DETERMINATION OF GROWTH PARAMETERS

Introduction

- Growth parameters are used as input data in the estimation of mortality parameters and in yield / recruit in fish stock assessment.
- Growth parameters differ from species to species, even between the sexes and also differ from stock to stock of a species.
- If differences exist, they should be calculated separately.

Data needed to estimate growth parameters

a) Length frequency data

b) Mark recapture experiments (Tagging)

c) Estimation of age and growth data by counting of year rings on hard parts such as scales, otolith sagitta or other bones

Methods / equations used to study growth parameters

(i) Gulland and Holt Plot

The linear relationship could be derived from VBGF equation

$$\frac{\Delta L}{\Delta t} = K^* \, [L_\infty - L(t)] \text{ cm/year} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

This equation can be written as $\frac{\Delta L}{\Delta t} = K * L_\infty - K * (t)$ .... (2)

(The length "L(t)" in the equation (2) represents the length range from Lt at age 't' to L(t) + Δt at age t + Δt).

The mean length equation $\overline{Lt} = \frac{L(t) + \Delta t + L(t)}{2}$ goes as entry data in Gulland Holt plot.

Using (t) as the independent variable and $\frac{\Delta L\,(t)}{\Delta t}$ as dependent variable, the above equation (equation 2) becomes linear function.

$$\frac{\Delta L}{\Delta t} = a + b^* \, (t) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Methods / equations used to study growth parameters

conted.....

The growth parameters K and L_∞ are calculated by using the formula

$$K = -b \quad \text{and} \quad L_\infty = -a/b$$

In Gulland and Holt Plot, the input data are't' and '$L(t)$'.

$L(t)$ and $\Delta L(t)$ are calculated between the successive 't' and 'Δt' respectively.

$\overline{Lt} = \frac{L(t) + \Delta t + L(t)}{2}$ is taken as 'x' variable

$\frac{\Delta L\ (t)}{\Delta t}$ is taken as 'y' variable.

Using the regression equation ($y = a + bx$), the K is determined by $K=-b$ and $L_\infty=-a/b$.

A graph can be drawn by taking mean length in 'x' axis and $\frac{\Delta L}{\Delta t}$ in 'y' axis. (Problem is given in practical section)

The Gulland and Holt equation is reasonable only for small values of Δt

Methods / equations used to study growth parameters

conted.....

ii) Ford – Walford plot & Chapman's method

This method was introduced by Ford (1933) and Walford (1946). Without calculation, L_∞ and K could be estimated graphically and quickly. The input data for Ford and Walford plot are L(t) as 'x' and L (t + Δt) as 'y'. 'L_∞' can be estimated graphically from the intersection point of the 45º diagonal where L (t) = L(t + Δt)

iii) Chapman's method

The input data needed are L(t) and L(t + Δt) – L(t)

Note : The Chapman and Gulland methods are based on a constant time interval Δt if pairs of observation the methods could be used. (Ford & Walford plot & Chapman's methods are given as problems in practical section).

Reasonable values of L_∞ can generally be obtained from the empirical relationship.

Methods / equations used to study growth parameters

conted.....

iv) Bagenals' least square method

$$Lt = L_{\infty} [1 - e^{-K(t - t_o)}] \text{ .... (1)}$$

The equation (1) can be rewritten

$$Lt+1 = L\infty (1-e^{-K}) + e^{-K} Lt \text{ .... (2)}$$

The equation 2 gives a linear regression of Lt+1 on Lt of the type

$$Lt+1 = a + b\,Lt \text{ .... (3)}$$

Where $a = L_{\infty} (1- e^{-K})$ and $b = e^{-K}$

a and b are estimated using the linear regression equation ($y = a + bx$)

Methods / equations used to study growth parameters

conted.....

Step (a): To estimate L_∞ and Kn

Transformation of length at age data into Lt and Lt + 1

(Lt as x and Lt +1 as y)

Apply linear regression analysis (y = a + bx)

Step (b): To estimate t_o

Take age in years as 'x' and Loge L_∞ - Lt as 'y'

Apply linear regression analysis (y = a + bx)

In the graphic method 't_o' is written as

t_o =

Which is of the simple linear form (y = a + bx)

't_o' could be estimated algebraically.

t_o = { (log e)+ kt}

Growth in weight

The VBGF equation for growth in weight is

$$Wt = W\infty\ [(1- e^{-K\ (t - t_0)})\ \text{.................................}\ (1)$$

The equation (1) can be rewritten as

$$W_t^{1/3}\ +1 = \ W_\infty^{1/3}(1 - e^{-K})\ +\ \ e^{-K}W_t^{1/3}\ \ \text{................................}\ (2)$$

The equation 2 gives a linear regression of Wt + 1 on Wt of the type.

$$W_t^{1/3}\ = a + b\ W_t^{1/3}\ \ \text{...}\ (3)$$

Where a = $W_\infty^{1/3}$ (1 - e $^{-K}$) and

b = e $^{-K}$

Growth in weight conted.....

Step (1): To find out 'a' & 'b' to arrise at W_∞ & K.

Applying simple linear regression to obtain a and b for the values of Wt (x) on Wt+1 (y) in the data.

$$W_\infty^{1/3} = \frac{a}{1-b}$$

K = - log e^b

Step (2): To find out 't_o' graphically, take t as x and $Log_e^{W_\infty - W_t}$ as y

$$t_o = \frac{a - log_e^{W_\infty^{1/3}}}{-b}$$

To calculate growth parameters for weight based age data using von Bertalanffy equation, Wt and Wt +1 are converted to respective cube root equivalents. Once this is accomplished, the procedure mentioned in the different methods for the growth in length could be used for estimation of W∞, K and 't_o'. (This method is given as problem in practical section)

Growth in weight conted.....

Estimation of t_o

The Gulland and Holt plot does not allow for estimation of the third parameter of the VBGF, 't_o'. This parameter is necessary. A rough estimate of 't_o' may be obtained from the empirical relationship.

$$Log_{10}(-t_o) = -0.3922 - 0.2752\ Log_{10}\ L\infty - 1.038\ Log_{10}\ K$$

Estimation of growth parameters for Elasmobranches

The growth parameters of Elasmobranches

$$Lt = L\infty\ [1 - e^{-K\ (t\ -\ to)}]\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (1)$$

Growth in weight conted.....

Estimation of growth parameters for Elasmobranches

This equation can be modified as

$$L_{t+T} - L_t = (L_\infty - L_t)(1 - e^{-KT}) \text{ .... (2)}$$

$$(\text{i.e. } L_{t+T}/L_\infty = 1 - e^{-KT}) \text{ .... (3)}$$

Where

Lt = Length at conception = 0 at zero time;

Lt +T = length at birth;

T = length of gestation or hatchery period (the elasmobranches being viviparous,

Ovoviviparous or oviparous, with the egg taking a long time to hatch).

L∞ = maximum observed length, i.e., Lmax.Since there is evidence that ‘T’ is exactly the value of t_0 in Eq.(1) or its modification, Eq.(2) could also be expressed in the form,

Growth in weight conted.....

Estimation of growth parameters for Elasmobranches

$Lo = L\infty(1- e^{-K/(o - t_0)})$ .... (4)

Where Lo = length at birth, (Lt + T) corresponding to O age, and t_0 = gestation or hatching period in years. Since Lo, t_0 and Lmax (= $L\infty$) in the above equation can be empirically recorded, the only parameter to be computed is K.

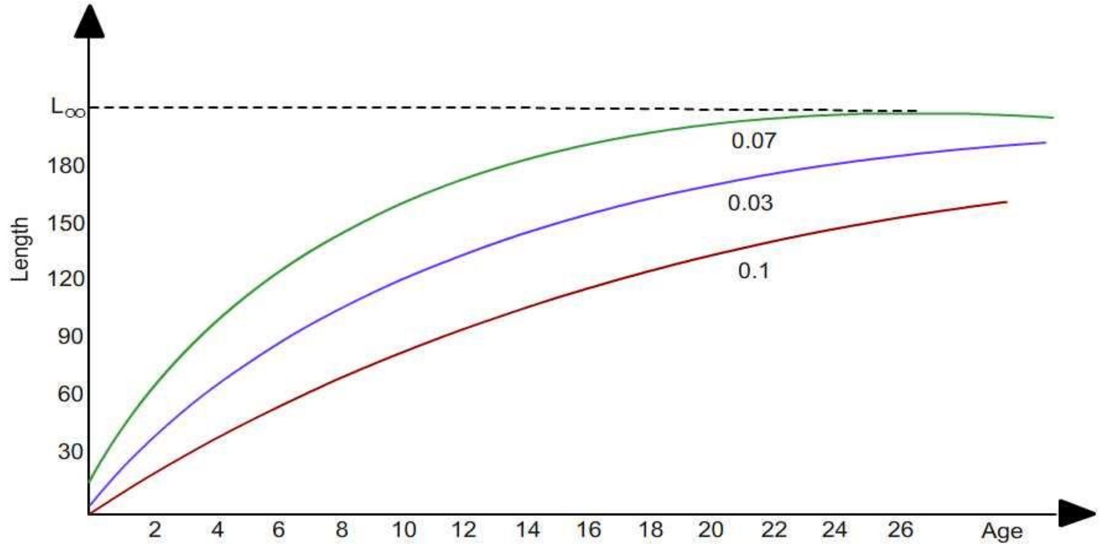
Once this is made, age for any given length can be estimated by incorporating K, t_0 and Lmax values in the equation (1)

Growth parameters and its application

- Used as input data in estimating mortality parameters.
- Used as input data in the yield/recruit models in assessing the fish stock.
- Used to predict the relationship of temperate and tropical fish stocks.

The growth parameter ‘K’ is related to the metabolic rate of the fish. Pelagic species are often more active than demersal species and have a higher K. The tropical fishes have higher K values compared to coldwater fishes.

Growth parameters and its application conted.....



The curvature parameter 'K' values are more related to M values. In short lived species, particularly tropical fishes, K is directly proportional to M. The M/K is inversely related to L_m/L_∞ and is also an index of reproductive stress. This value is found to be high for fish exhibiting post spawning death phenomena. (Lm is the minimum length at first maturity)

Temperate fishes live long compared to tropical species. The Natural mortality is high for shart lived species.

Growth parameters and its application **conted.....**

Temperate fishes live long compared to tropical species. The Natural mortality is high for shart lived species.

$Lm/L\infty$ is an index of reproductive stress.

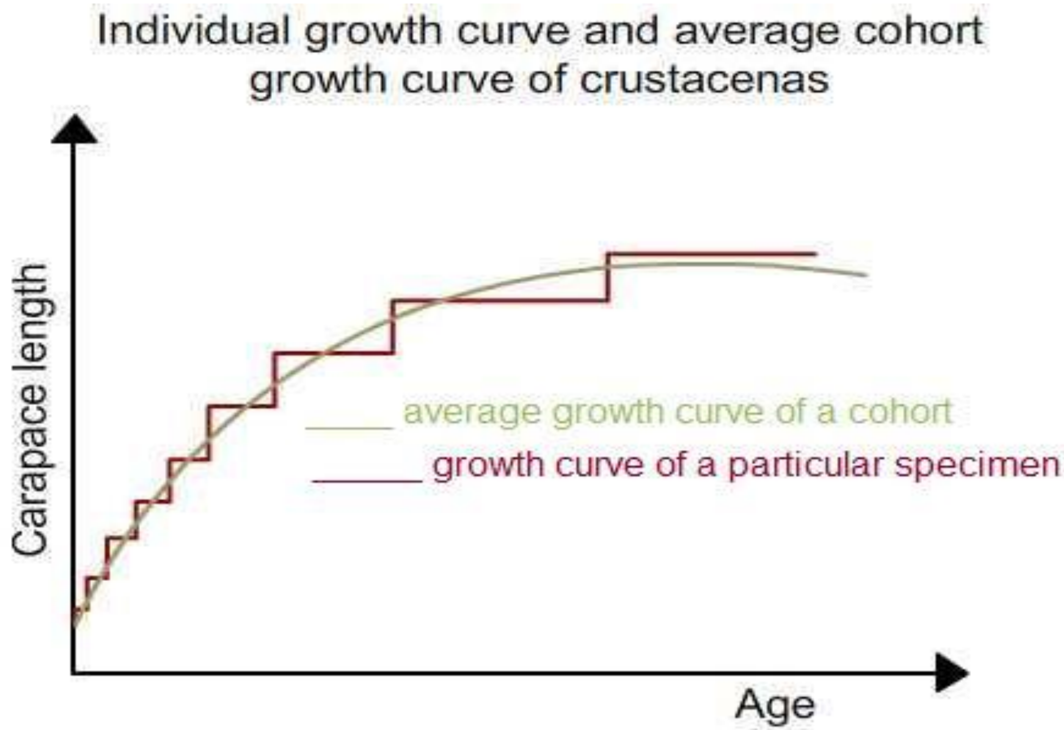
K is directly correlated with natural mortality.

$Lm/L\infty$ is inversely related to K and $L\infty$.

(This is because the larger the asymptotic size, K will be less and the rate of growth is high in short lived species, most of the tropical species have short life span compared to temperate species).

Growth parameters and its application conted.....

Moulting is common in crustaceans. An individual crustacean usually will not obey von Bertalanffy's model but to some 'stepwise curve. Each step indicates a moult. However the crustaceans moult different times in its life cycle. Therefore, the average growth curve of a crustacean will be a smooth curve.



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