Optimising Industry Adoption: Case studies on the efficacy of current Australian Seafood CRC research extension processes.

Conn and Associates

Project No. 2012/731

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ACRONYMS

AFMA	Australian Fisheries Management Authority
APEN	Asia Pacific Extension Network
APFA	Australian Prawn Farmers Association
CRC	Cooperative Research Centre
DPIVIC	Department of Primary Industries Victoria
DPIPWE	The Department of Primary Industries, Parks, Water and Environment (Tas)
FRDC	Fisheries Research and Development Corporation
IMAS	Institute of Marine and Arctic Studies
NFAEAS	The National Fishing and Aquaculture Extension and Adoption Strategy
NSW I & I	New South Wales Department of Industry and Investment
PIRSA	Primary Industries and Resources of South Australia
SARDI	South Australian Research and Development Institute
SELN	State Extension Leaders Network
SPOC	Sustainability and Profitability Options Committee
SCMC	Southern Cross Marine Culture
TRLFA	Tasmanian Rock Lobster Fisherman's Association
USC	University of the Sunshine Coast
UTAS	University of Tasmania
UW	University of Washington

1.0 NON-TEHCNICAL SUMMARY

2012/731 - Optimising Industry Adoption: Case studies on the efficacy of current Australian Seafood CRC research extension processes.

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1.1 Executive Summary

There is a distinct need for the evaluation of the effectiveness of current Australian Seafood CRC research extension practices and tools in order to understand how the extension pathways utilised by researchers have impacted upon industry adoption of research outputs.

The aim of this study was to assist in identifying the strategies and processes utilised in the extension, education and training of Seafood CRC research outcomes and to highlight the associated challenges and successes encountered during industry application of Seafood CRC facilitated research project outputs.

As series of case studies were carried out on four unique Seafood CRC Program 1 (Production Innovation) research projects, specifically focusing on the extension processes and strategies used in each and the subsequent level of industry adoption.

The Seafood CRC research projects investigated were:

- Spatial management of southern rocklobster fisheries to improve yield, value and sustainability (Project No. 2006/220)
- Population genetic structure of Sea Cucumber in Northern Australia (Project No. 2008/733)
- Genetic technologies to support a transformation to profitability and competitiveness in *F. merguiensis* and *P.monodon* (Project No. 2009/724)
- Oyster over-catch: Cold shock treatment (Project No. 2010/734)

Interviews were conducted with the principal researchers, the industry partners, government agencies and associated stakeholders from each of the four research projects investigated. Interviews were held in person when feasible or otherwise via telephone and email.

In summary, the most commonly identified research and development extension and adoption strategies, recognised as being effective by the interviewees from all four projects were as follows:

- Prioritising of commercial outcomes by research provider.
- Research direction and process driven by industry participant / participants
- Simple working / communication structure such as one research provider – one industry partner.
- Pre-existing, solid, respect based relationship between research provider and industry participant / participants
- No obstacles between researcher, industry partner and adoption.
- Fostering of research ownership by the industry partner / industry participants.
- Research, development and extension process not bound up in policies or process.
- Willingness to share IP and an open door policy to wider industry
- Effective project facilitation by Seafood CRC to underline expectations and streamline communication processes
- Ongoing face-to-face meetings between research provider and industry
- Real time communication between research provider and industry

These findings determined that for each of the four projects investigated the level of adoption of research outcomes and therefore the efficacy of the Australian Seafood CRC research extension processes involved was deemed to be high.

This study supports the findings of the recent FRDC funded research, entitled Understanding Extension and Adoption in the Fishing Industry (Rufus Jennings and Roberts Evaluation FRDC Report 2011/505). This research determined that the Australian fishing industry (including aquaculture) and in particular the FRDC is effectively enabling the delivery of extension and adoption activities through project and program support.

The FRDC research and this study indicates that most applications of extension methods within the scope of FRDC / Seafood CRC research and development are considered to be working well and so to this extent they should continue.

The current extension and adoption strategies developed and implemented by the Australian Seafood CRC are considered highly effective throughout the duration of Seafood CRC research projects. However it is important to ensure the longer-term extension of research outcomes in projects where proof of concept may take some time to achieve on a commercial scale.

In these instances a follow-up extension strategy should be employed to ensure that longer-term commercial implications, benefits and limitations of research outputs are properly evaluated and communicated to industry. This strategy would be built-in to the initial project design with time-scale for its implementation dependant upon the nature of the proposed research, industry / research participant sector and industry / participant capacity for commercialisation.

1.2 Introduction

Since 1991, the Australian Commonwealth government has established well over 100 Cooperative Research Centre's (CRC's) ranging across a wide variety of technical areas which include manufacturing, medical, information technology, environment, mining and agricultural technologies. The objective of the Federal CRC program is:

"To deliver significant economic, environmental and social benefits to Australia by supporting end-user driven research partnerships between publicly funded researchers and end-users to address clearly articulated, major challenges that require medium to long term collaborative efforts."

The Seafood CRC officially opened for business in August 2007 and is Australia's first entity to stimulate and provide comprehensive seafood-related research & development and industry leadership on a national basis. In the ensuing five and a half years the Seafood CRC has facilitated the undertaking of over 400 collaborative research projects by researchers, seafood industry participants and seafood industry stakeholders across the national seafood sector.

A key facet of all CRC programs is that they forge close links between researchers and industry to focus R&D efforts on finding innovative solutions to industry needs and drive progress towards **adoption** and **commercialisation**. The cornerstone to achieving effective adoption and commercialisation of research results is **extension.**

In this context **"extension"** can be defined as the processes by which research information is exchanged and translated between researchers, industry and industry stakeholders with the key objective in the majority of cases being to facilitate practice change. The effective adoption and commercialisation by industry of new technology or expertise is intrinsically linked to the efficacy of the extension activities employed before, during and after the research and development process.

A planned output of the Australian Seafood CRC Education and Training Program 3 in the Commonwealth Agreement (Milestone 3.2.3) is to conduct case studies illustrating industry application of outputs from Research Program 1 (Production Innovation).

There is a distinct need for the evaluation of the effectiveness of current Seafood CRC research extension practices and tools in order to understand how the extension pathways utilised by researchers have impacted upon industry adoption of research outputs. This project aims to assist in identifying the strategies and processes utilised in the extension, education and training of research outcomes and to highlight the associated challenges and successes encountered during industry application of Seafood CRC facilitated research project outputs. The project may also provide an insight into potential solutions and alternative strategies for future seafood industry research extension programs.

In April 2010, the Primary Industries Ministerial Council (PIMC) approved a National Strategy for Fishing and Aquaculture Research, Development and Extension, which establishes the future direction to improve the focus, efficiency and effectiveness of RD&E to support Australia's fishing and aquaculture industry. The Seafood CRC subsequently participated in a working group formed to develop a National Fishing and Aquaculture Extension and Adoption Strategy. The key objective of the Extension and Adoption strategy is to improve the capacity for extension and achieve improved adoption rates in the Australian fishing and aquaculture sector to maximize RD&E outcomes for all. The RD&E Strategy was finalised in June 2012 and is available online at www.frdc.com.au/research/national-framework.

Prior to the development of the RD&E Strategy, an independent study was commissioned to identify and document best practice examples of extension and adoption within the Australian fishing and Aquaculture industry. This FRDC funded research, entitled Understanding Extension and Adoption in the Fishing Industry (Rufus Jennings and Roberts Evaluation FRDC Report 2011/505) highlighted some best practice case studies that had achieved high levels of extension and adoption (practice change). The FRDC project provided insight into what extension activities should form the foundation for future planning and the approaches and activities that should be considered.

This Seafood CRC Case Studies project may serve to add to the findings of the aforementioned FRDC report by Rufus Jennings and Roberts Evaluation; Understanding Extension and Adoption in the Fishing Industry which details the efficacy of current extension and adoption strategies across a broad swathe of the Australian commercial and recreational fishing and aquaculture sectors. The FRDC report by Rufus Jennings and Roberts Evaluation includes a comprehensive literature review on the history, recent developments and current thinking regarding the theory and practice of extension. It details the role of extension in research, development and adoption and describes the "Seven Models of Extension" as identified by Coutts (1997).

This Seafood CRC Case Studies project will include a brief overview of current theories, practices and models of extension in order to be able to contextualise some of the case study findings. However for greater detail on the background and current theory and practice of extension please refer to the FRDC Report 2011/505.

1.3 Project Objectives

- To carry out a series of case studies on four unique Program 1 (Production Innovation) research projects, specifically focussing on the extension processes and strategies used in each and the subsequent level of industry adoption.

- Submission of an abridged version of one or more case study reports for publication in peer reviewed journal.

- Any “lessons learned” from the case studies will be highlighted in articles written for the Seafood CRC magazine on conclusion of the project.

1.4 The Case Study Approach

Interviews were conducted with the principal researchers, the industry partners, government agencies and associated stakeholders from each of the four research projects investigated. Interviews were held in person when feasible or otherwise via telephone and email.

This project aims to answer the following key questions for each of the four research projects being investigated:

- What is the current level of adoption and commercialisation of the research results / outputs?

- How quickly was the current level of adoption and commercialisation attained since the completion of the research?

- What extension and adoption strategies were employed during the research?

- Which extension and adoption strategies were successful and why?

- Which extension and adoption strategies were unsuccessful and why?

- In terms of extension and adoption strategies, what could have been done better?

Interviews were based on a set of formalised questions, designed to provide a standard framework for interviewee responses (See Appendix 1). However, the interviewer contextualised the questions to each research project and allowed the discussions to flow according to the information being provided in order to gain a comprehensive insight and good understanding of the fundamentals of, and approach taken during, each of the four, very different, projects. The interviewer also travelled to meet with the interviewees where feasible in order to better understand the research outputs in their applied context.

1.5 Understanding Extension

"The role of extension is to encourage adoption and innovation and turn R & D outputs into outcomes such as practice or management change" (NFAEAS 2012).

This is just one current definition of the term "extension". Various definitions of "extension" have been developed over the years with each being a product of its time.

The dissemination of information and advice to farmers can be dated back as far as 1800 B.C. from archaeological findings of Mesopotamian clay tablets inscribed with advice on watering crops and getting rid of rats. Some hieroglyphs on Egyptian columns also gave advice on avoiding crop damage and loss of life from the Nile's floods. (Jones and Garforth, 1997)

Modern day agricultural "extension" has its roots in the agricultural societies that became common in Europe in the early 1800's. These societies were formed by educated landowners who sought to take advantage of the emerging science of agriculture to increase the profitability of their tenants and the rent that they could tax from them. The push emerged for all farmers and not just the wealthy to benefit from improved production practices. The critical element in educating the "generality of farmers" was the role of the specialist or agent in directly advising and encouraging farmers.

Originally, these dedicated specialists devoted most of their time to working with farmers on-site but this community of specialists increasingly developed their principles and practical recommendations ex-situ and away from the commercial context of working farms. As a result the need arose for considered practical recommendations to be **extended** back to the target audience with the intent of improving on-farm productivity by influencing and hence, changing the management practices of those who worked the land. (Rufus Jennings and Roberts Evaluation 2011)

The practice of extension and different extension models have shifted over time from methods of technology transfer of expert knowledge to processes that support the co-creation of knowledge and the empowerment of stakeholders. In the Australian context, the current extension movement places focus on capacity building and community engagement. (SELN 2006). The responsibility for providing extension services has also shifted with time and the changing agricultural extension environment in Australia reflects a world-wide trend towards the privatisation of these services where once agricultural extension was the domain of government agencies. (Marsh and Pannell, 2000). For a detailed review on Australia's current extension environment refer to Coutts *et al* 2005. The Role of Extension in Building Capacity – What works and why?

1.6 Extension and Adoption Theory

The link between research, development, extension and adoption can be described in the general terms below however it is important to understand that in reality extension starts once the 'problem' is identified and continues right throughout the R & D process until either an answer is found or a solution is not forthcoming.

- The **research** is identified and undertaken in alignment with industry-defined priorities
- The **development** is undertaken in terms of commercialising the research.
- The **extension** is crucial to the promotion of the product through the implementation activities that have their roots in social theories of (practice) change
- The **products** are adopted if they are seen as useful by the target audience.

The above approach provides a simplistic, linear model for a research, development, extension, adoption pathway, however in reality extension and adoption can be much more complex. The process of going from research to adoption is often cyclical in that research produces more research questions or problems arise at the development stage that require further research or testing. (Rufus Jennings and Roberts Evaluation 2011).

Coutts *et al.* (2005) proposes that extension projects in Australia can generally be categorised by one of five models that contribute to capacity building. This helps to takes the mystery out of extension project processes and allows them to be viewed in terms of the appropriate model. The models can be used in isolation or can compliment each other when used in unison depending on the project objectives and the target audience/s. These models are outlined as follows:

The Group Facilitation / Empowerment Model

This model focuses on increasing the capacity of participants in planning and decision-making and in seeking their own education and training needs based on their situation. The project will often provide or fund a facilitator to help groups to define their own goals and learning needs and to help them realise these.

The Programmed Leaning Model

This model is about delivering specifically designed training programs or workshops or both to targeted groups to increase understanding or skills in defined areas. These can be delivered in a variety of modes and leaning approaches.

The Technology Development Model

This model is about working with individuals and groups to develop specific technologies, management practices or decision support systems, which will then be available to the rest of industry or community. It often involves local trials, demonstrations, field days and on-site visits.

The Information Access Model

This model is about providing a range of information that individuals and groups can access at a time that suits them. It can be based in a library, information centre, on a website or other centralised location

The Individual Consultant / Mentor Model

This model is about individualised one-on-one support. It may be a technical expert visiting and providing advice, diagnosis and recommendations. It may be an ongoing facilitating mentor relationship, which provides a sounding board for decision makers.

1.7 The Seafood CRC's Framework for Ensuring Effective Extension and Adoption

The Seafood CRC has a defined approach to ensuring effective extension and adoption of research outcomes implemented through two distinct programs; Communication and Education (Program 3) and Commercialisation and Utilisation (Program 4).

The aim of the Communication and Education Program (Program 3) is to develop the capabilities of researchers and industry participants to strengthen the capacity for industry to commercialise and utilise the CRC's research. The core components of this program are:

- **Research education and training** – to build capacity within the research sectors by providing opportunities for honours and masters involvement in CRC research, a PhD and post-doctoral program and opportunities for researchers to gain practical knowledge of and to develop new skills within the seafood industry.
- **Industry skills and capacity** – provision of specialised training for developing and improving the human capacity of industry participants using activities ranging from short workshops to formal qualifications.
- **Communication with end-users and other beneficiaries** – to ensure two-way communication with end-users and their involvement from the initial prioritisation of research through to commercialisation and utilisation of research outputs. Also to

develop strong communication links with other beneficiaries in order to maximise industrial, commercial and economic benefits.

The aim of the Commercialisation and Utilisation Program (Program 4) is to ensure effective technology transfer and uptake of the CRC's research outputs by end-users and on-transfer of those outputs to beneficiaries including those who represent the community and consumers. In addition Program 4 serves to protect the intellectual property (IP) for the commercial and industrial benefit of the Australian seafood industry and wider economic benefit or research benefit to the Australian community.

The CRC Board and the CRC's Research and Adoption Committee approach each research project with a commitment to ensuring that:

- Each project incorporates a commercialisation and utilisation plan that describes a clear path to market
- A separate budget appropriate to commercialisation and utilisation is provided
- Research outputs are regularly evaluated against commercial criteria and any substantive IP or valuable information that arises is reported, registered and (if appropriate) protected
- Commercial scale trials are conducted, where appropriate, to evaluate the technical and economic viability of laboratory-proven research outputs; and
- Project commercialisation contracts are prepared when commercialisation involves the protection of IP

2.0 CASE STUDIES

2.1 CASE STUDY 1: Spatial Management of Southern Rocklobster fisheries to improve yield, value and sustainability (Seafood CRC 2006/220)

Central Problem

In response to a decreasing trend in global catch rates and landings from capture fisheries, fishery stakeholders are working to restore depleted stocks and establish enhancement programmes to improve production and management of fishery resources. 'Translocation' or the mediated movement of wild individuals or populations from one area to free release in another, is just one of the diverse strategies being implemented to achieve these objectives. (Chandrapavan 2011). For the Australian southern rock lobster fishery, this novel management approach may provide the fishery with the key to increasing sustainability and optimising the economic yield of the fishery.

"Moving lobsters from deep water to shallow water is akin to a commercial sheep farmer being able to grow his/her sheep to the size of a cow simply by moving them from one paddock to another at the cost of 20 cents per animal"

It may sound implausible but for Dr. Caleb Gardner, Program Leader of Fisheries at the Institute for Marine and Antarctic Studies (IMAS), this analogy best explains the remarkable benefits of 'translocation', a strategy that is now being implemented commercially by the southern rock lobster fishery as a direct outcome of fresh research into how the spatially diverse fishery can be managed more effectively.

The Tasmanian, Victorian and South Australian rock lobster fishery is based on the harvest of the southern rock lobster, *Jasus edwardsii.* Total production across the three states in 2009/10 accounted for 3,310t with 50% of catch coming from South Australian, 42% from Tasmania and 8% from Victoria. (Pecl *et.al.* 2009). The fishery, which dates back to the late 1800's, is of high value commercially in particular in South Australia and Tasmania, with total production over the three states worth an estimated $165 million (at producer prices). (Southern Rock Lobster Ltd. 2012).

Concerns about stock decline in the southern rock lobster fishery arose in the 1990's and resulted in the establishment of an individual transferable quota management system in 1998 in Tasmania and in 2003 in South Australia and Victoria. The aim of this management reform was to cap the total commercial catch in an attempt to allow the exploitable biomass to rebuild. A secondary aim was to provide a mechanism for the industry to restructure and increase profitability. To date, significant progress towards these aims has been achieved however there is still considerable potential to improve the productivity and profitability of the fishery.

A critical, but challenging issue presently faced by southern rock lobster fishery managers in all three states is that there are significant regional differences in stock abundance, recruitment patterns, growth rates and egg production and as a result, management rules that are applied across broad areas are often sub-optimal for smaller locations within these zones.

Spatial variation in the biological traits of adult southern rock lobster can be a significant driver of fishing dynamics where fishers target stocks with a desired phenotype that elicit high price per unit. Almost all southern rock lobsters are exported, with the majority being sent live to Asian markets. External appearance has a significant impact on the price of lobsters sold live because lobsters are generally displayed alive in tanks and consumer preference is influenced by visual presentation. The most important market trait is shell colour and the Asian market pays a premium for a live, vital, red-coloured live lobster without limb and carapace damage.

Shallow water lobsters (<30 m) are typically red whereas lobsters caught from depths >30m are paler and are commercially graded into categories of "pale" and "white". The deep water lobsters are also associated with characteristics such as long spindly legs and / or narrow tails in comparison with their carapace. As a result, pale coloured, deep water lobsters are generally sold at discounted prices and this has made them uneconomical to fish. Quota management combined with higher prices for shallow-water lobsters has effectively driven fishing effort inshore as fishers now manage their businesses to optimise the value of each kilogram caught rather than maximising total catch.

Additional management issues due to spatial variation in southern rock lobster biology have been identified as:

<u>Unfished Stock</u> – Female lobsters in deep water off the SW coast of Tasmania rarely reach legal size and represent a significant unfished stock. Regions of the fishery have size limits that are too large and where animals are reaching maturity without reaching legal size.

<u>Discarding or Upgrading</u> – Fishers discard a large proportion of their catch because of the lower prices they would fetch (e.g. the market prefers animals within a narrow size range (800 – 1500g) and so large males or small, legal individuals are often discarded. This practice reduces yield and shifts effort onto egg producing females.

<u>Growth Overfishing</u> – The average size of legal-sized lobsters taken has decreased in some areas where growth is above average thus reducing maximum yield and net value. Productivity gains from better management of size at harvest would potentially increase yield.

A clear need for improved management capability to follow stocks at different depths and to evaluate novel harvest strategies suited to the particular spatial characteristics of the stocks was identified by southern rock lobster fishery stakeholders in the mid 2000's. Hilary Revill, the Principal Fisheries Management Officer with DPIPWE, Tasmania, explains the need for more effective management.

“From about 2000 – 2005, lobster stocks were booming. Stock rebuilding (from the decline in the 1990’s) was happening at a rapid rate and we were holding the Total Allowable Catch constant. That all changed and in 2006 we saw a dramatic decline in stocks due to poor recruitment. We recognised the need to manage the fishery smarter in having regional management strategies in place”.

“We are very fortunate here (in Tasmania) in that researchers and government and industry have a very close working relationship and collectively we identified the need to manage differently within different parts of the fishery because primarily everything is done on a whole of state level so there are the same size limits, same fishing seasons, and these same rules that have applied across the fishery for the last 50 years.”

“It has been apparent for some time that we could get better outcomes in terms of productivity or economic benefit by actually managing differently in different parts of the state primarily because growth rates are so different between the south and the north. For example in the far south of the fishery lobsters grow on average 1mm per year whereas in the north grow rates can be as much as 20mm per year”.

Researching a Solution

Managers and fishers of the southern rock lobster fishery have long been aware of the need for more information on which to make informed choices on alternative management strategies that better address spatial variation within the fishery.

“From a management perspective, we have been particularly keen on being able to investigate how to try to encourage fishers to get a greater proportion of the catch from deeper waters where people have just stopped fishing” says Hilary, “We also need to understand the impacts of changing size limits”

For Caleb, the idea of translocating lobsters to improve growth and marketability is not new.

“Fishers have been discussing the potential of translocation for years. They have long been aware of the number of small lobsters in deep water and their slow growth rate. In 2005 industry got behind and jointly funded with the FRDC a pilot project to look at the economic feasibility of translocation, which gave promising results for increasing productivity at low cost. The next step was to look at the effects of translocation on lobster biology such as survival and genetics and to determine any adverse impacts on the ecosystem”.

In 2006, Caleb Gardner and his IMAS research team put forward a proposal to the Seafood CRC and Fisheries Research and Development Corporation to fund a research project to investigate the large-scale geographic variation of the southern rock lobster fishery with a focus on providing more effective management and the opportunity for sustainable increase in the value of harvests.

The project proposed to investigate three different spatial management strategies.

These strategies were.

1. Applying regional size limits better suited to local growth rates
2. The use of additional catch as an incentive to encourage a greater proportion of catch from deeper water.
3. Translocation of lower yield and lower value lobsters from deep water to shallow water.

The following project was approved,

“Spatial management of southern rock lobster fisheries to improve yield, value and sustainability”. (Seafood CRC 2006/20).

and a large-scale collaborative research project ensued comprising the following agencies: Institute of Marine and Antarctic Studies (IMAS), University of Tasmania (UTAS), South Australian Research and Development Institute (SARDI), Department of Primary industries (DPI) Victoria, University of Washington (UW), Tasmanian Rock Lobster Fishermen’s Association, (TRLFA), Department of Primary Industries, Parks, Water and Environment (DPIPWE) Tasmania.

The objectives of the project were as follows:

1. To enable assessment reporting of trends in biomass and egg production by depth.
2. To evaluate separate deep-water quota to increase yield and egg production.
3. To evaluate regional size limits in Tasmania for increase in yield and egg production.
4. To conduct field experiments and sampling to provide additional data required for alternative harvest strategy:
   i. Fisher catch sampling
   ii. Translocation release survival
   iii. Release movement
   iv. Translocation growth transition
   v. Effects of translocation on maturity and egg production parameters
   vi. Density dependent growth
5. To conduct field experiments on translocation to provide addition data required for economic evaluations:
   i. Change in colour
   ii. Tail width
   iii. Condition
   iv. Survival in live transport
6. To evaluate translocation options that increase yield and egg production
7. To evaluate and compare spatial management options by economic analysis
8. To determine the extent of ecological community change in deep water reef habitats in response to increased harvest rates of lobsters
9. To develop functional management and monitoring recommendations to apply outcomes.

Research Outcomes

The research has enabled Tasmania, South Australia and Victoria to now conduct stock assessments with the same length-based stock assessment model structure, which includes demographic traits, fleet movements, and catch rates from that region. This has led to improvements in reporting and management decision making such as in the setting of TAC's and capacity to improve management decisions is expected to have a large effect on the marginal economic yield of the fishery.

The model was modified for the Tasmanian fishery to include economic data so that harvest strategies could be compared in terms of economic outcomes. This capability was important for examining spatial management aspects of the project but was first applied in the context of TACC setting and results showed that the current TACC was to high to maximise economic yield, leaving the industry vulnerable to temporal changes in productivity.

As yet, neither Victoria nor South Australia have adopted spatial management changes as a result of the project, however all three management strategies investigated appeared to provide opportunity for sustainable increase in the value of southern rock lobster harvests with translocation presenting the potential for greatest gain overall.

It was shown that regional size limits, better suited to local growth rates could increase yield, particularly in areas that are growth underfished in Tasmania and South Australia. Hilary says that the fishery managers in Tasmania are now using the modelling to evaluate the implication of changing the size limits but changes will not be implemented yet.

"We haven't had to implement a size limit change as yet and we are just monitoring the stocks in the southwest and north at present. One of the areas we are looking at is the southwest of the fishery where the current size limit overprotects the lobsters. However we decided in conjunction with industry that it wasn't sensible to implement translocation and a decrease in size limits at the same time".

The use of additional catch as an incentive to encourage a portion of the catch into deeper water was implemented with some success although record low recruitment into the fishery led to a hiatus in this initiative after two years.

"We trialled the concept and practicalities of allowing extra gear to be used in deep water and allowing extra quota that you could only take from deep water in addition to the normal TAC allocation", says Hilary, "What we found was that even though the incentives were quite reasonable and were worked through with industry it didn't really generate any new boats that weren't currently fishing there already. In addition to this the trial was carried out at a time when the stock was in decline which made it difficult for fishers to justify any economic advantage of the incentives offered".

“It could be that the extra quota was too conservative to encourage fishers out into deep water but we haven’t moved further with investigating this because the focus is now on getting translocation to the next stage. When you model the benefits of translocation it far outweighs the benefits of trying to get a few more fishers to take more lobsters from the deeper water”.

Of the three spatial management strategies investigated, the greatest potential gains came from the translocation of lower yield and value lobsters from deep water to shallow water as evaluated through a large-scale pilot experiment, which investigated the impacts of translocating 30,000 lobsters.

“The translocation component of the project has worked very well”, explains Caleb, “The research has shown radical gains in growth rate. Where a lobster in deep water may take ten years to grow that extra 1cm to legal size, a lobster in shallow water will take 6 months.

“The results also showed a significant increase in marketable traits like red colour and body width with no adverse impacts on the survival or biology of the lobster and no adverse impacts on the ecosystems they were taken from or introduced to”

“Translocation is a commercial reality. Modelling has again shown that it is economically feasible and we estimate that even small scale operations of moving 100,000 lobsters per year could return an increase in net present value of the resource of over $40 million”.

In Tasmania, several management decisions were made based on the research results. Firstly both government and industry voted to reduce the TAC by 20% in 2009, resulting in a gain in market capitalisation of $65 million by the end of 2011. Secondly, regional seasonal closures were introduced in 2011 allowing for regions of the fishery to remain open in October where higher quality, hard shelled lobsters are available. Finally, translocation has been adopted on a pilot scale with industry deciding to extend results by contributing funds for small scale commercial operations to move 100,000 lobsters per year with the potential for future commercial scale movement of 500,000 lobsters per year in the far SW region alone. This commercial roll-out will involve facilitating the governance arrangements, monitoring the translocation operation and tracking performance under large-scale operation.

Extension Delivery and Industry Uptake - Strategies and Results

According to Caleb, the Principal Investigator on the project, one of the most critical aspects behind the success of the project has been the prevailing strong relationship between researchers and stakeholders. Caleb has worked for over 15 years as a researcher within the southern rock lobster fishery field and during this time has developed solid relationships with fishers along the way, building mutual respect and understanding. Hilary says this is crucial to the extension and adoption process,

“Caleb has a very good track record and industry have a high regard for him. What we find is that there are many fishers that respect Caleb’s research will go along with his research recommendations because of the relationships he has built with industry and the reputation he has for effective outcomes".

The other critical aspect was undertaking the project with commercial management outcomes in mind and a focus on consultation, engagement and transparency for all stakeholders during the project planning and research stages and through to completion. The planned extension process was mapped out within the Seafood CRC application and represented an important criterion on which the project submission was assessed.

In Tasmania alone there are just over 300 rock lobster entitlements (licences) and estimates show that over the last few seasons the number of active vessels participating in the fishery has varied between 205 and 220. (TRLFA 2012). In addition to fishers the industry comprises processors and exporters and is estimated to provide employment for approximately 3500 people across Tasmania, South Australia and Victoria.

The industry in Tasmania is represented by the Tasmanian Rock Lobster Fishermen's Association (TRLFA), a peak body with a strong voice on the Ministerial Advisory Committee for crustacean fisheries. Industry members play a key role in determining research priorities and annual fishery assessments.

Rodney Treloggen is the CEO of the TRLFA and was a Co-Investigator on the project. Rodney acknowledges the ever-present challenges involved with consulting with a large number of stakeholders but says that optimising industry communication, extension and adoption processes is of highest priority for the TRLFA.

"We have worked for a long time together with fishery managers from DPIPWE and research organisations such as IMAS on getting these processes right. TRLFA and DPIPWE hold a series of joint departmental meetings twice each year. Hilary (Revill) and I visit about 10 ports around the state in early May and October and it is common for Caleb (Gardner) from IMAS or other scientists to be there at these meetings. We have two-hour face-to-face meetings with in general 10 – 15 fishers (boat owners, quota owners, skippers, processors) at each port and then hold TRLFA general meetings at the end of May and October".

"We use these meetings to communicate information from researchers and the government departments and fishers can provide feedback and members can vote on issues at the general meetings. In addition to this we also disseminate written material to all licence holders and post industry updates on the TRLFA website".

Hilary explains that although this process works well, it does require active participation by those in industry, which sometimes doesn't transpire.

"These meetings are open to anyone but we tend to get the same people coming to meetings as those that don't. There are about 200 or so fishers that participate overall. But engagement is a problem for those that never come to meetings and although we send information in the mail we don't know that they read it. We do everything possible to make the process open and accessible to all but it is difficult to engage those that simply don't want to be engaged and we accept that there may always be a portion of industry that we can't reach".

Under Coutts Five Models of Extension, the regular meeting process employed by the TRLFA can best be described as imitating the Group Facilitation / Empowerment model where a group of individuals (fishery stakeholders) with a long term commitment to the process have an agreed framework for communication exchange and information uptake.

In addition to this, the TRLFA, IMAS and DPIPWE have also employed the Coutts Information Access model to get research results out to wider industry which means that information is provided in a manner that individuals and groups can access at their convenience such as through conference presentations, reports, newsletters and website updates.

Mal Maloney is a southern rock lobster licence holder and also a member of SPOC (Sustainability and Profitability Options Committee). Mal explains SPOC's role within the TRLFA and the strategy that is employed by SPOC to consult with members.

"SPOC was established in 2008 by the TRLFA to identify, assess and advise the TRLFA membership of potential opportunities to improve the sustainability and profitability of the fishery"

"The strategy at TRLFA workshops and general meetings at which contentious recommendations from SPOC are to be discussed is to seat the usual 100-plus attendees around tables with about eight people at each and take and record on white board progressive reports from each individual table. This tends to give almost everybody a voice and prevents a loud clique dominating to the extent that many less confident fishers will not put their points of view or indeed attend free-for-all meetings".

Rodney says that the establishment of SPOC has stopped the disputes at meetings that tend to draw focus away from the issue at hand.

"The SPOC has a liaison role with industry. Any issue that comes up from the members or externally is run past this committee. They then do all the groundwork and the research and then report back to the members through written material or through face-to-face forums. We have constant input from all the members on that committee and constant feedback from that committee back to the members so we really liaise very well this way with the industry".

The process of extending the results from Caleb's spatial management research, in particular the concept of translocation, has been interesting, says Rodney, in that the impetus for researching the potential for translocation came originally from industry itself.

“We as an industry have talked about the possibility for using translocation for 15 years. Fishers had been aware for many years about all these small lobsters in deep water. They knew from their own experience, even though no testing had been done, that these animals were only growing a small amount each year. We discussed it with Caleb at IMAS at length and kept talking about it and eventually got a pilot project going”.

“There was no opposition to the pilot project. It was only when we stated to talk about moving large numbers, hundreds of thousands of lobsters, that there became some opposition from those areas from which the fish were going to be taken from”.

“The concept of translocation has a lot more supporters than detractors but there is a process that we have to go through to ensure that those who are opposed and who have genuine reasons for thinking that translocation could result in direct problems for them and the fishery are given all the information possible to allay the fears they may have”.

“We have had countless meetings about translocation. It has been raised at just about every meeting we have had over the past 10 years. There has never been any lack of consultation but the process of acceptance of the research findings from those in opposition will take time. What will bring about acceptance will be the absolute gains that will be made for the fishery in the long term”.

“The resistance to change is understandable. Some fishers have struggled to get to grips with the advances that translocation can bring such as colour change and change in size. It is a lot for people to accept in a very short time and it is normal for people not to want things to change that could potentially interfere with their way of life. We have had to dispel various myths and rumours during the consultation process but this is all part of it”.

“Because it was a contentious issue we went out of our way to ensure everyone was informed and had their say. Interestingly, one of the most vehemently opposed fishers now sits on the governance committee. He actually became part of the committee saying that if it was going to happen then he wanted it to happen properly. He is now fully committed to the idea”.

Mal Maloney describes the consultation process in more detail.

“Caleb Gardner and his IMAS team communicated the outcomes of the pilot R&D project to SPOC in writing and in person. They showed that, from the perspective of a research scale project, translocation of rock lobsters in Tasmania offered an almost unbelievable opportunity to improve yield, market value and biological sustainability with no identifiable downside. This was to be achieved by moving sub-legal size lobsters from offshore patches of slow growth and over-population to heavily-fished inshore locations where, the project showed, they would grow quickly into premium fish of marketable size and market-preferred colour.”

“SPOC saw it, I believe, as a once-in-a-lifetime opportunity. Not just because it pressed all the biological buttons with no apparent risk, but also because the real world economic credentials of Caleb and his colleague Klaas Hartmann (IMAS) allowed them to identify significant and believable bottom line outcomes.”

“Consequently, SPOC’s goal was to convince the TRLFA membership that this was an opportunity to be grasped with both hands – one that, although confined to the west, would benefit fishers state-wide because of the counter-balancing nature of a quota fishery. In reality this was never going to be easy. That membership was aging, conservative, suspicious of science and scientists, with a default position of opposition to change.”

Mal explains that the fishery was simultaneously in a time of crisis.

“It was also enduring one of the fishery’s most prolonged depressions, with no end in sight. Recruitment of young lobsters to the legal-size biomass had been virtually non-existent for a number of years, resulting in three consecutive TACC cuts amounting to almost 30 per cent - the first and biggest volunteered by the TRLFA (on SPOC’s advice), the following two imposed against bitter majority opposition. In addition, erratic but prolonged market disruption in China imposed a further layer of uncertainty on the viability of individual businesses.”

“For translocation, the precise difficulty was that, to grasp the opportunity with both hands, a depressed, financially-strapped, quota-owning TRLFA membership had first to be persuaded to put one of those hands into a threadbare pocket to help fund a two-consecutive-seasons commercial-scale trial.”

“In light of this, the simple strategy adopted by the TRLFA Board, its CEO and SPOC was developed in collaboration with Caleb and the IMAS team and the fishery manager, DPIPWE’s Hilary Revill. Hilary, by invitation, had attended and contributed at most SPOC meetings and her excellent cooperation ensured there would not be any overlooked or unforeseen regulatory or management impediments to catching and moving big numbers of sub-legal fish.”

“So in a report mailed to TRLFA members in September 2010 SPOC pointed to the highlights of the IMAS project, asking that the TRLFA’s annual general meeting the following month authorise SPOC to design a draft commercial translocation plan in consultation with DPIPWE and IMAS; and present it to a special TRLFA workshop for consideration. At that AGM Caleb gave a polished presentation of the findings and a majority agreed that SPOC should prepare a plan ‘for consideration’.”

“Prior to the subsequent workshop in November 2011 a SPOC report mailed to TRLFA members was accompanied by an updated IMAS report and a ways and means assurance from SPOC that the proposed commercial trial should be industry-driven. It proposed that 100,000 rock lobsters be translocated offshore to inshore on the west coast in each of two consecutive seasons.”

“The TRLFA would run the catch and release using charter boats, selected by an independent industry committee, under permit conditions negotiated with DPIPWE. With Seafood CRC funding, IMAS would measure the changes in colour, growth and wellbeing of the translocated stock and the financial benefits to industry of increasing the value of rock lobster in this way. The industry financial contribution would be $100,000 a season, raised through a DPIPWE-collected levy of $10 per ITQ.”

The IMAS report estimated that the annual benefit of translocation at this scale would be the equivalent of an across the board quota increase of five kilograms per ITQ.

During the workshop it was made clear that if the TRLFA did not wish to proceed with the trial, DPIPWE would advise the Fisheries Minister to further reduce ITQs by the five kilos mentioned above.

The meeting voted to proceed with a commercial trial as proposed.

Subsequently, the TRLFA appointed two sub-committees:

- A Governance subcommittee of TRLFA members, chosen by their peers, mostly experienced west coast fishers, chaired by TRLFA CEO Rodney Treloggen and with Caleb and Hilary as advisers. It nominated the catch and release sites.

- A Tender Selection subcommittee of TRLFA and IMAS representatives chaired by former Fisheries Minister David Llewellyn. Its brief: Oversee the tendering of catch and release.

The commercial-scale translocation project, under Caleb’s guidance, is now in its second season, with excellent cooperation between the TRLFA, IMAS and DPIPWE. Because of seasonal timing, only 60,000 fish were moved in Season One but tenders have been let for the translocation of 140,000 in the current season.

Mal says he believes the communication and consultation leading up to project implementation was excellent.

“IMAS and TRLFA communication was delivered in hard copy to all industry members in advance of annual workshops or AGMs, then verbally at those gatherings with critical PowerPoint graphs. All attending industry members were entitled to speak, although secret ballot voting in person or by proxy was restricted to TRLFA members”.

“The journey from IMAS-SPOC beginnings to project start was tediously slow, because the TRLFA horse had to be slowly and gently advised of the location of the water trough. But from a science-regulatory-financing viewpoint it was amazingly smooth, thanks in great degree to Caleb and Hilary’s positivity and direct participation in the SPOC and subsequent process – we didn’t end up in any dry gullies or find progress barred by immoveable management plan or regulatory barriers”.

Hilary says that the process of industry consultation, engagement and extension is far from over.

“While translocation is still determined to be the best management solution to the lobster stocks and viability of the fishery we will definitely continue to communicate the benefits of the strategy to al fishers”.

Part of the current commercialisation process, says Hilary, is to develop a more formal system as to how translocation can be used in the fishery on an ongoing basis.

“We will continue to examine and monitor the translocation process, the costs and the benefits and will continue to work with industry to determine a mechanism by which it can be taken forward practically”.

“Fishers understandably want proof that the productivity suggested by the model will actually eventuate. That is going to take time, perhaps a number of years.

There are a number of challenges associated with the implementation of spatial management strategies in a fishery. For fishers, having ‘lines’ on the water inevitably means there are different operational restrictions in different areas and this can either increase their operational costs or restrict the choices that they are used to being able to make.

“We understand the practical consequences of introducing spatial management regulations, from both the fishers perspective and also the managers compliance perspective. Therefore even if all the data has pointed to having to make a particular change we work very hard to make sure we reach a consensus position with industry otherwise such a changes is impossible to implement”.

Caleb thinks that overall the project has been very successful and that the extension and adoption process has been well managed.

“In general I don’t think we could have improved on the extension and adoption process. It is always very hard to instigate change in people, to get them to change their perceptions and accept a new status quo. However we made the process open and transparent and focused on fostering inclusion and ownership. A core group of fishers very much took ownership of the project and championed the extension and adoption process”.

“This project was really driven by industry from start to finish and that is one of the key reasons behind its success”.

Rodney says that he believes the preliminary translocation trials will be scaled up to be fully commercialised.

“Provided all the ducks line up I am confident that we will be able to scale up to full commercialisation of this process. There are of course a range of other things that can impact the process such as the market situation and how catchable the lobsters are but fishers aren’t adverse to putting their hands in their pocket if they can see that there will be a direct benefit to them and the fishery”.

More time is needed before the real benefits to the fishery and industry from these spatial management initiatives can be properly evaluated, however it would seem that stakeholders now possess a broader suite of management tools that can be utilised towards increasing the sustainability and optimising economic yield of the Australian southern rock lobster fishery.

Summary of Extension Strategies and Extension Limitations

Extension strategies employed

- Pre-existing solid respect-based relationship between IMAS researchers and southern rock lobster fishery stakeholders.
- Bi-annual port meetings and TRLFA general meetings open to all industry stakeholders, project researchers and fishery managers (Coutts Group Facilitation / Empowerment model).
- Prioritising of commercial outcomes by IMAS, TRLFA and DPIPWE during project development process.
- Dissemination of research information in form accessible to industry at their convenience through TRLFA, IMAS and DPIPWE reports, newsletters, conference presentations and website updates. (Coutts Information Access model).
- Facilitation of industry consultation and engagement and streamlining of communication process through TRLFA Sustainability and Profitability Options Committee.
- The appointment of a TRLFA governance sub-committee comprising experience westcoast fishers to nominate translocation catch and release sites
- The appointment of a TRLFA tender selection sub-committee chaired by former Fisheries Minister David Llewellyn to oversee the tendering of catch and release.
- Project planned, developed and driven by a core group of fishers - fostering inclusion and ownership.

Extension and Adoption Limitations

- Fishery in a depression during the time of the research due to recruitment decline and export market disruption.
- Large number of stakeholders (>300 in Tasmania)
- Recurrent non-participation in port meetings and TRLFA general meetings by some stakeholders
- Circulation within industry of false information resulting in myths and rumours about the research and its ramifications.
- Ageing, conservative TRLFA membership, sceptical of science and scientists.

2.2 CASE STUDY 2: Population genetic structure of Sea Cucumber in Northern Australia (Seafood CRC 2008/733)

Central Problem

"We would like to think that the work we are doing will pave the way for another great Australian export industry" says Grant Leeworthy, Fisheries Research Manager at Tasmanian Seafoods. "Our long terms goals are about making the industry viable".

The industry that Grant is talking about is that of the Sea Cucumber fishing industry in Australia's Northern Territory. The Sea Cucumber, *Holothuria scabra*, commonly called the sandfish, is a commercially important species found throughout the Asia-Pacific region. Sea cucumbers are a popular luxury food item in Asian seafood markets where most of the product is traded and sold in the dried form, called bêche-de-mer or trepang. Of the 50 or so tropical species of Sea Cucumber that are commonly traded, the sandfish, *Holothuria scabra*, is one of the most valuable and sells in Hong Kong for US $240 / kg dried or US $20 / kg gutted boiled; (drying shrinks the gutted boiled weight 10 fold), (Leeworthy, *Pers. Comm*).

Representing Australia's oldest export industry, sandfish have been harvested and traded in the NT since the 1700's when Macassans from Celeb, Indonesia travelled across the Timor Sea to gather and process sandfish in cooperation with the local Aborigines. Estimates based on historical data indicate annual catches of around 800 tonnnes at that time. The NT *H.scabra* fishery then underwent a significant period of low or no commercial exploitation until the 1980's when six licenses were issued that covered the entire NT coastline.

Two management areas currently exist: east of Cape Grey to the Queensland border and west of Cape Grey to the Western Australian border. Three licences operate within each management zone and fishing is restricted by area, species, minimum size and the number of divers on each vessel. Tasmanian Seafoods Pty. Ltd. is the largest processor of sandfish in Australia and currently holds all six fishing licenses for sandfish in the Northern Territory.

Since 2004, Tasmanian Seafoods has been investigating the potential of propagation and juvenile production of sandfish with a view to enhancing the existing wild fishery through sea ranching.

"Our main goal is to start stock enhancement of sandfish in the Northern Territory", explains Grant, "We want to re-establish the industry and we purchased the licenses in order to do this. The industry was non-viable at the time we purchased the licences but we have done our research and understand that a major (but potentially resolvable) limitation to its success is recruitment".

"Through previous stock assessments we have determined that the fishery is capable of holding more stock but the stock just isn't there".

Sea ranching involves the propagation of hatchery produced juveniles, which are then released into the wild within the licensed fishing management area and left to grow in the natural environment until ready to be harvested by the licensed fisher.

The primary challenge for Tasmanian Seafoods, despite their own sandfish stock research, was the scarcity of background information on the fisheries biology and recruitment patterns of *H.scabra*, which meant that the regulations governing the NT Sea Cucumber fishery were not well informed.

The NT State Government had released a discussion paper in 2004 that identified some of the ecological, social and economic considerations of sandfish stock augmentation and sea ranching (NT Department of Business, Industry and Resources Development 2004). However there was no formalising of policy on implementation of sea ranching projects. Therefore in order progress the stock enhancement initiative, Tasmanian Seafoods entered into negotiations with the NT Government Department of Resources Fisheries Group to develop appropriate policies and management arrangements that would conform to the NT's *Fisheries Act 1998.* (Bowman 2012).

Will Bowman is the Hatchery Manager at Tasmanian Seafoods Darwin based *H. scabra* hatchery.

"We (Tasmanian Seafoods) have really had to take the lead on this initiative. The NT Department of Fisheries were supportive but initially not able to provide a position on whether sea ranching of sandfish could be progressed because of the lack of data they had to work with".

"During discussions it was determined that more biological and spatial data was needed on existing sandfish populations, particularly on the genetic structure of the populations. So we proposed a project to survey existing populations to get an understanding of the genetic diversity between or within stocks. This information would allow any future stock enhancement program to be managed so as to maintain the genetic integrity of the wild stocks".

When releasing hatchery-produced progeny it is crucial that the genetic structure of wild populations is taken into account and that an appropriate genetic management strategy is in place for hatchery broodstock.

The long-established genetics of wild sandfish populations may allow for adaptations to local conditions or to infrequent environmental or biotic (disease) stressors. The potential risk of not considering the genetic make-up of the wild populations and the interbreeding of different stocks is outbreeding depression which can result in the loss of these adaptations and a subsequently genetically weakened wild population less resistant to such stressors. In other words, without careful management of the genetics of introduced stocks, outbreeding could lead to a reduction in the fitness of the wild population and therefore a potential increased susceptibility to changes in environment or disease, increasing vulnerability to extinction over time. (Gardner 2012)

For both Tasmanian Seafoods and the Northern Territory Department of Fisheries gaining information on the genetic structure of existing sandfish populations within the NT fishery was therefore necessary as a first step towards the effective development and management of the proposed stock enhancement and sea ranching initiative.

Researching a Solution

In 2008 Tasmanian Seafoods approached Dr. Graham Mair at the Seafood CRC with a project proposal. Graham, Program Manager for Production Innovation and Dr. Len Stephens, Managing Director of the Seafood CRC met frequently with several of the Tasmanian Seafoods team to discuss project objectives and worked together to develop the project that was subsequently approved and initiated:

Population genetic structure of Sea Cucumbers (bêche-de-mer) in northern Australia. (Seafood CRC Project No. 2008/733)

The project objectives were as follows:

1. To characterise the genetic population structure of *Holothuria scabra* within the range fished by Tasmania Seafoods

2. To characterise the genetic diversity of the hatchery broodstock and progeny arrays relative to the natural populations.

3. To refine and/or recommend policies and strategies for the sustainable management and enhancement, through ranching of *H. scabra* fisheries.

Through a tendering process the Seafood CRC facilitated the engagement of Dr. Mike Gardner and Dr. Alison Fitch from Flinders University with assistance from Professor Li Xiaoxu from the South Australian Research and Development Institute (SARDI) to undertake the research.

Sandfish tissue samples from a total of 737 *H.scabra* individuals were collected from 16 locations ranging along the NT coast from Popham Bay near Darwin to Groote Eylandt in the east. Sandfish were collected by hand or by diving with hookah units.

To examine genetic variation within hatchery produced juveniles, to determine the genetic implications of current breeding patterns and to assess inheritance of microsatellite loci, broodstock and juveniles were also sampled from three separate spawning events.

The samples were preserved and transferred to the laboratories at the South Australian Regional Facility for Molecular Evolution and Ecology (SARFMEE) for analysis.

Research Results

Mike Gardner and his research team were able to develop a panel of eighteen usable microsatellite markers and also primers to sequence a segment of a mitochondrial DNA gene. The microsatellites and the mtDNA were then used to investigate the genetic structure of the sandfish within the fished area and to assess parentage of hatchery stock.

The research showed that NT sandfish populations between Popham Bay and Groote Eylandt could be grouped into two genetic populations roughly divided east to west and corresponding to the Gulf of Carpentaria (eastern population) and Arafura Sea (western population).

The results indicated that dispersal of the sandfish larvae is limited to these two areas with little gene flow between them. On the basis of this, Mike and his research team recommended that the NT sandfish fishery should be managed as two separate, genetically distinct stocks with captive broodstock and progeny from the two areas kept separately and only released back to the areas containing individuals from the same genetic stock that their parents originated from.

The research also determined, by the use of microsatellite markers to assign parentage, that a small number of the broodstock tended to dominate successful spawning. This indicates a potential for low genetic diversity amongst the progeny from captive spawning however further research into genetic input from spawning is needed as Luke Turner, Hatchery Technician at Tasmanian Seafoods explains.

“The progeny array suggested that there was a limited genetic input from spawning. We had a large number of broodstock that we used in the spawning but only very few of them spawned and we think that was due to the suboptimal conditions at the time of spawning”.

“We are improving on our hatchery management and conditions all the time and we think now that with better conditioning we will be able to improve on the process and will then use those figures for our ongoing genetic management strategy”.

For Tasmanian Seafoods, the Flinders genetic population survey research has overlapped effectively with the company’s other Seafood CRC supported research project into propagation and sea based growout of sandfish. This project focuses on larval / nursery production of sandfish and subsequent propagation, relocation and grow-out and survival at sea. Based on the genetic research carried out by Flinders University and SARDI, a variation has been built in to the Tasmanian Seafoods propagation project to include further genotyping of progeny arrays to more accurately represent typical sandfish spawning.

Upon completion of the genetics project a workshop was held in Darwin in May 2012 where the research results were communicated by Mike’s research team, Tasmanian Seafoods and the Seafood CRC to scientists from the NT Department of Fisheries and the Australian Fisheries Management Authority. The workshop discussions lead to the identification of several additional steps for Tasmanian Seafoods to take in the development of an appropriate genetic management strategy that will be critical to obtaining regulatory approval for commercial scale ranching of *H. scabra* in the NT.

Further developments include:

1. Further genotyping of progeny arrays to more accurately represent typical spawning (to be undertaken as part of Tasmanian Seafoods / Seafood CRC propagation project. (Seafood CRC Project No. 2009/744)
2. Clarification of target effective population size of broodstock to produce juveniles for ranching.
3. Areas for intended ranching activities should be clarified.
4. Standing stocks should be estimated in potential ranching areas.
5. Tasmanian Seafoods to develop a genetic management plan for hatchery reared *H.scabra* in conjunction with Flinders University, Seafood CRC and NT Department of Fisheries (to be undertaken as part of Tasmanian Seafoods / Seafood CRC propagation project. (Seafood CRC Project No. 2009/744)
6. Information on local ocean currents should be sources to identify potential drivers of populations genetic structure.

Current fishery management zoning of *H.scabra* stocks reflect fairly closely the results of the genetic population survey and so implementation of a zone change in response to this genetic data by the NT Department of Fisheries will be relatively straightforward.

For the Tasmanian Seafoods team this project has taken them to the next stage of progression towards commercialisation of sea ranching of sandfish in the NT.

“We are finally at the next stage”, says Grant, “We have completed the pilot phase of the project after 6 years of hard slog and now we are ready to go into more commercial scale production”.

“The NT Department of Fisheries has drawn up a set of management recommendations for pilot scale stock enhancement work and we are working on a commercial framework now”.

“If we hadn’t done this project we would be in a standstill position with the NT Department of Fisheries as they didn’t have the data needed in order to formulate a policy position. Now we have this data and are in the process of drawing up a genetic management plan that will assist government policy over the management of the fishery”.

“It’s exciting that we are now at this stage and are undertaking some basic release trials to monitor how our hatchery juveniles perform in the wild environment”.

Tasmanian Seafoods also has forged close links with the coastal aboriginal communities in development of the sea-ranching initiative says Grant.

“We have a Memorandum of Understanding with the aboriginal community in one particular area on Groote Eylandt. It has been important for us to build a good relationship with the local Umbakumba community as we are working around their traditional fishing grounds. We are working to establish joint ventures with them and have already carried out a successful trial with the community to harvest and process 2.5 tonnes of sandfish. Having the communities involved when the initiative becomes fully commercialised will be a win-win for Tasmanian Seafoods and the Umbakumba”.

Extension Delivery and Industry Uptake - Strategies and Results

Mike believes that the success and timeliness of the project has been due primarily to the direct working relationship between his research team at Flinders / SARDI and sole industry partner Tasmanian Seafoods.

“This was a commercial problem for Tasmanian Seafoods. They wanted to start a re-stocking program in order to make the NT sandfish fishery sustainable and viable but in consultation with the NT Department of Fisheries were advised that they first needed to determine the genetic structure of the wild stocks”.

Mike was the principal investigator on the project and says the beauty of a project structure like this is that there are no obstacles between the researcher, the industry partner and adoption.

“In terms of stakeholder communication and engagement it was logistically a lot easier to manager this project because Tasmanian Seafoods were the only fisher involved. Dealing with one partner meant the research process was unimpeded by the need to consult with other entities and decisions could be made upon one phone call”.

Grant echoes Mike’s opinion. “The process of working with Flinders University and the Seafood CRC has been straightforward. We have all had the same focus and communication has been very good. We have been communicating by phone or face-to-face and this sort of communication is great for decision-making. You almost have an obligation to resolve the issues rather than defer them and it’s amazing how quickly things happen when everyone agrees”.

Under Coutts Five Models of Extension, this process can best be described as imitating the Technology Development / Problem Solving model which is where researchers work with individual partners or groups to develop specific technologies, which will then be available to wider industry.

In this instance the research by Flinders University has resulted in the identification of the genetic structure of wild NT sandfish populations, which will assist in the development of a genetic management strategy for implementation by Tasmanian Seafoods and the NT Department of Fisheries. This will help, through the planned stock augmentation initiative by Tasmanian Seafoods, in the development of a more viable and sustainable fishery with direct commercial benefits to the fisher and local NT communities.

Mike explains that the strong client – researcher relationship was founded in large part from the sense of ownership that Tasmanian Seafoods had for the research.

“The Tasmanian Seafoods team had a high degree of ownership over this project. They drove it and I was guided largely by them. They were clear on what they wanted and if they wanted something done and it was within our project scope I would do it. There has been good collaboration and it has worked very well”.

Will says that this situation is a great example of industry taking the lead role.

"The research would not have happened if we hadn't proposed it and I think Tasmanian Seafoods should be recognised for the role the company has taken in driving this initiative with the view to improving the fishery and all the positive outcomes that these improvements will deliver".

Will says that communication of project outcomes all happened within the project timeframes and that he and his team at the Tasmanian Seafoods hatchery were kept in the loop through the duration of the analysis.

"There is a reporting process that the Seafood CRC has in place so we were kept informed as to research progress through milestone reports drawn up by Mike and his team".

Mike specifically mentions the project management process employed by the Seafood CRC.

"The Seafood CRC, in particular Graham Mair, was very instrumental in facilitating the project initially but then also during the course of the research, ensuring the project was on track and assisting with communication of results".

"Graham helped initially to provide me with a better understanding of the expectations of the Seafood CRC and with facilitating contact with Tasmanian Seafoods. He was also instrumental in setting up go-to meetings where my research team and I could discuss results with the Tasmanian Seafoods team."

"The go-to meetings and Skype were a good strategy. They enabled face-to-face contact early on in the project, which is when it is important that all agree on research direction and methodology. Once the project was underway we could communicate effectively by email or if a quick response was required we would just pick up the phone".

Will points out that the strategy for the dissemination of research results to stakeholders was particularly effective.

"One approach that worked very well was the workshop that we held for the Flinders team to deliver the research results to the NT Department of Fisheries and other stakeholders. There were some people we invited specifically because we felt they should attend but the forum was open to anyone and all stakeholders were welcome. I was very happy with the outcomes of that workshop because everyone was engaged and focused on the positive outputs of the research and we reached agreement on what should happen next".

There is no IP associated with the research and at least two publications in peer-reviewed journals are planned. The first is a Primer Note outlining the development of the microsatellite loci. This manuscript is titled "Development of eighteen microsatellite markers for the commercially valuable Sea Cucumber, *Holothuria scabra* (Echinodermata: Holothuriidae)" and has been accepted for publication in the Australian Journal of Zoology (Gardner M. 2013).

The second manuscript will be based on the results of the stock delineation and is still to be prepared.

Limitations to extension and adoption

The project was not free of problems however and delays were encountered when it was discovered that the sampling methodology was not going to be effective. Will explains what happened.

"In the original Seafood CRC application there was the understanding that we (Tasmanian Seafoods) would collect all the samples ourselves. We assumed, perhaps naively, that it would be easy for our skippers to collect samples while they were out fishing. However that turned out to be problematic as although their intentions were very good they are just contractors and were not focussed on the job and we learnt the hard way that it is better to have someone technical on board who's focus is just on getting samples".

"We then had to arrange a trip specifically to collect samples, which was funded out of the project. Because it was so crucial to get right, Mike came up and went out on the boat with us to collect the samples. However once that happened the project really got started to a much bigger degree and in the end we didn't lose much time but certainly learnt a lesson".

This is not so much an example of a limitation in terms of the extension and adoption process as it is an example of how Flinders and Tasmanian Seafoods worked effectively together to solve a problem that could have jeopardised the project had it not been addressed quickly.

Grant says, "There were some management issues being resolved within the company at the time so the process of organising a boat to make a specific sampling trip proved a challenge but Mike was great in his patient approach and we got out there and collected the samples we needed and the project was able to be brought back on track quickly".

So for Tasmanian Seafoods, the sea-ranching of NT sandfish is now moving towards commercial reality and Grant says that the project they embarked on ten years ago is finally coming to fruition.

"The propagation project has about another year to run. We can now start running a few release trials on a larger scale and we should be able to roll out to commercial production towards the end of the propagation project. Our goal is to be where this becomes an ongoing commercial proposition. The goal of research funding is to overcome a technical risk or market failure and that is what we have been trying to do, slowly and steadily address the environmental, social and economic risks involved.

However I think we are at the point where the tiger is awakening and we are about to unleash. We have just increased our production capacity at the hatchery ten fold and from that we are aiming to propagate a significant tonnage from eight or ten sites. If we can achieve that then it is a roll, it's a commercial proposition, it's on the go".

Summary of Extension Strategies and Extension Limitations

Extension Strategies Employed

- One research provider – one industry participant model (Coutts Technology Development / Problem Solving model)
- Prioritisation of commercial outcomes by Flinders University research team and Tasmanian Seafoods during project development process.
- Effective project facilitation by Seafood CRC to underline expectations and streamline communication process
- Face-to-face communication between the Seafood CRC, Flinders research team and Tasmanian Seafoods team favoured during project planning and design.
- Ongoing meetings between project investigators set up through Skype to facilitate further face-to-face contact during project implementation and in addition to the communication initiatives set out in the Seafood CRC project application.
- Research results disseminated to Fishery Managers and other key stakeholders through an open-to-all workshop process.
- Project planned, developed and driven by a single fisher - fostering inclusion and ownership.
- No IP issues over the outputs produced and research information to be published in peer-reviewed journals.

Extension and Adoption Limitations

- The research does not have any direct public or wider industry benefit outcomes although the maintenance of genetic diversity of wildstock and informed management is of indirect public benefit
- Sampling methodology initially problematic but direct working relationship between researcher and industry partner meant this was quickly resolved.

2.3 CASE STUDY 3: Genetic technologies to support a transformation to profitability and competitiveness in *F. merguiensis* and *P. monodon* (Seafood CRC 2009/724)

Central Problem

The power of selective breeding in increasing productivity and efficiency has been amply demonstrated in farming practices of traditional terrestrial livestock species such as chickens, pigs, sheep and cattle. However aquaculture species have hardly benefitted from modern developments in animal breeding despite the successful closure of the life cycle of many commercial species. The use of genetically improved stocks in aquaculture production is very low and it is estimated that only 8.2% of global production is based on genetically improved stocks. (Gjedrem 2012).

The low uptake of selective breeding by the aquaculture industry is at odds with the potential significant gains that can be made by the implementation of selective breeding. It is well documented that for aquatic species it is possible to obtain a genetic gain of 10%-20% for growth rate per generation, which is 5 – 6 times higher compared with what is usually obtained for farm animals. (Gjedrem and Baranski 2009).

Narrow profit margins apply to most primary (commodity) agribusiness. Use of genetically improved strains is one option for increasing competitiveness. For marginal companies (=5% profit on cost), even modest genetic gains (=10%) can double profits. (Knibb 2000).

Nothing illustrates the power of selective breeding better than the extraordinary change observed in commercially grown chickens over the past half century. In 2003, Dr. Gerry Havenstein undertook a study of weight gain in chickens, comparing (under identical conditions) a modern 21st century breed with a 1957 breed that had been conserved. He found that at six weeks of age, the modern chicken was six times as heavy and had 9% more breast meat. Of that improvement he found that 85% came from genetics and only 15% from better feed. (Havenstein *et al*, 2003)

The chicken that consumers worldwide now take for granted as an inexpensive, reliable, consistent food source is predominantly the result of genetic improvements made within the last 50 years. In turn, the global broiler industry is more productive, more efficient and less wasteful than at any time before and remarkably this rate of genetic improvement shows no sign of tailing off.

Most aquaculture industries in Australia are still at an early stage of development and would benefit from the introduction of genetic improvement programs. Industry and researchers perceive size at harvest as the trait that will most influence profitability, however this is unlikely to be sufficient to meet the future needs of the aquaculture industry. To meet future demands, breeding programs will most likely have to include additional traits such as survival, disease resistance, feed efficiency or flesh quality rather than only growth performance. (Nguyen & Ponzoni 2006).

For Courtney Remilton, Hatchery Manager at Seafarm, there is no question over the justification for genetic improvement.

“For Seafarm, this is a necessity. Costs are rising constantly and the market is increasingly competitive. As Australian prawn farmers, we either choose to become more productive or we go backwards. Continued genetic improvement of our stocks is a no-brainer”

Seafarm, based in Far North Queensland, has been farming prawns for over 25 years and has played a pioneering role in developing the production technology and the market for farmed prawns in Australia. The company produces *Fenneropenaeus merguiensis* (Banana prawns) and markets them under the Crystal Bay Prawn brand.

In 2001 Seafarm closed the life cycle and initiated a domesticated breeding program for *F. merguiensis* and is currently producing its 20th generation of domesticated stock. Seafarm has maintained eight families of pure breeding bloodlines over the past 11 years. General manager Gary Davis says their breeding program has been a key part of Seafarm’s success.

“We’ve got our domesticated prawns with our breeding lines; we have to actually keep selecting broodstock and stock ponds all year round to maintain our genetic lines. The domesticated prawn is the reason we exist. If we relied on wild prawn we wouldn’t be here anymore”.

Gary believes the domesticated prawn is a far better prawn to work with.

“They feed consistently. They grow uniformly. Even their behaviour is better; they are more docile. They go more to plan. Wild caught are much more limited for growth”.

Seafarm’s selective breeding program has involved selecting broodstock for size in order to breed a bigger, faster growing prawn. Over the course of 20 breeding generations analysis now shows that Seafarm’s purebred domesticated strains of *F. merguiensis* are 23% larger than their wild counterparts.

It is widely acknowledged however that maintaining purebred family lines can result in inbreeding, which generally leads to detrimental effects on fitness, survival, growth rate, high frequency of deformities and reduction in genetic variance. In a closed population inbreeding will inevitably accumulate over time. As a general rule increases of 0.5% or less per generation are desirable and up to 1% per generation tolerable. (Gjedrem and Baranski 2009)

In 2007, Seafarm recognised the need to examine the degree of purity of its 8 family lines and sent samples from each family line for genetic analysis. The results showed that the family lines were indeed pure and that as a result the stocks had been inbred for about 6 years. In order to determine the genetic impact of this inbreeding, more work was needed.

Researching a Solution

For Seafarm, the opportunity to undertake further R & D into the genetic improvement of its stocks arose with the formation of the Seafood Cooperative Research Centre and the company applied for research funding assistance through the Australian Prawn Farmers Association.

Seafarm had already established a good relationship with the University of the Sunshine Coast (USC) prior to the formation of the Seafood CRC, in particular with Dr. Wayne Knibb who is the Associate Professor of Genetics and currently the principle or co-investigator on several Seafood CRC genetics research projects. Courtney had previously approached Wayne at USC to discuss how best to design Seafarms' genetic program and therefore when the Seafood CRC project arrangements were being made, it was logical for Seafarm to choose to partner with USC and Wayne's research team.

The project was developed to use DNA technologies to verify the genetic status of the domesticated *F. merguiensis* stock at Seafarm with a view to further genetic improvement of the stock. Seafarm were the primary audience for the research, as the only prawn farming company in Australia that farms *F. merguiensis* however the Seafood CRC was also keen to see that the results were extended to the *P. monodon* industry. The following project was approved:

"Genetic technologies to support a transformation to profitability and competitiveness in *F. merguiensis* and *P.monodon*" (Seafood CRC Project No 2009/724).

Project objectives were as follows:

1. Understand if past and existing breeding practices led to significant inbreeding (more than 2% per generation) and if substantial inbreeding has occurred and will continue to occur, develop options to track family pedigrees and so more effectively limit inbreeding.

2. Estimate genetic heritabilities and correlations for commercially important traits. This information will be available for companies to develop efficient breeding programs.

3. Determine if functional markers for a range of commercial traits are commercially feasible. If so, these markers will be available for companies to integrate into their breeding programs through a selection index.

The USC research team comprised: Dr. Wayne Knibb. Dr. Abigail Elizur, Dr. Anna Kuballa, Paul Whatmore, Nicole Ertl, Rob Lamont, Dan Powell, Angelico Madaro, Jane Quinn and Dr. Nguyen Nguyen. Seafarm project contributors were: Courtney Remilton (Co-Investigator), Andrew Crole and Gary Davis. The project management team also comprised Dr. Richard Smullen from Ridley Aquafeeds.

At the time of project inception Dr. Trevor Anderson was Seafarm's General Manager and was initially the principle investigator on the project. Trevor was instrumental in putting together the project application, setting up the terms of reference, partnership and budget, however Trevor had to leave the company before the project's conclusion.

This loss of a key contributor to the project is not deemed to have had an overall adverse impact on its success, however there was a period of uncertainty surrounding the company around the time of Trevor's departure, which meant that some sampling was done out of schedule and perhaps not optimally. However this was considered a minor disruption to the project process.

Operationally, Wayne had been hosting the principle investigator role throughout the duration of the project and at Seafarm, Courtney had taken the lead on the project after its inception which meant that Wayne and Courtney were able to maintain the working partnership and project process effectively and without disruption upon Trevor's departure.

Research Results

Genetic diversity of existing broodstock.

The first objective was to establish whether or not past breeding practices at Seafarm had led to loss of genetic diversity of their stocks. This was determined by analyzing the comparative haplotype frequency of individual Crystal Bay prawn family lines with that of wild caught populations. It was determined that there had been an approximate inbreeding depression or loss of 12.5% during the years of the domesticated breeding program. However, the results showed that although the genetic diversity within each family line had been reduced, much of the original genetic diversity between all groups had been maintained. The results suggested that current Seafarm breeding practices were contributing to significant loss of genetic diversity down individual lineages but that cross-breeding between lineages could reintroduce genetic diversity to future generations.

"We investigated as to whether Seafarm's historical breeding program was based on good principles and was sustainable or whether it was becoming inbred due to the breeding of relatives and uncontrolled mating," explains Wayne, "What we found was that Seafarm's breeding program was not sustainable in the long term"

"The good news was that by recombining the pure lines into one line and then comparing the diversity of the recombined bloodline we found the genetic diversity to be almost that of the wild stock".

"Based on these results we were able to give Seafarm a revised plan on how to go about their breeding and start to cross inbred lines. Seafarm has adopted this plan and the indications are that the results of this cross-breeding are now showing and that implementation of the revised breeding plan has had a rapid and positive impact on production".

Courtney says, “We were fairly sure that inbreeding was happening within our domesticated stock but USC were able to provide the hard data to verify this”.

“We have now started a breeding process of joining all the family lines which will give much greater genetic variation. This process is already showing positive results. Our incidence of disease has reduced. If something is inbred, its susceptibility to disease, abnormality or growth issues is higher. Now we have reintroduced genetic variation back into the stocks the results are showing in our increased production figures.”

Interestingly, a result of crossbreeding the pure bred lines has been another increase in weight. So not only has the original weight increase of 23% from the domestication of wild stocks been preserved but crossbreeding genetic variation back into the family lines may also have further improved weight gains.

“We saw positive results in the very next crop,” says Courtney of the new breeding strategy. “In terms of production, we’ve seen increases in the 5% range. Growth rate has increased and disease susceptibility and therefore tonnages lost to disease, have dropped”.

“It seems as thought the data are supporting each other”, says Wayne. “The performance data actually on the farm is consistent with the genetic information we are uncovering from our forensic DNA technology”.

This cross-breeding plan will reduce the inbreeding rate to about 1.5% which is a tolerable rate and will serve Seafarm for several generations until Seafarm can move to a full pedigree genetic program. Seafarms long-term objective is to move to full pedigree based selection where every breeding animal is tagged, interrogated and selected according to their genealogy rather than by mass selection, as is the current process. This will require more investment but will be possible with the discovery of functional markers along with improvements to hatchery and breeding infrastructure and operations.

Commercial traits.

The second project objective was to determine the genetic basis to commercially important traits such as growth rate, colour and disease resistance. Seafarm has been carrying out phenotype-based selection for traits such as length and colour for many years. The question was, how useful is it to select for these traits? What traits are heritable and what traits are influenced by environmental factors?

“If we know the genetic basis of the traits”, says Wayne, “we can design the most efficient ways to make breeding selections, meaning the most efficient way to make commercial progress.”

If genetic heritability was determined, the next question was whether there are any genetic correlations between traits? Certain genetic traits are positively linked. I.e. if you select for one trait, you get the other. However sometimes they are antagonistic i.e. if you select for one trait you lose the other. For example if size and colour were to have a negative genetic correlation and the prawns were selected based on their size, the farmer would also be inadvertently selecting to lose colour.

Determining heritability relies on being able to identify parentage, i.e. which broodstock produced which progeny. USC have been able to do this by developing a DNA microsatellite test specifically for *F. merguiensis* that can be used to establish the genetic profile of an individual animal.

"We've now got very advanced ways of picking an animal out of a pond and 'reading' it for DNA and that tells us who the parents were," says Wayne. "This is something we have developed with Seafarm".

"The results of the investigation into heritability of commercially valuable traits are still not fully conclusive. However at this point the advice from USC based on the research results is that Seafarm should select for weight instead of length and should also select for presence / absence and level of disease- in particular Hepatopancreatic parvovirus disease (HPV)".

Seafarm has rapidly adopted these trait selection recommendations and broodstock are now selected based on weight. Seafarm is also employing a routine screening process to check presence, absence and level of HPV in their broodstock.

"After identifying potential broodstock from the best performing ponds" says Courtney, "we take hepatopancreas samples from 10 – 30 prawns from each pond and send them to USC for analysis for HPV disease status. We then pick broodstock ponds based on the results of the analysis. If HPV is absent then that is a bonus. If HPV is present in high levels we avoid using the pond and if we have no choice but to use a pond for broodstock where HPV is present then we choose the pond with the lowest incidence of HPV".

Marker assisted selection

The third objective was to find genetic markers for commercially valuable traits such as growth rate, colour and disease resistance. Genetic markers are unique DNA sequences that occur in proximity to a gene of interest and enable an indirect selection process where a gene responsible for a trait of interest is selected, not based on the gene itself, but on a marker linked to it. Broodstock selection through the identification of genetic or 'functional' markers can remove uncertainty and subjectivity from the trait selection process.

The primary focus of USC's work on genetic markers has been on finding markers that relate to animal colour. The work is still provisional but the results are encouraging. Wayne explains, “We found that one particular gene was closely related to colour formation.”

The gene is involved in the expression of Crustacyanin - a protein that binds to highly reactive astaxanthin pigment to form a carotenoprotein complex, which stabilizes pigment and thus colour, in crustaceans. (Ertl *et al* 2012).

“We found that this gene has a strong effect on the differences between light and dark animals. The challenge with the functional marker is to understand not just that the gene is connected with colour – we know that – and that the gene is heritable – we know that too – but we need to determine that the gene is not just different between light and dark animals but that there is a difference between light and dark families in that there is a genetic component and that the gene is aiding and abetting colour formation in a genetic sense and not a mechanistic sense”.

“The issue is that the gene responsible for Crustacyanin expression may be reacting to the level of colour in the animal and not causing it. Therefore it won’t help to select for the cause of the variation in the gene i.e. the flesh colour. We need to find out that the colour is caused by the gene itself and that the gene is not reacting to the colour.”

“Through analysis of pedigree on a family basis we will be able to see if the form of the gene produces consistently high colour. From that we will be able to determine that we have a functional marker that might be able to be used to select for colour”.

“In an operational sense, the only reason that selection for colour would be improved by using a functional marker would be if prawn colour appearance was affected by variable influences such as time of day, water quality, prawn age, stress etc. Clearly if this was so you would not make any good genetic progress by just selecting for the phenotype of the animal and so if possible it is much better to select based on the gene”.

Wayne says more work is required in the search for commercially important genes and their functional markers;

“We are still at the research stage and are some way from industry adoption. We need to connect the dots before getting to some sort of commercial outcome for a functional marker”.

“The project has been extended so that USC can do more work in this area and investigate HPV segregation in a population. There is hope that the technology developed by USC can be used to look for genes for HPV resistance in *F. merguiensis*. This work can then serve as a model for diseases in other species such as *P. monodon*.”

Until genes for HPV disease resistance can be identified and functional markers can be utilised in the broodstock selection process, Seafarm will continue to implement a full screening program for pre-testing of broodstock for HPV presence and level.

Monogamous prawns

During the investigation into functional markers, the USC team made an incidental discovery: that banana prawns are monogamous. The researchers found that female prawns appear to mate with only one male within each moult cycle and for each breeding episode. This made their investigation easier as it greatly simplified calculations.

Project outcomes

Genetic improvement programs in the aquaculture industry are rarely successful due to the myriad of critical factors that must be optimal and aligned such as: weather, expertise, management, finances, biology etc. This project has therefore been exceptional in its success, not just because of the technology that has been developed and worked, but because the outcomes have already had a positive commercial impact for Seafarm and are governing management decisions made by the company.

To-date the project outcomes have been:

- Inbreeding restoration
- Technology to undertake on-farm testing
- New high quality DNA pedigree markers
- Breeding values and a selection index for traits

And the project has lead to the discovery of:

- Heritabilities for colour in crustacean
- Candidates genes for commercial traits
- Prawn monogamy

Extension Delivery and Industry Uptake - Strategies and Results

There have been two stages of extension delivery during the project:

The first was the process through which the research team at USC worked directly with sole industry partner Seafarm on the project. According to Wayne, the term ‘partner’ is key to why the project has worked so well.

“The project for Seafarm began with a commercial question and ended with a commercial outcome. USC didn’t research these genetic parameters out of curiosity. We did it so that Seafarm could develop the most efficient genetics program.”

“There was no barrier between USC, Seafarm and adoption. Information generated during the research process didn’t have to be written up formally before being communicated.

Seafarm were actually given real time information upon testing of their samples. They were informed of the data as soon as it was hitting the bench. Their priorities were and are commercial and they knew they needed a different system. The ease of communication meant there was no delay in adoption"

The efficacy of this working structure can be put down to the straightforward two-way open line of communication and because research process was unimpeded by the need to consult with other parties. This made it feasible for research direction / focus to adapt quickly, when necessary, in response to Seafarm's commercial needs and facilitated rapid uptake of outcomes.

Under Coutts Five Models of Extension, this process can best be described as imitating the Technology Development / Problem Solving model which is where researchers work with individual partners or groups to develop specific technologies, which will then be available to wider industry.

In this instance the extension delivery of the research results by USC has resulted in the development of specific DNA technologies that have facilitated the improvement of Seafarm's existing breeding program which has in turn returned immediate commercial benefits to productivity.

Wayne explains, "This project is a great example of a good client – researcher relationship. We had a clear mission and everyone involved knew what we had to do and did it. There was great clarity with Seafarm and we weren't confused and rumbled by other companies or different players or competing research providers pulling the project in different directions."

"We were able to look at the project direction and do the obvious thing as long as it was possible within budget frameworks. That sort of smoothness of process doesn't happen in the world of consortia, as you need to get approvals, reviews, consultants etc. However as science is taken into the pointy end of commercial outcomes, the R & D approach needs to be adaptive and reactive and not bound up in process and policies."

Courtney agrees, "The project was initiated in the right way and for the right reason. This was a commercially relevant project and that has been the focus throughout. USC are fully focussed on the commercial reality of what we are trying to do. Wayne uses the word 'commercial' four or five times in every conversation that I have with him. We all went into this with a commercial objective in mind and stuck with it. That is the difference. It is easy for these projects to go off on tangents and I have seen a few that have but this collaboration with USC has been successful simply because they also want to see commercial outcomes".

Courtney was involved in the projects inception, design and planning and says the Seafood CRC project development process places a critical emphasis on how research outcomes will be commercialised.

“The project application had to formally detail the various mechanisms by which research outputs were to be delivered and the project management strategies that would be employed to ensure adoption and implementation”.

“And lets not forget”, says Courtney, “that this process is not a one-way street and that the USC have their objectives also. They need to put University Graduates on jobs so they need outcomes as well”.

Wayne says, “Effectively the communication process has been seamless. Courtney, as hatchery manager and co-principle investigator has worked very closely with the USC research team. We have had ongoing meetings in addition to the communication initiatives set out in the CRC project application. Additionally we set up regular meetings where the USC team has gone to Seafarm and the Seafarm team has come to USC and all have met with Ridley’s at Narangbah. These regular exchanges have meant that we’ve jointly been able to review the project results and these outcomes have been able to be immediately adopted by Seafarm”.

The second stage of the extension delivery was for USC and Seafarm to disseminate the research results from the project to wider industry.

The research is still being conducted, but preliminary results have been communicated to wider industry through information circulated by the APFA and the Seafood CRC newsletters. Reports have been written for the APFA R & D committee and Wayne presented findings at the APFA 2012 conference and will have the opportunity to do the same again at the APFA conference 2013. An article has also been published in Austasia Aquaculture magazine (Vol. 27. No.1 Autumn 2013).

Wayne and his team are also submitting papers for publishing (in Aquaculture and / or a molecular journal) and estimate that four papers will come out of the research. One paper, in draft form, will be written on genetic heritability, one will be on inbreeding, one on genetic parameter estimates and one will be written on perfect markers.

The extension strategies employed by USC and aimed at getting the research results out to wider industry can in this case best be described by Coutts ‘Information Access’ Model where information is provided in a manner that individuals and groups can access at their convenience.

It is too early to assess the direct effect of these extension activities on industry understanding of the breeding improvements achieved at Seafarm through the work done by USC. The Australian prawn farming industry mostly comprises *P. monodon* farmers and the domestication of this prawn species is still in its infancy. The dissemination of the research results must clearly articulate the potential application of genetic transformation technologies for *P.monodon* culture with respect to the current capacity of *P. monodon* producers to domesticate their stocks.

Limitations to extension and adoption

As with all research projects there were challenges to face and situations where the research process did not go to plan. The problems were mostly technical and part of the process regularly encountered during research of discovering what works and what doesn't.

One non-technical setback was the issue of senior management change at Seafarm and the uncertainty about the company's future. This resulted in samples being collected out of schedule, which necessitated unforeseen investment. However there were also some technical problems;

"On Seafarm's part we could have identified the process of sampling a bit better early on", says Courtney, "for example we started off taking pleopod samples for HPV testing only to find that this didn't work and we were better of sampling the hepatopancreas".

Wayne describes two additional technical challenges.

"When initially sampling for genetic parameters, the high level of inbreeding and purity of the bloodlines meant that diagnostics / forensics were getting compromised in terms of figuring out lineage. We had to expend extra time and effort and expense determining lineage which translated into an extra 6 months of work".

"With hindsight we would also have designed some of the sampling more efficiently and increased sample sizes. One sample size for heritability was 400, which we thought would be enough but because of inbreeding there had been loss of variation so to get good estimates we had to take 1000 samples. This was not so much a mistake as a revelation and this science is a good foundation if we wish to use it to build upon".

However these issues were considered minor and part of the research process.

The biggest challenge came in the form of Cyclone Yasi, a category 5 storm system that struck land directly over Seafarm in early February 2011. The system bore a 500km wide path of destruction over Far North Queensland, with Cardwell receiving the full fury of its 300km/h winds and a 7m storm surge.

The 128 hectares of Seafarm production ponds at Cardwell were without mains power for almost 3 weeks and critical infrastructure such as water pumping and aeration systems was destroyed. Two ponds of prawns were lost directly during the cyclone and over the ensuing days and weeks a total of 250 tonnes of prawns were lost due to the compounding problems from the savage weather event.

“Operationally and production-wise we fell to our knees after Cyclone Yasi”, explains Courtney, “we estimate that we’ve lost a year of production as a result. As far as the project goes, if Cyclone Yasi hadn’t come we would be four times as advanced with it.”

Some aspects of the research project had to be suspended until Seafarm was fully operational and back in production.

“In order to give USC the commercial answers they needed to take the research further we had to be producing large volumes. USC had completed some work on the heritability of commercial traits but we didn’t have the volumes to verify the results. We could say that one pond had done well but that wasn’t an accurate reflection of the research outputs”.

Thankfully Seafarm is now back in production and the research work can continue without delay. The three-year project has received approval for the work to continue for a fourth year to enable the investigation to make lost ground and to enable further work to be carried out on identification of commercially valuable genes.

Courtney is already looking towards the future of Seafarm’s breeding program.

“We believe that for us pedigree based selection is feasible. Now that the company is getting back on its feet our goal is to be able to use pedigrees along with commercial traits for breeding. The research we’ve been able to do in partnership with USC is already giving us increased production on the farm and a return in terms of dollars and cents. We’ve seen the preliminary benefits of improving our breeding program - now we need to take it to the next level”.

Summary of Extension Strategies and Extension Limitations

Extension Strategies Employed

- One research provider – one industry participant model (Coutts Technology Development / Problem Solving model).
- Prioritising of commercial outcomes by USC
- Real time communication of research results by USC to Seafarm and vice versa
- Breeding recommendations developed into a set of procedures for Seafarm
- Ongoing meetings between stakeholders in addition to the communication initiatives set out in the Seafood CRC project application
- Dissemination of research information in form accessible to industry at their convenience (Coutts Information Access model)
- Reports circulated through Australian Prawn Farmers Association and Seafood CRC newsletters
- Article in Austasia Aquaculture (Vol. 27. No. 1 Autumn 2013)
- Presentations at 2012 and at 2013 Australian Prawn Farmers Association
- Expected submission of 4 papers by USC for publication in peer-reviewed scientific journals.

Extension and Adoption Limitations

- Technical sampling and forensic issues encountered during the research process determined to have had only minor adverse impact.
- Cyclone Yasi impacted severely on Seafarm production and caused a significant setback to research progress / uptake.
- Departure of Principle Investigator during the course of the project; impact mitigated by capacity of co-principle investigator / research leader.
- No other Australian company currently farming *F. merguiensis.* Results to be clearly translated for application in *P. monodon* genetic improvement.
- Domestication of *P. monodon* is in its infancy and most producers still currently use progeny from wild broodstock.

2.4 CASE STUDY 4: Oyster over catch: Cold shock treatment (Seafood CRC 2010/734)

Central Problem

As many an innovative Australian would attest, some of the best ideas come when you least expect them. For Bob Cox, Director of Southern Cross Marine Culture, his "eureka" moment came similarly out of the blue.

"I was in a pub and was by chance chatting with the publican about their beer chilling system," says Bob Cox, "when it suddenly dawned on me that an oyster chilling system might just provide the solution to our problem. The concept for the Super Salty Slush Puppy grew from there".

The "problem" that Bob refers to is **'over-catch'**, a problem that negatively impacts oyster culture worldwide. Over-catch, also sometimes termed 'fouling', refers to the myriad of other marine organisms such as oysters, barnacles, sea squirts, flatworms, and mudworms all of which may colonise and often compromise cultured oysters and their growing environment.

In Australia, whilst these pests are regionally specific, the issue of over-catch is common across all oyster-growing areas and in all cases places a major financial burden on growers. Losses arise from discarding over-caught or worm infected oysters, retarded growth, labour and treatment costs involved in amelioration and market returns. Over-catch also affects oyster growing equipment and infrastructure such as trays and baskets causing flow issues, damage and wear and handling problems due to the weight of the over-catch.

The problem of over-catch is not restricted to the oyster industry. The Pearl industry suffers from severe over-catch problems and as a result must handle stock exceptionally often to remove fouling, which is mostly done by hand. The mussel industry too suffers from significant over-catch problems and has suffered significant losses due to flatworm predation.

Dr. Wayne O' Connor is the Principal Research Scientist at the NSW Department of Industry and Investment, Port Stephens Fisheries Research Institute.

"The monetary losses derived from the problems of over-catch are difficult to quantify but estimates from the Australian oyster industry suggest that dealing with problem over-catch can add 20% - 30% to the total operational costs of oyster growers" says Wayne.

In Port Stephens alone, oyster over-catch is estimated to cost the industry more than $1.5 million/annum in operating costs and lost production.

"Oyster farmers want a nice clean product to take to market. Over-catch draws food out of the water that the oyster would otherwise use for growth, binds oysters together and retains silt which can lead to increased mudworm infestation resulting in blisters on the inside of the oysters. Farmers lose productivity to the extent that they won't take out leases in areas where over-catch is a problem".

Southern Cross Marine Culture (SCMC) is one of Australia's larger and leading privately owned oyster producing companies with Pacific oyster aquaculture leases in Tasmania, South Australia and NSW. The company has been growing and selling Pacific oysters for the past 25 years.

In 2005, SCMC acquired intertidal oyster leases in the Port Stephens estuary in NSW on which to culture Pacific oysters, but were averse to developing their leases to start commercial production until they could be sure they would be able to effectively control the problem of over-catch that plagues the Port Stephens estuary.

Harvey Calvert was one of the first oyster farmers in southeast Tasmania and is a Director of Southern Cross Marine Culture.

"We looked at our business model and decided that it would give us greater year-round market presence if we expanded our operations into NSW. We know we can grow great Pacific oysters and that Port Stephens is one of the best places for oyster culture in Australia but we also knew that if we grew them up here and got over-catch that it would be enough to send us out of business".

The Port Stephens estuary has long been recognised as one of the prime oyster growing areas on the east coast of Australia. Its nutrient rich, warm waters supported a vibrant native Sydney rock oyster farming industry that originated in the late 1800's and peaked in 1976/77 with production reaching around 14 million dozen. Disease issues and coastal development have been partly responsible for the gradual decline in production since, with annual oyster production levelling off at around 4.5 million dozen. (NSW DPI 2006). However the biggest impact on Sydney rock oyster production decline in Port Stephens estuary was the illegal introduction of Pacific oysters in the 1980's and their subsequent proliferation and outcompeting of the native oyster species.

The Pacific oyster *Crassostrea gigas* is endemic to Japan and was first introduced into southeastern and western Australian waters by the CSIRO in the 1940s in an attempt to establish commercial oyster industries in theses areas which water temperatures were too cold for Sydney rock oyster cultivation. Due to concerns as to their possible impact on the NSW oyster industry the NSW Government refused to allow the Pacific oyster to be introduced by the CSIRO into NSW waters. The Pacific oyster now makes up the bulk of farmed oyster production in South Australia and Tasmania.

Pacific oyster production was restricted to the southern states but in the 1980's Pacific oysters were introduced illegally into Port Stephens and on this occasion quickly spread and invaded intertidal habitats. Because of their high fecundity and ability to develop high-density populations within the intertidal zone they rapidly out-competed other native oyster species for food and space. In some areas Pacific oysters have become the dominant oyster species, displacing native species such as the Sydney rock oyster (*Saccostrea glomerata) and the* Flat oyster *Ostrea angasi,.* Pacific oysters are declared a noxious species in all NSW waters except Port Stephens. (www.dpi.nsw.gov.au/fisheries/pests-diseases/marine-pests/nsw/pacific-oyster)

Because of the overwhelming numbers of wild Pacific oysters present at Port Stephens, permission was granted by the NSW Government in 1990 for aquaculture permit holders to cultivate diploid Pacific oysters in the estuary and Pacific oysters have since formed the basis of an important aquaculture industry in Port Stephens.

The Sydney rock oyster farmers of NSW have been contending with Pacific oyster over-catch since the species was introduced into the state. The spawning frequency of Pacific oysters in the warmer NSW waters is much greater than that exhibited in the southern states and as a result there are periods where Pacific oyster spat is so abundant that the spat can settle in the hundreds of thousands including on Sydney rock or Pacific oysters under culture as well as culture infrastructure.

Harvey explains why Pacific oyster over-catch is particularly problematic in the NSW waters.

“Someone brought Pacific oysters up to Port Stephens – illegally – and put them in the warm water. Down in Tassie they would only spawn in January, but up in NSW the warm water full of nutrients made them go bananas and they would spawn in December, get fat again, spawn in January, get fat again, spawn in February etc. and the spat just went everywhere and smothered every oyster in the estuary”.

“The problem is that Pacific oysters are so fast growing in the warmer water. Whereas in Tassie a Pacific oyster may take 18 months to grow to eatable size, in Port Stephens a Pacific oyster will grow to eatable size in 12 months. They will settle on the Sydney rock oysters that are much slower growing and then outgrow the Sydney rocks. This has buggered the industry and lots of Sydney rock oyster farmers have gone broke”.

“You also get Pacific oyster over-catch growing on Pacific oysters, Rock oyster over-catch growing on Pacific oysters and Rock oyster over-catch growing on Rock oysters so clearly oyster over-catch is quite a problem for farmers of both species.”

The evolution of the Australian oyster farming industry has been such that the majority of production is now conducted on intertidal leases. This in part is because farming in an intertidal zone allows for oysters to be temporarily exposed out of the water on low tide. This periodic ‘drying’ exposes the fouling organisms on the oysters and infrastructure to air and sunlight, which is effective in limiting the impact of fouling and pest species. However, whilst useful as a cheap and regular management tool, the interval of each intertidal exposure is not sufficient to overcome fouling by oysters and barnacles in all culture areas.

As a result, farmers have developed other methods of controlling over-catch. For Sydney rock oysters, the traditional method has been to move their oysters completely out of the water for longer periods. Farmers move their oyster trays to land or up onto rafts or utilise new technologies where floats are on one side of the cage and when pulled over the cage floats out of the water and sits in the sun.

Wayne O'Connor has spent the past 30 years in mollusc research and in that time has seen oyster growers world-wide trial various different over-catch control methods such as waxing, tarring, cooking, salting and culling (physical removal). Waxing, tarring and salting have limitations as control methods, cooking works but is hazardous to both the oyster and the operator and culling or physical removal is simply too laborious and costly. Wayne says that drying is still the most commonly used over-catch control method although it too has its limitations.

"Drying is a fantastic control method, particularly for soft fouling species. Barnacles, ascidians (sea squirts), algae and some pest species like mudworm and flat worm are all very effectively controlled by drying" says Wayne, "however the problem of oyster over-catch or oysters growing on oysters, is much more difficult to control".

"Drying can be used to control oyster-on-oyster over-catch but is most effective for treating Sydney rock oysters with a Pacific oyster over-catch. This is because Sydney rock oysters are much hardier than Pacific oysters and will survive quite happily out of the water at the right temperature for two to three weeks. A small Pacific oyster out of water on the other hand could die within a few days."

For Pacific oyster growers, Sydney rock oyster over-catch on Pacific oyster hosts is most difficult to control.

Harvey explains, "To control Pacific oyster over-catch, Sydney rock oyster farmers simply take their trays or baskets (containing the host Sydney rock oysters) out of the water and leave them on the shore for a fortnight, which kills their over-catch"

"If you tried the same method for Pacific oysters with Sydney rock oyster over-catch, yes you would kill the oyster over-catch but you would also kill the host oysters".

Drying, therefore is not an effective control method for treating Pacific oysters with Sydney Rock oyster or Pacific oyster over-catch. An extreme problem such as this demands an extreme control treatment and for want of a more effective method this explains why Pacific oyster farmers predominantly still use cooking to treat for over-catch.

"They have a system up here called cooking", says Harvey. "What they do is set up tanks with big gas blowers and heat the water up to near boiling and put the trays or baskets into the water for 3 seconds at a time but their timing has to be spot-on. Cooking for two and a half seconds is too short to kill the over-catch but three and a half seconds kills the oysters themselves. Not much margin for error!"

"The process is that two guys take a tray, dip it in the boiling water, count to three and then go on to the next one. Some farmers do this on land and take their oysters to shore but others do it on the water. It's incredibly laborious and it's also risky, not just because of the safety issues of gas and boiling water but of killing some of your stock in the process. Oysters hate heat and if they survive the cooking process their mantle (their food ingestion point) can end up stunted".

Due to the disadvantages involved, cooking as a control method for over-catch was determined by Southern Cross Marine Culture as risky and unacceptable and the company therefore began searching for a alternative solution. Bob recalls:

"We knew that the reason that cooking works to kill over-catch is due to temperature "shock" and we reasoned that cold temperature shock might work equally well and present less risk for the oysters and handlers".

"We wanted to come up with a solution that would be a back-up for our existing over-catch management strategies so that we had a way of treating the over-catch if we were caught out by spat settlement and needed a more effective control method. We needed to know firstly whether cold-shock would work".

Researching a Solution

Southern Cross Marine Culture commissioned initial investigative research through the NSW Department of Industry and Investment (at the time NSW Department of Primary Industries) to determine the efficacy of cold shock treatment on oyster over-catch.

These initial laboratory trials, carried out by Dr. Mike Heasman at the Port Stephens Fisheries Institute, NSW, used an immersion quick freeze unit similar to those found on fishing boats and immersed heavily over-caught oysters in -19^{o}C hypersaline water for varying times. Heasman confirmed the potential of cold shock to treat small Sydney Rock oyster over-catch on large Pacific oyster hosts. It was shown that cold shock could kill Sydney rock oyster over-catch within 60 seconds while no discernable negative effects on the health and meat condition of the host Pacific oysters were detected for immersion durations of up to 2 minutes.

Based on the promising results of this investigation, Southern Cross Marine Culture took the bold step of designing and commissioning the construction of a prototype, commercial scale, automated, hypersaline cold-shock unit. Dubbed the 'Super Salty Slush Puppy', the machine was built by SED Shellfish Equipment Pty Ltd in Wynyard, Tasmania and relocated to Port Stephens where preliminary commissioning and shed based trials were undertaken using oysters from Port Stephens that had been left out over spring and summer to be over-caught.

The host oysters used in the trials were from areas within existing leases and of a variety of sizes and included both Sydney rock oysters and Pacific oysters over-caught with both species. These factory and shed trials confirmed the efficacy and application of the Heasman research and showed that the machine could operate at a commercially viable speed (2.5 seconds per clip-off, clip-on SEAPA basket unit in/output). The trials also identified the need for a much more comprehensive study into the range of host sizes and ages, and the type and sizes of the over-catch against varied salt concentrates in the batch and bath temperature. In addition, there was the need to trial the operations for unit throughput and latent temperature maintenance.

Thus, with funding assistance from the Seafood CRC and with the support of the Oyster Consortium, Southern Cross Marine Culture and researchers from NSW I & I embarked on a collaborative project to evaluate commercial-scale cold shock treatment in the field and develop standard operating protocols for different fouling types.

The project team comprised Bob Cox, (Principle Investigator and Director SCMC), Peter Kosmeyer (Director, SCMC), Dr. Wayne O'Connor, Dr. Michael Dove and Kyle Johnstone (Researchers NSW I & I).

Planned project outputs included:

- Providing proof of concept of cold-shock treatment for over-catch control in a commercial environment
- Establishing operating guidelines for the applications of cold-shock in treating Sydney rock and Pacific oyster over-catch on crops of Sydney rock oysters and diploid and triploid Pacific oysters.
- Confirming the effectiveness of cold shock in treating a range of additional pest species (barnacles, hairy mussels, flatworms etc).
- Providing industry access to the treatment protocols, range of impacts and access to the prototype equipment used in the operation.

Research Results

The research verified the commercial application for hypersaline cold-shock treatment of over-catch and biofouling and its effectiveness for a range of pest species.

The research results demonstrated that cold-shock tolerance of both Sydney rock oysters (*Saccostrea glomerata*) and Pacific oysters (*Crassostrea gigas*) was size dependent with smaller individuals succumbing faster. Comparatively, Sydney rock oysters of up to commercial size were less tolerant of hypersaline cold-shock than Pacific oysters.

The cold-shock tolerance of both species was found to be the same at small size however as the Pacific oysters increased in size they became progressively more tolerant, eventually being capable of surviving emersion for more than 60 seconds, an outcome not observed with Sydney rock oysters at any of the sizes tested up to 65mm. For Sydney rock oysters, mortality in small spat (<35mm) could be observed after as little as 5 seconds. All Sydney rock oysters less than 45 mm were killed within 30 seconds while all tested oysters up to 65mm (small commercial size) succumbed within 60 seconds.

The difference in cold-shock tolerance between Sydney rock oysters and Pacific oysters would come as little surprise to industry, which has clearly seen similar differences between thermal tolerance of the two species during cold storage prior to sale. Sydney rock oysters will usually die when refrigerated whereas large Pacific oysters can survive very well in refrigeration – with a recent study by Strand et. Al 2011 showing 50% of large Pacific oysters (10 – 15cm) surviving 24 hours in storage at -22^{o}C.

Tolerance of pest species to cold-shock varied significantly. Large mussels (*T.hirsutus*) showed a greater tolerance to cold shock than either of the two oyster species, although the vast majority were killed within 60 seconds of immersion. Barnacles (*B. trigonus* and *A. variegatus*) and Flatworms (*I. mcgrathi*) were all killed within 15 seconds of immersion and although it was not practically possible to directly assess the value of hypersaline cold-shock in mudworm control, the observations were encouraging and further experimentation appears warranted.

Overall the project was deemed a success and the efficacy of cold-shock hypersaline treatment as a control method for over-catch was confirmed. However Wayne O'Connor acknowledges that there is no possible way to give defined operating guidelines for the Slush Puppy at this stage.

"The challenge is that in a lab, an individual animal is completely exposed. In field trials with over-catch there is less exposure (to the cold hypersaline water). Growers will have to undertake their own trials. The guidelines that came out of the project are lab-based and conservative – but they will get a grower started".

More work will be needed to fully determine operating parameters and application guidelines for hypersaline cold-shock treatment. So great is the variety of fouling organisms and so extensive is the range of operating variables that can be manipulated, that the study was only able to provide an insight into the potential of the process. Variables such as bath temperature, temperature differential between ambient seawater and the bath, the duration of emersion before and after treatment and the temperature during emersion are a few examples thought to be of significance and worthy of further investigation.

The Super Salty Slush Puppy Technology

It is important to note that the Slush Puppy machine developed by SCMC is but one example of an application method for the science of hypersaline cold-shock treatment.

Bob Cox explains.

“For this treatment all that’s needed is a vessel to hold a tank of high salt concentrate water, a means of chilling water down to -20oC or so and a mechanisms to bring the oysters into the tank and after treatment immediately plunge the oysters back into normal temperature water. That and a very loud egg timer!”

Southern Cross Marine Culture designed the Slush Puppy specifically for use ‘on lease’ to reduce labour costs. It was designed and built so that it could be lifted by forklift or crane onto a boat and powered by generator out on the lease. Costing approximately $80,000 to build, the machine did not come cheap. However, the unit was designed to be very substantial and to be capable of handling very large volumes “on-lease”. Harvey does not think their particular design could have been built cheaper.

“The cost in the machine is the stainless steel – its all 316 grade stainless. It is also fully insulated so that when we cool it down to -18oC and put the lid on it only loses 2 degrees overnight. The water is refrigerated by a condenser and recirculated around the tank and the conveyor that takes the baskets is automated with an adjustable timer so that throughput rate can be slowed or increased as needed”

SCMC have also invested $58,000 in a large, quad hull, aluminium punt with a carrying capacity of 8 tonnes. The boat, built by Maxcraft NZ, has been designed to function as a working punt on their lease but also to carry the Slush Puppy, which weighs 3 tonnes when full of water, in order that they can cold-shock treat for over-catch in-situ.

“The boat has walkways that can be lowered into the water so you are actually walking on the boat but walking in the water. The idea is that we drive along between two lines and unclip the baskets as we go and send them through the Slush Puppy as a continuous process”

“We’ve tested the Slush Puppy extensively here in the shed and it works like a dream. We worked out that we could unclip a basket and place it in the machine every two and a half seconds. The bloke in front could put them back at the same rate so the boat will continuously move. We think we can do about 5 hectares in a day. We have 48 hectares out there so we could potentially treat the entire crop for over-catch in two weeks – weather depending”.

Cost of Treatment

The cost to treat has two components, capital cost and operating costs:

Capital Costs

The Slush Puppy is a very substantial piece of equipment designed to handle a farm holding up to 12 million oysters at any one time on 48 hectares of leases. However the application of the technology is not restricted to such a grand scale operation and could be applied to shore based plunge systems such as are used in cooking treatment. This could be done at minimal cost with the potential there for retrofitting existing equipment.

Southern Cross Marine Culture invested approximately $140,000 in the development of the Slush Puppy and a vessel to carry it on-lease. However for a shore based plunge operation using a retrofitted hot water lunging tank and connected to shore power the capital costs are likely to be less than $10,000.

SCMC have calculated the per the capital component of the sale product per unit cost based on the volume treated on an annualised basis over the estimated equipment life.

They used the expectation of a one in four year treatment. Treatment every year is not anticipated given the usual over-catch control mechanisms in place such as emersion, moving stock out of known over-catch areas and holding on high clips to maximise rumbling. If it transpires that more frequent treatment is needed then the capital cost per sale oyster reduces. Therefore based on developed holding capacity and a 20-year equipment life, the capital cost per thousand sale oysters treated on an annual basis is $2.70.

For a shore based, smaller scale unit the per thousand sale oyster capital cost of treatment would be as low as 27 cents based on treating every 4 years and using the same sale volumes.

Operating Costs

In calculating operating costs, SCMC made a number of assumptions:

- The cost of generator fuel is the same as current electricity charges ($0.34 pKWH)
- Time on lease is 4 hours and basket unclipping and relocation time consumes 50% of available time.
- Size of product being treated is 50-60mm
- Over-catch is <10mm
- Salt consumption based on pool salt cost of $5 for 25kg bad and tank is maintained for 3 days with a daily top up of 40% due to dilution
- Fuel costs for the punt and labour costs etc. not included.

They were then able to determine that the operating cost of the Slush Puppy would be approximately 12 cents per thousand oysters.

Cost to Treat

The costings presented are somewhat uncertain due to both the variable need (due to circumstance and over-catch mitigation measures employed) and how the technology is applied (i.e. size, build and throughput of equipment).

If the maximum cost approach is taken the overall cost to treat works out at approximately $2.85 per thousand oysters treated - or 3.4 cents per dozen.

Extension Delivery and Industry Uptake - Strategies and Results

There were two stages of extension delivery during the project:

The first was the process through which the research team at NSW Department of Industry and Investment partnered with industry participant Southern Cross Marine Culture to verify the use of hypersaline cold-shock treatment as a method for controlling over-catch and to help SCMC to develop a prototype treatment system and standard operating protocols for fouling types.

The NSW I & I research team worked directly with SCMC as the sole industry partner on the project. According to both NSW I & I and SCMC, the efficacy of this working structure was due to the straightforward two-way open line of communication and because research process was unimpeded by the need to consult with other parties. This made it feasible for research direction / focus to adapt quickly, when necessary, in response to the commercial needs of SCMC and enabled immediate uptake of research outputs by SCMC upon communication by NSW I & I.

In this instance the extension delivery of the research results by NSW I & I verifying the efficacy of hypersaline cold shock as a control method for overcatch resulted in the development by SCMC of a prototype hypersaline cold-shock prototype treatment system that has been proven to work in on-shore testing and is ready to be trialled using commercial volumes in-situ. In addition, a set of general operating guidelines for the treatment were also developed.

Under Coutts Five Models of Extension, this process can best be described as imitating the Technology Development / Problem Solving model which is where researchers work with individual partners or groups to develop specific technologies, which will then be available to wider industry.

Both NSW I & I and SCMC reported this extension delivery method to be successful with both parties being very satisfied with the results. Neither party reported any shortcomings to the process and reiterated that the one research provider - one industry participant model works extremely well due to the direct and straightforward two-way communication pathway. SCMC were able to clearly articulate their R & D needs and NSW I & I were able to interpret and translate these into an effective research project that generated commercially viable outputs for direct SCMC uptake.

The second stage of the extension delivery was for NSW I & I and SCMC to disseminate the research results from the cold shock verification project to wider industry.

SCMC circulated their own newsletter to every oyster permit holder in NSW describing the research results and the development of the Slush Puppy technology. This newsletter was also distributed widely in Tasmania, Victoria and South Australia. SCMC also submitted regular updates to the NSW Industry and Investment department newsletter.

Articles were published in Austasia Aquaculture and WA Fish eNews, and presentations were made at the 2011 International Oyster Symposium, at the 2012 Australasian Aquaculture Conference and at the 2012 Shellfish Futures Conference.

In addition the hypersaline cold-shock treatment initiative was heavily promoted at NSW I & I field days at the Port Stephens Fisheries Institute and by appointment inspections of the Slush Puppy in situ at SCMC's premises in Port Stephens. SED Shellfish Equipment, the company that built the machine, has also carried out promotion of the equipment.

The processes adopted by the researchers and SCMC in this case can be best described by Coutts Information Access Model where information is provided in a manner that individuals and groups can access at their convenience.

It is too early to assess the direct effect of these extension activities on industry understanding and level of adoption of hypersaline cold shock overcatch control but Wayne O'Connor confirms that many growers know of and are talking about the research results and feels that, although there is always the opportunity to do more, that in this case the extension process has been effective in reaching a wide audience within the oyster industry.

Arguably the key driver of any future uptake of hypersaline cold-shock treatment by the oyster industry has been Southern Cross Marine Culture's decision to share their knowledge and the intellectual property (IP) they have developed, with the wider oyster industry.

Their willingness and even proactive approach to disseminating information stems in part from their open admission that they are poor at managing IP but mostly from the recognition that from wider industry participation comes the opportunity to obtain further scientific proof and support for the treatment being developed, and ultimately a wider acceptance, adoption and lower cost of production.

Admitting that their intentions may not be wholly altruistic, Southern Cross Marine Culture recognise that if their neighbours employ the same over-catch mitigation measure, then the incidence of pest species infestation for all nearby leases, including SCMC's are reduced. In effect, it becomes a win-win scenario.

SCMC are leaving their doors open for further inspection of the equipment and will welcome farmers interested in observing it in operation.

A key planned project output was "Industry access to the treatment protocols, range of impacts and access to the prototype equipment in operation". This aim was written into the project framework during project conception and this output is considered to have been achieved.

Wayne O'Connor says that good researchers recognise that the key to extension and industry adoption is to make dissemination a part of the research outputs. "Priorities are built within research committees and this is implicit in the research process. The CRC has a requirement that information is disseminated to its participants and the role of the CRC is that industry sets research direction",

In reality however, extending information to farmers can be difficult and Wayne freely admits that sometimes this is not done effectively. He uses extension through the industry associations as an example.

"The coverage in terms of the % of farmers exposed to extension information varies between states. In the southern states such as Tasmania, Victoria and South Australia the farmers are generally 1st or 2nd generation farmers who are much younger and more pro-active about joining and participating in their industry associations. They get up to 90% industry participation rate in the southern states, whereas in NSW the rate is more like 40% of industry and therefore we have to look at other ways of disseminating extension information rather than just going through the associations"

Steve McOrrie is the aquaculture policy officer for NSW Industry and Investment and is based at the Port Stephens Fisheries Institute. Steve has had first hand experience of the challenges faced by government research organisations in getting information out to industry.

"We have tried all sorts of extension models over the years. We used to have an open day here at the Port Stephens Institute for oyster farmers that used to attract oyster farmers, their families and workers and their suppliers. Back in the hey day of industry in the mid to late 80's it was an event where all oyster farmers came from all over NSW and they would come to this site to do a lot of their purchasing. The boat companies, tool companies and timber companies would congregate en masse and farmers would spend large amounts of money on annual purchases for their business"

“But when the NSW Sydney rock oyster industry started to crash in the 90’s due to the proliferation of Pacific oysters and the emergence of QX disease in a number of key estuaries, people started not to have that sort of disposable income. We continued running the open days but the turnout started to drop right off. We even tried hiring busses to bring farmers in from the south and north costs but in the end they were losing interest. A large proportion of the industry started to go inside their shell and became very parochial. In recent years we have started taking the field days to them holding a couple of field days each year in cooperation with the NSW Farmers’ Oyster association, one on the north coast and one on the south coast – which seems to work quite well and we continue to do this”**.**

“I’ve found over the years that you can do as much extension as you like and produce as many scientific papers as you like but most times farmers learn from other oyster farmers. They will look over the fence and watch Fred. If Fred is doing it and it seems to be going well then they will copy him. The majority are not going to listen to a public servant telling them how to do something new over what their father did and what his father before him did. It takes a very long time to change these traditions and outlooks”.

This reticence towards change is particularly true of the oyster farmers in NSW where oyster leases have been handed down through multiple generations and the age demographic leans to more mature farmers who have been following family-farming techniques that have been tailored to their individual leases and estuary for decades. Steve explains.

“There are a few young guys coming through and they are usually the ones doing the moving and shaking and are the rising stars. However in NSW they don’t represent the majority of the industry. This is in contrast to the southern states where the age demographic seems to be a lot younger”.

Harvey believes that it is not just traditionalist perceptions that blinker farmers to innovation and potential new farming practices but that the cost to change practices may be the key limiting factor.

“The feedback to the research has been good. We have been approached by several farmers who are interested in the treatment and we have had lots of positive response to the concept but as soon as you mention cost they back off”

“This is not a great time for oyster farmers in NSW. Many farmers are simply making a living and cannot afford significant capital investment. For the oyster growers up here survival is the biggest priority. Banks have become wary of lending to growers due to the current economic climate and the disease issues that continue to affect parts of the oyster industry. Growers therefore may have the heart or will to adopt new innovations but are financially restricted to do so”

Steve agrees with this point and says that oyster growers are not going to adopt a new innovative technology until they are 100% sure that they will save money by doing so.

“Most of the oyster farmers are using hot dipping and have used this to control oyster over-catch for many years and know exactly how much it costs them to do it. Oyster farmers may come across at times as not being that technologically savvy with computers; smart phones etc. but they definitely know how to add up. Unless you can give farmers concrete figures on how much they will save by changing to cold-shock treatment and clearly outline the other benefits they are not going to look at it”

“Ask any oyster farmer how much it costs to cook oysters and they will be there humming and harring to the 4th decimal place because they know how much a gas bottle costs, how long they will last and they knows how many trays or baskets they can get through the system per bottle”

“I’ve seen the Slush Puppy in action and it is truly innovative and takes a lot of the risks out of controlling over-catch that is present with the current cooking system”. I’m sure many oyster farmers are aware of the system, but I have a feeling that most may waiting for some one to give it a go commercially before they commit”.

Harvey thinks it will take time for the innovation to be taken up.

“I don’t think at this point in time there is a volume market for the Slush Puppy technology. However it may be that if Southern Cross Marine Culture is successful in NSW and other farmers see what we are doing with it that the technology will start being taken up more widely”

“The other issue that is currently limiting the NSW oyster industry is that Pacific Oyster Mortality Syndrome has just been discovered in the Hawkesbury. No one is really sure of the pathology / epidemiology of the disease and farmers are hesitant about investing in leases until they can be sure of the risks”

An alternative to investing in a Slush Puppy machine outright would be for farmers to form a collaborative to invest in a machine, which could then be contracted out to other farmers. A similar model is followed with photograder machines which are also an expensive piece of technology but that are bought by collaboratives or single wealthy farmers and then leased out to other farmers. Growers in Batemans Bay and Merimbula have adopted this approach where one grower looks after the machine and other growers pay to use it.

Harvey thinks that this model could be applied to the Slush Puppy if the arrangement was such that the machine was maintained and leased by a single contractor but that difficulties might arise with transportation of the machine between leases and the need for farmers to use the machine during the same few weeks of the year.

More work would be needed to determine the cost and feasibility of a contract machine arrangement with attention to details such as location, accessibility; whether leased with or without an operator and whether in fact the narrow seasonal window for over-catch treatment would limit the number of leases that could be treated by a single machine in any one season.

Steve explains that whereas grading operations can be staggered based on growth rate, treatment for over-catch often needs to be done simultaneously across specific growing areas. While this often occurs around the same time each year, there is often only a very narrow window of opportunity to control over-catch.

"Pacific oyster over-catch grows like the clappers – once settled, the spat will double in size in just a few weeks. So there is a window of only three or four weeks where farmers can cost effectively deal with the over-catch problem".

The problem of over-catch on growing infrastructure was not directly addressed by the research. According to Steve, there is a significant cost to industry of removing over-catch from equipment such as baskets and trays and that this may be an area where cold-shock may present an opportunity for additional savings.

"In NSW controlling over-catch on baskets and trays is done at the farms land base and this usually requires a fair bit of space and a lot of physical effort. The potential savings of being able to simultaneously manage over-catch on crops and growing infrastructure needs to be explored further. I'm aware that the need to control biofouling on growing infrastructure is also a significant issue in the southern States".

The industry wide scope for the Slush Puppy is not clear. It seems that although most of the Australian oyster industry suffers problems with over-catch and pest species that the situation is most severe and difficult to control in NSW. Cooking to control over-catch is mainly carried out in Port Stephens and in the Hastings River, at Pambula, Batemans Bay and sometimes at Shoalhaven.

So it appears that commercial proof of concept, accurate costing, a more viable industry and time to accept the idea may all be the vital ingredients needed before farmer uptake of hypersaline cold-shock over-catch treatment is seen at any significant level in NSW.

For now at least it seems that the extension process for the Super Salty Slush Puppy hypersaline cold-shock treatment initiative has gone as far as it can given the current level of understanding of the operating guidelines and cost to operate of the machine. Once SCMC has had the opportunity to apply the Slush Puppy in situ using commercial volumes the real operating costs, cost benefits and scope of the treatment technology will become much clearer.

For those farmers looking over the fence, the proof will, as they say, be in the pudding. In the meantime Southern Cross Marine Culture's open door policy to its Slush Puppy technology will continue to help the wider industry to further understand and evaluate the potential of hypersaline cold-shock treatment as an over-catch control method for future adoption.

Summary of Extension Strategies and Extension Limitations

Extension Strategies Employed

- One research provider – one industry participant model (Coutts Technology Development / Problem Solving model).
- An “open door’ policy by Southern Cross Marine Culture to their knowledge and intellectual property developed during the project.
- Dissemination of research information in form accessible to industry at their convenience (Coutts Information Access model)
- Newsletters on the Slush Puppy science disseminated throughout oyster industry
- Articles in Austasia Aquaculture and WA Fish e News
- Presentations at 2011 International Oyster Symposium, 2012 Australasian Aquaculture Conference, 2012 Shellfish Futures Conference
- Field days held by NSW DPI and face-to-face extension by department officers with growers.
- Oyster industry conference at Port Stephens in 2013
- Open invitation by appointment for growers to view the Slush Puppy technology in operation in situ at Southern Cross Marine Cultures premises.

Extension and Adoption Limitations

- Low participation rates of growers in NSW industry association and a decreasing trend in participation in government run group extension activities.
- Slush Puppy is not immediately portable and therefore difficult to take to growers to see it.
- Many growers currently struggling to survive and innovation is not a priority or option.
- Many growers are traditionalist – why change their practices when the old ways work.
- Capital and operating costs of Slush Puppy are not yet 100% definitive.
- Capital costs are too high for many farmers and it is difficult for them to acquire funds as banks have curbed their lending.
- Growers want proof of concept in situ with commercial volumes.
- Industry waiting to see what happens with spread of Pacific Oyster Mortality Syndrome

Potential Additional Extension Strategies

- Potential to bring the Slush Puppy to a large audience at the oyster industry conference in Port Stephens in 2013,
- Use video technology to record and distribute film of the Slush Puppy in action.
- Highlight any potential for using hypersaline cold-shock treatment to control fouling on equipment and infrastructure.

3.0 DISCUSSION

The study examined four Australian Seafood CRC research projects. Three of these projects were structured so that one research provider worked with a sole industry participant. The fourth project was structured so that one research provider worked with multiple industry participants.

The clear message from the interviewees who were involved in the one research provider – one industry participant projects was that the level of efficacy of the extension and adoption processes applied in each of these projects was high. In each of these three cases, the project was conceived, designed and implemented with commercialisation in mind and research direction was driven largely by the industry participant.

The efficacy of this research and development working structure can be put down to the straightforward two-way open line of communication and because research process was unimpeded by the need to consult with other parties. This made it feasible for research direction / focus to adapt quickly, when necessary, in response to the industry participants commercial needs and facilitated rapid uptake of outcomes.

In each case the Coutts Technology Development / Problem Solving model best describes the engagement process followed during the research phase and the working structure between the research provider and the industry participant. This is a model where researchers work with individual partners or groups to develop specific technologies, which will then be available to wider industry.

In two of the one research provider – one industry participant projects, the next phase was the extension of the research results to wider industry, which was done using the Coutts Information Access model where information is provided in a manner that individuals and groups can access at their convenience such as through reports, newsletters, conference presentations, publications and website updates.

The fourth research project investigated a project where one research provider worked with multiple industry participants.

The feedback from the interviewees involved in this project was that the level of efficacy of the extension and adoption processes applied was still high but that the complexity of the extension process was also high. In this case, the project was also conceived, designed and implemented with commercialisation in mind and a core group of industry representatives drove and took ownership of the research direction and industry engagement process.

Face-to-face meetings in various strategic locations between the researchers and multiple industry participants were favoured as an effective method of disseminating information and gaining feedback from stakeholders.

The process was largely driven by a peak industry body sub-committee that focused on transparency and on making the information as widely accessible as possible. Written material was also distributed in an effort to reach stakeholders that could not or would not attend the industry driven meetings.

The regular meeting process employed during this project can best be described as imitating the Coutts Group Facilitation / Empowerment model where a group of individuals (fishery stakeholders) with a long term commitment to the process have an agreed framework for communication exchange and information uptake.

In addition to this, this project also employed the Coutts Information Access model to disseminate research results to wider industry by providing information in a manner that individuals and groups could access at their convenience such as through conference presentations, reports, newsletters and website updates.

For each of the four projects, one of the key facets behind the effectiveness of the project extension and adoption approach was identified as the Seafood CRC project application process.

During project development, researchers in collaboration with industry participants and the Seafood CRC, have to formally detail the various mechanisms by which research outputs are to be delivered and the project management strategies that will be employed to ensure effective extension processes are implemented. The application of these strategies is then ensured and monitored via the Seafood CRC milestone reporting process.

In summary, the most commonly identified research and development extension and adoption strategies, recognised as being effective by the interviewees from all four projects were as follows:

- Prioritising of commercial outcomes by research provider.
- Research direction and process driven by industry participant / participants
- Simple working / communication structure such as one research provider – one industry partner.
- Pre-existing, solid, respect based relationship between research provider and industry participant / participants
- No obstacles between researcher, industry partner and adoption.
- Fostering of research ownership by the industry partner / industry participants.
- Research, development and extension process not bound up in policies or process.
- Willingness to share IP and an open door policy to wider industry

- Effective project facilitation by Seafood CRC to underline expectations and streamline communication processes
- Ongoing face-to-face meetings between research provider and industry
- Real time communication between research provider and industry

These findings determined that the level of adoption of research outcomes and therefore the efficacy of the Australian Seafood CRC research extension processes involved was deemed to be high in each of the four projects investigated.

This study supports the findings of the recent FRDC funded research, entitled Understanding Extension and Adoption in the Fishing Industry (Rufus Jennings and Roberts Evaluation FRDC Report 2011/505). This research determined that the Australian fishing industry (including aquaculture) and in particular the FRDC is effectively enabling the delivery of extension and adoption activities through project and program support.

The results of this study are concurrent with the above FRDC research and indicate that most applications of extension methods within the scope of FRDC / Seafood CRC research and development are considered to be working well and so to this extent they should continue.

4.0 RECOMMENDATIONS

The findings from this study indicate that the Australian Seafood CRC is effective in its application of extension and adoption strategies. Seafood CRC research projects are designed, developed and driven largely by the industry participant in close collaboration with the research provider to achieve specific commercial outcomes. Extension and adoption strategies are built-in to the initial project design.

This process of integration of extension and adoption strategy into the project design was applied effectively in each of the four Seafood CRC projects investigated and the implementation of these strategies was considered to be successful.

Sea Cucumber Genetics

The Sea Cucumber genetics project delivered population genetics data required to advance commercial ranching of fish by an individual industry participant; Tasmanian Seafoods, and was designed and implemented with this particular commercial outcome in mind.

In terms of extension and adoption, the research results have been effectively communicated to the NT Department of Fisheries and the Australian Fisheries Management Authority for use in management policy development and the genetics data derived will be published in an international journal and will be available to industry stakeholders via self-paced access. This should complete the extension and adoption process.

Oyster Cold Shock

In the case of the Prawn Genetic Technologies project, the Oyster Cold Shock project and the Southern Rock Lobster Spatial Management project, the research delivered new technologies that are now being scaled up and applied commercially.

It is important to ensure that the results of the commercialisation stage of each of these research projects are effectively communicated to industry.

The Oyster Cold Shock over-catch treatment has not yet (at the time of writing) been applied by Southern Cross Marine Culture for commercial volumes because there has been no need for the treatment on their culture leases to-date.

When proof of concept of the cold shock treatment is attained at commercial volumes, this information should be made available to the Australian oyster growing industry. Southern Cross Marine Culture (SCMC) in association with NSW Department of Primary Industries and the Seafood CRC should consider the strategy by which they will disseminate this information.

Communication of these results could be through the distribution of written material such as a one page flyer or similar, via the industry associations such as Oysters Australia, Oysters SA, or Oysters Tasmania and publications such as Austasia Aquaculture. In conjunction, results could be presented at the annual Shellfish Futures conference and annual

International Oyster Symposium and at forthcoming NSW Oyster conference and trade show events.

It is recommended that when oyster over-catch cold shock treatment is proven by SCMC at commercial volumes that a more detailed cost analysis for the treatment methodology is carried out and that these costs are clarified in any information subsequently distributed.

To date, the extension strategy employed on the oyster cold shock project has been effective in that the Australian oyster growing industry is aware of the potential of over-catch cold shock methodology. Adoption, however, won't occur at a significant level before proof of concept is attained for commercial volumes and costs are well evaluated and this information is effectively distributed within the industry.

Southern Rock Lobster Spatial Management

The Southern Rock Lobster (SRL) industry is heavily engaged with its fishery managers and researchers. The commercialisation of translocation of stock is just one area of current management focus and the SRL industry will be kept informed of the progress of this commercialisation process through existing, effective communication pathways between industry, government and researchers.

These pathways include the bi-annual port meetings and TRLFA general meetings open to all industry stakeholders, project researchers and fishery managers and the dissemination of research information through TRLFA, IMAS and DPIPWE reports, newsletters, conference presentations and website updates.

Prawn Genetic Technologies

The Australian prawn farming industry is *P. monodon* dominated, with currently only one producer, Seafarm, culturing *F. merguiensis.* Domestication of *P. monodon* is in its infancy and most producers still presently use progeny from wild broodstock.

After being impacted by Cyclone Yasi in 2011, Seafarm could not produce at full capacity for many months and sample collection for the project was delayed. The full extent of the commercial outcomes of the genetics research and their impact on farm profitability can be better evaluated now that Seafarm *F. merguiensis* production volumes are recovered. (NB. At the time of writing the functional marker component of the research is still underway and won't be complete until the end of 2013.)

It is recommended that upon conclusion of the research, the impact on profitability of the genetic transformations of Seafarm *F. merguiensis* stock be quantitatively analysed and that this data be clearly translated for the application in *P. monodon* genetic improvement.

Effective extension pathways for disseminating this information include APFA notifications, newsletters, website updates and conference presentations and through the APFA Research and Development Committee.

Summation

The current extension and adoption strategies developed and implemented by the Australian Seafood CRC are effective throughout the duration of Seafood CRC research projects. However it is important to ensure the longer-term extension of research outcomes in projects where proof of concept may take some time to achieve on a commercial scale.

In these instances a follow-up extension strategy should be employed to ensure that longer-term commercial implications, benefits and limitations of research outputs are properly evaluated and communicated to industry. This strategy would be built-in to the initial project design with time-scale for its implementation dependant upon the nature of the proposed research, industry / research participant sector and industry / participant capacity for commercialisation.

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APPENDIX 1

Optimising industry adoption: Case studies on the efficacy of current Australian Seafood CRC Research Extension Processes

Interview Question Framework

1. What was your role in the project?

2. Which organisations commissioned the initial research?

3. Which organisations / individuals were responsible for driving the extension and adoption process?

4. Were there any other stakeholders involved in the delivery of the extension and adoption activities?

5. Has there been a specific budget for extension and adoption activities?

6. What or who is the primary target audience for the research?
   (e.g. farmers)

7. What or who is the secondary target audience?
   (e.g. government, industry group etc.)

8. In terms of extension and adoption, what were the project objectives?

9. In what way, (if any) were the project stages of research and development conducted with extension and adoption in mind? *(i.e. how (if at all) were the project stages intentionally aligned with the need to extend the products of research and development).*

10. How were all stakeholders included in this? Was this effective?

11. What models of extension and adoption approaches / activities have been used?
    (i.e.
    - Group learning / empowerment
    - Technology Development / Problem Solving
    - Programmed Learning / Training
    - Information Access
    - Individual Consultant / Mentoring
    - Multi-stakeholder Negotiation
    - Industry Development

12. At what stages of the project were extension and adoption activities delivered?

13. How effective has the project been in achieving extension and adoption across the target audiences? Can this be measured?

14. How quickly has adoption occurred (or you anticipate it to occur) as a result of the extension activities implemented? *(i.e. before the project; during the project; within 1 - 3 years of the project finishing; over 3 years; don't know yet)*

15. Were there any examples of where the extension and adoption process worked well? What were the critical success factors?

16. What have been the shortcomings of the extension and adoption approach and why did they occur (if any)?

17. What improvements could have been made to the extension and adoption activities implemented? *(i.e. How could the activities be more strategic in terms of delivering outcomes and outputs of research and development)*

18. What have you learnt about the extension and adoption process during the course of this project?

19. Have there been any unintended consequences?

20. Overall do you think the extension and adoption activities employed have been successful?

21. Do you think industry / the research provider would agree? Why or why not?

22. Any other comments?