Seafood research from fish to dish

Quality, safety and processing of wild and farmed fish

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Effect of catch location, season and quality defects on value of Icelandic cod (*Gadus morhua*) products

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Abstract

Effect of location of catch, season and quality defects of cod on the proportion of high-value cod products was studied in close cooperation with two Icelandic fisheries companies. Data from 2001-2004 on season and high-value cod products were collected in a fish processing plant in West-Iceland. Seasonal-, spatial-, quality defects-, and high-value product data were collected onboard fishing vessels and in another fish processing plant in North-Iceland. Results show seasonal and spatial variation in proportion of high-value cod products. Close correlation between quality defects factors and proportion of high-value products indicates that lower defect rate of cod fillets would result in significantly higher product value.

Keywords: cod, product value, gaping, seasonal variation, spatial variation

Introduction

The return from cod catching and processing has been connected to variables like fillet yield, gaping and parasites (Birgisson 1995). Another variable, which is considered of importance for the return of cod processing, is the proportion of different products, *i.e.* the proportion between "cheap" and "expensive" products. An example of "cheap" cod product is mince, while different fillet portion products are "expensive" products. The product types in Table 1 are widespread in Icelandic seafoood industry.

Table 1 Common product types in cod processing.

1	Fish fillets, fresh. Chilled or on ice
2	Tail (sometimes classified with 3)
3	Frozen fish fillets / frozen portions
4	Frozen fish fillets, in blocks
5	Minced or strained fish, frozen

A common indicator for the value of the fillet is the Fillet Portion ratio or FP-ratio, where the first 3 product types in Table 1 are taken into one category, called fillet portions. FP-ratio is the proportion of the fillet that becomes fillet portions after trimming.

Previous results indicate that return of Icelandic fishing industry can be increased considerably by managing catching and processing simultaneously (Eyjolfsson and others 2001; Teitsson 1990). Managing catching and processing unabridged and use of prior knowledge along with the use of previous data to synchronize fisheries and processing can simplify planning for both fisheries and processing managers (Bjarnason 1997).

Over 40% of the annual cod catch in Iceland is caught by trawlers (Anonymous 2004). It has long been assumed that both length and size the haul could effect on the quality of the catch. One haul is the process of dropping a trawl, towing it by the trawler and hauling it in again. The length of a haul is the time-lag from when the trawl is dropped until it is hauled in again. The size of the haul is the weight of the catch. It is obligatory for all trawlers catching in Icelandic waters to register how long the haul is, the size of it, proportion of different fish species, depth, weather conditions, date and the location of the catch (in GPS coordinates and square numbers shown in Figure 1).

During the last years increased emphasis has been put on increasing the FP-ratio (Asgeirsson 2005). However, there is limited literature available on the matter. Other important variables for the return of cod catching and 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

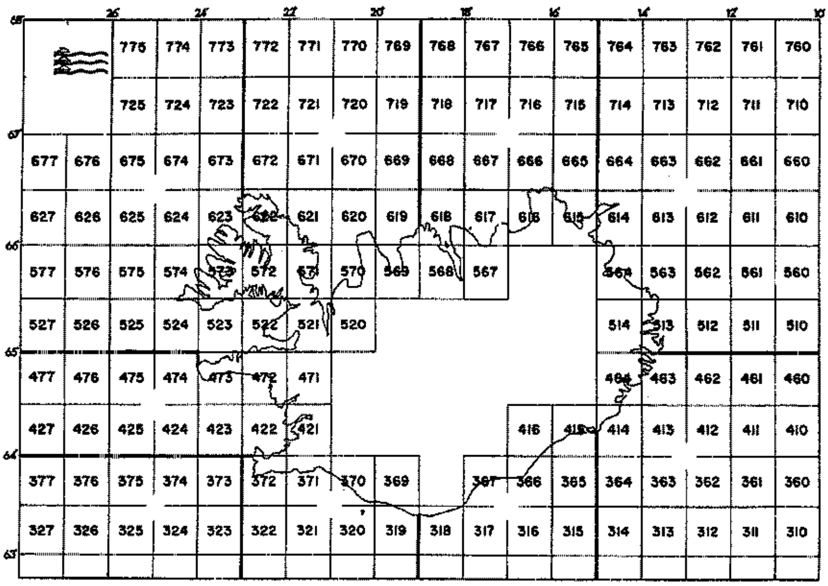

Figure 1. It is obligatory for all boats, fishing in Icelandic waters to register the location of their catch.

correlated with condition factor (weight/(length)^3) and proportion of viscera. Morphology of the fish has been related to fillet yield (Cibert and others 1999) and it is likely that condition factor can be used as an indicator for fillet yield. Eyjolfsson and others (2001) and Margeirsson and others (2003) found a significant correlation between fillet yield and condition factor and stated that there was a considerable difference in condition factor and fillet yield between catching areas in Icelandic waters.

The aim of this study was to map FP-ratio in Icelandic cod, both with respect to catching date and the location of catching ground and to find out what variables affect FP-ratio most. The study was carried out in cooperation with two Icelandic companies, Samherji and Gudmundur Runolfsson (GR). Both companies own trawlers which serve as resources for their land-based processing.

Methods

Data in this study were twofold. The first data set was collected from the intern production system of GR in W-Iceland. This data set ranged from January 2001 - June 2004 and showed how fillets were utilised into different products in the company. Total number of production days under investigation was 619. All data were scaled with the mean of corresponding year, as shown in Equation 1. This was done to minimize possible error because of different machines, labour *etc*.

$$FP_{ik}^{new} = \frac{FP_{ik}}{mean\ (FP_k)} \quad (1)$$

FP_{ik} = FP-ratio from measurement i at year k
FP_k = All FP-ratio measurements at year k

Data from Samherji were collected from November 2003 - May 2005. Measurements were done on 512 cods in total. They all came from the same trawler, Bjorgulfur EA-312. The date and location of each haul were registered, along with the length and size of the haul. The location was registered as GPS coordinates at the time the trawl was dropped. The depth and ocean temperature were registered. After hauling the fish were gutted and iced in tubs. The size of the haul was estimated by counting number of tubs. After unloading the catch, but before processing, samples of four cods were taken from 2-3 tubs (hauls) from each fishing tour. The total weight of cod in the tubs and the length and weight of the sampled cod were measured and registered. Marel® PV 1740 (d = 20 g) was used for weighing and the length of the fish was measured with a steel yardstick. The fish was headed, weighed (using Marel PV 1740), filleted and skinned. Heading was done with Baader® 434 and filleting with Baader 189. The skinning machine was Baader 51. The fillets were weighed using Marel PL 2010 (d = 1 g) and all visual parasites counted and plucked out. Gaping was measured by putting a transparent plastic card with a grid on the fillets (Figure 2). The grids were 4cm x 4cm. If a gaping area on the fillet covered one grid cell, it counted as one gaping unit. One unit was also counted if the aggregated area of two or more gaping areas covered one grid cell. The same measurement was used for bloodstains and redness. At last, the fillets were cut into different product types and the amount in product types weighed.

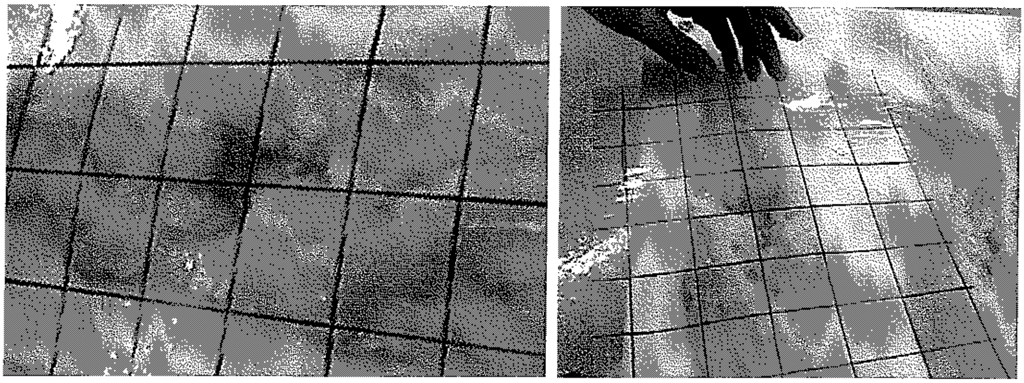

Figure 2. A plastic card with a grid, used for measurements on bruises and gaping

The geostatistical analysis was mainly based on semivariograms and kriging. Variowin® 2.21, software available on the internet (Pannatier 1999) was used for making semivariograms, which show if there is spatial correlation in the data (Nielsen 2004; Anselin 2003).

Semivariogram (experimental): $\hat{\gamma}(h) = \frac{1}{2N(h)} \sum_{k=1}^{N(h)} [z(r_k) - z(r_k+h)]^2$,

where $z(r_k)$ and $z(r_k+h)$ are scalar measurements from the points r and $r+h$ and $N(h)$ is the number of point pairs separated by the vector h. It is custom to calculate average of $\hat{\gamma}(h)$ over the interval $h+\Delta h$ in order to obtain $N(h)$ high enough for attaining low estimation of the $\hat{\gamma}(h)$ variance.

On later stages, a smaller dataset was obtained from the whole dataset, called sub-dataset A. Sub-dataset A included measurements from 15.11.2003-6.2.2004 (measurements from 20.1.2004 - 26.1.2004 though discarded).

Multivariate regression analysis was used to search for a functional relationship (multivariate linear model) between the response variables and the independent variables after a thorough outlier detection of all variables. S-PLUS® 6.1 (MathSoft) and Matlab® (MathWorks) were used for statistical analysis.

Results and discussion

GR data - Seasonal effect

The data from GR were analysed with respect to time of processing only. Figure 3 (left) shows how the FP-ratio changed with the season. It is evident from the figure that the FP-ratio is low in April and the late summer months. Figure 3 (right) shows the catching location of GR's trawlers from 2.3.2004-10.5.2004. It can be assumed that approximately the same area applies to the catching locations in the March-May period in 1999-2003 and therefore also that GR catches close to known spawning areas out of the West and South coast (Begg and Marteinsdottir 2003). Gaping has been connected to chemical changes right after spawning in cod (Anonymous 2005), and spawning might therefore explain the decrease in FP-ratio in April. The most likely reasons for the late-summer drop in FP-ratio were considered labour force connected (Gudmundur Smari

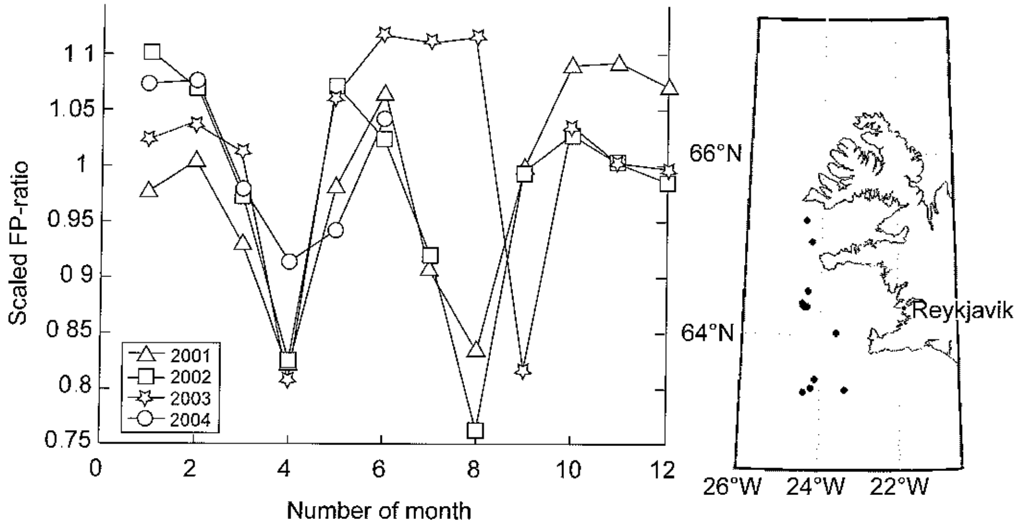

Figure 3. Left: Scaled FP-ratio with respect to number of month in 2001-2004. Right: Catch locations of GR trawlers 2 3 2004-10 5 2004

Gudmundsson, personal communication). Emphasis on processing of other fish species than cod in the summer along with vacations may reduce the cod-processing competence of the labour force. It was considered unlikely that such reasons were connected to the FP-drop in April.

Samherji data – spatial and seasonal effect

Figure 4 shows all FP-ratio measurements from Samherji (November 2003-May 2005). A visual inspection reveals a considerable internal spatial variability in each area. Despite this variability one can find significant difference in FP-ratio between areas. The area marked as 1 on Figure 4 had for instance a mean FP-ratio of 0.695 ± 0.018 (95% confidence limit) while area 2 had a mean FP-ratio of 0.744 ± 0.017. The rise in the semivariogram for sub-dataset A (Figure 5) implies more similarity between measurements that are spatial neighbours than between measurements that are distant from each other, which also indicates spatial difference in FP-ratio.

To analyze the effect of season, the data were plotted as a function of time (Figure 6). Although having some effect, season did not have nearly as much effect on FP-ratio here as by the measurements at GR. The reason for less effect of season on FP-ratio at Samherji than GR is probably twofold. Firstly, Samherji's processing is focused on cod all year round and should therefore not suffer from lack of labour force training at any time. Secondly, Samherji's trawlers are catching in other areas than GR's trawlers (see Figure 4 and Figure 3 (right)). The GR-trawlers catch close to spawning areas while the Samherji-trawlers do not, at least not to the same extent.

Effect of quality defects, environmental conditions and catching method

Even though season and location of catch may be important factors in terms of FP-ratio, it is evident that other variables may come into play or even be underlying reasons for the importance of season and location. ANOVA (Analysis of variance) was used in order to find relationship between the measured independent variables (such as weight of the cod and haul

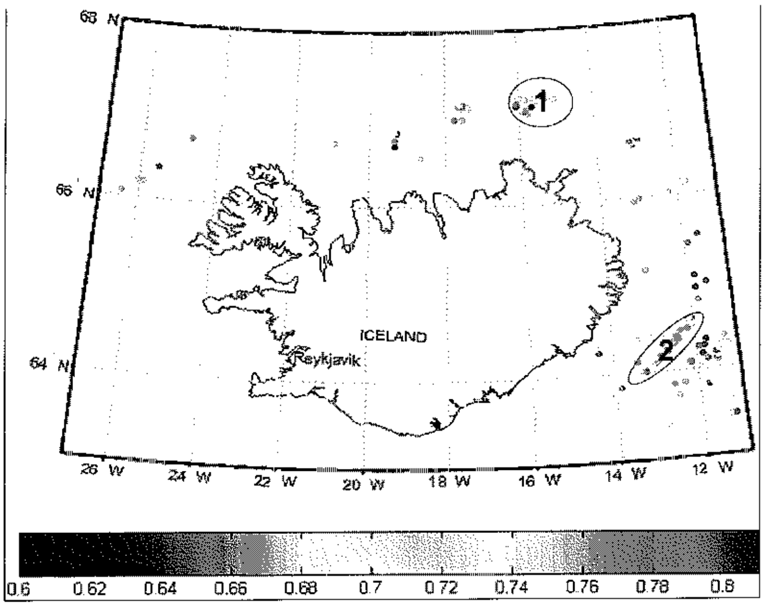

Figure 4. FP-ratio from all measurements in Samherji, November 2003 – May 2005

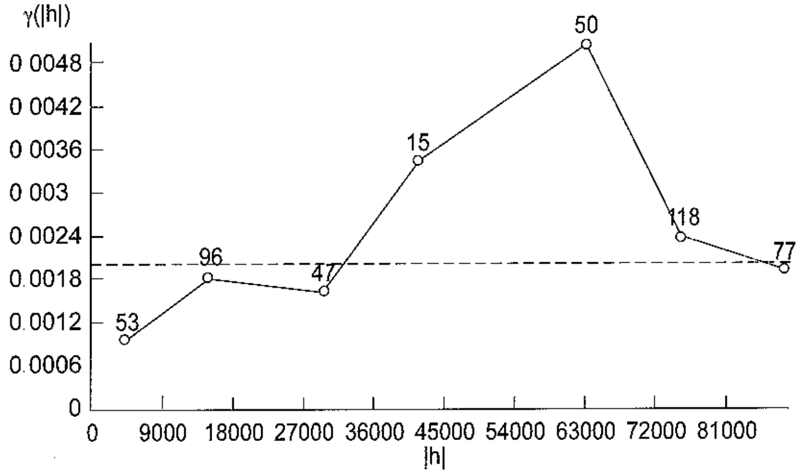

Figure 5. Semivariogram for FP-ratio, sub-dataset A

size) and FP-ratio. Thereafter a multivariate linear regression model was made with the most important independent variables (variables with lowest p-values). As a start of the analysis, assumption of normality of FP-ratio was checked. There was some deviation from normality (skewness), but it was however not considered necessary to sacrifice the simplicity of the data by transforming them.

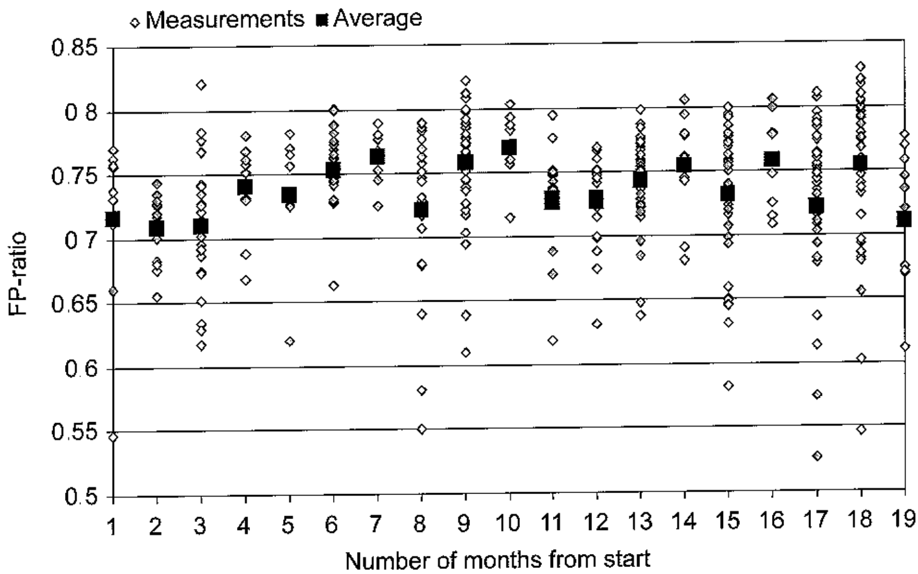

Figure 6. FP-ratio as a function of month from start of measurements Month number one is November 2003, month number 19 is May 2005.

Table 2 Analysis of variance of the measured variables (main effect) The variables with p<0.05 have significant effect on FP-ratio (95% confidence)

Source	d.f.	Sum of squares	F	p
Nematodes/kg	1	0.0022	0 79	0 37
Bloodstains/kg	1	0.0030	10 85	0.001
Redness/kg	1	0.0022	0 80	0.37
Gaping/kg	1	0.18	66 61	<0 0001
Age	1	0.00008	0 03	0.87
Haul length	1	0.00035	0 12	0 72
Haul size	1	0.00038	0 14	0 71
Weight of cod	1	0.0061	2 19	0 14
Condition Factor	1	0.0047	1 68	0 20
Head proportion	1	0.000077	0 028	0 87
Residual error	377	1.05	0 0028	

The ANOVA was perfomed on the whole Samherji dataset. The effect of bloodstains/kg, gaping/kg and weight (the variables with the lowest p-values) was estimated with a classical linear regression model (Johnson and Wichern 2002) explained in Equation 2.

$$Y = 0.74 - 0.0061x_1 - 0.0046x_2 + 0.0073x_3 \quad (2)$$

As the low correlation coefficient indicates, only a small amount of the variability in the data can be explained by the model. This is caused by at least two factors. Firstly, spatial and seasonal effects are not modelled. As previous results show, both catch location and season affect FP-ratio. It was however not considered feasible to model the effect of location and season with such few data. Secondly, there are a number of factors that are not registered or measured in this study which may increase variability in the data. Different crews onboard the vessel, different weather conditions, feed and genetic diversity are examples of such factors. However, even though only a little amount of the variability is modelled, it is important to know that bloodstains, gaping and weight affect FP-ratio, *e.g.* when explaining to vessel crews why and how they shall avoid bloodstains and gaping.

Table 3 shows that bloodstains/kg and gaping/kg have significant ($p<0.05$) negative effect on FP-ratio. The mean values for bloodstains/kg and gaping/kg were 0.47 and 2.83 respectively (the Samherji data). It can therefore be estimated that the average cod has lost over 1.5 percentage points in FP-ratio only because of bloodstains and gaping. On the other hand can the processing manager expect 0.7 percentage points increase in FP-ratio for every kg's increase in weight of the (gutted) cod ($p=0.059$). It may though be a dangerous long-term strategy only to go after the large cods (*i.e.* by size-selective fishing gear), since it has been shown that large cod in Icelandic waters produces greater quantity of eggs and more viable larvae than younger and smaller cod (Marteinsdottir and others 2000a; Marteinsdottir and Begg 2002).

Table 3. Coefficients in linear regression for FP-ratio.

	Symbol in Equation 2	Value	Std. Error	t-value	p(|t|)
(Intercept)		0.74	0.01	74.9	<0.0001
Bloodstains/kg	x_1	-0.0061	0.0025	-2.44	0.015
Gaping/kg	x_2	-0.0046	0.0010	-4.87	<0.0001
Weight of cod	x_3	0.0073	0.0038	1.90	0.059

R-squared = 0.093

Conclusion

Seasonal and spatial difference in FP-ratio in Icelandic cod was found to some extent. More data is required for confirmation. The spatial difference might be caused by a certain regionality of individual cods. That would concur with recent studies indicating differential regional spawning components (Begg and Marteinsdottir 2000; Marteinsdottir and others 2000b) and older tag-recapture studies where most tags turned up in close proximity to where the fish was tagged (Thorsteinsson and Marteinsdottir 1992; Jónsson 1996). Gaping, bloodstains and the weight of the cod were the variables found to affect FP-ratio most, but modelling with those variables only explained a small amount of the variability in the data. The knowledge gained in the study may be of use in managing catching and processing as a whole in Icelandic fisheries companies, although much is to be done in order to gain a full understanding of the factors that affect value of cod products.

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References

Anonymous 2004. Aflahefti 2003-2004 (Catch report 2003-2004). Fiskistofa, Ingolfsstræti 1. IS-101. Reykjavik

Anonymous 2005. Gaping of fillets http://www.fao org/wairdocs/tan/x5935e/x5935e01 htm Visited 23 8.2005. Fao org Source of website: R. M. Love. Ministry of Agriculture. Fisheries and Food. Torry research station (Torry advisory note no. 61)

Anselin L June 24, 2003. An Introduction to Variography using Variowin. Available at: http://sal uiuc.edu/csiss/pdf/variowin pdf Visited 19.5 2005

Asgeirsson A. 2005 Increased value of seafood through new and improved technology. Lecture in a congress on increased value of seafood, organised by the ministry of fisheries in Iceland, 8.9.2005.

Begg GA. Marteinsdottir G. 2000 Spawning origins of pelagic juvenile cod Gadus morhua inferred from spatially explicit age distributions: potential influences on year-class strength and recruitment Mar Ecol Progr Ser 202:193-217

Begg GA. Marteinsdottir G 2003. Spatial partitioning of relative fishing mortality and spawning stock biomass of Icelandic cod. Fish Res 59:343-362.

Birgisson R. 1995 AFLABÓT. Náttúrulegur breytileiki þorsks með tilliti til eiginleika í vinnslu (Natural variability of cod regarding production properties). Icelandic Fisheries Laboratories. Report 111:6-14.

Bjarnason KG 1997 Upplýsingakerfi skipstjóra Aflakort og aflaspár (Information systems for captains). University of Iceland, Mechanical Engineering Reykjavik M Sc thesis. p.60

Cibert C, Fermon Y. Vallod D, Meunier FJ. 1999. Morphological screening of carp *Cyprinus carpio*: relationship between morphology and fillet yield. Aquatic Living Resources, 12(1):1-10

Eyjolfsson B. Arason S, Þorkelsson G. Stefánsson G 2001. Holdafar þorsks, vinnslunýting og vinnslustjórnun (Condition factor of cod, production yield and production management) Report 2-01 Icelandic Fisheries Laboratories Reykjavik.

Johnson RA, Wichern DW 2002 Applied Multivariate Statistical Analysis. Prentice Hall. New Jersey

Jónsson J, 1996. Tagging of cod (*Gadus morhua*) in Icelandic waters 1948-1986 Rit Fiskideildar 14:1-82.

Karlsdottir H (supervision), 2005 Statistical Series Fisheries. Statistics Iceland. Borgartuni 21a, 150 Reykjavik. p. 11-12.

Love RM. 1975. Variability in Atlantic Cod (*Gadus morhua*) from the Northeast Atlantic: a Review of Seasonal and Environmental Influences on Various Attributes of the Flesh J. Fish. Res Board Can 32:2333-2342

Margeirsson S, Jónsson GR. Arason S, Þorkelsson G 2003 Yield. physical characteristics and quality of cod catch (Nýting, eðliseiginleikar og gæði þorskafla) M Sc thesis, University of Iceland, department of engineering. 53-67 (in Icelandic)

Marteinsdottir G, Guðmundsdóttir A, Þorsteinsson V. Stefánsson G. 2000a. Spatial variation in abundance. size composition and viable egg production of spawning cod (*Gadus morhua* L.) in Icelandic waters. ICES J. Mar Sci 57:824-83.

Marteinsdottir G, Gunnarsson B, Suthers IM. 2000b. Spatial variation in hatch date distribution and origin of pelagic juvenile cod in Icelandic waters ICES J Mar Sci 57:1184-1197.

Marteinsdottir G. Begg GA 2002. Essential relationship incorporating the influence of age, size and condition on variables required for estimation of reproductive potential in Atlantic cod Gadus morhua stocks. Mar Ecol Progr Ser 235(2003):235-256.

Nielsen AA 2004. Geostatistik og analyse af spatielle data Course material. IMM. Technical University of Denmark p 1-5.

Pannatier Y 1999. VARIOWIN: Software for Spatial Data Analysis in 2D. Available at http://www-sst.unil.ch/research/variowin/#DOWNLOAD Visited 19.5.2005.

Rikhardsson JH. Birgisson R. 1996. Aflabót (Improved catch). Icelandic Fisheries Laboratory Reykjavik. Report no. 48:44-51.

Thorsteinsson V, Marteinsdottir G. 1992 Tagging of cod at spawning sites on the North and East Coast in 1991 Ægir 2:60-64 (in Icelandic)