Abstract

I simulated fluctuating year-class strength in a brown trout (<u>Salmo trutta</u>) fishery to estimate how the annual variability in population size and harvest was affected by exploitation under different minimum size limits and fishing mortality rates. My model included realistic details common to many fish populations in temperate regions; discrete annual reproduction and age-specific natural mortality, maturity, and fecundity. I hypothesized the primary mechanism regulating population size was density-dependent mortality in early life, but also that early mortality had a density-independent component which varied due to random environmental factors. I proposed a new method of representing this hypothesis quantitatively and of interpreting it ecologically. I conducted two series of stochastic simulations in which random variation was introduced at different stages of year-class formation. In the first, a range of instantaneous fishing mortality rates from 0.0 to 2.0 was simulated for 60 years each while the minimum size limit was held constant at 229 mm. In the second, a range of minimum size limits from 120 mm to 305 mm was simulated for 60 years each while the instantaneous fishing mortality rate was held constant at 0.7. Coefficients of variation ($100\ s/\bar{x}$) for mean population sizes and harvests were used to compare relative variability between simulations. I found that the number of fish in the simulated populations had minimum variability when exploited near maximum sustainable yield (MSY) in weight, fishing rates of 0.6 to 1.6 at the 229-mm size limit and size limits of 150 mm to 250 mm at the 0.7 fishing rate. Simulated populations were highly variable when lightly exploited because the compensatory-density-dependent response was strong enough to overshoot the population's equilibrium level after a random disturbance. As exploitation increased, it reduced the strength of the density-dependent response. Near MSY, the strength of density dependence was about equal to the strength of random disturbances, and this minimized variation in population size. Higher exploitation reduced the strength of density dependence to where it could not fully compensate for random disturbances, so variability increased. Variability of harvests did not match variability of populations because they had different age structures, a normal consequence of minimum size limit regulations or gear selectivity. Changing the fishing rate had little effect on variability of harvest, but changing the size limit from 120 mm to 305 mm increased the coefficient of variation of harvest from 13% to 44% when the standard deviations of random year-class fluctuations were 50% of their means. I concluded that for fisheries with fluctuating year-class strength, variability in annual catch is minimized by maintaining the lowest practical size limit and managing the fishery by controlling fishing effort.