Traceability Systems for Wild Caught Lobster, Via Sense-T and Pathways to Market

Phase Two: Development and Implementation

FINAL REPORT 17/12/19

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Abbreviations

ARLEA	Australian Southern Rock Lobster Exporters Association
CTE	Critical Tracking Event
FRDC	Fisheries Research and Development Corporation
GLN	Global Location Number
GTIN	Global Trade Item Number
KDE	Key Data Element
SRLA	Southern Rock Lobster Association
TRLFA	Tasmanian Rock Lobster Fisherman’s Association
SARLAC	South Australian Rock Lobster Advisory Council
VRLA	Victorian Rock Lobster Association

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Executive Summary

This document is the final report of the project (FRDC2016/177) 'Traceability Systems for Wild Caught Lobsters'. It has been prepared by researchers from University of Tasmania.

Background

The project 'Traceability Systems for Wild Caught Lobster, via Sense-T and Pathways to Market' aims to contribute to improving traceability and product provenance within the wild caught Southern Rock Lobster supply chain. The project was divided into two phases:

- **Phase One:** a multidisciplinary scoping phase previously completed (FRDC 2016/288) and,
- **Phase Two:** a system design and trial evaluation phase that is the focus of this final report (FRDC2016/177)

The overall project arises from changes to international and national settings relevant to the SRL industry. In particular, the China Free Trade Agreement (ChAFTA) is a key driver, as changes in the Chinese market will continue to impact on the way lobster are traded to China into the future. In designing the overall project, the research team considered earlier FRDC/ASCRC (Australian Seafood Cooperative Research Centre) project reports and these included: 2012/704, 2012/705, 2012/741, 2010/716, CRC Supply Chain Technology Report. Other project reports the team were aware of prior to conducting this research proposal included: 2012/702, 2011/748, 2012/703, 2008/790, 2007/700, 2007/708.

Aims & Objectives

The Phase Two project was specifically focused on the following aims and objectives:

- Determining how to increase the breadth, depth and precision of existing SRL traceability practises along the supply chain;
- Designing a low cost, low impact traceability framework for use across the SRL supply chain to accommodate different business capabilities;
- Supporting the use of traceability systems and technologies by developing an implementation guide to support "better practises" in industry utilisation of technologies, tools and techniques to enhance traceability along SRL supply chains.

Methodology

Using the extensible traceability framework developed in Phase One, the research approach used in Phase Two was designed to accommodate differential levels of existing traceability amongst businesses of different sizes along the rock lobster supply chain. As a consequence, the investigation and enhancement of traceability was conducted at three different levels reflecting differential needs/capacity of industry participants to achieve levels of breadth, depth and precision in their traceability systems.

The three levels of traceability focused on were:

- Batch level;
- Batch level with individual tagging;
- Item level with individual tagging.

These different levels of traceability were then investigated and implemented using a variety of systems and technologies in the six work programs mapped onto the traceability framework and structured as follows:

- WP1 - Batch Level Traceability (boat/truck/processor)
- WP2 - Batch Level Traceability with Individual Tagging (processor)
- WP3 - Batch Level Traceability with Individual Tagging (boat)
- WP4 - Batch Level Traceability with Individual Tagging (processor/overseas processor)
- WP5 - Item Level traceability with individual tagging (boat/truck/processor)
- WP6 - Item Level traceability with individual tagging (processor/overseas processor)

The research team used a range of data collection and analysis techniques in this applied research work. Building on phase one, the team continued to work closely with industry to refine and tailor the approach to SRL traceability, to develop policies and procedures, data models and checklists to bench-mark performance. The team also developed a number of digital tools and deployed them in trial and evaluation work along the SRL supply chain to develop a series of case studies.

Results and Outputs

Based on the research conducted in these work packages the research team have generated results and outputs that directly address the aims and objectives of the project. Through engagement with the industry the team have developed a tailored approach to SRL traceability systems supported by policies and procedures, data models and a series of benchmarking checklists.

The research has also produced several digital tools and techniques that have been deployed as part of the trial and evaluation work conducted with industry. These trials and their evaluation are presented as a series of case studies presented throughout this section of the report. The case studies provide standards and practical advice on how to implement and achieve defined levels of traceability. This work is based on the globally recognised GSM1 standards and was customised for the SRL industry through survey and engagement with the industry across South Australia, Tasmania and Victoria.

The combined insights from this research work have also been integrated into two standalone guides for on-going use by the SRL industry:

(i) The traceability implementation guide aims to directly support industry to improve their traceability practises:

(ii) The traceability systems and technology products guide provides insights into suitable tools to support traceability at different levels and at different points along the supply chain.

The results and outputs section is structured as follows:

Survey and Engagement with the SRL Industry;

Building on Phase 1 work the research team actively engaged with industry partners in South Australia, Victoria and Tasmania to understand the challenges and opportunities in enhancing traceability systems within SRL supply chains. The results highlight the key features, benefits, constraints and contemporary traceability practises along SRL supply chains including insights from the China.

Case study: **Mobile Apps Digitising Processor Documentation.** presents the successful development and deployment of a mobile application suite supporting the digitisation of lobster processor consignment documentation.

The Approach for SRL Traceability Systems

Based on quality management principles including continuous improvement the research team worked with the industry to build an approach for SRL traceability systems that is (i) Flexible and responsive in the face of changing regulatory, systems, technologies and product requirements. This approach aimed to be compatible with the range of different pre-existing levels of traceability practises in SRL supply chains to enable businesses with a pathway of steps to improve their traceability practises either incrementally or through major initiatives; (ii) Able to support traceability of products at varying levels of sophistication from batch level (consignment and carton level) through to item level (individual and unique product), with associated price points; (iii) Able to take advantage of resources already present in individual SRL businesses along the supply chain and to provide an upgrade pathway that is cost effective, contributes to achieving minimum levels of standards and compliance, and future proofs investments. A key part of this approach involves recognition of the need to support all stakeholders to engage in incremental improvement using a 'Plan – Do – Check – Act' cycle for traceability. This section also describes the processes of implementing the six work-packages investigating traceability using the tailored approach for SRL traceability systems developed by the project.

Case study: **Barcode and Labelling Database** presents the successful use and deployment of GS1-128 barcodes and labels to identify SRL products and equipment within the SRL sub-supply chains to support low-cost effective traceability.

Case study: **Traceability Levels of Precision: item or Batch** presents insights into opportunity costs related to achieving differential levels of traceability precision.

Improving Traceability Practises: Policy and Procedures

A key part of the process of implementing the approach for SRL traceability systems involved the development of traceability specifications and exemplar templates for improving traceability policies and procedures that map to key roles and responsibilities and minimum Key Data Elements (KDEs) for each supply chain entity. This section presents policy and procedural templates for individual businesses to use as part of their governance structures for traceability as these businesses interact with their supply chain partners. The procedures outlined have been developed to offer operating guidance in the form of a simple checklist containing criteria synthesized from the approach for SRL traceability systems.

Case study: **Dashboarding of Collected Traceability Data** presents prototype example of a management electronic dashboard supporting rapid collection, analysis and filtering of data on SRL moving through a processor facility

Case study: **Using Temperature and Humidity Data Loggers** presents successful testing of time, temperature and humidity data loggers for tracking environmental conditions during lobster movement along the SRL supply chain.

Improving Traceability Practises: Using the KDE and CTE Data Models

Another key dimension of implementing the approach to SRL traceability systems presented in this report involves businesses understanding the minimum data requirements to support traceability. Building on analyses of existing key data elements (KDEs) available to support traceability, this section presents an initial set of KDEs within identified SRL Critical Tracking Events (CTEs) along lobster supply chains. The data models presented are intended to be further updated subject to new technologies being deployed or entering the market. The aim is to establish a minimum standard for what data format is necessary to undertake analysis of product traceability regardless of the technology used to collect and/or record this data. Underpinning this work are principles of traceability better practice adopted directly from GS1 the international not-for-profit organisation that develops and maintains standards for business communication <https://www.gs1au.org/>.

Case study: **Design and Implementation of Improved Labels** presents the successful design and implementation of avery identification labels containing KDE data including the product identifier (GTIN) shown as a GS1-128 barcode.

Case study: **Industry Use and Feedback of Improved Label Designs** presents the successful use and evaluation of different labelling solutions at Lobster processor to accommodate differences in traceability capabilities.

Benchmarking Traceability Performance: Evaluation Checklists

This section aims to support stakeholders to evaluate the current breadth, depth and precision of their existing traceability practises. It describes the approach developed and implemented to support industry to benchmark its traceability performance. This auditing process is achieved through evaluation checklists to provide stakeholders at any point along the supply chain with the ability to assess their current capacity to capture, record and report the minimum data requirements for traceability as defined in the KDE and CTE data models. This benchmarking provides an ability to make evidence based, informed decisions about the current state of the traceability of lobsters within that stakeholder's custody and within the immediate up-stream and down-stream dimensions of their operations.

Case study: **Sensing Lobster Tank Water Quality** presents comparison between low-cost and high-cost sensors and highlights that the low-cost solutions could be reliably calibrated for wide-spread use in SRL supply chains.

Case study: **Deploying GPS Pot Tags** presents successful testing of GPS pot tags to validate ease of data collection, analysis and storage of relevant catch-data that can easily become part of traceability improvement initiatives.

Supporting Traceability: Developed Digital Tools & Techniques

This section briefly describes the digital systems and tools developed as part of the project. Many of these tools and techniques are illustrated in the case studies presented throughout this final report. This section also provides a guide to the digital archive that has been prepared to facilitate handover of these tools to the FRDC and SRL to support future work.

Traceability Implementation: A Guide for the Southern Rock Lobster Industry

Presented as a standalone document. The guide provides practical advice on how to identify, assess and improve traceability practises by every industry stakeholder. The guide builds on an iterative 'plan-do-check act' continuous improvement approach that supports all stakeholders to engage in incremental traceability improvement whatever their baseline starting point. The guide also explains in detail how to enhance different levels of traceability whether batch level; batch level with individual tagging; or, item level with individual tagging

Traceability Systems and Technology Products Guide

Presented as a standalone document. This guide is an accompaniment to the traceability implementation guide. This updated guide provides insight into existing and new systems and technologies to support traceability at different levels and at different points along the supply chain.

Conclusions

This project has raised awareness of the importance of traceability within and along the southern rock lobster supply chain. The research team have engaged with the industry on their current practices and identified and demonstrated through trial and evaluation a range of mechanisms, tools and techniques to enhance SRL traceability systems. The research project has directly contributed to enhancing SRL traceability practises. The production of a 'Traceability Implementation' guide provides the SRL industry with a genuine opportunity to take a step forward to 'better traceability practises' and it opens up the possibility for the industry to consider the development of an industry traceability platform for coordination and integration of an industry-wide traceability system built on GS1 standards.

Recommendations

Based on the results and outputs from this project it is evident that there are still several challenges to the implementation of standard industry-wide traceability practises. However, this project has raised awareness and demonstrated a way forward to achieving this goal. To that end, the following recommendations can be made:

- Continued consultation and engagement with industry stakeholders to strengthen the desire and willingness to progress traceability improvements across the industry. The benefits of traceability and the value it adds to the fishery are well recognised, indicating that further research into the development and implementation of specific, actionable traceability system elements will likely be well received.
- The occurrence of harmful algal blooms such as *Alexandrium tamarense*, which cause the build-up of paralytic shellfish toxin, will force the industry to adopt some system of traceability or face closures and brand damage. As blooms have been limited to Tasmania thus far, this segment of the SRL industry is at particular risk. The implementation of at least batch level traceability with evidence of where lobsters were caught will help to mitigate this risk.
- Further research into the development of tagging approaches and alternatives should be a priority. Tagging lobsters with unique identifiers is a critical element of any highly precise traceability system. Unfortunately, it is also labour intensive and time consuming and represents a barrier to acceptance and uptake by the industry. The development of a new tagging approaches or even ‘tagless techniques’ hold promise and should continue to be investigated.
- Brand differentiation between rock lobsters is a potential area of growth for the SRL industry. Although the SRL industry considers itself to be producing a premium product, the reality is that there is currently no differentiation between SRL and other rock lobsters at markets and wholesalers in China. Further development of the SRL brand and provenance can take advantage of this and position SRL as a prestige product.
- Industry members expressed enthusiasm for the development of water quality monitoring devices that can be incorporated into traceability systems. The understanding and management of water quality is variable across the industry, so tools that assist the measurement and recording of water quality will help to improve holding practises as well as provide evidence of good care of stock along the supply chain.

Project Extension

Building on these recommendations is the idea of developing a traceability software platform which could integrate batch and item level technologies along the supply chain and underpin SRL quality and safety auditing programmes. The key elements of this platform have been trialled as part of this existing project so there is a genuine opportunity to significantly extend this platform to all industry participants and to facilitate moving the whole industry forward in its adoption of traceability better practises.

Another important area for consideration for project extension results from on-going doctoral research that has been aligned to this research project. This PhD research is continuing to explore new technologies using digital image processing to develop approaches for ‘tagless’ hybrid traceability solutions integrating automatic grading with biometric identification through use of computer vision and AI for use along the rock lobster supply chain including for providing provenance authentication information to end-consumers.

Keywords
Traceability, Information Technology, Provenance, Rock Lobster, Supply Chains

Introduction

The Australian Southern Rock Lobster (SRL) fishery is worth over $200 million and continues to be one of the most valuable seafood products in South Australia and Victoria and remains the second most valuable seafood product in Tasmania. In all three states, SRL accounted for nearly half of the value of all fisheries (Mobsby 2018). Importantly over 90% of the value of this production comes from export into China and this is nearly entirely in the form of live exports (Putten et al 2015; Mobsby 2018). Steadily increasing demand from Chinese consumers has delivered increased financial returns for industry participants and the communities they help support. However, the high concentration of sales into this single, although diverse, market also means that the industry faces risks which require it be ready to proactively respond to the changing demands of both Chinese consumers and regulators.

Improving and optimising product traceability in all the Southern Rock Lobster Fishery zones is a critical step in meeting these twin imperatives, particularly as the Chinese Australia Free Trade Agreement (ChAFTA) will alter the commercial and regulatory environment. Traceability can be understood as the ability to “track any food, feed, food-producing animal or substance that will be used for consumption, through all stages of production, processing and distribution” (European Commission 2002). This ability offers the potential to increase the value of Southern Rock Lobster and reduce risks in several key areas. These opportunities/risks include (i) Maintaining and building the market position of Southern Rock Lobster as a premium product (ii) Supporting ongoing access to markets through regulatory compliance including in the post ChAFTA environment (iii) Reducing the cost of market closures associated with the increasing incidence of harmful algal bloom events (iv) Providing greater security to the mortality claims process (v) Potentially contributing to reducing fisheries management and compliance costs over the medium term. For example, the implementation of a tagging/traceability system could support clear identification and differentiation of SRL from other rock lobster products imported from Australia (e.g. Western Rock Lobster) and/or other countries (e.g. New Zealand SRL, South African Rock Lobster).

In recognition of these risks and opportunities, addressing the traceability improvement challenge has been embedded as a key priority in SRL’s Strategy 2022 within Objective 1 (‘Add value along the supply chain from fisher to customers’) and was previously also acknowledged as important in SRL’s 2011-16 Strategic Plan. This objective acknowledges that traceability related requirements are increasingly being applied in traded foods and that these requirements are evolving rapidly and that enhancing traceability within SRL will also support compliance with the emerging Global Seafood Sustainability Initiative (GSSI). Importantly, however there are several characteristics of the SRL industry that require consideration in moving forward with any design and implementation of traceability systems in SRL supply chains. These characteristics include: (i) Relatively fragmented production systems with limited economies of scale or inter-firm cooperation, despite some more recent consolidation at the processor level; (ii) Continued State-based variation in fishing practises, material handling and regulatory compliance protocols, including regulator acceptance of digital records (iii) Challenges managing bio-toxin prevalence that varies both between and within States but poses risks across the whole industry

It is in this context that the project on traceability systems for wild caught lobster was funded. The project aimed to directly contribute to improving traceability and product provenance within the wild caught Southern Rock Lobster supply chain. The project was broken into two phases: a multidisciplinary scoping phase now completed (FRDC 2016/288) and a system design and trial evaluation phase that is the focus of this final report (FRDC2016/177)

The overall project has been conducted in the context of evolving changes to international and national settings relevant to the SRL industry. As mentioned above, the China Free Trade Agreement (ChAFTA) is a key driver, as changes in the Chinese market will continue to impact on the way lobster are traded to China into the future. In designing the overall project, the research team considered earlier FRDC/ASCRC (Australian Seafood Cooperative Research Centre) project reports and these include: 2012/704, 2012/705, 2012/741, 2010/716, Seafood CRC Supply Chain Technology Report. Other project reports the team examined as part of this final report include: 2012/702, 2011/748, 2012/703, 2008/790, 2007/700, 2007/708.

The Phase One report recognised the importance of strengthening the supply chain into China and recommended investigating the feasibility of the introduction of a tagging/traceability system to clearly identify and differentiate SRL in the Chinese market. More specifically, it was acknowledged that the need to find ways to improve traceability is intimately related to both supporting continued and enhanced market access, and also for the industry to be able to respond directly to the challenges and/or opportunities associated with: Algal blooms (HABs); Food safety recalls; Quality; Provenance; and, Branding. Phase one also identified additional considerations including improving the industry’s ability to:

- Comply rapidly with any changes to requirements of importing countries;
- Enhance Business2Business and Business2Consumer verification of food safety and quality, and sustainability credentials;
- Engage in continuous improvement to allow evaluation of harvest operations in terms of better practises for servicing consumers and guaranteeing product quality;
- Support the development of a consumer facing industry brand.

It was also recognised that enhancing traceability is challenging not just because of some of the characteristics of the SRL industry, but also because there are few examples of how to design and implement holistic traceability systems and technologies in lobster supply chains. During six months of consultation directly with the SRL industry and its regulators during phase one a strong level of interest and support for moving forward with research to improve traceability was identified. Building on a conceptual ‘extensible traceability framework’ developed during phase one as a roadmap for implementation of improved traceability in the SRL industry, the research team developed the phase 2 approach described in this final report.

The phase 2 project was designed around three key objectives described below and investigated and implemented using a variety of systems and technologies in six work-packages.

The three (3) levels of traceability focused on in the framework reflect different levels of depth, breadth and precision in the traceability systems investigated. The three levels are:

(i) Batch level;
(ii) Batch level with individual tagging;
(iii) Item level with individual tagging.

These different levels of traceability were then investigated and implemented using a variety of systems and technologies in the six work programs structured as follows:

- WP1 - Batch Level Traceability (boat/truck/processor)
- WP2 - Batch Level Traceability with Individual Tagging (processor)
- WP3 - Batch Level Traceability with Individual Tagging (boat)
- WP4 - Batch Level Traceability with Individual Tagging (processor/overseas processor)
- WP5 - Item Level traceability with individual tagging (boat/truck/processor)
- WP6 - Item Level traceability with individual tagging (processor/overseas processor)

The work packages aimed to leverage the range of business principles, workflows, and the trialling and demonstration of new and existing systems and technologies to support traceability along the SRL supply chain. The extensible traceability framework (Figure 1) acknowledges that SRL supply chains, systems and technologies, and business value are complex and dynamic. As such, the framework provides a canvas onto which these elements can be modelled, demonstrated and analysed in a whole-of-system manner to derive the practical views of the traceability models and improved practise.

Aims and Objectives

Through engagement with the industry the team have developed a tailored approach to SRL traceability systems supported by policies and procedures, data models and a series of benchmarking checklists. The research has also produced several digital artefacts that have been deployed as part of the trial and evaluation of traceability technologies conducted with industry. These trials and their evaluation are presented as a series of case studies presented throughout this section of the report. The case studies provide standards and practical advice on how to implement and achieve defined levels of traceability. This work is based on the globally recognised GSM1 standards and was customised for the SRL industry through survey and engagement with the industry across South Australia, Tasmania and Victoria.

Across the six work programs the three key project objectives were to:

1. **Determine how to increase the breadth, depth and precision of existing SRL traceability practises along the supply chain.**

   Across the SRL industry in Tasmania, Victoria and South Australia, a robust system of compliance and legislation for managing the integrity of the available fish stock exists. This presents a point from which the industry can leverage and expand the quality of existing traceability practises. Phase 2 research has:

- Developed an approach for SRL traceability systems that leverages the overarching extensible framework and provides a practical traceability implementation guide for the SRL industry to accommodate the different scope and scale of business needs and capabilities to meet minimum standards for traceability;
- Developed traceability specifications and exemplar templates for improving traceability policies and procedures that map to key roles and responsibilities and minimum Key Data Elements (KDEs) for each supply chain entity;
- Designed, developed and evaluated improved data fields across existing paper and electronic systems to improve traceability KDEs especially for critical tracking events (CTEs) along SRL supply chains building on GSM1 standard models.

2. **Design a low cost, low impact traceability framework for use across the SRL supply chain to accommodate different business capabilities**

   While Tasmania, Victoria and South Australia each maintain their own domestic systems for compliance and regulation, there is strong variation amongst how data is collected, stored, access and analysed. Moreover, there is strong variation between how individual operators, from the boat through to the export processor, choose to run their operations. The range of variety within the SRL industry allied with the complexity of poorly understood business operational practises in China, highlights that any enhanced traceability system will need to be flexible enough for the complexities of the industry. Phase 2 research has:

   - Collated and analysed the range of available data sets across government and industry and evaluated the available key data elements (KDEs) against minimum standards for traceability;
   - Prepare and present an initial set of KDEs within identified SRL Critical Tracking Events (CTEs) along lobster supply chains. The data models presented are intended to be further updated subject to new technologies being deployed or entering the market. The aim is to establish a minimum standard for what data format is necessary to undertake analysis of product traceability regardless of the technology used to collect and/or record this data;
   - Explored options for accessing and/or developing electronic interfaces to access the range of government compliance database data sets to provide optional data to be allied to proprietary data sets for traceability by the SRL industry.

3. **Support the use of traceability systems and technologies by developing an implementation guide to support "better practises" in industry utilisation of technologies, tools and techniques to enhance traceability along SRL supply chains.**

   A prescriptive approach towards adoption and utilisation of systems and technologies for traceability was identified as unhelpful and unlikely to be effective given the variety of practises, procedures and differential levels of technical capacity across the industry. This objective therefore involves research and development to explore a range of systems and technologies that can support traceability better practises at a number of levels of depth, breadth and precision in the industry. It also aims to acknowledge emerging changes in seafood traceability brought about (potentially) by groups such as WWF and MSC and broader initiatives such at the Global Sustainable Seafood initiative (GSSI). Phase 2 research has:

- Developed and implemented an approach to support industry to benchmark its traceability performance. This auditing is achieved through evaluation checklists that aim to support industry to evaluate the current breadth, depth and precision of their existing traceability practises. The evaluation checklists provide stakeholders at any point along the supply chain with the ability to assess their current capacity to capture, record and report the minimum data requirements for traceability as defined in the KDE and CTE data models. This benchmarking provides an ability to make evidence based, informed decisions about the current state of traceability of lobsters within that stakeholder's custody and within the immediate up-stream and down-stream dimensions of their operations.
- Engaged in trial and evaluation of traceability solutions for technical and logistical feasibility. In parallel with deploying commercially available technologies the research team also produced several digital artefacts and deployed them as part of the trial and evaluation activities. Combined these trials and their evaluation are presented as a series of case studies presented throughout the report. The case studies provide standards and practical advice on how to implement and achieve defined levels of traceability. This work is based on the globally recognised GSM1 standards and was customised for the SRL industry through survey and engagement with the industry across South Australia, Tasmania and Victoria.
- Produced an updated standalone 'Traceability Systems and technology products guide' that provides insight into suitable tools to support traceability at different levels and at different points along the supply chain.
- Produced a standalone 'Traceability Implementation Guide for the SRL industry'. The guide provides practical advice for boats, processors and export distributors in China on how to meet minimum standards and to identify, assess and improve traceability. The guide builds on an iterative 'plan-do-check act' continuous improvement approach that supports all stakeholders to engage in incremental traceability improvement whatever their baseline starting point. The guide also explains in detail how to enhance different levels of traceability whether batch level; batch level with individual tagging; or, item level with individual tagging

Specifically, these work packages have validated the traceability framework and traceability approach developed for SRL through industry engagements across numerous case studies presented in this final report. The case studies have cumulative outcomes demonstrating to industry the value propositions and technical underpinnings of an industry-wide approach to whole-of-supply-chain traceability systems improvements for wild caught lobsters. The traceability framework captures the interrelationship between the supply chain and suitable systems and technologies to improve the quality (depth, breadth and precision) for business. To accommodate differences in pre-existing traceability practises and technical capacities the approach used a phased approach to the research and development.

Methodology

The Extensible Traceability Framework

The methodology used in phase two builds on a conceptual 'extensible traceability framework' developed during phase one as a roadmap for implementation of improved traceability in the SRL industry. It allows for the accommodation of diverse business value propositions and recognises that there are multiple technological and process improvements that may be used by industry to improve traceability whether these are relatively low-cost standalone improvements or integrated and interoperable systems level investments.

The methods used in phase two are also based on a thorough understanding of the current nature and level of traceability within the SRL industry developed from detailed consultation with industry stakeholders in this project. As a result, the research aims to avoid prescriptive approaches to traceability for the entire Southern Rock Lobster (SRL) industry. Significantly the approach acknowledges that a single unified traceability approach is unrealistic at this stage given the high degree of diversity in SRL regulatory and commercial environments. The conceptual model therefore promotes flexibility, collaboration and evolution rather than a 'one-size-fits all' approach. This has led to the development of a tailored approach for SRL traceability systems that incorporates three levels of traceability for moving forwards: Batch level; Batch level with individual tagging; and, item level with individual tagging.

Within the approach developed based on the conceptual framework it is possible to investigate traceability practises on three axes: supply chain, systems and technologies, and business value.

(i) The supply chain axis enables the various entities, workflows, processes, procedures and business rules to be captured;

(ii) The systems and technologies axis enables product configurations to be captured and 'best practises' based on research and/or available commercial technologies, tools and techniques to be mapped to these configurations in each business;

(iii) The value axis enables consideration of the value creation implications of the different models of traceability for different participants. This axis highlights potential optimal paths for traceability system adoption that are sensitive to context.

As illustrated in figure 1 the extensible traceability framework supports exploration of options for traceability through different intersections of the axes covering: how it is achieved, the different components and entities that are engaged and impacted, and where the business value is likely to emerge under adopted configuration.

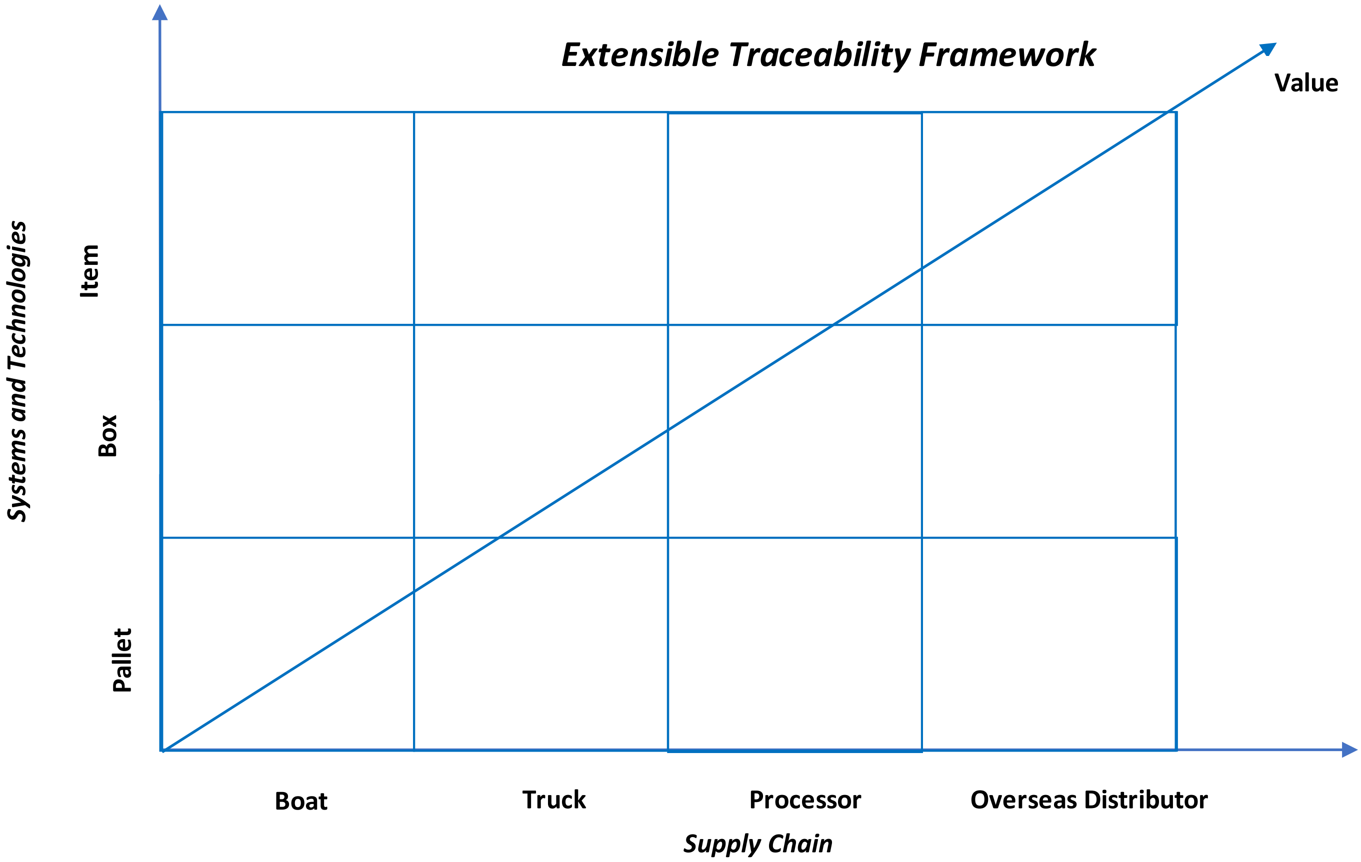


Figure 1 Extensible Traceability Framework (Phase 1)

As the individual capabilities and traceability gaps amongst a range of SRL stakeholders were identified, a business process management approach was employed to formulate appropriate systems for implementing traceability to be trialled with stakeholders across the supply chain. The business process management approach works by introducing improvement objectives which, in the case of traceability, relate to reducing costs, improving track and trace, alignment of information and material flows to enhance provenance and product authentication, improve execution and wait times and reduce product mortality caused by errors and environmental factors. The approach of business process management as illustrated in figure 2 requires identification of the processes within an organisations core operation that can be leveraged to

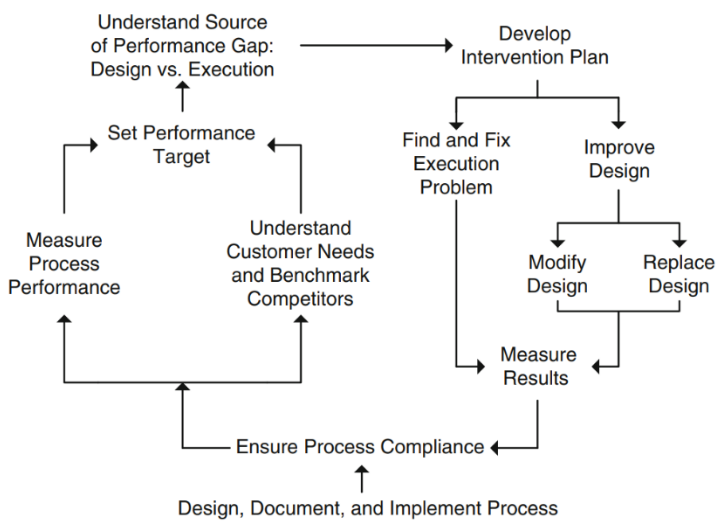


Figure 2 Process Management Cycle (Von Brocke & Rosemann, 2010)

identify and improve elements where challenges and/or opportunities exist (Vom Brocke & Rosemann 2010). The process management cycle is a cycle of continuous improvement in which interventions are planned, designed, documented, implemented, and evaluated.

Business process management requires an understanding of the 'as-is' current processes, strategy, and goals at each level of an organisation or supply chain, with input from stakeholders of all levels. Formal and informal processes are identified and documented in consultation with stakeholders and experts. These processes are measured for success to a defined performance target, and where a target is not met, or there is a gap, the source process, or task within a process, is identified for change. An intervention, or change plan is then developed, identifying whether the process requires process reengineering, replacement, or creation, or if a task simply needs tweaking to fix an execution problem. During this process, measurable benefits and performance targets are identified and set. The process is then designed, documented, and implemented with all required training and support. Auditing is also carried out to ensure process compliance where necessary. The cycle then iterates, measuring performance, identifying gaps, and intervening in a cycle of continuous improvement.

Through the field trials conducted in this project, this approach was used at both a supply chain and an organisational level, to address specific common characteristics in the SRL supply chain. The supply chain characteristics addressed included:

(i) The relatively fragmented production systems with limited economies of scale or inter-firm cooperation, despite some more recent consolidation at the processor level;

(ii) Continued State-based variation in fishing practises, material handling and regulatory compliance protocols, including regulator acceptance of digital records;

(iii) Challenges managing bio-toxin prevalence that varies both between and within States but clearly poses risks across the whole industry.

Individual organisational characteristics were also identified along the Critical Tracking Elements (details below) of the SRL supply chain, and these characteristics were addressed on a case-by-case basis. This aimed to take into account the traceability level of the organisation, capabilities and resourcing available, and the individual processes which were implemented on each site.

As a function of the iterative, continuous improvement approach employed by this project for developing an optimal traceability approach for the SRL industry, it was necessary to employ business process reengineering, in which processes, either identified within a business process management approach, or independently, are re-planned and designed with the goal of taking advantage of an opportunity or fixing an existing problem. Business processes were identified for reengineering on the basis of balancing the improvement to traceability while minimising the impact and impost on the business.

Six Work-Packages addressing Three Levels of Traceability

In phase two organisations traceability current approaches were defined at three different levels reflecting differential needs/capacity of industry participants to achieve levels of breadth, depth and precision in their traceability systems. The three levels of traceability focused on were:

- Batch level;
- Batch level with individual tagging;
- Item level with individual tagging.

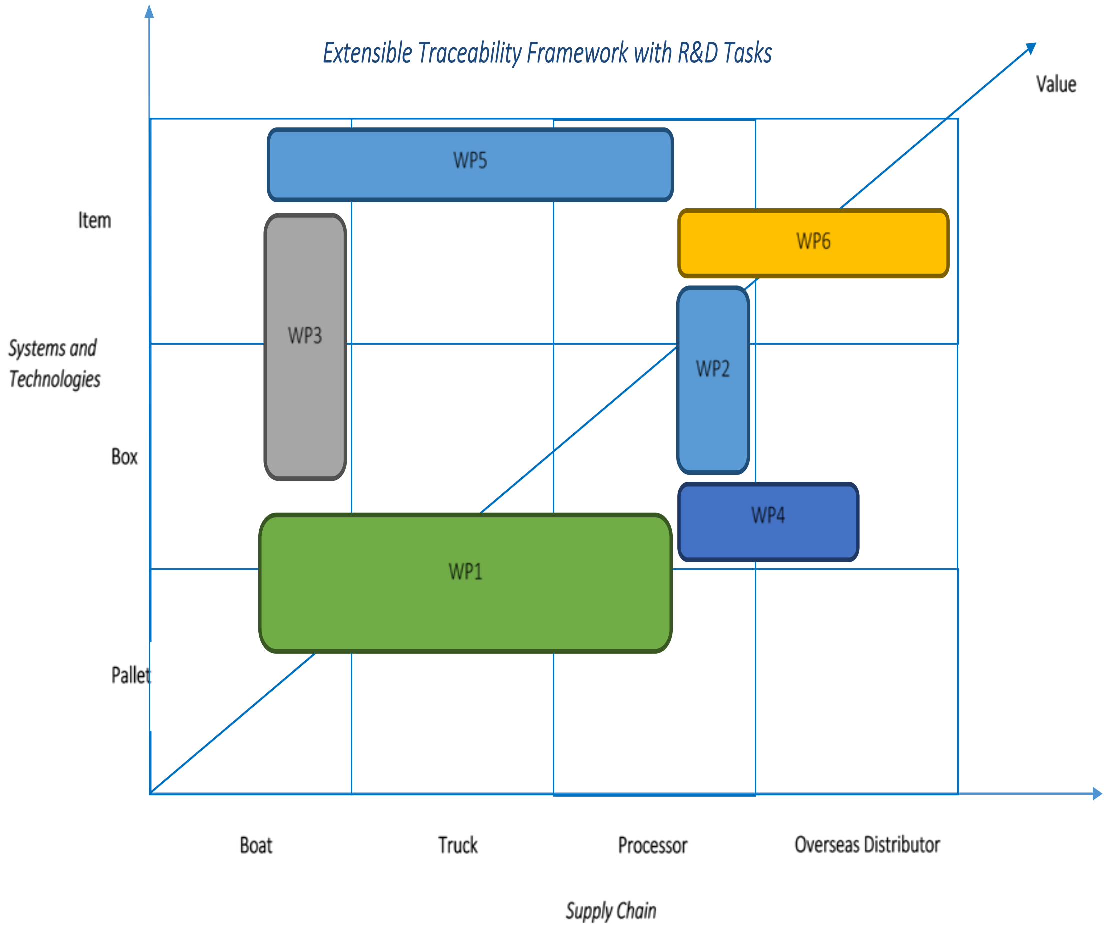


Figure 3 Phase Two: Work packages Mapped on the Extensible Traceability Framework

These different levels of traceability were linked to six developed work program structures as follows:

- WP1 - Batch Level Traceability (boat/truck/processor)
- WP2 - Batch Level Traceability with Individual Tagging (processor)
- WP3 - Batch Level Traceability with Individual Tagging (boat)
- WP4 - Batch Level Traceability with Individual Tagging (processor/overseas processor)

- WP5 - Item Level traceability with individual tagging (boat/truck/processor)
- WP6 - Item Level traceability with individual tagging (processor/overseas processor)

For each level of traceability investigated during the field-based trials in the project several key steps/considerations were identified across the six work-packages as being commonly beneficial and important. The work-packages can be mapped onto the conceptual extensible traceability framework as illustrated in the figure above. These identified steps/considerations were a starting point for business process reengineering planning and were taken into the interviewing and workshopping that was undertaken with stakeholders at an organisational level discussed below.

The remainder of this section of the report provides a brief summary of the key approaches deployed by the research team to capture and analyse data and engage in trial and evaluation work to generate the projects key results and outputs.

Engagement with the SRL Industry

The research team extended the Phase 1 industry engagement activities and continued to actively communicate with SRL industry partners in South Australia, Victoria and Tasmania. The focus was to deepen understanding of the challenges and opportunities for enhancing traceability systems within SRL supply chains. This involved continued interviewing, workshops and surveys of organisational and supply chain practices impacting on traceability and potential mechanisms for its improvement. A key technique deployed to support these industry engagement and data collection activities was the use of Value chain analysis (VCA). This diagnostic technique was employed to both analyse and assist supply chains to function more effectively to optimise value and support resilience. The focus of VCA involves understanding and then optimising alignment between product material flows, information flows and organisational relationships (governance) dynamics in the SRL supply chain.

The research team consulted widely with stakeholders across the SRL industry to quantify current capability and resourcing, to capture views on the value propositions of traceability, the feasibility of different approaches and industry support to participate in small-scale traceability improvement trials to develop demonstration case studies. The insights generated from this engagement with the SRL industry informed the overall approach. This work enabled the research team to refine and tailor the approach to SRL traceability, to develop policies and procedures, data models and checklists to bench-mark performance.

The research team also engaged in fieldwork in China to understand key issues of relevance to enhancing the approach to SRL traceability systems.

As discussed below, the team also developed a number of digital tools and deployed them in trial and evaluation work along the SRL supply chain to develop a series of case studies

Importantly insights from engagement with the industry highlighted the need to for an approach to traceability improvement that was adaptable to the variety of processes, capabilities and capacities of different participants in the SRL supply chain, including fishermen, processors and freight forwarders.

Developing an Approach for SRL Traceability Systems

Building on analysis of the data captured through engagement with the SRL industry, the research team used quality management principles including continuous improvement to work with the industry to start developing a tailored approach for SRL traceability systems that would be compatible with the range of different pre-existing levels of traceability practises in SRL supply chains. The goal being to allow businesses with a pathway of steps to improve their traceability practises either incrementally or through major initiatives.

The approach being developed was also designed to support traceability of products at varying levels of sophistication from batch level (consignment and carton level) through to item level (individual and unique product), with associated price points and to be tested through different case studies aligned to the 6 work-packages outlined above.

Importantly, the developing approach aimed to leverage resources already present in individual SRL businesses along the supply chain and to provide businesses with an upgrade pathway that would be cost effective and contribute to achieving a minimum level of standards and compliance while future proofing on-going investments. A key part of this developing approach involves recognition of the need to support all stakeholders to engage in incremental improvement using a 'Plan – Do – Check – Act' cycle for traceability (presented in detail in the results and outputs section of this report below).

The developing approach to SRL traceability Systems also integrates the insights developed from data, tools and techniques generated through the methodological approaches described in the following sub-sections of the report:

- Developing appropriate policy and procedures;
- Developing appropriate KDE and CTE data models for traceability;
- Developing appropriate Traceability Performance Measures
- Developing Digital Tools and Techniques
- Developing Traceability Implementation: Guides for the SRL Industry

Developing Appropriate Policy and Procedures

An important dimension of the work to develop a tailored approach to SRL traceability systems involved the production of appropriate policy and procedures template documents that could be adapted and applied to individual business within the Southern Rock Lobster (SRL) supply chain to provide them with a governance structure that supports strategic and operational use of traceability systems both internal and external to the business.

To develop these relevant policy and procedures templates for implementing traceability the research team utilised two business development techniques: user-centred design and agile systems development.

While the policy and procedures templates produced are deliberately generic, they are grounded in field-work conducted with SRL stakeholders and informed by the case studies presented throughout this report. These case studies deployed a continuous improvement cycle quality management approach that involved successive iterations of tools and techniques used in the trial and evaluation work. This aimed to emulate how traceability implementation would likely occur in an SRL industry stakeholder's operation.

User-Centred Design

The user-centred design work involved a process focusing on usability throughout the entire development process and further throughout the system life cycle The key elements of user-centred design are as follows (Gulliksen et al. 2003):

- A focus on the user, where the goals of the activity, the domain/context of use, the goals of the user, and their tasks and needs guide the development
- Representative users, or stakeholders, should actively participate early and continuously throughout the development and system lifecycle
- System development is iterative and incremental
- Design representations are created in a way that is clearly understood by all users and stakeholders
- Evaluation of use is carried out in the context of which use would occur
- Prototypes are delivered early and continuously, being used to visualise and evaluate ideas and design solutions

Employment of user-centred design ensured that the approaches developed were appropriate for the specific organisation for which the system was being developed and that it matched the needs and capabilities of their operation.

Agile Systems Development

The second process employed in the development of the policy and procedures for the 'Approach to SRL Traceability Systems' was agile development. This is a set of development techniques that focus on iterative design, evolving solutions, and the consistent improvement of requirements identification, understanding and specification (Beck et al. 2001). Agile systems development delivers software and hardware solutions incrementally, focusing on providing usable sub-sets at regular intervals from which further learning and improvement can be captured in the next iterative design.

Agile systems development requires consistent feedback and analysis from stakeholders can is often intimately linked to user-centred design where design decisions, priorities and identified requirements are co-designed with users. Where technological development is required, rapid application development is used to create usable prototypes which evolve over time to meet all lower priority requirements, without significant wait time or down time (Beck et al. 2001). The agile development methodologies allowed for a user-centred design approach which enabled stakeholders and organisations to be able to shape and control the way that new processes and technologies impacted on their operating procedures, costings, and resources.

In keeping with user centred design within agile development methodologies a mixed methodologies approach was taken to the development of both process and technological implementations, to ensure that the approach was clear and appropriate on an organisational case by case basis. The work packages were explored, and an approach was mapped across with consideration for the three levels of traceability being focused on:

Work Package 1:

The key foci were to support batch level traceability across the boat-truck-processor segment of the supply chain, improved labels were applied to the crates used to transport lobsters from the boats to the processing factories. By assigning unique GS1 bar codes to the boats, crates and facilities, lobsters could be tracked along the supply chain through the use of digital applications developed by the research team to capture key data elements (KDEs) and to automate the mandatory policy and procedural reporting at each step in the chain to achieve batch level traceability.

Work Packages 2, 3 and 4:

The key foci were to support batch level traceability of individually tagged lobsters at processors, boats and at export. This method involved lobsters being individually tagged on the fishing boat with antenna tags that had unique GS1 bar codes. Individual lobsters were linked to the uniquely identified crates developed in WP1, providing batch level traceability from the boat to the truck and from the truck to the processor.

Work Packages 5 and 6:

The key foci were to support item level traceability with individual tagging across boat, truck and processor as well as a individually tagging into export overseas market processor facilities. This involved individual lobsters tagged on the boat and linked to pots with pot tags. Upon offloading from the boats, lobsters were scanned to link them to crates. Upon arrival at the processing facility, lobsters were scanned as they were placed into holding tanks and when they were packaged for export, providing individual traceability along the entire chain and into the export facilities.

Developing Appropriate KDE and CTE Data Models for the SRL Traceability

Another key dimension of implementing the approach to SRL traceability systems presented in this report involves businesses understanding the minimum data requirements to support traceability. Building on analyses of existing key data elements (KDEs) available to support traceability, an initial set of KDEs within identified SRL Critical Tracking Events (CTEs) along lobster supply chains were identified.

These data models are intended to be further updated as new technologies are deployed or enter the market. Underpinning this work are principles of traceability better practice adopted directly from GS1 the international not-for-profit organisation that develops and maintains standards for business communication <https://www.gs1au.org/>.

GS1 identify the collection of Key Data Elements (KDEs) and certain Critical Tracking Events (CTEs) as essential to any approach to traceability systems. Collecting these data at these events enables an operator to implement internal traceability and the transmission of these data along the supply chain enable supply chain, or end-to-end traceability. Analysis of the business processes of the SRL industry revealed that despite the differences between individual operators and differences in mandatory State reporting requirements and characteristics of the fishery in each state, there are a number of key business processes common throughout the industry were identified. These are illustrated in the figure below.

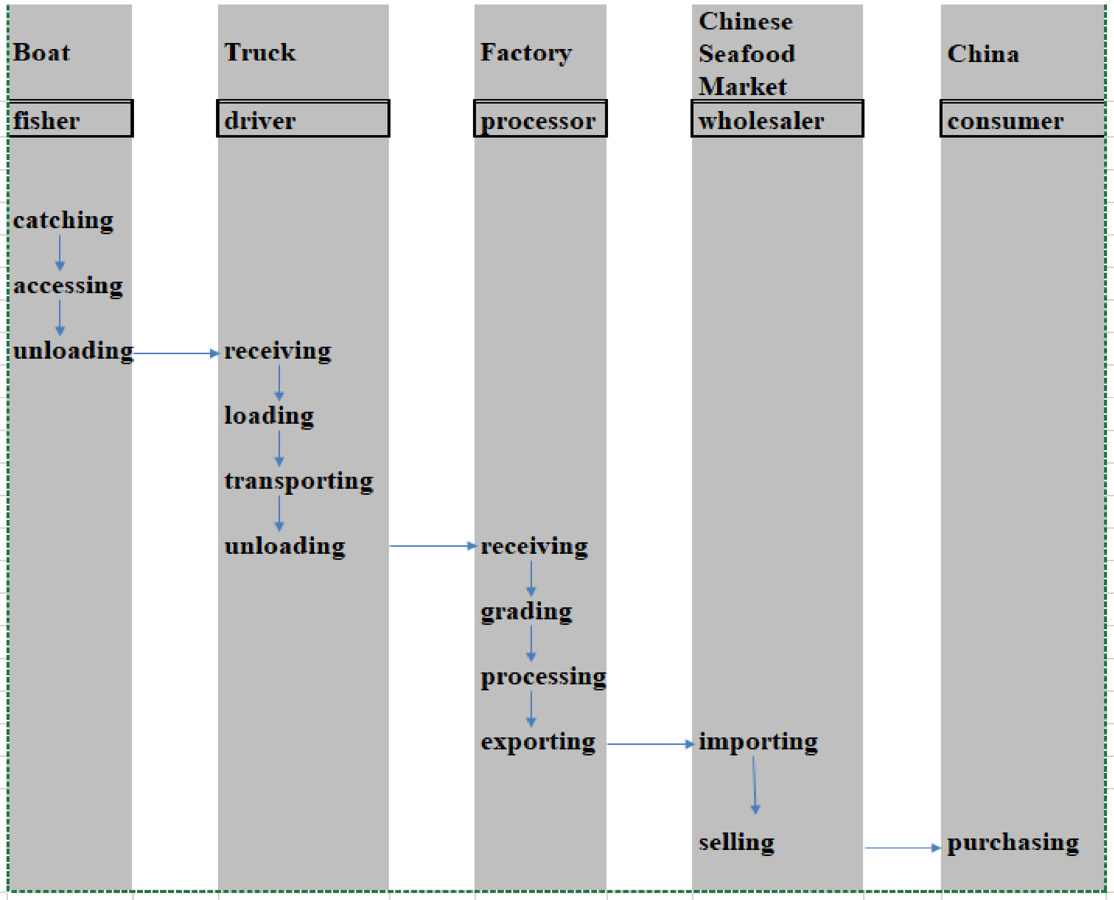


Figure 4 Key Business Processes of the SRL supply chain

These processes were identified through the survey of the industry and analysis of these processes formed the basis of the KDE and CTE data models presented in this final report. The methodological approach aimed to reveal the CTEs and KDEs common to SRL Industry stakeholders along the entirety of the supply chain along with a set of roles and responsibilities for operators within each segment of the supply chain. The GS1 standards were applied to these data to provide an understanding of how data should be collected and stored along the SRL supply chain.

Developing Appropriate Traceability Performance Measures

sAnother key aspect of the approach to SRL Traceability Systems involves industry being able to benchmark performance in relation to any traceability initiatives undertaken and also to assess their pre-existing levels of traceability practise.

The research team developed a series of evaluation checklists to quantify the depth, breadth and precision of existing industry practices to ensure that the data necessary for KDE and CTEs was captured and used appropriately. These checklists are based on the KDEs and CTEs identified within this project and incorporate the data that is currently being collected to meet Australian State-based regulations and/or business practise compliance requirements.

The checklists developed are now able to be used as a resource to support stakeholders to evaluate on an on-going basis the breadth, depth and precision of their traceability practises. This benchmarking approach aims to provide industry with an ability to make evidence based, informed decisions about the current state of the traceability of lobsters within any stakeholder's custody and within the immediate up-stream and down-stream dimensions of their operations.

Developing Digital Tools and Techniques

As part of the methodological approach used in this project, the research team actively developed a number of digital tools and techniques that were trialled and evaluated with industry partners in different parts of the SRL supply chain.

Many of these digital tools and techniques are illustrated in the case studies presented throughout this final report.

In the results and outputs section of this report an overview of these digital tools and techniques is presented as well as a guide to the digital archive that has been prepared to facilitate handover of these tools to the FRDC and SRL to support future work.

Developing Traceability Implementation: Guides for the SRL Industry

As part of the outputs of this project the research team have synthesized the key insights arising from the work into a practical traceability implementation guide for use by industry to enhance traceability. Based on the practises and processes identified in this project, a pair of stand-alone guides have been developed and included within the Results and Discussion section of this report.

The first guide is the *Traceability Implementation: A Guide for the Southern Rock Lobster Industry*, synthesises the outcomes of this report into a best-practises approach to provide stakeholders with advice on the implementation of the traceability approach described in this report into their operations. The guide builds on an iterative ‘plan-do-check act’ continuous improvement approach that supports all stakeholders to engage in incremental traceability improvement whatever their baseline starting point. The guide also explains in detail how to enhance different levels of traceability whether batch level; batch level with individual tagging; or, item level with individual tagging

The second guide, the *Traceability Systems and Technology Products Guide*, presents the technologies and systems used and reviewed over the course of this project to make stakeholders aware of what is currently available on the market. This guide presents a range of options that can be employed to collect KDE data at each CTE with the appropriate segments of the supply chain identified. It tabulates options presented objectively without recommendation towards one product or another so operators can choose what options best fits their capabilities and data collection requirements.

Results & Outputs

Survey and Engagement with the SRL Industry

This project has raised awareness of the importance of traceability within and along the southern rock lobster supply chain. Through reviewing current practises, identifying and demonstrating through trial evaluation mechanisms to enhance traceability the project has contributed directly towards enhancing SRL traceability practises. The production of a traceability implementation guide supports ‘better practises’ and a genuine opportunity for the SRL industry to take a major step forward in enhancing its traceability practises. It also opens up the possibility for the industry to consider the development of an industry traceability platform for coordination and integration of an industry-wide traceability system built on GS1 standards discussed in the project extension section of this report below.

Building on Phase 1 work the research team actively engaged with industry partners in South Australia, Victoria and Tasmania to understand the challenges and opportunities in enhancing traceability systems within SRL supply chains. The results highlight the key features, benefits, constraints and contemporary traceability practises along SRL supply chains. A case study on the successful development and deployment of a mobile application to improve a lobster processor’s paperwork is presented and is illustrative of the simple steps that can be taken to enhance traceability.

As part of the approach the research team used value chain analysis (VCA) as a diagnostic technique to understand how best to enhance SRL supply chains and assist them to function more effectively as value chains. The focus of VCA analysis produced results that have advanced understanding of SRL supply chains in ways that will contribute to alignment of material flows and information flows with governance policy and procedures for effective traceability systems.

Insights from Value Chain Analysis of SRL Supply Chains

The SRL industry relies on overseas, primarily Chinese, markets for over 75% of its annual value (Mobsby 2018), with substantial increases realised through a shift from a supply-driven to a demand-driven market over the last 10-15 years (Wilkinson 2006). With this shift, the development of an efficient supply chain for the production and delivery of a product to market is no longer enough to ensure sustainable competitive advantage in international agri-food markets, including in seafood export markets (Bonney et al. 2007a; Sankaran & Suchitra Mouly 2006).

As consumers become more discerning and enjoy greater levels of choice, agri-food supply chains are increasingly required to operate as ‘value chains’ with the capacity to “undertake purposeful collaborative management … to deliver the value attributes demanded by consumers” (Collins et al. 2015). Traceability of products from place of production through to final consumption is one such value attribute requiring collaborative management practises along a value chain (Charlier & Valceschini 2008).

Value chain analysis (VCA) was used as both a research methodology and supply chain improvement process and proved to be an effective means of identifying and fostering collaboration opportunities between chain members (Taylor 2005). This is because the value chain research activities were carried out with significant involvement from stakeholders in the SRL industry.

Building on the VCA conducted in phase one of the project, the research team continued to engage with stakeholders for the purposes of understanding current material, information and relationship dynamics, to ensure detailed appreciation of how increased traceability will affect customer valuations as well as compliance within evolving regulatory regimes.

This phase two engagement work also supported the research team's detailed understanding of SRL industry operations and structure, including the significant State-based variations that exist and impacted directly on the approach advocated for effective approach for an SRL traceability system.

The team continued survey and engagement with the industry and this has ensured that the approach developed meets the general requirements of the SRL industry while remaining flexible enough to accommodate the specific processes of individual operators. The VCA map produced in phase one, while it was a simplification, was useful for identifying key industry features and constraints. Phase two analysis has identified that achieving the range of value propositions or benefits identified required an approach capable of overcoming a range of industry specific constraints and this led to a set of three broad types of traceability systems being advocated with associated benefits and constraints with each: ie. Batch level; Batch level with individual tagging; item level with individual tagging.

Industry Engagement

In order to understand the opportunities and challenges associated with implementing a traceability system in the SRL industry broadly, as well as within individual State-based supply chains, the project undertook extensive industry engagement activities. This involved meeting with stakeholders at every step of the supply chain and regulatory function. The majority of industry engagement activities detailed below were conducted in or around functioning workplaces, thereby enabling the research team to make relevant field observations giving additional depth and context to stakeholder conversations.

Table 1 Industry Engagement Activities during phases 1 and 2 of this project

Industry Role	Organisation	Contact	Position	State
Fisher	Owner Operator	Kent Way	Owner Operator	TAS
Fisher	Owner Operator	Clive Perryman	Owner Operator	TAS
Fisher	Owner Operators	Various	Owner Operator	SA
Fisher	Apollo Bay Co-op	Glen Fisk	Vessel captain	VIC
Fisher	Owner Operator	Brendan Taylor	Vessel captain	TAS
Processor – Exporter	A R Garth	Ken Smith	Site Manager	TAS
Processor – Exporter	Abtec	Steve Bartels	Owner Operator	TAS
Processor - Exporter	Craig Mostyn Group	Barry Charles	Operations Manager	TAS
Processor -Exporter	Craig Mostyn Group	David Dillon	Site Manager	TAS
Processor - Exporter	Craig Mostyn Group	Nathan Maxwell-Mcginn	Marketing Manager	SA, VIC, TAS
Processor – Exporter	JSJ Seafoods	Stuart Charles	Site Manager	TAS
Processor - Exporter	South Australian Lobster Company	Michael Blake	Operations Manager	TAS
Processor - Exporter	Fergusons Australia	Andrew Ferguson	Managing Director	SA
Processor - Exporter	The Fish Factory	Yiotis Toumazos	Manager	SA
Processor - Exporter	Ballande Groupe Australasia	John Brady	CEO	VIC
Processor – Exporter	Apollo Bay Co-op	Alan Nicholls	Manager	VIC
China facing marketer	Craig Mostyn Group	Dana Celna	Broker	VIC
Industry Association	Tasmanian Lobster Fisherman's Association	Clive Perryman	Chairperson	TAS
Industry Association	South Eastern Professional Fisherman's Assoc	Justin Phillips	Executive Officer	SA
Industry Association	Southern Rock Lobster Limited	Ross Hodge	Executive Officer	TAS
Regulator	DPIPWE	Hilary Revill James Parkinson	Senior Fisheries Management Officer	TAS

Regulator	PIRSA	Annabel Jones	Senior Fisheries Management officer	SA
Scientific Research Body	Institute for Marine and Antarctic Studies (IMAS)	Caleb Gardner		TAS
Scientific Research Body	South Australian Research and Development Institute (SARDI)	SARDI Representative		SA
Key Technology Supplier	Real Time Data Pty Ltd	Simon Dick	Director	SA
Technology Provider	Hallprint	Darren Evens		
Fisherman	Mures	Heath Rogers		TAS
Regulator	MAST	Peter Key		TAS
Regulator	DPIWE	Kim Griggs		TAS

Key industry features

The State based regulatory framework which encompass the SRL fishery is extensive and has significant variation between South Australia, Tasmania and Victoria where the industry is concentrated. This complex regulatory environment presents both challenges and opportunities for the development of a traceability system. On the one hand, regulators currently capture significant amounts of information which could be incorporated into a traceability system without adding additional cost to industry. On the other hand, the State-based regulators have significantly different levels of capacity when it comes to capturing and sharing data from a technical perspective. In addition, the ability of State-based regulators to share data obtained from industry participants is affected by confidentiality constraints.

Table 2 Key industry features by State

State	**Fishing Zones**	**2016 Allowable Catch (Tonnes)**	**2019/20 Allowable Catch (Tonnes)**	**Fleet size**	**Average trip length**	**Government scales at wharf**	**Using Deckhand software**
South Australia	Northern	360	296	63	4-10 days	No	Commencing
	Southern	1245	1245.7	180	1 day	Yes	100%
Tasmania	Eastern catch cap	115	170	202	1-2 days	No	Limited trials

	Western	1050.7	1050.7		5-14 days	No	Limited trials
Victoria	Eastern	59	59	59		No	eCatch July 2020
	Western	230	220.5			No	

The value chain map presented below provides a graphical representation of the key regulatory and material flow characteristics of the chain. This map is useful for highlighting key material and information bottlenecks as well as key relationships. For example, the map highlights the central role that Melbourne airport currently plays in the chain as well as the relatively high level of regulatory and structural differences in the industry given that the majority of fish are sold through the same market channel.

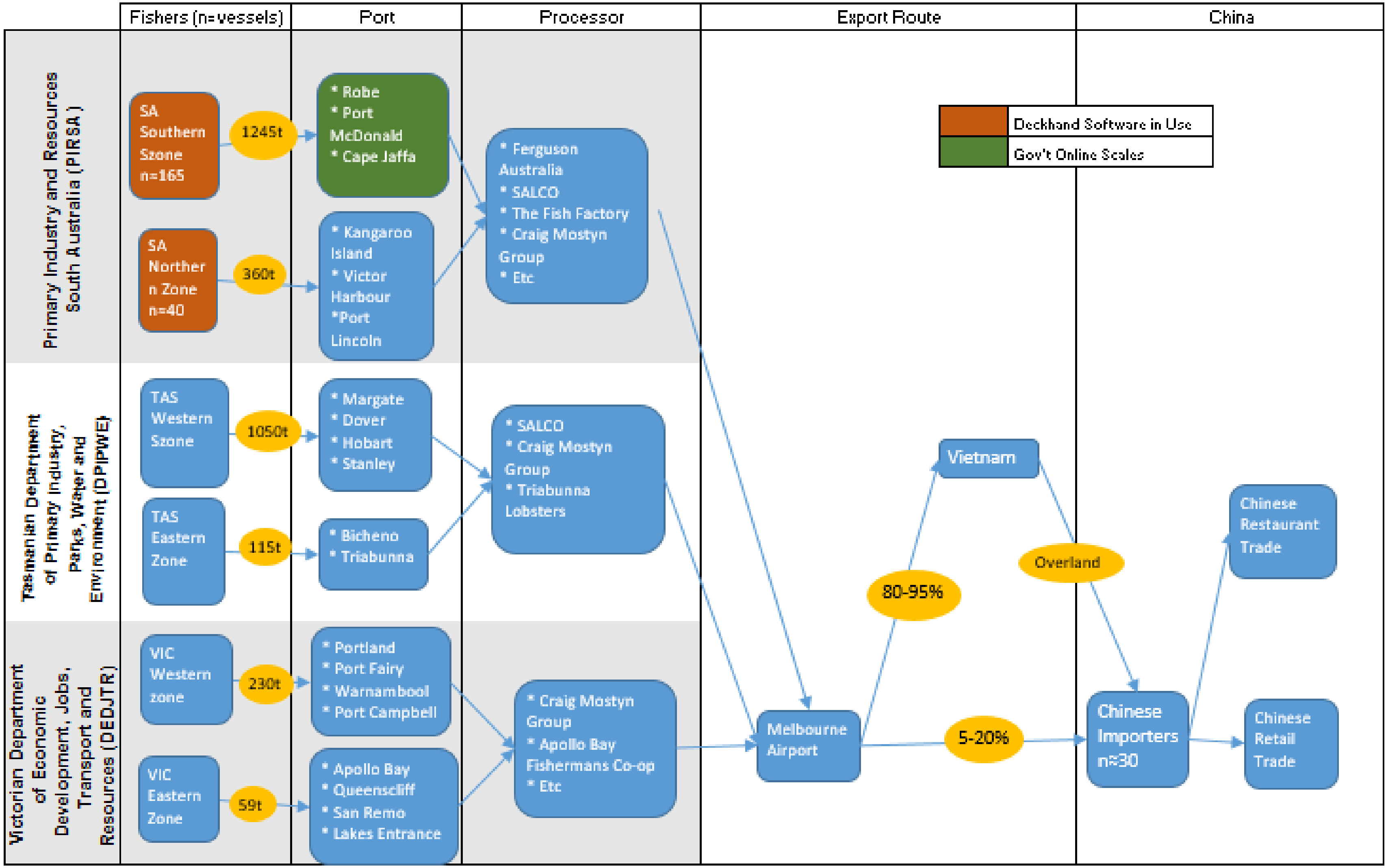


Figure 5 Regulatory and Material Flow Map for Southern Rock Lobster Industry

Benefits of Traceability in the Southern Rock Lobster Industry

A number of key benefits were identified in phase one. These were reviewed, updated and further validated during phase two. They are re-iterated in the sub-sections below as they provide a valuable context for understanding the basis of the approach for SRL traceability systems developed and advocated by this project.

Supporting increased ability to meet requirements for direct shipments into China (and/or other markets): Prior to 2019-2020 more than 75% of all Southern Rock Lobster (SRL) were exported as a live product to China (Putten et al. 2015; Mobsby 2018). However, discussions with multiple exporters suggest that more than 80% of fish are transhipped via Vietnam, due to tariff barriers on Australian lobsters sold directly into the Chinese mainland. However, the recent signing of the China Australia Free Trade Agreement (ChAFTA) means that the 17% tariff (but not the 15% value added tax) is being phased to zero between 2015 and January 1st 2019 (DFAT 2016). This phased reduction in the Chinese import tariff is already driving increased levels of direct export of SRL to the Chinese mainland, with some exporters now sending up to 20% of their stock direct into Southern China. While the avoidance of both tariffs and the Chinese value added tax gives transhipped products a gross price advantage of 28%, the phasing out of the tariff, combined with the introduction of direct flights to China from both Hobart and Adelaide, and growing concern about the effect of Vietnamese transhipment on product quality, all suggest that direct imports to China are likely to increase in the near to medium term.

While the choice between direct shipments and transhipment through Vietnam is made by the Chinese buyers rather than Australian processor/exporters, and is primarily based upon price considerations, increased traceability will help prepare the industry for increased demand for direct sales into what is an increasingly regulated Chinese market (Everstine et al. 2013; Tang et al. 2015). Furthermore, increased traceability would also help ensure the industry is able to meet the requirements of other markets such as Europe, which has regulated traceability requirements. Increased traceability will help reduce the risk associated with the high proportion of fish being sold via transhipments through Vietnam specifically, and Chinese market more generally (Charlebois et al. 2014).

Supporting increased ability to add product value from the perspective of Chinese Consumers: China is the world's third largest importer of seafood (FAO 2018) and within China SRL has a reputation for quality as evidenced by its high market price. This is driven by the attribute of the fish, including its firm eating texture, its culturally auspicious red colour, and the fact that it contains more meat than clawed lobster. Traditionally lobsters have been given as gifts during important celebrations such as weddings as a means of reinforcing status and prestige, meaning that as disposable incomes grow in China there is likely to be continued growth in demand for SRL as a highly recognisable prestige product. This does not mean that the prices for SRL are always rising though, as Shearer (2009) points out; "as lobster is generally a celebratory menu item, the market requirements are continuously reacting and evolving, with the changing economic prosperity". Thus Chinese demand is strongly affected by both predictable cultural events and unpredictable economic cycles. In addition, while a number of SRL industry members stated that the SRL is the most desirable lobster species in the Chinese market, research by Norman-López et al. (2014) indicates that "all four [Australian lobster] species and producers/export states are perceived to be substitutes for one another, so that in the long run, prices paid to operators in the industry will move together". So while Chinese consumers may (or may not) consider the SRL to be a superior product, additional branding and communication may be required to differentiate the product from other offerings in the market, particularly other Australian Lobster.

An understanding of Chinese consumer preferences presents opportunities for value adding, including in ways directly related to the development of increased traceability through the chain. The significant market reforms that have taken place in China in recent decades have drastically altered the food system, the most significant of these being the widespread introduction of for-profit businesses into the food production and distribution system. While these changes have greatly increased food choices for Chinese consumers, research suggests that Chinese consumers now also experience significant levels of anxiety about food safety in the modern food system (Veeck et al. 2010). In order to manage these perceived risks consumers are making increasing use of well-known brands as a marker of safety and quality (Veeck et al. 2010). This desire to purchase products with trusted and identifiable brands presents an opportunity to add value to SRL in the eyes of the consumer through the application of a branded tag which forms part of a traceability system. Such a system would enable the development of a unique SRL brand in the Chinese market, including the ability to highlight quality assurance programs such as SRL's 'Clean Green' program and may also assist in gaining the right to use a trusted third party certification. However, in relation to the use of environmental certification systems, research by Fabinyi and Liu (2014) found that Chinese consumers did not prioritise environmental sustainability, as communicated by brands such as the Marine Stewardship Council, instead focusing on a brand's ability to signal factors such as "social status and prestige, food safety and quality, and health and nutrition".

Supporting increased vertical and horizontal collaboration amongst industry participants: The SRL industry has a large percentage of small owner operated businesses who engage with their industry peers on a purely competitive basis and their upstream and downstream trading partners on a largely transactional basis. The absence of both significant scale economies within individual firms and ongoing 'pre-competitive' collaboration between firms was nominated by a range of stakeholders as being a significant impediment to the introduction and operation of an industry wide traceability system, as well as placing the industry at a disadvantage more generally against international competitors like the New Zealand SRL industry which is creating a coordinated and customer orientated 'value chain' (Bonney et al. 2007b). However, while inter-firm governance issues exist in the Australian SRL industry, the fact that several processor/exporters have expressed a desire to be involved in development trials for a traceability system suggest that the process of developing such a system, particularly via a value chain analysis approach (Collins et al. 2015), offers an opportunity to foster increased vertical and horizontal collaboration.

Supporting an increased ability to safeguard against product misidentification or intentional substitution with species of lesser value: The use of a branded lobster tag which is sufficiently hard to replicate or tamper with may ease consumer concern about food fraud and seafood substitution for inferior products (Johnson 2014; Villacorta-Rath et al. 2016). However, the extent of protection offered by a tag-based system may be limited due to potential counterfeiting of the tags themselves.

Supporting an increased ability to safeguard against fraudulent mortality claims by buyers: Given that SRL are predominantly sold as a live product into distant export markets, a compensation system exists for buyers when fish mortality exceeds a given level. Typically, the exporter will refund 50% of the value of dead fish in excess of 5% of a consignment (e.g. a 7% mortality rate would result in the processor providing a refund worth 1% of the total sale). While such a system may be necessary, exporters expressed reservations about the veracity of the mortality claims they receive, with one exporter stating that he had been sent the exact same photo on more than one occasion as supposed documentary evidence of mortality. A SRL traceability system which includes a tag based unique identifier may limit fraudulent behaviour as vendors could require photographic evidence of dead fish with tags intact.

Food safety and regulatory compliance:

Biotoxins: The presence of naturally occurring biotoxins such as paralytic shellfish toxin (PST) has emerged as a major issue for the industry. Without the ability to accurately distinguish between fish which have and haven't been caught in PST affected waters, widespread product recalls are possible. At present PST has only impacted the east coast of Tasmania, however fish from this catchment zone are indistinguishable from fish from other zones once they are mixed at the processor/exporter level in Tasmania, or within export consignments at Melbourne airport. The widespread inability to trace fish origin means that fish from all zones are at risk of being quarantined or recalled. To reduce this risk a number of processors have initiated their own product tracing system within their holding tanks using tank dividers and a simple whiteboard accounting system which tracks movement of fish from different ports and dates as they move through their system. While this system is a promising development, there is no codified industry-wide practice and the level of detail and accuracy achieved by processors may differ widely. A codified and digitised traceability system would provide a more robust risk reduction system in the event of continued and potentially more widespread biotoxin events.

Supporting a wider range of biotoxin management options: In response to a 2012 PST event in Tasmania's East Coast Rock Lobster fishery, the Tasmanian Department of Primary Industry, Parks, Water and the Environment (DPIPWE) in consultation with Tasmanian Rock Lobster Fishermen's Association and the Commonwealth Department of Agriculture, developed the Rock Lobster Biotoxin Plan and Decision Protocol (DPIPWE 2015). This protocol specifies a detailed scientific testing regime for the detection of harmful levels of PST on the east coast of Tasmania as well as how to deal with an outbreak if detected. The testing and biotoxin management zones for eastern Tasmania (the only fishery in which PST has been detected) are shown below. The specified testing regime relies on the regular monitoring of *sentinel* species such as oyster and muscles to check if biotoxin limits are within acceptable levels (Campbell et al. 2014). In addition to the cost of lost earnings from the closure of zones during testing and after PST has been detected, the testing regime itself comes with significant costs: each laboratory test costs $500, and significant ongoing fuel and labour costs for the sampling regime, such that the estimated cost of the current sampling and testing regime has been put at $64,000 for a four month period (DPIPWE 2015).

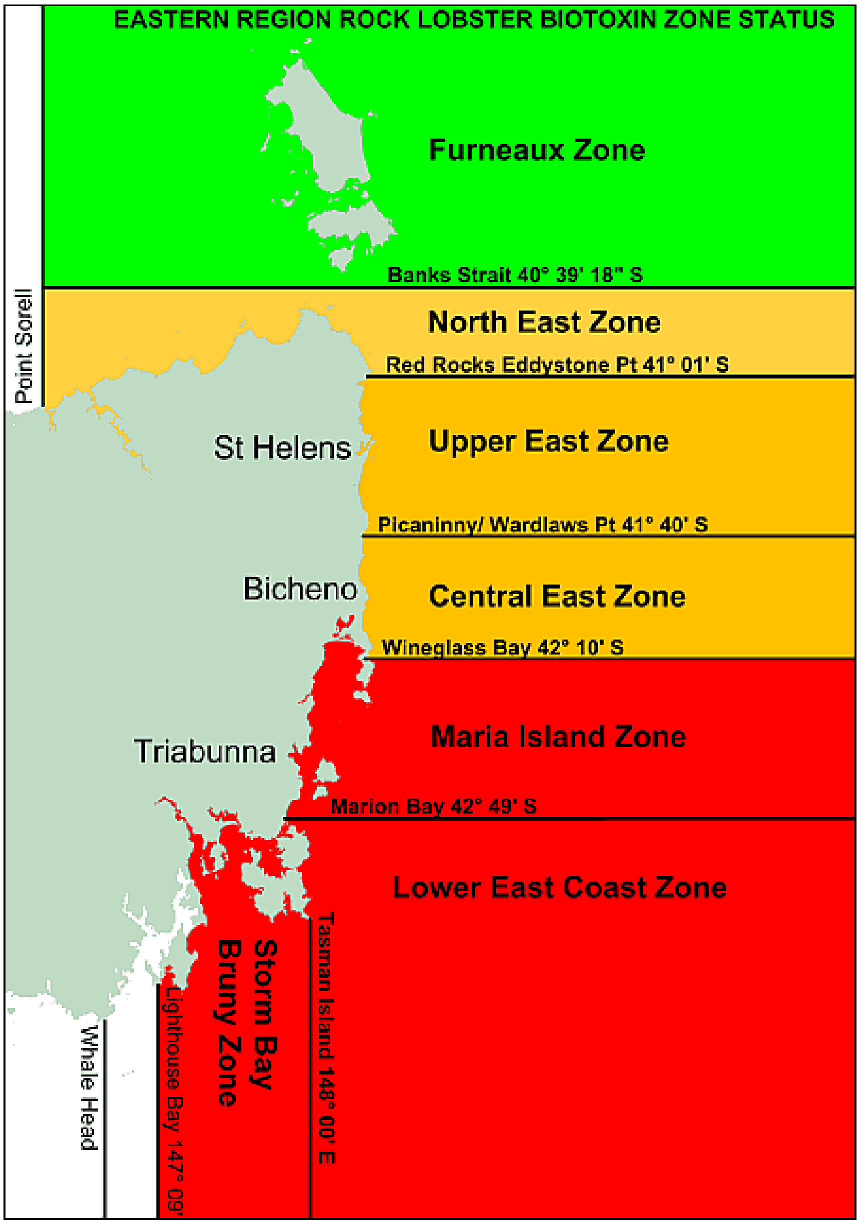


Figure 6 Tasmanian Biotoxin Testing Zones

A number of alternative protocols were canvased but not adopted during the establishment of the current Biotoxin Management Plan. Two of these options; differential labelling of product based upon the results of sentinel data (e.g. "do not eat the gut") and holding suspect fish in segregated tanks until testing has been completed; may become more viable options with increased levels of traceability. The latter option would only be viable when sufficient spare holding tank space was available at the processor/exporter level, however, this option is apparently now under consideration by the New Zealand SRL industry as it has the advantage of only discarding fish that are demonstrably affected.

Fisheries management: Increased use of digital tools for mandatory reporting tasks would likely reduce the cost of processing the current range of paper-based forms. Given that the industry is regulated on a full cost recovery basis, these efficiencies should flow through to reduced licence fees for industry members. Any such cost savings would be in addition to the time savings that fishers and processors may save in any traceability system related move from paper to digital fisheries management reporting. The capture of finer grained catch and effort data through a digital traceability system may also preclude the adoption of precautionary fisheries management practises in the absence of quality data.

Constraints on Traceability in the Southern Rock Lobster Industry:

Higher labour and material costs associated with the individual tagging of fish: The previous SRL traceability pilot program documented by Muggleton (2004) proposed individual tagging of fish, with tagging activity to be carried on board fishing vessels. Fisherman involved in this process stated that it was a labour intensive and potentially dangerous (in rough conditions) process that was only viable where a price premium ($3-$5 in 2005) was paid to the fisherman. While the cost of basic non-electronic tags is relatively low, being in the order of 10c per item, labour costs and process change costs are likely to be more significant. The cost of tag related damage to fish is also likely to grow in relation to the length of time that fish are stored together in tanks, as anecdotal evidence suggest tags affixed to horns result in increased horn loss, which can result in reduced fish value.

Lack of physical space and infrastructure to enable segregation of fish: Significant heterogeneity exists in both the capacity and design of vessels and on-land fish storage tanks. Capacity differences for on-land processor/exporter operations are particularly significant as space limitations restrict the extent to which fish can be segregated according to origin or date of catch/receipt. Even where processors do have relatively more room, capacity may still become constrained at busy times of year, such as in the lead up to Chinese New Year celebrations. Any traceability segregation system should therefore be designed to maximise space and flexibility.

Market requirements for sortation by colour and size: According to the Chinese market place, the quality (and price) of a lobster is primarily determined by its colour and size. When sold as individual fish in China, Red fish are more valued than mottled fish or white fish due to cultural reasons; while small fish are relatively more valuable per kg than large fish, due to the desire of final customers to serve individual guests a whole lobster. However, when exporters transact with Chinese buyers' they do not charge according the attributes of individual fish, but rather the weight of the total consignment. For this reason, exporters tend to pack export consignments in a way that ensures no one customer gets an ‘unfair’ concentration of lower value product. In turn this means that when packing fish, exporters choose fish from across their stock according to colour and age (length of hold time is also important), rather than according to fish origin. This results in a reduction in the granularity of traceability available as fish from different locations and date windows are mixed together.

Buyer resistance to increased traceability for transhipped fish: The majority of SRL (greater than 75%) are currently sold to Chinese buyers who request that the fish are ‘transhipped’ via Vietnam before being road freighted into China. One of the intended outcomes of this process, from the perspective of the Chinese buyer, is to render information about fish origin opaque within the Chinese regulatory environment. Therefore any changes which make information about fish origin more difficult or costly to manipulate are likely to be resisted by these buyers when ordering fish to be delivered via Vietnam. However, as the same relatively small group of Chinese companies order fish through both the Vietnamese ‘grey’ trade and direct into mainland China, a situation may arise where the one buyer would like increased traceability data for some shipments and not for others. It is however, acknowledged that with the introduction of the CHAfTA agreement this situation is likely to pose a considerably smaller risk into the future.

Continued Value Added Tax (VAT) differential: Fish currently transhipped via Vietnam currently avoid both Chinese import tariffs and VAT resulting in a gross (not taking into account increased shipping costs and increased mortality) price advantage of 28% over fish which are imported directly. While import tariffs will be phased to zero by end of 2019 under ChAFTA, VAT will continue to apply; therefore transhipped fish will continue to enjoy a price advantage. Whether this advantage is sufficient to continue overcoming the additional costs and risks associated with this channel is yet to be determined.

Variable technical capacity across both industry and government: There is currently a gap in the level of technology uptake by both industry participants and regulators between South Australia, Tasmania and Victoria. South Australia is currently the most technologically advanced state, using technologies such as automated government weight stations at port, on-board digital record keeping, RFID tagged fish crates, and regulator approved digital reporting systems. These technologies are not currently employed in the other states and this differential makes a one size fits all technical solution difficult in the short term. While from a technical perspective there are no significant barriers to closing this gap, it is evident that a number of organisational, procedural and human factors are likely to continue to inhibit widespread adoption of common technical approaches and practices across the industry.

Limited vertical integration and/or collaborative culture within industry: Through a combination of historical legacy and regulatory design the SRL industry is comprised of a relatively large number of small family operated businesses. These businesses, including both fishers and processors/exporters, play an important part in the economic and social life of many small coastal communities. This is a fact which is recognised by relevant State-based legislation which stipulate that the fishery should be managed with environmental, economic and social concerns in mind. This is achieved in part by regulations which limit the amount of fishing quota that can be owned by any one individual or company, thereby limiting the amount of market concentration which is possible. While this situation may have social benefits for some communities, it may also serve to limit the economies of scale and vertical integration. As a result, a number of stakeholders felt that the industry was relatively fragmented and did not have the kind of collaborative culture seen in other countries and industries and which may support industry competitiveness in international markets.

Traceability Practises along the SRL Supply Chains

Traceability practises along the SRL supply chains were examined during phase one of the project. These were reviewed, updated and further validated during phase two. They are re-iterated in the sub-sections below with some additional insights. They provide a valuable context for understanding the basis of the approach for SRL traceability systems developed and advocated by this project. More specifically, the research continued with interviews and site visits conducted across Tasmania, South Australia and Victoria and moved forward with the trial and evaluation of a number of digital tools and techniques to enhance traceability practises with industry.

On water: Some differences between States around length and duration of a fishing trip are present. The Tasmanian approach is to stay at sea for up to 14-days in order to fulfil catch quota objectives. Conversely in the Southern Zone of South Australia the tendency is for short-haul trips of up to 3-days, where the Northern Zone is generally at most, day trips.

Additionally, there are some differences in the style of storing caught fish given the duration of the fishing trips as well as the size of boat. In Tasmania, the widespread practise is to aggregate all caught fish in a fishing boat's hold for the entire duration of the trip – each subsequent catch during a trip is added to the common hold, with no segregation of catch. Conversely, in South Australia, in both the Southern and Northern zones, the common practise of storing caught fish in plastic containers prior to lowering them into a common hold is made possible with the use of larger fishing vessels.

Across Australia SRL are harvested using an available set of fishing boats – what is of interest to the report is the operational supply chain logistics of the fishing process engaged by the fishing fleet which differs dramatically around Australia.

Trip length can vary depending on where in Australia a boat is operating. In Tasmania for example, the average length of a fishing trip to catch and harvest SRL is somewhere between 9 to 14 days. This can also vary depending on season – in summer Tasmanian fishermen report average catches of up to 2-tonne, where in winter, they report on average catches of up to 1-tonne.

Depending on season, and the time during a particular season, another factor that varies is the size of the SRL. The average fish size in Tasmania is approximately 680 grams, with highest reported SRL at approximately 900 grams.

In Tasmania the average size of a boat can hold up to 55 pots. Trip length (and associated cycle time) is intimately related to catchment size with varying trip lengths being determined by catch but also available on-boat resources. With smaller boats generally available in Tasmania, estimates of approximately 1-tonne are fish are sought within a 9 to 14 days boat trip required to accumulate this load. Conversely, in the Southern Zone of South Australia, the average trip length is usually one day to catch an equal amount of fish.

Usually the haulage of pots onto a boat is completed in sequence, with individual pots pulled from the water one after the other. This simplifies sortation and merchandising of SRL as the pot is unloaded on the boat. Estimates vary but reports of up to 100 pots in a single day in Tasmania, for example, are not uncommon.

When a pot is unloaded in a boat a sequence of actions is performed to pull, sort, measure, grade and store (or discard) a SRL. Following this sequence of actions, if an SRL is determined to be an allowed catch, it is immediately in turned in the hold of the boat. Depending on the size of the boat and the jurisdiction, whether the SRL is simply stored in aggregate in the hold or stored in a holding container amongst a group of SRL can vary.

In Tasmania, most SRL are stored unsorted as a collection of fish in the hold – this requires individual sortation of fish at dock once the boat returns and packing into plastic containers - whereas in South Australia the tendency is to store a group of SRL in a plastic container, and this is loaded into the hold so the hold comprises numerous groupings of SRL in containers, with the aim of future offloading and sortation easier and more rapid. Across all types of boats, the hold contains and is filled with salt-water.

The level of experience of a fisherman has a lot do with the success of an individual fishing trip. Site selection and hence fishing areas or shots, is based on this personal experience of having previously identified ideal fishing grounds within a range the range of operating constraints.

Every 'shot' goes into a map and is plotted prior to travelling to the destination. An array of 7.5 x 7.5 harvest sites aids in this site selection process. Blocks are 7.5 x 7.5 miles in size, divided into major and minor blocks. A software tool on the boat's computer provides navigational aid for using the map.

On-board measuring of fish occurs but is generally enacted only when the size of a fish is too close to the 'accept' or 'reject' size. An experienced operator usually makes a good and fast decision to accept/reject. Where the decision is difficult, in Tasmania it is common to apply a set of analogue callipers to measure the carapace of the fish to determine its size. Conversely, in South Australia, for example, digital callipers are the norm.

The specialised tasks of measuring, grading and sorting fish prior to storage is a primarily human task with the only technology used being primarily an analogue calliper (if size of fish is too difficult to discern). There is little if any other technologies present during this phase primarily due to operational constraints – digital scales need to be calibrated and this calibration needs to be accurate which is made difficult on a moving boat. Tagging of fish is not practised as it is not mandated as a compliance requirement, and any tagging is perceived to be both a risk to the animal and likely to increase cycle time during this stage.

Whilst on board, fishermen are required to comply with both legislated practises and procedures for fishing SRL and maintain accurate documentation to validate compliance. In Tasmania, the system of documentation is paper based, whereas in South Australia in the Southern Zone the documentation is fully electronic (and is called, ‘Deck Hand’).

Fishermen in Tasmania have trialled Deck Hand and there are mixed feelings from a range of stakeholders. Amongst fishermen the advantages of increased accuracy are understood but the chief concern relates to cost and maintenance of the system. Amongst other stakeholders, the chief concern is about privacy and control of data – who has access to the data (whether this is government or a fisherman’s competitors, or the processors) etc.

On land – transportation: Once off-loaded, consignments of fish are transported using Less-than-truckload (<4 gvmt) trucks from dockside to processor. There are at least two elements to transportation worth considering: truck interaction at dockside with boat-load out; and consignment interaction with processor on load-in.

In Tasmania, fish are off-loaded at dockside by retrieving individual animals from a boat’s hold, storage in plastic crates, additional measuring of carapace length, and then weighing of plastic crates prior to loading onto a truck. In Tasmania, as SRL are generally stored aggregate in the hold of a boat, significant amount of manual re-handling of SRL occurs at this stage: SRL are retrieved individually from within the hold and stored in plastic containers, which are then loaded out of the boat onto the dockside. The offload procedure is followed generally by weighing at dockside with a set of calibrated digital scales provided by an awaiting haulage operator – fish are resorted into plastic containers to make a up a load defined by a defined net weight of 23 Kg.

In South Australia the system varies. In the Southern Zone, as fish are already packaged in plastic crates, the crates are retrieved, weighed at dockside using an electronic set of weigh scales monitored remotely by CCTV, with associated catch-effort data collected either by DeckHand or the government’s telephone system. In the Northern Zone however, the system varies again, with plastic crates offloaded and sealed with zip-lock tags, and forwarded for weighing at the processor.

The Deckhand system is in widespread use in the southern zone of the South Australian SRL fishery. Trial of Deckhand have taken place in areas outside of South Australia. In Tasmania trials of Deckhand were generally warmly received by participants of the trial.

There is anticipated future uptake of Deckhand in the northern zone of the South Australian SRL fishery. In the southern zone of South Australia the procedure differs, with pre-packed plastic containers emerging from the hold of a boat and being offloaded onto the dockside. At this offloading point, these containers are taken to the designated electronic weigh-scale (which is also monitored remotely using CCTV) for weighing and entry into the South Australian fisheries electronic monitoring systems. The documentation that accompanies and aligns with catch in South Australia can either be electronic (using DeckHand, anticipated other electronic systems coming online soon ~ 2017), or paper-based.

Augmenting the use of the electronic data collection system in South Australia, Deckhand, is the widespread use in the Southern Zone of electronic weigh-scales, telephone reporting and remote video monitoring at landing at dockside allied with the use of RFID enabled containers to store SRL prior to offloading them from a boat.

In the Northern Zone a different system is in place which does not require weighing at dockside. In the Northern Zone, the system is that fish are stored in plastic boxes prior to be being offloaded at the dockside with these boxes being sealed with tamper evident tags. Rather than weighing at dockside, these boxes are transported directly to a processor for weighing.

On land – processing and load-out: The system for order fulfilment across most operations is quite simple, involving a 'picker' working from a 'pick list' or 'order' which provides crude requirements from the client on fish: grade, quality, size and price. The picker uses the order requirements to select from available fish currently on hand in the processing facility to make up and fulfil the order. As such, whilst the order requirements are maximised, this comes currently with a loss of traceability as stock is mixed and aggregated from any available stock wherever it is located – any system of discretising inbound stock to fishermen and particular holding tanks is lost. In South Australia work is already underway to develop an innovative and specialised SRL tagging technology. Hallprint Australia with Solex, already have designs for a plastic-poly tag which overcomes many of anticipated constraints for item-level tagging on a boat. The tag which is currently in a developmental state applies to fish horn using an applicator gun, capable of holding upwards of 30 tags, making rapid application and minimal impact to the animal a real possibility. This advances over previous and earlier tagging technologies by reducing cycle time and increasing reliability during storage and transit of the SRL along the supply chain. Generally there is limited mixing of Tasmanian fish with those caught from other States such as Victoria or South Australia. Unfortunately, fish entering a single processing or redistribution facilitate in China may be sourced from multiple Australian States and then mixed at this point. Several larger processors in Tasmania and South Australia have already implemented systems for batch level traceability back to a catch and individual fishermen. In the observed operations, a colour-coded tagging system and white-board are used to link fish in a particular tank to a particular fishermen's catch. The approach is regarded as 'leading edge' for processors and is based on a simple technology allied with streamlined workflows. However, whilst the system presents good batch level traceability whilst fish are stored and prepared for export, the tendency on export load-out is to select fish based on a pick-list based on price and grade which is then picked from a range of tanks, and therefore, across multiple fishermen's catches. As such, on export the system's ability to accurately trace a fish back to an individual fisherman is reduced to a time-window. These systems are administered largely by human personnel and require the strict oversight of a good manager. Their success or failure on any given day depends entirely on staff being able to follow the strict 'in house' protocols around affixing colour-coded tags to boxes and maintaining an accurate record on a white-board.

Case study: **Mobile Apps Digitising Processor Documentation.** presents the successful development and deployment of a mobile application suite supporting the digitisation of lobster processor consignment documentation.

Case Study – Mobile Apps Digitising Processor Documentation

Introduction

Processing lobsters has always involved much manual handling for inspection and filling in paperwork with three key areas grading, rejecting and shipping of the batch of lobsters. In some cases, five or six pieces of paper are used for a single batch of lobsters for each step in the process. When considering the huge numbers of lobsters being processed, it's no surprise that companies are spending several hours a day typing up forms. While this is good for profits, it also leads to missed traceability data. This study aims to improve information collected from the product so that this lobster profile data can be sent along the supply chain with a tagged lobster. This is information that both downstream processors in China and customers want to know, as it helps them judge the quality and price of lobsters.

Methodology

The researchers reviewed the paperwork used to process lobsters during all three stages while working with processors in Tasmania and Victoria. The problems that became apparent were the sheer volume of paperwork, the number of transcription errors during the grading process and the time spent reproducing the data. Firstly, the researchers spent time converting the paperwork to apps and testing the software in the lab. After this, a trial-evaluation was conducted with personnel in processing centres. This focussed on usability — making sure the apps were easy to use and errors did not occur. The apps are designed to be visually simple and easy to use. People in processing centres care about functionality rather than features, so we focused on recording data rather than adding many buttons or menus.

Results and Discussion

This study involved digitising lobster processor paperwork on a single mobile app. This application could handle several forms at once, with an example of one form shown in the Figure below covering all three key processes while adapting to the needs of the processer using it. This in turn means that all paperwork used when processing a lobster can be eliminated. Furthermore, digitising the paperwork and storing it a computerised database allows for the efficient handling much larger sets of data in ways more sophisticated than possible when using paper-based recording methods.

Another benefit is that this digital information can be emailed to wholesalers in China ahead of their order, so they know exactly what lobsters are included in their order. This will make the goods-receiving process easier and more efficient.

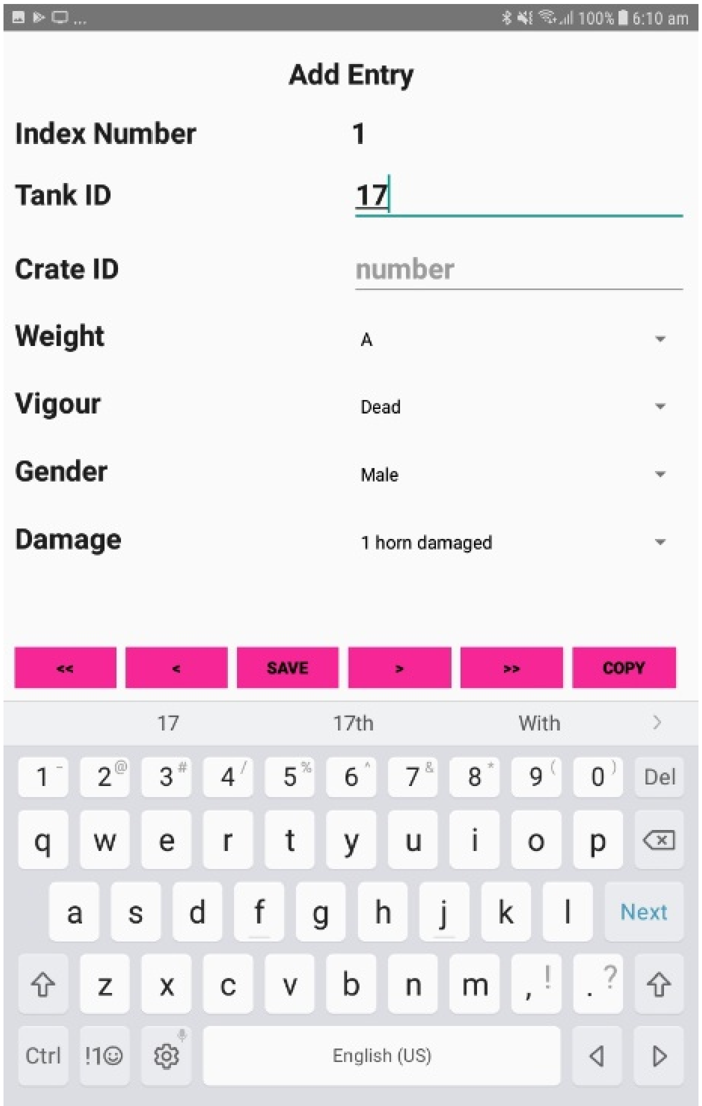


Figure 7 Mobile Application for SRL Processing

Data entry example for the mobile app developed for use by SRL Processing facilities. This screenshot shows the form for logging rejects and mortalities to be removed from stock.

In the future, this information could be linked to individually tagged lobsters, meaning that buyers can scan their lobsters in China. The grading information from Australia will then be immediately available online to wholesalers and customers. As a result, customers will be more confident in their product's quality. This offers a substantial improvement over traditional paper-based record systems still widespread in the industry.

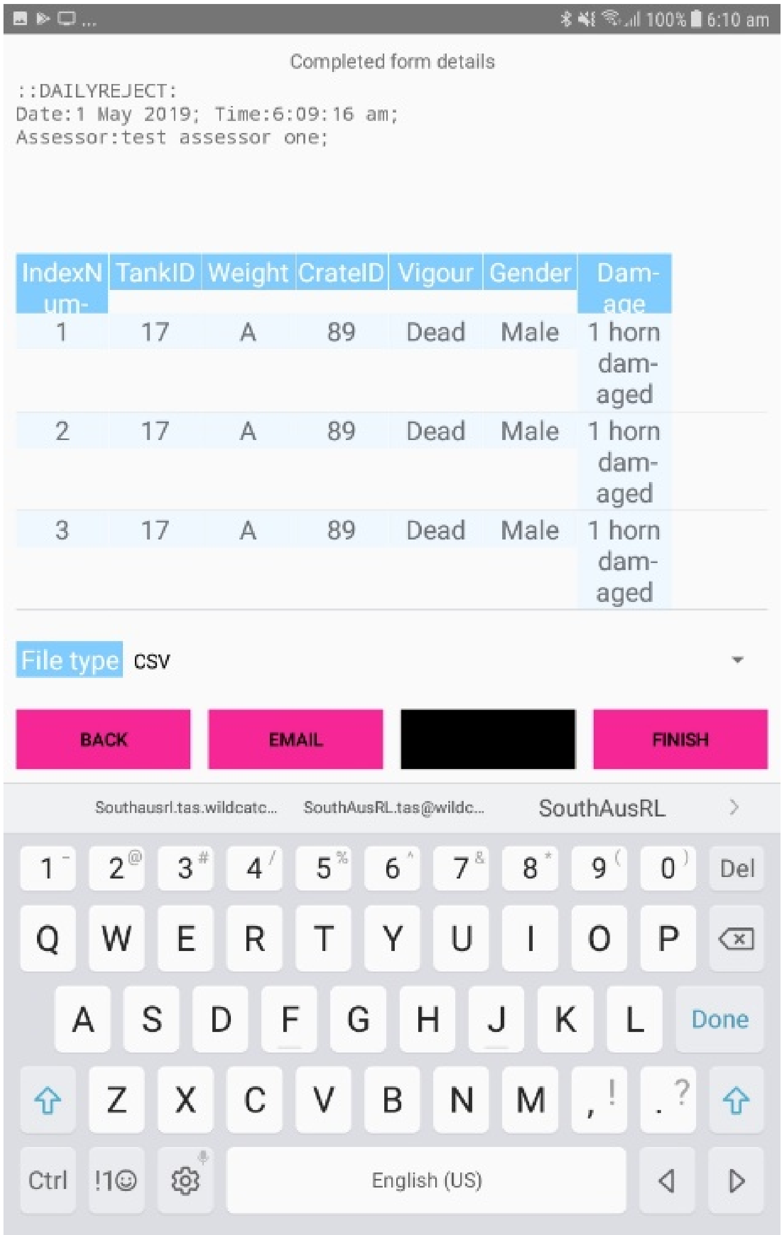


Figure 8 Screenshot of Mobile Application 'logged rejects form' for SRL Processors.

Take home messages

The vast majority of lobster processing centres still rely on paperwork to record their processes. This is clearly illogical and inefficient given the availability of low-cost tablets and smartphones and the ease with which apps can be developed. As such:

(i) Lobsters can be processed using the one application through multiple forms eliminating paperwork entirely.

(ii) These apps can also provide valuable track-and-trace data with the lobster as it travels along the supply chain.

This all means that with digitized grading information, wholesalers and customers in China get more accurate traceability information about Australian lobsters. Thus, customers will be more confident in their products and this will hopefully translate into higher prices.

Compliance and Regulation in SRL Supply Chains

Within each SRL State fishery, a robust system of compliance and regulation exists and is managed by each governments State fisheries body.

In Tasmania, a mix of electronic and paper-based systems and technologies support compliance with SRL/fisheries compliance requirements. On boat, fisherman are tasked with recording catch and effort data into paper based log books. On land, the government collects, collates and analyses catch-effort data and uses the data for fisheries management. The Fisheries Integrated Licensing Management (FILMS) database is a government owned and managed database which integrates licensing, quota management and catch-effort data. Use of FILMS is supported by a contingent of data analysts who oversee the integrity of the fishery by reviewing FILMS data against compliance regulation. The FILMS database is a modern database system which is web-enabled and regularly facilitates external office stakeholders from accessing its data directly or through batch-level extract reporting. It has the capability to be linked to electronic data entry systems supporting fisheries log books although present legislative requirements around dual-signatures along the supply chain pose restrictions on any immediate changes to how this operates.

Due to the threat and risks posed by bio-toxins, there is a system of monitoring and risk management in place managed by the Department of Primary Industries, Water and the Environment (DPIWE). Presently there is no testing regime on the West-Coast of Tasmania. On the East Coast however, sentinel oysters are tested on a regular basis – if a detection occurs, then additional testing of sentinel oysters in a broader area occurs. If testing levels of toxin are reported above 0.6 then lobsters are tested – the fisher is closed when toxin levels are above 0.8. It takes roughly 6-weeks for a lobster to clear toxin from its body. Conversely, there is no system to manage the risk of bio-toxins in South Australia and Victoria as there is no identified risk yet. Monitoring of sentinel seafood does occur in these regions. Across jurisdictions, the data collected from boats, in transit and processing is done so through a suite of jurisdictional paperwork or electronic data collection systems.

In Tasmania, the department responsible for management of the fishery and associated regulatory framework is the Department of Primary Industries, Water, and Environment (DPIWE). The back-end database containing SRL fisheries data in DPIWE is called FILMS. The databased is an amalgamation of three (3) previous databases. It is web-enabled and accessible to a limited number of external third-parties including the University of Tasmania (receives and extract of the FILMS database for scientific research), Tasmania police, and Tasmanian search and rescue. In Tasmania the system for data collection on boats, in transit and processing is currently paper based and is anticipated to remain so for many years to come. As such, there is a back-end administrative process in place in DPIWE which requires human labour to enter data, validate data and perform various checks and balances on reported catch. Whilst there has been significant progress in automating some validation on this data, the process still involves significant labour as many of the validation checks involve checking of plausibility of catch against reported catch and local know-how of the catchment zones. These things are difficult to encode electronically and in an automated way.

A critical identified constraint in adopting an electronic system in Tasmania is the statuary requirements around the current paper-based approach. Under law the current system requires duplication of paper-based forms across key duty holders (fishermen, processors and government), and physical dual-signatures on paper quota dockets. Until these things are modified in law, there is limited opportunity to introduce an electronic system.

Whilst these currently present limitations on the introduction of an electronic system, applying to modify the law to accept electronic system is a possibility, with examples from South Australian fisheries where this has already taken place. In South Australia, an electronic system has been used by fishermen to submit catch and effort data and check the real-time quota balance. Through incorporating the GPS technology, it can automatically the path and location of fishing (Deckhand 2013). However, the Deckhand system currently is only open to fishermen. The data stored in the Deckhand system must be reported to government regulators for the checking process. In Victoria, the Interactive Voice Response (IVR) system is used for fishermen to report their fishing data after landing and also for government regulators to monitor the fishing activities (Hobday and Punt 2001). The data in the system are then required to be reported to government regulators' database.

As this brief summary highlights data are not recorded and managed in a consistent way along SRL supply chains. This fragmentation poses risks not just for compliance and regulation but also exposes the industry to risks in its main market in China as consumer preferences change and evidence of quality, safety, verification and product authentication become increasingly relevant to market price.

On land – export and redistribution: Fish are packed for export using low-cost poly-foam boxes which are packed with straw and kept in a cooled environment. Critically, as animals are cooled, they become significantly less active and are more easily handled.

Systems and Technologies used for Traceability in SRL supply chains:

There is a wealth of information available in literature available from researchers, government and industry as well as commercial vendors and the peak fisheries research body. Specifically, secondary literature-based research across these four (4) categories of literature sources was completed. In excess of (200) research papers on traceability, seafood eco-labelling, compliance and regulation, and the science of rock lobsters were reviewed. In excess of (130) FRDC Southern Rock Lobster industry project reports were reviewed from publically available sources.

As well as desktop searching and review of literature, commercial provider of systems and technologies were contacted – in total enquiries to (48) commercial vendors and (150)+ email enquiries were fielded to form an understanding of available commercial systems and technologies.

R&D based systems and technologies analysis: The primary focus of the review of the research literature focused on identifying, classifying and reviewing literature which broadly discussed systems and technologies usage and implementation for SRL. While there have been many research studies covering traceability in a range of different seafood including abalone, shark and blue-fin tuna, generally there is limited focus has been placed on traceability systems for Southern Rock Lobster. There was limited evidence of research into SRL traceability systems that spanned the full breadth of the supply chain, from on-water through to consumption in export markets.

The exception is the 'Trace My Lobster' project, which uses uniquely coded tags attached to lobster caught in the United States (US) allied with fisherman and fishing details, to present a story behind the origin of the caught fish. However, it is important to highlight with the 'Trace My Lobster' project, that this presently has limited end to end traceability, as the system does not appear to associate all entities which handle the product along the chain with the product's history. Additionally, the other example is early work supported by the Canadian Lobster Council in 2011 which aims to identify the gaps and implementation design of a system for tracing lobsters. It considered implementing a traceability system using a combination of commercially available electronic systems and technologies, new processes and changed business practises.

More common than not, what was discovered, was a range of individual and discrete studies, which highlight the potentiality to be leveraged and conjoined to form the elements of traceability in SRL. There has been significant focus on governance using the Marine Stewardship Council (MSC) framework across the globe to underpin environmentally sustainable fisheries. Research conducted in Baja California Lobster Fishery highlights the steps involved in introducing MSC into a rock lobster fishery for sustainability of local fishing operations.

Eco-Labelling of seafood including rock lobster (ex-Australia) has highlighted the benefits of identifying individual packaged fish and allying the physical product to MSC to signify fish have been sourced from MSC operations and/or supply chains. Work to identify the physical fish, either whilst in water or post-harvest, has been completed. Experiments have been conducted to evaluate the effectiveness of surface marking inks on the fish, which can be applied on wet or dry surfaces for the purposes of identifying fish. Some work using Radio Frequency Identification (RFID) tags in limited and small-scale application including a novel application of RFIDs to Norwegian lobsters in fish tanks.

Other electronic systems to support data collection and collation along the supply chain have also been investigated from a research perspective. The Southern Gaspe lobster fishery is reported to have developed its own electronic log book system. Work closer to home, by Richards (2006) does however highlight the need to balance electronic systems with operational supply chain constraints. Another reported means to identify the fish uniquely is through DNA sequencing, and Villacorta-Rath et al., (2016) reports on potential of 'double digest restriction site-associated DNA sequencing (ddRADseq), to uniquely trace country of origin markers suitable to underpin a system of food traceability.

Commercially ready systems and technologies analysis: The analysis of traceability spent time identifying commercially available systems and technologies which could be leveraged to support traceability in the SRL industry. These have been compiled in a standalone document arising from this project: "Traceability Systems and Technology Products Guide". An overview of this document is provided below in the results and outputs sub-section entitled:

Traceability Systems and Technology Products Guide.

Insights on Traceability from China

As part of this project the research team also conducted fieldwork in China to ensure the recommended approach for SRL traceability Systems would be aligned to evolving circumstances in this major market.

Norman-López et al (2014) identified that that customers from other countries such as China find it hard to distinguish the species of Australian lobsters based on appearance. Therefore, different species of Australian Rock Lobsters are perfect substitutes in the market, though the costs are clearly different. Despite these differences in costs Australian Rock Lobsters regardless of species tend to generate similar market prices based simply on colour and size. Unsurprisingly SRL industry continues to be confronted with the serious risk of product substitution. These types of illegal behaviours also pose a directly threat to damaging of the brand image of SRL that in-turn may cause a decrease of price. Improved traceability is clearly one set of mechanisms to guard against these types of risks. Other factors impacting on SRL pricing include increased customer preference for validation of quality and safety of products. Again, traceability offers one set of mechanisms to support improved product verification and authentication for Chinese consumers.

Given the reliance of the SRL industry on the Chinese market being sensitive to consumer trends is an essential aspect of any approach to enhanced traceability. Fabinyi (2018) states that the value of Australian seafood exports as grown from around 1 billion dollars in 2013 to 1.4 billion dollars in 2017. Based on the statistics from Savage and Hobsbawn (2014), the value of all exported Australian Rock Lobster reached $693 million dollars between 2015 and 2016, occupying the largest component in the value of Australian seafood exports. The value of exported SRL was estimated to over $300 million dollars annually, which accounts for a large percentage of the Australian Rock Lobster export industry (Hodge 2017).

It is anticipated that the value of SRL exports will continue to grow due to increasing demand from the Chinese market (Fabinyi 2016) and as a result of the Australian government and Chinese government, CHAFTA, trade agreement. This growth is also anticipated because of the growing wealth of Chinese consumers and their increased sensitivity to food safety following numerous food safety problems.

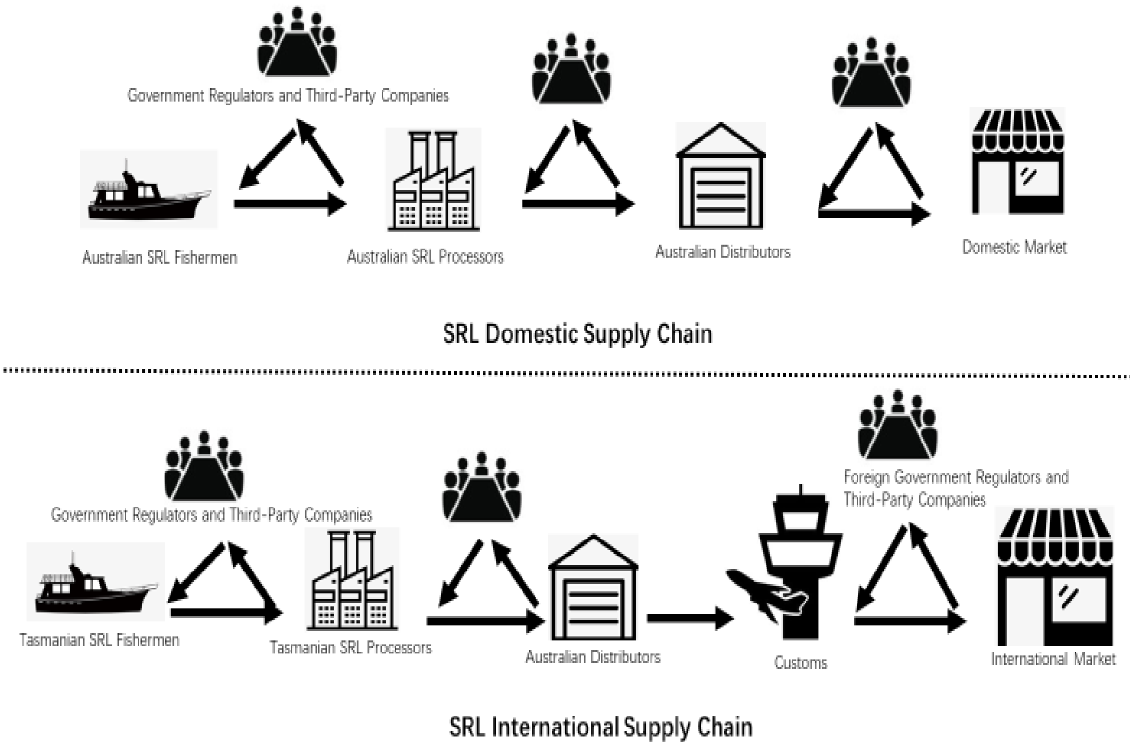


Figure 9 SRL Domestic and International Supply Chains

Indeed Galvin (2017) records that over 50% of 133,000 Chinese participants surveyed were worried about the quality and safety of the food in China. Increasingly Chinese consumers are eager to know whether unhealthy pesticides or additives are still in their food and whether the food is processed in an unhealthy/unhygienic manner.

The response to these changing Chinese consumer expectations has been rapid developments in Chinese retailing with many companies competing to offer more traceability information to Chinese consumers. For instance, in Fresh Hema stores, consumers can scan the QR code on most products with their mobile phones to access to traceability information (Hsu 2018). The information is presented on a webpage, which includes various data elements, like a food-safety certificate and business licenses of the distributor (Hsu 2018). Although the products tend to be more expensive than those in traditional markets consumers are increasingly purchasing these products over products that do not have traceability information. These developments clearly have great relevance for the SRL industry moving forward.

Below are details from fieldwork visits to some Chinese seafood retailers to provide insights on the types of traceability information that Chinese consumers are already being exposed to with a range of products.

FreshHema

FreshHema is a subsidiary of Alibaba and promotes itself as innovative retailer in China by combining different functions together (FreshHema 2018). FreshHema is not only a physical supermarket, but also an on-line store. Customers can order products with FreshHema's app without visiting the store. FreshHema is also attempting to connect on-line with off-line shopping through home deliver Meanwhile, customers who visit the physical store to buy seafood can also get the seafood cooked and served at the store.

In addition, by digitising the supply chain, logistics and retailing, FreshHema has claimed to reduce labour and time costs through the use of smart devices to achieve product receiving, packing and delivery. FreshHema promises to deliver free in 30 minutes within 3 kilometers of the nearest store – this is the latest service delivery model (FreshHema 2018). As of September 2018, FreshHema had more than 50 physical stores across 16 major cities in China, including Shanghai, Beijing, Shenzhen, Guangzhou, Chengdu, Hangzhou, Suzhou, Kunshan, Xi'an, Wuhan, Nanjing, Fuzhou, Ningbo, Guiyang, Nantong and Haikou (FreshHema 2018).

Figure 10 Customer at the FreshHema Store in Chaoyang, Beijing

(Photo: Dong Feng 2017)

Gfresh

Gfresh is a B2B e-commercial company with 5 offices in China, Australia and Canada, that specializes in seafood trading and was established in 2014 in Shanghai (Shanghai Gfresh Network E-Commerce Co. 2018). The company sells seafood products originating from various continents, like treasure crabs, lobsters, abalone, oysters, king crabs and salmon from Australia, New Zealand, North and South America and Southeast Asia. The commodities sold by Gfresh are purchased directly from overseas factories without middlemen, therefore, the average price tends to be lower than some other business models. The products are replenished at 11 o'clock and 17 o'clock (Beijing time) daily, in order to meet customers' need (Shanghai Gfresh Network E-Commerce Co. 2018). In addition, Gfresh promises to send messages to consumers when the ordered products obtain customs clearance and leave the local airports.

Yuegezhuang market

This is a traditional seafood market in Beijing. Wholesalers do not use any information technology to verify the origin of Australian lobsters. The lobsters are put together into the tanks. Similarly in local restaurants (e.g.Zhixin seafood restaurant) no traceability information was available. Consumers were simply purchasing items in both locations based on visual inspection. Clearly this highlights the differences that still exist in the Chinese market. They also highlight how SRL are rarely being differentiated as a premium lobster product as compared to other species of lobsters from other countries.

Figure 11 Australian Lobsters Sold in a Traditional Market, China

This stated, the trend in retailing companies, like FreshHema, 7FRESH and Metro, is to compete for customers by providing more information on food products and to leverage digital technologies to support food authentication, verification and consumers communication and sales. For instance, in addition to paper product labels, FreshHema have also recently adopted PVC labels to certain live seafood e.g. a QR code is attached to Carp fish. After scanning the QR code with mobile phones, customers can obtain the corresponding traceability information of the product, including the product picture, certificates of the distributor and basic product information. Moreover, the basic product information contains a variety of data elements, such as: product name, supplier name and distributor name.

Similiarly the 7FRESH retailer that is a subsidiary of JD.Com promotes its ‘Magic Mirror’ technology to attract consumers. The company publicizes its ‘Magic Mirror’ technology utilizes block chain technology to ensure the integrity of the product information. The food product information is presented on the ‘mirror’ displayed on the food cabinet. After consumers scan the bar code with the reader installed on the product shelf a screen, displays the information on the product including provenance information.

Figure 12 Product Information displayed by ‘Magic Mirror’ technology in 7Fresh Store

In summary, the Chinese field trips have identified that there is a trend towards increasing sophistication in traceability information being provided to, and demanded by Chinese consumers. This trend has direct implications for the SRL industry selling it product into the Chinese market and strengthens the case for pushing forward with improved traceability systems.

The Approach for SRL Traceability Systems

Broadly Phase Two of this project aimed to develop a tailored approach for SRL traceability systems that would support the industry to improve tracking and tracing of Southern Rock Lobster (SRL). Work completed in several adjacent industries including salmon, abalone, prawns and reef fish have contributed frameworks for traceability which are in widespread use. More broadly the Marine Stewardship Council (MSC) has introduced a set of traceability requirements making all MSC-certified seafood responsible for being traceable back to origin. Other industries also have established traceability practises and these industries include: beef, pork, chicken as well as forestry, timber and cotton.

Whilst all previous work agrees on the principles of traceability ('…the capability to trace something'), what becomes apparent from reviewing this work is that traceability is distinctly different from a methodological level. Tracing a tree or cow is different from tracing a prawn or salmon – largely as the type of Critical Tracking Events (CTEs) and Key Data Elements (KDEs), vary from product to product, and from industry to industry. As such reusing one of these existing traceability methodologies is broadly not possible given the variation.

Developing a Tailored approach for SRL traceability improvement

Whilst work has previously been done already by Muggleton (2004) on SRL systems, this work did not extrapolate a traceability approach that could accommodate the variety of sub-supply chains and varying business practises which exist within the Southern Rock Lobster (SRL) industry. The work largely focused on demonstrating the use of a small selection of technologies for item level tracking, and recording of temperature conditions on products, at a time which tended to predate rapidly changing conditions in government compliance and regulations, and systems and technologies development (particularly around the smart phones, the internet, and low-cost tags).

The literature review completed as part of the project identified a range of possible approaches to tracking and tracing products in SRL supply chains. Most critically, it included a distinction between tracking product batches and product items. A batch is a group of products which typically have a set of common attributes such as product type, manufacturing date, and supplier. Conversely, product items are the individual product within a batch and include all batch level attributes in addition to individual ones such as weight or use by date.

Often batch level traceability shares a common identifier with all products of a batch, whereas item level traceability shares both a common batch identifier and appends a unique identifier to the end of the number to identify the item within a batch. Often the use of batch or item level identifiers is associated with choice of traceability labelling. Barcodes are often batch level identifiers (and therefore require barcode number schemes, barcode readers and databases). Conversely item level identifiers are often associated with Quick Response (QR) codes and tags, or Radio Frequency Identification Number (RFID) Electronic Product Codes (EPCs) and tagging technologies.

The preliminary survey of Southern Rock Lobster (SRL) stakeholders from Phase One identified a range of characteristics of SRL supply chains, products, and business practises likely to impact on traceability systems design and implementation. Most critically different entities exist along the supply chain which handle the main product (live SRL) in different formats (individually, cartonized and palletized) in both fresh and live states and with varying levels of sophistication. Some businesses are highly sophisticated already employing information technologies including handhelds, barcode scanners and databases, while other businesses rely only on government-manded paper-based systems of reporting.

Other characteristics of the supply chain present both opportunities and challenges for the design and implementation of an approach to traceability. These range from where the supply chain starts and terminates – some are domestic only supply chains operating only within Australia, and others are international spanning multiple countries. Another common consideration is whether individual SRL are handled as live animals or frozen, or some part of a frozen animal (such as frozen tails).

As a result of the above characteristics and the research team's understanding of the SRL industry context, existing levels of traceability, technology usage and supply chains, it has been necessary to propose a tailored traceability systems approach, as this is much more likely to be effective for Southern Rock Lobster (SRL) supply chains.

This tailored approach for SRL traceability systems integrates several techniques reviewed in the previous sections of this report and is designed to work within the above characteristics. As such, by integrating the SRL supply chain characteristics, traceability requirements and available techniques, this section of the report presents the traceability systems approach designed for SRL supply chains. The aim of this approach is to be:

- Flexible and responsive in the face of changing regulatory, systems, technologies and product requirements, while being compatible with different pre-existing levels of traceability practice to enable businesses with a variety of ways to improve their traceability practises either incrementally or in major initiatives;

- Able to support traceability of products at varying levels of sophistication from batch level (consignment and carton level) through to item level (individual and unique product), with associated price points;

- Able to take advantage of resources already present in individual SRL businesses along the supply chain and provides an upgrade pathway which is cost effective, works to achieve minimum levels of standards and compliance, and future proofs investment.

To facilitate this, the approach is based on the integration of two systems methodologies - Quality Management, and Traceability. From Quality Management, the SRL traceability approach leverages the concepts of: continuous improvement and plan-do-check-act. Conversely from traceability techniques the SRL traceability approach leverages the concepts of: breadth, depth, precision; and one-up-one-down traceability.

Quality Management Principles

The approach for SRL traceability systems leverages the principles of Quality Management (QM) in order to provide guidance around applying and maintaining the approach in practice. QM promotes the idea of 'continuous improvement' – starting with a system design, implementing it, and then updating it. It promotes the idea of constantly looking at ways to improve and make things better. Taking advantage of developments in systems, technologies as well as new information and knowledge as it emerges.

As many of the businesses in the SRL industry have limited traceability systems in place, the principle of continuous improvement provides them with an opportunity to build on their existing traceability systems rather than replace them. It provides them with encouragement that they can start with a minimum traceability set of practises and progressively build up over time to a more complete system. Continuous improvement also lends itself to businesses' in the SRL industry which already have a strong record of traceability. It also provides them with incentives to maintain, upgrade and improve their traceability practises as and when new systems, technologies, information and requirements emerge.

QM in traceability also offers an approach to the entire SRL supply chain which is made up of businesses of varying traceability capability. As the individual business within the supply chain becomes more sophisticated the overall supply chain can become more sophisticated in its approach to traceability. It encourages all parties in a supply chain to upgrade their own traceability performance as a way of upgrading the entire supply chains traceability performance.

Critically, QM in SRL traceability supply chains is not about adopting a one-size-fits-all traceability system, or even an end-to-end traceability system, as one single system implementation. Rather it encourages progressive and piecemeal systems development, based on defined needs which emerge over time.

Continuous Improvement

Central to the approach for SRL traceability systems is the QM principle of 'continuous improvement'. For this tailored approach for SRL traceability systems it specifically means:

- Designing a suitable traceability system for the sub-supply chain by identifying which CTEs and KDEs are to be tracked;
- Implementing the design using systems and technologies either off-the-shelf or through custom development; and
- Following implementation, conducting a review (at defined times or triggered events) and responding to the identified improvements through further design and implementation.

Essential to a continuous improvement approach is under what conditions a system should be updated i.e. how often should the plan-do-check-act cycle (illustrated in the figure below) be repeated.

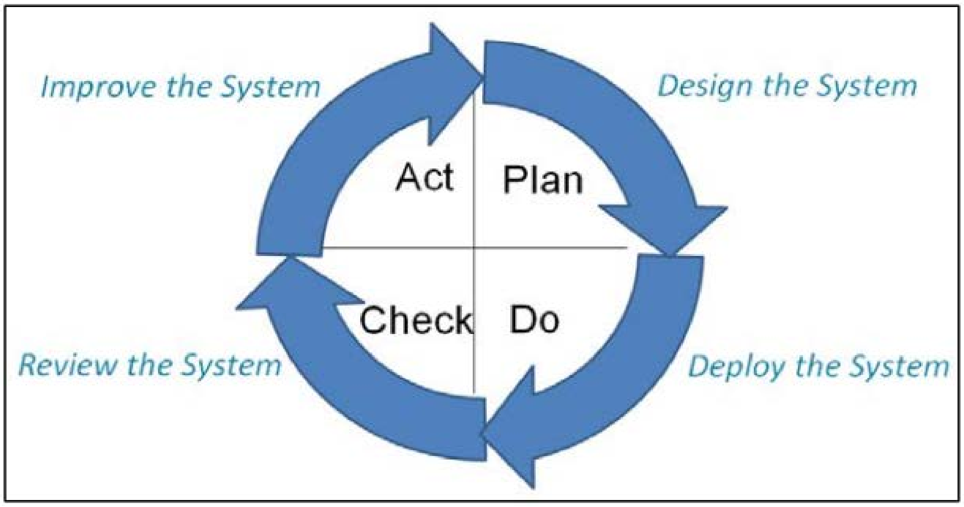


Figure 13 Diagram of the Plan – Do – Check – Act method of quality management.

This approach has been adopted for this project and is advocated for the industry moving forward as it supports continuous, incremental improvement for stakeholders within SRL supply chains. This approach includes both triggers for a traceability review and simple planning steps for regular traceability reviews. These are summarized below.

Triggers for traceability review include:

- **Voluntary or mandatory recall of SRL products.** For example, if a bio-toxin outbreak occurred and the government instructed Export Packers to recall product in the supply chain. In this scenario the traceability system should be reviewed, and any performance improvement identified should be acted upon.
- **Changes in Legislation.** For example, if the China Free Trade Agreement (CHAFTA) introduced new regulatory compliance requirements for traceable product. The identified changes would need to be introduced into the traceability system and updated.
- **Changes in SRL industry best practises or guidance material.** For example, if Clean and Green guidelines suggested a better way of tracking and tracing SRL, the traceability system would need to incorporate these improvements.
- **Changes in available systems and technologies.** For example, if a better traceability system or technology became available, the traceability system should be updated to leverage the better system/technology.

Planned traceability reviews: These should be reviewed annually by the business to establish conformance with system performance requirements.

- **Annual review of system performance:** the traceability system should be reviewed annually to check performance. For example, review against established conformance criteria, or any known performance issues are fixed.

- **Annual review of system performance under simulated recall requirements:** the traceability system should be 'stress tested' annually to confirm it could operate effectively considering a voluntary or mandatory recall of SRL product.

The QM principle of continuous improvement encapsulates the tailored approach for SLR traceability systems. It embeds 'traceability principles' that define how CTEs and KDEs are to be operationalized in SRL supply chains are discussed below.

Traceability Principles

The approach for SRL Traceability Systems assumes a supply chain management dimension that requires SRL trading partners to track and trace products along their supply chains.

The definition of 'product' includes: whole live SRL; frozen whole SRL; frozen SRL tails; and food products containing SRL meat. These products are distributed in both Australian domestic supply chains and foreign (primarily China) international supply chains, with transformation events making it possible to move from one SRL 'product' to another at different stages along these supply chains. The approach developed is therefore not limited to just live export supply chains.

Enhancing traceability practice involves each trading partner along an SRL supply chain collecting and maintaining information that enables products to be identified, and their origin from the transmitting trading partner recorded by the receiving partner in the chain. This supports, at the very least, "one up/one down" visibility of the SRL product's movement through the supply chain.

Thus, Supply chain traceability is the net result of two complementary business processes: *internal traceability* and *external traceability*. *Internal traceability* involves processes within an SRL trading partner's business to link the identity of received SRL products to the identity of delivered SRL products. *External traceability* involves the communication of SRL product identity, transport information and/or transformation information between trading partners.

Given the characteristics and contemporary context of SRL supply chains, the approach for SRL traceability systems has been primarily focused on enhancing one-up-one-down traceability. In essence, if enough trading partners in a supply chain cooperate for traceability purposes, then the approach anticipates that *'End-to-end' traceability* will be achieved. That is, when trading partners effectively implement internal and external traceability processes that support each traceability partner to identify the direct source and direct recipient of traceable SRL product. This is the "one up/one down" principle.

As such, to have an effective traceability system across the supply chain:

- Any SRL product that needs to be traced forward or backward should be globally identified in the supply chain;
- All SRL trading partners should implement both internal and external traceability practises; and

- Implementation of internal traceability should assure that the necessary linkages between inputs and outputs are maintained (especially important when transformation events create new SRL products e.g. frozen SRL tails).
- Linkages between SRL products with packaging, cartons, or crates must be maintained and by the adjacent trading partner. For example, a traceable SRL product and carton must be linked through internal traceability to each other. Trading partners must then record traceable identifier of the outer-most packaging.

Implementing traceability across the SRL supply chain relies on trading partners collecting, recording, storing, and sharing minimum pieces of information for traceability. In addition, the approach for SRL traceability systems leverages several specific traceability principles. These are:

Breadth
Traceability must meet minimum type and amount of information requirements.

Depth
Traceability must comply with back or forward information sharing requirements.

Precision
Traceability must comply with batch and item movement or characteristics requirements.

Key Data Elements (KDEs)
KDEs are those data required to successfully trace a SRL product and/or its ingredients through all relevant CTEs.

Critical Tracking Events (CTEs)
CTEs are points where a SRL product is moved between premises or is transformed, or is determined to be a point where data capture is necessary to maintain traceability.

Traceable Entity Workflows
Traceable Entity Workflows capture the need for both internal and external traceability. Internal traceability involves processes within an organization to link the batch identity of raw materials to the batches of the finished goods. These processes support traceability by associating input products with output products when industry participant creates a new product.(Internal CTE workflows illustrated in the figure below).

External traceability involves the communication of product identity and transport information between trading partners. To maintain external traceability, traceable item identification numbers must be communicated to distribution channel participants on product labels and used in related paper or electronic business documents.

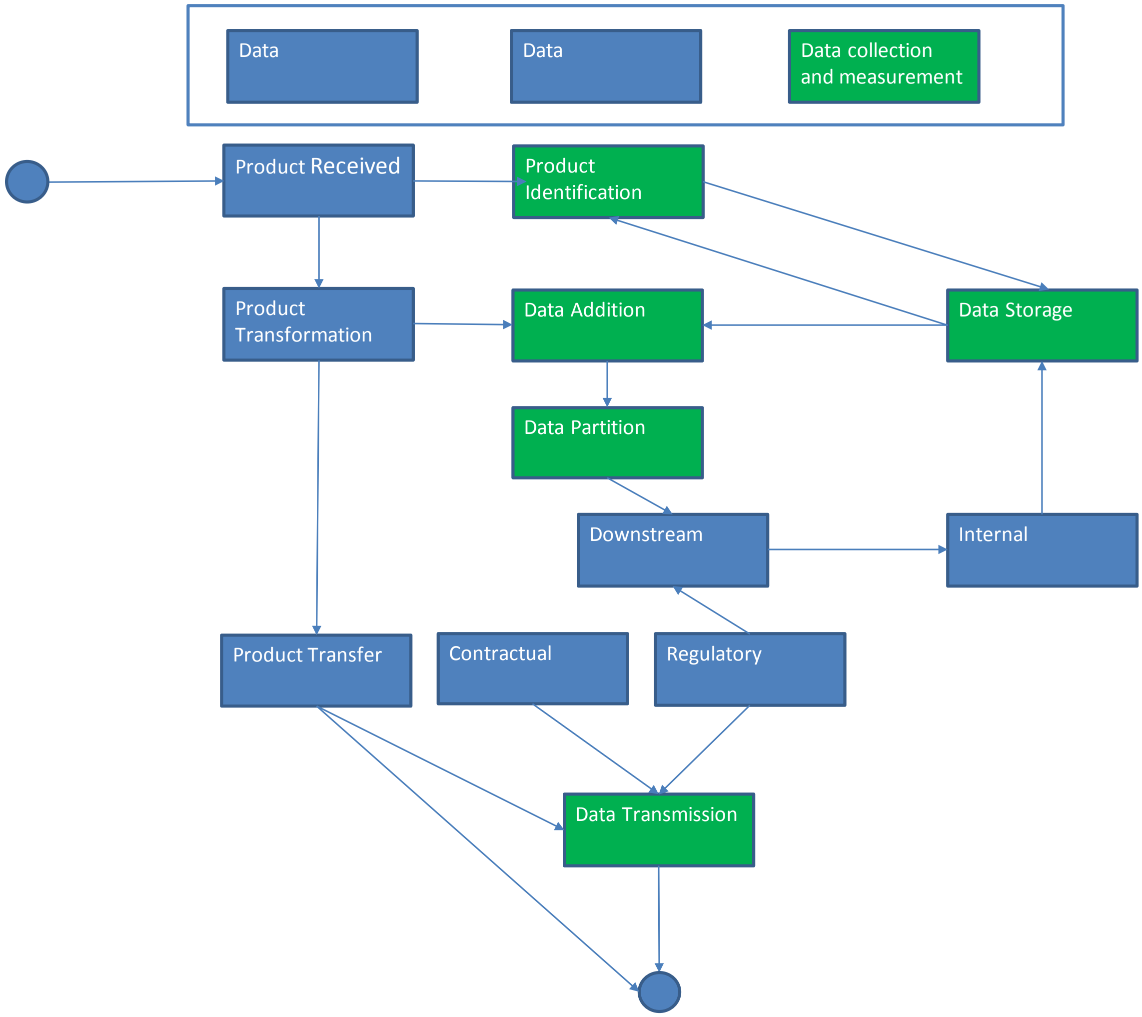


Figure 14 Traceability entity workflow for the SRL Industry showing internal CTEs

Case Study – Barcode and Labelling Database

Introduction

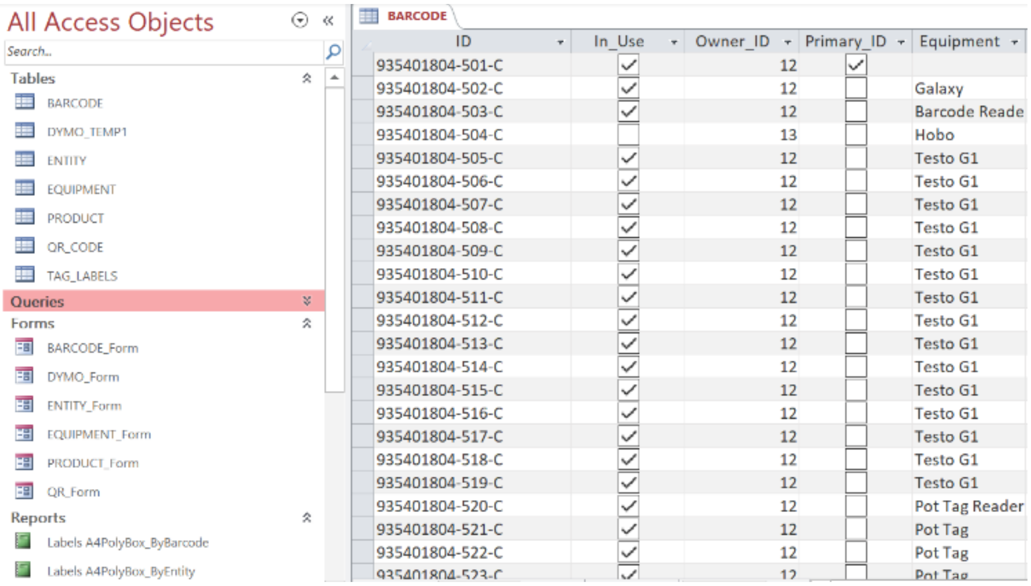
A key requirement of the approach for SRL traceability systems in Phase Two was the ability to have a globally unique identification system to identify batch and item level SRL products given the international nature of the supply chain and large number of supply chain participants. As a globally unique identification and numbering system for products in supply chains called GS1 was used. Specifically, the project used GS1-128 barcodes to identify SRL products and equipment within the SRL sub-supply chains which were of focus in Phase Two. A GS1 account was registered and 10,000 Global Trade Item Number (GTINs) i.e. barcodes, for the GS1-128 barcodes being used. A database was developed to store the barcodes and link them to SRL supply chain products (e.g. batch and item level SRL products), entities (e.g. Boats, factories, trucks), and equipment (e.g. holding tanks, cartons and poly boxes) used for traceability, as well as the Global Trade Item Number (GTINs) for the GS1-128 barcodes being used.

The aim of this case study is to demonstrate low cost, low impact traceability and data storage for GTINs and connected data which can be used to track and trace batch and item level products within SRL supply chains.

Methodology

The tracking of GTINs, affixed to batch or item level products, was identified as being a high priority for the project. The barcodes on labels were identified as needing to be linkable to the items they were attached to, and this information needed to be accessible when not physically on site. The software implementations designed did not allow for the storage of some KDE information attached to the GTIN, but it was key that this information be available, updateable, and in a format that could interface with the software implementations at a later stage.

A database (Fig. 3.2.2) was developed in Microsoft Access that stored information relating to barcodes, entities, products, and equipment within the supply chain. The database was developed to be flexible and extendable; able to be used for one Entity within a CTE, or along one or more supply chains. The database focused primarily on the GTIN, with each GTIN purchased and available coming pre-entered in the database (Fig. 3.2.3). Users could then add entities, products, equipment, and QR codes, with linked information relevant to each item able to be stored. The database was also linked to the printing functions for all labels, so that labels could be assigned and printed with ease, and information about the item being labelled could be displayed on the labels in a human readable fashion, along with the scannable barcode.

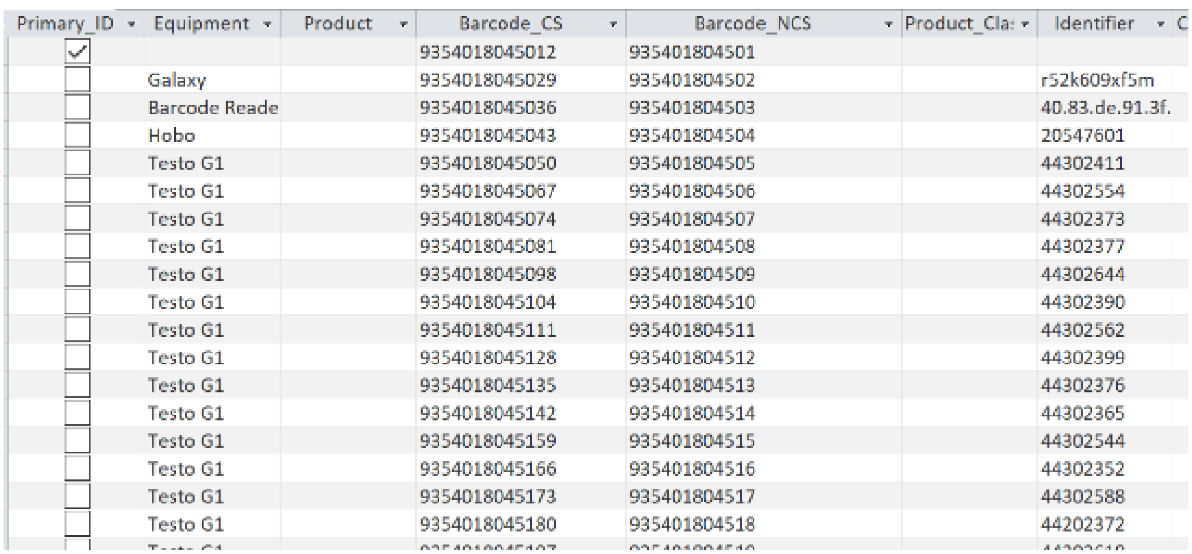


ID	In_Use	Owner_ID	Primary_ID	Equipment
935401804-501-C	✓	12	✓	
935401804-502-C	✓	12		Galaxy
935401804-503-C	✓	12		Barcode Reade
935401804-504-C		13		Hobo
935401804-505-C	✓	12		Testo G1
935401804-506-C	✓	12		Testo G1
935401804-507-C	✓	12		Testo G1
935401804-508-C	✓	12		Testo G1
935401804-509-C	✓	12		Testo G1
935401804-510-C	✓	12		Testo G1
935401804-511-C	✓	12		Testo G1
935401804-512-C	✓	12		Testo G1
935401804-513-C	✓	12		Testo G1
935401804-514-C	✓	12		Testo G1
935401804-515-C	✓	12		Testo G1
935401804-516-C	✓	12		Testo G1
935401804-517-C	✓	12		Testo G1
935401804-518-C	✓	12		Testo G1
935401804-519-C	✓	12		Testo G1
935401804-520-C	✓	12		Pot Tag Reader
935401804-521-C	✓	12		Pot Tag
935401804-522-C	✓	12		Pot Tag
935401804-523-C	✓	12		Pot Tag

Figure 15 Developed Database, showing elements of the BARCODE table

Results and Discussion

The database was used to assign barcodes through a check-in process, de-assign barcodes through a check-out process, and print labels of all sizes through either internal print report generation, or the creation of temporary tables for use with proprietary label printing software. The database was used to track each entity and supply chain in the research, all GTIN owned by them, and all other non-assigned GTIN.



Primary_ID	Equipment	Product	Barcode_CS	Barcode_NCS	Product_Cla:	Identifier	C
✓			9354018045012	935401804501			
	Galaxy		9354018045029	935401804502		r52k609xf5m	
	Barcode Reade		9354018045036	935401804503		40.83.de.91.3f.	
	Hobo		9354018045043	935401804504		20547601	
	Testo G1		9354018045050	935401804505		44302411	
	Testo G1		9354018045067	935401804506		44302554	
	Testo G1		9354018045074	935401804507		44302373	
	Testo G1		9354018045081	935401804508		44302377	
	Testo G1		9354018045098	935401804509		44302644	
	Testo G1		9354018045104	935401804510		44302390	
	Testo G1		9354018045111	935401804511		44302562	
	Testo G1		9354018045128	935401804512		44302399	
	Testo G1		9354018045135	935401804513		44302376	
	Testo G1		9354018045142	935401804514		44302365	
	Testo G1		9354018045159	935401804515		44302544	
	Testo G1		9354018045166	935401804516		44302352	
	Testo G1		9354018045173	935401804517		44302588	
	Testo G1		9354018045180	935401804518		44202372	
	[illegible]		[illegible]	[illegible]		[illegible]	

Figure 16 Identifiers in the GTIN table of the database

It was identified that a form of redundancy was required to ensure that, in the case of the detachment of a label, a barcode could still be linked to the tag, container, or technology. This would allow for the manual entry of data, the ability to recall information on a product or equipment, and the ability to reissue a label with the same barcode. Without a form of redundancy, if a label was detached, the item being tracked would no longer appear in the one-up one-down traceability system, leading to loss of information and potential miscalculations within the supply chain. Identifiers for the item attached were added where appropriate, to ensure that redundancy was possible.

The decision was made to use TBarcode instead of storing images, to ensure that the database did not have requirements for storage that may exceed the resources within small organisations along the supply chain. TBarcode software, which is embeddable within all Microsoft products, was used to generate GS1-128 barcodes for printing where required. The processing time required by TBarcode was tested and found to be insignificant when printing large batches of labels, making it attractive. The TBarcode software was also used as required, to generate QR codes based on the QR code data stored within the database and can generate a variety of barcode types, where required.

Take home messages

Implementation and use of the barcode database identified that:

- Redundancy for labels in traceability is important, and easily implementable at the time of labelling, provided that the technological implementation used allows for its entry
- Database storage requirements can impact on organisations with lower resourcing, and the use of embedded software to generate images at time of processing does not significantly impact the time taken to carry out the labelling process
- The database developed was designed to be flexible, able to assign barcodes for an entire supply chain, or a single organisation within it, dubbed an entity.

Moving forwards, the SRL Industry may consider registering a single GS1 account and purchasing sufficient GTINs to assign all SRL supply chain participants with identifiers to track and trace their products as part of a single unified approach to track and trace.

Traceability Practises

Traceability practises encompass the sophistication of traceability data in the system. The aim of this section *is not* to provide specific guidance or recommendations on which specific vendor systems or technology should be used to conduct traceability practises. This section is about focusing on the data and describing the relationship between physical traceable entities and workflows in the supply chain, and associated data and data functions (This is illustrated in the figure below). Arising from this is an awareness that the greater the number of traceability processes the more sophisticated the traceability system.

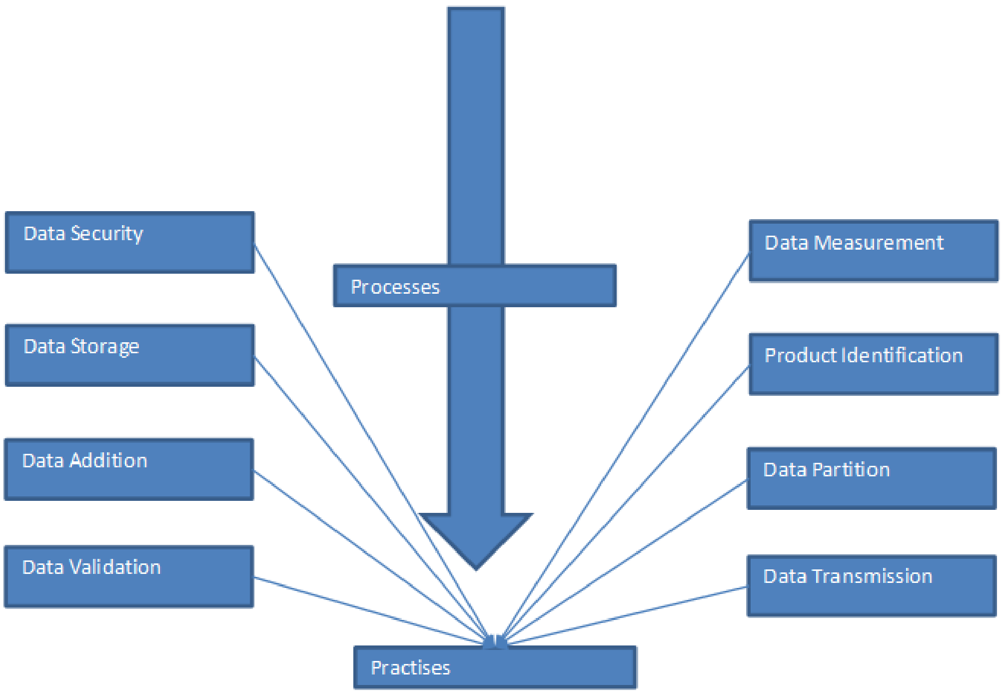


Figure 17 Relationship between Traceability Processes and Business Practises

Product Identification: The traceability system can generate data which identifies traceable entities either at the batch or item level. Product identification usually requires the use of a numbering system such as GS1 Barcodes along with entity surrogates such as tags or labels. Product identification associates a number via a surrogate to the physical traceable entity in the supply chain. Data is generated when the surrogate is within range of a reader (such as a barcode scanner) or is visually inspected by a person.

Data Addition: The traceability system can take multiple sets of product identification information from within the same traceable entity workflow, or between traceability entity workflows, adding information to create new traceable records. An example of this is when a business receives traceable lobsters from an upstream supplier, recording the arrival in their database along with other arrivals information.

Data Partition: The traceability system can disassemble a traceable entity into smaller packages or consignments, and by way of separation, also separate or 'partition' data. An example of this is when a 44 AKE (load container) arrives in China and some of the cartons are separated by the wholesaler – the physical consignment is separated, and as such, the data records are now separated for the consignment.

Data Storage: The traceability system can store traceable entity data in using paper based or electronic systems. Paper based systems could include folders containing consignment, order or delivery slips. Electronic systems could include flat files, databases, e-commerce websites or emails.

Data Transmission: The traceability system can share information within the business or between businesses in the supply chain. Data transmission is influenced by data storage mechanisms – electronic data storage in a database is usually linked with capability to transmit traceability data in electronic format. Data transmission can also be paper-based with carbon copies of airway bills, information displayed on the outside of AKEs (load containers) or lobster cartons also acting as examples here.

Data Security: The traceability system can ensure data is protected from unauthorized use or access by utilizing appropriate information security controls. If data is in paper format, then this might include ensuring physical access to data records by way of a locked filing cabinet. If data is in electronic format then this might include the use of usernames and passwords, or encryption technologies.

Data security is also fundamentally linked to data integrity – that traceable data is not modified by unauthorized users. As such appropriate security controls should also ensure data is not able to be modified, or there are mechanisms in place to expose changes in data. As a large amount of data in a traceability system is based on security and integrity of the traceability system identification capability, protections need to exist at this layer to ensure data security.

In systems using labels or tags for example, it might mean ensuring labels or tags cannot be removed from traceable entities (such as Lobsters or Cartons), cable tie tags are one such solution here. It might also mean the use of additional surrogates to establish authenticity of traceable entities – holograms on cartons for example, which cannot be easily copied, to establish authenticity of the actual box.

Data Measurement: The traceability system can derive new traceable entity information or data from measurement systems or technologies and instantiate this into the traceability system. An example of this would be the use of Time Temperature Indicators (TTIs) in lobster cartons. The TTIs are responsible for generating new data about a traceable entity. This data must be associated with a traceable entity and as such, the TTI and Carton could be linked by way of Carton Identifier or Consignment Identifier.

Data Validation: The traceability system can establish the accuracy of data by way of validation against reference or benchmarks. An example of this is when a consignee for SRL receives an order and confirms the cartons and contents with the order form. Conversely, it could occur when a TTI is used to validate the temperature of a carton along the supply chain.

Roadmap for Implementation of the Approach for SRL Traceability

Building on this tailored approach for SRL Traceability systems described above, a roadmap for implementation of improved traceability in the SRL industry was developed. The approach is described below.

These methods were based on a thorough understanding of the state of traceability within the SRL industry and have been developed based on detailed consultation with industry stakeholders in this project.

Importantly several characteristics of the SRL industry required the research team to find approaches, tools and techniques that could accommodate the diversity of characteristics of the SRL industry businesses and their various supply chains:

The supply chain characteristics to be addressed included:

(iv) The relatively fragmented production systems with limited economies of scale or inter-firm cooperation, despite some more recent consolidation at the processor level;

(v) Continued State-based variation in fishing practises, material handling and regulatory compliance protocols, including regulator acceptance of digital records;

(vi) Challenges managing bio-toxin prevalence that varies both between and within States but clearly poses risks across the whole industry.

As consequence of these industry characteristics the approach involved a design that could investigate traceability along the supply chain at three different levels reflecting differential needs/capacity of industry participants to achieve levels of breadth, depth and precision in their traceability systems.

The three levels of traceability focused on were:

- Batch level;
- Batch level with individual tagging;
- Item level with individual tagging.

These different levels of traceability were then investigated and implemented using a variety of systems and technologies in the six work programs structured as follows:

- WP1 - Batch Level Traceability (boat/truck/processor)
- WP2 - Batch Level Traceability with Individual Tagging (processor)
- WP3 - Batch Level Traceability with Individual Tagging (boat)
- WP4 - Batch Level Traceability with Individual Tagging (processor/overseas processor)
- WP5 - Item Level traceability with individual tagging (boat/truck/processor)

- WP6 - Item Level traceability with individual tagging (processor/overseas processor)

For each level of traceability investigated in the project several key steps/considerations were identified as follows across the six work-packages:

Batch level: Foci in work package 1.

- Modification and extension of current better practise using holding tank dividers at the processor/exporter stage.
- Where practical, fish to be segregated within processor/exporter holding tanks according to date of landing and either individual fisher ID or port of landing ID (if fish from multiple fishers are aggregated for transport at port).
- Processor/exporter to maintain digital records about which fisherman caught the fish being held in different segmented areas of the holding tanks as well as details of the landing date of the fish.
- Processor/exporter to append fisher/date data (or linkable reference) with all export consignments.
- Traceability is retained to a finite number of fisheries management grid reference blocks (e.g. 7.5nm2 in TAS and 55nm2 in SA) using current catch and effort reporting data. Confidentiality of data will need to be considered and legislated requirements to upload data in a timely manner. Options to leverage technologies including DeckHand may provide a basis for solving data sharing challenges.
- Processor/exporter record keeping maintained in a digital format and should be linked with the digital catch and effort record keeping system, possible via an extension to Deckhand.

Batch level Traceability with Individual Tagging: Foci in work-packages 1, 2, 3 and 4.

- Modification and extension of current better practice using holding tank dividers at the processor/exporter stage but also using individual tagging
- Processor to attach sequentially numbered tags to individual lobsters immediately after submersion in cold water and immediately prior to packing for final shipment.
- Processor to record sequential tag ID at beginning or end of packing each export consignment. All intervening tag IDs are assigned to a specific export consignment and should be linked to data on the fisher IDs and landing dates in a single digital database (e.g. tag numbers 500 through 1450 might be linked to three fishers and two dates).
- Overseas processor receipt and return of all tags/sensors as part of supply chain verification process.

Item level traceability with individual tagging: Foci in work-packages 5 and 6

- Fisherman to attach sequentially numbered tags to individual lobsters after they are caught and before they are mixed with other fish in the hold.
- Fisherman to enter details of the last tag number into electronic database (possibly modified Deckhand or equivalent) after each shot, or at the end of the trip.

- Where the fisherman enters the tag details after each shot, individual fish can be traced to specific GPS coordinates, or at least an individual fisheries management grid reference block.
- Where the fisherman enters details at the end of the voyage only, traceability is retained to all grid reference blocks visited, even if the catch is subsequently mixed with other fish at the processor/exporter stage.

Drawing on the approach for SRL traceability systems the differential levels of traceability were then investigated and implemented using a variety of systems and technologies. The project implemented the six work programs to investigate and implement traceability across these three levels in different segments of SRL industry supply chains in the 3 States (South Australia, Victoria and Tasmania).

Work Package 1:

The key foci were to support batch level traceability across the boat-truck-processor segment of the supply chain, improved labels were applied to the crates used to transport lobsters from the boats to the processing factories. By assigning unique GS1 bar codes to the boats, crates and facilities, lobsters could be tracked along the supply chain through the use of digital applications developed by the research team to capture KDEs and to automate the mandatory reporting at each step in the chain at the batch level of traceability.

Work Packages 2, 3 and 4:

The key foci were to support batch level traceability of individually tagged lobsters at processors, boats and at export. This method involved lobsters being individually tagged on the fishing boat with antenna tags that had unique GS1 bar codes. Individual lobsters were linked to the uniquely identified crates developed in WP1, providing batch level traceability from the boat to the truck and from the truck to the processor.

Work Packages 5 and 6:

The key foci were to support item level traceability with individual tagging across boat, truck and processor as well as individually tagging into export overseas market processor facilities. This involved individual lobsters tagged on the boat and linked to pots with pot tags. Upon offloading from the boats, lobsters were scanned to link them to crates. Upon arrival at the processing facility, lobsters were scanned as they were placed into holding tanks and when they were packaged for export, providing individual traceability along the entire chain and into the export facilities.

Approach to implementing trial and evaluation work

To demonstrate the utility of the traceability approach implemented in these work packages and to tangibly demonstrate improved traceability along the lobster supply chain – the research team have illustrated the approach through a series of trials and evaluation.

As an example, a trial conducted in Tasmania was designed to follow a single supply chain comprised of one boat and one processing facility. Prior to the trialcommencement the existing level of traceability was assessed using the benchmarking checklists presented in this report. Based on this analysis, the research team selected and deployed systems and technologies along the trial supply chain. On the fishing boat, pot tags that recorded GPS location and depth were deployed on 5 pots. Each pot tag was assigned a unique GS1 bar code and all lobsters caught using these pots were individually tagged using antenna tags with unique bar codes.

As these lobsters were removed from the pots, the identifying bar code of the boat, the pot and the lobster identification bar codes were scanned to create a record of the first CTE. When the lobsters were unloaded from the boat, each individual lobster was scanned, along with the crate into which it was placed. A data logger that recorded temperature, humidity and vibration (*g* force) was also scanned and placed into the crate. These crates were loaded onto a truck operated by the processing facility, which was also assigned a unique identifier. The truck transported the lobsters to the facility, where the crates were scanned as the lobsters entered the facility. At the facility, the processor scanned lobsters as they were placed into holding tanks and then into poly boxes for export. The KDEs collected at each CTE in this trial are presented below (see Table below). At the conclusion of this trial, the traceability checklists were conducted again for each segment of the supply chain to provide an objective measure of the improvement in traceability.

Critical Tracking Element	Key Data Elements collected		
CTE 1	Boat ID	Pot ID	Lobster ID
CTE 2	Lobster ID	Crate ID	Logger ID
CTE 3	Crate ID	Truck ID	
CTE 4	Crate ID	Facility ID	
CTE 5	Lobster ID	Tank ID	
CTE 6	Lobster ID	Poly Box ID	Logger ID
CTE 7	Poly Box ID	Truck ID	

Table 3 Key Data Elements collected at each CTE: Boat – Truck- Processor

This approach to the trial and evaluation work has been employed consistently across Tasmania, Victoria and South Australia throughout the Phase two work.

In summary, the research team conduct a benchmarking exercise to understand current traceability practises, identify suitable technologies to deploy, conduct the trial and subsequently re-evaluate to identify enhancements in traceability practises.

The checklists to benchmark performance are a key output of this project and are discussed and presented in a separate section below. Importantly they were used by the research team to evaluate contemporary traceability practises along the rock lobster supply chain and also to support benchmarking of traceability practice improvement from the trial and evaluation work conducted with project trial evaluation participants in Tasmania, Victoria and South Australia. The checklists measure Traceability Breadth, Depth and Precision along each segment of the SRL supply chain. The criteria 'precision' (the process and practises currently used in that supply chain segment) is assessed across each of the three types of traceability using 8 criteria evaluating the quality of the data/information collected and stored by these traceability practises (see Table below).

Traceability Precision Assessment							
Batch Level Traceability							
Batch Level Traceability with individual tagging							
Item Level Traceability with individual tagging							
1.Identified	2.Added	3.Partitioned	4.Stored	5.Transmitted	6.Secure or accessible	7.Collected or measured	8.Validated

Table 4 Benchmarking Performance: Assessing Traceability Precision

Simultaneously with the benchmarking of each segment of the supply chain the research team actively identified and evaluated new and existing traceability systems and technologies for use in the trial evaluation work conducted as part of the project. There were three aspects to this research work.

1. Updating and revising the Traceability Systems and Technology Products Guide provided as a standalone document accompanying this report. This is an up-to-date resource for industry to identify technologies suitable to advance their pre-existing levels of traceability into the future.
2. Conduct of laboratory testing of low-cost sensors to validate their accuracy and utility for deployment within particular segments of the rock lobster supply chain. From phase 1 work it was evident that the relative high cost of some systems for traceability has acted as a dis-incentive to industry investment. By evaluating new lower cost sensors entering the market-place and affirming their accuracy it was possible for the research team to deploy them as part of the trial and evaluation work.
3. Purchase, set-up and distribution of traceability systems and technologies as part of the trial evaluation research in Tasmania, Victoria and South Australia. As part of preparations for this deployment the research team designed and implemented a framework to integrate GS1 GTIN barcodes to provide global traceability to trialled tagging technologies used during in-field trial-evaluation work.

Case Study – Traceability Levels of Precision: item and Batch

Introduction

When traceability within the SRL supply chain is discussed, it is often assumed that the goal is the tracking of individual lobsters, which has been the goal of previous studies of traceability and the focus of other seafood industries such as the U.S. and Canadian lobster industry. However, traceability systems can be designed at different levels of precision, based on what information is captured and at what point in the supply chain. Here, we evaluate item level and batch level approaches to traceability within the SRL industry to better understand what the requirements are to achieve each respective level and what the pros and cons of each approach are for industry stakeholders.

Methods

Individual level

A fishing vessel in Tasmania was supplied with a set of 3 GPS pot tags and antenna tags with unique identification numbers. Over the course of a week-long fishing trip, all lobsters captured within a pot that had a pot tag were individually tagged with an antenna tag and the pot ID and lobster ID were recorded. When the vessel returned to the wharf, tagged lobsters were scanned using a barcode scanner (Fig. 3.2.5) as they were transferred to barcoded crates for shipment on to a processing facility, where IDs were again scanned and the lobsters were handled according to standard procedures. The collected data, consisting of the time stamp of each scanning event, was analysed to demonstrate that by linking each scanning event, lobsters were traceable from the GPS coordinates of the pot through to the processing factory.

Figure 18 Lobsters individually identified with unique, barcoded antenna tags

These fish are scanned upon transfer from the fishing vessel to transport truck, providing a traceable history linking the location of the pot to the crate received by the processing factory.

Batch level

Two methods of implementing batch level traceability were trialled in this study. In the first trial, the capture of data began on the fishing vessel, where lobsters captured in a pot containing a GPS pot tag were placed into a plastic crate with a bar-code ID. A barcode scanner was used to scan the pot tag ID and the crate ID (Fig. 3.2.6). The crate ID was scanned again when it was transferred from the vessel to the transport truck and upon arrival at the processing factory. Analysis of the collected time stamps and ID scans was conducted to show the chain of custody of the lobsters contained within the crate.

Figure 19 Plastic crate labelled with unique barcode identification

These barcodes were used in a traceability trial commenced on the fishing vessel.

In a second trial, conducted at a processing facility in Victoria, batch level traceability was evaluated by developing a system of procedures for processing in and holding lobsters by using movable dividers (see figure below). When a fishing vessel dropped off a load of lobsters, they were processed in all at once and placed into a section of a sub-divided tank according to the receipt date and the fishing vessel on which they were caught.

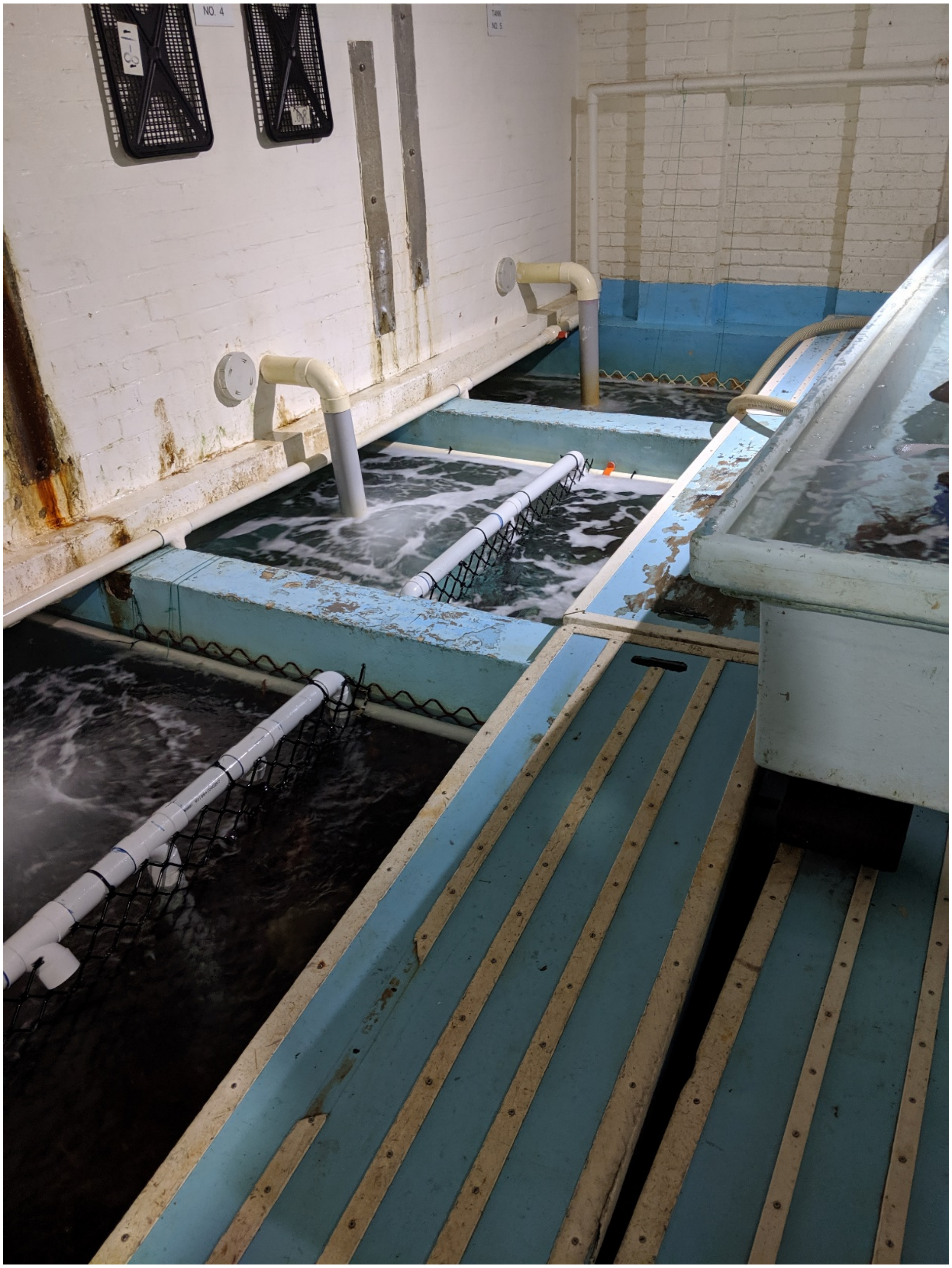


Figure 20 Holding tanks fitted with movable dividers to enable segregation of lobsters

The dividers allow catch to be separated by receipt date and fisherman to support batch level traceability.

Results and Discussion

Precision in traceability systems describes how fine the level of traceability is or is not. In the SRL industry, a high precision traceability system may be able to trace the entire pot-to-plate history of an individual lobster for sale in a Chinese restaurant. This level of traceability was achieved from the pot to the processing facility in the individual level trial in this study, but individual tagging was required to achieve it. Individual tagging is unlikely to be feasible for a number of reasons, including how labour and time intensive it is, the extra handling of the lobsters required and the potential hazard to the crew on fishing vessels during inclement weather.

In batch level traceability, information is collected that allows groups of lobsters, such as those caught on different boats or on different dates, to be distinguished from each other. However, within each group, there is no information that can differentiate between individuals. In this study, this level of traceability was achieved from the vessel and within a processing facility through means that were less intensive than individual level traceability required.

It is also important to consider that there are different levels of precision within "batch level." For example, a batch may consist of all the lobsters caught by a single fisherman during a week-long fishing trip in Tasmania. If the hold of that vessel is subdivided, however, the batch might consist of lobsters caught at a particular location or on a specific day. In the South Australian SRL fishery, where day trips are more typical, holding lobsters in crates can enable even further precision, such as to an individual pot.

Take home message

- Various levels of traceability precision can be achieved within the SRL industry and determining the desired level of precision is an important aspect of designing a traceability system.
- Individual level traceability can readily be achieved, but currently available approaches universally depend on tagging lobsters.
- Batch level traceability can be achieved through low tech adjustments to processes (i.e. holding tank dividers) and through the implementation of new technology (i.e. barcode scanners)
- The figures below illustrate the nature and type of precision data that is collected and analysed when assessing both item and batch level traceability.

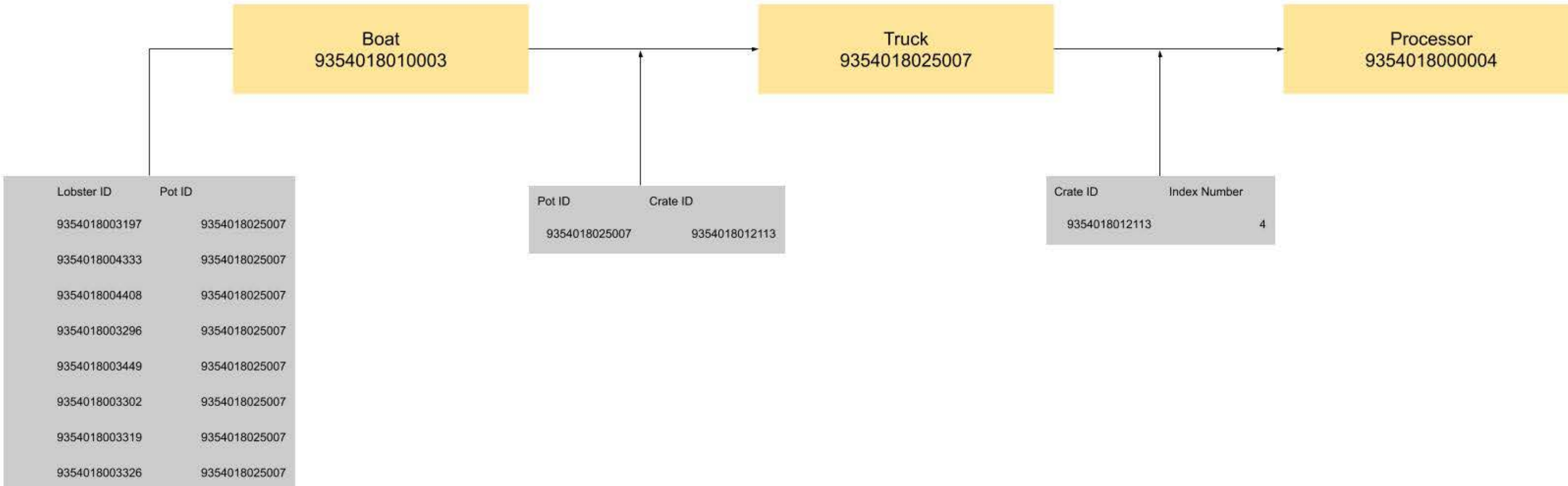


Figure 21 Data on individually tagged lobster demonstrating item level traceability.

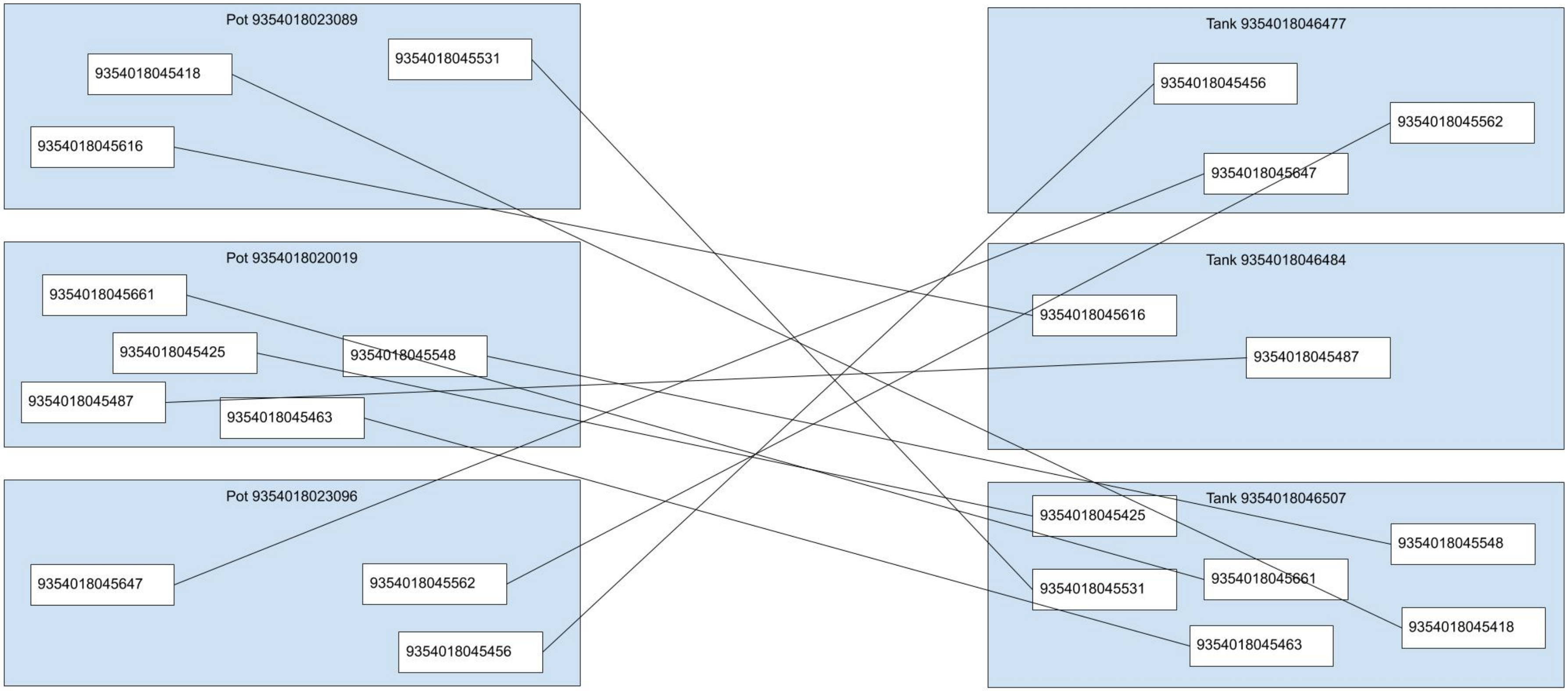


Figure 22 Batch level traceability data

Schematic of batch level traceability, where blue boxes on the left represent lobster pots identified with GPS pot tags, the numbers in the white boxes represent tagged lobsters and the blue boxes on the right represent tanks within a processor facility. The matching of lobster ID numbers demonstrates the ability to trace lobsters within a tank to the pot in which they were caught, which has its own time, date and location data.

Improving Traceability Practises: Policy and Procedures

In this section the essential elements of the tailored approach for SRL traceability systems is examined in relation to the required policy and procedures to support traceability practises. To support the approach the research team developed traceability specifications and exemplar templates for improving traceability policies and procedures that map to key roles and responsibilities and identify minimum Key Data Elements (KDEs) for each supply chain entity.

Policy and procedural templates are presented for individual businesses to use as part of their governance structures for traceability as these businesses interact with their supply chain partners. The procedures outlined have been developed to offer operating guidance in the form of a simple checklist containing criteria synthesized from the approach for SRL traceability systems. It is anticipated that this governance structure will encourage the strategic and operational use of traceability systems both internal and external to the business.

Purpose of Policy and Procedures Templates

The policy guideline provides the strategic basis and justification for traceability to a business and its supply chain partners. It does this by describing the scope of the business traceability system, the traceability objectives, the type of traceability, any key traceability principles, implementation guidance, and roles and responsibilities. These provide scope for all major decisions and actions related to traceability for the business.

The guidance on procedures aims to contribute operational advice through a simple checklist to confirm which parts of the approach for SRL Traceability systems have been adopted by the business. The checklist contains 19 key criteria synthesized out of the traceability approach which will assist SRL businesses to confirm their conformance to the advocated approach for SRL traceability systems.

As such, use of these policy and procedures should ensure the business traceability system produces outputs which are compatible with the tailored approach for SRL traceability systems. This is achieved through confirmation against the checklist criteria as some questions relate to key undertakings by the business (For example, 'how long have SRL been at the site?'), and also undertakings by the adjacent supply chain business partner (For example, 'does the sender of this lot and batch of SRL have back and forward traceability').

While it is not required for an adjacent supply chain business partner to conform to the policy and procedures, working through the checklist will directly assist the business to understand non-conformance – and support discussion on steps to be taken to lift traceability. It also makes adjacent supply chain business partners aware that a business is enhancing its traceability system in which their product is to be instantiated and tracked.

It is important to note: Both the policy and procedures guidelines have been carefully designed in order not to duplicate information that can be found in other traceability documents provided by this project. Where information is already available, references are made to these documents, to keep the guidance around policy and procedures succinct. Additionally, the policy and procedures guidelines intentionally avoid referencing specific traceability systems and technologies. This is to provide each business with scope to select any system or technology which meets the principles of the approach for SRL traceability systems. The guidelines are therefore generic and designed to be adapted to the needs of any individual business and its circumstances. To illustrate this generic approach the templates refer to "Company X" as a shorthand placeholder for any information relevant to tailoring the policy and procedures to any individual business that would then be able to add its business name, date, key personnel or associated policies etc.

It is acknowledged that many trading partners in the SRL supply chain already collect/record traceability information about inbound and outbound SRL for each CTE at points in the SRLs movement along the supply chain. This already supports the "one up/one down" principle of tracing a product's movement through the supply chain. However, formalising policy and procedures for this traceability linked to KDE and CTE data models support a much more strategic approach to implementing easily interoperable traceability data at key events in the SRL Industry supply chain. It also means that regardless of the existing approach to traceability (paper or electronic) it will be possible to rapidly improve traceability along SRL supply chains building on GSM1 standard models.

Case Study - Dashboard of Collected Traceability Data

Introduction

When collecting digital data on lobsters – in this case the lobster processing applications – a large quantity of raw data is collected. To manually search this data every time a report is needed would be time consuming and while it would advantage a business there is a high chance for human error.

This case study aims to improve the processing of data by making live reports that can be accessed by anyone with the right credentials. These reports allow better choices to be made at a management level without having to trawl through data that is hard to understand.

Methodology

The researchers reviewed the data gathered by the lobster processing application from the work done with processors in Tasmania and Victoria. When looking at this data it became apparent that it was hard to interpret without specialised knowledge and a large time investment.

The researchers spent time talking with the processors to understand the types of reports that would be useful to them. After this a trial was undertaken to see how the data could be represented in the ways needed by the processors.

Results and Discussion

The study was an initial test of the concept but still helps to show that this data can also be used by a processor. The reports were generated in real time and as a result all manual processing of the data by untrained end users was eliminated.

Another benefit is that this data can be viewed by as many people as are granted access meaning a reduction in the amount of printed and emailed reports. In one case these reports allowed a processor to stop the manual counting of the lobsters each time a stock request was put in.

Due to significant changes by the provider of the data processing software it was deemed not possible for the project to continue into this line of inquiry due to the increased time investment to learn the updated software.

In the future more reports are hoped to be generated with multiple access levels as well as readable displays of the data in raw format to ensure any error in entry of reporting are caught.

As a result, managers will not be stuck processing endless reports when their valuable time could be used in better areas.

Take home messages

A large part of lobster processing data is used to generate reports manually. This is clearly ineffective given the relative ease with which reports can be set up to automatically generate.

- Processing data can be reported on automatically eliminating the need for manual processing of data
- These reports can give real time data allowing for issues to be caught sooner and without having as much of an impact.

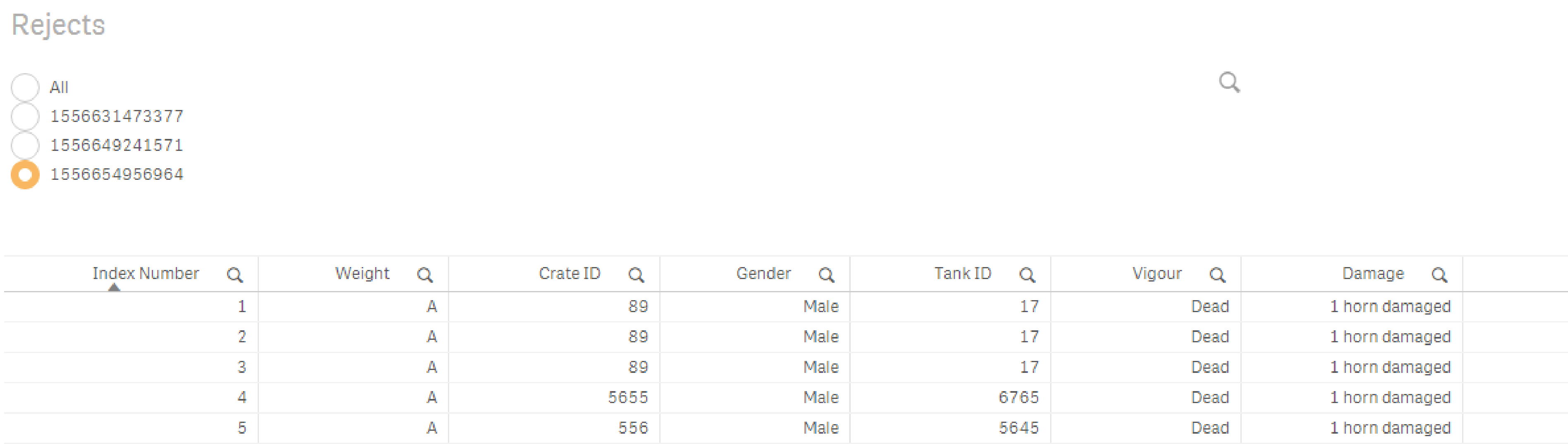
This means that with automatic reports managers and high-level employees can have more accurate reports in a shorter period of time. Thus, managers can be more confident that they are up to date with the current situation leading to better outcomes for the business.

Rejects

- All
- 1556631473377
- 1556649241571
- 1556654956964

Index Number	Weight	Crate ID	Gender	Tank ID	Vigour	Damage
1	A	89	Male	17	Dead	1 horn damaged
1	A	565	Male	667	Dead	1 horn damaged
1	A	56556	Male	7667u6	Dead	1 horn damaged
2	A	89	Male	17	Dead	1 horn damaged
2	A	565	Male	667	Dead	1 horn damaged
2	A	56556	Male	7667u6	Dead	1 horn damaged
3	A	89	Male	17	Dead	1 horn damaged
3	A	565	Male	667	Dead	1 horn damaged
3	A	56556	Male	7667u6	Dead	1 horn damaged
4	A	565	Male	667	Dead	1 horn damaged
4	A	5655	Male	6765	Dead	1 horn damaged
4	A	56556	Male	7667u6	Dead	1 horn damaged
5	A	556	Male	5645	Dead	1 horn damaged
5	A	565	Male	667	Dead	1 horn damaged
5	A	56556	Male	7667u6	Dead	1 horn damaged
6	A	565	Male	667	Dead	1 horn damaged
6	A	56556	Male	7667u6	Dead	1 horn damaged
7	A	565	Male	667	Dead	1 horn damaged
7	A	56556	Male	7667u6	Dead	1 horn damaged
8	A	565	Male	667	Dead	1 horn damaged
8	A	56556	Male	7667u6	Dead	1 horn damaged
9	A	565	Male	667	Dead	1 horn damaged
9	A	56556	Male	7667u6	Dead	1 horn damaged
10	A	56556	Male	7667u6	Dead	1 horn damaged
11	A	56556	Female	7667u6	Weak	Aesthetic concerns
12	A	56556	Female	7667u6	Weak	Aesthetic concerns
13	A	56556	Female	7667u6	Weak	Aesthetic concerns
14	A	56556	Female	7667u6	Weak	Aesthetic concerns
15	A	56556	Female	7667u6	Weak	Aesthetic concerns

Figure 23 Example of a large dataset generated using the Processor mobile app.



Index Number	Weight	Crate ID	Gender	Tank ID	Vigour	Damage
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3	A	89	Male	17	Dead	1 horn damaged
4	A	5655	Male	6765	Dead	1 horn damaged
5	A	556	Male	5645	Dead	1 horn damaged

Figure 24 Screenshot from database demonstrating ability to filter large datasets

The screen shot illustrates that the filtering function allows users to view only the desired information, for example, which were the reject lobsters from a particular batch (e.g. landed on a particular day or purchased from a particular fisherman) as illustrated in the case above.

Traceability Policy Template

Example: SRL Traceability Policy for Company X
Scope

This policy applies to all Southern Rock Lobster (SRL):

- Stored at any Company X site;
- Travelling to and from any Company X site.

Objectives

- Company X is committed to traceability for all SRL for customers and wholesalers along its supply chain.
- The SRL Traceability Policy aims to manage, mitigate and where possible, eliminate the risks of defective SRL in the supply chain.
- The policy is designed to meet the requirements of any legislation, rules, regulations and manuals relevant to Company X.

Definitions

Traceability is the ability to trace the history, application or location of that which is under consideration.

Traceability: types

- **Product traceability**: the physical location of a product at any stage in the supply chain.
- **Process traceability**: the type of activities that have affected the product during the growing and post-harvest operations (what, where and when).
- **Genetic traceability**: the genetic composition of the product and includes information on the type and origin (source, supplier).
- **Inputs traceability**: type and origin (source, supplier) of inputs, e.g. chemicals, processes or inputs used for preservation or transformation of the raw materials into processed products.
- **Disease and pest traceability**: the epidemiology of microbiological hazards and pests that may contaminate products.
- **Measurement traceability**: individual measurement results through calibrations to reference standards and assures the quality of measurements by observing various factors which may have impact on results (such as environmental factors, operations etc.).

Policy Statement

- All Company X workers must be made aware of this policy and the associated procedures;
- All Company X workers must comply with the principles of this policy and the associated procedures to ensure traceability of SRL at all times.

Principles

- **Breadth**: traceability must meet minimum type and amount of information requirements.
- **Depth**: traceability must comply with back or forward information sharing requirements.
- **Precision**: traceability must comply with batch and item movement or characteristics requirements.

Manuals for Implementation

Company X Executive Management must ensure that all ?? workers are aware of the Traceability Procedure, Traceability Manuals, and related training materials.

Responsibility for Implementation

The Company X Executive Management are responsible for the traceability of SRL and must ensure that the SRL Traceability Policy is correctly implemented. They must ensure that the Policy Principles and the SRL Traceability Procedure are followed by all Company X workers to manage traceability.

Related policies and Legislation

X (To be added by individual business)

X (To be added by individual business)

Effective Date

The Policy will come into effect on the day/month/year

Policy Review

The Policy will be reviewed annually by day/month

Contact Information for person responsible for policy implementation & maintenance

Name:

Mobile:

Email:

Example: SRL Traceability Procedure for Company X
Scope

This policy applies to all Southern Rock Lobster (SRL):

- Stored at any Company X site;
- Travelling to and from any Company X site.

Objectives

- Company X is committed to traceability for all SRL for customers and wholesalers along its supply chain.
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- **Product traceability**: the physical location of a product at any stage in the supply chain.
- **Process traceability**: the type of activities that have affected the product during the growing and post-harvest operations (what, where and when).
- **Genetic traceability**: the genetic composition of the product and includes information on the type and origin (source, supplier).
- **Inputs traceability**: type and origin (source, supplier) of inputs, e.g. chemicals, processes or inputs used for preservation or transformation of the raw materials into processed products.
- **Disease and pest traceability**: the epidemiology of microbiological hazards and pests that may contaminate products.
- **Measurement traceability**: individual measurement results through calibrations to reference standards and assures the quality of measurements by observing various factors which may have impact on results (such as environmental factors, operations etc.).

Critical Tracking Events (CTEs) are points where product is moved between premises or is transformed or is determined to be a point in the supply chain where data capture is necessary to maintain traceability.

Key Data Elements (KDEs) are those data required to successfully trace a product and/or its ingredients through all relevant CTEs.

Data Collection and Management defines how and where information related to products, customers, vendors and transactional data is collected, stored, analysed and moved across the supply chain.

Internal traceability involves processes within an organization to link the batch identity of raw materials to the batches of the finished goods. These processes support traceability by associating input products with output products when an industry participant creates a new product.

External traceability involves the communication of product identity and transport information between trading partners. To maintain external traceability, traceable item identification numbers must be communicated to distribution channel participants on product labels and used in related paper or electronic business documents. This links the physical products with the information needed for traceability. Standards are essential to this effort because they provide the common language that enables trading partners to exchange data and enables their IT systems to process and manage that data.

End-to-end traceability is achieved when trading partners effectively implement internal and external traceability processes that enable each traceability partner to identify the direct source and direct recipient of traceable items. This is the "one step up, one step down" principle. To have an effective traceability system across the supply chain:

Implementing the Traceability Procedures

The Company X Traceability Procedure above provides a template that is underpinned by a practical set of actions that must be completed to ensure traceability of SRL, in accordance with the Company X Traceability Policy and its associated principles.

In summary:

Policy Statement

- All Company X workers must be made aware of this policy and the associated procedures;
- All Company X workers must comply with the principles of this policy and the associated procedures to ensure traceability of SRL at all times.

Principles

- **Breadth:** traceability must meet minimum type and amount of information requirements.
- **Depth:** traceability must comply with back or forward information sharing requirements.
- **Precision:** traceability must comply with batch and item movement or characteristics requirements.

To practically progress the policy and procedures for traceability implementation the following questions should be answerable from the data generated by the traceability system as advocated by the tailored Approach for SRL traceability systems developed by this project. The questions are presented in the Table below:

1	*Does the sender of this Lot and Batch of SRL have back and forward traceability?*
2	*What Lot No. and Batch No. do the SRL belong to (goods receivable)?*
3	*When did the SRL Lot and Batch arrive in the site?*
4	*How long has the SRL Lot and Batch been in storage at the site?*
5	*How many SRL and their type make up the Lot and Batch?*
6	*What Grade, Condition and Sex are the SRL in the Lot and Batch?*
7	*Where are the SRL currently stored at the site?*
8	*How long have the SRL been at the site?*
9	*What is the condition of the holding tank at the site?*
10	*How many other SRL are packed with these SRL at the site?*

11	*Where are the SRL going and when?*
12	*Has all outbound logistics documentation been completed satisfactorily?*
13	*Does the receiver of this Lot and Batch of SRL have back and forward traceability?*
14	*Are all crates or cartons labelled with a GS1 barcode?*
15	*Is the barcode a batch or item level barcode?*
16	*Are all SRL labelled with a GS1 barcode?*
17	*Are all GS1 barcodes recorded on outbound logistics documentation?*
18	*Is the internal storage for Lot and Batch up to date with this consignment?*
19	*Is all accompanying shipment information prepared and linked to the consignment?*

Table 5 Traceability Evaluation Questionnaire

Case Study – The Use of Temperature and Humidity Loggers

Introduction

During transit live export produce can be exposed to environmental changes which can affect the mortality, quality, and safety. While manual tracking of environment is common, it does not accurately capture the full time that produce is in transit. This case study will give an overview of two technologies that were used to collect temperature, humidity, and shock data while produce was in transit. The implementation of loggers, whether it be temperature and humidity or some other parameter, is an example of process traceability that can be used to better understand and record the environmental conditions product is subject to during transport along the supply chain.

Methodology

Two brands of sensors were used for the collection of temperature, humidity, and/or shock while produce was in transit. These were the Temptale 4 temperature and humidity sensor (see figure), and the Testo H1 & G1 temperature, humidity, and shock sensors (See figure).

Figure 25 TempTale 4 USB Sensor

Temptale 4 temperature and humidity sensors are single use sensors which capture temperature and humidity at set intervals and export this information to a non-proprietary encrypted format. Output data can be analysed using proprietary TempTale Manager Desktop 6.0 or using traditional analysis methods. The sensors are USB connected and include alarm functionality.

Testo G1 and H1 sensors are multi-use sensors run on non-proprietary batteries. H1 sensors capture temperature and humidity at set intervals, and G1 sensors also capture shock. Data is output as a PDF Report, however the proprietary comfort software offers more in-depth access to the data, as well as some analysis functions. The sensors are USB connected and include significant customisation and alarm functionality.

Figure 26 Testo H1 USB Sensor

The sensors were deployed in multiple processors for internal recording, as well as along all CTEs for tracking during transportation.

Results and Discussion

The TempTale 4 sensors and the Testo H1 sensors worked as expected, recording and outputting routine temperature and humidity information. Testo H1 and G1 sensors were pre-configured on an as-needed basis, whereas TempTale 4 sensors came preconfigured.

It was identified that visual output of alarms could pose a risk while the sensors were in transit as individuals within the supply chain may experience anxiety or concern when faced with the alarm. To avoid behavioural changes or anxiety the alarm function was continued, however visual cues as to the state of the alarm were disabled.

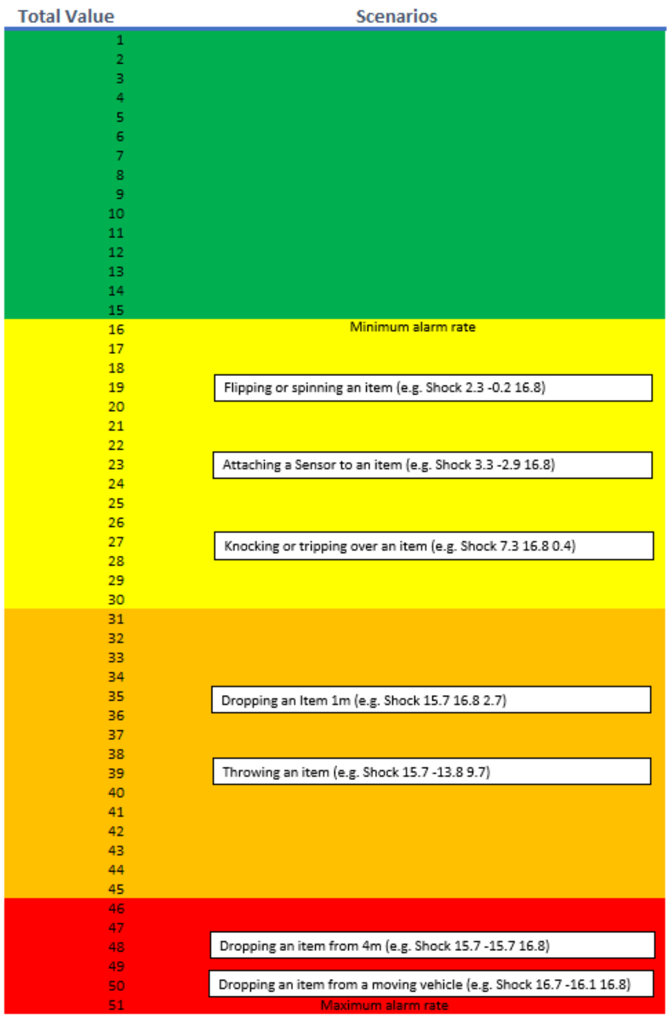


Figure 27 Testo G1 Sensor Shock Methodology Range

Early issues were identified with the shock outputs provided by the Testo G1 sensors. Due to the algorithm used to quantify shock levels, the outputs within the PDF report were not reflective of the impact being taken and were capped at too low a value to be significantly useful. Using the comfort software, a new method of quantifying impact was designed by normalising and adding the impact values on the x, y, and z axis, which were compared to a range. Testing was carried out to identify certain common behaviours along this new range (as displayed in the figure) and the method was shared with one processor, who analysed the data on site. The processor found success using the new method and were able to confirm the levels identified for common behaviours as being appropriate.

Take home messages

- TempTale 4 USB and Testo G1 and H1 sensors are appropriate for tracking temperature, humidity, and/or shock in transit. Each sensor has benefits and disbenefits which should be considered when selecting a sensor to use
- Visual representations that may or may not indicate mishandling should be disabled to ensure behaviour changes and anxiety do not occur for individuals handling the sensors and/or produce
- Pre-set algorithms within the Testo G1 sensors which quantified shock were insufficient as they were capped at a low value and often covered a significant range within one output.
- The data collected by these loggers can be used to demonstrate quality management, verify that current transport practises are optimal or to investigate the cause of losses.

Traceability Policy and Procedures: Next steps

The Southern Rock Lobster (SRL) industry should anticipate Australian and Chinese import/export regulations to mandate the use of batch, batch-item and item level traceability systems. Whilst the Chinese Free Trade Agreement (CHAFTA) does not specifically mandate any requirements around traceability for food safety purposes products need to be clearly identifiable back to their Australia origin.

The other recent change here has been a domestic one from by the Australian Department of Foreign Affairs (DFAT) which has expanded the requirement for 'known consignors' to any exporter of Australian products. The changes to known consignor legislation have forced SRL exporters to enhance export packing security through the use of: approved personnel; export paperwork; worksite security procedures; x-ray machines for consignments; and, tamper evident tape. These changes have strengthened 'batch' level security around consignments and fall only marginally short of introducing requirements to batch level traceability.

Although any further changes here are unlikely to mandate a specific set of systems and technologies and is almost certain to mandate stronger governance structures around track and trace SRL within the business and further along the SRL supply chain. A further stimulant to this could also arise from the potential increase prevalence of biotoxin outbreaks and the need to recall contaminated product. To this end, the guideline Policy and Procedure developed in the project provide business with an appropriate governance structure which should provide regulators with confidence the business has a strategic and operationally functioning traceability system.

To be of any significant use, traceability systems should extend as far along a supply chain as possible, and this is likely to be the intention of any regulations that mandate the use of traceability systems for the SRL industry. The question the SRL industry and its many stakeholder businesses should therefore be asking is 'how to encourage adjacent supply chain partner businesses to adopt and buy into the concept of traceability?'

Part of the answer is through the adoption of Policy and Procedure by individual business as this communicates governance requirements to business, sets expectations around traceability inputs and outputs, whilst providing a level of separation around specific systems and technologies (and critically, how an individual business is required to implement and invest to meet traceability requirements). The optimal situation is where an entire supply chain has adopted a single unified Policy and Guideline for traceability. The guideline presented here is careful to not limit itself to an individual business and therefore could be adopted by an entire chain. It can be adopted by business along an SRL supply chain, and then with enough uptake across the chain, be unified.

More broadly the Policy and Procedure introduced in this sub-section aims to proactively address the governance requirements around traceability in SRL supply chains and align the governance with a tailored SRL traceability approach

In order to provide the strategic and operational scope for the adoption and use of traceability systems in Southern Rock Lobster (SRL) supply chains, this Section has contributed a guideline Policy and Procedure. It can be adopted outright or adapted and integrated based on need, for business, in the supply chain to highlight the business commitment to traceability practises.

The Policy and Procedure align with the approach for SRL traceability systems put forward in the previous Section by capturing all the essential elements. It is focused on communicating the scope of traceability, the core operating principles, roles and responsibilities, and identifying essential criteria to meet. It avoids duplicating information from other traceability documents from the project and does not specify any system or technology leaving room for a business to decide on how they meet the requirements.

The major benefit provided by the guideline Policy and Procedure is a communicate tool to inform the business and its trading partners with its expectations for SRL traceability. It provides a scope to the business internal traceability undertakings and change practises. It also provides a basic for the business to checkpoint its adjunct business partners to identify their conformance to the approach for SRL traceability systems and identify how/where these business partners could upgrade their traceability in order to conform to the Policy and Procedure.

Another major benefit is Policy and Procedure's communicative use for the business to speak with regulators both in Australia and overseas. Whilst the legislation both domestically and internationally for Southern Rock Lobsters (SRL) does not currently mandate a functioning traceability system, in anticipation of changes from a range of driving forces (including: CHAFTA requirements, known-consignors, or biotoxin compliance), a business can adopt the guideline Policy and Procedure to demonstrate their commitment to enhanced SRL traceability.

Improving Traceability Practises: Using the KDE and CTE Data Models

Another key dimension of implementing the approach to SRL traceability systems presented in this report involves businesses understanding the minimum data requirements to support traceability. Building on analyses of existing key data elements (KDEs) available to support traceability, this section presents an initial set of KDEs within identified SRL Critical Tracking Events (CTEs) along lobster supply chains. The data models presented are intended to be further updated subject to new technologies being deployed or entering the market. The aim is to establish a minimum standard for what data format is necessary to undertake analysis of product traceability regardless of the technology used to collect and/or record this data. Underpinning this work are principles of traceability better practice adopted directly from GS1 the international not-for-profit organisation that develops and maintains standards for business communication <https://www.gs1au.org/>.

Supply chain traceability systems create an environment in which information and material flows are aligned. The forward movement of products in the supply chain can be recorded and archived in the event of a product recall, to provide provenance, authenticity or other marketing and branding information to consumers. As an example, For SRL supply chains there might a need for detailed traceability information due to a government-mandated recall of SRL products due to a biotoxin detection. These types of events require parties in the supply chain to determine who received a product and when, or where a product was sourced from and by whom, in order for those products to be recalled safely. Traceability can also be useful where a need arises to recall defective products, products which do not meet specification, or products which have exceeded product shelf life guidelines. Many of these recall scenarios are also broadly applicable to SRL supply chains. For example, live SRL product can be defective when mortality events occur or as a result of damage to product in transit (i.e. missing legs), SRL can be out of specification when temperature of consignments is above or below designated temperature ranges, and shelf life of SRL can be exceeded when live SRL stay out of water or above/below a temperature range beyond a designated time period (i.e. in conflict with established standards like those defined by ‘Clean and Green’). Regardless of the primary motivation for traceability, most scenarios have overlapping data requirements and similar data generation and data analysis solutions to instantiate traceability. That is, recalling a product due to a contamination event often requires very similar information as a recall due to a defective product. Data on who received the product, who sent the product, where did it go or come from, and when (date and time) are common data required.

In scenarios where enough entities along the supply chain between the source of the analysis requirement, and the original source, are collecting this data (i.e. end to end traceability exists) then it should be possible to successfully support appropriate traceability. Getting to start however is not straightforward as traceability data requirements vary for each industry and supply chain, and therefore, the question is, what data is required in the first place to make all of this happen?

KDE and CTE Data Models for SRL

This sub-section contributes data models that identify the traceability data requirements for SRL supply chains. These consist of Key Data Elements (KDEs) and Critical Tracking Events (CTEs) for the Southern Rock Lobster (SRL) supply chain – the who, where and when elements of a traceability system for all segments in the supply chain. The models are extensible with an initial set of KDEs and CTEs being identified here that it is anticipated witll be subsequently updated. This updating will likely occur depending on existing available technologies and new technologies which come onto the market and are adopted by individual businesses. As such, the objective here is to establish the minimum standard for what data is necessary to undertake an analysis for product traceability without losing sight of 'how' it can be implemented. As such, the focus is on developing an industry traceability data format as distinct from a traceability data implementation guide.

As the Southern Rock Lobster (SRL) industry is comprised of a large array of trading partners, from the fishermen to retailers (in Australia and overseas), these have been captured in the model as well as the known available data elements which should exist. What is not captured is the specific technology which can generate or capture the data as this is left to the technologies guide which is presented later in the report.

As such, this sub-section is applicable to: all SRL trading partners for use; all supply chain roles (including fishermen, transporters, processors, exporters, distributors, and retailers); and traceability practises along the supply chain, from the fishermen to the retailers.

This Section defines the minimum business processes, and traceability practises, needed to support traceability and demonstrates options for advanced traceability. And it should be used in conjunction with other results sections when planning, implementing (doing), checking, or responding (acting) to SRL traceability systems requirements.

Underpinning this work are principles of traceability better practice adopted directly from GS1 the international not-for-profit organisation that develops and maintains standards for business communication <https://www.gs1au.org/>.

Trading partners in the SRL supply chain collect/record traceability information about inbound and outbound SRL for each CTE at any point in the SRLs movement. This supports the "one up/one down" principle of tracing a product's movement through the supply chain, with the key events in the SRL Industry supply chain shown in the Figure below.

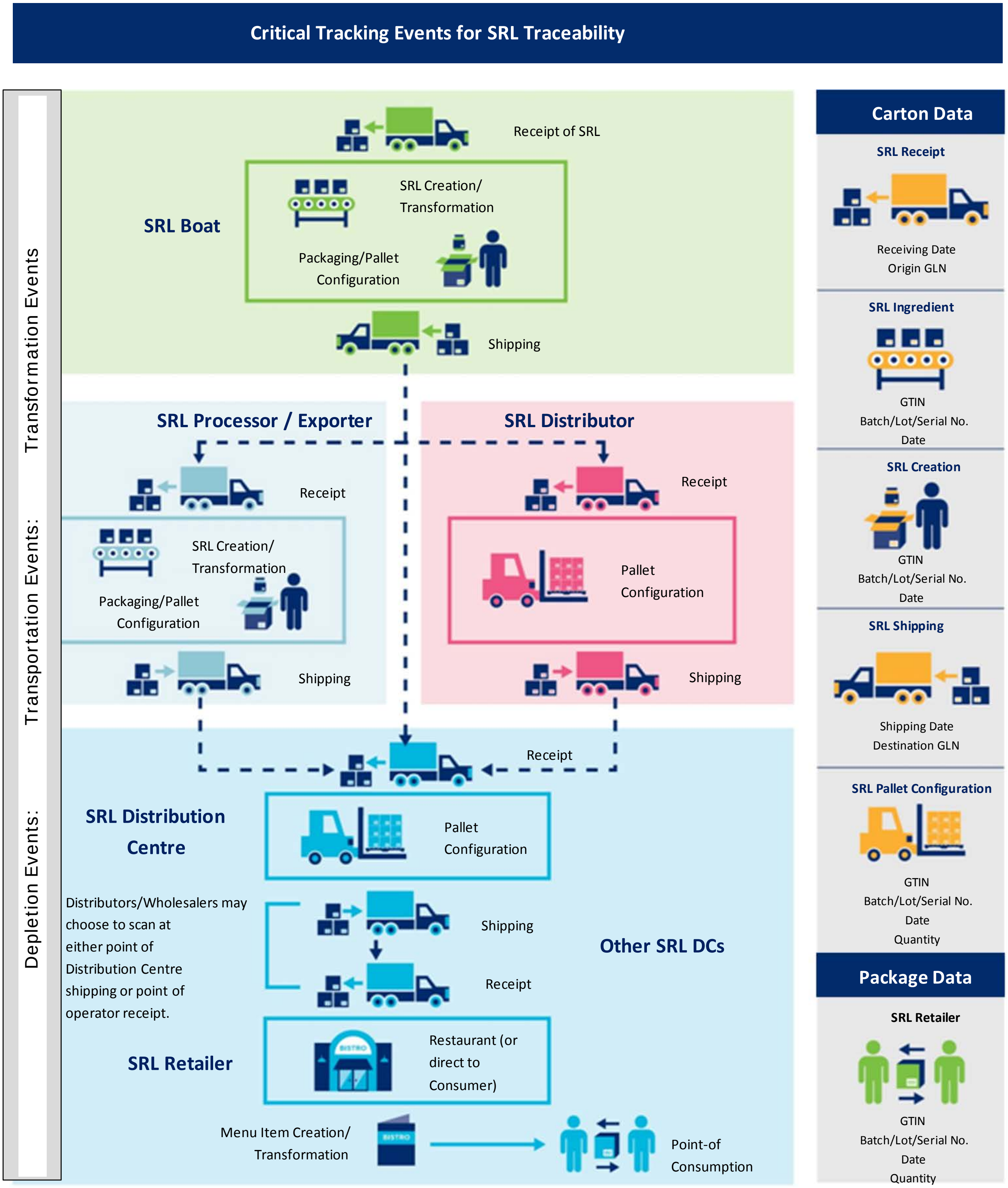


Figure 28 Critical Tracking Events for SRL Traceability

Identifying Data for Traceability in SRL supply chains

Table 6 shows the three types of CTEs that should be collected in an SRL supply chain with industry relevant examples.

Table 6 Types of SRL Critical Tracking Elements (CTEs)

Event Type	CTE	Description	SRL Example
TRANSFORMATION EVENTS *Events that typically support internal traceability within an SRL business*	TRANSFORMATION INPUT	An event where one or more SRL products are temporarily held to produce a new traceable SRL product in the supply chain.	Holding a live ungraded whole SRL in a processing centre, and then killing it to make frozen product.
	TRANSFORMATION OUTPUT	An event where a new traceable SRL product is entered or re-entered into the supply chain.	Exporting a graded live whole SRL. Cooked SRL for domestic sale which are packaged and labelled.
TRANSPORTATION EVENTS *Events that support external traceability between supply chain SRL businesses*	SHIPPING	An event where traceable SRL product is dispatched from a defined location to another defined location.	SRL consigned to truck at wharf.
	RECEIVING	An event where traceable SRL product is received at a defined location from another defined location.	Arrival of SRL at processing facility.
DEPLETION EVENTS *Events that capture how traceable SRL product is removed from the supply chain*	CONSUMPTION	An event where a traceable SRL product becomes available to consumers (Point-of-Sale or Prepared in Restaurant).	Restaurant in China.
	DISPOSAL	An event where a traceable SRL product is destroyed, discarded or otherwise handled in a manner that the SRL product can no longer be used as a food ingredient or made available to consumers.	Disposal of an SRL due to unplanned mortality.

Transformation CTE

Transformation events occur whenever a traceable SRL product is transformed either by:

- changing the nature of the SRL product itself by mixing different sources of product, adding ingredients, or cooking; and/or
- by changing the nature of the SRL product packaging, such as when a business places bulk SRL product in consumer-sized bags for consumer self-service.

There are two types of transformation events, "Transformation Input" for documenting the identity of input SRL products used in a transformation event, and "Transformation Output" for documenting the identity of output SRL products from a transformation event.

Transformation Input Event

An event where one or more SRL products are used to produce a traceable SRL product that enters the supply chain. Examples of a transformation input event are when whole live SRL product from one or more suppliers or sources are processed, combined, or further processed by cutting, cooking, repackaging, etc. The objective is to capture the supplier, product ID, and production unit designation (e.g., batch/lot number, carton serial number, sell-by or use-by date, production date, etc.) of all ingredients used to create a traceable product.

Transformation Output Event

An event where a traceable SRL product is packaged and labeled for entry into the supply chain. Examples of a transformation output event are when a new output product is placed into consumer item containers, and/or cartons and all package levels are marked to indicate supplier, product ID, and production unit designation.

Transportation CTE

Transportation events occur whenever a traceable SRL product is physically transferred from one trading partner to another. This product may be used as an ingredient in a later transformation event by the receiving business, or it could be traceable SRL product that is shipped by the receiving business to another trading partner without transformation. In some cartons the transportation of a traceable product between two processing or storage facilities of the same business may be documented as a transportation event. Typically, transportation events occur as a Shipping Event followed by a Receiving Event.

Shipping Event

An event where traceable SRL product is despatched from a defined location to another defined location in the SRL supply chain. Shipping CTEs are typically followed by a subsequent Receiving event. In some scenarios, a business could determine that shipping and receiving events should be recorded within their own business, such as when a SRL product batch in an interim state is transferred to another production facility to complete the production process e.g. dead lobsters are transferred from a boat to a export packer for freezing to produce packaged frozen lobster products. More typically, this event occurs when a traceable product is sent by airline, truck, rail, or ship from one supply chain business to another supply chain business.

Receiving Event

An event where traceable product is received at a defined location from another defined location. Receiving CTEs typically occur in response to an earlier Shipping event. Typically, this event occurs when a traceable SRL product is received at a location after being transported by airline, truck, rail, or ship between any two supply chain businesses but could also include receipt at one physical location after shipment from another physical location under the same ownership.

Depletion CTE

Depletion events occur when the product leaves the supply chain either by consumption events that make the product available to the ultimate consumer or by disposal events that remove the product from the supply chain in a manner that it can no longer be offered to or used by consumers.

Consumption Event

An event where a traceable product becomes available to consumers. Examples of consumption events include: when a carton of live SRL is opened and one or more lobsters is placed in a tank for sale to a consumer.

Disposal Event

An event where a traceable SRL product is destroyed or discarded or otherwise handled in a manner that the product can no longer be used as a food ingredient or become available to consumers. An example of a disposal event is when a carton of SRL product arrives at restaurant or retail store after its expiration date and is properly discarded.

Steps for Collecting and Evaluation of KDEs

For every CTE there are a large number of KDEs that are required. This sub-section explores the steps for collecting and evaluating KDEs

What information should be collected: Key Data Elements (KDEs): The traceability information to be collected/recorded for each Critical Tracking Event (CTEs) are known as Key Data Elements (KDEs). KDEs provide essential information about the time and place of the event, the party reporting the event, and the identification of the product involved. In addition, KDEs include related essential information about the transformation, transportation, or depletion of a traceable SRL product.

In short, the KDEs associated with each Critical Tracking Event (CTE) should answer the four

W's of SRL traceability:

- **What SRL** product was involved;
- **When** was it done;
- **Where** was it done;
- **Why** was it done.

The table below lists the minimum traceability information (KDE) that SRL trading partners need to capture about traceable SRL products (or linked packaging) for each CTE.

Table 7 Types of SRL Key Data Elements (KDE)

KDE	Description
Event Location	The Event Location is the location where the event occurs (e.g., boat, processing centre, transport company, export packer, wholesaler, etc.). The preferred identification is the GS1 Global Location Number (GLN).
Data Owner	The Data Owner is the identification of the party that observed and is reporting the event and the party that should be consulted if trading partners or government authorities need more information about the event. The preferred identification is the GS1 Global Location Number for that party's corporate or regional office location.
Trading Partner	The location identification of the SRL Trading Partner of the "recipient" party for a CTE. For instance, in a Shipping CTE, it would be the location of the business that will receive the SRL product being shipped. For a Transformation Input CTE, it would be the SRL supplier identification of the Item ID. The preferred identification is the GS1 Global Location Number.
Activity Type	Activity Type describes the document used to identify the SRL CTE or business process being met.
Activity Number	The Activity Number is the identification number of the Activity Type document used to uniquely identify a segment of holding or production for a transformation event or a set of products shipped for a transportation event. For example, in a transformation event, the Activity ID ties the identity of the input SRL products with the corresponding output products. For transportation activities, the Activity ID may be a purchase order number or a bill of lading number that as a reference number identifies the set of products shipped and received.
Date/Time of data capture	The Event Date is the calendar day at the event location (formatted as an ISO 8601 Date standard YYYYMMDD) and Event Time is the time formatted in Greenwich Mean Time when an event is completed.

Product Identifier	The reference value that identifies the SRL product's essential product and packaging characteristics (product specification, type of product (e.g. fresh or frozen, whole or tail), level of processing, type of cooking, and packaging, etc.). The preferred identification is the Global Trade Item Number. For all events, the use of the GTIN as the item identifier is strongly encouraged, as it is globally unique and denotes both the supplier and product (as GS1 maintains a record of which trading partner is assigned which GTINs).
Batch/Lot or Serial Number	A unique coded identifier assigned by the product supplier that combines SRL products that have undergone combination, transformation, packaging, or manipulation under a common set of circumstances such as time, production team, or ingredient lot.
Product Date	Production Date, Packaging Date, Best Before Date, Use By Date, or Expiration Date
Quantity	The Quantity is a numeric value that indicates the amount of product involved in the event e.g. pieces (pc) or kilograms (Kg).
Unit of Measure (UOM)	The Unit of Measure is the designation that indicates the measurement unit associated with the Quantity reported for the event.

Where to get the information (KDE): Traceability KDEs can be found in GS1-128 barcodes on an SRL carton or container (e.g. boat's blue lobster crates, or export packers white poly-boxes), human-readable text on carton labels, and in transactions (e.g., Purchase Orders; Invoices; Advance Ship Notices; etc.). The table 8 below presents each KDE to be collected and the various places where that information may be located:

Table 8 Data sources for SRL KDEs

KDE	Data Sources
Event Location	Transaction documents
Data Owner	Transaction documents
Trading Partner	Transaction documents
Activity Type	Transaction documents
Activity Number	Transaction documents
Date/Time of data capture	Actual date/time
Product Identifier (GTIN)	GS1-128 barcode* or carton label text
Batch/Lot or Serial Number	GS1-128 barcode* or carton label text
Product Date	GS1-128 barcode* or carton label text
Quantity	Carton label text or transaction documents
Unit of Measure (UOM)	Carton label text or transaction documents

* Best practice for maintaining traceability in keeping with GS1 specifications is to scan the carton GS1-128 barcode to capture the foundational information of: GTIN; batch/lot or serial number; and product date. Then to link to the rest of the KDEs using data from SRL 'Data Storage' (e.g. SRL traceability database, SRL Traceability app, or supply chain paperwork including government compliance records).

How to record the information: For the KDE/CTE model described in this Section, SRL Trading partners are only responsible for storing their own traceability events, not those of their SRL trading partners, as this manual promotes the concept of 1-up/1-down traceability.

What type of record: To support traceability in an SRL supply chain, each SRL trading partner needs to create and maintain a record of each Critical Tracking Event (CTE) which includes the Key Data Elements (KDE). These records can take a variety of forms (e.g., spreadsheet; handwritten documents; data files, etc.), and SRL trading partners may use whichever method works best for them. However, it should be noted that best practice is to use an electronic recording method (as electronic technologies are generally more accurate and make it easier to transfer data within and between SRL businesses).

To support this preference for electronic tools, the project has created and made available several freely available mobile apps are available for SRL trading partners for this purpose at the project website: ***www.wildcatchlobsters.com.au***

What data format for KDE: In the following table (Table 9 below) the minimum data format for each KDE that trading partners need to capture is presented:

Table 9 KDE Data Format

KDE	Valid Values	Data Type	Length
Event Location	GLN	Numeric	13
Data Owner	GLN	Numeric	13
Trading Partner	GLN	Numeric	13
Activity Type	Bill of Lading, Purchase Order, Invoice, Production Order, etc.	SRL Code List	1-35
Activity Number	Bill of Lading number, Purchase Order number, Invoice number, Production Order number, etc.	Alphanumeric	1-35
Date/Time of data capture	YYYYMMDD:MM:HH:SS	ISO standard	17
Product Identifier	GTIN	Numeric	14
Batch/Lot or Serial Number	Batch/Lot or Serial Number	Alphanumeric	20
Product Date	YYMMDD	Numeric	6
Quantity	Positive number	Numeric	10.3
Unit of Measure (UOM)	Pallet, cartons, inner packs, consumer items	SRL Code List	3

How should information be archived and stored: All SRL trading partners should maintain records which will facilitate timely and accurate traceability and support any SRL product recalls. It is recommended that each business establish an internal data 'Data Storage' policy based on the following considerations:

- Individual business risk tolerances. Some SRL businesses may want to store for longer/shorter periods of time based on individual risk tolerance.
- Legal/regulatory requirements (e.g. Chinese Free Trade Agreement CHAFTA requirements).
- Length of time product may exist in the distribution channel beyond two years. This is based on the type of product (chilled, frozen or fresh SRL).
- The need to promptly retrieve data in the event of an epidemiological event which may or may not implicate your SRL products.
- Industry agreements or customer requirements.

Case Study - Design and Implementation of Improved Data Labels

Introduction

The use of labels to communicate batch and item level identifiers to support identification of products within traceability systems is documented across many industries and supply chains, however the requirements of businesses in the SRL supply chain for traceability has had limited exploration by previous researchers.

In this study the design decisions and considerations made during the initial label creation process were considered to provide SRL industry stakeholders with information to help develop labels that will be effective in data collection.

Methodology

Requirements were identified for the creation of labels, specifically that the physical properties of the labels be adequate for the environment, and that the design of the label faces be both human and computer readable.

The physical properties of the labels required was considered, taking into account the environments in which the labels may need to function for long periods of time. Labels that would be affixed to crates, boxes, and technology should be expected to maintain quality when in contact with fresh and salt water, as well as when exposed to the elements. The labels would need to retain the readability and adhesiveness, while being accessible to CTEs within the chain. Labels that would be affixed to water sensors and lobster tags would need to be able to retain quality during immersion with live SRL. The size of the labels was also a consideration, with the labels needing to be affixable to lobster tags used for individual identification.

The design of the label face required the inclusion of specific KDE data, including the product identifier (GTIN) shown as a GS1-128 barcode and where applicable:

- The product/resource owner
- The product/resource type
- The batch/lot or serial identifier, where appropriate
- A QR-code linking to the owner's website

This information is required to be human readable, as well as stored for analysis where necessary. In addition to this data, the label face was also required to be identifiable and consistent, to ensure that they were clearly distinguishable from other labels, barcodes, and identifiers within the environment.

A database was developed where GTIN were assigned to specific owners, and KDE data was attached for easy identification and analysis. The database was also designed to take identifying information from the product/resource to ensure that, in the case of label mismanagement or loss, the traceability up until that point was recoverable and linkable to the product/resource.

The database also allowed for the checking in and out of GTIN numbers, where they would only be in use for a short time, and the mass generation of labels for printing.

Results and Discussion

Avery Ultra Resistant Identification Labels – Industrial Grade were identified as suitable for Crate, Entity, Box, and Technology labels for supply chain traceability in SRL as they offer both salt and fresh water resistance and are weatherproof. The labels come in 7 standard sizings, of which 4 were used within the case study:

- 210x148mm for entity, tank and crate labels
- 99.1x139mm for alternative crate, box, and technologies labels
- 99.1x67.7mm for alternative box and alternative technologies labels

DYMO Durable 64x19mm labels were identified as suitable for immersed lobster tags and technologies, as in addition to being salt and fresh water resistant, they are also tear and solvent resistant, ensuring longer affixion time and minimizing readability damage.

Figure 29 Examples of the labels from the Data Labels case study.

The Barcode label on the left was used to identify cartons/crates; The bar code on the right was a label applied to a lobster horn tag to identify individual lobsters using barcode and QR code.

Label faces were designed to centrally show the scannable barcode, with other appropriate information as required (See figure above). A surrounding box was designed, which identified the label as being a 'traceability identifier'.

Take home messages

- Labels for traceability need to be designed to be identifiable and separate from other labels within a supply chain environment. This requires consistency across all labels, irrelevant of size, shape and use.
- Label sizing should be fit-for-purpose, to allow for both clear marking of a resource/product and easy machine and human readability.
- There are a number of off-the-shelf options available that can produce high quality, dependable labels for use in the SRL industry.

Moving forwards the effective design of a label is needed to ensure batch and item level identification is made possible in SRL supply chains. Depending on the product to be tracked, whether it is a carton or an individual SRL, influences the type of labelling technology. At the batch level, labels like those designed and demonstrated above are enough. Conversely at the item level, appropriate labelling technologies need further exploration including tagging (which encapsulates a label and an applicator).

Implementing Traceability Data Models along the SRL Supply Chain

This sub-section describes implementation of traceability data models along the SRL supply chains. It defines the roles and responsibilities of each supply chain participant, identifies the business steps (CTEs) they need to capture, and provides guidance about the traceability information (KDE) they need to record. A series of tables are provided for each role to provide generic guidance on the data required to supporting traceability.

SRL Fisherman Roles & Responsibilities

- Assign Global Location Number (GLNs) to identify SRL fisherman entity and facility locations (i.e. boat)
  - Entities: Crew, Equipment (e.g. pots, coffs, holding tanks)
  - Facility locations: Boats
- Mark cartons with GS1-128 barcodes
- Capture carton batch/lot or serial number
  - At transfer from boat to truck
- Share product and location information electronically with SRL trading partners
  - Shared database or upon request

SRL Fisherman Business Steps and Data to be Captured: To support SRL traceability, boats record a standard set of data (known as Key Data Elements or "KDEs") whenever they perform one of the following business steps (known as Critical Tracking Events or "CTEs"):

- Receiving (i.e. when SRL are caught)
- Shipping (i.e. at transfer to trucks/processors)
- Transformation (i.e. catch or split SRL to sell between two or more processors)

The KDEs to be captured for each type of event are defined below.

Generic Receiving Events

Table 10 KDEs for Generic Receiving Events: Fisherman

KDE	Example / Guidance
Event Location	Ship-to GLN (boat)
Data Owner	Boat GLN
Trading Partner	Ship-from GLN (if transshipment occurs)
Activity Type	Catching (or Purchase Order if transshipment)
Activity Number	Catching (or Purchase Order Number)
Date/Time of data capture	Date/Time of Receipt
Contents of Receipt --	*capture the data below for each carton received:*
Product Identifier(s)	GTIN(s)
Batch/Lot or Serial Number	*(for each GTIN)*
Product Date	e.g., Packaging Date, Use By, etc. *(for each GTIN)*
Quantity	*(for each GTIN)*
Unit of Measure (UOM)	*(for each GTIN)*

Transformation Events

Note: When an SRL product is combined with others, processed, reconfigured, or re -packed, the new SRL product must have its own unique product identifier (i.e., GTIN). For example, combining individual SRL into a new crate at the point of transfer onto truck waiting at the port requires the create to have a new GTIN.

Table 11 KDEs for Generic Transformation Events: Fisherman

KDE	Example / Guidance
Event Location	GLN for the boat where transformation event occurs
Data Owner	Boat GLN
Trading Partner	GLN for a specific customer or another boat
Activity Type	Production Work Order
Activity Number	Production Work Order Number
Date/Time of data capture	Date/Time of Transformation
Transformation Input --	*capture the data below for each ingredient input:*
Product Identifier(s)	GTIN(s)
Batch/Lot or Serial Number	*(for each GTIN)*
Product Date	e.g., Packaging Date, Use By, etc. *(for each GTIN)*
Quantity	*(for each GTIN)*
Unit of Measure (UOM)	*(for each GTIN)*
Transformation Output --	*capture the data below for each carton output:*
Product Identifier(s)	GTIN(s)
Batch/Lot or Serial Number	*(for each GTIN)*
Product Date	e.g., Packaging Date, Use By, etc. *(for each GTIN)*
Quantity	*(for each GTIN)*
Unit of Measure (UOM)	*(for each GTIN)*

Shipping Events

Table 12 KDEs for Generic Shipping Events: Fisherman

KDE	Example / Guidance
Event Location	Ship-from GLN (boat)
Data Owner	Boat GLN
Trading Partner	Ship-to GLN (truck, processor or distributor)
Activity Type	Purchase Order
Activity Number	Purchase Order Number
Date/Time of data capture	Date/Time of Shipment
Contents of Shipment --	*capture the data below for each carton shipped:*
Product Identifier(s)	GTIN(s)
Batch/Lot or Serial Number	*(for each GTIN)*
Product Date	e.g., Packaging Date, Use By, etc. *(for each GTIN)*
Quantity	*(for each GTIN)*
Unit of Measure (UOM)	*(for each GTIN)*

SRL Processors and Export Packers Roles & Responsibilities

- Assign GLNs to identify processing/manufacturing locations
  - Holding tanks, equipment used during grading, etc.
- Scan GS1-128 barcodes on cartons provided by Boats
  - All crates or cartons involved in transporting SRL products to or from facility
- Assign GTINs to identify crates or cartons
- Capture carton batch/lot or serial number
- Mark cartons with GS1-128 barcodes
- Share product and location information electronically with trading partners
  - Shared database or upon request

SRL Processors and Export Packers Business Steps and Data to be Captured: To support SRL supply chain traceability, Processors record a standard set of data (known as Key Data Elements or “KDEs”) whenever they perform one of the following business steps (known as Critical Tracking Events or “CTEs”):

- Receiving

- Shipping
- Transformation

The KDEs to be captured for each type of event are defined below.

Receiving Events

Table 13 KDEs for Generic Receiving Events: SRL Processors and Export Packers

KDE	Example / Guidance
Event Location	Ship-to GLN (Processor or third party location)
Data Owner	Processor GLN
Trading Partner	Ship-from GLN (boat/supplier)
Activity Type	Purchase Order
Activity Number	Purchase Order Number
Date/Time of data capture	Date/Time of Receipt
Contents of Receipt --	*capture the data below for each carton received:*
Product Identifier(s)	GTIN(s)
Batch/Lot or Serial Number	*(for each GTIN)*
Product Date	e.g., Packaging Date, Use By, etc. *(for each GTIN)*
Quantity	*(for each GTIN)*
Unit of Measure (UOM)	*(for each GTIN)*

Transformation Events

- For transformation of goods (e.g., Fresh or Frozen)

When an SRL product is combined with others, processed, reconfigured, or re-packed, the new "product" must have its own unique product identifier (i.e., GTIN).

The label showing the lot identification of the traceable input item should remain on the packaging until that entire traceable SRL product is consumed. This principle applies even when the traceable SRL is part of a larger packaging hierarchy.

Transformation Events

Table 14 KDEs for Generic Transformation Event: SRL Processors and Export Packers

KDE	Example / Guidance
Event Location	GLN for the facility/location where transformation event occurs
Data Owner	Processor GLN
Trading Partner	GLN for a specific customer or another facility
Activity Type	Production Work Order
Activity Number	Production Work Order Number
Date/Time of data capture	Date/Time of Transformation
Transformation Input --	*capture the carton data below for each input/ingredient:*
Product Identifier(s)	GTIN(s)
Batch/Lot or Serial Number	*(for each GTIN)*
Product Date	e.g., Packaging Date, Use By, etc. *(for each GTIN)*
Quantity	*(for each GTIN)*
Unit of Measure (UOM)	*(for each GTIN)*
Transformation Output --	*capture the data below for each carton output:*
Product Identifier(s)	GTIN(s)
Batch/Lot or Serial Number	*(for each GTIN)*
Product Date	e.g., Packaging Date, Use By, etc. *(for each GTIN)*
Quantity	*(for each GTIN)*
Unit of Measure (UOM)	*(for each GTIN)*

Shipping Events

Table 15 KDEs for Generic Shipping Events: SRL Processors and Export Packers

KDE	Example / Guidance
Event Location	Ship-from GLN (processor or third-party location)
Data Owner	Processor GLN
Trading Partner	Ship-to GLN (distributor)
Activity Type	Purchase Order
Activity Number	Purchase Order Number
Date/Time of data capture	Date/Time of Shipment
Contents of Shipment --	*capture the data below for each carton shipped:*
Product Identifier(s)	GTIN(s)
Batch/Lot or Serial Number	*(for each GTIN)*
Product Date	e.g., Packaging Date, Use By, etc. *(for each GTIN)*
Quantity	*(for each GTIN)*
Unit of Measure (UOM)	*(for each GTIN)*

SRL Distributors (or Wholesalers) Roles & Responsibilities

- Assign GLNs to identify distribution or wholesale warehouse locations
- Scan GS1-128 barcodes on cartons provided by processors and store information in internal systems
- Assign GTINs to identify any private label cartons
- Capture carton batch/lot or serial number
- Create GS1-128 barcodes for cartons
- Mark cartons with GS1-128 barcodes
- Share product and location information electronically with SRL trading partners

SRL Distributors (or Wholesalers) Business Steps and Data to be Captured: To support SRL Industry traceability, Distributors (or Wholesalers) record a standard set of data (known as Key Data Elements or “KDEs”) whenever they perform one of the following business steps (known as Critical Tracking Events or “CTEs”):

- Receiving

- Shipping

The KDEs to be captured for each type of event are defined below.

Receiving Events for Distributors or Wholesalers

Table 16 KDEs for Generic Receiving Events: Distributors or Wholesalers

KDE	Example / Guidance
Event Location	Ship-to GLN
Data Owner	Distributor
Trading Partner	Ship-from GLN (supplier)
Activity Type	Distributor's Purchase Order (PO) or Supplier's Bill of Lading (BOL)
Activity Number	Purchase Order Number or Supplier's BOL Number
Date/Time of data capture	Date/Time of Receipt
Contents of Receipt --	*capture the data below for each carton received:*
Product Identifier(s)	GTIN(s)
Batch/Lot or Serial Number	*(for each GTIN)*
Product Date	e.g., Packaging Date, Use By, etc. *(for each GTIN)*
Quantity	*(for each GTIN)*
Unit of Measure (UOM)	*(for each GTIN)*

Shipping Events for Distributors

Table 17 KDEs for Generic Shipping Events: Distributors or Wholesalers

KDE	Example / Guidance
Event Location	Ship-from GLN (distributor or third-party location)
Data Owner	Distributor GLN
Trading Partner	Ship-to GLN (restaurant)
Activity Type	Restaurant's (or second/third tier distributor) Purchase Order
Activity Number	Purchase Order Number
Date/Time of data capture	Date/Time of Shipment
Contents of Shipment --	*capture the data below for each carton shipped:*
Product Identifier(s)	GTIN(s)
Batch/Lot or Serial Number	*(for each GTIN)*
Product Date	e.g., Packaging Date, Use By, etc. *(for each*

	GTIN)
Quantity	*(for each GTIN)*
Unit of Measure (UOM)	*(for each GTIN)*

Retailers or Restaurants Roles & Responsibilities

- Assign GLNs to identify restaurant, or retailer, or second or third tier distributor locations
- Scan GS1-128 barcodes on cartons provided by distributor
- Capture KDEs via one of the below methods:
    - Scan GS1-128 barcodes on cartons provided by distributor
    - Feed carton level data received from delivery into corporate systems

Retailers or Restaurants Business Steps and Data to be Captured: To support SRL Industry traceability, Wholesalers or Restaurants (or other downstream distributors) record a standard set of data (known as Key Data Elements or "KDEs") whenever they perform the following business steps (known as Critical Tracking Events or "CTEs"):

- Receiving

The KDEs to be captured for these events are defined below.

Receiving Events

Table 18 KDEs Generic Receiving Events: Retailers or Restaurants

KDE	Example / Guidance
Event Location	Ship-to GLN (operator or restaurant location)
Data Owner	Operator/Restaurant/Distributor GLN
Trading Partner	Ship-from GLN (distributor)
Activity Type	Purchase Order (PO)
Activity Number	Purchase Order Number
Date/Time of data capture	Date/Time of Receipt
Contents of Receipt --	*capture the data below for each carton received:*
Product Identifier(s)	GTIN(s)
Batch/Lot or Serial Number	*(for each GTIN)*
Product Date	e.g., Packaging Date, Use By, etc. *(for each GTIN)*
Quantity	*(for each GTIN)*
Unit of Measure (UOM)	*(for each GTIN)*

Key Traceability Data Considerations relevant to All Roles

In order to support best practises for maintaining a traceability process in a Southern Rock Lobster (SRL) supply chain, there are five basic business processes that should be put in place among supply chain trading partners and these are:

1. Plan and organise how to assign, collect, share, and maintain SRL traceability information.
2. Determine how to align master data for SRL products and trading partner and other physical locations.
3. Record traceability information as SRL products are created and shipped and modified (Critical Tracking Events).
4. Periodically (and in line with 'Checking' stage method as part of the Approach for SRL Traceability Systems) request a simulated trace forward or back using at least one of the four information sources listed here:
    1. GTIN and some additional form of the item identification like batch/lot or serial number;
    2. GLN or some form of the traceability partners' name or attribute;
    3. GLN of the physical location for the targeted product;
    4. Dates or time periods for targeted product.
5. Use the information provided to take the appropriate traceability objectives or actions e.g. SRL product recall.

KDEs for each Critical Tracking Event

When each industry participant has successfully collected and collated KDEs relevant to their own in-house traceability practises they will find themselves in a strong position to provide all the information relating to CTEs within their supply chain. To illustrate this point the following tables in this sub-section highlight the generic KDEs that allow for completion of traceability data at each major CTE in the SRL supply chain.

Table 19 KDE for CTE Transformation: (Transformation Input & Output)

KDE	Description
Event Location	GLN – facility location
Data Owner	GLN – who is responsible for this data
Trading Partner	GLN – specific to a customer or another facility
Activity Type	e.g., Production Work Order
Activity Number	e.g., Production Work Order Number
Date/Time of data capture	ISO 8601 Date/Time

Transformation Input	GTIN(s), Lot, Product Date (Production Date, Use By, etc.), Quantity, UOM
Transformation Output	GTIN(s), Lot, Product Date (Production Date, Use By, etc.)
Quantity	
Unit of Measure (UOM)	

Table 20 KDE for CTE Transportation: Shipping

KDE	Description
Event Location	GLN – facility location
Data Owner	GLN – who is responsible for this data
Trading Partner	GLN – Ship to
Activity Type	Purchase Order, BOL, ASN
Activity Number	PO Number, BOL Number, etc.
Date/Time of data capture	ISO 8601 Date/Time
Product Identifier(s)	GTIN(s)
Batch/Lot or Serial Number	
Product Date	Production Date, Use By, etc.
Quantity	
Unit of Measure (UOM)	

Table 21 KDE for CTE Transportation: Receiving

KDE	Description
Event Location	GLN – facility location
Data Owner	GLN – who is responsible for this data
Trading Partner	GLN – Ship to
Activity Type	Purchase Order, BOL, ASN
Activity Number	PO Number, BOL Number, etc.
Date/Time of data capture	ISO 8601 Date/Time
Product Identifier(s)	GTIN(s)
Batch/Lot or Serial Number	
Product Date	Production Date, Use By, etc.
Quantity	
Unit of Measure (UOM)	

Table 22 KDE for CTE Depletion: Consumption

KDE	Description
Event Location	GLN – facility location
Data Owner	GLN – who is responsible for this data
Trading Partner	GLN –
Activity Type	e.g., POS, served in menu item, etc.
Activity Number	e.g., Receipt number; Check number; Recipe ID; etc.
Date/Time of data capture	ISO 8601 Date/Time
Product Identifier(s)	GTIN(s)
Batch/Lot or Serial Number	
Product Date	Production Date, Use By, etc.
Quantity	
Unit of Measure (UOM)	

Table 23 KDE for CTE Depletion: Dispose

KDE	Description
Event Location	GLN – facility location
Data Owner	GLN – who is responsible for this data
Trading Partner	GLN
Activity Type	e.g., Discard Work Order
Activity Number	e.g., Discard Work Order Number
Date/Time of data capture	ISO 8601 Date/Time
Product Identifier(s)	GTIN(s)
Batch/Lot or Serial Number	
Product Date	Production Date, Use By, etc.
Quantity	
Unit of Measure (UOM)	

Considerations for applying the KDE and CTE Data Models

There are a range of considerations for applying the KDE and CTE models put forward in this sub-section that require further discussion. This sub-section aims to acknowledge the benefits and the opportunities made possible by the models presented that have not previously existed in approach to SRL traceability. However, there are some known limitations of the models and these need to be identified. As will be explained, these limitations broadly relate to keeping the models up to date.

Historically there has not been a centralized repository of knowledge pertaining to CTEs and KDEs for the Southern Rock Lobster (SRL) supply chain. The models presented in this section highlights the need to centralizes this information into a single location and to ensure stakeholders are aware of and understand the minimum data requirements for building and implementing traceability systems for SRL supply chains. The approach documents what control points exist in the supply chain, and what data each control point could generate in relation to the approach for the SRL traceability system. The major benefit is the establishment of a minimum standard around SRL CTEs and KDEs.

Arising from a centralized record of SRL CTEs and KDEs are a range of efficiency gains which would include:

- an accurate list and description of CTEs and KDEs;
- clear explanation of how CTEs are connected to each other (to form traceability workflows);
- separation of traceability data from technologies implementation.

The list of CTEs and KDEs presented has identified what data exists (or needs to exist) within each CTE, using common terminology and descriptions. The modelz organizes CTEs and KDEs in order of flow along the supply chain which makes it possible to see how each CTE (and KDEs set) contributes to traceability workflows. It is noticeable that in much of the literature on these models there is a strong tendency to focus on how the models are implemented by technology rather than to be technology agnostic and to focus on the underlying data requirements. The research team in this project have focused on what data is needed, thereby separating design from implementation and accommodating incremental traceability improvement in the SRL supply chain where the diversity of industry capabilities and capacities make a techno-centric approach highly problematic.

More specifically this approach ensures a separation between technology choices and traceability improvements creating greater flexibility for business in SRL supply chains when it comes to making a choice around any solution choice. That is, a business can focus on meeting the data format requirements and select systems and technologies which work within their process and procedure, expertise and knowledge, budget and overarching corporate strategy. And when new technologies become available, they can be retrofitted into the traceability system (provided they continue to meet the data format requirements). This is far more powerful than a specific technologies implementation guide (as is contributed below) as technologies change frequently as does implementation but data format and traceability requirements for traceability systems scenarios do not vary as often.

Finally, this Section leverages concepts put forwards in the GS1 traceability guide and adapts them to Southern Rock Lobster (SRL) supply chains. Whilst the guide is focused on the use of barcodes (and this is promoted by this report as the preferred traceability identification system) it remains broadly applicable to other globally managed identification systems including the Electronic Product Code (EPC), and locally managed (and proprietary) identification systems such as those using Quick Response (QR) code technologies.

The model of Critical Tracking Events (CTEs) and Key Data Elements (KDEs) introduced in this section aims to establish a minimum set of data which must be collected by entities along the supply chain. It is suited to the Planning stage of traceability systems for Southern Rock Lobster (SRL) supply chains as it serves as a guide of what is known about CTEs and KDEs in the supply chain. It should be used to guide the identification of what data is required, and facilitate an early selection of technologies, leaving actual technologies implementation to later stages of the development and implementation lifecycle.

As the models are focused in the planning or design stages, it is suited to the design of traceability systems for Southern Rock Lobster (SRL) supply chains as these CTEs and KDEs are focused specifically on this supply chain. As such, it is not suitable for traceability systems design for other supply chains as the data is focused only on SRL.

It is important to note: these data models are also not intended to provide a complete and comprehensive record of all SRL entities and available data but only those that are required to facilitate minimum standards for traceability. As such it is recommended that all SRL traceability systems work to meet the CTEs and KDEs identified in the model and only then consider additional CTEs and KDEs which may be available and provide additional traceability insight. These are not identified here as it is unclear whether they would be needed to answer the most essential traceability scenarios such as a product recall.

Case Study – Processor Use and Feedback on Improved Data Label Designs

Introduction

Labels designed within the *Better Label Design and Implementation* case study were implemented in supply chain environments to improve or enable traceability. This case study will explore the implementation of labels within two SRL processors; Victoria and Tasmania, looking at the success of label implementation, and the differences between the unique organisations and how they affected the way labels were implemented and used on site.

Methodology

Labels designed within the better labels case study were documented and printed within the research team, with researchers identifying the needs of the organisations involved in collaboration with stakeholders on site.

Label choices within the processors were made based on existing traceability capabilities, resourcing, and staffing, pre-existing processes and procedures for traceability, and organisational strategy and goals relating to traceability, processes, and storage.

Each organisation worked with members of the research team to implement labels for traceability, which in included the introduction of new processes. Organisational stakeholders received training from the research team, including demonstrations and documentation. Ongoing support was also offered, but not required, for labelling.

Results and Discussion

During implementation in the Tasmanian processor the research team identified a need for the following label types:

- Entity/Organisation labels, printed on 99.1x139mm Avery label stock
- Crate labels, printed on 99.1x67.7mm Avery label stock
- Tank labels, printed on 210x148mm Avery label stock
- Lobster tag labels, printed on 64x19mm DYMO Durable label stock

The organisation reported success using the entity/organisation labels, tank labels, and lobster tag labels, however due to the environments of the crate labels, identified significant failure with the Avery label stock. The labels often fell off when the crates were submerged for significant periods of time. The crate labels were replaced with the DYMO durable 64x19mm DYMO Durable label stock, which while smaller, maintained adhesiveness successfully.

During implementation at the Victorian Processor the research team identified a need for the following label types:

- Entity/Organisation labels, printed on 99.1x139mm Avery label stock
- Crate labels, printed on 99.1x67.7mm Avery label stock
- Tank labels, printed on 210x148mm Avery label stock

Figure 30 Installed tank separators for grade storage

The Victorian Processor did not identify a need for item level traceability and carried out all traceability at batch level. Their current capacity did not allow them to separate stored stock by grade, leading to staff handling stock at multiple points for each potential export/sale. The organisation was also unable to identify current stock by grade, leading to re-weighing current stock each time a stock enquiry came in. As part of the label implementation, research team members installed separators in existing tanks, to allow the staff on site to store and label according to grade. This process was linked to a technical implementation provided by the research team, which allowed members of staff to identify current stock using office computers, without handling.

Figure 31 Labels in Use in Packing Zone

Labels for the Victorian processor were backed up, for access via clipboard during the packing process, where scanning the tanks was inappropriate or time consuming. These allowed staff members packing within designated zones, to quickly access tank and entity labels.

Take home messages

- Due to the differences in traceability capability and processes within processor CTEs, standard implementations need to be flexible and customisable. The ability for organisations to identify and select labels, label stock, and label types based on their environment and capabilities is key to long-term success.
- Readability and adhesive qualities are key factors in wet CTE environments, and the choices made for label stock, positioning, and design must be based on the environment and processes undertaken within each organisation.
- Scannable labels were received positively within organisations, however, in cases where traceability capacity is low, manual entry of data in conjunction with scannable labels allows organisations to implement traceability in existing processes using existing capabilities.

Benchmarking Traceability Performance: Evaluation Checklists

Building on the previous sections of this report, this section aims to support stakeholders to evaluate the current breadth, depth and precision of their existing traceability practises. It describes the approach developed and implemented to support industry to benchmark its traceability performance. This auditing process is achieved through evaluation checklists to provide stakeholders at any point along the supply chain with the ability to assess their current capacity to capture, record and report the minimum data requirements for traceability as defined in the KDE and CTE data models. This benchmarking provides an ability to make evidence based, informed decisions about the current state of the traceability of lobsters within that stakeholder's custody and within the immediate up-stream and down-stream dimensions of their operations.

Based on the key underpinnings of traceability breadth, depth and precision this project is aiming to support all SRL businesses to build internally robust and externally interoperable traceability practises. These principles support businesses to reflect on how far into their business traceability data is being collected, how detailed that information is for the business, and how far along the supply chain these traceability practises are implemented by adjunct supply chain partner businesses. This raises the questions of 'how can one ensure any business, and/or all businesses in the supply chain' are meeting these principles.'

To make it easy for an individual business in a SRL supply chain to validate themselves with the principles of breadth, depth and precision – or for a research or consultant to do the same - this research team have developed a performance benchmarking approach that deploys simple checklists encapsulating the principles of breadth, depth and precision for each Critical Tracking Event, associated Key Data Elements, and along the 8 essential traceability practises (see table 4 on Assessing traceability precision) As such, an individual business can use the checklists to benchmark themselves by meeting the minimum requirements for Key Data Elements (KDEs) from the approach for SRL traceability systems, evaluating how the KDEs are instantiated, and at examining what level of precision is currently provided.

Like the preceding sections which describe the traceability approach this section does not specify how any of the specific traceability functions should be achieved using systems and technologies. This is intentional as there are numerous ways in which they could be achieved. For example, for a boat 'identification' at 'batch level' could occur using catch-record formwork, and conversely using mobile application software such as Deck Hand. What is important is that the data is being captured. At the same time however, there is a bias towards the use of digital technologies in the checklists as a business moves further along the traceability criteria. A business may be able to use paper-based methods for identifying, adding, partitioning and storing data. However, when it comes to ensuring data in the traceability system can be transmitted, secured, collect or collated, or validated – the use of digital technologies for most Critical Tracking Events (CTEs) is likely to prove more common, effective and widespread.

Using the Evaluation Checklists

As far as using the checklists goes, an individual business can keep a paper or digital copy of the checklists and complete them during an audit of their traceability practises. If dated and signed by the business owner, the checklists become a good record of conformance to the traceability approach and can form part of the traceability system record keeping. The data compiled by the checklist provides insight to the business on their current conformance to the traceability approach, as well as identifying the gaps and areas where the business can focus on making improvements. Applied to a business's adjunct trading partners, the checklists also form a record of conformance and help to identify areas where traceability can be improved.

Definitions

The checklist for each Critical Tracking Event (CTE) uses specific traceability terminology and this is briefly explained in this sub-section.

Identified: The traceability system can generate data which identifies traceable entities either at the batch or item level. Product identification usually requires the use of a numbering system such as GS1 Barcodes along with entity surrogates such as tags or labels.

Product identification associates a number via a surrogate to the physical traceable entity in the supply chain. Data is generated when the surrogate is within range of a reader (such as a barcode scanner) or is visually inspected by a person.

Added: The traceability system can take multiple sets of product identification information from within the same traceable entity workflow, or between traceability entity workflows, adding information to create new traceable records. An example of this is when a business receives traceable lobsters from an upstream supplier, recording the arrival in their database along with other arrivals information.

Partitioned: The traceability system can take disassemble a traceable entity into smaller packages or consignments, and by way of separation, also separate or 'partition' data. An example of this is when a 44 AKE (load container) arrives in China and some of the cartons are separated by the wholesaler – the physical consignment is separated, and as such, the data records are now separated for the consignment.

Stored: The traceability system can store traceable entity data in using paper based or electronic systems. Paper based systems could include folders containing consignment, order or delivery slips. Electronic systems could include flat files, databases, e-commerce websites or emails.

Transmitted: The traceability system can share information within the business or between businesses in the supply chain. Data transmission is influenced by data storage mechanisms – electronic data storage in a database is usually linked with capability to transmit traceability data in electronic format. Data transmission can also be paper based with carbon copies of airway bills, information displayed on the outside of AKEs (load container) or lobster cartons also acting as examples here.

Secure or Accessible: The traceability system can ensure data is protected from unauthorized use or access by utilizing appropriate information security controls. If data is in paper format, then this might include ensuring physical access to data records by way of a locked filing cabinet. If data is in electronic format then this might include the use of usernames and passwords, or encryption technologies.

Data security is also fundamentally linked to data integrity – that traceable data is not modified by unauthorized users. As such appropriate security controls should also ensure data is not able to be modified, or there are mechanisms in place to expose changes in data. As a large amount of data in a traceability system is based on security and integrity of the traceability system identification capability, protections need to exist at this layer to ensure data security.

In systems using labels or tags for example, it might mean ensuring labels or tags cannot be removed from traceable entities (such as Lobsters or Cartons), cable tie tags are one such solution here. It might also mean the use of additional surrogates to establish authenticity of traceable entities – holograms on cartons for example, which cannot be easily copied, to establish authenticity of the actual box.

Collected or Measured: The traceability system can derive new traceable entity information or data from measurement systems or technologies and instantiate this into the traceability system. An example of this would be the use of Time Temperature Indicators (TTIs) in lobster cartons. The TTIs are responsible for generating new data about a traceable entity. This data must be associated with a traceable entity and as such, the TTI and Carton could be linked by way of Carton Identifier or Consignment Identifier.

Validated: The traceability system can establish the accuracy of data by way of validation against reference or benchmarks. An example of this is when a consignee for SRL receives an order and confirms the cartons and contents with the order form. Conversely, it could occur when a TTI is used to validate the temperature of a carton along the supply chain.

Case Study – Sensing Lobster Tank Water Quality for Lobster Traceability

Introduction

Managing water quality is one of the most important aspects of aquaculture, as good water quality translates to healthy crayfish, lower losses and higher profits. Through a survey of the SRL processing industry, we have identified two substantial challenges to water quality maintenance. The first is that the processes that degrade water quality are a complex mix of chemistry and biology that can require years of study to fully understand. The second is that accurate, precise monitoring equipment represents a significant start-up, ongoing and labour cost to facilities.

The aim of this project is to develop an affordable, easy to use water quality monitoring system that can be deployed throughout the SRL industry. While this system will not necessarily perform all the functions of a high quality, professional grade system, it will represent a marked increase in performance from what is currently available for a fraction of the investment.

Background

The study involves placing both low-cost and high-cost water quality sensors into IMAS lobster tanks and recording the data. Salinity, oxygen, temperature and pH data will be collected.

Firstly, the low-cost sensor prototype was built with four probes: salinity, pH, dissolved oxygen and temperature. Then, the data is uploaded to a central server so it can be easily accessed and analysed by scientists and companies.

Figure 32 Sample multifunction water quality sensor

Whereas other sensors systems are expensive, costing in the thousands of dollars, the final cost of this one was several hundred dollars. This makes it a prime candidate for widespread use across boats and processing centres. The completed system will be field-tested on lobster boats and processing centre holding tanks.

It is important to get a good sense of the water quality so customers know the fish were not contaminated. This will also help the industry establish how water quality affects lobsters' lifespans and extends their shelf life.

Methodology

To evaluate the accuracy and precision of the dissolved oxygen and salinity functions of the Low Cost Water Sensor (LCWS), a comparison was made with a Hach HQ40d meter equipped with an IntelliCAL LDO101 rugged luminescent/optical dissolved oxygen probe and a IntelliCAL CDC401 rugged salinity probe.

To test the dissolved oxygen probe, the performance of the LCWS was compared to the Hach probe across a series of readings beginning with a sample of highly aerated seawater (100% dissolved oxygen saturation) to which an increasing concentration of sodium sulfite (Na_2SO3) was added. Sodium sulfite scrubs dissolved oxygen from water by forming reacting with the oxygen to form sodium sulphate, a water-soluble salt, meaning that as increasing amounts of sodium sulfite are added, a corresponding amount of dissolved oxygen is removed from the water.

To test the salinity probe, a 40 parts-per-thousand (ppt) sodium chloride (NaCl) standard was made and then diluted across a series of concentrations. Readings were made with both the LCWS and the Hach probes and the results were compared.

Results and Discussion

Over the range of increasing sodium sulfite concentrations, both probes recorded a decreasing dissolved concentration (See figure below). The LCWS probe returned a lower reading than the Hach probe at most points, however, the difference was generally consistent, with a mean 7.4 ± 1.1% difference across a biologically relevant range (60-100% dissolved oxygen). Furthermore, when the %DO readings between the two meters were compared directly, a nearly perfect linear relationship (R^2=0.995) was found, indicating that the differences in the reported values of the probes were consistent. This means that the output of the LCWS probe can be adjusted following calibration and will report values consistent with the Hach probe.

For the salinity probe, the LCWS probe returned a substantially higher reading than the Hach probe (Figure below), reporting a mean 23.9 ± 1.3% greater salinity across the tested range. However, when the LCWS probe was compared directly against the Hach probe, it was again nearly perfectly linear (Figure below R^2 = 0.997), indicating that the difference was consistent and can be corrected.

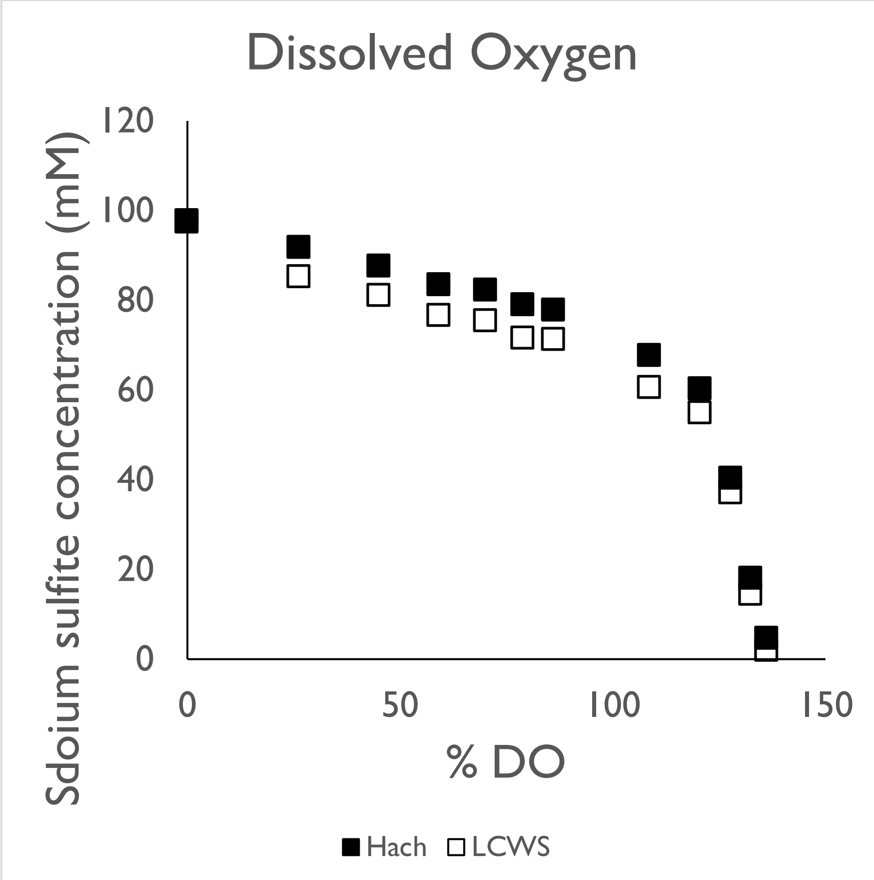


Figure 33 Dissolved oxygen comparison between LCWS and Hach probes.

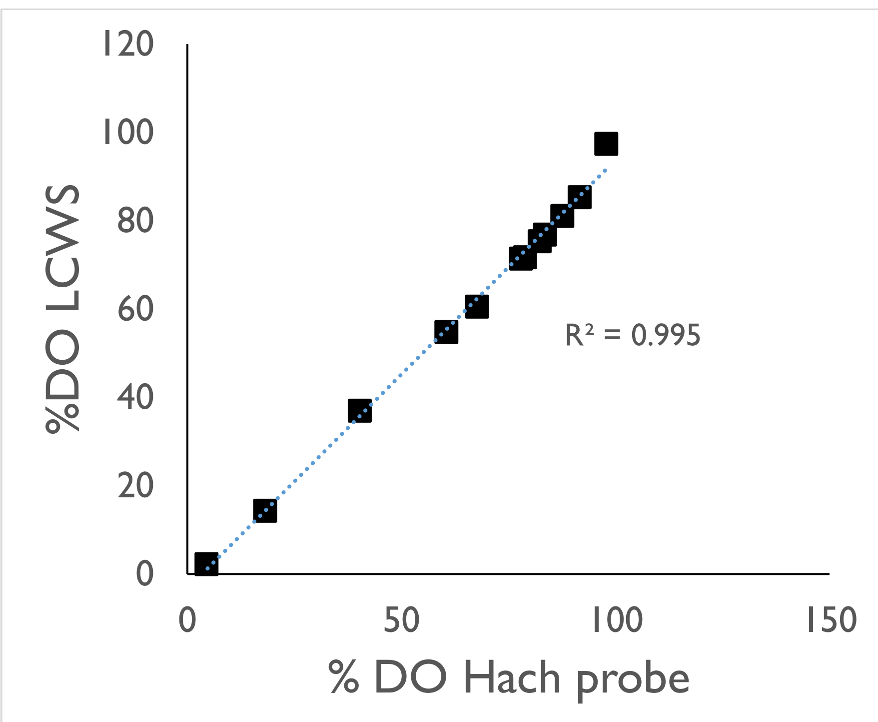


Figure 34 Dissolved oxygen comparison of values between probes

An R2 value of 0.995 indicates a nearly perfectly linear relationship, indicating that the difference between the LCWS probe and the Hach probe is consistent and can be adjusted for.

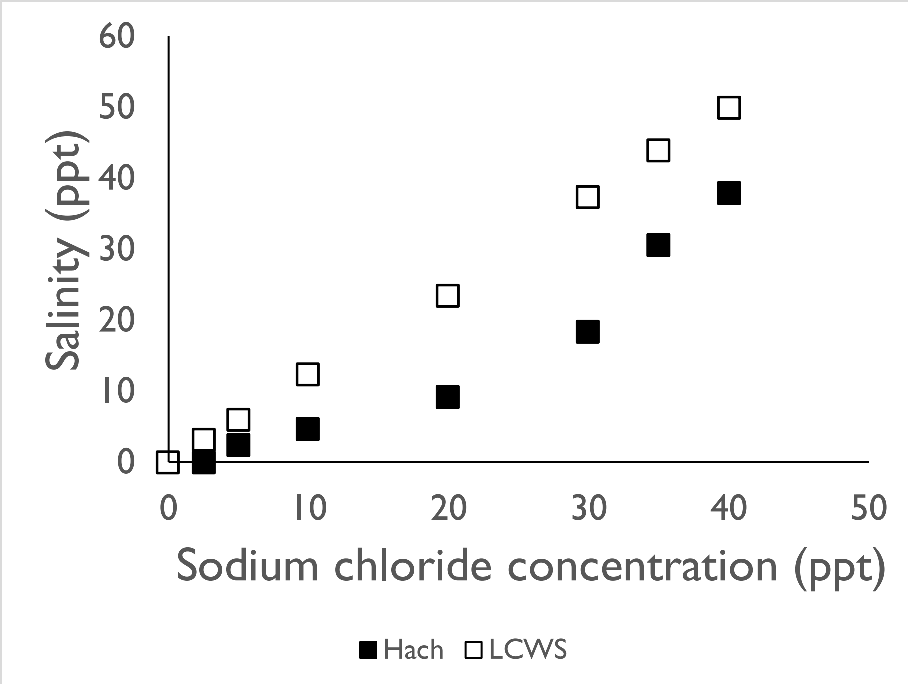


Figure 35 Salinity reading comparison between probes.

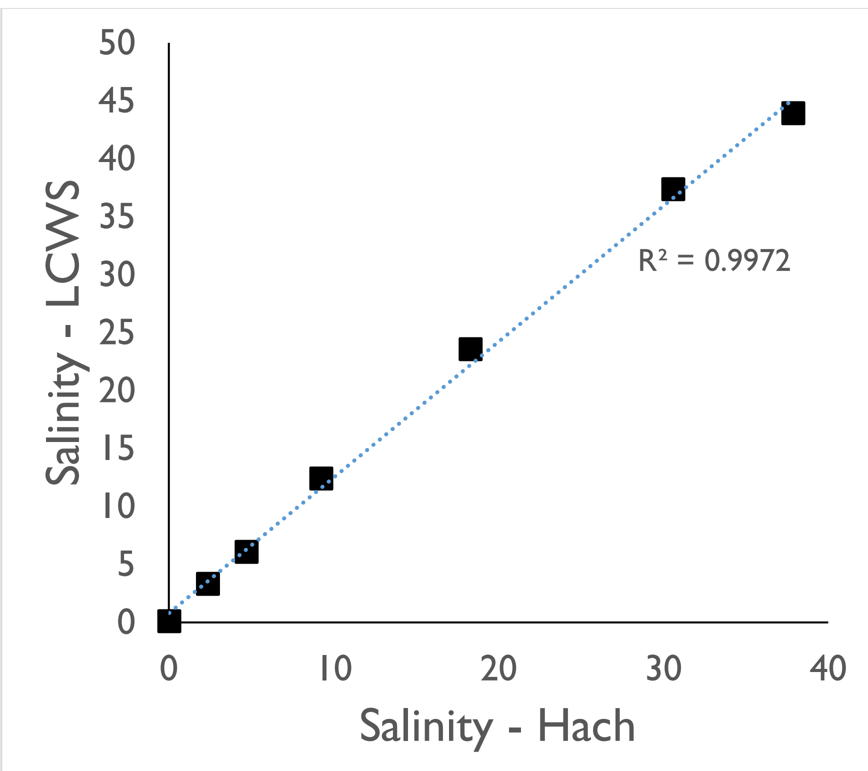


Figure 36 Comparison of LCWS and HACH salinity values

Take home messages

Laboratory testing of the Low Cost Water Sensor suggests that it is a reliable alternative for professional grade probes in terms of reporting accurate values.

- Comparisons of the Low Cost Water Sensor against the professional grade Hach probes showed that the dissolved oxygen probe read slightly lower and the salinity probe read considerably higher across all ranges tested.
- However, these differences were consistent across all ranges tested for both probes, which means that the Low Cost Water Sensor reported values are accurate when a correction factor is applied.

The next step of the process will be to evaluate performance and lifespan in field conditions (i.e. at processor facilities and in fishing boats).

Checklist for Point of Harvest Wild Capture

			Batch Level Traceability							
			Batch Level traceability with Individual Tagging							
			Item Level Traceability with individual tagging							
KDE Type (Product, Process, Genetic, Input, Disease, Measurement)	**KDE**		**Identified**	**Added**	**Partitioned**	**Stored**	**Transmitted**	**Secure or Accessible**	**Collected or measured**	**Validated**
Product	Latin species name									
	Common or market name									
	Catch location									
		FAO major fishing zone								
		Country of catch								
		Region								
		Management authority								
		Stock								
Process	Landing date									
	Time of harvest									
	Vessel info									
		Flag of fishing vessel								
		Name of fishing vessel								
		Captain name								
		Home port								
		IMO								
Process	Fishing method									
	Total weight of catch									

	Certification status and chain of custody code									
Product	Sex									
	Grade									
	Size									
	Weight									
	Colour									
	Vitality									
	Legs									
	Antennae									
	Mortality									

Checklist for Retained By-Catch

Batch Level Traceability										
			Batch Level traceability with Individual Tagging							
			Item Level Traceability with individual tagging							
KDE Type (Product, Process, Genetic, Input, Disease, Measurement)	**KDE**		**Identified**	**Added**	**Partitioned**	**Stored**	**Transmitted**	**Secure or Accessible**	**Collected or measured**	**Validated**
	Species									
	Stock									
	Size of bycatch									
	Quantity of bycatch									
	Date and time of bycatch									
	Location of bycatch									
	Catch certificate/license									

Checklist for Trans-shipment, Shipping and Receiving

Batch Level Traceability											
			Batch Level traceability with Individual Tagging								
			Item Level Traceability with individual tagging								
KDE Type (Product, Process, Genetic, Input, Disease, Measurement)	**KDE**		**Identified**	**Added**	**Partitioned**	**Stored**	**Transmitted**	**Secure or Accessible**	**Collected or measured**	**Validated**
	Was the product transshipped									
	Tonnage trans shipment									
	IMO number of catch vessel and carrier									
	Identity of receiving and shipping vessels									
	Date and time of transfer									
	Location of transfer									
	Species or common name									
	Quantity									
	Lot, batch of shipment number									

Checklist for Transportation

Batch Level Traceability											
			Batch Level traceability with Individual Tagging								
			Item Level Traceability with individual tagging								
KDE Type (Product, Process, Genetic, Input, Disease, Measurement)	**KDE**		**Identified**	**Added**	**Partitioned**	**Stored**	**Transmitted**	**Secure or Accessible**	**Collected or measured**	**Validated**
Boat/Vessel	Location landed									
	Date landed									
	Identity of vessel									
	Event owner									
	Species, stock, size									
	Catch certificate of license number									
	Quantity of fish									
Truck/Transporter	Truck home base									
	Truck license									
	Driver license									
	Consignor									
	Consignee									
	Customer/Delivery									
Process	Temperature									
	Humidity									
	Date In									
	Date Out									

Checklist for Processing

				Batch Level Traceability							
				Batch Level traceability with Individual Tagging							
				Item Level Traceability with individual tagging							
KDE Type (Product, Process, Genetic, Input, Disease, Measurement)	**KDE**			**Identified**	**Added**	**Partitioned**	**Stored**	**Transmitted**	**Secure or Accessible**	**Collected or measured**	**Validated**
	Species										
	Dates and times received										
	Location received										
	Weight										
	Lot number										
	Batch code										
	Dates and times shipped										
	Name of processor / packing plant										
	Pallet identifier										
	Supplier										
	Customer										
Product	Sex										
	Grade										
	Size										
	Weight										
	Color										
	Vitality										
	Legs										
	Antennae										
	Mortality										
Process	Tank										
	Water Quality										

	Date In										
	Date Out										

Checklist for Distribution, Wholesaling and Retailing

Batch Level Traceability										
			Batch Level traceability with Individual Tagging							
			Item Level Traceability with individual tagging							
KDE Type (Product, Process, Genetic, Input, Disease, Measurement)	**KDE**		**Identified**	**Added**	**Partitioned**	**Stored**	**Transmitted**	**Secure or Accessible**	**Collected or measured**	**Validated**
Product	Product									
	Weight									
	Container/seal number									
	Pallet identifier									
	Lot number/batch number/serial number									
	Pallet identifier									
	Dispatch date									
	Receiving date									
	Transport companies									
	GTIN/UPC code									
	Quantities									
Process	Temperature									
	Humidty									
Process	Water quality									
	Temperature									
	Humidity									
	Water quality									
	Temperature									
	Humidity									

Next Steps: Evaluating Traceability Practise

The approach for SRL traceability systems introduced in this final report provides a comprehensive plan for enhancing traceability in Southern Rock Lobster (SRL) supply chains. As such from an operational standpoint the use of the checklists are an easy to use and important method of assessing an individual CTE for conformance to the approach for SRL traceability systems as well as communicating the level of conformance to the business and its adjacent trading partners in the supply chain.

As a quantitative methodology for checking conformance to the approach for traceability systems, an individual business generates a conformance score based on the checklist findings with a point given for every one of the 8 precision criteria (see Table 4) achieved in each level of traceability: Batch; Batch with individual tagging, and item level with individual tagging. For example, the greater the number of conformances points across breadth, depth and precision, the greater the conformance to the approach for traceability systems. As such, individual business within a CTE could then be compared based on their aggregate scores for the supply chain to get a quick insight into the depth, breadth and precision of traceability. For Example, all the boats within a specific supply chain, could use the checklists to evaluate and benchmark themselves using the boat CTE, and their scores used to indicate the level of their traceability achieved. Whilst this may oversimplify the purpose of the checklists it does provide a quick way for the supply chain to understand the level of traceability being currently achieved within each segment in order to focus attention on where improvements are needed to reach minimum levels of conformance with the traceability approach advocated in this report.

Importantly it is noted: These checklists encapsulate the major CTEs and KDEs across the 8 traceability practises explained in the approach for SRL traceability systems. These can be rapidly ticked-off by a user in a business through visual inspection of the business practises, in conversation with key personnel, or through a document review of the business traceability system. It does not seek out specific system or technologies, only an indication of whether key principals are being met and the data is available. This may mean it becomes difficult to ensure adjacent trading partners do not miss opportunities to ensure system compatibility using common systems and technologies or avoid duplicating efforts around the collection of some KDEs. However, the aim has been to accommodate the diversity of existing practises and provide a simple to use set of mechanisms that will support the SRL industry to advance its traceability practises.

Additionally, whilst every effort has been made to provide a representative collection of CTEs and KDEs for the Southern Rock Lobster (SRL) supply chain using the supplied checklists, its likely advances in systems and technologies, as well as in changes to SRL business practises, are likely to see new CTEs and KDEs emerge over time. As such, the business using these checklists can extend them based on any new information which comes to hand. Critically however the core principles of breadth, depth and precision should be maintained by maintaining the structure of the checklist tables. As a way of simplifying the validation of conformance with the approach for SRL traceability systems, this sub-section has contributed a series of evaluation checklist to benchmark traceability performance that can be applied to each Critical Tracking

Event (CTE) in the supply chain. These directly link to other sections of the report on policy and procedures, and data models that combined generate the approach to SRL traceability systems used in this report and advocated for on-going utilization by industry.

Case Study – GPS Pot Tags

Introduction

Analysis of SRL industry practises revealed fishermen capture a wealth of data on where their lobsters come from and that much of this data is reported on mandatory state forms, such as quota documents, but that little is transmitted down the supply chain. With minor changes to current practises, this data can be leveraged into a traceability system with substantial benefits at minimal costs.

In this case study, GPS tags were attached to lobster pots to enable the collection, recording, storage and transmitting of the digital data collected during fishing.

Methods

A range of GPS tagging technologies exist on the market featuring a variety of specific functions and designs. For this study, GPS pot tags comprised of a Diver Data Logger coupled with GPS Data Logger developed by Scilex Pty Ltd., a Tasmanian company that develops electronic technology for use in harsh environments, were used. These tags were capable of recording GPS position, time and date, depth (as a function of water pressure) and water temperature.

Figure 37 Scilex GPS pot tag attached to a lobster pot.

Pot tags were attached to lobster pots using either plastic cable ties or stainless-steel shackles on boats in Tasmania and Victoria. The tagged pots were used as normal by fishermen for several weeks, during which time the pot tags were active.

At the conclusion of the usage period, data were downloaded from the loggers using the GPS Data Logger via a RF connection. Data can also be accessed by 4G mobile upload. Data from pot tags was downloaded and analysed and presented to the fishermen who collected it.

Results & Discussion

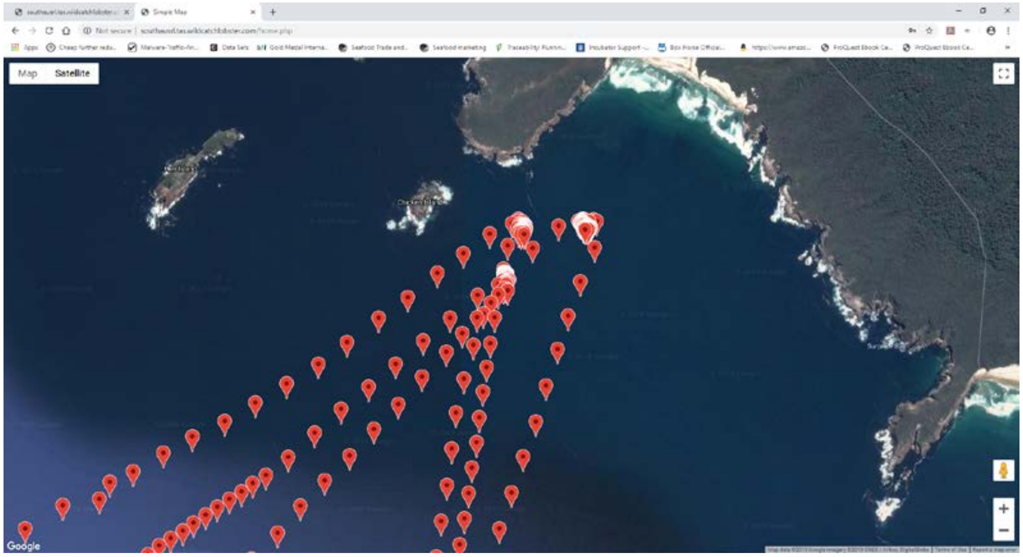


Figure 38 Fishing vessel track from GPS pot tags over multi-day fishing trip (Tasmania)

The GPS data from the loggers was collected and displayed on a map, with a sample shown in (figure above). The logger collected a high level of detail on the path of the vessel. Zooming in to where pots were dropped enabled a detailed view (Figure below)

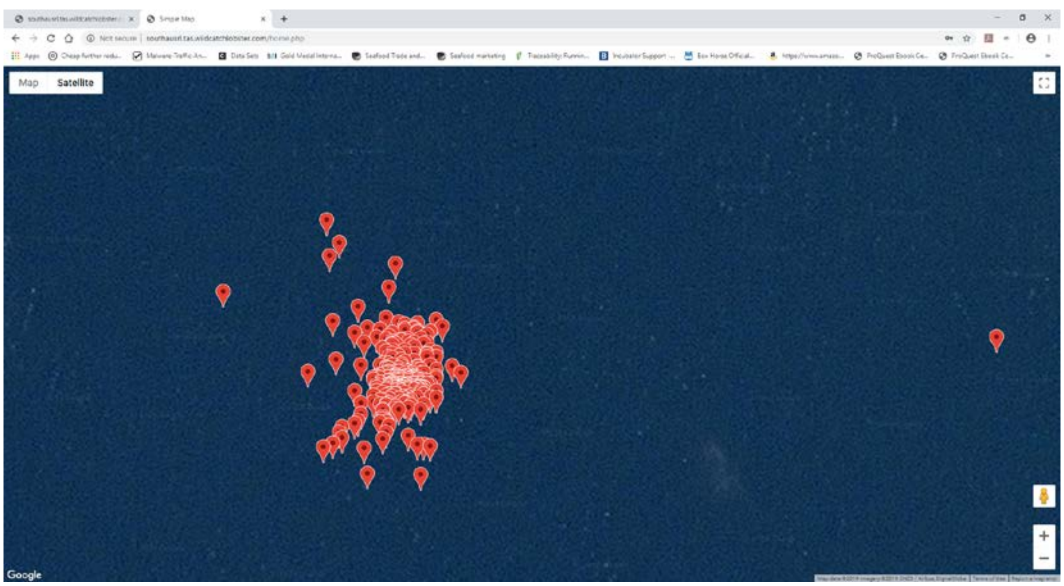


Figure 39 GPS logs of pot locations.

The fishermen who participated in this study found that Pot tags provided a convenient way to collect and store digital data. This data could replace the manual recording of similar data (i.e. mandatory catch reports). The fishermen that used the pot tags as part of trials continued to use them on a voluntary basis after the conclusion of the trial after recognising their value in creating a database of fishing trips and the ability to analyse for time of year, weather conditions, etc.

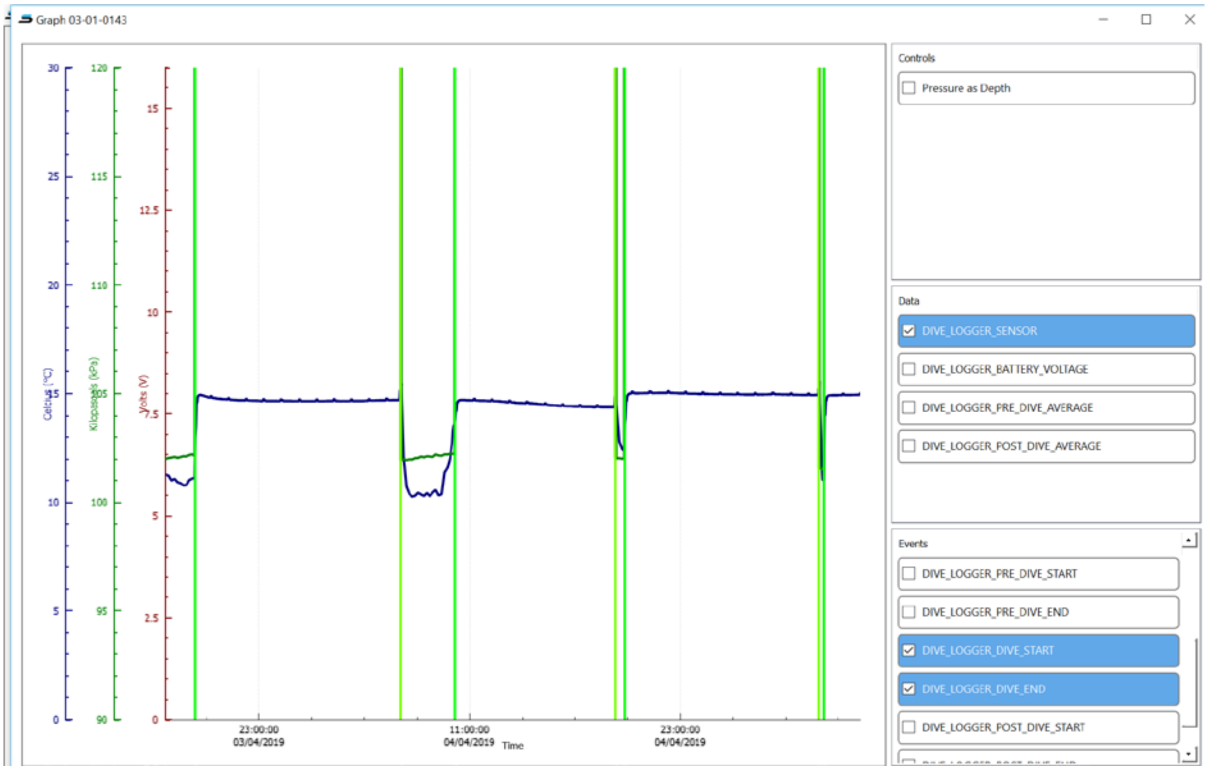


Figure 40 Data collected by the GPS pot tag logger

This data showing temperature (blue) and depth as a function of pressure (green). Pot soak time is indicated by the space between vertical green lines. In this example, pots were dropped three times over the logging interval.

The data from these pot tags can be attached to lobsters going forward to generate traceability. For example, if all the lobsters caught at the locations shown in Figure were stored together (i.e. same partition within a hold or within identified crates), upon offloading for transport to a processing facility, this data could be passed on giving a record of when and where the lobsters were caught.

Take home messages

- There are a range of technological options that can increase the efficiency of collecting data through digitalisation
- Digitising paperwork can improve traceability and the function of a business simultaneously
- Much of these data are already being collected and can be implemented into an effective traceability system with only minor changes to processes and a modest investment in equipment

Supporting Traceability: Developed Digital Tools & Techniques

As part of the approach used in this project, the research team actively developed several digital tools and techniques that were trialled and evaluated with industry partners in different parts of the SRL supply chain. Many of these digital tools and techniques are illustrated in the case studies presented throughout this final report. This section provides a brief guide to the digital archive that has been prepared to facilitate handover of these tools to the FRDC and SRL to support future work.

Specifically, this section lists and describes the design and implementation of key components to build a traceability system and offers a 'developer's guide to the digital tools and techniques arising from project activities.

This section is also linked to an online digital archive of all software artefacts which comprise the traceability system and which are downloadable by SRL members.

Note: All files referenced in this section are contained within the online digital archive and when referenced it is assumed that the user is searching from the root directory of the archive.

Location of the Online Archive of Digital Tools:
https://drive.google.com/drive/folders/16Oo0UUkrKn1svLOFKYNd2eriNw9-hIwo?usp=sharing

The google-drive account is accessed with the following details:

Username: tas.lobster.project@gmail.com
Password: CsQyV8td77B5a2A
Within the Google Drive:

- There is a file containing all other passwords relating to on-going systems development
- There is a folder containing all software and systems linked to the developer: the contents of this folder is discussed in detail in this sub-section of the final report through the developer guide.
- There is a folder containing word versions of the final report and two standalone guides

The project has also developed a number of videos on the trial and evaluation work presented in the case studies that have been linked to QR codes developed as part of the project work:

Digital Tools and Techniques Video Demonstrations

1. Label tags: https://youtu.be/NJ94IZfH7Us

2. Temperature and humidity loggers: https://youtu.be/qz4T4_ybj6I

3. Multifunction loggers with g-force detection: https://youtu.be/y5zQ05YdM_w

4. Processor app: https://youtu.be/nk_ALH8swoI

5. Database: https://youtu.be/4rZOq_wRDJg

6. Barcode scanners: https://youtu.be/gkaqlPP327k

Developer Guide: Getting Started with the Traceability System

Minimum Deployment of the Traceability System: The traceability system can be deployed for an individual entity in a Southern Rock Lobster (SRL) supply chain to afford the entity basic traceability capability such as ability to label and track their products. This requires only a minimum set of digital artefacts from the archive and these are:

- FTP server set up with forms for the application
- Tracking application set up with forms
- Label designs for tags, cartons and crates
- GS1 barcode pool architecture

To support this minimum deployment of the traceability system, several commercial resources are also required, and these are:

- FTP server
- Android device(s)
- Microsoft access instance

Full Deployment of the Traceability System: The traceability system can also be deployed to provide a group of cooperating entities in an SRL supply chain with comprehensive one-up one-down traceability. To requires a broader set of digital artefacts from the archive and these are:

- Standard Operating Procedure (SOP) for 1 up 1 down traceability
- Tracking database
- Website with at minimum rest.php set up correctly

To support a full deployment of the traceability system, several commercial resources are also required, and these include:

- LAMP stack server accessible through the internet

Online Digital Archive Resources

The online digital archive is segmented into several sub-folders each containing digital artefacts for the traceability system trialled and evaluated in this project. The table below lists and describes the contents of each sub folder:

Table 24 List of folders within the online digital archive.

Folder Name	Purpose
Database	Contains resources for building the databases used in the project

Documentation	Contains resources to assist with the continuation of software development for the project
DYMO Labels	Contains templates for the barcodes used in the project
QlikView	Contains files used for with the initial testing of data viewing through the QlikView platform
Scale Trial App	Contains all resources needed to use and continue development on the scale trial application
Screenshots	Contains a variety of screenshots taken at various stages through development
Tasmania	Contains all data gathered from and given to the Tasmanian processor involved in the project
Tracking App	Contains all resources needed to use and continue development of the tracking application
WebFiles	Contains all resources needed to use and continue development of the online portion of the project

System Architectures

The digital archive artefacts are the key components of the traceability system trialled and evaluated in this project and are essential for the traceability system to function. Some of these components are custom software applications written by the software developer employed by the Project (e.g. Tracking Application; and, Scale Trial Application), and other components are proprietary software applications purchased under license agreement for the duration of the Project (e.g. QlikView; and, FTP server).

The artefacts function as a set of discrete software programs each performing a separate function and communicating with each other by sharing and exchanging data. This means that each artefact is a self-contained software application which runs independently of any other software application. Each artefact is connected to other artefacts via simple information sharing protocols depending on the artefact. For example, the database and website communicate via simple 'NoSQL' data exchanges, whereas the QlikView and Website communicate via simple HTTP requests to share 'tracking data.'

This approach to communication is necessary for the traceability system to manage the stochastic nature of information exchange in the Southern Rock Lobster (SRL) supply chain amongst all the different businesses. Each business can produce varying amounts of data at any time based on their role in the supply chain, volume of production, and level of digital adoption of the traceability system.

The other reason for this incremental approach to traceability systems development is to enable scalability amongst businesses using the traceability system. As more businesses are added into the traceability system, additional digital artefacts can be connected to it. If an individual business only adopts several digital artefacts, the information flow from these digital artefacts can be easily connected into the system. Conversely, if a business wants to use a digital artefact (such as the Tracking Application) without centralised connectivity via the traceability system, their data can be easily routed to a local server.

To model all the above, the figure below represents the architecture of the traceability system based on the high-level flow of information between the artefacts.

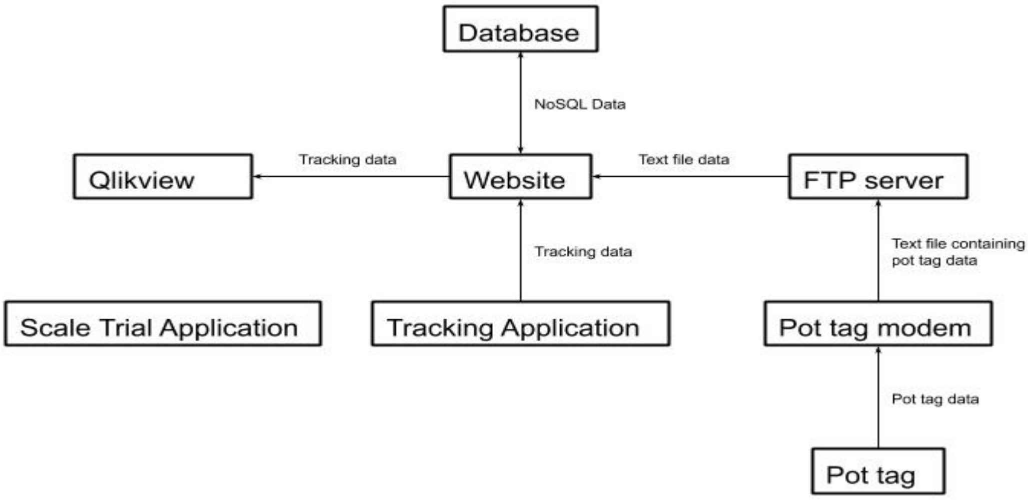


Figure 41 Traceability System Architecture.

To assist a software developer in understanding the detailed nature of the flow of information between the digital artefacts, the following diagram provides a summary of the format and type of information which each digital artefact communicates.

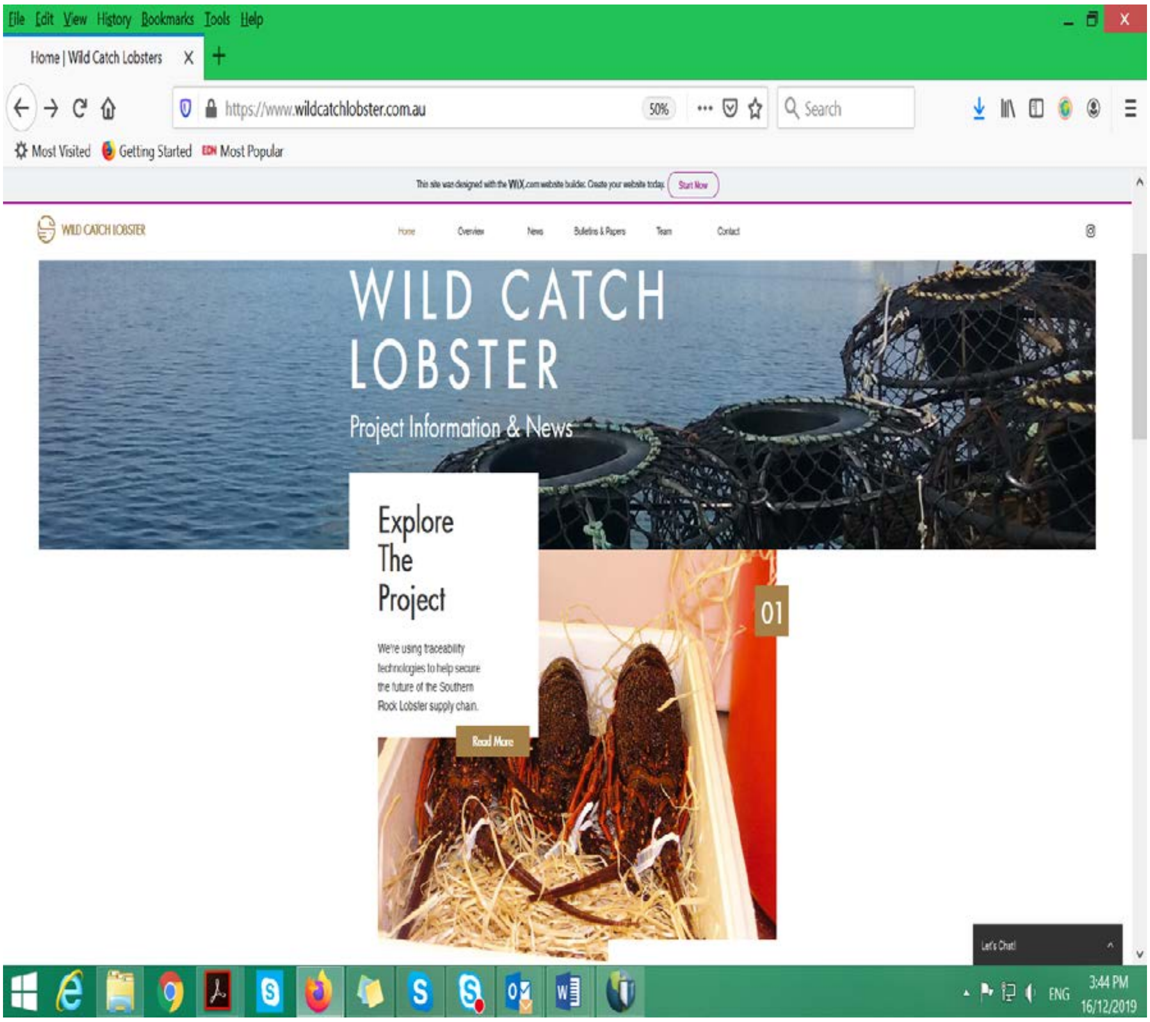


Figure 42 Project Website: https://www.wildcatchlobster.com.au/

The project website www.wildcatchlobster.com.au has been used as entry point for information dissemination and to facilitate promotion of the project to stakeholders and to track interest through the Qlikview platform.

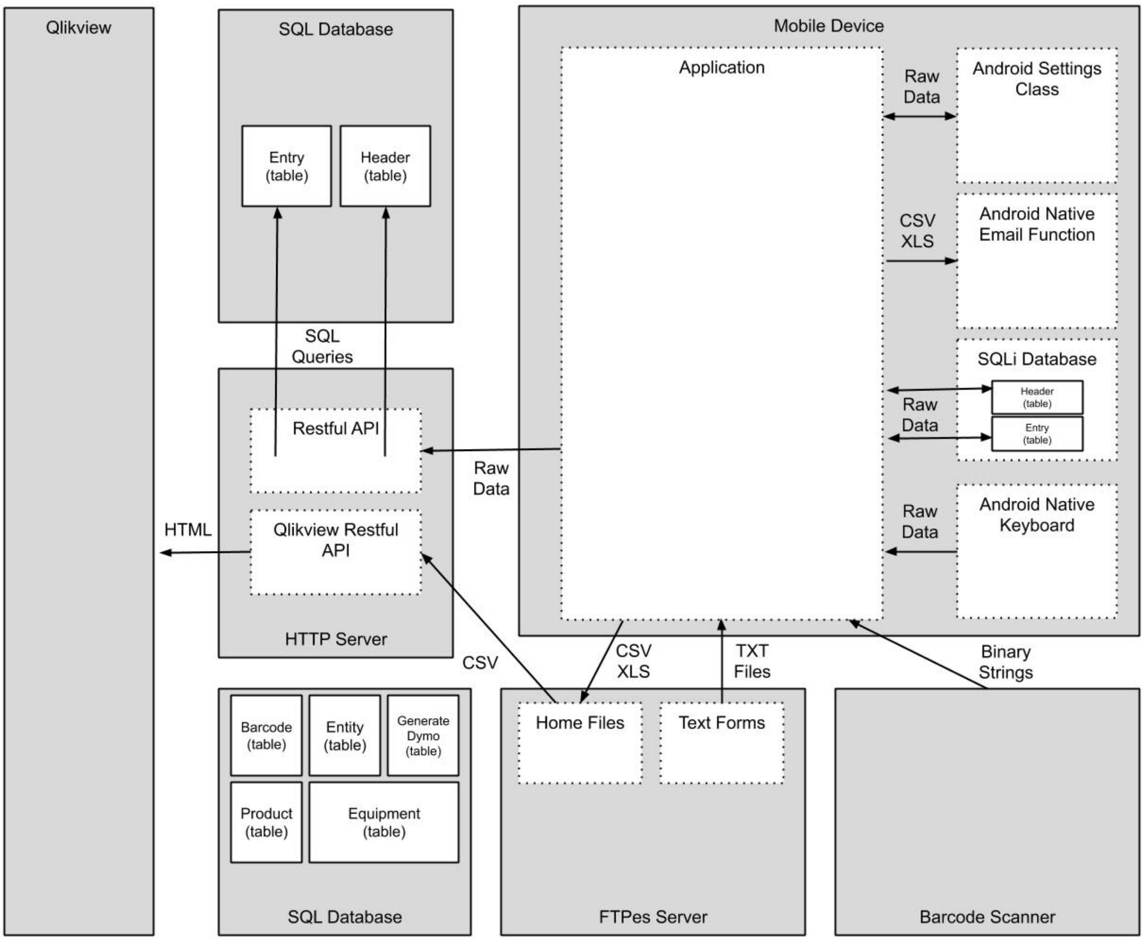


Figure 43 Traceability system communication and data flow architecture.

To assist a software developer in understanding the detailed nature of the main 'Tracking Application' in the traceability system, the follow diagram provides a summary of the main software files in the Android application and the external dependencies into the traceability system.

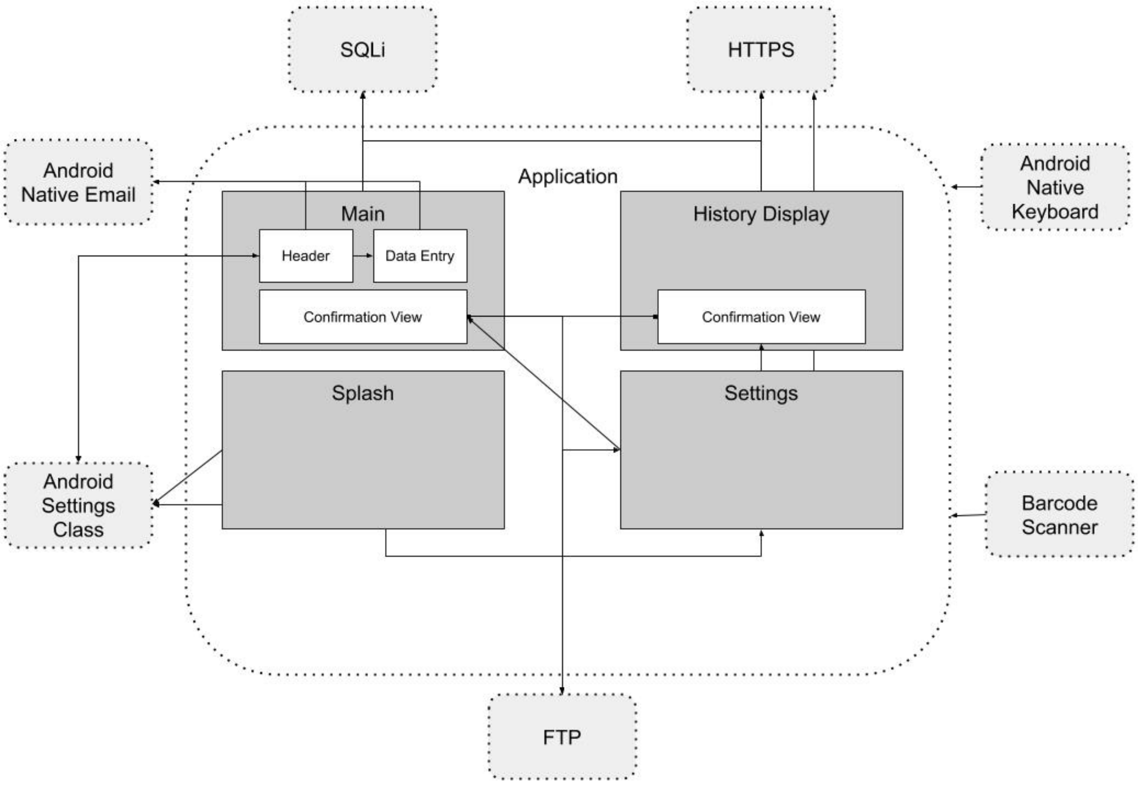


Figure 44 Tracking Application interfaces with traceability system components.

The rest of this sub-section provides information useful for a software developer to re-deploy the traceability system and/or engage in further software development.

Barcode Assignment Database

The barcode assignment database is an Access 2007-2016 database that can be duplicated for each entity within the research or used as a primary hold for all barcodes within a supply chain or for further research. It consists of Tables, Queries, Forms, and Reports, and interfaces with the TBarcode barcode generation software and the DYMO Printer software.

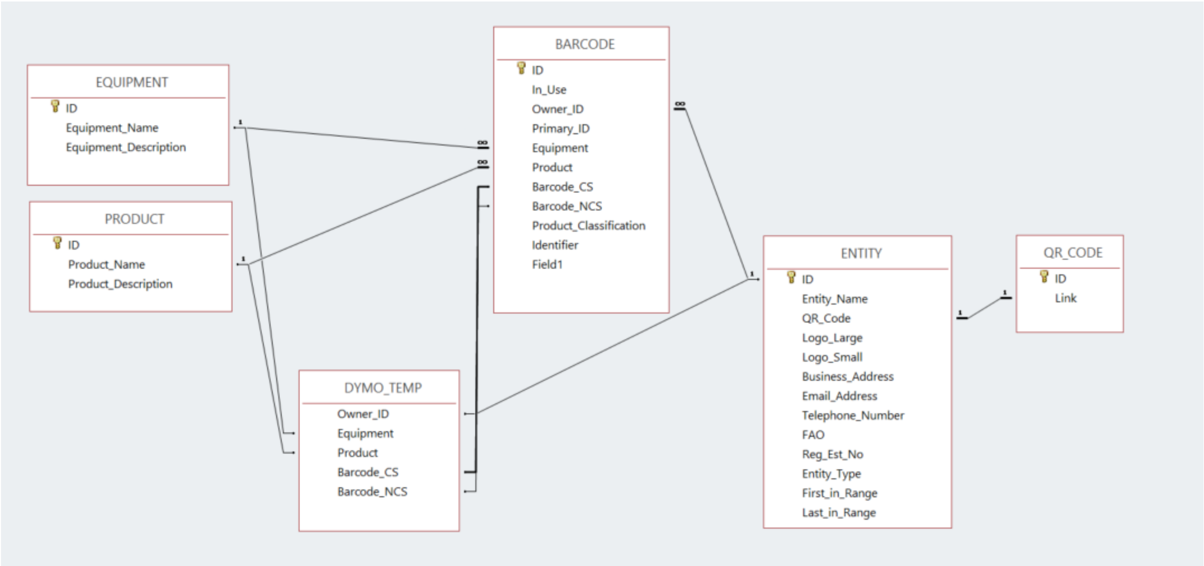


Figure 45 Barcode Assignment Database tables architecture.

Database Tables
In the database the tables store information pertaining to the GS1 barcodes and the entities in the supply chain which have been allocated barcodes.

BARCODE Table
The Barcodes table holds all current owned, assigned, and unassigned GS1 barcodes. It includes the following columns

- ID (long string) composed of a GS1 formatted barcode, not including checksum
- IN_USE (Boolean) which shows the current assigned status of the barcode
- OWNER_ID (int, foreign key for ENTITY) which shows the current entity ownership
- PRIMARY_ID (Boolean) which identifies whether the barcode is the entity identifier
- EQUIPMENT (long string, foreign key for EQUIPMENT) which identifies the type of equipment, where barcode is for a piece of equipment
- PRODUCT (long string, foreign key for PRODUCT) which identifies the type of product, where barcode is for a specific product
- BARCODE_CS (long string) composed of a GS1 non-formatted barcode, including checksum
- BARCODE_NCS (long string) composed of a GS1 non-formatted barcode, not including checksum
- PRODUCT_CLASSIFICATION (long string) which identifies specific genus, where appropriate, for barcodes identified as products
- IDENTIFIER (long string) which identifies the organic identifier for any item being labelled, for use when 0 loss is required
- CHECKOUT_DATE (int) formatted ddwwyy, showing the date the barcode was assigned, for printing, check-in, and check-out processes
- NOTES (long int) for any additional information required, including expiration, use, or other

ENTITY table
The Entity table holds all currently registered entities along the identified supply chains. It includes the following columns

- ID (auto-generated int) unique identifier for each entity
- ENTITY_NAME (long string) full business name of each entity
- QR_CODE (long string, as URL) optional organisational QR Code for entities
- LOGO_LARGE (long string, as URL) Full Logo of the entity
- LOGO_SMALL (long string, as URL) small square correspondence logo of the entity
- BUSINESS_ADDRESS (long string) operating location for the entity
- EMAIL_ADDRESS (long string) preferred contact email for the organisation
- TELEPHONE_NUMBER (long string) preferred contact number for the organisation
- FAO (long string) FAO of the entity
- REG_EST_NO (long string) registration number for the entity
- ENTITY_TYPE (string) type of entity within the supply chain

- FIRST_IN_RANGE (long int) first NCS barcode within barcode batch
- LAST_IN_RANGE (long int) last NCS barcode within the barcode batch

EQUIPMENT table

The equipment table holds all current types of equipment used for traceability. It includes the following columns

- ID (auto-generated int) unique identifier for the equipment type
- EQUIPMENT_NAME (long string) the name of the equipment
- EQUIPMENT_DESCRIPTION (long string) a description of the equipment, including required software, included functionality, and recommended use

PRODUCT table

The product table holds all current types of product being traced. It includes the following columns

- ID (auto-generated int) unique identifier for the product type
- PRODUCT_NAME (long string) the name of the product
- PRODUCT_DESCRIPTION (long string) a description of the product, including genus types, requirements, and considerations

QR_CODE table

The QR code table holds all current stored QR codes for entities. It includes the following columns

- ID (auto-generated int) unique identifier for the qr code
- LINK (long string) a URL to the QR_CODE

AUTO-GENERATED tables

The database queries also have auto-generate tables, for identifying in-use barcodes, out of use barcodes, and for printing via the DYMO label printing software. These will include already existing fields from other tables, where appropriate.

QUERIES

In the database, queries are used to retrieve information from tables. There are 3 types of built-in queries: Generate; PrintBy and MassSet.

Generate query

Generate queries are used to build temporary tables for DYMO Label Printing software. Generate queries generate based on:

- Barcode ID
- Date entered
- Entity – type of equipment
- Entity – type of product

PrintBy query

PrintBy queries are used by reports to print information onto Avery Labels. PrintBy queries select information based on:

- Barcode ID
- Entity – type of equipment
- Entity – type of product
- Entity – where barcode is primary identifier

MassSet query

MassSet queries are used to assign multiple barcodes at one time. MassSet queries select information based on:

- Type of equipment
- Type of product
- Entity ownership

Forms

In the database forms are used to enable the user to enter new data and visualise existing data. The built-in forms allow for easy viewing and editing of each table, and related foreign information from other tables. There are various forms in the database, and these are not explained in detail here as their functionality is already captured in the explanation of the queries and tables.

Reports

In the database various reports are used to generate custom label sheets for printing onto Avery Label-stock in order to enable a user to print off barcode labels. For each size, in addition to a basic A4 sheet, labels can be printed by using the following Reports:

- Barcode ID
- Entity – type of equipment
- Entity – type of product
- Entity – where barcode is primary identifier

Generating a new barcode

The most important use of the database is to generate a new barcode for an entity in the Southern Rock Lobster (SRL) supply chain. This section briefly explains how this can be achieved. The Barcode form is where all available barcodes from the GS1 pool are visible. The pool of barcodes can be viewed by using the forward and backward facing arrows at the bottom of the form.

The database uses an external software plugin in the auto-generate a barcode based on its numerical representation and this barcode is generated when the form is loaded.

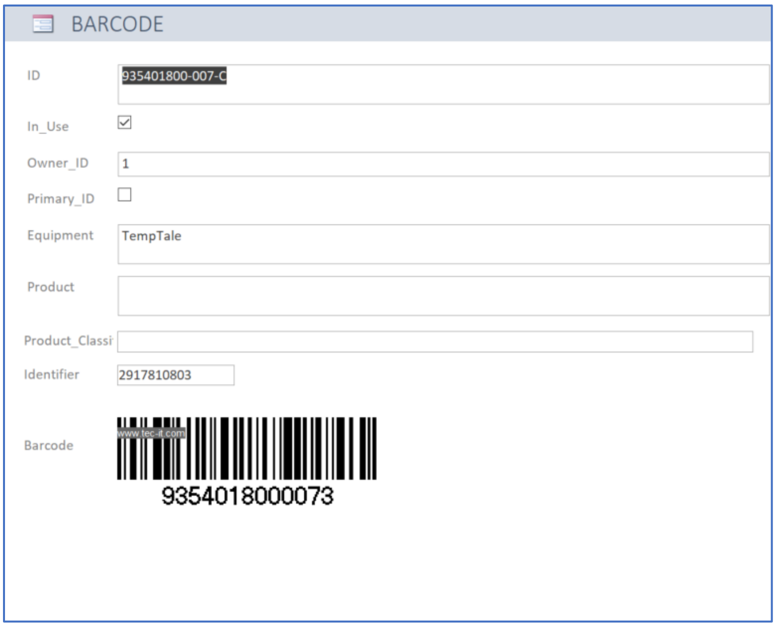


Figure 46 Barcode form in Barcode Assignment Database.

After viewing the available barcodes in the database, the next important step is allocating or assigning the barcode to an entity in the SRL supply chain. This occurs using the 'Entity' form in the database. The 'Entity' form enables a user to enter in a new Entity (e.g. lobster processor) and all associated details.

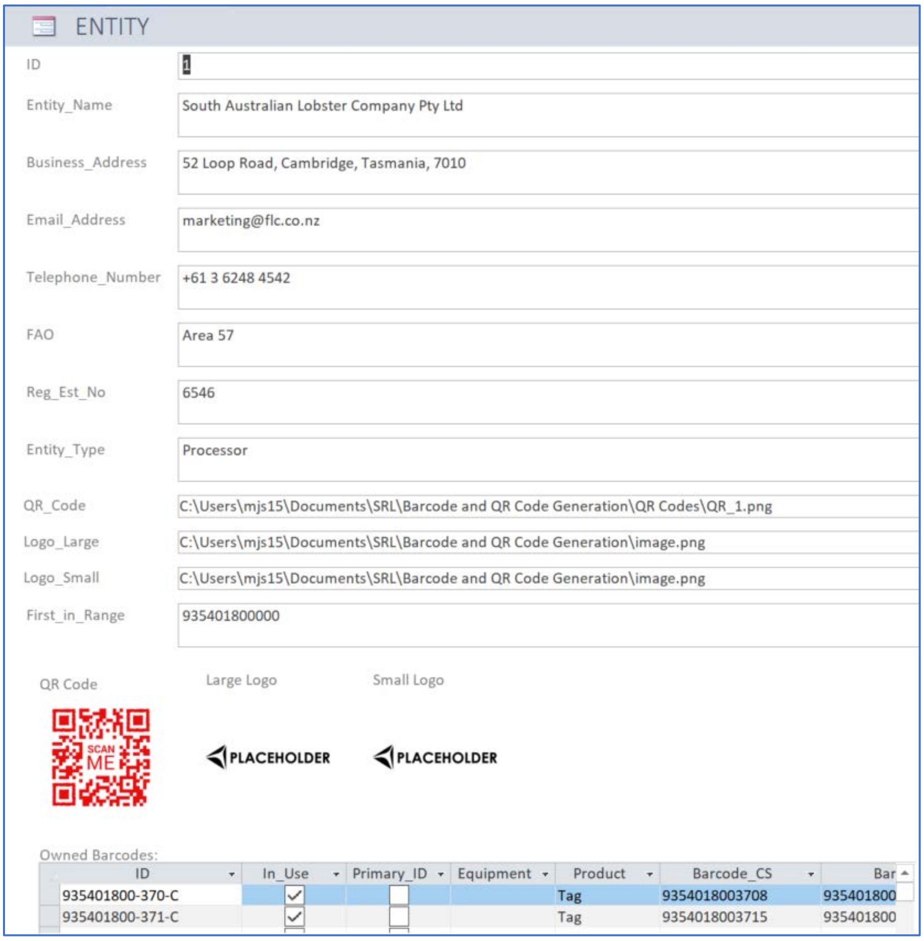


Figure 47 Entity form in Barcode Assignment Database.

Following allocation or assignment of barcodes to an entity, it is also possible to print off an entity's barcodes directly to Dymo labels.

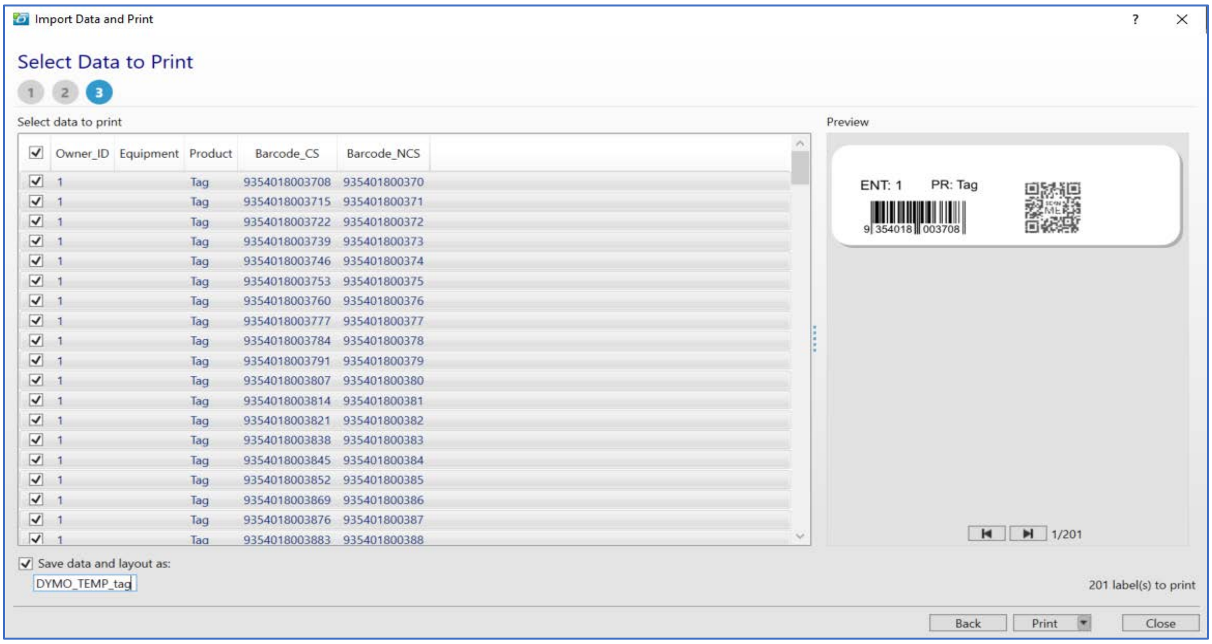


Figure 48 Print form in Barcode Assignment Database.

GS1 Barcode information

The project and its traceability system rely on the GS1 barcode system to generate and assign a master list of globally unique barcodes. The GS1 system is a paid service managed by GS1 Australia using the barcode system.

The project purchased a GS1 account and obtained a pool of 10,000 barcodes. These barcodes were entered into the 'Barcode Assignment Database.'

Table 25 GS1 barcode pool for the project.

Number Type	Number Range From	Number Range To	Number of GTINs from Allocation	Status	Description	Date Allocated	Last Change Date	GS1 Company Prefix Length	GS1 Company Prefix	Primary GLN
GS1 Company Prefix	935401800-000-C	935401809-999-C	10,000	Current		01/08/2018	01/08/2018	8	93540180	n/a
GLN	9377779408537		n/a	Current		01/08/2018	01/08/2018	n/a	n/a	n/a

Barcode Label Formats

The project designed a paper label that can be printed to display a barcode. The format of the paper label is saved in the 'Barcode Assignment Database' and a template for use with a label printing machine (from Dymo) also saved in the digital archive folder.

Figure 49 Traceability label design without QR code placeholder.

Figure 50 Traceability label design with QR code placeholder.

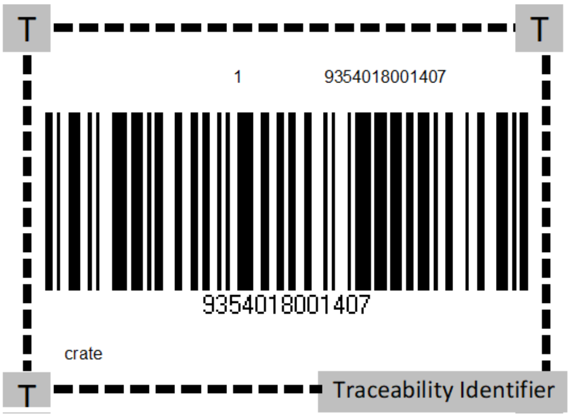


Figure 51 Traceability label design for GS1 barcodes only.

Key Files

Table 26 Key files for Dymo printer to print traceability labels.

Location	Use
./Database/SRL_BARCODES.accdb	Access database files for rebuilding the access database
./DYMO Lables/	Folder containing the formats for barcode printing

Tracking Database

The tracking database is an online database which aggregates all traceability data from the various digital artefacts in the traceability system. This database is separate from the 'Barcode Assignment Database,' it is an SQL database which can be duplicated for each entity within the research. It consists of two tables that are built to allow the flexibility of the application.

Tables

In the database the tables store information pertaining to all traceability information from all businesses enrolled in the traceability system. If a business is using a digital artefact such as the Tracking Application and they have configured the application to share data, then this data will be uploaded to the 'Tracking Database' and store in the relevant tables.

EntryData table

The EntryData table contains all entry data sent to the database from the application. It contains the following columns

- documentNumber (text) application assigned document numbers, one of three unique identifiers, used to link to header data.
- formName (text) name of application form used to generate data, used to decipher data fields type.
- deviceID (text) application assigned device identifier, one of three unique identifiers, used to link header data
- indexNumber (text) application assigned index number, one of three unique identifiers, used to separate data
- dataOne – dataFourteen (text) data fields, used to store application tracking data

HeaderData table

The HeaderData table contains all header data sent to the database from the application. It contains the following columns

- documentNumber (text) application assigned document numbers, one of two unique identifiers, used to link to header data.
- formName (text) name of application form used to generate data, used to decipher data fields type.
- deviceID (text) application assigned device identifier, one of two unique identifiers, used to link header data
- formVersion (text) application form version number, used to decipher data fields type
- dataOne – dataTwelve (text) data fields, used to store application tracking data

Key Files

Table 27 Key files for tracking database.

Location	Use
./Database/template.sql	SQL commands to build empty template tracking database
./Tasmania/Tasmania.sql	SQL commands to build and repopulate database used by the Tasmanian processor

./Victoria/Victoria.sql	SQL commands to build and repopulate database used by the Victorian processor

Dependencies
SQL server

FTP Server

The FTP server was used to hold forms for the application as well as initially being used to initially store files from the application for processing. The application is set up to use FTPeX as the protocol, but any FTP server can be used with some modification to the code. A later use of the FTP server was to hold data for the Pot tags and modem, this data could then be accessed by a website which would put human readable data on a map to demonstrate how it would work.

Key Files
None
Dependencies
Webserver with FTP capabilities

Pot Tags and Modem

The hardware provided by SciElex allowed the tracking of conditions as a pot was being used for fishing. It would track the time submerged as well as a set of conditions at a set polling rate, this rate could be changed as needed. The modem could then collect the data from the tags and upload it to a FTP server.
Key Files
None
Dependencies
Webserver with FTP capabilities to connect to

Qlikview

The software provided by Qlik allowed the processing of data from the tracking database. This data was processed using an api built into the website that allowed the program to access the database. The file is a proof of concept only and as a result can retrieve and process data but does not currently contain any advanced features.
Key Files

Table 28 Key files for QlikView software.

Location	Use
./Qlikview/LobsterTrial.qvf	File allowing the import and viewing of data within Qlikview
./Webfiles/data.php	Webfile that displays database data as json strings to allow easier processing

Dependencies

Webserver hosting database and webfiles
Qlikview instance, this file was tested on both cloud and desktop versions before changes on 24/09/2019.

Scale Trial Application

The scale trial application was developed to display how an interface would be built to allow better grading without having to interact with the scales.

Key Files

Table 29 Key files for the scale trial application.

Location	Use
./Scale Trial App/app-release.apk	Apk file allowing quick installation on many android devices.
./Scale Trial App/ScaleDemo.zip	Zip file containing all assets needed to continue development with android studio.

Dependencies

The apk needs at least android SDK version 20 and is targeted for SDK version 28.

Android studio is required to properly edit and work with the files contained within the zip, it is recommended to use the latest version to access these files.

Tracking Application

The tracking application allows the use of customised forms to input data for tracking purposes. The application requires forms, an FTP server for forms to be stored in and an android device to work, if further functionality is required a LAMP stack webserver with both the database and rest.php file set up correctly will allow further functions. Once a form has been filled out an email can be sent from the device using one of the devices native email applications.

Key Files

Table 30 Key files for the tracking application.

Location	Use
./Scale Trial App/app-release.apk	Apk file allowing quick installation on many android devices.
./Scale Trial App/ScaleDemo.zip	Zip file containing all assets needed to continue development with android studio.
./Webfiles/rest.php	Webfile allowing the input of data from the application to the tracking database.

Dependencies

The '.apk' file needs at least android SDK version 20 and is targeted for SDK version 28. Android studio is required to properly edit and work with the files contained within the zip, it is recommended to use the latest version to access these files.

Future development

Future projects for the application include the addition of recognition of previously scanned barcodes to reduce duplicate data entry and improvement to the speed of data upload to the database.

Website

The website serves two purposes both of which depend on the database running with the correct tables in place. The codes file contains all data and passwords required to access the database and other key files. Through a correctly formatted .htaccess file the index.php file is able to serve as the primary file for all web access requests apart from requests to data.php and rest.php. Critical file are the connect.php and codes.php files, from there data.php, rest.php and index.php can run, index.php is required to run the rest of the files.

Key Files

Table 31 Key files for the website.

Location	Use
./Webfiles/codes.php	A series of codes that specify what data can be shown as well as where the database is located
./Webfiles/connect.php	Establishes a connection with the database based on the codes provided
./Webfiles/connectUser.php	Establishes a connection with the database to check if a valid username and password is in use
./Webfiles/data.php	Displays the data as json objects to allow easy importation of data into reporting software
./Webfiles/index.php	Index file to control what is shown on the website
./Webfiles/potdata.php	Displays any pot tag data held in a specified ftp server
./Webfiles/potmap.php	Displays any pot tag data held in a specified ftp server on a map
./Webfiles/records.php	Displays database information in a human readable format
./Webfiles/rest.php	Allows the application to post tracking data through to the database
./Webfiles/stock.php	Displays current stock levels based on tracking data

A properly set up .htaccess file is needed for the main site to work however this file changes from server to server so it is not included. Both the data.php and rest.php files do not require a .htaccess file.

Dependencies
LAMP stack webserver running php5.5.

Future development
Future development for the website would include the addition of business analytics to the main web pages allowing for better choices to be made by a business accessing their data.

Onboarding a New Entity into the Traceability System

The process to onboard a new entity from the Southern Rock Lobster (SRL) supply chain into the tracability system is explained in this section. It describes the resources from software (i.e. contained in the digital archive) and hardware which the new entity will require. It also describes the steps involved for each software or hardware component. Whilst this is not a comprehensive description it is sufficient for a software developer to ascertain the detailed steps upon close inspection of the digital archive.

Hardware

Item and Batch Traceability Tags and Labels

- Create an entity ID for barcode system
- Assign barcodes (Note: up to 1000 barcodes available per new entity) to an entity in barcode system for each entity in the supply chain
- Assign one barcode for the entity's primary ID in barcode system
- Assign any number of barcodes for the entity's product items and batches in barcode system
- Following creation/assignment of entity barcodes, then print waterproof DYMO barcodes using DYMO Label v.8 and pre-designed labels
- Print small, medium and large AVERY barcodes using the barcode system and pre-designed labels
- Affix waterproof DYMO barcodes to lobster tags where appropriate, and record serial identifier in barcode system

G1 and H1 Testo Sensors

- Assign barcodes to these Testo sensors in barcode system – typically only one barcode per sensor is required
- Print waterproof DYMO barcodes using DYMO Label v.8 and pre-designed labels
- Affix waterproof DYMO barcodes to each sensor where appropriate, and record serial identifiers in barcode system
- Connect sensor to laptop and open the "Testo 184 configuration" file using Adobe Acrobat
- Import the correct configuration file for each sensor type, then save the configuration on the sensor
- Disconnect the sensor from the computer

Temptale 4 Sensors

- Assign barcodes to sensors in barcode system – typically only one barcode per sensor
- Print waterproof DYMO barcodes using DYMO Label v.8 and pre-designed labels
- Affix waterproof DYMO barcodes to sensors where appropriate, and record serial identifiers in barcode system
- Confirm that display is showing small sun and is ready to record

HOBO Sensors

- Assign barcodes to sensors (1 per) in barcode system
- Print waterproof DYMO barcodes using DYMO Label v.8 and pre-designed labels
- Affix waterproof DYMO barcodes to sensors where appropriate, and record serial identifiers in barcode system

Galaxy Tablets

- Assign barcodes to tablets in barcode system – typically only one barcode per tablet
- Print waterproof DYMO barcodes using DYMO Label v.8 and pre-designed labels
- Affix waterproof DYMO barcodes to galaxies where appropriate, and record MAC addresses in barcode system
- Enable developer mode on tablets

Barcode Scanners

- Assign barcodes to scanners (1 per) in barcode system
- Print waterproof DYMO barcodes using DYMO Label v.8 and pre-designed labels
- Affix waterproof DYMO barcodes to scanners where appropriate, and record MAC addresses in barcode system
- Connect to tablet via Bluetooth

Database

- Create entity prefix in format EntryShorthand[.location] location is only needed if the entity has multiple locations
- Create new database user using entity ID from barcode system
- Create new database from entity prefix
- Copy table template to new database for both EntryData and HeaderData
- Note database name, username and password for website

Website

- Create new subdomain with entity prefix
- Import relevant pages from the template directory
- Fill in the codes.php file with the database information
- Note the restful API location for input to application settings

FTP Server

- Create new account using entity ID from barcode system
- Note username password for input to application settings
- Generate unique six-digit hex code for the entity form
- Create subdirectory under the settings ftp account named with the six-digit hex code
- Import forms that the entity is to use
- Note hex code for input to application settings

Applications

- Ensure latest version of the application is in use
- Install software from android studio and set correct permissions
- Launch software, navigate to settings and set relevant parameters

Application Instruction Sets

Installing/Starting the Application via Android Studio

1. Open project in Android Studio and run on device
2. Application installs and attempts first launch
3. If permission error appears enable relevant permissions on device
4. Application can be launched from icon in future

Installing/Starting the Application via

1. Download APK to device and launch APK
2. Application installs and attempts first launch
3. If permission error appears enable relevant permissions on device
4. Application can be launched from icon in future

Selecting a Form

1. Ensure current progress has been saved
2. Navigate to main menu (launch page)
3. Press the label next to the current form label
4. Select form that is needed
5. Accept that current progress is deleted

Changing Settings

1. Navigate to main menu
2. Select settings button in main menu

Entering Data

1. Navigate to main menu
2. Ensure correct form is selected (see selecting a form)
3. Press the new or resume button
4. Enter or scan in data
5. Once all data entered swipe left
6. Select desired email output
7. Press email button to prepare email
8. Press finish button to save and complete data

Viewing Entered Data

1. Navigate to main menu
2. Ensure correct form is selected (see selecting a form)
3. Select desired entry from the list

Summary

This section has outlined the essential components of the developed digital tools and techniques digital archive. It provides a reference point for a software developer to understand how the traceability system functions from a technical standpoint. It provides them with an understanding of each of the digital artefacts, how they connect, and how data is shared amongst the artefacts. It also highlights the key files in each digital artefact for entry into the software for development purposes.

The archive is provided to facilitate a software developer to re-deploy the tracability system to an executable or development state. It contains all the necessary source code and example executables needed for redeployment. In addition, each digital artefact contains in-line comments for all software artefacts developed by the project are also available – these are visible in the software source code.

Traceability Implementation: A Guide for the Southern Rock Lobster Industry

This guide is provided as a stand-alone best practice guide for distribution to SRL industry stakeholders. Its aim is to present the outcomes of this project in a practical, accessible manner and to aggregate findings, insights and advice for use by the SRL industry. As it draws on the outcomes of this project, it necessarily reiterates the high-level concepts and many of the materials presented in the final report.

The guide is provided as an appendix to this final report (PDF format). A word version along with all other project resources is available online at the following address:

https://drive.google.com/drive/folders/16Oo0UUkrKn1svLOFKYNd2eriNw9-hIwo?usp=sharing

This google drive can be accessed with the following account and password:

Username: tas.lobster.project@gmail.com

Password: CsQyV8td77B5a2A

Traceability Systems and Technology Products Guide

This guide is provided as a stand-alone products guide for distribution to the SRL industry stakeholders. It aims to identify and briefly review systems and technology products currently available for purchase and use by SRL industry stakeholders. Where possible the KDEs that can be produced by these systems and technology products have been identified.

The guide is provided as an appendix to this final report (PDF Format). A word version along with all other project resources is available online at the following address:

https://drive.google.com/drive/folders/16Oo0UUkrKn1svLOFKYNd2eriNw9-hIwo?usp=sharing

This google drive can be accessed with the following account and password:

Username: tas.lobster.project@gmail.com

Password: CsQyV8td77B5a2A

Conclusions

This project has raised awareness of the importance of traceability within and along the southern rock lobster supply chain. The research team have engaged with the industry on their current practices and identified and demonstrated through trial and evaluation a range of mechanisms, tools and techniques to enhance SRL traceability systems. The research project has directly contributed to enhancing SRL traceability practises. The production of a 'Traceability Implementation' guide provides the SRL industry with a genuine opportunity to take a step forward to 'better traceability practises' and it opens up the possibility for the industry to consider the development of an industry traceability platform for coordination and integration of an industry-wide traceability system built on GS1 standards.

In summary:

- Consultation with industry demonstrated a widespread, in-principle desire for traceability and a general recognition of the benefits;
- Costs, in terms of investment, time and manpower, are the main hinderance to adoption for most stakeholders but attitudes and awareness of the need for better traceability are emerging strongly;
- "Traceability" implies individual, item-level tagging to much of the industry, an approach that is unpalatable and challenging. This work has raised awareness amongst the industry that there are other constructive steps that can be taken to enhance traceability prior to any formal move to instantiate individual tagging. There is also a realisation that hybrid and/or tag-less technologies may emerge to make individual tagging less of an impost on contemporary business models;
- The fragmented nature of SRL industry across and within states indicates that implementing traceability may continue to be the responsibility of individual operations/supply chains in the short-term, unless the industry pursues a joint initiative to a traceability platform;
- A "one size fits all" approach is unlikely to be successfully implemented due to differing levels of capability and desire amongst the SRL industry;
- External factors, such as SRL/Clean Green introducing traceability requirements (like that of Marine Stewardship Council in the Western Rock Lobster industry) or financial incentives like split pricing for traceable *versus* non-traceable product, are the most likely drivers for implementing traceability in the SRL industry;
- A great deal of the data needed to implement traceability are currently being captured by the industry. However, these data are not being retained or transmitted in an efficient or effective manner it is anticipated that the results and outputs of this project will contribute to addressing many of these issues;
- Importantly within many operations, implementing an improvement over current levels of traceability can be achieved through modest adjustment of current operating procedures as illustrated by the case studies presented in this report.

Recommendations

The benefits of traceability and the value it adds to the fishery are well recognised, indicating that further research into the development and implementation of specific, actionable traceability system elements will likely be well received.

Based on the results of this project it is evident that there are still a number of challenges to the implementation of standard industry-wide traceability practises. However, this project has raised awareness and demonstrated a way forward to achieving this goal. To that end, the following recommendations can be made:

- Continued consultation and engagement with industry stakeholders to strengthen the desire and willingness to progress traceability improvements across the industry. Given market trends and the ChAFTA it is recommended that the SRL industry move to the development of an industry wide traceability platform. This is outlined in the project extension section of the report.

- The occurrence of harmful algal blooms such as *Alexandrium tamarense*, which cause the build-up of paralytic shellfish toxin, will force the industry to adopt some system of traceability or face closures and brand damage. As blooms have been limited to Tasmania thus far, this segment of the SRL industry is at particular risk. The implementation of at least batch level traceability with evidence of where lobsters were caught will help to mitigate this risk.

- Further research into the development of tagging approaches and alternatives should be a priority. Tagging lobsters with unique identifiers is a critical element of any highly precise traceability system. Unfortunately, it is also labour intensive and time consuming and represents a barrier to acceptance and uptake by the industry. The development of a new tagging approaches or even 'tagless techniques' hold promise and should continue to be investigated. This is discussed in detail in the project extension section of this report.

- Brand differentiation between rock lobsters is a potential area of growth for the SRL industry. Although the SRL industry considers itself to be producing a premium product, the reality is that there is currently no differentiation between SRL and other rock lobsters at markets and wholesalers in China. Further development of the SRL brand and provenance can take advantage of this and position SRL as a prestige product.

- Industry members expressed enthusiasm for the development of water quality monitoring devices that can be incorporated into traceability systems. The understanding and management of water quality is variable across the industry, so tools that assist the measurement and recording of water quality will help to improve holding practises as well as provide evidence of good care of stock along the supply chain.

Project Extension

There are two inter-related areas of significant opportunity for extending the SRL traceability system work that has been completed in this project.

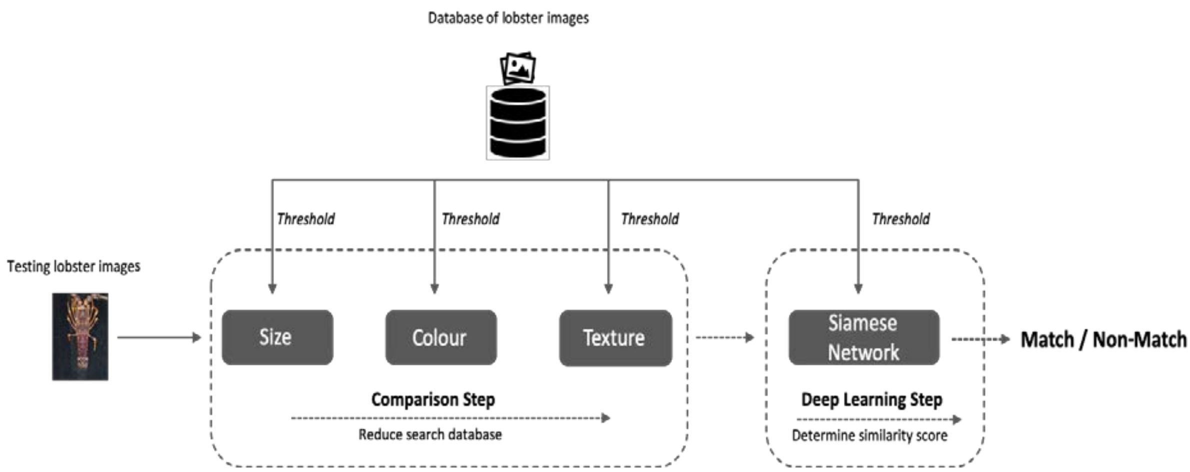
Integrated Traceability Platform

Building on these recommendations is the idea of developing a traceability software platform which could integrate batch and item level technologies along the supply chain and underpins SRL quality and safety auditing programmes. The key elements of this platform have been trialled as part of this existing project so there is a genuine opportunity to significantly extend this platform to all industry participants and to facilitate moving the whole industry forward in its adoption of traceability better practises.

Biometric Identification & Batch Level Authentication in the SRL Supply Chain

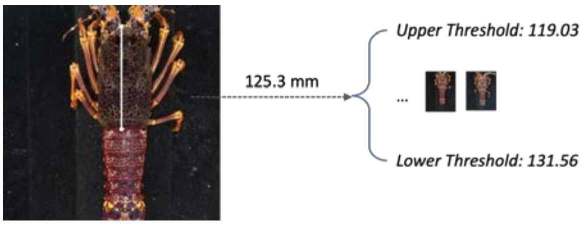
Low-Cost Biometric Identification for Individual SRL:

The model of biometric ID for individual SRLs is built on set of attributes extracted from lobster images that can be captured by low-cost cameras. The operational of this model is enabled by a set of image processing techniques and convolutional neural networks (CNN). Lobster metrics are arranged in a linear checking mechanism as illustrated in the diagram below. In the first phase, size, colour and texture are used as comparative metrics to reduce the search database. This output is then processed by a CNN model in the second phase to decide a testing image to be matched or unmatched based on similarity scores.



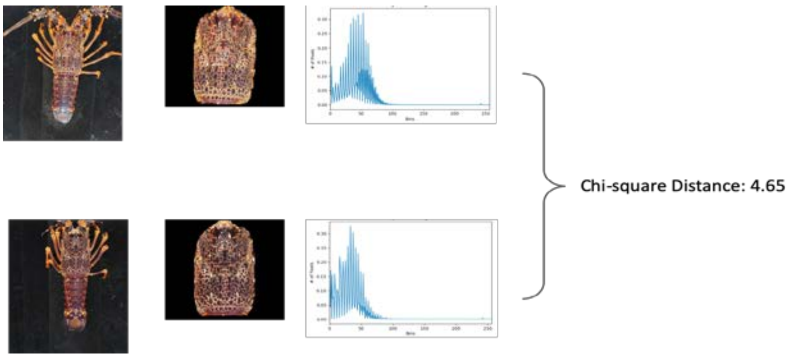
At the species identification level, the powerful metrics including colour histogram, texture and Siamese score can be used to detect SRL and non-SRL products. The testing samples below demonstrate the quantified differences between the SRL-SRL pair and the SRL-Western Rock Lobster pair.

Size Comparison:

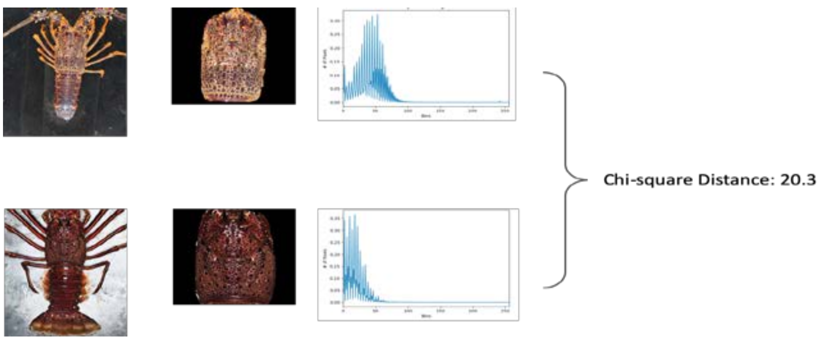


Colour Comparison:

(a)



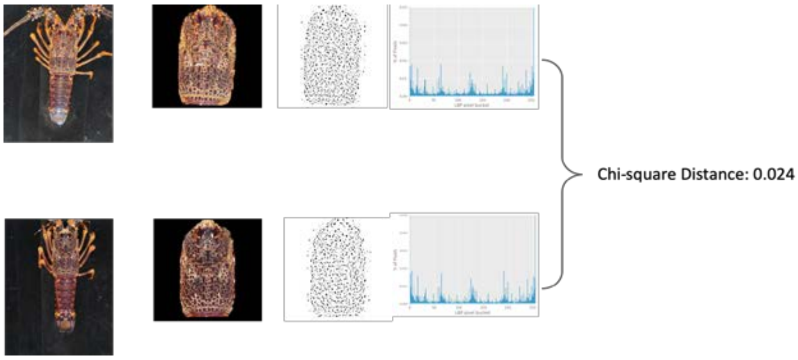
(b)



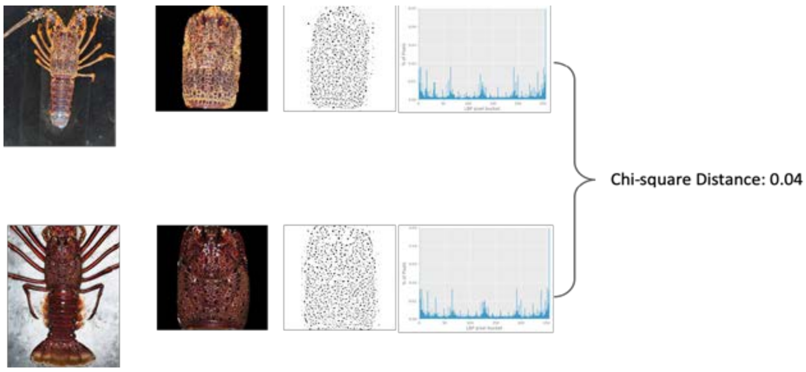
(a) Two lobsters in the same SRL species (b) Two lobsters from different species.

Texture Comparison:

(a)



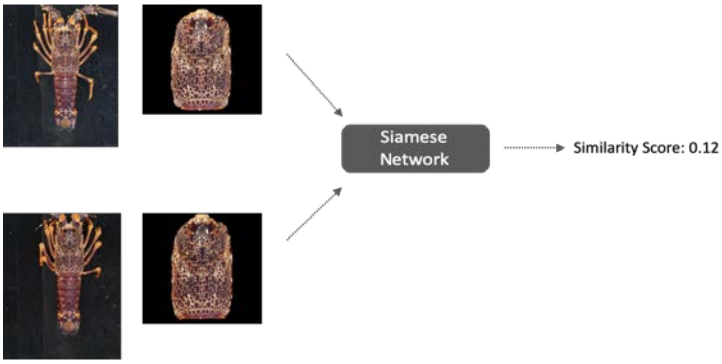
(b)



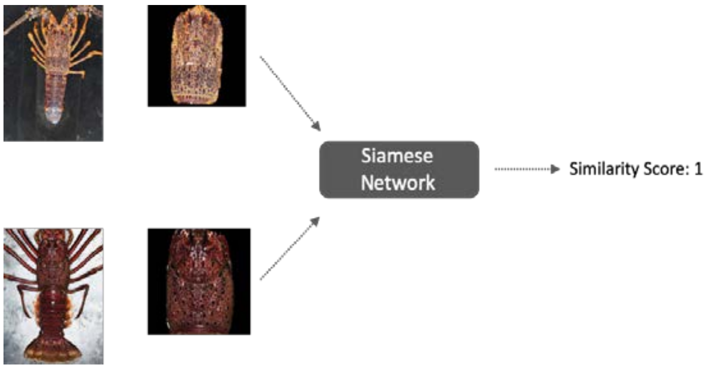
(a) Two lobsters in the same SRL species (b) Two lobsters from different species.

Siamese Network (Using CNN):

(a)



(b)

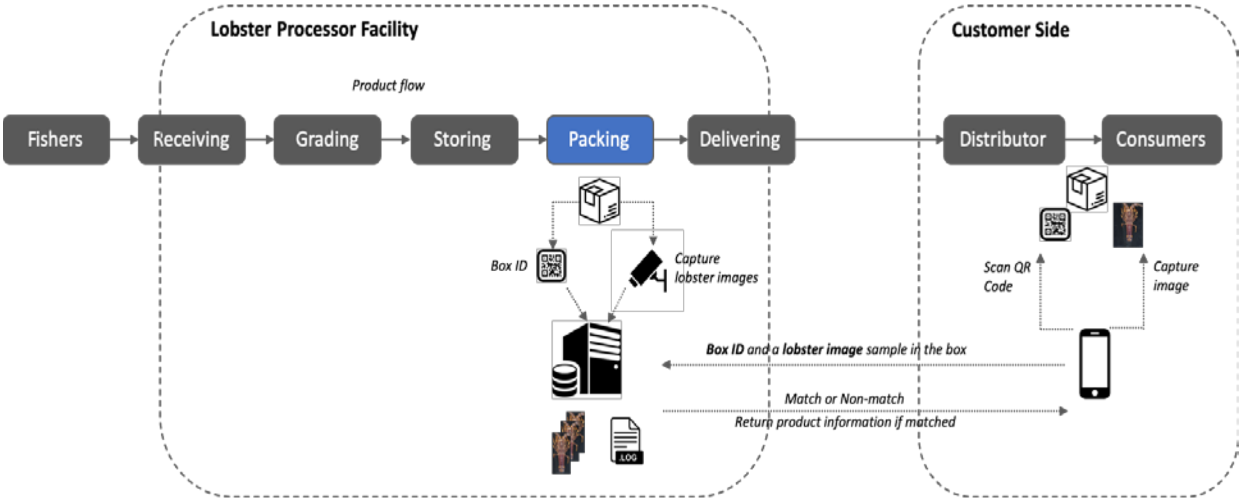


(a) Two different images of the same lobster (b) Two different lobsters.

Note: The lower score means the higher confidence on the similarity.

Applying Biometric Identification to Batch Level Tracking in the SRL Supply Chain:

To strengthen the batch level tracking in the SRL supply chain, a proposed model is established based on the association of box identity number (ID) and biometric identification as illustrated in the diagram below. In this operation, the biometric attributes act as the pieces of evidence in addition to box ID to validate the genuine products.



At Lobster Processor Facility: For every box of products delivered to customers, its ID and lobster images are captured and managed in a central database. The logfile is responsible to link the box ID to lobster images, grading attributes and other product information such as caching location, landing date, fisher, seller, etc. The server then provides an API for downstream customers to verify the authenticity and provenance of SRL products over the Internet connection.

At Customer Side: A mobile application (**SRL Tracking**) is developed to help customers verify the genuine products. This application offers two main functions:
Lobster Grading: Users can capture lobster image or choose a photo from library to process the grading including size, weight, product category and colour. For batch level tracking, users can pick a random lobster in the box to capture image.

Lobster Verification: After the grading step, users can choose to query product information. To enable the authentication mode for batch level tracking, users need to scan the QR code on the box to proceed the task. Once the box ID is sent to the server together with a lobster image (captured at the grading step), the system performs a **1-to-some** matching mechanism to determine ***match*** or ***non-match*** result. With a ***match*** result, a confirmation of product authenticity together with information of product origin are returned to users.

Appendices

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FRDC FINAL REPORT CHECKLIST

Project Title:	Traceability Systems for Wild Caught Lobster		
Principal Investigators:	Luke Mirowski, Ryan Day, Mikaela Seabourne, Shayden vanWinden, Sumit Verma, Son Vo, Laurie Bonney, Caleb Gardner, Paul Turner		
Project Number:	2016/177		
Description:	This research project contributes to improving traceability and product provenance within the wild caught Southern Rock Lobster supply chains. The results and outputs of this research will support industry to determine how to increase the breadth, depth and precision of existing SRL traceability practises along their supply chains. By developing an approach to traceability underpinned by a traceability framework the research highlights what steps industry can take to identify, improve and benchmark their traceability practises. The approach is incremental in that regardless of different starting points or business capabilities it is possible to map a way to move forward to improve traceability. The research has synthesized the key insights into a traceability implementation guide to support "better practises" adoption and implementation by industry.		
Published Date:	17/12/2019	**Year:**	2019
ISBN:	XXXXX (if applicable)	**ISSN:**	XXXXXXXXXXXXX (if applicable)
Key Words:	Traceability Systems, Southern Rock Lobster, Information Technology, Supply chains, Provenance		

Please use this checklist to self-assess your report before submitting to FRDC. Checklist should accompany the report.

	Is it included (Y/N)	**Comments**
Foreword (optional)	N	
Acknowledgments	Y	
Abbreviations	Y	
Executive Summary	Y	
- **What the report is about**	Y	
- **Background – why project was undertaken**	Y	
- **Aims/objectives – what you wanted to achieve at the beginning**	Y	
- **Methodology – outline how you did the project**	Y	
- **Results/key findings – this should outline what you found or key results**	Y	
- **Implications for relevant stakeholders**	Y	

- **Recommendations**	Y	
Introduction	Y	
Objectives	Y	
Methodology	Y	
Results	Y	
Discussion	N	Included in the results section
Conclusion	Y	
Implications	N	Covered in recommendations
Recommendations	Y	
Further development	N	Covered in project extension
Extension and Adoption	Y	
Project coverage	N	Covered in introduction section and results and outputs section
Glossary	N	
Project materials developed	Y	
Appendices	Y	
EXTENSION		
Extension plan developed?	**N**	
Extension undertaken?	**N**	
If extension was undertaken, who was it undertaken with and was it successful? **(Detail answer in comments section)**	**N**	
If No, then is further extension necessary? **With who?** **How? (detail answer in comments section)**	**N**	The next steps are to be determined with the industry. In the extension and adoption section the research team have made some suggestions in this regard.