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STUDY OF THE QUALITY MANAGEMENT SYSTEM AND PRODUCT TRACEABILITY IN A FISH PROCESSING COMPANY

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ABSTRACT

A field study of the quality system and product traceability was conducted at ÚA, a fish processing company focusing on processing operations and quality control for redfish (*Sebastes marinus/mentella*). The traceability system from catch until transport to the shipping company was followed and studied, including how the information is recorded and registered in each link. Evaluation of raw material and fillets was carried out, based on data and information collected and on sensory evaluation applying the QIM method. High quality and safe products are the result of an effective quality system. The quality system at ÚA ensures product traceability. It was confirmed that it is possible to trace back and forward the history of the products, when it is well supported by a recording system to register the information in each step of the chain. The QIM is a fast and convenient sensory method for determining the freshness of raw fish.

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1. INTRODUCTION

A well structured quality management system should be implemented in all companies processing seafood, in vessels where processing is done and at fish auctions to fulfil all requirements regarding quality and safety. It is also known that legislation and inspection authorities recommend or require adopting the Hazard Analysis Critical Control Point (HACCP) system in production and include it as part of the quality system. The need for HACCP in seafood industries is due to growing awareness of consumers and the fear of food illnesses. This has lead to enforced hygienic and sanitary regulations to ensure wholesome and safe food products. The growing trend in international trade for worldwide equivalence of food products is also to be considered for all producers and sellers.

To guarantee safe and wholesome fishery products, a seafood processing company must have an appropriate quality system operating effectively. The quality system includes Good Manufacturing Practices (GMP), Standard Sanitation Operational Procedures (SSOP) and a well documented HACCP plan. The HACCP system is the basis of the regulations on fish inspection adopted by the European Economic Community (EEC), USA, Canada and a number of developing countries (Huss 1994).

The quality system based on HACCP is widely used and internationally recognized by Codex Alimentarius, which recommends its adoption (Codex 1997). The Food and Drug Administration (FDA) regulations require fish processors to implement HACCP systems (FDA 1995). The European Union (EU) recommends the same in its Council Directive 91/493 (EEC 1991).

The maintenance of the HACCP system is as important as its implementation. Verification procedures and record keeping are strong elements of those activities. It is unlikely that the products produced, the process, the environment, likely hazards or the people in the plant will remain unchanged over time (Mortimore 2001). Recording all the parameters concerning catching, handling, processing and quality is an essential tool to verify how the system is working. Record keeping also offers product traceability in the whole chain, from catch until the final product is delivered to the consumer, so procedures for product identification and traceability during all stages should be established (Huss 1994). Traceability is becoming an important issue for producers and sellers in all countries, not only in the EU.

In Iceland the Directorate of Fisheries (DOF) through its Surveillance Department is the competent authority responsible for enforcing laws and regulations regarding handling, processing and distribution of marine products. It focuses on ensuring that fishery products are processed under satisfactory hygienic conditions and that consumers can rely on their wholesomeness and safety. The department issues processing licenses to processors of fishery products and operating permits to fish markets and fishing vessels, provided that they meet the requirements concerning appropriate facilities, equipment, sanitation procedures and a documented check system based on HACCP. The Surveillance Department issues health certificates for exported fishery products (DOF 2001).

Developing countries are playing an important role worldwide by exporting their products to Europe and other markets, characterised by increasing demand, both on quantity and high quality products. To be competitive, these countries also need to adopt and implement quality management systems based on HACCP and in the near future, be able to have an effective system for traceability of the products they are exporting.

In the last decades Cuba has been exporting seafood products to different countries in Europe, Asia and Canada. Main products are processed lobster and shrimp with profits from exports in 1999 contributing nearly USD 200 million to the country's economy (MIP 2000). Forty fishery establishments are engaged in fish and shellfish processing, of which 14 are certified for export (Hernández-Torres 2000).

In 1992, the Cuban fisheries industry began HACCP implementation to meet the requirements of its major export markets and to put inspection and quality control activities in line with those taking place worldwide (Hernández-Torres 2000). According to Resolution No 344/1996 of the Minister of Fisheries Industry it is mandatory for seafood processors and trading companies to put a quality system based on HACCP into operation (Hernández-Torres 2000). All the factories producing for export and most of those producing for the domestic market in Cuba have an appropriate quality system. However, problems have been observed when assessing HACCP. They include different approaches to identifying Critical Control Points (CCP), defining critical limits, and badly documented monitoring procedures. Lack of floor staff training in applying corrective actions in case of deviations of critical limits has also been observed, as well as corrective actions that are not appropriate to eliminate causes giving rise to deviations.

A field study to investigate the quality system, the traceability of products and quality monitoring in an Icelandic company is a practical experience, which will be helpful in future work in Cuba. This experience will be valuable and useful to promote the improvement of quality systems in the fisheries sector in Cuba, and especially in product traceability issues.

The main objectives are:

- ♦ Study the quality system of the fish processing company ÚA for redfish (*Sebastes marinus/mentella*), focusing on processing operations and quality control.
- ♦ Study traceability throughout the process, from catch until final product. Definition and labelling of batches in the whole chain.

The field study in ÚA fish processing plant gives an opportunity to study sensory evaluation of fish. First, it is important because it is a way to check in practice this critical aspect in the own check system, and secondly, to improve and acquire new skills, especially in applying a new sensory method, the Quality Index Method (QIM). From the above mentioned comes the third objective:

- ♦ Sensory evaluation of raw material and final product to compare and see how this is related to processing and quality parameters recorded in the quality system.

2. LITERATURE REVIEW

2.1 HACCP based quality system

HACCP is a management system in which food safety is addressed through the analysis and control of biological, chemical and physical hazards from the raw material, to processing, distribution and consumption of the finished product (NACMCF 1997). It was developed nearly 30 years ago by the Pillsbury Company working together with the National Atmospheric and Space Agency (NASA) in USA, with the objective of finding a method to provide safe food for astronauts. The system focuses on preventing hazards that could cause food-borne illnesses, by applying controls to the production line, from raw material to the finished products (FDA 2001).

HACCP is a tool to assess hazards and establish control systems that focus on prevention rather than relying on end-product testing. Implementation of HACCP enhances food safety and promotes trade by increasing confidence in safe foods (Codex 1997).

Before the application of HACCP principles (EEC 1994, FDA 2001) the following tasks should be carried out:

- Assembling of the HACCP team, involving experts from production, quality assurance, engineering and product development areas. It could also be useful to have representatives from other areas.
- Product description and intended use. Includes principal raw materials, process technologies used, storage conditions and shelf life. This is particularly important if the product is intended for especially vulnerable groups of the population, such as infants or ill people.
- Process flow diagram. It should cover all the steps in the process, from raw material through to distribution. Such flow chart is the basis of the hazard analysis.
- On-site verification of the flow diagram. The HACCP team should check the operation against the flow diagram during all stages and hours of operation and make the amendments where appropriate.

The seven principles of HACCP are the following (EEC 1994, Huss 1994, FDA 1995):

1. Conduct a hazard analysis. Potential hazards associated with food and preventive measures to control those hazards.
2. Identify Critical Control Points (CCP). A CCP is an operation (practice, procedure, process or location) at which a preventive or control measure will eliminate, prevent or minimise one or several hazards.
3. Establish critical limits for each preventive measure at a CCP.
4. Establish CCP monitoring procedures. Include what is to be checked, when, how and by whom.
5. Establish what corrective actions are to be taken when monitoring shows that a critical limit has been exceeded.
6. Establish verification procedures to verify that the HACCP system is working correctly.
7. Establish an effective record keeping system to document the HACCP system.

Records need to be kept as evidence that the system has been working correctly (Huss 1994). They are useful for trend analysis, which can be used for monitoring and making the system more effective.

HACCP is not a system that stands alone, it is supported by other programmes known as prerequisites (NACMCF 1997), such as Good Manufacturing Practices (GMP) and Standard Sanitation Operational Procedures (SSOP). Prerequisite programmes provide the basic environmental and operating conditions that are necessary for the production of safe, wholesome food. The Codex Alimentarius General Principles of Food Hygiene describe the basic conditions and practices expected for food intended for international trade. In addition to the requirements specified in regulations, industry often adopts procedures specific to their operations. Prerequisite programmes may include facilities, supplier control, specifications of raw materials, ingredients, packaging materials and products, equipment, cleaning and sanitation, personal hygiene, training, traceability and recall procedures, pest control, etc. (NACMCF 1997).

2.2 Traceability in the fish industry

According to ISO 9000:2000, traceability is defined as the ability to trace the history, application or location of that which is under consideration. In terms of products it relates to the origin of materials and parts, the processing history, and the distribution of the product after delivery (ISO 2000). In other words traceability means the ability to trace and follow a food through all stages of production and distribution (Tall 2001).

Two types of traceability can be identified: internal and chain traceability. Internal is within one company and relates to data about raw materials and processes to the final product before it is delivered. Chain traceability is focused on the information about the product from one link in the chain to the next, it describes what data are transmitted and received, and how (Tracefish 2001). Chain traceability is between companies and countries and depends on the presence of internal traceability in each link (Olsen 2001).

The public confidence in food safety has been damaged by recent food scares associated with beef because of mouth and foot disease and BSE - mad cow disease, in cattle, dioxin in fish meal and other. This is driving the industry and government agencies to improve controls at all stages in the food chain (Tall 2001). Traceability is then needed to meet food safety requirements, especially in case of product recall, for commercial reasons to ensure supply chain standards and because it is required by legislation relating to labelling, animal health and welfare, fish marketing, fisheries control and product liability and safety (Denton 2001).

The EU Fisheries Control Regulations demand a specific traceability system from the fishing grounds to the processors. The EU Fish Marketing Regulations demand that from 2002, much of the fish at retail sale (including wet fish) will have to be labelled with its area of origin. The proposed revision of the EU General Product Safety Directive requires full traceability by 2003, including product recall systems. The EU Food Law, which is now under revision, requires full traceability by 2004 (FQLM 2001). The proposed new Regulation on the General Principles and Requirements of

Food Law lays down the general food safety requirements. Regarding traceability, it establishes the need for traceability at all stages of production and distribution. It is proposed that food and feed business operators must identify their raw material suppliers and identify to whom they supply products (one up, one down traceability). They must have systems to provide those data to the competent authorities, label or identify products to ensure traceability, and withdraw and recall unsafe food from the market (Tracefish 2001).

The fish industry trades globally in a vast range of species and products and is diverse in comparison to other protein sources. There are hundreds of different species of fish captured with different methods of catching, handling and food safety requirements. A wide range of live, chilled, frozen and value added fishery products are produced and traded within the various distribution chains, which also have their specialised food handling and food safety requirements. There is a huge and complex international trade in the raw materials and in primary and secondary processed products (Tracefish 2001).

Although there are major structural differences between the chains for different types of fish, products and countries, there is also a degree of commonality in information requirements. These information requirements can be categorised as (Tracefish 2001):

- Fundamental to traceability. Each food business has to collect and keep information and make it available to the competent authorities and to other food business operators for the purpose of product withdrawal or recall.
- Specifically required information on the nature of the food and the operations involved. This is information required by law for particular purposes and must be made available to the appropriate authorities.
- Commercially desirable information on the nature of the food and the operations. This information can be requested by food business for different reasons such as ethical, environmental, GMP, quality assurance records, raw material or product standards and specifications, etc.

At present, a lot of information is being recorded in the product information system of the processing and distribution chains. Some of that information passes from one link in the chain to the next, either on the label or in the documents, the rest is held by the producer or the distributor. To properly implement traceability it is necessary to define the physical unit and batch. A physical unit can be an individual large fish, a box or a tub of fish, a package, case or pallet of products, a freight container. The batch can be a catching day, production date, a shipment, etc. The information attached to the unit is to be the key to traceability, i.e. the product number (code), production date and producer's number makes it possible to trace the product to the producer and look up the required information.

Figure 1 is an example of the chain from catch to the consumer with the multiple links and information flow. If the information is available with all the data and a unique identifier to label the batch at each link, then the product can be traced.

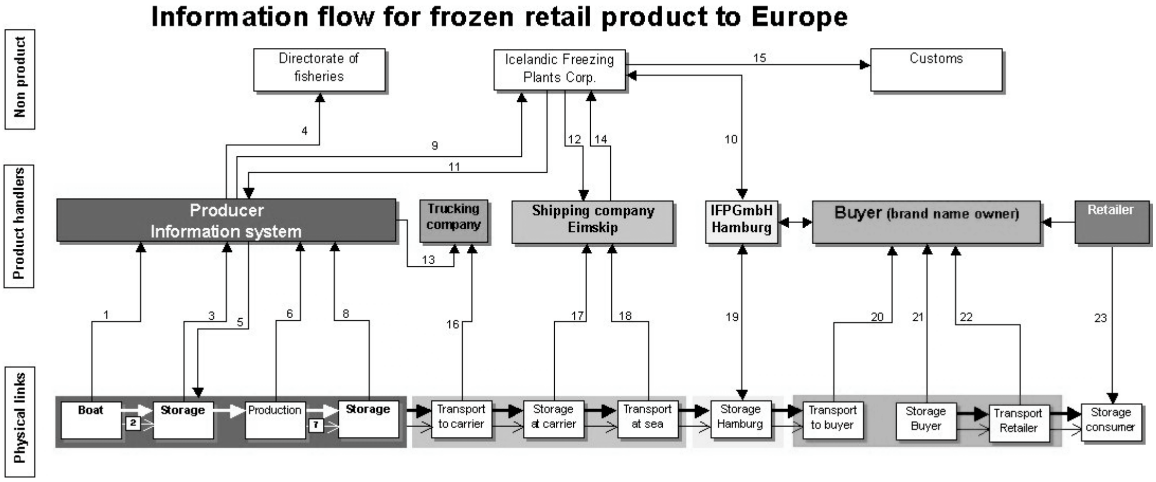

Figure 1: Example of the chain and information flow for redfish caught and processed into frozen fillets in Iceland and sold to Germany (Pálsson and Ólafsdóttir 2001).

A product can be traced either backward or forward. Backward leads to the origin and history, everything that went to a batch and depends on all links mapping identification (ID) of output batches to ID of input batches. Forward trace explains what happened to a certain batch, all the processes and output batches that the batch in question went into. Keeping track of batches and their properties is the key to implementing chain traceability. It means that we must record what batches we use, we must have the ability to access to their properties, and we must relate input batches and properties to the batches we make (Olsen 2001).

A step forward in the implementation of traceability will be the development of a standard for electronic transmission of data and information. Because of increasing information demands from buyers and consumers, it is no longer practical to transmit all the data physically along with the product. A more sensible approach is to mark each package with a unique identifier, and then transmit or extract all the relevant information electronically (Pálsson *et al.* 2000). But so far it is common to use other ways like telephone, e-mail and fax for communication between the links.

2.3 Quality factors

Definitions of quality as applied to food products vary according to the author. Different qualities with respect to seafood include safety, nutritional quality, availability, convenience and integrity, and freshness quality (Bisogni *et al.* 1987, Botta 1995, Bremner 2000). The most important is seafood safety.

Seafood quality is usually influenced by freshness or degree of spoilage of the raw material or the product. Freshness is considered as one of the most important factors determining quality of fish (Sørensen 1992, Sakaguchi and Koike 1992, Botta 1995, Ólafsdóttir 1997). Handling, processing and storage techniques can also affect the quality of fish and fishery products as they can result in the occurrence of defects such as bruises, bloodstains, trimming imperfections, etc. (Sørensen 1992, Valdimarsson 1992).

Many studies have been done on spoilage processes of fish stored in ice and frozen storage, considering a whole range of influencing factors, which can affect the fish quality. Among others, these factors are related to fish species, size and seasonal condition, fishing method, handling, processing technology, time and temperature development.

2.3.1 Freshness parameters

Fish is a perishable commodity. Upon death a series of natural changes start, leading to spoilage affecting the shelf life of the fish. Freshness or the extent of spoilage during storage under chilled conditions is the key determinant of the quality of fish and fishery products (Whittle *et al.* 1990, Ólafsdóttir *et al.* 1997). Shelf life of fish is defined as the length of time it is fit for human consumption (Martinsdóttir *et al.* 2001). Spoilage due to microbial activity is the main limitation of the shelf life of iced or refrigerated fish.

Off-odours and off-flavours, slime formation, gas production, discoloration and changes in texture are obvious signs of spoilage (Huss 1994). The development of these spoilage conditions in fish and fishery products is due to a combination of chemical, autolytic and microbiological changes, but the spoilage rate can be reduced by taking preventive measures like icing or keeping a low temperature during storage. According to Bonnell (1994), controlling the temperature of fish is perhaps the most important element in the preservation of fresh fish. The proper cooling of fish has a number of advantages. Firstly, bacterial activity depends very much on temperature, the closer it is to 0°C, the slower the rate of bacterial spoilage. Likewise, enzyme activity also decreases as temperature falls, so the rate of autolytic spoilage is significantly slowed. Chemical spoilage or development of rancidity can be prevented by rapid handling onboard and storage of products under anaerobic conditions.

A rise in product temperature accelerates deterioration and reduces quality. If the rate of deterioration is known, it should be possible to determine the quality at any time by continuously monitoring the time and temperature history of fish *post mortem* (Whittle *et al.* 1990). A number of authors have attempted to derive simple mathematical relationships that provide an acceptable measure of deterioration in fish with a known time/temperature history. These relationships have been used in conjunction with time/temperature recording devices to monitor the deterioration of quality in batches of fish. *Post mortem* changes in electrical properties of fish skin and flesh are also used in determining the potential shelf life of whole fish, but it is not useful for frozen products (Whittle *et al.* 1990, Huss 1995).

2.3.2 Defects

Sensory inspection of processed fish is used in fish industry to find defects that have occurred during handling and processing (Oehlenschlager 1997). These defects are well described in the technical specifications for the products.

Defects can be related to the condition of the fish flesh, appearance, which includes colour defects (bruises, bloodspots) and dehydration, workmanship defects such as improper packaging and cutting and trimming imperfections, scales, bones, foreign matters, skin and black membrane and the size of fillets (USDC 1990). Evaluation of defects is widely used in control of processes and to grade fish for selling or buying purposes.

2.4 Methods to evaluate fish freshness

Huss (1995) and Bonnell (1994) discuss the methods applied to evaluate the freshness of fish, which are divided in two categories, sensory and instrumental techniques. Instrumental methods include biochemical and chemical, microbiological and physical. Each of these methods measure different spoilage indicators in fish and fishery products. Only through a combination of instrumental and sensory analysis can optimal information on the product be obtained.

2.4.1 Microbiological methods.

The activity of microorganisms is the main factor limiting the shelf life of fresh fish. The aim of microbiological examinations is to evaluate the possible presence of bacteria or organisms of public health significance and to give an impression of the hygienic quality of the fish. This includes temperature abuse and hygiene during handling and processing (Huss 1995). An estimation of the total viable count (TVC) is used as an index in standards, guidelines and specifications. Specific spoilage organisms (SSO) capable of producing hydrogen sulphide or reducing trimethylamine oxide (TMAO) are considered more useful to estimate spoilage and the remaining shelf life of fish and fishery products (Ólafsdóttir *et al.* 1997).

2.4.2 Biochemical and chemical methods

Classical chemical methods for the analysis of total volatile bases (TVB) and trimethylamine (TMA) are used for the determination of fish freshness (Ólafsdóttir *et al.* 1997). TVB only reflect later stages of spoilage, so it is not reliable for the first days of chilled storage of fish (Huss 1995). Adenosine triphosphate (ATP) is another indicator of fish freshness. The extent of ATP degradation is expressed as the K value, which is defined as the ratio of the sum of inosine and hypoxanthine concentrations to the total concentration of ATP metabolites (Ólafsdóttir *et al.* 1997). There are other methods related to lipid oxidation such as determination of peroxide, thiobarbituric acid and iodine values.

2.4.3 Physical methods.

Ólafsdóttir *et al.* (1997) describe physical methods based on changes in the electric properties of the fish muscle. Different devices are available to measure electrical properties: the Torrymeter, the Fish tester and the RT-Freshness Grader, but they can only be used for fresh fish. Changes of structure and colour also occur in the fish flesh. Texturometers are used to measure the structural changes.

Time-temperature indicators (TTI) are based on using some biological, chemical or physical processes that depend on time and temperature and can give information about the time-temperature history of the food. All methods mentioned above provide information on parameters related to fish freshness, but none of them alone is capable to determine whether a fish is fresh or not.

2.4.4 Sensory methods

Sensory evaluation is the most important method for assessing freshness and quality of fish and fish products (Martinsdóttir *et al.* 2001). Sensory methods offer a rapid and accurate measurement of perceived attributes providing information about food. Sensory evaluation is defined as the scientific discipline used to evoke, measure, analyse and interpret characteristics of food as perceived by the senses of sight, smell, taste, touch and hearing (Huss 1995, Ólafsdóttir *et al.* 1997). Sensory tests can be divided into three groups: discriminative, descriptive and affective. The first two are analytical tests in which a trained panel is used, while the third are subjective consumer tests based on a measure of preference or acceptance. The most commonly used descriptive tests are structured scaling for quality assessment and profiling for a detailed description of one or more attributes. Sensory evaluation is currently the most important method used for freshness evaluation in the fish sector.

The most common sensory method used in Europe is the EU scheme (Ólafsdóttir *et al.* 1997, Martinsdóttir *et al.* 2001), in which three grades of freshness are established: E, A and B, corresponding to various stages of spoilage. Extra is the highest quality, while B is the level where fish is considered unfit for human consumption. This scheme does not take into account differences between species because only general parameters are used. The Torry scheme, a ten score system for the evaluation of cooked fish, is another method used for sensory evaluation of fish freshness.

The Quality Index Method (QIM) is based on characteristic changes in raw fish that occur in the appearance of eyes, skin and gills, and odour and texture, and a score system from 0 to 3 demerit points (Bremner 1985, Martinsdóttir *et al.* 2001). The scores for all the attributes are summarised to give an overall sensory score, the Quality Index, which is then compared to a QIM calibration curve to establish the relative freshness in terms of storage (predicted) days in ice and to predict the remaining storage life (shelf life). The description of each score for each parameter is listed in the QIM scheme (Ólafsdóttir *et al.* 1997, Martinsdóttir *et al.* 2001). The QIM and the schemes have been developed for several fish species e.g. cod, haddock, redfish, herring, saithe, and shrimp. In this study the QIM method is used in the evaluation of redfish (*Sebastes marinus/mentella).*

3. FIELD STUDY AT ÚTGERÐARFÉLAG AKUREYRAR (ÚA)

The ÚA Seafood Group in Akureyri was visited for a two weeks period, from November 18th to the 30th. This company, and in particular the parent company, was chosen for the study, knowing the fact that ÚA Seafood Group is one of the leading companies in Iceland, operating fishing vessels and processing plants. The company's role is catching, processing and selling a variety of high quality, safe seafood products.

During the field study at ÚA the documentation of the quality system was accessed and carefully studied. The production and quality managers explained *in situ* the processing flow for the different products made from redfish and cod as well, even though cod was not a part of this study. The processing line was visited daily for a better understanding of the process and the quality control.

It was studied how the information about the process and products is generated, how this information is transmitted along the chain and how it is recorded and stored for the purposes of traceability. This means that information is available to attend customer claims, recall of products and also to verify the quality and handling of the products. Data and information were collected from evaluations conducted and from the records stored in the company's system. This will be presented in chapter 4.

3.1 The structure of the company and main products

The group consists of the parent company and four subsidiaries: Laugafiskur ltd., specialising in drying fish; Jökull ltd., concentrating on the processing of whole-frozen pelagic fish; Hólmadrangur ltd., for shrimp processing; and GPG Saltfish ltd., specialising in the production of splitted salted fish. The parent company operates trawlers and processes demersal fish, either on shore or on board factory trawlers (ÚA 2001a). The main species harvested are cod (*Gadus morhua*), redfish (*S. marinus/mentella*), Greenland halibut (*Reinhardtius hippoglossoides*), and prawns (*Pandalus borealis*). In 2000 the total catch of company vessels was 22,689 tons (ÚA 2001c).

The main products of the group are frozen seafood and dried fish products. The total production of the company in 2000 was more than 17,000 tons with a value of ISK 5.3 billion. Table 1 shows the production by species/product.

ÚA operates a sales and marketing department which is responsible for the group sales of fresh and frozen products. The access to fresh fish allows the company to offer high quality products, supported by a quality assurance system based on HACCP, which ensures product safety. The biggest markets for the group are in the USA and UK. Other important markets are Germany, Nigeria, Japan and Taiwan, France and Denmark (ÚA 2001a).

Table 1: Volume of production of ÚA Seafood Group in 2000 (ÚA 2001b).

Product/Species	tons
Cod	6,086
Redfish	2,833
Haddock	287
Saithe	177
Greenland halibut	1,232
Capelin roe	248
Shrimp in the shell	3,224
Cooked and peeled shrimp	1,255
Total frozen products	**15,342**
Stockfish	2,215
Total	**17,557**

The ÚA parent company operates five fishing vessels and two land-based processing plants. Three of the vessels are fresh fish trawlers, supplying the factories in Akureyri and Grenivík, one vessel is a freezing trawler for demersal fish, and the fifth vessel is a shrimp-freezing trawler. The fresh fish trawlers concentrate on the catching of cod (*G. morhua*), haddock (*Melanogammus aeglefinus*), redfish (*S. marinus/mentella*) and saithe (*Pollachius virens*), while the freezing trawlers focus on Greenland halibut (*R. hippoglossoides*), redfish (*S. marinus/mentella*) and shrimp (*P. borealis*) (ÚA 2001a). The ÚA plant in Akureyri is one of the largest of its kind in the North Atlantic and specialises in the processing of cod and redfish. The plant in Grenivík is smaller and processes haddock, saithe and cod.

3.2 The quality system at ÚA

The ÚA Seafood company quality system was studied, especially for redfish (*S. marinus/mentella*). Data and information from the processing line was gathered, including information on the traceability system. For effective quality and process control the plant has implemented a quality system based on HACCP, which is properly described in the company's Quality Handbook (ÚA 1999). The handbook consists of 19 sections. The sections are listed in Table 2 and comments given on those sections which are of particular relevance to the present study.

3.3 Redfish processing

The redfish (*Sebastes marinus/mentella*) is a temperate marine species, inhabiting the North Atlantic ocean waters along the European and American coasts. The two species of redfish: ocean perch (*S. marinus*) and deepwater redfish (*S. mentella*) are difficult to distinguish. Ocean perch (*S. marinus*) has a bright red skin and a chubby shape, it can attain a maximum length of 100 cm and weight up to 15 kg (Hureau and Litvinenko 1986), while deepwater redfish attains a maximum size of 55 cm. Redfish is utilised fresh and frozen. It is a good table fish with a firm and tasty flesh (Bykov 1983). As a result of different storage studies it has been estimated that redfish kept in ice at 0°C has a shelf life of 18 days, granted that the fish was handled under good manufacturing practices on board the vessels (Martinsdóttir *et al.* 2001).

Table 2: Sections of the quality handbook of the ÚA fish processing company, with comments on some of them according to its relevance to the study.

<table>
<tr><th>Section</th><th>Comments</th></tr>
<tr><td>1. Organogram of the company</td><td></td></tr>
<tr><td>2. Management responsibilities</td><td></td></tr>
<tr><td>3. Flow charts</td><td>See Figure 1 and a description of the process</td></tr>
<tr><td>4. HACCP (own check) system specified in the HACCP handbook</td><td>See Appendix 1</td></tr>
<tr><td>5. Preventive measures</td><td>Includes training of the staff in personal hygiene and operating procedures.</td></tr>
<tr><td>6. Cleaning and sanitising</td><td>Includes all the procedures for cleaning and sanitation of equipment and facilities and the checklist.</td></tr>
<tr><td>7. Quality policy</td><td>The aim of ÚA is to produce products of high quality and to be a leading company in quality issues in the market.</td></tr>
<tr><td>7.1 Description of final product.</td><td>Frozen and fresh products from cod (Gadus morhua), haddock (Melanogrammus aeglefinus), redfish (S. marinus/mentella) and other species. The fish is either whole or fillets, skin-on or skin-less, trimmed. All products are processed according to specifications required by the buyers, packed for retail or catering, or for further processing (blocks). All the products should be cooked before consumption.</td></tr>
<tr><td>8. Records</td><td>Most of the data are recorded in computers using software from Navision Financial and Marel. Every record or form should be filled accurately with all the information required, and must have the date and signature of the person responsible.</td></tr>
<tr><td>9. Verification of the system</td><td>It can be by daily inspection, on a regular basis or by audit. The audit is carried out 4 times a year. Once per year the Directorate of Fisheries performs a verification.</td></tr>
<tr><td>10. Marking and traceability</td><td>All individual packages should be labelled with plant number and production date, according to the rules of day coding as stated in the Quality Handbook. Detailed information about marking master cases and pallets is in the Quality Handbook. To trace the product it has to be labelled with processing number (plant number), origin, lot number, EU plant number. Also information about catch, production and stock should be available.</td></tr>
<tr><td>11. Recall system</td><td>In case of something going wrong and a product has to be withdrawn or recalled, the Production Manager should take the appropriate actions and inform the inspection authority, who decides what to do with the product.</td></tr>
<tr><td>12. Claims and complaints</td><td></td></tr>
<tr><td>13. Record keeping</td><td>All records, including those of traceability are stored for a minimum of two years.</td></tr>
<tr><td>14. Sanitary and/or health certification of water, ice, fish, employees</td><td>For certification, samples should be taken and sent for analysis. Frequency for water - once a year; ice - once per month; fish - 5 or 6 samples weekly.</td></tr>
<tr><td>15. Personal hygiene</td><td>All the employees and persons who enter the processing plant should follow the rules set for personal hygiene. The Quality Manager is responsible to look after this.</td></tr>
<tr><td>16. Microbiological guidelines</td><td><table>
<tr><th></th><th>Good</th><th>Defective</th><th>Reject</th></tr>
<tr><td>TPC, 30°C</td><td>150 000</td><td>150 000 - 350 000</td><td>>350 000</td></tr>
<tr><td>Coliforms, MPN/g</td><td><100</td><td>100 - 200</td><td>>200</td></tr>
<tr><td>E. Coli, MPN/g</td><td>0,3</td><td>0,3 - 0,4</td><td>>0,4</td></tr>
<tr><td>Listeria, in 25 g</td><td>Negative</td><td></td><td>Positive</td></tr>
</table></td></tr>
<tr><td>17. Calibration</td><td></td></tr>
<tr><td>18. Forms used</td><td></td></tr>
<tr><td>19. Layout</td><td></td></tr>
</table>

3.3.1 Flow chart and description of redfish fillets production

Frozen redfish fillets are produced following the operations presented in Figure 2. The raw material entering the process can be whole ungutted fresh fish or frozen at sea (FAS) fillets.

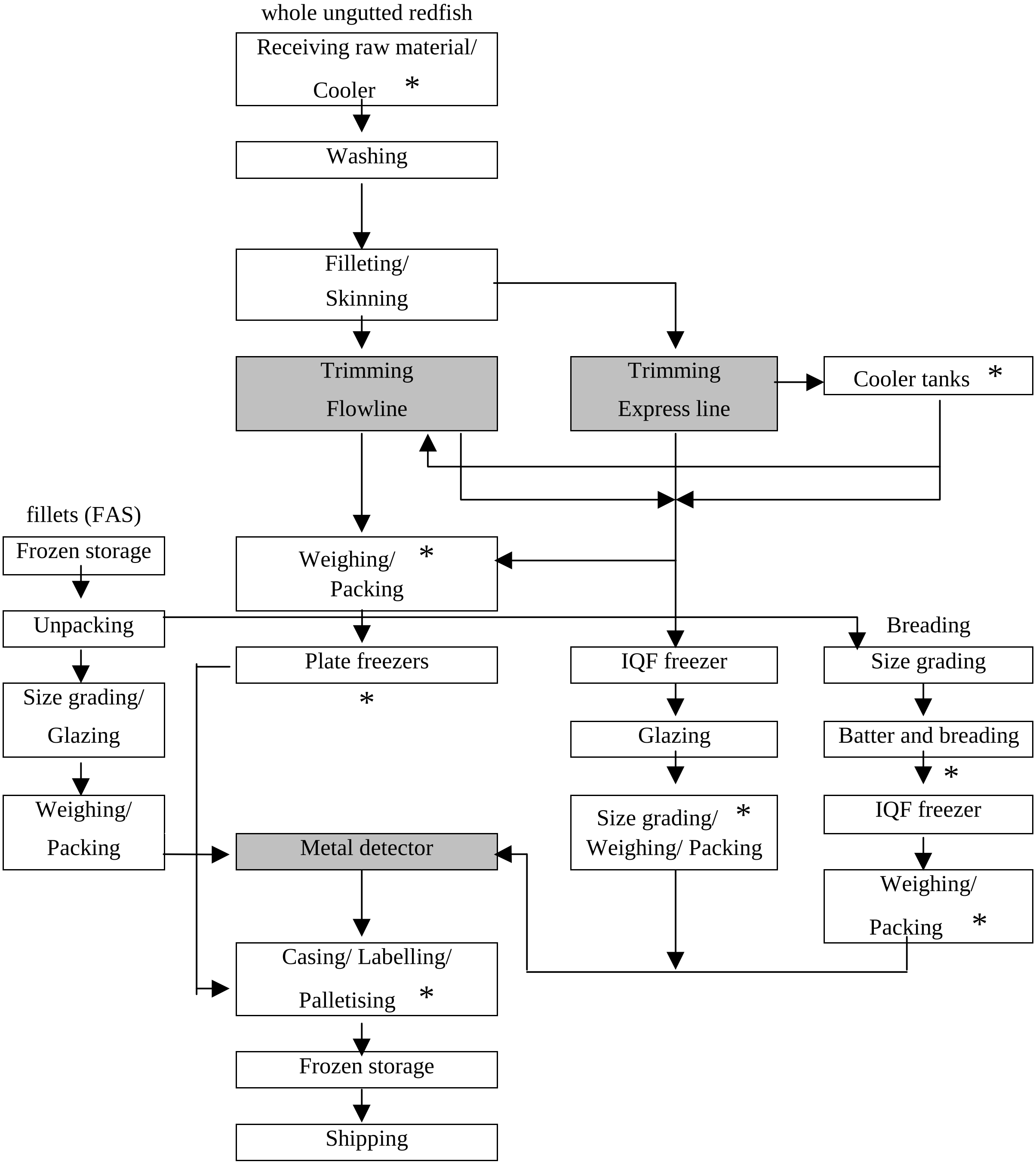

Figure 2: Flow chart for frozen redfish fillets processing, modified from the flow chart for fish processing in the Quality Handbook (ÚA 1999). The shaded boxes in the chart represent the CCPs, the * symbol indicates the CPs along the processing line.

Receiving raw material/Cooler. From the fresh fish trawlers fish is received whole ungutted, washed properly and iced, in plastic tubs 460 litres capacity, labelled with the catching day. Temperature in the cooler is kept at 0 to 4°C.
Frozen at sea (FAS) fillets are received and kept in frozen storage at –20 to –24°C.

Washing. The plastic tubs with fish are emptied into a hopper with sloping steel conveyor belt with fresh iced water. The fish is washed there before grading into sizes. There is a steady overflow of fresh water in the hopper.
All fish entering to process in the same day is considered a batch. A batch usually includes several catching days from one vessel, and rarely from different vessels.

Filleting and skinning. After grading, the fish is filleted and skinned in the Baader machines.

Trimming. The fillets enter the so-called express line, where the quantity depends on the infection rate by the copepod parasite *Sphyrion lumpi*. If the fillets are free of this parasite then the fillets go through a faster trimming process. If the fillets need more careful trimming, for example because of parasite infection, or because the fillet should be free of pin bones, they are sent directly to the traditional trimming flow line. After trimming the fillets can go directly to the Individually Quick Frozen (IQF) freezer, they can be pumped to cooler tanks, where the fillets are iced properly for storage at temperature around 0,5°C; or they can be sent to produce fillet blocks.

Weighing and packing. Blocks: Fillets blocks are packed directly into carton boxes. The cartons are labelled according to specifications with production date, plant number, product number and origin. The packed products are placed into freezing pans or block frames. The freezing pans are placed into racks.

Plate freezers and depanning. The freezing pans are taken from the racks and put into the plate freezers. Freezing time is usually 2.5-3 hours or until the core temperature has reached –24°C at minimum. After freezing the cartons are depanned.

IQF fillets. IQF freezer/glazing
Fillets are placed on in-feed conveyor belt for the IQF freezer. The core temperature must reach at least –24°C. After leaving the IQF freezer the fillets are sprayed with potable water to reach desirable glaze percentage if required.

Breading. A part of the redfish fillets, either frozen at sea (FAS) or IQF frozen in the plant are breaded in a special batter and breading line. The fillets are arranged on an in-feed conveyor belt where they are covered with batter that is continuously renewed and then the battered fillets are automatically covered with breadcrumbs. Then the breaded fillets enter an IQF freezer. From there the fillets are transferred to the packing area.

IQF size grading/Weighing/Packing. Size grading is automatic. Weighing can be either automatic or manual. The retail bags are closed by heat sealing, coded according to specifications and passed through a metal detector. Other IQF products are put into plastic bag inside of a master case and closed with a tape.

Casing, labelling and palletising. The cartons are packed in master cases, taped or closed with plastic straps and labelled according to specifications. Master cases are stacked on pallets and strapped with plastic and labelled. IQF products other than retail packs are already in master cases and are therefore only labelled and palletised at this stage.

Frozen storage. Palletised products are placed immediately into frozen storage at a maximum temperature of –24°C.

Shipping. Palletised product is taken directly from frozen storage to freezer containers at –24°C.

Specific operational procedures for each product are detailed on product specifications.

3.4 HACCP (own check) system of the company

The HACCP system, also called own check system is fully described in the HACCP handbook (ÚA 1999). A scheme of the system is presented in Appendix 1. The HACCP analysis and the HACCP plan are shown in Appendices 2 and 3, respectively.

Control points are established to monitor both product and process in the own check system of the plant. These points are located in the reception area, after trimming, freezing, in casing/labelling/palletising; after battering and breading for breaded products and finally in weighing/packing operation in IQF products. At each control point samples are taken and evaluated according to the specifications and procedures. Quality and processing parameters controlled are well described in Appendix 1.

Temperature is monitored in every step of the process including frozen storage of final products. All the information generated is recorded electronically or in the corresponding form for each operation or product.

3.5 Labelling and traceability in the fish processing plant

From the moment the fish is brought on board the vessel information is generated and recorded until the product reaches the end customer. Part of the information will be transmitted from one link to the next, attached to the unit. The rest will remain in the link for internal use and will be accessible if necessary. Most of the information originates in the catching and processing links.

Redfish fillets blocks were chosen in our study as an example to illustrate the information recorded during each step of the processing and distribution chain. First it is necessary to identify batches and units within the chain (See Table 3).

Table 3: Identification of batches and units in the processing and distribution chain for frozen redfish fillets blocks exported to Europe.

Step	Batch	Units
Catching	Catching day	Tub
Production	Production day	Cartons, pallet
Transport to carrier	Production date (Lot number)	Pallet, container
Storage at carrier (Eimskip)	Production date (Lot number)	Pallet, container
Transport at sea (Eimskip)	Shipment	Pallet, container, kg or ton
Export company (IFPC, SIF)	An order or shipment	Pallet, container, kg or ton
Customs	Shipment	Kg, ton
Directorate of Fisheries	Catch - Fishing trip Export - Shipment	Pallet, container, kg or ton

Note: IFPC is the abbreviation of Icelandic Freezing Plants Corporation

Figure 3 is a simple illustration of the chain for frozen redfish fillets blocks produced at ÚA fish processing company and exported to Europe. Major export companies for ÚA fish products are IFPC and the SIF Group. The shipping company is EIMSKIP, which stores the product in frozen storage and freights it to Europe.

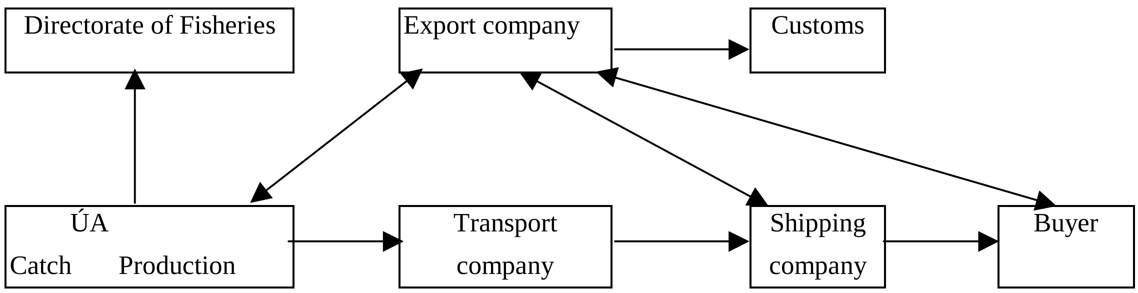

Figure 3: Scheme of production and distribution chain for frozen redfish fillets blocks exported to Europe, showing the entities involved and the transmission of information.

ÚA receives the raw material to be processed in the plant from its own fishing vessels. The information about the catch and finished products sent for export is given to the Directorate of Fisheries. Information is transmitted between ÚA and the export company about the fish products available for export. At the request of ÚA the transport company freights the product to frozen storage at the carrier (EIMSKIP). The export company interacts with the shipping company and the buyer in Europe regarding shipments. The export company also provides the information requested by customs about shipment of products. The information registered in each step is presented in Figure 4.

Part of the information is printed out on a label attached to the unit and transmitted to the next link in the production and distribution chain. This information varies according to the product type and packaging. Table 4 shows this information for frozen redfish fillets blocks.

Catching
Vessel name
Fishing trip number
Time of catch
Fishing area
Fishing gear
Quantity in a haul
Hauling time
Fish species
Quantity of fish (tubs)
Other parameters

Processing	
Information from catch:	Information from production:
Vessel name	Name of product
Fishing trip number	Origin of raw material
Fishing area	Plant number
Fish species	EU authorisation number
Units per catching day	Product number/code
Condition of fish	Production date/lot number
Weight of fish	Best before date
Ice/fish ratio	Weight
Other parameters	Temperature
	Quality and processing parameters
	Sensory evaluation results
	Microbiological results

Transport and storage
Producers name
Carrier name
Exporter name
Product name and number
Pallet number
Temperature during transport and storage
Container number
Dates and places when received and delivered

Export company
Product name and number
EU author. number
Producers name and number
Origin of the product
Order number
Shipment number
Invoice number
Customs id. number
Name of buyer
Addresses

Customs	Directorate of Fisheries	
Fish species	Information about catch:	Information about exports:
Product name and description	Species	Species
Origin of the product	Vessel name and number	Product name and description
Destination	Date and place of landing	Producers name
	Quantity	Country of destination
		Carrier name
		Departure date
		Quantity

Figure 4: Information registered at each step in the chain for frozen redfish fillets blocks.

Table 4: Information provided in the label for frozen redfish fillets blocks exported to Europe.

Step	Unit	Information attached
Catch	Tub	Catching day
Production	Case	Production date/lot number Plant number Origin EU authorisation number
	Pallet	Pallet number Product number Production date/lot number Plant number EU authorisation number Origin
Transport and storage	Pallet, container	Pallet number Product number Production date/lot number Plant number EU authorisation number Origin Container number

3.5.1 *Example of the chain (Catch-Processing-Transport) for frozen redfish fillets blocks.*

Using the information collected during the field study, an example of how the product can be traced back and forward is illustrated in Figure 5. Starting with the catch, raw material from 6 catching days went to a new batch, fishing trip 23 from the fishing trawler Hardbakur. The fish from this batch was processed in three different production days or batches, corresponding to September 26, 27 and 28 production dates, as shown in the figure. Product processed on September 26 was palletised in three pallets that were finally transported as units of a new batch to storage at the shipping company to be exported to Europe. Once the fish has entered to the processing line, it is not longer possible to identify the catching day.

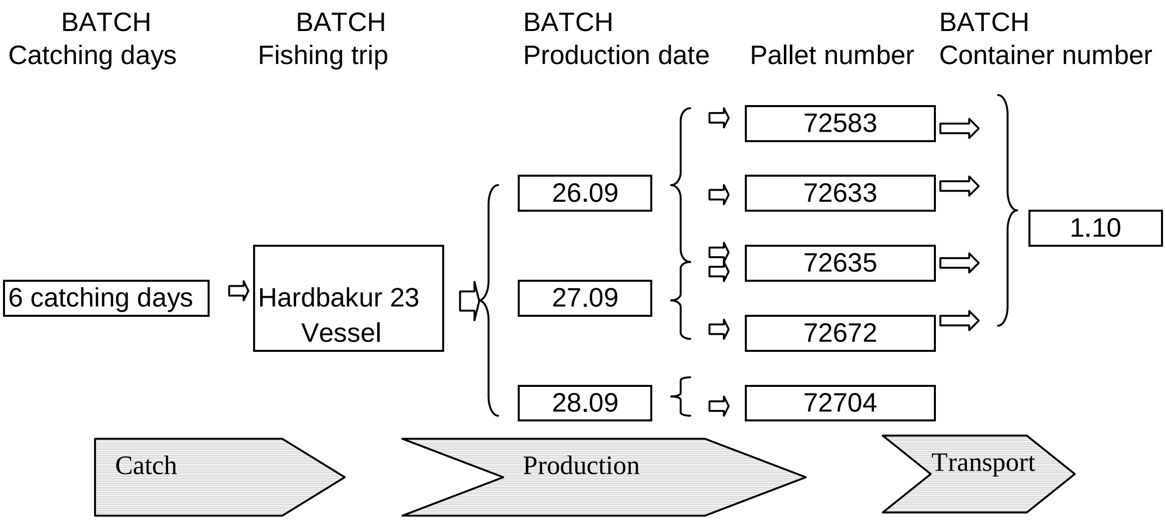

Figure 5: Example of catch-production-transport links for frozen redfish fillets processed in ÚA, showing the different batches identifiers in each step.

4. EVALUATION OF DATA FROM THE QUALITY SYSTEM AND FRESHNESS EVALUATION OF REDFISH

4.1 Introduction

Quality evaluation of fish is one of the most important aspects to be considered in the quality system of a fish processing plant. The field study carried out at ÚA provided a good opportunity to perform evaluations, using the information available in the plant and taking samples to conduct the analysis, thus gaining skills and experience.

4.2 Materials and methods

Evaluation of raw material and fillets were carried out based on the quality system of the company. Moreover, sensory evaluation of the raw material using the QIM was done on samples from one fishing trip (November 21-27) of the vessel Arbakur.

4.2.1 Evaluation of raw material

At ÚA every batch of fish is evaluated at the moment of landing and reception in the plant. A batch in this case is the fish of the same species from all the catch of one fishing trip. The samples are taken randomly from different catching days and evaluated using the form shown in Table 5. This form includes the vessel's name, the number of the fishing trip and date of evaluation. Once the evaluation has been carried out, a new form is filled with the final scores given to the parameters checked. These results are valid for the whole fishing trip (batch). A five score scheme is used. Fish with score 2 or less is unsuitable for processing.

Information about the redfish received from the vessels for a period one month, from September 23rd to October 24th, was accessed and analysed. Whole ungutted redfish from 8 batches was evaluated looking at the handling on board: weight of fish and ice, washing, how the fish was aligned in the tub and icing, i.e. fish-ice layers and ice/fish ratio. The data was recorded (Appendix 4) and analysed using the principal component analysis technique (PCA) in Unscrambler (Camo, Norway).

Table 5: Form for the evaluation of raw material (redfish) in the reception area

Catching day	Species	Ice				Alignment of fishes in tub	Washing	Other species	No. of fishes in sample	No. of defects	Netto, kg	Ice, kg	Brutto, kg	Ice/Fish, %	Contamination
		Top	Middle	Bottom	Average										

4.2.2 Evaluation of fillets

After trimming, a random sample of fish fillets are checked for defects in appearance (bones, parasites, bloodspots, bruises, black membrane). Colour and smell are evaluated on a scale from 2 to 5. In this study data collection and evaluation were carried out for redfish fillets after trimming.

Data from the quality system on evaluation of fish fillets after trimming were studied. Information was collected from ten processing days, starting from September 26th to October 18th. The raw material came from eight fishing trips of the three vessels that the company owns. The data were recorded as shown in Table 7.

4.2.3 Quality Index Method

Sensory evaluation of raw material using the QIM method was conducted under processing conditions as part of this study. A batch consisting of three catching days from one vessel's fishing trip was sampled, taking five samples from each catching day. The fishing trip in this case was 6 days long. The samples came from the second, fourth and sixth catching days, it means that they had been in ice for six, four and two days, respectively (Table 8). The scores for each parameter were determined by consensus of the two untrained assessors evaluating fish, the author of this report and the inspector in the reception area in the plant.

4.3 Results and discussion

4.3.1 Raw material

The current evaluation of raw material (redfish) mainly focuses on handling parameters, as shown in the form in Table 5 and in Appendix 4.

PCA was done to study the main trend in the data set from evaluation of raw material in the reception area. This technique allows the analysis of different variables at the same time. In this evaluation the useful information is icing, ice/fish ratio and catching day. Figure 6 shows two main grouping of the data, which mean that samples with parameters of similar values are correlated. PC1 explains 75% of the variation in the data and is mainly giving information about the amount of icing which appears to be related to the catching days. Samples located on the right side of the plot are mainly from catching days 6, 7 and 8, while those on the left side are from days 1, 2 and 3. The position of the samples with missing catching day on the plot gives an idea of their catching day because they have similar values as those samples located close to them. One outlier (Arb, 26-1) is observed at the bottom left side of the figure. Looking in Appendix 4 we find that it corresponded to a tub of fish with a score of 1 for icing. This tub was overloaded with fish, so the quantity of ice was insufficient to cool the fish properly. Another outlier (Kaldb, 23-2) is on the top right side of the figure. In this case the quantity of ice was more than the necessary.

Current evaluation of redfish in the plant is focused on handling parameters. There is no regular evaluation of freshness attributes of fish. There may be two main reasons for this; one is that the raw material is received from their own vessels. The other reason is that each tub of fish is labelled with the catching day, which means that the days fish has been in ice are known, so the freshness of fish and the remaining shelf life can be determined.

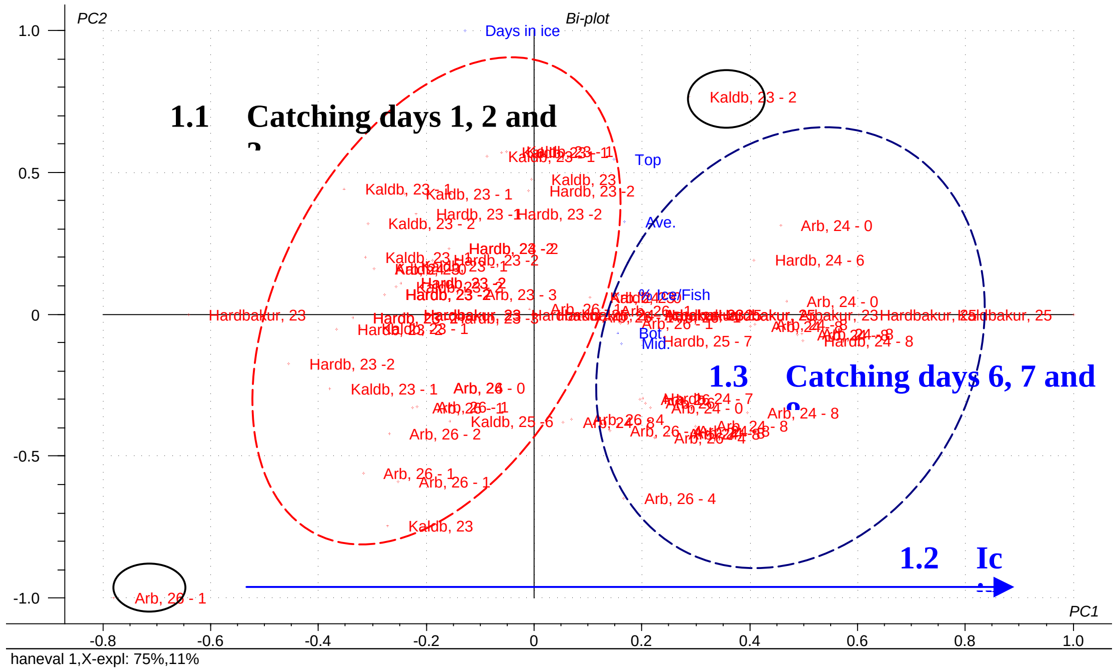

Figure 6 : Bi-plot of the principal component analysis model for the evaluation of raw material in the reception area. The labels mean the name of the vessel, the fishing trip and the catching day. Note that the 0 means that information about catching day is missing.

4.3.2 Fillets after trimming

In general, the results in Table 7 of the evaluation of fillets after trimming show that the process was under control. The overall quality of the fillets was good, with a score of 4 for smell and colour. In only two samples of 37 the specification for bones was over the limit of 2 units in 5 lbs or 1 unit/kg for fillet blocks, as established in the guidelines presented in Table 6 for redfish. The defects in bloodspots and bruises are rare in this control point, indicating that they are accurately removed during trimming.

Table 6: Guidelines for defects in appearance for redfish fillets and blocks. (ÚA 1999)

	Product	Average, in 5 lbs.	Maximum, in 5 lbs.
Bones	Fillets	1,0	2,0
	Blocks	2,0	4,0
Parasites	Fillets	1,0	2,0
	Blocks	2,0	4,0
Bloodspots	Fillets	2,0	4,0
	Blocks	3,0	6,0
Bruises	Fillets	2,0	4,0
	Blocks	3,0	6,0
Skin and black membrane	Fillets and Blocks	3,0	6,0

The scores for colour and smell are surprisingly consistent. It is difficult to evaluate the small changes in colour in the fillets at this point, which indicates that the grading scheme is not very useful and to some extent, too strict. There is no score of 5 for colour and smell. The reason, according to the company's managers, could be that fish caught by trawling loses quality because of stress and pressure in the codend of the trawl. Perhaps it will not be necessary to evaluate colour and smell of fillets after trimming, if the freshness of the raw material was evaluated in the beginning. The convenient QIM method is installed in the factory and sensory evaluation of the raw material in the reception area is possible.

Table 7: Evaluation of redfish fillets after trimming and the values for bones and parasites per kg.

Sample	Weight, g	Colour, score	Smell, score	Bones, unit	Parasites, unit	Bloodsp. unit	Bruises, unit	Membr unit	Bones/kg	Parasites/kg
1	3288	4	4	1	0	0	0	0	0.3	0
2	3354	4	4	1	0	0	0	0	0.3	0
3	3808	4	4	0	0	0	1	0	0	0
4	3856	4	4	1	0	0	0	0	0.26	0
5	3646	4	4	0	0	0	0	0	0	0
6	3746	4	4	0	0	0	0	0	0	0
7	3236	4	4	1	0	0	0	0	0.31	0
8	3502	4	4	1	0	0	0	0	0.29	0
9	3170	4	4	0	1	0	0	0	0	0.32
10	2458	4	4	2	0	0	0	0	0.81	0
11	2410	4	4	4	0	0	0	0	1.66	0
12	2440	4	4	0	0	0	0	0	0	0
13	2470	4	4	0	0	0	0	0	0	0
14	2432	4	4	1	1	0	0	0	0.41	0.41
15	3360	4	4	1	0	0	0	0	0.3	0
16	7635	4	4	5	1	0	0	0	0.65	0.13
17	7650	4	4	3	1	0	1	0	0.39	0.13
18	3098	4	4	1	0	0	0	0	0.32	0
19	3338	4	4	1	0	0	1	0	0.3	0
20	3280	4	4	2	1	0	0	0	0.61	0.3
21	2518	4	4	2	0	0	0	0	0.79	0
22	2412	4	4	1	1	0	0	1	0.41	0.41
23	2600	4	4	0	0	0	1	0	0	0
24	2348	4	4	2	0	0	0	0	0.85	0
25	2968	4	4	1	0	0	2	0	0.34	0
26	3892	4	4	1	0	0	0	0	0.26	0
27	3634	4	4	1	0	0	2	0	0.28	0
28	2636	4	4	0	0	0	0	0	0	0
29	3406	4	4	1	0	0	0	0	0.29	0
30	3590	4	4	1	1	0	0	0	0.28	0.28
31	3836	4	4	2	0	0	1	0	0.52	0
32	3331	4	4	2	0	0	0	0	0.6	0
33	2510	4	4	4	0	0	0	0	1.59	0
34	2540	4	4	2	0	0	0	0	0.79	0
35	2480	4	4	0	0	1	0	0	0	0
36	2554	4	4	0	0	0	0	0	0	0
37	2584	4	4	1	0	0	0	1	0.39	0

4.3.3 Quality Index Method

Results shown in Table 8 of sensory evaluation applying the QIM gave an average score of 10, 7 and 6 to the fish. The predicted days in ice are 11, 8 and 7, which is not a good prediction for the fish that was stored for 6, 4 and 2 days, respectively.

Table 8: Sensory evaluation of raw material (redfish) using the QI Method in the reception area.

Catching day		2	2	2	2	2	4	4	4	4	4	6	6	6	6	6
Sample number		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Days in ice (from catching day)		6	6	6	6	6	4	4	4	4	4	2	2	2	2	2
Appearance	Skin	1	1	0	2	1	1	0	0	0	0	1	1	1	1	1
	Stiffness	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Eyes	Cornea	1	1	1	1	1	1	1	0	0	1	0	1	0	1	0
	Form	1	1	1	1	1	1	0	1	1	1	0	0	0	0	0
	Colour of pupil	0	0	2	0	0	0	1	0	0	0	0	0	0	0	0
Gills	Colour	2	2	2	2	2	1	1	2	1	1	1	1	1	1	1
	Smell	2	0	1	2	2	2	2	0	0	1	1	0	1	1	1
	Mucus	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1
Viscera		1	0	1	0	0	1	1	1	1	1	0	1	1	0	1
Flesh		0	0	1	0	0	1	0	0	1	1	0	1	1	0	1
QI		11	7	11	10	9	10	7	6	6	8	5	7	7	6	7
Average QI				10					7					6		
Days in ice, (Predicted)				11					8					7		
Remaining shelf life, days				8					10					11		

These results can be explained by insufficient training of the assessors and/or improper fish handling on board the fishing vessel. The QIM method is not routinely used in the plant. QIM is useful if the origin of the raw material is not known, i.e. fish from auctions. This is the case for cod at ÚA but not for redfish.

Lack of training of both assessors is likely to be the main cause of the results obtained. Untrained assessors tend to be too strict in evaluations. The characteristic smell of gills is a strong seaweedy odour in the beginning, changing with time, becoming less strong. If there is not a spoiled sample for comparison, an untrained assessor can evaluate wrongly the attributes of smell and colour. This is observed in Table 8, where high scores were given for colour and smell of gills of fresh fish.

As stated above, the inspection of raw material focuses mainly on handling parameters such as icing, weight of fish and washing, while the appearance is seldom assessed. They rely on the fact that at the time of landing and reception, the raw material has been stored in ice for no more than 7-8 days, and that it has not gone through any changes in freshness and quality. Therefore, they assume they have homogeneous quality, as can be seen by the consistent score of 4 for colour and smell (Table 7).

On the other hand, the raw material can be affected if not well handled, which implies proper washing, rapid cooling after catch using sufficient ice and no temperature fluctuations. Nevertheless, a difference in the Quality Index corresponding to the time (days) the fish has been stored in ice was observed. It can therefore be concluded that the freshness of the batch is not homogeneous.

5. CONCLUSIONS AND RECOMMENDATIONS

A well implemented quality system based on HACCP results in high quality and safe seafood products. The evaluations of products carried out at ÚA for raw material and fillets showed that quality parameters were within the limits established in the own check system, and the process was under control.

A traceability system can be a valuable tool to trace the history of a product. It is important to have a recording system for all the information generated in the processing and distribution chain. Labelling and definition of batches and units is the key for tracing back and forward and finding the information needed. Problems exist in the catching link, because the units (catching day) are not identifiable once the fish enters the processing line.

The quality of the raw material (redfish) received is generally good. Nevertheless, it could be useful to evaluate the quality of the fish using other parameters than handling, i.e. sensory evaluation applying the QIM method. Maybe it will not be necessary to evaluate colour and smell of fillets after trimming, if the QIM is used for the raw material. For instance, it can reduce the cost of processing by rejecting raw material that might be of doubtful quality, in the first step of the production.

The QIM is a fast and convenient method to determine the freshness of fish. It is very important that assessors conducting the evaluation are properly trained and experienced to guarantee reliable results.

The QIM method could be applied in the fisheries sector in Cuba. In that case, the corresponding schemes for the commercial species from Cuban fishing grounds would have to be developed.

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APPENDIX 1: Own check system of the company ÚA (ÚA 1999)

Production step/Hazard	Monitoring frequency	Preventive measures	Parameter range Control limits	Actions	Reference	Operation Responsible
Receiving Overall quality of raw material Contamination	Temperature recording Use of ice Sensory properties-general visual inspection Each lot	Chilling of raw material on board vessel General rules of handling on board	Raw material assessment acceptable or better. Ice visible Temperature in raw material 0-4°C Contamination - none	Raw material chilled in iced water, sensory evaluation Decomposed and contaminated raw material destroyed	Raw material purchasing rules	Foreman in reception Production Manager Quality Manager
Traceability	Day catch labelling All containers	Correct labelling of catch on board vessel	None	Unlabelled raw material evaluated specially	Raw material purchasing rules	Foreman in reception Production Manager
Chiller Decomposition	Temperature Continuous monitoring	Raw material well iced Keep door to chiller closed as much as possible Sanitation according to plan	Raw material assessment acceptable or better. Ice visible. Temperature in raw material 0 - 4°C	Raw material chilled in iced water, sensory evaluation. Decomposed raw material destroyed	Quality manual	Foreman in reception Production Manager
Filleting/skinning Raw material quality	Evaluation of 10 whole fish and 20 fillets	Handling and condition good	Sensory evaluation 3 or higher on a 5 point scale	Raw material not according to specifications report to Quality manager Production manager	Specifications	Quality control Production manager Quality manager
Trimming Microbial growth	Temperature of fillets every time a sample is taken	Production flow good, no bottlenecks. Lines emptied in longer stops and rinsed Sanitation according to plan	Temperature not over 7 °C.	Report to Production manager Filleting stopped, lines emptied. Raw material chilled if necessary	Code of practice	Quality control Production manager Quality manager

APPENDIX 1 - Continued

Production step/Hazard	Monitoring frequency	Preventive measures	Parameter range Control limits	Actions	Reference	Operation Responsible
Bones, parasites, blood spots bruises Cooked evaluation of raw material	Continuous control	Training of staff	Average faults: according to specifications Cooked evaluation score according to specifications	Raw material reworked Increase inspection	Specifications	Quality control
Cutting/Forming	Continuous monitoring of the nuggets	Training of staff. Make sure that enough forming material is in the machine	No misshapen, also that nuggets do not lie together	Remove misshapen and pieces which lie together	Quality manual	Quality control Foreman in breading area
Batter and breading	Pick-up, viscosity measured every hour. Breading defects every 15 minutes	Training of staff Adjust machinery Sanitation according to plan	According to specifications	Notify foreman in breading area which will adjust the machinery	Specifications	Quality control Foreman in breading area
Pre frying	Temperature and time every hour. Colour of the product every 15 minutes	Check the oil heat before using the fryer Check oil level and circulation	Colour golden Temperature 195-200 °C	Notify foreman in breading area which will adjust the machinery	Quality manual	Quality control Foreman in breading area
IQF freezer Temperature in product	Continuous monitoring of temperature in IQF Temperature measured in product every time a sample is taken	Keep door to IQF closed	Temperature <-18°C	Slow down the IQF freezer Increase cooling	Quality manual	Quality control Foreman in breading area
Packing Microbial growth	Temperature in product	Time in freezer correct Product placed in cold store directly	Temperature in product not higher than -18 °C when placed in cold store	If temperature is lower than -18 °C then adjust flow and temperature of freezer	Quality manual	Quality control
Weighing	Weight of bag/case Bag and case closure Every hour	Grader correctly adjusted Training of staff	According to specifications	Adjust grader Regrade since last inspection	Specifications	Quality control Production manager Quality manager

APPENDIX 1 - Continued

Production step/Hazard	Monitoring frequency	Preventive measures	Parameter range Control limits	Actions	Reference	Operation Responsible
Metal detector Metal fragments	Continuous	A sliver of metal >2mm in length is passed through the metal detector three times per day	>2mm in length	The foreman or the quality manager is called. He inspects the package, and tries to trace the origin to eliminate the source	Quality manual	Quality control
Labelling	Labels inspected on each product number	Adjust printer Information on label compared to specifications and ISI production almanac	None	Labelling not correct, then re-label all packs	Specifications	Quality control
Cold storage Temperature	Continuous recording of temperature in cold storage	Temperature <-25 °C Limit time that doors are open. De-ice regularly	Temperature <-18°C	Adjust temperature in cold store	Quality manual	Foreman at cold store
Transport Temperature of product	Temperature of product at time of dispatch	Temperature <-22 °C Limit time that doors are open. De-ice regularly	Temperature of product <-20°C	Evaluate with transport company the fitness of the product for transport	Quality manual Transport company code of practice	Foreman at cold store Production manager

APPENDIX 2: Hazard analysis for fillet processing (ÚA 1999)

(1) Ingredient / Processing step	**(2)** Potential hazards introduced, controlled or enhanced at this step	**(3)** Are any potential food-safety hazards significant? (yes/no)	**(4)** Justify your decision for column 3	**(5)** What preventative measures can be applied to prevent the significant hazards?	**(6)** Is this step a critical control point? (yes/no)
Reception and cooler	Biological: bacterial pathogens	No	Raw material remains in the receiving area for a short period of time and is cooled while it waits to be processed (0-4°C). Products cooked before consumption		No
	Physical: metal fragments	Yes	Metal fibres from the wires of the fishing gear can possibly enter fish flesh	Inspected on candling tables in trimming and/ or in metal detector	No
	Glass	No	No history of glass. Controlled by SSOP		No
	Chemical: oils, lubricants, detergents and sanitizers	No	Chemicals such as lubricants and hydraulic fluid can contaminate fish on board the vessel. Contaminated raw material can not be carried undetected into processing due to the strong odour of the chemicals. Detergents and sanitizers are kept in closed compartments.		No
Washing	Biological: bacterial pathogens	No	Water and ice quality controlled by SSOP		No
	Physical: glass	No	No history. Not likely because of SSOP		No
	Chemical: detergents and sanitizers	No	Only chemicals accepted for food processing used. Kept in closed compartments during processing		No

APPENDIX 2 - Continued

(1)	(2)	(3)	(4)	(5)	(6)
Heading, filleting, skinning	Biological: bacterial pathogens	No	Product is cooked before consumption		No
	Physical: metal fragments	Yes	Fractures from machine blades etc. could enter fish flesh	Regular inspection of machine blades. Inspection of every fillet on candling tables. Metal detection of retail packs	No
	Chemical: lubricants	No	Only lubricants accepted for food processing are used.		No
Trimming, flow line	Biological: parasites: nematodes and Sphyrion lumpi	No	Parasites are killed at -35°C in 18 hours and at -20°C in 7 days. They also are killed when cooked.		No
	Physical: bones	No	One can not guarantee 100% boneless product because bones are removed manually. Bones in seafood products are not mentioned in National HACCP Alliance Education and Training Guide as a potential hazard but as uncontrollable quality defects that should be kept at minimum		No
	metal fragments	Yes	Can be carried to raw material from the fishing gear or from the processing line	Every fillet is visually inspected on a candling table. Metal detection of retail packs.	Yes
	glass	No	Controlled by SSOP		No
	Chemical: detergents and sanitizers	No	Only chemicals accepted for food processing used. Kept in closed compartments during processing		No

APPENDIX 2 - Continued

(1)	(2)	(3)	(4)	(5)	(6)
Trimming, express line	Biological: bacterial pathogens, parasites Physical: bones metal fragments glass Chemical: detergents and sanitizers	No No Yes No No	Cooked before consumption Fillets either boneless or with pin bones - in. See in Trimming, flow line Metal fibres from wires of the fishing gear or from the processing line e.g. fractures from machine blades can be carried to the fish Controlled by SSOP Controlled by SSOP	 Fillets are inspected on a candling table, foreign objects included. Part of the production goes through a metal detector. Regular inspection of machine blades. Processing line thoroughly washed after repairs	No No Yes No No
Cooler tanks	Biological: bacterial pathogens Physical none Chemical: detergents and sanitizers	No No	Cooked before consumption Controlled by SSOP		No No
Weighing and packing	Biological: pathogens Physical none Chemical: detergents and sanitizers	No No No	Cooked before consumption Not reasonably likely at this stage Controlled by SSOP		No No No
Freezers (plate freezers and IQF freezers)	Biological: pathogens Physical: none Chemical: ammonium	No No	No growth condition Ammonium leak is immediately detected due to its strong odour. Not harmful for food contact		No No

APPENDIX 2 - Continued

(1)	(2)	(3)	(4)	(5)	(6)
Glazing	Biological: bacterial pathogens Physical: none Chemical: none	No	Water quality controlled. Cooked before consumption		No
Batter and breading	Biological: bacterial pathogens Physical: none Chemical: none	No	Cooked before consumption. Continuously fresh batter added		No
Weighing and packing (IQF line)	Biological: none Physical: Chemical: detergents and sanitizers	No	Product is frozen at this step. No growth conditions		No
Metal detector	Biological: none Physical: metal fragments Chemical: none	 Yes	 Metal objects can be hazardous to consumers' health. Make sure that the detector is in good working condition.	 All retail packs are examined with a metal detector.	 Yes
Casing palletising	Biological: bacterial contamination of packing material due to rodents Physical: foreign objects Chemical: detergents and sanitizers	No No No	Regular rodent control. The product is cooked before consumption All master cases are inspected before casing Controlled by SSOP		No No No
Frozen storage	Biological: none Physical: none Chemical: ammonium	 No	 Ammonium is detected immediately due to a strong odour.		 No

APPENDIX 3. HACCP plan form for fillet processing (ÚA 1999)

Critical control point/ processing stages	**Significant Hazard**	**Critical limits for each preventive measure**	**Monitoring**				**Corrective actions**	**Records**	**Verification**
			What	**How**	**Frequency**	**Who**			
Trimming. Flow line/ express line	Metal fragments	No metal fragments > 5 mm in length	Metal fragments	Inspection on candling tables	Continuous	Trimmers	All visible metal fragments removed at trimming. If a metal fragment is found by a trimmer, then the production should be stopped and the origin traced if possible and the source eliminated. If a QC inspector finds a metal fragment then he isolates the production from last inspection and puts "On hold" on the isolated cases. Afterwards these cases will be run through a metal detector	QC inspection forms	Continuous QC inspections by QC staff. The Quality Manager examines the register daily
Metal detector	Metal fragments	No metal fragments > 2mm in length	Metal fragments	By metal detector	Continuous	QC staff	The package in question is placed to one side. The Foreman is called. He inspects the package with a metal detector. He searches the product for metal fragments and tries to trace the origin to eliminate the source	Metal detector log	A sliver of metal > 2mm in length is passed through the metal detector three times during day while processing The Quality Manager examines the daily records

APPENDIX 4. Results of the evaluation of raw material in the reception

Vessel name and fishing trip number	Catch day	Days in ice	Icing				Weight, kg			Ice/Fish
			Top	Mid.	Bot.	Ave.	Netto	Ice	Brutto	%
Kaldbakur, 23	1	8	3	3	4	3	309.5	30.5	340.0	9
	1	8	4	3	4	4	287.5	40.0	327.5	12
	1	8	4	2	3	3	313.0	23.5	336.5	7
	1	8	4	3	4	4	294.0	55.0	349.0	16
	1	8	2	3	4	3	308.5	22.0	330.5	7
	1	8	3	3	3	3	300.0	33.0	333.0	10
	1	8	1	3	4	3	295.5	22.0	317.5	7
	1	8	4	3	3	3	292.0	40.5	332.5	12
	2	7	3	2	4	3	254.0	41.0	295.0	14
	1	8	4	3	4	4	283.0	48.0	331.0	15
	0	-	3	2	4	3	281.5	29.0	310.5	9
	0	-	4	3	4	4	275.5	49.5	325.0	15
	2	7	5	4	5	5	272.0	71.5	343.5	21
	2	7	4	2	3	3	282.5	31.0	313.5	10
	0	-	4	4	4	4	282.0	62.5	344.5	18
	0	-	2	3	4	3	297.5	32.0	329.5	10
Arbakur, 24	8	1	5	4	5	5	277.5	78.5	356.0	22
	8	1	5	5	5	5	268.0	84.5	352.5	24
	0	-	5	5	5	5	273.0	82.5	355.5	23
	8	1	4	4	5	4	278.5	72.0	350.5	21
	0	-	4	4	5	4	265.0	71.5	336.5	21
	8	1	4	4	5	4	277.0	71.0	348.0	20
	8	1	4	4	5	4	262.0	74.0	336.0	22
	8	1	4	4	5	4	269.5	95.5	365.0	26
	0	-	5	4	5	5	257.5	110.5	368.0	30
	8	1	4	4	5	4	218.0	128.5	346.5	37
	8	1	5	4	5	5	276.5	80.5	357.0	23
	8	1	5	5	5	5	276.0	92.5	368.5	25
	0	-	4	4	4	4	297.0	65.0	362.0	18
	0	-	3	2	4	3	324.0	34.0	358.0	9
	0	-	3	3	4	3	317.0	41.5	358.5	12
	8	1	4	3	4	4	305.0	50.0	355.0	14
Arbakur, 26	1	4	1	1	2	1	344.5	13.5	358.0	4
	1	4	3	3	3	3	320.5	42.0	362.5	12
	1	4	4	4	4	4	296.0	74.5	370.5	20
	1	4	4	4	5	4	326.0	63.0	389.0	16
	1	4	4	4	4	4	312.0	60.0	372.0	16
	1	4	4	3	4	4	314.0	48.0	362.0	13
	0	-	3	3	4	3	289.0	41.0	330.0	12
	1	4	2	3	4	3	338.5	27.0	365.5	7
	1	4	2	3	3	3	341.0	29.5	370.5	8
	1	4	3	3	3	3	318.0	46.5	364.5	13
	1	4	4	4	5	4	269.0	74.5	343.5	22
	2	3	3	2	3	3	279.5	43.5	323.0	13
	4	1	4	4	4	4	280.5	54.5	335.0	16
	0	-	4	4	5	4	267.5	65.5	333.0	20
	0	-	4	4	5	4	269.5	61.5	331.0	19

APPENDIX 4 - Continued

Vessel name and fishing trip number	Catch day	Days in ice	Icing				Weight, kg			Ice/Fish
			Top	Mid.	Bot.	Ave.	Netto	Ice	Brutto	%
	4	1	3	4	5	4	267.5	56.0	323.5	17
	4	1	4	4	5	4	285.5	58.0	343.5	17
	4	1	4	3	4	4	271.0	51.0	322.0	16
Arbakur, 23	0	-					179.0	60.5	239.5	25
	0	-					274.0	67.0	341.0	20
	0	-					177.5	69.0	346.5	20
	3	6					214.5	34.5	249.0	14
Kaldbakur, 25	0	-					136.0	76.0	212.0	36
	6	4					297.5	29.0	326.5	9
Hardbakur, 23	0	-					58.0	7.0	65.0	11
	1	8					273.0	47.5	320.5	15
	2	7					282.0	69.0	351.0	20
	2	7					288.0	37.5	325.5	12
	2	7					285.5	64.0	349.5	18
	2	7					287.5	29.5	317.0	9
	2	7					292.0	39.5	331.5	12
	2	7					287.0	36.0	323.0	11
	2	7					301.5	36.0	337.5	11
	2	7					310.0	16.5	326.5	5
	2	7					286.0	28.0	314.0	9
	2	7					299.5	36.0	335.5	11
	2	7					272.0	48.5	320.5	15
	0	-					301.0	8.5	309.5	3
	2	7					298.5	24.5	323.0	8
	2	7					286.5	34.5	321.0	11
	3	6					297.5	41.0	338.5	12
	2	7					287.0	45.0	332.0	14
	0	-					306.0	36.0	342.0	11
Hardbakur, 24	0	-					166.0	31.5	197.5	16
	8	1					264.0	90.0	354.0	25
	6	3					289.5	100.5	390.0	26
	7	2					295.5	58.5	354.0	17
	2	7					281.0	50.5	331.5	15
Hardbakur, 25	7	3					283.0	66.0	349.0	19
	0	-					240.0	59.0	299.0	20
	0	-					236.5	94.0	330.5	28
	0	-					297.0	53.5	350.5	15
	0	-					305.5	86.5	392.0	22
	0	-					292.5	81.5	374.0	22

Note: The catching days represented with "0" mean that the label on the tub was missing and consequently the days in ice are not determined.