Transactions of the American Fisheries Society 143:1592–1604, 2014

DOI: 10.1080/00028487.2014.954051

Supplement: Fish Energy Density Equations

Energy density was estimated for 165 Lake Trout by using the relationship between energy density and percent dry weight (DW) developed by Hartman and Brandt (1995) for Lake Trout:

$$\text{Energy density (J/g ww)} = a + b \cdot \text{DW}, \qquad \text{(S.1)}$$

where ww = wet weight; a and b are both empirical values (for Lake Trout, $a = -3{,}809$ and $b = 397.9$); and DW is percent dry weight.

Dry weight was determined by placing fish samples in a drying oven at 70°C until a consistent weight (±0.2 g) was reached. Using ww and DW separately, percent DW was calculated and used to determine the energy density of the fish.

During fish bioenergetics experiments, we were unable to utilize fish from every trial for purposes of energy density analysis. To predict the energy density for lean and humper morphotypes, the energy density estimates from the 165 fish across the size range tested (Figure S.1) were used to develop a simple linear regression model describing the relationship between fish ww and energy density for both morphotypes:

$$\text{Energy density}_{i,j} = a_j + b_j \cdot \text{ww}_{i,j} + \varepsilon_{ij}, \qquad \text{(S.2)}$$

where energy density$_{i,j}$ is fish energy density (J/g ww) for each observation i ($i = 1, \ldots, 165$) and morphotype j ($j = 1, 2$); a_j is the intercept for each morphotype j; b_j is the relationship between ww and fish energy density for each morphotype; ww$_{i,j}$ is fish wet weight; and ε_{ij} is the residual error, with $\varepsilon_{ij} \sim N(0, \sigma^2)$ (Table S.1).

A sensitivity analysis was performed to evaluate whether the wide range of estimated energy density values (3,801–8,540 J/g ww) was significantly affecting the final growth estimations. The sensitivity analysis consisted of fitting the model for a 40-g fish held at 12°C (both morphotypes) using the full range of energy density values and comparing the growth estimates to those from an analysis that was restricted to a narrower range of energy densities (6,002–8,540 J/g ww). Outputs for growth when using the full range of energy density values were 0.686 $g \cdot g^{-1} \cdot d^{-1}$ (posterior mean; 95% credible interval [CRI] = 0.482–0.891) for the humper morphotype and 0.668 $g \cdot g^{-1} \cdot d^{-1}$ (95% CRI = 0.481–0.858) for the lean morphotype. Using the restricted energy density range, growth was 0.633 $g \cdot g^{-1} \cdot d^{-1}$ (95% CRI = 0.443–0.821) for the lean morphotype and 0.588 $g \cdot g^{-1} \cdot d^{-1}$ (95% CRI = 0.424–0.755) for the humper morphotype. The CRIs for the two morphotypes overlapped under each range of energy density values, indicating that growth estimates were not overly sensitive to the wide range of energy densities observed in this study.

Supplementary Table S.1. Fish energy density parameter estimates for Klondike-strain humper Lake Trout and Lake Champlain-strain lean Lake Trout over the size ranges of fish tested. Estimates (J/g wet weight [ww]) for each parameter of interest in equation (S.2) are given as posterior means with 95% credible interval (CRIs). Both morphotypes were assumed to have similar residual variance (σ^2).

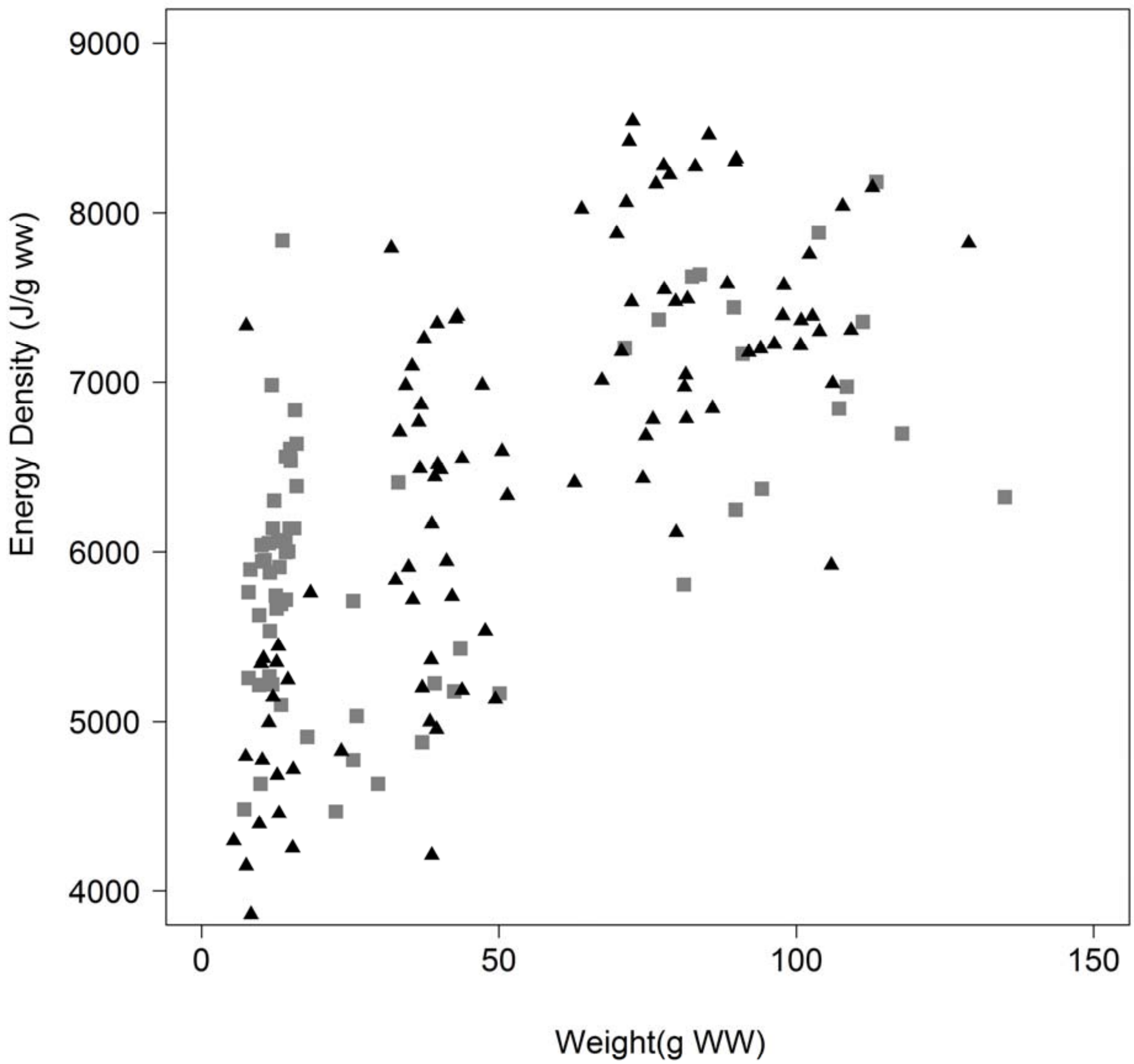
	Lean morphotype		Humper morphotype	
Parameter	Posterior mean	95% CRI	Posterior mean	95% CRI
a	5,506.9	5,238.0–5,768.0	4,854.5	4,533.0–5,171.0
b	14.4	9.2–19.7	29.7	24.8–34.7
σ^2	799.1	716.3–896.1		

Supplementary Table S.2. Derived parameter estimates for the combined model using data from Klondike-strain humper Lake Trout and Lake Champlain-strain lean Lake Trout (C = consumption; C_{max} = maximum consumption; p = proportion of maximum consumption; R = respiration, including both active and at rest; R_r = respiration at rest; ACT = activity multiplier). Equations for C_{max} and R_r are defined in the text with parameters estimated. Estimates are given as posterior means with 95% credible intervals (CRIs).

Parameter	Mean	95% CRI
	Consumption ($C = p \cdot C_{max}$)	
a	–2.460	–2.714 to –2.216
b	–0.114	–0.173 to –0.053
b_2	0.112	0.040–0.184
b_3	0.003	–0.003 to 0.010
b_4	–0.0003	–0.0002 to –0.0005
σ^2	0.133	0.118–0.149
	Respiration ($R = R_r \cdot$ACT)	
a	0.874	0.738–1.010
b	–0.356	–0.437 to –0.274
b_2	0.056	0.050–0.062
σ^2	0.201	0.180–0.225

Supplementary Table S.3. Percent differences for observed and predicted consumption and growth for all tanks in the validation experiment using the combined model for Klondike-strain humper Lake Trout (tanks H1–H5) and Lake Champlain-strain lean Lake Trout (tanks L6–L10). Two ration levels were tested: satiation (SR) and 50% reduced ration (RR). $Weight_i$ and $Weight_f$ represent average initial and final observed weights; predicted weight is the final weight predicted by the combined model. For consumption, both observed and predicted total average values are given.

		Growth					Consumption			
Tank	Ration	$Weight_i$ (g)	$Weight_f$ (g)	Predicted weight (g)	% Difference	Absolute difference (g)	Observed consumption (g)	Predicted consumption (g)	% Difference	Absolute difference (g)
H1	SR	96.2	143.7	128.4	−11.2	−15.3	127	157	17.9	30
H2	SR	86.7	127.7	119.9	−6.3	−7.8	121	136	11.7	15
H3	SR	90.5	131.7	124.4	−5.7	−7.3	123	138	11.6	15
H4	RR	69.4	96.8	77.5	−22.1	−19.3	69	101	37.3	32
H5	RR	84.5	116.1	95.3	−19.7	−20.8	80	117	37.8	37
L6	RR	10.9	16.8	16.6	−1.2	−0.2	20	21	6.8	1
L7	RR	14.0	22.2	19.5	−12.9	−2.7	23	28	19.3	5
L8	RR	13.6	21.9	18.1	−19.0	−3.8	22	27	21.1	5
L9	RR	13.6	18.6	12.3	−40.8	−6.3	12	23	61.3	11
L10	RR	15.3	21.1	14.0	−40.5	−7.1	14	26	58.2	12



Supplementary Figure S.1. Relationship between energy density (J/g wet weight [ww]) and wet weight (g) for the 165 Lake Trout from which dry weights were obtained during the experiments. This relationship was used to predict Lake Trout energy density for model predictions (Table S.1). Gray squares represent the humper morphotype (adjusted $R^2 = 0.54$); black triangles represent the lean morphotype (adjusted $R^2 = 0.29$).