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Analysis of Fish Production Conversion Data Collected in 1981 from the Northwest Atlantic

by

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ABSTRACT

A preliminary experimental study (Kulka 1981) revealed some factors used to convert product to round weight of fish departed from those in the official FAO list (Anon 1980). Also, poorly defined, unstandardized product form definitions led to ambiguous product categories and possible misapplication of factors. Using the standard experimental methods and product definitions outlined in Kulka (1983) data were collected by fisheries observers in operating factories of the various fleets fishing in Canadian waters.

An analysis of variance of species and process method categories showed no significant differences between countries and areas. The analysis resulted in 24 amalgamated species/process category (means), many of which differed substantially from conversion factor values of previously published lists. Five of these conversion factors were derived from data collected over a representative range of seasons, areas, countries and processing types and are considered applicable as all purpose factors. Differences between processing machines used were not tested. The estimators of conversion factors derived in this study are: gutted cod, 1.22±0.01; split fresh cod, 1.66±0.02; skinless fillets of cod, 3.26±0.07; gutted, head and tail off grenadier, 2.33±0.03; and gutted head off turbot, 1.45±0.04. Because about 50 major processes are used in the western Atlantic, excluding those resulting in cured product, considerably more analyses are required. Some of the factors which affect magnitude and variance of product yield in commercial conditions, are discussed.

RESUME

Une étude préliminaire (Kulka 1981) a démontré que certains facteurs de conversion de poids du poisson traité en poids du poisson rond différaient de ceux contenus dans la liste officielle de la FAO (Anon. 1980). De plus, des formes de produits non standardisées et mal définies ont résulté en des catégories ambiguës et des applications erronnées des facteurs. Utilisant les méthodes expérimentales et les définitions de produits standard esquissées dans Kulka (1983), des observateurs ont recueilli des données dans les usines des diverses flottilles pêchant dans les eaux canadiennes.

Une analyse de variance des espèces et des catégories de traitement n'a pas révélé de différences significatives entre pays et lieux de pêches. L'analyse a donné 24 catégories d'espèces/procédés amalgamés (moyennes) avec, pour plusieurs, des facteurs de conversion substantiellement différents de listes publiées antérieurement. Cinq de ces facteurs ont été calculés à partir de données recueillies dans un éventail représentatif de saisons, régions, pays et types de traitement, et sont considérés comme universellement applicables. Les différences entre machines à traiter le poisson n'ont pas été testées. Les estimateurs de facteurs découlant de cette étude sont : morue éviscérée, 1,22 ± 0,01; morue fraîche tranchée, 1,66 ± 0,02; filets de morue sans la peau, 3,26 ± 0,07; grenadier éviscéré, sans la tête ni la queue, 2,33 ± 0,03; et turbot éviscéré, sans la tête, 1,45 ± 0,04. Quand on songe qu'il existe environ 50 principales méthodes de traitement en Atlantique occidental, sans compter celles des produits marinés, on conçoit qu'il faudra beaucoup plus d'analyses. Nous examinons certains facteurs influant sur l'ampleur et la variance du rendement en produits dans des conditions commerciales.

INTRODUCTION

Application of conversion factors to stored fish products has long been recognized as the most convenient (and probably most accurate) method of estimating round weight of catches at sea where direct weighing is not possible. This method is quite accurate if the factor properly reflects average yields from the machinery used, because careful records are kept for the amounts of product put down. However, a preliminary study of experimentally derived product to whole weight conversion factors (Kulka 1981) revealed several significant departures from those given in the official FAO list (Anon 1980). These listed values were most often lower because they tended to reflect maximum rather than average machine yields.

In 1981 the preliminary conversion factor program was expanded to cover a wider range of processes. Collection methods and standardized product form definitions given in Kulka (1983) were used. The aim of the paper is to provide a series of condensed categories of experimentally determined conversion factors by species and process, applicable to the Northwest Atlantic fisheries. Also discussed are some of the factors which affect magnitude and variance of product yield under commercial conditions.

METHODS

The conversion factor data for 1981 were collected by singly deployed fisheries observers on board the factory ships of ten countries fishing within the Canadian zone. Since deployment patterns were based on factors other than the attainment of production data the strategy was to opportunistically collect information for the dominant processes encountered. Such information included whole to product weight ratios for particular machinery, average fish lengths in the samples and auxillary data such as make and capabilities of processing machinery, factory layout, proportionate use of various machines, production figures (product put down) and details of subprocess methods.

The general techniques of sample selection, detailed product category descriptions and recording formats given in Kulka (1983) were used as a guide for the present study. Specifically, subsets of random samples of the catches were selected to conform to the size range capabilities of specific processing machines being used. The aim was to have the samples of fish processed by different machines in proportion to their use during normal production. In addition, a small number of specific size selected samples were taken in order to observe any differences in magnitude of conversion factors for size of fish within the commercial range.

Raw samples were grouped according to species, process method, stock area and country. Machine type differences were assumed to be insignificant. Sample means for each category were calculated using the following formula:

$$\bar{x} = \frac{\sum_{1}^{n} \frac{WW_i}{PW_i}}{n} \quad \text{(mean of sample ratios)}$$

Where $\bar{x}$ = estimated conversion factor for the category

WW_i = whole weight of the ith sample

PW_i = product weight of the ith sample

n = number of samples

The associated variance was estimated by:

$$s^2 = \frac{\sum (x_i - \bar{x})^2}{(n-1)}$$

$$\text{where } x_i = \frac{WW_i}{PW_i}$$

The range of sample weights, for practical reasons was very narrow (see Kulka 1983). In categories where range of weights was wide enough, a regression of round weight on product weight was performed, intercepts were tested and found not to be significantly different from zero. Given this, the ratio and regression estimates of conversion factor means should be equivalent. This is expected because most sample weights fell within a very narrow range.

In the context of commercial operations it is practical to reduce number of production categories and their corresponding conversion factors, hence at the second stage, analysis of variance was used to compare country/area categories in order to consolidate, where possible. The analysis of variance package (Proc GLM) available in the Statistical Analysis System (SAS Users Guide: Statistics, 1982 ed.) was used. Prior to analysis, cells of data were checked for homogeneity using Bartletts procedure (Ostle and Mensing 1975) and frequencies of means were checked for normality using the method of Shapiro and Wilk (Shapiro and Wilk, 1965) in order to verify assumptions underlying analysis of variance.

RESULTS

Data were compiled into species/process categories. Where significant differences at the .05 level did not occur between country/area cells, processes were pooled and presented in Table I.

The reduction produced 24 grouped species/process means from the original 78 categories, 7 for cod, 3 for redfish, 2 for grenadier, 6 for turbot, and 1 each for plaice, witch, porbeagle, pollock, squid, and shrimp. Two indicators of variance of the sample means, the coefficient of variation ($s/\sqrt{\bar{x}}$) and the 95% confidence interval ($\pm\ s/\sqrt{n} \times t$) , accompany the conversion factor estimates. For practical purposes variance of the estimated conversion factor was considered to be adequately small when the value of the 95% confidence limit was no further away than 5% of the mean. Seventeen of the 24 grouped categories listed met this criteria.

The analysis showed only one case where there was a significant difference in conversion factor estimates between areas. Yields for shrimp in 0 and 2H taken by Faroese vessels were shown to be marginally different, however, sample size was very small (n=2 for 2H and n=3 for 0). Qualitative observations indicate that size of shrimp processed can affect magnitude of the factor and it is likely that this contributed to the areal differences observed.

For between country comparisons (areas combined), Table I shows gutted, head off cod processed on Japanese vessels produced a significantly lower yield than those on Portuguese and Norwegian vessels in all areas examined. This may be attributed to a different heading technique used. A significant difference between diagonally headed redfish processed by USSR, as opposed to GDR/Poland, indicated differences in cutting techniques for this species as well. Sample size was very small (n=2 for USSR) and additional study is required to properly define this process.

Columns 3 and 4 of Table I indicate the months in which samples were taken and the types of processing (machine or hand) that were used. Not enough data were available to compare yield for the various machines used, but for 4 species/process categories, data covering a wide temporal span did allow for limited seasonal comparisons. It revealed no significant differences between quarters of the year for gutted cod (winter and summer only), split cod (spring values were slightly elevated), skinless, boneless, trimmed cod fillets (winter and fall only), grenadier, gutted, head and tail off (summer and fall only) and turbot, gutted, head off. Only a relatively small portion of samples were taken during peak spawning periods, hence, this study is not definitive in describing total seasonal patterns. Regardless, most fisheries are limited in time span and the observed period matched the actual period of fishing for those listed above. Hence, results of these categories are thought to be representative.

Another factor that might influence yield is the average size of fish processed. In 1981 mean length of the fish was recorded for a limited number of samples where individuals were randomly selected from the catch. No significant correlations were observed between fish size and yield over the relatively narrow range of mean lengths for 6 process categories examined. It should be noted that this preliminary analysis was geared to examine only a very narrow commercial size range. Yield at the extremes may be affected by size of fish, particularly for the more primary products such as gutting or splitting.

DISCUSSION

Samples for the 1981 study were taken strictly on an opportunistic basis as dictated by the prevailing conditions. Their distribution by area and season reflect relative time spent by observers in the particular fisheries rather than a carefully planned sampling strategy. Many classes are missing and sample numbers in existing categories are unbalanced (n ranges from 2 to 120). The study however does yield adequate product to whole weight conversion factors for certain species/process categories. To examine the effect of processing type (machine type, age of machine, average machine quality, extent of hand cutting), gonad size, gut fullness, size and condition of fish a more detailed and complete sampling scheme would be required.

By comparing the values obtained in this study to the updated FAO list, substantial differences were noted. As well, certain vessels had their own conversion factors which were different from the official list. For example, FAO factors for gutted cod ranged between 1.11 and 1.25. The factor 1.20 given for Canada closely matched the experimentally obtained value of 1.22±0.001 (a difference of less than 2%). For the Portugese and Norwegian fleets, gutting and heading was almost always an intermediate step preceding splitting. The most commonly used pre-splitting, heading procedure was the round cut as described in Kulka (1983). The listed Norwegian values were 1.4 and 1.6 (spawning). This compares with 1.49±0.054, the combined mean for the two countries derived from this study. In contrast, the average observed factor on Japanese vessels was 1.71±0.060, indicating that a substantially different heading process was used with greater loss of flesh in the latter case. This corresponds with an average factor of 1.78 observed in 1980 for a limited number of experiments done on Japanese vessels (Kulka, 1981). Certainly the very wide range of 1.38 to 1.78 given in the FAO list and the observed differences in factors used by the various countries indicate the use of more than one type of cut. Further study is required to differentiate these.

The most thoroughly studied process was split fresh cod, before salting. This split stage, referred to as "green" in Kulka (1983) is actually for unsalted product although green implies application of salt. Both hand and machine cut fish were examined over most seasons and areas. With the exception of 1.70 listed for Canada in the original FAO document (Anon 1970) all published split cod factors refer to the product after curing. The range of split fresh factors used by Portugese, French, and Faroese vessels was 1.60-1.80. Experimentally determined averages of 1.67 for Portugal and 1.69 for Spain from the 1980 study (Kulka, 1981) support the validity of 1.66±0.023 obtained in the present study as an average for all countries, seasons, and areas.

Fillet product names in the various published lists are ambiguous. The set defined in this study therefore is not directly comparable to past lists. For instance, fillet trimming as defined in Kulka (1983) and the present paper is not the act of removing blood spots and fin bits but rather is extensive removal of peripheral flesh for the purpose of yielding a uniform, high quality product (trimming was not included as a subprocess in either the FAO or NAFO lists despite its obvious affect on yield). Boning refers to the removal of a V-shaped portion of flesh at the anterior of the fillet containing the lateral spines of the vertebrae. Lack of definition of both of these subprocesses caused categorization problems in early experiments. In 1980 and 1981 observers often referred in their reports to blood spot removal as trimming and fin bit removal as boning. As a result data had to be reclassified by re-examining diary and detailed trip report product descriptions. This re-examination indicated that the 1980 French factor 2.9 listed in Kulka (1981) for boneless fillets was actually for fillets before removal of the bone, skin or fin bits (the product was boned after the sample product weights were taken). A mean of 3.26±0.150 obtained in the present study for skinless fillets on French vessels and 3.31 for a similar product on Polish vessels given in Kulka (1981) also suggest that 2.9 for fillets may be low because skin removal and post-machine treatments result in considerable additional weight loss.

Large differences in conversion factors for particular fillet processes between countries indicates improper categorization and mixing of subprocesses within classifications on the FAO list. The substantial and variable weight loss due to trimming and boning was not always reflected in the magnitude of factors actually used by the various fleets. Trimming alone including blood spot and fin bit removal and extensive removal of peripheral flesh can reduce yield by as much as 20% in extreme cases although a flesh loss of 10-15% is average. The factor 2.81 used by French vessels is respectively 15%, 14%, 19%, and 21% lower than skin on fillet, skinless fillet, skinless boneless fillet, and skinless, boneless, lightly trimmed fillet factors, derived in this study. GDR vessels used 3.33 regardless of subprocess. Since substantial trimming and boning were done on French and German vessels as well as those of other fleets, the used factors are considered low.

A sampling problem occurred particularly for fillet processes when greater care was taken by the crew during cutting and trimming procedures during experiments. In certain instances machine blades were carefully adjusted or trimming was reduced intentionally to produce higher yields than normal. As a result, certain of the derived values should be considered as minimum estimates only. The factor 3.57±0.119 for skinless, boneless, trimmed fillets obtained on German and French vessels should be regarded as such. Heavier, more normal trimming would probably reduce yield by a further 5%. This problem was encountered mainly during the processing of cod into fillets.

The dominant product from round nose grenadier (USSR and GDR) is gutted, head and tail removed, fins on or off. The delicate skin of this species is left on since almost all scales come off while the fish are in the net and hold. A substantial number of experiments carried out over most of the fishing season and area resulted in a factor estimate of 2.33±0.042. This is very similar to 2.39 listed by Kulka (1981) but is 9% higher than 2.11 given in the updated FAO list. The conversion factors used by most USSR (2.28) and GDR (2.32) vessels were closer to the value determined in this analysis.

The estimated mean for gutted redfish was 1.17±0.012, falling in the upper part of the range (1.06-1.20) given in the FAO list. Two different cuts, straight and diagonal, were observed for headed redfish, the latter producing a substantially smaller yield. The FAO list does not distinguish between the two cuts but lists a wide range of 1.44 to 2.02. The listed USSR value, 1.51

corresponds with 1.53±0.026 determined for the straight cut on Soviet vessels in the present study. It is, however, significantly different from the GDR/Poland diagonal cut mean of 1.98±0.094 and USSR diagonal cut mean of 1.84±0.127. The observed difference between the last two may be due to sample size or possibly to more extensive removal of belly flap and gut in the former case. Average values listed by Kulka (1981) were 2.08 for GDR and 1.88 for Poland. Further study on these two processes is required.

Four experiments on gutted plaice produced an average of 1.15±0.029, in agreement with the 1.10 to 1.18 range given in the FAO list. A mean of 1.28±0.037 for gutted, head off witch also corresponds with the 1.27-1.31 range of factors used by individual Polish vessels. As well, a mean of 1.45±0.039 for gutted, head off turbot falls close to the range of 1.40-1.44 used by the Polish and Soviet vessels. Values in the FAO list are somewhat lower, between 1.15 and 1.43. The mean for topside turbot fillets, 5.37±0.097 determined in this study was substantially higher than the factors used by individual vessels.

For tubed squid, the September average was 2.10±0.093, slightly higher than 2.0 used by the observed vessel. This factor may be affected by the change in average size of squid over the season and a detailed seasonal study would be required to define this pattern. The average for cooked and peeled shrimp was 4.89±1.46 but magnitude of this factor seems to be strongly influenced by size of shrimp.

Conversion factors were experimentally determined in the present study for 24 of about 50 of the major processes by species used in the Canadian zone, excluding the cured or dryed processes. In some cases sample size or sampling coverage were inadequate. However, for 5 of the species/processes where sample size was large (greater than 10), variance was small (confidence limit less than 5% away from the mean) and which covered a representative range of areas, seasons, countries, and machine types or hand processing, the estimated conversion factors can be considered representative. They are as follows:

Cod, gutted	1.22±0.01	n=50
Cod, split green	1.66±0.02	n=120
Cod, fillets skinless	3.26±0.17 (winter)	n=63
Roundnose Grenadier, gutted, head & tail off	2.33±0.03	n=54
Turbot, gutted, head off	1.45±0.04	n=28

The above values can be applied for general use and are marked as such on Table 1 although further detailed study must be carried out for these as well as other categories to determine how the various factors contribute to the variance. Such analyses should examine the effect of machine type, age of machine, size of fish in the catch, and also the effect of crew on trimming and other hand cutting procedures. These factors could lead to differences between fleets, vessels within fleets, seasons, and are not area specific. Particular attention should be paid to processes where no experimental data is presently available and to the more complicated processes such as filleting and its subcategories.

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Table I. 1981 Conversion factor analysis

Country/ Countries	Area/s	Month/s	Process	Use**	Conversion Factor	FAO Conv. Factor	# Samples	Coeff. Variation	95% CI ±	*95% CI as a % of $\overline{X}$
					CATEGORY - PORBEAGLE, GUTTED HEAD AND TAIL OFF					
Faroes	4WX	3,4	Hand	P	1.490	-	24	0.036	0.019	1.3
					COD - GUTTED					
Canada Portugal	2J,3KL 3N,4W	1,2,5 7	Hand	G	1.219	1.20(Can)	50	0.043	0.014	1.2
					COD - GUTTED HEAD OFF					
Japan	3L	10,11,12	Hand Machine	P	1.710	-	26	0.082	0.043	2.5
Portugal Norway	2J,3L,3N	5,10,11	Hand (presplitting)	P	1.485	1.6(N)spawning 1.4(N)	16	0.068	0.044	3.0
					COD - SPLIT FRESH					
Faroes France Norway Portugal	2H,2J 3K,3L 3N,3M 4Vn	2,4,5 7,9,10 11,12	Hand Machine	G	1.660	-	120	0.077	0.023	1.4

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Table I. (Cont'd.)

Country/ Countries	Area/s	Month/s	Process	Use	Conversion Factor	FAO Conv. Factor	# Samples	Coeff. Variation	95% CI ±	*95% CI as a % of $\overline{X}$
					COD - FILLET, SKINLESS, BONELESS TRIMMED (LIGHT)					
France GDR	2H,3Pn 4R	1,2,11 12	B338 Machine	P	3.571	-	7	0.036	0.119	3.3
					COD - FILLET, SKINLESS BONELESS					
France GDR	2H,4R 4Vn	1,2 11	B338 B38 B189	P	3.461	-	7	0.018	0.031	0.9
					COD - FILLET, SKINLESS					
France	3Pn 4R,4Vn	1,2,3	B338 B38 B189	G	3.256	-	63	0.085	0.070	2.1
					POLLOCK - FILLET, SKINLESS					
France	4R,4Vn	2	B338	P	2.310	-	2	0.091	1.906	82.5
					ROUNDNOSE GRENADIER - GUTTED HEAD AND TAIL OFF (FINS ON OR OFF)					
USSR GDR	2G,2H 2J,3K	8,9,10 11,12	Hand	G	2.328	2.11(USSR)	54	0.062	0.026	1.1

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Table I. (Cont'd.)

Country/ Countries	Area/s	Month/s	Process	Use	Conversion Factor	FAO Conv. Factor	# Samples	Coeff. Variation	95% CI ±	*95% CI as a % of $\bar{X}$
					ROUNDNOSE GRENADIER - LIVERS ONLY					
USSR	0	11	Hand	P	17.335	-	2	0.054	8.449	48.7
					REDFISH - GUTTED					
USSR	3K,30	3,8	Hand Machine	P	1.173	-	12	0.016	0.012	1.0
					REDFISH - HEAD OFF, STRAIGHT CUT					
USSR	2J,3K,3L	3	-	P	1.529	1.51(USSR)	8	0.021	0.026	1.7
					REDFISH - HEAD OFF, DIAGONAL CUT					
USSR	3K	11	-	P	1.840	1.51(USSR)	2	0.008	0.127	6.9
GDR Poland	2J,3K 3L	4,5,9,10 11	Hand	P	1.983	-	8	0.057	0.094	4.7
					PLAICE - GUTTED					
Can	3L	5	Hand	P	1.150	1.10(Can)	4	0.031	0.057	4.9
					WITCH - GUTTED HEAD OFF					
Poland	2H,3K	1,3,4,5	Hand	P	1.283	-	28	0.074	0.037	2.9

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Table I. (Cont'd.)

Country/ Countries	Area/s	Month/s	Process	Use	Conversion Factor	FAO Conv. Factor	# Samples	Coeff. Variation	95% CI ±	*95% CI as a % of $\bar{X}$
					TURBOT - GUTTED HEAD OFF (FINS ON OR OFF)					
USSR Poland	2G,2H 3K	1,2,4 5,8,9,10	Hand		1.453	1.43(Poland)	28	0.069	0.039	2.7
					TURBOT - FILLETS, SKINLESS					
GDR	2H	9	Hand	P	2.90	-	3	0.038	0.275	9.5
					TURBOT- TOPSIDE FILLET, (SKIN ON OR OFF)					
USSR	0	11,12	Hand	P	5.372	-	18	0.076	0.088	1.6
					TURBOT - LIVERS					
USSR	0	11,12	Hand	P	68.582	-	6	0.436	31.394	45.8
					TURBOT - BODIES					
USSR	0	11,12	Hand	P	2.599	-	16	0.166	0.230	8.9
					TURBOT - HEADS					
USSR	0	11,12	Hand	P	3.453	-	12	0.059	0.189	5.5
					SQUID - TUBED					
France	4X	9	Hand	P	2.095	-	6	0.042	0.093	4.4

. . . Cont'd.

Table I. (Cont'd.)

Country/ Countries	Area/s	Month/s	Process	Use	Conversion Factor	FAO Conv. Factor	# Samples	Coeff. Variation	95% CI ±	*95% CI as a % of $\bar{X}$
					SHRIMP - PEELED, COOKED					
Denmark Faroes	0,2H	6,7 8	Machine	P	4.886	-	13	0.494	1.460	29.9

*(t x S.E. ÷ $\bar{x}$) x 100

**G denotes conversion factor categories containing data from most or all countries using the process over most or all areas and seasons fished. They also have sufficiently small variance and may be applied as a general factor for the particular category.

P denotes factors derived from limited country/area data and are not recommended for general use until further, more extensive studies have been carried out.