Measurement Of The Natural Growth Rates Of Decapod Crustaceans

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FISHERY BIOLOGY, insofar as it is a branch of ecology, is largely concerned with the factors affecting the rates of birth, growth and death which govern the species-mass time-derivatives. A peculiarity of the science is that it must often deal with the dynamics of populations which cannot be directly observed. Thus, the correspondence of measurements of population properties which it is feasible to make, with those actually obtaining in the whole population, is usually in doubt.

In some fishes and molluscs, a record of the age and previous growth of the individual is supplied by periodic changes in the structure of skeletal parts. In decapod crustaceans, however, the skeleton is cast off at each change in dimensions of the individual, which increases to the highest degree the difficulty of determining the effect of the fishery on the stock.

Three methods have been used in estimating growth rate of shrimp: (1) growth of captive individuals; (2) growth of tagged individuals; and (3) change in frequency-distribution of sizes in repeated samples of a population.

None of these methods is wholly satisfactory.

Growth in ponds or aquaria yields interesting information which cannot, however, be presumed applicable to the wild populations.

Tagging has an unknown effect on growth, especially where the tag-injury is relatively large. It is an expensive procedure, thus not well-suited to repetition year after year for the purpose of defining variations. Recovery of tags depends chiefly on the fishery, so that stages smaller than are captured for use cannot well be studied. The rate of recovery of tagged shrimp evidently drops rapidly in a matter of weeks, so that adequate growth records would require massive experiments. In shrimp, also, shifts in range are so frequent that tagging is not well adapted to defining growth rate in a given locality at a given time.

Changes in size-frequencies do not necessarily represent growth. In shrimp, young are usually being added in a given part of the range, while at the same time the older individuals emigrate; hence, repeated samples in the same locality do not represent the same population. The rates of mortality and addition of new individuals seem so high for shrimp that it would hardly be satisfactory even to sample the whole population and weight the length-frequencies according to changes in distribution. At the same time, precise interpretation of size-frequency data for shrimp in terms of variations in growth would require corrections, probably large, for changes in mortality-rate at different stages of development (resulting from changes in vulnerability to predation, etc.). This is impracticable, since nothing is known about mortality rates in shrimp except that they must be high at all stages.

The method of measurement of growth rate here described is that of calculation from natural rates of molting and of increase in size per molt. Rate of molting in nature may be determined in two ways: (a) from percentage of soft-shelled individuals (or those at another restricted stage of intermolt cycle) in samples captured; and (b) from frequency of shedding in captive samples during the first day or so. For (a), it is necessary to know the rate at which hardening of the new shell proceeds; this is variable with temperature and other immediate environmental conditions, and also presumably with previous history of the individual. For (b) it is necessary to know whether capture and brief captivity have a significant effect in advancing or retarding the molt, at advanced stages of preparation for it. As complications, the molting of populations seems often to be periodic, both diurnally and over longer periods; also, different types of gear tend to select different molt-cycle stages. Finally, spatial segregation at ecdysis often occurs.

Rate of increase in size per molt can easily be determined only by holding molted individuals till expansion is complete, and comparing with the cast skin. Percentage expansion varies with history and immediate environment. To test whether a short period of aquarium confinement affects expansion rate, it is necessary to compare with results in individuals retained under observation without the shock of capture and transplantation, under conditions in which they would have remained in any case.

Among other complications in use of the method, morphometry demonstrates extensive changes in the body proportions of shrimp. For example, during many molts after the planktonic postmysis larvae of *Penaeus duorarum* settle on the bottom, the nightly ecdysis results in increase of stoutness rather than of length; and the customary linear measurements fail to reflect growth. It must also be remembered that expansion is not always the normal result of ecdysis, even in well-fed crustaceans on their native ground. In adult female Caridean shrimp, for example, molting regularly precedes oviposition and follows hatching of the brood, often without appreciable growth. Although the reproductive activities are quite different in Peneids, it would not be surprising if the molt-expansion in old spawners of *Penaeus* were very much below the thirty per cent volumetric rate frequent in actively growing juveniles, or zero, or even sometimes negative.

A fishery affects its own potential harvest through the direct or indirect, delayed or immediate, reaction of the rates of birth, growth and natural death to change in mass of the standing crop. According to some estimates from Texas data on shrimp taken per unit of area trawl-swept, and on predation natural and human (of which natural appears the greater), the shrimp stock alive at a given instant is evidently only a small fraction of the total mass produced during the year. At such unprecedented turnover rates, it is especially unsafe to presume that the catch of shrimp per unit of effort could (even at the present high rates of exploitation and on the long-term average) be increased by restriction of fishing, without a more than proportional loss of harvest or reduction in average size of the shrimp caught. Since birth and natural mortality are even more difficult to measure than growth, the detection of variations in growth rate is here of peculiar interest. Preliminary work with the molt-frequency method of growth-rate determination suggests that, despite the difficulties and complications touched upon above, the technique offers a relatively favorable approach to this problem. Apart from the question of variation, it also appears that average individual growth of shrimp may be faster than has been realized.