ON IMPROVING OPERATION AND USE OF THE ELEFAN PROGRAMS. PART II. IMPROVING THE ESTIMATION OF L_∞

by
Daniel Pauly
ICLARM, P.O. Box 1501, Makati
Metro Manila, Philippines

This contribution is the second of a series, addressed to users of the ELEFAN programs, on how to improve their version and use of ELEFAN 0, I and II.

In the first contribution of this series, an outline was given of an approach to improve the estimation of the K parameter of the von Bertalanffy growth equation using ELEFAN I.

Here, four simple approaches for improved estimation of L_∞ are presented which rely on slightly modified versions of ELEFAN I and/or II. These approaches are all geared toward counteracting the tendency of ELEFAN I to overestimate L_∞.

Approach I: Excluding isolated large fishes from samples analyzed

In ELEFAN I, isolated large fishes (i.e. fishes not part of a contiguous distribution (see Fig 1) have a very strong impact on L_∞ estimates i.e.:

i) In the present versions of the ELEFAN system, L_∞ cannot be smaller than the upper class limit of the largest class included, plus 1/2 a class interval, and

ii) In old versions of ELEFAN I, isolated peaks (such as generated by a single isolated fish) were given a relatively high number of positive "points".

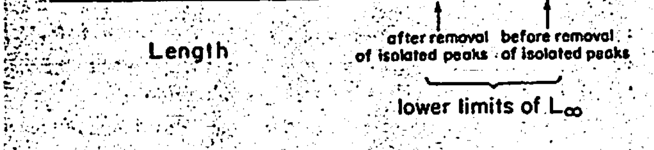

Fig. 1. Schematic representation of a non-contiguous length-frequency distribution, and definition of its contiguous parts and isolated peaks. Removal of isolated frequencies from original sample lowers the limit for the lowest possible value of L_∞ that can be handled by ELEFAN I.

Thus, deleting the fish in the highest length class(es) from the length-frequency sample(s) to be analyzed by ELEFAN I will usually result in lower estimates of L_∞. However, this deletion may also result in total mortality being overestimated by ELEFAN II, since old fish will be missing when Z is estimated via catch curve or mean length.

Approach II. Modifying ELEFAN I such as to reduce the impact of isolated large fishes

Two small modifications of ELEFAN I can be implemented which will reduce the impact of large fish on the computation of ESP and hence on the estimation of L_∞. They are:

i) Attributing less positive "points" to isolated peaks (i.e. peaks surrounded by zero frequencies) than is done in older version of ELEFAN I, and

ii) Attributing less negative "points" to the highest length classes in a set of samples to be analyzed.

The first of these two modifications refers to the "routine to de-emphasize isolated peaks" (see REMs of listings in Pauly et al 1980). The modification suggested is to divide the number of points originally attributed to a length class belonging to isolated peak by 2^n, where n is the number of zero frequencies within 2 classes (up or down) of length class "i" (The division by 2^n should replace the multiplicative factor (1 - 0.2n) used in older versions of ELEFAN I).

The second modification consists of identifying the highest length class in the set of samples to be analyzed (L_{max}), and the class immediately preceding it (L_{max-1}) (These classes may occur in one or several samples of a given length-frequency data set).

and MFV NARMADA from December 1982 to December 1983. The fish were caught by pelagic or bottom trawl nets. C. dussumieri is present to a depth of 40 m. In a total of 5,514 specimens, sampled for length frequency analysis, 1,248 mature females were present. The average length, weight and age for mature females was 16.55 cm, 13.50 g and 0.96 year.

The ovaries of mature female specimens were preserved in 10% formalin for ova-diameter studies. 300 eggs were counted and weighed for fecundity studies and annual fecundity was calculated using the formula:

$$\text{Fecundity} = \frac{\text{total weight of ovary}}{\text{weight of sampled ova}} \times 300$$

The procedure for estimating the survival rate of eggs per female was as follows: On random sampling, a number of mature females (P_M), were obtained from within a sampled population X. Using Pope's (1972) cohort analysis the number of fish present for each age group (N_t) was estimated. The 0+ and 1/2+ year classes were considered to be the recruits (R) and 1+ and 1/2+ year classes, the parent stock (S). P_T would be the number of mature females present within a total stock as determined by the sex ratio of the mature specimens of X, for that particular year, and the average fecundity for the same period would be F. Then,

$$\text{Number of eggs produced} = P_T \cdot F \quad (1)$$

The resultant total mortality for eggs, larvae and prerecruits (M_T) would be

$$M_T = (P_T \cdot F) - R \quad (2)$$

Therefore, the computed mortality from the egg to the recruit stage (M_R) (per female) would be:

$$M_R = M_T/P_T \quad (3)$$

Hence, the number of eggs surviving (S_E) (per female) would be:

$$S_E = F - M_R \quad (4)$$

Results and Discussion

Using Eq. (1) with $P_T = 3.11 \times 10^8$ and F = 3000, the total number of eggs produced by the mature females within the total stock of 40,058.65 tonnes for the period 1981-1982 was estimated to be 9.33×10^{11}.

The number of recruits (R) was 1.39×10^{10}. Therefore, the resultant total mortality (M_T) for P_T was 9.19×10^{11}. Hence, the mortality (M_R) from egg to the recruit stage per female was 2,955 in 1982 and the egg survival per female was 45. On an average, chances of egg survival per female fish was 1.49% and the remaining 98.51% of eggs, larvae and prerecruits die, from natural causes, before reaching the size at which they become liable to capture by the fishery.

Acknowledgements

I wish to acknowledge Dr S.N. Dwivedi, Director, Central Institute of Fisheries Education (ICAR), Bombay, for his permission to use the data obtained from the Institute's research vessels, MFV SARASWATI and MFV NARMADA and the facilities at the Institute.

References

Navaluna, N.A. 1982. Morphometrics, biology and population dynamics of croaker fish, Otolithes ruber. p 38-55 In D. Pauly and A.N. Mines, (Eds.) Small-scale fisheries of San Miguel Bay, Philippines: biology and stock assessment. ICLARM Technical Reports 7: 124 p.

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Then, if found to be negative, the "point" value for the class corresponding to L_{max} is set equal to zero, while the "point" value for the class corresponding to L_{max-1} is multiplied by 0.5 if it also was negative (if the points corresponding to L_{max} and L_{max-1} are positive, they should be left as they are). This modification will have the effect of making it unnecessary for the growth curve to "avoid" passing through the classes corresponding to L_{max} and L_{max-1} by "aiming" at a higher L_∞ value. (Note with regard to the previous contribution in this series that, while positive point values are counted only once when computing ESP, negative point values are still counted every time their corresponding classes are hit).
hit).

Approach III. Estimating L_∞ independently of growth data

Wetherall (see p. 12-14) and Wetherall et al (in press) have developed an extremely ingenious method for estimation of L_∞ from length-frequency data representative of a steady-state population (i.e. the type of data used to construct length-converted catch curves) and which does not require the associated value of K to be known.

Obviously, this method may be incorporated into ELEFAN II, and used to estimate L_∞ from a length-frequency data file entered via ELEFAN 0, based on the routine for summation of samples built into ELEFAN II for construction of length-converted catch curves.

One modification suggested here and which will be incorporated in future versions of ELEFAN II is that instead of plotting the successive mean lengths ($\bar{L}_i$) against their corresponding values of (L'_i) one should plot $\bar{L}_i - L'_i$ on L'_i, which results in

$$\bar{L}_i - L'_i = a + b\,L'_i \qquad (1)$$

where

$$L_\infty = a/-b \qquad (2)$$

and

$$Z/K = (1 + b)/-b \qquad (3)$$

$\bar{L}_i$ is defined here as the mean length, computed from L'_i upward, in a given length-frequency sample (representative of a steady state population with constant exponential decay and von Bertalanffy growth). L'_i is the limit of the first length class used in computing a mean length $\bar{L}_i$.

This plot (see Fig. 2) appears easier to interpret visually than the one suggested by Wetherall (this vol., see p. 12-14) and does not lead to an estimate of L_∞ obtained via division by a small difference.

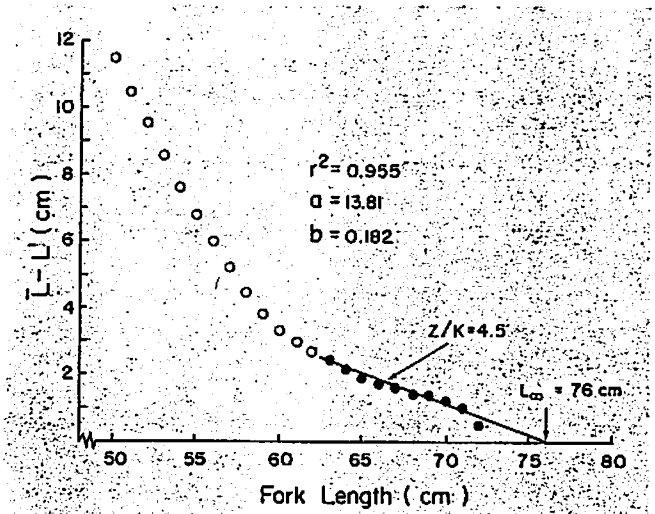

Fig. 2. Estimation of L_∞ and Z/K in Peruvian bonito *(Sarda chiliensis chiliensis)*, based on equations (1-3) and length-frequency data for the years 1952-1953 (adapted from Pauly et al., MS).

Approach IV. Allowing L_∞ to be smaller than L_{max} by modifiying ELEFAN I

The ultimate approach to solving the problem of the overestimation of L_∞ is, obviously to modify ELEFAN I such that it accommodates values of L_∞ smaller than L_{max}. Versions of ELEFAN I are available for use on Apple II (CP/M) and IBM PC (& compatibles) which incorporate this modification, as well as those discussed under Approaches II and III (Brey and Pauly 1986). Readers are invited to to write to this author concerning availability of these programs.

Of the four approaches presented here to improve estimation of L_∞, the third is probably the most useful, and the one which will lead, once implemented, to the largest improvements of estimates of L_∞ from length-frequency data. Nevertheless, readers are encouraged, to also implement the modifications of ELEFAN I suggested in Approach II.

Incorporation of equation (I) as a routine of ELEFAN II should consider the following:

- There should be a graphic display of the values of the points ($\bar{L}$, L'_i) such as to allow selection of points to be included in the regression equation (as in the case of the length-converted catch curve, which also includes points representing incompletely selected fish that must not be included in the regression), and
- The data points included in the regression should be weighted by the number of fish up to each point.

In the context of the ELEFAN system of programs, the new method for independent estimation of L_∞ is extremely useful because, after a value of L_∞ has been estimated, it permits the identification (using ELEFAN I) of the K value compatible with this (fixed) value of L_∞. This is a much more rapid procedure which provides values of K which are much more reliable than when this parameter is estimated together with L_∞.

The next part of this series shall deal with the effect of incomplete selection and recruitment on estimation of L_∞ and K using ELEFAN I, and a simple approach to remove the considerable bias that might occur when uncorrected length-frequency data are analyzed.

References

Brey, T. and D. Pauly. 1986. A User's Guide to ELEFAN 0, 1 and 2 (revised and expanded version) Ber. Inst. f. Meeresk. Univ. Kiel No. 149, 77 p.

Pauly, D., N. David and J. Ingles. 1980. ELEFAN I: User's Instruction and program listing. ICLARM Mimeo. 33p.

Wetherall, J.A., J.J. Polovina and S. Ralston. Estimating growth and mortality in steady-state fish stocks from length frequency data. In D. Pauly and G. Morgan (Eds) Theory and application of length-based stock assessments. ICLARM Conference Proceedings. (in press).

SOFTWARE DEVELOPMENTS

COHORT ANALYSIS

An MBASIC Cohort Analysis program has been developed by Dr. G. Murphy. Listings of the Spanish version (for IBM-PC) or compatibles and an English CP/M version are available by writing to Dr. Murphy at P.O. Box 49, Mullumbimby, N.S.W. 2482, Australia.

YIELD PER RECRUIT MODEL USING LOTUS 1-2-3

Users of Lotus 1-2-3 will be interested in a yield per recruit model based upon this package. This runs on an IBM-PC or compatible (DOS 2.0 onwards) and is described in the South Australian Department of Fisheries Research Paper 13 (1985). It is obtainable from the author, Dr. P. Sluczanowski at Dept. of Fisheries, P.O. Box 1625, Adelaide S.A. 5001, Australia.

ELEFAN 0, I AND II FOR THE COMMODORE 64

Satish C. Choy, c/o Sch. of Pure & Applied Sciences, Univ. of the South Pacific, PO Box 1168, Suva, Fiji Is., has modified ELEFAN 0, I and II to run on the Commodore 64 with a 1541 Disk drive. All the three programmes have been combined into one and have been removed and put in a separate file so that they can be inserted if needed by anyone unfamiliar with the system. Please contact him if interested in the program.