innovation to develop saline aquaculture in inland New South Wales, Australia. Australasian Aquaculture 2006, Adelaide, Australia, August 28 – 30. Invited speaker.
- Fielder, D.S., S. Raizada, J Hasan, U.K. Maheshwari, D. Kumar, S.C. Mukherjee and S. Ayyappan, 2006. Hatchery seed production of giant freshwater prawns using amended inland saline groundwater. World Aquaculture Society Conference, Firenze, Italy, May 9 – 13.

Figure 6. ISA Research Centre facilities, Wakool, NSW.

5.2. Managing communication and technology transfer

5.2.1. Introduction

A total of four major Steering Committee meetings and two teleconferences were conducted over the duration of the project:

- 1st Steering Committee meeting 1 – 2 April 2004, Sydney.
- 2nd Steering Committee meeting 3 – 5 August 2005, Melbourne.
- 3rd Steering Committee meeting 30 January to 2 February 2006, Northam and Fremantle.
- 1st Teleconference 21 December 2005, chaired by Dr Geoff Allan.
- 2nd Teleconference 27 October 2006, chaired by Dr Geoff Allan.

Agendas of the Steering Committee meetings and agendas and notes from the Teleconferences are listed in the following section. Full minutes and detailed reports of the Steering Committee meetings were produced from each meeting and circulated to all members of the Steering Committee and other key stakeholders. These are not included here.

5.2.2. Committee meetings and teleconferences

5.2.2.1. 1st steering committee meeting

FRDC Project 2004/241

Development of industrial-scale ISA:

Coordination and communication of R&D in Australia

Date: Thursday 1st and Friday 2nd April 2004

Time: Thursday: 10:00 am to 5:00 pm
Friday: 9:00 am to 3:15 pm

Venue: BOARDROOM 2
Rydges Cronulla
20 – 26 The Kingsway
Cronulla NSW 2300
Tel: 02 9527 3100
Fax: 02 9544 4089

Accommodation:

Please organise your own accommodation. On the Wotif website (www.wotif.com) Rydges offer rooms for $100 per night for 1st April if you book on the internet using your credit card. This is significantly cheaper than $157 per night corporate rate offered by the Hotel itself. If you require assistance booking accommodation, please let me know. Reimbursement of air-fare, accommodation and other expenses will be met by NAC on receipt of a tax invoice.

DRAFT AGENDA

<u>DAY 1:</u>	**1st April 2004**	
10:00	Welcome.	*Simon Bennison*
10:15 – 10:45	FRDC/AAAIC Project.	*Geoff Allan*
10:45	Demonstration Facilities – criteria & plan.	
11:30	**Morning Tea**	
11:45	Demonstration Facilities – regional plans:	
	1. Western Australia.	*Greg Jenkins*
	2. NSW.	*Stew Fielder*
	3. Qld.	*Adrian Collins*
13:00	**Lunch**	
13:45	Demonstration facilities – regional plans (cont'd):	
	4. SA.	*Steve Clarke/Wayne Hutchinson*
	5. Other comments/discussion.	
14:45	Discussion on demonstration facilities.	
15:15	Industry perspective – an example from WA.	*Jasper Trendall*
15:30	What are the barriers to rapid commercialisation and how can this project help overcome them? – discussion.	
16:00	**Afternoon Tea**	
16:15	Communication (clarification of role of NAC & NSWF).	*Simon Bennison*
17:00	**End of Day 1**	
18:30	**Drinks/Dinner**	
<u>DAY 2:</u>	**2nd April 2004**	
9:00 – 11:00	Gaps in knowledge – review of National R&D Plan.	*(led by Geoff Allan)*
11:00	**Break**	
11:15	Investment Directory.	*(led by Simon Bennison)*
11:45	Other consultancies referred to in application:	
	1. Resource allocation.	
	2. Economic feasibility.	
	3. Market research.	
	4. Temperature modelling.	
12:45	**Lunch**	
13:45	Scientific Methodology – how best to conduct research with inland saline facilities and commercial farms:	
	1. Perspectives from Qld.	*Adrian Collins*
	2. Perspectives from SA.	*Steve Clarke/Wayne Hutchinson*
	3. Perspectives from WA.	*Greg Jenkins*
	4. Perspectives from NSW.	*Stew Fielder/Geoff Allan*
	5. Perspectives from Vic.	*Geoff Gooley*
15:00	Next meeting and review of plans.	
15:15	**Close**	

CRITERIA FOR ISA DEMONSTRATION FACILITIES

A demonstration facility for industrial-scale ISA that seeks NAC/FRDC funding should have all of the following:

Property

- A secured property either owned or leased for a defined period of time by the proponent. It may be necessary for the owner to be willing for a caveat to be placed over the property if on private or leasehold land.
- A property that has a secure saline water supply that can maintain the demonstration farm program year round.
- A water source of “sufficient” salinity to enable culture of estuarine and marine species and thus be representative of ISA.
- A secure power supply, or suitable contingency plans for power outages.
- The demonstration site should be located within a region associated with land and water salinisation to ensure proximity to a developing ISA industry.

Production systems, species and expertise

- A production system capable of industrial scale activities.
- An aquaculture species (or preferably several) with commercial possibilities.
- The required technical and scientific expertise and proven track record in ISA aquaculture production, to facilitate the demonstration and extension program.

Planning and extension

- A plan to disseminate all relevant information of the demonstration farm activities including: a series of public open days, publications in newspapers, industry magazines and journals and direct industry training opportunities.
- Plans to develop an economic model for the system and species.
- Plans to develop a marketing strategy for the product.

Funding

- The facility should have sufficient funds to maintain the demonstration for the defined period of time.
- Financial and management support services are available to the demonstration program for the defined time period.
- A significant contribution from other sources, government and /or private. Some cash to be included.

Access to the property

- Willingness to cooperate with independent audits of farm activities and funding as required.

WHAT DO WE NEED FROM THE STAFF RUNNING THE DEMONSTRATION FACILITIES?

- Overview of past activities/results of research (1 June 2004).
- Overview of facilities (particularly those purchased through project) (1 June 2004).
- Update of activities/results (twice per year, 1 June and 1 Dec).
- Culture manual(s).
- Scientific manuscripts (at least 2 per centre during project).
- Non-technical articles (at least 2 per centre during project).
- Presentations at AA04 and/or AA06.
- Economic analyses.
- Business planning advice (builds on culture manual & economic analyses & investment directory to assist farmers actually get started).
- Open days/training seminars (2/yr).
- Information for web site (update to NAC communications officer every 3 months).

Documents attached to this agenda but not included in this final report:

- FRDC R&D Funding application 2004/241.
- Developing Commercial ISA in Australia: Part 1: R&D Plan.

5.2.2.2. 2nd steering committee meeting

FRDC Project 2004/241

Development of industrial-scale ISA:

Coordination and communication of R&D in Australia

Date: Wednesday 3rd, Thursday 4th and Friday 5th August 2005

Time:
Wednesday: 9:30 am to 5:30 pm
Thursday 8:30 am to 5:30 pm
Friday: 8:00 am to 9:30 am for majority of Steering Committee
8:00 am to 1:00 pm for Geoff Allan, Stewart Fielder, Mike Curll & Richard Sheldrake

Venue & Accommodation:

Wednesday (including overnight):
Airport Motel & Convention Centre
33 Ardlie Street, Attwood, Melbourne
Tel: 03 9333 2255; Fax: 03 9333 3366
Email: conventions_amcc@bigpond.com

Thursday:
Road tour PIRVAC (Pyramid Hill) & ISARC (Wakool)
Overnight at:
Riverview Motel
Butler Street (opp. Charlotte Street)
Deniliquin
Tel: 03 5881 2311

Friday:
Murray Irrigation Limited
443 Charlotte Street
Deniliquin
Tel: 93 5881 9300

Participants:

Steering Committee Members
Simon Bennison, NAC
Geoff Allan, NSW DPI
Adrian Collins, QDPI&F
Wayne Hutchinson, SARDI
Geoff Gooley, VIC DPI
Greg Jenkins, WA Challenger TAFE
Patrick Hone, FRDC
John Talbot, DAFF
Karl Mathers, representing MDBC
George Warne, MIL – apologies, not attending
Jasper Trendall, Industry rep. – apologies, not attending

Invited guests
Alexandra Bagnara, NAC – apologies, not attending
Stewart Fielder, NSW DPI

Gavin Partridge, WA Challenger TAFE
Gavin Sarre, CY O'CONNOR College of TAFE, WA
Fiona Gavine, PIRVAC (Dinner Thursday night)
Ravi Fotedar, Curtin University, WA
Helena Heasman, NSW DPI (Wednesday only)
Alex Marshall, MIL (Dinner Thursday night/Friday morning)

NSW DPI Group

Mike Curll, NSW DPI (Dinner Thursday night/Friday morning)
Richard Sheldrake, NSW DPI (Dinner Thursday night/Friday morning)
Diana Brettschneider, NSW DPI Wakool (Dinner Thursday night/lunch Friday)

15 for Meeting and dinner Wednesday night
15 for accommodation Wednesday night (Airport Motel & Convention Centre)
13 for lunch Thursday – boxed lunch to take on road trip
17 for dinner Thursday night
14 for accommodation Thursday night (Riverview Motel)
6 for lunch Friday (Geoff, Stewart, Di, Mike, Richard & possibly Simon)

DRAFT AGENDA

DAY 1:	**3rd August 2005**	
9:00 – 9:30	**Morning tea on arrival**	
9:30 – 9:45	Welcome & overview of NAC ISA section of portal; links with other national projects (e.g., marketing).	*Simon Bennison*
9:45 – 10:00	Website and communications.	*Simon Bennison*
10:00 – 10:15	Progress with consultancies.	*Geoff Allan*
10:15 – 12:45	Regional presentations – 20 minutes each:	
	1. Qld.	*Adrian Collins*
	2. SA (including new pre-proposal).	*Wayne Hutchinson*
	3. WA (including new proposal).	*Greg Jenkins*
	4. VIC.	*Geoff Gooley*
	5. NSW (including plans for commercialisation).	*Stewart Fielder*
	Presentations to cover the following:	
	- Progress with R&D and demonstration facilities (e.g., open days, communication, tours etc).	
	- Future plans towards commercialisation and research.	
	- Other linked activities (e.g., gas project in Qld), new projects and research applications.	
	- What is missing to make ISA happen in each state (each issue will be discussed at length in the *'Gaps to Knowledge'* session in the afternoon.	
12:45 – 13:00	ISA research activities at Curtin University.	*Ravi Fotedar*
13:00 – 14:00	**Working Lunch**	
14:00 – 14:15	FRDC vision for ISA and planning process; New CRC development role for ISA.	*Patrick Hone*
14:15 – 14:30	DAFF perspective on ISA.	*John Talbot*
14:30 – 15:00	Proposed ISA session for AA'06, Adelaide.	*Simon Benison*
15:00 – 15:15	**Afternoon Tea**	
15:15 – 16:00	Development of protocols to describe and develop project objectives and methods (Scientific Workshop discussion).	*Steering C'tee discussion led*
16:00 – 17:00	Gaps in knowledge – what are the priorities for ISA R&D;	*by Geoff Allan*

	what is stopping commercial development; continuation of the ISA coordination group.
17:00	**End of Day 1**
18:00	Drinks/Dinner at Airport Motel & Convention Centre; stay overnight.

DAY 2: **4th August 2005**

FIELD TRIP	
8:30 – 11:00	Travel to Pyramid Hill in mini-bus + hire car.
11:00 – 13:00	Tour PIRVAC (Fiona Gavine).
13:00 – 14:00	**Boxed lunch en route**
14:00 – 15:00	Travel to Wakool.
15:00 – 17:30	Tour of ISARC led by Stewart & Di.
17:30 – 18:30	Travel to Deniliquin.
18:30	Check in to Riverview Motel.
19:00	Dinner at Deniliquin with George Warne, Mike Curll & Richard Sheldrake.

DAY 3: **5th August 2005**

8:30 – 9:30	Meet at Murray Irrigation Limited, Deniliquin. Presentation by Alex Marshall, Environmental Manager, MIL, as given at the ISARC Open Day.
9:30	Majority of SC members to travel back to Melbourne Airport.
9:30 – 10:30	Geoff, Stewart, Mike & Richard travel to Wakool.
10:30 – 12:00	Tour of ISARC.
12:00 – 13:00	**Lunch**
13:00 – 16:00	Geoff & Stewart to travel back to Melbourne Airport.

5.2.2.3. Notes of a teleconference held 21st December 2005, 3:00 – 5:30 pm (NSW)

FIS/2004/241

Development of industrial-scale inland saline aquaculture: Coordination and communication of R&D in Australia

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Present: Geoff Allan (Chair); Stewart Fielder, Simon Bennison, Adrian Collins, Gavin Sarre, Steven Clarke, Tim Flowers, Crispian Ashby, (Helena Heasman took notes).

Apologies: Gavin Partridge, Greg Jenkins, Wayne Hutchinson, Geoff Gooley, Fiona Gavine, Alex Bagnara.

Outline agenda items for adoption:

- New Seafood CRC – to gauge level of interest in participation.
- R&D Planning.
- Update of activities state by state.
- 3rd Steering Committee meeting in WA early next year.

1. New Seafood CRC

Geoff gave a brief description of the proposed new CRC and sought comments from committee members on the level of interest from commercial partners in the various states. Steven Clarke described new CRC for Integrated Biosystems (waste stream utilisation) headed by Martin Kumar with collaborators including Uni of SA, Murdoch & Flinders Unis, MLA etc. ISA could well fit into this CRC. Potential synergy with Seafood CRC.

- **NSW**: MIL interested in taking part on a site specific, pilot scale commercialisation basis.
- **WA:** Springfield Waters are interested in the R&D and marketing side and have already committed $100,000 to FRDC project. Challenger TAFE want to be involved in improving skills base with a training component.
- **SA:** Industry partner Inland Aquaculture Association of SA have expressed interest however they lack $. SA Government have just made $ available with their new Marine Innovation initiative. Focus should be primarily on:
    - Production.
    - Sustainability (nutrient waste).
    - Quality and safety.
    - Extension and technology transfer.
- **Qld:** Early stages of interest but foresee it should be production and species based. Link with Cotton CRC already established.

In summary, there is early stage interest from all states and further development is dependant upon attracting cash contributions from industry partners. PDS wants the new Seafood CRC proposal crystallised within the next five weeks.

2. R&D Planning

WA

Geoff highly commended these detailed plans. The first of 4 trials has commenced with the new SIFTS systems aiming for a production of ~30 t/ha. **Detailed plan attached.**

NSW

Stew received good feedback from Gavin Partridge on his plans which outlined trials on the effect of floating solar covers on the growth and survival of mulloway. Stew explained that replicated experiments with translucent inflatable greenhouse covers have not been conducted before. Stew answered questions on surface area of pond (500 m^2); number of fish per pond (10 t/ha), salinity (20 – 35 ppt) and bottom temperature (8^oC). **Detailed plan attached.**

Qld

Trails in fully lined ponds with banana and black tiger prawns have commenced to refine pond management techniques to avoid last year's problems. This information will be used in the Economic Model. The use of organically certifiable feeds as an opportunity of value-adding is also being investigated. **Detailed plan attached.**

SA

Completion of infrastructure at new site is main focus – should be fully operational early February. 1st trial with snapper & mulloway in 6 x 10,000 L tanks underway. Next year growth trials with snapper and yellowtail kingfish in groundwater will commence. 12 month water quality monitoring program has picked up fluctuation of salinities between pipelines. Still experiencing difficulty importing the Israeli recirc system. Tim Flowers MSc concerns how mulloway recover after stress. The use of saline water to growth turf and other salt tolerant agricultural species is also being investigated in SA and work with micro-algal production for biodiesel may commence in July. A detailed plan will be forwarded to committee members.

It was noted that most states are working with mulloway and the question raised '*does this potentially have any long-term market significance?*' However, there is no experimental duplication – systems are all very different and it's an opportunity to share growth data. It was also noted that although snapper is not as good as other species for ISA, industry partners especially request it.

Steve to liaise with Alex re more information for ISA website and also liaise with Gavin Sarre on salt-tolerant grass.

3. Coordination project activities

- Representatives from state-wide Catchment Management Authorities visited PSFC in November. Geoff gave a tour of the Centre and briefed them on ISA initiatives. It is proposed to make follow-up contact.
- A meeting and tour of the ISARC facility at Wakool was given to representatives of MDBC.
- Councils in the Murray Darling Basin have been contacted.
- Temperature data has been collected for Wakool and will be used to reconstruct the temperature model developed by Tom Losordo. This will take a little time.

4. Meeting in WA early 2006

Issues for meeting:

- Opportunity for face to face contact to build closer collaborations.
- Discuss and confirm AA'06 program for ISA.
- Further develop and confirm CRC activities.
- Whiteboard new CRC projects.

Actions

- Helena to circulate flight details for committee members to book and pay themselves. Helena to book accommodation but everyone to settle own account. Invoice NAC for reimbursement if relevant. PLEASE NOTE: ONLY 1 REPRESENTATIVE FROM EACH STATE WILL BE PAID FOR BY NAC. OTHERS VERY WELCOME, IF WILLING TO PAY YOUR OWN WAY. Suggested flights are attached.
- Please send Gavin arrival times on Friday to see if a pm meeting is an option.
- Geoff G. to Draft ISA program for AA’06.

5.2.2.4. 3rd steering committee workshop

FRDC Project 2004/241

Development of industrial-scale inland saline aquaculture:

Coordination and communication of R&D in Australia

30th January to 2nd February 2006

WA

ITINERARY

Monday, 30th January

Noon – 2:30	Members arrive in Perth between 12 noon and 2:30 pm. Rendezvous with mini-bus outside Arrivals Terminal
3:00 pm	Travel by mini-bus to Northam
5:00 pm	Book into Northam Motel 13 John Street, Northam Tel: 08 9622 5166 $82 per double room. Breakfast extra.
6:00 pm	BBQ at Sarre property (no cost to workshop attendees) – 3 mins. from town and 120 m from Springfield Fish Farm for informal tour if interested.

Tuesday, 31st January

9:00 am	Tour Springfield Waters Demonstration Farm, SIFTS FRDC project.
11:00 am	CY O'Connor College of TAFE – presentation by Dr Richard George WA salinity researcher/manager.
12:00 noon	**Lunch**
1:00 pm	SC meeting (agenda overleaf).
5:00 pm	Travel back to Fremantle.
7:00 pm	Book into Terrace Central B&B 83 – 85 South Terrace, Fremantle Tel: 08 9335 6600 $122 including breakfast
7:30 pm	Dinner at own expense. Venue TBA.

Wednesday, 1st February

8:30 am	SC meeting (agenda overleaf) at ADU.
10:30 am	Morning Tea.
10:45 am	Continue meeting.
12:30 pm	Lunch.
1:30 pm	Continue meeting.
3:00 pm	Tour of ADU.
5:00 pm	Meeting closes.
6:00 pm	Dinner at own expense. Venue TBA.

Geoff Gooley departs. 2nd night at Terrace Central B&B for others.

Thursday, 2nd February

6:45 am	Skywest flight from Perth to Albany (1 hour).
7:45 am onwards	Visit Bouverie Trout and Marron Farm (Mt Barker); Saltlands Trout. Farm (Dumbleyung); Lunch on the road. Drive back to Albany.
7:35 pm	Skywest flight from Albany to Perth (1 Hour).
10:40pm	Geoff, Stewart, Helena, Wayne fly out. Ben to stay on.

Tuesday 31st January – CY O'Connor College of TAFE

1:00 – 2:00	Welcome. New Seafood CRC.	*Geoff Allan/Simon Bennison*
2:00 – 3:00	ISA Session of AA'06 Conference. Need to find a new Session Chair & identify speakers.	*Geoff Allan to lead discussion*
3:00 – 3:15	Afternoon Tea.	
3:15 – 4:00	Introduction to the future of the ISA Coordination project to be discussed in detail on Wednesday. To think about overnight:- - Should the project be extended? - What are the constraints to further commercial development? - How can these be addressed by new projects? - Should a new ISA Subprogram be considered? - Does the R&D Plan need further review?	*Geoff Allan/Simon Bennison*
5:00 (or before)	Depart for Fremantle.	
7:00	Book into Terrace Central B&B 83 – 85 South Terrace, Fremantle	
7:30	Dinner at own expense	

Wednesday 1st February – Fremantle ADU

9:00 – 11:00	**Part 1** State-by-State updates. 30 mins + 30 mins discussion. - Progress (including economic modelling). - Plans. - Commercial activities in State. - Constraints to commercial development. - Recommendations to overcome constraints.	*Stewart & Wayne*
11:00 – 11:15	Morning Tea	
11:15 – 1:15	**Part 2** – State-by-State updates.	*Ben Russell & Geoff G.*
1:15 – 2:15	Lunch	
2:15 – 3:15	Industry perspectives 20 – 30 mins each.	*Tony Smith, Jasper Trendall, Stan Malinowski, Brett Brenchley*
3:15 – 3:30	Afternoon Tea.	
3:30 – 4:30	New application extension. Whiteboard suggestions. from preliminary discussions held Tuesday afternoon.	*Geoff Allan to facilitate*
4:30 – 5:30	Tour of ADU.	
6:00	Dinner at own expense.	

5.2.2.5. *Notes of the 2nd teleconference held Friday 27 October 2006, 10:00 – 11:45*

FRDC Project 2004/241

Development of industrial-scale inland saline aquaculture: Coordination and communication of R&D in Australia

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Participants

Geoff Allan	02 4982 1092	NSW	10:00
Stewart Fielder			
Helena Heasman			
Simon Bennison	0407 776 439	WA	08:00
Gavin Partridge	(08) 9239 8030	WA	08:00
Geoff Gooley	(03) 5976 6218	VIC	10:00
Michael Burke	(07) 5499 6853	Qld	10:00
Wayne Hutchinson	(08) 8207 5444	SA	09:30
Gavin Sarre	(08) 9621 1296	WA	08:00

Agenda

- Future experimental plans for demonstration facilities.
- Final report format.
- Venue for final meeting.
- Other issues.

1. Progress and future plans for demonstration facilities

Michael Burke, Qld

- Bauple prawn farm will not operate 2006/2007 due to financial constraints.
- Demonstration facility will therefore be established near Dalby in 6 x 30 t floating raceways using waste water generated from coal seam gas.
- 12 ha compacted earthen dam receiving 1 ML/day.
- Murray cod to be trialled then other euryhaline species such as barra, mulloway & cobia that can tolerate 8 ppt.
- The site was chosen because of good existing infrastructure although salinity concentration is less than ideal. Preferable to use intermediate reservoir as culture facility rather than terminal end-use evaporation water. However, funds not available for this.
- Bioassays of water being carried out at present – calcium is ~25% of that found in seawater. Potassium will need to be added. Soil chemistry will need to be tested also. Salinity will increase with evaporation. Suggest developing “water budget” before stocking.
- Paul McVeigh allowing use of Tamco raceways, walkways, generator, office facilities.
- Suggest retrofitting for nutrient solids removal – may be considered.
- Mike to populate Bill Johnson’s economic model with Bauple prawn data. Could be very useful for farmers with salty bores.

Stewart Fielder, NSW

- Commercial trout operation continuing with MIL & Lonsec.
- Water security an issue – now only 20 ML/day because of drought. Considering re-use of water.
- Rainbow trout: CO2 issues not a problem with raceways. Flow-through will continue through winter. No mortality experienced.
- Mulloway: 20% increase in growth using solar cover. Investigating improved design and commercial implications.
- 4 – 5,000 mulloway 500 g + subject of marketing study with local community.
- Economic model to be populated with mulloway data.
- Link/compare with Waikerie data.
- Temperature model also to be populated and validated.
- Looking at options of purchasing and installing recirc equipment at Wakool.
- Future R&D opportunities include fingerling and post-larval prawn production and evaluation of naturally occurring zooplankton.
- Final report to ACIAR to be prepared and on-going publication of results through journals.
- Discussion on economics of long-term greenhousing.

Geoff Gooley, VIC

- Final season at Kyabram using Murray cod in aboveground recirculating raceways. Focus on nursery production only.
- Good results with cod even through severe winter. Experiments comparing growth of different cohorts in 20 m long x 1.5 m deep raceways.
- Fish then transferred to Mildura and held until March next year in open water irrigation storage ponds for grow-out.
- Discussion regarding three different methods of culture:
  - Cage system possibly the best. Low start-up cost and farmers can stock at 30 kg/m^3 (straight-forward, simple technology).
  - Raceways are technically more sophisticated but very reliable. Can carry 50 – 60 kg/m^3. Higher entry cost for farmers but good if flow-through water is limited.
  - SIFTS. Using prototype and experiencing teething problems as a consequence. Not commercially viable in current configuration. Suggest using in conjunction with other simpler systems. Only 3 – 4 months of limited data available.
- Carrying capacity for irrigation storages in Mildura/Northern Victoria could be as much as 1,000 t plus in 3 – 5 years time. Some farmers scaling up with 100 t systems.
- Would like to look at linkages with S.E. Qld – take farmers up for “cross-pollination” of ideas.

Gavin Sarre & Gavin Partridge, WA

- Because of trout mortality in SIFTS, conducted fish-less simulator trial to look at nutrient build-up, changing orientation of SIFTS airlift and evaluating floating aquamats.
- Aquamats did not work – TAN still high. Ponds now drained and being refilled for next trial. Trials on Aquamats will continue in Fremantle.
- Changing airlift orientation appeared to be effective, but the dinoflagellate algae that was hypothesised to be the major contributing factor to last year’s destratification, was not present in the ponds over winter.

- New trial to start in December to address destratification and high TAN caused by microalgal blooms:
  - Pond 1: Test destratification measures outlined above during first half of the summer trial when *heterocapsa* should be present. In the second half of the trial, Artemia will be grown in modified SIFTS to determine if they can ameliorate the effects of strong microalgal blooms.
  - Pond 2: Heterotrophic pond management to overcome high TAN and pH.
  - 4 plots of NyPa grass (each 10 x 10 m) will be tested. 2 irrigated with nutrient-free saline bore water. 2 irrigated with water from ponds.
- Artemia in SIFTS easier to manage and retain using a constantly back-washing, rotating 180 µm screen.
- NyPa grass is a bioremediator and is also a secondary crop – source of food for sheep and cattle.
- Economic model populated and being used to evaluate the potential for ISA in Shire of Merredin, where 600 kL of 15 ppt water is being pumped daily as part of state government's Rural Towns Program.
- Ian McRobert has formed new company – McRobert Aquaculture Group, with overseas investors and interested primarily in large-scale production (>300t/year 50 m^3). May not be interested in small-scale inland opportunities with SIFTS.

Wayne Hutchinson, SA

- Opening at Waikerie very successful with stakeholders and media present.
- Riverland Field Day held after opening – also well attended.
- Invited registration of interest from those seriously interested in saline interception schemes – 100 subscribed – very successful.
- Ongoing trials with mulloway stocked in big 70 KL tanks. Growth has dropped off and need to reduce numbers (sell fish).
- Application prepared for new Seafood CRC with Stehr Group (CleanSeas contributing).
- Another research application to look at halophytes.
- If the Seafood CRC gets up, suggest linking ISARC & Waikerie into national program.

2. Final report

- Draft final report due June 2007.
- To include:
  - All outputs to date (as appeared on web site).
  - Summary of R&D results.
  - Summary of "demonstration" activities.
  - Complete bioeconomic model(s).
  - Commercial recommendations on capacity for growth, water sources & land availability, market issues, problems arising.
  - Recommendations for future R&D or technology transfer.
- Helena to set up a Final Report template with draft Table of Contents and circulate.

3. Final meeting

- During last meeting in Perth, it was tentatively suggested that SA host final meeting, however, most people visited Waikerie during AA'06 in August.
- Suggest Qld instead – March 2007. Agreed.
- Suggested agenda:

  Day 1:
  - Arrive Qld. Site visit coal seam gas facility Dalby. Return to BIARC & overnight.

Day 2:
- Workshop at BIARC all day.
- Review progress state by state.
- Bioeconomic models.
- Present draft report as ppt.

Day 3:
- Workshop half day.
- Final discussion.
- Travel home.

4. Other items

Simon Bennison

- Issues relating to prompt submission of progress reports and milestone payments. Wayne's report still outstanding. Wayne to submit within 5 days.
- Potential for project extension as discussed in Perth? Will not continue in existing format. New Seafood CRC will have large component of ISA but perhaps funding can be sought for annual workshop to maintain and foster successful links established over the course of the project? To discuss further at final meeting.

5.2.2.6. 4th steering committee workshop

FRDC Project 2004/241

Development of industrial-scale inland saline aquaculture:

Coordination and communication of R&D in Australia

27 – 28 June 2007

Joondoburri Conference Centre – 144 North Street, Woorim, Qld, 4507

AGENDA

Tuesday 26th June

Arrive Brisbane Airport late afternoon. Maxi taxi booked for 7:00 pm outside Jetstar Arrivals Terminal. 8 travelling in taxi: Geoff Allan, Stewart Fielder, Helena Heasman, Wayne Hutchinson, Shane Hartney, Justin Fromm, Simon Bennison, Stan Malinowski. Geoff's mobile: 0419 185 510. Travel to Bribie Island. Informal dinner arranged at Conference Centre for 9 people – Stuart Rowland to join us. Greg Jenkins and Ian McRobert staying independently.

Wednesday 27th June

08:30	Introduction and Welcome. Housekeeping/Agenda/Introduce Final Report. Introduce R&D Plan/Project future in Seafood CRC.	*Geoff Allan,* *Justin Fromm (FRDC),* *Simon Bennison*
09:10	Summary of ISA activities and commercialisation in each state (about 15 – 20 minutes each).	
09:10 – 09:30	WA.	*Greg Jenkins*
09:30 – 09:50	SA.	*Wayne Hutchinson*
09:50 – 10:10	NSW.	*Stewart Fielder*
10:10 – 10:30	Qld.	*Michael Burke*
10:30 – 11:00	**Morning Tea**	
11:00 – 11:20	Discussion on ISA and activities at demonstration facilities.	
11:20 – 11:40	Irrigation and gas field aquaculture in Qld.	*Michael Burke*
11:40 – 12:00	Irrigation aquaculture in NSW.	*Stuart Rowland*
12:00 – 13:00	Industry perspective: progress and plans.	*Stan Malinowski, Shane Hartney, Ian McRobert*
13:00 – 14:00	**Lunch**	
14:00 – 15:30	Review R&D Plan.	
15:30 – 16:00	**Afternoon Tea**	
16:00 – 18:00	Review final report and general discussion.	
18:00	**Close**	
18:30	Bar open (TAB)	
19:30	BBQ dinner (paid by project).	

Thursday 28th June

07:00	Depart for Dalby gas fields trip with packed breakfasts.
17:00	Return to Brisbane Airport.

5.2.3. Other meetings of significance

June 2004

SARDI convened a National Aquaculture Council (NAC) funded two-day workshop on ISA at the South Australian Aquatic Service Centre (SAASC) 24 – 25 June 2004. There were 22 attendees at the workshop with an agenda that covered:

- A summary of research conducted to date at CPISARC.
- Presentation of SARDI's vision for inland aquaculture aligned to Salinity Interception Schemes in SA.
- A selection of presentations from a range of industry, regulatory and planning agencies involved with the range of issues that will effect the development of commercial Aquaculture Parks aligned to Salinity Interception Schemes.
- Discussion of these issues and collation of views to assist planning for the R&D and demonstration facility and the commercial Aquaculture Park concept.
- Opportunity for identification of collaborators for ongoing R&D and commercialisation activities.

August 2004

Adrian Collins (QDPID) attended the Aquaculture Association of Queensland Annual Conference and Workshop, Hervey Bay, Queensland, 27 – 28 August 2004 and talked on '*Integrated Aquaculture Research: water, fish, prawns, crops and more fish*'.

February 2005

A generic briefing on ISA at ISARC in NSW was delivered by Stewart Fielder to the Murray Land and Management Plan review in Deniliquin. At this review, the following government departments and agencies participated: NSW DPI, CSIRO, shareholders and employees of Murray Irrigation Limited (MIL) and councillors and employees of Wakool Shire Council. MDBC were invited to this review and have been present on all previous occasions. However, their representative resigned on the day before the review. It was planned to conduct a specific briefing for MDBC. Unfortunately contact with MDBS has been through Phil Pfeiffer who has been on extended leave. His alternative is Karl Mather who used to work with MIL and was pivotal to the development O ISARC. There is no need to brief Karl. More senior MDBC managers will be targeted during the second half of 2005 for a briefing and update.

May 2005

Greg Jenkins, Gavin Partridge and Gavin Sarre delivered a presentation entitled *'TAFEWA and Sustainable ISA'* at the WA Innovation Festival at the Maritime Museum on 7 May 2005.

July to December 2005

The MDBC Board visited the demonstration facilities run by NSW DPI (ISARC) near Wakool, NSW. Members were thoroughly briefed on ISA and results from ISARC generally. Mr Grant Webster led the briefing.

November 2005

The Catchment Management Authorities met at PSFC 17 – 18 November 2005 and were briefed by Geoff Allan about ISA. Full briefing materials were provided, including the web address, and interested members are being followed up.

December 2005

Gavin Partridge and Ian McRobert were selected from 48 episode winners to appear on the grand final of the ABC/s The New Inventors. The SIFTS invention was also highlighted again in the 100th episode of The New Inventors in June 2006.

January to June 2006

The following groups were provided with tours/information seminars of the Northam ISA facility in WA:

- Apex (55 delegates attending the WA state convention).
- Australian Grains Institute (38 board and members).
- 17 individual Wheatbelt landowners/farmers.

January 2006

CY O'Connor and Challenger TAFES, WA, hosted the annual meeting of the National ISA Steering Committee. The members and invited guests were provided with a tour of the Northam facility prior to a two day workshop at the CY O'Connor and Challenger TAFE campuses.

February 2006

Gavin Sarre was an invited guest to the WA government cabinet luncheon held in Northam. Dr Sarre took the opportunity to brief the Minister for Fisheries, The Ho. John Ford, on the progress of the ISA project and general issues associated with aquaculture development in the wheatbelt region. Dr Sarre has delivered two ISA information seminars to prospective aquaculturists and landowners in the wheatbelt region.

March 2006

CY O'Connor ERADE Village presentation by Greg Jenkins regarding the potential use of by-products of production from the Northam FRDC project 10 March 2006.

May 2006

Geoff Allan and Stewart Fielder attended a briefing workshop which was held with Lonsec Pty Ltd, Murray Irrigation Limited and a company specialising in managing aquaculture farms in Melbourne on 1 May 2006. The specific purpose of this workshop was to progress the commercialisation of ISA of trout in association with groundwater interception and evaporation schemes (in this case the Wakool-Tullakool Sub-Surface Drainage Scheme). Details of research progress with trout from NSW (and a summary of activities with trout and other species from other states) were provided to the workshop. A Business Plan to progress development is being prepared. This is in-confidence at this stage.

5.2.4. Communications plan and report

Contributors

The steering committee for the development of the ISA (ISA) Communications Plan consists of:

- Alexandra Bagnara – Communications Officer, National Aquaculture Council.
- Simon Bennison – CEO, National Aquaculture Council.
- John Jenkin – Chairman, National Aquaculture Council.
- Geoff Allan – ISA Project Manager, NSW Fisheries.
- Patrick Hone – Programs Manager, Fisheries Research & Development Corporation.
- Peter Horvat – Communications Manager, Fisheries Research & Development Corporation.
- Annette Healy – Public Relations Officer, Department of Agriculture, Fisheries & Forestry.

Situation analysis

Proposal

Recommendations from the Fisheries Research & Development Corporation (FRDC) research and development plan on ISA (ISA) have led to joint funding approvals for the National Aquaculture Council (NAC) and NSW Department of Fisheries (NSWF).

The focus of this communication plan, a milestone component of the joint NAC/NSWF application, is on coordination and communication of ISA projects.

Most of the projects funded under the joint application have commenced and are proving excellent results. The projects will end 30 June 2007. A key objective of the communications plan is to provide information on the progress and results of projects to stakeholders and the wider public.

Current Positioning

Demand for seafood throughout the world is increasing while landings from capture fisheries are static. In Australia, the growing seafood consumption is being increasingly met by importation (imports of fisheries products have increased by 52%, over the period 19919/92 to 2001/02: ABARE 2002). In Australia, the value of aquaculture production has trebled since 1991/92 representing an annual growth of 14% in nominal terms and 11% in real terms.

Over the last three years the Australian Government and industry have been developing an Aquaculture Industry Action Agenda, a national initiative to help the aquaculture industry successfully meet the challenges and capitalise on its competitive advantages and growth opportunities.

The Australian Government and aquaculture industry have agreed to implement 10 key initiatives to drive the industry's future growth, realise its vision of sales of $2.5 billion a year by 2010 and lay the foundation for an extended program of cooperation between industry and government.

The 10 strategic initiatives are:
- Making a National Aquaculture Policy Statement.
- Promoting a regulatory and business environment that supports aquaculture.
- Implementing an industry-driven action agenda.

- Growing the industry within an ecologically sustainable framework.
- Enhancing aquatic animal health and biosecurity.
- Investing for growth.
- Promoting aquaculture products in Australia and globally.
- Tackling the research and innovation challenges.
- Making the most of education, training and workplace opportunities.
- Creating an industry for all Australians.

Expansion of coastal aquaculture is limited by a shortage of suitable sites with the necessary water quality, depth and proximity to land-based infrastructure that are not either being used or considered for urban and tourist related development or judged to be of too high environmental value for aquaculture. Investigating ISA is a specific priority in the action agenda.

Rising saline groundwater is the biggest environmental problem in Australia and currently affects over 2.5 million ha of land. It is estimated that within the next 30 – 40 years, the affected area will grow more than fourfold. One of the key methods to ameliorate the effects of salinisation is to pump the saline groundwater into large ponds for disposal by evaporation.

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.

Preliminary research had indicated that provided potassium is added to saline groundwater it is suitable for farming marine fish. In order to generate enough accurate data to allow the economics of ISA to be evaluated, the ISA Research Centre (ISARC) at Wakool-Tullakool Sub-Surface Drainage Scheme was constructed. The ISARC at Wakool is the only research centre mainly focused on proving the commercial validity of ISA.

Project background

The fragmented nature of inland saline research in Australia has made it difficult for those interested in the field to easily access the collective information available. This stimulated a project to coordinate ISA in Australia. This project *'Development of industrial-scale ISA: coordination and communication of R&D in Australia'* is being funded through the Fisheries Research & Development Corporation with significant contributions from the Australian Government, Department of Agriculture, Fisheries & Forestry through the Aquaculture Action Agenda. The Applicant is the National Aquaculture Council with Dr Geoff Allan (NASW DPI contracted as Principal Investigator).

There are several other projects in other States including WA, SA & Qld & Victoria aimed at developing ISA. A national network between various State Departments in Australia is needed to improve the quality of research, prevent unnecessary repetition of the research programs, help ensure efficient technology transfer and finally, if the commercial validity is proven, develop an aquaculture industry based on saline water in inland Australia. ACIAR has committed to a project at ISARC. The ISARC can act as a focal point for this R&D and communicate progress to stakeholders. This view has been supported by the Aquaculture Committee of the Australian Fisheries Management Forum.

International research developments must also be considered and communicated to stakeholders.

Demonstration facilities

To adequately evaluate the success of ISA programs, demonstration facilities have been funded. Projects have been set up by the following:

- **NSW – Inland Saline Aquaculture Research Centre (ISARC).** The need for an evaluation of the potential for using saline groundwater in aquaculture culminated in the construction of the ISA Research Centre (ISARC) near Wakool in the southern edge of the Murray Darling Basin. In the two years since research at the new ISARC commenced, survival and growth trials have been conducted with silver perch (a salt-tolerant, native freshwater fish), mulloway (an estuarine fish), black tiger prawns (a marine prawn tolerant of a wide range of salt concentrations) and rainbow trout. Silver perch survive and grow in water of salinity at or below 10 mg/L without potassium adjustment, trout grow at salinities up to those equivalent to full strength sea water and provided potassium is added for mulloway and prawns, survival and growth in tanks is similar to that in water with salinity adjusted using ocean salts. Trout survival and growth over the period April to November was excellent and equivalent to that recorded in freshwater raceway systems.

- **Queensland Department of Primary Industries & Fisheries.** Commencing with a series of laboratory based survival trials, the saline water delivered by this site's aquifer was observed to be highly suitable for the production of black tiger prawns. With the construction of a 0.26 hectare recirculating prawn production facility in 2002, this pilot site replicated the success of the laboratory trials through the exceptional production performance of the black tiger prawns stocked within it. In 2003-04 this performance was further improved with growth rates as high as 28.2 grams within 87 days, and commanding higher than standard market prices, the suitability for prawn production at this site appears absolute.

- **South Australia Research & Development Institute (SARDI).** For the past five years research has been conducted at the Cooke Plains ISA Research Centre (CPISARC). The results from experiments conducted at the centre resulted in an up-grade of the facility in 2002. In 2003, a six month growth trial was also conducted at CPISARC to examine the aquaculture potential of saline groundwater. SARDI is currently keen to assist the Coorong District Council to transfer operation of CPISARC to a commercial user, which would be greatly facilitated by the development of extension material targeted at summarising the research results to date in a form suitable for investment attraction. A new aquaculture R&D facility aligned to the Woolpunda/Qualco Salt Interception Scheme (SIS). This SIS discharges 30 million litres per day of intercepted water into the stockyard plains disposal basin (SPDB) that would otherwise enter the River Murray. Activities will concentrate on finding a commercially viable use for this water by maximising the advantages provided by the flow and water temperature of this otherwise wasted resource.

- **Western Australia – Technical & Further Education (TAFE).** A collaborative project between Murdoch University and the Aquaculture Development Unit of Challenger TAFE utilised Springfield Waters Aquaculture as the R&D field site for a project focusing on black bream in inland water bodies. A series of replicated, pond-based research trials were carried out between 1997 and 1999. The end result of this work was the development of guidelines for farmers to assist in maximising the survival and growth of black bream cultured in inland saline water bodies. A series of field trials at the site were also conducted to evaluate the aquaculture potential of several marine/estuarine species in inland saline groundwater. This work has identified that barramundi and trout possess the required survival and growth characteristics to be viable wheat belt aquaculture species. Current research is now focused on the development and evaluation of production technologies to enable cost-effective, commercial aquaculture production using saline groundwater.

SWOT analysis

Strengths

- Environmental sustainability.
- Scientific, education and training resources.
- Aquaculture production in a more controlled environment.
- Complements existing land use.
- Availability of research and development support.
- Business assistance schemes and incentives.

Weaknesses

- Geographic distribution of stakeholders.
- Lack of centralised information base.
- Capital outlay required for operation.
- Lack of business planning precedents.
- Environmental approvals and regulatory requirements.

Opportunities

- Saline groundwater solution.
- Increasing seafood demand.
- Declining wild-catch supply.
- Agribusiness diversification.
- Regional employment.
- Triple bottom line (social, environmental and economic).

Threats

- Fluctuating market demand trends.
- New and emerging industries may not be seen as economically viable.
- Animal cruelty activism.
- Business management risks.
- Lack of national regulation.

Target Markets

The target market consists of 4 main groups:

- Target Group A – Industry.
- Target Group B – Research Community.
- Target Group C – Government.
- Target Group D –Community.

This strategy acknowledges the overlap potential for target markets.

Target Group A – Industry

Primary

- Industry groups (national, state and regional) such as Australian Prawn Farmers Association, Tasmanian Salmonid Growers Association, Gippsland Aquaculture Industry Network).
- Aquaculture councils, state aquaculture associations.
- Industry Communications networks (such as Fish e-news, Intrafish, Fish Farming International).
- Aquaculturists.
- Environmental standards officers.

Secondary

- Farmers seeking diversification opportunities.
- Industry supply chain members (post harvest, retail).

Target Group B – Research Community

Primary

- ISA Research Centres (NSW, Qld, SA, WA).
- ISA Project managers.
- Communications personnel in research provider organisations.
- Fisheries Research & Development Corporation.
- NSW Fisheries project manager.

Secondary

- CSIRO.
- Aquafin CRCs.
- AIMS.
- Universities and TAFEs academics such as University of Tasmania, TAFE WA.
- Aquaculture students (university, TAFEs).

Target Group C – Government

These include federal, state and local government and political representatives with an interest in aquaculture and salinity issues:

Primary

- Minister for Agriculture, Fisheries & Forestry.
- Minister for Fisheries, Forestry & Conservation.
- Parliamentary Secretary to the Minister for Agriculture, Fisheries & Forestry.
- Other members of Federal Parliament – in particular members whose roles are related to, or who have an interest in aquaculture or salinity issues.
- Department of Environment & Heritage.
- Murray Darling Basin Commission.

- Department of Agriculture, Fisheries & Forestry.
- State departments of primary industry and fisheries.
- State departments of environment and regional services (including water authorities and chambers of commerce).
- Regulators.
- Funding providers.
- National Action Plan for Salinity & Water.

Target Group D – Community

Secondary

- Schools (primary and high school).
- Media (environmental, fishing, farming, general).
- Indigenous communities.
- Local communities in areas affected by salinity.
- Members of the community who have an interest in ISA and environmental sustainability.

<u>Strategy</u>

Industry has been considered as a target audience with the purpose of communicating project benefits to encourage investment in and uptake of ISA. Existing aquaculturists can be informed of current technology and practices, and potential aquaculturists can better understand the process and requirements for investment in ISA.

The research community has been targeted to facilitate information exchange regarding projects and the broader educational community. This will ensure project leaders are aware of developments of other projects and encourage further study and interest in the field. The research community will be a main source of information from which to base communication materials.

Government stakeholders include politicians and leaders of responsible portfolios, to ensure they are aware of progress with the projects. This group includes regulatory bodies and funding agencies to which communication on program outcomes is crucial.

The community stakeholder group includes a series of networks with whom the NAC wants to communicate. Environmental sustainability in aquaculture practices can be communicated to educational institutions such as primary schools and high schools. The media is also a sub-group and is integral in communicating benefits of ISA programs, strengthening the positioning of ISA.

Key Messages

- ISA is environmentally sustainable.
- ISA does not contribute to increased salinity.
- ISA presents an opportunity to make a bad situation a good one.
- There are potential benefits to social and economic circumstances.
- If you invest wisely, there are lucrative benefits.
- The demonstration projects are proving the viability of ISA.
- Practices are compatible with native title plans and are respectful of natural resources.
- Ocean stocks can be replenished.
- There are good opportunities for agribusiness diversification.
- There is a solution to salinity problems.

- Social gains to the community can be had.
- There is a very supportive policy framework and assistance schemes & incentives.
- There is a high availability of R&D support & services.
- Sites location & access to natural resources are plentiful.
- Business owners have increased capacity to understand whole supply chain.

Goals

- Manage communication, information and technology transfer among Stakeholders including:
- Research providers.
- Funding agencies.
- Salinity managers (Federal, State and Local Government, MDBC).
- Industry, and
- The National Action Plan for Salinity & Water Quality.
- Increase general awareness of benefits and projects associated with ISA initiatives:
- Communication media (e.g., fact sheets, media releases, newsletters, website forums),
- Investment directory.
- Research and development priorities (including technological developments, best-practice initiatives).
- Demonstration facilities progress.
- Present status of project at Australasian Aquaculture Conference 2004.
- Continue communications activities to facilitate continued interest in and uptake of ISA.

Objectives

Objectives will continue to evolve with project development and as opportunities arise and the communications plan is evaluated.

- Manage communication of stakeholder network to achieve recognition of NAC as the key information exchange body for ISA information and resources.
- Increase awareness of ISA projects in 20% of primary target audience stakeholders within 6 months of campaign operation.
- Increase website participation (calculated by hits and length of visit to ISA pages) by over 50% within a year.

Implementation

Communication schedule

Along with the projects outlined below, regular communication activities will be undertaken on a daily basis to assist with development of materials:

Daily:

- Scan media for articles relating to aquaculture and related projects. Circulate to stakeholders where necessary, or keep for review if pertinent.

Weekly:

- Update ISA segment of the aquaculture portal.

Monthly:

- Obtain website statistics.
- Prepare progress report for NAC CEO.
- Update website action agenda sections.

Quarterly:

- Circulate progress and outcomes of ISA projects through NAC newsletter.
- Provide steering committee with communications plan update.

Annually:

- Advertise in aquaculture and related industry publications.
- Participate in annual conference.

Biennially:

- Australasian Aquaculture International Conference and Trade Show.

Sporadically:

- Issue media releases relating to ISA projects where relevant.
- Prepare briefs for executive and board.
- Write articles on ISA for publications aimed at secondary target audiences.

Timeline

June – September 2004

- ISA issues were raised internally at board meetings and the communications plan will be discussed.
- A stakeholder database developed and maintained to include members of each of these target audiences. Contact officer, position, organisation, addresses, phone fax and email data will be obtained for members of each sections of the target audiences identified.
- Market research conducted to gauge levels of stakeholder awareness and participation.
- The website is being updated to include information on the various ISA projects. The forum on ISA has also been instigated.
- The Australasian Aquaculture Conference 2004 held in September. The NAC had a prominent stand at this event and utilised the opportunity to showcase products (fact sheets, frequently asked questions, case studies, DVDs) to strengthen the level of awareness in stakeholder groups.
- Banners and display material with a focus on environmental sustainability and ISA developed.
- Opportunities for cross promotion sought. Publications (both scientific, and industry) are avenues for reaching target audiences.
- The first edition of the NAC newsletter contained an insert on ISA.
- Stakeholders notified of the specific ISA forum to be held at the conference in September.
- Content for fact sheets and background material developed and published.

October – December

- Preparation of the ISA special in the NAC newsletter and exclusive offering to an industry publication.
- Development of materials for school projects (primary and secondary).
- Communiqué on project progress and outcomes circulated to primary target audiences.

January – June 05

- Further market testing conducted to evaluate campaign effectiveness and alter communication plan.
- Specific milestones for communications strategy for next financial year finalised.

July 2005 to May 2007

- The communications officer was lost to the project in May 2006.
- The Australasian Conference in 2006 was very successful in bringing together a programme to meet the needs of the target audiences and excellent presentations were provided. These presentations were placed on the website for the conference for a period of 12 months post the conference.
- The biennial conference is to be held in Brisbane in 2008 and again a key feature will be a component on ISA with research results being presented.

<u>Website</u>

The ISA website has been maintained by the NAC and is up to date with all information as provided by the participants. Feedback from various audiences has ensured that any problems have been effectively resolved by the NAC communications personnel and the CEO along with extensive support from NSW DPI.

Interested personnel are encouraged to go to the aquaculture portal and access the ISA website.

Post the project July 2007 onwards

- The NAC intends to keep the ISA website up to date wherever possible.
- A new communications and event manager person has been appointed to the NAC as of the 23rd April and this person will take on responsibility of updating the site.

Promotional Mix

Direct marketing

- NAC Newsletter features / inserts.
- Project communiqués.
- Case studies / ISA Business profiles.
- Video case study.
- Fact sheets.
- Database management.
- Aquaculture Biennial Conference & Trade Show.

Public relations and display materials

- Media releases.
- Conferences.
- Website.
- Interactive web forum.
- School project kits.
- Community visits.

Advertising

- Specific section in the aquaculture yearbook on ISA.
- Advertising in selected aquaculture and related industry publications.

Budget and evaluation

Budget

The marketing communications budget has been mostly consumed with operational equipment and maintenance of the website. A communications officer was appointed, graphic design, web-publishing and photographic equipment and software has been purchased, and design for publication, display and video production quotes are being sought with the intention of purchase by the end of this financial year. Estimates for continuing years follow.

ISA Communications Operating Budget

Item	**Expenditure 2003/04 Financial Year**	**Expenditure 2004/05 Financial Year**	**Expenditure 2005/06 Financial Year**	**Expenditure 2006/07 Financial Year**
IT Hardware (Desktop PC & accessories)	4,000	2,000		
Comms Software (Software and upgrades)	1,500	1,000	1,000	
Events and launches		2,000	5,000	
Materials design (banners etc)	2,000	2,000		
Digital Camera, Compact Flash Cards & Tripod	2,000			
Advertising and cross promotion		5,000		
ISA Printed materials (factsheets, FAQ, kits, banners)	1,000	15,000	10,000	
ISA Demonstration DVD	15,000			
Media releases (estimated at one per month, includes VNRs)	600	3,000	1,000.	
Distribution and mail outs		5,000	2,000	
Conference materials		3,000	3,000	
Website Maintenance				3,000
TOTAL	**26,100**	**38,000**	**22,000**	**3,000**

Evaluation

The communication plan will continue to be amended. The tools that work along side the plan, such as stakeholder databases, key messages and publication opportunities, will continue to shape the content and implementation of the strategies outlined.

Survey research

- Survey research will be used on commencement, mid way and on completion of the campaign. Questions on ISA will be included in the surveys that will be conducted as part of the NAC questionnaire. The surveys will require candidates to provide opinions on their understanding of ISA.
- Candidates will be from a cross section of target audience and will be willing to be involved. Candidates will be approached via post communications, and will be a mix of both potential and existing members of the Australian Aquaculture Portal and other ISA communication vehicles.

Media monitoring

A media evaluation service will be engaged to ascertain whether the media objectives were reached.

Website participation

- Capabilities already exist within the NAC to monitor and record.
- Visits to the website comparing to previous months (Visits equal the total number of times that people have visited the website.
- Time spent per page (ISA page times will be evaluated as the campaign progresses. It is expected that the time spent on ISA pages will increase).
- Pages viewed (this tool will be particularly helpful in gauging the popularity of ISA pages compared to the overall site use).

The correlation between communications and ISA page visits will be analysed.

Table 1. Website usage statistics for Australian-Aquacultureportal.com for last 12 months.

Summary by Month										
Month	**Daily Avg**				**Monthly Totals**					
	Hits	**Files**	**Pages**	**Visits**	**Sites**	**KBytes**	**Visits**	**Pages**	**Files**	**Hits**
Jun 2007	8769	4363	456	256	2700	1095072	3330	5934	56725	114006
May 2007	10158	5219	531	272	5653	2726512	8449	16471	161801	314898
Apr 2007	9236	4701	706	260	4730	2434360	7812	21207	141042	277100
Mar 2007	9343	4708	597	271	4632	2263416	8421	18510	145950	289654
Feb 2007	6864	3489	404	192	3404	1617497	5383	11328	97717	192217
Jan 2007	7194	4494	1513	586	8940	2705685	18176	46922	139327	223022
Dec 2006	9264	5533	1158	367	11796	2423226	11020	34745	165998	277937
Nov 2006	24815	20324	8689	1299	9700	3890830	18194	121652	284537	347410
Oct 2006	10469	7147	1858	700	16669	4021342	21707	57625	221571	324551
Sep 2006	16366	8441	1693	429	14674	3261047	12890	50813	253233	491000
Aug 2006	12375	7660	1132	319	15808	2421749	9914	35099	237481	383635
Jul 2006	13639	8640	1580	336	16633	2664824	10438	48981	267870	422827
Totals							**135734**	**469287**	**2173252**	**3658257**

<u>Key to main headings:</u>

Hits represent the total number of requests made to the server during the given time period (month, day, hour etc.).

Files represent the total number of hits (requests) that actually resulted in something being sent back to the user. Not all hits will send data, such as 404-Not Found requests and requests for pages that are already in the browsers cache.

Tip: By looking at the difference between hits and files, you can get a rough indication of repeat visitors, as the greater the difference between the two, the more people are requesting pages they already have cached (have viewed already).

Sites is the number of unique IP addresses/hostnames that made requests to the server. Care should be taken when using this metric for anything other than that. Many users can appear to come from a single site, and they can also appear to come from many ip addresses so it should be used simply as a rough gauge as to the number of visitors to your server.

Visits occur when some remote site makes a request for a *page* on your server for the first time. As long as the same site keeps making requests within a given timeout period, they will all be considered part of the same **Visit**. If the site makes a request to your server, and the length of time since the last request is greater than the specified timeout period (*default is 30 minutes*), a new **Visit** is started and counted, and the sequence repeats. Since only *pages* will trigger a visit, remotes sites that link to graphic and other non- page URLs will not be counted in the visit totals, reducing the number of *false* visits.

Pages are those URLs that would be considered the actual page being requested, and not all of the individual items that make it up (such as graphics and audio clips). Some people call this metric *page views* or *page impressions*, and defaults to any URL that has an extension of **.htm**, **.html** or **.cgi**.

A KByte (KB) is 1024 bytes (1 Kilobyte). Used to show the amount of data that was transferred between the server and the remote machine, based on the data found in the server log.

Top 3 documents downloaded from portal:

Jun 07

- 620 /saline/pdf/RD04-0074 Integrated Aqua Review complete.pdf
- 205 /saline/pdf/Tom Losordo NSW Final Report.doc
- 204 /saline/pdf/WA_FinalRep_0705.pdf

May 07

- 659 /saline/pdf/RD04-0074 Integrated Aqua Review complete.pdf
- 378 /saline/pdf/WA_FinalRep_0705.pdf

Apr 07

- 864 /saline/pdf/RD04-0074 Integrated Aqua Review complete.pdf
- 167 /saline/pdf/WA_FinalRep_0705.pdf

Mar 07

- 676 /saline/pdf/RD04-0074 Integrated Aqua Review complete.pdf
- 192 /saline/pdf/WA_FinalRep_0705.pdf
- 235 /saline/pdf/PPK1_OPUS.pdf

Feb 07

- 449 /saline/pdf/RD04-0074 Integrated Aqua Review complete.pdf
- 96 /saline/pdf/Tom Losordo NSW Final Report.doc
- 127 /saline/pdf/WA_FinalRep_0705.pdf

Jan 07

- 521 /saline/pdf/RD04-0074 Integrated Aqua Review complete.pdf
- 111 /saline/pdf/Tom Losordo NSW Final Report.doc
- 147 /saline/pdf/WA_FinalRep_0705.pdf

Dec 06

- 649 /saline/pdf/RD04-0074 Integrated Aqua Review complete.pdf
- 138 /saline/pdf/Tom Losordo NSW Final Report.doc
- 184 /saline/pdf/WA_FinalRep_0705.pdf

Nov 06

- 811 /saline/pdf/RD04-0074 Integrated Aqua Review complete.pdf
- 173 /saline/pdf/Tom Losordo NSW Final Report.doc
- 230 /saline/pdf/WA_FinalRep_0705.pdf

Oct 06

- 758 /saline/pdf/RD04-0074 Integrated Aqua Review complete.pdf
- 162 /saline/pdf/Tom Losordo NSW Final Report.doc
- 215 /saline/pdf/WA_FinalRep_0705.pdf

Sep 06

- 1147 /saline/pdf/RD04-0074 Integrated Aqua Review complete.pdf
- 245 /saline/pdf/Tom Losordo NSW Final Report.doc
- 325 /saline/pdf/WA_FinalRep_0705.pdf

Aug 06

- 896 /saline/pdf/RD04-0074 Integrated Aqua Review complete.pdf
- 191 /saline/pdf/Tom Losordo NSW Final Report.doc
- 254 /saline/pdf/WA_FinalRep_0705.pdf

Jul 06

- 987 /saline/pdf/RD04-0074 Integrated Aqua Review complete.pdf
- 211 /saline/pdf/Tom Losordo NSW Final Report.doc
- 280 /saline/pdf/WA_FinalRep_0705.pdf

5.3. Review of R&D Plan

A preliminary review of the R&D Plan [Allan, G.L., Dignam, A. & Fielder, D.S. (2001). Developing Commercial ISA in Australia: Part 1 R D Plan. Final Report to FRDC Project No. 98/335. NSW Fisheries Final Report Series No. 30, 33 pp.] was undertaken at the first Steering Committee meeting held in April 2004. A second review was undertaken at the final Steering Committee meeting in June 2007 and the mission statement was retained:

> *"To establish commercial inland saline aquaculture in Australia through applied research and extension by identifying and overcoming bottlenecks to commercial development".*

Table 1. The status of ISA in 2000 and achievements by 2007.

ISA 2000	ISA 2007
Inland saline water resources poorly documented.	Greatly improved documentation.
Primary R&D activity in NSW, Vic, SA & WA.	Most activities still R&D based. Consolidation of WA inland saline trout aquaculture; commercial investment in NSW progressing.
Relevant R&D projects often ad hoc, regionally driven, site-driven.	Less *ad hoc* approach to project initiation. Improved sharing of information between R&D projects. Projects in different states are quite different in terms of water quality, quantity etc.
Focus on survivability, technical feasibility, specific water resources.	Increasing focus on economics.
No unequivocal commercial operations.	Still no fully commercial operations but several in development (Salt Water Trout Alliance in WA steady; NSW commercial inland ocean trout project being developed).
The most prospective water resources are shallow and deep aquifers; the most prospective commercial production systems are semi-intensive open ponds.	Potential for raceways, tanks, cages and more intensive systems in ponds.
The prospective species are barramundi, silver perch, prawns, mulloway, salmonids and artemia.	Confirmed all are prospective species. Economies of scale with respect to water availability and economics will determine species choice.
Most prospective technologies "imported" from local coastal and/or freshwater aquaculture.	SIFTS technology developed and other technologies being adapted.
Communications networks developing.	Successful Steering Committee/Network established and working well.
Public interest accelerating.	Still public interest and support for product marketed in regional communities. Increasing awareness of the need for better water use. Increased awareness of problems with salinity. Open Days and tours of demonstration facilities very successful.
General industry optimism re commercial feasibility.	Increasing recognition that large-scale commercial feasibility will rest with corporate investment rather than small-scale diversified agriculture.

Table 2. "Report card" of planned outcomes arising from successful completion of activities described in the 2000 – 2005 R&D Plan.

Planned Outcomes	**Results/Comments**
High potential inland saline water resources identified and characterised.	Completed.
Commercial potential validated through R&D projects.	True in most cases. The demonstration facilities helped potential investors to visualise operations. Disappointing response from salinity managers, including MDBC.
Inaugural commercial enterprises established in target areas.	Not as yet but some progress made in some areas.
Bio-economic models substantiating target activities.	Three models developed and used to substantiate some target activities.
Incorporation of ISA into existing and planned saline groundwater interception schemes.	Yes in SA but disappointing response in NSW.
Updated nationally coordinated R&D Plan reflecting commercial perspectives.	Completed.
Improved formal and informal communications networks, including international, to improve success ratios.	Yes, including work presented at national and international conferences.
Best practice guidelines documented and available for new entrants in target activities.	Completed for some activities and developing for others. Investment Directory to help guide new entrants.
Industry development phase to generate critical mass for species, regional markets, processing facilities etc.	Not as yet.
R&D shift from core technologies and pilot commercial projects to productivity improvement, enhancement, value addition, marketing, export, industry extension.	Yes for economic appraisal and overcoming economic bottlenecks to development.
Skills development.	Very effective.
Public education and promotion.	Very effective, especially the demonstration facilities.

In mid 2007 an R&D planning workshop of researchers and industry representatives was convened in Brisbane to review emerging findings and to agree priorities for future R&D. The following prospects were collectively identified:

Species	Activity	Water Source	Score
Barramundi	Grow-out	Shallow aquifers	H in tropics
Silver perch	Grow-out	Shallow aquifers	M
Prawns	Grow-out	Shallow aquifers	H in tropics
Mulloway	Grow-out	Shallow aquifers	H
Salmonids	Grow-out	Shallow aquifers	H in cool Australia
Artemia	Grow-out	Shallow aquifers	L
Prawns	Hatchery	Deep aquifers	L
Marine fish	Hatchery	Aquifers	H
Barramundi	Grow-out	Deep aquifers	L
Snapper	Grow-out	Deep aquifers	L
Salmonids	Grow-out	Deep aquifers	L
Prawns	Grow-out	Deep aquifers	L
Ornamental fish	Hatchery	Shallow or deep aquifers	M-H

The group then identified seven project areas that would explore specific development opportunities for ISA or address emerging constraints. These project areas are:

1. Grow-out of marine species using shallow aquifers.
2. Aquaculture from deep artesian water.
3. Winter culture of salmonids using shallow aquifers.
4. High health fish or prawn (including for ornamentals) hatchery.
5. Environmental guidelines for ISA.
6. Research and extension networking.
7. Investment support.

Table 3. The basis of the proposed seven R&D project areas.

R&D Project Areas	**Justification/Comments**
Grow-out of marine species using shallow aquifers (e.g., evaporation ponds constructed as part of groundwater interception schemes).	Drought has moderated optimistic views on water availability. Quality and quantity will limit the scope of activities in some areas: - Trout - Prawns and barramundi in Qld - Mulloway and kingfish in SA
Aquaculture from deep artesian water.	Coal seam gas extraction also brings saline water to the surface from deep aquifers and offers the opportunity for aquaculture.
Winter culture of salmonids using shallow aquifers.	- Current knowledge-base shows salmonids have prospects in Vic, WA and NSW - Opportunity for stand-alone commercial enterprises. - Limited opportunity for farm diversification except where strong cooperatives are formed. - Scarcity of freshwater supplies and issues with effluent discharge for freshwater trout culture. - Better tasting saltwater fish.
High health fish or prawn hatchery.	- Ornamentals - Other marine species - Potential for high health prawn hatchery moderated by the reduced demand for PLs and reduced climate for investment due to competition from imported product.
Environmental guidelines for ISA.	Impacts of effluent release into SA disposal basins/wetlands on ecology need to be assessed.
Research and extension networking.	Highly recommend maintaining to hold at least one workshop per year.
Investment support.	Need to maintain network linking potential investors with information on accrued results, economic analyses, market studies etc.

5.4. Investment Directory Consultancy: Inland saline aquaculture investment risk analysis framework for evaluating investment in ISA production systems and species

Carl Young

Seafood Farming Services, Aquaculture Consultants,
35 Market Street, Toowong, Qld, 4066

5.4.1. Outline of investment directory consultancy

The consultancy was advertised and won on the basis of price, merit and capacity, by Carl Young, Seafood Farming Services. The key output for this consultancy is web-based with links to other information and resource material. The following written summary provides some of the information. For a complete understanding of the Directory, please go to: http://www.australian-aquacultureportal.com

The objectives, planned tasks and deliverables for this consultancy are presented below:

5.4.2. Objectives

- A risk analysis framework for evaluating production systems and species.
- A synopsis as to the best candidates concerning species selection.
- Information on regional (state and local government) planning and approval processes for aquaculture.
- Available key resources for ISA (including location and characteristics of saline groundwater, interception schemes, saline lakes, evaporative ponds and other key infrastructure). Further objectives of this component are to:
  - Review and update the Resource Inventory and Assessment (Allan, G.L. Banens R. & D.S. Fielder, 2001. Developing Commercial ISA In Australia: Part 2. Resource Inventory and Assessment. Final Report to FRDC. [Project 98/335]. NSW Fisheries Final Report Series No. 31. NSW Fisheries, Sydney, 143 pp.).
  - Review data from Western Australia, Murray-Darling basin Commission, Victoria, South Australia and Queensland.
  - Summarise findings for presentation at Australasian Aquaculture 2004, 26 – 29 September 2004.
  - Provide linkages to the other consultancies comprising this initiative as listed above.
- An inventory of R&D projects, personnel and results.
- An inventory of Government (and others) assistance schemes.
- An inventory on relevant projects, experience and research outcomes from overseas plus any useful contacts.
- Submit a draft progress reports on 31 May and 10 June 2004 outlining how the project will be completed.
- Provide an electronic report including links to relevant electronic sources of information for use on National Aquaculture Council (NAC) web site to NAC Communications Officer by 30 June 2004. A PDF of the inventory and a list of industry and government representatives consulted to be included.
- Present the directory in a format that can be published and circulated to all interested stakeholders, public at large and possible investors.

5.4.3. Tasks and deliverables

(i) A risk analysis framework for evaluating production systems and species.

It is understood that the directory is to be a complete information source for prospective investors and other stakeholders interested in the development of ISA.

A risk analysis tool will assist commercial investors, government, and others to make informed decisions regarding the various species and production systems that may be established in the various saline locations.

The risk analysis framework will encourage users to consider issues related to location, water availability and quality, and resource access as well as the technical aspects of production system and the relative advantages of the various target species.

A project to determine the financial viability of ISA is being undertaken and will be incorporated into the investment directory as appropriate.

(ii) A synopsis as to the best candidates concerning species selection.

The work previously undertaken to identify the merits of aquaculture species will be reviewed and updated in light of recent ISA research. The synopsis should include information on commercial and environmental issues associated with the culture of each target species as well as the technical constraints.

The synopsis may include a brief appraisal of each species in the context of broader issues affecting that sector. Issues such as consumption patterns, market price pressures, production forecast of traditional aquaculture, and the pressures and constraints on traditional aquaculture in Australia.

(iii) Information on regional (state and local government) planning and approval processes for aquaculture.

A recent Productivity Commission report into Environmental Regulatory Arrangements for Aquaculture in Australia identified that *"Aquaculture production is subject to an unnecessarily complex array of legislation and agencies covering… environmental management, land use planning, land tenure, and quarantine and translocation"*. Burdensome approvals processes are limiting the growth of traditional forms of aquaculture in Australia. Therefore it is important to identify licensing, policy and planning issues that may constrain ISA.

The approvals process likely for the various forms of ISA in the various regions of Australia should be outlined and where necessary constraining regulatory issues highlighted.

(iv) Available key resources for ISA (including location and characteristics of saline groundwater, interception schemes, saline lakes, evaporative ponds and other key infrastructure).

a) Review and update the Resource Inventory and Assessment (Allan, G.L. Banens R. & D.S. Fielder, 2001. Developing Commercial ISA in Australia: Part 2. Resource Inventory and Assessment. Final Report to FRDC. [Project 98/335]. NSW Fisheries Final Report Series No. 31. NSW Fisheries, Sydney, 143 pp.).

   The data in the report may require updating as a result of research work and the establishment of new interception and evaporation schemes. Further work specifically relating to water quality and suitability may now be available and should be incorporated into an updated version of the report.

b) Review data from Western Australia, Murray-Darling basin Commission, Victoria, South Australia and Queensland.

Recent data is now available from Western Australia, the Murray-Darling Basin Commission, Victoria, South Australia and Queensland for incorporation into an update of the report.

The presentation of summary data/information from the report should tie in closely with the format used throughout directory.

c) Summarise findings for presentation at Australasian Aquaculture 2004, 26 – 29 September 2004.

The Sydney conference will provide an excellent forum for information exchange and to target potential directory users.

d) Provide linkages to the other consultancies comprising this initiative as listed above.

The directory, both electrical and hard copy, should be constructed so that it can be updated regularly, and be easy to use. Investors and stakeholders should be able to identify and contact relevant individuals in Government agencies and the commercial sector. Therefore, in addition to presenting inventories and outcomes of recent initiatives and R&D projects, the directory should be constructed in a manner that facilitates access to detailed information, related projects and relevant personnel.

e) An inventory of R&D projects, personnel and results.

The tender documents identified that ISA R&D effort was fragmented and uncoordinated in the past. The directory will consolidate the information collected to date and assist researchers to target effort in future.

An inventory of Government (and others) assistance schemes.

The form in which government assistance may available to investors often changes and will need to be updated regularly.

f) An inventory on relevant projects, experience and research outcomes from overseas plus any useful contacts.

It is important to take account of projects that may be unrelated but relevant and also the opportunities for technology transfer from work done on similar issues overseas.

5.4.4. Investment directory – a risk analysis framework

Introduction

The following risk analysis framework has been prepared to guide potential investors through a series of issues or elements of a project that should be considered when looking at ISA business opportunities.

The investment risk analysis considers the issues or elements most likely to affect the commercial success of ISA projects. Each element is analysed in a similar manner. Not all of the issues and elements outlined below will be relevant to all potential ISA projects. The information is provided to highlight the important investment risks associated with ISA. The investor will need to identify the specific risks associated with each project under consideration.

There are a number of assumptions behind the information provided in this investment risk analysis framework. These assumptions apply to most aquaculture projects, not just ISA. For example:

A commercial aquaculture operation has profitability as a primary objective. Regardless of whether it is a stand-alone investment or farm diversification, extensive or intensive, small or large project, profitability must be a primary requirement.

Regardless of the type of aquaculture system employed, there is a size of operation below which profitability is unlikely.

Treating and recycling water in aquaculture systems increases production costs relative to conventional production systems. Recirculation aquaculture systems are usually more expensive to construct and operate, and more complicated to run.

The productive capacity of closed systems, low flow or extensive systems without water treatment is limited. Experience in Australia shows that larger, or efficient aquaculture operations have greater commercial success.

The seafood wholesale and retail sector is highly competitive in Australia. Domestic prices are often based on inexpensive imported product. New aquaculture operators often overestimate market demand and have a poor understanding of price structure and competitive forces affecting seafood. The market price for aquaculture product in Australia (and everywhere else!) depends on demand and supply; as supply increases the price drops.

It has been assumed that need to recirculate water, or operate closed or low productivity systems, small operations, or complex systems will impact on the output and/or cost of the project, and therefore potentially increase the commercial risk.

Risk analysis format

The format of the risk analysis broadly follows that described in the International Standard – Risk Management AS/NZS 4360:1999.

Issues & elements

A number of issues associated with, or elements of, ISA operations have been identified that may impact on the commercial feasibility of the project.

Aspects & impacts

An issue or element may have a number of associated aspects that could impact in many different ways on a projects' commercial success. A range of aspects have been listed below and their associated impacts described.

Likelihood & consequence

The framework then provides an initial risk analysis based on the information provided and assumptions made. This is done by considering the likelihood that the aspect or impact will occur and the consequences of the aspect or impact on the commercial viability of the project.

Risk analysis

The likelihood and consequence can be ranked into a number of categories. The rankings are then entered into a risk analysis matrix to determine the risk associated with the aspect and impact.

Risk analysis matrix

			Consequence		
Likelihood	**Negligible 5**	**Minor 4**	**Moderate 3**	**Major 2**	**Catastrophic 1**
1 Rare	Low	Moderate	Moderate	High	High
2 Unlikely	Low	Moderate	High	High	High
3 Possible	Low	Moderate	High	Extreme	Extreme
4 Occasional	Low	Moderate	High	Extreme	Extreme
5 Likely	Low	High	High	Extreme	Extreme

The following table provides some suggestions to help interpret the results of the risk assessment:

Result from the risk assessment	**Possible interpretation of risk assessment**
Low	Not considered a threat to commercial viability. Proven management procedures available. No affect on profitability.
Moderate	May incur increased but acceptable capital and/operating costs. Uncertainties that could be managed. Profitability could be affected. No significant R&D required prior to operation.
High	Raises serious concerns about the proposal. Uncertainties require investigation. Profitability will be affected. More R&D may be required.
Extreme	Large commitment required, high capital and operating costs. Unproven technologies involved. Unprofitable. High risk, probable show stopper.

<u>ISA issues and elements</u>

A number of the issues (or elements) have been listed in the table below along with some aspects that might impact on the commercial viability of a project. Each of the aspects are considered in more detail in the sections that follow.

Issues/Elements	**Aspect**
1. Water Supply	Water quality. Volume of water available. Continuity of supply – Intermittent or irregular flows.
2. Location	Remoteness. Climate conditions.
3. Policy	Planning and approvals processes.
4. Production system & species	High capital and operating costs. Marketing and sales of target species. Commercially unproven production systems.

1. WATER SUPPLY

A description of the water supplies that may be available for ISA can be found in:

Allan, G.L., Banens B. & Fielder, D.S. 2001, Developing Commercial ISA in Australia: Part 2 Resource Inventory and Assessment. Atech Group & NSW Fisheries, FRDC Project No 98/335

Also refer to the NAC ISA website: www.australian-aquacultureportal.com ISA Resource Page

Water quality

Discussion

Water quality requirements vary for each aquaculture species. Also the composition of inland saline water can vary considerably within a small geographic area and at different depths. Variations in composition have also been recorded in different seasons although this is less common. The most common compositional problem with inland saline water is potassium deficiency. This must be adjusted before culture of some species is possible. The composition of other ions and other aspects of water quality must be checked before aquaculture is considered A number of studies have been undertaken to determine the suitability of inland saline water for the production of a number of different fish species.

Also refer to the NAC ISA website: www.australian-aquacultureportal.com ISA R&D & Publications Page.

Impact

Water quality unsuitable for the species proposed or requires treatment prior to use.

Likelihood

The composition of inland saline water supplies may vary substantially both temporally and geographically over relatively short distances. Inland saline water supplies may need some form of treatment prior to use therefore all potential water supplies will need to be tested. A bioassay of the proposed water supply may need to be undertaken.

Water Source	Unsuitable and/or requires treatment
Interception Scheme	Depending on species being cultured, likely to require treatment.
Shallow Aquifer	Depending on species being cultured, likely to require treatment.
Deep Aquifer	Depending on species being cultured, likely to require treatment.

Consequence

The commercial consequence of developing a facility that utilises a water supply of inadequate quality is dependent on the type of system proposed. Some water sources will be totally unsuitable for aquaculture others may require varying amounts of treatment which will impact on the operation depending on its size and the level of treatment required.

System	Consequence
Flow through systems	Severely limited operating capacity if treatment required.
Closed/semi closed systems	Will impact on cost and complexity of production depending on size of operation and treatment required.
Recirculation	Will impact on cost and complexity of production depending on size of operation and treatment required.

Therefore inadequate quality water or water that requires treatment may:

- Preclude any form of aquaculture in a particular area.
- Result in sub optimal growing conditions.
- Limit/influence the species that can be produced.
- Increase the cost of the water used in the operation.
- Influence the type of production system that can be established. Water may need to be recycled to reduce to overall water requirement.
- Limit the size of the operation. Particularly where flow through or partial recirculation is undertaken.
- Restrict the size of operation/s at a location.
- Limit the number of operators or industry at a given location.
- Impact on the profitability of the operation where output of the farm is restricted by low/limited water supplies and/or high treatment costs.

Analysis

It is possible that the water available to an ISA facility will require some form of treatment prior to use and this will depend on the species being cultured. As a result the facility may incur additional costs, increasing the need to limit water loss and or recycle water. It may limit production to ensure control over the system. As the uncertainty over water quality increases, greater will be the need to recycle water.

The need to treat inland saline water will constitute a low to moderate risk and may substantially influence the nature and commercial viability of the culture system adopted.

<u>Volume of water available</u>

Discussion

Although the saline groundwater resources are enormous, the volume of water at any one location may be limited, for more information refer to:

Nulsen, B. (1999) Inland Saline Waters in Australia in: Smith, B. and Barlow, C. (Editors) 1999, ISA Workshop. Proceedings of a workshop held on 6 and 7 August 1997 in Perth, Western Australia. ACIAR Proceedings.

The most significant quantity of available water for ISA at a single location is likely to be associated with an interception scheme. Allan, G.L., Dignam, A. & Fielder D.S. 2001 reports that 49000 ML of water each year is evaporated through 11 interception schemes in the Murray Darling Basin.

Water flows at Wakool and the Stockyard Plains Interception Scheme Flowers, T.J. & Hutchinson, W.G. (2004) are estimated at around 30ML per day.

The capacity of the production system will be very dependent on the type of system and species adopted. For example many existing Australian prawn farms have ponds of around 1 hectare (15ML volume) and the daily discharge may average around 5%.

On this basis an individual interception scheme with 30 or possibly 50ML of water per day may supply sufficient water for 40 conventional intensive/semi intensive ponds of around 1 hectare (of the type used for prawn or barramundi culture). A 40 ha prawn farm could produce in the vicinity of 240 tonnes of product and a barramundi operation around 800 tonnes per annum.

The adoption of low flow or static production systems may allow a greater volume of production of some species. For example static silver perch culture requires 40ML per hectare per year. Therefore a 30ML per day supply (i.e., around 10000ML/year) may be sufficient for around 250 one-hectare static ponds producing up 10 tonnes of fish per hectare or 2500 tonnes in total.

Recirculation systems recycle water thereby using substantially lower volumes. Conversely, high flow raceway systems utilise enormous quantities of water. A traditional trout raceway system may use around 1L/kg of fish per minute (5 – 10L/sec/tonne). Therefore 30ML per day will be sufficient to carry between 20 and 40 tonnes of trout in an intensive flow-through raceway system.

The amount of product that can be produced in a system does not necessarily correspond with profitability; investors must look at capital expenditure and return on investment. Also, it should be noted that the interception schemes might be able to provide significantly more water at minimal pumping cost. In some ISA scenarios it is not the availability of water to the farm that will limit production, rather the ability to remove and dispose of salty water once it has been utilised.

Shallow aquifer saline water although extensive, particularly in WA is spread over a large area and individual bores may only pump relatively small volumes of water. Also, the disposal of discharge water may be problematic in some locations.

Impact

Limited volume of water available to individual ISA operations

Likelihood

Water Source	**Limits of Supply**
Interception Scheme	Individual flows may be limited however may be supplemented through additional pumping.
Shallow Aquifer	Low flows likely from individual bores may be in the vicinity of $35m^3$ per hour
Deep Aquifer	Greater volumes likely from individual bores

Consequence

The consequence of low water supplies will be very dependent on the type of system proposed:

System	Consequence
Flow through systems	Severely limited operating capacity.
Closed/semi closed systems	May have little impact.
Recirculation	May have little impact.

Therefore limited water supplies will:

- Influence the type of production system that can be established. Water may need to be recycled to compensate for low water volumes.
- Limit the size of the operation – particularly where flow through or partial recirculation is undertaken.
- Limit the number of operators or industry at a given location.
- Impact on the profitability of the operation where output of the farm is restricted by limited water supplies.

Analysis

It is highly likely that the volume of water available to an ISA facility will be limited therefore the facility will need to restrict water loss, recycle water or limit production to ensure control over the system. As the uncertainty over water supply increases, greater will be the need to recycle.

Low volumes of available inland saline water will constitute a moderate to extreme risk and will substantially influence the nature and commercial viability of the culture system adopted.

Continuity of supply

Discussion

Interception schemes may operate intermittently depending on the time of year and the rainfall. As a result, the volume of water supplied to an ISA facility attached to an interception scheme will vary. In dry conditions the scheme may not need to pump to lower or maintain the depth of the aquifer and therefore flows to the ISA facility may drop. This is likely to occur in summer when water temperatures and evaporation are highest. Most schemes still have the capacity to pump water at relatively low cost even when the water table has dropped and saline groundwater no longer has to be pumped to protect agricultural land.

There may be natural variations in water flows from shallow aquifers depending on season and rainfall. Water supply from deep aquifers is likely to be more stable.

Impact

Intermittent or irregular flows. Possibility of having to pay for pumping.

Likelihood (of the aspect or impact occurring)

Water source	Intermittent or irregular flows
Interception Scheme	Water flows from interception schemes may be variable depending of the size and nature of the interception scheme; there may be large seasonal variations. May have to pay for pumping at these times.
Shallow Aquifer	May be highly variable.
Deep Aquifer	More consistent supplies, more expense for pumping.

Consequence (of the aspect/impact occurring)

The consequence of intermittent water supplies will be very dependent on the type of system proposed:

System	Consequence
Flow through systems	Severely limited operating capacity
Closed/semi closed systems	May have little impact
Recirculation	May have little impact

Therefore intermittent or irregular water supplies will:

- Influence the type of production system that can be established. Water will need to be recycled to deal with unpredictable water supplies.
- Limit the size of the operation. Particularly where flow through or partial recirculation is undertaken.
- Limit the period of operation. Anything other than a closed system will require a reliable flow of water.
- Limit the species farmed. Certain species require fairly constant culture conditions.

Analysis

It is highly likely that the volume of water available to an ISA facility will be variable therefore the facility will need to limit water loss, recycle water or limit production to ensure control over the system. As the uncertainty over water supply increases, greater will be the need to recycle water. An ISA operation associated with an interception scheme may be able to pump additional water to ensure continuity of supply. It is likely this water will incur additional costs.

The intermittent nature of inland saline water supply will constitute a moderate to extreme risk and will influence the nature and commercial viability of the culture system adopted.

2. LOCATION

Remoteness

Discussion

The recent interest in the use of inland saline water for aquaculture has come about for a number of reasons. Salinisation of large areas of Australia is recognised as one of the most significant environmental problems facing the country. This salinisation is associated with agricultural activity. Therefore many of the opportunities for ISA are considered to occur near to, or in association with existing agricultural activity, irrigation or interception schemes.

Often the resources for ISA are not far from major cities or regional centres. Wakool for example is only three hours from Melbourne and very close to the country towns of Deniliquin and Echuca. However there are significant issues that need to be considered by prospective investors that may affect the commercial viability of a project. Most significant are the proximity to markets, infrastructure and services.

Impact

Lack of necessary infrastructure, services and excessive distance to markets

Likelihood

Water Source	**Lack of Infrastructure, services, market access**
Interception Scheme	Possible – despite location along relatively well populated areas of the Murray.
Shallow Aquifer	Possible – problems likely to be compounded in small operations. Must be considered on site by site basis.
Deep Aquifer	Possible – should be taken into consideration on site by site basis.

Consequence

The commercial consequence of developing a facility in a remote location may be dependent on the production system that is established, for example more intensive units often rely more heavily on power for pumps and aerators.

It should be noted that an operation may be located relatively close to relatively highly populated areas (2 – 3 hours drive) and face significant isolation issues. The following consequences of locating in a remote or isolated location should be taken into consideration:

Transport: A remote location may result in increased production costs, for example higher transport costs resulting in more expensive feed, juveniles, equipment, and services (technical support).

Power: Lack of power supply will seriously limit the type and size of production facility that can be operated. The cost of laying power lines for a small operation is likely to be prohibitive. Costly cultural heritage surveys may be required for the power line. Limited power supplies will limit cool room and processing capacity.

Distribution: Costs to deliver product to market may be higher than competition with closer proximity to major population centres.

Market Proximity: A lack of local market may require product to be shipped long distances to major cities or distribution centres. Local outlets may be fragmented geographically and serviced with infrequent, inefficient delivery systems. Regional consumers may not be familiar with the products being produced.

Staff: It is unlikely that specialist local technical expertise is available. As the complexity of the production system increases (through intensive recirculation) the greater will be the need for specialised staff. Occasionally aquaculture operations find it difficult to source staff that are willing to live and work in isolated conditions. Labour costs may increase to reflect this.

Analysis

It is likely that issues of remoteness and isolation will impact on an ISA facility in some way. As a result the facility may incur additional costs, and/or face complex management and administrative issues.

The need to locate and operate an ISA operation in a remote location will constitute a moderate to extreme risk and may substantially influence the nature and commercial viability of the culture system adopted.

The costs associated with operating in a remote location will impact on the species and production system choice. Low production, small output, inefficient systems producing low value species may encounter serious profitability issues.

Investors make investment decisions based on a number of factors. The number of investors willing to invest in a relatively risky aquaculture operation that is also located in a remote or unfamiliar location may be limited.

Climatic conditions, temperature profile

Discussion

Aquaculture species have specific temperature requirements for optimal growth. Outside of these optimum conditions growth can be slow or the animal suffers stress that can impair its health. Aquatic animals that can live in a wide range of temperatures may not be able to tolerate rapid change in temperature.

While inland saline water sources are varied and numerous and may be relatively constant in temperature, the use of large open shallow ponds to grow fish results in the culture water being directly affected by ambient air temperatures.

Unfortunately the air temperatures at many of the locations being considered for ISA are notable for wide seasonal and diurnal (daily) variations. Therefore in many cases systems will need to be established that have the capacity to control water temperatures otherwise the production season will be significantly shortened or the culture stock unduly stressed.

It has been suggested that two crops could be grown in a single pond each year. Each crop would be a different species that displayed optimal growth at the time of year in which it was grown.

Impact

Adverse diurnal or seasonal climatic temperature profile (for year round optimal growth of the proposed species).

Likelihood

Water Source	**Adverse diurnal or seasonal climatic temperature profile**
Interception Scheme	Highly likely.
Shallow Aquifer	Highly likely.
Deep Aquifer	Highly likely (however constant source water temperatures likely).

Consequence

The consequence of sub optimal water temperatures will be very dependent on the type of system proposed:

System	**Consequence**
Flow through systems	May have little short term impact on culture stock. Seasonal impact may be severe resulting in limited operating capacity.
Closed/semi closed systems	Severe impact in open pond systems.
Recirculation	Costly temperature control likely.

Therefore inadequate water temperatures may:

- Preclude aquaculture in a particular region.
- Result in sub optimal growing conditions.
- Limit/influence the species that can be produced.
- Affect continuity of production and therefore could constitute a significant marketing constraint.
- Increase the operating and capital cost of the project through expensive temperature controls.
- Influence the type of production system that can be established. Intensification of culture system may be required to justify cost and complexity associated with recycling and temperature control.
- Limit the size of the operation. Particularly where low flow or partial recirculation is undertaken.
- Restrict the size of operation/s at a location.
- Limit the number of operators or industry at a given location.

An inappropriate temperature profile will impact on profitability, particularly in small operations where output is restricted by low/limited water supplies and/or high treatment costs.

Analysis

It is likely that the water available to an ISA facility will require some form of temperature control to enable year round production. As a result, the facility may incur additional costs, and need to limit water loss, recycle water or limit production to ensure control over the system. As the climatic temperature variation increases, greater will be the need to recycle water.

The need to establish culture systems that control water temperature will constitute a moderate to extreme risk and will substantially influence the nature and commercial viability of the business proposition.

3. POLICY

Planning and approvals requirements

Discussion

States and territories have legislation in place governing aquaculture development. Aquaculture in Australia is recognised as a highly regulated industry. Any new commercial aquaculture development will require a range of government approvals. The Productivity Commission Report identified that current regulatory procedures for aquaculture development are often confusing, uncoordinated, and restrictive.

The aquaculture investor in Australia is faced with a range of regulatory requirements, the complexity, and cost, of which depends on the location of the proposed operation, the type of system, the species farmed, and the environmental impact of the proposal.

One of the potential commercial advantages of ISA is that it may be undertaken in parts of the country where there are fewer regulatory constraints and less competition for water, land or other resources.

The environmental impacts from ISA may be less than conventional systems located in more populated catchments or near the coast however this is highly site specific.

It should be recognised that as the quality of the wastewater discharged from existing aquaculture improves and new developments adopt treatment and recirculation technologies, regardless of water source, then ISA will lose any competitive advantage based on environmental impact and regulatory requirements it may have.

In general recirculation aquaculture systems face fewer regulatory hurdles regardless of their location.

ISA may involve the translocation of aquatic species into regions that are outside of their natural range. There are inter and intra State policies governing the translocation of aquatic plants and animals. Each new translocation request will require a risk analysis to be undertaken.

Also, depending on the location, pond permeability and salt water seepage needs to be determined. Queensland for example has very restrictive policies regarding the “alienation” of agricultural land, i.e., land cannot easily be removed from agricultural use for aquaculture. Other States have policies that prohibit the release of water from land based aquaculture facilities in certain locations, or circumstances. On the other hand, most ISA is likely to take place in areas degraded by salinity where regulatory authorities are often supportive of genuine alternative land use proposals.

The aquaculture investor needs to have a clear path through the approvals process. Time delays in obtaining approvals and uncertainties over regulatory requirements and policies are a commercial risk that incurs a direct cost to a project.

Impact

The regulatory requirements and/or policy instruments will influence the economic viability/success of the proposal.

Likelihood

The environmental impacts of all new ISA projects will need to be assessed prior to the issuance of approvals. It is highly likely that all species for ISA will require some form of risk analysis to be undertaken. The complexity and cost of the environmental assessment and risk analysis will be site, species, state, etc specific.

System	**Regulatory Requirements**
Flow through	Likely to be high.
Closed discharge no discharge	Likely to be much lower.
Recirculation	Likely to be much lower.

Consequence

Therefore regulatory requirements may:

- Preclude any form of aquaculture in a particular area.
- Limit/influence the species that can be produced.
- Increase the cost of the water used in the operation through discharge treatment.
- Influence the type of production system that can be established. Water may need to be recycled to address regulatory requirements.
- Limit the size of the operation, particularly where flow through or partial recirculation is undertaken.
- Restrict the size of operation/s at a location.
- Limit the number of operators or industry at a given location.
- Result in an increased capital and operating costs to comply with regulatory requirements.
- Stifle investment through uncertainty and investor frustration.

Analysis

It is inevitable that ISA proposals will require a range of government approvals. It is likely that the approvals will involve environmental controls that will influence the design, construction and operation of the facility. As a result, the facility may incur additional costs, and/or need to limit water loss, recycle water or limit production to ensure control over the. However, it is most likely that the regulatory costs and costs of obtaining approvals will be much less than for coastal areas or even areas of highly productive agricultural land.

Regulatory requirements will constitute a moderate to extreme risk and will substantially influence the nature and commercial viability of the ISA business proposed.

4. *PRODUCTION SYSTEMS AND SPECIES*

Technical complexity of the production system

Discussion

Aquaculture is a highly specialised activity requiring considerable technical and business expertise. The ISA research undertaken to date has identified that in order to produce fish continuously throughout the year in one system either a combination of species will be grown or the environmental and water quality parameters will be controlled. Usually this is achieved through the incorporation of some form of recirculation system.

As the intensity of the aquaculture system increases and (or) the system moves to control the environmental and water quality parameters though recirculation then it can become very complex. Therefore ISA is likely to be a relatively complex form of aquaculture.

Not only will the technical complexity of the ISA system impact on the capital and operating cost but also on the technical expertise of the staff required to operate the system. This is an important consideration particularly as ISA has been identified as a means of helping farming communities to diversify from traditional agriculture. Traditional farmers will have very little knowledge of recirculating aquaculture.

Significant advances have been made to date in farming aquatic animals in inland saline waters however for many species there are still many unknowns, and the best production system has yet to be identified.

Impact

Significant technical skills required to operate an ISA production unit

Likelihood

System	**High level of skills required**
Flow through	May be simple systems, depending on species.
Closed discharge no discharge	May be simple systems, depending on species.
RAS	Increasingly complex and more difficult to manage.

Consequence

The consequence of a complex production system will be to limit investors with the technical capacity and confidence to run the operation. There may be limited staff available with the expertise to operate the system. These problems are compounded if the operation is undertaken in isolated areas.

Therefore ISA systems of increasing intensity and complexity may:
- Preclude aquaculture in a particular region.
- Preclude investment in ISA by agricultural farmers wishing to diversify.
- Limit/influence the species that can be produced.
- Increase the operating and capital cost of the project through expensive temperature and water quality control.

- Limit the size of the operation. A minimum size of operation may be required to justify the greater expense of the production system.

Analysis

Recirculation Aquaculture Systems (RAS) can be very complex. The complexity of RAS utilising inland saline waters will increase particularly where incoming water quality and water temperatures need to be controlled.

The need to establish a complex production system will constitute a high to extreme risk and will substantially influence the attractiveness of the proposal to the potential investor, particularly if the operation is to be located in a remote or isolated location.

Marketing and sales of target species

Discussion

The Australian wholesale and retail seafood market is highly competitive. Seafood sellers have easy access to cheap Asian and African imports, and the majority of Australian seafood consumers make seafood purchase decisions based on price. Multiple retailers such as Coles and Woolworths offering inexpensive imported product have become the main source of seafood for many Australians.

In general Australians have conservative tastes in seafood with a preference for relatively bland, white fleshed, ocean caught, “chunky” fillets. Although Tasmanian farm reared Atlantic salmon and trout have made some inroads on the domestic market with boneless, skinless portions.

Australia is a relatively small seafood market and the market price of fish is very sensitive to product availability. By far the largest seafood markets are Sydney and Melbourne.

Very little sustained promotion of seafood is undertaken by producers in the aquaculture industry, with a small number of notable exceptions. Producers do not cooperate in marketing and tend to be price takers, at the mercy of the vagaries of the market and in particular uncoordinated market supply.

Rainbow trout, barramundi, silver perch, mulloway and black tiger prawn have been identified as the most likely ISA production species. This appears to be based on their production characteristics rather than their marketability. Traits such as temperature and salinity tolerance, ease of production and robustness, proven production techniques and available expertise have been cited as reasons for their use in ISA trials.

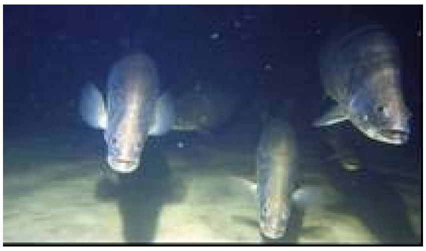
Nevertheless, the species are well known in Australian markets and are, with the exception of mulloway, currently farmed and sold in reasonably large quantities.

Impact

Market price and demand for target species poor

Likelihood

The following is a very cursory assessment of the market potential of the species and readers should refer to Ruello & Associates Pty Ltd., (2004) for more information. It has been assumed that there is no real competitive market advantage to producing product in ISA facilities. It may be possible for a small amount of product to be sold directly into the regions and realise a premium, this is highly dependent on location.

<u>**Species**</u>	<u>**Markets and price**</u>
 **Trout**	Plate size freshwater product currently realise low price. Saltwater Tasmanian product targets large fish but has large capacity to produce plate sized product. Prices sensitive to supply – it is likely that prices (in major markets) will drop with an increase in supply, unless demand is stimulated.
 **Mulloway**	Relatively small amounts of wild caught product reach the market. Therefore supply small, however prices are relatively low. Small fish have a poor reputation; flesh considered soft. It is possible that demand and price may be poor. Starting from a low demand/price position.
 **Prawns**	Increasing volumes of inexpensive imports in the Australian market. Downward price pressure on local farmed product, particularly the smaller sizes. Unless an ISA facility can produce contra seasonal or large sized prawns it is likely that the market price and demand will reflect the current much reduced market price. Large seasonal price fluctuations dependent on wild and farmed availability.
 **Barramundi**	Barramundi is a popular aquaculture species currently grown in every conceivable type of production system in Australia. Prices continue to drop as domestic supplies increase. Also, increasing Asian imports are affecting prices. It is possible that local demand could increase as the price of domestic product drops. However, in the long term, it is likely that the market price of barramundi will continue to fall.
 **Silver Perch**	Salt water reared silver perch may display a distinctively salt water taste that may result in a premium price however the domestic market for this fish continues to be small and therefore the market price very sensitive to even small increases in supply.

Consequence

Low current or future market price will directly affect the profitability of an ISA proposal. Most of the species being considered for ISA have been sold in Australia for many years and a lot of market information is available. It should be possible to make a very accurate assessment of likely drop in market price as supply increases.

Once the market price irrevocably drops, the profitability of an aquaculture enterprise can only be re established by:

- Increasing the productivity of the facility.
- Reducing costs and increasing the efficiency of production.
- Increasing the overall level of production.

Analysis

It is almost certain that the market price of the species being investigated for IAS will drop as supply increases. The proposed operation must be capable of producing fish at a cost that will enable a profit to be achieved despite the anticipated fall in market price. International and domestic experience would suggest that the cost of production and size of operation becomes critical to profitability. Market price and demand must pose an extreme risk to ISA proposals. Particularly where small or expensive systems are being considered.

<u>Commercially unproven production systems (rearing technology & procedures)</u>

Discussion

Species

Much work has been undertaken to identify potential candidates for aquaculture in Australia. Despite many native species having been considered for aquaculture and considerable effort put into researching the technology to produce a number of these, there are only 7 aquaculture sectors in Australia with a gross annual production of more than $10m, these are tuna, pearl oysters, edible oysters, Atlantic salmon, prawns, rainbow trout and barramundi. Tuna, pearl and Atlantic salmon production account for over 80% of the Australian industry.

It may be assumed that tuna, pearl and edible oysters will not be produced commercially in ISA systems. The choice of commercial aquaculture species suitable for ISA production appears to have been narrowed to the salmonids particularly trout, and the penaeid prawn *Penaeus monodon*, silver perch and barramundi. All of which have reasonably wide salt tolerance.

The suitability of these species for ISA is further considered in Investment in ISA – Species Appraisal.

Several other species have been considered for ISA including mulloway, black bream and snapper. Of these only mulloway is considered to have potential for ISA at this stage. Refer Investment in ISA – Species Appraisal.

Of the species under consideration only barramundi has been produced profitably, in commercial quantities, in the systems that are being considered for ISA (i.e., recirculation aquaculture systems). Although technically feasible, market price (considered elsewhere), cost of production, and system productivity are equally important commercial considerations.

Systems

There are no fully commercial profitable ISA operations at the current time (Winter 2004). The following table highlights the commercial status of each potential ISA species sector based on the production system and identifies the ISA systems under investigation for each species.

System	Trout	Penaeid prawns	Silver perch	Mulloway	Barramundi
Flow through	Proven/ commercial No ISA	Proven/ commercial No ISA	Proven/ commercial No ISA	Untried No ISA	Proven/ commercial No ISA
Closed/Low discharge. No recirculation	Untried ISA Pilot	Untried ISA Pilot	Unviable No ISA	Untried No ISA	Unviable No ISA
Recirculation	Proven/ Unviable ISA Pilot	Experimental No ISA	Proven Unviable No ISA	Untried Experimental No ISA	Proven/ Commercial No ISA

The table illustrates that ISA research work to date appears to be targeting production technologies that have either not been undertaken commercially in Australia or have in the past been shown to be commercially unviable.

Research

It is doubtful whether there is sufficient information from the research undertaken to date for the prospective investor to make a decision to invest in an ISA project safe in the knowledge of long-term profitability.

Currently, ISA research (and ISA related research) around the country is focused on the mechanics of producing fish in inland saline water. The results to date show that it is possible to grow fish, although the water supply often requires treatment to ensure survival.

The production systems being investigated are as diverse as the species and water resources used in them. However the research effort does have a common theme, it attempts to utilise inland saline water in its various forms to produce aquaculture products. Whether the intent is to establish a stand-alone production unit or one integrated with other agricultural or environmental control activities, it is a production, not market, driven approach to aquaculture development.

Now that the initial work to verify the suitability of inland saline water resources for aquaculture has been undertaken it may be appropriate to assess the production of commercial candidates under commercial conditions. However in some cases it is probable that sufficient information is currently available to make an informed decision about the potential profitability of ISA without any further trials.

The likely competitive advantages offered by ISA must be considered on a case-by-case basis to ensure that further research is justified.

Impact

Unproven technology and production procedures prevent investors from making ISA investment decisions.

Likelihood

Insufficient (production system) information is available to investors to enable confident commercial investment in ISA.

Water Source	**Investor Ready Status**
Interception Scheme	Trials ongoing: Small quantity of fish produced to date at one scheme, small experimental ponds in place, low flow system, water treatment required, occasional unexplained mortalities. Not commercial investor ready.
Shallow Aquifer	Trials ongoing: Static pond systems (trout), closed or recirculation ponds (prawns) and multispecies recirculation system (SA) undertaken. Small-scale trials to date, further work required to improve system efficiency. Research required. Not commercial investor ready
Deep Aquifer	No research to date although non-saline deep aquifer production has been proven technically and in one instance commercially. One deep aquifer saline barramundi successfully produced high quality fish but has now ceased operation.

However sufficient information is available to the investor and researcher to make an informed decision on the continuation of existing research or future commercial investment into ISA research, particularly where the objective of the research is to establish commercially profitable aquaculture ventures.

Investors (and researchers) should not make decisions based only on a systems ability to produce fish, factors such as market price, capital cost, operating cost, and system productivity are equally important considerations.

Consequence

As a consequence of the experimental status of most ISA, it is likely that the potential commercial investors are:

- Unable to identify current commercial ISA opportunities.
- Unwilling to invest in ISA.
- Required to fund further research prior to commercial production.

Analysis

The lack of proven commercial production procedures and the requirement to participate in what may be extensive research will influence investor willingness to invest in ISA. It is highly likely that further research is required regardless of system, species, water source or location. The consequence may be protracted and expensive research work that may not result in a positive outcome.

The uncertainty associated with ISA production will constitute a high to extreme investment risk and will substantially influence investment decisions in to invest in ISA business proposal.

5.5. Temperature Model Consultancy: Modelling temperature and thermal stratification in inland saline aquaculture ponds

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5.5.1. Introduction

The demand for seafood throughout the world is increasing while landings from capture fisheries remain static. In Australia, the US, and much of the developed world, growing seafood consumption is being increasingly met by importation. In Australia, the value of aquaculture production has trebled since 1991/92 representing an annual growth of 14% in nominal terms and 11% in real terms. The Australian Federal Government has committed to an Aquaculture Industry Action Agenda that plans to triple the value of aquaculture production to AU$2.5 billion by 2010 and create 29,000 new jobs. However, expansion of coastal aquaculture is limited by a shortage of suitable sites with the necessary water quality, depth and proximity to land-based infrastructure that are not either being used or considered for urban and tourist related development or judged to be of too high environmental value for aquaculture. Investigating ISA is a specific priority in the Australian Aquaculture Action Agenda.

Rising salinity is the biggest environmental problem facing inland Australia with millions of hectares of land becoming unproductive because of rising salt. Hundreds of millions of dollars have already been spent and at least $100 million more are planned to be spent over the next ten years to construct saline groundwater interception and evaporation schemes to prevent saltwater rising to the plant root zone. These schemes are effective but are very expensive and leave a large “foot print”. If commercially viable aquaculture can be developed in association with these schemes, it may mitigate the costs of establishment and maintenance of both the schemes and aquaculture.

In other parts of Australia, e.g., Western Australia, South Australia and Queensland, saline groundwater or saline lakes also offer the potential for aquaculture. Provided effluent can be managed and salty water does not leak into freshwater drainage systems, these resources may offer exciting opportunities for commercial aquaculture. Incorporation of aquaculture into existing and planned groundwater interception schemes was highlighted in the R&D Plan for ISA that was released by the Fisheries Research & Development Corporation (FRDC). A companion Resource Assessment that lists major sources of inland saltwater in groundwater interception schemes, saline lakes, underground saline aquifers and other sources was released by FRDC at the same time.

The recent FRDC publication *‘Modelling Australia’s Fisheries to 2050: Policy and Management Implications’* states that aquaculture, particularly ISA presents exciting opportunities to bridge the supply-demand gap for seafood in Australia over the next 50 years. Investigating ISA is a specific priority under initiative 4 (growing aquaculture within an ecologically sustainable framework) of the Aquaculture Industry Action Agenda.

Research providers in Australia have been investigating the potential for using inland saline groundwater for aquaculture for several years. However, the fragmented nature of inland saline research in Australia has made it difficult for those interested in the field to easily access the collective information available. This stimulated a project to coordinate ISA in Australia. This project *‘Development of industrial-scale ISA: Coordination and communication of R&D in Australia’* was funded through the Fisheries Research & Development Corporation with significant contributions from the Australian Government, Department of Agriculture, Fisheries & Forestry through the Aquaculture Action Agenda. Key activities in this project include the management of several investigations to develop information and tools to assist potential investors. These investigations include the development of an Investment Directory, a Resource Assessment, a Profit Model, a Temperature Model, and a Customised Risk Assessment Template. This project and investigation focused on the development of the pond temperature model.

5.5.2. The modelling approach and model development

Modelling the temperature of shallow aquaculture ponds is not a simple endeavour as both freshwater and saline water ponds can become stratified both chemically (dissolved oxygen, pH) and thermally in a diurnal (24 hour) cycle. Algal blooms limit light penetration, which ultimately leads to warm water at the surface overlying cool water at the bottom of a pond. Estimation of the temperature at any given depth requires the knowledge the rate of solar radiation, pond turbidity, wind speed, wind direction, air temperature, and relative humidity. In modelling these shallow ponds, the model must be constructed such that it will estimate the density gradient built up during the day due to temperature differences in the water column and the mixing forces generated by winds at the pond surface.

5.5.3. Model origins and software

From 1985 through 1988, the Principal Investigator of this project developed a computer simulation model that described the thermal and oxygen stratification in shallow freshwater aquaculture ponds (Losordo, 1988). A description of the temperature model was published by Losordo and Piedrahita, 1991. The model was implemented using a dynamic simulation language called “STELLA” using an Apple Macintosh computer. The model had not been run since 1992 and only on Macintosh computers. With the assistance of ISEE Systems, Inc. (Hanover, NH, USA) the original model was updated to be used with the new STELLA software version 8.0 and adapted to be run on computers with a MS Windows based operating system. This updated model has been created in STELLA version 8. The new model has been modified to simulate temperature profiles in ponds with water depths of 1.6 meters. Additionally, a new “input – output” section has been added to the model (based on the upgraded STELLA software) to allow for easy modification of input data and to facilitate the running and observation of the pond temperature simulation. The model can be viewed and used with the ISEE Player 8.1 software that is available and downloadable for free at www.ISEEsystems.com.

STELLA was originally developed for use with Apple Macintosh computers. As such, the model building process takes a visual approach using icons as seen in Figure 1. In the model building process with STELLA, accumulations of heat or mass in volumetric elements are represented by rectangular icons called Stocks. The flow of heat or mass to or from a Stock occurs through Flow Valves that contain and represent the rate equations for various processes. One Flow Valve icon is required for each rate equation that governs the flow rate of heat or mass. The dark cloud-like icons represents an infinite source or sink of heat or mass. Numerical operations not carried out in Flow Valves or Stocks in STELLA are carried out in circular icons called Converters. Converters can be configured to contain graphical functions. These specialised converters can contain time varying input data such as weather or environmental information. The reader is referred to the ISEE Systems website for more detailed information on the STELLA modelling software.

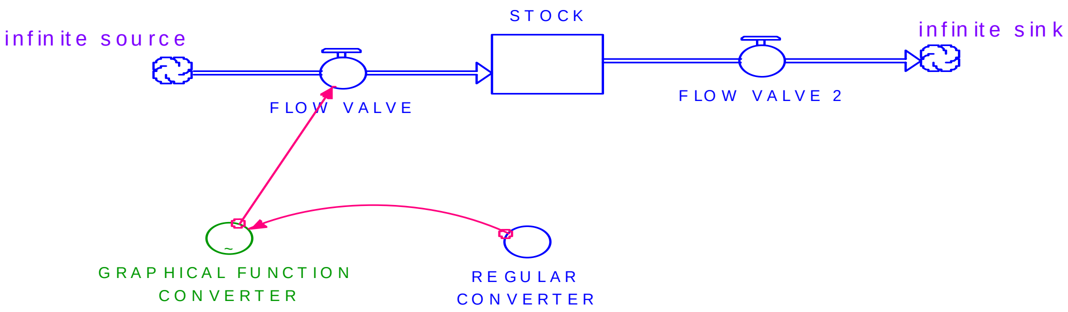


Figure 1. Basic building blocks for a STELLA model using various icons.

5.5.4. Model introduction

Aquaculture ponds are shallow and relatively turbid bodies of water. As such, these ponds tend to thermally and chemically stratify (differences in temperature, DO and pH top to bottom) on a diurnal (24 hour) cycle. Prior to the development of this model in 1988, there were no computer simulations available to predict and quantify thermal and chemical stratification in aquaculture ponds. The model was structured to simulate the water column of the pond in discrete mixed (horizontal) volumetric elements (layers). This particular version of the model has been designed to simulate the dynamic (changing) thermal profile of a shallow (1.6 meter) aquaculture pond over a five day period of time. The model divides the water column into 6 volumetric elements, the top element being from the surface to 10 cm, the second being from 10 – 40 cm, third being from 40 – 70 cm, forth from 70 – 100 cm, fifth from 100 – 130, and sixth from 130 – 160 cm. A bottom sediment element resides below the sixth water column element. For purposes of describing this model, the heat transfer processes were divided into surface, water column, and bottom heat transfer. The basic model implemented in STELLA can be seen in Figure 2.

5.5.5. Surface energy considerations

The net energy flow between the surface of the pond and the atmosphere over a given period of time (referred to as a time step in the simulation) is the sum total of penetrating short wave solar irradiance, water surface back radiation, net atmospheric radiation, evaporative heat transfer and sensible heat transfer. Short-Wave Radiation: As short-wave (400 – 1100 nm) solar radiation strikes the water surface, it is either reflected or penetrates the surface. The factors dictating the reflectivity of the pond surface include the solar altitude (based on site location, time of day, and day of year), and the roughness of the surface of the pond (depends on wind speed over the pond). Atmospheric (long-wave) Radiation: Atmospheric radiation is primarily due the emission of absorbed solar radiation by water vapour, carbon dioxide, and ozone in the atmosphere above the pond. It is estimated with knowledge of the absolute air temperature (degrees Kelvin) 2 meters above the water surface.

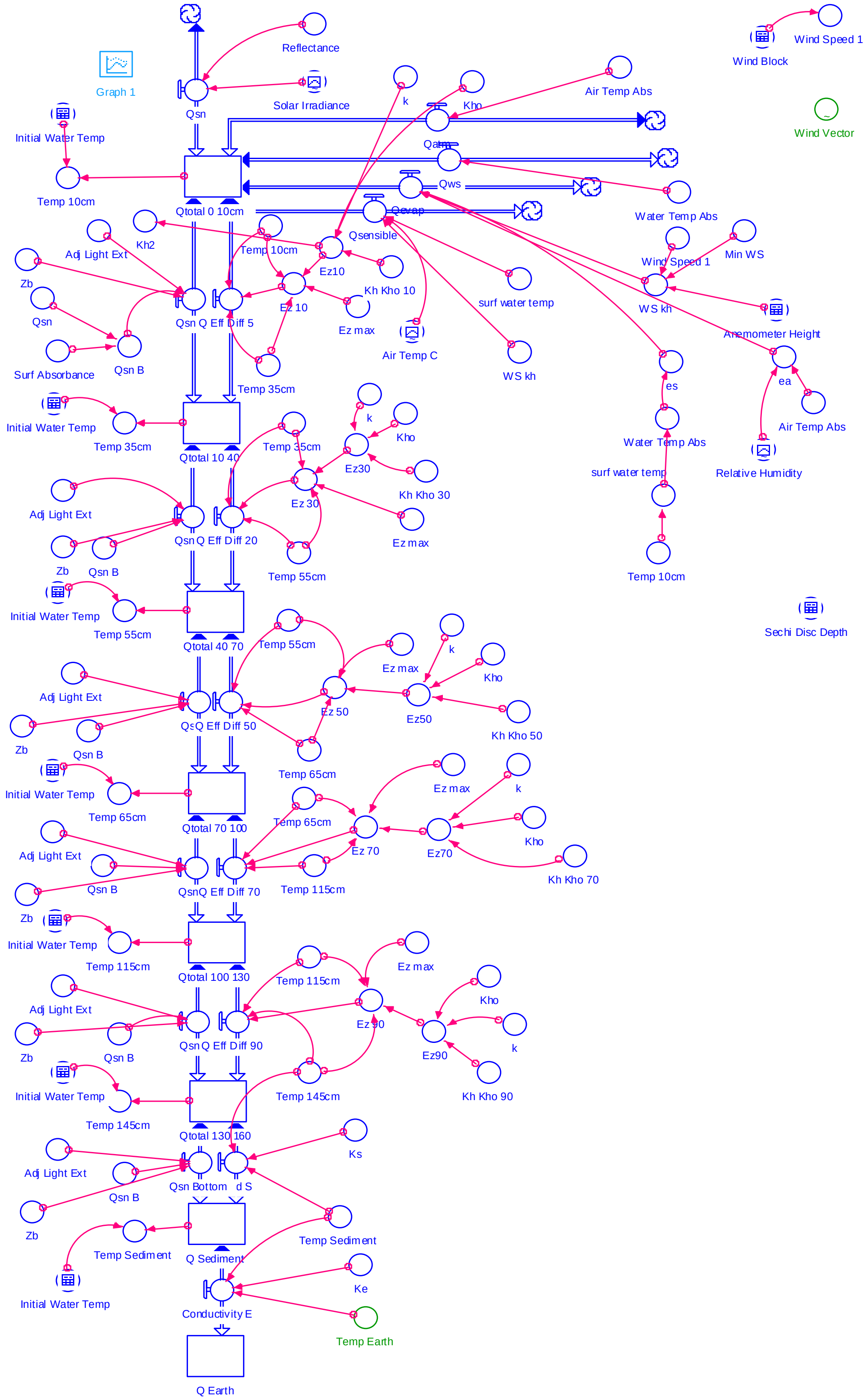


Figure 2. The model of the water column containing six volumetric elements, one sediment element and one earth element acting as a infinite source or sink for heat.

Water Surface Radiation: The loss of energy from a water body by long-wave radiation is estimated with knowledge of the absolute water temperature (degrees K), and the use of empirical constants. Evaporative Heat Transfer: Evaporative heat loss is a result of the change in state of water from a liquid to a gas (water vapour) and the associated loss of heat due to the latent heat of vaporisation. Estimation of heat loss due to evaporation requires the knowledge of the temperature of the air above the pond, temperature of the water at the surface of the pond, the wind speed above the pond and use of numerous empirical coefficients. Sensible Heat Transfer: The sensible (convective) addition or removal of heat from the water surface is heat that is transferred between the air and water by conduction and transported away from or towards the air/water interface by convection associated with air movement. Sensible heat transfer can be estimated with the knowledge of wind speed, and water and air temperature.

5.5.6. Water column energy transport

The net radiant energy penetrating the water surface with wavelengths greater than 1200 nm is absorbed within the first few cm of the water column. The transportation of heat to the lower water column is simulated in the model through the transmittance of short-wave solar irradiance and the processes of turbulent diffusion. Short-wave Radiation Transmittance and Attenuation: The attenuating effects of the absorption and scattering of light in the water column must be accounted for in the modelling of solar radiation that penetrates the water surface. The attenuation of solar radiation is commonly modelled using the Lambert-Beer Law. This model estimates the solar radiation at a given depth as a function of the solar radiation that penetrates the surface and the exponential extinction of light over the water column. The light extinction coefficient can be estimated with the knowledge of the light intensity at two depths in the water column. In the absence of underwater light data, the Secchi disk depth can be and has been used in this model as a means of estimating the light extinction coefficient. Heat Transfer by Effective Diffusion: Heat transfer through the depth of the pond in this model is based upon the concept of turbulent or eddy diffusion. This concept has been used extensively in modelling turbulent energy transport in lakes and reservoirs. In these types of models, it is common to combine the effects of the molecular diffusion of energy (non-turbulent) with the turbulent diffusion of energy by eddies into a term referred to as the effective diffusion. In this model, energy transferred between the volumetric elements is based upon the concept of effective diffusion. This concept is implemented by estimating the rate of transfer of heat between the volumetric elements based upon the density gradient in the water column at the volumetric element interface and the shear stress caused by wind at the surface. The shear stress applied to the interface of the volumetric elements has to be modified to reflect a reduction or decay of this shear effect with increasing depth in the water column.

5.5.7. Using the model

The model, operated with ISEE Player 8.1 will allow the user to change numerous input variables that are used to describe the weather situation at the pond site. The model will simulate water temperatures at 5 depths (10 cm, 35 cm, 55 cm 65 cm and 145 cm) over a 5 day (120 hour) period. The predicted temperatures are displayed on the model Input/ Output page in graphical and table formats. The structure of the model can be viewed by pointing and “clicking” on the inverted triangle on the left hand margin of the output page. The user will be able to see the structure of the model by clicking on each of the “converters”, “flows” or “stocks” that make up the model. However, the user cannot change the structure of the model. By clicking the inverted triangle once more from the model structural viewing page, the user can go to the model equation list page. The page contains all of the differential equations that make up the model and all of the data input to the model. Now click on the “upright” triangle in the left hand margin of the page and return to the model Input / Output page.

Date and location

The data input area is on the right hand side of the Input / Output page. The first inputs required can be found in the "Date & Location" input section. The user should locate the cursor over the Julian Day number and click once until the section is "highlighted". Once highlighted, the user should input the Julian calendar day (1 – 365) that is to be the first day of the model simulation. The model currently is set for Julian Day 170. In the year 2005, this would be May 20th. Just below the date input location the user should specify whether the pond is in the northern or southern hemisphere. Input 1 for northern or 2 for southern (currently set for southern). Just below this input the user inputs the latitude of the pond site. The user should input the latitude in degrees (currently set at 40).

Pond information

In this section, the user inputs important information about the pond. The first data to input is a measure of pond water turbidity. The Secchi Disk is used to determine relative light transmittance in the water column. Input the Secchi Disk depth here in cm. The model needs to be initialised with a starting water temperature. It is best to start with a morning temperature when the pond is completely mixed. Enter the initial pond temperature here in degrees C. Wind speed is an important input in calculating mixing of the pond water column and evaporative cooling at the water surface. Next, the user should input (in meters) the height of the anemometer above the water surface of the pond. Pond geometry is important in calculating the effect of wind on pond mixing and cooling. In the next two input points, the user specifies the length of each major axis of the pond, east to west and north to south. The lengths are input in meters. The final input for this section allows the user to add "wind-block" to the pond. The data is input as a decimal fraction (0.6 = 60%). The wind-block function can be used to simulate the addition of natural or artificial barriers to the wind next to or near the pond.

Local weather conditions

At the bottom right of the model input section are 5 graphical input points for weather conditions. Double clicking on any one of the graphical inputs brings up a graph with two columns of data. The left hand column is the time of the simulation (this model is set to time step forward in 20-minute (0.33 hr) increments). The right hand column is the weather data at that point in time. Thus double clicking on the Solar Irradiance graphical input will bring up a graph and columns of data for the solar radiation at the pond location starting at time zero running until hour 120. Solar Irradiance is input at kW / m^2. Relative Humidity is input next every 20 minutes as a decimal fraction. Wind speed is entered next in units of meters per second. Next the user should input the air temperature above the pond in degrees C. Finally, the user should input the wind direction in degrees.

5.5.8. Running the model

A number of yellow buttons have been placed on all major input and output areas of the models Input / Output page. Click once on these buttons and a dialog box will appear. Once the data is input into the model the simulation is started by pushing the RUN button. The model simulation can be suspended by pushing the PAUSE button and started again by pushing the RESUME button. Finally, the simulation can be stopped by pushing the STOP button or the user can wait for the simulation to reach 120 hours.

5.5.9. Examples of uses for the model

Current model inputs and output

As set, the model begins with an initial morning temperature of approximately 24°C in a completely mixed pond (no stratification). The solar radiation data input to the model begins with sunrise and, predictably the pond water temperature increases in the morning. By mid-day of the first day of simulation, the surface temperature of the pond has raised to just under 30°C while the bottom pond temperature has increased to only 24.5°C. In the afternoon of the first day, the temperature declines in the top layers and mixes with each of the bottom layers except for the deepest at 145 cm. This layer remains cooler than the overlying layers through-out the simulation period. Over the five day simulation, the pattern repeats until the peak stratified water temperature reaches nearly 31°C while the bottom layer approaches only 26°C.

Modified model inputs and outputs

Dynamic simulation models are great tools for asking the “what if” kind of question. Using this model we can do just that. For example, the user can ask; “what if the pond turbidity increases?” To see the results and answer this question, change the Secchi Disk Depth to 50 cm (effectively decreasing the light transmittance by 50%). The results are significant. In this case, the surface water temperature increases each day to between 31 and 33°C. Additionally, the pond water below the 65 cm level remains stratified throughout the simulation, with the 145 cm layer not increasing in temperature and the 65 cm layer increasing only 1°C over the 5 day simulation period. Next, return the Secchi Disk Depth to 100 cm and remove the wind block by setting the wind block to 0% and run the model. You will see that the temperature of the pond surface layers increases to only 27°C and does not increase beyond this for the 5 day simulation period. This indicates that evaporative cooling caused by the wind action on the pond surface is enough to keep temperatures from rising over the 5 day period. Many more input changes will yield sometimes counter-intuitive results.

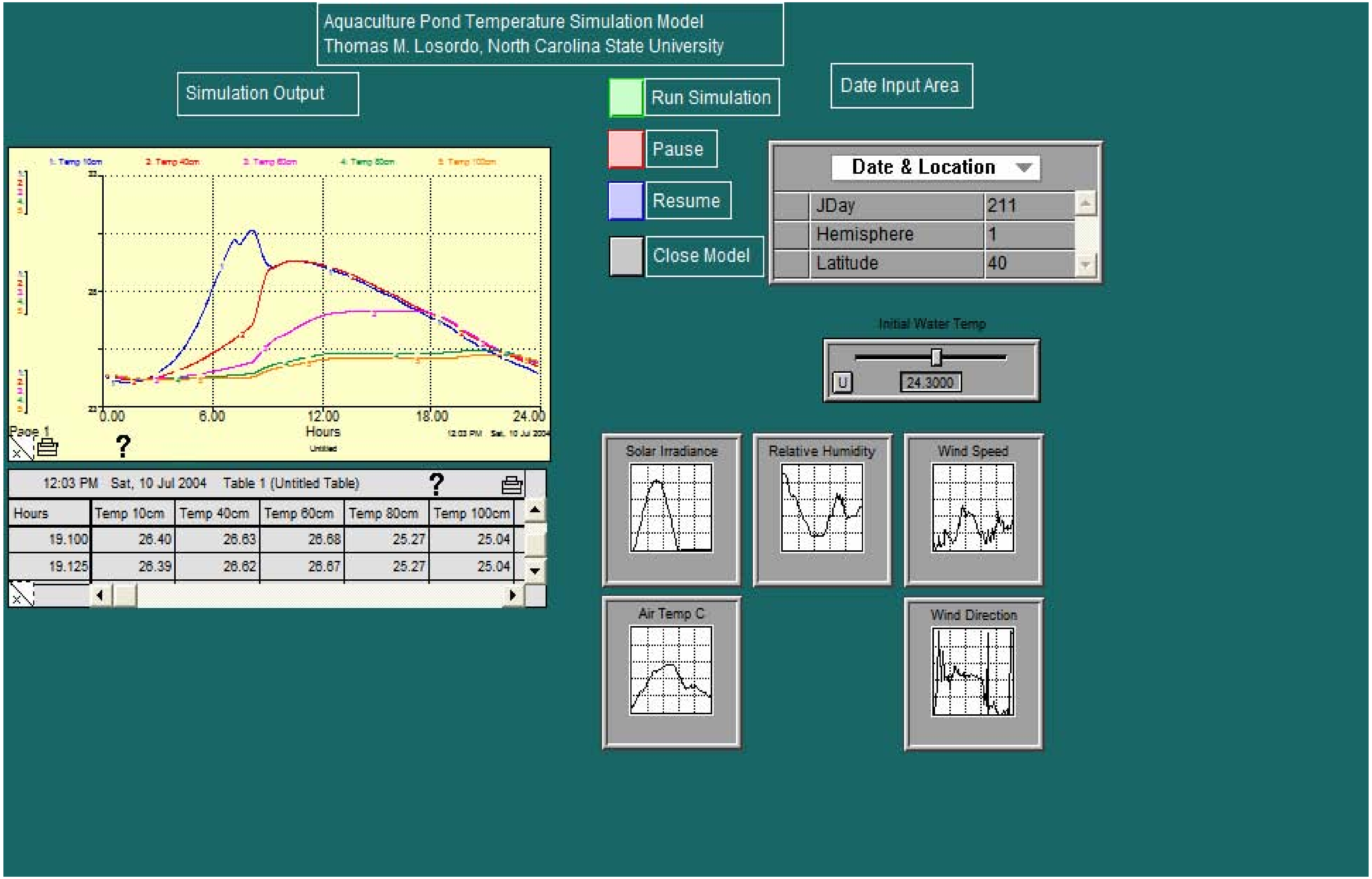
5.5.10. Questions?

If you have questions about or are interested in the software, go to www.iseesystems.com. If you have questions about the model, you may contact the creator[1] of this model (Professor Tom Losordo) at: tlosordo@ncsu.edu

Losordo, T.M. 1988. Characterisation and modelling of thermal and oxygen stratification in aquaculture ponds. PhD. Dissertation. University of California, Davis, CA. USA.

Losordo, T.M., R.H. Piedrahita. 1991. Modelling temperature variation and thermal stratification in shallow aquaculture ponds. Ecological Modelling 54:189–226.

[1] Model is copyrighted by NC State University, May 2005.


Aquaculture Pond Temperature Simulation Model
Thomas M. Losordo, North Carolina State University
Simulation Output
Run Simulation
Pause
Resume
Close Model
Date Input Area
Date & Location
JDay 211
Hemisphere 1
Latitude 40
Initial Water Temp
U
24.3000
0.00
6.00
12.00
18.00
24.00
Hours
Page 1
12:03 PM Sat, 10 Jul 2004 Table 1 (Untitled Table)
Hours | Temp 10cm | Temp 40cm | Temp 60cm | Temp 80cm | Temp 100cm
19.100 | 26.40 | 26.63 | 26.68 | 25.27 | 25.04
19.125 | 26.39 | 26.62 | 26.67 | 25.27 | 25.04
Solar Irradiance
Relative Humidity
Wind Speed
Air Temp C
Wind Direction

5.6. Profit Model Consultancy: Economic models for inland saline aquaculture of finfish, prawns and recirculation culture

Bill Johnston

Business Manager
Queensland Department for Primary Industries & Fisheries,
Rural Industry Business Services
S.E. Regional Office, 91 – 95 Howard Street, Nambour, Qld, 4560

5.6.1. Project structure

1. Review and modification of existing models were developed, namely the economic decision tool developed for coastal marine prawn culture, finfish culture and recirculation aquaculture.

2. Research into the biological and economic parameters required for model development and operation.

3. Preliminary development of the inland aquaculture economic decision mode. The models were based upon the cost-benefit analysis technique. Cost-benefit analysis is a conceptual framework for the economic evaluation of projects, in this case, aquaculture projects. The basic premise of cost-benefit analysis is to assist you to make a decision in regard to the allocation of resources. In particular, it helps you to make decisions about whether or not to invest in aquaculture.

4. Beta testing and review – the model allows input of information specific to the operation and specific management regimes, thus determining the profitability of the operation. It is important to trial and test to ensure calculation and framework are correct.

5. Risk analysis – The benefits are determined using risk assessment methodology. This involves the use of cumulative distributions for each of the variables used in the model. This allows the full range of possible outcomes to be included with the probability of occurrence detailed which contributes to the overall assessment of the profitability of the project. The output from the model not only provides a Net Present Value (NPV) and cost benefit ratio of the most likely outcome but also determines the probability of achieving this outcome. More importantly the model determines the probability of the project being unprofitable. The model provides a prospective investor with far more information in respect to the profitability and risk profile of their investment than was previously available from cost benefit analysis that determined viability from the use of average figures to describe the possible variables used in the analysis.

5.6.2. Background and supporting information

AquaProfit is the culmination of QDPI&F’s commitment to aquaculture industry development. The series is designed specifically for the key aquaculture industries in Australia. The initial catalyst for the AquaProfit project was the development of BarraProfit, a comprehensive decision tool and information package for barramundi farmers in Queensland and northern Australia.

By using the various model farmers can assess impacts and evaluate such factors as disease, fluctuating water quality, varying feed conversion ratios and market prices. They can also assess price changes on profitability from inputs such as feed, fingerlings, electricity, packaging and transport. AquaProfit models can also be used to evaluate improvements in genetics, future development plans (i.e., addition of ponds), or a change in production methods.

The AquaProfit project aims to extend the development of such decision tools (& information packs) to include innovative or existing aquaculture industries such as Pearls.

5.6.3. Need and consultant background

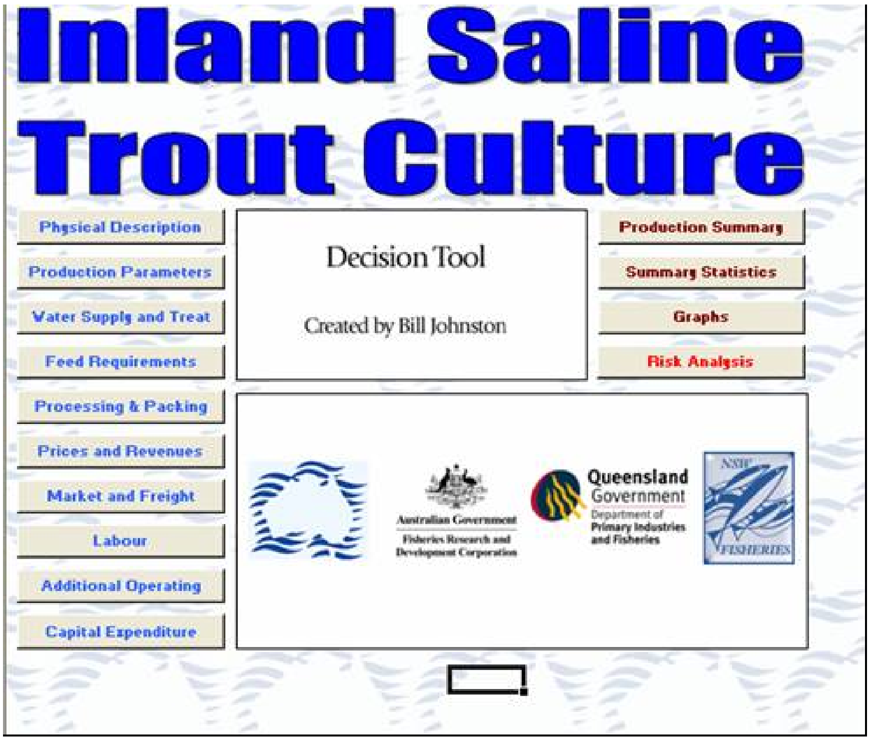
Over the past four years Bill Johnston has been working closely with a diverse group of aquaculture industries. Initially, Bill developed the concept of BarraProfit, as the economics of barramundi farming had been difficult to access. There was little or no information available to farmers and interested investors about establishment costs or the profitability of operating a barramundi aquaculture enterprise. In addition, prevailing market conditions made it very important to thoroughly research and identify markets for cultured barramundi before venturing into production. These comments apply to almost all emerging industries, particularly aquaculture, where it is very much a trial and error process.

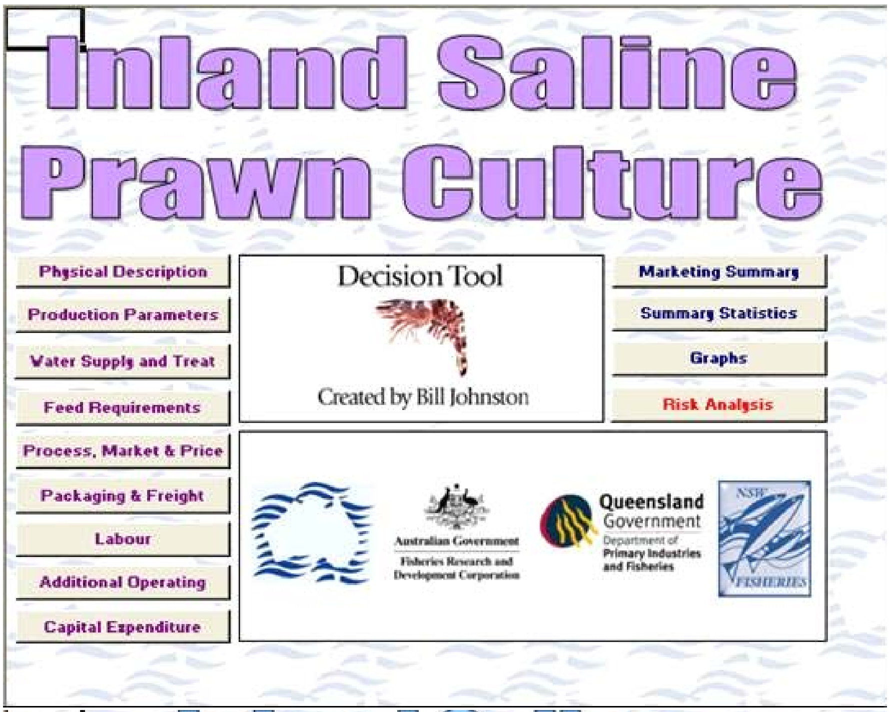
Developing an effective, sustainable and profitable aquaculture enterprise requires a lot of time and capital input. For this reason there have been a number of failures across most aquaculture industries, with few rising to become successful in the sense of self-sufficiency. By providing a tool for investors and farmers we aim to provide them with the knowledge and information necessary so they are fully prepared and understand the capital required, operating costs, the labour input and the profit margins they might expect to receive.

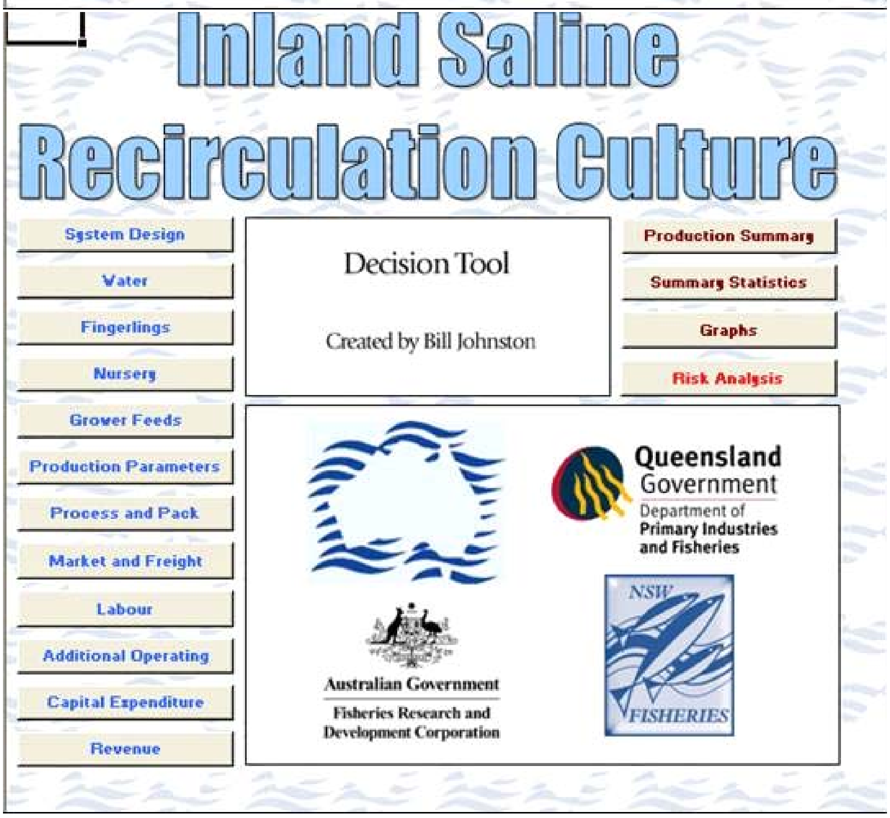
5.6.4. Delivery response

Computer based economic models for ISA – The models were developed using Excel spreadsheets and enhanced using visual basic applications for ease of use. The models are based on the cost benefit analysis technique and use discounted cash flow analysis as the basis.

The final models are presented on CD-ROM as excel files as depicted in the following figures.




Inland Saline
Prawn Culture
Physical Description
Production Parameters
Water Supply and Treat
Feed Requirements
Process, Market & Price
Packaging & Freight
Labour
Additional Operating
Capital Expenditure
Decision Tool
Created by Bill Johnston
Marketing Summary
Summary Statistics
Graphs
Risk Analysis
Australian Government
Fisheries Research and Development Corporation
Queensland Government
Department of Primary Industries and Fisheries
NSW
FISHERIES


Inland Saline
Recirculation Culture
System Design
Water
Fingerlings
Nursery
Grower Feeds
Production Parameters
Process and Pack
Market and Freight
Labour
Additional Operating
Capital Expenditure
Revenue
Decision Tool
Created by Bill Johnston
Production Summary
Summary Statistics
Graphs
Risk Analysis
Queensland Government
Department of Primary Industries and Fisheries
Australian Government
Fisheries Research and Development Corporation
NSW
FISHERIES

5.7. Market research consultancy

5.7.1. Inland saline aquaculture market and supply chain development

Nick Ruello

Ruello & Associates Pty Ltd
P.O. Box 333, Clifton Beach, Qld, 4879

5.7.1.1. Foreward and disclaimer

This report has been prepared for the national Aquaculture Council. The report is based on information gathered from published reports, desk research and by means of interview with persons believed to be reputable and reliable.

I believe the report to be accurate but it contains evaluations of future events and readers should therefore make their own enquiries to satisfy themselves on all matters.

Nick V Ruello, Principal
Ruello & Associate Pty Ltd

5.7.1.2. Acronyms and definitions

ABARE	Australian Bureau of Agriculture & Resource Economics
AFFA	Agriculture Forestry Fisheries of Australia (Department)
CIF	Cost Insurance & Freight
CWM	Central wholesale market
FAO	Food & Agriculture Organisation of the United Nations
FIS	Free In Store
FRDC	Fisheries Research & Development Corporation
ISA	ISA
NAC	National Aquaculture Council
R&D	Research & Development
SFM	Sydney Fish Market
vs	versus

5.7.1.3. Definition of terms

Seafood. Unless otherwise indicated the term seafood is used to encompass finfish, crustacean, mollusc and other species, from fresh, saline or marine waters of all kinds.

Supply Chain. The chain of firms that takes inputs and converts them into products or services and distributes and retails them to consumers (after Professor R. Collins University of Queensland, Gatton, in AFFA 2002).

Supply Chain Management. This is a business strategy where the whole chain is seen as the competitive unit, instead of the individual firms within it. By working together on, and building better relationships between the partners in the chain they create more value for others in the chain and greater consumer satisfaction (after Professor R Collins University of Queensland, Gatton, in AFFA 2002).

Traditional aquaculture. Aquaculture as commonly undertaken in freshwater, brackish or marine waters i.e., non ISA.

5.7.1.4. Executive summary

This study on ISA (ISA) market and supply chain development was commissioned as part of a National Aquaculture Council Research & Development initiative on coordination and communication of ISA research.

ISA is still in its infancy with 2003/04 production amounting to about 10 tonnes of trout from the Western Australian Trout Alliance, several tonnes of mulloway from a NSW farm and less than a tonne of black tiger from a Queensland farm; nevertheless ISA is regarded as offering exciting opportunities to bridge the demand-supply gap for seafood in Australia.

The study objectives were to:

- Briefly review current production, marketing and supply chain structure for ISA.
- Overview potential ISA species and markets.
- Describe the supply chain structures existing in the Australian seafood market.
- Review options for market and supply chain development in ISA.

The seafood supply chains in Australia are invariably informal and weakly integrated having grown from traditional arms length business practices where documented contractual arrangements or specifications are the exception rather than the rule and short term price driven deals or transactional relationships are commonplace. Most persons interviewed in this study were unfamiliar with the term supply chain management although many were operating in effective supply chains in an unplanned manner.

A Queensland ISA prawn farm grows and cooks prawns and operates within a small informal localised supply chain serving local restaurants and a wholesaler in Queensland. A NSW ISA finfish farm markets mulloway to restaurants within its region and it too operates inside a short informal supply chain. These two ISA supply chains are not unlike those found elsewhere in Australian aquaculture or fisheries.

The Western Australian Saltwater Trout Alliance however is an incorporated group of five growers, which has increased economies of scale and bargaining capability supplying processors, retailers and restaurateurs though this alliance.

The market outlook for the aquaculture sector is mostly positive because populations are increasing, demand for seafood is growing, and aquaculture is widely seen as the best way of filling the gap between seafood supply and increasing demand.

The Australian farmed prawn sector has faced increasing import competition and falling prices in the past three years but the domestic market nevertheless has the capacity for substantial expansion –a doubling of output over a period of five years through product and market diversification, shifting more to fresh (vs frozen) and uncooked (vs cooked) and promotion of the Australian ***fresh*** products. The market outlook for cost efficient farms marketing the larger more valuable size grades is particularly attractive.

Enterprises with a short supply chain to consumers such as the current Queensland ISA venture and farms actively marketing their product (rather than just selling) are able to capture a higher profit margin than farms relying on market intermediaries.

The market for farmed mulloway is still new and expanding rapidly and has room for further rapid growth by providing a better range of fish sizes to meet demand for fillet, intermediate and plate size fish. The demand and likely prices for large mulloway are difficult to forecast because the species is in the same market segment as better known fish such as Atlantic salmon, barramundi as well as the new farmed kingfish.

The freshwater rainbow trout industry has been remarkably stable over the past few years because of drought and environmental constraints but the aggregate market for this species can be doubled from its current levels if supply and marketing efforts are expanded in parallel. The fish is commonly well regarded, inexpensive and one of the most pleasing, whole smoked fish available. With investment in marketing effort the demand for plate fish, smoked fish and other processed forms can be increased substantially in quick time.

ISA offers new products and flavours with known species to consumers and so has the potential to tap into new markets, outlined below, and it is well placed to serve inland consumers wanting fresh seafood. Tourism is another avenue for income generation in some situations.

Prospective ISA species with attractive market prospects include barramundi, snapper. and golden perch. The three are well regarded by seafood merchants, restaurateurs and consumers. Farmed barramundi output has grown rapidly in the past three years but the aggregate market from domestic and international sales can be more than doubled in a few years with further product innovation and promotional effort. Snapper and golden perch are unusual species in that there is substantial unmet demand for plate size fish, and a demand-supply gap that is increasing because of diminishing wild fish supply.

The demand level and market growth rates achieved by any species or farmed product will depend on the effort expended: the dollars and creativity invested in product and market development.

The most attractive strategic market development option for new ISA entrants is to enter the traditional marketing channels and also start an ***eco fish*** supply chain to supply consumers seeking eco-friendly seafood and prepared to pay a price premium for the new/different flavour and the “feel good” psychic benefits it offers. The organic food market is an option for further development at some appropriate time. Regardless of development option selected it is imperative that farmers make adequate budget provision for market development in their business plan.

Many Australian Government Department of Agriculture, Fisheries & Forestry (AFFA) initiatives to assist agribusiness, including aquaculture, with training and other help with implementation of supply chains come at no cost to industry, some offer access to grants and so they are all worthy of examination.

5.7.1.5. Introduction

ISA presents exciting opportunities to bridge the supply demand gap for seafood in Australia over the next 50 years according to a recent review on Australia’s fisheries policy management for the Fisheries R& D Corporation (Kearney *et al.* 2003). ISA has however attracted the interests of farmers and researchers for more than ten years (Ruello 1996) and the Fisheries R&D Corporation currently has ISA as a specific research priority.

The fragmented nature of ISA research has made it difficult for those interested in the subject to easily access the totality of information available. The Fisheries R&D Corporation with the assistance of the AFFA's National Action Agenda has therefore funded a project on coordination and communications of ISA R&D in Australia through the National Aquaculture Council.

This report was commissioned as part of this coordination and communication project managed by Dr G Allan of the NSW Department of Primary Industries (formerly NSW Fisheries) on behalf of the NAC to provide an overview of the existing and prospective market for ISA products.

Supply chains and supply chain management have not been items of interest amongst aquaculturists or fishers until the last few years when the Australian government launched several marketing and supply chain initiatives as part of its New Industries Development Program.

The subject of supply chain management therefore remains largely unknown to most people operating in the seafood industry and, according to a recent news report on the silver perch industry in the Queensland Aquaculture News June 2004, it seems many silver perch growers remain uncertain about the benefit of supply chain development and management.

This situation is due to the short history of the discipline of supply chain management and the paucity of discussion in this industry. A case study on an Australian fishing company published in 1998 is the only documented case in Australian seafood industry (DPIE 1998).
A recent report on trout farmers in Western Australia (Trendall 2004) describes how a horizontal alliance between producers increased economies of scale and bargaining capability (discussed further in Section 5.7.2).

There are different perceptions of the concept of supply chains amongst different people so we have followed the University of Queensland's definition of supply chain and supply chain management (AFFA 2002) as seen in the earlier page on definitions.

This definition of supply chain essentially equals the traditional marketing chain or distribution channel to consumers plus the suppliers of inputs such as feed, fingerlings, fuel and finance.

The study objectives were:

- Briefly review current production, marketing and supply chain structure for ISA
- Overview potential ISA species and markets
- Describe the supply chain structures in the Australian seafood market
- Review options for market and supply chain development in ISA.

Report presentation

The report starts with a review of the Australian seafood market, domestic and import volumes, consumption trends and consumer attitudes and the supply chains existing in the seafood marketplace today. This sets the national background for a discussion of the production and seafood marketing of current ISA ventures and the supply chains utilised by this new sector of Australian aquaculture.

A situation analysis of Australian ISA is presented in Chapter 6. This is followed by a discussion of the market outlook for current and prospective ISA species. A number of strategic options and operational tactics for tackling the market opportunities identified and for supply chain development are presented in Chapter 8 which is followed by a general discussion and conclusion.

While the study deals predominantly with domestic marketing the discussion is mostly equally applicable to export marketing because marketing and supply chain management principles are the same regardless of whether the target market is domestic or international.

5.7.1.6. Methodology

This report is based on desk research and phone or personal consultation (in Sydney) with industry and government agencies because time and budget limitations precluded field work. In all, personal or telephone interviews were conducted with 43 ISA researchers and people involved in the feed business, farming, processing, transport, wholesale, retail or restaurant business to gain an understanding of the status of aquaculture, particularly ISA, marketing and supply chain management in Australia.

Because of the limited time and budget we have also drawn on unpublished proprietary material gained in market studies undertaken on various seafood products and farmed species over the past decade.

Every attempt has been made to provide the most precise information available, however because of the small number of persons involved in some activities (sometimes only one) and the business rivalry which prevails in some situations some data has been aggregated or information "masked" to protect commercially sensitive information or business relationships.

5.7.1.7. The Australian seafood market and consumption

The Australian Fishing Zone (of 200 nautical miles) is one of the largest in the world but the waters are relatively poor in nutrients, consequently most species are not particularly abundant and the total tonnage landed only ranks Australia at about 50th in the world according to the United Nation's Food and Agriculture Organization (FAO) statistics.

Despite the large fishing zone and high species diversity there is not one Australian fishery able to provide one species in sufficient tonnage to provide a year round supply of fish for filleting. Australia therefore relies heavily on imported fish and shellfish, particularly the processed forms and especially with canned fish. Nonetheless Australia is also an exporter of high valued fish and shellfish, mostly minimally processed forms such as live, chilled or frozen at sea product.

Table 1. A summary of the national seafood production and trade data for 2002/03*.

Total production wild catch and aquaculture:	249 000 tonnes
Import:	165 000
Exports:	160 000
Net result is: consumption of 254 000 tonnes of Australian and imported seafood	

**ABARE statistics*

It should be noted that the import items are mostly ready to eat foods such as canned fish and ready to cook fillets while the exports are mostly whole fish and shellfish with heads and innards intact. Thus the imports provide a substantial part of the seafood diet in Australia, as discussed below.

According to ABARE statistics Australian aquaculture contributed approximately 44,000 tonnes of seafood in 2002/03 including 27,000 tonnes of fish and almost 10, 000 tonnes of oysters. If we subtract some 9,000 tonnes of farmed tuna and about 1,000 tonnes of farmed salmon which were exported then there was about 17,000 tonnes of Australian farmed fish eaten in the country.

Other noteworthy characteristics of the Australian seafood trade is the highly competitive domestic market because of the absence of import taxes and tariffs on fish, the free trade between States and with New Zealand and almost no barriers to entry into the processing or marketing sectors in Australia.

Most of the major fisheries around Australia are fully fished or overfished, while several are uncertain or under fished according to the Australian Government's Fishery Status Reports for 2002/2003 (BRS 2003). The fishing sector is therefore focussing on improving the handling, quality and value of the wild catch and targeting new markets with the "old" species or products as well as some of the lesser utilised species.

The aquaculture sector too is not large by world standards, with the exception of the NSW oyster industry and the tuna ranching operations of South Australia, but it has been growing at about 15% per year and contributed about a third of the domestic produced seafood supply in 2002/3 according to ABARE and it is widely recognised as capable of much greater growth still.

Consumption trends and consumer attitudes

The ABARE fisheries statistics for 2002/3 indicate that some 89,000 tonnes of Australian seafood, wild catch and aquaculture whole weight, was consumed here (national production less exports). This is about a third of the whole weight equivalent of the imports consumed here according to the ABARE data reproduced below.

Table 2. Summary of major imports in 2002/03.

Import product item	**Tonnes***
Hake fillets (Fresh, chilled and frozen):	7,900
Other fillets (Fresh, chilled and frozen):	28,800
Canned fish (mostly tuna and salmon):	44,900
Canned crustaceans and molluscs:	9,300
Total of these categories:	*90,900*

**ABARE statistics, rounded to the nearest 100 tonnes*

The total volume of the imported fillets and canned product categories of some 90,000 tonnes (above) would be equivalent to more than 200,000 tonnes of whole fish and shellfish. There was also another 74,000 tonnes of other edible seafood imported into Australia in 2002/2003 (about 15,000 tonnes of which was whole fish). This raised the total national consumption of imported seafood in 2002/03 to about 274,000 tonnes on a whole weight basis

The noteworthy point in this table is the high volumes of fish fillet and canned fish consumed. These are the two most important categories of seafood in the Australian diet and both have shown some of the highest rates of increase in Sydney and Perth in recent years despite a perception in some quarters that canned fish is an old fashioned food. The quiet success of canned fish in Australia has been attributed to product and packaging innovations offering greater convenience, quality and value than other seafood (FRDC 2002).

Fish is not "top of mind" with Australian consumers when they go shopping; it is most strongly associated with entrée for entertaining or as something to eat out; it is certainly not regarded as an everyday meal to cook at home. Consumers in Australia show a marked preference for fresh vs frozen and Australian vs imported (Ruello & Associates 1999a).

Nevertheless Australia's per capita fish consumption is typical of western nations at about 15kg edible weight per year and still increasing slowly, as is the national population.

In home consumption is greater than out of home consumption volume but the latter is increasing more rapidly as consumer eating habits change and preferences favour more casual, convenient and quicker meals. A noticeable change in both in home and out of home eating has been a trend from eating white fish to boneless fillets and portions (Ruello & Associates 1999a).

Australian wild finfish consumption

The table below shows the Australian wild fish catch, rounded average figures for the four years to 2002/03, for species for which the majority of landings are consumed in Australia.

Other high volume fish species such as tunas and mullet are mostly exported and not a very important part of domestic consumption although they may be important in some areas. The fish in Table 3 therefore represent the Australian species of greatest importance to domestic consumption.

Table 3. The Australian finfish catch of key domestic consumption species for 2002/03*.

Species	Tonnes*
Barramundi	2,500
Blue Grenadier	9,000
Flatheads	4,500
Orange Roughy	4,500
Sharks	7,000
Snapper (pink)	1,800
Spanish Mackerel	2,500
Warehous	4,000
Whitings	3,600

**ABARE statistics, rounded to the nearest 100 tonnes*

It is noteworthy that:

- all of the species in Table 3 are often or predominantly consumed in the fillet form;
- all those with average annual landings of 4000 or more tonnes are commonly retailed as fillets rather than as whole or headless fish or as cutlets;
- only one in three (the flathead, snapper and whiting) are offered for retail sale as a plate size fish.

In other words the greatest trade is in fillets, often without skin or bones, while the whole fish category (with head and bones) is only a small part of current trade in Australia. This situation is similar to that noted with imported fish volumes which dominate Australian consumption.

This represents a significant contrast with the traditional Australian aquaculture trade where fish with the head on is still a common form in retail and restaurant trade and in most retail displays. With farmed salmon, barramundi and more recently kingfish the dominance has moved to fillets and portions but the gilled and gutted fish still remains a common sight while the demand for whole fish declines each year.

Wild shellfish consumption

Unlike finfish, Australia has great shellfish diversity as well as several abundant species groups such as prawns, rock lobster, oysters and abalone and Australia is one of the world's largest producer of wild abalone.

Rock lobster and abalone are mostly exported and do not play a great role in seafood consumption here. The crab, scallop and squid landings are mostly consumed in Australia along with imported scallop, squid and crab products too, but these are not of importance to this study.

Table 4. The 2002/03 wild catch of various shellfish***.**

Shellfish	Tonnes
Prawns	25,896
Rock lobster	17,060
Crab	6,707
Abalone	5,135
Scallop	9,671
Squid	3,331

** ABARE statistics*

Prawns however are a most important item because:

- Australia maintains a positive trade balance with prawns despite large volumes of imports and exports.
- They are very popular at home and when eating out and consequently there is also a substantial trade in Australian and imported farmed prawns around the country.

The table below shows the national trade and consumption volumes of prawns in 2002/03 but the Australian market for prawns is discussed at length in Chapter 7 because of its economic value and relevance to ISA.

Table 5. National trade and consumption volumes of prawns in 2002/03*.

Item	Volume in tonnes
Australian wild catch (whole weight)	25,896
Exports (predominantly wild whole products)	9,532
Imports (farmed and wild, predominantly whole farmed)	13,086
Australian Aquaculture production (whole weight)	3,403
Net consumption in Australia:	*32,853***

* *ABARE statistics.*

** *The consumption volume includes both whole weight tonnage as well as headless prawn tonnages so the volume of edible prawn consumption is not clear.*

Aquaculture production and consumption

The Australian aquaculture industry has been dominated by salmon and oyster production for the past decade but tuna production volume has risen particularly rapidly over this period and is now near 10, 000 tonnes per annum. Table 6 shows the production volume of the major species or groups for the last reported year.

Table 6. Australian aquaculture food volumes and values for 2002/03*.

Species	Volume (tonnes)	Total Value $'000
Fish		
Salmon	13,972	109,064
Trout	1,878	12,921
Tuna	9,000	255,600
Silver Perch	353	3,212
Barramundi	1,486	12,023
Other	443	8421
Total	*27,132*	*401,241*
Crustaceans		
Prawn	3,403	56,878
Yabbies	125	1,677
Marron	56	1,342
Redclaw	74	1,000
Total	*3658*	*60,897*
Molluscs		
Oysters	9,855	62,423
Mussels	2,877	7,496
Other	42	1,467
Total	*12,774*	*246,386*
Grand Total	44,059	743,452

**ABARE statistics*

The tuna output has shown little change over the past three years but the industry is based on ocean ranching, almost entirely targeted on export markets, and therefore has little relevance to this report on ISA.

The salmon industry however is not only the largest fish producer, by far most of it is consumed here in Australia and salmon has become one of the most common Australian fish in retail and restaurant sale, although it is evident from news reports that the salmon industry has suffered from depressed prices and other problems in recent years. Fillets, cutlets or portions are now seen in fishmongers and supermarket display counters nationwide.

The market success of salmon, and ocean trout, from Tasmania over the past decade has however dampened price growth over the past decade. Barramundi has recorded remarkable increases in aggregate output from around Australia over the past few years, with negligible impact on prices, because of the rapid increase in sales of large fish from Queensland and the Northern Territory (Chapter 7).

By contrast silver perch and other native fish species farmers focussed on plate sized fish have seen very little growth in output volumes. The markets and marketing of these above finfish species is examined further in Chapter 7.

Oyster and mussels have little relevance to this study. The farmed prawn sector has recorded modest increases in volume over the last three years but has faced increasing price competition from imports over this period (Chapter 7).

It should be noted that all of the tonnages shown in the above tables are for whole weight and that the aggregate Australian farmed finfish output consumed here is about 17,000 tonnes whole weight (the remainder is tuna and salmon exports) representing far less than 10% of per capita total consumption.

Australian farmed prawns also play just a small part in overall consumption for their category of seafood. Oysters however, and to a lesser extent mussels, make a substantial contribution to the national consumption figure for their seafood category.

5.7.1.8. The seafood supply chain

NSW plays a pre-eminent role in Australia's seafood supply chain because Sydney's large and cosmopolitan population is ready to try new food and attracts the interest of seafood producers and importers from all around the country. Consequently the wholesale companies and/or the fish auction at Pyrmont are typically the first distribution outlet for almost all fresh seafood and most frozen imports consumed in Australia. Sydney is the geographical target for about half of the Australian black tiger prawn sold away from the production area (Ruello & Associates 2002).

Sydney is not only the largest and most diverse market for seafood in Australia it is also regarded as the most price competitive market for wholesale, retail and restaurant trade.

Although the Sydney Fish Markets site at Pyrmont is the focal point of the seafood trade in Sydney the auction represents just the tip of the seafood trade iceberg because the wholesalers there together with their colleagues elsewhere in Sydney far outsell the SFM with its historical reliance on fresh seafood, particularly that caught by NSW fishers. The volume of frozen seafood sold by the SFM is a negligible part of consumption.

Sydney wholesalers and retailers are operating in a competitive open marketplace and their market power and profit margins are constrained by competitive pressures; monopolistic or oligopolistic situations are rare and short lived. This is particularly so with aquaculture produce because many farmers are supplying a number of wholesalers as well as the SFM auction with identical undifferentiated products: usually unbranded whole fish or shellfish or products with minimal processing.

The central wholesale markets (CWM) in Melbourne, Brisbane Adelaide and Perth also have an auction and act as the focal point for trade in those cities but these markets and their on site wholesalers do not have as strong a role in their State as does Sydney.

There is little vertical integration in the industry although there are a few exceptions in both fishing and aquaculture and there are a handful of companies which have diverse interests covering commercial fishing, farming, processing, wholesale and export trade.

Horizontal integration or alliances are more common, particularly in the fishing and retail sector where multi-fishing licence holders and retail chains/franchises respectively are not unusual, and there is a trout grower's alliance in Western Australia, as noted in the Introduction. A common element across all sectors is that small and medium enterprises, usually family companies predominate; public companies are few.

The supply of fresh and frozen Australian seafood from producer to consumer, whether it is sea caught or farmed, mostly follows the same pathway through a few market intermediaries before reaching consumers, as shown in the Figures 1 to 3 on the following pages. The supply chain can be very short (Producer-Consumer) or long because many producers use multiple, sometimes competing supply chains, as seen in Figure 2 which also shows the competition and complexity added by imported product. Figure 6 shows the diverse supply chains in the fresh farmed prawn trade.

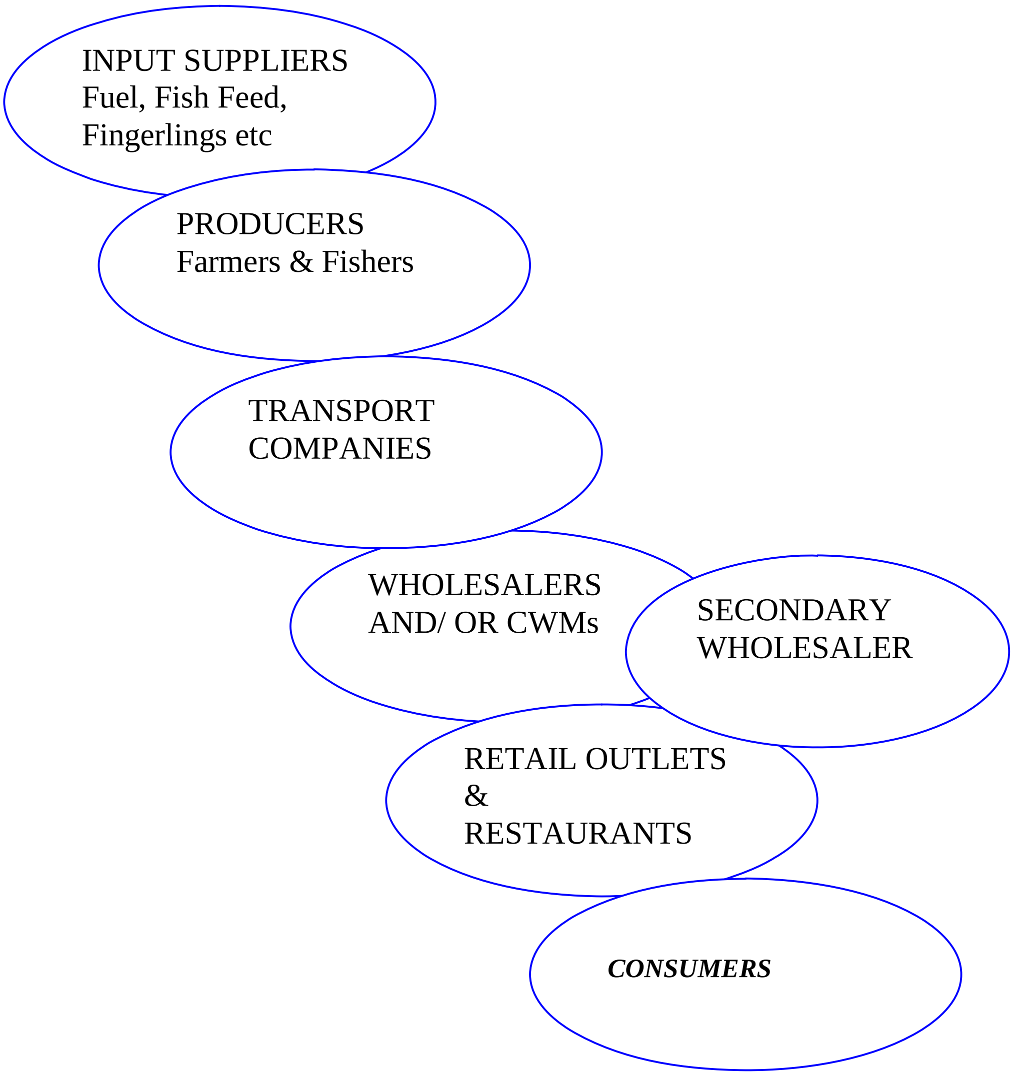


Figure 1. A typical supply chain from Australian fresh fish producers (e.g., snapper) to the consumer.

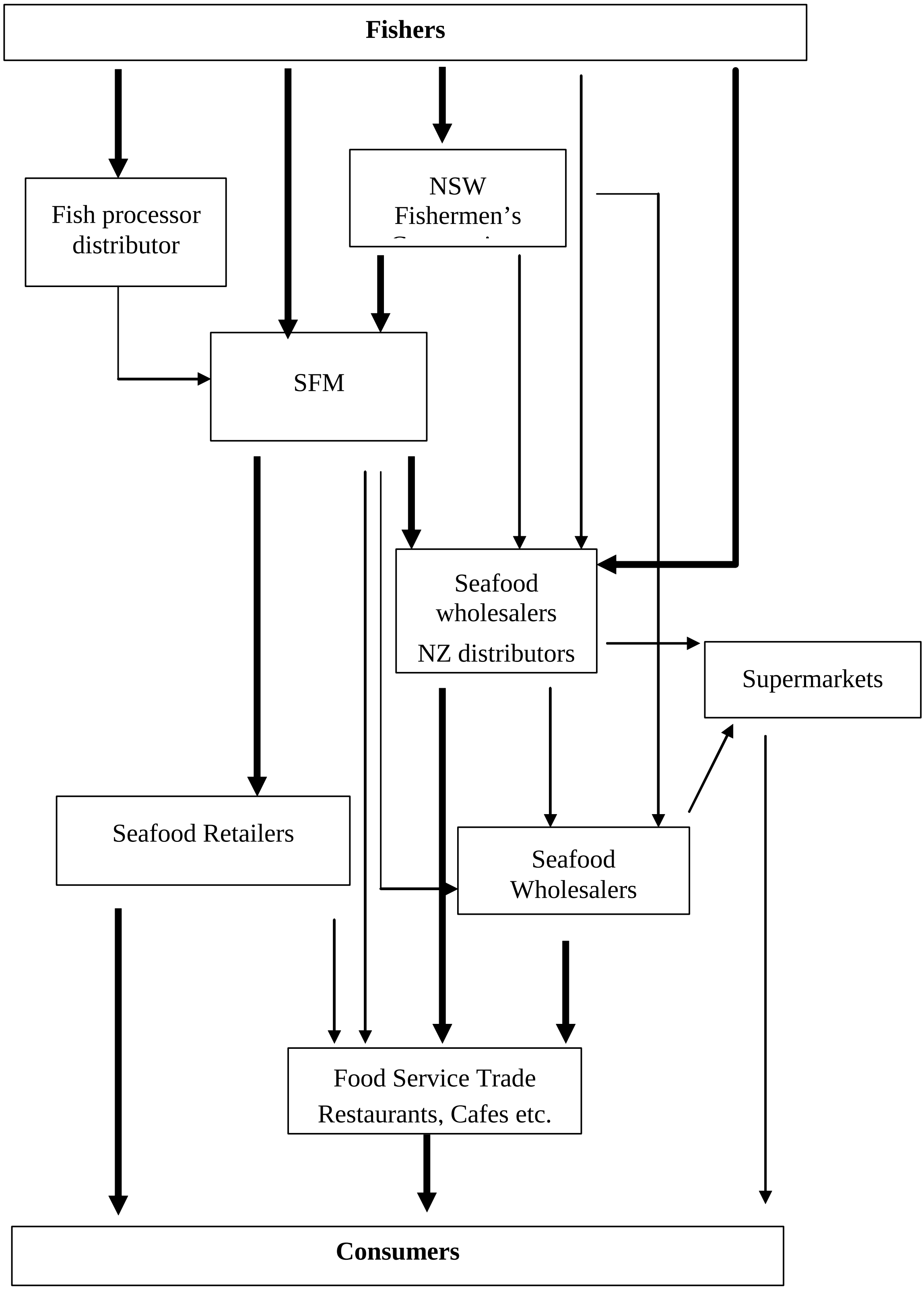


Figure 2. Fresh wild snapper marketing channels in Australia.

The difference between the fresh and frozen chain is that the frozen seafood supply chain commonly has at least one refrigerated transport company and one or more cold storage companies participating in the product flow from producer to consumer (figure below).

In many cases, as with this cooked prawn example the farmer or fisher is often the processor too (cooking and freezing on site/on board). Secondary or multiple wholesalers are no more unusual with frozen foods as they are with fresh, with the primary wholesaler typically in a capital city and the secondary wholesaler in the same city or elsewhere. As noted earlier imports dominate the frozen seafood trade volumes and add to the network of Australian supply chains shown below.

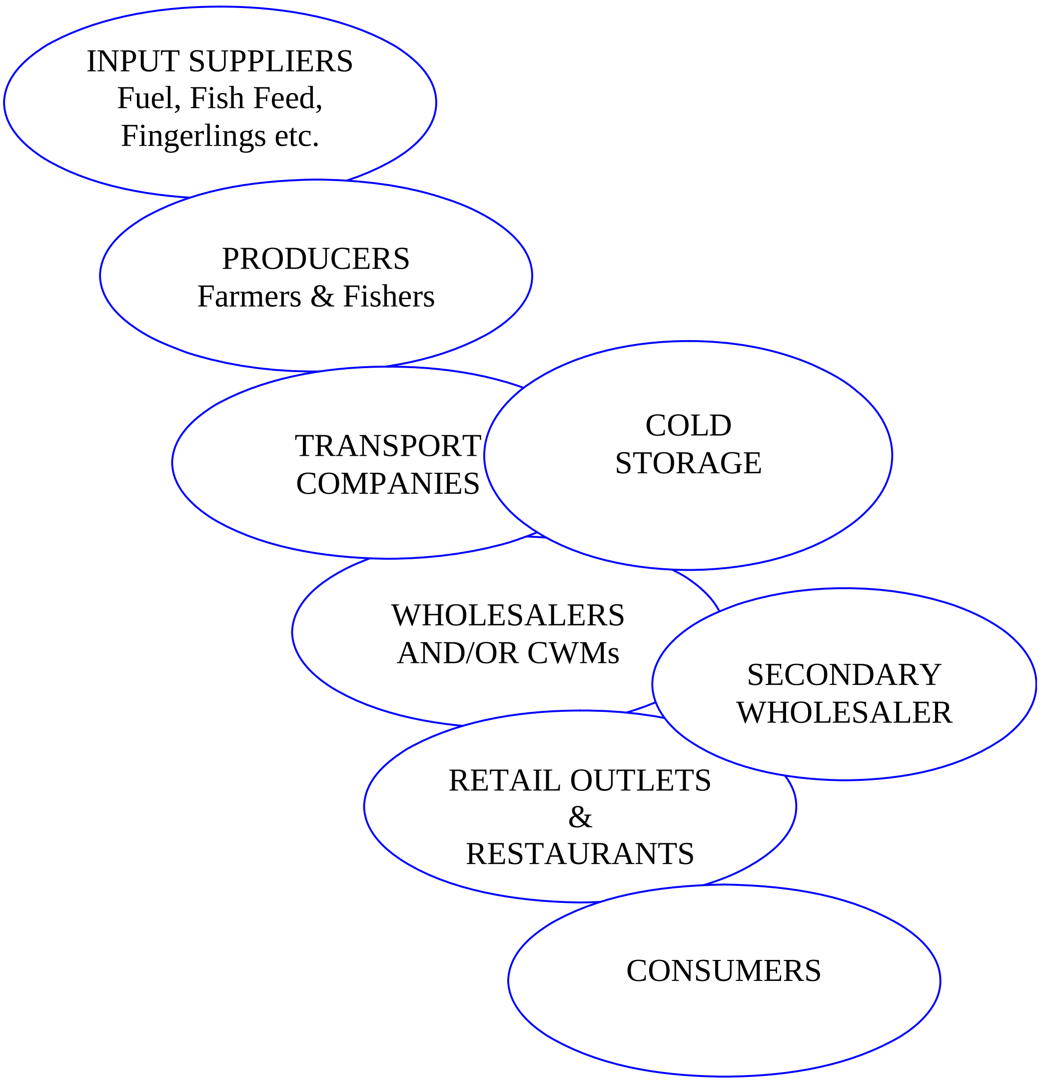


Figure 3. A typical supply chain between Australian frozen seafood producers (e.g., for cooked prawns) and the consumer.

Canned or frozen branded ready to eat seafood consumer packs (e.g., smoked salmon packets) are distributed via the grocery trade and not the seafood wholesale distributors.

The seafood supply chains in Australia are predominantly informal and weakly integrated, having grown from traditional arms length business practices where documented contractual arrangements or specifications are the exception rather than the rule and short-term price driven deals or transactional relationships are commonplace.

Most persons interviewed in this study were not familiar with the term supply chain management although many were operating in an effective informal supply chain where the participants had intuitively recognised that there were benefits to be had in working together to meet the consumer's wants.

Aquaculturists have typically started their search for customers with local restaurants and seafood wholesalers in Sydney or other capital city, and utilised the same transport and traditional distribution outlets as fishers hence the supply chains for aquaculture products parallel those for the wild catch although aquaculture, theoretically at least, has greater scope for innovative distribution and marketing.

The oyster industry supply chain in NSW is somewhat different in that the industry has grown on the sales of processed i.e., opened and bottled shellfish (rather than whole fish) and farmers frequently sell direct to consumers, but these farmers too rely heavily on the traditional fish marketing chains in Australia to distribute most of their products.

Another noteworthy point about the seafood industry supply chains is that many of the input suppliers to fishers and farmers such as fuel, finance, cold storage and transport companies are not thought of as valued partners in the supply chain but rather as another cost to their business. Sentiments commonly expressed by various parties in the chain were a need to "do it yourself", "make more by going direct" and to "eliminate the middleman" to save on costs. By contrast most of the input companies in the aquaculture supply chain strongly identify themselves as part of the (aquaculture) industry.

Exclusive distribution arrangements are rarely seen in seafood marketing but there has been a growth in preferred supplier arrangements and tendering for the seafood supply to major hotel or restaurant groups. The national supermarket chains have long had a preferred supplier arrangement with seafood importers and wholesalers and more recently with a few aquaculture companies.

The supermarket chains are investing heavily in supply chain innovation focusing on reducing the costs and time involved in warehouse/cold storage and distribution to stores, but the seafood supply chain, particularly the producer end, has not received much attention yet.

The typical seafood supply chain in Australia today for both aquaculture products and wild catch is probably best described as a production driven distribution chain rather than a consumer led linkage of like minded chain partners willingly sharing pricing and other information.

The farmers' and fishers' widespread indifference or turning a blind eye to their retailer and restaurateur customers' practice of mislabelling of thawed (frozen) seafood as fresh is probably one of the best illustration of the paucity of concern about consumer's interests in many quarters.

According to the AFFA Industry Development Division's Supply Chain web site on agribusiness *"Australia has not yet embraced supply chain management to the extent that other countries have. Many farmers still view themselves as commodity producers only, rather than as links in supply* *chains. This occurs right through to the consumer. Each link of the chain is viewed separately, and the relationship between buyer and seller is still mostly adversarial".*

Our observations on fishing and aquaculture enterprises and seafood processing, wholesaling, retailing and restaurant operations are consistent with the above sentiments. Some of the adversarial nature of the industry can be deduced from the numerous and competitive/conflicting channels used to supply consumers with fresh snapper and fresh farmed prawns, as seen in the graphical representation in Figure 2 and 6.

A common supply chain management issue cited by seafood wholesalers was order fulfilment and delivery problems. Paradoxically the most common supply chain management issue cited by producers, especially oyster farmers, was a difficulty in getting prompt payment. Yet the buyers of premium quality oysters were very complimentary about their relationship with their oyster suppliers.

5.7.1.9. Inland saline aquaculture production, marketing and supply chain

ISA is still in its infancy after moving from the pilot stage to commercial operations in the late 1990s in both eastern and western Australia. Hence the volume and variety of seafood produced is still very small and the supply chains are for the most part informal, short and vertical.

The aggregate output of product from ISA in 2002/03 was a little less than 15 tonnes, with trout and mulloway representing almost all of this production. This is but a tiny fraction of the Australian trout production of 1900 tonnes let alone the aggregate Australian aquaculture output of 44,000 tonnes in 2002/03.

The supply chains seen in ISA today were mostly entered into in an unplanned manner and therefore typical of those found in the seafood industry.

Most traditional producers (farmers and fishermen) however are involved in more complex supply chains than are common in ISA today because of the longer history in business and the greater supply of product, as discussed below.

In south-western Australia a group of farmers seeking to diversify their rural operations stocked their dams with rainbow trout in the late 1990s and then incorporated as the Saltwater Trout Alliance in October 2001 to facilitate processing and marketing of the trout to seafood retailers and to regional restaurants. This represents the first planned attempt by Australian fish growers at a establishing a supply chain to gain benefits from coordinating supply and developing markets in a collaborative manner.

This group of five farmers produces about 10 tonnes of plate size "saltwater trout" (of a total state production of about 15 tonnes in 2003) which is sold to retailers and restaurateurs as whole fresh fish or smoked gilled and gutted fish. In 2000 trout production in Western Australia was 15 tonnes all from fresh water operations (Trendall 2004).

A case study on this group's activities, with a detailed account of the planning and implementation of the supply chain has recently been completed for the National Aquaculture Council (Trendall 2004) and so the remainder of this chapter will focus on the two other ISA enterprises, in eastern Australia: a prawn farming enterprise in Queensland and a finfish farming operation in NSW.

NSW finfish

A finfish enterprise in the Hunter Valley of NSW has been selling mulloway grown in saline water ponds for the past five years after initial trials with snapper, silver perch, bream and trout. The latter species were discontinued because the mulloway were found to be hardier and faster growing in the one hectare ponds with ground water of 28 ppt salinity.

The enterprise sold two tonnes of fish in 2003/04 and now has ten one hectare ponds. It is an integrated farming operation with its own hatchery and recently joined a new business venture which expands its capabilities considerably.

The volume of product sold has been very small as the enterprise has focussed on hatchery and fingerling production in the past. With the new business arrangement more fish will be grown out for sale as table fish but the enterprise is not planning any rapid increase in volume of output because it intends to steadily increase the volume of fish going to the food market in parallel with its market expansion.

This enterprise is a member of a short and simple vertical supply chain as it owns a hatchery and all sales – of whole fish – are made direct to restaurants in the region (Figure 4). The enterprise owner, an experienced businessman from another industry, is responsible for sales and advises that:

- the enterprise has established good relationships with its customers;
- had good feedback on its product quality;
- he plans to personally increase the number of customers in a gradual manner as needed and time permits.

This enterprise has developed this short but successful supply chain steadily over a period of some eight years, in an informal manner without any documented or explicit plan i.e., in a more or less passive manner that is typical of that seen elsewhere in the Australian seafood industry. The supply chain is unlikely to change in form over the next few years although the number of customers is bound to increase.

The early success of this simple supply chain can be attributed to the farmer's intuitive recognition of the need to service customers' wants and to develop positive relationship with customers and other supply chain partners.

The prices received were cited as being better than average for the product type and the gross profit margins were high because of direct sales to restaurants eliminated a wholesaler's margin or auction costs.

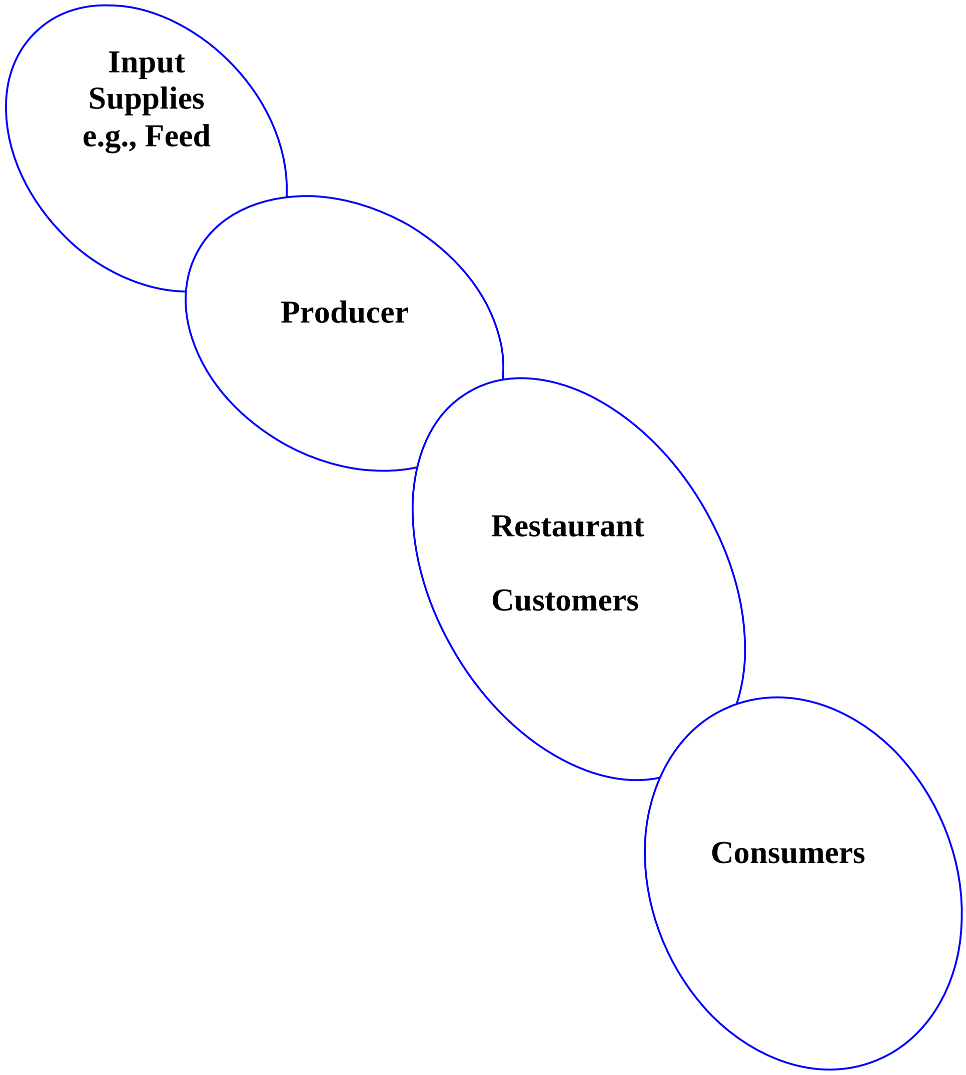


Figure 4. Supply chain for NSW ISA finfish

Queensland prawns

A small crop of black tiger prawns (less than one tonne) were grown in low salinity bore water in north western Queensland in 2003 and then sold to several restaurants and a seafood wholesaler in the raw and cooked form by the producer.

The prawns were grown in a salinity of approximately 3ppt in four ponds 20 x 20 metres in size. The harvest was equivalent to more than 5 tonnes per hectare and the colour and taste were judged as very good by experienced prawn buyers and consumers.

The farmer is a former prawn fisherman and cooked and sold the prawns himself to customers he had dealt with in the past as a fisherman. Thus the ISA product fitted in to the traditional marketing channels although they were differentiated as inland produce to the buyers in all cases. The prices received were regarded as very satisfying. The main inputs to the farming operation were pellet feed and post larvae from a Queensland hatchery. The prawns for sale were picked up at the farm or delivered to customers by the farmer.

The very short and relatively simple vertical supply chain in this operation (Figure 5) was easily assembled, in a typically Australian informal manner, because of the farmer's previous experience in prawn processing, quality control and marketing and the extensive information available on prawn farming in Australia.

The farmer has found this simple supply chain quite satisfactory to date and it is likely to remain short and simple in the foreseeable future as inputs and outputs are not going to change markedly: the farmer is planning to develop the area devoted to prawn farming slowly to about 3 hectares and increase profitability by raising productivity of the new and enlarged pondage (now 50x50 m) to about 8t/ha.

The enterprise has good relationship with customers and has had positive feedback on:

- the ISA product from customers and consumers;
- the farmer's continual attention on product quality and reliable deliveries.

One of its key customers commented that he was particularly pleased with the attention to his requirements for product information and output forecasts.

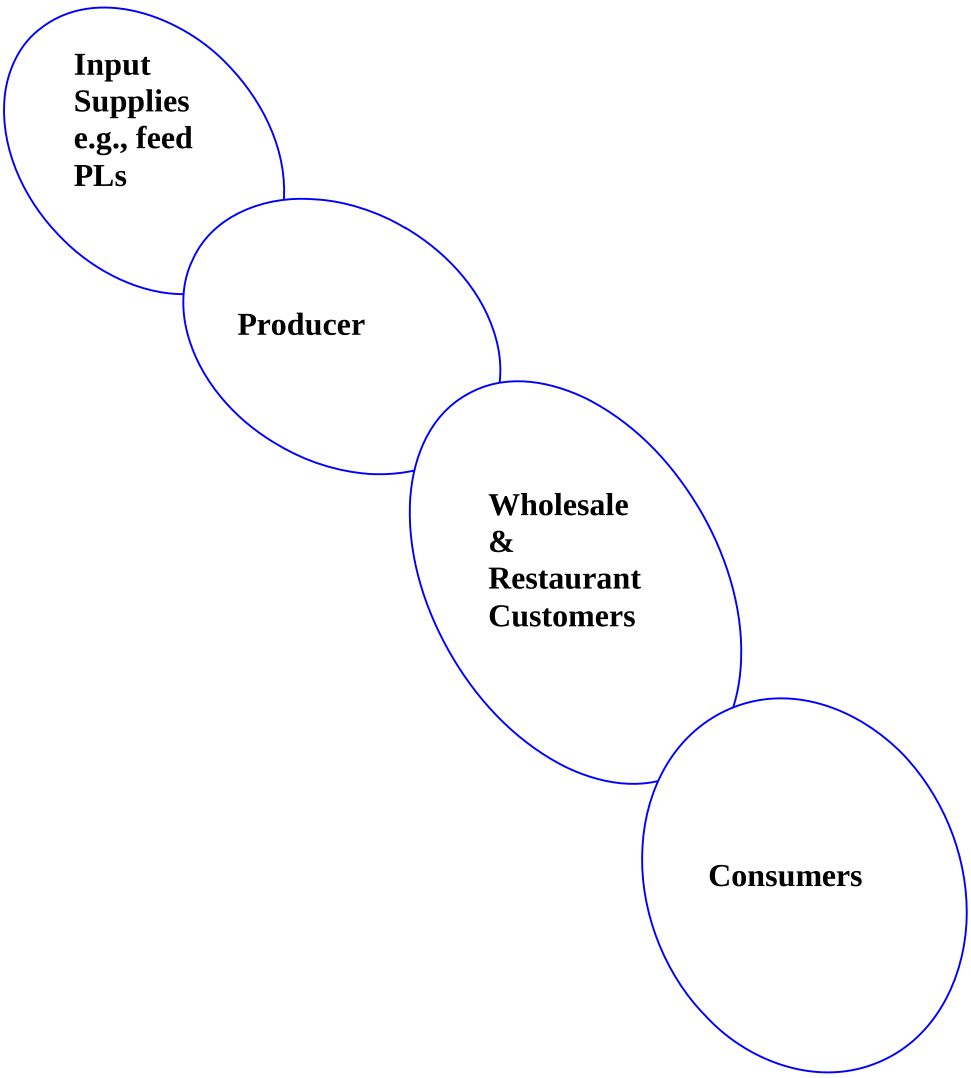


Figure 5. Supply chain for Queensland ISA prawns

5.7.1.10. ISA situation analysis

Information gained from a literature review and interviews with growers in ISA and traditional aquaculture, as well as personnel engaged in seafood processing, marketing, restaurant, transport or other input supply companies was used to assess the ISA sector's situation regarding marketing and supply chain management as outlined below. This analysis does not cover technical aspects or overall economic viability of inland aquaculture.

The overall situation for ISA is positive as it has substantial strengths and several exciting opportunities notwithstanding several weakness and threats which can be attended to. A number of options for capturing these development opportunities and dealing with weakness and threats are discussed at length in the following section.

Strengths

- Saline water is a plus in growing freshwater species given the perception that the taste the fish is improved in salt water.
- Inland location gives it an advantage in marketing fresh seafood to inland consumers at premium price.
- Strong government support at all levels: national, state and regional.
- ISA offers a new flavour or taste for a restaurant industry and consumers looking for new products.
- ISA is ecologically sustainable and has a good environmental/ecological news element to it, particularly where "damaging" saline waters are being put to constructive use.
- ISA product offers "feel good" psychic benefits to environmentally concerned consumers.

Weakness

- Awareness of the existence of ISA in the community and in the seafood trade is very low. ISA produce is an almost totally unknown, untasted seafood product.
- Inland location may be perceived as a strange place to be growing marine species.
- Some inland locations may be too remote/costly re transport of inputs or outputs.
- Scattered inland enterprises make coordinated action, market promotion, meetings and information sharing more difficult and costly.
- Rudimentary marketing and supply chain management skills and knowledge in some situations.
- Small number of enterprises limits political power and economies of scale.

Opportunities

- ISA can open up new market supply chains with environmentally concerned consumers keen to "help the environment" by supporting eco-friendly ISA: an eco market.
- Some ISA has the potential for organic farming and access to this small but growing market.
- Some inland locations offer great biosecurity situations and the potential for exotic species e.g., sturgeon for flesh and caviar.
- ISA with its positive "eco-story" offers opportunity for eco-tourism stays and experiences
- A new industry sector has the opportunity to avoid the mistakes of its antecedents.
- ISA like all aquaculture has long term opportunity because of static or declining wild catch situation.

Threats

- The greatest threat to ISA is arguably the price competition of large scale traditional Australian aquaculture products.
- Increased government charges and restrictions on aquaculture and water use.
- Insufficient working capital to invest in market development is a threat to most aquaculture ventures.

Chapter 8 outlines options for addressing some of the weaknesses identified above and a number of strategic and tactical considerations for embracing the opportunities facing ISA.

5.7.1.11. Market outlook

The market outlook for aquaculture species is mostly positive but difficult to quantify because the demand for existing products e.g., freshwater plate size barramundi is affected by many factors in varying ways. It is difficult to estimate the cumulative impact of new product development (e.g., ISA plate size barramundi), promotional activities and market diversification across several species which all affect the demand for a particular product such as the traditional freshwater plate size barramundi example used here.

It is therefore worthwhile reviewing some of the key factors affecting seafood demand and how they may impact on a particular species before discussing the market outlook for existing and prospective ISA species.

Market growth for existing products depends on factors affecting the product and the many other competitive seafood products (farmed and wild) as well as a multitude of other foods (common meats such as poultry and beef and the more exotic items such as imported truffles and foie gras). These include:

- Increasing population.
- Strong economic conditions, including low interest rates.
- Rising wages and salaries.
- Good news stories on seafood.

All of these factors, individually or collectively, help to increase demand across most seafood products. The beneficial effects of a growing population and good publicity are well known but it is not so widely known that strong economic conditions and salary increases help seafood sales because seafood is not cheap nor an everyday consumption item and therefore becomes more attractive when there is more disposable income available for discretionary spending.

But:

- Weakening economic conditions and high interest rates.
- Adverse publicity on seafood.
- Both weaken demand across most products (population decline and falling salaries are unlikely here in the foreseeable future).

Additionally, changes in:

- The price of the product.
- Its geographical availability.
- Promotional activity for the product.
- Can individually or together affect demand and sales.

Increasing prices usually has a negative impact on sales while increases in distribution and availability or in promotional activity have a positive impact.

Price, availability and promotional activity of competing products (e.g., large barramundi or plate size Murray cod) also impact on the demand and markets for the product of interest (e.g., plate size barramundi), but in the opposite manner.

Lower prices for competing products makes them more attractive and are likely to reduce sales of “your product” (other things remaining the same), while rising prices in competitive products commonly works to your advantage. Better distribution and availability and increased promotional activity with competing products is likely to have a negative impact on your business.

The arrival of a new product on the market also has an impact on demand for the existing products over the short to mid term, particularly in the restaurant sector which is always looking for new tastes. The widespread availability of large barramundi dampened demand for salmon in 2002, just as the influx of large farmed kingfish in turn dampened demand for large barramundi for a short period in 2003.

The demand level and market growth achieved for any species will ultimately depend on the effort invested in marketing: the dollars and creative human resources allocated to this important function, because per capita fish consumption will not increase significantly without it (Chapter 9).

<u>*Current ISA species*</u>

Black tiger prawns

The farmed prawn market has traditionally been dominated by cooked whole black tiger prawns from Queensland or Thai farms. But import volumes and sources have increased steadily in recent years as has the output of banana prawns from Queensland and in calendar year 2003 farmed prawn imports rose to 12,900 tonnes, from 7300 tonnes in 2002, with the influx of low priced *vannamei* prawn species.

Australian farmed prawn output in 2002/03 fell to 3403 tonnes (black tiger, banana and Kuruma species) from a peak of 3,757 tonnes in 2001/02 according to the ABARE statistics. About 2500 tonnes of the 2002/03 production was black tiger prawns, with about 90% from Queensland and the remainder from NSW and the Northern Territory. The remaining 900 tonnes was predominantly banana prawns sold in Australia, and about 100 tonnes of Kuruma prawns sold predominantly in Japan (Lobegeiger and Wingfield 2004).

A detailed analysis of the farmed prawn market two years ago, involving 29 farms, (Ruello & Associates 2002) found:

- the tonnage and consumption of wild catch prawns outweighs Australian farmed output about five to one;
- farmed black tiger prawns accounted for more than 90% of Australian production and had gained widespread acceptance with retailers;
- whole cooked farmed black tiger prawns outsold cooked medium king prawns in the majority of Sydney retail seafood outlets;
- almost 50% of the 2000/2001 Australian production was cooked and sold fresh whole, predominantly as unbranded product;
- that 40% was cooked whole, frozen and sold later predominantly unbranded, mostly in retail outlets as thawed “fresh”, and in direct competition with the cheaper imported black tiger prawns;
- 4% was exported in various forms.

The product mix and market distribution in 2003/04 was similar to that noted in 2002 according to industry sources but with a shift from 16 kg to 10 kg cases for distribution and an increased percentage of cooked product frozen.

The major distribution chain for prawns is Producer-Wholesaler-Retailer-Consumer with almost all of the large farms cooking and freezing on site with Sydney as the main geographical target accounting for about half of production. The second most common distribution chain is Producer-Sales Agent-Retailer-Consumer, but many farmers use multiple supply chains and short chains consisting of direct sales to retailers or consumers are not uncommon (Figure 6, drawn from Ruello & Associates 2002).

The large volume of imported frozen *vanname*i prawns in 2003, added to the traditional Thai prawn price competition faced by Australian farmers who freeze the majority of their catch and the average price for black tiger prawns in 2003/4 is reported to be significantly lower than that for the previous year (SFM average for cooked medium size grade was $14.29 down from the record high of $15.88 in 2002/03).

It is difficult to quantify the market outlook for farmed Australian prawns with any precision because:

- the annual general meeting of the Australian Prawn Farmers Association is to discuss the current weakness in Australian prawn prices on 30 July but the weak financial situation of some farms means they may be unable to restock or to participate in any industry backed market development initiatives;
- the appreciating A$, effectively reduces the price of imported product and the attractiveness of overseas markets for Australian exporters the domestic supply of wild prawns, which far outweighs farmed tonnage and has a large impact on prawn marketing, but is closely related to rainfall and therefore itself unpredictable;
- the USA's announcements of tariffs of around 100% on Chinese and Vietnamese prawn imports on the 6th July 2004 has created uncertainty in global trade and may lead to greater volumes to countries like Australia if it is upheld (American trade groups have initiated action to have this decision reversed).

Nevertheless prawns are a universally popular seafood across all demographics, farmed prawns are growing in market acceptance and the Australian population and aggregate prawn consumption continue to grow therefore the market for Australian farmed prawns still has the capacity for stronger prices and to grow in volume, without great expenditure on market promotion.

Australian farmed prawns represent only about 10% of aggregate prawn consumption in this country therefore with improved handling and marketing practices, investment in product and market development to expand product range and sales outside of Sydney the industry can profitably continue to increase output substantially, as it did in the late 1990s, to more than double current levels.

But if the individual companies and the industry collectively do not:

- address some of the less desirable handling and selling practices;
- become more consumer focussed, towards fresh (vs frozen) and follow the changing consumer preference from cooked to uncooked product;
- avoid direct competition with the (cheaper) imported frozen product by focusing on larger size grades cooked and uncooked where there is no import competition;
- invest more in new product development and market development;
- the economic situation of most farms is unlikely to improve.

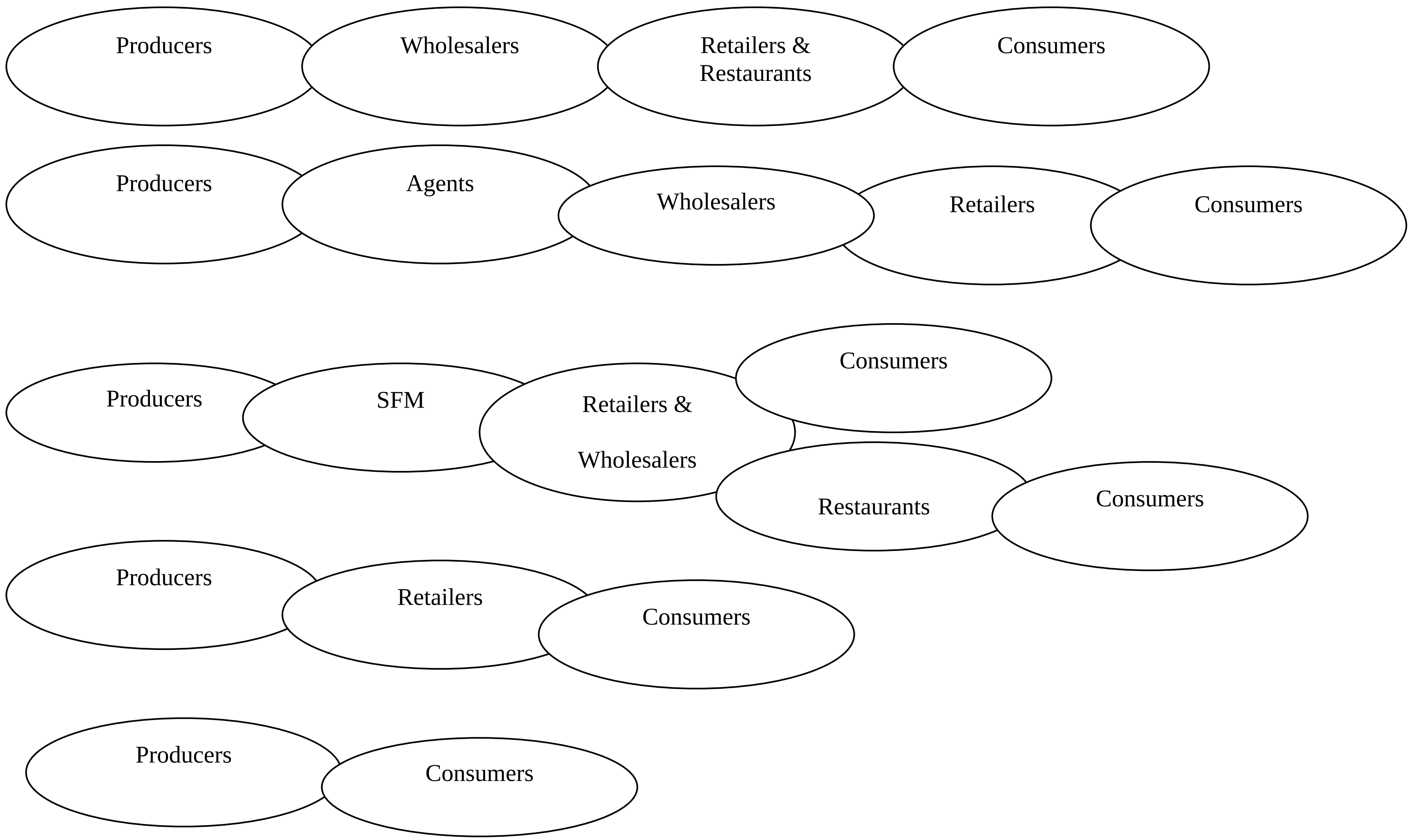


Figure 6. Supply chains for fresh cooked whole farmed prawns, shown in decreasing order of importance (inputs omitted). This shows the many pathways to consumers when farmers use several supply chains (long and short) to maximise sales or profits.

The outlook for farmers who are able to produce and market their prawns in the fresh form is particularly attractive if they are able to turn out their product in August- September and/or December when traditionally there are fresh prawn supply shortfalls and prices are very strong. The relative returns for producers of the larger size grades such as 10/15 count are stronger at all times because the fresh large size grades rarely face competition from imported product and gain a substantial price premium over smaller size grades.

The market prospects for ISA produce are essentially positive as indicated above as long as ISA production costs don't significantly exceed those in traditional marine farming. Individual farm returns will of course be dependent on the taste, price and promotion of the product by the enterprise.

ISA produce will require differentiation and promotion if a company wants to increase its output volumes rapidly and profitably in traditional markets and in the eco market noted earlier (Chapter 6). The strategic options and tactical considerations for doing so are discussed in the following chapter.

Trout

The freshwater or rainbow trout market in Australia is dominated by plate size rainbow trout grown in Victoria – about three quarters of national production – and NSW with a smaller volume coming from South Australia and Western Australia respectively (ABARE statistics).

The most common product, accounting for about half of the production, has been the fresh gilled and gutted (mostly plate size) fish distributed through the traditional fish supply channels of Producer-Wholesaler-Retailer-Consumer. The central wholesale markets play a minor part in the trout supply chains as do direct sales to restaurants. The table below shows the remarkably steady output volumes and prices of trout (predominantly rainbow trout) for the past three years.

Table 7. Trout volumes and prices*.

Year	Volume (tonnes)	Average $/kg
2002/03	1878	6.88
2001/02	1864	6.91
2000/01	1950	6.58

**ABARE statistics*

In recent years there have been small but unrecorded volumes of gilled and gutted brook trout and brown trout and some saltwater fish from South Australian sea cages sold in parallel with the rainbow trout and there are also tiny volumes of a golden strain of the rainbow trout in the marketplace at times. Because of the small volumes of these products there is no reliable information on their trade.

The Western Australian product is marketed within the state to meet local demand for fresh product; the high cost of transport to distant markets is prohibitive especially when faced with competition from the cheaper product from the larger producers in eastern states. Fish from South Australia is sold in nearby states and the fish from Victorian and NSW farms is marketed almost throughout the entire country.

The WA trout industry has been the subject of detailed market research which found that the market in 2001 consisted of:

- 23 tonne of fresh fish (including interstate fish);

- 3.4 tonne of value added local fish (predominantly smoked fish);
- a frozen market of 47 tonne of frozen dominated by Victorian product (Colmar Brunton 2003).

As indicated earlier fish from ISA production outnumbers traditional freshwater WA trout, fresh and smoked, by about two to one.

The Victoria (freshwater) trout industry has faced drought and increasing regulatory demands and costs over the past few years and so output has been constrained more than anticipated by both government and industry.

Nevertheless the industry has been actively changing its product mix and markets, moving away from its reliance on the raw plate size fish and expanding output of larger fish, smoked fish, fillets and boneless product onto domestic and Asian markets. Smoked fish now account for around 25% of production and exports for about 5% according to industry sources.

The outlook for rainbow trout in terms of demand or price is difficult to forecast because the fish has been overshadowed to a great extent by the farmed salmon and ocean trout from Tasmania. The demand for the freshwater trout fillet in particular is constrained by the higher but nevertheless competitive price of the whole fish or fillet from the sea cage grown trout and salmon.

While the salmon and ocean trout industry in Tasmania have been expanding and promoting their products the freshwater trout industry in the south-eastern states has been dealing with drought and environmental concerns and therefore has not been able to promote its product, or even defend market share, because of limited fish supply and funds for such activities.

Plate size trout appear to be in the mature phase of their product market life cycle and need to be given new life through product innovation or relaunched with some promotional initiative or they will enter a decline phase.

The market demand for rainbow trout from fresh or ISA waters, on both sides of the continent, can be expanded with well planned and managed promotional initiatives because it is such a well known fish:

- mostly well regarded by trade and consumers;
- with attractive tasty flesh;
- and with a relatively low price.

It is usually the cheapest farmed fish on sale, at about $6.50 FIS Sydney for gilled and gutted fish, and often cheaper than most wild fish.

With modest investment in market promotion the national market can be doubled over a period of about five years with existing products, users and supply channels. With further R&D investment in new products and market diversification the aggregate demand for trout can be expanded more quickly and/or to a higher level. Product innovation with more ready-to-eat quick and easy convenient products can accelerate the growth in demand noticeably.

ISA trout can compete well in the traditional rainbow trout market because of the perception of better flavour when grown in saline water. It also has additional opportunities with new markets as described in Chapter 8.

Mulloway

The mulloway is a marine species that has been grown commercially in South Australia and NSW sea cages and in inland saline water in the Hunter Valley of NSW over the past few years. There are only a handful of farms growing this species and aggregate output is still small and sales data remain confidential.

Industry sources estimate that aggregate sales were about 100 – 200 tonnes over the 2003/04 year, predominantly whole fish 500 – 1500 grams from South Australia and less than 10 tonnes of fish 500 – 2500 grams from NSW. One South Australian enterprise offers gilled and gutted fish, headless fish, fillets and skinless boneless loins but the aggregate volume of these products represents only a minor part of production.

Sydney restaurants and retail outlets have been the users of this farmed fish which has been distributed whole via wholesalers and the SFM. Fish from the ISA venture in the Hunter Valley and a small farm in Botany Bay are sold direct to restaurants in their local region.

The many names given to this fish species complicate an assessment of the market for the farmed fish because it is commonly known as jewfish in NSW, Queensland and the Northern Territory, butterfish in South Australia and river kingfish in Western Australia. Much of the farmed fish from South Australia has been sold under the name **Suzuki** a Japanese name for a similar species, a practice which has generated confusion amongst some buyers because it is used as a product name as well as a trade name by several growers while other retailers do not realise it is a mulloway.

The sea cage farmed fish have been compared to the wild fish from eastern Australia by seafood wholesalers and retailers in NSW who mostly report it as "OK" but note that:

- the farmed product has often been too large for plate size use and too small for fillet;
- far too small for cutlet use – the traditional common use for large wild caught mulloway;
- at around $9 per kilogram FIS Sydney wholesalers, much dearer than the equivalent sized wild fish at about $7 at the SFM auction (the major source);
- dearer than large wild fish from South Australia and the Northern Territory which have an FIS Sydney price of around $7 per kilogram, often headless.

The sea cage fish are keenly bought at the SFM auction when prices fall to the $5 – 6 price range as are the wild fish of similar size.

"Early adopter" restaurateurs keenly looking for new fish varieties when given the opportunity to try the fish have generally been more favourably impressed than retailers, but as indicated above, plate size fish nor large fillet size fish have not always been available and so the market is largely untested by the majority, mainstream restaurateurs and retailers who are more price conscious or late adopters.

This early history of mulloway aquaculture provides an example of production led farming where the species may be right but the product offered was not what customers want.

In retail establishments the farmed fish are mostly not differentiated as aquaculture product and so consumer awareness remains low.

Although there are several species of mulloway caught around Australia, with aggregate landings of several hundred tonnes per annum (ABARE statistics), they all share a number of pleasing features:

- Attractive appearance.
- Pale colour flesh when raw, changing to white when cooked.
- Tasty flaky flesh.
- The fillet holds together well when raw or cooked.
- Large fish are perceived as having few or no bones in the fillet.

The market prospects for farmed mulloway are positive overall, but especially for larger fish with their higher versatility and potentially higher per kilo value than small mulloway (large wild mulloway sell for significantly higher prices than smaller fish), particularly if the farm gate price can be lowered to make it more price competitive. According to industry sources farm gate prices for large barramundi, arguably the major competitor, have been as low as $7 per kilogram for much of this year.

As indicated in Chapter 3, the aggregate market for whole/plate size fish (all species) is not a rapidly growing one and hence is not attractive for a long-term investment with a “new farmed fish”. The market outlook for fillets and less so for cutlets, is far better because of the faster growing demand for boneless fillets and portion controlled pieces.

It should be added that market success will however depend on the industry investing in market development for whole fish or any new mulloway product such as portions because farmed mulloway is essentially still an unknown food item for most of the population, both here and overseas.

Product differentiation and promotion are particularly vital in NSW because:

- The market is becoming saturated with competing farmed fish products (salmon, barramundi, trout, and kingfish to name a few).
- Plate size mulloway are known, unfavourably, by some NSW consumers and fishers as “soapy” jewfish because of their soft unappetising taste.
- The food media is mostly headquartered in Sydney hence the influential writers and restaurateurs in Sydney need to be “won over” if mulloway is to make an impact on the national table.

In short the domestic market for mulloway can be expanded to the current output of freshwater trout or barramundi at around two thousand tonnes per year ***if*** it is actively managed and promoted and based on large fish (>1.5 kg) rather than small.

According to industry sources there were about one million mulloway “in the water” in South Australia at the end of June. This represents around 1000 tonnes if the fish are grown out to a kilogram each (assuming nil mortality), more if larger fish are eventually sold. This volume is unlikely to be sold at the asking price of about $8 to $9 per kilogram in Australia in less than a year without substantial investment in market development.

Mulloway have no known natural or competitive advantage if grown in ISA hence it would be competing directly with sea cage or wild mulloway (and other species) in most parts of Australia so price control and quality control would be imperative and a new eco market would be the most attractive one.

A primary target for new producers (of any species) but particularly ISA producers of mulloway should be local customers as well as customers seeking new flavours or products.

Given that marine farmed mulloway has little market presence yet, partly because many south Australian growers are focussed on kingfish (rather than mulloway), ISA product has an opportunity to grab consumer, trade and the food media attention.

Prospective ISA species

Prawn species

The western king prawn, the brown tiger prawn and the Kuruma prawn are three high value prawn species that are regarded as prospective candidates for ISA by researchers or industry.

The Kuruma prawn industry in Queensland, which relies almost entirely on export sales of live prawns to Japan has not fared well in recent years according to the annual Queensland DPI Aquaculture Information Report (Lobegeiger and Wingfield 2004). It showed that production fell almost 40% from 156 tonnes in 2001/02 to 95 tonnes in 2002/03 while the average price (CIF Japan) increased 3%.

Given recent history, the high costs involved in growing and marketing this species, and the currency risk inherent in trading almost entirely on overseas markets, the market and economic risk in growing this species in ISA would have to be examined more carefully than most, as they do not appear attractive at this time.

The brown tiger prawn is grown in Queensland according to Lobegeiger and Wingfield (2004) but in such small quantities that it is not discussed and just noted as one of the three species grown in the state. The western king prawn has not been farmed profitably in Australia yet, despite earlier attempts to do so.

The market outlet for the western king prawns and the brown tiger species is positive for the larger size grades as they are in keen demand here and overseas, the latter especially in Japan. The ABARE statistics indicate exports of these species in the several thousand tonnes per annum range at high prices: more than $30 per kilogram for large tigers and around $20 for larger kings.

The farming of king and tiger prawns in ISA, particularly the former which is not grown in marine farms, would probably attract interest especially in the restaurant trade which is continually looking for novel products. This would give the new product some assistance in gaining attention in an arguably well supplied marketplace. While the market prospects may appear attractive the market and economic risk in growing this species in ISA would have to be examined more carefully than most, as they are not clear at this time.

Prospective freshwater finfish species

Silver and Golden Perch are two salt tolerant native species which are currently grown commercially in freshwater. Golden perch farming is still in its infancy with tiny volumes coming from NSW and Queensland farms while silver perch production has been underway for about a decade.

Golden perch

Farmed golden perch grown in freshwater have occasionally been marketed at the SFM auction, unidentified as farmed fish, and received prices equal to the wild fish on the day. Whole golden perch grown in freshwater at the Queensland DPI Walkamin research station have been sold at auction at the SFM on more than 10 occasions, clearly identified as aquaculture product, and also received prices equivalent to those for similar sized wild fish.

The $12 to $18 per kilogram prices gained by whole unpurged Walkamin golden perch, in consignments of about 150 – 200 kg per day in 2003 (Walker 2004), have clearly demonstrated that farmed golden perch is a well regarded product. Fish in the 600 – 800 g were identified by buyers as the preferred size although fish from 400 g + size were nominated as acceptable.

The national market for golden perch has declined from former levels of around 500 tonnes per annum down to about 100 tonnes over the past few years because of the closure of inland fishing in NSW and increasing restrictions on fishing activities in South Australia.

The market prospects for whole golden perch grown in ISA would therefore appear to be very attractive given:

- the high price of the farmed fish, even as small as 400grams;
- the unmet demand due to declining wild catch;
- that fish from saline waters would most likely be perceived as having a better flavour than the freshwater fish;
- the widespread appeal of golden perch to many cultural groups;
- this species is not regarded as “muddy” or “earthy” as some of its freshwater competitors such as silver perch.

The national market for this farmed fish could probably be expanded to more than 500 tonnes per annum in a few years with modest market development effort because of the latent demand and the increasing demand-supply shortfall with wild fish, which will eventually be totally banned.

Market expansion beyond a thousand tonnes per annum is possible with development of large fish for premium price fillets but this will require more time and greater industry investment because it is not a fast growing fish.

ISA golden perch would be able to compete in traditional markets and fare well in any new markets because it would be perceived as having a better taste than fish from freshwater farms.

Silver perch

The silver perch market consists solely of farmed fish and has grown gradually over the past ten years to its current level of about 400 tonnes per annum in 2003/04 according to industry sources. The table below shows a modest growth in output and average prices over the past few years.

Table 8. Silver perch volumes and prices over the past three years*.

Year	Volume (tonnes)	Average $/kg
2002/03	353	9.10
2001/02	322	8.66
2000/01	285	8.96

**ABARE statistics*

The trade is dominated by the live fish market with product mostly in the 500 – 700 gram size category going predominantly from NSW farms to eastern states restaurants with Asian cuisine or to retail fish markets patronised by Asian consumers. The typical supply chain is Producer-Wholesaler-Retailer/Restaurant-Consumer. There are also very small volumes of other products such as gilled and gutted fish, fillets and smoked fish or fillet sold.

The market for silver perch has been reviewed several times and a number of issues prevail:

- Trade is dominated by whole fish, invariably with a high fat content.
- The very high fat content and “earthy” flavour of some fish are recognised as impediments to expanding demand in the non Asian consumer segment i.e., the mass market.
- Almost all farms produce less than 100 tonnes per annum and therefore have little economy of scale and high costs.

- High farm gate prices and small fish size make the fish expensive for the fillet trade – the product category in which other species such as barramundi have seen strong growth.

The domestic "Asian market" appears saturated at current price levels and the relatively high price and high fat content are major impediments to further market diversification and growth for the species. Farm gate prices of about $6 per kilogram, and much larger fish, are required to make this species competitive in the fresh fish fillet trade against other Australian produced fish species (Ruello & Associates 1999b).

Given the taste problems faced by some freshwater fish, ISA may be able to produce a leaner fish with an improved taste profile which would allow it to compete strongly against plate size freshwater silver perch.

However it should be noted that the greatest business growth potential over the long term is with fish that can be grown to a sufficiently large size where boneless fillet, and preferably even cutlet portions, are possible. In this regard silver perch is not as attractive as golden perch or barramundi which are both capable of faster growth in fresh or saline water.

Prospective marine finfish

Snapper and bream

Snapper and bream have both been grown commercially in marine and brackish waters respectively, and in pilot trials in inland waters in NSW and Western Australia respectively.

Both species share a number of pleasing features:
- Well known name.
- Widely well regarded species, especially snapper which is also eaten raw.
- Well regarded as plate size fish.
- Attractive appearance.
- Pale colour flesh when raw, changing to white when cooked.
- Tasty versatile flesh.

Both species share a relatively slow growth rate which has constrained Australian aquaculture to plate size and the whole fish market, although the snapper can be grown to a larger size that would allow the production of a plate size fillet.

Farmed snapper from South Australian sea cages and the now closed Pisces sea cage operation off Port Stephens have been marketed in Sydney on many occasions. These fish were widely regarded as a little too variable and dark for the traditional retail trade but restaurateurs found them satisfactory despite the darker colour because:
- The unusual (dark) colour was not evident after cooking.
- The fish had a very pleasant taste, sometimes described as better than the wild fish.
- The common supply chain was Producer-Wholesaler-Retail/Restaurant-Consumer.

The market outlook for farmed snapper is nevertheless attractive given that there is a decline in the supply of wild fish, especially the plate size fish from NSW and New Zealand fisheries and that the FIS Sydney price for farmed snapper (about $9.50 per kilogram) was similar to that for wild plate size fish at the SFM auction about a year ago when farmed snapper were last sold there.

Although the aggregate snapper market has been steady at around 3000 tonnes per annum in recent years with about 1000 tonnes from New Zealand and the remainder coming mainly from WA and SA, small size grade fish (i.e., mostly plate size) make up less than 15% of this trade (ABARE, New Zealand and SFM statistics).

The price gap between wild plate size snapper and farmed plate size fish is shrinking and farmed fish can now fetch about $10 per kilogram FIS Sydney. There could also be a latent market for plate size snapper in South and Western Australia where fishing regulations prevent the sale of this size fish.

The price of wild larger fish more suited to fillets and cutlets at about $5 per kilogram is substantially lower than for the plate size and so farmed fish of such size would face price pressure from wild product that would constrain demand.

The bream market is much smaller at about 600 tonnes per annum (several species) nationally and bream prices are significantly lower than those for snapper so ISA aquaculture of bream would mean competing in a small low price market or great investment in market development to create new demand in addition to competition from faster growing better regarded species such as snapper or barramundi.

The market prospects for farmed snapper from marine or ISA are far more attractive.

The market potential for farmed snapper can be estimated at about 1000 tonnes for plate size fish, attained in a matter of a few years with active marketing or far lower output achieved more slowly with passive selling and little market promotion as has been the case to date.

We have this seemingly optimistic outlook for a plate size fish because snapper’s widespread appeal lends itself to large scale distribution to supermarkets as well as the traditional retail fish outlets and restaurants.

While supermarkets are sometimes not seen as the right place for farmed fish because it “turns them into commodities” this type of comment overlooks the fact that:

- aquaculture products need such distribution channels to expand sales volumes;
- most consumers find supermarkets attractive places to shop, some having more trust in them than specialist stores such as fishmongers;
- supermarkets can do a better job in selling fish, especially when they have fishing or aquaculture industry assistance with in store support to check on product presentation and sales as do other food sectors.

Yes, producers can find other distribution channels for their fish if they prefer, but finding alternative markets is more costly and so they rarely do so.

If larger fish were added to the product range then the market for farmed snapper could probably be expanded to more than 2000 tonnes over a period of about 5 years with active marketing.

ISA product could easily be absorbed in a growing traditional market for aquaculture snapper or ISA producers could develop their own eco markets, although probably at a slower pace.

Barramundi

Barramundi are grown in all mainland states using a variety of techniques and facilities including:

- Intensive recirculation systems with indoor and outdoor freshwater tanks.
- Earthen freshwater and salt water ponds with fish free ranging or in cages.
- Sea cages.
- It was grown in saline bore water in NSW in the 1990s but this operation ceased for a number of reasons.

The industry has recorded strong growth in output and a decline in average prices over the past thee years as shown in the table below.

Table 9. Farmed barramundi volumes and prices*.

Year	Volume (tonnes)	Average $/kg
2002/03	1486	8.09
2001/02	1150	8.62
2000/01	898	9.40

**Source ABARE statistics*

Despite the declining average price the industry has mostly fared well because of lower production costs arising from increasing economies of scale and market diversification as can be seen from the diverse product ranges available now.

Current product ranges include:

- Large freshwater fish.
- Large brackish water fish.
- Large marine cage fish.
- Live and chilled freshwater plate size fish.
- Live and chilled spring water plate size fish.
- Live and chilled salt water plate size fish.
- Fillets from large fish.
- Fillets and portions from large fish in modified atmosphere packs for supermarket distribution.
- Smoked fillets.

The largest farms focus on turning out large fish (3+kilograms) for domestic and export sale and fillet production, and the large fish from fresh and saltwater now account for more than 50% of production. The smallest farms with annual production of less than 50 tonnes per annum concentrate on plate size fish for the live and chilled fish market; chilled fish are commonly sold within the state while live fish often is transported interstate. The output of smoked fillets is very small.

The predominant supply chain for live or chilled fish is:

- Producer-Wholesaler-Retailer/Restaurant-Consumer.

Export sales of more than 3 tonnes per week last year, to the USA, accounting for about 10% of national production have decreased due to the rising Australian dollar (versus the US$) this year (O'Sullivan 2004) and export market expansion has slowed now due to the strong dollar and rising costs of small shipments to distant markets such as the USA because of increased concerns about terrorism.

The farmed barramundi industry has a history spanning almost 20 years but the product development and market expansion of recent years is the result of various Australian Barramundi Farmers Association initiatives over the last decade (Ruello 2001) including:

- Product handling and value adding R&D in the late 1990s.
- Market research in 2001.
- Generic and industry promotion in 2001/02.
- Product quality standards development in 2003.

The market for farmed barramundi still has room for growth by expanding into new marketing channels and outlets both in Australia and abroad. Because of the falling fish production costs there is also the potential to develop new products with further processing of fish to ready to cook items and ready to heat and eat meal items. The highly transformed fish option requires the greatest investment in product R&D and in market development but it may well already have been started by either of the two companies predominantly responsible for the national supply of large fish.

A range of new ready to cook boneless portions would have the potential to utilise more than a thousand tonnes of fish per annum while the expansion of demand for raw fillet and portions arguably has the greatest potential and least risk as it requires less capital investment in R&D and promotional cost.

All in all, the market for farmed barramundi could arguably be increased from the current almost two thousand to about four thousand tonnes, at current prices, with modest investment in product and market R&D and in marketing in a period of about five years.

ISA has the potential to supply part of this increased output by producing a new product range which can be differentiated as inland salt water eco-friendly or organic barramundi (Chapter 8).

Sturgeon

Sturgeon is a fish that has a high value as a table fish and even greater value as a source of caviar. Although it is not native to Australia this species is nominated here for discussion and consideration by industry and government as a prospective fish for ISA R&D, subject to the necessary quarantine precautions, because of the unique biosecurity opportunities offered by inland sites and the somewhat unique market potential for sturgeon.

Sturgeon has a strong market image and a substantial latent demand for table fish and caviar, especially the latter, in Australia and nearby South Pacific countries, remarkably similar to those of Atlantic salmon some 20 years ago. ISA is uniquely positioned to be part of such an exciting new development.

5.7.1.12. Options for ISA market development

A number of species including black tiger prawns, mulloway and rainbow trout are being grown in a profitable manner in inland saline waters. The traditional market for each of these species is capable of further growth at a modest rate with the now characteristic passive selling and minimal investment in market development typical of most Australian aquaculture sectors.

The alternative is for farmers in ISA, and indeed traditional aquaculture to individually and/or collectively invest more heavily in product and market R&D to accelerate product and market diversification and substantially raise aggregate demand for seafood.

The ISA industry has a number of options for market and supply chain development:

- Stick with the status quo and stay with the existing traditional markets;
- Supply a new or alternative market with existing species/products – the eco market suggested in Chapter 6.
- Create an entirely new product range for the organic market.

These strategic options are not mutually exclusive, two or three of them can be adopted simultaneously, or sequentially as listed, and described below.

Whatever approach is selected by new ISA enterprises it would be advantageous for them to differentiate their product as ISA as part of their market entry strategy in order to find their first customers and make their first transaction at a price equal to (or greater) than that from traditional product. This avoids direct price competition with the traditional marine or freshwater product and being “forced” to take a lower price simply because of inexperience in a seemingly crowded market.

Market development

The status quo

This option is easily and quickly adopted with minimal costs but it has limitations on long term profitability because it entails competing with existing freshwater or marine produce growers in traditional marketing channels for existing consumers.

Furthermore these existing supply chains, characterised by passive selling rather than active or innovative marketing, offer average prices and profit margins only and are likely to only record single digit growth per annum without a boost in marketing effort.

This approach is unlikely to prove profitable for some ISA producers because new producers frequently start business as price takers and remain so, and as the last supplier to a particular customer are likely to be the first to be dropped or offered low prices when product supply exceeds demand.

A new eco market

There are a number of food distributors and retailers, and seafood merchants, who are interested in environmental and ecological matters and prepared to support new products that have some environmentally friendly feature or benefit – the “eco-friendly fish”. These people in turn sell their products to businesses and consumers who are also concerned about their environment and wish to make some positive contribution to bettering the global environment and ecological outlook.

Most ISA ventures would have some environmentally friendly feature that can be used to differentiate the product from competitive freshwater or marine product and thereby gain preferred product status and probably a price premium with such distributors, retailers and consumers.

Furthermore fish grown in inland saline waters could be promoted as having a unique taste thereby adding to their appeal for environmentally concerned consumers.

This eco-friendly supply chain may not necessarily offer a greater return to farmers at the beginning but it represents a stronger marketing chain as it involves like minded or environmentally concerned participants and offers more security in the long run.

As indicated earlier this option can be:

- Adopted on its own as a market entry strategy.
- Adopted in tandem with option one on market entry.
- Added to option one for market expansion.
- Adopted as a replacement for option one at some appropriate time.

There is a gap in the marketplace for eco-friendly fish and for organic fish because there is a latent demand for these types of products from environmentally concerned consumers and organic produce consumers respectively. Growers markets and organic markets are increasing in numbers and in their geographical spread around the country and they now represent a substantial number of outlets (see the www.organicfoodmarkets.com.au web site for details).

The introduction of such new products to supply the eco market will require considerable time and money for market entry and for ongoing market expansion and a budget allocation of around $10,000 or more per annum for the first three or so years. In return it offers opportunities for a significant price premium and above average profits for produce and perhaps the greatest market potential over the long term.

Eco-friendly seafood does not have to be promoted in an aggressive manner viz a viz traditional aquaculture produce with unsubstantiated claims that they are better. The eco-friendly feature of the ISA product offers a “feel good” psychic benefit along with a new/different flavour to environmentally concerned consumers and this provides a unique selling proposition for the ISA sector.

ISA produce can be labelled, tagged and promoted as different, subtly different to traditional produce from marine or fresh waters. After all it is the consumer’s perception of taste that matters and some consumers will perceive a different taste from each farm.

Organic seafood market

The organic food market is currently a small but rapidly growing market segment in Australia and elsewhere but there is negligible certified organic farmed seafood on offer in this country yet and a Sydney restaurateur recently lamented this absence of organic seafood in the widely read Daily Telegraph of 19 May 2004 (see following page).

Organically grown, certified, black tiger shrimp from Vietnam are currently a featured item in a Swiss supermarket chain which reports strong demand for organic seafood (Sporrer 2004). The Vietnamese farmers receive a 20% price premium over traditionally farmed black tiger shrimps.

According to John Newton, writing in the quarterly Eco feature in the Sydney Morning Herald of June 2003, and quoting figures from the Rural Industries R&D Corporation, the organic food market in Australia is growing at a rate of 10 – 20% per annum and valued at about $300 million in 2002.

The organic food market prefers certified organic foods and hence it is really accessible only to farmers growing according to prescribed principles and with the willingness to invest the necessary time and funds to this development path. This requires funds for inspection, certification and promotion of the organic seafood; the promotion funds needed for this option are about $5,000 to $10,000 per annum for the first few years.

However farmers aiming for eventual certification can start an organic seafood supply chain with seafood grown according to organic principles provided it is sold as such without implying that it is ***certified*** organic.

The market demand for organic seafood (or eco seafood) is unknown and so the cost-benefit ratio of certification and meeting on going requirements is difficult to quantify and may not prove attractive in the short-term. Demand for organic produce however is not limited to the current consumers; these foods most probably appeal also to eco friendly consumers and conventional consumers who also perceive that they offer more health benefits and/or taste than conventional production methods.

It is noteworthy that European research on the motivation driving organic food buyers has shown that health concerns are the main driver (cited by 74% of respondents) but environmental aspects are almost as important being cited by 60% of interviewees (Sporrer 2004). This augers well for organic and Eco seafood. Equally noteworthy is the finding that 56% of interviewees were prepared to pay more than 15% extra for organic food.

The organic food development option can also be adopted at the commencement of business or it can be adopted at some appropriate time on its own or in combination with the other options when deemed appropriate. It too offers opportunities for price premiums and higher profits per kilogram of fish than the traditional markets.

It may however prove best for new entrants to ISA interested in the organic market as a long term goal to plan for supplying the eco market and entering the organic supply chain later when their output and market demand grows and resources permit.

Article from the Sydney Daily Telegraphy

Fringe benefits of organic idea

Cafe owners **Betty Leone** and **Rebecca Simmonds** left high-flying corporate careers to open a Surry Hills cafe. One year on, they've succeeded in obtaining organic certification for the business, **Fringe Cafe**.

It's Australia's first licensed certified organic restaurant. The stringent certification process involved everything from the ingredients to the detergents used in the kitchen.

"We wanted to sell organic foods for the joy of eating *real* food with real flavour," says Leone. "We are also very concerned about issues like Genetically modified [GM] foods and think their sale elsewhere is just the thin of the wedge.

"We also want to support Australian farmers."

Despite the certification, only about half the menu is organic.

"We couldn't offer a fully certified organic menu because certain foods are simply not available. For instance, there's no certified organic seafood," says Leone.

To obtain organic certification, foods must have been grown without artificial fertilisers, herbicides or pesticides and they cannot be artificially ripened.

Organic dishes already popular with customers include porridge with fruit and honey at breakfast; gnocchi; beef and pizza later in the day.

❑ *Fringe Cafe, 23-33 Mary St, Surry Hills, 9280 1161. Open breakfast and lunch, Monday to Saturday*

Fresh concept: the Fringe Cafe in Mary St, Surry Hills is Australia's first licensed certified organic restaurant *Picture: KATRINA TEPPER*

34—THE DAILY TELEGRAPH, www.dailytelegraph.com.au Wednesday, May 19, 2004—34

Existing ISA farmers can create a new image and new markets for their product by clearly differentiating it as an eco-friendly produce from the mass produced item with attractive tags or labelling as appropriate and at some later time introducing organic seafood and labelling when this option looks attractive.

An eco umbrella program

A further step in ISA industry development, that warrants attention when the sector has developed some critical mass with more produce and financial resources, would be for ISA farmers to work together to generically promote the full range of ISA product (prawns, finfish and other products as they become available), and to promote their industry sector through some type of eco umbrella group.

This group can start in an informal and ad-hoc way and develop a more formal structure later but working with the long term aim of introducing an ISA Code of Practice and an umbrella eco brand, with a vision statement and marketing slogan such as Working With Nature, Producing New Flavours. This collective marketing approach would allow for a pooling of resources and skills to protect the integrity of their eco products and to maximise the impact from limited financial resources.

Any regional or national Eco branding exercise is a major undertaking which needs to be carefully planned and implemented with consideration to costs-benefits, standards, registration/certification, and compliance issues.

Finally, all of the discussion in this section is relevant to domestic as well as export markets—but with higher export market development costs —however it would be prudent for new entrants to aquaculture and seafood marketing to develop seafood handling and marketing skills locally before embarking on more distant national or international markets.

Supply chain development and management

Supply chain management is still a little known subject for many aquaculturists and their trading partners but there is sufficient evidence that supply chain management has much to offer as a business management strategy and therefore warrants greater consideration in business and marketing planning.

To quote from Jan van Roekel, the Managing Director of Agri Chain Competence Foundation of the Netherlands *"It is becoming increasingly evident that achievement of the desired market position cannot be achieved solely through the company's own efforts. Because each company is just one link in the production chain, with upstream and downstream links, it has to cooperate. The more effectively it does this, the stronger its competitive position in the marketplace"* (DPIE 1998).

Closer to home, Queensland fisher Sandy Woods Meredith reports that active participation and reformation of his supply chain ensured the survival of his fish export business when it was faced with several hurdles (DPIE 1998).

The Australian Government Department of Agriculture, Fisheries & Forestry (AFFA) has a number of initiatives to assist agribusinesses, including aquaculture, in training and implementation of supply chains. The National Food Industry Strategy offers $20,000 of supply chain mentoring to agribusiness. More details on this can be obtained from Stuart.Clarke@agric.wa.gov.au

The AFFA Agribusiness Supply Chains – Learning From Others CD (compact disk) with its training workbook, case studies, readings and other materials is a valuable resource, available gratis, by telephoning 1300 884 588. (Or go to the web site www.affa.gov.au/content/output.cfm?ObjectID=631078B5-8755-4801-865B46677B3CB9D8. The CD is an excellent starting point for individuals or groups interested in exploring this subject.

The workbook available in this CD provides a number of modules which allow the readers to assess their current situation and supply chain partners. It also poses a number of questions which allows an assessment of one's readiness to engage in partnering and compatibility with input suppliers and customers. It also provides a number of useful contacts from where further assistance may be obtained.

AFFA's National Food Industry Strategy is also funding a new Supply Chain initiative specifically for the seafood industry. This was announced in July 2004 and so is still in the planning stages but information on this can be obtained from Seafood Services Australia by telephoning Alan Snow on 1300 130 321.

The strategic issue of forming a supply chain (the why, when and how questions) is covered in detail in the AFFA Agribusiness Supply Chains CD and so will not be repeated here. The remainder of this chapter reviews a number of tactical or operational issues in terms of the six key principles for managing supply chains, using examples and questions raised by this ISA study.

<u>*Tactical considerations*</u>

Six key supply chain management principles

1. *Focus on customers and consumers*
   - Customers and consumers are usually not the same people;
   - Consumers are the last person to handle the food, and they look for quality, value and convenience when they eat your seafood at home or when dining out;
   - Your customers are business people who provide products or services to you or others;
   - The consumer's wants and needs are different to those of your customers;

Producers should move away from the current focus on the production of fish and focus more on supplying the product and service the customer and consumer wants, when and how they want it.

2. *Creating and sharing value*
   - Do your chain partners share your values regarding seafood and service?
   - Do you understand what role they play in getting seafood to the consumer?
   - Do your input suppliers understand what you are doing, and why?
   - Do you understand how your distributors add value to your product?

Producers sometimes rush to enlist customers and later find they have their new Rolls Royce on sale in a second hand car lot. If your product and service is good be selective.

3. *Getting the product right*
   - Is your product tasty, safe to eat and with sufficient shelf life for consumers?
   - Is your seafood packed in a manner suitable for your customer.
   - Is your seafood packed in a manner suitable for your consumers.
   - Is the product size grading true to label.
   - Is the product taste, appearance and shelf life consistent from one batch to another?

Think about products and not just species: a 750 gm fish is a poor product for most species because its uses are limited at this size. Product size grading and taste consistency are widely mentioned by buyers as needing improvement.

4. *Ensuring effective logistics and distribution*
   - Is your delivery schedule designed around your comfort or needs, or your customers' and consumers' needs.
   - Can you offer more frequent delivery.
   - Can you offer delivery at a day/time which will give your customers some competitive advantage.

- Is your paper work in order and do you fill orders efficiently.
- Do you ever check the temperature control of your product in transit?

Many wholesalers report that lead times required on some fish orders are too long and thereby prevent them using more of this fish.

5. Having an information and communication strategy

- Can you give your customers more/better information on your product's features and benefits to help develop the market?
- Do you have consumer information materials to help promote sales as well as trade promotion materials?
- Do you seek and receive feedback from customers and consumers on what you can do to improve your product and service?
- Are you getting regular market information news from your customers.
- Do you or one of your representatives visit customers and suppliers at least once a year.
- Are you open and honest on market prices with fellow producers.
- Do you communicate changes in supply schedule and product availability to customers quickly.

Open up and encourage frequent and frank feedback of comments (complimentary and critical) and market information up and down the supply chain. Most producers use one leaflet to inform the trade and consumers; customers and consumers have different interests so different materials/messages are needed to effectively communicate the key points for each group.

6. Building effective relationships

- Are you "good friends" with your customers, do you "just do business" or is it a case of "everyone is out to get the best deal possible"? Business is better when dealing with people you like; its easier building long term relationships with people like yourself.
- Do you regard customers as business partners or "middlemen" Do you sell to your customer's customers and in effect undercut your primary distributor? Work with your customers to grow the market together, don't compete with your distributor.
- Are you capable of discussing prices and terms of payment with suppliers and customers in a confident and constructive manner? If not comfortable dealing with customers or input suppliers ask someone else more capable in this area to do so.

Do not promise more than you can deliver in regard to product quality, product consistency or service; it's better to under-promise and then over-deliver on expectations.

Finally, some observations on selling prices and payment terms. Producer interviewees commonly expressed frustration over low prices and slow payments and one occasionally hears talk of collusion and a "Greek cartel" or "Greek mafia" in the seafood trade in Sydney or Melbourne. This sort of talk is unfounded and arises out of ignorance or a wish to promote one's own company or interests at the expense of the so called Greek fish merchants.

Anyone walking around the Sydney or Melbourne fish markets will see a great cultural diversity and open competition, and not collusion, between buyers; anyone long familiar with the industry in either city can tell of sibling rivalry and litigation over business interests that rebut the idea of collusion.

Fish buyers are well informed on market conditions and prices and hence in a strong negotiating position especially when dealing with new fish farmers or ill informed "old hands". It is not an unusual business practice to delay paying creditors and to diligently pursue outstanding debtors.

Producers can be equally efficient and powerful by sharing market intelligence (on prices “bad payers”, etc.) with each other honestly so they can be as well informed as the buyers; after all knowledge is power. Furthermore by negotiating agreeable payment terms as well as prices before finalising a sale they are not at the mercy of buyers who take advantage of the fact that a payment date was never discussed.

5.7.1.13. General discussion and conclusions

The Australian market for seafood has been growing at a steady but modest rate each year but the contribution of Australian aquaculture produce to national consumption remains small given that most of the tuna farmed here is eaten in Japan. However the population is growing and has a preference for produce of Australia, so Australian aquaculturists have ample opportunity to play a greater role in supplying seafood to consumers here and in overseas markets.

The market outlook for Australian aquaculture is mostly positive but the market demand and price outlook for a particular species is difficult to quantify because there are many factors involved, and we cannot foresee the cumulative impact of a simultaneous rapid increase in output of several species such as barramundi, trout, kingfish and mulloway over the next few years.

As suggested earlier the market for any one species could be expanded profitably by a two or three thousand tonnes over three to five years with active marketing efforts but it is unlikely that the Australian market could “absorb” an extra 10,000 tonnes from all farmed species over a few years without substantial declines in prices of at least one and/or a cannibalisation of market share of another, unless the seafood industry invests far more heavily in new product development and market promotion than it has in the past, to gain a substantial boost in aggregate consumption per capita.

After all, Australian aggregate seafood consumption only increased at a rate of less than 2 percent per annum in the 1990s (FRDC 2002), with incredible volumes of free publicity on the health benefits of eating seafood and the farmed fish are now competing for space on a restaurant menu or retail display which has limited room for all of the seafood products available today.

While marketing has gained a high place on the national aquaculture agenda there is as yet little investment in marketing by most sectors or companies with the notable exception of the Tasmanian salmonid enterprises.

Any industry sector wanting to expand output rapidly and profitably has to invest in new product and market development otherwise it must be content with the more modest growth rates of about 10 – 20% per annum seen to date.

The prevailing reliance on selling whole raw fish to Sydney needs to be diminished through product and market diversification so more consumers can get the quick and easy meals that they want these days (Ruello & Associates 2002).

The demand level and market growth rates achieved by any industry group or company will depend on the effort expended: the dollars and creativity invested in product and market diversification. Creative ideas are needed to make up for the limited funds commonly available in seafood marketing.

Many farmers have insufficient working capital and do not recognise that marketing is just as essential for long term survival as when a new pump is needed to save an enterprise from an impending disaster. But market planning and adequate investment in marketing is critical to success.

Ideally fish production and marketing should be coordinated so that supply and demand can be increased in parallel but better communication and greater collaboration between farmers is needed to achieve this.

Overseas markets are often seen as a panacea by Australian aquaculturists but they are no easier – and arguably more difficult/less profitable because of cultural problems, added costs and currency uncertainties – because competition is rife in all significant markets and the same marketing principles apply overseas as they do here.

Regardless of markets, success depends on being a cost effective, well informed producer with effective marketing.

The ISA sector can continue to grow alongside the traditional aquaculture industry but it also has new opportunities available because it offers new products and flavours from known (and new) species and it has the potential to tap into the latent demand for eco-friendly products and the existing organic food supply chains with their higher price premium; additionally it is well placed to serve inland consumers wanting fresh seafood. Tourism is another avenue for income generation in some situations.

Farmers growing seafood in inland areas with rising salinity or other problems have a particularly interesting good news story which can be used to promote their product and business in an inexpensive manner.

Supply chain management (SCM) is still essentially an unknown subject for most aquaculturists but it has much to offer as a business management strategy and it therefore warrants greater consideration in business planning. A consideration of the six key principles of SCM is of value to existing farmers as well as prospective aquaculturists, because many current growers have not yet critically reviewed their traditional marketing practices.

The Australian Government Department of Agriculture, Fisheries & Forestry (AFFA) has a number of initiatives to assist agribusiness including aquaculture to help in training and implementation of supply chains. Most come at no cost to industry and some offer access to grants so they are all are worthy of examination.

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5.7.1.15. Acknowledgments

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5.7.2. Inland saltwater aquaculture saltwater trout: A case study in supply chain development

Jasper Trendall

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5.7.2.1. Summary

At a time when freshwater is in limited or short supply one of the attractions of inland saltwater is the abundance of the resource – there are very large volumes and they are widely distributed. The ability to grow a high quality rainbow trout using inland saltwater is now well established. The challenge is to move beyond a small number of individual enterprises and translate the abundance of the resource into an industry that is able to achieve economies of scale and deliver sustainable economic, environmental and social returns.

The development of saltwater trout production in Western Australia has been based on the Farm Diversification business model. This reflects the fact that the early stages of any new industry lack the track-record of profitable performance necessary for dedicated business enterprise investment. Farmers producing small volumes as a way of diversifying farm income have a critical interest in the capacity of the supply chain to deliver secure market access. The ability of producers to aggregate product in volume or over time and thereby improve market access and income predictability can be a key benefit of supply chain participation for small producers. This form of engagement in a supply chain requires collaboration in two dimensions – horizontal and vertical.

All supply chains share a basic set of common features which drive and maintain participant loyalty to the operation and success of the chain:

- It must deliver tangible benefits for the participants. These benefits must be derived from the supply chain and not otherwise be easily available.
- The performance and benefits of the supply chain must be measurable;
- The flow of all transactions, especially information, must be open and transparent;

The Saltwater Trout Alliance Incorporated is a small group of primary producers that are working together to farm and sell rainbow trout that have been grown using inland saltwater. The Alliance was established in October 2001 and its members have undertaken a range of activities to identify markets, trade saltwater trout and develop the supply chain capacity that is needed to operate commercially.

The Alliance has planned and implemented supply chains for several product types including: Hot-smoked trout supplied to local restaurants; deboned trout supplied directly to local restaurants, and; Whole fresh trout supplied to retail outlets in Perth.

This report is based on the approach one small group of regional producers in the south-west of Western Australia have taken to the main problem that faces all regional producers and especially in new industries. How to get product from farm to market and sell it? This case study uses the experience of saltwater trout to outline the general principles involved in building a regional supply chain for inland saltwater aquaculture.

5.7.2.2. Inland saltwater aquaculture and regional supply chains

Salinity has changed the landscape of Australia and altered the balance of resources available to farmers. There is now more saltwater and less land available for conventional cropping. Primary producers affected by salinity need new ways of using their land and water to generate a sustainable income. After more than six years of exploratory work and pilot-scale production by farmers in the south-west of Western Australia, the growing of rainbow trout using inland saltwater has been identified as a new production opportunity.

At a time when freshwater is in limited or short supply one of the attractions of inland saltwater is the abundance of the resource – there are very large volumes and they are widely distributed. The ability to grow a high quality rainbow trout using inland saltwater is now well established, although ongoing research to improve the cost of production will always be of benefit. The challenge is to move beyond a small number of individual enterprises and translate the abundance of the resource into an industry that is able to achieve economies of scale and deliver sustainable economic, environmental and social returns.

For a variety of reasons some degree of producer collaboration is a prerequisite if the production opportunity presented by saltwater trout is to be broadly realised across Australia. Collaboration can occur in many ways and this report is based on the approach one small group of regional producers in the south-west of Western Australia have taken to the main problem that faces all regional producers and especially in new industries. How to get product from farm to market and sell it? This report outlines the general principles involved in building a regional supply chain for inland saltwater aquaculture. It is not intended to be an economic analysis of saltwater trout production.

Basic business models in regional aquaculture

The development of commercial aquaculture is based on the direct investment of cash and the scale of the industry is determined by the scale of investment. This is a function of both the number of producers and the average value of investment by individual producers. Industry growth can be achieved by increasing participation and by increasing the level of investment per participant.

As an example, the yabby farming industry is based on low individual investment by producers but there is a level of participation in the industry which achieves annual gross returns of approximately two million dollars. In contrast, the production of beta-carotene in Western Australia is based on a few large investments, each of which is well in excess of a million dollars.

These two forms of industry development, high investment/low participation and low investment/high participation, have different needs and face different constraints. The approaches to supply chain development are also different. This report uses two industry models to characterise these different approaches and the different constraints to development.

It is important to recognise that both approaches to aquaculture development have a demonstrated ability to deliver very large, industry-scale volumes of production and that they are not mutually exclusive.

Farm diversification or distributed production model

Characteristics

Farmers can potentially participate in aquaculture with minimal investment by utilising existing land and water resources. The underlying objective of the Farm Diversification Model is to maximise the use of farm resources – including land, water, machinery and people. It is characterised by a small cash investment and the commercial value of the aquaculture production is measured through its contribution to the total farm income.

Constraints to growth

For farms which already have access to basic resources, such as land, water and labour, the cash investment involved in aquaculture is generally small (e.g., stock, gear) and not a constraint to participation. The principal constraint is the existence of customers for small or irregular quantities of product.

Development strategy

The development of common supply chain services and infrastructure is essential for industry growth. It is only by pooling product and sharing facilities that small producers are able to achieve sales and a return for small and irregular production.

Business enterprise or centralised production model

Characteristics

An alternative approach to small-scale production using existing farm resources is the establishment of dedicated aquaculture production facilities. In this respect the aquaculture industry has the same basic requirements as any business, with one of the main pre-requisites being a scale of production that will generate sufficient income to cover costs and generate an acceptable profit. The quantity of product that is required for an aquaculture business to be profitable will determine the scale of an entry level investment for the industry.

Constraints to growth

Aquaculture using inland saltwater is a new industry and lacks a track record of production and profitability. The lack of an industry track record means that investment carries a higher level of uncertainty and risk. Information on commercial performance is the key constraint to financial investment.

Development strategy

High-quality, reliable information is the only means of providing the confidence necessary to attract sustainable financial investment. The information required to encourage investment in commercial aquaculture needs to address all of the areas critical for commercial success and not simply the requirements for production. Investment confidence will reflect the degree of risk associated with any of the steps in the supply chain.

Information which defines the commercial opportunities, risks and returns will allow investors to make informed decisions. It will follow that profitable enterprises will attract investment.

Saltwater trout is farm diversification or distributed production

The development of saltwater trout production in Western Australia has been based on the Farm Diversification business model. This reflects the simple reality that the early stage (i.e., 10 to 15 years) of any new industry will lack the track-record of profitable performance necessary for dedicated business enterprise investment.

For farms which already have access to basic resources, such as land, water and labour, the cash investment involved in saltwater trout production is generally small (e.g., stock, gear) and not a major barrier to participation. The principal constraint to investment is the existence of customers for small, irregular quantities of product.

The supply chain development case study in this report is for a group of producers for whom the production of saltwater trout is a supplementary activity to their existing business. It is only by working together to aggregate product and share facilities and services that these producers have been able to access customers and a cash return.

The features of supply chains

A supply chain is the term used to describe the "chain" of participants that are inter-connected or linked together by the transactions that are required to produce, process, transport and deliver a product to a customer. The ultimate function of a supply chain is to meet the perceived needs of customers for particular products.

All businesses in which a product or service is provided to a customer are participants in a supply chain. It is possible for a complex supply chain in which there are lots of raw materials and processing or manufacturing steps can be carried out by a single business. This is termed vertical integration. It is more common for complex supply chains to involve more than one business at different stages in the chain. In primary production there are generally several steps between raw material and customer and farmers are commonly involved in one or more steps of a supply chain.

For practical purposes a supply chain is rarely a simple, one-dimensional sequence of transactions. For example, if a consumer of farmed trout prefers fish with a "natural" red colour in the flesh – then the farmer growing fish needs to source food that will deliver the required colour and the supplier of food needs to use natural pigments in the ingredients. This means the "chain" from hatchery to farmer to processor and ultimately customer will have branches, each with one or more steps. A supply chain and its associated branches is often referred to as a supply network – in this report the terms supply chain and supply network are used interchangeably.

A supply chain involves four key types of transaction:

- *Goods* – these are the "hard" products that have physical requirements for handling, storage and shipping. For example fish, plastic bags, ice, etc..
- *Services* – the "soft" products that are needed to enable transactions between supply chain participants. For example, transport of live fish, book-keeping, quality inspection.
- *Cash* – the movement of cash through the chain. This is ultimately sourced from the consumer and feeds back down the chain – but the nature and timing of the flow of cash is a key difference between an integrated supply chain and a group of independent businesses with a common interest.
- *Information* – the effective and open flow of information across the supply chain is a key driver of transaction efficiency. Information in a supply chain flows in a loop which begins and ends with the customer. It starts with information coming from customers about their requirements and finishes with information going to the customer about the ability of the products to satisfy those requirements.

All supply chains share a basic set of common features which drive and maintain participant loyalty to the operation and success of the chain:

- It must deliver tangible benefits for the participants. These benefits must be derived from the supply chain and not otherwise be easily available.
- The performance and benefits of the supply chain must be measurable.
- The flow of all transactions, especially information, must be open and transparent.

The characteristics of regional supply chains

For primary producers the success of their farm business can be highly dependent on the efficiency of the complete supply chain. In part because there may be few alternative avenues for selling product in regional areas.

Farmers producing small volumes as a way of diversifying farm income have a critical interest in the capacity of the supply chain to deliver secure market access. The ability of producers to aggregate product in volume or over time and thereby improve market access and income predictability can be a key benefit of supply chain participation for small producers. This form of engagement in a supply chain requires collaboration in two dimensions – horizontal and vertical.

The horizontal dimension is the collaboration between producers and the vertical dimension is the collaboration between industry sectors. The ability for farmers to grow and trade small volumes of product is dependent upon effective collaboration in both dimensions. Effective collaboration among producers is a key mechanism for achieving the economies of scale and consistent required for survival in the high volume, low margin trading environments that are typical of commodities such as seafood.

Collaboration is also the mechanism by which producers sustain the services and infrastructure that are required for the vertical dimension of the supply chain. Close relationships between all participants in a supply chain allows producers to develop and maintain long-term relationships with customers that are demanding products that are both highly specialised and competitively priced.

Competent collaboration requires well-developed administration, communication and participation. In the early stages of industry development collaboration between producers is often informal and characterised by industry "associations". In mature industries, the need to reduce the risks associated with large-scale production make formal collaboration between producers essential.

Producers can achieve formal collaboration in a variety of ways, including private shareholder companies, co-operatives and contractual supply arrangements.

The transition from informal collaboration in the early stages of industry development to formal collaboration in later stages can be problematic, particularly for small producers. Establishing an effective mechanism for formal collaboration between producers at an early stage of industry development can potentially assist the transition for individual producers as the industry grows from a small-scale to large-scale production.

5.7.2.3. Saltwater rainbow trout

Background to saltwater rainbow trout

The winter-cropping of rainbow trout in inland saltwater involves two small changes to the traditional way in which trout have traditionally been stocked and farmed in Western Australia. Firstly, the fish are stocked and grown in inland saltwater rather than freshwater. Secondly, the fish are only held and grown for a single season, winter. This allows the trout to be farmed in many areas in which summer water temperatures are too warm for trout.

Rainbow trout have a long history of domestication. They are currently farmed in freshwater ponds and sea cages in Australia. In Western Australia in 2000, the estimated production of approximately 15t per year, valued at $200,000 was entirely from fresh water. This production has now been largely displaced by saltwater trout with approximately 10t of saltwater trout produced in 2003 and less than 5t of freshwater trout.

Like all salmonids, rainbow trout prefer water temperatures below 20˚C, although Western Australian strains appear to be more resistant to higher temperatures. A number of studies have indicated that growth and/or survival of trout in warmer waters is improved at higher salinities.

In 1997 the Department of Fisheries and the Department of Agriculture in Western Australia initiated a project to assess the feasibility of using inland salt water for aquaculture (Trendall and Pitman 1998). After surveying resources on five test farms in 1997, trout were grown out over winter at 6 farms in 1998, achieving satisfactory growth rates and market acceptance. Using trout as a lead species the work was extended over time to include a wide range of participants and the concept of winter-cropping rainbow trout using inland salt water was trialled in some detail to ascertain whether adequate growth rates could be repeated and to assess product quality and consumer acceptance (Trendall and Lymbery, 2000, Temby *et al.* 2002).

Key points include:

- The winter water temperatures of surface water are suitable for the winter-cropping of rainbow trout throughout the wheatbelt of Western Australia.
- Trout are not especially sensitive to water chemistry and are able to survive and grow in a wide variety of inland salt water bodies up to seawater salinities.
- Much inland saltwater is not suitable for aquaculture (including trout) but the abundance of land and saltwater means that even a small proportion of the two million or more hectares estimated to be salt-affected is sufficient to support large-scale production (e.g., 5% = 150,000 hectares in Western Australia).
- Trout have been grown using a range of production techniques: from conventional intensive fish farming using tanks, manufactured food and pumped salt groundwater to extensive ponds with supplemental natural food to achieve a lower cost of production.
- Initial consumer acceptance trials indicate that rainbow trout farmed in inland saltwater can be competitive in quality with similar products in the marketplace, including farmed salmon.

The development of inland saltwater trout production in Western Australia is now largely driven by industry with some support from regional Development Commissions including the Great Southern Development Commission.

<u>Development of a supply chain for saltwater rainbow trout</u>

The current status quo of saltwater trout farming in Western Australia was summarised in a recent review of saltwater trout production that was jointly commissioned by three Regional Development Commissions in Western Australia. The primary conclusion of the review was that the industry *"is viable in a limited form and in specific market segments."* The review estimated the annual size of the fresh rainbow trout market in Western Australia at 23 tons per year in 2001 and identified a number of competitive advantages that WA producers have over Victorian producers in this niche market.

Producers in the Great Southern region have a number of competitive advantages over producers further east and north in Western Australia. The region has a cooler summer climate which helps maintain continuity of supply, there are lower transport costs to access stock from Pemberton hatcheries which helps lower the cost of production and there are established facilities in Albany for handling seafood which helps access consumables such as ice and packaging.

The Saltwater Trout Alliance Incorporated is a small group of primary producers that are working together to farm and sell rainbow trout that have been grown using inland saltwater. The Alliance was established in October 2001 and its members have undertaken a range of activities to identify markets, trade saltwater trout and develop the supply chain capacity that is needed to operate commercially.

The collaboration between the participants in the Alliance is relatively informal with a minimum of prescriptive or regulatory regimes. The emphasis has been on participation that reflects willingness and a commitment to be actively involved. The Alliance effectively combines both horizontal and vertical dimensions of collaboration. Alliance producers work together to manage production and harvesting and vertical supply chain participants (e.g., hatchery, retail customers) use the Alliance as a vehicle to engage directly with producers.

5.7.2.4. Planning a supply chain

There are two stages to the process outlined in this report.

The first stage involves assembling information about a new supply chain and is the first and most important stage of building a new regional supply chain. It is a planning stage and the outcome is a Supply Chain Plan. The strength and substance of the Supply Chain Plan underwrite any decision to proceed with the practical implementation of the proposed chain. For example, market research is an essential component of a Supply Chain Plan because it identifies the end-point customer in a chain.

The second stage is the translation of a Supply Chain Plan into a functional trading network. This is the implementation part of the process and it involves a financial and time commitment from all of the participants in the chain and the outcome is a detailed analysis of all transactions, including the benefits for each participant.

<u>The process of planning a supply chain</u>

The process of planning a supply chain involves preparing a detailed plan which becomes a basis for building and implementing supply chain function. The plan should also enable a determination to be made about the relative costs and risks associated with various supply chain options and the resources and commitment that will be required if the plan is to be implemented.

This planning process builds a picture of the participants and resources that already exist, their actual and potential capacity, the products that can be delivered, the markets for those products and the benefits that might be generated. If there is sufficient information to proceed then individual supply chains can be specified and budgeted for each product. The specifications for the supply chain also include the standards for measuring the performance and success or failure of the chain.

It recognises that a supply chain is dynamic in that it functions and is driven by the interaction and communication between the participants. The process of assembling the components and resources needed for the supply chain to operate will be wasted without active involvement by the participants.

Assessing production capacity

In the same way that market research is a pre-requisite to assessing the ability of a supply chain to deliver a product and generate benefits for the participants, some level of demonstrated production performance is a prerequisite for establishing that a supply chain has production competence.

A recorded history of production is the simplest way of demonstrating the capacity to deliver a product. There are many variables that can influence production. Some of these are within the control of the producer and some, such as climate and disease, may be out of the control of the producer. A production history that extends over several production “seasons” will provide greater confidence in the basis for establishment of a supply chain.

The absence of a demonstrated production history indicates that there is little point in attempting to develop a supply chain plan. Farmers in the Great Southern region were the first in Western Australia to trial the production of saltwater trout in 1997 and the members of the Alliance have accumulated a substantial body of experience in the growing, processing and marketing of saltwater trout.

Importantly, the Alliance includes a hatchery as part of the supply chain and a secure hatchery/nursery capability are critical requirements for long-term production growth.

The producers currently available to the supply chain have the capacity to:

- Grow rainbow or brown trout.
- Grow the fish in fresh and/or saltwater.
- Grow the fish to sizes between 300 and 800 g.
- Hold some fish for 12 months of the year.
- Process fish.
- Hot-smoke fish.
- Freeze and store fish.
- Sell fresh and frozen fish.
- Comply with AQIS and Foodsafe processing requirements.
- Assess fish for taste and appearance.
- Facilitate communication between members of the supply chain.

Potential capacity:

- Cold-smoking facilities.
- Wholesale distribution.
- Comply with on-farm HACCP requirements.
- Comply with on-farm environmental management system.

Assessing products

In practical terms the scope of operation of a supply chain is determined by the physical capacity of its participants to deliver a product and the form of the product or products sets practical boundaries for the scope and definition of markets and customers.

Once the production capacity that is available to the chain has been identified then the ability to deliver actual and potential products can be determined.

The plan needs to recognise both actual and potential products. The definition of the products will need to be related to the conclusions or outcomes of the market research but some degree of flexibility is essential. Once a list of actual and potential products has been determined then additional market research can be used to help refine and review the list of products that can be delivered by the supply chain.

The key product feature for the Alliance is a perception of superior product quality for saltwater rainbow trout. In comparison with other salmonid species they are judged to be closer in quality to ocean trout and Atlantic salmon than to freshwater rainbow trout. There has been some formal product testing which supports the perception of a quality difference and extensive informal consumer taste testing. The principal measure of quality perception used by the Alliance is repeat customer purchase.

It is essential to recognise that there is quality variation within any seafood category – there is both good and poor quality Atlantic salmon, ocean trout and freshwater trout. The capacity to differentiate product in the marketplace on the basis of quality is only partially driven by technical measurement of perceived quality or taste. The most important factor is the efficiency of the supply chain in quality management and control at all stages – from the farm through to the point-of-sale. The Alliance has placed initial emphasis on quality management rather than technical measurement of any perceived quality difference. A customer does not care if a fish is supposed to taste better if it doesn't actually taste better.

Actual product forms:

- Fresh.
- Frozen.
- Whole.
- Gilled and gutted.
- Fillet (with pinbones).
- Fillet (boneless).
- Boneless whole.
- Hot-smoked gilled and gutted fish.

Potential product forms:

- Hot-smoked fillet.
- Cold-smoked fillet.
- Cooked fish in any of the above forms.

Assessing markets

Some form of market research is a pre-requisite before there is any serious attempt to commission a supply chain. Without market research there will be little or no basis for specifying the products and benefits that might be achievable through the formation of a supply chain.

There are many different ways in which effective market research can be undertaken. Desk-top analysis is a common approach and there are well defined procedures for surveying buyers, sellers and transactions in any marketplace. Alternative approaches may include informal collaboration by prospective supply chain participants to actively test the value and volume of a market by delivering product in limited volumes or over a limited time.

The quality of information that is obtained from the market research will determine the strength of the supply chain plan and the confidence of the participants. One of the difficulties with attempting to prescribe a particular type of marketing research is that it can be very difficult to establish good estimates of value and volume for new products. Farm diversification often involves the development of products which are "new" to a particular market and it can be almost impossible to get good information for something with which consumers have little or no experience.

In whatever way it is achieved the aim of initial market research is to provide a clear understanding of the extent to which prospective products and markets can be defined and the risks associated with any lack of clarity.

The benchmark prices in the seafood trade for a new rainbow trout product are set by freshwater trout. This reflects ready availability and established margins for existing supply chain participants for rainbow trout from freshwater producers.

Key buying factors:

- Consistency (taste, colour and size).
- Freshness.
- Gutting/gilling.
- Delivery reliability.
- Year round supply.

Buy price for fresh fish:

- Supermarkets $9 – 10/Kg.
- Fish Shops $8.50 – 12/Kg.
- Catering $10 – 14/Kg.

Assessing the availability of resources

The resources are the physical facilities that are required to carry out the transactions involved in the supply chain. The resource list should include everything that will be required for the chain to work. It will include both participants who are actively engaged in the supply chain and service providers who may be contracted or employed as part of the supply chain activities. The resources can also be split into those resources that already exist (actual resources) and those that do not currently exist but may possibly be accessed (potential resources). This division recognises that some resources will be immediately available while access to others may involve one or more constraints.

From the list of resources that can be accessed by the prospective supply chain an assessment of the resources for supply chain operations can be carried out. The resource assessment will also recognise actual and potential resources and it provides the context for specifying the structure and function of the supply chain.

Actual resources available for the Supply Chain:

- Customer.
- Restaurant.
- Gourmet delicatessen.
- Fish retail shop.

- Fish processor and packer.
- Producer.
- Nursery.
- Hatchery.
- Supply of various production and processing equipment.
- Certification of on-farm quality compliance.
- Certification of quality of fish for taste and colour.
- Transport of fish from processor to restaurant.
- Collection and distribution of money.
- Administration.
- Communication.

Potential resources available for the supply chain:

- Transport of live fish from hatchery to nursery to farm.
- Marketing and promotion.
- Transport of chilled fish from farm to processor.
- Certification of on-farm environmental compliance.
- Processor for hot and/or cold-smoking fish.

Assessing the benefits for supply chain participants

The catalyst that is needed to start a supply chain for a new primary production industry is the identification of incentives or benefits for key stakeholders. The adequacy of the incentives is linked to both the extent of the benefit and the timeframe over which it is likely to be realised.

The benefit assessment provides a framework within which the participants in the chain can commit to initial involvement and then review their on-going participation as the supply chain develops. It is essential that there is a net benefit derived from the continuity of supply chain relationships.

The balance of benefits from building a long-term supply chain relationship must be positive and if there are any short-term costs they must be clearly offset by significant medium to long-term gains.

The business skill in investing in supply chain function is to be able to evaluate the individual enterprise in a supply chain context and be able to identify those benefits which can only be realised through the supply chain participation. Ultimately this recognises that a successful supply chain is greater than the sum of its parts.

For example, for farm diversification this may mean that the supply chain function delivers outcomes that cannot be achieved by the individual enterprises. For example, shared costs for processing and common services.

Actual benefits for participants:

- *Customers*. Regular supply. Fresh product, Consistent colour and flavour.
- *Processors*. Regular work.
- *Producers*. Access to markets, Predictable and price, Quality control.
- *Nursery*. Predictable demand, Consistent price.
- *Hatchery.* Predictable demand, Consistent price.

Potential benefits for participants:

- *Customers.* Compliance with environmental accreditation.
- *Retail outlets*. Product difference.

Completing a supply chain plan

The completed supply chain plan draws together the information that has been compiled by the assessments of production capacity, products, markets, resources and participant benefits. The plan may include flowcharts which represent the supply chain graphically.

A plan will enable a producer to identify the supply chain options for the farm diversification venture that is under consideration. It will also allow the producer to evaluate the likely costs and risks associated with each of the supply chain options and the farm diversification venture.

A completed supply chain plan should contain sufficient information for a decision to either proceed with implementation and supply chain specification or to obtain more information on one or more aspects of the supply chain plan before proceeding with implementation.

5.7.2.5. Implementing a supply chain

The process of implementing a supply chain plan from concept to functioning reality uses detailed tables to specify the form (or structure) of the supply chain; the function (or operation) of the supply chain, and; the benefits or incentives that the chain provides to the individual participants.

For every product and market there will be a separate supply chain. If there are many similar products entering the same or similar markets then there can be substantial overlap between the different chains. However, for the purpose of implementing a plan and understanding the processes involved a separate supply chain specification should be constructed for each product in each market.

The Alliance has planned and implemented supply chains for three product types: Hot-smoked trout supplied to local restaurants through a distributor; deboned trout supplied directly to local restaurants, and; whole fresh trout supplied to retail outlets in Perth.

Specifying the form of a supply chain

Having identified a product and market – specify the physical supply chain that is required to service the customers. Start at the top of the chain with the customer who will be purchasing the product. This is the decision that ultimately fuels the operation of the chain.

Then work back down the chain identifying each essential link – including services which may or may not be considered formal participants in the supply chain. It may be that there are additional links that are not recognised or specified at this stage.

Hot-smoked saltwater trout

The principal feature of this supply chain is that it uses frozen product that can be stored for more than 12 months after harvest. This enables seasonal harvesting of quantities of fish, primary processing and then freezer storage and progressive release for smoking and sale. The product has a comparatively low value and is distributed to restaurants and cafes that sell fish meals with a plate value between $15 and $21.

Table 1. Form of supply chain for hot-smoked saltwater trout.

PRODUCT		Hot-smoked gill-gut vacuum packed trout.
	Description	300 g to 350 g Frozen gill-gut fish in freezer storage quality assured for colour and flavour.
CUSTOMER		Regional restaurants and cafes.
	Description	Low to mid-price meals &$15 to $21 per plate).
PARTICIPANTS		
	Point of sale	Local restaurants and cafes.
	Distribution	Local distributor.
	Packaging	Local processor.
	Hot-smoking	Local processor.
	Processing	Producer.
	Production	All producers.
	Nursery	Nursery supplier A.
	Hatchery	Hatchery supplier A.
		Hatchery supplier B.
SERVICES		
	Quality Control	Producers.
	Accounts	Producers.
	Scheduling	Local distributor.
	Food supplier	Local food distributor.
	Transport	Local distributor.
	Storage	Local processor.
		Local distributor.

Deboned whole saltwater trout

This product was introduced in response to market research that clearly identified consumer demand for a trout product without bones.

There was resistance to the product form at both the processor and retailer levels of the supply chain. The slower processing rate required to deliver a boneless product means that the hourly throughput in the processing facility is low. The profit margin in $/Kg is no greater than more conventional forms of processing (such as gill-gut or fillet) and the lower throughput at a similar profit margin results in lower profitability for the processor.

The restaurants that were supplied with sample products expressed enthusiasm for the product but doubt that it could initially achieve a plate-price required to sustain the full product cost. This was based on a perception that customers would not necessarily pay more for a boneless saltwater trout than a conventional rainbow trout. Initial pilot trials at a lower entry price have been very successful and there is now demand from the restaurant partner for an ongoing supply of product but the chain was discontinued because the processor costs could not be sustained.

Table 2. Form of supply chain for deboned whole saltwater trout.

PRODUCT		hole deboned fish.
	escription	00 g to 380 g weekly supply quality assured for colour and flavour.
CUSTOMER		iner at local restaurant.
	escription	isitor to the region looking for a local dish that used local ingredients.
PARTICIPANTS		
	oint of sale	ocal restaurants.
	istribution	ocal distributor.
	ackaging	ocal processor.
	rocessing	ocal processor.
	roduction	ll producers.
	ursery	ursery A, B.
	atchery	atchery A.
SERVICES		
	uality Control	lliance.
	ccounts	lliance.
	cheduling	lliance.
	ood supplier	ood supplier A.

<u>Fresh whole saltwater trout</u>

Initial samples of fresh whole fish were well received with the continuity of supply and quality were the principal concerns raised by prospective retail partners. Retail partners include specialist seafood retailers who handles only high-quality fresh fish.

Initial acceptance of the fish at low volumes was followed by demand for increased supplies. Transportation and product handling are based on the simplest possible form of supply chain – in which the fish are transported directly from the producer to the retailer without intermediate packing and handling. The benefits of this chain form are lower cost and quicker delivery.

The principal concerns raised by the retail partner is quality assurance associated with the timing of delivery and handling for whole fish.

Table 3. Function of supply chain for whole fresh saltwater trout.

PRODUCT		Whole fresh fish.
	Description	350 g to 450 g Fresh weekly supply. Quality assured for colour and flavour.
CUSTOMER		Shopper at retail fish outlet.
PARTICIPANTS		
	Point of sale	Retail Stores.
	Distribution	Contracted transport.
	Packaging	Chiller.
	Processing	None.
	Production	Producers.
	Nursery	Nursery supplier.
	Hatchery	Hatchery supplier A.
		Hatchery supplier B.
SERVICES		
	Quality control	Producers.
	Accounts	Alliance.
	Scheduling	Alliance.
	Food supplier	Local food distributor.
	Transport	Contract service.

Specifying the benefits of a supply chain

The benefits that are realised through participation in the supply chain can be measured by comparing them with the benefits that would be realised by participants in the absence of the supply chain. The first step is to use a comparative analysis of benefits that can exist with and without the supply chain. A general comparative analysis is then used to identify key benefits that can be benchmarked and measured. If the supply chain is unable to deliver benefits it may not sustain itself. Determining if there is a benefit for individual participants will need to recognise that it may take time to achieve some benefits. The benchmarks for the key benefits are used to set performance targets over an appropriate period of time. The performance targets provide a means for all participants in the supply chain to determine if the supply chain is delivering the benefits that are required for it to operate sustainably.

Table 4. Function of supply chain for hot-smoked saltwater trout.

Function	Step	Transaction	Time	Transaction value
		Hatcheries supply farms		
		Transport live fish from hatcheries		
		Payment to hatcheries		
		Nurseries supply farms		
		Payment to nurseries		
		Farm harvest scheduled		
		Fish harvested		
		Transport from farm to processor		
		Fish graded and cleared for sale		
		Fish gilled and gutted		
		Fish packed and frozen		
		Storage contracted by producers		
		Retailer orders fish from distributor		
		Distributor orders fish from smoker		
		Smoker orders fish from producers		
		Producers ship frozen fish to smoker		
		Smoker pays producers for fish		
		Smoker smokes and packs fish		
		Smoker supplies fish to distributor		
		Distributor pays smoker for fish		
		Distributor stores chilled fish		
		Distributor delivers fish to retailer		
		Retailer pays distributor		

Table 5. Function of supply chain for deboned whole saltwater trout.

Function	Step	Transaction	Time	Transaction value
		Hatcheries supply nurseries		
		Transport live fish from hatcheries		
		Payment to hatcheries		
		Nurseries supply farms		
		Transport live fish to farms		
		Payment to nurseries		
		Farm harvest scheduled		
		Fish harvested		
		Transport from farm to processor		
		Sample of fish quality tested		
		Fish processed and cleared for sale		
		Payment to processor		
		Fish packed and frozen		
		Fish ordered by restaurant		
		Fish delivered		
		Payment for transport		
		Payment for fish (30 day account)		

Table 6. Function of supply chain for whole fresh saltwater trout.

Function	Step	Transaction	Time	Transaction value
		Hatcheries supply nurseries		
		Hatcheries supply farms		
		Transport live fish from hatcheries		
		Payment to hatcheries		
		Nurseries supply farms		
		Transport live fish to farms		
		Payment to nurseries		
		Farm harvest on staggered schedule		
		Fish harvested		
		Transport from farm to retailer		
		Sample of fish quality tested		
		Fish graded and cleared for sale		
		Payment for fish (30 day account)		
		Payment for transport		
		Payment for quality testing		

Specifying the benefits of a supply chain

The benefits that are realised through participation in the supply chain can be measured by comparing them with the benefits that would be realised by participants in the absence of the supply chain.

The first step is to use a comparative analysis of benefits that can exist with and without the supply chain. A general comparative analysis is then used to identify key benefits that can be benchmarked and measured.

If the supply chain is unable to deliver benefits it may not sustain itself. Determining if there is a benefit for individual participants will need to recognise that it may take time to achieve some benefits.

The benchmarks for the key benefits are used to set performance targets over an appropriate period of time. The performance targets provide a means for all participants in the supply chain to determine if the supply chain is delivering the benefits that are required for it to operate sustainably.

Table 7. Benefits of supply chain for hot-smoked saltwater trout.

Participant	Without supply chain	With supply chain	Benchmark
Customer	No local supply of fish	Regular supply	Continuity
		Quality assurance	Size
			Colour
			Flavour
Retail outlet	No local supply	Regular supply	Continuity
		Quality assurance	Quality compliance
Processor	Seasonal work	Regular work	Continuity
Producer	Price fluctuations	Consistent pricing	Consistent price
	Unpredictable market	Predictable market	Predictable demand
		Quality control	Quality compliance
Nursery	Unpredictable demand	Predictable demand	Predictable demand
Hatchery	Unpredictable demand	Predictable demand	Predictable demand

Table 8. Benefits of supply chain for deboned whole saltwater trout.

Participant	Without supply chain	With supply chain	Benchmark
Customer	No similar product	Regular supply	Quality
		Quality assurance	Continuity
		Boneless fish	
Restaurant	No similar product	Regular supply	Continuity
		Unique product	
Processor	No equivalent work	Regular work	
Producer	No access to customers who avoid fish with bones	Access to new customers	
Nursery	Unpredictable demand	More predictable demand	
Hatchery	Unpredictable demand	Predictable demand	

Table 9. Benefits of supply chain for whole fresh saltwater trout.

Participant	Without supply chain	With supply chain	Benchmark
Customer	Seasonal supply of fish	Regular supply	Continuity
	Seasonal pricing	Quality assurance	Freshness
	No consistent QA		Colour Flavour
			Quality compliance
Retail outlet	Seasonal supply	Regular supply	Continuity
		Quality assurance	Quality compliance
Processor	Seasonal work	Regular work	Continuity
Producer	Price fluctuations	Consistent pricing	Consistent price
	Unpredictable market	Predictable market	Predictable demand
		Quality control	Quality compliance
Nursery	Unpredictable demand	Predictable demand	Predictable demand
A	Unpredictable demand	Predictable demand	Predictable demand

Preparing supply chain budgets

The key transaction flow in a supply chain is the movement of cash through the chain and this is the basis for the product costing. Implementation of the supply chain plan involves adoption of the budgets and the costs and returns that are detailed. Although the supply chain may deliver several benefits to a participant the financial benefits are a critical measure. The supply chain budgets provide a relevant and easily measured index for the performance of the chain and the benefits of participation.

Table 10. Reviewing the performance of the supply chain.

Participant	Benefit	Standard	Frequency	Performance Assessment
Customer	Consistent quality Consistent supply Consistent price	Set the benchmark that needs to be achieved to satisfy the requirements of the customer and chain participants	Establish the frequency with which compliance to the benchmark must be determined i.e., weekly shipment, annual	Establish an independent mechanism for testing and recording compliance with procedures and attainment of benchmarks
Retailer	Consistent supply Consistent QA Predictable price			
Processor	Predicable work Predictable income			
Producer	Consistent demand Predictable price Predictable payment			

Performance assessment procedures

The procedures for assessing performance of the supply chain must enable performance of the supply chain to be measurable and the information that is generated must be transparent and communicated efficiently to chain participants.

The transparency should be reinforced by independence where possible. Independence in testing and verification in record keeping will provide confidence in the assessment procedures. The estimated cost of compliance should be incorporated into supply chain budgets so that changes or improvements in quality management can be accounted into the retail price of the product.

Performance benchmarks

- Continuity.
- Freshness.
- Taste.
- Colour.
- Price.

Quality assurance mechanisms

- Continuity – Delivery frequency and volume.
- Freshness – Harvest and Transport Log.
- Taste – Independent Taste Panel.
- Colour – Independent Taste Panel.
- Price – Written agreement for price and trading terms.

As an example of a performance assessment the supply chain for the provision of deboned fish to local restaurants was discontinued after four months. Initial resistance to both the price and form of the product was overcome in a weekly sample of 10 deboned fish provided to a premium restaurant participant at a reduced initial cost. The restaurant wished to continue serving the product but the processing costs were not sustainable and the plate-price could not be increased.

5.7.2.6. References

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5.8. Australasian Aquaculture 2004 and 2006 conferences

5.8.1. Australasian Aquaculture 2004, 26 – 19 September 2004, Sydney Convention Centre

INLAND SALINE AND ARID AQUACULTURE

Tuesday 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

1. **14:20** **Adrian Collins, Benjamin Russell**
EMERGING OPPORTUNITIES FOR PRAWN AQUACULTURE USING SALINE GROUNDWATER

14:40 **Sudhir Raizada**
HATCHERY SEED PRODUCTION OF GIANT FRESHWATER PRAWN *Macrobrachium rosenbergi* IN GROUND SALINE WATER OF ROHTAK (HARYANA), INDIA

2. **15:00** **Luke Dutney**
COMMERCIAL PRODUCTION OF MULLOWAY *Argyrosomus japonicus* USING SALINE GROUND WATER

(Session continues in this room after the break)

AUSTRALASIAN AQUACULTURE
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INLAND SALINE AND ARID AQUACULTURE

Tuesday 15:50-17:10 Tumbalong 1

Session Chair: Stewart Fielder

3. **15:50** **Geoff Allan, Simon Bennison**
INLAND SALINE AQUACULTURE: NATIONAL COORDINATION OF R&D IN AUSTRALIA

4. **16:10** **Stewart Fielder, Grant Webster, Mehdi Doroudi & Geoff Allan**
STATUS OF R&D AT THE INLAND SALINE AQUACULTURE RESEARCH CENTRE, WAKOOL, NSW

5. **16:30** **Gavin Partridge, Gavin Sarre, Greg Jenkins**
NEW TECHNOLOGY FOR THE COMMERCIALISATION OF INLAND SALINE AQUACULTURE IN WESTERN AUSTRALIA

6. **16:50** **Tim Flowers**
CURRENT RESEARCH IN DEVELOPING AN AQUACULTURE INDUSTRY USING WATER FROM SALT INTERCEPTION SCHEMES IN SOUTH AUSTRALIA

7. **17:10** **Geoff Gooley**
WATER USE SUSTAINABILITY IN AGRICULTURAL LANDSCAPES: A CONCEPTUAL FRAMEWORK FOR INLAND AQUACULTURE DEVELOPMENT IN AUSTRALIA

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5.8.1.1. Emerging opportunities for prawn aquaculture using saline groundwater

Adrian Collins* and Benjamin Russell

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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 utilise saline groundwater for profit in an environmentally responsible manner. In Queensland, the best candidate for ISA 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 favourable status. In Queensland the irrigation industry uses almost 65% of the state's water. Of this, almost half is groundwater. Salt levels in groundwater are relatively high with a third of the state's irrigation bores yielding water in excess of 1.8 ppt. 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 – 2 ppt) these treatments are relatively cheap, provide immediate survival and growth benefits and are simple to administer. If acclimated properly, in water with favourable 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.

5.8.1.2. *Commercial production of mulloway Argyrosomus japonicus using saline ground water*

Luke Dutney

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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 ground water used is formerly oceanic water that is trapped in a subterranean 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 an environmentally sustainable enterprise.

5.8.1.3. Inland saline aquaculture: progress with national coordination of R&D in Australia

Geoff Allan* and Simon Bennison

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In Australia, seafood consumption is growing and is being increasingly met by imports. The volume of imports of edible fish increased by 76% from 1993/94 to 2003/04 (106,700 t to 188,014 t). 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. ISA (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 and 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 & Forestry and the Fisheries Research & Development Corporation. Specific objectives of this project are to help commercialisation of ISA in different regions, manage communication and technology transfer, identify and review national priorities, and help ensure “best-practice” science.

Commercialisation has been assisted by: 1) results and open days from four demonstration facilities in NSW, Qld, SA and WA; 2) an ISA investment directory (including an inventory of available resources of water and land and a risk assessment framework); 3) biological data derived from field experiments used to form the basis for economic analyses and investment analyses (especially in NSW and WA), a market analysis for ISA products; and 5) regular meetings between researchers, commercial investors and salinity managers.

The progress with the coordination project will be discussed. Potential investors in ISA in Australia will be provided with advice on how to access information to assist with investment decisions. More details are available from www.australianaquacultureportal.com

5.8.1.4. *Status of R&D at the Inland Saline Aquaculture Research Centre, Wakool, NSW*

Stewart Fielder*, Grant Webster, Mehdi Doroudi and Geoff Allan

NSW Department of Primary Industries
Port Stephens Fisheries Centre
Taylors Beach Road, Taylors Beach, NSW, 2316
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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 ISA 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 NSW. The Centre includes 6 x 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 replicate 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 levels are adjusted to above 40% of those concentrations present in seawater 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 bidyanus*) and rainbow trout (*Oncorhynchus mykiss*) at salinities tested to date of 10 ppt and 5 – 20 ppt, 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.

5.8.1.5. *New technology for the commercialisation of inland saline aquaculture in Western Australia*

Gavin Partridge*, Gavin Sarre and Greg Jenkins

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Over the fast 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, waster 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.

5.8.1.6. *Current research in developing an aquaculture industry using water from salt interception schemes in South Australia*

Tim Flowers* and Wayne Hutchinson

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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 known 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 – 17 ppt. 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 ISA 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 (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. The difference in growth between the two treatments continued until the experiment was terminated on the 30 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 2 and WB 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 FCRs.

Currently in SA another SIS is being constructed near Loxton, 100 km east of Waikerie. This SIS will be known as the Bookpurnong/Loxton scheme and is expected to intercept 100 ml/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.

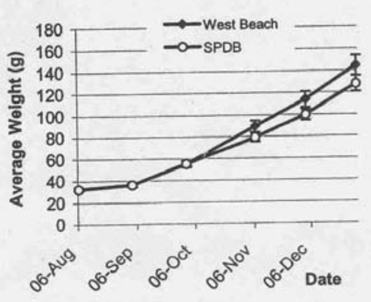

Figure 1: Average monthly weights for mulloway grown in SPDB water and salinity adjusted oceanic water.

5.8.1.7. Water use sustainability in agricultural landscapes: a conceptual framework for inland aquaculture development in Australia

Geoff Gooley and Fiona Gavine

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Inland aquaculture in Australia is a relatively small commercial fisheries sector dominated historically by intensive, flow-through 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 proving the opportunity for inland aquaculture in Australia to progress to the next level, thereby delivering significant socio-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 with impose a significantly small ecological footprint on the natural landscape. More specifically, the role of Integrated Agri-Aquaculture Systems (IASS) and complementary “green economics-based” resource management policy, is elucidated in this context. Recent R&D in this area is summarised and reviewed and long term industry development strategy and vision outlined.

5.8.2. *Skretting 2006 Australasian Aquaculture, 27 – 30 August 2006, Adelaide Convention Centre*

Wednesday 30 August

8:30 – 10:10 ISA: RESOURCES & INVESTMENT
1. *George Warne* – Dealing with rising saline water: Why is Murray Irrigation Limited investing in Aquaculture?
2. *Greg Jenkins* – Inland saline water resources in Western Australia.
3. *Michael Burke* – Evaluation of the potential for aquaculture in cotton catchments and other inland areas in Queensland – quantity and quality of water resources and infrastructure.
4. *Jim Blackburn* – Investment considerations for ISA.

10:40 – 12:20 ISA: INNOVATIVE PRODUCTION SYSTEMS
5. *Wayne Hutchinson* – Aquaculture systems for utilising saline water from interception schemes in South Australia.
6. *Gavin Sarre* – Semi intensive floating tank system (SIFTS) – application in saline water bodies in Western Australia.
7. *Stewart Fielder* – Going outside the loop – a need for innovation to develop saline aquaculture in inland New South Wales, Australia.

13:40 – 15:20 ISA: CONSTRAINT TO COMMERCIALISATION
8. *Geoff Allan* – ISA: progress with national coordination of Research and Development in Australia.

5.8.2.1. Dealing with rising saline water: Why is Murray Irrigation Limited investing in aquaculture?

George Warne

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Salinity and rising water tables are the most serious threat to the continued health and agricultural productivity of the southern Riverina, where Murray Irrigation Limited's operations are based. The company operates a bulk water supply and drainage system for irrigation in southern NSW, over an area of 748,000ha between Mulwala in the east and Swan Hill in the west.

Land clearing, the introduction of irrigation, the major flood of 1956, followed by another major flood in 1974 have all contributed to rising water tables across the region. With shallow groundwater salinity varying from 300EC to more than 100,000EC this groundwater is largely unsuitable for irrigation, and dramatically reduces the productivity of affected areas and threatens regional biodiversity.

Between 1978 and 1992 the NSW Government built the Wakool/Tullakool Sub-Surface Drainage Scheme on a 2,100 hectare site near Wakool. Saline groundwater is pumped through a network of underground pipes into evaporation basins. The pumping of this groundwater directly protects 25,000ha and indirectly protects another 25,000ha from rising water tables and salinity.

Inland, saline aquaculture provides the potential to turn an economic and environmental threat into an opportunity with both commercial and environmental benefits.

Murray Irrigation initiated a joint venture research project with NSW Fisheries to assess the viability of aquaculture in saline groundwater. The company's main objective has been to develop a commercially viable use for saline groundwater.

Landholders had raised aquaculture as a possible option and the company wanted to develop a sound scientific assessment of its viability and framework for operations, in the light of landholder interest. If viable, establishing a commercial operation at the Wakool site would also provide an opportunity to offset the significant costs of operating the scheme.

A commercially viable use for saline groundwater, such as aquaculture, also has the potential for much wider application across Murray Irrigation's area of operations and other regions affected with highly saline water tables.

5.8.2.2. Inland saline water resources in Western Australia

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Rapid changes in the climate of south-western Australia have led to reduced surface water yield, increased water salinity, changed efficiency/reliability of current water harvesting and storage structures, loss of capital value of existing structures and need for investment in new ones. However Western Australia has expanding groundwater resources and the largest area of impact by salinity in Australia, with approximately 70% of the landscape (1.1 M hectares) affected in the southwest agricultural region.

Salinity endangers rural infrastructure and is a direct threat to biodiversity in WA if trends observed prior to 2000 continue. About 450 vascular plant species at risk, a predicted loss of 220 species of aquatic invertebrates and a 50% recorded decline in water birds using rural wetlands. Pumping schemes are in operation to protect some rural towns and biodiversity recovery areas (e.g., Merredin, Wagin and Toolibin Lake).

As a result of excess recharge over the past century, there are now significant saline (10,000 – 35,000mg/l, pH 3 – 7) groundwater resources available for use in southwest Western Australia with recharge of approximately 1000GL/yr. Opportunities for aquaculture from specific aquifers, may be of the order of 1ml/day from sources such as palaeochannels, combined pumping from some Rural Towns and other conservation pumping and drainage diversion projects.

Preliminary investigations show some promise for aquaculture using some of these resources. Water quality remains a constraint.

Keywords: water resources, salinity, groundwater, aquaculture, Western Australia

5.8.2.3. Evaluation of the potential for aquaculture in cotton catchments and other inland areas in Queensland – quantity and quality of water resources and infrastructure

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Water is a valuable and limited natural commodity. To improve the returns from water, cotton growers have progressively adopted more efficient and cost effective irrigation technologies. However, as water costs continue to rise, many growers have recognised the potential for new water based enterprises to provide additional returns. Aquaculture is one activity that can integrate well with the cotton industry, its infrastructure and water resources. Native freshwater fish are already grown in irrigation schemes across the country in a variety of systems including ponds, cages and raceways. Recently, the Queensland DPI&F has demonstrated that even marine prawn farming is possible using irrigation groundwater.

The development of aquaculture in cotton catchments creates opportunities for irrigators to link with other industries to access new water resources or to re-develop and sustainably use saline water resources of their own. Energy companies developing coal seam gas (CSG) extraction facilities favour the concept of irrigators utilising the millions of litres of water they yield as a by-product of their activities. While agribusinesses such as aquaculture, piggeries and cattle feedlots can use CSG water in its raw form, it is often too saline for irrigation. The installation of water treatment facilities can make this water suitable for irrigation but is not cost effective for irrigators alone. If a number of users can access this water, the cost of treatment for each use will be reduced. Similarly, the use of saline groundwater on cotton farms might also be improved or reduced if other industries can utilise this water in a sustainable fashion.

The thousands of hectares of water storages built on Australian cotton farms and the heavy reliance on groundwater for cotton production represents both a potentially significant resource for aquaculture and a unique diversification option. However, this potential needs to be measured against the actual suitability of this infrastructure for the purpose of farming fish. Similarly, the extent to which groundwater resources have been developed for irrigation may not directly translate to its availability for aquaculture. The location, suitability and availability of all resources and infrastructure needs to be understood before the true potential for aquaculture is known. To successfully develop these opportunities, further research is needed to demonstrate that aquaculture can be an attractive investment opportunity for new entrants like cotton growers.

5.8.2.4. Investment considerations for inland saline aquaculture

Jim Blackburn

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Across the Australian aquaculture sector, there are many different perspectives as to the so called “secrets” of attracting investment. In its broadest sense these are not secrets but relate in one way or another to the sustainability of the on ground or at sea operation and suitability of the investment risk / return proposition. However, can be a difficult task to communicate these ideas clearly, and combine them with a clear definition of the investors needs. The first part of this discussion will seek to expand on these broad concepts, and present a number of simple investment fundamentals using as an example a project in progress that is defining a commercialisation strategy for the production of rainbow trout in association with a saline groundwater interception and evaporation scheme near Wakool. These fundamentals include:

- Industry sectors with positive long-term outlooks.
- Operations that are sustainable and employ best practice management.
- Businesses with strong potential to generate reliable and attractive financial returns based on well defined, authoritative, supporting evidence.
- Businesses that form part of a dedicated supply chain model.
- Businesses with excellent risk management.

The second part of this discussion will look at the processes and key components of developing a robust investment proposal. These include:

- Different investment Vehicles (brief overview).
- Business / Development Planning.
- Sales and Marketing Strategy.
- Financial Drivers.
- Assets acquisition / Expansion.
- Exist Strategies / Liquidity.

The session will conclude with a recap of investment fundamentals and the investment process, and by identifying some useful resources for industry participants to follow up.

5.8.2.5. Aquaculture systems for utilising saline water from interception schemes in South Australia

Wayne Hutchinson* and Tim Flowers

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Salinity interception schemes (SIS's) provide an engineering approach to assist the management of salinity levels in important waterways. The Woolpunda, Waikerie and Qualco SIS in the Waikerie region of the Riverland comprises 93 bores adjacent to the Murray River that intercept approximately 30 million litres of saline groundwater per day that would otherwise enter the river. The intercepted saline groundwater is pumped to the Stockyard Plains Disposal Basin located 12 kilometres South-West of Waikerie.

The saline groundwater intercepted has an annual water temperature of 20 – 22^{o}C and a salinity of 18 – 20 g/l. SARDI has designed the Waikerie ISA Centre (WISAC) to evaluate culture systems that can maximise productive use of this saline groundwater resource to provide economic benefit to the region.

Two types of aquaculture systems have been selected for initial evaluation. In both cases pilot commercial scale systems will be used to generate performance and economic data required for commercial investment.

1. A semi-intensive reuse system designed to support a target final stocking density of 30 – 40 kg/KL. The objective of research for this system is to identify the relationships between the amount of new and reused water that can maintain optimal water temperature and water quality to maximise production throughout the year. This is a relatively low technology approach that aims to allow rapid commercial use of the available saline groundwater to establish production and market development.

2. An intensive recirculating aquaculture system designed to support a target final stocking density of 80 – 100/KL. The Megaflow® system from Israel will be the first intensive system evaluated. This system has been selected based upon the low head high water flow design principles incorporated, relatively low energy use, reduced construction costs and simplicity of operation. SARDI will evaluate the applicability of this system for exploitation of the saline groundwater resource available from the SIS. This higher level of technology provides the opportunity to greatly increase productivity that can be achieved from the available saline groundwater resource.

A summary will be presented of the performance of mulloway (*Argyrosomus japonicus*) in the first of these systems that have been operating since 10 May 2006. Information will also be presented on the design and operational considerations that have been incorporated to allow operation of WISAC in conjunction with a major SIS.

5.8.2.6. Semi-Intensive Floating Tank System (SIFTS) – Application in saline water bodies in Western Australia

Gavin A. Sarre*, Gavin J Partridge, Robert G. Doupé,

Alan J. Lymbery, Gavin D. Kay and Greg I. Jenkins

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The "Semi-Intensive Floating Tank System (SIFTS)" was originally developed by our research group for commercial fish production in the static, inland saline water bodies that abound throughout Western Australia's Wheatbelt. A pilot trial of this technology in 2004 demonstrated significant advantages in fish harvesting and management, waste removal and increased yields over conventional static pond-based systems.

The biological, technical and economic performance of the SIFTS is currently being evaluated on a semi-commercial scale in a project funded by industry, the Fisheries Research & Development Corporation and the Wheatbelt Development Commission in Northam, 100 km east of Perth. The major objectives of this project are to determine the effectiveness of in-pond and out-of-pond bioremediation techniques and their potential for facilitating increased fish production in static, inland saline ponds. Such techniques include the SIFTS waste removal system, artificial substrates for nutrient removal via periphyton growth and nitrification/denitrification, cropping of microalgae using Artemia and the production of halophytic fodder crops. These objectives will be achieved over four production cycles of barramundi and trout during which detailed data on cost inputs and outputs will be collected for populating economic models for fish production using SIFTS in inland saline water.

This presentation will discuss the results obtained from the first of these four production cycles, in which the effects of the SIFTS waste removal system on microalgal blooms was investigated. In addition, data on the efficacy of the halophytic fodder crop NyPa Forage, in extracting dissolved and particulate nutrients from waste water, and the effects of SIFTS waste on plant growth, will be presented.

5.8.2.7. *Going outside the loop – a need for innovation to develop saline aquaculture in inland New South Wales, Australia*

Stewart Fielder*, Grant Webster and Geoff Allan

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Opportunities exist to develop aquaculture in inland Australia using saline groundwater which is pumped from sub-surface drainage schemes into evaporation ponds for disposal. The largest scheme in Australia, the Wakool/Tullakool Sub-Surface Drainage Scheme (WTSSDS), is situated at Wakool in semi-arid, south-western NSW and pumps 35 – 50ML/day of saline groundwater (~10ppt) into 1600 ha of ponds. However, research done at the ISA Research Centre (ISARC) at Wakool has demonstrated that direct translocation of standard methods used for culture of fish and prawn species in coastal or freshwater conditions has not been always possible. The most significant challenges to successful fish production have related to environmental factors including the chemistry of the groundwater and varying climatic conditions, especially temperature. Dealing with these challenges in order to identify sustainable, economically feasible aquaculture has required innovation and regular review of R&D priorities based on experimental and pilot-commercial results.

Saline groundwater from the WTSSDS has approximately 95% less potassium than similar salinity coastal seawater and consequently is not suitable for survival and growth of marine species including snapper (*Pagrus auratus*), mulloway (*Argyrosomus japonicus*), black tiger prawns (*Penaeus monodon*) and Kuruma prawns (*Marsupenaeus japonicus*). However, the potassium of the groundwater can be increased easily and cheaply by addition of KCl (potash) and provided the potassium concentration is above 40% of the concentration in seawater of the same salinity these species held in temperature-controlled tanks grew at similar rates as they grew in seawater. On the other hand, un-fortified groundwater is suitable for salt-tolerant freshwater silver perch (*Bidyanus bidyanus*) and diadromous rainbow trout (*Oncorhynchus mykiss*) in salinities tested of 10ppt and 5 – 30ppt, respectively.

The WTSSDS is situated in a semi-arid environment and ambient air temperature is highly variable seasonally, but importantly cool nights and hot, windy days in summer can result in daily pond temperature ranging from 20 to 30^{o}C. The variable and cool summer water temperatures had a profound effect on reducing growth of tropical prawns and was suspected of reducing survival of the temperate snapper. A novel method of stabilising the pond temperature by floating solar covers is currently being investigated and results will be discussed.

Pond water temperatures suitable for trout production (8 – 23^{o}C) are available for 7 months of the year. Pilot commercial production of rainbow trout has been completed for two successive seasons. Development of commercial trout farming at the WTSSDS seems most likely based on the production and bioeconomic data generated from pilot trials.

5.8.2.8. Inland saline aquaculture: progress with national coordination of R&D in Australia

Geoff L. Allan and Simon Bennison

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In Australia, seafood consumption is growing and is being increasingly met by imports. The volume of imports of edible fish increased by 76% from 1993/94 to 2003/04 (106,700 t to 188, 014 t). 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. ISA (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 & Forestry and the Fisheries Research & Development Corporation. Specific Objectives of this project are to help commercialisation of ISA in different regions, manage communication and technology transfer, identify and review national priorities, and help ensure “best-practice” science.

Commercialisation has been assisted by: 1) results and open days from four demonstration facilities in NSW, Qld, SA and WA, 2) an ISA investment directory (including an inventory of available resources of water and land and a risk assessment framework), 3) biological data derived from field experiments used to form the basis for economic analyses and investment analyses (especially in NSW and WA), a market analysis for ISA products, and 5) regular meetings between researchers, commercial investors and salinity managers.

The progress with the coordination project will be discussed. Potential investors in ISA 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

6. BENEFITS

There are two key sectors that have and will continue to benefit from this project. Firstly, those managing salinity in the Australian landscape are able to consider aquaculture as a productive use of the degraded saline waters. Managers of salinity might be managers of groundwater interception schemes, irrigators with saline bores, other land owners, policy makers. For these people, finding accurate, reliable information about aquaculture is very difficult and the negative experiences with some aquaculture investments in the 1980s and 1990s have tended to encourage these managers to discount the potential for aquaculture. The information produced and collated under the current project is easily accessible through the website and contact officers. Some salinity managers have already invested heavily in aquaculture. Most notably Murray Irrigation Limited (MIL) who have spent hundreds of thousands of dollars building an R&D facility and supporting research with NSW DPI. Recently they commissioned an independent investment analysis using data from that research and the positive outcome will guide further investment by MIL as that company attempts to develop large-scale commercial ISA.

Salinity managers involved with the Riverland region in SA are also supporting research at the Waikerie Aquaculture Park and hope to capture commercial benefits using saline water from their salt interception scheme before it is dispersed at the Stockyard Plain Dispersal basin.

In WA, land owners with saline ponds now have reliable, science-based information to assess the potential for aquaculture. Research in WA with the use of salt waste effluent from fish farming ponds for irrigating salt-tolerant grasses is still underway and offers another potential productive use of saline groundwater.

In Queensland, research with production of prawns in low-salinity bore water used for irrigation demonstrated both the water and species were suitable for aquaculture. Unfortunately, given current price structures, the necessarily small farms that could be constructed using salty bore water are unlikely to be economically viable. Saline water is a by-product of gas extraction and in Queensland this water is being evaluated for aquaculture. Aligning aquaculture practices with those of gas extraction will be a challenge but technology developed in Queensland, including as part of ISA research, may assist in realising the potential.

The second sector that will benefit from this project are aquaculture farmers who are able to establish businesses using saline groundwater. Commercial growers in WA have invested in R&D with a view to maintain a commercial enterprise and in NSW, a commercial company is in negotiation with MIL to lease their groundwater delivery and dispersal system to evaluate large-scale inland saline commercial trout aquaculture. In SA, aquaculture managers have used biological information, commissioned economic and market analyses and intend to stimulate commercial development in a similar manner to the way that state has facilitated sea cage aquaculture.

Finally, researchers involved with inland aquaculture have much better access to results from their colleagues and in a significant way have contributed to ensuring that research done in Australia on ISA has been of the highest standard.

7. FURTHER DEVELOPMENT

Following results from research in NSW on ISA (funded primarily by ACIAR, NSW DPI and MIL), MIL commissioned Lonsec Ltd to prepare a detailed investment analysis of the potential for an inland saline trout farm based at the Wakool/Tullakool Sub-Surface Drainage Scheme. This analysis was positive, Lonsec and MIL identified a commercial partner (Aquaculture Solutions Australia Enterprise) and together with NSW DPI prepared plans to develop a 200 t/yr trout farm using inland saline groundwater. This project has now been approved as a Seafood CRC project to allow the new farm to be used as a commercial demonstration farm and to address on-going R&D challenges such as how to run the farm with reduced water supply due to the drought. Significant potential exists for expansion of aquaculture to other saline groundwater interception and evaporation schemes.

In Queensland, the relatively small-scale of inland saline farms (relying on small flow saline bores) has made the economic viability of stand-alone prawn farming problematic. The declining price of prawns due in part to increased imports has deterred commercial investment in inland saline prawn culture in Queensland. In Queensland, and to a lesser extent NSW, the development of gas fields will result in a large volume of saline water and evaporation basins for disposal. This resource has been shown to be suitable for culture of some species and when the gas extraction industry is established may present opportunities for commercial aquaculture. Significant new research and production technology, species selection and product quality (e.g., residues) will be required at this time.

In South Australia, the high flow and constant temperature of saline groundwater at Waikerie presents a number of opportunities for commercial development. The cost of nutrient removal from effluent to meet stringent environmental standards and the distance to "market" for the product are challenges that must be addressed. The Aquaculture of Primary Industry and Resources South Australia (PIRSA) have funded an independent economic analysis and a market assessment and have completed a GIS-based resource assessment. These "tools" will be used to help stimulate commercial development of ISA using saline groundwater from interception schemes in SA.

In Western Australia, the difficulties in managing aquaculture in small saline water bodies with limited water available for exchange were addressed using modified recirculation technology (SIFTS). On-going problems with nutrient levels and algal bloom management are likely to at least delay significant new commercial investment in ISA using this technology in WA. However, the SIFTS technology is being adapted for use in estuarine locations unsuited to seacage aquaculture. A large 50 t/yr demonstration facility has been established in Fremantle Harbour. The Saltwater Trout Alliance is a cooperative of small farmers growing trout in saline water south of Perth. The alliance is continuing and there is potential for modest expansion.

The conclusion for this coordination/communication project will be presented at AA'08 where national and international experts will assemble to hear of other developments.

One of the major benefits of the current project has been the establishment of a network of stakeholders including researchers, farmers, salinity managers and administrators. It is recommended that this network be continued to help steer ongoing R&D in ISA in Australia and to retain an emphasis on development of a commercial industry.

8. PLANNED OUTCOMES

1. **The establishment of industrial-scale ISA businesses in Australia**. Industrial scale ISA has yet to be established in Australia although on the basis of positive investment analysis, new investment is occurring in NSW and is likely in SA. One farmer is operating in WA and a small collective of trout farmers in WA (the Salt Water Trout Alliance) is producing small quantities of trout.

2. **The profitable utilisation of saline waste-water from groundwater interception schemes**. If the commercialisation of ISA in NSW proceeds as planned, MIL will receive income from their evaporation basins for dispersal.

3. **Employment generation in rural and remote Australia**. There has been no significant employment in the ISA sector yet.

4. **Recognition by governments of ISA as a credible means of meeting the increasing demand for seafood**. Governments continue to support inland saline R&D. FRDC lists ISA as a priority area for R&D and the new Seafood CRC will support the MIL project to commercialise inland saline trout aquaculture. The government in SA supports continued development of commercial aquaculture in SA.

9. CONCLUSIONS

1. The coordination and communication of R&D in Australia was funded to help establish commercial ISA. The project brought researchers together with salinity managers, aquaculture farmers, government officials and investment advisors to share information, identify constraints to commercial development, reduce duplication and maintain a clear focus on achieving a commercially viable business for ISA. The project team established demonstration facilities in NSW, Qld, SA and WA and they hosted open days for potential investors and members of the public. The project team developed a website with a comprehensive investment directory that provides a "one-stop-shop" for potential investors. Information available includes research results, key contacts, government regulations, resources available, R&D plan, economic decision-making tools and a detailed risk assessment plan. The project team convened four major workshops on ISA as well as several teleconferences, and organised and ran two sessions on ISA at the international conferences, Australasian Aquaculture 2004 and 2006.

2. In NSW, results from research funded largely by ACIAR, NSW DPI and MIL and demonstrated/communicated by the current project, was used by investment analysts, Lonsec Ltd, to analyse investment potential. These results were attractive, a business model was developed and a commercial aquaculture company have agreed to invest in developing a 200 t/yr trout farm in conjunction with the largest saline groundwater interception/evaporation scheme in Australia (run by MIL). To help extend this model to other interception schemes, the Seafood CRC has approved a project to use the farm as a commercial-scale demonstration facility and to address on-going R&D issues such as matching aquaculture water needs with the operation of the interception scheme, especially in times of drought.

3. In SA, research at Waikerie is on-going. This site, and much of the potential areas in SA for ISA, are characterised by large volumes of saline water at a constant temperature but the challenge is to produce effluent low in nutrients. The added challenge in SA is the distance to market. However, the water is very suitable for marine and estuarine species and the site could be a viable option for production of advanced fingerlings. The Aquaculture Unit of Primary Industry and Resources South Australia (PIRSA) have recently completed an economic analysis and market assessment of the potential of ISA associated with saline groundwater from interception schemes. Together with GIS based inventory of suitable sites and water resources, these reports will stimulate commercial development of ISA in SA.

4. In WA, the challenges of extensive saline affected areas but with relatively low potential water flows means that the water available for aquaculture is relatively limited. New modified technology for recirculation aquaculture (the Semi-Intensive, Floating Technology System or SIFTS) was developed to reduce the need for water exchange in saline ponds and while this was very effective in dealing with fluctuating dissolved oxygen, problems with other toxic products associated with uncontrollable algal blooms were encountered. While there are still likely to be opportunities for commercial ISA in WA they are likely to be limited. Small-scale, commercial ISA of trout in saline ponds is occurring, facilitated by cooperative marketing and purchasing arrangements, and there is some potential for expansion. The SIFTS technology is being used in estuarine/near-shore situations for mariculture.

5. In Qld, inland saline prawn farming was shown to be technically feasible. However, the relatively small water flows from saline bores will limit the size of inland saline prawn farming and given the current market outlook (supply and price) is likely to make inland saline prawn farming uneconomic. There is new potential for ISA in association with waste saline water produced as a by-product of methane gas extraction but while this has been shown to be technically feasible, considerably more R&D is needed to determine if it is economically feasible and comparable with gas-field operation. This is an R&D priority.

6. The network established as part of this project was effective in reducing duplication, sharing results, improving the science and in the facilitation of technology transfer. It was useful for potential investors and those individuals benefited from being able to easily access information and meet key researchers at annual workshops. It is strongly recommended that the network be maintained and regular (i.e., annual) workshops held. Expanding the scope to inland aquaculture warrants investigation.

10. APPENDICES

10.1. Appendix 1 – Intellectual Property

All information brought into this project or developed during the project is public domain.

10.2. Appendix 2 – Staff

- Dr Geoff Allan, Principal Investigator, NSW Department of Primary Industries, Port Stephens Fisheries Centre.
- Mrs Helena Heasman, Executive Officer, NSW Department of Primary Industries, Port Stephens Fisheries Centre.
- Mr Simon Bennison, Chief Executive Officer, National Aquaculture Council.
- Ms Alexandra Bagnara, Communications Officer, National Aquaculture Council.

Demonstration facilities

- **NSW:** Dr Stewart Fielder, NSW Department of Primary Industries, Port Stephens Fisheries Centre.; Mr Grant Webster; Ms Dianna Brettschneider, NSW Department of Primary Industries, ISA Research Centre, Wakool.
- **WA.** Dr Greg Jenkins; Dr Gavin Partridge, Challenger TAFE, Fremantle; Dr Gavin Sarre, Northam TAFE, Northam.
- **SA:** Wayne Hutchinson, Tim Flowers, SARDI, Henley Beach.
- **Qld:** Michael Burke, Qld Department of Primary Industries & Fisheries, Brisbane.

Consultants

- Carl Young, Seafood Farming Services, Aquaculture Consultants, Toowong, Qld.
- Nick Ruello, Ruello and Associates Pty Ltd, Clifton Beach, Qld.
- Dr Tom Losordo, Department of Biological and Agricultural Engineering, North Carolina State University, Raleigh, North Carolina.
- Jasper Trendall, Salt Water Trout Alliance, Sea Dragon Farm, Albany, WA.
- Bill Johnstone, Business Manager, Queensland Department for Primary Industries & Fisheries, Rural Industry Business Services, Nambour, Qld.

10.3. Promotional and educational material

10.3.1. Flyer which was displayed at all retail outlets for ISARC rainbow trout

NSW DEPARTMENT OF PRIMARY INDUSTRIES

INLAND OCEAN TROUT

Murray Irrigation Limited

NSW DPI is involved in a collaborative program with Murray Irrigation Limited to develop technology for inland saline aquaculture at the Inland Saline Aquaculture Research Centre (ISARC). The Australian Centre for International Agricultural Research (ACIAR), is also supporting this research through a collaborative research project with India. One of the species that has shown promise is rainbow trout. In 2004, a pilot-scale trial was initiated to produce 1-3 tonnes of trout to yield information on fish survival, growth, food conversion efficiency, costs of production and market potential. Freshwater trout are marketed in a variety of ways including smoked, fresh and frozen. Trout grown in saline water in WA are labelled and promoted as a different product to freshwater trout and have been receiving a premium price up to several dollars per kilogram higher than for freshwater trout.

Problems with mortality were experienced early in the trial because of a lack of water exchange. Once a new pump was installed and ponds were managed with limited suspended organic matter, trout grew very rapidly with minimal further mortality. Fish were harvested from ponds at ISARC from September to November 2004. They were purged in clean flowing saline groundwater for up to one week, euthanased rapidly using an ice slurry and packed for transport. Best practice methods used by trout producers in NSW and WA were followed. The fish have been sold in two forms; whole fresh and whole smoked, in shops in the Deniliquin and Barham area. Retail prices of $14/kg for fresh and $26/kg for smoked product have been received.

Near Wakool in south-western NSW, Murray Irrigation Limited pumps salty groundwater to protect over 60,000 ha of valuable agriculture land from rising salinity. This crystal clear salty water is being used to grow premium quality fish and prawns in inland Australia.

The inland 'ocean' trout were grown in this environment on the highest quality fish feeds before being carefully graded and packed within hours of reaching the market place or the smoke house.

Welcome Industry Groups Links Events & Meetings Media Centre About this Portal

Check out the **Saline Aquaculture web site** at www.australian-aquacultureportal.com

INLAND SALINE AQUACULTURE RESEARCH CENTRE, WAKOOL

www.dpi.nsw.gov.au

10.3.2. Flyer on 'Inland Saline Aquaculture: National Coordination of R&D in Australia'

NSW DEPARTMENT OF PRIMARY INDUSTRIES

National Aquaculture Council

INLAND SALINE AQUACULTURE:
National co-ordination of R&D in Australia

Australian Government Fisheries Research and Development Corporation

Australian Government Department of Agriculture, Fisheries and Forestry

The fragmented nature of inland saline aquaculture research in Australia has made it difficult to easily access available information. This stimulated a project to co-ordinate Inland Saline Aquaculture in Australia. This project is being funded through the National Aquaculture Council by the Fisheries Research and Development Corporation with significant contributions from the Australian Government Department of Agriculture, Fisheries and Forestry (through the Aquaculture Action Agenda).

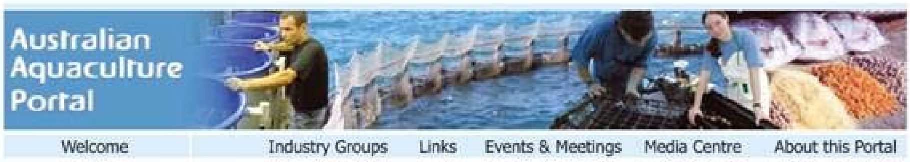


Specific aims and outputs of the project are:

1 To facilitate rapid commercialisation of regionally appropriate inland saline aquaculture.
- Assistance has been provided to four centres in NSW, Queensland, South Australia and Western Australia to help develop facilities to demonstrate inland saline aquaculture.
- An investment directory has been produced that includes a comprehensive review of state and regional approval procedures, an inventory of R&D projects, personnel and results, government assistance schemes, overseas results and a simplified risk assessment framework.
- A series of economic models are being developed for use by potential investors as decision making tools. The results from the R&D facilities will supply information for these models.
- A comprehensive market review has been completed to look at market opportunities for inland saline aquaculture product and to identify possible niche market opportunities. A small case study of market and supply chain arrangements for inland saline trout produced in WA has also been completed.
- An interactive temperature model is being developed to help potential investors and managers of inland aquaculture facilities to predict pond water temperatures. The inland climate is very difficult from that on the coast and this has a large effect on growth and survival of many species.

2 Manage communication and technology transfer. This is being achieved through the web site www.australian-aquacultureportal.com and through a series of open days at each of the four inland saline facilities - NSW, SA, QLD and WA.

3 Regular meetings and workshops are being held to help review R&D practices and to ensure that best practice science is being applied to ensure this regionally appropriate technology is developed and transferred to the commercial industry.



All outputs from this project are available from the **Saline Aquaculture web site** at www.australian-aquacultureportal.com

INLAND SALINE AQUACULTURE RESEARCH CENTRE, WAKOOL

www.dpi.nsw.gov.au

10.3.3. Assorted press clippings on inland saline aquaculture activities at ISARC

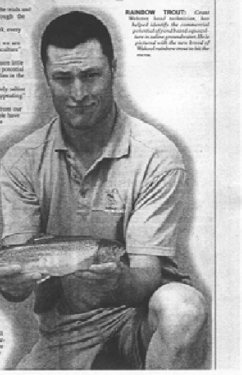
SOUTHERN WEEKLY

Week commencing Monday, November 8, 2004

INSIDE: BLYTH MERINOS TO $2600 • PAGE 3 | TRIBUTE TO A FAITHFUL FRIEND • PAGE 7 | CHERRY CAPITAL CELEBRATES • FEATURE PAGE 9

Wakool trout make a splash

Story: CHANTEL MYERS



RAINBOW TROUT: Grant Webster, local technician, has helped identify the commercial potential of inland-based aquaculture in saline groundwater.

Pastoral Times, Friday, November 12, 2004

Deniliquin Pastoral Times 26-11

Fish trials step closer to commercial venture

ALMOST 170 people attended an open day at the Inland Saline Aquaculture Research Centre near Wakool earlier this month, to hear the latest information on fish trials underway.

Visitors were able to taste smoked rainbow trout grown to market size at the centre, while presentations outlined the history and future directions of research.

The trout have proved popular with customers at local outlets.

The Inland Saline Aquaculture Research Centre near Wakool is part of the operations at Murray Irrigation's Wakool Tullakool Sub Surface Drainage Scheme and is a joint venture between Murray Irrigation and the Department of Primary Industries (DPI).

DPI researchers Dr Stuart Fielder and Dr Geoff Allan said they were pleased with the turn out at the open day.

Dr Fielder is responsible for DPI's marine fish breeding program and has overseen trials at the research centre. Species trialled include mulloway, silver perch, prawns and snapper.

Dr Allan is the principal scientist for the DPI aquaculture program.

Dr Fielder said the trout had proven successful because they could tolerate cold conditions at the Wakool operations in winter and water quality issues were less complex for this species.

Prawns being produced as a short season summer crop were still troubled by fluctuating temperatures.

Hot house techniques are being trialled to improve growth rates of the Black Tiger Prawns, which are a tropical species.

Murray Irrigation environment manager Alex Marshall said comments from visitors about the research centre and the Wakool drainage scheme were unanimously positive.

The drainage scheme and evaporation basins have successfully protected more than 50,000ha against risin[g] watertables and salinit[y], he said.

The aquaculture r[e]search is another pos[i]tive, building on tha[t] producing somethin[g] from the groundwat[er] that is pumped into th[e] basins.

It may be possible t[o] establish a commerci[al] aquaculture venture a[s] part of the evaporatio[n] basin operations in fu[ture] years, and there ar[e] interested investors a[l]ready involved i[n] discussions with DPI.

However, we sti[ll] have some research t[o] conduct before we ca[n] be sure it will be financially viable an[d] sustainable enterpris[e], Mr Marshall said.

The Weekly Times, October 6, 2004

Fresh idea: Deniliquin butcher Jim Hetherington (far left) and NSW Fisheries technician Murray Elliott with a serve of fresh trout.

Salt water ends trout drought

By SANDRA GODWIN

THE first commercial harvest of fish raised in saline groundwater in the Riverina began last week.

The rainbow trout have been grown by NSW Fisheries staff in saline groundwater pumped from the Murray Irrigation Wakool Tullakool sub-surface drainage scheme, west of Wakool.

The fish farm is part of the Inland Saline Aquaculture Research Centre which has also investigated the feasibility and commercial viability of using the groundwater to grow shrimp and prawns.

A 200kg sample of black tiger prawns raised at the farm was sent to the Melbourne and Sydney fish markets in April, making $14 a kilogram at auction in Melbourne.

The trout will be available fresh or smoked — while stocks last — at the Wakool Shop, Barham Meats, Haynes Butchery at Finley and Mokanger Pastoral Company Butchers at Deniliquin.

About 700kg of the fish are expected to be harvested in the next month.

NSW Fisheries technician Grant Webster said the fish were part of a growth trial which started at Easter.

Now they were reaching pl[ate size]... about 300-400g each, the fish were being caught in a seine net once a week and the biggest graded off for sale.

Those that didn't make the grade went back into the water to continue growing.

Mr Webster said the sale of the trout had created great excitement among locals who had never before been able to buy fresh fish.

"We can have it in the shops by 9.30am and they can buy it and take it home and eat it the same day," he said.

Article from *The Land*, 28 April 2007

AGRICULTU

News

Salty aquaculture trout

JOANNE FINLAY
Orange

The first harvest of trout from the Inland Saline Aquaculture Research Centre ponds at Wakool in western NSW yielded about half a tonne.

RAINBOW trout are being harvested in the Riverina, as part of a bold experiment to develop a new industry to make inland saline areas productive again.

NSW DPI principal aquaculture scientist, Dr Geoff Allan, said the first trial harvest of trout occurred late last year at the Inland Saline Aquaculture Research Centre at Wakool, in western NSW.

Scientific trials are being conducted at the centre to determine the viability of growing marine and freshwater fish in inland areas.

Dr Allan said the research indicates that not only trout but a variety of marine species - including snapper, mulloway, black tiger prawns and kuruma prawns - are capable of surviving in degraded inland environments.

"The main difficulty appears to be that salt-affected groundwater contains far too little potassium - about 95 per cent less potassium than salt water from oceans, despite having the same salinity," he said.

"When potassium in the form of potash is added to levels 40pc or higher than those in seawater of the same salinity, marine species such as prawns and mulloway not only survive - they also grow at similar rates to what they do in seawater."

Dr Allan said two freshwater species have also been tested - silver perch *(Bidyanus bidyanus)* and rainbow trout *(Oncorhynchus mykiss)*.

"Silver perch can survive in groundwater that contains one-third the salt of seawater; while rainbow trout are able to survive in saline water which is as salty as seawater.

"Potassium does not need to be added for either of these freshwater species."

Small-scale production of rainbow trout began at Wakool in April last year. The facility contains six 0.05 hectare earth ponds lined with plastic, which are supplied with freshwater and saline groundwater.

Dr Allan said the first run of trout from the ponds yielded about half a tonne. Some of these trout were smoked but most were sold fresh through butchers in Deniliquin, Barham, Wakool and Finley. They were very popular with consumers in the area who often struggle to purchase fresh fish.

Imports of seafood to Australia have risen by 52pc in the decade to 2002 and the value of aquaculture trebled in this period.

Dr Allan said expansion of coastal aquaculture is limited by a shortage of sites with the necessary water quality, depth and proximity to suitable infrastructure.

Dr Stewart Fielder and Mr Grant Webster of NSW DPI are running the project with an industry partner, Murray Irrigation Limited. It is also supported by the Australian Centre for International Agricultural Research and the Fisheries Research and Development Corporation.

■ Contact Dr Geoff Allan, Port Stephens, 4916 3909 allang@fisheries.nsw.gov.au

10.3.4. Prime Fact on Inland Saline Aquaculture

NSW DPI primefacts PROFITABLE & SUSTAINABLE PRIMARY INDUSTRIES www.dpi.nsw.gov.au

Inland Saline Aquaculture Research

Stewart Fielder[1], Grant Webster[2] and Geoff Allan[3]

1 Research Scientist, Marine Fish Breeding, Port Stephens Fisheries Centre, Taylors Beach
2. Fisheries Technician, ISA Research Centre (ISARC), Wakool
3. Research Leader, Aquaculture and Port Stephens Fisheries Centre Director, Taylors Beach

Introduction

Aquaculture is the fastest growing food producing industry in the world and has been for the last 3 decades. Increasing aquaculture production is necessary to meet increasing demand caused by increasing population and increasing per capita consumption of seafood. In Australia, aquaculture is also growing rapidly as the value of the industry increased from $256 million to $743 million in the decade to 2002/03 representing an 8% real growth rate.

ISA is a new area of aquaculture research and development in Australia. It involves culture of various species of marine, euryhaline, diadromous or freshwater-salt tolerant juveniles in saline groundwater from inland locations. Expansion of coastal aquaculture is limited by a shortage of suitable sites with the necessary water quality, depth and proximity to land-based infrastructure, high land cost or environmental value, conflict with

Establishment of ISARC

NSW DPI is involved in a collaborative research program with Murray Irrigation near Wakool, NSW to develop an ISA industry. Salinity affects more then 2.5 million hectares of Australia's interior and it is estimated that this area will increase fourfold within 40 years. In 2002, the ISA Research Centre (ISARC) was established to evaluate the potential of various species of salt tolerant finfish and crustacean species for ISA. The facility includes 6 small plastic-lined ponds, an experimental tank system and a temperature controlled room. Fresh and saline waters of different salinity are available. ISARC is located at the Wakool-Tullakool Sub-Surface Drainage Scheme (WTSSDS), the largest evaporation scheme in Australia disposing of 35,000ML of saline water each year. The scheme comprises of 60 bore pumps and 1600ha of evaporation ponds for salt interception and disposal. It is estimated that the scheme has helped return 50,000 hectares of unproductive salt-degraded land back to productive farming. Research at ISARC indicated that the inland saline ground water from the WTSSDS had 95% less potassium than marine water and as such was not initially suitable for survival and growth of marine species. A method was developed to counteract the deficiency by adding potash to the water. Initial small-scale experiments demonstrated marine species survived and grew in fortified inland saline groundwater at similar growth rates reported for the species in marine water. Potassium addition is not required for silver perch and rainbow trout as they grew well in raw inland saline groundwater.

Wakool Tullakool Sub-Surface Drainage Scheme evaporation basins at ISARC

NSW DEPARTMENT OF **PRIMARY INDUSTRIES**

Recently, pilot-scale commercial production of black tiger prawns, snapper, mulloway and rainbow trout has been completed. The research facility has also evaluated silver perch, brown trout, Atlantic salmon, kuruma prawns and Sydney rock oysters. These species were selected for research as they all have established culture technology, a closed lifecycle, access to juveniles, are high value and are tolerant of various levels of salinity.

Rainbow trout

Cool winters and fluctuating daily water temperatures limited the growth of snapper and black tiger prawns. However, mulloway grew well in the summer. Rainbow trout (*Oncorhynchus mykiss*) have emerged from trials at ISARC as one of the best performing species. Rainbow trout is one of the most popular aquaculture species with world production exceeding 500,000 tonne/year. In Australia, 2000 tonne/year of rainbow trout is produced from land based freshwater farms with an additional 490 tonne/year from seacages in Tasmania. Rainbow trout are cultured in both freshwater and seawater, have a fast rate of growth and are robust osmoregulators.

Rainbow trout have been reared to market size over 4 consecutive seasons during 2004, 2005, 2006 and 2007. Approximately 1700 kg of rainbow trout have been sold fresh and smoked through local butchers, cafes and supermarkets averaging 600g per fish. The product was very popular with consumers as it had a fresh, salty flavour. Saline rainbow trout were sold for a premium price of several dollars per kg more than freshwater trout as they were found to be a superior product.

The performance of Rainbow trout in inland saline groundwater is impressive. A market size of 600 g was reached after only 3 – 6 months with a food conversion ratio of 1.1:1. The fish display good growth in all ranges of salinity trailed, including fish as small as 10 g which grew well in salinities of up to 14 ppt. The fish displayed strong appetite and high levels of feed intake. Rainbow trout had very high levels of survival while remaining tolerant of high density, handling and fluctuating salinity. The best method of production was semi-intensive flowthrough pond culture.

Market size rainbow trout ready for processing

Towards commercialisation

Commercialisation of this rainbow trout research is imminent. A commercial inland saline rainbow trout farm is to be constructed near the Wakool Tullakool Sub-Surface Drainage Scheme in 2008. The farm plan and financial models have been established using data from rainbow trout grown at ISARC. If successful, it is planned to incorporate similar farms in other Sub-Surface Drainage Schemes and salt affected areas. Further research is planned to establish the most efficient way to utilise groundwater on-farm including investigating recycling and remediation of the water supply.

Projects in other states have also found species and water sources that are suitable for ISA. Several consultancies have been published regarding investment, marketing and promotion.

Aquaculture is becoming increasingly important in the supply of fish to our markets as the commercial fishery is static and the human population continues to increase. In 2007, global aquaculture production increased to a point where it equalled that of the commercial fishery for the first time. This highlights the importance of further research and development in aquaculture. ISARC will continue to be at the forefront of ISA research.

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