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Preliminary results of experiments on the measurement of meshes with different gauges and by different operators

by E. J. Sandeman and A. W. May
Fisheries Research Board of Canada, Biolotical Station, St. John's, Newfoundland

Abstract

Measurements of trawl net meshes which are made at sea by different operators using the ICNAF and Scottish gauges have shown differences between operators and gauges greater than any previously reported in the literature. Two experiments have been carried out in the laboratory to investigate these differences. The first was designed to examine variation between operators using the ICNAF gauge only, while the second was designed to examine operator variation and to compare the results obtained with the ICNAF, Scottish and Westhoff gauges.

Statistically significant differences between average mesh sizes were found in all but one of the comparisons between operators in the first experiment (ICNAF gauge only).

Comparisons between gauges as used by the same operator in the second experiment gave statistically significant differences in 19 of 20 comparisons involving the ICNAF gauge. Such differences were obtained in only 5 of the 10 comparisons between the Scottish and Westhoff gauges. Comparisons between operators using the same gauge resulted in great variability with the ICNAF gauge, less with the Scottish gauge and very little with the Westhoff gauge.

In both experiments the great variation between operators with the ICNAF gauge was found to be due largely to improper use of this gauge.

Introduction

Differences in the measurements of trawl net meshes by the ICNAF and Scottish gauges have been investigated by several authors, notably Parrish, Jones and Pope (1956) and von Brandt and Bohl (MS, 1959). The results of these experiments have shown that not only does the ICNAF gauge offer less precision (higher standard error) and more operator bias than the Scottish gauge, but also the measurements obtained by the former are consistently greater than those by the latter. Parrish et al (1956) found that when three operators on two occasions each, measured 50 random meshes of a 70 mm mesh manila codend, the ICNAF type pressure gauge yielded results higher than the Scottish gauge by amounts ranging from 1.39 mm to 3.65 mm. The differences found between these gauges by von Brandt and Bohl (MS, 1959), when four operators measured the same set of 118 meshes in a 130 mm codend, ranged from 0.33 mm higher with the ICNAF gauge by one operator to 6.48 mm higher by another. McCracken (MS, 1957), in experiments involving the measurement of 50 random meshes of a heavy manila codend (about 4 3/4" (121 mm) mesh size) by three operators using each gauge, found the ICNAF gauge to measure higher than the Scottish by the following amounts: 0.11" (2.79 mm), 0.31" (7.87 mm) and 0.17" (4.32 mm). He did not, however, find significant differences between operators using the ICNAF gauge, as did Parrish et al (1956). Templeman (MS, 1957) has reported a similar order of difference of 0.15" (3.81 mm) between the ICNAF and Scottish gauges from measurements on a manila codend with mesh size of about 4 3/4" (121 mm).

During the recent mesh-selection experiments it has been the practice of this laboratory to measure meshes with both the ICNAF and Scottish gauges. We have been aware for some time that measurements made by the ICNAF gauge have shown considerable operator bias, and this has been aggravated by the fact that measurements in the field are made by some ten different operators. It was decided that some experiments in the laboratory would do much to clarify the situation.

Two separate experiments have been carried out. The first included the ICNAF gauge only and was designed to test differences between operators using this gauge. The second experiment was originally designed to ascertain the differences between the ICNAF and Scottish gauges as used by the same operator, and by different operators. Measurements made at sea using these two gauges gave differences considerably greater than those reported above. In a recent cruise, when the same net as used in experiment II was measured on three occasions by two different operators using both the ICNAF and Scottish gauges, the average codend mesh sizes with the ICNAF gauge were found to be 4. 74", 4. 53" and 4. 53" compared with 4. 23", 4. 08" and 4. 19" respectively.

During the second experiment the modified Scottish or Westhoff type gauge (Westhoff and Parrish, MS, 1959) became available to us, and this gauge was included in the experiment.

Experiment I

This experiment was designed to examine operator variation using the ICNAF gauge in the manner in which each was accustomed.

(1) The Design of the Experiment

It was decided that better comparisons would be obtained if the measurements were made over the same row of meshes. The major disadvantage of repeated measurements of the same row of meshes is that irreversible stretching or tightening of the knots might occur and invalidate the comparison. In spite of the fact that von Brandt and Bohl (MS, 1959) found very little stretching in a Perlon codend when 59 meshes were measured 12 times, it was considered best to design the experiment in such a manner that any stretching of the meshes could be compensated for.

It was decided that the form of the experiment most likely to yield useful results, and at the same time not require a large number of measurements, would be a 4 x 4 block of the form:

A	B	C	D
C	A	D	B
B	D	A	C
D	C	B	A

Thus in each "block" all four operators would measure the net four times. The arrangement of the block is such, that provided any stretch is constant for each operator, the mean values calculated for each should be comparable over the block. The above design also provides that each operator follows a different operator at each measurement.

A single longitudinal row of 50 meshes was marked off in the centre of the codend, and this row was successively measured. In an attempt to minimize bias, and reduce the possibility of remembering mesh sizes, it was deciced that measurements should not start from the same mesh each time. For this reason the meshes were numbered, and the number of the mesh at which each operator started was determined from a set of random numbers.

As each operator took his turn he was instructed to make sure that the person holding the net was holding it as the measurer preferred. Apart from the fact that conditions were more comfortable than would be the case at sea (warm hands, a clean orderly net), every attempt was made to approach field conditions.

A single independent recorder was used throughout the experiment.

(2) The Net

The upper half of a used codend of a #41A otter trawl was used for the experiment. Specifications:- 42 x 58 meshes 5" mesh (as ordered, dry between knot centres). 50/4 manila twine, double, untreated.

The codend had previously been used for 19 sets during one cruise and 4 sets during a later cruise of the research vessel A. T. Cameron. The mean measurement as measured by two technicians during the former cruise was 3. 94" (100. 08 mm) (based on 330 measurements with the ICNAF gauge).

(3) The Experiment

The same longitudinal row of 50 meshes was measured throughout the experiment. Before starting, the net was soaked in fresh water for a period of about 18 hours. To keep the mesh consistently wet it was hosed down after each operator had made his 50 measurements.

Six of the senior technicians were available for the experiment and these technicians were tested against each other in three "blocks".

A	B	C	D
C	A	D	B
B	D	A	C
D	C	B	A

Block I

A	C	E	F
E	A	F	C
C	F	A	E
F	E	C	A

Block II

B	D	F	E
F	B	E	D
D	E	B	F
E	F	D	B

Block III

Within each block the four operators measured the meshes (50) four times, thus the means from each operator in the block are based on 200 measurements.

Prior to the experiment the dynamometer in the gauge was checked as reading correct at the desired pressure of 12 lb. (5. 4 Kg).

(4) Results

At the very start, it was apparent that the experiment was going to provide little or no information on the variability between operators using the ICNAF gauge. None of the technicians used the gauge as it was designed to be used, viz. at the constant pressure of 12 lb. (5. 4 Kg). This constant pressure was approached by two operators, but others, and in particular operator B, used the gauge more as if it was an ordinary wedge type gauge with no constant pressure device.

The means and standard errors obtained by the different operators within each block, as well as the overall mean for each operator for each block are shown in Table I. The differences between the operators can be seen more easily in Fig. 1 where the means obtained by each operator for each measurement of 50 meshes are plotted against time (as represented by the sequential order of measurement). It is apparent from this figure that considerable stretching of the meshes took place over the complete experiment. However, as stretching of the meshes (or tightening of the knots) was greater during the first measurements (Block I) this block has been repeated - Block IV. In Blocks II, III and IV the stretching is less and appears to have stabilized at a relatively constant rate. This trend can be seen rather clearly in the measurements of operator B.

"t" tests show that, with a few exceptions, within each block (excluding Block I) the difference between the mean mesh sizes obtained by an operator in his four measurements are not statistically significant. The exceptions occur when there are occasional extra high or low measurements and do not appear due to the gradual stretching of the mesh. This is not true of operator A, for whom there exists independent evidence that the pressure used by him increased throughout the experiment.

A comparison between operators reveals that the difference between the mean mesh sizes obtained by one operator and any other, within the same block, is highly significant (Table II). Only in one of the 18 comparisons was a significant difference not found. This involved operator A, whose lack of consistency in pressure applied makes interpretation of his results difficult.

(5) Discussion and Conclusions

The main conclusion to be drawn from this experiment is that our technicians were not using the gauge correctly. This was particularly so in the case of operator B. It is likely that the means obtained by operator F approached those which would have been obtained had the gauge been used correctly.

Of more general interest is the gradual increase in mesh size which occurred over the entire course of the experiment. This stretching of the mesh (or tightening of the knots) occurred rather slowly. The fact that the mean mesh sizes obtained by each operator within any block were not generally significantly different, is indicative that with only four measurements on any individual mesh little irreversible stretching would be expected to occur. Also, because the pressure exerted on the meshes was far greater by some operators than would be so if the gauge was used correctly, the stretch must be considered abnormal. It is interesting that in Block II, when operator B was not present, the stretch appeared to be less and this is reflected in the results of all the operators in the block (Fig. 1).

Because of this tendency for greater stretching to be caused by those operators who used greater pressures, it is really invalid to make comparisons between blocks or to combine data from different blocks without special precautions. In spite of this, and remembering the limitations of doing so, some clarification is obtained by fitting straight lines to the measurements of each operator over the period in which the overall stretching of the mesh appeared constant (Blocks II, III and IV). This is shown in Fig. 2, and here the overall differences between operators can be more clearly seen. Operator A has been omitted because of the documented inconsistency of the pressure he applied. Also shown is the one measurement of the 50 meshes made by the senior author, who took care in applying no more or less pressure than 12 lb. (5.4 Kg). This measurement was made at the conclusion of the experiment and has been plotted (in the figure) at its correct position on the sequential time scale. It may be noted that this measurement coincides with the extrapolated fitted line for the measurements obtained by operator F. If operator F's measurements are regarded as approaching those that would be obtained had a true pressure of 12 lb. (5.4 Kg) been used over the experiment (excluding Block I), approximate figures for the differences between each operator and the estimate of the true ICNAF gauge value may be obtained.

Operator B - 0.22" to 0.28", mean = 0.25"
C - 0.08" to 0.18", " = 0.13"
D - 0.06" to 0.14", " = 0.10"
E - 0.04" to 0.06", " = 0.05"

Because the differences quoted above refer only to the period when the stretch (or tightening of the knots) had stabilized at a relatively constant rate and were considerably less than those found at the very start of the experiment, they must be regarded as minimum values and greater differences would most likely be found between these operators measuring unstretched meshes.

Experiment No. II

This experiment was designed to examine variation between operators and to compare the results obtained in measuring meshes by the Scottish and the ICNAF gauges, operated in the manner in which each operator was accustomed. The experiment was extended after it had commenced to include a comparison of these gauges with the Westhoff gauge.

(1) The Design of the Experiment

In view of the stretching that occurred when a long series of repeated measurements was made on the same row of meshes (Expt. I), it was considered best to limit the number of times a particular row of meshes was measured to four times. In fact, with the inclusion of the Westhoff gauge in the experiment, this was increased to six. It was necessary to test if any significant stretching had occurred, as well as whether or not there were any differences attributable to gauges or operators.

With ten operators taking part in the experiment it was decided to conduct it in two series of five operators, each operator measuring two rows. Thus ten longitudinal rows of 32 meshes were chosen in the central part of the codend. Each row, which started at the 3rd mesh, was labelled with a tag. Each operator then measured a row with the Scottish gauge and the adjacent row with the ICNAF gauge. When the five operators had completed measuring their pair of rows, they then started again, each using the Scottish gauge on the row previously measured by him with the ICNAF gauge, and vice versa. On completion of this second lot of measurements, each operator used the Westhoff gauge on one of his rows, and after the first round of measurements with this gauge he used it again on the other.

This whole sequence was later repeated by the second series of five operators.

(2) The Net

The upper section of a double twine manila codend of a No. 41A otter trawl was used in the experiment. Specifications:- 38 x 52 meshes, 5 3/4" mesh (as ordered dry between knot centres) 50/4 manila twine, untreated.

The codend had previously been used in seven 30 minute tows on a haddock savings gear cruise of the research vessel A. T. Cameron. The total catches from these sets ranged from 0 to 8000 lb. (3.63 m tons).

(3) The Experiment

The general form of the experiment has been previously described. It is summarized here in diagrammatic form.

Series I

Rows	Operator	Gauge	Gauge	Gauge	Gauge
a	A	Scottish	ICNAF	Westhoff	
b	A	ICNAF	Scottish		Westhoff
c	B	Scottish	ICNAF	Westhoff	
d	B	ICNAF	Scottish		Westhoff
e	C	Scottish	ICNAF	Westhoff	
f	C	ICNAF	Scottish		Westhoff
g	D	Scottish	ICNAF	Westhoff	
h	D	ICNAF	Scottish		Westhoff
i	E	Scottish	ICNAF	Westhoff	
j	E	ICNAF	Scottish		Westhoff

Series II was a duplicate of the above with the other five operators making the measurements.

All measurements were made on a well wetted net. Before starting the first half of the experiment the net was soaked in fresh water for a period of about 48 hours, and before starting the second half a further period of soaking of about 10 days was allowed to elapse. During each part of the experiment the net was hosed down with fresh water about every 20 minutes.

Most of the operators had used the ICNAF gauge many times before, and the specific instruction was given that they should use it during the experiment in the manner in which they were accustomed. Only three of the operators had previous experience with the Scottish gauge and none had used the Westhoff gauge. In using the different gauges, each measurer had the same person holding the net for him in the manner that the measurer preferred, although different persons held the net for different operators. Operator I, however, for the Scottish and Westhoff gauges, preferred to spread the net out flat and measure without anyone holding.

Prior to the experiment the dynamometer in each gauge was checked with the following results:- ICNAF gauge, 12 lb. (5. 4 Kg); Scottish gauge, 12-13 lb. (5. 4-5. 9 Kg); Westhoff gauge, 12-14 lb. (5. 4-6. 4 Kg).

Measurements were made in inches and tenths of inches with the ICNAF gauge and in millimeters with the Scottish and Westhoff gauges. The results obtained by these latter gauges have been converted to inches.

(4) Results

The results (means and standard errors) for each measurement of 32 meshes are shown in Table III.

To allow a straightforward comparison between the different operators and gauges, it is necessary first to establish that differential stretching of the meshes, particularly inasmuch as measurements with the ICNAF gauge are concerned, does not occur. Also, as different rows of meshes are measured by different operators, the possibilityof variability between rows must be examined.

(a) Stretching of the meshes

For each operator we have measurements of one row in which the ICNAF gauge was used followed by the Scottish gauge, and of the other row which was measured in the reverse order.

For each row the difference in mean mesh size between the ICNAF and Scottish gauges and the standard error of this difference were calculated. This difference was then compared, by means of "t" tests, to the difference obtained between the gauges in the other row of each operator's pair, in which the gauges had been used in the reverse order (Table IV).

These tests showed that the differences which were present between the ICNAF and Scottish gauges were not affected by the order in which the measurements were made, and in every case the difference between the differences was not significant at the 95% level. Furthermore the difference between the differences did not occur in the same direction all the time and for the 10 operators the insignificant stretch that might have taken place could be attributed to the Scottish gauge 5 times and to the ICNAF gauge 5 times.

On the basis of these tests it seems fair to conclude that stretching within a series was negligible. Also, with only a single measurement being made by the Westhoff gauge between the one series and the start of the next, stretching of the meshes between series or over the six measurements on each row of meshes is most unlikely.

(b) Variation between rows

We have already shown above that it does not matter whether a row is measured first by the ICNAF or Scottish gauge. Thus a comparison can be made between the mean measurement obtained by an operator using the one gauge in the one row to that obtained by him using the same gauge in his other row. If significant differences occur in the comparison this could be due either to variability within the one gauge or to variation between rows.

The results of these comparisons using "t" tests are shown in Table V. It is apparent that with both the Scottish and Westhoff gauges the differences between the two rows of each operators pair are not significant. With the ICNAF gauge significant differences can be seen between the rows of three of the operators but not between those of the other seven. Also in connection with these significantly different measurements, it can be noted that they did not occur in the same pair of rows in the two series (i. e. no single pair of rows is responsible for these differences).

Thus with both the Scottish and Westhoff gauges, it would appear that the variation between rows is within the limits of variability of the gauge, and that in the case of the ICNAF gauge the significant differences obtained are more likely due to variability of the gauge or method of using it than to variation between the rows.

Thus we may conclude that the two rows making up each pair can be considered similar. Although, on the results of this analysis, we cannot say conclusively that there are no differences between the five pairs of rows used, it is evident that such differences are most unlikely. This is further supported by the lack of variation between operators when the results of the Westhoff gauge are examined.

The similarity of the rows in each pair allows combination of the results obtained for subsequent analyses in comparing operators and gauges.

(c) Difference between gauges for each operator

We have shown in the previous section that it is valid to combine the measurements for the two rows measured by each operator with each gauge. This has been done and the means and standard errors of the combined data are displayed in Fig. 3. It is quite evident from this figure that significant differences between the gauges and between operators are of very common occurrence. This is particularly noteworthy in the case of comparisons involving the ICNAF gauge.

The means obtained by each gauge were compared by "t" tests for each operator in turn, and these results confirm what is evident in Fig. 3. The results of these tests are summarized in Table VI, and it is striking that only in one of the 20 comparisons involving the ICNAF gauge was a difference obtained which could not be considered as extremely significant. The Scottish gauge could be considered as yielding similar results to the Westhoff gauge in the hands of five out of the ten operators.

(d) Comparisons between operators using the same gauge

We have attempted to show, in a previous section, that the likelihood of variation between rows is extremely small. If this is so and the rows of meshes are normal samples of the total net section, then comparisons between operators measuring different rows are in order.

For each gauge in turn the mean measurement obtained by each operator has been compared by means of "t" tests, against that obtained by each other operator. The results of these tests are shown in Tables VII, VIII and IX for the ICNAF, Scottish and Westhoff gauges respectively. It can be seen (Table VII) that only very occasionally are comparable results obtained between different operators using the ICNAF gauge. Better results were obtained using the Scottish gauge (Table VIII), most of the significant differences being caused by particularly low means obtained by operators A and B. For the Westhoff gauge, excellent agreement between operators was obtained with the exception of operator I and to a lesser extent operator B. Operator I obtained measurements considerably higher than all other operators and he attributes this partly to his lack of familiarity with the gauge. Also this operator (the senior author) possesses rather small hands and he found it difficult to maintain tension on the dynamometer while reading the scale. In this connection it should be noted that, although the Westhoff gauge locks in position when the correct tension is reached, if the tension is not maintained while the reading of mesh size is made, the jaws of the instrument may close and unlock the ratchet mechanism. If this happens, and tension is again applied to the mesh without resetting the ratchet mechanism, the locking mechanism fails to function, and pressures greater than that prescribed can be applied.

(5) Discussion and Conclusions

The graphical summary (Fig. 4) of the mean mesh sizes obtained by each operator and gauge may be helpful in this section. The conclusion that the Westhoff gauge is superior to the Scottish gauge and far superior to the ICNAF gauge as handled by the present methods of the operators, is inescapable. Not only does it show less variability when used by the same operator on different rows, but in the hands of different operators it provides similar measurements. As judged from its ability to yield similar measurements between operators, results with the Scottish gauge approach those with the Westhoff gauge, but greater variability between operators may be noted.

The ICNAF gauge shows up very poorly in the comparison between operators, and not too well in the comparison within operators. The large differences found in the measurements from one operator to the next do not reflect the variability of the gauge but rather variation in the method of using it, as was shown in experiment I. However, the fact that this gauge is, or at least can be, abused in such a manner reflects rather poorly on the gauge itself.

Figure 4 shows the overall means for each gauge. In the case of the ICNAF gauge this mean is rather meaningless, but it does allow a comparison between the overall measurements as obtained by each gauge. It is apparent that the overall difference between the Scottish and ICNAF gauges of .37 inches (9.4 mm) is slightly greater than that obtained by other authors, and even the means obtained by operators I and J, who took pains to ensure that the correct pressure was applied, show differences of 0.18" (46 mm) and 0.27" (6.9 mm) respectively between their measurements using the ICNAF gauge and the overall Scottish gauge average. The difference of 0.11" (2.8 mm) obtained between the overall means of the Westhoff and Scottish gauges is more difficult to understand.

Better and more comparable results could probably have been obtained if attention had been paid to the point raised by Bedford and Beverton (MS, 1958), namely that of ensuring that the gauge is always inserted toward the open side of the assymetrical knot.

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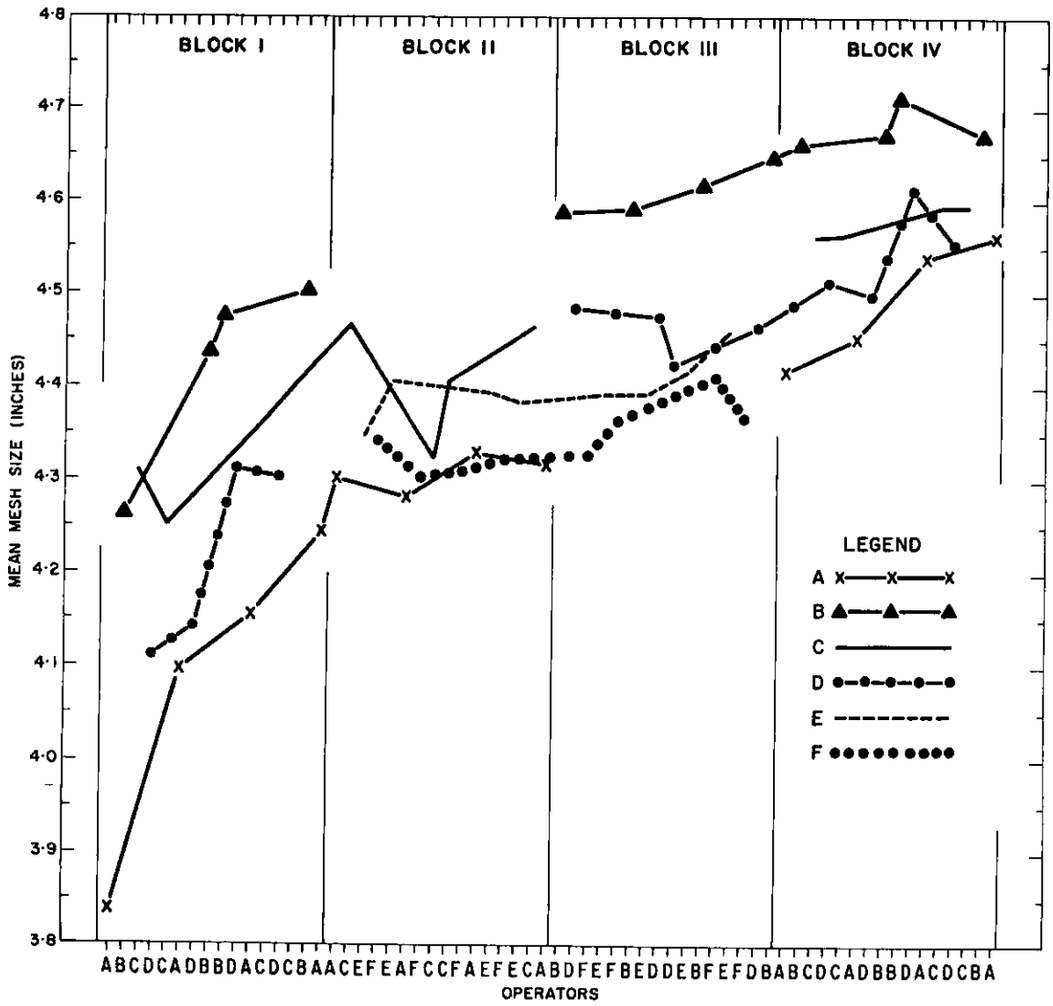

Fig. 1. Mean mesh sizes obtained in each measurement of 50 meshes. (Experiment I).

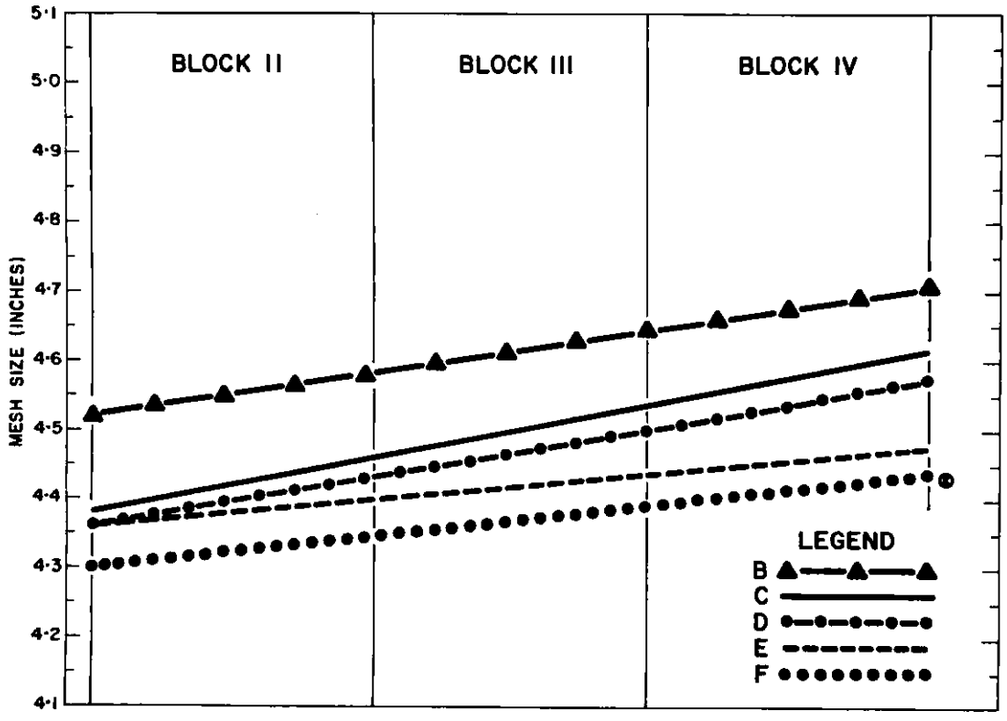

Fig. 2. Experiment I. Straight lines fitted to measurements of each operator over Blocks II, III and IV.

⊛ Shows the one measurement of 50 meshes made by the senior author.

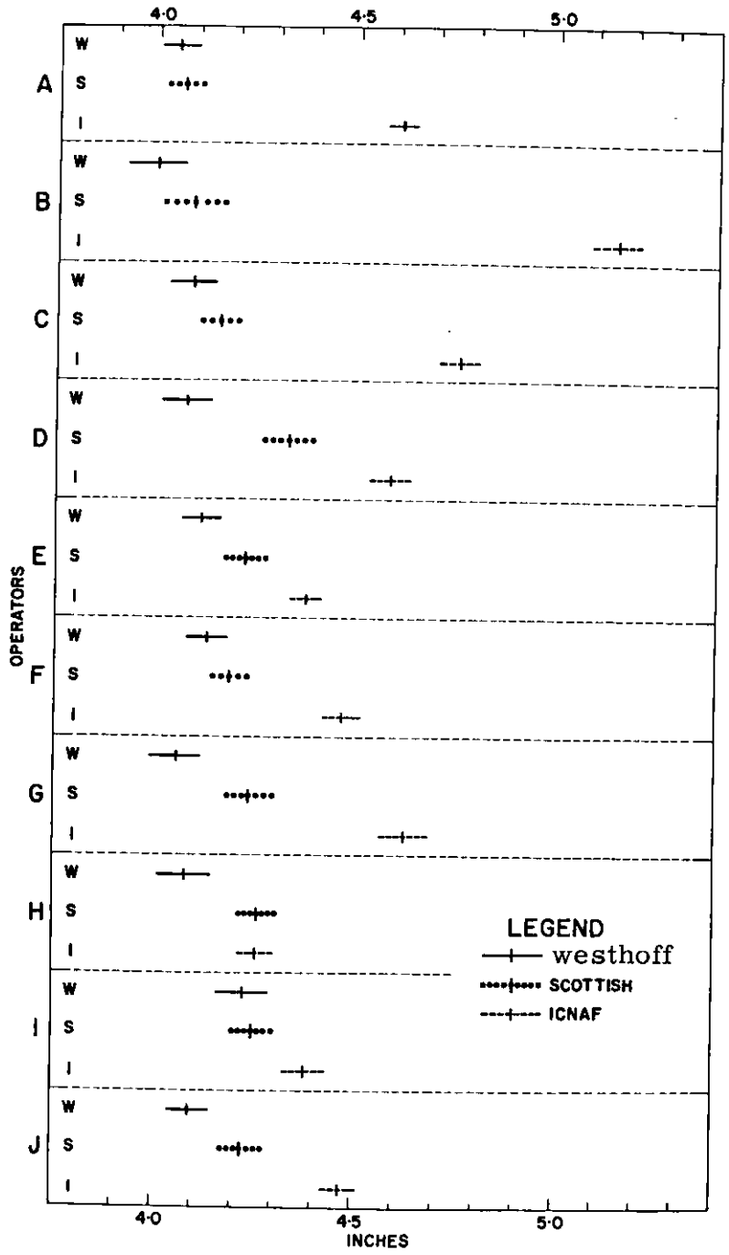

Fig. 3. Summary of the measurements obtained by each operator using each gauge. The measurements of the two rows (32 + 32 = 64 meshes) as obtained by each operator have been combined. The mean is designated by the vertical stroke and two standard errors are shown on either side.

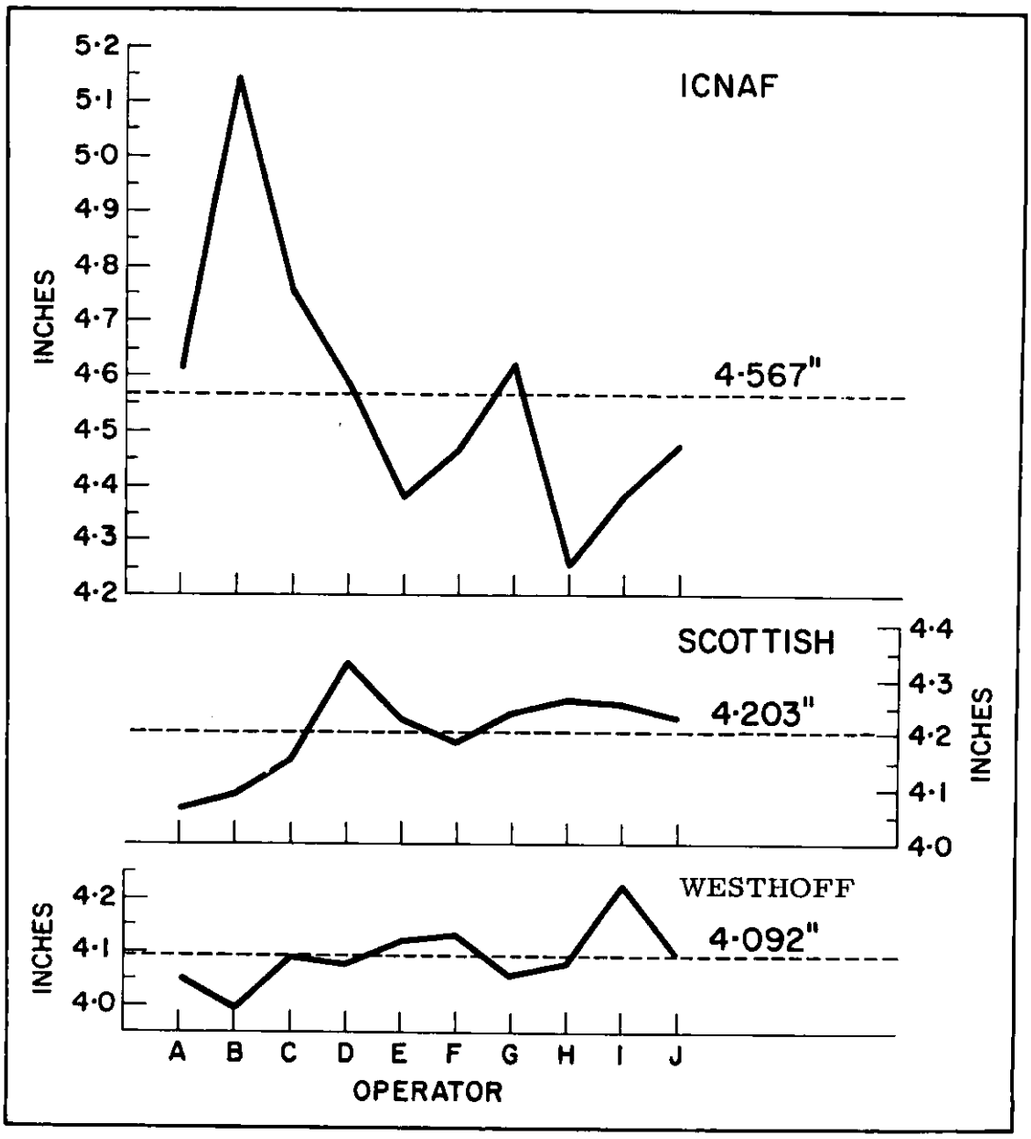

Fig. 4. Graphical summary of means obtained by each operator using each gauge. Also shown are the overall means for each gauge.

Table I. --Means and standard errors of the different operators in experiment I.

Block I

1	A 3.836 ± .020	B 4.264 ± .028	C 4.310 ± .021	C 4.112 ± .019
2	C 4.252 ± .021	A 4.098 ± .019	D 4.144 ± .021	B 4.436 ± .019
3	B 4.476 ± .020	D 4.312 ± .020	A 4.154 ± .025	C 4.368 ± .016
4	D 4.304 ± .020	C 4.400 ± .021	B 4.502 ± .020	A 4.246 ± .018

Means for Block
A = 4.084 ± .015
B = 4.420 ± .013
C = 4.333 ± .011
D = 4.218 ± .012

Block II

1	A 4.302 ± .020	C 4.466 ± .021	E 4.348 ± .017	G 4.342 ± .020
2	E 4.406 ± .019	A 4.282 ± .017	G 4.304 ± .019	C 4.324 ± .018
3	C 4.408 ± .021	G 4.310 ± .017	A 4.330 ± .017	E 4.396 ± .019
4	G 4.322 ± .021	E 4.384 ± .018	C 4.464 ± .019	A 4.316 ± .017

Means for Block
A = 4.308 ± .0089
C = 4.416 ± .0106
E = 4.383 ± .0091
G = 4.320 ± .0094

Block III

1	B 4.586 ± .021	D 4.484 ± .023	G 4.328 ± .021	E 4.392 ± .020
2	G 4.366 ± .021	B 4.592 ± .017	E 4.394 ± .021	D 4.474 ± .018
3	D 4.424 ± .022	E 4.418 ± .020	B 4.618 ± .018	G 4.410 ± .021
4	E 4.460 ± .017	G 4.368 ± .019	D 4.464 ± .018	B 4.650 ± .021

Means for Block
B = 4.612 ± .0098
D = 4.462 ± .0102
G = 4.368 ± .0104
E = 4.416 ± .0099

Block IV

1	A 4.418 ± .016	B 4.662 ± .020	C 4.562 ± .027	D 4.512 ± .026
2	C 4.564 ± .022	A 4.452 ± .019	D 4.498 ± .023	B 4.672 ± .019
3	B 4.712 ± .018	D 4.614 ± .022	A 4.540 ± .017	C 4.596 ± .022
4	D 4.554 ± .021	C 4.596 ± .020	B 4.672 ± .021	A 4.562 ± .020

Means for Block
A = 4.493 ± .0099
B = 4.679 ± .0098
C = 4.579 ± .0113
D = 4.545 ± .0119

Table II. --"t" values obtained in the comparison of means between operators. Operators have been compared only within each block.

Operators	A	B	C	D	E	F
A		13.381	7.770	3.355	5.859	0.923
B			6.711	10.563	14.101	17.063
C	5.733			2.073	2.357	6.761
D		8.701			3.217	6.438
E						3.333
F					4.773	

at df = 400

P =	0.5	0.10	0.05	0.02	0.01
t =	0.675	1.65	1.97	2.34	2.59

Table III. --Experiment II - Summary of results.

Operator	Row	ICNAF $\bar{x}$	ICNAF $SE_{\bar{x}}$	Scottish $\bar{x}$	Scottish $SE_{\bar{x}}$	Westhoff $\bar{x}$	Westhoff $SE_{\bar{x}}$
A	a	4.619	.026	4.093	.032	4.050	.029
	b	4.597	.026	4.034	.036	4.053	.035
	a&b	4.608	.018	4.064	.024	4.052	.023
B	c	5.166	.051	4.060	.071	3.967	.050
	d	5.128	.035	4.120	.039	4.027	.052
	c&d	5.147	.031	4.090	.040	3.997	.036
C	e	4.800	.035	4.192	.036	4.088	.043
	f	4.706	.035	4.122	.034	4.091	.035
	e&f	4.753	.025	4.157	.025	4.090	.028
D	g	4.647	.041	4.344	.041	4.094	.049
	h	4.519	.028	4.315	.053	4.058	.035
	g&h	4.583	.025	4.330	.033	4.076	.030
E	i	4.331	.025	4.213	.041	4.083	.029
	j	4.419	.025	4.237	.038	4.147	.038
	i&j	4.375	.018	4.225	.028	4.115	.024
F	a	4.441	.034	4.213	.028	4.156	.037
	b	4.494	.031	4.163	.038	4.103	.034
	a&b	4.468	.023	4.188	.024	4.130	.025
G	c	4.681	.051	4.238	.056	4.085	.055
	d	4.569	.030	4.240	.033	4.032	.040
	c&d	4.625	.030	4.239	.032	4.059	.034
H	e	4.209	.032	4.259	.033	4.075	.045
	f	4.309	.030	4.262	.037	4.085	.048
	e&f	4.259	.022	4.261	.025	4.080	.033
I	g	4.366	.042	4.249	.042	4.207	.050
	h	4.397	.032	4.254	.034	4.248	.041
	g&h	4.382	.026	4.252	.027	4.228	.032
J	i	4.500	.030	4.208	.032	4.103	.037
	j	4.444	.028	4.246	.044	4.088	.033
	i&j	4.472	.021	4.227	.027	4.096	.025
Overall average		4.567		4.203		4.092	

Table IV. --Differences and "t" values obtained in test for stretching of mesh.

Operator	Δa	Δb	Δa-Δb	t
A	1.106	1.008	0.098	0.965
B	0.608	0.584	0.024	0.342
C	0.526	0.563	-0.037	0.611
D	0.303	0.204	0.099	1.192
E	0.118	0.182	-0.064	0.967
F	0.228	0.331	-0.103	1.563
G	0.443	0.329	0.114	1.297
H	-0.050	0.047	-0.097	1.465
I	0.117	0.143	-0.026	0.344
J	0.292	0.198	0.094	1.379

at df = 125

P =	0.50	0.10	0.05	0.02	0.01
t =	0.676	1.66	1.98	2.36	2.62

Δa = mean mesh size from ICNAF gauge measured first less the mean from Scottish gauge measured second, on the same row.

Δb = mean mesh size from ICNAF measured second less the mean from the Scottish gauge measured first, on the same row.

Table V. --"t" values obtained in comparing the two rows measured by the same operator using the same gauge.

Rows compared	Operator	Gauge ICNAF	Gauge Scottish	Gauge Westhoff
ab	A	0.595	1.229	0.066
cd	B	0.613	0.746	0.830
ef	C	1.888	1.420	0.054
gh	D	2.575 **	0.435	0.595
ij	E	2.472 **	0.430	1.339
ab	F	1.142	1.053	1.064
cd	G	1.886	0.031	0.782
ef	H	2.288 *	0.061	0.152
gh	I	0.587	0.092	0.632
ij	J	1.363	0.699	0.305

at df = 60

P =	0.50	0.10	0.05	0.02	0.01
t =	0.678	1.67	2.00	2.39	2.66
			*	**	***

Table VI. --"t" values obtained in comparing the three gauges as used by each operator.

Operator	Gauges compared ICNAF-Scottish	ICNAF-Westhoff	Scottish-Westhoff
A	17.95 ***	18.98 ***	0.364
B	20.81 ***	24.16 ***	1.719
C	16.98 ***	17.82 ***	1.806
D	6.10 ***	12.93 ***	5.64 ***
E	4.53 ***	8.73 ***	3.00 ***
F	8.43 ***	9.94 ***	1.686
G	8.81 ***	12.55 ***	3.85 ***
H	0.061	4.53 ***	4.39 ***
I	3.44 ***	3.68 ***	0.567
J	7.19 ***	11.71 ***	3.57 ***

at df = 125

P =	0.50	0.10	0.05	0.02	0.01
t =	0.676	1.66	1.98	2.36	2.62

* ** *** →

Table VII. --"t" values obtained in comparison of operators using the ICNAF gauge.

	Operators								
A	B	C	D	E	F	G	H	I	J
A	14.931 ***	4.677 ***	0.806	9.066 ***	4.714 ***	0.486	12.203 ***	7.019 ***	4.910 ***
	B	9.899 ***	14.207 ***	21.564 ***	17.545 ***	12.168 ***	23.368 ***	18.796 ***	18.145 ***
		C	4.830 ***	12.353 ***	8.382 ***	3.307 ***	14.924 ***	10.220 ***	8.700 ***
			D	6.797 ***	3.382 ***	1.085	9.789 ***	5.552 ***	3.437 ***
				E	3.185 ***	7.225 ***	4.113 ***	0.220	3.566 ***
					F	4.164 ***	6.552 ***	2.450 **	0.129
						G	9.919 ***	6.121 ***	4.238 ***
							H	3.586 ***	7.100 ***
								I	2.687 ***

at df = 125

P =	0.50	0.10	0.05	0.02	0.01
t =	0.676	1.66	1.98	2.36	2.62

* ** ***

Table VIII. --"t" values obtained in comparison of operators using Scottish gauge.

				Operators					
A	B	C	D	E	F	G	H	I	J
A	0.556	2.703 ***	6.488 ***	4.375 ***	3.669 ***	4.353 ***	5.710 ***	5.193 ***	4.503 ***
	B	1.419	4.598 ***	2.761 ***	2.099 *	2.888 ***	3.623 ***	3.340 ***	2.825 ***
		C	4.179 ***	1.823	0.904	2.020 *	2.980 ***	2.596 **	1.907
			D	2.419 **	3.472 ***	1.961	1.663	1.818	2.395 **
				E	1.008	0.329	0.965	0.694	0.051
					F	1.272	2.128 *	1.778	1.080
						G	0.541	0.309	0.284
							H	0.245	0.924
								I	0.651

at df = 125

P =	0.50	0.10	0.05	0.02	0.01
t =	0.676	1.66	1.98	2.36	2.62
			*	**	*** →

Table IX. --"t" values obtained in comparison of operators using Westhoff gauge.

	Operators								
A	B	C	D	E	F	G	H	I	J
A	1.288	1.061	0.635	1.915	2.315 *	0.172	0.700	4.444 ***	1.313
	B	2.044 *	1.677	2.725 ***	3.030 ***	1.250	1.697	4.753 ***	2.265 *
		C	0.341	0.685	1.075	0.708	0.233	3.239 ***	0.162
			D	1.013	1.378	0.374	0.089	3.423 ***	0.513
				E	0.435	1.349	0.860	2.804 ***	0.554
					F	1.686	1.211	2.396 **	0.971
						G	0.444	3.603 ***	0.883
							H	3.203 ***	0.389
								I	3.243 ***

at df = 125

P =	0.50	0.10	0.05	0.02	0.01
t =	0.676	1.66	1.98	2.36	2.62
			*	**	*** →