Possible option for modeling juvenile salmon emigrants based on escapement and trapping data

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Definitions

Here are some definitions for model variables and parameters. They ignore location for now.

- S_y: number of observed female spawners in brood year y (data)
- N_y: number of true female spawners in brood year y (unknown state)
- f_y: product of fecundity and egg-juvenile survival in year y (unknown parameter)
- J_y: total number of juveniles produced from brood year y (unknown state)
- $E_{d,k,y}$: number of true emigrants on day d in season k and year y (unknown state)
- $C_{d,k,y}$: number of juvenile emigrants caught in a trap on day d in season k and year y (data)
- $p_{k,y}$: capture probability of juvenile emigrants in season k and year y (unknown parameter)

Data models

$$\log(S_y) \sim \text{Normal}(\log(N_y), \sigma_S) \tag{1}$$

$$C_{d,k,y} \sim \text{Binomial}(E_{d,k,y}, p_{k,y}) \tag{2}$$

$$p_{k,y} = \left(\frac{recaps}{releases}\right)_{k,y} \tag{3}$$

State models

$$J_y \sim \text{Poisson}(\lambda_y) \tag{4}$$

$$\lambda_y = f_y N_y \tag{5}$$

$$J_y \sim \text{NegBin}(r, p) \tag{6}$$

$$r = \frac{(f_y N_y)^2}{\sigma^2 - f_y N_y} \tag{7}$$

$$p = \frac{r}{r + f_y N_y} \tag{8}$$

$$\log(E_{k,y}) \sim \text{Normal}(\log(g(J_{k,y})), \sigma_J) \tag{9}$$

$$E_{k,y} = \sum^{d} E_{d,k,y} \tag{10}$$

$$J_{k,y} = \begin{cases} J_{k,y}, & \text{if k} = 1 \\ J_{k-1,y} - E_{k-1,y}, & \text{if k} > 1 \end{cases} \tag{11}$$

where $g(J_y)$ is a (potentially) nonlinear function mapping the density of juveniles onto the number of emigrants .