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Report

Functionality for integration of food safety information with EPC tagged items

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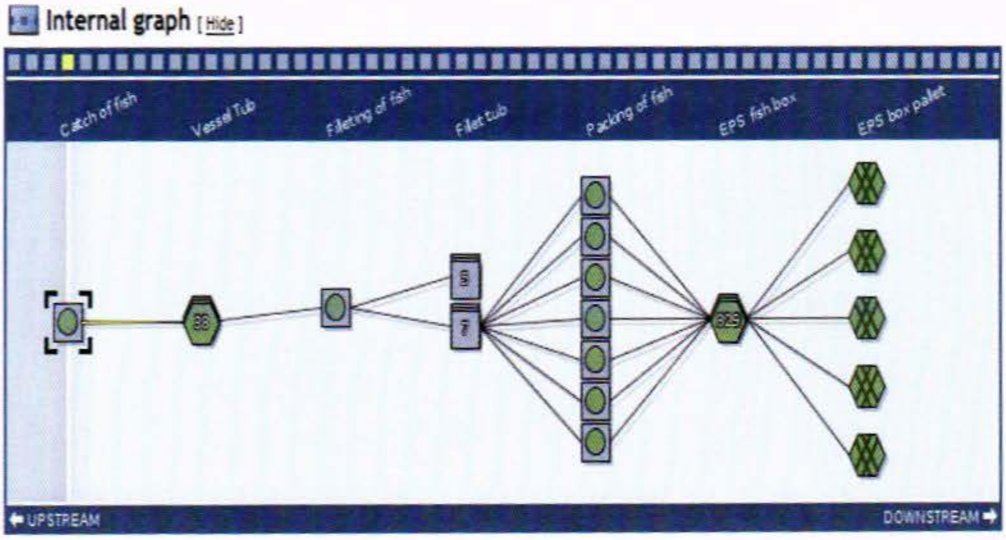

SINTEF Fisheries and Aquaculture
Aquaculture Technology

2011-03-08

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The aim of the eTrace project within SAFEFOODERA is to specify, develop and evaluate an electronic traceability system where different information sources related to food safety and suitable enterprise management systems are integrated. This report is part of work package 4 in eTrace with the focus on integration of food safety information into an electronic traceability system. Ensuring food safety is an important objective of traceability systems. Under current industry practices, information related to the food product is available in several stand-alone applications, such as HACCP systems, laboratory analysis, logistics systems, production management systems, etc. We present an information model based on the EPCIS standard that integrates food safety and traceability information and links it to the related traceable units. This information model was tested in an Icelandic fish supply chain pilot where RFID tags were used to uniquely label the product and read using scanners as it moved through the supply chain. Temperature recorded using RFID based sensors was used as one of food safety and quality parameters that was linked to the tagged items. This functionality is of great importance to the food industry where information is often lost or information access is time consuming because of a lack of standardized communication between different systems.

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1 Introduction

The aim of the eTrace project within SAFEFOODERA is to specify, develop and evaluate an electronic traceability system where different information sources related to food safety and suitable enterprise management systems are integrated. The purpose of this system is to provide efficient traceability operations so that precise and reliable recalls can be performed in case of food scares. This report is part of work package 4 in eTrace with the focus on integration of food safety information into an electronic traceability system.

Traceability and food quality and safety aspects in food industry have been studied independently. Under current industry practices, information related to the food product is available in several stand-alone applications, such as HACCP systems, laboratory analysis, logistics systems, production management systems, etc. Food safety and quality issues generally occur due to incorrect processing and handling of food products. Monitoring the flow of products, their quality and the process parameters throughout production and linking them to each transition in the state of these products is an effective way of implementing and ensuring product safety and traceability (Thakur et al., 2011).

Several product transformations and processing steps take place during industrial production of food. These transformations alter the food composition, and if not monitored properly, can affect the food quality as well as food safety. Little research has been conducted where the information related to the food product integrity, the processing techniques and their affect on the food quality and safety is recorded simultaneously. In order to perform efficient traceability, there is need to integrate all this information into a framework where a problem caused either due to processing or handling/logistics can be identified and traced back to the source.

Several external information sources for food safety publicly available on the internet (Gunnlaugsson and Sørensen, 2011). However, it is difficult to select and extract the relevant information in a format that is easily manageable and link useful information to traceable food items. Also, such extraction from external sources is time consuming if done manually and needs to be regularly repeated and audited to remain accurate and up to date. Currently, internal food safety information sources are most suitable for integration with electronic traceability systems, in combination with well managed and audited external information. Internal food process information like food temperature in process, water activity (a_w), pH and salt content are important factors in assuring quality and safety of products. Also it is interesting to include the monitoring results for Critical Control Points (CCP) and temperature – time studies during transport and storage in the product supply chain in the electronic traceability system linked to the traceable items.

Electronic traceability systems based on software applications and automatic data capture are the most effective solution for providing relevant information to the food industry and consumers. Automated traceability is based on electronic data capture and exchange. Electronic data capture can be optical or radio-wave systems, for example, barcodes and RFID technology. The interest in RFID technology for traceability has been increasing recently. RFID tags essentially contain generation 2 Electronic Product Codes (EPC) (EPCglobal, 2007). EPC provides a method for unique identification of all items in a supply chain. The use of EPC also makes it possible to register internal and external events electronically that are related to the movement of tagged items. EPCIS is an EPCglobal standard designed to enable EPC-related data sharing within and across enterprises (EPCIS Standard, 2007). This standard for using RFID is based on the EPCglobal standard. Automated traceability systems based on software applications have existed in Nordic countries for several years (Storøy and Olsen, 2007) but EPCIS makes the data capture and exchange electronic thus making EPCIS an applicable standard. There are two kinds of EPCIS data, event data and master data. Event data is created in the course of carrying out business processes, and is captured through the EPCIS Capture Interface and made available for query through the EPCIS Query Interfaces. Master data is additional data that provides the necessary context for interpreting the event data. It is available for query through the EPCIS Query Control Interface. The EPCIS events cover normal logistic and stock control processes by the use of the Event classes: ObjectEvent, AggregationEvent, QuantityEvent and TransactionEvent. The basic chain traceability requirements with respect to managing and recording transactions between different business actors are directly covered by EPCIS Events. EPCIS has promising properties related to food supply chain traceability.

The application of the EPCIS standard for food traceability purposes was tested in this project. The food safety information sources were integrated into the EPCIS system and linked to EPC tagged traceable items. The approach used is based on identification of states and events in food production and mapping these events to the EPCIS standard. The generic events that take place in food production and processing are shown in Figure 1. For details of this model, see Thakur et al. (2011).

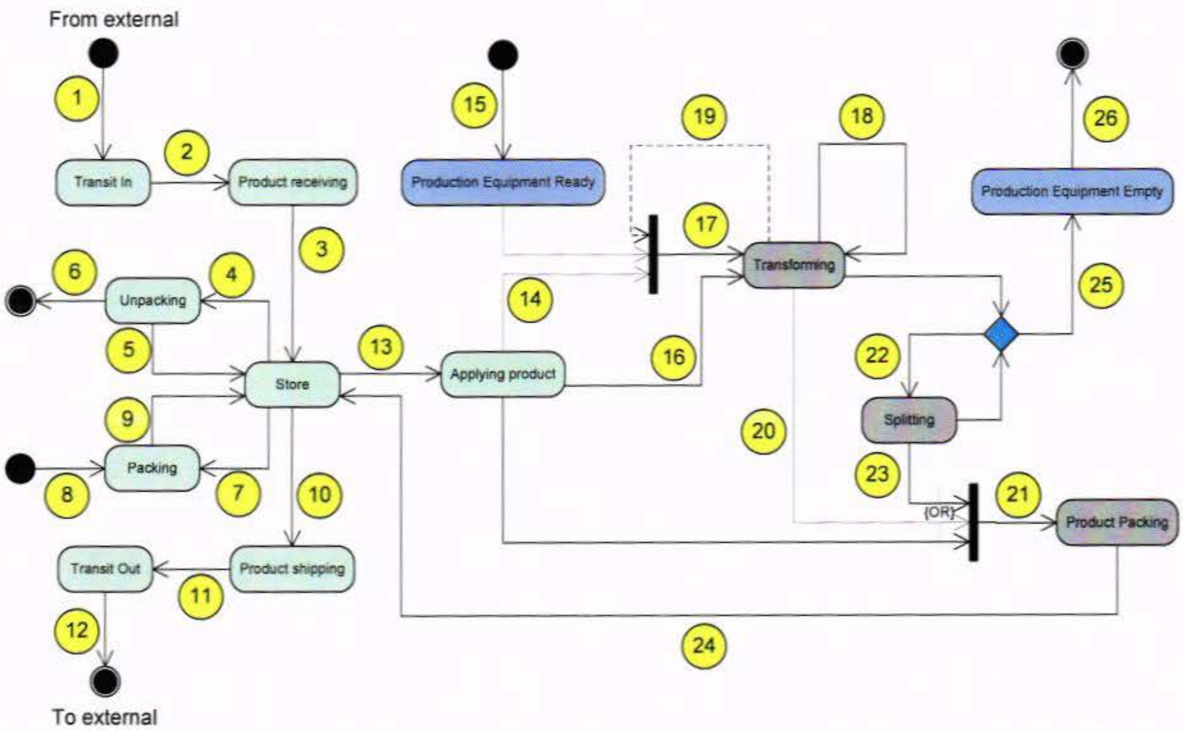

Figure 1. Generic events in food production and processing

2 Methodology

The focus was on including the time-temperature data linked to the EPC tagged items as well as information about the catch vessel, nutritional information about fish caught in a particular catch area, results of unwanted substances in catch area, and the chain of custody certification scheme are included.

In this report, results from a pilot study in redfish chain in Iceland are presented to illustrate the integration of food safety information with EPC tagged items. The pilot took place in Reykjavik, Iceland at a redfish production facility in October, 2010. A catch from a fishing vessel was loaded into returnable plastic boxes that were labeled with EPC based RFID tags. The plastic boxes used in production and filleting processes and the finished cardboard boxes and pallets were also labeled with EPC based RFID tags. The tagged items were read using a handheld RFID reader as they moved through the production process. The goal was to track the fish through all stages in production from receiving the catch to final shipment of packed fillets. Quality information included ambient temperature and product temperature was monitored throughout the production processes and linked to specific TUs (traceable units). The detailed state-event model with read points and bizLocations is shown in Figure 2. The orange circles refer to the read point and yellow squares refer to bizLocation. All read points and bizLocations identified in the production process are shown in Figure 2 but only the red-outlined points were used in the pilot study.

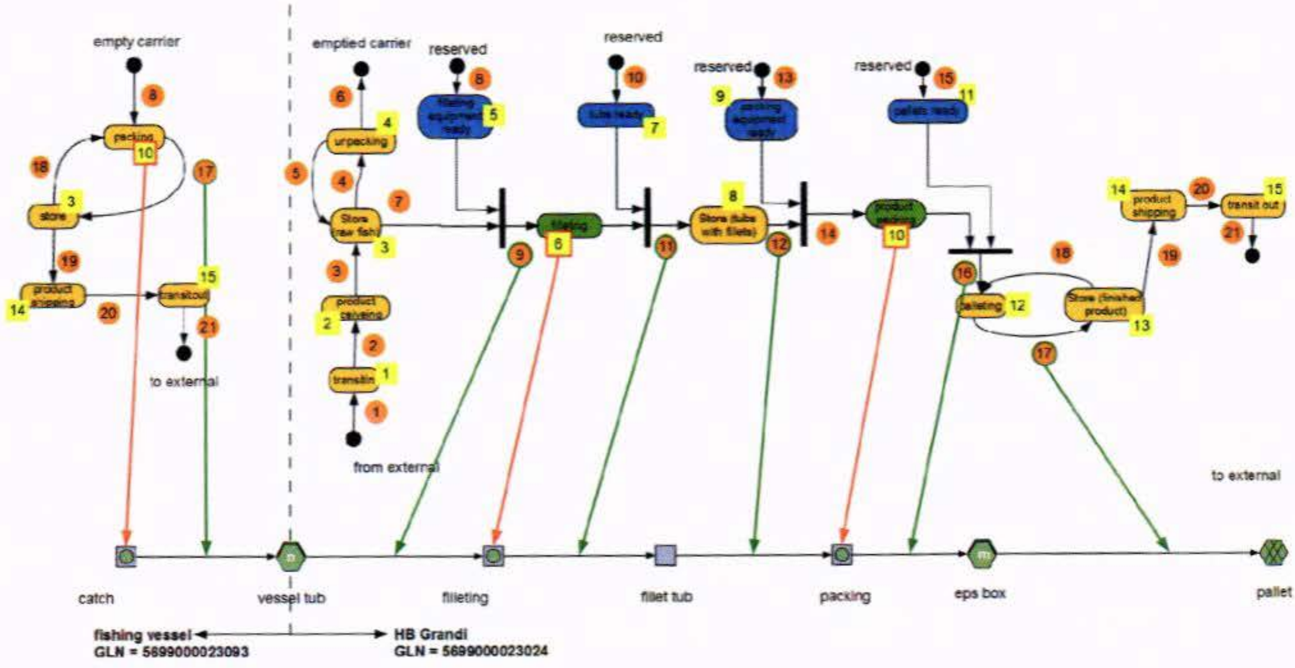

Figure 2. State-event model for redfish fillet production

The data from RFID readers was uploaded to an EPCIS repository provided by TraceTracker. These uploads relied on a local server that handled all parts of the communication between the EPCIS and the computer with the data files. This way there was no need for a human operator to be involved. TraceTracker's EPCIS repository, known as TIX, enables diverse organizations to share information about EPC-tagged products. The TIX stores and manages standardized "event" data related to individual items- the "what, why, when and where" of that item. For example, when a box of fish is scanned and information is uploaded from the RFID reader, the TIX records the unique identification of the box, its location and then other relevant information such as the processing step and time.

When the same box is scanned multiple times at different steps, or divided into smaller cases, that information is also stored, creating a history of the fish.

The following sequence was used for uploading the XML files. The timestamps recorded as eventTime followed the chronological order.

1. Create catch
2. Populate catch with attributes
3. Create vessel tub
4. Split catch on one or more vessel tubs
5. Populate vessel tubs with attributes
6. Create filleting
7. Mix vessel tubs into filleting
8. Create fillet tubs
9. Split from filleting into fillet tubs
10. Create packing
11. Create EPS (trade unit for sale) boxes
12. Mix fillet tubs into packing
13. Split from packing into EPS boxes
14. Create pallet
15. Aggregate EPS boxes onto pallet

The transformations 4, 7, 9, 12, 15 refer to traceable entities that are created (eventTime) before the transformation takes place. Otherwise one may not get the expected relationships, as chronologic development is broken.

3 Results and Discussion

Figure 3 shows the user interface for the traceability model for redfish fillet production. The views in the user interface are based on the traceable entities defined in the underlying model shown in Figure 3. It can be seen that 38 vessel tubs (catch) went into filleting process that resulted in 12 tubs with fillets. Out of these 12 fillet tubs, 7 were followed into the packaging process in this study. These 7 fillet tubs resulted in 329 EPS boxes that were assembled on 5 different pallets before shipment. The traceability graph and transformations of the catch are shown in the user interface on Figure 3. Various entities (TUs) can be selected in this interface and corresponding properties and transformations for each TU can be obtained.

In addition, integration of other product parameters such as factors affecting food safety and quality information was also included in this study and the results are presented in the next sections.

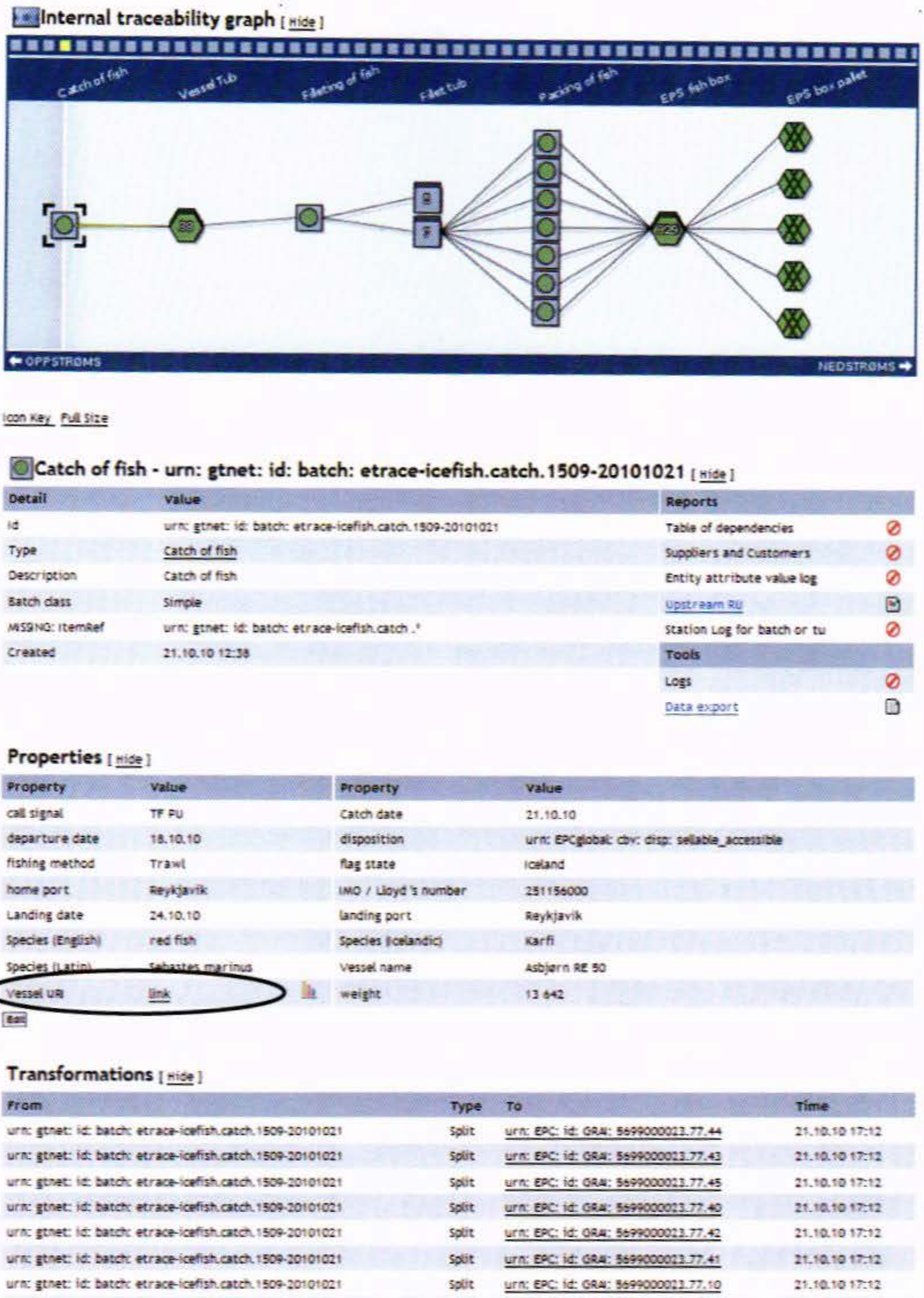

Figure 3. User interface for the traceability model for redfish fillet production

3.1 Integration of food safety and quality information

One of the main objectives of this work was to integrate the food safety and quality information into the EPCIS system and link these parameters to the EPC tagged items that can be tracked throughout the supply chain. The quality and safety parameters selected for this work were the temperature data (both product and ambient), redfish nutritional data and data on undesirable substances in Icelandic waters. These parameters were linked to the corresponding TUs and information was stored and available to be exchanged in the EPCIS repository.

3.1.1 Temperature data

Temperature sensors were used to record temperature in ten locations in redfish fillet production. The temperature was recorded at 10 minute intervals during the production process. The overall temperature profile for the redfish fillet production is shown in Figure 4. The location numbers included in Figure 4 correspond to the bizLocations in Figure 2. For instance, *Product receiving [2]* refers to the product reception area and corresponds to bizLocation 2 as shown in the state-event model in Figure 2. The ambient temperature was recorded at the following locations:

- Product receiving [2]
- Cooler 1 [3]
- Cooler 2 [3]
- Grading area [4]
- Filleting area [6]
- Product packing area [10]
- Pallet in storage [13]

Also, the redfish product temperature was recorded for the following entities and locations:

- Tub 1 with fillets [8]
- Tub 2 with fillets [8]
- Inside EPS box in storage [13]

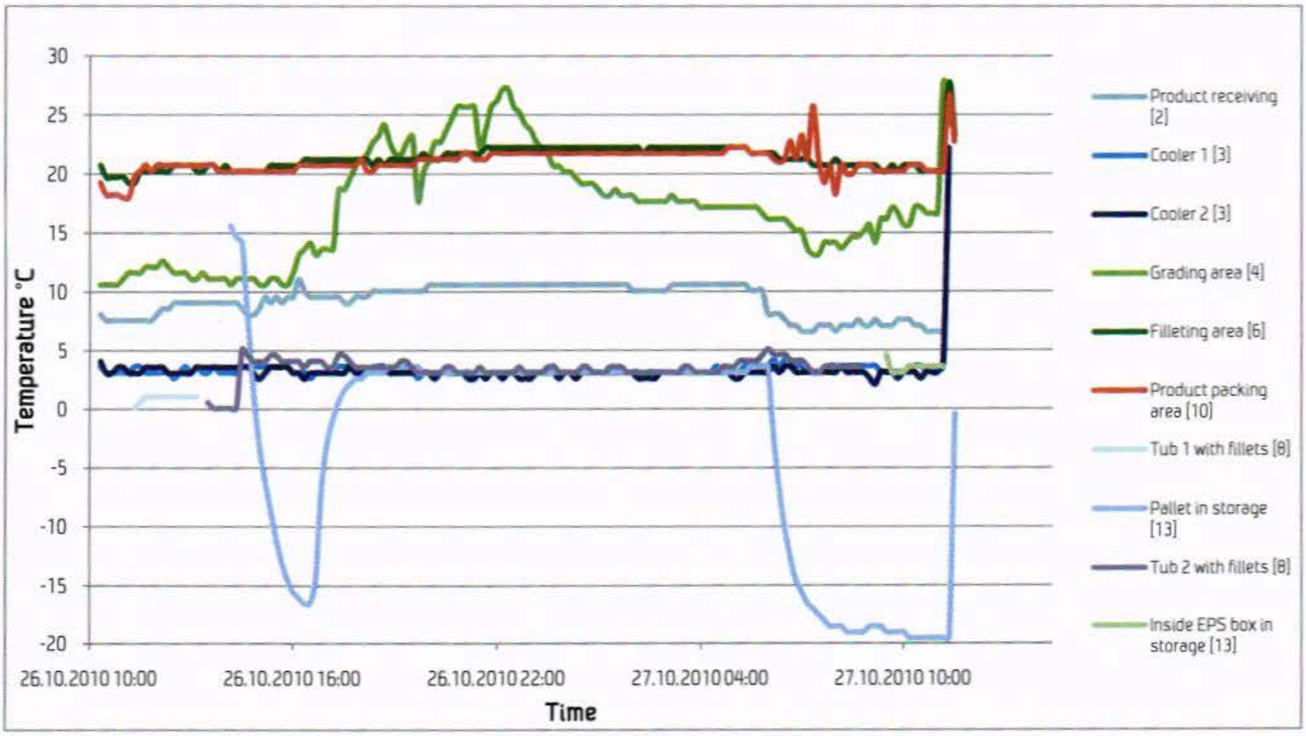

Figure 4. Temperature profile for redfish fillet production

The temperature data was integrated into the EPCIS system. To illustrate, the XML file for temperature records for the filleting process is shown below. The *temperaturerecord* attribute was created and given a value.


```
<epcis:EPCISDocument schemaVersion="1" creationDate="2005-07-11T11:30:47.0Z"
xsi:schemaLocation="urn:epcglobal:epcis:xsd:1
http://svn.tt.tracetracker.com/ttdoc/PM/testdata/epcis/schema/EPCglobal-epcis-
1_0.xsd" xmlns:tc="http://www.tracefood.org/schema/epcis"
xmlns:tttrd="http://www.tracetracker.com/trd" xmlns:epcis="urn:epcglobal:epcis:xsd:1"
xmlns:gtnet="http://www.globaltraceability.net/schema/epcis"
xmlns:ttdata="http://www.tracetracker.com/data"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
<EPCISBody trdRef="TRD-epcis-etrace-icefish">
<EventList>
<ObjectEvent>
<eventTime>2010-10-02T11:00:00+02:00</eventTime>
<eventTimeZoneOffset>+02:00</eventTimeZoneOffset>
<epcList>
<epc>urn:gtnet:id:batch:etrace-icefish.fileting.20101002-A</epc>
</epcList>
<action>OBSERVE</action>
<gtnet:entityClass>Batch</gtnet:entityClass>
<gtnet:trdType>fileting</gtnet:trdType>
<ttdata:temperaturerecord>3.14</ttdata:temperaturerecord>
</ObjectEvent>
</EventList>
</EPCISBody>
</epcis:EPCISDocument>
```


This next file looks exactly the same with the only difference that the *eventTime* and value for *temperaturerecord* has changed. These values are stored as a log for the *temperaturerecord* attribute in the EPCIS system where users can access the entire log corresponding to a particular TU or location. Figure 5 shows the temperature record for a particular vessel tub containing raw redfish in the storage cooler. The temperature refers to the ambient temperature for the duration that the fish was kept in the cooler before filleting process. In this case, the temperature record is linked to the given TU labeled GRAI:5699000023.77.44.

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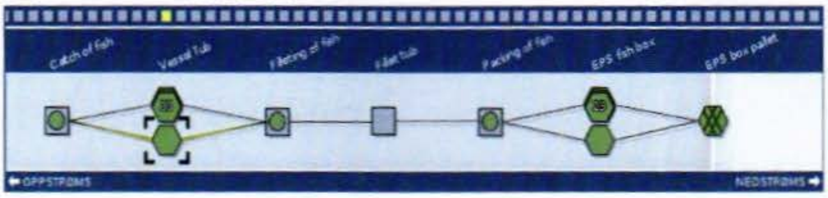
Internal traceability graph [Hide]



Icon Key Full Size

Vessel Tub - urn: EPC: id: GRAI: 5699000023.77.44 [Hide]

Detail	Value	Reports
Id	urn: EPC: id: GRAI: 5699000023.77.44	Table of dependencies
Type	Vessel Tub	Suppliers and Customers
Description	Tub with fish from fishing vessel	Entity attribute value log
Trade Unit Class	Simple	Upstream RU
MISSING: ItemRef	urn: EPC: id: GRAI: 5699000023.77.*	Station Log for batch or tu
Created	21.10.10 17:11	**Tools**
		Logs
		Data export

Properties [Hide]

Property	Value	Property	Value
Catch date	21.10.10	certificationscheme	link
disposition	urn: EPCglobal: cbv: disp: sellable_not_accessible	fishing method	Trawl
Ice weight	52	Landing date	24.10.10
product conditioning	qualified	product form	WHL
Species (English)	redfish	Temperature Control Method	ice
temperature record	21,68	type of unit	tub

Property History [Hide]

Id	Type	Description
urn: EPC: id: GRAI: 5699000023.77.44	Vessel Tub	Tub with fish from fishing vessel

Property	Value	Unit	Created
temperature record	21,68		21.10.10 17:11

History [Graf]

From 26.10.10 To 27.10.10 (Default: Today)

82 Values found

Value	Unit	Time
3,65		26.10.10 10:20
3,15		26.10.10 10:30
3,15		26.10.10 10:40
3,15		26.10.10 10:50
3,15		26.10.10 11:00
3,15		26.10.10 11:10
3,65		26.10.10 11:20
3,65		26.10.10 11:30
3,15		26.10.10 11:40
3,15		26.10.10 11:50
3,15		26.10.10 12:00
3,15		26.10.10 12:10
3,15		26.10.10 12:20
2,64		26.10.10 12:30
3,15		26.10.10 12:40
3,65		26.10.10 12:50
3,15		26.10.10 13:00
3,65		26.10.10 13:10
3,15		26.10.10 13:20
3,15		26.10.10 13:30

Figure 5. Temperature record for redfish in storage cooler

3.1.2 Vessel information

Similar to the temperature data, the vessel information is also integrated into the EPCIS system. The link to the vessel information is shown in Figure 3 and is directed to the website containing the information about the particular vessel as shown in Figure 6.

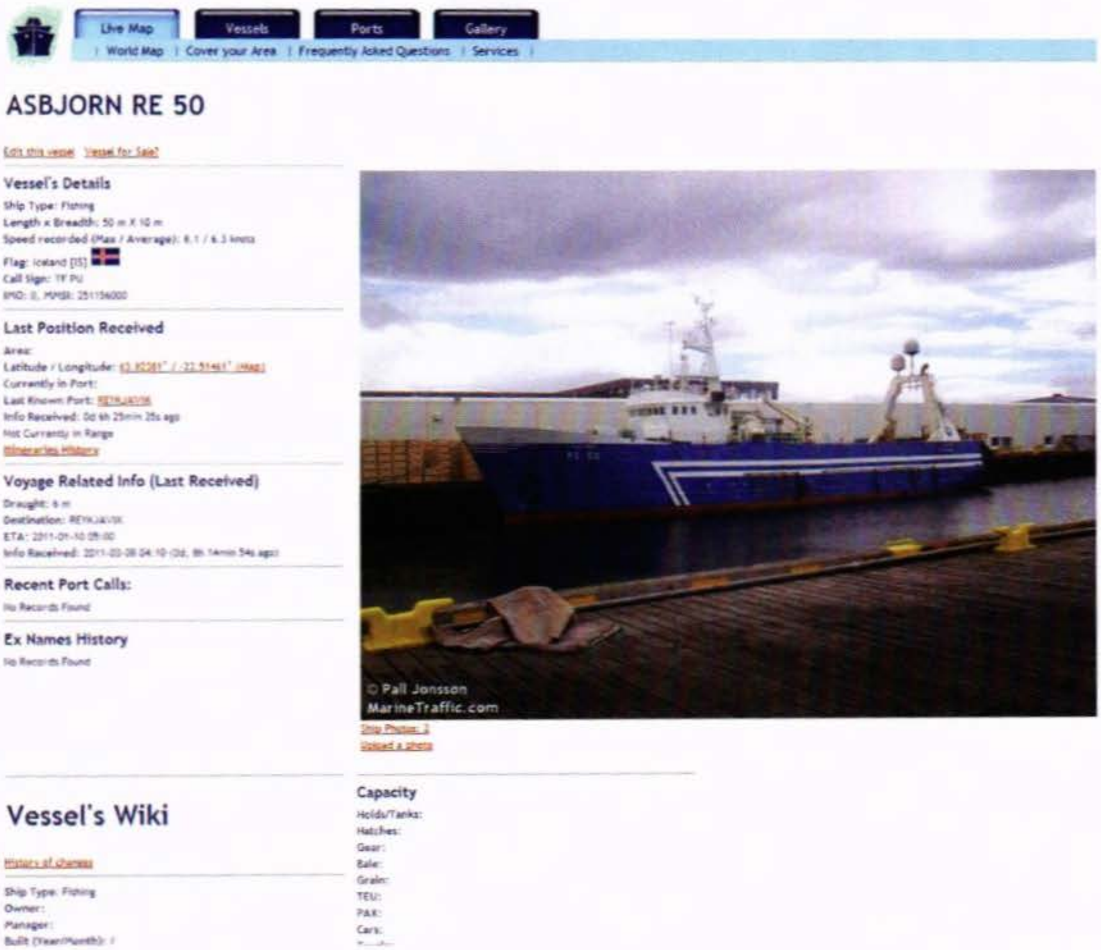


Figure 6. Vessel information included in EPCIS system

3.1.3 Nutritional information

The nutritional information for redfish and the undesirable substances found in Icelandic waters was also included and linked to the EPS boxes as shown in Figure 7.

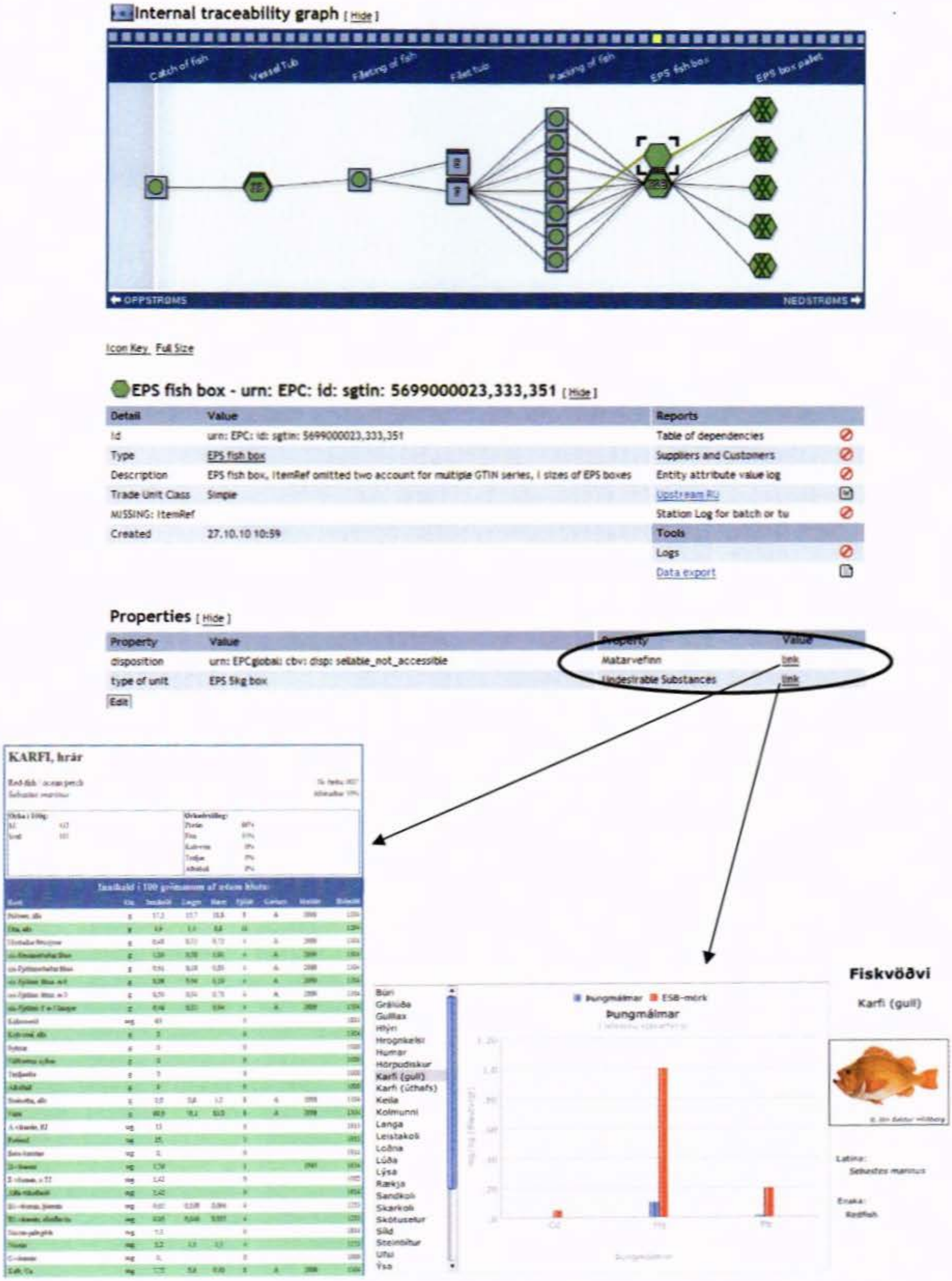


Figure 7. Nutritional information and undesirable substances included in EPCIS system
(Link to nutritional information: http://www1.matis.is/ISGEM/details1.aspx?FAEDA=0027 and to undesirable substances: http://www.matis.is/media/valadskotaefna/adskotaefni.htm)

3.2 Improved internal traceability

Internal traceability is improved by use of the EPCIS system and the production process becomes more visible. The TUs at each stage in production are clearly identified and corresponding product parameters are linked to these TUs. The transformations for each TU were modelled in this project and could help in tracing the cause and tracking the extent of a food safety related event.

3.3 Information visibility

The user interface developed in this project improves information visibility as the relationships between the catch, vessel boxes, fillet boxes, EPS boxes and pallets have become visible. The generic EPCIS modeling has no corresponding view that aggregates information from multiple events.

3.4 Improved chain traceability

The EPCIS repository developed in this project also includes mechanisms for information exchange between different organizations using different traceability systems. To be able to use this system, the sender must indicate which item he sends to which customer, and the receiver must say which item he receives from which supplier. These two are then matched by a hub infrastructure, leading to a link being created between the same items at the two parties.

The fragments of the EPCIS XML to express this communication between the supplier and the receiver are shown below.

Supplier


```xml
  <!--SentTo => ObjectEvent(OBSERVE)-->
<ObjectEvent>
   <eventTime>2004-07-03T08:00:00.0Z</eventTime>
   <eventTimeZoneOffset>+00:00</eventTimeZoneOffset>
   <epcList>
    <epc>urn:gtnet:070100000001.gutfresh_1.0001</epc>
   </epcList>
   <action>OBSERVE</action>
   <bizStep>urn:epcglobal:cbv:bizstep:shipping</bizStep>
 <gtnet:shipToBusinessLocationCode>urn:gtnet:org-mapping:Retailer</gtnet:shipToBusinessLocationCode>
 <gtnet:shipToPhysicalLocationCode>urn:gtnet:org-mapping:Retailer</gtnet:shipToPhysicalLocationCode>
   <gtnet:party_id>Retailer</gtnet:party_id>
   <gtnet:party_id_type>org-mapping</gtnet:party_id_type>
</ObjectEvent>
```


Receiver


```xml
<!--ReceivedFrom => ObjectEvent(OBSERVE)-->
 <ObjectEvent>
   <eventTime>2001-02-02T13:00:00.0Z</eventTime>
   <eventTimeZoneOffset>+00:00</eventTimeZoneOffset>
   <epcList>
    <epc>urn:gtnet:070306400001.Prod_1.0002</epc>
   </epcList>
   <action>OBSERVE</action>
   <bizStep>urn:epcglobal:cbv:bizstep:receiving</bizStep>
 <gtnet:shipFromBusinessLocationCode>urn:gtnet:org-name:no.feed</gtnet:shipFromBusinessLocationCode>
```

```xml
&lt;gtnet:shipFromPhysicalLocationCode&gt;urn:gtnet:org-name:no.feed&lt;/gtnet:shipFromPhysicalLocationCode&gt;
  &lt;gtnet:party_id&gt;no.feed&lt;/gtnet:party_id&gt;
  &lt;gtnet:party_id_type&gt;org-name&lt;/gtnet:party_id_type&gt;
&lt;/ObjectEvent&gt;
```

Based on this system, chains of companies can be linked together, resulting in the all-up/all down traceability needed for end-to-end traceability. As a result the EPCIS technology presented in this paper combines the advantages of a standard (EPCIS) with features for tying independent systems together in chains that mirror the physical relationships between companies. This allows easy deployment and efficient use of end-to-end traceability in chains for production of food and other types of products.

4 References

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