Bioenergetics

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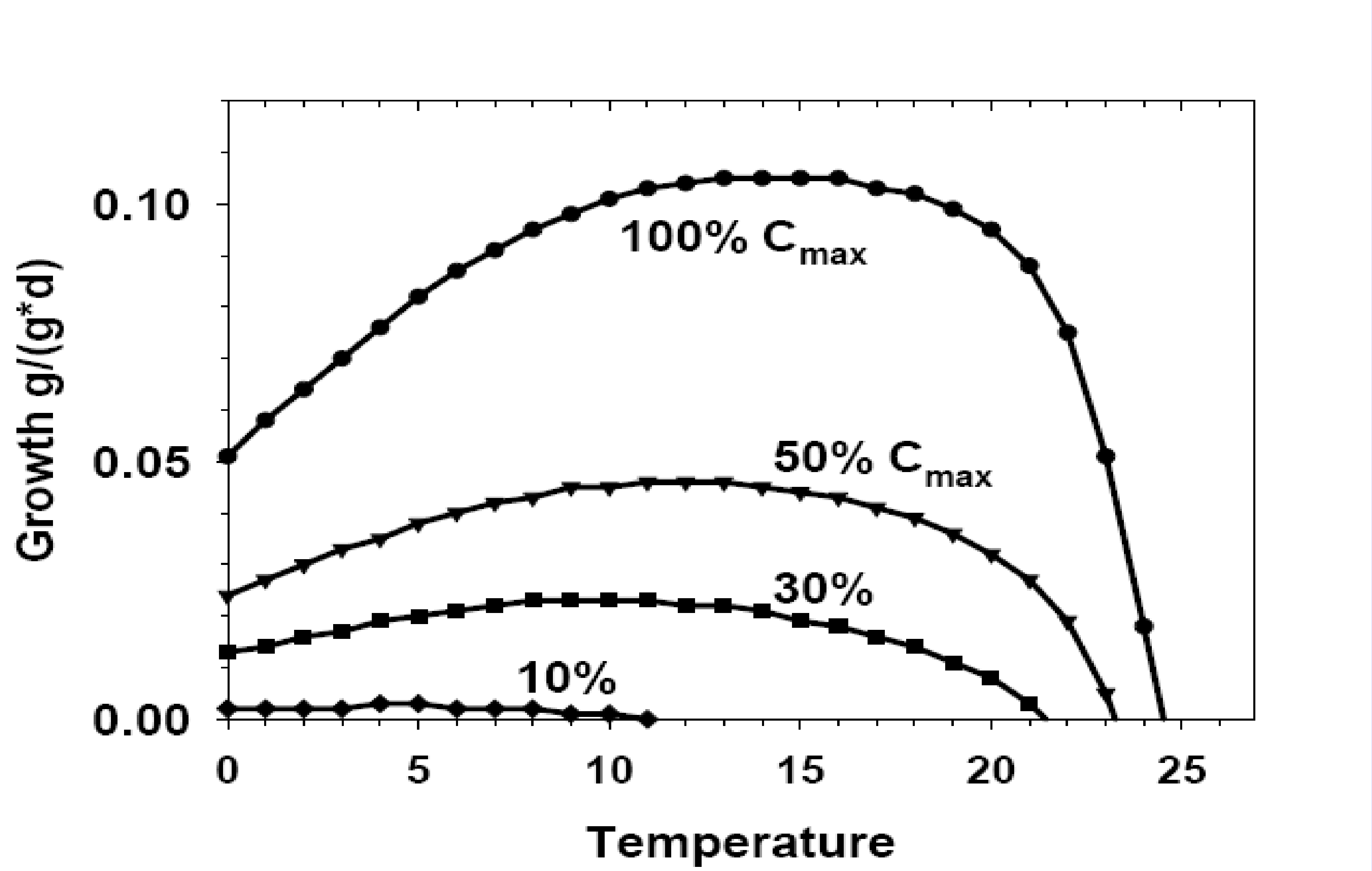
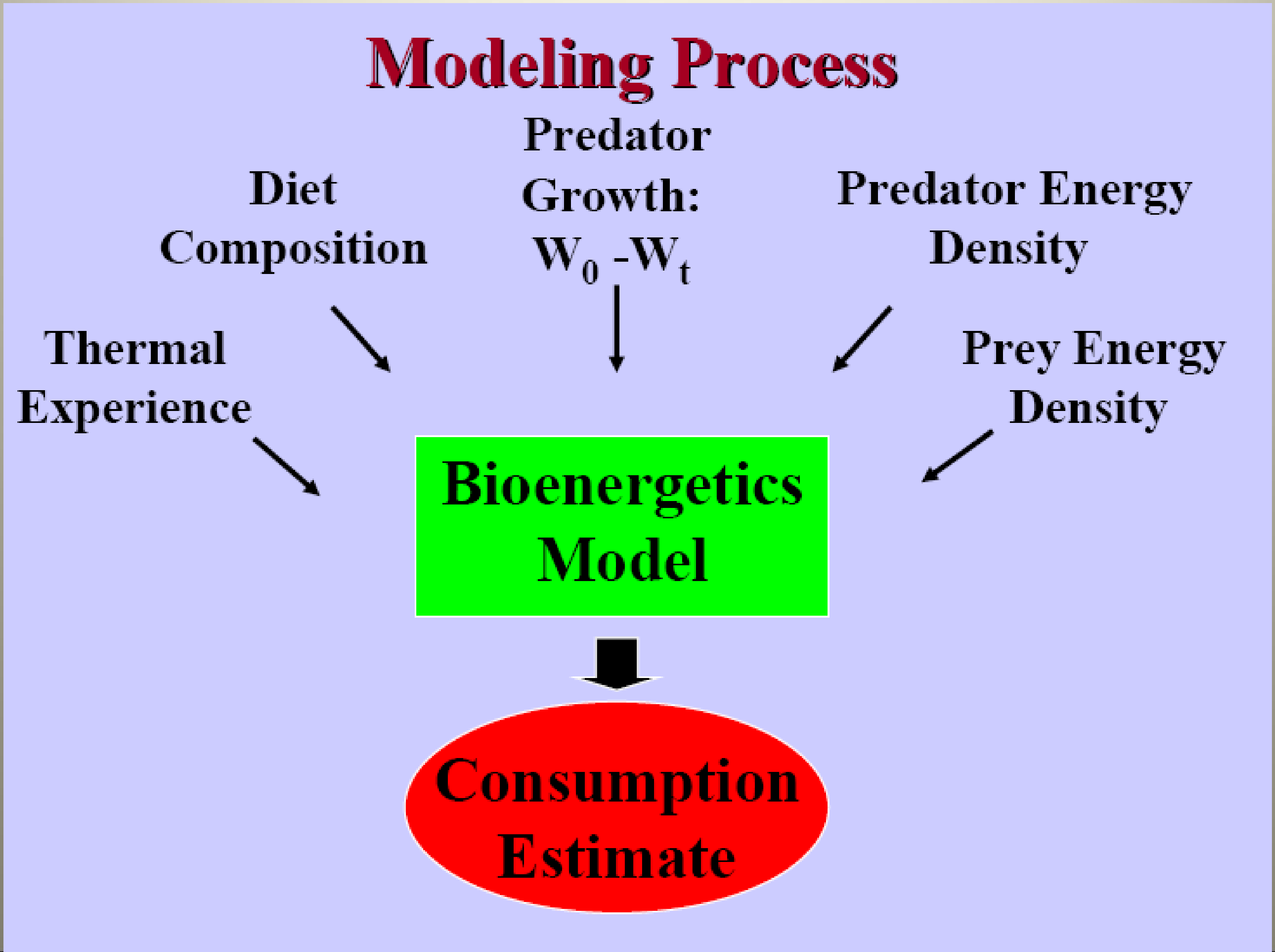
Bioenergetics models

Optimal Temperature Declines with Declining Ration



Bioenergetics models



The basic bioenergetics model

Growth=Consumption-Egestion-Respiration- Reproduction

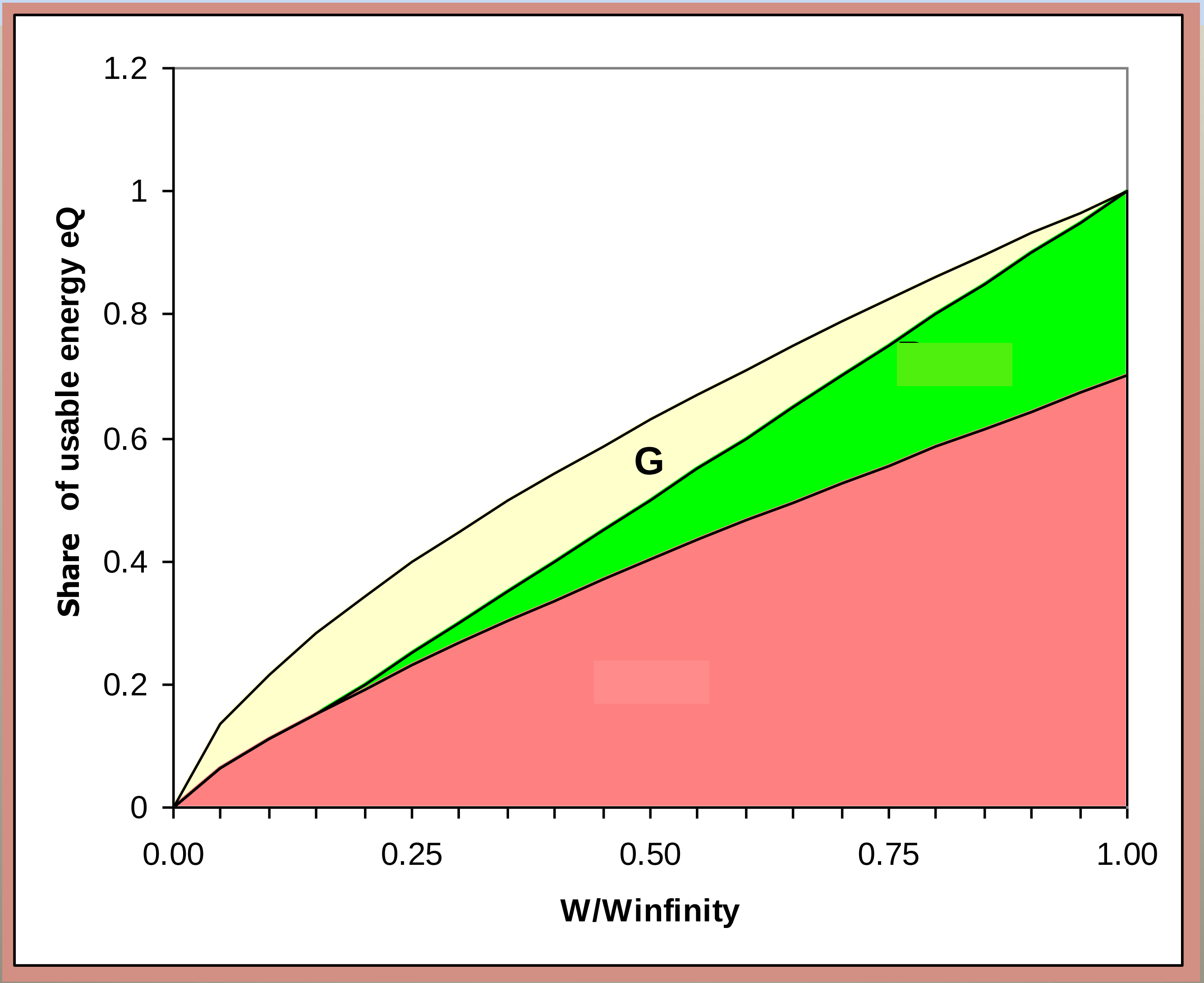
Better form:

Growth=e(Consumption)-Standard metabolism-Reproduction

Here, "e" is around 0.5-0.6, and represents the proportion of consumption that is assimilated (not egested) and is not used for digestion

(digestive cost=0.2 x Consumption is called "Specific Dynamic Action") or active metabolism proportional to food intake

Body size is a key determinant of the components of energy intake and share



Bioenergetics models

Several bioenergetics models have been developed to predict energy requirements and growth of fish under a variety of conditions. In several bioenergetics models developed mostly by fish ecologists, FE, UE+ZE, HiE, HeE, and the GE content of the carcass are considered a fixed fraction of IE regardless of the composition of the feed and performance of the fish. It is common to observe energy requirements expressed as the absolute amount of DE required per kilogram body weight per day for maximal production or energy expenditure, and deposition expressed as a proportion of the maximum feed consumption (*Cmax)* in numerous fish bioenergetics studies .It is important to recognize that the maximal production and *Cmax* of an animal are factors of genetics, diet, environmental conditions (e.g., temperature), husbandry practices, health status, and other factors. Maximum production and *Cmax* are, therefore, highly variable parameters.

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Consequently, the energy requirement for maximum production calculated in some studies (i.e., energy requirement expressed as an absolute term such as kJ fish−1 day−1) can be valid only for the specific conditions (diet composition, strain, temperature, culture conditions, etc.) encountered in the study. Fish growing at different rates will deposit nutrients at different rates and, consequently, have different energy and feed requirements. Energy requirements should therefore be calculated for explicitly expressed levels of performance (e.g., expected or achievable level of performance), feed composition, and life stage . In addition, this should be done using factorial approaches i.e., approaches that divide energy requirements into different components or fractions, as opposed to lumping them into one estimate as is commonly done.

Bioenergetics models

Cho (1991) proposed factorial models to determine energy requirements of fish based on expected level of performance, diet composition, and expected body composition. These models were updated by Cho (1992) and Cho and Bureau (1998). Using this approach, calculation of the total energy requirement and, consequently, the feed requirements (or allocation) can be accomplished as follows.

1. Characterization of diet (including DE content)
2. Calculation of expected live weight gain and RE
3. Allocation of HeE based on fish size and water temperature
4. Allocation of HiE for maintenance and energy deposition
5. Allocation of UE+ZE
6. Calculation of minimum DE requirement
7. Calculation of feed requirement

Heat increment (HiE)

Basal Metabolism (HeE)

Bioenergetics models

Determination or estimation of DE, HeE, HiE, and UE+ZE can be done using the approaches described above or by carefully analyzing the literature.

Accurate prediction of the growth potential of a fish stock under given husbandry conditions is an expected requirement to estimation of the energy or feed requirement (e.g., weekly ration). The formula most commonly used for fish growth rate expression is the instantaneous growth rate, known as the "specific growth rate" (SGR), which is based on the natural logarithm of body weight:

$$SGR = (\ln FBW - \ln IBW)/D.$$

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The SGR has been widely used by most biologists to describe the growth rate of fish. However, the exponent of the natural logarithm underestimates the weight gain between the IBW and the FBW used in the calculation and it grossly overestimates the predicted body weight at weights higher than the FBW used. Furthermore, the SGR is dependent on the IBW, making comparisons of growth rates among groups meaningless unless the IBW are similar.

A more accurate and useful coefficient for fish growth prediction in relation to water temperature is based on the exponent 1/3 power of body weight (Iwama and Tautz, 1981).

$$\text{Thermal-unit growth coefficient (TGC)} = [FBW^{1/3} - IBW^{1/3}] / \Sigma [T\,D]\ 100$$

$$\text{Predicted final body weight} = [IBW^{1/3} + \Sigma\ (TGC/100\,T\,D)]^3$$

(NOTE: 1/3 exponent must contain at least 4 decimals
(e.g. 0.3333) to maintain good accuracy)

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This model equation has been shown to represent very faithfully the actual growth curves of rainbow trout, lake trout, brown trout, chinook salmon, and Atlantic salmon over a wide range of temperatures. Figure 1.6 shows the growth curve of rainbow trout fed to near-satiation and reared at 8.5◦C. Live weight increases curvilinearly, whereas the cubic root of live weight increases in a highly linear fashion, supporting the observations of and the validity of the TGC model. Since these TGC values and growth rate are dependent on species, stock (genetics), nutrition, environment, husbandry, and others factors, it isessential to calculate the TGC for a given aquaculture condition using past growth records or records obtained from similar stocks and husbandry conditions.

Once the weight gain is known, RE can quite easily be predicted using simple models (as shown by Figs. 1and 2, for example). Development of such models can be done relatively easily, as it may quite simply involve sampling animals at different sizes and determining their chemical composition.