```
model{

#$$$$$$$$$$$$$$#
#  FIRST PART      #
#$$$$$$$$$$$$$$#

  #################
  # 1.CALIBRATION #
  #################

  d_moy~dgamma(1,0.001)
  beta_d~dgamma(0.001,0.001)

  inv_kappa ~ dgamma(0.001,0.001)
  kappa <-1/ inv_kappa

  #eta  ~ dgamma(0.001,0.001)

  L_sigma_p~dunif(0.0001,10)
  L_tau_p<-pow(L_sigma_p,-2)
  L_var_p<-1/L_tau_p

  L_mu_p ~dnorm(0,0.001)
  logit(mu_p)<-L_mu_p

  alpha_d<-d_moy * beta_d

  for (g in 1:calib){

    #=====================
    # 1.1 Density part
    #=====================
    d[g]~dgamma(alpha_d,beta_d)
    lambda_IA[g]<-kappa*d[g]    #kappa*pow(d[g],eta)
    EF_IA[g]~dpois(lambda_IA[g])
    lambda_N[g]<-(d[g]*S[g])-EF_IA[g]

    #Abundance follows a Poisson distribution
    N_tot[g]~dpois(lambda_N[g])I(,2000)

    L_p[g]~dnorm(L_mu_p,L_tau_p)
    logit(p[g]) <- L_p[g]

    # depletion pass part
    C_1[g]~dbin(p[g],N_tot[g])
    N_1[g]<-N_tot[g]-C_1[g]
    C_2[g]~dbin(p[g],N_1[g])

    #=====================
    # 1.2 Posterior check
    #=====================
    rep_lambda_IA[g]<-kappa*d[g]    #kappa*pow(d[g],eta)
    rep_EF_IA[g]~dpois(rep_lambda_IA[g])
    res_IA_EF[g]<-EF_IA[g] - rep_EF_IA[g]

    # calculation of the residuals for the predicted C1,C2,C3 conditionally to densities
    rep_C_1[g] ~ dbin(p[g],N_tot[g])
    rep_C_2[g] ~ dbin(p[g],N_1[g])

    res_C_1[g] <- C_1[g]-rep_C_1[g]
```

```
    res_C_2[g] <- C_2[g]-rep_C_2[g]
    res_C1_N_tot[g] <- (C_1[g]-rep_C_1[g])/N_tot[g]
    res_C_2_N_1[g] <- (C_2[g]-rep_C_2[g])/N_1[g]

  }

    #=====================================================
    # 1.3 cut of all the parameters of the calibration
    #=====================================================
    L_mu_p_cut<-cut(L_mu_p)
    L_tau_p_cut<-cut(L_tau_p)
    kappa_cut<-cut(kappa)
    #eta_cut<-cut(eta)
    # on suppose que le parametre d'echelle est le meme au fil des années
    beta_d_cut<-cut(beta_d)


  #####################
  # 2. REDD/SPAWNERS #
  #####################
    #==========================================================
    # 2.1 Parameters of the Redd/spawner relationship model
    #==========================================================
    mu_zone[1]~dgamma(1,0.001)
    mu_zone[2]<-1    #~dgamma(1,0.001)

    beta_zone~dgamma(0.01,0.01)

    alpha_zone[1]<- mu_zone[1]*beta_zone

    alpha_zone[2]<- mu_zone[2]*beta_zone

    #=====================================
    # 2.2 Methodology and spatial effect
    #=====================================
      #--------------------------
      # 2.2.1 Methodology effect
      #--------------------------
      hel_effect[1]<-1
      hel_effect[2]~dgamma(1,1)
      #-----------------------
      # 2.2.2 Spatial effect
      #-----------------------
      for (t in 1:T){
        zone_effect[t,1]~dgamma(alpha_zone[1],beta_zone)I(0.001,)    #I(0.001,)    #dnorm(0,0.01)    #dunif(0,20)
#
        zone_effect[t,2]~dgamma(alpha_zone[1],beta_zone)I(0.001,)    #I(0.001,)    #dnorm(0,0.01)    #dunif(0,3.5)
#

      }
      for (t in 12:T){
        zone_effect[t,3]~dgamma(alpha_zone[2],beta_zone)I(0.001,)
      }
      #------------------------------------
      # 2.2.3 Verification of both effects
      #------------------------------------
      diff_hel_effect<-1-hel_effect[2]
      P_diff_hel<-step(diff_hel_effect)

      diff_zone1_2<-mu_zone[1]-mu_zone[2]
```

```
    p_diff_zone1_2<-step(diff_zone1_2 )

   #======================
   # 2.3 Area prospected
   #======================
   #loops for proportion of area prospected
   for (t in 1:T){
     for (k in 1:2){
       logit(p_area[t,k])<-  L_p_area[t,k]
     }
   }

   for (t in 12:T){
     logit(p_area[t,3])<- L_p_area[t,3]
   }

   #======================
   # 2.4 Hyperparameters
   #======================
   sigma_Vichy <- sqrt( 1 / tau_vichy)    #~dunif(0.001,5)
   tau_vichy~dgamma(0.001,0.001)    #<-pow(sigma_Vichy,-2)
   L_mu_vichy~dnorm(0,0.01)

   sigma_p_langeac<-sqrt(1/tau_p_langeac)    #~dchisqr(1)#I(0.001,)    #<-sqrt(1/tau_p_langeac)
#dunif(0.001,10)
   tau_p_langeac~dgamma(0.01,0.01)    #<-pow(sigma_p_langeac,-2)    #,

   sigma_p_poutes<-sqrt(1/tau_p_poutes)    #~dunif(0,10)
   tau_p_poutes~dgamma(0.01,0.01)    #<-pow(sigma_p_poutes,-2)

   I_surv[7] <- 1
   I_surv_prim[7] <- 1

   level_s~dnorm(0,1)

   for (t in 8:T){
     I_surv_prim[t] ~ dbern(0.5)
     I_surv[t] <-  I_surv[t-1] * I_surv_prim[t]
   }

   for (t in 7:11){
     min_N_1[t]<-tot_C[t]  + S_stocking[t]+2
     pool_juv[t]<-s_juv2ad* Juv_tot_system[t] + s_smolt * (0.5 * smolts_tot[t+1] + 0.5 * smolts_tot[t] )
     L_mu_Vichy_nm[t]<-log( s_juv2ad * Juv_tot_system[t] + s_smolt * (0.5 * smolts_tot[t+1] + 0.5 *
smolts_tot[t] )) + level_s * I_surv[t]
     mean_y_surv[t] <- s_juv2ad * exp(level_s * I_surv[t])

     N[t,1]~dlnorm(L_mu_Vichy_nm[t],tau_vichy)I(min_N_1[t],15000)
     res_Vichy[t] <- log(N[t,1]) - L_mu_Vichy_nm[t]
   }


  ##############################
  # 3. JUVENILE PRODUCTION   #
  ##############################
   #=================================
   # 3.1 Beverthon & Holt parameters
   #=================================
   # BH slope parameter
   #not sure about the beta parameters ...
```

```
zt~dbeta(1,9)    #(1,2)
a<-zt *8000    #I~dunif(1,8000)    #~dgamma(0.01,0.01)I(,8000)#(0.1,)    #~dlnorm(0,0.01)    #
alpha_dd<- 1/a

a_juv ~dbeta(2,2)
alpha_dd_juv<- 1/a_juv

Rmax~dunif(0,2)    #    dgamma(0.01,0.01)I(,15)    #log(Rmax)<-L_Rmax
beta_dd<- 1 / Rmax

#s_juv~dbeta(2,2) --> n'existe pas par la suite
s_egg~dbeta(2,2)#I(0.0001,)
s_juv2ad~dbeta(2,2)

#=====================
# 3.2 Hyperparameters
#=====================
alpha_tau <- mu_tau +1
mu_tau ~ dgamma(0.1,0.1)I(0.000001,)    #(1,0.01)I(0.001,)    #dgamma(0.01,0.01)
beta_tau ~ dgamma(0.1,0.1)I(0.001,)    #(0.01,0.01)I(0.001,)    # dgamma(0.01,0.01)

tau_wild_moy~dgamma(alpha_tau,beta_tau)    #[3]<-tau_wild_moy[2]
tau_wild_site~dgamma(alpha_tau,beta_tau)

tau_juv_moy[1]~dgamma(0.01,0.01)
tau_juv_site[1]~dgamma(0.01,0.01)
tau_juv_moy[2]~dgamma(alpha_tau,beta_tau)
tau_juv_site[2]~dgamma(alpha_tau,beta_tau)

tau_egg_moy[1]~dgamma(0.01,0.01)I(0.01,)
tau_egg_site[1]~dgamma(0.01,0.01)I(0.01,)
tau_egg_moy[2]~dgamma(alpha_tau,beta_tau)#I(,50)
tau_egg_site[2]~dgamma(alpha_tau,beta_tau)

sigma_wild_moy <- sqrt( 1 / tau_wild_moy)
sigma_wild_site <- sqrt( 1 / tau_wild_site)
sigma_juv_moy <- sqrt( 1 / tau_juv_moy[2])
sigma_juv_site <- sqrt( 1 / tau_juv_site[2])
sigma_egg_moy <- sqrt( 1 / tau_egg_moy[2])
sigma_egg_site <- sqrt( 1 / tau_egg_site[2])

nu_wild_avg~dnorm(0,0.01)
nu_wild[1] <-  -nu_wild_avg
nu_wild[2] <- nu_wild_avg
nu_wild[3] <- nu_wild_avg

nu_juv_avg~dnorm(0,0.01)
nu_juv[1] <- -nu_juv_avg
nu_juv[2] <- nu_juv_avg
nu_juv[3] <- nu_juv_avg

rho_poutes~dbeta(2,2)
#=========================================================================
# 3.3 Number of juveniles 0+ returning in the Allier river for a given year
#=========================================================================
# 0+ Juvenile returning in the Allier for a given year
# and originating from the 3 areas of interest
for (t in 7:T){
  Juv_tot[t,1] <- (1/3) * Juv[t-3,1] + (1/3) * Juv[t-4,1] + (1/3) * Juv[t-5,1]
  Juv_tot[t,2] <- (1/3) * Juv[t-3,2] + (1/3) * Juv[t-4,2] + (1/3) * Juv[t-5,2]
```

```
    }
    for (t in 1:15){
       Juv_tot[t,3]<-0
    }
    for (t in 16:16){
      Juv_tot[t,3] <- (1/3) * Juv[t-3,3]
    }
    for (t in 17:17){
      Juv_tot[t,3] <- (1/3) * Juv[t-3,3] + (1/3) * Juv[t-4,3]
    }
    for (t in 18:T){
      Juv_tot[t,3] <- (1/3) * Juv[t-3,3] + (1/3) * Juv[t-4,3] + (1/3) * Juv[t-5,3]
    }
    for (t in 7:15){
      Juv_tot_system[t] <- Juv_tot[t,1]+Juv_tot[t,2]
    }
    for (t in 16:T){
      Juv_tot_system[t] <- Juv_tot[t,1]+Juv_tot[t,2] +rho_poutes*Juv_tot[t,3]
    }
      #dd_returns~dnorm(0,0.01)-->n'existe pas par la suite

    #=========================================================
    # 3.4 Probability of passing at Vichy, Langeac and Poutes
    #=========================================================
    # incorporating the effect that probability of passing at Langeac and Poutes is conditioned by the amount of
juvenile produced

    #Probability to reach Vichy if not catch downstream
    p_reach_V~dbeta(2,1)
    for (t in 1:T){
      C_dwn_reach[t] <- p_reach_V * C_dwn[t]
      tot_C[t] <-round( C_dwn_reach[t] + C_up[t])
    }
    for (t in 1:6){
      min_N_1[t]<- tot_C[t] + S_stocking[t]+2
      N[t,1]~dlnorm(6.9,0.0453)I(min_N_1[t],15000)
    }

    # For Langeac et Poutes : filter:
      # if negative : fish returning in smaller proportion than what was expected regarding juvenile production
      # if positive : fish returning in higher proportion than what was expected regarding juvenile production
    adjust_p_L ~ dnorm(0,0.01)
    adjust_p_P ~ dnorm(0,0.01)
    rho_station~dbeta(2,2)

    for (t in 1:T){
       for (i in 1:3){
          ratio_habitat[t,i] <- S_juv_JP[t,i] /( S_juv_JP[t,1]+S_juv_JP[t,2]+S_juv_JP[t,3])
       }
    }

    for (t in 1:4){
      ratio_juv_prod_V[t] <-1 - ratio_juv_prod_L[t]

      ratio_juv_prod_L[t]~dbeta(2,2)
      ratio_juv_L[t]<- rho_station * (ratio_habitat[t,2] / (1 - ratio_habitat[t,3] ) ) + (1 -  rho_station) *
ratio_juv_prod_L[t]
      L_ratio_juv_L[t] <- logit(ratio_juv_L[t])
      L_mu_p_langeac[t]<-L_ratio_juv_L[t] + adjust_p_L
      L_p_langeac[t]~dnorm(L_mu_p_langeac[t],tau_p_langeac)
```

```
      res_p_langeac[t] <- L_p_langeac[t] - L_mu_p_langeac[t]
    }
    for (t in 5:5){
      ratio_juv_prod_V[t] <-1 - ratio_juv_prod_L[t]

      ratio_juv_prod_L[t] <-  Juv[t-3,2] / ( Juv[t-3,1] + Juv[t-3,2] )
      ratio_juv_L[t]<- rho_station * (ratio_habitat[t,2] / (1 - ratio_habitat[t,3] )) + (1 -  rho_station) *
ratio_juv_prod_L[t]
      L_ratio_juv_L[t] <- logit(ratio_juv_L[t])
      L_mu_p_langeac[t]<-L_ratio_juv_L[t]+ adjust_p_L
      L_p_langeac[t]~dnorm(L_mu_p_langeac[t],tau_p_langeac)
      res_p_langeac[t] <- L_p_langeac[t] - L_mu_p_langeac[t]
    }
    for (t in 6:6){
      ratio_juv_prod_V[t] <-1 - ratio_juv_prod_L[t]

      ratio_juv_prod_L[t] <-  (Juv[t-3,2] + Juv[t-4,2] ) / ( Juv[t-3,1] + Juv[t-4,1] + Juv[t-3,2] +Juv[t-4,2]  )
      ratio_juv_L[t]<- rho_station * (ratio_habitat[t,2] / (1 - ratio_habitat[t,3] )) + (1 -  rho_station) *
ratio_juv_prod_L[t]
      L_ratio_juv_L[t] <- logit(ratio_juv_L[t])
      L_mu_p_langeac[t]<-L_ratio_juv_L[t]+ adjust_p_L
      L_p_langeac[t]~dnorm(L_mu_p_langeac[t],tau_p_langeac)
      res_p_langeac[t] <- L_p_langeac[t] - L_mu_p_langeac[t]
    }
    for (t in 7:11){
      ratio_juv_prod_V[t] <-1 - ratio_juv_prod_L[t]

      ratio_juv_prod_L[t] <-  Juv_tot[t,2] / ( Juv_tot[t,1] + Juv_tot[t,2] )
      ratio_juv_L[t]<- rho_station * (ratio_habitat[t,2] / (1 - ratio_habitat[t,3] )) + (1 -  rho_station) *
ratio_juv_prod_L[t]
      L_ratio_juv_L[t] <- logit(ratio_juv_L[t])
      L_mu_p_langeac[t]<-L_ratio_juv_L[t]+ adjust_p_L
      L_p_langeac[t]~dnorm(L_mu_p_langeac[t],tau_p_langeac)
      res_p_langeac[t] <- L_p_langeac[t] - L_mu_p_langeac[t]
    }
    for (t in 12:15){
      ratio_juv_prod_V[t] <-1 - ratio_juv_prod_L[t]

      ratio_juv_prod_L[t] <-  Juv_tot[t,2] / ( Juv_tot[t,1] + Juv_tot[t,2] )
      ratio_juv_L[t]<- rho_station * (ratio_habitat[t,2]+ratio_habitat[t,3]) + (1 -  rho_station) * ratio_juv_prod_L[t]
      L_ratio_juv_L[t] <- logit(ratio_juv_L[t])
      L_mu_p_langeac[t]<-L_ratio_juv_L[t]+ adjust_p_L
      L_p_langeac[t]~dnorm(L_mu_p_langeac[t],tau_p_langeac)
      res_p_langeac[t] <- L_p_langeac[t] - L_mu_p_langeac[t]

      ratio_juv_prod_P[t] <- 0
     ratio_juv_P[t]<- rho_station * (S_juv_JP[t,3] / (S_juv_JP[t,2] + S_juv_JP[t,3]) ) + (1 -  rho_station) *
ratio_juv_prod_P[t]
      L_ratio_juv_P[t] <-  logit(ratio_juv_P[t])
      L_mu_p_poutes[t]<-L_ratio_juv_P[t] + adjust_p_P
      L_p_poutes[t]~dnorm(L_mu_p_poutes[t],tau_p_poutes)
      res_p_poutes[t] <- L_p_poutes[t] - L_mu_p_poutes[t]
    }
    for (t in 16:T){
      ratio_juv_prod_V[t] <-1 - ratio_juv_prod_L[t]

      ratio_juv_prod_L[t] <-  (Juv_tot[t,2] + Juv_tot[t,3]*rho_poutes) / ( Juv_tot[t,1] + Juv_tot[t,2] + Juv_tot[t,3]
*rho_poutes)
      ratio_juv_L[t]<- rho_station * (ratio_habitat[t,2]+ratio_habitat[t,3]) + (1 -  rho_station) * ratio_juv_prod_L[t]
      L_ratio_juv_L[t] <- logit(ratio_juv_L[t])
```

```
      L_mu_p_langeac[t]<-L_ratio_juv_L[t]+ adjust_p_L
      L_p_langeac[t]~dnorm(L_mu_p_langeac[t],tau_p_langeac)
      res_p_langeac[t] <- L_p_langeac[t] - L_mu_p_langeac[t]

      ratio_juv_prod_P[t] <-  Juv_tot[t,3] *rho_poutes/ ( Juv_tot[t,2] + Juv_tot[t,3] *rho_poutes)
      ratio_juv_P[t]<- rho_station * (S_juv_JP[t,3] / (S_juv_JP[t,2] + S_juv_JP[t,3])) + (1 -  rho_station) *
ratio_juv_prod_P[t]
      L_ratio_juv_P[t] <- logit(ratio_juv_P[t])
      L_mu_p_poutes[t]<-L_ratio_juv_P[t]+ adjust_p_P
      L_p_poutes[t]~dnorm(L_mu_p_poutes[t],tau_p_poutes)
      res_p_poutes[t] <- L_p_poutes[t] - L_mu_p_poutes[t]
    }




#$$$$$$$$$$$$$$$$#
#  SECONDE PART #
#$$$$$$$$$$$$$$$$#

  ################################################
  # 1. LOOP FOR YEARS (only downstream Poutès)      #
  ################################################
  for (t in 1:11){
    #========================
    # 1.1 Redd/Spawners part
    #========================
    logit(p_langeac[t])<- L_p_langeac[t]
    #mu_N_L[t]<-N[t,1] * p_langeac[t]
    #tau_N_L[t]<-1/ (N[t,1] * p_langeac[t] * (1-p_langeac[t]) )
    max_N_langeac[t]<- N_corrected[t] - 1    #N[t,1] - S_stocking[t] - 1
    #without fish caught for breeeding or rod catches
    N_corrected[t] <- N[t,1] - tot_C[t] - S_stocking[t]     #

    N[t,2]~dbin(p_langeac[t],N_corrected[t])     #~dnorm(mu_N_L[t],tau_N_L[t])I(min_L[t],max_N_langeac[t])
#N[t,1])     ##
      #-----------------------------------
      #1.1.1 Number of potential spawners
      #-----------------------------------
      S_ts[t,1]<- max( N[t,1] - tot_C[t] - S_stocking[t] - N[t,2] ,1)
      S_ts[t,2]<- max(N[t,2],1)
      ratio_S[t,1] <- S_ts[t,1] / ( S_ts[t,1] + S_ts[t,2] )
      ratio_S[t,2] <- S_ts[t,2] / ( S_ts[t,1] + S_ts[t,2] )


#==============================================================================
    # 1.2 Loop for zones (1= Vichy-Langeac, 2= Langeac-Poutès, 3= upstream Poutès)

#==============================================================================
    for (i in 1:2){
      #-------------------------
      # 1.2.1 Redd/Spawners part
      #-------------------------
        #....................................
        # 1.2.1.1 estimation of the spawners
        #....................................
        R[t,i] ~dpois(lambda[t,i])
        lambda[t,i] <- S_ts[t,i]  *zone_effect[t,i] * hel_effect[1] *p_area[t,i]

        #residus calculés pour êtres centrés sur 0 avec varaince homogene
```

```
      res_R[t,i]<-(R[t,i]-lambda[t,i])/sqrt(lambda[t,i])
      #..............................
      # 1.2.1.2 Cut of all parameters
      #..............................
      lambda_cut[t,i]<-cut(lambda[t,i])
      R_rep[t,i]~dpois(lambda_cut[t,i])
    #--------------------------
    # 1.2.2 Juvenile production
    #--------------------------
    # I_juv_moy = indicator for stocking of 0+ or not
    # I_egg_moy = indicator for stocking of eggs or not
    #d_tot_moy without taking into acount area for the stocked juveniles (data only from year 31)
    d_tot_moy[t+1,i] <- d_wild_moy[t+1,i] + I_juv_moy[t+1,i] * d_juv_moy[t+1,i]
    Juv[t+1,i] <- d_tot_moy[t+1,i]*S_juv_JP[t+1,i]
      #.......................
      # 1.2.2.1 Wild component
      #.......................
      log(d_wild_moy[t+1,i]) <- L_d_wild_moy[t+1,i]
      L_d_wild_moy[t+1,i] ~ dnorm(L_mu_d_wild[t+1,i],tau_wild_moy)I(-6.91,1.09)
      L_mu_d_wild[t+1,i] <-  log((S_ts[t,i]/S_juv_JP[t,i]) / (alpha_dd + beta_dd * (S_ts[t,i]/S_juv_JP[t,i]))) +
nu_wild[i]
      res_wild_moy[t+1,i] <-  L_d_wild_moy[t+1,i] - L_mu_d_wild[t+1,i]
      #...................................
      # 1.2.2.2 stocked juvenile component
      #...................................
      log(d_juv_moy[t+1,i]) <- L_d_juv_moy[t+1,i]
      L_d_juv_moy[t+1,i] ~ dnorm(L_mu_d_juv[t+1,i],tau_juv_moy[ I_juv_moy[t+1,i]+1])I(-6.91,1.09)    #<-
L_mu_d_juv[t+1,i]     #
      Rmax_juv_temp[t+1,i] <- (  Rmax - ((S_ts[t,i]/S_juv_JP[t,i]) / (alpha_dd + beta_dd *
(S_ts[t,i]/S_juv_JP[t,i]))) ) * exp(nu_wild[i])
      Rmax_juv[t+1,i] <- max(Rmax_juv_temp[t+1,i] ,0.000001)
      beta_dd_juv[t+1,i] <- 1 / Rmax_juv[t+1,i]
      L_mu_d_juv[t+1,i] <-  I_juv_moy[t+1,i] * log( (stock_juv[t+1,i]/S_juv_JP[t+1,i]) /
(alpha_dd_juv/exp(nu_wild[i]) +  beta_dd_juv[t+1,i] * (stock_juv[t+1,i]/S_juv_JP[t+1,i]))) #+  (1 -
I_juv_moy[t+1,i]) * 0
      res_juv_moy[t+1,i] <- L_d_juv_moy[t+1,i] - L_mu_d_juv[t+1,i]
      # getting out of the zone loop, one loop for each zones and the local densitie
      # to avoid using 3 dimensions matrix
   }
    #-----------------------------------
    # 1.2.3 Successive removal fisheries
    #-----------------------------------
    #  I_site_juv_V/L/P = indicator for presence/absence of stocking on the site
    # loop for sites with successive removal EF (DE LURY)
      #................................
      # 1.2.3.1 zone 1 : Vichy Langeac
      #................................
      for (k in 1:J[t+1,1]){
        d_V[t+1,k]<- d_wild_V[t+1,k] + I_site_juv_V[t+1,k] * d_juv_V[t+1,k]
        log(d_wild_V[t+1,k])<-L_d_wild_V[t+1,k]
        L_d_wild_V[t+1,k] ~ dnorm( L_d_wild_moy[t+1,1] , tau_wild_site)I(-6.91,1.09)
        log(d_juv_V[t+1,k]) <- L_d_juv_V[t+1,k]
        L_d_juv_V[t+1,k] ~ dnorm( L_d_juv_moy[t+1,1] , tau_juv_site[ I_site_juv_V[t+1,k] + 1])I(-6.91,1.09)

        lambda_N_V[t+1,k]<-d_V[t+1,k]*S_depl_V[t+1,k]
        #Abundance follows a Poisson distribution
        N_tot_V[t+1,k]~dpois(lambda_N_V[t+1,k])

        L_p_V[t+1,k]~dnorm(L_mu_p_cut,L_tau_p_cut)
        logit(p_V[t+1,k]) <-L_p_V[t+1,k]
```

```
        C_1_V[t+1,k]~dbin(p_V[t+1,k],N_tot_V[t+1,k])
        N_1_V[t+1,k]<-N_tot_V[t+1,k]-C_1_V[t+1,k]
        #not all sites have 2 pass, this vector show which sites does
          for (h in 1:pass_2_V[t+1,k]){
            C_2_V[t+1,k]~dbin(p_V[t+1,k],N_1_V[t+1,k])
            N_2_V[t+1,k]<-N_1_V[t+1,k]-C_2_V[t+1,k]
          }
      }
      #................................
      # 1.2.3.2 zone 2 : Langeac Poutes
      #................................
      for (k in 1:J[t+1,2]){
        d_L[t+1,k]<- d_wild_L[t+1,k] + I_site_juv_L[t+1,k] * d_juv_L[t+1,k]
        log(d_wild_L[t+1,k])<-L_d_wild_L[t+1,k]
        L_d_wild_L[t+1,k] ~ dnorm( L_d_wild_moy[t+1,2] , tau_wild_site)I(-6.91,1.09)
        log(d_juv_L[t+1,k]) <- L_d_juv_L[t+1,k]
        L_d_juv_L[t+1,k] ~ dnorm( L_d_juv_moy[t+1,2] , tau_juv_site[ I_site_juv_L[t+1,k] + 1])I(-6.91,1.09)

        lambda_N_L[t+1,k]<-d_L[t+1,k]*S_depl_L[t+1,k]
        #Abundance follows a Poisson distribution
        N_tot_L[t+1,k]~dpois(lambda_N_L[t+1,k])

        L_p_L[t+1,k]~dnorm(L_mu_p_cut,L_tau_p_cut)
        logit(p_L[t+1,k]) <-L_p_L[t+1,k]

        C_1_L[t+1,k]~dbin(p_L[t+1,k],N_tot_L[t+1,k])
        N_1_L[t+1,k]<-N_tot_L[t+1,k]-C_1_L[t+1,k]
        #not all sites have 2 pass, this vector show which sites does
          for (h in 1:pass_2_L[t+1,k]){
            C_2_L[t+1,k]~dbin(p_L[t+1,k],N_1_L[t+1,k])
            N_2_L[t+1,k]<-N_1_L[t+1,k]-C_2_L[t+1,k]
            #not all sites have 3 pass, this vector show which sites does
            for (m in 1:pass_3_L[t+1,k]){
              C_3_L[t+1,k]~dbin(p_L[t+1,k],N_2_L[t+1,k])
            }
          }
      }
    }


  ############################################################################################
  # 2. LOOP FOR YEARS (all zones mais pas encore de juvéniles à Poutès - seulement en année T=16)    #
  ############################################################################################
  for (t in 12:22){
    #========================
    # 2.1 Redd/Spawners part
    #========================
    logit(p_langeac[t])<- L_p_langeac[t]
    logit(p_poutes[t])<- L_p_poutes[t]
    pool_juv[t]<-s_juv2ad * Juv_tot_system[t] + s_smolt * (0.5 * smolts_tot[t+1] + 0.5 * smolts_tot[t] )
    L_mu_Vichy_nm[t]<-log(s_juv2ad * Juv_tot_system[t] + s_smolt * (0.5 * smolts_tot[t+1] + 0.5 * smolts_tot[t]
)) + level_s *I_surv[t]
    mean_y_surv[t] <- s_juv2ad * exp(level_s * I_surv[t])

    #min_N_1[t]<-max(N[t,3]+2 , min_L[t]) + S_stocking[t] + 2
    min_N_1[t]<-max(N[t,3]+2,tot_C[t] +2)+S_stocking[t]
    N[t,1]~dlnorm(L_mu_Vichy_nm[t],tau_vichy)I(min_N_1[t],15000)
    #without fish caught for breeeding or rod catches
    N_corrected[t] <- N[t,1] - tot_C[t] - S_stocking[t]
    res_Vichy[t] <- log(N[t,1]) - L_mu_Vichy_nm[t]
```

```
    #mu_N_L[t]<-N[t,1] * p_langeac[t]
    #tau_N_L[t]<-1/ (N[t,1] * p_langeac[t] * (1-p_langeac[t]) )
    max_N_langeac[t]<- N_corrected[t] - 1      #N[t,1] - S_stocking[t]-1
    min_L_P[t]<-max(min_L[t], N[t,3]+1)     #    max(N[t,3]+1 , min_L[t])
    N[t,2]~dbin(p_langeac[t],N_corrected[t])I(min_L_P[t],)
#~dnorm(mu_N_L[t],tau_N_L[t])I(min_L_P[t],max_N_langeac[t])    #    #

    #mu_N_P[t]<-N[t,2] * p_poutes[t]
    #tau_N_P[t]<-1/ (N[t,2] * p_poutes[t] * (1-p_poutes[t]) )
    max_N_poutes[t]<-N[t,2]-1
    N[t,3]~dbin(p_poutes[t],N[t,2])    #~dnorm(mu_N_P[t],tau_N_P[t])I(1,max_N_poutes[t])    ##
      #-----------------------------------
      # 2.1.1 Number of potential spawners
      #-----------------------------------
      mu_S_ts[t,1]<- N[t,1] - N[t,2] - S_stocking[t]
      mu_S_ts[t,2]<- N[t,2]-N[t,3]
      test[t]<-mu_S_ts[t,1]-S_ts[t,1]

      S_ts[t,1]<- max(N[t,1] - N[t,2] - S_stocking[t] - tot_C[t] ,1)    #~dnorm(mu_S_ts[t,1],1)I(0.001,)    #
      S_ts[t,2]<- max( N[t,2]-N[t,3],1)    #~dnorm(mu_S_ts[t,2],1)    #
      S_ts[t,3]<-max( N[t,3],1)
      ratio_S[t,1] <- S_ts[t,1] / ( S_ts[t,1] + S_ts[t,2] + S_ts[t,3])
      ratio_S[t,2] <- S_ts[t,2] / ( S_ts[t,1] + S_ts[t,2] + S_ts[t,3])
      ratio_S[t,3] <- S_ts[t,3] / ( S_ts[t,1] + S_ts[t,2] + S_ts[t,3])


#=================================================================================
    # 2.2 Loop for zones (1= Vichy-Langeac, 2= Langeac-Poutès, 3= upstream Poutès)

#=================================================================================
    for (i in 1:3){
      #-------------------------
      # 2.2.1 Redd/Spawners part
      #-------------------------
        #…………………………………
        # 2.2.1.1 estimation of the spawners
        #…………………………………
        R[t,i]~dpois(lambda[t,i])
        lambda[t,i] <- S_ts[t,i]  *zone_effect[t,i]* hel_effect[1] *p_area[t,i]
        res_R[t,i]<-(R[t,i]-lambda[t,i])/sqrt(lambda[t,i])
        #…………………………
        # 2.2.1.2 Cut of all parameters
        #…………………………
        lambda_cut[t,i]<-cut(lambda[t,i])
        R_rep[t,i]~dpois(lambda_cut[t,i])

         #S_counter[t,i]<-R[t,i] / (zone_effect[t,i] *p_area[t,i])
         #chisq_disc_R[t,i]<- (R[t,i]-lambda[t,i]) * (R[t,i]-lambda[t,i]) / (lambda[t,i])
         #chisq_disc_R_rep[t,i]<- (R_rep[t,i]-lambda[t,i]) * (R_rep[t,i]-lambda[t,i]) / (lambda[t,i])
      #--------------------------
      # 2.2.2 Juvenile production
      #--------------------------
      # I_juv_moy = indicator for stocking of 0+ or not
      # I_egg_moy = indicator for stocking of eggs or not
      #d_tot_moy without taking into acount area for the stocked juveniles (data only from year 31)
      d_tot_moy[t+1,i] <- d_wild_moy[t+1,i] + I_juv_moy[t+1,i] * d_juv_moy[t+1,i] + I_egg_moy[t+1,i] *
d_egg_moy_surf[t+1,i]
      Juv[t+1,i] <- d_tot_moy[t+1,i]*S_juv_JP[t+1,i]
      d_egg_moy_surf[t+1,i] <-  d_egg_moy[t+1,i]
```

```
        #.........................
        # 2.2.2.1 Wild component
        #.........................
        log(d_wild_moy[t+1,i]) <- L_d_wild_moy[t+1,i]
        L_d_wild_moy[t+1,i] ~ dnorm(L_mu_d_wild[t+1,i],tau_wild_moy)I(-6.91,1.09)    #<- L_mu_d_wild[t+1,i]
#
        L_mu_d_wild[t+1,i] <-  log((S_ts[t,i]/S_juv_JP[t,i]) / (alpha_dd + beta_dd * (S_ts[t,i]/S_juv_JP[t,i]))) +
nu_wild[i]
        res_wild_moy[t+1,i] <-  L_d_wild_moy[t+1,i] -  L_mu_d_wild[t+1,i]
        #...................................
        # 2.2.2.2 stocked juvenile component
        #...................................
        log(d_juv_moy[t+1,i]) <- L_d_juv_moy[t+1,i]
        L_d_juv_moy[t+1,i] ~ dnorm(L_mu_d_juv[t+1,i],tau_juv_moy[ I_juv_moy[t+1,i]+1])I(,1.09)
        # We recaculate the Rmax "available" to stocked 0+  by substracting wild 0+ density and stocked eggs
density
        # to the total Rmax of the density dependence relationship
        Rmax_juv_temp[t+1,i] <- (  Rmax - ((S_ts[t,i]/S_juv_JP[t,i]) / (alpha_dd + beta_dd *
(S_ts[t,i]/S_juv_JP[t,i]))) ) * exp(nu_wild[i])
        Rmax_juv[t+1,i]<-max( Rmax_juv_temp[t+1,i] , 0.000001)
        beta_dd_juv[t+1,i] <- 1 / Rmax_juv[t+1,i]
        L_mu_d_juv[t+1,i] <- I_juv_moy[t+1,i] * log( (stock_juv[t+1,i]/S_juv_JP[t+1,i]) /
(alpha_dd_juv/exp(nu_wild[i]) +  beta_dd_juv[t+1,i]*(stock_juv[t+1,i]/S_juv_JP[t+1,i])))
        res_juv_moy[t+1,i] <- L_d_juv_moy[t+1,i] - L_mu_d_juv[t+1,i]
        #................................
        # 2.2.2.3 stocked egg component
        #................................
        log(d_egg_moy[t+1,i]) <- L_d_egg_moy[t+1,i]
        L_d_egg_moy[t+1,i]~  dnorm(L_mu_d_egg[t+1,i],tau_egg_moy[ I_egg_moy[t+1,i] +1])I(-6.91,1.09)    #
        res_egg_moy[t+1,i] <- L_d_egg_moy[t+1,i] - L_mu_d_egg[t+1,i]

        # I_egg_unit = indicator of presence of incubators or not: only zone 1 and 2 concerned
        # I_egg_VL = indicator for incubators in zone 1
        # I_egg_LP = indicator for incubators in zone 2
        # I_list_inc = indicator for each incabutors loaded or not
        L_mu_d_egg[t+1,i] <-  equals(i,1) *
                        log(
                        (1- I_egg_moy[t+1,1]) +
                        (s_egg * ((stock_egg[t+1,1] + stock_egg[t+1,2] + stock_egg[t+1,3] + stock_egg[t+1,4]) /
S_juv_JP[t+1,1] ))
                        )
                       +
                       equals(i,2) *
                        log(
                        (1- I_egg_moy[t+1,2]) +
                        (s_egg * ((stock_egg[t+1,5] +stock_egg[t+1,6]) / S_juv_JP[t+1,2] ))
                        )

        # getting out of the zone loop, one loop for each zones and the local densitie
        # to avoid using 3 dimensions matrix
    }
      #-----------------------------------
      # 2.2.3 Successive removal fisheries
      #-----------------------------------
      #  I_site_juv_V/L/P = indicator for presence/absence of stocking on the site
      # loop for  sites with successive removal EF
        #................................
        # 2.2.3.1 zone 1 : Vichy Langeac
        #................................
        for (k in 1:J[t+1,1]){
```

```
  d_V[t+1,k]<- d_wild_V[t+1,k] + I_site_juv_V[t+1,k] * d_juv_V[t+1,k]
  log(d_wild_V[t+1,k])<-L_d_wild_V[t+1,k]
  L_d_wild_V[t+1,k] ~ dnorm( L_d_wild_moy[t+1,1] , tau_wild_site)I(-6.91,1.09)

  log(d_juv_V[t+1,k]) <- L_d_juv_V[t+1,k]
  L_d_juv_V[t+1,k] ~ dnorm( L_d_juv_moy[t+1,1] , tau_juv_site[I_site_juv_V[t+1,k] + 1])I(-6.91,1.09)

  lambda_N_V[t+1,k]<-d_V[t+1,k]*S_depl_V[t+1,k]
  #Abundance follows a Poisson distribution
  N_tot_V[t+1,k]~dpois(lambda_N_V[t+1,k])

  L_p_V[t+1,k]~dnorm(L_mu_p_cut,L_tau_p_cut)
  logit(p_V[t+1,k]) <-L_p_V[t+1,k]

  C_1_V[t+1,k]~dbin(p_V[t+1,k],N_tot_V[t+1,k])
  N_1_V[t+1,k]<-N_tot_V[t+1,k]-C_1_V[t+1,k]
  #not all sites have 2 pass, this vector show which sites does
    for (h in 1:pass_2_V[t+1,k]){
      C_2_V[t+1,k]~dbin(p_V[t+1,k],N_1_V[t+1,k])
      N_2_V[t+1,k]<-N_1_V[t+1,k]-C_2_V[t+1,k]
    }
}
#...............................
# 2.2.3.2 zone 2 : Langeac Poutes
#...............................
for (k in 1:J[t+1,2]){
  d_L[t+1,k]<- d_wild_L[t+1,k] + I_site_juv_L[t+1,k] * d_juv_L[t+1,k]
  log(d_wild_L[t+1,k])<-L_d_wild_L[t+1,k]
  L_d_wild_L[t+1,k] ~ dnorm( L_d_wild_moy[t+1,2] , tau_wild_site)I(-6.91,3)

  log(d_juv_L[t+1,k]) <- L_d_juv_L[t+1,k]
  L_d_juv_L[t+1,k] ~ dnorm( L_d_juv_moy[t+1,2] , tau_juv_site[ I_site_juv_L[t+1,k] + 1])I(-6.91,1.09)

  lambda_N_L[t+1,k]<-d_L[t+1,k]*S_depl_L[t+1,k]
  #Abundance follows a Poisson distribution
  N_tot_L[t+1,k]~dpois(lambda_N_L[t+1,k])

  L_p_L[t+1,k]~dnorm(L_mu_p_cut,L_tau_p_cut)
  logit(p_L[t+1,k]) <-L_p_L[t+1,k]

  C_1_L[t+1,k]~dbin(p_L[t+1,k],N_tot_L[t+1,k])
  N_1_L[t+1,k]<-N_tot_L[t+1,k]-C_1_L[t+1,k]
  #not all sites have 2 pass, this vector show which sites does
    for (h in 1:pass_2_L[t+1,k]){
      C_2_L[t+1,k]~dbin(p_L[t+1,k],N_1_L[t+1,k])
      N_2_L[t+1,k]<-N_1_L[t+1,k]-C_2_L[t+1,k]
      #not all sites have 2 pass, this vector show which sites does
        for (m in 1:pass_3_L[t+1,k]){
          C_3_L[t+1,k]~dbin(p_L[t+1,k],N_2_L[t+1,k])
        }
    }
}
#.................................
# 2.2.3.3 zone 3 : upstream Poutes
#.................................
for (k in 1:J[t+1,3]){
  d_P[t+1,k]<- d_wild_P[t+1,k] + I_site_juv_P[t+1,k] * d_juv_P[t+1,k]
  log(d_wild_P[t+1,k])<-L_d_wild_P[t+1,k]
  L_d_wild_P[t+1,k] ~ dnorm( L_d_wild_moy[t+1,3] , tau_wild_site)I(-6.91,1.09)
```

```
        log(d_juv_P[t+1,k]) <- L_d_juv_P[t+1,k]
        L_d_juv_P[t+1,k] ~ dnorm( L_d_juv_moy[t+1,3] , tau_juv_site[ I_site_juv_P[t+1,k] + 1])I(-6.91,1.09)

        lambda_N_P[t+1,k]<-d_P[t+1,k]*S_depl_P[t+1,k]
        #Abundance follows a Poisson distribution
        N_tot_P[t+1,k]~dpois(lambda_N_P[t+1,k])

        L_p_P[t+1,k]~dnorm(L_mu_p_cut,L_tau_p_cut)
        logit(p_P[t+1,k]) <-L_p_P[t+1,k]

        C_1_P[t+1,k]~dbin(p_P[t+1,k],N_tot_P[t+1,k])
        N_1_P[t+1,k]<-N_tot_P[t+1,k]-C_1_P[t+1,k]
        #not all sites have 2 pass, this vector show which sites does
          for (h in 1:pass_2_P[t+1,k]){
            C_2_P[t+1,k]~dbin(p_P[t+1,k],N_1_P[t+1,k])
            N_2_P[t+1,k]<-N_1_P[t+1,k]-C_2_P[t+1,k]
          }
      }
    #---------------------------
    # 2.2.4 5 min IA fisheries
    #---------------------------
      #................................
      # 2.2.4.1 zone 1 : Vichy Langeac
      #................................
      for (k in 1:K[t+1,1]){
        d_V[t+1,k]<- d_wild_V[t+1,k] + I_site_juv_V[t+1,k] * d_juv_V[t+1,k] +  I_site_egg_V[t+1,k] *
d_egg_V[t+1,k]
        log(d_wild_V[t+1,k])<-L_d_wild_V[t+1,k]
        L_d_wild_V[t+1,k] ~ dnorm( L_d_wild_moy[t+1,1] , tau_wild_site)I(-6.91,3)

        log(d_juv_V[t+1,k]) <- L_d_juv_V[t+1,k]
        L_d_juv_V[t+1,k] ~ dnorm( L_d_juv_moy[t+1,1] , tau_juv_site[ I_site_juv_V[t+1,k] + 1])I(-6.91,1.09)

        log(d_egg_V[t+1,k]) <- L_d_egg_V[t+1,k]
        L_d_egg_moy_V_inc[t+1,k]<- I_site_egg_V[t+1,k] * ( L_d_egg_moy[t+1,1] +  log( S_juv_JP[t+1,1]) -
log(S_inc_JP[t+1,1]) )
        L_d_egg_V[t+1,k] ~  dnorm( L_d_egg_moy_V_inc[t+1,k] , tau_egg_site[I_site_egg_V[t+1,k] + 1])I(-
6.91,1.09)

        #5minute EF part
        lambda_IA_V[t+1,k]<-kappa_cut*d_V[t+1,k]     #kappa_cut*pow(d_V[t+1,k],eta_cut)
        EF_IA_V[t+1,k]~dpois(lambda_IA_V[t+1,k])
      }
      #.................................
      # 2.2.4.2 zone 2 : Langeac Poutes
      #.................................
      for (k in 1:K[t+1,2]){
        d_L[t+1,k]<- d_wild_L[t+1,k] + I_site_juv_L[t+1,k] * d_juv_L[t+1,k] +  I_site_egg_L[t+1,k] *
d_egg_L[t+1,k]
        log(d_wild_L[t+1,k])<-L_d_wild_L[t+1,k]
        L_d_wild_L[t+1,k] ~ dnorm( L_d_wild_moy[t+1,2] , tau_wild_site)I(-6.91,1.09)

        log(d_juv_L[t+1,k]) <- L_d_juv_L[t+1,k]
        L_d_juv_L[t+1,k] ~ dnorm( L_d_juv_moy[t+1,2] , tau_juv_site[ I_site_juv_L[t+1,k] + 1])I(-6.91,1.09)

        log(d_egg_L[t+1,k]) <- L_d_egg_L[t+1,k]
        L_d_egg_moy_L_inc[t+1,k]<-  I_site_egg_L[t+1,k] * ( L_d_egg_moy[t+1,2] +  log( S_juv_JP[t+1,2]) -
log(S_inc_JP[t+1,2]) )
        L_d_egg_L[t+1,k] ~  dnorm( L_d_egg_moy_L_inc[t+1,k] , tau_egg_site[I_site_egg_L[t+1,k] + 1])I(-
6.91,1.09)
```

```
        #5minute EF part
        lambda_IA_L[t+1,k]<-kappa_cut*d_L[t+1,k]    #kappa_cut*pow(d_L[t+1,k],eta_cut)
        EF_IA_L[t+1,k]~dpois(lambda_IA_L[t+1,k])
      }
      #...................................
      # 2.2.4.3 zone 3 : upstream Poutes
      #...................................
      for (k in 1:K[t+1,3]){
        d_P[t+1,k]<- d_wild_P[t+1,k] + I_site_juv_P[t+1,k] * d_juv_P[t+1,k]
        log(d_wild_P[t+1,k])<-L_d_wild_P[t+1,k]
        L_d_wild_P[t+1,k] ~ dnorm( L_d_wild_moy[t+1,3] , tau_wild_site)I(-6.91,1.09)

        log(d_juv_P[t+1,k]) <- L_d_juv_P[t+1,k]
        L_d_juv_P[t+1,k] ~ dnorm( L_d_juv_moy[t+1,3] , tau_juv_site[ I_site_juv_P[t+1,k] + 1])I(-6.91,1.09)

        #5minute EF part
        lambda_IA_P[t+1,k]<-kappa_cut*d_P[t+1,k]    #kappa_cut*pow(d_P[t+1,k],eta_cut)
        EF_IA_P[t+1,k]~dpois(lambda_IA_P[t+1,k])
      }
  }


  ##################################################
  # 3. Change in redd count methodology #
  ##################################################
  for (t in 23:30){
    #=========================
    # 3.1 Redd/Spawners part
    #=========================
    logit(p_langeac[t])<- L_p_langeac[t]
    logit(p_poutes[t])<- L_p_poutes[t]
    pool_juv[t]<-s_juv2ad * Juv_tot_system[t] + s_smolt * (0.5 * smolts_tot[t+1] + 0.5 * smolts_tot[t] )
    L_mu_Vichy_nm[t]<-log(s_juv2ad * Juv_tot_system[t] + s_smolt * (0.5 * smolts_tot[t+1] + 0.5 * smolts_tot[t]
)) + level_s *I_surv[t]
    mean_y_surv[t] <- s_juv2ad * exp(level_s * I_surv[t])
    #min_N_1[t]<-max(N[t,3]+2 , min_L[t]) + S_stocking[t] + 2
    # max is only added for the year we only have a minimum figure at vichy
    temp[t]<-max(tot_C[t]  + S_stocking[t]+2,min_N_V[t])

    min_N_1[t]<-max(N[t,3]+2,temp[t] +2)+S_stocking[t]
    N[t,1]~dlnorm(L_mu_Vichy_nm[t],tau_vichy)I(min_N_1[t],15000)
    #without fish caught for breeeding or rod catches
    N_corrected[t] <- N[t,1] - tot_C[t] - S_stocking[t]
    res_Vichy[t] <- log(N[t,1]) - L_mu_Vichy_nm[t]

    #mu_N_L[t]<-N[t,1] * p_langeac[t]
    #tau_N_L[t]<-1/ (N[t,1] * p_langeac[t] * (1-p_langeac[t]) )
    max_N_langeac[t]<- N_corrected[t] - 1     #N[t,1] - S_stocking[t]-1
    min_L_P[t]<-max(min_L[t], N[t,3]+1)    #    max(N[t,3]+1 , min_L[t])
    N[t,2]~dbin(p_langeac[t],N_corrected[t])I(min_L_P[t],)    #
~dnorm(mu_N_L[t],tau_N_L[t])I(min_L_P[t],max_N_langeac[t])    ##

    #mu_N_P[t]<-N[t,2] * p_poutes[t]
    #tau_N_P[t]<-1/ (N[t,2] * p_poutes[t] * (1-p_poutes[t]) )
    max_N_poutes[t]<-N[t,2]-1
    N[t,3]~dbin(p_poutes[t],N[t,2])    #~dnorm(mu_N_P[t],tau_N_P[t])I(1,max_N_poutes[t])    ##
      #------------------------------------
      # 3.1.1 Number of potential spawners
      #------------------------------------
```

```
      mu_S_ts[t,1]<- N[t,1] - N[t,2] - S_stocking[t]
      mu_S_ts[t,2]<- N[t,2]-N[t,3]
      test[t]<-mu_S_ts[t,1]-S_ts[t,1]

      S_ts[t,1]<- max(N[t,1] - N[t,2] - S_stocking[t] - tot_C[t] ,1)    #~dnorm(mu_S_ts[t,1],1)I(0.001,)    #
      S_ts[t,2]<- max( N[t,2]-N[t,3],1)    #~dnorm(mu_S_ts[t,2],1)    #
      S_ts[t,3]<-max( N[t,3],1)

      ratio_S[t,1] <- S_ts[t,1] / ( S_ts[t,1] + S_ts[t,2] + S_ts[t,3])
      ratio_S[t,2] <- S_ts[t,2] / ( S_ts[t,1] + S_ts[t,2] + S_ts[t,3])
      ratio_S[t,3] <- S_ts[t,3] / ( S_ts[t,1] + S_ts[t,2] + S_ts[t,3])


#================================================================================
   # 3.2 Loop for zones (1= Vichy-Langeac, 2= Langeac-Poutès, 3= upstream Poutès)

#================================================================================
   for (i in 1:3){
     #---------------------------
     # 3.2.1 Redd/Spawners part
     #---------------------------
       #....................................
       # 3.2.1.1 Estimation of the spawners
       #....................................
       R[t,i]~dpois(lambda[t,i])
       lambda[t,i] <- S_ts[t,i]  *zone_effect[t,i]* hel_effect[2] *p_area[t,i]
       res_R[t,i]<-(R[t,i]-lambda[t,i])/sqrt(lambda[t,i])
       #.............................
       # 3.2.1.2 Cut of all parameters
       #.............................
       lambda_cut[t,i]<-cut(lambda[t,i])
       R_rep[t,i]~dpois(lambda_cut[t,i])

       #S_counter[t,i]<-R[t,i] / (zone_effect[t,i] *p_area[t,i])
       #chisq_disc_R[t,i]<- (R[t,i]-lambda[t,i]) * (R[t,i]-lambda[t,i]) / (lambda[t,i])
       #chisq_disc_R_rep[t,i]<- (R_rep[t,i]-lambda[t,i]) * (R_rep[t,i]-lambda[t,i]) / (lambda[t,i])
     #---------------------------
     # 3.2.2 Juvenile production
     #---------------------------
     # I_juv_moy = indicator for stocking of 0+ or not
     # I_egg_moy = indicator for stocking of eggs or not
     #d_tot_moy without taking into acount area for the stocked juveniles (data only from year 31)
     d_tot_moy[t+1,i] <- d_wild_moy[t+1,i] + I_juv_moy[t+1,i] * d_juv_moy[t+1,i] + I_egg_moy[t+1,i] *
d_egg_moy_surf[t+1,i]
     Juv[t+1,i] <- d_tot_moy[t+1,i]*S_juv_JP[t+1,i]
     d_egg_moy_surf[t+1,i] <- d_egg_moy[t+1,i]
       #.........................
       # 3.2.2.1 Wild component
       #.........................
       log(d_wild_moy[t+1,i]) <- L_d_wild_moy[t+1,i]
       L_d_wild_moy[t+1,i] ~ dnorm(L_mu_d_wild[t+1,i],tau_wild_moy)I(-6.91,1.09)    #<- L_mu_d_wild[t+1,i]    #
       L_mu_d_wild[t+1,i] <-  log((S_ts[t,i]/S_juv_JP[t,i]) / (alpha_dd + beta_dd * (S_ts[t,i]/S_juv_JP[t,i]))) +
nu_wild[i]
       res_wild_moy[t+1,i] <-  L_d_wild_moy[t+1,i] -  L_mu_d_wild[t+1,i]
       #...................................
       # 3.2.2.2 Stocked juvenile component
       #...................................
       log(d_juv_moy[t+1,i]) <- L_d_juv_moy[t+1,i]
       L_d_juv_moy[t+1,i] ~ dnorm(L_mu_d_juv[t+1,i],tau_juv_moy[ I_juv_moy[t+1,i]+1])I(,1.09)
```

```
        # We recaculate the Rmax "available" to stocked 0+  by substracting wild 0+ density and stocked eggs
density
        # to the total Rmax of the density dependence relationship
        Rmax_juv_temp[t+1,i] <- (  Rmax - ((S_ts[t,i]/S_juv_JP[t,i]) / (alpha_dd + beta_dd *
(S_ts[t,i]/S_juv_JP[t,i]))) ) * exp(nu_wild[i])
        Rmax_juv[t+1,i] <- max(Rmax_juv_temp[t+1,i] ,0.000001)
        beta_dd_juv[t+1,i] <- 1 / Rmax_juv[t+1,i]
        L_mu_d_juv[t+1,i] <-  I_juv_moy[t+1,i] * log( (stock_juv[t+1,i]/S_juv_JP[t+1,i]) /
(alpha_dd_juv/exp(nu_wild[i]) +  beta_dd_juv[t+1,i] * (stock_juv[t+1,i]/S_juv_JP[t+1,i])))
        res_juv_moy[t+1,i] <- L_d_juv_moy[t+1,i] - L_mu_d_juv[t+1,i]
        #................................
        # 3.2.2.3 Stocked egg component
        #................................
        log(d_egg_moy[t+1,i]) <- L_d_egg_moy[t+1,i]
        L_d_egg_moy[t+1,i]~  dnorm(L_mu_d_egg[t+1,i],tau_egg_moy[ I_egg_moy[t+1,i] +1])I(-6.91,1.09)    #
        res_egg_moy[t+1,i] <- L_d_egg_moy[t+1,i] - L_mu_d_egg[t+1,i]

        # I_egg_unit = indicator of presence of incubators or not: only zone 1 and 2 concerned
        # I_egg_VL = indicator for incubators in zone 1
        # I_egg_LP = indicator for incubators in zone 2
        # I_list_inc = indicator for each incabutors loaded or not
        L_mu_d_egg[t+1,i] <-  equals(i,1) *
                    log(
                    (1- I_egg_moy[t+1,1]) +
                    (s_egg * ((stock_egg[t+1,1] + stock_egg[t+1,2] + stock_egg[t+1,3] + stock_egg[t+1,4]) /
S_juv_JP[t+1,1] ))
                    )
                   +
                   equals(i,2) *
                    log(
                    (1- I_egg_moy[t+1,2]) +
                    (s_egg * ((stock_egg[t+1,5] +stock_egg[t+1,6]) / S_juv_JP[t+1,2] ))
                    )
        # getting out of the zone loop, one loop for each zones and the local densitie
        # to avoid using 3 dimensions matrix
    }
      #-----------------------------------
      # 3.2.3 Successive removal fisheries
      #-----------------------------------
      #  I_site_juv_V/L/P = indicator for presence/absence of stocking on the site
      # loop for  sites with successive removal EF
        #................................
        # 3.2.3.1 zone 1 : Vichy Langeac
        #................................
        for (k in 1:J[t+1,1]){
          d_V[t+1,k]<- d_wild_V[t+1,k] + I_site_juv_V[t+1,k] * d_juv_V[t+1,k]
          log(d_wild_V[t+1,k])<-L_d_wild_V[t+1,k]
          L_d_wild_V[t+1,k] ~ dnorm( L_d_wild_moy[t+1,1] , tau_wild_site)I(-6.91,1.09)

          log(d_juv_V[t+1,k]) <- L_d_juv_V[t+1,k]
          L_d_juv_V[t+1,k] ~ dnorm( L_d_juv_moy[t+1,1] , tau_juv_site[I_site_juv_V[t+1,k] + 1])I(-6.91,1.09)

          lambda_N_V[t+1,k]<-d_V[t+1,k]*S_depl_V[t+1,k]
          #Abundance follows a Poisson distribution
          N_tot_V[t+1,k]~dpois(lambda_N_V[t+1,k])

          L_p_V[t+1,k]~dnorm(L_mu_p_cut,L_tau_p_cut)
          logit(p_V[t+1,k]) <-L_p_V[t+1,k]

          C_1_V[t+1,k]~dbin(p_V[t+1,k],N_tot_V[t+1,k])
```

```
  N_1_V[t+1,k]<-N_tot_V[t+1,k]-C_1_V[t+1,k]
  #not all sites have 2 pass, this vector show which sites does
    for (h in 1:pass_2_V[t+1,k]){
      C_2_V[t+1,k]~dbin(p_V[t+1,k],N_1_V[t+1,k])
      N_2_V[t+1,k]<-N_1_V[t+1,k]-C_2_V[t+1,k]
    }
}
#................................
# 3.2.3.2 zone 2 : Langeac Poutes
#................................
for (k in 1:J[t+1,2]){
  d_L[t+1,k]<- d_wild_L[t+1,k] + I_site_juv_L[t+1,k] * d_juv_L[t+1,k]
  log(d_wild_L[t+1,k])<-L_d_wild_L[t+1,k]
  L_d_wild_L[t+1,k] ~ dnorm( L_d_wild_moy[t+1,2] , tau_wild_site)I(-6.91,3)

  log(d_juv_L[t+1,k]) <- L_d_juv_L[t+1,k]
  L_d_juv_L[t+1,k] ~ dnorm( L_d_juv_moy[t+1,2] , tau_juv_site[ I_site_juv_L[t+1,k] + 1])I(-6.91,1.09)

  lambda_N_L[t+1,k]<-d_L[t+1,k]*S_depl_L[t+1,k]
  #Abundance follows a Poisson distribution
  N_tot_L[t+1,k]~dpois(lambda_N_L[t+1,k])

  L_p_L[t+1,k]~dnorm(L_mu_p_cut,L_tau_p_cut)
  logit(p_L[t+1,k]) <-L_p_L[t+1,k]

   C_1_L[t+1,k]~dbin(p_L[t+1,k],N_tot_L[t+1,k])
   N_1_L[t+1,k]<-N_tot_L[t+1,k]-C_1_L[t+1,k]
   #not all sites have 2 pass, this vector show which sites does
    for (h in 1:pass_2_L[t+1,k]){
      C_2_L[t+1,k]~dbin(p_L[t+1,k],N_1_L[t+1,k])
      N_2_L[t+1,k]<-N_1_L[t+1,k]-C_2_L[t+1,k]
      #not all sites have 2 pass, this vector show which sites does
        for (m in 1:pass_3_L[t+1,k]){
          C_3_L[t+1,k]~dbin(p_L[t+1,k],N_2_L[t+1,k])
        }
    }
}
#.................................
# 3.2.3.3 zone 3 : upstream Poutes
#.................................
for (k in 1:J[t+1,3]){
  d_P[t+1,k]<- d_wild_P[t+1,k] + I_site_juv_P[t+1,k] * d_juv_P[t+1,k]
  log(d_wild_P[t+1,k])<-L_d_wild_P[t+1,k]
  L_d_wild_P[t+1,k] ~ dnorm( L_d_wild_moy[t+1,3] , tau_wild_site)I(-6.91,1.09)

  log(d_juv_P[t+1,k]) <- L_d_juv_P[t+1,k]
  L_d_juv_P[t+1,k] ~ dnorm( L_d_juv_moy[t+1,3] , tau_juv_site[ I_site_juv_P[t+1,k] + 1])I(-6.91,1.09)

  lambda_N_P[t+1,k]<-d_P[t+1,k]*S_depl_P[t+1,k]
  #Abundance follows a Poisson distribution
  N_tot_P[t+1,k]~dpois(lambda_N_P[t+1,k])

  L_p_P[t+1,k]~dnorm(L_mu_p_cut,L_tau_p_cut)
  logit(p_P[t+1,k]) <-L_p_P[t+1,k]

  C_1_P[t+1,k]~dbin(p_P[t+1,k],N_tot_P[t+1,k])
  N_1_P[t+1,k]<-N_tot_P[t+1,k]-C_1_P[t+1,k]
  #not all sites have 2 pass, this vector show which sites does
    for (h in 1:pass_2_P[t+1,k]){
      C_2_P[t+1,k]~dbin(p_P[t+1,k],N_1_P[t+1,k])
```

```
            N_2_P[t+1,k]<-N_1_P[t+1,k]-C_2_P[t+1,k]
          }
        }
      #------------------------------------
      # 3.2.4 5 min IA fisheries
      #------------------------------------
        #................................
        # 3.2.4.1 zone 1 : Vichy Langeac
        #................................
        for (k in 1:K[t+1,1]){
          d_V[t+1,k]<- d_wild_V[t+1,k] + I_site_juv_V[t+1,k] * d_juv_V[t+1,k] +  I_site_egg_V[t+1,k] *
d_egg_V[t+1,k]
          log(d_wild_V[t+1,k])<-L_d_wild_V[t+1,k]
          L_d_wild_V[t+1,k] ~ dnorm( L_d_wild_moy[t+1,1] , tau_wild_site)I(-6.91,3)

          log(d_juv_V[t+1,k]) <- L_d_juv_V[t+1,k]
          L_d_juv_V[t+1,k] ~ dnorm( L_d_juv_moy[t+1,1] , tau_juv_site[ I_site_juv_V[t+1,k] + 1])I(-6.91,1.09)

          log(d_egg_V[t+1,k]) <- L_d_egg_V[t+1,k]
          L_d_egg_moy_V_inc[t+1,k]<- I_site_egg_V[t+1,k] * ( L_d_egg_moy[t+1,1] +  log( S_juv_JP[t+1,1]) -
log(S_inc_JP[t+1,1]) )
          L_d_egg_V[t+1,k] ~  dnorm( L_d_egg_moy_V_inc[t+1,k] , tau_egg_site[I_site_egg_V[t+1,k] + 1])I(-
6.91,1.09)

          #5minute EF part
          lambda_IA_V[t+1,k]<-kappa_cut*d_V[t+1,k]    #kappa_cut*pow(d_V[t+1,k],eta_cut)
          EF_IA_V[t+1,k]~dpois(lambda_IA_V[t+1,k])
        }
        #.................................
        # 3.2.4.2 zone 2 : Langeac Poutes
        #.................................
        for (k in 1:K[t+1,2]){
          d_L[t+1,k]<- d_wild_L[t+1,k] + I_site_juv_L[t+1,k] * d_juv_L[t+1,k] +  I_site_egg_L[t+1,k] *
d_egg_L[t+1,k]
          log(d_wild_L[t+1,k])<-L_d_wild_L[t+1,k]
          L_d_wild_L[t+1,k] ~ dnorm( L_d_wild_moy[t+1,2] , tau_wild_site)I(-6.91,1.09)

          log(d_juv_L[t+1,k]) <- L_d_juv_L[t+1,k]
          L_d_juv_L[t+1,k] ~ dnorm( L_d_juv_moy[t+1,2] , tau_juv_site[ I_site_juv_L[t+1,k] + 1])I(-6.91,1.09)

          log(d_egg_L[t+1,k]) <- L_d_egg_L[t+1,k]
          L_d_egg_moy_L_inc[t+1,k]<-  I_site_egg_L[t+1,k] * ( L_d_egg_moy[t+1,2] +  log( S_juv_JP[t+1,2]) -
log(S_inc_JP[t+1,2]) )
          L_d_egg_L[t+1,k] ~  dnorm( L_d_egg_moy_L_inc[t+1,k] , tau_egg_site[I_site_egg_L[t+1,k] + 1])I(-
6.91,1.09)

          #5minute EF part
          lambda_IA_L[t+1,k]<-kappa_cut*d_L[t+1,k]    #kappa_cut*pow(d_L[t+1,k],eta_cut)
          EF_IA_L[t+1,k]~dpois(lambda_IA_L[t+1,k])
        }
        #..................................
        # 3.2.4.3 zone 3 : upstream Poutes
        #..................................
        for (k in 1:K[t+1,3]){
          d_P[t+1,k]<- d_wild_P[t+1,k] + I_site_juv_P[t+1,k] * d_juv_P[t+1,k]
          log(d_wild_P[t+1,k])<-L_d_wild_P[t+1,k]
          L_d_wild_P[t+1,k] ~ dnorm( L_d_wild_moy[t+1,3] , tau_wild_site)I(-6.91,1.09)

          log(d_juv_P[t+1,k]) <- L_d_juv_P[t+1,k]
          L_d_juv_P[t+1,k] ~ dnorm( L_d_juv_moy[t+1,3] , tau_juv_site[ I_site_juv_P[t+1,k] + 1])I(-6.91,1.09)
```

```
        #5minute EF part
        lambda_IA_P[t+1,k]<-kappa_cut*d_P[t+1,k]    #kappa_cut*pow(d_P[t+1,k],eta_cut)
        EF_IA_P[t+1,k]~dpois(lambda_IA_P[t+1,k])
      }
  }

  #################################################
  # 4. Take into acount the area used for stocked juveniles #
  #################################################
  for (t in 31:T-1){
    #========================
    # 4.1 Redd/Spawners part
    #========================
    logit(p_langeac[t])<- L_p_langeac[t]
    logit(p_poutes[t])<- L_p_poutes[t]
    pool_juv[t]<-s_juv2ad * Juv_tot_system[t] + s_smolt * (0.5 * smolts_tot[t+1] + 0.5 * smolts_tot[t] )
     L_mu_Vichy_nm[t]<-log(s_juv2ad * Juv_tot_system[t] + s_smolt * (0.5 * smolts_tot[t+1] + 0.5 *
smolts_tot[t] )) + level_s *I_surv[t]
    mean_y_surv[t] <- s_juv2ad * exp(level_s * I_surv[t])
    #min_N_1[t]<-max(N[t,3]+2 , min_L[t]) + S_stocking[t] + 2
    # max is only added for the year we only have a minimum figure at vichy
    temp[t]<-max(tot_C[t]  + S_stocking[t]+2,min_N_V[t])

    min_N_1[t]<-max(N[t,3]+2,temp[t] +2)+S_stocking[t]
    N[t,1]~dlnorm(L_mu_Vichy_nm[t],tau_vichy)I(min_N_1[t],15000)
    #without fish caught for breeeding or rod catches
    N_corrected[t] <- N[t,1] - tot_C[t] - S_stocking[t]
    res_Vichy[t] <- log(N[t,1]) - L_mu_Vichy_nm[t]

    #mu_N_L[t]<-N[t,1] * p_langeac[t]
    #tau_N_L[t]<-1/ (N[t,1] * p_langeac[t] * (1-p_langeac[t]) )
    max_N_langeac[t]<- N_corrected[t] - 1     #N[t,1] - S_stocking[t]-1
    min_L_P[t]<-max(min_L[t], N[t,3]+1)    #    max(N[t,3]+1 , min_L[t])
    N[t,2]~dbin(p_langeac[t],N_corrected[t])I(min_L_P[t],)    #
~dnorm(mu_N_L[t],tau_N_L[t])I(min_L_P[t],max_N_langeac[t])    ##

    #mu_N_P[t]<-N[t,2] * p_poutes[t]
    #tau_N_P[t]<-1/ (N[t,2] * p_poutes[t] * (1-p_poutes[t]) )
    max_N_poutes[t]<-N[t,2]-1
    N[t,3]~dbin(p_poutes[t],N[t,2])    #~dnorm(mu_N_P[t],tau_N_P[t])I(1,max_N_poutes[t])    ##
      #------------------------------------
      # 4.1.1 Number of potential spawners
      #------------------------------------
      mu_S_ts[t,1]<- N[t,1] - N[t,2] - S_stocking[t]
      mu_S_ts[t,2]<- N[t,2]-N[t,3]
      test[t]<-mu_S_ts[t,1]-S_ts[t,1]

      S_ts[t,1]<- max(N[t,1] - N[t,2] - S_stocking[t] - tot_C[t] ,1)    #~dnorm(mu_S_ts[t,1],1)I(0.001,)    #
      S_ts[t,2]<- max( N[t,2]-N[t,3],1)    #~dnorm(mu_S_ts[t,2],1)    #
      S_ts[t,3]<-max( N[t,3],1)

      ratio_S[t,1] <- S_ts[t,1] / ( S_ts[t,1] + S_ts[t,2] + S_ts[t,3])
      ratio_S[t,2] <- S_ts[t,2] / ( S_ts[t,1] + S_ts[t,2] + S_ts[t,3])
      ratio_S[t,3] <- S_ts[t,3] / ( S_ts[t,1] + S_ts[t,2] + S_ts[t,3])


#============================================================================
    # 4.2 Loop for zones (1= Vichy-Langeac, 2= Langeac-Poutès, 3= upstream Poutès)
```

```
#===============================================================================
    for (i in 1:3){
      #--------------------------
      # 4.2.1 Redd/Spawners part
      #--------------------------
        #....................................
        # 4.2.1.1 Estimation of the spawners
        #....................................
        R[t,i]~dpois(lambda[t,i])
        lambda[t,i] <- S_ts[t,i]  *zone_effect[t,i]* hel_effect[2] *p_area[t,i]
        res_R[t,i]<-(R[t,i]-lambda[t,i])/sqrt(lambda[t,i])
        #.............................
        # 4.2.1.2 Cut of all parameters
        #.............................
        lambda_cut[t,i]<-cut(lambda[t,i])
        R_rep[t,i]~dpois(lambda_cut[t,i])

        #S_counter[t,i]<-R[t,i] / (zone_effect[t,i] *p_area[t,i])
        #chisq_disc_R[t,i]<- (R[t,i]-lambda[t,i]) * (R[t,i]-lambda[t,i]) / (lambda[t,i])
        #chisq_disc_R_rep[t,i]<- (R_rep[t,i]-lambda[t,i]) * (R_rep[t,i]-lambda[t,i]) / (lambda[t,i])
      #--------------------------
      # 4.2.2 Juvenile production
      #--------------------------
      # I_juv_moy = indicator for stocking of 0+ or not
      # I_egg_moy = indicator for stocking of eggs or not
      #d_tot_moy with taking into acount area for the stocked juveniles (data only from year 31)
      d_tot_moy[t+1,i] <- d_wild_moy[t+1,i] + I_juv_moy[t+1,i] *
d_juv_moy[t+1,i]*S_juv_JP_dev[t+1,i]/S_juv_JP[t+1,i]  + I_egg_moy[t+1,i] * d_egg_moy_surf[t+1,i]
      Juv[t+1,i] <- d_tot_moy[t+1,i]*S_juv_JP[t+1,i]
      d_egg_moy_surf[t+1,i] <- d_egg_moy[t+1,i]
        #.........................
        # 4.2.2.1 Wild component
        #.........................
        log(d_wild_moy[t+1,i]) <- L_d_wild_moy[t+1,i]
        L_d_wild_moy[t+1,i] ~ dnorm(L_mu_d_wild[t+1,i],tau_wild_moy)I(-6.91,1.09)    #<- L_mu_d_wild[t+1,i]    #
        L_mu_d_wild[t+1,i] <-  log((S_ts[t,i]/S_juv_JP[t,i]) / (alpha_dd + beta_dd * (S_ts[t,i]/S_juv_JP[t,i]))) +
nu_wild[i]
        res_wild_moy[t+1,i] <-  L_d_wild_moy[t+1,i] -  L_mu_d_wild[t+1,i]
        #...................................
        # 4.2.2.2 Stocked juvenile component
        #...................................
        log(d_juv_moy[t+1,i]) <- L_d_juv_moy[t+1,i]
        L_d_juv_moy[t+1,i] ~ dnorm(L_mu_d_juv[t+1,i],tau_juv_moy[ I_juv_moy[t+1,i]+1])I(,1.09)

        # We recaculate the Rmax "available" to stocked 0+  by substracting wild 0+ density and stocked eggs
density
        # to the total Rmax of the density dependence relationship
        Rmax_juv_temp[t+1,i] <- (  Rmax - ((S_ts[t,i]/S_juv_JP[t,i]) / (alpha_dd + beta_dd *
(S_ts[t,i]/S_juv_JP[t,i]))) ) * exp(nu_wild[i])
        Rmax_juv[t+1,i] <- max(Rmax_juv_temp[t+1,i] ,0.000001)
        beta_dd_juv[t+1,i] <- 1 / Rmax_juv[t+1,i]
        L_mu_d_juv[t+1,i] <-  I_juv_moy[t+1,i] * log( (stock_juv[t+1,i]/S_juv_JP[t+1,i]) /
(alpha_dd_juv/exp(nu_wild[i]) +  beta_dd_juv[t+1,i] * (stock_juv[t+1,i]/S_juv_JP[t+1,i])))
        res_juv_moy[t+1,i] <- L_d_juv_moy[t+1,i] - L_mu_d_juv[t+1,i]
        #................................
        # 4.2.2.3 Stocked egg component
        #................................
        log(d_egg_moy[t+1,i]) <- L_d_egg_moy[t+1,i]
        L_d_egg_moy[t+1,i]~  dnorm(L_mu_d_egg[t+1,i],tau_egg_moy[ I_egg_moy[t+1,i] +1])I(-6.91,1.09)    #
        res_egg_moy[t+1,i] <- L_d_egg_moy[t+1,i] - L_mu_d_egg[t+1,i]
```

```
      # I_egg_unit = indicator of presence of incubators or not: only zone 1 and 2 concerned
      # I_egg_VL = indicator for incubators in zone 1
      # I_egg_LP = indicator for incubators in zone 2
      # I_list_inc = indicator for each incabutors loaded or not
      L_mu_d_egg[t+1,i] <-  equals(i,1) *
                      log(
                      (1- I_egg_moy[t+1,1]) +
                      (s_egg * ((stock_egg[t+1,1] + stock_egg[t+1,2] + stock_egg[t+1,3] + stock_egg[t+1,4]) /
S_juv_JP[t+1,1] ))
                      )
                     +
                     equals(i,2) *
                      log(
                      (1- I_egg_moy[t+1,2]) +
                      (s_egg * ((stock_egg[t+1,5] +stock_egg[t+1,6]) / S_juv_JP[t+1,2] ))
                      )
      # getting out of the zone loop, one loop for each zones and the local densitie
      # to avoid using 3 dimensions matrix
    }
     #------------------------------------
     # 4.2.3 Successive removal fisheries
     #------------------------------------
     #  I_site_juv_V/L/P = indicator for presence/absence of stocking on the site
     # loop for  sites with successive removal EF
      #................................
      # 4.2.3.1 zone 1 : Vichy Langeac
      #................................
      for (k in 1:J[t+1,1]){
        d_V[t+1,k]<- d_wild_V[t+1,k] + I_site_juv_V[t+1,k] * d_juv_V[t+1,k]
        log(d_wild_V[t+1,k])<-L_d_wild_V[t+1,k]
        L_d_wild_V[t+1,k] ~ dnorm( L_d_wild_moy[t+1,1] , tau_wild_site)I(-6.91,1.09)

        log(d_juv_V[t+1,k]) <- L_d_juv_V[t+1,k]
        L_d_juv_V[t+1,k] ~ dnorm( L_d_juv_moy[t+1,1] , tau_juv_site[I_site_juv_V[t+1,k] + 1])I(-6.91,1.09)

        lambda_N_V[t+1,k]<-d_V[t+1,k]*S_depl_V[t+1,k]
        #Abundance follows a Poisson distribution
        N_tot_V[t+1,k]~dpois(lambda_N_V[t+1,k])

        L_p_V[t+1,k]~dnorm(L_mu_p_cut,L_tau_p_cut)
        logit(p_V[t+1,k]) <-L_p_V[t+1,k]

        C_1_V[t+1,k]~dbin(p_V[t+1,k],N_tot_V[t+1,k])
        N_1_V[t+1,k]<-N_tot_V[t+1,k]-C_1_V[t+1,k]
        #not all sites have 2 pass, this vector show which sites does
          for (h in 1:pass_2_V[t+1,k]){
            C_2_V[t+1,k]~dbin(p_V[t+1,k],N_1_V[t+1,k])
            N_2_V[t+1,k]<-N_1_V[t+1,k]-C_2_V[t+1,k]
          }
      }
      #................................
      # 4.2.3.2 zone 2 : Langeac Poutes
      #................................
      for (k in 1:J[t+1,2]){
        d_L[t+1,k]<- d_wild_L[t+1,k] + I_site_juv_L[t+1,k] * d_juv_L[t+1,k]
        log(d_wild_L[t+1,k])<-L_d_wild_L[t+1,k]
        L_d_wild_L[t+1,k] ~ dnorm( L_d_wild_moy[t+1,2] , tau_wild_site)I(-6.91,3)

        log(d_juv_L[t+1,k]) <- L_d_juv_L[t+1,k]
```

```
    L_d_juv_L[t+1,k] ~ dnorm( L_d_juv_moy[t+1,2] , tau_juv_site[ I_site_juv_L[t+1,k] + 1])I(-6.91,1.09)

    lambda_N_L[t+1,k]<-d_L[t+1,k]*S_depl_L[t+1,k]
    #Abundance follows a Poisson distribution
    N_tot_L[t+1,k]~dpois(lambda_N_L[t+1,k])

    L_p_L[t+1,k]~dnorm(L_mu_p_cut,L_tau_p_cut)
    logit(p_L[t+1,k]) <-L_p_L[t+1,k]

     C_1_L[t+1,k]~dbin(p_L[t+1,k],N_tot_L[t+1,k])
     N_1_L[t+1,k]<-N_tot_L[t+1,k]-C_1_L[t+1,k]
     #not all sites have 2 pass, this vector show which sites does
      for (h in 1:pass_2_L[t+1,k]){
        C_2_L[t+1,k]~dbin(p_L[t+1,k],N_1_L[t+1,k])
        N_2_L[t+1,k]<-N_1_L[t+1,k]-C_2_L[t+1,k]
        #not all sites have 2 pass, this vector show which sites does
          for (m in 1:pass_3_L[t+1,k]){
            C_3_L[t+1,k]~dbin(p_L[t+1,k],N_2_L[t+1,k])
          }
      }
  }
  #.................................
  # 4.2.3.3 zone 3 : upstream Poutes
  #.................................
  for (k in 1:J[t+1,3]){
    d_P[t+1,k]<- d_wild_P[t+1,k] + I_site_juv_P[t+1,k] * d_juv_P[t+1,k]
    log(d_wild_P[t+1,k])<-L_d_wild_P[t+1,k]
    L_d_wild_P[t+1,k] ~ dnorm( L_d_wild_moy[t+1,3] , tau_wild_site)I(-6.91,1.09)

    log(d_juv_P[t+1,k]) <- L_d_juv_P[t+1,k]
    L_d_juv_P[t+1,k] ~ dnorm( L_d_juv_moy[t+1,3] , tau_juv_site[ I_site_juv_P[t+1,k] + 1])I(-6.91,1.09)

    lambda_N_P[t+1,k]<-d_P[t+1,k]*S_depl_P[t+1,k]
    #Abundance follows a Poisson distribution
    N_tot_P[t+1,k]~dpois(lambda_N_P[t+1,k])

    L_p_P[t+1,k]~dnorm(L_mu_p_cut,L_tau_p_cut)
    logit(p_P[t+1,k]) <-L_p_P[t+1,k]

    C_1_P[t+1,k]~dbin(p_P[t+1,k],N_tot_P[t+1,k])
    N_1_P[t+1,k]<-N_tot_P[t+1,k]-C_1_P[t+1,k]
    #not all sites have 2 pass, this vector show which sites does
      for (h in 1:pass_2_P[t+1,k]){
        C_2_P[t+1,k]~dbin(p_P[t+1,k],N_1_P[t+1,k])
        N_2_P[t+1,k]<-N_1_P[t+1,k]-C_2_P[t+1,k]
      }
  }
 #-----------------------------------
 # 4.2.4 5 min IA fisheries
 #-----------------------------------
  #................................
  # 4.2.4.1 zone 1 : Vichy Langeac
  #................................
  for (k in 1:K[t+1,1]){
    d_V[t+1,k]<- d_wild_V[t+1,k] + I_site_juv_V[t+1,k] * d_juv_V[t+1,k] +  I_site_egg_V[t+1,k] *
d_egg_V[t+1,k]
    log(d_wild_V[t+1,k])<-L_d_wild_V[t+1,k]
    L_d_wild_V[t+1,k] ~ dnorm( L_d_wild_moy[t+1,1] , tau_wild_site)I(-6.91,3)

    log(d_juv_V[t+1,k]) <- L_d_juv_V[t+1,k]
```

```
        L_d_juv_V[t+1,k] ~ dnorm( L_d_juv_moy[t+1,1] , tau_juv_site[ I_site_juv_V[t+1,k] + 1])I(-6.91,1.09)

        log(d_egg_V[t+1,k]) <- L_d_egg_V[t+1,k]
        L_d_egg_moy_V_inc[t+1,k]<- I_site_egg_V[t+1,k] * ( L_d_egg_moy[t+1,1] +  log( S_juv_JP[t+1,1]) -
log(S_inc_JP[t+1,1]) )
        L_d_egg_V[t+1,k] ~  dnorm( L_d_egg_moy_V_inc[t+1,k] , tau_egg_site[I_site_egg_V[t+1,k] + 1])I(-
6.91,1.09)

        #5minute EF part
        lambda_IA_V[t+1,k]<-kappa_cut*d_V[t+1,k]    #kappa_cut*pow(d_V[t+1,k],eta_cut)
        EF_IA_V[t+1,k]~dpois(lambda_IA_V[t+1,k])
      }
      #................................
      # 4.2.4.2 zone 2 : Langeac Poutes
      #................................
      for (k in 1:K[t+1,2]){
        d_L[t+1,k]<- d_wild_L[t+1,k] + I_site_juv_L[t+1,k] * d_juv_L[t+1,k] +  I_site_egg_L[t+1,k] *
d_egg_L[t+1,k]
        log(d_wild_L[t+1,k])<-L_d_wild_L[t+1,k]
        L_d_wild_L[t+1,k] ~ dnorm( L_d_wild_moy[t+1,2] , tau_wild_site)I(-6.91,1.09)

        log(d_juv_L[t+1,k]) <- L_d_juv_L[t+1,k]
        L_d_juv_L[t+1,k] ~ dnorm( L_d_juv_moy[t+1,2] , tau_juv_site[ I_site_juv_L[t+1,k] + 1])I(-6.91,1.09)

        log(d_egg_L[t+1,k]) <- L_d_egg_L[t+1,k]
        L_d_egg_moy_L_inc[t+1,k]<-  I_site_egg_L[t+1,k] * ( L_d_egg_moy[t+1,2] +  log( S_juv_JP[t+1,2]) -
log(S_inc_JP[t+1,2]) )
        L_d_egg_L[t+1,k] ~  dnorm( L_d_egg_moy_L_inc[t+1,k] , tau_egg_site[I_site_egg_L[t+1,k] + 1])I(-
6.91,1.09)

        #5minute EF part
        lambda_IA_L[t+1,k]<-kappa_cut*d_L[t+1,k]    #kappa_cut*pow(d_L[t+1,k],eta_cut)
        EF_IA_L[t+1,k]~dpois(lambda_IA_L[t+1,k])
      }
      #.................................
      # 4.2.4.3 zone 3 : upstream Poutes
      #.................................
      for (k in 1:K[t+1,3]){
        d_P[t+1,k]<- d_wild_P[t+1,k] + I_site_juv_P[t+1,k] * d_juv_P[t+1,k]
        log(d_wild_P[t+1,k])<-L_d_wild_P[t+1,k]
        L_d_wild_P[t+1,k] ~ dnorm( L_d_wild_moy[t+1,3] , tau_wild_site)I(-6.91,1.09)

        log(d_juv_P[t+1,k]) <- L_d_juv_P[t+1,k]
        L_d_juv_P[t+1,k] ~ dnorm( L_d_juv_moy[t+1,3] , tau_juv_site[ I_site_juv_P[t+1,k] + 1])I(-6.91,1.09)

        #5minute EF part
        lambda_IA_P[t+1,k]<-kappa_cut*d_P[t+1,k]    #kappa_cut*pow(d_P[t+1,k],eta_cut)
        EF_IA_P[t+1,k]~dpois(lambda_IA_P[t+1,k])
      }
  }

  ##############################################
  # 5. Just the last year to estimate spawners       #
  ##############################################
  for (t in T:T){
    #========================
    # 5.1 Redd/Spawners part
    #========================
     logit(p_langeac[t])<- L_p_langeac[t]
     logit(p_poutes[t])<- L_p_poutes[t]
```

```
    pool_juv[t]<-s_juv2ad* Juv_tot_system[t] + s_smolt * (0.5 * smolts_tot[t+1] + 0.5 * smolts_tot[t] )
    L_mu_Vichy_nm[t]<-log(s_juv2ad *Juv_tot_system[t] + s_smolt * (0.5 * smolts_tot[t+1] + 0.5 * smolts_tot[t]
)) + level_s *l_surv[t]

    min_N_1[t]<-max(N[t,3]+2,tot_C[t] +2)+S_stocking[t]
    N[t,1]~dlnorm(L_mu_Vichy_nm[t],tau_vichy)I(min_N_1[t],15000)
    res_Vichy[t] <- log(N[t,1]) - L_mu_Vichy_nm[t]
    N_corrected[t]<-N[t,1]-S_stocking[t]

    max_N_langeac[t]<- N_corrected[t] -1    #N[t,1] - S_stocking[t]-1
    min_L_P[t]<-N[t,3]+1    #max(N[t,3]+2 , min_L[t])
    #mu_N_L[t]<-N[t,1] * p_langeac[t]
    #tau_N_L[t]<-1/ (N[t,1] * p_langeac[t] * (1-p_langeac[t]) )
    N[t,2]~dbin(p_langeac[t],N_corrected[t])I(min_L_P[t],)    #
~dnorm(mu_N_L[t],tau_N_L[t])I(min_L_P[t],max_N_langeac[t])    ##

    #mu_N_P[t]<-N[t,2] * p_poutes[t]
    #tau_N_P[t]<-1/ (N[t,2] * p_poutes[t] * (1-p_poutes[t]) )
    max_N_poutes[t]<-N[t,2]-1
    N[t,3]~dbin(p_poutes[t],N[t,2])    #~dnorm(mu_N_P[t],tau_N_P[t])I(1,max_N_poutes[t])
#~dnorm(mu_N_P[t],tau_N_P[t])I(1,max_N_poutes[t])
     #-------------------------------------
     # 5.1.1 Number of potential spawners
     #-------------------------------------
     S_ts[t,1]<- max( N[t,1] - S_stocking[t] -tot_C[t]-N[t,2],1)
     S_ts[t,2]<- max( N[t,2]-N[t,3],1)
     S_ts[t,3]<-max( N[t,3],1)

     ratio_S[t,1] <- S_ts[t,1] / ( S_ts[t,1] + S_ts[t,2] + S_ts[t,3])
     ratio_S[t,2] <- S_ts[t,2] / ( S_ts[t,1] + S_ts[t,2] + S_ts[t,3])
     ratio_S[t,3] <- S_ts[t,3] / ( S_ts[t,1] + S_ts[t,2] + S_ts[t,3])

    #========================================================================
    # 5.2 Loop for zones (1= Vichy-Langeac, 2= Langeac-Poutès, 3= upstream Poutès)
    #========================================================================
    for (i in 1:3){
      #---------------------------
      # 5.2.1 Redd/Spawners part
      #---------------------------
        #.....................................
        # 5.2.1.1 Estimation of the spawners
        #.....................................
        R[t,i]~dpois(lambda[t,i])
        lambda[t,i] <- S_ts[t,i]  *zone_effect[t,i] * hel_effect[2]*p_area[t,i]
        res_R[t,i]<-(R[t,i]-lambda[t,i])/sqrt(lambda[t,i])
        #................................
        # 5.2.1.2 Cut of all parameters
        #................................
        lambda_cut[t,i]<-cut(lambda[t,i])
        R_rep[t,i]~dpois(lambda_cut[t,i])

        #S_counter[t,i]<-R[t,i] / (zone_effect[t,i] *p_area[t,i])
        #chisq_disc_R[t,i]<- (R[t,i]-lambda[t,i]) * (R[t,i]-lambda[t,i]) / (lambda[t,i])
        #chisq_disc_R_rep[t,i]<- (R_rep[t,i]-lambda[t,i]) * (R_rep[t,i]-lambda[t,i]) / (lambda[t,i])
     #----------------------------------------
     # 5.2.2 Juvenile production (wild only)
     #----------------------------------------
     d_tot_moy[t+1,i] <- d_wild_moy[t+1,i]
     Juv[t+1,i] <- d_tot_moy[t+1,i]*S_juv_JP[t+1,i]
       #........................
```

```
        # 5.2.2.1 Wild component
        #........................
        log(d_wild_moy[t+1,i]) <- L_d_wild_moy[t+1,i]
        L_d_wild_moy[t+1,i] ~ dnorm(L_mu_d_wild[t+1,i],tau_wild_moy)I(-6.91,1.09)
        L_mu_d_wild[t+1,i] <-  log((S_ts[t,i]/S_juv_JP[t,i]) / (alpha_dd + beta_dd * (S_ts[t,i]/S_juv_JP[t,i]))) +
nu_wild[i]
        res_wild_moy[t+1,i] <-  L_d_wild_moy[t+1,i] -  L_mu_d_wild[t+1,i]
    }
  }


### END MODEL BRACKET
}
```