

Modified von Bertalanffy Growth Function to Directly Estimate the Age at a Critical Length

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College of Natural Resources, University of Wisconsin-Stevens Point

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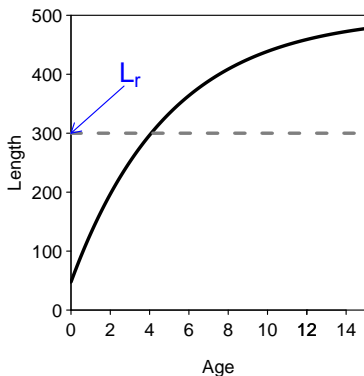
- 1 Concept of Critical Times
- 2 Critical Time is Often Estimated by Inverting the VBGF
- 3 Reparameterize the VBGF to Estimate Critical Time
- 4 An Example with Lake Michigan Lake Whitefish
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Definitions

- Critical points in a fish's life are often defined.
 - e.g., length or age at maturity or recruitment.
 - e.g., length as defined by a regulation (e.g., minimum length limit).

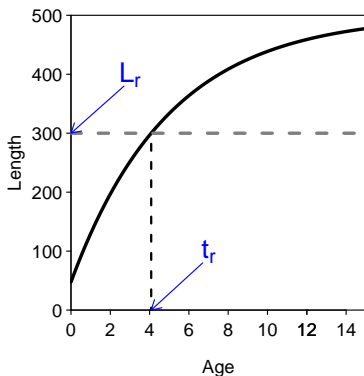
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- t_r
 - Age (time) at the critical point.
 - To be estimated.

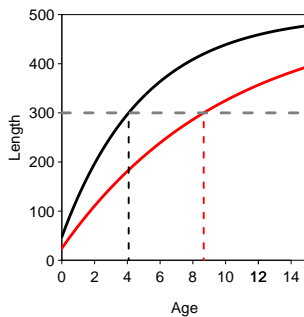


Importance

- Understanding t_r is important.

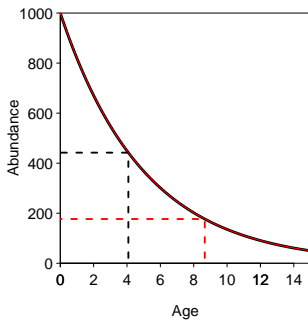
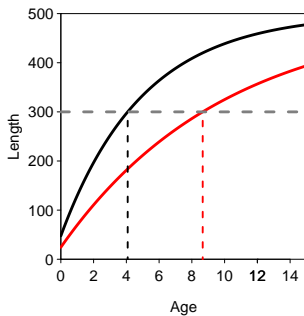
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North American Journal of Fisheries Management 27:918–931, 2007

[Article]

Yellow Perch in South Dakota: Population Variability and Predicted Effects of Creel Limit Reductions and Minimum Length Limits

DANIEL A. ISERMANN*¹ AND DAVID W. WILLIS

*Department of Wildlife and Fisheries Sciences, South Dakota State University,
Box 2140B, Brookings, South Dakota 57007, USA*

Length limit modeling.—We conducted length limit modeling for four of the six lakes where yellow perch population characteristics were described. We excluded East 81 Slough and Enemy Swim Lake from length limit modeling because fishing mortality may not be a significant source of mortality in these populations (Blackwell 2005a; Isermann et al. 2005) and because growth of yellow perch in these systems is slow. Dynamic-pool models utilizing Jones' (1957) modification to the equilibrium yield equation of Beverton and Holt (1957), as available in Fishery Analyses and Simulation Tools (FAST version 2.0; Slipke and

intercept (t_0) estimates due to the lack of mean length data for ages 0 and 1. Consequently, t_0 was fixed at zero when deriving k and L_{inf} from the von Bertalanffy model and in all length limit simulations. Our length limit modeling assumed that growth remained constant at the designated level across year-classes and that density-dependent growth responses did not occur. To further describe growth, we used von Bertalanffy models to estimate the time (years) required to reach lengths of 178 (t_{178}), 229 (t_{229}), 254 (t_{254}), and 279 mm (t_{279}).

Using the customized recruitment option available in

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North American Journal of Fisheries Management 22:1349–1357, 2002

Predictive Evaluation of Size Restrictions as Management Strategies for Tennessee Reservoir Crappie Fisheries

DANIEL A. ISERMANN,*¹ STEVE M. SAMMONS,² AND PHILLIP W. BETTOLI
TIMOTHY N. CHURCHILL

North American Journal of Fisheries Management 22:1306–1313, 2002

Effect and Acceptance of Bluegill Length Limits in Nebraska Natural Lakes

CRAIG P. PAUKERT*¹ AND DAVID W. WILLIS
DONALD W. GABELHOUSE, JR.

North American Journal of Fisheries Management 31:269–279, 2011

Simulated Population Responses of Common Carp to Commercial Exploitation

Michael J. Weber,* Matthew J. Hennen,¹ and Michael L. Brown

Environ Biol Fish (2007) 79:11–25

The New River, Virginia, muskellunge fishery: population dynamics, harvest regulation modeling, and angler attitudes

Travis O. Brenden · Eric M. Hallerman · Brian R. Murphy · John R. Copeland ·

North American Journal of Fisheries Management 22:1340–1348, 2002

Rescinding a 254-mm Minimum Length Limit on White Crappies at Ft. Supply Reservoir, Oklahoma: The Influence of Variable Recruitment, Compensatory Mortality, and Angler Dissatisfaction

JEFF BOXRUCKER*

North American Journal of Fisheries Management 29:1183–1194, 2009

Fishery and Population Characteristics of Blue Catfish and Channel Catfish and Potential Impacts of Minimum Length Limits on the Fishery in Lake Wilson, Alabama

MICHAEL P. HOLLEY,¹ MATTHEW D. MARSHALL, AND MICHAEL J. MACEINA*

Transactions of the American Fisheries Society 134:1285–1298, 2005

Population Characteristics and Assessment of Overfishing for an Exploited Paddlefish Population in the Lower Tennessee River

GEORGE D. SCHOLTEN*¹ PHILLIP W. BETTOLI

North American Journal of Fisheries Management 15:766–772, 1995

An Evaluation of the Value of Harvest Restrictions in Managing Crappie Fisheries

M. S. ALLEN AND L. E. MIRANDA

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Inverting the VBGF

$$L_t = L_{\infty} (1 - e^{-K(t-t_0)})$$

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- Suppose $L_\infty=450$, $K=0.2$, and $t_0=-1$ (as estimated from data).
- ... and that the critical length of interest is set at 300.

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$$t = \frac{\log_e \left(1 - \frac{300}{450} \right)}{-0.2} + -1 = 4.5$$

Computing t_r from Inverse VBGF

That was easy!

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- **BUT** ... how do you compute confidence intervals for t_r ?
 - Could use bootstrap, delta method, or error propagation.
 - Could *try* to fit inverse function and predict t_r at L_r .

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We need a better method!

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Revisit (Typical) VBGF

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- ... may be rewritten as ...

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Revisit (Original) VBGF

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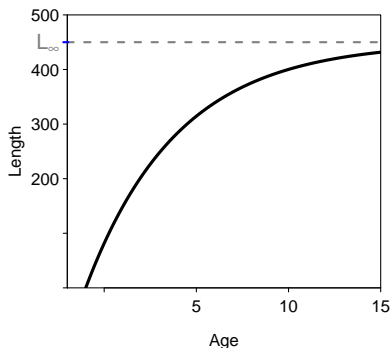
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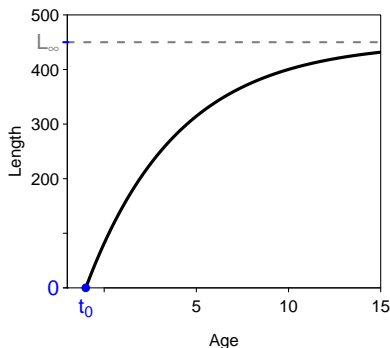
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- These VBGFs simply define different points on the same line.



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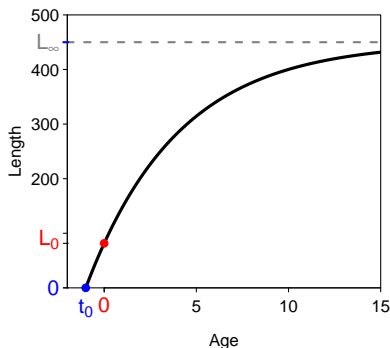
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Reparameterize VBGF

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- Such that ...

- Typical VBGF sets $L_r = 0$ and estimates $t_r (=t_0)$.
- Original VBGF sets $t_r = 0$ and estimates $L_r (=L_0)$.

- **Importantly, L_r can be set to any critical length to estimate t_r .**

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Example with Lake Michigan Lake Whitefish

- Data from Belnap (2014).¹
 - Fish from commercial trapnets in six management zones.
 - Measured total length (TL; mm).
 - Estimated age (yrs) from otolith thin sections.
 - Interested in t_{480} (480 mm is length at full vulnerability to harvest).

¹Belnap, M.J. 2014. Stock Characteristics of Lake Whitefish in Lake Michigan. M.Sc. Thesis, Univ. Wis. - Stevens Point.

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- Fit typical and modified VBGF to fish from Big Bay de Noc.
 - Compared parameter estimates and predicted mean lengths-at-age.

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 - Compared parameter estimates and predicted mean lengths-at-age.
- Fit modified VBGF to fish from Big Bay de Noc and Green Bay to illustrate t_r comparison.²

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Comparison of VBGF Results

Typical VBGF

	Estimate	LCI	UCI
L_{∞}	549.51	541.56	560.99
K	0.29	0.19	0.39
t_0	2.70	-0.32	4.32
t_{480}	9.88	-	-

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t_{480}	9.88	9.43	10.28

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Age	Pred Len
8.00	429.97
15.00	533.56
25.00	548.61
9.88	480.00

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Comparing t_r Between Groups

- Fit all (8) models where all, two, one, or no parameters differed between the two locations (Big Bay de Noc and Green Bay).

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Model	Params	AICc	Δ AICc	Weight
L_{∞}, t_{480}	6	3203.3	0.00	0.38
K, t_{480}	6	3203.5	0.19	0.34
L_{∞}, K, t_{480}	7	3204.7	1.40	0.19
t_{480}	5	3206.2	2.90	0.09
L_{∞}	5	3221.2	17.91	0.00
K	5	3222.5	19.14	0.00
L_{∞}, K	6	3223.3	19.97	0.00
None	4	3230.0	26.68	0.00

Comparing t_r Between Groups

Big Bay de Noc

	Estimate	LCI	UCI
L_∞	549.51	541.79	560.50
K	0.29	0.20	0.38
t_{480}	9.88	9.44	10.27

Green Bay

	Estimate	LCI	UCI
L_∞	555.91	546.84	571.16
K	0.39	0.18	1.23
t_{480}	7.56	6.20	8.48

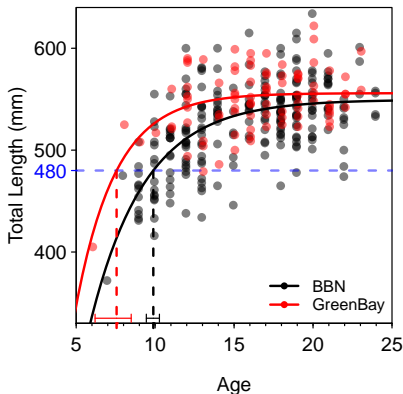
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 - Easy interval estimates of t_r .
 - Compare t_r between groups with standard (ANCOVA-like) methods.

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- Benefits
 - Easy interval estimates of t_r .
 - Compare t_r between groups with standard (ANCOVA-like) methods.
- Costs
 - No direct estimate of t_0 (from the typical VBGF).

Recommendation

$$L_t = L_r + (L_\infty - L_r) (1 - e^{-K(t-t_r)})$$

Use this modified VBGF in place of the typical VBGF.

Acknowledgments

- Matthew Belnap for collection and initial processing of Whitefish data.
- Ben Wegleitner, Zach Kleemann, Andrew Gullickson, and Connie Isermann for help processing the Whitefish otoliths.
- David Staples (Minnesota DNR) and Joshua McCormick (Oregon Department of Fisheries & Wildlife) for comments on the modified VBGF.

