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[Article]

Development and Evaluation of Condition Indices for the Lake Whitefish

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Abstract.—Despite frequent use of length-based condition indices by fisheries managers and scientists to describe the overall well-being of fish, these indices are rarely evaluated to determine how well they correlate with more direct measures of physiological or ecological condition. We evaluated common condition indices (Fulton's condition factor K_F, Le Cren's condition index K_{LC}, and two methods of estimating relative weight W_r) against more direct measures of physiological condition (energy density, percent lipid content, and percent dry mass) and ecological condition (prey availability) for lake whitefish *Coregonus clupeaformis* in Lake Huron. We developed four standard weight (W_s) equations using the regression length percentile (RLP) method: one for the species as a whole, and three separate equations describing immature, mature male, and mature female lake whitefish from 385 populations in North America. Species RLP-W_s showed less length-related bias and more closely matched empirical quartiles of lake-specific mean weight than did maturity- or sex-specific RLP-W_s equations. Significant length-related bias was detected in EmP-W_r. No biologically significant length-related bias was detected in K_{LC}, but this index was specific to a single population of fish. Species RLP-W_r showed no significant length-related bias, and K_F was significantly size dependent. All length-based condition indices were significantly correlated with energy density, percent lipid content, and percent dry mass. The index most strongly correlated with all three measures of physiological condition was K_F, likely because both the physiological measures and K_F exhibited positive relationships with body size. Across two Lake Huron sites, RLP-W_r was significantly correlated with density of prey (amphipods *Diporeia* spp.). Of the two condition indices developed in this study, RLP-W_r was consistently more strongly correlated with physiological condition indices than was EmP-W_r.

Length-based condition indices have been used by fisheries biologists for nearly 100 years to describe the energetic status, overall well-being, or reproductive status of fish (Froese 2006; Nash et al. 2006). These indices describe the body size for fish of a given length (Gerow et al. 2004, 2005); fish with greater mass than their counterparts of similar length are considered to be in good condition, whereas fish with lower mass at a given length are considered to be in poor condition. These simple considerations of condition are frequently utilized because they can be easily estimated from standard fisheries data (length and weight data from a sample of fish in one or more populations).

Studies evaluating length-based condition indices against more direct measures of energetic status or physiological stress in fish (e.g., energy density [ED], prey availability, and lipid content) are rare, and those that have done so report mixed conclusions. Laboratory studies manipulating consumption found strong positive correlations between percent fat (PF; whole-body composite and percent weight of visceral fat) and condition (relative weight W_r) in juvenile striped bass *Morone saxatilis* and hybrid striped bass (striped bass *M. saxatilis* × white bass *M. chrysops*; Brown and Murphy 1991). Condition indices (W_r) in populations of pumpkinseeds *Lepomis gibbosus* and golden shiners *Notemigonus crysoleucas* in southern Québec were positively correlated with food availability (Liao et al. 1995). More recently, a field study demonstrated that Fulton's condition factor (K_F) and W_r in bluegills *L. macrochirus* were positively and significantly correlated with nonpolar lipid density (Neff and Cargnelli 2004) and that K_F was correlated with both parasite density and male paternity. In contrast, weak correlations between common condition indices (K_F, Le Cren's condition index K_{LC}, and W_r) and more direct measures of energy content (PF, energy density, and percent dry mass [PD]) were reported for two salmon species (Trudel et al. 2005), and condition indices (K_F and two measures of W_r) in stocked walleyes *Sander vitreus* were poorly correlated with lipid

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density (Copeland and Carline 2004). This variation in findings among studies suggests that the informative value of condition indices may vary between species, particularly when applied to wild fish stocks.

Any length-based condition index should be free of systematic length-related bias to allow comparisons among populations in space or time (Gerow et al. 2004 and references therein); if this is not the case, then what might be interpreted as a change in condition from small to large fish within or among populations might simply be an artifact of a change in the average size of a population. To this end, a variety of indices have been proposed in the literature. Three frequently used indices are K_F (Ricker 1975), K_{LC} (Le Cren 1951), and W_r (Wege and Anderson 1978). Each has been widely utilized and critiqued, as described below. Fulton's K is expressed as

$$K_F = 10^7 \times (W/L^3), \qquad (1)$$

where W is weight (g) and L is some measure of length (mm; e.g., total length [TL] as was used here). However, the assumption of a cubic relationship between the length and weight of a fish is frequently violated, making K_F highly subject to length-related bias.

The following equation describes K_{LC}:

$$K_{LC} = [W/(b \times L^m)] \times 100, \qquad (2)$$

where b and m are empirically derived constants from the relationship between W and L. The major limitation of K_{LC} is that it is often too specific to be ecologically informative. Slopes of length–weight regressions differ among fish populations (e.g., Table A.1), and such differences may be due to variation in ecological niches between populations rather than energetic status specifically (e.g., Svanback and Eklov 2004). This effectively limits the application of K_{LC} to single populations only. A simplistic approach of estimating a single b or m parameter over the entire species results in an equation that overrepresents populations with large sample sizes and would not provide comparable weighting of populations that might otherwise describe the legitimate range of body shapes observed in the species.

Relative weight is described as

$$W_r = (W/W_{s,L}) \times 100, \qquad (3)$$

where $W_{s,L}$ is the standard weight (W_s) of a fish of length L, and the equation for W_s is an empirically derived model from representative populations (both morphologically and geographically) of a particular species. The traditional method for estimating W_s is the regression length percentile (RLP) method (hereafter, RLP-W_s; Murphy et al. 1990; based on the technique of Wege and Anderson [1978]). Using linear regression, one estimates the coefficients of the relationship of $\log_{10}W$ on $\log_{10}L$ for each of the I populations under study. The estimated weight for each population i at length j ($\hat{W}_{i,j}$) is calculated across a predetermined range of lengths applicable to the species at hand. This range is subdivided into J length-classes with midpoint L_j ($j = 1, \ldots J$; 10-mm length increments were used in this study). Based on the computation of $\hat{W}_{i,j}$ for all combinations of i and j, the 75th percentile of back-transformed predicted weights for each 10-mm length increment, $Q_j(\hat{W}_{i,j})$, is estimated (Murphy et al. 1990). The W_s equation for the species is estimated as the linear regression of $\log_{10}(Q_j[\hat{W}_{i,j}])$ against $\log_{10}(L_j)$. Thus, $W_{s,L}$ is simply the back-transformed predicted weight at length L from the W_s equation and should represent approximately the 75th percentile of mean weights among populations (Gerow et al. 2004).

Estimates of W_r based on RLP-W_s have been reported to be superior to the previously mentioned measures of condition because the RLP-W_s relationship is empirically derived using data from many populations and therefore is thought to offer a more thorough characterization of the relationship between length and weight for a particular species as a whole (Brown and Murphy 1991). However, the RLP-W_s method has recently been critiqued (Gerow et al. 2004, 2005) and an alternative W_s estimation method, the empirical quartile method (EmP-W_s), has been proposed. In this case, mean $\log_{10}$ observed weights ($W_{i,j}$) is estimated for each population over the J defined length-classes. The third quartile of these, $Q_j(W_{i,j})$, is estimated. These empirical quartiles are then fitted against $\log_{10}(L_j)$ using polynomial regression weighted by the number of populations represented in each length-class (Gerow et al. 2004, 2005).

Length-based condition indices have been used to track recent ecological changes in Great Lakes populations of lake whitefish *Coregonus clupeaformis* (Pothoven et al. 2001; Lumb et al. 2007). The lake whitefish is an important commercial species in both the Great Lakes and inland lakes of Canada, supporting a multimillion dollar annual fishery that is marketed internationally. Recent declines in the condition and growth of Great Lakes lake whitefish stocks have been observed in Lake Michigan (Pothoven et al. 2001), Lake Ontario (Hoyle et al. 1999; Lumb et al. 2007), and southwestern Lake Huron (Pothoven et al. 2006). Given the economic importance of this species to North American economies (Madenjian et al. 2006) and the scarcity of historic data on lake whitefish physiological status (i.e., ED, PF, and water content or PD), knowledge of relationships between physiological

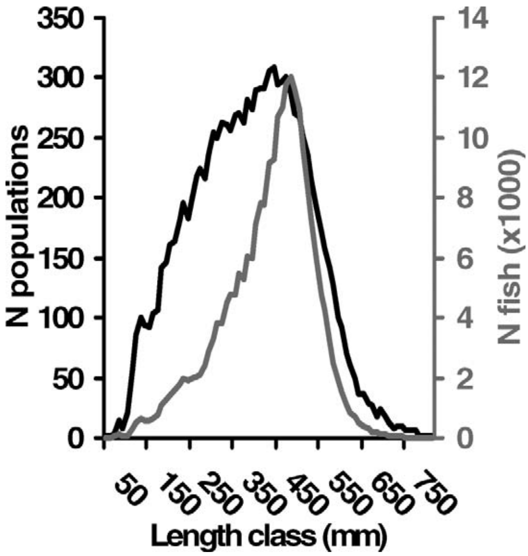

FIGURE 1.—Number of lake whitefish populations included in each length-class (mm total length; primary *y*-axis, black line) used for estimation of relative weight equations, and number of individual fish (× 1,000) included in each length-class (secondary *y*-axis, gray line).

status and length-based condition indices would allow scientists and managers to better interpret changes detected in lake whitefish condition over time. Therefore, we set out to thoroughly evaluate each of these common condition indices against more direct measures of fish physiological status (ED, PF, PD) or ecological well-being (i.e., prey availability) for this species.

The allocation of energy to either somatic growth or reproduction changes as fish mature (Lester et al. 2004) and often differs between males and females (Henderson et al. 2003). This is true of lake whitefish, which are sexually dimorphic in size and age at maturity (Beauchamp et al. 2004). Differing strategies of energy allocation between immature and mature fish or between males and females might lead to maturity- or sex-dependent differences in shape that cannot be sufficiently captured using standard linear regression and therefore potentially require the use of separate RLP-W_s equations (e.g., Flammang et al. 1999). We examined this possibility for immature, mature male, and mature female lake whitefish based on a subset of our original data for which information on sex and maturity was available.

Methods

Data sources.—Records of lake whitefish fork length (FL, mm), TL (mm), weight (g), sex, maturity, and date of capture were compiled from 419 populations for the development of W_s equations. Data from British Columbia populations were obtained through BC Hydro reports (Jesson 1990; Langston and McLean 1998a, 1998b; Zemlak 2000; Phillipow and Langston 2002; Zemlak and Cowie 2004) available online. Manitoba, Northwest Territories, and Laurentian Great Lakes population data were obtained from B. Henderson, Ontario Ministry of Natural Resources (OMNR; data summarized by Beauchamp [2002] and Beauchamp et al. [2004]). These data were further augmented with Great Lakes data collected by a number of agencies in 2004. Data for 109 Ontario inland populations were obtained from the OMNR Inventory Monitoring and Assessment Section. Data for 237 populations from Quebec and 1 population from Labrador were provided by Hydro Québec. Where possible, TL was estimated from FL using lake-specific equations relating the two parameters. When only FL was available, TL was estimated using the following equation based on recorded FL and TL for Ontario lakes:

$$\mathrm{TL} = (\mathrm{FL} \times 1.0953) + 6.8847 \qquad (4)$$

($F = 3.64 \times 10^6$; df = 1, 35,887; $R^2 = 0.99$; $P < 0.0001$). Populations were examined for outliers, and those that were clearly identified as data entry errors (e.g., impossible TLs or round weights) were removed.

Populations were included in the calculation for W_s equations if they passed the following criteria: (1) regression of $\log_{10}$(TL) on $\log_{10}W$ resulted in an R^2 greater than or equal to 0.80, (2) N was greater than or equal to 18, (3) the range of observations over the regression was greater than or equal to 140 mm TL, and (4) the minimum size was less than 400 mm (unless the size range over the regression >200 mm). This set of criteria was chosen so as to exclude potentially spurious relationships for populations due to small sample sizes over a narrow size range in the reported catch while retaining populations from a broad geographic range. Data from 34 lakes, primarily in Québec, were excluded based on these criteria. The final database resulted in 238,038 individual fish observations from 385 populations (Table A.1); the fish were between 48 and 820 mm TL (Figure 1) and encompassed the species' geographic range (Scott and Crossman 1973).

Regression length percentile method of standard weight estimation.—Relative weight should be free of any large-scale systematic length-related bias (i.e., increasing values with size, or vice versa; Murphy et al. 1990). Additionally, W_r should also reflect the W_r values calculated from the observed or empirical quartiles of mean weight (EmPQs) within the defined size-classes (Gerow et al. 2004). Relative weight estimates based on the RLP technique (RLP-W_r) were evaluated for length-related bias in two ways. First, we examined RLP-W_r for systematic bias across the length range used to develop the equation, where W in equation (3) is the third quartile of predicted weights and $W_{s,L}$ is the W_s predicted from the RLP-W_s equation (Murphy et al. 1990). Second, we examined length-related bias in W_r estimates based on the EmPQs, where W in equation (3) represents EmPQ and $W_{s,L}$ is the W_s predicted from the RLP-W_s equation (Gerow et al. 2004). We also compared W_r calculated by the two above methods in order to determine how well they matched within the defined length-classes.

We then developed separate $\log_{10}$(TL) versus $\log_{10}W$ models for immature, mature male, and mature female fish from each population. Only populations with a minimum of 20 observations for any particular category (immature fish, mature males, and mature females) were retained. Lakes with R^2-values less than 0.60 were excluded (one lake for immature fish, five lakes for male fish, and seven lakes for female fish). Regressions applied to a smaller range of the independent variable will always reflect more variation than that of a similar regression based on the same data over a larger range of observations. Therefore, our acceptance criteria of R^2 was relaxed and N was increased in an attempt to obtain lake-specific equations that realistically described observed variation while minimizing the expected increase in unexplained variation within the maturity- and sex-specific models. These constraints and an additional constraint (that sex and maturity status were not estimated for every fish in the original data set) reduced the number of populations in these analyses to 107 for immature fish, 172 for mature males, and 171 for mature females. These maturation-dependent condition indices were then evaluated for length-related bias and deviance from empirical third quartiles as described in the previous section.

For consistency, all quartiles were estimated using the Blom method for both the RLP and EmP procedures (Gerow et al. 2005). Quartiles were calculated in R software (R Development Core Team 2006) by specifying "type = 9" as the quartile estimation method, which corresponds to the method employed by Gerow et al. (2005). It must be noted that although the Blom method of estimating quartiles in the original Gerow et al. (2005) manuscript was incorrect as described (K. Gerow, Department of Statistics, University of Wyoming, Laramie, personal communication), the method that was actually employed by the authors in that study does indeed match the method employed here.

Empirical method of standard weight estimation.—Quadratic regression of $\log_{10}$(length-class) on the empirical third quartiles of mean $\log_{10}W$ was used to determine EmP-W_s and was weighted for the number of populations contributing data to each length-class as described by Gerow et al. (2005). Estimates of EmP-W_r were then evaluated for length-related bias by linear regression against TL (Figure 2), where W_r was estimated as the third quartile of empirical weights divided by the back-calculated predicted values from EmP-W_s. We did not investigate maturity- and sex-specific EmP equations, because this method employs polynomial regression, which should account for potential maturation-related inflection points in the length–weight relationship to a greater extent than the RLP method.

Estimation of additional condition indices.—Fulton's K was estimated as described in equation (1). Because K_{LC} is based on a single length–weight relationship, it is only appropriately applied to fish within a particular population. We calculated K_{LC} for fish from the South Bay (Manitoulin Island, Lake Huron) population only. Both K_F and K_{LC} were evaluated for length-related bias using linear regression.

Relationships between condition indices and physiological and ecological condition measures.—Linear regression was used to determine the amount of variation in direct estimates of physiological condition—specifically, PF, PD, and ED—that could be explained by each length-based condition index. For this purpose, we used previously unpublished data from lake whitefish collected in late summer at three Lake Huron sites: South Bay, an inlet of Lake Huron on Manitoulin Island (2001–2003); Cape Rich of Georgian Bay (2003); and Grand Bend on the southeastern shore of the main basin (2003). Whole fish were homogenized at the time of collection (2001–2003) for energetic analyses. Whole-fish homogenates of 429 fish were dried at 100°C for 24 h or until constant weight was achieved, and PD was then estimated. Lake whitefish PF (g of fat/g of wet whole-fish homogenate) was estimated using a modification of the method of Bligh and Dyer (1959) as described by Henderson et al. (1996). Remaining dried homogenate was then labeled and stored in freezers at –20°C. Energy density was estimated for a subsample (39 fish) of these frozen, dried homogenates in 2005 using bomb calorimetry as described by Henderson et al. (2000). Estimation of PF was repeated in 2005 on 19 of the 39 samples to ensure that samples had not degraded over time while in frozen storage. We found

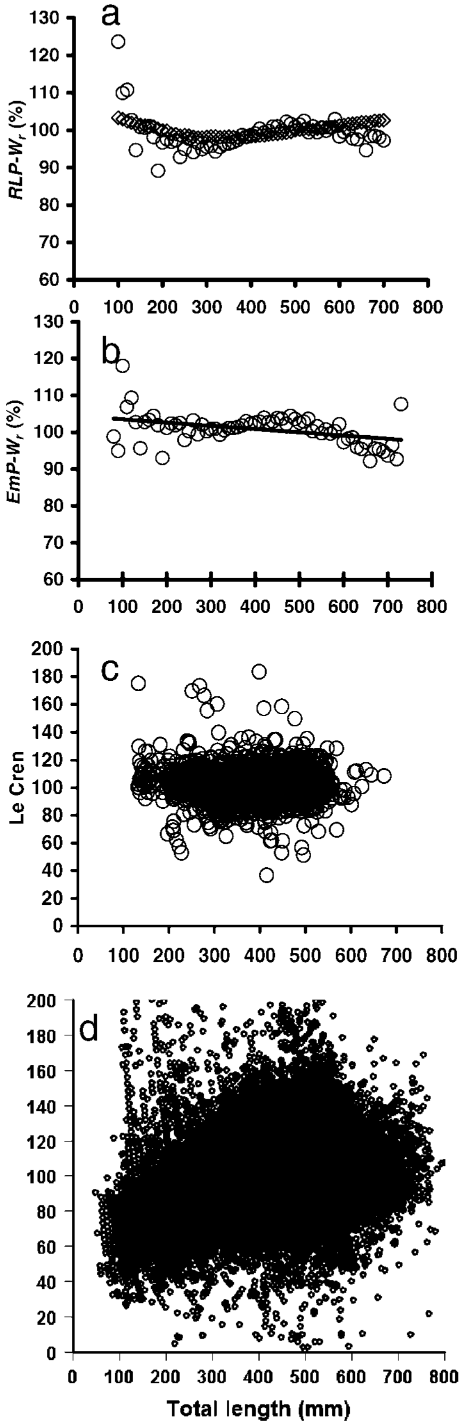

FIGURE 2.—Lake whitefish condition indices plotted against total length (TL) for evaluation of length-related bias: **(a)** relative weight (W_r) based on the regression length percentile method (RLP-W_r; diamonds = W_r [%] based on third quartiles of predicted weights within length-classes standardized by RLP-estimated standard weight [W_s]; circles = W_r based on empirical 75th percentiles of lake-specific mean weights in each length-class standardized by RLP-W_s); **(b)** W_r based on the empirical quartile method (EmP-W_r; circles = W_r based on third quartiles of lake-specific mean weights within length-classes standardized by EmP-estimated W_s; solid line shows significant negative relationship between EmP-W_r and TL); **(c)** Le Cren's condition index (Le Cren); and **(d)** Fulton's condition factor (K). Data in (a), (b), and (d) are from 385 North American populations; data in **(c)** describe a single population (South Bay, Lake Huron).

no difference over time between PF estimates for the same dried fish homogenates stored for 2–4 years (absolute mean difference = 0.4%; paired t-test: t_{18} = –0.81; $P_{\text{two-tailed}}$ = 0.43). Fish homogenates for ED estimations were selected to best capture the range of estimated PF values (above) and body size values in Lake Huron populations. Energy densities are reported on a wet weight basis. Benzoic acid standards were measured at 26,426 ± 10.8 J/g (mean ± SD; three replicates), which encompasses the reported value of 26,435 J/g. Seven fish (not among those analyzed for ED) were removed from the final analysis due to outlier values that were probably attributable to errors in data entry or methodology. Variables were transformed where necessary to satisfy assumptions of linear regression. Because K_{LC} was calculated for the South Bay population only, we used only the physiological status data from that population for its evaluation.

Other studies have shown that RLP-W_r is correlated with abundance of important food items in the field (Liao et al. 1995). To determine whether this was true of lake whitefish, we examined the relationship between $\log_{10}$(mean annual abundance of amphipods *Diporeia* spp.) and mean annual lake whitefish condition estimates in South Bay and Cape Rich, Lake Huron, using a weighted linear regression; mean annual abundance of *Diporeia* was weighted by the number of dredges used to obtain the samples. Thirteen years of data describing abundance of *Diporeia* and condition estimates were available from South Bay, and 4 years of such data were available for Cape Rich. *Diporeia* is widely cited in the literature as being an important prey item of lake whitefish (Hart 1931; Ihssen et al. 1981; McNickle et al. 2006), and its decline has been associated with declines in length-based condition indices of lake whitefish elsewhere on the Great Lakes (Pothoven et al. 2001; Lumb et al. 2007). Densities of *Diporeia* are those reported by McNickle et al. (2006).

TABLE 1.—Standard weight (W_s) equations for immature, mature male, and mature female lake whitefish. Presented for comparison to regression length percentile estimated (see text). Units of measure are weight (W) in grams and total length (TL) in mm.

Life stage and sex	Equation	Size range applicable (mm)
Immature (both sexes)	$\log_{10}(W_s) = 3.168290 \cdot \log_{10}(\text{TL}) - 5.456068$	110–560 mm
Mature male	$\log_{10}(W_s) = 3.130084 \cdot \log_{10}(\text{TL}) - 5.330007$	180–650 mm
Mature female	$\log_{10}(W_s) = 3.185490 \cdot \log_{10}(\text{TL}) - 5.470165$	170–670 mm

Results

Length-Based Condition Indices for Lake Whitefish

The proposed RLP-W_s equation for lake whitefish as a species is

$$\log_{10}(\text{RLP}-W_s) = -5.559919 + [3.218445 \times \log_{10}(\text{TL})]. \quad (5)$$

This equation was generated for fish between 100 and 700 mm TL (10-mm size-classes; fish from at least 18 water bodies were represented in each size-class; Figure 1) and should only be applied to fish within this size range. When plotting the value of RLP-W_r calculated from the W_s of the 10-mm length-classes, a slight curvature was evident, ranging from a high of 103.3% at 100 mm to a low of 97.9% at 370 mm (Figure 2a). Linear regression of RLP-W_r on TL was not significant ($P = 0.07$). Relative weight based on the species RLP-W_s and observed third quartiles (EmPQs) demonstrated curvature to a larger degree (Figure 2a). Differences between W_r estimated methods were largest for the smallest fish; empirical weights of 100–130-mm fish were 7–20% underpredicted by the W_s equation. However, biases appeared to be minimal for the rest of the distribution; the average absolute difference between W_r estimated methods was 2.8%. Regression of RLP-W_r based on EmPQs on length was also nonsignificant ($P = 0.40$), indicating that the curvature present was not indicative of systematic length-related bias (i.e., no systematic decrease or increase with fish size).

The proposed EmP-W_s equation for lake whitefish is the quadratic function,

$$\log_{10}(\text{EmP}-W_s) = -4.18945 + [2.07184 \times \log_{10}(\text{TL})] + \left\{0.23571 \times [\log_{10}(\text{TL})]^2\right\}. \quad (6)$$

Relative weight estimated for EmPQs of lake-specific mean weights demonstrated significant negative length-related bias (Figure 2b; $F = 12.8$; df = 1, 64; $P = 0.0007$). The EmP-W_s equations were generated for fish between 80 and 730 mm TL (10-mm size-classes; at least 50 fish/length-class; Figure 1) and were weighted by the number of populations contributing to each quartile estimate, as recommended by Gerow et al. (2005). As such, our EmP-W_s equation should only be applied to lake whitefish within this size range.

The relationship used to determine K_{LC} for the South Bay population was

$$\log_{10}W = -5.8871 + [3.3155 \times \log_{10}(\text{TL})]. \quad (7)$$

This relationship is applicable to fish of 130–670 mm TL, which represents the range of fish sizes used to generate the equation. A plot of K_{LC} for the South Bay population against TL showed no clear size-based bias (Figure 2c). A regression of K_{LC} against TL was statistically significant ($F = 5.57$; df = 1, 3,331; $P = 0.0018$). However, this was probably a result of large sample size; the small slope of the relationship (0.005) indicates a biologically insignificant rate of change over the length range of fish under study.

There was a clear and significant positive bias in K_F with fish size (Figure 2d; $F = 2{,}176$; df = 1, 238,056; $P < 0.0001$). The equation generated from this relationship predicted K_F values of 80 for a 100-mm fish and 107 for a 700-mm fish; these values translate to a percent difference of almost 35% over the size range used for development of lake whitefish RLP-W_s.

Maturity- and Sex-Specific Regression Length Percentile Estimated Standard Weight

Equations for RLP-W_s that were specific to immature (both sexes), mature male, and mature female lake whitefish and applicable size ranges are listed in Table 1. Applicable size ranges for these equations were determined from size-classes represented by a minimum of 17 water bodies. Immature fish RLP-W_r was very similar to the species RLP-W_r, and both fit well with W_r calculated from EmPQs of immature fish standardized by immature W_s (Figure 3a). Sex-specific RLP-W_r for both males and females based on EmPQs showed a higher degree of curvature than the species RLP-W_r, particularly at smaller sizes (Figure 3b, c). For both mature males and females, the species RLP-W_r and sex-specific RLP-W_r predicted higher W_r at small (<350-mm) and large (>600-mm) sizes than did W_r calculated from EmPQs standardized by sex-specific W_s; this effect was more pronounced for sex-specific

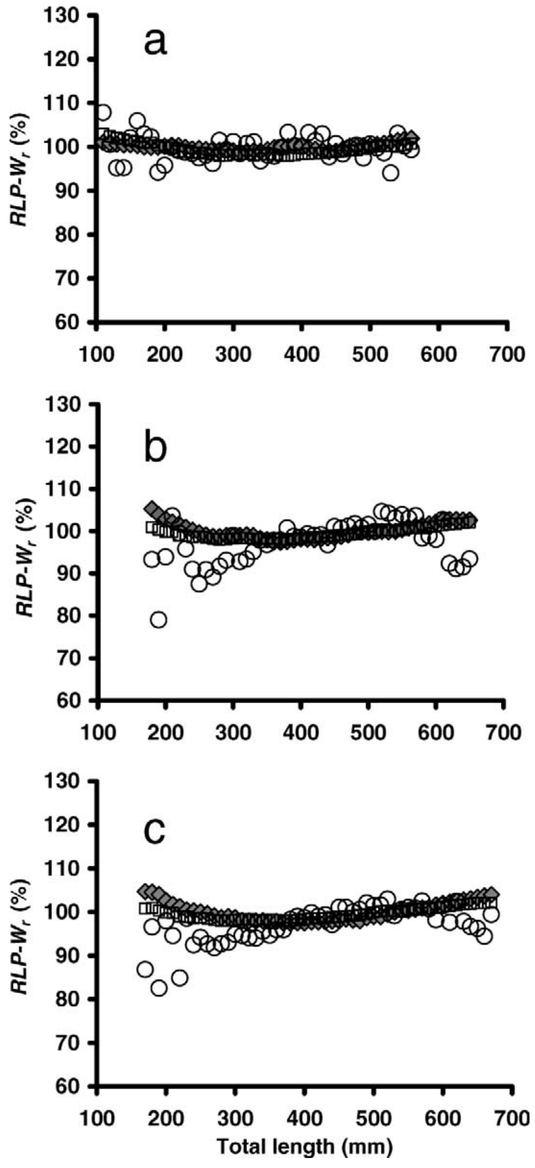

FIGURE 3.—Lake whitefish relative weight (W_r; %) estimated by the regression length percentile (RLP) method and plotted against total length (TL) for **(a)** immature fish (both sexes), **(b)** mature males, and **(c)** mature females. Data are from a subset of the original data (see text and Table A.1). Open squares represent species RLP-W_r as shown in Figure 3a (provided for comparison). Shaded diamonds represent RLP-W_r predicted by the specific equation (i.e., for immature, mature male, or mature female fish) standardized by the appropriate standard weight (W_s) equation. Circles represent W_r values that are based on empirical 75th percentiles of lake-specific mean weights in each length-class standardized by the appropriate W_s equation.

RLP-W_r than for species RLP-W_r. Based on the similarity between immature RLP-W_r and species RLP-W_r and the overestimation of sex-specific RLP-W_r in comparison with EmP-W_r, we chose to examine only the species RLP-W_r for correlations with other physiological condition measures.

Condition Indices versus Individual Physiological Parameters

Based on R^2-values, K_F was the index that was most strongly correlated with all measures of lake whitefish physiological status (Table 2). All three condition indices were most strongly correlated with ED and had weaker correlations with PF and PD (Table 2). Both PF and PD demonstrated exploding variance when regressed with either condition indices or body size, violating assumptions of linear regression (Figure 4). Log transformation of these variables resulted in poorer fits than untransformed variables based on reductions in R^2. As such, we present regressions based on untransformed variables for PF and PD, but we note where assumptions of linear regression have been violated (Table 2). Similar variance patterns between PD and W, K_F, or K_{LC} have been reported in other salmonid species (Trudel et al. 2005). Compared with EmP-W_r, RLP-W_r consistently explained more variation in direct measures of condition (Table 2).

Like K_F, all three measures of physiological status were correlated with lake whitefish size (Figure 5; Table 3; correlations with W are shown, but correlations with TL were also significant and had similar goodness of fit). A comparison of ED–weight relationships with those reported for Lake Michigan (Madenjian et al. 2006), Lakes Erie and Ontario (Lumb 2005), and southwestern Lake Huron (Pothoven et al. 2006) indicated that all were positive to varying degrees (Figure 5a).

Relationship between Condition Indices and Field Estimates of Food Availability

Mean annual RLP-W_r was positively correlated with $\log_{10}$(mean annual *Diporeia* abundance) in South Bay (Figure 6; $F = 7.74$; df = 1, 11; $P = 0.018$; $R^2 = 0.41$), as was the relationship between mean annual K_{LC} and $\log_{10}$(mean annual *Diporeia* abundance) ($F = 6.67$; df = 1, 11; $P = 0.025$; $R^2 = 0.38$). Because W_r describes condition for the species, we expanded the relationship to include observations from Cape Rich, Lake Huron (2000–2003; L. Mohr, OMNR, unpublished data; T. Nalepa, National Oceanic and Atmospheric Administration [NOAA], unpublished data). These data followed a similar trend as that observed in South Bay (Figure 6; combined relationship for both populations: $F = 8.106$; df = 1, 15; $P = 0.011$; $R^2 = 0.36$). Note that this combination of data across populations is only

TABLE 2.—Equations describing relations between physiological condition measures (ED = energy density, J/g wet weight; PF = percent fat; PD = percent dry mass) and condition indices (W_r = relative weight estimated by the regression length percentile [RLP] method or the empirical quartile [EmP] method; K_{LC} = Le Cren's condition index; K_F = Fulton's condition factor) of Lake Huron lake whitefish. Asterisks indicate regressions that violated the assumption of homogeneous residuals (see text for details).

Equation	F	df	P	R^2
$\log_{10}(ED) = 0.39262 \cdot \log_{10}(\text{RLP-}W_r) + 3.00368$	40.21	1, 37	<0.0001	0.52
$\log_{10}(ED) = 0.37205 \cdot \log_{10}(\text{EmP-}W_r) + 3.03869$	32.92	1, 37	<0.0001	0.47
$\log_{10}(ED) = 0.36732 \cdot \log_{10}(K_{LC}) + 3.01750$	25.99	1, 21	0.0002	0.55
$\log_{10}(ED) = 0.41628 \cdot \log_{10}(K_F) + 2.95392$	59.6	1, 37	<0.0001	0.62
$PF = 0.0924 \cdot (\text{RLP-}W_r) - 3.0551$	74.62	1, 417	<0.0001	0.15*
$PF = 0.07189 \cdot (\text{EmP-}W_r) - 1.58851$	44.98	1, 417	<0.0001	0.10*
$PF = 0.04491 \cdot K_{LC} - 0.1014$	26.71	1, 266	<0.0001	0.09*
$PF = 0.1249 \cdot K_F - 5.7548$	255.1	1, 417	<0.0001	0.38*
$PD = 0.1282 \cdot (\text{RLP-}W_r) + 14.39$	121.4	1, 419	<0.0001	0.17*
$PD = 0.1067 \cdot (\text{EmP-}W_r) + 15.84$	59.89	1, 419	<0.0001	0.13*
$PD = 0.06647 \cdot K_{LC} + 18.44$	26.38	1, 268	<0.0001	0.09*
$PD = 0.1628 \cdot K_F + 11.50$	252.9	1, 419	<0.0001	0.38*

possible for RLP-W_r due to the size sensitivity (K_F, EmP-W_r) or population specificity (K_{LC}) of the other condition indices investigated here.

Discussion

A common goal of any length-based condition index, including those investigated here, is the effective removal of any major length-related biases since all these methods attempt to describe the weight of fish across equivalent lengths. The removal of such biases allows for comparisons between fish of different sizes within a population (as is the case with K_{LC} due to its reliance on population-based length–weight relationships) or across populations (RLP-W_r and, theoretically, EmP-W_r and K_F). With regards to population-specific length-based indices, K_{LC} appears to best

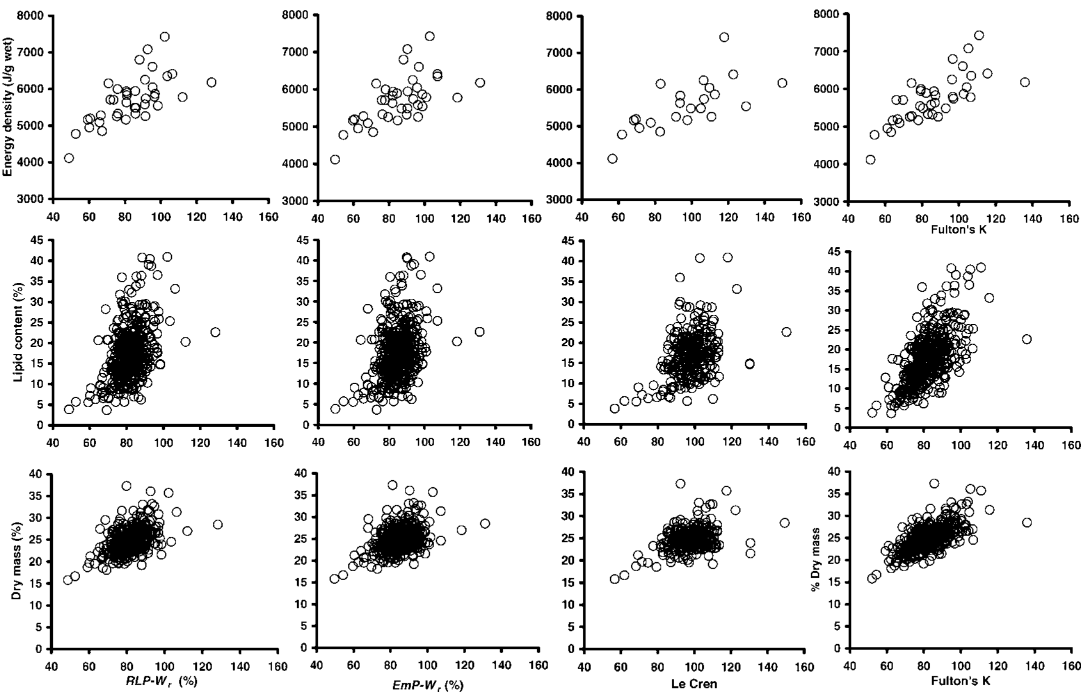

FIGURE 4.—Relationships between physiological condition measures and length-based condition indices in Lake Huron lake whitefish. Physiological measures are energy density (J/g wet weight), percent lipid content (g lipid/g wet weight), and percent dry mass (g dry weight/g wet weight). Condition indices are regression length percentile (RLP) estimated relative weight (RLP-W_r), empirical quartile (EmP) estimated relative weight (EmP-W_r), Le Cren's condition index (Le Cren), and Fulton's condition factor (K). The Le Cren index data describe only a single Lake Huron population (South Bay).

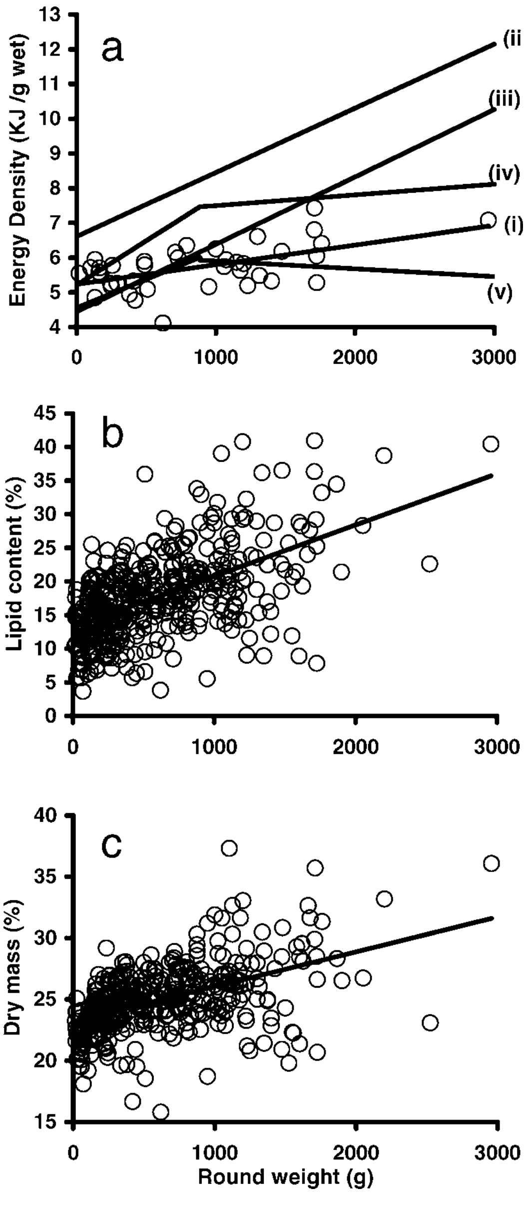

FIGURE 5.—Relationship between **(a)** energy density (ED; kJ/g wet weight), **(b)** percent lipid content (g lipid/g wet weight), or **(c)** percent dry mass (g dry weight/g wet weight) and round weight (g) in Lake Huron lake whitefish. Numbered lines in (a) correspond to site-specific ED–weight relationships as follows: (i) eastern Lake Huron (this study); (ii) Lake Erie (Lumb 2005); (iii) Lake Ontario (Lumb 2005); (iv) Lake Michigan (Madenjian et al. 2006); and (v) southern Lake Huron (Pothoven et al. 2006). Line (v) follows line (iii) closely until 800 g and then levels out, as in (iv).

TABLE 3.—Equations describing relations between physiological condition measures (ED = energy density, J/g wet weight; PF = percent fat; PD = percent dry mass) and round weight (W) of Lake Huron lake whitefish.

Equation	F	df	P	R^2
ED = $0.5650 \cdot W + 5233.70$	17.83	1, 37	0.0002	0.33
PF = $0.002599 \cdot W + 2.963$	227.8	1, 417	<0.0001	0.35
PD = $0.002838 \cdot W + 23.20$	137.1	1, 417	<0.0001	0.25

eliminate length-related bias when considering the South Bay population only. This is expected since the index is, by definition, specific to one particular population and does not account for variation across populations. For length-based indices that were applicable across populations, length-related bias was most evident in K_F, and bias was much smaller and much less severe for RLP-W_r and EmP-W_r than for K_F. Length-related bias was observed using the EmP method such that lake whitefish condition was negatively correlated with body size. While the RLP-W_r that was specific to immature lake whitefish was free of length-related bias, it did not provide a substantially better fit than species RLP-W_r. In contrast, RLP-W_r based on mature males and females showed greater length-related bias than the species RLP-W_r, particularly at small sizes.

Fulton's K was the condition index that was most strongly correlated with all three measures of physiological status in this study. This can be explained by the fact that these physiological measures, like K_F, were all

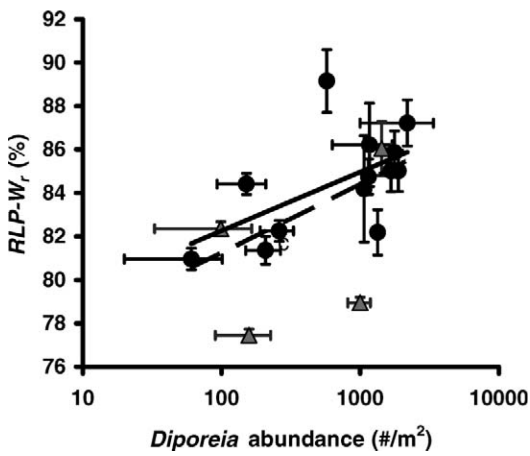

FIGURE 6.—Relationship between regression length percentile (RLP) estimated relative weight (RLP-W_r) of lake whitefish and density of their amphipod prey, *Diporeia* spp., in Lake Huron (mean ± SE; black circles = data from South Bay, Manitoulin Island; gray triangles = data from Cape Rich, Georgian Bay). The solid line represents the relationship for South Bay only; the dashed line represents the relationship for all data from both sites.

strongly correlated with lake whitefish size. A study examining condition in Pacific salmon also found correlations between physiological condition measures and body size (Trudel et al. 2005). Contrary to our findings for lake whitefish, Trudel et al. (2005) found that RLP-W_r in Chinook salmon *Oncorhynchus tshawytscha* described variation in ED and PF better than did either K_F or K_{LC}. The proportion of variance in ED that was explained by condition indices in our study is similar to that reported in studies of other wild populations of fish (Jonas et al. 1996; Trudel et al. 2005); our study also demonstrates variance patterns in relationships between direct measures of energetic status (PD, PF) and condition indices (K_F, K_{LC}) that are similar to those reported for other salmonid species (Trudel et al. 2005).

Mean annual abundance of *Diporeia*, our proxy measure of prey availability, was most strongly associated with mean annual RLP-W_r relative to mean annual K_{LC} for the South Bay population. When the South Bay and Cape Rich populations were considered together, RLP-W_r was again significantly related to prey availability. Significant associations between RLP-W_r and prey availability have been observed for two other fish species in the field (Liao et al. 1995).

Based on our findings, it seems that the choice of condition index should depend largely on the information the investigator hopes to gain from its use. For instance, high correlations between K_F and physiological condition measures (ED, PF, and PD) suggest that K_F may have predictive potential for estimating these variables. This would be particularly useful in generating estimates of ED, which are typically required as inputs in bioenergetic models (e.g., Madenjian et al. 2006). However, the length-related bias of K_F and EmP-W_r precludes their use in examining "average" condition in lake whitefish populations over time or in comparing condition between populations, since size is a significant covariate for these two indices. Approaches like analysis of covariance may provide a means for making K_F and EmP-W_r comparisons between populations or over time for this species, but thorough validation of this approach would require a large amount of data on ED or other physiological measures across size ranges from a number of populations (not currently available to the investigators of this study). When comparing average condition over time, our results suggest that RLP-W_r in the South Bay population is more strongly correlated with food availability (abundance of *Diporeia*) than is K_{LC}. Because K_{LC} is further limited to comparisons within a single population, our study suggests that comparisons of average condition within or between populations would be best made with RLP-W_r.

To our knowledge, this study is the first to evaluate EmP-W_r estimates against other measures of physiological or ecological condition and to compare these associations with those of other condition indices. The EmP method has been proposed as being more sound than the RLP method for estimating W_r in fish species, as it avoids issues regarding extrapolation and artifactual effects from using least-squares linear regression to generate predicted values in each length-class when determining W_s third quartiles (Gerow et al. 2004, 2005). Regardless of the index employed in a study, relations between length-based condition indices and physiological or ecological condition measures are required for investigators to better interpret the importance of any changes or differences in length-based condition (besides a simple change in fish shape). However, very few studies have actually set out to evaluate this in wild populations (e.g., Trudel et al. 2005; this study). Our study suggests that further field-based empirical work is required to compare length-based condition indices with measures of physiological or ecological condition in other species.

Length-based condition indices explained a similar or greater proportion of variance in ED than did weight (Lumb 2005; Pothoven et al. 2006; this study). The capacity of length-based condition indices in predicting ED and proximate constituents has been demonstrated for other coregonid species during laboratory experiments (Pangle and Sutton 2005). It has been suggested that laboratory-based studies are more likely to find relationships between condition indices and proximate constituents or ED (Trudel et al. 2005). In contrast, our relationships are based entirely on field data. However, the length-based condition indices reported here were evaluated in relation to physiological measures of energetic status for eastern Lake Huron lake whitefish populations only, and these relationships should be further validated using similar data from other populations. This is particularly important given the observed variation among Great Lakes lake whitefish populations with respect to ED–weight and ED–PD relationships (Lumb 2005; Pothoven et al. 2006; this study). We encourage investigators to further evaluate the applicability of the observed relationships between condition indices and physiological or ecological condition measures for other wild lake whitefish populations.

The systematically low values of W_r observed for small fish based on EmPQs of mature males and females may reflect a higher energetic cost of early maturity in this species. Typical size at reproduction is 373 ± 50 mm for females (mean ± SD; 406 mm in Great Lakes populations) and 369 ± 30 mm for males (371 mm in Great Lakes populations; Beauchamp et al. 2004). Thus, fish maturing before 320 mm might be doing so at the cost of somatic investment, and this cost may be reflected in lower body condition. Mature male W_r based on EmPQs is typically below that predicted from species RLP-W_s until 320 mm (Figure 3b), and the same is true of female fish below 290 mm (Figure 2c). The fact that no such bias is apparent in immature fish in this size range (Figure 3a), when considered in combination with our findings relating W_r to physiological status, suggests that fish maturing at smaller sizes incur greater energetic costs than do larger-maturing fish. Trudel et al. (2001) reported higher metabolic costs in dwarf forms of lake whitefish (which also mature earlier than normal forms). Though condition between dwarf and normal forms or between early and late-maturing populations has yet to be compared to directly test this hypothesis, some supporting evidence for reduced condition of early-maturing lake whitefish exists in recent work, where dwarf × normal hybrids were back-crossed with dwarf and normal strains (Rogers and Bernatchez 2007). Those investigators reported that dwarf back-crossed hybrids had poorer condition (K_F) than normal back-crossed hybrids when raised under similar conditions (Rogers and Bernatchez 2007).

In summary, we hope that the development and evaluation of length-based condition indices reported here for lake whitefish will allow investigators to choose condition indices appropriately when more physiologically meaningful data (ED, PF, or PD) are otherwise unavailable. Relationships reported here between physiological status and length-based condition indices for lake whitefish in Lake Huron have helped to provide a physiological and ecological context for the use of these indices in the field. Furthermore, our study has provided additional evidence for the hypothesis that RLP-W_r is related to prey availability in the field, and we believe it is the first study to demonstrate relationships between fish physiological condition and the recently proposed EmP-W_r.

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Appendix: Lakes Used to Generate Standard Weight Equations

TABLE A.1.—Description of lake whitefish sampling areas (L. = Lake; Res. = Reservoir; Isl. = Island; Pt. = Point; R. = River) used to generate standard weight (W_s) equations. Minimum (min) and maximum (max) values of total length (TL, mm) and weight (W, g); sample size (N); and the slope (m), intercept (b), F-value (all $P < 0.0001$), and coefficient of determination (R^2) for the regression of $\log_{10}$(TL) on $\log_{10}W$ are presented. Submodel column describes whether the given population was used in regression length percentile estimated W_s submodels for immature fish (i), mature males (m), and mature females (f). Regions are British Columbia (BC), Lake Erie (GLErie), Lake Huron (GLHuron), Lake Michigan (GLMichigan), Lake Superior (GLSuperior), Manitoba (MB), Newfoundland and Labrador (NL), Northwest Territories (NWT), Ontario (ON), and Quebec (QC).

Region	Population	Latitude	Longitude	Years
BC	Butternutt	50°00′52″N	123°05′40″W	1990, 1999
	Emerslund L.	56°23′05″N	123°04′25″W	1993
	Lions L.	55°15′05″N	123°06′40″W	2001
	Willston Res.	56°00′00″N	124°00′00″W	1988, 2000
GLErie		42°24′00″N	80°21′00″W	1989–1999, 2004
GLHuron	Alpena	45°00′00″N	83°15′00″W	1986, 1988–1990, 1998
	Cape Rich	44°32′03″N	80°37′19″W	1981–1998, 2000–2003
	Detour	45°55′00″N	83°25′00″W	1980, 1984–1987, 1989, 1991–1998, 2004
	Drummond Isl.	45°55′00″N	84°00′00″W	1989, 1990–1998
	Grand Bend	43°15′09″N	81°51′53″W	1984–1985, 1989–1992, 1997–1999, 2003
	Hammond Bay	45°45′00″N	84°20′00″W	1980, 1985–1998
	Les Cheneaux Isl.	46°00′00″N	84°40′00″W	1980, 1983, 1985–1987, 1991–1998
	North Channel	46°00′00″N	83°00′00″W	2004
	Oliphant	42°41′38″N	81°28′04″W	1981–1985, 1989–1992, 1997–1999
	South Bay	45°40′00″N	81°55′00″W	1965, 1968–1984, 1986–1992, 1997, 2001–2004
GLMichigan	Arcadia	44°30′00″N	86°15′00″W	1983
	Beaver Isl.	45°45′00″N	85°35′00″W	1981–1983, 1985–1998
	Big Bay de Noc	45°30′00″N	86°40′00″W	1980, 1992, 1995–1996, 2004
	Fox Isl.	45°15′00″N	85°30′00″W	1979, 1981–1995, 1997
	Naubinway	46°00′00″N	85°25′00″W	1981–1983, 1986–1998, 2004
	Pt. aux Barques	45°50′00″N	86°25′00″W	1986–1998
GLSuperior	Apostle Isl.	47°00′00″N	90°30′00″W	2004
	Grand Marais	46°35′00″N	85°25′00″W	1985–1998
	Munising	46°30′00″N	86°30′00″W	1980, 1983–1988, 1990–1998
	L. Superior	48°00′00″N	87°00′00″W	2002
	Thunder Bay	48°25′00″N	89°00′00″W	1988, 1991, 1996
	Whitefish Bay	46°30′00″N	84°35′00″W	1966, 1980–1998, 2004
	Whitefish Pt.	46°45′00″N	85°15′00″W	1977–1978, 1980–1998
MB	Central L. Winnipeg	52°60′00″N	97°50′00″W	1979–1999
	L. 226	49°41′00″N	93°44′00″W	1973–1979, 1983, 1985–1989, 1991, 1994–2000
	North L. Winnipeg	52°60′00″N	97°50′00″W	1979–1999
NL	L. Astray	54°35′00″N	66°35′00″W	1977
NWT	L. Alexie	62°82′00″N	114°05′00″W	1971–1991
	L. Baptiste	62°82′00″N	114°11′00″W	1971–1991
	L. Chitty	62°82′00″N	114°08′00″W	1971–1991
	L. Drygeese	62°82′00″N	114°10′00″W	1971–1991
	Great Slave L.	62°42′10″N	108°59′00″W	1972, 1974, 1977, 1980–1981
	L. Nueltin	60°00′00″N	99°50′00″W	1981
	L. Prelude	62°00′00″N	114°00′00″W	1979
	L. Prosperous	62°00′00″N	114°00′00″W	1979
	L. Snowbird	60°40′00″N	102°55′00″W	1982
ON	L. Abitibi	48°39′30″N	79°50′42″W	1995–1996, 2001
	Abram L.	50°03′26″N	91°55′54″W	2001
	Angelina L.	49°44′38″N	84°14′46″W	2002
	Aylen L.	45°36′48″N	77°50′55″W	1978–1983, 1985, 1987
	Ball L.	50°17′26″N	93°59′31″W	1997–1998
	Bark L.	45°26′52″N	77°50′10″W	2001
	Beaverhouse L.	48°32′36″N	92°06′09″W	1996
	Bernard L.	45°44′17″N	79°23′03″W	1995, 2000
	Big Gull L.	44°49′33″N	76°57′24″W	1998
	Bigfour L.	47°39′58″N	81°11′14″W	2002
	Biscotasi L.	47°17′58″N	82°04′55″W	1999–2000
	Botsford L.	50°08′42″N	91°38′32″W	2001
	Cedar L.	50°12′34″N	93°08′16″W	2003
	Chiblow L.	46°20′37″N	83°02′57″W	2002
	Clear L.	46°05′54″N	79°46′53″W	1985, 1990
	Crooked Pine L.	48°47′04″N	91°05′36″W	1981–1983, 1998
	L. des Mille Lacs	48°50′57″N	90°30′37″W	1988–1994, 2000, 2002

TABLE A.1.—Extended.

Region	TL_{min}	TL_{max}	W_{min}	W_{max}	N	m	b	F	R^2	Submodel
BC	134	403	20	824	70	3.2467	−5.6257	5,151	0.987	
	242	472	113	1,000	20	2.9247	−4.9307	149	0.892	
	191	396	53	553	26	3.3048	−5.8264	4,992	0.995	
	148	297	34	311	138	2.9771	−4.9002	5,120	0.974	
GLErie	176	656	40	3,520	906	3.3218	−5.8319	93,559	0.990	i, m, f
GLHuron	253	703	110	2,980	755	3.0505	−5.1697	15,303	0.953	i, m, f
	123	785	10	11,460	8,218	3.2721	−5.7910	375,575	0.979	i, m, f
	266	655	140	3,230	2,816	3.1548	−5.4639	33,593	0.923	i, m, f
	246	720	100	3,770	1,175	3.2794	−5.7948	33,457	0.966	i, m, f
	167	652	35	3,158	3,105	3.2851	−5.7806	126,990	0.977	i, m, f
	170	727	90	3,800	2,751	2.9391	−4.8691	25,542	0.903	i, m, f
	210	708	50	8,500	2,734	3.1748	−5.5227	24,876	0.901	i, m, f
	182	607	20	2,325	747	3.3888	−6.0909	30,126	0.976	
	4	687	35	3,700	3,837	3.2877	−5.8001	240,079	0.984	i, m, f
	132	673	14	3,350	3,332	3.3221	−5.9039	222,850	0.985	i, f
GLMichigan	438	769	880	6,600	253	3.4218	−6.1214	3,885	0.939	
	270	772	150	5,800	8,404	3.0847	−5.2388	43,490	0.838	i, m, f
	206	597	140	1,990	743	2.8431	−4.6399	3,737	0.835	m, f
	262	815	140	9,400	9,458	3.0267	−5.0915	49,738	0.840	i, m, f
	234	698	115	3,380	11,025	3.0513	−5.1836	54,930	0.835	i, m, f
	295	696	240	3,810	4,299	3.0254	−5.0837	24,397	0.850	i, m, f
GLSuperior	77	483	2	1,167	126	3.2235	−5.6331	1,351	0.916	
	432	772	679	6,000	1,933	3.1709	−5.4890	16,884	0.897	i, m, f
	388	765	470	5,250	1,665	3.1632	−5.4747	13,135	0.888	i, m, f
	111	602	9	2,027	41	3.2618	−5.7463	2,012	0.981	
	220	650	91	2,500	167	3.1567	−5.4406	2,273	0.932	i, m, f
	120	754	46	5,200	6,656	3.0946	−5.2901	70,782	0.914	i, m, f
	136	800	20	6,400	16,610	3.2329	−5.6726	148,241	0.899	i, m, f
MB	276	616	160	3,420	4,775	3.1901	−5.4488	50,860	0.914	i, m, f
	95	575	6	2,130	864	3.2101	−5.5812	50,249	0.983	
	250	592	130	3,100	23,502	3.1076	−5.2569	302,650	0.928	i, m, f
NL	315	480	330	1,260	31	3.0386	−5.0098	243	0.893	
NWT	100	672	5	2,750	5,983	3.4019	−6.0905	724,818	0.992	i, m, f
	101	648	5	2,800	2,541	3.3461	−5.9738	251,396	0.990	i, m, f
	96	633	4	2,260	3,328	3.3720	−6.0132	392,856	0.992	i, m, f
	101	670	5	3,100	3,672	3.3906	−6.0896	370,006	0.990	i, m, f
	107	652	20	3,150	9,161	3.3074	−5.7987	207,688	0.958	i
	178	736	50	4,800	561	3.2618	−5.7133	33,891	0.984	i
	189	552	50	1,750	305	3.2919	−5.7963	16,090	0.982	i
	179	511	40	1,300	270	3.2814	−5.7647	11,242	0.977	i
	224	649	50	3,000	624	3.4299	−6.1572	11,532	0.949	i, m, f
ON	260	519	185	2,025	158	3.1652	−5.3585	1,544	0.908	m, f
	310	526	264	1,571	20	3.4194	−6.1021	376	0.954	
	177	535	44	1,730	36	3.3726	−5.9598	12,953	0.997	
	156	429	23	737	446	3.1101	−5.3773	9,901	0.957	
	264	583	150	2,300	104	3.2947	−5.7784	2,051	0.953	
	224	536	85	1,543	152	3.3413	−5.9148	5,316	0.979	m, f
	365	628	450	2,500	28	3.0943	−5.2725	728	0.966	
	182	629	40	2,560	494	3.2308	−5.6783	31,711	0.985	
	356	645	504	3,300	31	2.9878	−4.8614	436	0.938	
	234	483	125	1,150	89	2.8012	−4.4605	942	0.916	
	281	619	220	3,500	233	3.2323	−5.5025	1,674	0.879	m
	184	533	47	1,705	33	3.4044	−6.0656	1,956	0.984	
	414	644	774	2,384	19	3.0919	−5.2206	192	0.919	
	262	597	210	1,950	104	3.2545	−5.7350	4,226	0.976	i, m, f
	259	597	200	2,625	62	3.2776	−5.6791	3,976	0.986	
	111	622	10	8,300	271	3.4068	−6.0434	9,717	0.973	i, m, f
	105	627	13	2,900	561	3.1974	−5.4646	27,871	0.980	i, m, f

TABLE A.1.—Continued.

Region	Population	Latitude	Longitude	Years
ON	Dog L.	48°45′50″N	89°32′33″W	1997–2002
	Eagle L.	49°40′53″N	93°04′10″W	2000
	Favourable L.	52°50′57″N	93°54′55″W	1995
	Fawcett L.	47°32′00″N	81°07′00″W	1989, 1990, 1993, 1995–1998, 2002
	Gammon L.	51°00′31″N	94°44′03″W	2000
	Garden L.	49°31′25″N	89°49′34″W	1997
	Golden L.	45°33′56″N	77°19′29″W	1997
	Granitehill L.	49°05′11″N	85°15′53″W	2001
	Grassy L.	47°47′42″N	81°14′10″W	1997
	Hammer L.	48°24′11″N	85°05′48″W	1999
	Highbrush L.	47°45′10″N	83°32′51″W	2001
	Indian L.	47°07′37″N	82°07′36″W	2002
	Ivanhoe L.	48°04′58″N	82°37′37″W	1998
	Jackfish L.	48°56′26″N	93°35′46″W	1989, 2000
	L. Joseph	45°10′35″N	79°43′49″W	1989–1994
	Kenetogami L.	47°46′56″N	81°38′20″W	1998
	Kilburn L.	50°41′34″N	94°28′50″W	2000
	Larder L.	48°05′08″N	79°38′37″W	1997
	Leonard L.	45°04′28″N	79°26′48″W	2001
	Little Sandford L.	49°06′00″N	91°36′28″W	2000
	Little Trout L.	51°03′10″N	93°14′20″W	1998
	Lount L.	50°10′06″N	94°18′30″W	1997–1998
	Low Water L.	47°09′10″N	81°41′40″W	2002
	Mainville L.	48°52′06″N	93°13′38″W	1998
	Mattagami L.	47°50′09″N	81°33′40″W	1998
	McAree L.	48°18′02″N	91°56′21″W	1996
	Mesomikenda L.	47°38′53″N	81°52′44″W	2000
	Miminiska L.	51°33′11″N	88°35′55″W	2001
	Mindemoya L.	45°45′40″N	82°12′14″W	1997, 2001
	Minisinakwa L.	47°39′48″N	81°44′18″W	1999
	Minnitaki L.	49°58′26″N	91°58′31″W	2001
	Moose R.	51°20′00″N	80°24′00″W	1996–1997
	Mount L.	49°00′47″N	92°10′47″W	2000
	Muskeg L.	49°01′02″N	90°03′06″W	1991–1992, 1997
	L. Nipigon	49°50′00″N	88°30′00″W	1981–1998, 2000–2001
	L. Nipissing	46°17′00″N	80°00′00″W	1977, 1980–1981, 1986–1991, 1999–2001
	Northern Light L.	48°15′04″N	90°40′45″W	1998
	Northwind L.	49°51′07″N	87°57′46″W	2003
	Oba L.	48°38′18″N	84°17′49″W	2004
	Obushkong L.	47°42′26″N	80°48′00″W	2001–2002
	L. of the Woods	49°14′59″N	94°45′02″W	1986–1987, 1990–1995
	Old Man L.	49°02′04″N	91°02′11″W	1992, 2000
	Onaman L.	50°00′17″N	87°26′09″W	2003
	Opeepeesway L.	47°37′00″N	82°15′00″W	1998
	Opeongo L.	45°42′33″N	78°22′06″W	1981–1982, 1986, 1988, 1990, 1997–1999
	Opikinimika L.	47°22′00″N	81°25′00″W	2001
	Otukamamoan L.	48°57′42″N	92°51′48″W	1989
	Pakwash L.	50°45′02″N	93°28′53″W	1982, 1988, 1994
	Pekagoning L.	49°09′00″N	92°11′27″W	1988, 1998–1999
	Perch L.	48°44′49″N	91°50′41″W	1998
	Perrault L.	50°17′28″N	93°08′26″W	2003
	Peterlong L.	48°05′17″N	81°24′40″W	2002
	Pettit L.	48°57′07″N	92°16′02″W	1986, 2000
	Pickerel L.	48°37′29″N	91°26′40″W	1981
	Pierre L.	49°30′10″N	80°42′55″W	1992, 1995–1996
	Pipestone L.	49°05′28″N	93°33′15″W	1989, 2000
	Pogamasing L.	46°58′04″N	81°50′09″W	2002
	Racine L.	48°01′06″N	83°19′49″W	2002
	Rainy L.	48°42′00″N	93°10′00″W	
	Ramsey L.	47°15′43″N	82°15′57″W	2002
	Red Cedar L.	46°42′45″N	79°56′14″W	2001
	Red L.	51°02′34″N	93°56′54″W	2000
	Remi L.	49°25′46″N	82°09′11″W	2002
	Restoule L.	46°03′14″N	79°46′19″W	1985, 1989
	Robinson L.	48°11′46″N	91°39′40″W	1985, 1999
	L. Rosseau	45°10′26″N	79°35′06″W	1993–1996, 2000
	Round L.	48°00′58″N	80°02′17″W	1994, 1997, 2001–2002
	Separation L.	50°14′45″N	94°23′43″W	1996–1997
	Shoal L.	49°33′00″N	95°01′00″W	1998, 2000–2001
	Sideburned L.	47°44′38″N	83°31′08″W	2001

TABLE A.1.—Extended, continued.

Region	TL_{min}	TL_{max}	W_{min}	W_{max}	N	m	b	F	R^2	Submodel
ON	206	563	80	3,000	34	3.0414	−5.1162	612	0.950	
	189	592	50	2,021	185	3.2861	−5.7957	11,433	0.984	i, m, f
	102	600	50	2,650	19	2.1179	−2.7330	129	0.883	
	290	570	200	2,300	31	3.6925	−6.8002	1,380	0.979	
	223	525	75	1,950	42	3.3921	−6.0649	767	0.950	
	365	548	400	1,600	20	2.8784	−4.6960	114	0.864	
	258	647	100	3,700	45	3.9561	−7.5496	939	0.956	
	226	645	124	2,700	35	3.1747	−5.3814	1,872	0.983	
	262	621	183	3,330	33	3.2872	−5.7383	1,488	0.980	
	113	451	10	813	112	3.1729	−5.5182	22,127	0.995	
	263	584	200	3,300	123	3.3946	−5.9393	2,486	0.954	f
	269	543	179	1,740	127	3.1713	−5.4152	1,691	0.931	f
	255	452	160	850	25	3.0816	−5.2444	619	0.964	
	260	596	160	2,725	44	3.3104	−5.8366	1,403	0.971	
	394	701	530	4,320	88	3.3272	−5.8776	987	0.921	
	237	497	50	1,450	50	3.6710	−6.6916	330	0.873	
	123	570	25	2,150	25	3.0150	−5.0575	319	0.933	
	185	455	43	866	73	3.3347	−5.9394	4,435	0.984	
	213	518	74	1,402	86	3.2971	−5.7993	6,793	0.988	m, f
	240	659	100	2,900	50	3.3288	−5.9280	6,685	0.993	
	286	560	225	1,600	33	3.1371	−5.3793	314	0.910	
	256	575	120	2,000	37	3.4139	−6.0728	1,477	0.977	
	270	470	220	1,250	204	2.9310	−4.7646	2,294	0.919	
	221	465	96	1,180	109	3.4808	−6.1669	1,402	0.929	
	353	525	450	1,700	21	2.6407	−3.9936	100	0.841	
	315	550	260	2,000	22	3.4200	−6.1362	440	0.957	
	164	600	20	2,350	69	3.7269	−6.9171	2,227	0.971	
	325	535	314	1,529	21	3.1406	−5.3594	216	0.919	
	309	479	244	1,212	28	2.8175	−4.5625	168	0.863	
	228	522	100	1,400	100	3.1870	−5.4625	3,240	0.971	
	298	530	260	1,543	23	3.2485	−5.6582	585	0.965	
	168	490	20	1,550	194	3.7013	−6.8292	10,031	0.981	
	194	499	50	920	30	3.2050	−5.6052	2,417	0.989	
	69	539	2	1,850	287	3.3113	−5.8029	19,246	0.985	i, m, f
	81	818	5	5,100	14,649	3.2107	−5.5863	354,045	0.984	i, m, f
	294	619	250	2,950	119	3.2120	−5.5158	1,832	0.940	
	154	570	28	2,100	80	3.1447	−5.3437	1,584	0.953	f
	147	507	22	1,341	50	3.3143	−5.8514	2,363	0.989	
	292	525	237	1,772	39	3.3375	−5.8229	984	0.964	
	400	565	788	2,477	45	3.3829	−5.9404	369	0.896	f
	181	654	40	3,000	194	3.3454	−5.9015	3,591	0.949	i, m, f
	267	538	100	1,425	48	3.5944	−6.6077	533	0.921	
	207	581	120	2,480	252	3.1063	−5.1939	5,153	0.965	m, f
	159	492	22	1,260	97	3.3831	−5.9747	1,638	0.945	i
	180	530	35	1,395	322	3.4712	−6.2446	13,876	0.977	i, m, f
	342	519	360	1,850	63	3.5158	−6.3113	412	0.871	
	202	600	50	2,220	100	2.8994	−4.7292	2,938	0.968	
	194	585	75	1,800	583	3.2268	−5.5431	4,109	0.876	
	183	557	49	1,800	90	3.3785	−6.0164	7,653	0.989	i
	365	561	460	1,930	19	3.2539	−5.6510	168	0.908	f
	307	591	225	1,984	116	3.3212	−5.8736	5,027	0.978	i, m
	116	524	14	1,800	41	3.2709	−5.6943	5,438	0.993	
	187	542	20	1,700	174	3.6959	−6.9134	4,075	0.960	i, m, f
	105	582	8	2,010	105	3.2843	−5.5977	19,495	0.995	
	216	550	100	2,250	130	3.1232	−5.3166	1,055	0.892	
	187	768	40	2,280	147	3.3131	−5.8693	6,350	0.978	
	261	485	147	1,145	36	3.3071	−5.8403	360	0.914	
	139	595	15	3,100	219	3.4680	−6.1194	7,593	0.972	m, f
	217	691	80	3,770	1,520	3.1583	−5.3700	18,726	0.925	m, f
	260	582	200	2,520	163	3.2765	−5.6733	3,579	0.957	m
	220	547	80	1,605	34	3.4013	−6.0774	3,880	0.992	
	120	559	25	1,775	44	2.9451	−4.8497	1,661	0.975	
	250	580	200	2,000	182	2.8616	−4.6176	866	0.828	
	147	496	10	1,400	116	3.5586	−6.4558	2,899	0.962	
	191	698	40	4,300	97	3.0622	−5.1288	2,673	0.964	m, f
	281	668	160	4,150	40	3.3907	−6.0494	1,073	0.966	
	184	610	49	2,600	30	3.4309	−6.0939	2,112	0.987	
	245	567	150	2,100	68	3.2171	−5.5427	1,365	0.954	
	173	690	48	3,300	402	3.2597	−5.7181	13,890	0.972	i, m, f
	262	568	170	2,400	35	3.6100	−6.5258	3,491	0.991	

TABLE A.1.—Continued.

Region	Population	Latitude	Longitude	Years
ON	L. Simcoe	44°25′00″N	79°20′00″W	1984–1985, 1988, 2002
	Sisseney L.	47°51′59″N	80°40′12″W	2001–2002
	Smoke L.	45°30′55″N	78°40′53″W	1978–1983, 1985, 1987, 1990–1991, 1998
	Smoothrock L.	50°31′31″N	89°26′47″W	2001
	L. St. Joseph	51°04′36″N	90°43′25″W	1989
	Stumpy L.	47°34′38″N	80°45′24″W	2001–2002
	Sutton L.	54°15′14″N	84°41′52″W	1976, 1991
	Sydney L.	50°39′10″N	94°26′34″W	2000
	Toronto L.	50°21′11″N	87°49′17″W	2000
	Trout L.	51°11′55″N	93°18′33″W	1998
	Twelve Mile L.	45°01′31″N	78°42′22″W	1994, 2000
	Wababimiga L.	50°20′38″N	86°22′25″W	1997
	Wabashkang L.	50°23′31″N	93°10′07″W	2003
	Wabatongushi L.	48°27′55″N	84°13′37″W	1998
	Wabigoon L.	49°44′17″N	92°43′07″W	2001
	Wakami L.	47°29′22″N	82°51′03″W	1998, 2001–2002
	Walsh L.	51°07′42″N	93°37′29″W	2002
	Wawang L.	49°25′35″N	90°33′07″W	1998
	Wenebegon L.	47°23′42″N	83°05′56″W	1997
	Wilson L.	46°57′33″N	79°48′22″W	2002
	Wintering L.	49°26′14″N	87°16′22″W	2001
	Wolf L.	47°38′14″N	81°59′14″W	1999
QC	5 km west of Sakami outlet	53°31′40″N	76°45′15″W	1991
	L. Achiyaskunapisuch	52°30′37″N	75°12′39″W	1990
	L. Akwatuk	53°39′52″N	79°03′11″W	1990, 1992
	L. Alder	53°37′32″N	77°17′05″W	1973
	Amont R.	54°45′45″N	69°51′39″W	1973–1974
	Approx L.	50°55′20″N	69°16′13″W	1990
	Apulco L.	54°19′00″N	70°05′40″W	1980, 1981
	Arbour L.	54°09′40″N	72°36′00″W	1993, 1995, 1997, 1999
	L. Atichikami	53°35′27″N	78°22′16″W	1990
	L. BA02	53°28′29″N	76°55′54″W	1980
	Basile Gorge	52°14′29″N	78°06′26″W	1982, 1992
	Baskatong	46°47′58″N	75°50′19″W	1987, 1999
	Bay of Corbeau	50°48′14″N	76°44′18″W	1990–1991
	Bay South of Goose Bay	53°54′15″N	79°04′27″W	1990
	L. Bienvlle	54°43′27″N	72°25′34″W	1989–1990
	L. Bilbo	52°57′06″N	76°58′20″W	1978–1981
	Black Island	53°48′18″N	79°03′15″W	1996
	Blanc Res.	47°47′36″N	73°09′26″W	1990–1991
	Boatswain Bay	51°48′14″N	78°54′53″W	1991
	Border of Duncan Dyke	53°36′27″N	77°30′30″W	1981
	L. Boyd	52°47′30″N	76°40′37″W	1973, 1977, 1992
	L. Brisay	54°30′11″N	70°37′07″W	1982, 1987, 1989, 1991, 1993, 1995, 1997, 1999
	Broadback R.	51°33′10″N	74°49′11″W	1991
	L. Bruce	53°11′17″N	77°56′01″W	1988
	Bustard convergence, Long Forest	50°39′00″N	69°14′00″W	1992
	C L.	53°39′22″N	78°18′40″W	1990
	Cachechu Pt.	51°40′37″N	79°26′12″W	1991
	L. Cambrien	56°22′35″N	69°17′33″W	1980–1984, 1987, 1989, 1991, 1993, 1995
	L. Camousitchouane	51°08′57″N	75°20′24″W	1973, 1976
	L. Caniapiscau	54°09′59″N	69°46′25″W	1980–1982, 1987, 1989, 1991, 1993, 1995, 1997, 1999
	L. Canotaicane	51°09′57″N	76°32′33″W	1979
	L. Carbillet	53°54′23″N	76°33′09″W	1973
	L. Casey	52°06′28″N	75°48′13″W	1980
	L. Chastelain	54°50′36″N	70°06′20″W	1973
	L. Chastenay	48°23′15″N	73°51′48″W	1993
	L. Chisasibi	53°49′00″N	78°55′05″W	1986, 1996, 2000
	Cisapisipuyu Bay	53°57′47″N	76°19′34″W	1978–1984, 1986, 1998, 1990, 1992, 1994, 1996, 1998, 2000
	L. Clarkie	52°13′52″N	75°30′30″W	1980, 1990
	Clay L.	54°37′10″N	79°12′35″W	1990
	Clearcut zone D-21	53°34′00″N	77°29′40″W	1992, 1994, 1996
	L. Corvette	53°25′49″N	74°03′53″W	1973, 1989
	L. Cote	52°42′00″N	76°39′00″W	1986, 1988, 1990, 1992, 1994, 1996, 2000
	L. Coutaceau	53°32′06″N	76°38′03″W	1978–1984, 1986, 1988, 1990, 1992, 1994, 1996, 1998, 2000
	L. Coutaceau	53°31′33″N	76°43′38″W	1973
	L. Craven	54°21′02″N	76°55′23″W	1988
	L. Dana	50°53′00″N	77°20′00″W	1979, 1990–1991
	Dead Duck Bay tributary	53°34′00″N	78°57′00″W	1987
	Dead Duck L.	53°33′31″N	78°56′08″W	1990, 1992, 1996

TABLE A.1.—Extended, continued.

Region	TL_{min}	TL_{max}	W_{min}	W_{max}	N	m	b	F	R^2	Submodel
ON	197	688	35	4,850	2,274	3.3436	−5.9731	12,144	0.842	
	346	541	396	1,700	25	3.1991	−5.5160	795	0.972	
	151	486	22	1,300	279	3.3738	−6.0017	11,848	0.977	
	246	531	100	1,940	21	3.5931	−6.5850	283	0.937	
	164	519	50	1,700	22	3.2228	−5.5560	994	0.980	
	213	496	84	1,167	156	3.2532	−5.6631	6,964	0.978	i, m, f
	181	586	40	2,100	106	3.1657	−5.4631	3,817	0.974	
	283	583	225	2,025	27	3.0676	−5.2016	631	0.962	
	205	691	80	3,160	84	3.1883	−5.5040	10,133	0.992	m, f
	401	608	500	2,100	32	3.3948	−6.1086	239	0.888	
	220	690	48	3,700	91	3.6808	−6.8733	2,083	0.959	
	164	553	31	2,126	36	3.5599	−6.4731	3,955	0.992	
	242	566	100	1,974	50	3.4415	−6.1698	3,320	0.986	m
	214	498	74	1,356	29	3.3665	−5.9683	2,463	0.989	
	122	640	16	4,367	107	3.3133	−5.7872	8,933	0.988	i, m, f
	212	590	98	2,750	157	3.4059	−6.0308	9,943	0.985	m, f
	315	613	280	2,200	42	2.9436	−4.8282	327	0.891	i
	225	549	120	1,575	25	2.9400	−4.8574	612	0.964	
	250	517	155	1,500	117	3.0549	−5.1247	1,016	0.898	m
	221	526	72	1,709	40	3.4488	−6.1829	573	0.938	f
	119	573	12	1,850	26	3.2690	−5.7701	690	0.966	
	223	502	100	1,350	106	3.1926	−5.5071	945	0.901	
QC	300	600	220	2,730	26	3.4999	−6.3127	818	0.972	
	116	550	12	1,765	71	3.2232	−5.6372	5,327	0.987	
	297	542	190	2,000	23	3.6861	−6.8024	962	0.979	
	220	520	100	1,500	63	3.2679	−5.6986	2,520	0.976	i
	108	532	11	1,300	33	2.9836	−5.0084	7,080	0.996	
	182	519	50	1,575	68	3.4684	−6.2127	1,691	0.962	m, f
	111	603	11	2,220	503	3.2158	−5.6220	45,540	0.989	i, m, f
	117	581	8	2,035	545	3.2585	−5.7488	38,331	0.986	m, f
	136	535	24	2,000	70	3.2989	−5.7195	11,082	0.994	i, m, f
	210	496	80	1,185	22	3.2827	−5.7161	1,418	0.986	
	323	489	261	1,113	120	3.4231	−6.1417	1,207	0.911	m, f
	230	565	95	1,575	234	3.2273	−5.6336	8,388	0.973	m, f
	285	497	195	1,290	31	3.1734	−5.4884	837	0.967	
	204	485	62	1,400	37	3.3461	−5.8981	2,571	0.987	
	127	610	9	2,650	152	3.2764	−5.7866	28,229	0.995	m, f
	102	540	9	1,740	825	3.1747	−5.4679	82,483	0.990	i, m, f
	215	500	75	1,320	245	3.2189	−5.6150	17,930	0.987	i
	200	535	55	1,400	42	3.3295	−5.8760	1,140	0.966	
	79	430	10	780	71	3.0826	−5.3191	1,835	0.964	
	380	557	590	2,810	46	3.8140	−7.0824	277	0.863	m
	130	578	10	2,800	229	3.3497	−5.9141	15,052	0.985	i, m, f
	116	637	10	3,405	2,658	3.2411	−5.6907	188,397	0.986	i, m, f
	112	490	8	1,220	101	3.3396	−5.9012	3,174	0.970	m
	110	457	12	885	25	3.0983	−5.2896	6,106	0.996	
	122	615	13	2,360	89	3.2768	−5.7386	16,587	0.995	m, f
	139	372	22	550	63	3.2547	−5.5653	3,229	0.981	i
	163	489	35	1,295	63	3.2623	−5.7078	2,703	0.978	f
	110	614	10	1,740	407	3.2481	−5.7136	31,950	0.987	i, m, f
	200	598	100	2,350	121	2.8519	−4.6090	4,243	0.973	
	80	581	2	2,200	687	3.3622	−6.0035	99,928	0.993	i, m, f
	296	568	215	2,300	23	3.7346	−6.9201	1,253	0.984	
	210	445	70	720	27	3.3465	−5.9639	511	0.953	
	129	414	10	680	39	3.3279	−5.9003	2,410	0.985	
	337	494	330	1,150	67	2.9740	−4.9733	725	0.918	
	178	445	50	880	37	2.7771	−4.4434	360	0.911	
	248	555	141	2,000	113	3.3337	−5.9102	1,049	0.904	m, f
	133	605	16	3,375	873	3.3808	−6.0074	24,902	0.966	i, m, f
	158	579	30	2,110	46	3.3158	−5.8670	5,845	0.993	
	360	590	450	2,190	32	3.0806	−5.2477	415	0.933	
	112	738	11	5,425	3,638	3.2925	−5.7432	62,291	0.945	m, f
	118	672	11	2,365	29	3.2698	−5.7631	6,065	0.996	
	110	600	9	2,100	401	3.1778	−5.5000	30,739	0.987	i, m, f
	106	682	10	3,850	1,268	3.3556	−5.9273	161,665	0.992	i, f
	235	510	160	1,675	80	3.2293	−5.5797	1,226	0.940	i, m, f
	140	535	18	1,700	24	3.2383	−5.6868	4,728	0.995	
	222	496	115	1,325	114	3.2168	−5.5419	1,605	0.935	m, f
	327	475	280	970	30	3.2679	−5.7570	393	0.933	
	167	503	30	1,150	281	3.3635	−5.9802	9,922	0.973	m, f

TABLE A.1.—Continued.

Region	Population	Latitude	Longitude	Years
QC	Delorme	54°31′08″N	69°52′05″W	1980–1982
	L. Denys	54°56′03″N	76°46′57″W	1989
	L. Des Voeux	53°56′36″N	72°37′40″W	1987, 1991, 1993, 1995, 1997, 1999
	L. Deschamps	51°44′08″N	75°14′13″W	1979, 1990, 1991
	L. Detchevery	53°27′13″N	77°27′06″W	1978–1984, 1988, 1990, 1992, 1994, 1996, 1998, 2000
	L. Deverick	48°31′17″N	73°58′34″W	1991
	L. Dollier	54°30′17″N	69°12′58″W	1980–1982, 1987, 1989, 1991, 1993, 1995, 1997, 1999
	L. Douze	53°46′41″N	76°29′41″W	1976
	Downstream Eastmain R.	52°14′17″N	78°27′24″W	1982, 1992
	L. Du Grand Detour	49°58′19″N	70°32′22″W	1999
	L. Duncan	53°29′31″N	77°48′29″W	1977, 1990
	Eastmain	52°15′25″N	77°13′27″W	1978–1984, 1986, 1988, 1990, 1992, 1994, 1996, 2000
	Eastmain tributary	52°14′25″N	78°20′25″W	1984, 1988, 1992,
	Eaton	55°20′19″N	68°45′20″W	1980–1984, 1987, 1989, 1991, 1993, 1995, 1999
	L. Ell.	52°40′50″N	76°07′00″W	1977
	L. Embarras	46°54′02″N	76°30′35″W	1987
	L. Evans	50°51′29″N	77°20′26″W	1976, 1979, 1990–1991
	L. Faguy	48°32′36″N	73°49′50″W	1990
	L. Flamand	47°38′21″N	73°22′25″W	1991
	L. Fontanges	54°37′49″N	71°07′20″W	1973, 1989, 1991, 1993, 1995, 1997, 1999
	Fort George	53°49′46″N	78°56′01″W	1978–1984, 1986, 1988, 1990, 1992, 1994, 1998, 2000
	L. Fregate	53°11′36″N	74°41′30″W	1989
	L. Fressel	55°25′47″N	75°11′57″W	1989
	L. Gabbro	53°44′57″N	65°22′02″W	1987
	L. Gaillarbois	51°52′11″N	67°23′00″W	1997
	Gavaudan L.	53°41′28″N	74°36′23″W	1976, 1988, 1990, 1992, 1994, 1996, 1998, 2000
	L. Giffard	51°10′00″N	76°55′00″W	1979, 1990
	L. Goeland	49°49′15″N	76°47′44″W	1979, 1988, 1990
	Goose Isl.	53°02′00″N	79°00′00″W	1990
	L. Goselier	55°13′00″N	73°14′60″W	1990
	Gouin Res.	48°23′08″N	74°09′32″W	1990
	Grande Pt.	53°51′38″N	75°39′41″W	1986, 1990, 1992, 1994, 1996, 1998, 2000
	Grande R. (km 172)	55°03′00″N	75°53′04″W	1990
	Grande R. upstream of GB1	55°02′00″N	76°11′00″W	1990
	L. Grande-Pointe	53°52′18″N	75°30′21″W	1973
	L. Gras	52°20′00″N	67°08′00″W	1987
	L. Grasset	49°56′00″N	78°10′00″W	1990
	L. Gull	52°58′60″N	61°19′54″W	1987, 1992
	L. Guyer	53°32′40″N	75°22′26″W	1976
	L. Hazeur	54°57′54″N	69°13′41″W	1982, 1987, 1991, 1993, 1995, 1997, 1999
	L. Helene	53°26′27″N	77°33′25″W	1974–1976
	L. Herve	54°27′12″N	71°12′54″W	1977, 1987
	L. Hore	51°43′42″N	74°58′42″W	1991
	L. Hurault	54°15′50″N	70°47′17″W	1977
	L. Intersection	54°24′41″N	77°30′42″W	1988
	Jacob Isl.	51°44′19″N	79°17′13″W	1991
	James Bay	53°49′25″N	79°05′23″W	1973, 1992, 1996
	L. Jean Pere	47°04′00″N	76°38′00″W	1989
	L. Jobert	54°13′60″N	72°41′55″W	1987, 1991, 1993, 1995, 1997, 1999
	L. Jolliet	51°33′00″N	76°54′40″W	1979, 1990–1991
	L. Julian	54°27′53″N	77°49′58″W	1988
	L. Kachiuschekw Marsh	51°29′00″N	76°07′00″W	1990–1991
	L. Kakupis	55°42′05″N	75°36′05″W	1989–1990
	L. Kamichikamach	53°37′00″N	75°25′00″W	1988
	Kamuwashaukau Reef	51°57′15″N	78°54′09″W	1991
	Kanaaupscow Res.	53°55′38″N	76°40′36″W	1978–1984
	L. Kawayapiskaw	54°17′02″N	77°13′50″W	1989
	L. Kaychikutinaw	52°58′00″N	77°10′00″W	1988
	LA2 Res.	54°31′38″N	70°32′20″W	1989
	Ladouceur	53°26′38″N	76°42′32″W	1986, 1988, 1990, 1992, 1994, 1996, 2000
	Laforge 1 phase 2	54°31′57″N	72°17′63″W	1993, 1995, 1997, 1999
	Laforge LA1	54°15′30″N	72°25′30″W	1987, 1989, 1991, 1993, 1995, 1997, 1999
	Unnamed L. (9 km west of L. Frontange)	53°49′01″N	74°36′46″W	1976
	Lanouette	53°50′00″N	73°27′00″W	1987, 1989, 1991, 1993, 1995, 1997, 1999
	Unnamed L. (3 km south of the fjord of LG3)	53°36′36″N	75°23′35″W	1976
	L. Le Bel	55°25′24″N	77°10′27″W	1973, 1991
	L. Le Fer	55°17′34″N	67°20′30″W	1980
	L. Lemoine (L. Canichico)	56°46′35″N	68°51′04″W	1980

TABLE A.1.—Extended, continued.

Region	TL_{min}	TL_{max}	W_{min}	W_{max}	N	m	b	F	R^2	Submodel
QC	163	593	34	2,330	238	3.2949	−5.8225	11,561	0.980	m, f
	187	515	46	1,180	23	3.3535	−5.9883	4,252	0.995	
	82	662	3	2,650	205	3.2330	−5.6788	59,617	0.997	m, f
	170	550	45	1,720	115	2.9484	−4.8969	2,387	0.955	m, f
	200	525	40	1,365	209	3.3015	−5.8144	3,184	0.939	m, f
	178	484	47	1,039	70	3.0942	−5.2830	19,616	0.997	
	75	612	2	2,410	2,284	3.3144	−5.8712	410,686	0.994	i, m, f
	219	456	80	840	23	3.1424	−5.4399	3,073	0.993	
	267	454	140	865	99	3.1194	−5.3721	2,103	0.956	i, m, f
	138	520	20	1,250	40	3.1198	−5.4607	284	0.882	
	210	537	66	1,515	99	3.2702	−5.7314	9,072	0.989	m, f
	101	625	10	7,750	1,131	3.2119	−5.5717	49,846	0.978	i, m, f
	48	502	1	1,400	782	3.2023	−5.5311	170,572	0.995	i, m, f
	130	531	14	1,375	627	3.2373	−5.7026	29,464	0.979	i, m, f
	305	475	235	1,140	24	3.4457	−6.1812	2,354	0.991	
	180	462	30	880	32	3.2971	−5.8461	2,063	0.986	
	101	540	5	1,875	397	3.2618	−5.6752	41,934	0.991	i, m, f
	101	477	9	910	300	3.0324	−5.1176	20,294	0.986	m, f
	156	485	32	1,062	50	3.2979	−5.8012	6,734	0.993	
	120	694	12	2,040	565	3.3043	−5.8499	67,388	0.992	m, f
	117	591	13	1,730	430	3.2668	−5.7087	26,249	0.984	i, m, f
	121	590	11	1,860	21	3.2735	−5.8138	6,842	0.997	
	134	541	17	1,360	36	3.2732	−5.7867	7,982	0.996	
	200	570	80	2,400	64	3.1203	−5.3023	2,726	0.978	
	120	545	13	1,440	46	3.1771	−5.5183	10,955	0.996	i
	111	610	10	2,280	194	3.3172	−5.8651	23,192	0.992	m, f
	107	538	10	1,595	70	3.2393	−5.6028	23,065	0.997	
	102	530	10	1,700	179	2.9292	−4.8317	4,506	0.962	f
	303	470	283	1,021	56	2.8946	−4.7314	318	0.855	m, f
	125	475	10	925	25	3.2677	−5.7781	1,211	0.981	
	131	461	15	927	30	3.2086	−5.5964	5,333	0.995	
	124	630	13	3,360	265	3.2905	−5.7849	12,991	0.980	i, m, f
	200	514	50	2,980	22	3.3245	−5.9058	170	0.895	
	130	552	29	1,670	23	2.9285	−4.8872	2,180	0.990	
	226	557	85	1,650	50	3.3990	−6.0638	4,614	0.990	f
	122	509	11	1,394	82	3.2140	−5.6284	7,097	0.989	i, f
	258	465	180	945	28	2.9526	−4.8571	608	0.959	
	241	466	103	981	57	3.2504	−5.6813	1,947	0.973	
	128	612	16	2,515	97	3.2488	−5.7024	29,847	0.997	i, m, f
	78	589	3	2,160	1,325	3.2840	−5.7993	294,525	0.996	i, m, f
	80	485	4	1,140	322	3.1181	−5.3232	60,842	0.995	i, m, f
	199	545	59	1,600	59	3.2796	−5.8054	6,485	0.991	m
	436	607	760	2,150	30	3.2128	−5.5956	544	0.951	m
	172	578	37	1,770	23	3.2270	−5.6427	1,081	0.981	
	180	472	35	850	20	3.3269	−5.9131	3,152	0.994	
	75	313	3	270	35	3.1960	−5.5297	1,735	0.983	
	208	515	70	1,225	70	3.3046	−5.8330	3,727	0.982	i
	185	516	75	1,400	243	3.1100	−5.3109	7,805	0.970	i, m, f
	115	535	11	1,455	784	3.1931	−5.5639	55,770	0.986	i, m, f
	160	568	20	1,890	181	3.4057	−6.0990	7,958	0.978	m, f
	253	586	110	2,130	20	3.1213	−5.3406	278	0.939	
	180	517	35	1,260	81	3.3694	−6.0032	3,927	0.980	i, m, f
	133	615	15	2,310	121	3.3055	−5.8506	27,184	0.996	
	123	573	11	1,490	31	3.3143	−5.9084	2,342	0.988	
	115	452	12	945	37	3.2859	−5.7834	2,710	0.987	
	111	590	11	2,370	400	3.3456	−5.8882	15,650	0.975	i, m, f
	146	596	20	2,300	59	3.4681	−6.2252	8,819	0.994	
	155	560	24	1,245	23	3.1264	−5.4533	3,334	0.994	
	118	617	12	2,645	1,907	3.2442	−5.6373	100,083	0.981	
	108	556	4	2,090	226	3.2883	−5.7842	20,798	0.989	i, m, f
	110	585	10	2,040	1,478	3.0882	−5.2877	206,898	0.993	i, m, f
	110	572	10	2,000	521	3.2351	−5.6502	81,136	0.994	i, m, f
	345	505	320	1,275	26	3.4713	−6.2825	481	0.952	
	138	581	16	2,305	316	3.3682	−5.9880	30,065	0.990	m, f
	130	331	14	300	30	3.2474	−5.7333	3,702	0.992	
	241	542	100	1,550	26	3.3558	−5.9826	1,268	0.981	
	140	569	10	1,845	69	3.4804	−6.2976	6,334	0.990	f
	210	480	50	1,080	24	3.5786	−6.5722	2,758	0.992	

TABLE A.1.—Continued.

Region	Population	Latitude	Longitude	Years
QC	L. Lessard	49°27′00″N	75°45′00″W	1976, 1989
	L. Letemplier	49°27′30″N	68°48′00″W	1988
	L. Levasseur	48°30′00″N	74°02′22″W	1990
	LG1 downstream	53°44′44″N	78°33′28″W	1978–1984, 1986, 1988, 1990, 1992, 1994, 1996, 1998, 2000
	LG2 downstream	53°47′30″N	77°33′00″W	1986, 1988, 1990, 1992, 1994, 1996, 1998, 2000
	LG2 northwest	53°49′40″N	77°21′13″W	1978–1984, 1986, 1988, 1990, 1992, 1994, 1996, 1998, 2000
	LG2 (previously L. Detcheverry)	53°26′18″N	77°29′02″W	1973–1976
	LG2 (previously L. Toto)	53°29′27″N	77°06′04″W	1978–1984, 1986, 1988, 1990, 1992, 1994, 1996, 1998, 2000
	LG3 downstream	53°43′06″N	76°10′01″W	1978–1984, 1986, 1988, 1990, 1992, 1994, 1996, 1998, 2000
	LG4 downstream	53°42′00″N	74°02′00″W	1984, 1993, 1995, 1997, 1999
	LG4 Res.	53°58′23″N	73°33′09″W	1976
	L. Lobstick	53°33′32″N	64°16′59″W	1987, 1992
	Long Forest	50°55′00″N	68°55′00″W	1990
	L. Loups Marins	56°30′12″N	73°34′21″W	1989–1990
	L. Low	52°25′44″N	76°26′55″W	1978–1984, 1988, 1990, 1992, 1994, 1996, 1998, 2000
	L. Low section 2	52°28′47″N	76°18′38″W	1973
	L. Maicasagi	49°57′00″N	76°40′00″W	1979, 1990
	Manic 5 Res.	51°21′06″N	68°49′13″W	1985, 1988, 1990
	Manic 5 Res.	50°35′00″N	68°37′00″W	1988–1989
	L. Manuup	54°40′56″N	79°23′52″W	1990
	L. Marcel	56°50′33″N	68°06′19″W	1980
	L. Matagami (east)	49°52′12″N	77°23′22″W	1973, 1976, 1979, 1990–1991
	L. Matagami (west)	49°51′46″N	77°40′08″W	1973, 1976, 1979, 1990–1991
	L. McNab	52°53′50″N	77°26′17″W	1988
	L. Mesgouez	51°22′12″N	75°08′24″W	1973, 1979, 1990, 1991
	Mestao Falls	50°47′20″N	69°18′40″W	1992
	L. Midway	52°28′30″N	67°02′00″W	1992
	L. Minahikuskaw	54°27′39″N	79°06′21″W	1990
	L. Mistassini	50°30′21″N	73°40′22″W	1973, 1976
	L. Montmort	51°09′00″N	74°50′00″W	1990
	L. Morpain	55°00′06″N	74°17′59″W	1989
	L. Mureau	54°56′01″N	75°13′12″W	1989–1990
	L. Nachicapau	56°39′34″N	68°11′32″W	1980
	L. Nathalie	53°27′34″N	77°25′36″W	1974–1976
	L. Nemiscau	51°28′18″N	76°36′31″W	1979, 1990–1991
	L. Nemiscau downstream	51°24′25″N	76°45′28″W	1990–1991
	North River L. Narrows	54°39′16″N	79°19′45″W	1990
	L. North Village	52°11′47″N	75°18′28″W	1980, 1990
	Nottaway R., first rapids	51°10′34″N	78°54′25″W	1991
	Nottaway R. (km 55)	50°56′54″N	78°16′10″W	1990–1991
	L. Nouveau	53°58′49″N	69°03′12″W	1980–1981
	L. Noye	52°30′45″N	76°35′24″W	1978–1984, 1988, 1990, 1992, 1994, 1996, 1998, 2000
	L. of Cedars	52°03′00″N	67°09′00″W	1992
	L. of Tast Bay	51°00′00″N	77°20′00″W	1979, 1990
	L. Old Factory	52°35′00″N	78°46′00″W	1990
	L. Olga	49°48′48″N	77°11′42″W	1976, 1979, 1990–1991
	L. Opinaca	52°40′04″N	76°31′55″W	1978–1984, 1986, 1988, 1990, 1992, 1994, 1996, 1998, 2000
	L. Opinaca North West Bay	52°39′25″N	76°19′30″W	1973
	L. Otelnuk	56°08′32″N	68°14′35″W	1980
	Outardes 2 Res.	49°24′27″N	69°24′14″W	1984, 1992
	Outardes 4 Res.	50°25′00″N	69°15′00″W	1990, 1992
	Outardes 5 Res.	50°45′00″N	69°16′30″W	1992
	L. Page	54°09′30″N	73°13′30″W	1987, 1989, 1991, 1993, 1995, 1997, 1999
	L. Pamigamachi	54°10′26″N	77°28′55″W	1988
	Paul Bay	54°01′29″N	79°04′11″W	1990, 1992, 1996
	L. Petit	53°48′30″N	74°50′26″W	1976
	L. Petit east of L. Magin	53°34′35″N	74°10′37″W	1976
	L. Petit south of LG3	53°32′32″N	75°31′52″W	1976
	L. Pine Mountain	53°58′39″N	75°38′25″W	1988
	Pipmuacan Res.	49°40′00″N	70°20′00″W	1990
	L. Pletipi	51°45′00″N	70°05′00″W	1990
	Point Fiedmont	52°14′54″N	78°34′59″W	1992
	Polaris Grande R.	53°49′20″N	73°02′00″W	1991
	L. Poncheville	50°05′35″N	77°19′28″W	1979, 1990–1991
	L. Poncheville North Isl.	50°21′31″N	76°43′20″W	1991
	L. Poree	54°46′39″N	69°38′43″W	1973
	L. Pres Elizabeth	55°40′02″N	75°36′38″W	1973
	L. Pusticamica	49°19′00″N	76°27′00″W	1976, 1988
	L. Rejean	48°24′55″N	73°58′25″W	1988
	L. Rocher	50°35′21″N	76°25′10″W	1976, 1990

TABLE A.1.—Extended, continued.

Region	TL_{min}	TL_{max}	W_{min}	W_{max}	N	m	b	F	R^2	Submodel
QC	390	534	535	1,870	34	3.0458	−5.1066	261	0.891	
	127	600	15	2,200	82	3.1927	−5.5584	6,531	0.988	m, f
	126	442	15	795	51	3.1574	−5.4615	6,956	0.993	f
	107	616	9	2,785	1,743	3.3007	−5.7906	84,722	0.980	i, m, f
	131	666	17	8,420	2,922	3.4992	−6.3276	38,704	0.930	i, m, f
	110	635	11	3,075	1,174	3.3427	−5.8846	48,064	0.976	f
	262	514	140	1,385	251	3.1804	−5.4683	3,642	0.936	i, m, f
	171	780	50	3,250	91	2.9604	−4.8803	2,110	0.960	i, m, f
	102	621	8	2,980	1,005	3.3023	−5.7661	55,330	0.982	i, m, f
	110	665	5	2,880	226	3.3952	−6.0705	28,138	0.992	m, f
	124	491	12	1,140	32	3.1911	−5.5637	7,397	0.996	
	122	536	20	2,192	91	3.0636	−5.1799	3,032	0.971	
	123	763	25	2,775	65	2.9632	−4.9664	2,615	0.976	m, f
	141	465	15	970	90	3.3193	−5.8709	2,537	0.966	m
	111	641	10	3,000	655	3.3150	−5.8372	45,462	0.986	
	335	590	334	2,150	27	3.1784	−5.5032	964	0.975	i, m, f
	140	455	25	1,050	26	2.9275	−4.8189	1,502	0.984	
	112	630	9	2,600	1,208	3.2502	−5.7054	102,503	0.988	i, m, f
	120	540	9	1,890	145	3.4346	−6.1432	5,614	0.975	m, f
	124	468	16	950	45	3.1845	−5.5249	7,146	0.994	
	160	580	20	1,850	28	3.4997	−6.3786	4,798	0.995	
	125	512	20	1,475	165	3.3873	−5.9509	3,133	0.951	i, m
	116	518	10	1,325	174	3.2644	−5.6810	3,089	0.947	m, f
	151	387	28	595	18	3.2445	−5.6647	2,341	0.993	
	121	510	10	1,300	150	3.2311	−5.6323	10,198	0.986	i, f
	117	582	10	2,060	29	3.2683	−5.7229	6,737	0.996	
	112	594	9	2,349	86	3.3345	−5.8592	17,931	0.995	
	146	590	26	2,230	120	3.1859	−5.4912	9,985	0.988	i, m, f
	163	624	50	2,400	60	3.2191	−5.5952	1,543	0.964	
	195	534	50	1,550	32	3.3438	−5.9358	4,324	0.993	
	125	320	13	260	87	3.4290	−6.1139	1,382	0.942	m, f
	135	658	15	935	162	3.2481	−5.6784	3,694	0.958	m, f
	133	712	20	4,200	22	3.2221	−5.6406	2,695	0.993	
	291	540	180	1,420	368	3.1789	−5.4643	3,129	0.895	i, f
	325	530	340	1,675	146	2.9445	−4.8781	1,179	0.891	m, f
	106	575	5	1,475	244	3.1789	−5.5200	4,198	0.946	m, f
	390	530	550	1,540	50	3.2549	−5.6966	364	0.884	m, f
	125	583	10	1,580	88	3.2051	−5.6171	5,588	0.985	
	285	480	175	1,105	37	3.4773	−6.2424	606	0.945	
	118	522	10	1,645	22	3.4429	−6.1327	3,525	0.994	
	132	622	17	2,530	262	3.2463	−5.7024	35,275	0.993	m, f
	100	677	10	3,620	3,181	3.2593	−5.6354	196,851	0.984	i, m, f
	110	433	9	773	88	3.2460	−5.6975	11,583	0.993	m, f
	172	522	50	1,920	112	3.0680	−5.1423	1,007	0.902	m, f
	325	546	283	2,041	90	3.4669	−6.2044	2,059	0.959	m, f
	163	484	35	1,370	96	3.6382	−6.6074	2,294	0.961	
	102	627	8	3,160	1,022	3.2998	−5.7702	46,793	0.979	i, m, f
	230	522	100	1,500	102	3.2514	−5.6724	4,660	0.979	m
	136	690	15	3,945	34	3.3841	−6.0257	9,759	0.997	
	115	530	15	1,475	72	2.9824	−4.9977	1,842	0.963	
	110	625	15	2,500	219	2.8958	−4.6802	25,835	0.992	m, f
	120	598	11	2,310	69	3.3689	−5.9722	8,723	0.992	m, f
	106	595	10	2,360	459	3.2186	−5.6157	129,196	0.996	i, m, f
	190	530	50	1,470	20	3.2862	−5.8074	2,384	0.993	
	131	535	5	2,150	104	3.4058	−6.0982	449	0.815	m
	377	613	460	2,060	24	3.1692	−5.4977	465	0.955	
	273	503	150	1,400	24	3.2777	−5.7712	1,453	0.985	
	333	502	310	1,160	34	2.9244	−4.8618	248	0.886	
	223	604	80	1,890	24	3.1418	−5.4390	333	0.938	
	110	633	25	3,000	295	2.8448	−4.6181	7,111	0.960	i, m, f
	109	667	25	3,750	174	2.7134	−4.3179	4,312	0.962	f
	53	446	1	905	100	3.1975	−5.5256	64,298	0.998	i, f
	216	590	76	2,370	19	3.5555	−6.5035	1,190	0.986	
	105	555	10	1,915	126	3.1253	−5.3330	9,098	0.987	m
	282	524	170	1,560	32	3.1424	−5.4399	3,073	0.993	m
	372	582	450	1,690	23	3.0270	−5.1208	861	0.976	
	216	496	80	1,080	30	3.1202	−5.4161	730	0.963	
	251	520	125	2,050	73	3.5037	−6.2347	454	0.865	
	165	312	32	300	26	3.4040	−6.0771	1,518	0.984	
	150	513	20	1,700	31	3.2888	−5.7121	2,423	0.988	

TABLE A.1.—Continued.

Region	Population	Latitude	Longitude	Years
QC	L. Rodayer	50°52′00″N	77°42′00″W	1990
	L. Roggan	54°09′33″N	77°46′58″W	1988
	L. Rond-de-Poele	52°34′24″N	77°04′24″W	1978–1984, 1986, 1988, 1990, 1992, 1994, 1996, 1998, 2000
	Rouge Falls	49°51′50″N	77°12′19″W	1990
	L. Roy	53°28′23″N	75°56′57″W	1986, 1988, 1990, 1992, 1994, 1996, 1998, 2000
	L. Rupert-Misjaway	51°27′10″N	75°01′33″W	1990
	L. Saindon	55°43′08″N	73°25′38″W	1990
	L. Sakami	53°36′27″N	76°42′33″W	1973, 1977
	L. Sakami, sector 2	53°05′17″N	76°56′01″W	1978–1984, 1986, 1988, 1990, 1992, 1994, 1996, 1998, 2000
	L. Sandgrit	53°56′40″N	65°00′40″W	1987, 1992
	L. Schetange	54°27′30″N	72°05′00″W	1987
	L. Scott	49°49′00″N	74°40′00″W	1976
	L. Serginy	55°20′59″N	69°40′41″W	1980, 1993, 1995, 1997, 1999
	L. Seuil	52°28′11″N	77°05′04″W	1988
	SM2	50°12′56″N	66°39′54″W	1987, 1992
	L. Smokey Hill	51°30′00″N	78°23′00″W	1991
	L. Soscumica	50°16′27″N	77°33′08″W	1979, 1990
	Spiral pools LG2	53°47′00″N	77°32′00″W	1988, 1990
	L. St. Jean	49°29′18″N	73°21′00″W	1989
	St. Marguerite Res.	51°23′40″N	66°57′30″W	1987
	St. Maurice Jetty	47°43′03″N	73°17′24″W	1991–1992
	T L.	51°58′42″N	75°38′52″W	1981
	L. Tetepisca	51°02′29″N	69°23′58″W	1989
	L. Theodat	50°54′20″N	76°11′12″W	1990
	Tributary L. of Lac Boyd	52°54′22″N	76°51′40″W	1977
	Tributary of L. Desegenettes	54°22′22″N	68°40′33″W	1997
	Tributary of L. Lamartilleres	54°27′11″N	68°48′09″W	1997
	Tributary of Lecourbe Bay	54°12′38″N	69°01′15″W	1997
	Tributary, Robert Bourassa Res.	53°52′35″N	76°59′55″W	1981, 1983
	Unnamed	52°14′10″N	78°08′25″W	1982, 1994, 1992
	Unnamed	51°09′20″N	67°01′00″W	1996
	Unnamed	53°46′47″N	79°05′22″W	1987, 1990
	L. Upasi	54°30′58″N	79°13′19″W	1990
	L. Vallee de Detour	55°44′26″N	76°03′27″W	1990
	L. Vaulezar	54°31′40″N	71°51′49″W	1993
	L. Vermeulle	54°43′11″N	69°28′58″W	1980–1982, 1987, 1989, 1991, 1993, 1995, 1997, 1999
	L. Vincelotte	54°35′30″N	71°21′30″W	1987, 1989, 1991, 1993, 1995, 1997, 1999
	L. Waconichi	50°03′00″N	74°08′00″W	1976
	L. Walleye	54°15′09″N	75°57′55″W	1976
	L. Wapaskw	55°29′00″N	76°27′00″W	1973, 1989
	L. Waswanipi	49°30′11″N	76°29′30″W	1976, 1979, 1988, 1990
	L. Wawa	54°16′19″N	76°45′38″W	1976, 1986
	Whale R. tributary	56°00′03″N	76°47′02″W	1990
	Whale R. rapids	55°59′12″N	76°42′08″W	1990
	L. Winokapau	53°08′55″N	62°69′30″W	1987
	L. Winokapau south of Churchill R.	53°30′44″N	64°00′37″W	1987, 1992
	L. Woollett	51°24′28″N	73°46′23″W	1973, 1976
	L. Yasinski	53°16′28″N	77°34′43″W	1973, 1988
	L. Zaidi	53°56′50″N	74°26′00″W	1986, 1988

TABLE A.1.—Extended, continued.

Region	TL_{min}	TL_{max}	W_{min}	W_{max}	N	m	b	F	R^2	Submodel
QC	100	515	20	1,640	154	2.6847	−4.2773	2,331	0.939	m, f
	137	555	10	1,685	28	3.4550	−6.2519	3,028	0.991	
	109	577	9	1,920	1,548	3.2488	−5.6670	137,472	0.989	i, m, f
	302	518	260	1,465	95	3.0765	−5.2043	1,594	0.945	m, f
	110	690	12	4,600	421	3.2252	−5.6061	17,136	0.976	m, f
	336	552	320	1,700	26	2.5669	−3.9301	912	0.974	
	385	630	550	2,620	21	2.9188	−4.7955	352	0.949	f
	161	562	33	1,899	284	3.2237	−5.5984	7,457	0.964	i, m, f
	117	614	10	2,395	977	3.2608	−5.7229	75,524	0.987	i, m, f
	154	560	20	1,800	190	3.2699	−5.7331	5,077	0.964	m, f
	118	561	12	1,665	102	3.1697	−5.4956	35,301	0.997	
	350	510	450	1,800	60	2.8600	−4.5493	260	0.817	
	81	602	4	1,950	327	3.2532	−5.7114	38,426	0.992	i, m, f
	105	545	9	1,880	68	3.2051	−5.5065	3,312	0.980	
	146	480	22	1,299	59	3.3916	−6.0414	5,001	0.989	m, f
	206	488	65	1,105	44	3.2554	−5.7177	3,098	0.987	m
	189	424	50	865	65	3.1974	−5.4808	2,507	0.975	
	300	575	260	1,870	63	3.2408	−5.6570	1,062	0.946	
	165	551	50	1,800	52	2.9769	−5.0104	425	0.895	
	116	529	11	1,500	34	3.1780	−5.5366	10,504	0.997	
	187	487	50	1,025	87	3.1329	−5.3718	4,106	0.980	
	306	545	260	1,920	26	3.3507	−5.9091	940	0.975	
	120	530	11	1,500	90	3.1598	−5.4768	22,764	0.996	
	166	596	40	2,010	75	3.1133	−5.3335	4,422	0.984	m, f
	293	472	220	1,250	25	3.5950	−6.5257	1,707	0.987	
	170	590	25	2,400	210	3.2969	−5.8672	3,475	0.944	f
	180	588	40	1,900	131	3.1955	−5.6046	2,988	0.959	i, f
	195	568	50	1,825	27	3.7757	−7.1265	620	0.961	
	162	507	33	1,910	59	3.3526	−5.9304	5,883	0.990	m, f
	306	504	235	1,430	107	3.3098	−5.8502	2,010	0.950	f
	96	326	6	260	63	3.1469	−5.4799	10,617	0.994	i
	323	550	280	1,850	28	3.4454	−6.2099	767	0.967	
	260	565	150	2,000	28	3.2857	−5.7312	2,556	0.990	
	175	442	40	880	33	3.1780	−5.5091	3,434	0.991	
	148	560	20	1,850	106	3.3098	−5.8597	27,492	0.996	m, f
	80	574	3	2,300	1,721	3.3303	−5.9162	164,326	0.990	i, m, f
	116	590	8	2,510	1,104	3.2485	−5.7256	87,775	0.988	i, m, f
	400	550	625	1,700	30	3.4191	−6.1342	283	0.910	
	180	547	42	1,638	26	3.3088	−5.8646	8,290	0.997	
	131	534	15	1,690	56	3.3145	−5.8773	3,842	0.986	
	202	527	70	1,700	234	3.0408	−5.1026	1,758	0.883	m, f
	128	546	14	1,520	54	3.2741	−5.7862	12,649	0.996	
	162	488	32	466	29	2.8841	−4.7856	393	0.936	
	164	378	29	497	23	3.3984	−6.0553	952	0.978	
	117	450	10	1,000	56	3.3965	−6.0338	1,995	0.974	
	113	512	10	1,540	79	3.1083	−5.2982	5,421	0.986	m, f
	150	565	50	1,900	35	2.8585	−4.5850	933	0.966	
	164	520	30	1,250	217	3.1891	−5.5348	10,948	0.981	i, m, f
	275	598	140	2,005	45	3.2589	−5.6934	366	0.895	