library(rstan)

library(loo)

#

# Model 1, Differing Process and Measurement Variances

#

sink("surplus1.stan")

cat(" data {

int<lower=0> N;

real C[N]; // Catch data

real AI[N]; // Abundance Index

}

parameters {

real<lower=0.01> r;

real<lower=0.01 > P[N];

real logq;

real logsigma2;

real<lower=3.92> logK;

real<lower=0.01> lambda;

}

transformed parameters {

real<lower=0> q;

real<lower=50> K;

real<lower=0> Q;

real<lower=0> sigmao;

real<lower=0> sigmap;

sigmao=exp(logsigma2\*0.5);

sigmap=lambda\*sigmao;

q =exp(logq);

K = exp(logK);

Q = q\*K; }

model { logK ~ uniform(3.92,7.6);

r ~ uniform(0.01,3);

lambda ~ exponential(1);

logsigma2 ~ uniform(-10,10);

logq ~ uniform(-20,2);

// state equation

{ real muP[N];

muP[1] = 0.8;

P[1] ~ lognormal(muP[1], 0.5);

for (i in 2:N) { muP[i] = log(fmax(P[i-1] + r\*P[i-1]\*(1-P[i-1]) - C[i-1]/K, 0.01));

P[i] ~ lognormal(muP[i],sigmap); } }

// observation equation (abundance index)

for (i in 1:N) { real mu[N];

mu[i] = log(Q\*P[i]);

AI[i] ~ lognormal(mu[i],sigmao); } }

generated quantities {

real B[N];

real MSY;

vector [N] LL1;

vector [N] LL2;

LL2[1] = lognormal\_lpdf(P[1]|0.8, 0.5);

for (n in 1:N){LL1[n] = lognormal\_lpdf(AI[n]|log(Q\*P[n]), sigmao);}

for (n in 2:N){LL2[n]=lognormal\_lpdf(P[n]|log(fmax(P[n-1]

+r\*P[n-1]\*(1-P[n-1]) -C[n-1]/K,0.01)),sigmap);}

for (i in 1:N){ B[i] = K\*P[i]; }

MSY = r\*K/4; }

", fill=T)

sink()

# Compile and Estimate

sm <- stan\_model(file="surplus1.stan",verbose=FALSE)

D <-list(N=35,C=c(54.79,66.56,60.95,70.49,74.25,87.88,71.15,68.67,63.2,61.23,

57.59,50.85,55.64,63.29,47.38,49.31,41.09,39.94,32.54,40.80,36.01,41.87,

41.3,40.4,48.99,37.52,37.33,37.46,42.55,45.28,42.61,41.23,38.58,40.1,40.69),AI=c(1.352,1.402,1.210,1.268,1.364,1.126,1.107,1.050,0.909,0.779,0.912,0.68,0.712,0.642,0.672,0.853,0.892,1.068,0.659,0.778,0.733,0.908,0.923,0.982,1.0,1.120,1.115,1.188,1.098,1.225,1.102,0.893,0.867,1.202,1.208))

fit1 <- sampling(sm, data=D, iter = 10500,warmup=500,chains=2,seed=12345)

print(fit1,digits=4)

**# Correlation between K and q**

Kpost= as.matrix(fit1,pars="K")

qpost= as.matrix(fit1,pars="q")

**# Fit**

LL1=as.matrix(fit1,pars="LL1")

LL2=as.matrix(fit1,pars="LL2")

LL=cbind(LL1,LL2)

loo(LL)

#

# Model 2, Process and Measurement Variances Equated

#

sink("surplus2.stan")

cat(" data {

int<lower=0> N;

real C[N]; // Catch data

real AI[N]; // Abundance Index

}

parameters {

real<lower=0.01> r;

real<lower=0.01 > P[N];

real logq;

real logsigma2;

real<lower=3.92> logK;

}

transformed parameters {

real<lower=0> q;

real<lower=50> K;

real<lower=0> Q;

real<lower=0> sigmao;

real<lower=0> sigmap;

sigmao=exp(logsigma2\*0.5);

sigmap=sigmao;

q =exp(logq);

K = exp(logK);

Q = q\*K; }

model { logK ~ uniform(3.92,7.6);

r ~ uniform(0.01,3);

logsigma2 ~ uniform(-10,10);

logq ~ uniform(-20,2);

// state equation

{ real muP[N];

muP[1] = 0.8;

P[1] ~ lognormal(muP[1], 0.5);

for (i in 2:N) { muP[i] = log(fmax(P[i-1] + r\*P[i-1]\*(1-P[i-1]) - C[i-1]/K, 0.01));

P[i] ~ lognormal(muP[i],sigmap); } }

// observation equation (abundance index)

for (i in 1:N) { real mu[N];

mu[i] = log(Q\*P[i]);

AI[i] ~ lognormal(mu[i],sigmao); } }

generated quantities {

real B[N];

real MSY;

vector [N] LL1;

vector [N] LL2;

LL2[1] = lognormal\_lpdf(P[1]|0.8, 0.5);

for (n in 1:N){LL1[n] = lognormal\_lpdf(AI[n]|log(Q\*P[n]), sigmao);}

for (n in 2:N){LL2[n]=lognormal\_lpdf(P[n]|log(fmax(P[n-1]

+r\*P[n-1]\*(1-P[n-1]) -C[n-1]/K,0.01)),sigmap);}

for (i in 1:N){ B[i] = K\*P[i]; }

MSY = r\*K/4; }

", fill=T)

sink()

# Compile and Estimate

sm <- stan\_model(file="surplus2.stan",verbose=FALSE)

fit2 <- sampling(sm, data=D, iter = 10500,warmup=500,chains=2,seed=12345)

print(fit2,digits=4)

**# Correlation between K and q**

Kpost= as.matrix(fit2,pars="K")

qpost= as.matrix(fit2,pars="q")

cor(Kpost,qpost)

**# Fit**

LL1=as.matrix(fit2,pars="LL1")

LL2=as.matrix(fit2,pars="LL2")

LL=cbind(LL1,LL2)

loo(LL)