

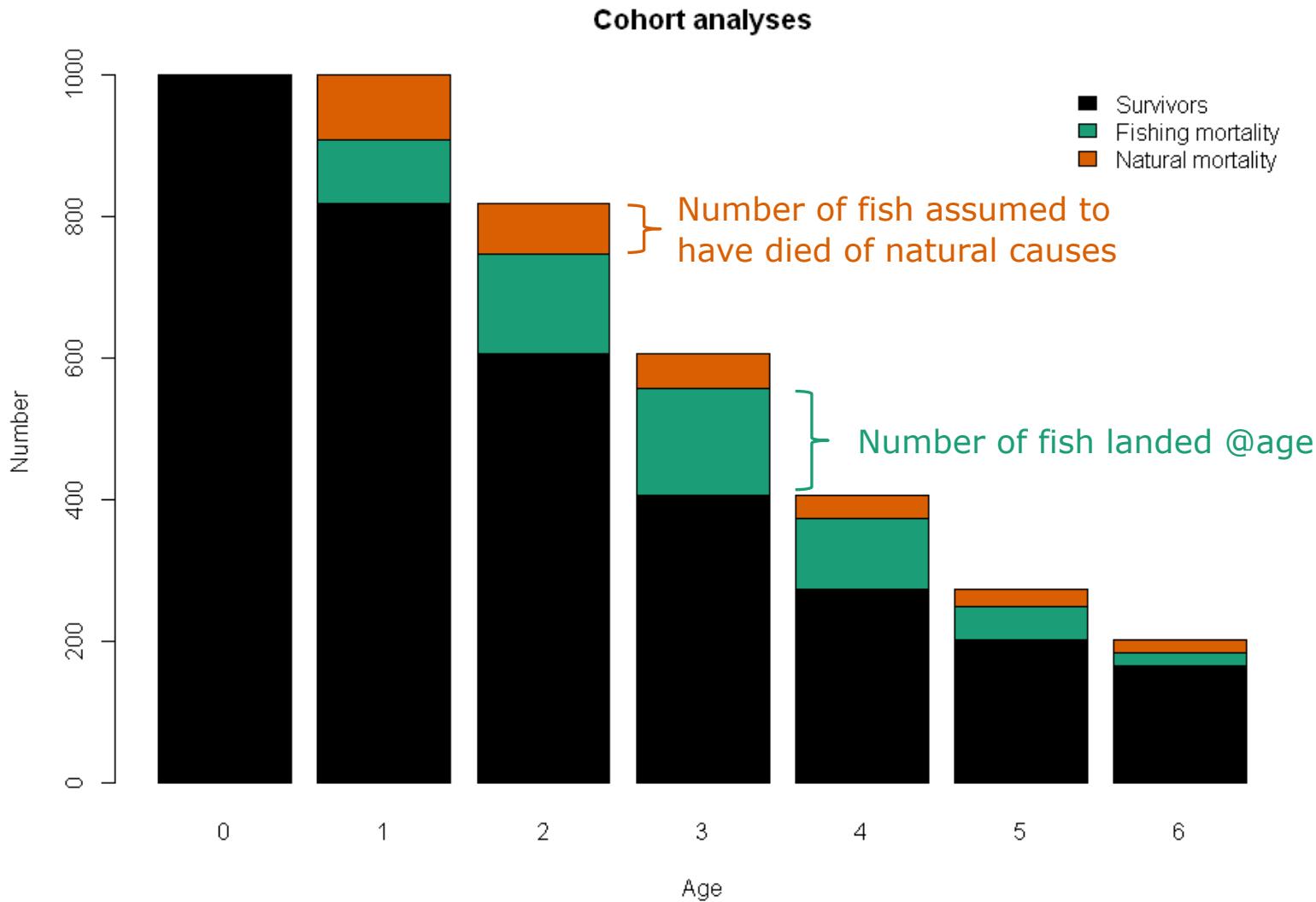
The State-Space assessment model

BlackSea4Fish project Online Presentation Series 1

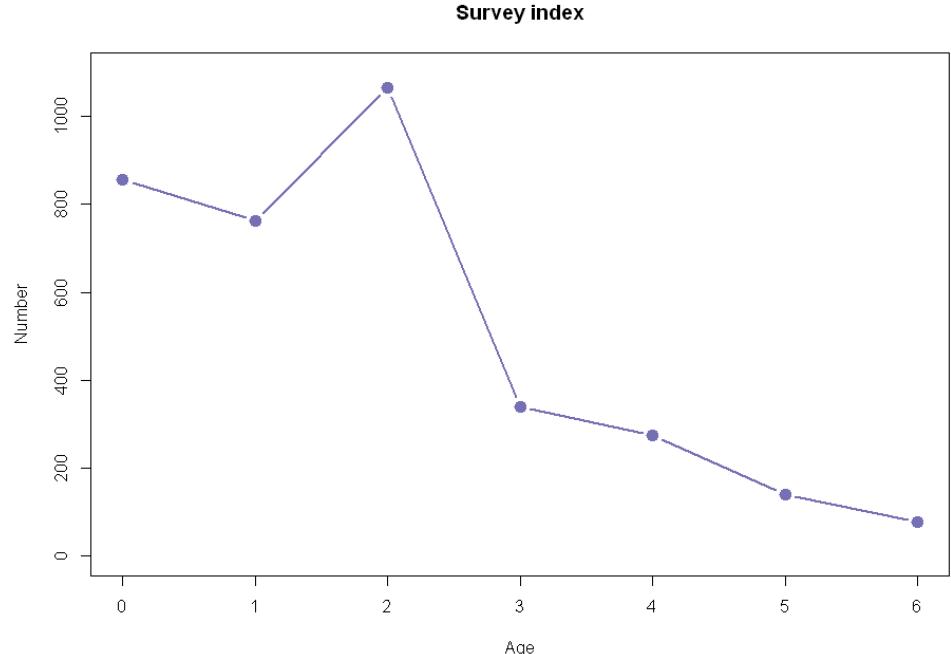
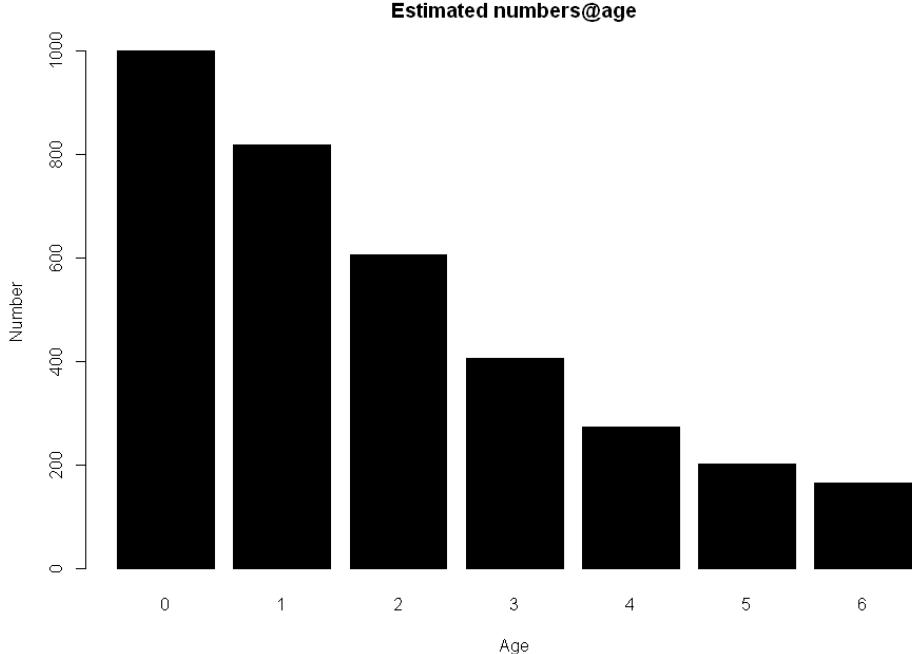
6th of June 2020, Niels Hintzen



The concept of a stock assessment model



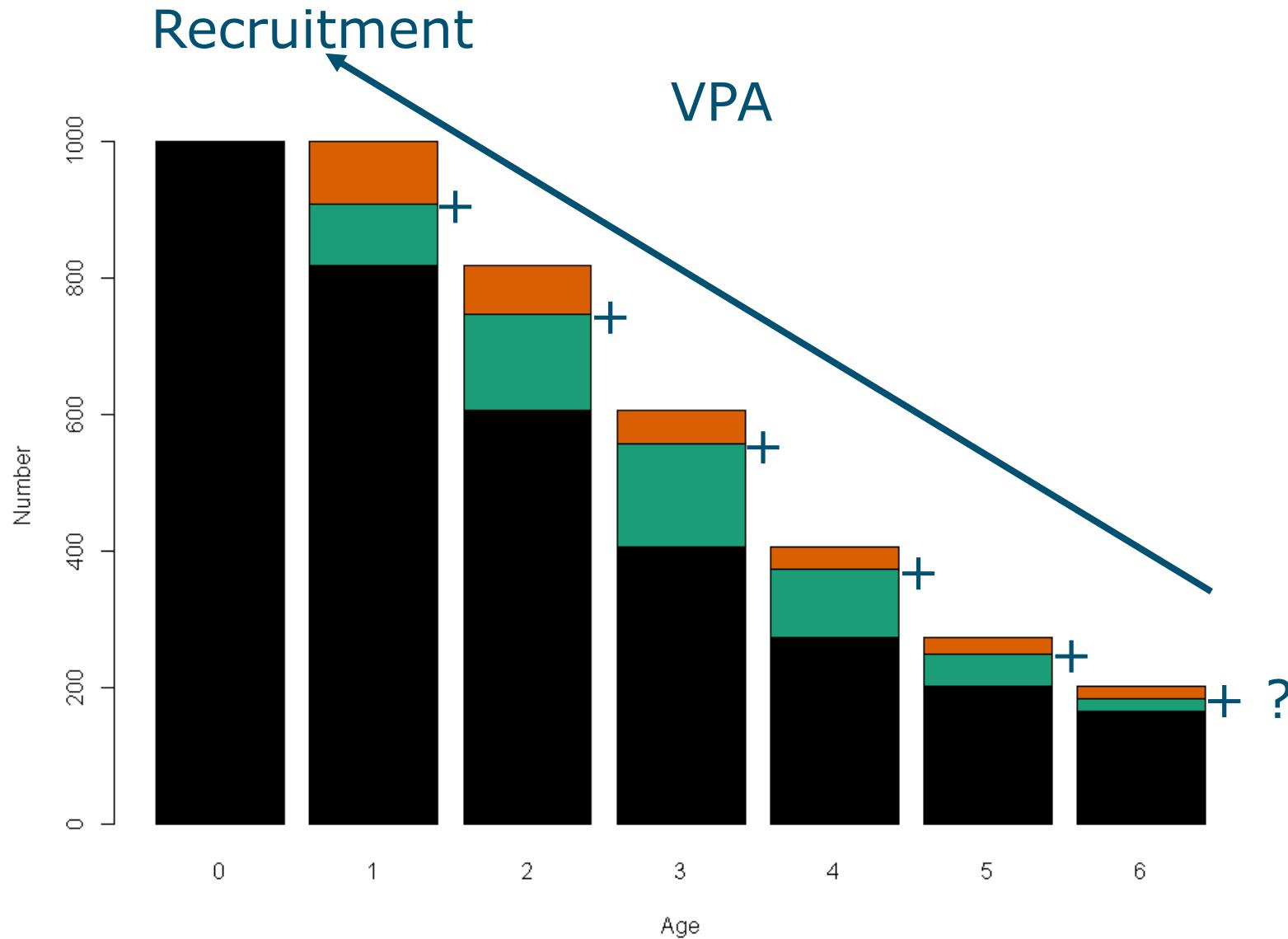
The concept of a stock assessment model



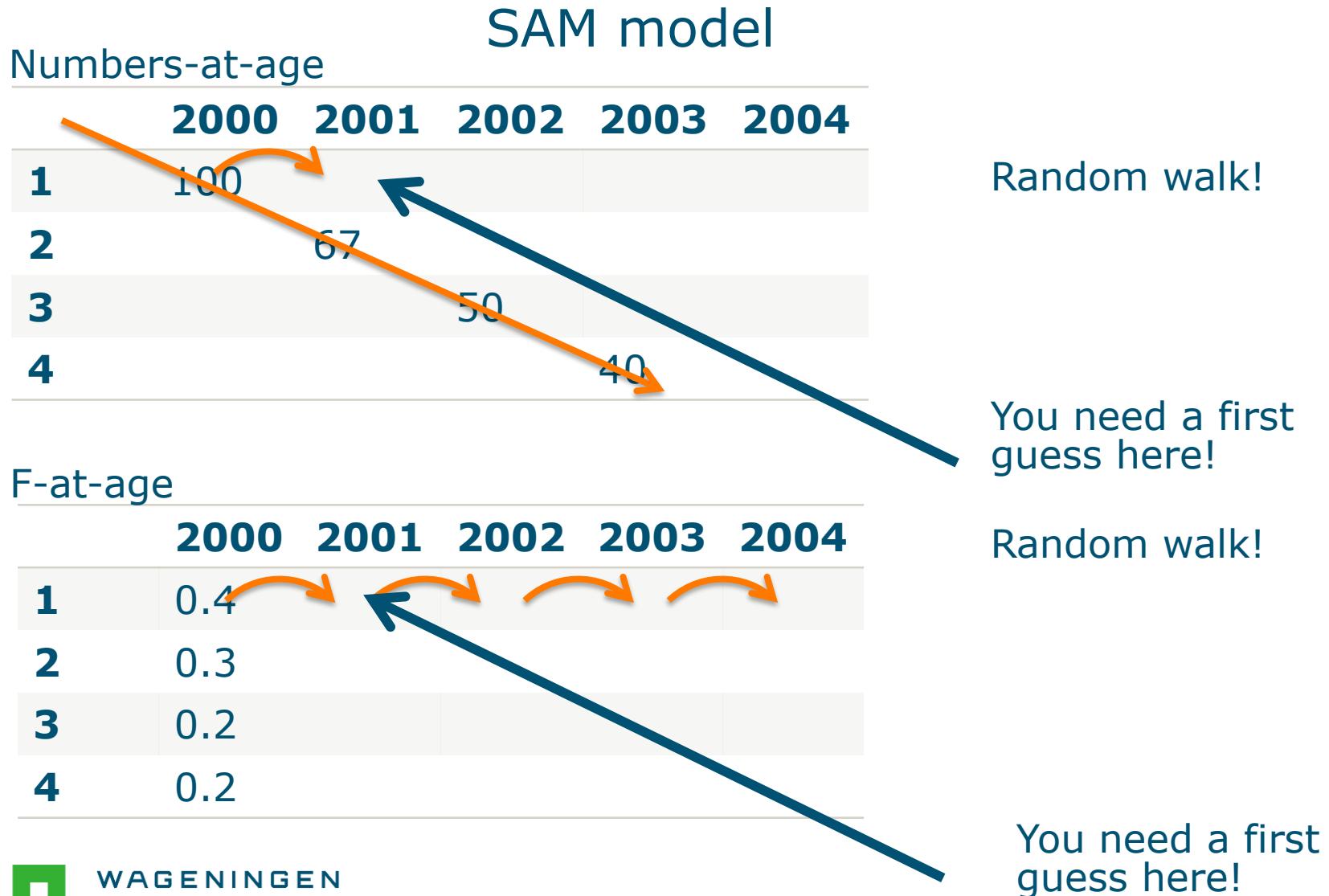
Comparison with simpler models

- Validity of assumptions
 - Fishing mortality at last age
 - Constant selectivity & shape of selection pattern
 - Perfect reconstruction of N@age (i.e. catch information without error)
 - Effect of surveys in historic part of the assessment
- Number of parameters to estimate
 - Low vs high
- Missing data

Comparison with simpler models



Comparison with simpler models



Comparison with simpler models

In simpler assessment models

$$N_{y+1,a+1} = N_{y,a} * \exp(-Z_{y,a})$$



I have perfect knowledge

$$I_{y,a} = Q_a * N_{y,a} + \epsilon$$



My experiment is not perfect!

One year later...

$$N_{y+2,a+2} = N_{y+1,a+1} * \exp(-Z_{y+1,a+1})$$

$$I_{y+1,a+1} = Q_{a+1} * N_{y+1,a+1} + \epsilon$$

All noise goes into ϵ



Did I do something wrong!?

Comparison with simpler models

SAM model

$$N_{y+1,a+1} = N_{y,a} * \exp(-Z_{y,a}) + \varepsilon$$



$$I_{y,a} = Q_a * N_{y,a} + \varepsilon$$



One year later...

$$N_{y+2,a+2} = N_{y+1,a+1} + \varepsilon * \exp(-Z_{y+1,a+1})$$

$$I_{y+1,a+1} = Q_{a+1} * N_{y+1,a+1} + \varepsilon$$

Noise goes into both ε

Comparison with simpler models

$$I_{y,a} = Q_a * N_{y,a} + \varepsilon$$



I know how large this observation error is!

simpler assessment models



I can guess, but let the statistical model decide!

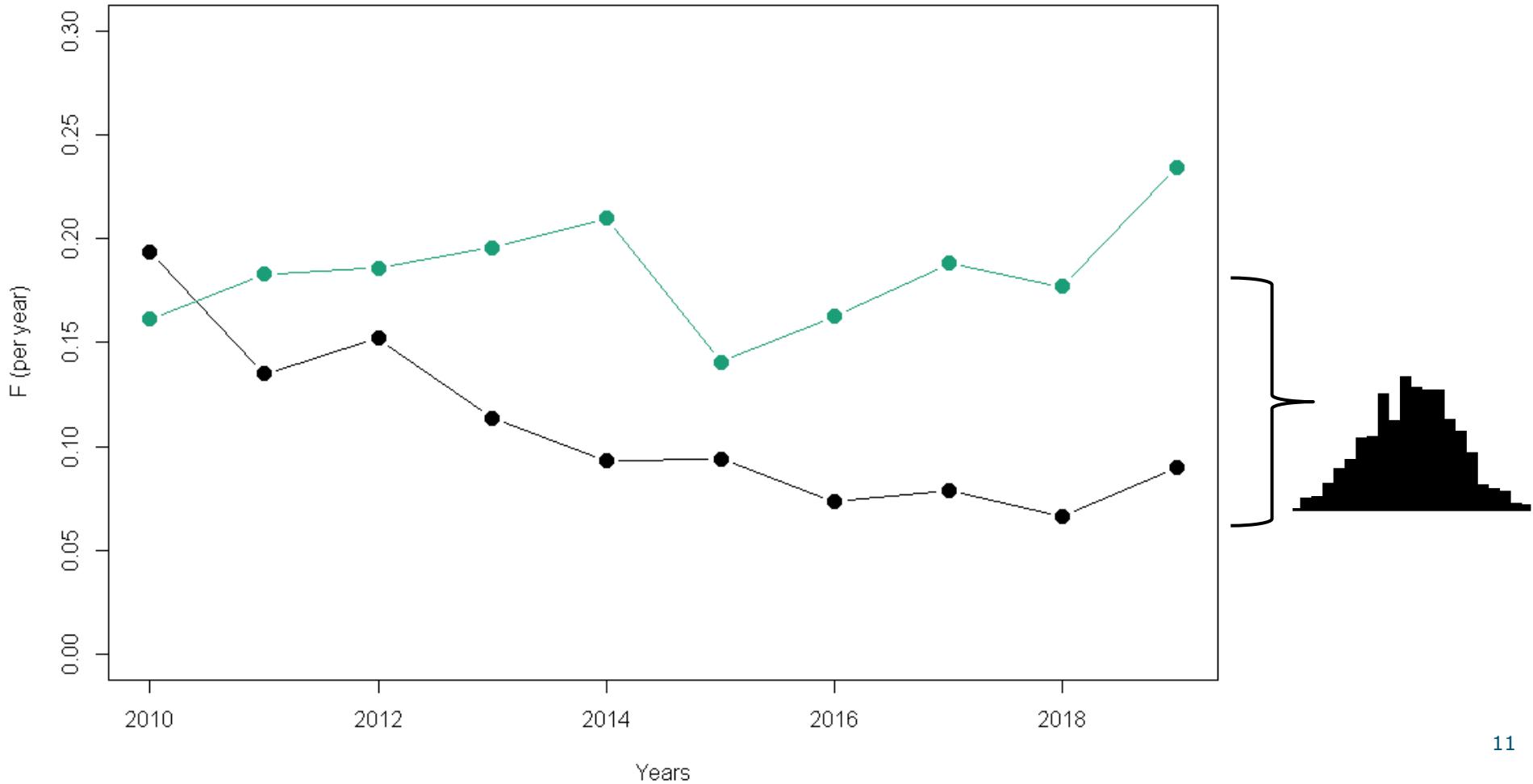
SAM model

Introduction into SAM

- State-space...?
- States: Numbers at age, Fishing mortality at age are not observed
- Space: variables evolve over time in a way that depends on the values they have and on observation data and input variables

Introduction into SAM

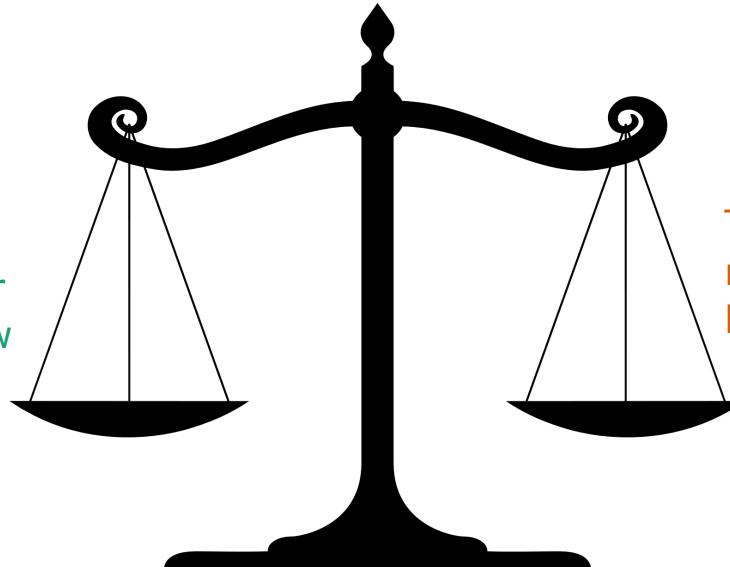
- Random walks...?
 - In F and recruitment



Introduction into SAM

- Observation variance (OV)...?
 - In catch, survey indices

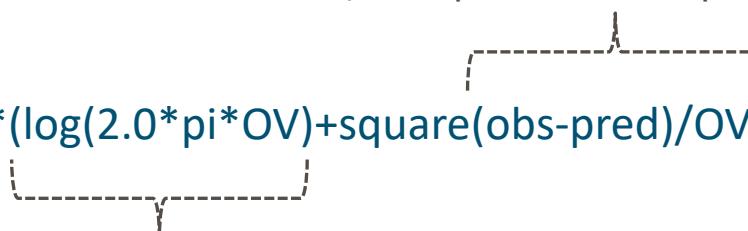
This dataset has similar cohort patterns as other datasets, and low noise, so OV = low



This dataset looks like random noise, so OV = high

OV low, this part of the equation goes up

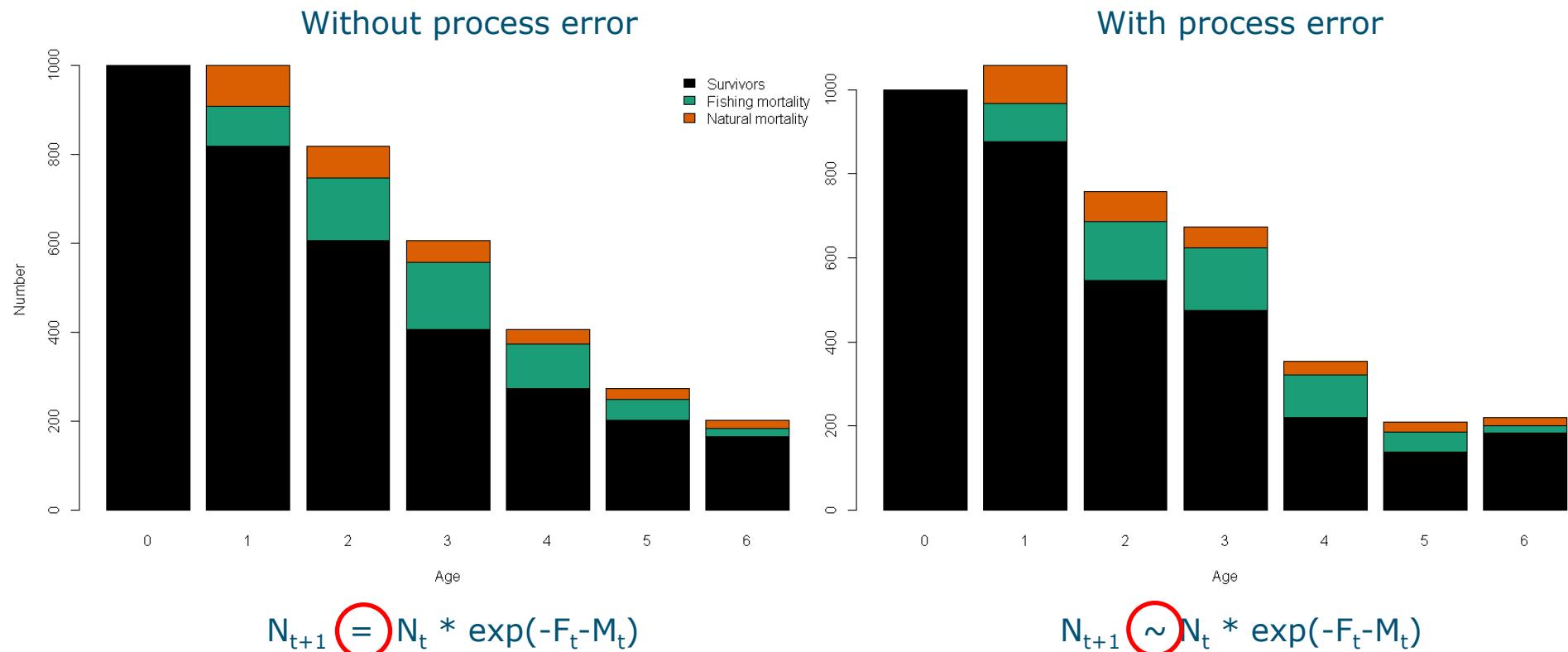
Likelihood contribution = $0.5 * (\log(2.0 * \pi * OV) + \text{square}(\text{obs-pred}) / OV)$



OV low, this part of the equation goes down

Introduction into SAM

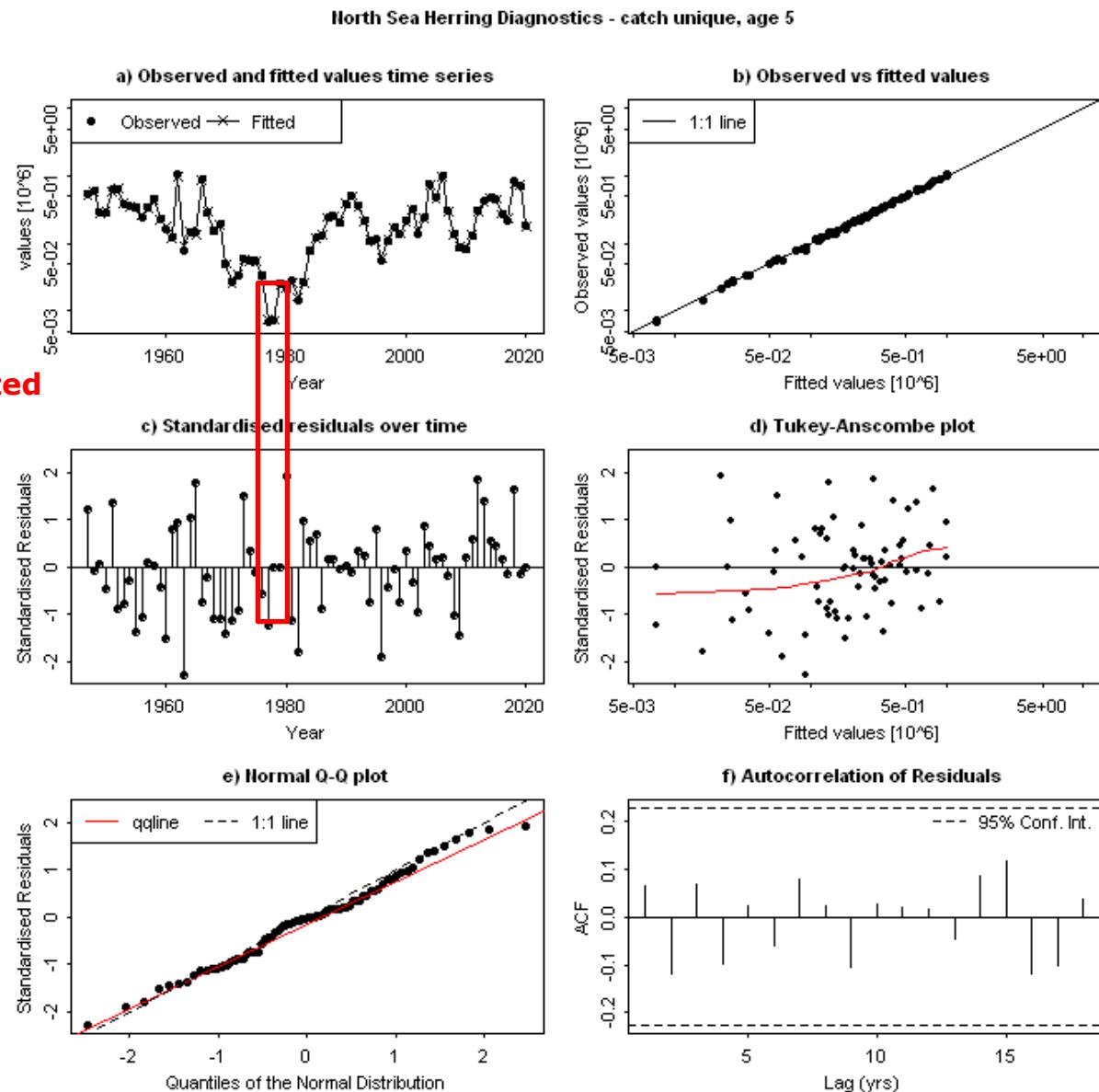
■ Process error (PE)...?



SAM diagnostics

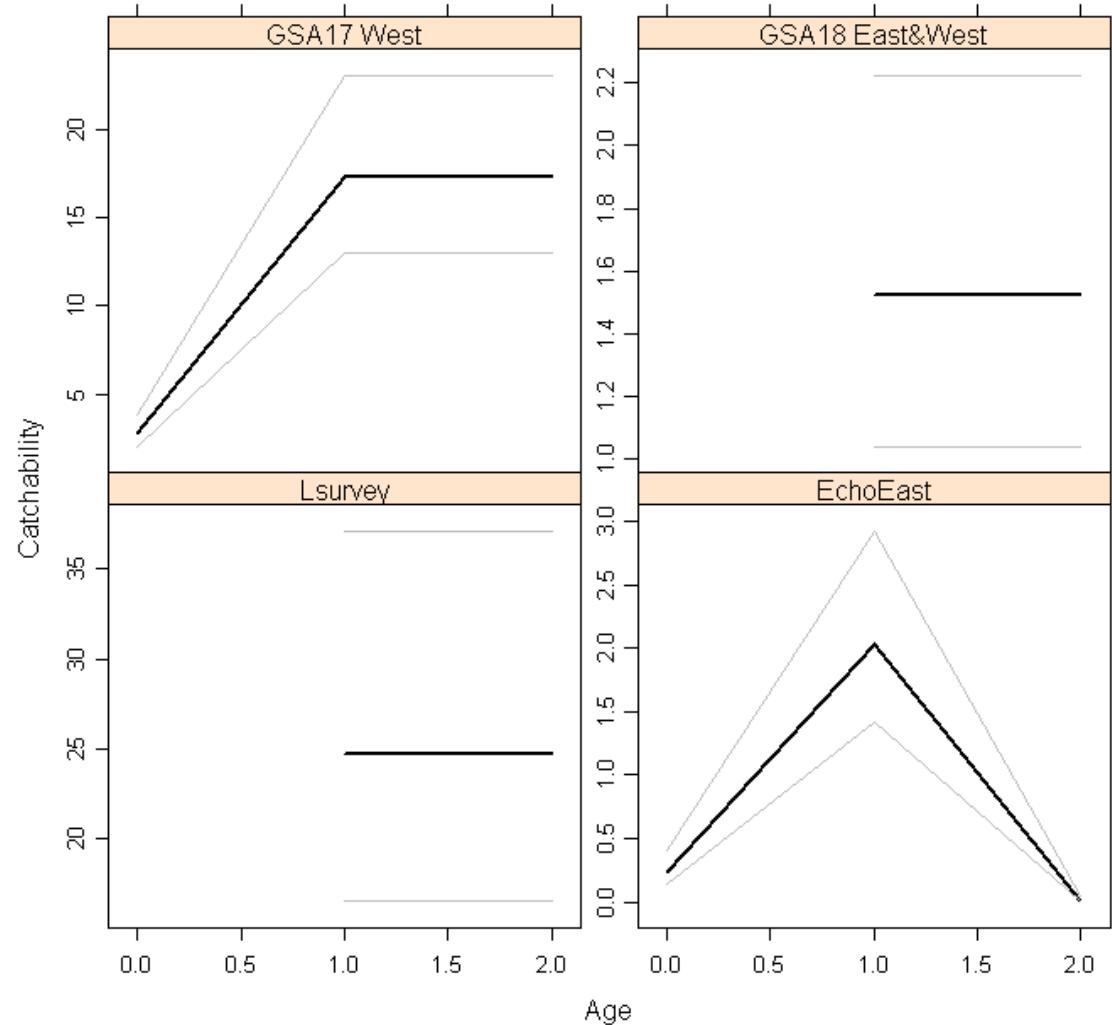
Missing data – not estimated

Missing data - estimated

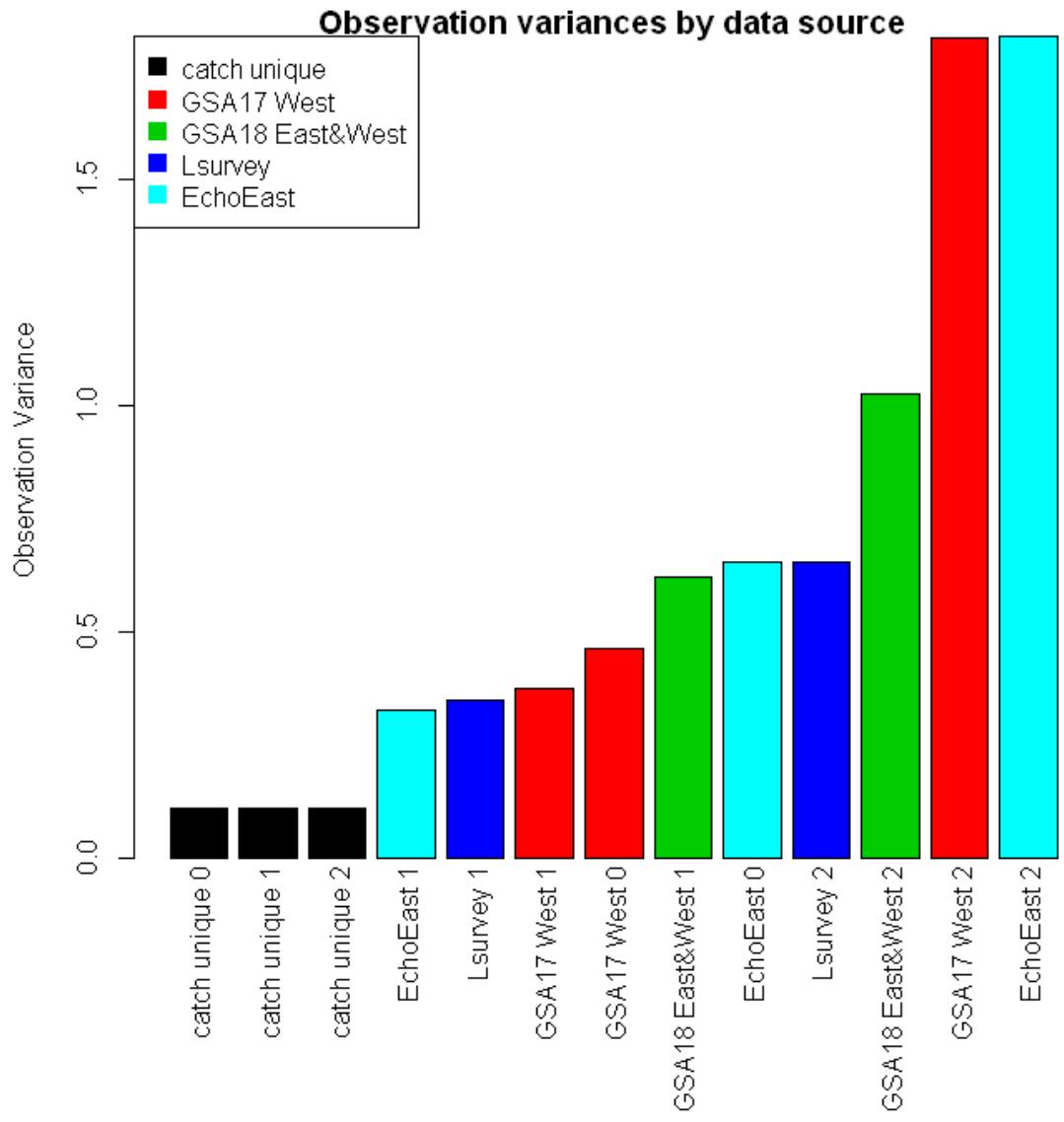


SAM diagnostics

Survey catchability parameters

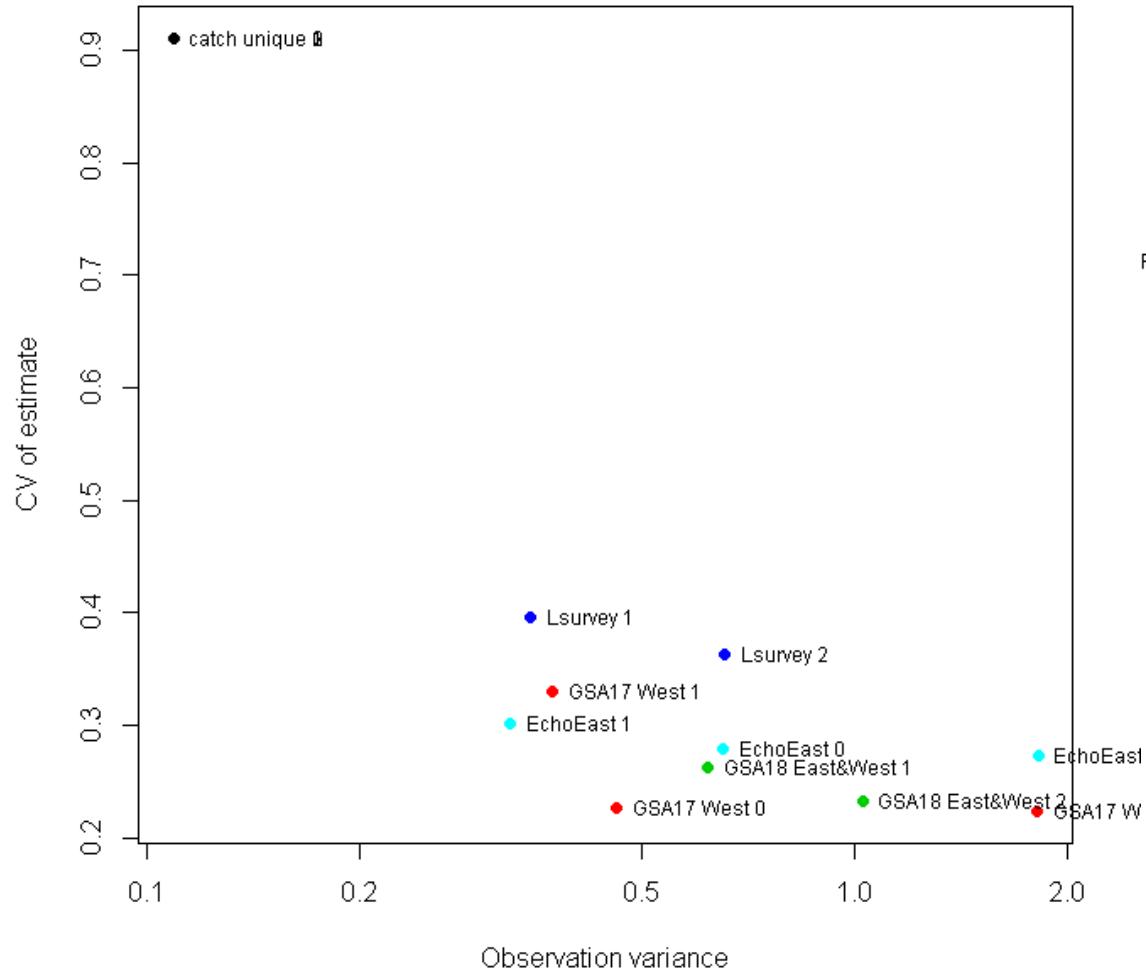


SAM diagnostics



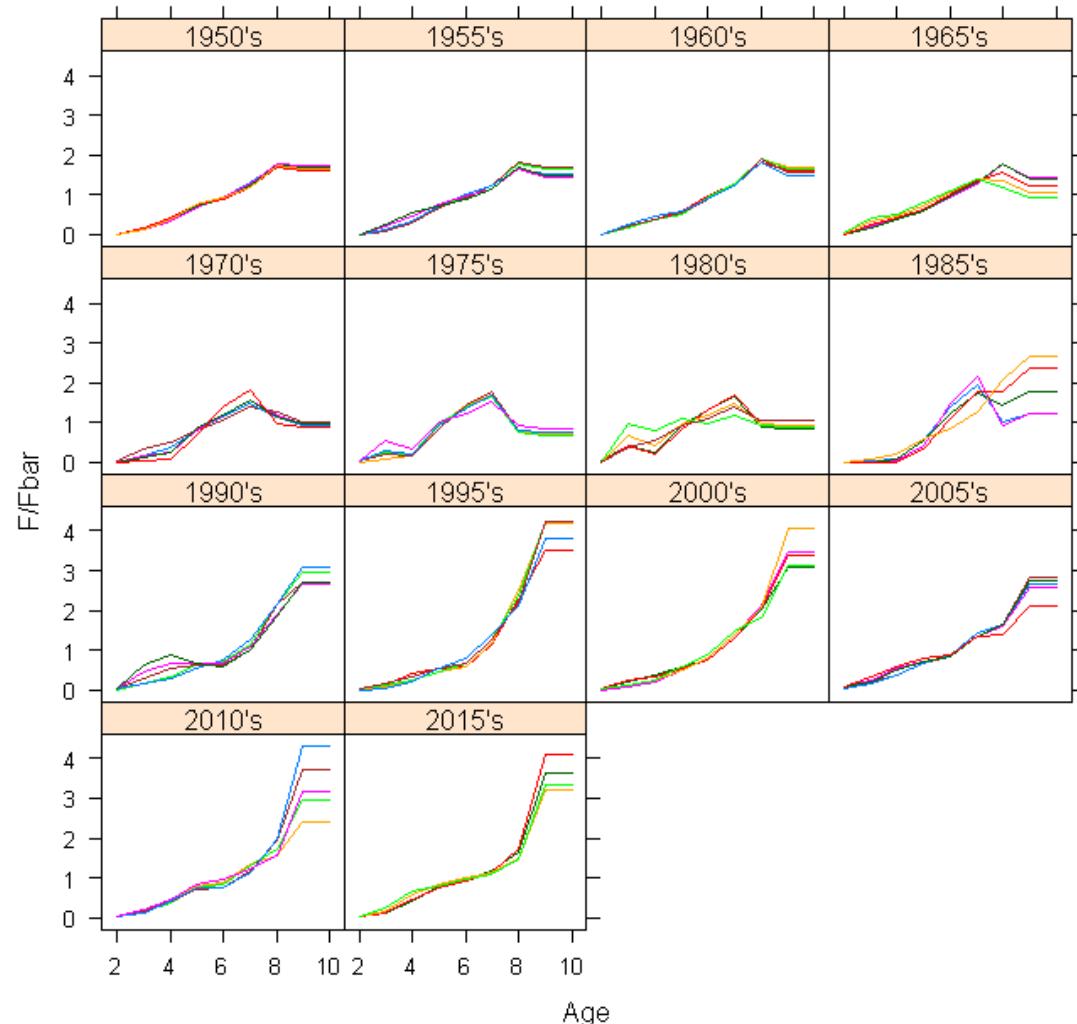
SAM diagnostics

Observation variance vs uncertainty



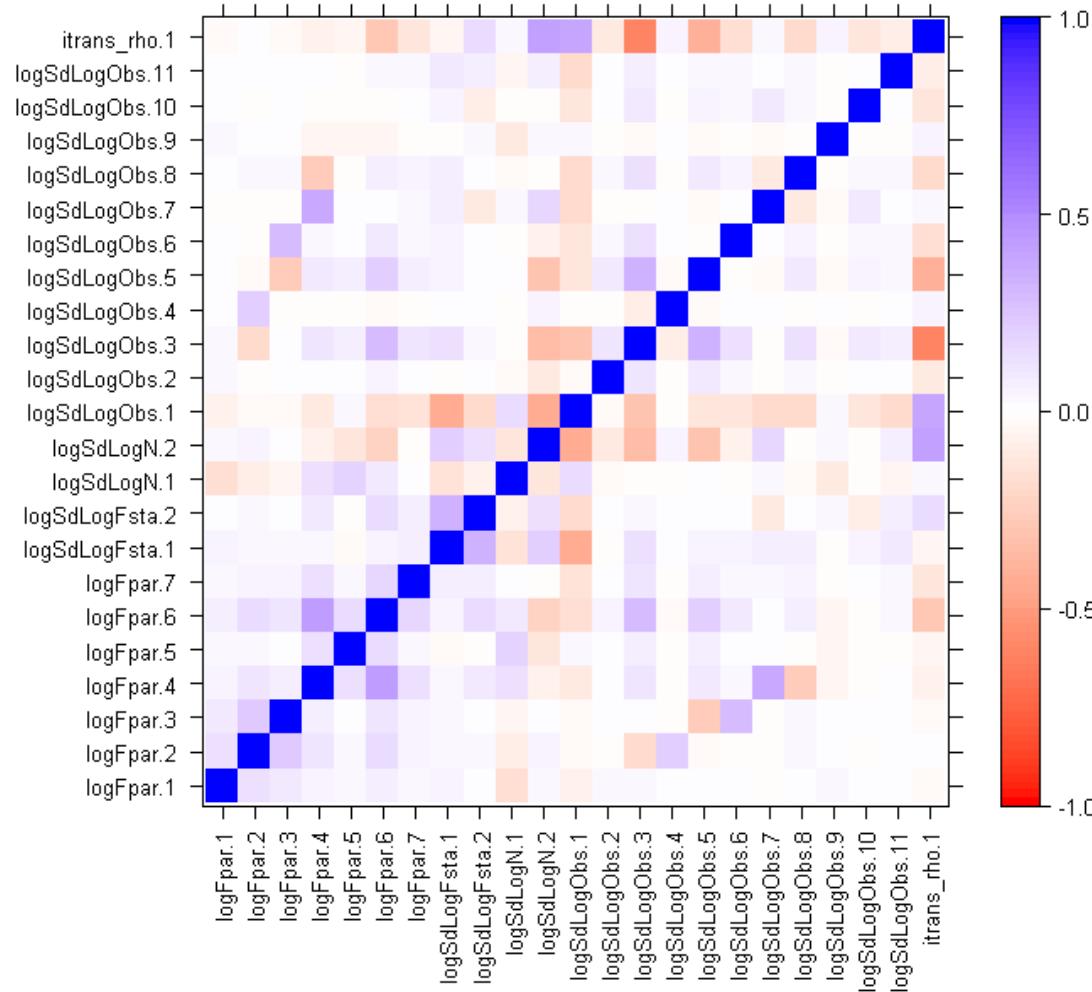
SAM diagnostics

Selectivity of the Fishery by Pentad



SAM diagnostics

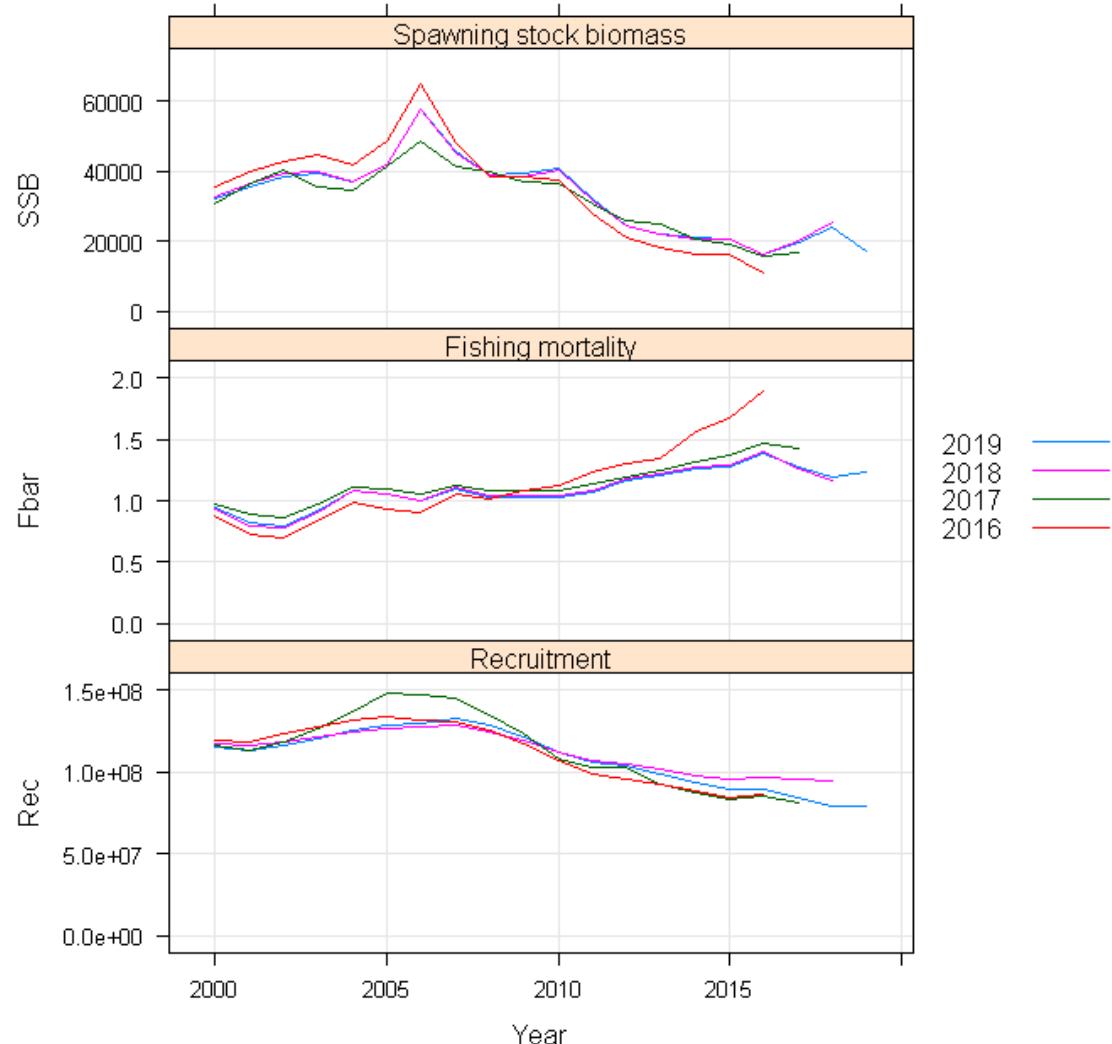
Anchovy - Adriatic Sea - GSA 17 and 18



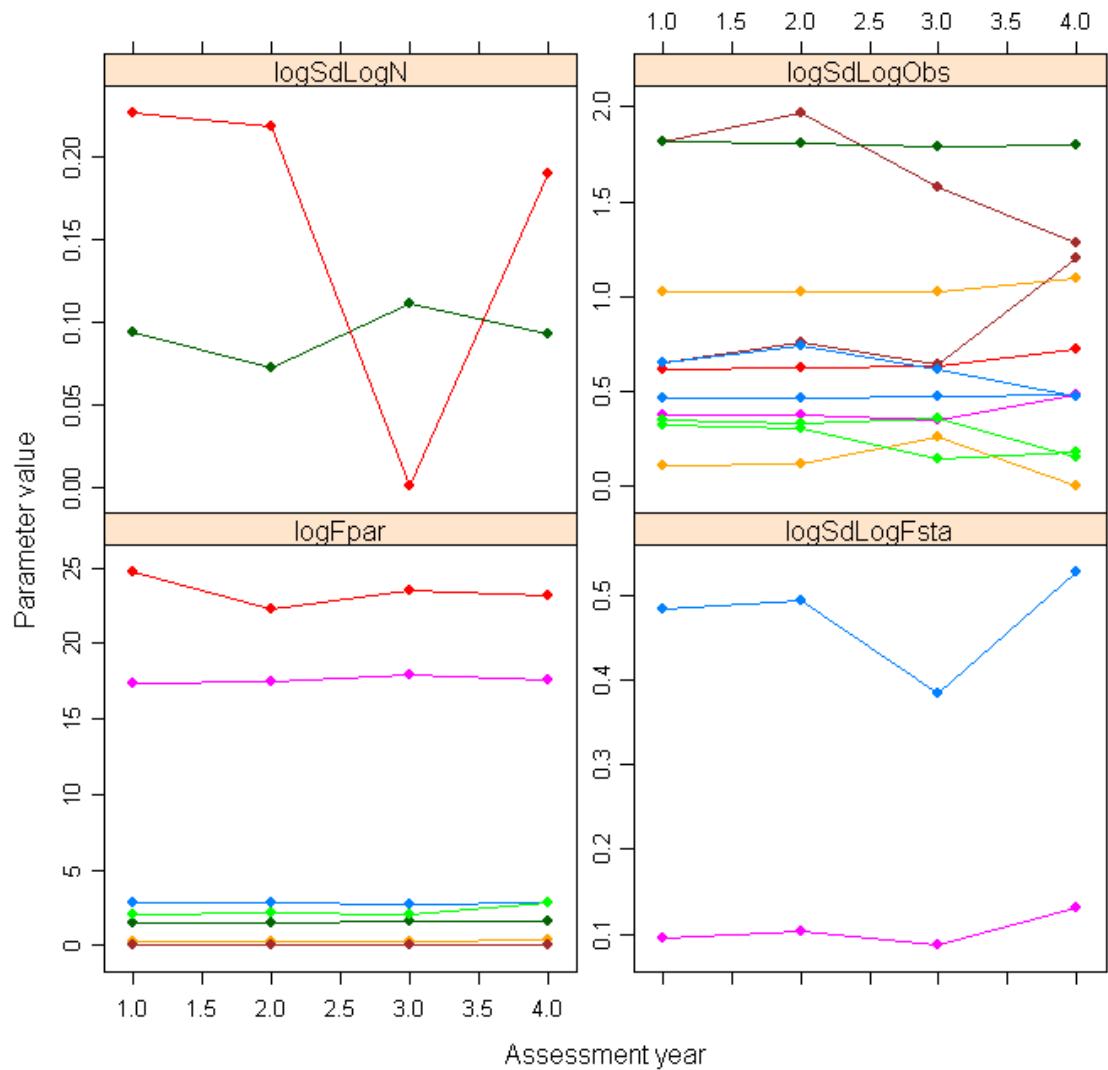
SAM diagnostics



SAM diagnostics

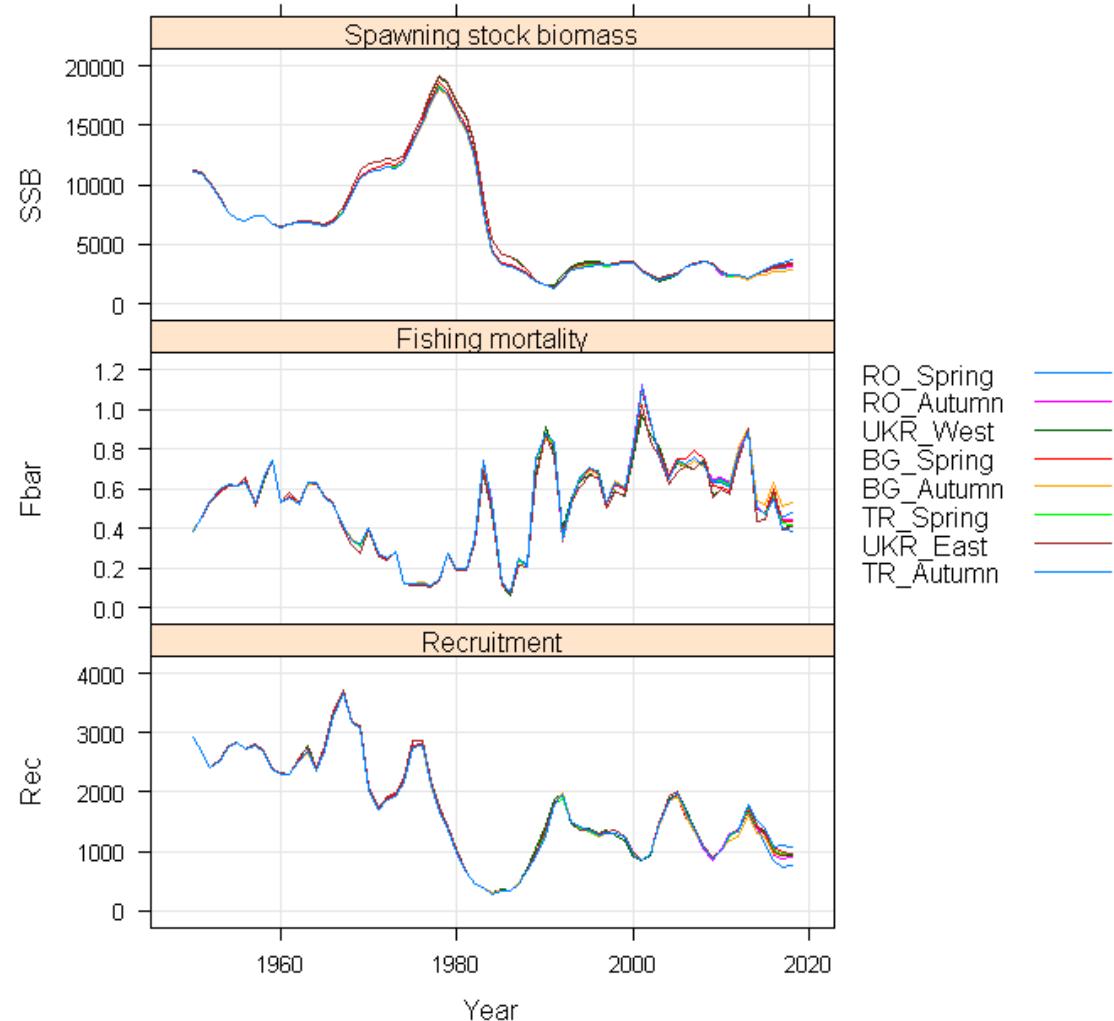


SAM diagnostics



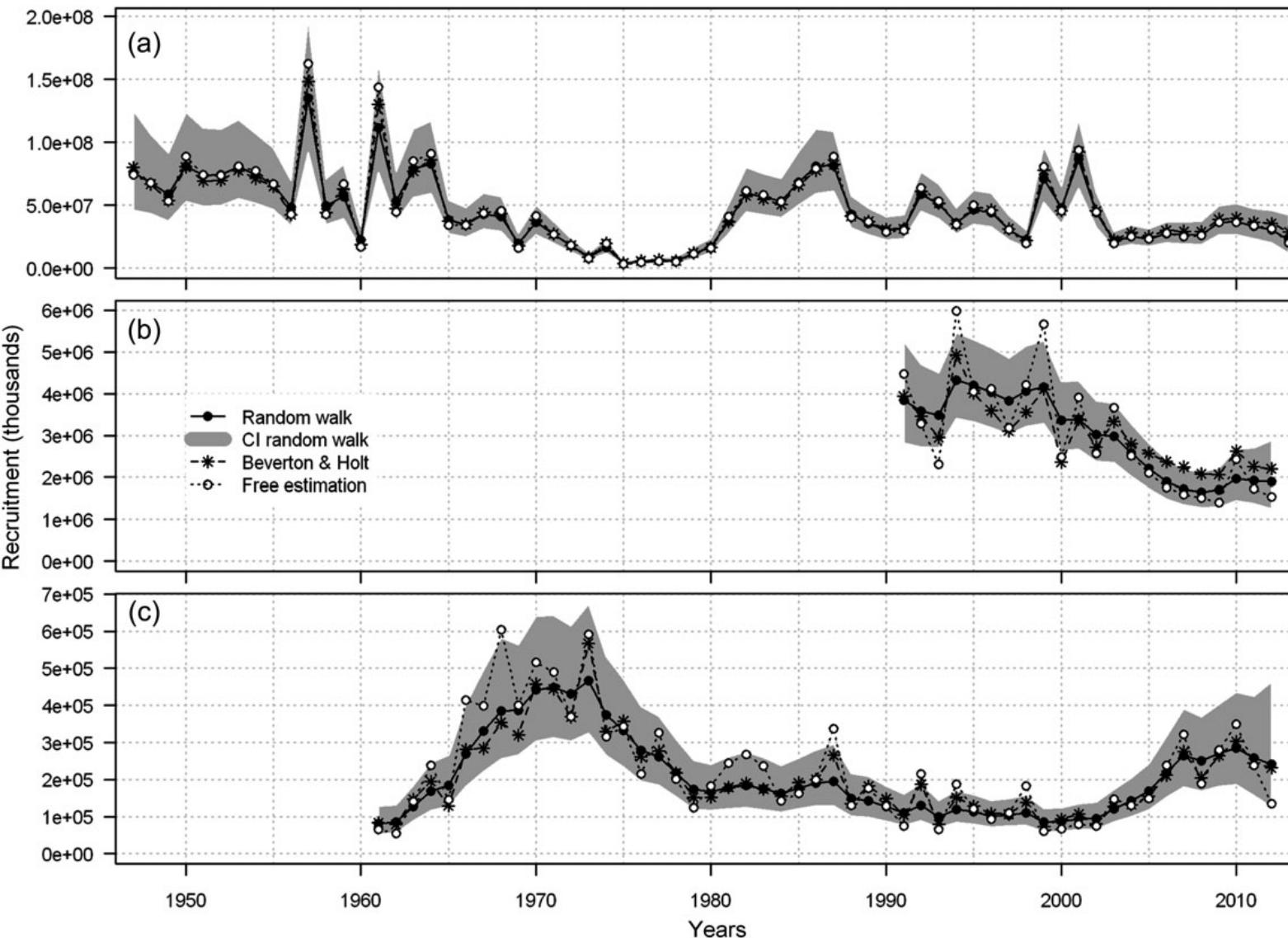
SAM diagnostics

Leave one out



Example of SAM

Dickey-Collas, Hintzen, Nash, Schön, Payne, IJMS, 2015



Pitfalls of SAM

- Smoothed time-series
- Convergence - residuals
- Convergence - parameter estimates
- Estimation of process error
- Speed (takes a lot longer than VPA or XSA)

Benchmarking SAM

Testing different model specifications and parameter settings

Same data sources

- Nested models -> Log-ratio test 'lr.test(FLSAMs)'
- Non nested models -> AIC? 'AIC(FLSAMs)'

Different data sources

- Common sense

Run plenty of retrospectives, not just as the last step!

Run plenty of Leave-one-out runs

Be careful with missing data

How to get SAM running

- FLSAM is no different from SAM
- FLSAM is simply a wrapper in R
- FLSAM is not as flexible as SAM because changes in the code require changes in FLSAM too
- FLSAM throws you some understandable errors if you try to do something stupid
- If you can setup SAM you can setup FLSAM and vice versa

How to get SAM running

- FLSAM is a new FLR (S4) class
- FLSAMs is also a new FLR (S4) class
 - Its a combination of multiple FLSAM objects
- FLSAM.control is also a new FLR (S4) class
- Under the hood there is one extra class: FLSAMinput
- Functions as: ssb, fbar, tsb, catch, +, n, f, rec all work with FLSAM / FLSAMs

How to get SAM running

```
library(FLSAM)
```

```
data(SOL)
```

```
summary(SOL)
```

```
#- Running an assessment yourself
```

```
SOL.sam <- FLSAM(SOL,SOL.tun,SOL.ctrl) # +/- 2min
```

```
#- updating a stock object with FLSAM object
```

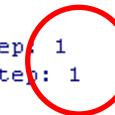
```
SOL <- SOL + SOL.sam
```

How to get SAM running

RGui (64-bit) - [R Console]

File Edit View Misc Packages Windows Help

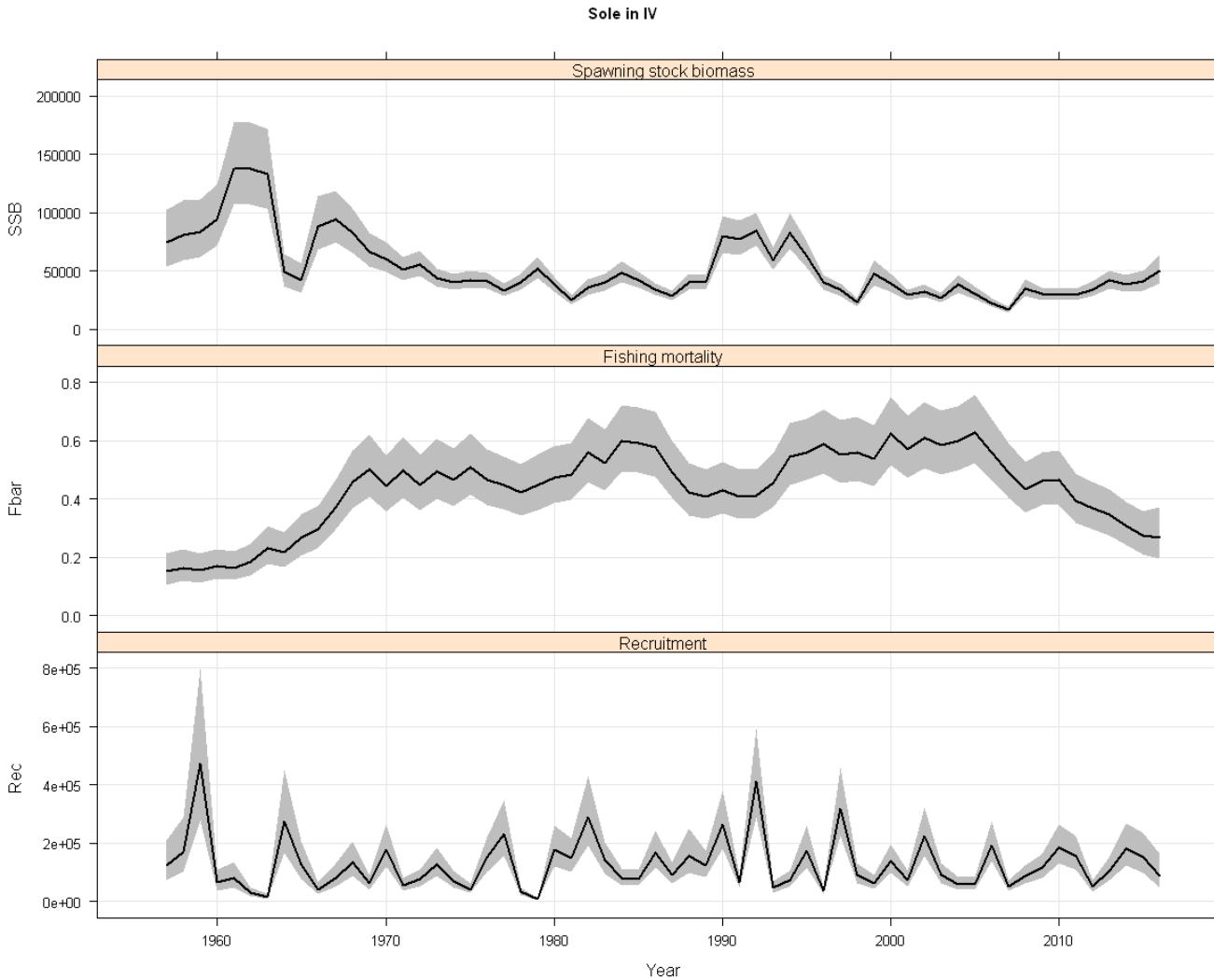
[Icons: File, New, Open, Save, Print, Stop, Refresh]

```
iter: 1 value: -293.6269 mgc: 0.002495566 ustep: 1
iter: 2 value: -293.6269 mgc: 6.765883e-08 ustep: 1
iter: 3 mgc: 1.758593e-13
outer mgc: 0.1008131

iter: 1 value: -293.6254 mgc: 0.002495566 ustep: 1
iter: 2 value: -293.6254 mgc: 6.764528e-08 ustep: 1
iter: 3 mgc: 1.900702e-13
outer mgc: 0.1013295
iter: 1 value: -293.6271 mgc: 0.002495566 ustep: 1
iter: 2 value: -293.6271 mgc: 1.446546e-07 ustep: 1
iter: 3 mgc: 1.953993e-13
outer mgc: 0.1017833
iter: 1 value: -293.6251 mgc: 0.002495566 ustep: 1
iter: 2 value: -293.6251 mgc: 1.446082e-07 ustep: 1
iter: 3 mgc: 1.705303e-13
outer mgc: 0.1020729
iter: 1 value: -293.6273 mgc: 0.002495566 ustep: 1
iter: 2 value: -293.6273 mgc: 1.362748e-07 ustep: 1
iter: 3 mgc: 1.965095e-13
outer mgc: 0.09050557
iter: 1 value: -293.625 mgc: 0.002495566 ustep: 1
iter: 2 value: -293.625 mgc: 1.362322e-07 ustep: 1
iter: 3 mgc: 1.625367e-13
outer mgc: 0.09075347
iter: 1 value: -293.6281 mgc: 0.002495566 ustep: 1
iter: 2 value: -293.6281 mgc: 2.683533e-07 ustep: 1
iter: 3 mgc: 2.177147e-13
outer mgc: 0.1220778
iter: 1 value: -293.6241 mgc: 0.002495566 ustep: 1
iter: 2 value: -293.6241 mgc: 2.681969e-07 ustep: 1
iter: 3 mgc: 1.829648e-13
outer mgc: 0.1221314
```

1 = good, anything smaller may be problematic...

How to get SAM running

plot(SOL.sam)



How to get SAM running

slotNames(SOL.sam)

```
"control"  "nohess"   "nopar"    "n.states"  "states"   "nlogl"    "vcov"  
"rescov"   "obscov"   "params"   "stock.n"   "harvest"  "residuals"  
"info"     "name"     "desc"     "range"
```

dim(SOL.sam@vcov)

head(SOL.sam@params,29)

head(SOL.sam@residuals,29)

How to get SAM running

slotNames(SOL.ctrl)

```
"name"      "desc"       "range"        "fleets"      "plus.group"  
"states"    "logN.vars"   "catchabilities" "power.law.exps" "f.vars"  
"obs.vars"   "obs.weight"  "srr"          "scaleNoYears"  
"scaleYears" "scalePars"   "cor.F"         "cor.obs"  
"cor.obs.Flag" "biomassTreat" "nohess"       "timeout"     "likFlag"  
"fixVarToWeight" "simulate"    "residuals"     "sam.binary"
```

- In case you change parameters, be careful not to estimate e.g. 1 parameter for 2 completely different datasets.
- Use: SOL.ctrl <- update(SOL.ctrl)

How to get SAM running

```
SOL.ctrl <- FLSAM.control(SOL,SOL.tun)
```

Slot "range":

| min | max | plusgroup | minyear | maxyear | minfbar | maxfbar |
|-----|-----|-----------|---------|---------|---------|---------|
| 1 | 10 | 10 | 1957 | 2016 | 2 | 6 |

Slot "fleets":

| catch | BTS-ISIS | SNS |
|-------|----------|-----|
| 0 | 2 | 2 |

0: catch-at-age of fisheries dependent

1: commercial index

2: number index

3: biomass survey (options 0, 1,2)

5: tagging data

How to get SAM running

Slot "plus.group":

plusgroup

Slot "states":

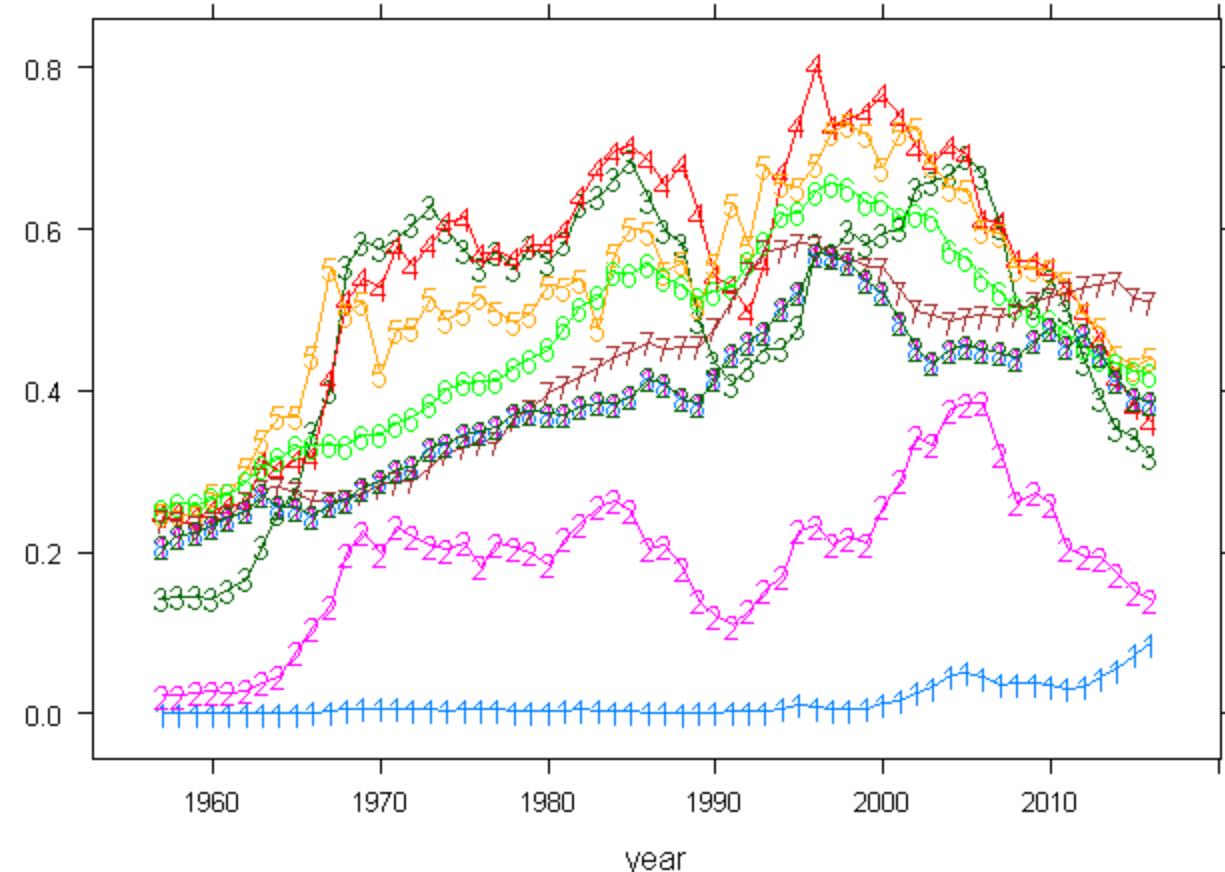
- N and F are called 'states'
- "states" here defines only the random walks over F
- You can choose which age-groups to bind together and which ones to estimate freely (but bind at least the last true age + plusgroup together). Binding means that they encounter the exact same F-at-age
- Best practice: Estimate all free, and visualize

How to get SAM running: choosing states

```
dat <- as.data.frame(SOL@harvest)
```

```
xyplot(data ~ year,data=dat,groups=age,type="b")
```

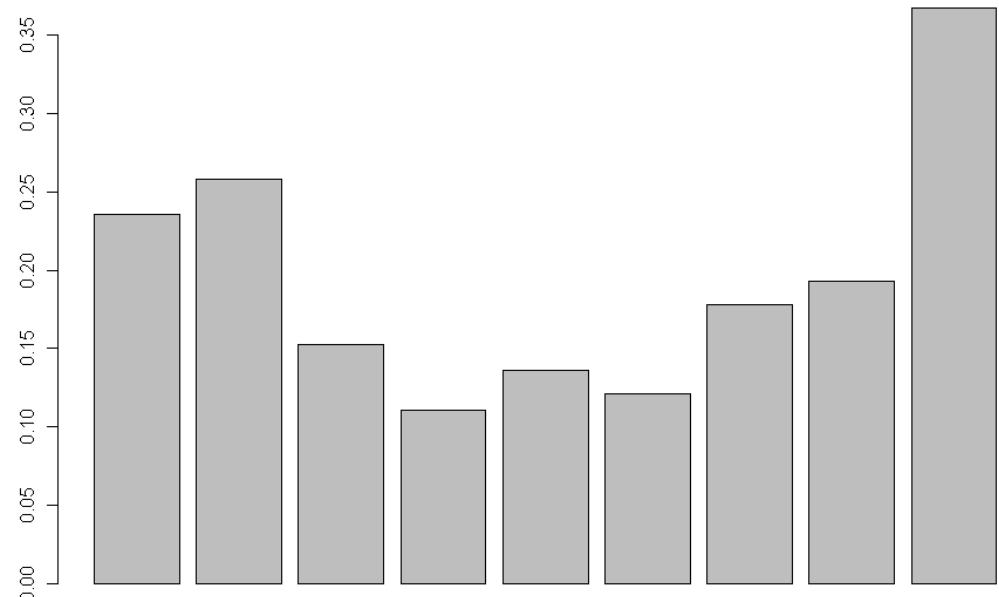
- Most ages seem quite unique in their pattern?!
- Estimating F is an important step, do not bind these together because it's easy. You need a clear reason!



How to get SAM running: choosing logN.vars

Slot "logN.vars":

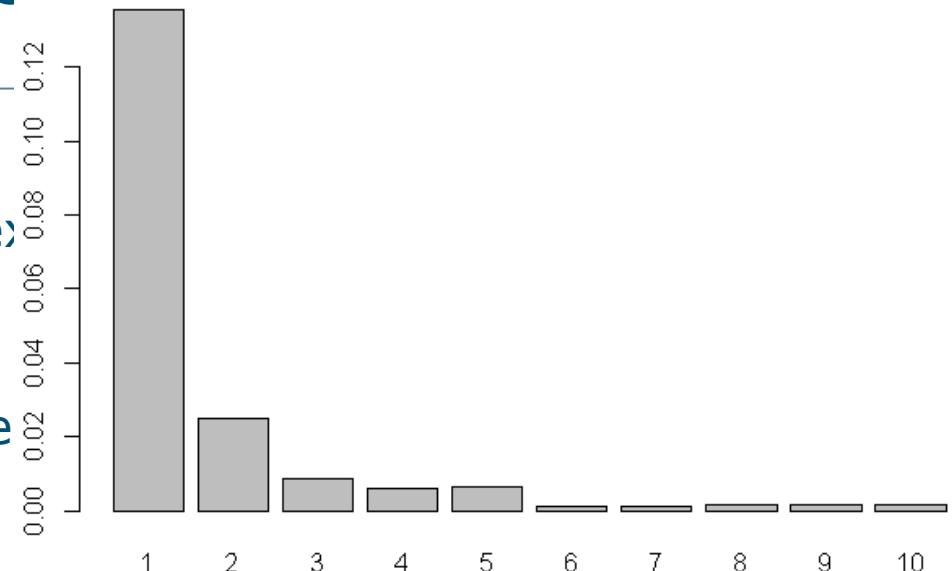
- Variability between predicted and observed numbers in each age group
- Binding of parameters
- Best practice: free parameter for recruitment, rest set to 1 parameter



How to get SAM running: choosing power.law.exps

Slot "power.law.exps":

- Allows to fit a power law index
- Binding of parameters
- Best practice: Common sense



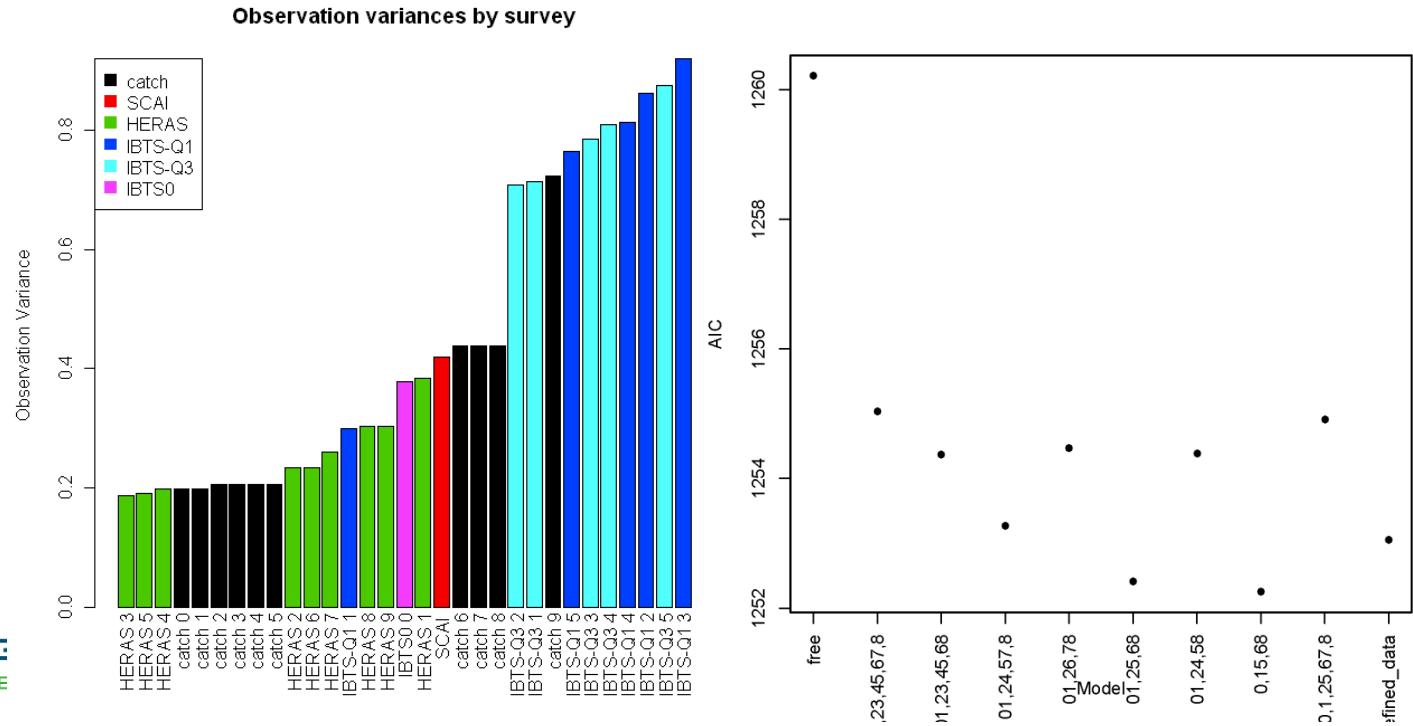
Slot "f.vars":

- Variability in the F random walk steps (F from one year to the next, what is the deviation / step)
- Binding of parameters (F is not identical, only var of steps is identical)
- Best practice: Analyse previous harvest patterns:
`barplot(apply(apply(log(SOL@harvest[,drop=T]),1,diff),2,var))`

How to get SAM running: choosing obs.vars

Slot "obs.var":

- Observation noise on each of the datasets (at age)
- Bindings of parameters
- Best practice: Estimate all free, and visualize



How to get SAM running: choosing obs.weight & scaleYears

Slot "obs.weight":

- Put extra weight onto one of the datasets
- Best practice: common sense (default to NA / do not use it unless you are very sure of what you are doing)

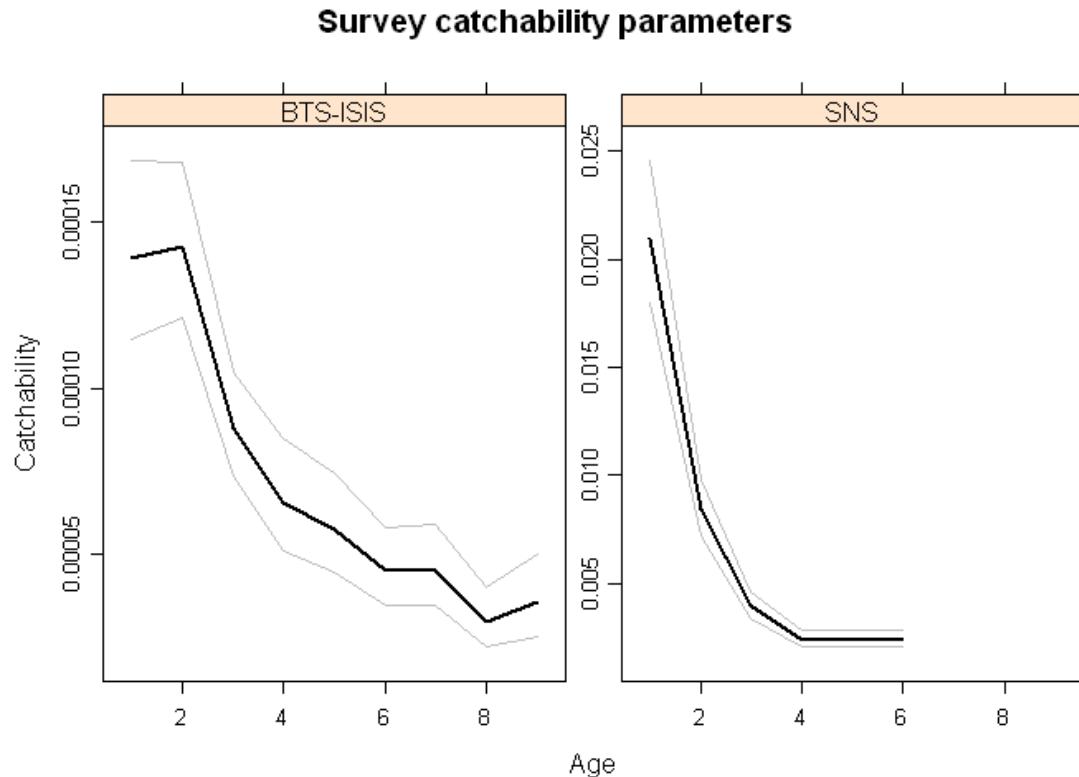
Slot "scaleYears"

- Option to estimate a catch multiplier
- Best practice: Do not use it

How to get SAM running: choosing catchabilities

Slot "catchabilities":

- Catchabilities of the surveys (at age)
- Bindings of parameters
- Best practice: Estimate all free, and visualize



How to get SAM running: choosing cor.F

Slot "cor.F":

- Assume a correlation structure between the F random walks
 - Smoother effects
 - Set to 0 (no correlation), 1 (same correlation across ages) or 2 (same correlation between age-pairs, reduces by age distance)
- Best practice: Run retrospective with each of these settings

How to get SAM running: choosing cor.obs

Slot "cor.obs":

- Assume a correlation structure for your survey observations
 - Ability to get rid of survey year-effects
 - Set cor.obs.Flag to AR for the surveys you want
- Bindings of parameters
- Best practice: Estimate all free, and visualize

Thank you for your attention

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