The Importance of Plankton to Fish: Food Web Studies through Integrated Sensors

Garry Sprules[1] and Brian J. Shuter[2]

[1] Department of Zoology, University of Toronto at Mississauga,
Mississauga, ON, L5L 1C6
gsprules@cyclops.erin.utoronto.ca
(905) 828 3987

[2] Ontario Ministry of Natural Resource and Department of Zoology, University of Toronto,
shuter@zoo.utoronto.ca
(416) 978-7338

The rates of many ecological processes, including those such as growth and consumption, are strongly correlated with body size in freshwater organisms (Peters 1984). Boudreau and Dickies (1992) developed a model of energy transfer between adjacent trophic groups (e.g., zooplankton to fish) based on the fact that a) specific production (production: biomass) of the predator is size dependent, b) the product of predator growth efficiency and the predator mortality imposed on the prey is size dependent, and c) the predator: prey size ratio is constant for all adjacent trophic groups. Thiebaux and Dickie (1992) presented an analytical solution to this model that can be visualised as a biomass size spectrum –a double-logarithmic graph of body mass (X-axis) against normalized biomass (total biomass per logarithmic mass interval divided by the width of the interval). Such a graph consists of a series of parabolas of constant curvature, each one corresponding to a major trophic grouping (algae, zooplankton, fish). The parabolas are arranged along a roughly straight line of negative slope with each parabola shifted constant distances down the Y-axis and along the X-axis relative to the previous one (Kerr and Dickie 2001).

Working with mean annual biomasses measured in logarithmic size intervals for all pelagic organisms in Lake Ontario, Sprules and Goyke (1994) estimated all parameters required for a complete specification of the biomass size spectrum and its componenet parabolas. They also showed for Lake Ontario that estimates of seasonal zooplankton and planktivorous fish production derived from the Thiebaux-Dickie model conform closely to independent estimates based on egg-ratio or bioenergetic models. Since the food webs of Lake Ontario and Lake Opeongo are broadly similar (large salmon or lake trout (*Salvelinus namaycush*) feed on smaller alewives (*Alosa pseudoharengus*) and cisco that feed on a small-bodied assemblages of zooplankton), it is reasonable to use the Lake Ontario size spectrum to predict annual lake trout production in Lake Opeongo from data on zooplankton biomass.

Zooplankton biomass was estimated from repeated surveys along a linear transect in the upper portion of the south arm of Lake Opeongo during spring, summer and fall from 1998 to 2000 using an Optical Plankton Counter (Herman 1992). The mean and variance in the zooplankton biomass parabola for Lake Opeongo were specified from these data. This parabola was then shifted along the X and Y-axes of the size spectrum to the position expected for the Lake Opeongo fish parabola using the Lake Ontario parameters. The biomass of fish in the bodymass range occupied by lake trout from 4 to 12 years of age (approximately 100-4000g) was converted to annual production through multiplication by size-dependent annual production:biomass (P:B) ratios (Banse and Mosher 1980) to give a value of 8197 kg (bootstrapped 90% confidence interval 2,249-47,670 kg) for the whole lake. This value compares to 4,060 kg computed for the same aged fish from creel data and virtual population analyses for the period 1960 to 1983 (Carl *et al*. 1991).

These values compare well considering that the only sampling date used from Lake Opeongo was for zooplankton and that the parameter values are from Lake Ontario. The production estimate from the size spectrum is higher than that based on lake trout population to date, but it must be realised that any fish falling into the size range used for lake trout are included (e.g., lake whitefish-*Coregonus clupeaformis*, burbot-*Lota lota*). Bootstrapped variability in the size spectrum prediction is very large indicating high sensitivity of the model to some parameters. These results suggest some promise for the use of easily collected body size and biomass data on one group of organisms as a basis for establishing the general range within which production of a target group of organism falls.

References

Banse, K. and S. Mosher. 1980. Adult body mass and annual production/biomass relationships of field populations. *Ecological Monographs,* 50: 335-379.

Boudreau, P.R. and L.M. Dickie. 1992. Biomass spectra of aquatic ecosystems in relation to fisheries yield. *Canadian Journal of Fisheries and Aquatic Science,* 49: 1528-1538.

Carl, L.M., B.J. Shuter and J.E. Matszek. 1991. Production and instantaneous growth rates of lake trout (*Salvelinus namaycush*) before and after lake herring (*Coregonus artedii*) introduction in Lake Opeongo, Ontario. *American Fisheries Society Symposium* 12: 476-480.

Herman, A.W. 1992. Design and calibration of a new optical plankton counter capable of sizing small zooplankton. *Deep-Sea Research,* 39: 395-415.

Kerr,S.R. and L.M. Dickie. 2001. *The Biomass Size Spectrum: A Predator-Prey Theory of Aquatic Production*. Columbia University Press, New York, 320.

Peters, R.H. 1983. *The Ecological Implications of Body Size*. Cambridge University Press, Cambridge, 329.

Sprules, W.G. and A.P. Goyke. 1994. Size-based structure and production in the pelagia of Lakes Ontario and Michigan. *Canadian Journal of Fisheries and Aquatic Science,* 51: 2603-2611.

Thiebaux, M.L. and L.M. Dickie. 1992 Models of aquatic biomass size spectra and the common structure of their solutions. *Journal of Theoretical Biology,,* 159:147-161.