Detailed responses to some of the conclusions and recommendations from the Review Panel regarding Body condition trend in the Antarctic minke whale

SC/65b/J13Rev

Kenji Konishi and Lars Walløe[2]

[1]*Institute of Cetacean Research, 4-5 Toyomi-cho, Chuo-ku, Tokyo 104-0055, Japan*

[2] *Department of Physiology, Institute of Basic Medical Sciences, University of Oslo, P.O. Box 1103 Blindern, N-0317 Oslo, Norway*

The review Panel writes on the statistical modelling:

'Following the selection of which factors to consider in the modelling, the following steps should be undertaken:

(1) identify whether any of the covariates are highly correlated and either (a) exclude a subset of the covariates so that the remaining covariates are uncorrelated or (b) develop new covariates which represent independent aspects of the current covariates (using for example PCA);
(2) select a 'full model' (this may be difficult if the data set is unbalanced) and base selection of which factors and their interactions to treat as random effects - the models should be fitted using REML and a model selection approach such AIC, BIC or standard hypothesis testing approach applied; and
(3) select the fixed effects structure given the random effects structure selected at step (2), where the models are fitted using maximum likelihood;
(4) use REML to fit the best model identified in (3) above.'

Comment on (1): The potential correlations between the independent correlates have been extensively discussed in meetings of the Scientific Committee. The variables age, body length and body weight are highly correlated, which is the reason why the authors preferred to use only length (values of the two other variables were not available for all whales) as independent variable in the models. The correlation matrix for the independent variables is provided in Appendix 1. The matrix shows that all the other correlations between the independent variables have values less than about 0.1 (except the correlation between longitude and latitude caused by the catches in the Ross Sea). For this reason the authors have not considered it necessary either to exclude any of the other variables (except age and body weight) or to develop new independent variables by the use of principal component analysis (PCA). In the published linear regression paper (Konishi et al. 2008) correlations between independent variables were taken into account by the use of Abraham Wald's forwards stepping procedure.

Comments on (2) to (4):

a) There is no objective 'full model'. The choice of the 'full model' is dependent on what one regards as relevant and plausible assumptions. In the following the authors comment only on the modelling of storage of energy during the JARPA period, since this is the period which has been discussed repeatedly in the SC.
b) The authors' understanding from reading the report from the Review Panel and listening to the Panel discussions is that the linear models lm 1 to lm 6.18 are explored in a useful way, but that they have missed out an important model when they tried out interaction models with random effects. The random term should first have been explored as an interaction term. An example of this is the model

1 This version incorporates the recommendation by the chair of EM that the title should be more inofrmative. In addition, some calculations which had no shown year coefficients in the Appendix 2 because of equation error were fixed and recalculated.

lm(BT11 ~ YearNum + BLm^3 + DateNum + Diatom +LatNum +LongNum + LongCat11 + Sex + DateNum :LongNum) + (DateNum : YearCat))

which should have been explored before random effects model BT11jarpa 18 was explored:

lmer(BT11 ~ YearNum + BLm^3 + DateNum + Diatom +LatNum +LongNum + LongCat11 + Sex + DateNum:LongNum) + (DateNum | YearCat)).

The authors have now performed these calculations for the interaction terms which were suggested by the SC in 2013and an interaction term which they found useful based on de la Mare et al.'s models from their paper O6. The models and the results from 'BT11' and 'FatWeight' are presented in Appendix 2. This adjustment did not result in any change in model selection (based on lowest BIC value) in any of the cases we have explored.

The Review Panel writes on the presentation of results:

'SC/F14/J13 and SC/F14/J14 do not report many fit diagnostics. The Panel **recommends** that any revised papers provide at least plots of the residuals versus the predictor variables (including year and stratum), histograms of residuals and random effects, plots of residuals spatially, and Q-Q plots for the 'best model'.'

Response: The authors have now developed the plots recommended for the four of the best models (three sets of plots for 'BT11' and one for 'FatWeight' (Appendix 3).

The review Panel further writes:

'The Panel also **recommends** that future analyses of the data on the condition of Antarctic minke whales include (a) consideration of a model in which year is a categorical variable and is treated as a random effect if a plot of residuals against year show there are residual patterns by year,'

As can be seen clearly from Appendix 3 the plots of residuals against year show no pattern for any of the models explored. For this reason the authors see no reason to consider a model in which year is a categorical variable and is treated as a random effect.

Appendix 1

Correlations among independent variables

The correlation matrix for the independent variables							
	BLm	DateNum	Diatom	LatNum	LongNum	LtimeNum	YearNum
BLm	1.000	0.105	-0.087	-0.117	-0.082	0.000	0.052
DateNum	0.105	1.000	0.111	-0.364	0.105	-0.065	-0.047
Diatom	-0.087	0.111	1.000	-0.080	0.039	0.005	-0.030
LatNum	-0.117	-0.364	-0.080	1.000	-0.474	0.062	-0.097
LongNum	-0.082	0.105	0.039	-0.474	1.000	-0.051	0.052
LtimeNum	0.000	-0.065	0.005	0.062	-0.051	1.000	-0.042
YearNum	0.052	-0.047	-0.030	-0.097	0.052	-0.042	1.000

Appendix 2 The models and the results of models for ‘BT11’ and ‘FatWeight’

Results of linear and linear mixed-effects models with the BT11 as the response variable							
Covariates of random effects	No.	BIC	Year effct	SE	t	model	
Date-LonSect	1	10822.3	-0.0026	0.01	-0.35	M11ModKW_BT11.1 <- lm(BT11 ~ DateNum*Sex + DiatomNum + YearNum + BLm + (DateNum:LonSect:Year))	
	2	***10649.6***	***-0.0154***	***0.01***	***-2.24***	***M11ModKW_BT11.2 <- lmer(BT11 ~ DateNum*Sex + DiatomNum + YearNum + BLm + (DateNum|LonSect:Year)) # Original from J13 modified m11***	
	3	10764.3	-0.0189	0.00	-8.50	M11ModKW_BT11.3 <- lm(BT11 ~ DateNum*Sex + DiatomNum + YearNum + BLm + DateNum:LonSect)	
	4	10824.8	-0.0195	0.00	-8.24	M11ModKW_BT11.5 <- lmer(BT11 ~ DateNum*Sex + DiatomNum + YearNum + BLm + DateNum|LonSect)	
YearNum-LatNum	1	10828.9	-0.0034	0.04	-0.10	BT11jarpa12 <- lm(formula = BT11 ~ YearNum + I(BLm^3) + DateNum + Diatom + LatNum + LongNum + LongCat11 + Sex + YearNum:LatNum)	
	2	10818.4	-0.0200	0.04	-0.55	BT11jarpa12F <- lm(formula = BT11 ~ YearNum + I(BLm^3) + DateNum + Diatom + LatNum + LongNum + LongCat11 + Sex + DateNum:LongNum + YearNum:LatNum)	
	3	10965.0	-0.0196	0.00	-7.78	BT11jarpa12F.2 <- lmer(formula = BT11 ~ YearNum + I(BLm^3) + DateNum + Diatom + LatNum + LongNum + LongCat11 + Sex + DateNum:LongNum + YearNum|LatNum)	
	4	10811.2	-0.0208	0.04	-0.58	BT11jarpa12F.5 <- lm(formula = BT11 ~ YearNum + I(BLm^3) + DateNum + Diatom + LatNum + LongCat11 + Sex + DateNum:LongNum + YearNum:LatNum) # - LongNum	
	5	10804.0	-0.0537	0.02	-2.54	BT11jarpa12F.6 <- lm(formula = BT11 ~ YearNum + I(BLm^3) + DateNum + Diatom + LongCat11 + Sex + DateNum:LongNum + YearNum:LatNum) # - LongNum, - Latnum	
	6	**10798.2**	**-0.0195**	**0.00**	**-8.39**	**BT11jarpa12F.7 <- lm(formula = BT11 ~ YearNum + I(BLm^3) + DateNum + Diatom + LongCat11 + Sex + DateNum:LongNum) # - LongNum, - Latnum, - YearNum:LatNum**	
YearNum-Ice	1	10818.0	-0.0211	0.00	-6.78	BT11jarpa12F.10 <- lm(formula = BT11 ~ YearNum + I(BLm^3) + DateNum + Diatom + LatNum + LongNum + LongCat11 + Sex + DateNum:LongNum + YearNum:Ice)	
	2	10972.7	-0.0175	0.01	-2.79	BT11jarpa12F.12 <- lmer(formula = BT11 ~ YearNum + I(BLm^3) + DateNum + Diatom + LatNum + LongNum + LongCat11 + Sex + DateNum:LongNum + YearNum|Ice)	
	3	10810.8	-0.0210	0.00	-6.76	BT11jarpa12F.15 <- lm(formula = BT11 ~ YearNum + I(BLm^3) + DateNum + Diatom + LatNum + LongCat11 + Sex + DateNum:LongNum + YearNum:Ice) # - LongNum	
	4	10804.4	-0.0223	0.00	-7.46	BT11jarpa12F.16 <- lm(formula = BT11 ~ YearNum + I(BLm^3) + DateNum + Diatom + LongCat11 + Sex + DateNum:LongNum + YearNum:Ice) # - LongNum, -LatNum	
	5	**10798.2**	**-0.0195**	**0.00**	**-8.39**	**BT11jarpa12F.17 <- lm(formula = BT11 ~ YearNum + I(BLm^3) + DateNum + Diatom + LongCat11 + Sex + DateNum:LongNum) # - LongNum, -LatNum, -YearNun**	Same as BT11jarpa12F.7

Results of linear and linear mixed-effects models with the FatWeight as the response variable							
Covariates of random effects	No.	BIC	ear effect	SE	t	model	
DateNum and LonSect	1	-168.6	0.0005	0.00	0.11	FatWeightModKW.1 <- lm(FatWeight ~ DateNum*Sex + DiatomNum + YearNum + BLm + (DateNum:LonSect:Year))	
	2	-277.3	-0.0095	0.00	-4.10	FatWeightModKW.2 <- lmer(FatWeight ~ DateNum*Sex + DiatomNum + YearNum + BLm + (DateNum|LonSect:Year)) # Original from J13 modified m11	
	3	**-299.7**	**-0.0087**	**0.00**	**-5.96**	FatWeightModKW.3 <- lm(FatWeight ~ DateNum*Sex + DiatomNum + YearNum + BLm + DateNum:LonSect)	
	4	-250.2	-0.0093	0.00	-6.25	FatWeightModKW.5 <- lmer(FatWeight ~ DateNum*Sex + DiatomNum + YearNum + BLm + (DateNum|LonSec))	
	5	-304.3	-0.0088	0.00	-6.02	FatWeightModKW.3.1 <- lm(FatWeight ~ DateNum*Sex + DiatomNum + YearNum + BLm + DateNum:LonSect - DateNum:Sex) #FatWeightModKW.3 - DateNum:Sex	
	6	***-330.1***	***-0.0084***	***0.00***	***-5.90***	***FatWeightModKW.3.2 <- lm(FatWeight ~ DateNum*Sex + DiatomNum + YearNum + BLm - DateNum:Sex) #- DateNum:Sex, - DateNum:LonSect***	
YearNum-LatNum	1	-276.9	-0.0052	0.02	-0.22	FatWeightjarpa12F <- lm(formula = FatWeight ~ YearNum + I(BLm^3) + DateNum + Diatom + LatNum + LongNum + LongCat11 + Sex + DateNum:LongNum + YearNum:LatNum) # + DateNum:LongNum	
	2	-101.9	-0.0090	0.00	-5.89	FatWeightjarpa12F.2 <- lmer(formula = FatWeight ~ YearNum + I(BLm^3) + DateNum + Diatom + LatNum + LongNum + LongCat11 + Sex + DateNum:LongNum + (YearNum|LatNum)) # + YearNum|LatNum	
	3	-283.4	-0.0049	0.02	-0.21	FatWeightjarpa12F.5 <- lm(formula = FatWeight ~ YearNum + I(BLm^3) + DateNum + Diatom + LatNum + LongCat11 + Sex + DateNum:LongNum + YearNum:LatNum) # - LongNum	
	4	-290.0	-0.0057	0.01	-0.42	FatWeightjarpa12F.6 <- lm(formula = FatWeight ~ YearNum + I(BLm^3) + DateNum + Diatom + LongCat11 + Sex + DateNum:LongNum + YearNum:LatNum) # - LongNum, - LatNum	
	5	-296.6	-0.0089	0.00	-6.06	FatWeightjarpa12F.7 <- lm(formula = FatWeight ~ YearNum + I(BLm^3) + DateNum + Diatom + LongCat11 + Sex + DateNum:LongNum) # - LongNum, - LatNum, - YearNum:LatNum	
	6	**-300.7**	**-0.0087**	**0.00**	**-5.92**	**FatWeightjarpa12F.8 <- lm(formula = FatWeight ~ YearNum + I(BLm^3) + Diatom + LongCat11 + Sex + DateNum:LongNum) # - LongNum, - LatNum, - YearNum:LatNum, - DateNum**	
YearNum-Ice	1	-277.6	-0.0098	0.00	-5.43	FatWeightjarpa12F.10 <- lm(formula = FatWeight ~ YearNum + I(BLm^3) + DateNum + Diatom + LatNum + LongNum + LongCat11 + Sex + DateNum:LongNum + YearNum:Ice)	
	2	-100.6	-0.0089	0.00	-6.02	FatWeightjarpa12F.12 <- lmer(formula = FatWeight ~ YearNum + I(BLm^3) + DateNum + Diatom + LatNum + LongNum + LongCat11 + Sex + DateNum:LongNum + (YearNum|Ice))	
	3	-284.1	-0.0098	0.00	-5.44	FatWeightjarpa12F.15 <- lm(formula = FatWeight ~ YearNum + I(BLm^3) + DateNum + Diatom + LatNum + LongCat11 + Sex + DateNum:LongNum + YearNum:Ice) # - LongNum	
	4	**-290.4**	**-0.0096**	**0.00**	**-5.46**	FatWeightjarpa12F.16 <- lm(formula = FatWeight ~ YearNum + I(BLm^3) + DateNum + Diatom + LongCat11 + Sex + DateNum:LongNum + YearNum:Ice) # - LongNum, - LatNum	
	5	-296.6	-0.0089	0.00	-6.06	FatWeightjarpa12F.7 <- lm(formula = FatWeight ~ YearNum + I(BLm^3) + DateNum + Diatom + LongCat11 + Sex + DateNum:LongNum) # - LongNum, - LatNum, - YearNum:LatNum	Same as BT11jarpa12F.7
	6	**-300.7**	**-0.0087**	**0.00**	**-5.92**	**FatWeightjarpa12F.17 <- lm(formula = FatWeight ~ YearNum + I(BLm^3) + DateNum + Diatom + LongCat11 + Sex + DateNum:LongNum) # - LongNum, - LatNum, -YearNum:Ice**	Same as BT11jarpa12F.8

Results of M11ModKW_BT11.2
BT11 ~ DateNum * Sex + DiatomNum + YearNum + BLm + (DateNum | LonSect:Year)

Random effects:

Groups	Name	Variance	Std.Dev.	Corr
LonSect:Year	(Intercept)	1.34e-01	0.366046	
	DateNum	4.62e-05	0.006797	-0.87
Residual		5.26e-01	0.725291	

Number of obs: 4719, groups: LonSect:Year, 44

Fixed effects:

	Estimate	Std. Error	t value
(Intercept)	2.0269530	0.2587477	7.834
DateNum	0.0121695	0.0014020	8.680
Sex[T.M]	-0.7193948	0.0633247	-11.360
DiatomNum	0.2313461	0.0090855	25.463
YearNum	-0.0153637	0.0068451	-2.244
BLm	0.1107355	0.0265370	4.173
DateNum:Sex[T.M]	0.0057632	0.0009243	6.235

Result of the model FatWeightModKW.3.2
FatWeight ~ DateNum * Sex + DiatomNum + YearNum + BLm - DateNum:Sex)

Residuals:

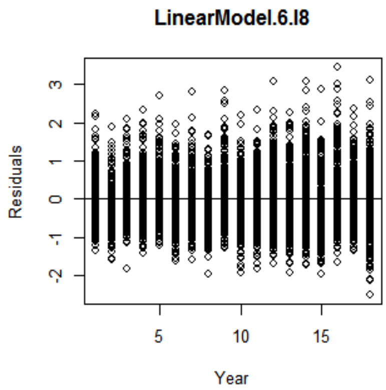
Min	1Q	Median	3Q	Max
-0.63386	-0.13028	-0.01238	0.11409	0.65558

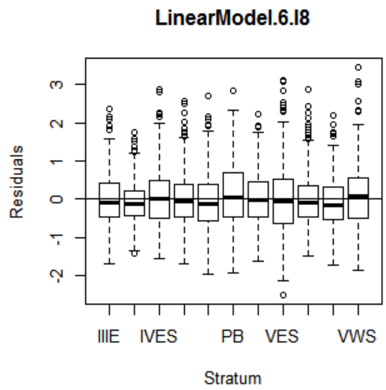
Coefficients:

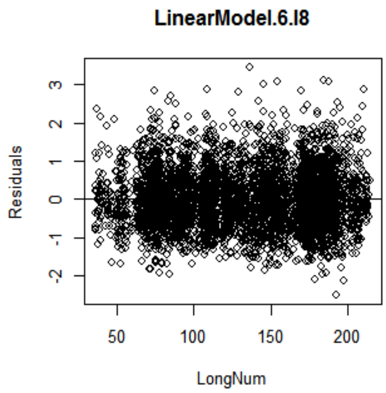
	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	-2.218507	0.151496	-14.644	< 2e-16 ***
DateNum	0.003238	0.000251	12.902	< 2e-16 ***
Sex[T.M]	-0.132435	0.017378	-7.621	7.83e-14 ***
DiatomNum	0.041396	0.005895	7.022	5.00e-12 ***
YearNum	-0.008443	0.001432	-5.895	5.72e-09 ***
BLm	0.426379	0.016834	25.328	< 2e-16 ***

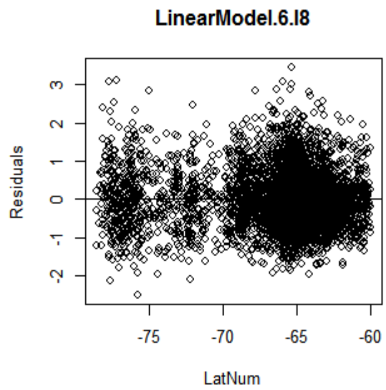
Appendix 3 Diagnosis plots for the models

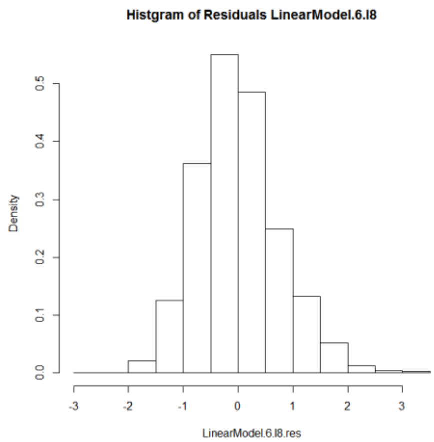
a) Model lm 6.18 for ‘BT11’

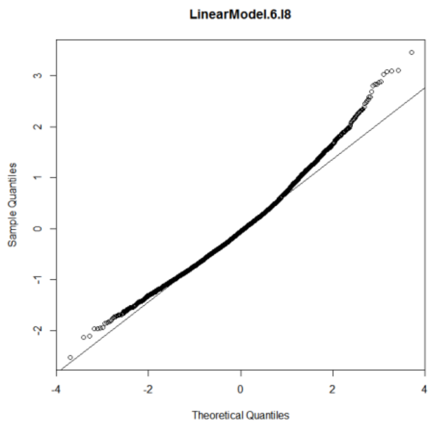




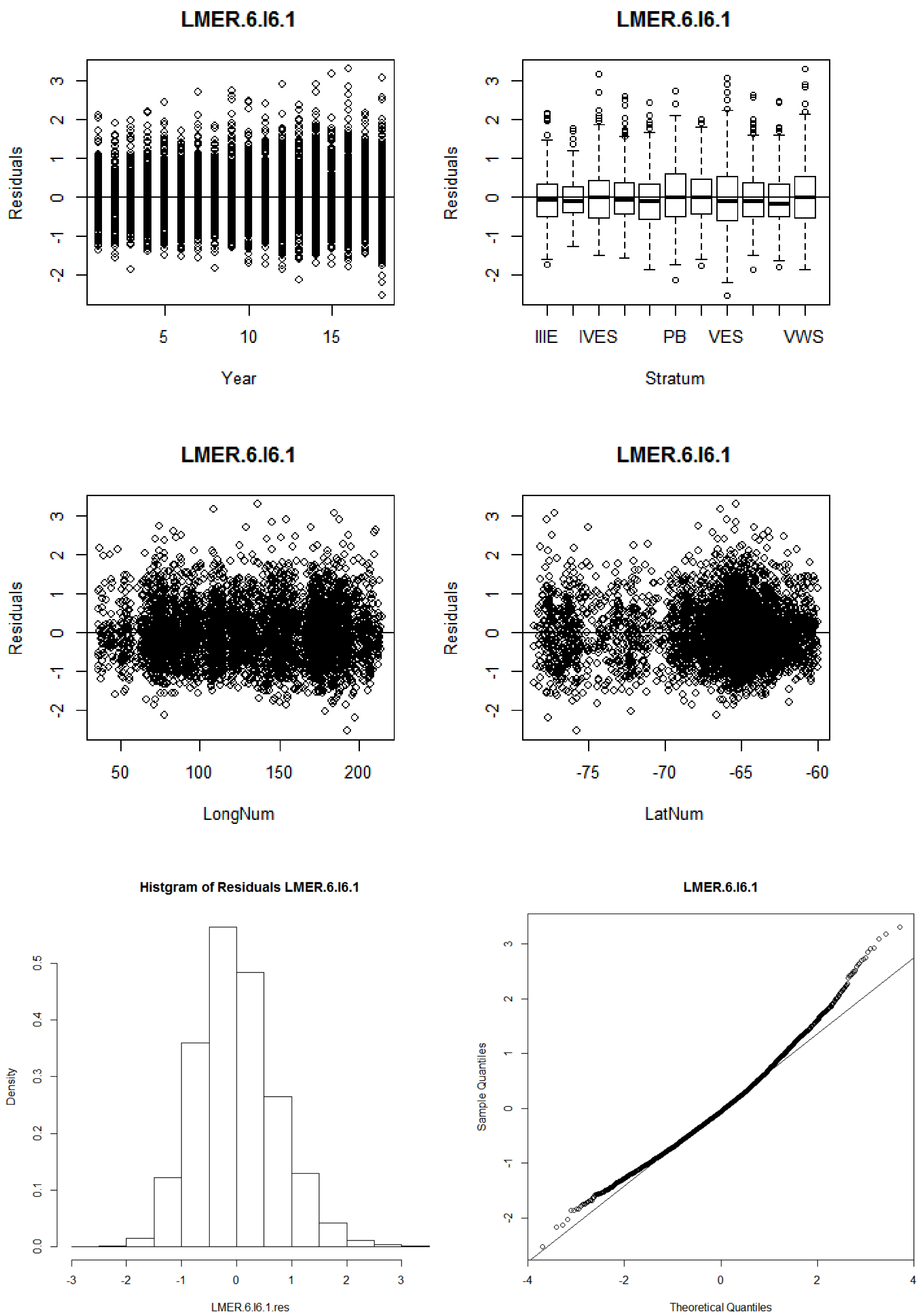




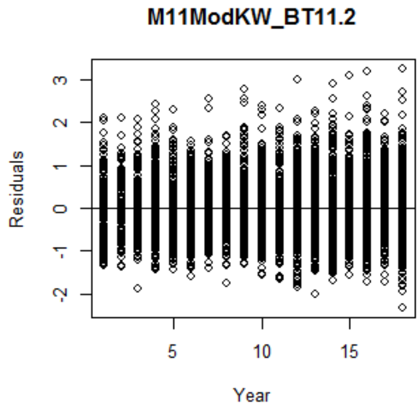


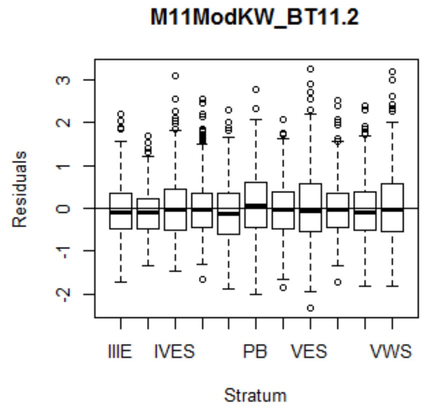


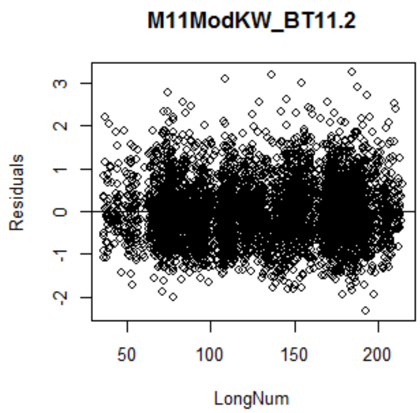
b) Model lmer 6.16.1 for ‘BT11’

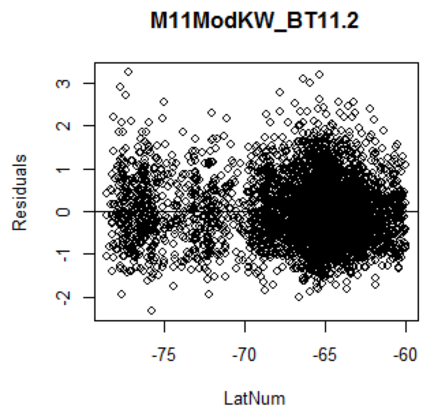


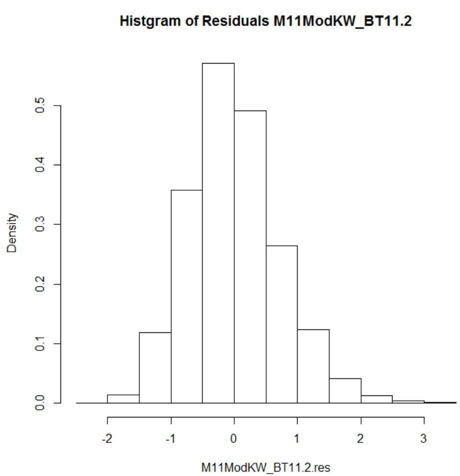
c) Model m11 modified KW for 'BT11'

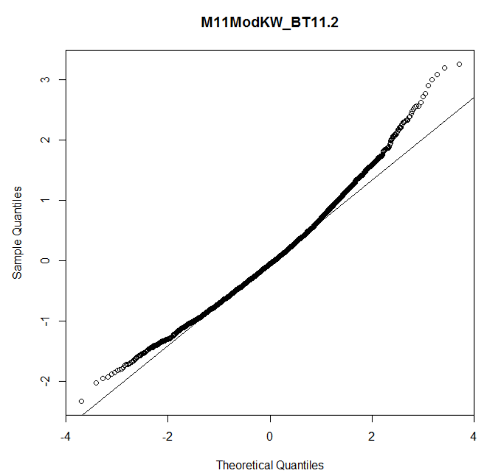












d) Diagnosis plots for the best model for FatWeight