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Contribution of catastrophic events to stochasticity of the recruitment process: an application to Atlantic Salmon

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“Catastrophic” events are one of the major threats to the conservation of populations, yet rarely considered in population models. We propose a mixture distribution for taking account of “catastrophic” events in environmental stochasticity. The mixture results from the combination of two distributions. A regular distribution, representing the most frequent regime of random process error and a “catastrophic” distribution, representing the random process error for rare events with strong negative effects on populations. A Bernoulli draw with a catastrophe probability indicates whether the process error associated to a given event results from the regular or the “catastrophic” distribution. The mixture distribution modelling is applied to the recruitment process of Atlantic salmon (*Salmo Salar*) which fishery scientists rely on to provide management advice. Stock-recruitment (SR) relationships, relating the number of eggs produced by pre-spawning females (stock) to the abundance of the resulting young-of-the-year juveniles (recruitment) are adjusted for the 18 main salmon populations of Brittany (France). A Bayesian hierarchical model, based on a Beverton-Holt type relationship is used for the joint analysis of all populations.

We estimate the probability of a catastrophe at 10%, that is, a catastrophic recruitment occurs one year out of ten whatever the population. During a catastrophic event, recruitment is estimated to be reduced by two thirds on average. The mixture distribution provides a better fit to the data than standard single lognormal distribution: to account for catastrophic events the latter assumes relatively high probability of extreme positive error that are never observed. Our approach constitutes an additional step toward a better accounting of uncertainty as recommended in the precautionary approach adopted by the North Atlantic Salmon Conservation Organization (NASCO) for the management of Atlantic salmon populations.