Comisión Interamericana del Atún Tropical
Inter-American Tropical Tuna Commission




Yellowfin: Growth rate estimates obtained from tagging data

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Dan Fuller, Kurt Schaefer, Mark Maunder and Chris Francis

Workshop on age and growth of bigeye and yellowfin tunas in the Pacific Ocean, La Jolla, CA, Jan 23-25, 2019

Outline

- Current growth model
- Tagging data
- Fits of the AMSF and AMSFc models to the otoliths and tagging data

Current growth model

GROWTH OF YELLOWFIN TUNA, *THUNNUS ALBACARES*, IN THE EASTERN PACIFIC OCEAN BASED ON OTOLITH INCREMENTS

CRECIMIENTO DEL ATUN ALETA AMARILLA, *THUNNUS ALBACARES*, EN EL OCEANO PACIFICO ORIENTAL, BASADA EN LOS INCREMENTOS DE LOS OTOLITOS

by — por
A. Wild

La Jolla, California
1986

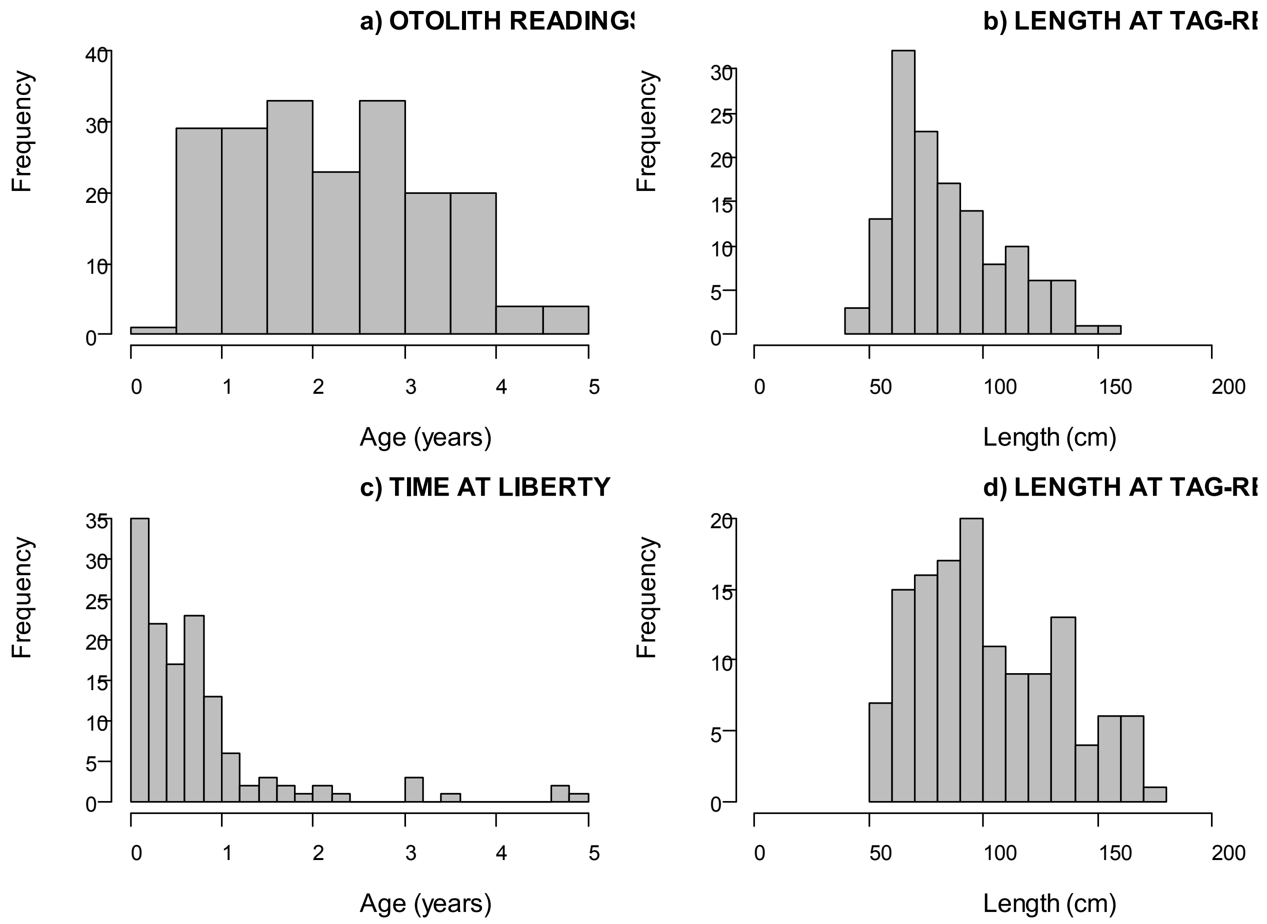
- Richard model fit to ageing done from daily increments in otoliths

$$L_a = L_\infty \left(1 + \frac{1}{p} e^{-K(a-t_0)}\right)^{-p}$$

- Validation studied corroborated the daily deposition of increments

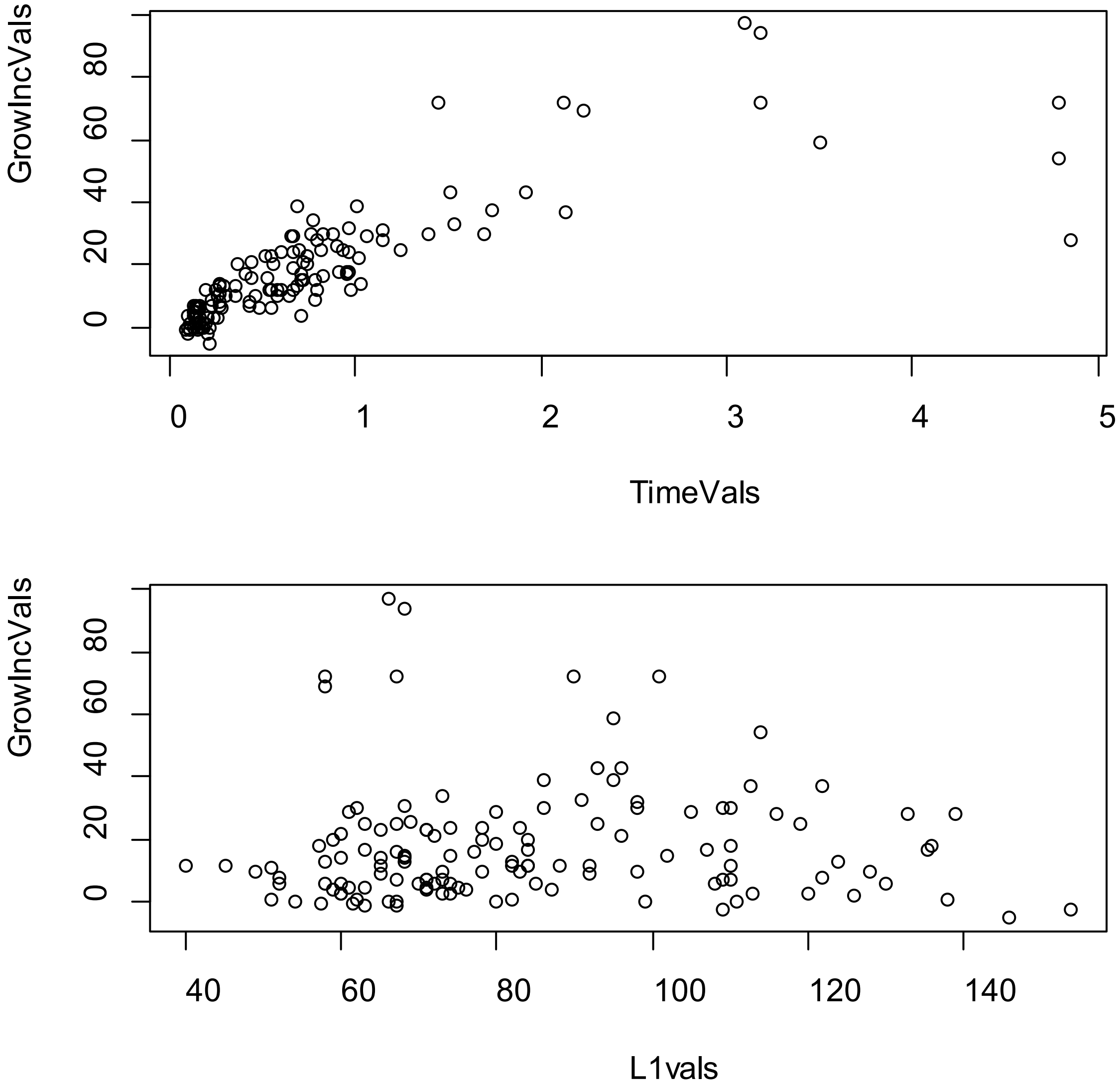
Tagging data

Data sources available to estimate the growth for yellowfin tuna in the EPO: (a) direct age estimates from otolith readings, (b) time at liberty for tagged bigeye, (c) length at tag-release (L1) and (d) length at tag-recapture (L2).

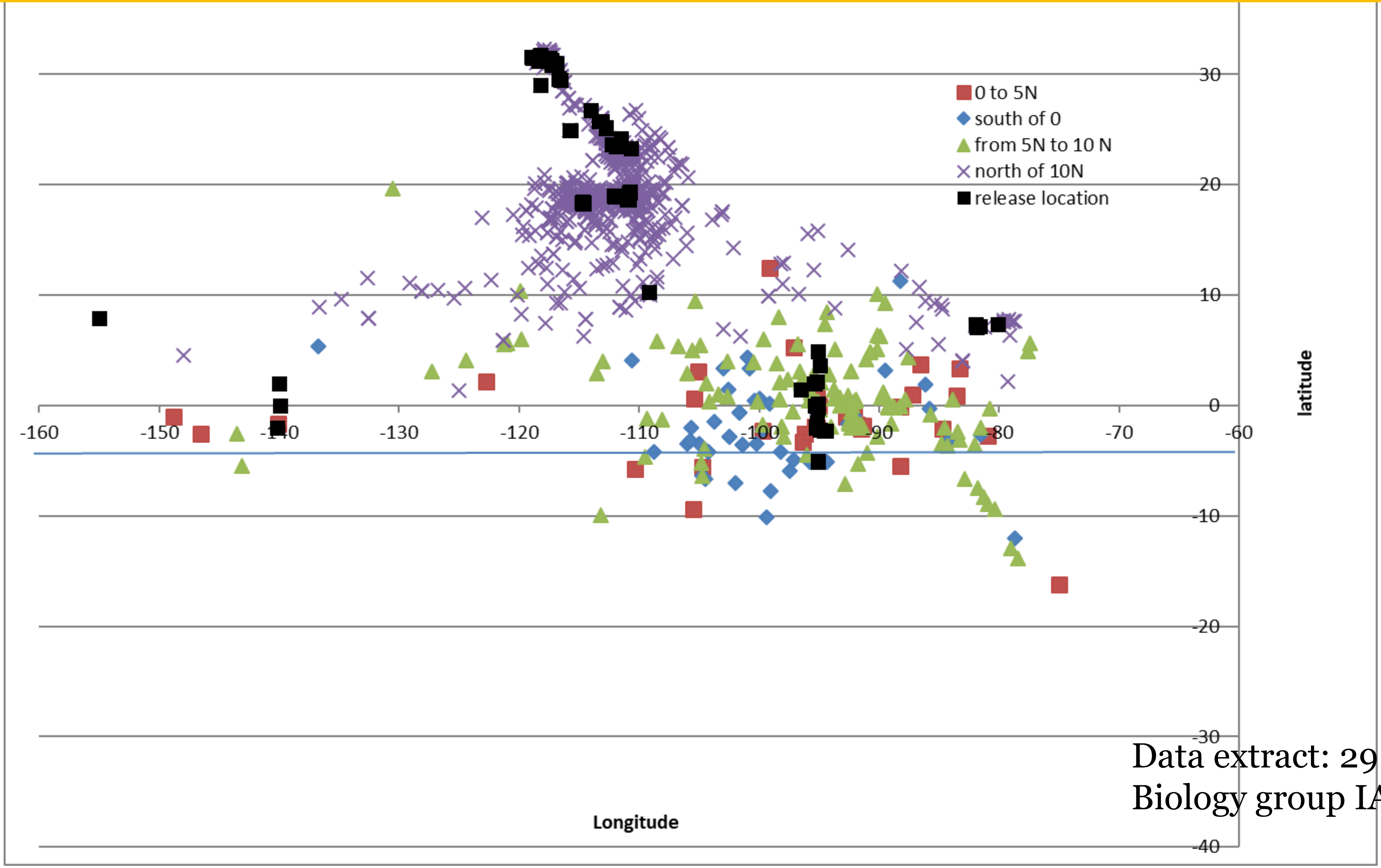


Tagging data

Growth increments as a function of time at liberty and length at tag-release (L1).

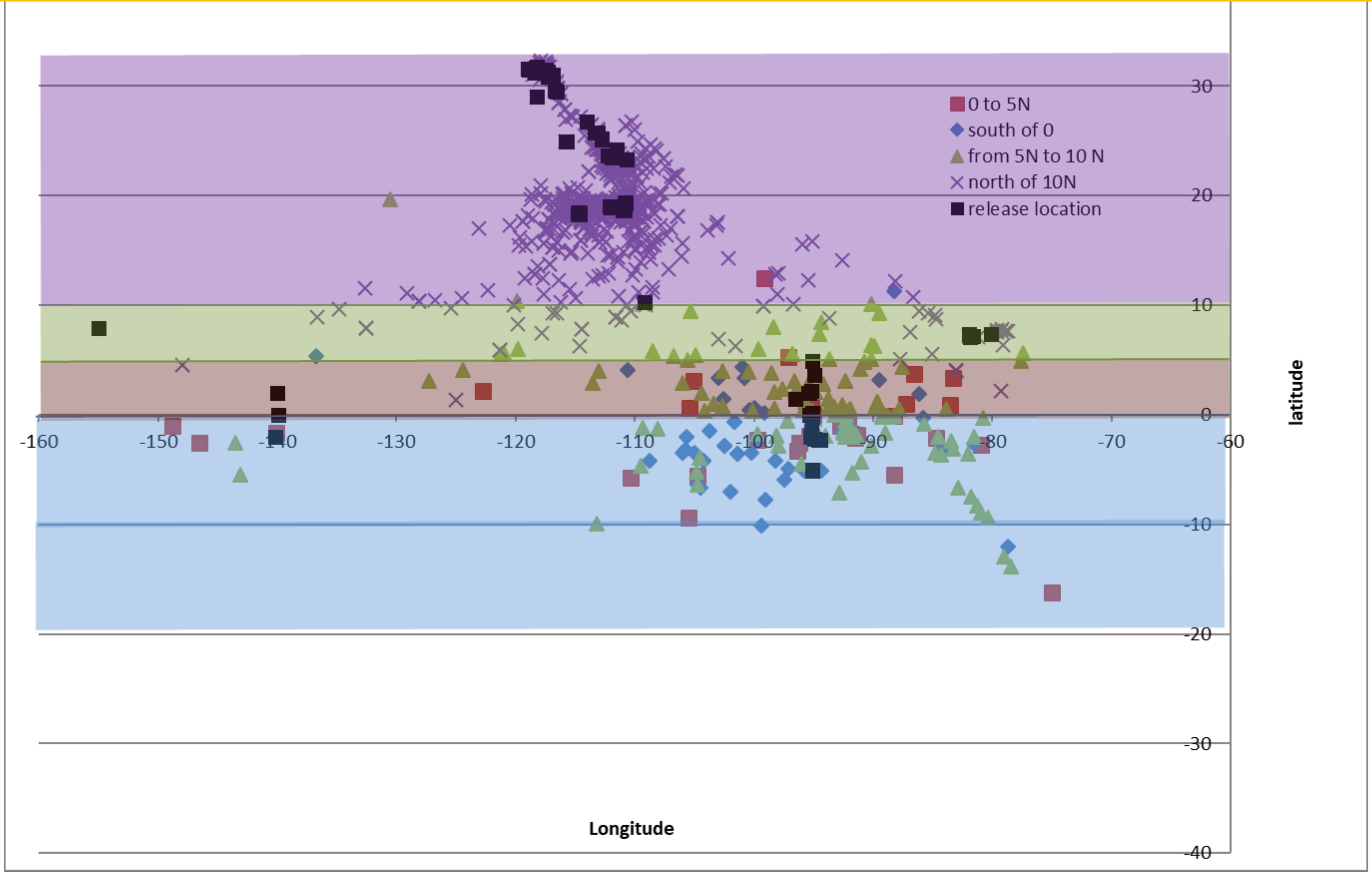


Tagging data: Spatial distribution

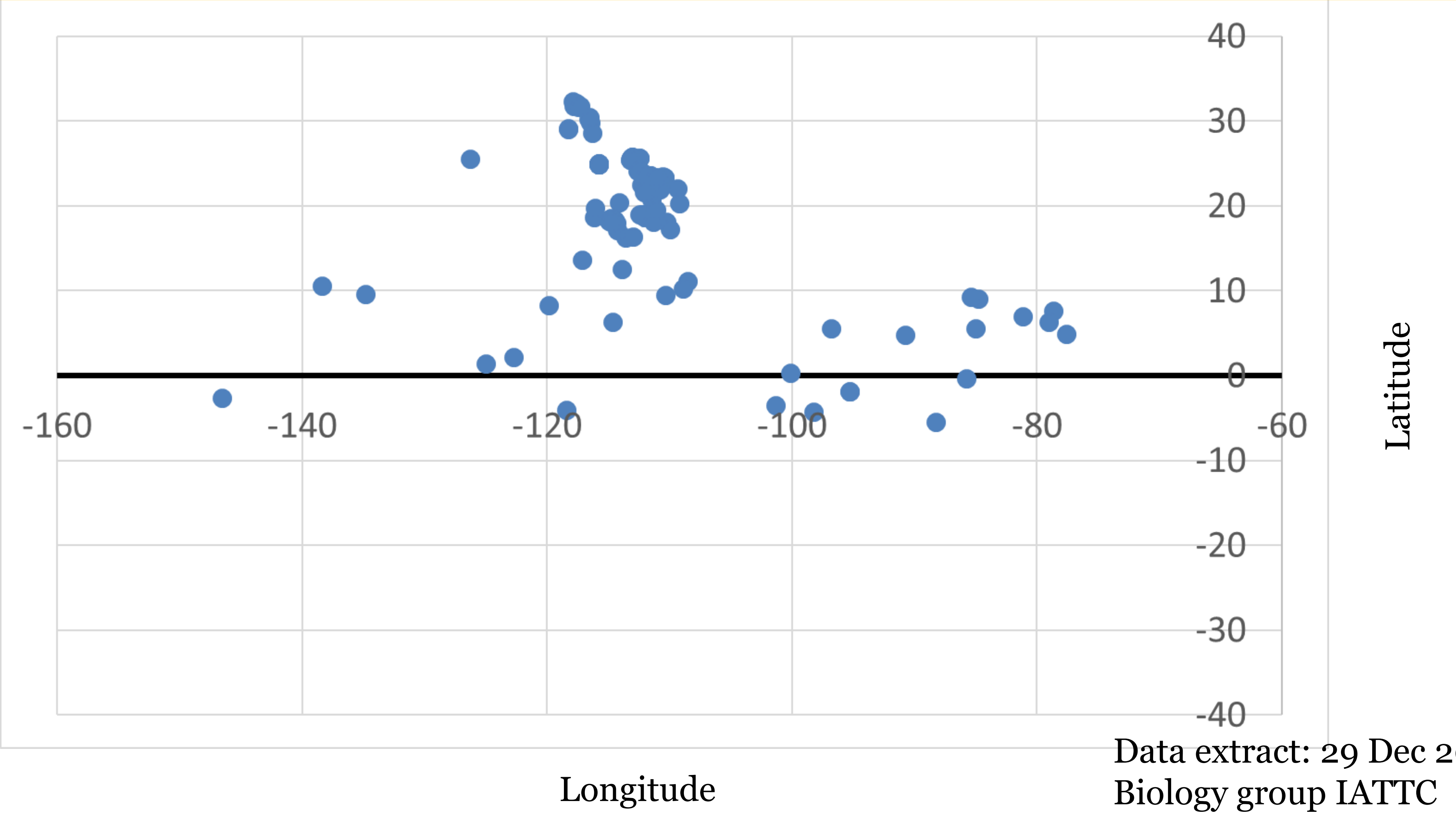


Data extract: 29 Dec 2015
Biology group IATTC

Tagging data: spatial distribution

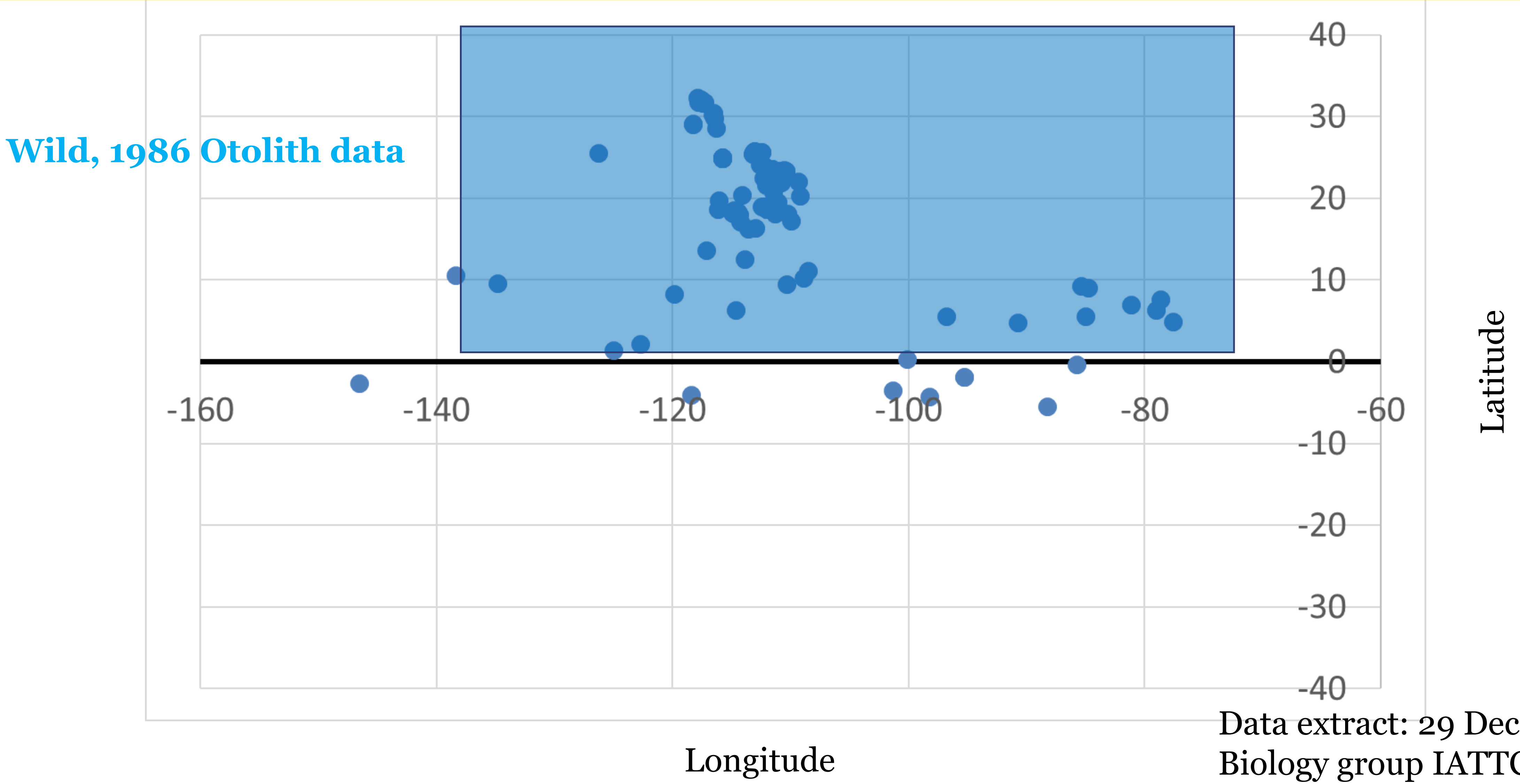


Tagging data: spatial distribution of high confidence data



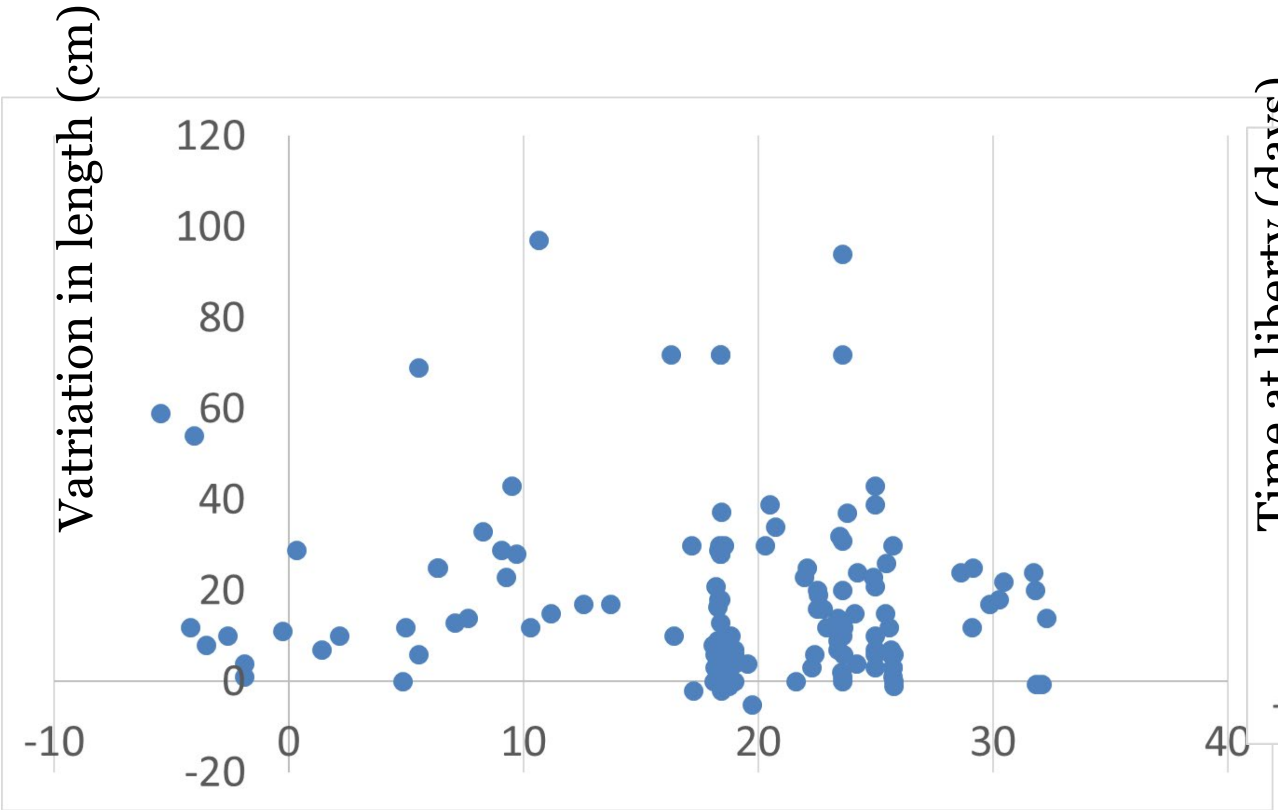
Data extract: 29 Dec 2015
Biology group IATTC

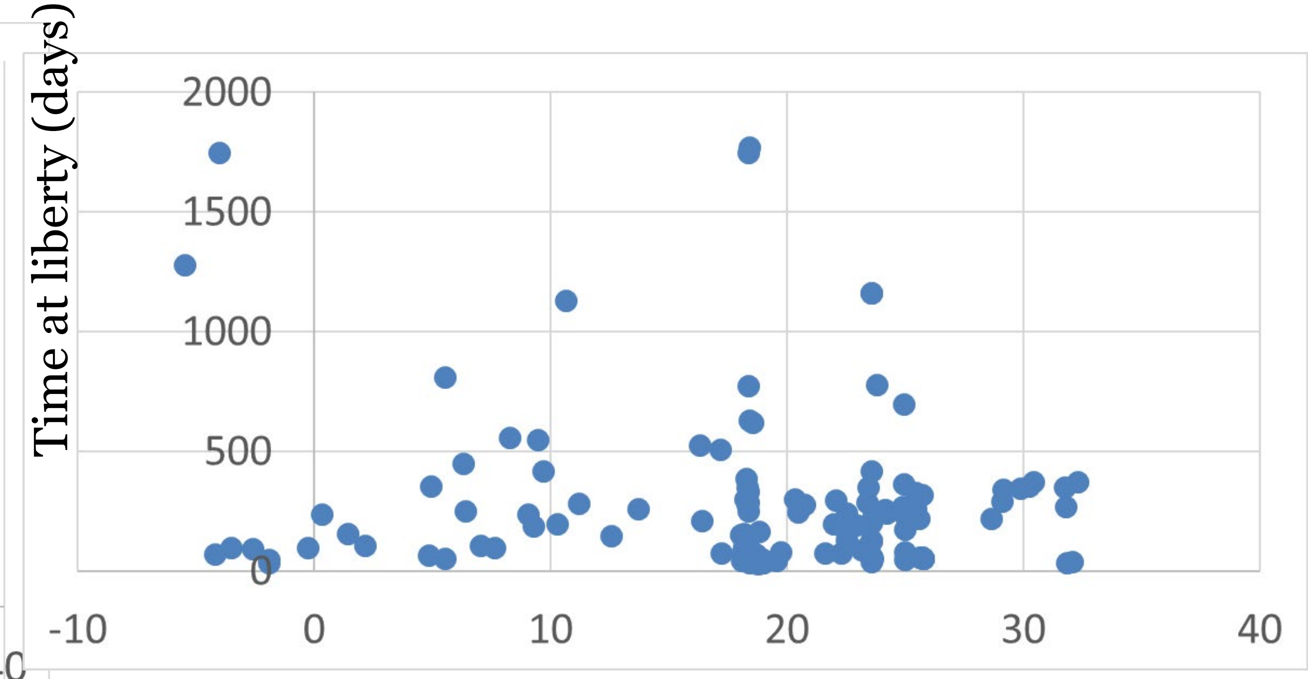
Tagging data: high confidence data



Data extract: 29 Dec 2015
Biology group IATTC

Tagging data: only high confidence data

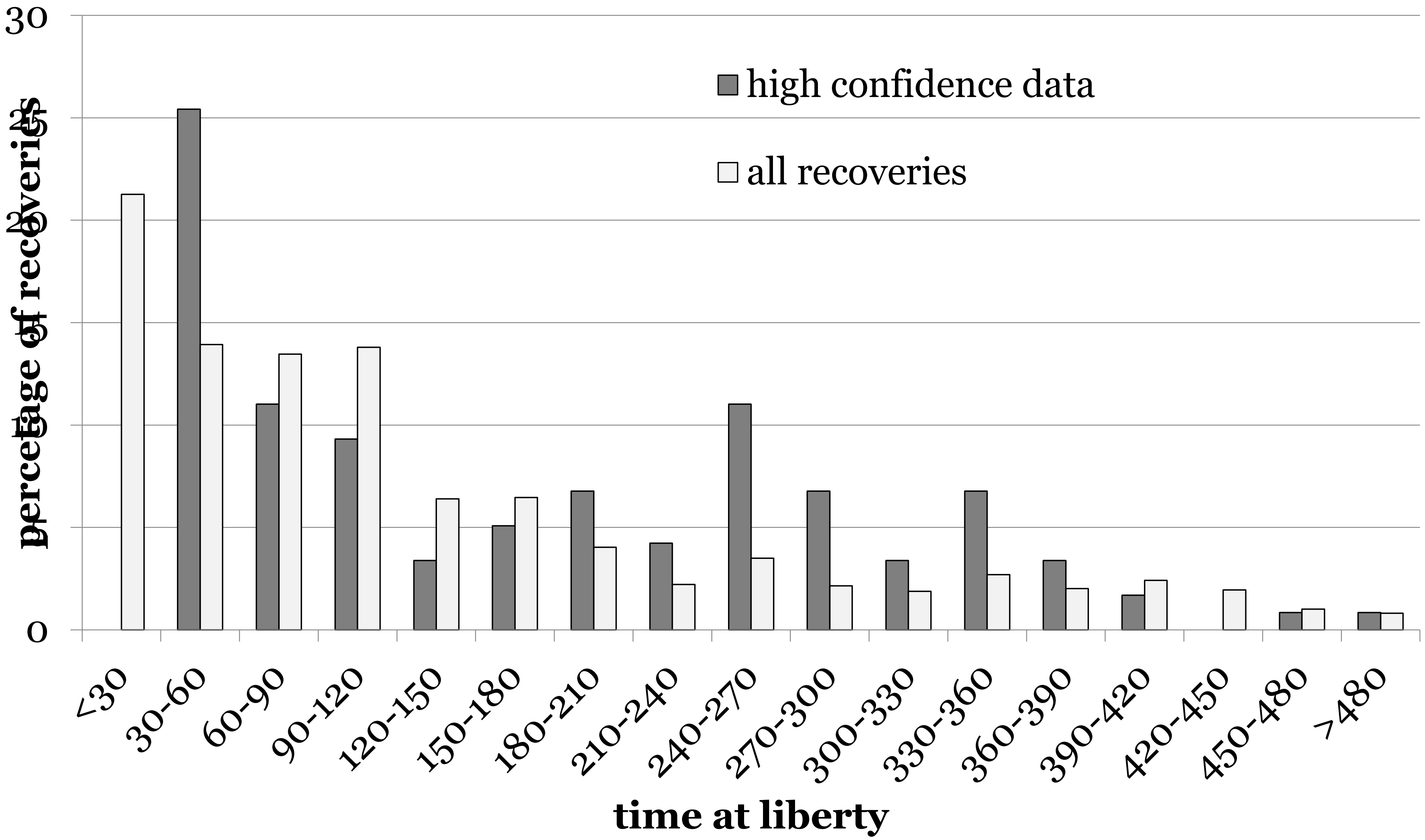




Latitude

Data extract: 29 Dec 2015
Biology group IATTC

Tagging data: comparison



Models

AMSF

Aires-da-Silva, A.M., Maunder, M.N., Schaefer, K.M., Fuller, D.W., 2015. Improved growth estimates from integrated analysis of direct aging and tag–recapture data: an illustration with bigeye tuna (*Thunnus obesus*) of the eastern Pacific Ocean with implications for management. Fish. Res. 163, 119–126.

AMSFc

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Estimating fish growth for stock assessments using both age–length and tagging-increment data

CrossMark

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The Richards growth curve, penalized likelihood approach

$$L_a = L_\infty \left(1 + \frac{1}{p} e^{-K(a-t_0)}\right)^{-p}$$

Added correlation between deviation of length at release and length at recovery

$$\rho = \mathrm{Cor}(\delta_{tag}, \delta_{rec}) = 1 - \frac{(1-\rho_0)}{1-\rho_0+\rho_0\exp(-k_\rho \Delta t)}$$

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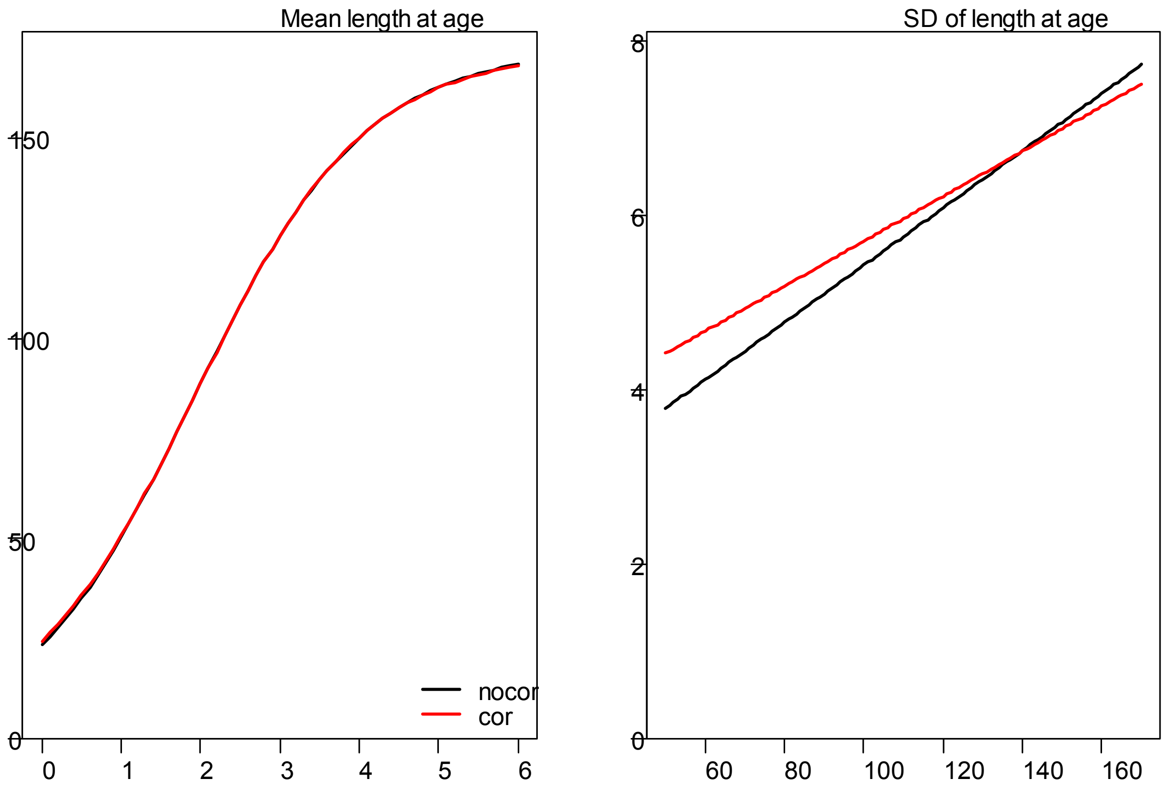
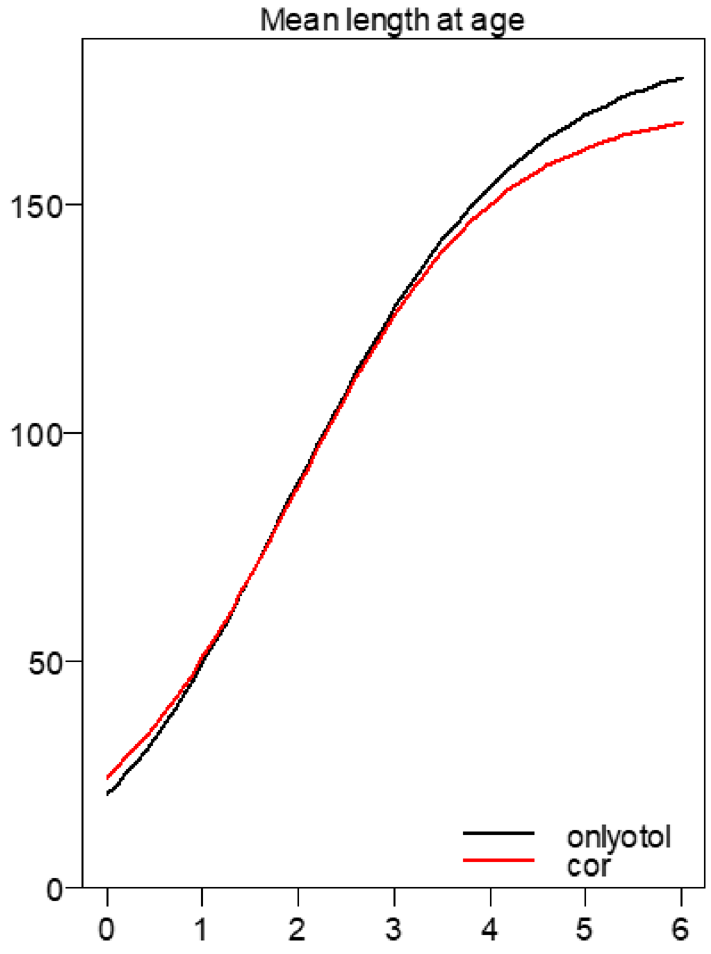
Results: integrated model

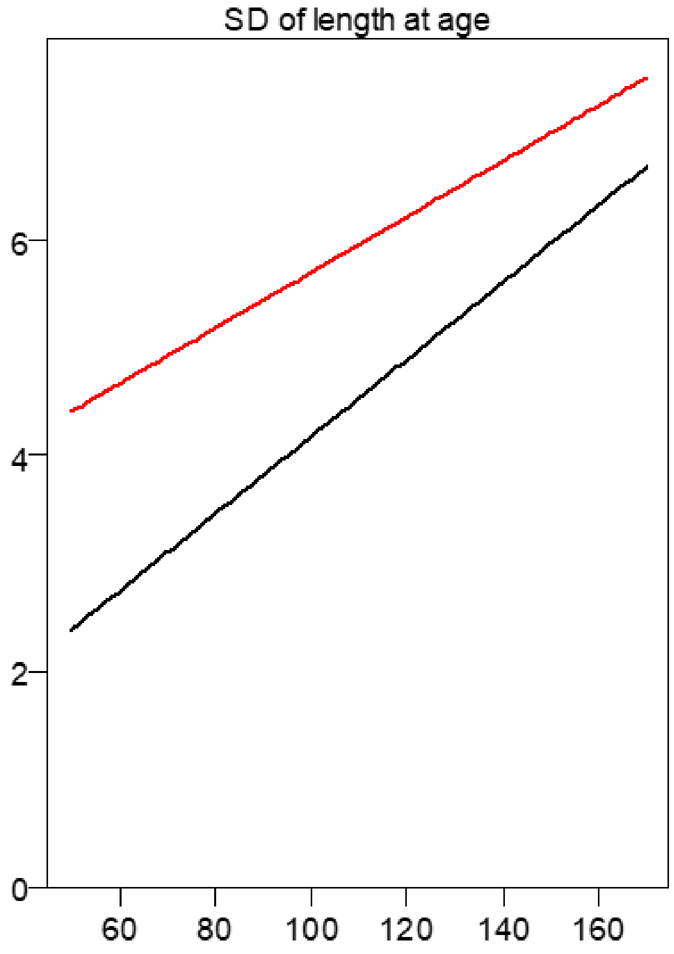
- Model **with correlation** (f=1094.62, 10 parameters, AIC=2209.24) fitted the data better
- than the model **without correlation** (f=1107.36, 8 parameters, AIC= 2230.72).
- The fit with correlation returned the same average size than the fit without correlation, but with a slight change in the standard deviation of size at age (plotted below as a function of average size at age) (Fig. 1)



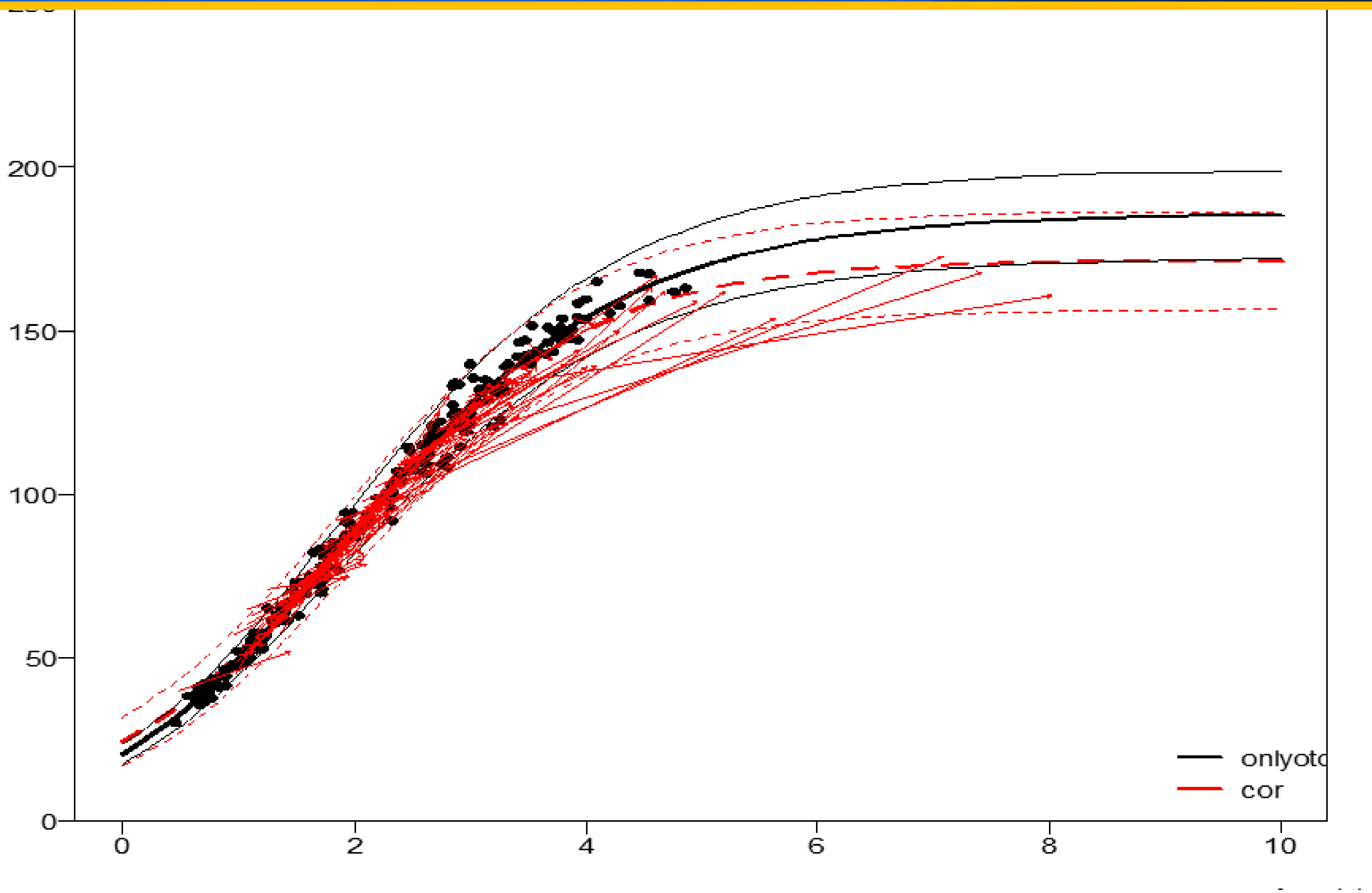
Results: integrated model X otolith only model

- When comparing the **integrated model with correlation** to the growth **model fit only to size at age data**, both the L2 and the variability of size at age are different. The two model start to differ around age 3.5 years

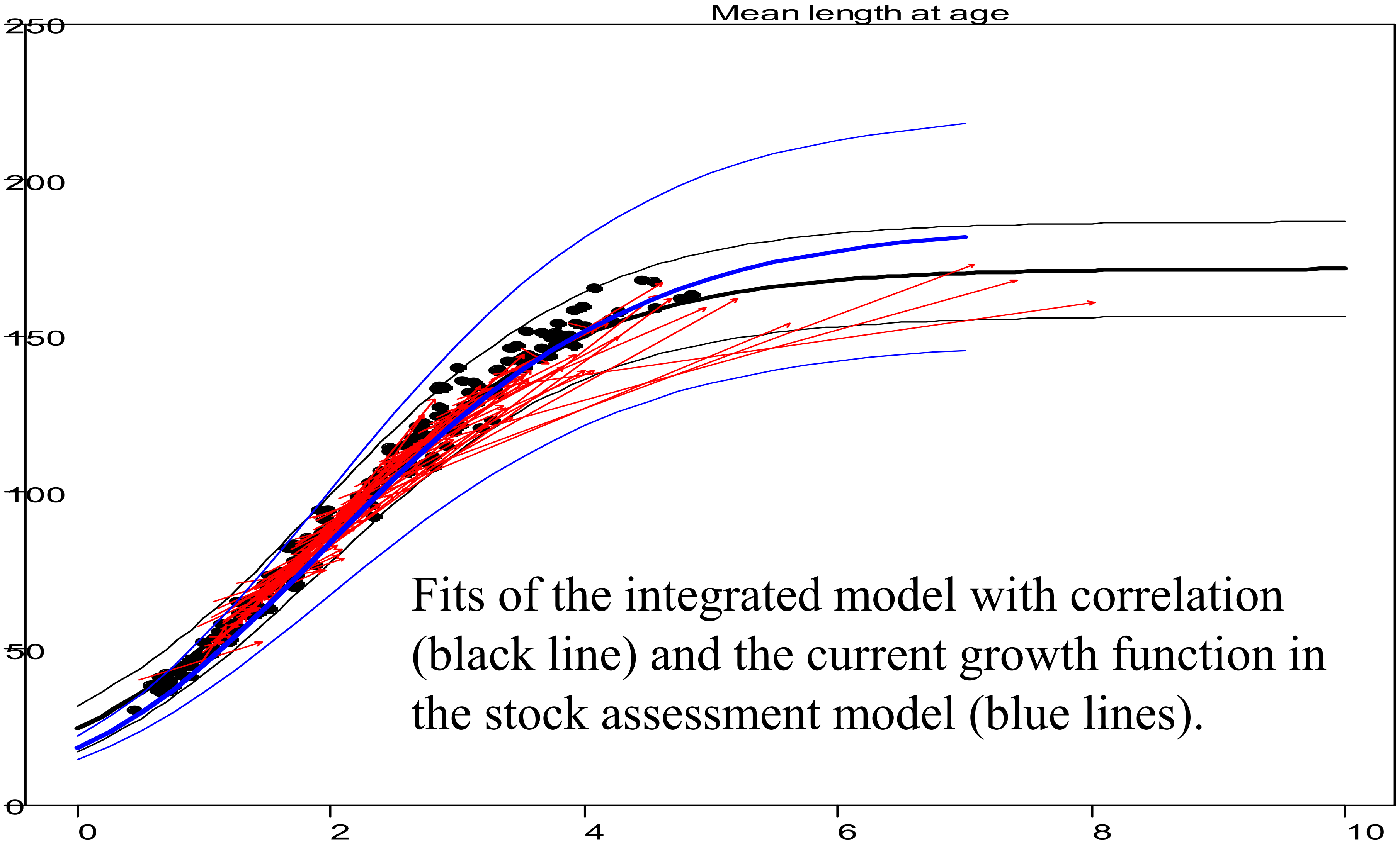




Results

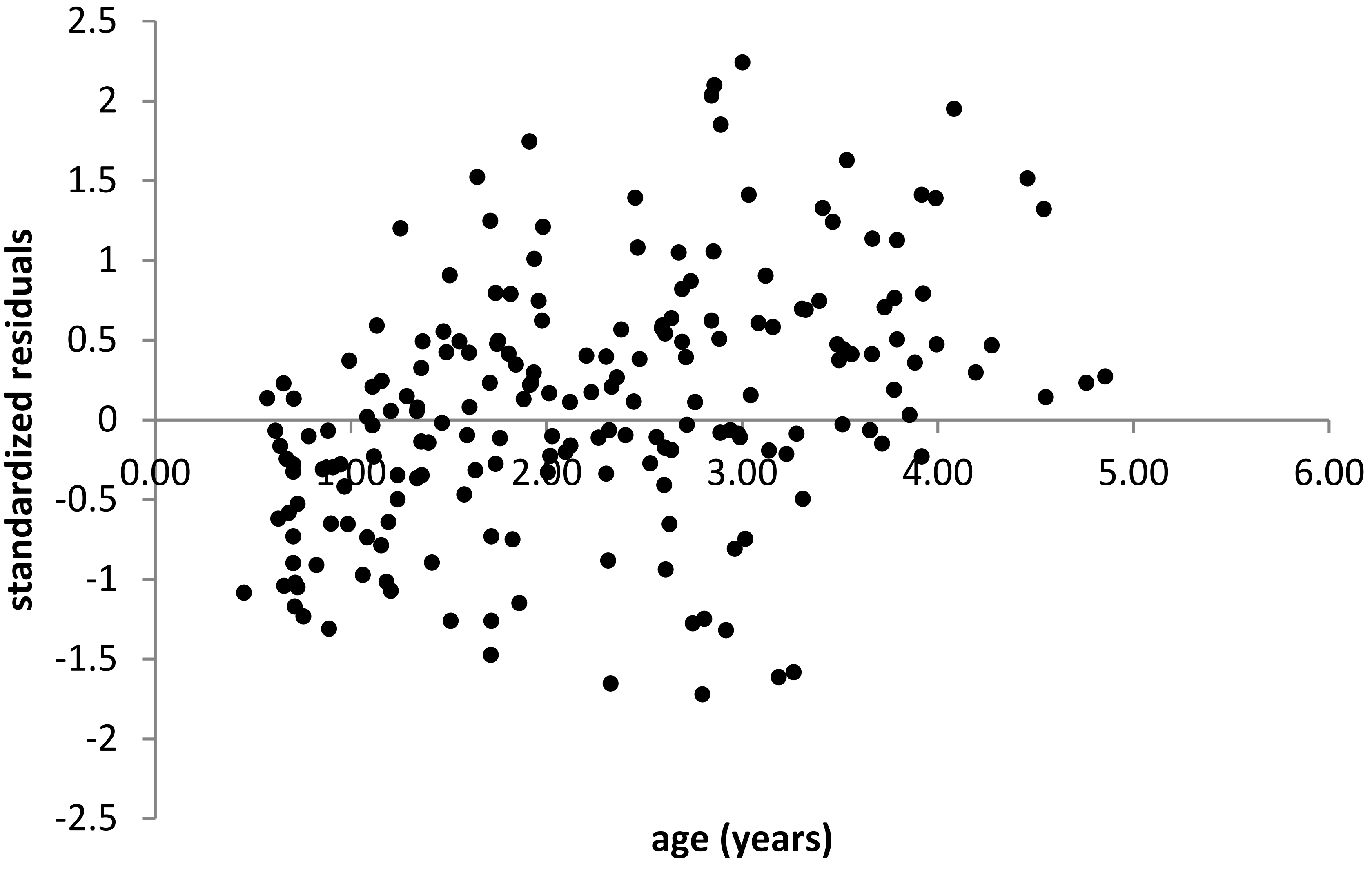


Results



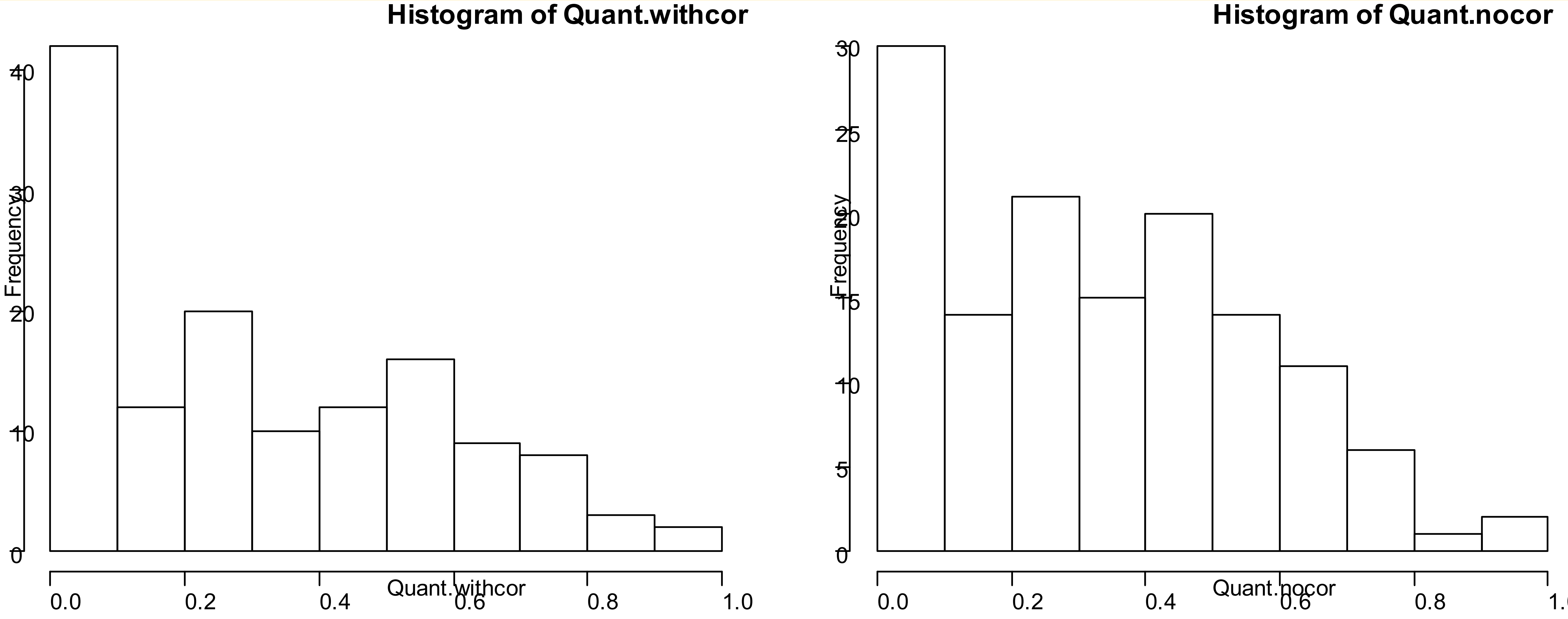
Mean length at age
250
200
150
100
50
0
0
2
4
6
8
10
Fits of the integrated model with correlation (black line) and the current growth function in the stock assessment model (blue lines).

Results: diagnostics



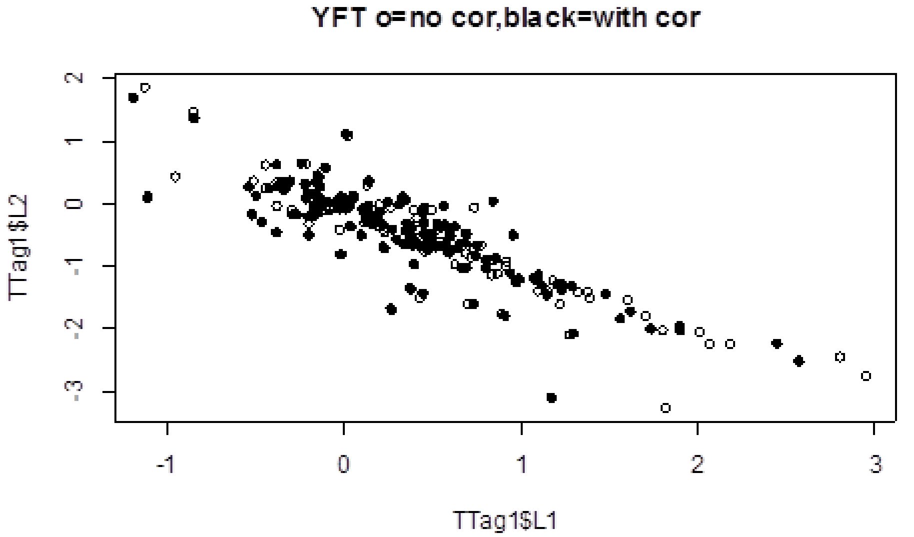
The standardized residuals for the size at age data (otoliths data) for the fits of the integrated model with correlation shows tendency **towards negative residuals** for very young ages and strong pattern of **positive residuals** for the older ages

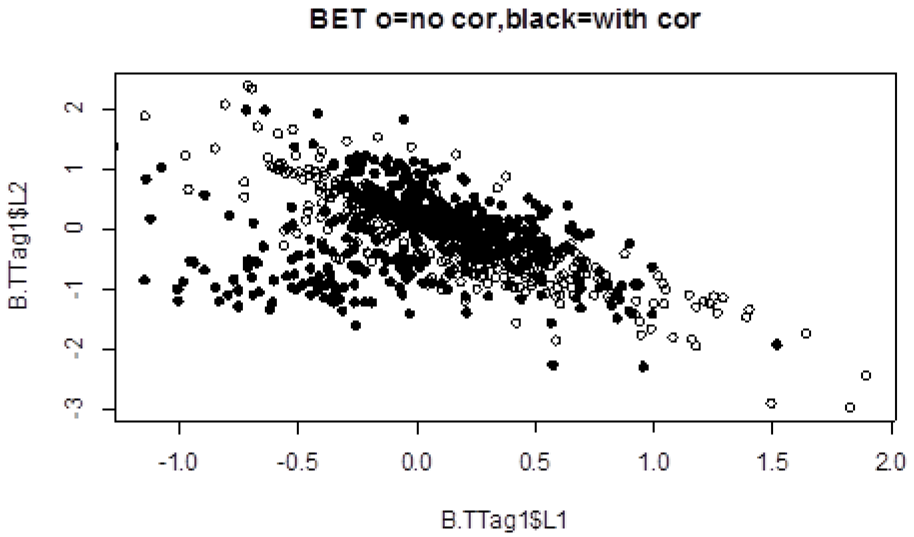
Results: diagnostics



The graph above uniform in case it is fitting well.
Both models (with and without correlation) would show an excess of quantiles in the first category in the Francis diagnostic, with the model without correlation showing a pattern more closer to the uniform one (Model without correlation One-sample Kolmogorov-Smirnov test D = 0.2738, p-value = 3.783e-09, model with correlation D = 0.2679, p-value = 8.855e-09). Francis et al (2015) suggest that this pattern can be improved by modelling the shrinkage of the fish due to freezing.

Results: comparision BET and YFT





Length deviates at tagging and recapture for model with and without correlation for both YFT and BET. There is more improvement by adding correlation for the BET data than for the YFT data.

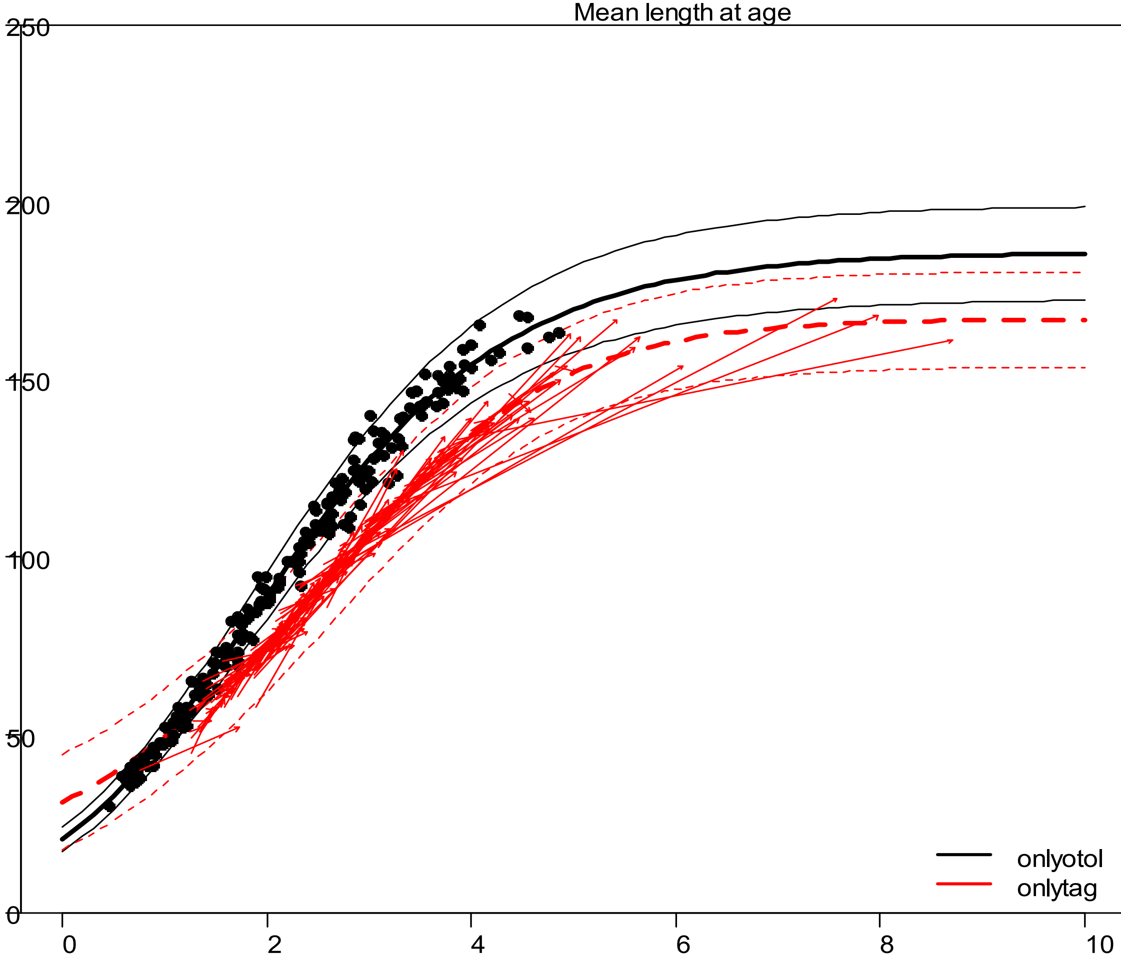
Results: model for tagging data only

Model fit to tagging data only, with L1 fixed at the MLE of the otolith data run (red)

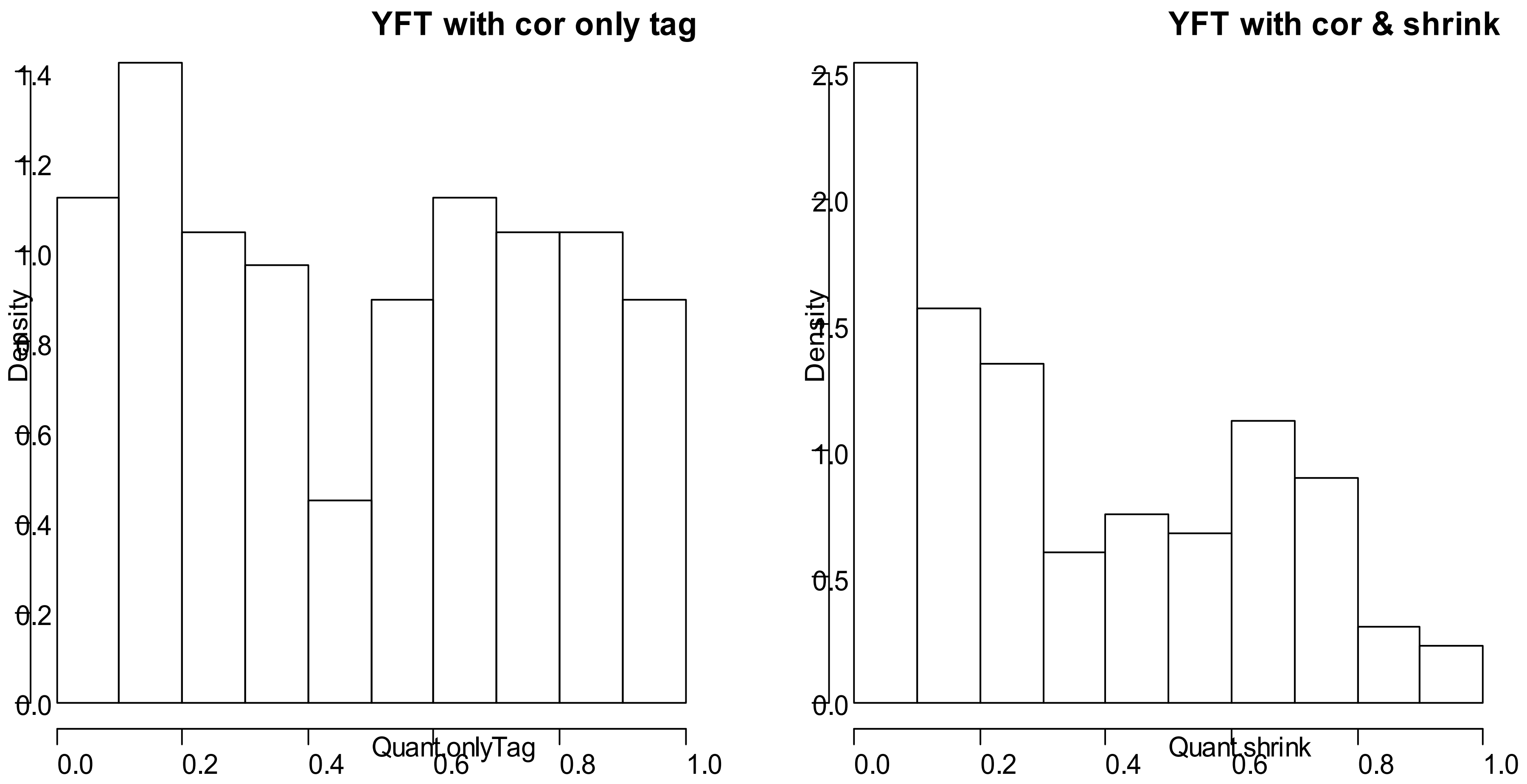
The tagging-only data predicts sizes much smaller than the otolith data.

That might be an indication of changes in growth, the otoliths data is from the 70's the tagging data from the 2000-2010.

(The integrated run with correlation run predicted average size at age in between the tagging and the otolith run.)



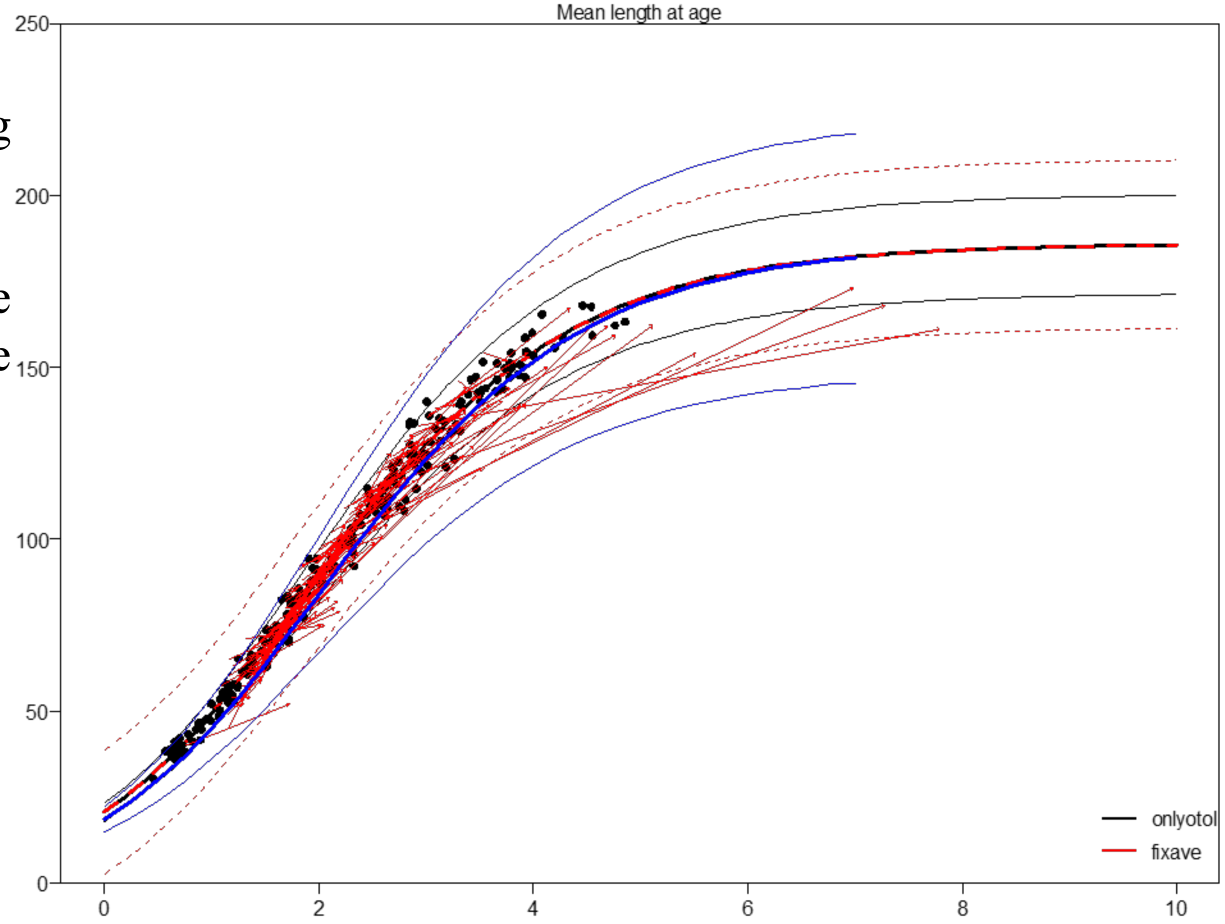
Results: diagnostics



Results: using tagging data to estimate variability

average size at age as predicted by the otolith data and estimate only the variability using both the otolith and tagging data.

Variability assumed in the current stock assessment (in blue) are much larger for older ages and smaller for younger ages than the ones estimated here.

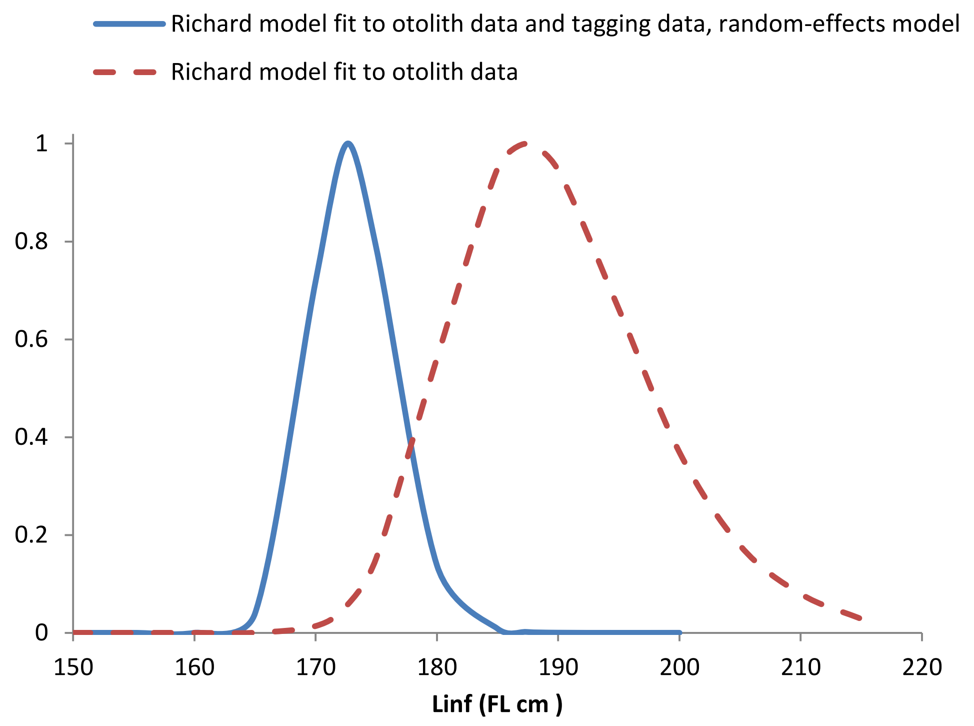


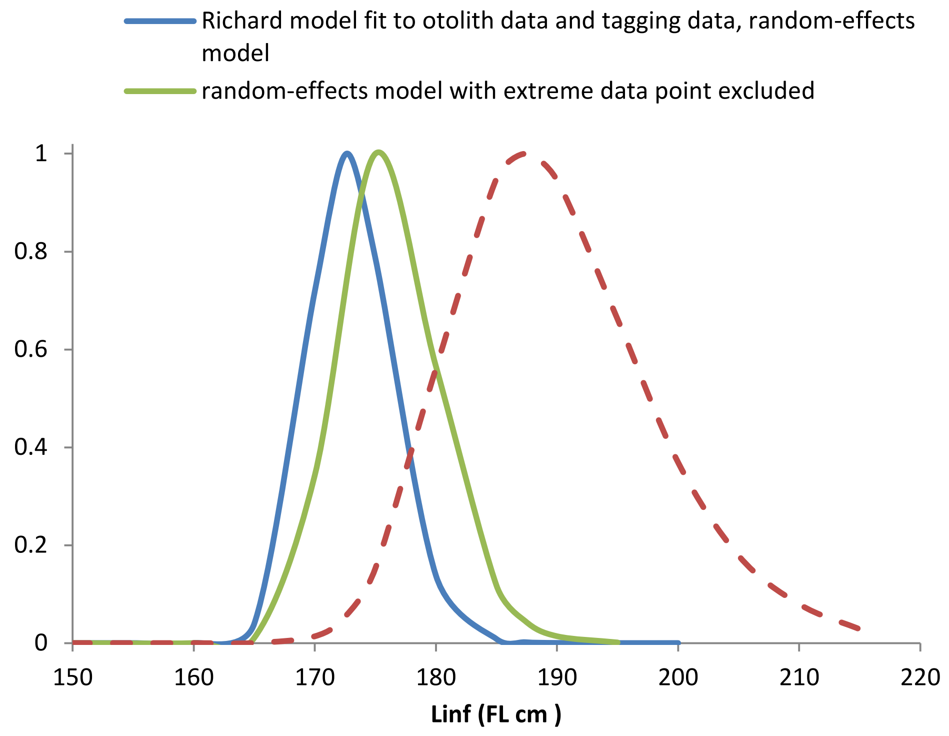
Parameter estimates

Parameter	Fit to otolith data only (age-at-length)	Fit to otolith and tagging data (with correlation)
Growth curve		
L_∞	185.48	171.5
K	0.7514	0.9459
t_0	1.8333	1.944
p	2.0427	0.9792
Variability of length at age		
a	0.6007	2.1216
b	0.0357	0.0258

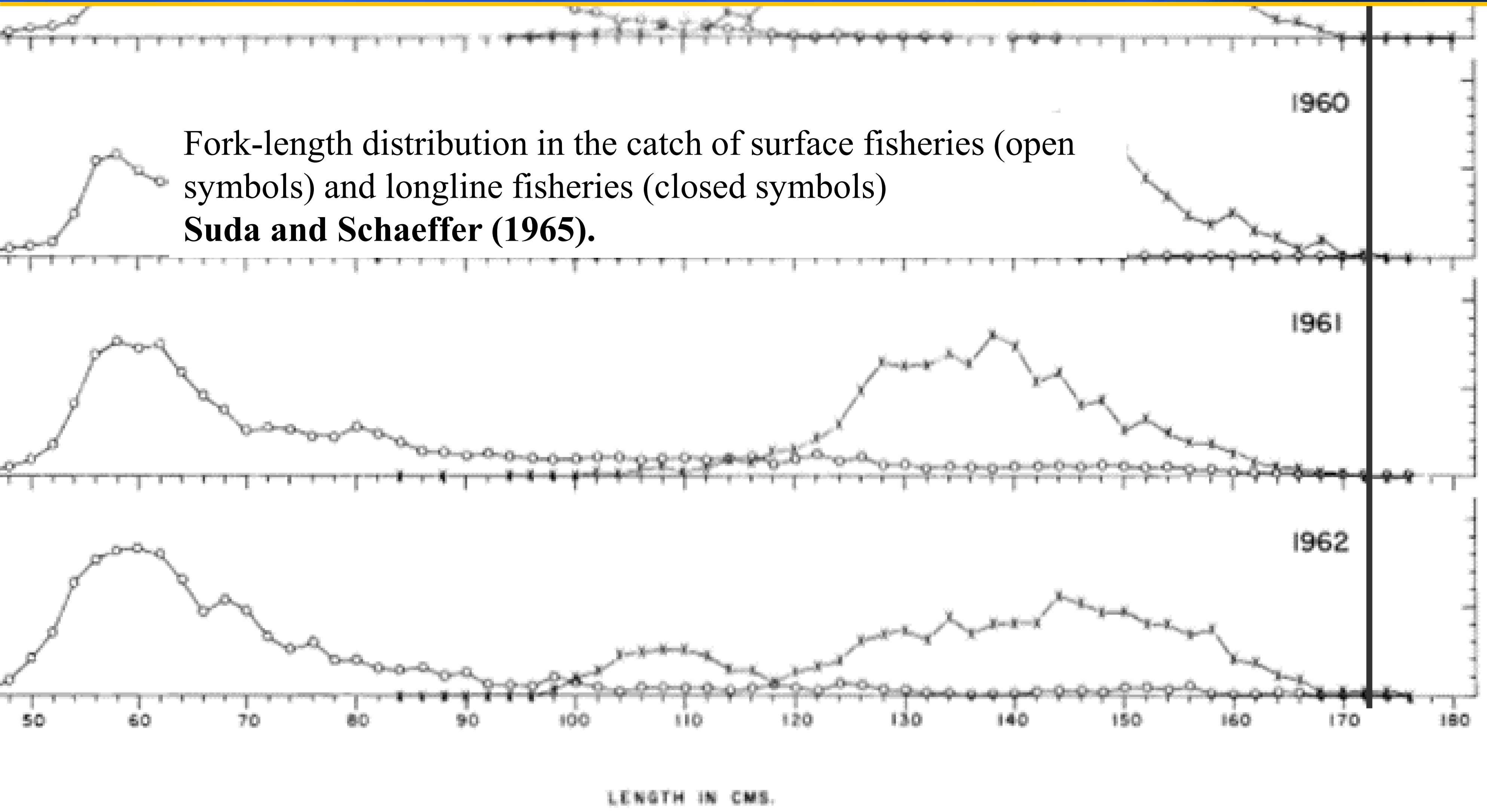
Likelihood profile for Linf

The likelihood profiles shows that even when the extreme-most tagging observation is excluded, the tagging data still supports a smaller Linf





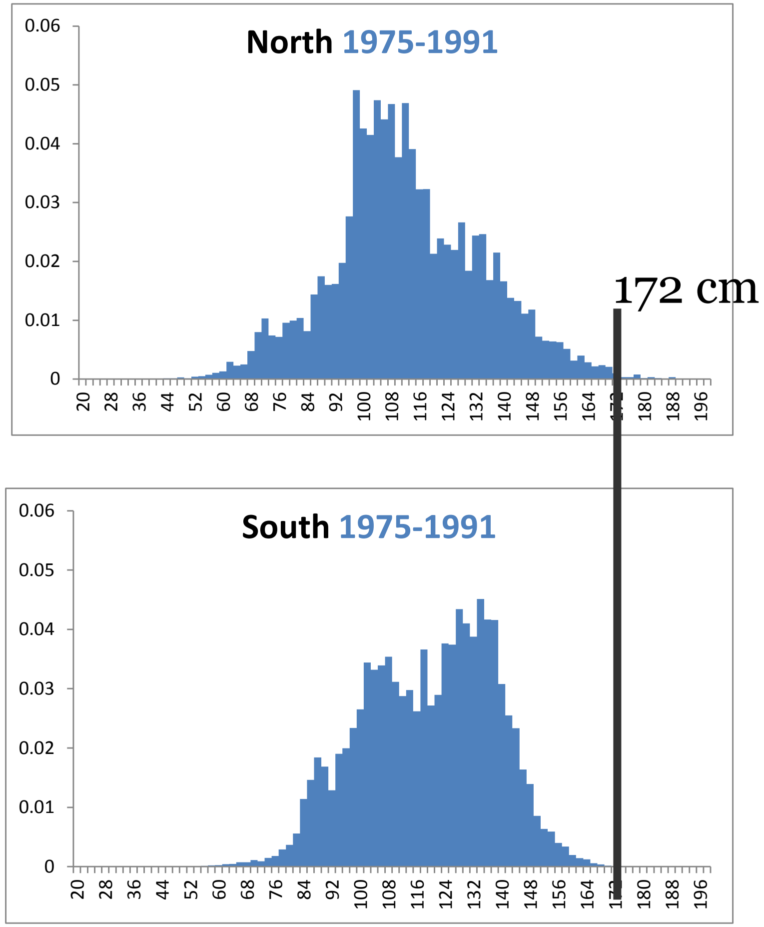
Historical size distribution

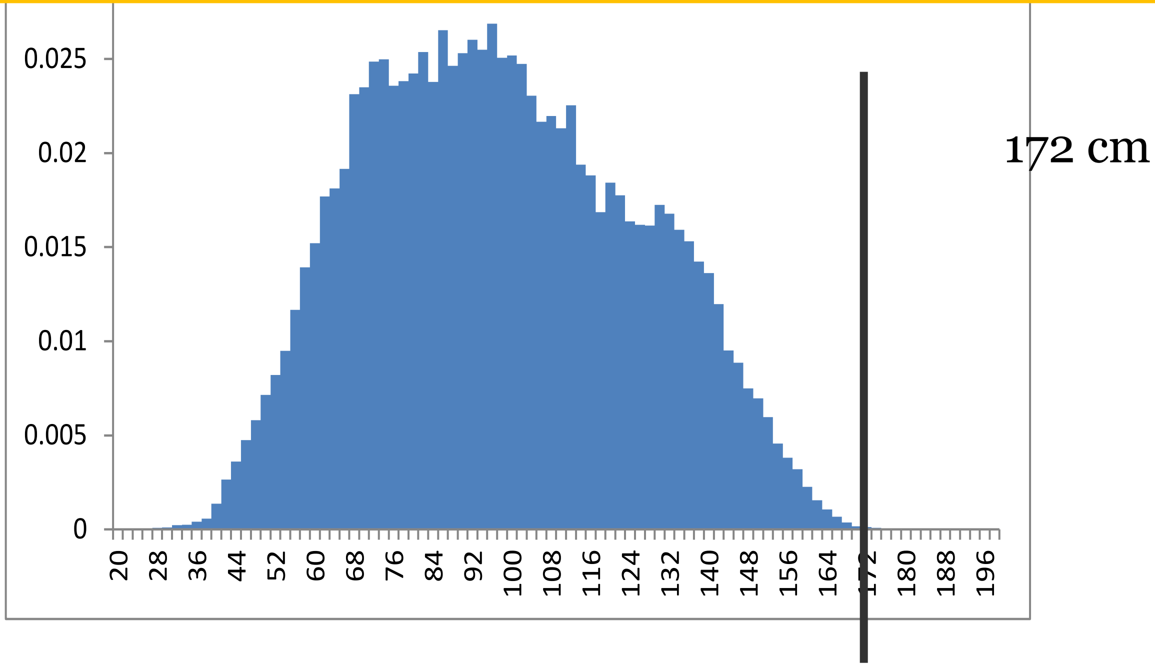


Fork-length distribution in the catch of surface fisheries (open symbols) and longline fisheries (closed symbols)
Suda and Schaeffer (1965).

ntage length-frequency distribution in the catch by the surface fishery in IATTC areas 05, 06 and 07 and by the long-line fishery east of 130°W.
centaje de la distribución de las frecuencias de longitud en la captura por la pesquería de superficie en las áreas 05, 06 y 07 de la CIAT y en la captura por la

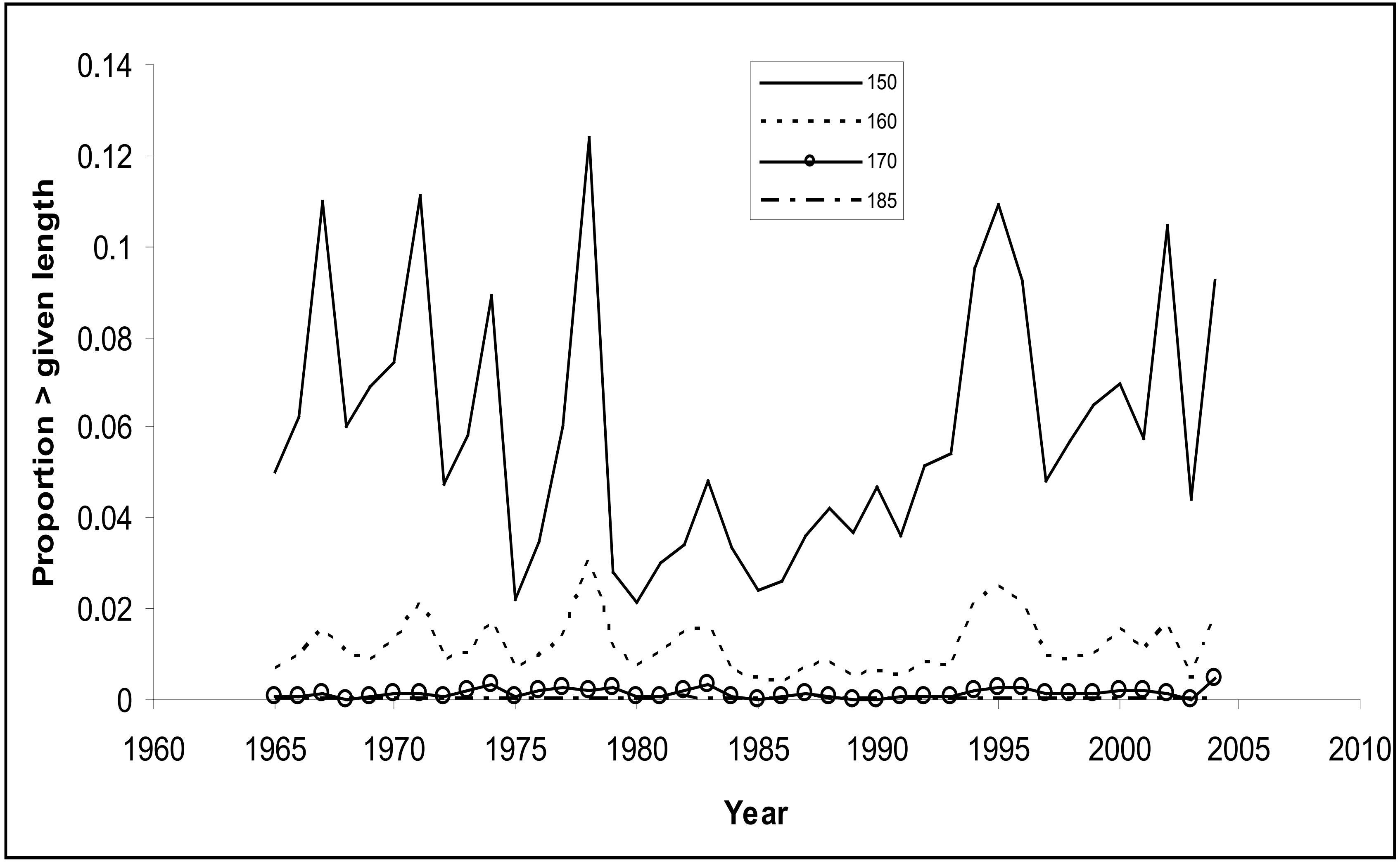
Size distribution in the YFT fisheries





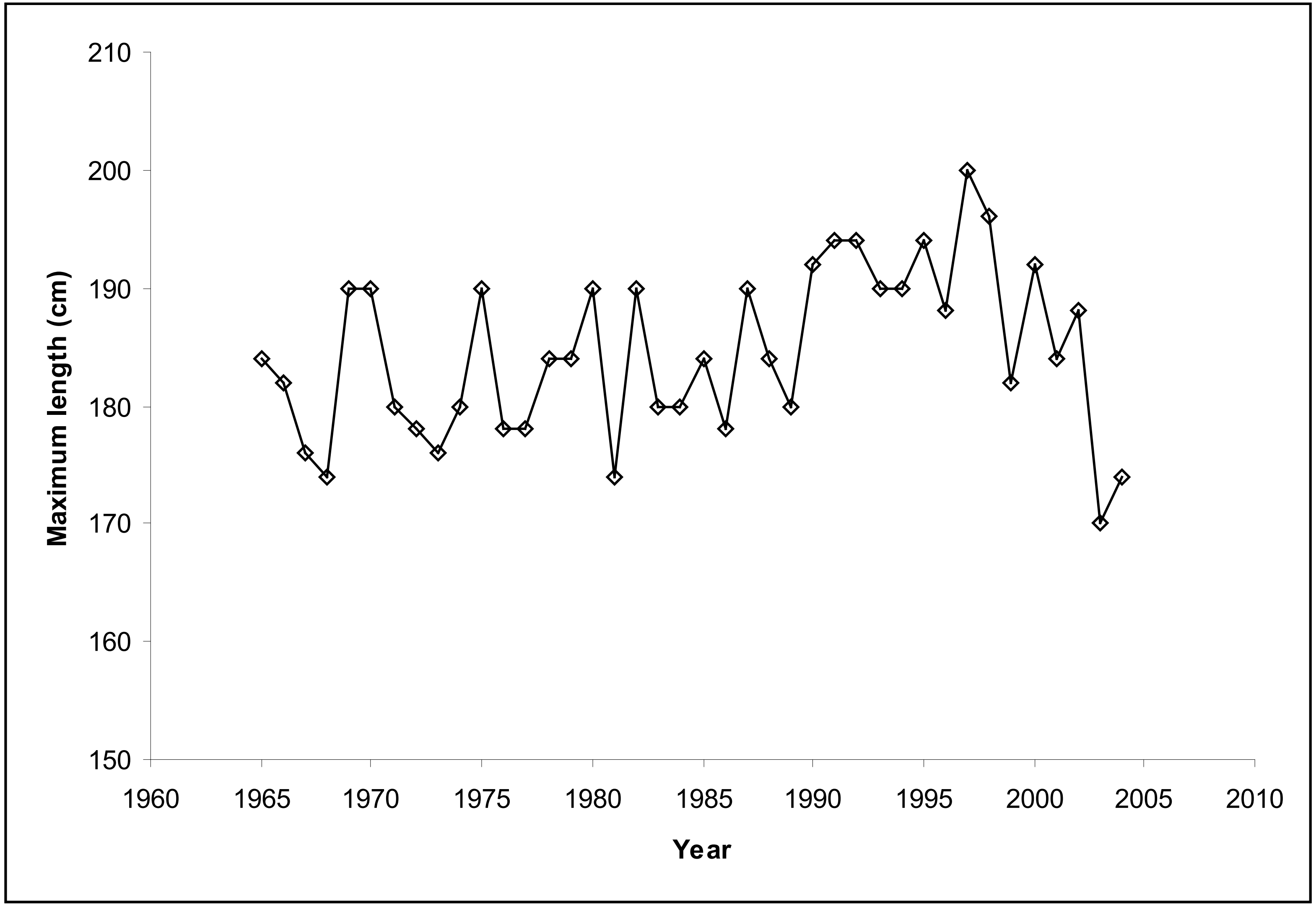
Fork-length distributions of JPN longline fisheries North and South of 17N in the early years in the stock assessment. (Bottom) Fork-length distributions of PS-DOL in the whole EPO for 1975 to 2014.

Proportion of largest sizes



Hoyle and Maunder 2006

Maximum observed length



Hoyle and Maunder 2006

Summary

- The tagging data used is mostly of northern fish as the otolith data
- The tagging data indicates that YFT growth to a smaller asymptotic size than the otolith data indicates, and closer to the large fish in the samples of length frequencies. The two data sets combined allow for a better estimation of the variability of size at age.
- The differences in the estimated growth may be due to:
  - Changes in growth over time
  - Effect of shrinkage
  - Different spatial distribution of the collections of otolith and tagging data (but the high confidence tagging data is from about the same area than the otolith data)

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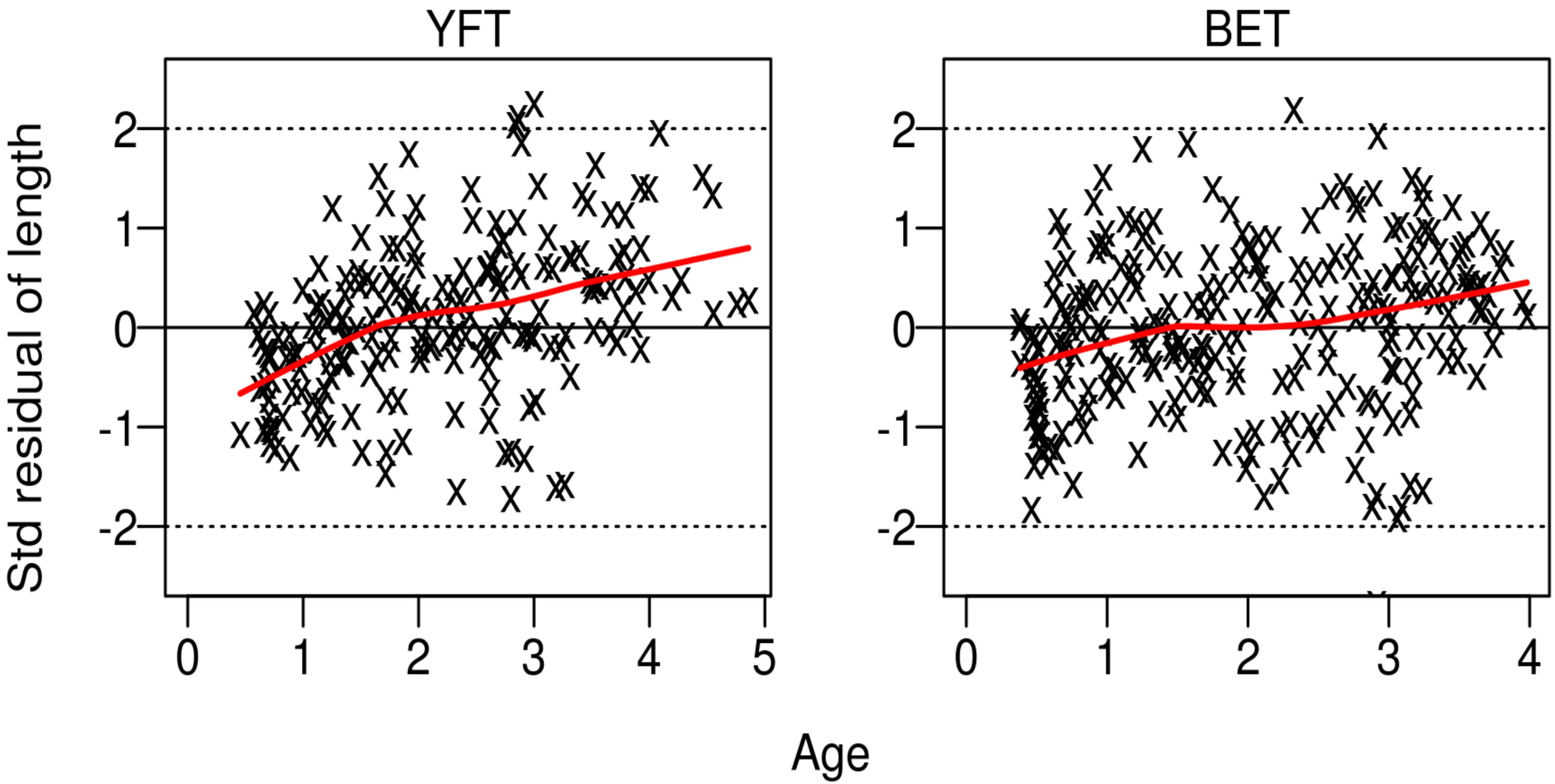
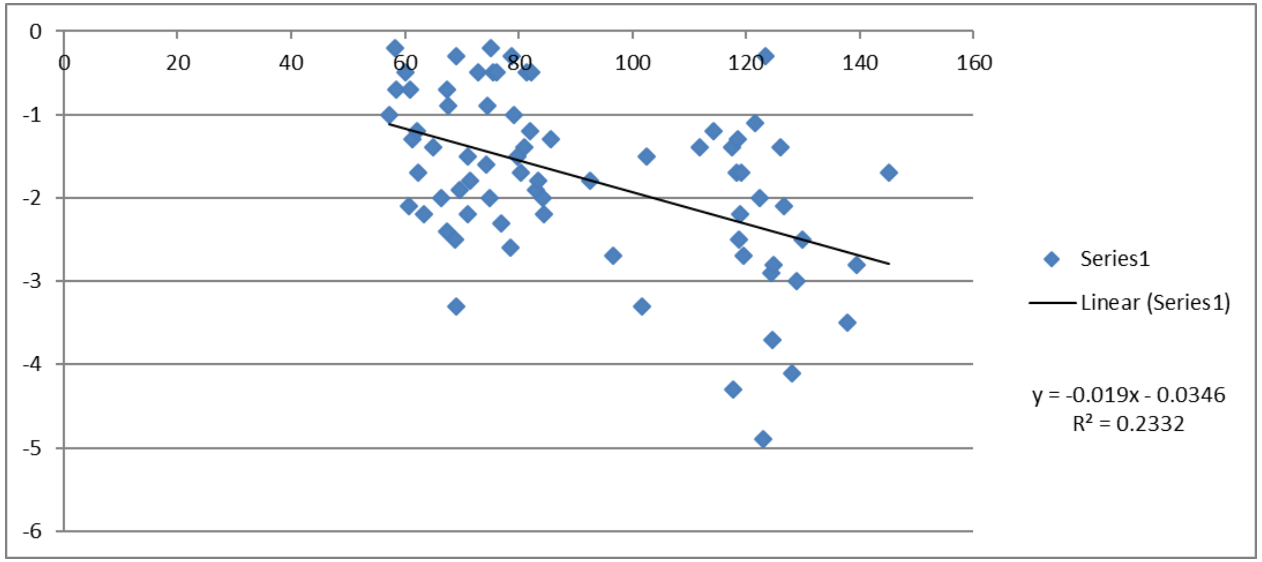
Thank you!

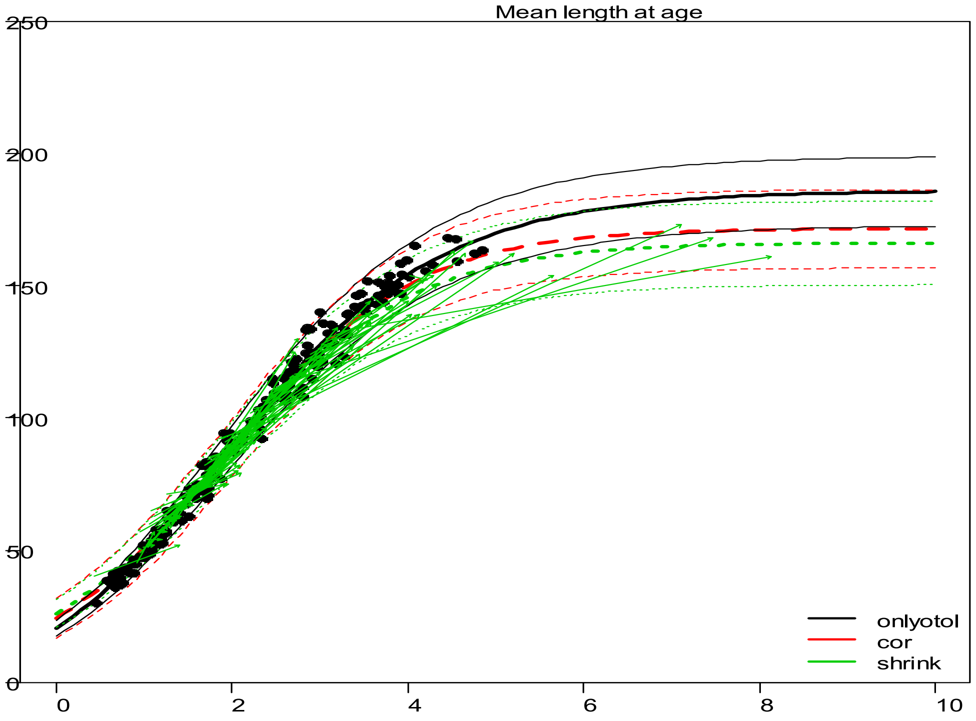


YFT
BET
Std residual of length
Age
2
1
0
-1
-2
0
1
2
3
4
5

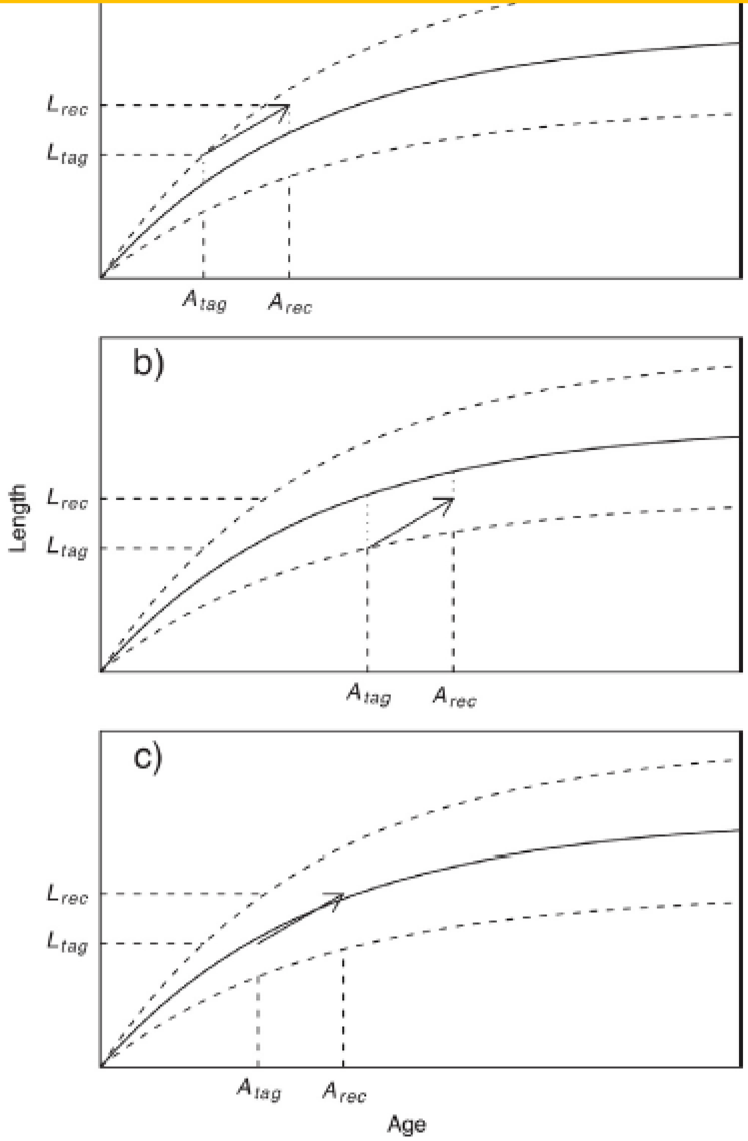
Results model with shrinkage

I tried the shrinkage option, but could not make it to work by estimating all parameters at once. So I fit the shrinkage data only (which is for BET), to estimate the shrinkage parameters and used the MLE of those parameters to fit the growth model to the rest of the data. I obtained the green growth curve below (Figure 6). I was expecting the shrinkage option to go the other way around, but instead the L2 decreased even more.





Outline



L rec
L tag
A tag
A rec
b)
Length
L rec
L tag
A tag
A rec
c)
L rec
L tag
A tag
A rec
Age