Letters to the Editor

Water Temperature and Cod Growth-Rate

HOLT's (1959) criticism of my paper "Cod growth and temperature" (TAYLOR, 1958a) necessarily draws attention to several misconceptions and misinterpretations of the von Bertalanffy (1938) growth function by BEVERTON and HOLT (1957) which these authors might have wished to emend in due course. These misconceptions result in rather serious errors in the interpretation both of the nature of growth and of the yield curves which result from variation in growth parameters.

BEVERTON and HOLT (1957, p. 105) regard variation of growth with density in fish populations as "perhaps the best established of the density dependent effects." They concede that while changes in food consumption may result in some change in general metabolic activity, "these changes are likely to be of minor importance compared with variations in the rate of anabolism that would result directly from considerable change in the rate of food consumption" (p. 106).

Their conclusion that the parameter E (H in HOLT's (1959) notation) is subject to environmentally-induced variation without concomitant variation in K is further confused by assuming that L_∞ (and thus W_∞) remains constant with a change in E. The result is their astonishing Figure 17·23 which shows four growth curves, representing four-fold changes in K, attaining the same asymptote. The substantial displacement of yield maxima on fishing intensity which should result from change in K does not, of course, appear in their Figure 17·22. With an assumed constancy in W_∞, it is easy to see from Figure 17·23 why HOLT considers that a change in K would result in no change in life-span, or average size composition of a population.

In a recent paper (TAYLOR, 1959) dealing with temperature and growth relations in the razor clam, *Siliqua patula*, I have shown that for many marine and freshwater species, the relation between E and K is a species-characteristic regression, both within and between environments. Recalling that $E = KL_\infty$, one can easily compute this regression for cod from the data of Table 1 (TAYLOR, 1958a, p. 367).

A characteristic regression between E and K, for every species we have examined for which the growth data are reasonably graduated by a von Bertalanffy equation, generalizes many aspects of fishery yield-assessment.

As for my alleged "misuse of terms" in defining "life-span", age and growth may be considered as irreversible processes and are defined by the von Bertalanffy function in terms of time and size. If HOLT is correct in stating that size at maturity in many fishes in 0·67 L_∞, then he may find it quite convenient to define, without ambiguity, the age at maturity of these fishes as

$$A_{0\cdot67} = 1\cdot109/K + t_0$$

For comparative purposes, and for estimating natural mortality limits, it is immaterial what fraction of time required to attain L_∞ we use. Perhaps for this purpose it would be more logical to use $A_{0\cdot50}$, the "half-life". $A_{0.95}$, or some value near it, appears preferable to the arbitrary t'_λ in BEVERTON and HOLT's yield equation.

It is interesting to note that although HOLT considers my use of $A_{0\cdot95}$ as "absurd", BEVERTON and HOLT (1957, p. 288) derive a mathematically identical expression

$$t_i - t_0 = 1/K \log \left(\frac{1}{1 - x^{1/3}}\right)$$

in which x is any given proportion of W_∞ and t_i is the age at which the specified proportion is reached. Thus t_i is equivalent to A_p and my derivation, but not interpretation, of the term apparently was already anticipated when I presented the concept in 1956 to the meeting of the International Commission for the Northwest Atlantic Fisheries at Biarritz (TAYLOR, 1958b).

HOLT's letter indicates he appreciates the potentialities of growth-temperature relationships. He points out that they may set probable limits to natural mortality and define growth-rates for animals difficult to age. Of even greater importance, by quantitatively relating biomass to an environmental factor, I believe we may be able eventually to abandon some fundamental premises of the "theory of fishing" in favour of more profitable hypotheses and to direct more attention to the environment, the multitudinous factors of which form a dangerously large gap between fishing theory and reality.

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