CoolFish: Traceability and Product Sensor Technologies to Manage Seafood Cool Chains: (2008/790)

AUSTRALIAN SEAFOOD COOPERATIVE RESEARCH CENTRE

Phase 1 Project Report: Project Scoping for Tasmanian Salmon Cool Chains

31 October 2009

University of Tasmania

UTAS

Preface

This document constitutes the completion of Phase 1 CoolFish Project (2008/790). It aims to provide information to the Seafood CRC and its industry partners including key participants from the Tasmanian Salmon Industry **to support the decision-making process on progress of the CoolFish Project into Phases 2 & 3.**

Phase 1 presents data gathered and assimilated from literature sources and directly from industry partners – **it does not report on any experimental work**. The report provides baseline information about logistics issues and challenges in Tasmanian Salmon Cool Chains; reviews established and commercially available traceability and sensor technologies; and, identifies those technologies with most potential for deployment in Phases 2 and 3 of the CoolFish project.

This report has been prepared by a team of researchers at the University of Tasmania led by Associate Professor Paul Turner, School of Computing & Information Systems. The report constitutes part of the University of Tasmania's on-going participation in the Seafood CRC.

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Acknowledgements

The authors of this report would like to acknowledge and thank the following organisations and individuals for their support and input into Phase 1 of the CoolFish project.

Listed Alphabetically:

Huon Aquaculture Pty Ltd
Jocelyn Midgeley
Petuna Seafoods Pty Ltd
Simplot Pty Ltd
Tasmanian Salmonid Growers Association
Tassal Pty Ltd

Suggested Citation for this Report:
Turner, P., Cambridge, S., Ross, T., Whitehouse, I., Mirowski, L., Bertoni, M., Tamplin, M. (2009) *Phase 1 Project Report: CoolFish: Traceability and Product Sensor Technologies to Manage Seafood Cool Chains*, University of Tasmania, Australian Seafood Cooperative Research Centre, Project 2008/790, October (www.seafoodcrc.com).

ISBN: 978-1-925983-23-4

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Executive Summary

Tasmanian Salmon Cool Chain participants are increasingly aware of the challenges and opportunities raised by product traceability and are actively considering their approaches. This report contributes to these considerations and highlights the potential for value generation and improved cool chain performance through the implementation of traceability and product sensor technologies. The report is structured in three main sections:

Section one of the report highlights key issues, challenges, trends and drivers facing the entire Australian seafood industry and provides insight into current logistics issues and challenges in Tasmania's Salmon cool chains including:

- Tasmanian salmon producers have advanced in-water technologies but are only in the planning stages regarding post-harvest technologies. They **recognize the potential to increase value by improving the cool chain;**
- Tasmanian salmon producers recognize the benefits of traceability technologies for **more effectively integrating data across the pre- and post-harvest boundary;**
- **Keep it cold - move it quick** is the tried and tested mantra that guides the practices and processes of the Tasmanian Salmon cool chain and currently ensures safe and effective product management;
- Tasmanian Salmon cool chain participants are aware that keeping the product within accepted temperature specifications does not guarantee premium condition and recognize that they currently have to **rely on sensory evaluation**;
- Tasmanian Salmon producers are knowledgeable on their own organisations processes and have a good understanding of their immediate supply chain partners, but have not currently embedded **a 'whole of cool chain' perspective** that encapsulates pre-harvest all the way to the dinner plate (fish to dish).
- A need for increased traceability, particularly of second-grade (and below) salmon products has **increased in importance as the Salmon product range expands**;
- Tasmanian Salmon producers acknowledge that they do not have a high level of detailed insight into the status of individual products or consignments thereof once they are transferred to their logistics providers and travel along the supply chain. They **base their judgments on 'experience-based' knowledge** due to a lack of detailed supply chain data;
- A need to **predict remaining shelf life** especially for second-grade (and below) salmon products was identified as a strong value proposition for improved traceability and sensor technologies;
- The **ability to extend shelf life by using a microbial growth prediction** embedded in the a traceability/tracking tool has the potential to prepare the cool chain to be able to respond to a number of emerging issues from regulators and retailers including reducing food miles, extending shelf life and protection against legal liabilities;

Section two of this report reviews established and commercially available traceability and sensor technologies including standards; and considers those with most potential for deployment in Phases 2 and 3. It promotes a primary focus on **the establishment of an integrated traceability system, using RFID as the primary means of identifying the product**. Critically, product level identification is required to optimise the application of predictive models. The traceability system provides the means by which a number of goals can be achieved including:

- An integrated cool chain data management approach based on **traceability to support safety, quality, compliance, branding and future proofing**;
- Sensors being able to identify when temperature deviations occur based on low cost robust and re-usable RFID tags;
- Predictor technologies deployed at product level to provide **a strong evidence base incorporating an effective decision rule sets for safety and quality**.

- Improved Logistics through **modelling, measurement and interaction assessments and performance testing** and evaluation of new systems;
- Environmental sustainability improvements through **evaluation of materials used, energy and storage efficiency, noise, gas or other discharges**;
- Enhanced and customised **uses of refrigeration and/or preservation methods** and optimisation of the whole Salmon cool chain;
- Brand and product authentication/verification and consumer marketing

From a standards perspective the report highlights:

- There are many sources of food safety and quality standards. Many of these Standards and **specifications display overlap with each other and almost all have a HACCP-like underpinning**;
- **Buyer's (e.g. supermarkets) are, increasingly, articulating their own specifications**, which are tending to be more stringent than government requirements;
- In Australia, local codes and standards such as those developed by **AQIS and MSQA follow the Codex standards and SQF**;
- Few standards/criteria specifically address cool chain temperatures, or acceptable temperature ranges for specific product types. For supply chains, the new ISO 22000 standard considers the requirements for safe transportation of food and there is a clear trend towards **requirements for traceability of products.**
- Australian national standards are frameworks to achieve outcomes, rather than stipulate requirements. This enables organisations with flexibility in how they achieve these outcomes;

Section 2 of the report also considers the implications of these technologies and standards in relation to drivers for the implementation of traceability systems within individual firms and across the whole of Seafood Cool Chains. It also considers a range of other emerging issues (including changing end customer demands, 'greening' of supply chains) that provide strong value propositions for the conduct of Phases 2 & 3 of CoolFish. In particular these sub-sections of the report highlight:

- **Factors strengthening the business case for an integrated traceability system in Salmon cool chains** include: changes in the regulatory landscape; lower technology implementation costs; improvements in technology standards and interoperability; emerging industry legislative requirements (both industry specific (marine, food handling etc) and others such as greenhouse emission trading schemes (ETS); changing consumer demands/behaviours; and, the need for future business stability and growth;
- An important element in the development of a 'whole of supply chain approach' is the requirement for **a high level of industry cooperation involving sharing of business intelligence** (not commercial in confidence information but rather a focus on the systems and processes, both physical and digital, that support and enhance the supply chain management requirements);
- **Australia's major supermarkets will shortly be instituting requirements for traceability to support marketing (e.g. green, sustainable, animal welfare) as well as zero food safety risk** (as defined by these supermarkets). This combination of demands is likely to be a bigger and more immediate driver than government regulations;
- Building supply chain management approaches that **are flexible, responsive and have scalability emerges as the 'best practice' approach** for responding to changing retailer/consumer demands. A customer driven 'traceability empowered supply chain model is one approach for conceptualising these requirements.

More broadly, this report emphasizes the benefits of linking new information systems (and more specifically traceability and product sensor technologies) to on-going R&D across production, management & seafood microbial ecology to strategic whole of value-chain approaches that promote new types of industry collaboration and validated by business imperatives.

Section three of the report presents the preliminary conclusions and outlines next steps including a proposed meeting to be hosted by the Seafood CRC with all industry participants to make decisions on next steps. A provisional date for this meeting in Hobart – is **Monday 30 November, 2009.**

Looking forward, CoolFish Phases 2 & 3 will support the generation of evidence and practical knowledge into:

- the nature of Salmon supply chains and the identification, development, demonstration and evaluation of systems for tracking, tracing, environmental monitoring and quality assurance the whole of supply chain;
- existing technologies to deliver mobile information systems that integrate the functions of on-line analytical processing systems with executive decision support systems on a real-time basis - to validate ROIs

This will stimulate and support innovation in supply chain logistics in a manner that:

- Improves product integrity, quality & safety from 'fish to dish';
- Supports logistics managers to respond to new challenges of consignment management;
- Enhances knowledge of and responsiveness to consumers changing preferences;
- Generates feedback to quality managers about product contamination post-harvest;
- Provides the basis for the development of whole of supply chain and whole of industry approaches to the management of seafood cool chains;
- Opens up the potential to generate intellectual property of commercial value to other seafood supply chains.

CoolFish Project Description

The overall objective of the CoolFish project is to:

> 'Utilise commercial traceability and product sensor technologies to address both current business impediments and business opportunities in cool chains to support increased sustainability and profitability in seafood supply chains'.

The project focus is on determining the factors that need to be addressed in order to optimise the implementation of traceability and sensor technologies into Australian seafood cool chains. This focus acknowledges that most currently available technologies are not integrated and/or implementable directly into Australian seafood industry supply chains and that there will continue to be a need for on-going customization and adaptation in order to meet evolving seafood industry requirements and to optimise benefits.

The project will directly assist in meeting the Seafood CRC business plan milestones. Specifically it aims to contribute directly to the theme **OzSeaValue: Seafood product, processing and value chain innovation** and in particular strategies 3 and 4 aimed at the development of new approaches to monitoring and managing seafood values chain performance; and, to ensuring product safety and quality underpin product standards and claims, respectively.

Traceability and product sensor technologies have the potential to assure seafood quality and integrity and to enhance value chain efficiencies. However, there remains a need for more applied research and practical experience with these technologies and their optimisation in Australian seafood value chains. The effective integration of traceability and freshness technologies and the development of 'best-practice' responses to the information they provide as the product moves through the supply chain from processing to wholesale/retail have still to be developed across all seafood supply chains.

This analysis needs to extend beyond the technologies themselves and into the knowledge and business rules required for their effective implementation and evaluation within real seafood cool chains. However, there are already positive examples of the benefits of the integration of sensor technology (that have a microbiological focus, and include food hygiene indices indexes for predicting the degree of microbial food spoilage and safety based on time-temperature data), and traceability technology (that have a spatial focus and include geo-spatial data).

The key questions for seafood producers, processors and sellers are ones of data management: How should an operator respond to the data generated by these technologies? The link between this information and protocols, guidelines and standards for seafood export, food safety or authenticity are not yet fully developed or tested across all seafood supply chains. However, with changing drivers in global competition, regulatory compliance and consumer demands, it will be critical for the Australian seafood industry to be able to respond. The CoolFish project has proposed the following key outcomes:

1. **Microbial Growth Predictor Tool:**
   This tool and the scientifically validated predictive models underpinning it will be able to be integrated into sensor technologies to reduce product rejection at point-of-receipt. It will also contribute directly to the education of end-customers and regulatory authorities about product quality and the relationship to losses in temperature/time along the cool chain.

2. **Asset Management and Tracking Tool**
   This tool can track and trace products along the cool chain and integrate this data with the microbial growth predictor tool to assess microbial growth leading to loss of quality or

safety. This will allow companies to assess the quality and integrity of products along the supply chain and to make decisions on the management of the delivery/retrieval of products. It will also contribute directly to improving supply chain transparency for all operators' if/when retrieval and/or redistribution is required.

3. Inventory Management and Control Tool
This tool aims to target the gap between harvest and processing that continues to cause unpredictability for the management of processing and order fulfilment. While there are differences across aquaculture/wild harvesting and processing of different products increasing information visibility should lead to significant improvement.

4. Traceability as a Marketing Tool
This tool will aim to leverage an emerging marketing opportunity arising from changing end-customer demands. The focus will be on selecting information available along the cool chain generated through the 3 tools above to support brand differentiation and/or defensibility.

The CoolFish project aims to generate insights applicable to a range of Australian seafood cool chains. However, it is recognised that there is a need to prove the value of traceability and product sensor technologies in one or more specific product cool chains. In this regard, discussions were held with Tasmanian Salmon industry representatives in January 2009.

CoolFish and Tasmanian Salmon Cool Chains

A scoping workshop for a proposed 'CoolFish Project on Traceability and Product Sensor Technologies to Manage Salmon Cool Chains was conducted on 23rd January 2009 at the University of Tasmania, Hobart. Participants included representatives from:

- Simplot Australia
- Huon Aquaculture Company
- Tassal Group Ltd
- Petuna Seafoods Pty Ltd
- Tasmanian Salmonid Growers Association (TSGA)
- Food Safety Centre, University of Tasmania
- School of Computing & Information Systems, University of Tasmania

Discussion centred on the following concepts/topics:

- Overview of predictive models and integration with sensor technologies
- Overview of traceability and product (freshness indicator) sensor technologies
- Commercially available technologies and those that could be adapted to seafood supply chains
- The Value Proposition – How traceability and product sensor technologies add value to the seafood business, as well as whole of supply chain benefits
- RFID platform issues and challenges – regarding the adoption of traceability and product sensor technologies and the generation of value including return on investment, compliance, market growth and competitive edge

During this workshop, significant discussion focussed around **"product rejection at the point of delivery/receipt based on the internal temperature of vehicles and not on product quality".** Traceability technologies with integrated freshness indicators (e.g. predictive models) were recognised as having significant potential to address this problem. More broadly, it was also suggested that traceability and sensor technologies were diverse concepts that needed to be validated in a 'real-world setting' (e.g. the Tasmanian Salmon cool chain) by resolving some current business impediments and highlighting potential for subsequent value propositions. Participants agreed:

1. There was a need to look at the entire cool chain to determine where the benefits and ROI were likely to lie – as they were currently not clear enough to present a case to an individual CRC partner.
2. A ROI business case was not for the research teams to identify, but for the industry partners to tailor to their own business needs, aligned with their strategic goals. Thus, any projects around traceability and sensor technologies should provide enough scope and information for the industry partner to make a decision for inclusion into their business operations.
3. It was critical to have an overall "traceability project objective" but that there should be a number of sub-projects that were essentially demonstrations of where traceability can support the cool chain. It was agreed that the four sub-projects (outlined above) needed to be integrated because predictive technology tools from one sub-project would be useful to solve the business impediments in other sub-projects.
4. A Proposed **Go/No go decision point** needed to be included before commencement of sub-projects.

Based on this agreement the CoolFish project proposal was developed and a **three Phase approach recommended** involving:

Phase 1: Project Scoping and Data Compilation on Tasmanian Salmon Cool Chains
Phase 2: Four sub-projects generating the tools described above
Phase 3: Evaluation of Process and Project Framework

Outputs from Phase 1 are to be used to determine the **Go/No Go Decision Point** for Phases 2 & 3 of the project. However, assuming that the project proceeds, it is anticipated that additional partners (potentially some non-CRC members) will be engaged for participation in individual sub-projects (e.g. retailers such as Coles and Woolworths, Logistics operators such as CHEP, Consumer/Market expertise such as FreshLogic) and regulators (FSANZ and local authorities). Phases 2 and 3 are detailed in **Appendix A.**

Aims of Phase 1

Phase 1 has the following key aims:

Firstly, to generate data about the industry partners including:

- baseline information about seafood spoilage mechanisms in the Tasmanian Salmon cool chain (extent, type and need for management);
- insight into the time-temperature safety parameters currently used for product/hazard combinations;
- details on customer profiles and issues (e.g. logistics partners, retailers, shipping partners etc);
- data about the level of traceability that is required and/or currently available to different industry partners (e.g. product level or pallet level);
- an overview of current distribution systems (nationally and internationally).

Secondly, to catalogue and validate current traceability and product sensor technologies used or trialled in the past including consideration of:

- Status of current/future regulations and standards;
- Drivers for implementation of technologies;
- Market appraisal of customer acceptability (e.g. retailers etc);
- Downstream effects such as highlighting potential issues with supply chain partners and identifying impediments (e.g. IT capability at retailer cold stores etc.)

It should be noted that data from a number of Seafood CRC funded projects contribute supportive baseline information to fulfil these two aims. Phase 1 is primarily data gathering and assimilation (not experimental work). This report fulfils these two aims and provides:

- Description of the existing cool chain and experiences/approaches used to date (issues/challenges);
- Understanding and articulation of the business drivers including compliance reporting; inventory management; asset tracking; food safety & quality; legal & regulatory/standards developments;
- Technology review (track/trace and sensor technologies) with a focus on RFIDs, and beyond, to consider integrated systems for cool chain management. It also considers the potential for 'whole of industry improvement' solutions that have implications across 'in-water' and 'post harvest' logistics);
- Consideration of 'Return on Investment' (ROI) and what this could/should mean including in relation to efficiency/effectiveness; customer/consumer loyalty; Safety& Quality; and, marketing/branding value propositions.

This Phase 1 report is structured in three main sections covering:

1. Tasmania's Salmon Cool Chains;
2. Traceability and Sensor Technologies; and,
3. Preliminary Conclusions & Next Steps.

Section One: Tasmanian Salmon Cool Chains

This section of the report provides summary data on Tasmanian Salmon cool chains covering:

- baseline information about seafood spoilage mechanisms in the Tasmanian Salmon cool chain (extent, type and need for management);
- insight into the time-temperature safety parameters currently used for product/hazard combinations;
- details on customer profiles and issues (e.g. logistics partners, retailers, shipping partners etc);
- data about the level of traceability that is required and/or currently available to different industry partners (e.g. product level or pallet level); and,
- an overview of current distribution systems (nationally and internationally).

The introduction aims to **highlight some key issues, challenges, trends and drivers facing the Australian seafood industry** and salmon aquaculture more particularly. It is anticipated that consideration of these **contextual factors** will assist project partners in their deliberations over progress of Phases 2 and 3 of CoolFish.

Introduction

The Australian aquaculture industry currently has revenues of nearly $800m. Of this, salmonids are the largest contributor accounting for approximately 30% of revenues with most produced in Tasmania. While the industry continues to face conventional business challenges of product price fluctuations, changing demand, growing global competition and evolving regulatory standards, new technologies are increasingly seen as mechanisms for increasing productivity, quality and safety[1].

Indeed, although fish nutrition and fish health remain the most important aquaculture research areas, it has been widely recognised that 'research on traceability and supply chain management and on the socio-economic impacts of aquaculture' are the areas most likely to impact positively on the industry in the next 5 years[2].

In 2007, a review of technical market issues for the seafood CRC[3] identified a number of factors directly relevant to this report including:

- Australia's edible seafood exports are worth $1.2B annually with 90% of Australian seafood exports (by value) concentrated in six main markets: Hong Kong, Japan, United States, China, Taiwan and Singapore. Each of these markets operate their own statutory frontier border inspection programs to assess **compliance with internal domestic food safety** standards.
- The European Initiative for Sustainable Development in Agriculture (2001) considers social and environmental sustainability including water, energy usage, animal welfare, biodiversity and waste management in the production of foods. Australian exporters can use this to **brand differentiate** for example through use of renewable energy, sustainable business practices and bio-degradable packaging to reduce their carbon score along the production and supply chain;

[1] Aquaculture in Australia: A0240 (2008) IBISWorld Industry Report, ABIX/LexisNexis Australia.
[2] Stricker, S. et al (2009) Whither Aquaculture R&D? Results report for Participants of the Delphi Study, February, Christian-Albrechts-University of Kiel, Germany.
[3] Padula, D.J., Pointon, A.R. (2007) Review of Technical Market Access Issues Relevant to Australian Seafood Industry Members of the Australian Seafood CRC, October, Food Innovation & Safety, SARDI, South Australia.

- Tesco supermarkets in Europe will begin **labelling seafood product with a carbon score from 2012**, this will be a mandatory program for suppliers and so there will be challenges for Australian exporters to develop the necessary record keeping systems to validate these purchasing criteria;
- The development of real time traceability systems will allow **verification of end-point** needs such as carbon footprint scores and differentiation of product in the EU market with competitor products.
- The development of **more rigorous food safety standards** such as in Japan, Hong Kong has led to greater scrutiny of products entering international markets. This is likely to spread rapidly to other countries including China. It will require a response from the Australian seafood export industry.
- Market access requirements including traceability, will continue to emerge in addition to changes to **regulatory limits on minimum residue levels (MRLs)**. Traceability models have been delegated by the EU to Denmark to develop for all EU member nations' benefit. Other markets such as Japan are developing seafood traceability systems for product differentiation purposes. Australia does have FSANZ traceability standards. These are modelled on the US FDA system but do not meet the stricter EU requirements.

More broadly, it is relevant to be aware of the on-going trade issues that will continue to impact on the Australian seafood industry and its ability to grow, particularly into export markets[4]. Additionally, in considering the development of domestic seafood markets it is important to recognize the potential of these technologies to contribute directly to the emerging Seafood CRC retail transformation project[5].

In this context **figure 1** overleaf usefully captures the key aspects of the value propositions in the Australian aquaculture industry and assists in conceptualization of the wide range of areas in which traceability and sensor technologies could add value.

[4] Stoler, A., Donaldson, V. (2008) Current International Trade Issues Affecting the Australian Seafood Industry, June, Institute for International Trade, University of Adelaide (on behalf of Seafood CRC).
[5] FRDC (2009) Retail Transformation Project: Pre-Prospectus, March, Seafood CRC.

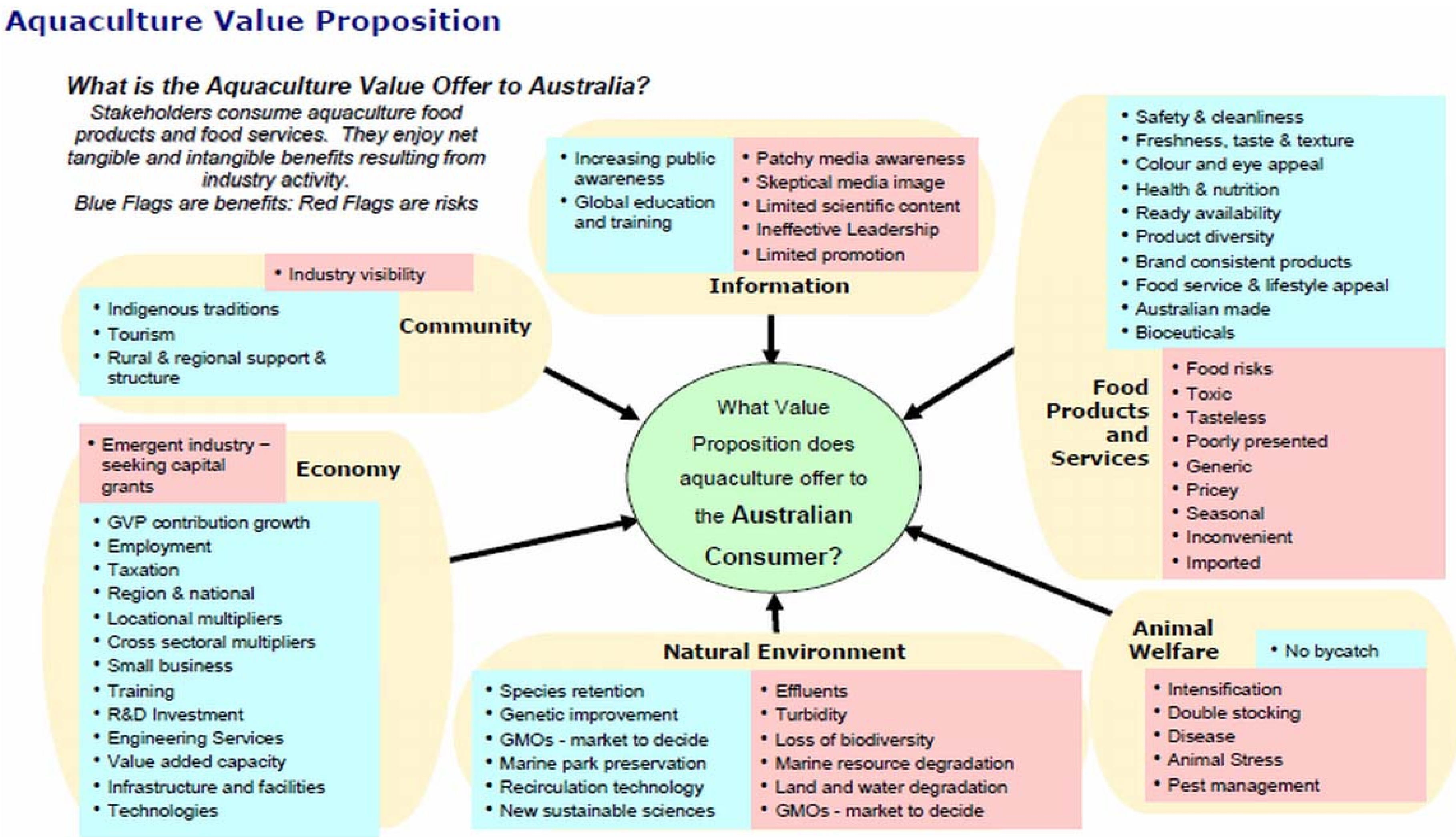


Figure 1 Australian Aquaculture Research and Innovation Strategy (Sept. 2004) www.australian-aquacultureportal.com/action_agenda/pdf/rdreport.pdf

The next sub-section provides background on the research team, its approach in Phase 1 and the research context.

Background for Phase 1

Research Team

The University of Tasmania has an international reputation for expertise in the area of modelling of the microbial ecology of foods, a discipline that has been termed '*predictive microbiology'*. Products of this research, primarily in the form or predictive tools and risk assessment, have been used by various industry sectors and government organisations to enhance access of food products in domestic and international markets.

The Seafood CRC has invested in predictive microbiology tools for the oyster industry[6]. The 'Oyster Refrigeration Index' project will provide oyster companies with a validated predictive tool to proactively manage *V. parahaemolyticus* risk in cold chains, optimise refrigeration schemes that control risk while reducing refrigeration costs, and result in scientifically validated Codes of Practice recognised by regulatory bodies.

Food Safety Centre, University of Tasmania
The UTAS Food Safety Centre team has a strong record of seafood industry collaboration, including conducting research for various oyster, abalone, mussel and salmon companies, both in Australia and in the USA. Collaborations also extend to other industries in Australia, most notably beef, pork, dairy and confectionary. Professors Mark Tamplin and Tom Ross both have very strong expertise and experience in the development of microbial growth predictive modelling used in food supply chains.

School of Computing and Information Technology, University of Tasmania
Associate Professor Paul Turner at the School of Computing and Information Technology, University of Tasmania works with supply chain technologies and currently has a Seafood CRC PhD student (Steven Cambridge) working in this area. Steven is a mature aged student with research specialities in the supply chain, use of information systems and food safety, with a focus on integrating traceability solutions with models of microbial growth in the seafood cold and chilled chains. Paul organised a research team with a variety of expertise to assist with Phase 1:

- Malcolm Bertoni: Logistics Standards Expertise and PhD candidate
- Luke Mirowski: RFID Technology Researcher and PhD candidate
- Ian Whitehouse: Expert Consultant in Supply Chain Technologies and PhD candidate

Research Approach

This Phase 1 report presents data gathered and assimilated from literature sources and directly from industry partners – **it does not report on any experimental work**. The report provides baseline information about logistics issues and challenges in Tasmanian Salmon Cool Chains; reviews established and commercially available traceability and sensor technologies; and, identifies those technologies with most potential for deployment in Phases 2 and 3 of the CoolFish project.

In this context, the research approach adopted in Phase 1 involved two steps:

[6] Madigan, T. (2009) A Critical Evaluation of Supply-Chain Temperature Profiles to Optimise Food Safety and Quality of Australian Oysters, SARDI and Seafood CRC (2007/700).

1. Data Compilation and Literature Review
Scientific research literature sources and industry materials were identified and analysed to generate insights into the Tasmanian Salmon cool chain and to catalogue and validate current technologies used or trialled in supply chains to support traceability or product sensing.

2. Interview Data Collection from Tasmanian Salmon Cool Chain Participants
Semi-structured interviews and focus groups were conducted with Tasmanian Salmon cool chain participants in Tasmania and in Melbourne. This data was analysed to identify current issues and critical success factors identified by participants. Participants included representatives from:

- Simplot Australia
- Huon Aquaculture Company
- Tassal Group Ltd
- Petuna Seafoods Pty Ltd

Research Context

Traceability technology is the term used to describe tools that 'trace' product along the supply chain from the producer or source to the consumer, recording and storing this data along the way. Similarly, the term 'freshness indicator' or 'sensor technology' describes those tools which measure and store data concerning variables such as temperature and time post-harvest, and can be useful in predicting product shelf-life[7].

Both applications include devices to measure, as well as software systems to record, store and analyse the measurements taken. Tracking devices already available on the market include bar coding systems; RFIDs (radio frequency identification devices); GPSs (global positioning systems), as well as 'microdot' or 'DNA' (digital nanoparticle authentication) technology.

Standard sensor devices are usually in the form of temperature loggers - automated instruments that record temperature against time; however convenient, miniaturised versions are now available in some segments of the food industry. Rapid developments are taking place in tracing and sensing equipment and in the integration of information technology systems and software. The drivers behind these developments are not only the need for compliance with regulations, but also in the greater efficiencies in cold-chain transport that can be achieved using the information provided by tracing and sensing technological tools and information systems.

Use of predictive modelling of microbiological activity or function has also proven to be a powerful tool in the management of risk in harvest, production process, delivery and consumption. Changes in microbiological populations on seafood have been estimated from changes in product parameters such as temperature, storage atmosphere, pH, salt level, water activity, chemical preservation etc).

The red meat industry (through Meat & Livestock Australia) has invested heavily in predictive microbiology projects of which a key outcome was the "Refrigeration Index". This Index is a new tool that is a scientifically validated measure of refrigeration effectiveness and is used to assess pathogen growth at each point in the processing chain and how industrial processes impact on meat safety. The impacts of implementing predictive microbiology into the red meat industry have included:

- Assurance of meat safety (for verification of product quality and safety following events such as refrigeration breakdowns);

[7] There are a range of chemical and biological time-temperature indicators that are classed as 'freshness indicators'. Most of these do not store data or support easy data retrieval about their 'freshness state'. This is an area of research that could also be developed in Phases 2 & 3.

- Regulators have moved from a rigid policy for fixed time-temperature cooling to one that provides industry with cost-saving flexibility science-based regulation has cut costs and boosted overall confidence;
- An independent economic evaluation showed that a $3.8 million investment in predictive microbiology by MLA and its research partners would (over 30 years) generate an industry benefit of $44 million, a benefit-cost ratio of 11:1, and more than $260 million of additional benefit in reduced social costs.

The Tasmanian Salmon Industry

Brief overview of the Tasmanian Salmon Industry

> "Marine farming of salmonoids has expanded rapidly in Tasmania since farming commenced in the mid-1980s. Tasmania's salmon is considered to be among the world's best quality and is available year round. There are five companies engaged in salmonoid farming in Tasmanian waters with most farming activity concentrated in the D'Entrecasteaux Channel and Huon River in the State's south. Sea-based grow-out operations are also situated in the waters around the Tasman Peninsula, in Macquarie Harbour, and the Tamar River" (DPIW, 2007).

Approximately 93% of Tasmanian salmonoid production is sold in the domestic market with more than 85% of this in Interstate sales. Figure 1 shows the importance of interstate markets with sales generating more than $300 million revenue in 2006-07. A major factor in the rapid growth in domestic markets has been the focus on promoting and marketing salmon to Australian consumers. The high quality of Tasmanian salmon has also been a key factor in establishing a strong domestic market (DPIW,2007). Sales data for 2005-06 to 2006-07 demonstrate the success of the marketing program and the impact it has had on Tasmanian salmonoid production and revenue. Tasmania's high quality product has niche markets overseas, with current exports to Japan, USA, Hong Kong and Singapore. Other export markets include Thailand, Indonesia, China, Taiwan, Singapore, Vietnam, Guam, Malaysia, the Philippines and India.[8]

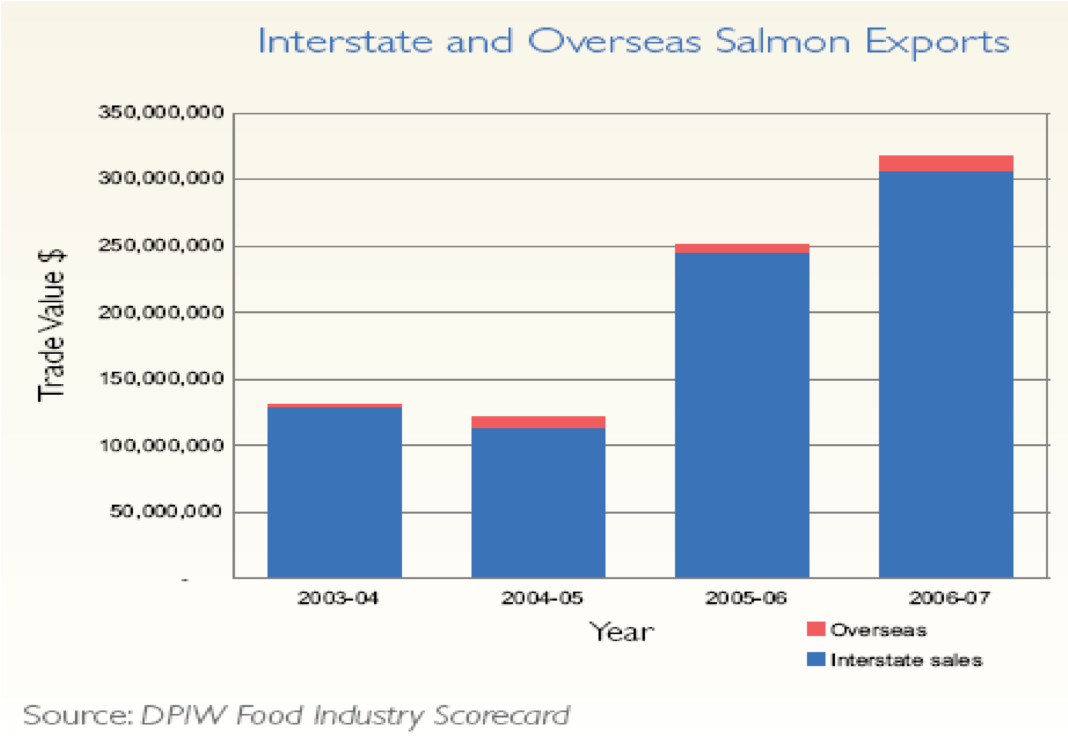


Table 1. Salmon Interstate and Overseas Exports (DPIW, 2007)

[8] The Tasmanian Salmon Industry http://www.dpiw.tas.gov.au/inter.nsf/Attachments/CART-7SPV8Y?open

Key Players[9] (Listed Alphabetically)

Huon Aquiculture

The Huon Aquaculture Group is a privately owned company based in southern Tasmania at Hideaway Bay in the D'Entrecasteaux Channel. The company produces over 11,000 tonnes of fresh salmon per year and is recognised globally as a premium producer of fresh and smoked salmon products. Huon Aquiculture is committed to ongoing research and development which is seen as an essential tool for achieving its aims and for generating useful insights and practical innovations.[10]

Petuna Seafoods

Petuna Seafoods is Tasmania's largest multi-species seafood company and is based on the Northwest Coast of Tasmania. Petuna Seafoods operates its own deep-sea fishing vessels and raises Ocean Trout, Atlantic Salmon and Saltwater Charr at aquaculture sea farms in the waters of Tasmania's southwest. Petuna Seafoods operate an extensive wholesale and retail seafood network servicing local, national and international markets. Shipments from Petuna Seafoods' processing plants arrive in Australian cities within 24 to 36 hours of dispatch. In the United States, the Middle East and Europe, product is received within 48 hours from dispatch and in Asia and Japan within 24 hours[11]

Simplot

Simplot Australia is a wholly owned subsidiary of the J R Simplot Company, a privately held food and agribusiness corporation based in Boise, Idaho with annual sales of more than $US3 billion. Simplot Australia was founded in 1995 when the J R Simplot Company acquired several of Australia's well-established food businesses/brands including Edgell, Chiko, Birds Eye, Harvest, Plumrose, and Leggo's. From that time the company has continued to develop through acquisition of businesses such as John West and product innovation[12]. Simplot Foodservice is one of the biggest foodservice suppliers in Australia, with key categories ranging from; frozen vegetables, canned vegetables, fish, finger foods, snacks, seafood, VA potato, chips, canned fruit, Leggo's tomato sauces and paste, desserts and the Chiko range[13]. Their Atlantic salmon sourced from Tassal, constitutes over 40% of Simplot's chilled seafood production and is their major seafood line.

Tassal

Tassal Group Ltd, a publically owned company, is the largest aquaculture company in Australia, with farms are located in the Huon River and the Tasman Peninsula that produce approximately 14,000 tonnes of fresh salmon per year. It is a vertically integrated company from financial involvement in hatchery operations, through to farming, processing, value-adding, distribution, sales & marketing. The company's net profit after tax for the financial year ended 30 June 2008 was $21.20 million, 32% up on the previous period. The company employs marine biologists, who, together with experienced salmon farming personnel, have pioneered many innovations in both fish husbandry and farm technology[14]

Research Data Collection and Analysis

Semi-structured interviews and focus groups were conducted with Tasmanian Salmon cool chain participants in Tasmania and in Melbourne. This data was analysed to identify current

[9] This is not a comprehensive list of all companies producing Salmonid products in Tasmania, but rather provides summary information on key partners for CoolFish Phases 2 & 3.
[10] http://www.huonaqua.com.au/huon.php
[11] http://www.Petuna Seafoods.com/aboutus/index.html
[12] http://www.simplot.com.au/about-simplot.asp
[13] http://www.simplotfoodservice.com.au/aboutus.asp?pgID=5
[14] http://www.tassal.com.au/_ab_AboutUs.aspx

issues and critical success factors identified by participants. Participants included representatives from:

- Simplot Australia
- Huon Aquaculture Company
- Tassal Group Ltd
- Petuna Seafoods Pty Ltd

The focus of this data collection was on: Current business impediments and business drivers; Current and planned use of technology; Insights into the Tasmanian Salmon Cool Chain and its challenges; and perspectives on future developments in whole of supply enhancements

Data Collection

The primary data collection methodology for this report consisted of the conduct of semi-structured interviews and focus groups with supply chain and quality control managers from the participating organisations. Data collection was conducted face-to-face during site visits and also via telephone for follow-up. The key questions asked were:

1. Can you explain the seafood spoilage mechanisms in your seafood supply chains (extent, type and need for management)
2. What are the time-temperature safety parameters for product/hazard combinations
3. Who are your logistics partners, retailers, shipping partners etc?
4. What level of traceability is required by different industry partners (e.g. product level or pallet level)
5. What are your current distribution systems (nationally and internationally)

Data Analysis

It should be noted that all **comments from industry partners have been de-identified,** however, the role of each interviewee quoted is retained to support understanding of validity and relevance. The key roles that participated in providing input into this process are:

- Supply Chain Manager (SCM)
- Quality Manager (QM)
- Operations Manager (OM)

Tasmanian salmon producers are acutely aware of the need to protect their product from spoilage and have put in place robust processes to ensure the salmon is protected from the point of harvest through to processing and along the supply chain to their customers. However, due to the complex nature of seafood spoilage organisms the process of identifying the specific spoilage bacteria for each product line can be problematic and research is on going in this area. '*We have done a lot of testing but there isn't one specific spoilage mechanism that causes the product to go off – but temperature seems to be the key*' SCM.

Downstream processors are aware that keeping the product within the temperature specifications does not guarantee that the product is in premium condition *'the main validation of incoming product is sensory, the look, smell quality of the gills and this is done on the shop floor during processing. It is possible for a fish to be OK temperature wise but still be unacceptable*' OM.

The management of the cool chain once it leaves the processing plants is left to the logistics providers "…*freight seem to be good at what they do – they know their job and have been doing it for years without any major problems'* SCM.

All of the Salmon producers have taken steps to test the management of the cool chain by the logistics providers. '*We occasionally verify the temperature along the cool chain using data loggers'* SCM.

These tests have shown that inside the polystyrene boxes there is little or no temperature variation, even when there has been a rise in ambient temperature of up to 11 degrees (as recorded by data loggers on the outside of boxes). *'Temperature differences between winter* *and summer don't seem to make much difference to the raw material due to the fast turnaround'* SCM. Similar comments were made by another SCM ' *We haven't had any out of temperature specs issues as the polystyrene boxes packed with ice are very robust and the timeframe from when the product is dispatched and the customer gets it is very short*' SCM .

The time-temperature safety parameters for first and second grade salmon, appear to be encapsulated in the temperature window of 0 to 4° and the shelf life time span of the various salmon products. '*The original risk assessment for the whole process to come up with our HACAP plan was done by --- the time and temperature safety parameters have come out of this work*' OM

Tasmanian Salmon producers do not just rely on the perception that the product is kept within the temperature specifications by the logistics providers – they also look to their customers to give the ultimate quality check. '*We rely on feedback from the customer to report out of spec product for example melted ice or problems with the fish*' SCM.

All participants in the Tasmanian salmon cool chain are aware that fresh hog and other fresh value added salmon products need to be kept within strict temperature limits. '*Seafood needs to be kept 'tight' - in a tight temperature variance normally between 0-4 degrees*' SCM. Too hot and it will allow spoilage organisms to propagate and if the seafood gets too cold, *'…there is a loss of product quality'* SCM

In relation to the logistics side of Salmon produced in Tasmania most is for inter-state sales and is transported by refrigerated road freight by TOLL, Fresh Freight, or Kelly Transport to Devonport and shipped overnight (still in their refrigerated trucks) to Melbourne by TT Line. Once in Melbourne, the salmon is sent via refrigerated road freight to all states on a daily basis to wholesalers and retailers such as Melbourne fish market, Sydney fish market and retail chains. All cross docking and deconsolidating for further transport legs is completed in temperature-controlled facilities.

Airfreight is occasionally used to transport the salmon around Australia but is cost prohibitive except in certain circumstances and is problematic because the planes are not refrigerated. Airfreight is also problematic due to regional airports lack of temperature controlled cross docking facilities and because of the faint but real possibility of a shipment being left on the tarmac for unknown periods. Despite these domestic issues with air freight in Australia, it is used exclusively for international destinations due to the short shelf life of first class salmon products.

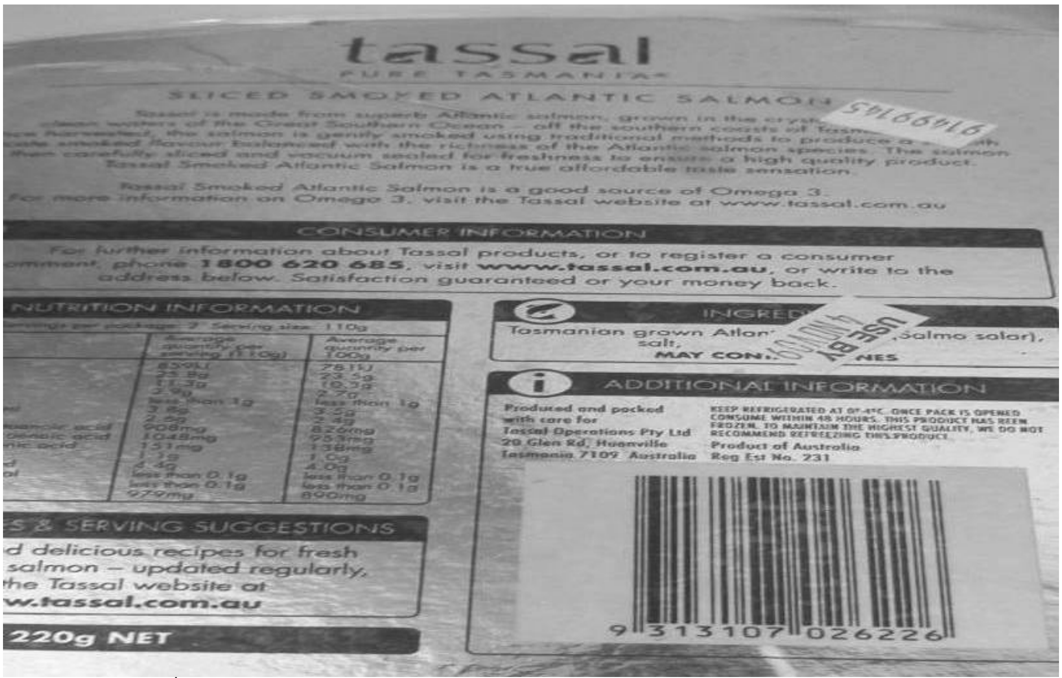
Approximately 10 tonne of the hog travelling along the supply chain out of Tasmania is delivered each week to Simplot's Laverton and Flemington processing plants where it is filleted and processed then vacuum packed or MAP (Modified Atmosphere Packaged). The product is then placed in ice filled polystyrene boxes and shipped to one of the six Coles' Distribution Centres (DC's) of which there is one in each state except the Northern Territory (which is supplied from the South Australian DC). Once the product is delivered to the DC, Coles takes over all responsibility for the shipment and management of the product.

Simplot use Harris Refrigerated Transport to transport the product to South Australia and Western Australia. Gourley Transport is used to transport to the Victorian DC, Lindsay Transport is used as the carrier to New South Wales and Queensland. On these specific legs Simplot use the **CoolTrax truck based system**. CoolTrax is a wireless (active-RFID) system that enables product temperature to be captured and reported automatically in real-time, whether from inside a truck, DC or a merchandising cabinet. The system also tracks the location of trucks and products, tracks who has custody of the shipment and monitors the performance of refrigerated assets.[15] It is interesting to note that since Simplot have been using CoolTrax the level of product rejection has reduced to zero, '*since implementing the new system we've had zero rejections from Coles DCs*' OM.

[15] http://www.cooltrax.com/

Traceability is already recognised as a key requirement by all the salmon cool chain participants. The current systems in place utilise barcodes and batch numbers. Significantly, when the salmon cool chain participants were asked about the level of traceability required by their industry partners the initial response was typically; '*we can already trace the end product back to its original pen and harvest date – more info on this would be redundant*' SCM.

However, on further enquiry, it appears that traceability requirements varied between first grade (see pictures 1 and 2 below) and second grade product. *'…don't see traceability as an issue with 1st grade product because it is processed and consumed within 2 weeks'* OM. Additionally, when this issue was explored further with another of the Salmon cool chain participants it was noted that; *'….obviously traceability is also broken when hog is removed from its poly boxes'* SCM



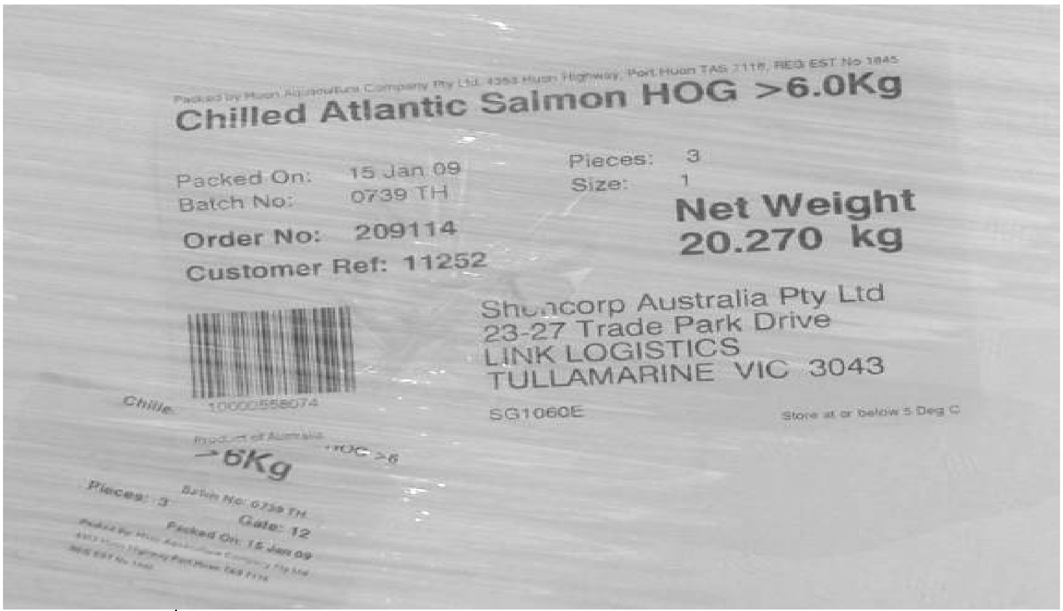
(Picture 1.) 1st Grade Value-Added -Traceability Elements

Second grade salmon use is growing and more product lines are being developed for market. The products themselves are also being kept on the shelves or in cool stores for much longer that first grade product. '..*2nd grade product that is either frozen or modified in some way and is not consumed for months is an area of concern as it can be a cause of problems – worrying about traceability on these products causes grey hairs'* OM

While the use of second-grade salmon is growing so is the use of currently considered waste salmon "*Waste product i.e. flesh off the frames is not currently utilised but a number of product lines are being developed to do so*" OM. Traceability of these products will prove even more problematic than for current second-grade salmon.

Even though the salmon cool chain participants have all developed and use traceability systems, there has so far been few direct requirements for them to do so. It was also reported that there was limited current pressure to build more efficient or robust traceability and that there is a general lack of 'push' from major down stream cool chain partners. When this was investigated further it was revealed that this push was not currently directed at Salmon because of its own branding. '*because the product is branded our major* [down stream partner] *does not require traceability of the product back to its source – if the product was* [unbranded] *then they might*' OM

Interestingly, while all supply chain managers interviewed were very knowledgeable on their own organisations processes and had a good understanding of their immediate supply chain partners, they did not express a 'whole of cool chain' perspective that encapsulated pre-harvest all the way to the dinner plate (fish to dish). Indeed, in terms of perspectives on improved traceability it was evident that a general perspective was that it could provide incremental improvement in a particular part of the cool chain rather than as a strategic initiative with implications across the whole cool chain and its business processes. 'I *think just focusing on post-catch traceability and process mapping is very important'* QM



(Picture 2.) 1st Grade Hog -Traceability Elements

During the course of the data collection a number of other comments were made including on the topic of shelf life. Shelf life is currently determined from the pack date and is fixed in time. This shelf life is designed to allow for small temperature fluctuations along the supply chain and while it is on display in the retailers cabinets. But there is currently no way to predict remaining shelf life more exactly or to gain detailed insight into the impact of temperature fluctuations in retailers cabinets and their impacts on consumers experience of the product. '*I'd like to know the exact temp history of the product so I can predict remaining shelf life*' SCM.

Knowledge of the temperature history would clearly improve the management of shelf-life and be a significant branding and marketing aid. This ability would both increase food safety and product experience for the consumer and increase profit for the producer and retailer.

Because salmon producers have to rely on third party logistics providers to monitor the temperature veracity of the produce as it travels along the cool chain a great deal of trust is required, '*It's all about the relationships you build up with your transport companies and at the end of the day you get what you pay for"* OM

Tasmanian salmon producers have been sending their produce through the cool chain for over 30 years with a great deal of success. However '*at the moment we just don't know the true status of the product as it is moving through the chain – we make a judgment on it based on a body of knowledge we have built up over the years'* OM

The CoolTrax traceability system is in use on two long haul legs out of Melbourne and has greatly increased information visibility for the supply chain managers, '*Problems can be made worse when the product is sent long haul when there is a problem with the shipment what do you do? – send someone up to fix what can't be fixed?* OM

Data Interpretation and Discussion

The primary producers of salmonoid product in Tasmania all exhibited similar supply chain characteristics except that only one has product wholly processed in Tasmania. After harvesting, which is done five or six days a week depending on the producer, the salmon is held in containers and cooled down with ice ready for processing. Once processed into either hog, (whole fish that has been gutted and head removed) or value added products (such as fillets; portions; and hot or cold smoked products that are either vacuum packed or modified gas packed. The product is placed into polystyrene boxes and packed with ice (or chill packs) these boxes are palletised and put into trucks. At this point the organisation relinquishes control of the temperature control of the product and the logistics providers take on that responsibility.

From the data collected from the Tasmanian salmon producers and their cool chain partners there seems to be an unspoken mantra for the effective delivery of premium product to their customers which is; **Keep it cold - move it quick**. They rely on a body of knowledge built up over the years to guide their practices and processes for safe and effective cool chain management.

Whilst there is an awareness of seafood spoilage organisms, at present the main weapons against them appear to be tight temperature control, effective packaging and the short time to market. CoolFish phase 2 Sub-Project 1- "Microbial growth predictor tool" has the potential to **add another layer of certainty, reliability and food safety to the already robust supply chain practices.**

A "Microbial growth predictor tool" requires detailed recording of the time temperature parameters of the product being monitored. Currently only occasional temperature audits are carried out by the salmon producers to verify the cool chain controlled by their second and third party logistics providers. If Sub-Project 1- "Microbial growth predictor tool" were embedded in Sub-Project 2 " Asset tracking and management tool" using RFID and its associated backend data management systems, real time temperature audits could be put in place across the whole cool chain.

As will be discussed (see, Section 2) there is a trend towards more regulation in Australian cool chains and it is probable that following the international trend Australian Salmon producers will shortly be required to meet more stringent regulations and standards for information visibility, traceability, accountability and liability along the whole food supply chain. Logistics partners have been delivering on time and in temperature specification for many years and have built up a strong trust-based relationship with Tasmanian salmon producers. However, the need for validating and verifying data on the safety & quality of the products transported is likely to change the nature of existing relationships – **indeed the valuable traditional methods of trust and reliance on customer feedback to monitor and report on the quality of its cool chain are unlikely to be sufficient in the near future.**

Beyond these regulations, it also seems probable that retailers (e.g. Supermarkets) may also impose tighter requirements on producers as they seek to respond to consumer demand for 'clean, green' products.

Summary of Insights from Industry Partners

In summary, this section of the report has highlighted the following:

- Tasmanian salmon producers have advanced in-water technologies but are only in the planning stages regarding post-harvest technologies. They **recognize the potential to increase value by improving the cool chain;**
- Tasmanian salmon producers recognize the benefits of traceability technologies for **more effectively integrating data across the pre- and post-harvest boundary;**
- **Keep it cold - move it quick** is the tried and tested mantra that guides the practices and processes of the Tasmanian Salmon cool chain and currently ensures safe and effective product management;

- Tasmanian Salmon cool chain participants are aware that keeping the product within accepted temperature specifications does not guarantee premium condition and recognize that they currently have to **rely on sensory evaluation**;
- Tasmanian Salmon producers are knowledgeable on their own organisations processes and have a good understanding of their immediate supply chain partners, but have not currently embedded **a 'whole of cool chain' perspective** that encapsulates pre-harvest all the way to the dinner plate (fish to dish).
- A need for increased traceability, particularly of second-grade (and below) salmon products has **increased in importance as the Salmon product range expands**;
- Tasmanian Salmon producers acknowledge that they do not have a high level of detailed insight into the status of individual products or consignments thereof once they are transferred to their logistics providers and travel along the supply chain. They **base their judgments on 'experience-based' knowledge** due to a lack of detailed supply chain data;
- A need to **predict remaining shelf life** especially for second-grade (and below) salmon products and was identified as a strong value proposition for improved traceability and sensor technologies;
- The **ability to extend shelf life by using a microbial growth prediction** embedded in the a traceability/tracking tool has the potential to prepare the cool chain to be able to respond to a number of emerging issues from regulators and retailers including reducing food miles, extending shelf life and protection against legal liabilities;

Section Two: Traceability and Sensor Technologies

This section of the report presents a review of established and commercially available traceability and sensor technologies; and, identifies those technologies with most potential for deployment in Phases 2 and 3 of the CoolFish project. It briefly considers the:

- Status of current/future regulations and standards;
- Drivers for implementation of technologies;
- Market appraisal of customer acceptability (e.g. retailers etc);
- Downstream effects such as highlighting potential issues with supply chain partners and potential impediments (e.g. IT capability at retailer cold stores etc.)

This section commences with an introduction providing a summary of traceability and product sensor technologies relevant to CoolFish. This summary directly leverages the reviews previously conducted on behalf of the Seafood CRC on traceability[16] and predictive and diagnostic technologies[17]. This section then proceeds to examine related issues of direct relevance to the CoolFish project including standards, implementation, markets and whole of supply chain issues.

Introduction

> ***"Traceability should be viewed as an opportunity****, not an imposition. Products and services have customarily been controlled by different paradigms, but the advent of smart packaging, product sensors and traceability systems and the integrating technologies of intelligent device networking can now serve to bring them together …identifying goods with tags or bar codes…. in the production sense ..provide… a means of identifying the goods and of following their history of [production and processing]… but they can also be thought of in the service sense as providing information to the end user and thus enhancing the product's value.* ***Information is the new value-added****" (FIP & Bremner,2007) [emphasis added]*

Traceability makes it possible to track "seafood" products from their point of origin all the way to the point of retail where they are purchased by end-customers/consumers. In Australia the current recommendation for the seafood industry is to enable **"one step forward and one step back"** traceability primarily achieved using paper based systems. The **current arrangements are not expected to meet forecast regulatory requirements in the near future**.

In their review of traceability and sensor technologies (FIP & Bremner, 2007) listed six elements of an integrated agricultural and food supply chain traceability system and considered how this related to data that might be collected on specific products to establish 'chain traceability" (i.e. Primary: raw materials and/or ingredients data; Secondary: packaging and processing; Tertiary: end products). The six elements are:

1. Product: physical location of the end-product at any stage in the supply chain.
2. Process: type of activities (what, where, when) affecting the product during growing & post harvest operations.
3. Genetic: Genetic composition of the product and type and origin (source, supplier).
4. Inputs: Type and origin (source, supplier) of inputs used for preservation/transformation of the raw materials into processed products.
5. Disease and pest: Epidemiology of microbiological hazards and pests, contaminants.
6. Measurement: individual measurements, standards for quality assurance etc.

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[16] FIP & Bremner & Associates (2007) Review of Traceability and Product Sensor Technologies relevant to the Seafood Industry, November, Seafood CRC, prepared by Food Innovation Partners (FIP) and Allan Bremner & Associates.
[17] Dods, K., Bremner, A. (2007) Predictive and Rapid Diagnostic Technologies for the Seafood Industry: A Literature Review, Seafood CRC report

Traceability and Sensor Technologies for Seafood Cool Chains

Product traceability is probably the most well understood dimension of traceability because of its potential for product rejection, loss of brand image or worse. It is however evident that managing the safety, quality and compliance of a product cannot meaningfully be isolated from the rest of the traceability chain. While paper based systems remain at many points along existing seafood traceability cool chains, barcodes have also been widely used for a number of years (See, www.tracetracker.org; www.wisefish.com). However, **a key impediment in the use of these systems has been the granularity and accessibility of the data during transportation** and it is these issues that have led to the strong interest in RFID (radio frequency identification) to support traceability systems

RFIDs offer a number of benefits over previous technologies because they **support the easy identification and active monitoring at the product level and opportunity to link data from freshness sensors**. The technology uses radio signals to communicate a unique serial number from the tag to the reader meaning products can be identified from several feet away and without requiring line of sight with a reader. As readers can read many tags at once, the product itself does not need to be static during the identification process. The information from tags can also be aggregated with other tags to enable temporal and spatial information to be combined against a product's electronic history. This means tagged products can be associated with **Time Temperature** data, collected by other tags that may be situated amongst them. As the technology is automatic this information can be sourced from the RFID system without human intervention.

More advanced RFIDs solutions are now being implemented that speed up the process of establishing the signals providing traceability and freshness data. This means that **products can be monitored not just periodically but at any time and while on the move.** This is the approach that is now being used in New Zealand's national cattle ID project where use of RFID rather than barcode is the preferred identification method of cattle. This is because it is more accurate with less chance of misreads and enables much faster identification of individual animals without slowing their movement[18]

Second and third generation RFIDs solutions are increasingly being deployed in the seafood industry and earlier challenges around their use in wet environments have largely been overcome. Several large seafood traceability research projects are now underway in a Europe:

- Seafood Plus (www.seafoodplus.org) involves 70 partners with traceability and RFID facilitating a large aspect of ensuring consumer health and safety for the project.
- The Chill-On project (www.chill-on.com) involves a consortium of European universities and companies developing traceability and safety mechanisms for cool chains. The focus of these systems is the generation of new technologies rather than in their application.

Both projects have **real potential for CoolFish** and could be leveraged as off-the-shelf technologies that could be integrated with a microbial growth predictor for use along the whole Salmon cool chain.

Traceability systems when implemented need to be accurate, reliable and cost effective. Some current systems still have an information gap caused by a delay between the arrival of products at downstream supply chain partners and the arrival of track and trace information about them. These obstacles and time delays inhibit effective action and responsiveness to incidents. They also often necessitate decisions being made about identifying spoilage based on limited evidence. This **issue of product rejection at the point of delivery/receipt** based on the internal temperature of vehicles and not on product quality was identified as a problem for Tasmanian Salmon cool chains during the January 2009 workshop.

[18] Friedlos, D. *New Zealand's national cattle ID project gets $23 million*. 2008, RFIDJournal (www.rfidjournal.com/article/articleview/4154/1/1/)

A critical step in the development of an integrated traceability and product sensor solution is to recognise the need for data collected from different elements to be associated with each other to support evidence based decision support. This solution can support a range of **value propositions including safety, quality, compliance, branding, supply chain efficiency** and future proofing – but the product should be identified for the quality to be managed. This can be achieved through information associations amongst data entities to convey temporal or spatial information useful to achieving finer grained levels of traceability. For example, having RFID tags directly linked with the seafood product enables associated time and temperature information to used in conjunction with microbial growth predictor models. There are already examples of this product level traceability being implemented even with **low cost perishable products**.

Schuitema, a supermarket operator and wholesaler in the **Netherlands has piloted a RFID based traceability system to help ensure the quality of fresh cut vegetables.** The impediment that they overcame was the problem that there was no real-time relationship between the physical flow of goods and the informational record chronicling that flow. The supply chain partners had to wait for an employee to record, input and upload data to a database before they could access it. This meant they were unable to act on information that would have alerted them to potential product routing errors or food spoilage. By applying RFID tags to around 2,500 plastic crates and implementing RFID readers in critical locations to monitor the flow of vegetables, they were able to alert employees to instances when a crate loaded with produce was out of cold storage for more than 15 minutes. The new traceability system produced a 10% reduction in product loss, improved overall quality of products because of reduced delays and reduced costs related to delivery errors[19].

Canadian Beef Products (ABP) attaches 125 Khz RFID tags to the ears of cattle prior to slaughter. Fixed readers at specific points along the processing factory associate a carcass to the starting point where the animal is slaughtered and to the point where Canadian Food Inspection Agency employees inspect the carcass. Where a carcass is deemed to be suspect, it can be removed from the line and electronic information associated with the outcome of biological evaluation accessed.[20]

Fish products have also been directly RFID tagged for similarly purposes. In Taiwan, Tekho's Ubiquitous Live Fish Traceability program provides restaurant patrons with the life history of farm-raised grouper because workers at the An Pin Live Fish Centre attach a passive 13.56 Mhz tag to each fish's gills by means of a wire extending to the mouth. Product level tagging of seafood is clearly feasible from a RFID perspective.[21]

At this level of tagging, **chain traceability across entities** (primary traceability of the raw materials and ingredients, secondary traceability through processing and packaging, tertiary traceability of the end product) is achievable subject to the means by which tags are read with options including gateway mounted readers or handheld Near Field Communication (NFC) phones.

Extending the traceability chain along the supply chain increasingly means utilising the Internet for information sharing. Worldwide the trend towards the Electronic Product Code (EPC) based tags means that in the future a global RFID data network will exist. In the near term however, a number of specialized traceability information delivery services can be considered for deployment. For example, TraceTracker (www.tracetracker.com) is the leading generic traceability network and has formed the backbone for a worldwide traceability network sponsored by GS1, IBM and SAP called the "TraceTracker Global Traceability Network" (GTNet). One way of instantiating data into the network is via RFID tags and this has already

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[19] Swedberg, C. *Schuitema ponders future of fresh-chain pilot*. 2007, RFID Journal (www.rfidjournal.com/article/articleview/3793/1/1/)
[20] Swedberg, C. *Beef tracking, the RFID way*. 2006, RFIDJournal (www.rfidjournal.com/article/articleview/2845/1/1/)
[21] Swedberg, C. *Taiwanese seafood producer tracks fish to dish*. 2008 (www.rfidjournal.com/article/articleview/3964/1/1/)

been achieved with perishable goods. **One advantage of TraceTracker is the close alignment and compliance with existing identification standards promoted by GS1,** and its backward compatibility with pre-existing barcode identification systems.

The global logistic company, TNT, has also recently initiated a cold chain data delivery service within Asia. This service tracks temperature levels associated with health-care, pharmaceutical and chemical goods as they move along the supply chain and facilitates delivery of this information to downstream partners. It is designed to provide quality assurance information to companies about how their products are stored and shipped and at what temperatures[22].

In the Australian context, Ceebron Smart Trace (www.ceebron.com) offers an outsourced traceability solution currently geared to Meat and Livestock Australia (MLA). An integrated solution where Time and Temperature Indicator (TTI) tags are embedded at the pallet level that transmits logs back to a centralized server that can be accessed by downstream partners under this scheme. The information can be acted upon **in *near* real time**. Overall these services overcome a number of the past limitations of upstream and downstream distribution of traceability information amongst supply chain partners. However, they **still require business agreement amongst supply chain partners for this to be delivered effectively and for value to optimised.**

Traceability information can also enable products to be monitored for freshness along a supply chain from their point of origin to the consumer. The time a product has remained in the supply chain is one factor that is used to calculate its best-before date although time is not the only factor. The way a fish is gutted will affect pathogen count on its body and the rapidity of freezing or cooling will affect fish flesh texture, and the means by which the fish was killed will affect freshness. This "kinetic" information can be used to establish evidence that a fish has actually spoiled. Therefore, knowing temporal information can be linked effectively with temperature to generate metrics for the classification of spoilage.

For example, Fresh-fruit producer Apo Conerpo and Conad, an Italian retailer, used Montalbano Technology Time Temperature Indicators (TTI) to track an average of six cases of cherries per day from producer to retailer with 65,000 temperature-tracking logs being recorded. The retailer express mailed the TTI tags back to the centre for processing (which saved on costs). As a result of the project, they learned that cherries underwent erratic temperature changes during the transport Phase[23]. At the product level time/temerature tags are an effective way of leveraging the traceability system as this information can be associated directly with the tags using radio signals. It also avoids naïve temperature information being associated because microclimates may vary the more layers exist between the product and the TTI.

In Australia, Global Cold Chain Solutions (www.globalcoldchain.com) manufacturers a range of TTIs that could be suitable for integration with product level tags to associate them with this level of information once the traceability system has been implemented. This traceability system, in conjunction with TTI, allows perishables to be associated with a more granular temperature reading rather than relying on higher layer readings which are less accurate, for example, at the delivery container level. A similar method has already been employed to increase perceptions of quality for Alaska's seafood industry. In one study they placed small active RFID tags into 50-pound wet-lock boxes filled with fresh salmon from various Alaskan locations. These tags monitored and recorded the interior temperature at 30 minutes intervals. They followed the supply chain from the point the fish were placed in boxes, through various processing stages, and finally to waiting retailers. At the end of the chain, the retailers took the tags back out of the boxes and flew them back to the university where the

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[22] Bacheldor, B. *TNT uses RFID to track temperatures of sensitive goods*. 2006, RFIDJournal (www.rfidjournal.com/article/view/2726)
[23] Wessel, R. *RFID keeps cherries fresh*. 2007 (www.rfidjournal.com/article/articleview/3554/1/1/)

data was aligned with transportation data and a story was derived to evaluate temperature changes.[24]

RFID supported traceability in conjunction with TTI tags can answer key questions accurately and quickly; **Did temperature abuse occur during transport? Did it spoil when it was in the truck?** This enables decisions to be made regarding how to proceed: "no wait no delay" tactical results facilitate dispute resolutions. This means that products about to expire can be shipped first. First to expire, first out (FEFO) rather than First In First Out (FIFO).

Organisations can **transform their cool chains into a quality-driven cool chain** rather than first in first out. The key to establishing this is however, that this information needs to be applied over time rather than when a tag, and hence product, has exceeded a particular threshold as it is the cumulative temperature history which will dictate spoilage and the relevant decision.

While in the past most TTI information has been processed after the products have reached their destination, advancements in onboard processing mean that nowadays tags can take into account time and temperature fluctuations to derive an immediate tactical indicator for downstream partners. For example, Infratab, an RFID company (www.infratab.com), sells a tag comprised of a chip that **senses temperature and integrates it over time (a key factor in accurate shelf life determination) to generate shelf life data on products.** They also have an optional visual display that provides green, yellow and red indicators of the status of an item. This means that temperature-sensitive products left sitting on a warehouse dock on a warm day have their shelf life re-calculated dynamically and the label changes colour to red, warning workers. This system aims to reduce the chance of spoiled products being uselessly propagated down the supply chain. By providing immediate feedback and not requiring analysis in the back-office it enables immediate responsiveness to the incident[25]. It is important to note however that while these tags could identify potential risk situations and direct workers to take direct action they would not be used as the final basis for assessing spoilage. This information would direct attention to a particular pallet that could then be evaluated in a more detailed way to make a final spoilage decision.

A more detailed review of predictive technologies has previously be generated by the Seafood CRC[26]. Essential to the success of applying these technologies within a traceability system is that this information is collected and associated at the product level, whether manually collected and updated against a tag or automatically via RFID. In general, most predictive technologies currently available require some manual intervention to associate them with product level traceability information – this is **clearly an opportunity for research & development that can be explored in Phase 2** of the CoolFish project.

Although TTI information is reasonably effective at calculating "ice days" other kinetic information that contributes to a "multivariate approach" can also be used to make more accurate freshness indications/ predictions. This extends an evidence based approach to deriving spoilage information, which when applied to traceability data, allows the product to be resolved against a profile. For example, the FreshScan project (www.freshscan.org) has proposed a way to combine RFID and static predictive technology read points. The first part consists of a semi active tag with temperature sensors to document the condition of meat, from slaughter to sale, and record temperatures on a continual basis. An RFID reader was integrated which used an optical detector utilizing a laser to analyse and record the meats condition against the tagged product. Although these technologies are still in their infancy, product level tagging means that any predictive information, established by predictive statically situated technologies, can be associated with the product rather than the container within which they were transported.

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[24] *Branding Alaskan goods with RFID*. 2005, RFIDJournal (www.rfidjournal.com/article/articleview/2001/1/128)
25 RFID tags for monitoring shelf life. 2003, RFID Journal (www.rfidjournal.com/article/articleview/428/1/1/)
26 Dods, K., Bremner, A. (2007) Predictive and Rapid Diagnostic Technologies for the Seafood Industry: A Literature Review, Seafood CRC report

It is also necessary to consider temperature variability as rapid fluctuations in temperature may cause different chemical reactions to occur and accelerate microbial growth in fish rather than simply exceeding safe temperature parameters. Analog means of establishing kinetic information for seafood exist; however, they are not the preferred approach as they typically do not collect sufficient kinetic information, such as bacteria or enzymatic reactions of the product, to produce an accurate result. Analog Time/Temperature Indicator (TTI) devices are useful as static markers to react to pre-programmed temperatures and can be a safeguard indicator of spoilage, although electronic TTIs are preferable. However, it should be acknowledged that there are limitations in applying these electronic devices at the product level. Sometimes kinetic information only manifests itself when the product is close to spoilage and therefore such devices would fail to detect spoilage in a timely manner. Also, bacteria are known to vary amongst different seafood catches which may mean a degree of customizability to account for the unpredictable levels of bacteria against programmed thresholds. There have been developments in this area see for example, indicators manufactured by Litmus (www.litmusfqi.com). There are also developments in Australia that are deploying sensors into marine environments for monitoring and assessment[27] that could potentially be linked into the Phases 2 & 3 CoolFish.

Clearly seafood cold chains present some unique challenges for the derivation of a quality indicator, but RFIDs can now be built into an effective traceability solution. Tags and readers come in a variety of forms, with a range of operating parameters and in casings that are robust enough to withstand the environmental hazards in seafood cool chains. A recent example from Norway is proof of this. Nortura has found success in employing RFID to track meat from its butchering and processing plant to the retail store. Norwegian meat undergoes a variety of processes before reaching a retailer. The animals are raised in Norway on hundreds of farms, and then transported to meat production factories to be butchered and then sent to thousands of Norwegian food stores. Throughout the supply chain the tags used undergo several washing cycles and pass through very cold environments so the tags used have been designed to withstand these conditions. Fundamentally, RFID is the electronic chip embedded inside a plastic "container" and the container itself **can be designed to withstand most environmental conditions[28].**

By approaching traceability from the seafood product level up to the higher informational layers, like TTI tags and integrating this information with other data available will facilitate robust traceability solution that can incorporate microbial growth prediction models. In Hawaii this approach has led to a "quality driven supply chain". Hawaii's Seal of Quality is an effort to improve the traceability of fresh food. Funded with $500,000 this system aims to provide an audit trail and help farmers, retailers and distributors monitor the movement of fresh produce. From the farm to the point of sale, employees use handheld readers to record the time when food arrives. If a box of food remains outside a cooler for too long, such as when being unloaded from a truck, an alert is raised that enables employees to respond. Within three years it is expected that all of the state's 5,000 farms will be using this RFID traceability system[29].

In summary the establishment of a traceability network based on RFID would overcome the limitations which are currently imposed by existing traceability options. RFIDs enable identification of the product via radio signals and this means that products can be associated automatically with other multivariate information sourced from predictive technologies.

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[27] CSIRO Future Manufacturing Flagship (www.csiro.au/news/sensors-to-protect-marine-and-freshwater-ecosystems.html) $9.6million on Sensor Systems for Analysis of Aquatic Environments (October 2009).
[28] Swedberg, C. Norwegian food group Nortura to track meat. 2008 (www.rfidjournal.com/article/articleview/4208/1/1/)
[29] Swedberg, C. *Hawaii plans trace-back program for fresh food*. 2007, RFIDJournal (www.rfidjournal.com/article/articleview/3702/)

A primary focus on the establishment of an integrated traceability system, using RFID should be encouraged as the primary means of identifying the product. Critically, product level identification is required to optimise the application of predictive models. The traceability system provides the means by which both goals can be achieved. More specifically:

- Traceability should be seen as the platform on which to build an integrated cool chain data management approach to support safety, quality, compliance, branding and future proofing. For this to occur traceability must be built from the product level up and then data from other levels assimilated to support evidence based decision-making;
- Sensors like TTI can be deployed at high layers, like in the pallet, with product identifiers clustered around them. The information cluster can then be updated to the product's profile;
- Traceability can provide other information like identifying when temperature deviations occur. Simply employing TTIs alone does not effectively provide information about changes at the product level and therefore cannot adequately supply granular information on product quality;
- RFID tags have come down in price and are increasingly robust and re-usable;
- Information derived from predictor technologies can be deployed at product level, but this will rely on a strong evidence base to produce an effective rule set. Information derived from fixed location predictor technologies can also be associated with traceability information;

Status of Current/Future regulations and standards[30]

> *Standards and general frameworks for setting up traceability systems* ***have been launched during recent years.*** *For example, the International Organisation for Standardization (ISO) introduced, in the beginning of 2006, two new standards that define the requirements for a traceability system within a food safety management system and the data that needs to be retained. The Codex Alimentarius Commission of the United Nations and other International and European organizations have also launched standards for traceability. The Australian Food Standards Code contains labelling requirements for identification and tracing food to facilitate retrieval of unsafe or unsuitable food from the market place. Certain sectors of the food industry (wholesalers, manufacturers and importers) are required to have recall systems but the obligation does not* ***[yet]*** *extend to traceability/ product tracing. However,* ***traceability/product tracing is being considered in the development of primary production standards on a sector by sector basis.*** *For example, under the Primary Production and Processing Standard for Seafood, seafood businesses are required to maintain records to enable seafood to be traced one step forward and one step back. The standard specifies that this is for food safety purposes only i.e. it is only for purposes where it is justifiable to protect consumers' health. (FIP & Bremner,2007) [emphasis added]*

Food safety standards have become increasingly important issues in relation to transportation and logistics, especially cold chain logistics, where shock, humidity, temperature and temperature range monitoring are vital aspects of food quality and safety.

Supply chains, especially perishable food supply chains, link many different types of organisations and extend across multiple borders before reaching the consumer. One weak link in the food supply chain can result in contamination and unsafe food dangerous to human health. If this occurs the damage can be considerable not just to individuals but also consumer confidence and brand reputation. Given that food safety hazards can enter the food

[30] This sub-section draws on work previously published: Bertoni, M et al (2008) Logistics Standards, in *RFID in Operations and Supply Chain Management*, Erich Schmidt Verlag & Co., T Blecker & G Q Huang (ed), Berlin, Germany, pp. 451-470. ISBN 978-3-503-10088-0.

chain at any stage, adequate control throughout is essential. Food safety is a joint responsibility of all participants in the food chain and requires their combined efforts.

Traceability in and across the food chain is now becoming an important requirement, especially in the European Union where there are continued food safety issues such as mad cow disease, dioxin in chicken feed, herbicides in chicken feed and more recently, the bird flu scare, ongoing food-borne illness from Salmonellosis and Campylobacteriosis and increasing levels of Listeriosis in Europe. For these reasons, food retailers are increasingly demanding that suppliers maintain a HACCP based food safety management system that can be, and is, audited by an independent third party.

Quality and Safety

A clear distinction should be made between food safety and food quality.

Food Quality is to what extent the legislated or commercial requirements relating to the food characteristics are met. Food quality is dependent on the quality of raw materials, ingredients and components (including microbiological properties) and the interaction with preparation and processes throughout the food manufacturing process. This premise includes the entire food supply chain and includes not only the creation of quality but also its maintenance through spoilage prevention. Food quality standards include ISO 9000 and ISO 22000.

Food Safety related to the actions taken to protect the food from microbial, chemical and physical contamination that may occur in the food production, processing, handling, transporting, distribution and storing of foods, and that could cause illness to consumers. Food safety is now widely regarded to require integrated actions at all stages in the food supply chain from growing foods, to harvest, processing, distribution and retail sale. Microbiological food safety management strategies are designed to reduce food borne illnesses, diseases and outbreaks, including provision of guidelines to producers, manufacturers, suppliers, retailers, transporters and the general public. Within a food business, the HACCP approach is almost universally accepted as the most effective food safety management strategy.

Food safety and quality management, particularly for perishable foods such as seafoods, are closely integrated. Food quality and safety management focuses primarily on the microbiological aspects of food and its control throughout the logistics supply chain. Nonetheless, a food might not conform to a quality standard but could still meet the safety standards or vice versa.

Food Chains & Cool Chains

The food and cool chains from the logistics perspective involve the transportation, storage and warehousing (and retailing) of food that is refrigerated to a required predetermined temperature. Refrigeration slows microbial growth and chemical changes in the product. Thus controlling temperatures, especially the range, is very important. While there are protocols in place in Australia that provide guidelines for the transportation and storage of products, there is currently no internationally accepted standard for cool chains – one that unifies a number of standards covering temperature sensitive products. Table 2 below summarises major food safety and quality assurance systems and sources of standards.

Table 2. Sources of food safety and quality assurance systems and standards

Sector	***Standard or Organisation***	***Relevance***	***Comments***
International			
	Codex Alimentarius Commission (under the auspices of the United Nations, *viz*. FAO and WHO).	Safety (HACCP) & International Food Safety Standards	Possibly the most widely accepted standards: cover both quality and safety
	ISO 9000	Quality Systems only	Quality assurance & quality

			management systems (all business types)
	ISO 22000	Safety (HACCP) and quality (e.g. Good Manufacturing Practice)	Extension of ISO 9000 covering food businesses and supply chains
European Union	**EurepGAP**	Good Agricultural Practices (GAP)	Food safety, environmental, OH&S Product traceability
National			
US	**SQF 1000**	Safety (generic HACCP) & Quality (some aspects of ISO 9000)	US focussed but accepted by European & other countries Possibly the next best option to Codex
	SQF 2000	Safety (customised HACCP) & Quality (some aspects of ISO 9000)	US focussed
Germany	**IFS**	Safety and reporting	Food safety assessment, traceability
UK	**BRC Global Food Standard**	Safety & Quality	Supplier assessment program, traceability
Australia	**Food Standards Australia New Zealand**	Safety & Quality	Joint Aus and NZ agreement Encompassed in the food standards code. Standard 3.2.1. Sector specific standards are being developed e.g. Standard 4.2.1. Production and Processing Standard for Seafood
	MSQA	Safety (HACCP) & Quality (ISO 9000)	For meat exports
	WQA	Safety (HACCP) & Quality	Supplier assessment program similar to BRC
	Freshcare	Safety (HACCP) & Quality	Supplier assessment program
	IFSI	Safety & Quality	Food export initiative Codex based
	AQIS	Safety, Validation & Verification	Seafood: Export Control (Fish and Fish Products) Orders 2005

RFIDs and the Cool Chain

As the discussion above has indicated RFIDs are already being intimately linked into new approaches for enhancing supply chain logistics. In terms of emerging technology standards the International Organization for Standardization[31] has already been mentioned. They have now defined the air interface for radio frequency identification (RFID) devices operating as an active RF tag. This facilitates the use of an existing ISO standard, ISO/IEC 18000-7:2008 that is an Information technology standard used for radio frequency identification for item management. The standard consist of seven parts: Part 1: Reference architecture and definition of parameters to be standardized; Part 2: Parameters for air interface communications below 135 kHz; Part 3: Parameters for air interface communications at 13.56& MHz; Part 4: Parameters for air interface communications at 2.45 GHz; Part 6:

[31] www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=43892

Parameters for air interface communications at 860-960 MHz; Part 7: Parameters for active air interface communications at 433 MHz.

The EPCglobal[32] framework is something of a competing framework for RFID technology, but EPCglobal has submitted EPC protocols to ISO and so it is anticipated that they will move from de facto to de jure standards over the next few years. Importantly, the frequencies used for RFID in the USA are currently incompatible with those of Europe or Japan. Furthermore, no emerging standard has yet become as universal as the barcode system.

More broadly, RFIDs are increasingly being used for more than information sharing, monitoring and tracking (quality and traceability). In this regard, it is useful to note some of the other potential uses that could be applicable to seafood cool chains that have already been implemented in other supply chains around the world. These include:

- Logistics improvement through modelling, measurement and interaction assessments;
- Environmental sustainability improvements through evaluation of materials used, energy and storage efficiency, noise, gas or other discharges;
- Performance testing and evaluation of new systems and technology;
- Optimisation of the whole food and cold chain – from grower to consumer;
- Behavioural criteria of food and cold products;
- Enhanced and customised uses of refrigeration and/or preservation methods;
- Brand and product authentication/verification and consumer marketing

Summary

There are many sources of food safety and quality standards. Equally, **buyer's (e.g. supermarkets) are, increasingly, articulating their own specifications, which are often more stringent than government requirements**. Many of these Standards and specifications display overlap with each other and almost all have a HACCP-like underpinning.

Many countries have developed local versions of international standards and countries that are part of the United Nations Codex Alimentarius process are encouraged to adopt Codex standards so as to harmonise (facilitate) international trade in foods, and Codex standards are the benchmark adopted by World Trade Organisation. In Australia, local codes and standards such as those developed by AQIS and MSQA follow the Codex standards and SQF seems to be well established in Australia.

Few standards/criteria specifically address cool chain temperatures, or acceptable temperature ranges for specific product types. For supply chains, the new ISO 22000 standard considers the requirements for safe transportation of food. However, of direct relevance to this report is the **increasing requirement for traceability of products.** In the EU this is becoming almost a mandatory requirement due to repacking, redistribution and delivery across more than one country in response to the potential for health, hygiene, contamination and food safety problems that this can bring. Although ISO 22000 and EurepGAP consider this traceability, cool chain integrity remains a concern.

Australia's approach has been to take a preventative approach to food safety, based upon international standards and principles. The Australian national standards are frameworks to achieve outcomes, rather than stipulate requirements. This enables organisations with flexibility in how they achieve these outcomes (Food Standards Australia New Zealand, 2005).

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[32] www.epcglobalinc.org/home

Importantly however, there is often confusion regarding Australian transport regulations and guidelines for food products. In this regard, the following points should be noted:

- There is no legislation or standard for the monitoring of food during transportation, even though is a legal requirement under Chapter 3 of the *Australia New Zealand Food Standards Code* for manufacturers, wholesalers, distributors and importers of food to have in place a written recall plan and comply with this plan when recalling unsafe food. **"one step forward and one step back". But this does not stipulate the technology and most approaches are still paper based.**

- **There is a trend towards imposing new requirements.** For example, food safety management systems are required for the harvesting, processing and distribution of oysters and bivalves. Organisations should comply with Standard 3.2.1. as well as 4.2.1. which lists compliance options: the Codex, HACCP system - *Australia New Zealand Food Standards Code*. http://www.foodstandards.gov.au/ However, it is important to re-emphasize the point above: increasinlgy buyer specifications (particularly those required by large supermarket chains) are imposing additional food safety management actions and criteria.

In the previous two sub-sections, brief over-views of traceability technologies and food safety standards were provided. The remainder of this section of the report is comprised of 4 sub-sections **aiming to take some of the insights generated to explore their implications.**

This exploration considers drivers for the implementation of these traceability systems within individual firms and across the whole of the Seafood Cool Chains. It also considers a range of other emerging issues (changing end customer demands, 'greening' of supply chains) that provide strong value propositions for the conduct of Phases 2 & 3 of CoolFish.

Drivers for Traceability Implementation

Based on the material presented above it is evident that there are a number of drivers for the implementation of a traceability network[33] for the Salmon Industry in Tasmania. These drivers have the potential to benefit the future direction of the sector and are based on the utilisation of an integrated solution utilising:

- RFID (mobile technologies and fixed gateways), sensors with embedded microbial growth predictor models and links with middleware applications (web-based);

Major changes in the regulatory landscape are emerging to make the business case more powerful. Lower technology implementation costs, improvements in technology standards and interoperability, emerging industry legislative requirements (both industry specific (marine, food handling etc) and other such as greenhouse emission trading schemes (ETS), as well as changing consumer demands/behaviours and the need for future business stability and growth are all contributing factors to be considered.

Future innovation, growth and market development will depend upon the industry[34] being able to continue to embrace change[35] and to continue to develop understanding about how market and consumer behaviours are transforming the industry and demand for their products.

[33] Adapted from The Consumer Driven Supply Chain http://www-03.ibm.com/industries/global/files/Retail_TheConsumerDrivenSupplyChain.pdf
[34] See Figure 2 An overview of integrated whole of supply chain value propositions supported by traceability (Whitehouse,2009)
[35] Aquaculture: Changing the Face of the Waters Meeting the Promise and Challenge of Sustainable Aquaculture - http://siteresources.worldbank.org/INTARD/Resources/Aquaculture_ESW_vGDP.pdf

Markets and End-Customers (Retailer Push – Consumer Demand)

There is increasing recognition that responding effectively to market transformations relies on a business, consumer[36] and compliance driven supply chain management approach:

> "In today's environment, businesses, consumers, legislation and compliance organisations drive most everything from farm gate, through to wholesale, value added retail/consumer products[37]. These aspects will increasingly decide the success or otherwise of products. Given this position and to continue to meet the expectations into the future it is important to focus on this approach as the basis for developing a business case. Moving forward by investigating, developing and deploying improvements with this outcome in mind is a sound strategic approach" [38]

This translates into industry leaders strategically focussing on the re-engineering of sophisticated (not complex) specialised supply chain models that are effective, efficient, adaptive, and responsive with a quality-centred set of metrics and reporting parameters (real time; when I need it; just in time; etc.) to meet these retailer, consumer and compliance demands. [39]

Many organisations have already discovered the challenges faced in achieving this, however there now exist a range of technologies, standards[40] and practices that have reduced the barriers faced. The key, it would seem, is to develop and implement whole of organisation and industry approaches that can be applied to operate across all levels throughout the supply chain regardless of role, function or size. Businesses and consumers will in the future continue to expect greater access to information and product knowledge particularly as it pertains to factors such as traceability[41], nutrition and environmental information. Additionally as the target markets continue to consolidate there will be a need to demonstrate points of difference to ensure product recognition and brand differentiation.

A key factor in such a 'whole of supply chain approach' is a high level of industry cooperation, sharing of business intelligence (not commercial in confidence information but rather a focus on the systems and processes, both physical and digital, that support and enhance the supply chain management requirements). Future business and consumer diversification will require a means of tracking purchasing and consumption in order to remain relevance and competitive edge. There will be greater demands placed on product ranges, quality control (production knowledge and product information) and origin of goods (traceability). Future supply chain management systems require careful and purposeful consideration and definition of the value propositions early on in the transformation process.

Critically, buyer specifications are increasingly going to be a key driver for quality and safety systems and criteria. The big supermarkets in Australia are following the lead of Europe and are able to act much more quickly than Codex or national governments in imposing requirements on producers. Moreover, these large retailers are most interested in how traceability can be used in marketing and legal liability. Their market power means that producers need to be ready to respond to new requirements. Indeed, It is very probable that **Australia's major supermarkets will shortly be instituting requirements for traceability to support marketing (e.g. green, sustainable, animal welfare) as well as zero food safety risk** (as defined by the supermarkets). This combination of demands is likely to be a bigger and more immediate driver than government regulations.

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36 http://www-935.ibm.com/services/us/index.wss/ibvstudy/imc/a1002490?cntxt=a1000046
37 A true 'farm-to-fork' traceability solution: www.rfidproductnews.com/issues/2007.11/cold.chain.php
38 The business case for traceability - http://www.env.gov.bc.ca/omfd/reports/traceability/Section3.pdf
39 The need for innovation - http://www.rfidproductnews.com/issues/2007.11/cold.chain.php
40 RFID: The Right Frequency for Government - http://www.rfidconsultation.eu/docs/ficheiros/WyldReport4_IBM.pdf and Getting the most out of RFID A starting guide to radio frequency identification for SMEshttp://www.dbcde.gov.au/__data/assets/pdf_file/0020/41249/Getting_the_most_out_of_RFID.pdf
41 Full Value Traceability A strategic imperative for consumer product companies to empower and protect their brands - http://www-935.ibm.com/services/us/gbs/bus/pdf/fvt_whitepaper_0069_en.pdf.

Whole of Supply Chain Value propositions

This section considers potential for broad downstream effects of introducing traceability empowered supply chain management. It highlights potential issues with supply chain partners and identify some challenges for consideration.

There has been much written and spoken about supply chain management value propositions with many examples being broad in their focus and discussion. A significant opportunity exists by exploiting the adaptive capability and capacity of the "holistic"[42] approach to supply chain management to improve service delivery, quality, margins and growth opportunities.

By thinking about it as an end to end solution and developing and adapting strategies and practices[43] that are applied holistically across the industry[44] a more robust, adaptive and scalable model/approach can be developed into the future[45]. By adopting this approach an opportunity exists to proactively shape the whole of the industry to ensure that:[46]

1. Businesses and consumers are given choice
    a. Customer traceability and quality controls, including an ability to access current location and conditions data on demand and quality control metric reports;
    b. Consumer product information;
2. Service improved across the whole chain: greater reliability and speed from farm (water + land) to market (warehouse + transportation + Customer aspects). With traceability and quality controls being managed automatically in real time thereby enabling increased speed through the cool chain and the availability of this information on demand;
3. There is effective management of the supply chain with a focus on automation opportunities using RFIDs embedded in the traceability network
4. Collaborative partnerships are genuine and deliver value for all partners and customers with service excellence: Win-Win is the aim so as to generate improvements in all aspects/areas of the supply chain including service culture, responsiveness, loyalty, trust and value throughout the supply chain

42 Sustainable Benchmarking of Food Supply Chains - http://www.clarku.edu/departments/marsh/news/WP2009-02.pdf

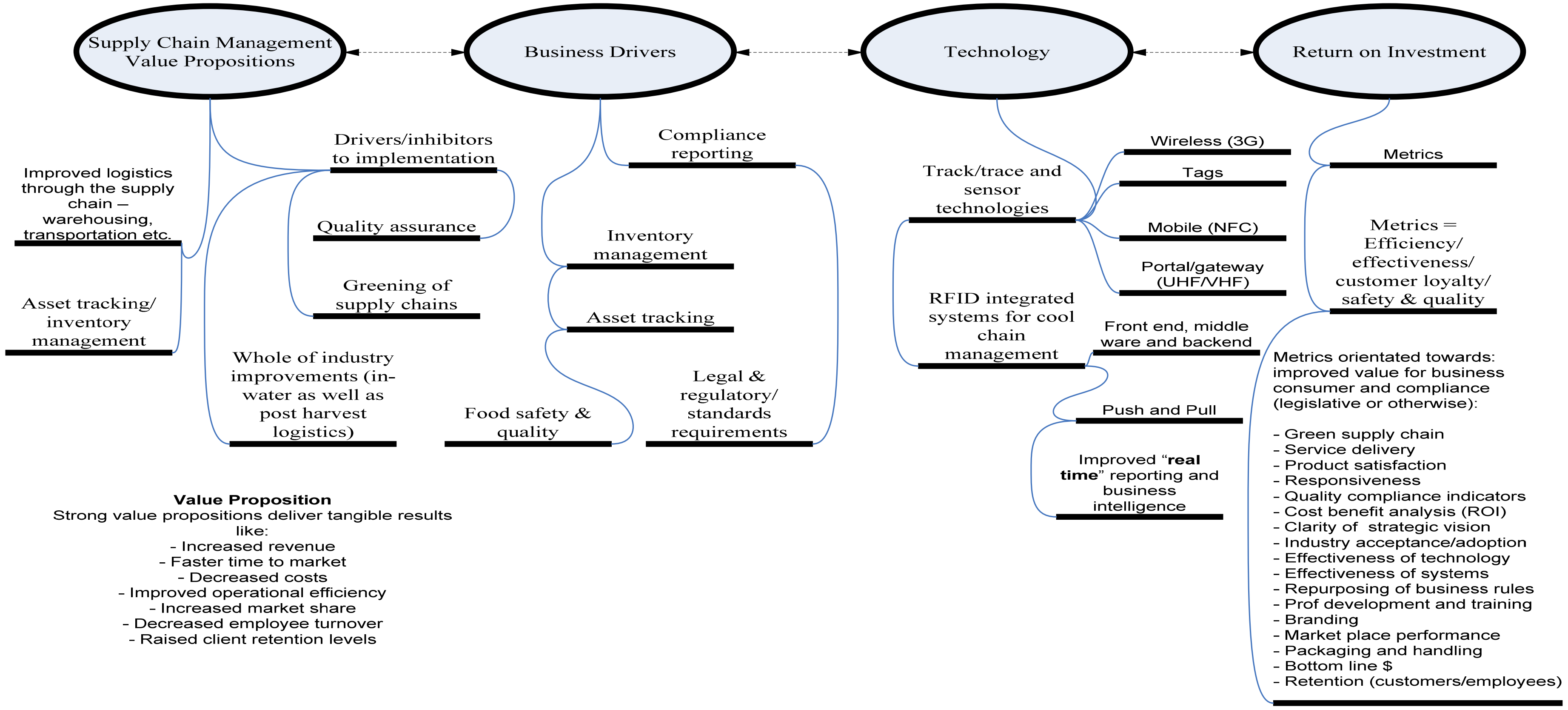
43 A strategic review of the potential for aquaculture to contribute to the future security of food and non-food products and services in the UK and specifically England - http://www.defra.gov.uk/foodfarm/fisheries/farm-health/aquaculture.htm

44 The salmon farming industry: Cooperation vs. competition for achieving a global positioning - http://www.steinbc.com/doc/salmon_farming_industry.pdf

45 Improving the safety of the food supply chain: The value of RFID and traceability on a growing problem - http://www.motorola.com/staticfiles/Business/Solutions/Industry%20Solutions/RFID%20Solutions/RFID%20in%20Retail/_Documents/_Static%20files/Improving_the_safety_of_the_food_supply_chain.pdf

46 http://www.australian-aquacultureportal.com/action_agenda/pdf/rdreport.pdf

Figure 2 An overview of integrated whole of supply chain value propositions supported by traceability (Whitehouse, 2009)



Emerging Issues in Supply Chain management

Real-time data collection (using both mobile[47] and fixed technologies) and on demand reporting (captured and stored in middleware and backend solutions) throughout the "whole supply chain" presumes informational assets including:

- Text (html, xml, sms, wiki, blog etc)
- GPS data
- Photographic evidence
- Audio information
- Automation of Server data: "dished up" (push and pull) instructions such as product handling knowledge at critical points in the supply chain
- Online forms/surveys as a data collection strategy for aspects such as quality assurance requirements at critical points in the supply chain and using digital signatures for authentication[48].

There are numerous example of this approach having been implemented across 'whole supply chains' for example, ESITO[49], Australia Post Logistics[50], Dell[51] and TNT[52] .

More specifically, a number of technology vendors have examined these issues in the context of food supply chains, for example Motorola has published a White Paper on "Improving the safety of the food supply chain: the value of RFID and traceability on a growing problem and cites the following three key benefits:

(1) real-time visibility into product condition during temperature-sensitive transportation
(2) Reduced opportunity for spoilage, contamination and food borne illnesses
(3) Real-time track and trace for cost-effective and accurate creation ..."[53]

More broadly, a number of other emerging issues for whole of supply chain management have recently been identified including most prominently 'green issues'. In this regard, Bellwether Services have recently released a white paper on "*Demystifying the Green Supply Chain Transformation, A Laser Focused Strategy for the North American Supply Base*". It presents a four-step green supply chain methodology for Tier 2 Suppliers[54] and highlights a supplier development strategy[55] Related reports on green trends amongst consumers highlight changing behaviours and demands particularly in relation to food products[56]

Building supply chain management approaches that are flexible, responsive and have scalability emerges as the 'best practice' approach for responding to changing retailer/consumer demands. The traditional supply chain model of a generic "one size fits all" is no longer as effective as perhaps it once was and the ability to individualise, real time solutions that are collaborative and integrated is a stronger value proposition.

Developing an effective industry wide strategic plan that all stakeholders sign onto is one important step to consider for the future and requires careful research, planning and agreement so as to understand future business opportunities that are focused on businesses

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[47] Fostering Mobile Technology Value Proposition through User Participation: Results from two Industrial Case Studies - Thurnher, B. Management of eBusiness, 2007. WCMeB 2007. Eighth World Congress on the Volume , Issue , 11-13 July 2007 Page(s):9 - 9
[48] http://www.oznetlaw.net/FactSheets/ElectronicTransactionsAct/tabid/935/Default.aspx
[49] ESITO (NZ) whole of industry (electrical) example using NFC/RFID mobile phone solution - http://www.esito.org.nz/research_and_projects/m_technology.aspx
[50] http://www.auspost.com.au/postlogistics/home/
[51] https://support.dell.com/support/order/status.aspx?c=us&cs=29&l=en&s=dhs
[52] http://cgi.tnt.co.uk/trackntrace/trackntrace.asp
[53] www.motorola.com
[54] www.joscm.com.br/download/JOSCM_05.pdf
[55] http://www.highbeam.com/doc/1G1-200688482.html
[56] http://www.deloitte.com/assets/Dcom-Shared%20Assets/Documents/US_CP_GMADeloitteGreenShopperStudy_2009.pdf

and consumer driven supply chain management requirements. These specific requirements need to take account current and future technologies and how they can be implemented and deployed within the supply chain environment in order to engage and provide a reason (business case) for the industry as a whole and the stakeholders that operate within it.

To get the most out of the future strategies the focus needs to consider:

- Strategy
- Business processes
- Process enablers
- Technology enablers
- Understanding, developing and embedding capabilities and capacities

Figure 3 presents a Customer Driven 'Traceability Empowered' Supply Chain Model (overleaf). This model aims to consolidate the major points identified in the previous four sub-sections above. These sub-sections aimed to explore some of the key implication of traceability and product sensor technologies and standards for Tasmanian Salmon cool chains.

The model presumes that an enabled infrastructure exists or is developed as part of the strategic planning and forms the nucleus/backbone of the required future middleware and integration technology requirements. These would include all required notification, communication, monitoring and reporting requirements for an end-to-end business and consumer solution.

Customer Driven 'Traceability Empowered' Supply Chain Model

An holistic model for consideration by Participants in the Tasmanian Cool Chain incorporating traceability to support ROI, quality assurance controls/metrics and 'best practice', on-demand reporting and monitoring by suppliers, processes, transporters, retailers and future proofing including 'green' supply chain management

CAGES	PROCESSING	TRANSPORTATION	WAREHOUSING/FORWARDING	RETAILER/CONSUMER
Product sourcing	Product processing/value adding	Product transport	Product Management	Product retail and information value add
Real time tracking and safety monitoring from fish to dish				

Phase	STEP 1	STEP 2	STEP 3
STRATEGY	Strategic Direction	Business Case	Project Plan
BUSINESS PROCESSES	Business Re-engineering	Business Metrics	Quality and Compliance
PROCESS ENABLERS	Existing (Organisational Aspects i.e. how it works now)	Intermediate (Organisational and Logistics Management)	Future (Whole Supply Chain)
TECHNOLOGY ENABLERS	Wireless technologies e.g. RFID, Predictors, Sensors,GPS etc.	Data, Information and Knowledge Management Integration Systems	"On Demand" Monitoring and Reporting Accessed Through Web Portals
UNDERSTANDING, DEVELOPING & EMBEDDING CAPABILITIES & CAPACITIES	Organisational Readiness e.g. IT infrastructure, human skills/ systems thinking	User/Consumer/Market Readiness e.g. Human, Financial and Physical attributes including - requirements/capacity/capability	Business Intelligence/Resilience e.g. to future green supply chain management

Figure 3. Adapted from The Consumer Driven Supply Chain (www-03.ibm.com/industries/global/files/Retail_TheConsumerDrivenSupplyChain.pdf

Section Three: Preliminary Conclusions & Next Steps

Introduction

Sections 1 & 2 above have provided baseline information about logistics issues and challenges in Tasmanian Salmon Cool Chains; reviewed established and commercially available traceability and sensor technologies; and, identified those technologies with most potential for deployment in Phases 2 and 3 of the CoolFish project.

This section of the report summarises the key insights generated:

Key Findings from Phase 1

This report provides baseline information about logistics issues and challenges in Tasmanian Salmon Cool Chains; reviews established and commercially available traceability and sensor technologies; and, identifies those technologies with most potential for deployment in Phases 2 and 3 of the CoolFish project.

Section One of the report commenced by highlighting some key issues, challenges, trends and drivers facing the Australian seafood industry including:

- changing compliance requirements for food safety;
- the emergence of 'green' issues and retailer imposed requirements
- the opportunities to utilise traceability information as part of marketing initiatives

This section of the report also generated insights into logistics issues and challenges in Tasmania's Salmon cool chains including:

- Tasmanian salmon producers have advanced in-water technologies but are only in the planning stages regarding post-harvest technologies. They **recognize the potential to increase value by improving the cool chain;**
- Tasmanian salmon producers recognize the benefits of traceability technologies for **more effectively integrating data across the pre- and post-harvest boundary;**
- **Keep it cold - move it quick** is the tried and tested mantra that guides the practices and processes of the Tasmanian Salmon cool chain and currently ensures safe and effective product management;
- Tasmanian Salmon cool chain participants are aware that keeping the product within accepted temperature specifications does not guarantee premium condition and recognize that they currently have to **rely on sensory evaluation**;
- Tasmanian Salmon producers are knowledgeable on their own organisations processes and have a good understanding of their immediate supply chain partners, but have not currently embedded **a 'whole of cool chain' perspective** that encapsulates pre-harvest all the way to the dinner plate (fish to dish).
- A need for increased traceability, particularly of second-grade (and below) salmon products has **increased in importance as the Salmon product range expands**;
- Tasmanian Salmon producers acknowledge that they do not have a high level of detailed insight into the status of individual products or consignments thereof once they are transferred to their logistics providers and travel along the supply chain. They **base their judgments on 'experience-based' knowledge** due to a lack of detailed supply chain data;
- A need to **predict remaining shelf life** especially for second-grade (and below) salmon products was identified as a strong value proposition for improved traceability and sensor technologies;
- The **ability to extend shelf life by using a microbial growth prediction** embedded in the a traceability/tracking tool has the potential to prepare the cool chain to be able to respond to a number of emerging issues from regulators and retailers including reducing food miles, extending shelf life and protection against legal liabilities;

Section two of this report reviewed established and commercially available traceability and sensor technologies including standards; and considered those with most potential for deployment in Phases 2 and 3. It promotes a primary focus on **the establishment of an integrated traceability system, using RFID as the primary means of identifying the product**. Critically, product level identification is required to optimise the application of predictive models. The traceability system provides the means by which a number of goals can be achieved including:

- An integrated cool chain data management approach based on **traceability to support safety, quality, compliance, branding and future proofing**;
- Sensors being able to identify when temperature deviations occur based on low cost robust and re-usable RFID tags;
- Predictor technologies deployed at product level to provide **a strong evidence base incorporating an effective decision rule sets for safety and quality**.
- Improved Logistics through **modelling, measurement and interaction assessments and performance testing** and evaluation of new systems;
- Environmental sustainability improvements through **evaluation of materials used, energy and storage efficiency, noise, gas or other discharges**;
- Enhanced and customised **uses of refrigeration and/or preservation methods** and optimisation of the whole Salmon cool chain;
- Brand and product authentication/verification and consumer marketing

From a standards perspective the report highlights:

- There are many sources of food safety and quality standards. Many of these Standards and **specifications display overlap with each other and almost all have a HACCP-like underpinning**;
- **Buyer's (e.g. supermarkets) are, increasingly, articulating their own specifications**, which are tending to be more stringent than government requirements;
- In Australia, local codes and standards such as those developed by **AQIS and MSQA follow the Codex standards and SQF**;
- Few standards/criteria specifically address cool chain temperatures, or acceptable temperature ranges for specific product types. For supply chains, the new ISO 22000 standard considers the requirements for safe transportation of food and there is a clear trend towards **requirements for traceability of products.**
- Australian national standards are frameworks to achieve outcomes, rather than stipulate requirements. This enables organisations with flexibility in how they achieve these outcomes;

Section 2 of the report also considered the implications of these technologies and standards in relation to drivers for the implementation of traceability systems within individual firms and across the whole of Seafood Cool Chains. It also considered a range of other emerging issues (including changing end customer demands, 'greening' of supply chains) that provide strong value propositions for the conduct of Phases 2 & 3 of CoolFish. In particular these sub-sections of the report highlighted:

- **Factors strengthening the business case for an integrated traceability system in Salmon cool chains** include: changes in the regulatory landscape; lower technology implementation costs; improvements in technology standards and interoperability; emerging industry legislative requirements (both industry specific (marine, food handling etc) and others such as greenhouse emission trading schemes (ETS); changing consumer demands/behaviours; and, the need for future business stability and growth;
- An important element in the development of a 'whole of supply chain approach' is the requirement for **a high level of industry cooperation involving sharing of business intelligence** (not commercial in confidence information but rather a focus on the systems and processes, both physical and digital, that support and enhance the supply chain management requirements);
- **Australia's major supermarkets will shortly be instituting requirements for traceability to support marketing (e.g. green, sustainable, animal welfare) as well as zero food safety risk** (as defined by these supermarkets). This combination of demands is likely to be a bigger and more immediate driver than government regulations;
- Building supply chain management approaches that **are flexible, responsive and have scalability emerges as the 'best practice' approach** for responding to changing

retailer/consumer demands. A customer driven ‘traceability empowered supply chain model is one approach for conceptualising these requirements.

Project Extension

Information gathered from CRC participant supply chains using product sensor technologies and the information compiled through a traceability system combined with enhanced knowledge of (microbial) spoilage process of MAP and VP raw salmon products, can be used to gather data to build predictive spoilage models.

Phases 2 and 3 will establish temperature and spoilage characteristics of the Tasmanian Salmon cool chain and ultimately expand to establish the specific spoilage organisms for seafood in the various regions of Australia for the main products in tropical, sub-tropical, temperate and cool regions.

Phases 2 & 3 will directly contribute outputs including:

- Attributes of Salmon products associated with shelf-life quality and knowledge of specific mechanisms or specific organisms associated with loss of quality/spoilage;
- Validated traceability and sensor technologies integrated in the Tasmanian Salmon Cool Chain;
- Logistics of Tasmanian Salmon Cool Chains supported through improved inventory and asset management tools;
- Enhanced responsiveness to changing customer-consumer demands through traceability marketing.

The results of the project will be disseminated through articles published in refereed journals, in technical reports provided to companies and organisations involved in the project through industry workshops. Workshops will be conducted to disseminate project results, strategies for integrating traceability and sensor tools, and realisation of increased profit.

Leveraging Related Seafood CRC Outputs

A number of related projects and reports have been identified as having on-going value for the CoolFish project Phases 2 & 3. These include:

Methodologies for the Implementation of Micro-Mobile Information Systems in The Cold Chain and the Resulting Implications of Time Temperature Logging for Models of Microbial Growth (Mr Steven Cambridge) is focusing on "Methodologies for the implementation of micro-mobile information systems in the cold chain and the resulting implications of time-temperature logging for models of microbial growth"

Intervention Strategies to Maintain the Safety and Quality in a Range of Value-Added Products Made with Under-Utilised SESSF Species (Sydney Fish Market): has produced information about spoilage profiles and spoilage organisms of processed fish products.

A Critical Evaluation of Supply-Chain Temperature Profiles to Optimise Food Safety and Quality of Australian Oysters (SARDI): has produced information about the time and temperature profiles of supply chains in Tasmania, South Australia and New South Wales.

Protecting the Safety and Quality of Australian Oysters using Predictive Models Integrated with “Intelligent" Cold Chain Technologies (Judith Fernandez) is focusing on predictive models for oyster safety and spoilage. The third Phase of the project will involve integrating predictive models with traceability and freshness sensors.

Seafood Molecular Biologist: Mapping Microbial Communities in Seafood Production and Processing Environments to Improve Targeting Intervention Strategies. One of the objectives of this project is to define the species specific organisms that impact the quality of processed fresh fish, define processing conditions and intervention strategies that influence their presence, and identify microbial species that can competitively exclude spoilage organisms. This information will assist in

customizing commercially available sensor technologies (freshness indicators) to the seafood cool chain (including Salmon)

Review of Traceability and Product Sensor Technologies relevant to the Seafood Industry (November 2007) Seafood CRC, prepared by Food Innovation Partners (FIP) and Allan Bremner & Associates.

Predictive and Rapid Diagnostic Technologies for the Seafood Industry: A Literature Review (Dods, K., Bremner, A., 2007) Seafood CRC report
Aquaculture in Australia: A0240 (2008) IBISWorld Industry Report, ABIX/LexisNexis Australia

Review of Technical Market Access Issues Relevant to Australian Seafood Industry Members of the Australian Seafood CRC, (Padula, D.J., Pointon, A.R. October, 2007), Food Innovation & Safety, SARDI, South Australia.

Current International Trade Issues Affecting the Australian Seafood Industry, June, Institute for International Trade (Stoler, A., Donaldson, V., 2008) University of Adelaide, on behalf Seafood CRC.

Retail Transformation Project: Pre-Prospectus, (FRDC March, 2009) for Seafood CRC.

Next Steps: Action Required

This report forms the basis for a decision on whether or not to proceed into Phase 2 & 3 of CoolFish

It is anticipated that a meeting will be held before Christmas 2009 by the Seafood CRC with all industry participants to make decisions on next steps.

A provisional date for this meeting in Hobart – is **Monday 30 November, 2009.**

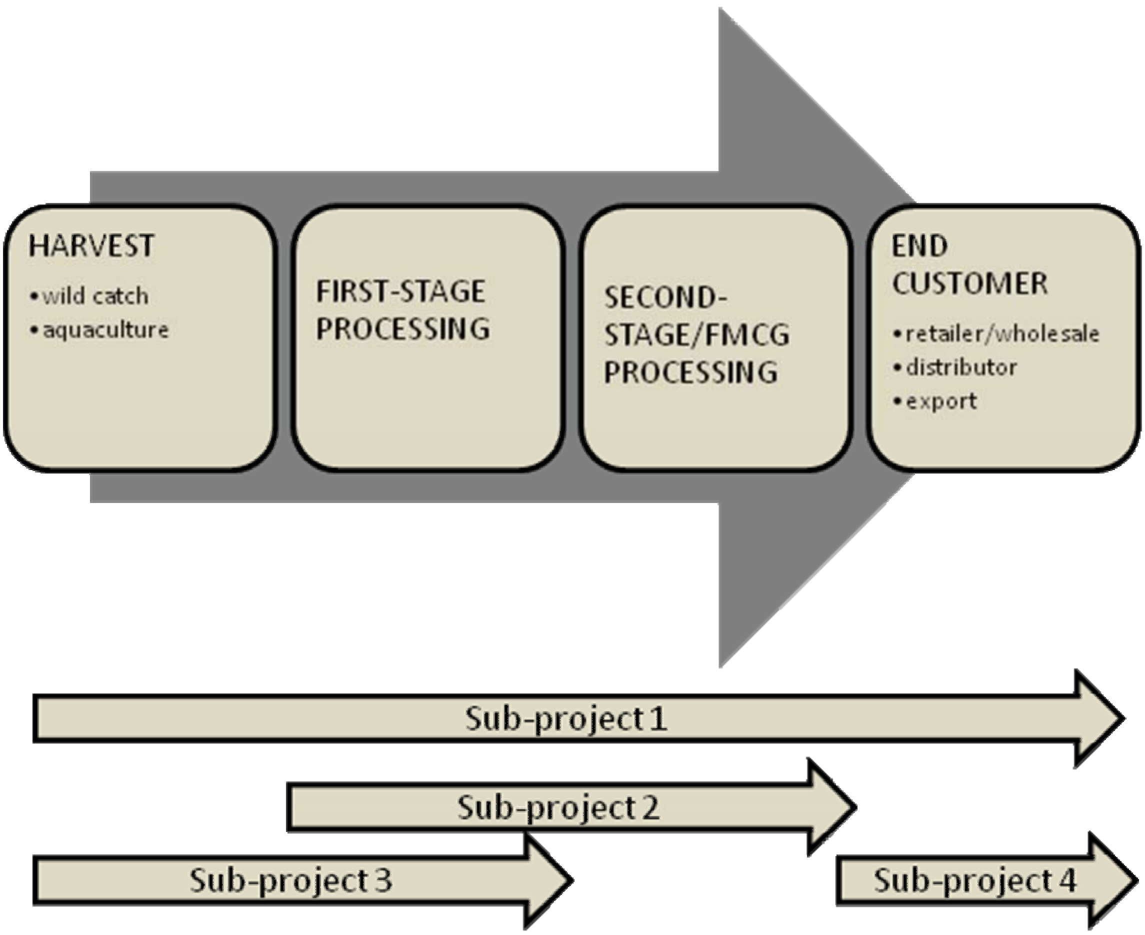
The Seafood CRC will be in contact with all industry partners following the release of this report.

Appendix A: CoolFish Phases 2 & 3

COOLFISH PROJECT – PHASES 2 AND 3

PHASE 2.
DEMONSTRATION SUB-PROJECTS THAT INTEGRATE TRACEABILITY SYSTEMS AND SENSOR TECHNOLOGIES TO ADDRESS CURRENT IMPEDIMENTS AND COOL CHAIN BUSINESS OPPORTUNITIES

Four sub-projects are proposed that utilise traceability and/or product sensor technologies to address a current business impediment or a cool chain business opportunity. The sub-projects address all sections of the cool chain and are integrated in that predictive technology tools that may be useful to solve the business impediment in Sub-project 1, could also be applicable in Sub-project 2. Conversely, the data required to design the tool for Sub-project 2 can assist in the tool for Sub-project 4.



Each of the sub-projects out-lined below will need to be further scoped with their relevant industry partner/s that have indicated interest in the CoolFish Project. The output of each sub-project is a "tool" that can be trialled and a generic case-study produced that can then be used in other CRC participant supply chains.

Sub-Project 1 – "Microbial Growth Predictor Tool"

Seafood businesses currently experience rejection of pallets at the point of receipt (eg. retailers cold stores) based on temperatures of the trucks being above 6°C – when in fact, there is no loss of quality of the product. There is an opportunity to educate both the end-customer and the regulatory authorities that the product is still of suitable quality and the loss in temperature/time is not warranted for rejection status. The red meat industry has undergone a transformation in regulations and tools for monitoring product quality and developed the "Refrigeration Index" and other spoilage predictive microbiology models.

In this sub-project, spoilage data will be available (from participating industry partners) and from already funded CRC projects (eg. "Seafood Molecular Biologist Mapping Microbial Communities". A predictive tool will be developed using the seafood pathogens of most significance for the seafood cool chain to be studied.

Significant information that this project will develop include:

- One or more predictive microbiology models/tools
- How to use this tool and how it would integrate with current QA systems
- Education of regulatory authorities and end-customers
- Generation of "Defensive data" to support product quality and integrity.

Tassal, Huon Aquaculture and Simplot have expressed initial interest in this sub-project.

Sub-Project 2 – "Asset Tracking and Management Tool"

Due to how logistics/freight is co-ordinated in Australia, pallets of product are frequently sent to the wrong destination. When this happens, it is difficult to re-call and often the product is written-off as a claim to the insurance company. A tool that can track and trace as well as apply microbial spoilage/safety prediction, would allow companies to make a decision on whether the product can be retrieved, but also that its quality and integrity has still been maintained. If a technology traceability platform can be developed, then the destination and tracing of the product is transparent to all operators in that supply chain.

A proposed scenario/method for this sub-project is to test a pallet of product in real-time using the selected technologies identified in Phase 1, at EACH of the industry partners discrete company sites. For example, a pallet can be traced from the process area into a cool room, held for the required time at the required temperature. Temperature and pallet movement will be logged and procedure documented. This approach will assist in protecting IP and 'secret know-how' for individual companies, and can tailor sub-projects to industry partners specific needs eg. if pallet moves before it has had required holding time, an alarm can be designed to ring, or a 'proof of delivery" receipt can be logger etc.

Tassal and Huon Aquaculture have expressed initial interest in this sub-project. Simplot is also interested particularly where it is possible to combine the microbial growth predictor tool (Sub-project 1) with Simplot's relationship using the CoolTrax existing technology. Though Sub-project 1 will be conducted separately to Sub-project 2, both are strongly linked in that Sub-project 2 provides a practical approach/realisation of sub-project 1).

Sub-Project 3 – "Inventory Management and Control Tool"

There is currently a considerable gap between harvest and processing which causes unpredictability in what is coming in to be processed and impacts on customer order fulfilment. A tool that addresses fresh caught inventory management will allow greater control through to processing.

The gap between harvest and processing at both Huon and Tassal is seen by both companies as an area of some concern and the sensor technologies that are to be trialled in the subprojects 1, 2 and 4 could also be adapted to this section of the cool chain. Whilst aquaculture harvest to processing is done 'in House' in a relatively controlled environment, wild catch harvest to processing is an unknown quantity where the time and temperature of the product is a critical factor to the quality and ultimate shelf life of the product. Due to this unknown, Simplot follows the recommendations of the UK food authority. They recommend limiting the shelf life of MAP fish products to 10 days to exclude the risk of

Clostridium Botulinum growth (particularly the toxin production). Simplot is conducting quality tests with the incoming raw material and rejects shipments which are not in specs. Needless to say, increasing information visibility could lead to significant financial gains and an increase in the quality (both perceived and real) of the product.

Tassal and Huon Aquaculture have expressed initial interest in this sub-project. Simplot would like to be a passive observer in its progress as they are a user and further processor of salmon products.

Sub-Project 4 – "Traceability as a Marketing Tool"

Traceability systems may be an opportunity, for the seafood sector, by providing access to information that can be used as a marketing tool. For example, provide product information that identifies:

- When seafood was caught/harvested
- Temperature profiles
- Regional information,
- Locally grown campaigns
- Verification of country of origin (for exports)
- Contaminants (eg. heavy metals)

The issues that this sub-project will need to address include:

- Robustness of the traceability system
- Brand differentiation – eg. Do customers purchase on regional appeal (ie. Tasmanian grown Salmon)?
- How would the information be stored (ie. publicly available, used only for marketing campaigns, only available to supply chain partners etc.)
- Should this information be collected for the sole purpose of 'defensibility data" and/or in the event that international legislation/standards impact on Australian product?
- How to ensure continuity of tracking and tracing from harvest through processing? e.g. a processor is likely to separate a carton of fillets for individual sale.

Tassal and Huon Aquaculture have expressed interest in this sub-project, though feel that this is likely lower on their priority list compared to Sub-project 1, 2 and 3.

PHASE 3.
EVALUATION OF PROJECT FRAMEWORK

- Identify project framework gaps and future work required
- Assess suitability of technologies to implement into additional seafood CRC participant supply chains.
- Promote good traceability practices in the industry to raise consciousness and to identify incentives for industry to change.