

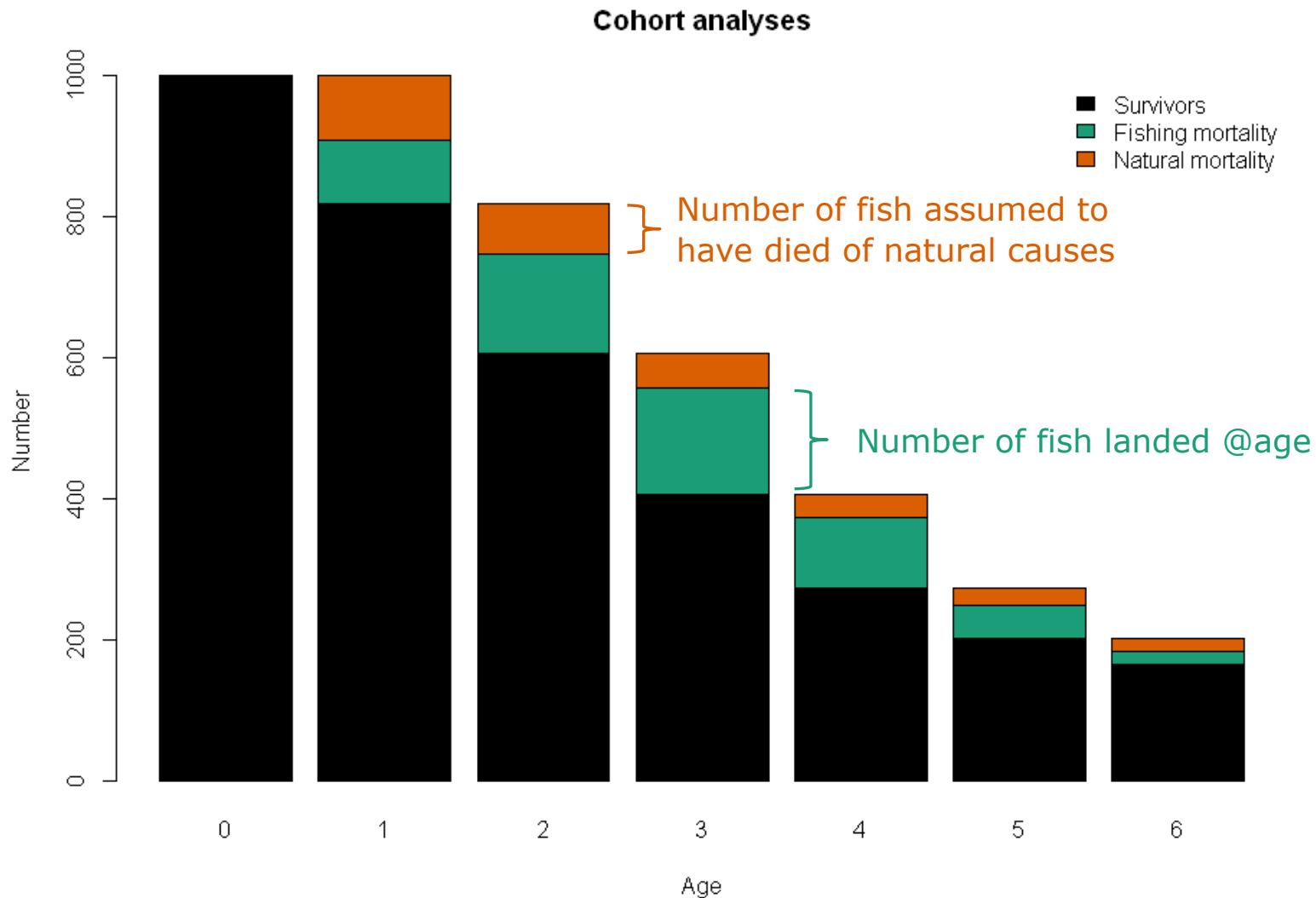
The State-Space assessment model

BlackSea4Fish project Online Presentation Series 1

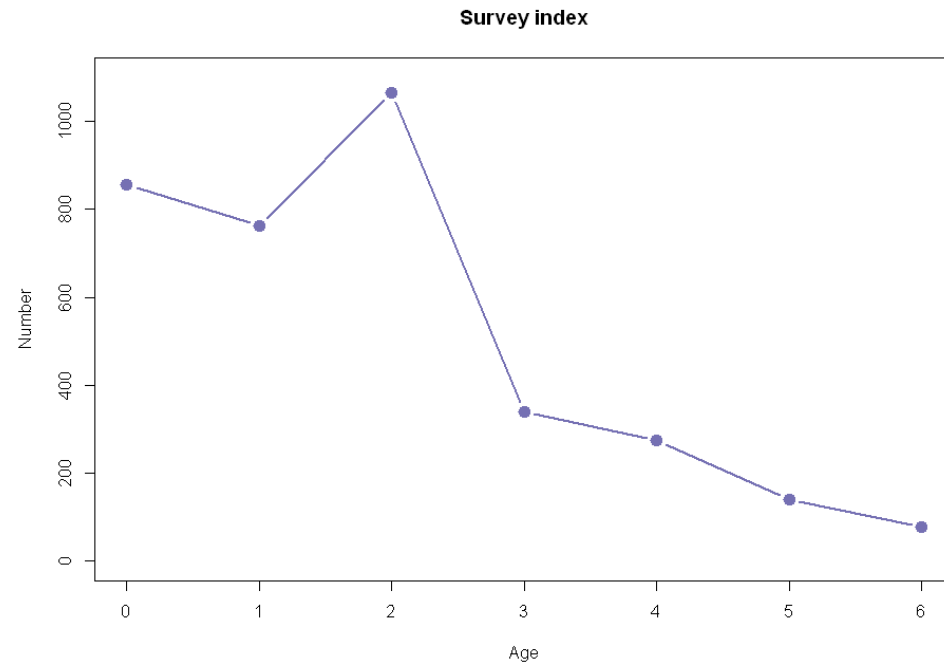
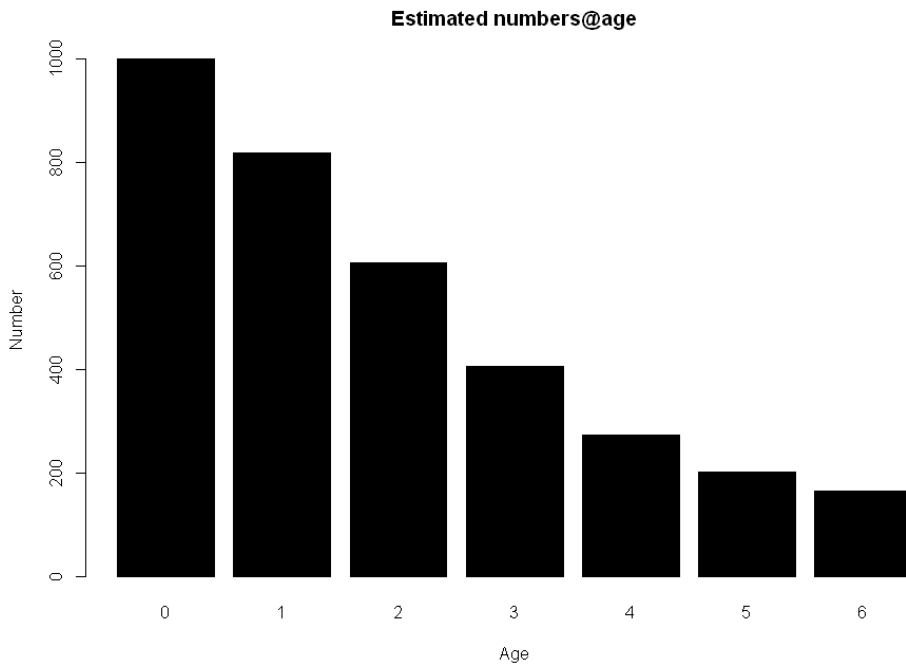
6th of June 2020, Niels Hintzen



The concept of a stock assessment model



The concept of a stock assessment model



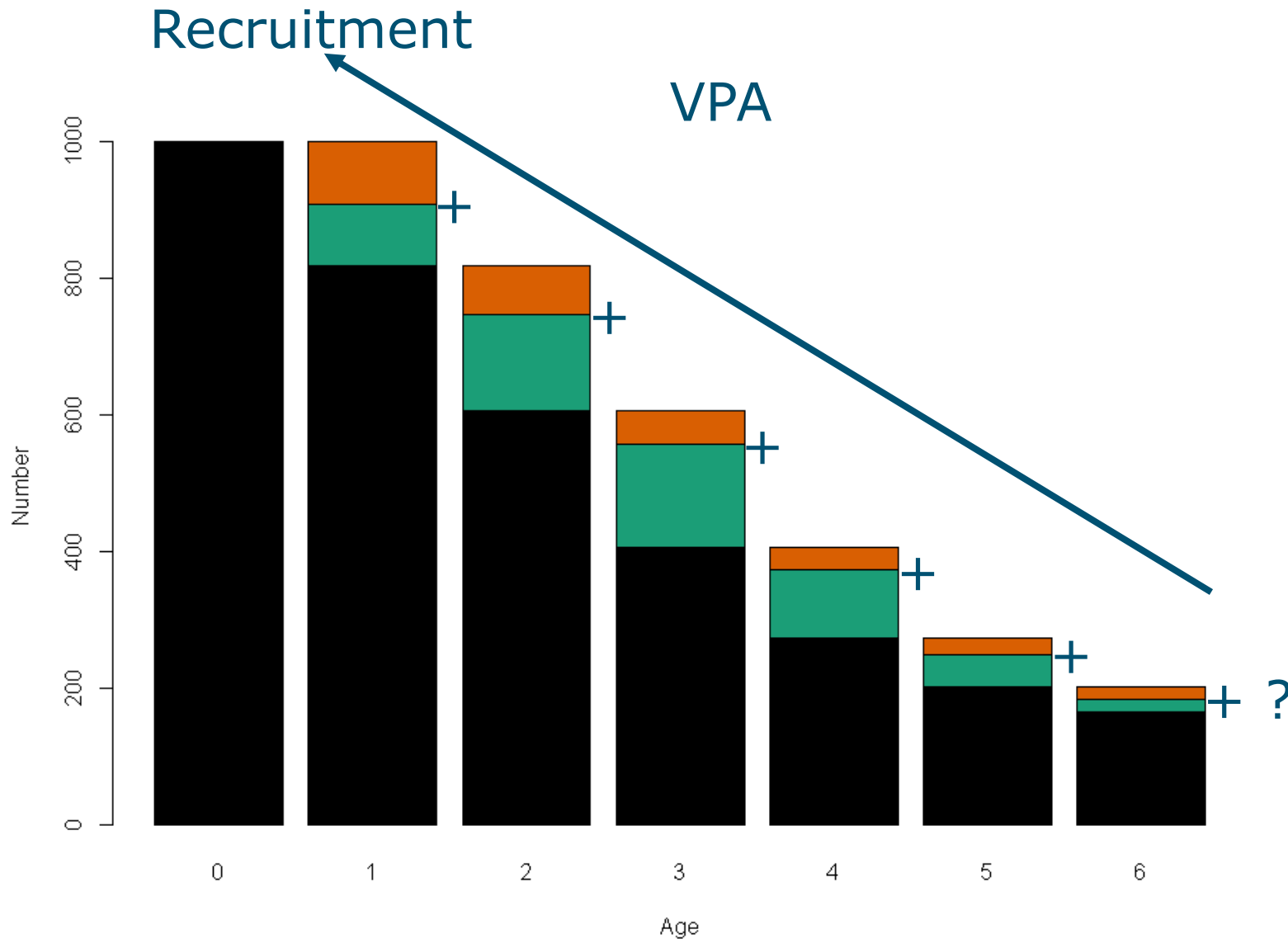
Comparison with simpler models

- 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

SAM model

Numbers-at-age

	2000	2001	2002	2003	2004
1	100				
2		67			
3			50		
4				40	

Random walk!

F-at-age

	2000	2001	2002	2003	2004
1	0.4				
2	0.3				
3	0.2				
4	0.2				

You need a first guess here!

Random walk!

You need a first guess here!

Comparison with simpler models

In simpler assessment models

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

I have perfect knowledge

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

My experiment is not perfect!

One year later...

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

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

Did I do something wrong!?

All noise goes into ε

Comparison with simpler models

SAM model

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

I have to admit, I can be off



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

My experiment is not perfect!?



One year later...

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

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

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

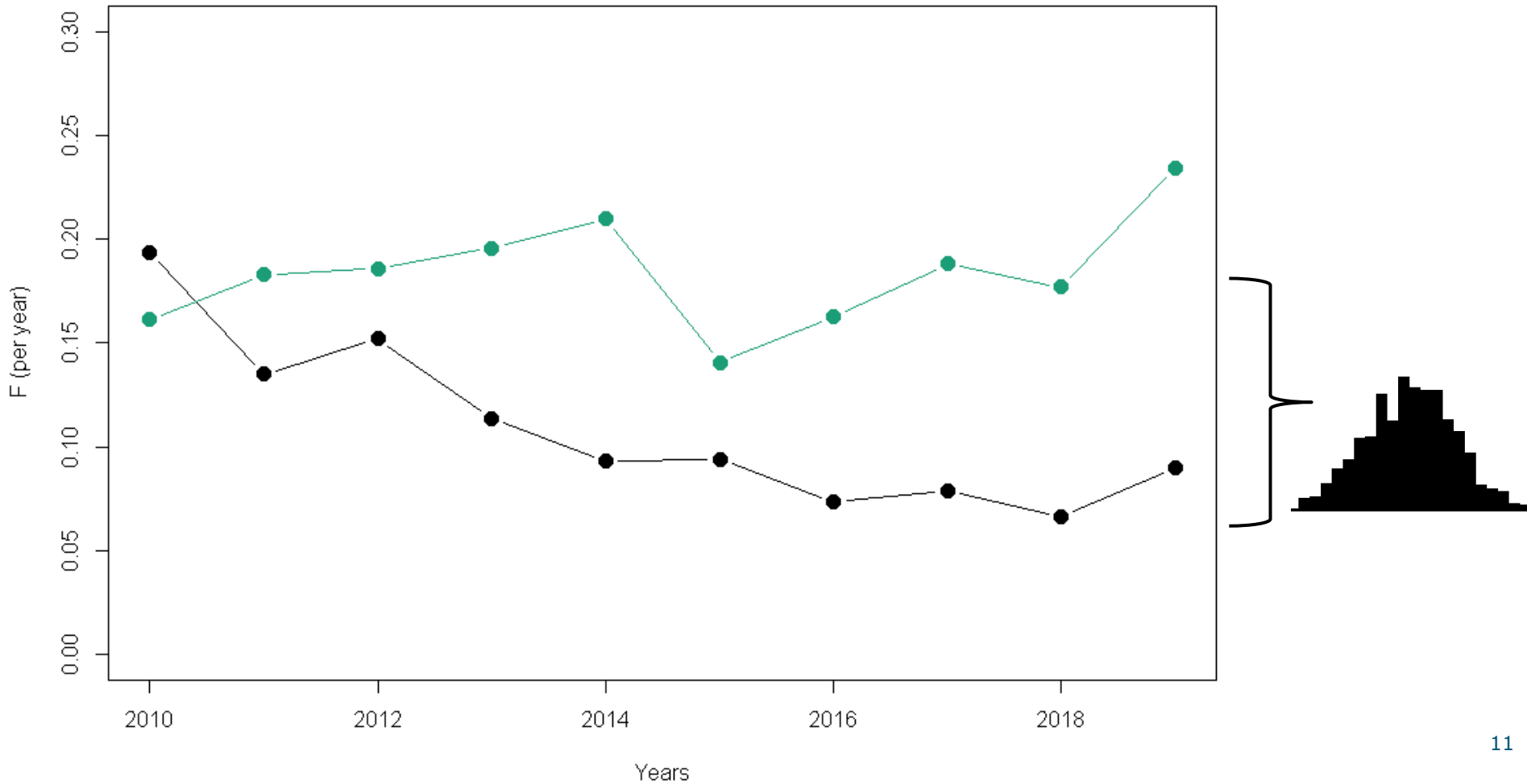
Introduction into SAM

- 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...?

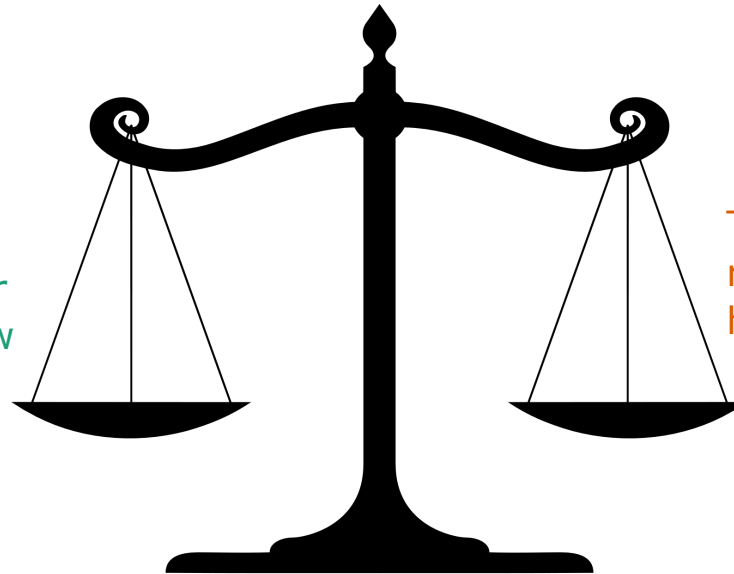
- In F and recruitment



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

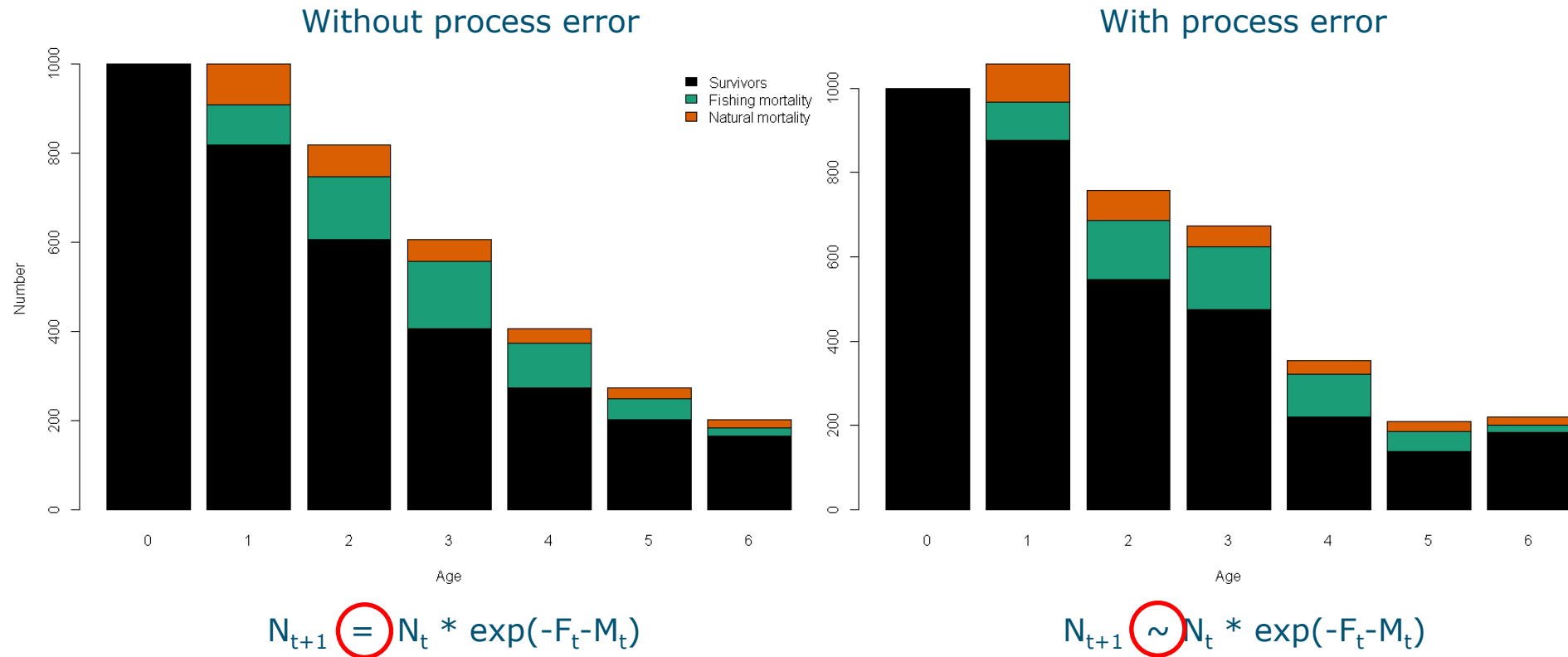
OV low, this part of the equation goes up

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)...

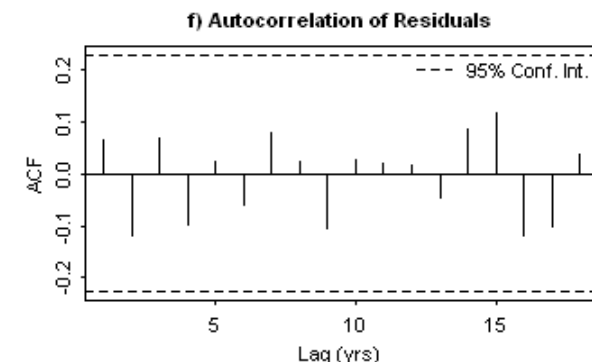
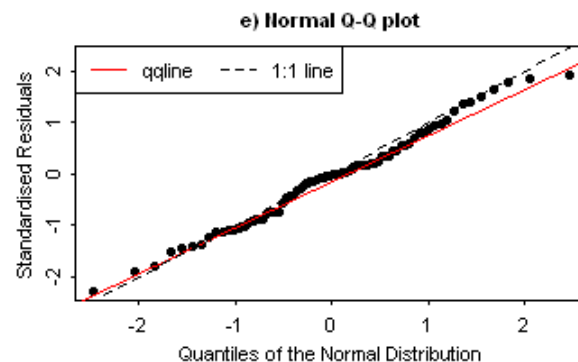
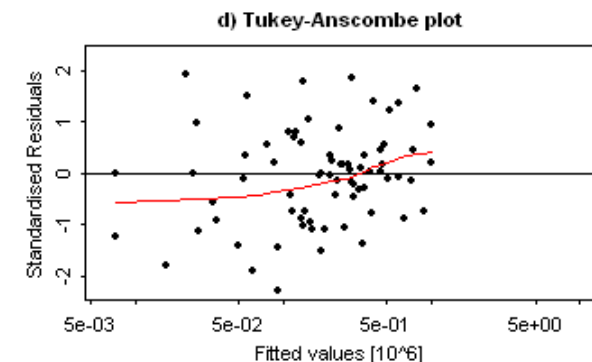
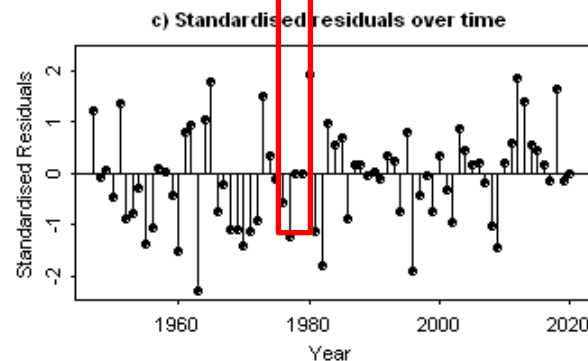
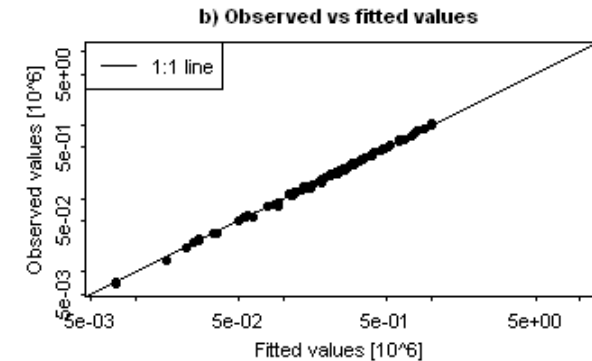
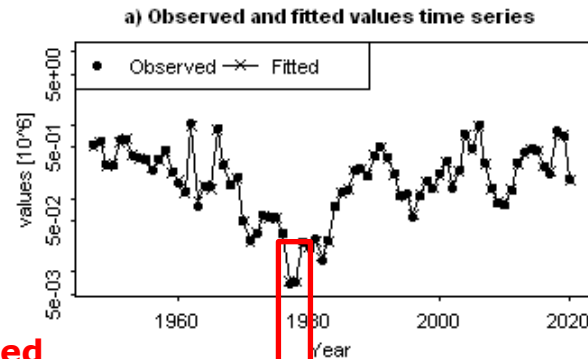


SAM diagnostics

North Sea Herring Diagnostics - catch unique, age 5

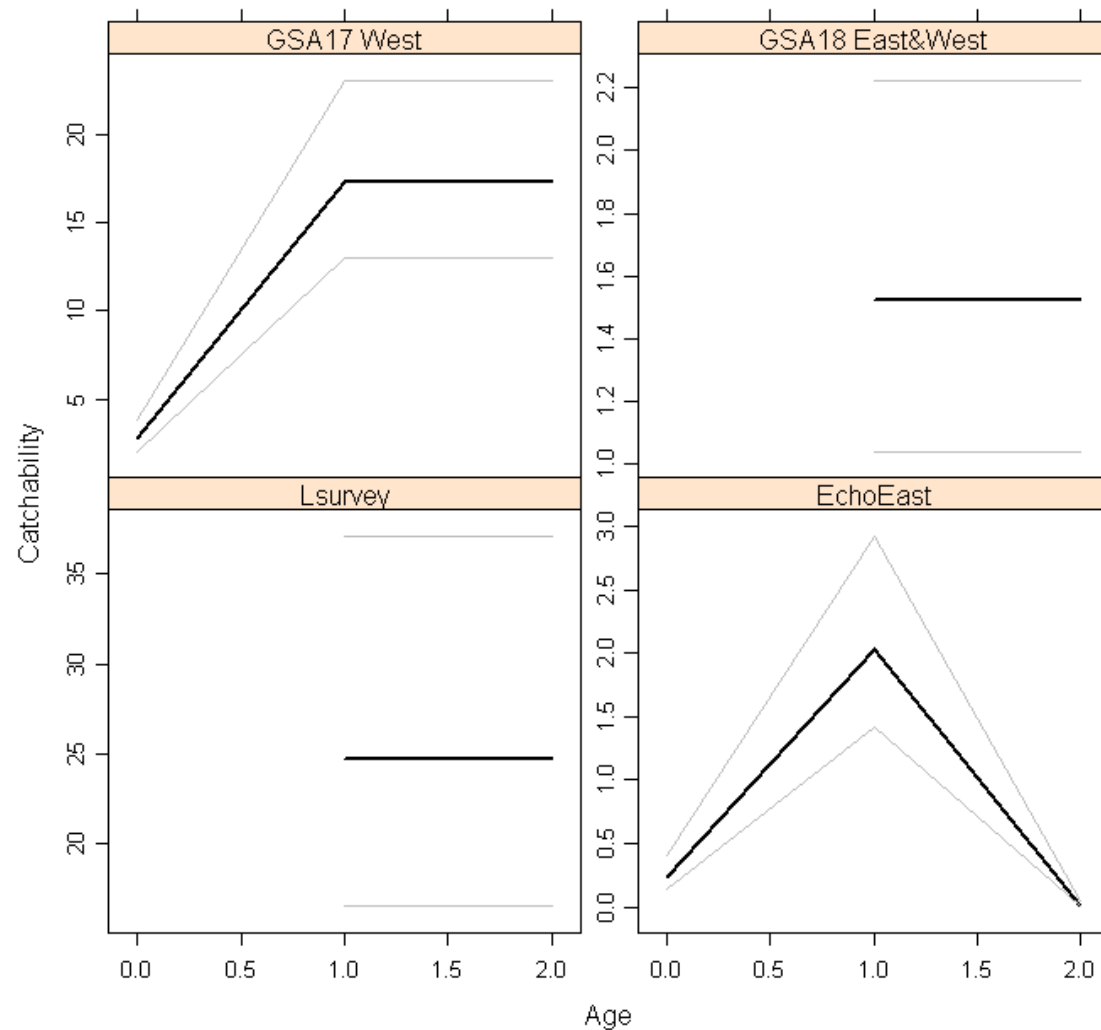
Missing data – not estimated

Missing data - estimated

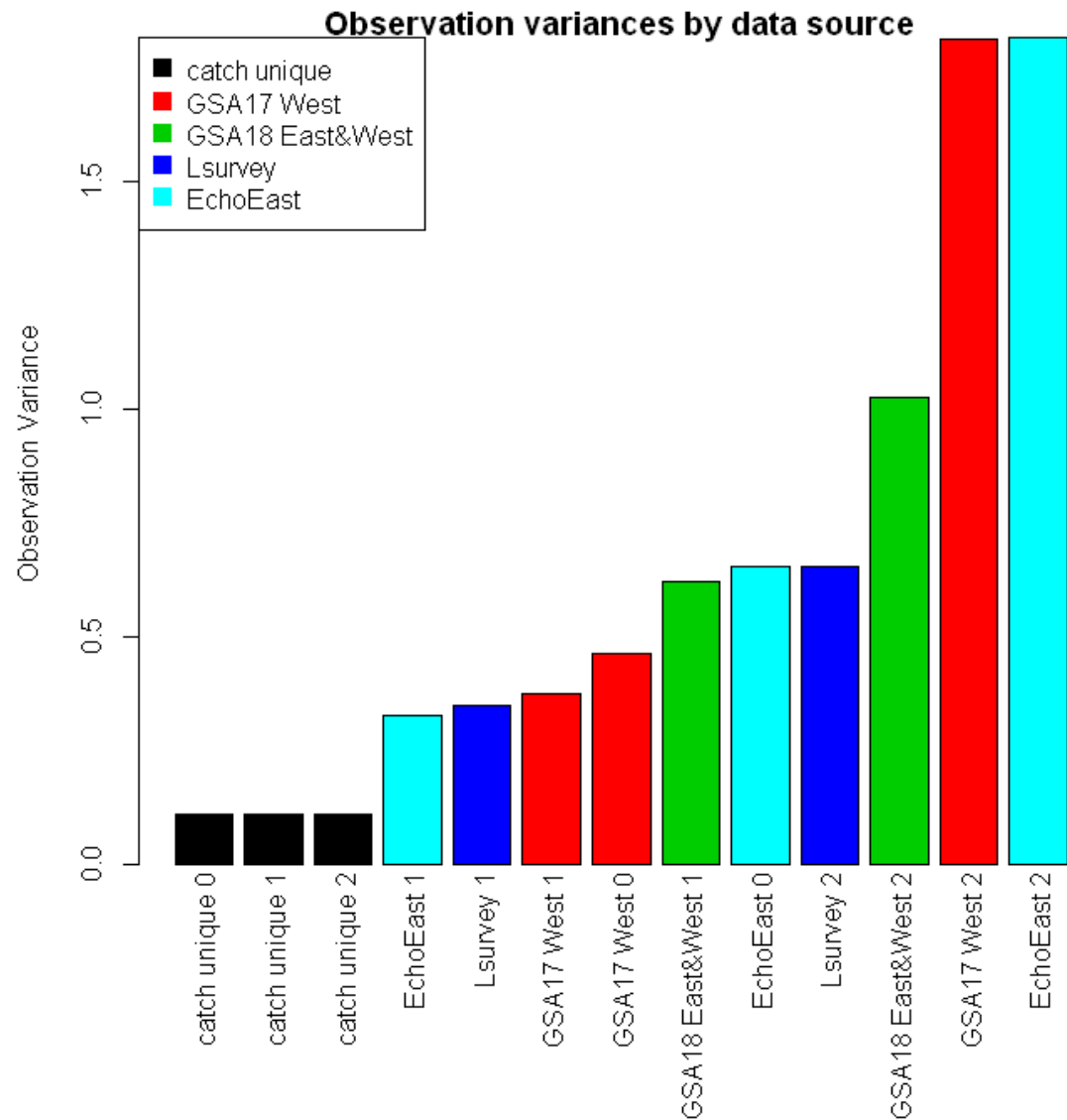


SAM diagnostics

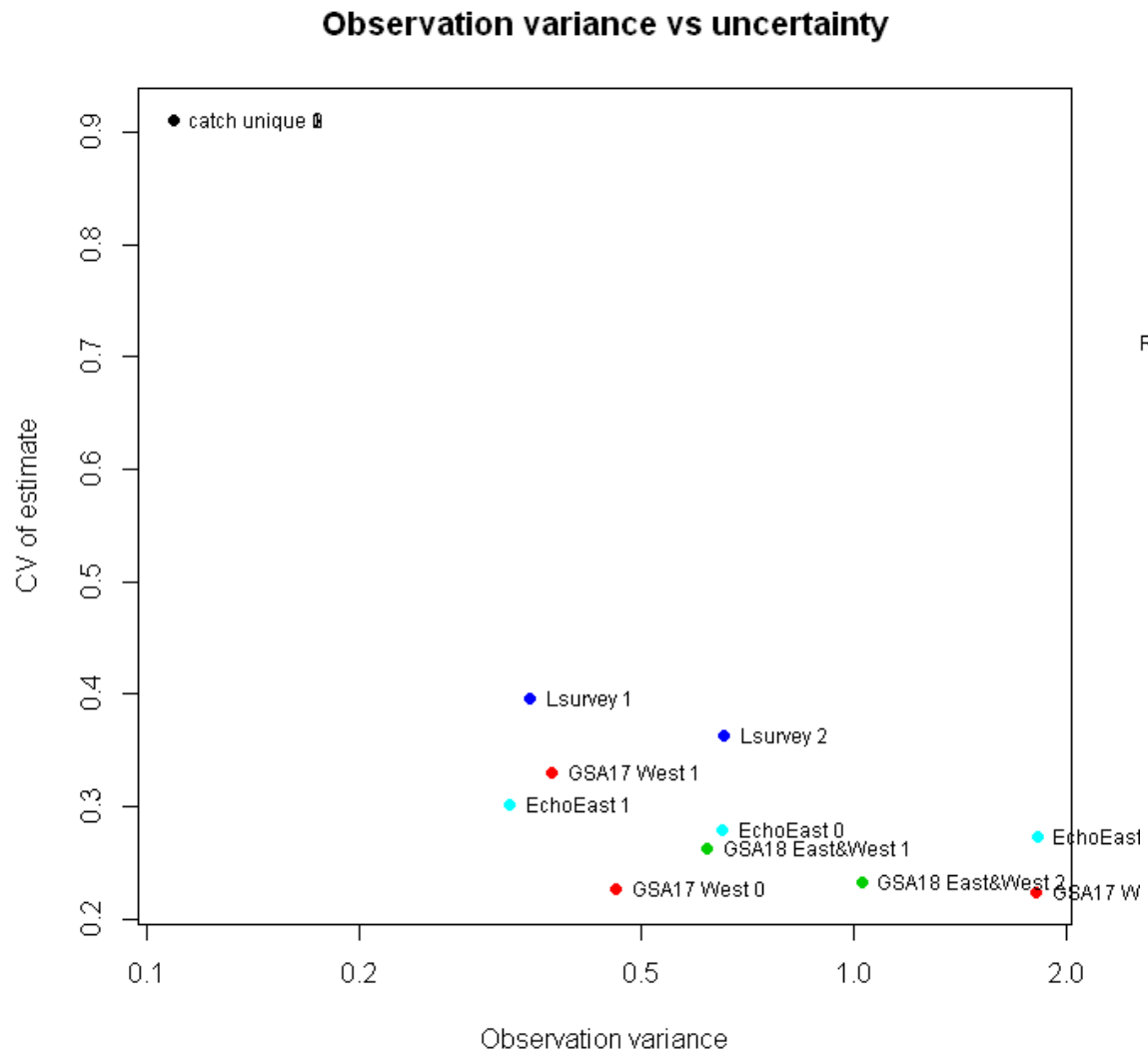
Survey catchability parameters



SAM diagnostics

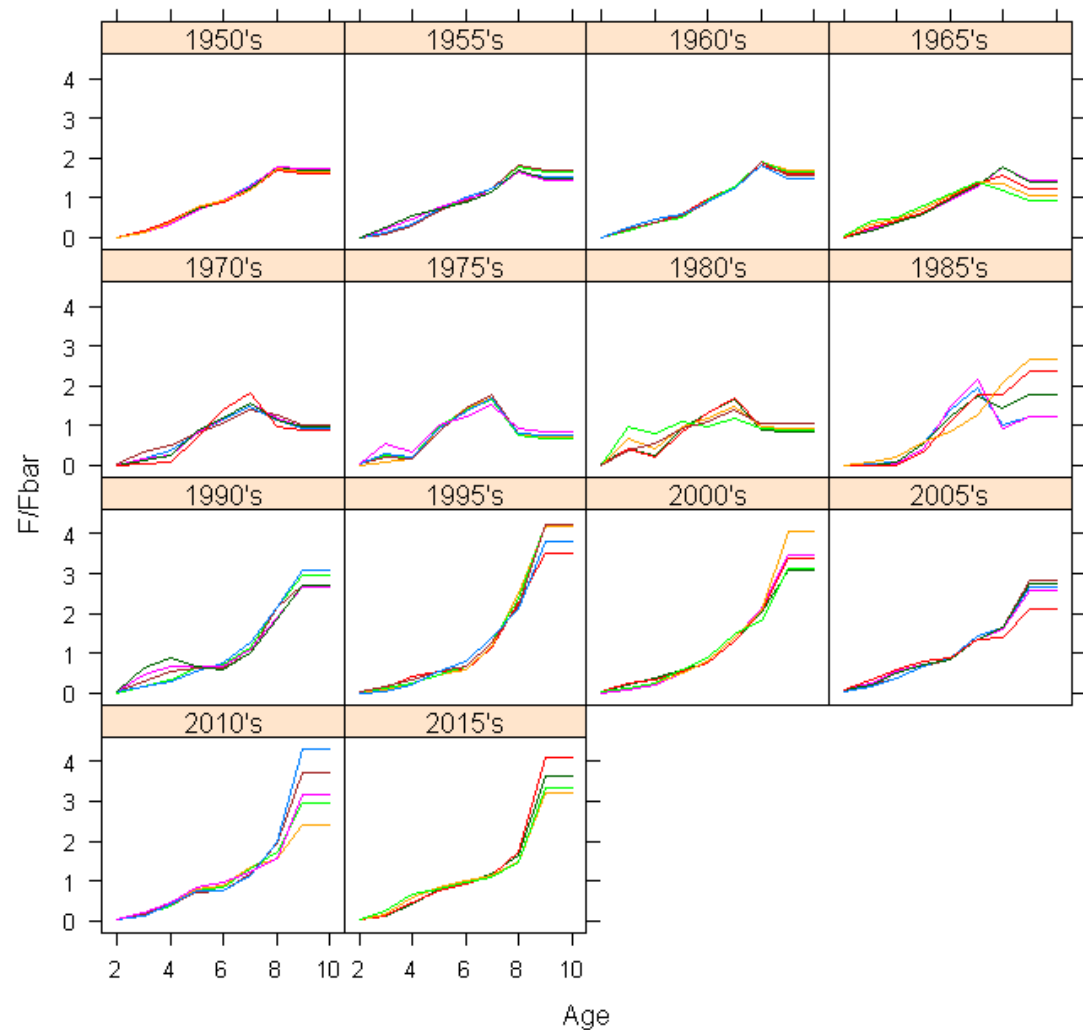


SAM diagnostics



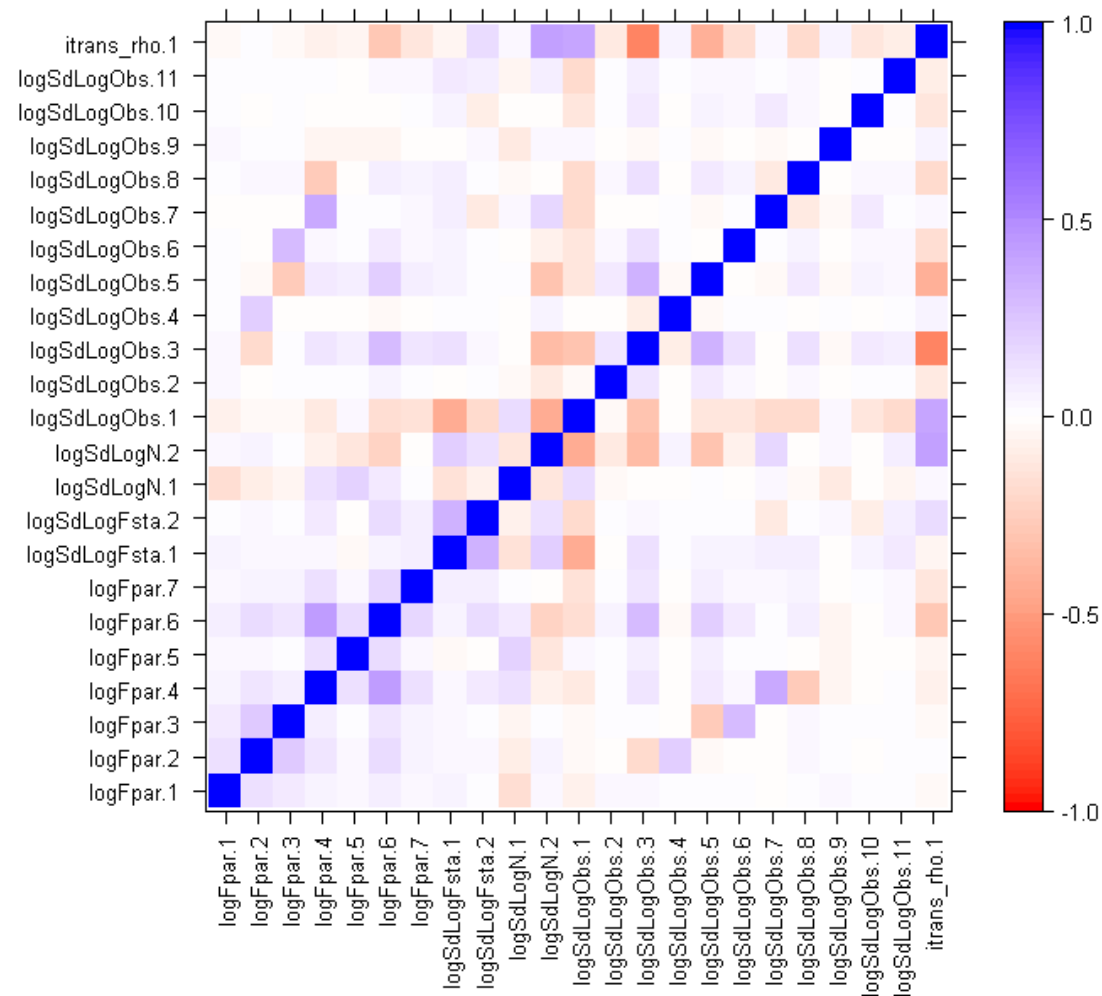
SAM diagnostics

Selectivity of the Fishery by Pentad



SAM diagnostics

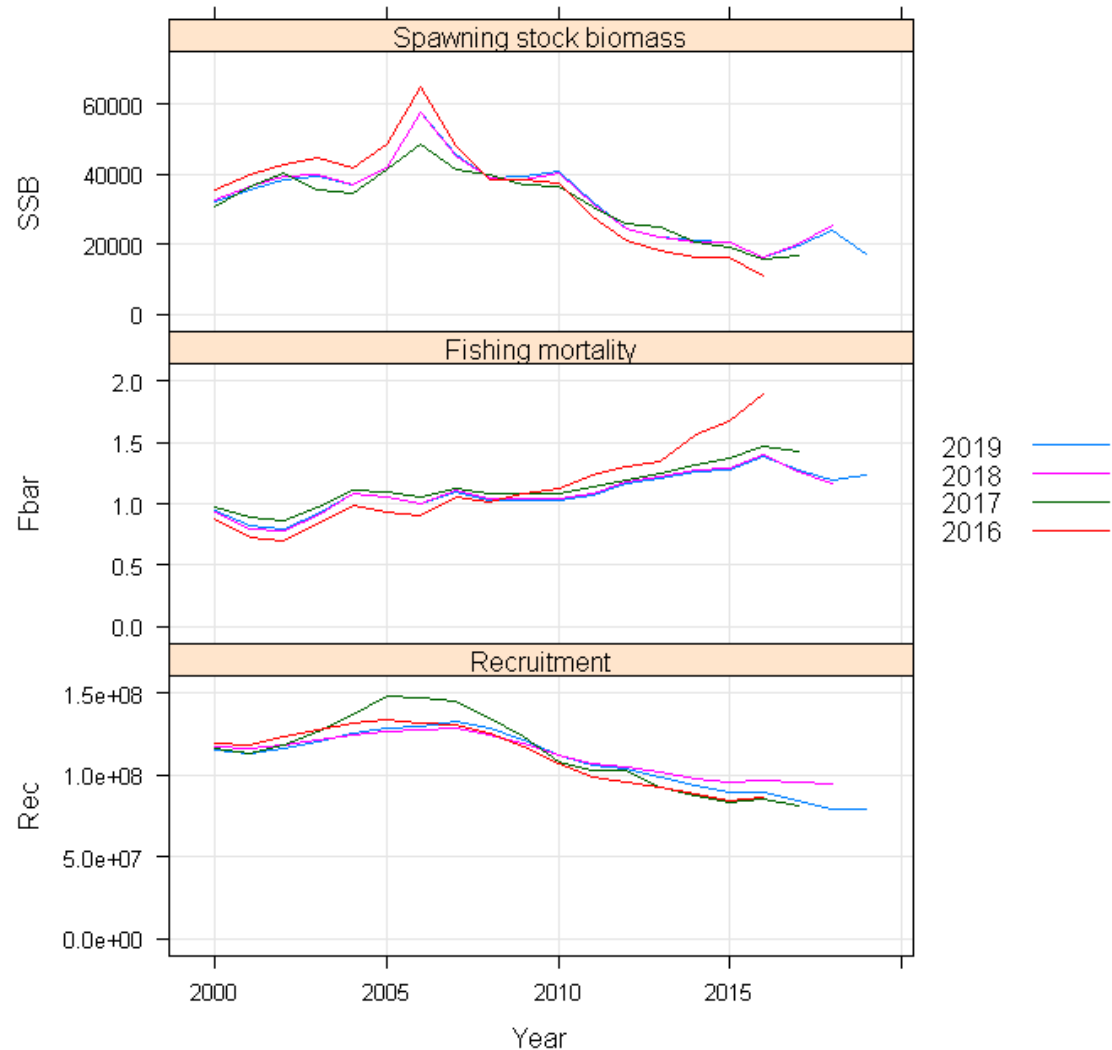
Anchovy - Adriatic Sea - GSA 17 and 18



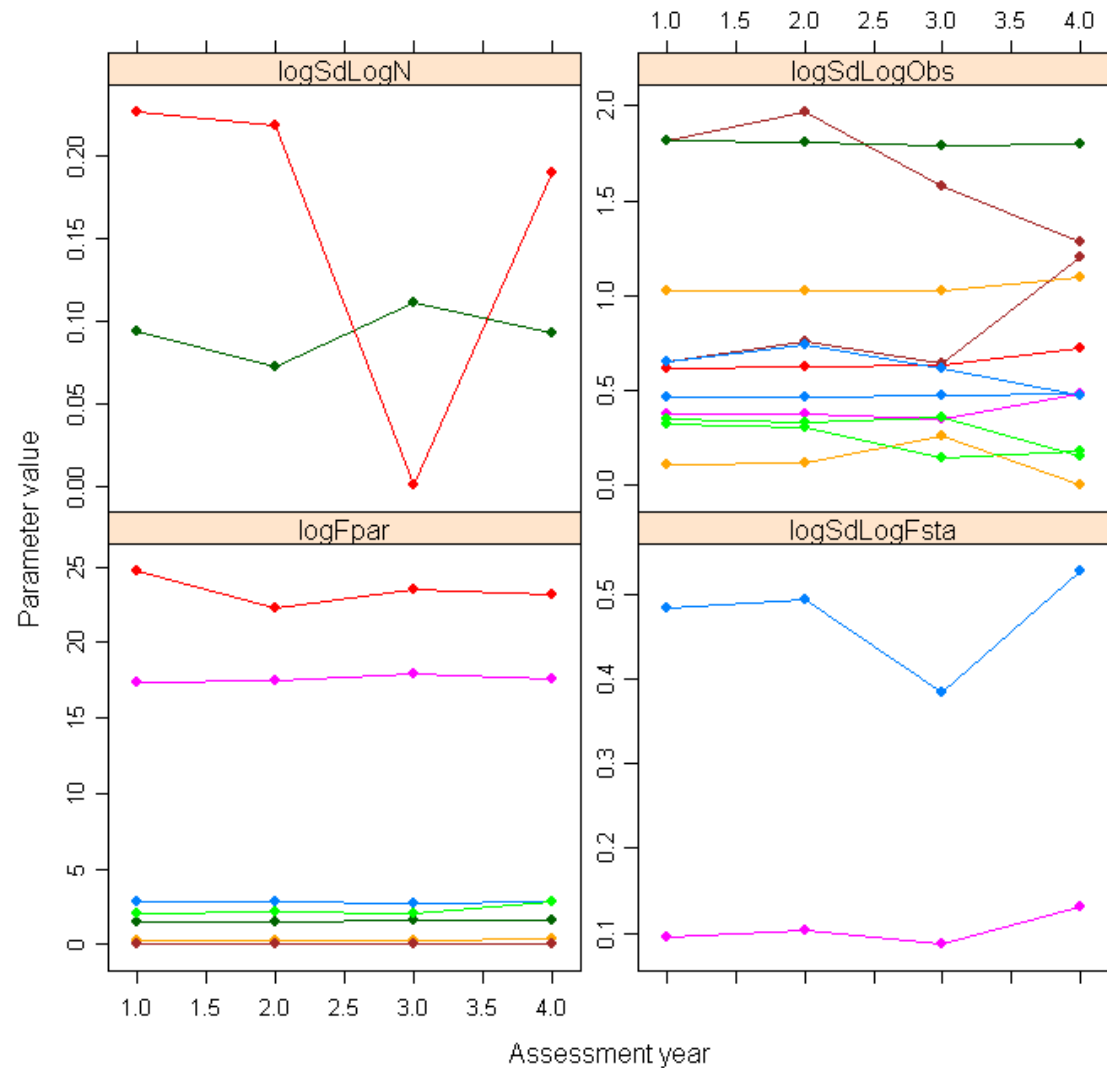
SAM diagnostics



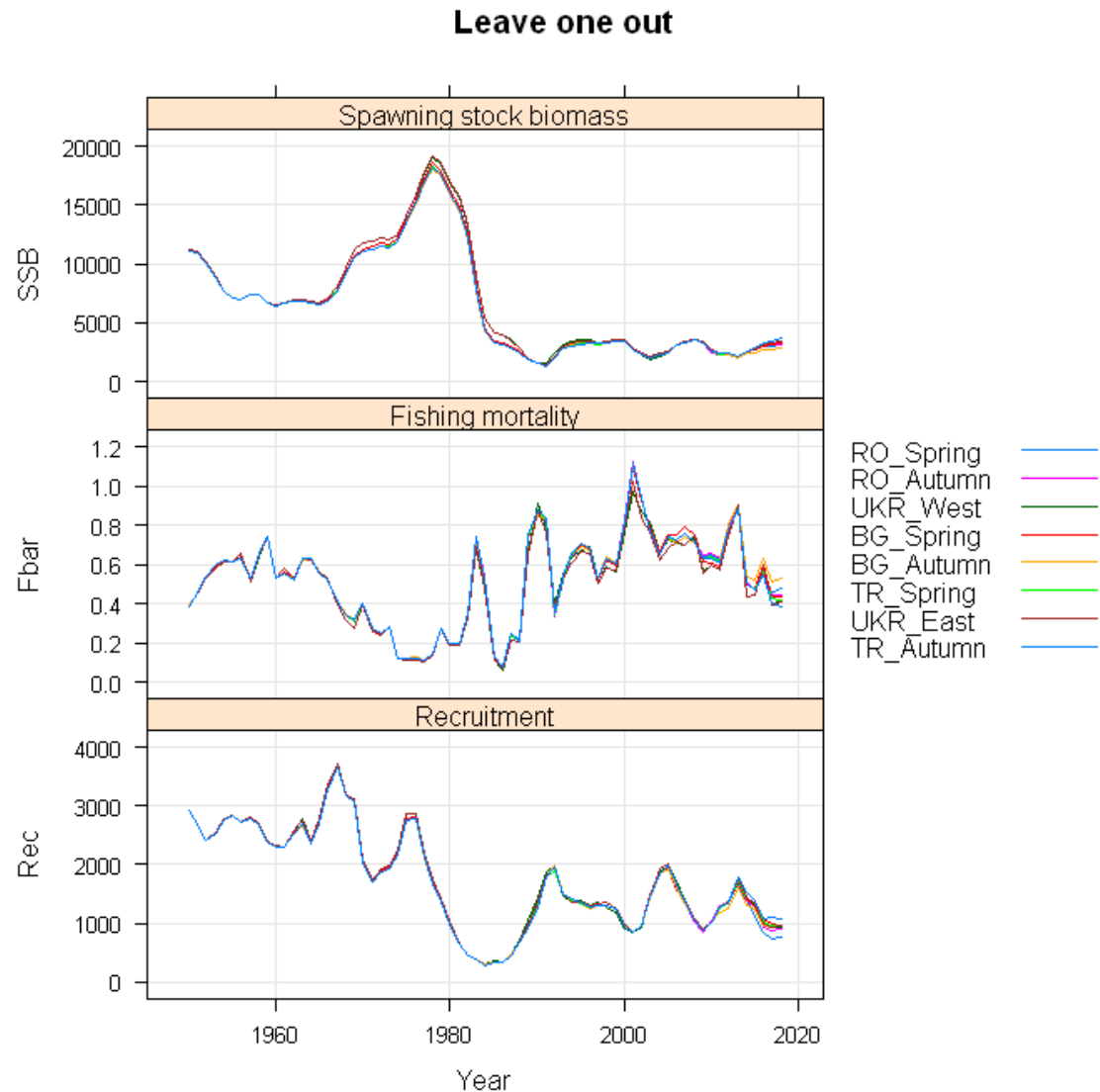
SAM diagnostics



SAM diagnostics

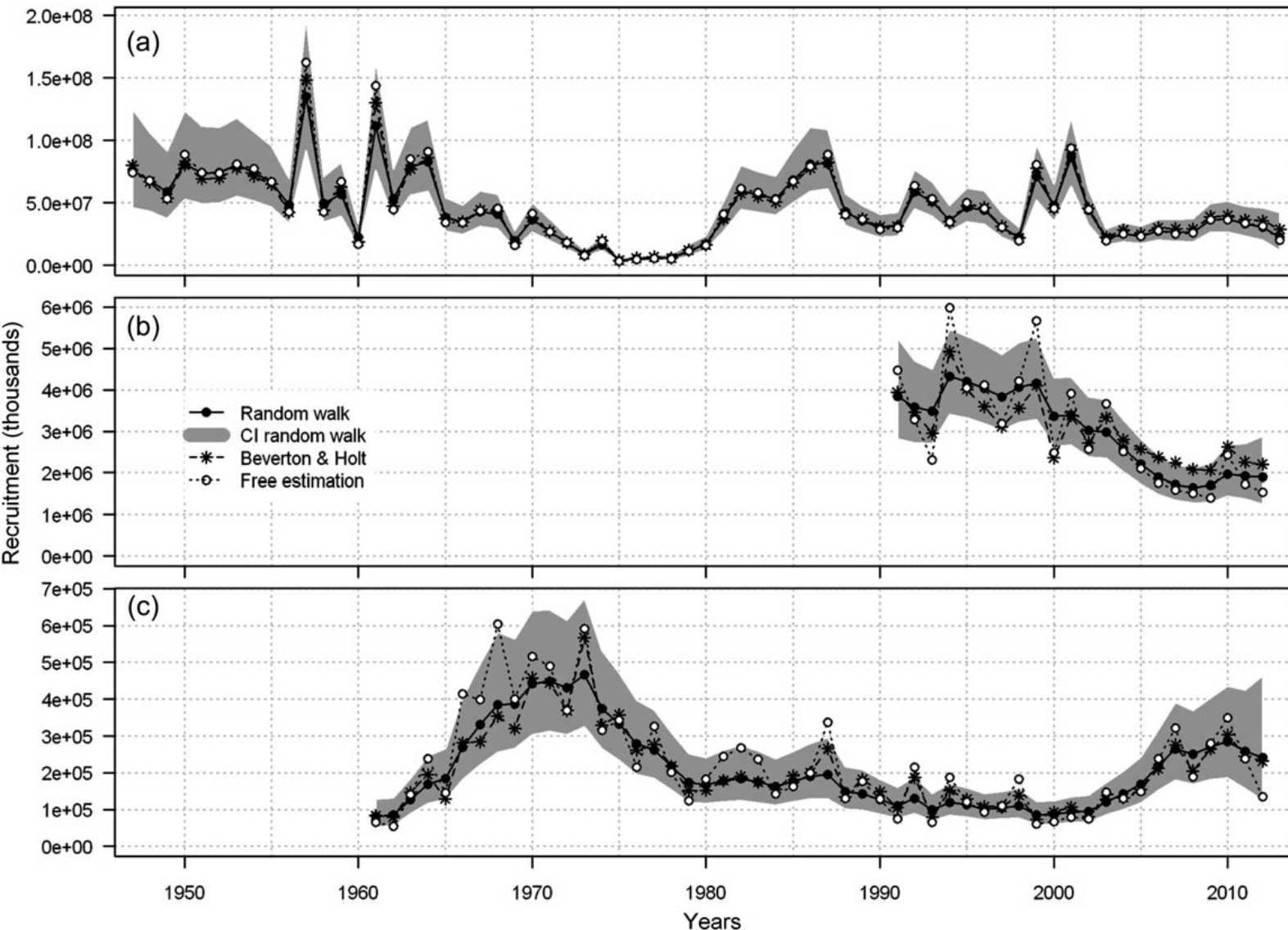


SAM diagnostics



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

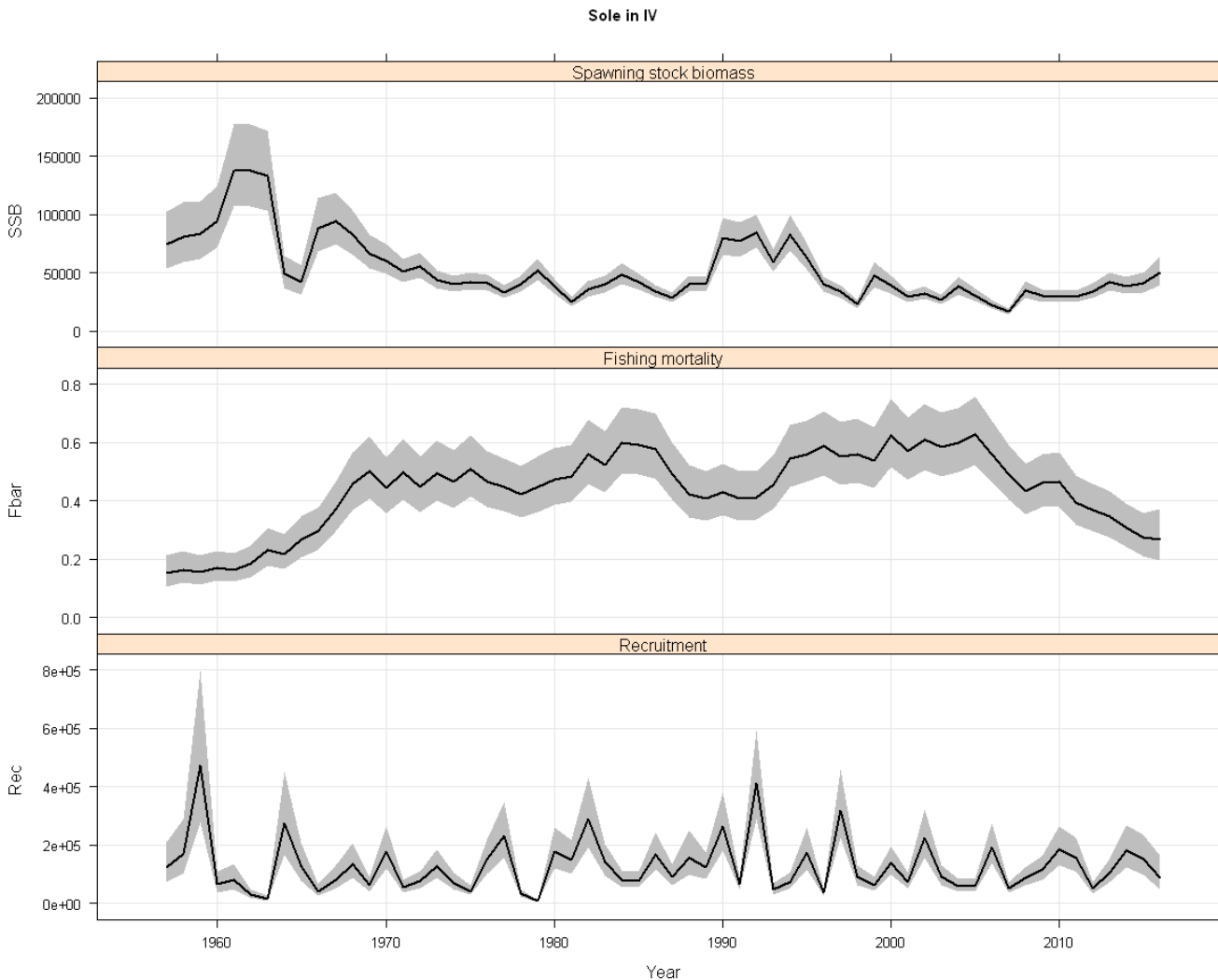


```
iter: 1 value: -293.6269 mgc: 0.002495566 ustep: 1
iter: 2 value: -293.6269 mgc: 6.765883e-08 ustep: 1
iter: 3 mgc: 1.758593e-13
outer mgc: 0.1008131
iter: 1 value: -293.6254 mgc: 0.002495566 ustep: 1
iter: 2 value: -293.6254 mgc: 6.764528e-08 ustep: 1
iter: 3 mgc: 1.900702e-13
outer mgc: 0.1013295
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

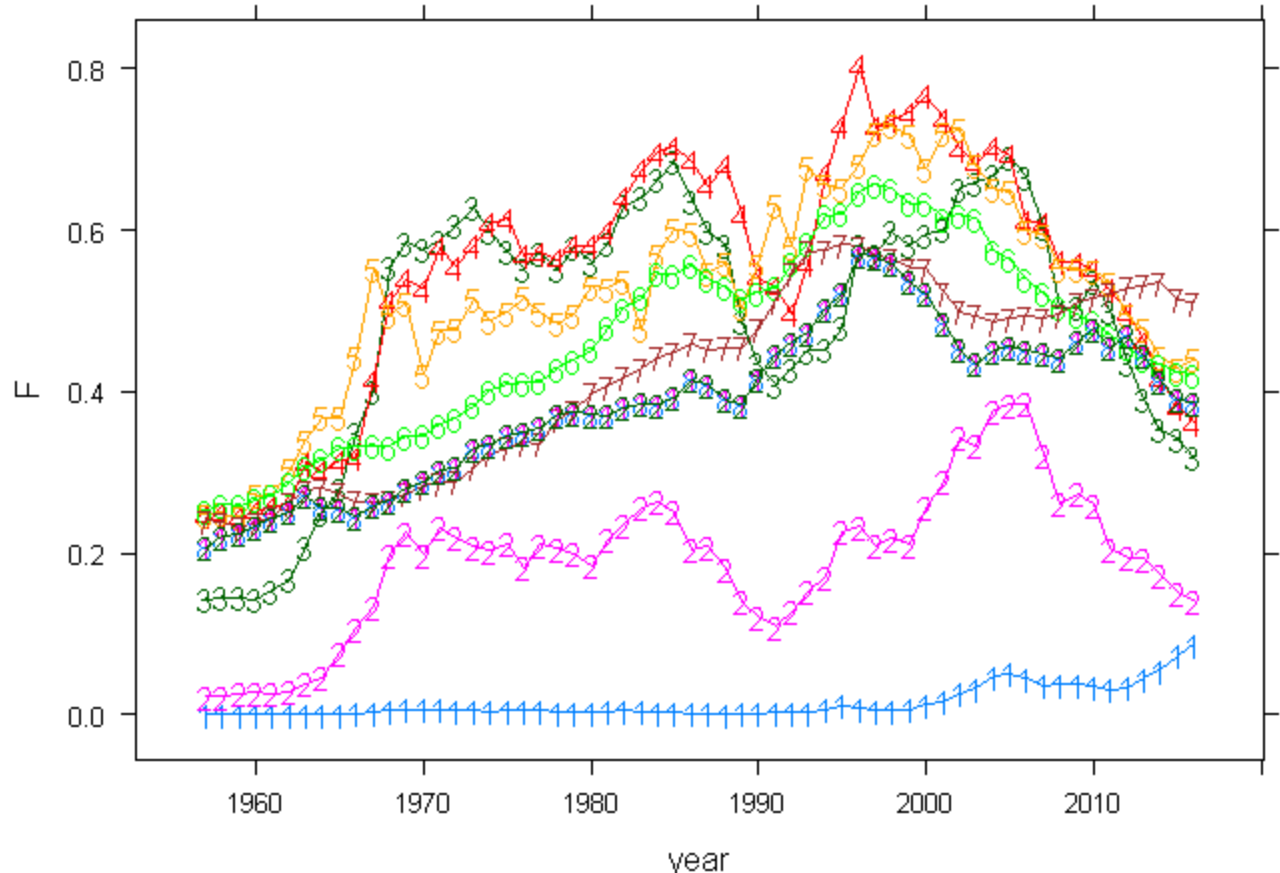
Slot "states":

- 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")
```

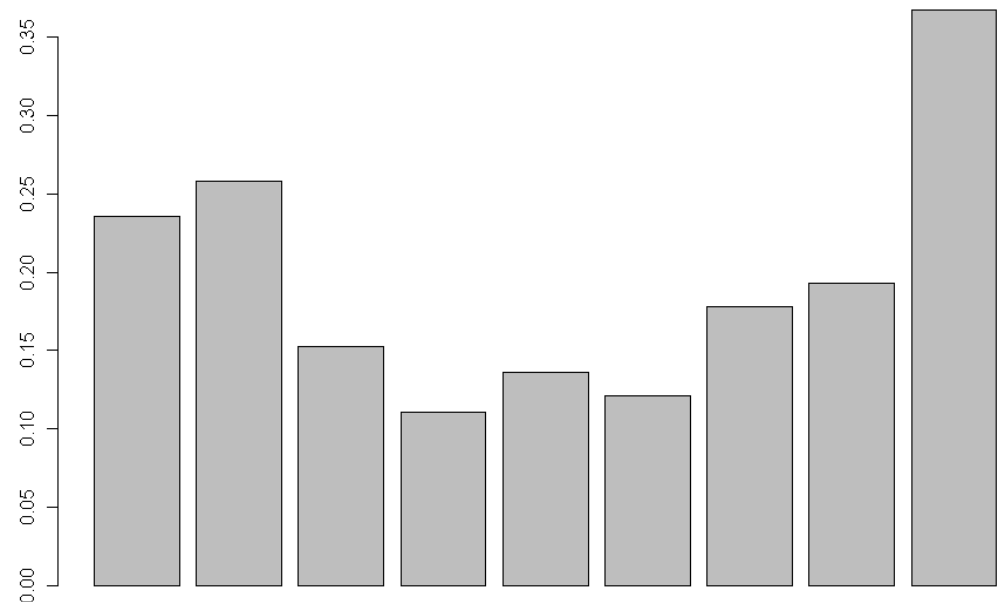
- Most ages seem quite unique in their pattern?!
- Estimating F is an important step, do not bind these together because it's easy. You need a clear reason!



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

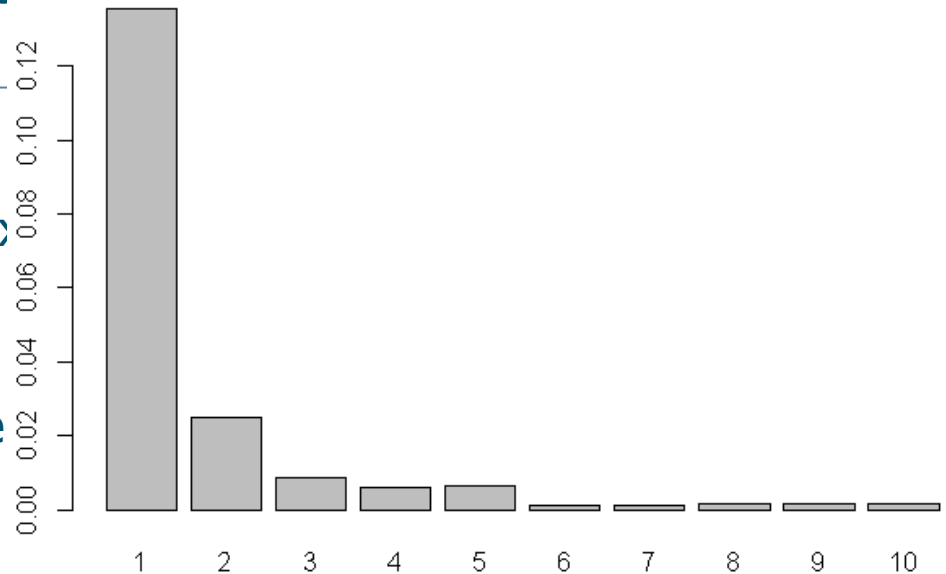
choosing power.law.exps

Slot "power.law.exps":

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

Slot "f.vars":

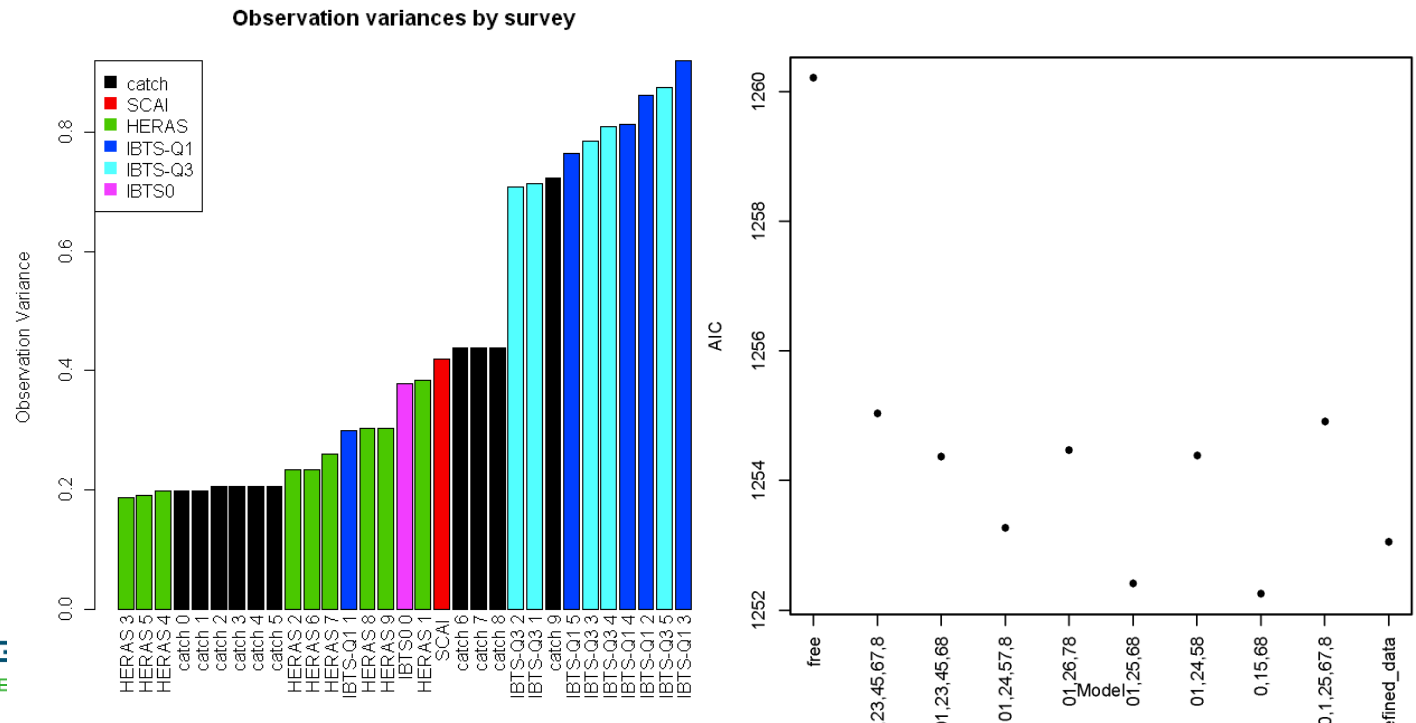
- Variability in the F random walk steps (F from one year to the next, what is the deviation / step)
- Binding of parameters (F is not identical, only var of steps is identical)
- Best practice: Analyse previous harvest patterns:
`barplot(apply(apply(log(SOL@harvest[,drop=T])),1,diff),2,var))`



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)

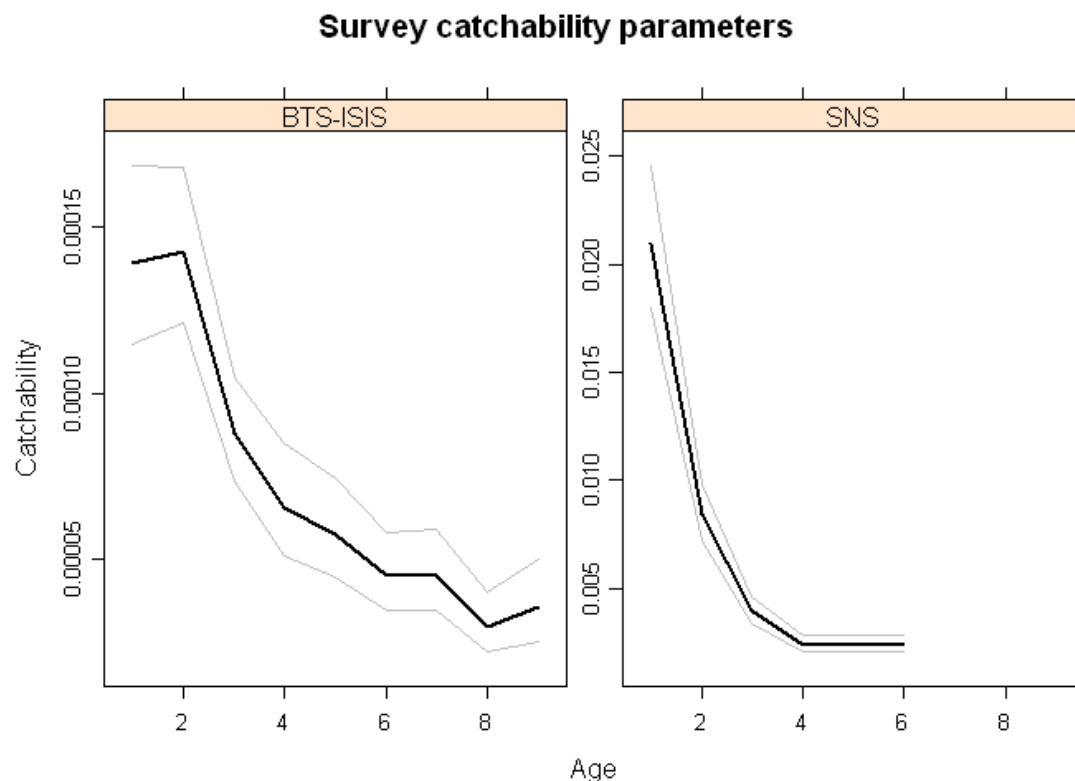
Slot "scaleYears"

- 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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