SJÁVAR KLASINN

455,000 tons into the dustbin/sea

A statistical analysis of the utilization of cod in the North Atlantic Ocean

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Abstract

The persistent depletion of fish stocks in fishing zones around the world has increased the urgency of complete fish utilization. This report aims to answer how much cod is actually wasted through discards at sea and waste in production in the North Atlantic Ocean by using available statistical figures. Ultimately, utilization was compared among four cod fishing nations, Canada, the Faroe Islands, Greenland and Iceland. The results are that there is a statistically relevant difference between the utilization rates of these countries as Iceland and the Faroe Islands surpass Greenland and Canada with the average utilization rate in the area being 48.8%. While these results undoubtedly suffer from some data errors and simplifications in the method used, they should give some ideas on the enormous amounts of fish that goes wasted every year in the North Atlantic. The results are a good start but future research is needed in order to comprehend and subsequently increase fish utilization in the area.

Glossary of terms

Aquaculture	Aquaculture, also known as aquafarming, is the farming of aquatic organisms such as fish, crustaceans, molluscs and aquatic plants under controlled conditions.
By-products	Parts of the fish not generally considered for production purposes such as heads, bones and viscera.
Discards	Discards, or discarded catch is the portion of the total catch, which is thrown away or dumped at sea for whatever reason.
Landings	Landings refer to the portion of the total catch brought ashore or transhipped from the vessel.
Live weight	Data on landed cod catch is typically expressed in live weight, the weight of the catch when it was removed from the sea. In order to convert landed weight to live weight, conversion factors are used as the fish may have been headed, gutted, filleted etc. before it is landed. These conversion factors are constructed based on species, fishing zone, size, season, and processing methods.
Utilization rate	The proportion of total catch (live weight) available for processing that is either consumed locally or exported abroad.

Table of contents

List of Figures

List of Tables

Introduction

The problem of waste in fish production because of discards and mismanagement has been stressed globally for decades. More recently, there has been an ongoing trend of increasing awareness of complete utilization of fish catches. In many fishing zones the depletion of fish stocks has forced new regulations and reduced the size of the catch available to each country. In order to make up for lost profits fisheries have progressively turned to utilizing new parts of the fish.

Fish capture is in itself somewhat imperfect making discards an unavoidable problem to some extent. The degree of utilization however is more manageable. Once caught, the main natural constraint to optimal use of the fish is derived from spoilage, that is, fish decays more rapidly than almost any other food and thus loses its value as foodstuff. Numerous preservation methods exist - including chilling, freezing, canning, boiling, smoking, drying and salting as well as packaging and refrigeration. Utilization is thus heavily dependent on how well these processing techniques are managed.

Another factor central to the discussion on utilization are by-products, products that are made out of those parts of the fish not usually considered for production. The field of fish by-products has experienced increasing growth and innovation during the last decade and production has increased significantly.

This report should be regarded as a starting point in a larger and more extensive project with the overall aim of increasing fish utilization in the North Atlantic Ocean, increasing value added in fish production and developing cooperation between companies and other involved parties. To further develop the project, the Iceland Ocean Cluster seeks to engage in extensive international collaboration with governments, institutions and firms.

The objective of this report is to use available statistical figures to hypothesize about the utilization of cod catches in the North Atlantic Ocean. The aim is to map out an overall

picture of how much of the annual cod catch in the North Atlantic is wasted through discards at sea and waste in production. The research relied on data from official institutions located in the countries in question as well as other sources.

We believe the results of this project are of significance to governments, academic and research institutions and other supporters of the topic. Furthermore, the results also bring commercial value to the fishing sectors in the North Atlantic, strengthening the ocean related firms abilities to share their knowledge on fish utilization with each other.

1.1 Previous research

The topic of fish utilization has indeed been explored in the past. Considerable research on discards at sea has been done but less on waste in the production process. A few reports have been written concerning fish by-product utilization but exclusively on an individual country basis. Furthermore, the two topics have seldom been combined and cod utilization in the North Atlantic as a whole has not been researched to any great extent.

Norden (The Nordic Innovation Centre) published a project report titled *Maximum resource utilization - Value added fish by-products* in 2009. The project's objective was to improve the competitiveness of the fish industry by industry driven research. This report exhibited the potential of increasing the value of processing under-utilized ingredients from fish, including fish mince, gelatin and fish protein. It did not however focus on the current utilization of fish stocks, only opportunities offered by new methods and increased utilization.

Arason, Margeirsson, Sigurgisladottir & Vidarsson (2010), all researchers at Matís ohf, demonstrated that there is a substantial difference between utilization in processing at sea and processing at land in Iceland. Their conclusion was that there are ample opportunities for increasing utilization at sea. Their research also suggested that most of the bigger fishing vessels in Iceland did not bother to bring by-products back to land for processing, opting instead to discard most of them into the sea.

The Rubin foundation[1] in Norway has stated that Norwegian by-product production increased from 185.000 tons in 1991 to 800.000 tons in 2009 along with increased total production volume. Still, only 10% of that was reported to be utilized for high quality products intended for human consumption such as: foodstuff, health products, clothing materials etc (Stiftelsen Rubin, 2000; Stiftelsen Rubin, 2012).

A 2011 study by Iversen, Klev, Bergersen, Storehaug and Røtnes testified that even though the Norwegian fish catch is on average double that of the Icelandic the value added from production in Iceland is almost equal to that in Norway. The cause: superior utilization of fish products in Iceland.

1.2 Scope and limitations

The initial intentions were to analyze data from the main countries fishing for cod in the North Atlantic. These include Canada, Denmark, The Faroe Islands, Greenland, Iceland, Norway, Russia, Sweden and The United Kingdom. However, in gathering the data it was found that only four countries presented data that was considered adequate enough for the analysis. This may stem from the different sizes of the countries, the amount of international trade each country has, the economic importance of fisheries or some other reasons. The four countries the analysis eventually focused on are Canada, The Faroe Islands, Greenland and Iceland.

Due to the inherent complexity of the subject, some assumptions had to be made to simplify the process and make comparison between countries easier. Although those assumptions simplify reality, the challenge of arriving at a conclusion within the allotted time and resources of the project deemed them a necessity. Despite any errors resulting from simplifications we are confident that this analysis at least serves as an indicator of the differences in utilization between countries and hopefully reveal many of the active trends within specific countries and the North-Atlantic as a whole.

[1] RUBIN was established in Norway in 1992, and works for increased and more profitable utilization of by-products from the fisheries and fish farming in Norway.

1.3 Structure

Following this introduction, the methodology used is described in detail after which the results of the analysis are demonstrated, broken down by individual countries. Subsequently the results from each country are compared. The last section of the report includes conclusions and discussions.

2 Methodology

A formula was developed to compute utilization in each country. In doing so some general assumptions had to be made:

- It was assumed that the whole weight of each fish could be utilized to some extent. Further processing a certain part of the fish was not assumed to prevent processing of any other parts.

- Fish stocks were all assumed to be of the same quality and no discards occurred because fish was not viable for processing.

- Natural weight-loss resulting from processing (loss of humidity for instance) was assumed to be the same in all countries. Additionally different methods of processing were not assumed to cause statistically relevant difference in natural weight-loss.

- Opportunities for utilizing every part of the fish were assumed to exist in all countries and any discards were therefore assumed to be lost opportunities for utilization and profit.

The formula was based on a simplified model of the fishing industry as shown in figure 2.1. Landed catch was assumed to come from the country's own ships landing in its own ports and from foreign imports. Adding these to the amount of cod created by aquaculture produced the total amount of catch available for processing. The catch was then processed and either exported or consumed domestically.

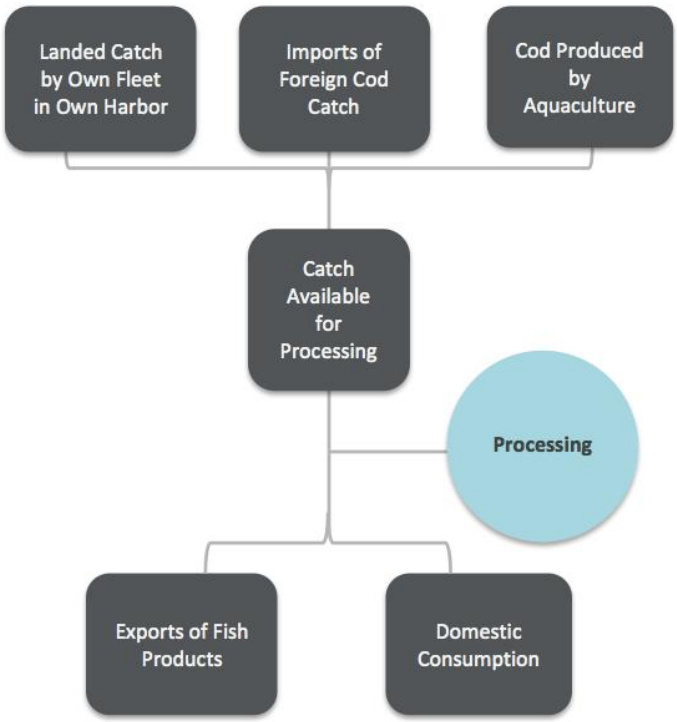

Figure 2.1: Model of the Fishing Industry

By using this model as a basis the following formula was created:

	Landed cod catch by own fleet in own harbor (live weight)
+	Imported cod catch (both landed by foreign vessels and imported separately, live weight)
-	Exported cod catch (both landed by own vessels in foreign harbors and exported separately, live weight)
=	Catch available for domestic production (live weight)

Utilization was then found by computing the rate between the sum of exported processed cod and domestic consumption of processed cod and the catch available for domestic production.

$$Utilization\ Rate = \frac{(Exported\ Processed\ Cod\ +\ Domestic\ Consumption\ of\ Proccessed\ Cod)}{Catch\ Available\ for\ Domestic\ Production}$$

This utilization rate is the arithmetic mean of all processing methods in the given country.

This way of computing utilization however is far from perfect. The computed rate is inherently understated since some of the weight-loss will be attributed to natural weight loss resulting from processing. Additionally inconsistencies both within individual datasets and between them inevitably lead to errors. Despite this the computed utilization rate at least gives a basis for judging to some extent the divergence of cod utilization between countries.

The time period of the data used in the analysis ranges from 1999 to 2010 and corresponds to the availability of data in each case.

3 Iceland

For centuries, cod has been Iceland's primary marine product. Following the rapid industrilization of the Icelandic fishing industry in the late ninteenth and early twentieth century the species also became one of the countries biggest scource of income. Today the species contributes roughly 40% of Icelandic export earnings from seafood the last decades (Statistics Iceland, 2012a).

3.1 Overview of data

The most ideal available data for the analysis came from Iceland, but even so the statistics used contain certain defects. As mentioned before, the mechanics used in the analysis required four sets of data.

Cod catch landed by own fleet in own harbor

Statistics Iceland are responsible for processing and publishing statistics on fish catches from the Directorate of Fisheries. The accuracy and reliability are dependent on fulfillment of laws that make weighing fish on a certified scale mandatory. Furthermore, the catch is calculated to live weight using conversion factors, so this has an influence on precision as well (Sigfinnson, G., Business statistics department at Statistics Iceland, personal communication, May 25th, 2012).

Imported cod catch

Statistics Iceland keeps detailed records of catch purchased by Icelandic fish processors from foreign vessels. This data is collected from the same statistics as data on domestic cod catch and reliability is dependent on the same elements (Sigfinnson, G. personal communication, Business statistics department at Statistics Iceland, May 25th, 2012).

Information on total cod imports was not available since Statistics Iceland does not classify these figures by species. This should not influence our analysis for two reasons:

a) We assume imports of cod for domestic consumption to be virtually non-existent in Iceland

b) This set of data is more fitting to our analysis since it involves only raw materials for production, in live weight

It thus should be noted that Iceland was the only country that presented data on imports expressed in live weight, making the computed utilization rate understated when compared to the other countries.

Aquaculture

Cod farming in Iceland as a profession is a relatively new idea and cod farming has not taken place yet on a commercal basis. Correspondingly, consistent data is not available.

Exported cod catch

Information on trade of goods is primarily based on customs declarations and is made available by Statistics Iceland. The data is also collected from the Icelandic Directorate of Shipping and the Civil Aviation Administration. Exporters are obligated to turn in customs declarations making it assumable they cover most of the external trade made by Icelandic parties. The figures however unavoidably hold particular errors due to time lag as well as registration errors, missing information or wrong information (Sigfinnson, G., Business statistics department at Statistics Iceland, personal communication, May 25th, 2012). Since fish drying is a very important industry in Iceland, actions were taken to correct the effects of water loss in the process on the computed utilization rate. Data on exports of dried cod was obtainable, so these numbers were converted as if no water loss had occurred[2]. Since (i) cod drying does not represent nearly as large a share in the cod exports of the other

[2] According to Matis, cod loses 75-80% of its weight when dried. In our calculations, the lower boundaries were used.

countries and (ii) export data divided into dried cod was unavailable in those cases, these conversions were considered practically unnecessary as well as impossible for Canada, the Faroe Islands and Greenland.

Domestic consumption

Throughout the data accumulation, statistics on domestic consumption proved to be the most arduous to attain. The Icelandic Directorate of Fisheries (I.D.F.) gathers this information from weighing and allocation reports it retrieves from producers and suppliers. (Directorate of Fisheries, 2012).

3.2 Computation of utilization rate

The computation of the utilization rate is seen on table 3.1. It can be seen that the amounts of imported fish catch, aquaculture production and domestic consumption are fairly insignificant. What can be perceived from these numbers is that the utilization rate has been rising for the past decade.

Table 3.1. Computations for the utilization rate in Iceland (Statistics Iceland,2012a; Statistics Iceland,2012b; Statistics Iceland 2012c; Directorate of Fisheries, 2012 and own calculations).

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Total catch of own vessels landed in own port	238,324	240,002	213,417	206,405	227,258	212,456	199,375	174,436	151,452	188,976	178,516
Imported fish catch	3,882	2,326	6,288	1,932	953	2,191	2,002	2,114	3,896	529	425
Aquaculture production	0	0	0	0	0	0	0	0	0	0	0
Catch available for processing	242,206	242,328	219,705	208,337	228,211	214,647	201,377	176,550	155,348	189,505	178,941
Domestic consumption	864	909	769	485	319	269	438	290	331	657	576
Exports	145,525	150,513	153,843	157,331	167,863	153,721	150,587	138,448	125,070	154,802	127,305
Domestic consumption and exports	146,389	151,422	154,612	157,816	168,182	153,990	151,026	138,738	125,401	155,459	127,881
Utilization rate percentage	60.30%	62.35%	70.27%	75.69%	73.66%	71.71%	74.94%	78.55%	80.68%	81.97%	71.37%

Figure 3.1 shows a definite upward trend as the rate climbed by over 10% in the years 2000-2009, from 60% to 82%.

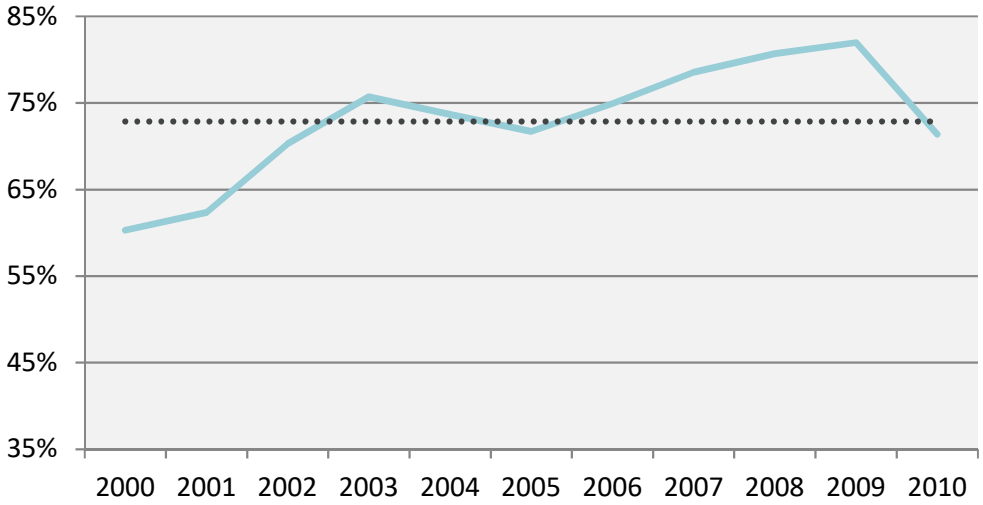

Figure 3.1: Utilization in Iceland from 2000-2010

3.3 Further analysis of utilization

By using the estimated utilization rate, the total live weight of cod wasted in Iceland has been computed in table 3.2.

Table 3.2. Further analysis of utilization in Iceland. Figures in thousands of tons (Statistics Iceland 2012a and own calculations)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Total catch	242,206	242,328	219,705	208,337	228,211	214,647	201,377	176,550	155,348	189,505	178,941
Utilization rate	60.30%	62.35%	70.27%	75.69%	73.66%	71.71%	74.94%	78.55%	80.68%	81.97%	71.37%
Inverse Utilization	39.70%	37.65%	29.73%	24.31%	26.34%	28.29%	25.06%	21.45%	19.32%	18.03%	28.63%
Volume wasted	96,160	125,709	106,520	95,374	104,167	100,576	91,890	76,009	66,901	79,651	83,228

The annual volume of landed versus wasted cod is illustrated in figure 3.2. The total colored area signifies total cod catch, the cyan part represents cod utilized and the grey part denotes total cod wasted.

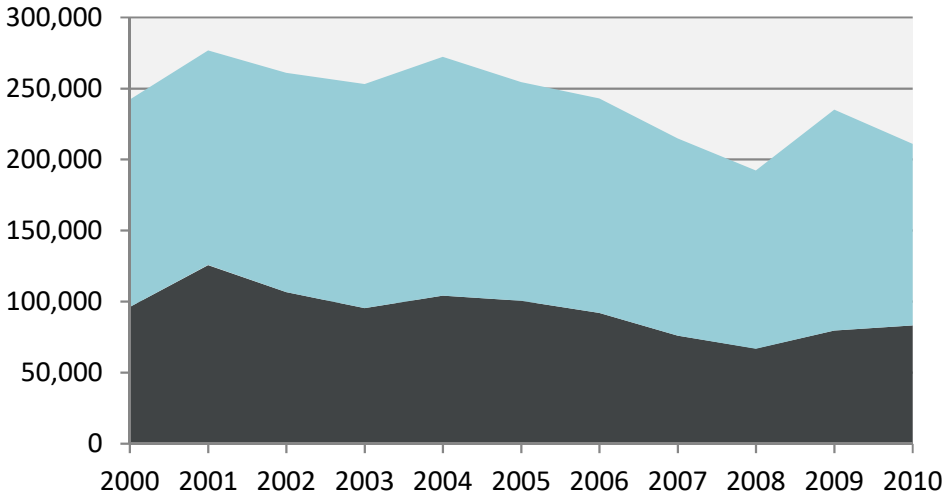

Figure 3.2: Ratio of utilized and wasted cod catch in Iceland 2000-2010

4 Greenland

The fishing sector accounts for the vast majority of Greenland's exports, in fact amounting to around 90% of it (Artic Climate Impact assesment, 2005). In 2011, shrimp played the major role in the countries export earnings, followed by halibut and cod. Exports of cod accounted for approximately 5% of export earnings in the same year while shrimp materialized over 50%. As a result of migration, cod stocks collapsed in the autumn of 1990 and all Greenland cod shipping companies left the country through bankruptcy and sales of vessels. For the last years, however, cod landings have been rising steadily. Virtually all commercial catches are landed and processed for export (Food and Agriculture Organization of the United Nations, 2004).

4.1 Overview of data

Cod catch landed by domestic and foreign vessels

Data on cod catches are published by Statistics Greenland which is under the Department of Finances of the Greenland Home Rule Government. This information comes primarily from logbooks since catch logging has been mandatory since 1996. Foreign vessels are subject to the requirement as well and data is also collected from seafood trading posts when needed (Statistics Greeland, 2012a).

Aquaculture

There is no aquaculture at present in Greenland. Farming of Arctic char and salmon have been tested but deemed impractical due to climate and other natural conditions (Food and Agriculture Organization of the United Nations, 2004).

Exported cod catch

Abundantly disaggregated export data had to be retrieved from statistical yearbooks published in Danish by Statistics Greenland. This material is gathered from customs declarations (Statistics Greeland, 2012b).

Domestic consumption

Due to the easy access to fish and limited population, a trivial part of the commercial production is consumed domestically. As expected, statistics about local cod consumption proved to be unobtainable.

4.2 Computation of utilization rate

Table 4.1. Computation of utilization rate in Greenland (Statistics Greeland, 2012a; Statistics Greeland, 2012b; Food and Agriculture Organization of the United Nations, 2004 and own calculations).

Year	2003	2004	2005	2006	2007	2008	2009	2010
Total catch of own vessels landed in own port	8,392	9,715	10,850	15,563	18,474	25,014	15,384	17,392
Imported fish catch	428	352	649	727	1,587	4,276	2,517	850
Aquaculture production	-	-	-	-	-	-	-	-
Catch available for processing	8,820	10,067	11,499	16,290	20,061	29,290	17,901	18,242
Domestic consumption	-	-	-	-	-	-	-	-
Exports	4,119	4,085	4,286	6,137	7,955	13,263	8,998	8,386
Domestic consumption and exports	4,119	4,085	4,286	6,137	7,955	13,263	8,998	8,386
Utilization rate percentage	47%	41%	37%	38%	40%	45%	50%	46%

Table 4.1 shows the utilization calculations. As mentioned before, practically all fish caught in Greenland is exported. Due to this fact as well as the limited scope of the industry, we assume this data is fairly accurate. The computed rate of utilization in Greenland ranges from 37% to 50% in the years 2003-2010 with a mean of 42,9%. It should be noted that one ought to be precautious when comparing these figures between individual years, as time inconsistencies between data sets inevitably exist.

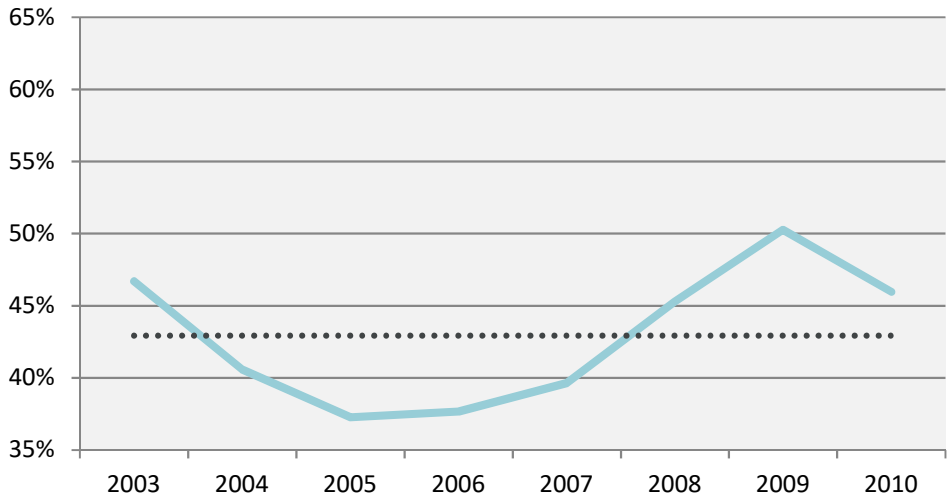

Figure 4.1: Utilization in Greenland from 2003-2010

In figure 4.1, the development of the utilization rate has been charted. As can be observed, the proportion declined considerably from 2003 to 2005 before making a steep ascent from 2006 to 2009.

4.3 Further analysis of utilization

The amount of cod wasted was estimated in table 4.2 by using the utilization rate computed before.

Table 4.2. Further analysis of utilization in Greenland (Statistics Greenland, 2012a; and own calculations).

Year	2003	2004	2005	2006	2007	2008	2009	2010
Total Catch	8,820	10,067	11,499	16,290	20,061	29,290	17,901	18,242
Utilization rate	47%	41%	37%	38%	40%	45%	50%	46%
Inverse Utilization rate	53%	59%	63%	62%	60%	55%	50%	54%
Total amount discarded	4,701	5,982	7,213	10,153	12,106	16,027	8,903	9,856

Figure 4.2 shows the total cod catch in Greenland over the given years. The colored area denotes the total live weight of the cod catch and the red area signifies total cod wasted. The blue part therefore indicates the amount of utilization. What can be read from the chart is that efficiency seems to increase as the total catch escalates in the years 2005-2008. The amount wasted declined less rapidly relative to the amount landed, possibly, at least in part, due to time inconsistencies between data sets.

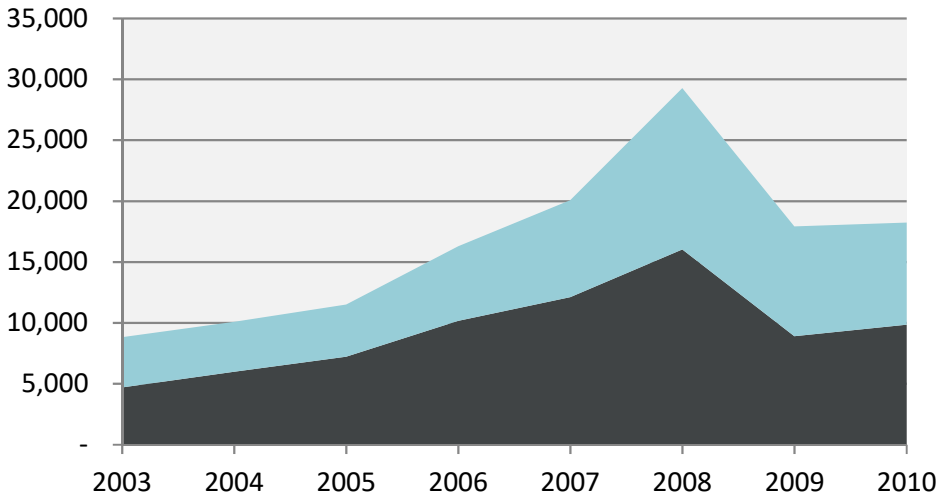

Figure 4.2: Ratio of utilized and wasted cod catch in Greenland 2003-2010

5 Faroe Islands

Like Iceland, the Faroe Islands have a long history of cod fishing. Although devastated by overfishing during the late 80s, the cod stocks around the islands have since invigorated. The islands' economy is mostly dependent on fishing, fish amounting to around 85% of all exports in 2012 with most of it being fish caught at sea. (Statistics Faroe Islands, 2012a).

5.1 Overview of data

Cod catch landed by own fleet in own harbor

Data about the catch of the Faroese fleet from 1999 – 2010 was obtained from Statistics Faroe Islands, which is an independent institute under the Faroese Ministry of Finance (Statistics Faroe Islands, 2012b). Statistics Faroe Islands is by Faroese law required to collect the information from other government institutions and publish it.

Imported cod catch

Data on imported cod catch was obtained from Statistics Faroe Islands (Statistics Faroe Islands, 2012c; Statistics Faroe Islands, 2012d).

Aquaculture production

No data was found regarding any aquaculture production of cod in the Faroe Islands. Statistics Faroe Islands keeps data on aquaculture on the islands but there was no mention of cod. It was therefore assumed that cod aquaculture production was virtually nonexistent.

Exported cod catch

Statistics Faroe Islands keeps a database on the exports of fish products. Data was found in that database (Statistics Faroe Islands, 2012e).

Domestic consumption

No data was found to be available on the domestic consumption of cod in the Faroe Islands. Instead an approximate was reached by assuming consumption habits to be similar to those in Iceland. By comparing Icelandic consumption as stated by the Icelandic Directorate of Fisheries (2012) and landed Icelandic catch the Icelandic rate of consumption to catch was found. This rate was then used to compute the domestic consumption in the Faroe Islands by multiplying the Faroe Islands landed catch by the Icelandic rate.

5.2 Computation of utilization rate

The computed utilization rate for the Faroe Islands can be seen in table 5.1. Since the data for 1999 and 2000 was incomplete it was not possible to calculate the utilization rate for either of those years.

Table 5.1. Computation of utilization rate in the Faroe Islands (Statistics Faroe Islands, 2012a; Statistics Faroe Islands, 2012b; Statistics Faroe Islands, 2012c; Statistics Faroe Islands, 2012d; Statistics Faroe Islands, 2012e and own computations).

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Total catch of own vessels landed in own port	33,725	-	39,762	55,726	58,029	45,941	35,754	30,754	28,141	27,102	27,308	33,003
Imported fish catch	788	656	969	920	808	820	584	347	456	474	392	366
Aquaculture production	-	-	-	-	-	-	-	-	-	-	-	-
Catch available for processing	34,513	-	40,731	56,646	58,837	46,761	36,338	31,101	28,597	27,576	27,700	33,369
Domestic consumption	-	-	105	147	153	121	94	81	74	71	72	87
Exports	19,205	22,673	23,270	33,839	28,839	25,905	18,463	15,825	13,961	13,357	12,931	16,356
Domestic consumption and exports	-	-	23,375	33,986	28,992	26,025	18,557	15,906	14,034	13,428	13,002	16,443
Utilization rate percentage	-	-	57%	60%	49%	56%	51%	51%	49%	49%	47%	49%

The utilization rate in the Faroe Islands was in the range of 40-60% during the years 2001-2010. It had a mean of 46.7%, with a standard deviation of around 4.43%. This means that on average the expected weight of processed cod was around 46.7% of the live weight cod catch for that year.

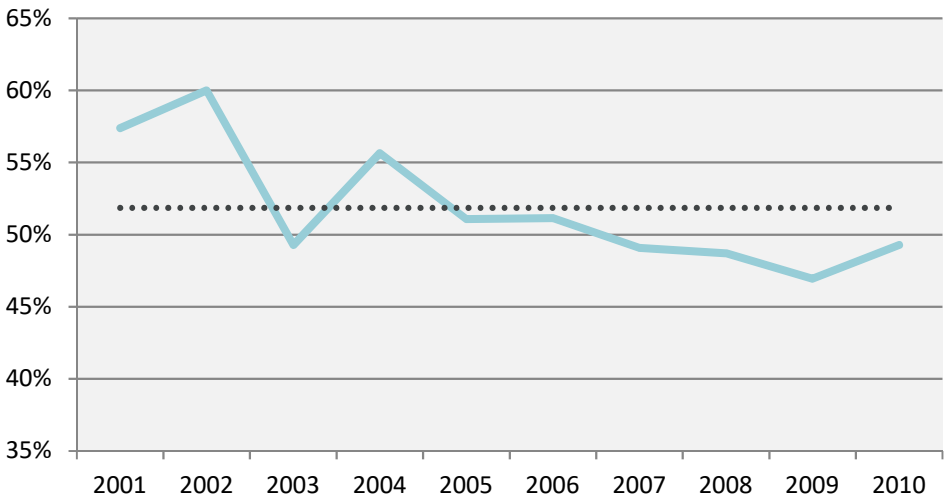

Figure 5.1: Utilization in the Faroe Islands from 2001-2010

As can be seen in figure 5.1, the utilization rate increased during the first two years of the time series. From 2004 to 2008 however there was a gradual reduction in utilization and then from 2009 to 2010 a slow turnaround again. Despite the reduction from 2004 to 2008 a runs test performed on the time series showed that the hypothesis of an upwards trend within the time series could be accepted with around 90% confidence. The utilization rate therefore appears to be increasing in the Faroe Islands, something that would probably be even more visible when looking at data for a longer period.

5.3 Further analysis of utilization

By using the computed utilization rate the amount of discarded cod was computed in table 5.2 and graphed in figure 5.2.

Table 5.2. Further analysis of utilization in the Faroe Islands (Statistics Faroe Islands, 2012a; and own computations).

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Total Catch	39,762	55,726	58,029	45,941	35,754	30,754	28,141	27,102	27,308	33,003
Utilization rate	57%	60%	49%	56%	51%	51%	49%	49%	47%	49%
Inverse Utilization rate	43%	40%	51%	44%	49%	49%	51%	51%	53%	51%
Total amount discarded	16,944	22,292	29,436	20,372	17,495	15,026	14,330	13,904	14,490	16,740

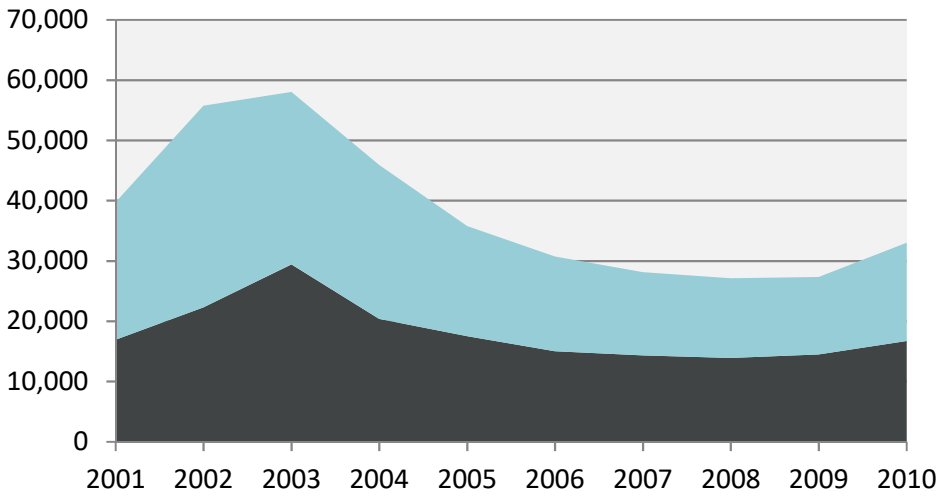

Figure 5.2: Ratio of utilized and wasted cod catch in the Faroe Islands 2001-2010

Figure 5.2 shows the total live weight catch for each year. The grey area is the amount discarded each year and the blue area shows the utilized amount of catch. The difference between the size of the blue area relative to the grey shows the utilization rate. As can be seen during the years from 2001 – 2003 utilization was slowly increasing. The amount of discarded cod also rose but the increase was caused by an increase in the total catch and not because of less utilization. As the amount of total catch declined from 2003 – 2009 so did discards. However discards declined less than the total amount of live catch, a direct result of worse utilization over the period. From 2009 – 2010 the total amount of live catch

increased again, increased utilization however caused discards to increase proportionally less.

6 Canada

Despite the collapse of cod stocks in Canadian waters in the 1990s, Canada remains one of the ten most active cod fishing nations in the North Atlantic. Canadian fisheries landed 17,226 tons of Atlantic cod in 2010 which contributes to around 3% of total Canadian fish landings (Fisheries and Oceans Canada, 2012a).

6.1 Overview of data

Cod catch landed by own fleet in own harbor

Canadian statistics related to aquaculture, fisheries and trade of fish is collected and compiled by the Statistical Services Unit of Fisheries and Oceans Canada (Fisheries and Oceans Canada, 2012a).

Imported cod catch

Data on the imports of fresh fish was obtained from Fisheries and Oceans Canada as well (2012b).

Aquaculture

Aquaculture is an active industry in Canada (mainly salmon trout and shellfish), but commercial cod farming has yet to take place. Thus data was neither needed nor available (Fisheries and Oceans Canada, 2012c).

Exported cod catch

Like the data on imports and landings, the data on exported fish products was obtained from Fisheries and Oceans Canada (2012d).

Domestic consumption

The domestic consumption of fish in Canada was retrived from a Food and Agricultural Organization database on consumption (2012). An approximation for the consumption of cod was then reached by assuming the ratio of cod consumption compared to total fish consumption to be the same as the ratio between the total fish catch and the cod fish catch plus imported cod products. This approach was used because reliable data on consumption proved to be difficult to find.

6.2 Computation of utilization rate

Table 6.1 shows the calculations for the utilization rate in Canada in the years 1999-2010 by using statistics on total catch, imports, domestic consumption and exports.

Table 6.1. Computation of utilization rate in Canada (Fisheries and Oceans Canada; 2012a; Fisheries and Oceans Canada; 2012b; Fisheries and Oceans Canada; 2012c; Fisheries and Oceans Canada; 2012d; Food and Aquaculture Organization of the United Nations, 2012 and own calculations).

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Total catch of own vessels landed in own port	55,478	46,177	40,440	35,741	22,768	24,730	26,156	27,412	26,732	26,837	19,948	17,226
Imports	32,133	29,941	26,615	31,544	36,318	28,361	18,066	13,418	12,944	12,390	13,589	14,973
Aquaculture production	0	0	0	0	0	0	0	0	0	0	0	0
Catch available for processing	87,611	76,118	67,055	67,285	59,086	53,091	44,222	40,830	39,676	39,227	33,537	32,199
Domestic consumption	17,472	13,346	11,844	10,322	7,022	7,244	7,620	7,754	7,477	7,322	5,200	4,770
Exports	25,671	24,202	20,385	20,213	20,982	16,746	13,178	11,345	11,096	9,819	8,768	8,605
Domestic consumption and exports	43,143	37,548	32,229	30,535	28,004	23,990	20,799	19,098	18,573	17,140	13,968	13,375
Utilization rate percentage	49%	49.33%	48.06%	45.38%	47.40%	45.19%	47.03%	46.78%	46.81%	43.70%	41.65%	41.54%

Figure 6.1 shows the utilization rate graphed along with it's mean over the period. A gradual downwards trend can notably be detected in the 11 year period with the utilization rate ranging from roughly 41 to 49 percent.

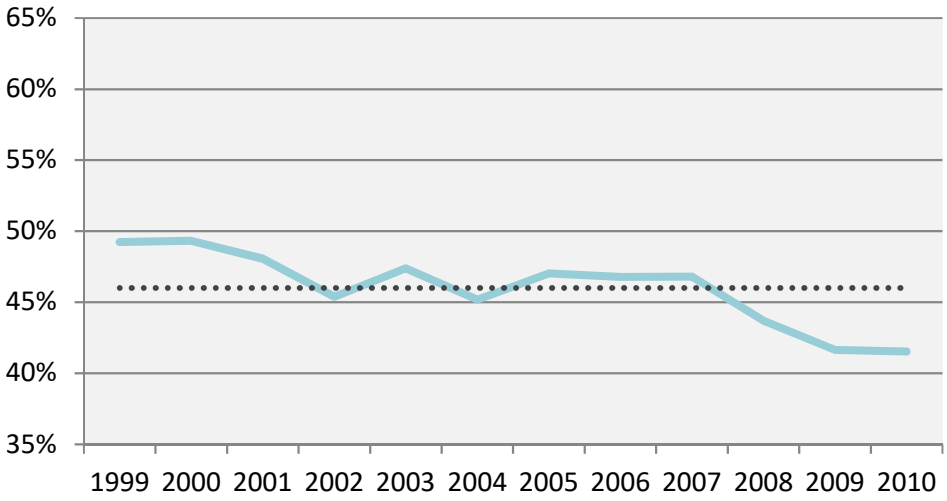

Figure 6.1: Utilization in Canada from 1999-2010

6.3 Further analysis of utilization

In table 6.2, the total amount of cod wasted annually in Canada has been estimated. This number predictably falls as total catch drops but by a smaller amount proportionally due to the decline of the utilization rate.

Table 6.2 Further analysis of utilization in Canada(Fisheries and Oceans Canada; 2012a; and own calculations)

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Total Catch	55,478	46,177	40,440	35,741	22,768	24,730	26,156	27,412	26,732	26,837	19,948	17,226
Utilization Rate	49.2%	49.3%	48.1%	45.4%	47.4%	45.2%	47.0%	46.8%	46.8%	43.7%	41.7%	41.5%
Inverse Utilization Rate	50.8%	50.7%	51.9%	54.6%	52.6%	54.8%	53.0%	53.2%	53.2%	56.3%	58.3%	58.5%
Total Amount Discarded	28,158	23,398	21,003	19,521	11,977	13,555	13,854	14,590	14,219	15,110	11,640	10,071

Canadian cod landings dropped sharply from 55,000 to around 17,000 tons in the years in question as has been portrayed in figure 6.2. The total colored area signifies total cod catch and is separated into blue and grey parts where blue represents utilized cod and grey represents wasted cod.

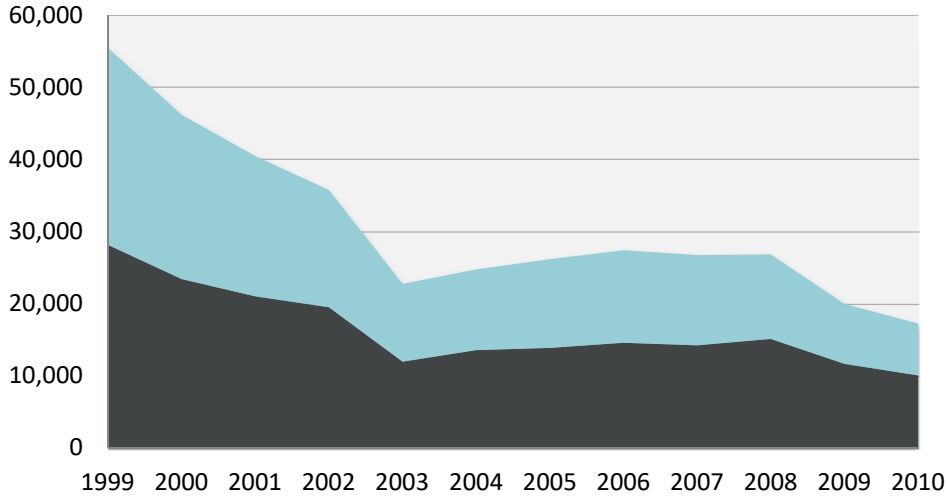

Figure 6.2: Ratio of utilized and wasted cod catch in Canada 1999-2010

7 Utilization Comparison between Countries

To begin comparing the four countries, the graphs of their individual utilization rates have been combined in figure 7.1 along with the overall average.

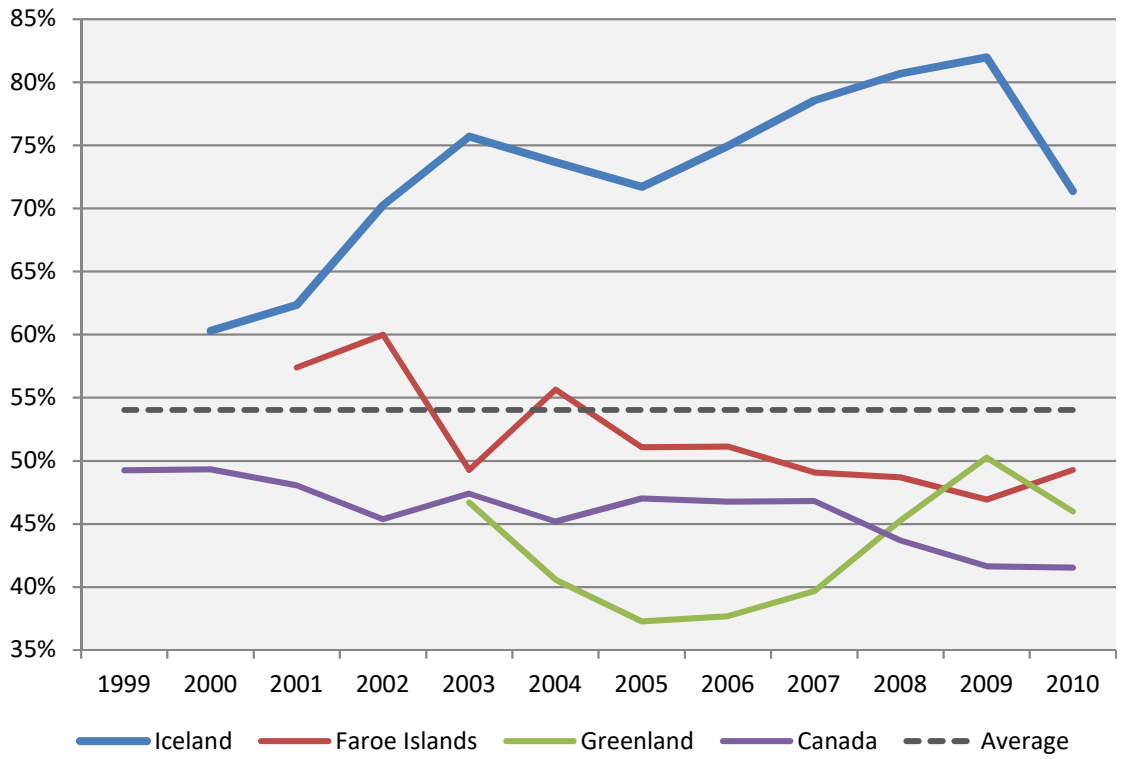

Figure 7.1: Combined utilization rate of all countries

Although these time series may not be fully comparable due to possible time inconsistencies and other data errors, it is interesting to see the different trends around the overall mean utilization. Furthermore, Iceland seems to be the only country where an upwards trend can be identified over the years.

In figure 7.2 the total catch of all four nations, divided into amount wasted and amount utilized, has been charted. The total catch of these nations has ranged from around 250 to 300 thousand tons annually, which is roughly a third of the annual global catch of Atlantic cod. In the year 2010, Canada, Faroe Islands, Greenland and Iceland landed 247,412 tons of

cod. According to our analysis, 159,520 tons were utilized while 87,892 tons were discarded at sea or wasted in production.

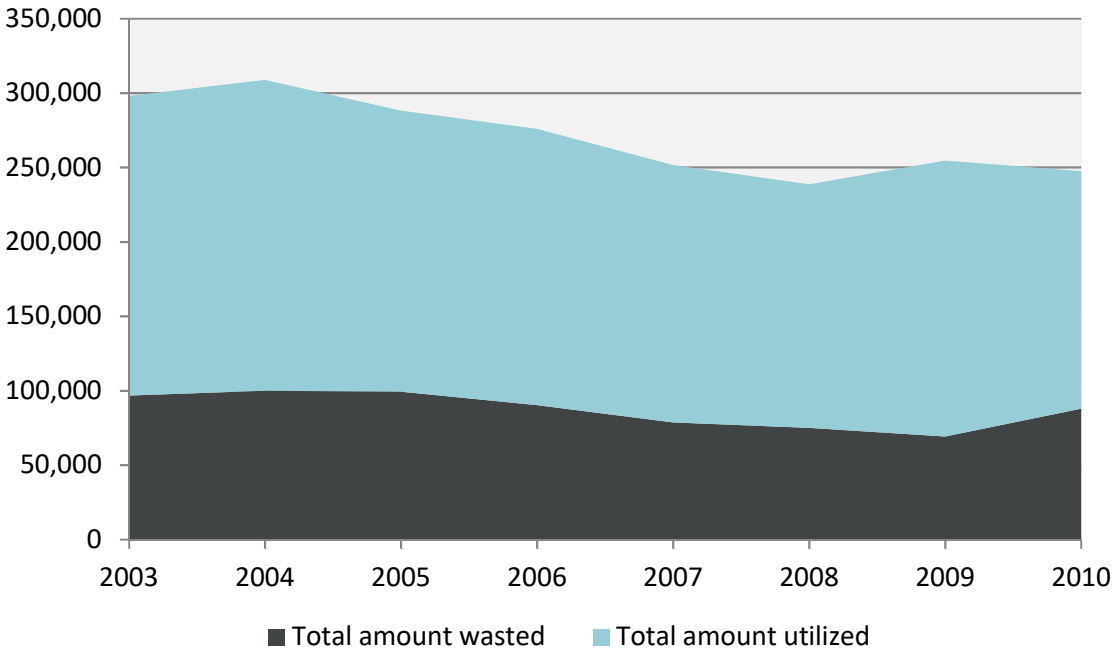

Figure 7.2: Combinded ratio of utilized and wasted cod catch for all countries

According to our analysis, the average utilization rate of cod in the years in question was 54.0%. If we assume that this is close to the overall average utilization rate in the North Atlantic, we can make assumptions about the total amount of cod wasted anually in the area. By using data from FAO[3] on the global annual catch of Atlantic cod, the total estmiated annual amount wasted in the years 1999-2010 has been charted in figure 7.3. According to this, the annual amount wasted ranged from 353 to 502 thousand tons with a mean of 415 thousand tons of cod.

[3] The Food and Agriculture Organization of the United Nations

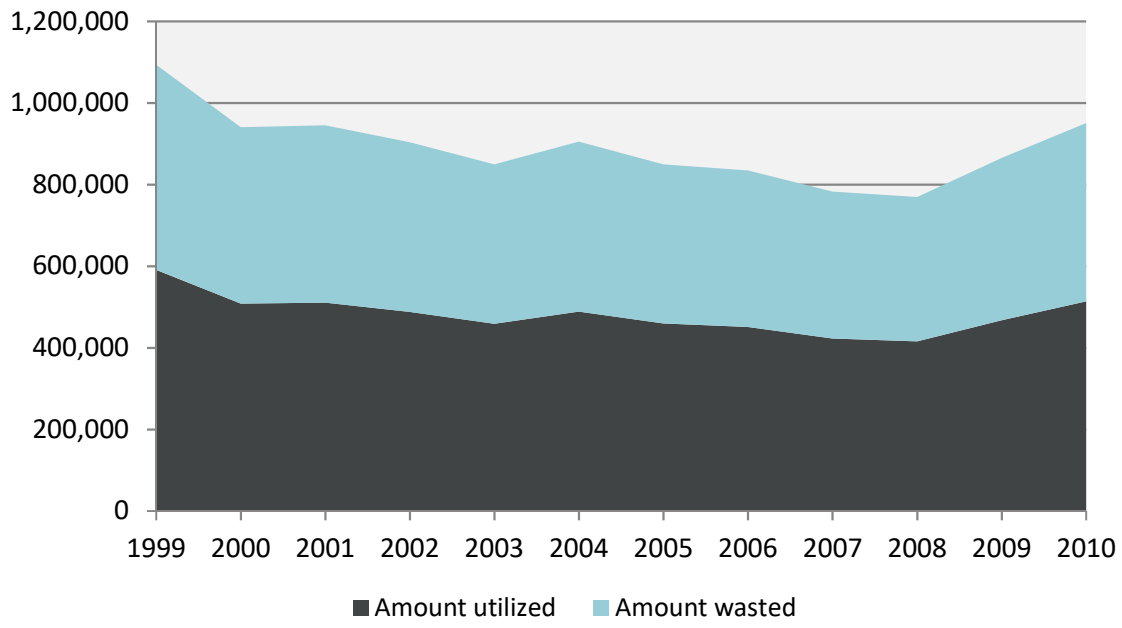

Figure 7.3: Ratio of utilized and wasted cod catch for total North-Atlantic cod catch

Furthermore, an analysis of variance was performed on the utilization rates of the countries. The results can be seen in table 7.1 and figure 7.4.

Table 7.1. Results from variance analysis of utilization rates (α=0.05).

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Iceland	8	6.085740	0.760718	0.00158
Greenland	8	3.433969	0.429246	0.00226
Faroe Islands	8	4.011286	0.501411	0.00067
Canada	8	3.600855	0.450107	0.00058

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.563735	3	0.187912	147.069	3.06E-17	2.946685
Within Groups	0.035776	28	0.001278			
Total	0.599511	31				

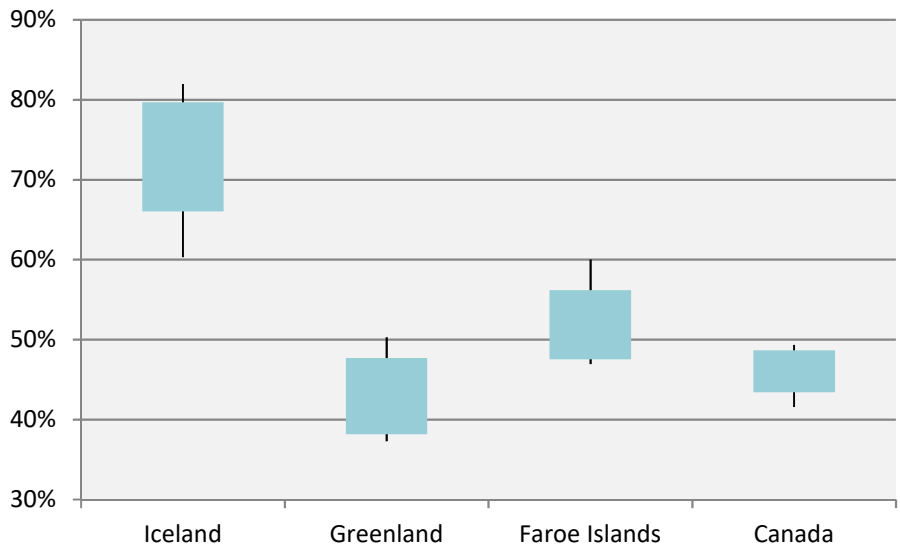

Figure 7.4: Analysis of variance between countries

In this analysis of variance, the null hypothesis is that the means are equal. The analysis clearly shows that there is a statistically relevant difference between the mean utilization of each country. With an F-value of around 147, compared to a critical F-value of around 3, the null hypothesis is rejected with the likelihood of a type 1 error less than minimal. That the values for Greenland have a much bigger variance and standard deviation than the others does pose some problems though. The test also does not produce the general order of utilization between countries, only that the mean utilization of Iceland (having the largest mean) is in all probability larger than the mean for Greenland (having the smallest mean). This raises the need for further tests and therefore individual hypothesis tests between each pairs of countries were performed, the results of which can be seen in table 7.2.

Table 7.2. Results from individual hypothesis tests.

Iceland and Greenland

		Iceland	*Greenland*
Mean		0.728623588	0.42924617
Variance		0.004681702	0.00226715
Observations		11	8
Hypothesized Difference	Mean	0	
df		17	
t Stat		11.243327	
P(T<=t) one-tail		1.35364E-09	
t Critical one-tail		1.739606726	
P(T<=t) two-tail		2.70728E-09	
t Critical two-tail		2.109815578	

Iceland and the Faroe Islands

		Iceland	*Faroe Islands*
Mean		0.728623588	0.51851256
Variance		0.004681702	0.00186258
Observations		11	10
Hypothesized Difference	Mean	0	
df		17	
t Stat		8.494152331	
P(T<=t) one-tail		7.9939E-08	
t Critical one-tail		1.739606726	
P(T<=t) two-tail		1.59878E-07	
t Critical two-tail		2.109815578	

Iceland and Canada

		Iceland	*Canada*
Mean		0.728624	0.46008
Variance		0.004682	0.00068
Observations		11	12
Hypothesized Difference	Mean	0	
df		13	
t Stat		12.22312	
P(T<=t) one-tail		8.37E-09	
t Critical one-tail		1.770933	
P(T<=t) two-tail		1.67E-08	
t Critical two-tail		2.160369	

Greenland and the Faroe Islands

		Greenland	*Faroe Islands*
Mean		0.429246173	0.51851256
Variance		0.002267154	0.00186258
Observations		8	10
Hypothesized Difference	Mean	0	
df		14	
t Stat		-4.119073776	
P(T<=t) one-tail		0.000521291	
t Critical one-tail		1.761310136	
P(T<=t) two-tail		0.001042581	
t Critical two-tail		2.144786688	

Greenland and Canada

		Greenland	*Canada*
Mean		0.429246173	0.46008588
Variance		0.002267154	0.00068467
Observations		8	12
Hypothesized Difference	Mean	0	
df		10	
t Stat		-1.671410334	
P(T<=t) one-tail		0.062795912	
t Critical one-tail		1.812461123	
P(T<=t) two-tail		0.125591825	
t Critical two-tail		2.228138852	

Faroe Islands and Canada

		Faroe Islands	*Canada*
Mean		0.518513	0.46008
Variance		0.001863	0.00068
Observations		10	12
Hypothesized Difference	Mean	0	
df		14	
t Stat		3.745646	
P(T<=t) one-tail		0.001086	
t Critical one-tail		1.76131	
P(T<=t) two-tail		0.002172	
t Critical two-tail		2.144787	

As can be seen the tests give a clear indicator that Iceland has a greater utilization rate than Canada, the Faroe Islands and Greenland, where the t-critical value is considerably lower than the computed t-value in all cases.

According to the tests, Greenland has a lower utilization rate than the Faroe Islands (t-critical one tail around 1.8 compared to a computed t-value of around -4.1). When compared to Canada however there does not seem to be a relevant statistical difference of utilization between the countries. It must be noted though that this is the result of the test when using 5% as the cutoff value for alpha and if the cutoff value was raised by as little as 1.5% the test would result in a statistically relevant difference. We will adhere to the results as given when alpha equals 5% and therefore consider Greenland and Canada to have a similar utilization rate, however that the p-value is this close to our alpha gives some hints as to Canada possibly having a greater utilization rate than Greenland.

Finally as we compare the Faroe Islands and Canada it is obvious that the utilization rate in the Faroe Islands is higher than that in Canada.

Judging from the results of the hypothesis tests as well as the variance analysis we know for sure there is a statistically relevant difference in utilization between each country. Furthermore thanks to the paired hypotheses tests we can rank the countries in terms of utilization:

1. Iceland
2. The Faroe Islands
3. Canada and Greenland

8 Conclusion & Discussion

The results of the analysis are that there is a statistically relevant difference between the utilization rates of the countries as computed using the method developed earlier in this paper. Iceland and the Faroe Islands are ahead of the others when it comes to utilization, with the highest utilization rate in Iceland. Utilization in Greenland and Canada is behind the others but they are both still on pair with each other.

When the average utilization rate of all the countries, which is 54%, is used to approximate the total tons of wasted cod in the North-Atlantic the result is that on average 415,000 tons would have been wasted every year from 1999-2010. This number is of course at best an educated guess, especially given that the four countries surveyed don't necessarily serve as the ideal sample of the nations that fish in the North-Atlantic. It does however at least give some ideas, no matter how vague, on the amount of fish-raw material that goes wasted every year in the Atlantic.

There are two factors though, that diminish the validity of this paper's results. The first is the method used for computing the utilization rates. While statistically convenient, measuring the amount of utilization by comparing the live-weight of fresh fish to the final product's weight disregards many important factors of the process involved in fishing and fish production. For instance it does not take into account the quality of the final product and can even sometimes record increased quality as reduced utilization (an example being when the bad parts of a fillet are cut away and discarded). Of course it is debatable which is better, a bigger amount of lower quality fish or a smaller amount of higher quality, but still this raises concerns of error. This is however a matter of the approach used to measure the utilization rate rather than a result breaking fault in the analysis. Therefore this actually does not skew the results significantly, only the interpretation is affected.

A far bigger problem though in reducing the validity of the results is the second factor. There was found to be a large shortage of reliable data available on many of the figures needed to compute the utilization rate. In fact originally the plan for this paper was to analyze the utilization in all the countries that fish cod in the North-Atlantic. This however proved impossible due to a lack of data and the number of countries was reduced to the four analyzed here, mainly because they were the only ones where the data was found to be consistent. Nonetheless in order to complete this analysis many of the figures had to be based on assumptive calculations and approximations. This obviously increases the possibility of errors within the analysis further.

Despite this, the results are interesting and hopefully can be duplicated given further research and better data. In fact, the next logical step following this paper is to start collection of reliable first hand data for each of the countries that fish for cod in the North-Atlantic. Following that, this analysis should be repeated and once the difference in utilization between countries has been established (if there is any) further action can be taken to discover the root of these differences.

To shed light on the opportunity costs involved, estimations were made on the potential value created had the fish been utilized more efficiently. According to the statistics, 127,516 tons of cod were wasted by the four countries in 2010. We can safely assume that a large share of the amount wasted were by-products such as heads, backbones, trimmings, skin and viscera, since these parts are commonly discarded at some time in the production process. In these assessments it was assumed that the share of each by-product part in the wasted amount was the same as in a whole, fully exploitable fish, which is undeniably a modest assumption. As an example, the opportunitiy costs were computed assuming two by-products had been further utilized, trimmings and dried cod heads.

- **Trimmings**

  The share of trimmings or cut-offs in a cods weight range from 2 to 9,5 percent based on conversion factors from the Icelandic Directorate of Fisheries. Trimmings

can be processed into mince, salted goods and other products. The market price of trimmings in 2010 was around 2.6 euros (approx. $3.4 at the time) according to a study published by Matis ohf. in Iceland (Arason, S., Margeirsson S., Sigurgísladóttir, S. & Vidarsson J.R., 2010). If this holds true, the potential value if 2% - 9.5% of the amount wasted had been utilized trimmings, ranges from 8.6 to 41 million dollars.

- **Heads**

  The share of a cods head in its total weight has been estimated to range from 26-36%[4]. The market price of a dried cod head was roughly $3.8 per kilogram in 2010, but due to water loss it's weight is reduced by approximately 78% when dried (Arason, S., Margeirsson S., Sigurgísladóttir, S. & Vidarsson J.R., 2010). If 26 to 36 percent of the 127,516 tons wasted in 2010 were heads, the potential value had these heads been dried and sold is somewhere between 27.7 and 38.4 million dollars.

These calculations include only two of an array of by-products available for production and are computed in a very modest manner. The combined potential value computed is nevertheless as high as USD 79.400.000. Clearly, the opportunities in increased fish utilization are vast.

[4] The Icelandic Directorate of Fisheries computes a live weight conversion factor for cod, according to which the head accounts for 34,5% of cod's weight on average. This ratio is however assumed to range from 26% to 36% depending on processing methods, size, vessels and other factors.

9 Bibliography

Arason, S., Margeirsson S., Sigurgísladóttir, S & Vidarsson J.R. (2010). *Bætt nýting sjávarafla (Improved Utilization of Marine Catch)*. Reykjavik: Matís ohf.

Directorate of Fisheries (2012). *Fiskur til neyslu innanlands 2005 - 2011, helstu tegundir*. Retrived 08/03/12 from http://www.fiskistofa.is/media/utgefid_efni/25072011innanlandsneysla_2005_til_2011.xls

Fisheries and Oceans Canada (2012a). *Commercial Fisheries: Landings: Seafisheries.* Retrived 03/08/12 from http://www.dfo-mpo.gc.ca/stats/commercial/sea-maritimes-eng.htm

Fisheries and Oceans Canada (2012b). *Aquaculture: Production Quantities and Values.* Retrived 03/08/12 from http://www.dfo-mpo.gc.ca/stats/aqua/aqua-prod-eng.htm

Fisheries and Oceans Canada (2012c). *Canadian Trade Imports.* Retrived 03/08/12 from http://www.dfo-mpo.gc.ca/stats/trade-commerce/can/import/import-eng.htm

Fisheries and Oceans Canada (2012d). *Canadian Trade Exports.* Retrived 03/08/12 from http://www.dfo-mpo.gc.ca/stats/trade-commerce/can/export/export-eng.htm

Food and Agriculture Organization of the United Nations (2004). *Fishery Country Profile: Greenland*. Retrived 08/03/12 from ftp://ftp.fao.org/FI/DOCUMENT/fcp/en/FI_CP_GL.pdf

Iversen, A., Klev, J.M., Bergersen, R.E., Storehaug, K. og Røtnes, R. (2011) Markeds- og verdikjedeanalyse. Fase 1 av prosjektet ”Value Propositions i nordisk marin sektor”. Nordic Innovation Center, 2011.

Statistics Faroe Islands (2012a). *Total catch in live weight by fishing zones and species (1990-2011)*. Retrived 08/06/12 from http://www.hagstova.fo/portal/page/portal/HAGSTOVAN/Statistics_%20Faroe_Islands/Statistics/FISHING_AQUA_AGRICUTLURE/Talva%20VEIDLEIHEI_EN

Statistics Faroe Islands (2012b). Retrived 08/06/12 from http://www.hagstova.fo/portal/page/portal/HAGSTOVAN/Statistics_%20Faroe_Islands/Statistics/FISHING_AQUA_AGRICUTLURE

Statistics Faroe Islands (2012c). *Export of fish products by fish species and months (1993-2012).* Retrived 03/08/12 from http://www.hagstova.fo/portal/page/portal/HAGSTOVAN/Statistics_%20Faroe_Islands/Statistics/Foreign_trade/UTSLAGNV_EN

Statistics Greeland (2012a). *Catches*. Retrived 03/08/12 from http://www.stat.gl/dialog/main.asp?lang=en&version=2010&link=FI&subthemecode=o3&colcode=o

Statistics Greenland (2012b). *TAC's near East and West Greenland.* Retrived 03/08/12 from http://www.stat.gl/dialog/main.asp?lang=en&version=2010&link=FI&colcode=t&version=2010

Statistics Iceland (2012a). *Catch and catch value by fishing area and species 1993-2010*. Retrived 08/03/12 from http://www.statice.is/?PageID=1214&src=/temp_en/Dialog/varval.asp?ma=SJA09001%26ti=Catch+and+catch+value+by+fishing+area+and+species+1993-2010%26path=../Database/sjavarutvegur/af3Fisk/%26lang=1%26units=Tonnes/1,000%20ISK

Statistics Iceland (2012b). *Imported raw material for fish processing by species, volume and value 1995-2010*. Retrived 08/03/12 from http://www.statice.is/?PageID=1216&src=/temp_en/Dialog/varval.asp?ma=SJA04001%26ti=Imported+raw+material+for+fish+processing+by+species%2C+volume+and+value+1995-2010%26path=../Database/sjavarutvegur/innf/%26lang=1%26units=Tonnes/thousand%20ISK

Statistics Iceland (2012c). *Exported marine products by commodities, branches of processing and countries 1999-2011.* Retrived 08/03/12 from http://www.statice.is/?PageID=1218&src=/temp_en/Dialog/varval.asp?ma=SJA04903%26ti=Exported+marine+products+by+commodities%2C+branches+of+processing+and+countries+1999-2011%26path=../Database/sjavarutvegur/utf/%26lang=1%26units=kg/ISK