Pauly, D. 1984. Length-converted catch curves: a powerful tool for fisheriesresearchin the tropics (Part II). *Fishbyte, Newsletter of the Network of Tropical Fisheries Scientists* 2(1): 17-19.

LENGTH-CONVERTED CATCH CURVES: A POWERFUL TOOL FOR FISHERIES RESEARCH IN THE TROPICS (PART II)[a]

by
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The first part of this contribution (Pauly, 1983), which defined the concept of a length-converted catch curve, showed how reliable estimates of total mortality (Z) can be obtained from representative length-frequency data and the estimates of the parameters L_∞ and K of the von Bertalanffy growth equation.

Length-converted catch curves, in addition to allowing for the direct estimation of Z from length-frequency data, allow a number of inferences from the detailed examination of the left, ascending arm of the curve.

When the growth parameters of the fishes are known plus the selection curve of the gear used to sample the data at hand, the natural mortality coefficient (M) can be estimated from the left side of an annual average length frequency distribution (Munro, 1984, in press). Conversely, when natural mortality is known, the selection curve of the gear can be inferred from the shape of the ascending arm of a length-converted catch curve and the growth parameters. The second of these two methods is discussed here.

Table 1 illustrates the derivation of selection data (probabilities of capture, by length) based on the left side of a length converted catch curve and an estimate of M. The computational steps involved here are demonstrated in Table 1 and are as follows:

(i) Set up a table which draws

Table 1. Derivation of a selection curve from the left side of a length-converted catch curve (values in square brackets plus estimates of growth parameters, K and L_∞ must be available before table is completed).

Midpoint of length class	Numbers caught (N_i)	Δt midpoint to midpoint[a]	Mortality I ($M \rightarrow Z$)	Mortality II (means)	Numbers available N_i/P_i[b]	$P = N_i/(N_i/P_i)$	Cumulative P.[d]
3	[0]		[M=1.14]		–	[0]	[0]
		–		–			
5	5		1.28		448	0.0112	0.0112
		0.158		1.35			
7	29		1.42		362	0.0801	0.0913
		0.171		1.49			
9	114		1.56		281	0.4057	0.4970
		0.188		1.63			
11	161		1.70		207	0.7778	1.2748
		0.208		1.77			
13	[143][c]		[Z=1.84]		[143][c]	[1.00]	2.2748

[a]Computed from $\Delta t = (1/K) \ln \{L_\infty - L_2 / L_\infty - L_1\}$ where L_1, L_2 are the lower and upper limits of a given length class, respectively.

[b]Computed from $N_i/P_i = N_{i+1}/P_{i+1}\, e^{Z\Delta t}$, where N_{i+1}/P_{i+1} is the number available in a length class and N_i/P_i the number available in the next lower length class.

[c]This number may be taken as the actual number caught in the first length class that is fully selected (i.e., the length corresponding to P_1), but a better approach is to compute this number from the equation of the catch curve, for the midpoint in question.

[d]The length which corresponds to P = 0.5 (i.e., to 50% of the cumulated probabilities, i.e., 2.2748/2 = 1.1374) is obtained through interpolation between 9 and 11 cm; it is L_c = 10.6 cm.

a) ICLARM Contribution No. 173.

together all information needed for further analysis.

(ii) Compute Δt using the appropriate equation.

(iii) Interpolate mortalities (Mortality I in Table 1) between Z and M, i.e. the mortality corresponding to the first adjacent length class with zero catch (see Table 1). The step size for the interpolations is estimated from (Z-M)/(n+1) where n is the number of classes for which mortality must be interpolated (here, n=4).

(iv) The mortalities estimated in (iii) are estimates of the mortality <u>within</u> a given length class. The mortalities <u>between</u> adjacent length classes (Mortality II) are estimated by taking means between adjacent length classes (see Table 1).

(v) Compute values of N_i/P_i from the equation given in Table 1, starting with the number of fish in the first class where the probability of capture is equal to unity (i.e., corresponding to point P_1 (see Fig. 1).

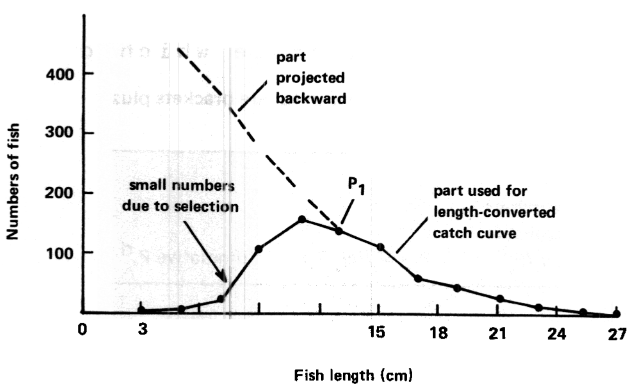

Fig. 1. Graphical representation of intermediate results of Table 1, showing numbers of fish caught, and computed numbers of fish available. (See Table 1 and Pauly 1983 for details on length-converted catch curve.)

(vi) Obtain probabilities of capture by dividing, for each length class, the numbers caught (N_i) by the numbers available (N_i/P_i).

(vii) Estimate mean length at first capture (L_c) through a cumulative plot, (see Table 1 and Fig. 2).

In stocks that are unexploited, the estimate of Z obtained from the catch curve can serve as the estimate of M; in this case, steps (iii) and (iv) are obviously superfluous.

The accuracy of the method de-

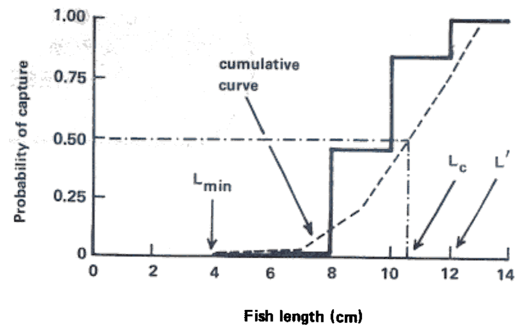

Fig. 2. Graph showing results of division of numbers caught by numbers available, corresponding to a selection curve. Note definition of L_{min}, L_c and L_i and cumulative method to estimate the latter (see also Table 1).

pends on the following assumption being met:

(i) The gear in question is a trawl or has a selection curve similar to that of a trawl (where it is only the smaller fish that are selected against).

(ii) The smallest fish caught (L_{min}) are fully recruited.

(iii) The value of M used for the fish below L_{min} and the mortalities generated by interpolation between M and the Z value for the fully selected fish are accurate.

The first of these assumptions can be easily verified. The second, when violated, implies that the computed probabilities will not strictly refer to a selection curve, but to a resultant curve, i.e., to the product of a selection and a recruitment curve (Gulland 1983, p.127). Whether the second assumption is met or not will thus affect the interpretation of the results, but not their computation.

The importance of the third assumption can be assessed using sensitivity analysis. As might be seen from Fig. 3, L_c shows little sensitivity to changes of M. The estimated probabilities of captures are, on the other hand, quite sensitive to the value of M used, especially at smaller lengths.

The following equation (Pauly 1980) can be used as an approximation of M for the purpose of implementing this method:

$$\log_{10}M=-0.0066-0.279\log_{10}L_{oo}+$$
$$0.654\log_{10}K+0.463\log_{10}T$$

where L_{oo} is in cm, K is put on an annual basis and T is the mean annual water temperature in ^{o}C.

The method outlined here appears

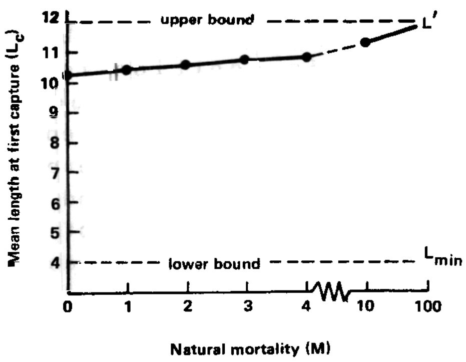

Fig. 3. Result of an analysis of the sensitivity of L_c estimates to change the natural mortality input. Note stability of L_c estimates over range of reasonable M values (based on data in Table 1).

particularly useful in that it extracts information on the selection process from the length-structure of the catch, rather than from (costly) selection experiments.

Anon. (1982) may be consulted for data on Mediterranean hakes and sardines which confirm that the values of L_c obtained through this method are indeed close to those obtained from selection experiments.

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