2014 orange roughy stock assessments: summary of methods and results

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- Assessment package (CASAL): NIWA
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  - NWCR: Andy McKenzie
  - ESCR: Matt Dunn
  - MEC: Owen Anderson
- New acoustic survey estimates: CSIRO, FRS
- New age frequencies: NIWA
- Supplying historical data: NIWA

Presentation structure

- Objectives
- General issues and methods:
  - Conceptual model of orange roughy stocks
  - Data quality
  - Transition-zone maturity and spawning
  - Model structure
  - Bayesian estimation
  - Model runs
  - Acoustic *q* priors
  - YCS parameterisation and priors
  - Reference points and fishing intensity
- Results

Objectives

- ISL was contracted by the DWG to do four ORH stock assessments for presentation at the 2014 Plenary: ESCR, NWCR, ORH7A, MEC
- Project objectives:
  - Review available data and identify data that needs to be prepared prior to stock assessment
  - Prepare available data and develop preliminary models to the end of 2012-13
  - Incorporate new data as it becomes available and assess stock status to the end of 2013-14
  - Prepare suitable documentation

General issues

- Conceptual model of orange roughy
- Can we get defensible biomass indices from:
  - CPUE?
  - Egg surveys?
  - Trawl surveys?
  - Acoustic surveys?
- Spawning biomass vs mature biomass

Conceptual model of orange roughy

- Movement:
  - Individual fish have a “home territory” (which is small compared to the spatial extent of the stock)
  - Mature fish may undertake an annual spawning migration but otherwise they are not highly mobile
- Maturity and spawning:
  - Not all (transition-zone) mature fish spawn each year
  - It is the older (and larger) mature fish that spawn
- Prime habitat occupied by older (and larger) fish

Defensible biomass indices: CPUE?

- CPUE is problematic (when used to provide abundance indices) for any species
- Highly problematic if the species is not very mobile:
  - Makes the species susceptible to localised and serial depletion
  - ORH have a history of concentrated catches in specific areas:
    - CPUE may measure local abundance but is unlikely to be measuring stock-wide abundance (unless there is ***simultaneous*** wide-spread fishing)

Defensible biomass indices: egg surveys?

- Daily method: measures number of eggs released on a particular day during the spawning season
  - High CVs expected because of patchy nature of eggs
  - Potential biases due to inadequate areal coverage and problems estimating egg mortality
- Scaled up from an egg estimate to female biomass, then to spawning biomass, then to transition-zone-mature biomass
- Each survey needs to be considered individually (**none were found to be reliable for these orange roughy stocks**; included in past assessments as absolute biomass and had high CVs; it was hoped they didn't make a difference)

Defensible biomass indices: trawl surveys?

- If the same vessel, gear, time of year, and area then they should provide defensible indices (i.e., constant q)
- Problems if the surveys occur during the spawning season and fish are pluming:
  - Requires constant proportion of biomass in the plumes each year
- Problems if the survey area contain hills:
  - Probably different availability and vulnerability for fish associated with hills compared to those associated with flat
  - Not a problem if most of the biomass is associated with the flat (or a constant proportion of biomass associated with the hills)
- **If obvious problems, with an otherwise consistent time series, then process error CV of 20% added to sampling CV**

Defensible biomass indices: acoustic surveys?

- Low ORH target strength makes biomass estimation from mixed species marks highly problematic
- ORH biomass estimates from wide-area acoustic surveys with mixed-species layers cannot be considered reliable
- Pure or near-pure ORH marks are needed
- Hill surveys problematic because of possible large dead-zones
- Need to consider each survey individually (**surveys of spawning plumes used**; wide-area surveys not used; surveys of hills using hull-mounted transducers not used in base models).

Spawning biomass vs mature biomass

- *Maturity* has been estimated from the transition-zone on otoliths
- Not all transition-zone mature fish spawn
- *Spawning* measured from gonad stage and/or presence on spawning ground
- Strong evidence that the spawning fish are an older-age subset of the mature fish. Corollary:
  - If there is a spawning fishery then spawning proportion will be expected to change over time (i.e., a constant spawning proportion is untenable)
- It is much easier to measure spawning biomass than it is to measure transition-zone mature biomass
- Stock assessment models should equate spawning with maturity and ignore transition-zone maturity (which is not needed for stock assessment).

2014 ORH general model structure

- Single area, single sex, age-structured with maturity in the partition
- Multiple fisheries modelled only if necessary and/or convenient:
  - MEC: south fishery catches smaller fish than north fishery (estimate fishery specific selectivities)
  - ESCR: catch histories and length frequencies already developed by Dunn for three fisheries (estimate fishery specific selectivities)
- Spawning equated with maturity (100% spawning)

Bayesian estimation

- Each estimated parameter must be given a *prior* distribution (which incorporates information from data not available to the model)
- A joint *posterior* distribution is estimated for the parameters (which updates the priors with the data – our best estimate of “truth” given the model structure, the priors, and the data)
- A (marginal) posterior can be calculated for any derived parameter of interest (e.g., current stock status)
- The median (of each marginal posterior) is used as the “best” point estimate

MPD estimates

- The MPD is the mode of the joint posterior distribution:
  - Gives rise to MPD estimates of derived parameters of interest
  - These are estimates associated with the “best fit”
  - Very useful to see if the model “makes sense” (fits, likelihood profiles)
  - MPD estimates may or may not be close to the medians of the posteriors
  - In the 2014 ORH assessments the base-model MPD estimate of stock status was always smaller than the MCMC estimate
  - In each case, the main cause were differences in MPD and MCMC YCS estimates with the MPD YCS estimates sometimes being atypical of the posterior distribution

Model runs

- Lots and lots of MPD runs:
  - Look at fits
  - Look at likelihood profiles
  - Check data weighting (use/in-spirit-of Francis 2011)
  - Decide on base model
  - Sensitivities: estimate M, lowM, highM, low mean q prior, high mean q prior, deterministic recruitment, half/double effective Ns for AFs and/or LFs, half/double recent acoustic observations, other sensitivity runs specific to the stock
- MCMC runs:
  - Base
  - Estimate M
  - LowM-Highq and HighM-Lowq (deviate by 20% from base)
  - Other sensitivity runs specific to the stock

Revised ORH TS prior (1)

- Pre-2014 prior used results from Macaulay et al. (2013, and earlier, from AOS), Kloser and Horne (2003), Coombs and Barr (2007), and McClatchie et al. (1999) (slope = 16.15)
- Further AOS results now available from Kloser et al. (2013)
- Revised prior uses just the AOS results and the McClatchie et al. (1999) slope

Revised ORH TS prior (2)

Table: Estimated ORH TS from AOS measurements. The Macaulay range is a 95% CI. The Kloser range comes from assumed normal tilt angle distributions from mean = 0 to 30 degrees (sd = 15 degrees). All estimates are for fish with mean length 33.9 cm

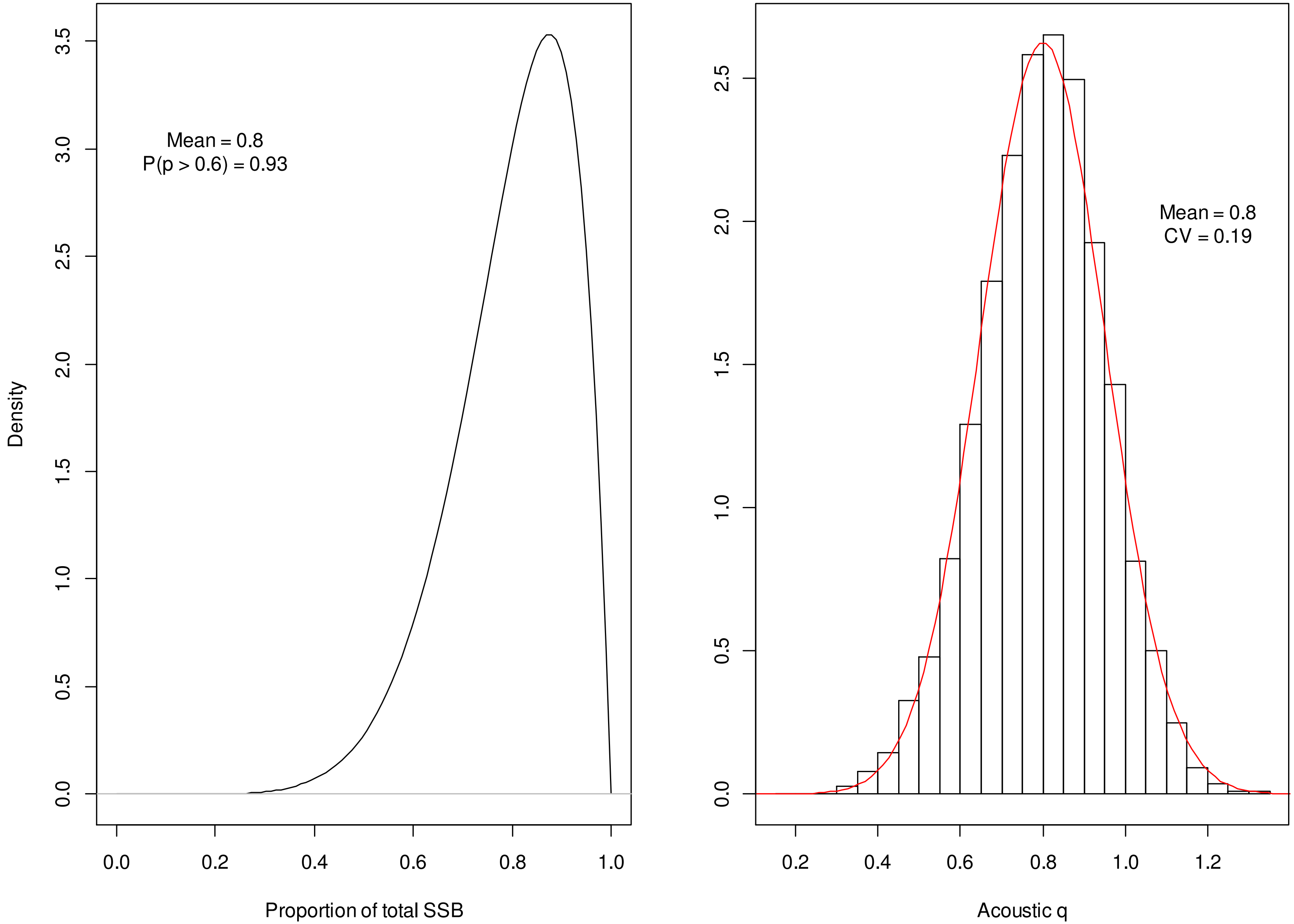
Source	TS (dB)	Range (dB)
Macaulay et al. (2013)	-52.0	-53.3 to -50.9
Kloser et al. (2013)	-51.1	
With tilt angle distributions		-52.2 to -50.7

Given a mean of -52.0 dB, a spread of ± 1.5 dB covers both ranges

Prior for acoustic q (surveying "most" SSB)

- Assume only two potential biases for the acoustic survey:
  - Error in assumed length-TS relationship
  - Proportion of the total SSB in the plumes/marks surveyed (p)
  - Only two sources needed since the last one is just an educated guess (i.e., no point putting in lots of minor sources)
- Informed prior needed for q:
  - $E(X) = qB$, $\quad q = p \times (ts_{true} / ts)$
- We have a prior for the ratio of true ts to assumed ts:
  - $LN(-\sigma^2/2, \sigma = 0.11)$
- For p use a Beta distribution:
  - $p \sim B(8,2)$
  - $E(p) = 8/(8+2) = 0.8$ (i.e., "most" = 80%)
- **q ~ N or LN(mean = 0.8, cv = 0.19), bounded: [0.1, 1.5]**

Prior for acoustics q (most=0.8)



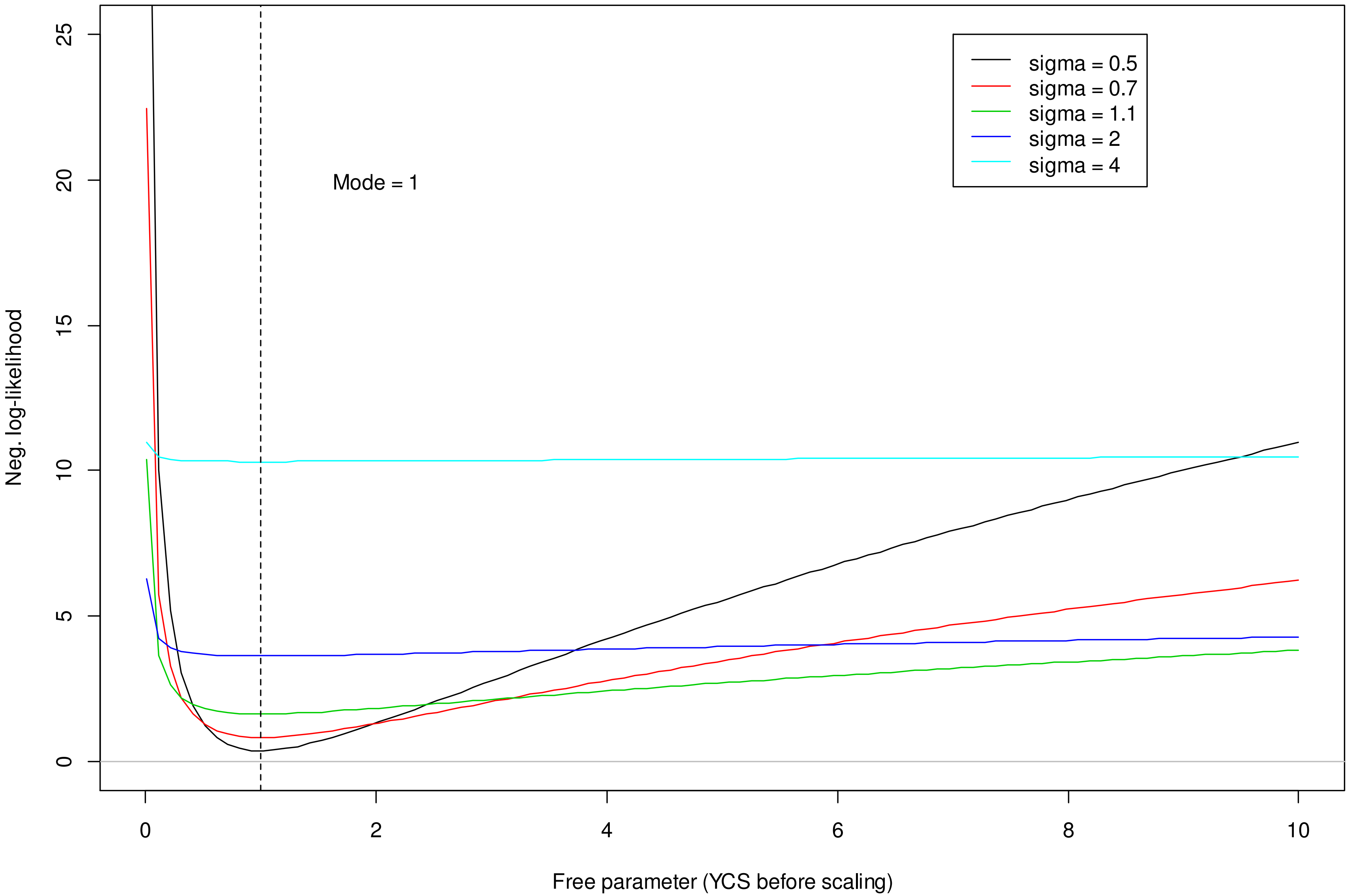
YCS parameterisation and priors

- In 2013 MEC assessment, Haist parameterisation:
  - Free parameters: y_i
  - $YCS_i = y_i / \mathrm{mean}(y_j)$
  - Uniform prior on the y_i
  - Average-to-1 penalty on y_i to keep the free parameters and YCS not too different
- Lognormal prior not used because of the relatively large influence of the priors on the estimate of B_0 (i.e., from looking at a likelihood profile):
  - Mode of lognormal for high rsd (σ=1.1) is much less than 1
  - Neg. log. likelihood gets a big negative contribution from y_i near the mode (which are then rescaled to give YCS)

A different approach for the YCS priors

- The uniform prior can lead to rather wild estimates of YCS (especially for MPDs):
  - The MPD estimate will often go off to a bound even with very little information to support very large/small YCS (i.e., fitting a bump somewhere in an LF)
  - It is desirable to have some curvature in the prior to stop the wild MPD estimates (and probably help MCMC convergence as well)
  - Might as well put the mode of the prior at 1 so that in the absence of information the MPD estimate is 1 without the need for rescaling (i.e. the y_i and the YCS_i are not very different – if the mode is well-defined)

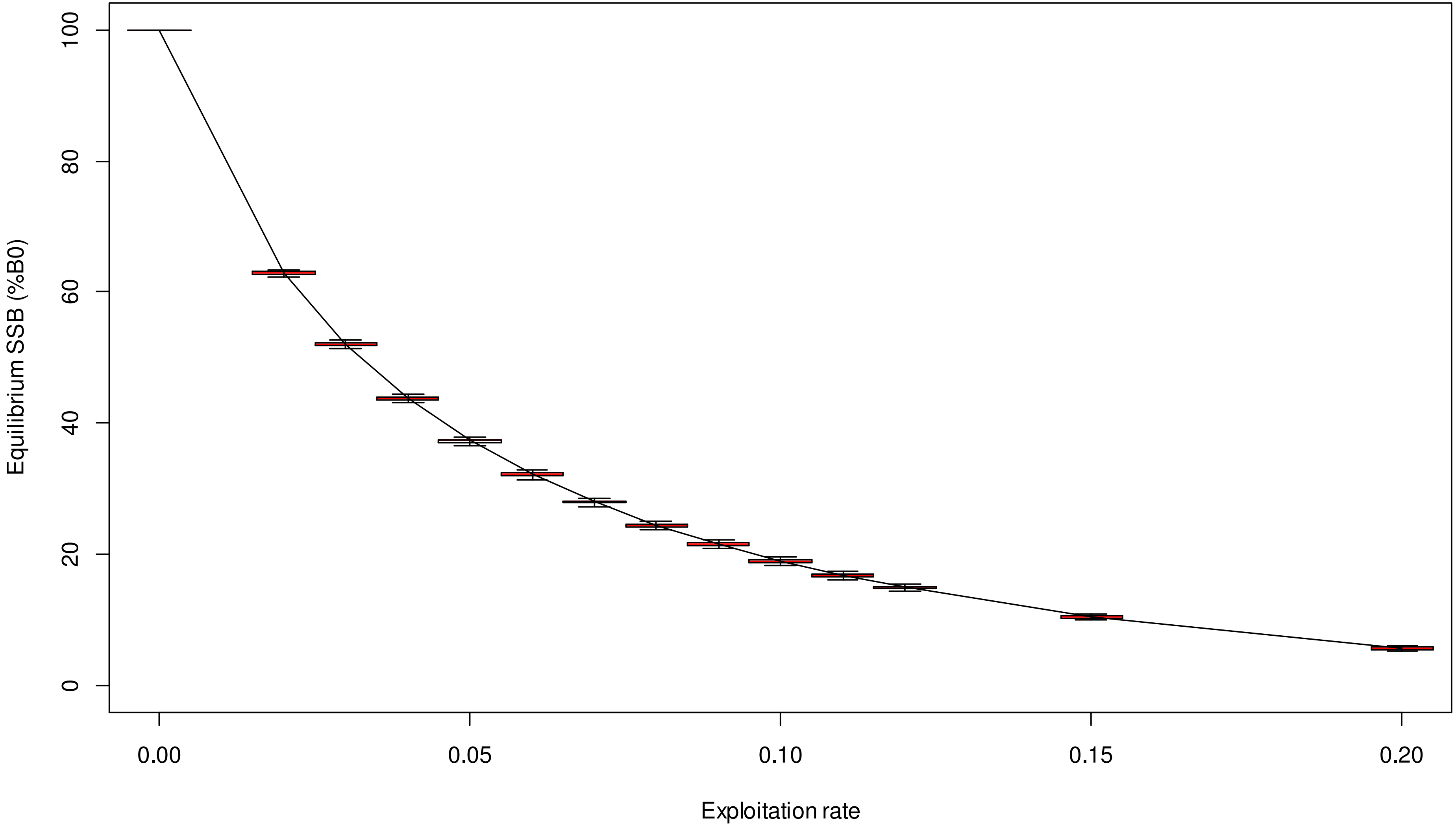
A single parameter defines the prior on each y_i



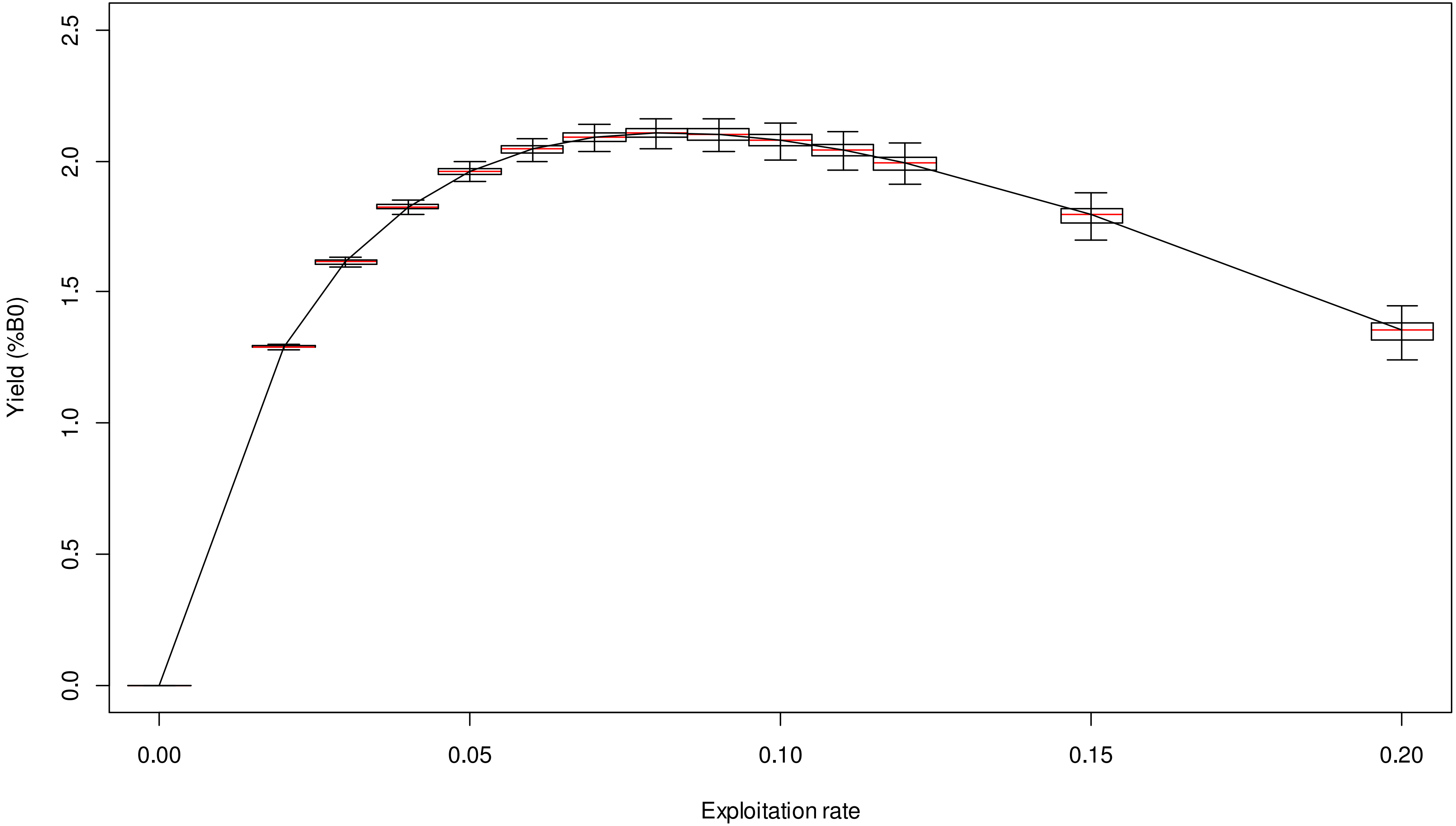
Reference points and fishing intensity

- Target biomass range 30-40% B_0
- Corresponding fishing intensities are $U_{30\%B0}$ and $U_{40\%B0}$ (fish at $U_{x\%B0}$ forever with deterministic recruitment and equilibrium SSB = x% B_0; $U_{x\%B0}$ has an ESD of x%)
- Fishing intensity can be put on a 100 – ESD scale (E.g. a fishing intensity of "70%" is equivalent to $U_{30\%B0}$)
- MCMC estimate of deterministic long-term yield (by determining $U_{35\%B0}$ and associated yield for each posterior sample)
- MCMC estimate of deterministic MSY, B_{MSY} (by determining yield and ESD curves for each posterior sample)

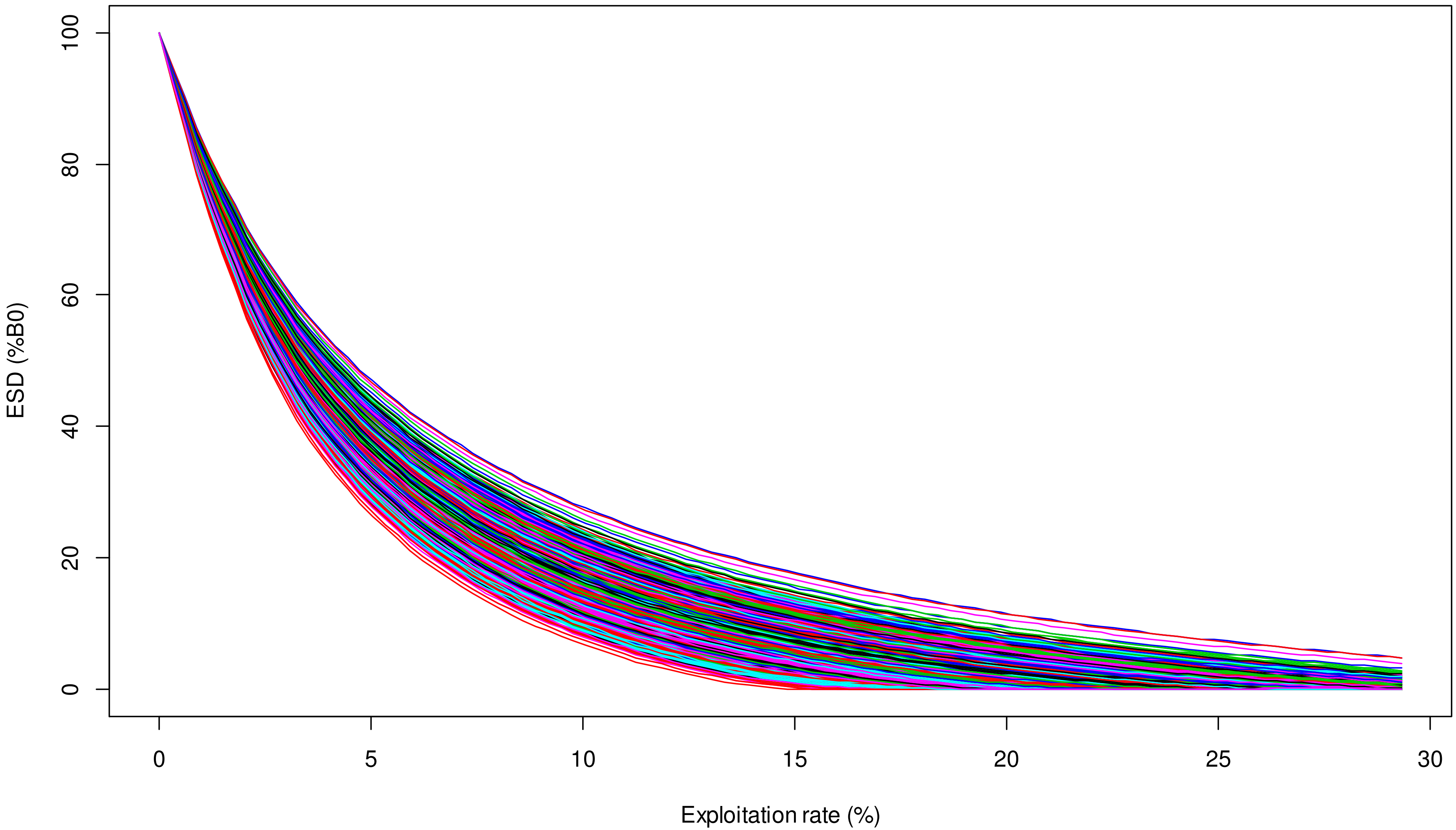
NWCR (a single fishery): MCMC estimates of ESD



NWCR: MCMC deterministic yield curve



MEC (two fisheries; proportions in most recent period): converting ESD to "exploitation rate" (adjusted CASAL total U)

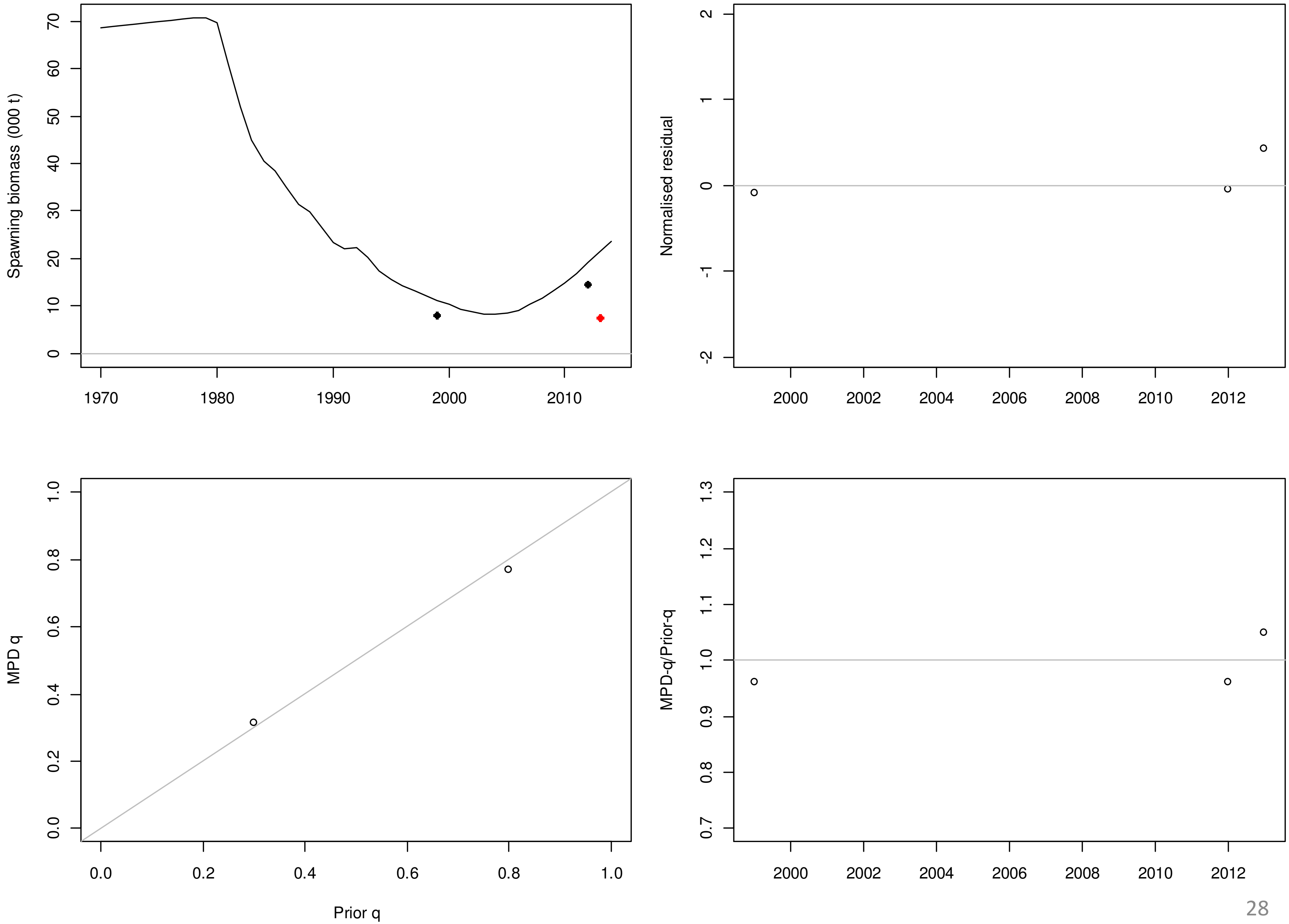


Use the "median" to do the conversion for snail trail y-axis labels

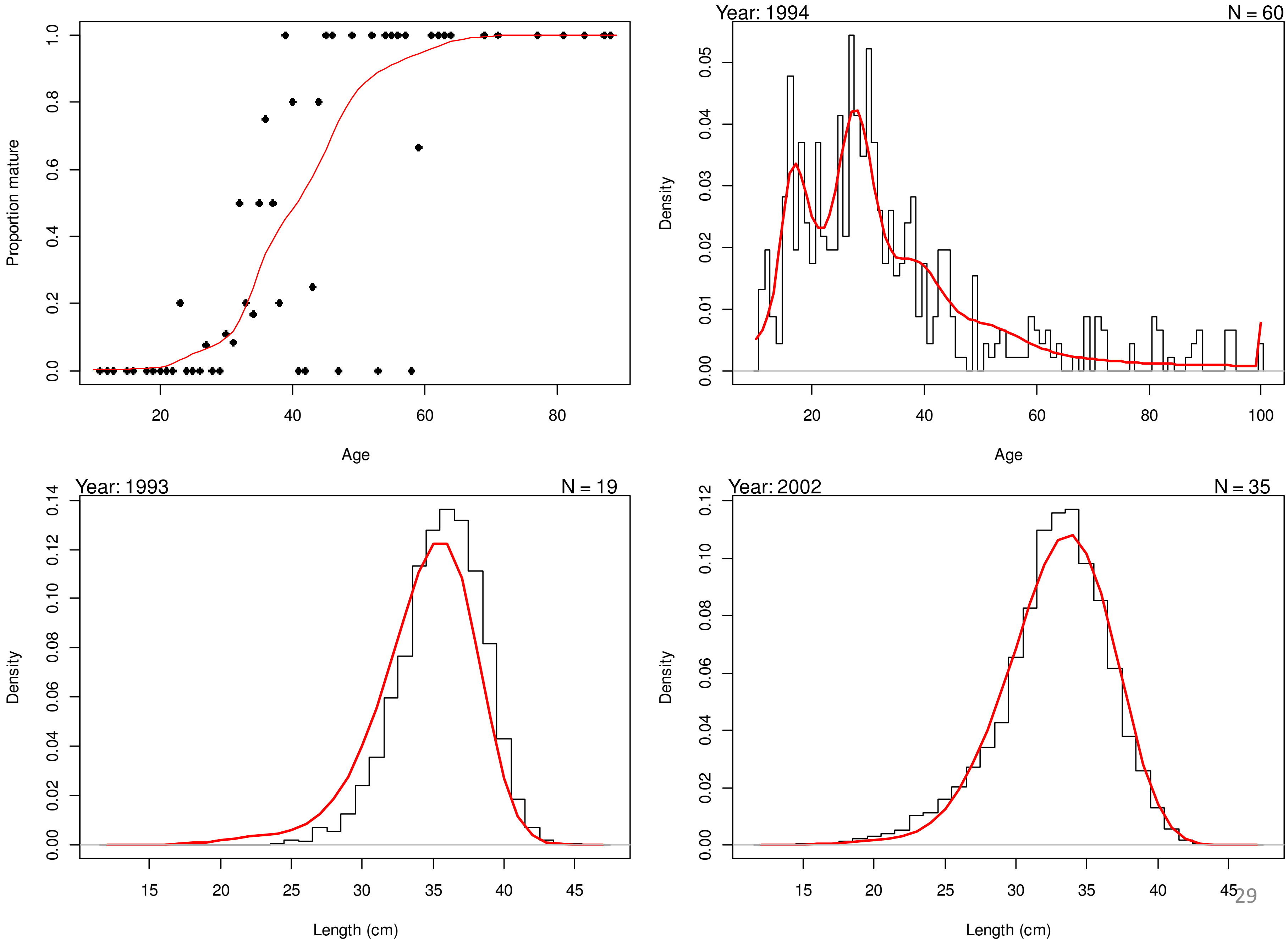
Results

- NWCR
  - MPD fits and estimates
  - MCMC results
- ESCR
  - MCMC results
- ORH7A
  - MCMC results
- MEC
  - A snail trail

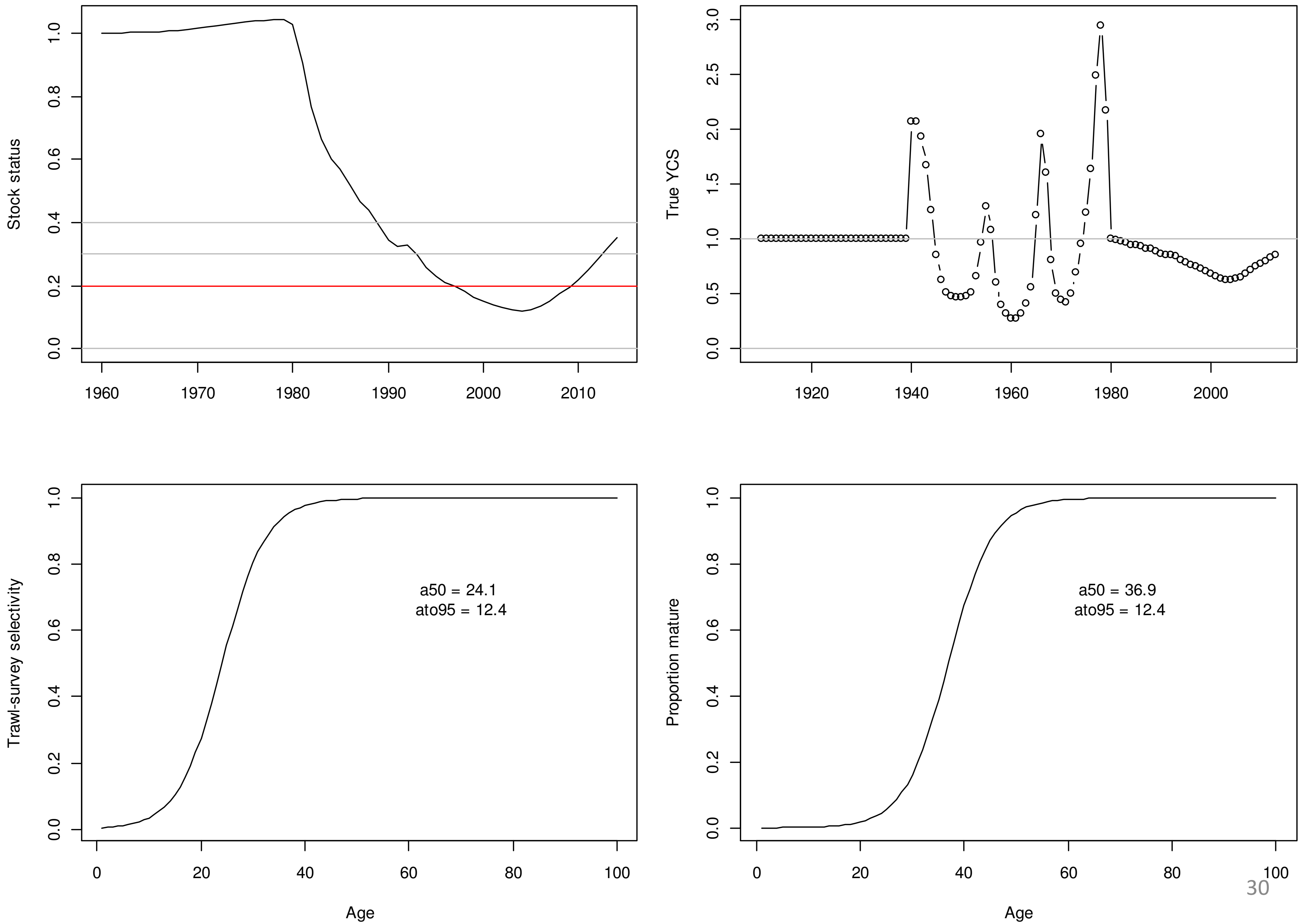
NWCR, base model: MPD fits (acoustics)



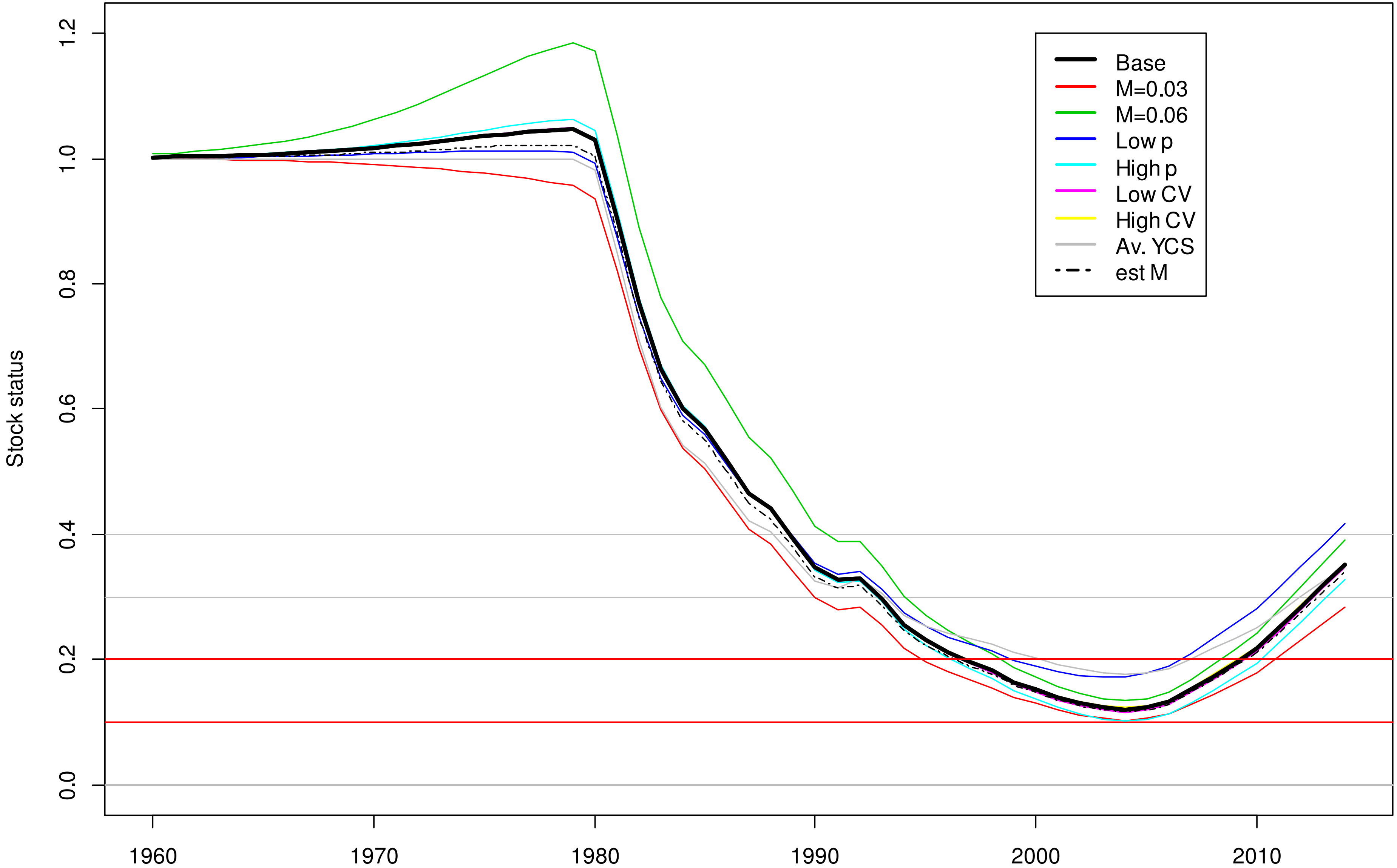
NWCR, base model: MPD fits (rest)



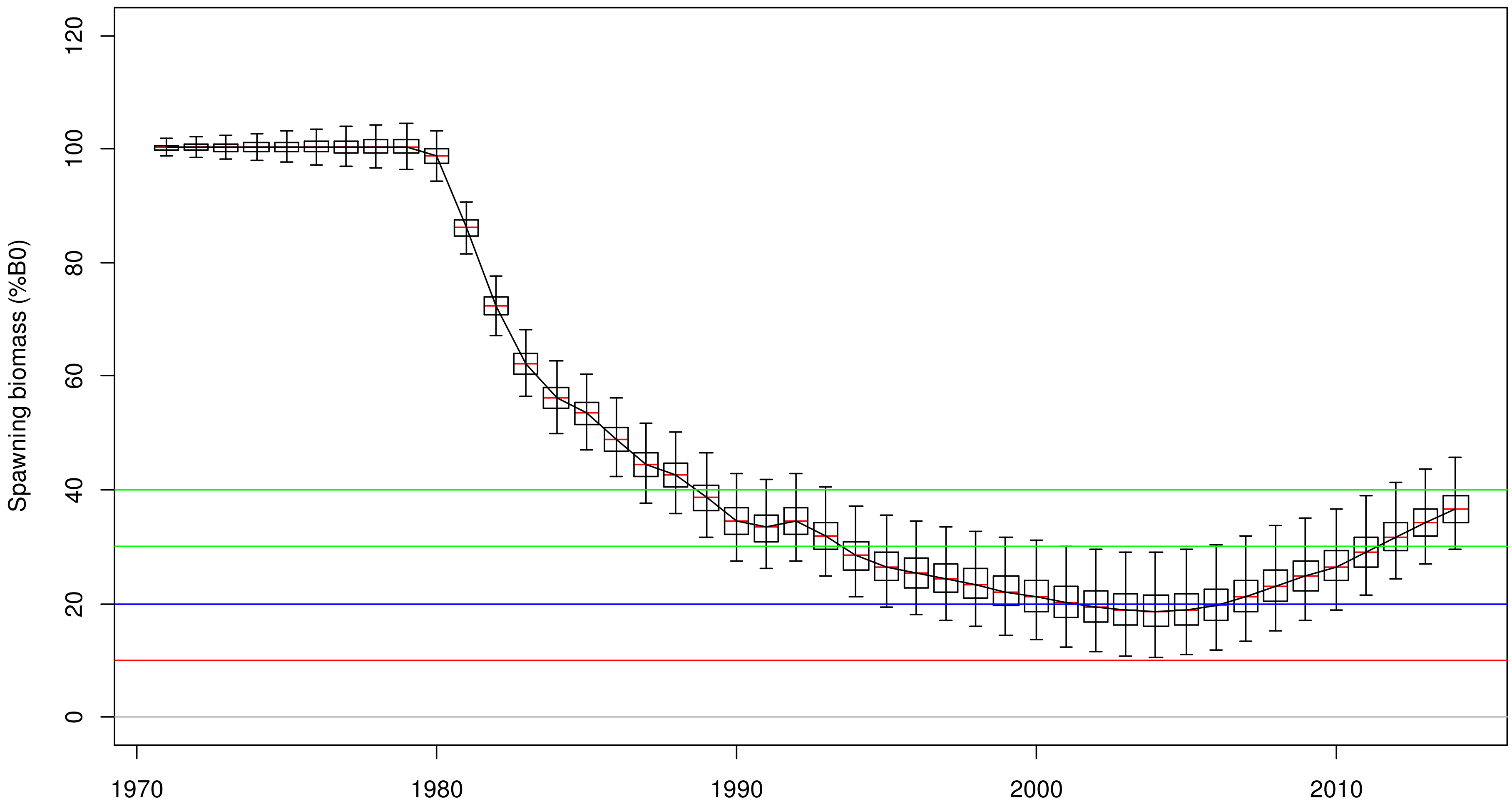
NWCR, base model: estimates



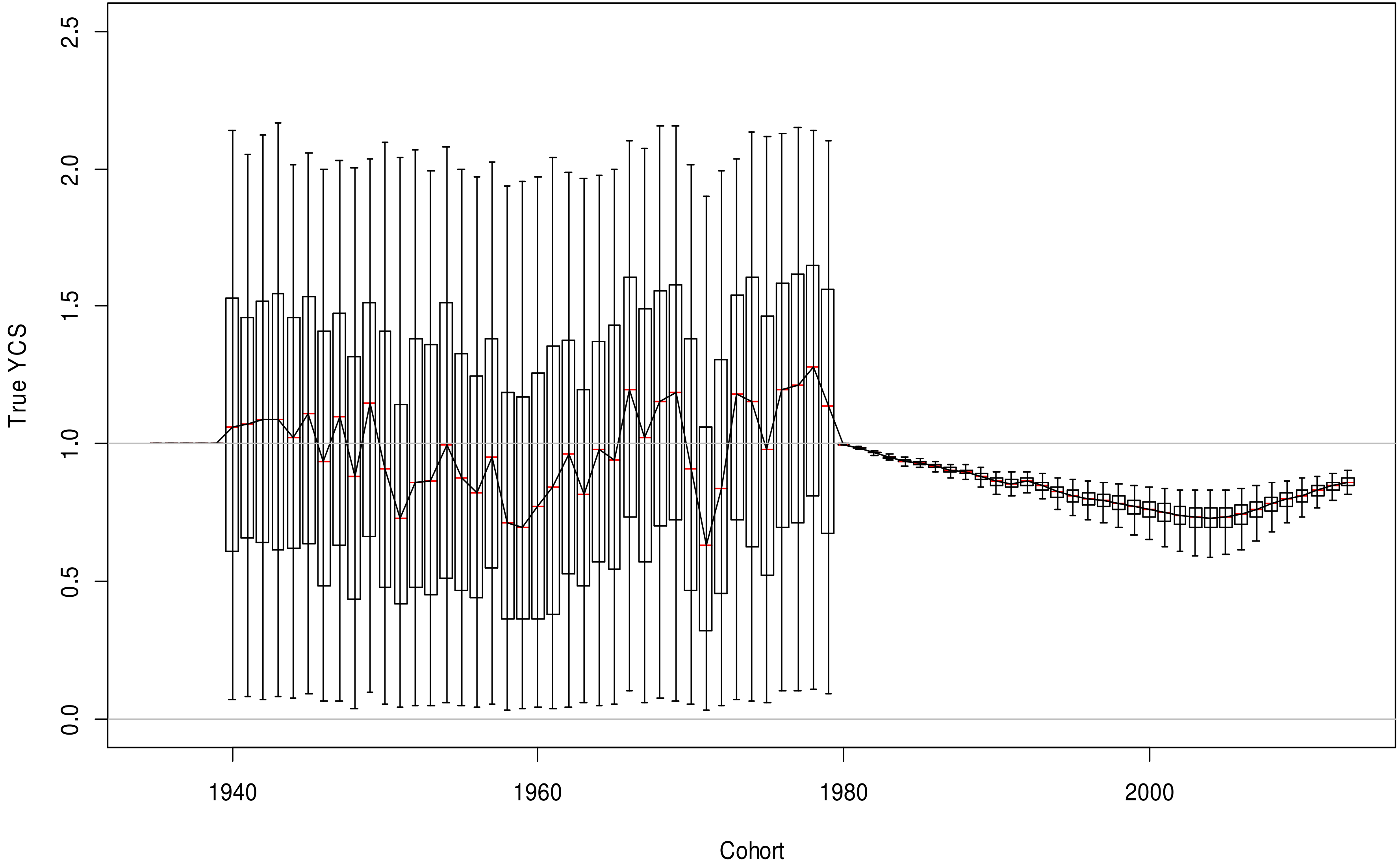
NWCR, base model: sensitivities



NWCR, base model: SSB trajectory (%B_0) (95% CI)



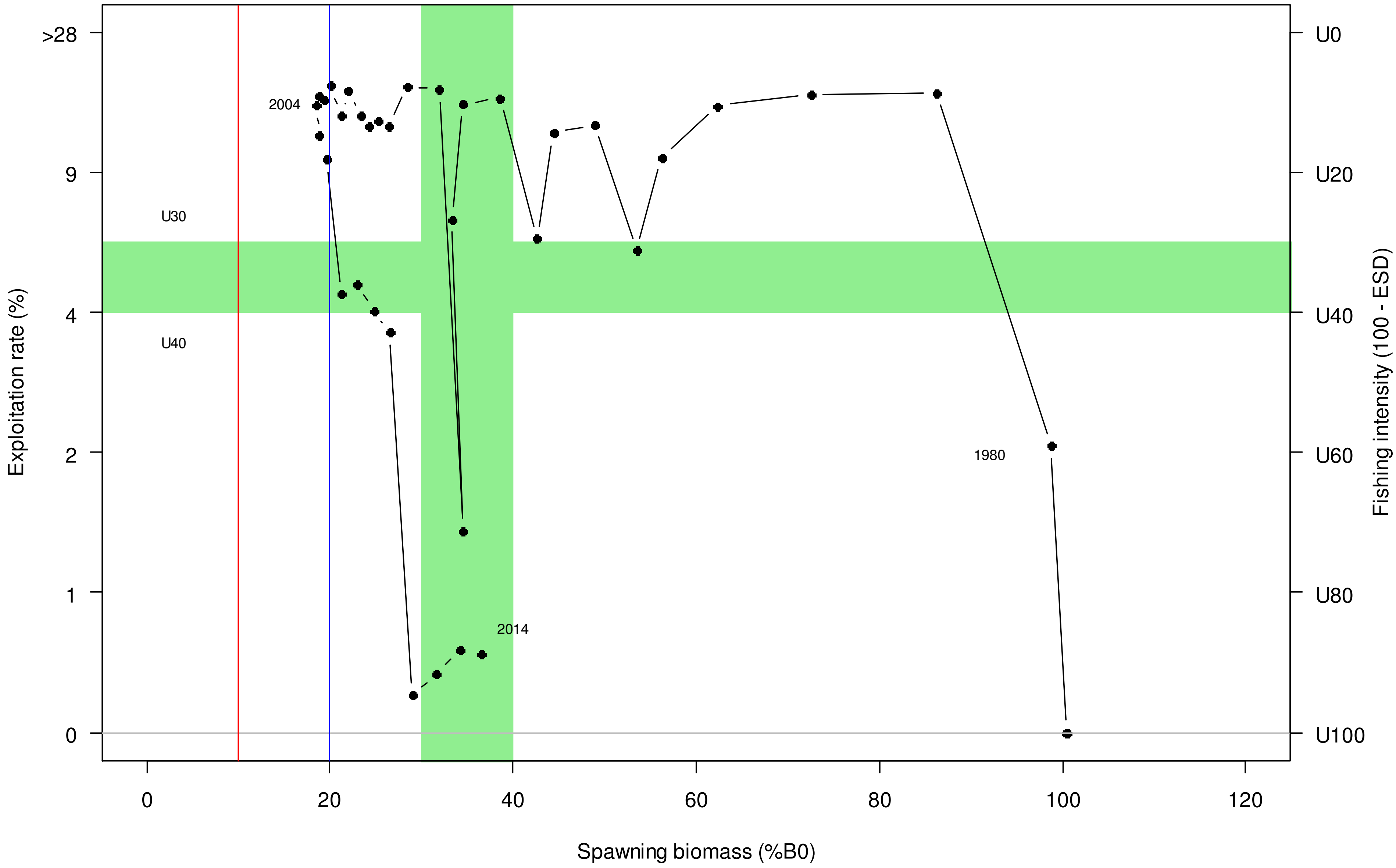
NWCR, base model: (true) YCS estimates (95% CI)



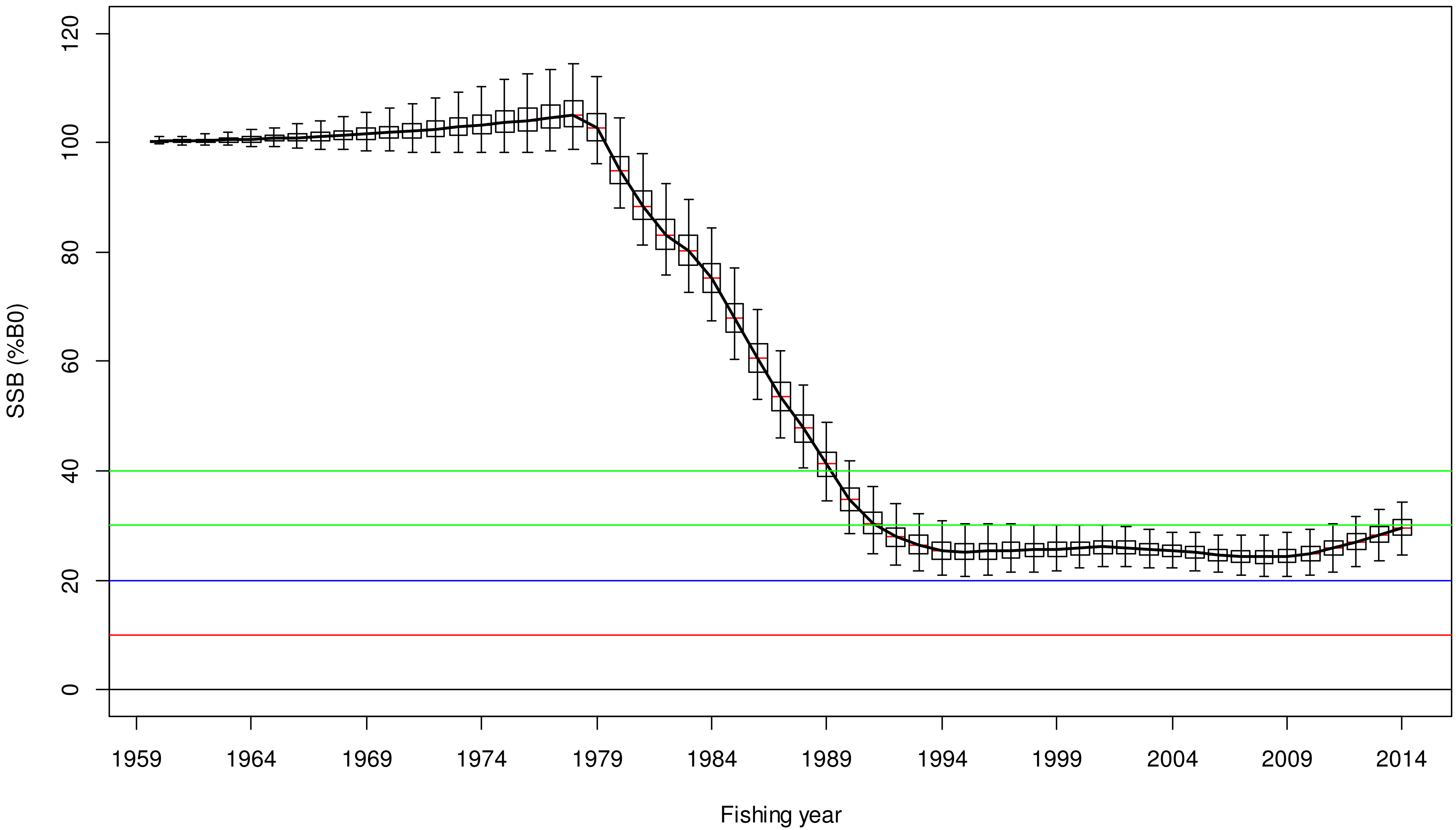
NWCR: MCMC sensitivities

	B_0 (000 t)	95% CI	B_{2014} (%B_0)	95% CI
Base	66	61-76	37	30-46
Extra	64	60-69	34	29-41
Est M (0.041)	68	61-78	34	26-45
Extra & Est M (0.040)	67	60-74	32	25-40
LowM-Highq	68	64-76	28	23-36
HighM-Lowq	66	59-78	46	38-56

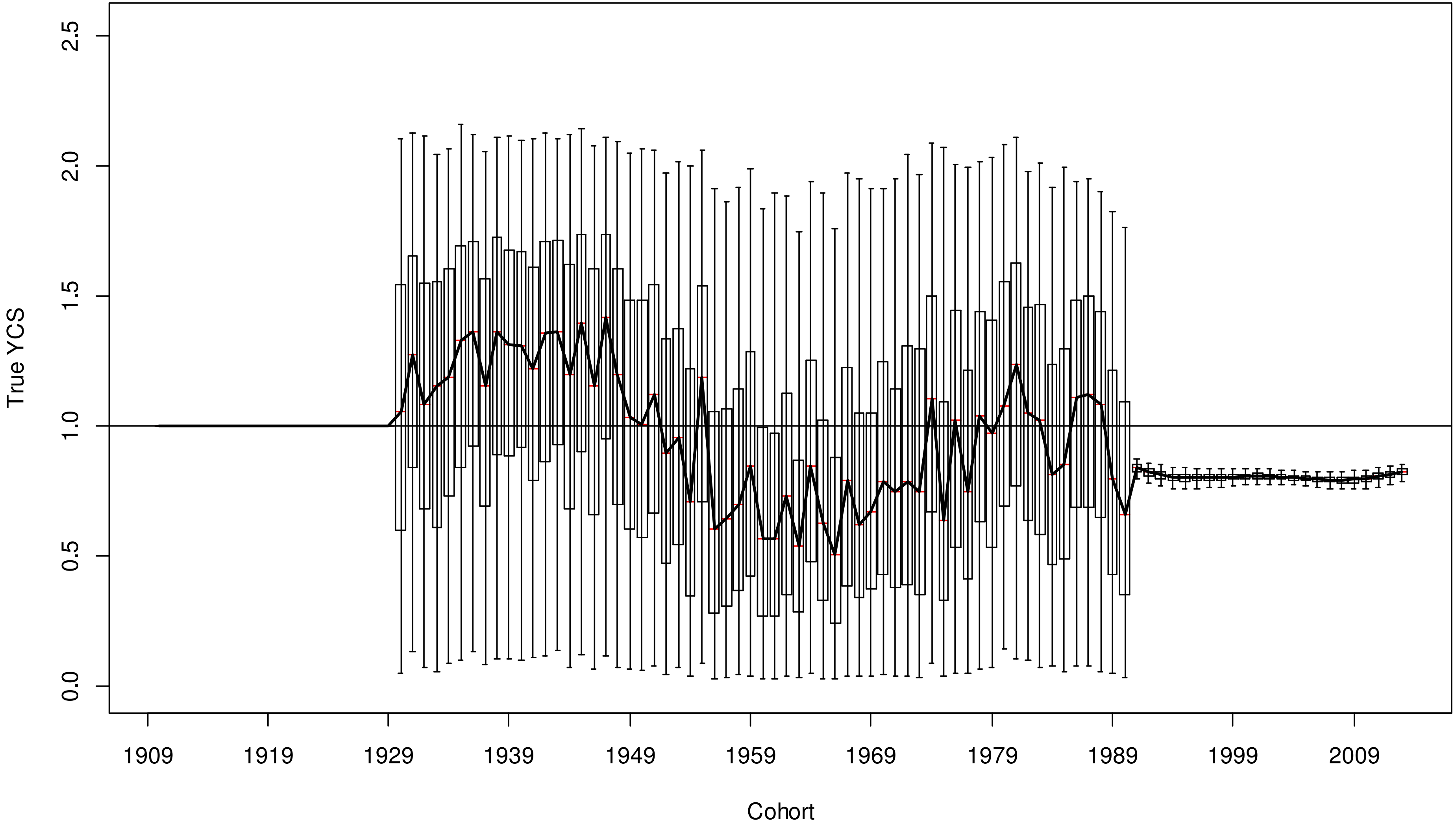
NWCR, base model, snail trail (MCMC medians)



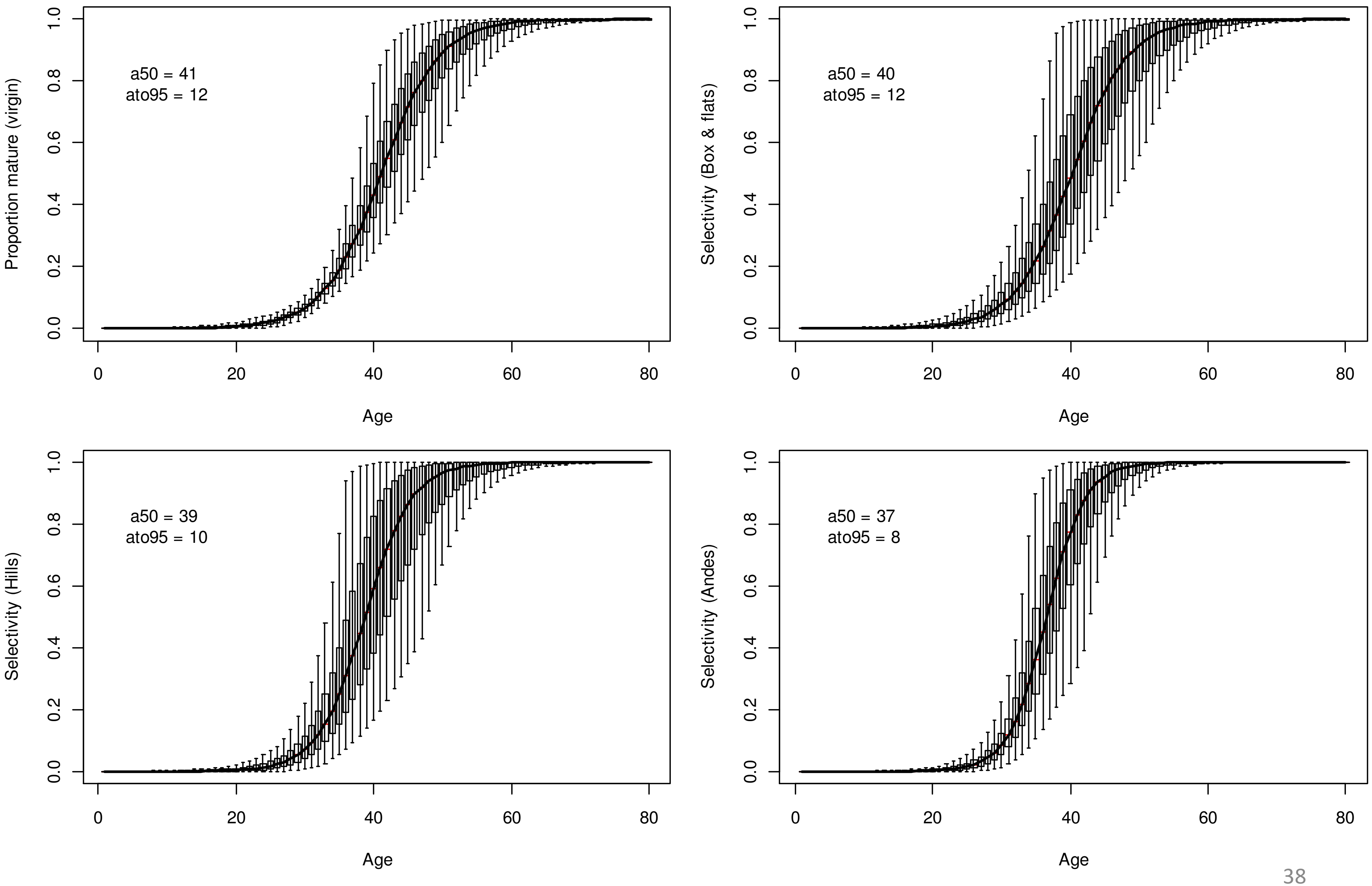
ESCR, base model: stock status trajectory (95% CI)



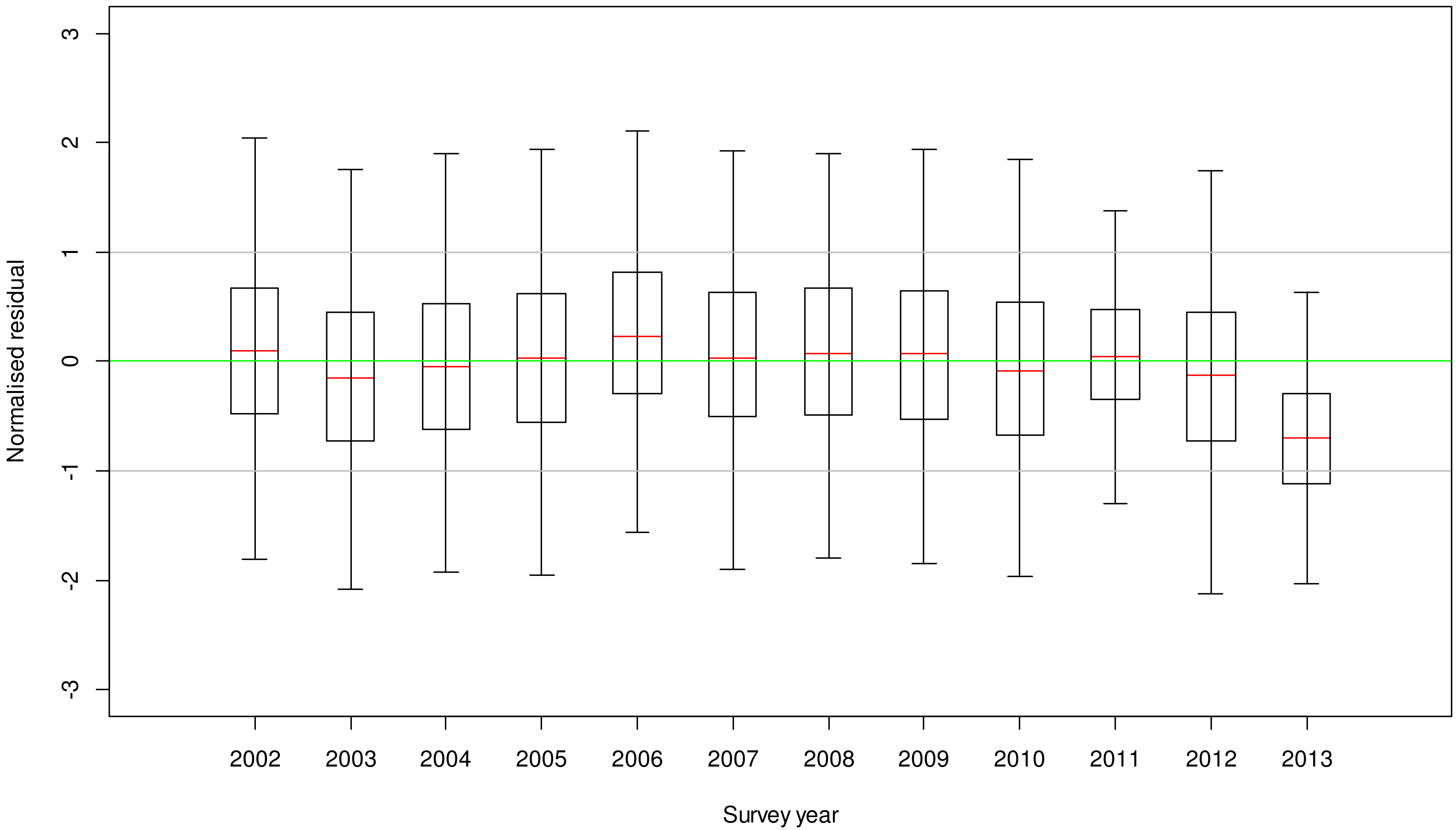
ESCR, base model: YCS (true) (95% CI)



ESCR, base model: maturity and fishing sels. (95% CI)



ESCR, base model: acoustic residuals



ESCR: three additional runs

- Alternative assumptions about the Rekohu plume:
  - Always existed: one of three spawning sites, each with a characteristic age structure (**Always**)
  - First came into existence in 2007 (**Rekohu2007**)
  - First came into existence in 2010 (**Rekohu2010**)
  - Not present in 2002; may have existed from 2003 onwards (**Base**)

Consequences for old plume acoustic time series

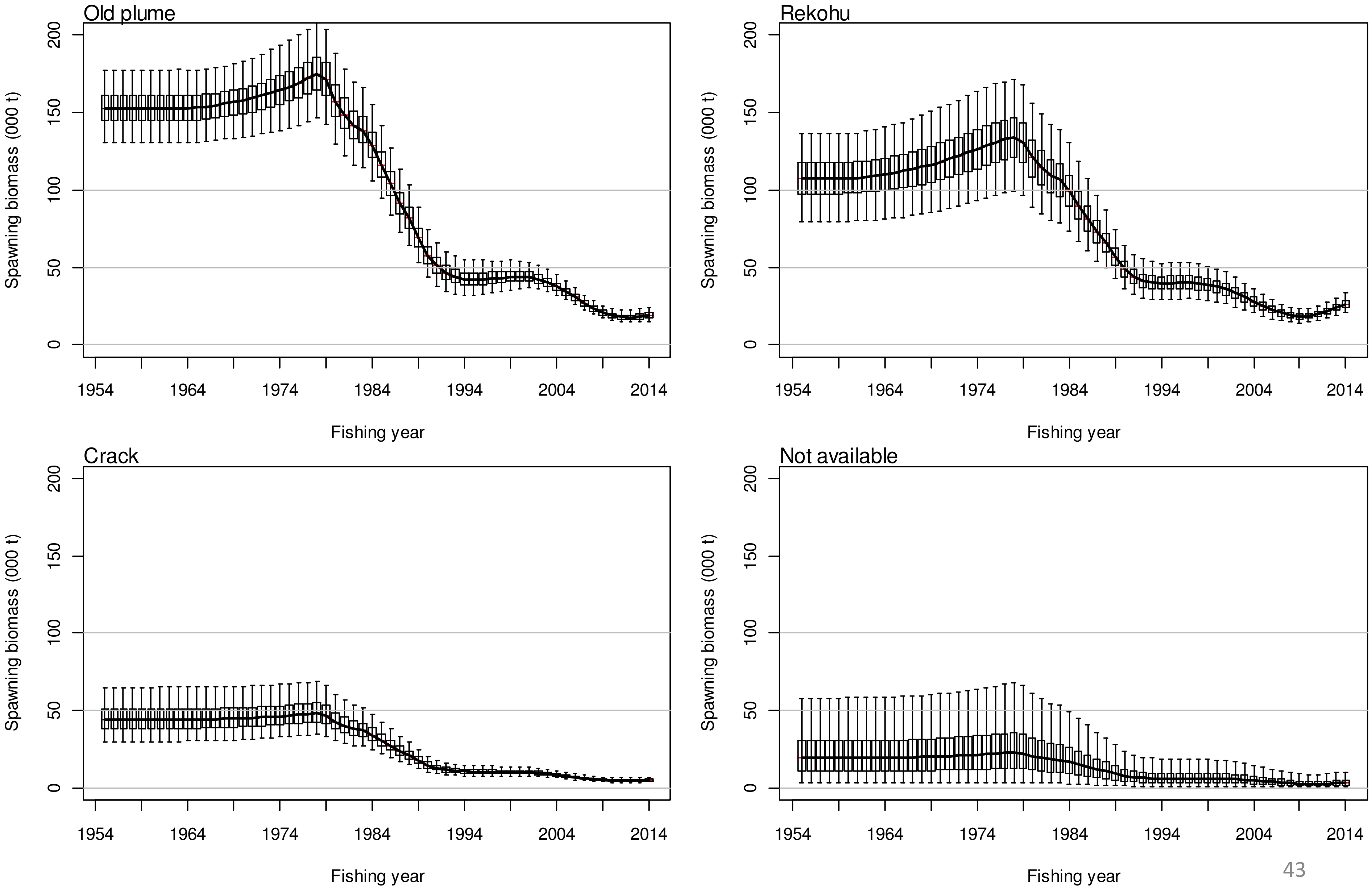
- **Always**: the old-plume time series is a relative index of age-selected spawning biomass (as are the 2 crack estimates and the 3 Rekohu estimates – each site has its own age-selectivity)
- **Rekohu2007**: the old-plume indexes SSB from 2002-2006 (constant q over this period)
- **Rekohu2010**: the old-plume indexes SSB from 2002-2009 (constant q over this period)
- **Base**: *apriori*, the old-plume time series contains little reliable trend information

MCMC runs (medians and 95% CIs)

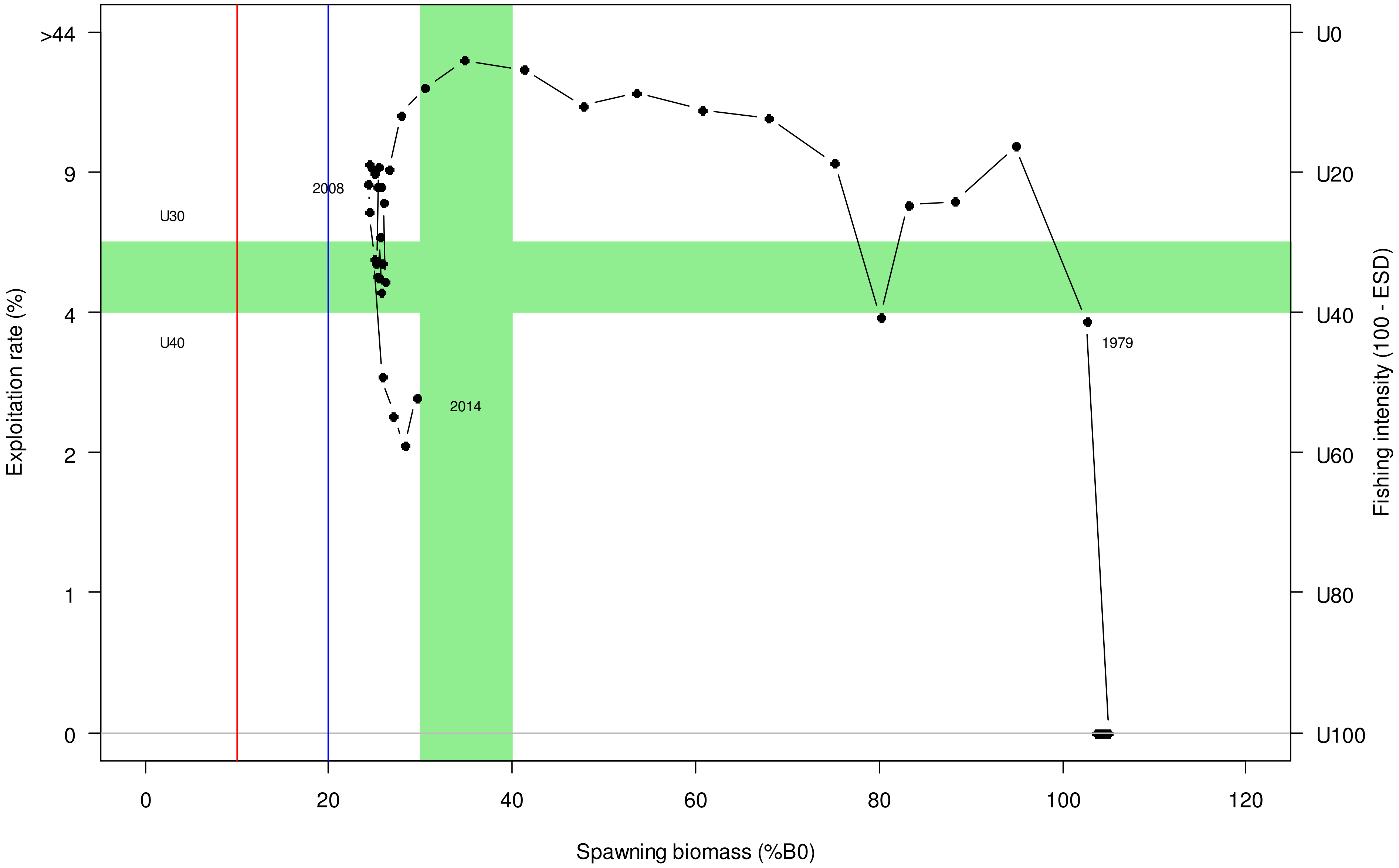
Run	Maturity (a_{50}, a_{to95})		B_0 (000 t)		B_{2014} (000 t)		B_{2014} (%B_0)	
Base	41	12	317	281-352	93	77-112	30	25-34
LowM-Highq	40	12	343	318-369	77	63-93	22	19-26
HighM-Lowq	41	12	309	279-345	116	97-139	38	32-43
Rekohu2007	41	12	311	281-343	80	67-96	26	22-30
Rekohu2010	38	7	319	288-349	61	49-76	19	16-23
Always	36	6	331	304-361	55	44-70	17	14-20

- Is it credible to assume the Rekohu plume always existed?
- Could the plume have started in 2010 and then been observed to have about 30,000 t of biomass in 2011? (short answer: No)

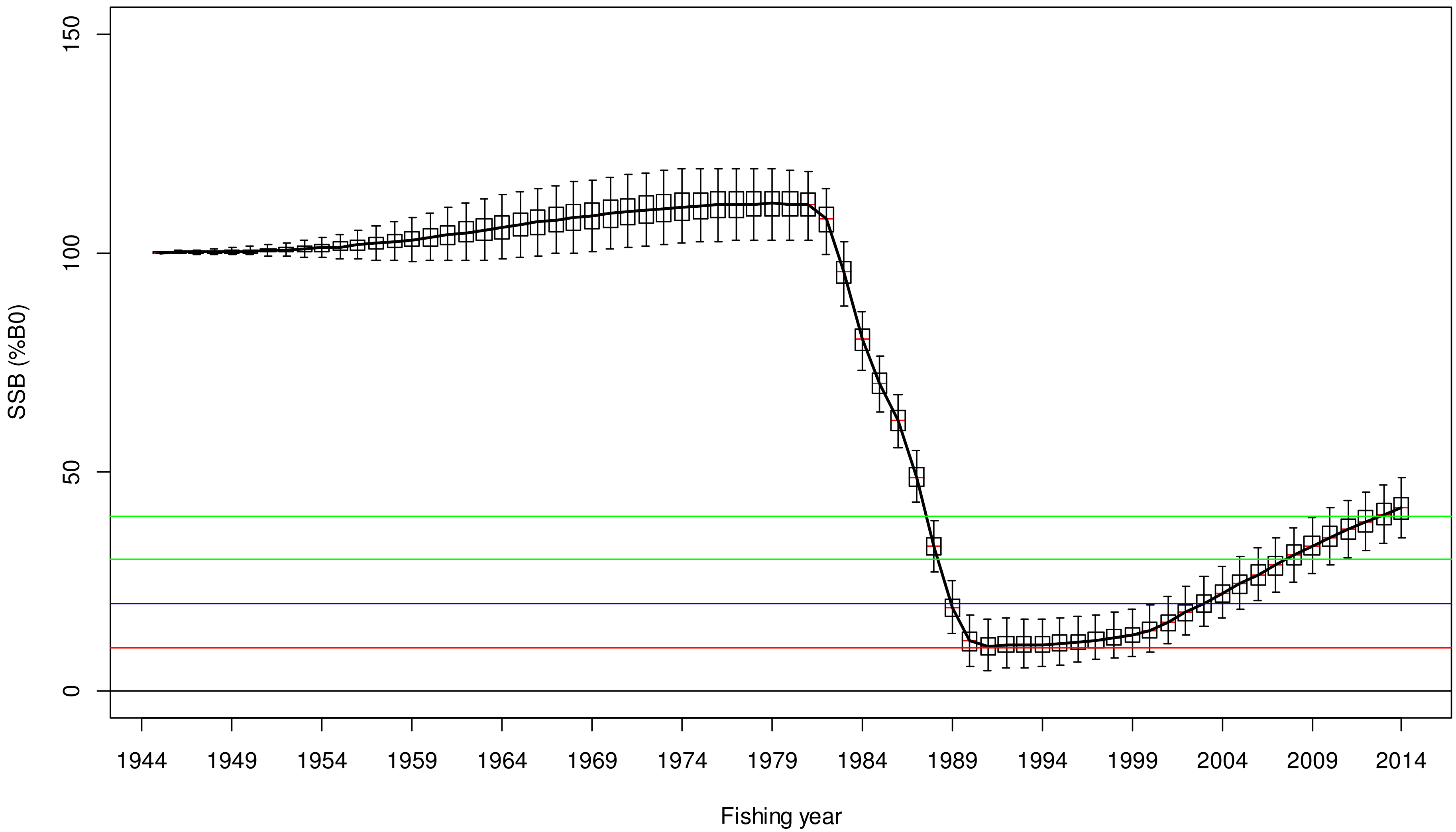
ESCR: Always: SSB by area (95% CI)



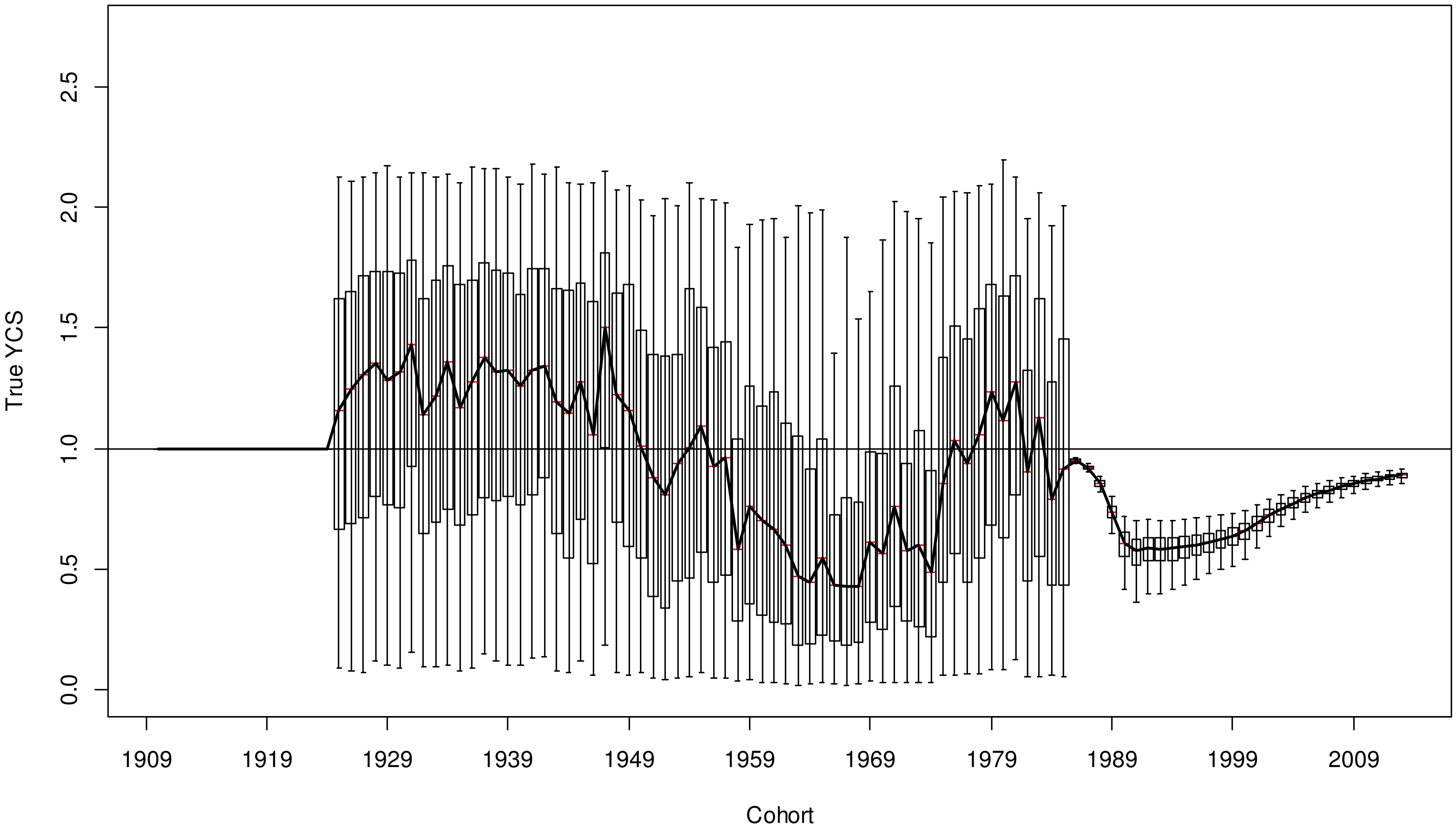
ESCR: MCMC snail trail (medians)



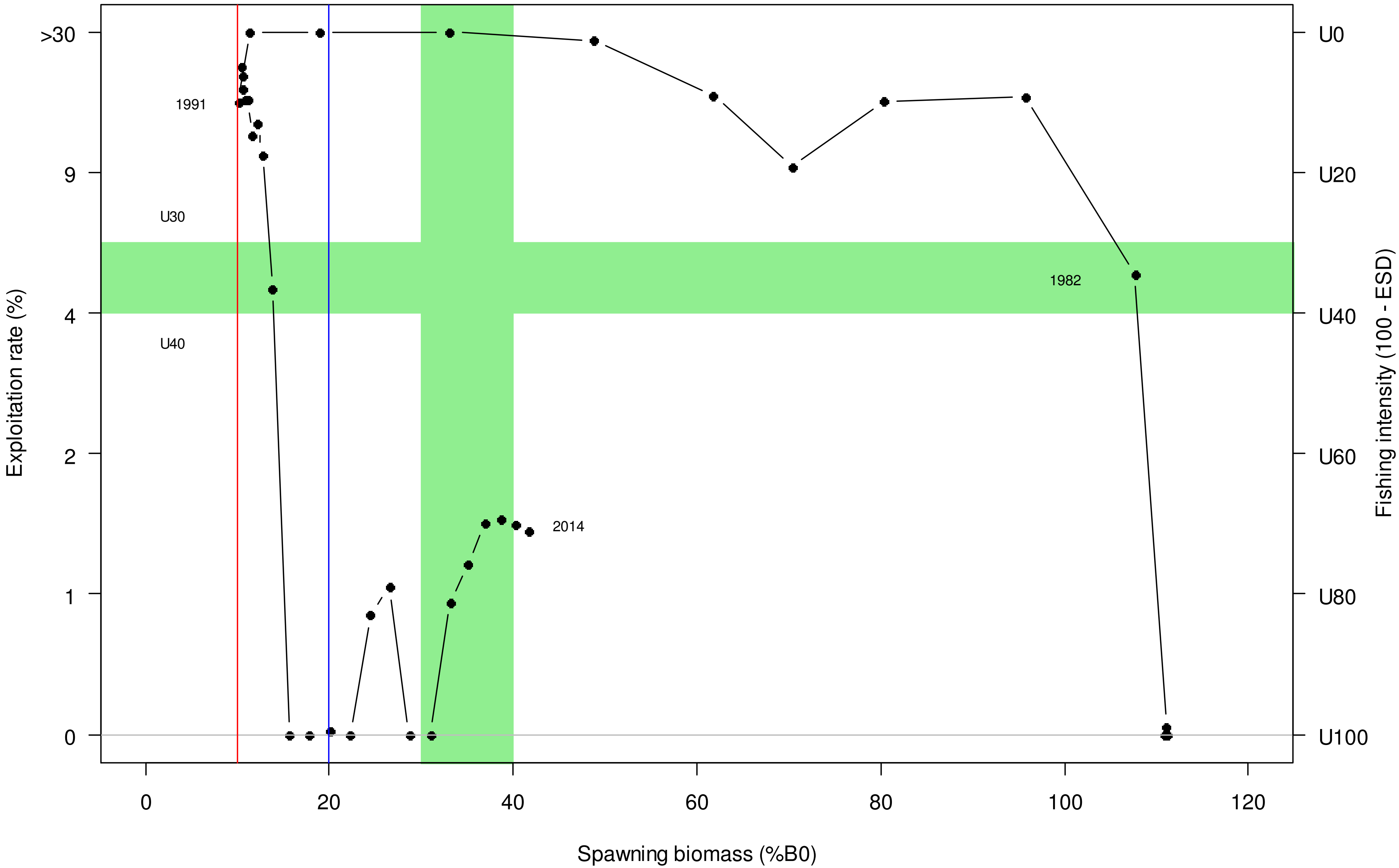
ORH7A, base: MCMC stock status trajectory (95% CI)



ORH7A, base model: YCS (true) (95% CI)



ORH7A, base: MCMC snail trail (medians)



MEC, base model: snail trail (MCMC medians)