Canadian Atlantic Fisheries Scientific Advisory Committee

Comité scientifique consultatif des pêches canadiennes dans l'Atlantique

CAFSAC Research Document 83/41

CSCPCA Document de recherche 83/41

Cod Fillet Conversion Factors From French Vessels in 1983

by

A. Sinclair
Marine Fish Division
Bedford Institute of Oceanography
Fisheries and Oceans
P.O. Box 1006
Dartmouth, Nova Scotia B2Y 4A2

R. Sciocchetti
Seawatch (N.S.) Division
Suite 201, 961 South Bland Street
Halifax, Nova Scotia B3H 2S6

and

H. Tucker
Hurley Fisheries Consultants
P.O. Box 3049 East
Dartmouth, Nova Scotia B2W 4Y2

Abstract

Reports from Canadian fisheries observers deployed on French vessels fishing cod in NAFO Divisions 4RS and Subdivisions 3Pn 4Vn indicated that a conversion factor of 2.81 has been used to estimate nominal catches of cod from fillet product weight. This factor was used regardless of the type of fillet produced. Preliminary experiments conducted by these observers indicated that the 2.81 conversion factor was too low. Two product types were identified, skinless-boneless fillets and skinless fillets. An extensive study was conducted at sea to determine appropriate conversion factors for those products. Estimates of 3.65 for skinless-boneless fillets and 3.19 for skinless fillets were determined. These figures suggest that catches by France have been underestimated by between 16%-31%. Changes to the historical conversion factor will have effects on both quota monitoring and stock assessment of the respective stocks.

Résumé

Les rapports produits par les observateurs canadiens placés à bord des bateaux de pêche français pêchant la morue dans les divisions 4RS et les subdivisions 3Pn et 4Vn de l'OPANO indiquent qu'un facteur de conversion de 2,81 a servi à estimer les prises nominales de morue à partir du poids des filets. Ce facteur a été utilisé, quel que soit le type de filets produits. Des expériences préliminaires menées par ces observateurs indiquent que le facteur de conversion de 2,81 était trop bas. Deux types de produits ont été identifiés, filets désossés sans la peau et filets sans la peau. Une étude poussée a été effectuée en mer en vue de déterminer des facteurs de conversion appropriés à ces produits. Il en est résulté des estimations de 3,65 pour les filets désossés sans la peau et 3,19 pour les filets sans la peau. Ces chiffres donnent à penser que les prises de bateaux français ont été sous-estimées d'environ 16 à 31 %. Des modifications apportées au facteur de conversion historique influeront à la fois sur la surveillance des contingents et l'évaluation des stocks respectifs.

Introduction

Conversion factors form an integral part of nominal catch reporting in Canadian fisheries. Nominal catches are the round weight equivalent of the weight of landings. In order to calculate round weight the following conversion factor is used:

$$\frac{\text{round weight}}{\text{product weight}}$$

Nominal catch figures from fisheries in Canadian waters are used for two main purposes. The immediate use is in quota monitoring where nominal catch is applied against a predetermined catch quota. Individual fisheries are controlled in such a way that these catch quotas are not exceeded, or at least not exceeded by very much. The second use is in establishing the historical record of nominal catch. These records are kept by the Northwest Atlantic Fisheries Organization (NAFO) and member countries are responsible for accurately reporting nominal catches. Inaccurate conversion factors will affect both quota monitoring and the historical data set.

The object of this paper is to describe the catch reporting practices of France in the winter cod fishery in NAFO Divisions 4RS and Subdivisions 3Pn 4Vn and to present the results of an experimental program designed to determine appropriate conversion factors for the fishery.

Catch Reporting by France

French vessels fishing in NAFO Divisions 4RS and Subdivisions 3Pn, 4Vn are required to report nominal catches to the Department of Fisheries and Oceans (DFO) on a weekly basis. The procedure used by individual vessels is as follows. Vessel personnel record the amount of fish produced in the week. This is, most commonly, in the form of frozen fillets. The product weights are tallied daily and converted, using a conversion factor, to an estimate of daily nominal catch. These estimates are recorded in the Canadian fishing log. The converted daily estimates are then hailed to French fisheries officials on St. Pierre. The French officials, in turn, report the nominal catch figures to DFO and these are then entered on the Foreign Licensing and Surveilance Hierarchy (FLASH) data base. No distinction is made in FLASH between Metropolitan France and St. Pierre based vessels.

Canadian fisheries observers have been deployed on all French vessels fishing in 4RS-3Pn and 4Vn since 1977. Reports from observers indicate that almost all vessels use the conversion factor of 2.81 to estimate nominal catch of cod regardless of production method.

France also reports nominal catches to NAFO. It is not known how these catch figures are derived. But, comparison of the catches reported to FLASH and NAFO separately for stock areas 3Pn-4RS and 4TVn for the years 1979-1983 reveals a very close similarity (Figure 1, Table 1). Since FLASH estimates were derived using a conversion factor these data suggest that the same conversion factor, 2.81, is used in reporting nominal catch to NAFO.

Accuracy of the 2.81 Conversion Factor

FAO (1980) lists 2.81 as the conversion factor for French cod fillets. However, no evidence was found in the literature to substantiate this figure.

The bulk of French caught cod is processed into 2 types of fillets. These are skinless fillets and skinless-boneless fillets. Skinless-boneless fillets differ from skinless fillets in that the small bones which project horizontally from the backbone into the flesh of the fillet have been removed. The bones are removed with a "V" shaped cut in the fillet (Figure 2). All fillets are trimmed to remove blood spots, ragged edges, and excess stain which remains attached to the fillets after cutting. Because of the extra flesh removal for skinless-boneless fillets it is expected that this type of product would have a higher conversion factor than skinless fillets. Thus it does not seem appropriate to have one conversion factor for these 2 product types.

The 2 types of fillets are readily identifiable both in the vessel hold and when the vessels are unloaded because the packing cartons are labeled differently. This is to be expected since the skinless-boneless fillet is considered to be of a higher quality and is sold for a higher price. This ease of identification is important when defining product types and applying conversion factors to product weights.

The accuracy of a 2.81 conversion factor was questionable for other reasons. Firstly, this is the factor specified in operating manuals for the filleting machines used on the French vessels. The machines are anywhere from 15-20 years old and the factors represent minimum values obtained under controlled conditions. Working conditions at sea often vary considerably from those on land and the age of the machines is likely to reduce their efficiency. It is expected that any departure from the ideal shore based conditions would result in a higher conversion factor. Furthermore, factory trawler operators would not be expected to place the same emphasis on maximizing yield as a shore based processing plant would. This is because the cost of the raw product would be substantially less to a factory trawler than to a fish plant. The fishing captain is more likely to want to maximize the amount caught and processed than to maximize processing efficiency.

Secondly, preliminary results from experiments conducted by Canadian fisheries observers on French vessels have indicated that the 2.81 conversion factor is too low. However, problems such as poor process method definition, inadequate training of observers, and poor experimental design have adversely affected the results of these preliminary studies. For example Kulka (1981) reported that the overall conversion factor for all fillet products from French vessels in 1980 was 2.90. Subsequent to publication of the results it was learned that this factor applied to the preliminary skin-on product and not to the final product.

Further study was necessary to obtain accurate estimates of conversion factors in actual production situations. The following sections of this paper describe the methods and results of an experiment designed to provide estimates of conversion factors for the 1983 French winter cod fishery.

Materials and Methods

Information obtained from observers deployed on French vessels in the 1979-1982 winter cod fisheries was used to design the experiment.

In addition to the 2 product types already described it was found that, prior to 1983, each vessel had 2 types of filleting machines. These were the Baader 38 for fish 40-55 cm in length, and the Baader 338 for fish 55-70 cm in length. The machines take round fish, behead them, and remove the 2 fillets. The blades of these machines are pre-set and fixed in a position to suit the size range of fish available. Skin-on fillets are produced. The fillets are then skinned mechanically. The skinless product is then passed to a cutting table where trimming and boning is performed (if necessary or desired).

Analysis of preliminary results from earlier conversion factor experiments indicated possible differences between product types and machines. A sampling strategy, which will be explained later, was developed to investigate these possible differences. However, in 1983 a new machine, the Baader 190, appeared on 3 of the 9 vessels in the fishery. This machine was able to adjust the position of its cutting blades automatically as fish passed through and thus it took fish of all sizes. The Baader 190's studied in this experiment were less than a year old.

Estimates of the variance of conversion factors were obtained from the preliminary analysis. The variance estimates were then used to determine sampling levels necessary to obtain 95% confidence intervals of mean conversion factors by product types and machine with a width of $\pm .10$ or less.

Two methods were used to estimate conversion factors and the associated variances of the preliminary data:

i) The ratio estimate (Cochran 1977)

$$\hat{R} = \frac{\Sigma Y}{\Sigma X}$$

with a variance

$$V(\hat{R}) = \frac{1-f}{n\bar{x}^2} (S_x^2 + \hat{R}^2 S_y^2 - 2\hat{R} S_{xy})$$

where R = estimated conversion factor

Y = product weight

X = whole weight

S_x^2 = variance of x

S_y^2 = variance of y

S_{xy} = covariance of x and y

ii) Quenouille's method, also called the "Jackknife" technique (Smith 1980).

The conversion factor is estimated by R_j.

$$\hat{R}_j = \frac{i}{n} \sum_{j=1}^{n} R_{-j}$$

where $R_{-j} = n\,R - (n-1)\,\frac{\Sigma Y_{-j}}{\Sigma X_{-j}}$

$$R = \frac{\Sigma Y}{\Sigma X}$$

with a variance

$$V(\hat{R}_j) = \frac{1}{n\,(n-1)} \sum_{j=1}^{n} (R_{-j} - \hat{R})^2$$

A total of 87 samples were available for this preliminary analysis. The 2 methods gave virtually identical results as shown in Table 2. Consequently only 1 method was used for further analysis, the Jackknife method.

This variance estimate was used to determine the sample size required to obtain a 95% confidence interval of width 0.10 using the formula

$$N_o^{\frac{1}{2}} = \frac{t_{\alpha/2}\,(V(R_j)\cdot N_s)^{\frac{1}{2}}}{L}$$

where N_o = desired sample size
N_s = preliminary sample size
L = desired interval width.

The sample size was estimated to be N_o=54. A total of 6 cells, made up of combinations of 2 product types and 3 machines, were identified as possibly differing. Therefore a total of 6 N_o=324 samples were required. There were 9 vessels involved in the fishery and we attempted to distribute sampling effort evenly among vessels, machines and product types.

Teams of 2 specially trained and equipped observers conducted the experimental work of the study and they were rotated through the fleet until all 9 vessels were covered. Each team was equipped with 2 scales; a 0-50 kg platform double beam scale, and a 0-100 kg hanging spring scale. Both scales were used concurrently to weigh the round fish and the finished product. The scales were calibrated prior to every experiment with certified lead weights.

Individual experiments were conducted in such a way that the normal working operations of the vessel were disrupted as little as possible. Samples of approximately 100 kg of round fish were used. Samples were collected after the catch had been culled for size by the crew in preparation for production by the different machines. The fish were measured for length and the exact round weight of the sample was determined. An appropriate machine for the sample was selected and checked to ensure that it was free of fillets. Normal processing of the sample was carried out by crew members, the number of remaining fillets were counted to ensure no extras were added, and then the final product was weighed.

An attempt was made to standardize all round weights to 100 kg and then to use product weight as the test statistic. This proved impractical at sea and consequently the ratio of round weight to product weight was used. Analysis of variance was used to test the equality of means between different groups. In preparation for this analysis the data were tested to ascertain whether the assumptions underlying the analysis of variance, i.e. normality and homogeneity of variance, were met. Skewness and kurtosis were used to assess the normality of the data and Bartletts' test was used to test homogeneity.

All data as a single group were found to be highly significantly skewed. When the data were grouped by product type the distribution of the test statistic for skinless fillets was found to be both highly skewed and highly kurtose. There was also highly significant heteroscedasticity.

A series of transformations from Tukey's "simple family" of transformations were attempted to satisfy the assumptions of normality and homogeneity. The transformation which produced satisfactory results was:

$$U_i = \log_{10} (-2+Vi)$$

where V_i = the ratio of round weight to product weight.

The variable U_i was used in the statistical tests while the Jackknife method was used to calculate the conversion factors and their confidence intervals.

These data were classified into categories and levels as follows:

Product type	1 - skinless-boneless fillets	
	2 - skinless fillets	
Machine	1 - Baader 190	
	2 - Baader 338	
	3 - Baader 38	
Stock area	1 - 4TVn	
	2 - 4RS-3Pn	
Month	1 - January	
	2 - February	
	3 - March	
Vessel	1 - Zelarde II	6 - Le Dauphin
	2 - Victor Pleven	7 - Joseph Roty II
	3 - Nevē	8 - Finlande III
	4 - Islande IV	9 - Commandant Gue
	5 - Capitaine Pleven II	

Results and Discussion

The conversion factor experiments were conducted between January 15 - March 15, 1983. A total of 321 samples were collected. The distribution of samples among categories and levels is shown in Table 3. Sampling effort was not distributed equally among all categories and levels due to technical constraints. Only three vessels were equipped with the Baader 190. One of these vessels (#6) fished only in stock area 4RS-3Pn and only used the Baader 190 while the observer team was onboard. Furthermore the fishery in 4TVn, which has a quota approximately half the size of the one in 4RS-3Pn, was closed in the latter part of February. Thus there were no observations from 4Vn in March.

There were 154 product type 1 samples and 154 product type 2 samples. When the analysis of variance was applied to the transformed data a highly significant difference between product type was found (Table 4). Jackknife estimates of conversion factor and the associated confidence intervals by product type are given in Table 5. As expected the conversion factor for skinless fillets (type 2) was less than that for skinless-boneless fillets (type 1).

An analysis of variance applied to the fixed variables product type and machine yielded highly significant differences between product types and machines with a significant interaction (Table 6). Conversion factors and confidence intervals for each machine and product type are given in Table 5. Box and whisker plots of the raw data distributions for each group are given in Figure 3.

These results indicate that within each product type the newer machine, the Baader 190 (#1), had lower conversion factors than the other 2. Furthermore the machine which took larger fish, the Baader 338 (#2), had lower conversion factors than the machine which took smaller fish. For each machine the mean conversion factor for skinless-boneless fillets was higher than the mean for skinless fillets.

All estimates given in Table 5 were recalculated using the ratio method. In all cases the 2 estimates were identical to 2 decimal places.

The interactive term in the 2-way analysis of variance indicates that there was less of a difference between the 3 machines for skinless-boneless fillets than there was for skinless fillets. It should be noted that with the high error degrees of freedom obtained in this study relatively small differences in means will appear statistically significant.

Examination of the effects of the variables product type, machine, area and month was complicated due to the distribution of sampling effort. In order to test the simultaneous effects of these variables a subset of the data was selected. These data were taken from vessels 1, 3, 4, 5, 8; for machines 2 and 3; and for months 1 and 2. This combination of data provided a suitable number of observations in each cell for factorial analysis. The object of this analysis was to identify which variables are important in determining conversion factors.

The results of the analysis are shown in Table 7. Highly significant differences were found across each variable. However product type was the most important variable accounting for 43% of the overall variance in the subset of data. Machine type contributed 8% of the variance while month and area accounted for 5% each. There was also a highly significant interaction between month and area. There was not a significant interaction term between product type and machine as in the previous analysis. This is likely due to the elimination of machine 1 from the factorial analysis.

Jackknife estimates of conversion factors for all possible combinations of product type, machine, area, and month using the entire data set are given in Table 8. The following trends were evident from the results. (1) Conversion factors for product type 1 were higher than for product type 2 when the other variables were held constant. (2) Conversion factors consistently increased for machines 1 to 3 when other variables were held constant. (3) Conversion factors for area 1 were higher than those from area 2 when other variables were held constant. (4) In area 2 monthly conversion factors decreased from month 1 to month 2 followed by an increase in month 3.

Area and month effects may be considered of minor importance. Each contributed approximately 5% to the overall variance in the subset of data. From the means presented in Table 8 it is indicated that the difference in mean conversion factors between the 2 areas was about 4% and the monthly trend was not in one direction. These differences are small in comparison to differences between process methods and machines.

When considering the setting of conversion factors it is important to consider some practical aspects. It would be reasonable to accept separate conversion factors for the different product types provided that they may be identified both in the hold of the ship and when the vessel is unloaded. This is the case for the 2 product types observed in this study. However there is no practical way to distinguish how much product is produced by each machine. Often fillets produced by different machines are packed into the same box. Consequently separate conversion factors are only practical for the different products.

Jackknife estimates of conversion factors by product type are given in Table 5. Assuming that the level of sampling effort applied to each machine represents the level of production from each machine these means would represent the overall average for each product. There was no reason to reject this assumption. For skinless-boneless fillets the estimated average conversion factor for all three machines was $3.65 \pm .04$. For skinless fillets the estimate was $3.19 \pm .04$. These estimates are likely to be underestimates of conversion factors for the years prior to 1983 since the newer machine (Baader 190), which had significantly lower conversion factors than the other 2, was only introduced in 1983. When only machines 2 and 3 are considered the estimates of conversion factors were $3.69 \pm .05$ and $3.25 \pm .04$ for product types 1 and 2 respectively. These latter factors are more representative of pre 1983 conversion factors.

Conclusions

Since 1979 France has reported virtually the same catch statistics for cod in stock areas 4RS-3Pn and 4TVn to NAFO as they have to FLASH. Catch statistics reported to FLASH have been based on production weights converted to whole weights using a conversion factor of 2.81 regardless of processing method. Thus it may be concluded that the same conversion factor was used in reporting nominal catch to NAFO.

The conversion factor of 2.81 used historically by France is an underestimate. This study has indicated that 2 conversion factors are appropriate for pre 1983 conversion factors. These are 3.25 for skinless fillets and 3.69 for skinless-boneless fillets. If these factors are accepted as being representative of the historical fishery, it means that catches calculated from skinless fillet product weights were undestimated by approximately 16% while those estimated from skinless-boneless fillet production were underestimated by approximately 31%.

This underreporting of catch has implications on the quota monitoring function of DFO and on the assessments of the respective stocks. French vessels reported catches of approximately 20,000 t from the 2 stock areas in the past 3 years. The actual catches were probably between 23,000 t - 26,000 t. Thus French cod quotas for the 2 stocks have been over fished, and removals at age used in the respective stock assessments have been underestimated. Furthermore, the introduction of new conversion factors to the nominal catch reporting process will further affect stock assessments by introducing a discontinuity to the historical catch record. The magnitude of these effects and ways of accounting for them are worthy of further study.

Acknowledgements

The following observers carried out the experiments in the 1983 fishery: M. Grace, P. Guest, C. MacGillivray, J. Manuel, M. Martin, C. Mason, R. Sekarek, K. Siddall, and D. Spallin. Other observers from the three Atlantic regions aided the study in collecting the preliminary data. Without their collective contributions this study would not have been possible. We gratefully acknowledge the logistic support provided by C. Goodwin, S.J. Smith gave valuable advice in the data analysis, and D. Waldron aided in the preliminary planning.

References

Cochran, W.G. 1977. Sampling Techniques, Ed. 3. John Wiley and Sons Toronto.

FAO. 1980. Conversion factors for selected fish species, processing methods and countries. Food and Agriculture Organization, Rome.

Kulka, D.W. 1981. An examination of the product form to whole weight conversion factors used by the foreign fleets in 1980 (Newfoundland Observer Program). CAFSAC Res. Doc. 81/60.

Smith, S.J. 1980. Comparison of two methods of estimating the variance of the estimate of catch per unit effort. Can. J. Fish. Aqua. Sci. 37: 2346-2351.

Table 1. Comparison of nominal catch (t) of cod reported by France to NAFO and to FLASH for 1979 - 1983.

YEAR	STOCK AREA	FLASH	NAFO
1979	4RS-3Pn	14409	13767
	4TVn	2710	2912
1980	4RS-3Pn	9024	9396
	4TVn	8725	9236
1981	4RS-3Pn	12955	12508
	4TVn	7658	8209
1982	4RS-3Pn	12160	-
	4TVn	6750	6745
1983	4RS-3Pn	12106	-
	4TVn	6411	6361

Source 1979-1980 - NAFO Statistical Bulletins
1981 - NAFO SCS DOC. 82/VI/7
1982-1983 - NAFO Circular Letter 83/50

Table 2. Comparison of Ratio and Jackknife estimates of conversion factor and variance for the preliminary data.

	MEAN	VARIANCE
Ratio	3.2678	.0016197
Jackknife	3.2676	.0016196

Table 3. Sampling distribution in the 1983 French cod conversion factor study.

			PRODUCT	TYPE				
				1 MACHINE			2 MACHINE	
VESSEL	MONTH	STOCK AREA	1	2	3	1	2	3
1	1	1	4	3	2	4	4	2
		2	6	8	4	4	6	3
2	1	1	13	-	4	8	-	4
		2	6	-	-	7	-	-
3	1	1	-	4	3	-	3	3
		2	-	3	3	-	5	4
3	2	1	-	3	4	-	4	2
		2	-	-	-	-	1	1
4	2	1	-	4	5	-	5	5
		2	-	4	4	-	4	4
5	2	1	-	5	6	-	4	5
		2	-	6	8	-	6	8
6	2	1	-	-	-	-	-	-
		2	-	-	-	2	-	-
6	3	1	-	-	-	-	-	-
		2	-	-	-	12	-	-
7	2	1	-	-	-	-	-	-
		2	-	2	2	-	2	2
7	3	1	-	-	-	-	-	-
		2	-	2	2	-	3	3
8	2	1	-	6	7	-	6	7
		2	-	6	7	-	6	8
9	2	1	-	-	-	-	-	-
		2	-	1	1	-	1	1
9	3	1	-	-	-	-	1	1
		2	-	3	3	-	4	4

Table. 4. Analysis of variance of conversion factors for the 2 product types.

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIFICANCE
Product type	1.647	1	1.647	232.3	.001
Residual	2.263	319	.007		
Total	3.910	320			

Table 5. Jackknife estimates of conversion factor and the associated 95% confidence intervals for product type and machines.

PRODUCT TYPE	MACHINE	MEAN	NUMBER OF OBSERVATIONS
1	1	3.50 ± .10	29
	2	3.57 ± .08	60
	3	3.80 ± .07	65
	all	3.65 ± .05	154
	2+3	3.69 ± .05	125
2	1	2.99 ± .06	37
	2	3.19 ± .05	64
	3	3.32 ± .05	66
	all	3.19 ± .04	167
	2+3	3.25 ± .04	130

Table. 6. Analysis of variance of conversion factors for the 2 product types and 3 machines.

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIFICANCE
Main effects					
Product type	1.572	1	1.572	291.0	.001
Machine	.523	2	.261	48.4	.001
Interaction	.039	2	.091	3.6	.029
Explained	2.209	5	.442	81.6	.001
Residual	1.701	315	.005		
Total	3.910	320			

Table. 7. Analysis of variance of conversion factors for product type, machine (2, 3), month (1, 2), and area. Data from vessels 1, 3, 4, 5, 8 was used.

SOURCE	SUM OF SQUARES	% OF VARIATION	DF	MEAN SQUARE	F
Main effects					
Product type	.864	43	1	.864	225.2
Machine	.155	8	1	.155	40.4
Month	.105	5	1	.105	27.4
Area	.102	5	1	.102	26.6
Interaction					
Area and month	.039	2	1	.039	10.2
Explained	1.278	63	15	.085	22.2
Residual	.748		195	.004	
Total	2.026		210		

Table 8. Jackknife estimates of conversion factors for all possible combinations of product type, machine, month, and area using all data.

		PRODUCT TYPE 1			PRODUCT TYPE 2		
		MACHINE			MACHINE		
Month	Area	1	2	3	1	2	3
1	1	3.59	3.73	4.07	2.95	3.27	3.60
	2	3.37	3.69	4.01	2.87	3.21	3.47
2	1	-	3.65	3.87	-	3.24	3.33
	2	-	3.37	3.61	3.14	3.10	3.21
3	1	-	-	-	-	-	-
	2	-	3.56	3.67	3.13	3.17	3.21

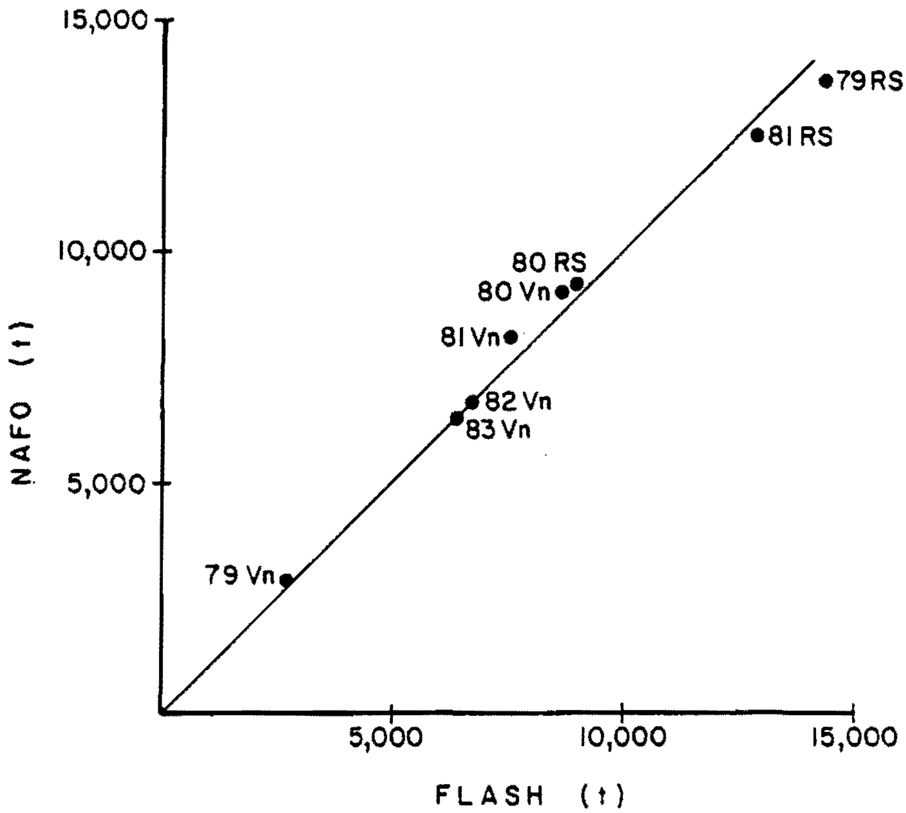

Figure 1. Comparison of nominal catches of cod reported to FLASH and to NAFO. A 45° line was added for comparison and does not represent a regression of the data.

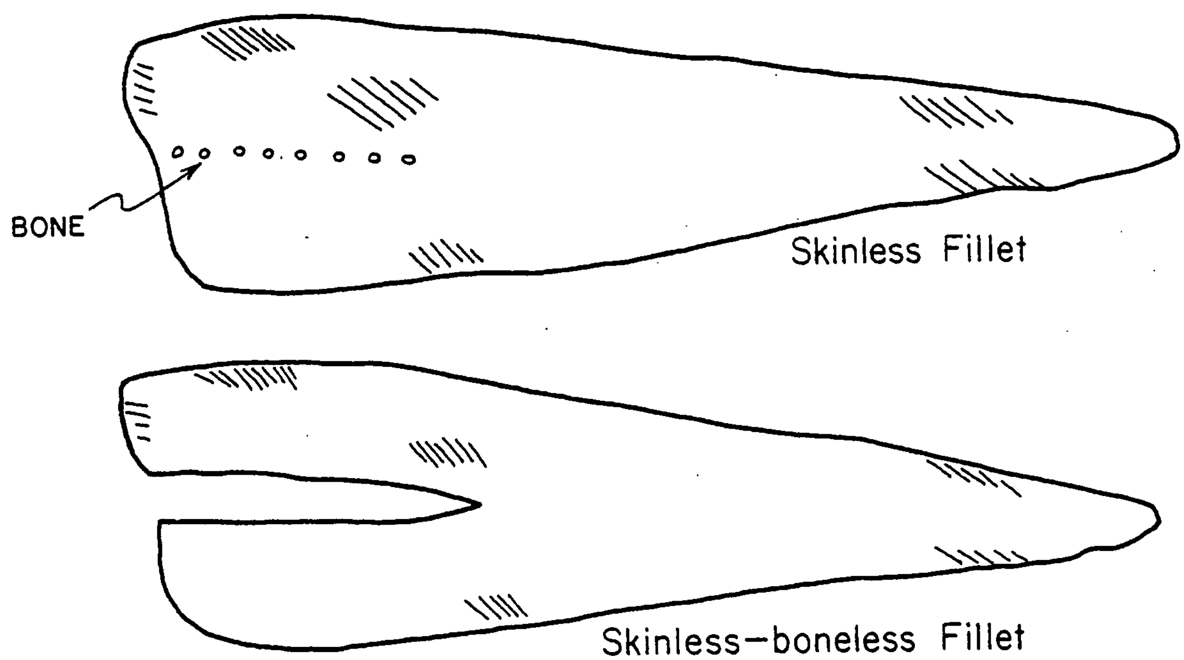

Figure 2. Comparison of skinless fillets and skinless-boneless fillets produced by France.

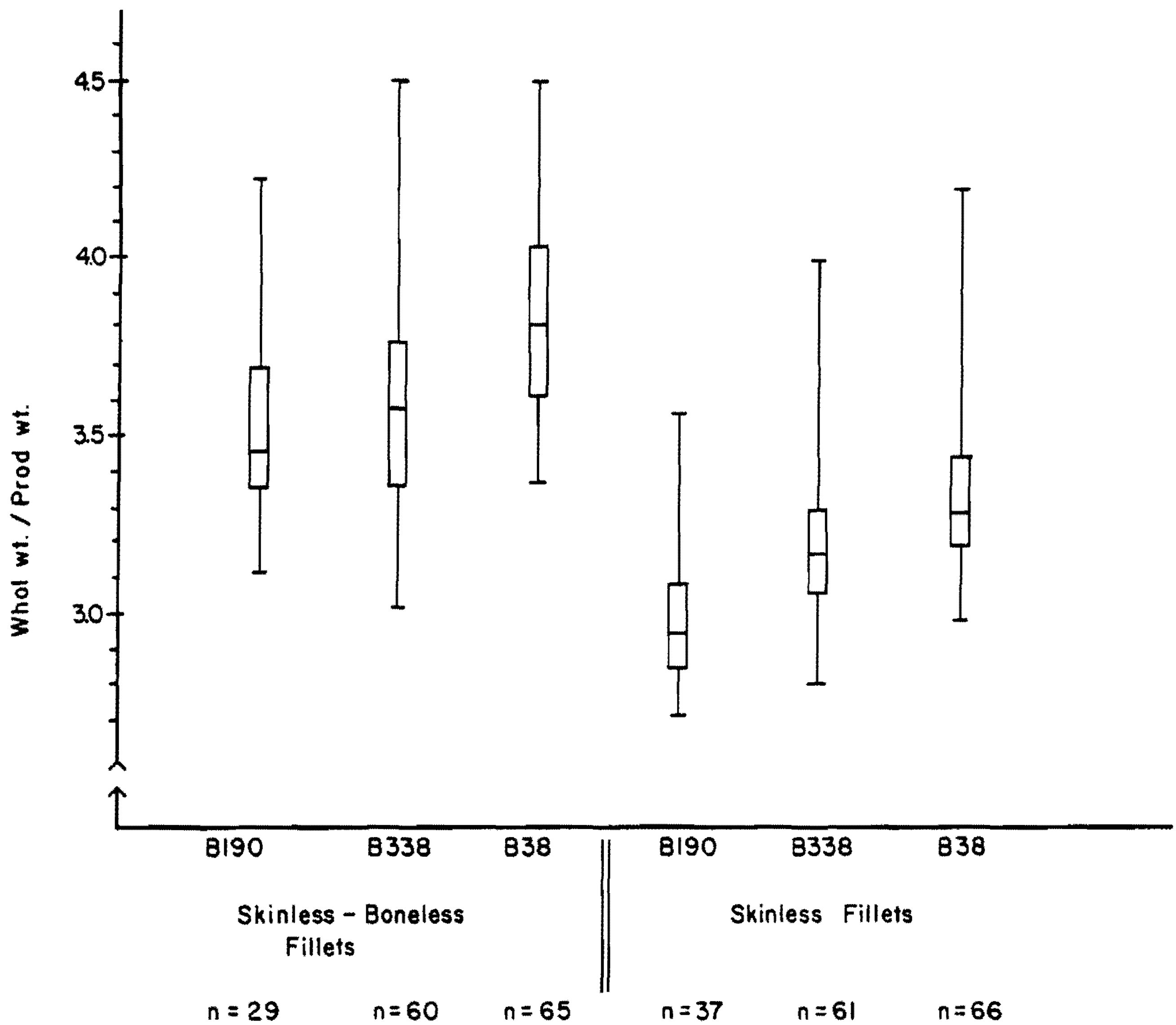

Figure 3. Box and whisker plots of the distribution of new data for the 3 machines and 2 product types.