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QUALITY CONTROL IN COD FISHING USING A TRACEABILITY SYSTEM

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ABSTRACT

The objective of this research project was twofold. Firstly, to examine how various factors in Icelandic cod fishing can influence the quality of the raw material, using traceability systems to link these quality factors with a plausible cause. And secondly, to transfer that knowledge and the techniques used in Iceland to the Brazilian seafood industry. The first part involved collecting data on four separate fishing trips in the autumn of 2007. Thirty randomly selected cods were measured onboard each of these fishing trips and then traced throughout the production chain. Afterwards, the data were analysed using regression analysis to find a functional relationship between various quality factors. The analysis showed, for example, that there is a correlation between the number of parasites (nematodes) in the fillets and location of the fishing ground. It also showed that fishing ground and volume in haul can influence gaping, and that fillet yield differs between fishing grounds. These conclusions could only be drawn because of the ability to trace the fish from catch and all the way through processing. Recommendations drawn from this research to the Brazilian Competent Authority are to revise the country's fisheries legislation in order to enable the implementation of a traceability system that could be used as a tool to improve the quality of the raw material.

Keywords: Quality control, traceability, cod fish, catch.

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1 INTRODUCTION

Brazil has a coastline of 8500 km and a fisheries jurisdiction (EEZ) that covers 3.5 million km^2 and 12% of the planet's reserve of available freshwater (SEAP 2003). The Brazilian annual fish production is around 1 million tons, 680 thousand tons from catch and 320 thousand tons from aquaculture (SEAP 2007_b). It has the potential to increase and the production can also be improved to produce and export high quality seafood. Brazilians need to implement an adequate quality control, which amongst others things, requires an efficient traceability system that covers the whole production chain from fishing to the consumer.

Traceability is the ability to trace the history, application or location of an entity by means of recorded information. Traceability can be considered in four distinct contexts and each of them has a slightly different application (ISO 1994):

- ✓ For products traceability creates a link between materials, their origin and processing, distribution and location after delivery.
- ✓ For data it relates the calculations and data generated through a quality loop and may link these back to the requirements for quality.
- ✓ In calibration it relates measuring equipment to national, international or primary standards, to basic physical constants or properties or to reference materials.
- ✓ In IT and programming it relates design and implementation processes back to the requirements for a system.

The seafood industry is a commercial food sector in which traceability is becoming a legal and commercial necessity (Borresen 2003). Globalisation of trade and the lack of international standards have made it difficult to identify the origin and history of seafood products (Thompson *et al.* 2003), raising concerns from retail, food service, and consumers about the safety of their seafood supplies to guarantee the final product quality.

The fisheries industry, already confronted by inherent safety concerns such as scrombroid poisoning, parasites, molluscs contaminated with ciguatera, contamination of trace metals and PCBs, must address existing and emerging legislation and its effects on trade. Besides, the concern over declining fish populations and the pressure from consumers for a maintainable production of foods will have a great impact on the market (Thompson *et al.* 2005).

A well-designed traceability system may benefit many in the seafood industry. Dickinson and Bailey (2002) suggest that traceability could become a valued public commodity, especially with regard to food safety. Companies that have accredited and verifiable traceability systems may be able to command favourable premiums from their insurance providers by reducing liability in foodborne illness cases (Gledhill 2002). By preserving the identity of favourable attributes throughout the entire food chain, seafood producers can provide quality assurance securing them a firm reputation (Unnevehr *et al.* 1999) and create value if the information is used to provide assurances to consumers for which they are willing to pay (Bailey *et al.* 2002). In the absence of mandatory traceability and in the case of seafood producers that do not export, the implementation of traceability systems will depend on the needs of the individual firm and the benefits that may be gained relative to potential costs (Thompson *et al.* 2005).

One of the main advantages of an effective traceability system is the ability to link various quality factors to a specific cause (Gardarson 2007). This has for example been done in the seafood sector, where it has been shown that the quality of the final product depends on variables like catching ground, seasons, time-lag from catch to processing, age, maturity, gaping, parasites and bruises. Over the last few years, Icelandic scientists have been working with traceability systems in order to predict where the best fishing grounds are, considering the above mentioned factors (Gudmundsson *et al*. 2006, Margeirsson *et al*. 2007). The results show that there is a direct link between various quality factors of cod fillets and the fishing ground.

Establishing quality parameters from catching to processing is important to guarantee the quality of the fish as raw material for the industry. Catching is the first and perhaps one of the most important links in the traceability chain. After bleeding, gutting, washing and size grading, the fish is ice chilled in tubs, each with a fixed number on it. The units are labelled with detailed information on things such as haul number, fishing date and fishing area and this information appears on each tub. That is the key to trace the catch back to the fishing date/area, even the exact fishing time. With the integration of all available information in the catch and processing chain it is possible to increase the yield and quality of the product. This information is valuable for the fishing industry, as it indicates various quality parameters, e.g. which fishing grounds the fishermen should focus on, and which fishing grounds they should stay clear of.

1.1 Objective and aims

The overall objective of this research is to contribute to the improvement of the quality control in cod fishing in Icelandic waters using a traceability system as a tool to improve the quality of the raw material.

The following aims were established for this project:

a) To study traceability linked to quality control in fishing, and observing the synergism between them.
b) To observe how some factors can interfere with the quality of raw material and suggest how they can be used by producers to maximise quality and yield.
c) To suggest a suitable quality control in the Brazilian fisheries using a traceability system to improve the quality of the raw material for the processing companies and assure the traceability of information throughout the whole chain, from catch to consumers.

1.2 Rationale

The project can be applied to the fisheries sector in Brazil. Presently there is no quality control onboard in Brazilian fishing vessels, but most of them are small boats operated by artisanal fishermen. These boats do not have the adequate facilities to ensure quality control of their catch. There is a lack of information regarding the origin of the fish being caught and quality control should be implemented immediately after fish is caught. The certified companies that should conduct the inspection services have limited or no information at all about the traceability of the catches and their processing. The Special Secretariat for Aquaculture and Fisheries by Law no 2.681 (SEAP 2006) in 2003, attached to the Presidency of the Republic, was created with the objective to provide support for the development for all areas of the fisheries sector. The fisheries sector lacks research programmes to improve the quality of the fish products, both for domestic use and export. This project is going to demonstrate that traceability, which includes gathering information at each stage of the production chain, is vital for quality control in seafood production.

2 LITERATURE REVIEW

This chapter outlines the available literature related to the topic of this report and is divided into four subchapters. The first subchapter is about cod fishing in Iceland, the second is about traceability of fish products in general, the third is about traceability systems in the Icelandic fishing industry and the fourth is about the quality of raw material.

2.1 Cod fishing in Iceland

Cod is caught all around Iceland throughout the year but fishing is often best in the winter. Spawning takes place in late winter, mainly off the southwest coast of Iceland (Icelandic Ministry of Fisheries 2007).

Atlantic cod (*Gadus mohua)* is the most important of all the marine resources in Iceland. In 2002, Atlantic cod products represented 37% of the catch value in Iceland and 38% of the total seafood export value (Iceland Trade Directory 2003), and 40.3% of the export value in 2004. Almost 100% of the catch is exported (Icelandic Ministry of Fisheries 2004).

Iceland is a fish producer and exporter and fisheries are one of the most important sectors of the national economy. In 2004, the fisheries sector contributed 8.1% of GDP (Gross Domestic Product), employed 6.7% of the labour force, and generated 60% of the export value (Icelandic Ministry of Fisheries 2004).

2.2 Traceability of fish products

The first project about traceability in seafood production was "Traceability of Fish Products", which was co-ordinated by the Norwegian Institute of Fisheries and Aquaculture and ran from December 2000 to November 2002. It was funded by the European Commission under the "Quality of Life and Management of Living Resources" thematic programme, and it was responsible for developing the TraceFish standards for captured fish, farmed fish and technical aspects, respectively (CEN 2002). The concept of tracing products from their origin to the consumer is not a new idea. Many industries have incorporated product tracing into their internal operations for decades. Most of us have purchased items, from cars to electronic equipment, which are labelled with unique serial numbers, allowing manufacturers and government authorities to identify and locate individual products. However, the introduction of traceability into the food supply sector is a relatively new concept that continues to gain momentum, particularly in the European Community (FAS 2002).

There are many regulations on food traceability that impinge on the sector. Denton (2001) summarised the direct and indirect requirements in EU law relating to traceability in the fisheries industry. The relevant aspects of product liability and safety, fish marketing, fisheries control and food law (food labelling, food safety and animal health and welfare) were included. EC Commission Regulation 2065/2001 lays down detailed provisions for the application of EU regulation 104/2000 and requires that all chilled, frozen, and smoked fish or fillets and shellfish, when offered for retail sale, be labelled in accordance to EU 104/2000. In addition to these requirements, this information must be provided at each stage of the marketing chain, either by direct labelling or by acceptable commercial documentation (EU 2000, EU 2001). These provisions require all chilled, frozen and smoked fish or fillets and shellfish, when offered for retail sale to the final consumer, to be labelled with the following: the commercial designation of the species, method of production (caught at sea, in inland waters or farmed) and the catch area (e.g. Pacific) or country of production, if farmed.

The regulation requires that the labelling information, as well as the scientific name of the species, be given at each stage of the marketing chain. This information can be given by labelling or on packaging, or by means of commercial documents accompanying the product. For example, in the UK it is generally understood that commercial documentation (e.g. sales note, invoice) is the usual means of providing this information through the chain (FAS 2002).

In the European Community, it is recognised that consumers have the right to receive information regarding the origin and composition of their food so they can make informed decisions (FAS 2002). Surveys have shown that a large majority of consumers both in the European Union (EU) and in the United States were willing to pay a premium price for products, which include country-of-origin-labelling (COOL) and geographical labelling and certifications (Wessells *et al*. 1999, Loureiro and McCluskey 2000, Clemens and Babcock 2002, Roosen *et al*. 2003, Umberger *et al*. 2003).

Information labelling requirements are likely to have a significant impact on the food market, helping to prevent fraud by providing more information to the consumer. Labelling by itself though does not provide traceability. However, it is an important aspect of traceability which allows the physical tracking of the product and can be used as an effective means of differentiating products and creating brand recognition (FAS 2002).

Good manufacturing practices (GMP), ISO 9000 quality management, and hazard analysis and critical control point (HACCP) procedures are growing in use and broadening the scope of traceability in accommodating this information (Moe 1998). Inspection and data systems such as HACCP, which are mandatory for all seafood, are designed to control biological, chemical, and physical hazards during processing. HACCP, however, does not require a traceability system because most of the collected data are not communicated to other market channel members in the supply chain (Hernandez 2001).

2.3 Traceability system in Icelandic fisheries

According to the Tracefish standard for captured fish, the key to the operation of traceability of fish products is the labelling of each unit of goods traded, whether of raw materials or final products, with a unique ID (CEN 2002). It is important to implement traceability from the start and that is why catching is a key link in the chain, making it possible to verify the origin of the product (Liu 2005).

Icelandic fish processing plants and auction markets have access to various types of information from the boat's logbooks. The following information is available before landing: catching grounds, catching time, landing day and time, fishing gear, processing method on board (fish older than 12 hours should be landed gutted), grading size (depending on the boat), temperature records and weight. Usually the lots are landed in tubs, and the tubs are identified with a unique number due to an agreement between the tub producers. After landing, it is necessary that a label on each tub will provide the following information: name of the boat which the lot comes from, fish age (from catch day), species, tub number, weight (of each tub) and date. If the lot is gathered from many boats, the necessary information is kept and made available in the auction's data system whenever needed (Almeida 2006). After bleeding, gutting, chilling and size grading, the fish is ice-chilled in each tub with a fixed number on it. The first unit is created, and detailed information such as haul number, fishing date and fishing area will follow with each tub, so the fixed number of each tub is the key to tracing back to the fishing date/area, even the exact fishing time (Liu 2005).

During sales, each lot has a unique identification (ID) by combining the following data: day of sale, action ID, auction number, number of the lot, bid number (a serial number of five digits, where the three first numbers are the bid serial number and the two last numbers are used if the lot is broken up), buyer ID, tub number, fish age and type, units available to be sold, weight (the weight of each lot is taken by weighing one tub, the ice percentage in it and the average is used for the whole lot) (Almeida 2006).

The batch number of raw material is created in the processing plant when the raw material is received. Although a batch of raw material may be processed over several days, the products can always be traced back to the raw material used by this batch number. So the batch number is the key to link products to raw material. All the detailed information about the raw material is carried with the batch number (Liu 2005).

When the fish is bought in an auction market or from another fishing boat, the traceability is less secure. In some cases, fish from different batches/boats can be mixed if the plant buys fish from more than one vessel (Liu 2005).

2.4 Quality of raw material from catches

The quality of seafood products depends on many variables like catching ground, season, time-lag from catch to processing, age and maturity of the fish, gaping, parasites and bruises. With a better understanding of these factors, it is possible to increase the quality of the raw material inside the traceability system (Birgisson 1995, Nahmias 2000, Margeirsson *et al.* 2007).

In recent times, a lot more emphasis has been put on increasing the FP-ratio (fillet proportion-ratio) (Asgeirsson 2005), and other important factors influencing the quality of cod for processing have been studied more thoroughly. Love (1975) found less gaping in large than in small cod. This was contradicted by Birgisson (1995) who found more gaping in larger cod. Rikhardsson and Birgisson (1996) concluded that gaping correlated positively with condition factor and proportion of viscera. Morphology of the fish has been related to fillet yield (Cibert *et al.* 1999) and it is likely that the condition factor can be used as an indicator for fillet yield, at least during the time of year when gonads are small. Variation in liver weight can also be used as a proxy for the condition of the fish. Eyjolfsson *et al*. (2001) and Margeirsson *et al.* (2003) found a significant positive correlation between fillet yield and the condition factor and stated that there was a considerable difference in the condition factor and fillet yield among catching areas in Icelandic waters. Many researchers have found data indicating seasonal and spatial differences in relation to the FP-ratio in Icelandic cod (Bedd and Marteinsdottir 2000, Margeirsson *et al.* 2006, Marteinsdottir *et al.* 2000)

According to Margeirsson *et al.* (2007) fishing ground and season has a significant effect on fillet yield, gaping and number of parasites. Time-lag from catch to processing (age of the raw material) affects gaping and bruises significantly. Fillet yield has closely correlated to the condition factor and head proportion. It is necessary to study all these factors that can significantly influence the quality of raw material, and to implement the quality control inside the traceability system from catch to the processing companies, to increase the quality and the return of the catch-processing chain.

3 METHODOLOGY

Data collection took place in four separate fishing trips, each roughly a month apart. The first trip was in the beginning of August, when the fishing vessel Sturlaugur H. Böðvarsson AK, which is a 430 GRT (Gross Register Ton) bottom trawler, went to the fishing grounds northwest of Iceland. The second trip, which took place in the end of September, was also onboard Sturlaugur H. Böðvarsson AK but this time they went to fishing grounds southwest of Iceland. The third trip was onboard the MRI's research vessel Bjarni Sæmundsson RE and took place in the middle of October northwest of Iceland. The final trip was in the beginning of December when a small bottom trawler, Hringur SH, gathered data in fishing grounds west of Iceland. The data collection was done in cooperation of Matis, the Marine Research Institute, the Directorate of Fisheries and the fisheries companies HB Grandi hf and Gudmundur Runolfsson hf (Table 1, Figure 1 and 2).

Table 1: Information about the fishing trips.

Date	Vessel	Gear	Location (square no)	Location (GPS-start)	Location (GPS-end)	Time when haul began	Time when haul ended	Length of haul (min)	Volume in haul (kg)
6.8.2007	Sturlaugur H. Böðvarsson	Bottom Trawl	624 - 674	66° 30/ 25°18	66° 37/ 24°48	04:12	07:00	168	6600
24.9.2007	Sturlaugur H. Böðvarsson	Bottom Trawl	324	63° 14/ 24° 05	63°14/ 24° 15	12:45	17:55	310	3300
19.10.2007	Bjarni Sæmundsson	Bottom Trawl	673 - 674	66° 51/ 24° 37	67° 00/ 23° 58	03:37	04:22	45	No data
			673 - 674	66° 53/ 24° 31	67° 02/ 23° 54	05:52	06:37	45	No data
6.12.2007	Hringur	Bottom Trawl	524	65° 23/ 24° 58	65° 18/ 24° 43	03:50	06:00	130	500

Sturlaugur H. Böðvarsson AK (1585)

Bjarni Sæmundsson RE (1131)

Hringur SH (2685)

Source: www.skip.is

Figure 1: Vessels used for the data collection.

Trip number 1 (Aug/07)

Trip number 2 (Sep/07)

Trip number 3 (Oct/07)

Trip number 4 (Dec/07)

Source: MRI

Figure 2: Location of the hauls

Data collection onboard the vessels was done by an employee of Matis in the first trip, the engineer of Sturlaugur H. Böðvarsson AK in the second trip, an employee of the MRI in the third trip and by an employee of the Directorate of Fisheries in the fourth trip.

The data collected onboard can be divided into two parts i.e. data from the bridge and data from the processing itself.

Data collected from the bridge was time (start and end of haul), location (GPS coordinates in the beginning and end of haul), and volume in the haul (Table 1).

Data collection in processing was done on the first 30 cods that came up on the conveyer belt in the last or second last haul of the trip. The 30 first cods were selected in order to ensure that the samples were relatively random, 30 cods were used because that gives statistically significant information without being too expensive, and samples were only taken on the last day of the trip in order to be able to process the catch in the fish processing plant on the fourth day (it is important to process the fish always at the same age). Each fish was marked with an ID tag (Figure 3) and then the length was measured with a steel yardstick (total length to the end of tail in cm), the weight of the fish was measured ungutted and gutted, and the maturity stage was estimated macroscopically using the Powels (1958) standards: level 1 for immature, 2 for ripening, 3 for spawning or 4 for spent.

The fish was then stored in plastic tubs (top layer), on ice in the holding room until it arrived in the processing plant.

Figure 3: Individual cods were marked with an ID tag and put on ice in the holding room.

When the fish had been offloaded it was processed on the fourth day from capture in HB Grandi's fish processing plant in Akranes (trips 1-3) or in the GR's fish processing plant in Grundarfjordur (trip 4) (Figure 4). All processing was done by the same employee of Matis following the example from the flowchart for cod processing in Figure 5, which made the following measurements:

- Weight of the whole fish
- Weight of the fish headed
- Weight of the fillets (skinless)
- Number of parasites in the fillets
- Gaping in the fillets

The number of parasites (nematodes) was counted through the manual inspection and trimming of each fish fillet on a candling table. Gaping was measured by putting a transparent plastic card with a grid on the fillets (Figure 6). The grids were 4x4 cm. If a gaping area in the fillet was as big as one grid, it counted as one grid (Margeirsson *et al.* 2006).

Figure 4: Processing line

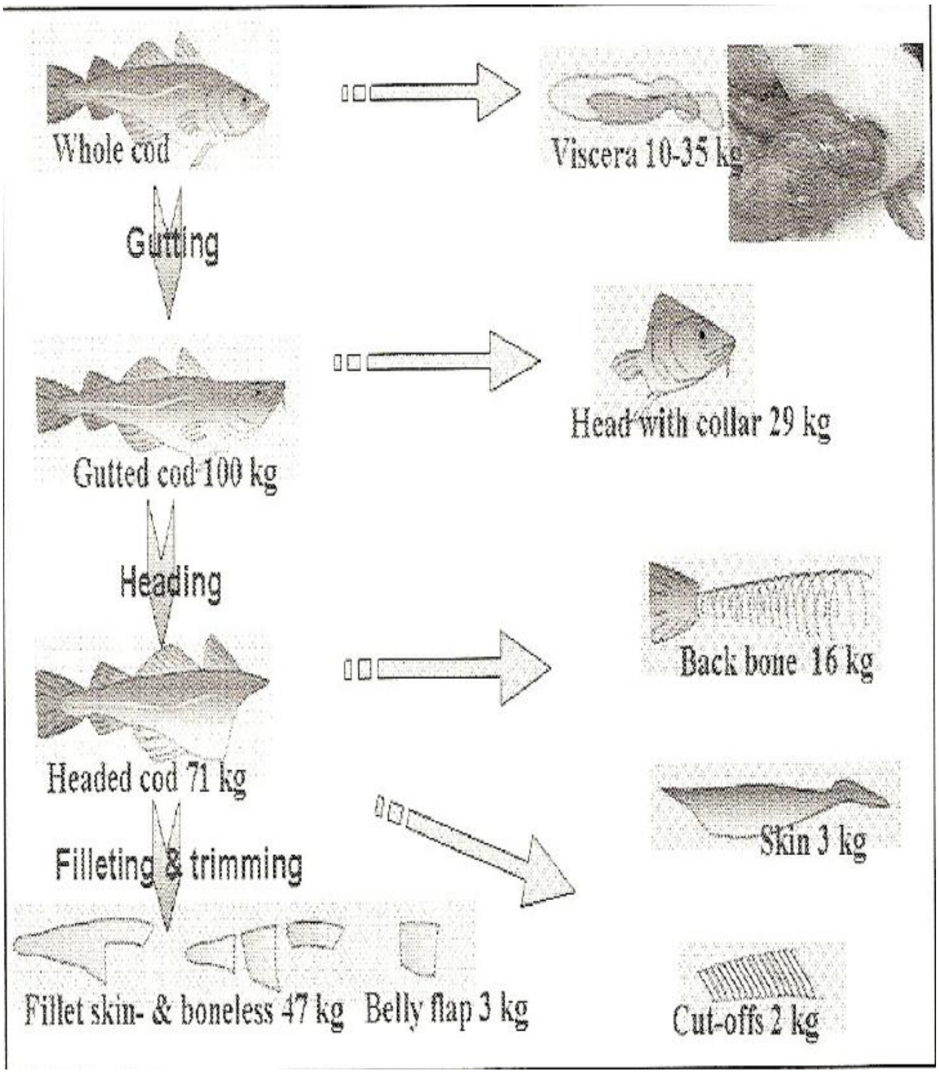

Figure 5: Flowchart of a typical cod processing.

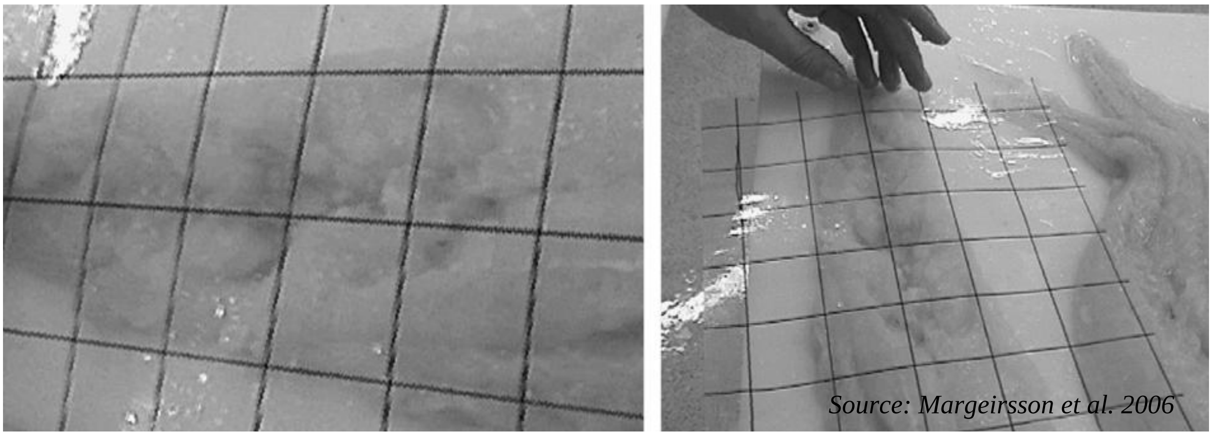

Figure 6: Gaping measured by putting a transparent plastic card with a grid on the fillets.

3.1 Data analysis

After having collected all the data, it was used for various calculations such as:

- Fillet yield
- Parasites pr. kg
- Gaping pr. kg
- Head proportion
- Condition factor

Fillet Yield was calculated using the formula: weight of fillets / weight of whole gutted fish on land (%).

Parasites and gaping per kg were simply calculated by dividing the number of parasites and volume of gaping into the weight of the fillets.

The head proportion was calculated by finding out the proportion (%) of head against the whole gutted fish on land.

The condition factor describes the relative robustness, or degree of well being of a fish and is calculated using the Fulton's K Factor, where $K = 100 (W/L^3)$, W is the round weight and L is total length (cm) (Williams 2000).

This information was then examined further using regression analysis to find a functional relationship (multivariate linear model) between the response variables and the independent variables after a thorough outlier detection of all variables. The variables were compared using the 95% Confidence Limits of the means for each factor using MS Excel.

4 RESULTS AND DISCUSSION

This chapter focuses on the results and discussion from analysing data for this project, and it will be divided into five subchapters. The first subchapter is about the incidence of parasites in different fishing grounds and the interference of size and maturity level in the parasite occurrence. The second is about the interference of fishing ground, volume of haul and maturity level in the gaping occurrence. The third is about the interference of fishing ground, maturity level and head proportion of the fillet yield. The fourth is about the condition factor in different fishing grounds. Finally, the fifth is a review of the overall results and a discussion of this research.

4.1 Parasites

The presence of parasites in fillets has been a serious problem for the fisheries industry for several decades (Would *et al.* 2001) and for some producers this is one of the most expensive factors of cod processing, because of the cost of cleaning the fillets and the decrease in yield and value (Dagbjartsson 1973).

Figure 7 shows that a difference was observed in parasites between fishing grounds and period of time. The figure shows that there is not a statistically significant difference between them, except between trips 1 (624/674) and 2 (324), with higher values observed in trip 1. This could be explained by the fact that the catching was done in different fishing grounds (Figure 2). Gudmundson *et al.* (2006) studying parasite occurrence, classified the fishing grounds according to incidence value and their data agreed with the data from this research. Other authors like Margeirson *et al.* (2006) found significant differences in parasite incidence in different catching locations. In the second trip there was less parasite incidence, which might be because this fishing ground is more distant from the coastline, and according to Dagbjartsson (1973) and Margeirsson *et al.* (2007), the number of parasites generally increases with less distance from shore.

An international standard, Codex Alimentarius, allows a maximum of 5 worms/kg fish. It should therefore be emphasised that the presence of worms in fish offered for sale does not imply carelessness or bad practice on the part of the processor (Wootten and Cann 2001).

By studying the fishing ground in different seasons it is possible to gain information about the parasite incidence in different times and areas, and consequently to choose the better fishing ground and the best time to fish there. Following recent recommendations by the Marine Research Institute, based on recent poor recruitment of the cod stock, the government decided in July 2007 that the TAC (Total Allowable Catch) for cod in the fishing year 2007/08 should be set at 20% of the fishable biomass decreasing the total catch by around 30% (130,000 tonnes) compared to the last fishing year (193,000 tonnes) (Icelandic Ministry of Fisheries 2007). Therefore, this information is important to the fisheries sector to improve the quality of the raw material and profits to the processing companies.

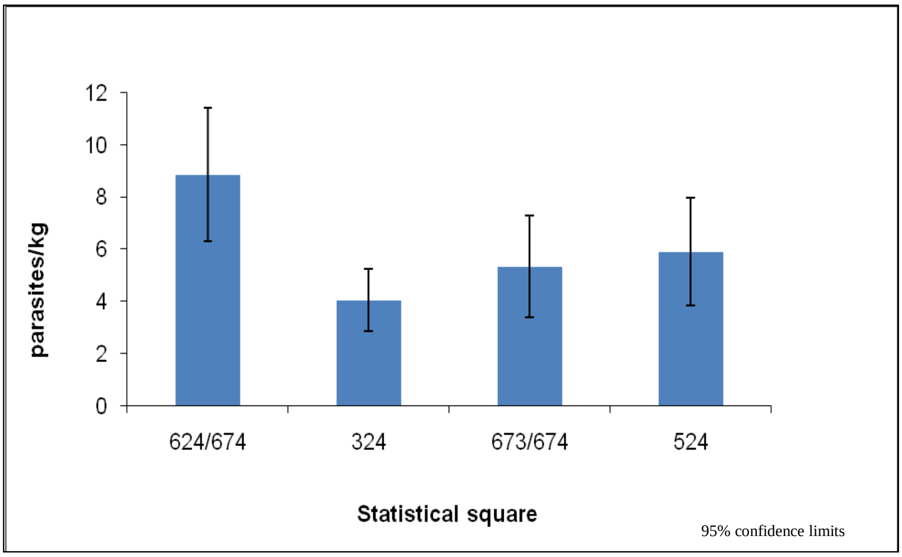

Figure 7: Comparison of parasites/weight of fish in kg among different fishing grounds.

Some authors have studied the significant effects between size of fish and parasite incidence (Birgisson 1995, Wootten and Cann 2001, Malgorzata Pilecka-Rapacz and Ewa Sobecka 2004, Margeirsson *et al*. 2007).

In general, large fish tend to be more heavily infested by round worms than small fish of the same specie (Wootten and Cann 2001). Therefore, the bigger the cod is, the more parasites it probably contains (Birgisson 1995, Margeirsson *et al.* 2007).

According to the data found in this research (Figure 7) there was a tendency that smaller fish presented more parasites per kg. This could be explained by the fact that the fish can grow faster than the number of parasites, or because the bigger cod (average 70.4 cm) are from a particular fishing ground with lower parasite incidence (Figure 8).

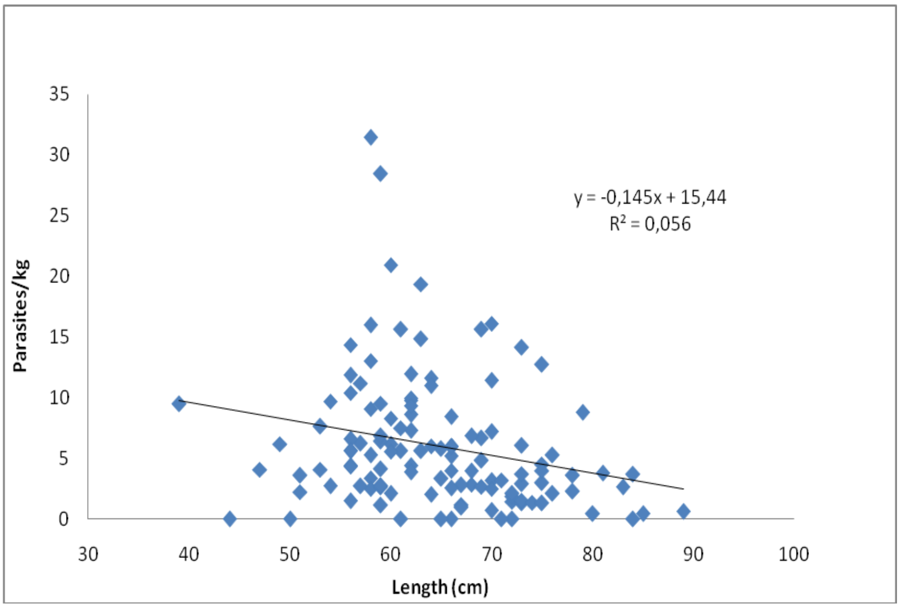

Figure 8: Comparison of length of the fish (cm) and parasites/weight of fish per kg in different fishing grounds.

According to Figure 9, the incidence of parasites decreased in relation with the maturity level. This could be explained by the fact that all the samples from trip 1 are from maturity level 1 (Figure 10), and according to Figure 2 that fishing ground has the biggest parasite occurrence among the fishing grounds studied. A statistical difference was only noticed between samples from maturity levels 1 and 4. In Figure 10 it is possible to see in each fishing trip (except fishing ground 624/674) the difference between maturity levels in each of the fishing grounds. However, it is necessary to collect more data to conclude something about this.

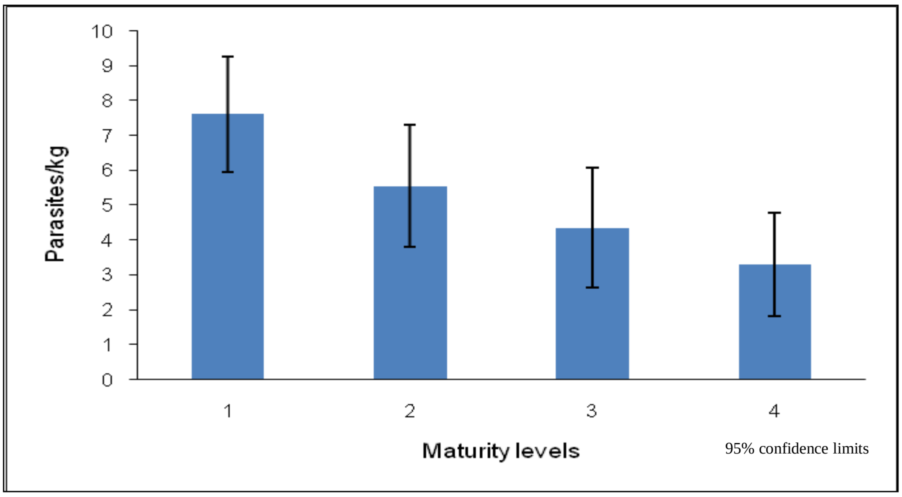

Figure 9: Comparasion of parasites/weight of fish in kg and different maturity levels.

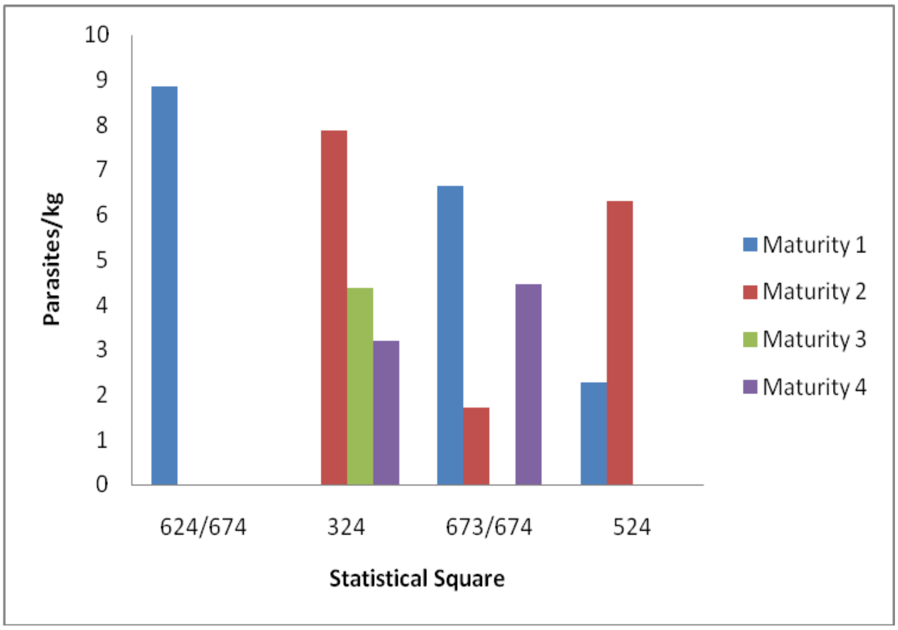

Figure 10: Comparison of parasite/weight of fish per kg and maturity levels in different fishing grounds.

4.2 Gaping

The term gaping is used for the undesirable separation of muscle blocks in a raw fillet (Lavety 2001). Many variables can affect gaping such as fishing ground, time-lag from catch to processing (age of the raw material), volume in haul, seasons etc. (Margeirsson *et al*. 2007).

The data presented a significant statistical difference between some of these variables (Figure 11). Gudmundsson *et al.* (2006) found higher gaping occurrences, studying the same areas during different periods.

The volume in the haul (Table 1) had a positive correlation with gaping (Figure 12), the bigger the haul the bigger the gaping. Other factors such as fishing ground, season, time lag of haul, could also affect the gaping incidence.

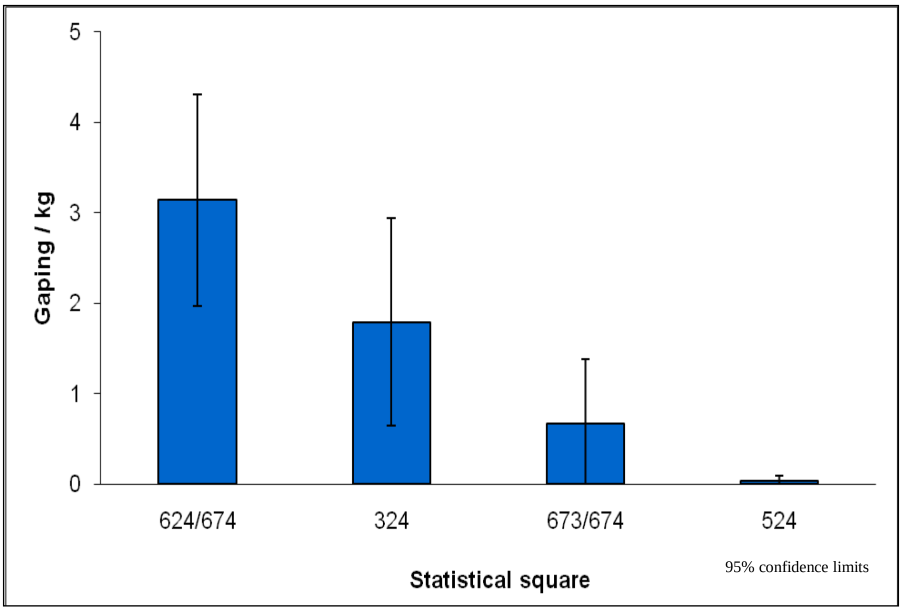

Figure 11: Comparison of gaping among the different fishing grounds.

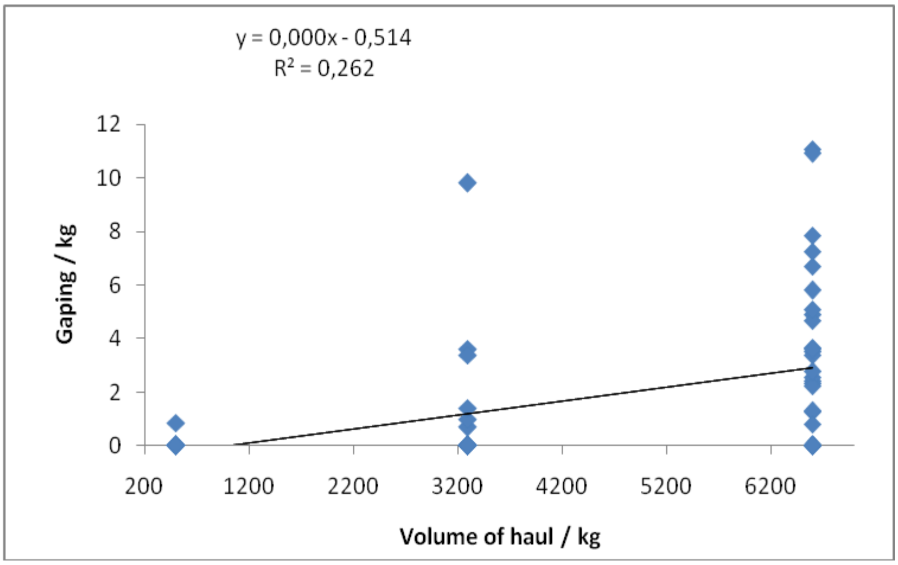

Figure 12: Comparison of gaping/kg and volume of haul/kg.

Some differences between the maturity levels on the different trips (Figure 13) were discovered. In maturity level 3, a high gaping incidence was discovered when compared with the other levels. There are many variables that might have more influence on gaping incidence, like for example fishing ground. But each different maturity level was not represented (found) in the different fishing grounds.

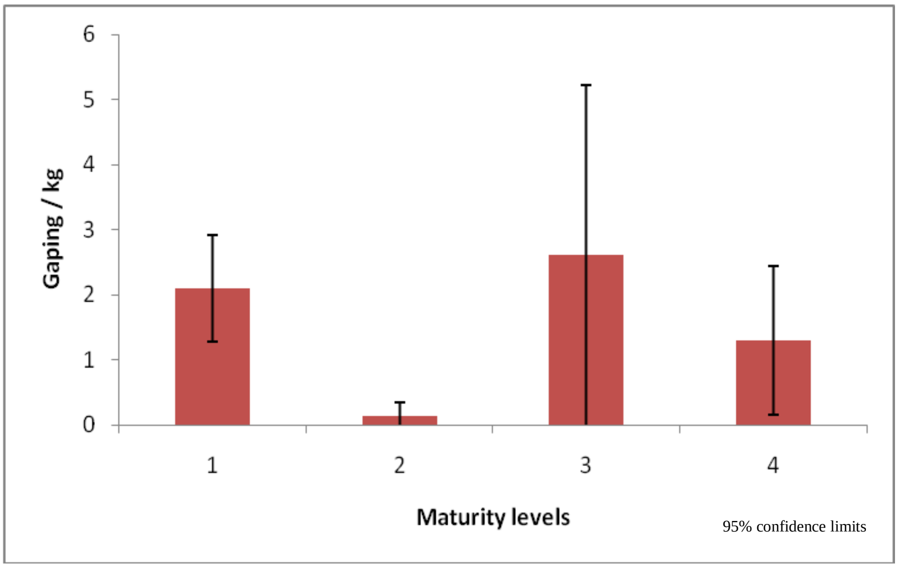

Figure 13: Comparasion of gaping/kg and different maturity levels.

4.3 Fillet yield

Fillet yield is probably the single most important factor influencing the return of cod processing (Cibert *et al.* 1999) and, according to Margeirsson *et al.* (2007), the fillet yield might be improved by controlling where and when the cod is caught, depending on the season. Some differences between the different fishing areas can be seen in this study (Figure 14). There is not a statistical difference between the fishing grounds in general, except between trip 2 (324) in relation with trip 3 (673/674) and trip 4 (524).

The average from the fishing ground 324, 673/674 were lower in comparison with data from Gudmundsson *et al.* (2006) that found a 50-52% FP-ratio for these areas. This maybe caused by different types of processing equipment (e.g. filleting machines) in these two differents studies.

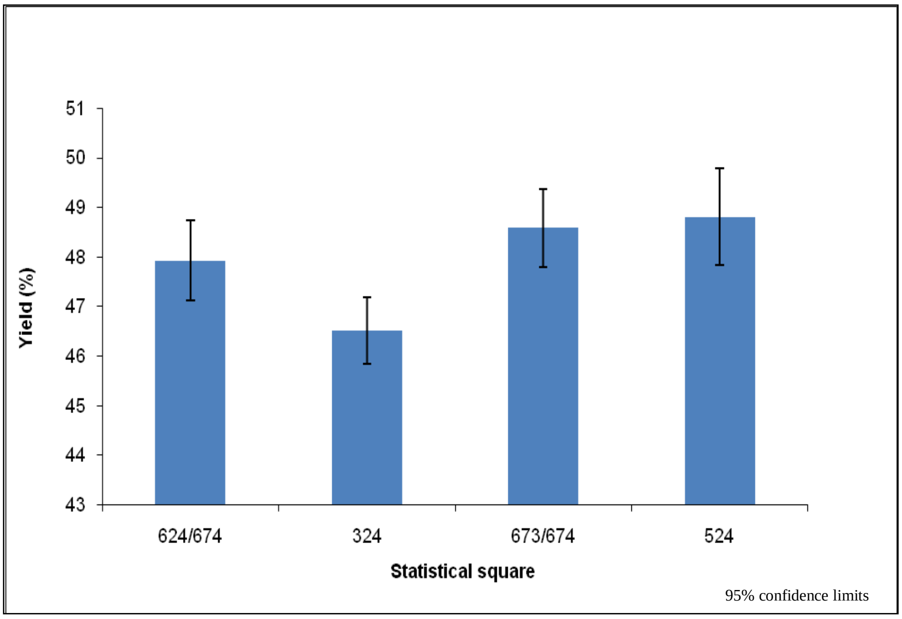

Figure 14: Comparison of yield processing in different fishing grounds.

According to the data from this research, there was a tendency to find lower fillet yields in higher maturity levels (Figure 15). Some differences between the different maturity levels can be seen in this study. In general there is not a statistical difference between the maturity levels, except between maturity level 4 in relation with maturity levels 1 and 2.

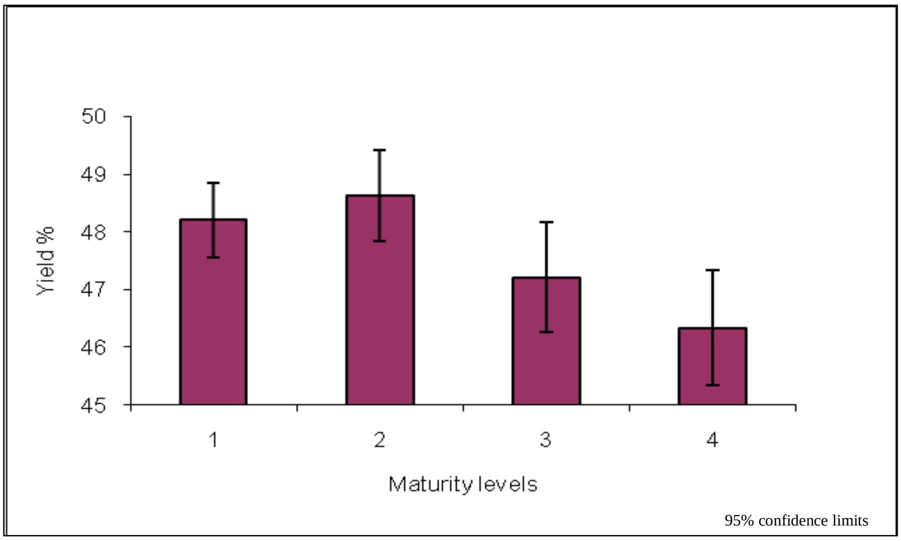

Figure 15: Comparison of fillet yield (%) in different maturity levels.

According to the data found in this research (Figure 16) bigger head proportion (%) was shown to cause lower fillet yield (%). These data are consistent with Margeirsson *et al.* (2007) that found negative correlation between fillet yield and head proportions.

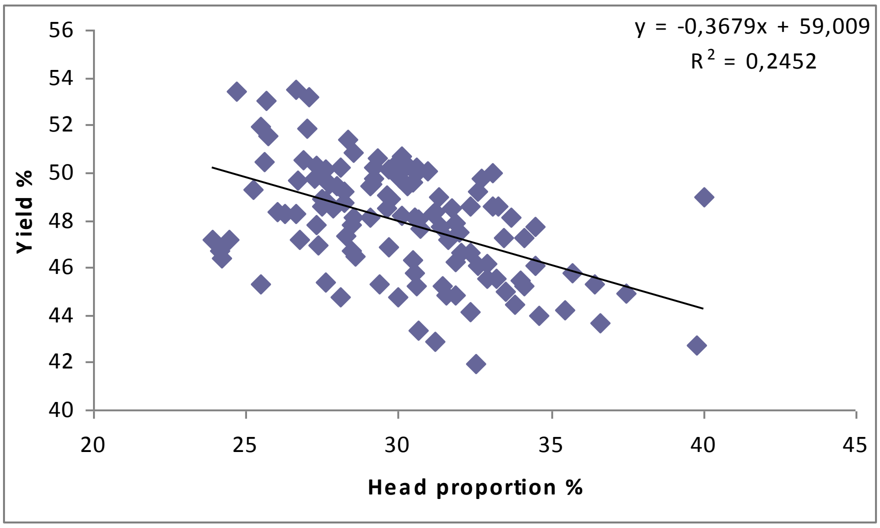

Figure 16: Comparison among head proportion (%) and fillet yield (%) in different fishing grounds.

4.4 Condition factor

The condition factor is used to determine the physiological state of the fish (Lizama *et al.* 2002). No significant statistical difference between them was found. Except with trip 1 (624/674) (Figure 17). Some authors have found a positive significant correlation between fillet yield and the condition factor, and have stated that sometimes there is a considerable difference in the condition factor and fillet yield between catching areas (Eyjolfsson *et al*. 2001). Therefore the condition factor can be used as an indicator for fillet yield (Margeirsson *et al.* 2007).

Differences in the condition factor are related to the spawning cycle, because fish lose condition during the spawning season. The North Sea cod are, for example, not usually completely restored until late July after having spawned in the spring (Love 2001).

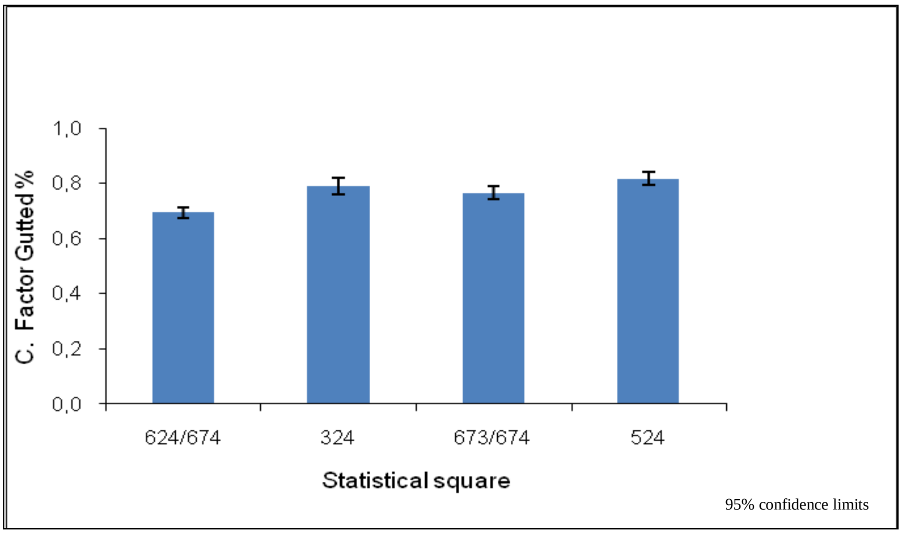

Figure 17: Comparison of the condition factor gutted (%) in different fishing grounds.

4.5 Overview of the findings from the research

There are some factors that can influence the quality of raw material from catch. In this research some of them were studied: fishing ground, parasites, gaping, fillet yield, condition factor, size, maturity levels and head proportion, with data from four different fishing grounds. These results are a part of a larger project at Matis – *Cod: from catch to consumers* which is supposed to take two years, including a total of 15 fishing trips. There are many variables that can influence the results of this study, because during the collection of data different vessels were used, different volumes and times of haul, the collections were done in different season and fishing grounds, therefore it is necessary to take these important variables into account when analysing the final results. The final conclusions will certainly be interesting when all the data have been gathered and processed, but until then it is possible to observe and partially concluded the following:

- The fishing ground can influence the incidence of parasites.
- Some differences between the maturity levels and incidences of parasites were found.
- A relationship between the fishing ground and gaping were found.
- The volume of haul can influence gaping incidence.
- The fishing ground can influence the fillet yield.
- There was a tendency to find a lower fillet yield in higher maturity levels and higher head proportions.It was only possible to draw the above-mentioned conclusions because of the ability to trace the fish from catch to processing.

5 THE FISHERIES SECTOR IN BRAZIL

This chapter is about the fisheries sector in Brazil and it is divided in two sections. The first is about the main characteristics of fishing in Brazil and the second is about the quality control and traceability system in seafood products from Brazil.

5.1 Main characteristics of fishing in Brazil

The fisheries sector generates approximately 800 thousand directive jobs, and the industry is composed of around 300 companies related to catching and processing. Already the total national fleet consists of 25,000 boats, of which approximately two thousand are industrial fishing vessels and the others consist of an artisanal fleet and small scale fishing (Dias-Neto and Murrul-Filho 2003).

Historically, fisheries have not played a particularly prominent role in national politics. However, if one considers the importance of fisheries in providing jobs and food to the population, fish is the most important source of protein and the national fishing industry is one of the few activities that has a high demand for unqualified labour, in some cases providing the only available job opportunities for certain excluded groups. Those facts show that the Brazilian fishing sector is a fundamental component for the social and economic situation of the country (Dias-Neto and Murrul-Filho 2003).

Marine fishing in Brazil can be classified in to the following four categories: amateur fishing, subsistence fishing, artisanal fishing (small scale) and large-scale industrial fishing. Amateur fishing is mostly practiced along the coastline, mainly in connection with tourism and sport, and the take from that activity cannot be sold or industrialised. Fishing for subsistence is exercised with the objective of obtaining sustenance with no commercial purpose, and is practiced with rudimentary techniques (Dias-Neto and Dornelles 1996).

Artisanal fishing is used both for commercial purposes and also with the objective of sustaining the family (Dias-Neto and Dornelles 1996). Diegues (1983) affirms that artisanal fishing in Brazil is based on the family unit or the neighbourhood group; the boats are small and also used for transport. The marketing from artisanal fishing is dominated by the people that do the commercialisation, generally someone from the community who is specialised in selling the fish, both to the consumers and processing companies.

In 2004 with Law N^0 3, May 12, about the General Fisheries Register (RGP) was passed, where the Special Secretariat for Aquaculture and Fisheries of Brazil (SEAP-PR) is responsible for certifying all the fisheries sector such as fishermen, boats, producers, companies (processing, marketing) and all activities linked with fishing. As a result the sector began to become more organised.

A programme that monitors the marine fisheries activities represented by the ESTATPESCA Project was created in 2005. This project has support from SEAP-PR /PROZEE (Foundation of Research Protection of Alive Resources in the Economic Exclusive Zone) / IBAMA (Brazilian Institute of Environmental Resources) and is called “Monitoring of fishing activity along the Brazilian coastline” (SEAP 2006).

The monitoring project originated due to the need for permanent action to supervise the exploitation of the main fishing stocks, in order to secure continuous flow of essential information for definition of the fishing policy that can guarantee the sustainability of the fishing activity (SEAP 2006).

The Brazilian coastline has a large diversity of environments and this is represented by the characteristics of the fishing activities. In 2004, the total fish production in the north was 18.7%, fished by a fleet of around 8,000 vessels, while along the coastline it was done by artisanal fishers with small and medium boats, and in the areas far from the coastline it was carried out by an industrial fishing fleet consisting of 2.6% of the fishing fleet, but artisanal fishing is predominant. The northeast coastline had a total production of 29.1% and in that region the artisanal fishing is predominant with around 40,000 small boats, but only 0.6% is done through industrial fishing. The southeast produced 21.7% and the fishing fleet there is around 4,600 boats, most of which are more than 8 m long. But the industrial fishing is only responsible for 1% of the catch in that region. The south had a bigger percentage participation in the annual total production, or around 30.5%. In this region there are some species with relevant economic value, and because of that, the fisheries in the south are more developed compared with other Brazilian regions. The fishing fleet was estimated at around 7,900 boats, with 5,500 less than 8 m long, therefore only 0.6% of the total catch comes from industrial fishing. In short, only 0.7% of Brazilian fisheries production is from industrial fishing, the artisanal fishing being the prevailing party in all Brazilian states (SEAP 2006).

In 2004, the production of seafood products generated an estimated US$ 1.75 billion, with a significant part coming from the export of high value products such as fresh, chilled and frozen products, with an emphasis on lobsters, shrimp and tuna, generating around US$ 0.85 billion. The industrial fisheries companies are composed of approximately 300 factories, which have a good structure to process the raw material. Today with the total catch decreasing, aquaculture has become more important to the sector (SEAP 2006).

Despite the recognised importance of fishing in the social and economic development of the country, the data from Brazilian fisheries are limited and hard to obtain, mostly because of a lack of human resources and data from the governmental agencies support (SEAP 2006).

5.2 Quality control and traceability system in Brazilian fishing

The world's seafood consumption in traditional markets has not changed drastically for a long time. What has changed, however, is the share of countries such as Iceland, Norway, Canada and USA, which have been prominent high-income supply countries and are now seeing their share of the world supply of fish and seafood products declining. Less developed countries such as those in Latin America and Asia are becoming increasingly important to the world fish trade (Bulmer 2004).

Due to the expansion of the international fish trade, and more recently the growth of fish retailing in food supermarket chains, stakeholders in the supply chain are increasingly focusing on quality control and traceability. Among other issues, which are becoming increasingly important are environmental issues, social responsibility, and sustainability. In Brazil, consumers sometimes distrust the quality of the seafood, because the fish consumption is lower in comparison with other countries. It is therefore important for local producers to assure the consumers of the quality of their products

The Brazilian government has already or is presently in the progress of implementing legislation to make traceability systems mandatory, but until now the industry itself has mostly led the way in developing and adopting these systems. The EU has imposed some restrictions on imports of Brazilian fish products with respect to quality and traceability, and now the traceability programme for seafood is a necessity for local and international marketing in Brazil.

Importers in the EU are increasingly asking suppliers from developing countries to provide evidence of the implementation of traceability systems for their fish and seafood products. Bilateral agreements between the fish exporter and the fish importer can overcome legal and practical problems in terms of traceability. This type of agreement can clarify minimum traceability requirements, both to the industry and fish inspection services. They can also allow fish exporters to differentiate more easily between regulatory requirements and non-regulatory traceability (Lupin 2006).

Thus, the whole chain from vessels to retailers can be managed in a more effective way, when the traceable information is actively used along with quality and safety information, to enhance mutual trust and cooperation between every link in the chain (European Union 2002).

In the case of primary production in Brazilian fisheries, the most important question is: how can a developed country like Brazil, with more than 90% of the catch deriving from artisanal fishing and small exploitation carried out with boats that do not have the adequate facilities to ensure quality control and traceability systems of the catch, operated by local fishermen without the necessary qualifications, cope with regulatory and contractual traceability requirements and quality control?

Currently, the monitoring of fishing vessels by satellites is considered fundamental in the fisheries sector management, having been implemented in all traditional fishing countries in South America. In Brazil, since 2000 until now, the traceability was restricted to fleets of foreign vessels. This experience gave excellent results and was very important for the purpose of collecting data and furthermore fundamental for the formulation of a National Programme. This traceability was extended to include the national fishing fleet, though for the moment it is limited to the industrial fishing fleet only.

The main objective of this monitoring project is to provide security for the workers of the industrial fishing fleet in case of accidents at sea, enable holders to keep track in real time of the fishing, allow the government to verify the use of the fishing permission in order to control the use of federal subsidies for the fishing. With this information, it will be possible through GPS (Global Positioning System) to identify each vessel, its location and consequently the fishing grounds.

The National Programmes of the Traceability of Fishing Vessels by Satellite – PREPS does not include in its objectives the collection of information about the origin of the raw material during catching. The industrial fishing sector is adopting the GPS system due to the new legislation for the fisheries sector and the industrial fleet will most certainly be able to include information about the fishing grounds i.e. where the fishing took place, which is essential since this is the first step in a traceability system. The vessels which can utilise GPS in Brazil are still very few since the artisanal fleet does not generally have preconditions to collect these data, but it is important to begin to implement it in a small part of the fleet, and eventually to implement it in all of the fleet.

Traceability concerns only the ability to trace things and this is very important information for the security of the food chain, but this information does not confer quality of the raw material. Because of this, it is important to have the support from the government to study the factors and variables influencing the quality of the raw material in relation with the catch. A few attempts have been made to study the quality control of the raw material and final products inside the processing companies, but more research is necessary. Moreover, research that would include collection of data from the time of catch, the influence of the different fishing grounds, seasons, fishing gear, time of the haul, age of the raw material, and the influence of these factors on quality parameters that affect the raw material, would be very useful. Such information could be used to improve the quality of the raw material and consequently could greatly benefit the Brazilian fisheries.

A possible interpretation of current traceability regulations, particularly in developed countries, could be that in addition to the requirement to keep records of information, they create a legal right for the inspection services (competent authorities) to access the information (Lupin 2006).

These improvements in the food and fish supply chain are also apparent in large cities in developing countries. This is a positive development towards world food security. Developing countries have also benefited from the improvement in traceability associated with quality control, which has contributed to the expansion of the international fish market during the last decades.

6 CONCLUSION

This project has shown that studying the variables from the catch and comparing them with information from the processing can be helpful when improving the quality of raw material. It has reviled that the traceability system is linked to the fishing quality control, and can be used as a tool to improve the quality of the seafood products. However, it is important to note that the traceability system alone does not improve the quality of the product. That is why it is important that quality control and traceability work together.

The results also show that various variables can affect quality, such as:

- The fishing ground can influence the occurrence of parasites and this factor affects the quality of the raw material. Therefore, it is very important to the fishing companies to have good knowledge about the fishing ground and to know which period and place is best for fishing.
- The volume of the haul can influence gaping incidence, therefore small volumes are recommended during the catching to produce raw material with better quality.

One of the objectives of this project was to use the knowledge from Iceland to come up with some recommendations for the Brazilian seafood industry concerning the subject. It is apparent that Brazil could definitely learn something about quality control and traceability from the Icelandic fishing industry. The following recommendations concerning Brazil are therefore the following:

- To recommend and assist the correlation between a traceability system and quality control from catch to the consumer.
- To suggest to the Brazilian Competent Authority the revision of the country's fisheries legislation to enable the implementation of traceability systems.
- To suggest to the Brazilian government to adopt through the National Programmes of the Traceability Fishing Vessels by Satellite – PREPS, the collection of data on catching origin.
- To adopt as a standard the collection of information regarding fishing grounds, catching time, landing day and time, fishing gear, processing method onboard and temperature records of all the catch, using the traceability system as a tool to improve the quality of raw material.

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