now crab assessment 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 (sort of) (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 and Model 1, no intermediate models were run.

Provide both the potlift data and the protocol used to extrapolate post-1991 discard data to

-1992 historical female discards.

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

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

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

odels 4 and 5 use an F penalty vector that is not broken out over time; evaluate a or broken over time.

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

plore a scenario in which the weight of the trawl discard likelihood is increased.

number 4 above.

Comments October 2015

e SSC requests adding a table of commercial fishery CPUE to the annual stock ssment; considerations of fishery CPUE could be investigated to help reconcile data icts.

s of fishery CPUE vs Model estimated CPUE are included in the plot files for ence. The q for estimating CPUE in the model is fixed and the fit is not included in kelihood. A table of fishery CPUE can be added to the assessment document as 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 and 1b explore fixing the transition point for growth and the effect on model stability.

More data near the transition point should improve stability

6. The SSC requests the reporting of additional model diagnostics, such as plots of retrospective patterns, plots of residuals from alternative model fit 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

pleted model scenarios are described in Table 1. Model scenarios were cho
ess CPT and SSC comments and to step through the transition from Model 0
el 5 (of September 2015). Other model scenarios were added based on rev
in AFSC as work progressed.

els 0 and 1 are the same as Models 0 and 1 from September 2015.

- Model 0 has two line segments for growth, transition points estimated, sd fixed at 0.5.
- Model 1 has reparameterized 95% selectivity parameters to an offset
  from 50% and survey q for 1978-1981 and 2010 BSFRF study area q on probit scale

els 0a, 1a and 1b explore how fixing the growth transition point for males a
ales effects model stability and convergence. Transition parameters were fix
average between model 0 and model 1 from sept 2015

- Model 0a – model 0 with growth transition for males and females fixed
- Model 1a – model 1 with growth transition for males and females fixed
- Model 1b – model 1 with growth transition for females fixed
- Model 1c – is no model 1c

els 2, 3, 4, 4a, 4b and 4c remove fishing mortality penalties.

Model 2 removes male fishing mortality penalties for 1992 to present

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.

$$potf = \frac{\sum \frac{potlifts(1992, y)}{F(1992, y)}}{(y - 1992)}$$

$$F(1978{,}1991) = \frac{potlifts(1978{,}1991)}{potf}$$

Models 4a and 4b explore different methods of estimating q for females (suggested from AFSC review).

- Model 4a – estimates q using likelihood component

$$\sum_{y=1978}^{2014} (log(F_y) - \log(qf_y))^2$$

F (1978,1991)= q*potlifts(1978,1991)

Model 4b – uses 1992 to 2014 only in the likelihood to estimate q

$$\sum_{y=1992}^{2014} (log(F_y) - \log(qf_y))^2$$

Model 4c - Model 3 with the female F penalties removed for 1992 to 2014/15 only (no use of potlifts). Female bycatch 1978-1991 estimated outside model using relationship to male catch.

Model Scenarios

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 this resulted in a good fit to 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, males and females (Model 11).

Model Scenarios

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.

Model Scenarios

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

- Model 14 - Model 13 with weight on growth likelihood for males increased from 1 (sd=0.7) to 2 (sd=0.5)
- Model 15 - Model 13 with weight on growth likelihood for females increased from 1 (sd=0.7) to 2 (sd=0.5)
- Model 16 - Model 13 with weight on growth likelihood for both males and females increased from 1 (sd=0.7) to 2 (sd=0.5)

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

- Model 17 -Model 13 with the upper bound of survey q for all surveys increased to 3.0 (arithmetic scale).
- Model 17a -The upper bound on q for the first period (1978-81) survey only was increased
- Model 17b - The upper bound on q for the survey in the study area in 2010 only was increased.

Model Scenarios

Model 18c uses Francis effective sample sizes to reduce input Ns for the survey, retained and total length composition data.

$N_{??} = \tilde{N}_{??} \; w_{?}$

equation TA1.8 from Francis (2011),

$$w_j = \frac{1}{Var_{?}\left\{\frac{Æ^{?}_{??} \, ? \; ?^{?}_{??}}{??\,?\,Æ^{?}_{??}}\right\}}$$

Where $\bar{O}_{jy}$ are the mean observed lengths by year (y) and data type (j) and $\bar{E}_{jy}$ are the predicted mean lengths by year (y) and data type (j).

The sample size for length composition data for groundfish and female discards was also reduced to 15 (but not by calculating the Francis Ns).

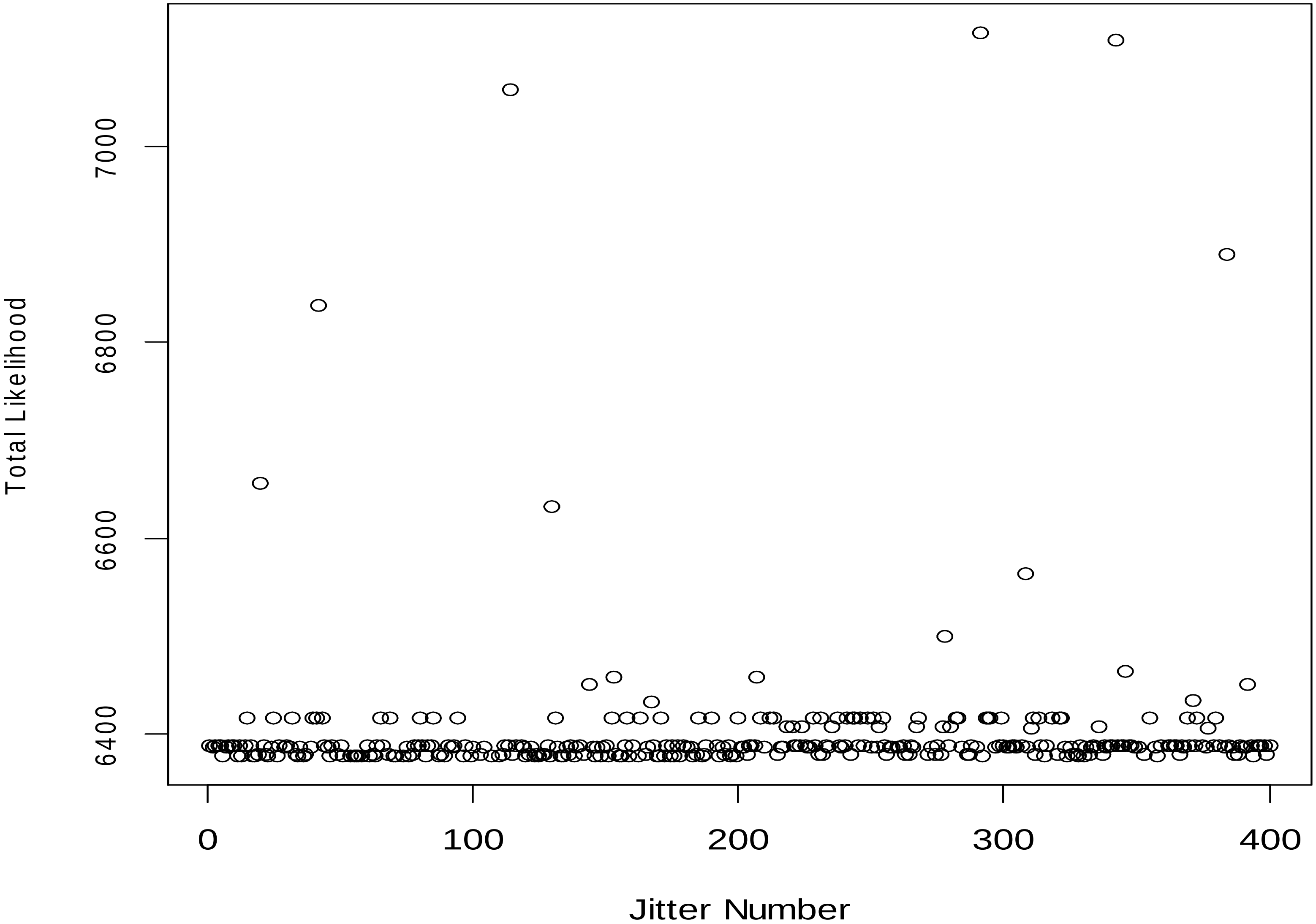
Model 18c uses Model 13 with iteration until sample sizes converged to two decimal places. Jittering was then done on Model 18c with the converged sample sizes.

ittering using R script

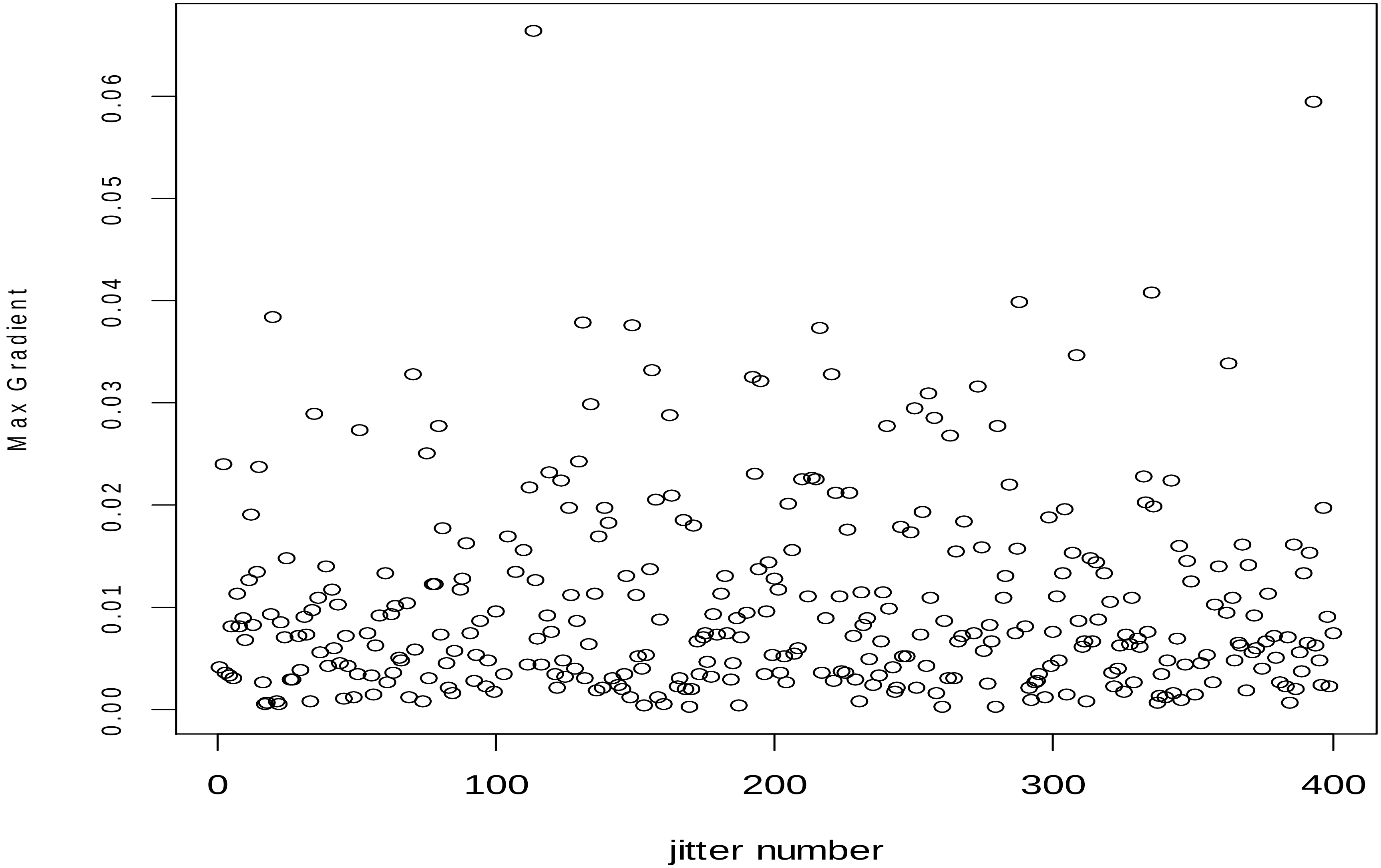
. Run model scenario
. Read in .par file
. Read in file with bounds for parameters
. Add uniform random number to 35 parameter values +/- 20%
. write out .par file
. Run model and save output files
. Repeat 4-6 100 times (mostly)

Gradients
  - Gradient is the change in likelihood relative to the change in parameter value
  - Gradients close to 0 should determine a minimum in the likelihood – however, may not be the global minimum
  - To output gradients put in the report section

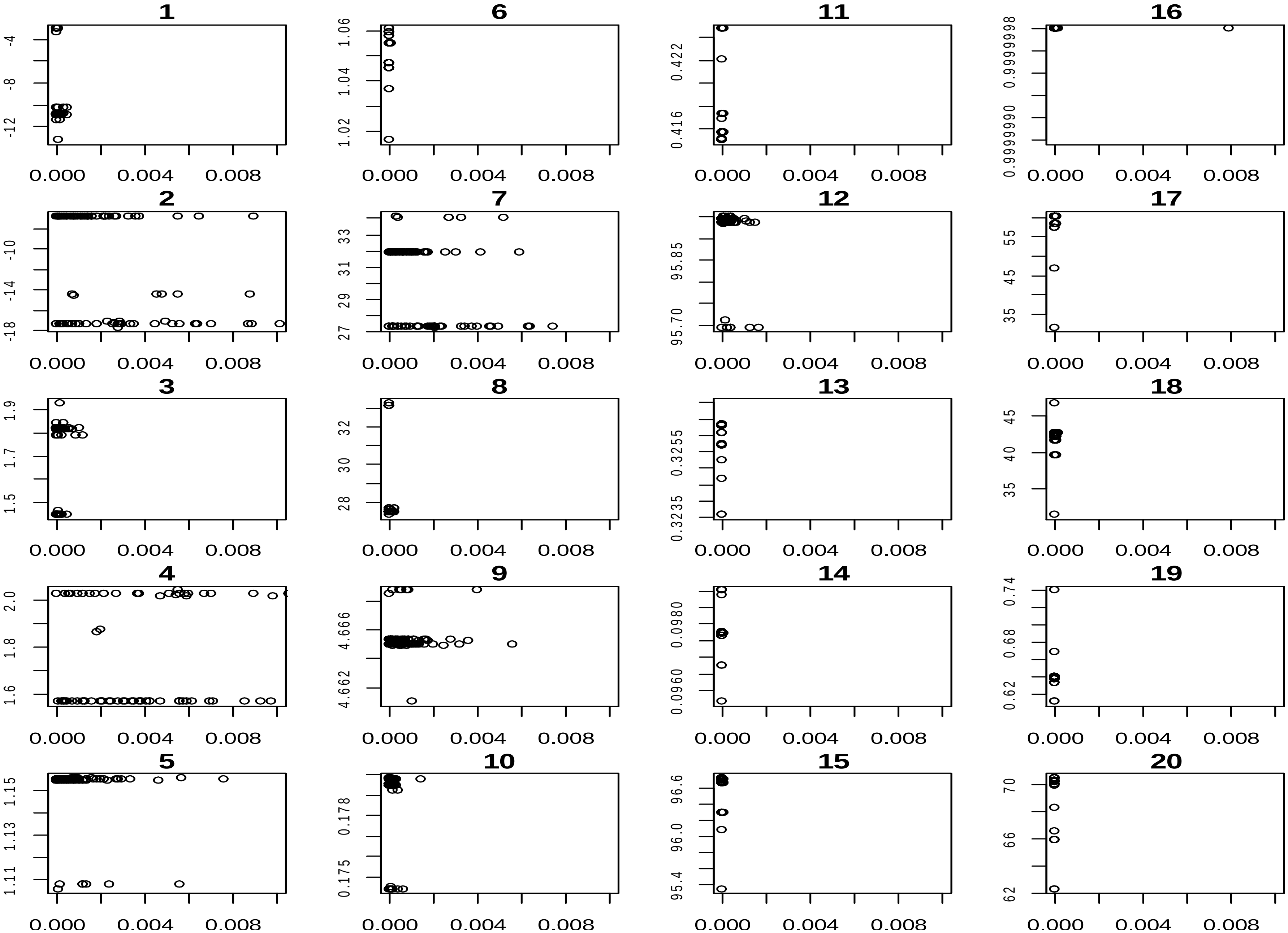
```
save_gradients(gradients);
```



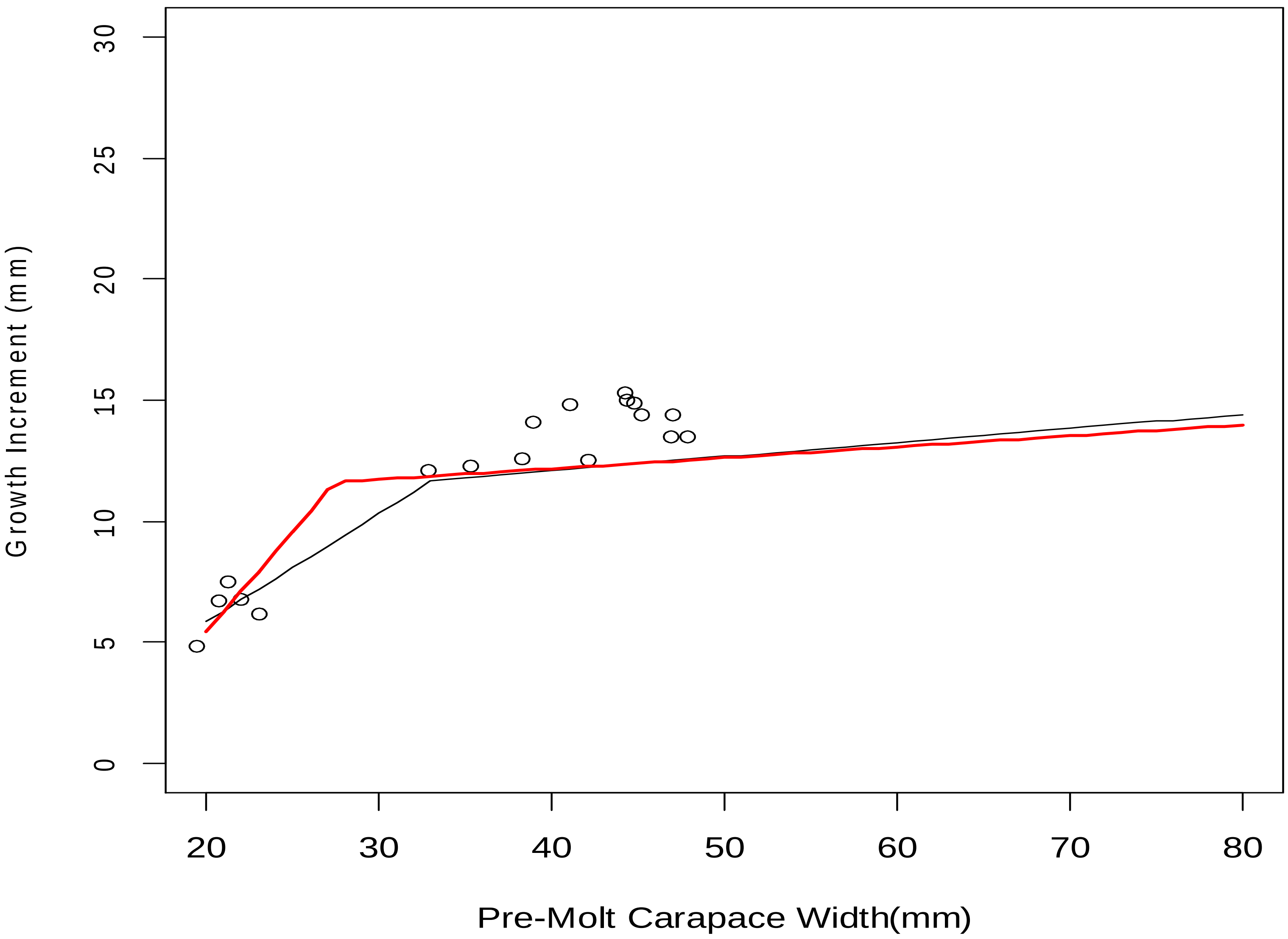
ure 2. Model 0. Total Likelihood by jitter number for runs that wrote the standard deviation file.
ee runs wrote the standard deviation file were not included in this plot that had maximum gradients greater t
uns were at the lowest likelihood (of 400).



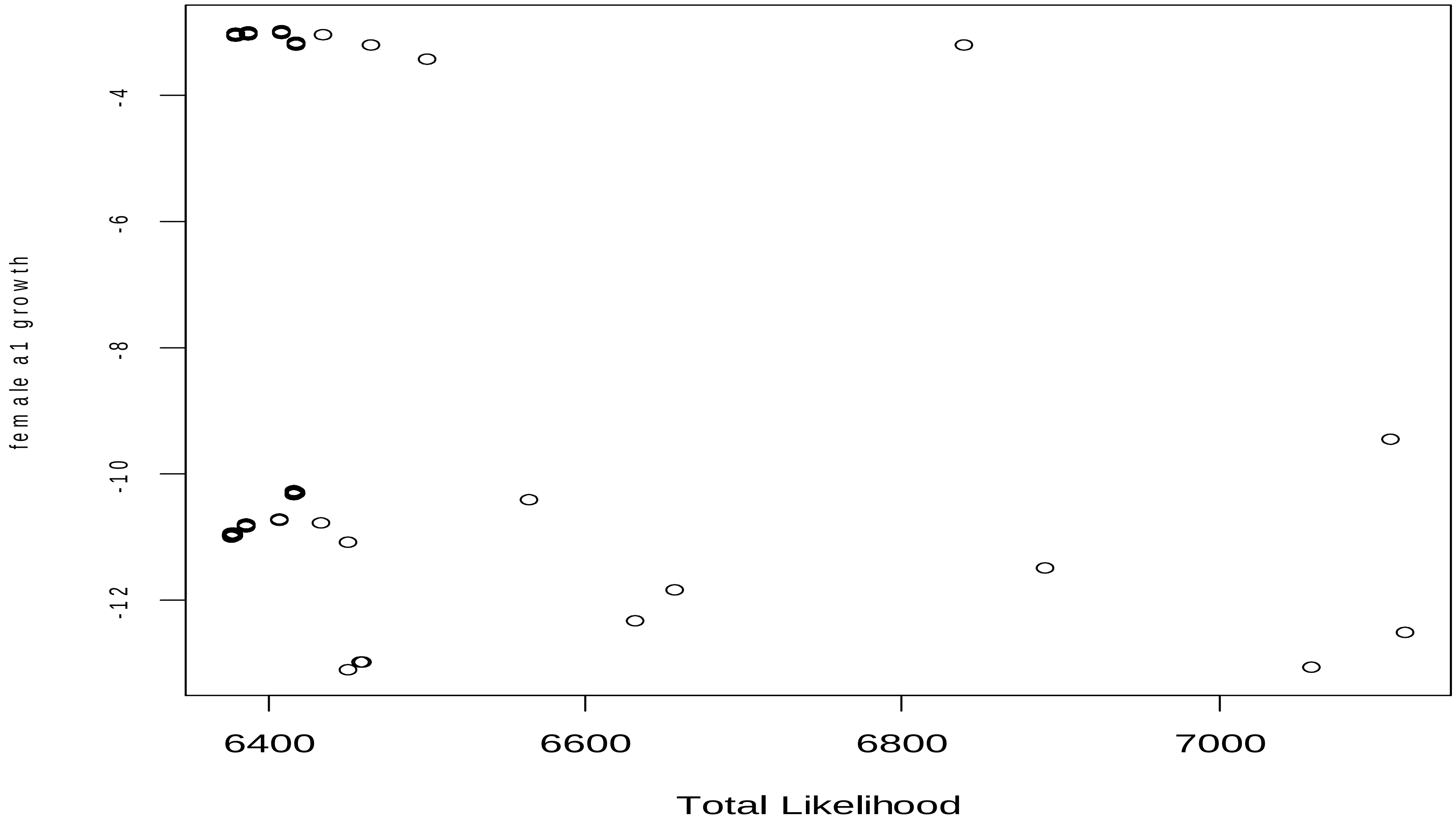
e 1. Model 0. Maximum gradient by jitter number for runs that wrote the standard deviation Three runs wrote the standard deviation file were not included in this plot that had maximum ents greater than 50.



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

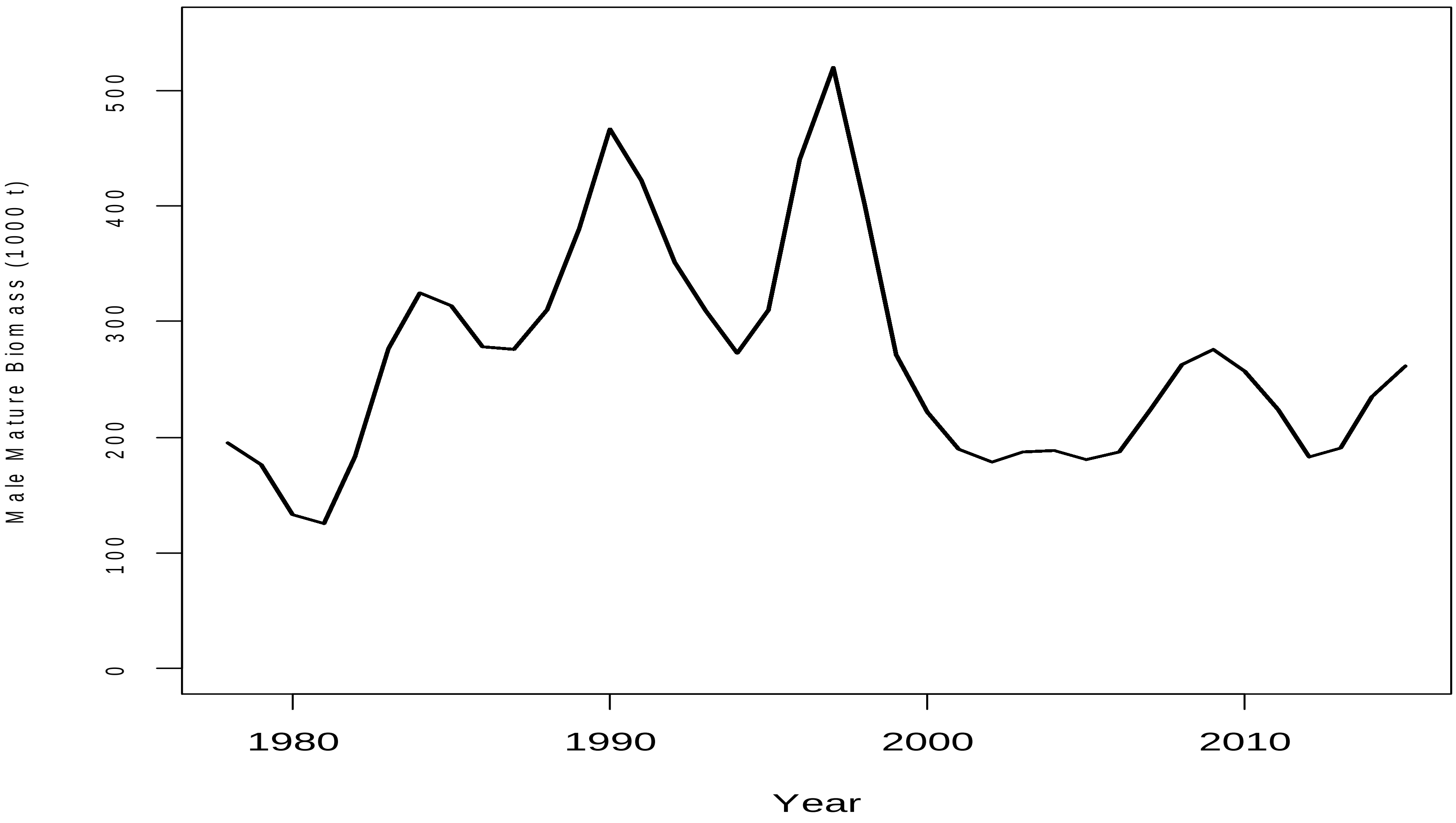


Female growth estimated from Model 0 6376.97 run (red line) and Model 0 6379.01 k line). Open circles are observed growth.

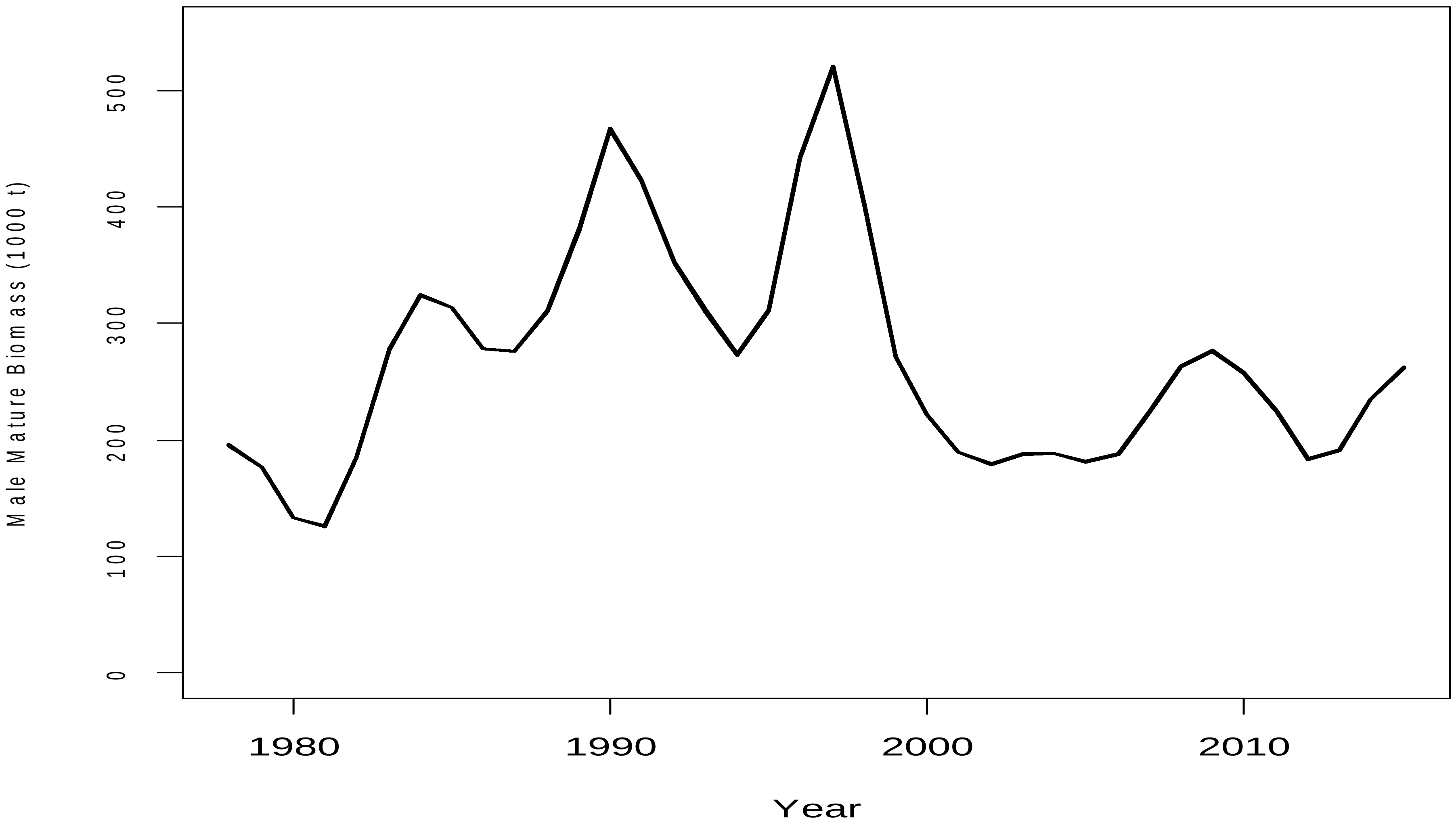


. Female growth parameter a1 vs Total Likelihood for models that wrote the standard deviation file. ave been jittered for plotting to show where multiple runs occurred. The parameter values for each od with multiple runs were virtually identical. Models estimated basically two different values of the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

abd 7c in document incorrect. All runs of Model 0 with lowest likelihood had same estimated biomass.



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



ure 7b. Model 0 estimated male mature biomass for 35 (out of 100) jitter runs that wrote the std f
ximum gradient < 1.0 and total likelihood of 6376.97 or 6379.01.

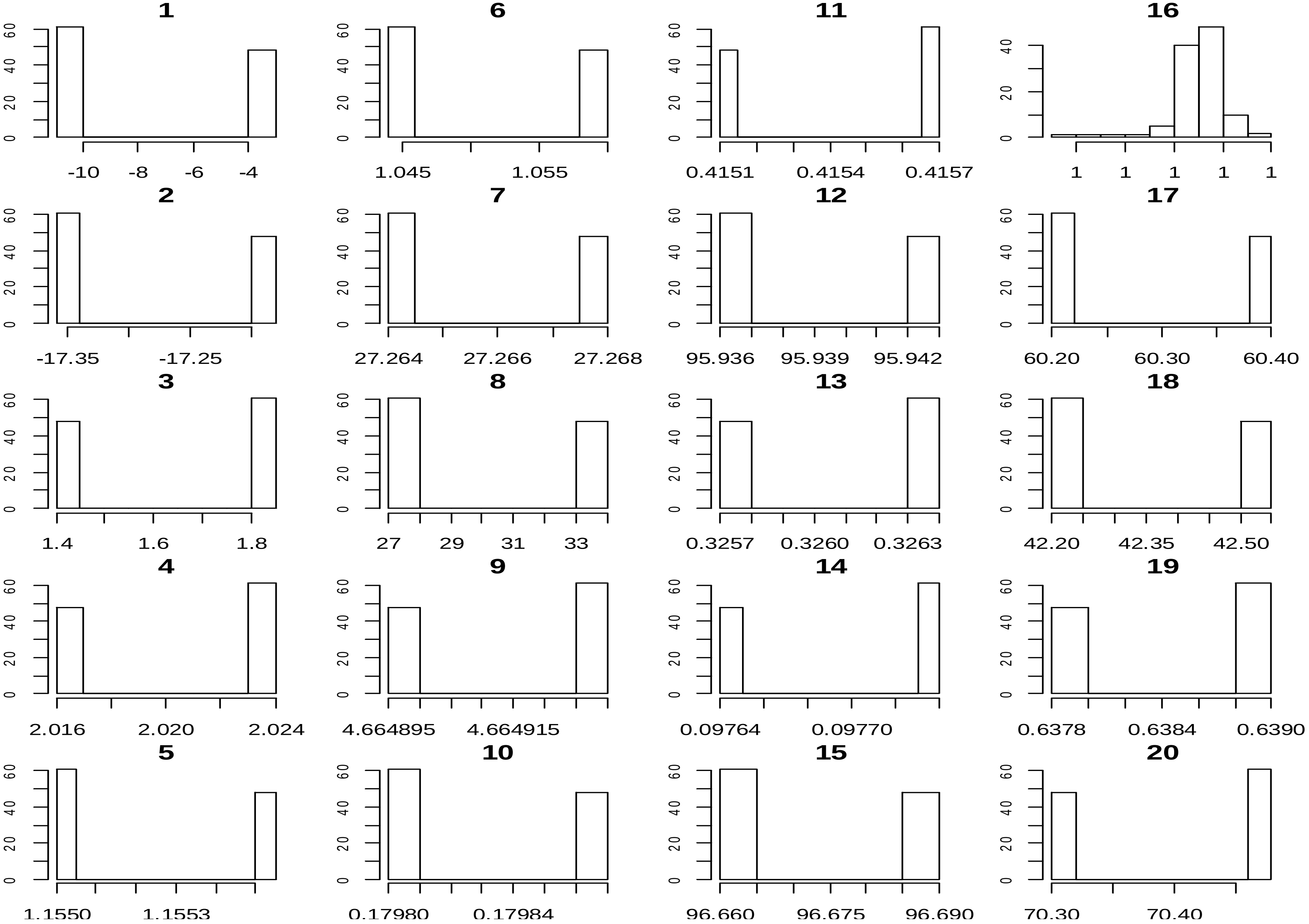
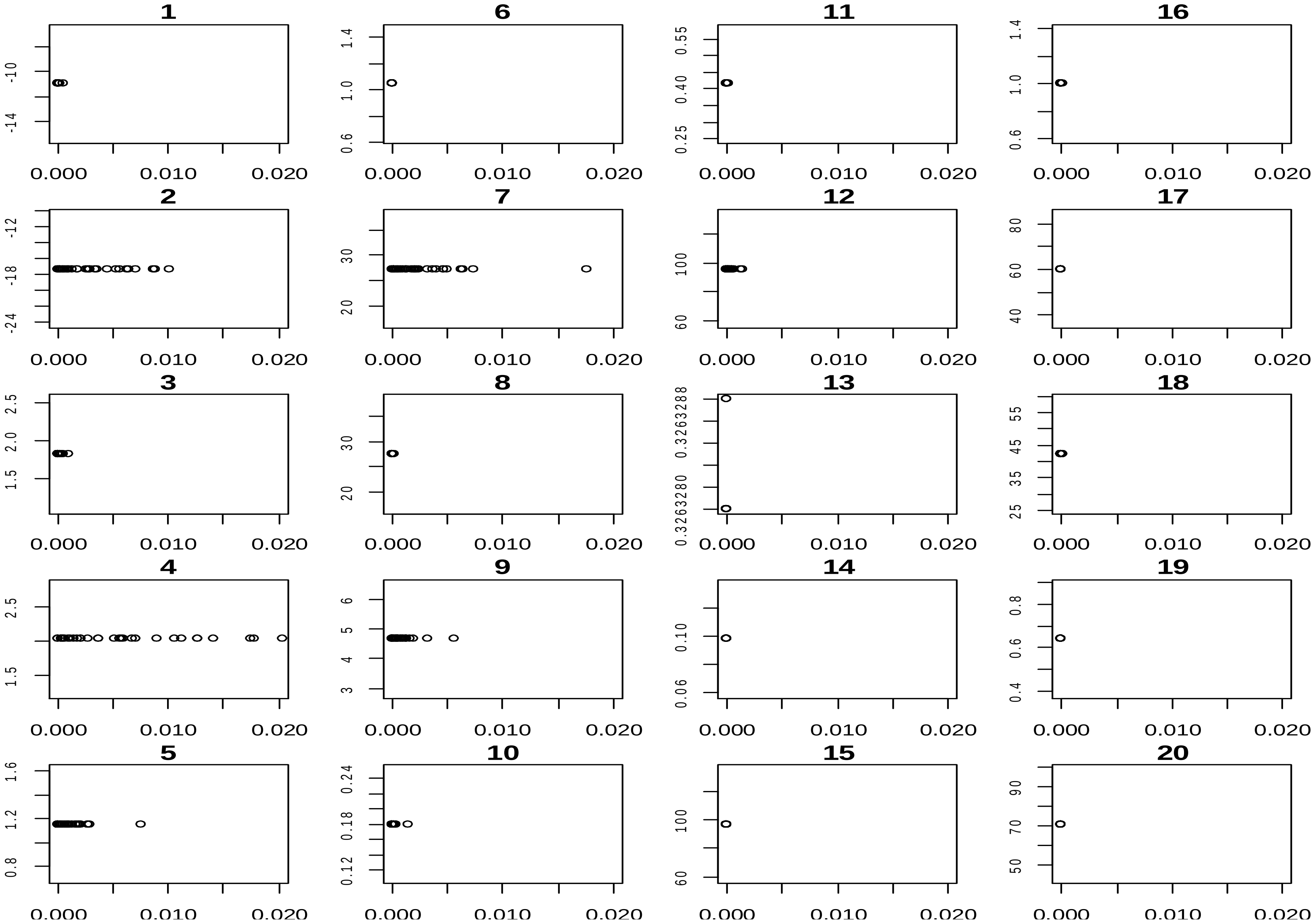


Figure 5. Parameter values for parameters 1-20 for runs where the total likelihood was 6379.01 (61 runs and 6376.97 (47 runs of 400). Refer to Table 1 for parameter names.



8. Model 0 for likelihood 6376.97 only. From 100 jitter runs. Parameter values
ent for parameters 1-20.

odel 0 from September 2015, 6379.01 total likelihood - parameter gradients. 12 arameters with largest gradients.

ame	Value	Gradient
slope (b1) growth	2.01649	-0.0023
evf(1991)	1.9501	-0.00146
evf(1987)	1.61484	0.001288
intercept(a1) growth	-17.1901	-0.00115
delta	27.2678	-0.00083
_dev(1990)	1.21549	-0.00051
vg_sel50_mn	4.6649	0.000501
_dev(1996)	-0.07388	-0.00048
_dev(1998)	0.390927	0.000396
evf(2003)	0.839771	0.000384
_dev(1989)	0.637854	0.000379
slope (b2) growth	1.15552	-0.00034

Model 1 from September 2015, 6376.97 total likelihood - parameter gradients. 12 Parameters with largest gradients.

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

Models 0a, 1a and 1b

Fixing the growth transition parameters resulted in a more stable model

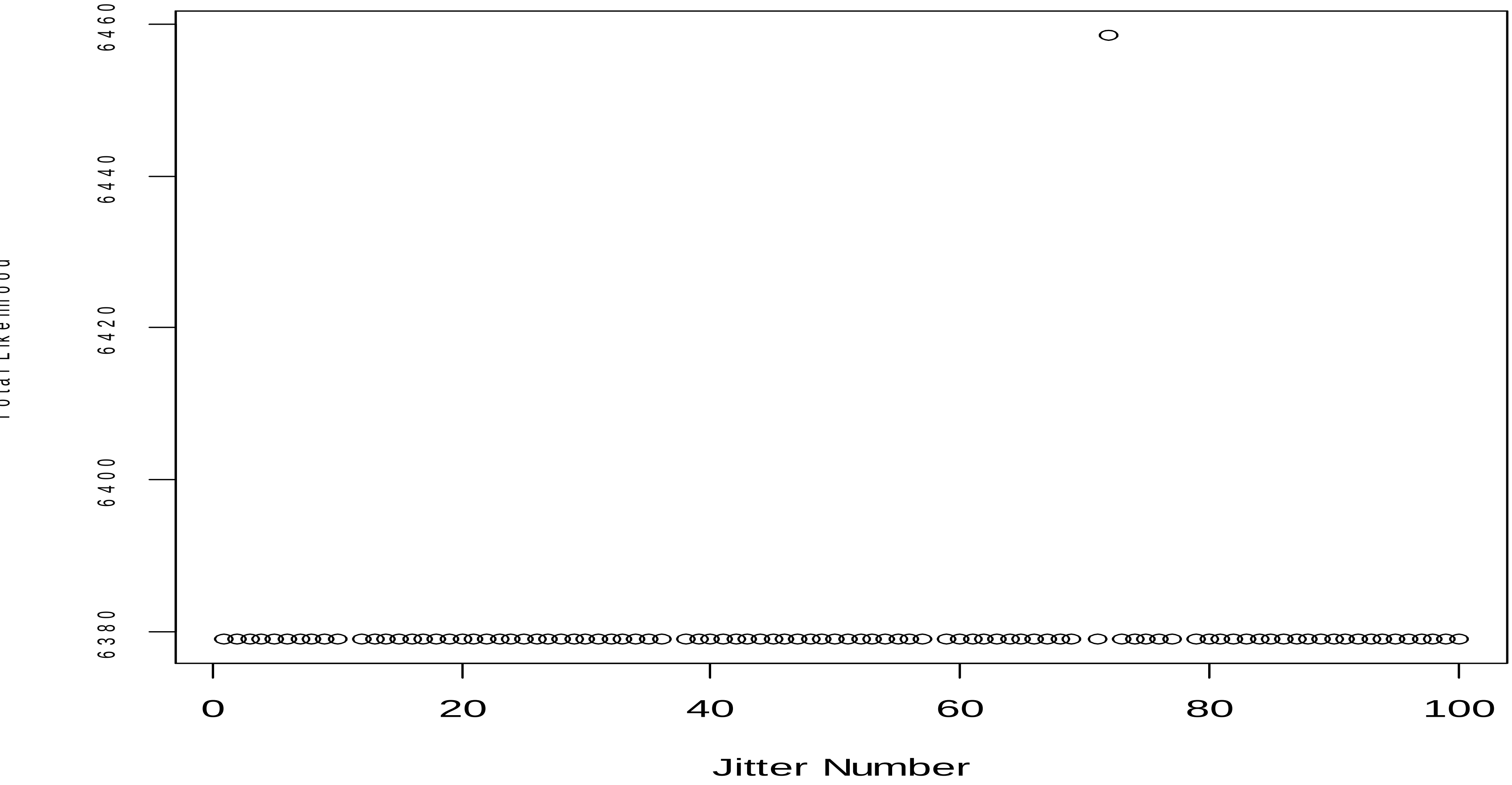
Model 0a and 1a - 94 (of 100) runs converged to the lowest likelihood

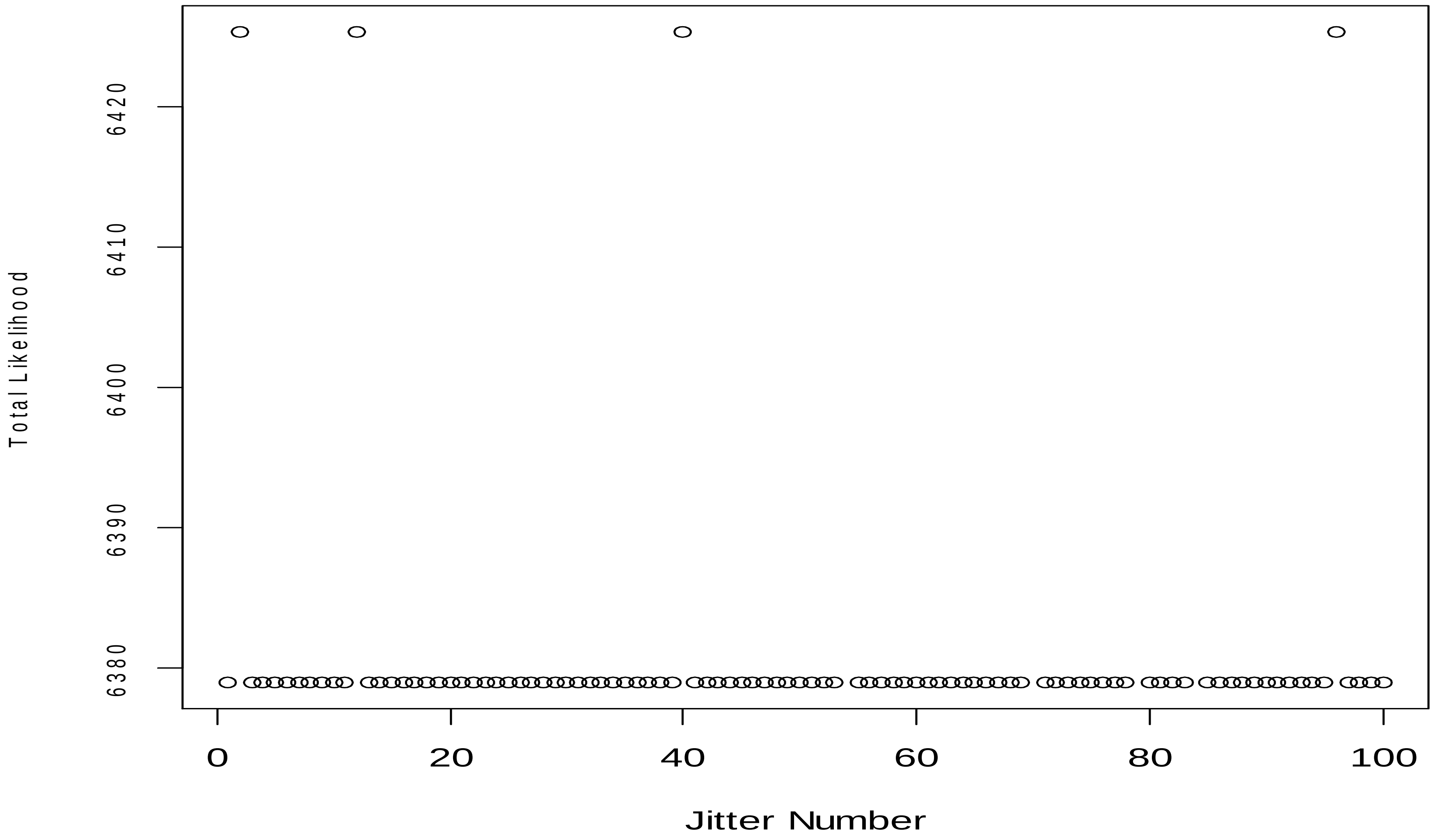
Model 1b – 51 (of 100) values converged to the lowest likelihood – the male growth parameters were mainly different between likelihoods

Lowest Likelihood values were the same for 0a, 1a and 1b.

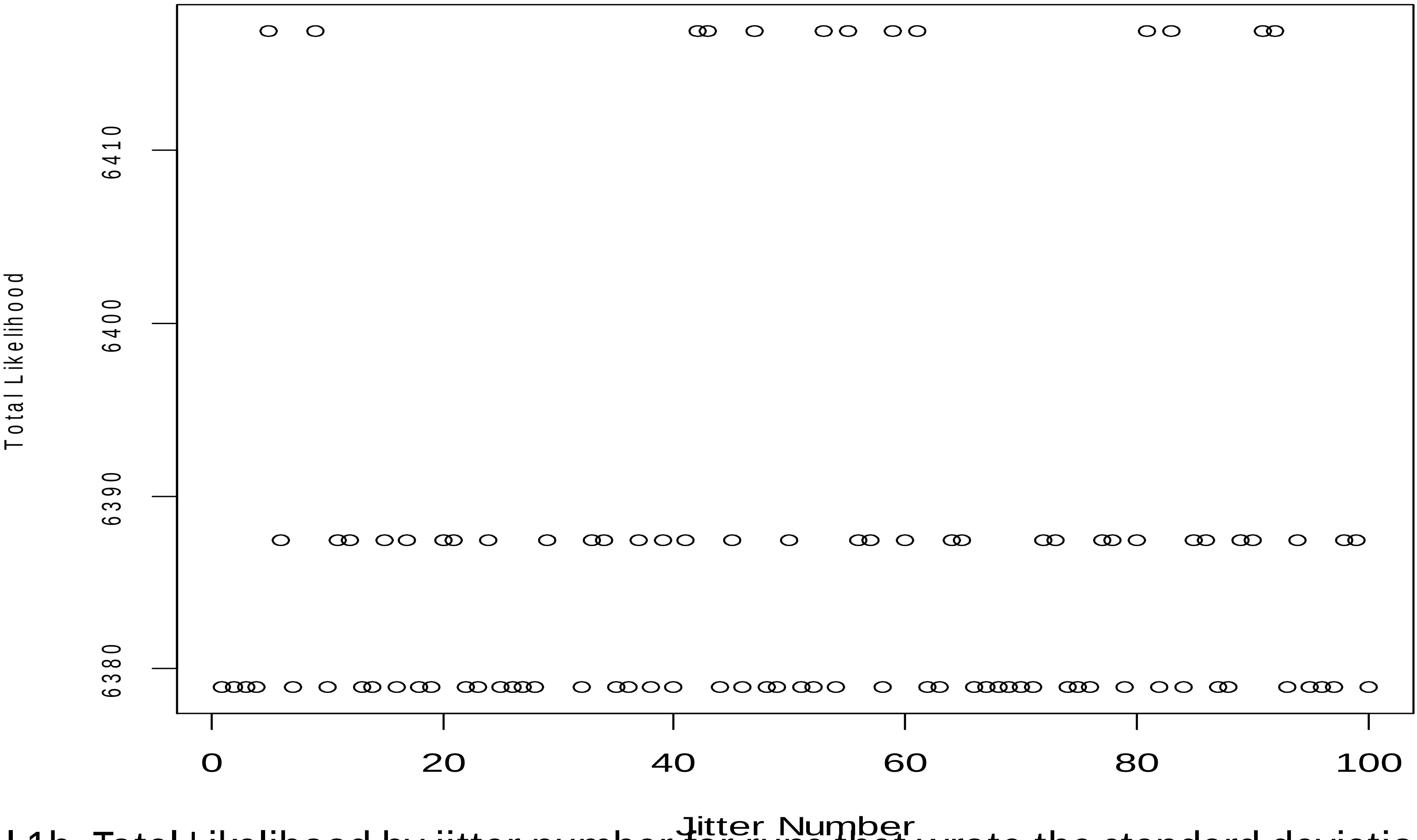
The male transition parameter in Model 1b converged to the same value and the fixed value in models 0a and 1a.

Figure 18. Model 0a total Likelihood by jitter number for runs that wrote the standard deviation fi
4 of the 100 runs converged to the lowest likelihood. Stabilizes Model 0.





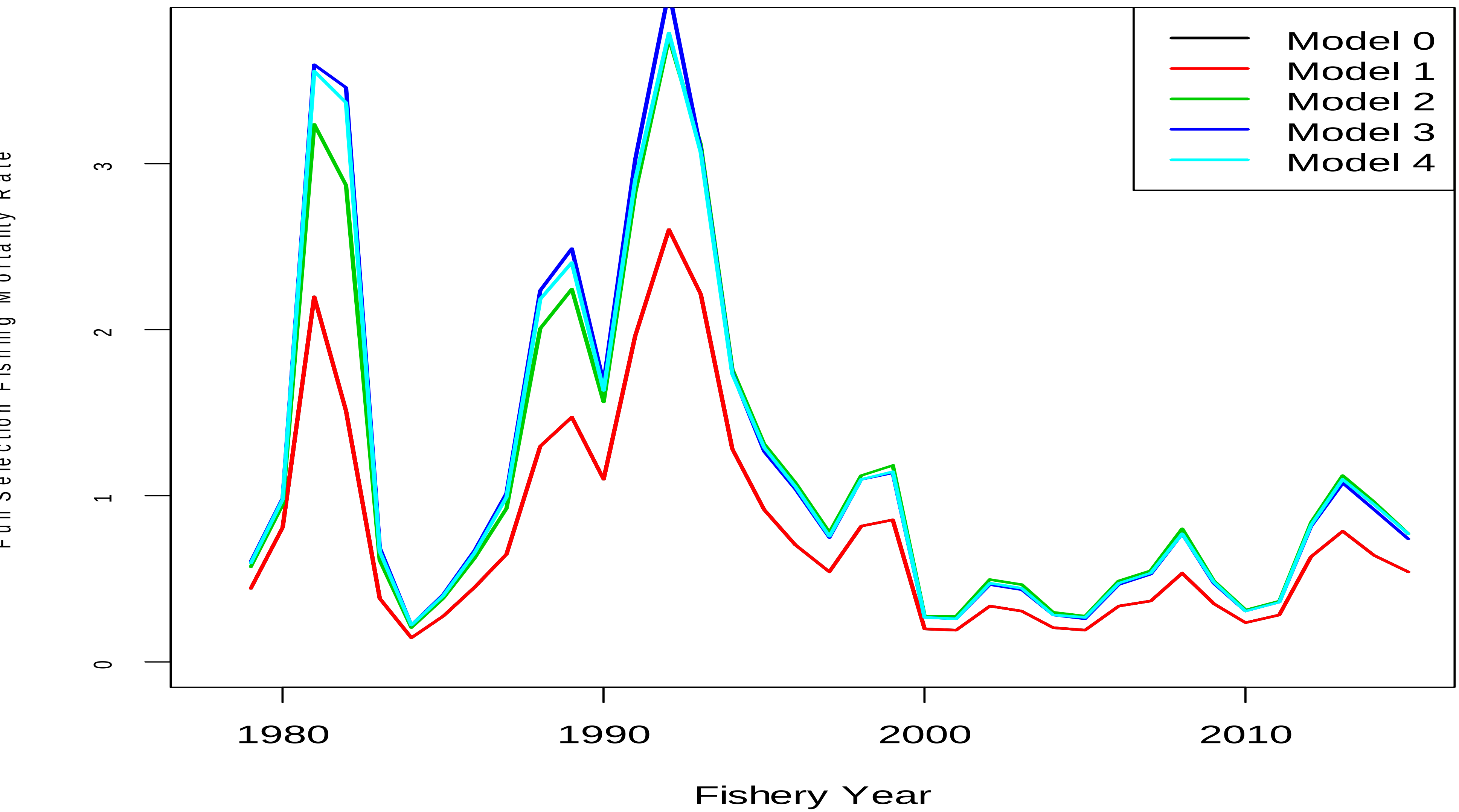
Model 1a. Total Likelihood by jitter number for runs that wrote the standard deviation file.



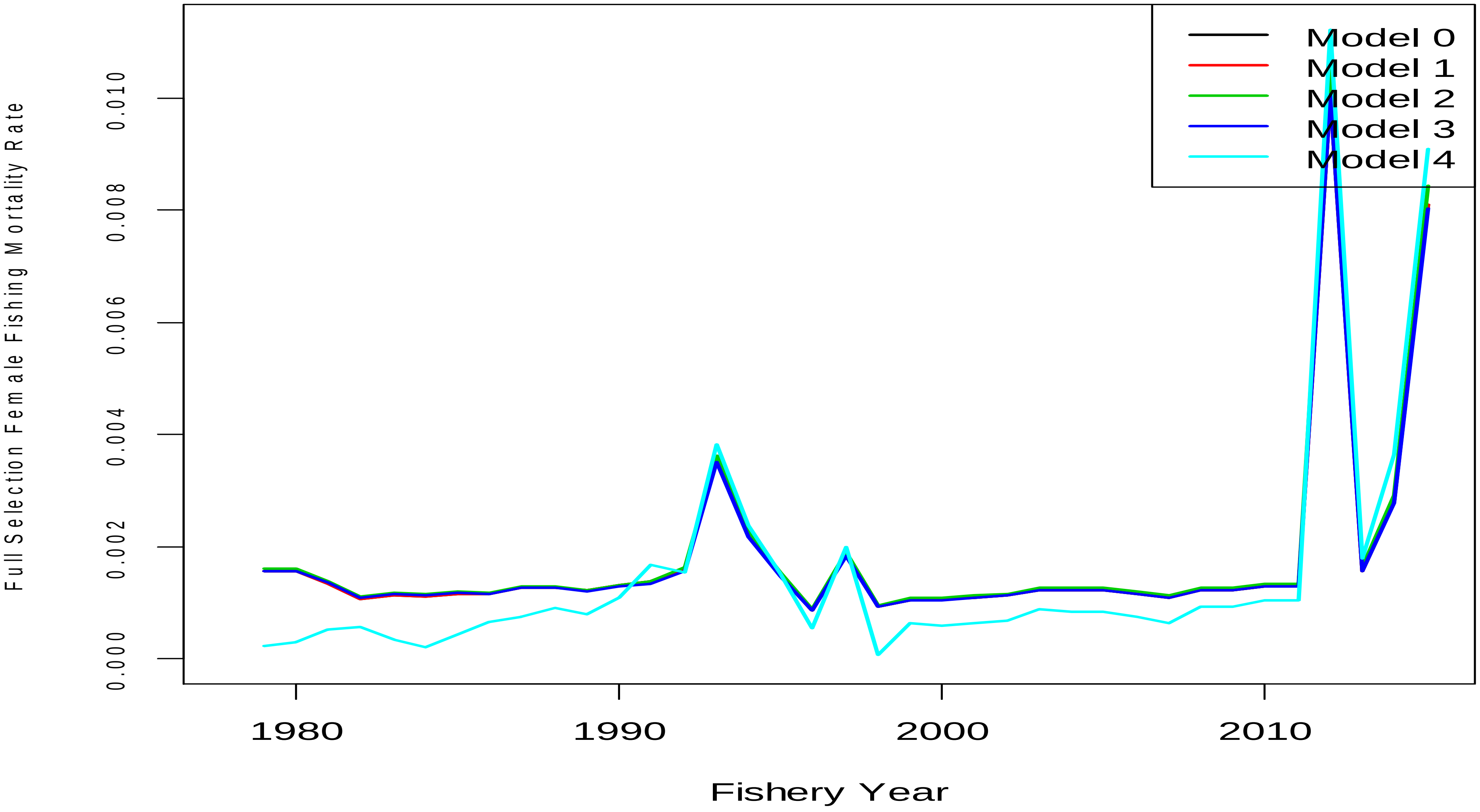
3. Model 1b. Total Likelihood by jitter number for runs that wrote the standard deviation file.
ransition fixed. Main differences male growth parameters.

Model 0a. Parameters and gradients.

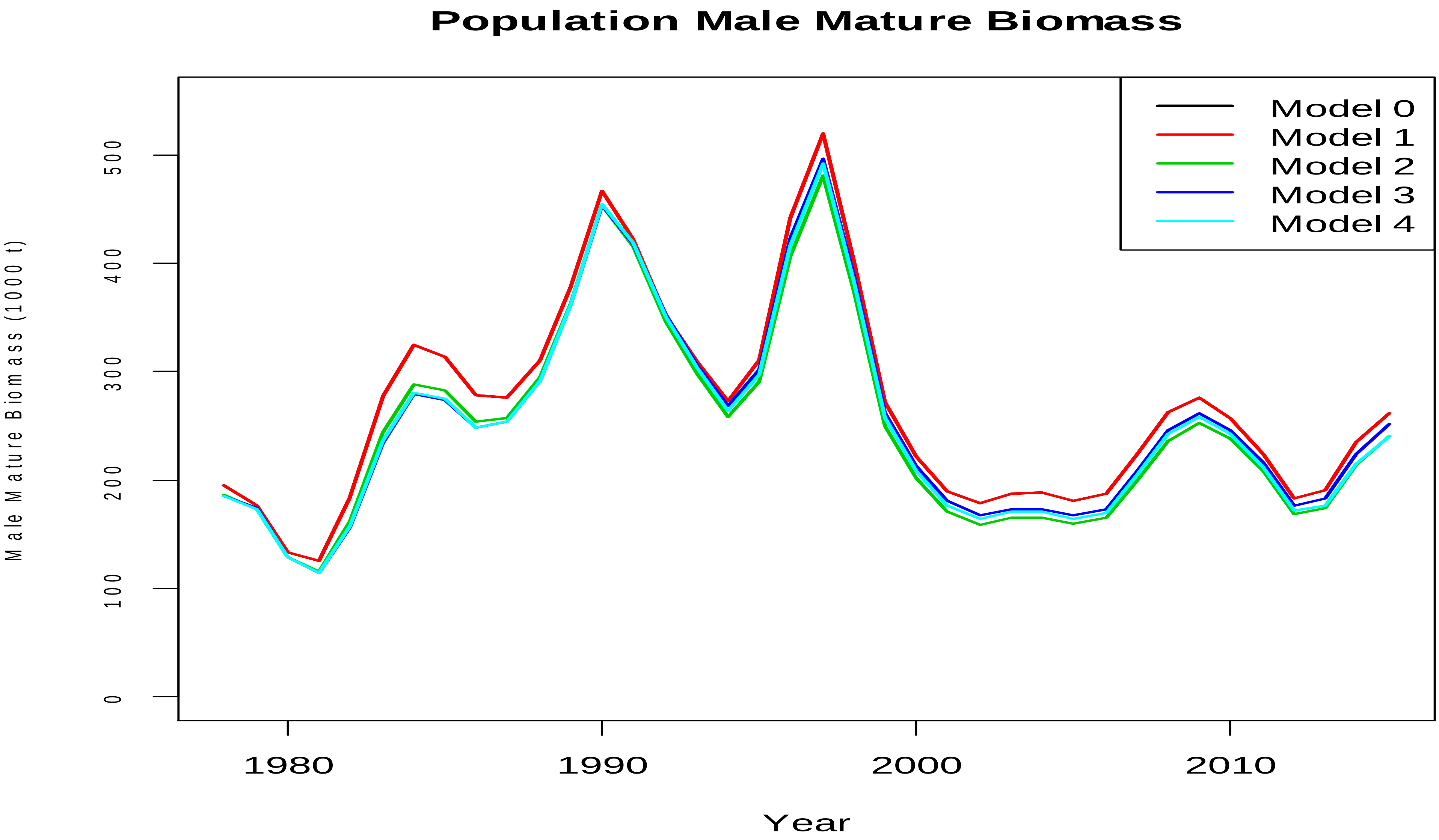
ParName	Value	Gradient
Male slope (b1) growth	2.01894	0.008872
rec_devf(1985)	1.629	0.005677
Male intercept(a1) growth	-17.2445	0.004437
rec_devf(1984)	1.0313	0.002093
rec_devf(1983)	0.802609	0.001845
Male slope (b2) growth	1.15535	0.00158
fmort_dev(1997)	0.339361	-0.00127
fmort_dev(1998)	0.390948	0.001238
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



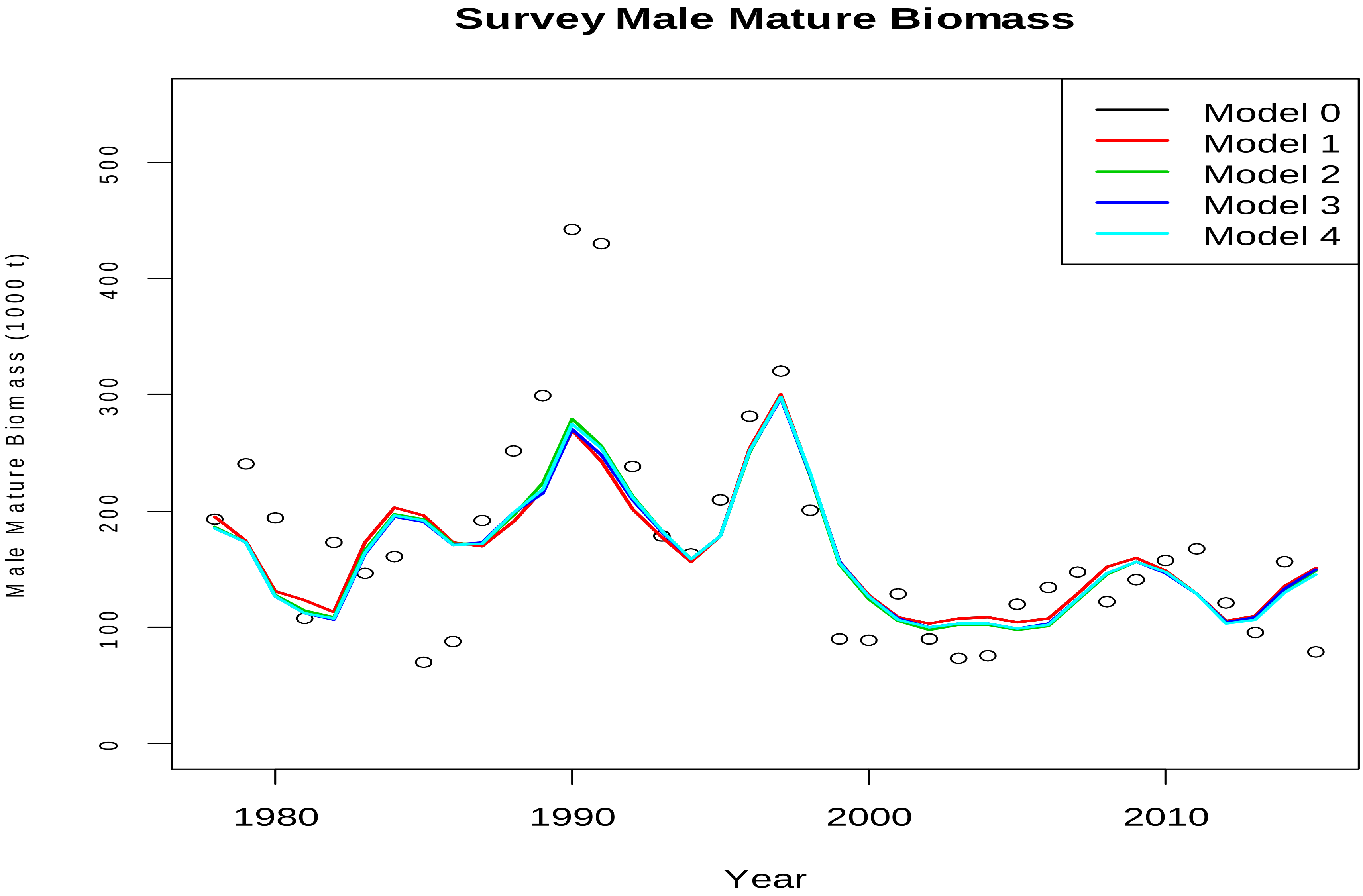
Fishing mortality for male directed fishery for models 0, 1, 2,3 and 4.
and 1 are exactly the same. The jitter run with the lowest likelihood and lowest gradient was used for each M



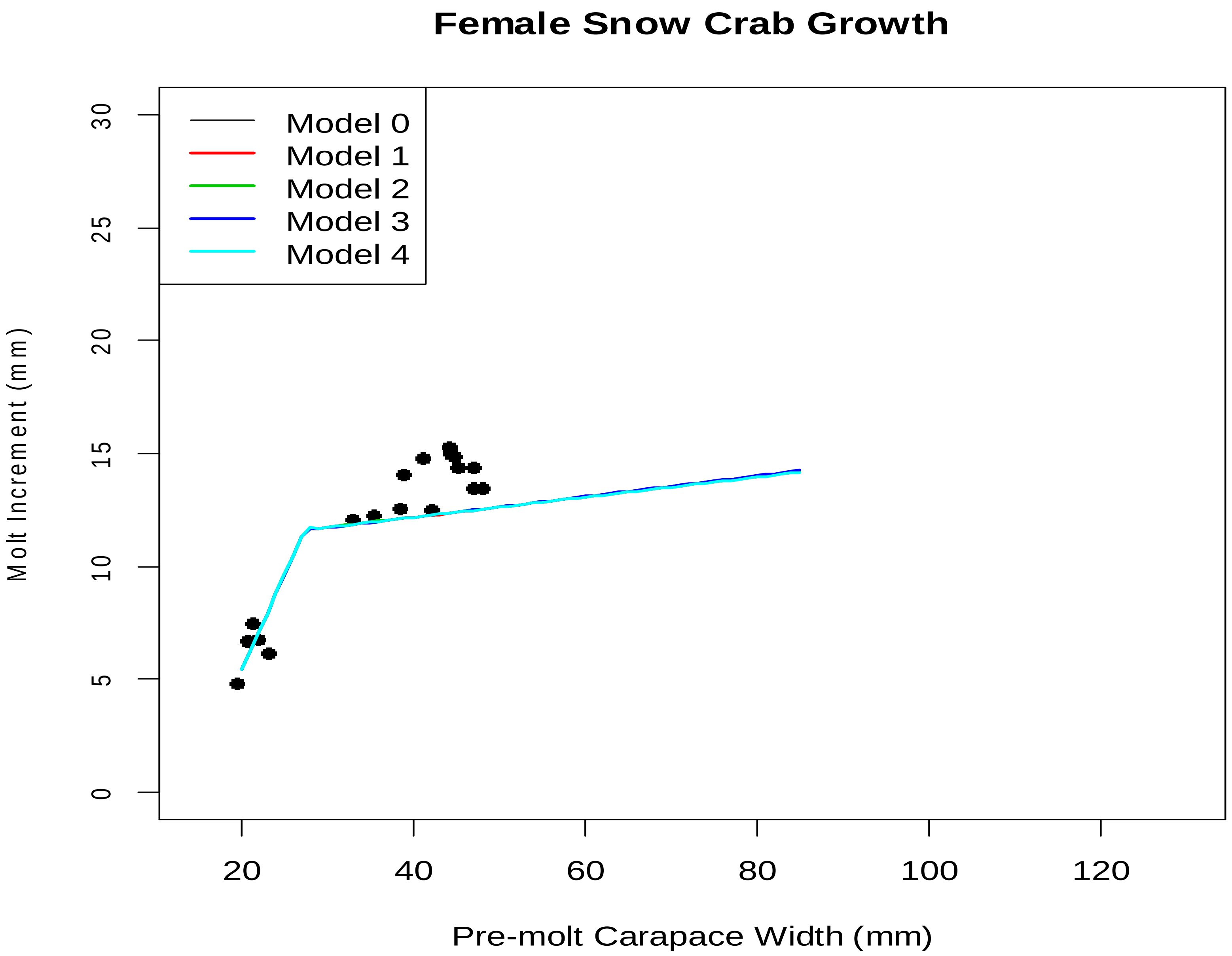
Fishing mortality for female directed fishery discards for models 0, 1, 2,3 and 4.
un with the lowest likelihood and lowest gradient was used for each Model.



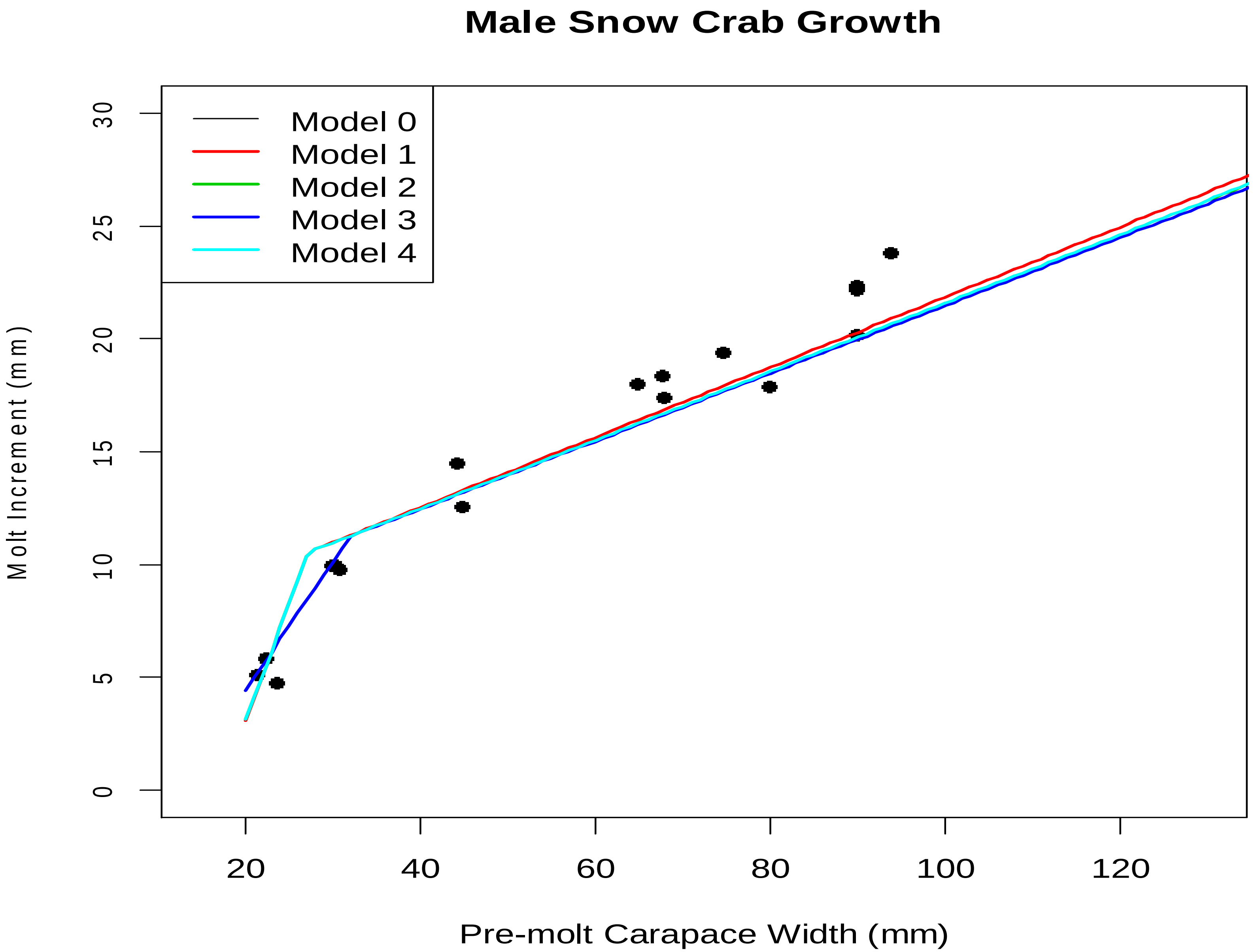
Population male mature biomass for models 0, 1, 2,3 and 4. The jitter run with the
elihood and lowest gradient was used for each Model.



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

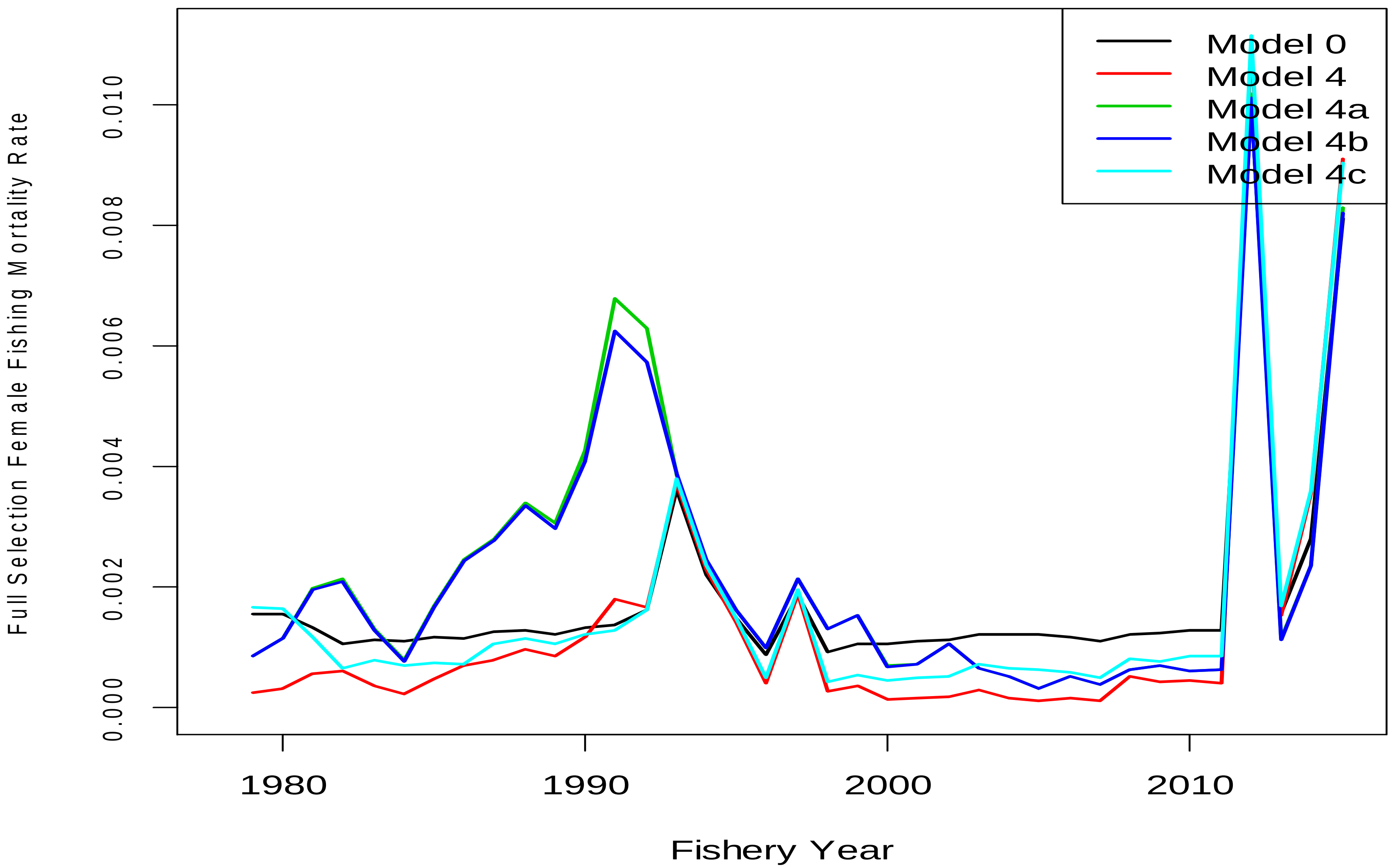


. Estimated growth for female crab for models 0, 1, 2,3 and 4.
run with the lowest likelihood and lowest gradient was used for each Model.

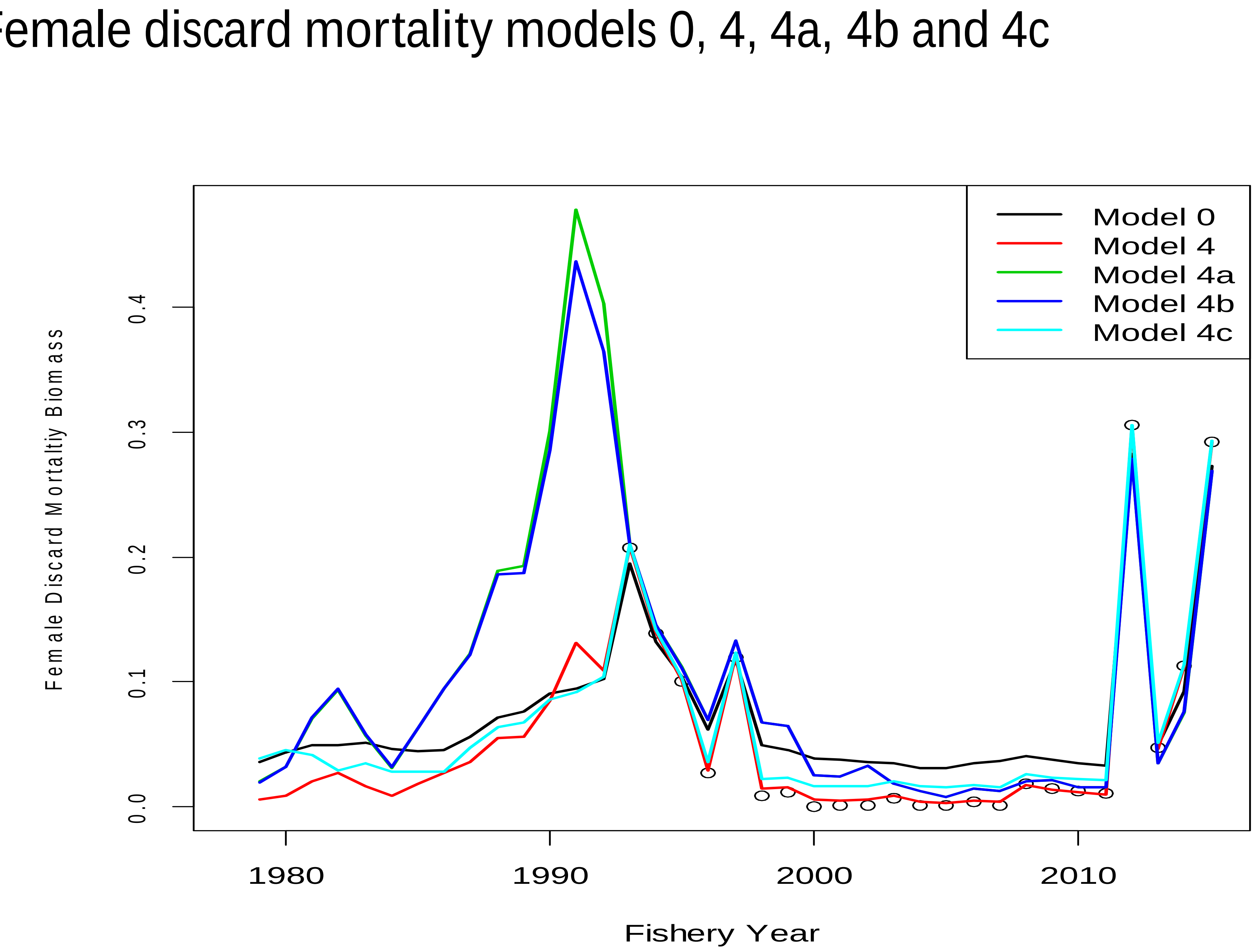


Estimated growth for male crab for models 0, 1, 2,3 and 4.
1,2 and 4 are similar and have a lower transition point than Model 3.
un with the lowest likelihood and lowest gradient was used for each Model.

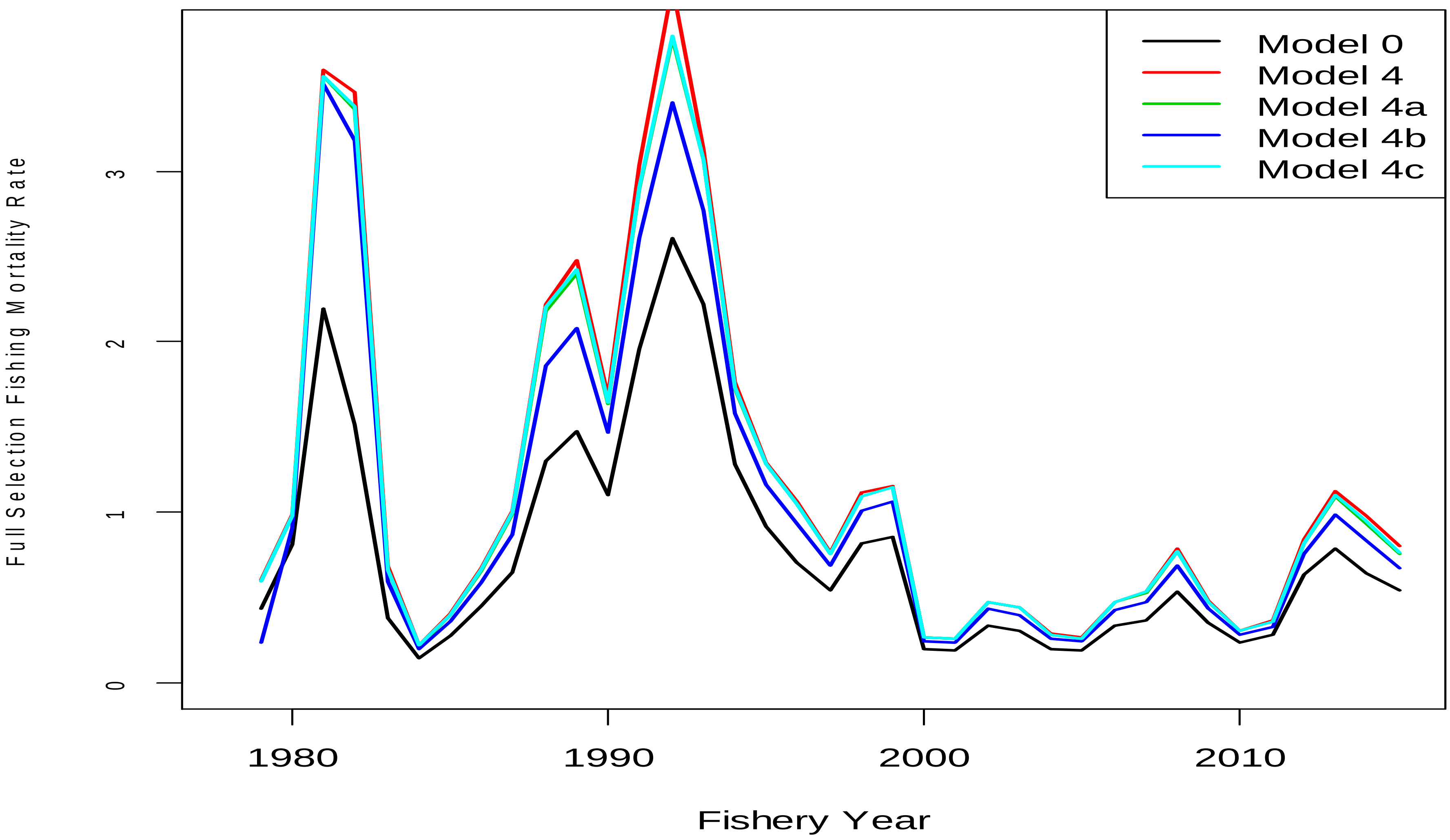
Models 4, 4a, 4b, 4c



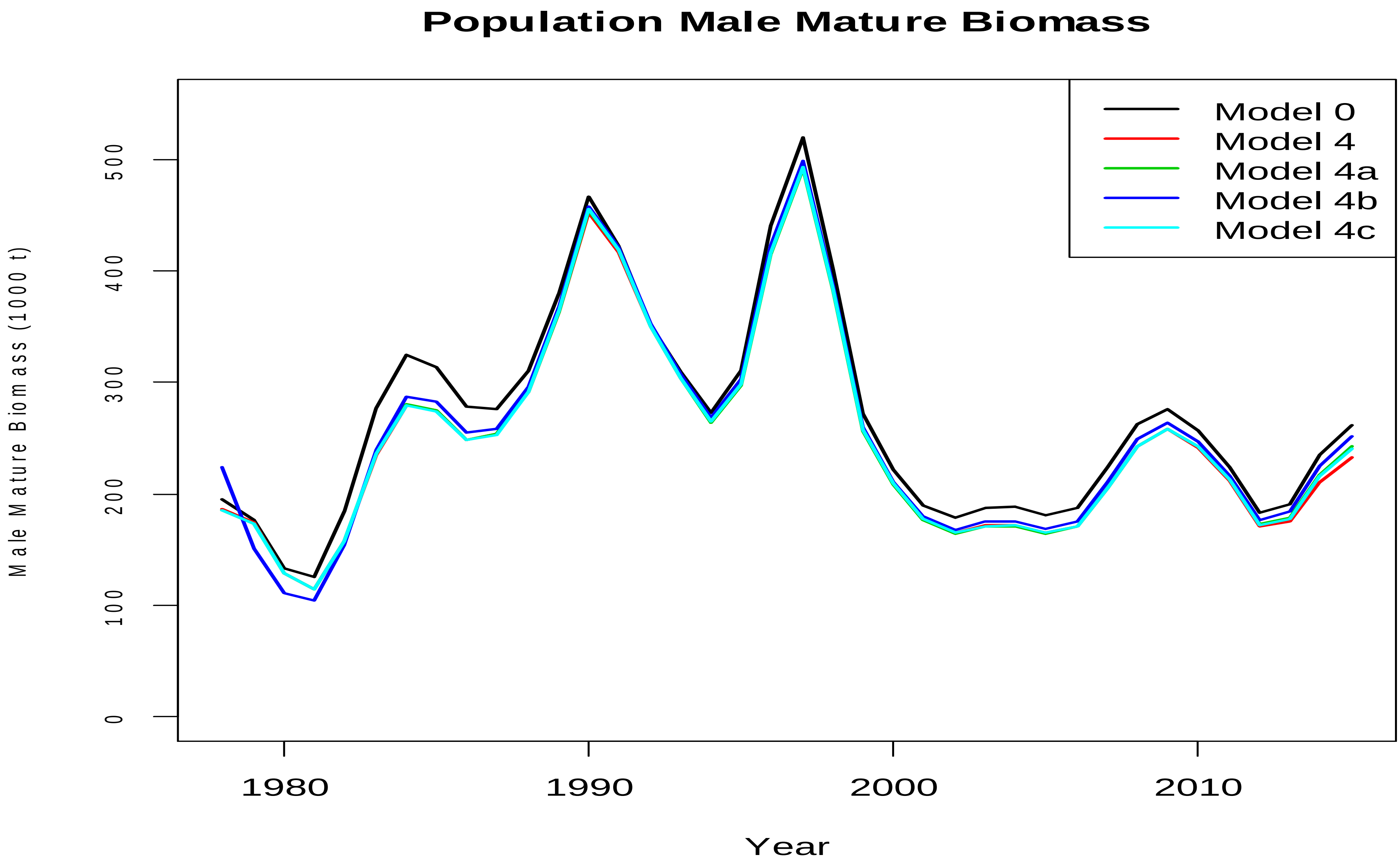
. Female fishing mortality estimates in the directed fishery for Models 0, 4, 4a, 4b and 4c.



emale discard mortality models 0, 4, 4a, 4b and 4c



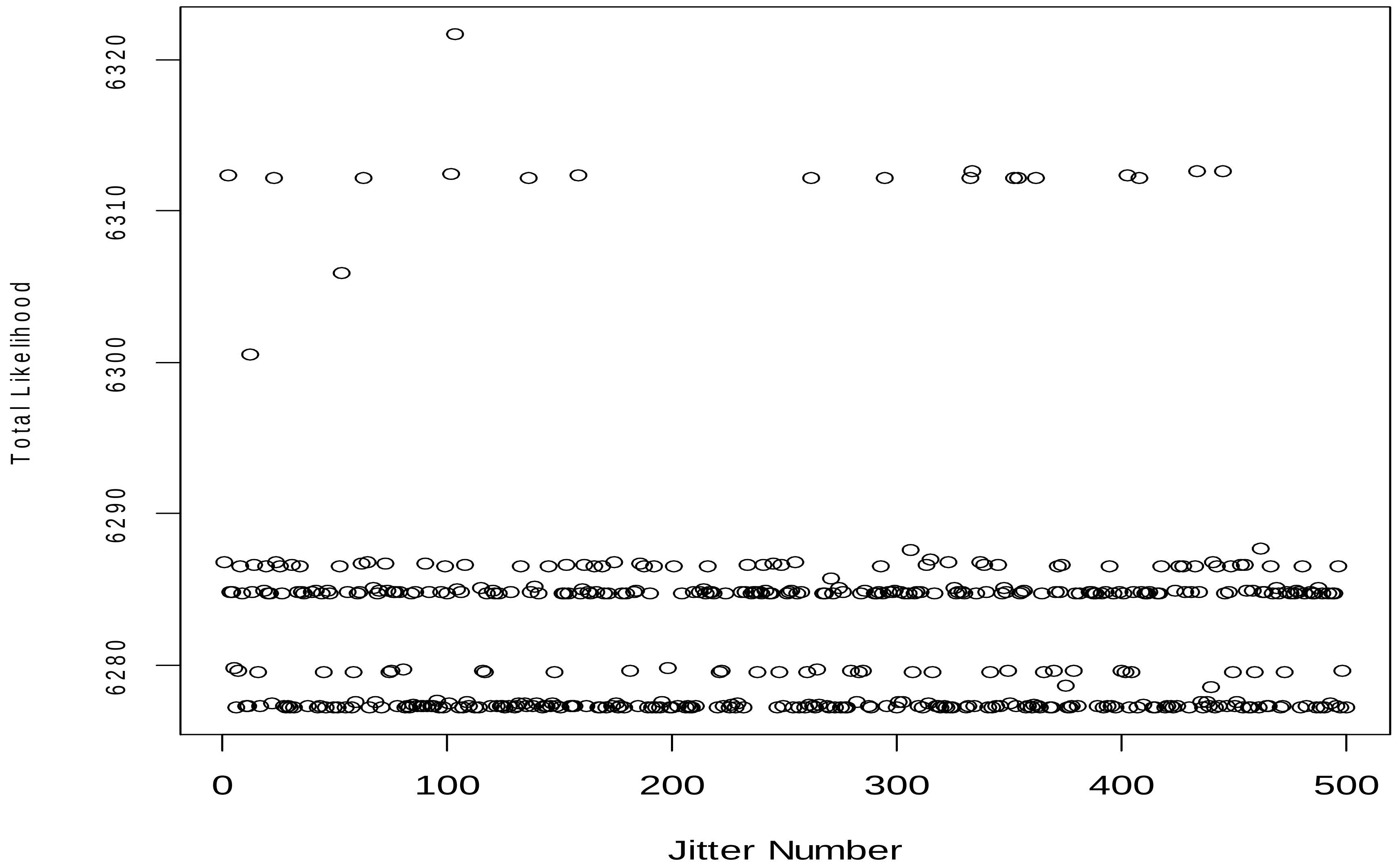
. Male fishing mortality estimates in the directed fishery for Models 0, 4, 4a, 4b and 4c.



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

Model 4a – jitter all parameters 500 runs

- jittering the subset of 35 parameters and 100 runs was adequate to fin e lowest likelihood run?
- odel 4a – all 325 parameters were jittered and 500 runs done.
- sults show that for Model 4a jittering 35 parameters and 100 runs was equate. The percentage of runs at the lowest likelihood was similar.
- nce jittering all parameters was setup, all subsequent runs have all timated parameters jittered and 100 runs conducted.



Model 4a. all 325 parameters jittered 500 runs (473 wrote std file). 91 runs had lowest likelihood of 6277.2
nodel 4a with 16 of 100 jitter runs at the lowest likelihood - 35 parameters jittered). Four runs had likelihood
an 12,000 and wrote the std file, not included here. Range of likelihoods were the same as for the 35
r jitter runs (6277.2 to 6321.72).

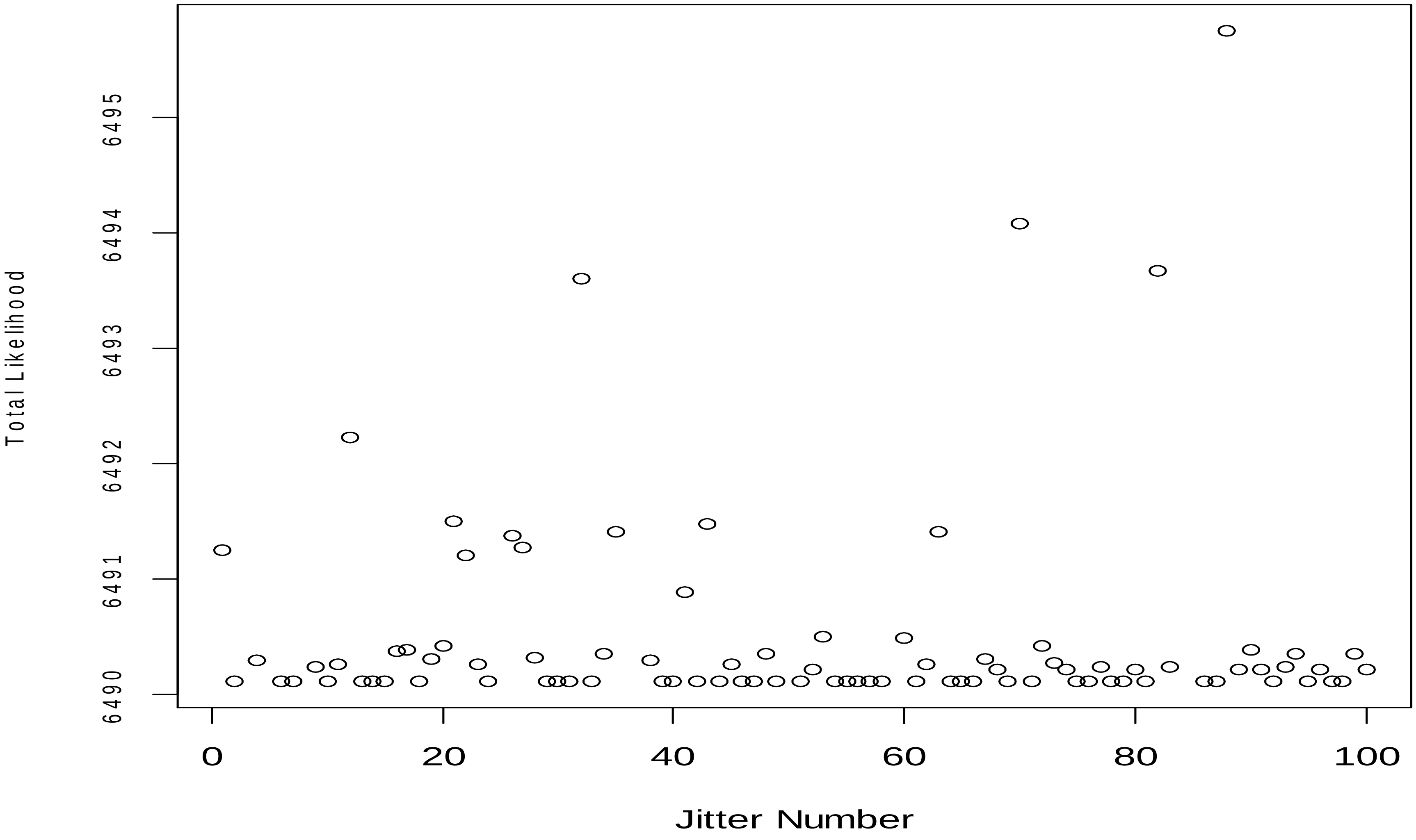
Models 8 and 8a

Remove lowest length bin (25-29mm)

One linear segment for growth estimated separately for males and females

Modified from Model 4a

Is this a more stable model?



. Model 8. Wt=2 (sd=0.5) on growth like. 43 runs with lowest likelihood of 6490.11.
(wt=1, sd=0.7, 24 runs at lowest likelihood).

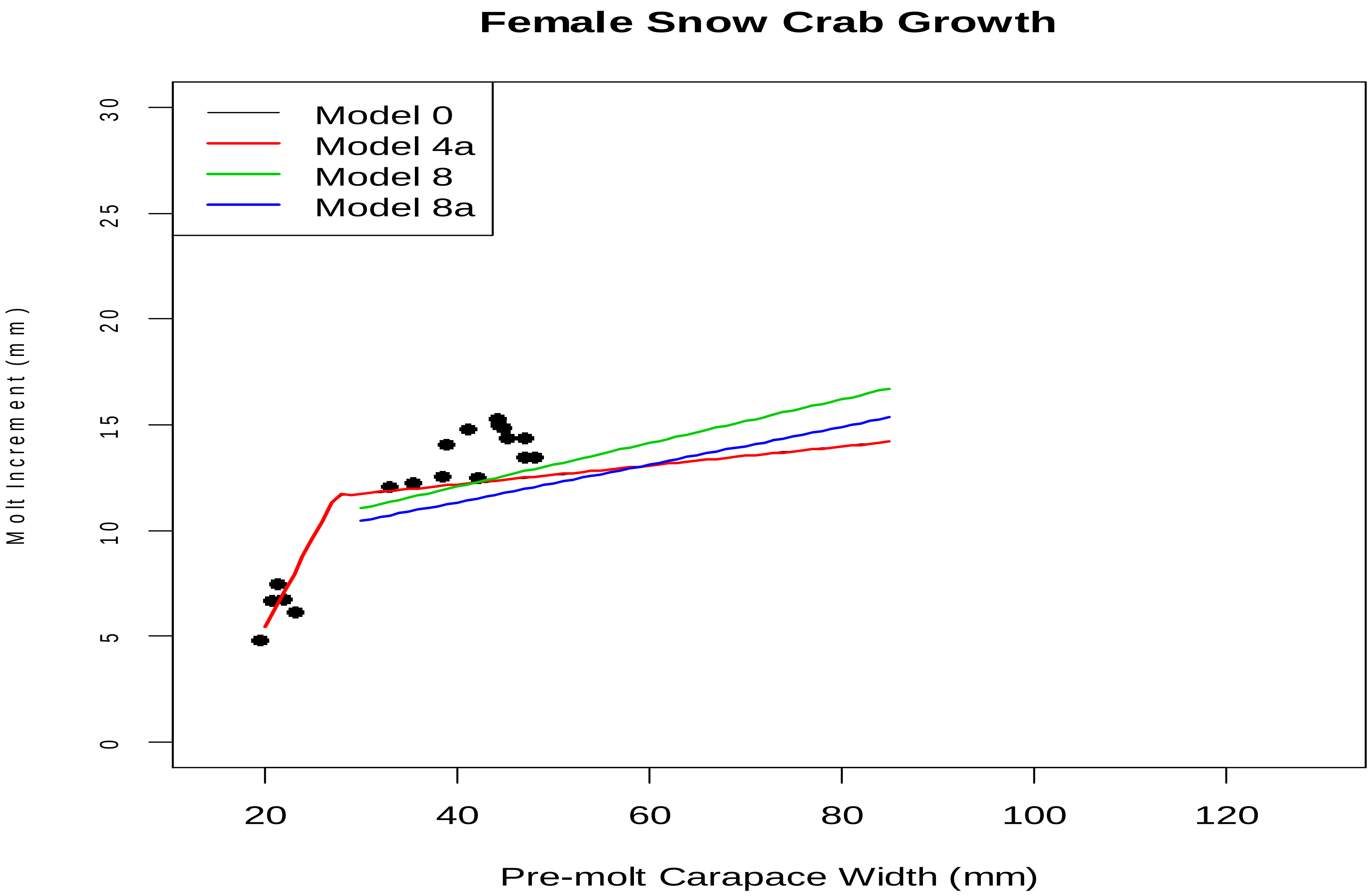
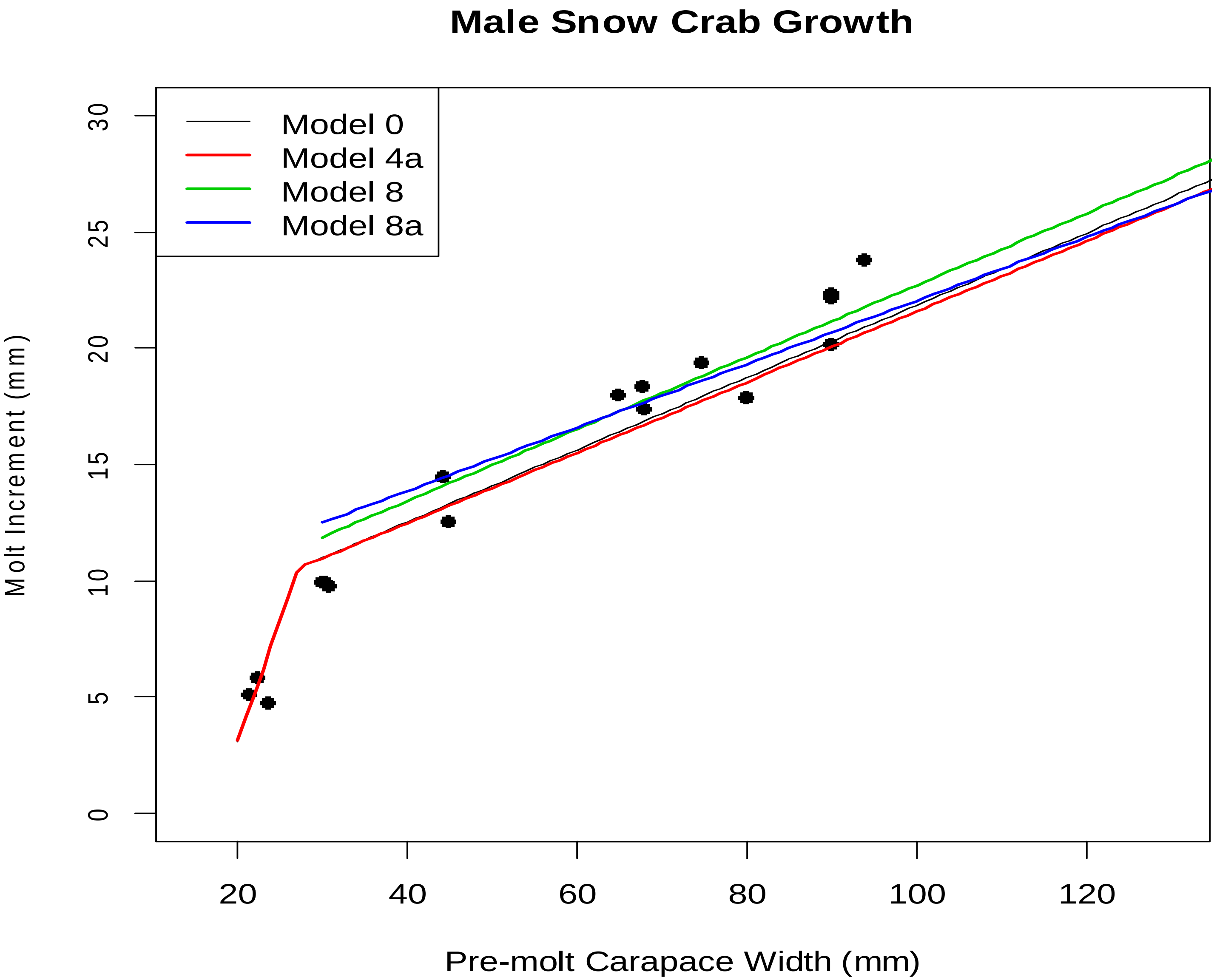
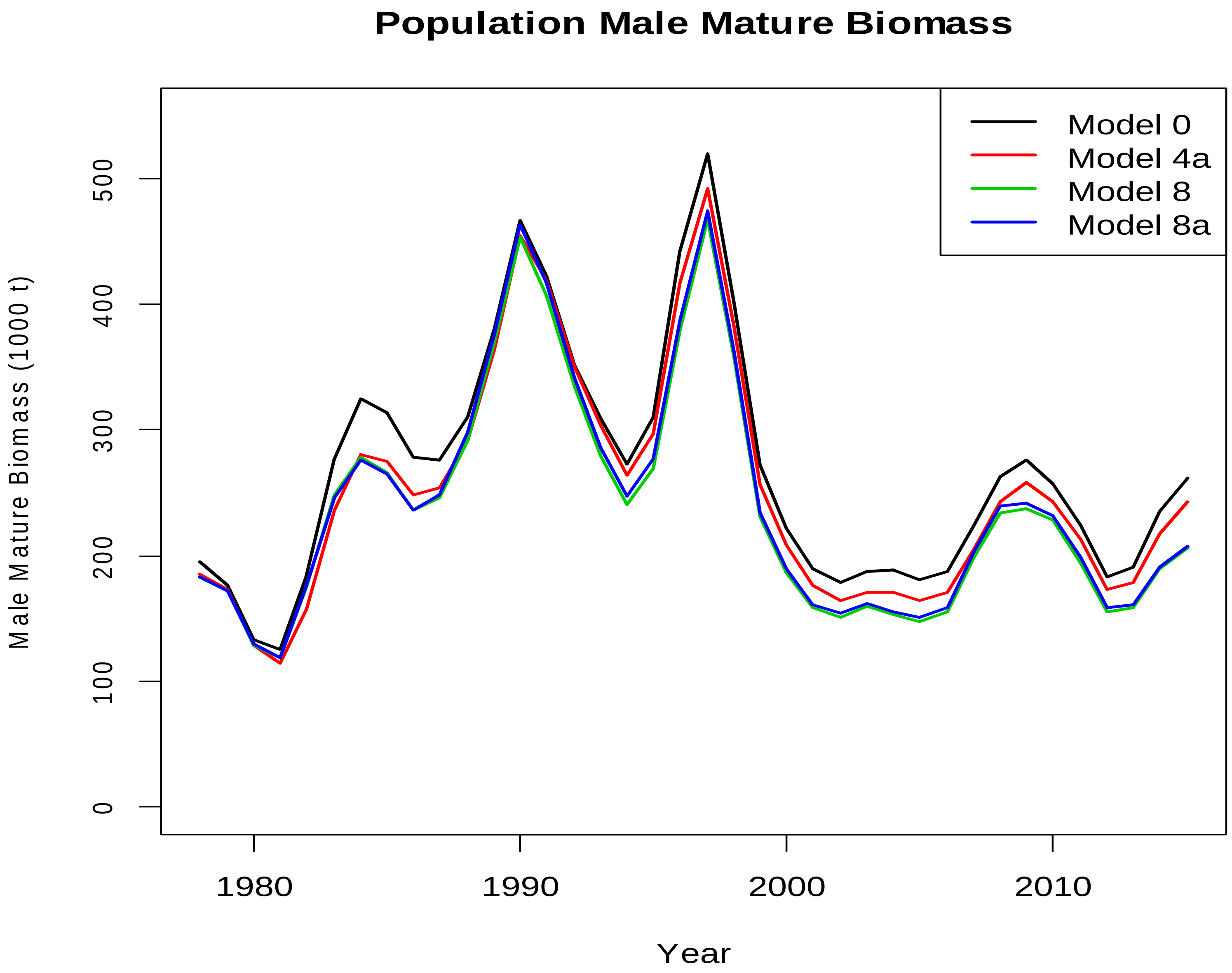


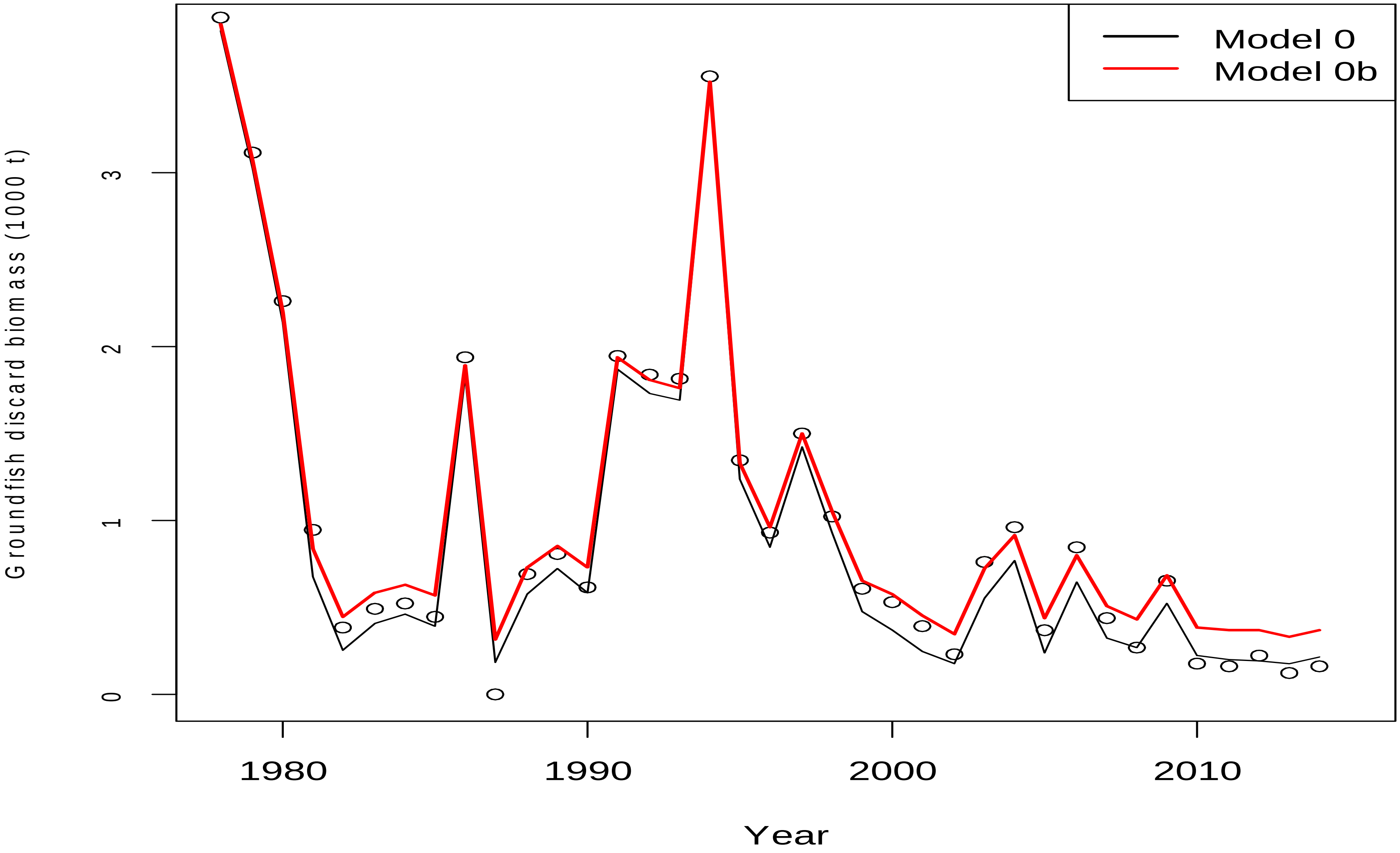
Figure 87. Female growth for models 0, 4a, 8 and 8a.



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



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



Model 0 and Model 0b estimated grounfish discard catch.

and 9 – estimation of average F for groundfish bycatch

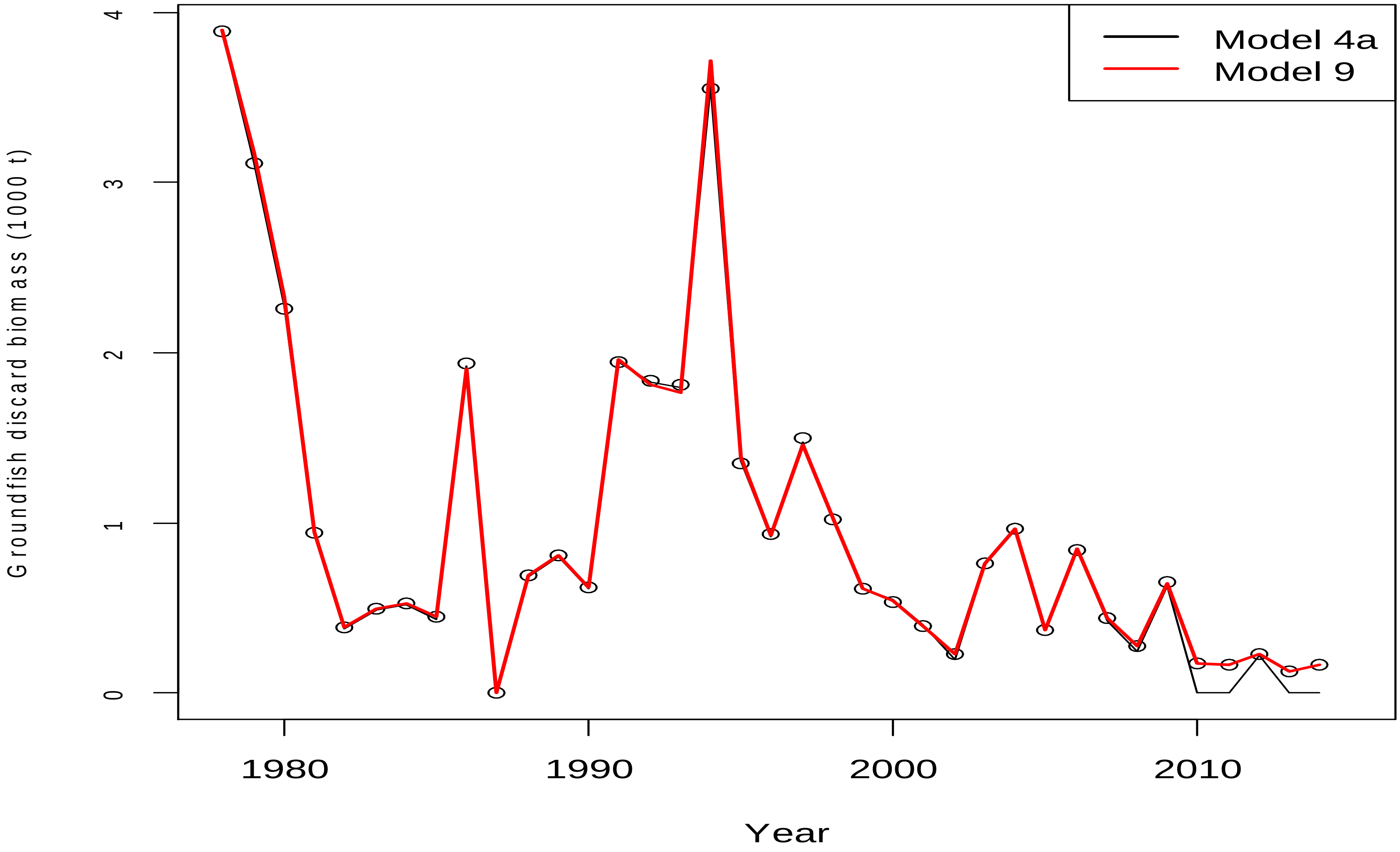


Figure 100. Fit to groundfish discard biomass for Model 4a and Model 9.

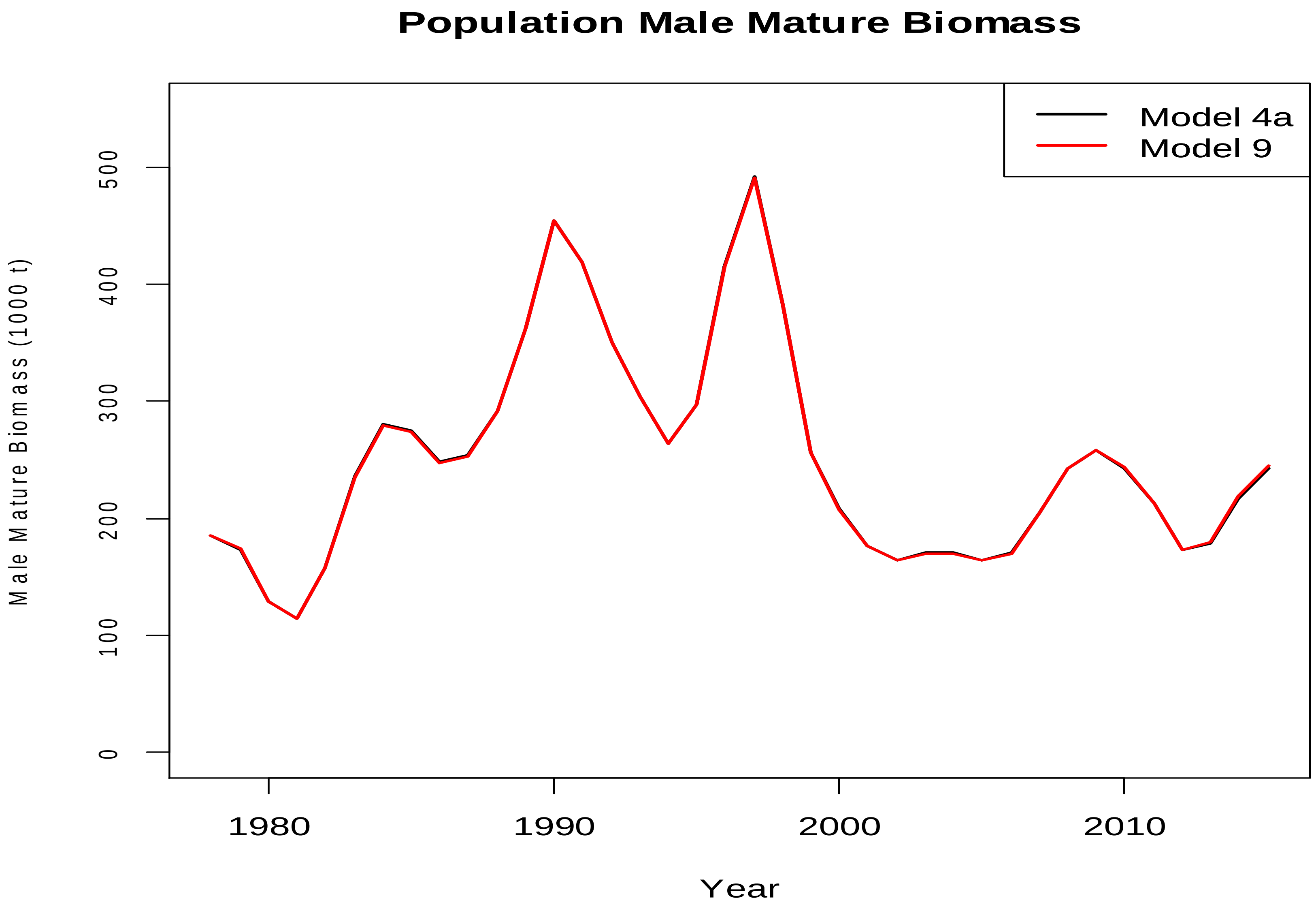


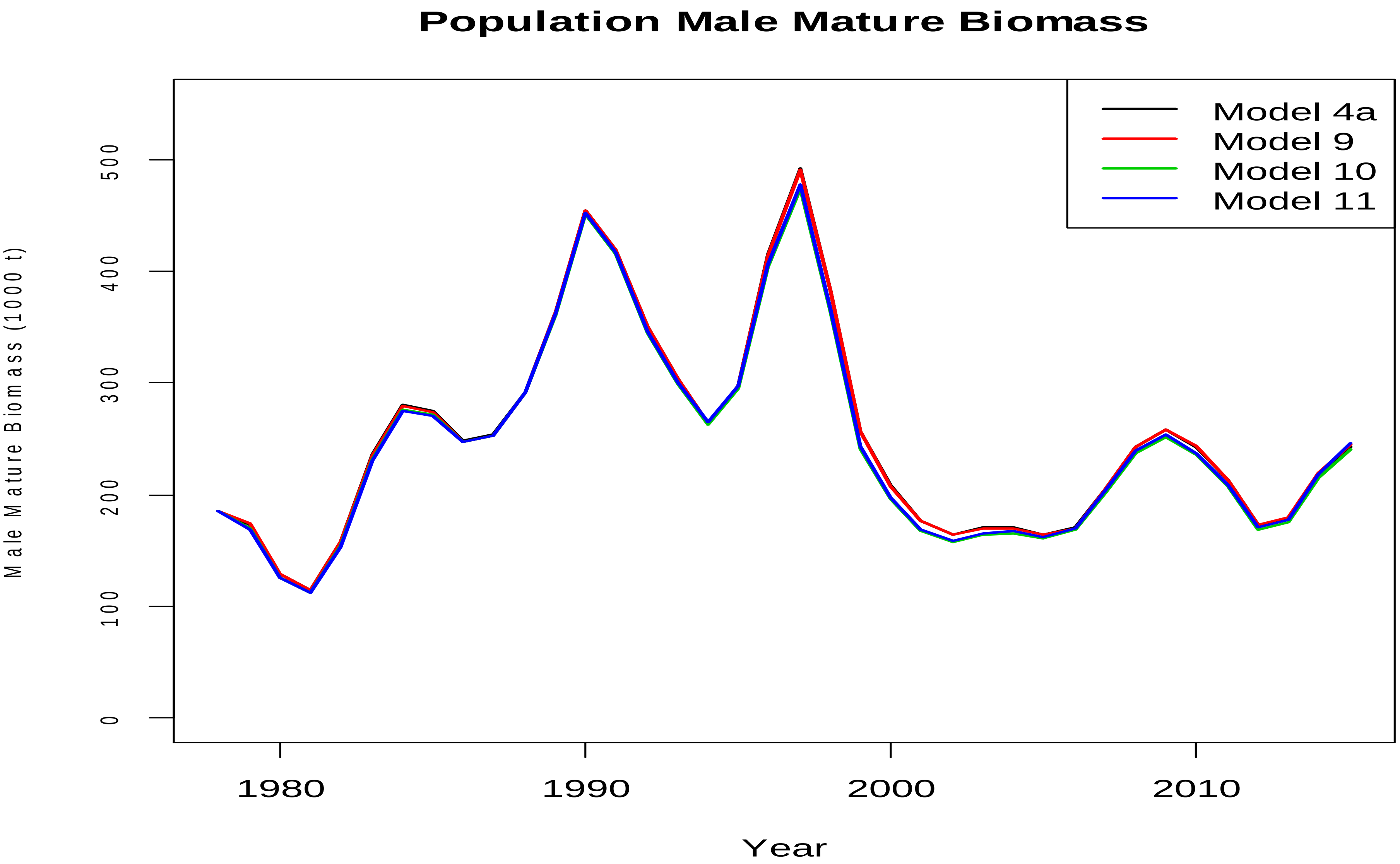
Figure 99. Model 4a and Model 9 population male mature biomass. Ending biomass for Model 4a was 242,895 t and for Model 9 245,232 t.

Models 10, 11

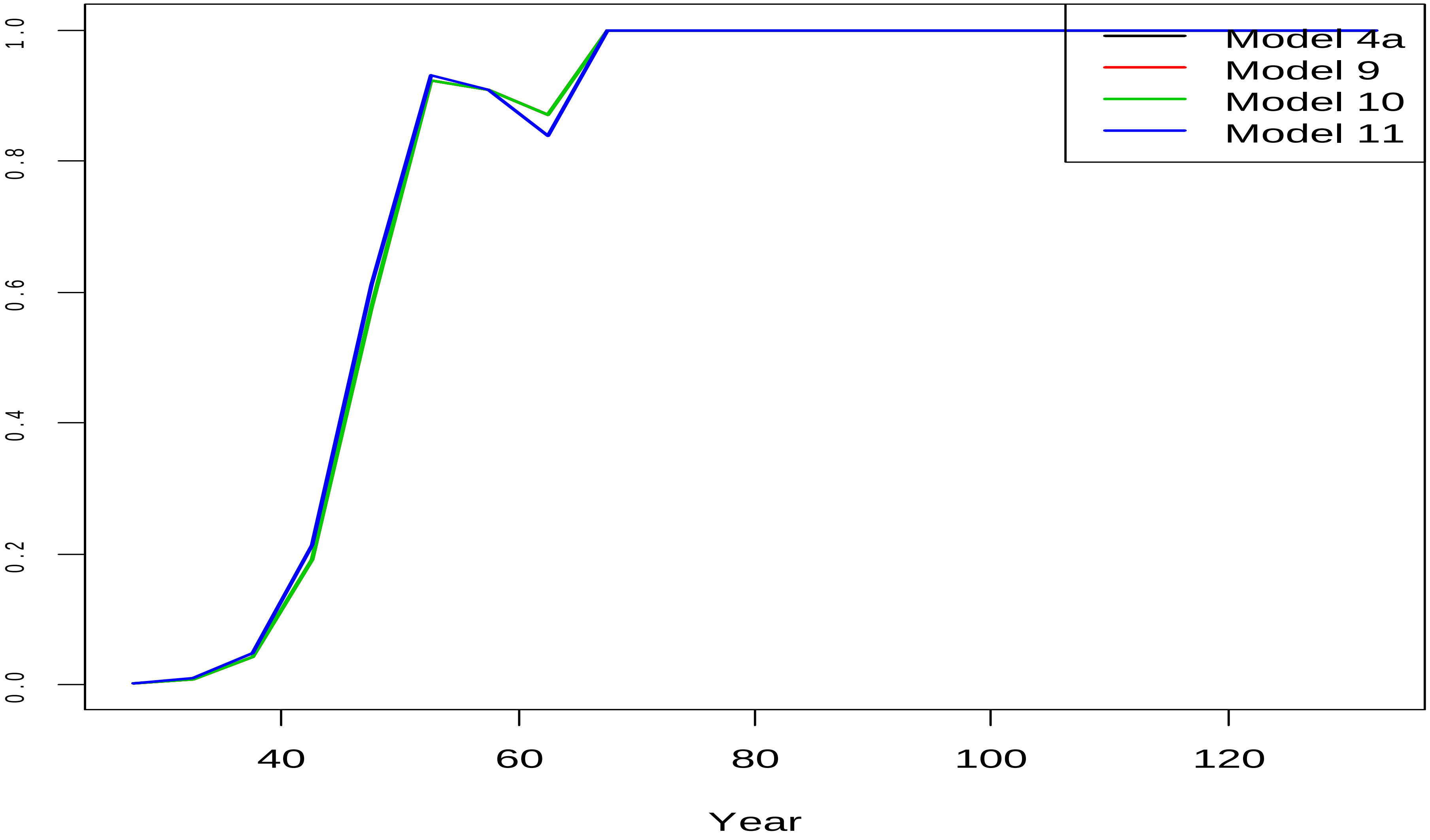
Removing priors on probability of maturing

Model 10 – males

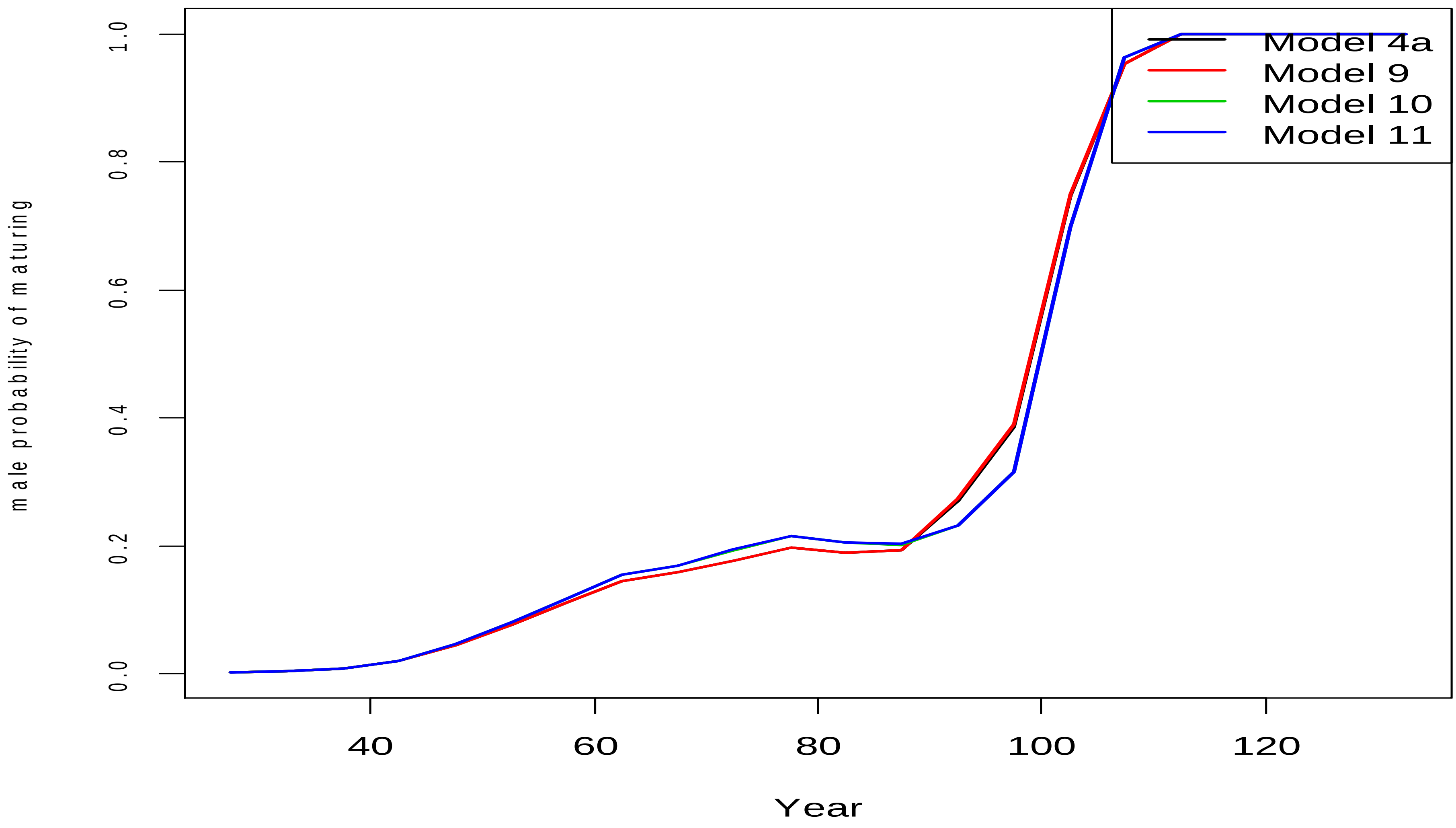
Model 11 – males and females



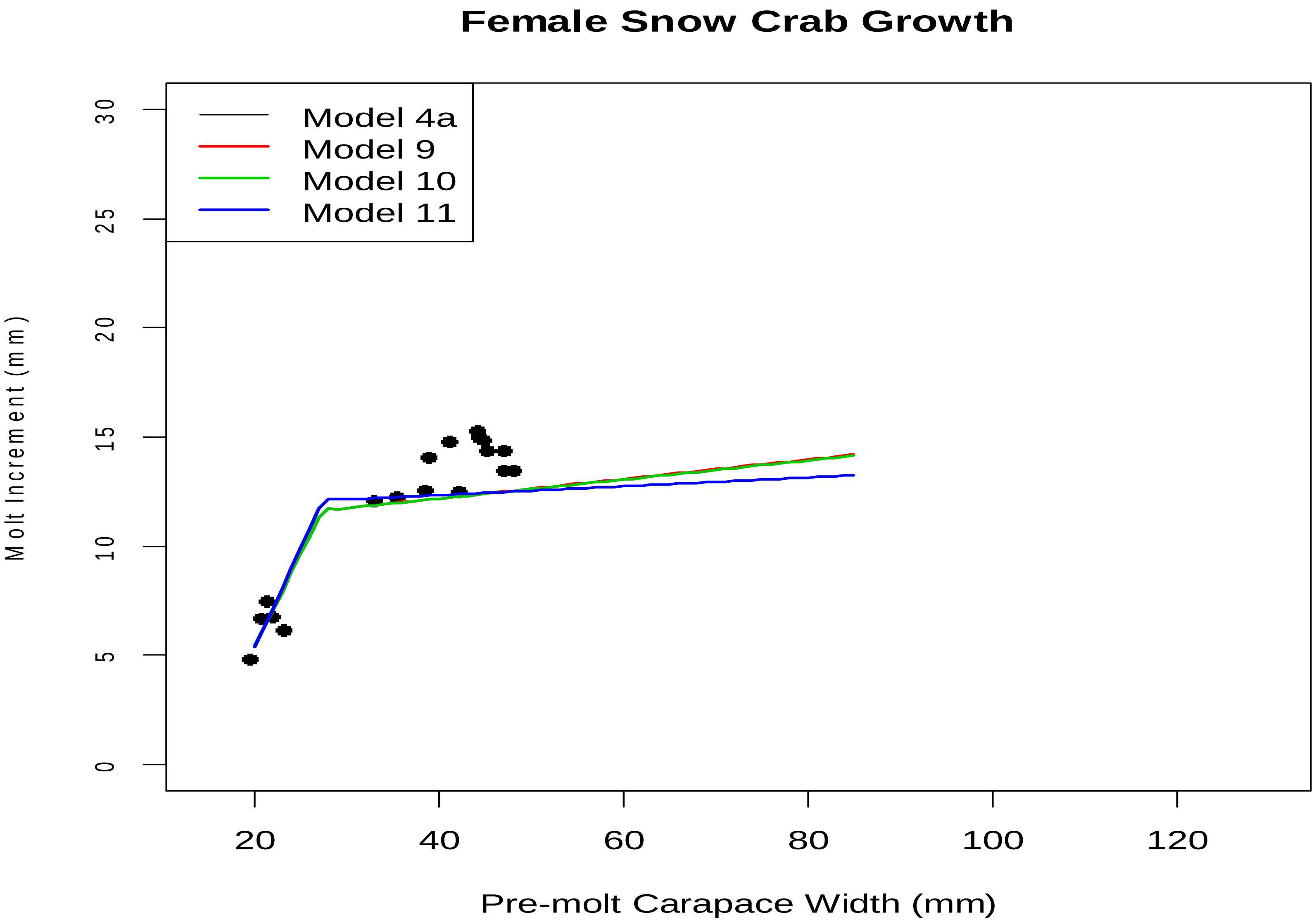
. Population male mature biomass estimates for Models 4a, 9, 10 and 11.



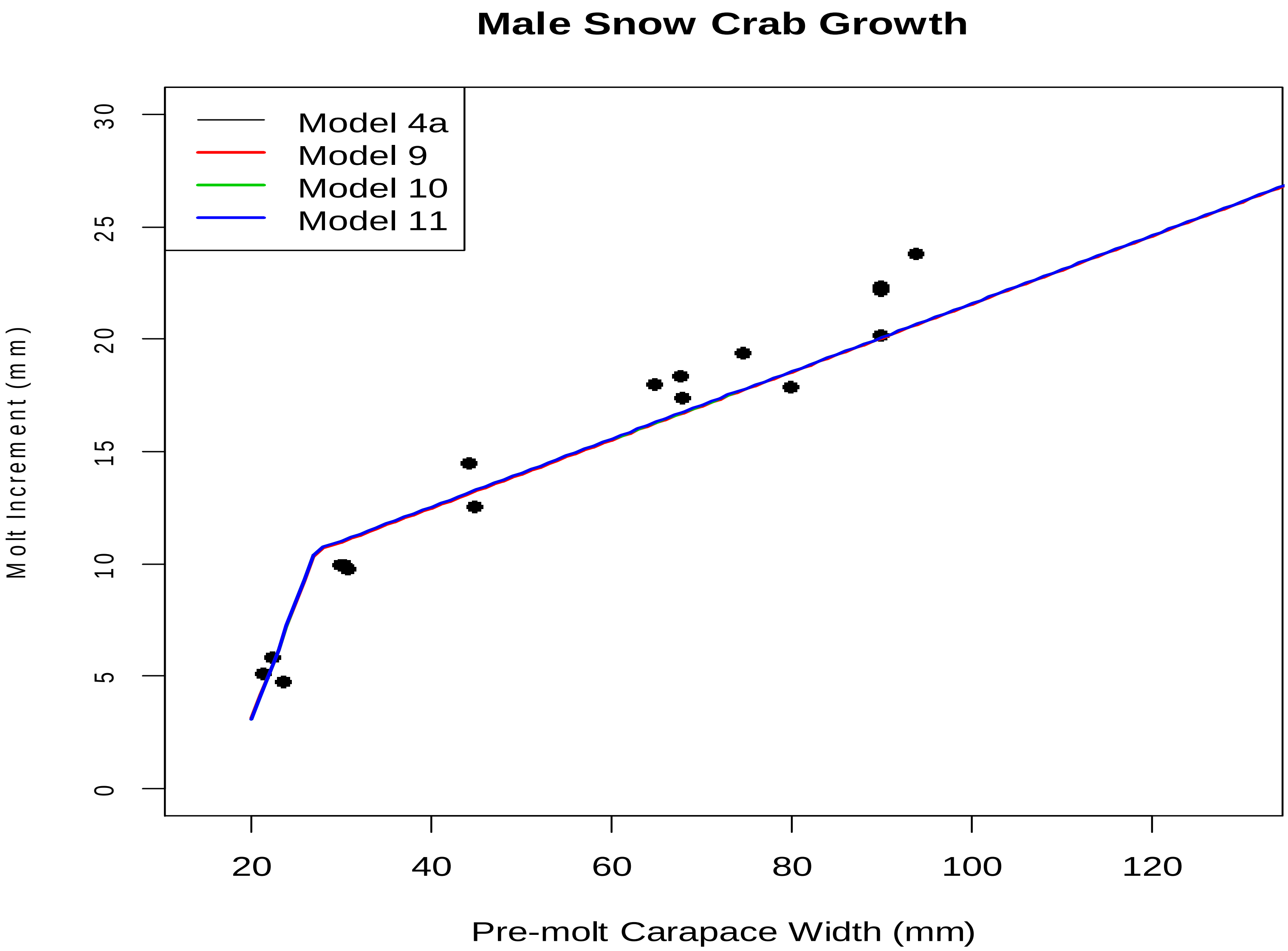
6. Female probability of maturing Models 4a, 9, 10 and 11.



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



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



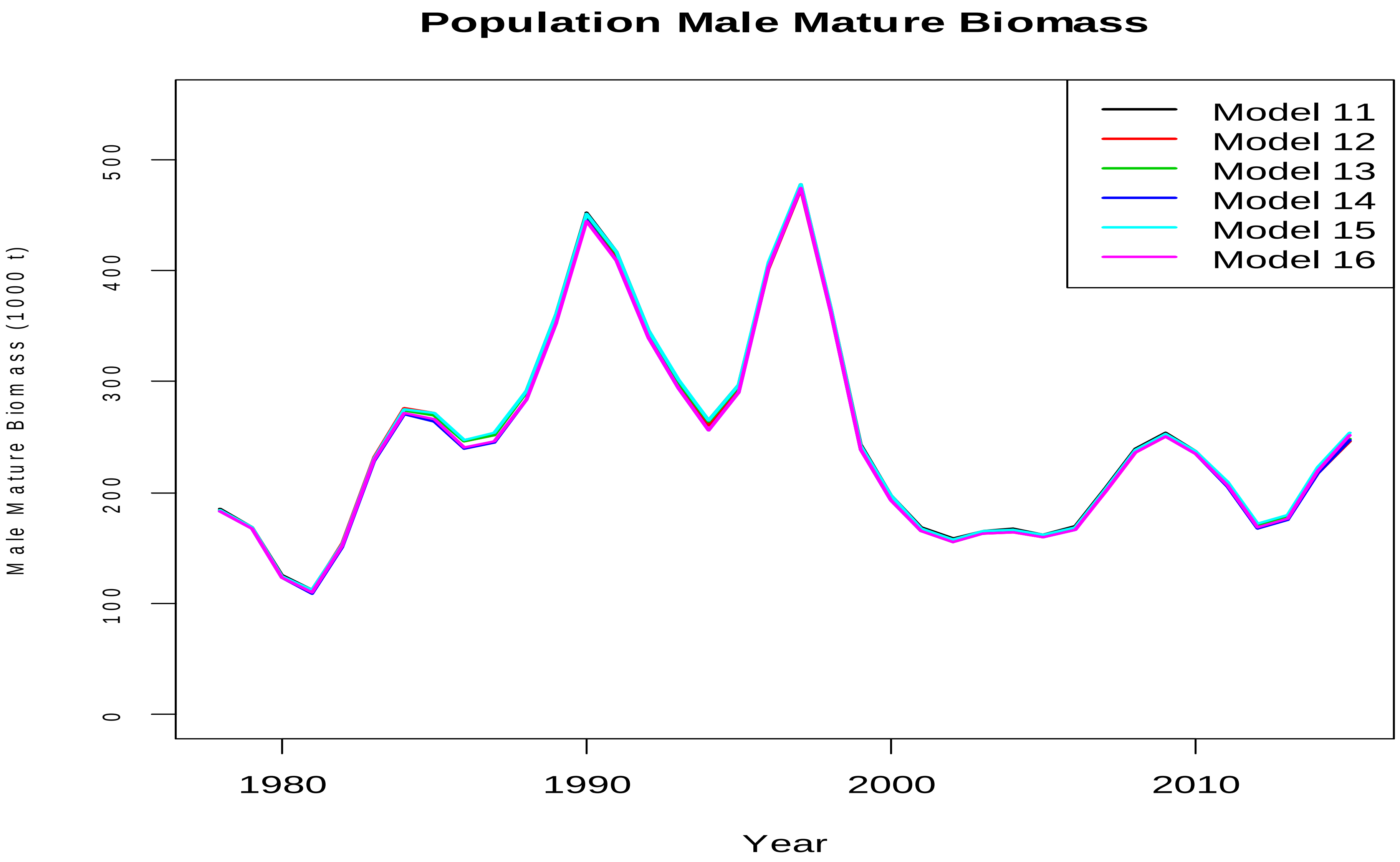
. Male growth for Models 4a, 9, 10 and 11.

Model 12 – increase weight on smoothness of female probability of maturing

Model 13 – estimate the female 50% selectivity parameter for fishery

Sensitivity to weight on growth likelihood

- Model 14 - weight on growth likelihood for males increased from 1 (sd=0.7) to 2 (sd=0.5)
- Model 15 - weight on growth likelihood for females increased from 1 (sd=0.7) to 2 (sd=0.5)
- Model 16 – weight on growth likelihood for both males and females increased from 1 (sd=0.7) to 2 (sd=0.5)



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

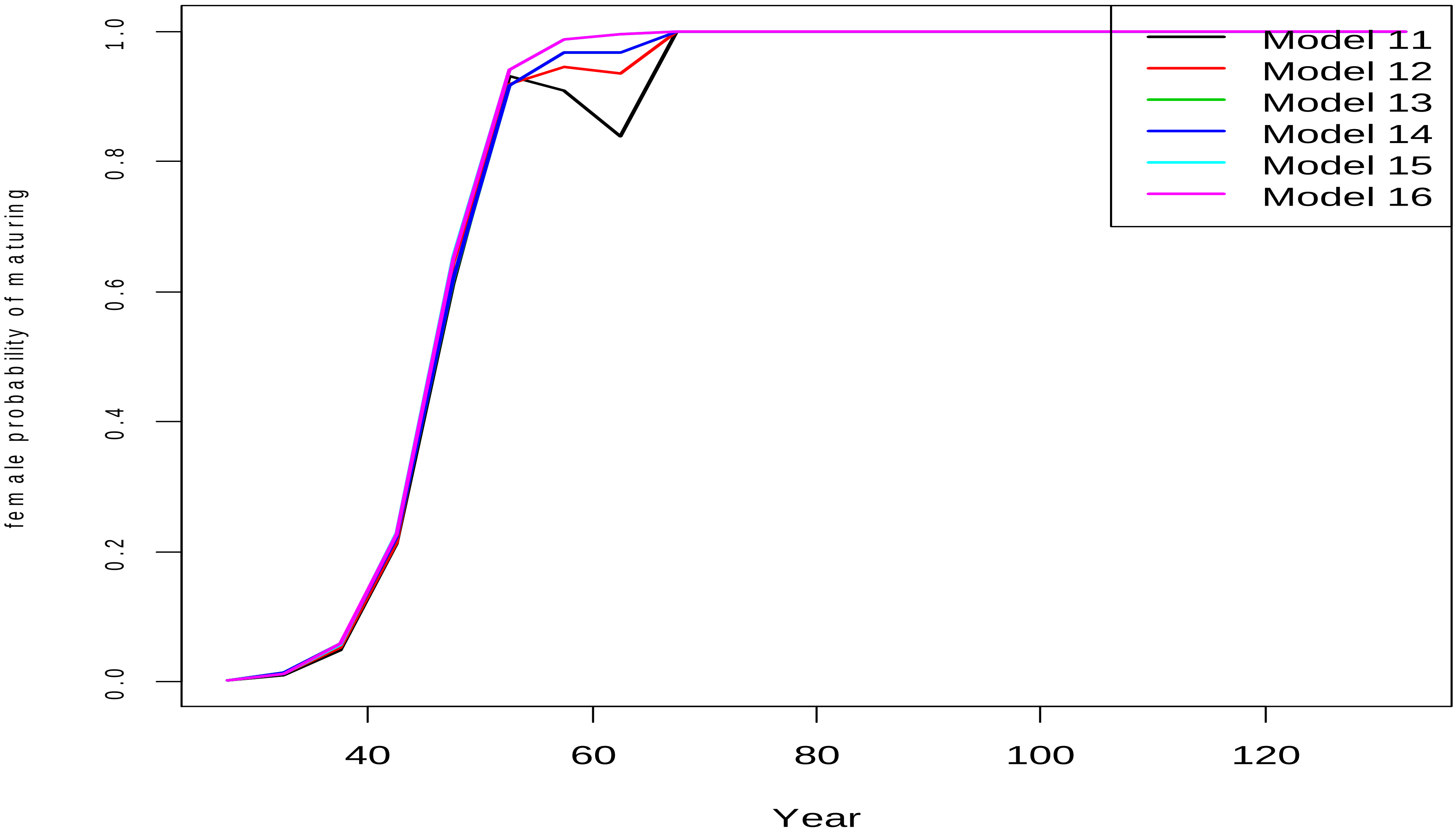
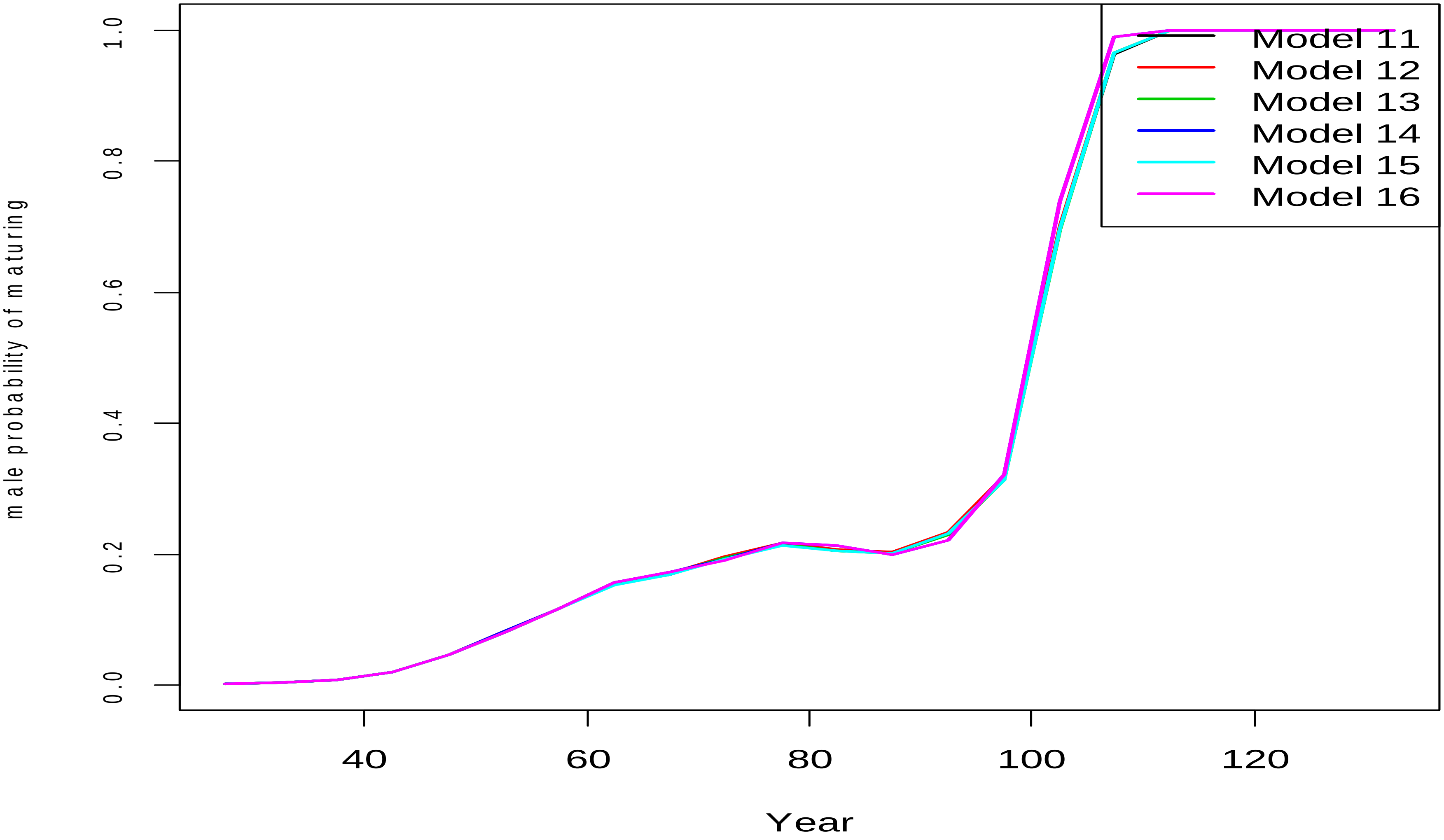
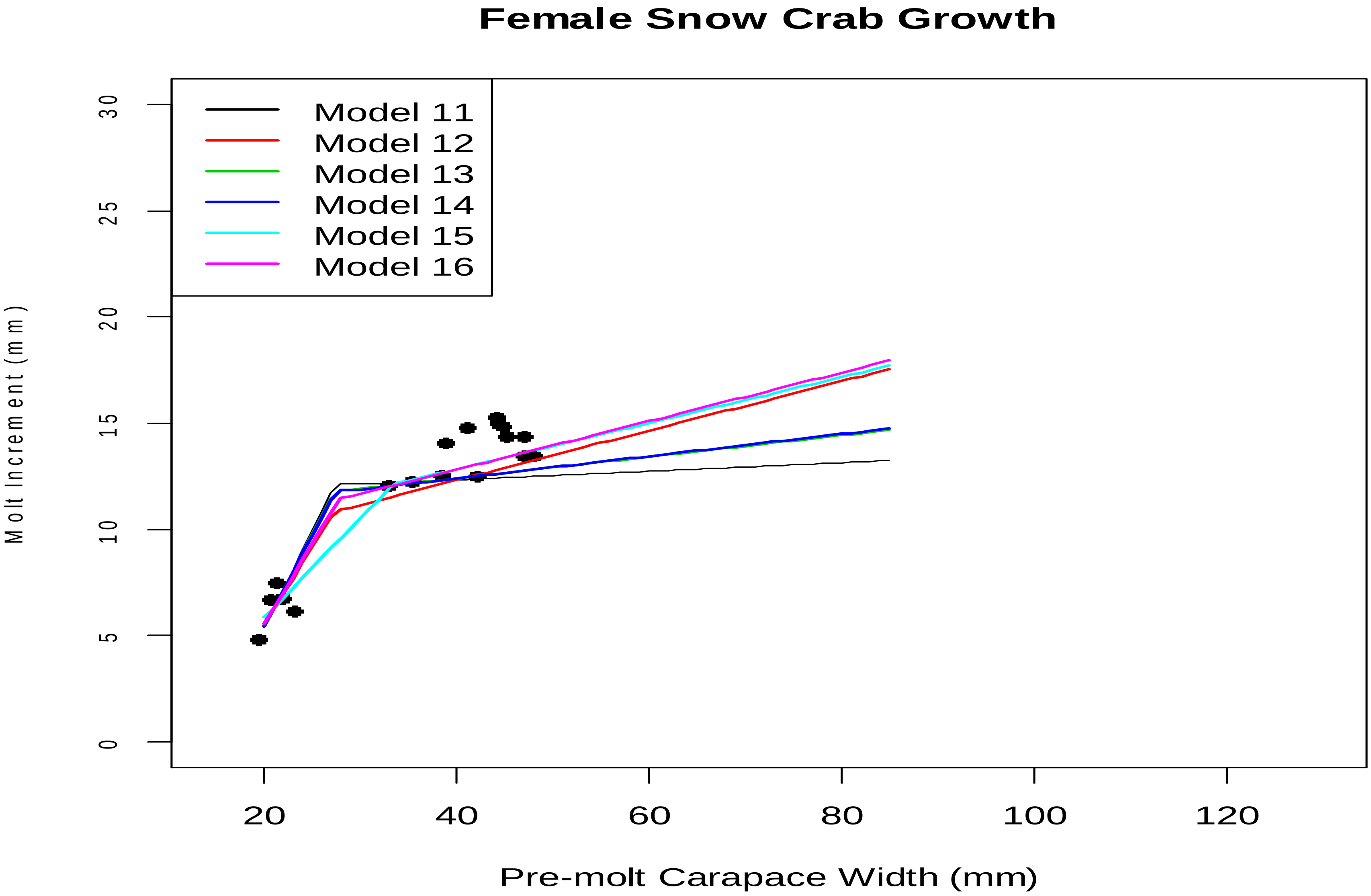


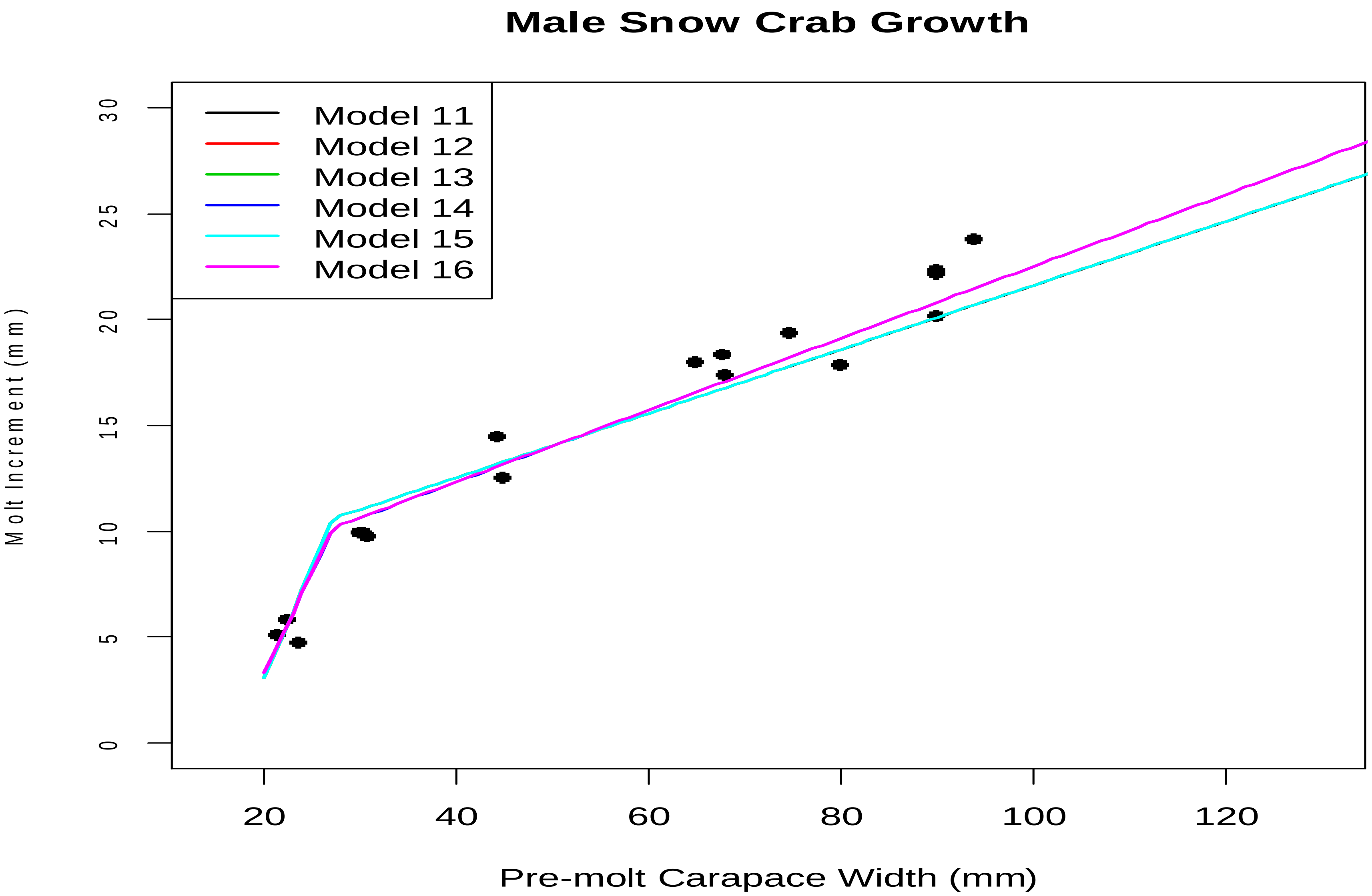
Figure 121. Comparison of female probability of maturing for Models 11-16. Models 13 and 14 are the same. Models 15 and 16 are the same.



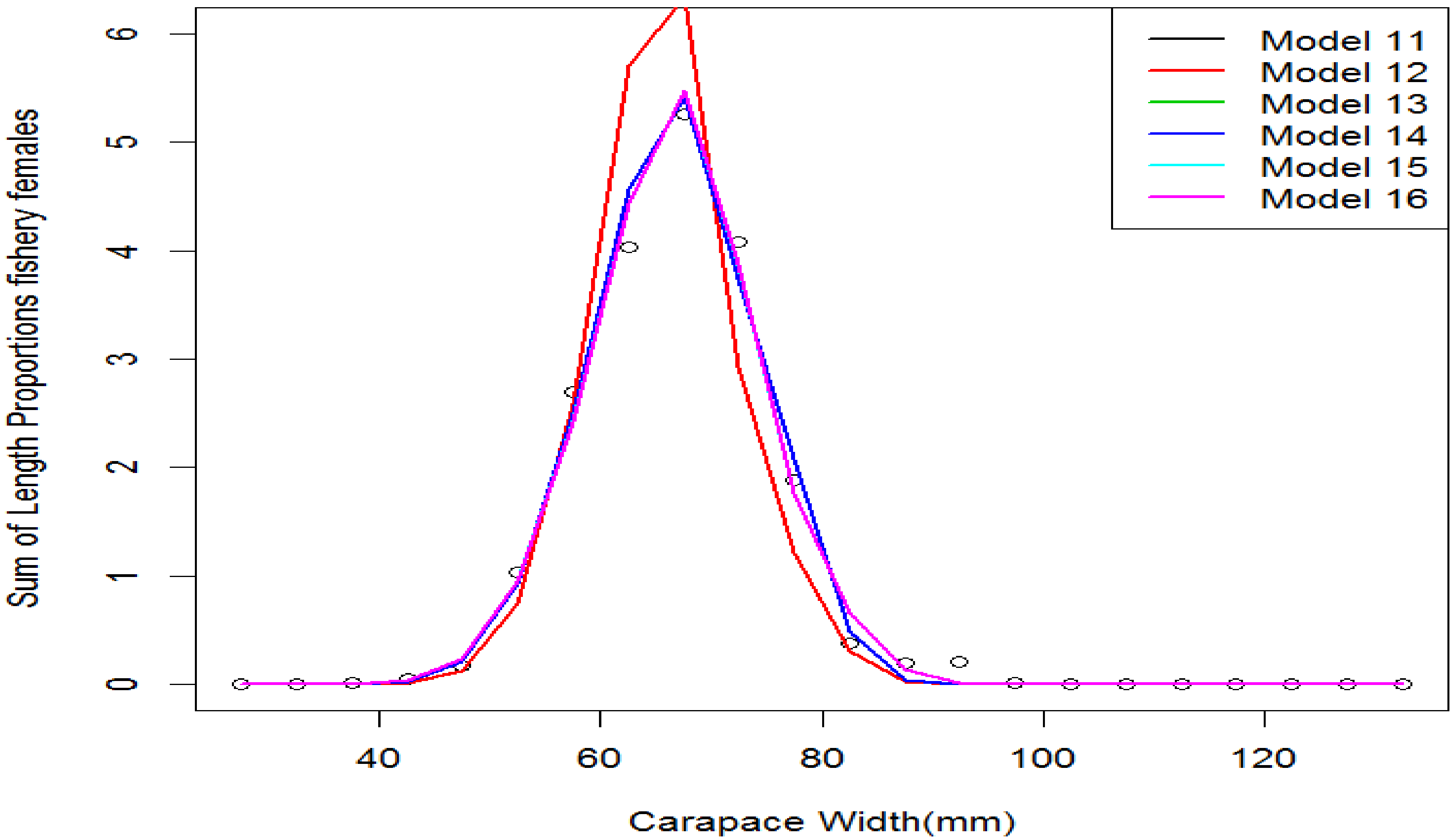
. Comparison of male probability of maturing for Models 11-16.



. Models 13 and 14 are same.



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

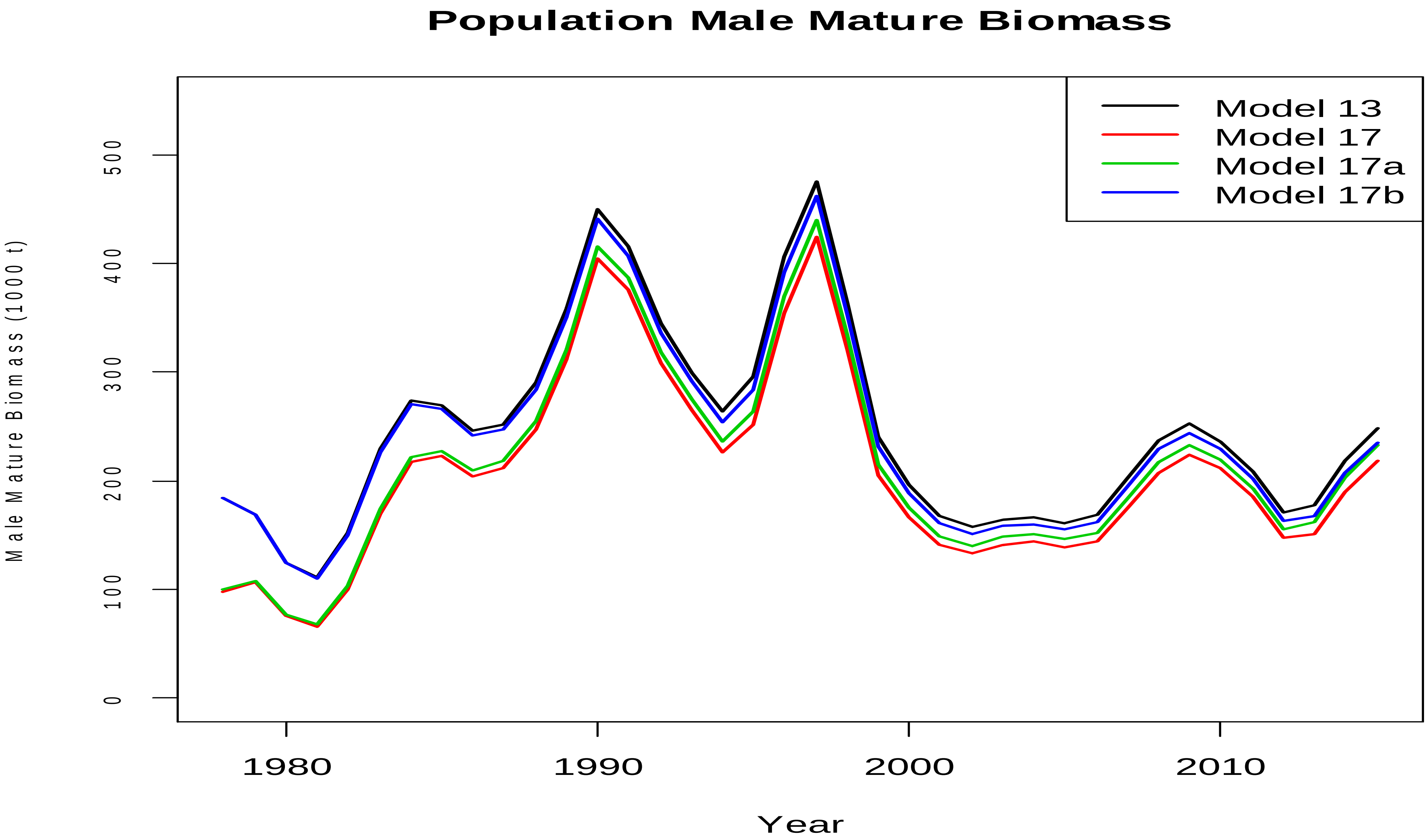


5. Comparison of summary fit to female directed fishery discard length frequency
ls 11,12,13,14, 15 and 16.

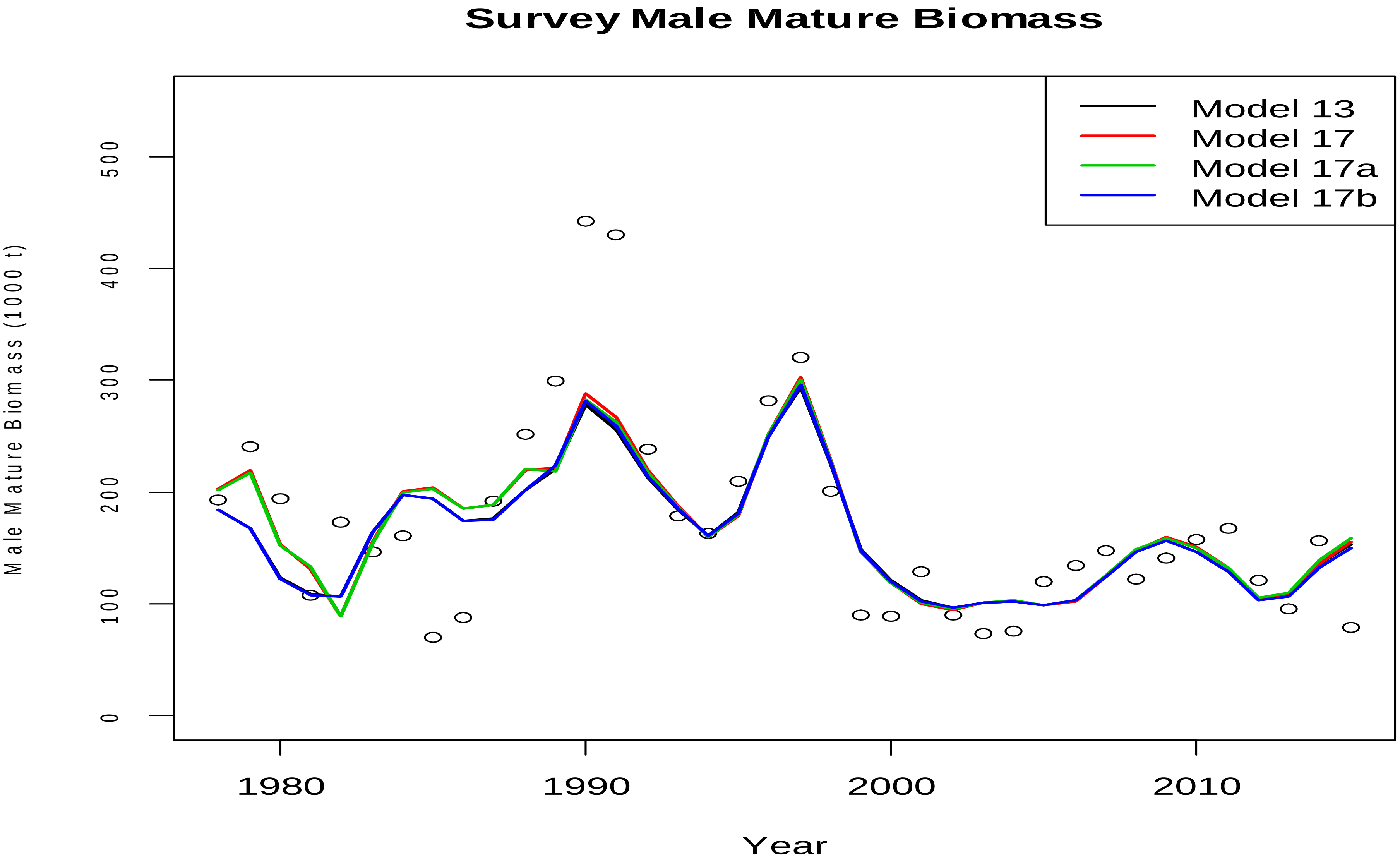
Models 14, 15 and 16 altered estimates of growth, however, did not introduce significant stability to the model (4, 1 and 4 runs at lowest likelihood)

Better fit to growth data results in higher likelihood for survey length data

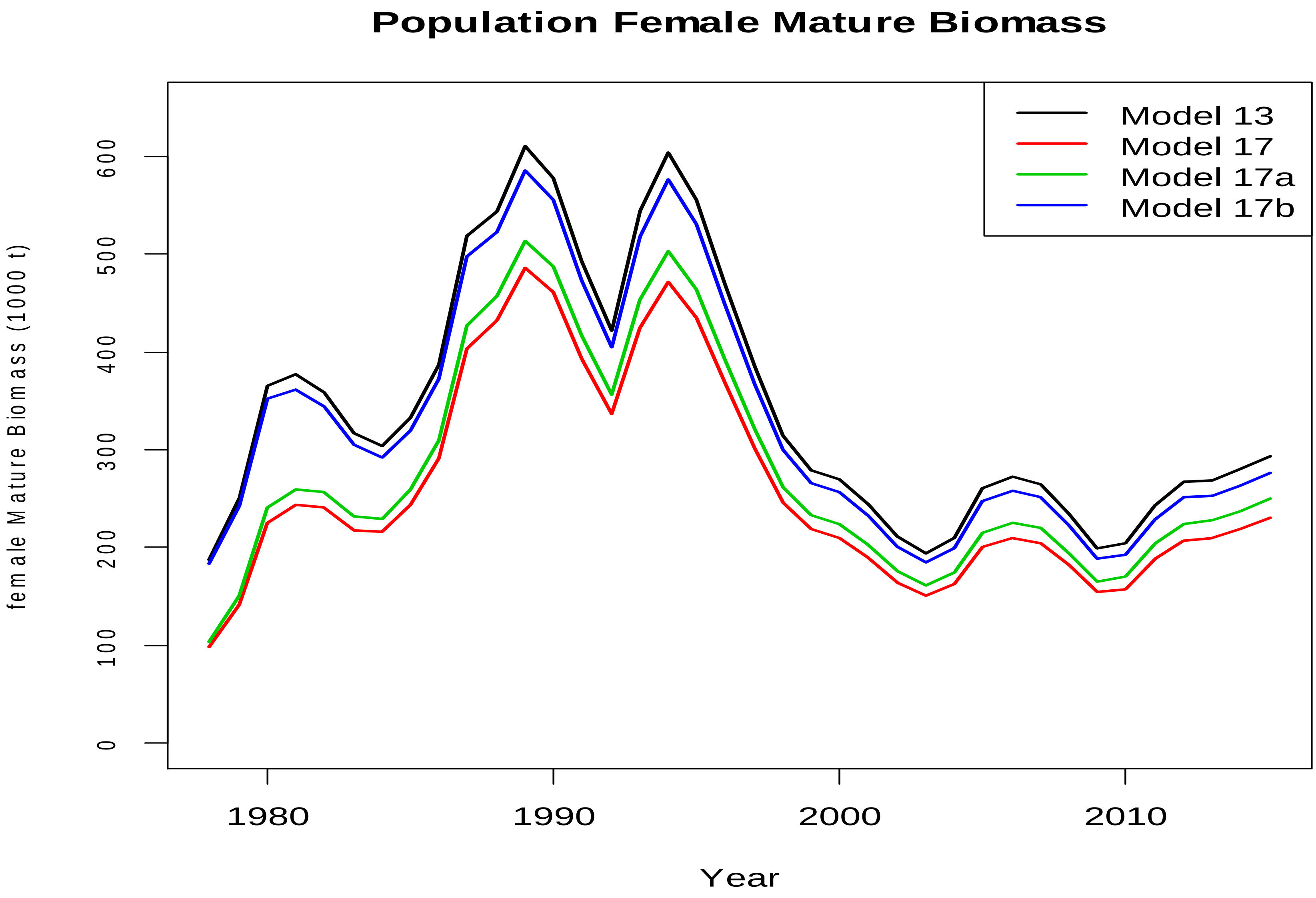
Models 17, 17a and 17b



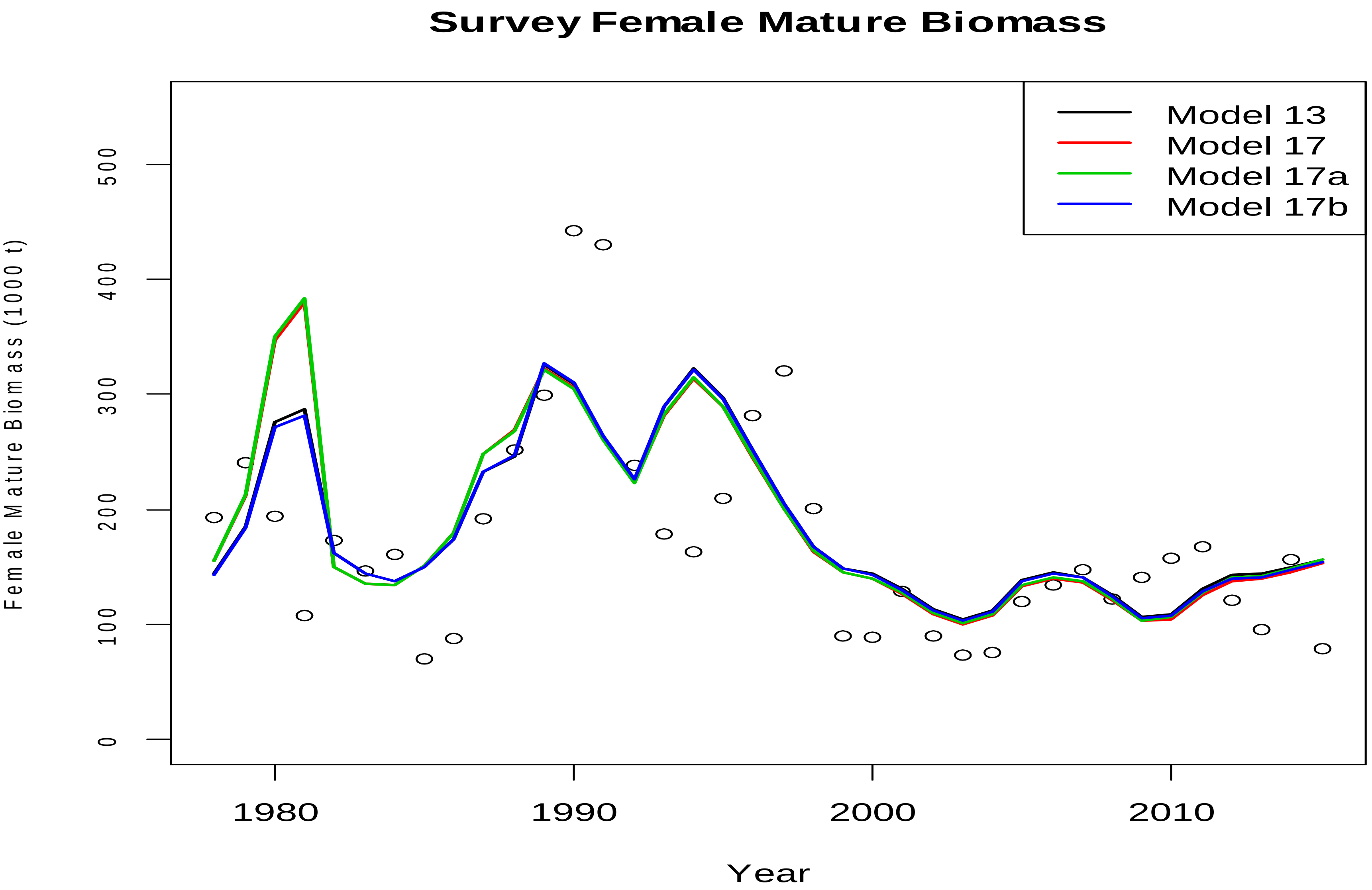
. Population mature male biomass comparison between models 13, 17, 17a and 17b.



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



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



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

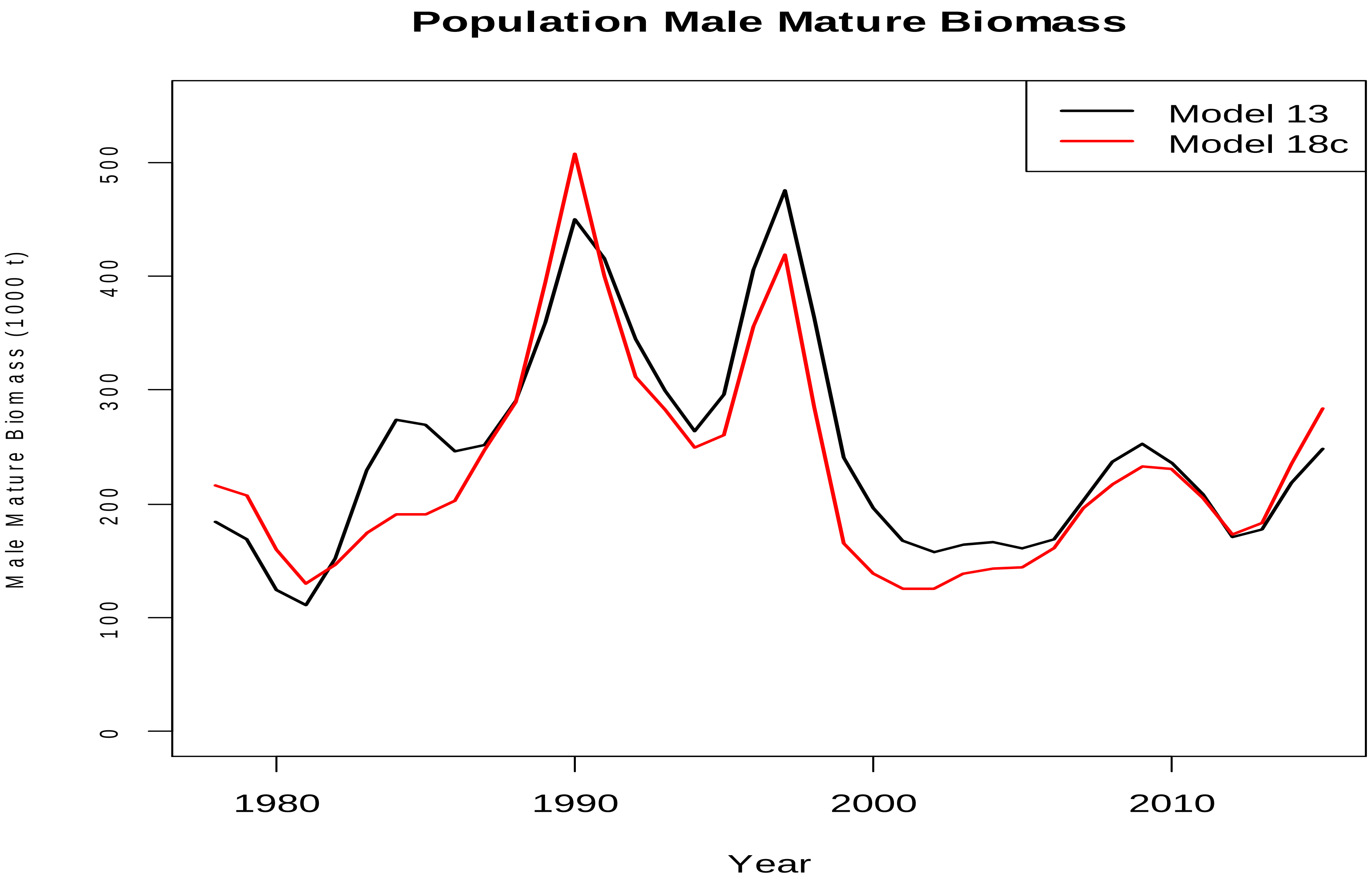
Models 13, 17, 17a, 17b

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

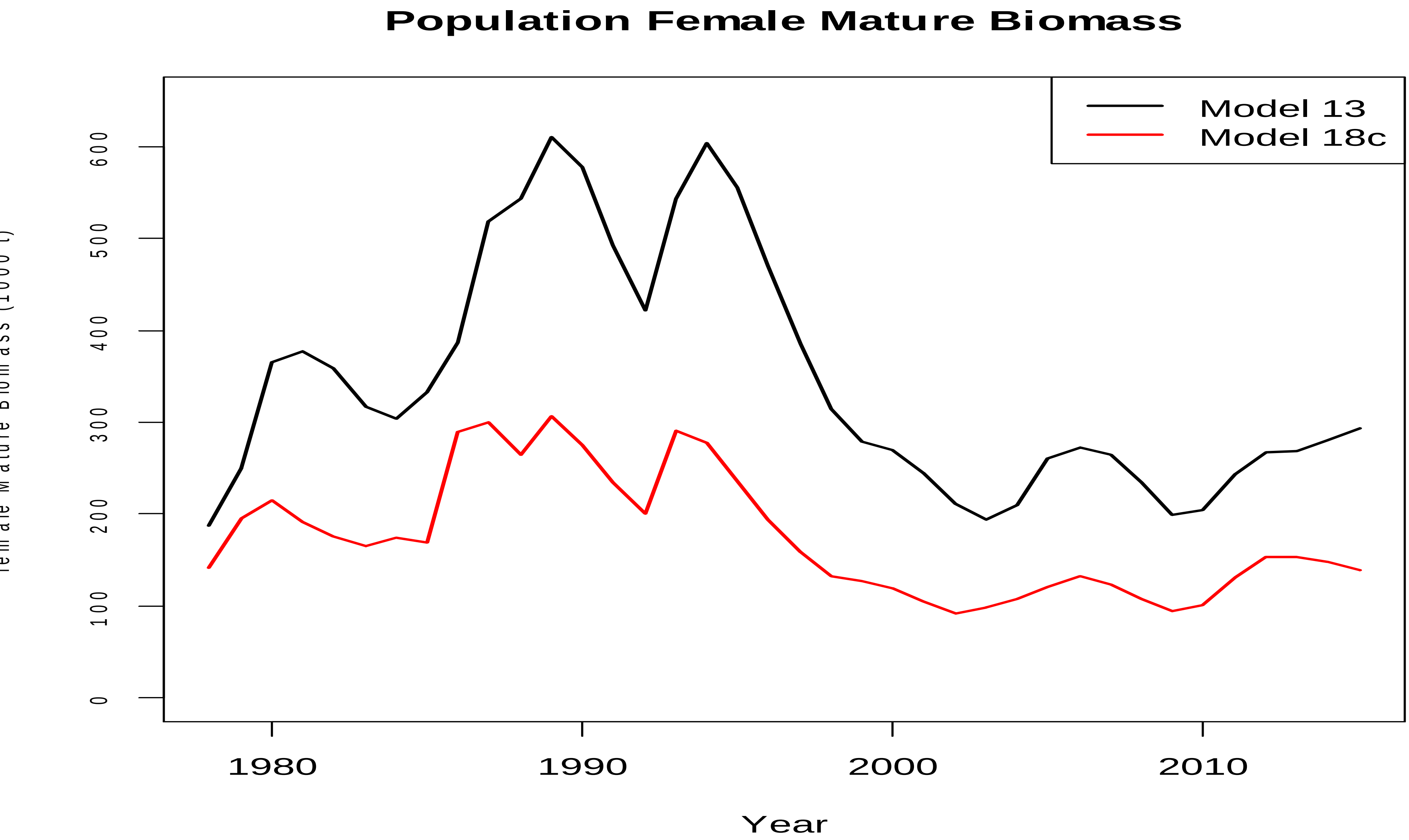
Model 18c – Reducing sample sizes on length data

	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

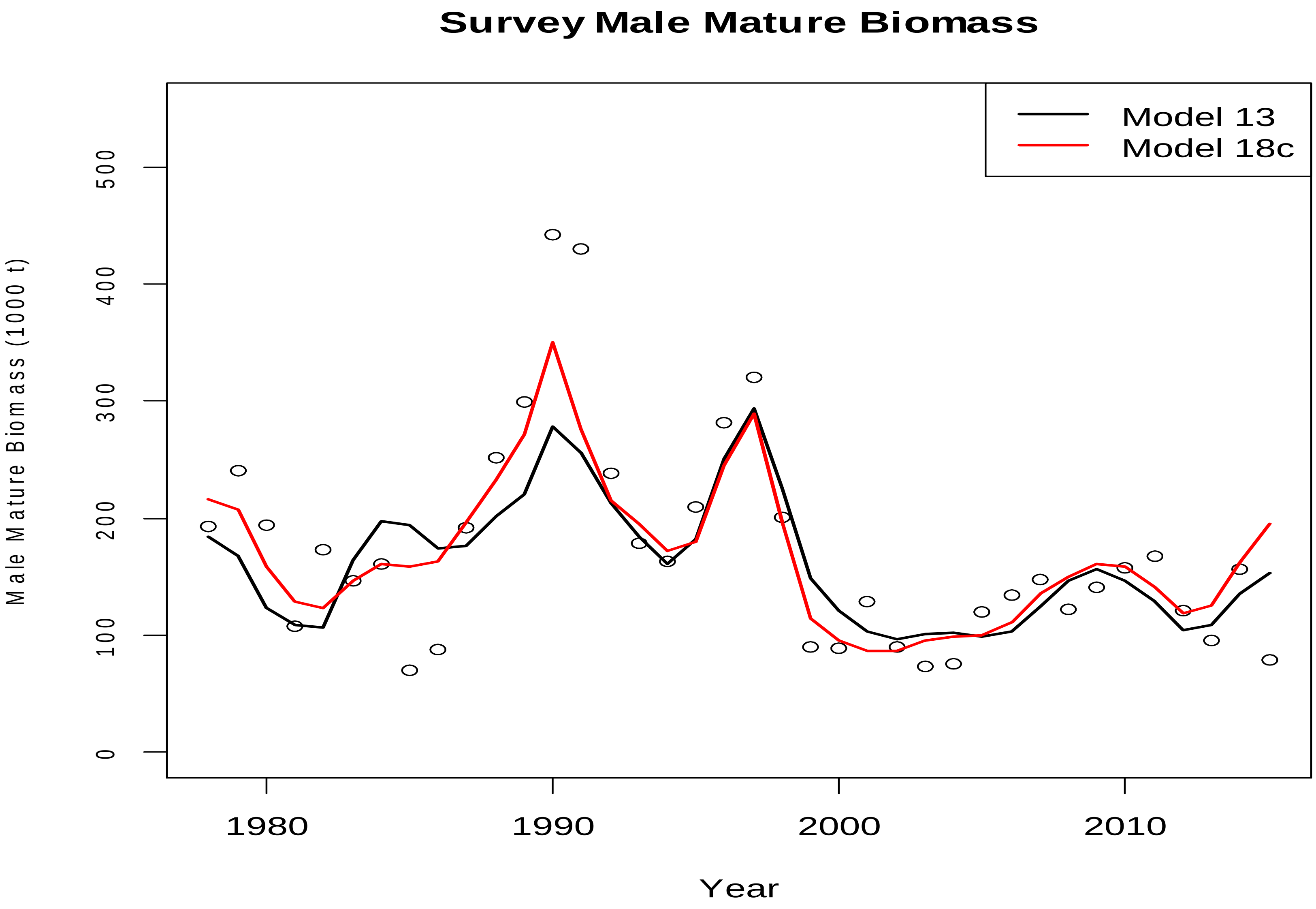
Model 18c – Reducing sample size on length composition data



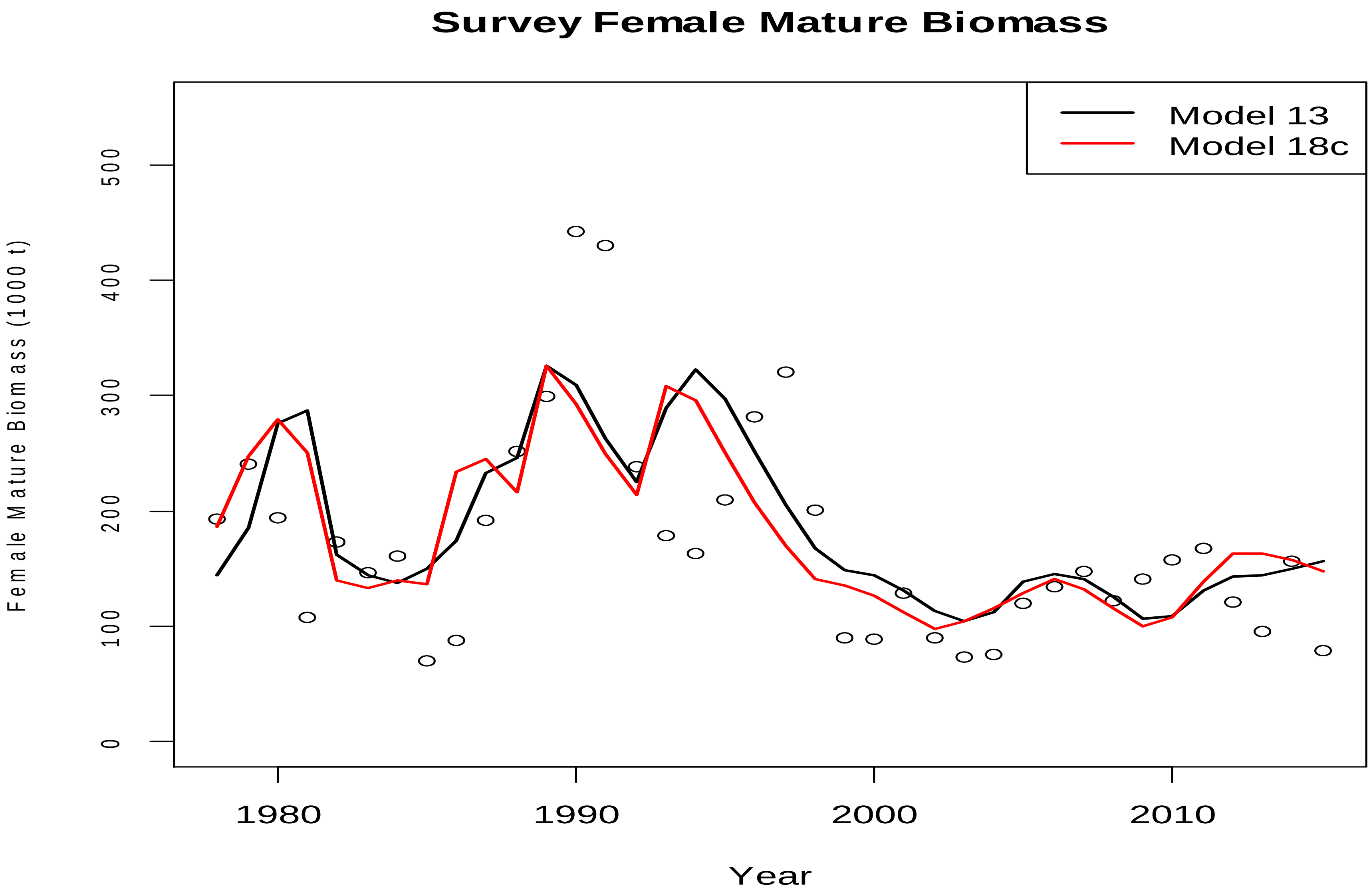
. Population mature male biomass comparison between models 13 and 18c.



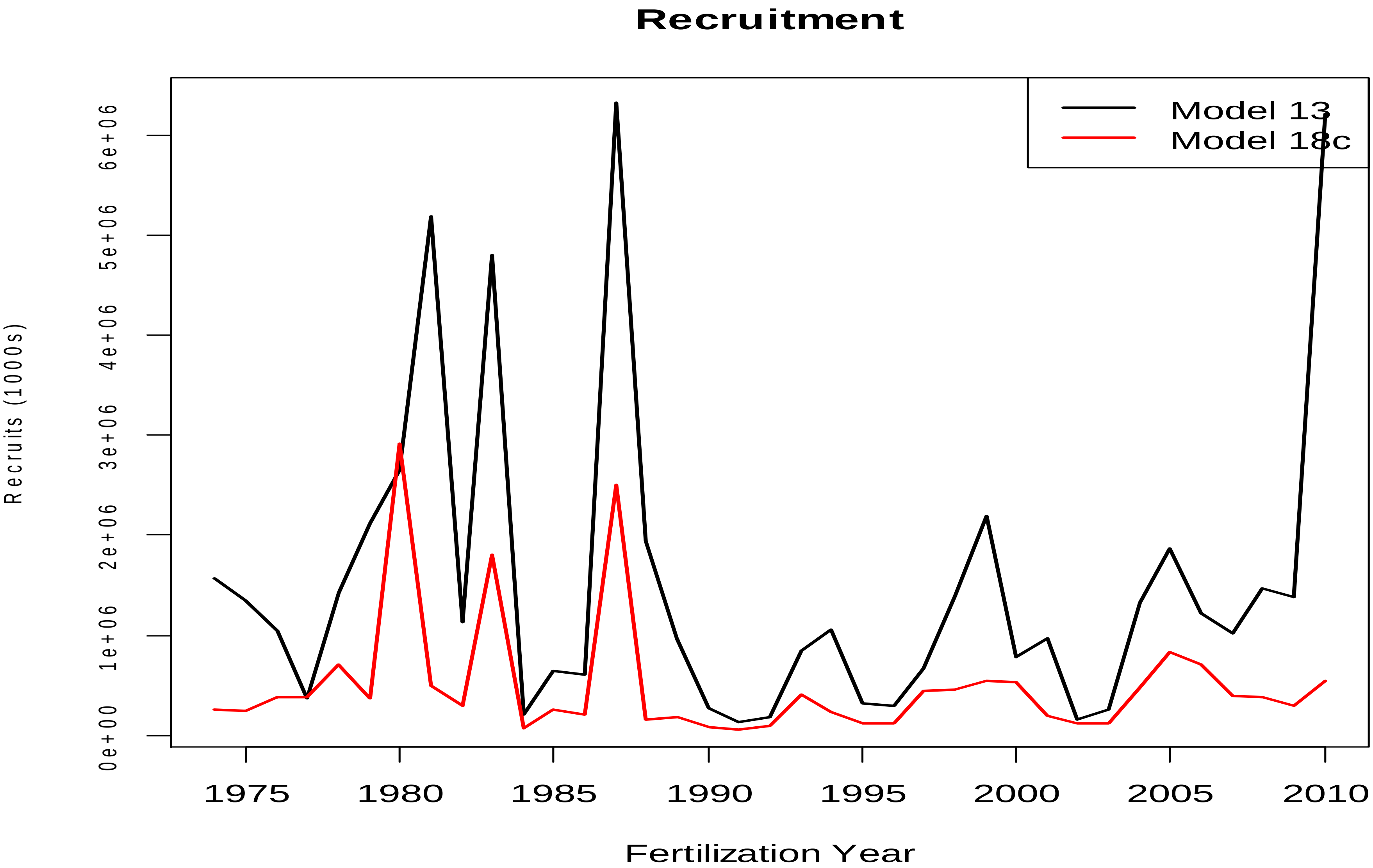
. Population mature female biomass comparison between models 13 and 18c.



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

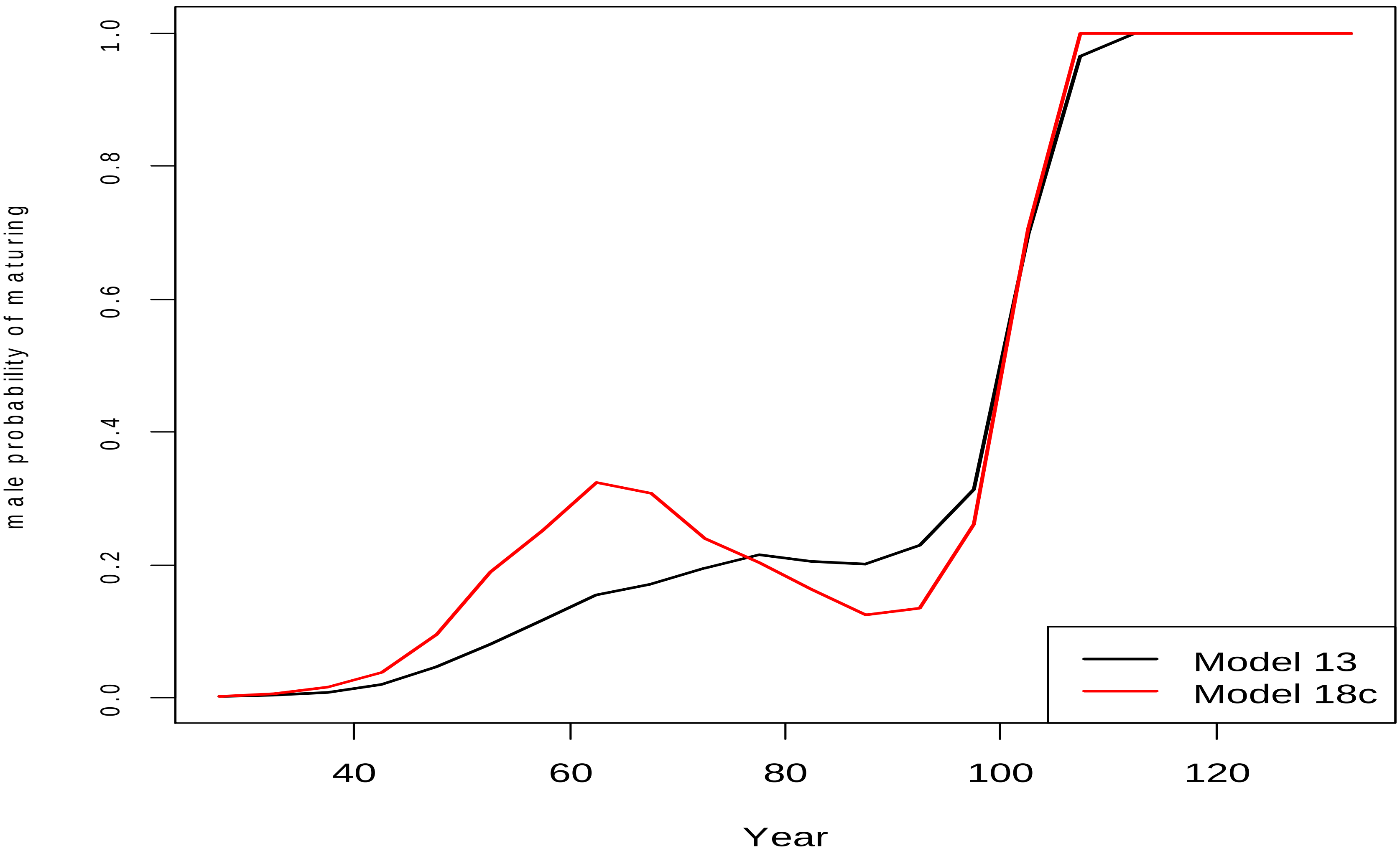


1. Fit to mature female biomass comparison between models 13 and 18c

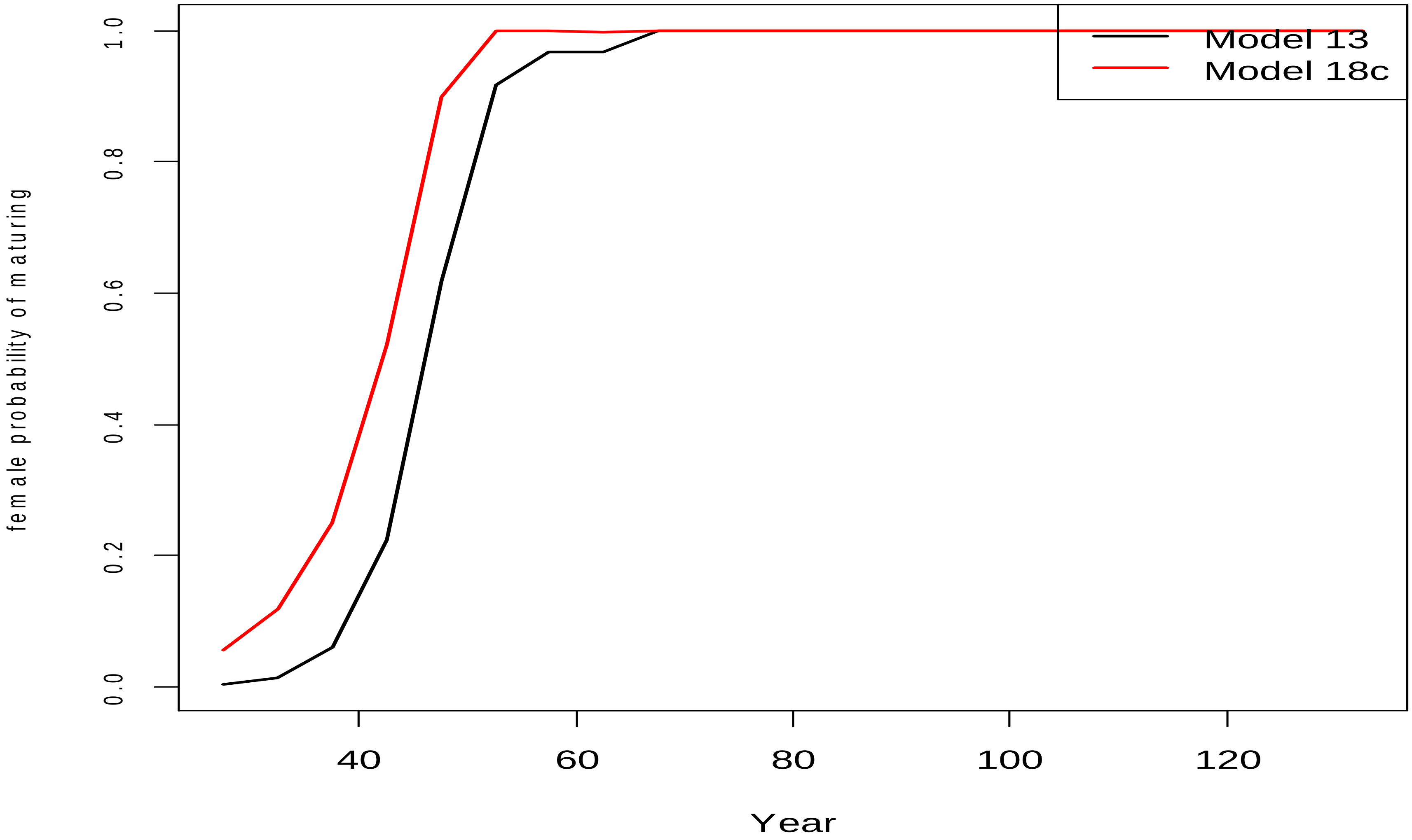


2. Recruitment estimates for models 13 and 18c.

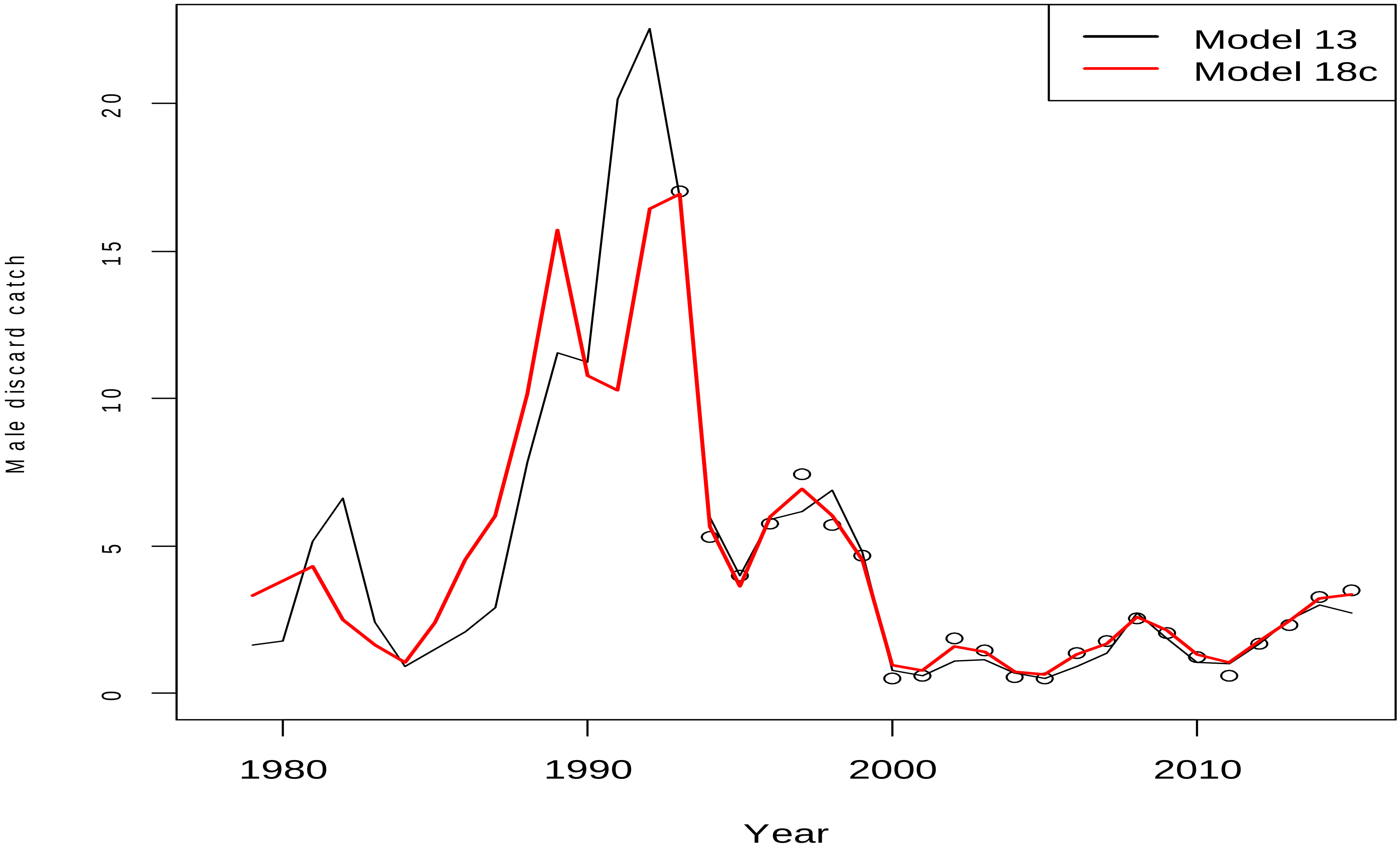
for immature crab, differences in growth and probability of maturing



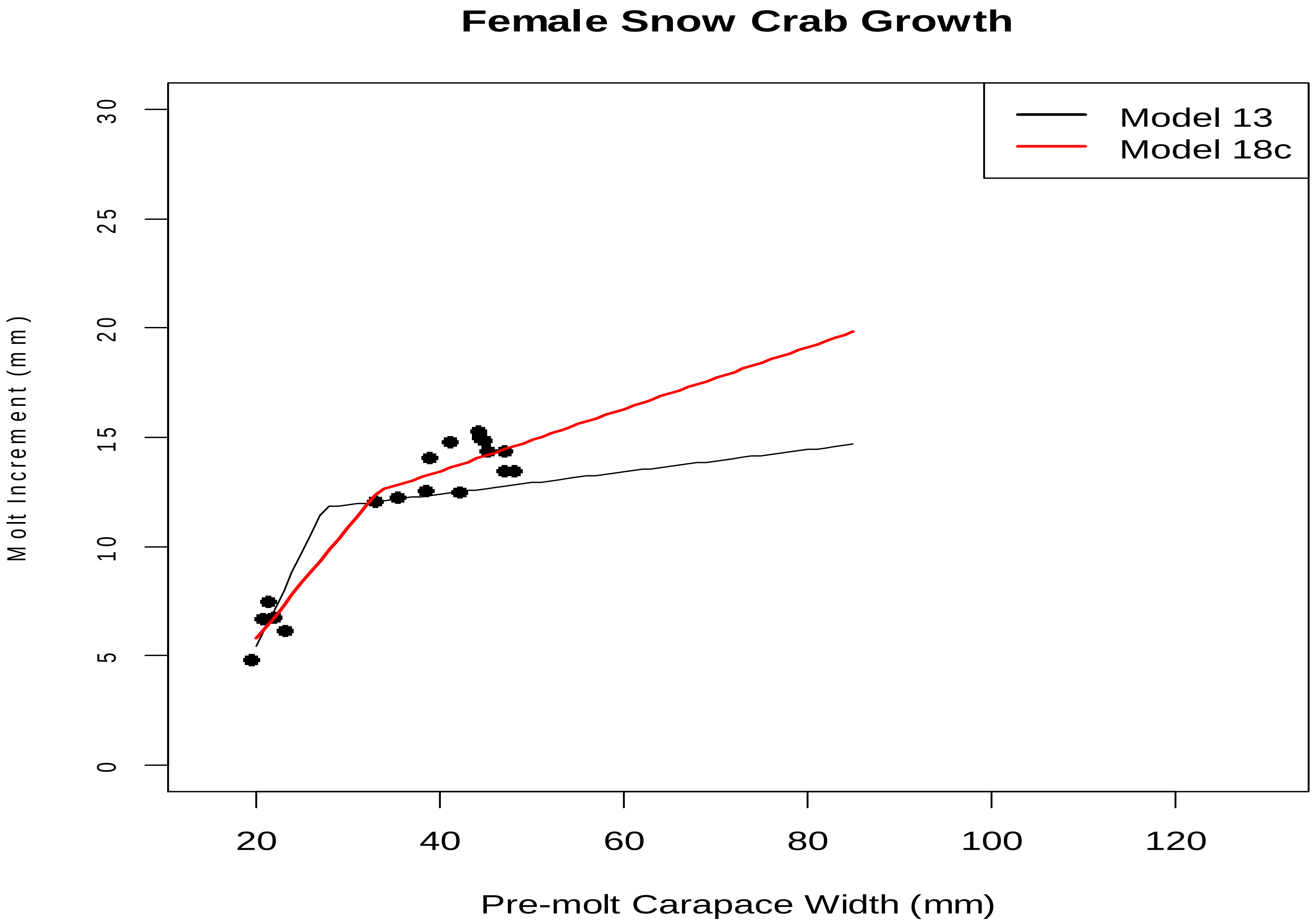
4. Probability of maturing for males for Models 13 and 18c.



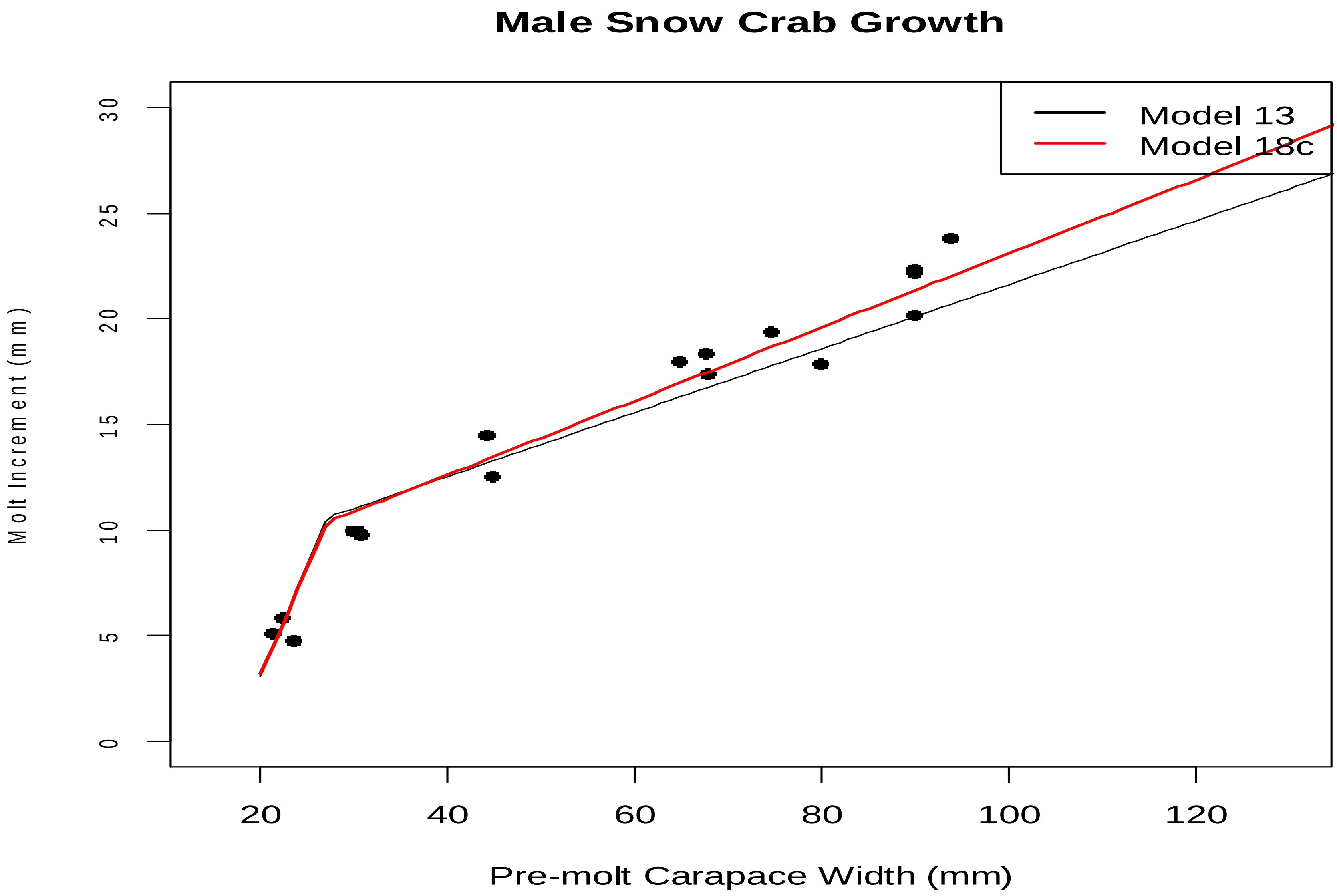
5. Probability of maturing for females for Models 13 and 18c.



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



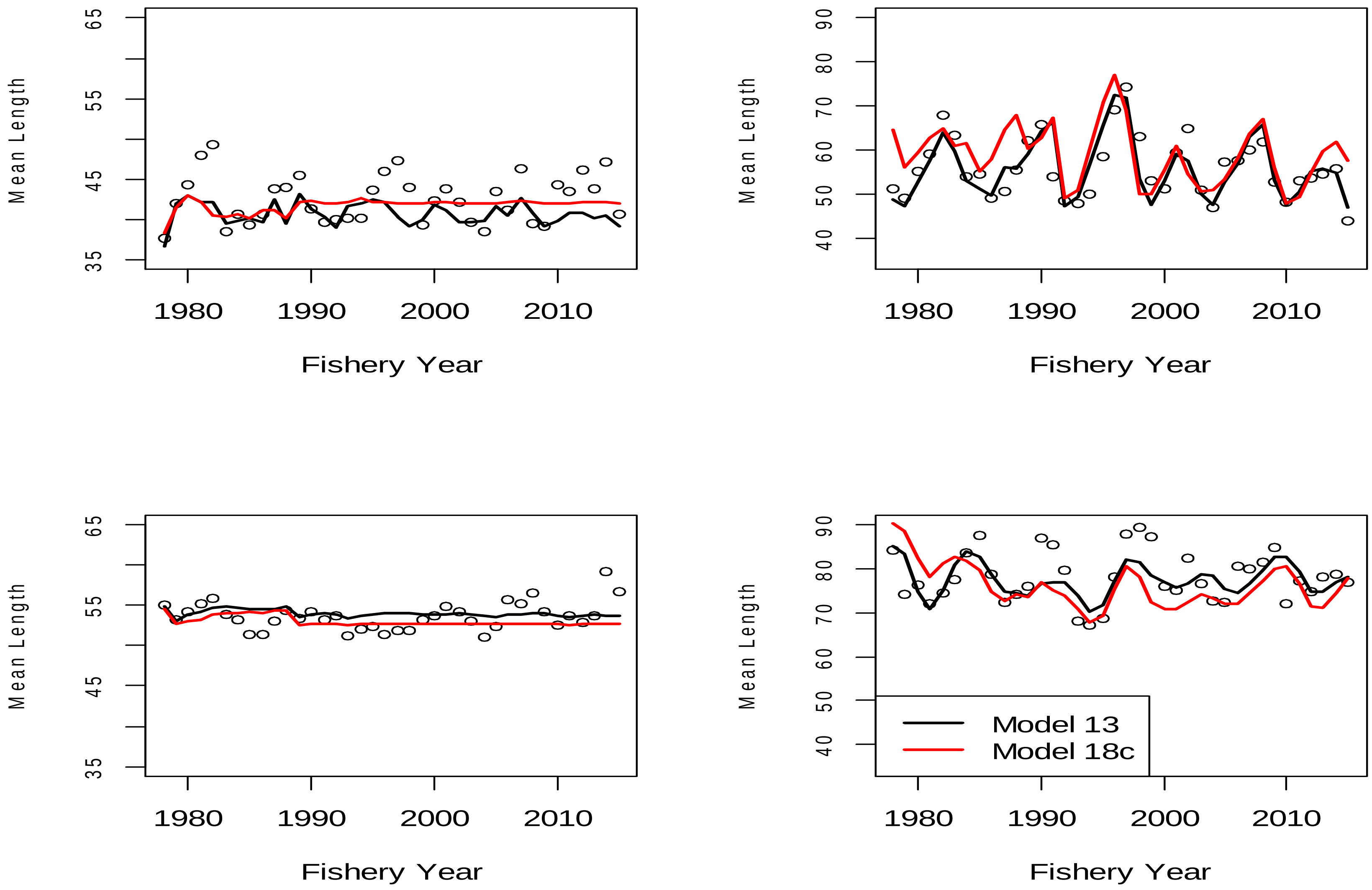
7. Fit to female growth for Models 13 and 18c.



8. Fit to male growth for Models 13 and 18c.

Model 18c parameters

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



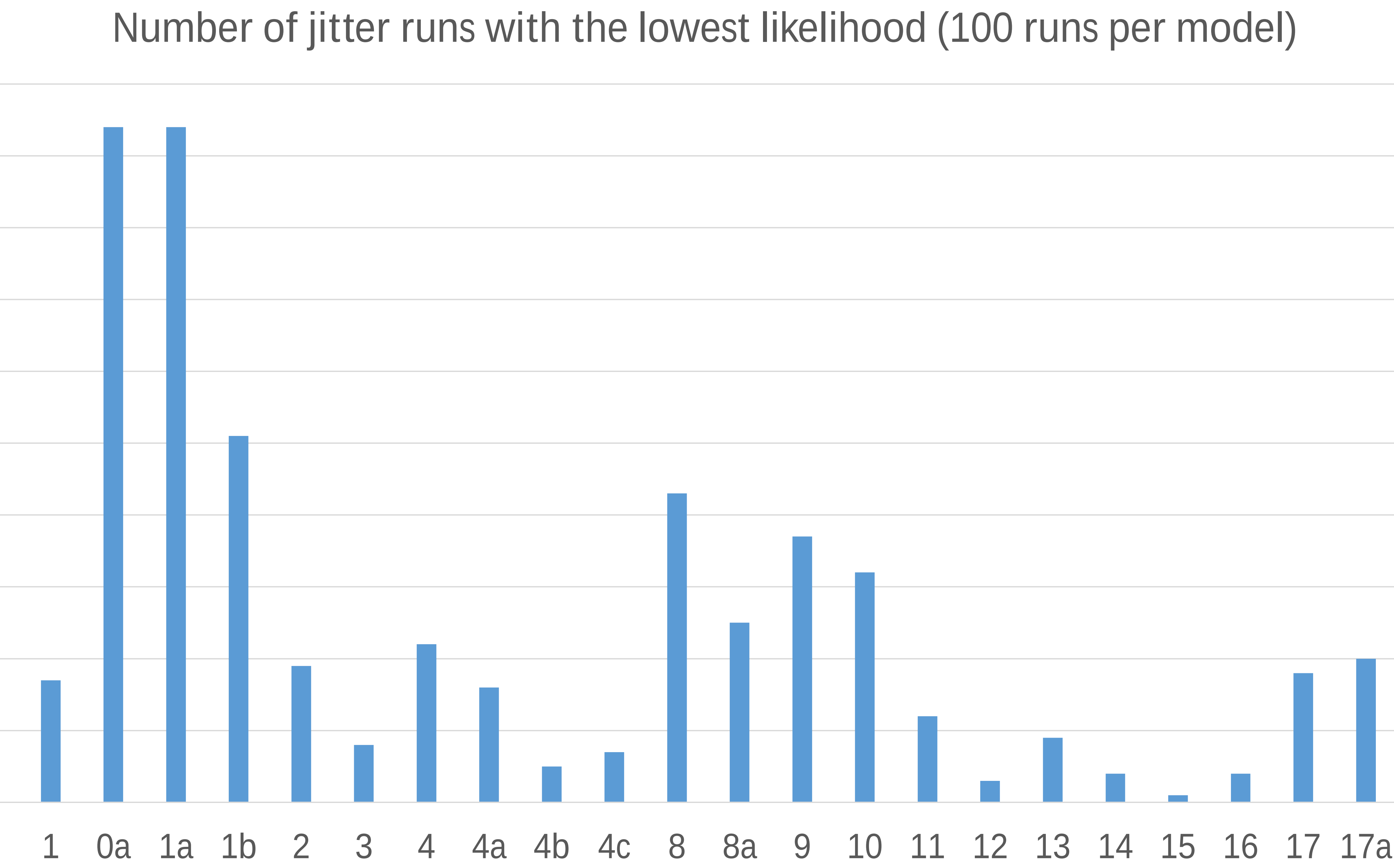
143. Observed and predicted mean length for immature females (top left), e females (bottom left), immature males(top right) and mature males (bottom right) odels 13 and 18c. Mean length values are used in the estimation of Francis effective N.

Model Stability

Model can be stabilized by fixing some growth parameters (models 0a, 1a and 1b) or estimating single linear growth (models 8 and 8a)

Conflicts in the data for estimation of growth (survey length data want lower growth than growth data) increase instability

More flexible model such as the snow crab model, where we are estimating a complex growth function, survey qs, natural mortalities, probability of maturing, etc., increases instability.



Number of jitter runs with the lowest likelihood (100 runs per model)

Finding the lowest likelihood is most important – use jittering

Small gradients can occur for many likelihood values

Gradient is not necessarily a good indicator of convergence– just because you have a small gradient doesn’t mean you have the lowest likelihood

Within runs at the lowest likelihood parameter estimates and results with max gradients up to about 0.06 are the same

Select model with the lowest likelihood and lowest gradient from the jittered runs

Problems with parameters – look at parameters values by likelihood to see which parameters change the most

Examine parameters with highest gradients

For the snow crab model appears that 100 jitter runs are adequate, however, if there are only a few runs with the lowest likelihood would recommend doing more runs to make sure.

35 key parameters jittered gave same results as all parameters – once setup jittering all parameters same as doing 35 parameters

September Model Scenarios?

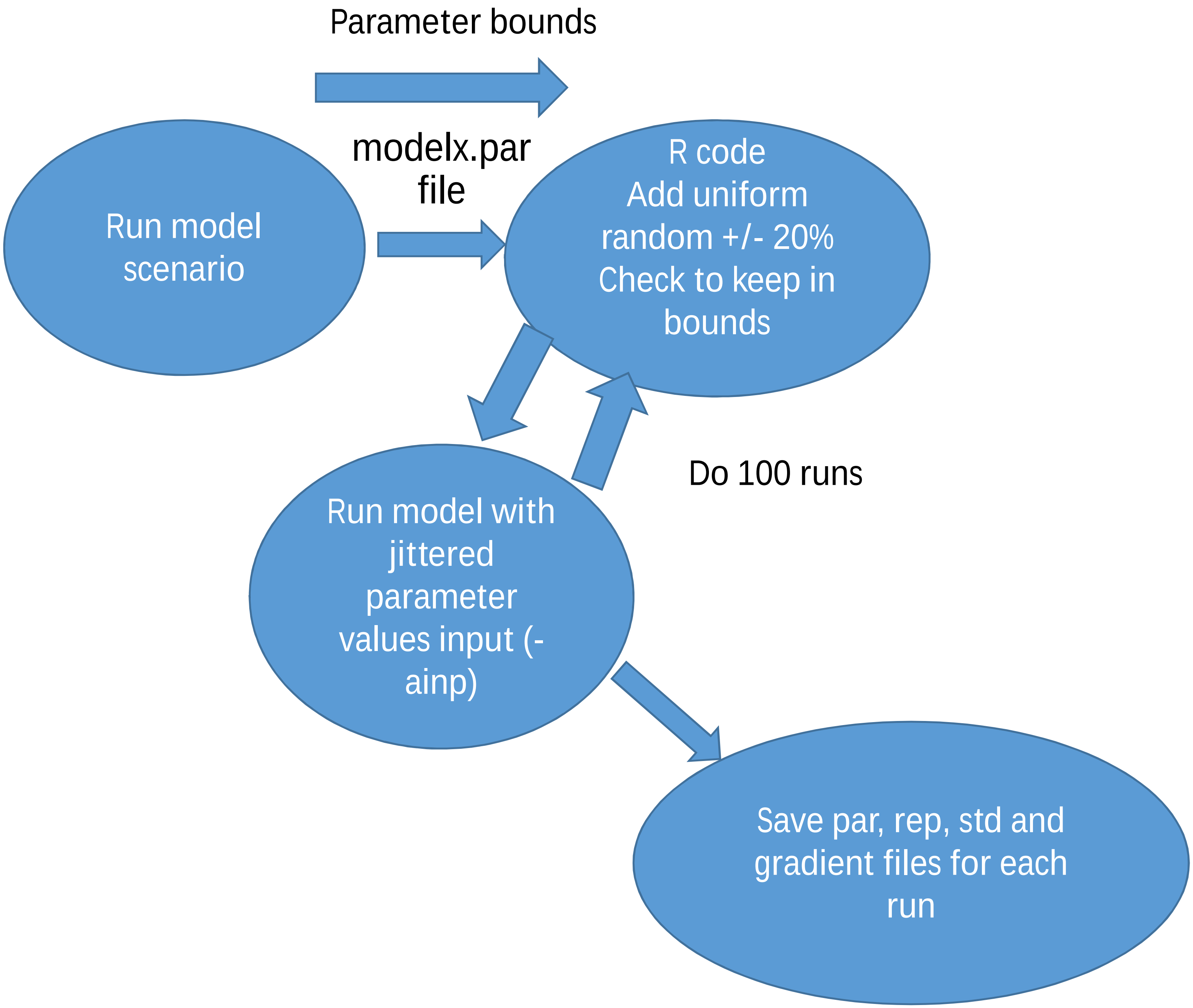
odel scenarios for September - 0, 1, 4a, 9, 11 and 13.

uld introduce more stability by fixing some growth parameters and
reasing weight on growth likelihood (depending on Model scenario).

rther sensitivity analysis?

d correlation between parameter values to the jittering. May increase
e number of runs that write the std file and/or converge to lowest
elihood.

End



Parameter bounds

Run model scenario

modelx.par file

R code
Add uniform random +/- 20%
Check to keep in bounds

Do 100 runs

Run model with jittered parameter values input (-ainp)

Save par, rep, std and gradient files for each run