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Conversion Factors for Newfoundland-Labrador Commercial Atlantic Salmon Fishery Statistics

by

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Abstract

Factors currently in use for converting weight of fish landed in the Newfoundland-Labrador commercial Atlantic salmon (*Salmo salar* L.) fishery with head-off and viscera removed (dressed) or head-on and viscera removed (gutted) overestimate the weight of individual fish and landings derived from them. The relationships between whole weight or gutted weight and whole weight on dressed weight were influenced by such factors as location of catch, sex of fish, size of fish, sea age, and year of capture. A factor of 1.24 is proposed to convert dressed weight to whole weight and a factor of 1.14 is proposed to convert gutted weight to whole weight.

Résumé

Les facteurs communément utilisés pour convertir le poids des poissons débarqués dans la pêcherie commerciale de saumon atlantique (*Salmo salar*) de Terre-Neuve et du Labrador sans la tête et sans les viscères (habillés) ou avec la tête mais sans les viscères (éviscérés) surestiment le poids des poissons individuels, donc des débarquements qui en découlent. Les relations entre le poids entier ou le poids éviscéré, d'une part, et entre le poids entier et le poids habillé, d'autre part, sont influencés par des facteurs tels que l'endroit de capture, le sexe des poissons, leur taille, la durée de leur séjour en mer et l'année de capture. Nous proposons un facteur de 1,24 pour convertir poids habillé en poids entier et un facteur de 1,14 pour convertir poids éviscéré en poids entier.

Introduction

Conversion factors are regularly used in all fisheries statistics where catches are recorded for fish with viscera removed and heads-on (gutted weight, GW) or viscera removed and heads-off (dressed weight, DW) and then converted to whole (live) weight (WW) (Anon. 1970). Newfoundland-Labrador commercial fishery statistics record Atlantic salmon (Salmo salar L.) landings in whole weight after multiplying gutted weight by a factor of 1.20 and dressed weight by a factor of 1.25 (Short and Reddin 1981). The conversion factors in use by other countries for converting gutted weight to whole are: Denmark 1.20, Faeroe Islands 1.15, Greenland 1.11 and Sweden 1.15 (Anon. 1970). For converting from dressed to whole weight the only documented factor is 1.43 for Greenland (Anon. 1970). Reddin (1981) using samples derived from research vessel catches at Greenland demonstrated that the factor in use for this fishery underestimates the whole weight of salmon landed by 4% and thereby influences assessments which utilize these converted landings to estimate numbers of fish caught. This report examines the accuracy of factors currently being used to calculate total Atlantic salmon landings in the Newfoundland-Labrador commercial fishery.

Methods

Data used to calculate conversion factors in this paper were derived from two sources: (1) random samples obtained from salmon caught in the commercial fishery from 1968 to 1980, and (2) fish caught during tagging studies which were unsuitable for release (Table 1). The commercial samples were weighed to the nearest 1/10th of a kilogram while the tagging mortalities were weighed to 1/100th of a kilogram. All regressions and analyses of covariance (ANCOVA) were done using the Biomedical Computer Programs (P-series, 1979) developed by the Health Sciences Computing Facility, University of California (Dixon 1981) at Los Angeles or Statistical Analysis Systems (SAS Institute Inc. 1982). The weighing devices used were checked for accuracy and precision with standard weights before and after use.

Reddin (1981), calculating conversion factors for the West Greenland salmon fishery, demonstrated that different sea age salmon had different conversion factors and that there could be differences in conversion factors between years. Because the data base consisted of random samples collected in different years from fish of different sea ages, sexes and measured variables (Table 1) a series of ANCOVAs were used to test the hypotheses that whole weight on gutted weight and dressed weight relationships differed by sex, sea age, size or year.

Results

Relationships of whole weight on gutted weight and dressed weight were done to compare previous spawners with virgin fish. In both cases, the slopes of these relationships were significantly different at less than the 5% level of significance (for WW on GW $F = 11.22$, $P = 0.0008$ and for WW on DW $F = 8.49$, $P = 0.0036$). Thus, previous spawners were separated from other sea ages for further comparisons; but as they were so few in number, no comparisons were made by sex, year or area for previously spawned salmon.

Relationships of whole weight on gutted weight were analyzed separately for 1-sea-winter (1SW) and multi-sea-winter (MSW) fish to compare males with females. Comparison of this relationship for male and female 1SW fish showed that the slopes were significantly different at less than the 1% level of significance but that the adjusted means were not significant at the 5% level (Table 2, Treatment No. 1). A similar comparison of males and females for MSW fish showed that neither the slopes nor adjusted means of this relationship were significantly different at 5% level of significance (Treatment No. 2). Relationships of whole weight on dressed weight were also analyzed for 1SW and MSW fish to compare males with females. Comparison of these relationships for males and females showed that for both 1SW and MSW fish slopes were significantly different at less than 1% but that the adjusted means were not different at 5% level of significance (Table 2, Treatments Nos. 3 and 4). This indicated that proportions of male and female fish are important considerations for conversion factors.

The hypothesis that the relationship of whole weight on gutted weight was different for 1SW and MSW fish was tested separately for males and females. The slopes and adjusted means were both significantly different at less than 1% level of significance when compared by ANCOVA (Table 2, Treatments Nos. 5 and 6). Whole weight on dressed weight relationships of 1SW and MSW fish were also compared separately for males and females by ANCOVA. The slopes and adjusted means of 1SW and MSW female fish were significantly different at less than 1% level of significance while the male fish had similar slopes at 5% level of significance but significantly different adjusted means at less than 1% level of significance (Table 2, Treatments Nos. 7 and 8).

Salmon landed by fishermen and sold to commercial fish plants are frequently separated into size categories for price purposes. While all of the landings are not recorded this way sufficient quantitites are separated into "small" and "large" categories to allow estimates of the total quantities of each type landed. An analysis for size differences was carried out based on dressed weight grades of less than 2.3 kg for small and greater than or equal to 2.3 kg for large. Comparisons of whole weight on dressed weight relationships of these two categories by ANCOVA showed that both slopes and adjusted means of males less than 2.3 kg, females less than 2.3 kg, males greater than or equal to 2.3 kg, and females greater than or equal to 2.3 kg were significantly different at less than 1% level of significance (Table 2, Treatment No. 9). This analysis was repeated for whole weight on gutted weight using market grades of less than or equal to 2.7 kg for small and greater than 2.7 kg for large. ANCOVA showed that males less than or equal to 2.7 kg, females less than or equal to 2.7 kg, males greater than 2.7 kg and females greater than 2.7 kg all had significantly different slopes and adjusted means at less than 1% level of significance (Table 2, Treatment No. 10). Thus, for salmon landed in dressed or gutted form both sex and size are important considerations in converting landed weight to whole weight.

Since samples had been obtained from commercial catches in various years (Table 1), differences between years were examined by selecting a subset of the data that contained a reasonable number of samples. Whole weight on gutted weight relationships for years 1970, 1971, 1972, and 1973 were compared by sex and sea age using ANCOVA. The results indicated that 1SW and MSW males have significantly different slopes and adjusted means at less than 1% level of significance (Treatments Nos. 11 and 12). However, 1SW and MSW females have similar slopes at 5% level of significance (Table 2, Treatments Nos. 13 and 14). The relationships of whole weight on dressed weight were compared by ANCOVA for years 1975, 1979 and 1980 separately for 1SW males, MSW males, 1SW females and MSW females. The slopes of these relationships for both 1SW and MSW males were not significantly different in different years at the 5% level of significance while the adjusted means of 1SW males were significantly different at less than 1% level but not for MSW males at 5% level of significance (Table 2, Treatments Nos. 15 and 16). These same relationships had significantly different slopes and adjusted means at less than 1% level of significance for female MSW and 1SW fish for these years (Treatments Nos. 17 and 18). This indicates that a conversion factor derived on the basis of one year may not adequately represent that of other years.

Relationships of whole weight on dressed weight were analyzed for differences between Statistical Areas by examining data from 1979 only and separating other factors i.e. sex and size from each other. Size categories of less than 2.3 kg for small and greater than or equal to 2.3 kg for large were used. Both slopes and adjusted means were significantly different at less than 1% level of significance when whole weight on dressed weight relationships were compared by ANCOVA for small males from Statistical Area J, large males from Statistical Area J, small females from Statistical Area J, large females from Statistical Area J, small males from Statistical Area O, large males from Statistical Area O, small females from Statistical Area O and large females from Statistical Area O (Table 2, Treatment No. 19). Relationships of whole weight on gutted weight were analyzed for differences between areas by examining data from 1971 only and separating other factors, i.e. sex and size from each other. The categories for size used were less than or equal to 2.7 kg for small and greater than 2.7 kg for large. There were no significant differences in slopes at less than 5% between small males from Statistical Areas AC; small females from Statistical Areas AC, small males from Statistical Area O, and small females from Statistical Area O (Table 2, Treatment No. 20). Adjusted means for these groups were significant at less than 5% level of significance. This suggested that conversion factors vary between statistical areas for dressed weight but did not for gutted weight.

Snedecor and Cochran (1967) recommend three ratio estimators for use with data for which Y is proportional to X. The null hypothesis that the intercept equals zero was tested for both dressed and gutted to whole weight conversions and, in both cases, the intercept was significantly different from zero at less than 5% level of significance. For whole weight on gutted weight the intercept was equal to 0.08592, T = 12.52 and P = 0.0001. For whole weight on dressed weight the intercept was equal to 0.0226, T = 4.33 and P = 0.0001. However, any discussion of the validity of intercept or non-intercept models to derive conversion factors for fisheries statistics is irrelevant when landings are recorded for more than one fish at a time. In this case, only the ratio estimators can be used and the question becomes which of $\Sigma XY/\Sigma X$, $\Sigma Y/\Sigma X$ or $\Sigma(Y/X)/n$ is most appropriate (Snedecor and Cochran 1967).

In spite of the fact that the slopes of the relationships of whole weight on gutted and dressed weight were significantly different for small and large salmon, there is a management requirement for single conversion factors inclusive of both groups. This is because a large proportion of the total landings are unsized; e.g. in 1979, 27% of the landings were unsized (Moores and Dawe, 1980). The most appropriate ratio estimator was chosen by residual analysis that examined the mean and sum of residuals for each of the above ratios; the better estimator having a mean residual closest to zero (Draper and Smith, 1966). Although only slight differences existed between each model, the results indicated that the ratio estimated by $\Sigma Y/\Sigma X$ was best (Table 3, Figs. 1-2). It is recommended that factors for conversions of weights of individual fish be based on the intercept model where appropriate and based on $Y = \Sigma Y/\Sigma X\ (X)$ for purposes of conversions of landed weights for fishery statistics.

Discussion

Conversion factors are used in most fisheries for converting the weights of fish landed in some semi-processed state to whole weight. Accuracy becomes important when converted landings are used to assess stock abundances and potential yields from them; and, inaccurate conversion factors may result in under- or over-estimates of yields. Conversion factors for Newfoundland-Labrador Atlantic salmon fishery statistics were derived using the ratio estimator $\Sigma Y/\Sigma X$ as recommended by Snedecor and Cochran (1967). It also allowed derivation of single factors for all sizes of fish. The conversion factors are for dressed weight to whole weight: 1.24 and for gutted weight to whole weight: 1.14.

The history of conversion factors used for Atlantic salmon in the Newfoundland fishery is not well documented. The factors currently in use are 1.20 for converting landings for gutted weight to whole weight and 1.25 for converting landings from dressed weight to whole weight (Anon., 1970). Department of Fisheries and Oceans, Economics Section, St. John's, Newfoundland, indicates that these factors have been used since 1968; while prior to this 1.10 and 1.20 were used (T. Donahue, pers. comm.). Murray (1966) reports that 1.20 was used to convert landings from dressed weight to whole weight at least up until 1963. Blair in an unfinished manuscript (V. Taylor, pers. comm.) states that 1.10 and 1.20 were in use by the Department of Fisheries up to 1952 for converting landings from gutted weight or dressed weight to whole weight.

The difference between conversion factors (current and proposed) can be readily calculated. The current conversion factors overestimated the landings in 1981 by 1.4% or 25641 kg (Table 4). However, the degree of overestimation will vary from year to year depending on the ratios of landings in dressed:gutted forms. The differences between current and proposed factors is more readily observed by calculating the error from each factor individually. For dressed to whole weight conversions the landings of salmon will be underestimated by less than 1%. For gutted to whole weight conversions the landings of salmon will be overestimated by 5.20%.

Inherent in the new conversion factors are several sources of error. Significant differences were found in some cases for the relationships of whole weight on dressed and gutted weights depending on size, sea age, sex, year and statistical area of the salmon catches. As it was impossible to weight the relative contributions of male and female fish to the conversion factors, any future significant deviations in sex ratios from that of the data will cause some error. Further error may be caused by combining data from all years since differences were observed from year to year. Differences in conversion factors from area to area, perhaps caused by different availability of food and rates of feeding by salmon in these areas could also introduce error as could size of fish and sea age.

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Table 1. Summary of sea ages and sex ratios of data used in conversion factor calculations.

Year	Statistical Area[1]	Whole and gutted weight data: Sea ages 1	Sea ages 2 & 3	Total[2]	% Male	Whole and dressed weight data: Sea ages 1	Sea ages 2 & 3	Total[2]	% Male
1968	O	0	32	34	29			-	-
1969	C,O	36	78	117	48			-	-
1970	C,J,O	114	325	446	39	77	223	306	38
1971	A,C,O	102	509	636	31	60	98	160	33
1972	C	647	326	996	38			-	-
1973	H,E,J,I,A	575	314	908	38	257	46	306	13
1974	E,J,K	0	10	11	40	128	162	302	35
1975	E,J,H	45	23	69	41	364	294	689	43
1976	B,E,J	63	29	103	31			-	-
1977	N,I,O	81	2	111	33			-	-
1978	B,O	17	5	25	28			-	-
1979	J,D,A	176	36	220	51	353	501	901	48
1980	J,B,O	92	91	187	49	498	207	720	50
Total				3863				3384	

[1]See Moores and Dawe 1980
[2]Includes fish that could not be aged and previous spawners

Table 2. Summary of ANCOVAs to compare relationships.

TREATMENT NO.	ANALYSIS	GROUPING	VARIABLE INDEPENDENT	VARIABLE DEPENDENT	SLOPES	[1]F to compare ADJ. Means	DF
1	1SW	SEX	GW	WW	1036.35 **	0.12 NS	1,1885
2	MSW	SEX	GW	WW	1.39 NS	0.04 NS	1,1733
3	1SW	SEX	DW	WW	15.44 **	1.56 NS	1,1425
4	MSW	SEX	DW	WW	9.60 **	3.67 NS	1,1438
5	MALES	SEA AGE	GW	WW	697.42 **	655.20 **	1,1339
6	FEMALES	SEA AGE	GW	WW	6.89 **	133.41 **	1,2184
7	MALES	SEA AGE	DW	WW	1.28 NS	43.63 **	1,1249
8	FEMALES	SEA AGE	DW	WW	30.65 **	82.59 **	1,1548
9	MALES & FEMALES	sex and size either <2.3 or ≥ 2.3 kg	DW	WW	38.03 **	26.96 **	3,3376
10	MALES & FEMALES	sex and size either ≤ 2.7 or >2.7 kg	GW	WW	236.48 **	125.40 **	3,3856
11	1SW, MALES	YEAR (70, 71, 72, 73)	GW	WW	162.90 **	5.72 **	3,657
12	MSW, MALES	YEAR (70, 71, 72, 73)	GW	WW	4.59 **	6.16 **	3,371
13	1SW, FEMALES	YEAR (70, 71, 72, 73)	GW	WW	1.94 NS	14.26 **	3,759
14	MSW, FEMALES	YEAR (70, 71, 72, 73)	GW	WW	1.05 NS	13.22 **	3,1076
15	1SW, MALES	YEARS 1975, 79, 80	DW	WW	1.01 NS	30.55 **	2,766
16	MSW, MALES	YEARS 1975, 79, 80	DW	WW	0.23 NS	1.49 NS	2,227
17	1SW, FEMALES	YEARS 1975, 79, 80	DW	WW	5.72 **	13.34 **	2,388
18	MSW, FEMALES	YEARS 1975, 79, 80	DW	WW	7.54 **	23.25 **	2,721
19	1979 data, size & sex	Compares Area 0 to J	DW	WW	7.29 **	16.31 **	7,885
20	1971 data, size & sex	Compares Areas A+C to 0	GW	WW	1.14 NS	3.45 *	7,609
	All fish	Virgin or previously spawned	GW	WW	11.22 **		
	"	"	DW	WW	8.49 **		

[1]Not significant (NS), significant at less than 5% level (*), significant at less than 1% level (**).

Table 3. Summary of models tested to derive factors to convert dressed weight (DW) or gutted weight (GW) landings to whole weight (WW).

Conversion	Model	Intercept	Regression Coefficient	Variance	Confidence Interval (95%)	R^2	F	Sum	Mean	N
1) DW→WW	Intercept	0.08592	1.2070	5.4×10^{-6}	1.2109-1.2030	0.9876	2.69×10^{-5}	-	-	3384
	$\Sigma XY/\Sigma X^2$	-	1.2329	1.0×10^{-6}	1.2349-1.2309	0.9974	1.28×10^{-6}	60.51	0.01788	3384
	$\Sigma Y/\Sigma X$	-	1.2397	1.5×10^{-6}	1.2421-1.2373	-	-	0.1526	0.00005	3384
	$\Sigma(Y/X)/n$	-	1.2453	0.00177	1.3278-1.1628	-	-	-49.56	-0.01464	3384
2) GW→WW	Intercept	0.02257	1.1328	4.0×10^{-6}	1.1367-1.1289	0.9920	4.76×10^{-5}	-	-	3863
	$\Sigma XY/\Sigma X$	-	1.1392	1.0×10^{-6}	1.1412-1.1372	0.9984	2.44×10^{-6}	16.14	0.00418	3863
	$\Sigma Y/\Sigma X$	-	1.1407	6.6×10^{-7}	1.1423-1.1391	-	-	-0.3318	-0.00009	3863
	$\Sigma(Y/X)/n$	-	1.1415	0.0012	1.2083-1.0747	-	-	-9.11	-0.00236	3863

Table 4. Errors in landings from using current vs proposed conversion factors based on 1981 landings.

Category	Condition	Landed Weight (kg)	Equivalent round weight (kg)	
			Based on proposed factors	Based on current factors
Small	head-off	410122	508428	512653
Large	and	769406	953833	961758
Total	gutted (DW)	1179528		
Small	head-on	79093	90221	94912
Large	and	148383	169260	178060
Total	gutted (GW)	227476		
Other	smoked, canned, etc.		133997	133997
Total all			1855739	1881380

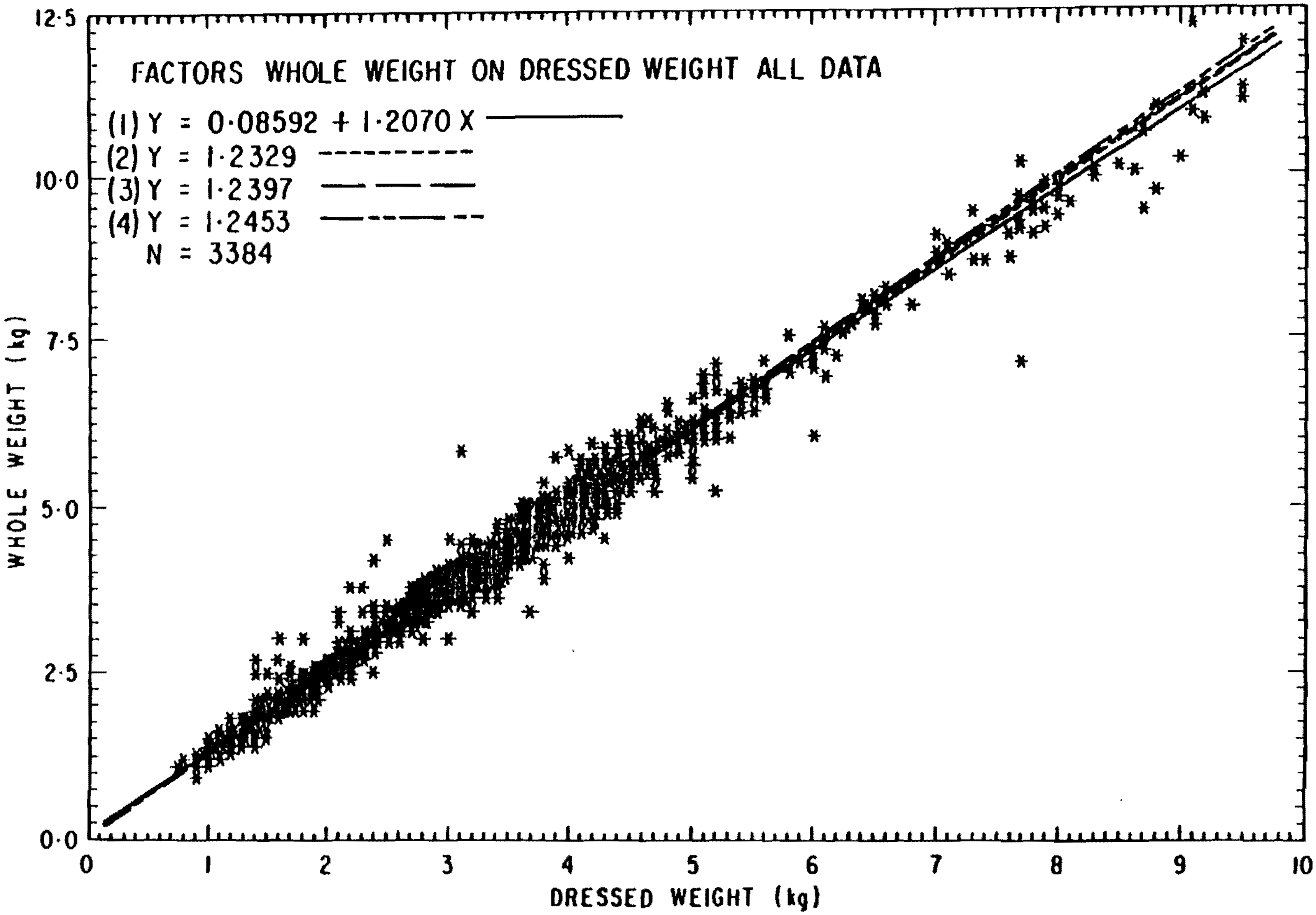

Fig. 1. Relationships between whole weight (WW) and dressed weight (DW) for Atlantic salmon caught in Newfoundland-Labrador commercial fishery in 1968-80. Models used to derive these relationships are:

(1) $y = ax + b$ (3) $y = \Sigma y/\Sigma x$

(2) $y = \Sigma xy/\Sigma x^2$ (4) $y = \Sigma(y/x)/N$

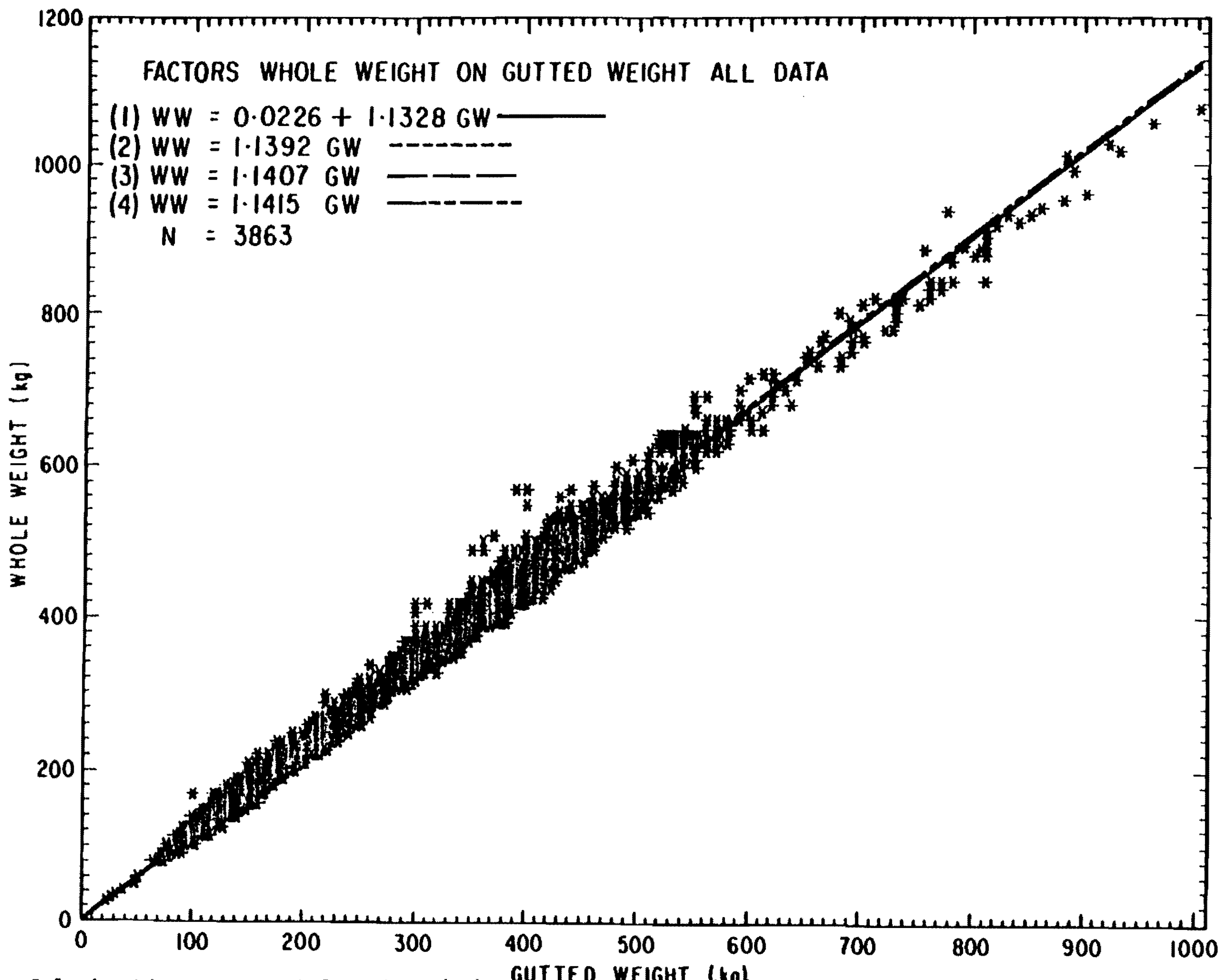

Fig. 2. Relationships between whole weight (WW) and gutted weight (GW) for Atlantic salmon caught in Newfoundland-Labrador commercial fishery in 1968-80. Models used to derive these relationships are:

(1) $y = ax + b$ (3) $y = \Sigma y / \Sigma x$

(2) $y = \Sigma xy / \Sigma x^2$ (4) $y = \Sigma (y/x) / N$