A new approach towards estimation of cephalopod growth

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Cephalopod resources from the world oceans have drawn increased attention as an alternative to the traditional marine harvest and would probably earn much larger reputation as a vital source of marine food for future generations. The world cephalopod landings have increased substantially over the last 25 years, while fin fish catches have elevated slowly, remained stable or declined.

The cephalopod production from the seas off Sri Lanka has been on an increasing trend over the past few years. It was also noted that substantial quantities of undersize individuals were exploited by the purse seins with light attraction. Apart from that, for annual species such as squids, there is no buffer for current seasonal fishing and failure of recruitment due to over fishing of the current year's stock could be detrimental for the existence of the resource. Therefore, to minimize the risk owing to overexploitation, a real time assessment and management is necessary. However, since the growth of many cephalopod species does not fit the von Bertalanffy growth model (VBGM), use of the conventional stock assessment procedures for cephalopods are highly argued. Development of new mathematically tractable models, which bear a closer relationship with the real life stocks, is therefore, another important aspect to focus attention in the stock assessment of cephalopods. Though it appears that the growth of cephalopod cannot successfully be explained using the von Bertalanffy growth model (refer equation 1), it could still be used with possible modifications so that the modified version would successfully explain the cephalopod growth. Therefore, the major objective of the present analysis is to formulate a better model to describe the squid growth modifying the von Bertalanffy growth model.

$$L = L_\infty [1 - \exp\{-K [t - t_0]\}] - [(CK/2\pi) \sin(2\pi (t - t_s))] \qquad (1)$$

During the present study, population parameters (L_{∞}, K, C and t_s) of *Loligo singhalensis*, were initially estimated using FiSAT computer programme. Since the model progression was clearly distinguished, a growth curve was manually drawn and, the values for age and the mean lengths (baseline information) of modes corresponding to the growth curve were estimated.

The baseline information and the initial estimates of population parameters were then transferred to an excel spreadsheet. The VBGM was derived using the already defined parameters. A graph was then drawn using the age data in the x-axis and both the actual and the estimated length data in the y-axis. Modifications were initially made to the major part of the VBGM, corresponding to the estimates in the vertical axis, followed by the modifications in the oscillation part (corresponding to the estimates in the horizontal axis) of the VBGM. The growth parameters were altered, until the estimated growth curve overlaps with the actual data points. The equation-derived (2) is as follows:

$$L= L_{\propto} [1 - \exp \{-K [t (x (tx)\hat{}x\hat{}C_f)-t_0]\}] – [(CK/2\pi) \text{Sin} (2\pi (t O_f - t_s))] \ldots\ldots\ldots(2)$$

Where, x, C_f - Curvature factor and O_f - Oscillation factor, are variables varied over the ranges 1.2-2.2, 0-2.5 and 1.2-2.2 respectively.

Since the equation properly explained the growth of *L. singhalensis*, the model was used to explain the growth of several other squid species. Based on the above estimations, the relationships between X and K and also O_f and K values for different squid species were estimated. The regression analysis indicated that $X= O_f =K$, resulting in the following growth equation (3). Though X = K, the two parameters behave independently. Therefore, K' denoted it. Growth parameters for different squid species were then reanalyzed using the final version of the equation (Table 1).

$$L= L_{\propto} [1 - \exp \{-K [t (K' (tK')\hat{}K'\hat{}C_f)-t_0]\}] – [(CK/2\pi) \text{Sin} (2\pi (t K' - t_s))] \ldots.\quad (3)$$

The new growth function could be denoted as Growth increment factor G = K[(tK)^K^C_f]

$$L = L_{\propto} [1 - \exp \{-K [t G-t_0]\}] - [(CK/2\pi) \sin (2\pi (t K' - t_s))] \ldots\ldots\ldots\ldots \quad (4)$$

Table 1 : Estimated growth parameters for different squid species

Species	L_∞	K	C	t_s	t_0	C_f	O_f	r^2
Sthenoteuthis oualaniensis	23	1.6	0.9	0.05	-0.4	0.9	1.6	0.89
Loligo plei	23	2.2	0.6	0.05	-0.2	1.4	2.2	0.81
Llex illecebrosus	26	1.8	0	0.2	-0.2	0	0	0.44
Todarodes pacificus	29	1.6	0	0.5	-0.15	0.65	0	0.99
Illex coindetii	35	1.28	0.6	0.15	-0.2	3	1.28	0.99
Todarodes angolensis- Male	36	1.3	0.7	0.75	-0.05	0.1	1.3	0.81
Todarodes angolensis - Female	42	1.2	0.4	0.7	-0.3	1.7	1.2	0.84
Loligo singhalensis	39	1.5	0.8	0.02	-0.01	0.5	1.5	0.99
Sthenoteuthis pteropus-Female	58	1.35	0.6	0.1	-0.2	2.5	1.35	0.99
Sthenoteuthis pteropus- Male	24	1.7	0.7	0.15	-0.1	0.2	1.7	0.93

The high r^2 values of the regression equations between the predicted and the actual data and its applicability over a wider range of growth parameters indicated that this model could successfully be used in the growth analysis of squids. Apart from that, the possible initiatives towards incorporation of the above in the existing stock assessment models will also be an interesting exercise.