559

G: Use of random effects in a stock assessment

Fish 559; Day 4: 14h30-15h30

559

Introduction-I

The qR method involves fitting an age-structured population dynamics model to time-series of catch-in-number and catch-in-weight data. The model is "effort conditioned". The initial conditions ("1983" for rock lobster in South Australia) are:

$$N_{1983,a} = \begin{cases} R_{1983} & \text{if } a = 1 \\ N_{1983,a-1}\, e^{-(M+F_0)} & \text{if } 1 < a < 20 \\ N_{1983,19}\, e^{-(M+F_0)} / (1 - e^{-(M+F_0)}) & \text{if } a = 20+ \end{cases}$$

559

Introduction-I

The annual dynamics are governed by

$$N_{y+1,a} = \begin{cases} R_y & \text{if } a = 1 \\ N_{y,a-1}\, e^{-(M+F_y)} & \text{if } 1 < a < 20 \\ N_{y,19}\, e^{-(M+F_y)} + N_{y,20+}\, e^{-(M+F_y)} & \text{if } a = 20+ \end{cases}$$

Fishing mortality is related to effort according to:

$$F_y = qE_y$$

559

Parameter estimation

The parameters of the population dynamics model are: *M* (assumed known), $\{R_y: y=1983, 1984, \ldots\}$, F_0, and q. The negative log-likelihood function is given by:

$$n.\ell n\sigma_N + \frac{1}{2\sigma_N^2}\sum_y (C_y^N - \hat{C}_y^N)^2 + n.\ell n\sigma_W + \frac{1}{2\sigma_w^2}\sum_y (C_y^W - \hat{C}_y^W)^2$$

where:

$$\hat{C}_y^N = \frac{F_y}{Z_y}(1-e^{-Z_y})\sum_a N_{y,a}$$

$$\hat{C}_y^W = \frac{F_y}{Z_y}(1-e^{-Z_y})\sum_a w_a N_{y,a}$$

and

$$F_y = qE_y$$

$$Z_y = M + F_y$$

559

Scenarios-I

The basic scenario treats all of the parameters as fixed effects, but we will consider some alternate models:

- The annual recruitments (1984 onwards) are treated as random effects, i.e.:

$$R_y = \bar{R}e^{\varepsilon_y} \qquad \varepsilon_y \sim N(0;\sigma_R^2)$$

- Catchability is modelled as a AR(1) process, i.e.

$$q_y = \bar{q}e^{\tilde{q}_y} \qquad \ell n\tilde{q}_y = \begin{cases} 0 \\ \rho \ell n\tilde{q}_{y-1} + \sqrt{1-\rho^2}\,\eta_y \end{cases} \qquad \eta_y \sim N(0;\sigma_\eta^2)$$

Scenarios-II

- There is an index of recruitment, i.e.:

$$n.\ell\mathrm{n}\,\sigma_I + \frac{1}{2\sigma_I^2}\sum_y (\ell\,\mathrm{n}\,I_y - \ell\mathrm{n}R_y)^2$$

where the extent of observation variation is an estimated parameter.

559

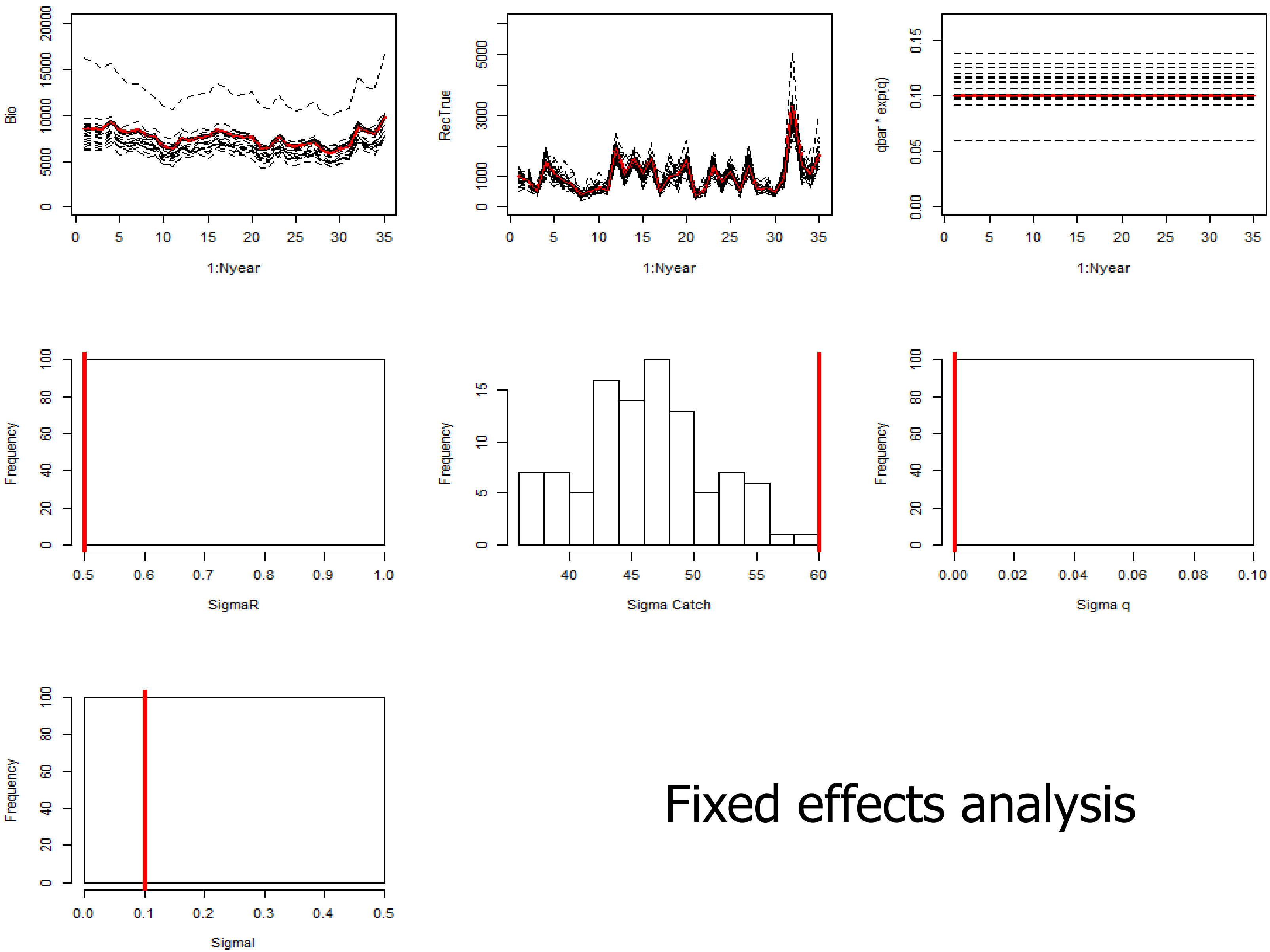
Evaluation-I

The data available are 35 years of effort and catch-in-number and in-mass.

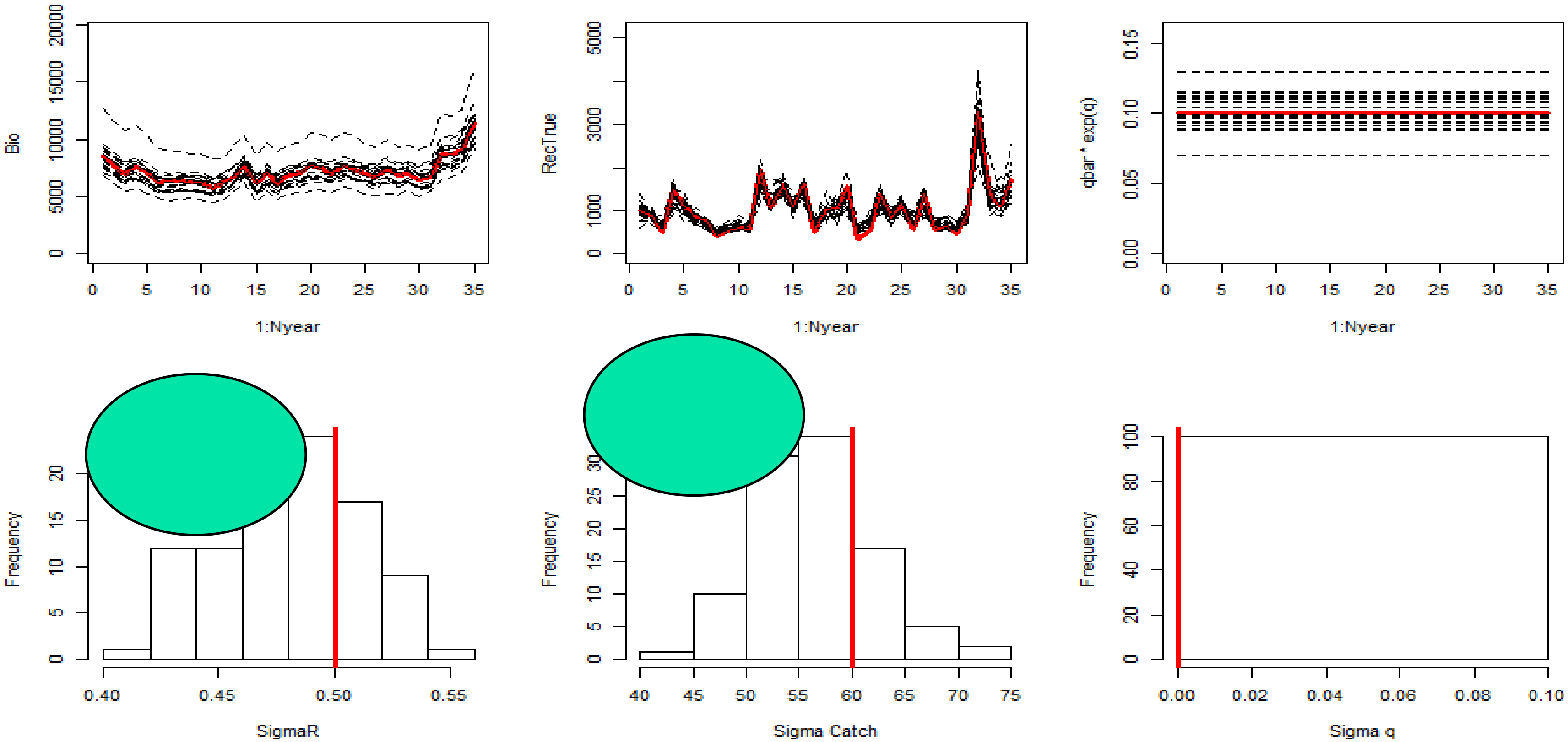
The performance metrics are the rmses for biomass, recruitment and q.

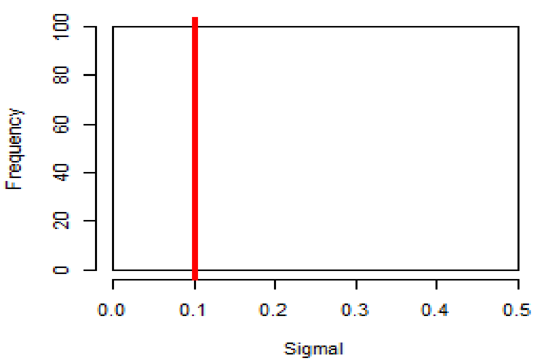
Two scenarios are considered:

- q is constant and equal to 0.1
- q changes as a AR(1) process and with ρ=0.9 and a standard deviation of 0.2.

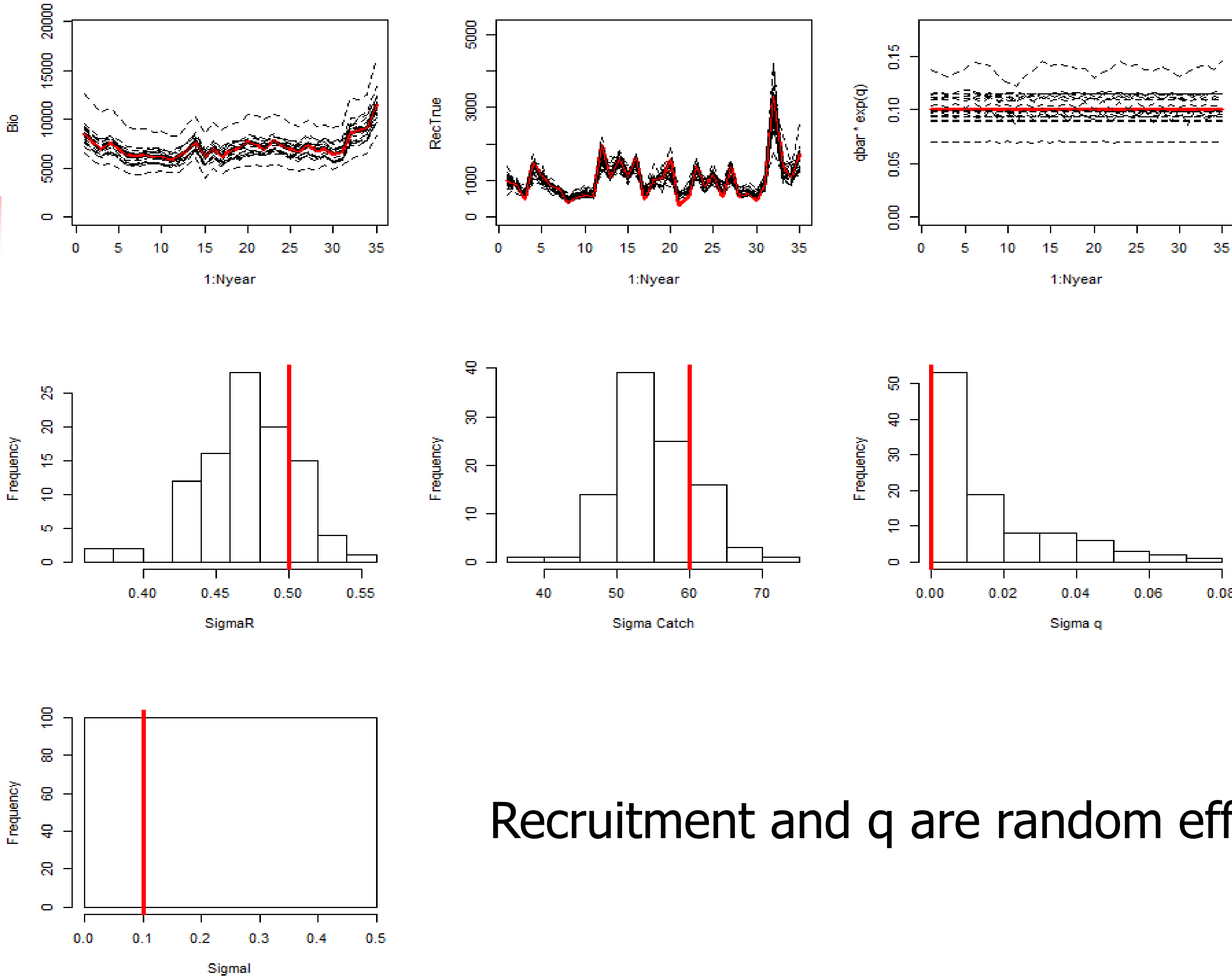


Fixed effects analysis

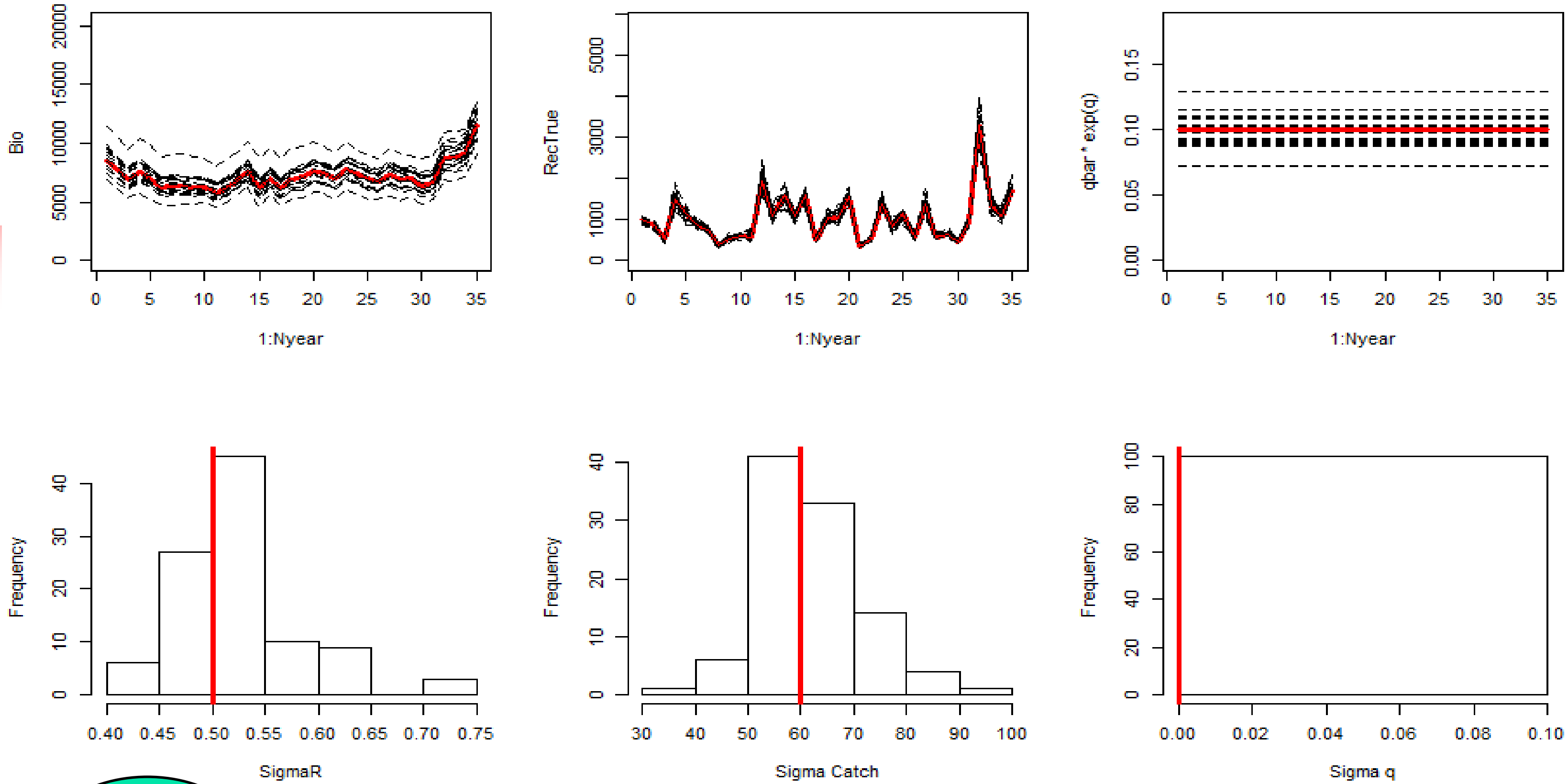


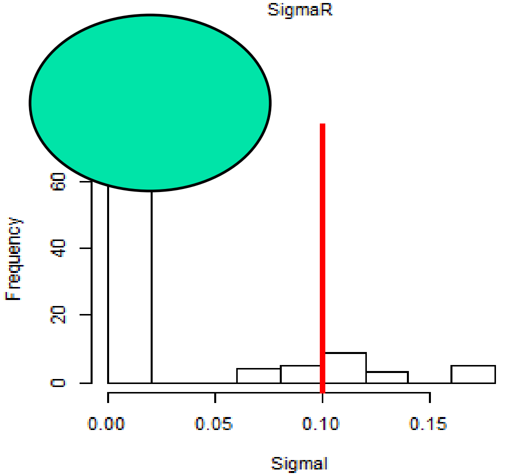


Recruitment is a random effect



Recruitment and q are random effects





Recruitment is a random effect, and there is a good recruitment index

559

Summary-I

Constant q

	Biomass	Recruitment	q
Fixed effects	20.07	24.84	19.37
Random recruitment	12.74	25.49	12.87
Random recruitment and q	12.94	25.81	13.31
Random recruitment and an index	16.51	11.64	14.88

Summary-II

Time-varying q

	Biomass	Recruitment	q
Fixed effects	17.73	43.48	15.11
Random recruitment	15.53	31.71	15.02
Random recruitment and q	Crashed!		
Random recruitment and an index	Outlier!		

559

Conclusions

- Allowing for random effects improves estimates of recruitment and also of σ_R, and the extent of observation error.
- There is not enough information to estimate trends in q from catches-in-number and in –in-weight alone.
- In principle, a random effects model can estimate to weight to assign to an index of recruitment but some simulations led to degenerate solutions.