RESTRICTED

INTERNATIONAL COMMISSION FOR THE NORTHWEST ATLANTIC FISHERIES

Serial No. 1672
(D. c. 2)

ICNAF Res. Doc. 66-64

ANNUAL MEETING - JUNE 1966

Fish length measurement and proposals for uniformity

by A. W. May and F. D. McCracken

Introduction

At the 1956 Annual Meeting of ICNAF, the Standing Committee on Research and Statistics "agreed informally that the use of fork length to the nearest centimetre would be the best standard to adopt for the ICNAF area" (1957 Annual Meeting, Proceedings No. 12, Serial No. 493, Appendix 5). A joint ICES/ICNAF agreement to report length measurements to the nearest centimetre was reached in 1957 (Redbook, 1958, p. 22). It is evident from "Notes on the Sampling Data" published in ICNAF Sampling Yearbooks that all countries have not adhered to these agreements. A new proposal is that ICNAF consider the adoption of total length as the ICNAF standard, and read length measurements to the length interval below. (Report of Joint ICES/ICNAF Sampling Meeting, ICNAF Res. Doc. 66-13).

Canadian scientists have for many years measured groundfish as fork length (equals total length for flounders) to the nearest centimetre. Following the above proposal from the Joint ICES/ICNAF Sampling Meeting, the implications of changing to total length to the centimetre below were discussed at length by the individuals concerned, with unanimous agreement that the disadvantages of such a change outweigh any benefits of uniformity in fish measuring that might come about, supposing that uniformity could be achieved by the proposed change. Accordingly Canadian scientists do not agree that the present ICNAF standard should be altered. Following are some considerations on the subject of fish length measuring which form the background for this decision.

What to Measure

There appears to be universal agreement that for ordinary purposes length measurement should begin from the anterior edge of the upper or lower jaw, depending on which protrudes, with the mouth closed. The choice of terminal position has resulted in a variety of length measurement definitions which may be grouped into 3 categories.

(1) Standard lengths - generally snout (anterior edge of upper or lower jaw) to caudal peduncle, but a great deal of ambiguity exists. Ricker and Merriman (1945) list 8 definitions.

(2) Total lengths - generally snout to end of the caudal fin, but at least 3 definitions exist, (a) and (b) below from Ricker and Merriman (1945), (c) from the current proposal (ICNAF Res. Doc. 66-13).

(a) Natural total length - to the end of the longest lobe of the tail with the tail in a "natural" position.

(b) Extreme total length - to the end of the longest lobe of the tail when the tail is squeezed to the position of maximum extension.

(c) Total length (present proposal) - maximum length as measured by bringing the longest lobe of the caudal fin into the mid-line of the fish.

(3) Fork length - snout to mid-fork (equals middle or mid-line) of the caudal fin. It has also been termed median length or mid-caudal length, but whatever it is called only one definition applies to most species since the measurement is made at the termination of the mid-line of the caudal fin. Mid-caudal length might be the best descriptive title since this would remove ambiguity for those species in which the caudal fin is not forked.

While one or more standard lengths may be appropriate in studies of fish systematics they are much too cumbersome in definition and practice for large scale measuring programs. Natural total length is generally dismissed as a useful measure because of the difficulty in deciding what is the "natural" position of the tail. Of the remainder, published arguments favour either extreme total length or fork length.

Royce (1942) favoured extreme total length over standard length, claiming that for 4 freshwater species weights could be estimated more accurately from the former. Carlander and Smith (1945) obtained equally accurate weight estimates from 2 different standard lengths, fork length and extreme total length, but favoured extreme total length since it could be obtained with greater accuracy. Again extreme total length is favoured by Hile (1948) on the basis that this "is the only measurement that includes all of the fish." Parrish (1958) proposes that "total length is undoubtedly the easiest to measure."

On the other hand Merriman (1941) preferred fork length "for it became evident in handling live fish ... that measurements of this type were the easiest to make and the least subject to error." Ricker (1942) agrees with the statement of Merriman (1941), considers it equally applicable to freshly-killed fish, and lists several disadvantages of extreme total length, in summary:

(1) As fish grow older the tips of the tail tend to wear off.

(2) The tips of the tail are not in the centre line of the fish so that in fish with deeply forked and widely spread tail fins measurement of total length involves considerable distortion.

(3) Difficulty is encountered in measuring preserved fish since the fin rays become stiff and are not easily manipulated.

The various choices are reviewed in detail by Ricker and Merriman (1945), who do not find the arguments of Royce (1942) and Carlander and Smith (1945) in support of extreme total length "to be particularly cogent," concluding that what these authors have really shown is that any clearly defined length measurement is amply accurate for ordinary purposes. The impartial observer (could one be found) must conclude that there is no scientific basis for preferring any particular measurement, and agree with Ricker and Merriman (1945) that "the criteria to be considered in choosing a length measurement appear to be limited to those of convenience and uniformity," and further that what constitutes convenience may vary with the species.

It is apparent that there may not be general agreement within ICNAF that complete uniformity is desirable. Thus the Report of the Joint ICES/ICNAF Sampling Meeting (ICNAF Res. Doc. 66-13) concludes both

(1) that the length dimension to be measured "need not necessarily be the same for all species (p. 2), but also

(2) that "uniformity is ... as important between species ... as within species (p. 3).

The first conclusion appears more reasonable on the basis that what is convenient depends on the species. Within a species, all other considerations aside, what is convenient is a highly subjective question.

When a particular system has been in use for some time this is undoubtedly the most convenient to those who are using it.

Ricker and Merriman (1945), while admitting that some of their arguments "may be tinged with rationalization," conclude that fork length is the most convenient to measure. The present authors consider that fork length (equals mid-caudal length) is the most convenient for ICNAF area groundfish species at least, for 3 most important reasons:

(1) that it is the most easily defined and least likely to be misconstrued - therefore most likely to achieve uniformity in practice;

(2) that it involves no manipulation of the caudal fin, is therefore more easily measured and consequently least susceptible to innaccuracies (this is particularly important in large specimens, e.g. of cod);

(3) that it is already the ICNAF standard.

Some other length measure may be more appropriate for those species in which the tail is very deeply forked. Some measure of total length might be more appropriate for species in which the tail is heterocercal.

How to Measure

The question of whether to measure to the nearest length interval or the length interval below has received much less attention, with the exception of the earlier ICNAF and ICNAF/ICES agreements previously noted, i.e. to measure or at least report to the nearest interval. Measuring to the nearest length interval means for example that the length of fish measuring 19.5 to 20.4 units (or 19.50 to 20.49) would be recorded as 20 units. This is accomplished, whatever measuring system or units are chosen, by using a scale having the unit intervals marked at 1.5, 2.5, etc., with the whole number placed between these intervals (Fig. 1A). For the example above, if the fish's tail falls on the 19.5 line, or anywhere within the interval marked 20, the length is read as 20.

Measuring to the length interval below means that fish measuring 20.0 to 20.9 units (or 20.00 to 20.99) are recorded as 20 units. With this system the scale markings are at whole number intervals with the number to which the mark applies placed at the right (Fig. 1B).

Thus when measuring, for example, to the nearest centimetre the length recorded is the mid-point of a centimetre group. When measuring to the centimetre below the length recorded is the bottom of a centimetre group, and for subsequent use must be corrected by adding 0.5 cm to each length interval of a length distribution, to calculated mean lengths, etc. Measurement to the interval below gives, in effect, a coded value which must subsequently be decoded to give a nearest interval measurement. However simple this decoding may be it must be concluded that the direct method of recording to the nearest length interval is more convenient and less likely to be misinterpreted.

The length interval in which length data are reported is not necessarily that in which the original measurements were made, and the choice of the length interval for reporting might conceivably be pertinent in deciding how to record the original measurements. Thus it has been stated (ICNAF Res. Doc. 66-13) that when 1/2 cm or smaller intervals are used "there are some difficulties in measuring to the nearest length interval," especially when the data are later grouped over larger intervals.

If original measurements are made in millimetres it probably matters little whether they are attempted to the interval below, the nearest or the interval above. Millimetre measurements may be grouped in half centimetres or whole centimetres, by either convention, as illustrated below.

Grouped to 1/2 cm below	200-204	=	20.0
	205-209	=	20.5
Grouped to nearest 1/2 cm	203-207	=	20.5
	208-212	=	21.0
Grouped to cm below	200-209	=	20
	210-219	=	21

Grouped to <u>nearest</u> cm	195-204	=	20
	205-214	=	21

The results are the same as if measurements had actually been made in half centimetres or centimetres, except when grouping to the nearest half centimetre. Here the end points of the intervals are not exactly the same as if measurements had originally been made to the nearest half centimetre (Fig. 2A), though the differences are slight and probably not of practical significance. This problem becomes more acute however when attempting to group measurements made to the nearest half centimetre.

If original measurements are made in half centimetres they may be grouped in centimetres as in the examples below.

(1) For measurements to the half centimetre below (Fig. 2B):

grouped to the centimetre below -

20 (10.00-10.49 cm) plus 21 (10.50-10.99 cm) become 10 cm, correcting later by adding 1/2 cm;

grouped to the nearest centimetre -

21 (10.50-10.99 cm) plus 22 (11.00-11.49 cm) become 11 cm.

Thus if measurements are made to the half centimetre below it is possible to group by either convention to give the same intervals and mid-points as if measurements had originally been made in centimetres.

(2) For measurements to the nearest half centimetre (Fig. 2A):

grouped to the nearest centimetre -

20 (9.75-10.24 cm) plus 21 (10.25-10.74 cm) give a centimetre grouping with different end and mid-points than measurements originally made to the nearest centimetre. The same problem arises when grouping to the centimetre below.

Thus measurements to the nearest half centimetre are impractical when it is necessary to later combine them in centimetre intervals. When measurements in half centimetres are required it is simplest to use a coded measuring board with divisions at each half centimetre. The board may be coded so that measurements are made to the interval below (Fig. 2B) or the interval above (Fig. 2C), and later combined to the centimetre below, above or nearest as required (Fig. 2B, 2C). Measurements in half centimetres require a special board and the resulting measurements allow flexibility in combination. There is no reason why measuring boards graded in centimetres should conform to the characteristics of the half centimetre board.

There is no difficulty in grouping from single centimetres as measured to 2 cm or 3 cm groups. With 2 cm groups from measurements to the centimetre below, and starting from zero, true mid-points are 1.0, 3.0, 5.0, etc.; with 3 cm groups the mid-points are 1.5, 4.5, 7.5, etc. The corresponding mid-points for measurements to the nearest centimetre are 0.5, 2.5, 4.5, etc. for 2 cm groups and 1.0, 4.0, 7.0, etc. for 3 cm groups.

The Problem of Conversion

Conversion of past data from centimetre below to nearest centimetre, or vice versa, presents no real problem, involving only addition of a constant 1/2 cm to the former or subtraction of the same constant from the latter. In fact it would not be worthwhile to undertake conversion of past data since the adjustment could easily be made to individual values, or length distributions in tabular or graphic form, as circumstances required.

Conversion between fork and total length is a much more difficult proposition since the adjustment changes with fish size. Thus there can be no simple addition or subtraction of a constant as in converting from the nearest interval to the interval below. This problem may be partially circumvented (e.g. Beckman, 1948) by working out average conversion ratios for several length groups over the species length range. A further complication however is that the conversion may alter with sex (Hile, 1941) or between populations of the same species (Carlander, 1950), though Carlander (1950) finds greater variation when conversion factors for the same species are reported by different biologists.

If it is assumed that fork length and total length are related linearly on an arithmetic plot, then one may be estimated from the other by means of a least squares regression equation fitted to the data. Since the data are not likely to be perfectly correlated (correlation coefficient will be less than unity), two regressions are possible: that of total length on fork length, and of fork length on total length. The one to be used in conversions depends on which of the measurements is being estimated from the other, i.e. which is chosen as the dependent variable. Given the appropriate regression, three situations are possible (Fig. 3).

(1) The regression line passes through the origin (zero intercept), i.e. has the form

$$Y = aX$$

Conversions are made simply by multiplying by the ratio $Y/X = a$. The conversion is constant for all fish lengths; the adjustment that is made changes with length since a cannot be unity.

(2) The regression line has a positive Y-intercept, i.e. of the form $Y = aX + b$.
Here

$$a = \frac{Y-b}{X}$$

is again constant but the ratio Y/X decreases with increasing fish length.

(3) The regression line has a negative Y-intercept, i.e. of the form $Y = aX-b$. The ratio Y/X increases with fish size. This is the type of relationship found to apply to Division 4X haddock (Fig. 4).

Whatever the relation it is obvious that conversions between fork length and total length present formidable problems when large amounts of data are involved. To take a single illustration suppose that fork length and total length of a species, assuming both are measured to the same interval, are related simply as

$$\text{Total length} = 1.04 \times \text{Fork length.}$$

All fish originally measuring 37 cm become 38.48 cm. All measuring 38 cm become 39.52 cm. If the converted values are now rounded to 38 cm and 40 cm, we are left with no 39 cm individuals. Possibly this problem is more aesthetic than scientific. However, it is clear that while average lengths or 50% selection lengths might easily be converted, the conversion of whole length distributions presents formidable obstacles in labour, if not in interpretation.

Conclusion

The authors see no point in risking a compounding of the present confusion, at least for the common groundfish species, by changing from the already accepted ICNAF standard of fork length to the nearest interval. In summary, this decision has been arrived at for the following reasons.

(1) Fork length is considered to be the most satisfactory length measure for groundfish species, remembering that fork length = total length when the posterior edge of the caudal fin is straight or convex.

(2) Measurement to the nearest centimetre is more satisfactory than measurement to the centimetre below (no necessity for later correction).

(3) The new proposal involves adoption of total length, and measurement to the centimetre below, as separate recommendations. There is no advantage in adopting either procedure as a standard without the other since uniformity would thereby not be achieved. Since the earlier ICNAF agreement has not resulted in uniformity, it appears questionable whether this proposal would result in any greater uniformity than has already been achieved.

(4) Conversion of past data from fork to total measurement is impractical, and the loss in continuity is not worth the gamble of achievement of uniformity.

(5) There is no scientific basis for the proposed change. While it would be convenient for some countries which have not adhered to the ICNAF standard, it would greatly inconvenience those which have.

References

Beckman, W. C. 1948. The length-weight relationship, factors for conversions between standard and total lengths, and coefficients of condition for seven Michigan fishes. Trans. Am. Fish. Soc., 75: 237-256.

Carlander, K. D. 1950. Some considerations in the use of fish growth data based upon scale studies. Trans. Am. Fish. Soc., 79: 187-194.

Carlander, K. D. and L. L. Smith. 1945. Some factors to consider in the choice between standard, fork or total lengths in fishery investigations. Copeia for 1945, No. 1, p. 7-12.

Hile, R. 1941. Age and growth of the rock bass, *Ambloplites rupestris* (Rafinesque), in Nebish Lake, Wisconsin. Trans. Wisconsin Acad. Sci., Arts and Letters, 33: 189-337.

1948. Standardization of methods for expressing lengths and weights of fish. Trans. Am. Fish. Soc., 75: 157-164.

Merriman, D. 1941. Studies on the striped bass (*Roccus saxatilis*) of the Atlantic Coast. U.S. Dept. Interior, Fish and Wild. Serv., Fish. Bull., 50(35): 1-77.

Parrish, B. B. 1958. Some notes on methods used in fishery research. Spec. Publ. int. Comm. Northw. Atlant. Fish., No. 1, p. 151-178.

Ricker, W. E. 1942. The rate of growth of bluegill sunfish in lakes of northern Indiana. Investig. Indiana Lakes and Streams 2: 161-214.

Ricker, W. E. and D. Merriman. 1945. On the methods of measuring fish. Copeia for 1945, No. 4, p. 184-191.

Royce, W. F. 1942. Standard length versus total length. Trans. Am. Fish. Soc., 71: 270-274.

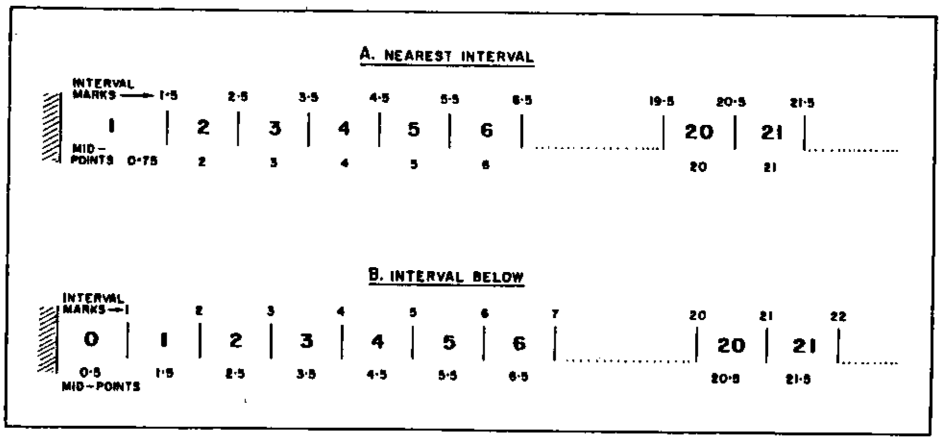

Fig. 1. Scales for measuring to <u>nearest</u> interval (A) and interval <u>below</u> (B).

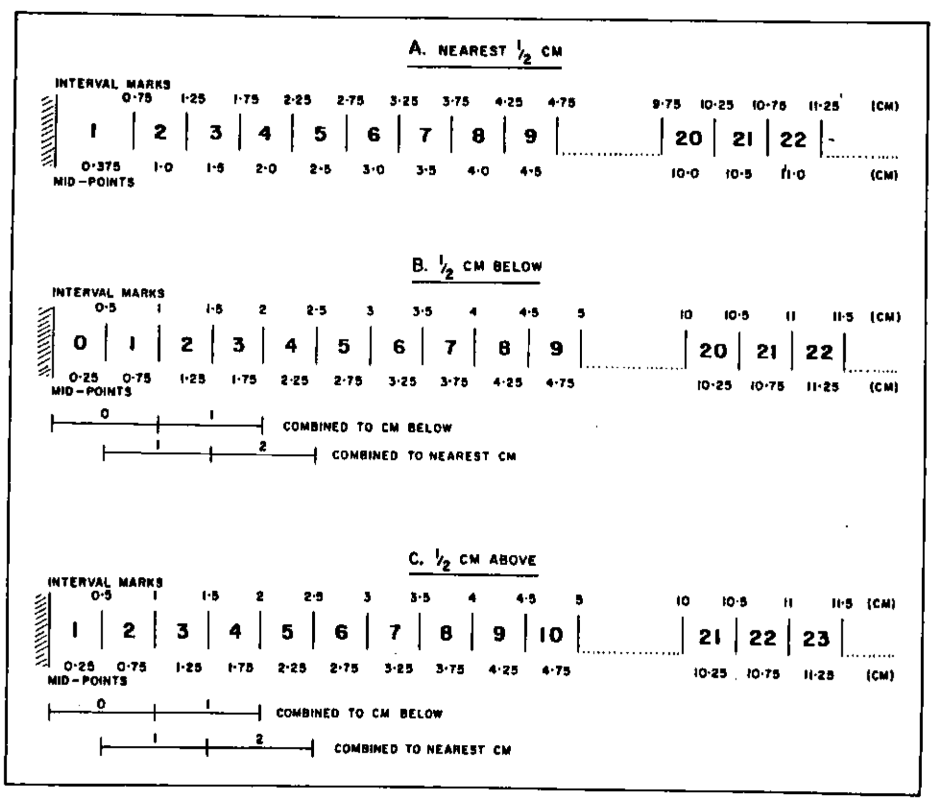

Fig. 2. Alternative methods for measuring in 1/2 cm units.

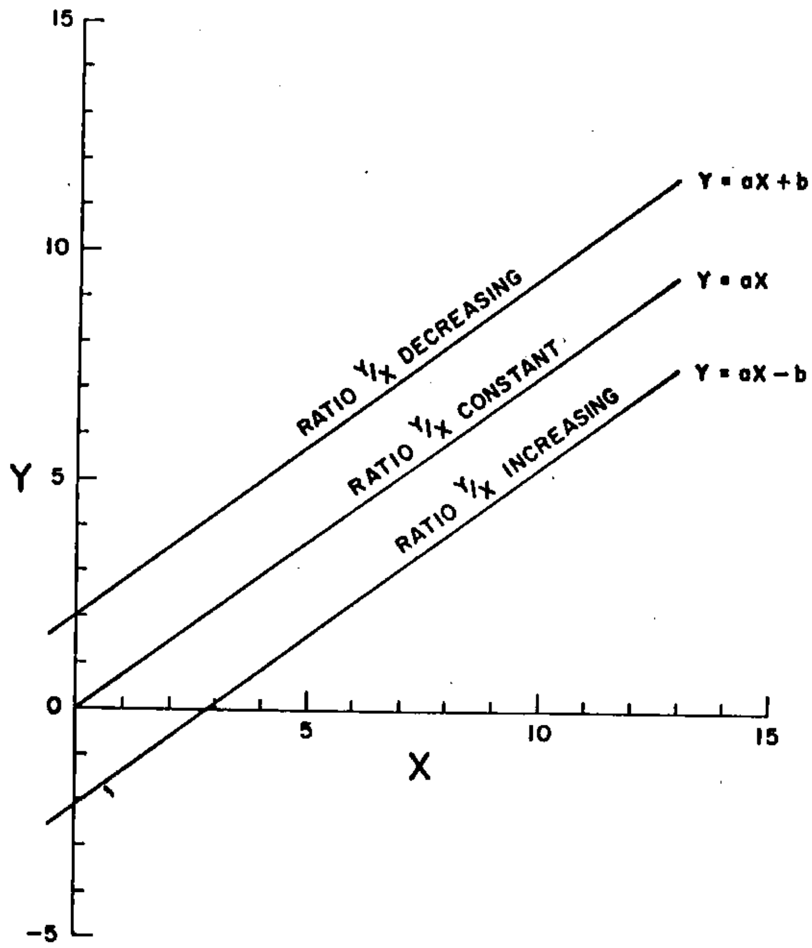

Fig. 3. Possible forms of the relationship between two different length measurements.

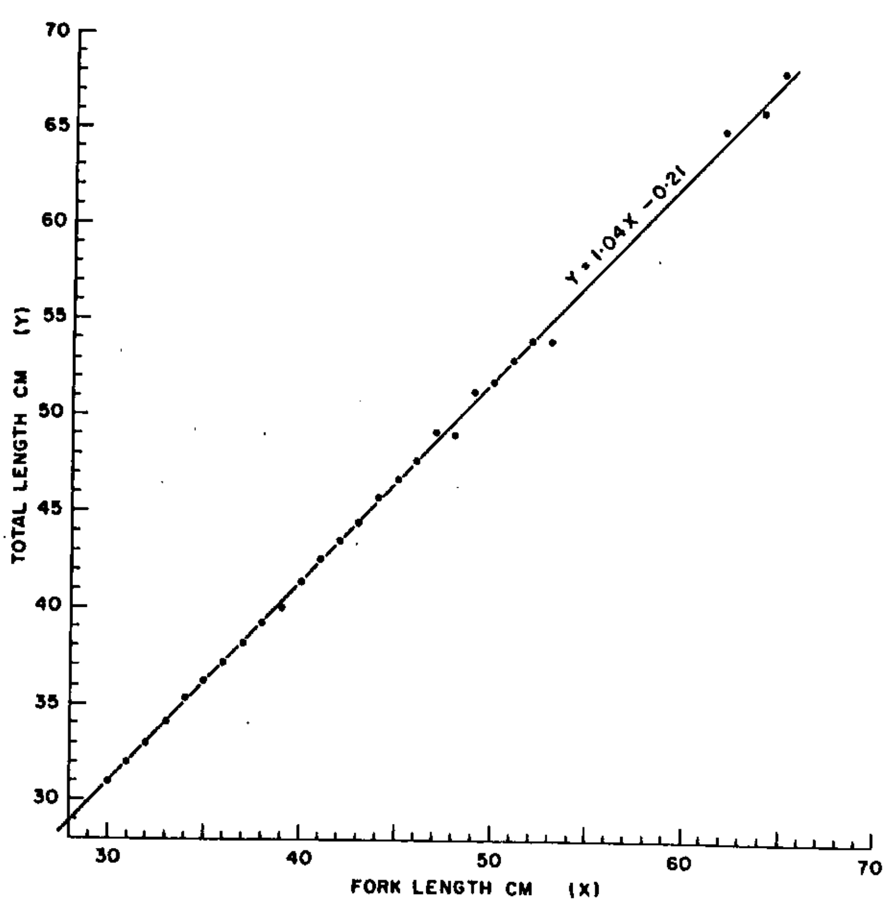

Fig. 4. Regression of total length on fork length for Division 4X haddock, both measurements to the nearest cm. The points represent average total lengths at each centimetre fork length, based on 150 specimens in all.