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Analysis of Various Length Measurements on Larvae Collected by the ICNAF Larval Herring Surveys

by

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Various length conventions have been used by the participants in measuring larvae collected on the surveys since the beginning of the Cooperative International ICNAF Larval Herring Surveys in 1971. The four measurements are: 1) standard length (snout to base of caudal fin) to nearest mm; 2) standard length to mm below; 3) total length to nearest mm; and 4) total length to mm below. The question arises, is there a significant difference among the length conventions as they relate to length-frequency distributions of larvae? This information is necessary to evaluate polymodal length-frequency distributions used to calculate production, growth, and mortality estimates of herring larvae in the Georges Bank-Gulf of Maine study area. The analysis presented in this paper first considers the problem from a theoretical approach, and second, a specific case is analyzed.

Methods

A. Theoretical Approach

A total of 102 standard length values (to .1 mm) were selected to approximate a normal length-frequency distribution by using probability tables to erect a normal-binomial distribution and generate the desired number of random values within each class unit. A bell-shaped curve resulted with a mean of 15.0 mm and a standard deviation of 2.9 mm when the values were grouped in 1 mm size classes to the nearest mm. The original standard length values were rounded down to the mm below and regrouped in 1 mm size classes. Total length values were calculated from standard length values using the regression formula of Tibbo and Legaré (1958, p. 1452) for larvae 12 mm and greater in length;

$$\text{Total Length} = 1.181\ \text{Standard Length} + 2.0$$

Total length to the mm below was obtained from the total length calculated values and regrouped in 1 mm size classes as above. The four length-frequency distributions were plotted; the mean and standard deviations were calculated for each measurement frequency.

The Kolmogorov-Smirnov two-sample test (Tate and Clelland, 1959, p. 93) was used to test for population differences. This test is based on differences in cumulative percentages and is very sensitive to changes in population shape and location.

B. Case Study

Results of the *ANTON DOHRN* ICNAF Larval Herring Cruise, 30 October-13 November 1972, in the Georges Bank-Gulf of Maine area are given by Schnack et al. (1973). Usually the entire .505 mm mesh sample was sorted for herring larvae. In the few instances where splitting of the sample was required, more than a 100 larvae were subsampled. Larvae were measured as total length to the nearest mm below and reported in the basic data summary by Federal Republic of Germany. These same larvae were remeasured by the US sorting group at Narragansett, R.I., to the nearest mm. However, only a subsample of 100 larvae were measured when larval densities exceeded 100 per sample.

Both the FRG and US measurement data were tallied and length-frequency plots made by 1 and 3 mm size classes for the total cruise stations and by smaller areas: Georges Bank, Nantucket Shoals, Georges Bank-Nantucket Shoals, Gulf of Maine, and Scotian Shelf. The means and standard deviations were calculated for each length-frequency distribution and the Kolmogorov-Smirnov test was used to test for population differences as above.

Results

The four theoretical larval length-frequency distributions are plotted in Figure 1. The means and standard deviations are given in Table 1. The mean for total length measurements was shifted 1 mm higher from the standard length for the population chosen in each case. Length measurements to the mm below shifted the population centers down by 0.5 mm. The only statistically significant difference between the four populations is for standard length, mm below, and total length, nearest mm, at the 1% level. The shape of the total length population curves was broadened somewhat compared to the standard length curves. Total length standard deviations were slightly greater than those of standard lengths. The dip in the left hand side of the total length curves at 12 mm is believed to be an artifact of the transformation of the standard length measurements to total length.

The *ANTON DOHRN* length frequency curves for both FRG and US measurements by 1 mm size classes are shown in Figure 2. Means and standard deviations for the entire sample and the two major modes are given in Table 2. Length-frequency graphs for more discrete areas and by 3 m class sizes are not shown here as the patterns were basically the same. Two length modes are dominant in Figure 2 for both measurement conventions. The US distribution is shifted to the greater size classes along the entire length, except in the 11-13 mm range. The US mean is greater than the FRB mean by 1.8 mm for the total length distribution, and 0.6 mm for both modal groups. A highly significant difference (1% level) was found between the FRG and US length-frequency distributions for any length grouping or area.

Discussion

The results of four theoretically generated length-frequency distributions agree with one's logical expectations. The application of these results to the case study, however, brought forth an inconsistency. One could expect the length-frequency population mean of the FRG data for larvae measured as total length to the mm below to be *ca.* 0.5 mm greater than the mean for the US data for larvae measured as standard length to the nearest mm. The results show the reverse situation; the FRG means were lower than the US means in all cases. If larvae less than 12 mm are essentially the same length measured as standard or total length as reported in the literature, then we would expect the FRG frequency for larvae measured to the mm below to be *ca.* .5 mm lower than the US frequency. This fact appears to account for the observed difference in the first mode, but not the second mode. This discrepancy may be accounted for by the larger sample size for measuring larvae by FRG, or the US larval measurements may have been biased by unconsciously choosing more of the larger larvae for the subsample of 100.

This study points out the need for more rigorous and standardized subsampling procedures. The total larvae per catch cannot always be sorted for practical reasons, particularly since very high densities of recently hatched larvae are common. The US Narragansett Laboratory sorting group have done further work along these lines and now seem to have a suitable method. When plankton samples have high densities of larvae that require subsampling (>100), all larvae greater than 20 mm are counted in the sample. Larvae less than 20 mm are subsampled for 100 specimens insuring that at least all major length modes are encompassed. An experiment that is still needed is to determine what effect sample size has on the shape and location of a polymodal length-frequency distribution, e.g. a subsample of 100 larvae versus 200, 400, etc.

All of the various conventions of length measurements have been used in reporting the larval herring data from the .505 mm mesh samples. Although only significant differences have been found in this study between standard length to the mm below and total length to the nearest mm, the basic larval length data for each cruise should be adjusted to standard length, nearest mm, for future analyses of growth and mortality. With the establishment of the Polish Sorting Center in Szczecin to begin processing the .333 mm mesh samples, subsampling procedures and length measurements will be standardized to insure uniformity of all data.

References

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Table 1. Mean and standard deviations for various generated larval length measurements.

Statistic	Standard length nearest mm	Standard length below mm	Total length nearest mm	Total length mm below
$\bar{X}$	15.0	14.5	16.0	15.56
s	2.9	2.9	3.2	3.2

Table 2. Mean and standard deviations for FRG and US larval measurements from 1972 ICNAF Larval Herring Survey, *ANTON DOHRN*.

Statistic	US Standard Length nearest mm	FRG Total Length mm below
	4-32 mm Length-Frequency	6-31 mm Length-Frequency
$\bar{X}$	12.4	10.6
s	3.6	3.2
	4-11 mm mode	6-11 mm mode
$\bar{X}$	9.3	8.7
s	1.1	1.1
	12-32 mm mode	12-31 mm mode
$\bar{X}$	15.1	14.5
s	2.6	2.6

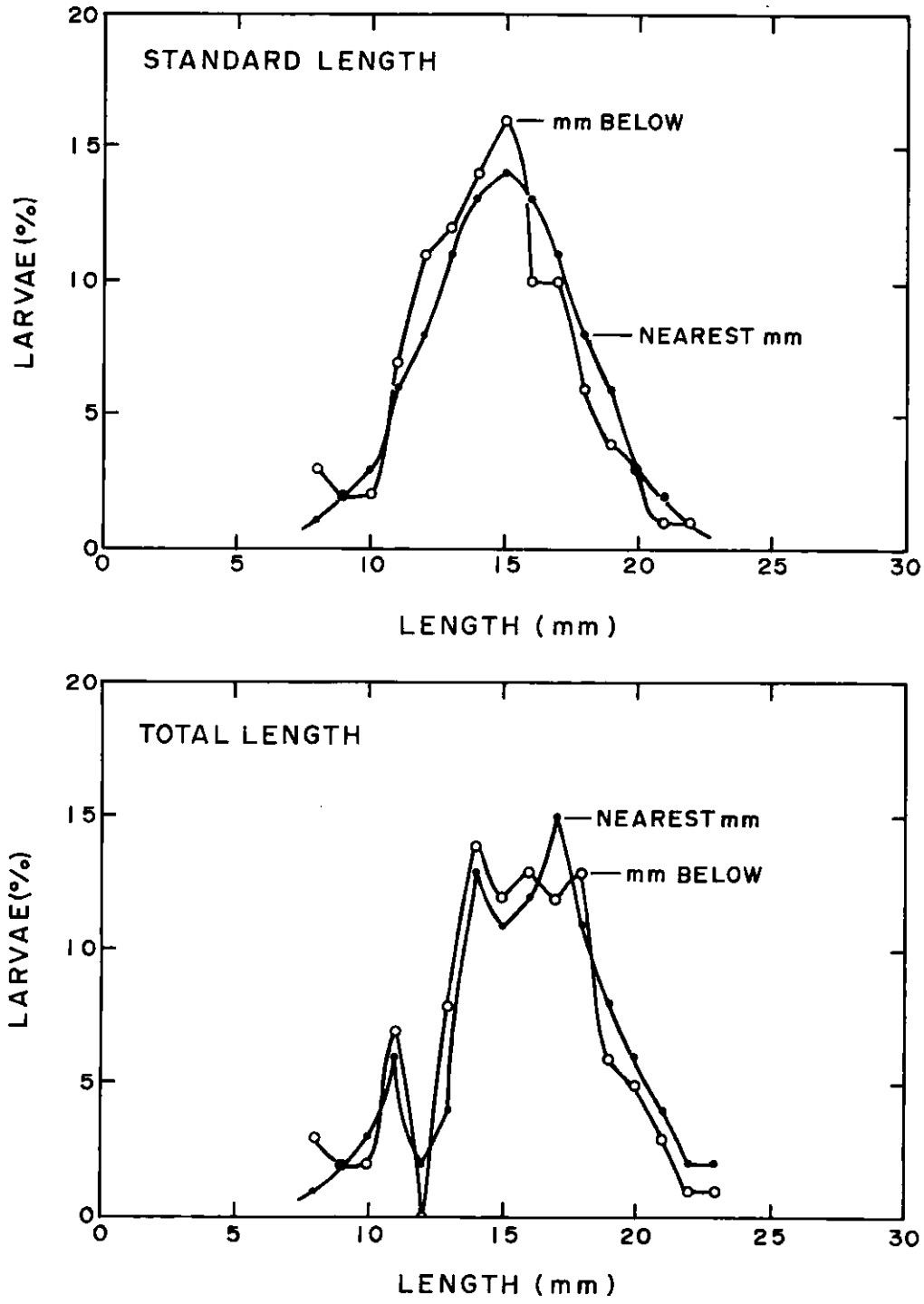

Figure 1. Theoretical larval length-frequency distributions. See text for details.

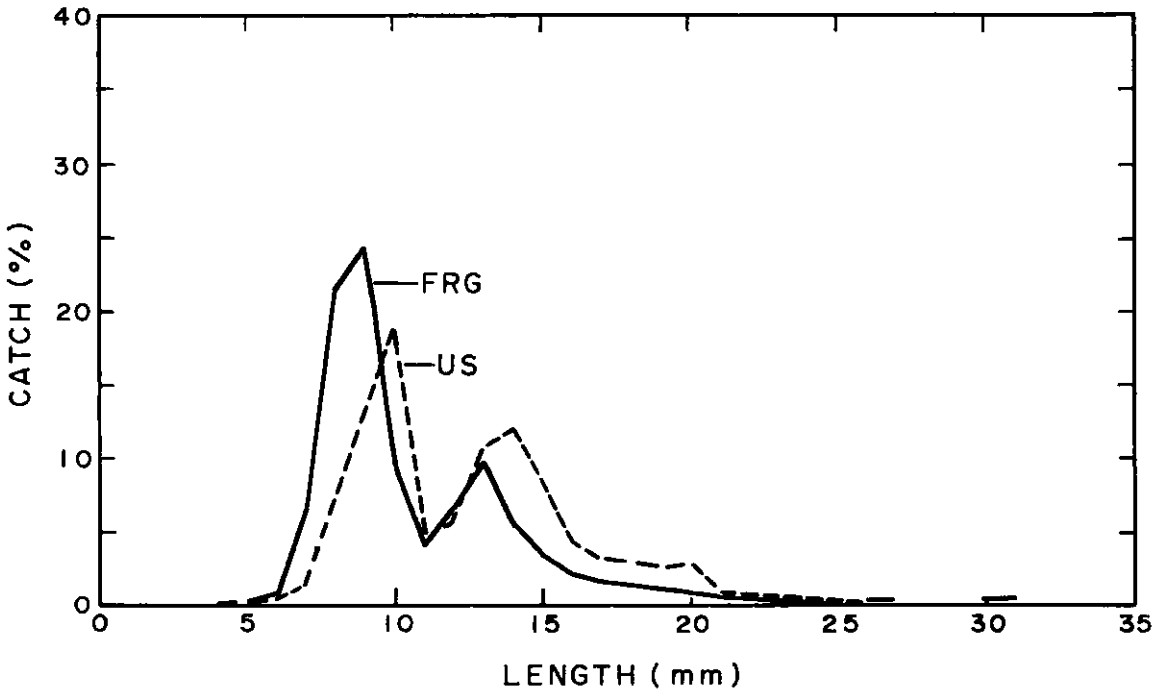

Figure 2. Length-frequency graph for FRG and US larval herring measurements from the 1972 ICNAF Larval Herring Survey, *ANTON DOHRN*. See text for details.