# Review of Traceability and Product Sensor Technologies relevant to the Seafood Industry


**Prepared by Food Innovation Partners and Allan Bremner & Associates for the**


**Australian Seafood Cooperative Research Centre**

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AUSTRALIAN SEAFOOD COOPERATIVE RESEARCH CENTRE

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# Table of Contents

# Executive Summary

Australia enjoys a high level of food quality from a clean safe environment, which is being used to brand and position them forefront of the consumers mind. However, like many other countries, we face the challenge of continually improving food quality. In Australia's seafood industry, traceability systems are the norm in most of the catching and harvesting sectors; the catch sector uses many sophisticated electronic instruments and devices in their operations and that electronic communications and computer use are wide spread on board, dockside and in processors. Traceability should be viewed as an opportunity, not an imposition.

Products and services have customarily been controlled by different paradigms, but the advent of smart packaging, product sensors and traceability systems and the integrating technologies of intelligent device networking can now serve to bring them together and a product and a service are supplied simultaneously. A simple example is that of identifying goods with tags or bar codes. These are used in the production sense to provide the manufacturer with a means of identifying the goods and of following their history of manufacture from raw materials, the processes used and the packaging but they can also be thought of in the service sense as providing information to the end user and thus enhancing the product's value. Information is the new value-added.

Products alone and services alone do not provide competitive advantages as either a product, or a service, can easily be copied by a competitor. The offering of both product and service provides a competitive edge that is less easily copied and helps lock in the information feed back loop with the customer.

Therefore the use of traceability and product sensors can be thought of as to whether they are an aid to making and distributing the product or whether they provide a service to the customers. Clearly both matters should be considered and those devices and techniques which offer the possibility of integrating both should be seen as the way of the future.

Traceability systems provide companies with competitive advantage through the ability to better to manage supply chains to ensure maximum product quality and freshness along with reduced waste, potential to enter premium markets.

There are six essential elements of traceability constituting an integrated agricultural and food supply chain traceability system. These elements are:

1. Product traceability defines the physical location of a product at any stage in the supply chain.

2. Process traceability ascertains the type of activities that have affected the product during the growing and post harvest operations (what, where and when).

3. Genetic traceability determines the genetic composition of the product and includes information on the type and origin (source, supplier).

4. Inputs traceability determines type and origin (source, supplier) of inputs, e.g. fertilizers, additives used for preservation or transformation of the raw materials into processed products.

5. Disease and pest traceability traces the epidemiology of microbiological hazards and pests, which may contaminate food products.

6. Measurement traceability relates 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, operator etc.).

The Australian Food Standards Code contains labelling requirements for identification and tracing food to facilitate retrieval of unsafe or unsuitable food from the market place. Certain sectors of the food industry (wholesalers, manufacturers and importers) are required to have recall systems but the obligation does not extend to traceability/product tracing. However, traceability/product tracing is being considered in the development of primary production standards on a sector by sector basis. For example, under the recently introduced Primary Production and Processing Standard for Seafood, seafood businesses are required to maintain records to enable seafood to be traced one step forward and one step back. The standard specifies that this is for food safety purposes only i.e. it is only for purposes where it is justifiable to protect consumers' health.

Seafood businesses now need to comply with the standard and it applies to both domestic and imported seafood. It is likely that traceability for food safety purposes will be required for other sectors as whole-of-chain standards are developed initially for dairy, meat, poultry, and eggs sectors. The traceability requirement is an example of food safety regulation that allows flexibility.

This project is a desk top study to critically evaluate the traceability and freshness indicator technologies that are relevant to the Australian seafood industry. This report will serve as the foundation for future studies within the Seafood CRC that will integrate relevant technologies, foster innovation and result in high quality and safe Australian seafood products. The study involved:

- Identification of currently available traceability and freshness indicator technologies relevant to the seafood industry,
- Identification of newly emerging traceability and freshness indicator technologies,
- Explanation of how such systems may be integrated into seafood businesses,
- Identification of key organisations involved in developing these technologies,
- Description of potential directions that these technologies may go over the next 10 years, and
- Recommendations describing how the CRC can trial and adapt traceability and freshness indicator technologies.

The ultimate aim for traceability systems is that they work totally electronically and integrate with technologies such as RFID, thus requiring no paper records. Although not a new technology perse, RFID is still evolving in terms of features, operation and application. Standards and general frameworks for setting up traceability systems have been launched during recent years. For example, the International Organisation for Standardization (ISO) introduced, in the beginning of 2006, two new standards that define the requirements for a traceability system within a food safety management system and the data that needs to be retained. Other international and European organizations (Codex Alimentarius) have also launched standards for traceability.

In practice the tools of traceability are labels containing alphanumerical codes (a sequence of numbers and letters of various sizes, generally owners' codes); bar codes and automatic radio frequency identification (RFID), of which bar codes seem to be the most frequently used systems currently. The data accuracy and reliability required as well as cost can guide the selection of the traceability tool.

In the Australian seafood industry, paper systems are the norm in most of the catching and harvesting sectors, despite the fact that the catch sector uses many sophisticated electronic instruments and devices in their operations and that electronic communications and computer use are wide spread on board, dockside and in processors.

RFID is a very promising technology, but due to the high cost of, tags it is not suitable for individual low-cost food products. However, as tags are produced more efficiently and the total cost decreases, in addition to tracking the goods, RFID-based systems will be used to monitor the quality of the products and the supply chain itself. For example, RFID-based remote sensing will enable the online spoilage detection of food products and the continuity of cold chain. Large, overseas retailers are rolling out RFID mandates to all their suppliers. The biggest of them all, Wal-Mart, is currently working out traceability standards for all fresh food products. As far as these retail giants are concerned, their primary motivation is building customer loyalty and trust. In driving these traceability measures down the supply chain, they are providing guarantees that if there is ever a recall, then any problem could be contained quickly without losing credibility. And the best way of ensuring this is to ensure that suppliers have full control. This is why retailers are leaning heavily on manufacturers to install technology that will guarantee complete traceability.

Another innovative technology utilizes microscopic, edible bar codes that can be applied directly onto foods to make them more secure, safer, and less expensive. In traceability investigations, often the origin of plant or animal-based raw material is sought. However, universal methods do not exist and indirect methods have to be coupled with modern analytical techniques in analysing the origin of foodstuffs. In the future, biosensors will most probably be used for various purposes such as the detection of mycotoxins, bactericides, allergens or contaminating microbes.

This report makes the following recommendations to the Australian Seafood Cooperative Research Centre:

**RECOMMENDATION 1 – Traceability mapping of selected chains using proven methodology**

Before traceability systems can be implemented a study of the chain of events that occur in the transformation of raw material into consumer product must be done.

- Identification of suitable chains and seafood industry participants, including technology providers
- Analysis and mapping of these chains
- Cataloguing of current technologies used
- Select prototype chain for development
- Develop the chain traceability system
- Validate the system
- Examine potential time and costs of operation in comparison to current methods
- Identify additional benefits

**RECOMMENDATION 2 – Test and modify the Good Traceability Practice Guide under Australian conditions.**

Assess the traceability systems identified in this report against the criteria in the “product traceability framework” and ensure they satisfy the seafood industries needs. This will also require testing and modifying the “Good Traceability Practice Guide” under Australian conditions with selected seafood products.

**RECOMMENDATION 3 – Evaluate Information platforms to support Traceability Systems under Australian conditions.**

Pilot test *InformationLeader* in the seafood industry. *InformationLeader* is an Information Management System designed to replace paper based systems and ad-hoc electronic solutions by providing a secure, centralised and highly flexible store of information. Possibly use on the trawler to capture catch information and establish the system all the way through to retail. Information Leader is compatible with RFID systems

**RECOMMENDATION 4 – Develop and implement a pilot Chain of Custody studies**

"Chain of Custody" is the new imperative in Seafood that involves the need to identify where fish come from to ensure that the fishing areas remain sustainable. Build on the E-boat initiative to include catch and traceability data.

Young's Seafood are the leaders in sustainable wild caught fishing and their approach should be applied and tried in a selected fishery such as that of Australian Sardines, or of a controlled prawn fishery (Spencer Gulf) or SETFIA.

**RECOMMENDATION 5 - Product sensors**

- Identify the attributes of specific seafood products for which sensors would be applied.
- Review availability of current Time-Temperature Integrator labels discussed in this report, and equipment that have correct kinetics that may be developed for Australian conditions, species and products.
- Work with local manufacturers of data loggers e.g. Global Cold Chain Solutions and others.
- Approach Ceebron to conduct trials on seafood products and develop a project based on the SmartTrace technology.
- In conjunction with other CRC projects, to establish temperature and spoilage characteristics of some key products and to establish the specific spoilage organisms for seafood in the various regions of Australia for the main products in tropical, sub-tropical, temperate and cool regions.
- Compare results from sensors with correct kinetics to those from Quality Index methods as either complementary or substitute methods and to cover products in which normal QI attributes are not present e.g., as with fillets and portions.
- Use the information to build spoilage models, or test current models, for their applicability.
- Select from available range of sensors those with appropriate characteristics for each situation and try them under practical conditions.

**RECOMMENDATION 6 – Promote good traceability practices in the industry to raise consciousness and to identify incentives for industry to change.**

Act, in conjunction with SSA and FRDC, as a focal point for traceability in the seafood industry and as a contact for involvement in international traceability initiatives.

Explore potential for financial incentives. Such incentives may include:

- A financial incentive through Federal Government assistance or industry organisations.
- Design, develop and demonstrate a ROI costing model. This work could be done in conjunction with Steven Cambridge of the Business Logistics research group in the School of Information Systems, University of Tasmania.
- Collaborate with software suppliers such as WiseFish and Olfish to instigate a national change to Australia's seafood industry.

This may be communicated through:

- A CRC Workshop – promoting good traceability practices
- Explaining traceability in the first CRC Newsletter

**RECOMMENDATION 7. Tests for authenticity and product origin**

The CRC should not become involved in research that develops the technology, unless requested and funded by a participant or unless there is a serendipitous spin-off from another activity that can be capitalised on.

**RECOMMENDATION 8. Research into Traceability and product sensors**

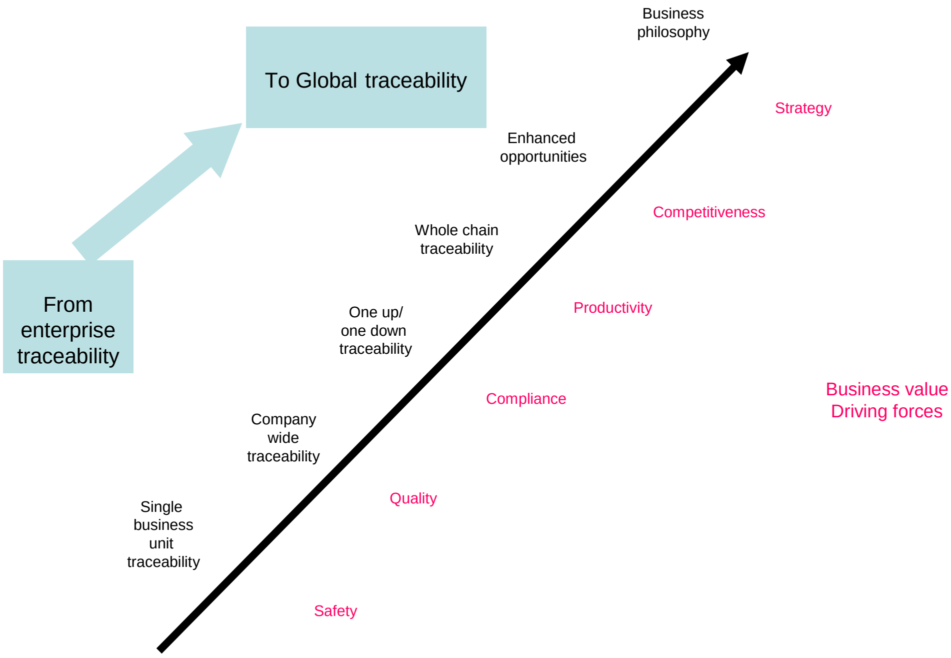
The Seafood CRC should not undertake research in the development of new Traceability and freshness indicator technologies but instead, should fund work that develops and integrates existing technologies into the Australian seafood supply chain.

# Traceability Systems

Two major factors compel the need for food traceability; consumer safety and brand protection. Consumers need to be assured of the safety of a product, of its origins, that it was made by approved procedures, that it consists of appropriate ingredients and that the food is true to label. From the producer's point of view the prime concern must be protection of their brand because the loss of consumer and buyer confidence in their product can result in far reaching consequences.

Traceability is an issue of business systems; it is not just a technical matter. The adoption of traceability systems provides an opportunity for increased efficiencies and better management. It is not merely an impost forced by compliance.

**The Traceability Arrow**




The three major aspects of traceability are:

- Primary traceability of raw materials and ingredients
- Secondary traceability within processing and packaging
- Tertiary traceability of the end product.

When all three aspects are in place this is defined as chain traceability.

The most widely known of these is the traceability of the end product, since problems with product and subsequent recall may become dramatically publicised events. The record shows that the consequences, the failure to effectively manage a recall, can be widespread, leading to sudden and marked loss of sales in all product lines, collapse of market share, drop in company share price, downgrading by investment houses and even company collapse or takeover.

Considerations of brand protection dictate that companies must have an integrated system that ensures traceability, which registers safety procedures, that their processes comply and that their system is capable of rapid recall.

The origins of many of the recent worldwide food safety problems have been found to come from problems at the primary production sector of the chain. However, the problems are usually identified at the other end of the food chain when products are sold to consumers. Thus industries need to be able to trace back through the chain to determine the source of the problems and then, in taking corrective action, to trace forward from those causes to identify, withdraw or recall all the unsafe products.

Two types of traceability information flow models in the supply chain can be identified. Most of the food businesses follow the "one step up-one step down" information flow model, which is also suggested by EU Regulation 178/2002. In cases when it is necessary for the consumer to have immediate access to information related to all stages of production and treatment (e.g. for organic products or fresh fish or meat for which particular treatment methods have been followed), aggregated information flow model is followed. Traceability data can be distinguished to static and dynamic. *Static data* refer to product features that cannot change, e.g. country of origin or size. *Dynamic data* refers to dynamic features that change over time while moving in the supply chain, e.g. lot/batch number or order ID.

Food Chain Traceability: the ability to trace and follow a food, feed, food producing animal or substance through all stages of production and distribution.

Stages of production and distribution: any stage including import, from and including the primary production of food, up to and including its sale or supply to the final consumer and, where relevant to food safety, the production, manufacture and distribution of feed.

Many manufacturing systems, including food manufacturing, have sought registration to the ISO 9001 Quality Standards. These require that the product should be able to be traced from the current stage back through all its stages of manufacture through accurate and timely record-keeping. The requirement for paper documentation has recently been changed; computer records solely can now be used as evidence of compliance.

Some of the current traceability systems are discussed briefly below.

### *Paper systems*

Paper needs no explanation, its uses are well known and its defects apparent although it continues to be widespread. It works but it is unwieldy, prone to error in transcription and readability, it is slow, requires endless duplication and the information chain is readily broken. Transcription into electronic formats and databases improves the potential for communication and provides the possibility for analysis. Software systems such as Muddy Boots and SAP have been developed that can help to keep track of paper systems. These are discussed further later in this report.

Barcoding can overcome some of the defects that plague paper systems, if it is used correctly. A barcode is merely a structured series of numbers, which are almost meaningless on their own, and which need interpreting by the correct software after decoding by a reader. The information about the product is all held in the computer. There are universally agreed barcode systems. GS1, a global not-for-profit organisation, has recently published a global traceability standard, the GS1 Traceability standard. GS1 is dedicated to the design and implementation of global standards, technologies and solutions to improve efficiency and visibility in supply and demand chains and is formed as a result of the merger of European Article Number EAN International and the Uniform Code Council (UCC). The standard defines the minimum requirements and business rules to be followed when designing and implementing a traceability system.

In consequence of development of data processing methods, it has become unavoidable to individualize products with a product code, to be able to e.g., develop management routines in production and delivery. Product code has usually been defined for the needs of a specific company, and the length, construction and input have consequently varied.

In the delivery chain a common product code, when applied in all documents, spares work due to avoidance of entering and recoding data, and it can be transferred directly in machine coded form. There are several regulations for recognizing and numbering single products. EAN numbering was developed to provide a simple standardized system for recognizing units in national and international food chains. With this code a product can be recognized at retail and at different stages of the delivery chain. This number consists of two parts, a number individualizing the product and a machine readable bar code corresponding to the number.

In electronic tracking and tracing systems, EAN-UCC (now GS1 system) is universally accepted as an identification and communication system which uniquely identifies products, locations, services, and assets and also includes a series of standard data structures known as Application Identifiers (AIs).

The system consists of three components:

1. Identification numbers – used to identify a product, location, logistic unit, service or asset.
2. Data carriers – the barcodes or RFID Tags used to represent these numbers.
3. Electronic messages – the means of connecting the physical flow of goods with the electronic flow of information.

In the seafood industry, commercial systems for barcoding boxes and weighing at sea have been available since before 1990 (e.g., Marel, Scanvaegt). Prototype systems to convey that information along the chain to point of sale in the supermarket were developed by 2000 (Frederiksen et al. 2002) and complete systems are now available e.g., Olfish, WiseFish and TraceTracker and are discussed later in this report.

### *Radio frequency identification (RFID) system*

Another technology for managing product identification is radio frequency identification (RFID)-system. In radio frequency identification, a transponder or ‘a tag’ is attached to a product. The tag consists of two parts: a microchip with memory and other electronics, and an antenna that enables the electromagnetic coupling between the microchip and a reader device. The tag memory is typically used for storing product information; either direct information in readable format or a product code, in which the information can be retrieved from a database. Many of today’s tags have reprogrammable memory, so that the memory content can be changed or added in various parts of the product chain. Although being commonly referred to as ‘a reader’, reprogramming is made wirelessly using the same device. To secure the tag data from unauthorized reprogramming, parts of the tag memory can be locked or protected with a password. The radio waves are able to penetrate the normally used packaging materials such as paper, cardboard or plastic and thus any line of sight between the tag and the reader is not required. In the products, no identification code (e.g. bar code) is needed to be shown.

RFID systems (e.g. car tolls, DVD hire, library books, tags on clothing etc.) reduce labour costs as no manual scanning operations are required. RFID readers can scan numerous tags at the same time. Identification is very simple and rapid, and additionally more effective resulting in reduction of profit losses caused by e.g. employee and customer theft, vendor fraud or administrative error. For especially food industry, RFID provides improved management of perishable food items (continuous monitoring of item routing reduces waste and improves customer service levels (e.g., Blue C , a Seattle sushi chain, deploys an RFID system to monitor product flow through its restaurant, ensure it is all in date and to optimize its operations (see www.rfid journal.com Oct 27,2007); improved tracking and tracing of quality problems by using individual product codes; as well as improved management of product recalls. RFID Tags are also more durable and enable reading in e.g. dirty and cold conditions, which may in the case of bar codes be almost impossible. Its larger memory enables individual recognition of products (Aarnisalo et al., 2007).

Wal-Mart, the largest volume retailer in the US, required its top 100 suppliers to ship the goods to it with radio-tagging technology (RFID) by the beginning of 2005. Despite the expenses and difficulties, 98 out of 100 of the suppliers managed to fulfil the requirement; only few if any can afford to ignore RFID. Other major retailers in US and Europe have been following.

Wet products, such as seafood, and wet environments present more of a problem than for dry goods. The read range and speed also provide difficulties. The EPC Global organization is that part of GS1 responsible for standards of RFID tags and is an international body made up of manufacturers and user groups. The second generation RFID tags known as EPC Global Gen 2 are superior in performance to the first generation (Gen 1) tags. Trials in 2005 by Sintef in Norway indicated that Gen1 tags were unreliable, but trials in 2006/7 in which pallet loads of plastic crates tagged with EPC Gen2/ISO 18000.6-C (VHF) tags were drawn through RFID portals, showed read rates of 100% in two factories and 99% in another, indicating the technology was usable under wet conditions in processors. Also ISO 15963 tags (HF) on fish pallets have been used successfully in shipments of mackerel to wholesalers in Spain.

The Danish company Lyngsoe Systems (who operate traceability systems for McDonalds Europe, baggage ID for all European airports, parcels for Australia Post and Deutsche Post amongst others), have supplied ¼ million plastic boxes with inbuilt RFID tags for the company that supplies the Danish fishing fleet. This was mainly to trace boxes and levy correct charges in the first instance but the boxes, designed to last 7 years, and hence the catch can form the first step in a fish traceability system. The box always retains its unique identity but the contents identity, along with date and time, can be entered electronically to match it through the first stages of the distribution chain.

To date RFID has mainly been used to tag equipment and boxes (even rubbish bins), rather than product itself, in the seafood industry. The weekly online journal (www.rfidjournal.com) is free and contains up to date information on applications of RFID.

It is important to note that as RFID tags are mainly in label form, they almost invariably carry the barcode and written words as well so if the reader system fails there are the two alternatives to read the identity codings at the very least. If the label captured other information such as temperature, then that will not be readable other than by RFID means.

## *Identification markers other than RFID and standard barcodes*

Markers other than RFID and standard barcodes have been developed that are essentially comprised of spray dots that form unique patterns. The problem with these markers is that they are not able to be read with the currently available standard equipment. New hardware (and maybe technologies) is required and it is not clear how the information becomes transcribed into existing systems. Further development may be slowed, because most companies in the chain at the sales and marketing end have large investments in current barcode technologies.

Several different barcodes using a matrix of lines or symbols, rather than 2 dimensional bars, have been proposed. These can encode far more than the basic information currently available on a barcode and will probably come into use in the future for specific purposes. Reliability of readout and need for greater protection from damage may hinder development and new readers, labellers, softwares etc. would be required.

DNA has been used as an authenticity marker by applying it to a label. This is to provide a means of proving an article is genuine or of ownership. At present it seems to be more of a marketing ploy. Genetic Solutions Pty Ltd (www.geneticsolutions.com.au) was formed following research undertaken by CSIRO Livestock Industries in Beef genetic identification while Catapult Genetics (www.catapultsystems.co.nz) provides leading edge genetic information technology for global livestock (sheep) and aquaculture industries.

Catapult Genetics, based in Australia and New Zealand, has been formed following the merger of Genetic Solutions and Catapult Systems; both global leaders in sheep and cattle DNA testing technologies. This technology offers food producers, processors and retailers a range of innovative testing systems required to improve predictability and control in the food production chain. Catapult Genetics provides the food industry with the underpinning technologies for product identification, validation, and traceability.

## *Global systems*

GS1 Traceability Standard is based on existing business practices and there is no need to purchase, create or integrate new systems. It uses a common language, the GS1 System of identification and bar coding, GS1 EANCOM® and GS1 XML messaging. GS1 Standard has a global approach as it is used in over 150 countries around the world. The standard is thorough, covering the fundamentals of traceability. It is also flexible, recognizing that circumstances vary within and between sectors and individual retailers and manufacturers (Foster, 2006).

These systems transmit information across the globe in fractions of a second. Information is held in the business systems of the various steps in the chain, as secure behind the firewall as all normal business data, but parts of the information related to a transaction can be retrieved by an authorised receiver. It may be that both sender and receiver have the same software and computing system, but this is not necessary as long as the sender's system can wrap the information in XML computer language (now becoming common e.g. with Microsoft Vista) and the receiver can unscramble it from XML into their system in whatever format they require. What is required is a software module at either end that links securely to the global system which sends and receives the information packages. Consequently, there is need to purchase only the software module – not a whole new system. Some modules e.g. TraceTracker will take in Excel spreadsheets and it is necessary only to purchase the add-on module. The global network makes its money by charging for the software module and the amount of traffic generated. These systems use internet connections but are not part of the web and traffic cannot appear on Google searches for example.

Many servers, Enterprise Resource Planning ERP systems and business software packages (SAP, Oracle, BizTalk, and Navision etc) come with a traceability function that can be linked to a global system such as Lyngsoe systems, TraceTracker, WiseFish and others.

## *Authenticity and Origin*

Authenticity and origin of foods are often confused with traceability. A traceability system may be used to aid in establishing authenticity and origin by providing the recorded history linked to unique identifiers. Authenticity means true to label and for seafood this generally means species identity for which there exists the Australian Standard Fish Names List for fish in commerce, now an official standard-. The Australian Fish Names Standard AS SSA5300-2007 - launched on 31 October 2007. This Fish names list is backed by the Latinate species name, taxonomical information and detailed tests such as DNA to establish beyond question the identity. Note that species identification will not supply information about the catch location or handling procedures except in a very broad sense that some species are particular to an area in which there is a common method of catch.

Authentication is also used in the sense that it describes a particular process that the food has undergone. This is more common in other commodities such as wines e.g. *method champenoise*. It is less common with seafood but traceability could be used to follow a product back to the processor who could show from their production records that a specific process was used e.g. a particular wood for smoking, or a special brine for pickling or sauce in canning.

If the information chain is not intact then authentication by chemical markers e.g. micro elements may be possible but mostly there is no data for comparison at this level.

Origin is an important marketing tool as seafood from certain areas have a good reputation for their desirable characteristics or that they come from a clean area or are caught by a certain method e.g., line not trawl, or all of these. Again traceability can be used to follow a product back and relate its origin to catch records if the chain of information is intact. If records are not intact then other micro-markers may prove or disprove an origin. This type of work has rarely been done, if at all, in Australia and the benefit-to-cost ratio would need to be well demonstrated for it to be feasible.

## *Building a traceability system*

Regattieri et al. (2007) described a general framework, based on product identification, data-to-trace, product routing and traceability tools, for product traceability. They suggested this framework to form a reference point for the design phase of a food supply chain. The “Product identification” is fundamental part containing product characteristics. “Data-to-trace” contains characteristics of the information that the system must manage. A product traceability system must take the production process into account and record product life along the supply chain and through both production activities and movement or storage activities (“Product routing”). The data accuracy and reliability required and also cost guide the selection of the traceability’s tools.

According to Opara and Mazaud (2001), when starting to build a traceability system, what is traced and why it is being traced should be considered. This should be done by performing a detailed hazard or risk analysis and this task could be included into hazard identification part of HACCP system. In building a traceability system, the following roadmap can be followed:

1. Draw a flow chart of the product supply chain; from point of harvest to point of final sale, and include sources of material inputs (e.g. medications, micro ingredients in food etc).

2. Upper level management (CEO, Board) must support the traceability initiative. Appoint a responsible person who is also responsible for product quality.

3. Conduct a hazard analysis of the supply chain using HACCP principles.

4. Document the reasons for embarking on the traceability of the products.

5. Consider what the needs and practices of your upstream and downstream partners are and talk about it with them not just for your main raw materials, but for packaging and ingredients.

6. Write down which data must be recorded and traced back at each step in the supply chain.

7. Specify the responsible persons for collecting and recording the data.
8. Develop a unique labelling system or bar code for easy identification of the product.
9. Document how the trace-back is to be carried out (include a diagram).
10. Test, validate and verify the traceability system.
11. Document all decisions and actions.

Additional explanatory information can be found in the very useful booklet 'Seafood traceability technologies' (2006) available from Seafood Services Australia (ISBN 0-9775219-2-3).

# Current traceability systems used in the Seafood Industry

The seafood industry is no exception to the need for traceability as it is an industry that trades both locally and globally in a vast range of finfish and shellfish species and their products, and which is hugely diverse in comparison to other protein sources. The diversity of the distribution chains range from short and direct chains supplying fresh seafood to local communities, to long and complex chains sourcing raw materials and supplying processed products worldwide.

A large amount of information is generated and used in the seafood distribution chains, for both legal and commercial reasons, but much of that information is effectively lost in respect of chain traceability. It is generated for specific reasons, such as for fisheries management or accounting purposes, usually in a specific form for its particular purpose, and is not made available for other purposes. In addition, this information is often not linked by a product identifier to the physical units of seafood it describes and so is useless for the purpose of traceability. Even if initially linked to those units it may later be mixed and so the linkage to the particular seafood may be lost. Any traceability system logically must be computerised and should dovetail into other electronic business systems to ensure relevant information is not lost or that it has to be re-entered.

## *International situation*

Europe suffered several food scares between 1990 and 2000 e.g., dioxin, BSE, Coca Cola, Perrier water, and new legislation was introduced in 2005 requiring a one up, one down traceability system to be operated throughout food distribution chains. This requires the identification of food at all stages, not merely the lot marking after processing. European systems probably lead the world in their understanding of traceability and in their practical and commercial application.

A consortium of the seafood industry and IT service providers developed traceability standards for the recording and exchange of traceability information in the seafood chains. This project, 'Tracefish' (www.tracefish.org) culminated in the production of three CEN - Commité Européan de Normalisation European Committee for Standardization-workshop agreements (voluntary standards) covering what information is desirable to describe traceability for both captured and farmed fish. A technical standard was developed for coding and electronic transmission of data in XML computer language that was universal and independent of the type of software and computing systems. These standards are used widely in commercial systems e.g., TraceTracker (www.tracetracker.org). The principles in the approach and the basic XML program can be applied to all foods and are the core (TraceCore) for other commodities; to date, TraceFish™, TraceCereal™, TraceMineralwater™, TraceChicken™, TraceShellfish™ (under development).

Later developments have included standard protocols for evaluating individual chains (Olsen 2007, in press) that have been used in Spain, Iceland, Norway, Denmark and other countries to map out chains for a variety of products. Additionally, a guide for Good Traceability Practice will be available through SEAFOODplus (www.seafoodplus.org).

Many large international seafood companies require that the source of their supply be from well-managed, sustainable fisheries in environmentally clean waters, caught by approved and humane practices. They pay a premium for these products and suppliers must be able to demonstrate its provenance. When the supply chain has instituted traceability additional benefits to authenticity and provenance have occurred. A classic example of this occurs with Youngs Seafoods (www.youngsseafoods.co.uk ) a very large, long-established, Scottish seafood company (Mark Boulter, personal comm.)

Youngs Seafoods have developed a simplified traceability system (Youngs Trace) at a level useful for entering catch data that is Tracefish compliant. As well as information entered on the keyboard other data such as from trawl speed and location sensors on the gear are automatically captured. The data is sent to Glasgow University Biology Dept. where it is subjected to analysis and the results sent to Youngs in a form they require. This gives them provenance of their product and accurate traceability data and also serves to reinforce their company ethic.

What they have found is that they are getting information far beyond what the fishery managers know. Consequently they can help re-direct the fleet and fishing effort to areas that are producing the best CPUE catch per unit effort and which avoid spawning stock. At this stage the data remains confidential proprietary knowledge of Youngs and they have agreed to a 4 year embargo on publication with Glasgow University.

Young's sign-up fishers and give them a good price but they must comply with requirements and install this software and measuring devices. What they find is that there are extra benefits in the way that these fishers handle the catch, as it opens them to a quality way of thinking; the result being a better product all round. These systems are now being rolled out for Youngs in Sri Lanka and Mexico.

A freeware program that monitors temperature and records catch data for pelagic fishers the Pelagic Information Program (PIP) is available from Dr Marco Frederiksen (maf@difres.dk) at the Danish Institute for Fisheries Research.

A further example is that of the TELOP Trace project in the salmon industry in Norway that includes some of the worlds largest companies in:- micro-ingredients (BASF AG), feed (Skrettings AS), salmon production (Fjord Seafood ASA), processing (AKVAsmart ASA, Maritech AS), shipping (NorCargo Thermo), labelling (Willett AS), barcoding and RFID (GS1 Norge), traceability (TraceTracker Innovation AS) and various supermarket chains. All companies use the TraceTracker system and for any given salmon product, e.g., a fillet in a store, the whole history from the broodstock to medications used in raising, to feed micro-ingredients, to process and distribution can all be displayed, almost instantaneously, by a few key strokes. This is an example of a distributed system in which each company owns and stores its own data but allows access to secure, authorised users for parts of it for agreed, legitimate purposes. Data is only exposed outside the company firewall for small fractions of a second.

The WiseFish system from Maritech in Iceland (www.wisefish.com ) contains the traceability module in a larger suite of software designed for managing seafood companies. It links closely in with HACCP systems and the business side of operations and has been in use for over 10 years.

Australia is a signatory to international agreements and standards such as Codex Alimentarius administered through the Food and Agriculture Organisation (FAO). In the Fisheries area, FAO has produced a number of voluntary guidelines as explanatory text to the international agreement on sustainable fishing to which Australia is a signatory. Appendix 1 is an extract concerning traceability from the Draft Revised Technical Guidelines for Responsible Fish Utilization: FAO, Rome (as at 13/08/2007).

## *Australian Situation*

There are requirements for a one-up, one-down traceability system in the new seafood primary production and processing standard (FSANZ FSC 4.2.1). The legislation's guidance document 'Safe Seafood Australia' also states that 'Businesses that mix batches of seafood should ensure that the batches making up the mix are known. This will avoid having to recall greater quantities of potentially unsafe product because specific affected product cannot be identified. This internal traceability system will enable the business to contribute to more targeted and accurate withdrawals or recalls. Hence a full internal traceability system is being asked for in the guidance document.

At a business level this technology is very slowly being adopted for internal use. However, the intra-business communication of this information i.e. a chain traceability system is not yet common practice in the Australian seafood industry.

Suppliers exporting product also have recording requirements of the AQIS EXDOC system to comply with. This information has to be sent electronically. Software is currently available from a number of different companies. For exporters it would be desirable that any chain traceability system could also export information in EXDOC and also in US FDA format.

***Information from Seafood Supply Chain Innovation (SSCI)***

Seafood Services Australia (SSA) received funding from AusIndustry for a project (in 2004-6) in Seafood Supply Chain Innovation (SSCI), one aspect of which was in traceability. Workshops for industry were held around Australia in seven locations, one international conference and one workshop in Papua New Guinea, with a total attendance of over 350 participants. This workshop consisted of talks explaining traceability systems, fleshed out with real examples and applications by technology and software suppliers, and was reinforced by workshop activities in which groups designed traceability systems for hypothetical seafood companies. Participants were presented with "How to" Guides for basic principles, for paper systems, for barcoding, for use of RFID and for global electronic systems. These guides, prepared by Allan Bremner, were then edited through SSA to make a published Decision Making Guide for industry (available from SSA). This guide is laid out as an introduction to traceability for companies and groups seeking to find out more about traceability and the options available.

The workshops were led by Alan Snow (then of SSA, now ASKonsulting) assisted by Allan Bremner and various technical providers (e.g., Cedar Creek Co Pty Ltd and Ironbark Pty Ltd and GS1 Australia). Participants were asked about their general knowledge of traceability and what they thought was appropriate for their company, organisation and industry. The general level of knowledge was not very detailed in many instances and the work groups tended to want to adopt the simplest basic paper system to solve the exercises they were given. Additionally, most considered that paper was sufficient to meet their current needs although they thought that one day they may need to move to barcoding. This fits with other observations made by Allan Bremner about the salmonoid industry (during 2004), and from discussions with companies in the South East (SE) trawl industry as well as with industry persons at seafood conferences (Seafood Directions and World Seafood Congress Sydney, 2005).

Paper systems are the norm in most of the catching and harvesting sectors, despite the fact that the catch sector uses many sophisticated electronic instruments and devices in their operations and that electronic communications and computer use are wide spread on board, dockside and in processors.

Barcoding of finished seafood products is common in retail and wholesale but the traceability that these systems allows rarely goes back to the harvest or to the unprocessed and part-processed stages. There is a discontinuity in information flow both forwards and backwards in the seafood chain and very little communication between supermarket, processor and catcher. Consequently any effects of processes on product yields, characteristics or quality attributes can rarely be followed accurately. This is a major barrier to performing industrial statistics on any scale to measure efficiencies and to make improvements. It affects forward planning such as prediction of capacity, the communication of these forward plans to enable staffing, stock control, rotation and the like within companies: but it also has a major effect on the ability to communicate externally.

Electronic transfer of information is the lifeblood of modern industry. The compatibility of formats, or of computer languages, facilitates this and the ability to communicate upstream and downstream rapidly and accurately is essential. Lack of traceability decreases efficiency to a large degree. These aspects do not seem to be appreciated widely and the common response is that any change brings cost. Like quality systems, the gains that can be obtained in efficiency and flexibility (often unforeseen at the outset) soon payback the costs (e.g., the Youngs example above). Traceability is an opportunity, not an imposition and whilst paper based systems can work, they are inherently inefficient and offer no scope for improvement.

There has been some improvement in practices in recent years since three export chains were studied (Frederiksen and Bremner 2001).

Resistance to adoption of new technologies in the seafood industry is notorious, and it is not at all obvious that the approach of continuous improvement is seen as being necessary for survival.

In contrast, some sectors have recently taken initiatives that put a public face on traceability. The Southern rock lobster industry has a new system (2007) in which each lobster is tagged onshore. This is possible as each lobster is a discrete traceable unit that is kept and sold intact through the chain. A buyer can read the tag and enter the number into the Sarlac website and obtain the name and details of who fished it and information about the port and area they operate from. At present it does not provide more detail but the website has links to the fact that the fishery has an EMS, considers OH&S issues, and promotes a clean and green image and other matters.

***Information from Southern & Eastern Shark and Scalefish Fishery (SESSF)***

Before traceability systems can be implemented a study of the chain of events that occur in the transformation of raw material into consumer product must be done.

The Southern & Eastern Shark and Scalefish Fishery have recently been subjected to supply chain analysis (DAFF project 73/06). This is an extremely detailed study that maps out the path of the fish from catch to consumer. Some products change hands up to eight times along the chain. The study forms a good foundation on which to base a traceability system.

In the South East Fishery Industry Development Subprogram (FRDC project 2000/242), the E Boat study explored the use of electronic log keeping and ship to shore transmission of data in the SE trawl fishery. The aim was mainly for ready collection of management data but, with modification, traceability of product could be included too. The Olfish program (www.olfish.com ) from Olrac of Capetown, South Africa, was modified to suit local purposes.

# Traceability systems used in wider food industry

In the wider food industry, many companies have implemented their own traceability systems by effectively automating paper-based traceability records (such as *Muddy Boots* and *Theta Technologies InformationLeader*). Others have extended their existing enterprise software applications and a growing number of users of the Systems, Applications and Products in Data Processing (SAP) Enterprise Resource Planning (ERP) system have also adopted the SAP traceability module. Programs used for controlling and following the process can also simultaneously be used for collecting and maintaining the traceability data, e.g. a system known as *FoodReg* (www.foodreg.com) provides operational execution of the HACCP plan at the same time as ensuring product and process traceability. An example of a traceability program is *Food Trak* (www.foodtrak.com) which has been developed by a private company in Great Britain. By means of this program, the retailer can see the history of a specific product already from the beginning of primary production of raw materials. Internet is used as a tool in transmitting the data. The drawback with the Food Trak system is that it is a portal system, not a distributed one. This means the information from all participants is lodged from the individual companies into the Food Trak database where it is stored and managed by Food Trak. Thus companies can only communicate via Food Trak and not directly with their chain partners. This is in contrast to the situation in which each individual company stores its own data and only exposes part of it outside its own firewall for the fractions of a second required to transmit relevant data to authorised approved users.

## *SAP Traceability*

SAP (www.sap.com) was founded in 1972 by five former IBM engineers. SAP is the world's largest business software company and the third-largest independent software provider in terms of revenue. SAP focuses on six industry sectors: process industries, discrete industries, consumer industries, service industries, financial services, and public services. It offers more than 25 industry solution portfolios for large enterprises and more than 550 micro-vertical solutions for midsize companies and small businesses. SAP ERP is the one of five major enterprise applications that makes up SAP's Business Suite. Other major product offerings include: the NetWeaver platform, Governance, Risk and Compliance (GRC) solutions, Duet (joint offering with Microsoft), Performance Management solutions and RFID.

SAP offers a systematic approach to enterprise service oriented architectures SOA, which is the technical standard that enables various enterprise software applications to exchange data effectively. Through enterprise SOA, SAP is focusing on enabling more flexible business processes as well as creating technical connections between IT systems and building a common language for business.

## *Ceebron - Smart-Trace™*

The ‘Smart-Trace System’ is currently being developed by the Australian company, Ceebron Pty Limited, in partnership with Meat and Livestock Australia (MLA), Motorola Inc., and Minorplanet Asia Pacific. Smart-Trace™ is not a traceability system per se, but provides a source of enhanced information to feed into a traceability system proper.

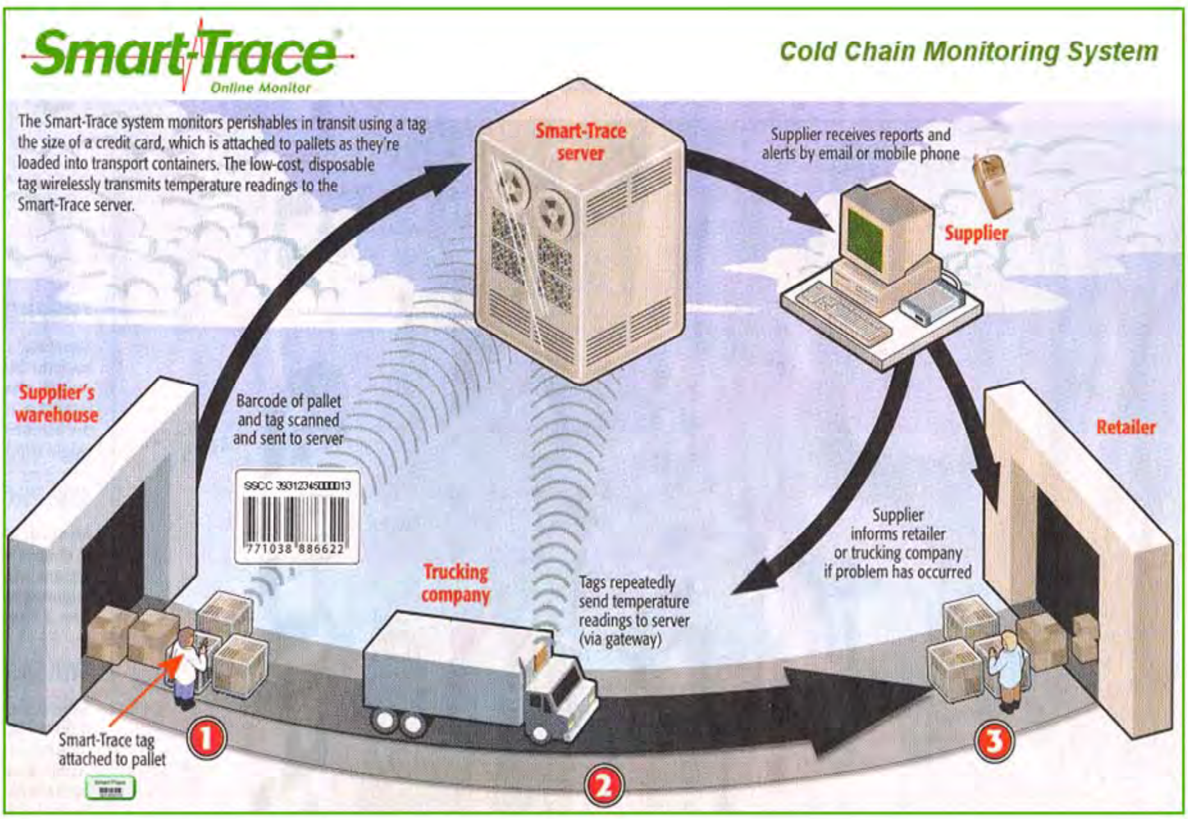
Smart-Trace™ provides its consignor customers with a near real-time, continuous trace of their perishables during delivery. The system uses low-cost, disposable, wireless sensors and mobile phone technology. It gives consignors continuous access to the identity, temperature, and location of their consignments at pallet load level via a web or mobile phone interface. The system provides customers with the 'first to know' advantage in the event of product abuse.

Smart-Trace™ is being developed in response to global demands for food safety, traceability, enhanced integrity and actionable transparency of cold chain performance. Once completed, Ceebron will provide its Smart-Trace™ hardware and software solution to the temperature sensitive food, beverage, pharmaceutical, and refrigerated transport industries.

Ceebron estimates the 2006 market for perishable shipped goods to exceed $30 billion in Australia and greater than $1 trillion in other OECD (Organisation for Economic Coordination and Development) target markets. According to the US Centre for Disease Control, two-thirds of the food spoilage/poisoning outbreaks are related to temperature handling abuse. Ceebron intends to ultimately provide a $25 Smart–Trace Tag (<1% pallet value) and linked monitoring service to dramatically reduce food spoilage and deliver other benefits to food industry companies and ultimately the consumers they serve.

While the system delivers benefits beyond food safety insurance, such as food quality, security, supply chain productivity and customer relationship benefits, it is 'food safety' and related brand/reputation, that is the only 'non negotiable' aspect of the unique Smart-Trace™ product/system offer. Manufactured red meat products represent some 1/3 of the food safety problems and will be treated as priority perishables in the project testing. Already MLA is well advanced in the 'traceability' of livestock; Ceebron's system will have the potential for adding end-to-end consignment traceability, at least to pallet/unit load level.

Motorola Inc. has 75 years in wireless technologies and has recently developed an appropriate new and low cost, reliable ad-hoc wireless solution for challenges such as Ceebron represent. This is new, emerging technology that has applications beyond Ceebron's specific 'cold chain' field of use. Recently MIT ranked ad-hoc wireless networks as one to the Top 10 'emerging technologies' likely to change our lives over the next decade. (Figure1).




Patented Internationally by Ceebron Pty Limited 1998

Figure 1 Near real-time monitoring of chilled and frozen products during distribution

**Technology Concept**

The Smart-Trace™ system utilises low-cost PAWN (Platform for Ad-hoc Wireless Networking) and works as follows:

- The consignor of a pallet of perishable goods attaches a Smart-Trace™ tag device to the pallet load and logs the consignment identity at dispatch, including EAN barcode and eventually RFID consignment data. It is possible to have up to 20 tags in a trailer in case of high risk/value perishables.
- These non-returnable Smart-Trace™ tags send a wireless signal to the transportation trailer/container fitted with a Smart-Trace™ Gateway. The Tag mini-network is self- healing and copes with consignment movement during distribution.
- The Gateway consists of a PAWN reader and mobile telephony engine which transmits the data plus GPS coordinates using wireless telephony to a base station/database.
- The database prepares reports and alarms (24x7) based on the temperature, time, ID and location data sent.
- Consignor accesses results automatically machine to machine via a secure Internet link or smart phone or receives an exception report into its warehouse management system.

Smart-Trace™ will provide the consignors of goods with the confidence that they have complied with relevant new food safety regulatory regimes and that their perishable cargo has not been contaminated or abused during the transportation process. Additionally it will provide longer-term records storage for HAACP purposes. A continuous temperature/time/date graph is the primary output (Figure 2).

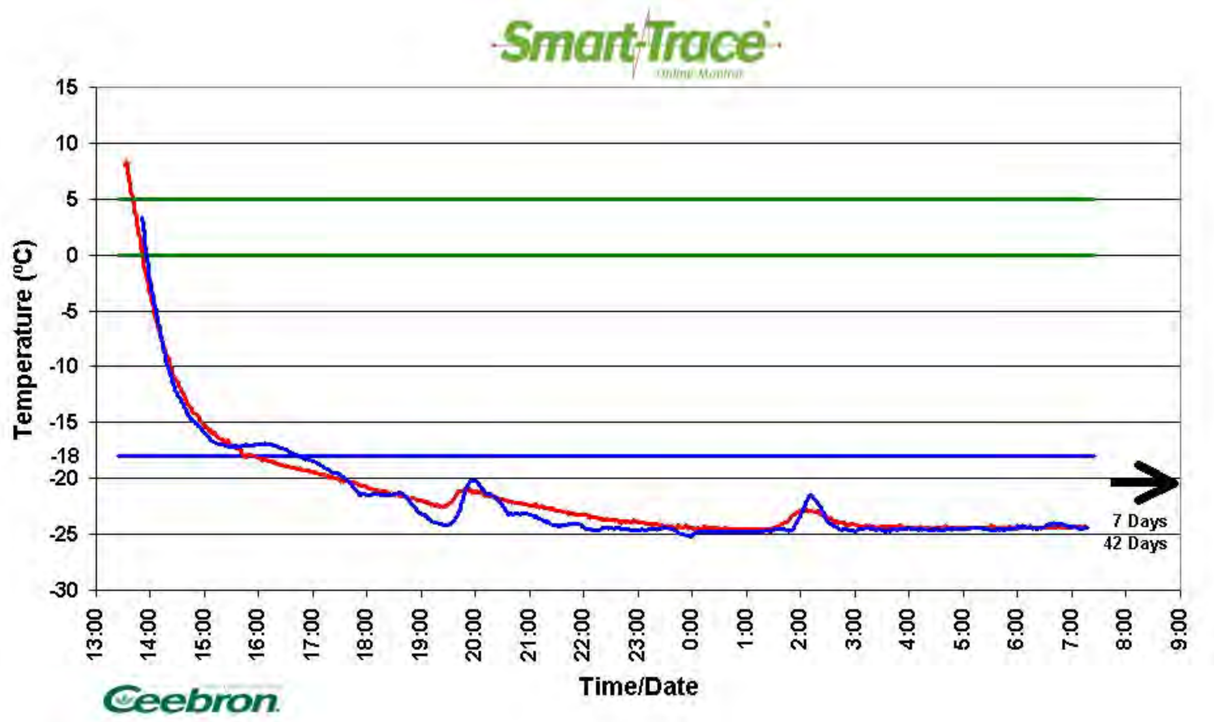



Figure 2: A temperature/time/date graph is one of the major outputs from the Smart Trace system.

Ceebron's target customers are processors of food and manufacturers of biomedicals. Smart-Trace™ offers customers the following benefits:

- Online access to critical and accurate data: Near real time temperature (within 0.5 degrees Celsius precision), location and time data, easily retrievable via the Internet, mobile phone, etc.
- Continuous tracing: Ability to trace shipment from the time the pallet is dispatched from the processing plant until it reaches the retailer's DC dock - including cross-docking, inter-modal transfers and delay at unloading
- Automatic monitoring: Product abuse can be detected in near real-time and corrective action taken to avoid expensive product recalls, or proactively recall products if necessary. Processors and manufacturers can avoid reputation and brand damage, and demonstrate that they have taken every precaution to protect consumers' safety.
- Low cost: Affordable pricing of around $25 per Tag device, due to rapid cost reductions in micro-wireless, data memory, long-term data storage and mobile transmission of data costs (initial cost of $1000 per Gateway installed).
- Security: Password protection ensures that only the consignor of the goods can access relevant data.
- Reports/data storage/supply chain management: Detailed reports can be produced, stored and retrieved to help comply with food safety regimes, resolve disputes, and analyse and improve processes.

The innovation provided by the successful development of this project will be used to supply a superior end product into local and export marketing opportunities that are displaying significant ongoing growth. Understanding the particular consumer expectations in each potential market, and targeting product development at satisfying those expectations is a critical requirement for the commercialisation of these products.

## *Muddy Boots Software*

Muddy Boots Software is the leading provider of food traceability and quality assurance solutions for principally the agricultural industry but also the food industry as a whole.

Muddy Boots has been developing data recording systems since 1996 and has experience in producing intelligent, mobile data capture, recording and auditing software. These systems based on Microsoft technologies act as building blocks to help deliver mobile integrated management and traceability solutions for the agri-food industry.

Muddy Boots *Produce Manager* is a tailored system for the management and traceability of fresh produce throughout any part of its commercial life. From applying inputs in the field, recording harvest, storage and dispatch, incorporating data at intake, processing, and right through to delivery to the retailer. Produce Manager delivers an integrated process management system ‘fit for purpose’.

**Modules in *Produce Manager* include:**

- Supply and Demand Forecasting
- Harvest Management
- Purchase Order Management
- Quality Management System
- Goods Intake
- Stock Management
- Production Planning
- Production Management
- Dispatch Management

**Features in *Produce Manager* include:**

- Mobile Warehouse Scanning Applications
- Live Product Inventory
- Total Product Traceability

Muddy Boots *Quickfire* dovetails with the *Produce Manager* to addresses brand protection, product safety, and quality assurance in one complete system. It is designed around field-based applications benefiting from the principle of one-time data entry. Uniquely combining portable and handheld PCs for remote data capture, with server based and internet based management reporting. Muddy Boots *Quickfire* can be adapted to accommodate virtually any inspection or verification protocol and can be used to monitor areas such as corporate governance, health and safety, ethics, food safety, social accountability and the environment.

A number of Australian fruit and vegetable growing and processing companies have considered implementing Muddy Boots in order to have full food chain traceability, from the raw/fresh produce to the retailer. However, feedback from industry noted, Muddy Boots is a fairly ridge software package and doesn't cater for HACCP, so may not be suitable for the seafood industry at this time.

**Contact details for the Muddy Boots Software**

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## *Theta Technologies – InformationLeader*

Theta Technologies is an Australian based company with extensive experience in food industry-based auditing, quality assurance and infrastructure. *InformationLeader* is the company's software solution designed to manage auditable data in regulated environments. Information is captured on business forms and workflows in an intuitive web based system that can be easily customised to meet specific business needs. *InformationLeader* has been purpose built with a robust feature set to ensure compliance with regulatory and traceability requirements worldwide. The software automates and enforces workflows and processes. It increases traceability transparency and minimises risk by providing automated notifications and real time reporting. This ensures that everyone in the company is working with the right information at the right time through a managed, centralised system.

*InformationLeader* is an Information Management System designed to replace paper based systems and ad-hoc electronic solutions by providing a secure, centralised and highly flexible store of information. This solution is a web-based application that features flexible form and workflow design, data auditability, document management and powerful reporting capabilities. Since 2001 Theta Technologies have successfully implemented *InformationLeader* in a number of organisations from a wide range of industries.

Users access the application through Internet Explorer which can be set up on a corporate intranet or over the internet. *InformationLeader* is served up to the clients via IIS6 based on ASP.Net pages. The *InformationLeader* data is centrally stored on a SQL Server 2000 platform for easy maintenance and backups.

The flexible web based interface of *InformationLeader* allows users to maintain electronic form design and security for user access. No installations are required for client machines, and upgrades are centrally maintained on the server. *InformationLeader* integrates with ActiveDirectory to streamline the user login process. Information can also be drawn from ODBC compliant data sources for use in electronic forms and reporting. ActiveDirectory is a Microsoft trademarked feature that allows for secure log on. Active Directory is a centralized and standardized system that automates network management of user data, security, and distributed resources."

**Contact details for Theta Technologies are:**

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### *International Food Chain Integrity and Traceability Project*

The International Food Chain Integrity and Traceability Project (IFCITP) initiated by Icon Global Link Pty Ltd, the Victorian Freight and Logistics Council (VFLC) and Unisys Pty Ltd, a global IT services company is designed to review, develop and test supply chain documentation systems to improve the quality, safety, security and business efficiency of food export supply chains. It will investigate every aspect of the process from paddock to shop shelf and will involve Victorian producers of beef and dairy, their commercial customers in Philadelphia USA, and each regulator, and transport and logistics supplier along the chain. The project had broad-based support from key Federal, State and private sector participants.

This Victorian initiative is cutting-edge and has gained the support of federal authorities including , the Federal Department of Transport and Regional Services (DOTARS) and the Victorian Freight and Logistics Council (VFLC), and in the USA, the Food and Drug Administration (FDA), the Department of Agriculture (USDA), the Federal Bureau of Investigation (FBI) and the Port of Philadelphia.

The value of the project for Victoria relates to the competitive edge it potentially provides exporters selling into US and world markets.

Transport, distribution, logistics and the food industry are vital to the productivity and growth of the Victorian economy. While there is an increasing need to establish Victoria's market credentials for supply chain excellence and food quality, safety and security, critical gaps remain in managing risk along food supply chains.

The ITP is a supply chain traceability and risk management project aiming to provide a simple, best practice, end-to-end business process description that incorporates the quality, safety and security elements of food throughout its entire production and distribution process.

The ITP was initiated by Icon Global Link Pty Ltd, a Victorian developer of supply chain software supporting food chain integrity, bio-security, process management and regulatory reporting solutions. Two other parties are involved in the project: the Victorian Freight and Logistics Council (VFLC), an industry association representing Victoria's sea, road and rail operators and rated as financially strong by DIIRD's Program Support Unit, and Unisys Pty Ltd, a global IT services company headquartered in Philadelphia, Pennsylvania, with extensive experience in global shipping and transport.

The VFLC, in its role as the auspice body for the ITP, has secured sponsorship funding from a range of government and industry stakeholders for the Inception Phase of Stage 1 of the project.

The ITP will build on the existing Victorian Government commitment to the food industry, through the Victorian *Next Generation Food Strategy* and its commitment to supply chain excellence through the *TDL Industry Action Plan*.

The ITP will strengthen the relationship between the Ports of Melbourne and Philadelphia and provide the means for the Victorian export industry to address innovatively the new legislative standards in the USA.

The project is currently in the trial phase (See Media Release below).

**VICTORIAN FREIGHT AND LOGISTICS COUNCIL**

*Media Release*

16 October 2007

The International Food Chain Integrity and Traceability project (IFCITP) has moved closer to its trial phase, with the completion of assessments of beef and dairy product supply chains, presented to the Steering Committee in Melbourne today. The trials will demonstrate a world first in “paddock-to-plate” food security risk monitoring system.

The project Steering Committee is now confident that full chain monitoring and reporting can be available to the US importer of Victorian food products. The first trial of beef and dairy products through the Port of Melbourne into the US East Coast via the Port of Philadelphia will commence in 2008.

The project enables monitoring and real/near time visibility of the product from the producer’s inputs in rural Victoria to the retail outlet in the US. Risk is monitored in every node and process, enabling management of product integrity, pedigree, traceability and chain of custody.

Joe Giblin, IFCITP Project Director and Principal of Icon Global Link Ltd. noted the benefits of the project in not only demonstrating compliance with standards, but avoiding the consequences of non-compliance. “Apart from the obvious bioterrorism risk, recent food recalls through unintentional contamination have cost companies in the food industry a huge amount. Recent examples are TOPPS Meat Company, Taco Bell, USA spinach and Bumble Bee Foods. In the food industry, this can mean the end of a brand, a business and people’s livelihoods.”

“While we see improved risk management in shipping, we are concerned about the landside logistics movements and how supply chain partners share information” stated Rose Elphick, Chair of the IFCITP Steering Committee. Victoria is Australia’s food bowl. Food represents a quarter of our State exports, so the integrity of these vital supply chains is a concern for the Victorian Freight and Logistics Council.”

**Further information: Joe Giblin, Project Director, 0408 885 377**

**Rose Elphick, Chief Executive, VFLC, (03) 9655 6457**

# Technologies to indicate "Freshness"

Freshness is a concept that goes hand in hand with that other important concept 'quality'. Overall food quality can be considered as the concerted sum of all the desirable characteristics that make food acceptable to eat. Therefore, being able to tell when food is fresh is vitally important, at home, in a grocery store, or when dining out.

Consumers are concerned about the wholesomeness and freshness of the food that they purchase from retail markets. Although sanitation is an important aspect of keeping food safe, data show that the overwhelming primary cause of food borne illness is improper maintenance of temperature in the shipment and storage of foods through retail sale and during consumer handling. The only appropriate temperature control in this setting is the temperature label.

The placement of good product with reasonable shelf-life on the supermarket counter relies on attention to detail and control over small things throughout the journey from harvest to final sale. This approach can be described as 'Everything is the thing'.

Therefore new ideas and technologies must be seen in context, not as ultimate answers but as a part of a system designed for the purpose of attaining good product with adequate shelf-life. If the new application does not fit into the system, or if other major parts of that system, such as logistics and temperature control, are lacking, then the technology is a waste of time and money.

The following evaluations of devices are based on first principles, some first-hand experience, from a watching brief on the literature and on observations in several countries of the lack of use of sensors on commercial products.

A useful technique that allows comparison of rates of deterioration is to express the rate at any particular temperature relative to the rate of deterioration at $0^oC$ by dividing the rate at the temperature by that at $0^0C$. Once these relative rates are known for a commodity or product then the actual clock time a product spends at any given chilled temperature can be converted to the equivalent period of time if the product were at temperature of $0^oC$ by multiplying the storage period by the relative rate. Seafood, milk and meat spoil at about the same relative rates although their actual rates are different. Seafood spoils faster than meat and the shelf-life of seafood compared to meats is less. The changes that occur in seafood after harvest are generally described colloquially as 'losses of freshness' and seafoods have a reputation as being one of the most difficult foods to keep fresh. The changes that occur are due to bacteria present on gills, skin and in the gut and to inherent enzymic processes in the flesh as well as to reactions with oxygen in the air. None of these mechanisms can be completely halted but at least bacterial changes and oxidative changes can be slowed down.

If you know when and where the fish was caught, and what its temperature has been you might be able to make an educated guess as to its state (colloquially called freshness) and this can be expressed in equivalent days in ice ($0^oC$). Thus the Icedays (or Icehours) are a basic means of evaluating seafood which can be equated to a defined freshness. Systematic inspection of a range of properties such as colour resilience eyes and odour can provide a Quality Index from which Icedays can be calculated. But if you are trying to determine whether to buy a piece of fish tightly wrapped in plastic and sitting on a Styrofoam tray, the decision might be more difficult.

The freshness and overall quality of food depend, in large part, on the distribution and marketing systems. Any mishandling of a food along the way accelerates changes and downgrades the acceptability of the product. To further ensure that food retains its desirable properties, consumers must practise careful food storage and handling habits at home, as well.

New indicator technologies are emerging that aim to monitor temperature and other important variables that play critical roles in determining the rates of change in foods and these technologies need examining for their usefulness in monitoring seafood during their movement from producer to supplier to consumers.

Temperature, humidity, oxygen and light intensity affect the rate of each reactive process and obviously the progress of these involves changes in sensory, nutritional and safety properties. Changes in fresh produce can be followed by either recording temperature changes or by monitoring bio-chemical changes in the product itself.

Oxygen scavengers, moisture absorbing pads and the like have been used in seafood packs for 40 years and fell into the category of smart packaging when first developed but are quite normal today. Their use is common and, at times superfluous, but is regarded as demonstrating that the producer cares for the product. They are not mentioned further.

## *Temperature recording devices*

Electronic temperature recorders have been in use with foods and seafood for over 40 years. Many small recording devices that can be included within foods have been developed. If they record both time and temperature then they can act as integrating devices to express an equivalent time at a standard temperature such as $0^oC$, which can then be expressed as equivalent days in ice or Icedays. However, if temperature is merely averaged over a period then any calculation of equivalents is a guess.

Small recorders such as Tiny Tags (www.tinytag.info) are commonly used for both experimental shipments and commercial shipments although commercial shipments mainly tend to rely on recording devices for the whole shipment e.g. a container or truckload. These recordings are notoriously variable as temperature fluctuates in different parts of a container or truck according to position in the load, temperature of loading, ambient fluctuations and how well the load is distributed. They are therefore too inaccurate for sensitive products such as seafood. Tiny Tags and others can also read parameters such as humidity, voltage, current, shock, vibrations, etc.

Global Cold Chain Solutions (www.globalcoldchain.com) of Melbourne market a variety of temperature recording devices and many related products including humidity and other sensors that are programmable.

Two approaches have been taken to help overcome these problems:

1. The recording device is situated on or within an individual pack or carton and from which data are downloaded at the destination and

2. The recording devices are located in the load but which transmit information externally to a receiver.

An example of the first approach (1) is the KSW Variosense tag (www.ksw-microtec.de) which is about the size of a credit card and contains a sensor, a chip, a battery and an aerial. The chip records time and temperature and the data is read from it when it is scanned and activated by the appropriate device at the stage of unloading. These tags are still too expensive to be used on most single packs but are affordable on master cartons as they are re-usable a few times. Aside from the issue of the correct placement of the tag to provide temperature relative to the product, their accuracy of ± $2^oC$ is not good enough for seafood in the chill region. This is particularly so if the data are to be used to predict or estimate microbial growth.

Another make is the ThermasureRF$^{TM}$ Wireless temperature recorder which uses a semi-conductor temperature probe and microchip (www.evidencia.biz ) and the recorded data are read with a hand-held scanner at the destination.

The second type (2) consists of a series of similar size tags that do not contain a battery but which can be scanned and activated to transmit a temperature reading at set time intervals during transport. The radio scanning and recording device sits on the truck or container exterior and connects via the mobile phone network to transmit the information in real-time to the control centre. If the truck or container is fitted with GPS, this system can locate it as well as transmit temperature. Decisions about a problem load can be made in transit to assign product to a closer destination or to get the problem e.g., refrigeration failure fixed. This system is said to have the features of being self-healing in that aberrant tags can be automatically deleted from the results at each reading time by comparison with their adjacent neighbours. The wireless frequency used requires less signal power and is less absorbed by water and metal - which present reading problems for normal RFID tags. This type of system was described earlier, and has been developed and tested in Australia with meat shipments by Ceebron (www.smart-trace.com) and is suitable for chilled seafood. The tags are usable once only and are not meant for small packs but for master packs and larger.

All these types using radio frequencies and electronic output have the advantage that data can be used in any algorithm to perform whatever calculation – bacterial growth, remaining shelf-life, and metabolite estimation – is required.

## *Time-temperature integrators (TTI) in smart packaging or on labels*

In the last few years the use of devices for monitoring thermal history (TTI =Time-Temperature Integrators) in the form of labels stuck to the product wrapping has been proposed both for research and application. They are structured in a way that they show a chromatic variation proportional to time-temperature exposure. At present, more than 100 of such devices have been patented.

These devices, programmed according to the kinetics of the change in a quality index can be used to study what shelf life a product may have and also to give information to consumers as well. TTI devices, once arranged, react to thermal conditions of exposure by getting darker. The product reaches its maximum time of preservation and consumption when the indicator has turned to certain darkness that can be estimated by comparing with a pre-printed area. This principle allows the consumer to buy safe products on a qualitative point of view and even to avoid preserving them too long in domestic refrigerators.

Different kinds of the above indicators (at low cost as well) suitable for monitoring refrigerated products are already available (they are commercialized also in Italy). Some devices to monitor frozen food have also been proposed, but there is no agreement about their effectiveness.

Besides checking products' shelf life, TTI devices can easily be used to monitor the food chain in real conditions. In this case the progressive exhaustion of the indicator response allows determining in any moment the cumulative time-temperature conditions of exposure at fluctuating temperature. It is therefore necessary that the rate of change of the TTI strip responds in the same manner as the food in question otherwise the result may be erroneous.

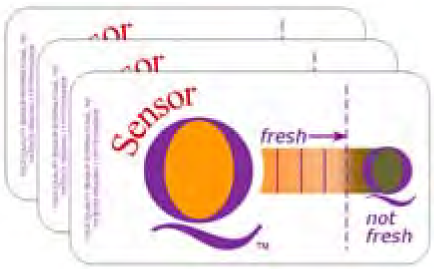
The advantages of this application, when compared with more refined monitoring systems, are the low cost of the indicator and the opportunity of positioning it locally (on the packing of a carrier-product, in a vehicle of transport, in a particularly unfavourable position in the display-case). Therefore by using these devices it's possible to have an extensive and repeated control.

Essentially, the technology is a tag or label stuck on the individual pack and which has a dot in the centre that changes colour from amber to orange to pink-magenta (or some other colour combination). This colour change occurs as a result of a chemical or an enzymatic reaction between the components in the bubble of the dot. These form a pass/fail (Yes/No) system and have had the greatest use if there is a commodity like a vaccine or medication that becomes inactivated over a certain temperature, even though 99% of the time it was at a correct temperature.

Vitsab TTI (www.vitsab.com/index.htm ) and Lifelines (www.lifelinestechnology.com ) indicators are among the most reliable and tested ones. They can be made in form of adhesive labels or can be part of packaging. Lifelines label show a darkening of the colour in the central area, and the colour variation is compared to an outer area of reference. Precisely, darkening is due to the polymerization of an acetylenic monomer. Even in the Fresh-Check indicator, that is the simplest and cheapest one, the darkening reaction is continuous and objectively measurable by using simple suitable equipment. However, the kinetics of chemical reactions is very different to those of bacteria and enzymatic reactions and these labels are unlikely to be capable of integrating the effects of variable temperatures. Thus they may result in false conclusions.

The Freshcheck label (www.temptimecorp.com ) is an example of where the colour inside the dot changes to that of the annular surround to indicate the product has reached a designated endpoint. The tag has been designed with a response that follows Arrhenius kinetics and is thus not suitable for use with chilled fish products.

Similarly the SensorQ (www.fqsinternational.com) is designed for retail display of red meat and chicken products.




The Coldmark indicators (www.tttechnologies.com.au) show if a product has ever been below a certain temperature, often freezing, at some point in its history. The available labels activate at -3$^{o}$C, 0$^{o}$C or +4$^{o}$C.

The Checkpoint III L series label (from Vitsab, Malmö, Sweden) is promoted as being used for chilled seafood. This label has been designed to provide an indication of safety from *Clostridium botulinum* and meets similar temperature characteristics for the conservative prediction of toxin production as outlined by Skinner and Martin (1998) of the USDA Hazard Analysis Branch. It is effectively a pass/fail indicator as the time between first indication of colour change from yellow to orange and a fail indication is brief. The company states they can tailor make a tag to products of different shelf-life at a given temperature. Presumably modifications are made to the balance of substrate(s), enzyme, or modified enzyme and buffer to suit differing conditions.

Another approach is similar and may consist of a tag with three or so coloured dots which progressively change with time and temperature. The Warmmark range-of-labels (www.tttechnologies.com.au) indicate the period of time a product has been 2$^{o}$C above a particular temperature either by diffusion of a colour along a wick or by a change in colour in a single or series of three indicator bubbles. A variety of times and temperature start points are available but that for 0$^{o}$C expires after only 48 hours.

Neither the single dot nor the series of dot indicators are very effective at integrating time and temperature and they are very crude devices for technical purposes. They are a gesture towards an apparent attempt at providing a guide for consumers and are not substitute for proper quality assurance and control. They have the advantage of being small and thus give indication about an individual pack.

A variant on the above is one in which a coloured substance diffuses along a strip at a rate dependent on temperature. Most of these devices have been designed and tested to provide linear results with time at set storage temperatures but they have different temperature characteristics to seafood products and hence are much less accurate if temperatures fluctuate.

Unfortunately designers of these tags have not always recognised the necessity of first knowing the temperature characteristics of seafood spoilage. If they do seek this information it is often not available and they are hampered by the lack of knowledge derived from independent research.

However there is a new promising development, that of the TRACEO label from the French start-up company Cryolog (www.cryolog.com). This transparent label is placed on the pack, e.g., over the bar code label, on a product and activity is initiated in the bacterial constituents (Lactobacilli) in the label. These Lactobacilli produce lactic acid, change the pH and an indicator turns the label from green during storage, to brown just before the end of shelf-life then rapidly through brown to red signifying the end of shelf-life. The bacterial strain and the constituents in the label are selected to match the spoilage characteristics of the product. Thus, the labels can be regarded as reliable shelf-life indicators that genuinely reflect changes in the product as the rate of change in the label matches the rate of spoilage in the product as storage temperature fluctuates. The desired shelf-life for a product must first be determined and a label designed, or selected from the current range, to suit that product. These labels do not indicate any progressive changes until the time the pH is such that the indicator starts to turn colour. If a product has a shelf-life of 10 days at $0^{o}C$ then the colour of the strip would remain unchanged for most of that time (probably 8-9 days). Further information has been requested from the manufacturers as to the commercial status, availability and range of standard labels.

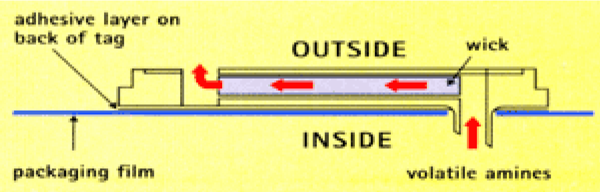
Amongst the disadvantages of many TTI labels are that they give a picture of the time and temperature without any actual knowledge of what has transpired to the food product within the package, as the TTI labels are attached to the package's exterior. There is also room for fraud by exchanging food wrappers together with the TTI labels by anyone involved in the whole chain from the food packers until the food arrives home to the consumer. Certain food products such as meat products, the TTI label is within the container in contact with the food product. The same disadvantages apply here as well wherein the label offers no information about any changes transpiring to the stored food product itself and fraud is still relatively easy.

### *Detecting parameters other than temperature*

There is currently interest in at least two forms of sensors that contain an indicator – for example, bromocresol green - that is simply a classical chemical indicator that responds to changes in pH. Seafoods produce volatile bases during storage, mainly due to bacterial action. These are trimethylamine (TMA) but ammonia and dimethylamine (DMA) and other more complex amines occur, collectively known as total volatile bases (TVB). TVB levels have been used as an indicator of spoilage of seafood for at least 50 years but it is crude. This is because TVB levels are naturally variable in recently caught seafood; some prawns for example have natural levels of TVB, when first caught, higher than some regulations state, so the start point is uncertain. The main amine, TMA, evolved during storage is due to bacteria so its evolution mirrors bacterial growth, but different species have different capabilities to produce TMA. Since microbial growth is logarithmic so is production of TMA, and the levels of TMA increase rapidly from one day to the next, once the bacterial population reaches about $10^6$/g. As a result the indicator only works near the end point of storage- no change for the majority of the storage period, then suddenly a colour change that rapidly intensifies. It does not give any indication of storage period expired or an estimate of shelf-life remaining.

One example is made by Litmus FQI (www.litmusfqi.com) and comes in 4 application types for containers, cartons, packs or as atmosphere sensor straws through which sample headspace is pumped. The indicator turns from yellow to blue when product is suspect (TVB levels reach some detectable threshold).

Another device has been developed in Ireland (Pacquit et al 2004; http://www.dcu.ie/chemistry/asg/pacquita/ ) and consists of a dot to be placed on the pack which turns colour, yellow to red) as the pH is changed by TVB gases. Considerable ingenuity has been put into developing a neat device that pierces the pack to allow gases to pass through it across the indicator wick. The colour change can be read by the naked eye, or more accurately by a small hand held colorimeter designed for the job




A lot of effort has been put into this system with tests on cod and whiting and trial shipments conducted (see http://www.dcu.ie/chemistry/asg/pacquita/) but a whole range of trials would be necessary to modify the indicator to get it to suit characteristics of Australian species. The Irish work related TVB to total viable counts and this relation does not always hold true, particularly if the total viable count has not estimated *Photobacterium phosphoreum* (many standard methods do not estimate this prodigious producer of TMA).

The papers, publicity and lectures from the originators of these tags are expressed in the usual confusion of the concepts freshness, quality and shelf-life without ever defining the terms. They are marketing documents that are not substantial in presenting their conclusions. This is not surprising as they wish to sell a product or their efforts in designing one.

Tags and labels that measure metabolites may have specific uses in proscribed circumstances but they are unlikely to have general applicability over many situations. They may be very useful in training or in screening trials conducted under differing conditions. A variety of specialised tags may be useful to meet particular circumstances in which there is a good body of information on which their design is based. Tags may be useful for trouble shooting in that they are cheaper than monitoring equipment and don't require return of equipment. They may also have a use in transport in direct sales where proper chill systems cannot be expected to be the norm, or in display cases. They are an admission of failure of the system.

Oxygen levels in packages can be detected externally using the oxysense (www.oxysense.com) technology. To sense oxygen within a package, an OxyDot™ is placed inside a bottle or package prior to filling. The dot is illuminated with a pulsed blue light from an LED. The blue light is absorbed by the dot and red light is emitted. The red light is detected by a photo-detector and the fluorescence lifetime is measured. Different lifetimes indicate different levels of oxygen within the package.The optical system can measure oxygen levels in transparent, translucent and semi-transparent packages, as long as the material can transmit light in the 470nm and 610nm range. The standard operating range is from 0% to 30% $O_2$ in the head space (the same system can also be used to monitor dissolved oxygen). The lower detection level for headspace measurement is 300ppm.

# Future traceability and product sensor technologies

When a common product code is applied in all documents of exchange of goods in a delivery chain, work is spared due to avoidance of recoding and data can be transferred directly in a machine coded form.

The current problem with attaching the traceability data to food products is that standard codes exist, but are rarely in use. The candidate codes are GTIN+ (GS1 code, extension to the existing GTIN product type code (GTIN = Global Trade Item Number), in practice carried on a GS1 128 bar code) or ePC (new electronic product code, in practice carried on a RFID-chip). The current system involves putting the information on the label and sending accompanying documentation, while a better system would be keying the data to the unique identifier and sending an electronic message beforehand in standard form (XML). The weakest link of the chain currently is the receiving of the information, as it may be in the form which is meaningful to the sending company only. However, XML can send plain words so the system can be tailored to the requirements of sender and receiver in the chain. Indeed the XML message can be read by humans. This emphasises the need for chain members to collaborate and consult when a system is being developed. The Tracefish standard has now incorporated automatic translation of equivalent terms in a number of European languages so all the information from simple to complex (boat name, species etc) can be sent in any language e.g., Icelandic and received in any other e.g., Greek, Portuguese, Finnish and so on. This is a powerful advantage and for Australian based systems to be able to communicate in the languages of our trading partners e.g., Mandarin, Japanese, Korean, and Thai we must seek to develop common terminology which can then be automatically, and correctly, translated. The TraceFish and TraceCore models provide this international scope.

Even though the traditional bar codes are the most used systems in marking the products, newer technologies, enabling more data to be included, are becoming more popular. The disadvantage in using barcodes is that they must be read in a certain position which requires human intervention (thus time and effort) and there is a possibility for error and inefficiency. A label is also easily damaged (Regattieri et al., 2007) as borne out by common experience at supermarket checkouts. In comparison, RFID systems reduce labour costs as no manual scanning operations are required. An RFID reader can scan numerous tags at the same time; identification is simple and rapid, resulting in reduction of profit losses caused by e.g. employee and customer theft, vendor fraud or administrative error. In the food industry, RFID provides improved management of perishable food items (continuous monitoring of item routing reduces waste and improves customer service levels); Improved tracking and tracing of quality problems by using individual product codes; as well as improved management of product recalls (Regattieri et al., 2007). RFID Tag is also more durable and enables reading in e.g. dirty and cold conditions, which may in case of bar codes be almost impossible. Its larger memory enables individual recognition of products.

The main limitation of RFID is the costs of tags. For a low-price food product the cost may be too high. There has been a great lack of standardization for all technical systems (numerical, or bar codes or TAGs), but the situation has been substantially improved. In the end of 2004 an ISO-standard 18000-6C came in force for UHF tags used in RFID technology. The standard is known by name EPC-Gen2. This increased the use and sale of UHF tags quickly followed by reduction of price.

In the near future, RFID-based systems will be used, in addition to tracking the goods, also to monitor the quality of the products and the supply chain itself. RFID-based remote sensing will enable e.g. the online spoilage detection of vacuum-packed food products and the continuity of cold chain (Aarnisalo et al, 2007).

As an alternative to conventional barcodes and RFID, new electrically readable coding techniques have also been developed. These electrically readable codes are cheaper than RFID tags but still have some major benefits of RFID technology. Electrically readable code can be attached to a product using conventional printing techniques combined with special inks. Electrical code itself can be invisible and is not as sensitive to dirt and other visible disturbances as a conventional barcode is. It is also possible to embed some sensor properties into these codes as with RFID tags. Read range and flexibility of the system is not comparable with RFID, though.

Innovative technology utilizes microscopic, edible bar codes that can be applied directly onto foods to make them more secure, safer, and also less expensive by replacing “one step forward, one step back” traceability protocols with reach-through and real-time documentation of the origin and subsequent history of a product. E.g. polydactyl acid or celluloses can be used for producing food markers by extrusion. The size and concentration of these markers must be such that they have no detectable effect on the tare or the texture of the marked product. The information has to be encoded on the surface of a fairly rigid microscopic particle and the particle attached to food by either (1) electrostatic attraction, (2) use of wetting agents, proteins, or lipids as adhesives, or (3) mixing the particles into a material that is subsequently mixed into or applied to a food. Generally binary codes are scored and embedded onto and within a fibre. When placed on/ in food, the markers by definition become Food Additives and must be safe for consumer at maximum level at which a consumer would be exposed. In some cases, it may be useful to use a marker that dissolves after a particular amount of time or after it has been heated to a particular temperature (Nightingale and Christens-Barry, 2005).

Product sensors and indicators of food freshness have developed rapidly in response to the growing need for quality and safety assurance in the food industry. However, to take things a little further, physical and chemical properties can be measured with sensors, such as an electronic nose. This technology is based on absorption and the desorption of volatile chemical substances. The detection system can be composed of gas sensors or a mass spectrograph together with statistical processing system for classification of the odours.

Biosensors have a biological identification part, such as antibodies, cells, receptors or nucleic acids (Patel and Beveridge, 2003). In the future, biosensors will most probably be used for various tasks, e.g. detection of mycotoxins, bactericides, allergens or contaminating microbes.

The CSIRO Food Futures Flagship has developed an olfactory biosensor technology called the Cybernose. The Biosensor Technologies project is developing new ways to quantify the volatile organic compounds which give rise to the flavour and aroma of food. These compounds are important quality determinants and may also be used as proxies for a range of non-volatile chemical changes in food. CSIRO has identified an unmet market need for rapid, on-site, highly sensitive, specific and quantitative measurement of odorants and for pattern-matching of complex odours in many potential application areas, including:

- Food and beverages
- Fragrances
- Water supply
- Pest control, animal production
- Biosecurity
- Medical
- Industrial
- Defence

Though untested in the seafood industry, in the near future, the cybernose may be useful for identifying shelf-life of seafood products and simultaneously scanning RFID tags on products.

Work in this area is being done in Europe, however, the sensors in electronic noses have different kinetics to the changes that occur in fish and this limits their use. However, electronic noses will probably have a role in at-line quality control to screen raw materials or processed product for specific properties or presence of certain features.

The authors' summary comments:

- Traceability must be seen as part of the business system employed to increase efficiency Traceability should form part of the ERP system of an enterprise and be a corner stone of the company quality management system.
- Quality can't be controlled if product cannot be identified.
- Traceability is essential to and enhances HACCP, Quality Assurance, Total Quality Management and Six Sigma management approaches.
- Traceability provides data to calculate yields and profitability at every step in the chain, not just as an overall figure of raw material in, product out.
- Paper systems are limited but common.
- Barcoding should be considered from point-of-harvest and throughout the chain. GS1 compatible barcoding should be used. Proprietary codes are reminiscent of Australia's multiple rail systems.
- Newer complex barcodes should be considered later in the life of the CRC when opportunities are identified arising from development of traceability systems in the industry.
- The adoption of RFID tags is hampered by lack of existing upstream and downstream systems to benefit from the information.
- Wireless networks (e.g. the Ceebron PAWN systems) can provide enhanced and reliable information to feed into traceability systems.
- All time temperature monitors should either be programmable with the correct kinetics to integrate changes in seafood or have output in electronic form that can be integrated and analysed in any algorithm required.
- Time-temperature indicator strips must also have similar kinetics to the seafood produced they are intended for use on.
- Tags that rely on chemical indicators may be useful as pass/fail indicators in some specific situations and in indicating shelf-life but [are not generally applicable] they do not provide any indication of remaining shelf-life or of storage period elapsed. They may help in marketing and with untrained staff.
- Shipment readouts and temperature monitors provide assurance but need to be integrated into traceability and QCM
- Tags on individual packs indicate market failure of QA to fully control systems and are a safeguard provided they give a true indication
- In specific instances indicator tags could prove useful from a safety point of view.

- With any new device, identifier or tag how does the information that it provides fit into existing systems and can it fit into projected systems? For example bar-coding systems are well advanced and universally used in the food and retail industry and will be retained for a considerable time whereas RFID systems are less used for foods at present but are widely adopted for large durable items.

# Conclusions and Recommendations

Looking into the future, the greatest pressure on traceability is likely to come from the general public. People are getting more and more concerned with what they eat. Does the food come from a sustainable source? Has it been produced, transported, and stored in conditions that will guarantee its safety? Is it healthy? What is its carbon footprint? The general increase in interest in the environment, climate change, animal welfare, sustainability, organic production and ecology means that there is growing public awareness about the source of seafood and whether it meets these requirements. Popular press, activist websites and scurrilous misreporting on TV has raised consciousness of these issues.

Major international retailers have already begun to focus on meeting the new demands. For example, the environmental policy of the Carrefour Group is becoming paramount when it makes its purchases. They now identify "risky" fishing areas before deciding on whether to buy certain fish products or not. This shifted focus can also be seen with more and more producers investing in eco-certification (producing seafood that is good for the ocean's ecosystem) or organic certification (producing organic seafood).

The effects of this trend can also already be seen in some supermarkets. Certain foodstuffs, like organic fruits, or eggs, can be traced right back to the farm that produced them through identifiers on the product that can be scanned by a small computer. By entering the identifier, you get information about the farm, and you can now do this with Southern rock lobster and soon with Western rock lobster.

This trend is likely to influence the selling of seafood as consumers decide they would really like to be able to make choices about what they eat and what they don't.

In Australia’s seafood industry, paper traceability systems are the norm in most of the catching and harvesting sectors, despite the fact that the catch sector uses many sophisticated electronic instruments and devices in their operations and that electronic communications and computer use are wide spread on board, dockside and in processors. Traceability should be viewed as an opportunity, not an imposition and whilst paper based systems can work, they are inherently inefficient and offer no scope for improvement.

Products and services have customarily been controlled by different paradigms, but the advent of smart packaging, product sensors and traceability systems and the integrating technologies of intelligent device networking can now serve to bring them together and a product and a service are supplied simultaneously. A simple example is that of identifying goods with tags or bar codes. These are used in the production sense to provide the manufacturer with a means of identifying the goods and of following their history of manufacture from raw materials, the processes used and the packaging but they can also be thought of in the service sense as providing information to the end user and thus enhancing the product’s value. Information is the new value-added.

Products alone and services alone do not provide competitive advantages as either a product, or a service, can easily be copied by a competitor. The offering of both product and service provides a competitive edge that is less easily copied and helps lock in the information feed back loop with the customer.

Therefore the use of traceability and product sensors can be thought of as to whether they are an aid to making and distributing the product or whether they provide a service to the customers. Clearly both matters should be considered and those devices and techniques which offer the possibility of integrating both should be seen as the way of the future.

This review has identified numerous areas where work on traceability and on product sensors is potentially of advantage to the CRC participants and the seafood industry in general. Traceability systems are a discipline in their own right but not all areas can be worked on and it is important to focus on those where the need or the payoffs are greatest. Furthermore seafood industry partners must be identified who have the desire to improve their existing systems. It is obvious we start from a fairly low base.

Before traceability systems can be implemented a study of the chain of events that occur in the transformation of raw material into consumer product must be done. Therefore the following recommendations are suggested by the authors.

**RECOMMENDATION 1 – Traceability mapping of selected chains using proven methodology**

- Identification of suitable chains and seafood industry participants, including technology providers
- Analysis and mapping of these chains
- Cataloguing of current technologies used
- Select prototype chain for development
- Develop the chain traceability system
- Validate the system
- Examine potential time and costs of operation in comparison to current methods
- Identify additional benefits

**RECOMMENDATION 2 – Test and modify the Good Traceability Practice Guide under Australian conditions.**

Assess the traceability systems identified in this report against the criteria in the “product traceability framework” and ensure they satisfy the seafood industries needs. This will also require testing and modifying the “Good Traceability Practice Guide” under Australian conditions with selected seafood products. Consideration should be given to using The Southern & Eastern Shark and Scale fish Fishery supply chain analysis (DAFF project 73/06) as foundation data on which to base a traceability system.

**RECOMMENDATION 3 – Evaluate Information platforms to support Traceability Systems under Australian conditions.**

- Pilot InformationLeader in the seafood industry. Possibly use on the trawler to capture catch information and establish the system all the way through to retail. Information Leader is compatible with RFID systems

**RECOMMENDATION 4 – Develop and implement a pilot Chain of Custody studies**

The system should consider:

> "Chain of Custody" is the new imperative in Seafood it involves the need to identify where fish come from to ensure that the fishing areas remain sustainable. Traceability systems that extend to point of catch and storage on board are necessary. This system also collects information on the catch statistics i.e., log books and biological data. Build on E-boat initiative to include catch and traceability data.

Young's Seafood are the leaders in sustainable wild caught fishing and their approach should be applied and tried in a selected fishery such as that of Australian Sardines, or of a controlled prawn fishery (Spencer Gulf).or SETFIA.

**RECOMMENDATION 5. Product sensors**

- Review availability of current Time-Temperature Integrator labels discussed in this report, and equipment that has correct kinetics that may be developed for Australian conditions, species and products
- Identify the product attributes that sensors should target
- Work with local manufacturers of data loggers e.g. Global Cold Chain Solutions and others.
- Approach Ceebron to conduct trials on seafood products and develop a project based on the SmartTrace technology.
- In conjunction with other CRC projects to establish temperature and spoilage characteristics of some key products and to establish the specific spoilage organisms for seafood in the various regions of Australia for the main products in tropical, sub-tropical, temperate and cool regions
- Use the information to build spoilage models, or test current models, for their applicability
- Select from available range of sensors those with appropriate characteristics for each situation and try them under practical conditions.

**RECOMMENDATION 6 – Promote good traceability practices in the industry to raise consciousness and to identify incentives for industry to change.**

Act, in conjunction with SSA and FRDC, as a focal point for traceability in the seafood industry and as a contact for involvement in international traceability initiatives.

Explore potential for financial incentives. Such incentives may include:

- A financial incentive through Federal Government assistance or industry organisations
- Design, develop and demonstrate a ROI costing model. This work could be done in conjunction with Steven Cambridge of the Business Logistics research group in the School of Information Systems, University of Tasmania.

- Collaborate with software suppliers such as WiseFish and Olfish to instigate a national change to Australia's seafood industry

This may be communicated through:

- A CRC Workshop – promoting good traceability practices
- Explaining traceability in the first CRC Newsletter

**RECOMMENDATION 7. Tests for authenticity and product origin**

The CRC should not become involved in research that develops the technology, unless requested and funded by a participant or unless there is a serendipitous spin-off from another activity that can be capitalised on.

**RECOMMENDATION 8. Research into traceability and product sensors**

The Seafood CRC should not undertake research in the development of Traceability and freshness indicator technologies but instead, should fund work that develops and integrates existing technologies into the Australian seafood supply chain.

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# Appendix 1

## Extract from Draft Revised Technical Guidelines for Responsible Fish Utilization: FAO, Rome (as at 13/08/2007)

**11.1.11 States should ensure that international and domestic trade in fish and fishery products accords with sound conservation and management practices through improving the identification of the origin of fish and fishery products traded.**

145. The ability to trace the origins of an end product through a system of documentation and records should be a precondition of a well-operated quality management system FAO/WHO 2006b. Information regarding origin, date and time of capture or harvesting and the various stages of processing and change of ownership should be incorporated into documentation which follows the product to the final sale and the consumer. This type of information can be incorporated into computerized stock control systems by the use of bar codes or radio frequency identity devices (RFID) and can be a requirement to show due diligence and the proper functioning of a quality assurance system. Products entering international trade will normally require traceability of product and a paper trail to be available so that responsibility for poor quality, for instance, can be traced back to particular events. On the other hand it is possible through such documentation to be able to trace good products/suppliers and so be able to repeat orders and build up trade. Not only is such a system a mechanism for assisting in trade but it also assists in protecting the consumer against fraud and this has been covered to some extent in the section above under Article11.1.2.

Discrepancies in the formats of barcodes and the frequencies used for RFID have been reconciled and the global organization GS1 (www.gs1.org) is the coordinator and issuer of barcodes and tags that are readable throughout the world. Unlike a label, these barcodes are merely an identity number and contain little information themselves. It is the software in the computer to which a tag reader is referred that interrogates its database and interprets and displays the detail about the product. On the other hand the newer generation (Gen 2) EPC RFID tags can carry more information than identity alone are more reliable and will become more widely used both internally within the company to trace batches and externally on consignments.

The ISO definition for traceability is the ‘’ability to trace the history, application or location of an entity by means of recorded information’ (ISO 8402:1994). The latest relevant standards from ISO for traceability of interest to fisheries are ISO:22205:2007 Traceability in the food and feed chain, 22000:2005 Food Safety Management Systems –Requirements and ISP22519 Traceability systems in the Agricultural Food Chain- general principles for design and development in the food industry.

Global traceability computer systems have been developed that can perform operations in fractions of a second to trace from a product in store back through to point of harvest. For aquaculture applications these systems can also trace the feed composition and the medications given the fish, not just when it was hatched from the egg, but back to the history of the broodstock.

Adoption of these systems requires the drawing out of a flow chart for the items of interest and a paper record of this system. This is then followed by a set of technical specifications for the system then by design of new software or adaptation of software packages, followed in turn by validation of the system and gradual rollout and testing of it in practice.

Fish technology researchers in Europe took the lead in developing food traceability systems in a series of EC funded projects with results available on the web at various sites e.g., www.tracefish.org, www.tracefood.org, www.seafoodplus.org,www.trace.eu.org, http://eu-peter.org. The Tracefish project established and developed a standard protocol for information collection and transfer for both aquaculture and capture fisheries that is accepted at the stage prior to being an ISO standard (CEN 2003a, CEN 2003b). The core software model, based on the eXtensive Mark-up Language (XML), is applicable to all foods and a version is downloadable from the Tracefood website and upgrades will be found there as they are required.

146. It is of considerable importance, from a trade and consumer confidence point of view, to be able to improve the identification of the origin of fish and fishery products. This, however, is not the underlying reason behind Article 11.1.11 above. The reason given for requiring improved identification of the origin of fish and fishery products traded is to accord with “sound conservation and management practices”

147. The concern of the public and consumer about the origins, sustainability and environmental effects of food supplies and the way they are produced is reflected in the recent moves towards the establishment of eco-labelling schemes. Such schemes, which assure the consumer that the product they purchase has been produced in a particular way (without harming dolphins or from sustainable stocks for instance), must be and be seen to be independent and impartial if they are to command world-wide acceptance and trust. These issues are covered within FAO Technical Consultations which are moving through draft stages (e.g. FAO 2005a).

148. Various species and stocks of fish and aquatic organisms are protected from harvesting by international, national or local legislation, custom or tradition. For instance the Convention on International Trade in Endangered Species (CITES) restricts the trade in certain species caught in the wild. It is, however, very difficult to tell whether an item being traded is from protected or non-protected stock. Indeed it can be difficult to tell whether fish flesh is from one species or another let alone whether it is from protected stock.

149. Assuming honesty and due diligence in all parts of the distribution chain, a written record of the history of the product would be sufficient to be able to identify the origins of the product and so ensure that sound conservation and management practices have been adhered to. This can be tediously slow and highly impractical in many cases, unless the records were entered into databases. However, it is necessary to be able to identify, for instance, whether a turtle product is from illegally caught stock or from farmed stock, whether eggs from sturgeon (caviar) are from CITES listed species/stock or from others, whether fish meat is of one type or another. Various combinations of environmental markers such as micro-elements or metabolites are being explored for these purposes using multivariate statistical analyses on the results of micro-analytical techniques.

150. Through the use of sophisticated biochemical and DNA techniques it is possible to distinguish between species. These techniques, however, are time consuming, expensive and require specialist equipment and knowledge. The minimum requirement for the first steps for identification of the origin of fish and fishery products should be the establishment of a routine paper trail system, which requires that information on the origin of the raw materials should accompany the goods from capture to final sale. This is not foolproof and disjunctions in information flow are the norm rather than the exception. It is not always possible, nor is it necessary, for the accumulated information about a product to travel with it. For many export markets much more is needed than this and finished goods are invariably recorded from the level of the container though, pallet, master carton, individual carton and product. Therefore recorded identifications, such as barcodes are necessary, and it is only the identity that needs be interrogated at each stage as the information is held elsewhere but is accessible through the identity and often may precede the product along the chain.

151. It should be a requirement that sellers of products are able to show that they have taken every care to ensure that the product for sale was not illegally harvested. One means of showing that this due diligence is being maintained is to be able to produce the “paper work” that goes with the product. Only in exceptional circumstances will it be feasible and necessary for more sophisticated

biochemical testing to be done. The use of "paper trail" , barcode and RFID type identification and tracking systems still meets resistance from fishermen, fish processors and traders, although a similar system is an integral part of a quality management system. At the catching stage onboard weighing scales and printers have expedited labelling and bar-coding at this initial step. For processors of the catch global traceability systems have been developed and these are expected to be part of compliance with quality assurance systems.

**References and reading matter relevant to ANNEXE 1**

There are numerous working parties in WHO, FAO, CAC, WTO, GS1, ISO and national bodies that have work in progress on the issues covered in this document and the reader is strongly advised to search the various websites for up-to-date information. Most have lists of document available for downloading from their sites.

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