$$\begin{bmatrix} n_0 \\ n_1 \\ \vdots \\ n_k \end{bmatrix}_{t+1} = \begin{bmatrix} F_0 & F_1 & \dots & F_k \\ S_0 & 0 & \dots & 0 \\ 0 & \ddots & \dots & 0 \\ 0 & 0 & S_{k-1} & 0 \end{bmatrix} \begin{bmatrix} n_0 \\ n_1 \\ \vdots \\ n_k \end{bmatrix}_t$$

where:

$$\begin{aligned} n_{k,t+1} &= \text{number of organisms in age class k at time t+1} \\ F_k &= \text{fecundity, the per capita average number of female} \\ &\quad \text{offspring born from mother of the age class k} \\ S_k &= \text{the fraction of individuals that survives from} \\ &\quad \text{age class t to age class t+1} \end{aligned}$$

$$F'_x = F_x e^{-\beta N}$$

where:

$$\begin{aligned} F'_x &= \text{adjusted fertility rate for age class x} \\ F_x &= \text{maximum fertility rate of age class x} \\ \beta &= \text{constant describing the decay of fertility} \\ N &= \text{total population size} \end{aligned}$$

$$S_{tox,x} = S_x(1 - M_{48})$$

where:

$$\begin{aligned} S_{tox,x} &= \text{survival rate after toxic for age class x} \\ S_x &= \text{maximum survival rate of age class x} \\ M_{48} &= \text{48h mortality rate based on logistic dose response model} \end{aligned}$$

$$M_{48} = \frac{1}{1 + e^{-\alpha \times \ln C_0 (\frac{1}{2}^{\frac{t}{HL}}) - \beta}}$$

where:

$$\begin{aligned} \alpha, \beta &= \text{coefficients of logistic dose response function} \\ C_0 &= \text{chemical initial concentration} \\ HL &= \text{chemical half life} \\ t &= \text{simulation duration} \end{aligned}$$