```
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+20){
      for (k in 1:2){
        logit(p\_area[t,k])<-  L\_p\_area[t,k]
      }
    }

    for (t in 12:T+20){
      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+20){
      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+20){
  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+20){
  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+20){
  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+20){
       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]) / ( Juv\_tot[t,1] +
Juv\_tot[t,2] + Juv\_tot[t,3] )
      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] / ( Juv\_tot[t,2] + Juv\_tot[t,3] )
      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]
    }

    #========================================
    # 3.5 Simulation for the 20 next years
```

```
    #=======================================
      #-------------------------------
      # 3.5.1 Cut of all the parameters
      #-------------------------------
      rho\_station\_cut <- cut(rho\_station)
      adjust\_p\_L\_cut <- cut(adjust\_p\_L)
      adjust\_p\_P\_cut <- cut(adjust\_p\_P)
      tau\_p\_langeac\_cut <- cut(tau\_p\_langeac)
      tau\_p\_poutes\_cut <- cut(tau\_p\_poutes)
      #--------------------
      # 3.5.2 Simulations
      #--------------------
      for (t in T+1:T+20){

        ratio\_juv\_prod\_V[t] <-1 - ratio\_juv\_prod\_L[t]
      ratio\_juv\_prod\_L[t] <-  (Juv\_tot[t,2] + Juv\_tot[t,3]) / ( Juv\_tot[t,1] +
Juv\_tot[t,2] + Juv\_tot[t,3] )
      ratio\_juv\_L[t]<- rho\_station\_cut *
(ratio\_habitat[t,2]+ratio\_habitat[t,3]) + (1 -  rho\_station\_cut) *
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\_cut
      L\_p\_langeac[t]~dnorm(L\_mu\_p\_langeac[t],tau\_p\_langeac\_cut)
      res\_p\_langeac[t] <- L\_p\_langeac[t] - L\_mu\_p\_langeac[t]

      ratio\_juv\_prod\_P[t] <-  Juv\_tot[t,3] / ( Juv\_tot[t,2] + Juv\_tot[t,3] )
      ratio\_juv\_P[t]<- rho\_station\_cut * (S\_juv\_JP[t,3] / (S\_juv\_JP[t,2] +
S\_juv\_JP[t,3])) + (1 -  rho\_station\_cut) * 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\_cut
      L\_p\_poutes[t]~dnorm(L\_mu\_p\_poutes[t],tau\_p\_poutes\_cut)
      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]
    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,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]

      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])    #      #


    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])

    # 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]

      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])     ##

    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])

     #--------------------------
     # 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])

    # 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]

      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])     ##

    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])

      #---------------------------
      # 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 *I\_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])
       N[t,2]~dbin(p\_langeac[t],N\_corrected[t])I(min\_L\_P[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])

      #----------------------------------------
      # 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
}
```