# Snow Crab Assessment Model Scenarios and Convergence Testing

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**CPT and SSC recommendations and author response**

***CPT Recommendations September 2015***

*"The CPT again cautioned that any sequential model revisions should incorporate only a single change so the effect of that change may be evaluated without confounding by other changes.* ***The CPT again requests that any model steps be evaluated in individual model scenarios."***

This report contains Model scenarios from Model 0 to Model 5 (of September 2015) in steps as requested by the CPT (see Table 1).

*1. Model 0 changed dramatically in this iteration – explore the convergence to a global minimum by starting at different parameter values.*

See results for jittering Models 0, 0a, 1, 1a and 1b. The lowest likelihood runs from jittering Model 0 were the same as the lowest likelihood runs from jittering Model 1.

*2. The CPT requests that any steps between Models 0 and 1 be evaluated in individual model scenarios.*

Since jittering starting parameter values resolved the differences in likelihoods between Model 0 and Model 1, no intermediate models were run.

*3. Provide both the potlift data and the protocol used to extrapolate post-1991 discard data to pre-1992 historical female discards.*

Models 2, 3, 4, 4a, 4b and 4c remove fishing mortality penalties for males and females. Models 4, 4a, 4b and 4c explore different methods of estimating female Fs using potlift data.

*4. Explore potential conflicts of trawl likelihood weighting (Model 2) with other data sources.*

Increasing the weight on the likelihood for the groundfish catch was an attempt to fit the catch data better. The issue with fitting the groundfish bycatch was that the average F to estimate bycatch was fixed in the model because in previous scenarios it could not be estimated. The fishing mortalities are estimated as a dev vector (dev vector as define in ADMB sums to 0) and an average F. Model 0b uses Model 0 and estimates the average F for groundfish catch. Model 9 is Model 4a with the addition of the estimation of the average F for groundfish bycatch. Both these models were able to estimate the average F and the fit to the groundfish bycatch was resolved without adding any additional weight to the likelihood. A normal likelihood was retained. A lognormal likelihood was implemented in a scenario not presented here which also fit well with the average F estimated.

*5. Explore the dramatic differences in sequential survey estimates and why the models do not split the difference between the last two survey years.*

The fit in the last few years of the model was explored at the January CPT meeting. The main data set influencing higher biomass at the end of the time series is the higher discard catch relative to retained catch. The higher discard influences recruitment estimates that result in higher ending biomass. Down-weighting the survey length data results in higher biomass at the end of the time series. If fishery selectivity is allowed to change or if the last two years of discard are replaced by the average discard relative to retained then lower ending biomass results. Down-weighting all of the length data (Model 18c in this report) also results in biomass increasing more at the end of the time series.

*6. Models 4 and 5 use an F penalty vector that is not broken out over time; evaluate a vector broken over time.*

Model 2 takes Model 1 and removes the F penalties for males only and has one dev vector for all years. Model 3 takes Model 1 and removes the F penalties for males only and splits the dev vector at 1991/92. Model 3 has 1 more parameter than Model 2 (the average F for the second period).

*7. Explore a scenario in which the weight of the trawl discard likelihood is increased.*

See number 4 above.

***SSC Comments October 2015***

*1. The SSC requests adding a table of commercial fishery CPUE to the annual stock assessment; considerations of fishery CPUE could be investigated to help reconcile data conflicts.*

Plots of fishery CPUE vs Model estimated CPUE are included in the plot files for reference. The q for estimating CPUE in the model is fixed and the fit is not included in the likelihood. A table of fishery CPUE can be added to the assessment document as well as the plot.

*2. As a matter of standard practice, the SSC requests that a suite of alternative starting parameter values be employed to help assure that models converge to a global, not a local, minimum.*

Jittering has been done for every model scenario included in this report.

*3. The SSC requests a sensitivity analysis to determine the effect of down-weighting size composition data.*

Model 18c uses Francis effective sample sizes to reduce input Ns for the survey, retained and total length composition data. The sample size for length composition data for groundfish and female discards was also reduced but not by calculating the Francis Ns. Model 18c uses Model 13 with iteration until sample sizes converged to two decimal places. Jittering was then done on Model 18c with the converged sample sizes.

*4. The SSC requests that a model be brought forward in which q is free and not bound by an upper limit of one.*

Models 17, 17a and 17b explore allowing survey qs to be estimated greater than 1.0.

*5. The SSC recommends that new studies on female growth should be a high research priority to better define the relationship between growth increment and pre-molt carapace width (e.g., Fig. 54d). The lack of data near the transition point in the growth curve and the clumped nature of the available data limit clear specification of the transition point with unknown consequences on the stock assessment.*

Models 0a and 1a, 1b and 1c explore fixing the transition point for growth and the effect on model stability.

*6. The SSC requests the reporting of additional model diagnostics, such as plots of retrospective patterns, plots of residuals from alternative model fits to survey biomass, and the like, as typically reported in other assessments.*

No retrospective analyses have been included in this report due to lack of time. These could be added in the future. This report includes plots comparing model scenarios and the set of plots for each model includes residual plots for male and female biomass fits.

**Model Scenarios**

Completed model scenarios for this report are described in Table 1. Model scenarios were chosen to address CPT and SSC comments and to step through the transition from Model 0 to Model 5 (of September 2015). Other model scenarios were added based on review within AFSC as work progressed.

Models 0 and 1 are the same as Models 0 and 1 from September 2015. Models 0a, 1a and 1b explore how fixing the growth transition point for males and females effects model stability and convergence. Models 2, 3, 4, 4a, 4b and 4c remove fishing mortality penalties. Model 2 removes male fishing mortality penalties, while Model 3 takes Model 2 and splits the F dev vector at 1991/92. Model 4 takes Model 3 and removes fishing mortality penalties on females using a fixed q. Models 4a, 4b and 4c explore different methods of estimating q for females (suggested from AFSC review).

Models 8 and 8a remove the lowest length bin and estimate one straight line for growth estimated separately for males and females with a higher weight on the growth likelihood for Model 8 (weight =2, sd=0.5) than Model 8a (weight = 1, sd = 0.7). These scenarios were suggested from AFSC review to explore stability and convergence of the model using one straight line for growth.

The issue of fitting the groundfish bycatch is addressed in models 0b (from Model 0) and 9 (takes Model 4a) where the average F is changed from being fixed to being an estimated parameter. The model was able to estimate the parameter (not the case in previous models) and so this resolved the issue of fitting the bycatch.

Models 10 (from Model 9) and 11 remove a prior that was used on the probability of maturing for males (Model 10) and females (Model 11).

Model 12 is Model 11 with a higher weight put on the second difference smooth constraint for the probability of maturing for females.

Model 13 is Model 12 with the 50% selectivity parameter for female discard is estimated and is the closest Model to Model 5 of September 2015. This parameter was fixed in previous models because it was not estimable. The differences between Model 13 and Model 5 are that the average F for the groundfish discard is estimated (not fixed) and no additional weight is put on the groundfish bycatch likelihood, the 50% selectivity parameter for female discard is estimated (not fixed), the fishing mortality dev vector for males is split at 1991/92 and no additional weight was put on the growth likelihoods.

Models 14, 15 and 16 alter weights on the growth likelihood to explore stability and sensitivity of the model.

Models 17, 17a and 17b explore allowing survey qs to be estimated greater than 1.0 (SSC request)

Model 18c uses Francis effective sample sizes to reduce input Ns for the survey, retained and total length composition data. The sample size for length composition data for groundfish and female discards was also reduced but not by calculating the Francis Ns. Model 18c uses Model 13 with iteration until sample sizes converged to two decimal places. Jittering was then done on Model 18c with the converged sample sizes.

**Model 0**

Model 0 from September 2015 assessment was tested for convergence by varying the starting values of 35 parameters with jittering +/- 20% from their converged values (Table 2). 400 runs were conducted of which 350 wrote the hessian and the standard deviation file. Three runs wrote the standard deviation file but had maximum gradients greater than 50 and total likelihoods greater than 6400. The maximum gradient was between 0.07 and 0.0002 for all other runs (Figure 1). The convergence criterion in the snow crab code for the last phase is set at 0.001. Runs that had maximum gradients larger than this criterion are included in the results. Runs where the maximum gradient was greater than 0.001 in the last phase would have a message written to the screen that the minimizer in ADMB could not make further progress, however, the Hessian was still positive definite and the std file was written.

The 35 parameters (323 total estimated parameters in Model 0) were growth parameters for males and females, all logistic curve selectivity parameters (fishery and survey) and natural mortality for immature crab and mature male crab. Parameters not jittered were recruitments, fishing mortalities, initial abundance parameters, parameters for smooth functions of selectivity and maturity. A uniform random distribution was used for jittering with the resulting parameter value constrained by the lower and upper bounds used in the snow crab ADMB assessment model code.

There were 61 runs (out of 400 total) where the total likelihood was the lowest at 6376.97 (same as Model 1 results from September 2015) and 47 where the likelihood was 6379.01 (same as model 0 results from September 2015) (Figure 2).

The parameter values between runs with the same total likelihood showed very little variability when plotted vs the parameter gradient (Figures 3 and 4). 100 jittered runs were done where the gradients for each parameter were saved for each run. The parameter gradients were not saved for the initial 400 jittered runs. To save the gradients for each parameter all that is needed is to add the line,

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save_gradients(gradients);
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in the report section.

The parameters that were different between the 6376.97 and 6379.01 likelihood values were female growth parameters (parameter numbers 1,3 and 8) that resulted in the transition between growth segments occurring at a lower size for the 6376.97 likelihood runs (Figures 3 and 5). The effect of the change in growth resulted in a slightly better fit to the survey length data (Table 2a). However, the ending biomass values and reference points, including OFL, were different by less than 0.7% (Snow crab assessment Sept 2015).

The size at which the female growth curve transition occurs is estimated between the two groups of growth data for the runs with 6376.97 likelihood and at the lower end of the upper group of data for the 6379.01 likelihood runs (Figure 5). The addition of more growth data in the sizes between 25mm and 35mm would provide more stability in the estimation of the transition.

Recall that growth was estimated as two joined straight line segments,

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Where ? is the cumulative distribution function for a standard normal random variable. ? constrains the breakpoint, and *s* is a scale parameter determining how smooth the transition is between equation segments.

Likelihood values for the Model 0, 6376.97 likelihood run are exactly the same as the Model 1 run from September 2015, and likelihood values from the Model 0, 6379.01 run are exactly the same as the Model 0 run from September 2015 (Table 2a).

The values of the female growth parameter a1 for each total likelihood (6376.97 and 6379.01) with multiple runs were virtually identical within each total likelihood (Figure 5). Models estimated basically two different values of the parameter that represent a shift in the transition of the growth curve (< -10 and > -4). The other female growth parameters shifted in a similar manner.

Figures 28-31 show no significant change in parameter values with gradient for Model 0 runs with total likelihood 6376.97 only. Previous figures show parameter values for all runs regardless of total likelihood.

Figures 7a, 7b and 7c show model estimated population mature male biomass for jitterred runs. Ending biomass varies were from 249,000 t to 263,000 t for all 79 (out of 100) jitter runs regardless of likelihood (Figure 7a). When runs were restricted to only the lowest two likelihoods (6376.97 and 6379.01) ending biomass was very similar for all runs except one run with likelihood 6376.97 where biomass was about 3% lower than other runs (Figures 7b). Figure 7c shows biomass for runs with 6376.97 likelihood only.

**Model 1**

Model 1 results for 100 jittered runs (94 runs wrote std file) are in Tables 4-6 and Figures 8-12. The lowest total likelihood was 6376.97 (17 runs), followed by 3 runs with 6379.01 likelihood, 44 runs at 6385.6 and the rest higher likelihoods. Parameter values vs parameter gradients for the two lowest likelihood runs (6376.97 and 6379.01) show differences for growth parameters similar to Model 0 runs.

Figures 32-35 show no significant change in parameter values with gradient for Model 1 runs with total likelihood 6376.97 only (17 runs). Previous figures show parameter values for all runs regardless of total likelihood.

**Model 1a**

Due to the issue with instability in the transition in growth for Models 0 and 1, two additional models were investigated where the growth transition for both males and females were fixed at the average of the values for Model 0 and Model 1.

Model 1a is the same as Model 1 with the fixed growth transition parameters for both males and females (Tables 7-9 and Figures 13-17). The growth transition parameters were fixed at the average of the values for Model 0 and Model 1 runs (females 30.27, males 27.26). Fixing the growth transition parameters stabilized the runs so that 94 of the 100 jittered runs converged to a total likelihood of 6378.94 (Figure 13). There was wide variability in the maximum gradient from 0.00029 to 0.05 (Figure 14), however virtually no difference in parameter values including recruitment deviations (Figures 15 and 16).

**Model 0a**

Model 0a is the same as Model 0 with the fixed growth transition parameters (Tables 10-11 and Figures 18-22). Fixing the growth transition parameters stabilized the runs so that 94 of the 100 jittered runs converged to a total likelihood of 6378.94 the same likelihood as Model 1a (Figure 13). Likelihood values were Identical between Model 0a and Model 1a (Table 9). There was wide variability in the maximum gradient from 0.00029 to 0.05 (Figure 14), however virtually no difference in parameter values including recruitment deviations with gradient size (Figures 15 and 16). Ending mature biomass values for female and male crab (2015) and mature male biomass at mating in 2014/15 were very close for all model scenarios (models 0, 1, 0a, 1a).

**Model 1b**

Model 1b is the same as Model 1 with the female growth transition parameter fixed at the average of Model 0 and Model 1 (30.27) (Tables 12-13 and Figures 23-27). Male growth transition parameter was estimated in the model. There were 97 runs that wrote the std file, 51 runs with 6378.94 likelihood, 33 runs with 6387.45 likelihood and 10 runs with 6416.92 likelihood. The difference between the 6378.94 runs and the 6387.45 runs was in the male growth parameters, with a higher transition size for the higher likelihood runs (Figure 27). Likelihood values for Models 0a, 1b and 1b were identical (Table 9). Parameters values were essentially unchanged with the size of the gradient within the 6378.94 likelihood runs (Figures 25 and 26). The maximum gradient of the single run of Model 1b (not jittered results) was 0.0047 (rec_devf(1987) Table 13). The first 13 parameters were recruitment deviations and some fishing mortality deviations. The gradient of the male growth parameter with the highest gradient was -0.00053.

**Model 2**

Model 2 moves directly from Model 1 with the male fishing mortality penalties for 1992 to the present removed (not to be confused with Model 2 from September 2015). Tables 14-18 and Figures 36-45 show results. There is a high degree of instability in the total likelihood by run (Figure 36) and a wide range in maximum gradient (up to 0.05, Figure 37). There were 4 runs with different likelihoods that made up the 5 runs with maximum gradient < 0.001 (Tables 16 and 17). Differences in parameter estimates for all runs (multiple likelihoods) are mainly in the growth parameters (Figures 38 and 39). Parameter estimates are very similar for runs at the lowest likelihood (6302.16, Figures 40 and 41). There was essentially no change in parameter values including recruitment deviations by gradient (Figures 42 -45).

**Model 3**

Model 3 takes Model 2 and splits the male fishing mortality deviation vector at 1991/92. The split adds one more parameter to the model: the mean log F for 1978 to 1991 (324 total parameters). There are fishing mortality deviations for 1978 to 1991 and a mean F, and a separate fishing mortality deviation vector for 1992 to present and a mean F. Tables 19-21 and Figures 46-53 show results. There was a wide range of likelihoods for Model 3 with the lowest at 6294.54 (12 runs) with 95 runs writing the std file (Table 18 and Figure 46-47). There were 11 runs that met the 0.001 maximum gradient criterion that ranged in Likelihood from 6294.54 to 6329.55 (Table 19). The largest gradients for the nonjittered run with likelihood 6294.54 (maximum gradient 0.014) were for male growth parameters and recruitment deviations in 1984, 1985 and 1991 (Table 21). Parameter estimates were stable across gradients and within the lowest likelihood runs (Figures 48-53).

**Model 4**

Model 4 is Model 3 with fishing mortality penalties for females removed for 1992 to present and the fishing mortalities for 1978 to 1991 estimated from potlift data (Table 25) (310 total parameters). Tables 22-24 and Figures 54-61 show results. Model 4 is similar to models 2 and 3 showing instability in total Likelihoods and maximum gradients by run (Tables and Figures 54-55). However, as with Models 2 and 3 parameter estimates are stable within the lowest likelihood runs independent of the gradient (Figures 56-61).

The estimation of fishing mortality for 1978 to 1991 assumes a linear relationship between potlifts and F for 1992 to ending year (y):

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Figures 62-68 show comparisons between models where the results are from the jitter run with the lowest likelihood and the lowest gradient. The maximum gradient was below 0.001 for each model. Fishing mortality for Models 2, 3 and 4 are higher than for Models 0 and 1 (Figure 62). Splitting the deviation vector at 1991/92 results in slightly higher F pre-1992 and slightly lower F post-1992. The lowest likelihood runs for Model 3 were 6294.54 compared to 6302.16 for Model 2. Model 3 has one more parameter than Model 2 and 7.62 fewer likelihood units. Female fishing mortality estimates for Model 4 were generally lower than Models 0,1,2 and 3 (Figure 63). Mature male biomass and MMB at mating estimates were the same for Models 0 and 1, lowest for Models 2 and 4 and Model 3 between the others (Figures 64 and 66). Female mature biomass estimates were similar for Models 0, 1 and 3, while Model 2 and 4 results were lower (Figure 65).

**Model 4a**

Model 4a estimates the q for F = q f , where f is potlifts for estimation of the female fishing mortalities for 1978 to 1991. Tables 27 to 29. Figures 69 and 70.

A likelihood component was added to estimate q,

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There were 16 runs with the lowest likelihood of 6277.2. The next lowest likelihood was 6277.33 with 9 runs (Tables 27 and 28). Gradients were variable as in other model runs with the male growth parameters and recruitment deviations having the highest gradients (Tables 28a and 29 and Figure 70).

**Model 4b**

Same as Model 4a except years 1992 to 2014/15 fit in the Likelihood for estimation of q. There were only 5 runs that achieved the lowest likelihood of 6298.6 (Table 30 and Figure 71). Gradients were variable as with other models with the male growth parameters and recruitment deviations having the highest gradients (Table 31 and Figure 72).

**Model 4c**

Model 3 with the female F penalties removed for 1992 to 2014/15 only (no use of potlifts). There were only 7 runs that achieved the lowest likelihood of 6281.76 (Table 32 and Figure 73). Gradients were variable as with other models with the male growth parameters and recruitment deviations having the highest gradients (Table 33 and Figure 74).

**Model 8**

Model 8 uses Model 4a and removes the lowest length bin and estimates one straight line for growth with separate parameters for males and females. The weight on the growth likelihoods for male and females was increased to 2 (sd=0.5). There were 43 runs that achieved the lowest likelihood of 6490.11 (Table 34 and Figure 75). The increased weight on the growth likelihood relative to Model 8a resulted in more stability of the model. Seven runs with the lowest likelihood had gradients < 0.001. Gradients were variable as with other models with the male growth slope parameter and recruitment deviations having the highest gradients (Table 35 and Figure 76).

**Model 8a**

Model 8 uses Model 4a and removes the lowest length bin and uses one straight line for growth estimation for both males and females. The weight on the growth likelihoods for male and females was left at 1 (sd=0.7) the same as Model 4a. There were 25 runs that achieved the lowest likelihood of 6408.04 (Table 36 and Figure 77). Eight runs with the lowest likelihood had gradients < 0.001. Gradients were variable as with other models with the male growth slope parameter and recruitment deviations having the highest gradients (similar to Model 8, Table 37 and 38, and Figure 78). Mature male biomass estimated from the jitter runs was very similar for all likelihoods except 3 runs with likelihoods about 30 units larger than the lowest likelihood (Figure 79). Mature male biomass estimates were virtually the same for 85 jitter runs with likelihoods < 6416 (6408.04 was lowest likelihood)(Figure 80). Male and female growth was also estimated the same over the 85 runs with likelihoods < 6416 (Figures 81 and 82).

**Comparison between Models 0 to 8a**

The estimates of female fishing mortality in the directed fishery were higher for model 4a and 4b with estimation of q for the period 1978 to 1991 than for models 0, 4 and 4c (Figure 82). However, the F's for females are very low so discard catches estimated are still low. Fishing mortality estimates for male crab in the directed fishery were higher for models 4, 4a and 4c than model 4b and model 0 (Figure 83).

Ending mature male biomass was lowest for Model 4, followed by Models 4a and 4c (very close), then Model 4b and highest was Model 0 (Figure 84).

Mature male biomass estimates for Models 8 and 8a were lower than Models 0 and 4a (Figure 85). Models 8 and 8a estimated lower ending survey biomass than models 0 and 4a (Figure 86). The addition of a higher weight on the growth likelihood for model 8 resulted in higher estimates of growth for females relative to Model 8a (Figure 87). Male growth was estimated higher for smaller sizes in Models 8 and 8a compared to Models 0 and 4a (Figure 88). The additional weight on the likelihood for Model 8 resulted in higher growth for larger males relative to Model 8a.

Model 8a (22 runs at lowest likelihood) does not seem to be much more stable in terms of total likelihood between jitter runs than model 4a (16 runs at lowest likelihood), however, there was no change in estimated growth between runs with different likelihoods for model 8a. There is some variability for estimated growth between jitter runs for Model 4a (Figures 89 and 90). There is a lower estimated ending biomass and possibly better fit to the last two years of survey biomass for model 8a (Figures 85 and 86).

**Jittering all estimated parameters**

To insure that the lowest likelihood has been achieved with jittering only 35 parameters of a total of 325 estimated parameters, 500 runs were done for Model 4a jittering all 325 parameters (+/-20% within bounds).

The lowest likelihood was the same as found for jittering 35 parameters and 100 runs (6277.20, Figures 91 and 92). There were 473 runs that wrote the std file of which 91 runs had the lowest likelihood. For the jittered runs with 35 parameters and 100 runs there were 16 runs that had the lowest likelihood. This shows that not all parameters need be jittered and that 100 runs are probably adequate for finding the lowest likelihood. However, since jittering all parameters has been setup, all further model scenarios in this report (Model 9 onward) will jitter all parameters.

**Model 9**

Model 9 is Model 4a with the average F for groundfish bycatch estimated. All 326 parameters were jittered for 100 runs. The fit to groundfish discard catch was poor at the end of the time series where observed catches have declined to lower values. Using a lognormal likelihood was suggested. I ran several scenarios (not included here) with lognormal likelihood and various weights on length data and bycatch likelihoods. While a lognormal likelihood did work for better fitting to the low catches it did not fit the higher catches as well. The issue however, with the lack of fit for groundfish bycatch in model 4a was that the average F was fixed in the code due to problems with estimating the average F parameter in previous models. However, since the F dev vector has to sum to zero, with the addition of several years of low catches and changes to the model structure this created a problem in the estimation. Model 9 takes Model 4a and estimates the average log F for groundfish catch and this fixes the issue (Figure 100). Population mature male biomass estimates for Model 4a and Model 9 are very similar (Figure 99). Ending biomass (2015) for Model 4a was 242,895 t and for Model 9, 245,232 t (<1% difference).

**Model 0b**

Model 0b is model 0 with the estimation of the average F for groundfish catch turned on (Figures 93-96). While there was essentially no difference in biomass between Model 4a and 9, there was about a 5% difference in ending male mature biomass between models 0 and 0b (model 0b with lower biomass). Model 0b fits the higher bycatch values better and fits high for lower values, while model 0 tends to fit low, however, fits the last 5 years reasonably well. This may be because the fixed average F for model 0 was reasonable with the F dev vector estimation and for other models (e.g. Model 4a) it was not.

**Model 10**

Model 10 takes Model 9 and removes a constraint on the male probability of maturing that probably is not needed since growth data are now being fit in the model (Figures 101 and 102). The constraint was a likelihood component that used a maturity curve for new shell crab as a prior on the probability of maturing that helped stabilize the estimation when no growth data was being fit in the model.

**Model 11**

Model 11 moves from Model 10 by removing the constraint on the female probability of maturing (Figures 103 and 104).

**Comparison Models 4a, 9, 10 and 11**

Population male mature biomass is very similar for Models 4a, 9, 10 and 11 (Figure 105). Differences between models for ending biomass are <1%. Female probability of maturing is the same for models 4a, 9 and 11, with Model 10 slightly different (Figure 106). Male probability of maturing shifts for Models 10 and 11 relative to Models 4a and 9 (Figure 107). The probability of maturing is lower for sizes about 55 mm to 85 mm, then is higher for sizes 85 mm to about 105 mm due to the removal of the constraint. Growth was different for females in Model 11 where the slope of the upper line was lower than Models 4a, 9 and 10 (Figure 108). Growth for males was the same for Models 4a, 9, 10 and 11 (Figure 109).

**Model 12**

Model 12 is Model 11 with an increase in the weight on the smoothness constraint from 2.0 to 10.0 on length bins 1 to 5 (25-30mm to 45-50mm) and weight of 50 on 50-55mm bin, 300 on 55-60mm bin and 500 on the 65-70 mm bin. There were 3 runs that reached the lowest likelihood of 6263.71 for Model 12 (Figure 110). The maximum gradients were similar to other models ranging up to 0.04 (Figure 111).

**Model 13**

Model 13 is Model 12 with the 50% selectivity parameter for female discard in directed fishery estimated (was fixed at 4.2 log scale (66.7mm). Previous models were not able to estimate the 50% selectivity parameter, however for Model 13 the estimate was OK (4.509 (90.8 mm)). The higher 50% selectivity results in low estimates of selectivity for most female crab and higher estimates of F, however, the length data are fit better overall and catch data fit about the same. The lowest likelihood was 6214.87 with 9 runs (Figures 112-113).

**Model 14**

Model 14 is Model 13 with weight on growth likelihood for males increased from 1 (sd=0.7) to 2 (sd=0.5) (Figures 114-115). The lowest likelihood was 6246.08 with 4 runs.

**Model 15**

Model 15 is Model 13 with weight on growth likelihood for females increased from 1 (sd=0.7) to 2 (sd=0.5) (Figures 116-117). Only 1 run achieved the lowest likelihood of 6243.27.

**Model 16**

Model 16 is Model 13 with weight on growth likelihood for both males and females increased from 1 (sd=0.7) to 2 (sd=0.5)(Figures 118-119). The lowest likelihood was 6274.23 with 4 runs.

**Comparison of Models 11, 12, 13, 14, 15 and 16**

Mature male population biomass was very close for Models 11-16 (Figure 120). The increase in the weight on smoothness (Model 12) removed most of the dip in probability of maturing for larger female crab (Figure 121). Model 15 (increased weight on female growth) and Model 16 (with increased weight on both male and female growth) was the smoothest curve for probability of maturing for females. Models 13 and 14 estimates were the same for female probability of maturing. The male probability of maturing was very similar between Models 11-16 (Figure 122).

Likelihood values for Models 4a and 9 through 16 are shown in Table 39. Model structure is different between models, so total likelihood is not comparable, however, some components can be compared between scenarios.

Models 15 and 16 (higher weight on female growth) fit the female growth data better than other models (Figure 123). Models 14 and 16 fit the male growth data better and estimate growth higher at larger sizes than other models (Figure 124). However, models 14, 15 and 16 with the increase in weight on the growth likelihood did not result in a more stable model compared to model 13. The fit to the survey length frequency data was not as good for Models 15 and 16 vs Models 13 and 14 (Table 39).

The fit to female discard length frequency data is better for Models 13-16 where the 50% selectivity parameter is estimated than models 11 and 12 (Figure 125).

**Model 17**

Model 17 is Model 13 with the upper bound of survey q for all surveys increased to 3.0. All q parameters were on an arithmetic scale not a probit scale to allow q estimates greater than 1.0. In model 13 two q estimates were at 1.0, the first period survey (1978-1981) and the q for the survey in the study area in 2010. The q for the first period survey was estimated at 2.09 for the first period for Model 17 and 2.46 for the study area in 2010. Other q estimates were higher for model 17 than Model 13 except female study area 2010 q which was lower.

| Estimated q | | Model | | |
|---|---|---|---|---|
| | 13 | 17 | 17a | 17b |
| survey period 1 1978-1981 males | 1.00 | 2.09 | 2.04 | 1.00 |
| survey period 2 1982-1988 males | 0.75 | 0.96 | 0.93 | 0.76 |
| survey period 3 1989-present males | 0.62 | 0.72 | 0.69 | 0.64 |
| Female multiplier on male survey q | 0.87 | 0.94 | 0.92 | 0.88 |
| study area 2009 NMFS male | 0.37 | 0.41 | 0.40 | 0.38 |
| study area 2009 NMFS female | 0.34 | 0.36 | 0.36 | 0.35 |
| study area 2010 NMFS male | 1.00 | 2.46 | 1.00 | 2.24 |
| study area 2010 NMFS female | 1.08 | 0.64 | 1.17 | 0.61 |

**Model 17a**

The q for the first period survey upper bound was increased and was estimated at 2.04 for the first period for Model 17a. The upper bound for the study area in 2010 was left at 1.0 (see above table). Other q estimates were higher than Model 13 but lower than Model 17.

**Model 17b**

The q for the first period survey was bound at 1.0 for Model 17b and estimated at 2.24 for the study area in 2010. Other q estimates were slightly higher than Model 13 except study area 2010 female which was lower.

**Comparison of Models 13, 17, 17a and 17b**

Likelihood values are in Table 40. The population male and female mature biomass estimates reflect the differing q estimates with ending biomass higher for Model 13 (lowest q) followed by Model 17b, 17a and 17 (Figures 132 and 134). The fit to mature biomass is very similar at the end of the time series, but is higher at the beginning for Models 17 and 17a (Figures 133 and 135).

**Model 18c**

Model 18c is Model 13 with sample size for all length frequencies reduced. The survey, retained and total length frequency Ns were reduced to estimates based on Francis (2011) after 6 iterations. The multinomial likelihood is used for length data in the snow crab model, the estimation of the effective Ns Francis (2011) T3.4 equation are,

? ?? ?̃?? ? ?

where $N_{jy}$ are the effective sample size and ?̃ ?? are the input sample sizes. The equation used here to estimate the $w_j$ was equation TA1.8 from Francis (2011),

? ? È / ? ? ?̃?? ? (Æ?̃?? − ?̃??) / (? ? ? Æ?̃??) ?

Where ?̃ jy are the mean observed lengths by year (y) and data type (j) and ?̃ jy are the predicted mean lengths by year (y) and data type (j).

Model 13 has sample sizes of 200 for all length frequencies except groundfish discard which are 50 and female discard lengths which are 40. The Francis estimates of effective sample size are set the same for every year of data. The Francis effective Ns estimated from the Model 13 fit were used as input Ns for iteration 1 in Model 18c. The code of Model 18c is the same as Model 13, only sample sizes in the data file are different. After 6 iterations there was no change in effective N to two decimal places (see Table below).

Groundfish and female discard length frequency Ns were set at 15, as there is no code in the Model for estimating the Francis Ns for these length frequencies at this time.

| | Immature females | mature females | immature males | mature males | Retained | Total | Groundfish | Female discard |
|---|---|---|---|---|---|---|---|---|
| Model 13 input N | 200 | 200 | 200 | 200 | 200 | 200 | 50 | 40 |
| Input N to Model 18c (iteration 1) | 5.57 | 14.10 | 16.83 | 19.45 | 21.41 | 34.63 | 15 | 15 |
| iteration 2 | 3.26 | 14.82 | 8.45 | 14.36 | 16.26 | 34.88 | 15 | 15 |
| 3 | 3.41 | 14.27 | 7.03 | 11.94 | 15.81 | 33.06 | 15 | 15 |
| 4 | 3.44 | 14.29 | 6.94 | 11.49 | 15.61 | 33.08 | 15 | 15 |
| 5 | 3.45 | 14.32 | 6.94 | 11.42 | 15.57 | 33.08 | 15 | 15 |
| 6 | 3.45 | 14.32 | 6.94 | 11.41 | 15.57 | 33.08 | 15 | 15 |
| 7 | 3.45 | 14.32 | 6.94 | 11.41 | 15.57 | 33.08 | 15 | 15 |

**Comparison of Models 13 and 18c**

Reducing the sample size for length data had an influence on both the fit to the survey biomass and the estimates of q for the surveys resulting in differences in population biomass estimates (Figures 138-141). The fit to male survey biomass was better for Model 18c, however, survey qs were higher resulting in generally lower biomass, but similar ending population biomass (Figure 138). Down-weighting the length data resulted in the model fitting the 2014 survey biomass better and a worse fit to the 2013 and 2015 estimates (Figure 139). Likelihood values are in Table 40. The q for female survey data was higher for model 18c resulting in much lower female mature biomass estimates (Figure 139) even though the fit to survey biomass was not very different (Figure 141).

Recruitment estimates for Model 18c were lower than Model 13 due to the higher survey q. The pattern of recruits also differed resulting in more of an increase in biomass in the last few years for Model 18c than Model 13 (Figure 142). Also the very high recruitment in 2010 fertilization year disappears as that is a signal from the survey length data.

The fit to mean length for the survey length data which are used in the estimation of the Francis effective Ns are shown in Figure 143.

Down-weighting the length frequency data results in an increase in the probability of maturing for smaller crab for both males and females (Figures 144 and 145). The male discard data is fit better in Model 18c including the last two years of higher discard catch (Figure 146). The model is able to fit the higher discard catch in the last few years with the length data down-weighted and the model also estimates a larger increase in mature male biomass in the last few years.

Growth is similar for Models 13 and 18c, however, Model 18c estimates higher growth for larger male and female crab (Figures 147 and 148).

Survey q estimates for models 13 and 18c.

| Male q | 13 | 18c |
|---|---|---|

| | | |
|---|---|---|
| Survey period 1 | 1 | 1 |
| Survey period 2 | 0.75 | 0.89 |
| Survey period 3 | 0.62 | 0.69 |
| Female q | | |
| Survey period 1 | 0.87 | 1.63 |
| Survey period 2 | 0.65 | 1.45 |
| Survey period 3 | 0.54 | 1.12 |
| immature M | 0.38 | 0.13 |
| male M | 0.27 | 0.24 |

## Literature Cited

Francis, C. R.I.C. 2011. Data weighting in statistical fisheries stock assessment models. Can. J. Fish. Aquat. Sci. 68: 1124–1138 (2011).

**R script example for jitter runs**

```
#change directory in R to jitterm18c
#this is the converged .par file for the single run of model
read.par=read.table("F://crab//crab.adm//snow2016may//model18c//sc2016maym18c.par")
read.par=as.numeric(unlist(read.par))
#make sure param.bounds file has correct parameters, bounds and parameter number
#first column is parameter number same as in the par file,
#second column lower bound, third column upper bound
bounds.par=read.table("F://crab//crab.adm//snow2016may//jitterm18c//param.bounds18c.all")
#this sets +/- fraction to 0.2 of parameter value for uniform random
fraction=rep(0.2,length(read.par))
for(j in 1:100){
par.jit=read.par
for(i in as.numeric(bounds.par[,1])){
par.jit[i]=read.par[i]+runif(1,min= -fraction[i]*abs(read.par[i]),max= fraction[i]*abs(read.par[i]))
#check to see if beyond bounds
if(par.jit[i]>as.numeric(bounds.par[as.numeric(bounds.par[,1])==i,3]))
par.jit[i]=bounds.par[as.numeric(bounds.par[,1])==i,3]
if(par.jit[i]<as.numeric(bounds.par[as.numeric(bounds.par[,1])==i,2]))
par.jit[i]=bounds.par[as.numeric(bounds.par[,1])==i,2]

}
#write out the par file with jittered parameters
write(par.jit,file=paste("F:/crab/crab.adm/snow2016may/jitterm18c/sc2016jit",j,".par",sep=""),ncol=1)
#run ADMB model with par file jittered parameters
comname=paste("sc2016maym18c -nox -ind sc2016maym18c.dat -ainp sc2016jit",j,".par",sep="")
shell(comname)
#rename output files to save each run results
shell(paste("copy sc2016maym18c.rep sc2016maym18c",j,".rep /Y",sep=""))
```

```
shell(paste("copy sc2016maym18c.par sc2016maym18c",j,".par /Y",sep=""))
shell(paste("if exist sc2016maym18c.std copy sc2016maym18c.std sc2016maym18c",j,".std /Y",sep=""))
shell(paste("copy R_inputmay2016m18c.txt R_inputmay2016m18c_",j,".txt /Y",sep=""))
shell(paste("if exist gradient.dat copy gradient.dat sc2016maym18cgrad",j,".dat /Y",sep=""))
shell("del sc2016maym18c.std")
shell("del gradient.dat")
}
```

Table 1. Completed Model Scenarios

| | |
|---|---|
| 0 | Model 0 from Sept. 2015 |
| 1 | Model 1 from Sept. 2015 - reparameterized 95% selectivity parameter to offset from 50% and survey q for 1978-1981 and probit scale |
| 0a | Model 0 with growth transition for males and females fixed |
| 1a | Model 1 with growth transition for males and females fixed |
| 1b | Model 1 with growth transition for females fixed |
| | |
| 2 | Model 1 with F penalties removed for males 1992-2014/15 |
| 3 | Model 2 with F dev vector split at 1991/92, this adds one parameter - the mean F for 1978 to 1991. |
| 4 | Model 3 with female F penalties removed 1992-2014/15 - q for female F 1978-1991 fixed and estimated from F and potlifts 1991-2014/15 |
| 4a | Model 3 with female F penalties removed 1992-2014/15 and q for female F 1978-1991 estimated in model with likelihood component with all F's and potlifts 1978-2014/15 |
| 4b | Model 4a except q for female F 1978-1991 estimated in model with likelihood component with F's and potlifts 1992-2014/15 only |
| 4c | Model 3 with female F penalties removed 1992-2014/15 only, and female Fs estimated as in model 3 (no use of potlifts) |
| 8 | Model 4a with lowest length bin in model 30 (instead of 25) and one linear growth estimated for both males and females - wt 2 on growth (sd=0.5) |
| 8a | Model 4a with lowest length bin in model 30 (instead of 25) and one linear growth estimated for both males and females- wt 1 on growth (sd=0.7) |
| 0b | Model 0 with estimation of average F for groundfish bycatch |
| 9 | Model 4a with estimation of average F for groundfish bycatch |
| 10 | Model 9 with removal constraint of prior maturity on probability of maturing for males |
| 11 | Model 10 with removal constraint of prior maturity on probability of maturing for females |
| 12 | Model 11 with weight on smoothness of female maturity probability increased from 2.0 to 10.0 |
| 13 | Model 12 with 50% selectivity for female discard in directed fishery estimated (was fixed) |
| 14 | Model 13 with weight on growth likelihood for males increased from 1 (sd=0.7) to 2 (sd=0.5) |
| 15 | Model 13 with weight on growth likelihood for females increased from 1 (sd=0.7) to 2 (sd=0.5) |
| 16 | Model 13 with weight on growth likelihood both males and females increased from 1 (sd=0.7) to 2 (sd=0.5) |
| 17 | Model 13 with upper bound of survey q's increased to 3.0, all q's arithmetic scale |
| 17a | Model 13 with upper bound of survey q for period 1 (1978-1981) upper bound at 3, all others upper bound at 1.0 |
| 17b | Model 13 with upper bound of survey q for 2010 special study NMFS upper bound at 3, all others upper bound at 1.0 |
| 18c | Model 13 with sample size for survey, retained and total length frequencies set to estimates for Francis N from Model 13. Sample size for female discard and groundfish length frequency set to 15. |

Table 2. Converged model parameters for Model 0 September 2015 that were jittered for Model 0 runs (35 parameters total).

| Parameter | Parameter number | Value | Lower Bound | Upper Bound |
|---|---|---|---|---|
| Female intercept (a1) growth | 1 | -3.03704 | -100 | 0 |
| Male intercept(a1) growth | 2 | -17.1901 | -50 | 0 |
| Female slope(b1) growth | 3 | 1.445165 | 1 | 10 |
| Male slope (b1) growth | 4 | 2.016493 | 1 | 5 |
| Male slope (b2) growth | 5 | 1.155515 | 1 | 1.5 |
| Female slope(b2) growth | 6 | 1.05804 | 1 | 2 |
| male delta | 7 | 27.26778 | 10 | 50 |
| female delta | 8 | 33.08787 | 5 | 50 |
| Fishery selectivity total males length at 50% (log scale) | 9 | 4.664896 | 4 | 5 |
| Fishery selectivity total males slope | 10 | 0.17986 | 0.1 | 0.5 |
| Fishery selectivity retention curve males slope | 11 | 0.415111 | 0.05 | 0.5 |
| Fishery selectivity retention curve males length at 50% | 12 | 95.94223 | 85 | 120 |
| Fishery discard selectivity female slope | 13 | 0.32573 | 0.1 | 0.7 |
| Trawl Fishery selectivity slope | 14 | 0.097645 | 0.01 | 0.3 |
| Trawl Fishery selectivity length at 50% | 15 | 96.68968 | 30 | 120 |
| Survey Q 1978-1981 male | 16 | 1 | 0.2 | 1 |
| Survey 1978-1981 length at 95% of Q male | 17 | 60.38573 | 30 | 150 |
| Survey 1978-1981 length at 50% of Q male | 18 | 42.52917 | 0 | 150 |
| Survey Q 1982-1988 male | 19 | 0.637813 | 0.2 | 1 |
| Survey 1982-1988 length at 95% of Q male | 20 | 70.3042 | 50 | 160 |
| Survey 1982-1988 length at 50% of Q male | 21 | 43.49934 | 0 | 80 |
| Survey Q 1989-present male | 22 | 0.579074 | 0.2 | 1 |
| Survey 1989-present, length at 95% of Q male | 23 | 57.76223 | 40 | 200 |
| Survey 1989-present length at 50% of Q male | 24 | 38.38521 | 25 | 90 |
| srvind_q - Male BSFRF 2009 Study area Q (availability) | 25 | 0.349541 | 0.1 | 1 |
| srvindfem_q- Female BSFRF 2009 Study area Q (availability) | 26 | 0.359651 | 0.01 | 1 |
| Female BSFRF 2009 Study area length at 95% of Q | 27 | 58.56339 | 55 | 120 |
| Female BSFRF 2009 Study are length at 50% of Q | 28 | 51.17912 | -50 | 55 |
| srv10ind_q - Male BSFRF 2010 Study area Q (availability) | 29 | 1 | 0.2 | 1 |
| srv10indfem_q - Female BSFRF 2010 Study area Q (availability) | 30 | 1.060603 | 0.5 | 2 |
| Female Survey 1989-present, length at 95% of Q | 31 | 46.15646 | 40 | 150 |
| Female Survey 1989-present length at 50% of Q | 32 | 34.56413 | 0 | 90 |
| Survey Q multiplier (on male Q) 1978-1981 and 1982 to 1988 Female | 33 | 0.899524 | 0.199 | 2 |
| Natural Mortality multiplier (on 0.23) immature females and males | 34 | 1.660032 | 0.2 | 2 |
| Natural Mortality multiplier (on 0.23) mature males | 35 | 1.165549 | 0.2 | 2 |

Table 2a. Likelihood differences between run with total likelihood 6376.97 and run with 6379.01 total likelihood.

| Like Component | Diff(6376.97 run-6379.01 run) | Model 0 6379.01 run | Model 0 6376.97 run | Model 0 sept 2015 | Model 1 sept 2015 |
|---|---|---|---|---|---|
| Recruitment | -0.195 | 35.66 | 35.47 | 35.66 | 35.47 |
| Initial numbers old shell males small length bins | 0.00629 | 2.21 | 2.22 | 2.21 | 2.22 |
| ret fishery length | 0.463 | 352.94 | 353.40 | 352.94 | 353.40 |
| total fish length | 0.222 | 787.15 | 787.37 | 787.15 | 787.37 |
| female fish length | 0.19 | 228.95 | 229.14 | 228.95 | 229.14 |
| survey length | -3.7 | 3845.13 | 3841.43 | 3845.13 | 3841.43 |
| trawl length | 0.395 | 274.61 | 275.01 | 274.61 | 275.01 |
| 2009 BSFRF length | 0.1867 | -83.22 | -83.03 | -83.22 | -83.03 |
| 2009 NMFS study area length | 0.1337 | -71.02 | -70.89 | -71.02 | -70.89 |
| M prior | -0.10794 | 9.62 | 9.51 | 9.62 | 9.51 |
| maturity smooth | 0.3006 | 57.29 | 57.59 | 57.29 | 57.59 |
| growth males | 0.1238 | 35.56 | 35.68 | 35.56 | 35.68 |
| growth females | 0.248 | 47.04 | 47.29 | 47.04 | 47.29 |
| 2009 BSFRF biomass | 0.002821 | 0.14 | 0.15 | 0.14 | 0.15 |
| 2009 NMFS study area biomass | 0.001833 | 0.06 | 0.06 | 0.06 | 0.06 |
| retained catch | 0.02038 | 2.36 | 2.38 | 2.36 | 2.38 |
| discard catch | 1.299 | 115.58 | 116.87 | 115.58 | 116.88 |
| trawl catch | 0.02202 | 9.30 | 9.32 | 9.30 | 9.32 |
| female discard catch | -0.0134 | 23.68 | 23.66 | 23.68 | 23.66 |
| survey biomass | -0.024 | 192.78 | 192.76 | 192.78 | 192.76 |
| F penalty | 0.1543 | 84.37 | 84.53 | 84.37 | 84.53 |
| 2010 BSFRF Biomass | -0.02761 | 1.50 | 1.47 | 1.50 | 1.47 |
| 2010 NMFS Biomass | 0.02205 | 1.01 | 1.03 | 1.01 | 1.03 |
| initial numbers fit | 0.514 | 508.09 | 508.61 | 508.09 | 508.61 |
| 2010 BSFRF length | -1.1589 | -58.25 | -59.41 | -58.25 | -59.41 |
| 2010 NMFS length | -0.6091 | -67.07 | -67.68 | -67.07 | -67.68 |
| male survey selectivity smooth constraint | -0.01821 | 3.74 | 3.72 | 3.74 | 3.72 |
| init nos smooth constraint | -0.4954 | 39.81 | 39.31 | 39.81 | 39.3103 |
| Total | -2.04407 | 6379.01 | 6376.97 | 6379.01 | 6376.97 |

Table 3. Model 0 from September 2015, 6379.01 total likelihood. Parameter values and gradient for 30 parameters with the largest gradients sorted high to low (without regard to sign). Year is first part of crab year, i.e. 1991 = 1991/92 crab year.

| ParName | Value | Gradient |
|---|---|---|
| Male slope (b1) growth | 2.01649 | -0.0023 |
| rec_devf(1991) | 1.9501 | -0.00146 |
| rec_devf(1987) | 1.61484 | 0.001288 |
| Male intercept(a1) growth | -17.1901 | -0.00115 |
| male delta | 27.2678 | -0.00083 |
| fmort_dev(1990) | 1.21549 | -0.00051 |
| log_avg_sel50_mn | 4.6649 | 0.000501 |
| fmort_dev(1996) | -0.07388 | -0.00048 |
| fmort_dev(1998) | 0.390927 | 0.000396 |
| rec_devf(2003) | 0.839771 | 0.000384 |
| fmort_dev(1989) | 0.637854 | 0.000379 |
| Male slope (b2) growth | 1.15552 | -0.00034 |
| rec_devf(1984) | 1.03241 | -0.00029 |
| fmort_dev(1997) | 0.338449 | -0.00029 |
| rec_devf(1990) | -0.3176 | -0.00025 |
| rec_devf(2008) | 0.36516 | -0.00024 |
| rec_devf(2009) | 0.676498 | -0.0002 |
| fmort_dev(1994) | 0.452908 | 0.000187 |
| rec_devf(1986) | -0.34573 | 0.000175 |
| fmort_dev(2009) | -0.901 | 0.000171 |
| fmort_dev(2010) | -0.72096 | 0.000161 |
| rec_devf(1985) | 1.62876 | -0.00016 |
| Female slope(b1) growth | 1.44517 | 0.000148 |
| rec_devf(1998) | 0.163738 | 0.000142 |
| fmort_dev(2007) | -0.08603 | -0.00013 |
| rec_devf(2004) | -0.22301 | 0.000118 |
| fmort_dev(1981) | 0.962524 | 0.000112 |
| fmort_dev(1993) | 0.793879 | 0.000112 |
| rec_devf(1983) | 0.807321 | 0.00011 |
| fmort_dev(1980) | 1.33392 | -0.00011 |

Table 4. Converged model parameters for Model 1 September 2015 that were jittered for Model 1 runs (35 parameters total).

| Parameter | Parameter number | Value | Lower Bound | Upper Bound |
|---|---|---|---|---|
| Female intercept (a1) growth | 1 | -10.9613 | -100 | 0 |
| Male intercept(a1) growth | 2 | -17.3409 | -50 | 0 |
| Female slope(b1) growth | 3 | 1.821845 | 1 | 10 |
| Male slope (b1) growth | 4 | 2.023283 | 1 | 5 |
| Male slope (b2) growth | 5 | 1.155007 | 1 | 1.5 |
| Female slope(b2) growth | 6 | 1.045262 | 1 | 2 |
| male delta | 7 | 27.26433 | 10 | 50 |
| female delta | 8 | 27.46127 | 5 | 50 |
| Fishery selectivity total males length at 50% (log scale) | 9 | 4.664925 | 4 | 5 |
| Fishery selectivity total males slope | 10 | 0.179804 | 0.1 | 0.5 |
| Fishery selectivity retention curve males slope | 11 | 0.415656 | 0.05 | 0.5 |
| Fishery selectivity retention curve males length at 50% | 12 | 95.93648 | 85 | 120 |
| Fishery discard selectivity female slope | 13 | 0.326329 | 0.1 | 0.7 |
| Trawl Fishery selectivity slope | 14 | 0.097736 | 0.01 | 0.3 |
| Trawl Fishery selectivity length at 50% | 15 | 96.66305 | 30 | 120 |
| Survey Q 1978-1981 male probit scale | 16 | 5.887367 | -5 | 6 |
| Survey 1978-1981 length at 95% offset of Q male | 17 | 17.96044 | 1 | 100 |
| Survey 1978-1981 length at 50% of Q male | 18 | 42.24562 | 0 | 150 |
| Survey Q 1982-1988 male | 19 | 0.638947 | 0.2 | 1 |
| Survey 1982-1988 length at 95% offset of Q male | 20 | 27.17483 | 1 | 100 |
| Survey 1982-1988 length at 50% of Q male | 21 | 43.2965 | 25 | 80 |
| Survey Q 1989-present male | 22 | 0.580942 | 0.2 | 1 |
| Survey 1989-present, length at 95% offset of Q male | 23 | 19.20864 | 1 | 100 |
| Survey 1989-present length at 50% of Q male | 24 | 38.22978 | 25 | 90 |
| srvind_q - Male BSFRF 2009 Study area Q (availability) | 25 | 0.349719 | 0.1 | 1 |
| srvindfem_q- Female BSFRF 2009 Study area Q (availability) | 26 | 0.359781 | 0.01 | 1 |
| Female BSFRF 2009 Study area length at 95% offset of Q | 27 | 7.375997 | 1 | 60 |
| Female BSFRF 2009 Study are length at 50% of Q | 28 | 51.1595 | -50 | 60 |
| srv10ind_q - Male BSFRF 2010 Study area Q (availability – probit | 29 | 5.732596 | -5 | 6 |
| srv10indfem_q - Female BSFRF 2010 Study area Q (availability) | 30 | 1.06225 | 0.5 | 2 |
| Female Survey 1989-present, length at 95% offset of Q | 31 | 11.67987 | 1 | 100 |
| Female Survey 1989-present length at 50% of Q | 32 | 34.12868 | 0 | 90 |
| Survey Q multiplier (on male Q) 1978-1981 and 1982 to 1988 Female | 33 | 0.892111 | 0.199 | 2 |
| Natural Mortality multiplier (on 0.23) immature females and males | 34 | 1.651624 | 0.2 | 2 |
| Natural Mortality multiplier (on 0.23) mature males | 35 | 1.164645 | 0.2 | 2 |

Table 5. Model 1 from September 2015, 6376.97 total likelihood. Parameter values and gradient for 30 parameters with the largest gradients sorted high to low (without regard to sign). Year is first part of crab year, i.e. 1991 = 1991/92 crab year.

| ParName | Value | Gradient |
|---|---|---|
| rec_devf(1991) | 1.93859 | -0.00332 |
| rec_devf(1985) | 1.62538 | 0.001726 |
| rec_devf(1983) | 0.793248 | 0.001288 |
| rec_devf(1982) | 0.306772 | 0.000977 |
| rec_devf(1992) | 0.615182 | -0.0008 |

| | | |
|---|---|---|
| fmort_dev(1991) | 1.50181 | 0.000741 |
| fmort_dev(1990) | 1.21748 | -0.00067 |
| rec_devf(1984) | 1.02963 | 0.000635 |
| fmort_dev(1988) | 0.932365 | 0.000441 |
| rec_devf(2003) | 0.832483 | 0.000432 |
| fmort_dev(1992) | 1.33983 | -0.00039 |
| log_avg_sel50_mn | 4.66493 | 0.000378 |
| rec_devf(1990) | -0.32337 | -0.00036 |
| rec_devf(1993) | 0.0197121 | -0.00031 |
| fmort_dev(1986) | 0.111873 | -0.00028 |
| Male slope (b1) growth | 2.02328 | -0.00027 |
| fmort_dev(2011) | 0.0913867 | 0.00027 |
| rec_devf(1978) | 0.574514 | -0.00026 |
| fmort_dev(1989) | 0.641119 | 0.000255 |
| fmort_dev(1985) | -0.242721 | -0.00025 |
| fmort_dev(1998) | 0.391409 | -0.00024 |
| rec_devf(2008) | 0.379936 | -0.00024 |
| fmort_dev(1996) | -0.0707549 | -0.00024 |
| fmort_dev(1994) | 0.456611 | 0.000229 |
| rec_devf(2002) | 0.430761 | 0.000229 |
| rec_devf(1979) | 0.41507 | -0.00022 |
| Female slope(b1) growth | 1.82184 | 0.000221 |
| rec_devf(2004) | -0.205424 | 0.000177 |
| rec_devf(2005) | -0.0130145 | 0.000171 |
| rec_devf(1998) | 0.150547 | 0.000169 |

Table 6. Likelihood values for Model 1 jittered runs with total likelihood 6376.97 and run with 6379.01 total likelihood compared to Model 0 and Model 1 September 2015 runs.

| Like Component | Diff(6376.97 run-6379.01 run) | Model 1 6379.01 run | Model 1 6376.97 run | Model 0 sept 2015 | Model 1 sept 2015 |
|---|---|---|---|---|---|
| Recruitment | -0.1950 | 35.66 | 35.47 | 35.66 | 35.47 |
| Initial numbers old shell males small length bins | 0.0063 | 2.21 | 2.22 | 2.21 | 2.22 |
| ret fishery length | 0.4630 | 352.94 | 353.40 | 352.94 | 353.40 |
| total fish length | 0.2220 | 787.15 | 787.37 | 787.15 | 787.37 |
| female fish length | 0.1900 | 228.95 | 229.14 | 228.95 | 229.14 |
| survey length | -3.7000 | 3845.13 | 3841.43 | 3845.13 | 3841.43 |

| | | | | | |
|---|---|---|---|---|---|
| trawl length | 0.3950 | 274.61 | 275.01 | 274.61 | 275.01 |
| 2009 BSFRF length | 0.1867 | -83.22 | -83.03 | -83.22 | -83.03 |
| 2009 NMFS study area length | 0.1337 | -71.02 | -70.89 | -71.02 | -70.89 |
| M prior | -0.1079 | 9.62 | 9.51 | 9.62 | 9.51 |
| maturity smooth | 0.3006 | 57.29 | 57.59 | 57.29 | 57.59 |
| growth males | 0.1238 | 35.56 | 35.68 | 35.56 | 35.68 |
| growth females | 0.2480 | 47.04 | 47.29 | 47.04 | 47.29 |
| 2009 BSFRF biomass | 0.0028 | 0.14 | 0.15 | 0.14 | 0.15 |
| 2009 NMFS study area biomass | 0.0018 | 0.06 | 0.06 | 0.06 | 0.06 |
| retained catch | 0.0204 | 2.36 | 2.38 | 2.36 | 2.38 |
| discard catch | 1.2990 | 115.58 | 116.87 | 115.58 | 116.88 |
| trawl catch | 0.0220 | 9.30 | 9.32 | 9.30 | 9.32 |
| female discard catch | -0.0134 | 23.68 | 23.66 | 23.68 | 23.66 |
| survey biomass | -0.0240 | 192.78 | 192.76 | 192.78 | 192.76 |
| F penalty | 0.1543 | 84.37 | 84.53 | 84.37 | 84.53 |
| 2010 BSFRF Biomass | -0.0276 | 1.50 | 1.47 | 1.50 | 1.47 |
| 2010 NMFS Biomass | 0.0220 | 1.01 | 1.03 | 1.01 | 1.03 |
| initial numbers fit | 0.5140 | 508.09 | 508.61 | 508.09 | 508.61 |
| 2010 BSFRF length | -1.1589 | -58.25 | -59.41 | -58.25 | -59.41 |
| 2010 NMFS length | -0.6091 | -67.07 | -67.68 | -67.07 | -67.68 |
| male survey selectivity smooth constraint | -0.0182 | 3.74 | 3.72 | 3.74 | 3.72 |
| init nos smooth constraint | -0.4954 | 39.81 | 39.31 | 39.81 | 39.31 |
| Total | -2.0441 | 6379.01 | 6376.97 | 6379.01 | 6376.97 |

Table 7. Converged model parameters for Model 1a that were jittered for Model 1a runs (33 parameters total).

| Parameter | Parameter number | Value | Lower Bound | Upper Bound |
|---|---|---|---|---|
| Female intercept (a1) growth | 1 | -5.39197 | -100 | 0 |
| Male intercept(a1) growth | 2 | -17.2445 | -50 | 0 |
| Female slope(b1) growth | 3 | 1.558075 | 1 | 10 |
| Male slope (b1) growth | 4 | 2.01894 | 1 | 5 |
| Male slope (b2) growth | 5 | 1.155349 | 1 | 1.5 |
| Female slope(b2) growth | 6 | 1.059203 | 1 | 2 |
| Fishery selectivity total males length at 50% (log scale) | 7 | 4.66491 | 4 | 5 |
| Fishery selectivity total males slope | 8 | 0.17984 | 0.1 | 0.5 |
| Fishery selectivity retention curve males slope | 9 | 0.415312 | 0.05 | 0.5 |
| Fishery selectivity retention curve males length at 50% | 10 | 95.93984 | 85 | 120 |
| Fishery discard selectivity female slope | 11 | 0.325693 | 0.1 | 0.7 |
| Trawl Fishery selectivity slope | 12 | 0.09767 | 0.01 | 0.3 |
| Trawl Fishery selectivity length at 50% | 13 | 96.68033 | 30 | 120 |
| Survey Q 1978-1981 male probit scale | 14 | 5.925888 | -5 | 6 |
| Survey 1978-1981 length at 95% offset of Q male | 15 | 17.925 | 1 | 100 |
| Survey 1978-1981 length at 50% of Q male | 16 | 42.43859 | 0 | 150 |
| Survey Q 1982-1988 male | 17 | 0.638551 | 0.2 | 1 |
| Survey 1982-1988 length at 95% offset of Q male | 18 | 26.94738 | 1 | 100 |
| Survey 1982-1988 length at 50% of Q male | 19 | 43.4525 | 25 | 80 |
| Survey Q 1989-present male | 20 | 0.579889 | 0.2 | 1 |
| Survey 1989-present, length at 95% offset of Q male | 21 | 19.31858 | 1 | 100 |
| Survey 1989-present length at 50% of Q male | 22 | 38.3319 | 25 | 90 |
| srvind_q - Male BSFRF 2009 Study area Q (availability) | 23 | 0.349569 | 0.1 | 1 |
| srvindfem_q- Female BSFRF 2009 Study area Q (availability) | 24 | 0.359955 | 0.01 | 1 |
| Female BSFRF 2009 Study area length at 95% offset of Q | 25 | 7.34846 | 1 | 60 |
| Female BSFRF 2009 Study are length at 50% of Q | 26 | 51.16671 | -50 | 60 |
| srv10ind_q - Male BSFRF 2010 Study area Q (availability – probit | 27 | 5.723864 | -5 | 6 |
| srv10indfem_q - Female BSFRF 2010 Study area Q (availability) | 28 | 1.061666 | 0.5 | 2 |
| Female Survey 1989-present, length at 95% offset of Q | 29 | 11.68039 | 1 | 100 |
| Female Survey 1989-present length at 50% of Q | 30 | 34.4286 | 0 | 90 |
| Survey Q multiplier (on male Q) 1978-1981 and 1982 to 1988 Female | 31 | 0.89736 | 0.199 | 2 |
| Natural Mortality multiplier (on 0.23) immature females and males | 32 | 1.657344 | 0.2 | 2 |
| Natural Mortality multiplier (on 0.23) mature males | 33 | 1.165298 | 0.2 | 2 |

Table 8. Model 1a 6378.94 total likelihood. Parameter values and gradient for 30 parameters with the largest gradients sorted high to low (without regard to sign). Year is first part of crab year, i.e. 1991 = 1991/92 crab year.

| ParName | Value | Gradient |
|---|---|---|
| Male slope (b1) growth | 2.01894 | 0.029326 |
| Male intercept(a1) | -17.2445 | 0.014686 |
| rec_devf(1985) | 1.629 | 0.012782 |
| rec_devf(1991) | 1.94598 | 0.010129 |
| rec_devf(1984) | 1.0313 | 0.006057 |
| rec_devf(1983) | 0.802609 | 0.004874 |
| Male slope (b2) growth | 1.15535 | 0.004667 |

| | | |
|---|---|---|
| rec_devf(1987) | 1.61367 | 0.004334 |
| rec_devf(2008) | 0.369991 | -0.00302 |
| rec_devf(2009) | 0.665333 | -0.00265 |
| Mmult_imat | 1.65734 | -0.0023 |
| rec_devf(1978) | 0.55086 | -0.00226 |
| fmort_dev(1997) | 0.339361 | 0.002189 |
| mean_log_rec1 | 13.797 | 0.002125 |
| rec_devf(1979) | 0.42013 | -0.00206 |
| fmort_dev(1992) | 1.33856 | 0.001963 |
| rec_devf(2007) | -1.29906 | -0.00173 |
| rec_devf(1982) | 0.309384 | 0.001684 |
| rec_devf(1980) | 0.044289 | -0.00167 |
| rec_devf(2005) | -0.00838 | -0.00159 |
| rec_devf(2002) | 0.443464 | -0.00157 |
| rec_devf(2010) | 0.170802 | -0.00153 |
| rec_devf(2004) | -0.21254 | -0.00151 |
| rec_devf(2006) | -1.85694 | -0.0015 |
| rec_devf(2003) | 0.834166 | -0.0015 |
| rec_devf(1988) | -1.44509 | -0.00143 |
| rec_devf(2013) | 0.338823 | -0.00137 |
| rec_devf(2011) | 0.068319 | -0.00134 |
| log_avg_sel50_mn | 4.66491 | -0.00134 |
| rec_devf(2012) | 0.414206 | -0.00134 |

Table 9. Likelihood values for Model 1a, Model 0a, Model 0, Model 1 and Model 1b.

| Like Component | Model 1a | Model 0a | Model 0 sept 2015 | Model 1 sept 2015 | Model 1b |
|---|---|---|---|---|---|
| Recruitment | 35.59 | 35.59 | 35.66 | 35.47 | 35.59 |
| Initial numbers old shell males small length bins | 2.22 | 2.22 | 2.21 | 2.22 | 2.22 |
| ret fishery length | 353.12 | 353.12 | 352.94 | 353.40 | 353.12 |
| total fish length | 787.22 | 787.22 | 787.15 | 787.37 | 787.22 |
| female fish length | 229.01 | 229.01 | 228.95 | 229.14 | 229.01 |
| survey length | 3844.24 | 3844.24 | 3845.13 | 3841.43 | 3844.24 |
| trawl length | 274.75 | 274.75 | 274.61 | 275.01 | 274.75 |
| 2009 BSFRF length | -83.20 | -83.20 | -83.22 | -83.03 | -83.20 |
| 2009 NMFS study area length | -70.99 | -70.99 | -71.02 | -70.89 | -70.99 |
| M prior | 9.59 | 9.59 | 9.62 | 9.51 | 9.59 |
| maturity smooth | 57.04 | 57.04 | 57.29 | 57.59 | 57.04 |
| growth males | 35.59 | 35.59 | 35.56 | 35.68 | 35.59 |
| growth females | 47.73 | 47.73 | 47.04 | 47.29 | 47.73 |
| 2009 BSFRF biomass | 0.14 | 0.14 | 0.14 | 0.15 | 0.14 |
| 2009 NMFS study area biomass | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 |
| retained catch | 2.36 | 2.36 | 2.36 | 2.38 | 2.36 |

| | | | | | |
|---|---|---|---|---|---|
| discard catch | 116.05 | 116.05 | 115.58 | 116.88 | 116.05 |
| trawl catch | 9.30 | 9.30 | 9.30 | 9.32 | 9.30 |
| female discard catch | 23.68 | 23.68 | 23.68 | 23.66 | 23.68 |
| survey biomass | 192.73 | 192.73 | 192.78 | 192.76 | 192.73 |
| F penalty | 84.42 | 84.42 | 84.37 | 84.53 | 84.42 |
| 2010 BSFRF Biomass | 1.49 | 1.49 | 1.50 | 1.47 | 1.49 |
| 2010 NMFS Biomass | 1.02 | 1.02 | 1.01 | 1.03 | 1.02 |
| initial numbers fit | 508.25 | 508.25 | 508.09 | 508.61 | 508.25 |
| 2010 BSFRF length | -58.61 | -58.61 | -58.25 | -59.41 | -58.61 |
| 2010 NMFS length | -67.26 | -67.26 | -67.07 | -67.68 | -67.26 |
| male survey selectivity smooth constraint | 3.74 | 3.74 | 3.74 | 3.72 | 3.74 |
| init nos smooth constraint | 39.69 | 39.69 | 39.81 | 39.31 | 39.69 |
| Total | 6378.94 | 6378.94 | 6379.01 | 6376.97 | 6378.94 |

Table 10. Converged model parameters for Model 0a that were jittered for Model 0a runs (33 parameters total).

| Parameter | Parameter number | Value | Lower Bound | Upper Bound |
|---|---|---|---|---|
| Female intercept (a1) growth | 1 | -5.39198 | -100 | 0 |
| Male intercept(a1) growth | 2 | -17.2445 | -50 | 0 |
| Female slope(b1) growth | 3 | 1.558075 | 1 | 10 |
| Male slope (b1) growth | 4 | 2.018941 | 1 | 5 |
| Male slope (b2) growth | 5 | 1.155349 | 1 | 1.5 |
| Female slope(b2) growth | 6 | 1.059203 | 1 | 2 |
| Fishery selectivity total males length at 50% (log scale) | 7 | 4.66491 | 4 | 5 |
| Fishery selectivity total males slope | 8 | 0.17984 | 0.1 | 0.5 |
| Fishery selectivity retention curve males slope | 9 | 0.415312 | 0.05 | 0.5 |
| Fishery selectivity retention curve males length at 50% | 10 | 95.93984 | 85 | 120 |
| Fishery discard selectivity female slope | 11 | 0.325693 | 0.1 | 0.7 |
| Trawl Fishery selectivity slope | 12 | 0.09767 | 0.01 | 0.3 |
| Trawl Fishery selectivity length at 50% | 13 | 96.68032 | 30 | 120 |
| Survey Q 1978-1981 male | 14 | 1 | -5 | 6 |
| Survey 1978-1981 length at 95% of Q male | 15 | 60.36359 | 1 | 100 |
| Survey 1978-1981 length at 50% of Q male | 16 | 42.43859 | 0 | 150 |
| Survey Q 1982-1988 male | 17 | 0.638551 | 0.2 | 1 |
| Survey 1982-1988 length at 95% of Q male | 18 | 70.39986 | 1 | 100 |
| Survey 1982-1988 length at 50% of Q male | 19 | 43.45249 | 25 | 80 |
| Survey Q 1989-present male | 20 | 0.579889 | 0.2 | 1 |
| Survey 1989-present, length at 95% of Q male | 21 | 57.65047 | 1 | 100 |
| Survey 1989-present length at 50% of Q male | 22 | 38.3319 | 25 | 90 |

| | | | | |
|---|---|---|---|---|
| srvind_q - Male BSFRF 2009 Study area Q (availability) | 23 | 0.349569 | 0.1 | 1 |
| srvindfem_q- Female BSFRF 2009 Study area Q (availability) | 24 | 0.359954 | 0.01 | 1 |
| Female BSFRF 2009 Study area length at 95% of Q | 25 | 58.51516 | 1 | 60 |
| Female BSFRF 2009 Study are length at 50% of Q | 26 | 51.16671 | -50 | 60 |
| srv10ind_q - Male BSFRF 2010 Study area Q (availability ) | 27 | 1 | -5 | 6 |
| srv10indfem_q - Female BSFRF 2010 Study area Q (availability) | 28 | 1.061666 | 0.5 | 2 |
| Female Survey 1989-present, length at 95% of Q | 29 | 46.10899 | 1 | 100 |
| Female Survey 1989-present length at 50% of Q | 30 | 34.4286 | 0 | 90 |
| Survey Q multiplier (on male Q) 1978-1981 and 1982 to 1988 Female | 31 | 0.89736 | 0.199 | 2 |
| Natural Mortality multiplier (on 0.23) immature females and males | 32 | 1.657344 | 0.2 | 2 |
| Natural Mortality multiplier (on 0.23) mature males | 33 | 1.165298 | 0.2 | 2 |

Table 11. Model 0a, 6378.94 total likelihood. Parameter values and gradient for 30 parameters with the largest gradients sorted high to low (without regard to sign). Year is first part of crab year, i.e. 1991 = 1991/92 crab year.

| ParName | Value | Gradient |
|---|---|---|
| Male slope (b1) growth | 2.01894 | 0.008872 |
| rec_devf(1985) | 1.629 | 0.005677 |
| Male intercept(a1) growth | -17.2445 | 0.004437 |
| rec_devf(1984) | 1.0313 | 0.002093 |
| rec_devf(1983) | 0.802609 | 0.001845 |
| Male slope (b2) growth | 1.15535 | 0.00158 |
| fmort_dev(1997) | 0.339361 | -0.00127 |
| fmort_dev(1998) | 0.390948 | 0.001238 |
| fmort_dev(1991) | 1.49895 | 0.001193 |
| Mmult_imat | 1.65734 | -0.00114 |
| fmort_dev(1990) | 1.21565 | -0.00108 |
| rec_devf(1987) | 1.61367 | 0.00107 |
| rec_devf(1991) | 1.94598 | 0.001025 |
| mean_log_rec1 | 13.797 | 0.000964 |
| rec_devf(2009) | 0.665334 | -0.00088 |
| rec_devf(2008) | 0.369991 | -0.00081 |
| rec_devf(1982) | 0.309384 | 0.000688 |
| rec_devf(2010) | 0.170802 | -0.00066 |
| rec_devf(2013) | 0.338823 | -0.00062 |
| rec_devf(2014) | 1.82742 | -0.00061 |
| rec_devf(2007) | -1.29906 | -0.00061 |
| rec_devf(2012) | 0.414206 | -0.00061 |
| rec_devf(1989) | -0.48754 | -0.00061 |
| rec_devf(2011) | 0.068319 | -0.00061 |
| rec_devf(1988) | -1.44508 | -0.00056 |
| rec_devf(2006) | -1.85694 | -0.00056 |
| rec_devf(1995) | -1.89734 | -0.00055 |
| rec_devf(2000) | -1.09856 | -0.00051 |
| rec_devf(1996) | -1.56236 | -0.00051 |
| rec_devf(1990) | -0.31908 | -0.0005 |

Table 11a. Model estimates of female mature biomass in 2015, male mature biomass in 2015 and Mature male biomass at mating in 2014/15 for models 0, 1, 0a and 1a.

| | Model 0 | Model 1 | Model 0a | Model 1a |
|---|---|---|---|---|
| female mature biomass 2015 | 292.188 | 294.499 | 292.648 | 292.648 |
| male mature biomass 2015 | 262.837 | 262.127 | 262.381 | 262.381 |
| MMB at mating 2014/15 | 168.035 | 167.426 | 167.684 | 167.684 |

Table 12. Converged model parameters for Model 1b that were jittered (34 parameters total).

| Parameter | Parameter number | Value | Lower Bound | Upper Bound |
|---|---|---|---|---|
| Female intercept (a1) growth | 1 | -5.39198 | -100 | 0 |
| Male intercept(a1) growth | 2 | -17.2431 | -50 | 0 |
| Female slope(b1) growth | 3 | 1.558075 | 1 | 10 |
| Male slope (b1) growth | 4 | 2.01888 | 1 | 5 |
| Male slope (b2) growth | 5 | 1.155349 | 1 | 1.5 |
| Female slope(b2) growth | 6 | 1.059203 | 1 | 2 |
| male delta | 7 | 27.26644 | 10 | 50 |
| Fishery selectivity total males length at 50% (log scale) | 8 | 4.66491 | 4 | 5 |
| Fishery selectivity total males slope | 9 | 0.17984 | 0.1 | 0.5 |
| Fishery selectivity retention curve males slope | 10 | 0.415312 | 0.05 | 0.5 |
| Fishery selectivity retention curve males length at 50% | 11 | 95.93984 | 85 | 120 |
| Fishery discard selectivity female slope | 12 | 0.325693 | 0.1 | 0.7 |
| Trawl Fishery selectivity slope | 13 | 0.09767 | 0.01 | 0.3 |
| Trawl Fishery selectivity length at 50% | 14 | 96.68033 | 30 | 120 |
| Survey Q 1978-1981 male probit scale | 15 | 5.85451 | -5 | 6 |
| Survey 1978-1981 length at 95% offset of Q male | 16 | 17.92499 | 1 | 100 |
| Survey 1978-1981 length at 50% of Q male | 17 | 42.43859 | 0 | 150 |
| Survey Q 1982-1988 male | 18 | 0.638551 | 0.2 | 1 |
| Survey 1982-1988 length at 95% offset of Q male | 19 | 26.94736 | 1 | 100 |
| Survey 1982-1988 length at 50% of Q male | 20 | 43.45249 | 25 | 80 |
| Survey Q 1989-present male | 21 | 0.579889 | 0.2 | 1 |
| Survey 1989-present, length at 95% offset of Q male | 22 | 19.31856 | 1 | 100 |
| Survey 1989-present length at 50% of Q male | 23 | 38.3319 | 25 | 90 |
| srvind_q - Male BSFRF 2009 Study area Q (availability) | 24 | 0.349569 | 0.1 | 1 |
| srvindfem_q- Female BSFRF 2009 Study area Q (availability) | 25 | 0.359954 | 0.01 | 1 |
| Female BSFRF 2009 Study area length at 95% offset of Q | 26 | 7.34846 | 1 | 60 |
| Female BSFRF 2009 Study are length at 50% of Q | 27 | 51.16671 | -50 | 60 |
| srv10ind_q - Male BSFRF 2010 Study area Q (availability – probit | 28 | 5.731918 | -5 | 6 |
| srv10indfem_q - Female BSFRF 2010 Study area Q (availability) | 29 | 1.061666 | 0.5 | 2 |
| Female Survey 1989-present, length at 95% offset of Q | 30 | 11.68039 | 1 | 100 |
| Female Survey 1989-present length at 50% of Q | 31 | 34.4286 | 0 | 90 |
| Survey Q multiplier (on male Q) 1978-1981 and 1982 to 1988 Female | 32 | 0.89736 | 0.199 | 2 |
| Natural Mortality multiplier (on 0.23) immature females and males | 33 | 1.657344 | 0.2 | 2 |
| Natural Mortality multiplier (on 0.23) mature males | 34 | 1.165298 | 0.2 | 2 |

Table 13. Model 1b 6378.94 total likelihood. Parameter values and gradient for 30 parameters with the largest gradients sorted high to low (without regard to sign). Year is first part of crab year, i.e. 1991 = 1991/92 crab year.

| ParName | Value | Gradient |
|---|---|---|
| rec_devf(1987) | 1.61367 | 0.004664 |
| rec_devf(1991) | 1.94598 | 0.002851 |
| rec_devf(1985) | 1.629 | -0.00218 |
| fmort_dev(1997) | 0.339361 | 0.001675 |
| rec_devf(1979) | 0.42013 | -0.00132 |
| rec_devf(1982) | 0.309384 | -0.00111 |
| rec_devf(1978) | 0.55086 | -0.0011 |
| rec_devf(1980) | 0.044289 | -0.00104 |
| rec_devf(1984) | 1.0313 | -0.00092 |
| rec_devf(1983) | 0.80261 | -0.00088 |
| fmort_dev(1991) | 1.49896 | -0.00078 |
| fmort_dev(1993) | 0.79473 | 0.000622 |
| rec_devf(2008) | 0.369991 | 0.000568 |
| Male slope (b1) growth | 2.01888 | -0.00053 |
| rec_devf(1981) | -1.05673 | -0.0005 |
| fmort_dev(1994) | 0.454175 | 0.00048 |
| fmort_dev(1996) | -0.07282 | -0.00045 |
| rec_devf(2009) | 0.665334 | 0.00045 |
| fmort_dev(1992) | 1.33856 | -0.00042 |
| rec_devf(1989) | -0.48755 | 0.000415 |
| rec_devf(1992) | 0.60046 | 0.000356 |
| fmort_dev(1987) | 0.810006 | -0.00031 |
| Female slope(b1) growth | 1.55808 | 0.000302 |
| fmort_dev(2014) | -0.07035 | 0.000295 |
| rec_devf(1988) | -1.44509 | 0.000282 |
| Male intercept(a1) growth | -17.2431 | -0.00027 |
| rec_devf(2003) | 0.834166 | -0.00027 |
| rec_devf(1990) | -0.31908 | 0.000268 |
| fmort_dev(1988) | 0.932559 | -0.00026 |
| fmort_dev(1979) | 0.333626 | -0.00025 |

Table 14. Converged model parameters for Model 2 that were jittered (35 parameters total).

| Parameter | Parameter | Value | Lower | Upper Bound |
|---|---|---|---|---|
| Female intercept (a1) growth | 1 | -11.037 | -100 | 0 |
| Male intercept(a1) growth | 2 | -17.2155 | -50 | 0 |
| Female slope(b1) growth | 3 | 1.8254 | 1 | 10 |
| Male slope (b1) growth | 4 | 2.0177 | 1 | 5 |
| Male slope (b2) growth | 5 | 1.1516 | 1 | 1.5 |
| Female slope(b2) growth | 6 | 1.0453 | 1 | 2 |
| male delta | 7 | 27.2735 | 10 | 50 |
| Female delta | 8 | 27.4506 | 5 | 50 |
| Fishery selectivity total males length at 50% (log scale) | 9 | 4.6823 | 4 | 5 |
| Fishery selectivity total males slope | 10 | 0.1797 | 0.1 | 0.5 |
| Fishery selectivity retention curve males slope | 11 | 0.4135 | 0.05 | 0.5 |
| Fishery selectivity retention curve males length at 50% | 12 | 95.6632 | 85 | 120 |
| Fishery discard selectivity female slope | 13 | 0.3257 | 0.1 | 0.7 |

| | | | | |
|---|---|---|---|---|
| Trawl Fishery selectivity slope | 14 | 0.0845 | 0.01 | 0.3 |
| Trawl Fishery selectivity length at 50% | 15 | 111.7164 | 30 | 120 |
| Survey Q 1978-1981 male probit scale | 16 | 5.9288 | -5 | 6 |
| Survey 1978-1981 length at 95% offset of Q male | 17 | 17.4309 | 1 | 100 |
| Survey 1978-1981 length at 50% of Q male | 18 | 41.557 | 0 | 150 |
| Survey Q 1982-1988 male | 19 | 0.7035 | 0.2 | 1 |
| Survey 1982-1988 length at 95% offset of Q male | 20 | 28.6816 | 1 | 100 |
| Survey 1982-1988 length at 50% of Q male | 21 | 44.6546 | 25 | 80 |
| Survey Q 1989-present male | 22 | 0.6217 | 0.2 | 1 |
| Survey 1989-present, length at 95% offset of Q male | 23 | 19.3515 | 1 | 100 |
| Survey 1989-present length at 50% of Q male | 24 | 38.2445 | 25 | 90 |
| srvind_q - Male BSFRF 2009 Study area Q (availability) | 25 | 0.3444 | 0.1 | 1 |
| srvindfem_q- Female BSFRF 2009 Study area Q (availability) | 26 | 0.3714 | 0.01 | 1 |
| Female BSFRF 2009 Study area length at 95% offset of Q | 27 | 7.3873 | 1 | 60 |
| Female BSFRF 2009 Study are length at 50% of Q | 28 | 51.1291 | -50 | 60 |
| srv10ind_q - Male BSFRF 2010 Study area Q (availability – probit | 29 | 5.609 | -5 | 6 |
| srv10indfem_q - Female BSFRF 2010 Study area Q (availability) | 30 | 1.0849 | 0.5 | 2 |
| Female Survey 1989-present, length at 95% offset of Q | 31 | 11.5752 | 1 | 100 |
| Female Survey 1989-present length at 50% of Q | 32 | 33.9791 | 0 | 90 |
| Survey Q multiplier (on male Q) 1978-1981 and 1982 to 1988 Female | 33 | 0.879 | 0.199 | 2 |
| Natural Mortality multiplier (on 0.23) immature females and males | 34 | 1.6418 | 0.2 | 2 |
| Natural Mortality multiplier (on 0.23) mature males | 35 | 1.1564 | 0.2 | 2 |

Table 15. Model 2 6302.16 total likelihood. Parameter values and gradient for 30 parameters with the largest gradients sorted high to low (without regard to sign). Year is first part of crab year, i.e. 1991 = 1991/92 crab year.

| ParName | Value | Gradient |
|---|---|---|
| rec_devf(1985) | 1.67056 | 0.008113 |
| Male slope (b1) growth | 2.01743 | 0.007766 |
| rec_devf(1984) | 1.04242 | 0.004078 |
| Male intercept(a1) growth | -17.2101 | 0.003869 |
| deltam | 27.2734 | 0.002795 |
| rec_devf(1991) | 1.8961 | -0.00149 |
| rec_devf(2003) | 0.841907 | -0.00142 |
| Male slope (b2) growth | 1.15175 | 0.001251 |
| rec_devf(1983) | 0.820212 | 0.001223 |
| rec_devf(2002) | 0.380462 | -0.00109 |
| rec_devf(1987) | 1.61402 | -0.00108 |
| fmort_dev(1991) | 1.50907 | 0.000741 |
| fmort_dev(1997) | 0.301756 | -0.00069 |
| fmort_dev(1990) | 1.22377 | 0.000688 |
| rec_devf(2004) | -0.18802 | -0.00067 |
| fmort_dev(1989) | 0.634987 | -0.00066 |
| rec_devf(1979) | 0.390853 | -0.00064 |
| rec_devf(2001) | -0.40268 | -0.00056 |
| fmort_dev(2011) | 0.009004 | -0.00056 |
| Mmult_imat | 1.64233 | -0.00053 |
| rec_devf(2005) | 0.038975 | -0.00053 |
| rec_devf(1986) | 0.11499 | 0.000519 |
| rec_devf(1980) | 0.065381 | -0.0005 |
| rec_devf(1978) | 0.516755 | -0.00046 |
| mean_log_rec1 | 13.7476 | 0.000453 |
| fish_fit_sel50_mn | 95.6683 | -0.0004 |

| | | |
|---|---|---|
| rec_devf(1990) | -0.50186 | -0.0004 |
| rec_devf(2000) | -1.18717 | -0.00039 |
| rec_devf(1989) | -0.43074 | -0.00039 |
| rec_devf(1992) | 0.800953 | -0.00038 |

Table 16. Model 2 maximum gradient count for 95 of 100 jitter runs that wrote std file.

| Gradient less than | Number of runs |
|---|---|
| 0.001 | 5 |
| 0.002 | 7 |
| 0.005 | 26 |
| 0.01 | 19 |
| 0.02 | 24 |
| 0.03 | 10 |
| 0.04 | 3 |
| 0.05 | 0 |
| 0.055664 | 1 |

Table 17. Model 2 likelihood values with maximum gradient less than 0.001 of 95 jittered runs that wrote std file.

| | 0.00057 | 0.00078 | 0.00082 | 0.00082 | 0.00091 |
|---|---|---|---|---|---|
| 6302.16 | 0 | 0 | 0 | 1 | 0 |
| 6302.38 | 0 | 0 | 1 | 0 | 0 |
| 6302.53 | 0 | 0 | 0 | 0 | 1 |
| 6309.83 | 1 | 1 | 0 | 0 | 0 |

Table 18. Model 3 frequency of total likelihoods for 100 jittered runs.

| Likelihood | Freq |
|---|---|
| 6294.54 | 8 |
| 6294.67 | 3 |
| 6294.69 | 2 |
| 6294.77 | 1 |
| 6294.89 | 1 |
| 6296.89 | 1 |
| 6297.02 | 1 |
| 6297.04 | 1 |
| 6297.24 | 1 |

| | |
|---|---|
| 6302.03 | 22 |
| 6302.15 | 12 |
| 6302.16 | 10 |
| 6302.17 | 2 |
| 6302.18 | 4 |
| 6302.26 | 2 |
| 6302.28 | 1 |
| 6302.38 | 2 |
| 6302.4 | 1 |
| 6303.3 | 1 |
| 6303.87 | 8 |
| 6303.99 | 3 |
| 6304.01 | 4 |
| 6329.52 | 2 |
| 6329.55 | 1 |
| 6329.93 | 1 |

Table 19. Model 3. Maximum gradient by total Likelihood for 95 jittered runs that wrote the std file.

| | (0,0.001] | (0.001,0.002] | (0.002,0.005] | (0.005,0.01] | (0.01,0.02] | (0.02,0.03] | (0.03,0.04] | (0.04,0.05] |
|---|---|---|---|---|---|---|---|---|
| 6294.54 | 1 | 0 | 3 | 3 | 0 | 1 | 0 | 0 |
| 6294.67 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| 6294.69 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| 6294.77 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6294.89 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 6296.89 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 6297.02 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 6297.04 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 6297.24 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 6302.03 | 4 | 0 | 5 | 7 | 3 | 1 | 1 | 1 |
| 6302.15 | 1 | 3 | 5 | 0 | 2 | 0 | 1 | 0 |
| 6302.16 | 2 | 0 | 3 | 2 | 1 | 2 | 0 | 0 |
| 6302.17 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| 6302.18 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| 6302.26 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 |
| 6302.28 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6302.38 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| 6302.4 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 6303.3 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 6303.87 | 0 | 0 | 2 | 3 | 2 | 0 | 1 | 0 |
| 6303.99 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 0 |
| 6304.01 | 0 | 0 | 1 | 0 | 2 | 1 | 0 | 0 |
| 6329.52 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 6329.55 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6329.93 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| | | | | | | | | |
| Total | 11 | 5 | 24 | 29 | 13 | 8 | 4 | 1 |

Table 20. Converged model parameters for Model 3 that were jittered (35 parameters total).

| Parameter | Parameter number | Value | Lower Bound | Upper Bound |
|---|---|---|---|---|
| Female intercept (a1) growth | 1 | -10.9365 | -100 | 0 |
| Male intercept(a1) growth | 2 | -6.91 | -50 | 0 |
| Female slope(b1) growth | 3 | 1.8207 | 1 | 10 |
| Male slope (b1) growth | 4 | 1.5676 | 1 | 5 |
| Male slope (b2) growth | 5 | 1.15 | 1 | 1.5 |
| Female slope(b2) growth | 6 | 1.046 | 1 | 2 |
| male delta | 7 | 31.9898 | 10 | 50 |
| Female delta | 8 | 27.4625 | 5 | 50 |
| Fishery selectivity total males length at 50% (log scale) | 9 | 4.6847 | 4 | 5 |
| Fishery selectivity total males slope | 10 | 0.1783 | 0.1 | 0.5 |
| Fishery selectivity retention curve males slope | 11 | 0.4128 | 0.05 | 0.5 |
| Fishery selectivity retention curve males length at 50% | 12 | 95.7076 | 85 | 120 |
| Fishery discard selectivity female slope | 13 | 0.3259 | 0.1 | 0.7 |
| Trawl Fishery selectivity slope | 14 | 0.0841 | 0.01 | 0.3 |
| Trawl Fishery selectivity length at 50% | 15 | 112.3107 | 30 | 120 |
| Survey Q 1978-1981 male probit scale | 16 | 5.8951 | -5 | 6 |
| Survey 1978-1981 length at 95% offset of Q male | 17 | 17.0878 | 1 | 100 |
| Survey 1978-1981 length at 50% of Q male | 18 | 41.5664 | 0 | 150 |
| Survey Q 1982-1988 male | 19 | 0.7219 | 0.2 | 1 |
| Survey 1982-1988 length at 95% offset of Q male | 20 | 29.0436 | 1 | 100 |
| Survey 1982-1988 length at 50% of Q male | 21 | 45.5612 | 25 | 80 |
| Survey Q 1989-present male | 22 | 0.6008 | 0.2 | 1 |
| Survey 1989-present, length at 95% offset of Q male | 23 | 18.8843 | 1 | 100 |
| Survey 1989-present length at 50% of Q male | 24 | 38.4431 | 25 | 90 |
| srvind_q - Male BSFRF 2009 Study area Q (availability) | 25 | 0.3361 | 0.1 | 1 |
| srvindfem_q- Female BSFRF 2009 Study area Q (availability) | 26 | 0.3726 | 0.01 | 1 |
| Female BSFRF 2009 Study area length at 95% offset of Q | 27 | 7.3867 | 1 | 60 |
| Female BSFRF 2009 Study are length at 50% of Q | 28 | 51.1527 | -50 | 60 |
| srv10ind_q - Male BSFRF 2010 Study area Q (availability – probit | 29 | 5.8561 | -5 | 6 |
| srv10indfem_q - Female BSFRF 2010 Study area Q (availability) | 30 | 1.0608 | 0.5 | 2 |
| Female Survey 1989-present, length at 95% offset of Q | 31 | 11.614 | 1 | 100 |
| Female Survey 1989-present length at 50% of Q | 32 | 34.0513 | 0 | 90 |
| Survey Q multiplier (on male Q) 1978-1981 and 1982 to 1988 | 33 | 0.8732 | 0.199 | 2 |
| Natural Mortality multiplier (on 0.23) immature females and males | 34 | 1.6566 | 0.2 | 2 |
| Natural Mortality multiplier (on 0.23) mature males | 35 | 1.1565 | 0.2 | 2 |

Table 21. Model 3 6294.54 total likelihood. Parameter values and gradient for 30 parameters with the largest gradients sorted high to low (without regard to sign). Year is first part of crab year, i.e. 1991 = 1991/92 crab year.

| ParName | Value | Gradient |
|---|---|---|
| Male slope (b1) growth | 1.5675 | 0.0140 |
| rec_devf(1985) | 1.6476 | 0.0065 |
| Male intercept(a1) growth | -6.9070 | 0.0052 |
| Deltam | 31.9889 | 0.0030 |
| rec_devf(1984) | 1.0628 | 0.0026 |
| Male slope (b2) growth | 1.1501 | 0.0023 |
| rec_devf(1991) | 1.9232 | 0.0018 |

| | | |
|---|---|---|
| fmort_dev2(1997) | 0.5314 | 0.0014 |
| rec_devf(1992) | 0.7922 | -0.0014 |
| rec_devf(1979) | 0.3450 | 0.0011 |
| fmort_dev2(1998) | 0.5687 | -0.0011 |
| rec_devf(1993) | -0.0748 | -0.0011 |
| rec_devf(2005) | 0.0454 | -0.0010 |
| Mmult_imat | 1.6571 | -0.0010 |
| rec_devf(2003) | 0.8821 | -0.0010 |
| log_avg_sel50_mn | 4.6844 | -0.0010 |
| rec_devf(1978) | 0.4291 | 0.0009 |
| rec_devf(1980) | 0.0352 | 0.0009 |
| fmort_dev2(1996) | 0.1519 | 0.0009 |
| rec_devf(1983) | 0.8072 | 0.0009 |
| mean_log_rec1 | 13.7873 | 0.0009 |
| rec_devf(1982) | 0.3958 | 0.0008 |
| rec_devf(2004) | -0.2607 | -0.0008 |
| rec_devf(1987) | 1.6226 | 0.0008 |
| rec_devf(1986) | 0.2540 | 0.0008 |
| rec_devf(2002) | 0.3989 | -0.0008 |
| rec_devf(1998) | 0.1486 | -0.0007 |
| rec_devf(2001) | -0.3982 | -0.0006 |
| fmort_dev1(1989) | 0.2619 | -0.0006 |
| rec_devf(1994) | -1.2243 | -0.0006 |

Table 22. Model 4. Maximum gradient by total Likelihood for 95 jittered runs that wrote the std file.

| | (0,0.001] | (0.001,0.002] | (0.002,0.005] | (0.005,0.01] | (0.01,0.02] | (0.02,0.03] | (0.03,0.04] | (0.04,0.05] |
|---|---|---|---|---|---|---|---|---|
| 6261.13 | 1 | 2 | 7 | 7 | 3 | 2 | 0 | 0 |
| 6261.26 | 1 | 1 | 4 | 3 | 1 | 0 | 0 | 0 |
| 6261.28 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6261.37 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| 6261.38 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 6261.51 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6261.72 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 6263.47 | 1 | 0 | 2 | 1 | 1 | 0 | 0 | 0 |
| 6263.61 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 6263.72 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 6268.61 | 4 | 2 | 5 | 2 | 8 | 0 | 0 | 0 |
| 6268.74 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| 6268.75 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| 6268.76 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 |
| 6268.84 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| 6268.86 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| 6268.89 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 6268.98 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 6270.45 | 0 | 0 | 1 | 3 | 2 | 0 | 0 | 0 |
| 6270.58 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 6270.6 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| 6271.47 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 6271.68 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 6295.17 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 6295.93 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |

Table 22a. Model 4 frequency of total Likelihoods.

| Var1 | Freq |
|---|---|
| 6261.13 | 22 |
| 6261.26 | 10 |
| 6261.28 | 1 |
| 6261.37 | 2 |
| 6261.38 | 1 |
| 6261.51 | 1 |

| | |
|---|---|
| 6261.72 | 1 |
| 6263.47 | 5 |
| 6263.61 | 1 |
| 6263.72 | 1 |
| 6268.61 | 22 |
| 6268.74 | 3 |
| 6268.75 | 2 |
| 6268.76 | 3 |
| 6268.84 | 3 |
| 6268.86 | 2 |
| 6268.89 | 1 |
| 6268.98 | 1 |
| 6270.45 | 6 |
| 6270.58 | 1 |
| 6270.6 | 2 |
| 6271.47 | 1 |
| 6271.68 | 1 |
| 6295.17 | 1 |
| 6295.93 | 1 |
| Number of runs | 95 |

Table 23. Converged model parameters for Model 4 that were jittered (35 parameters total).

| Parameter | Parameter number | Value | Lower Bound | Upper Bound |
|---|---|---|---|---|
| Female intercept (a1) growth | 1 | -3.0199 | -100 | 0 |
| Male intercept(a1) growth | 2 | -6.8866 | -50 | 0 |
| Female slope(b1) growth | 3 | 1.444 | 1 | 10 |
| Male slope (b1) growth | 4 | 1.5655 | 1 | 5 |
| Male slope (b2) growth | 5 | 1.1509 | 1 | 1.5 |
| Female slope(b2) growth | 6 | 1.0593 | 1 | 2 |
| male delta | 7 | 31.9924 | 10 | 50 |
| Female delta | 8 | 33.0671 | 5 | 50 |
| Fishery selectivity total males length at 50% (log scale) | 9 | 4.6844 | 4 | 5 |
| Fishery selectivity total males slope | 10 | 0.1789 | 0.1 | 0.5 |
| Fishery selectivity retention curve males slope | 11 | 0.4121 | 0.05 | 0.5 |
| Fishery selectivity retention curve males length at 50% | 12 | 95.6961 | 85 | 120 |
| Fishery discard selectivity female slope | 13 | 0.3254 | 0.1 | 0.7 |
| Trawl Fishery selectivity slope | 14 | 0.0843 | 0.01 | 0.3 |
| Trawl Fishery selectivity length at 50% | 15 | 112.2367 | 30 | 120 |
| Survey Q 1978-1981 male probit scale | 16 | 5.8841 | -5 | 6 |
| Survey 1978-1981 length at 95% offset of Q male | 17 | 17.0074 | 1 | 100 |
| Survey 1978-1981 length at 50% of Q male | 18 | 41.9968 | 0 | 150 |
| Survey Q 1982-1988 male | 19 | 0.7189 | 0.2 | 1 |
| Survey 1982-1988 length at 95% offset of Q male | 20 | 28.6823 | 1 | 100 |
| Survey 1982-1988 length at 50% of Q male | 21 | 45.7686 | 25 | 80 |
| Survey Q 1989-present male | 22 | 0.6069 | 0.2 | 1 |
| Survey 1989-present, length at 95% offset of Q male | 23 | 19.0672 | 1 | 100 |
| Survey 1989-present length at 50% of Q male | 24 | 38.5728 | 25 | 90 |
| srvind_q - Male BSFRF 2009 Study area Q (availability) | 25 | 0.3387 | 0.1 | 1 |
| srvindfem_q- Female BSFRF 2009 Study area Q (availability) | 26 | 0.3702 | 0.01 | 1 |
| Female BSFRF 2009 Study area length at 95% offset of Q | 27 | 7.4177 | 1 | 60 |
| Female BSFRF 2009 Study are length at 50% of Q | 28 | 51.1718 | -50 | 60 |
| srv10ind_q - Male BSFRF 2010 Study area Q (availability – probit | 29 | 5.8655 | -5 | 6 |
| srv10indfem_q - Female BSFRF 2010 Study area Q (availability) | 30 | 1.0679 | 0.5 | 2 |
| Female Survey 1989-present, length at 95% offset of Q | 31 | 11.5024 | 1 | 100 |
| Female Survey 1989-present length at 50% of Q | 32 | 34.3914 | 0 | 90 |
| Survey Q multiplier (on male Q) 1978-1981 and 1982 to 1988 Female | 33 | 0.8739 | 0.199 | 2 |
| Natural Mortality multiplier (on 0.23) immature females and males | 34 | 1.6791 | 0.2 | 2 |
| Natural Mortality multiplier (on 0.23) mature males | 35 | 1.156 | 0.2 | 2 |

Table 24. Model 4 6261.51 total likelihood single model run (not from jitters). Parameter values and gradient for 30 parameters with the largest gradients sorted high to low (without regard to sign). Year is first part of crab year, i.e. 1991 = 1991/92 crab year.

| ParName | Value | Gradient |
|---|---|---|
| rec_devf(1987) | 1.6241 | 0.004098 |
| rec_devf(1983) | 0.820596 | -0.00248 |
| rec_devf(1984) | 1.04642 | -0.00246 |
| Male slope (b1) growth | 2.01706 | 0.001563 |

| | | |
|---|---|---|
| fmort_dev1(1990) | 0.834194 | -0.00145 |
| rec_devf(1991) | 1.91211 | 0.001269 |
| rec_devf(1986) | 0.16769 | 0.001148 |
| rec_devf(1979) | 0.36827 | 0.000968 |
| rec_devf(1978) | 0.491281 | 0.000924 |
| log_avg_sel50_mn | 4.68303 | 0.000822 |
| rec_devf(1982) | 0.405438 | -0.00075 |
| Male intercept(a1) growth | -17.2016 | 0.000714 |
| rec_devf(2008) | 0.316924 | -0.00069 |
| fmort_dev1(1987) | 0.553602 | 0.000683 |
| rec_devf(2009) | 0.603775 | -0.00068 |
| Male delta | 27.2751 | 0.000628 |
| rec_devf(1980) | 0.05833 | 0.000562 |
| rec_devf(1992) | 0.819333 | -0.00045 |
| rec_devf(1985) | 1.68664 | 0.000429 |
| fmort_dev2(1992) | 1.54607 | 0.000415 |
| Male slope (b2) growth | 1.15165 | 0.000379 |
| fmort_dev1(1985) | -0.64514 | 0.000373 |
| fmort_dev2(1993) | 0.975344 | 0.000363 |
| rec_devf(1998) | 0.127888 | -0.00035 |
| fmort_dev2(1996) | 0.149465 | 0.000347 |
| rec_devf(2003) | 0.858114 | 0.000341 |
| fish_fit_sel50_mn | 95.6912 | -0.00034 |
| fmort_dev2(2014) | 0.18863 | -0.00032 |
| fmort_dev2(1998) | 0.563591 | -0.00031 |
| fmort_dev2(1994) | 0.678262 | -0.00031 |

Table 25. Number of potlifts in the directed snow crab fishery from 1978/79 to 2014/15 used in Model 4 for estimation of female fishing mortality from 1978 to 1991.

| Year (first year of crab year) | Number of potlifts |
|---|---|
| 1978 | 190,746 |
| 1979 | 255,102 |
| 1980 | 435,742 |
| 1981 | 469,091 |
| 1982 | 287,127 |
| 1983 | 173,591 |
| 1984 | 370,082 |
| 1985 | 542,346 |
| 1986 | 616,113 |
| 1987 | 747,395 |
| 1988 | 665,242 |
| 1989 | 912,718 |
| 1990 | 1,394,897 |
| 1991 | 1,281,796 |
| 1992 | 972,118 |
| 1993 | 716,524 |
| 1994 | 507,603 |
| 1995 | 520,685 |
| 1996 | 754,140 |
| 1997 | 930,794 |
| 1998 | 945,533 |
| 1999 | 182,634 |
| 2000 | 191,200 |
| 2001 | 326,977 |
| 2002 | 153,862 |
| 2003 | 123,709 |
| 2004 | 75,095 |
| 2005 | 120,582 |
| 2006 | 89,419 |
| 2007 | 144,039 |
| 2008 | 163,536 |
| 2009 | 137,018 |
| 2010 | 147,244 |
| 2011 | 270,602 |
| 2012 | 225,489 |
| 2013 | 231,614 |
| 2014/15 | 286,920 |

Table 26.  Lambda (weight) multiplier on normal likelihood with equivalent standard deviation.  Where:

$$? \quad ? \sqrt{\frac{È}{É * ?}}$$

Where normal likelihood is:

$$\frac{È}{É?^{?}} ? \quad Æ - ?^{?}$$

| lambda | St. Dev. |
|---|---|
| 1 | 0.707107 |
| 2 | 0.5 |
| 3 | 0.408248 |
| 4 | 0.353553 |
| 5 | 0.316228 |
| 6 | 0.288675 |
| 7 | 0.267261 |
| 8 | 0.25 |
| 9 | 0.235702 |
| 10 | 0.223607 |

Table 27. Frequency of Likelihoods for Model 4a jitter runs.

| Likelihood | Freq |
|---|---|
| 6277.2 | 16 |
| 6277.33 | 9 |
| 6277.34 | 1 |
| 6277.35 | 2 |
| 6277.43 | 3 |
| 6277.44 | 1 |
| 6277.56 | 1 |
| 6277.58 | 1 |
| 6277.65 | 1 |
| 6279.55 | 4 |

| | |
|---|---|
| 6279.68 | 2 |
| 6279.69 | 1 |
| 6279.78 | 1 |
| 6284.71 | 24 |
| 6284.83 | 4 |
| 6284.84 | 2 |
| 6284.85 | 1 |
| 6284.86 | 2 |
| 6284.94 | 4 |
| 6284.97 | 1 |
| 6285.1 | 1 |
| 6286.55 | 8 |
| 6286.67 | 1 |
| 6286.68 | 1 |
| 6286.69 | 1 |
| 6286.77 | 1 |
| 6312.21 | 1 |
| 6312.23 | 1 |
| 6321.46 | 1 |

Table 28. Frequency of Likelihoods by maximum gradient for Model 4a jitter runs.

| | (0,0.001] | (0.001,0.002] | (0.002,0.005] | (0.005,0.01] | (0.01,0.02] | (0.02,0.03] | (0.03,0.04] | (0.04,0.05] |
|---|---|---|---|---|---|---|---|---|
| 6277.2 | 0 | 0 | 4 | 5 | 6 | 1 | 0 | 0 |
| 6277.33 | 2 | 0 | 3 | 2 | 2 | 0 | 0 | 0 |
| 6277.34 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6277.35 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| 6277.43 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 |
| 6277.44 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6277.56 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 6277.58 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 6277.65 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 6279.55 | 0 | 0 | 0 | 1 | 1 | 2 | 0 | 0 |
| 6279.68 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 |
| 6279.69 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 6279.78 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 6284.71 | 3 | 4 | 3 | 6 | 2 | 2 | 3 | 0 |
| 6284.83 | 0 | 1 | 2 | 0 | 1 | 0 | 0 | 0 |
| 6284.84 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| 6284.85 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 6284.86 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 6284.94 | 0 | 0 | 0 | 2 | 2 | 0 | 0 | 0 |
| 6284.97 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 6285.1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 6286.55 | 0 | 1 | 3 | 1 | 2 | 1 | 0 | 0 |
| 6286.67 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 6286.68 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 6286.69 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 6286.77 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 6312.21 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 6312.23 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 6321.46 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| | | | | | | | | |

Table 28a. Parameter value and gradient for the 30 parameters with the highest gradients for Model 4a from single run. 6277.33 likelihood and 0.00469 max gradient.

| Par name | Value | Gradient |
|---|---|---|
| Male slope (b1) growth | 2.01744 | -0.00469 |
| Male intercept(a1) growth | -17.2102 | -0.00212 |
| Male delta | 27.2748 | -0.00211 |
| rec_devf(1987) | 1.61442 | -0.00172 |
| rec_devf(2003) | 0.853075 | -0.00122 |
| rec_devf(1991) | 1.9069 | 0.001179 |
| rec_devf(1982) | 0.395162 | -0.00117 |
| Male slope (b2) growth | 1.15172 | -0.00102 |
| rec_devf(1984) | 1.03838 | 0.00093 |
| Mmult_imat | 1.65865 | 0.000787 |
| mean_log_rec1 | 13.772 | -0.00067 |
| rec_devf(1985) | 1.67506 | -0.00063 |
| rec_devf(1980) | 0.048785 | -0.00062 |
| fmort_dev1(1988) | 0.644492 | -0.00059 |
| fmort_dev1(1987) | 0.547891 | -0.00058 |
| rec_devf(2005) | 0.035622 | -0.00056 |
| log_avg_sel50_mn | 4.68246 | 0.00053 |
| rec_devf(2012) | 0.379959 | 0.000433 |
| rec_devf(2008) | 0.334377 | -0.00043 |
| rec_devf(2013) | 0.279926 | 0.000428 |
| rec_devf(2011) | 0.006927 | 0.000425 |
| rec_devf(2014) | 1.79057 | 0.000419 |
| fmort_dev2(1997) | 0.523749 | 0.000416 |
| fmort_dev2(1992) | 1.55071 | -0.0004 |
| rec_devf(1988) | -1.50224 | 0.000395 |

| | | |
|---|---:|---:|
| rec_devf(1995) | -1.96379 | 0.000387 |
| rec_devf(1979) | 0.36003 | -0.00039 |
| rec_devf(1990) | -0.48304 | 0.000378 |
| rec_devf(2002) | 0.395328 | -0.00037 |
| Mmult | 1.15825 | 0.000373 |

Table 29. Parameter values and gradients for the 30 parameters with the highest gradients for Model 4a from the jitter run with the lowest likelihood (6277.2) and the lowest gradient (0.00259).

| Par name | Value | Gradient |
|---|---:|---:|
| rec_devf(1987) | 1.61467 | 0.00259 |
| Male slope (b1) growth | 2.01768 | 0.001538 |
| rec_devf(1991) | 1.90653 | -0.00133 |
| Male delta | 27.2748 | 0.000693 |
| Male intercept(a1) growth | -17.2155 | 0.000693 |
| rec_devf(1992) | 0.799728 | -0.00064 |
| rec_devf(2003) | 0.853307 | 0.000466 |
| rec_devf(1986) | 0.158027 | 0.000453 |
| rec_devf(1980) | 0.049258 | -0.00044 |
| fmort_dev1(1991) | 1.09895 | -0.0004 |
| fmort_dev2(1992) | 1.55023 | 0.000393 |
| fmort_dev2(1998) | 0.570194 | -0.00036 |
| rec_devf(1979) | 0.360234 | -0.00034 |
| Male slope (b2) growth | 1.15159 | 0.000302 |
| rec_devf(1984) | 1.03931 | -0.0003 |
| fmort_dev1(1990) | 0.8328 | -0.00028 |
| rec_devf(2002) | 0.394409 | 0.000252 |
| rec_devf(1993) | -0.00403 | -0.00023 |
| fmort_dev1(1984) | -1.14694 | 0.000225 |
| fmort_dev1(1979) | -0.25333 | 0.000203 |
| rec_devf(2005) | 0.036954 | 0.000193 |
| fmort_dev1(1989) | 0.260764 | 0.000192 |
| rec_devf(1981) | -0.98483 | -0.00017 |

| | | |
|---|---|---|
| fmort_dev1(1987) | 0.54992 | -0.00016 |
| rec_devf(1983) | 0.812588 | 0.000138 |
| fmort_dev2(1993) | 0.980059 | 0.000136 |
| Immature M multiplier | 1.65807 | -0.00013 |
| fmort_dev1(1986) | -0.23799 | -0.00013 |
| fmort_dev2(1996) | 0.153882 | 0.000123 |
| fmort_dev1(1988) | 0.646469 | 0.000122 |

Table 30. Model 4b maximum gradient by total likelihood values.

| | (0,0.001] | (0.001,0.002] | (0.002,0.005] | (0.005,0.01] | (0.01,0.02] | (0.02,0.03] | (0.03,0.04] | (0.04,0.05] |
|---|---|---|---|---|---|---|---|---|
| 6298.6 | 0 | 1 | 1 | 1 | 2 | 0 | 0 | 0 |
| 6298.64 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 |
| 6298.65 | 1 | 0 | 1 | 1 | 2 | 1 | 0 | 0 |
| 6298.77 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 6298.84 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 6298.85 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 6299.72 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 6300.64 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6300.68 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| 6300.69 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| 6300.7 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6300.8 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 6306.57 | 0 | 2 | 3 | 7 | 3 | 0 | 0 | 1 |
| 6306.62 | 1 | 0 | 0 | 1 | 2 | 0 | 0 | 0 |
| 6306.63 | 0 | 0 | 4 | 3 | 1 | 0 | 0 | 0 |
| 6306.71 | 2 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| 6306.73 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 6306.75 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 6306.76 | 0 | 1 | 0 | 2 | 0 | 0 | 0 | 0 |
| 6306.77 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 6306.81 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 6306.83 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6306.86 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 |
| 6306.87 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 6306.98 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6307 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 6308.12 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| 6308.16 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 |
| 6308.17 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 |
| 6308.18 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 |
| 6308.26 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| 6308.28 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 |
| 6332.72 | 0 | 1 | 1 | 5 | 0 | 1 | 0 | 0 |
| 6332.89 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |

Table 31. Model 4b parameters by gradient for Jitter run with lowest likelihood (6298.6) and lowest gradient (0.0012)

| ParName | Value | Gradient |
|---|---|---|
| rec_devf(1985) | 1.65562 | -0.00120 |
| rec_devf(1983) | 0.79883 | -0.00059 |
| Male slope (b1) growth | 2.02649 | 0.00054 |
| rec_devf(1984) | 1.01979 | -0.00049 |
| rec_devf(2003) | 0.84166 | 0.00046 |
| rec_devf(2002) | 0.40197 | 0.00042 |
| fmort_dev1(1990) | 0.88924 | 0.00035 |
| fmort_dev2(1997) | 0.53320 | 0.00028 |
| rec_devf(1987) | 1.60603 | -0.00028 |
| Male delta | 27.27200 | 0.00027 |
| rec_devf(1978) | 0.54744 | 0.00026 |
| fmort_dev1(1991) | 1.15509 | -0.00026 |
| rec_devf(1986) | 0.10192 | -0.00026 |
| fmort_dev2(1998) | 0.58459 | -0.00025 |
| fmort_dev1(1989) | 0.31376 | -0.00025 |
| log_avg_sel50_mn | 4.67696 | -0.00025 |
| Male intercept(a1) growth | -17.41090 | 0.00024 |
| rec_devf(2008) | 0.34831 | 0.00024 |
| rec_devf(1982) | 0.36703 | -0.00021 |
| rec_devf(2001) | -0.38184 | 0.00020 |
| rec_devf(2004) | -0.19158 | 0.00018 |
| rec_devf(1979) | 0.37004 | 0.00017 |
| rec_devf(2005) | 0.01800 | 0.00017 |
| rec_devf(1998) | 0.11916 | 0.00016 |
| fmort_dev1(1987) | 0.54938 | 0.00015 |
| rec_devf(2009) | 0.64206 | 0.00015 |
| rec_devf(1980) | 0.05904 | 0.00014 |
| rec_devf(1992) | 0.74348 | -0.00014 |
| Female slope(b1) growth | 1.81743 | 0.00013 |
| fmort_dev2(1996) | 0.15035 | 0.00012 |

Table 32. Model 4c maximum gradient by total likelihood values.

| | (0,0.001] | (0.001,0.002] | (0.002,0.005] | (0.005,0.01] | (0.01,0.02] | (0.02,0.03] | (0.03,0.04] | (0.04,0.05] |
|---|---|---|---|---|---|---|---|---|
| 6281.76 | 0 | 1 | 3 | 1 | 1 | 1 | 0 | 0 |
| 6281.89 | 0 | 0 | 3 | 0 | 1 | 0 | 0 | 0 |
| 6281.9 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6281.91 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0 |
| 6281.99 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 6284.12 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 6284.35 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 6289.25 | 3 | 3 | 5 | 6 | 2 | 5 | 0 | 1 |
| 6289.38 | 2 | 0 | 2 | 1 | 1 | 2 | 0 | 0 |
| 6289.39 | 2 | 2 | 2 | 0 | 1 | 1 | 0 | 0 |
| 6289.4 | 1 | 0 | 2 | 1 | 0 | 1 | 0 | 0 |
| 6289.48 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 6289.5 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 6289.63 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6289.64 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6289.74 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 6289.76 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6290.53 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 6291.1 | 0 | 1 | 4 | 1 | 2 | 0 | 0 | 0 |
| 6291.23 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| 6291.24 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 6291.25 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| 6316.11 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 6316.13 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 6316.25 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 6316.56 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 6318.78 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |

Table 33. Model 4c parameters by gradient for Jitter run with lowest likelihood and lowest gradient.

| ParName | Value | Gradient |
|---|---|---|
| Male slope (b1) growth | 2.01793 | -0.00186 |
| rec_devf(1991) | 1.90690 | -0.00140 |
| Male intercept(a1) growth | -17.22080 | -0.00085 |
| Male delta | 27.27510 | -0.00058 |

| | | |
|---|---|---|
| Male slope (b2) growth | 1.15159 | -0.00039 |
| fmort_dev1(1990) | 0.83221 | 0.00032 |
| rec_devf(2003) | 0.85295 | -0.00031 |
| rec_devf(1979) | 0.35820 | 0.00028 |
| rec_devf(1984) | 1.03894 | 0.00027 |
| fmort_dev2(1997) | 0.52116 | -0.00026 |
| rec_devf(1992) | 0.80690 | -0.00024 |
| rec_devf(1987) | 1.61580 | 0.00023 |
| rec_devf(1980) | 0.04875 | 0.00023 |
| rec_devf(1978) | 0.48204 | 0.00021 |
| rec_devf(2002) | 0.39380 | -0.00021 |
| log_avg_sel50_mn | 4.68297 | 0.00021 |
| fmort_dev2(1992) | 1.55024 | -0.00017 |
| fmort_dev1(1989) | 0.26139 | -0.00016 |
| mean_log_rec1 | 13.77640 | -0.00014 |
| fmort_dev2(1994) | 0.68088 | 0.00013 |
| rec_devf(1989) | -0.43282 | 0.00013 |
| rec_devf(1981) | -0.98522 | 0.00013 |
| Mmult_imat | 1.66354 | 0.00013 |
| rec_devf(2005) | 0.03623 | -0.00013 |
| rec_devf(1988) | -1.49825 | 0.00011 |
| fmort_dev1(1988) | 0.64980 | -0.00011 |
| fmort_dev1(1987) | 0.55435 | 0.00010 |
| rec_devf(2013) | 0.29430 | 0.00009 |
| rec_devf(2014) | 1.78885 | 0.00009 |
| rec_devf(2011) | 0.00747 | 0.00009 |

Table 34. Model 8. 43 runs with lowest likelihood of 6490.11. Frequency of maximum gradient for each total likelihood.

| | (0,0.001] | (0.001,0.002] | (0.002,0.005] | (0.005,0.01] | (0.01,0.02] | (0.02,0.03] | (0.03,0.04] | (0.04,0.05] |
|---|---|---|---|---|---|---|---|---|
| 6490.11 | 7 | 5 | 12 | 10 | 6 | 2 | 0 | 0 |
| 6490.21 | 2 | 1 | 1 | 1 | 2 | 0 | 1 | 0 |
| 6490.24 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 |
| 6490.26 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6490.27 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6490.3 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| 6490.31 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 6490.32 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6490.35 | 1 | 0 | 0 | 2 | 1 | 0 | 0 | 0 |
| 6490.37 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 6490.38 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| 6490.42 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 6490.49 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 6490.5 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 6490.89 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 6491.2 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 6491.25 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 6491.27 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6491.37 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6491.41 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 6491.48 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 6491.5 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6492.23 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6493.6 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 6493.67 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 6494.08 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 6495.75 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 6515.23 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Table 35. Model 8 parameters by gradient for Jitter run with lowest likelihood and lowest gradient.

| ParName | Value | Gradient |
|---|---|---|
| Male slope growth | 1.154 | -0.00012 |
| rec_devf(1992) | 1.823 | -5.6E-05 |
| rec_devf(1985) | 1.401 | 2.74E-05 |
| rec_devf(1988) | 1.189 | -1.5E-05 |
| rec_devf(1991) | 0.561 | -1.1E-05 |
| log_avg_sel50_mn | 4.677 | 1.07E-05 |
| fmort_dev2(1997) | 0.467 | -7.6E-06 |
| rec_devf(1986) | 1.122 | 7.19E-06 |
| Male intercept growth | 7.250 | -7E-06 |
| fmort_dev1(1991) | 1.234 | 6.98E-06 |
| fmort_dev1(1989) | 0.180 | -6.9E-06 |
| mean_log_rec1 | 13.691 | -6.4E-06 |
| Mmult_imat | 1.886 | 4.41E-06 |
| srvind_sel50f | 52.193 | -4.3E-06 |
| rec_devf(2014) | 1.356 | 4.12E-06 |
| rec_devf(2012) | 0.123 | 4.11E-06 |
| rec_devf(2013) | 0.290 | 4.06E-06 |
| rec_devf(2011) | 0.090 | 3.96E-06 |
| rec_devf(1993) | 0.202 | -3.9E-06 |
| rec_devf(1995) | -1.716 | 3.85E-06 |
| rec_devf(1996) | -1.889 | 3.82E-06 |
| fmort_dev2(1998) | 0.542 | -3.8E-06 |

| | | |
|---|---|---|
| rec_devf(1997) | -1.176 | 3.61E-06 |
| rec_devf(1987) | 0.967 | -3.6E-06 |
| selsmo10ind(5) | -0.001 | 3.47E-06 |
| rec_devf(2001) | -1.237 | 3.41E-06 |
| rec_devf(2000) | -1.083 | 3.4E-06 |
| rec_devf(1999) | -0.691 | 3.31E-06 |
| rec_devf(2010) | 0.237 | 2.98E-06 |
| rec_devf(1984) | 0.910 | -2.9E-06 |

Table 36. Model 8a. Frequency of maximum gradient for each total likelihood.

| | (0,0.001] | (0.001,0.002] | (0.002,0.005] | (0.005,0.01] | (0.01,0.02] | (0.02,0.03] | (0.03,0.04] | (0.04,0.05] |
|---|---|---|---|---|---|---|---|---|
| 6408.04 | 8 | 4 | 4 | 6 | 1 | 1 | 0 | 1 |
| 6408.12 | 3 | 0 | 3 | 5 | 3 | 0 | 0 | 0 |
| 6408.16 | 0 | 0 | 3 | 1 | 0 | 1 | 0 | 0 |
| 6408.18 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6408.19 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 0 |
| 6408.23 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 |
| 6408.24 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 6408.28 | 1 | 2 | 2 | 0 | 0 | 0 | 0 | 0 |
| 6408.3 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| 6408.34 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 6408.38 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6408.39 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6408.41 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 6408.42 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 6408.51 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6408.63 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6408.66 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6408.68 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 6409.05 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 6409.14 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 6409.17 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 6409.29 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 6409.33 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 6409.4 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 6409.5 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 6410.16 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6412.39 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 6415.07 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 6443.06 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6444.12 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 6446.75 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6522.03 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |

Table 37. Model 8a. Parameter value and gradient for the 30 parameters with the highest gradients from single run. likelihood 6408.04 and max gradient 0.00289.

| Par name | Value | Gradient |
|---|---|---|
| Male slope growth | 1.13607 | -2.89E-03 |
| rec_devf(1992) | 1.81653 | -2.68E-03 |
| rec_devf(1986) | 1.18289 | 1.76E-03 |
| rec_devf(1991) | 0.55643 | -8.22E-04 |
| rec_devf(2005) | 0.414961 | 7.40E-04 |
| rec_devf(1987) | 0.882775 | 7.37E-04 |
| rec_devf(1983) | 0.674568 | -5.59E-04 |
| fmort_dev2(1997) | 0.46615 | -5.01E-04 |
| fmort_dev1(1990) | 0.78623 | -4.75E-04 |
| log_avg_sel50_mn | 4.68081 | 4.68E-04 |
| rec_devf(1984) | 0.910939 | -4.29E-04 |
| rec_devf(2003) | 0.808346 | 3.92E-04 |
| rec_devf(1985) | 1.39719 | 3.73E-04 |
| rec_devf(2004) | -0.14021 | 3.14E-04 |
| fmort_dev1(1991) | 1.16455 | 3.14E-04 |
| rec_devf(1988) | 1.21083 | 2.97E-04 |
| rec_devf(1993) | 0.229673 | -2.65E-04 |
| rec_devf(2006) | -1.04336 | 2.28E-04 |
| fmort_dev2(2011) | 0.224543 | 2.20E-04 |
| rec_devf(1990) | -0.3855 | -1.93E-04 |
| fmort_dev2(1992) | 1.52751 | 1.59E-04 |
| rec_devf(1982) | -0.27693 | -1.37E-04 |
| fmort_dev1(1989) | 0.17725 | -1.27E-04 |

| | | |
|---|---|---|
| fmort_dev1(1986) | -0.05477 | 1.23E-04 |
| fmort_dev2(2012) | 0.556054 | 1.18E-04 |
| fmort_dev2(1996) | 0.21463 | -1.11E-04 |
| rec_devf(2007) | -1.34365 | 1.03E-04 |
| fmort_dev2(1998) | 0.548927 | -1.00E-04 |
| fmort_dev2(1994) | 0.666763 | 9.51E-05 |
| fmort_dev1(1988) | 0.635003 | -8.84E-05 |

Table 38. Model 8a. Parameter values and gradients for the 30 parameters with the highest gradients from the jitter run with the lowest likelihood (6408.04) and the lowest gradient (0.000129).

| Par name | Value | Gradient |
|---|---|---|
| Male slope growth | 1.13621 | -1.29E-04 |
| rec_devf(1985) | 1.39542 | -3.40E-05 |
| rec_devf(1992) | 1.8157 | -2.54E-05 |
| rec_devf(1986) | 1.18178 | -2.02E-05 |
| rec_devf(1984) | 0.909766 | -1.32E-05 |
| rec_devf(1987) | 0.876971 | -8.59E-06 |
| rec_devf(1988) | 1.21085 | -8.44E-06 |
| mean_log_rec1 | 13.7112 | -7.31E-06 |
| log_avg_sel50_mn | 4.68029 | 7.00E-06 |
| Male intercept growth | 8.41676 | -6.27E-06 |
| rec_devf(1996) | -1.89533 | 5.15E-06 |
| rec_devf(2014) | 1.31917 | 4.89E-06 |
| rec_devf(1995) | -1.72814 | 4.87E-06 |
| rec_devf(2013) | 0.24209 | 4.85E-06 |
| rec_devf(2012) | 0.100607 | 4.80E-06 |
| rec_devf(2010) | 0.241903 | 4.79E-06 |
| rec_devf(2011) | 0.054024 | 4.76E-06 |
| rec_devf(1997) | -1.17105 | 4.41E-06 |
| rec_devf(1981) | -0.58522 | 4.37E-06 |
| rec_devf(2000) | -1.08319 | 4.35E-06 |

| | | |
|---|---|---|
| rec_devf(1979) | 0.412097 | 4.26E-06 |
| rec_devf(2001) | -1.23553 | 4.26E-06 |
| rec_devf(2007) | -1.34412 | 4.23E-06 |
| rec_devf(2008) | -0.5159 | 4.13E-06 |
| rec_devf(1999) | -0.6676 | 4.11E-06 |
| rec_devf(2009) | 0.39623 | 4.10E-06 |
| rec_devf(2006) | -1.04565 | 4.08E-06 |
| rec_devf(1980) | 0.251476 | 4.05E-06 |
| rec_devf(2004) | -0.14119 | 4.03E-06 |
| rec_devf(1978) | 0.440955 | 3.98E-06 |
| | | |
| | | |

Table 39. Likelihood values for Models 4a and 9 through 16.

Model Scenario

| | 4a | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|
| Recruitment | 36.31 | 36.44 | 36.09 | 36.04 | 36.27 | 36.27 | 36.33 | 36.37 | 36.31 |
| Initial numbers old shell males small length bins | 2.38 | 2.38 | 2.35 | 2.35 | 2.34 | 2.35 | 2.38 | 2.34 | 2.38 |
| ret fishery length | 338.65 | 338.59 | 332.17 | 331.76 | 332.45 | 331.43 | 336.52 | 331.67 | 337.17 |
| total fish length | 782.22 | 782.18 | 777.76 | 777.98 | 777.78 | 777.92 | 780.65 | 778.10 | 780.94 |
| female fish length | 229.27 | 229.29 | 229.31 | 224.37 | 244.96 | 216.50 | 216.51 | 211.17 | 211.06 |
| survey length | 3841.53 | 3841.82 | 3850.65 | 3854.51 | 3873.84 | 3864.36 | 3864.72 | 3896.57 | 3894.26 |
| trawl length | 269.97 | 269.87 | 272.31 | 272.09 | 270.44 | 271.45 | 272.30 | 272.46 | 273.56 |
| 2009 BSFRF length | -83.31 | -83.36 | -82.64 | -82.32 | -83.79 | -83.11 | -82.87 | -83.47 | -83.18 |
| 2009 NMFS study area length | -70.44 | -70.43 | -70.52 | -70.21 | -71.42 | -71.78 | -71.78 | -71.86 | -71.78 |
| M prior | 8.78 | 8.70 | 9.56 | 9.49 | 10.26 | 9.80 | 10.11 | 9.50 | 9.76 |
| maturity smooth | 51.85 | 51.38 | 23.47 | 4.27 | 33.62 | 17.23 | 17.64 | 13.76 | 13.85 |
| growth males | 40.60 | 41.29 | 40.45 | 40.44 | 40.10 | 40.07 | 51.59 | 39.88 | 51.49 |
| growth females | 47.06 | 46.95 | 47.40 | 44.90 | 33.24 | 38.20 | 38.19 | 39.57 | 42.30 |
| 2009 BSFRF biomass | 0.17 | 0.17 | 0.19 | 0.19 | 0.19 | 0.18 | 0.19 | 0.18 | 0.19 |
| 2009 NMFS study area biomass | 0.08 | 0.08 | 0.09 | 0.09 | 0.10 | 0.10 | 0.11 | 0.09 | 0.11 |
| retained catch | 2.67 | 2.69 | 2.44 | 2.44 | 2.41 | 2.43 | 2.53 | 2.40 | 2.52 |
| discard catch | 120.47 | 120.67 | 111.88 | 112.41 | 110.39 | 111.91 | 118.57 | 110.91 | 118.30 |
| trawl catch | 2.12 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 |
| female discard catch | 4.27 | 4.26 | 4.25 | 4.23 | 4.15 | 4.48 | 4.49 | 4.58 | 4.59 |
| survey biomass | 189.61 | 188.98 | 185.51 | 185.34 | 184.52 | 184.16 | 185.13 | 184.34 | 185.14 |
| F penalty | 24.00 | 21.79 | 21.74 | 21.75 | 21.82 | 21.78 | 21.96 | 21.77 | 22.00 |
| 2010 BSFRF Biomass | 1.73 | 1.73 | 1.81 | 1.75 | 1.96 | 1.78 | 1.93 | 1.74 | 1.88 |
| 2010 NMFS Biomass | 1.31 | 1.31 | 1.50 | 1.44 | 1.55 | 1.47 | 1.50 | 1.40 | 1.47 |
| initial numbers fit | 507.07 | 507.01 | 506.99 | 507.23 | 506.38 | 507.24 | 507.24 | 508.06 | 508.48 |
| 2010 BSFRF length | -59.23 | -59.19 | -59.23 | -59.53 | -58.75 | -59.49 | -59.21 | -57.76 | -58.40 |
| 2010 NMFS length | -67.09 | -67.06 | -67.13 | -67.80 | -67.36 | -67.89 | -67.65 | -66.36 | -66.65 |
| male survey selectivity smooth constraint | 3.62 | 3.62 | 3.76 | 3.77 | 3.80 | 3.77 | 3.85 | 3.80 | 3.85 |
| q for potlifts female F | 12.42 | 12.37 | 12.33 | 12.25 | 12.01 | 11.92 | 11.92 | 11.42 | 11.44 |
| init nos smooth constraint | 39.09 | 38.93 | 40.42 | 40.34 | 40.41 | 40.28 | 41.14 | 40.59 | 41.11 |
| Total | 6277.20 | 6272.52 | 6235.00 | 6211.64 | 6263.71 | 6214.87 | 6246.07 | 6243.27 | 6274.23 |
| | | | | | | | | | |

Table 40. Likelihood values for Models 13, 17, 17a, 17b and 18c.

| | 13 | 17 | 17a | 17b | 18c |
|---|---|---|---|---|---|
| Recruitment | 36.27 | 36.81 | 36.78 | 36.28 | 29.26 |
| Initial numbers old shell males small length bins | 2.35 | 1.95 | 1.93 | 2.38 | 0.80 |
| ret fishery length | 331.43 | 317.66 | 317.42 | 332.09 | 40.50 |
| total fish length | 777.92 | 775.86 | 776.99 | 777.01 | 134.64 |
| female fish length | 216.50 | 216.45 | 216.42 | 216.53 | 78.50 |
| survey length | 3864.36 | 3861.55 | 3857.47 | 3867.53 | -162.55 |
| groundfish length | 271.45 | 274.11 | 272.75 | 272.51 | 84.03 |
| 2009 BSFRF length | -83.11 | -85.06 | -84.39 | -83.66 | -92.42 |
| 2009 NMFS study area length | -71.78 | -73.05 | -72.70 | -72.04 | -79.23 |
| M prior | 9.80 | 8.65 | 9.39 | 9.15 | 1.09 |
| maturity smooth | 17.23 | 17.51 | 17.44 | 17.28 | 7.91 |
| growth males | 40.07 | 34.29 | 35.13 | 39.35 | 21.26 |
| growth females | 38.20 | 39.10 | 38.97 | 38.31 | 12.61 |
| 2009 BSFRF biomass | 0.18 | 0.28 | 0.24 | 0.20 | 0.21 |
| 2009 NMFS study area biomass | 0.10 | 0.21 | 0.17 | 0.12 | 0.18 |
| retained catch | 2.43 | 2.30 | 2.35 | 2.39 | 0.54 |
| discard catch | 111.91 | 103.39 | 107.09 | 108.98 | 26.15 |
| groundfish catch | 0.07 | 0.07 | 0.07 | 0.07 | 0.01 |
| female discard catch | 4.48 | 4.64 | 4.56 | 4.54 | 3.87 |
| survey biomass | 184.16 | 180.08 | 181.34 | 183.37 | 129.72 |
| F penalty | 21.78 | 25.08 | 24.78 | 21.87 | 10.76 |
| 2010 BSFRF Biomass | 1.78 | 1.09 | 2.93 | 0.71 | 6.91 |
| 2010 NMFS Biomass | 1.47 | 4.55 | 2.29 | 2.87 | 3.63 |
| initial numbers fit | 507.24 | 512.89 | 512.87 | 507.06 | 26.57 |
| 2010 BSFRF length | -59.49 | -61.09 | -59.44 | -60.56 | -59.25 |
| 2010 NMFS length | -67.89 | -69.38 | -67.12 | -69.39 | -70.68 |
| male survey selectivity smooth constraint | 3.77 | 4.30 | 3.90 | 4.15 | 3.20 |
| q for potlifts female F | 11.92 | 11.92 | 11.80 | 12.02 | 9.64 |
| init nos smooth constraint | 40.28 | 34.83 | 34.95 | 40.35 | 10.21 |
| Total | 6214.87 | 6180.99 | 6186.37 | 6211.46 | 178.08 |

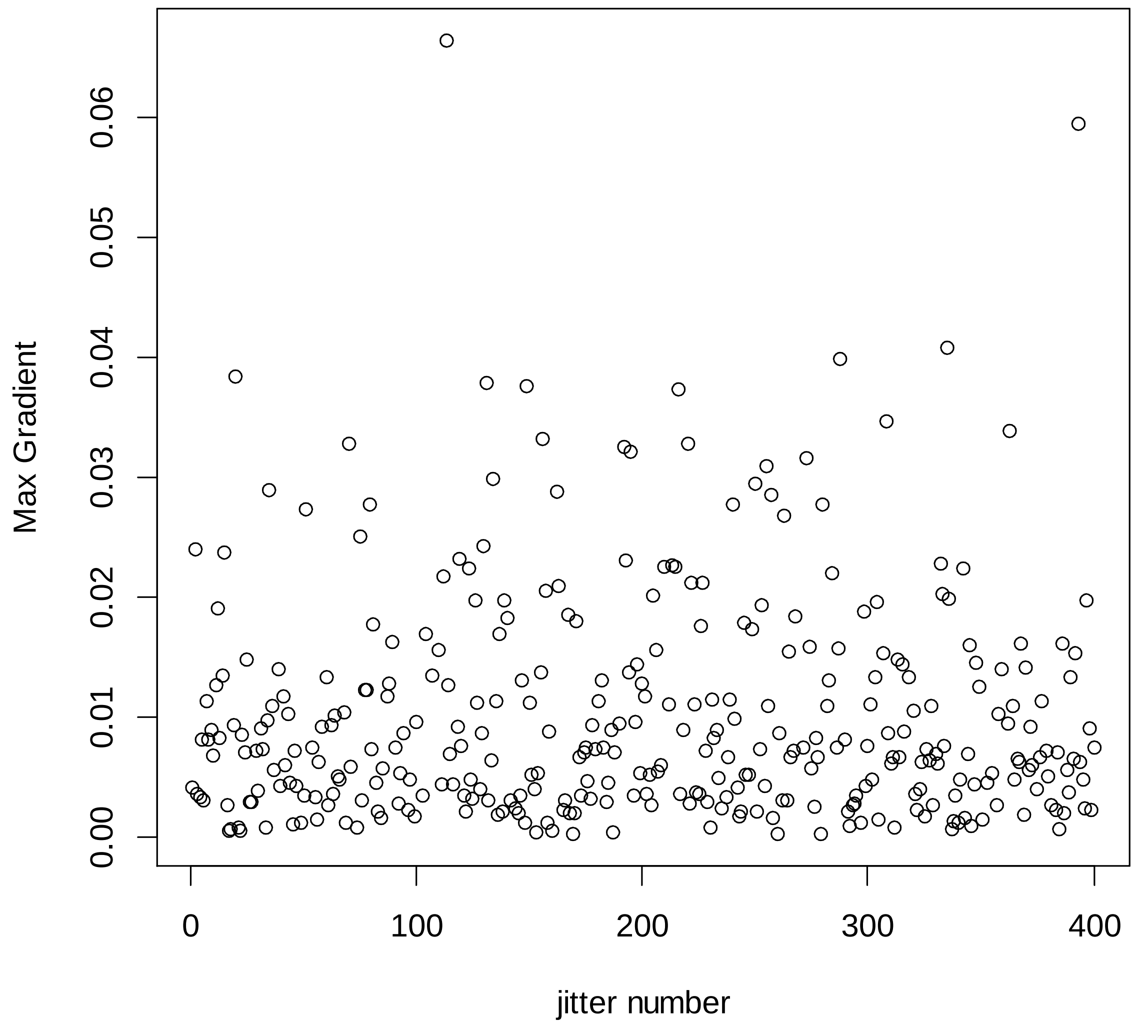


Figure 1. Maximum gradient by jitter number for runs that wrote the standard deviation file. Three runs wrote the standard deviation file were not included in this plot that had maximum gradients greater than 50.

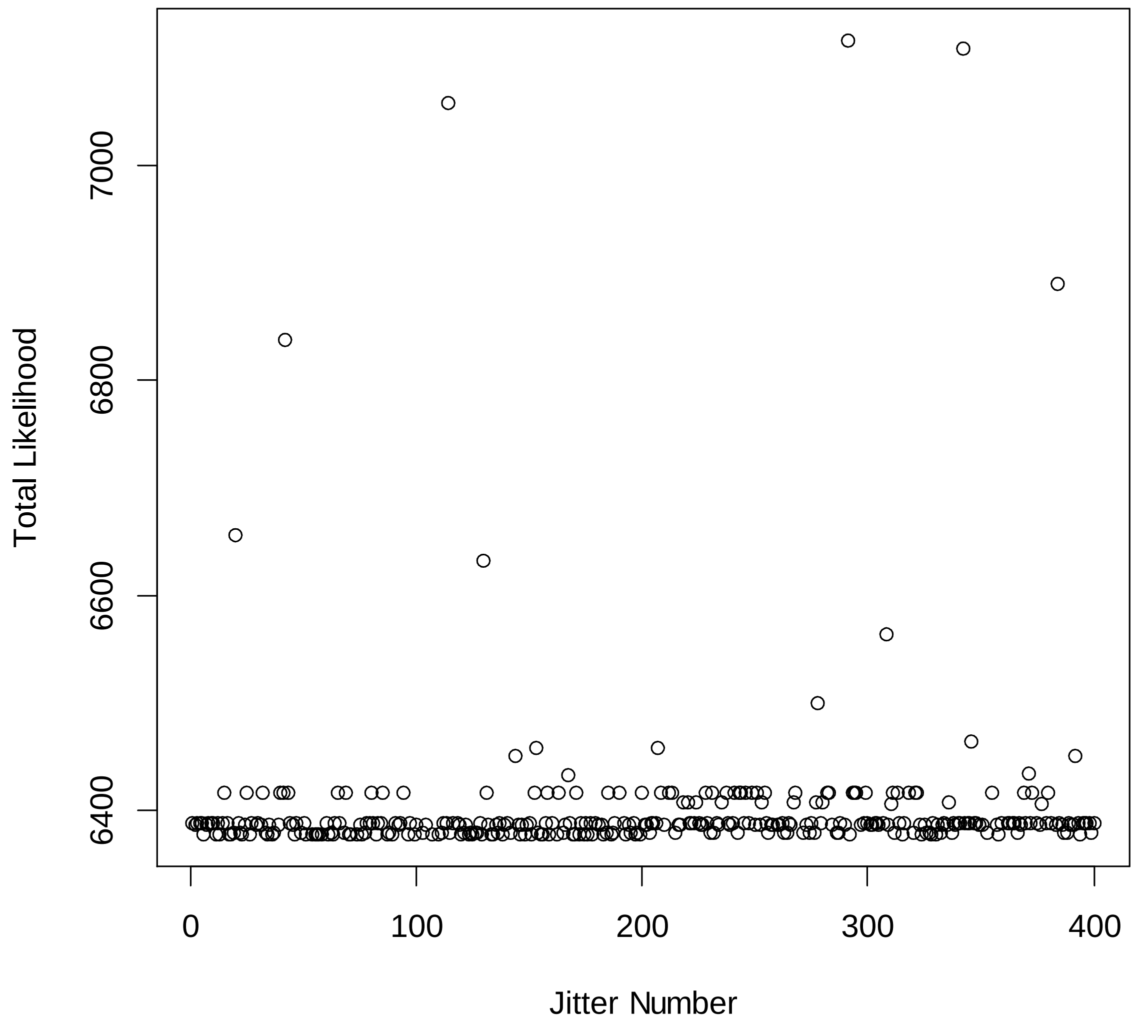


Figure 2. Model 0. Total Likelihood by jitter number for runs that wrote the standard deviation file. Three runs wrote the standard deviation file were not included in this plot that had maximum gradients greater than 50.

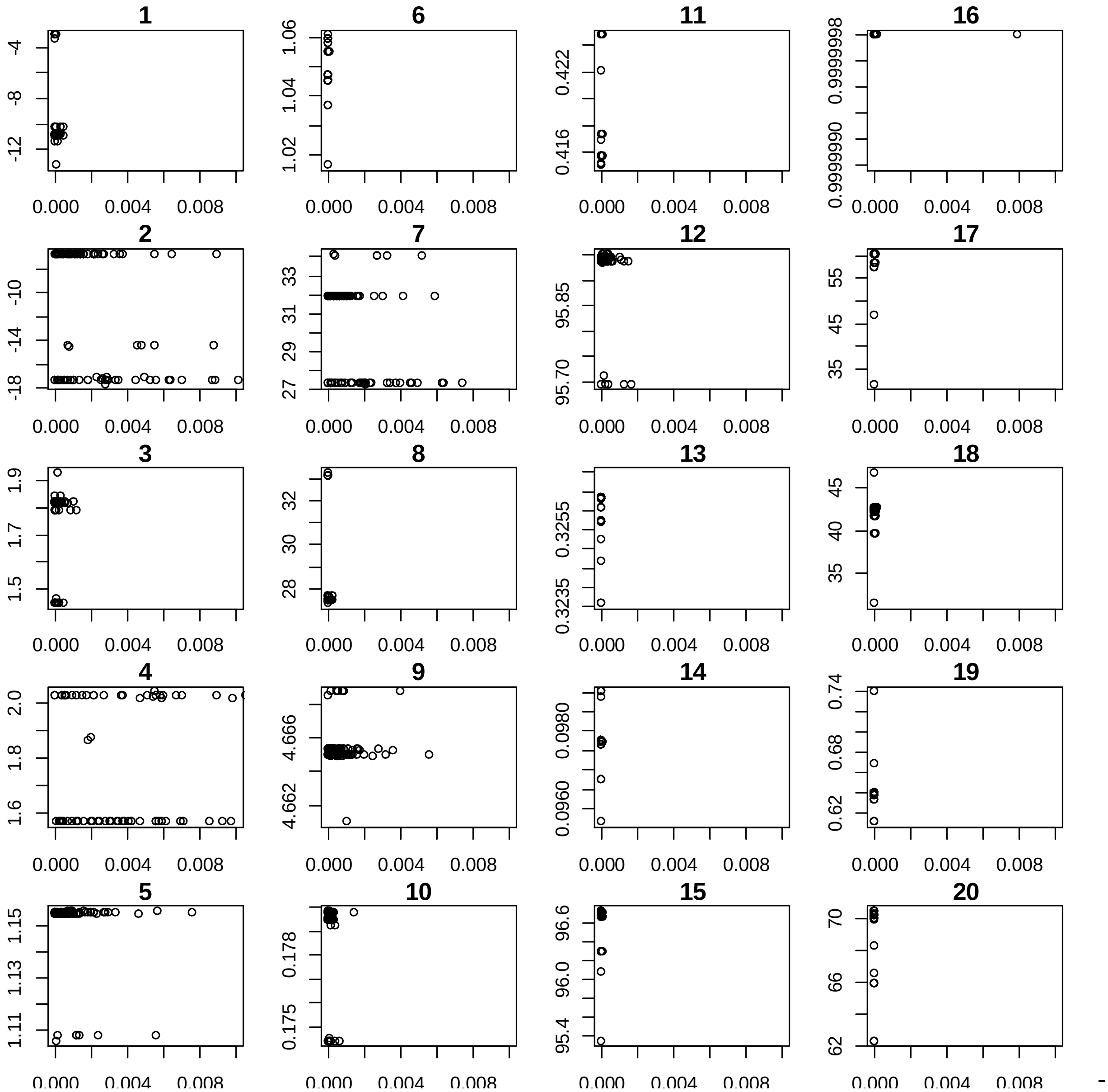


Figure 3. Parameter values (1-20 see Table 1) vs the parameter gradient for 100 jittered runs of Model 0. The gradient axis was limited to 0.01 maximum.

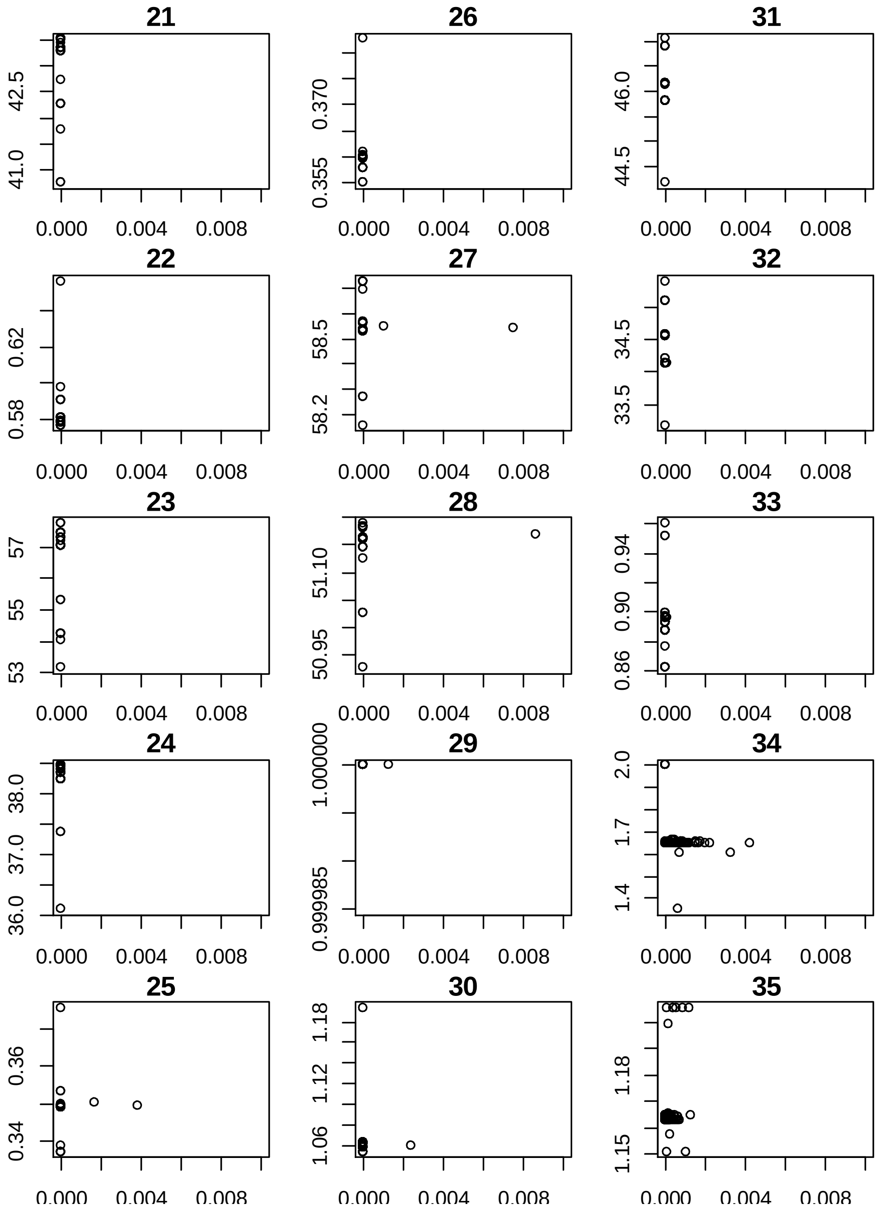


Figure 3 cont. Parameter values (21-35 see Table 1) vs the parameter gradient for 100 jittered runs of Model 0. The gradient axis was limited to 0.01 maximum.

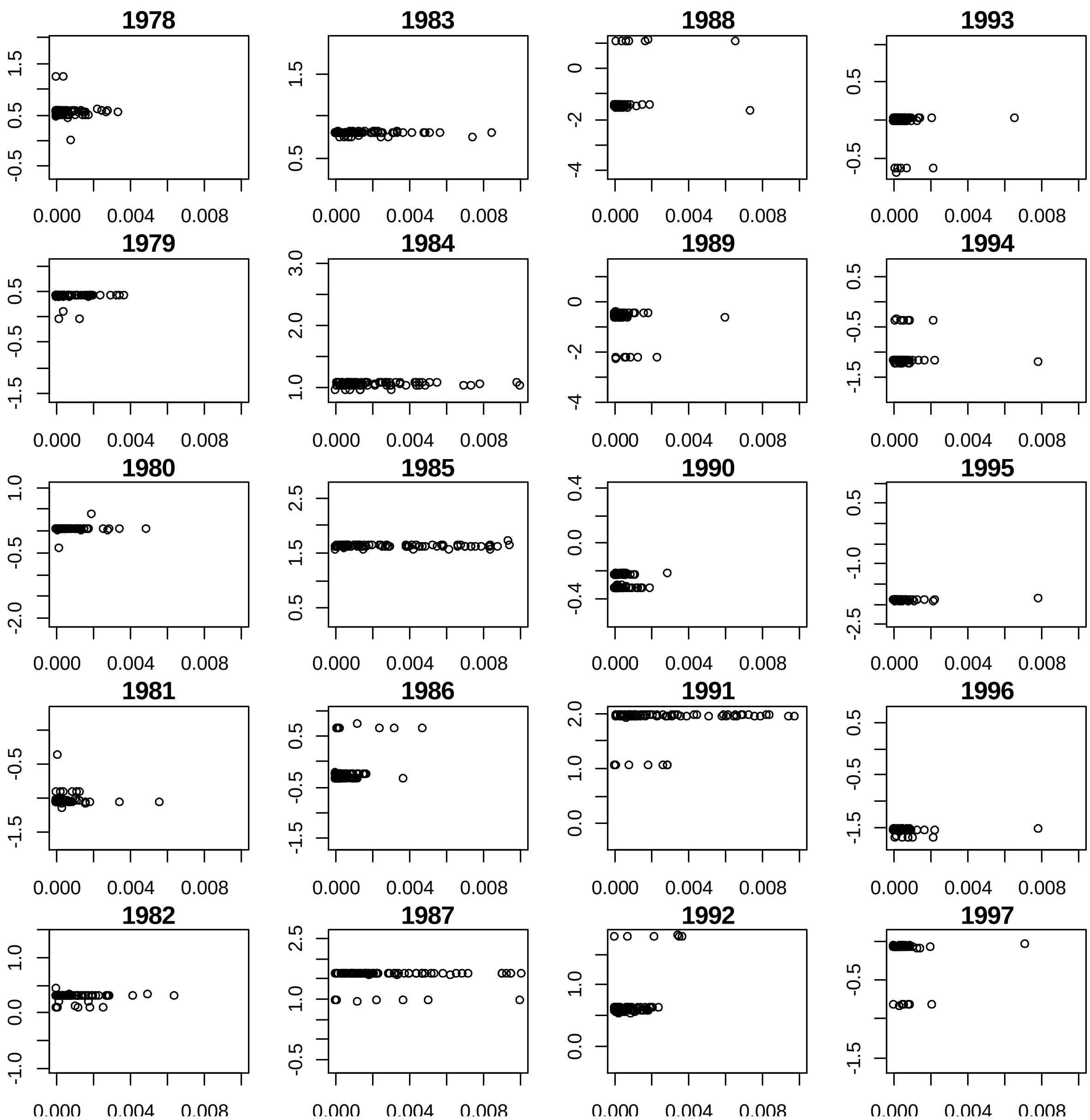


Figure 4. Recruitment deviation parameter values (title is year of deviation, 1978 = 1978/79 crab year) vs the parameter gradient for 100 jittered runs of Model 0. The gradient axis was limited to 0.01 maximum.

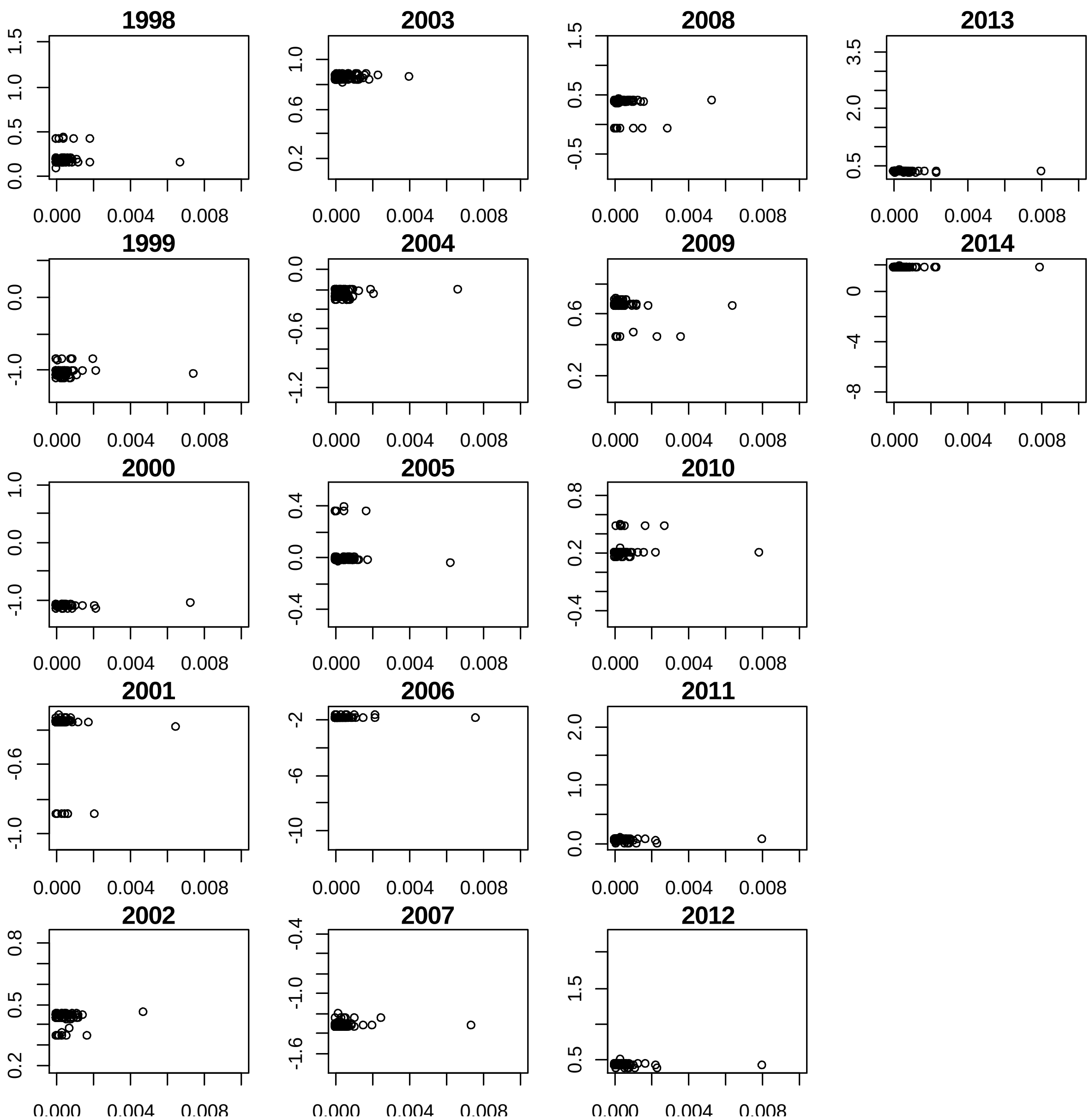


Figure 4 cont. Recruitment deviation parameter values (title is year of deviation, 1978 = 1978/79 crab year) vs the parameter gradient for 100 jittered runs of Model 0. The gradient axis was limited to 0.01 maximum.

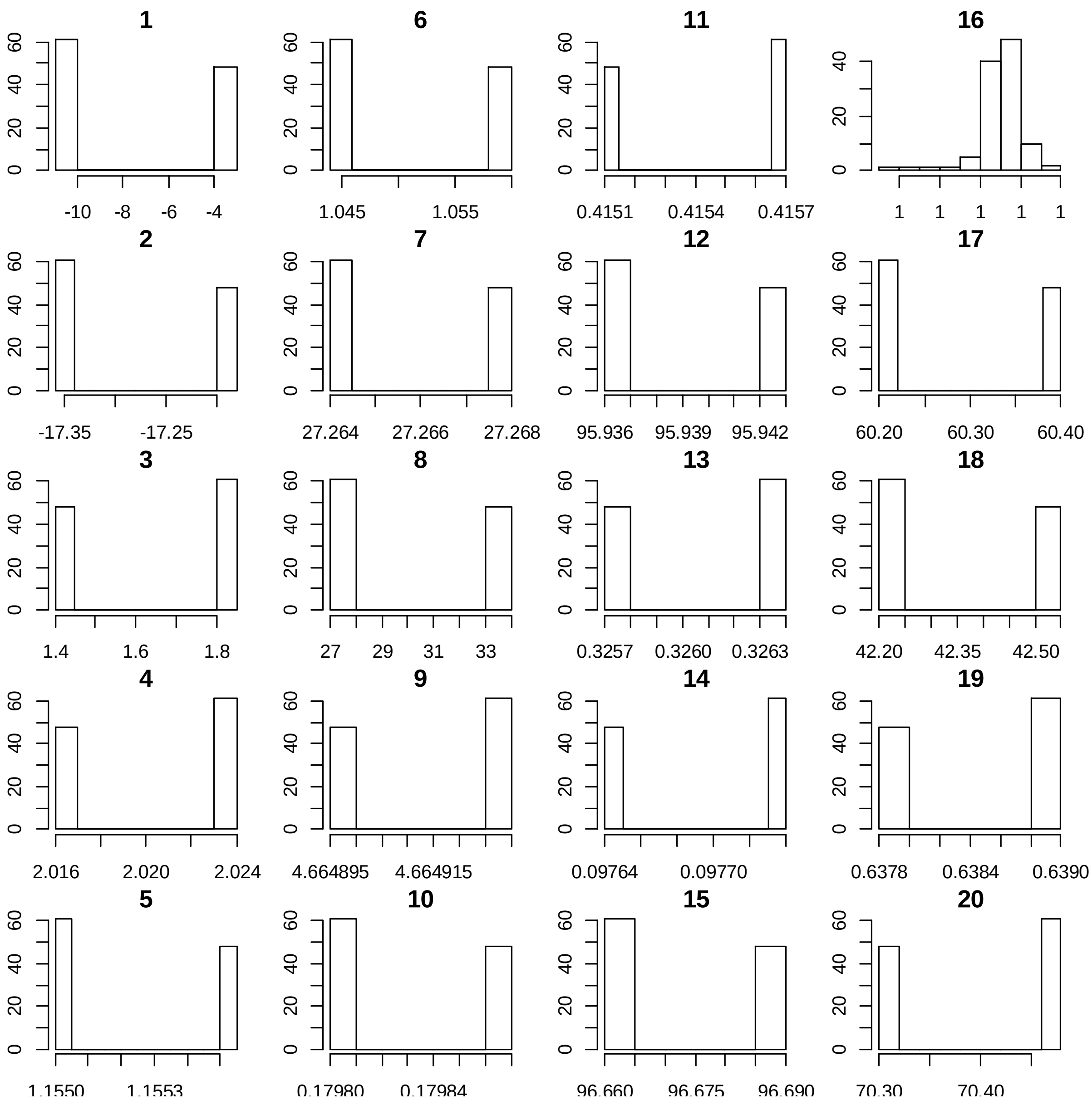


Figure 5. Parameter values for parameters 1-20 for runs where the total likelihood was 6379.01 (61 runs) and 6376.97 (47 runs). Refer to Table 1 for parameter names.

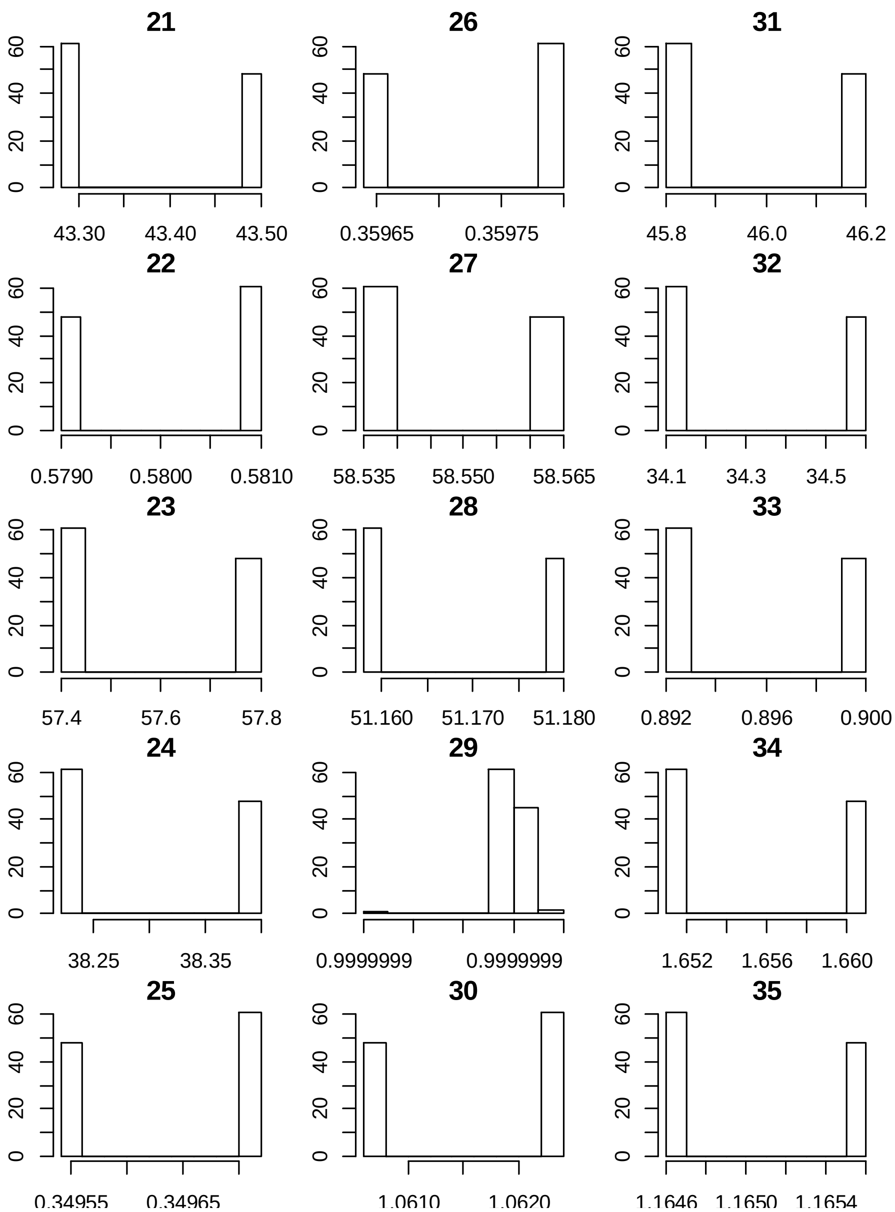


Figure 5 cont. Parameter values for parameters 21-35 for runs where the total likelihood was 6379.01 (61 runs) and 6376.97 (47 runs). Refer to Table 1 for parameter names.

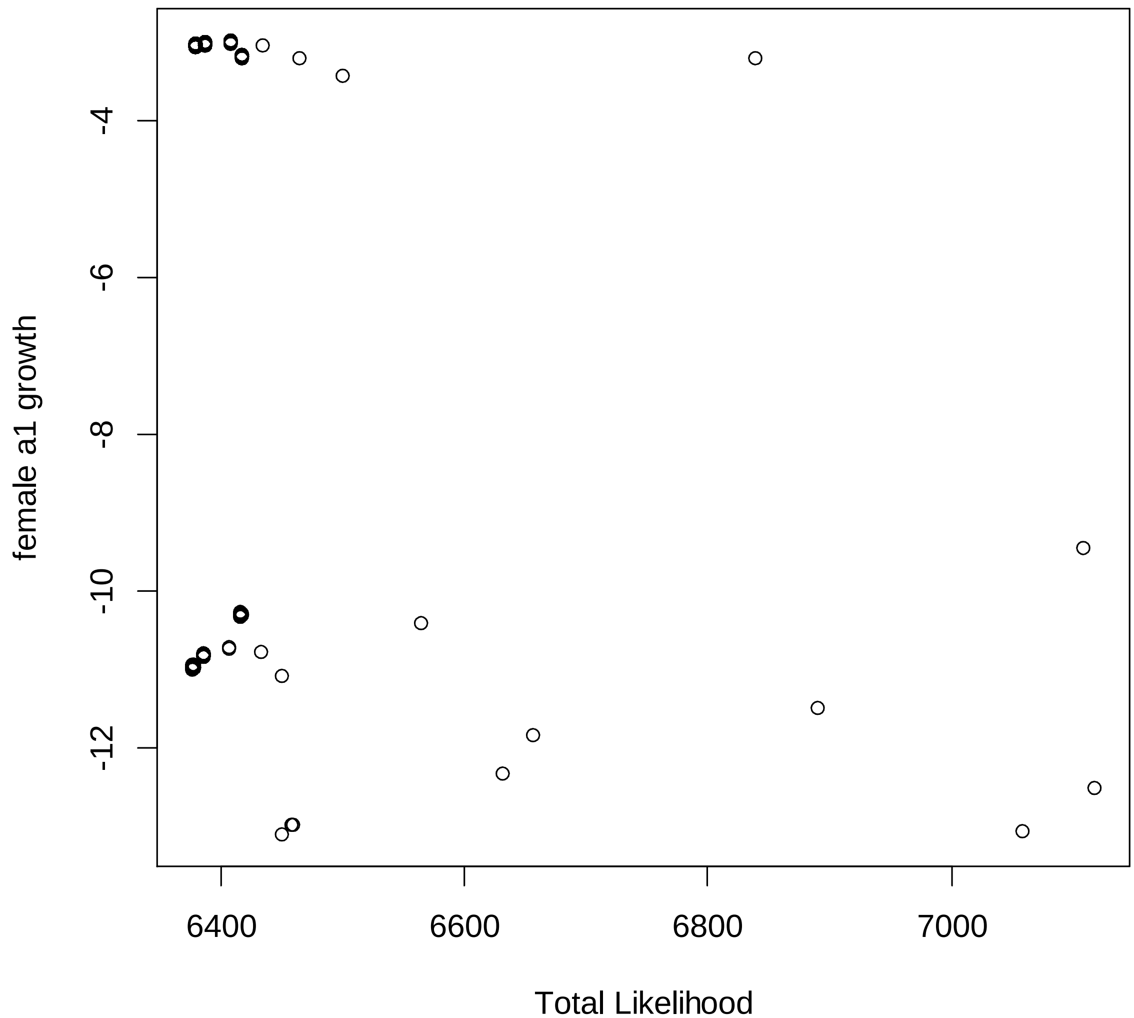


Figure 6. Female growth parameter a1 vs Total Likelihood for models that wrote the standard deviation file. Values have been jittered for plotting to show where multiple runs occurred. The parameter values for each likelihood with multiple runs were virtually identical. Models estimated basically two different values of the parameter that represent a shift in the transition of the growth curve (< -9 and > -4).

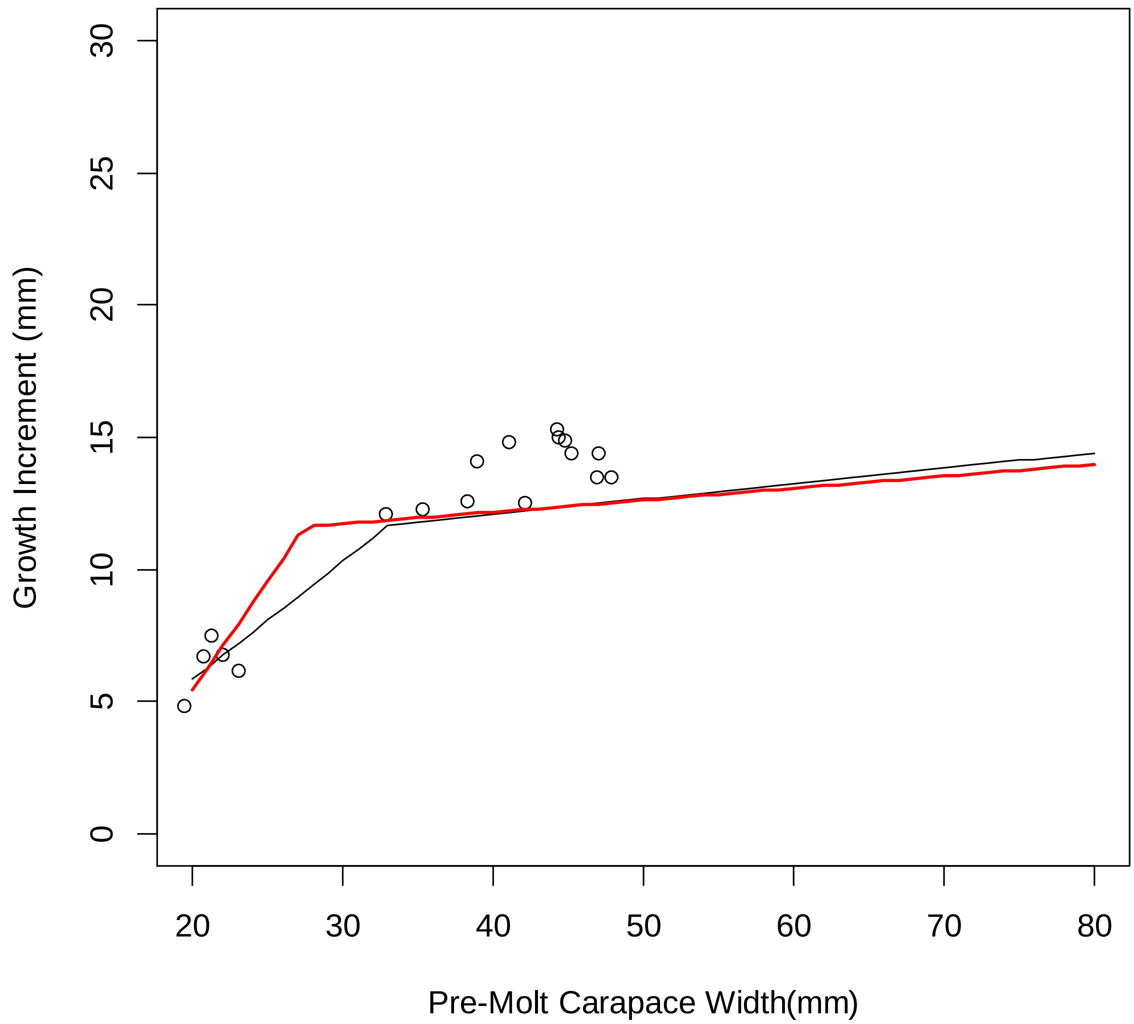


Figure 7. Female growth estimated from Model 0 6376.97 run (red line) and Model 0 6379.01 run (black line). Open circles are observed growth.

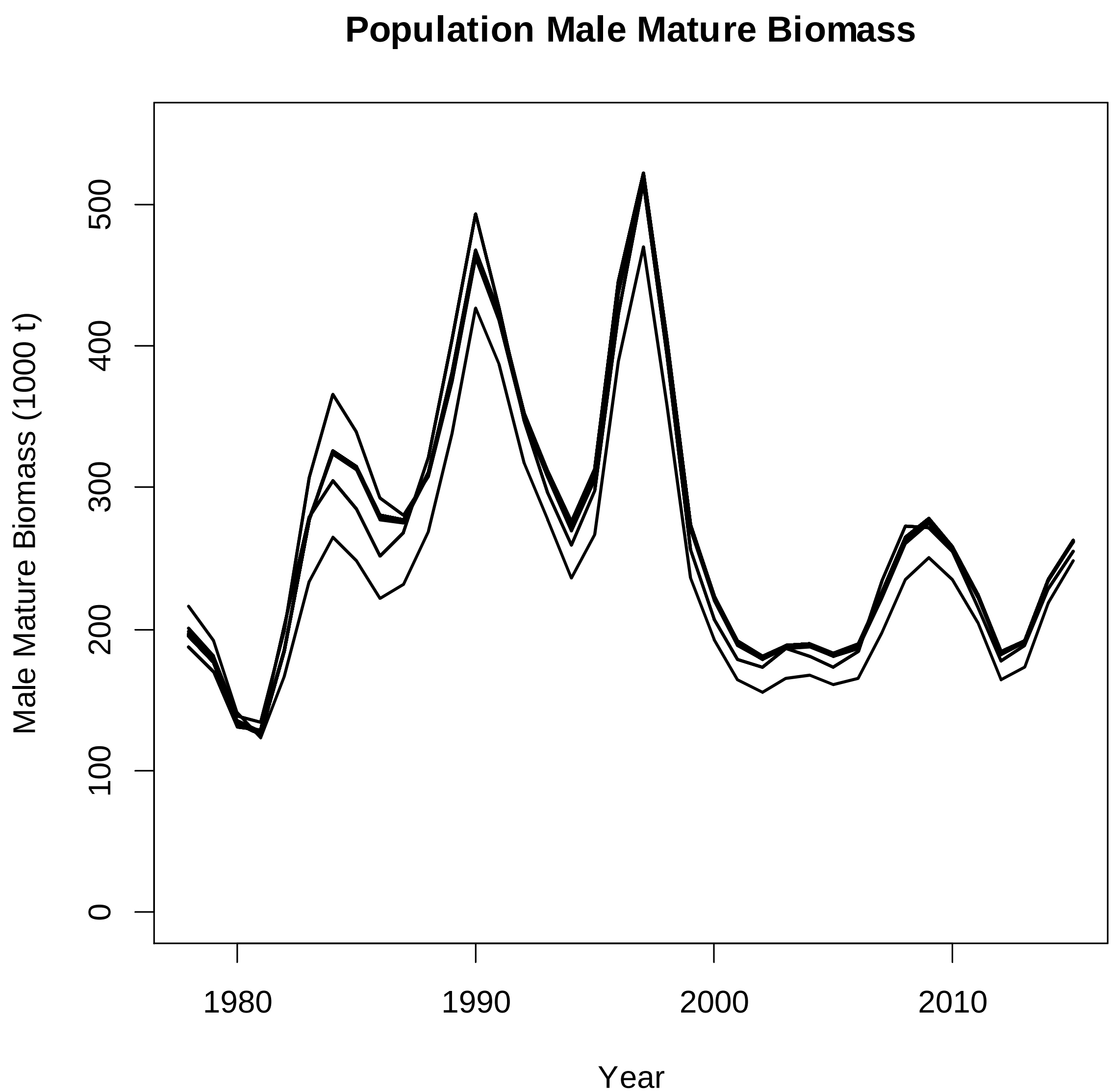


Figure 7a. Model 0 estimated male mature biomass for 79 (out of 100) jitter runs that wrote the std file, maximum gradient < 1.0 and total likelihood < 6500.

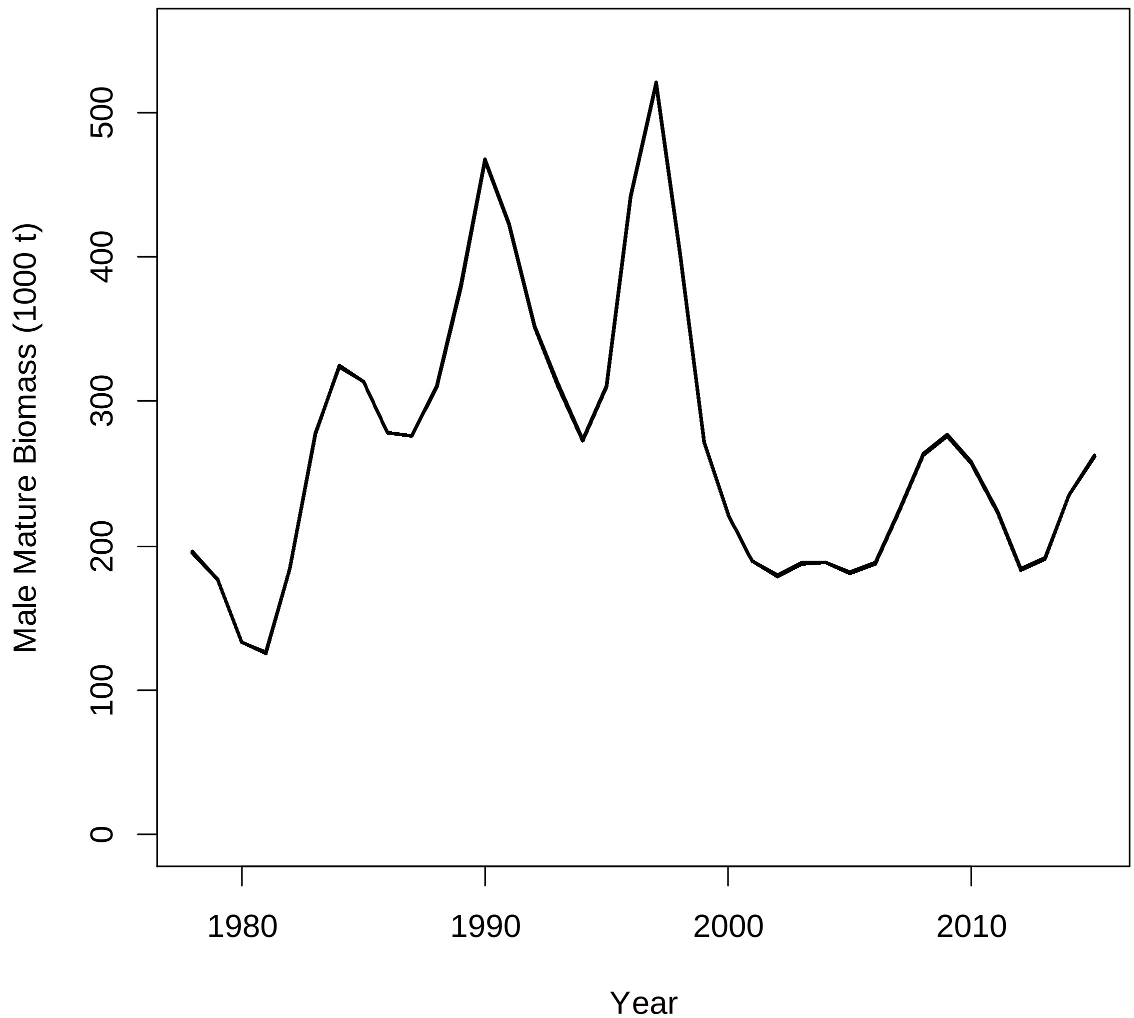


Figure 7b. Model 0 estimated male mature biomass for 3 (out of 100) jitter runs that wrote the std file, maximum gradient < 1.0 and total likelihood of 6376.97 or 6379.01.

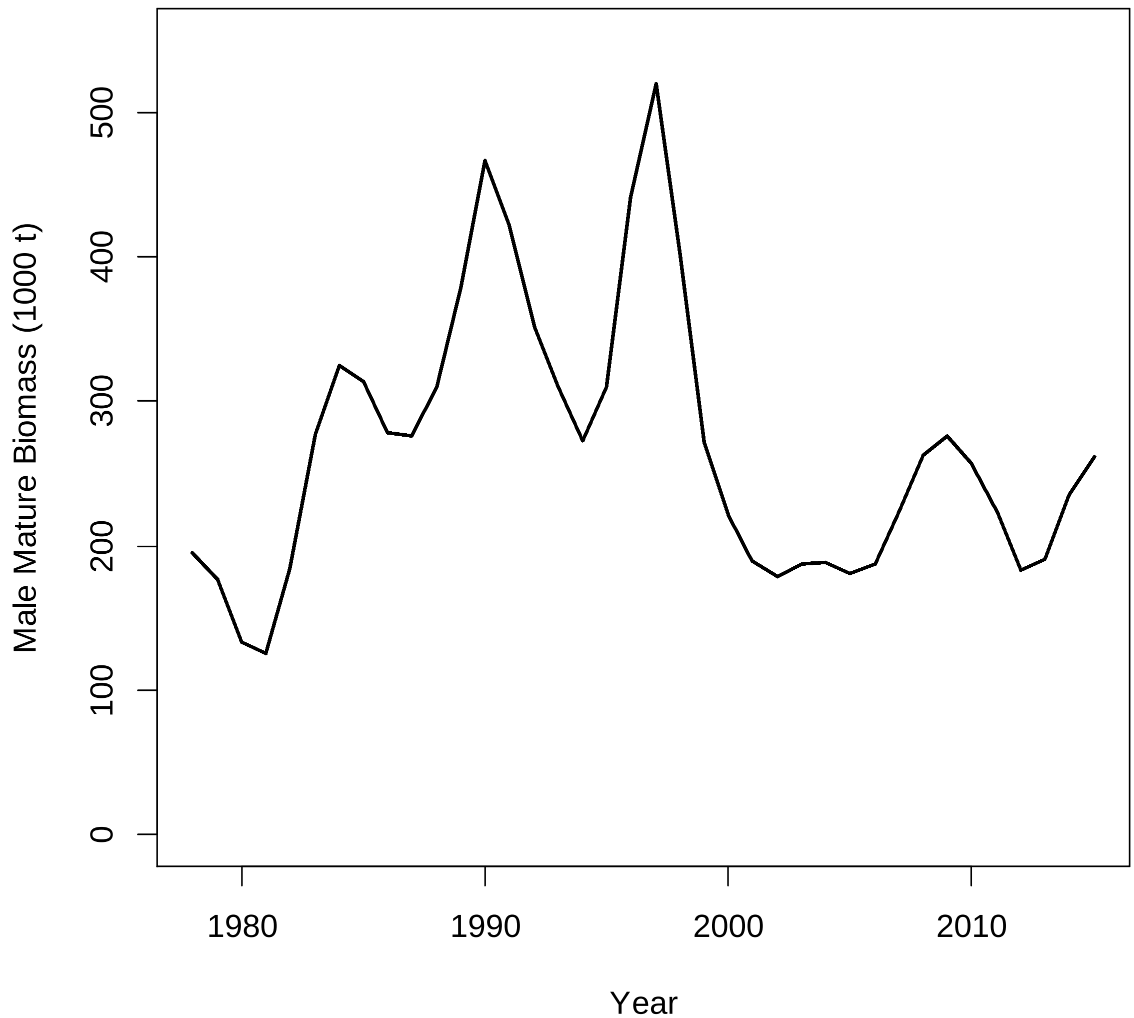


Figure 7c. Model 0 estimated male mature biomass for 32 (out of 100) jitter runs that wrote the std file, maximum gradient < 1.0 and the lowest total likelihood of 6376.97.

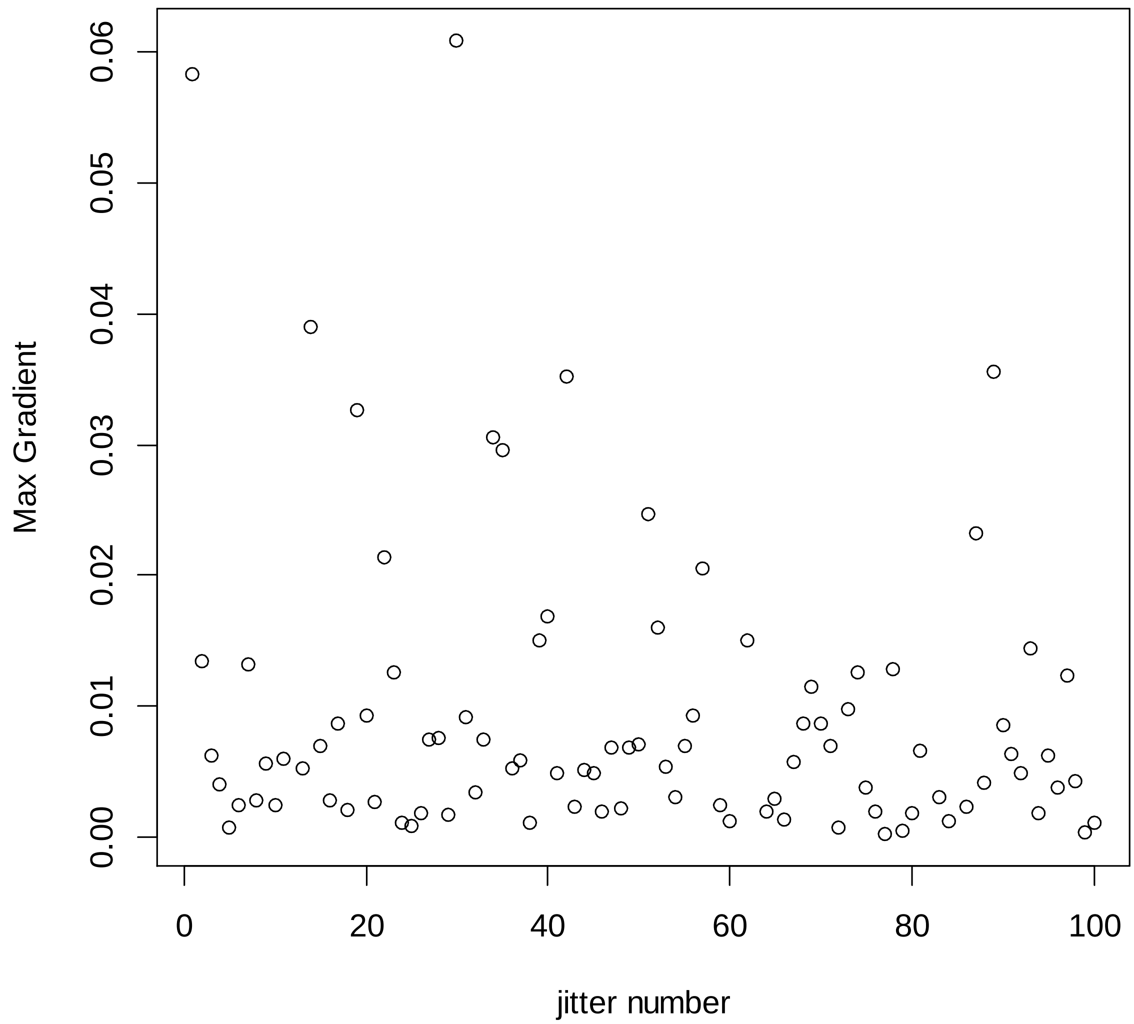


Figure 8. Model 1 maximum gradient by jitter number for runs that wrote the standard deviation file. One run wrote the standard deviation file and had a maximum gradient greater than 1 and was not included in this plot.

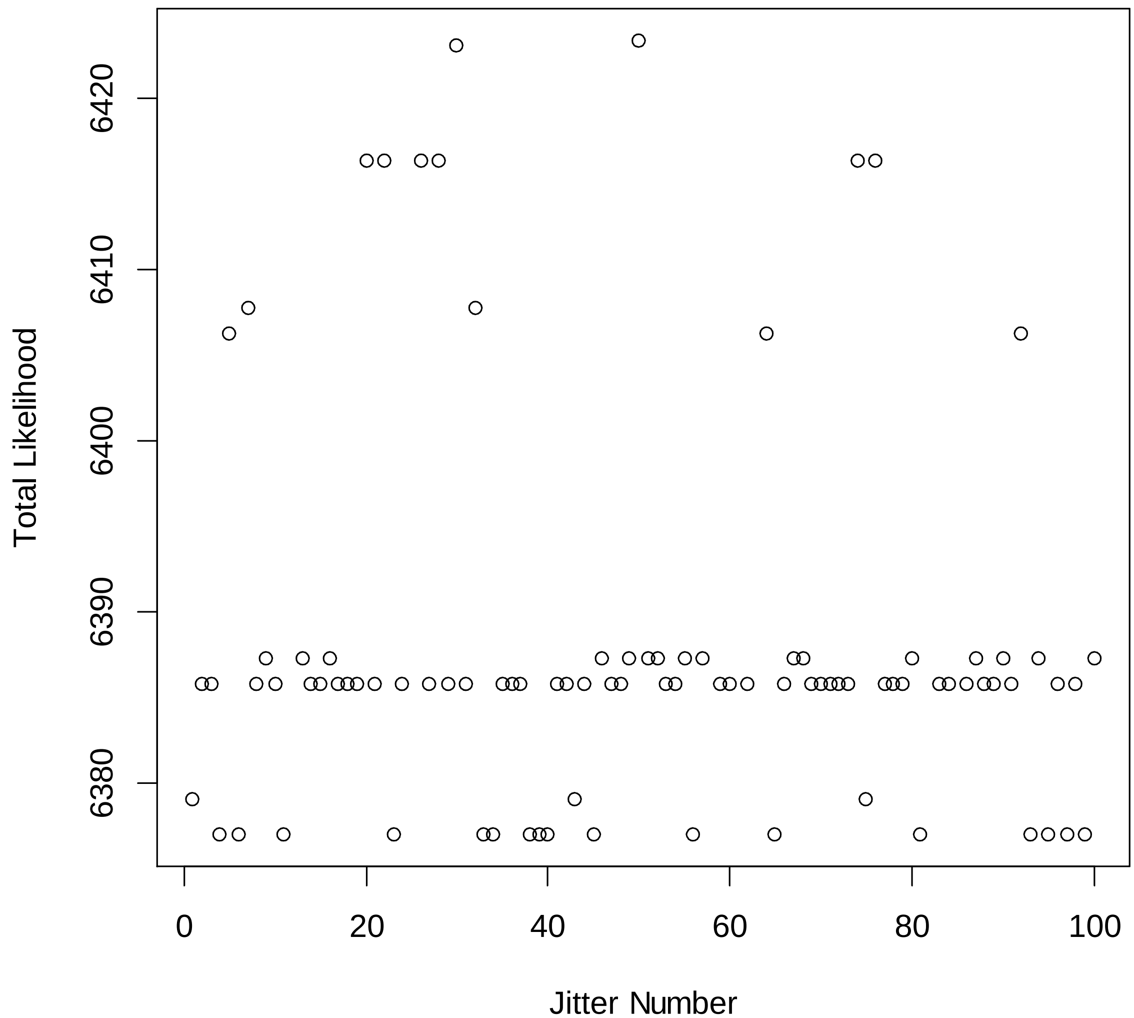


Figure 9. Model 1 total Likelihood by jitter number for runs that wrote the standard deviation file. Two runs wrote the standard deviation file were not included in this plot that had likelihoods greater than 6500.

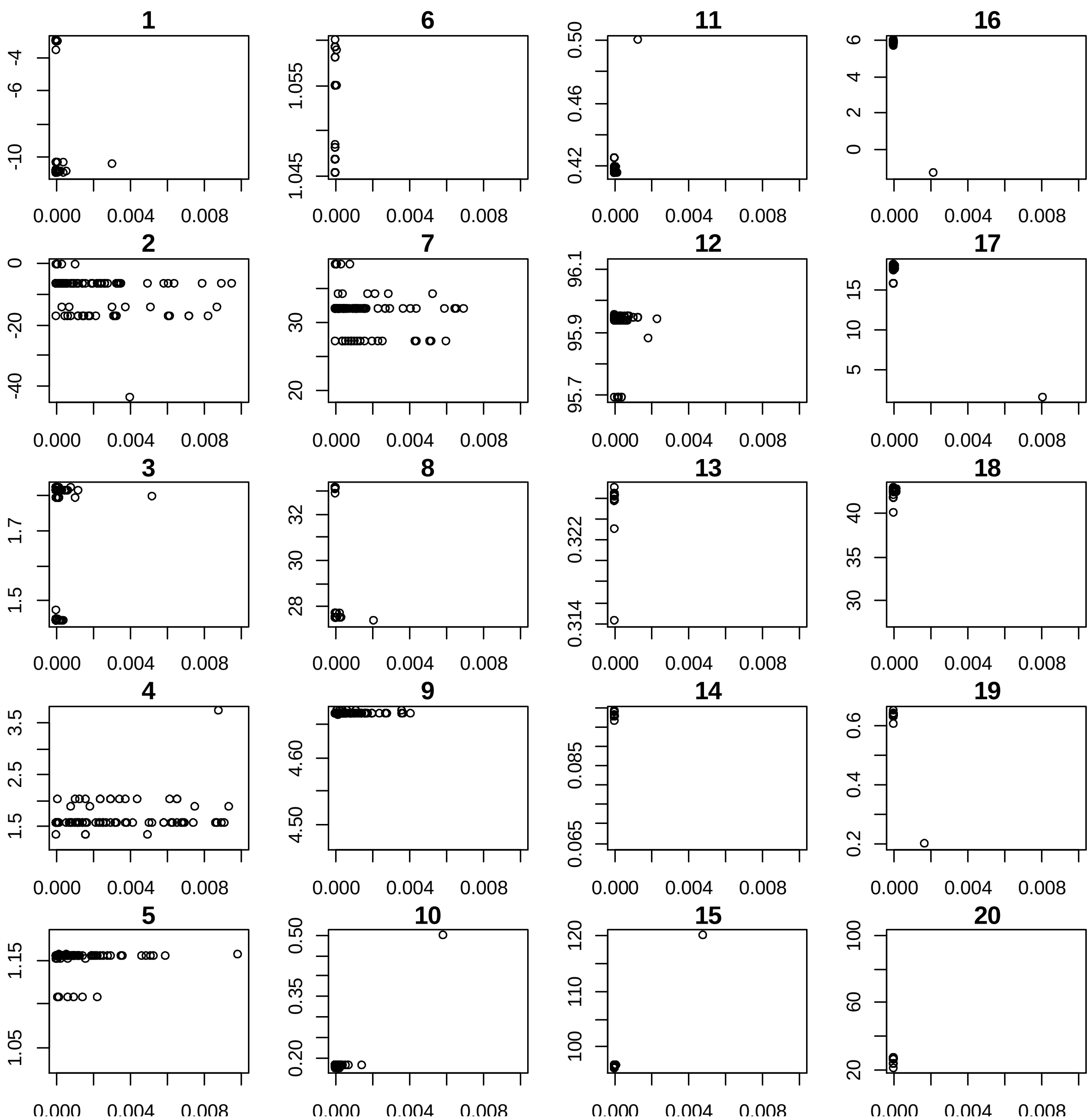

Figure 10. Parameter values (1-20 see Table 4) vs the parameter gradient for 94 (100 runs 6 did not write the std file) jittered runs of Model 1. The gradient axis was limited to 0.01 maximum.

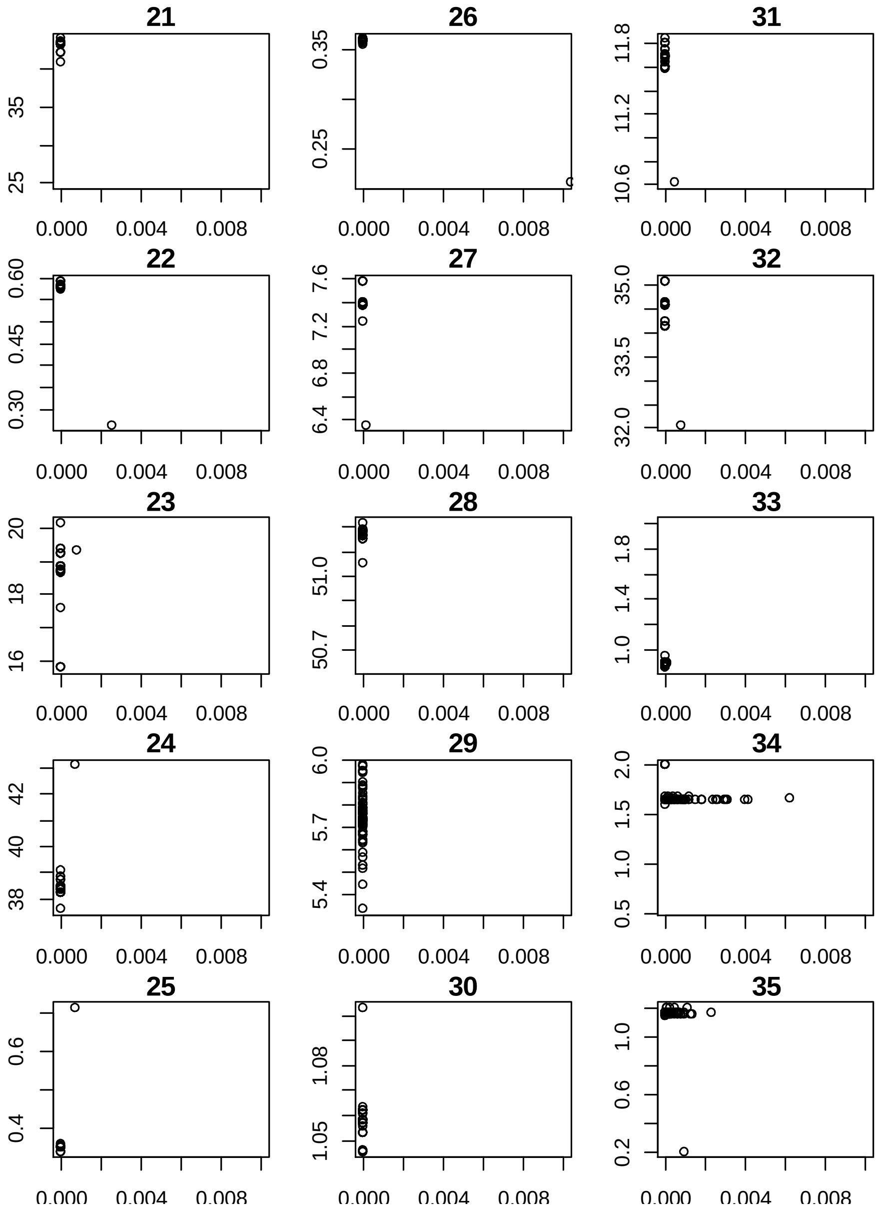


Figure 10 cont. Parameter values (21-35 see Table 4) vs the parameter gradient for 94 (100 runs 6 did not write the std file) jittered runs of Model 1. The gradient axis was limited to 0.01 maximum.

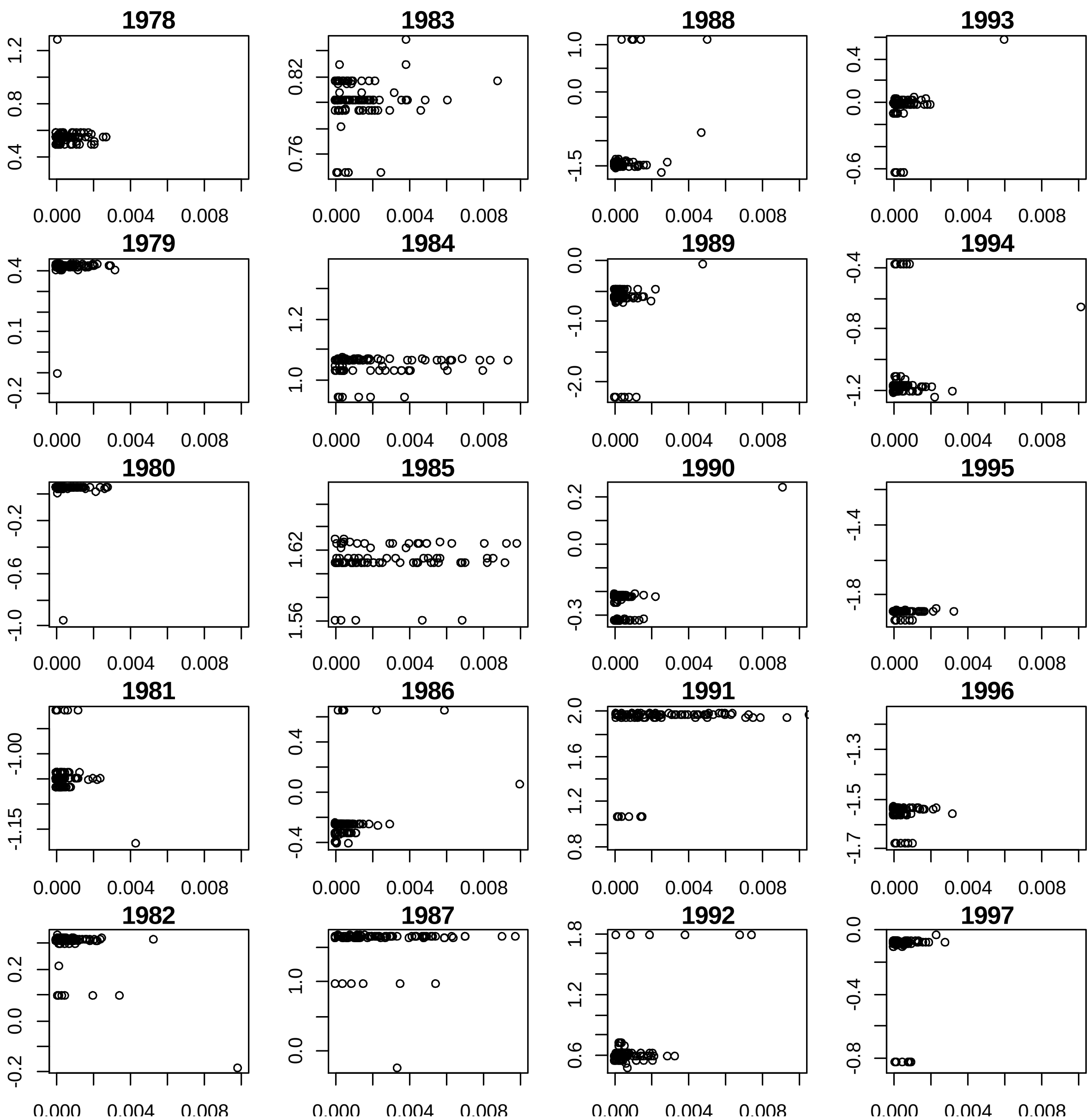


Figure 11. Recruitment deviation parameter values (title is year of deviation, 1978 = 1978/79 crab year) vs the parameter gradient for 94 (100 runs 6 did not write the std file) jittered runs of Model 1. The gradient axis was limited to 0.01 maximum.

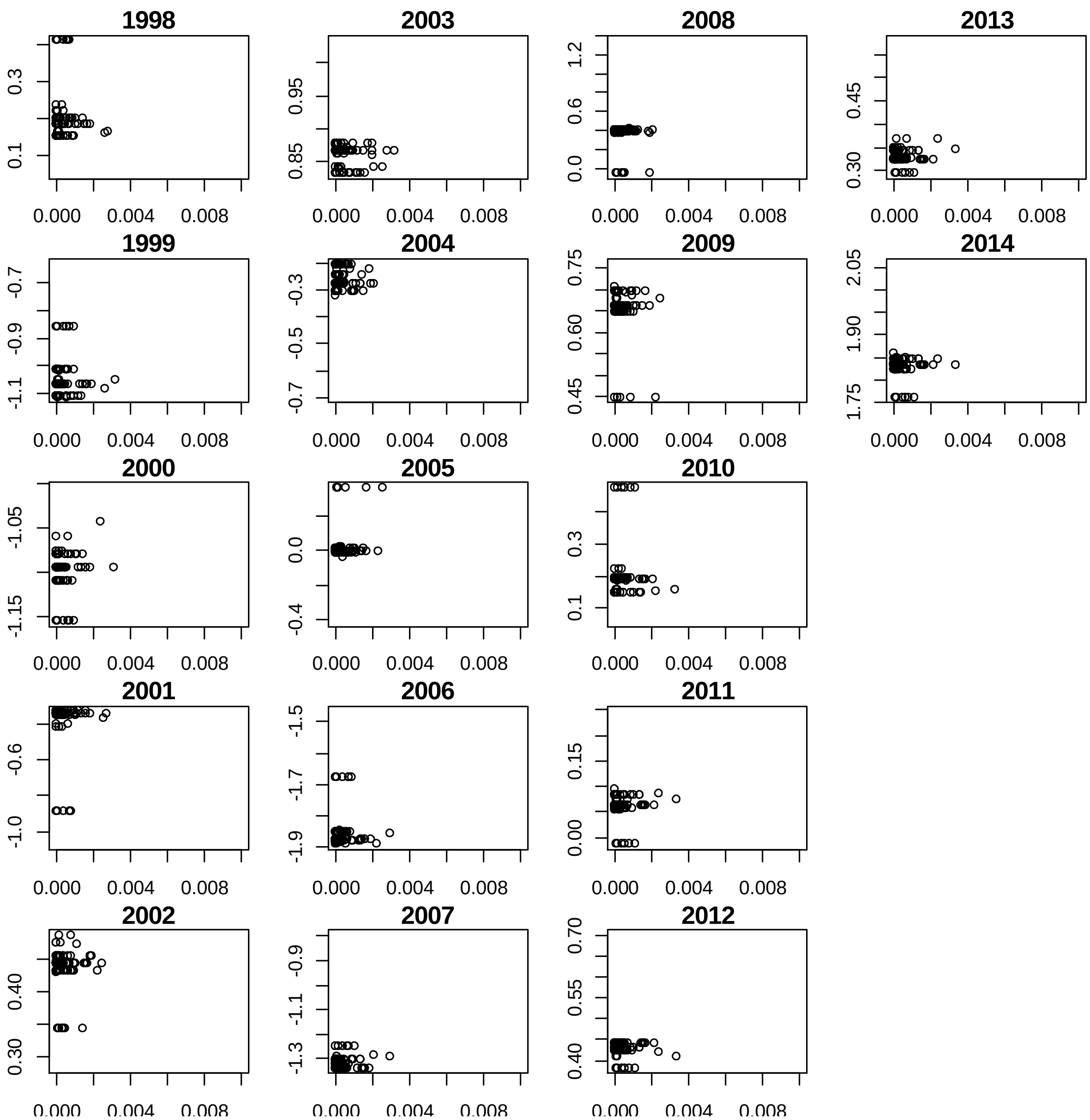


Figure 11 cont. Model 1. Recruitment deviation parameter values (title is year of deviation, 1978 = 1978/79 crab year) vs the parameter gradient for 94 (100 runs 6 did not write the std file) jittered runs of Model 1. The gradient axis was limited to 0.01 maximum.

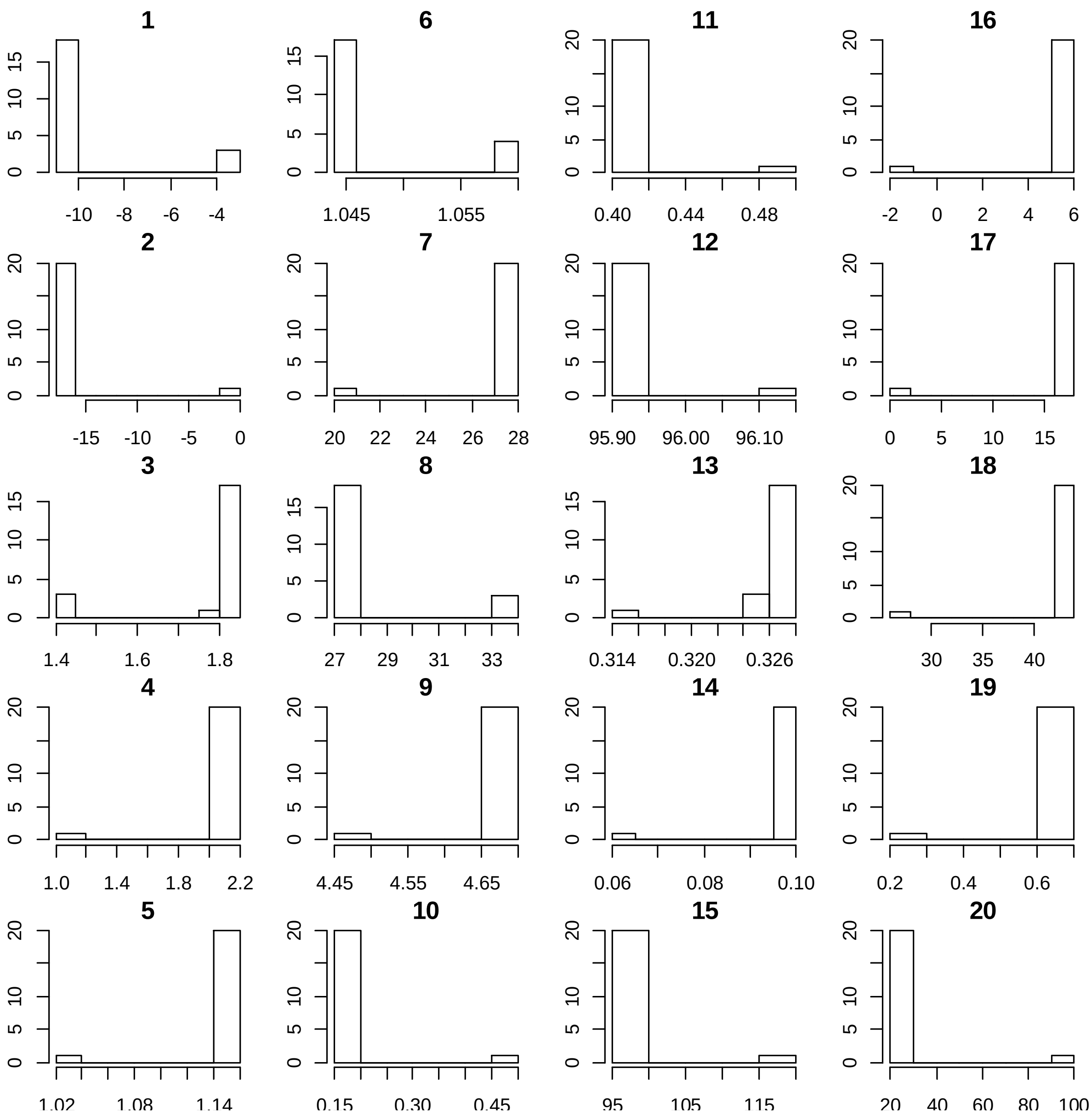


Figure 12. Model 1 parameter values for parameters 1-20 for runs where the total likelihood was 6379.01 (3 runs) and 6376.97 (17 runs). Refer to Table 4 for parameter names.

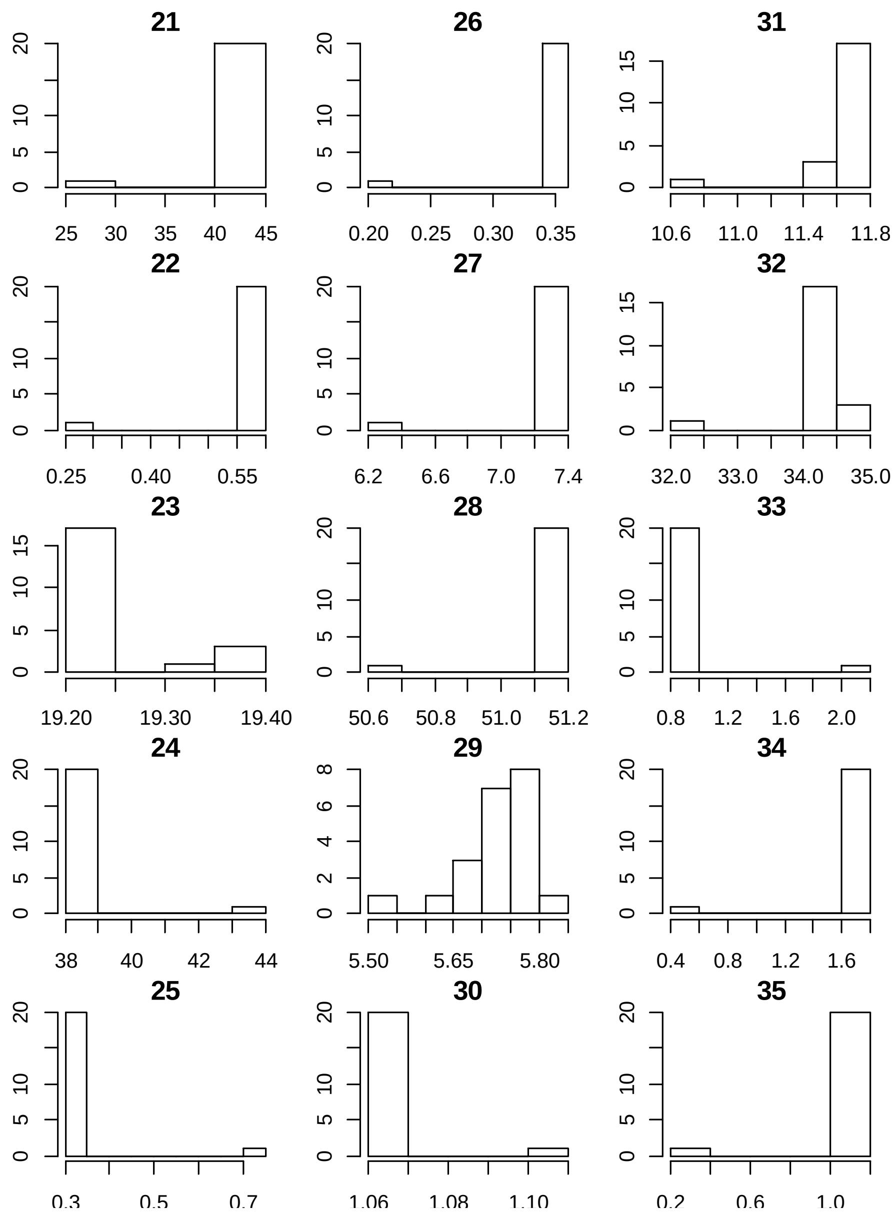


Figure 12 cont. Model 1 parameter values for parameters 21-35 for runs where the total likelihood was 6379.01 (3 runs) and 6376.97 (17 runs). Refer to Table 4 for parameter names.

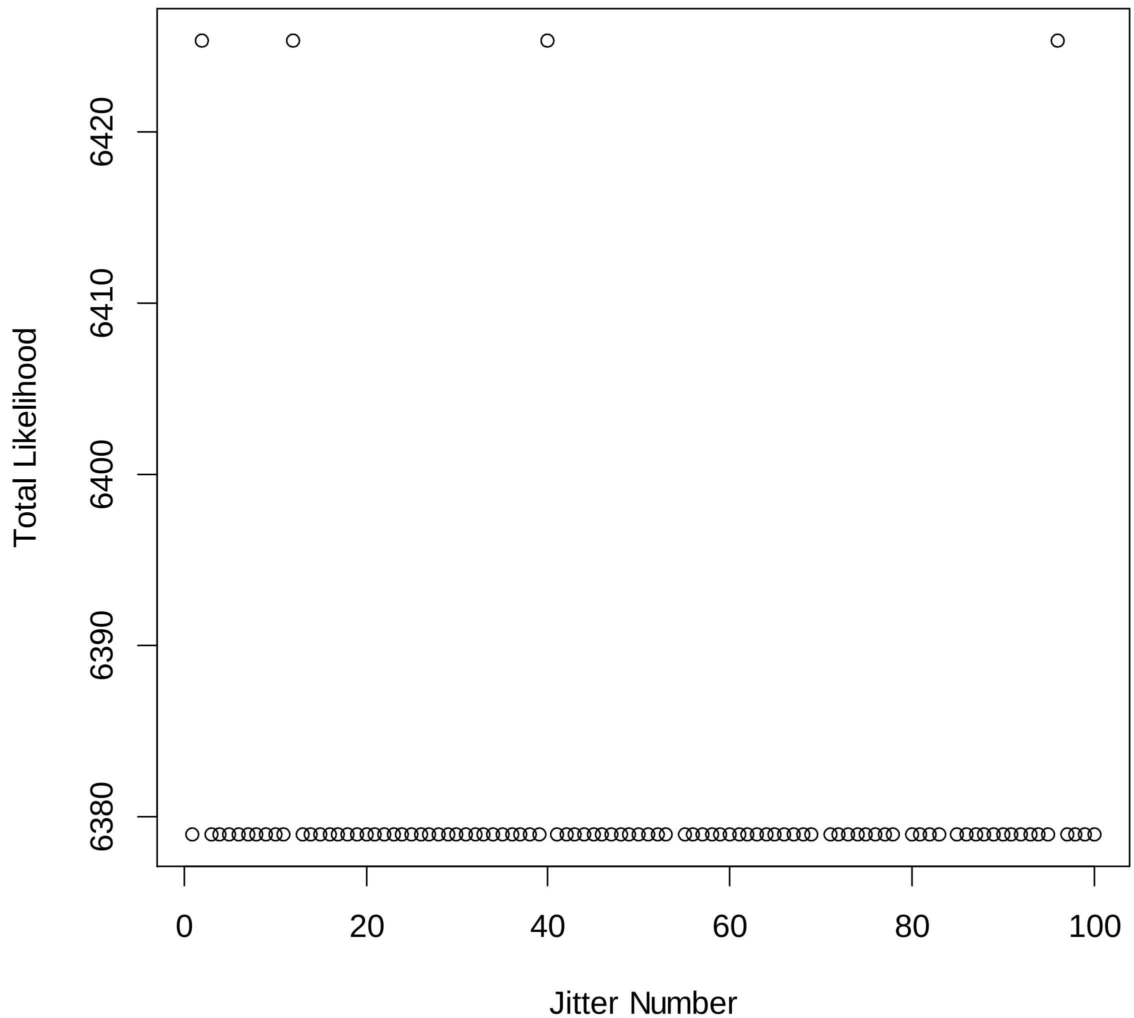


Figure 13. Model 1a. Total Likelihood by jitter number for runs that wrote the standard deviation file.

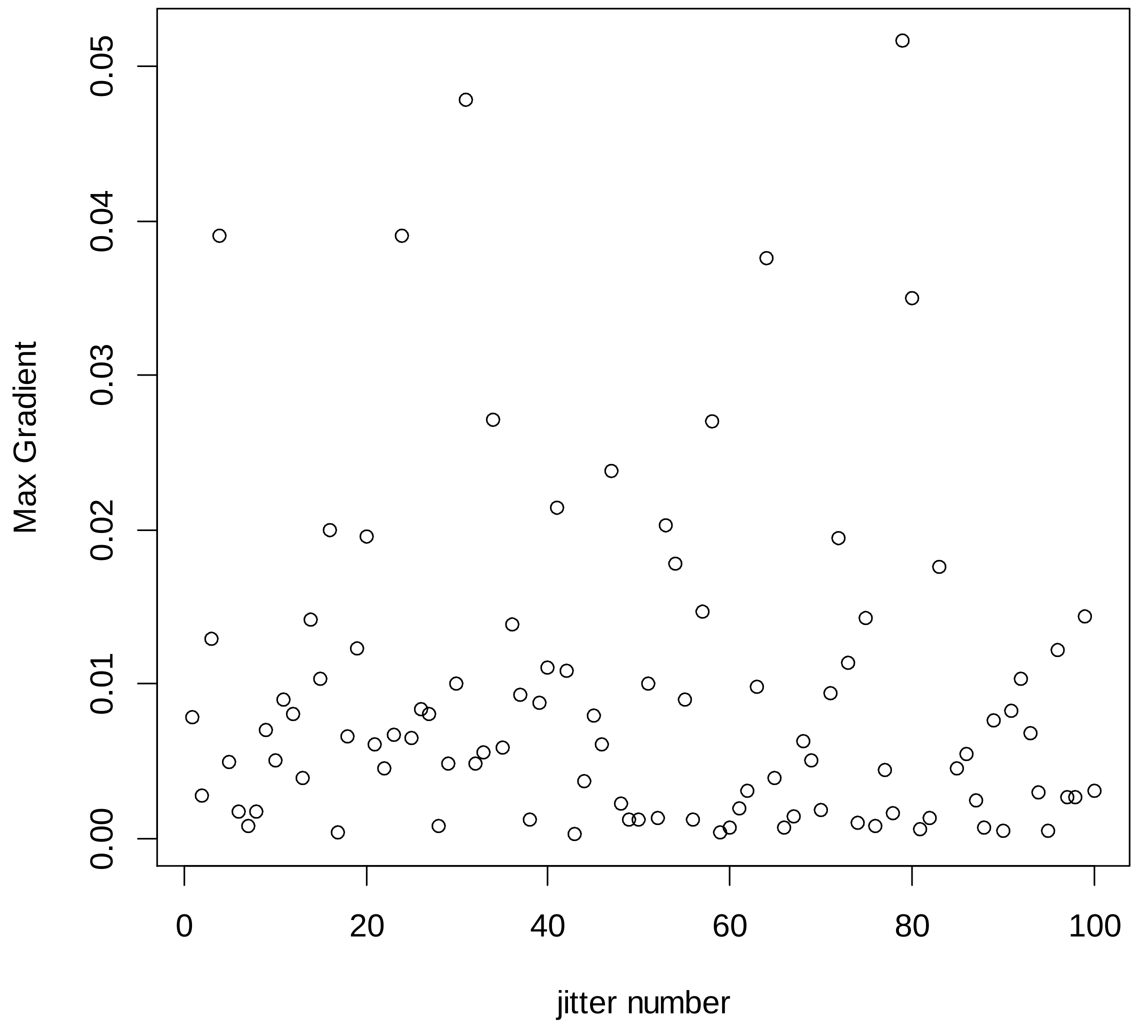


Figure 14. Model 1a. Maximum gradient by jitter number for runs that wrote the standard deviation file.

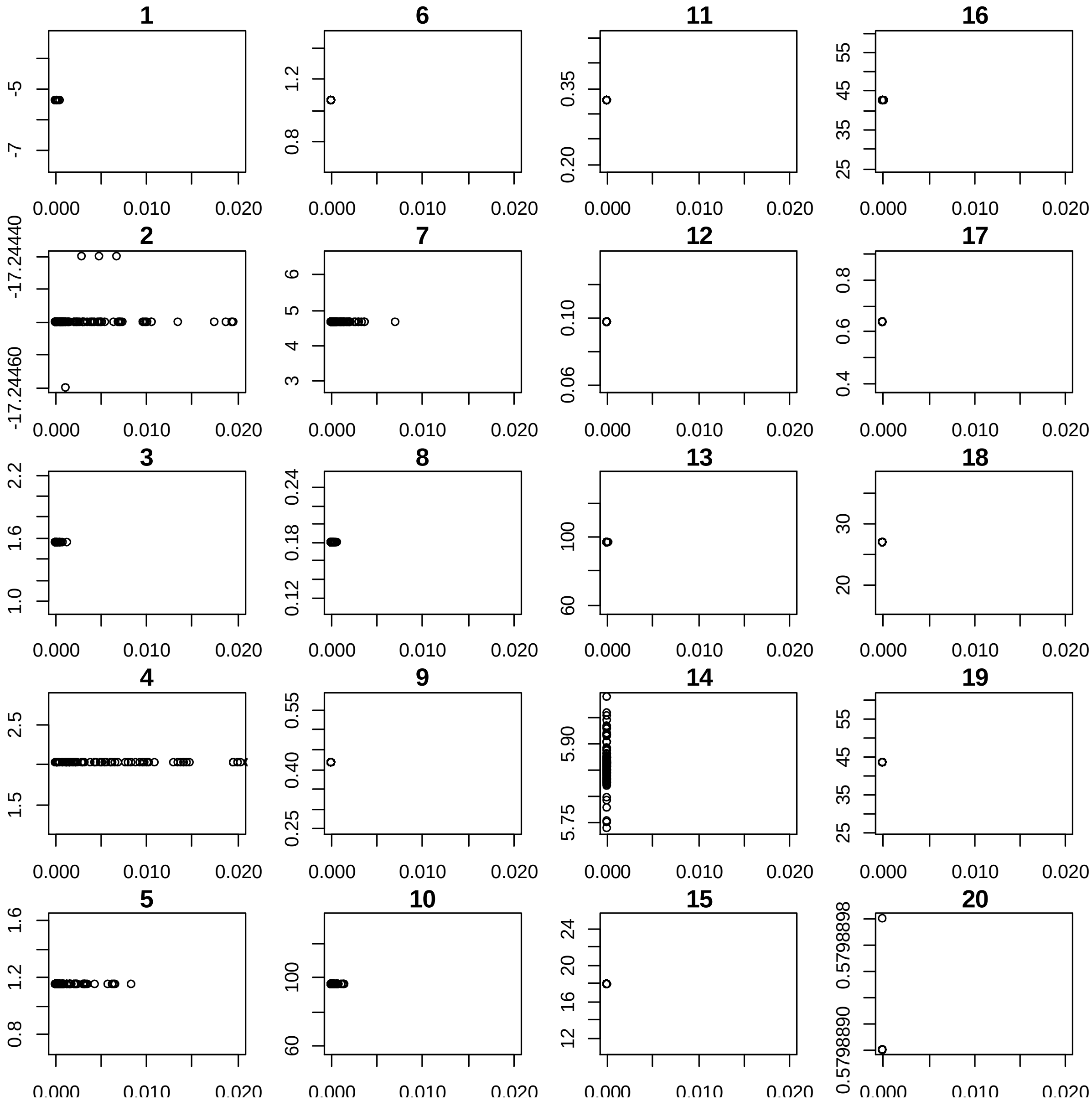

Figure 15. Model 1a. Parameter values (1-20 see Table 7) vs the parameter gradient for 94 runs where total likelihood was 6378.94. Scale to 0.02 although some gradients larger.

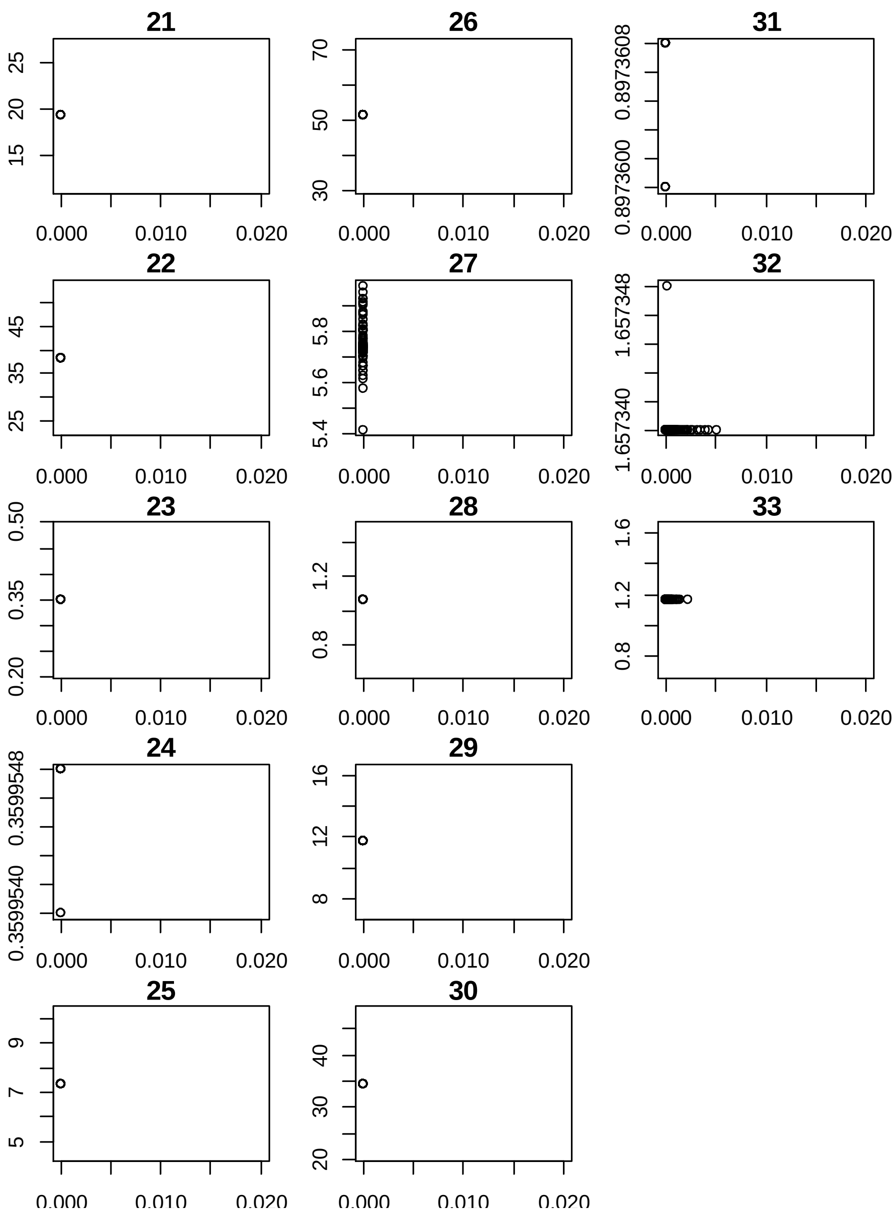


Figure 15 cont. Model 1a. Parameter values (11-33 see Table 7) vs the parameter gradient for 94 runs where total likelihood was 6378.94. Scale to 0.02 although some gradients larger.

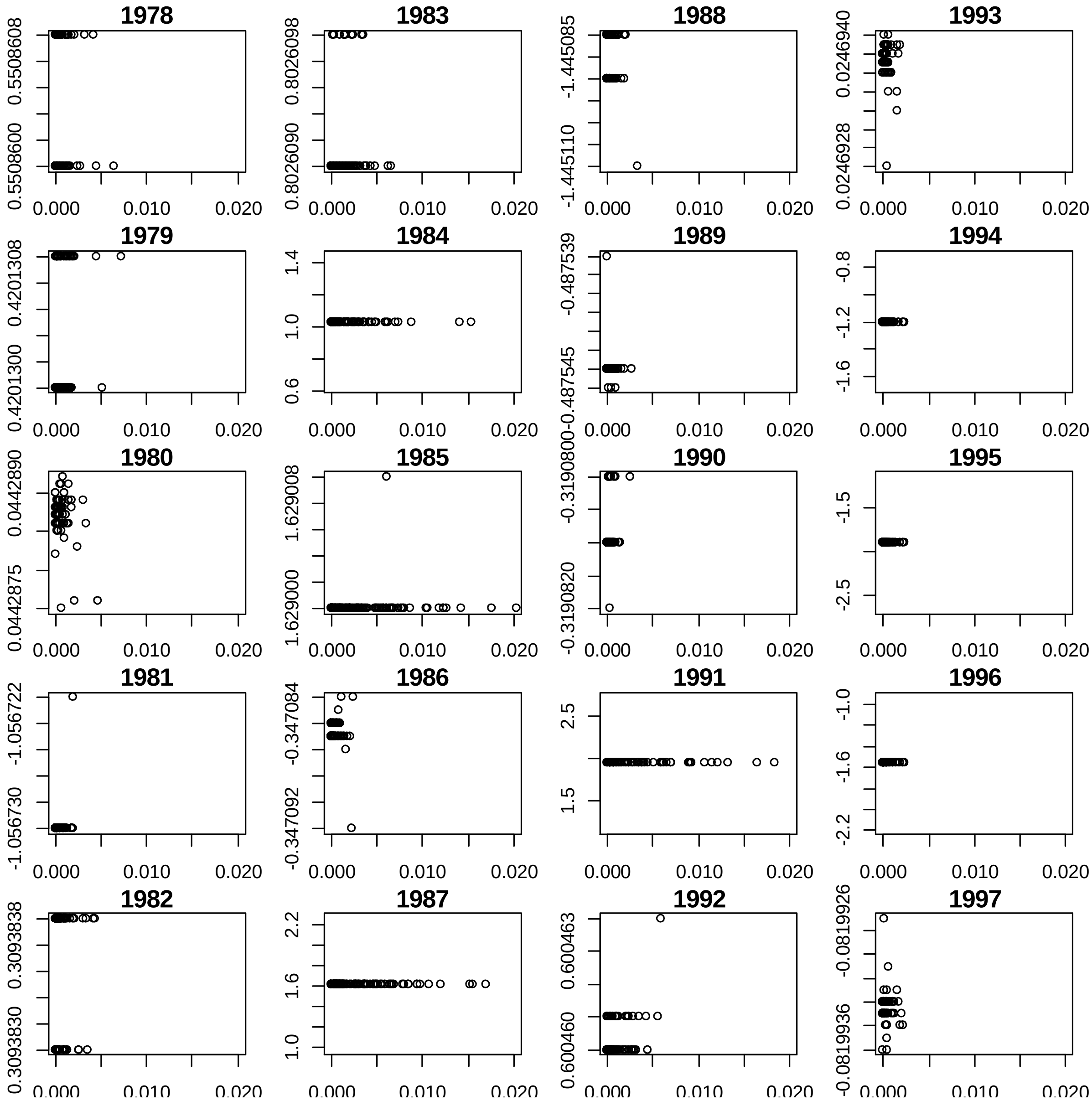


Figure 16. Model 1a. Recruitment deviation parameter values (title is year of deviation, 1978 = 1978/79 crab year) vs the parameter gradient for 100 jittered runs of Model 1a. The gradient axis was limited to 0.02 maximum.

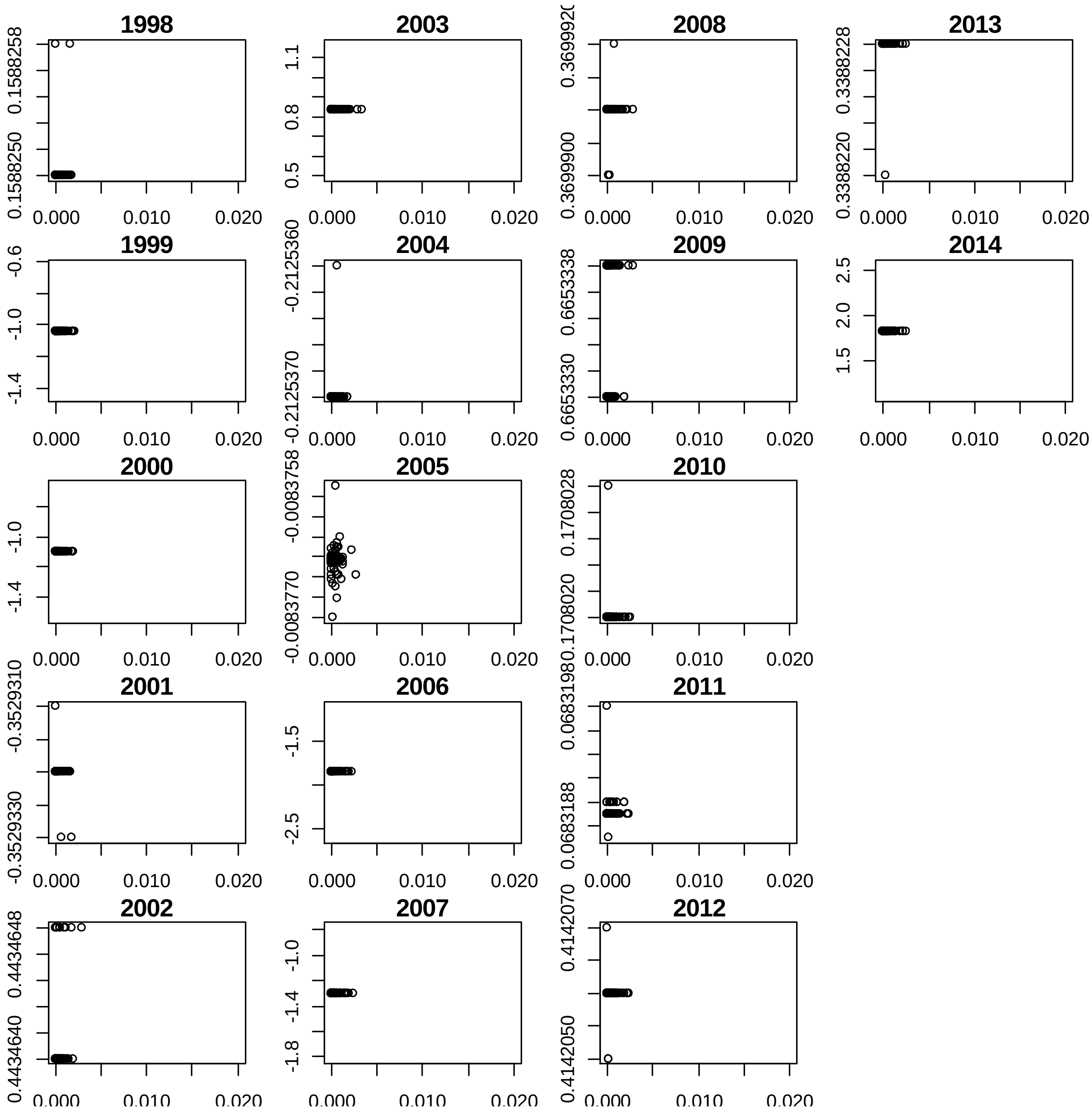


Figure 16 cont. Model 1a. Recruitment deviation parameter values (title is year of deviation, 1978 = 1978/79 crab year) vs the parameter gradient for 100 jittered runs of Model 1a. The gradient axis was limited to 0.02 maximum.

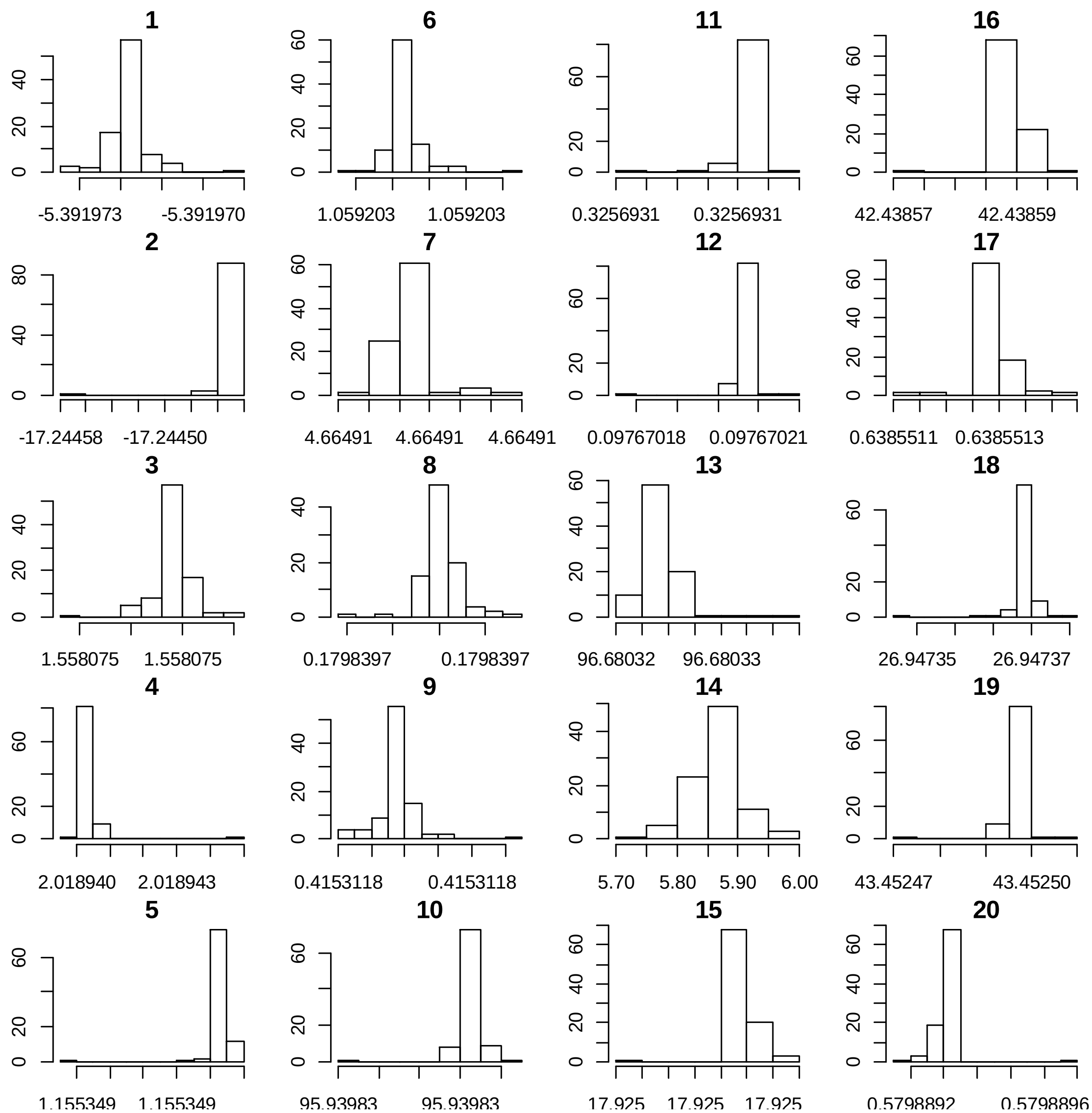


Figure 17. Model 1a. Parameter values for parameters 1-20 for runs where the total likelihood was 6378.94. Refer to Table 7 for parameter names.

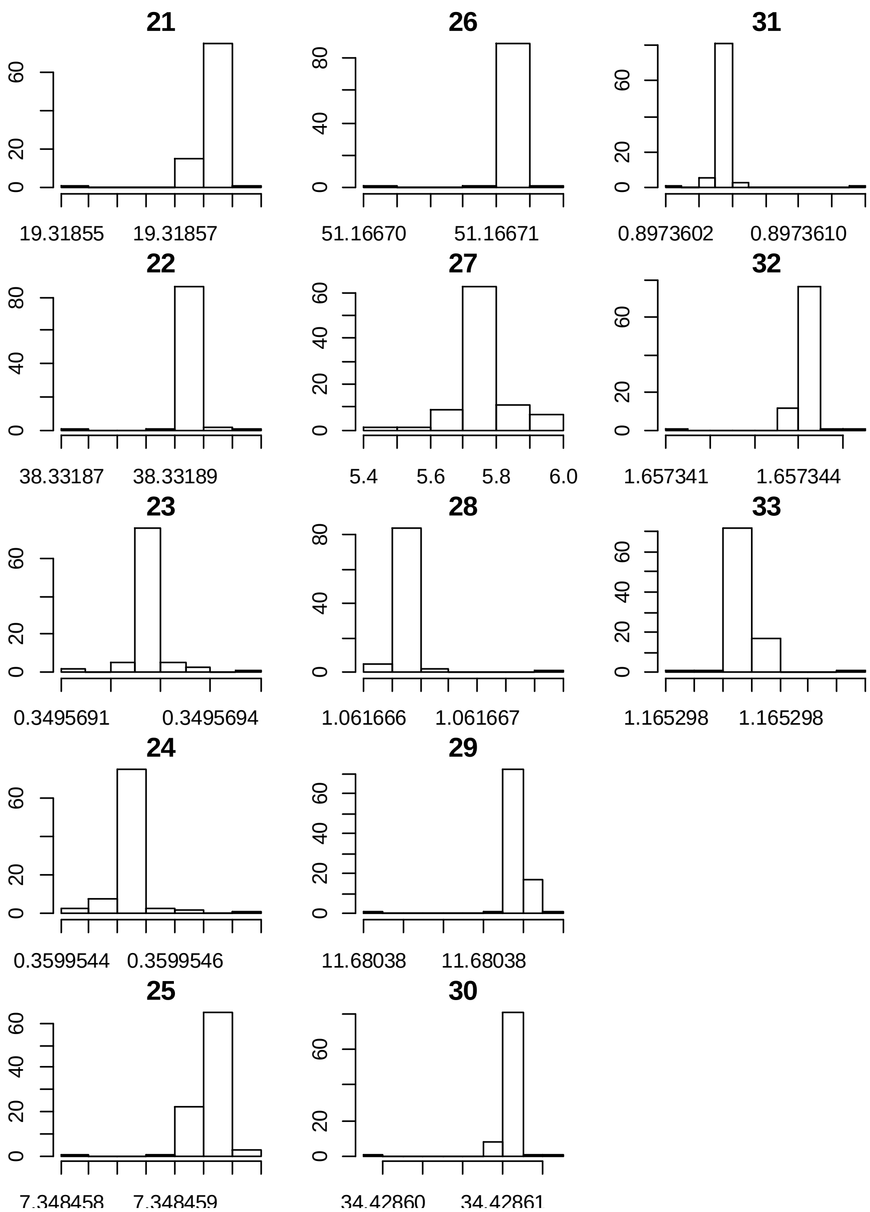


Figure 17 cont. Model 1a. Parameter values for parameters 21-33 for runs where the total likelihood was 6378.94. Refer to Table 7 for parameter names.

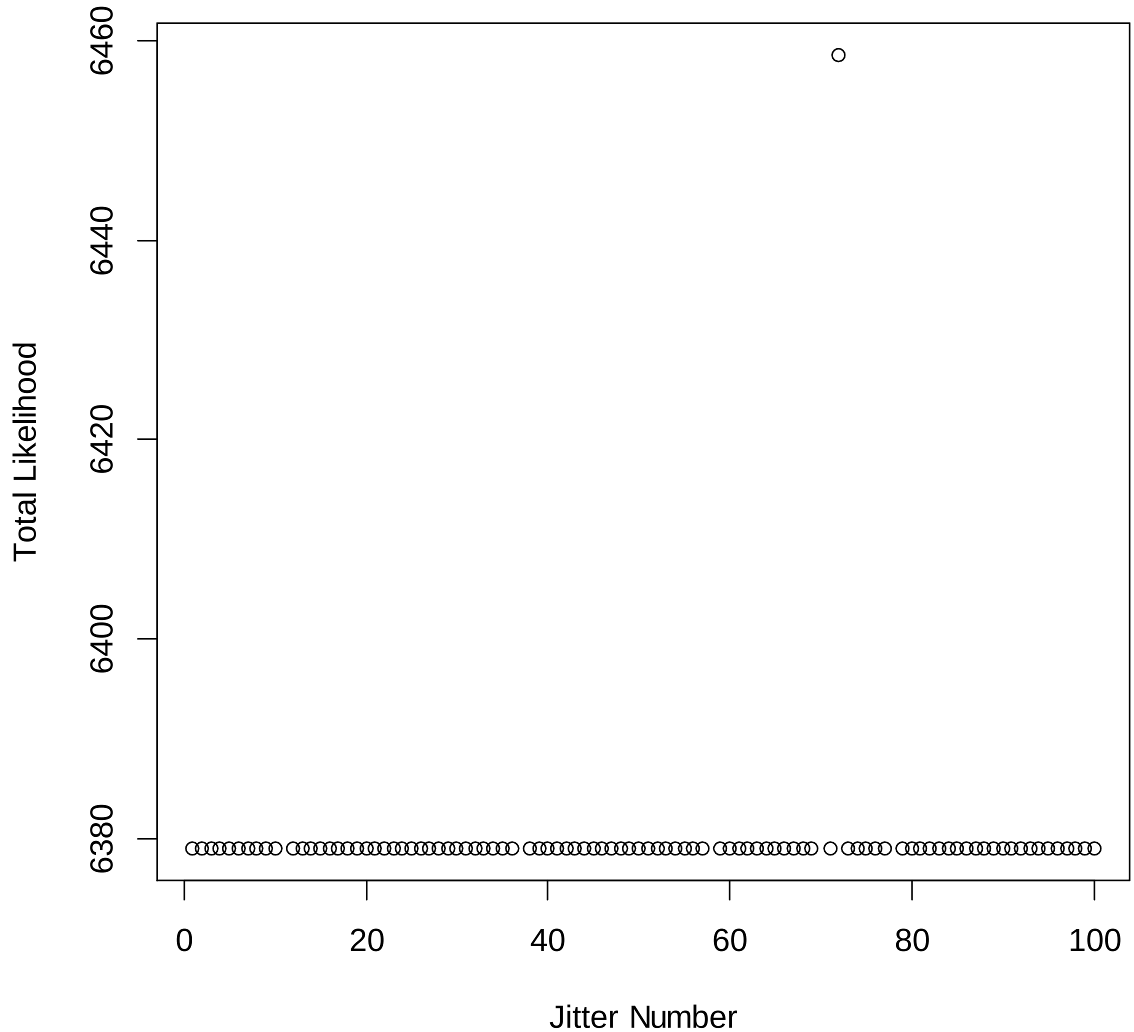


Figure 18. Model 0a total Likelihood by jitter number for runs that wrote the standard deviation file.

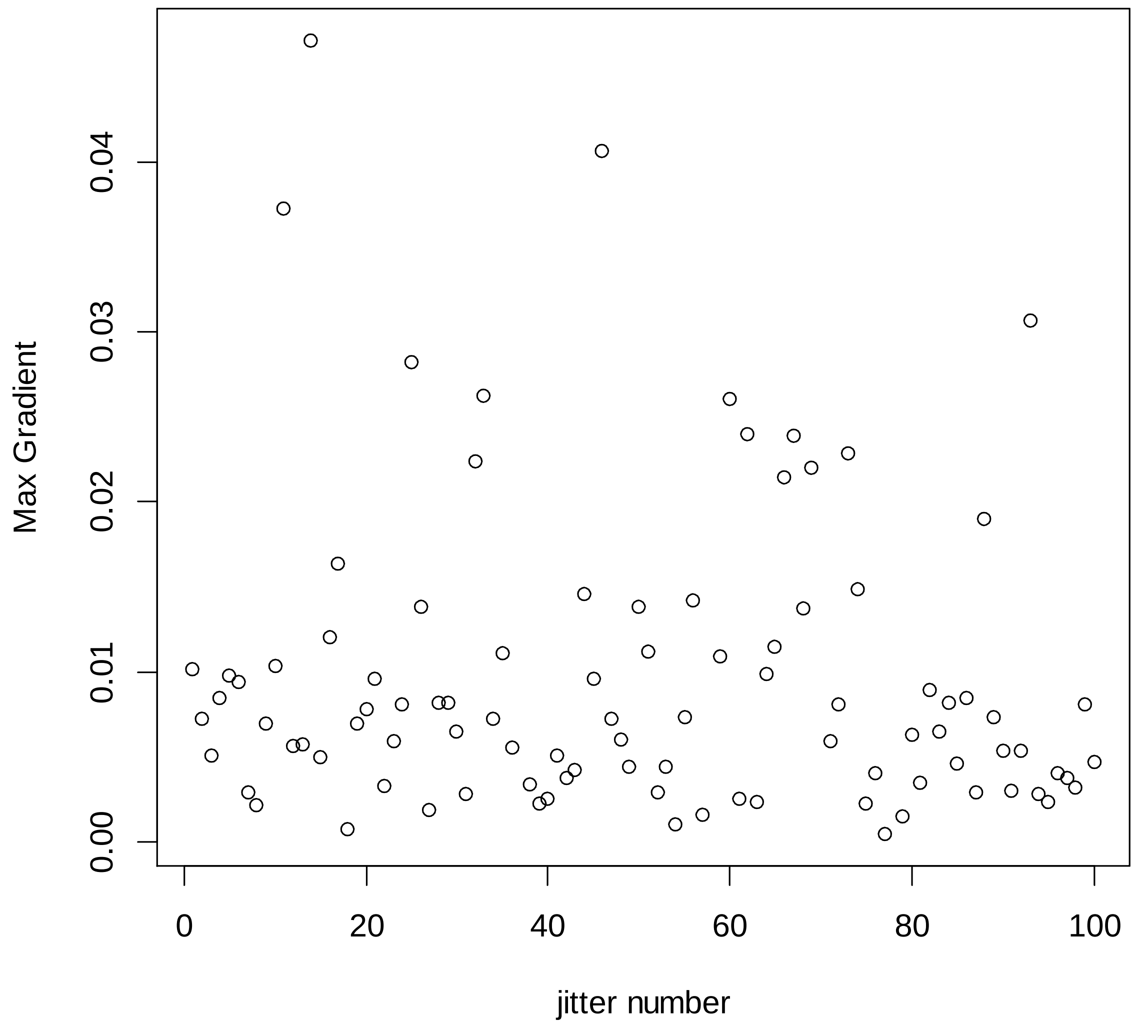


Figure 19. Model 0a maximum gradient by jitter number for runs that wrote the standard deviation file.

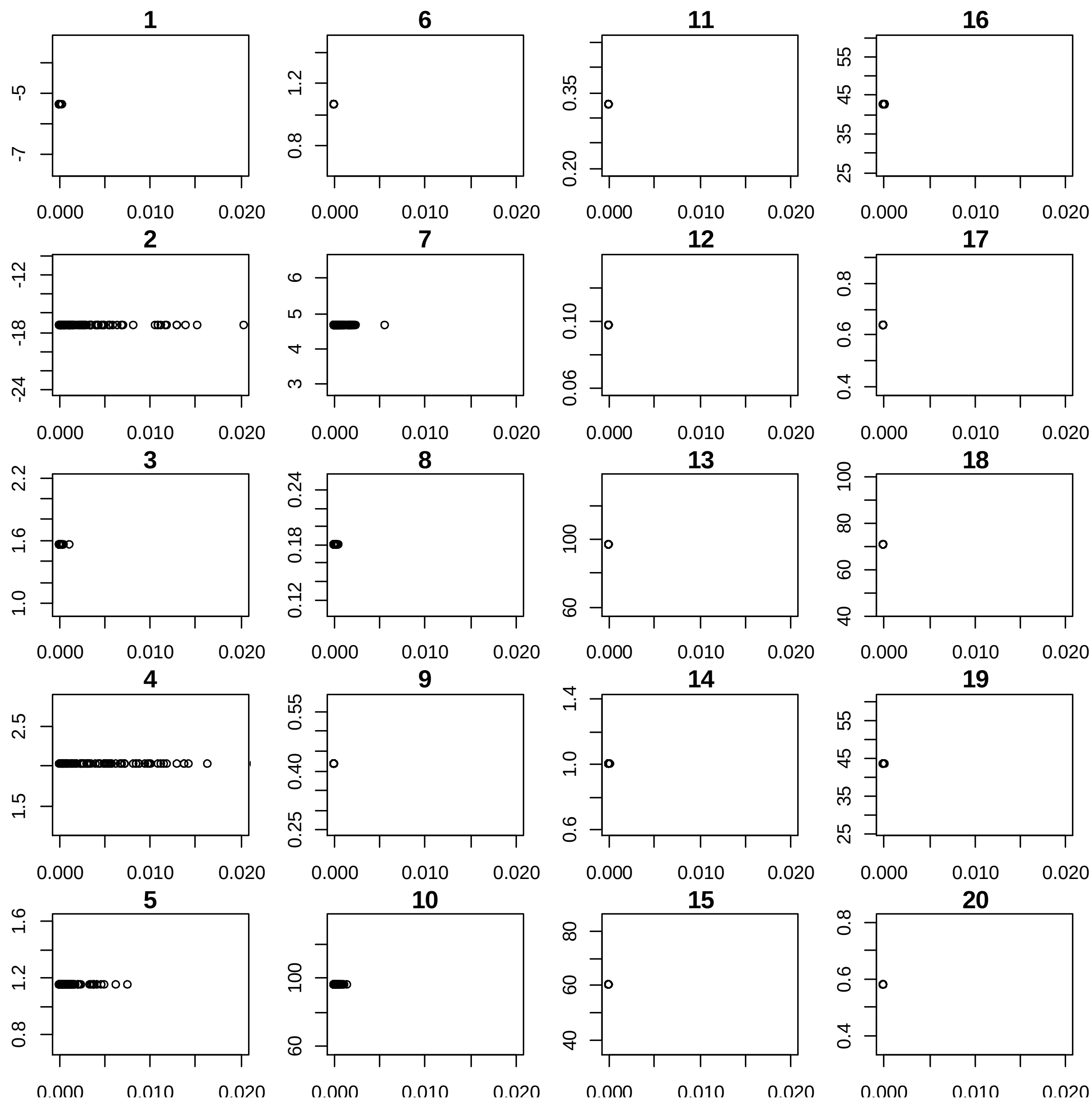

Figure 20. Model 0a. Parameter values (1-20 see Table 10) vs the parameter gradient for 94 with total likelihood 6378.94. The gradient axis was limited to 0.02 maximum.

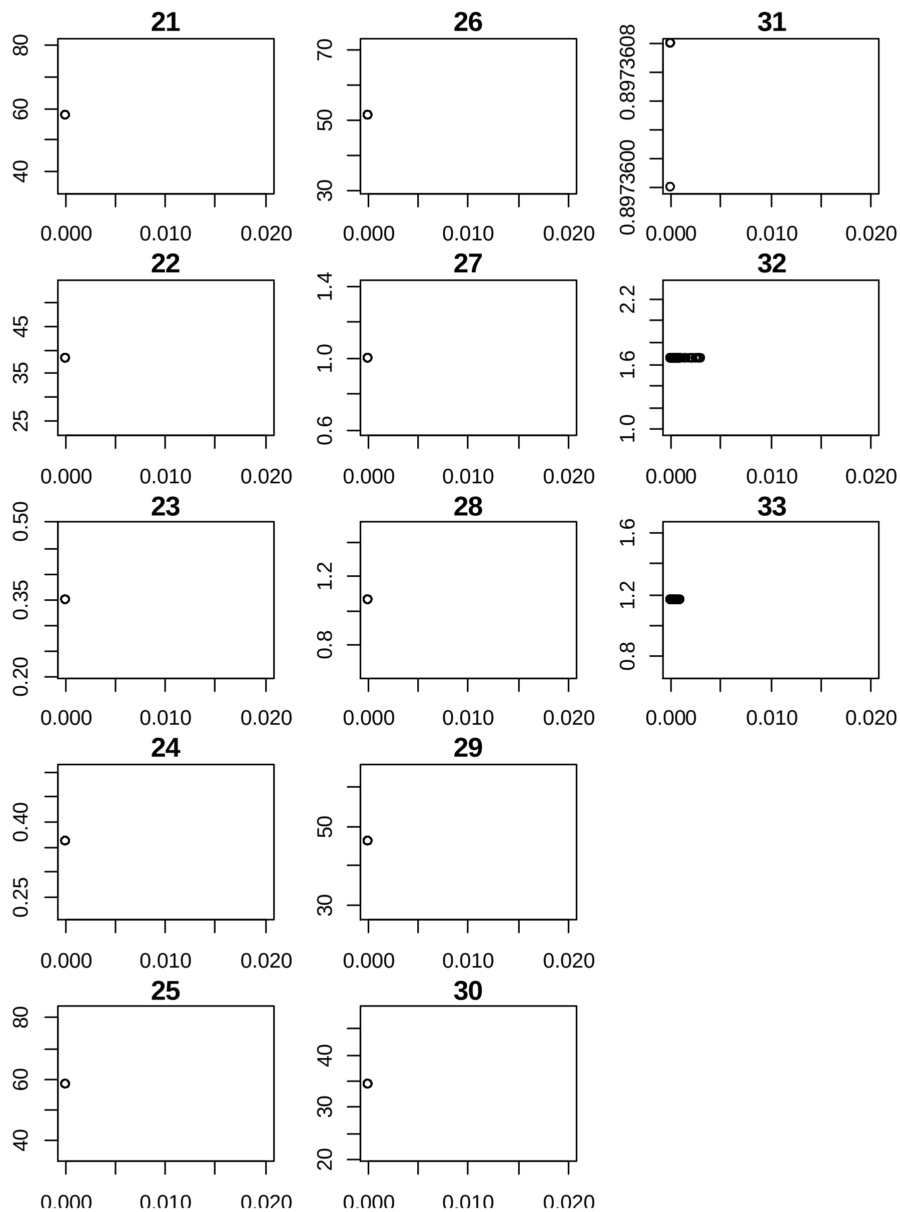


Figure 20 cont. Model 0a. Parameter values (21-33 see Table 10) vs the parameter gradient for 94 with total likelihood 6378.94. The gradient axis was limited to 0.02 maximum.

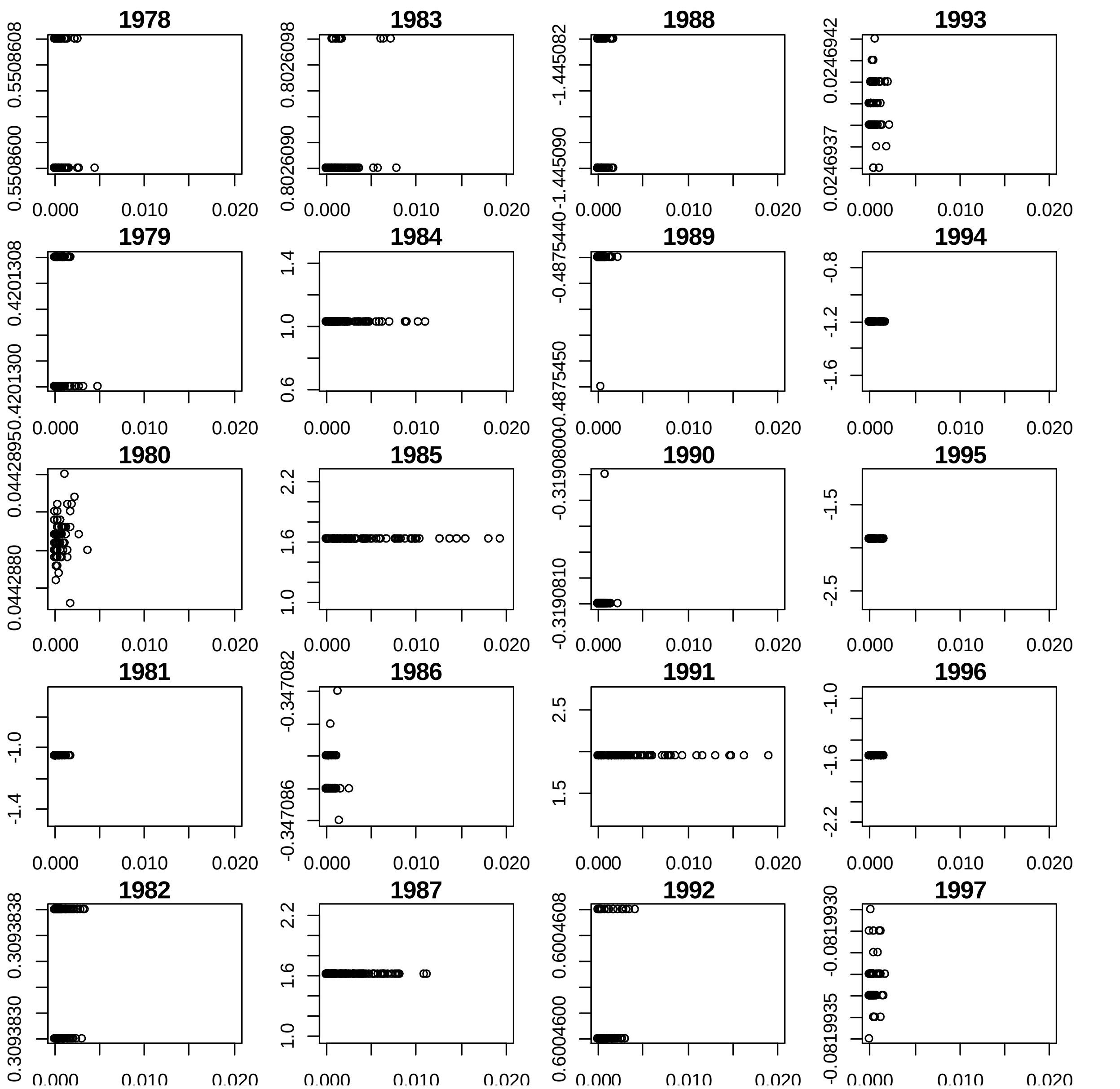

Figure 21. Model 0a. Recruitment deviation parameter values (title is year of deviation, 1978 = 1978/79 crab year) vs the parameter gradient for 94 with total likelihood 6378.94. The gradient axis was limited to 0.02 maximum.

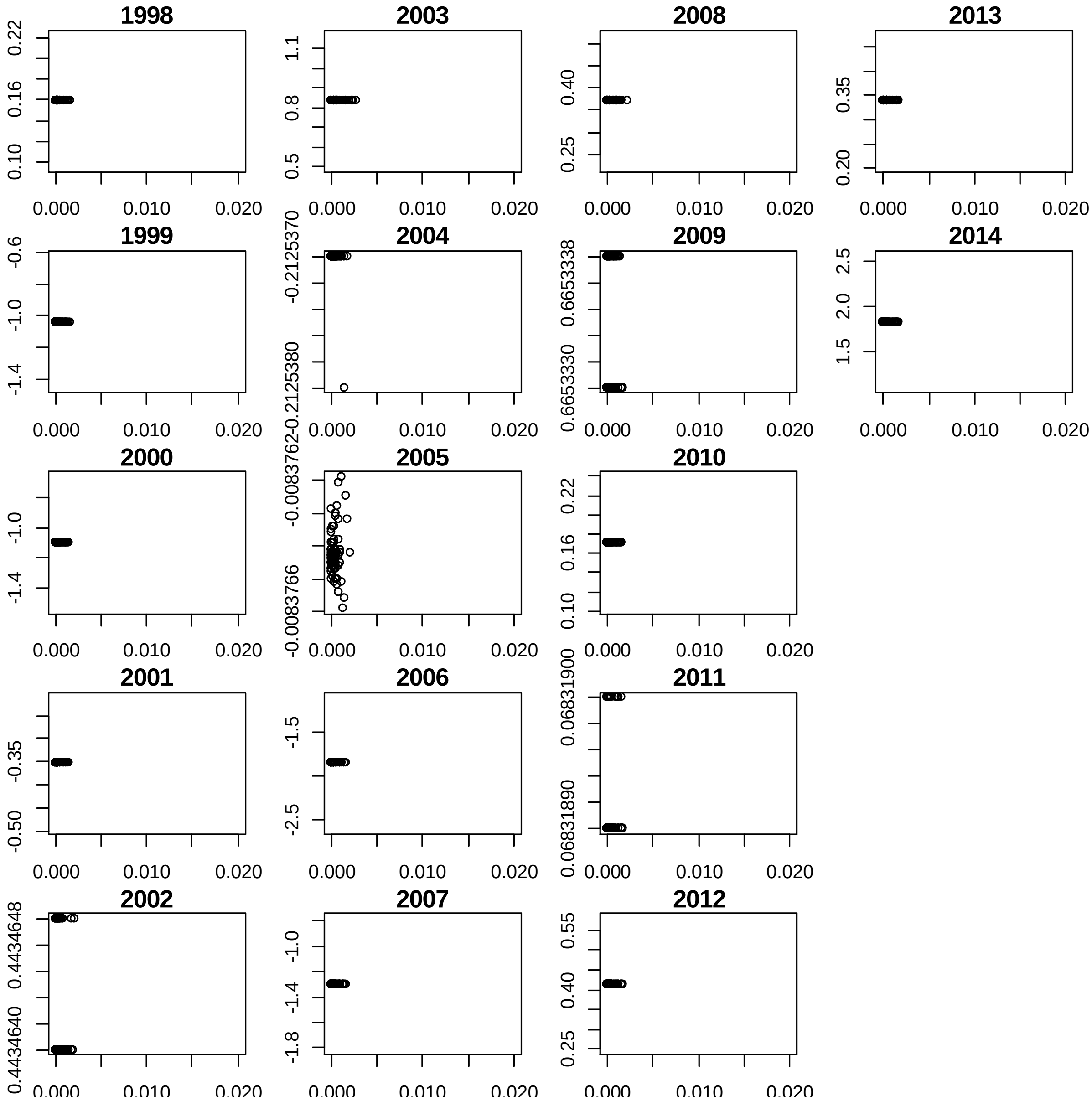


Figure 21 cont. Model 0a. Recruitment deviation parameter values (title is year of deviation, 1978 = 1978/79 crab year) vs the parameter gradient for 94 with total likelihood 6378.94. The gradient axis was limited to 0.02 maximum.

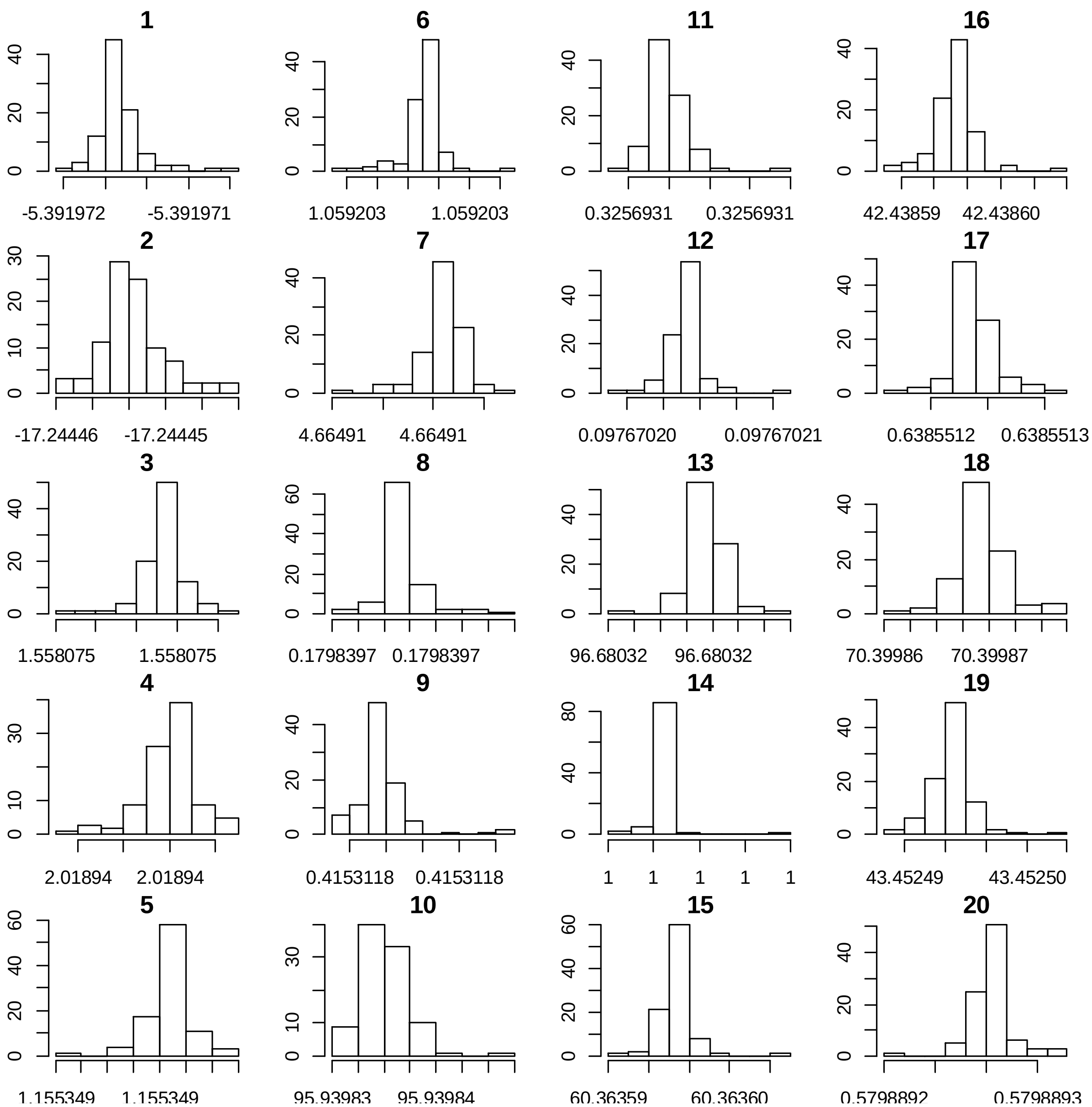


Figure 22. Model 0a. Parameter values for parameters 1-20 for runs where the total likelihood was 6378.94. Refer to Table 10 for parameter names.

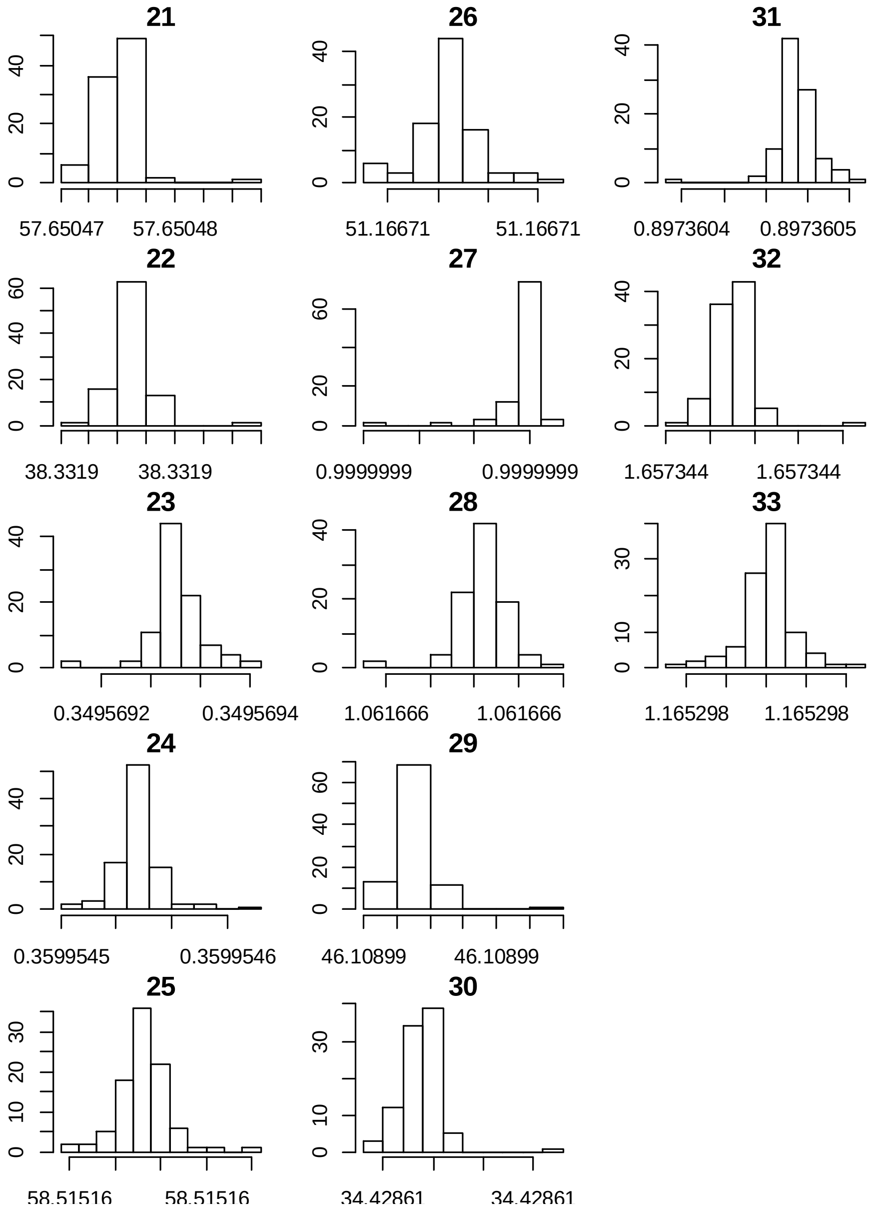


Figure 22 cont. Model 0a. Parameter values for parameters 21-33 for runs where the total likelihood was 6378.94. Refer to Table 10 for parameter names.

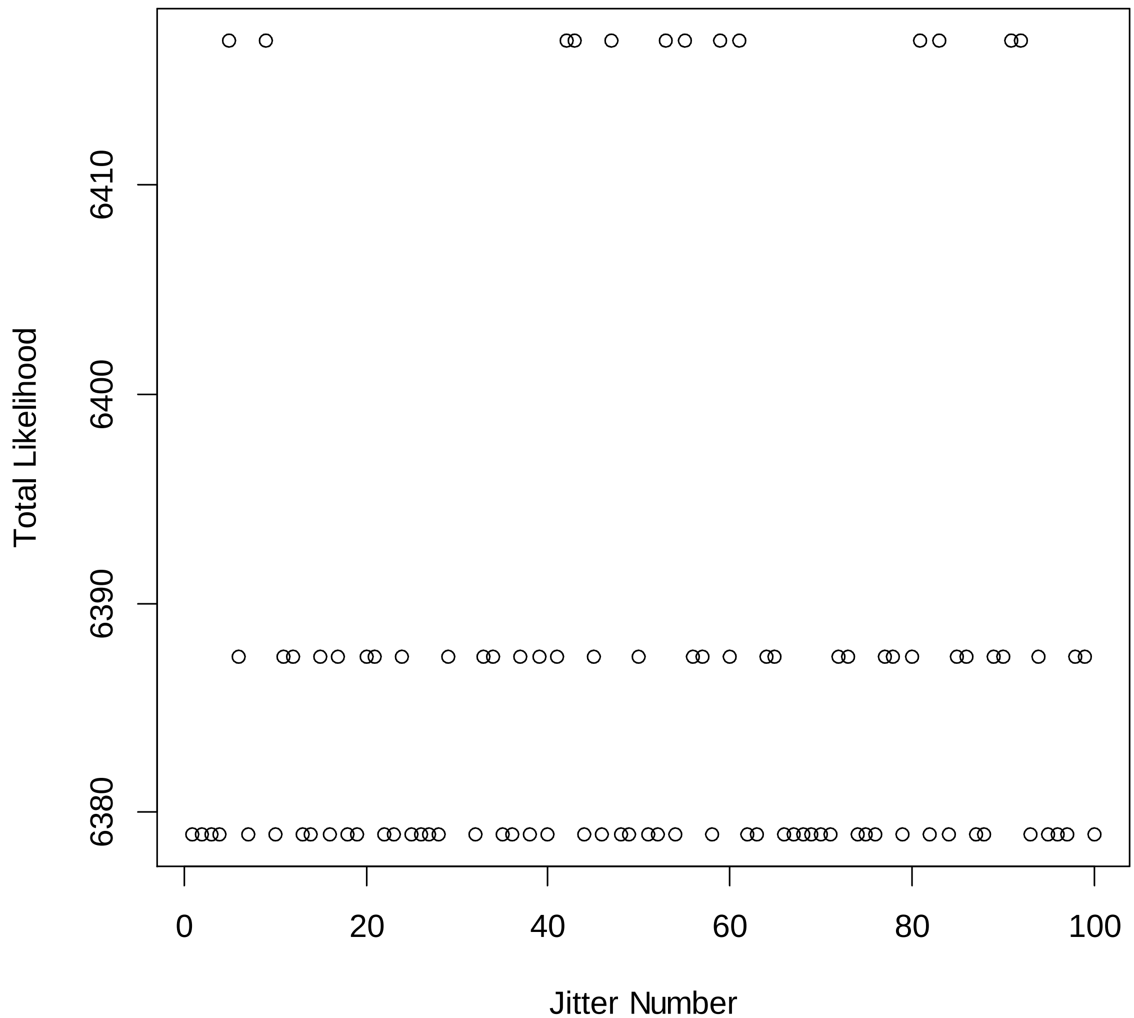


Figure 23. Model 1b. Total Likelihood by jitter number for runs that wrote the standard deviation file.

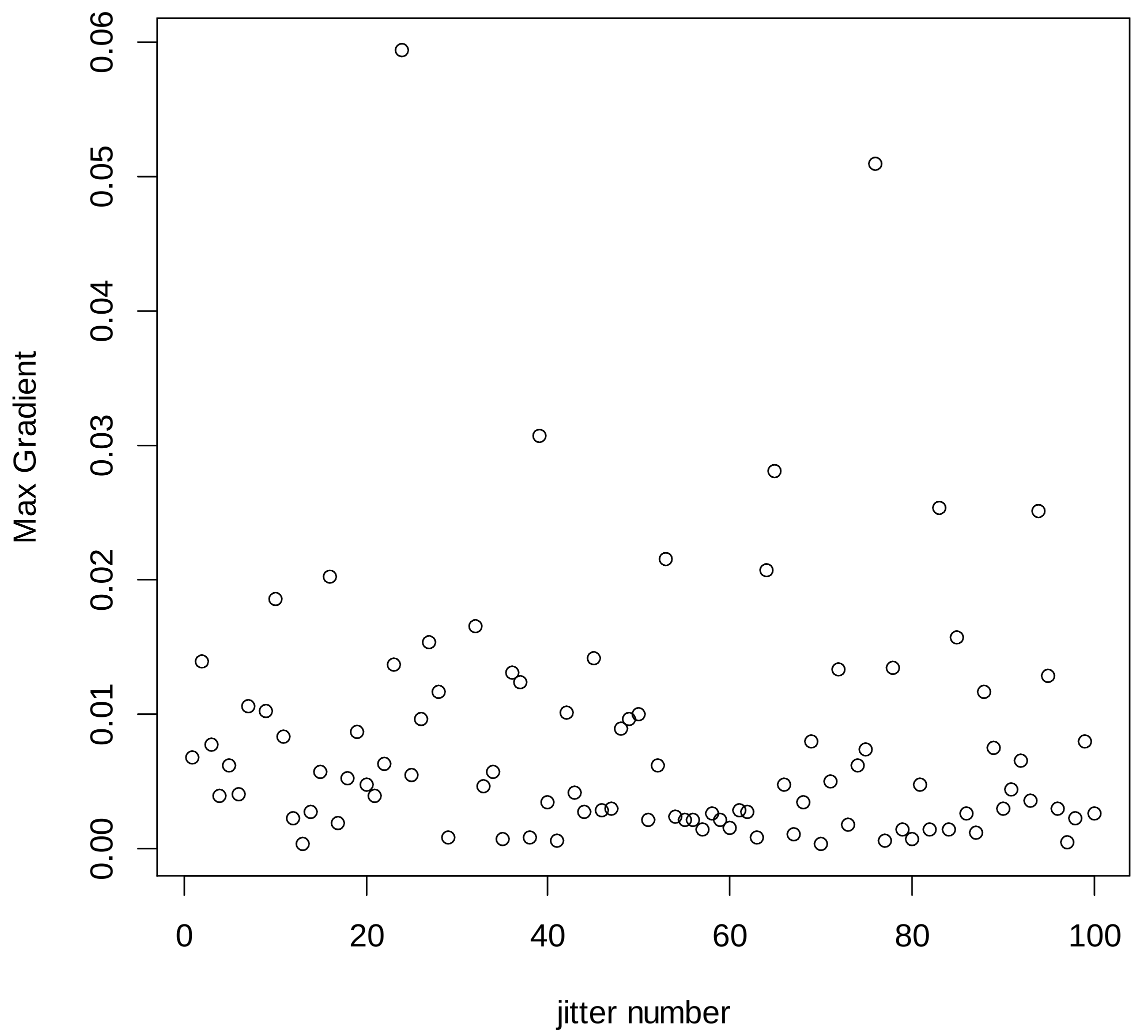


Figure 24. Model 1b. Maximum gradient by jitter number for runs that wrote the standard deviation file. Smallest max gradient = 0.000364, largest = 0.051 with 6378.94 likelihood.

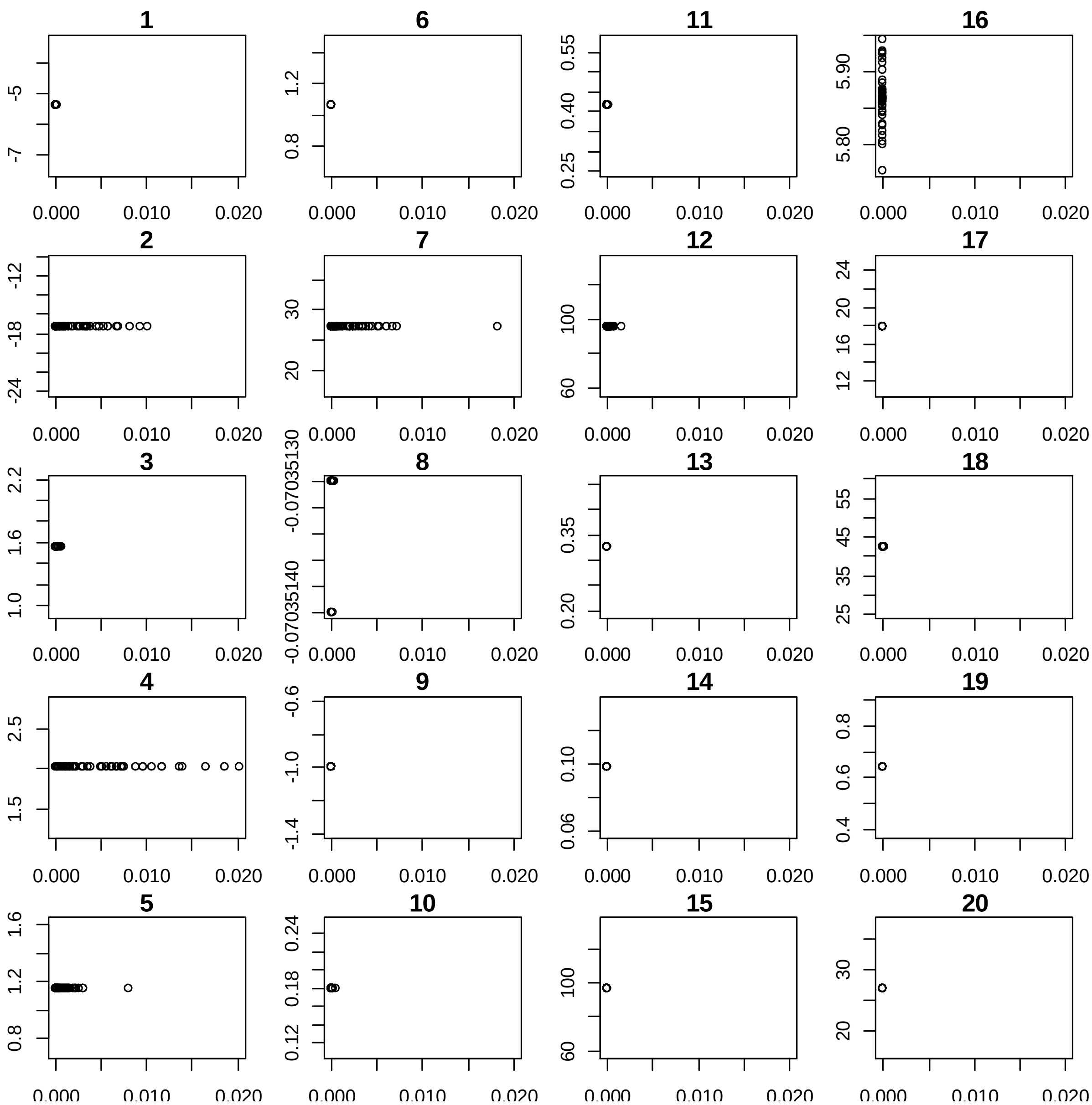


Figure 25. Model 1b. Parameter values (1-20 see Table 12) vs the parameter gradient for 51 runs where total likelihood was 6378.94. Scale to 0.02 although some gradients larger.

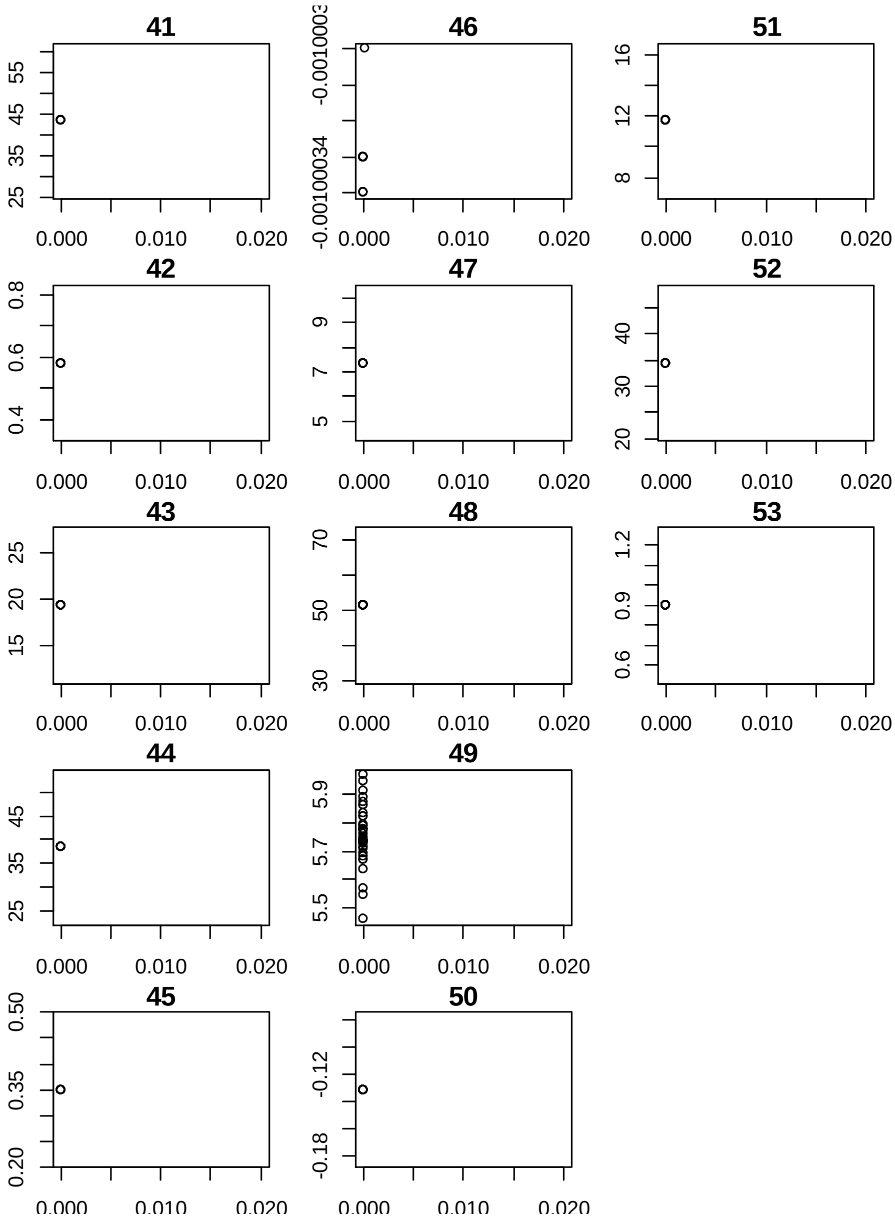


Figure 25 cont. Model 1b. Parameter values (21-35 see Table 12) vs the parameter gradient for 51 runs where total likelihood was 6378.94. Scale to 0.02 although some gradients larger.

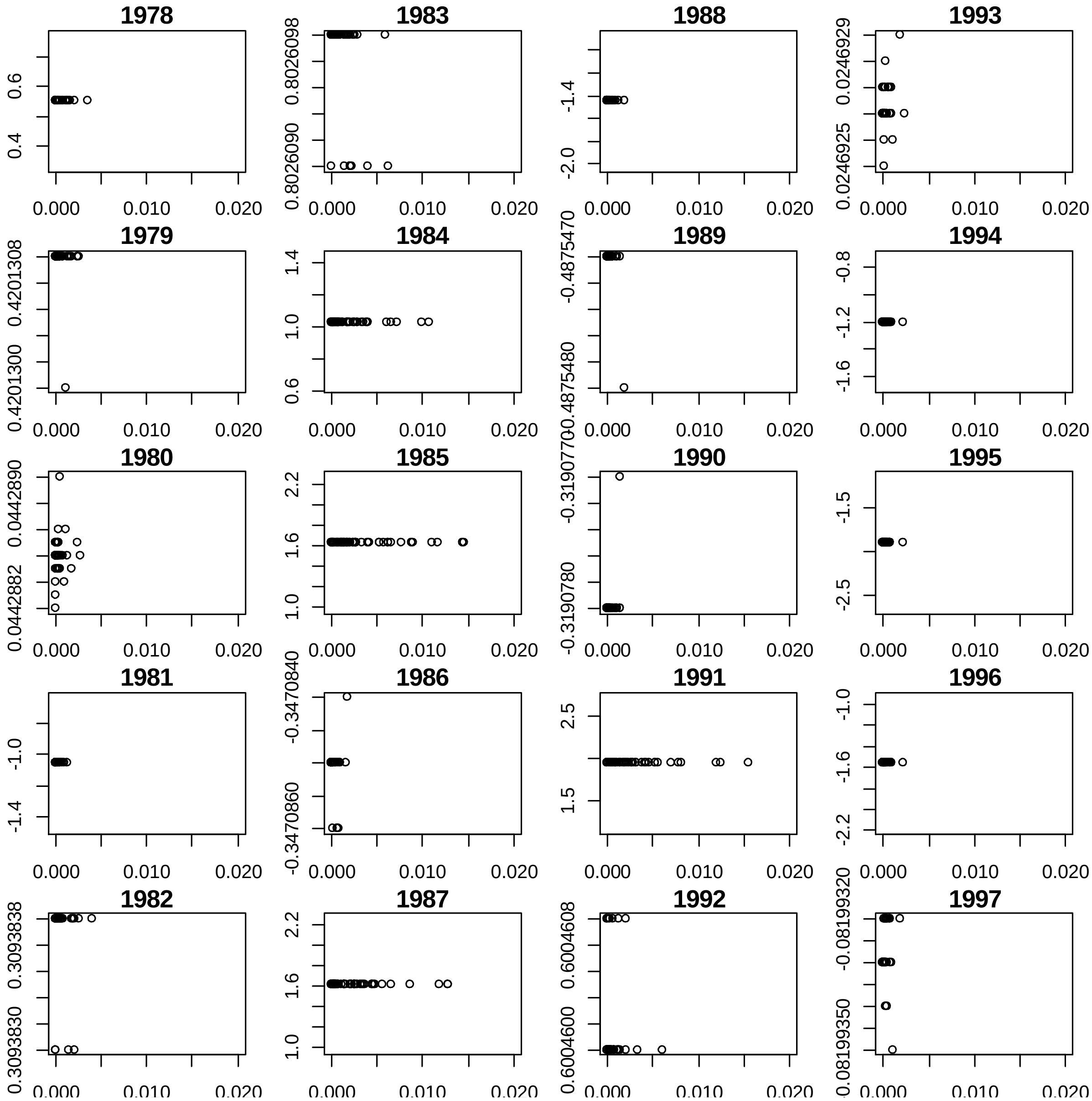

Figure 26. Model 1b. Recruitment deviation parameter values (title is year of deviation, 1978 = 1978/79 crab year) vs the parameter gradient where total likelihood was 6378.94 (51 runs). The gradient axis was limited to 0.02 maximum.

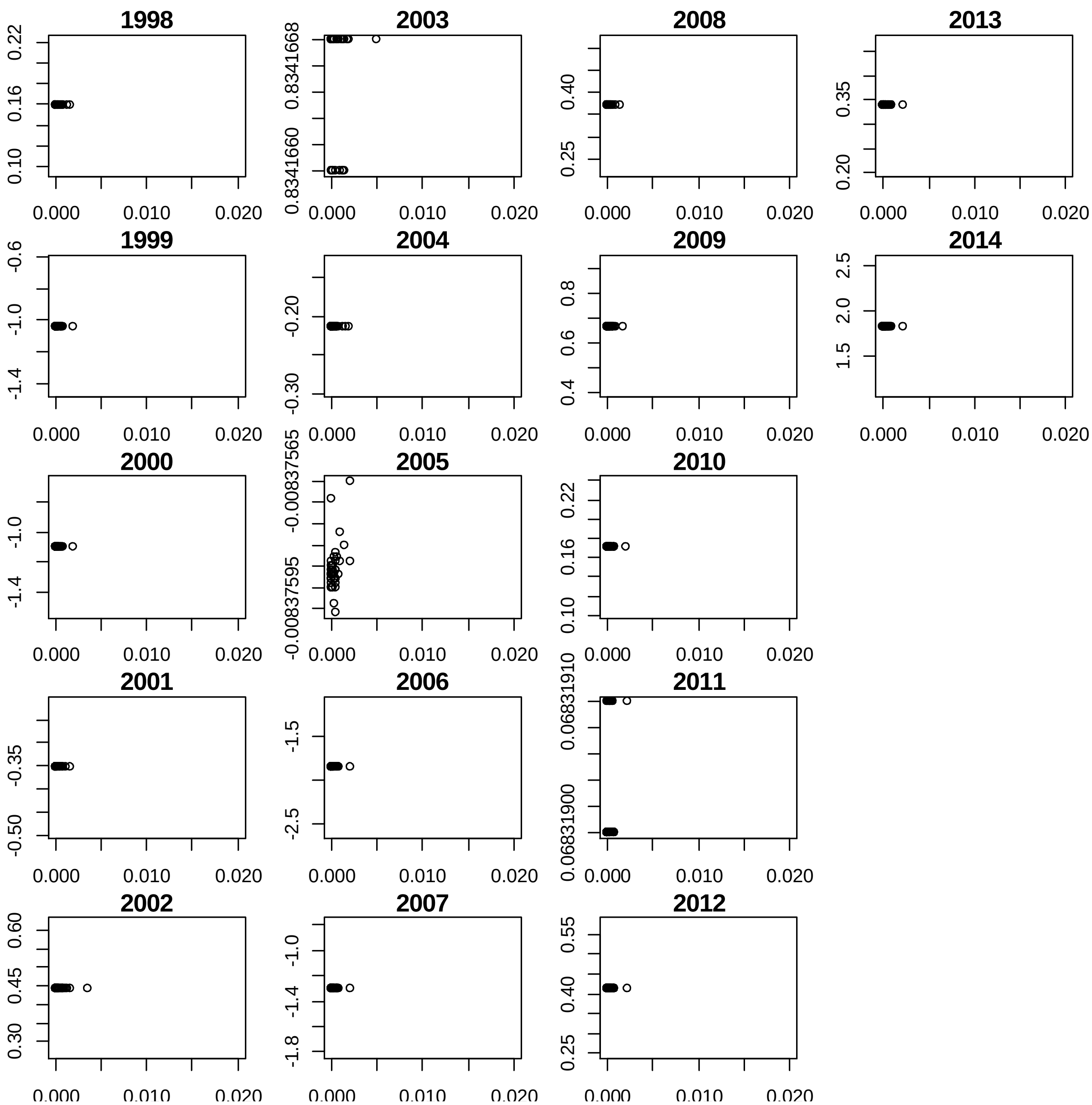


Figure 26 cont. Model 1b. Recruitment deviation parameter values (title is year of deviation, 1978 = 1978/79 crab year) vs the parameter gradient where total likelihood was 6378.94 (51 runs). The gradient axis was limited to 0.02 maximum.

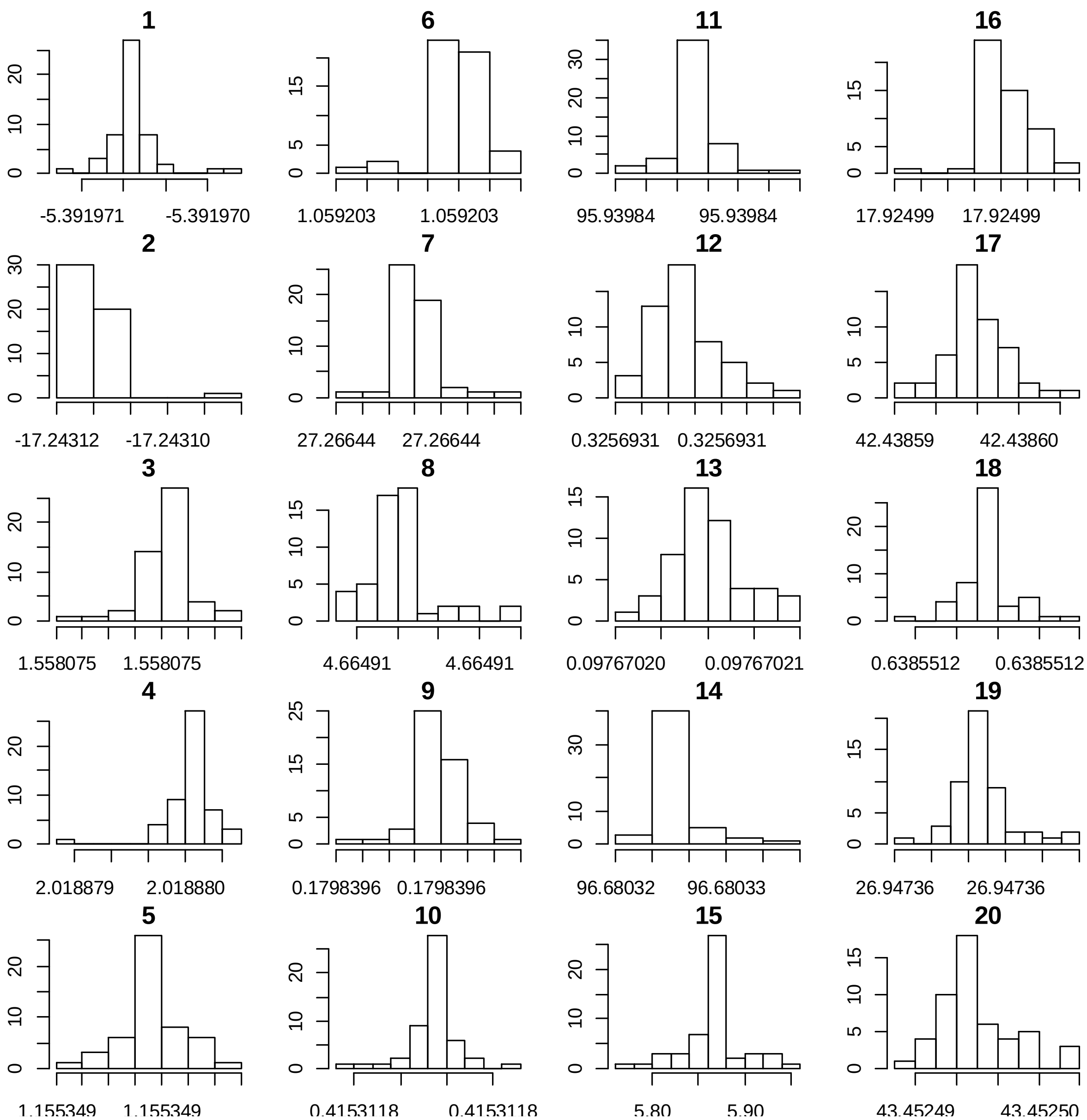


Figure 27. Model 1b. Parameter values for parameters 1-20 for runs where the total likelihood was 6378.94. Refer to Table 12 for parameter names.

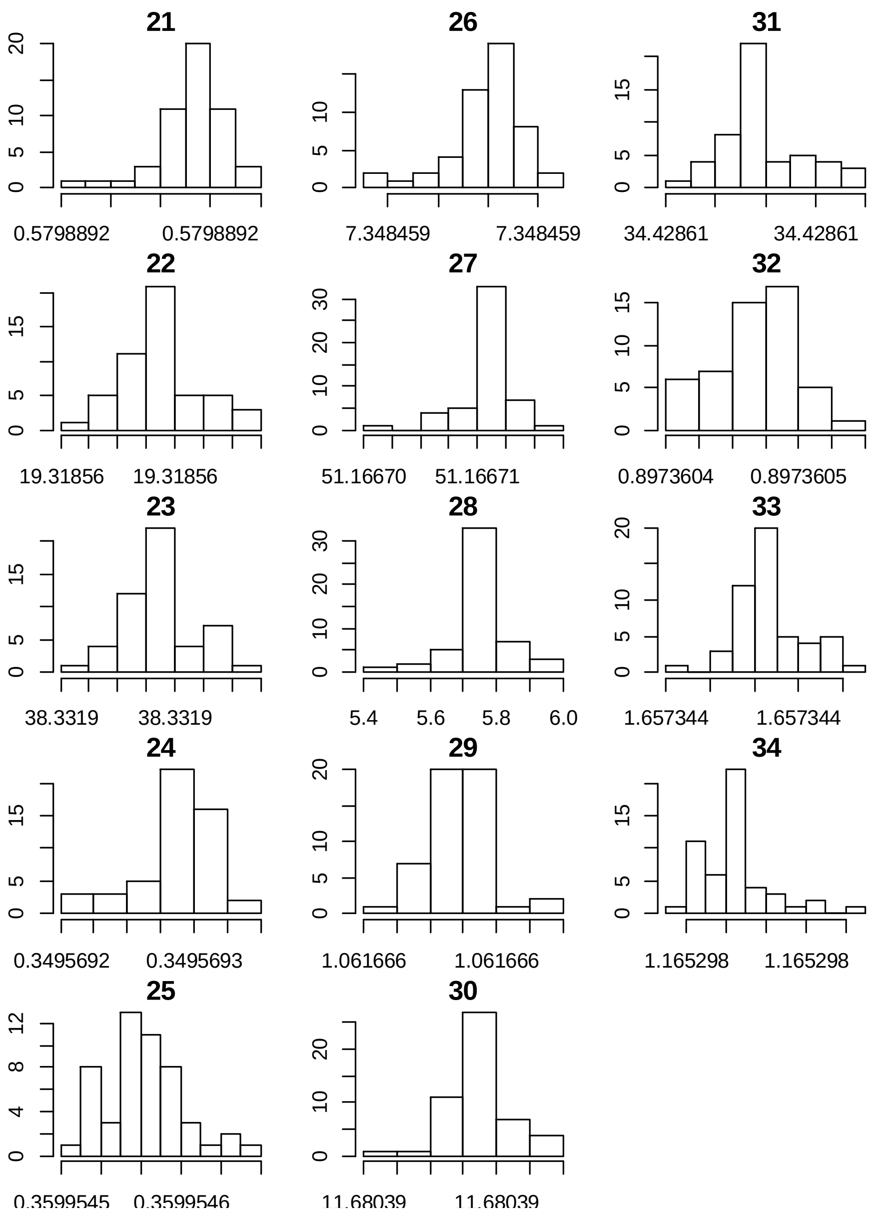


Figure 27 cont. Model 1b. Parameter values for parameters 1-20 for runs where the total likelihood was 6378.94. Refer to Table 12 for parameter names.

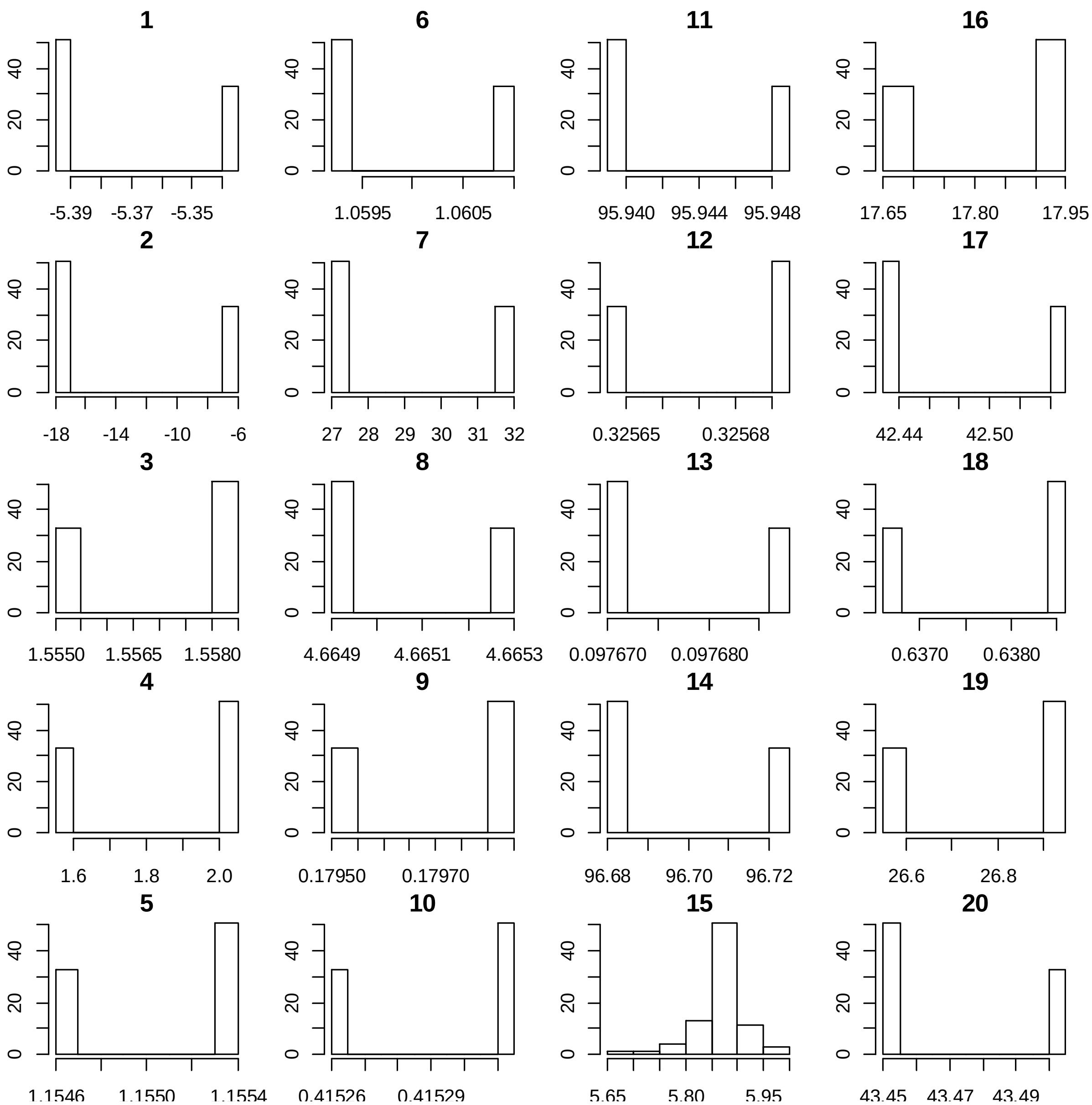


Figure 27a. Model 1b. Parameter values for parameters 1-20 for runs where the total likelihood was 6378.94 (51 runs) and 6387.45(33 runs) likelihoods. Male growth parameters are different for the two different likelihoods. Refer to Table 12 for parameter names.

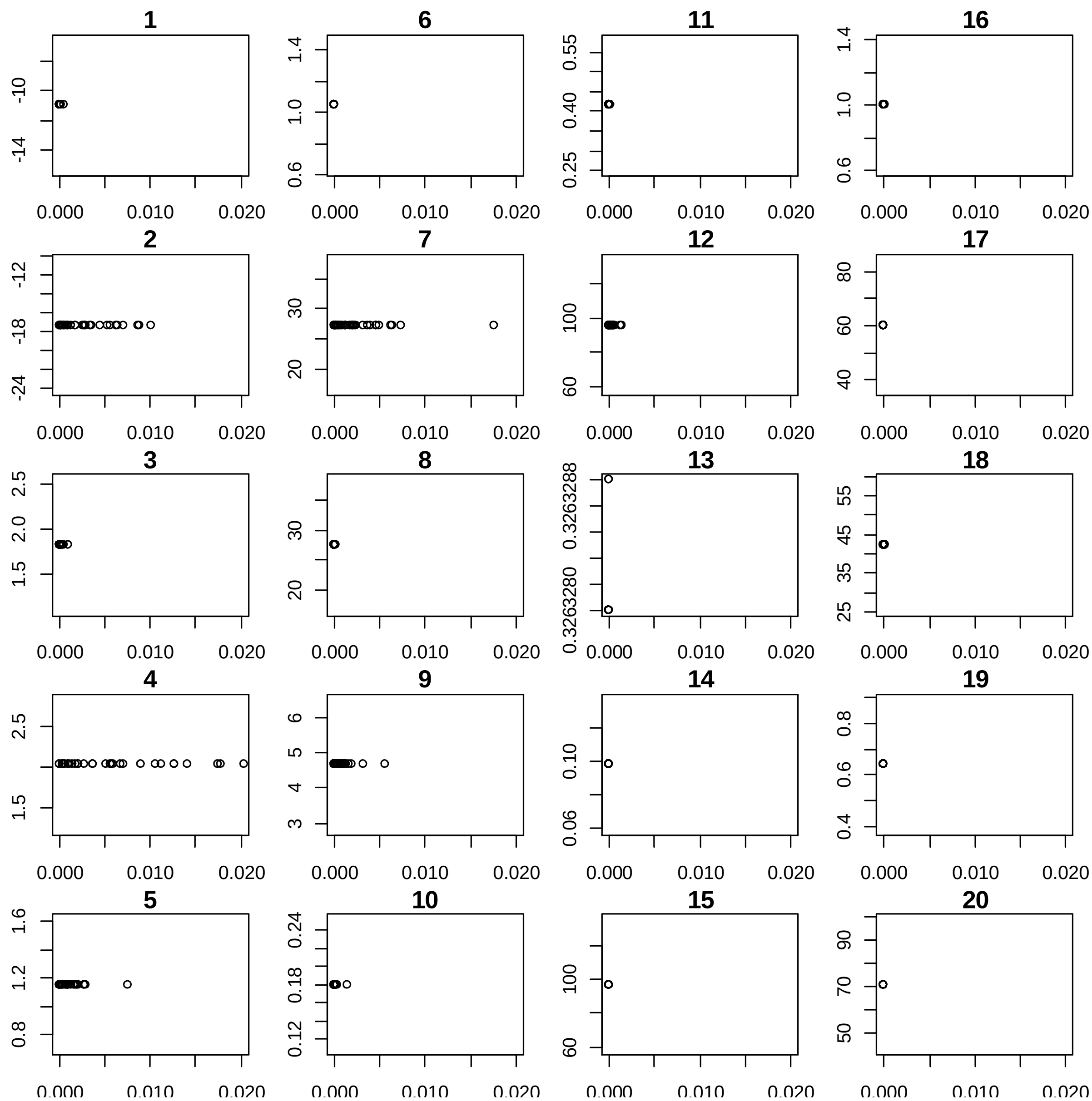


Figure 28. Model 0 for likelihood 6376.97 only. Parameter values by gradient for parameters 1-20.

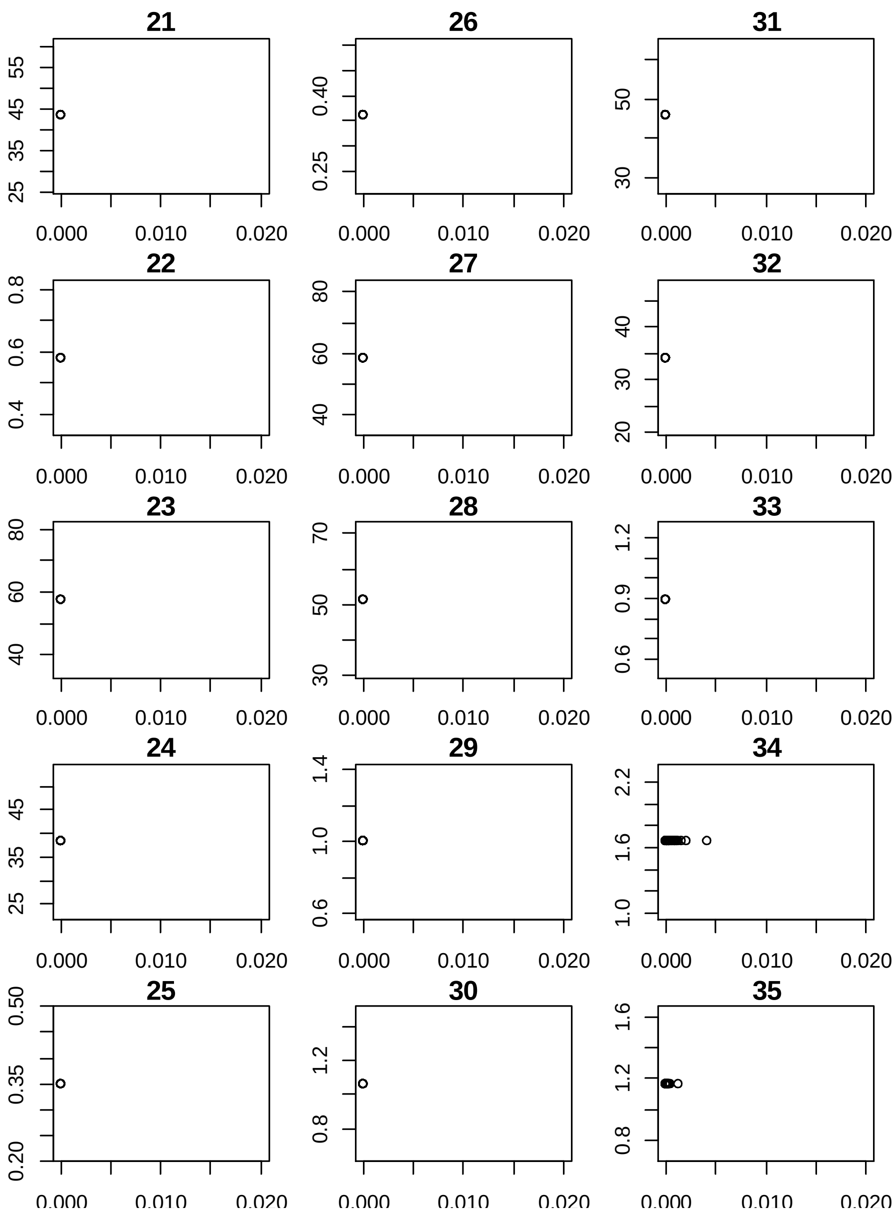

Figure 29. Model 0 for likelihood 6376.97 only. Parameter values by gradient for parameters 21-35.

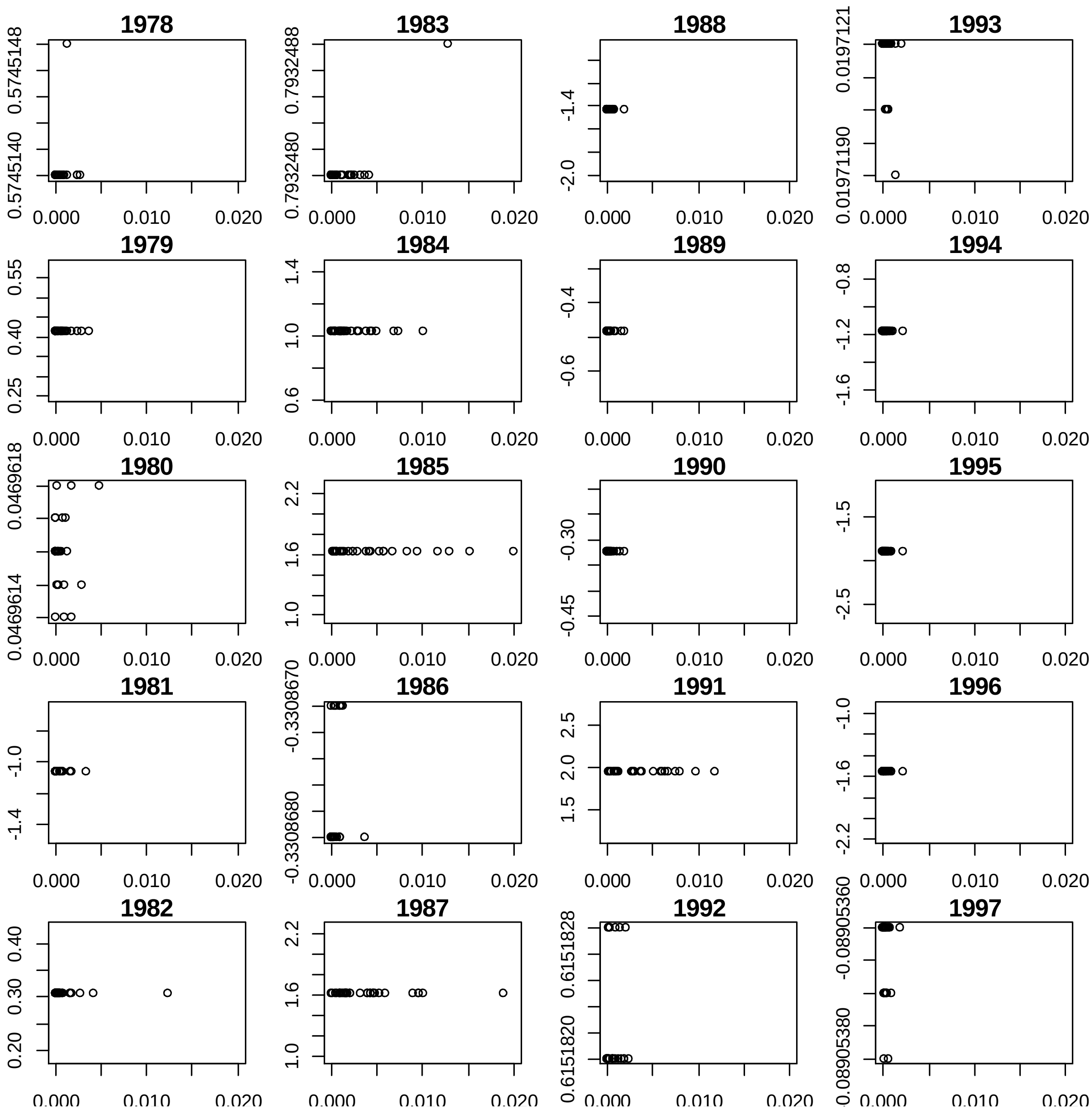


Figure 30. Model 0 for likelihood 6376.97 only. Recruitment deviations by gradient for 1978/79 to 1997/98.

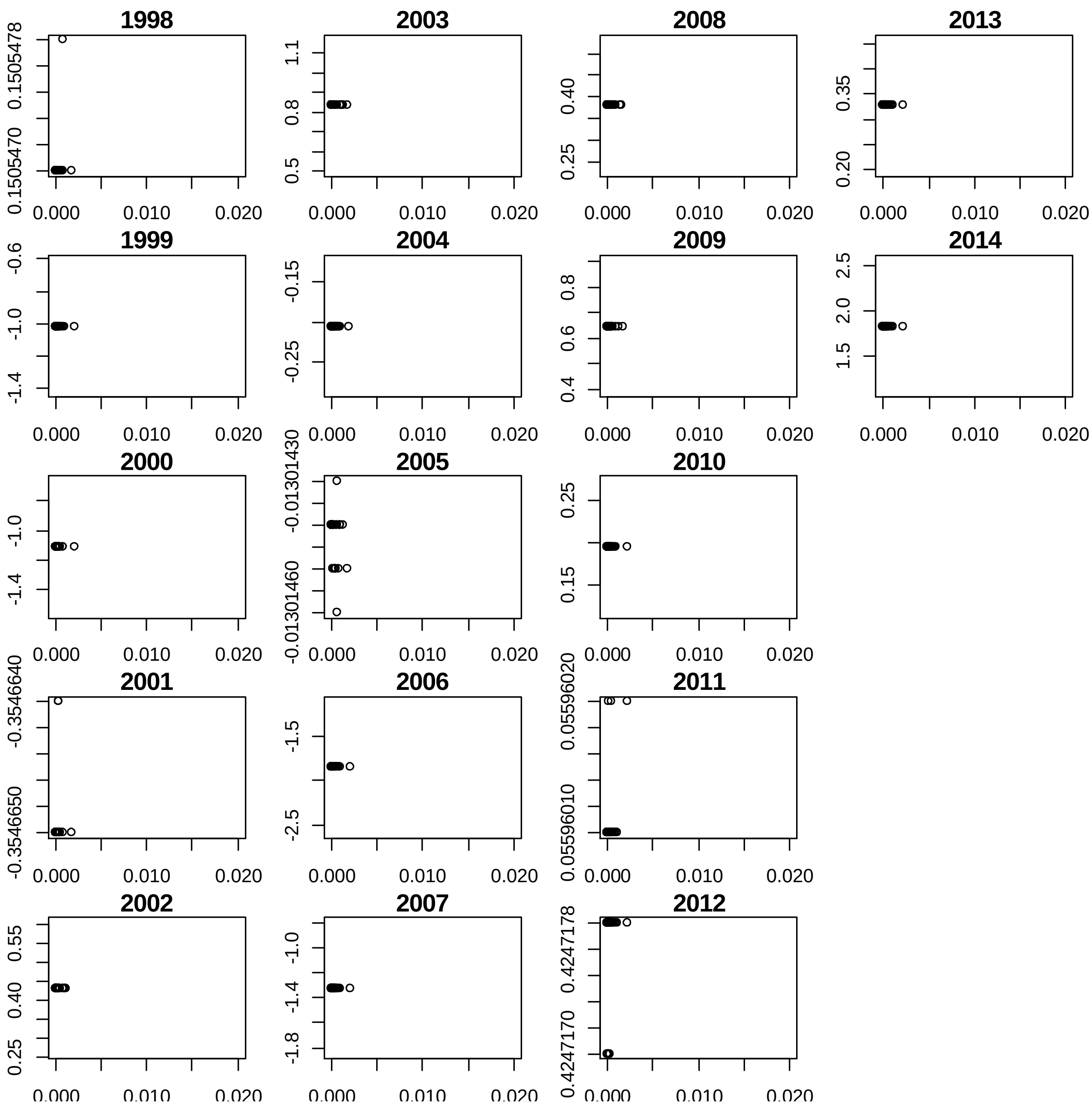


Figure 31. Model 0 for likelihood 6376.97 only. Recruitment deviations by gradient for 1998/99 to 2014/15.

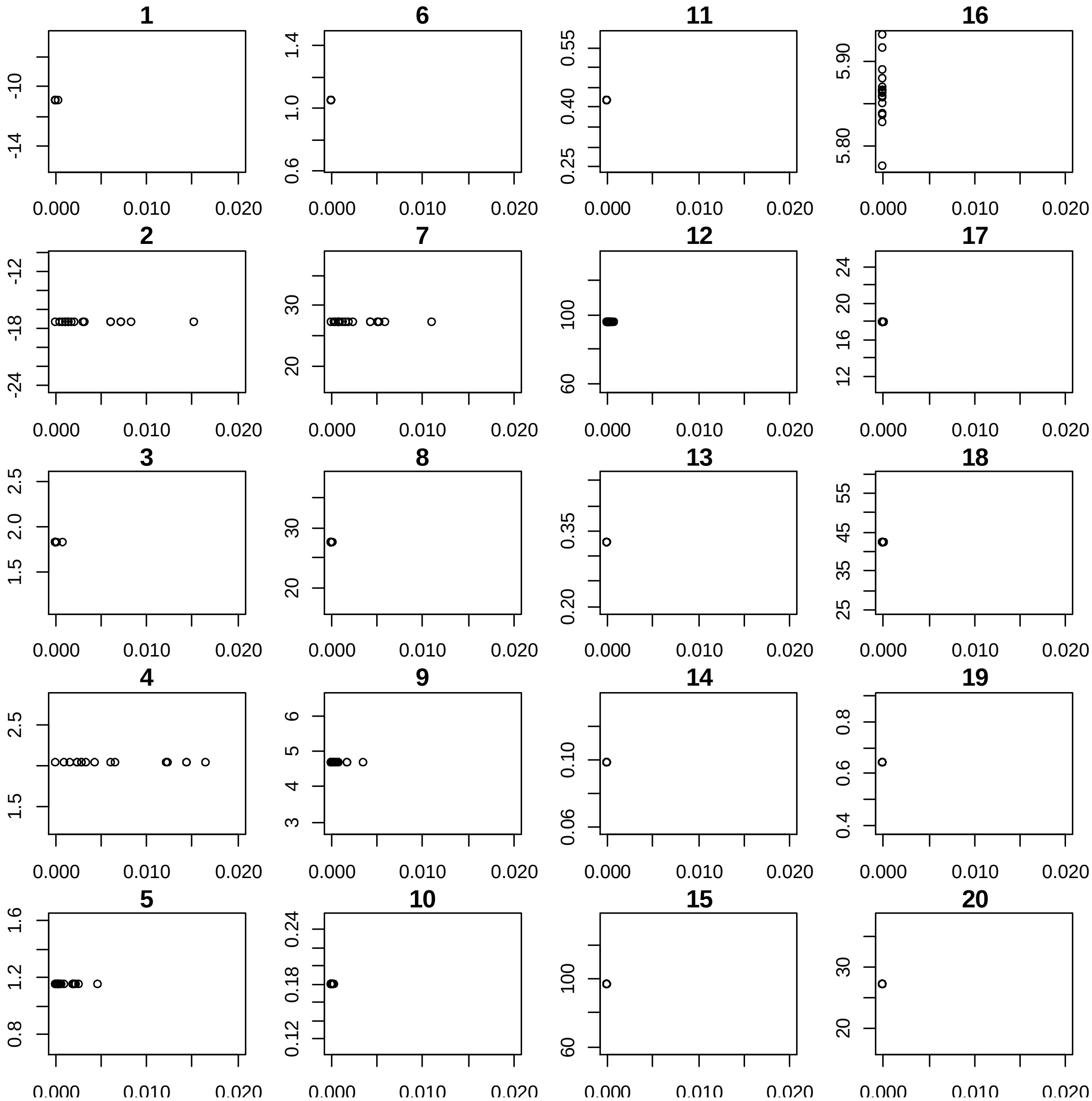


Figure 32. Model 1 6376.97 likelihood runs only. Parameter values by gradient for parameters 1-20.

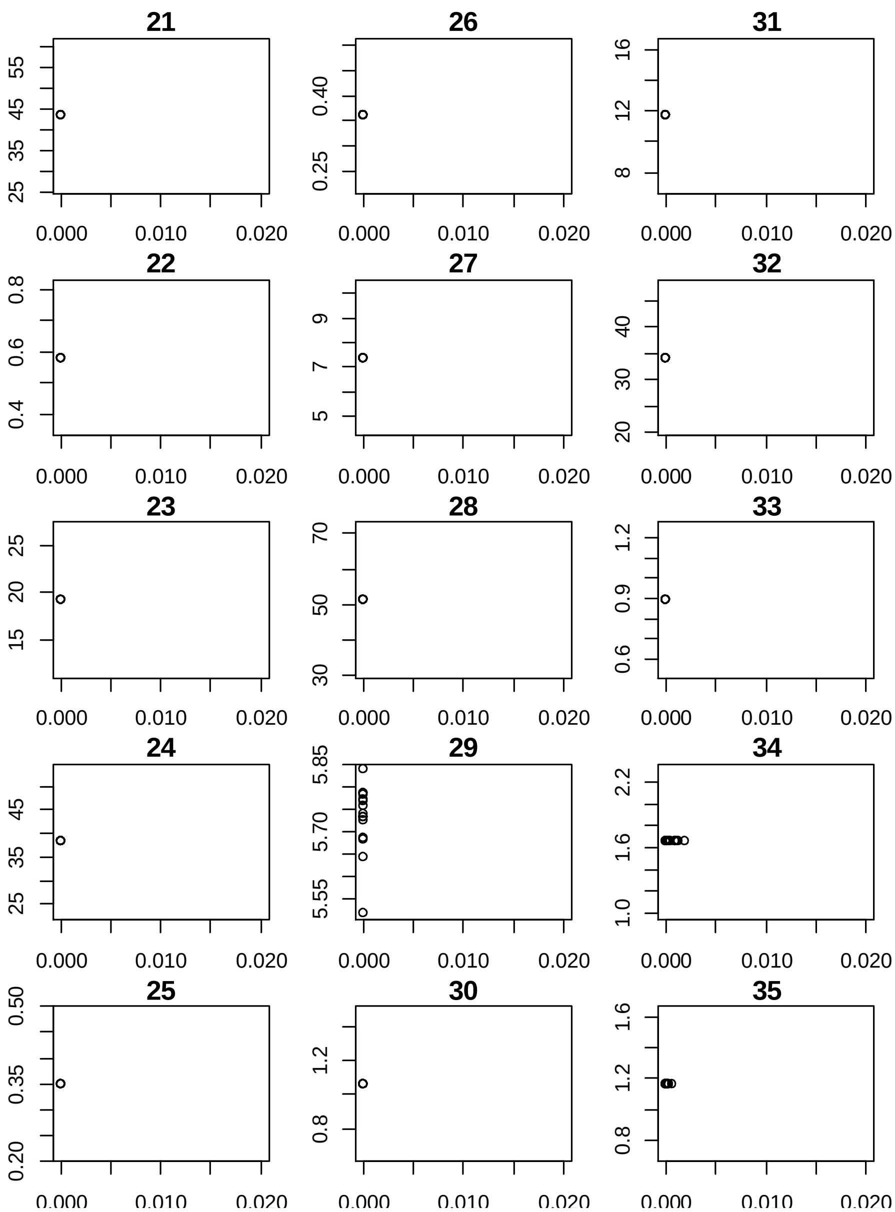

Figure 33. Model 1 6376.97 likelihood runs only. Parameter values by gradient for parameters 21-35.

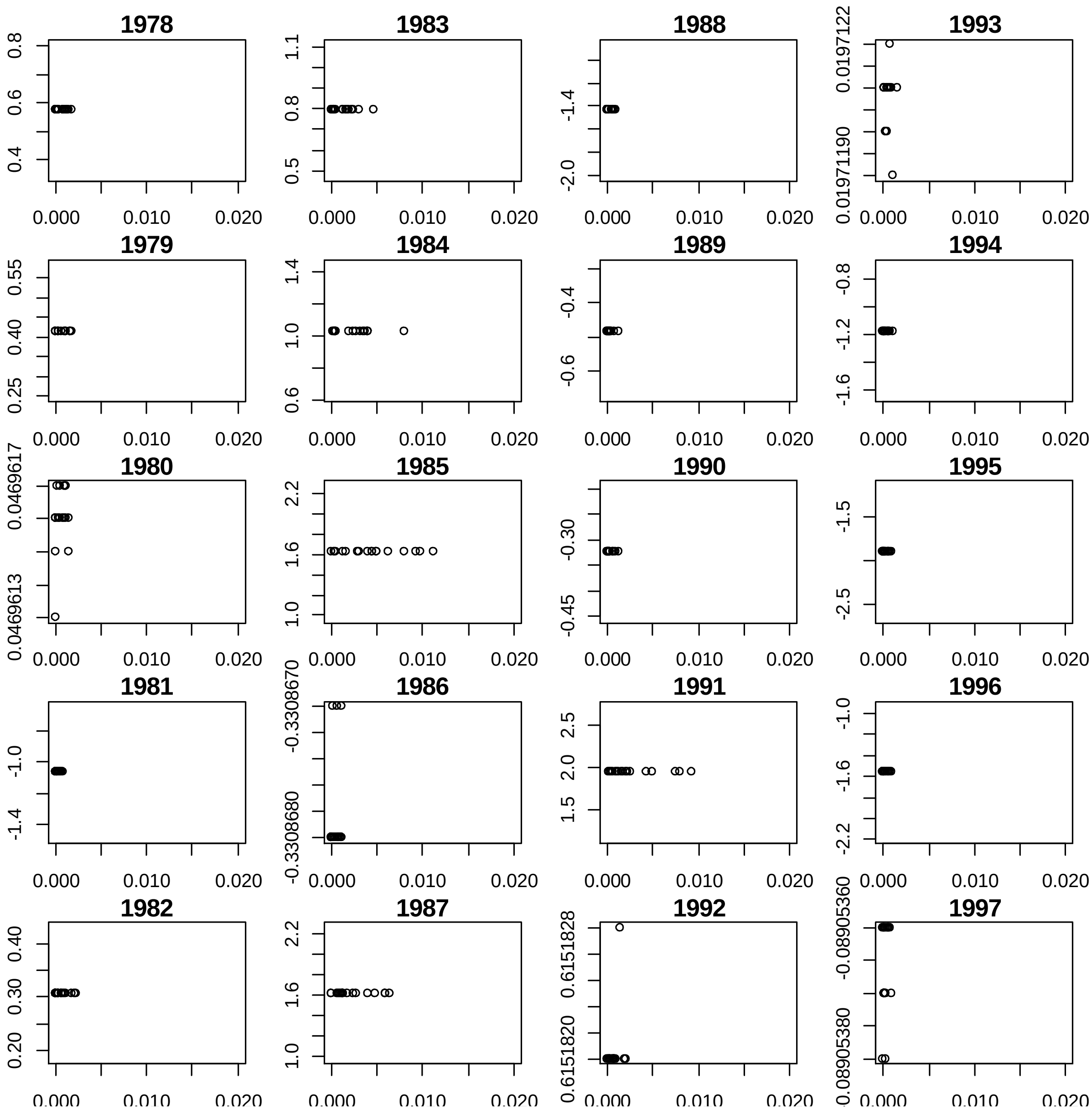


Figure 34. Model 1 6376.97 likelihood runs only. Recruitment deviations by gradient for 1978/79 to 1997/98.

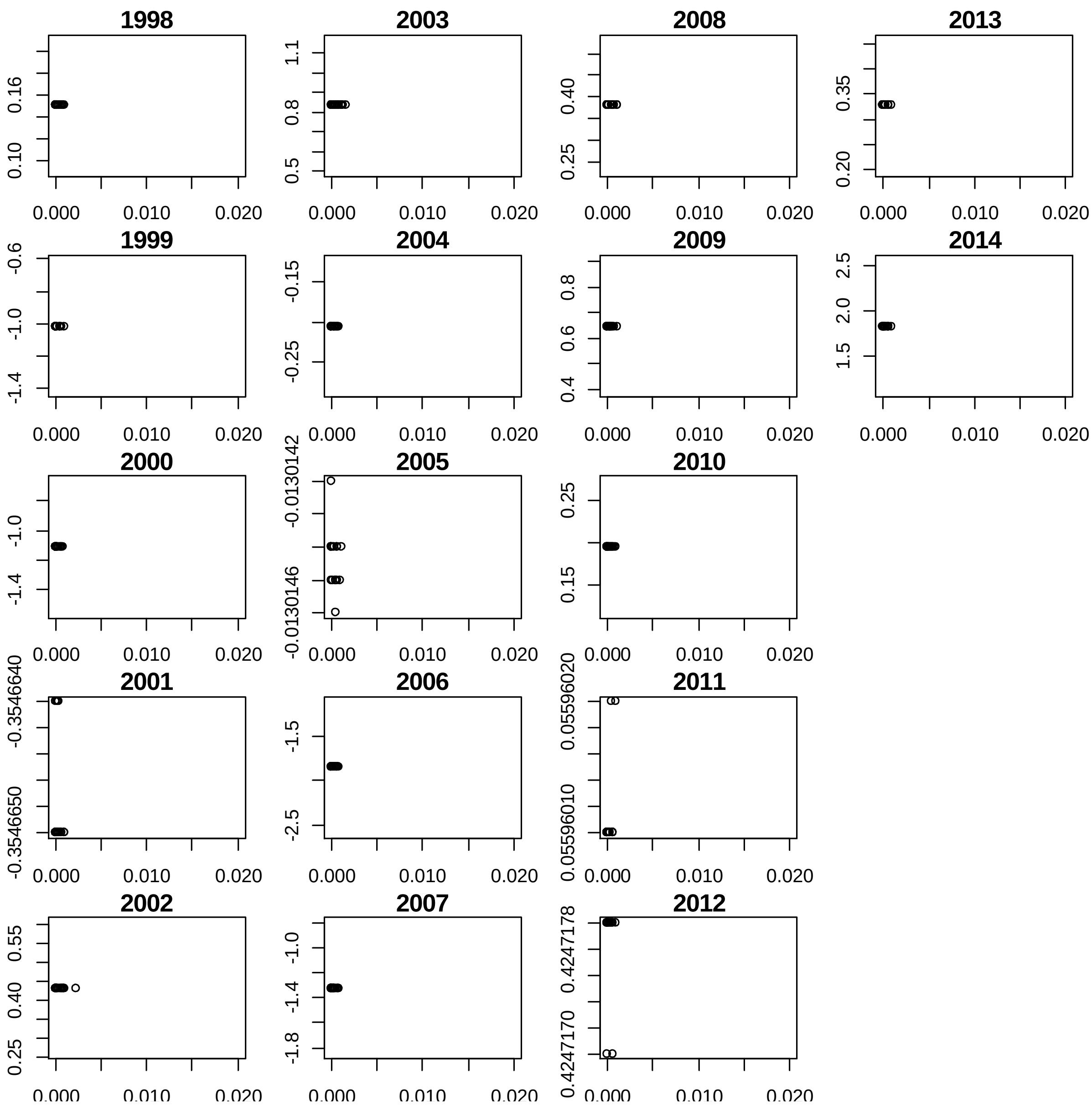


Figure 35. Model 1 6376.97 likelihood runs only. Recruitment deviations by gradient for 1998/99 to 2014/15.

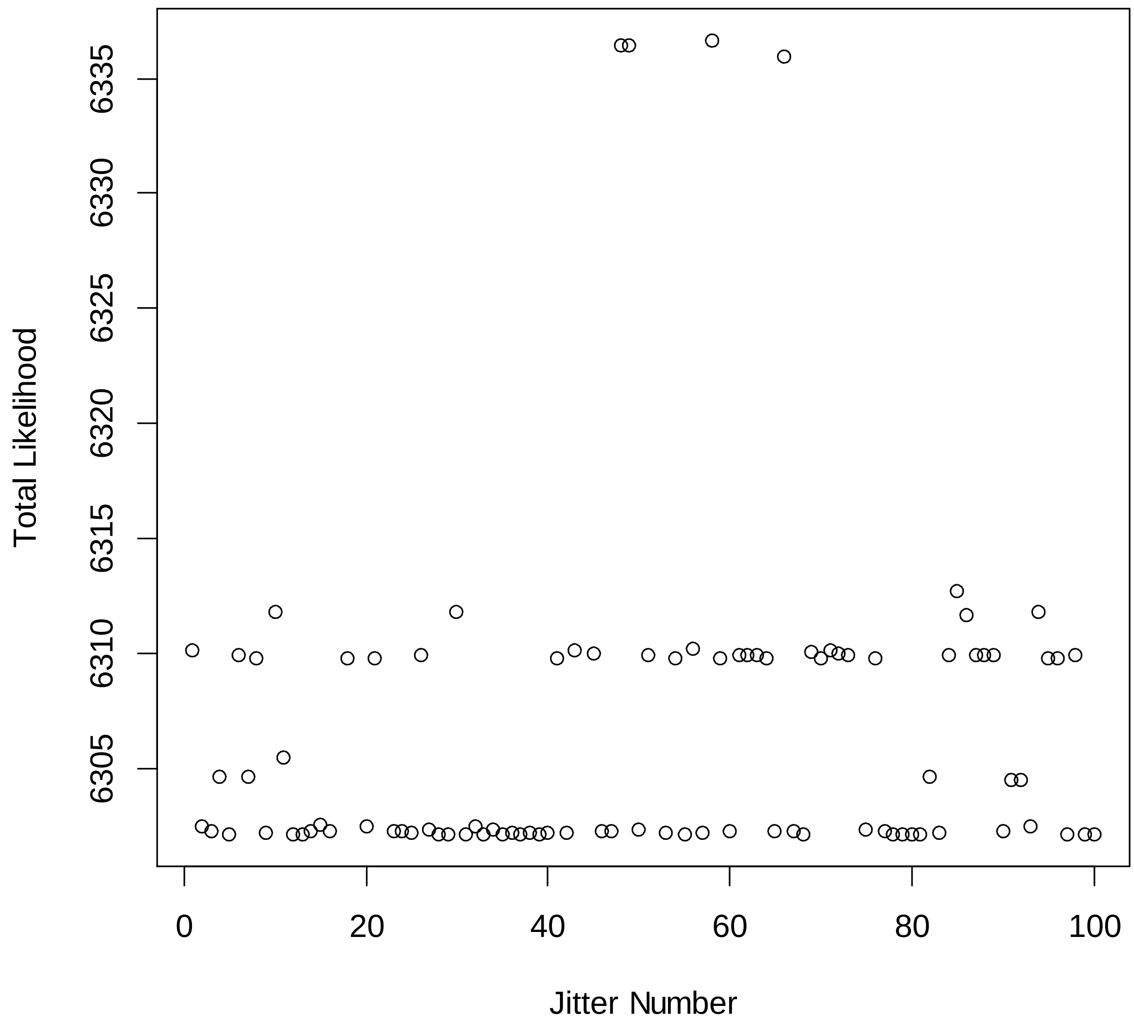


Figure 36. Model 2 – with F penalties for males 1992-present removed. Total Likelihood by jitter number for runs that wrote the standard deviation file.

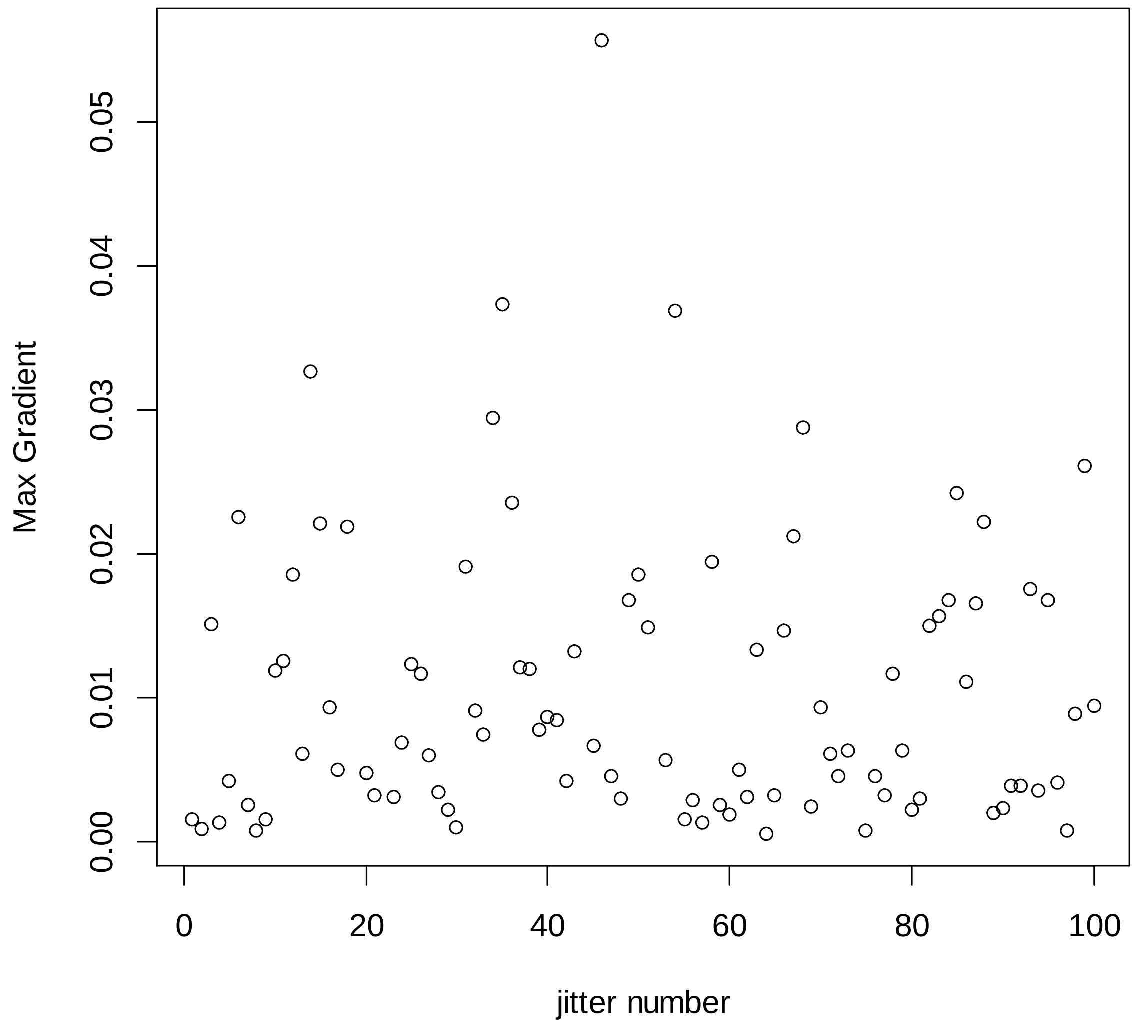


Figure 37. Model 2 – model 1 with F penalties for males 1992-present removed. Maximum gradient by jitter number for runs that wrote the standard deviation file.

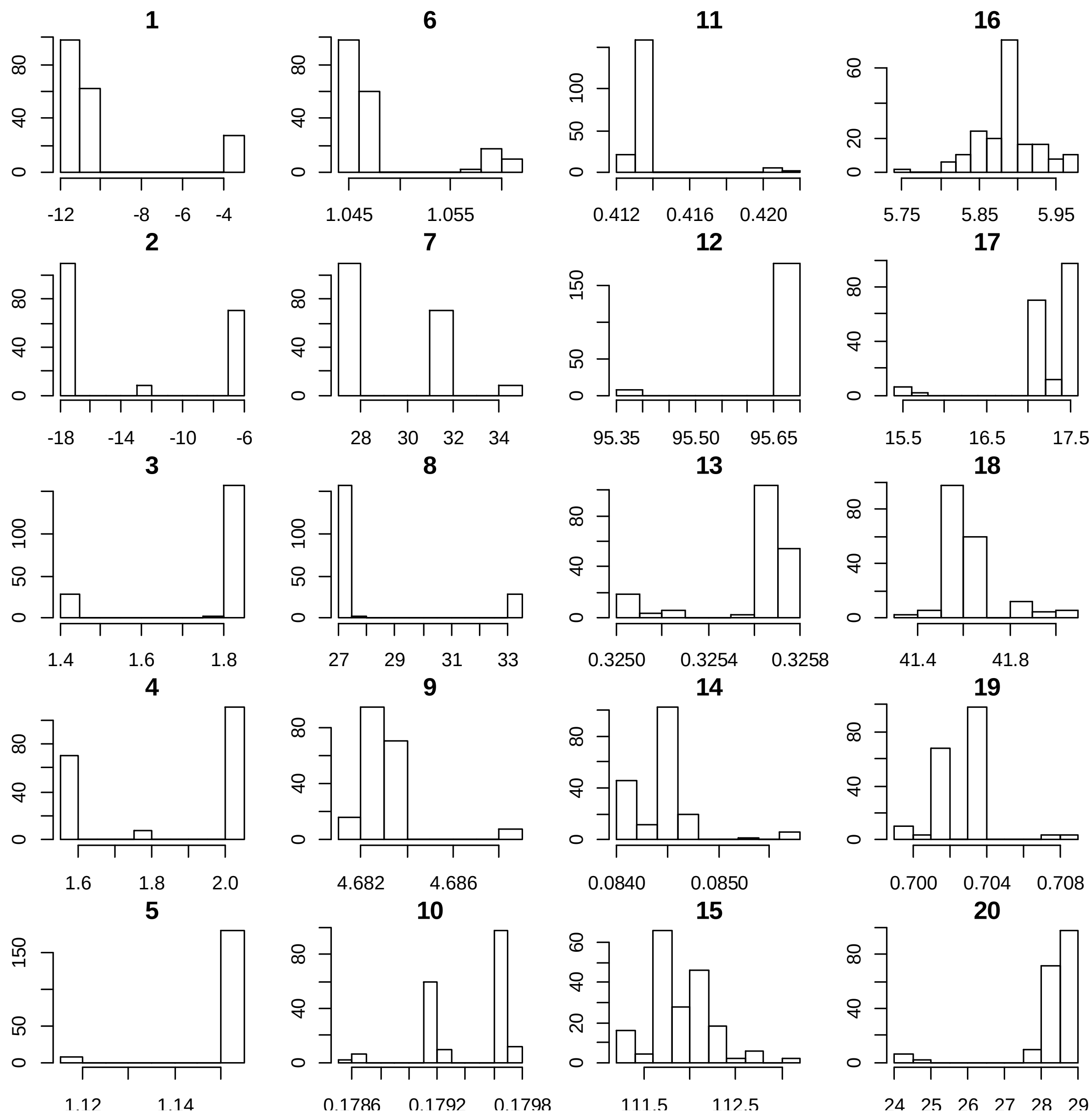


Figure 38. Model 2 parameter estimates – model 1 with F penalties for males 1992-present removed. This is for all likelihoods < 6500 (94 runs).

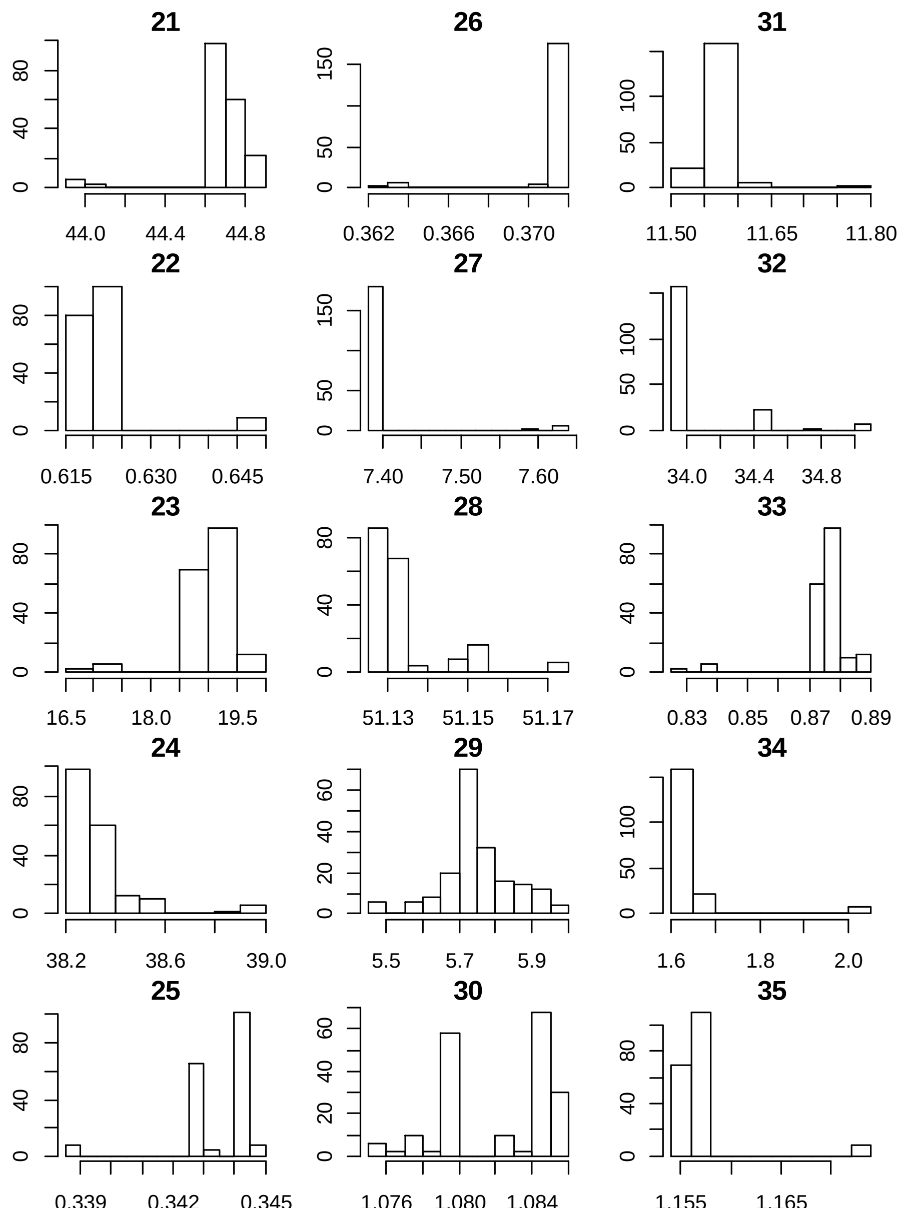


Figure 39. Model 2 parameter estimates – model 1 with F penalties for males 1992-present removed. This is for all likelihoods < 6500 (94 runs).

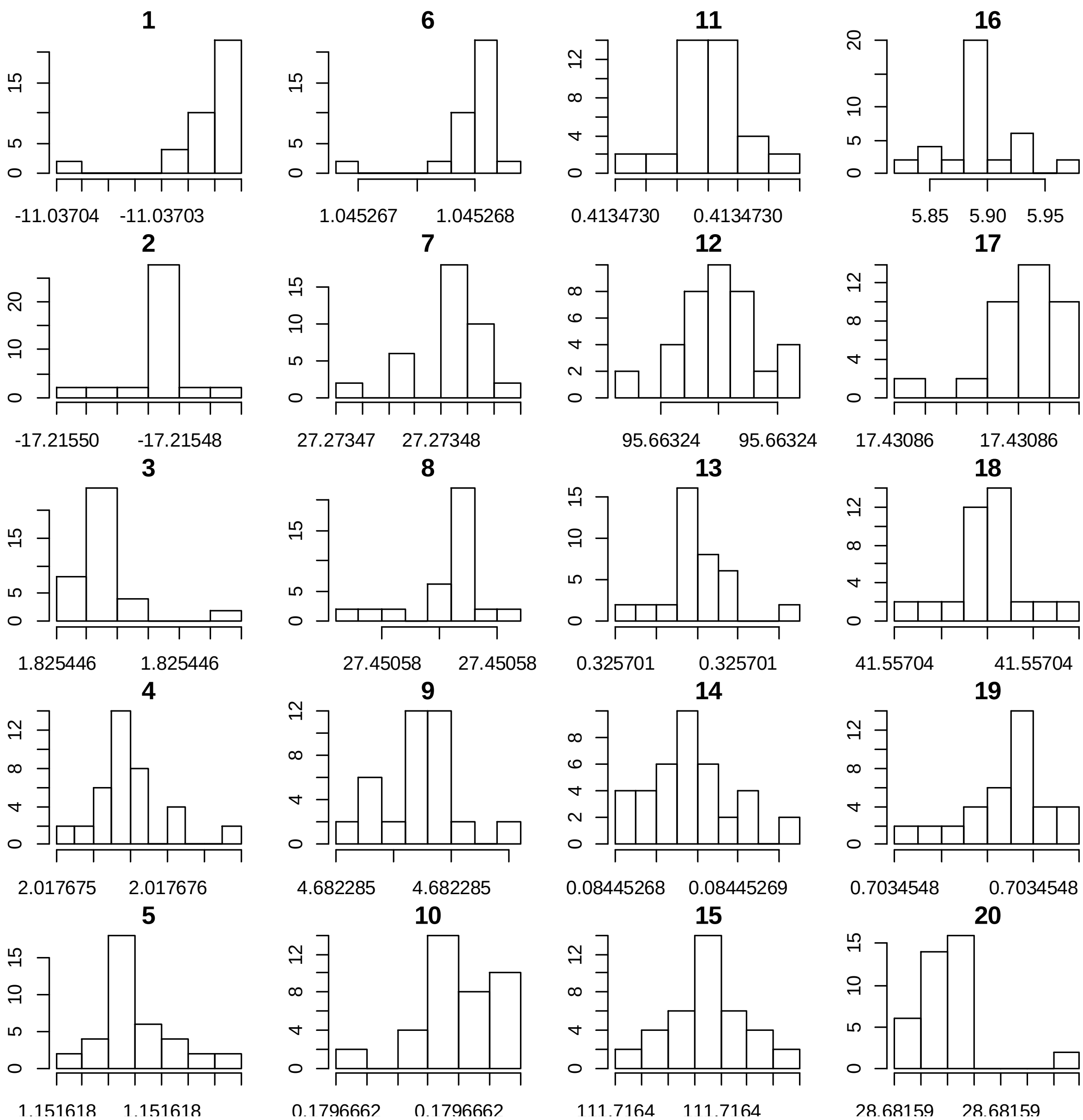


Figure 40. Model 2 parameter estimates for only the lowest likelihood runs of 6302.16. Model 2 is model 1 with F penalties for males 1992-present removed.

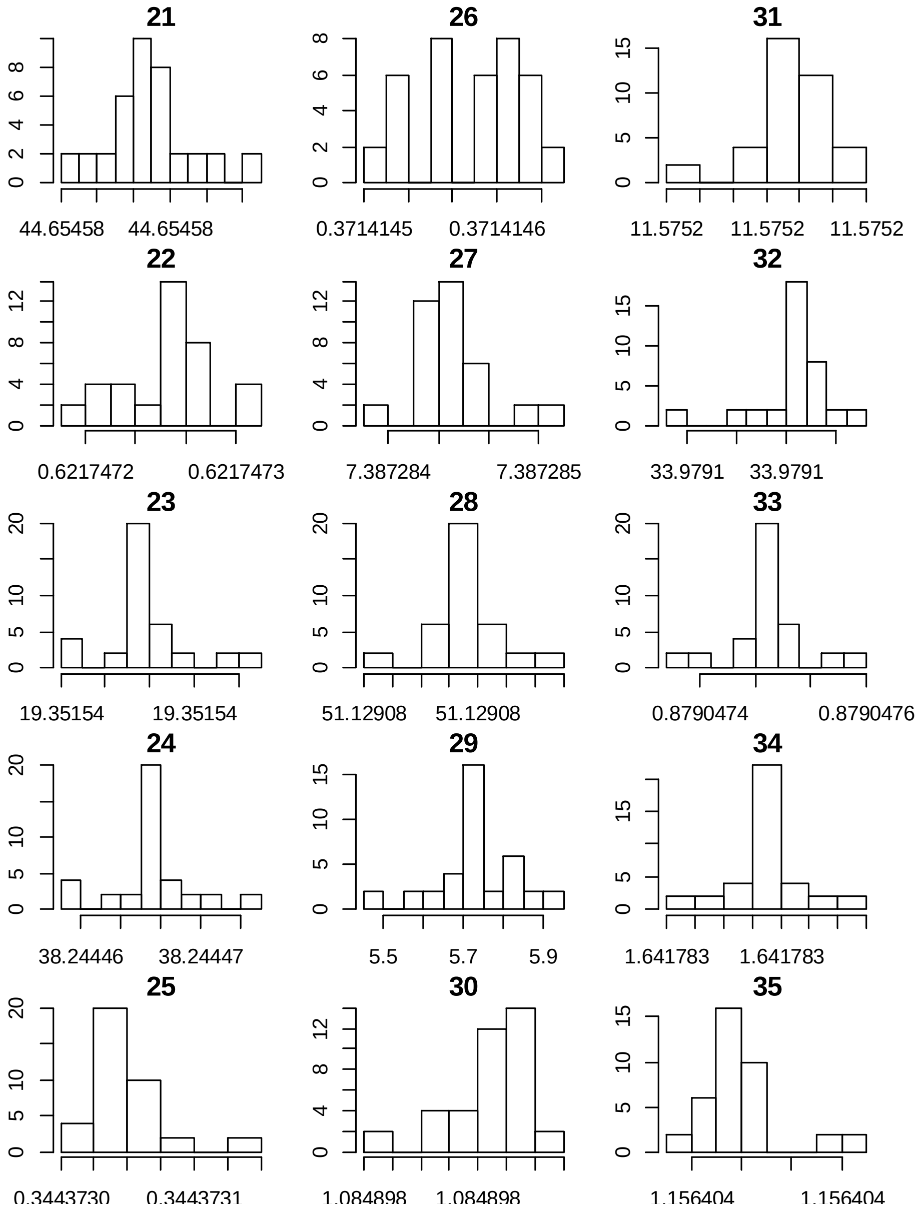


Figure 41. Model 2 parameter estimates for only the lowest likelihood runs of 6302.16. Model 2 is model 1 with F penalties for males 1992-present removed.

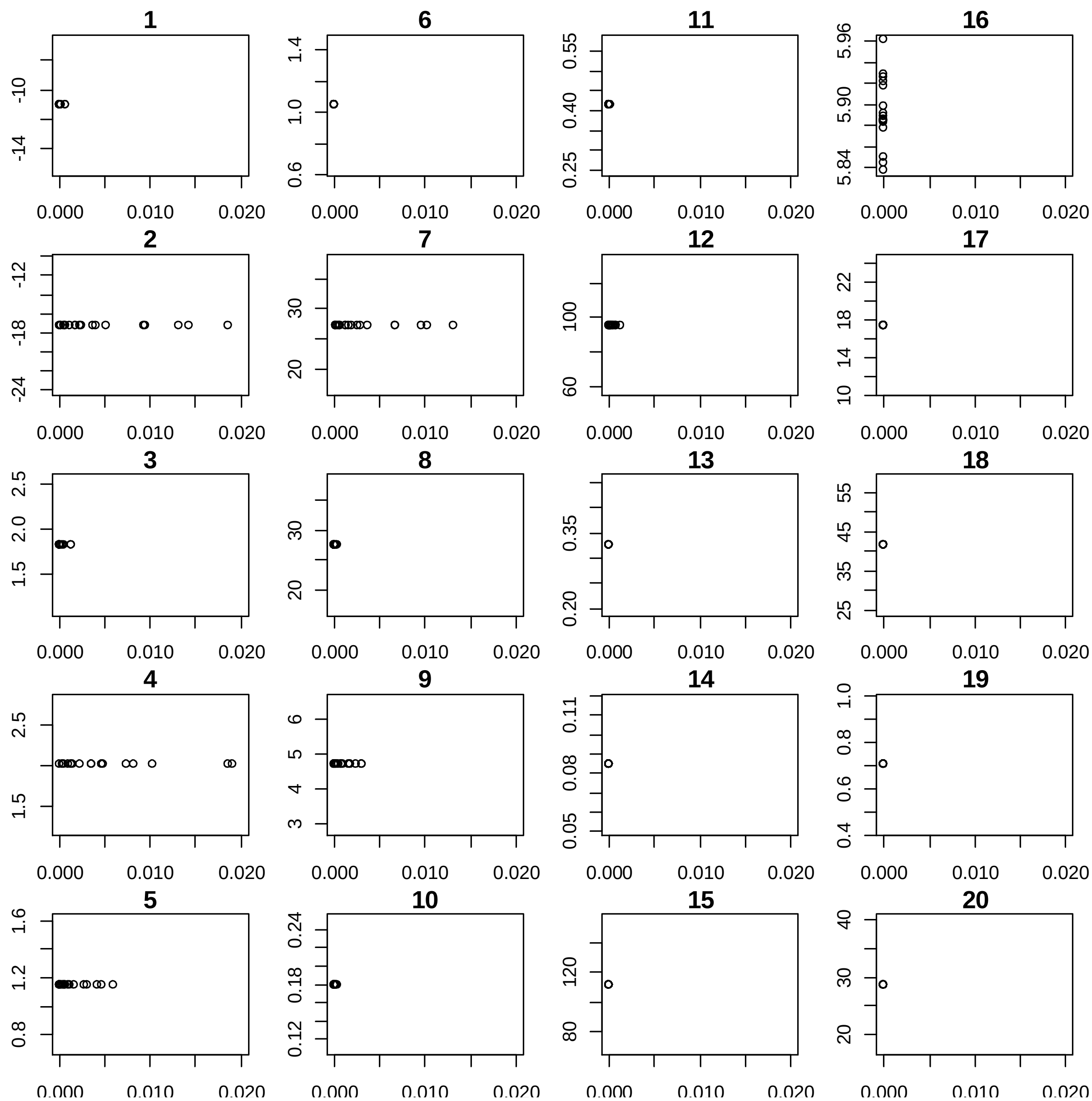

Figure 42. Model 2 Parameter values (1-20 see Table 14) vs the parameter gradient for only lowest likelihood of 6302.16. Model 2 is model 1 with F penalties for males 1992-present removed.

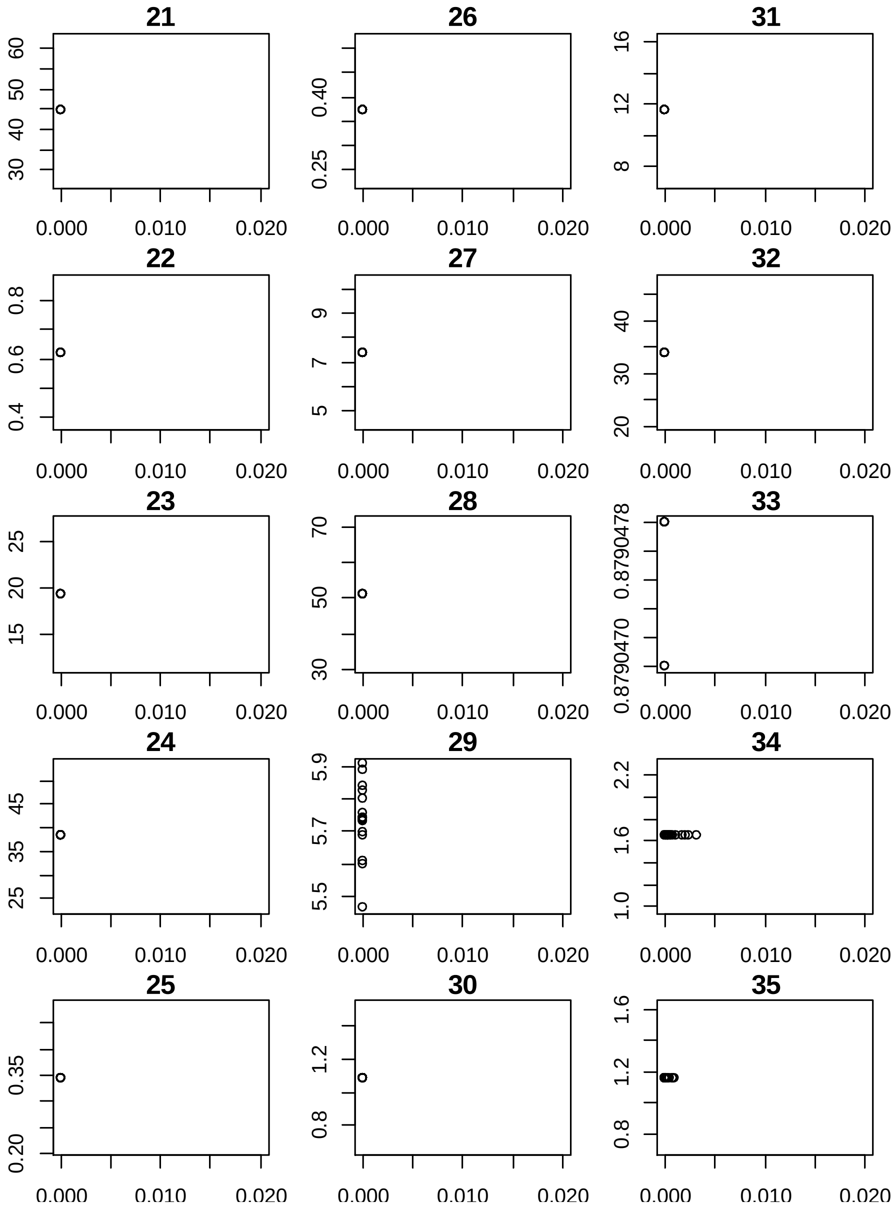


Figure 43. Model 2 Parameter values (21-35 see Table 14) vs the parameter gradient for only lowest likelihood of 6302.16. Model 2 is model 1 with F penalties for males 1992-present removed.

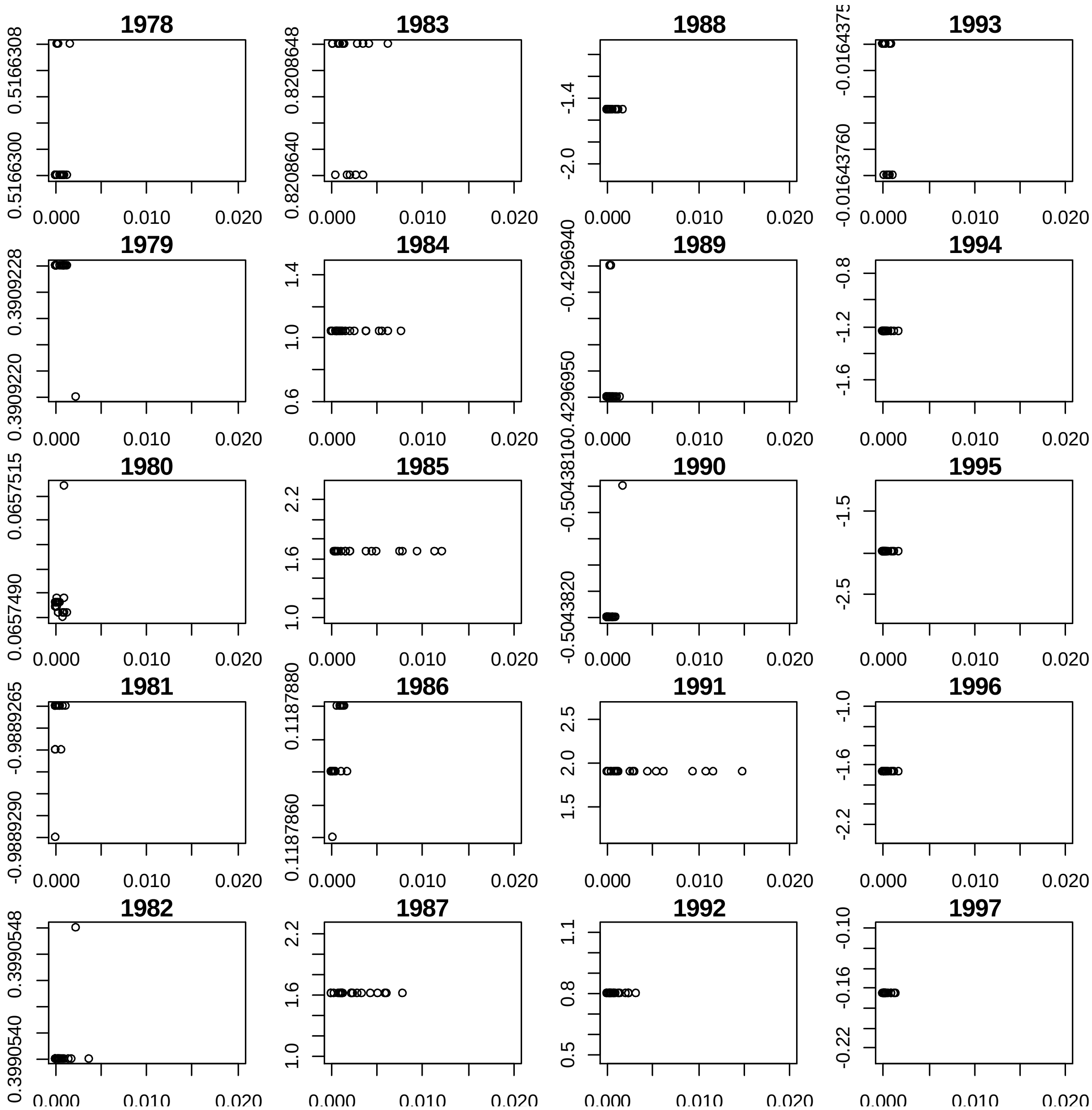


Figure 44. Model 2 Recruitment deviations vs the parameter gradient for only lowest likelihood of 6302.16. Model 2 is model 1 with F penalties for males 1992-present removed.

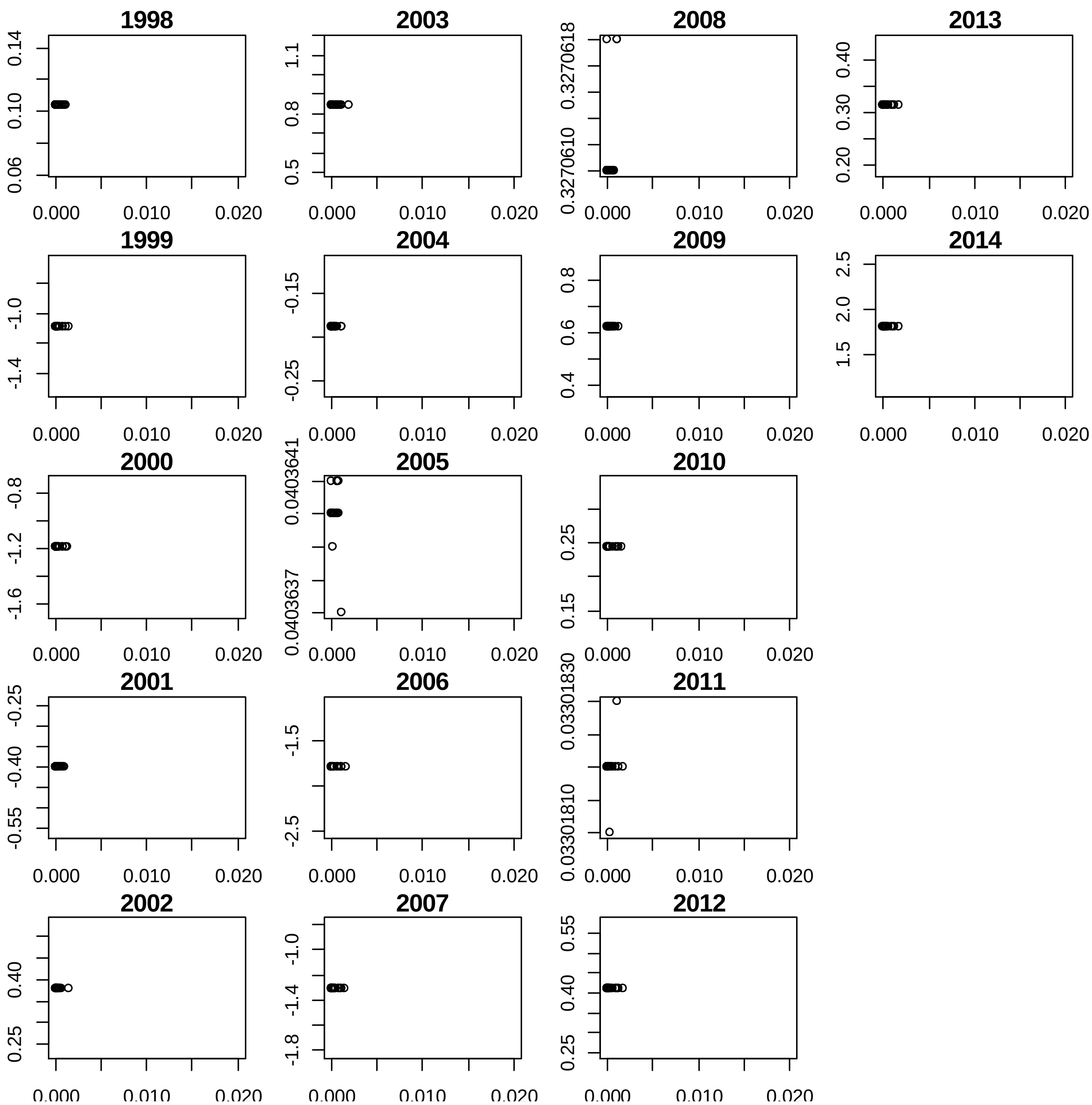


Figure 45. Model 2 Recruitment deviations vs the parameter gradient for only lowest likelihood of 6302.16. Model 2 is model 1 with F penalties for males 1992-present removed.

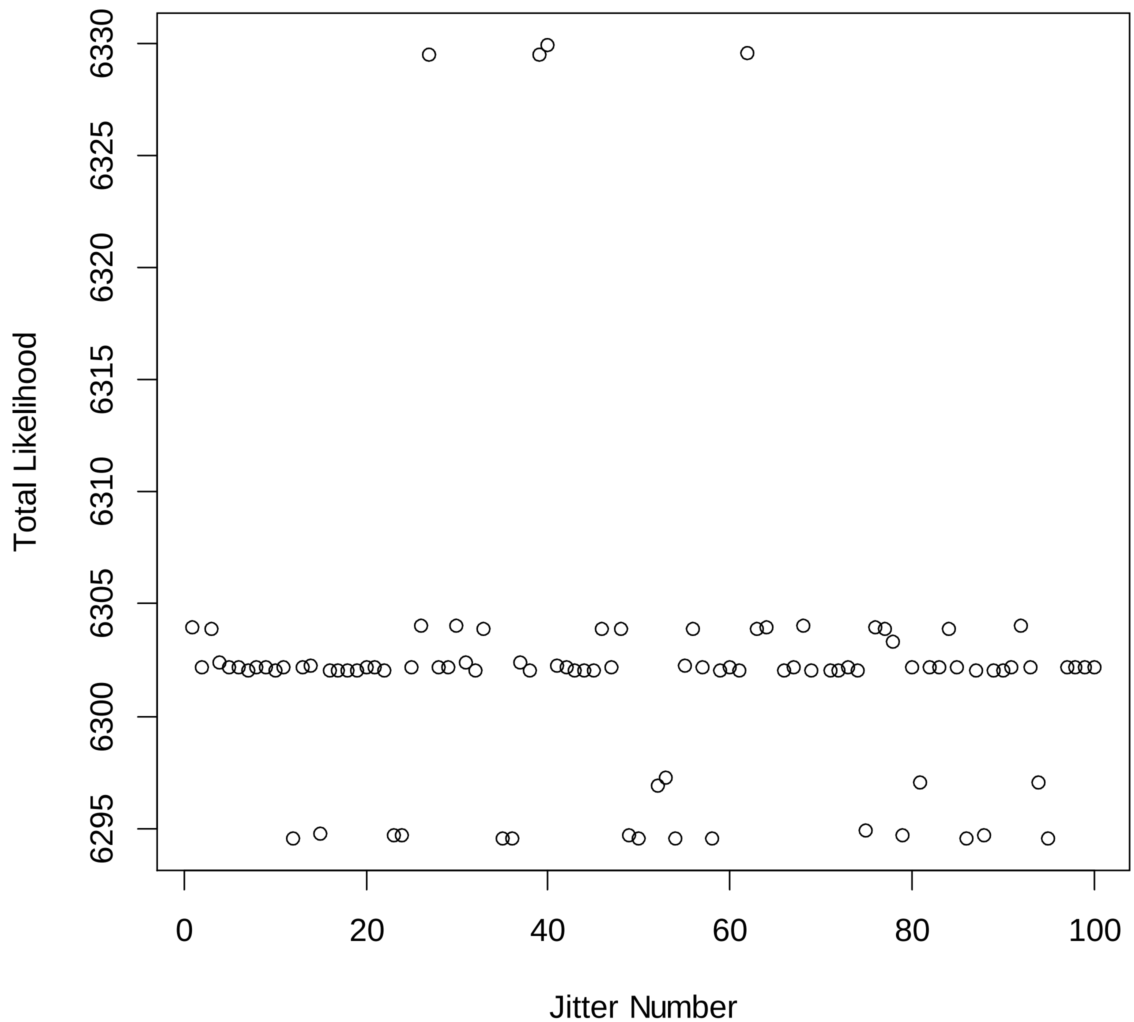


Figure 46. Model 3 is Model 2 with F deviation vector split at 1992 (adds one more parameter – mean F for 1978-1991). Total Likelihood by jitter number for runs that wrote the standard deviation file.

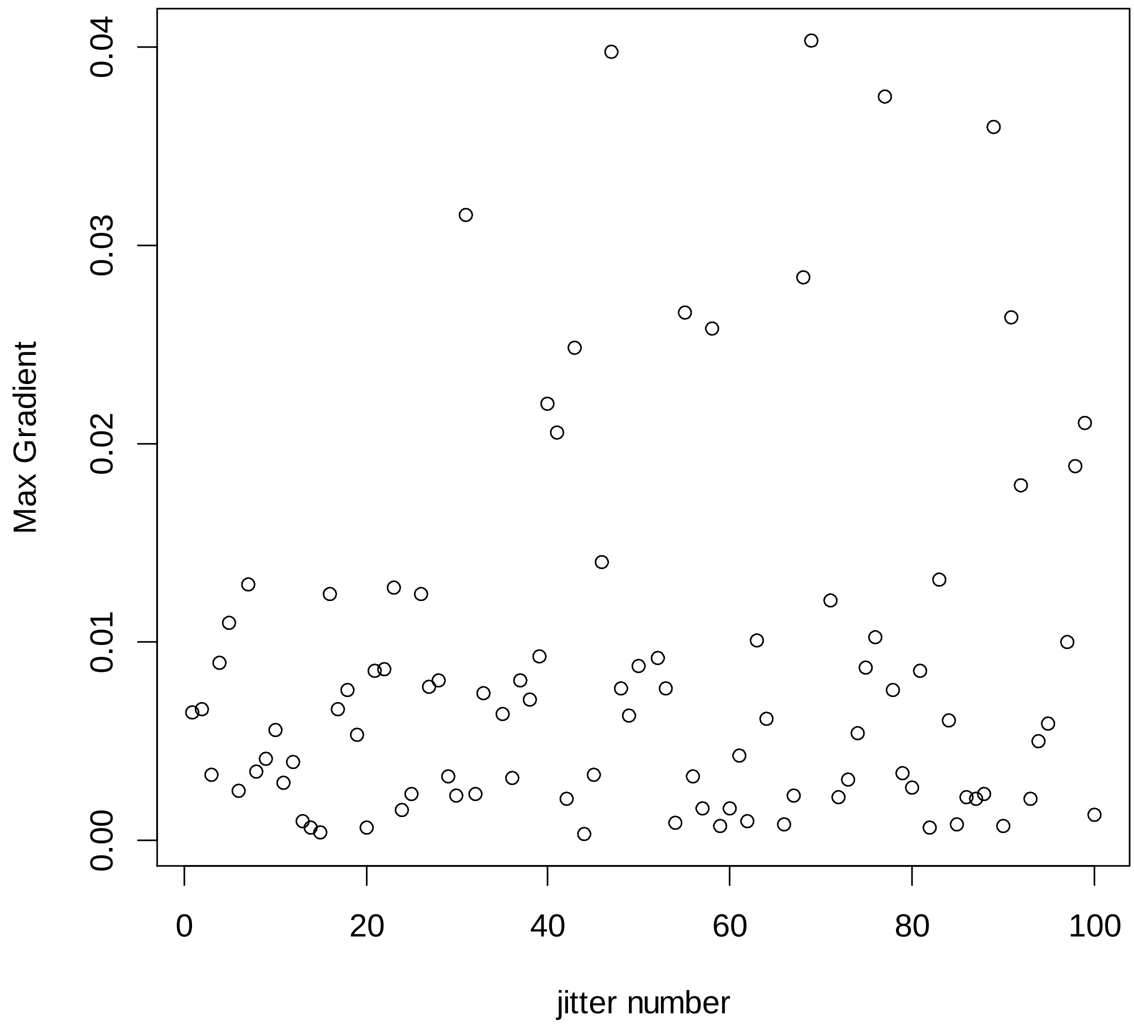


Figure 47. Model 3 is Model 2 with F deviation vector split at 1992 (adds one more parameter – mean F for 1978-1991). Maximum gradient by jitter number for runs that wrote the standard deviation file.

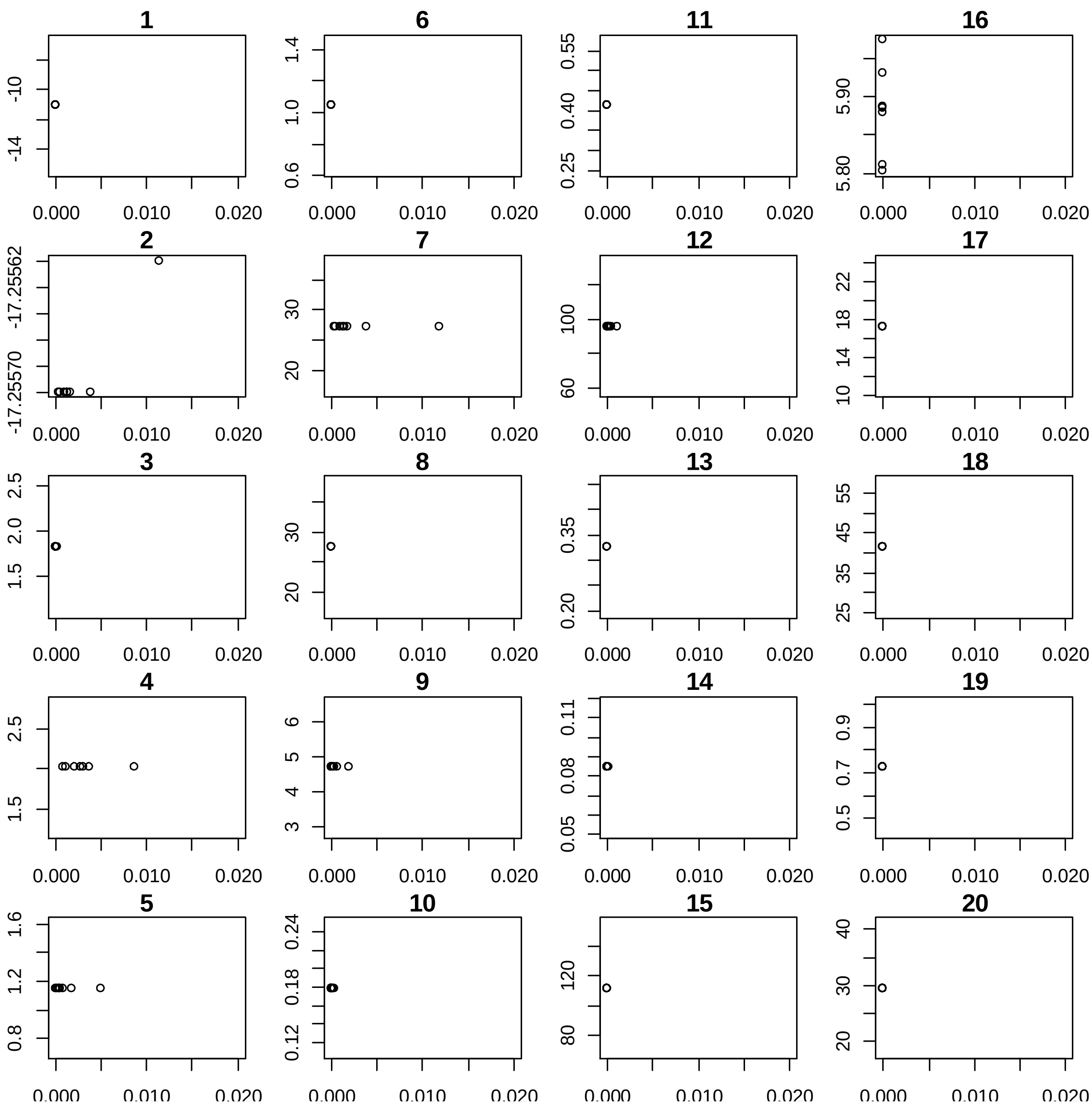


Figure 48. Model 3 parameter estimates by gradient for only the lowest likelihood runs of 6294.54. Model 3 is Model 2 with F deviation vector split at 1992 (adds one more parameter – mean F for 1978-1991).

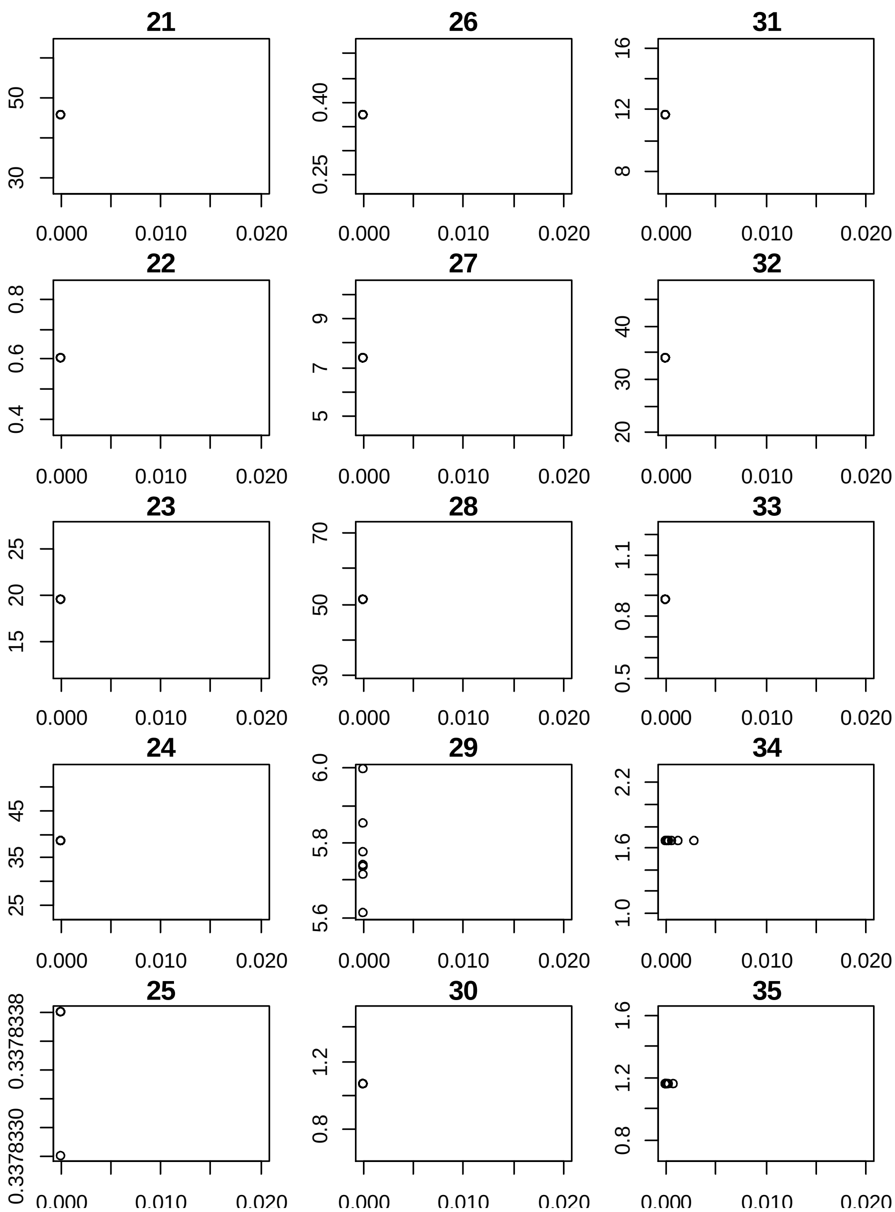


Figure 49. Model 3 parameter estimates by gradient for only the lowest likelihood runs of 6294.54. Model 3 is Model 2 with F deviation vector split at 1992 (adds one more parameter – mean F for 1978-1991).

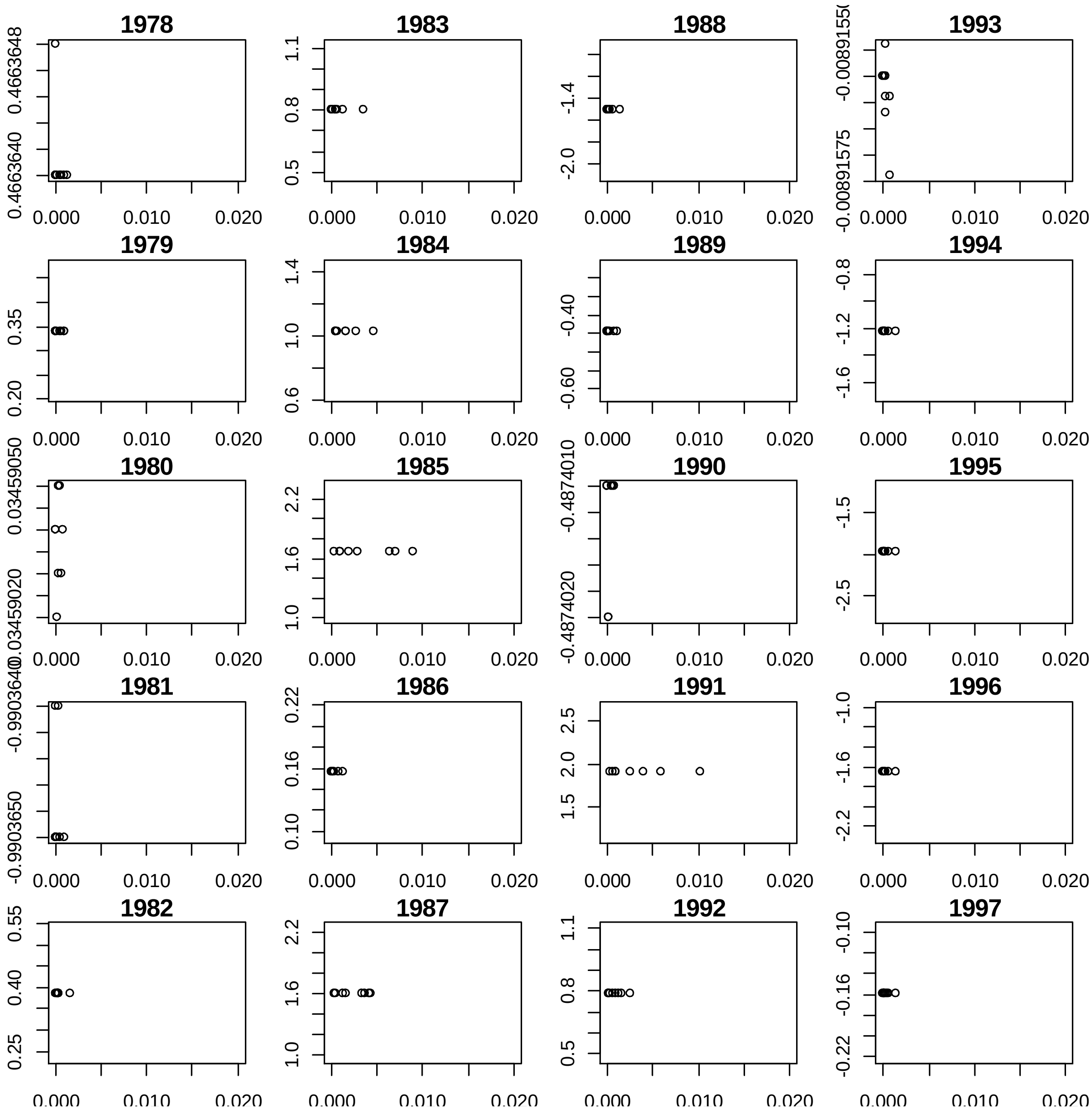

Figure 50. Model 3 recruitment deviations by gradient for only the lowest likelihood runs of 6294.54. Model 3 is Model 2 with F deviation vector split at 1992 (adds one more parameter – mean F for 1978-1991).

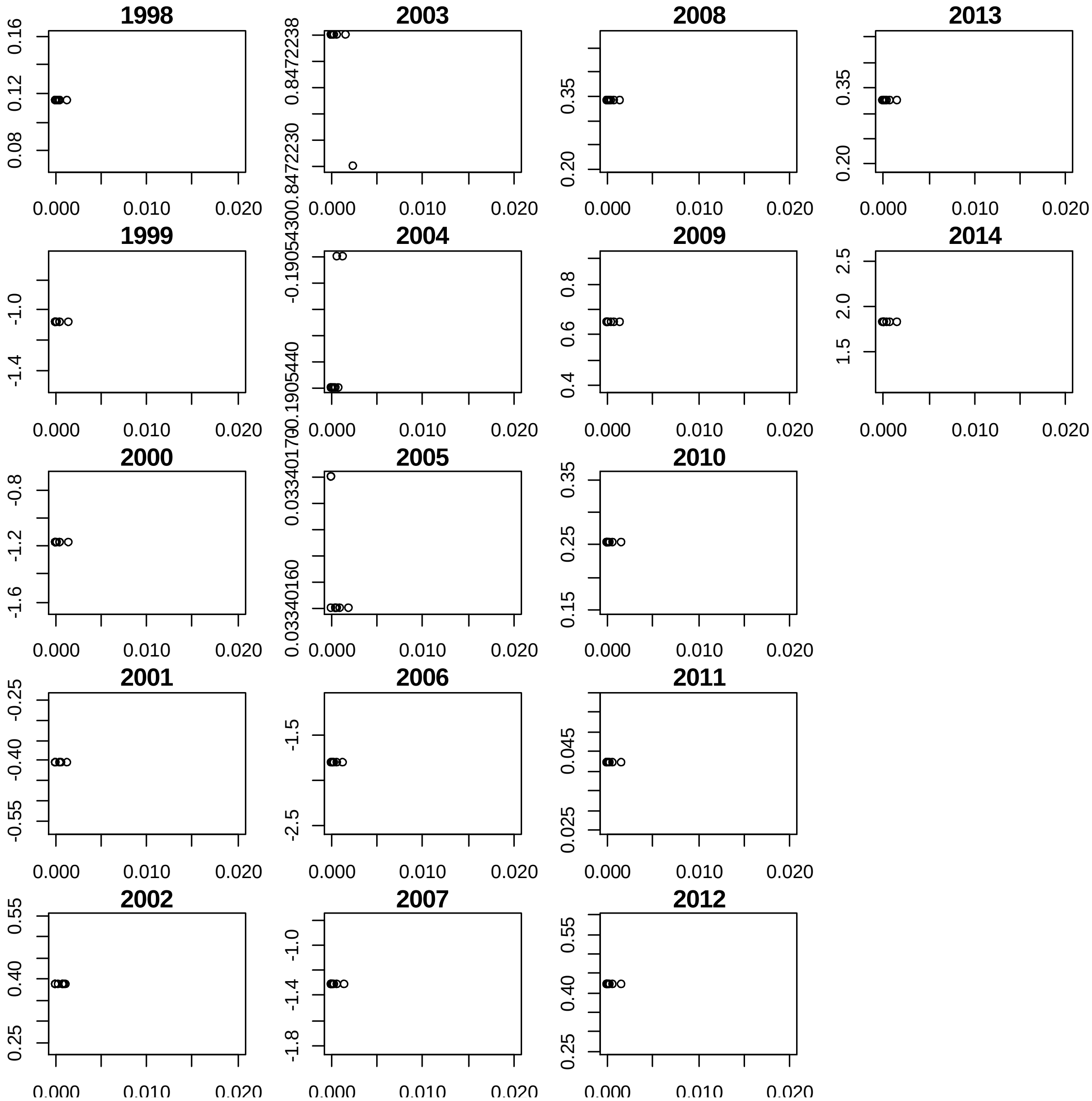


Figure 51. Model 3 recruitment deviations by gradient for only the lowest likelihood runs of 6294.54. Model 3 is  Model 2 with F deviation vector split at 1992 (adds one more parameter – mean F for 1978-1991).

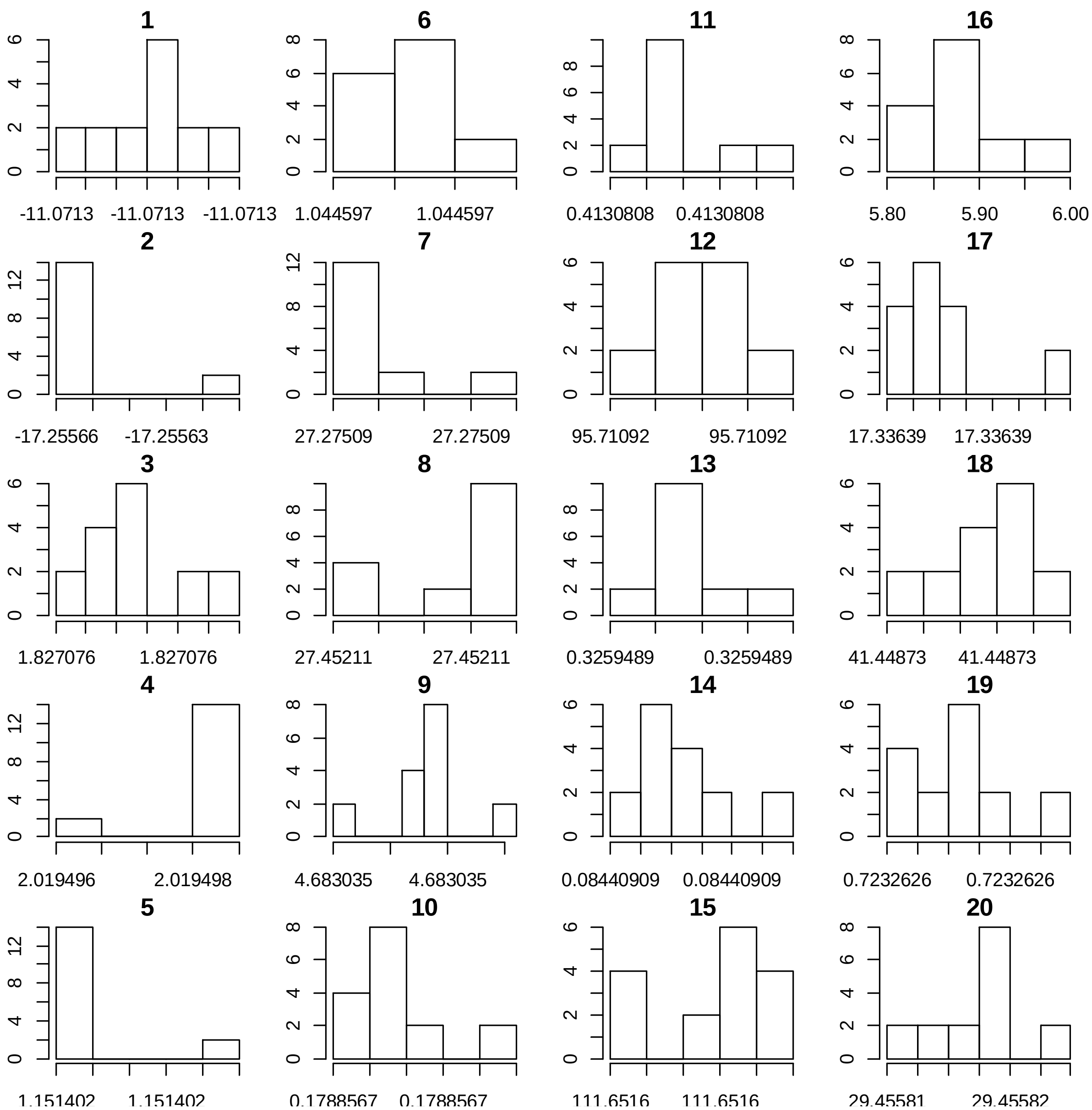

Figure 52.  Model 3 parameter estimates for only the lowest likelihood runs of 6294.54.  Model 3 is Model 2 with F deviation vector split at 1992 (adds one more parameter – mean F for 1978-1991).

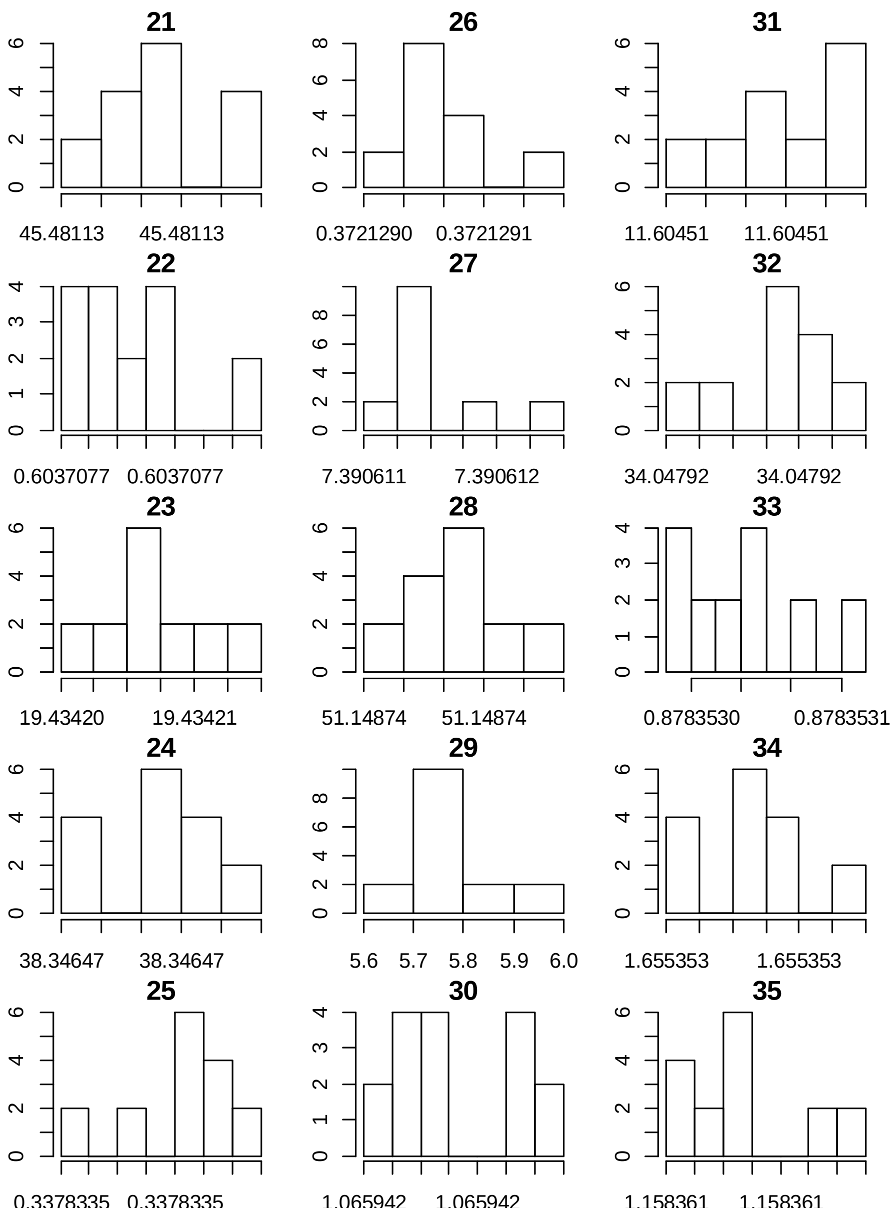


Figure 53. Model 3 parameter estimates for only the lowest likelihood runs of 6294.54. Model 3 is Model 2 with F deviation vector split at 1992 (adds one more parameter – mean F for 1978-1991).

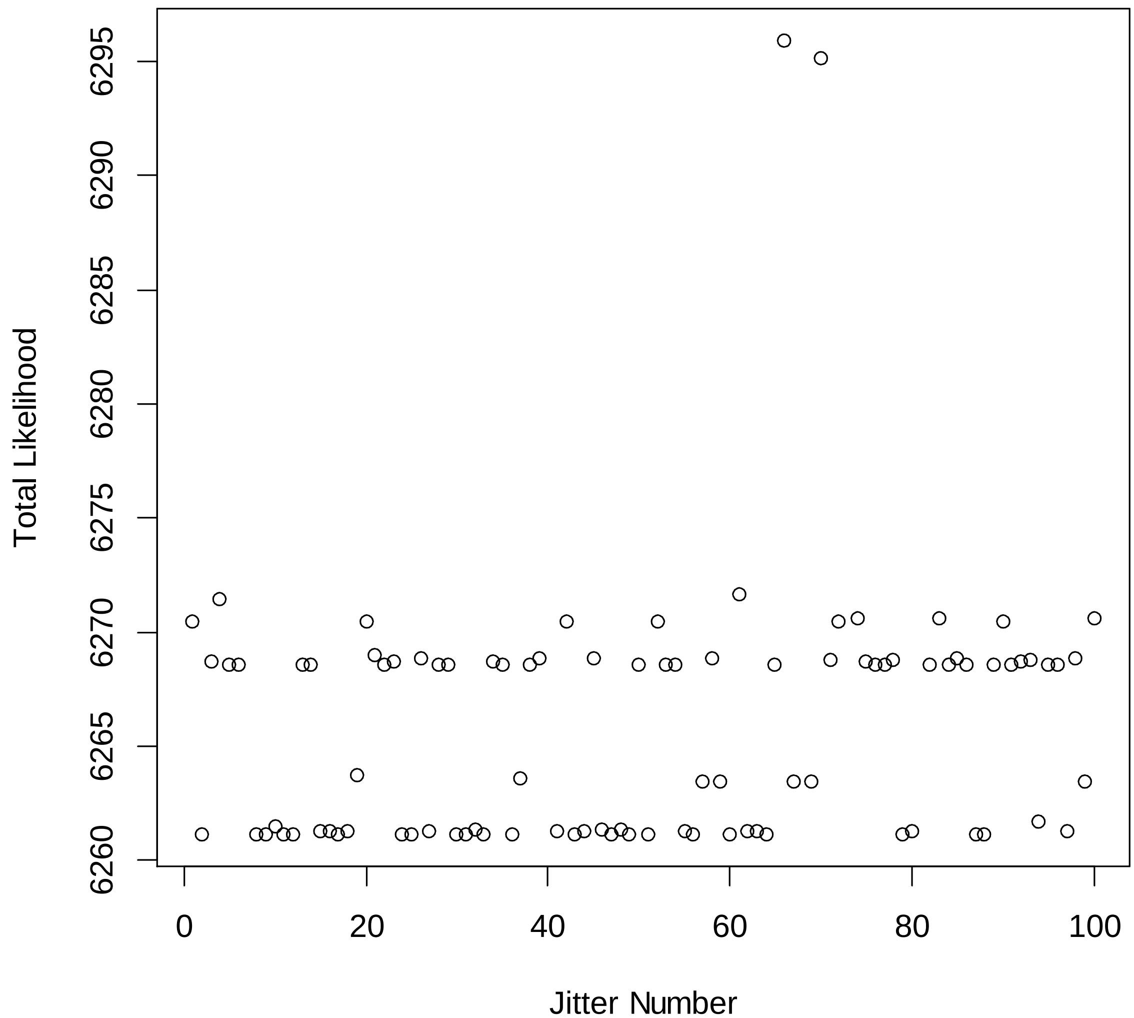


Figure 54. Model 4 Total Likelihood by jitter number for runs that wrote the standard deviation file. Model 4 is Model 3 with female fishing mortality penalties removed for 1992 to present. 95 runs wrote the std file, 12 runs had the lowest likelihood of 6261.13.

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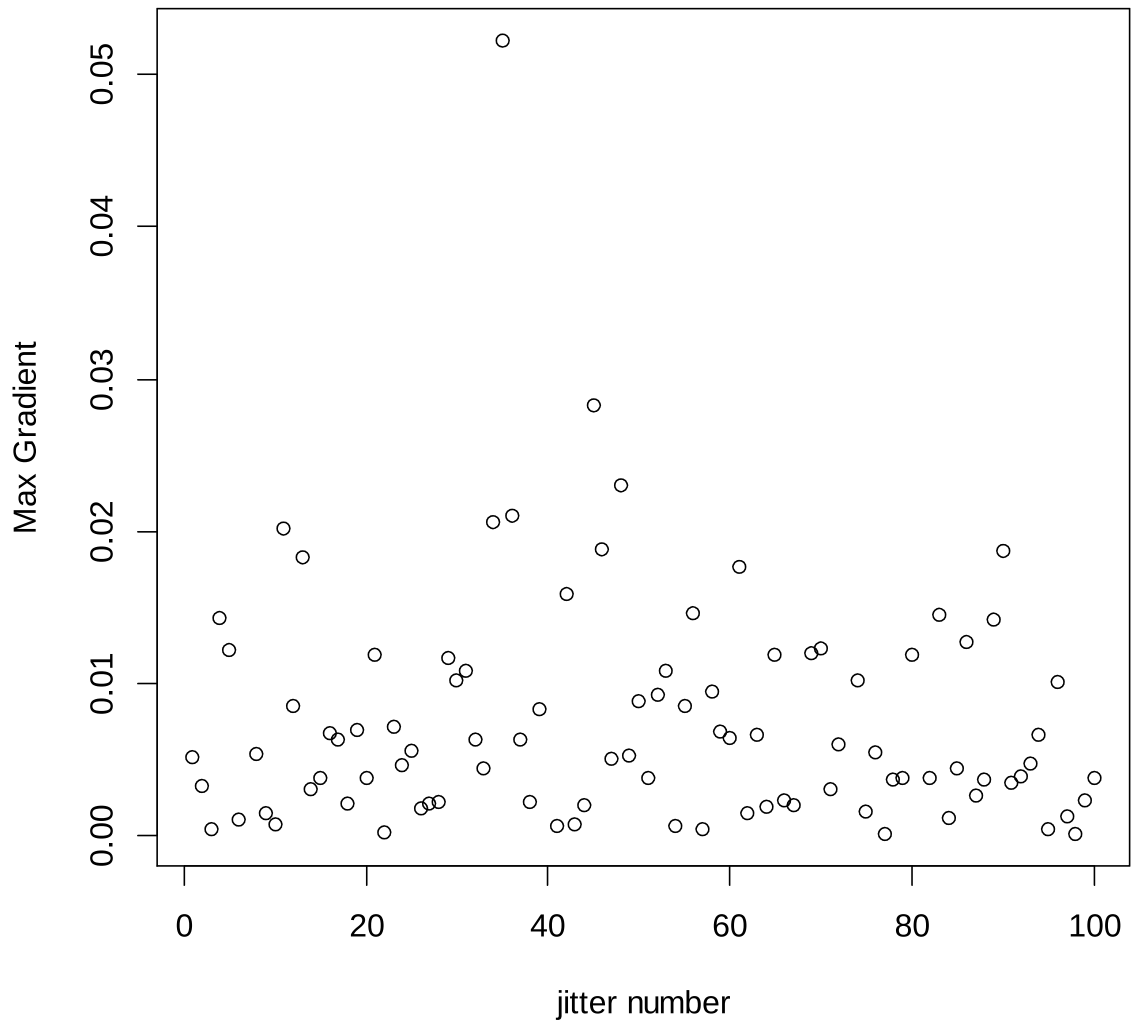


Figure 55. Model 4 Maximum gradient by jitter number for runs that wrote the standard deviation file. Model 4 is Model 3 with female fishing mortality penalties removed for 1992 to present. 95 runs wrote the std file, 12 runs had the lowest likelihood of 6261.13.

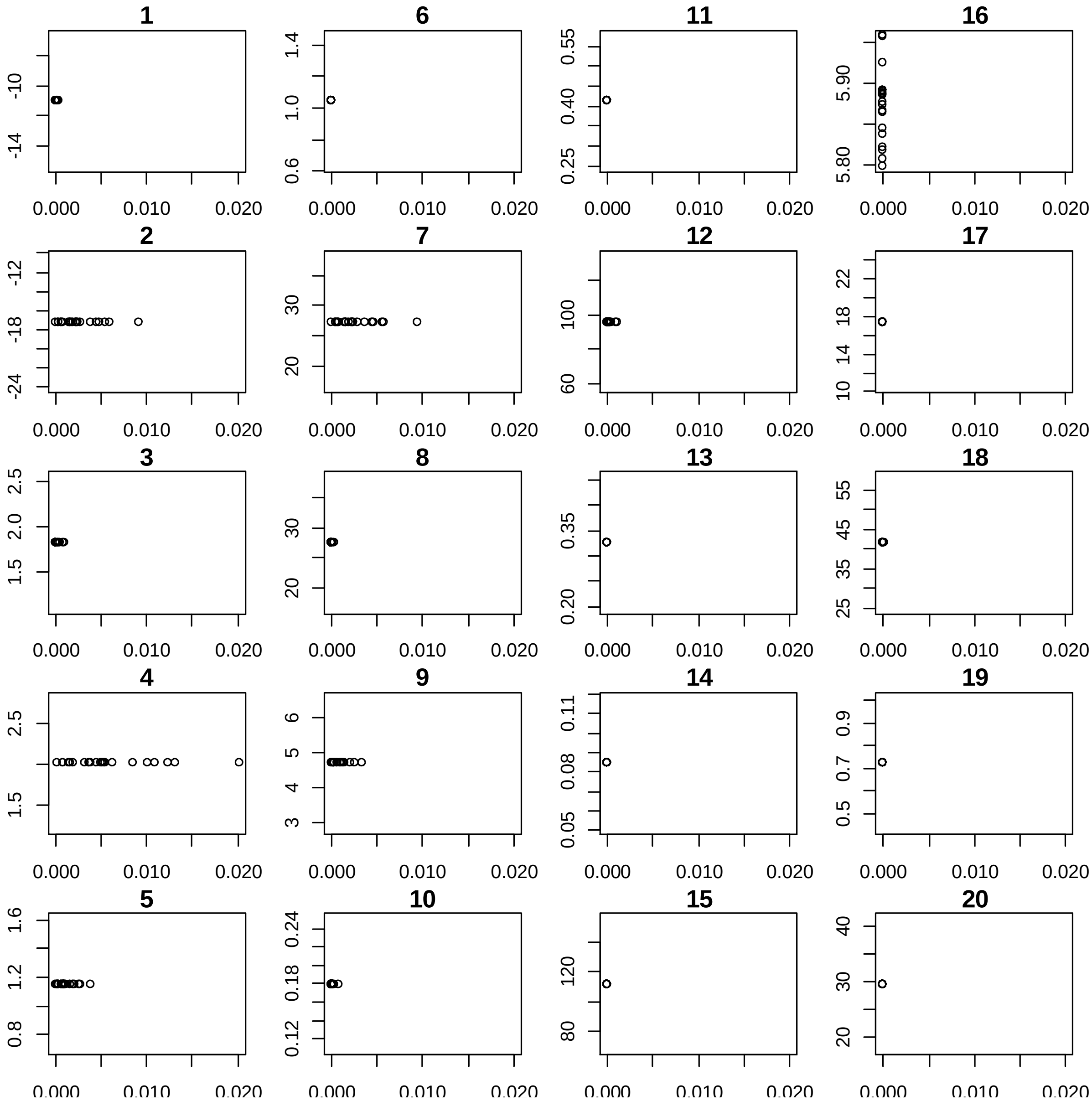


Figure 56. Model 4 parameter estimates by gradient for only the lowest likelihood runs of 6261.13.

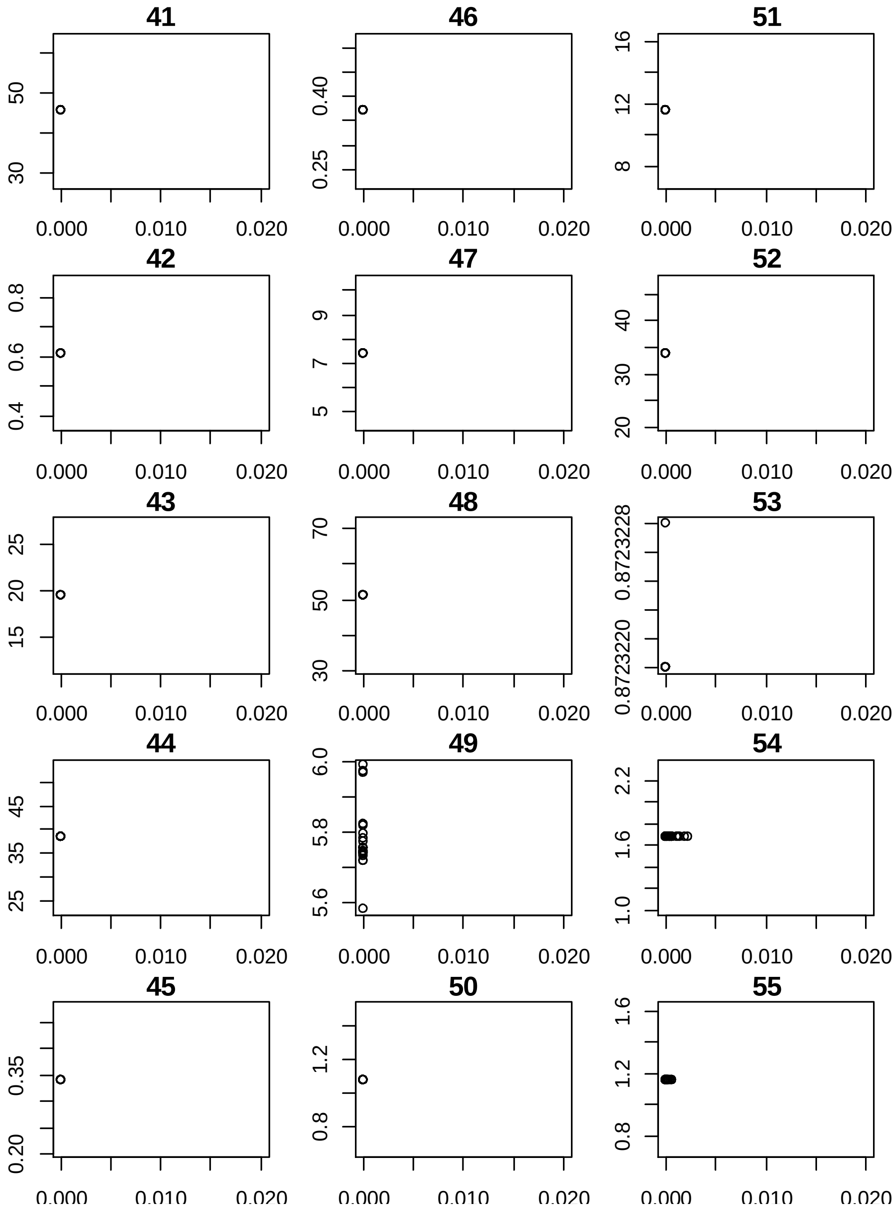


Figure 57. Model 4 parameter estimates by gradient for only the lowest likelihood runs of 6261.13.

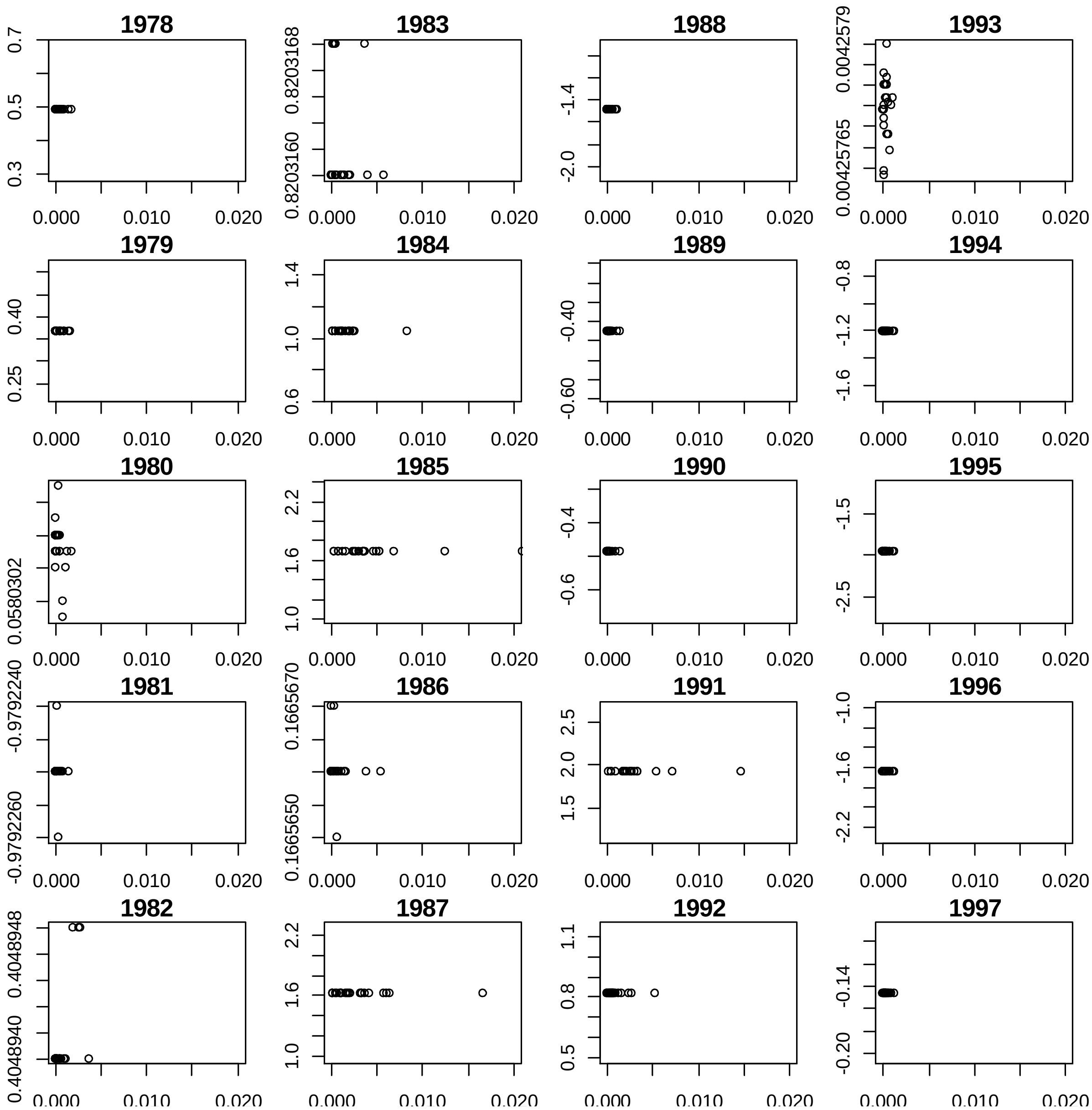

Figure 58. Model 4 recruitment deviations by gradient for only the lowest likelihood runs of 6261.13.

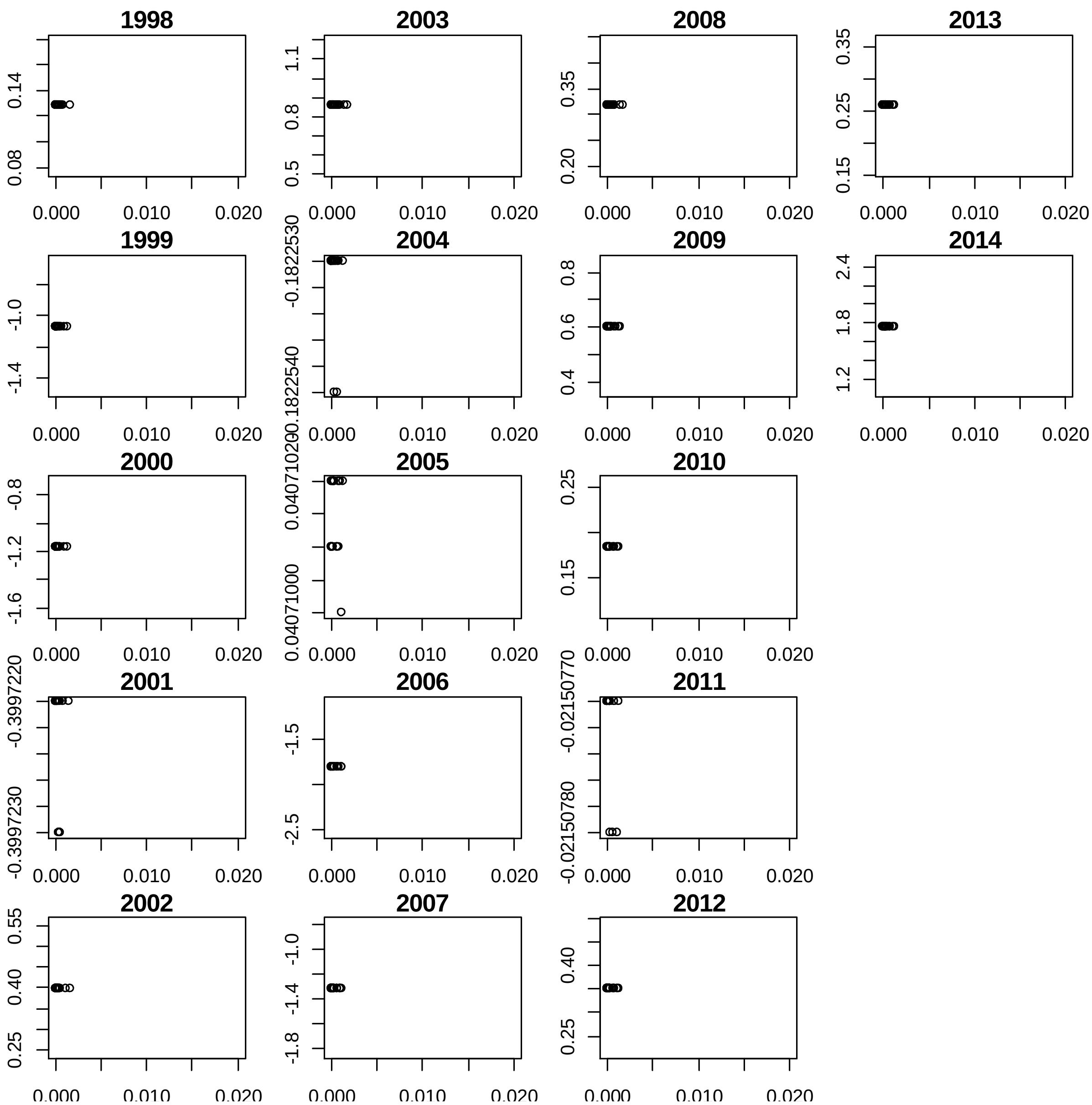


Figure 59. Model 4 recruitment deviations by gradient for only the lowest likelihood runs of 6261.13.

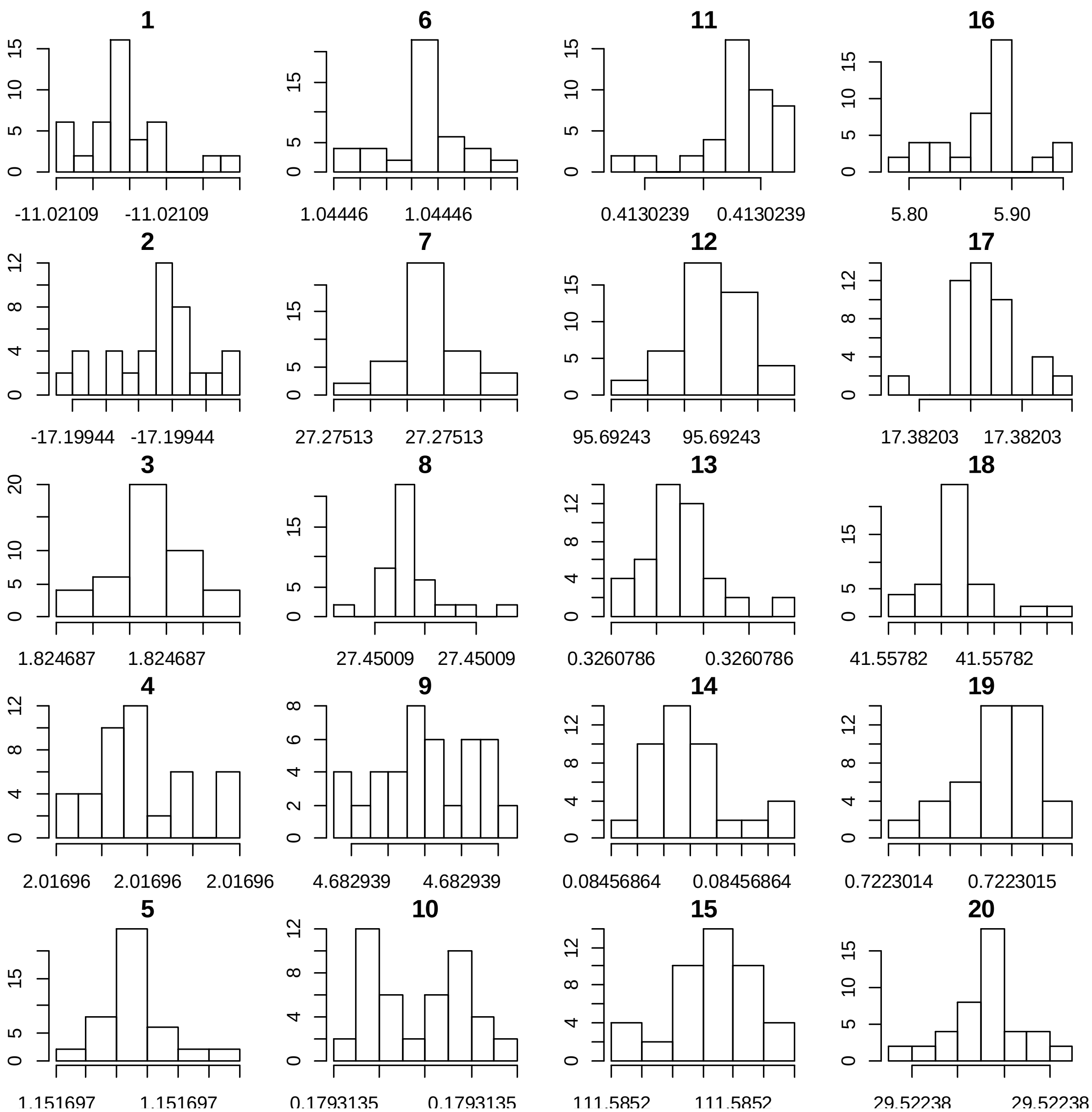


Figure 60. Model 4 parameter estimates for only the lowest likelihood runs of 6261.13.

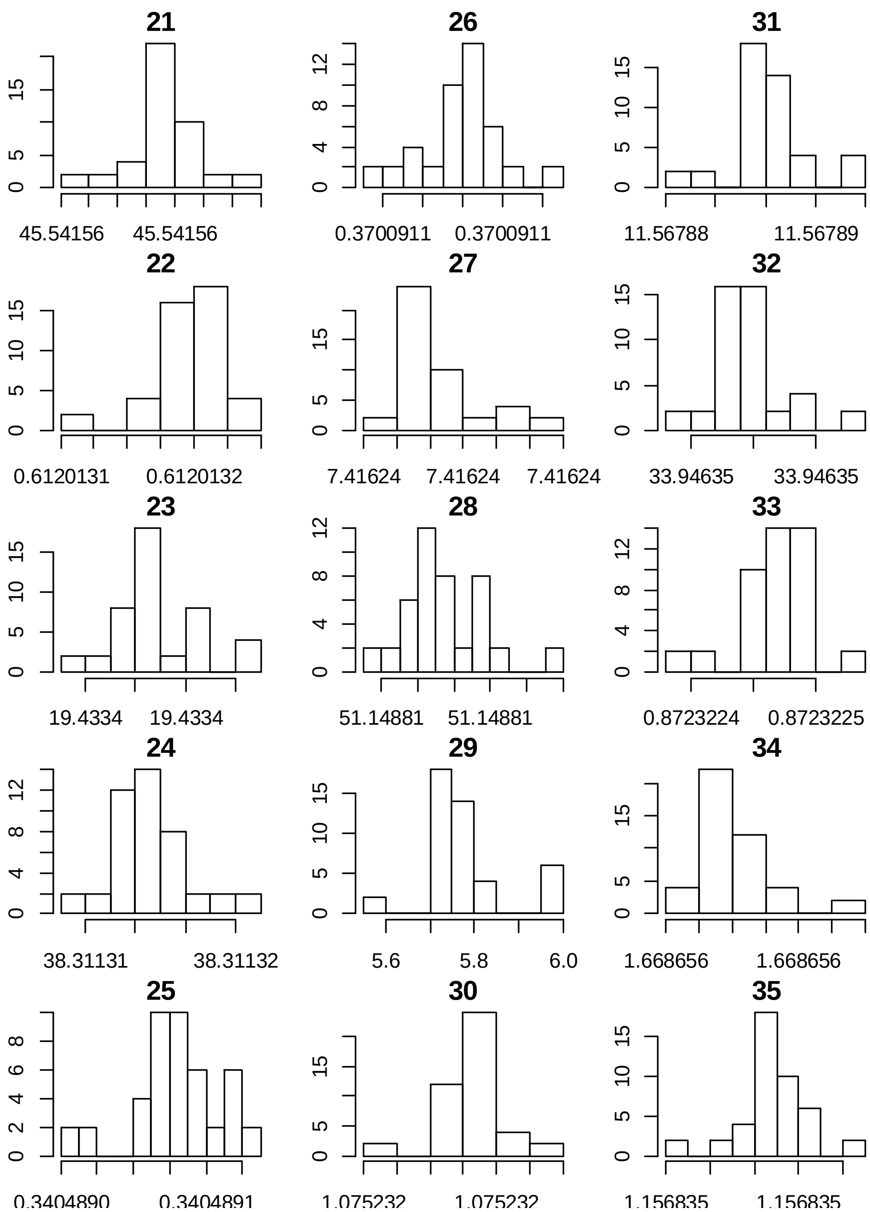


Figure 61. Model 4 parameter estimates for only the lowest likelihood runs of 6261.13.

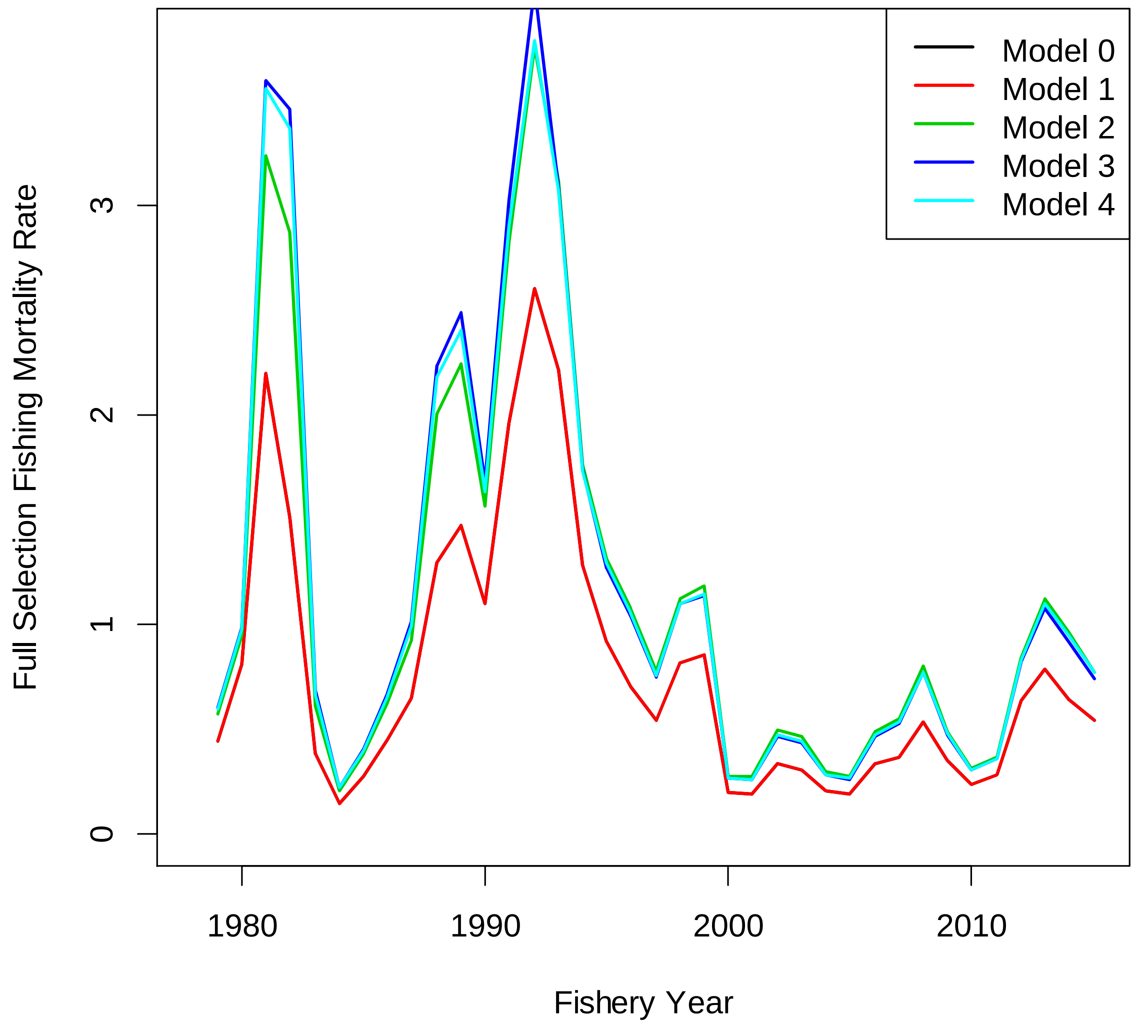


Figure 62. Fishing mortality for male directed fishery for models 0, 1, 2,3 and 4. Models 0 and 1 are exactly the same. The jitter run with the lowest likelihood and lowest gradient was used for each Model.

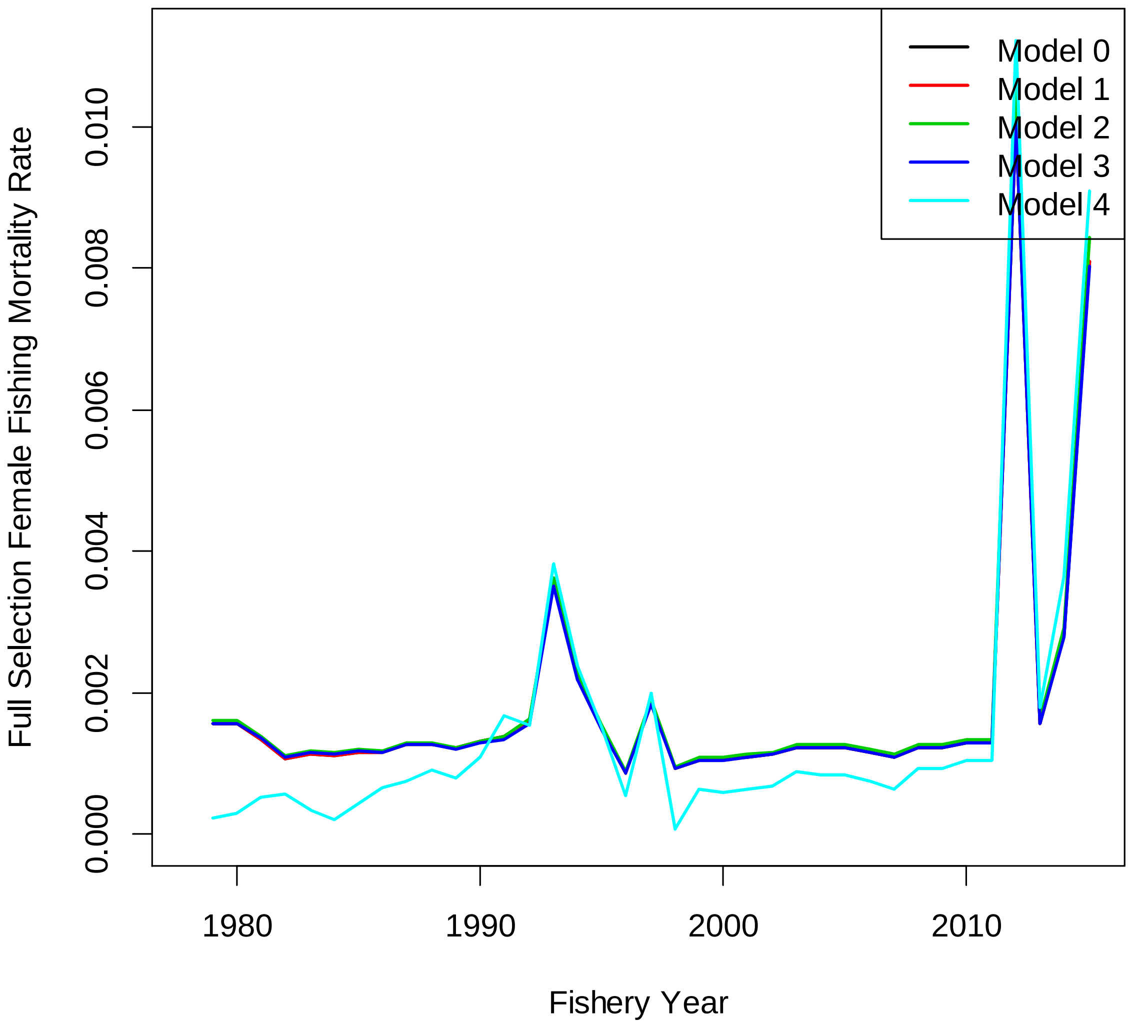


Figure 63. Fishing mortality for female directed fishery discards for models 0, 1, 2,3 and 4. The jitter run with the lowest likelihood and lowest gradient was used for each Model.

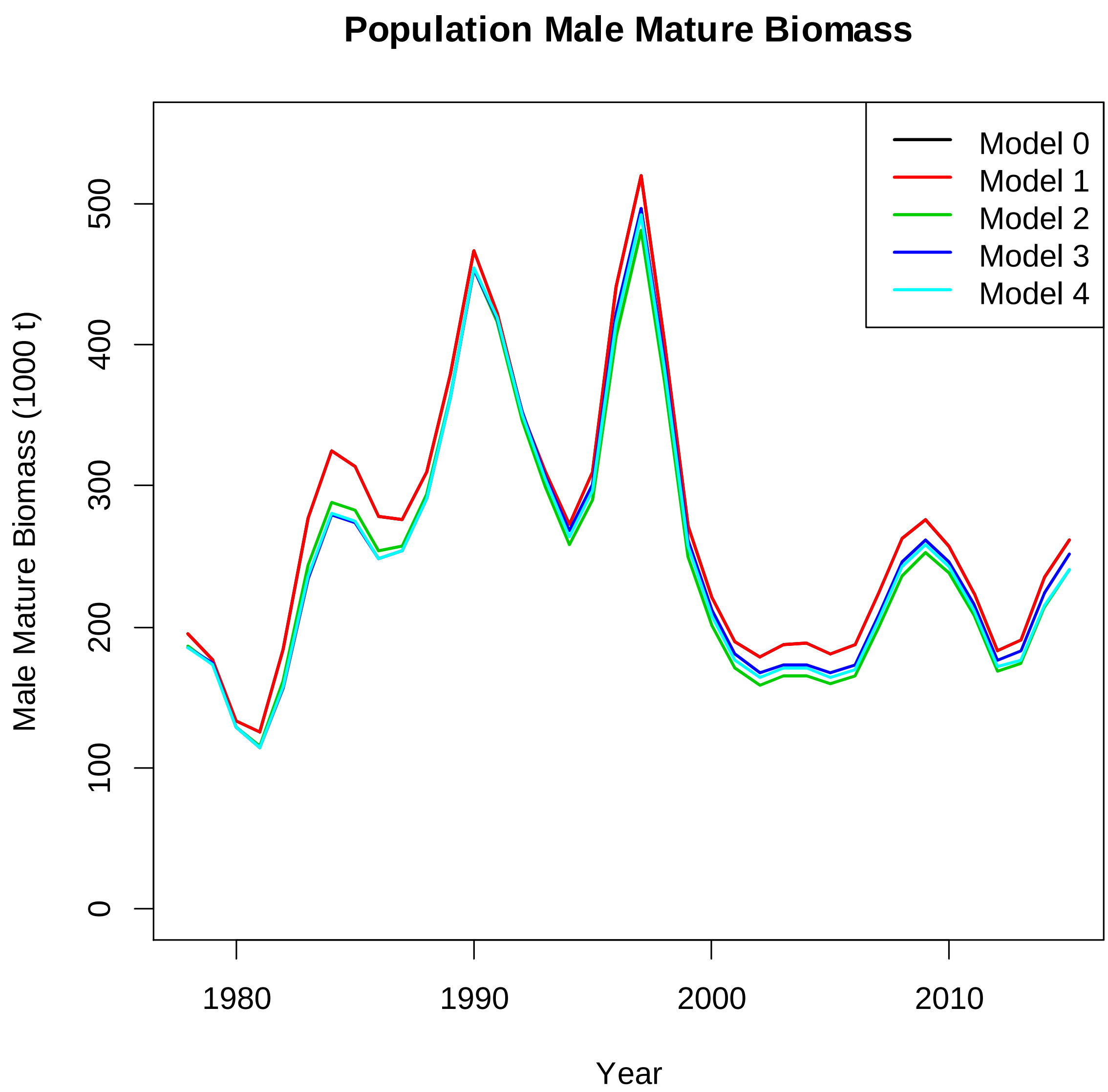


Figure 64. Population male mature biomass for models 0, 1, 2,3 and 4. The jitter run with the lowest likelihood and lowest gradient was used for each Model.

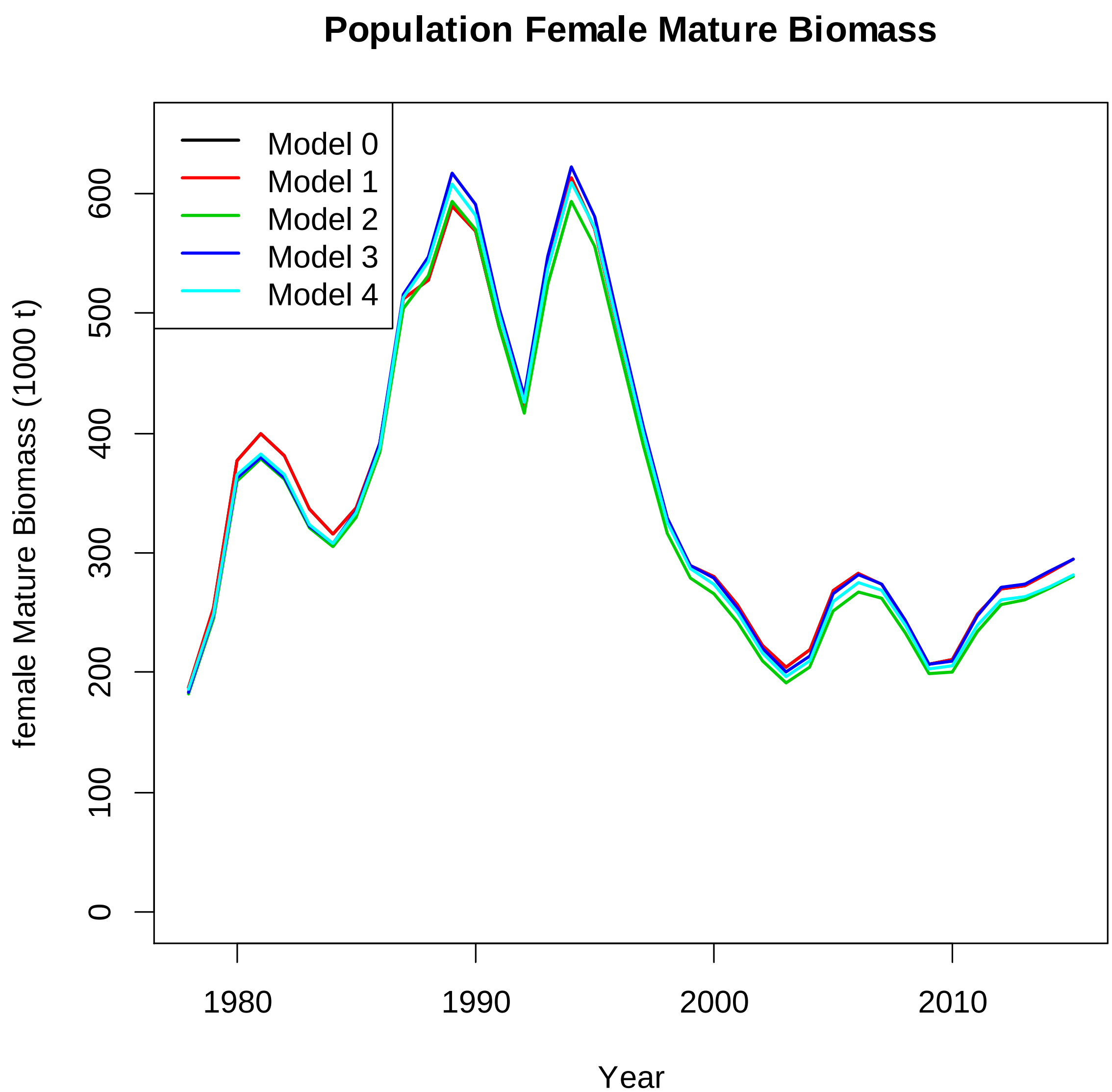


Figure 64. Population female mature biomass for models 0, 1, 2,3 and 4. The jitter run with the lowest likelihood and lowest gradient was used for each Model.

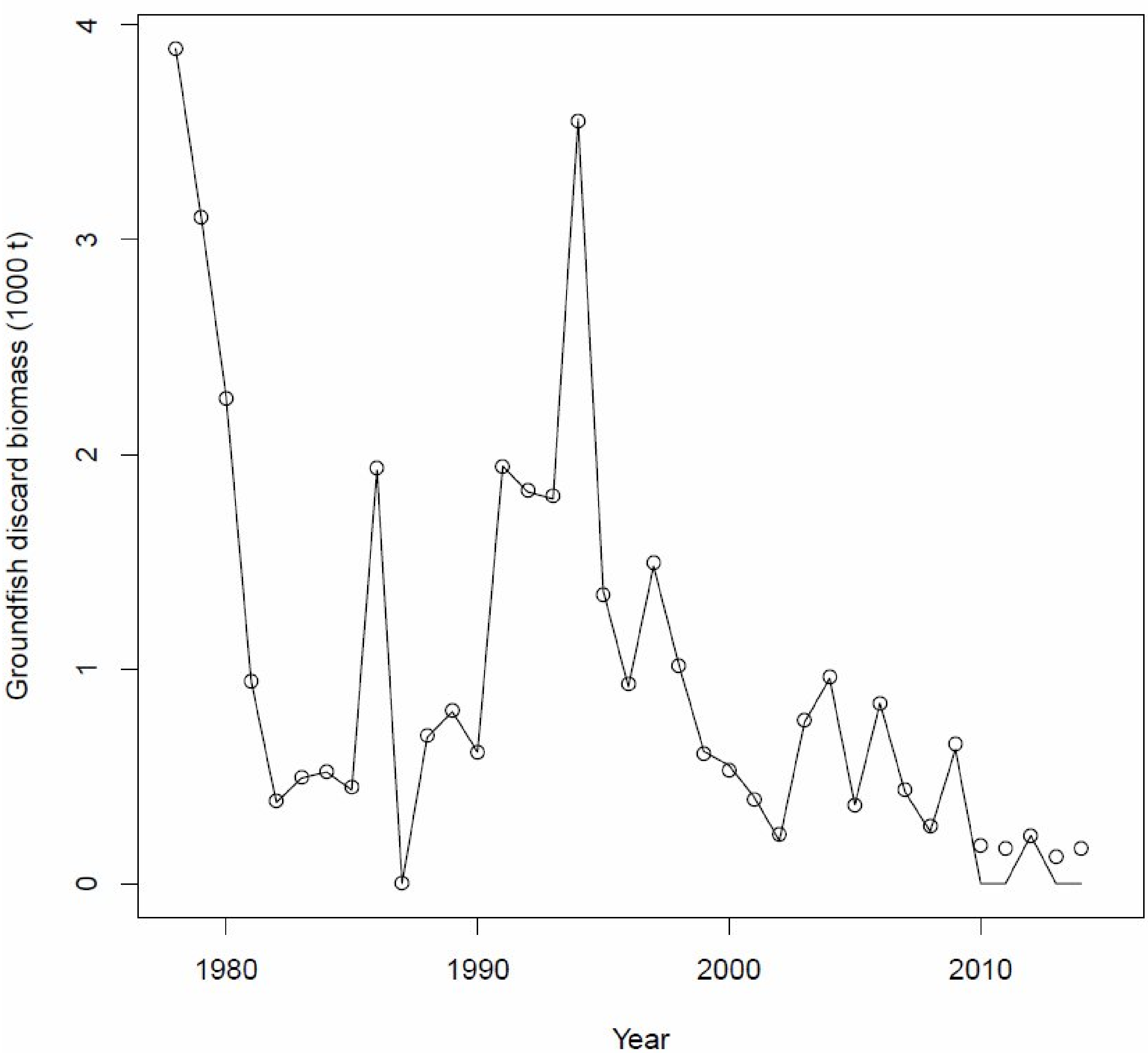


Figure 69. Model 4 fit to groundfish discard biomass. Results are for the jitter run with the lowest likelihood and lowest gradient.

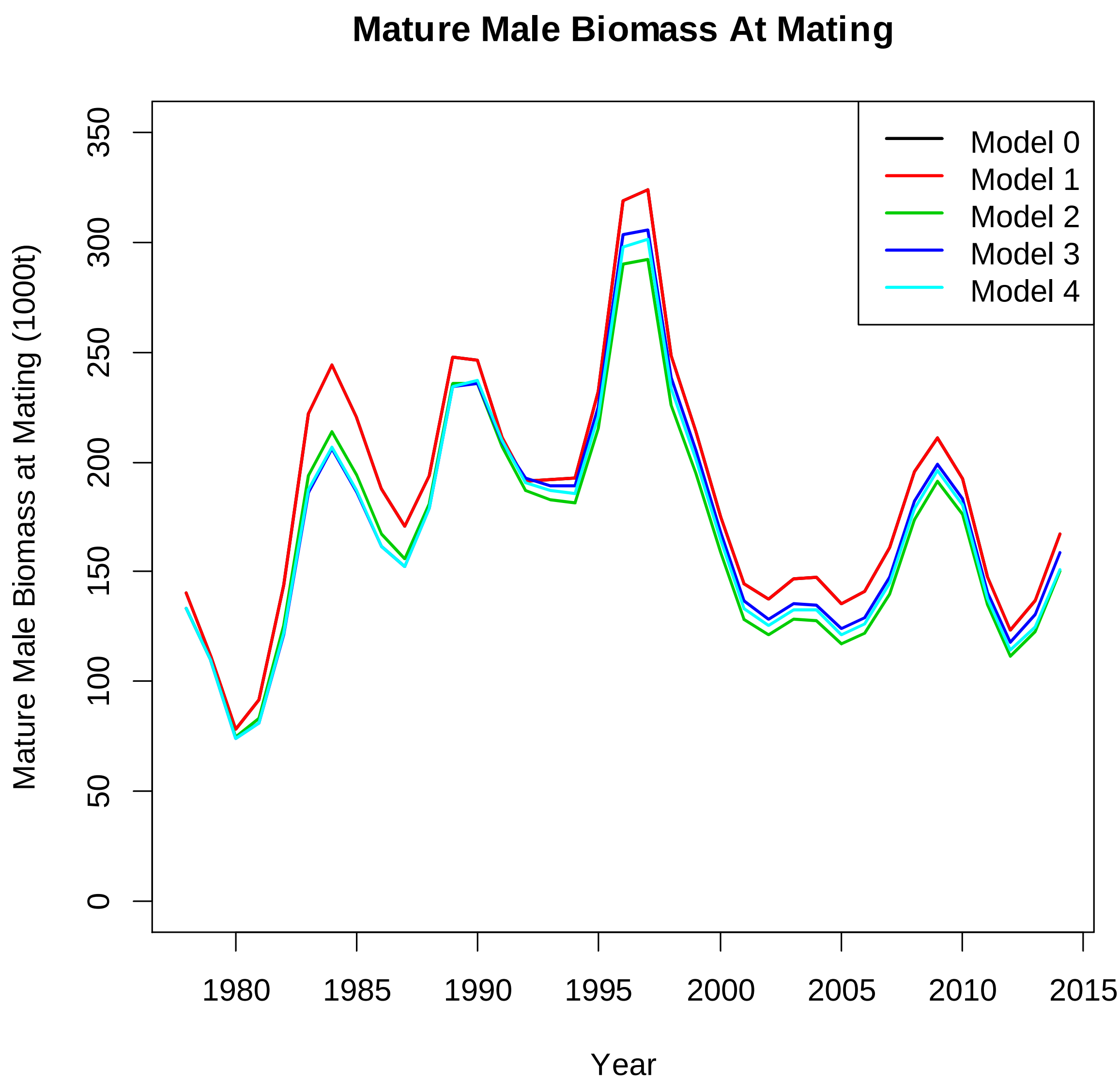


Figure 65. Male mature biomass at mating for models 0, 1, 2,3 and 4. The jitter run with the lowest likelihood and lowest gradient was used for each Model.

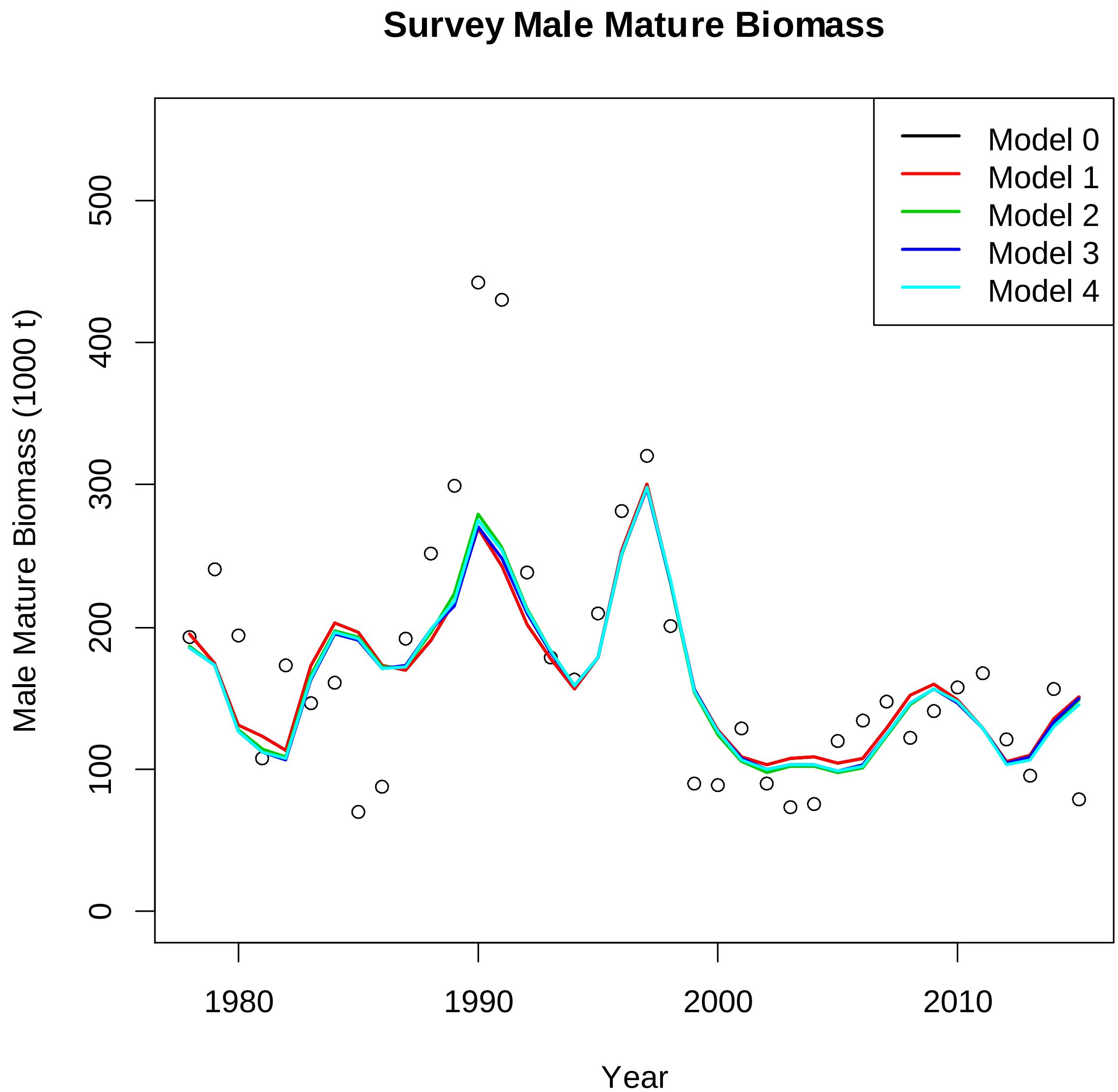


Figure 66. Model fit to survey male mature biomass for models 0, 1, 2,3 and 4. The jitter run with the lowest likelihood and lowest gradient was used for each Model.

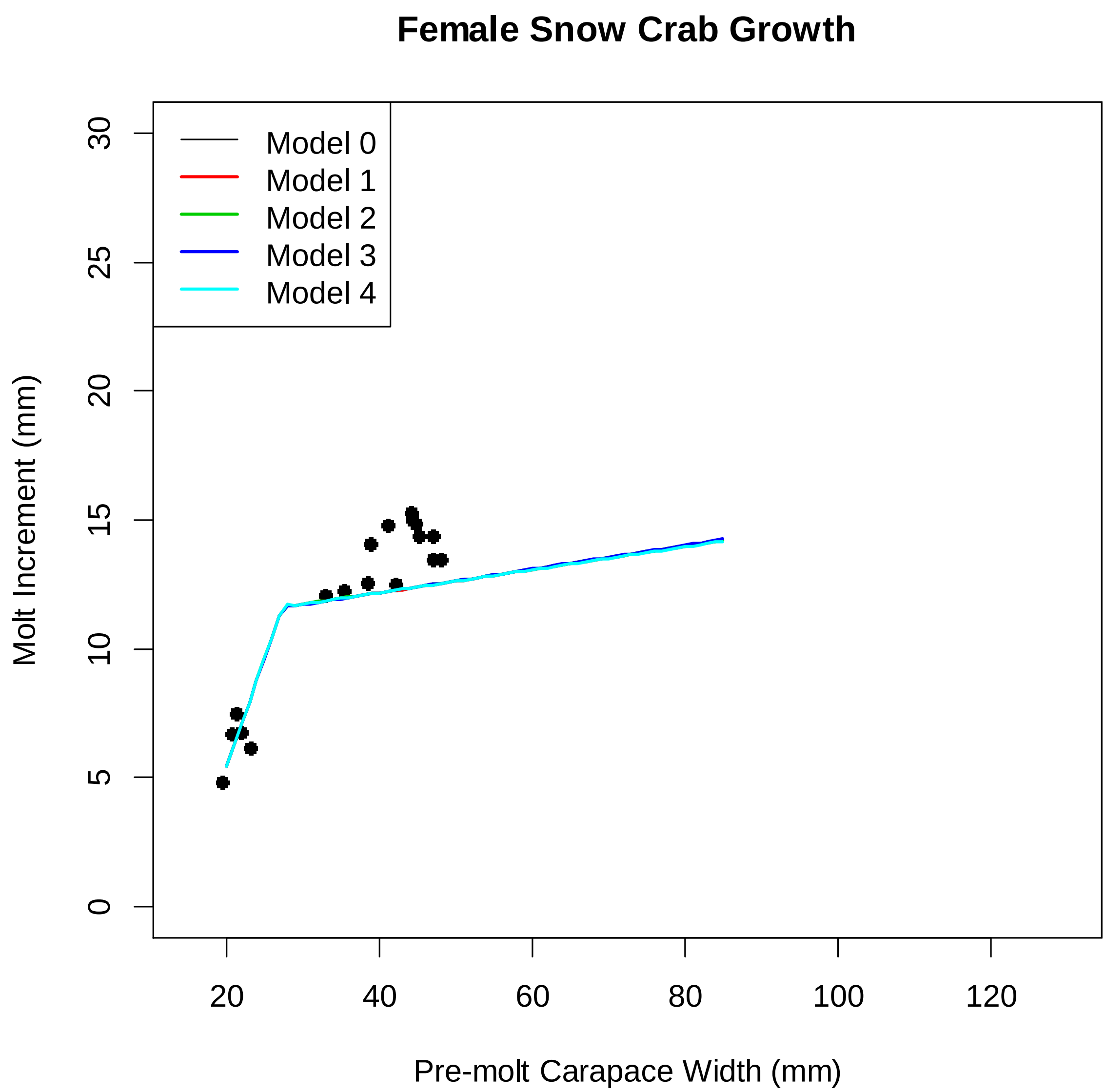


Figure 67. Estimated growth for female crab for models 0, 1, 2,3 and 4. The jitter run with the lowest likelihood and lowest gradient was used for each Model.

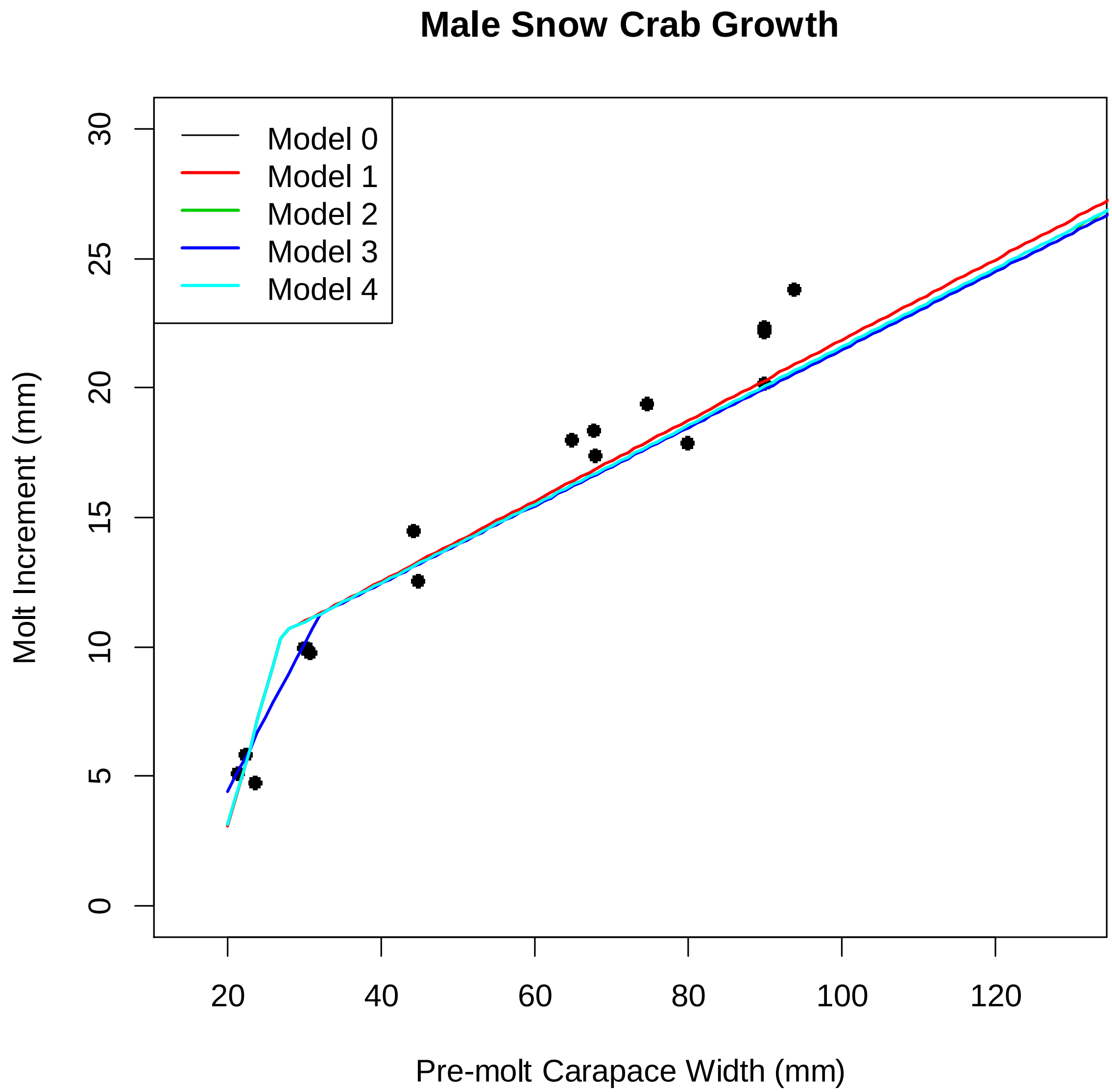


Figure 68. Estimated growth for male crab for models 0, 1, 2,3 and 4. Models 0, 1,2 and 4 are similar and have a lower transition point than Model 3. The jitter run with the lowest likelihood and lowest gradient was used for each Model.

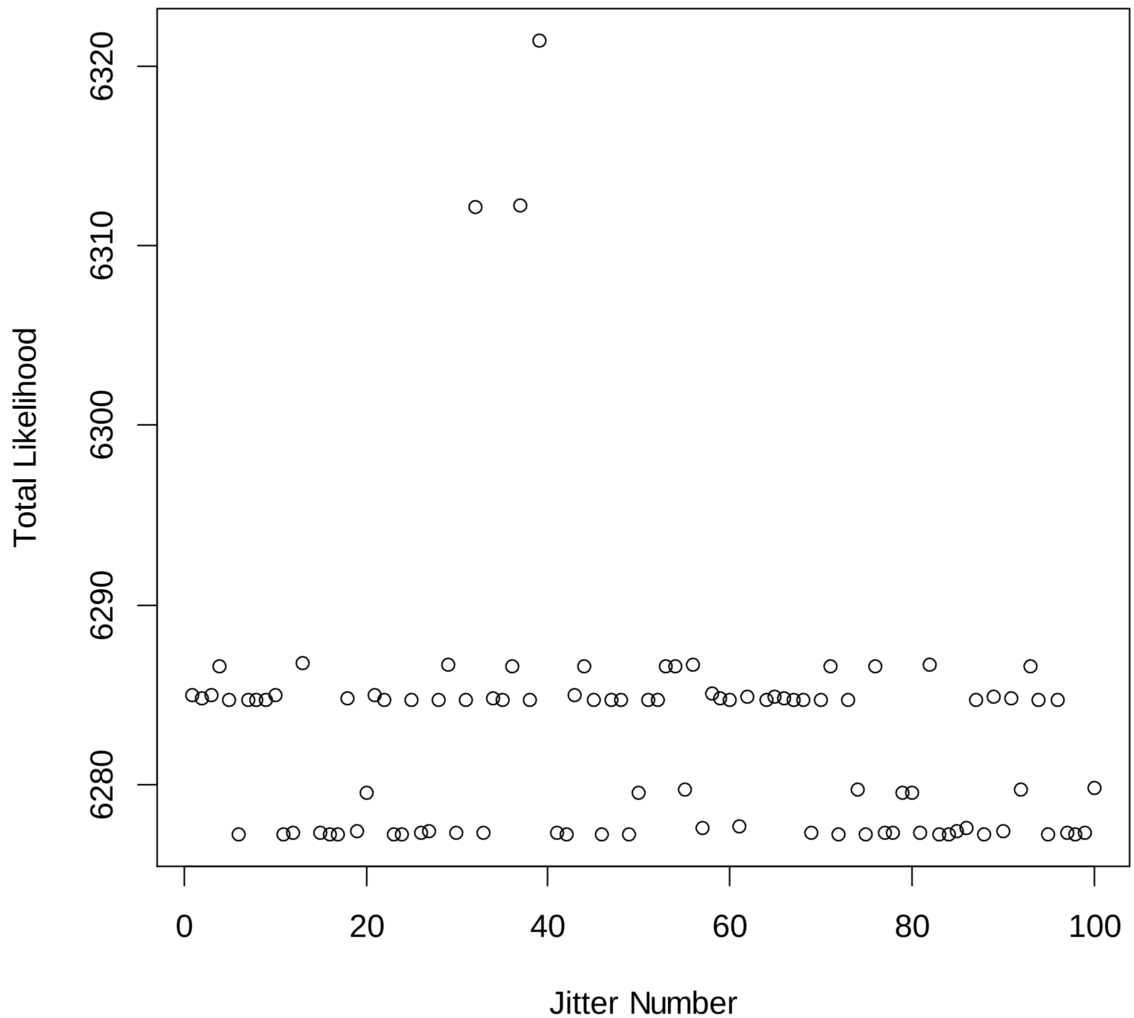


Figure 69. Model 4a.

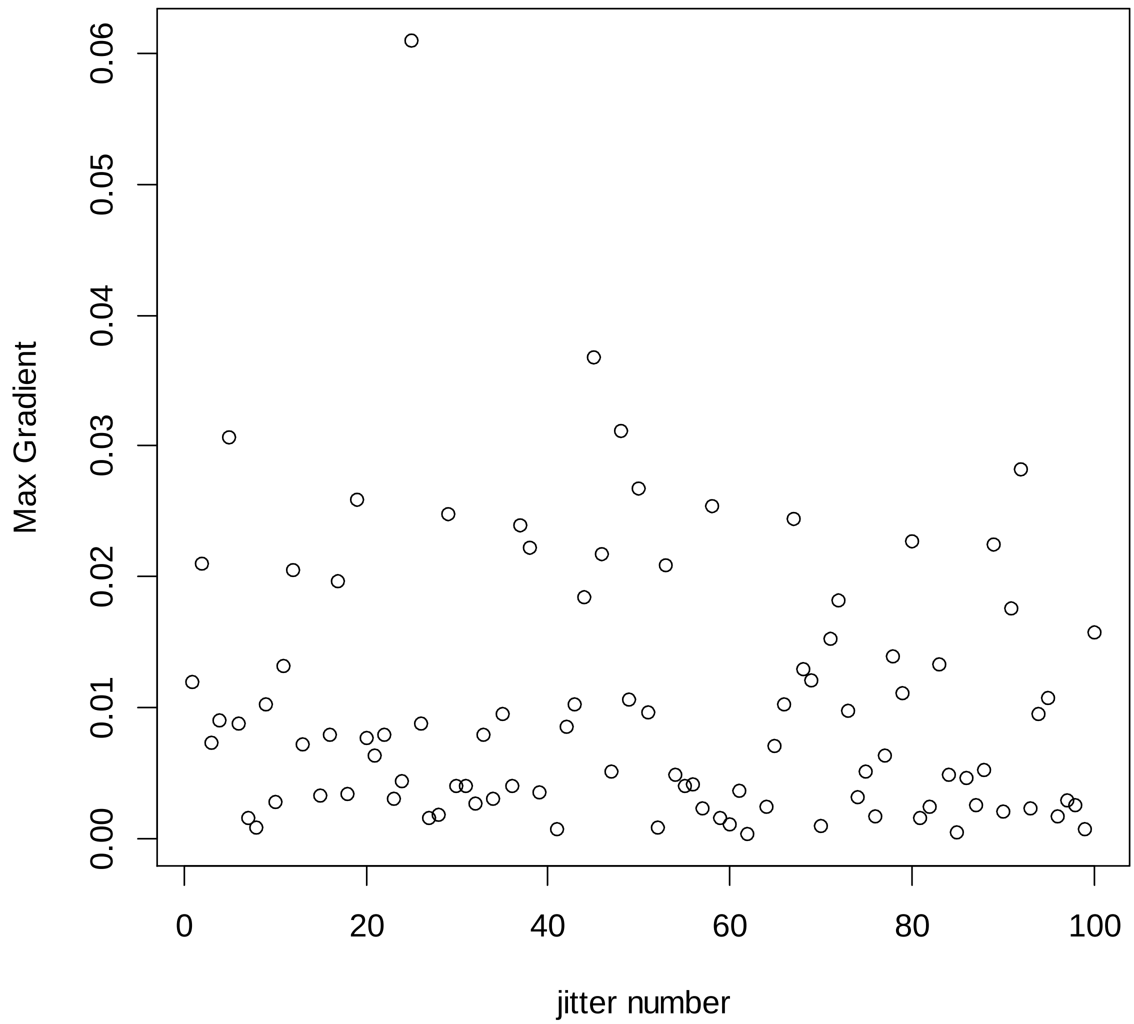


Figure 70. Model 4a.

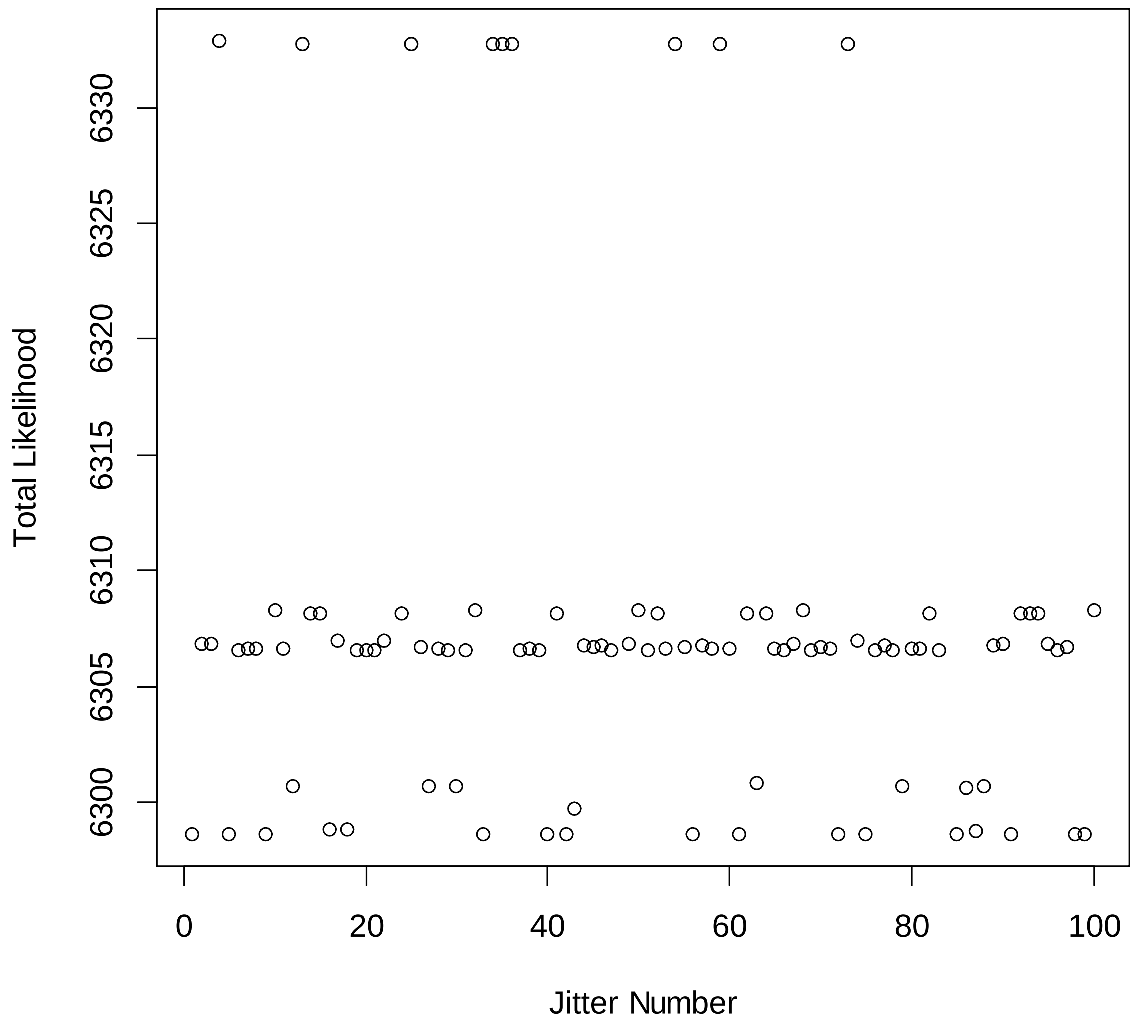


Figure 71. Model 4b. 5 runs had lowest likelihood of 6298.6.

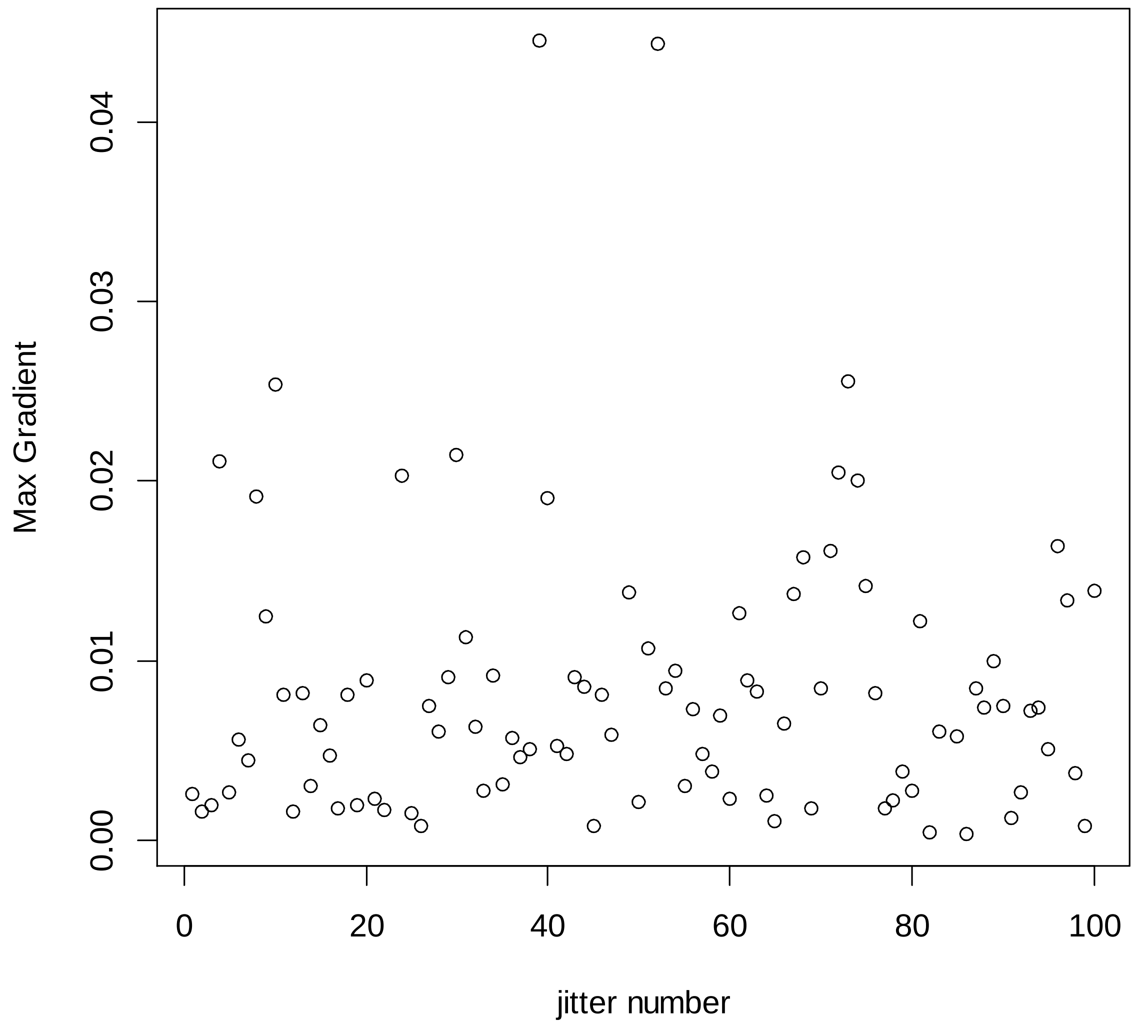


Figure 72.  Model 4b. Maximum gradient by jitter run.

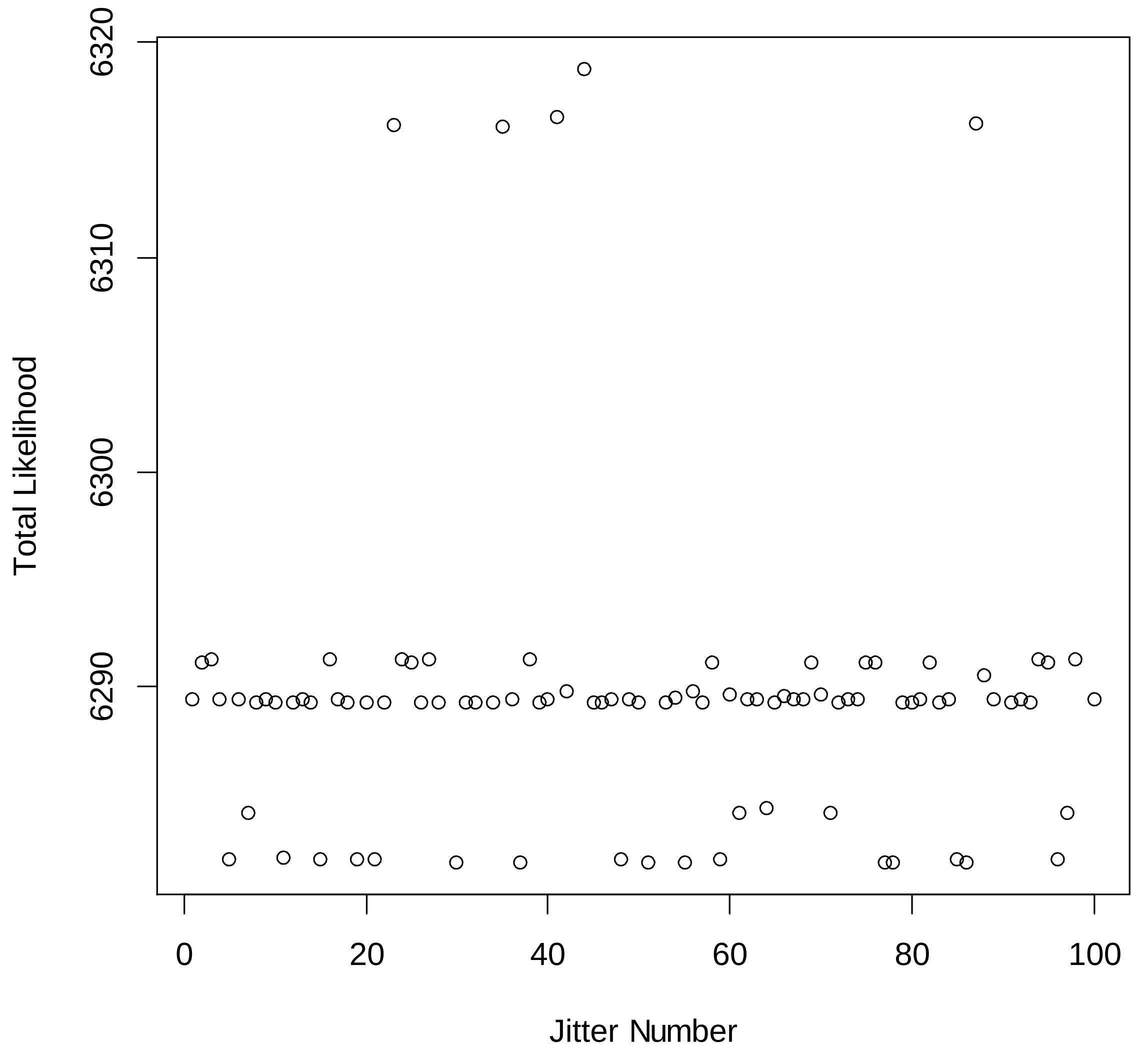


Figure 73. Model 4c. Total likelihood by jitter run. 7 runs had lowest likelihood of 6281.76.

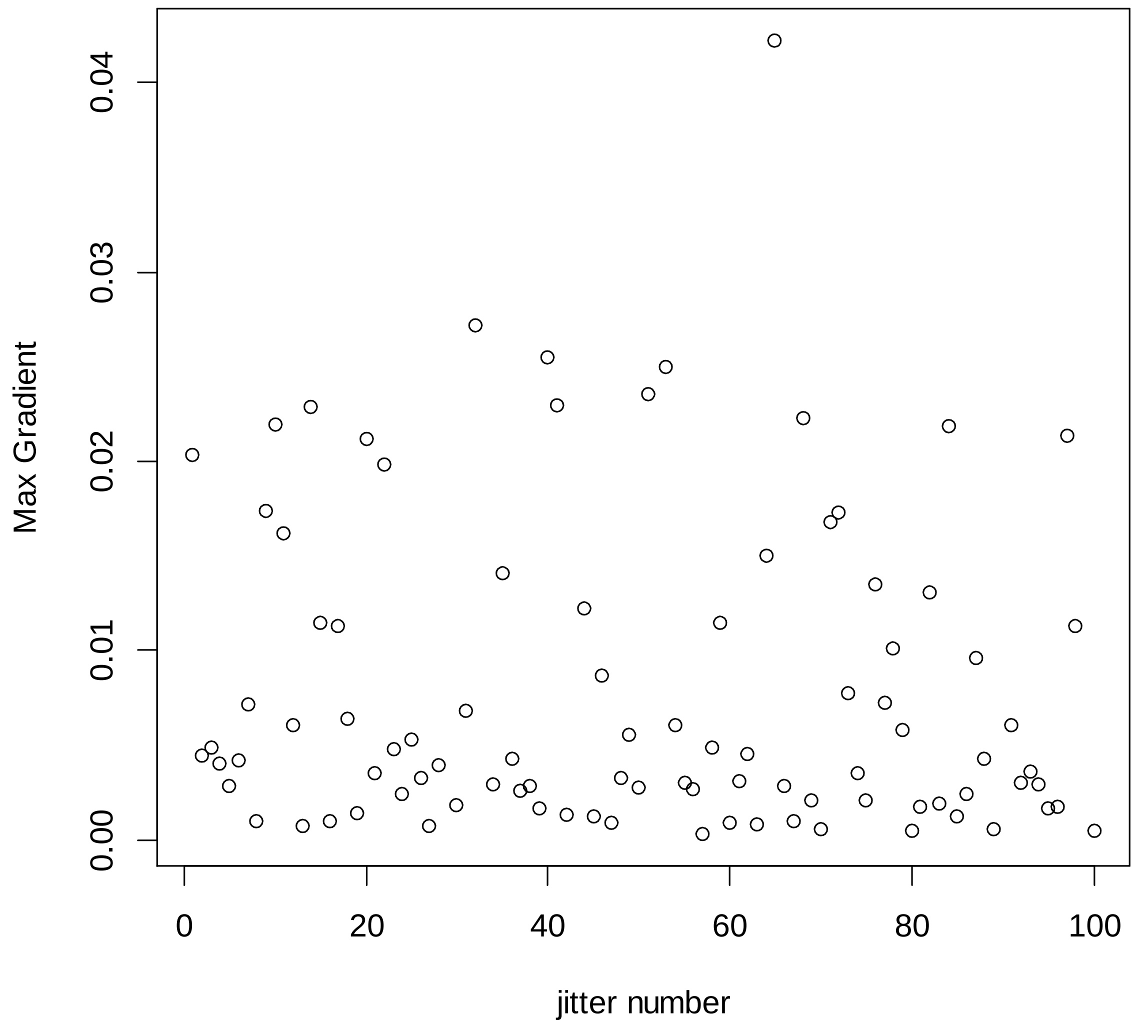


Figure 74. Model 4c. Maximum gradient by jitter run.

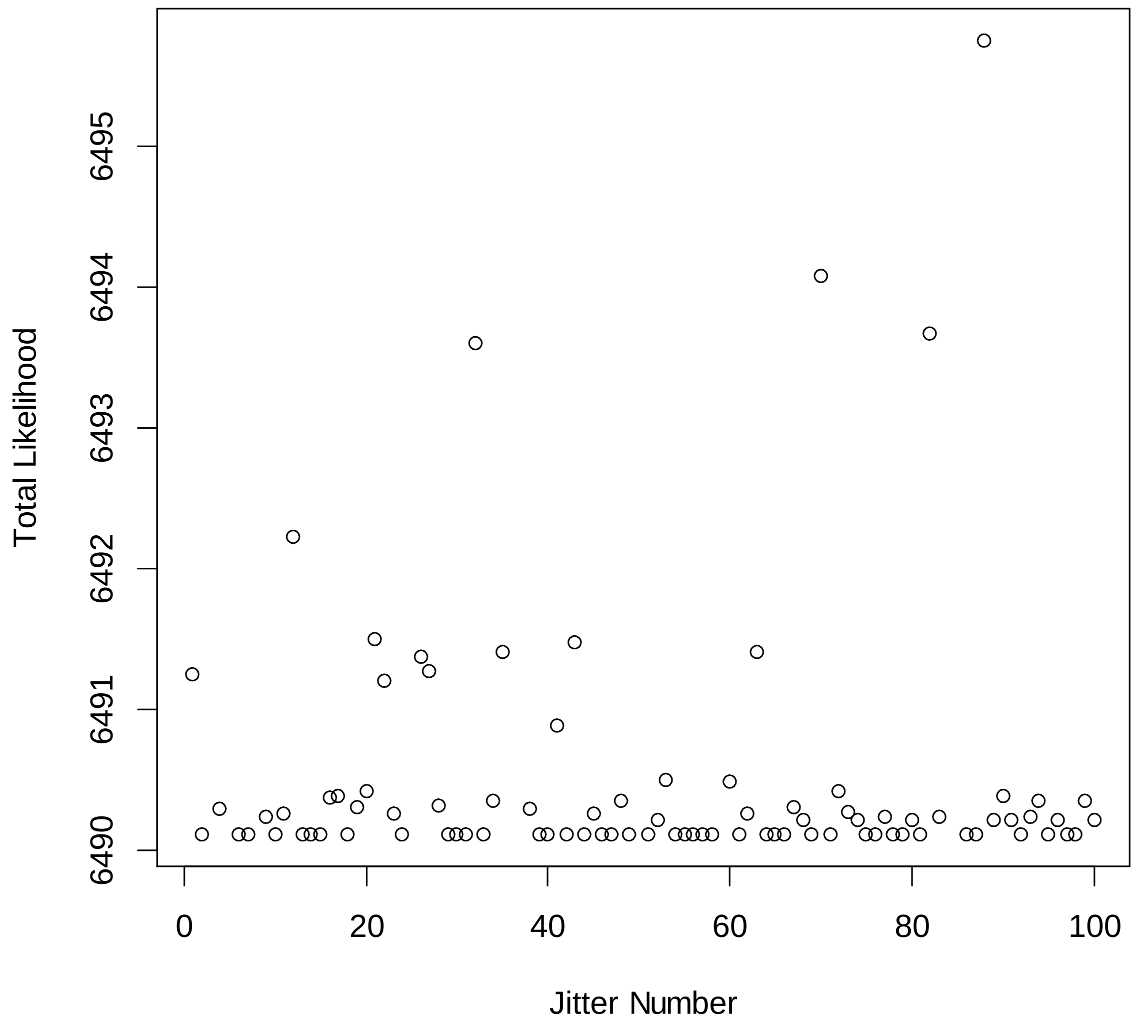


Figure 75. Model 8. Wt=2 (sd=0.5) on growth like. 43 runs with lowest likelihood of 6490.11.

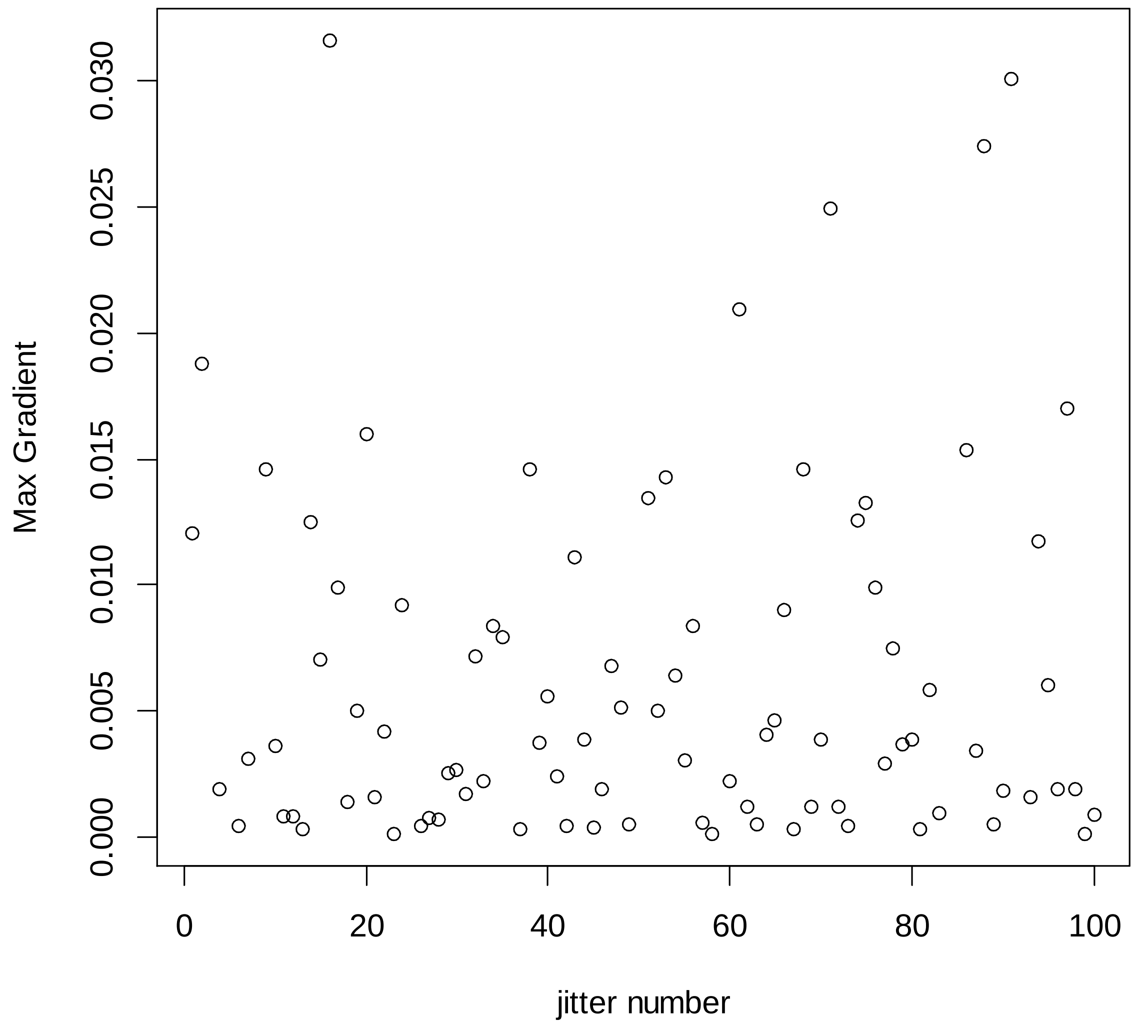


Figure 76. Model 8. Maximum gradient by jitter run. Wt=2 (sd=0.5) on growth like. 43 runs with lowest likelihood of 6490.11.

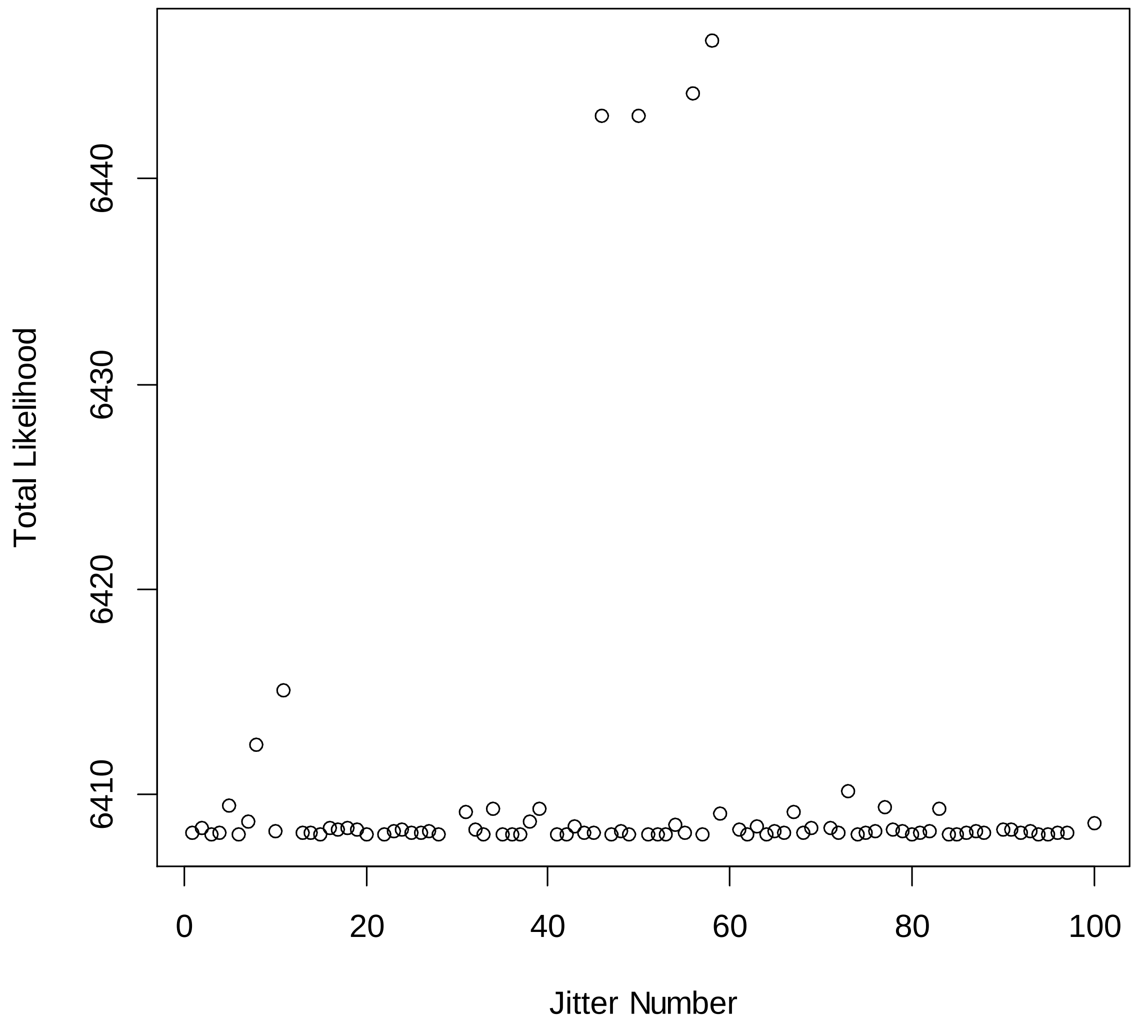


Figure 77. Model 8a. wt = 1 on growth like (sd=0.7). 24 runs with lowest likelihood of 6408.04.

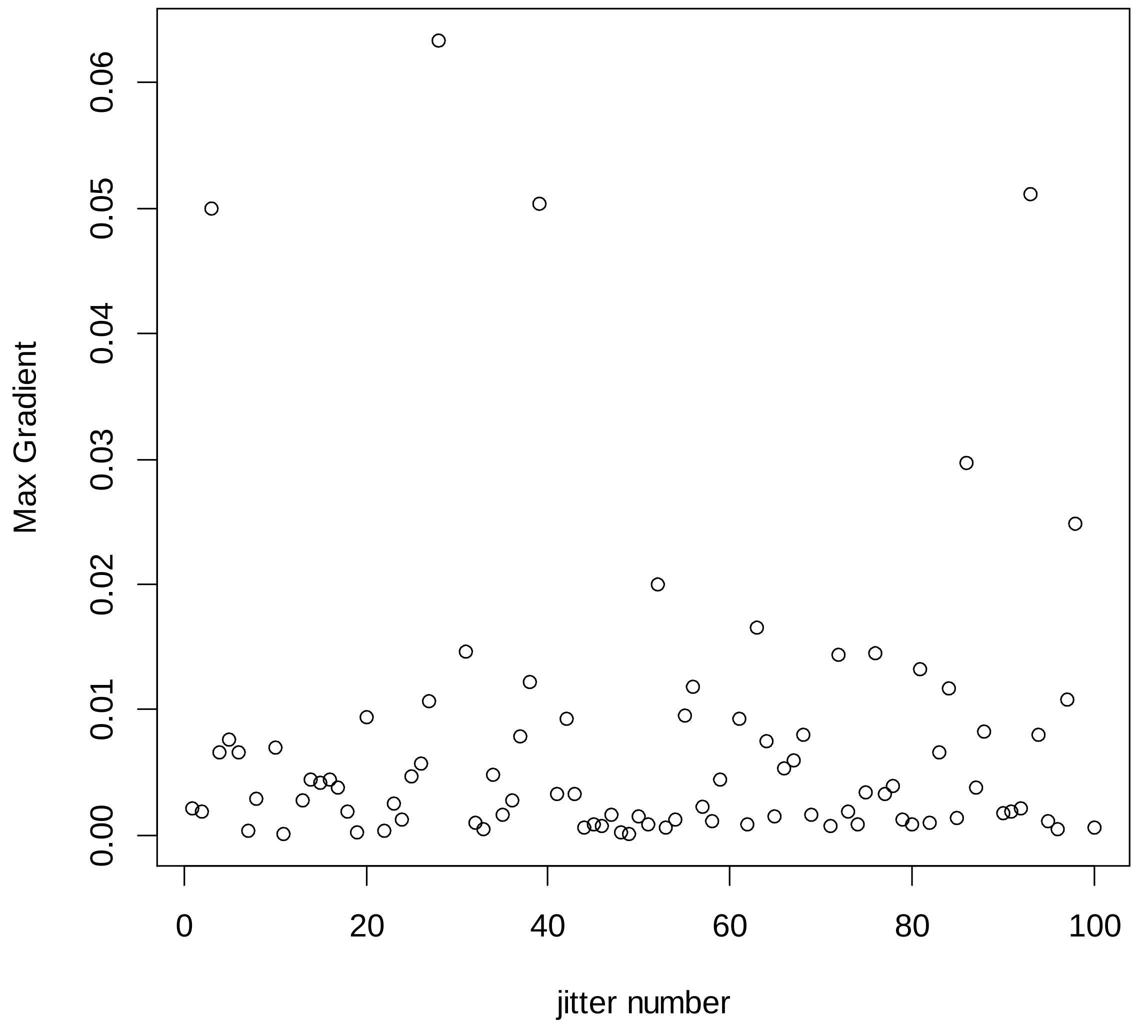


Figure 78. Model 8a. wt = 1 on growth like (sd=0.7). 24 runs with lowest likelihood of 6408.04.

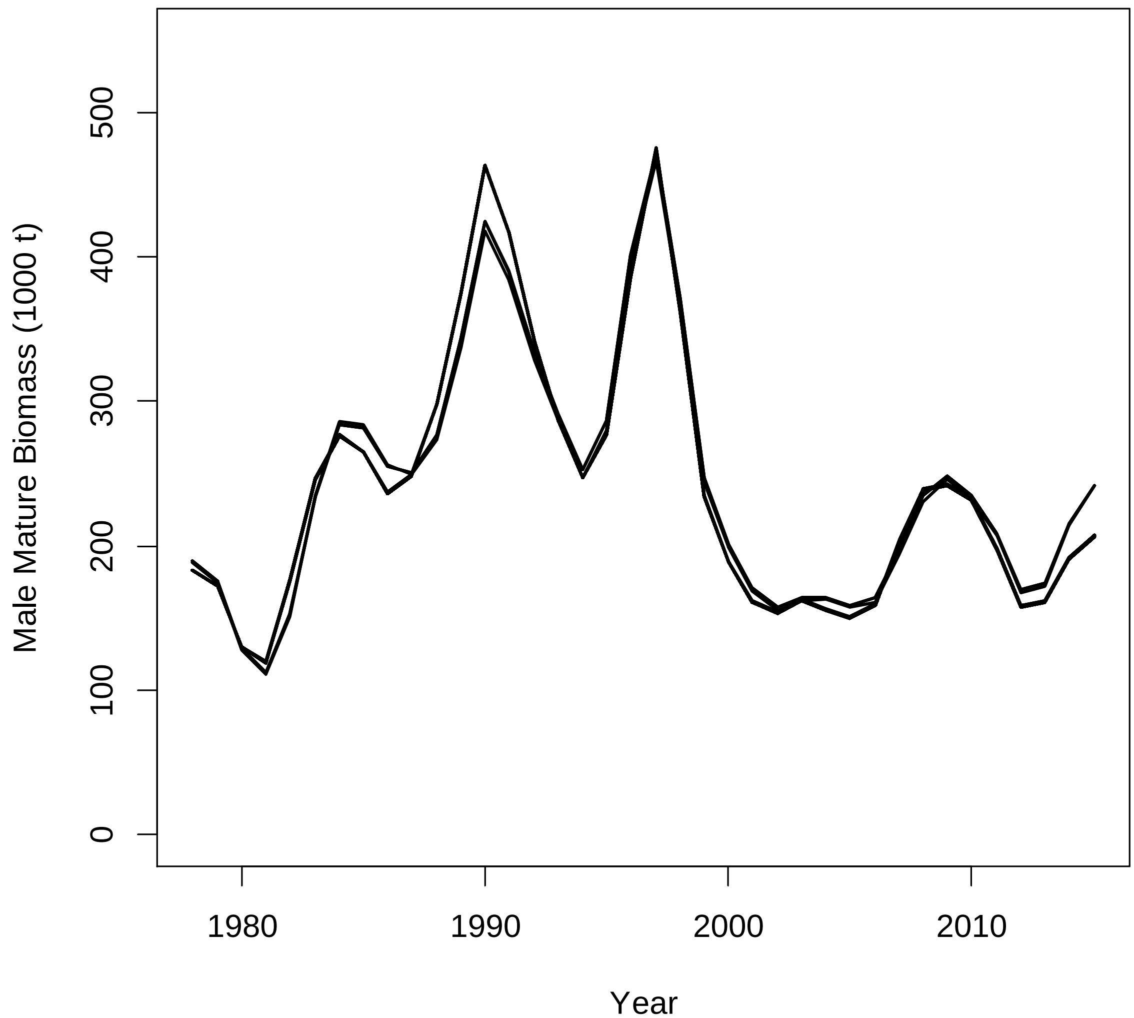


Figure 79. Model 8a. Male mature biomass for all jitter runs that wrote the std file (85 runs). Three runs with likelihoods from 6443 to 6446 had higher ending biomass than others. Rest of runs had likelihoods < 6416 and very similar ending biomass.

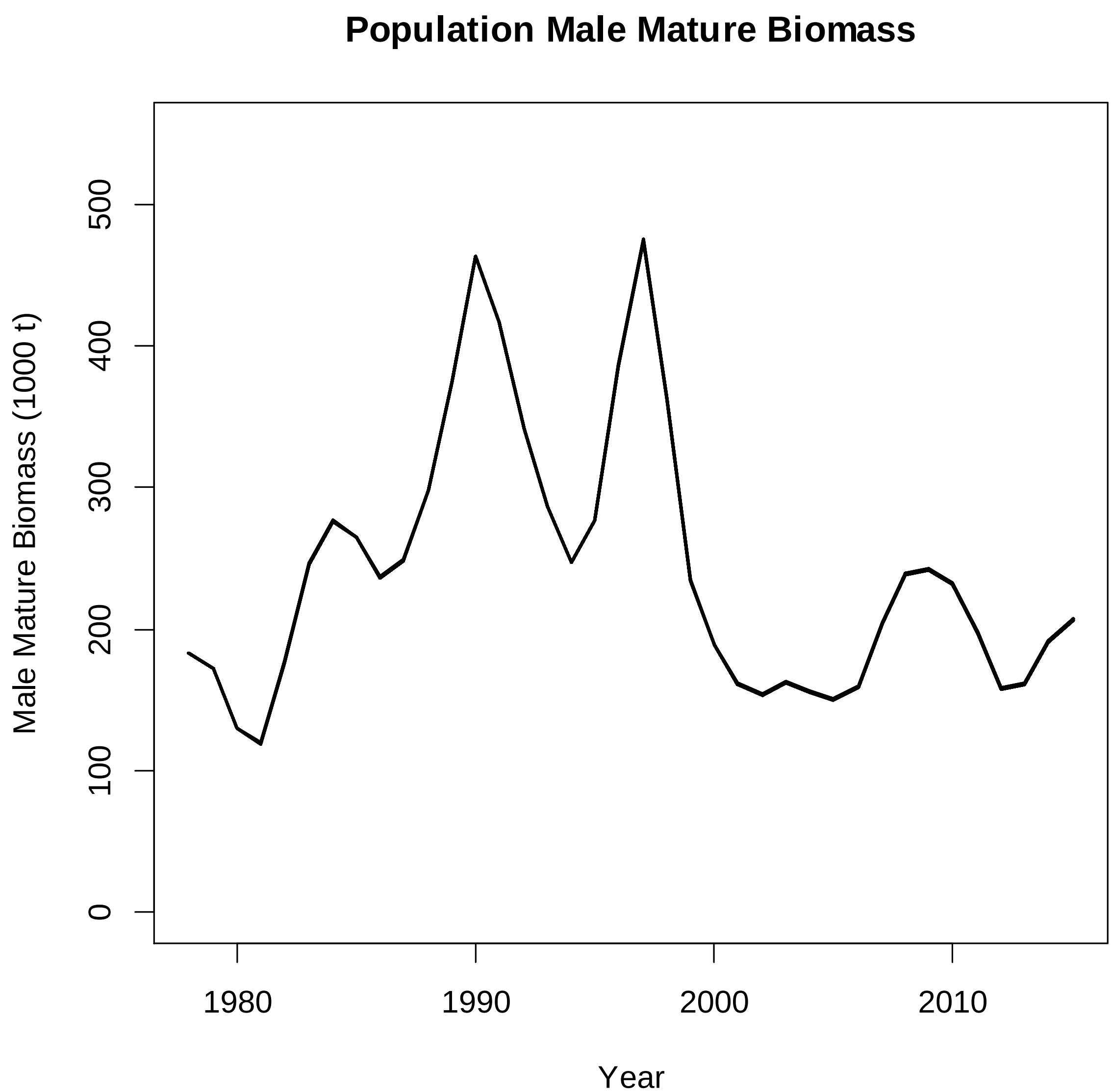


Figure 80. Model 8a. 85 jitter runs with likelihoods < 6416. Lowest likelihood was 6408.04 (24 runs).

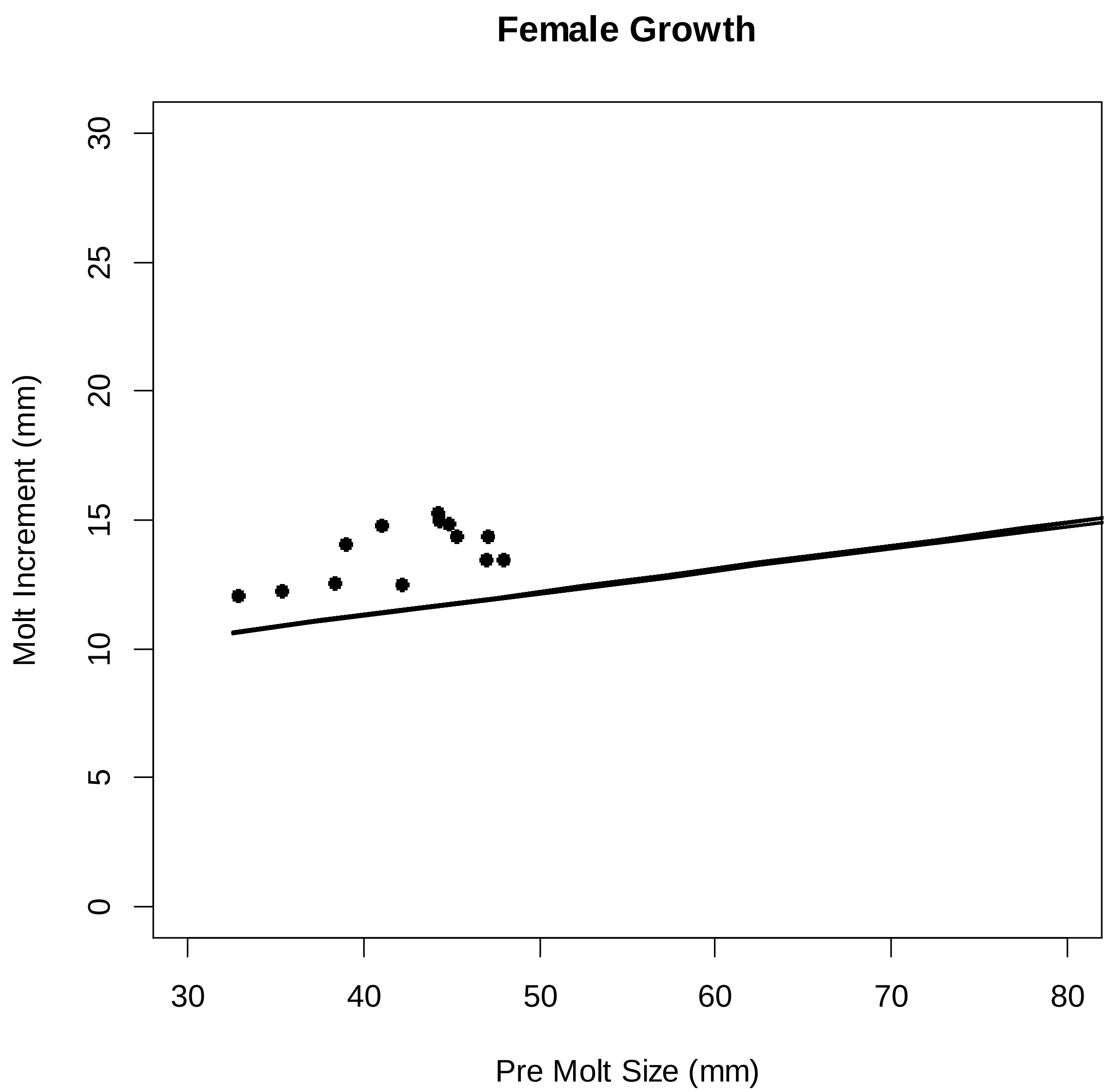


Figure 81. Model 8a female linear growth. 30mm to 80mm premolt size (mm).

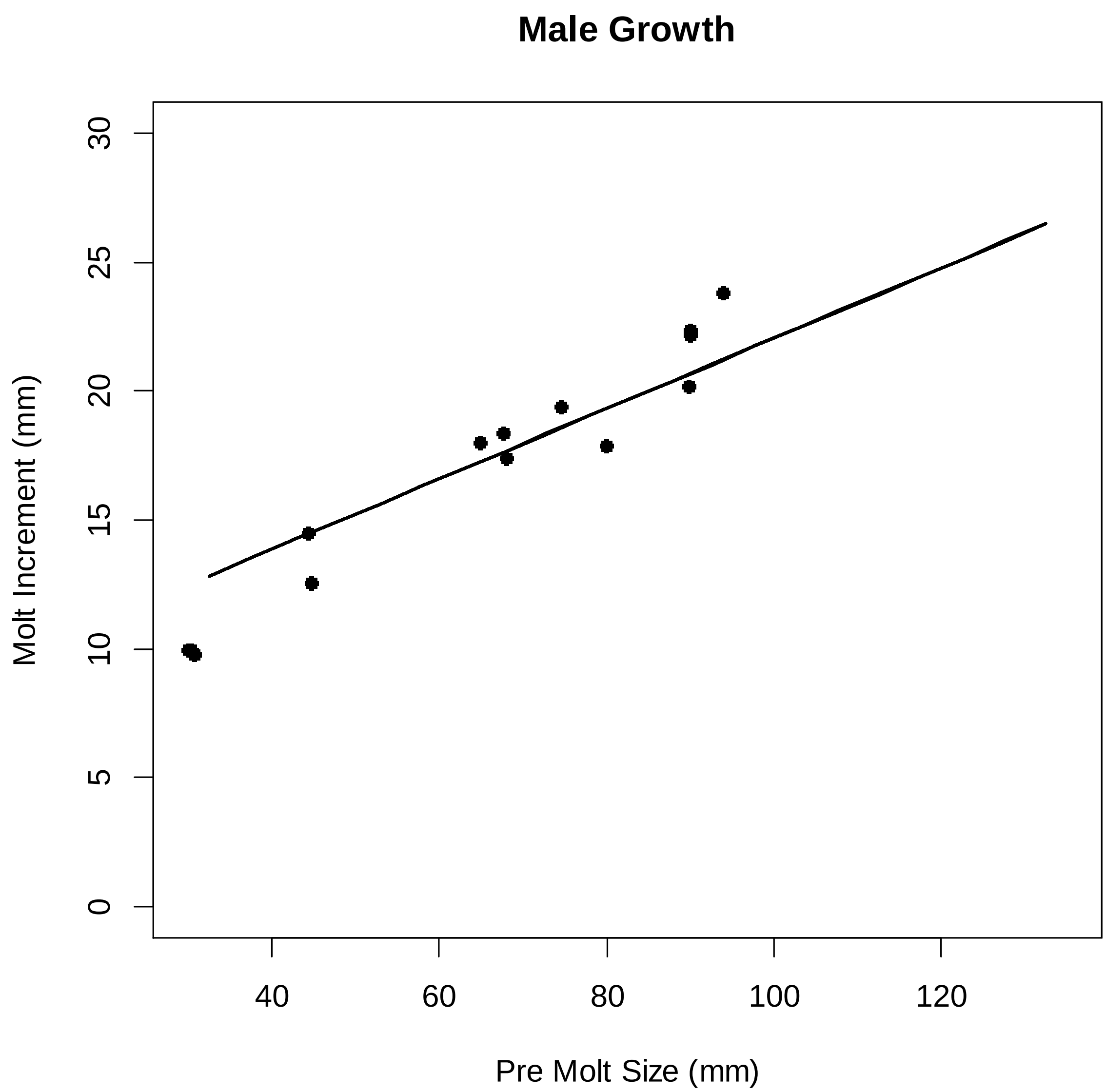


Figure 82. Model 8a male linear growth 30mm to 130mm premolt size (mm). Runs with likelihoods > 6440 not included (5 runs). Runs included likelihoods from 6408.04 to 6415.07 (85 runs).

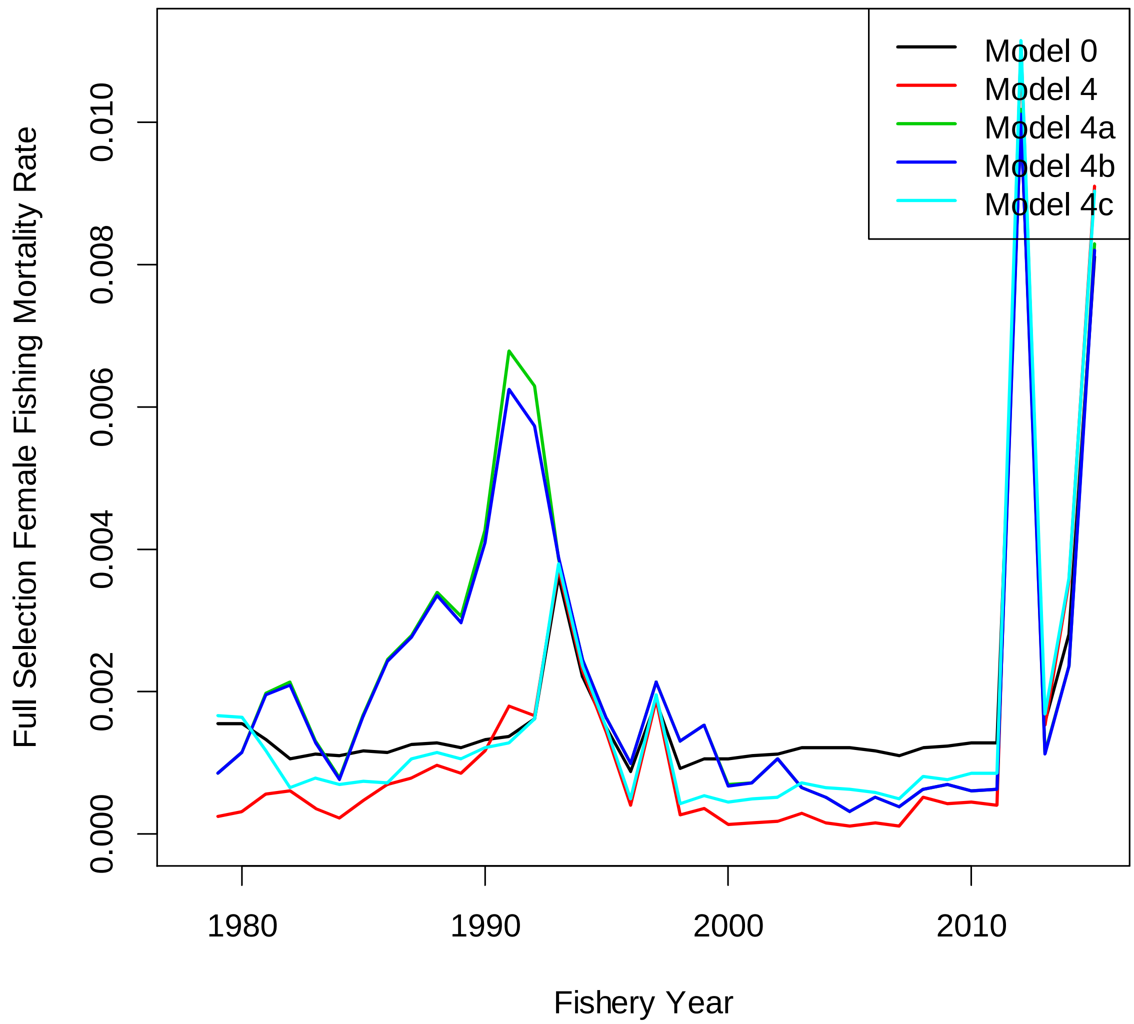


Figure 82. Female fishing mortality estimates in the directed fishery for Models 0, 4, 4a, 4b and 4c.

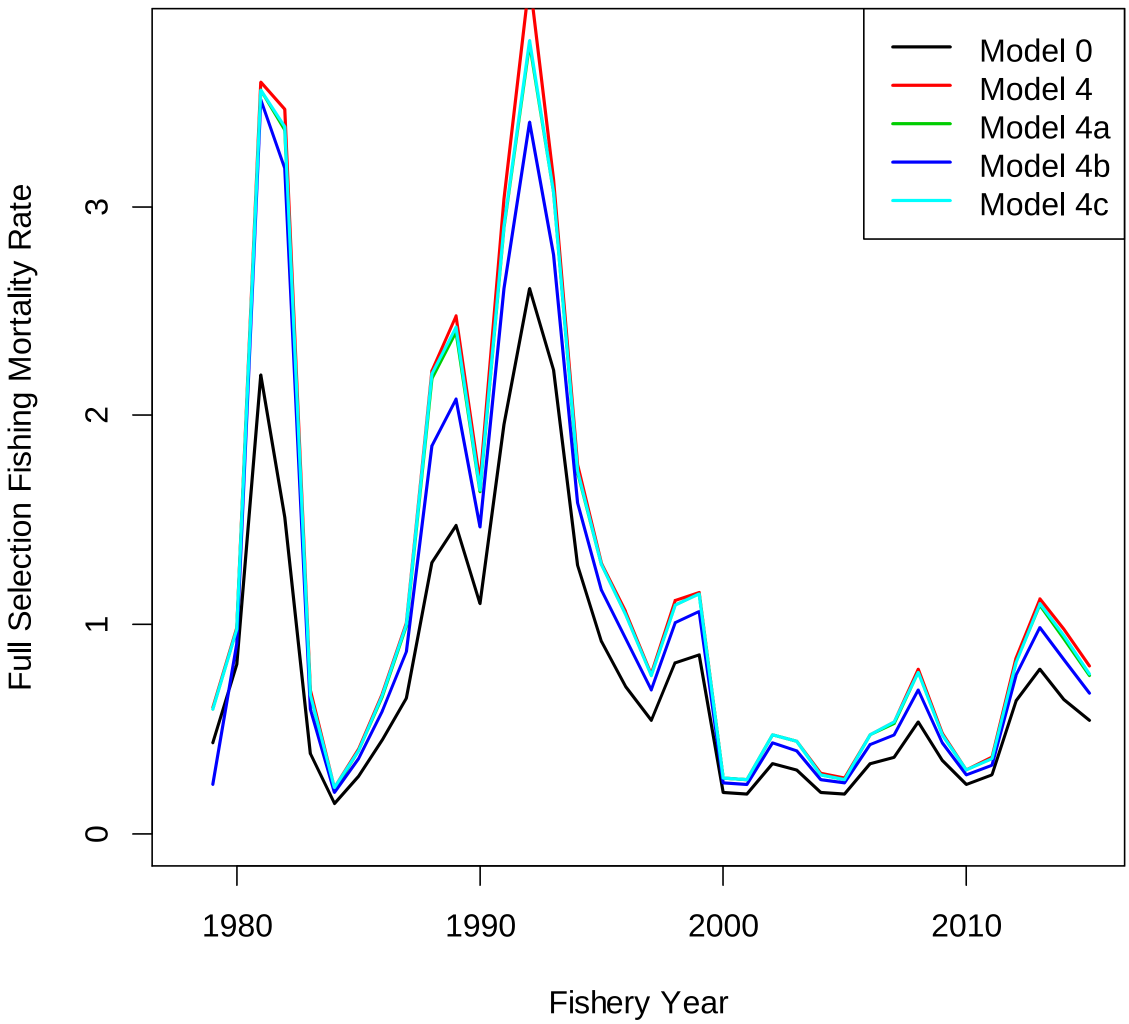


Figure 83. Male fishing mortality estimates in the directed fishery for Models 0, 4, 4a, 4b and 4c.

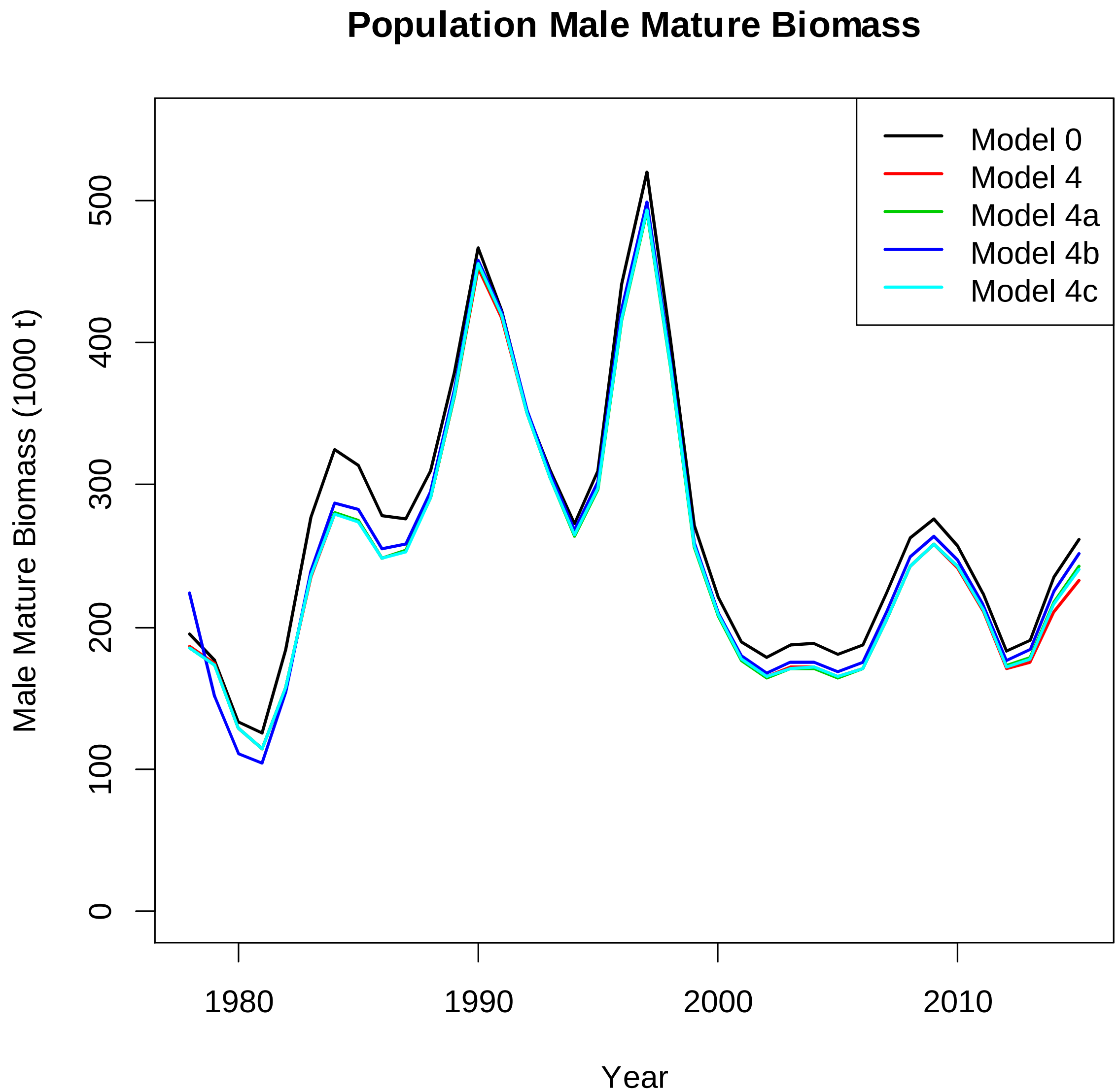


Figure 84. Population male mature biomass for models 0, 4, 4a, 4b and 4c. Ending biomass for models 4a and 4c are the same. Model 4 the lowest and Model 0 the highest.

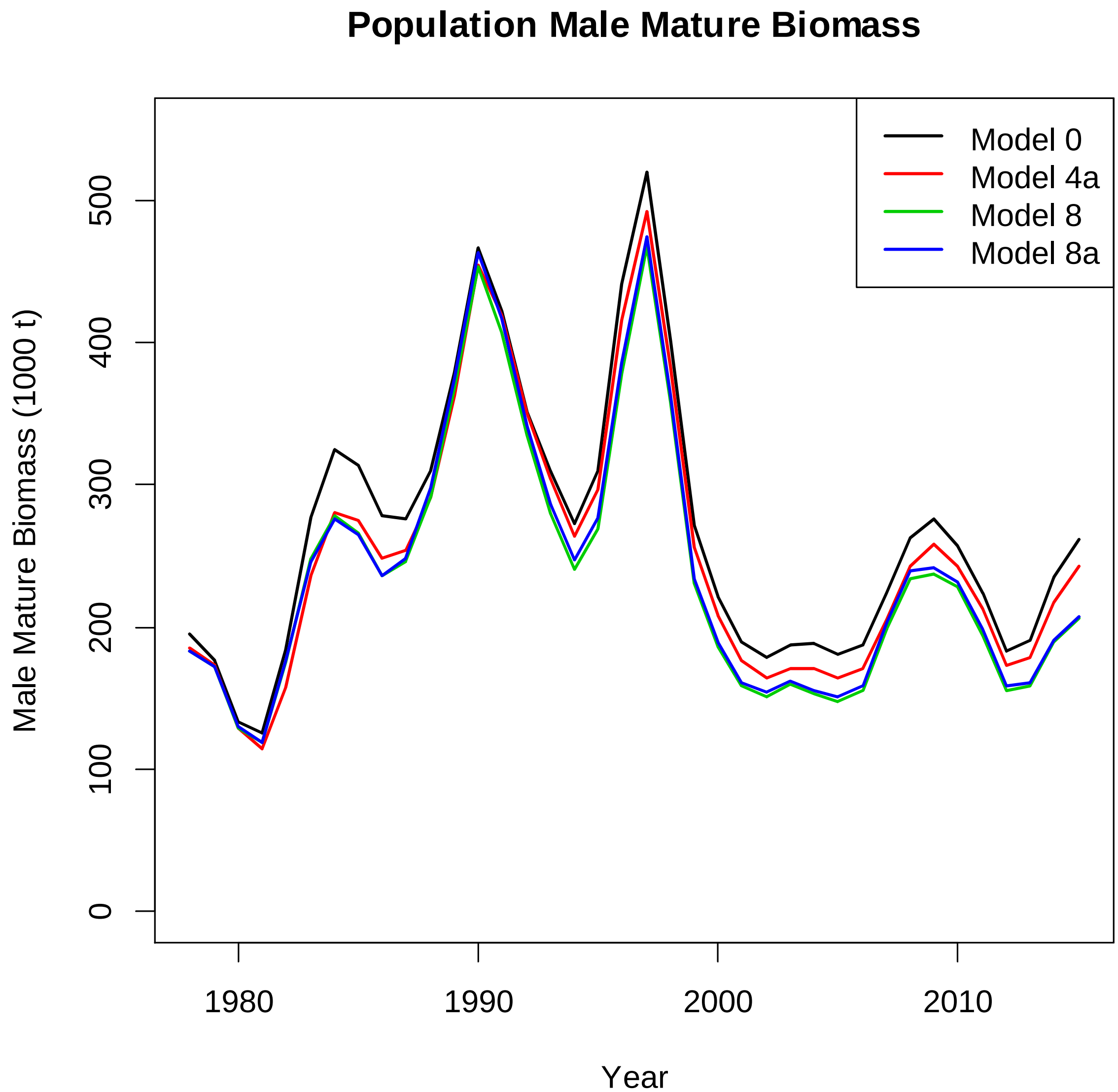


Figure 85. Population male mature biomass for models 0, 4a, 8 and 8a.

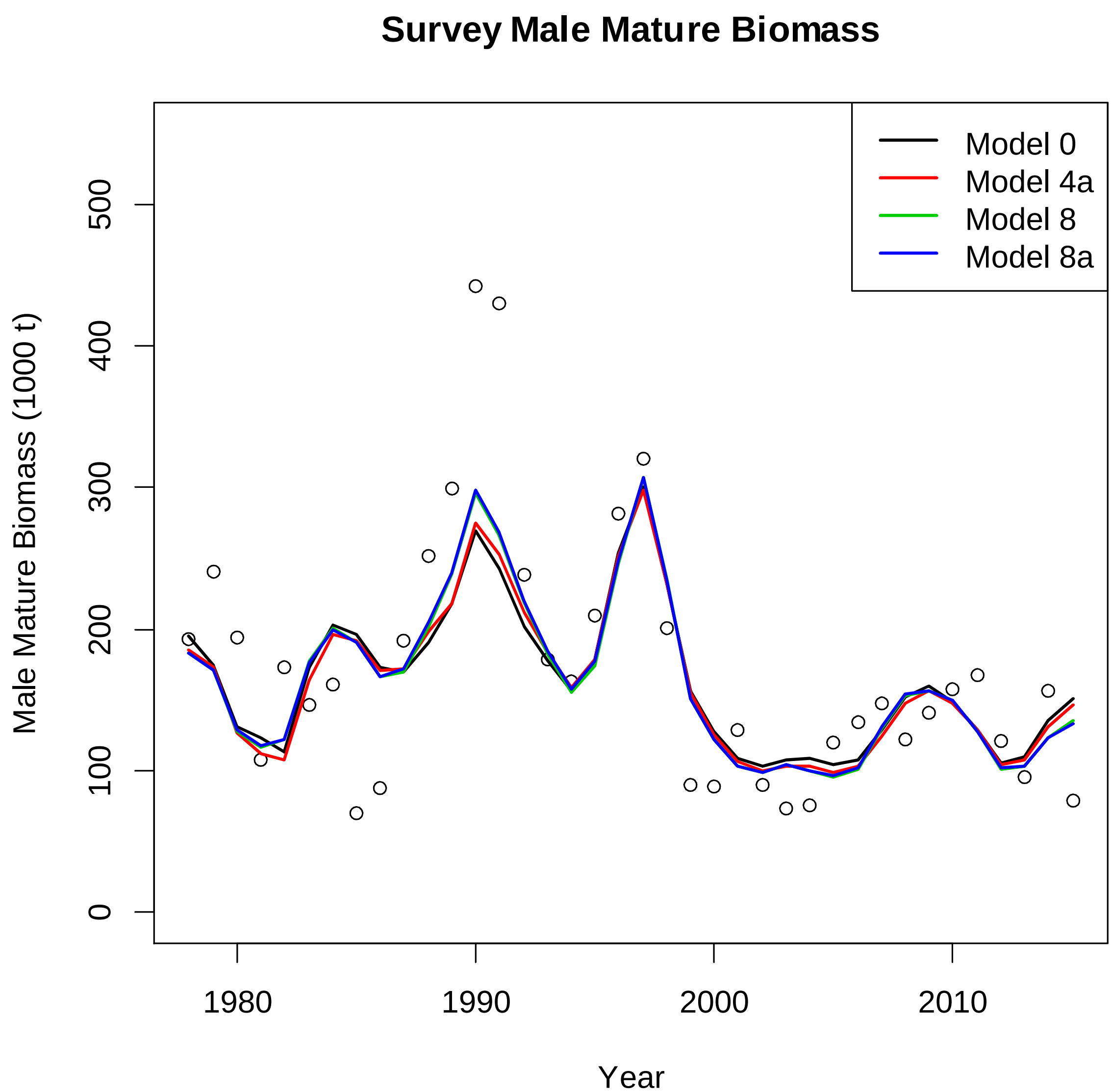


Figure 86. Survey male mature biomass fit for models 0, 4a, 8 and 8a.

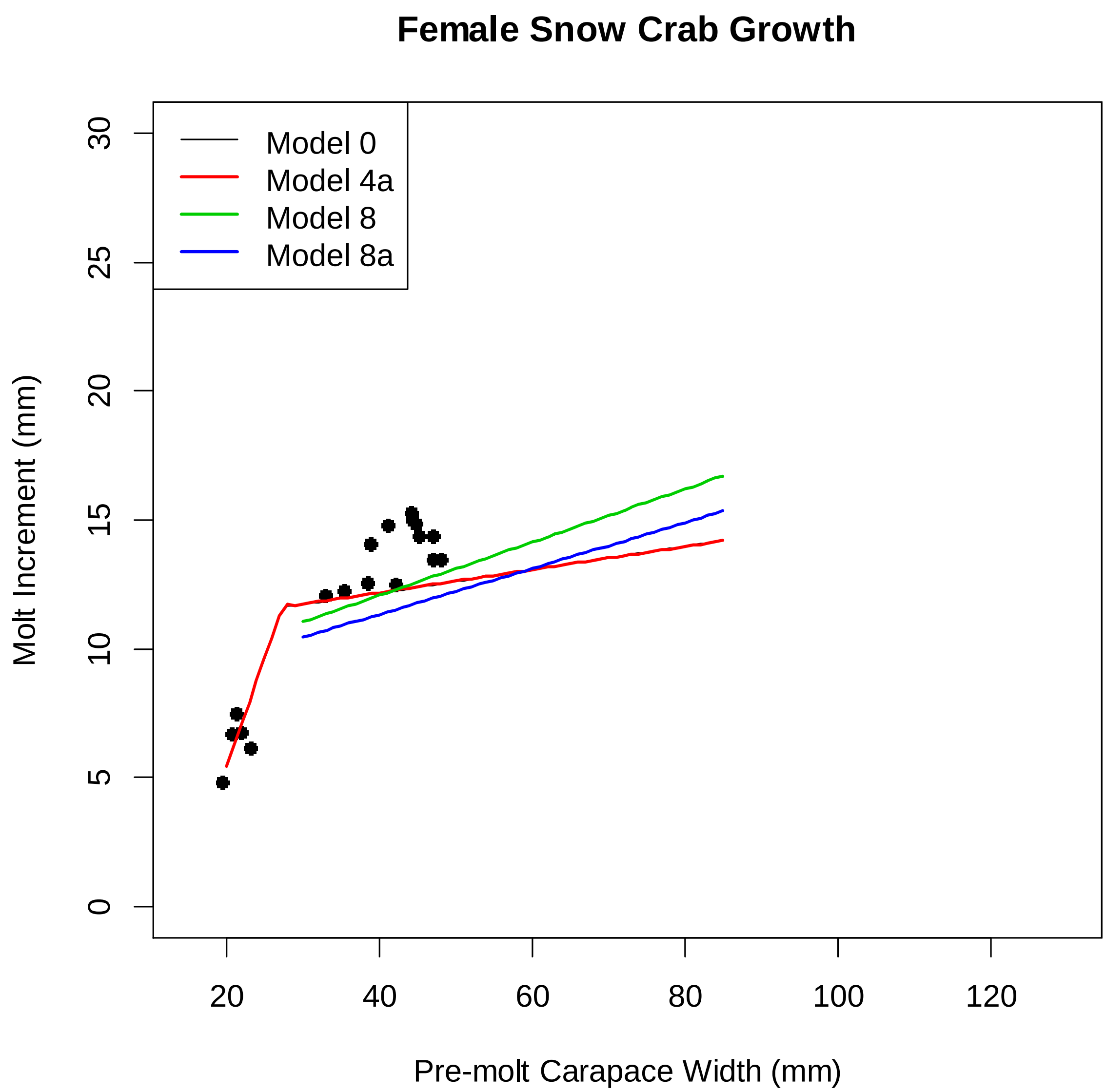


Figure 87. Female growth for models 0, 4a, 8 and 8a.

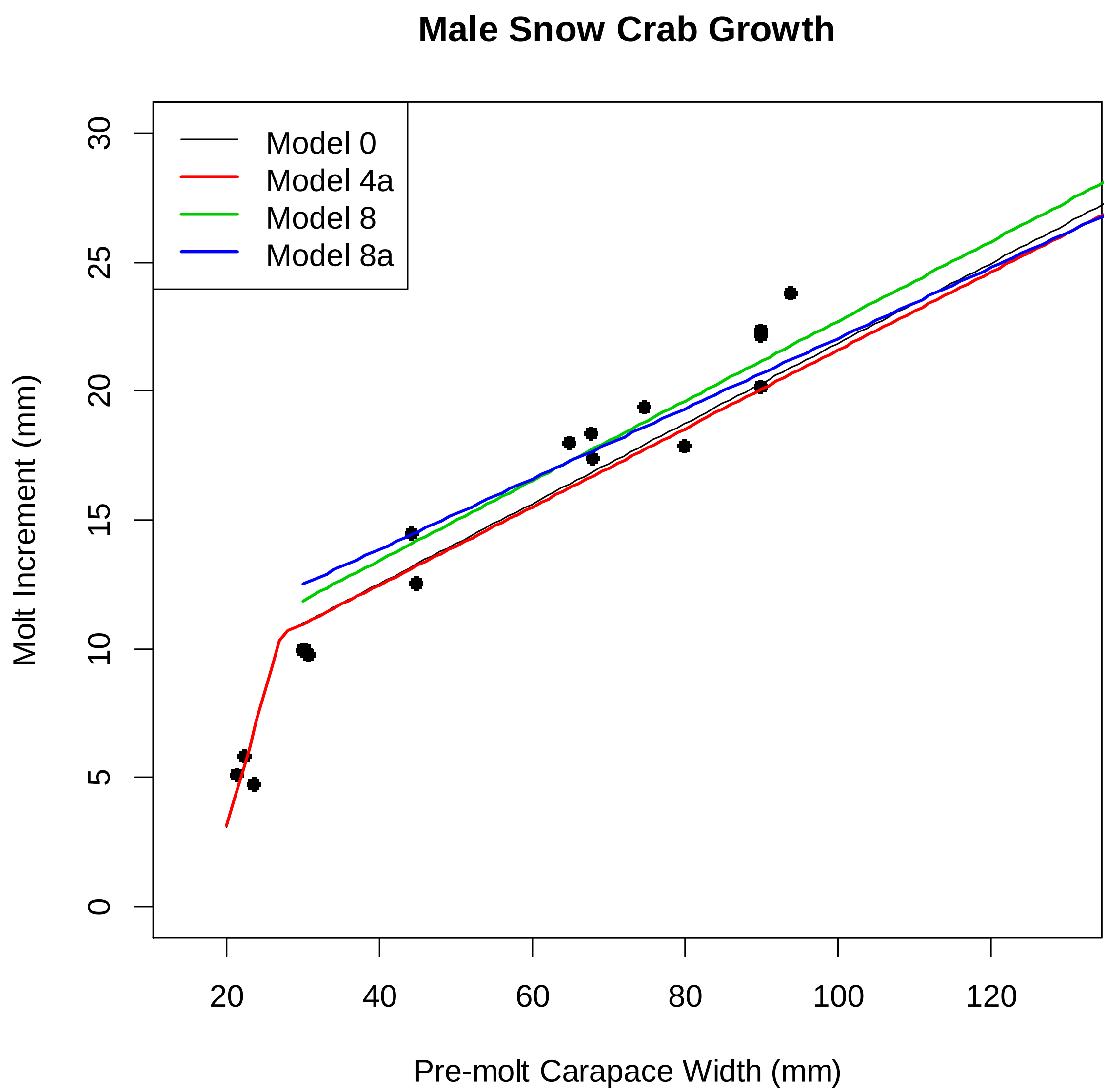


Figure 88. Male growth for models 0, 4a, 8 and 8a.

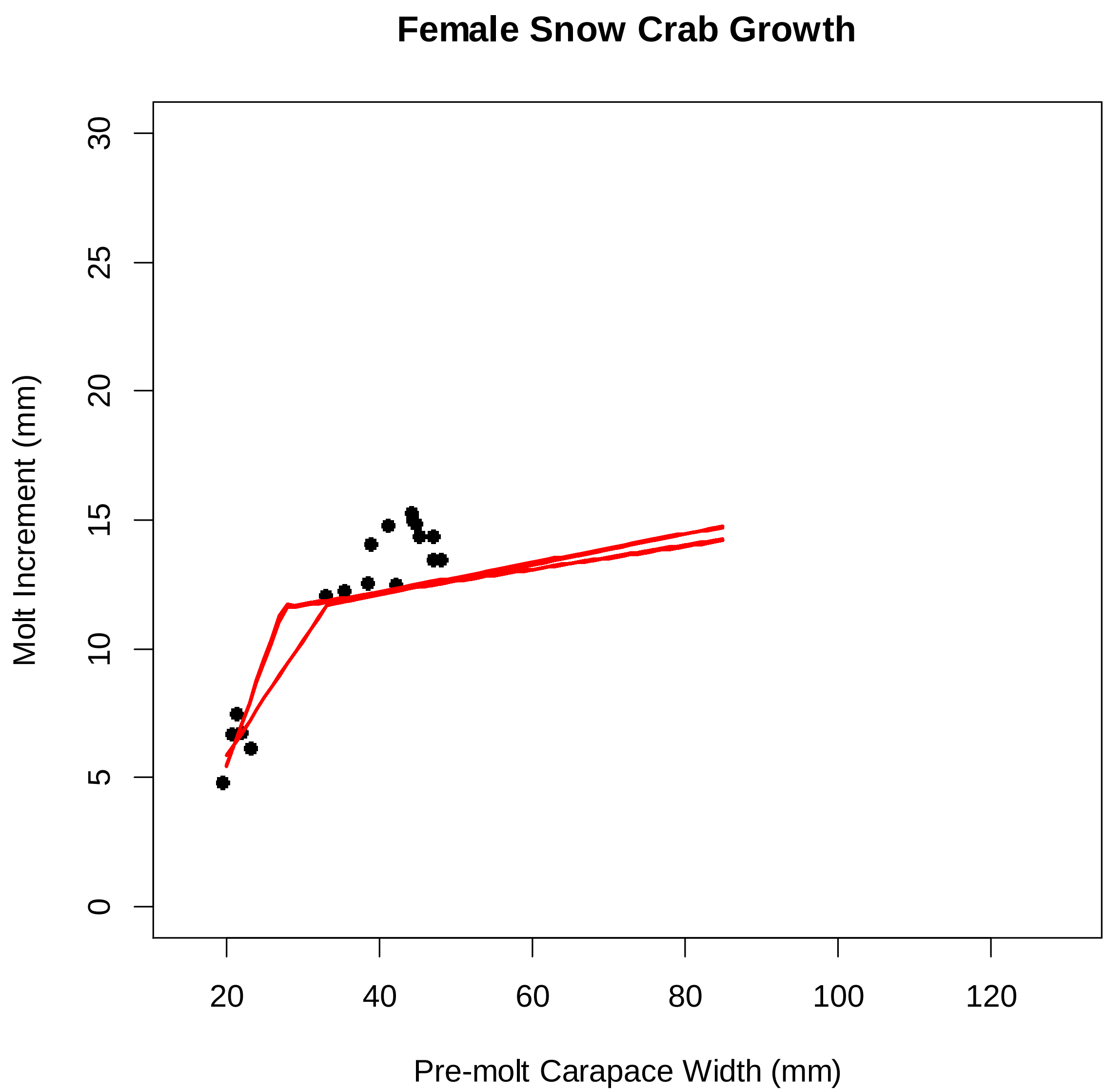


Figure 89. Model 4a all jitter runs female growth.

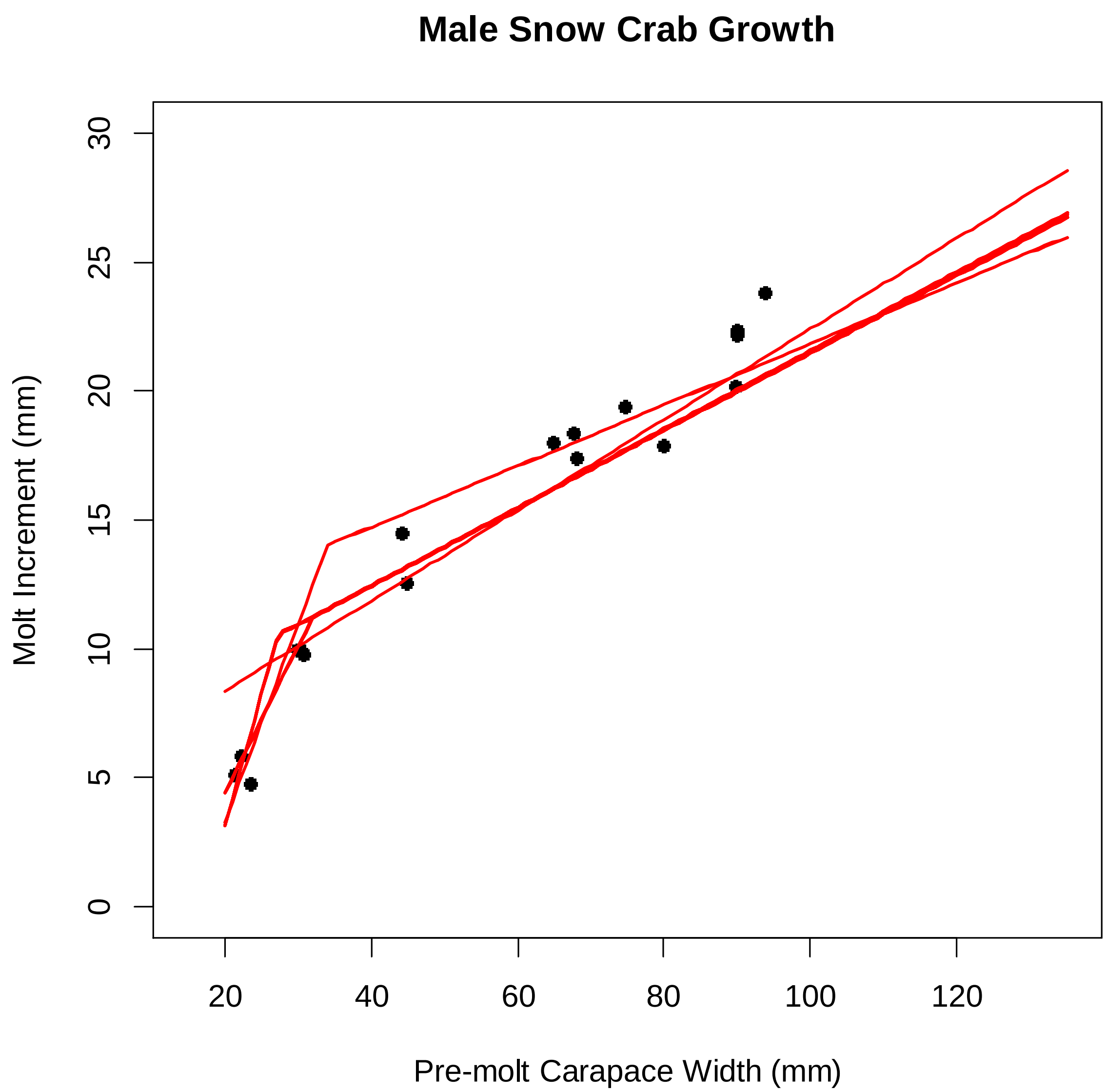


Figure 90. Model 4a all jitter runs male growth.

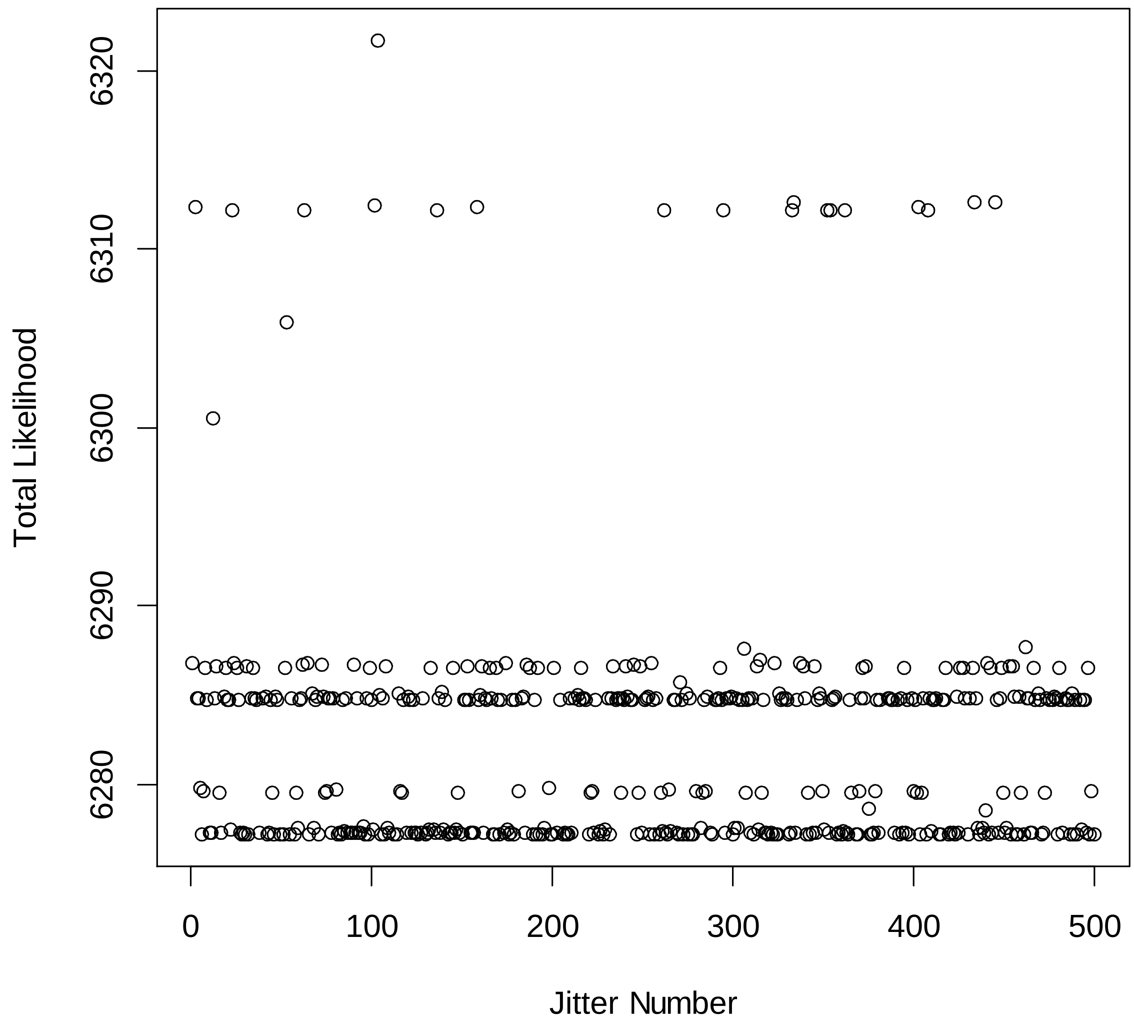


Figure 91. Model 4a. all 325 parameters jittered 500 runs (473 wrote std file). 91 runs had lowest likelihood of 6277.20 (same as model 4a with 100 jitter runs 35 parameters jittered). Four runs had likelihood greater than 12,000 and wrote the std file, not included here. Range of likelihoods were the same as for the 35 parameter jitter runs (6277.2 to 6321.72).

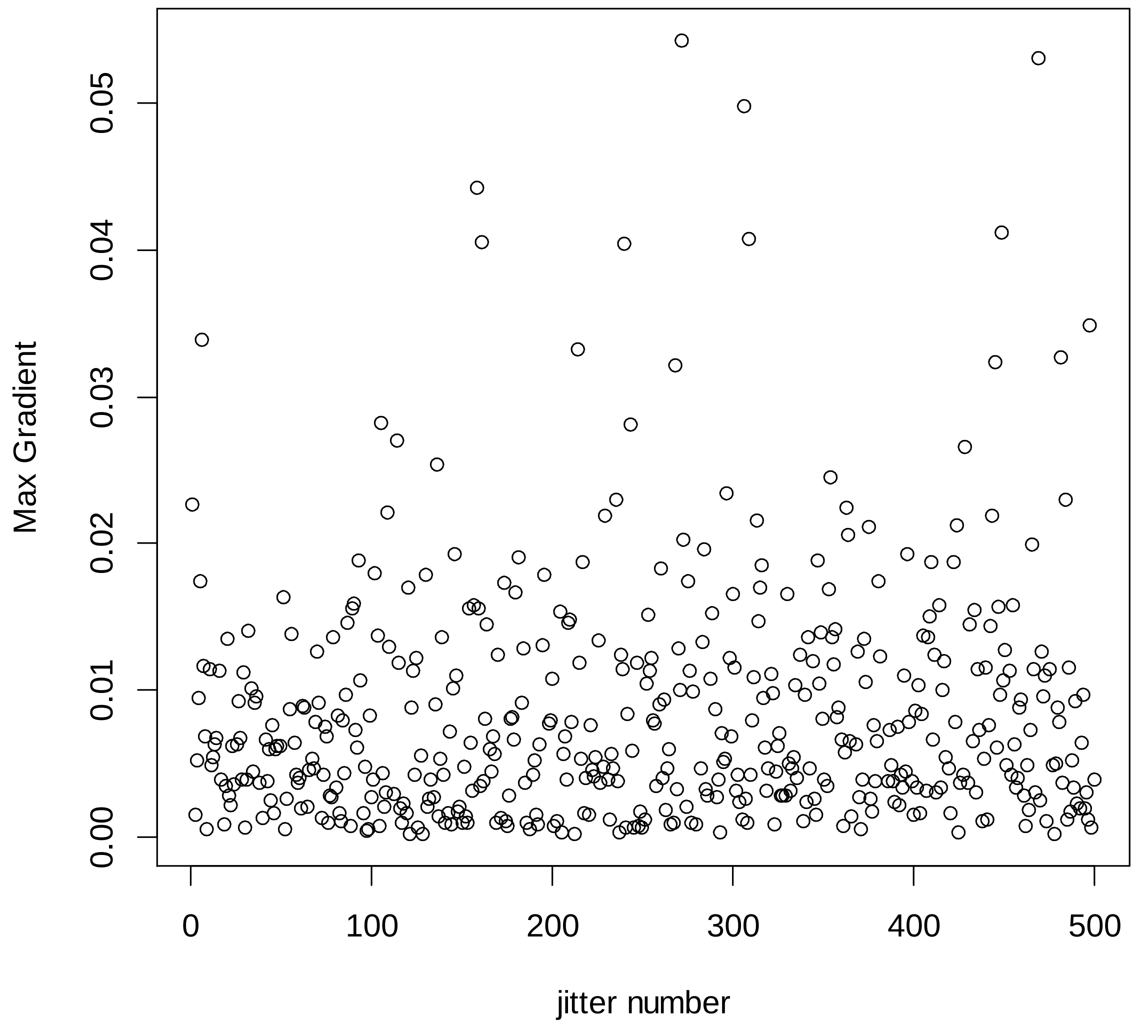


Figure 92. Model 4a. all 325 parameters jittered with 500 runs (473 wrote std file). 1 run of 473 had maximum gradient of 3.5, all others had maximum gradients less than 0.06. 43 runs had maximum gradient < 0.001, 5 runs had lowest likelihood and maximum gradient < 0.001.

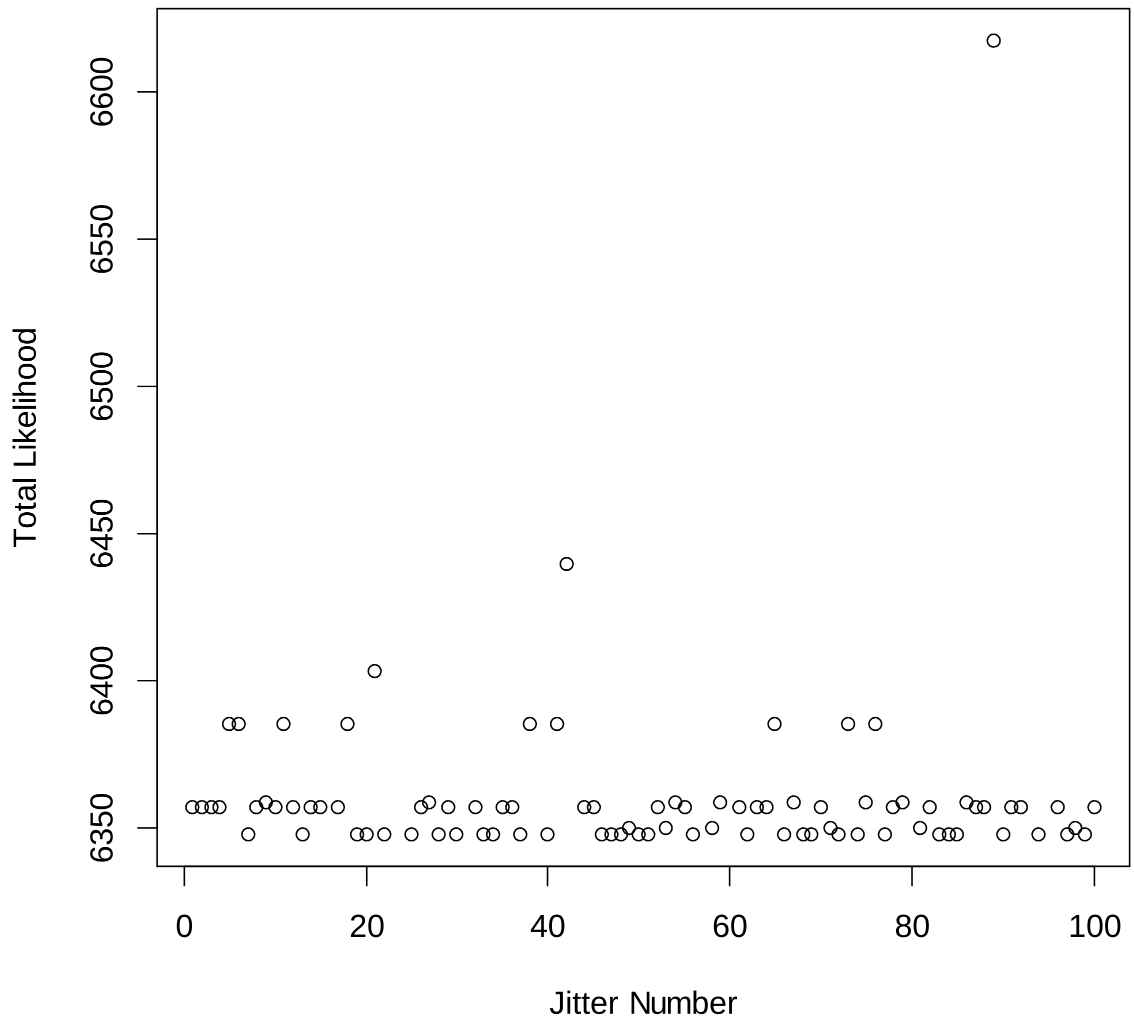


Figure 93. Model 0b. Lowest likelihood 6347.72. 89 runs of 100 wrote std file.

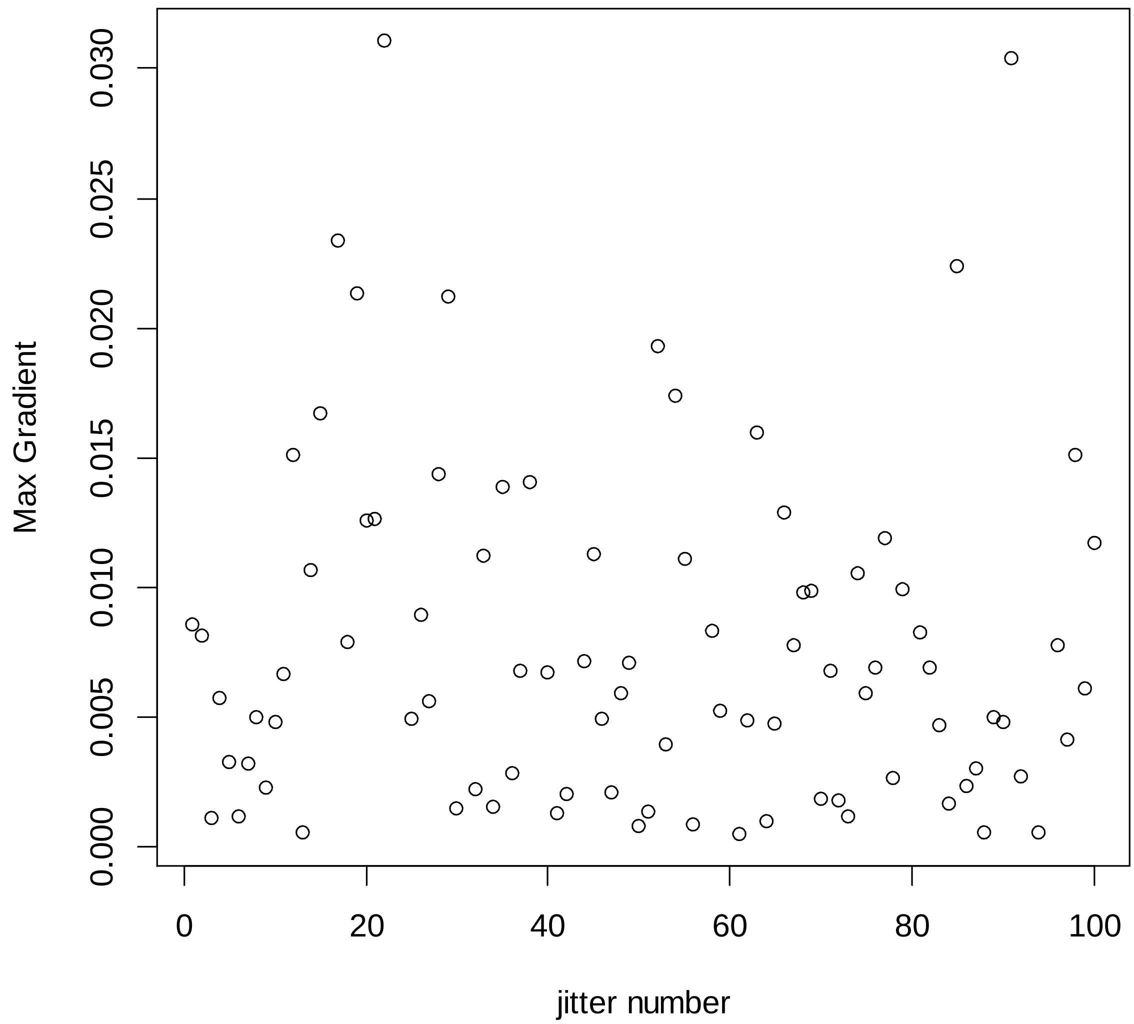


Figure 94. Model 0b. Lowest likelihood 6347.72. 89 runs of 100 wrote std file.

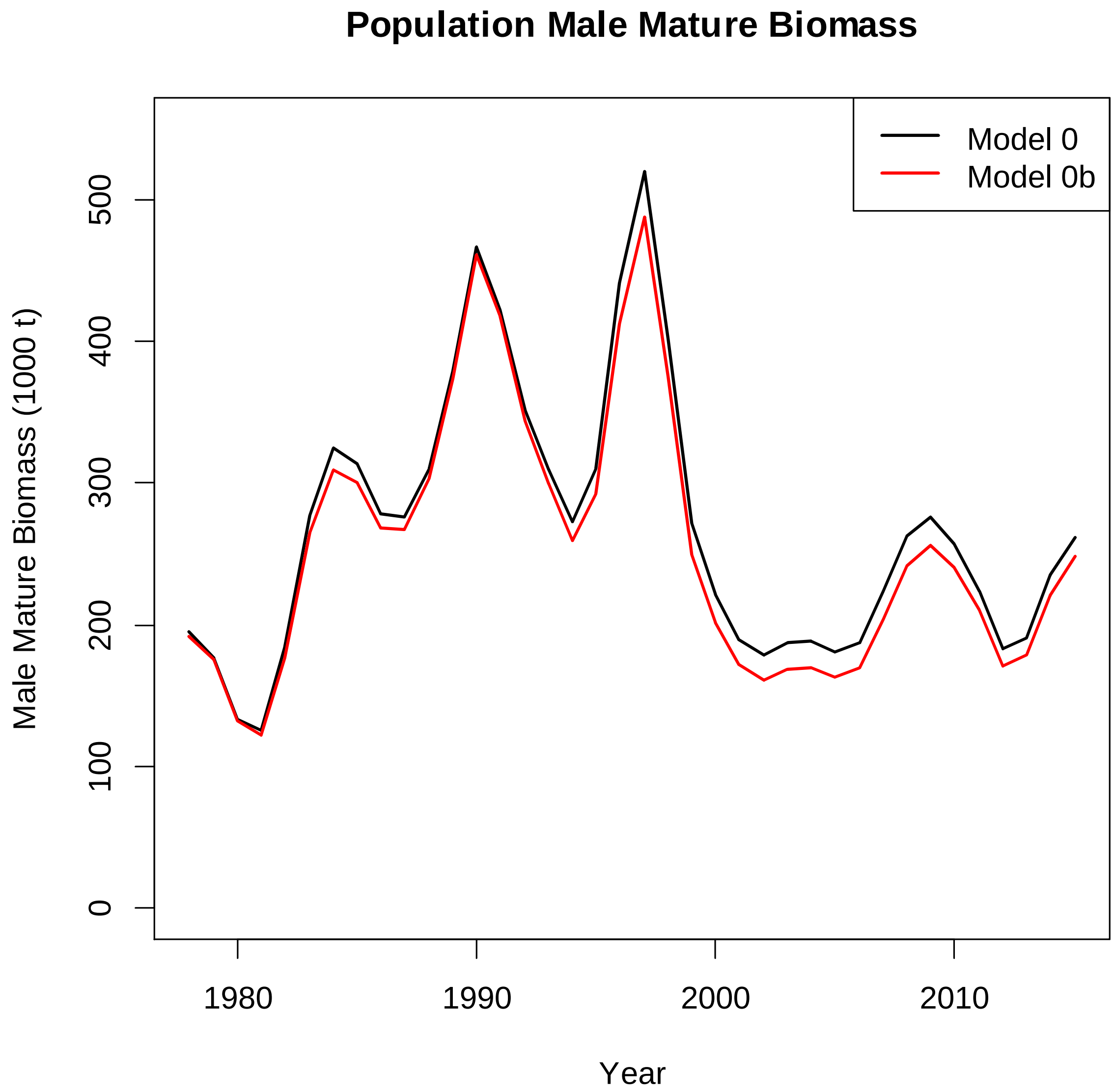


Figure 95. Model 0 and Model 0b population male mature biomass. Ending biomass Model 0 is 262,127 t, Model 0b is 248,355 t (about 5% lower) due to higher estimate of survey q for Model 0b (0.616) vs Model 0 ( 0.581).

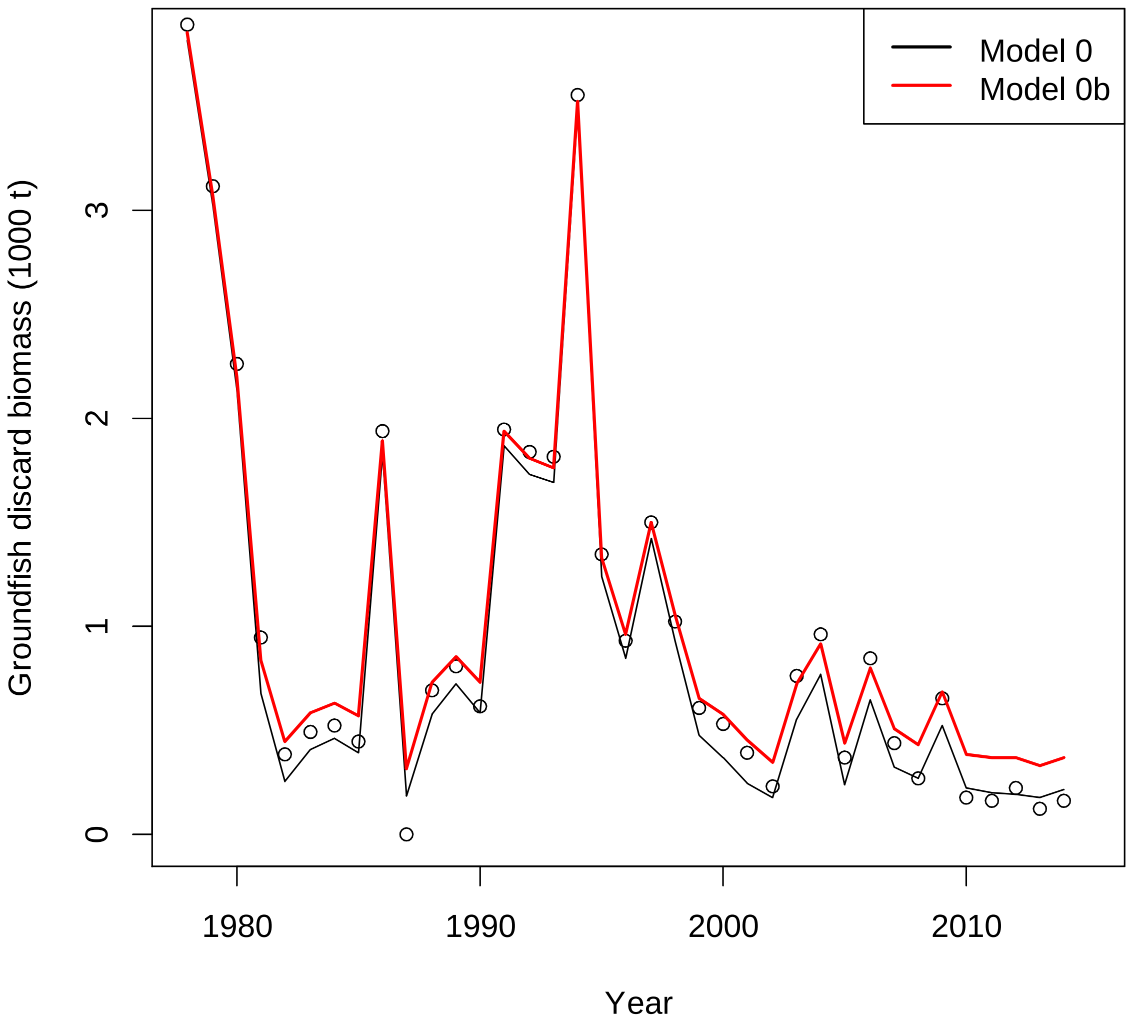


Figure 96. Model 0 and Model 0b estimated grounfish discard catch.

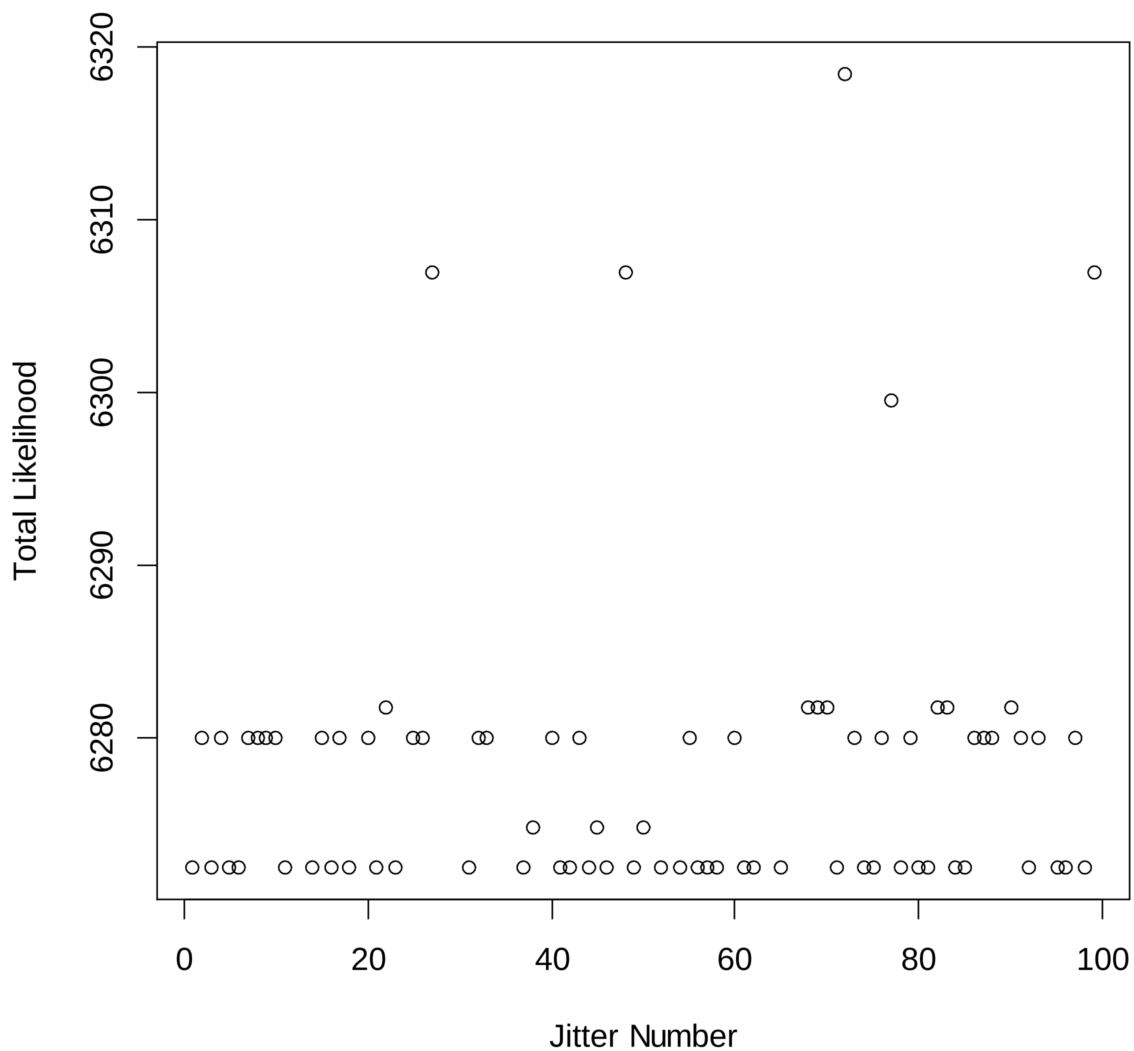


Figure 97. Model 9. Lowest likelihood was 6272.52 (37 runs).

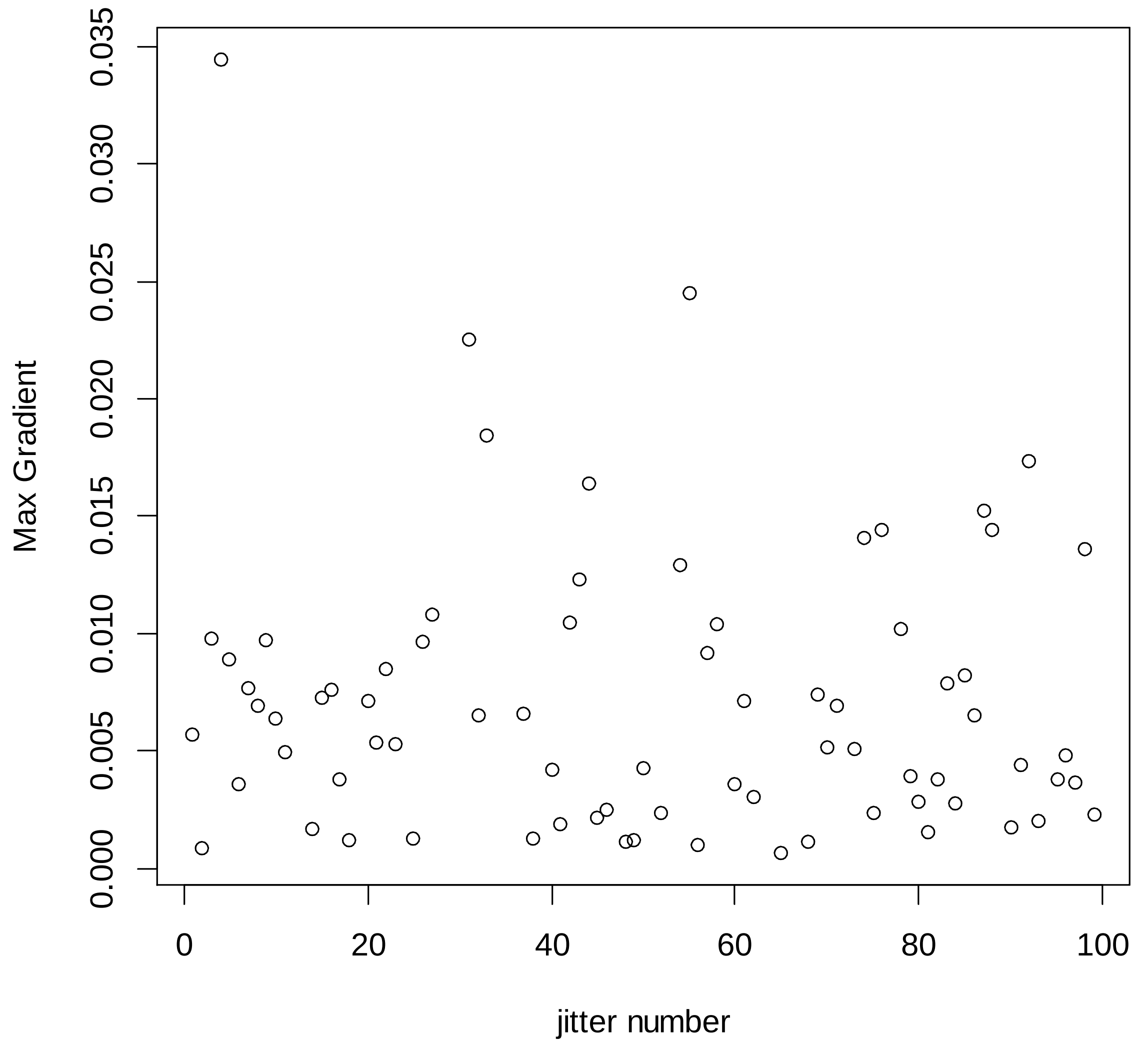


Figure 98. Model 9. Lowest likelihood was 6272.52 (37 runs).

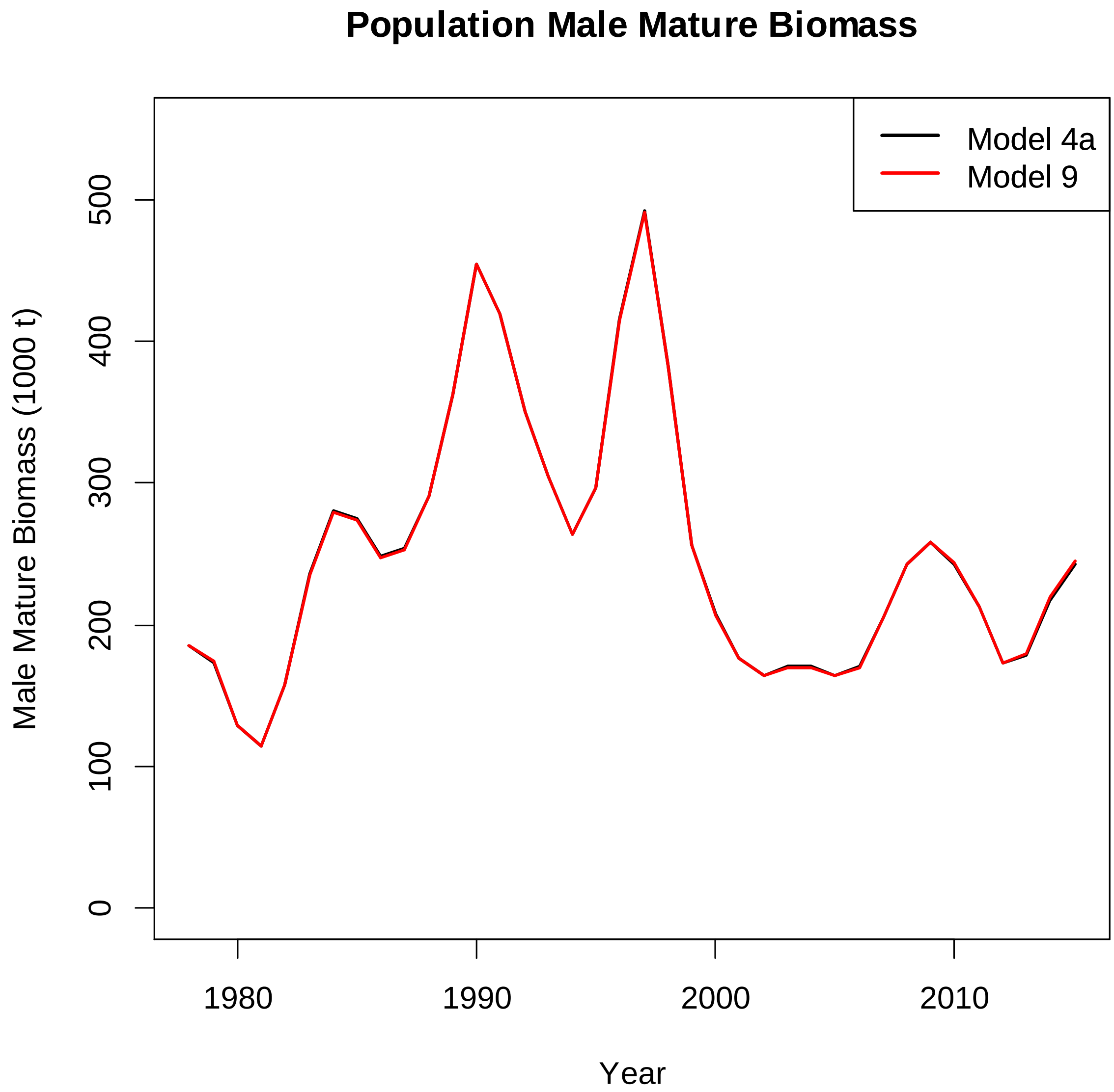


Figure 99. Model 4a and Model 9 population male mature biomass. Ending biomass for Model 4a was 242,895 t and for Model 9 245,232 t.

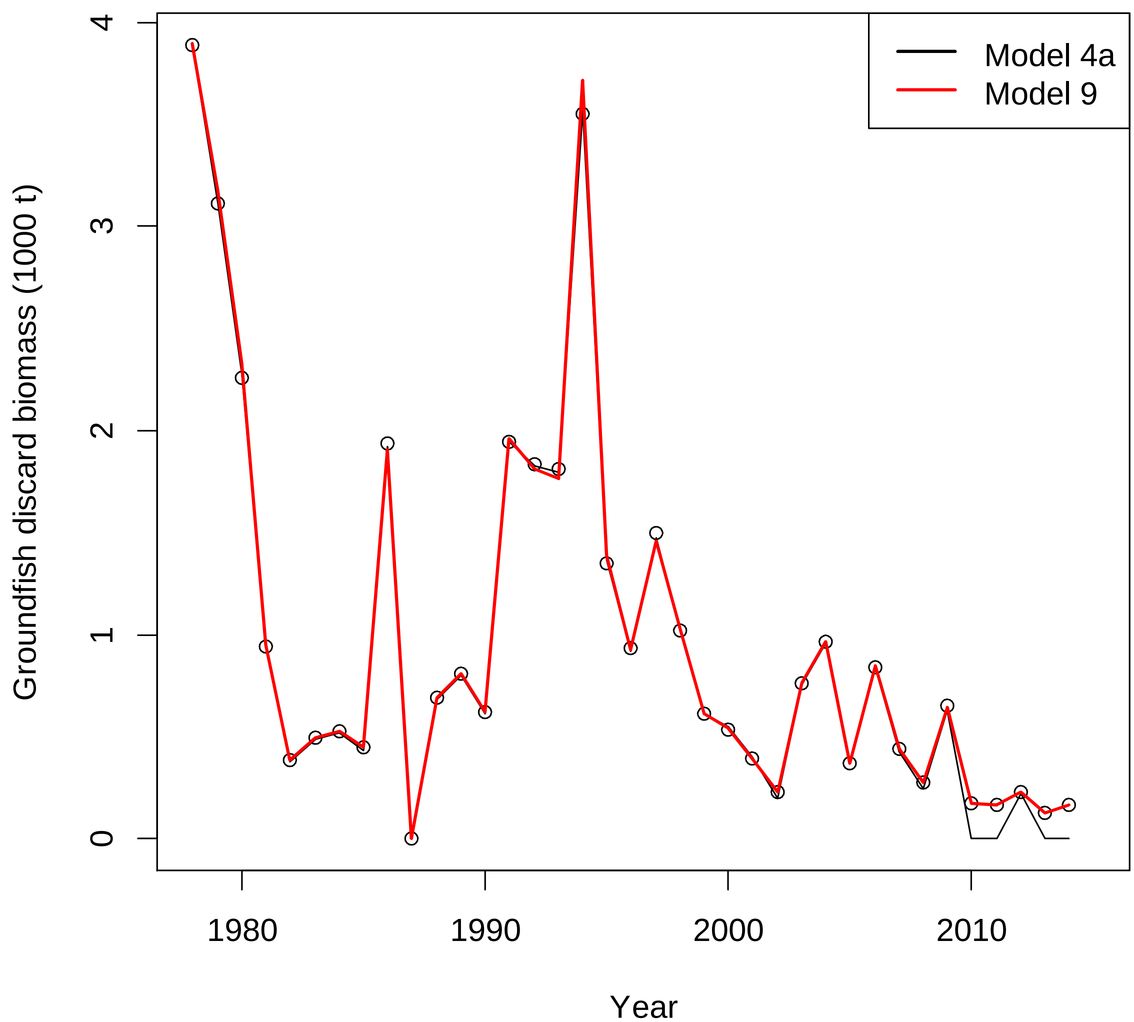


Figure 100. Fit to groundfish discard biomass for Model 4a and Model 9.

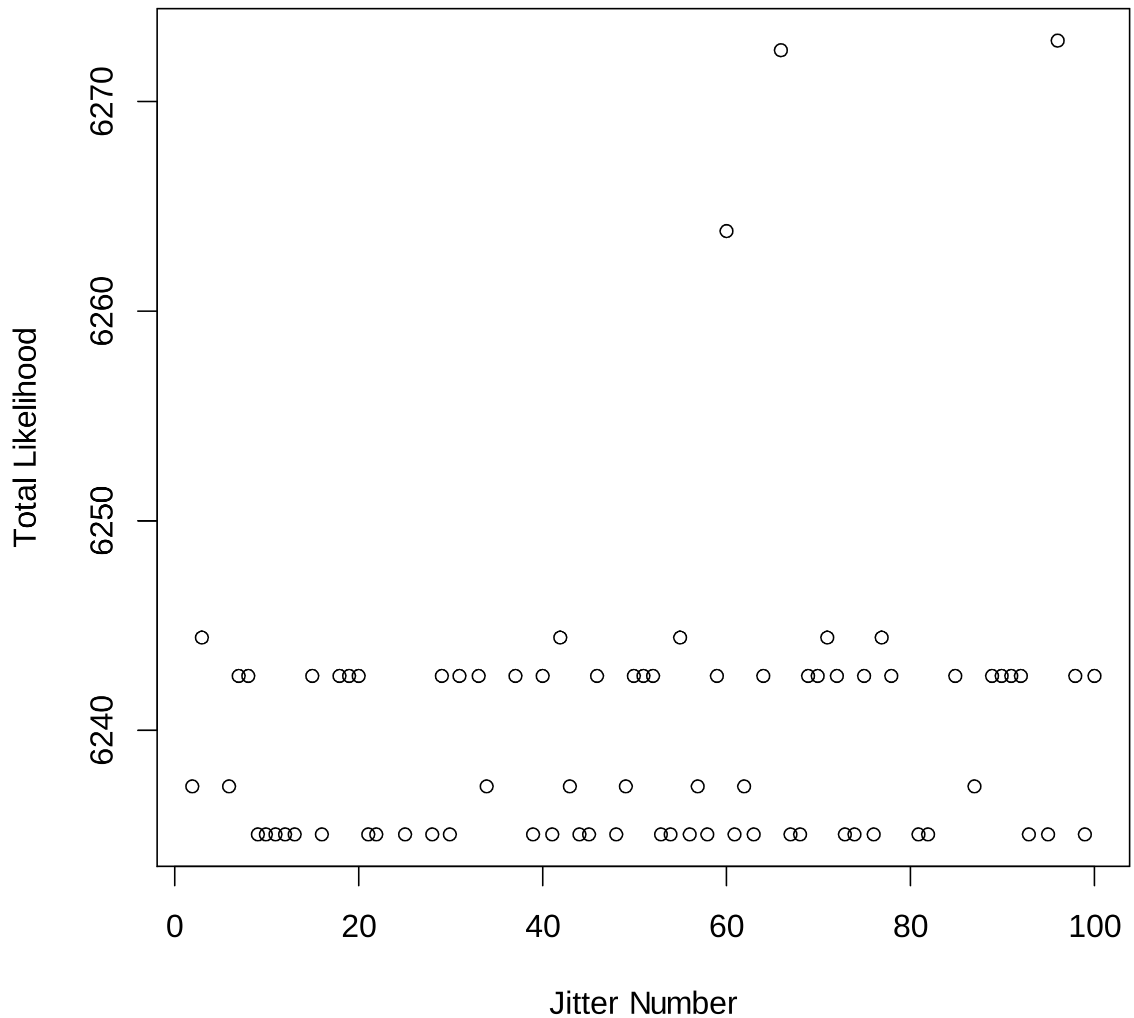


Figure 101. Model 10. Lowest likelihood was 6235.00 with 32 runs.

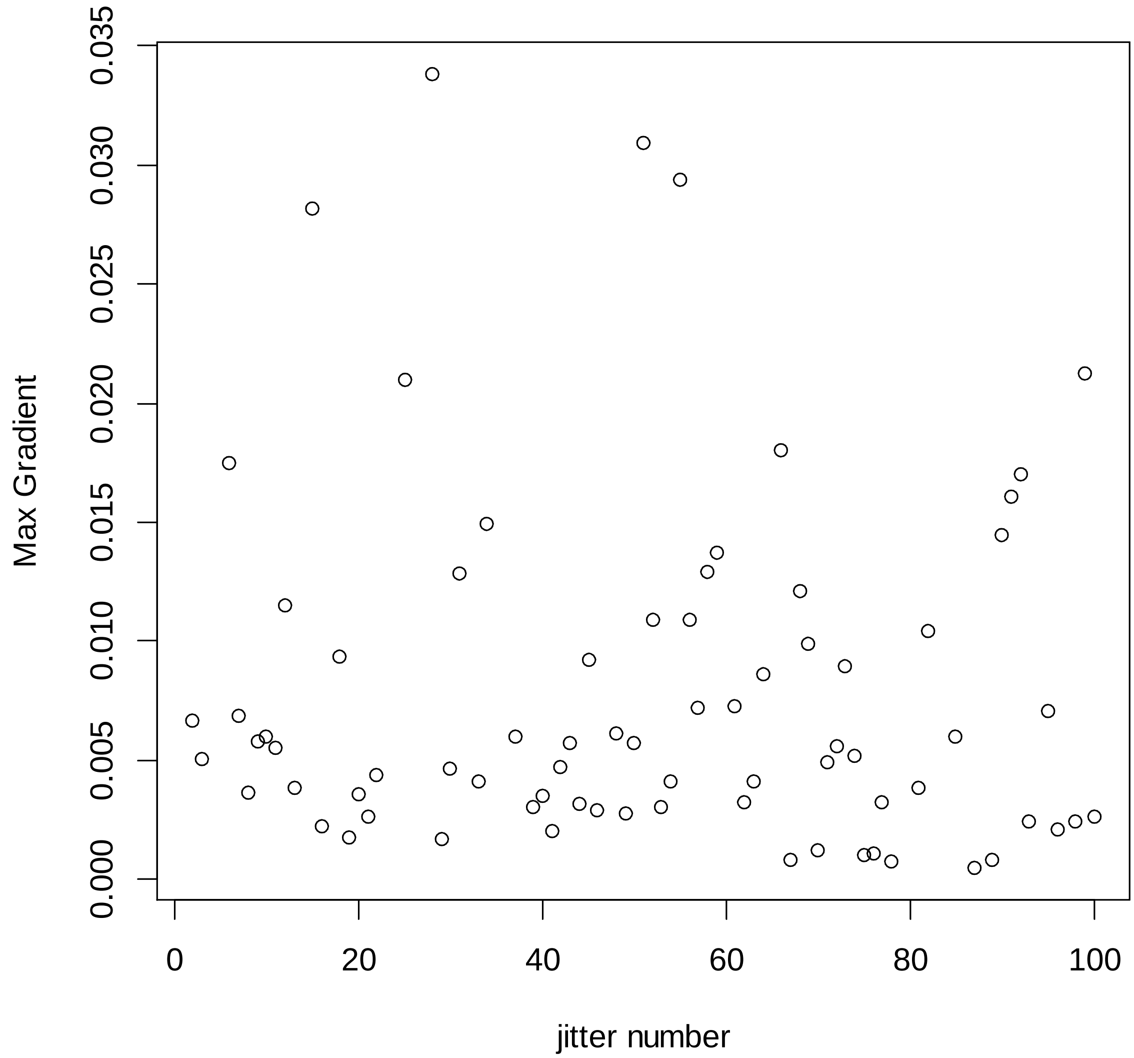


Figure 102. Model 10. Maximum gradient vs jitter run.

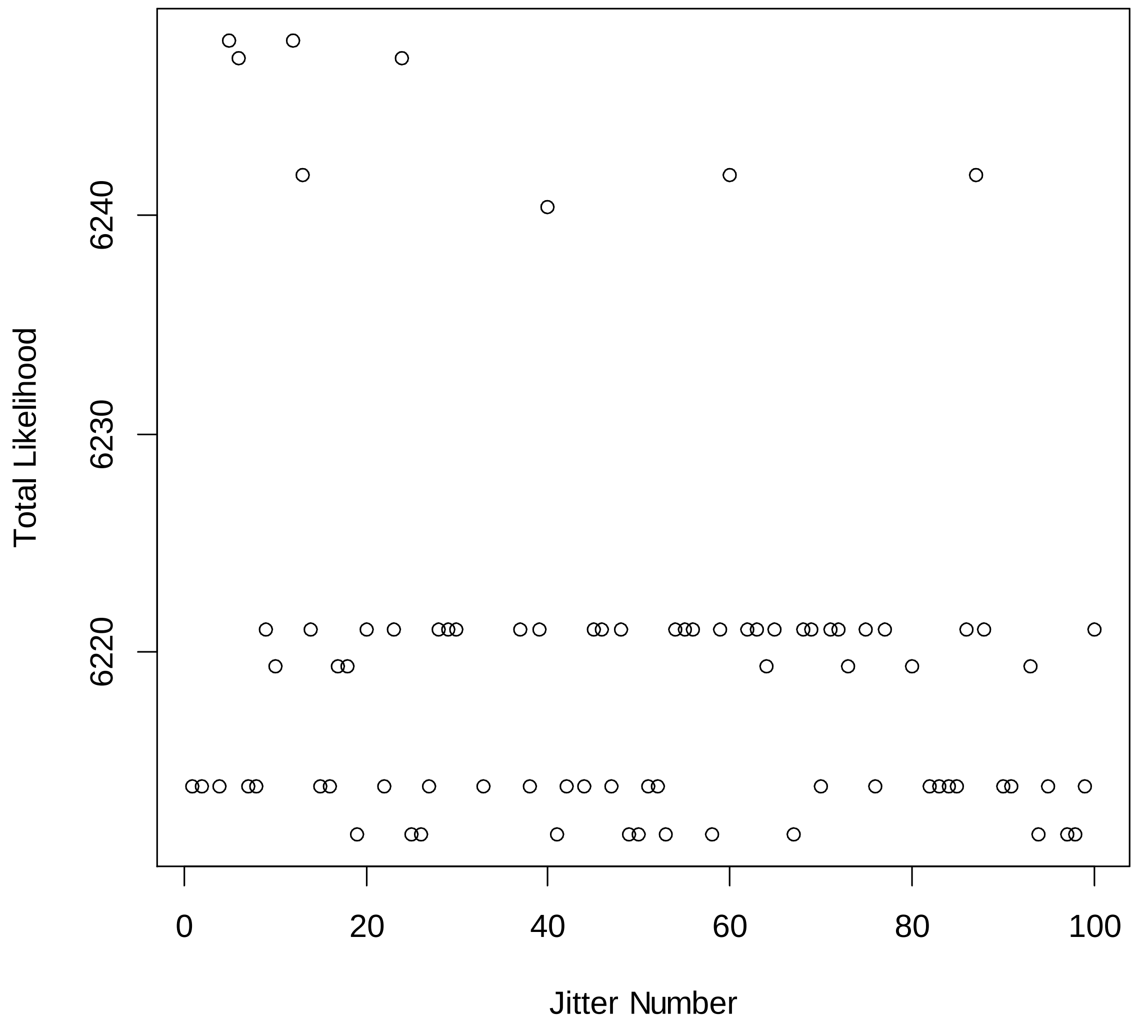


Figure 103. Model 11. Lowest likelihood was 6211.63 with 12 runs.

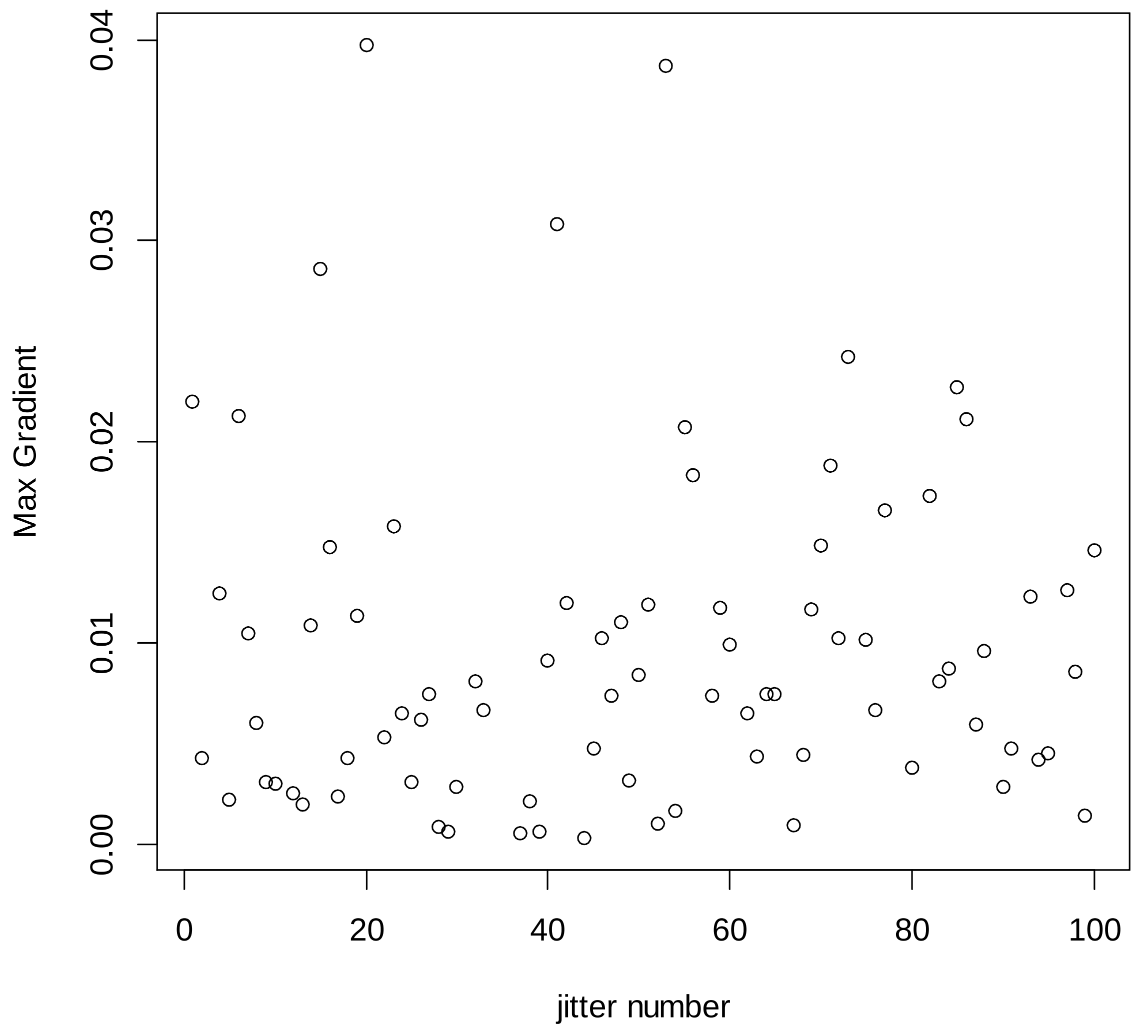


Figure 104. Model 11. Lowest likelihood was 6211.63 with 12 runs.

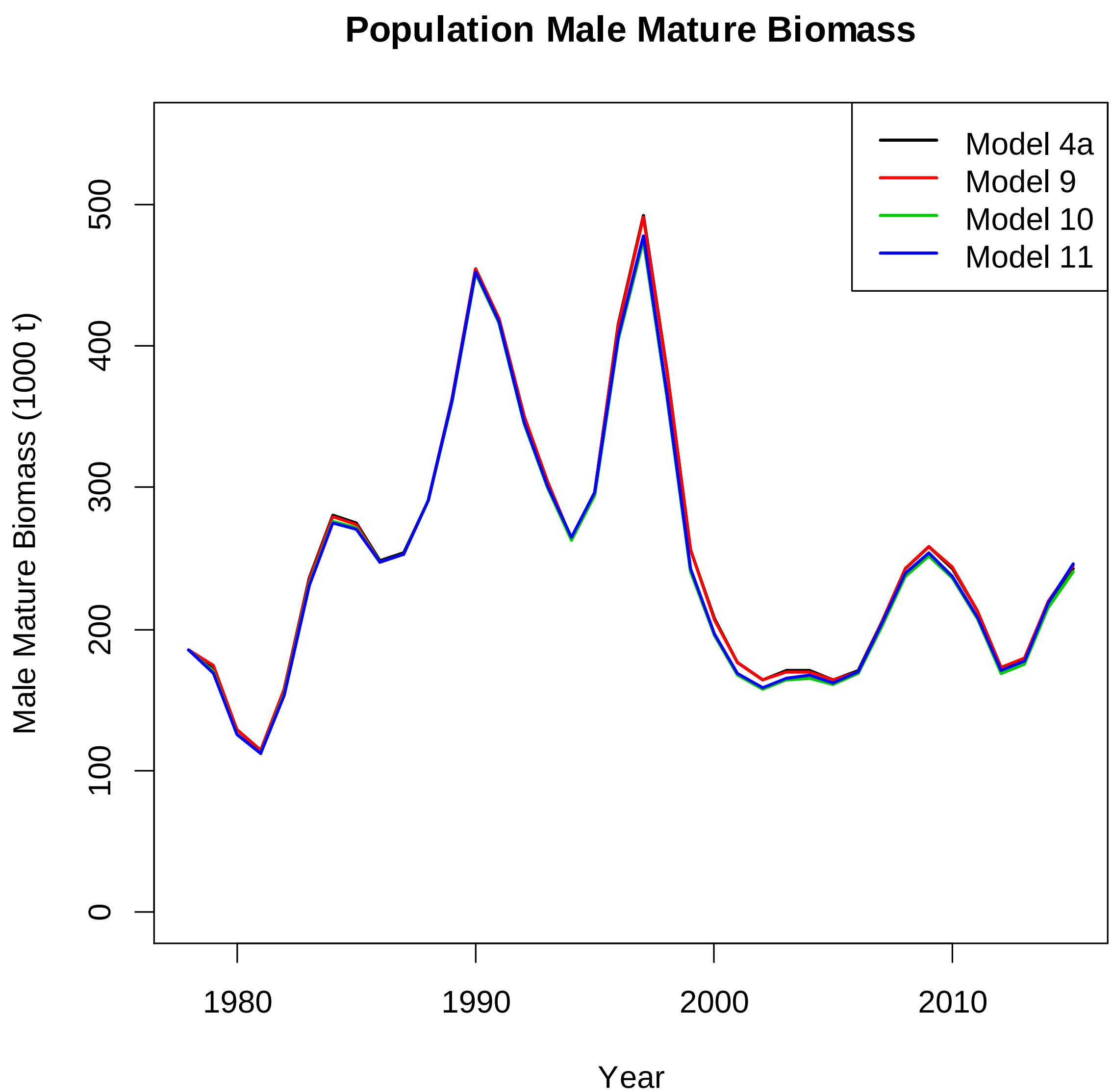


Figure 105. Population male mature biomass estimates for Models 4a, 9, 10 and 11.

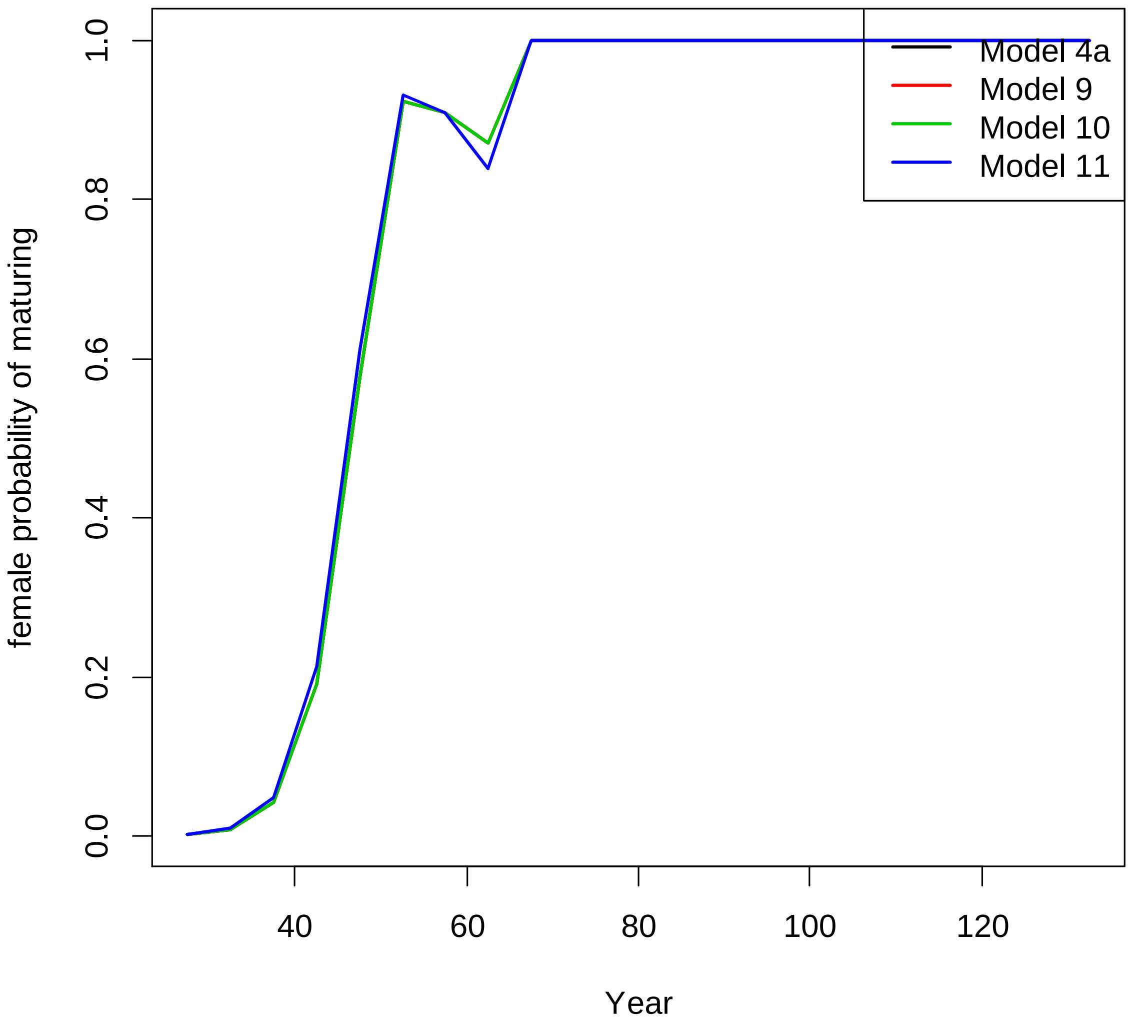


Figure 106. Female probability of maturing Models 4a, 9, 10 and 11.

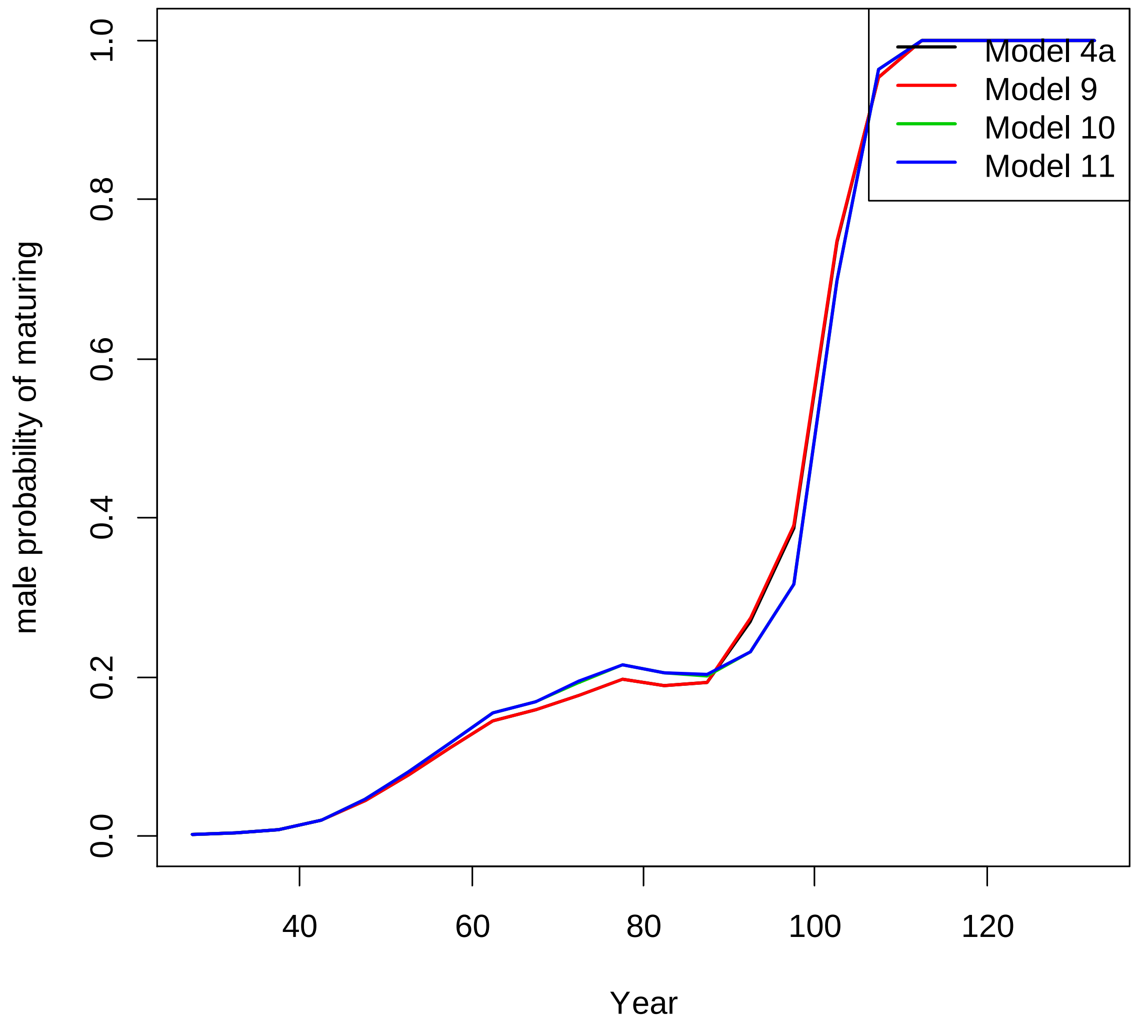


Figure 107. Male probability of maturing Models 4a, 9, 10 and 11. Estimates for Models 4a and 9 are the same and Models 10 and 11 are the same.

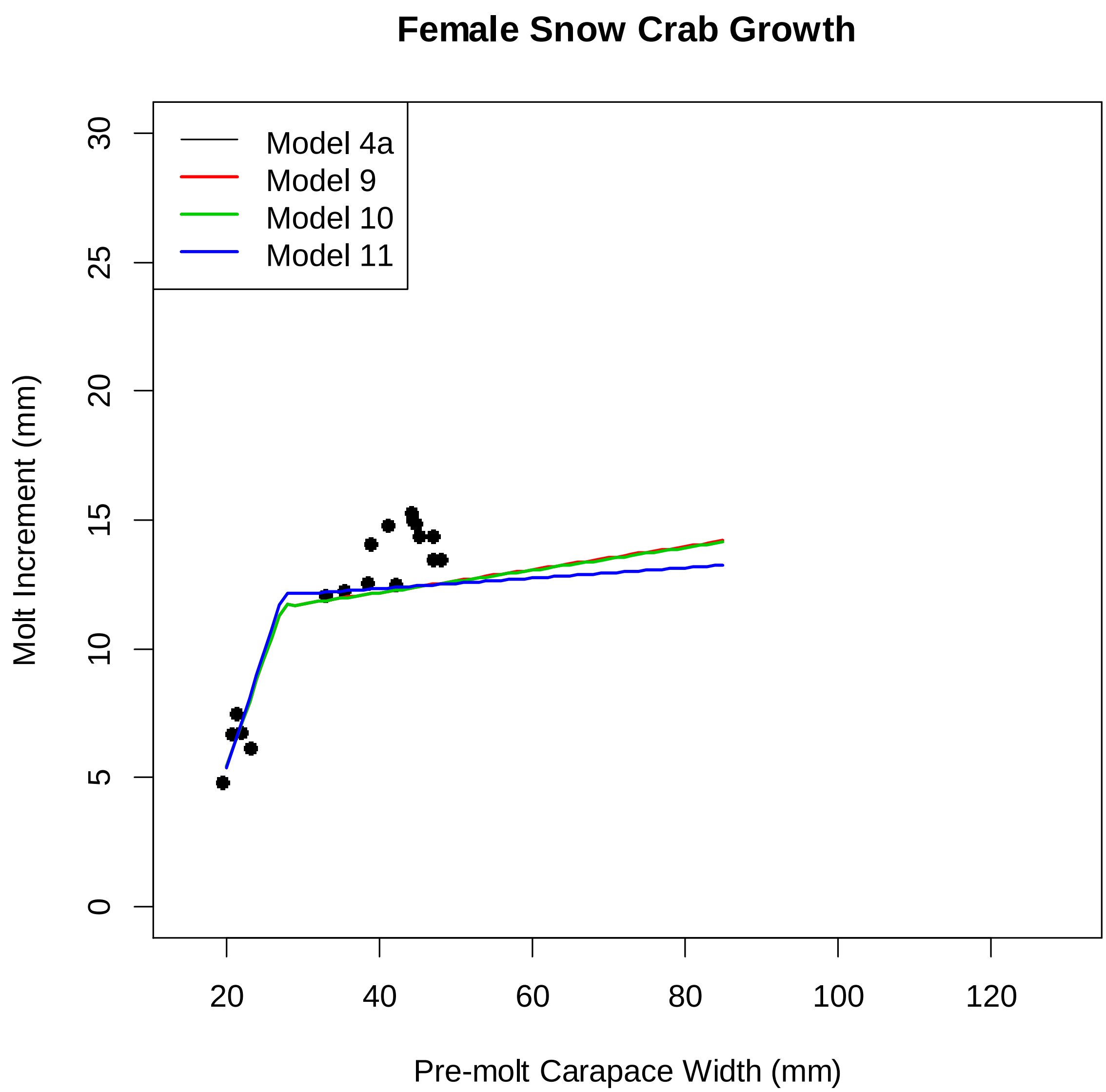


Figure 108. Female growth. Models 4a, 9 and 10 are the same. Model 11 has lower slope.

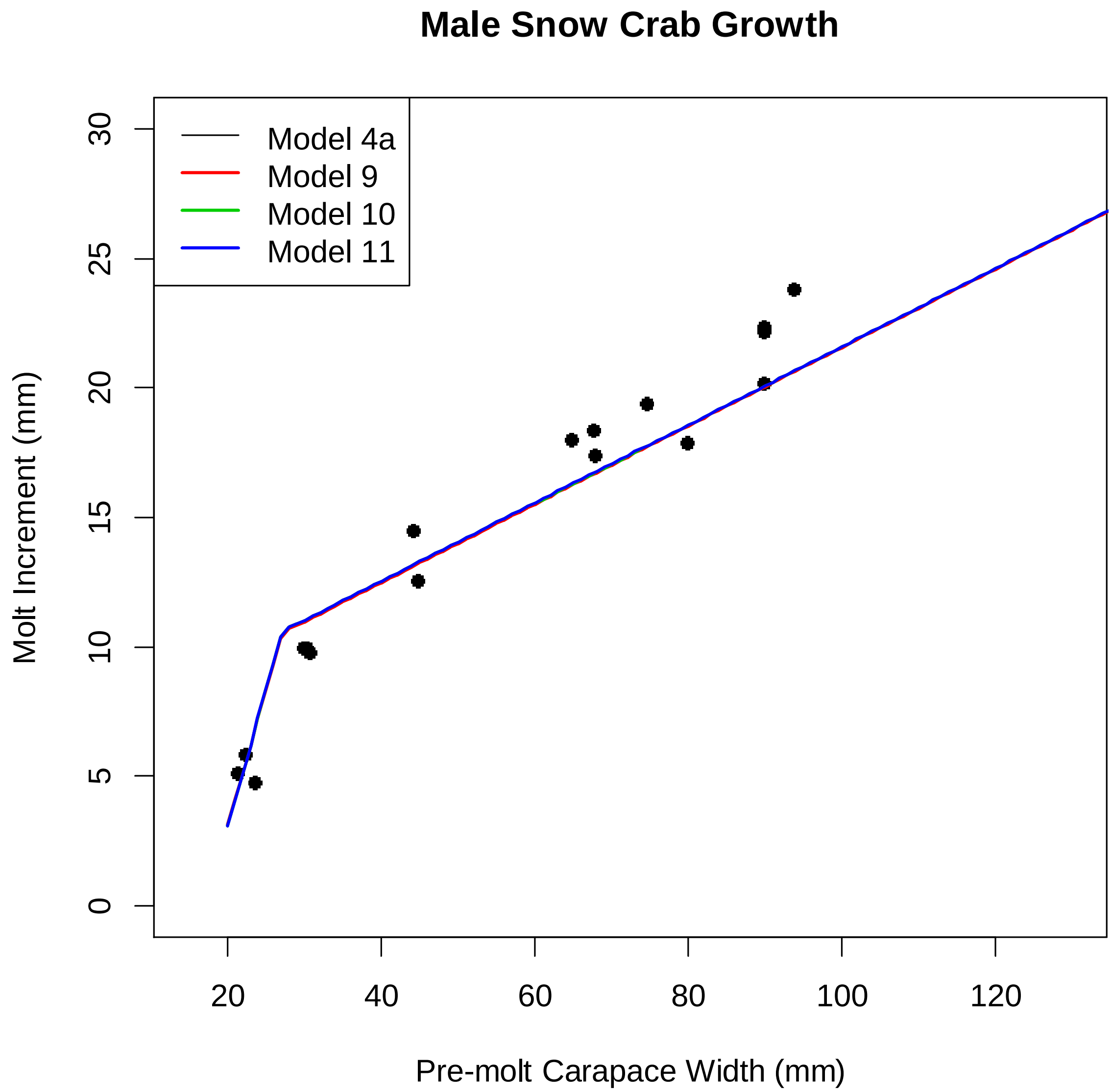


Figure 109. Male growth for Models 4a, 9, 10 and 11.

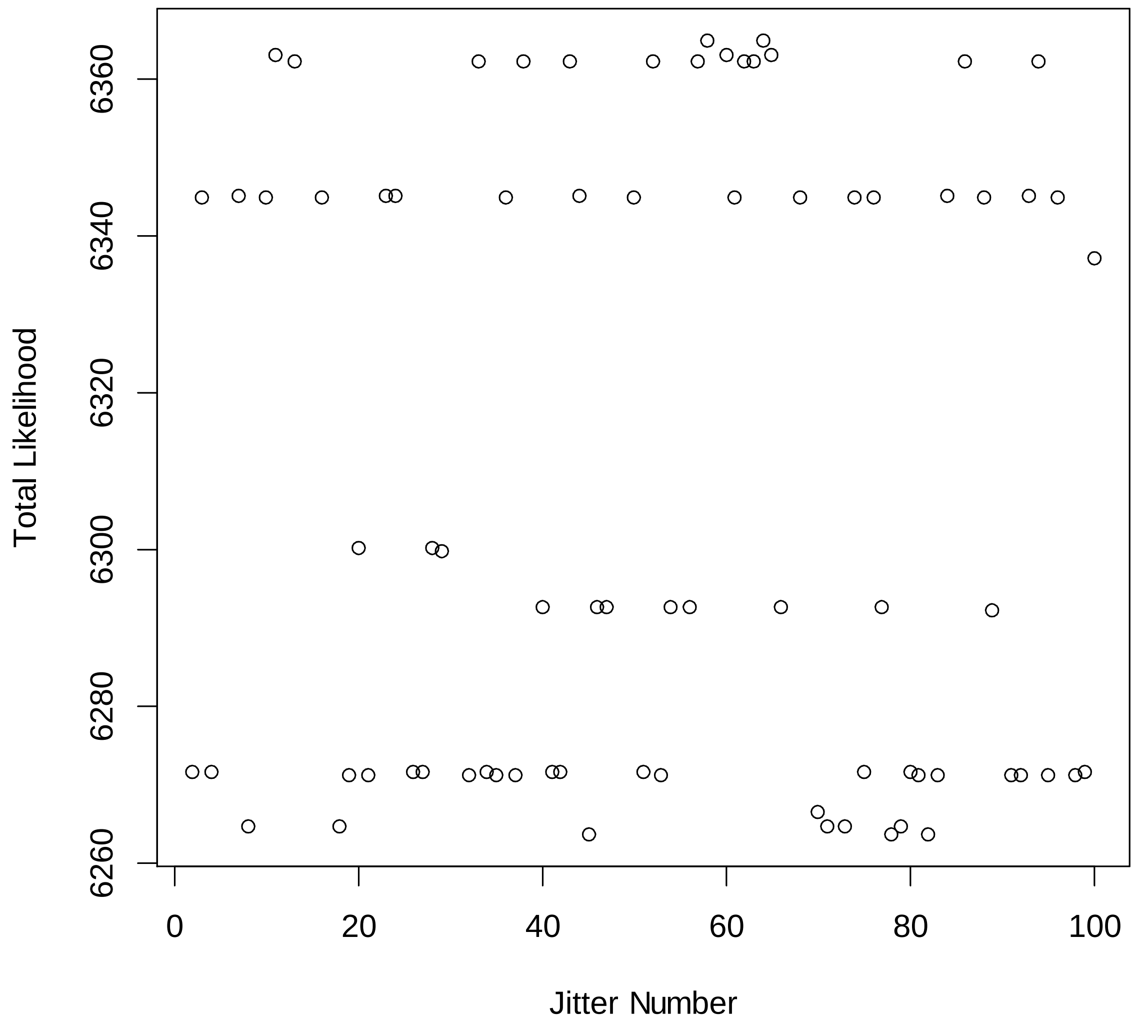


Figure 110. Model 12. 3 runs at lowest likelihood of 6263.71.

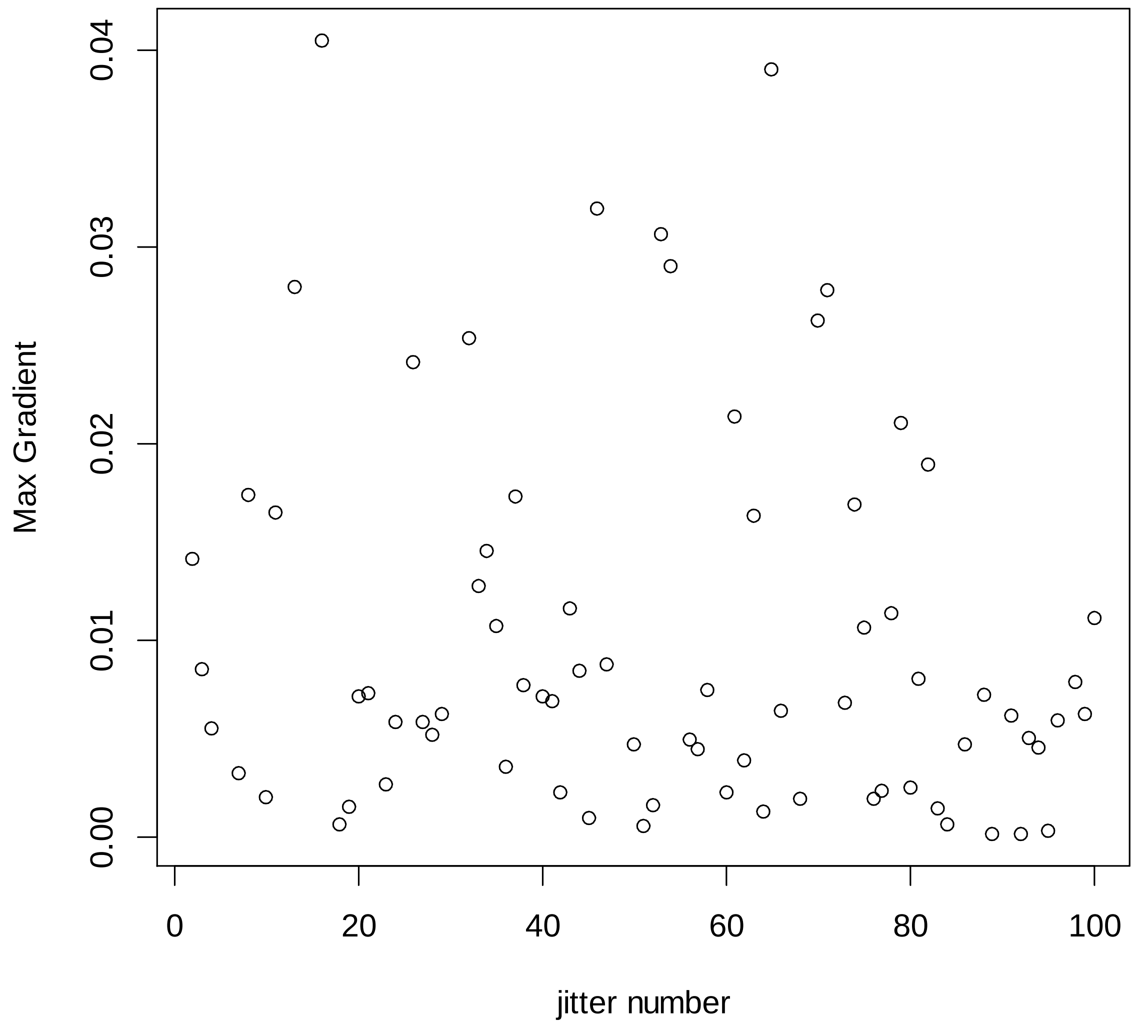


Figure 111. Model 12. Maximum gradient vs jitter run.

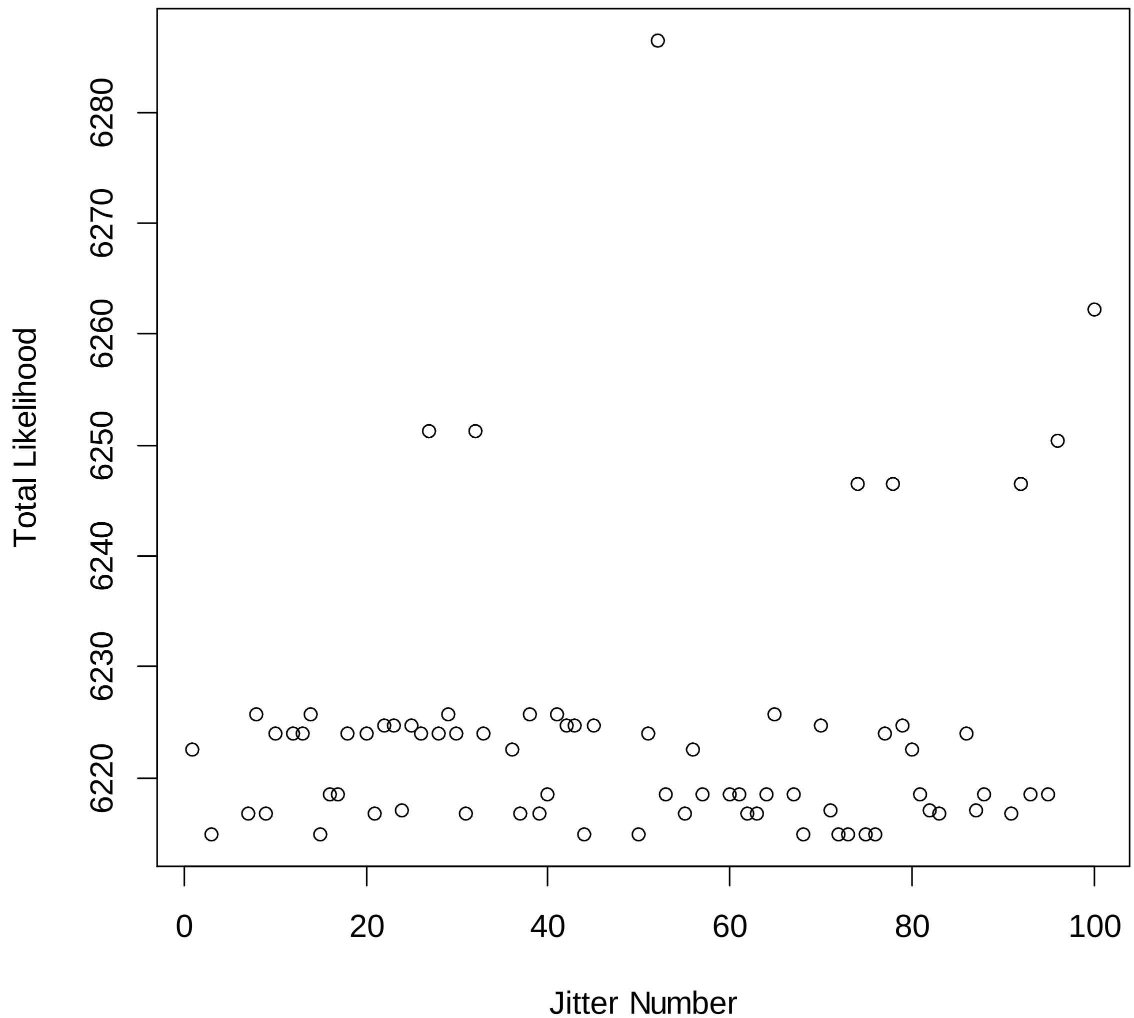


Figure 112.  Model 13.  Lowest likelihood 6214.87 with 9 runs.

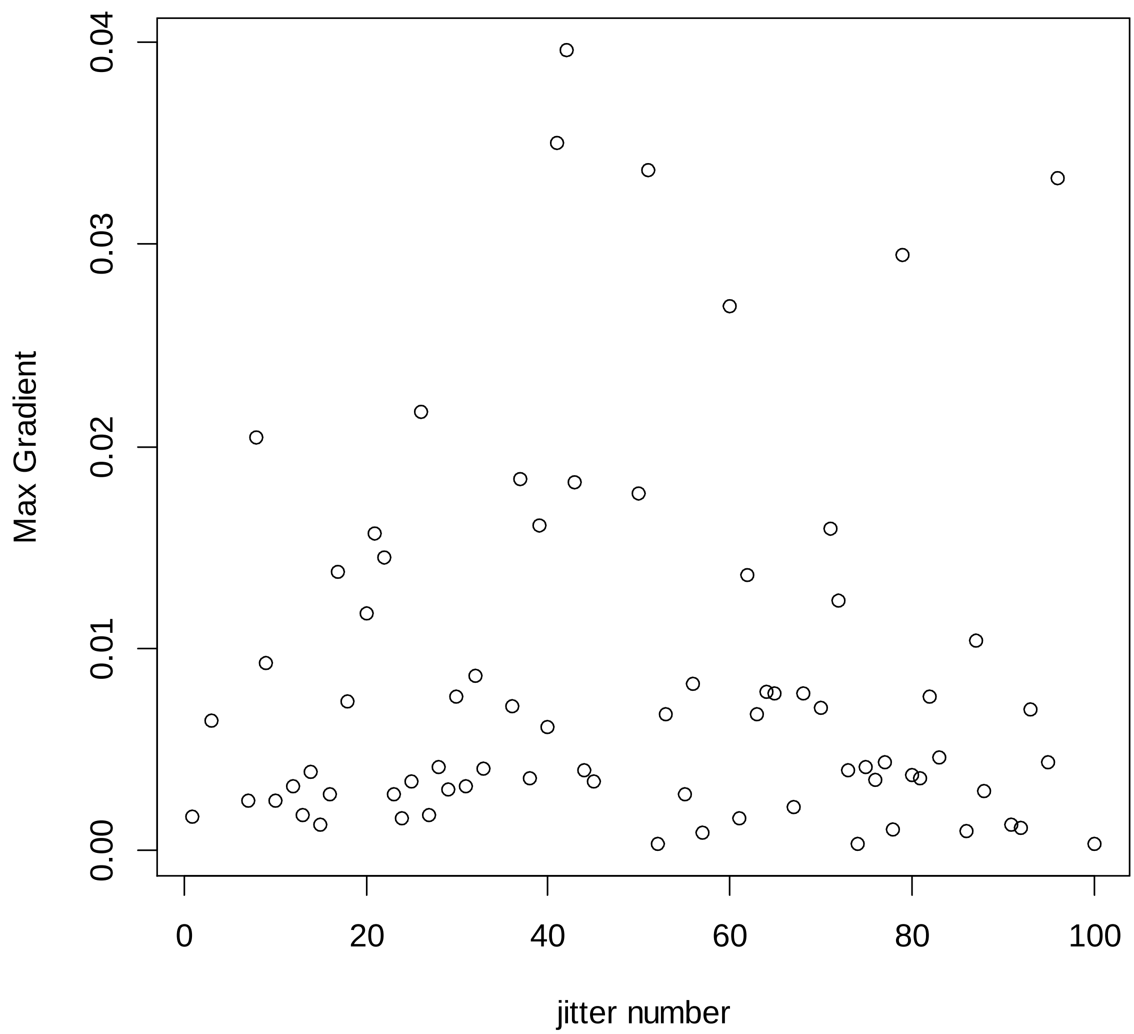


Figure 113. Model 13. Lowest likelihood 6214.87 with 9 runs.

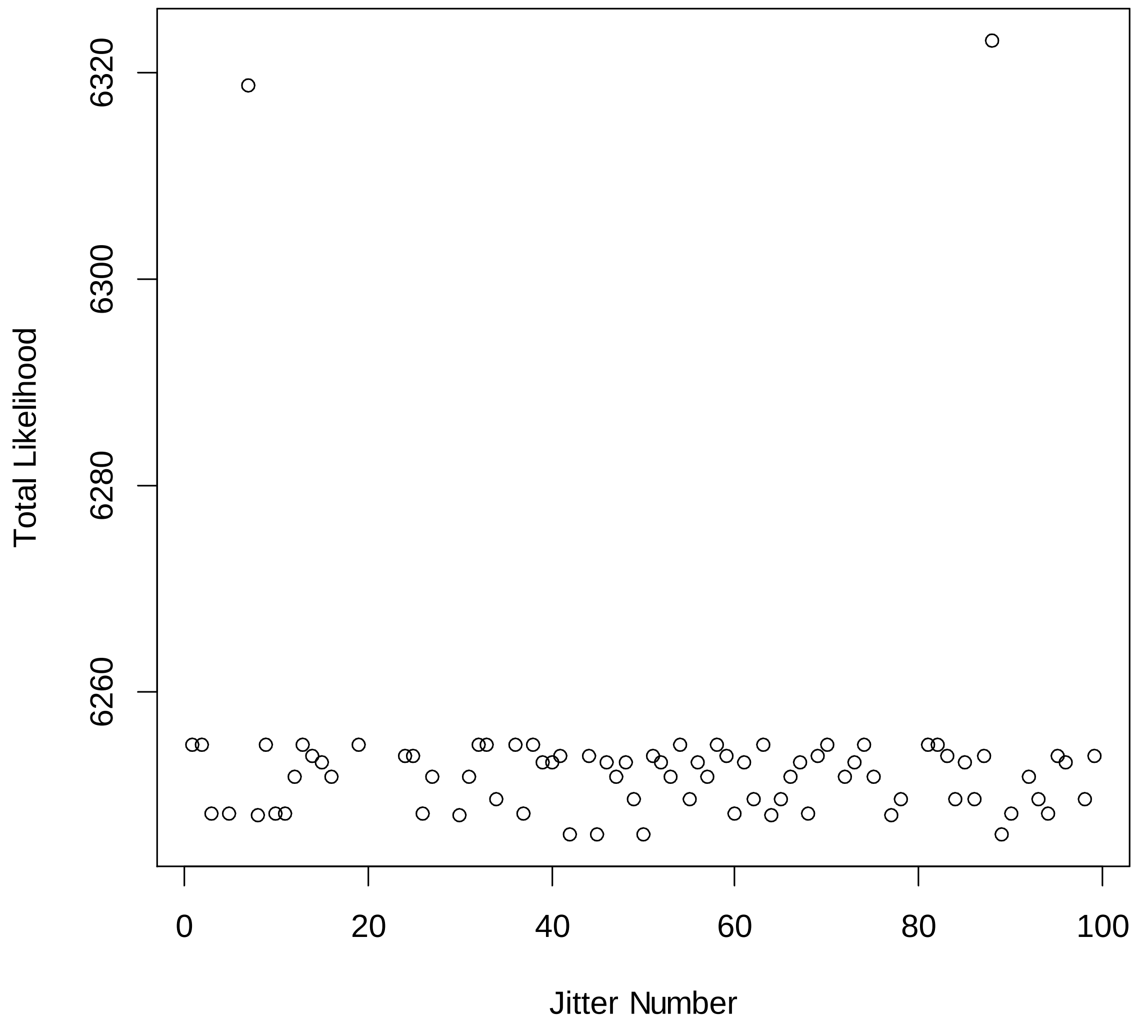


Figure 114. Model 14. Lowest likelihood was 6246.08 with 4 runs.

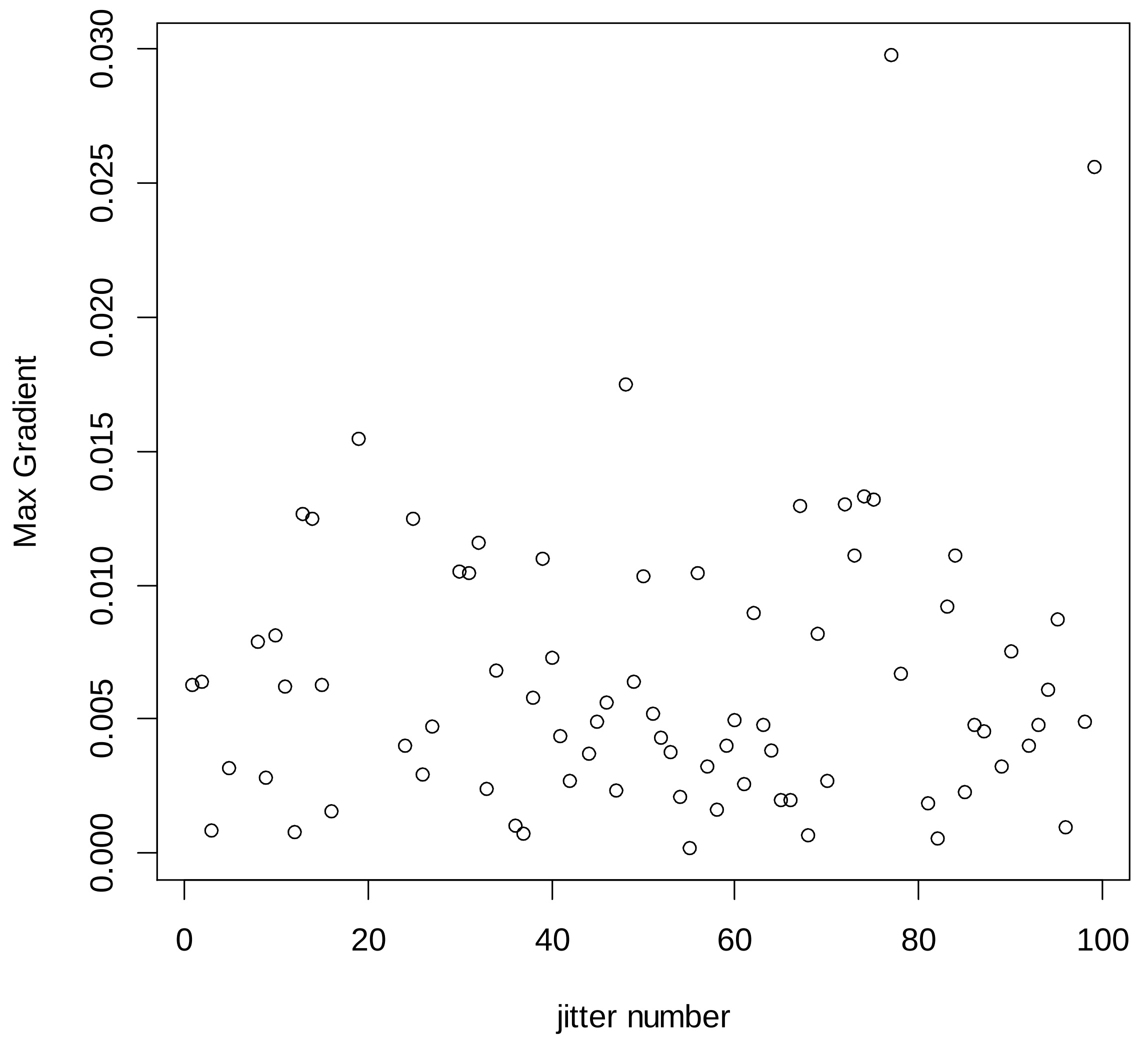


Figure 115. Model 14. Maximum gradient vs jitter run.

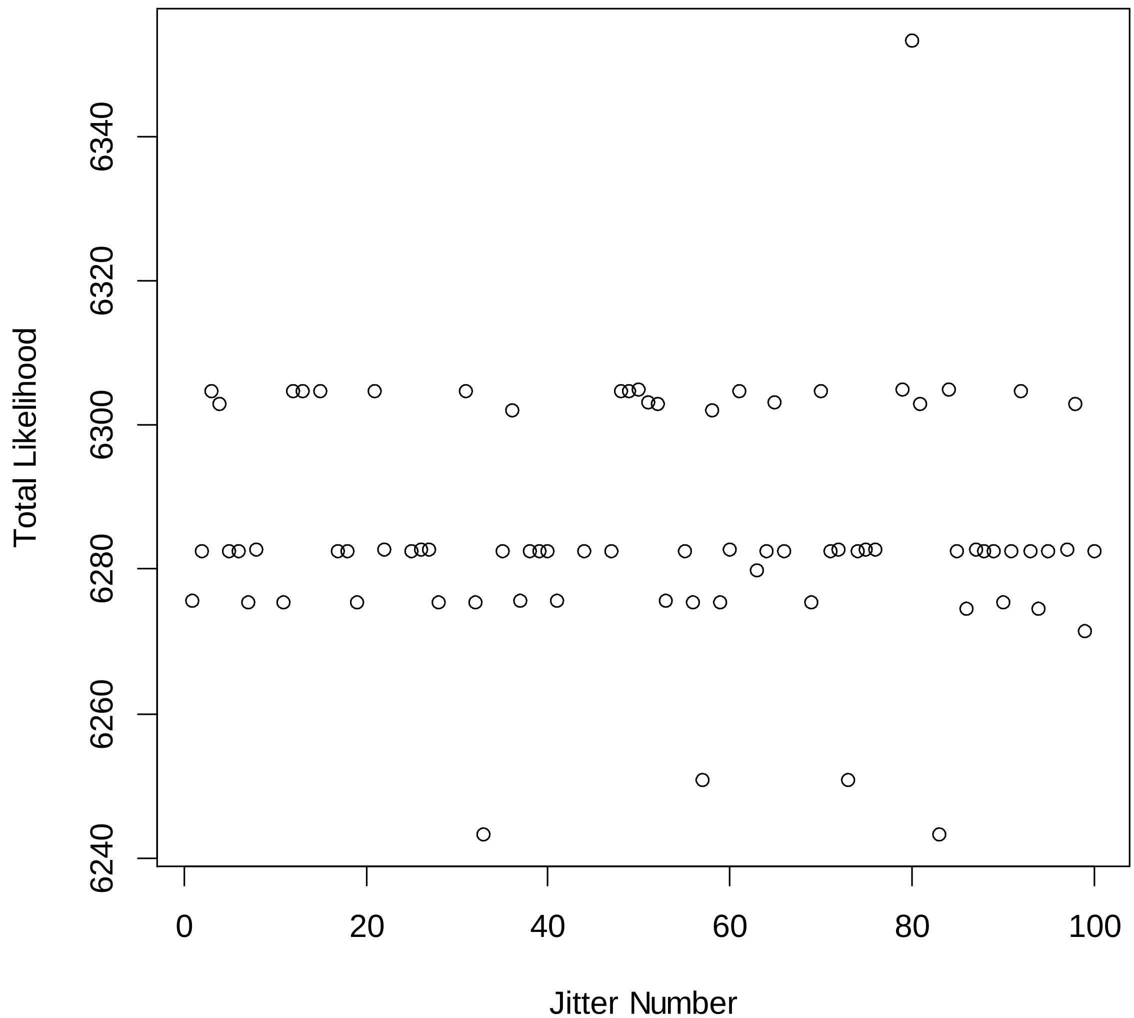


Figure 116. Model 15. Only 1 run achieved the lowest likelihood of 6243.27.

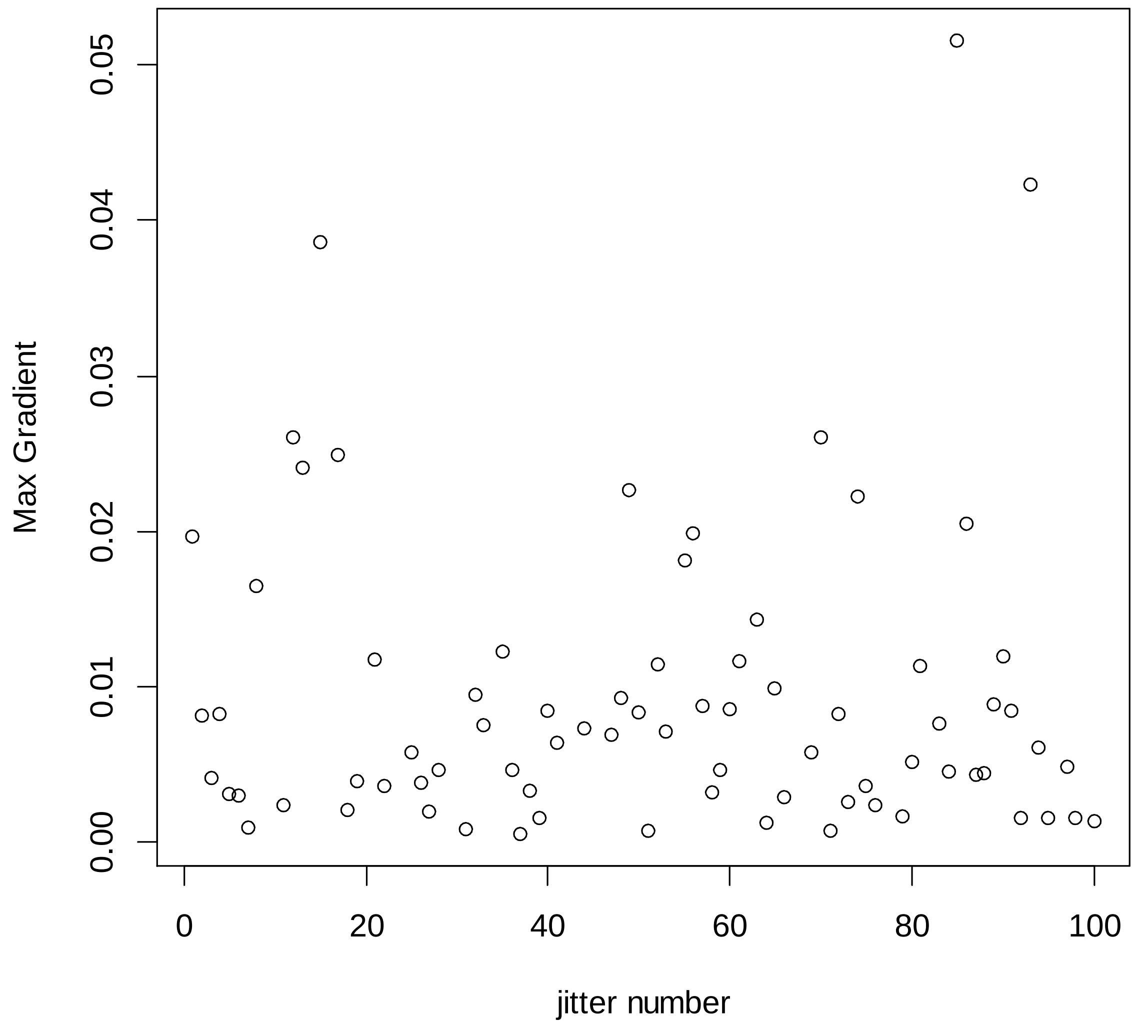


Figure 117. Model 15. Maximum gradient vs jitter run.

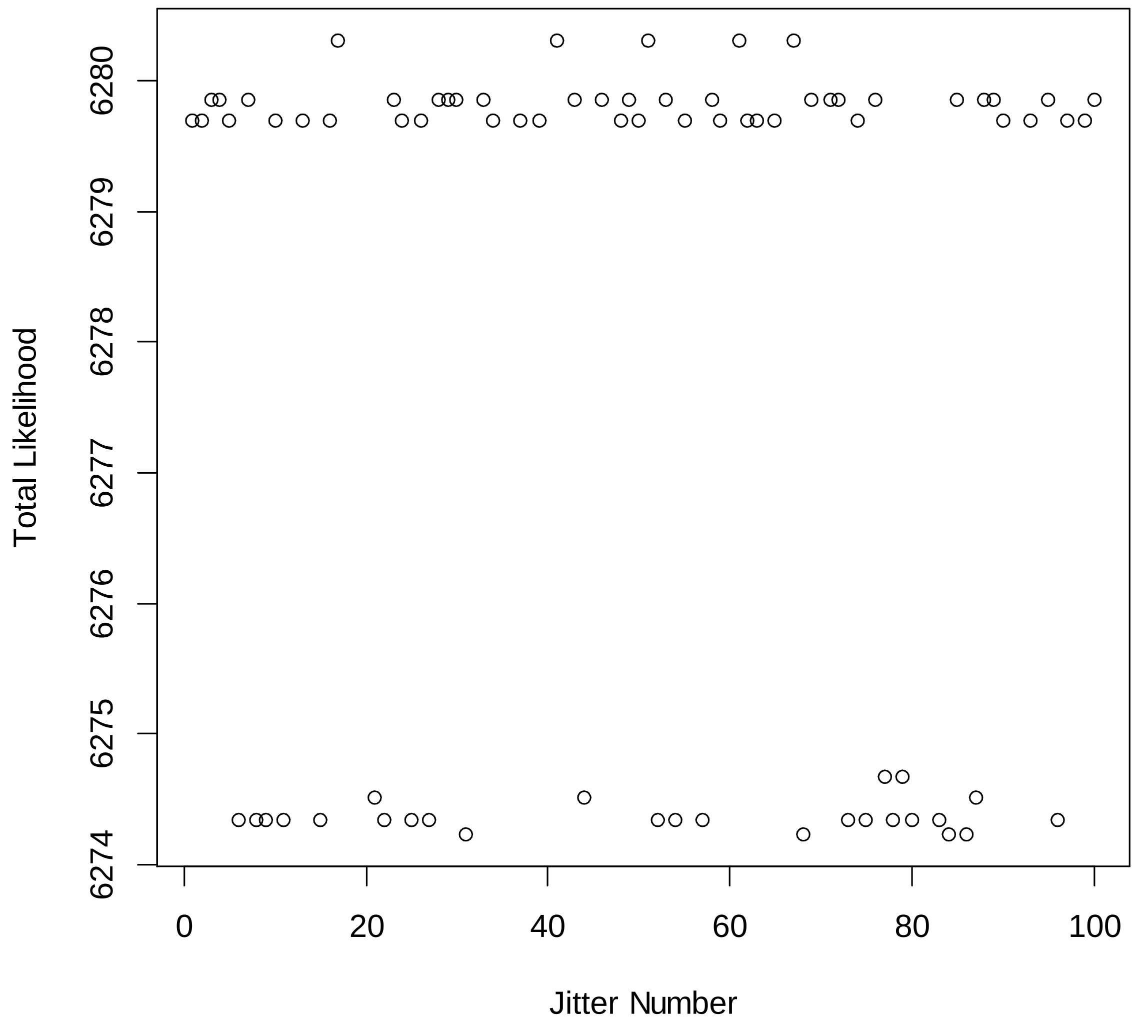


Figure 118. Model 16. The lowest likelihood was 6274.23 with 4 runs.

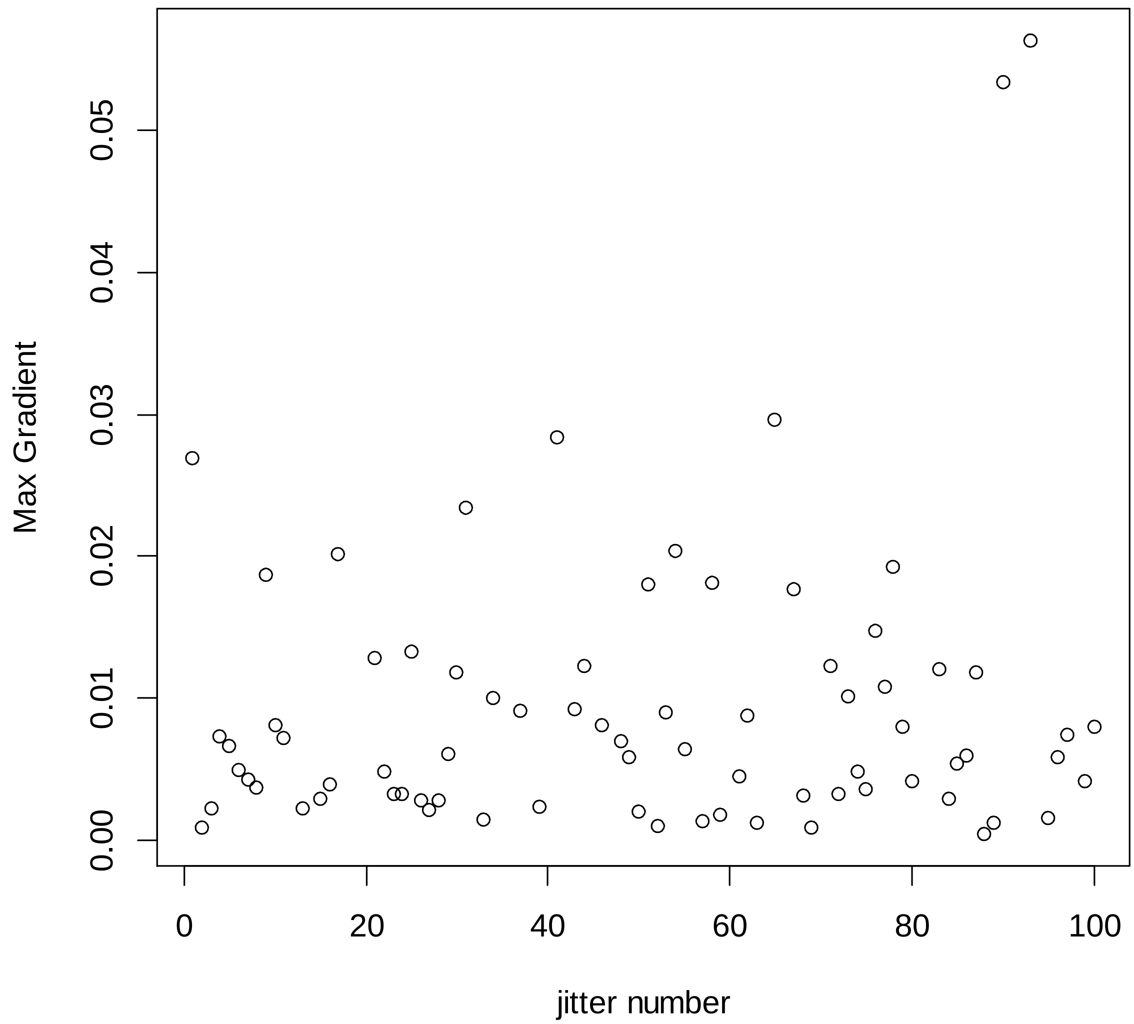


Figure 119. Model 16. Maximum gradient vs jitter run.

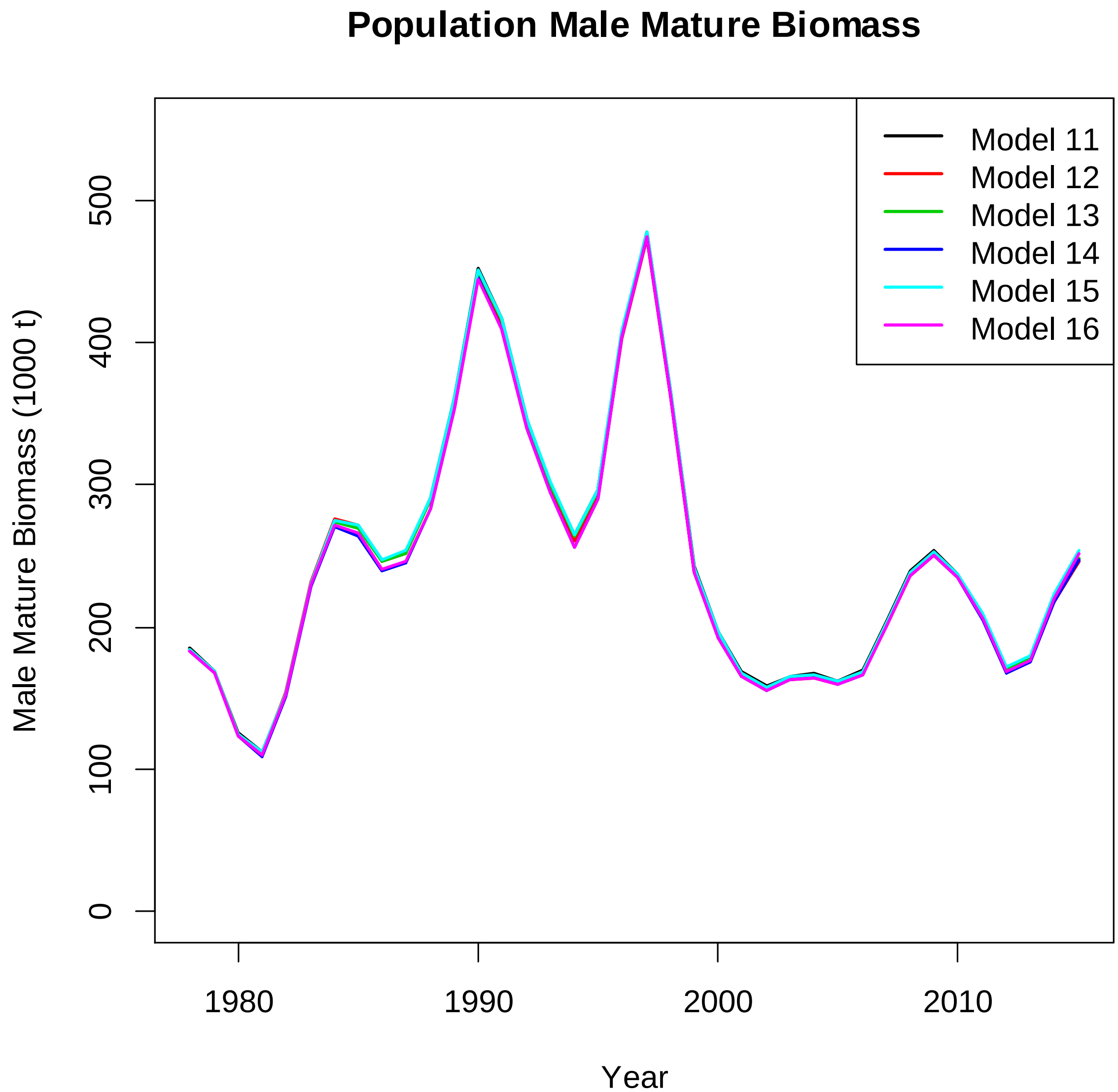


Figure 120. Comparison of population male mature biomass between Models 11, 12, 13,14, 15 and 16.

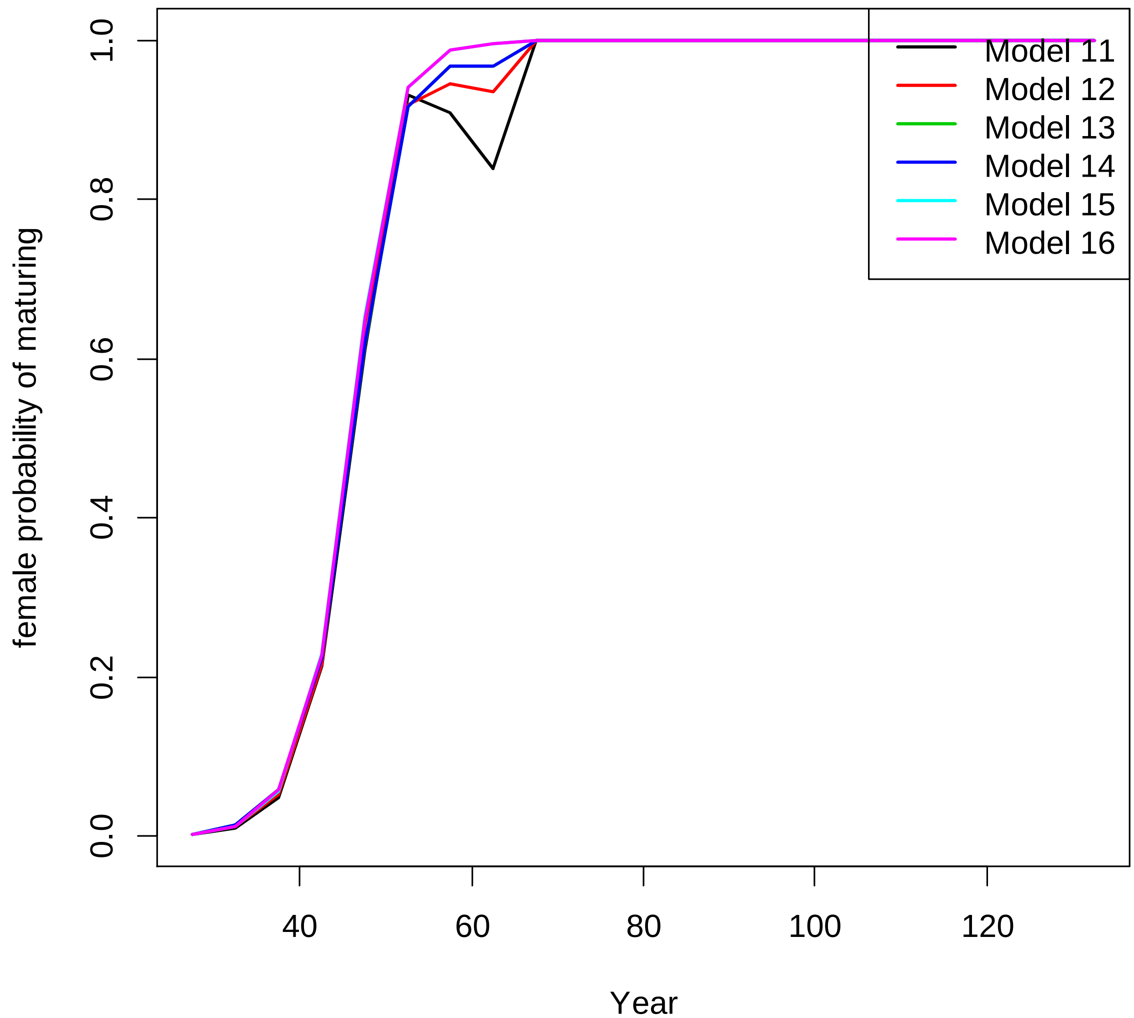


Figure 121. Comparison of female probability of maturing for Models 11-16. Models 13 and 14 are the same. Models 15 and 16 are the same.

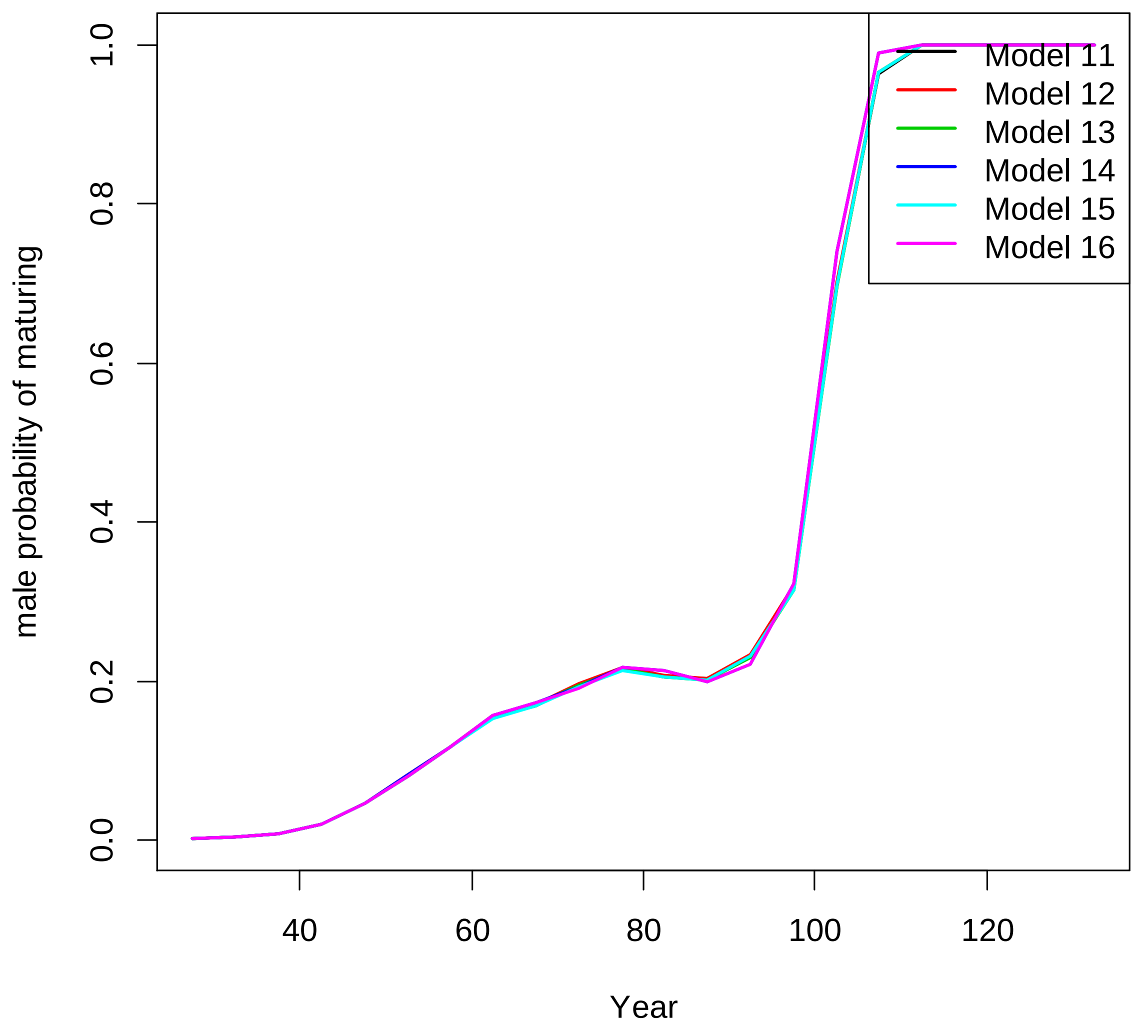


Figure 122. Comparison of male probability of maturing for Models 11-16.

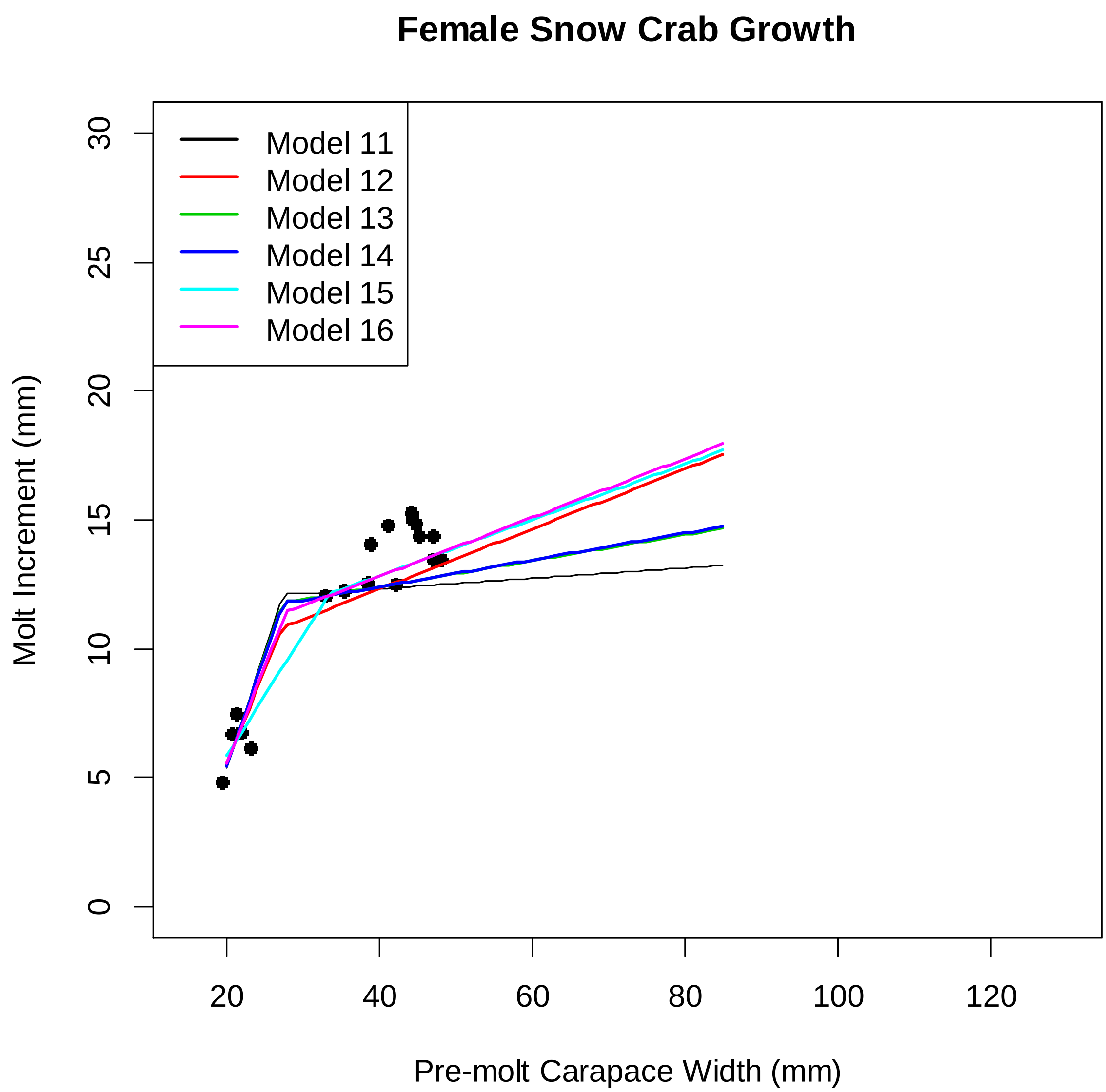


Figure 123.  Models 13 and 14 are same.

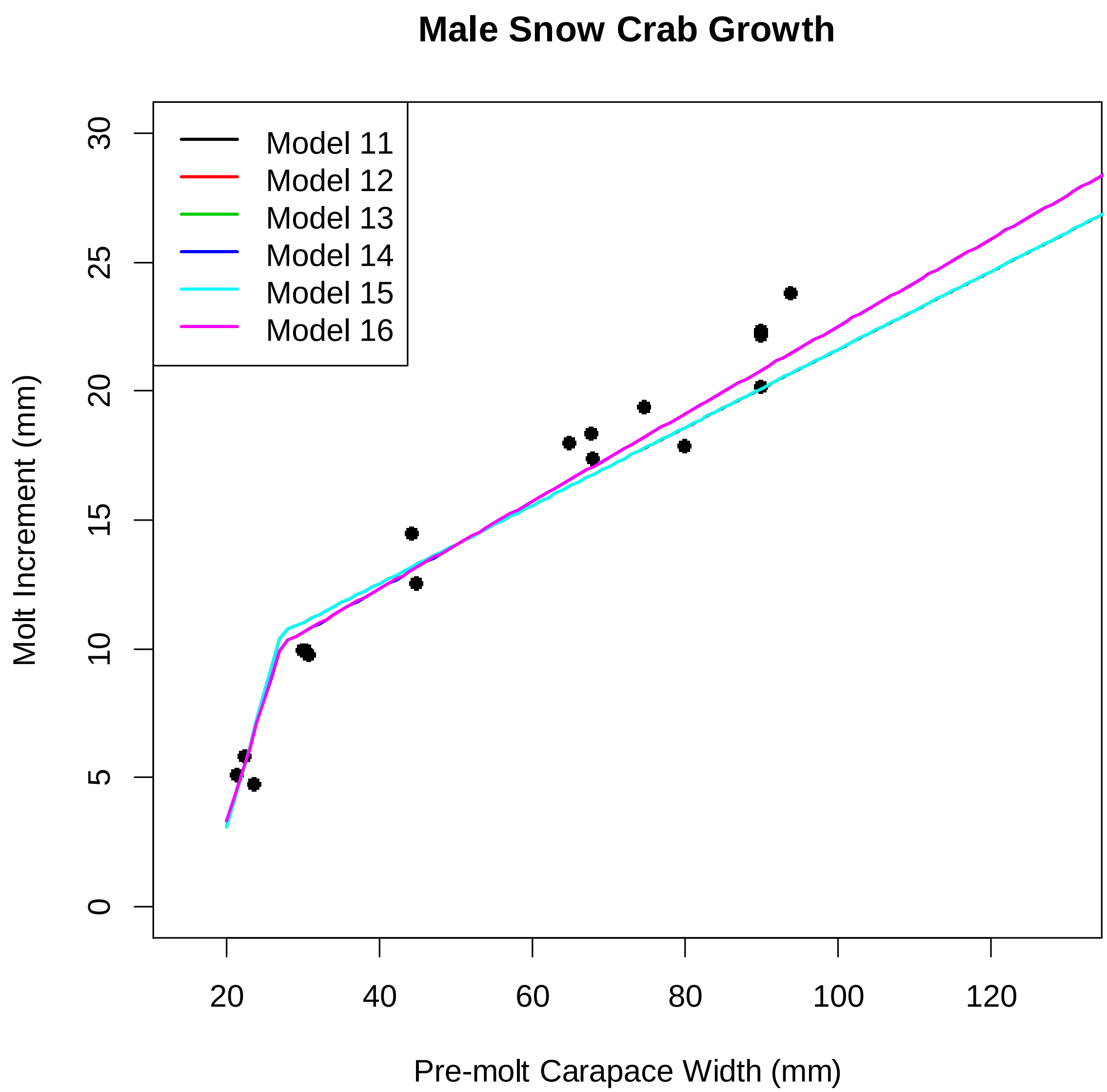


Figure 124. Comparison of male growth for Models 11,12,13,14, 15 and 16. Models 11, 12, 13, and 15 are all estimated the same. Models 14 and 16 estimate growth for males higher at larger sizes than other models.

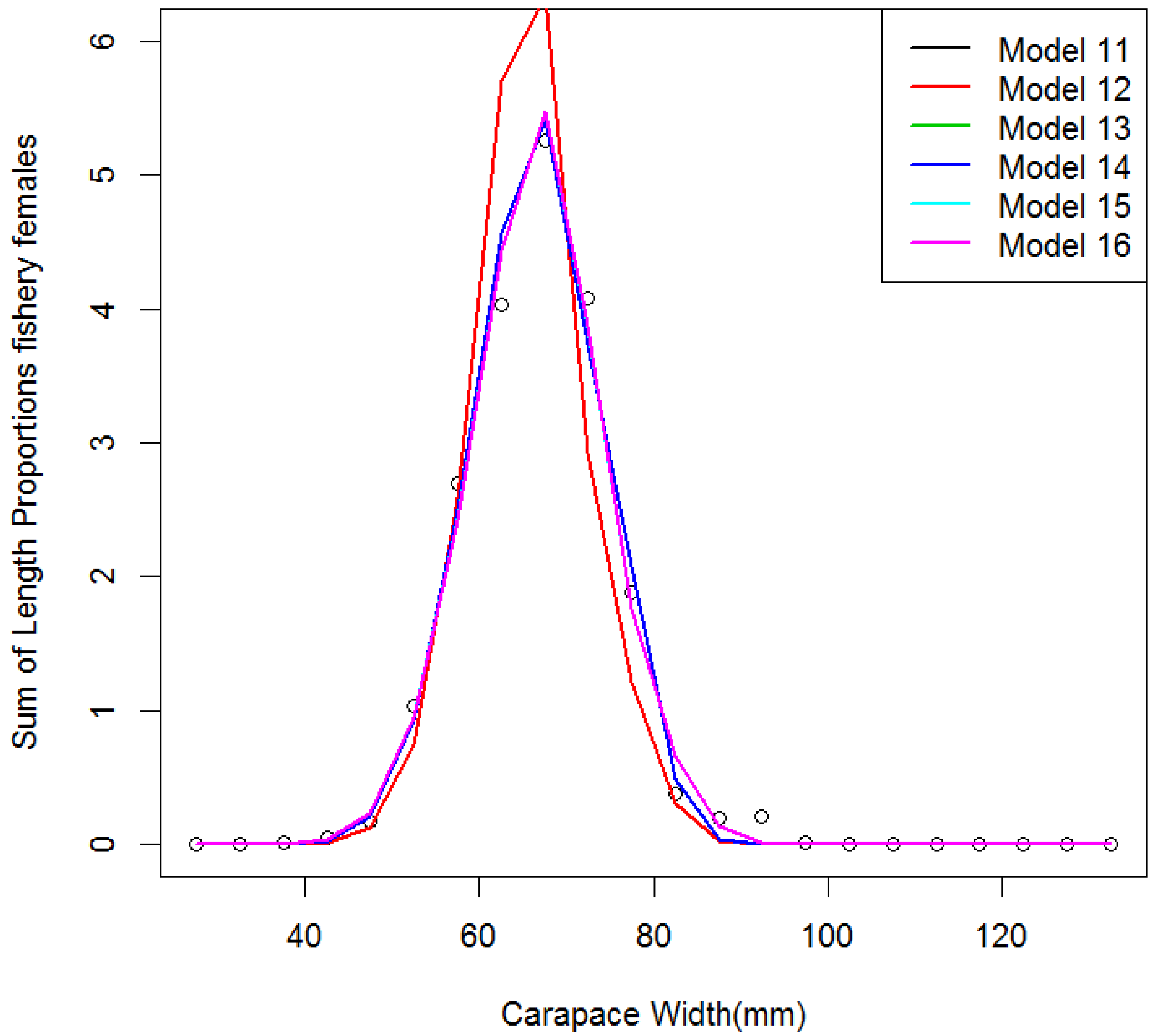


Figure 125. Comparison of summary fit to female directed fishery discard length frequency for Models 11,12,13,14, 15 and 16.

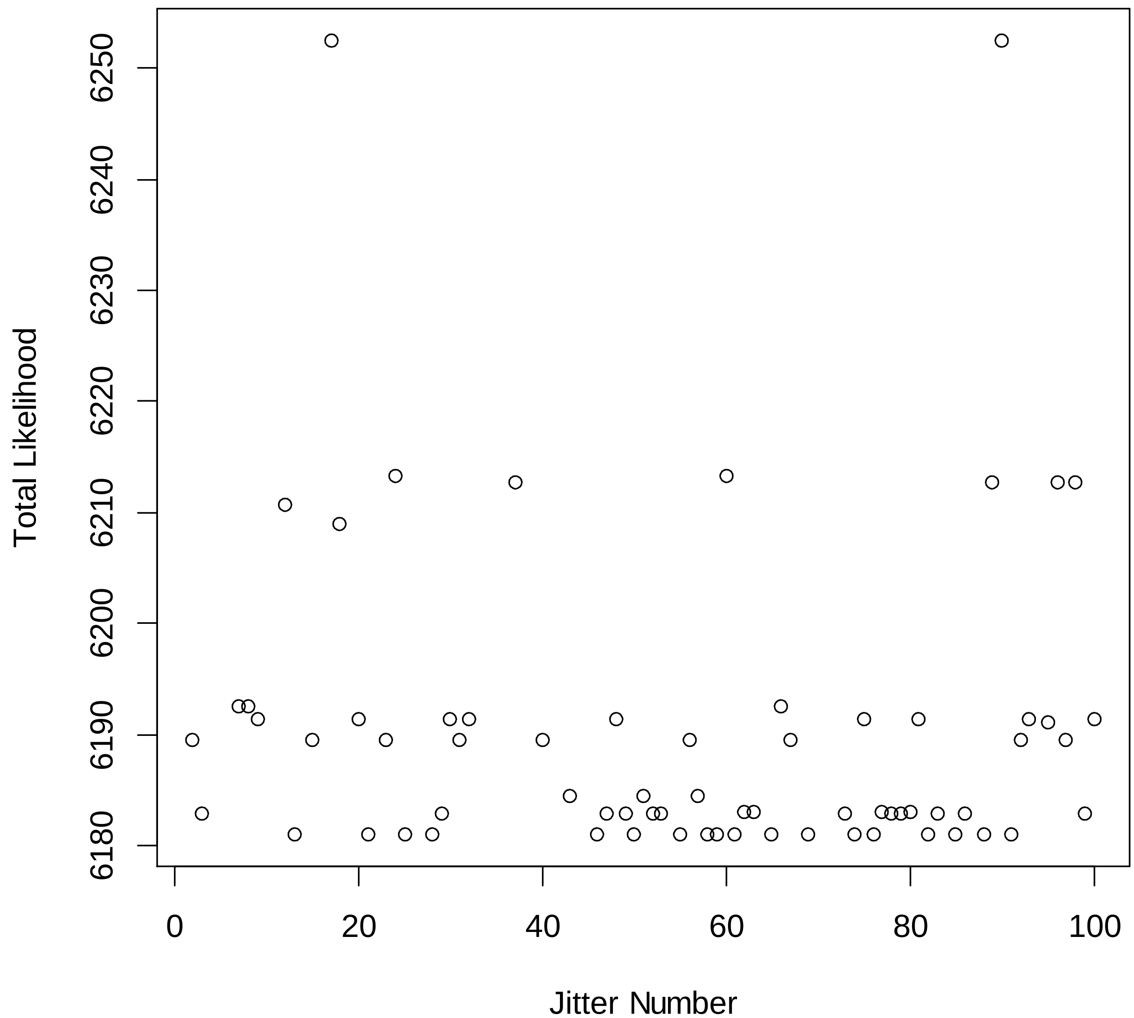


Figure 126. Model 17. Lowest Likelihood was 6180.99 18 runs.

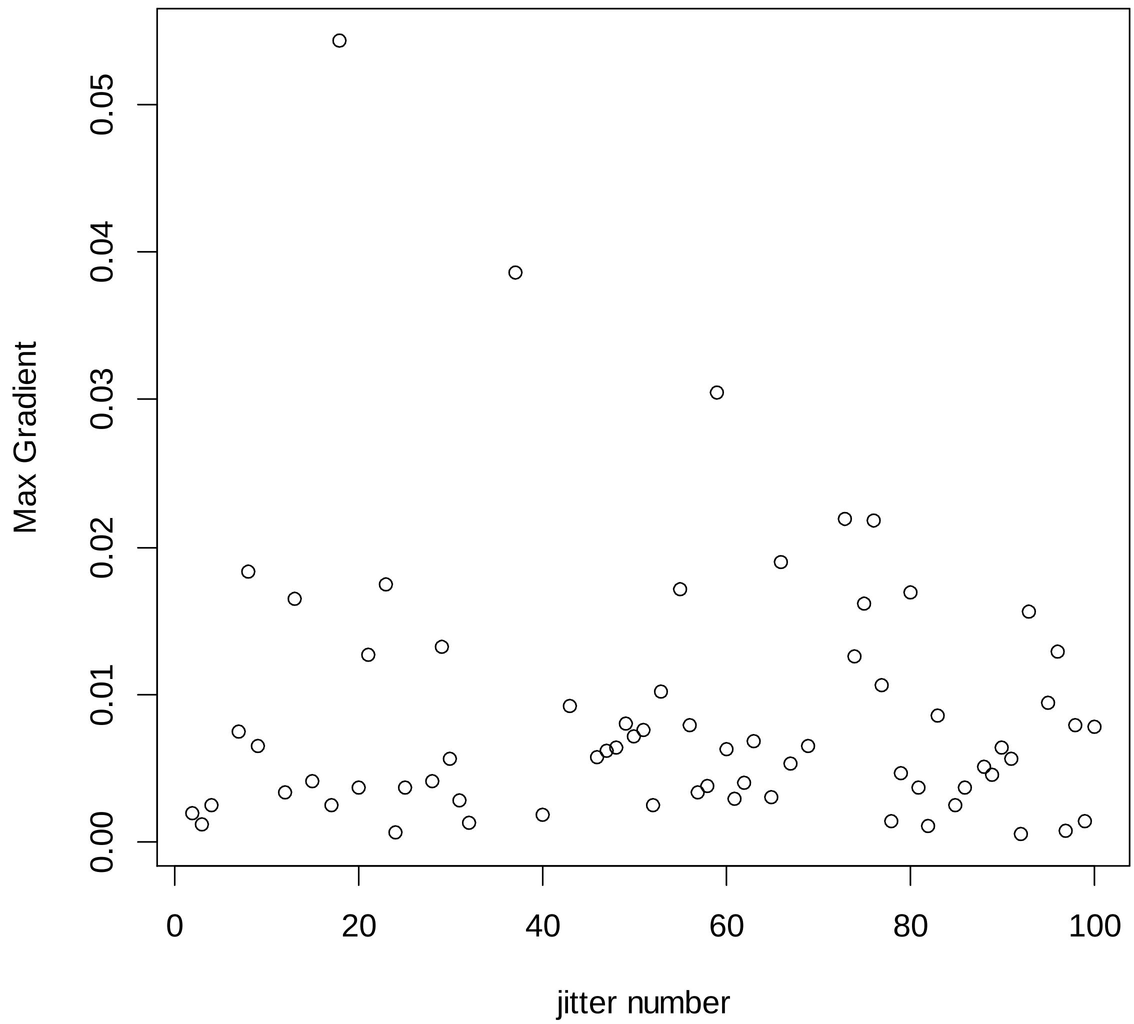


Figure 127. Model 17. Maximum gradient by jitter run.

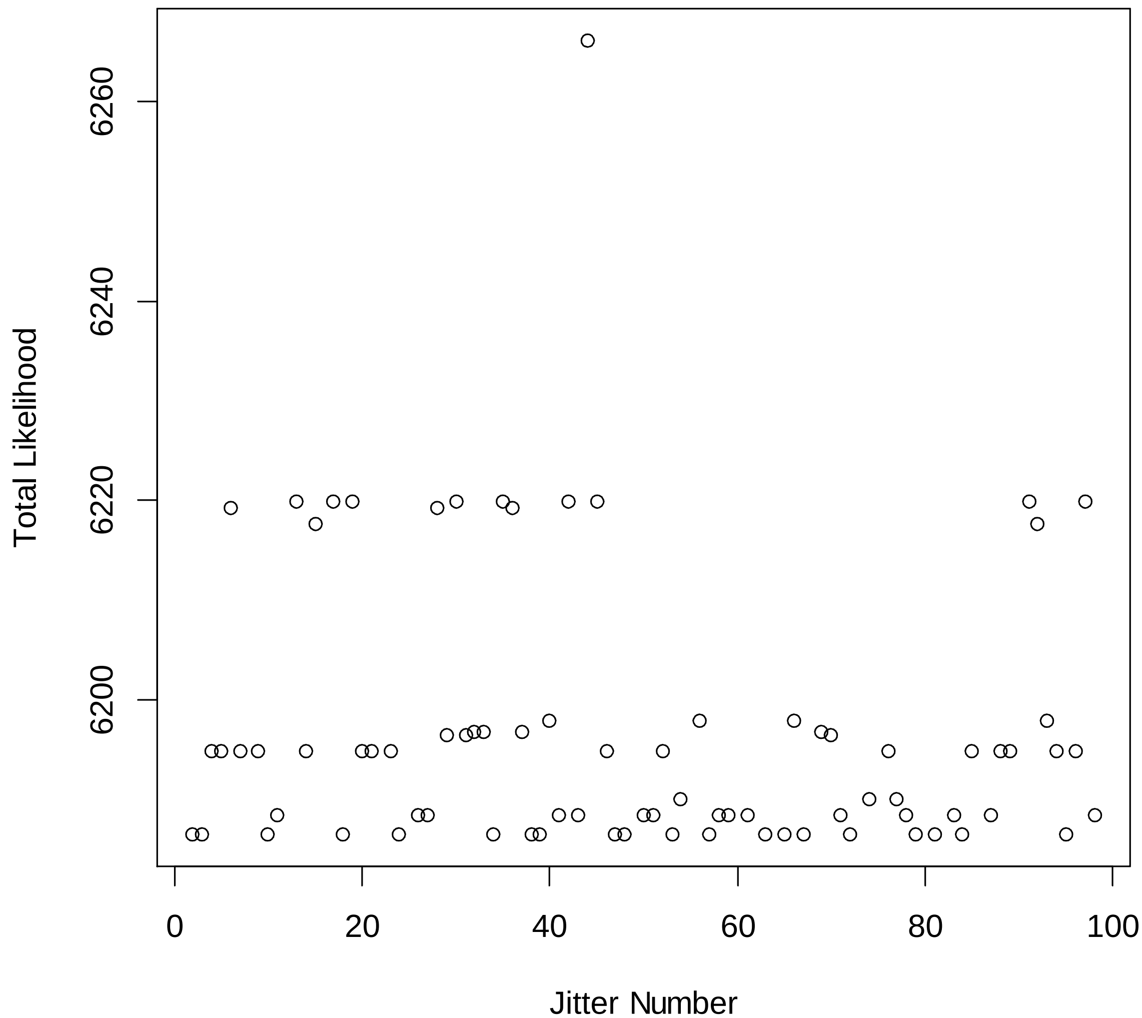


Figure 128. Model 17a. Lowest Likelihood was 6186.37 with 20 runs.

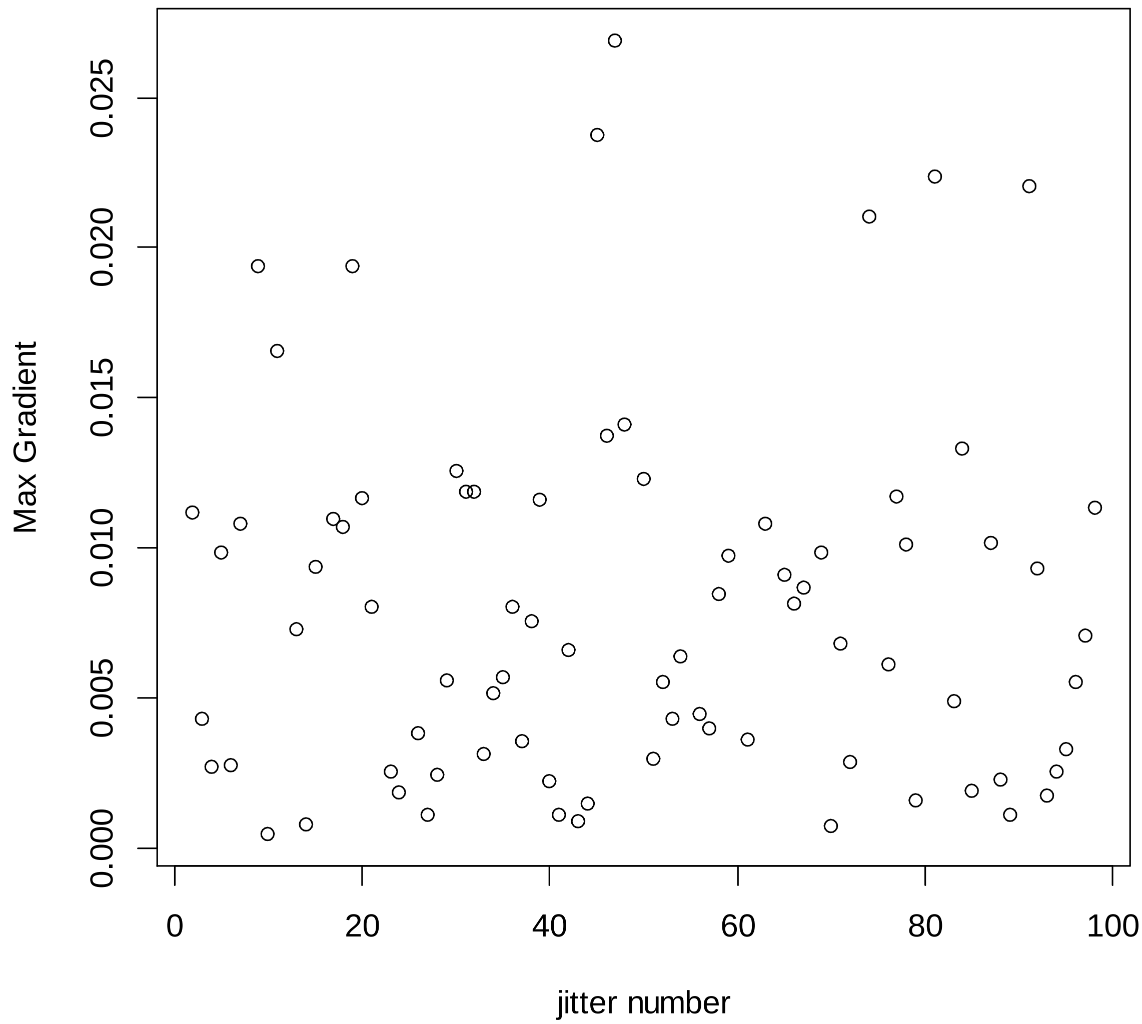


Figure 129. Model 17a. Maximum gradient by jitter run.

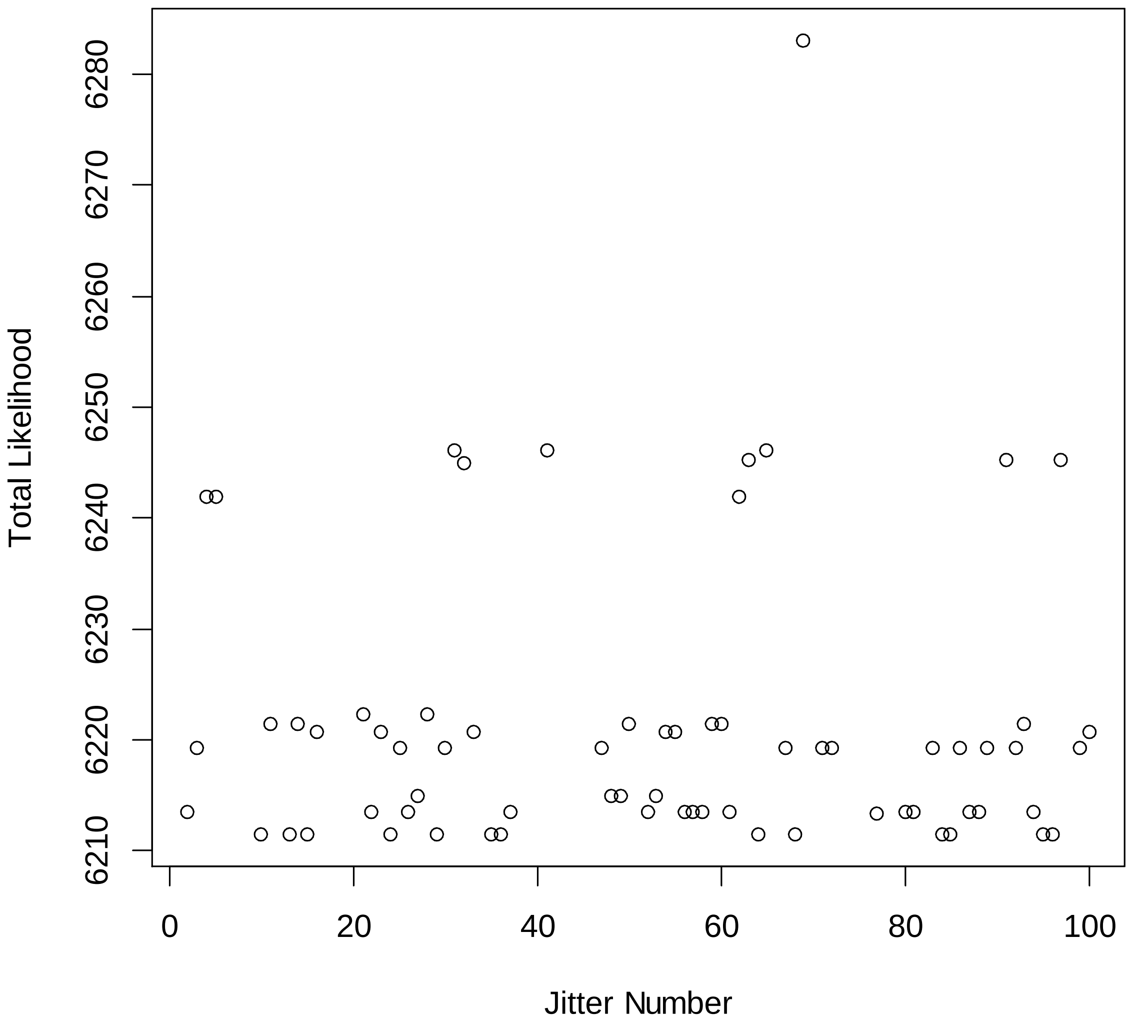


Figure 130. Model 17b. Lowest Likelihood was 6211.47 with 13 runs.

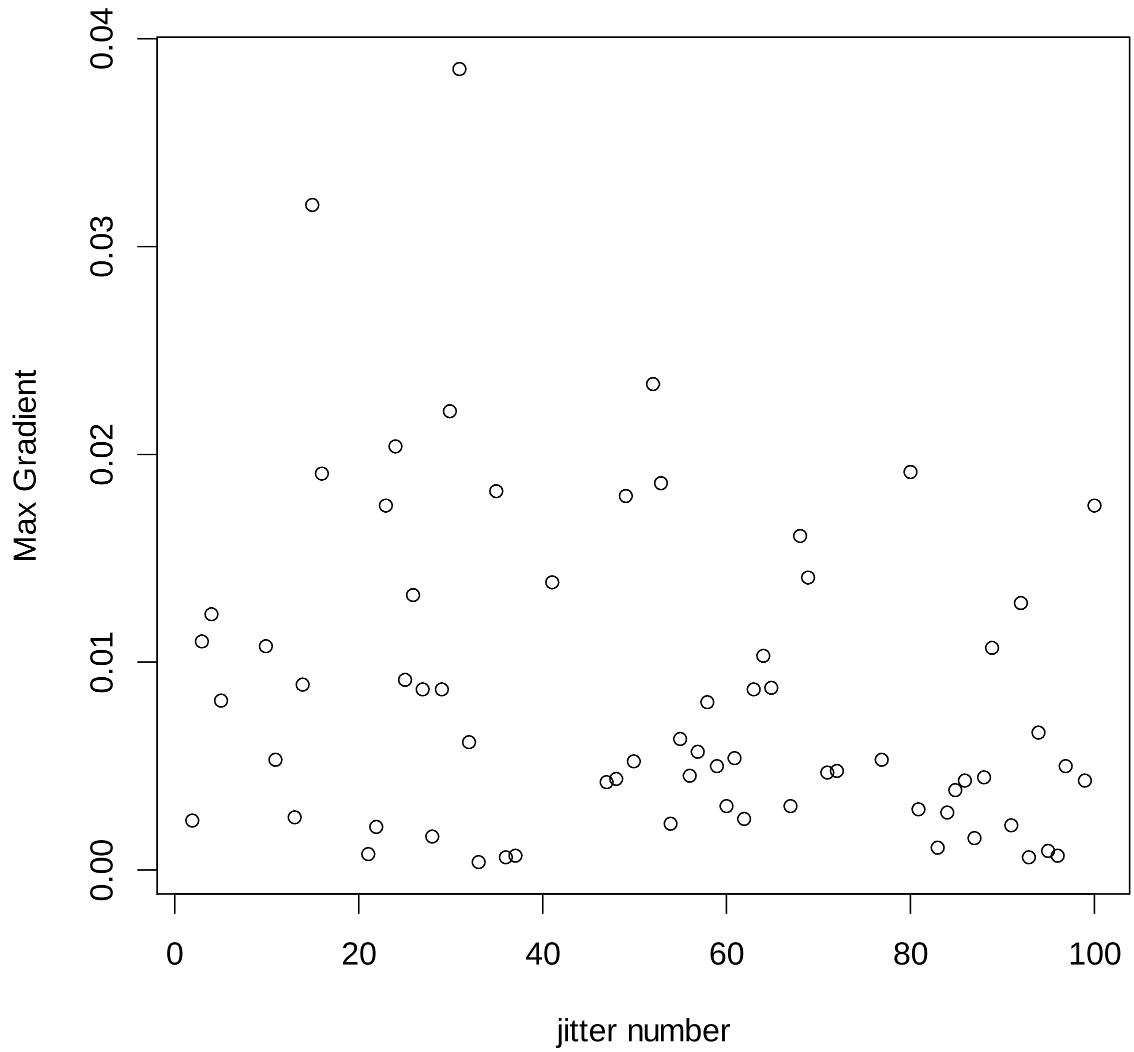


Figure 131. Model 17b. Maximum gradient by jitter run.

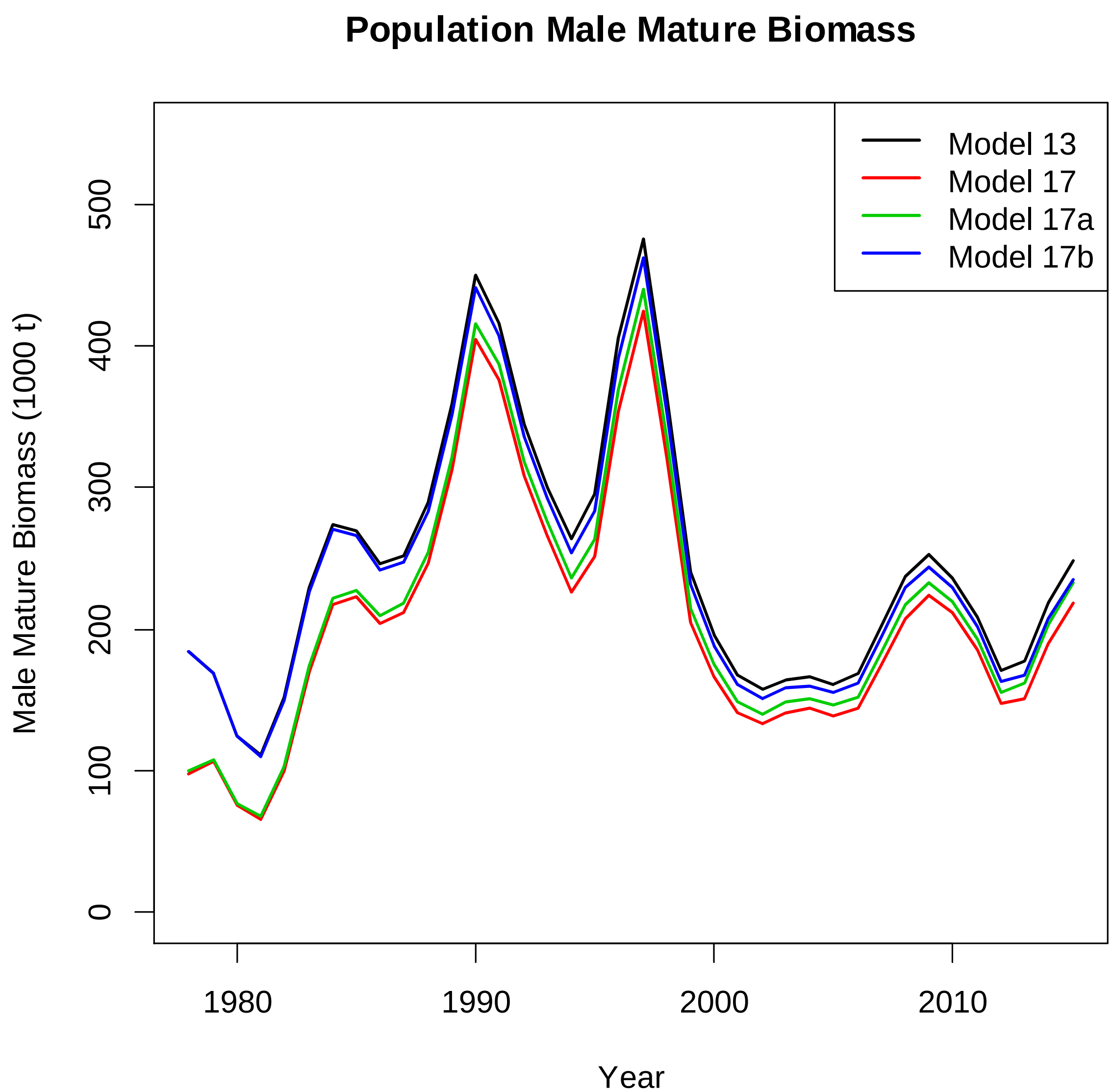


Figure 132. Population mature male biomass comparison between models 13, 17, 17a and 17b.

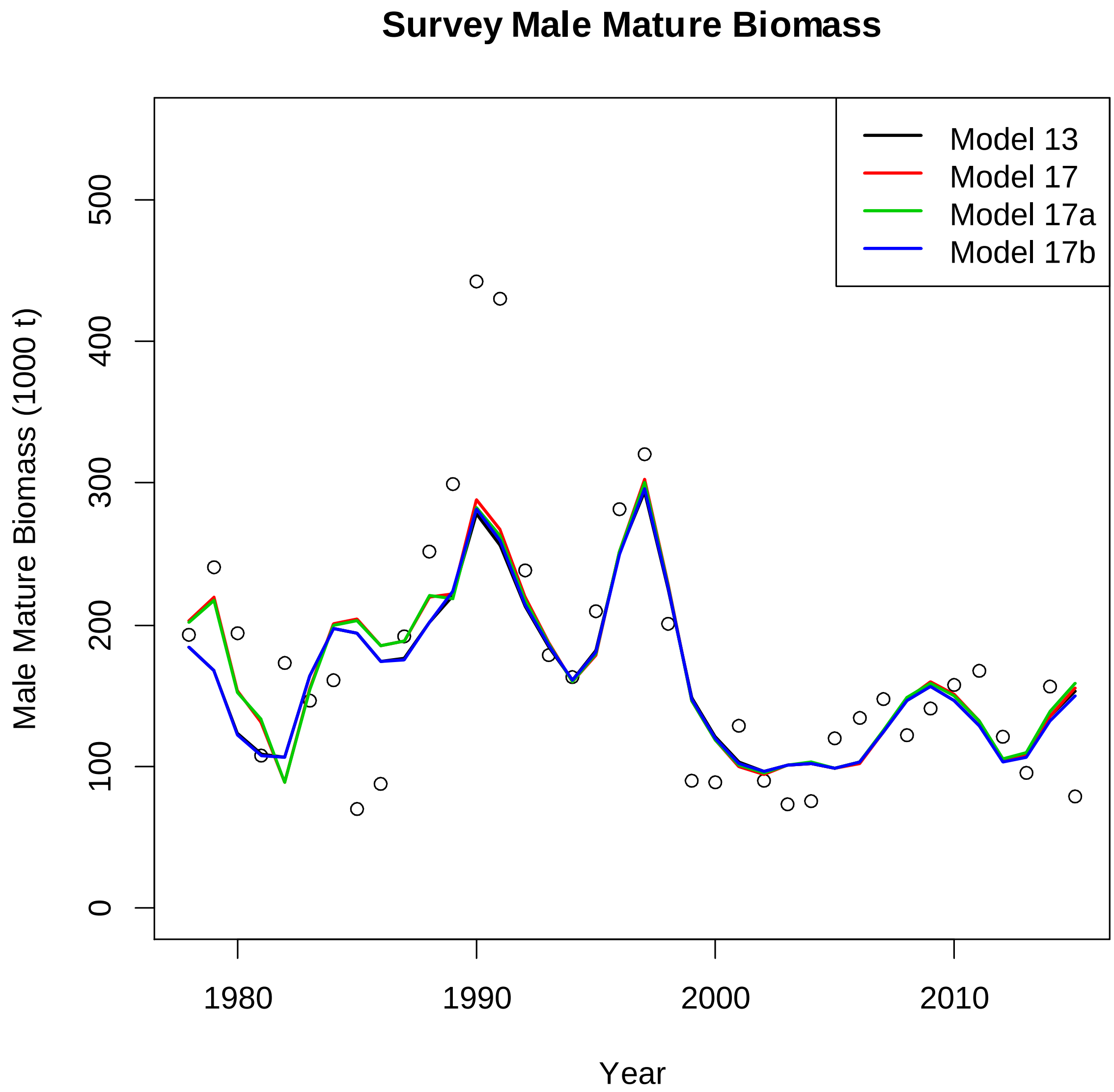


Figure 133. Model fit to mature male biomass comparison between models 13, 17, 17a and 17b.

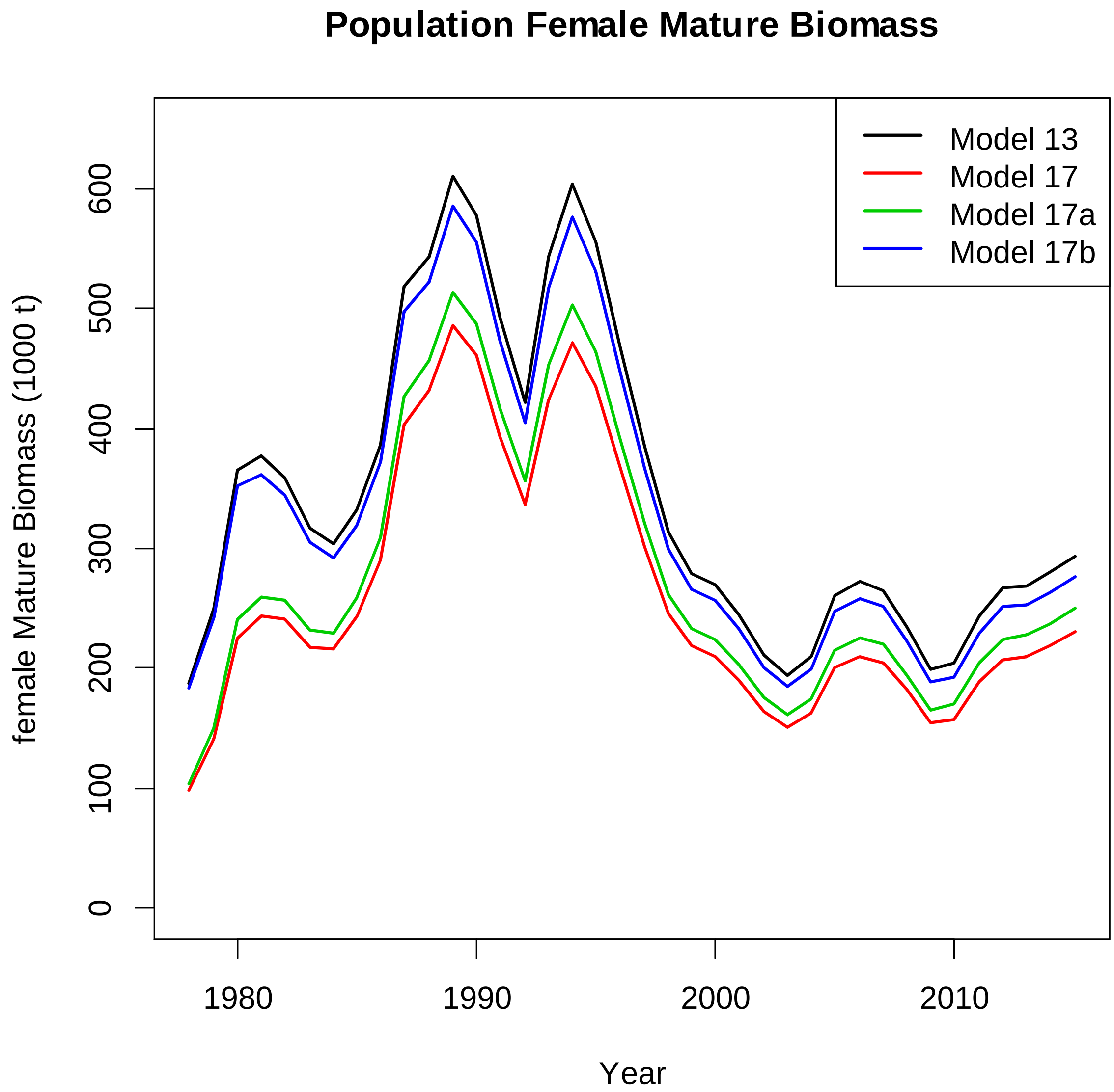


Figure 134. Population mature female biomass comparison between models 13, 17, 17a and 17b.

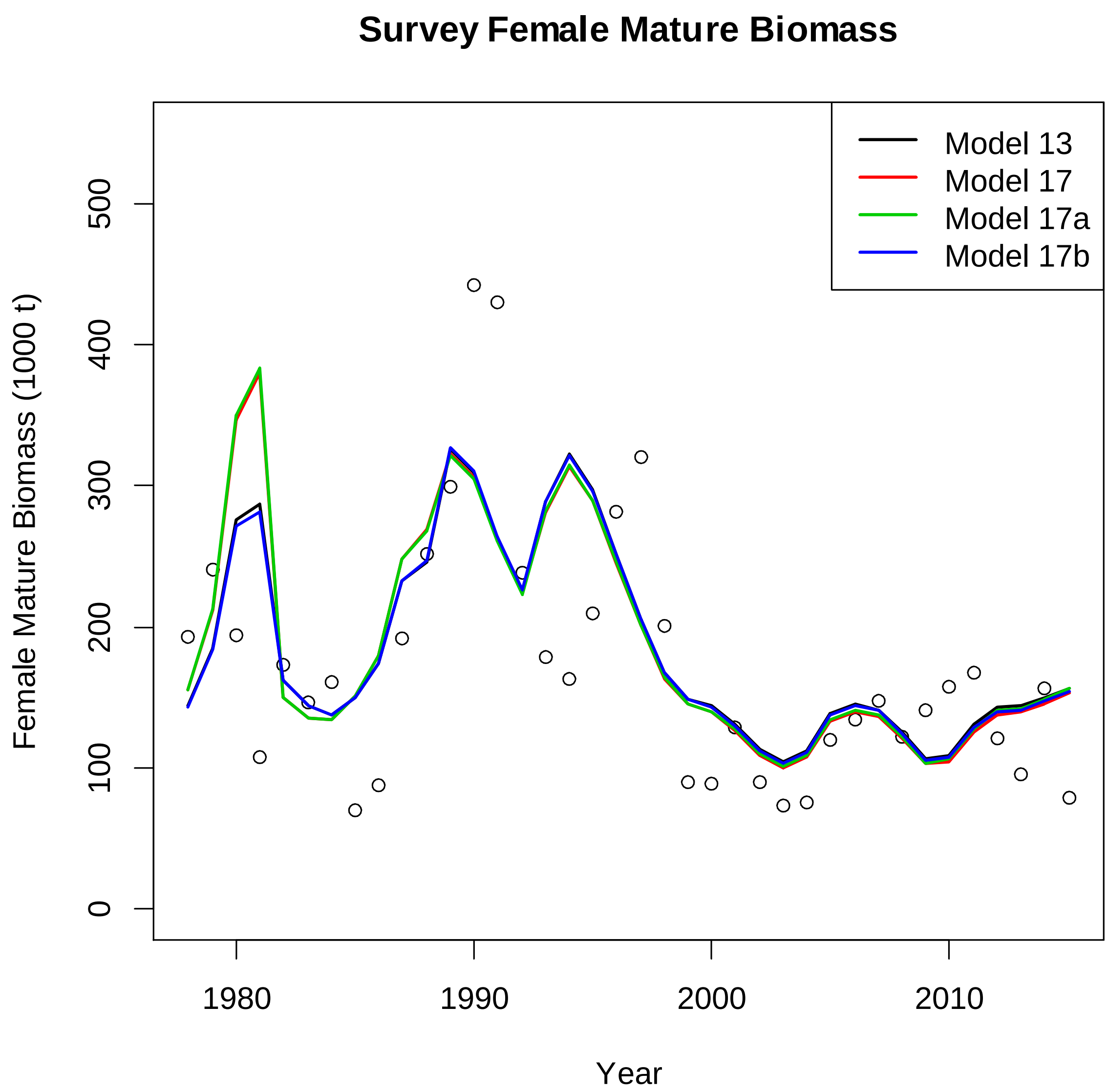


Figure 135. Model fit to mature female biomass comparison between models 13, 17, 17a and 17b.

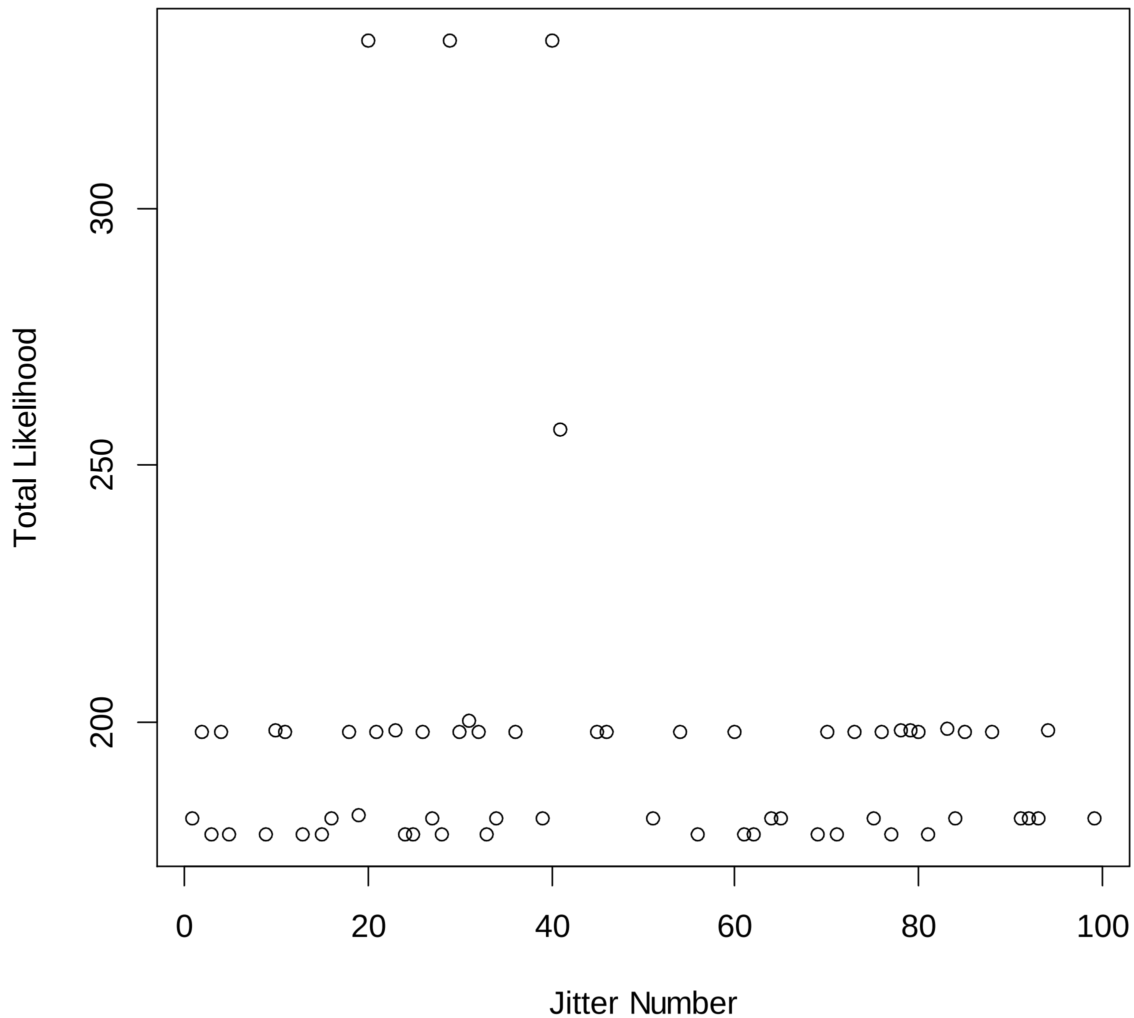


Figure 136. Model 18c. Lowest likelihood was 178.09 with 10 runs. 61 runs out of 100 wrote the std file.

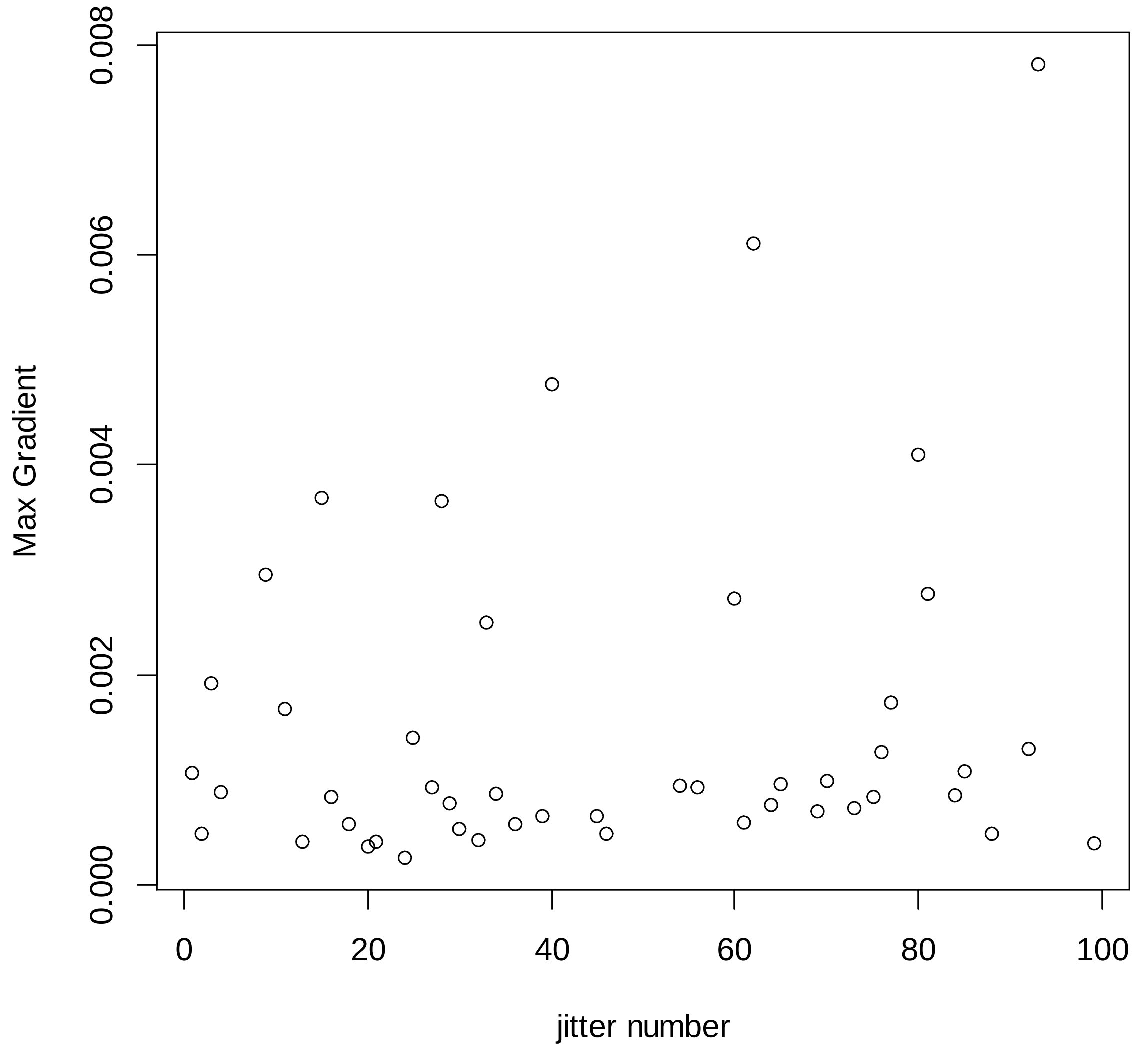


Figure 137. Model 18c. Maximum gradient vs jitter run.

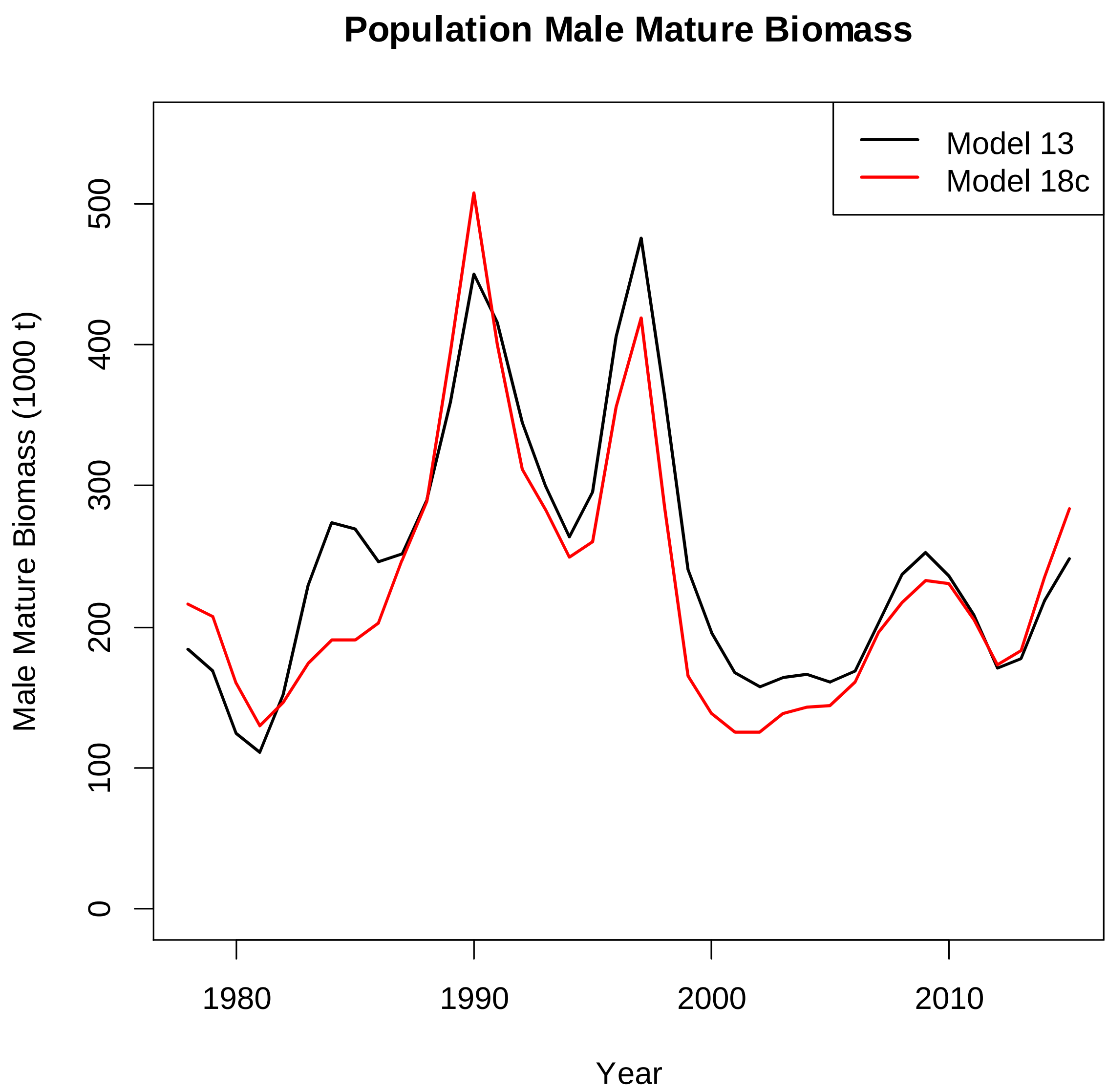


Figure 138. Population mature male biomass comparison between models 13 and 18c.

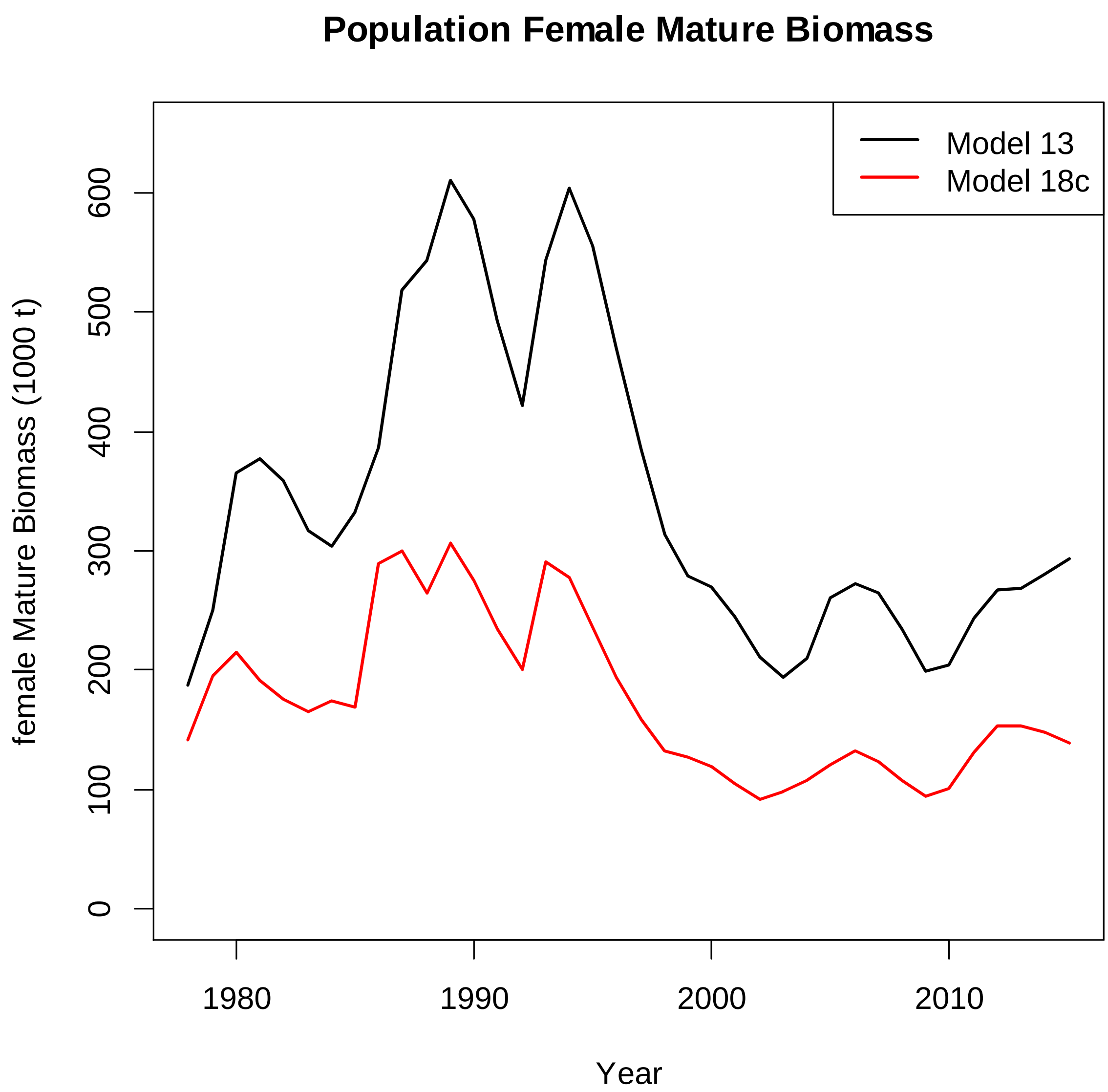


Figure 139. Population mature female biomass comparison between models 13 and 18c.

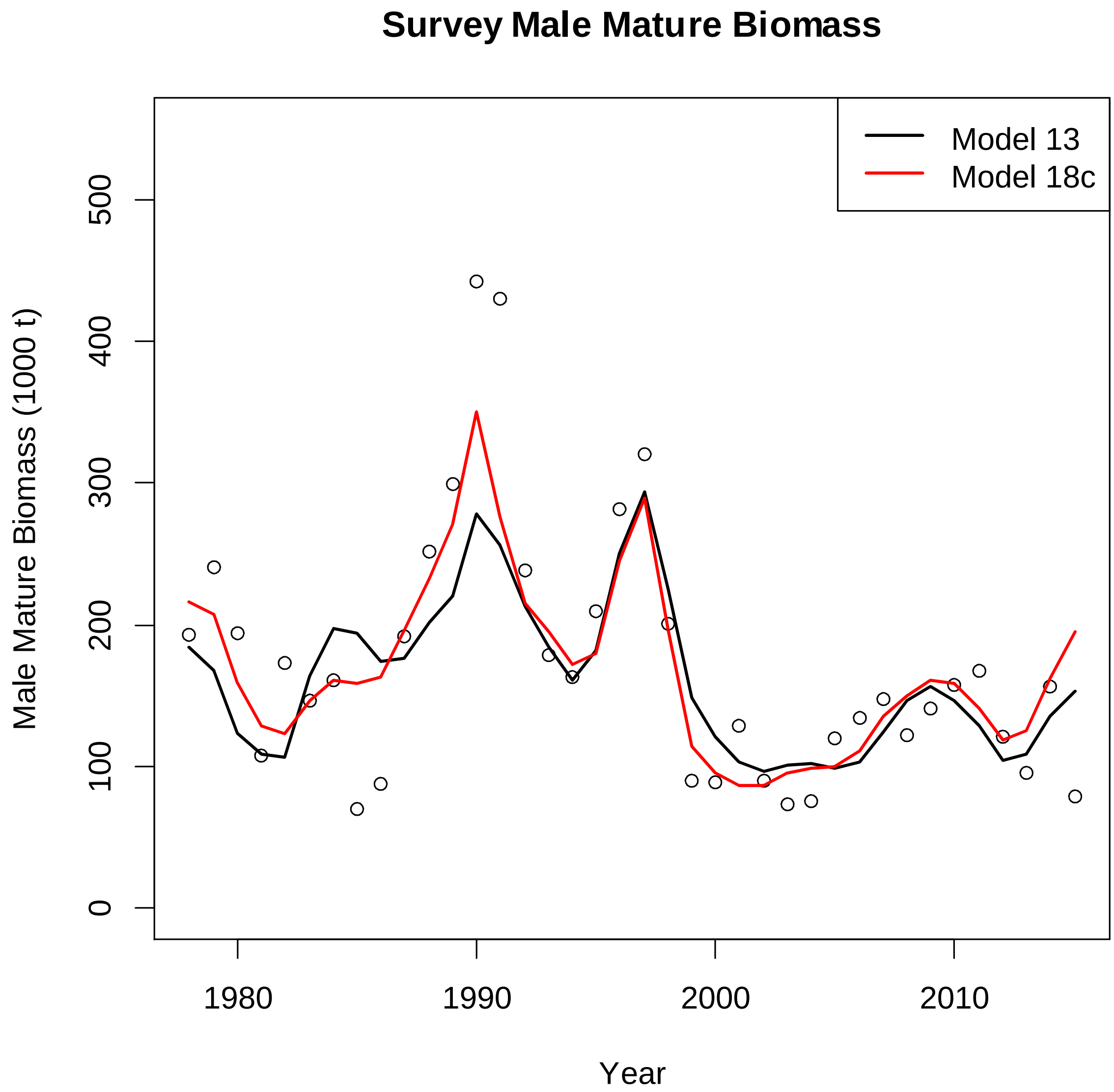


Figure 140. Fit to mature male biomass comparison between models 13 and 18c.

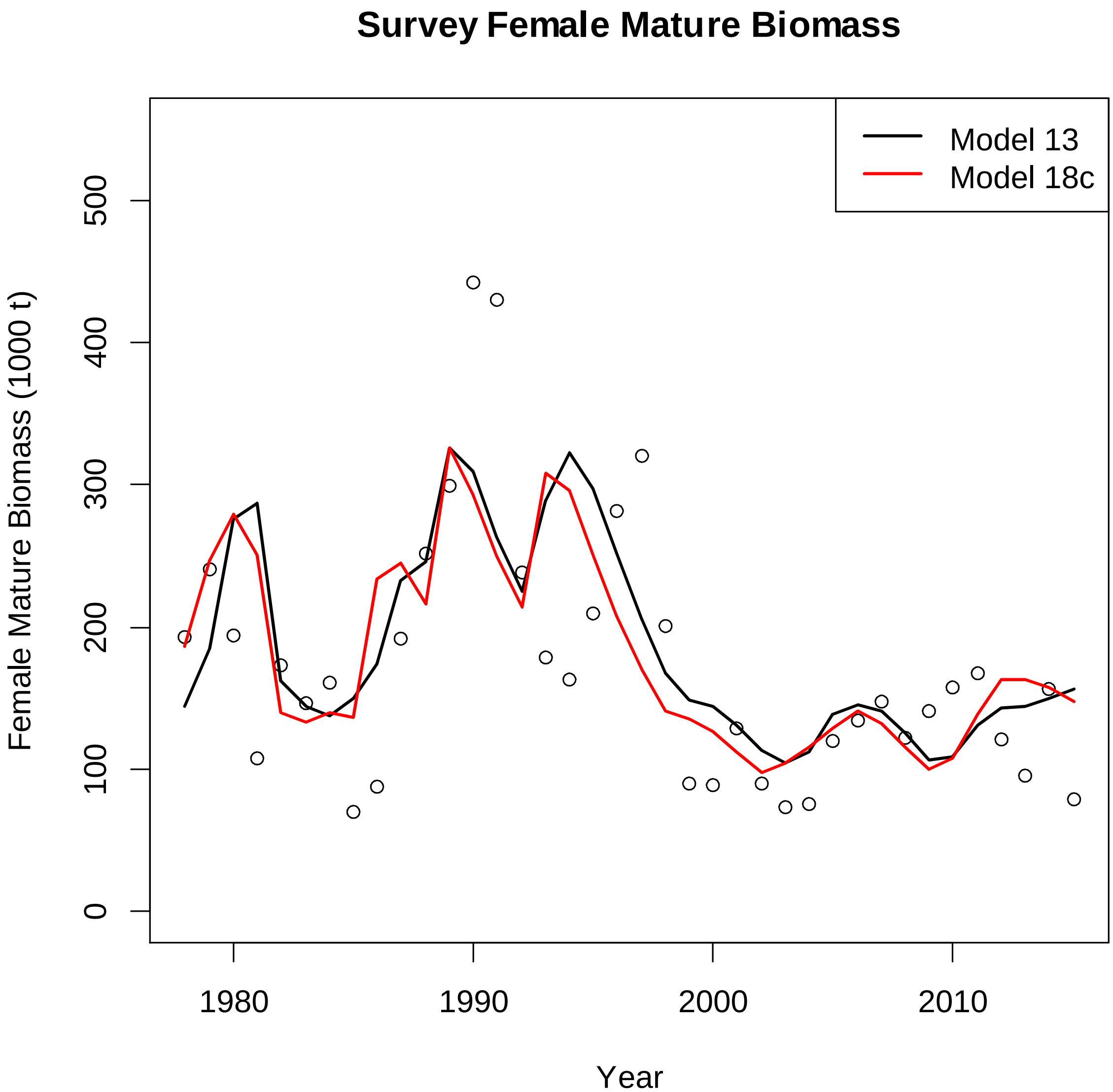


Figure 141. Fit to mature female biomass comparison between models 13 and 18c.

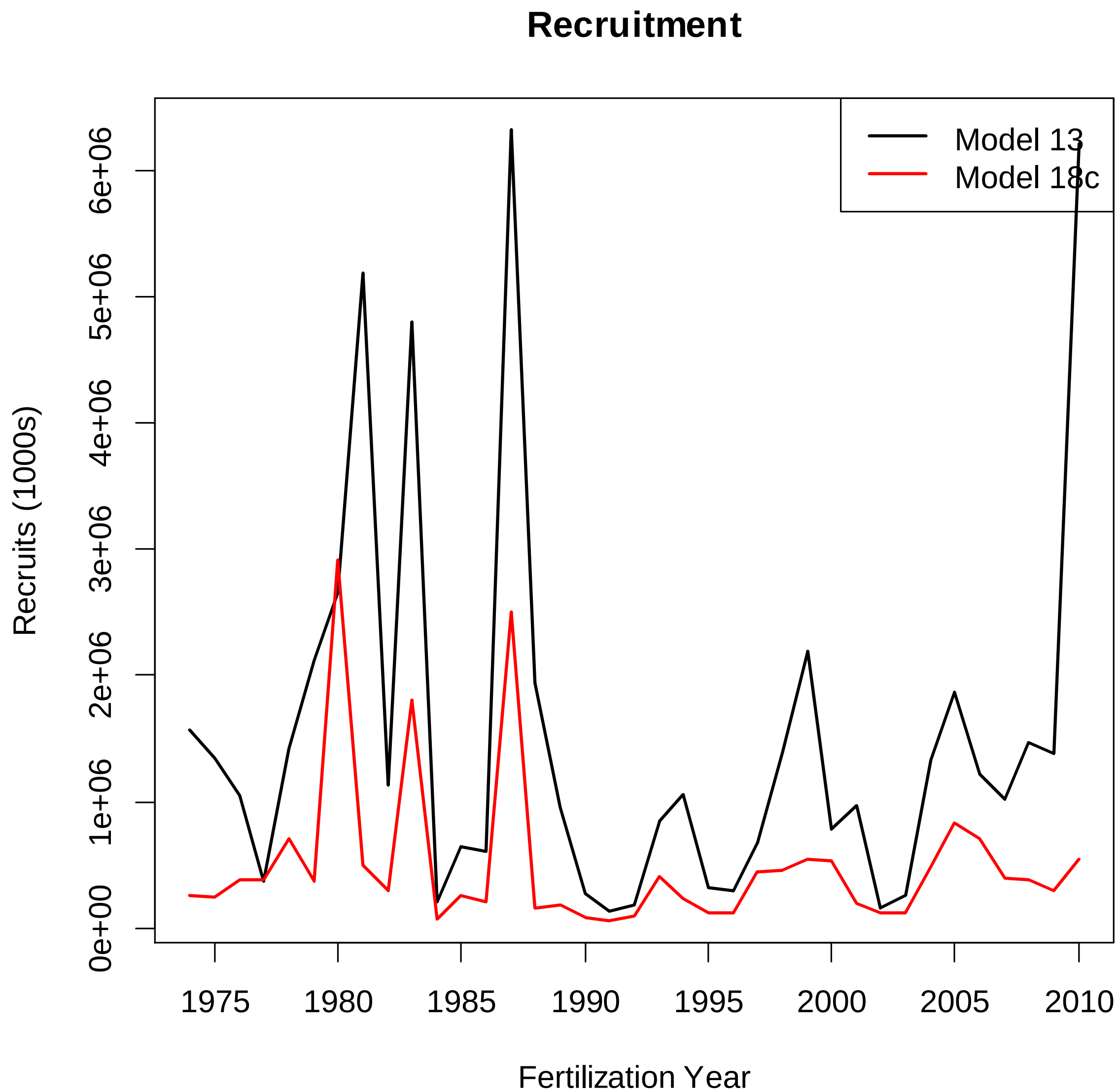


Figure 142. Recruitment estimates for models 13 and 18c.

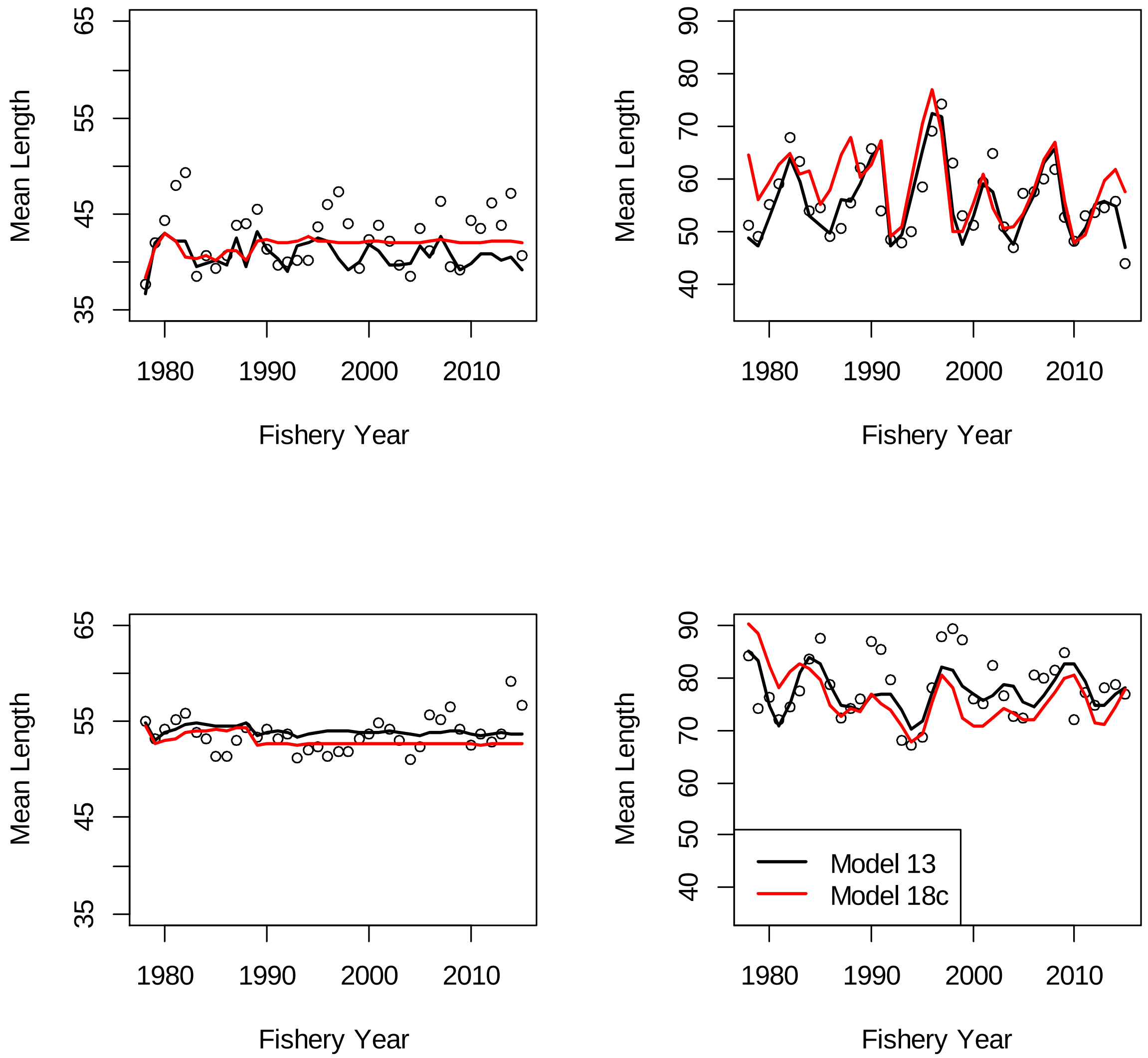


Figure 143. Observed and predicted mean length for immature females (top left), mature females (bottom left), immature males(top right) and mature males (bottom right) for Models 13 and 18c. Mean length values are used in the estimation of Francis effective N.

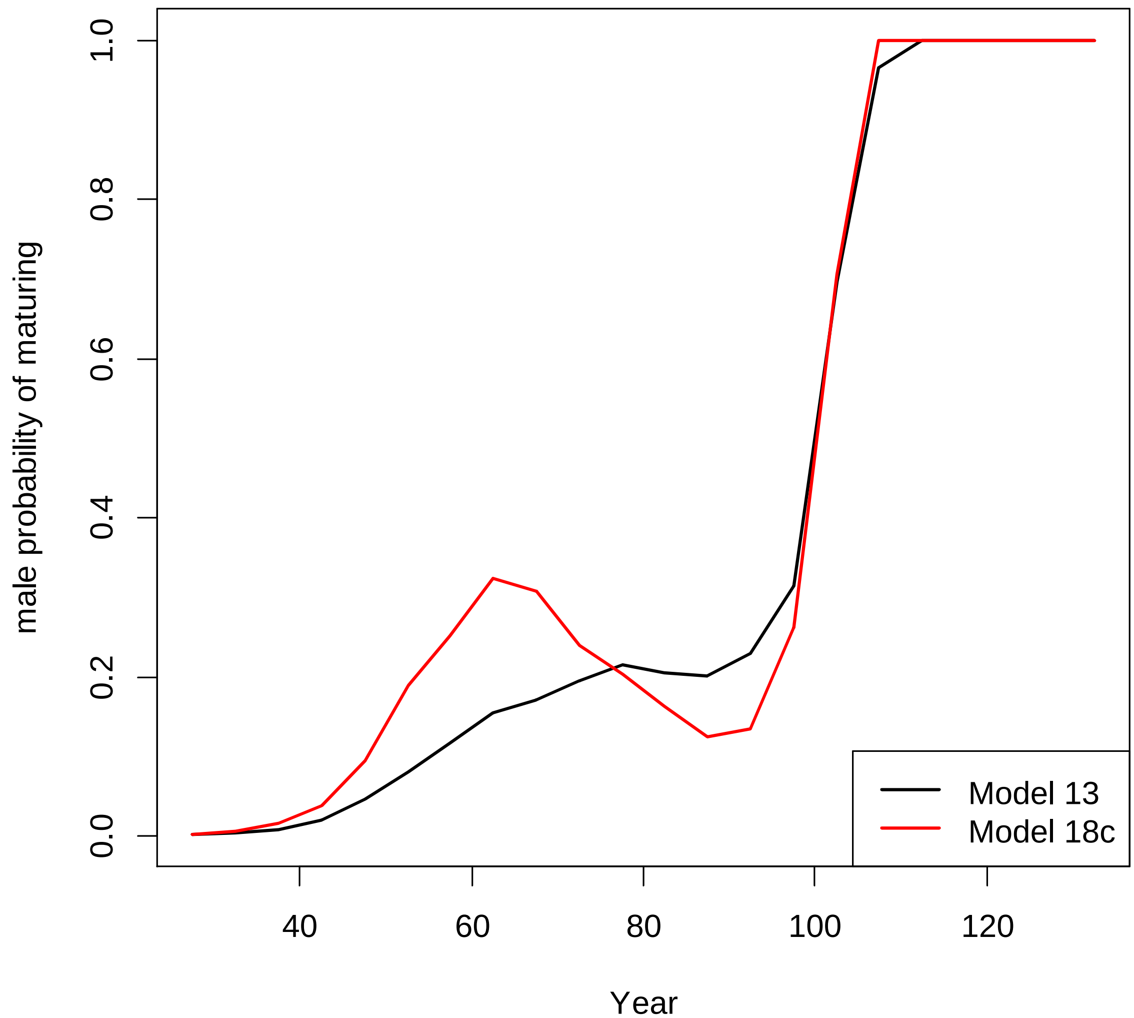


Figure 144. Probability of maturing for males for Models 13 and 18c.

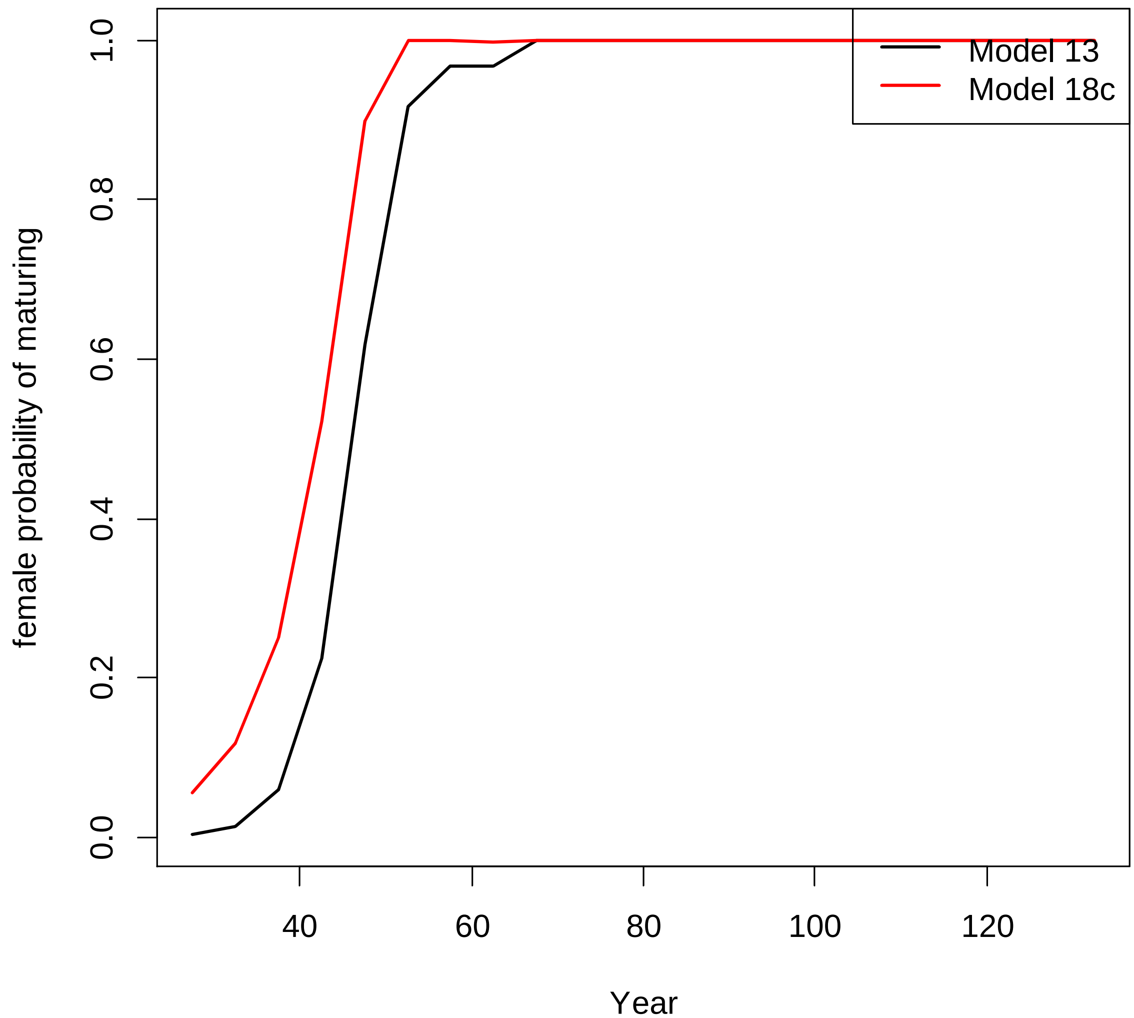


Figure 145. Probability of maturing for females for Models 13 and 18c.

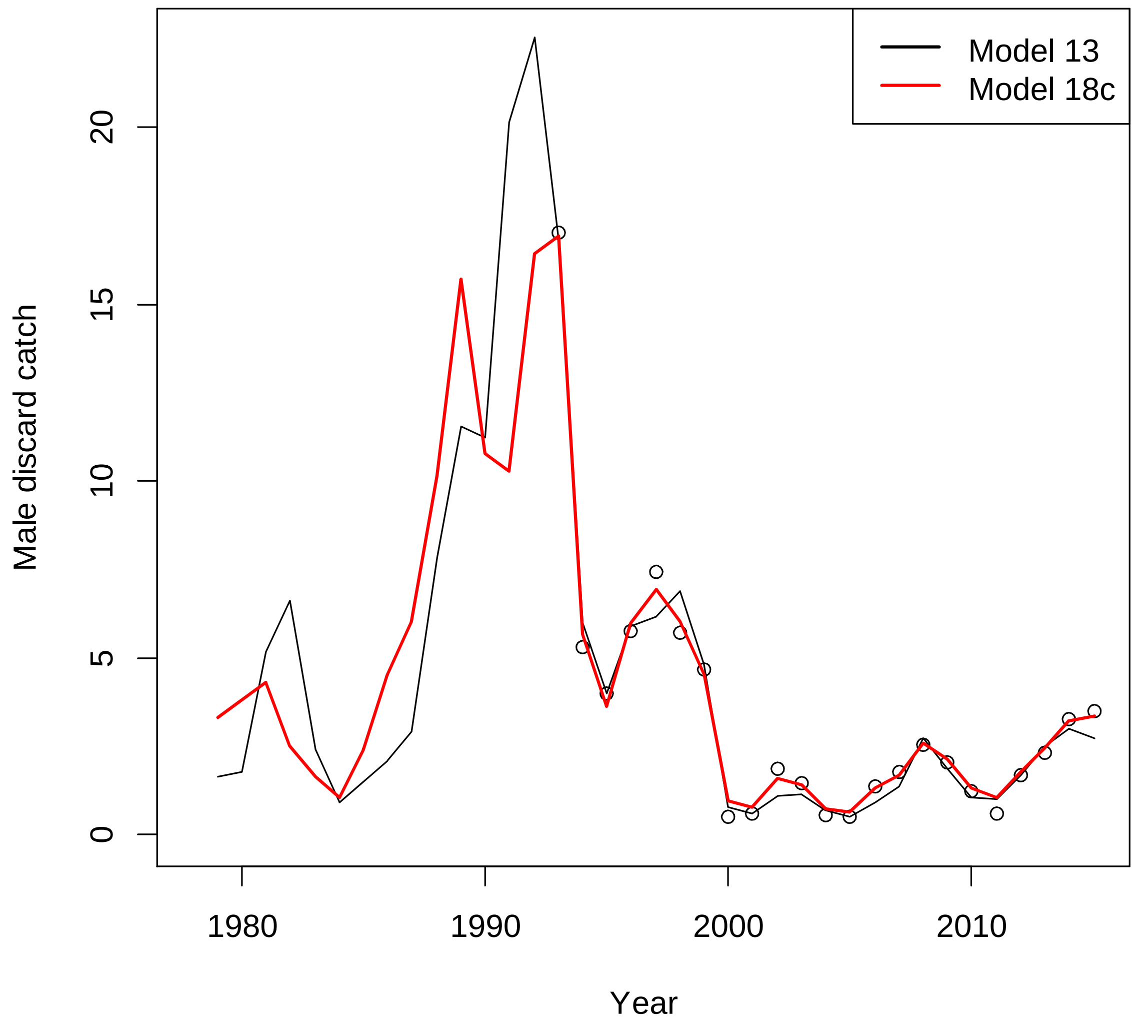


Figure 146. Fit to male discard biomass in the directed fishery for Models 13 and 18c.

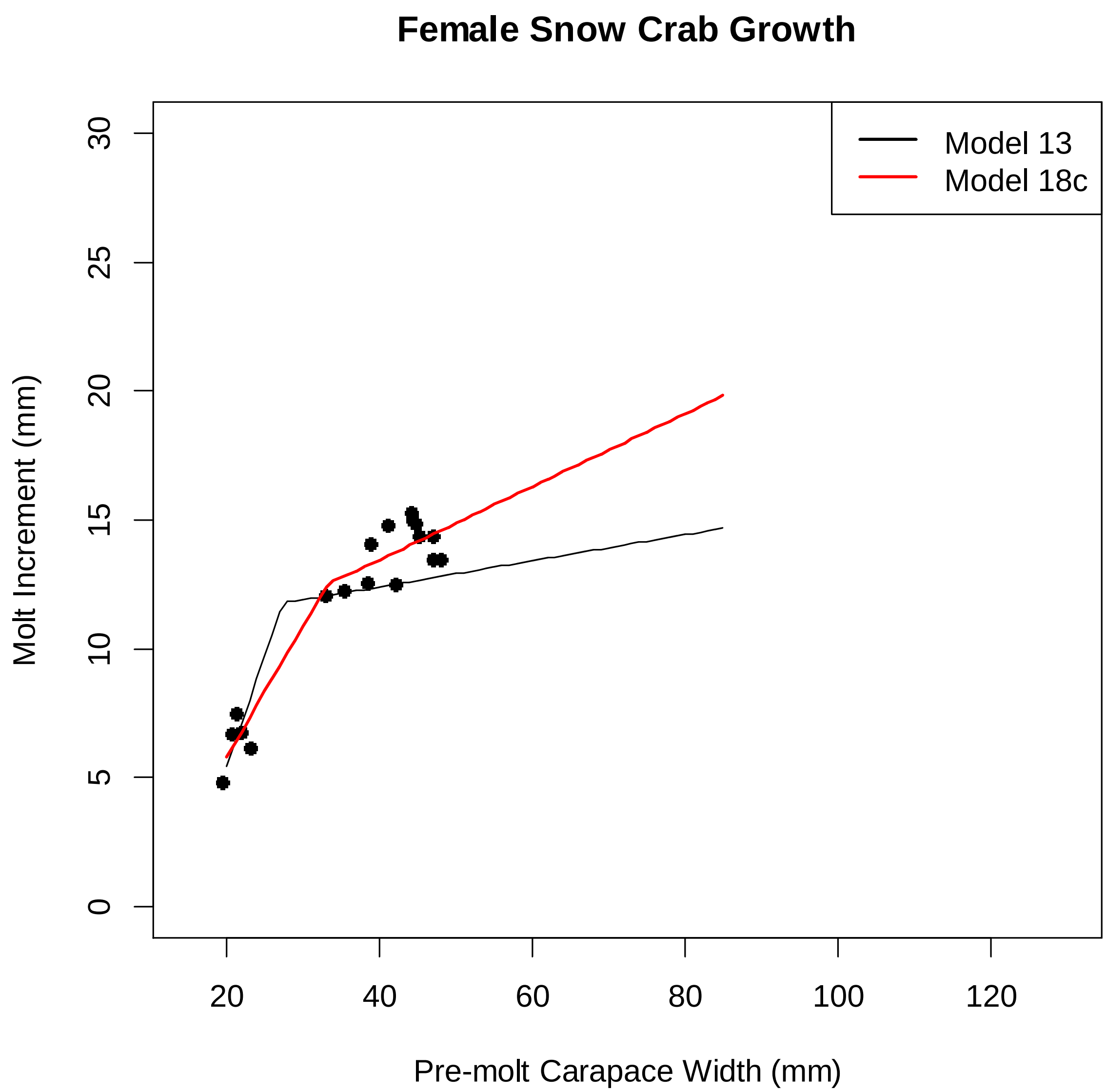


Figure 147. Fit to female growth for Models 13 and 18c.

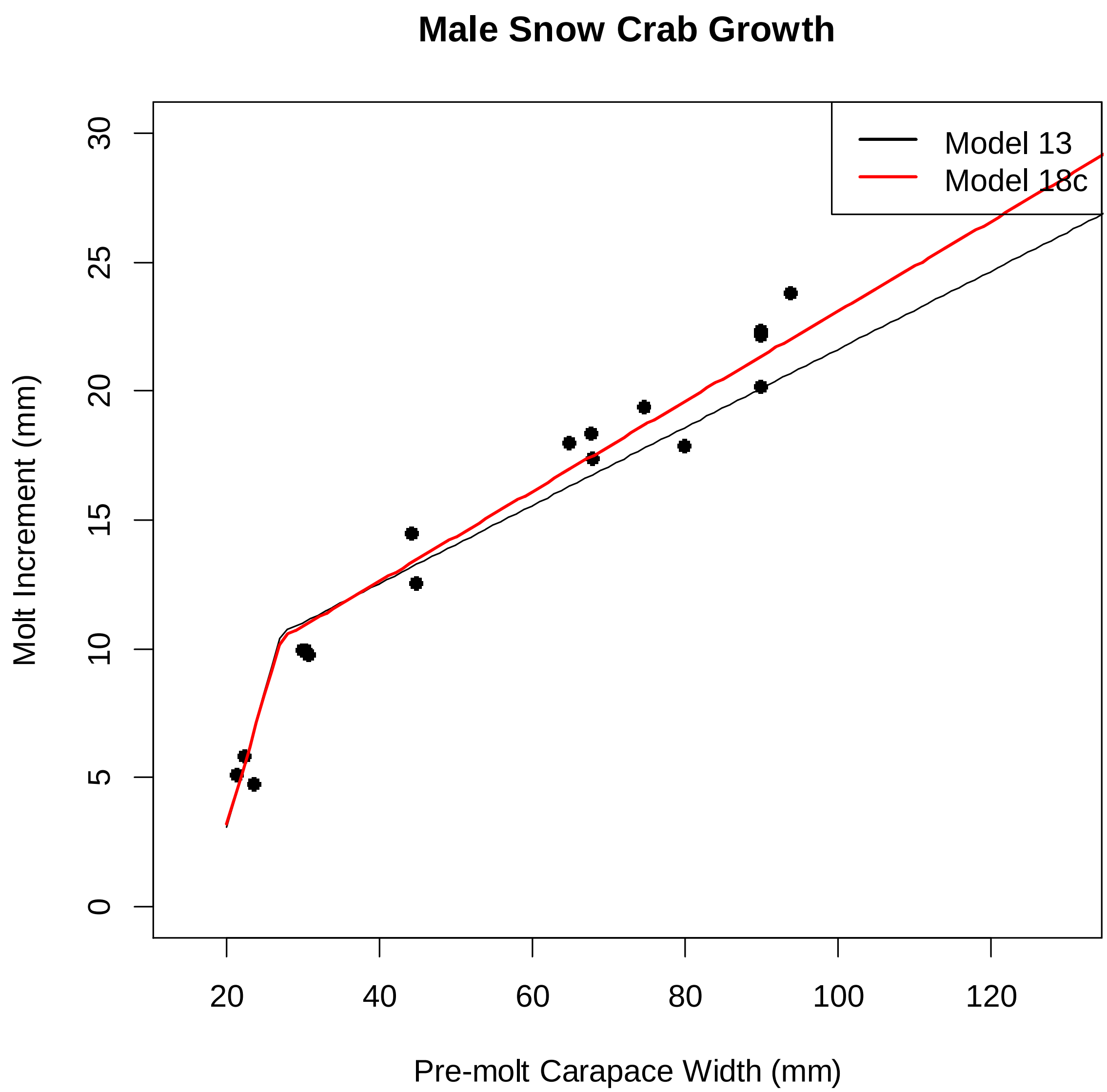


Figure 148. Fit to male growth for Models 13 and 18c.

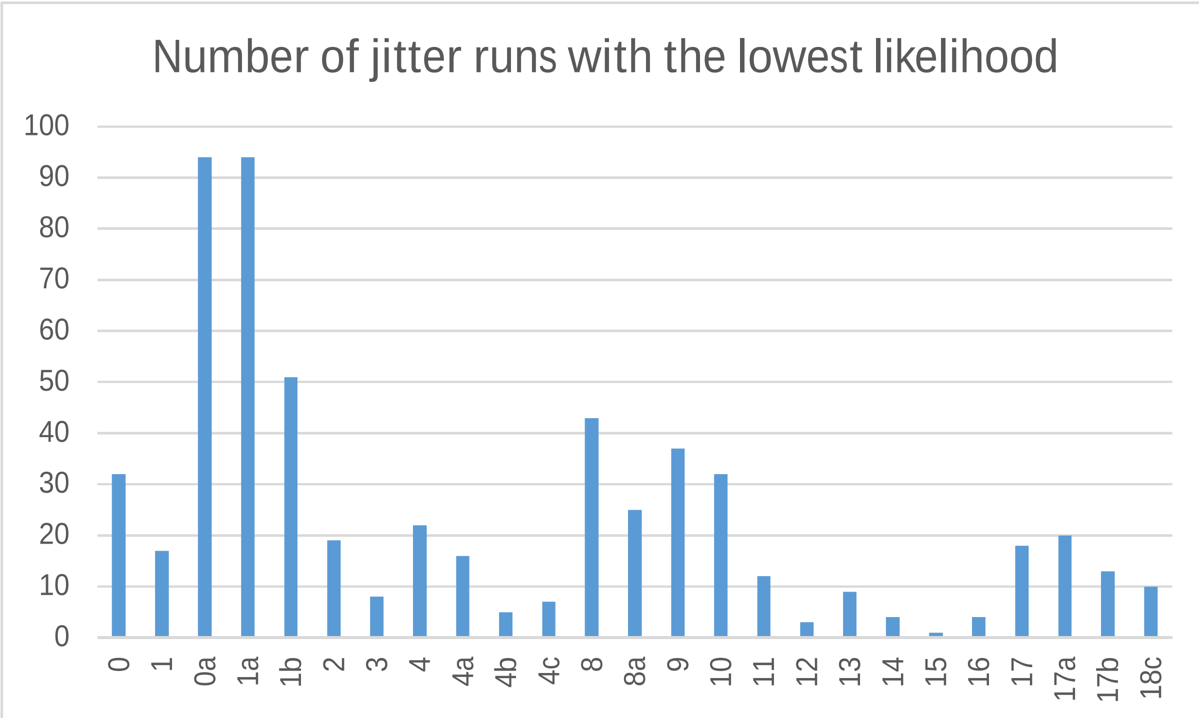


Figure 149. Number of jitter runs with lowest likelihood by model scenario.