



Letter to the Editor

**Comments to Froese et al. (2008): Size matters:
Ne quid nimis** ☆, ☆☆
**Keywords:**

Catch per unit effort
 L_{opt}
 Life-history invariants
 MSY
 Selectivity

Beverton and Holt (1957) described the main drivers in exploited fish population dynamics in the simple population model. The simple population model is tool primarily to be used for exploration of different management options. The simple population model shows that fishing regulations are basically related to questions on how much fishing effort and what kind of selectivity will be favourable in terms of yield in biomass or number, mean weight of fish in catch and available biomass per recruit in the fishable time or size span. The latter parameter is proportional to CPUE.

Froese et al. (2008) made an effort to elaborate on the simple population model, as to define how fisheries management could be improved by changes in length (L_c), i.e. indirectly on age at first catch (t_c). As such changes in the catch are related to gear selectivity, Froese et al. sought to explore the advantages of alterations in mesh sizes rather than in fishing mortality/fishing effort.

The selectivity parameter for an “optimal” fishery regulation scheme, named as Length optimal (L_{opt}), i.e. the length at first catch, was estimated by using an equation based solely on life-history invariants for determination of length at the global MSY – maximum yield per recruit (Beverton, 1992):

$$L_{opt} = \frac{L_{inf}3}{3 + (M/K)} \quad (1)$$

where L_{inf} and K are von Bertalanffy parameters and M is the rate of natural mortality. However, global MSY can only be obtained by applying infinite fishing mortality (F_{∞}) at the critical size or age when the cohort achieves maximum biomass (Quinn II and Deriso, 1999), where the total weight of a cohort depends on the balance between decrease in numbers through natural mortality and increase in weight of the survivors (Beverton and Holt, 1957).

So why are Froese et al. (2008) aiming for a treasure at the end of the rainbow? The argument is that the overall higher fish biomass will be both beneficial from an ecosystem approach to fishery (e.g. Brodziak and Link, 2002) and for the fishery due to higher CPUE (my underlining). The latter part of the argument is however based upon a fundamental misunderstanding of the concepts introduced

by Beverton and Holt (1957): at increasing L_c , or t_c , an increasing proportion of the total population biomass will be left unexploited.

The error committed by Froese et al. (2008) is simply due to a confounding effect of the total population biomass before and after the length/age at first catch. For estimation of mean population biomass per recruit, B/R , following equation is given by Beverton and Holt (1957):

$$\frac{B}{R} = W_{inf} \sum_{n=0}^3 \Omega_n * e^{-nK(t_r-t_0)} \left[\left(\frac{1 - e^{-(M+nK)p}}{M + nK} \right) + e^{-(M+nK)p} \left(\frac{1 - e^{-(F+M+nK)landa}}{F + M + nK} \right) \right] \quad (2)$$

where $\Omega_n = +1, -3, +3, -1$ for $n=0,1,2,3$ respectively; t_0 is a von Bertalanffy parameter, t_{λ} is the terminal age; t_r is age at recruitment; $landa = t_{\lambda} - t_c$ is the fishable life span; R is recruitment to the fished area, and $p = t_c - t_r$. For estimation of the annual mean biomass available for exploitation, B''/R , the following equation is given by Beverton and Holt (1957):

$$\frac{B''}{R} = W_{inf} \sum_{n=0}^3 \Omega_n * e^{-nK(t_c-t_0)} \left(\frac{1 - e^{-(F+M+nK)landa}}{F + M + nK} \right) \quad (3)$$

B''/R is proportional to CPUE and may also be expressed as:

$$\frac{B''}{R} = \frac{Yw}{(R/F)} \quad (4)$$

where Yw is the yield in weight. Froese et al. (2008) confound B/R for B''/R , i.e. fish below L_{opt} are included in the fishable population. This misunderstanding leads to the spurious conclusion that “cohort and stock biomass is several-fold higher, thus increasing CPUE and reducing cost of fishing”. However, according to the model referred to, this is clearly not what is happening: by using the parameter values given for the North Sea cod in Froese et al. (2008), it can be observed that after an initial slight increase, B''/R shows a decreasing trend with increasing L_c (Fig. 1). B''/R at L_{opt} at 86 cm is 19% lower than at $L_c = 60$ cm, using the same parameter values as defined L_{opt} , i.e. $L_{inf} = 129$ cm, $K = 0.14$, $F = 0.12$ and $M = 0.21$. On the other hand, B/R monotonically increases up to t_{λ} , i.e. until no fish is harvested.

There are some general remarks to be made. Adjustment in L_c or t_c should be made in combination with reductions in fishing effort (Beverton and Holt, 1957). Overall, the highest gains in yields and CPUE are to be obtained by restricting fishing effort and only to minor extent by adjusting L_c . In relation to an ecosystem-based approach to fisheries management it is obvious that a lowered fishing effort is beneficial to other environmental objectives such as less erosion of the sea bed and lower conversion rates of fossil fuels.

Furthermore, as pointed out by Beverton and Holt (1957), the simple population model, without any modifications, ignores dynamic aspects of increased L_c such as (1) a dynamic stock-recruitment relationship, (2) increased natural mortality at higher

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☆☆ Ne quid nimis–Not to that extent.

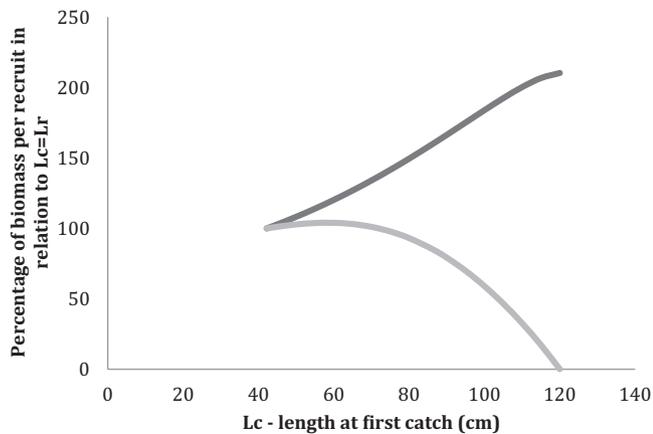


Fig. 1. The total mean biomass per recruit, B/R , and fishable mean biomass per recruit, B'/R , respectively) plotted against length at first catch, L_c , for North Sea cod, based on parameter values given in Froese et al. (2008). Biomass per recruit has been normalised as percentages of nominal values at $L_c = L_r$ (length at recruitment). B/R is shown as a black line, B'/R as a grey line.

population densities, (3) lower growth manifested as lower L_{inf} or W_{inf} at higher population densities. All these factors will reduce the benefits of an increased L_c by giving a lower Yw/R : higher population density may result in a lower recruitment, higher natural mortality rate will lower the positive effects of an increased L_c and decreased growth rates due to higher population biomass will restrict the span of possible beneficial L_c adjustments. Decreased growth rates due to an increased L_c might even give rise to a L_λ below L_c , thus ending up in a situation where there are hardly any fish to be harvested above a certain size limit. Such negative trade-offs between yield and increased population density should

also be taken into account before large-scale experiments on fish population dynamics are initiated.

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