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AGE DETERMINATION OF GEORGES BANK HADDOCK

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Dickie in Document 3, Appendix VI (ICNAF, 1959) examines effects of errors in scale reading on apparent year class strength and apparent mortality rate. Data from comparative scale-otolith readings of Georges Bank haddock (Kohler and Clark, 1958) are used to determine bias in age composition in a model with year classes alternating in strength in the ratio 1 to 5. It is assumed that otolith readings are correct and that each deviation of a scale from an otolith reading is a scale reading error. The author notes a resemblance in his Figure 2 to Graham (1952, Figure 6) and concludes that "apparent changes in the relative strength of year classes of haddock with age may be due entirely to mistakes in age reading." In an addendum, it is shown how one may "reconstruct an accurate age frequency diagram for Georges Bank haddock from available data."

The Gulf of Maine and Georges Bank haddock fishery has been under continuous scientific study by the U.S. Fish and Wildlife Service and its predecessor agency, the U.S. Bureau of Fisheries, since 1930. Scales for determination of the age structure of the landings have been collected routinely since 1931. By this method, year classes back to 1925 have been identified, their growth, size composition, relative abundance at each age, and contributions to the fishery determined. On the basis of these and other data collected and analyzed by many competent biologists and statisticians over the years, a firm recommendation for regulation of the mesh size in the Subarea 5 haddock fishery was made to and adopted by ICNAF.

The assertion that scale readings of haddock in Subarea 5 are subject to the gross errors indicated by Dickie in Document 3, Appendix VI requires a close examination of the evidence on which the assertion is based. He relies primarily on a study by Kohler and Clark (1958). His conclusions derive directly from the assumption that where otolith readings differ from scale readings, the otolith readings are correct.

Sample Size and Mean Age

The Kohler-Clark study is a factual presentation of age determinations made from 500 fish from Subarea 5 and 264 fish from Subarea 4. The authors conclude "that for Subarea 5 haddock there are no statistically significant difference in scale or otolith ages up to an age of about 7 years, from which point scale readings are consistently lower than ototlith readings."

The study is based on 301 fish from Georges Bank and 199 fish from the Gulf of Maine to make a total of 500 fish from Subarea 5 (one fish is not tabulated in their Table II). These fish are distributed among 11 age classes, about 45 fish per age group had the sample been stratified. Actual distribution of numbers by age, however, ranges from over 150 fish at age 5 to 1 or 2 at the oldest ages. The sample is thus small and not sufficiently representative of older ages to show any significant trends in readings by age. This appears very simply by comparing the mean scale and mean otolith age, 4.68 and 4.76 years respectively. The difference is not significant ($t = 0.2$).

Chi-square Tests

Kohler and Clark (1958, p. 1242) compare disagreements by age-groups, using a chi-square test. Unfortunately chi-square is computed incorrectly for testing the hypothesis that disagreements do not differ significantly from their mean. In addition, their grouping of older ages is subject to dispute because so very few fish are involved. The danger in this procedure is evident, first, from the fact that the mean ages of the whole group as determined by otolith and scale do not differ significantly and, secondly, because very slight shifts in the grouping of the older ages make profound changes in the estimated chi-square.

Grouping ages 8 to 12, instead of ages 9 to 12 (Table IV) and computing chi-square correctly, chi-square for ages 8 to 12 is 2.574 (not significant) compared to the computed 16.800 for ages 9 to 12. Grouping ages 8 to 13 (Table V), chi-square is only 0.577 instead of the incorrectly computed 6.189 for ages 9 to 13.

Total chi-square for Table IV is 27.479. When computed correctly, it is 20.375. When ages 8 to 12 are grouped, the total is only 12.775 (not significant).

In Table V, grouping ages 8 to 13 and computing chi-square correctly, 3 comparisons out of 6 are not significant instead of the 1 out of 6 shown.

Comparisons of Age Composition

In the interest of scientific objectivity, one must avoid the pitfall of assuming that because two methods differ the more attractive result must be right. The Kohler-Clark study offers no criterion for judgement of validity, their comparisons of age compositions and growth rates being, of course, inadequate in this respect. One criterion, however, seems to have been overlooked. Since about 67 percent of the comparisons agree, and since there appears to be no significant distribution of scale or otolith disagreements about agreements, it would seem fairly more objective to consider agreements as representing the true age composition rather than to assume arbitrarily that either otolith or scale determinations are correct.

Figure 1 shows the age compositions of the Subarea 5 haddock sample in 3 ways: as indicated by readings in agreement, as indicated by scale readings, and as indicated by otolith readings. The figure suggests that both scale and otolith readings are subject to some error, and that these errors are about equal.

Figure 1 cannot be interpreted as showing the extent of absolute error because the compositions are shown as percentages. The extent of absolute error is better indicated by the scale-otolith deviations in Figure 2 (Clark and Kohler, 1958) for those ages where the sample numbers are fairly adequate.

Interpretation of Scale-Otolith Comparisons

In the Kohler-Clark sample of 500 haddock from Subarea 5, there is an obvious but statistically nonsignificant tendency for otoliths to indicate older ages than scales at nearly every age. Granting that an adequate sample of comparisons would demonstrate differences of statistical significance at perhaps all ages, this would by no means establish the validity or nonvalidity of either method. We find, for example, that Kohler (1958, p. 1238) cites Kohler and Clark (1958) as evidence that scale readings over 9 years of age are not valid. At the same time, he assumes that because annuli are readily distinguished in the otoliths of fish beyond age 9, the otolith readings are valid.

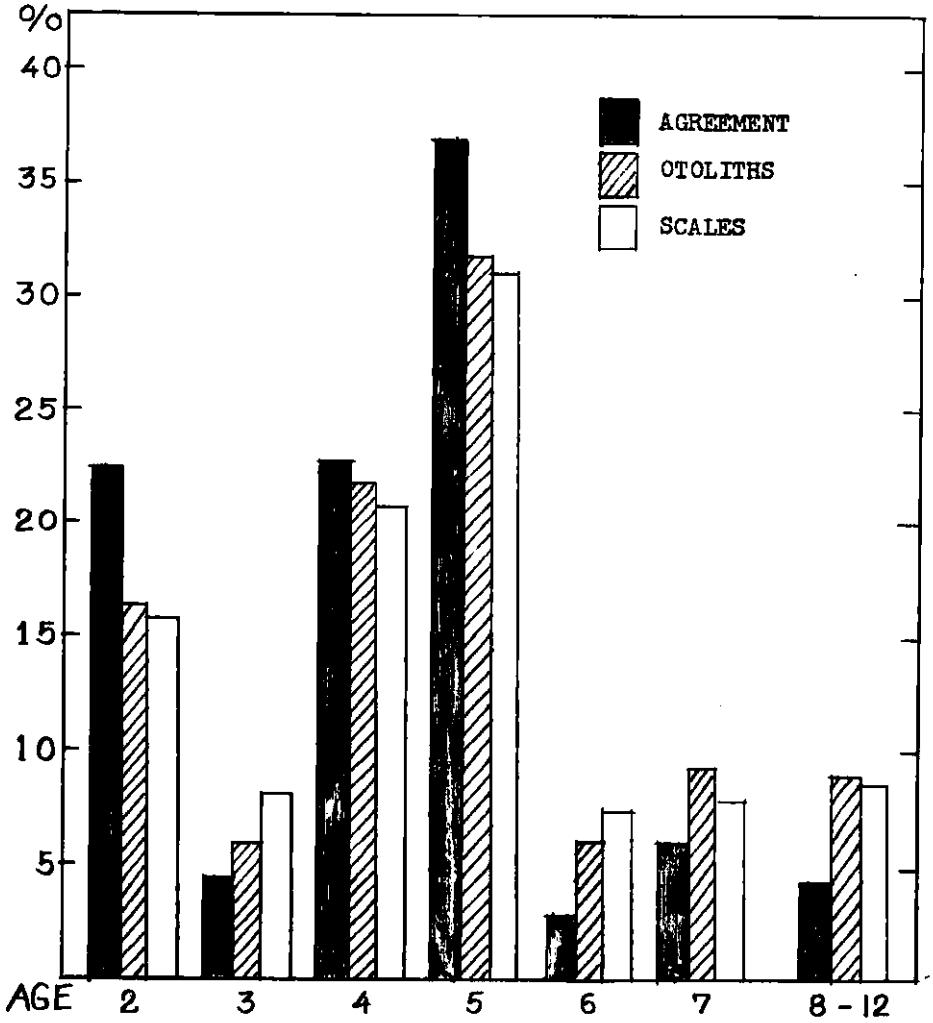

Figure 1. Percentage age composition of the Subarea 5 haddock sample as indicated by: agreement between scales and otolith (black), otoliths (cross hatched) and scales (white).

Kohler and Clark (1958) draw no conclusion about the relative validity of the two methods, other than a statement that "otoliths seemed to be a more promising tool for aging old fish than scales," and objective conclusion based on relative readability rather than on relative validity.

In reviewing literature on the utility of scales and otoliths as indicators of age (Rollefsen, 1933, 1935; Saetersdal, 1953, 1958; Trout, 1958; Kohler, 1958; et al.) it is clear that neither the scale nor otolith is an infallible guide without an intimate, year-to-year knowledge of the fish stock being aged. In using otoliths this seems especially important: "A blind counting of 'rings' can only bring confusion and doubt upon the method" (Trout, 1958).

A comparison, then, of scale and otolith age determinations by technicians familiar with the peculiarities of only one of the stocks being compared can be of value only insofar as it points up the need for more objective criteria in interpretation, especially the need for a closer study of the variations in markings on scale and otoliths within one area by the same technicians rather than between areas by different technicians. The study by Saetersdal (1953) is adequate in this respect.

It is well-known that otoliths are more sensitive indicators of varying hydrographic conditions than are scales (Rollefsen, 1933; Kohler, 1958, p. 1232, Fig. 2; Hickling, 1933, p. 30; Saetersdal, 1953). Hyaline or opaque material may be deposited at the edge of the otolith during any month of the year, depending often on a typical, more than transitory hydrographic conditions. These subsidiary zones, together with spawning zones, furnish ample opportunities for errors in interpretation, tending generally toward adding to the true age of the fish. Because of this, the marked tendency of otolith readings toward older ages when compared to scales must not be interpreted as a superiority but must be viewed most critically and with the utmost suspicion.

When hyaline or opaque material is observed at the edge of an otolith in midsummer, there is little danger of misinterpretation no matter how wide or narrow the zone may be. On the other hand, if the fish is not captured until some years later, considerable subjective judgement in interpretation is required.

Failure of a minority of haddock of the 1948 year class to form broad sclerites in the summer of 1949 is noted by Saetersdal (1953, 1958). The same fish, however, showed an unusually narrow opaque zone in the otolith by which their age could be correctly determined. Is any "very narrow" (Saetersdal, 1958) opaque zone to be interpreted as an annual mark even when it does not occur on the edge of the scale?

Summary and Conclusions

The Kohler-Clark (1958) samples of 500 fish from Subarea 5 and 264 fish from Subarea 4 are inadequate to establish statistically significant differences in age readings beyond 7 years. Demonstration of statistically significant differences at any age is insufficient to establish validity of either method in question; it probably should be regarded as a measure of the familiarity of the technicians with the stock of fish they are aging.

Comparison of scale-otolith age compositions to the age compostion indicated by scale-otolith readings in agreement indicates both methods involve errors of about the same magnitude (Figure 1).

The conclusion that Georges Bank age compositions require extensive reconstruction because of errors in scale reading must, on the basis of available evidence, be regarded as a subjective judgement.

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