

NOTES

ON THE COMPATIBILITY OF A NEW EXPRESSION FOR GROSS CONVERSION EFFICIENCY WITH THE VON BERTALANFFY GROWTH EQUATION¹

Gross food conversion efficiency (K_1) is defined by

$$K_1 = \text{growth increment/food ingested} \quad (1)$$

$$= \frac{dW}{dt} / I$$

where I is the ingestion rate (Ivlev 1939; Ricker 1966); data from feeding experiments are usually fit to an allometric model of the form

$$K_1 = c W^\alpha \quad (2)$$

where W is the body weight, and c and α are empirical constants which, however, have the disadvantage of always predicting values of $K_1 > 0$, although the fish and other aquatic animals to which the model is meant to apply usually experience size constraints and hence must reach a value of W where $K_1 = 0$. It is therefore preferable to choose a functional form for K_1 which falls to zero as W approaches W_∞ . Furthermore, recent analysis of feeding studies of a number of fish species indicates that K_1 can approach arbitrarily close to unity for the smallest fishes, which suggests the alternate equation

$$K_1 = 1 - (W/W_\infty)^\beta \quad (3)$$

where W_∞ is the weight at which $K_1 = 0$, and β is an empirical constant estimated from the slope of

$$\log(1 - K_1) = \beta \log W - \beta \log W_\infty \quad (4)$$

(Pauly 1986).

In this note we show that Equation (3) is compatible with the von Bertalanffy growth function (VBGF), both in its standard (von Bertalanffy 1938) and generalized forms (Richards 1959; Pauly 1981), which is not true of Equation (2).

We assume that the ingestion rate (I) can be expressed as an allometric expression of weight of the

form

$$I = HW^d, \quad (5)$$

where H and d are empirical constants. From Equation (1) we then obtain for the growth rate

$$dW/dt = K_1 HW^d \quad (6)$$

which combined with Equation (3) gives

$$dW/dt = (1 - (W/W_\infty)^\beta) HW^d \quad (7)$$

and hence

$$dW/dt = HW^d - kW^m \quad (8)$$

where $m = d + \beta$ and $k = H/W_\infty^\beta$. Equation (8) is the differential form of the VBGF, and can be integrated for various values of the constants m and d . Setting $d = 2/3$ and $m = 1$ (i.e., $\beta = 1/3$) yields the "normal" VBGF for weight,

$$W_t = W_\infty (1 - e^{-K(t-t_0)})^3 \quad (9)$$

where $K = k/3$, while if $m = 1$ and $0 < d < 1$ we get the generalized VBGF sensu Pauly (1981),

$$W_t = W_\infty (1 - e^{-KD(t-t_0)})^{3/D} \quad (10)$$

where $D = 3(1 - d)$. This second form is probably more useful as it allows for the exponent of the allometric relationship linking ingestion and weight (Equation (5)) to take wider range of values, as needed to fit various data sets and/or to mimic various models in the literature (see, e.g., Paloheimo and Dickie 1966 or Ursin et al. 1985).

The compatibility shown here between the recently proposed Equation (3) expressing K_1 as a function of fish weight and the VBGF is encouraging, as it supports the method suggested by Pauly (1986) for combining these two equations when estimating the food consumption of fish populations and leads to a mathematically consistent approach for the analysis of feeding and growth data.

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EFFECT OF A RIVER-DOMINATED ESTUARY ON THE PREVALENCE OF *CARCINONEMERTES ERRANS*, AN EGG PREDATOR OF THE DUNGENESS CRAB, *CANCER MAGISTER*

Carcinonemertes errans is a host-specific nemertean that can destroy large numbers of Dungeness crab, *Cancer magister*, eggs (Wickham 1979, 1980). Although the ectosymbiotic nemertean is present on adult and juvenile crabs of both sexes, its only known detrimental effect is to the egg stage. Wickham (1979) estimated that the direct mortality to eggs of Dungeness crabs off central California was 55%. High egg mortalities in the San Francisco, CA, area were suggested as a possible cause of the drastic decline in Dungeness crab populations in that area (Fisher and Wickham 1976; Wickham 1979).

From November 1983 through October 1985, the

National Marine Fisheries Service (NMFS) conducted a comprehensive study of the distribution, abundance, and size-class structure of Dungeness crabs in the Columbia River estuary, a river-dominated estuary. Limited sampling was also done in adjacent coastal areas. As an incidental part of the study, we examined crabs for *C. errans*, and observed an effect of the river-dominated estuarine environment on the prevalence of *C. errans* on Dungeness crabs.

Methods

The study was done in the lower Columbia River estuary and adjacent coastal areas (Fig. 1). The estuary is a drowned river mouth that is dominated by river flows. Highest flows typically occur during the spring and lowest flows during late summer and fall. Estimated river flows (monthly averages) during the study period ranged from 3,121 m³/s (August 1985) to 14,091 m³/s (May 1985) (U.S. Geological Survey, Portland, OR). Salinities fluctuate widely in the estuary depending on river flow, tidal stage, and distance from the river mouth (Neal 1972). Inversely related to river flows, the salinity intrusion is typically least during spring and greatest during late summer and fall.

Sampling was done monthly at a maximum of 28 estuarine and ocean sites (Fig. 1). At 26 of the sites, an 8 m semiballoon shrimp trawl with stretched mesh size of 38.1 mm was used to collect samples; a 9.5 mm liner was inserted in the cod end of the net to prevent escape of small Dungeness crabs. Sampling in the estuary was normally done during times of higher salinity (early flood to early ebb tide).

Generally a subsample of at least 100 Dungeness crabs (≥ 20 mm) from each trawl effort was measured to the nearest mm (carapace width, anterior to the 10th anterolateral spines), weighed, sexed, and checked for eggs and *C. errans*. Specific body areas—the undersurface of the abdomen, the thoracic area covered by the abdomen, and the pleopods—were examined for *C. errans*. Dungeness crab catches at individual stations varied considerably, ranging from 0 to >100 crabs per trawl effort. Crabs <20 mm were measured and weighed, but were not routinely sexed or checked for *C. errans*.

Dungeness crabs were separated into four size classes: I (<50 mm), II (50-99 mm), III (100-129 mm), and IV (>129 mm). We used the chi-square test to compare the prevalences of *C. errans* on crabs in the ocean and the estuary and to compare the level of infestation between males and females within the two areas.