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Hurry Up and Wait: Growth of Young Bluegills in Ponds and in Simulations with an Individual-based Model

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Abstract.–The growth of young-of-the-year bluegills *Lepomis macrochirus* was measured in six experimental ponds and simulated with an individual-based model. In the ponds the young bluegills grew at a rate of about 0.6 mm/d for 3-4 weeks. An abrupt reduction in growth rate to about 0.2 mm/d occurred when total zooplankton density (exclusive of rotifers) decreased below about 50 organisms/L, and growth rate decreased to nearly zero by September. The model included daily foraging for several sizes of open-water or benthic prey and a revised set of bioenergetics parameters for bluegill. The simulations suggest that the initially rapid growth rate was near the limit set by maximum daily ration; the fish may have obtained full rations even with suboptimal foraging during this phase. Over a wide range of fry densities, the time of growth reduction and the average final fish size at the end of the growing season were strongly density dependent, both in the simulations and the ponds. Two natal cohorts started 10 d apart in the simulations. The size-frequency distributions produced by this individual-based model showed that these two cohorts remained distinct at starting densities below about 1 fish/m^3, but tended to overlap in size at higher densities.

Knowledge of the density-dependent processes occurring in the early life stages of fish is important for understanding recruitment and population dynamics. Individual-based models can help elucidate these density-dependent processes (Huston et al. 1988; Madenjian and Carpenter 1991). Individual-based models are used for studying a population's responses to various factors by simulating the responses of many individuals and aggregating the results as means or distributions for the population. Compared to other modeling approaches, an individual-based model can be easier to construct, easier to explain and interpret, and easier to parameterize. In some situations, it may be the only proper model. A model of many individuals may be required in cases where strong local interactions occur between individuals or where stochastic effects at low population sizes can predominate. For example, if only a few predators are stocked into a pond, the consequences for predator growth and prey behavior and survival may depend greatly on the particular sizes of individuals stocked, particularly on the extreme sizes. For another example, the chance that a predator's attack will be successful may depend on the sizes of the predator and the prey, and this chance may