

**McLaren I A.** Effects of temperature on growth of zooplankton, and the adaptive value of vertical migration. *J. Fish. Res. Board Can.* 20:685-727, 1963.  
[Fisheries Research Board of Canada, Arctic Unit, Montreal, Quebec, Canada]

A model was developed whereby zooplankton feeding near the surface and metabolizing in deeper, colder water gain in size and fecundity. Many patterns in vertical migration seemed thus accounted for. [The SCI® indicates that this paper has been cited in over 175 publications since 1963.]

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"My 1963 analytical review originated during an exceedingly pleasant four months in 1957, spent camping alone with my wife by Ogac Lake on Baffin Island. The lake is in fact the virtually landlocked head of a fiord, with an isolated marine fauna. The next year, on leave from my employment, I took my data and samples to study at Yale University, where my thesis committee (surely unmatched for the topic) consisted of G.E. Hutchinson (director), E.S. Deevey, and C.A. Riley. Possibly to their disappointment, my PhD thesis was a limnological *pot-pourri*, but it contained some notions that I have pursued more deeply since.

"Ogac Lake is warmer than the Arctic waters outside and clearly revealed the influence of temperature on sizes and cycles in the plankton. More insight came from a sharp temperature minimum at mid-depth, acting as a 'trap' for descending older stages of some zooplankton, which thus seemed to be seeking low temperatures and not depth *per se*. Because their body sizes and therefore fecundities increase at low temperatures, I proposed in my thesis that diel or

seasonal vertical migration in thermally stratified waters could enhance zooplankton reproductive rates. The 1963 paper was an amplification of this idea.

"Part of my review promoted the conceptual and empirical advantages of Bělehrádek's temperature function for development rates and sizes of poikilotherms. Although this function has since been widely used (and sometimes criticised), I do not believe that this aspect has led to very many citations. Most seem to refer, approvingly or otherwise, to my views on vertical migration.

"My initial analyses showed that enhanced fecundity could be outweighed by delayed maturation at lower temperatures. I got around this by proposing that animals feeding near the surface by descending to cold depths could use more of their food to attain an even larger adult size and greater fecundity. I modelled this possibility by using data from a copepod and a chaetognath in a generalized version of the well-known von Bertalanffy growth equation.

"The energetic-metabolic argument was basically a dodge to save the proposed demographic advantage. Yet the notion that migration to cold depths can save energy has seemingly commanded the most attention and has even been referred to as the 'McLaren effect,'<sup>1</sup> embarrassingly since the effect is obvious and was mooted earlier by others. Furthermore, in 1979<sup>2</sup> I showed that the demographic basis for the 1963 model was misleading and the assumption of an energy bonus unnecessary. Yet, to quote a recent review<sup>3</sup> of a multiauthored book on zooplankton, the 1963 work 'is still generating more research and rhetoric than the one intended to replace it.' This may be partly because biological limnologists and oceanographers generally favor analyses cast in terms of energy or matter, with only a minority seeing fitness as a more basic coinage and demography as a means of analysis."

1. Roe K E & Frederick R G. *Dictionary of theoretical concepts in biology*. Metuchen, NJ: Scarecrow Press, 1980. 267 p.

2. McLaren I A. Demographic strategy of vertical migration by a marine copepod. *Amer. Naturalist* 108:91-102, 1979.

3. Mills E L. Review of "Evolution and ecology of zooplankton communities" edited by W.C. Kerfoot. *Science* 212:534-5, 1981.