Dissect SAM: Fishing mortality

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SAM assumes

$$\log N_{1,y} = \log R(\mathbf{N}_{y-1}) + \eta_{1,y}$$
$$\log N_{a,y} = \log N_{a-1,y-1} - F_{a-1,y-1} - M_{a-1,y-1} + \eta_{a,y}$$
$$\log N_{A,y} = \log(N_{A-1,y-1}e^{-F_{A-1,y-1}-M_{A-1,y-1}} + N_{A,y-1}e^{-F_{A,y-1}-M_{A,y-1}}) + \eta_{A,y}$$

were

$$\log \mathbf{F}_y = \log \mathbf{F}_{y-1} + \boldsymbol{\xi}_y$$

Observe:

$$\log C_{a,y} = \log\left(\frac{F_{a,y}}{F_{a,y}+M_{a,y}}(1-e^{-F_{a,y}-M_{a,y}})N_{a,y}\right) + \epsilon^c_{a,y}$$
$$\log I^{(s)}_y = \log(Q^{(s)}_a e^{-(F_{a,y}+M_{a,y})day^{(s)}/365}N_{a,y}) + \epsilon^s_{a,y}$$

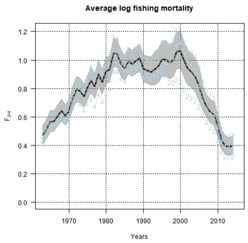
Assumes $\boldsymbol{\eta}_y$, $\boldsymbol{\xi}_y$ and $\boldsymbol{\epsilon}^C_y$ and $\boldsymbol{\epsilon}^s_y$ all Gaussian distributed.

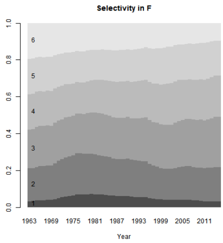
Dissect SAM: Fishing mortality

- The fishing mortality is included as a latent random variable
- The process model for **F** is defined as:

$$\log \mathbf{F}_y = \log \mathbf{F}_{y-1} + \xi_y$$

- Time varying selectivity is a side effect in this formulation
- Note that we can set up correlated **F** increments within years





Why include correlated increments

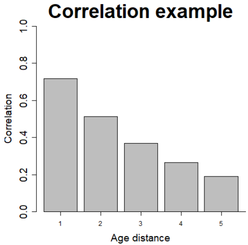
Remember

$$\log \mathbf{F}_y = \log \mathbf{F}_{y-1} + \xi_y, \text{ where } \xi_y \sim N(0, \mathbf{\Sigma})$$

Why do we want to include correlated increments?

- Assume we know how much $F_{a,y}$ changes in a given year
- We may then indirectly know something about how e.g. $F_{a-1,y}$ changes in the same year.
- Such structures are expressed mathematically through $\mathbf{\Sigma}$

Often are random variables close to each other more correlated



Suggested options for correlated process

- Remember

$$\log \mathbf{F}_y = \log \mathbf{F}_{y-1} + \xi_y, \text{ where } \xi_y \sim N(0, \mathbf{\Sigma})$$

- Suggestions for Σ. For $a \neq \tilde{a}$, let:
  a) Independent: $\Sigma_{a,\tilde{a}} = 0 \quad \Leftrightarrow \quad \rho_{a,\tilde{a}} = 0$
  b) Compound symmetry: $\Sigma_{a,\tilde{a}} = \phi\sqrt{\Sigma_{a,a}\Sigma_{\tilde{a},\tilde{a}}} \quad \Leftrightarrow \quad \rho_{a,\tilde{a}} = \phi$
  c) AR(1): $\Sigma_{a,\tilde{a}} = \phi^{|a-\tilde{a}|}\sqrt{\Sigma_{a,a}\Sigma_{\tilde{a},\tilde{a}}} \quad \Leftrightarrow \quad \rho_{a,\tilde{a}} = \phi^{|a-\tilde{a}|}$
  d) Parallel: $\Sigma_{a,\tilde{a}} = \sqrt{\Sigma_{a,a}\Sigma_{\tilde{a},\tilde{a}}} \quad \Leftrightarrow \quad \rho_{a,\tilde{a}} = 1$

Fishing mortality exercise

- The data set `Fobs.RData` contains 'observations' of $F_{a,y}$.
    - Assume we observe

$$\log F_{a,y}^{(obs)} = \log F_{a,y} + \epsilon_{a,y} \text{ where } \epsilon_{a,y} \sim N(0, \sigma^2)$$

- Exercise a) Implement the process models for $\log F$ with Σ as defined in b) and c).
    - An implemented version of a) is provided in `Fobs.cpp`
- Exercise b) How can you apply option d) with a combination of the `map` variable and one of the other options?
- Exercise c) Which model is a best description of the underlying structure?

Fishing mortality configurations

Remember

$$\log \mathbf{F}_y = \log \mathbf{F}_{y-1} + \xi_y, \text{ where } \xi_y \sim N(0, \mathbf{\Sigma})$$

- Trough the configuration settings we modify $\mathbf{\Sigma}$
- Two elements of importance
  - `keyVarF` says which $\Sigma_{a,a}$ that are coupled
  - `corFlag` says which correlation structure we use

Configuration example:

```
$corFlag
# Correlation of fishing mortality across ages (0 independent, 1 compound symmetry, 2 AR(1), 3 separable AR(1).
 2

$keyVarF
# Coupling of process variance parameters for log(F)-process (nomally only first row is used)
   0   1   1   1   1   1
  -1  -1  -1  -1  -1  -1
  -1  -1  -1  -1  -1  -1
```

Practical exercise

- Code to fit SAM with North Sea herring:

```
library(stockassessment)
cn<-read.ices("cn.dat")
cw<-read.ices("cw.dat")
dw<-read.ices("dw.dat")
lf<-read.ices("lf.dat")
lw<-read.ices("lw.dat")
mo<-read.ices("mo.dat")
nm<-read.ices("nm.dat")
pf<-read.ices("pf.dat")
pm<-read.ices("pm.dat")
sw<-read.ices("sw.dat")
surveys<-read.ices("survey.dat")

dat<-setup.sam.data(surveys=surveys,residual.fleet=cn, prop.mature=mo,
     stock.mean.weight=sw, catch.mean.weight=cw, dis.mean.weight=dw,
     land.mean.weight=lw,prop.f=pf, prop.m=pm, natural.mortality=nm, land.frac=lf)

conf<-loadConf(dat,"model.cfg")
par<-defpar(dat,conf)
fit<-sam.fit(dat,conf,par)
```

- Data provided in shared folder

Practical exercise

- Exercise a) Which correlation structure in F should we choose based on AIC?
- Exercise b) Use map-functionality to assume $F = F_y F_a$ (no time varying selectivity).