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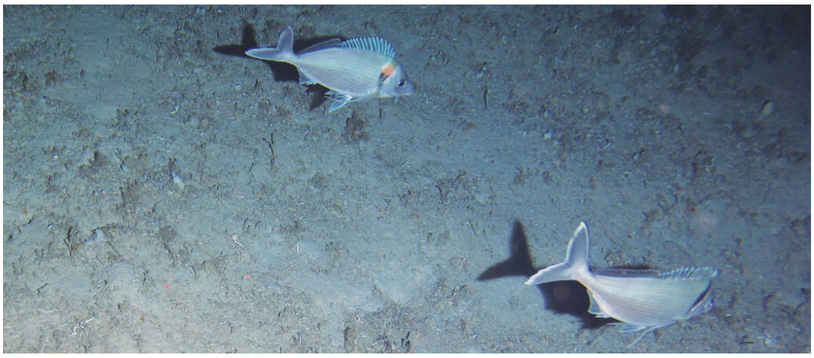
2019/0800 May 2022

Stock Assessment for the Southern and Eastern Scalefish and Shark Fishery: 2020 and 2021



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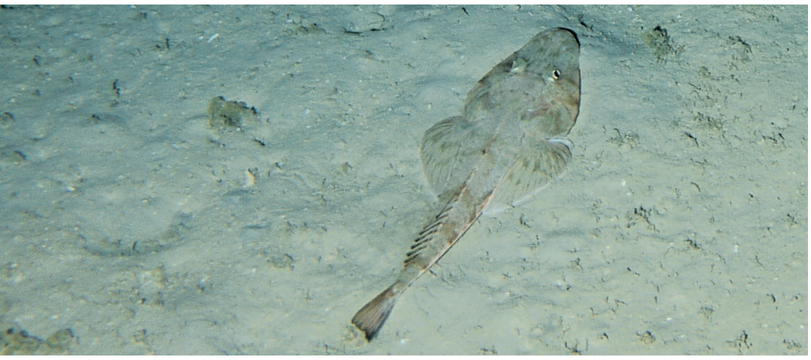

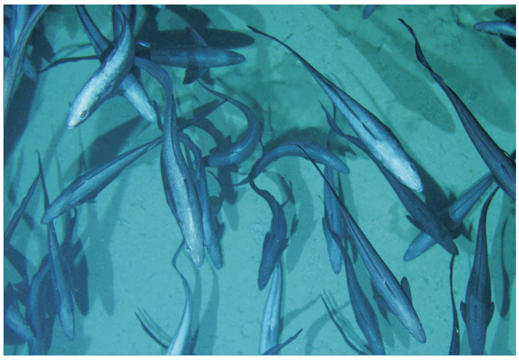

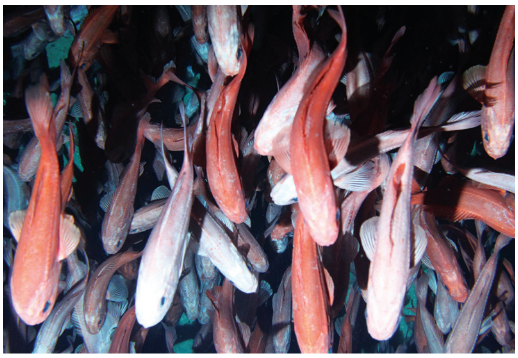

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Cover photographs

Front cover, jackass morwong, orange roughy, blue grenadier, and flathead.

Report structure

Part 1 of this report describes the Tier 1 assessments of 2021. Part 2 describes the Tier 4 and Tier 5 assessments, catch rate standardisations and other work contributing to the assessment and management of SESSF stocks in 2021.

Stock Assessment for the Southern and Eastern Scalefish and Shark Fishery 2020 and 2021

Part 1: 2021

G.N. Tuck
May 2022
Report 2019/0800

Australian Fisheries Management Authority

Stock Assessment for the Southern and Eastern Scalefish and Shark Fishery: 2021

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5. Blue grenadier (*Macruronus novaezelandiae*) stock assessment based on data up to 2020 – development of a preliminary base case

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5.1 Executive Summary

This document presents the preliminary base case for an updated quantitative Tier 1 assessment of Blue Grenadier (*Macruronus novaezelandiae*) for presentation at the SERAG2 meeting in October 2021. The last full assessment was conducted during 2018 (Castillo-Jordán and Tuck, 2018b). The preliminary base case has been updated with the inclusion of data up to the end of 2020, which entails an additional 3 years of catch, discard, CPUE, length and age data and ageing error updates since the 2018 assessment. This document describes the process used to develop a preliminary base case for Blue Grenadier through the sequential updating of recent data in the stock assessment, using the stock assessment package Stock Synthesis (SS-V3.30, Methot and Wetzel (2013)).

This document describes the standard Bridge 1, which updates the assessment to the most recent version of Stock Synthesis, ensures correct settings are used and updates the historical catch series, and Bridge 2, which sequentially incorporates updated data through to 2020. The base case specifications agreed by the SERAG in 2018 were maintained into the preliminary base case presented here. The main differences between the model of 2018 and 2021 are: replacing the variable length bins with 2 cm length bins (standard method across SESSF Tier 1 assessments) and using the latest methods for assigning final weights to the various data sources.

Results of the preliminary base case show reasonably good fits to the length-composition data, conditional age at length, egg survey, discards and acoustic survey. As has been noted in previous Blue Grenadier assessments, the fit to the standardized non-spawning catch-rate index is generally poor; the model is unable to fit to the high early catch rates and over-estimates catch rates during the early 2000s. More recent catch rates fit reasonably well, including the recent marked increase in catch rate in 2019 and 2020.

The estimated time series of recruitment under the base-case parameter set shows the typical episodic nature of Blue Grenadier recruitment, with strong year-classes in 1979, the mid-1980s, 1994, and 2003, with very little recruitment between these years. However, the recent recruitments are more stable, as was first observed in the 2018 assessment. The trajectories of spawning biomass show increases and decreases in spawning biomass as strong cohorts move into and out of the spawning population.

The estimated virgin female spawning biomass (B_0) is 40,759 t tonnes and the projected 2022 spawning stock biomass will be 126% of virgin female spawning biomass (projected assuming 2020 catches in 2021), compared to 122% for 2019 in the 2018 assessment.

Further development and sensitivity testing should include the addition of the FIS lengths and estimating selectivity for the FIS fleet (rather than mirroring to the selectivity of the non-spawning fleet) and estimating male natural mortality.

5.2 Introduction

5.2.1 2021 Blue Grenadier assessment base case.

The 2021 preliminary base case assessment of Blue Grenadier uses an age- and size-structured model implemented in the generalized stock assessment software package, Stock Synthesis (SS) (Version 3.30.17.00, Methot et al. (2021)). The methods utilised in SS are based on the integrated analysis paradigm. SS can allow for multiple seasons, areas and fleets, but most applications are based on a single season and area. Recruitment is governed by a stochastic Beverton-Holt stock-recruitment relationship, parameterized in terms of the steepness of the stock-recruitment function (h), the expected average recruitment in an unfished population (R_0), and the degree of variability about the stock-recruitment relationship (σ_r). SS allows the user to choose among a large number of age- and length-specific selectivity patterns. The values for the parameters of SS are estimated by fitting to data on catches, catch-rates, discard mass, discard and retained catch length-frequencies, and conditional age-at-length data. The population dynamics model and the statistical approach used in fitting the model to the various data types are given in the SS technical documentation (Methot, 2005).

Model data have been updated by the inclusion of data up to the 2020 calendar year (length-composition and conditional age-at-length data; age reading-error matrices, standardized catch rate series; landings and discard catch weight) and information from acoustic surveys of spawning biomass (series from 2003-2010, pertaining to total spawning biomass), with an assumption of 2-times turnover on the spawning ground (Russell and Smith, 2006; Punt et al. 2015). The base-case egg survey estimates of female (only) spawning biomass for 1994 and 1995 are included, as are the FIS survey estimates for the non-spawning fishery. The model fits directly to length-composition data (by sex where possible) and conditional age-at-length data by fleet. Retained length-composition data from port and onboard samples are separated.

The first bridging exercise (Bridge 1) highlights changes that have occurred since 2018 simply through changes to software and assessment practices. The subsequent bridging exercise (Bridge 2) then sequentially updates the assessment model with new data through to 2020.

The base–case model includes the following key features:

a) Blue grenadier consists of a single stock within the area of the fishery.

b) The model accounts for males and females separately (growth, natural mortality, age at first breeding).

c) The population was at its unfished biomass with the corresponding equilibrium (unfished) age-structure at the start of 1960.

d) The rate of natural mortality, M, is assumed to be constant with age, and also time-invariant. The value for female M is estimated within the assessment. Following previous assessments, male natural mortality is assumed be 20% greater than that of females.

e) Recruitment to the stock is assumed to follow a Beverton-Holt type stock-recruitment relationship, parameterised by the average recruitment at unexploited spawning biomass, R_0, and the steepness parameter, h. Steepness for the base-case analysis is set to 0.75. Deviations from the average recruitment at a given spawning biomass (recruitment residuals) are estimated for 1974 to 2017. Deviations are not estimated before 1974 or after 2017 because there are insufficient data to permit reliable estimation of recruitment residuals outside of this time period.

f) The population plus-group is modelled at age 20 years. The maximum age for age observations is 20 years.

g) Growth is assumed to follow a von Bertalanffy type length-at-age relationship, with the parameters of the growth function being estimated separately for females and males inside the assessment model. Growth is also assumed to vary through time and to be cohort (year class) specific. Evidence for time-varying and cohort specific growth in blue grenadier has been accumulating over several decades (see Punt and Smith 2001; Whitten et al., 2013). The 2021 base-case model treats conditional age-at-length information as data (i.e. to incorporate error), and predicts the expected length-at-age for each year. This is achieved by estimating the parameters of a von Bertalanffy growth function where the expected annual growth increment is based on the von Bertalanffy growth function but with a growth rate parameter that is determined by an expected value and a cohort-specific deviation. Cohort-specific deviations from average growth are estimated in the base case model for year classes 1978 to 2017.

h) Two fleets are included in the model – the spawning sub-fishery that operates during winter (June – August inclusive) off western Tasmania (zone 40), and the non-spawning sub-fishery that operates during other times of the year and in other areas throughout the year.

i) Each selectivity pattern was assumed to be length-specific, logistic and time-invariant for the spawning fleet and dome-shaped for the non-spawning fleet. The parameters of the selectivity function for each fleet were estimated within the assessment.

j) The inclusion of the FIS is considered for the non-spawning area, and the selectivity mirrors the corresponding non-spawning fleet (Fleet 2).

k) The CVs of the CPUE indices were initially set at a value equal to the standard error from a loess fit (0.252; Sporcic, 2021), before being re-tuned to the model-estimated standard errors within SS. The acoustic estimates were tuned through the estimation of an extra variance component that is added to the model input standard errors. This is done within SS.

l) Discard tonnage was estimated through the assignment of a retention function for the non-spawning fleet. This was defined as a logistic function of length, and the inflection and slope of this function were estimated where discard information was available. In addition, the discard length data from 1993, 1995 and 1996 were removed for the 2018 base case as recommended by SERAG (September, 2018) due to the existence of unusually large fish in the length distribution which is likely to be misreporting.

m) Retained and discarded onboard length sample sizes were capped at 200 and a minimum of 100 fish measured was required for length-composition data to be included in the assessment. For port samples, numbers of trips were used as the sampling unit, with a cap of 100. The number of fish measured is not used as the sample size because the appropriate sample size for length-composition data is probably more closely related to the number of shots (onboard) or trips (port) sampled, rather than the number of fish measured.

The values assumed for fixed parameters of the preliminary base case model are shown in Table 5.1.

Table 5.1. Parameter values assumed for some of the non-estimated parameters of the base-case model

Parameter	Description	Value
M_f	Natural mortality for females	Estimated
M_m	Natural mortality for males	1.2* M_f
h	"steepness" of the Beverton-Holt stock-recruit curve	0.75
x	age observation plus group	20 years
μ	fraction of mature population that spawn each year	0.84
a_f	Female allometric length-weight equations	0.01502 g^{-1}.cm
b_f	Female allometric length-weight equations	2.728
a_m	Male allometric length-weight equations	0.0168 g^{-1}.cm
b_m	Male allometric length-weight equations	2.680
l_m	Female length at 50% maturity	63.7cm
l_s	Parameter defining the slope of the maturity ogive	-0.261

5.3 The fishery

Blue grenadier are found from New South Wales around southern Australia to Western Australia, including the coast of Tasmania. Blue grenadier is a moderately long-lived species with a maximum age of about 25 years. Age at maturity is approximately 4 years for males and 5 years for females (length-at-50% maturity for females is 57cm and 64cm respectively) based upon 32,000 blue grenadier sampled between February 1999 and October 2001 (Russell and Smith, 2006). There is also evidence that availability to the gear on the spawning ground differs by sex, with a higher proportion of small males being caught than females. This is most likely due to the arrival of males on the spawning ground at a smaller size (and younger age) than females. This was also noted by Russell and Smith (2006) who state that "young males entered the fishery one year earlier than females" and is consistent with information for Hoki from New Zealand (Annala et al., 2003). Large fish arrive earlier in the spawning season than small fish. Spawning occurs predominantly off western Tasmania in winter (the peak spawning period based upon mean GSIs calculated by month was estimated to be between June and August according to Russell and Smith (2006)). There is some evidence that a high proportion of fish remain spawning in September. Variations in spawning period noted by Gunn et al. (1989) may occur due to inter-annual differences in the development of coastal current patterns around Tasmania. Adults disperse following the spawning season and while fish are found throughout the south east region during the non-spawning season, their range is not well defined. Spawning fish have been caught off the east coast of Australia, and larvae from a likely eastern spawning area have been described by Bruce et al. (2001). Blue grenadier are caught by demersal trawling. There are two defined fleets: the spawning (Zone 40, months June, July and August) and non-spawning fisheries (all other months and zones).

5.4 Bridging methodology

The previous full quantitative assessment for Blue Grenadier was performed in 2018 (Castillo-Jordán and Tuck, 2018) using Stock Synthesis (version SS-V3.30.12.00, Methot et al. (2018)). The 2021 assessment uses the current version of Stock Synthesis (version SS-V3.30.17.00, Methot et al. (2021)).

As a first step in the process of bridging to a new model, the data used in the 2018 assessment was used in the new software (SS-V3.30.17.00). Once this translation was complete, improved features unavailable in SS-V3.12.00 were incorporated into the SS-V3.30.17 assessment. The catch series was then updated to include any amended estimates for the historical period from 1998 to 2017 since the 2018 assessment. Following this step, the model was re-tuned using the most recent tuning protocols (Pacific Fishery Management Council, 2018), thus allowing the examination of changes to both assessment practices and the tuning procedure on the previous model structure. These changes to software and tuning practices may lead to changes to key model outputs, such as the estimates of depletion and the trajectory of spawning biomass. This initial bridging phase (Bridge 1) highlights changes that have occurred since 2018 simply through changes to software and assessment practices.

The subsequent bridging exercise (Bridge 2) then sequentially updates the model with new data through to 2020. These additional data included new catch, discard estimates, CPUE, length composition data, conditional age-at-length data and an updated ageing error matrix. The last year of recruitment estimation and cohort dependent growth was extended to 2017 (from 2014 in Castillo-Jordán and Tuck (2018b)). The final step is to re-tune the model.

5.5 Bridge 1

The 2018 Blue Grenadier assessment (labelled 'GRE_2018_30_12_00') was converted to the most recent version of the software, Stock Synthesis version SS-V3.30.17.00 (labelled 'GRE_2018_30_17_00'). This resulted in no changes to the stock status estimates throughout the timeseries (Figure 5.1). There were no discernible changes that resulted from alteration of settings. Likewise, updating catches to 2017 also resulted in no discernible changes (labelled 'Updated_catch' and includes the previous changes (Figure 5.1)). The assessment was then tuned using the latest tuning protocol (labelled 'Tuned'). This process demonstrates the outcomes that could theoretically have been achieved with the last assessment if we had the latest software, tuning protocols and corrected data available in 2018. This initial bridging step, Bridge 1, does not incorporate any data after 2017 or any structural changes to the assessment. Re-tuning led to a reduction in the initial estimate of virgin biomass (Figure 5.1). Sensitivity to this parameter has been noted in previous assessments (Figure 5.2; Castillo-Jordán and Tuck, 2018a).

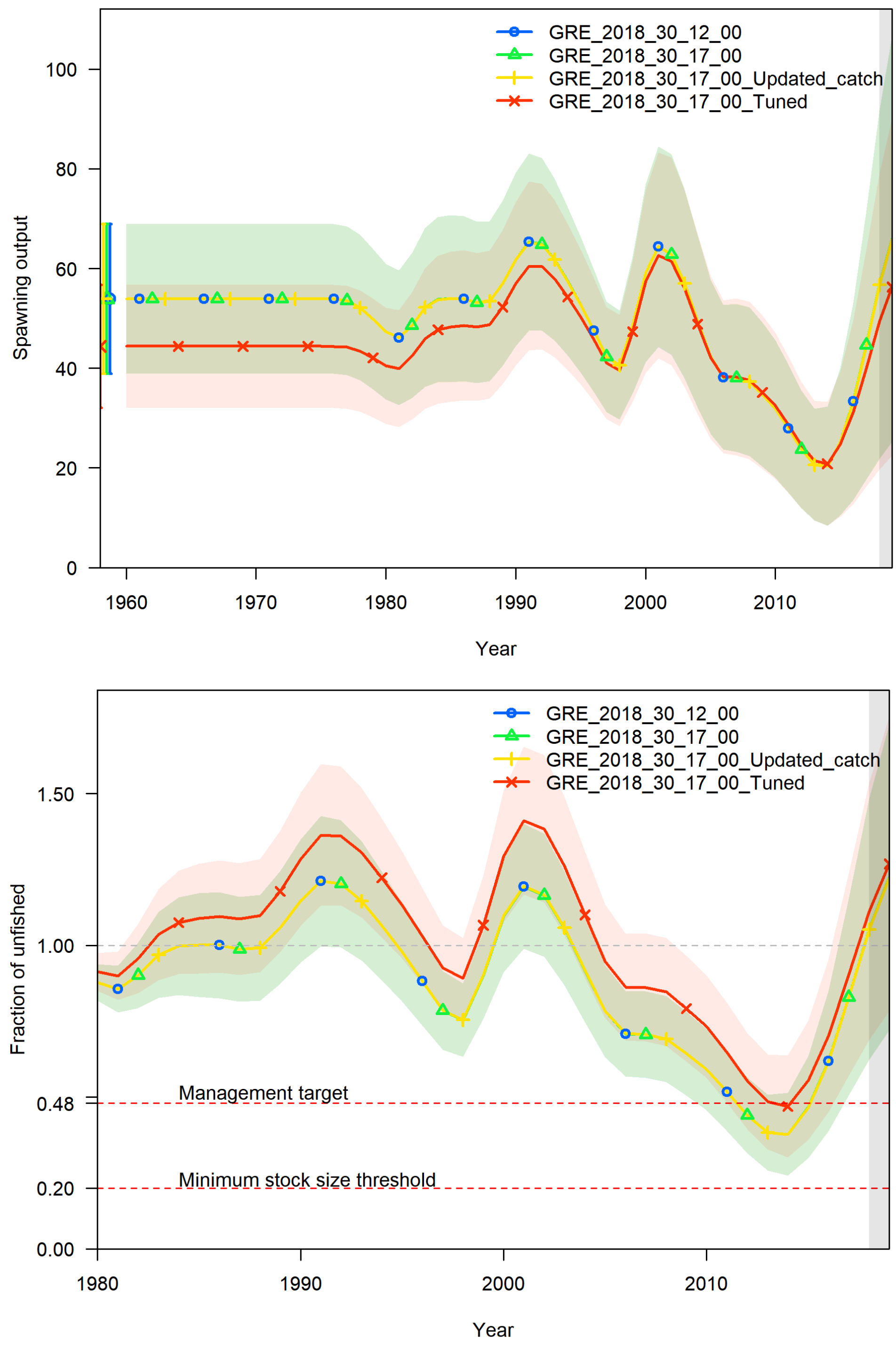

Figure 5.1. Comparison of the spawning (top) and relative (bottom) biomass time series for the 2018 assessment (SS3-30.12), a model converted to SS-V3.30.17, with updated settings and catches (Updated_catch) and then re-tuned (Tuned).

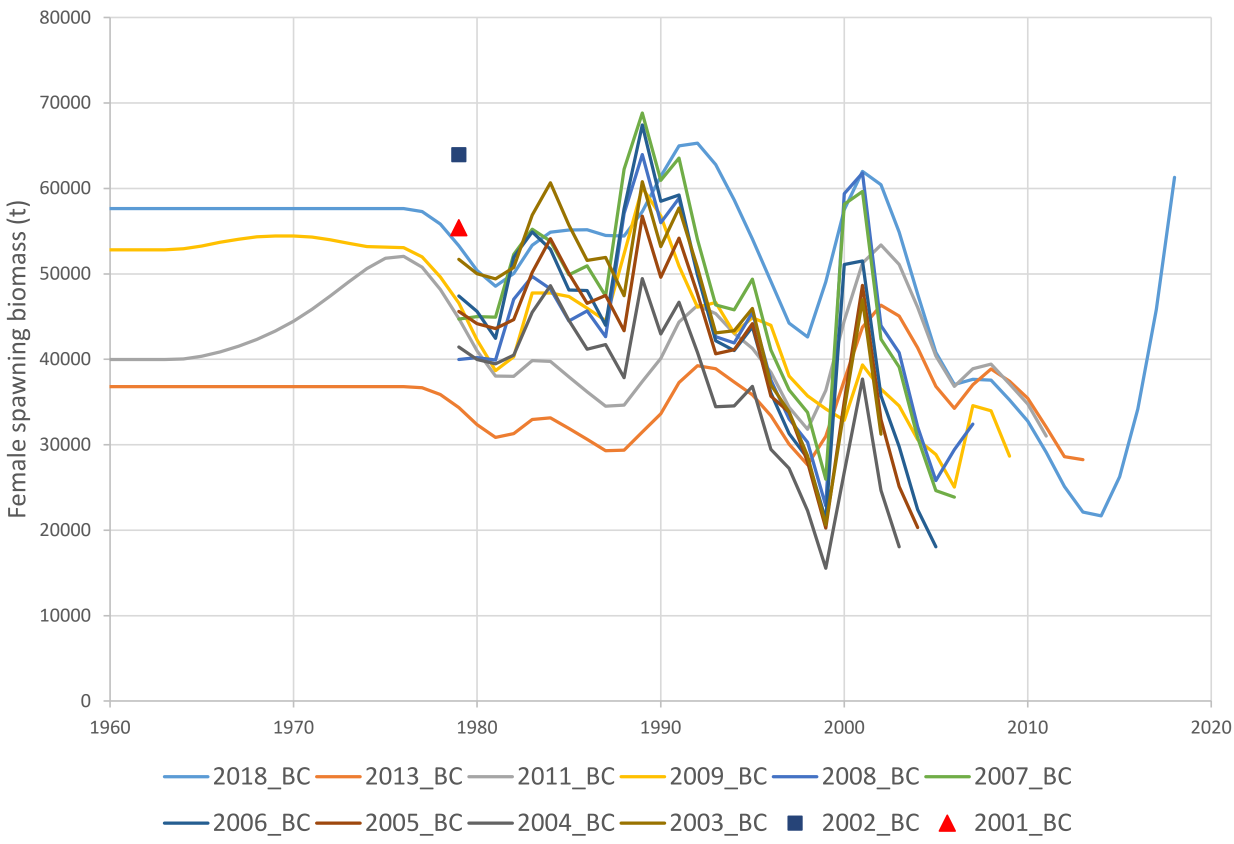

Figure 5.2. A retrospective of assessment outputs of female spawning biomass from each stock assessment from 2001 to 2018. Note that for 2001 and 2002 only values of biomass at 1979 were available (from Castillo-Jordán and Tuck, 2018a).

5.6 Bridge 2

5.6.1 Inclusion of new data

The data inputs to the assessment comes from multiple sources, including: length and conditional age-at-length data, updated standardized CPUE series (Sporcic, 2021), the annual total mass landed, discard mass, and age-reading error.

Starting from the converted 2018 base case model (labelled GRE_2018_Updated) additional and updated data to 2020 were added sequentially to develop a preliminary base case for the 2021 assessment, these steps included:

1. Change final assessment year to 2020, add catch to 2020 (addCatch2020).
2. Add CPUE to 2020 (from Sporcic (2021)) (addCPUE2020).
3. Add updated discard estimates to 2020 (add_Discards2020).
4. Update length frequency data, including both port and onboard length frequencies (addLengths2020). Conditional-age-at-length were also updated at this step due to changing the length bins used in the assessment.
5. Add updated age error matrix (addAgeErr2020).

6. Change the final year for which recruitments are estimated from 2014 to 2017 (extendRec2017).
7. Change the final year for which cohort dependent growth is estimated from 2014 to 2017 (extendCGD2017).
8. Retune using latest tuning protocols, including Francis weighting on length-compositions and conditional age-at-length data (Tuned_3).

5.6.2 *Results – base case*

Inclusion of the new data resulted in a series of changes to the outputs of the model. The addition of updated catch data and catch rate data made minimal difference to the estimated spawning biomass (Figure 5.3). The addition of updated discard estimates markedly reduced initial and final estimates of spawning biomass (Figure 5.3). There were minimal changes resulting from the addition of length and age data (Figure 5.3). Extending recruitment deviations and cohort dependent growth led to an increase in initial and final biomass due to the greater freedom to fit to recent input data (eg the catch rate series, Figure 5.3). Tuning resulted in downward revisions to the biomass series, with initial biomass similar to the updated 2018 assessment (Figure 5.3).

The sequential addition of data resulted in various changes to the recruitment estimates (Figure 5.4). The addition of further recruitment years (to 2017; GRE_2021_extendRec2017) has led to a marked increase in the magnitude of recent recruitment (between 2014 -2017) over the assumed values from the recruitment curve (Figure 5.4). Final tuning also increased the estimates of recruitment from the early years of the fishery (late 1970s and mid 1980s, Figure 5.4).

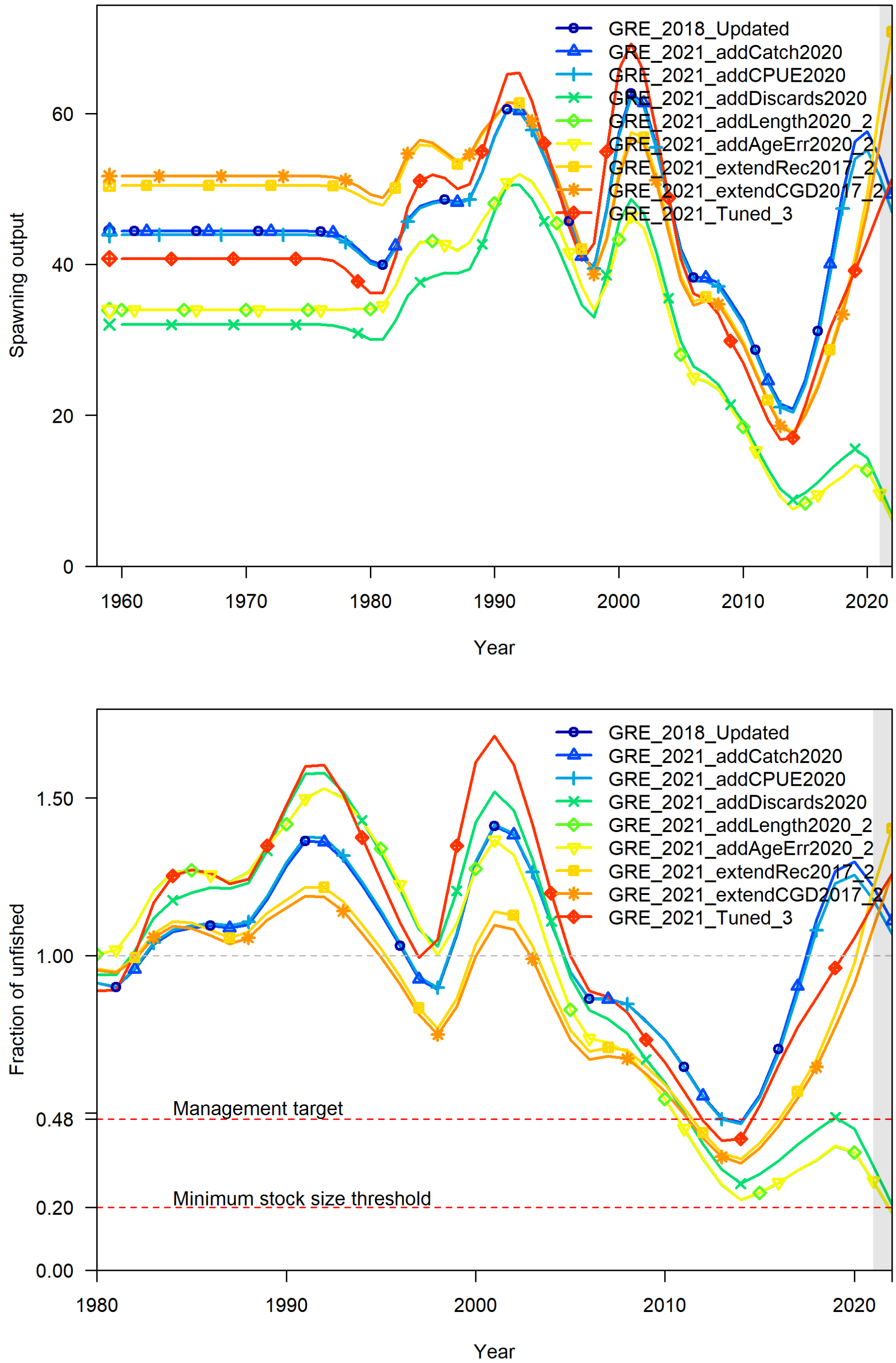

Figure 5.3. Comparison of the absolute (top) and relative (bottom) spawning biomass for the updated 2018 assessment converted to SS-V3.30.17 (GRE_2018_Updated – dark blue) with various bridging models leading to the 2021 base case (GRE_2021_Tuned_3 - red)

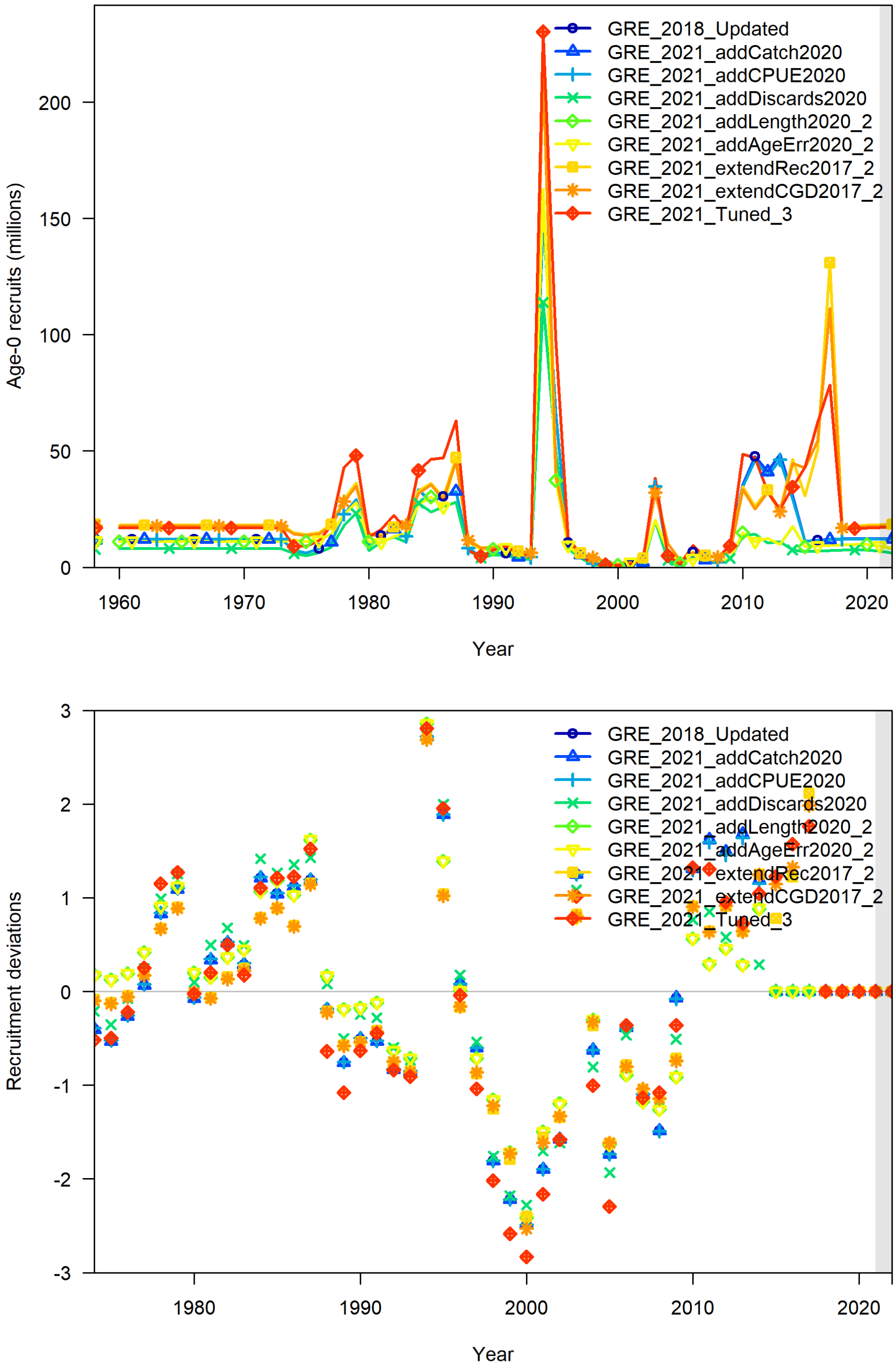

Figure 5.4. Comparison of the estimated recruitment (top) and deviations (bottom) for the updated 2018 assessment model converted to SS-V3.30.17 (GRE_2018_Updated – dark blue) with various bridging steps leading to the 2021 base case (GRE_2021_Tuned_3 - red)

The impacts of inclusion of new data on fits to the non-spawning fishery CPUE series are illustrated in Figure 5.5. As has been noted before, the fits to CPUE are generally poor until the mid-2000s. The addition of new data and extending recruitment estimation to 2017 has allowed a reasonable fit to the recent marked increase in CPUE since 2018.

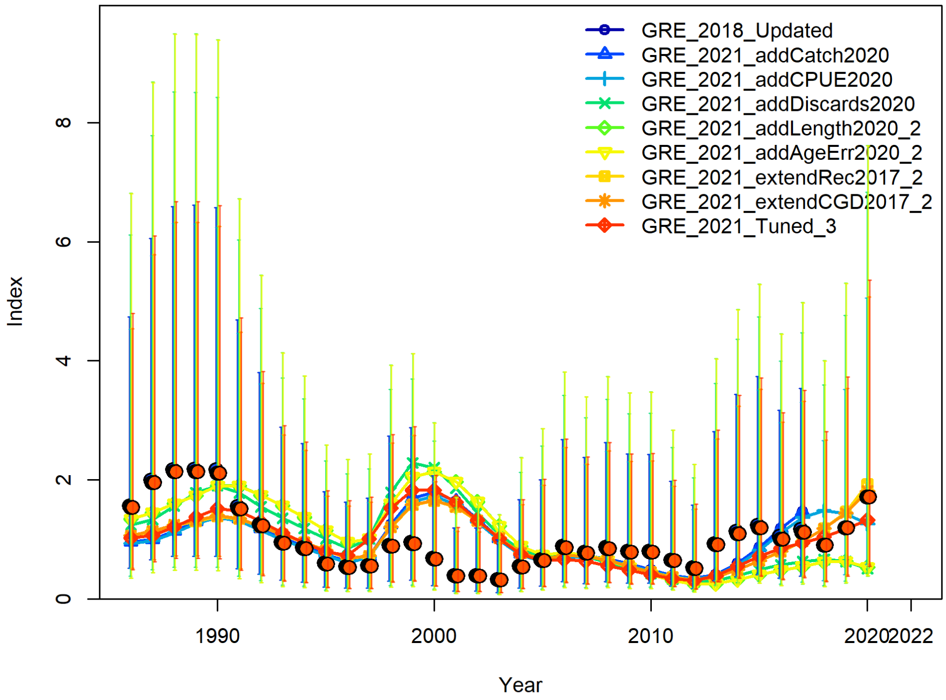

Figure 5.5. Comparison of the fit to the non-spawning fishery CPUE index for the updated 2018 assessment model converted to SS-V3.30.17 (GRE_2018_Updated – dark blue) with various bridging models leading to the 2021 preliminary base case (GRE_2021_Tuned_3 - red)

5.6.3 *Fits to data – base case*

Estimated outputs and fits to the data of the preliminary base case are presented in Figure 5.6–Figure 5.13. Fits are comparable to those in the previous assessment (see Castillo- Jordán and Tuck (2018b)). Fits to the acoustic and FIS surveys are reasonable, although there is little variation in the estimated values and the fit is relatively flat while passing through the confidence intervals. The fit to discard mass is reasonable, although there is some under-fitting from 2015-17. Fits to the length composition data are good across the retained and discard lengths, and for port and onboard lengths. Note the saw-tooth port lengths which may be due to in-port rounding of measurements. This will be further investigated.

5.6.4 *Assessment outcomes -base case*

The estimated virgin female biomass is 40,759 tonnes (compared to 53,909 tonnes in 2018 and 36,815 tonnes in the 2013 assessments). Initial biomass is known to be sensitive in this model and often has varied betweem 35,000 tonnes and 60,000 tonnes. Castillo- Jordán and Tuck (2018a) showed that there is uncertainty regarding the initial biomass from the likelihood profile for $\ln R_0$ (Figure 5.15). A likelhood profile on initial biomass (amongst others) will be conducted for SERAG3 in 2021 to further investigate this sensitivity.

The projected 2022 spawning stock biomass will be 126% of virgin female spawning biomass (projected assuming 2020 catches in 2021), compared to 122% for 2019 in the 2018 assessment, and 94% for 2014 in the 2013 assessment.

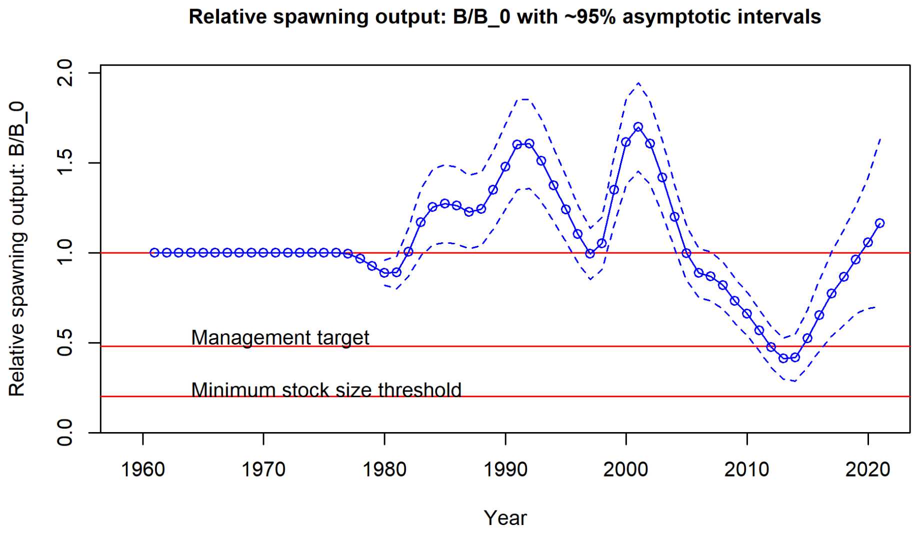

Figure 5.6. The estimated time-series of relative spawning biomass for the 2021 preliminary base case assessment

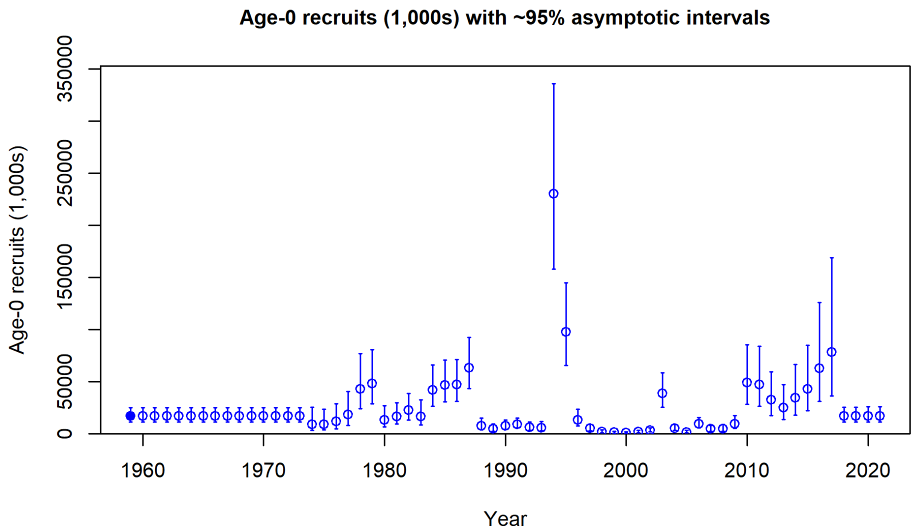

Figure 5.7. The estimated time-series of recruitment for the 2021 preliminary base case assessment

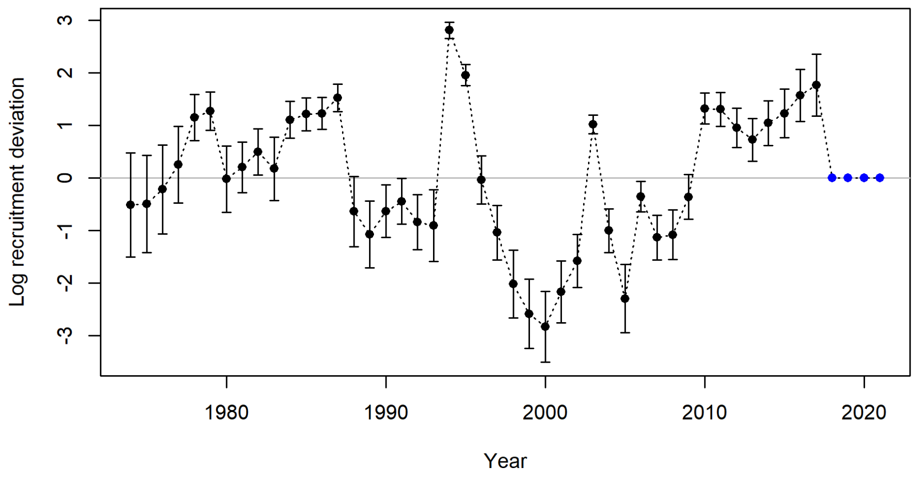

Figure 5.8. The estimated time-series of recruitment deviations for the 2021 preliminary base case assessment

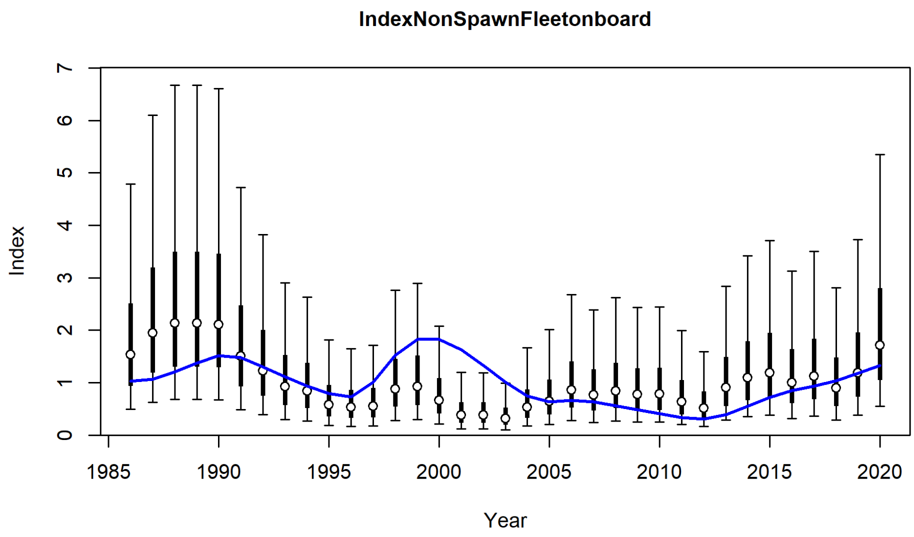

Figure 5.9. Fits to the non-spawning fishery CPUE for the 2021 preliminary base case assessment

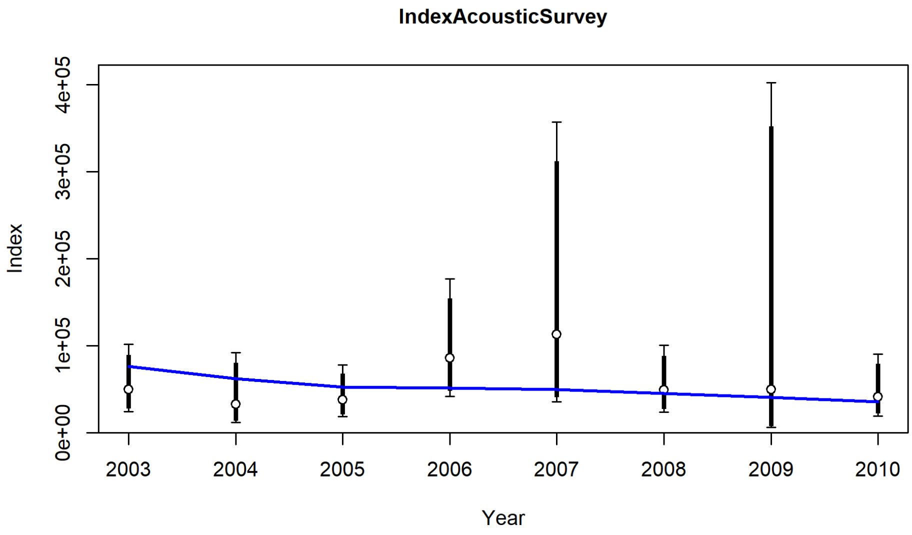

Figure 5.10. Fits to the acoustic survey for the 2021 preliminary base case assessment

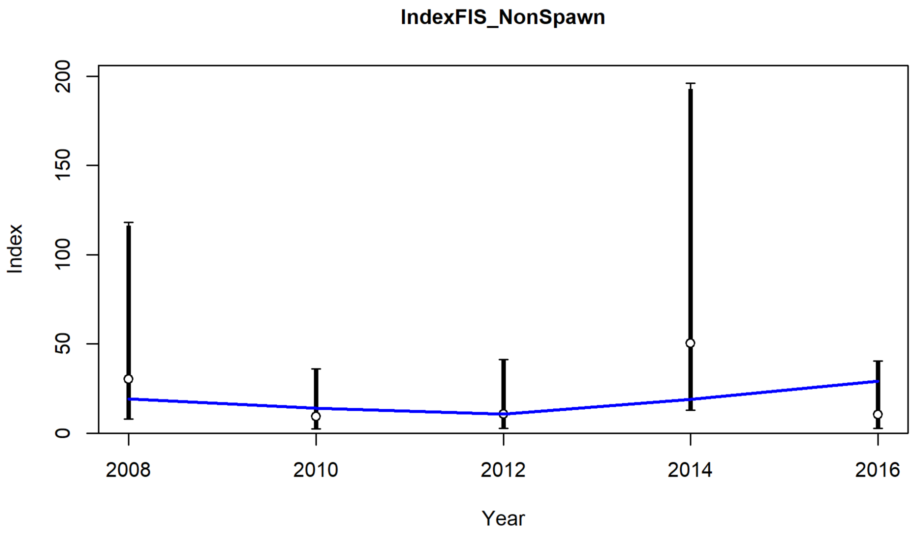

Figure 5.11. Fits to the FIS winter non-spawning survey for the 2021 preliminary base case assessment

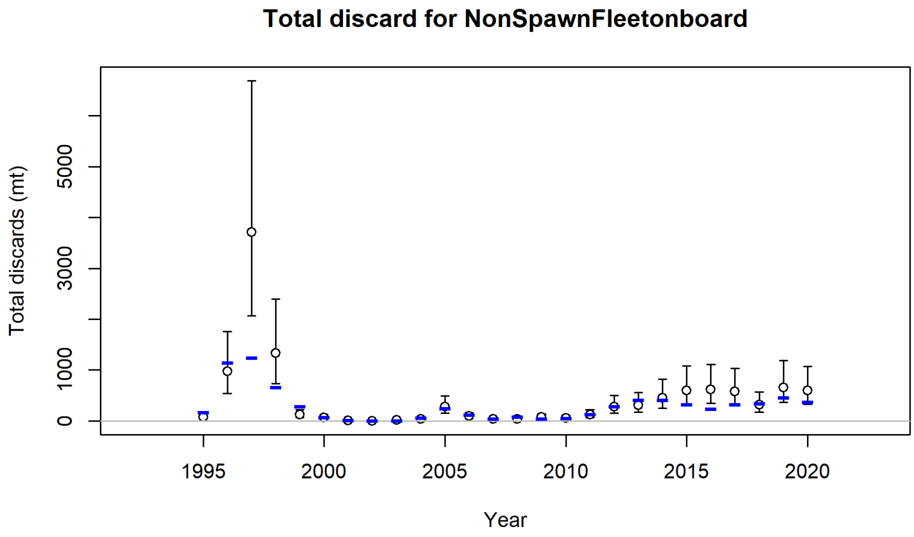

Figure 5.12. Fits to the non-spawning fishery discards for the 2021 preliminary base case assessment

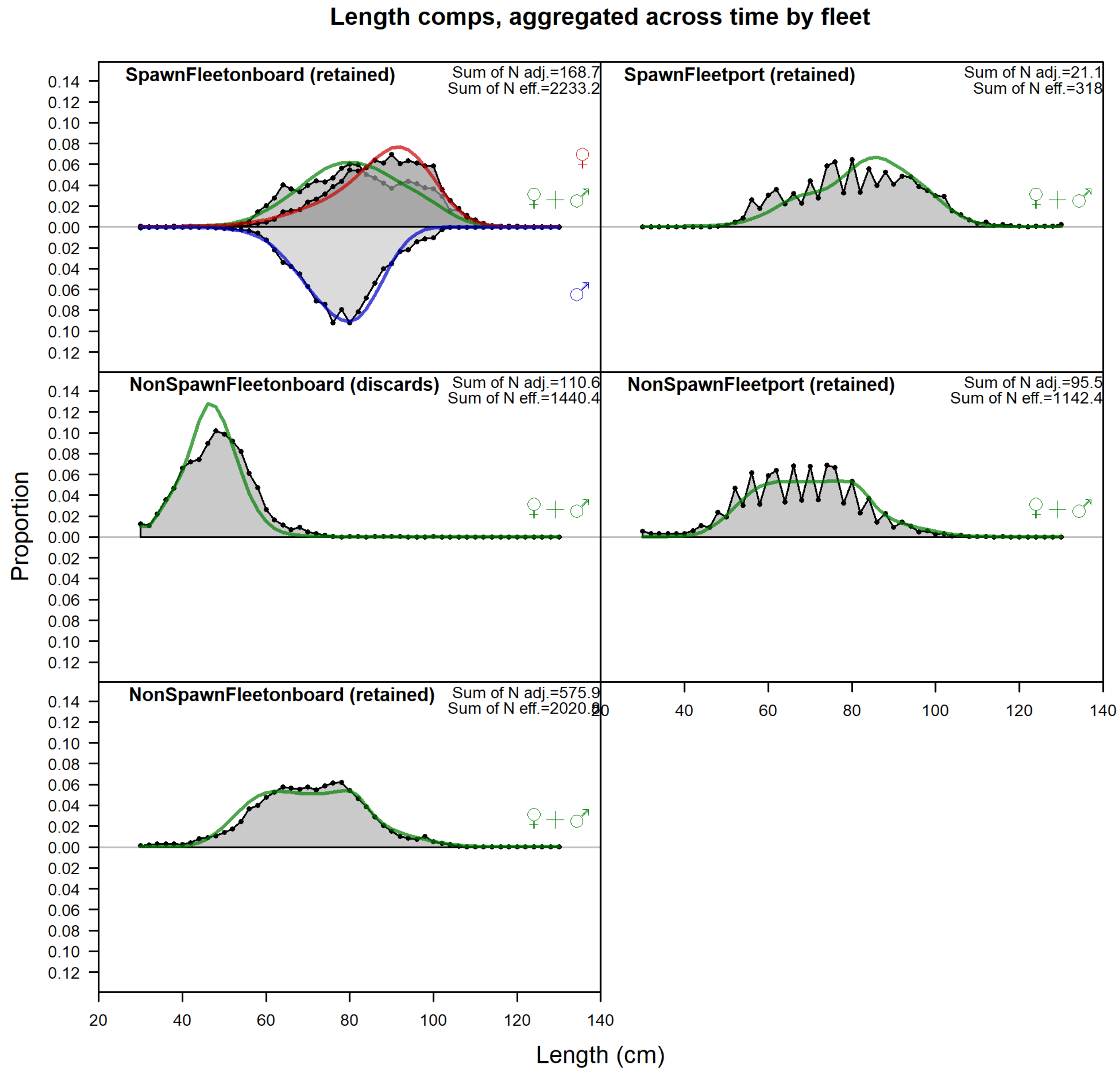

Figure 5.13. Fits to the aggregated length data for the 2021 preliminary base case assessment

5.7 Acknowledgements

Age data were provided by Kyne Krusic-Golub (Fish Ageing Services), ISMP and AFMA logbook and CDR data were provided by John Garvey (AFMA). Mike Fuller, Paul Burch, Robin Thomson, Roy Deng, Franzis Althaus, Toni Cannard and Caroline Sutton (CSIRO) pre-processed the data. Miriana Sporcic provided standardised CPUE. Malcolm Haddon provided useful code for auto-balancing, Athol Whitten provided useful R code for organising plots. Paul Burch provided an updated ageing error matrix. Jemery Day, Andre Punt, Robin Thomson and Paul Burch (CSIRO) provided valuable review and discussion of this work. Ian Taylor, Chantel Wetzel, Kathryn Doering and Kelli Johnson (NOAA) are thanked for helpful reccomendations and fixes in relation to the the r4ss package. The r4ss package maintained by Ian Taylor (https://github.com/r4ss/r4ss) was critical for producing multiple diagnostic plots, and tuning models.

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5.9 Appendix

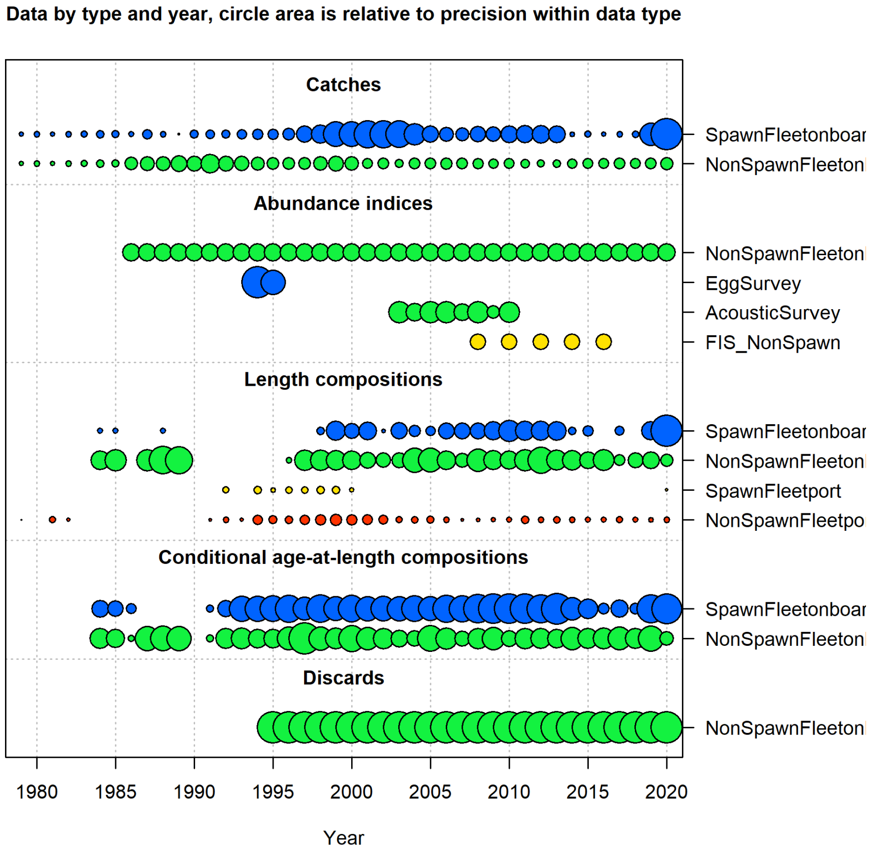


Figure 5.14. Summary of Blue Grenadier data sources

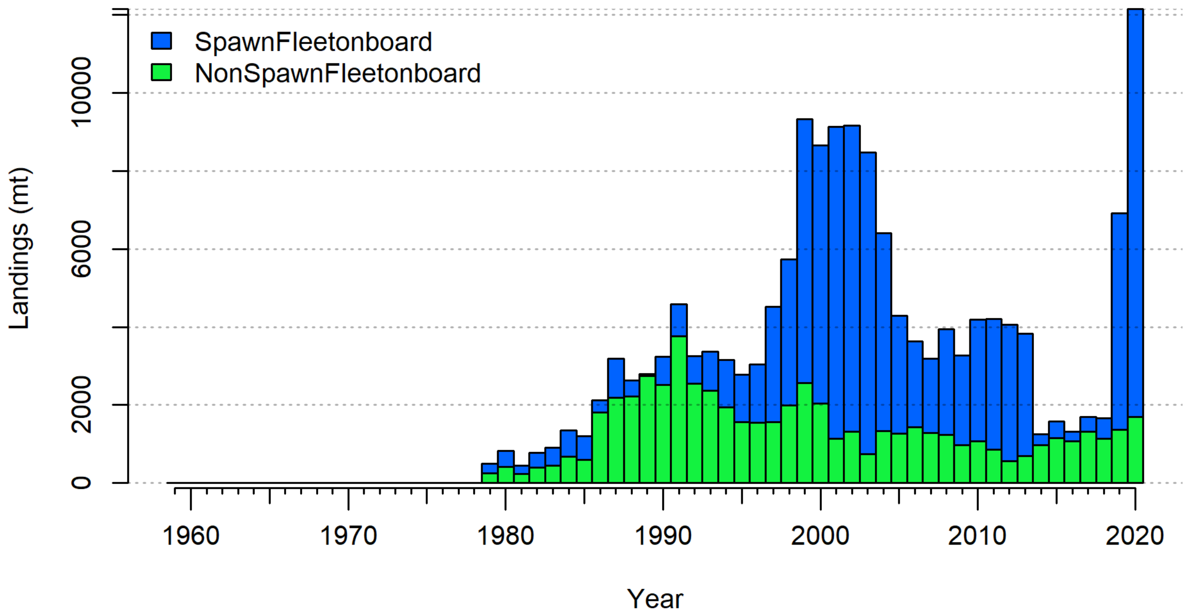


Figure 5.15. Summary of catch by fleet

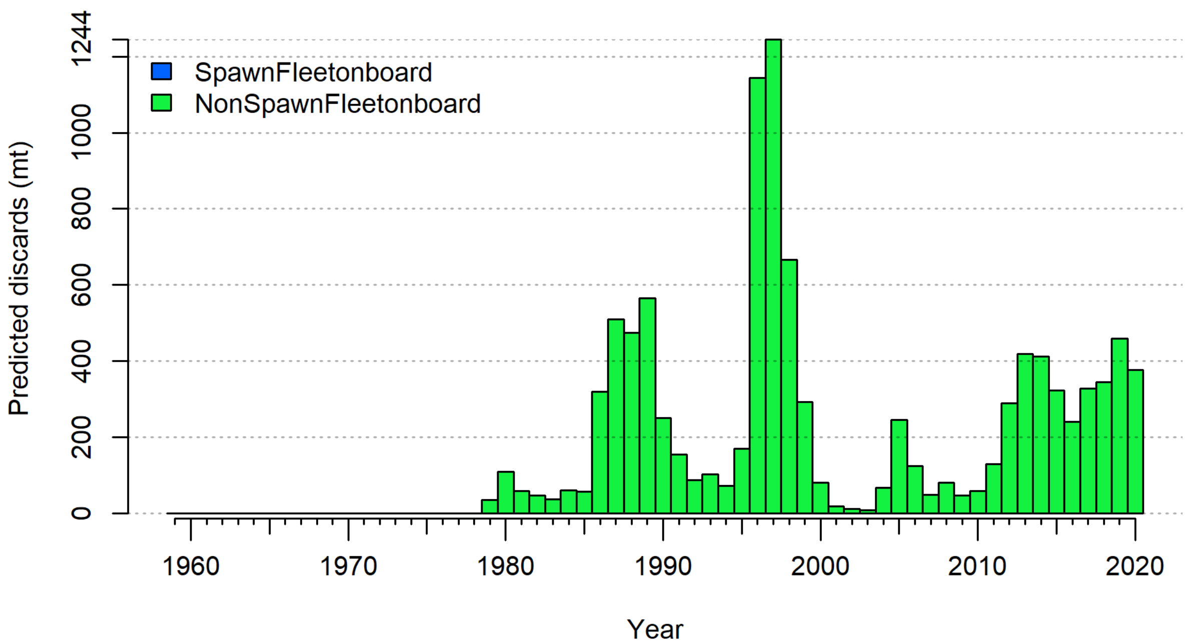


Figure 5.16. Summary of total discards by fleet

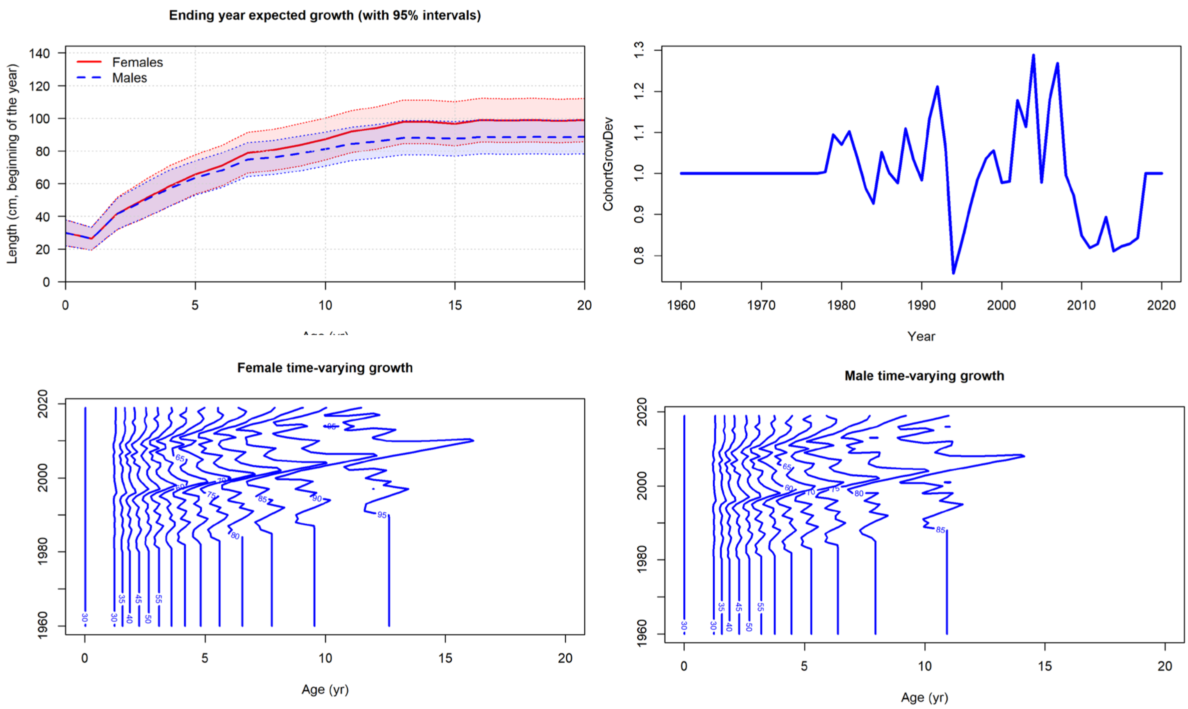


Figure 5.17. Estimated growth for Blue Grenadier

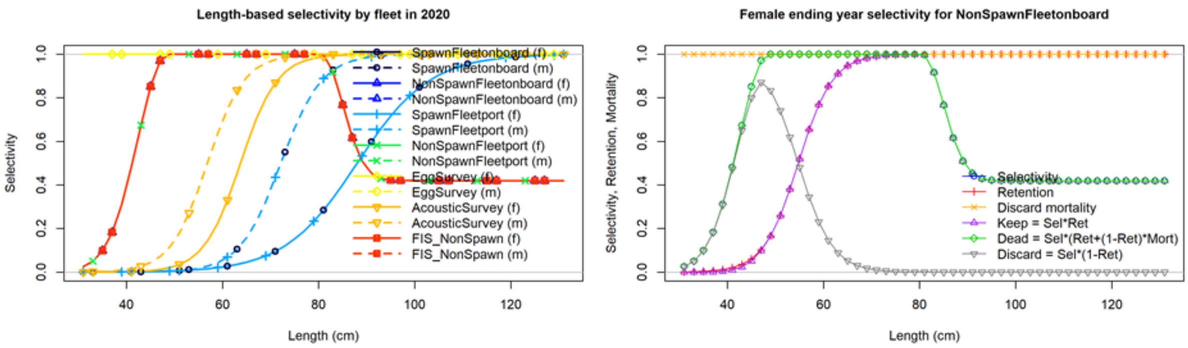


Figure 5.18. Estimated selectivity and retention by fleet for the base case

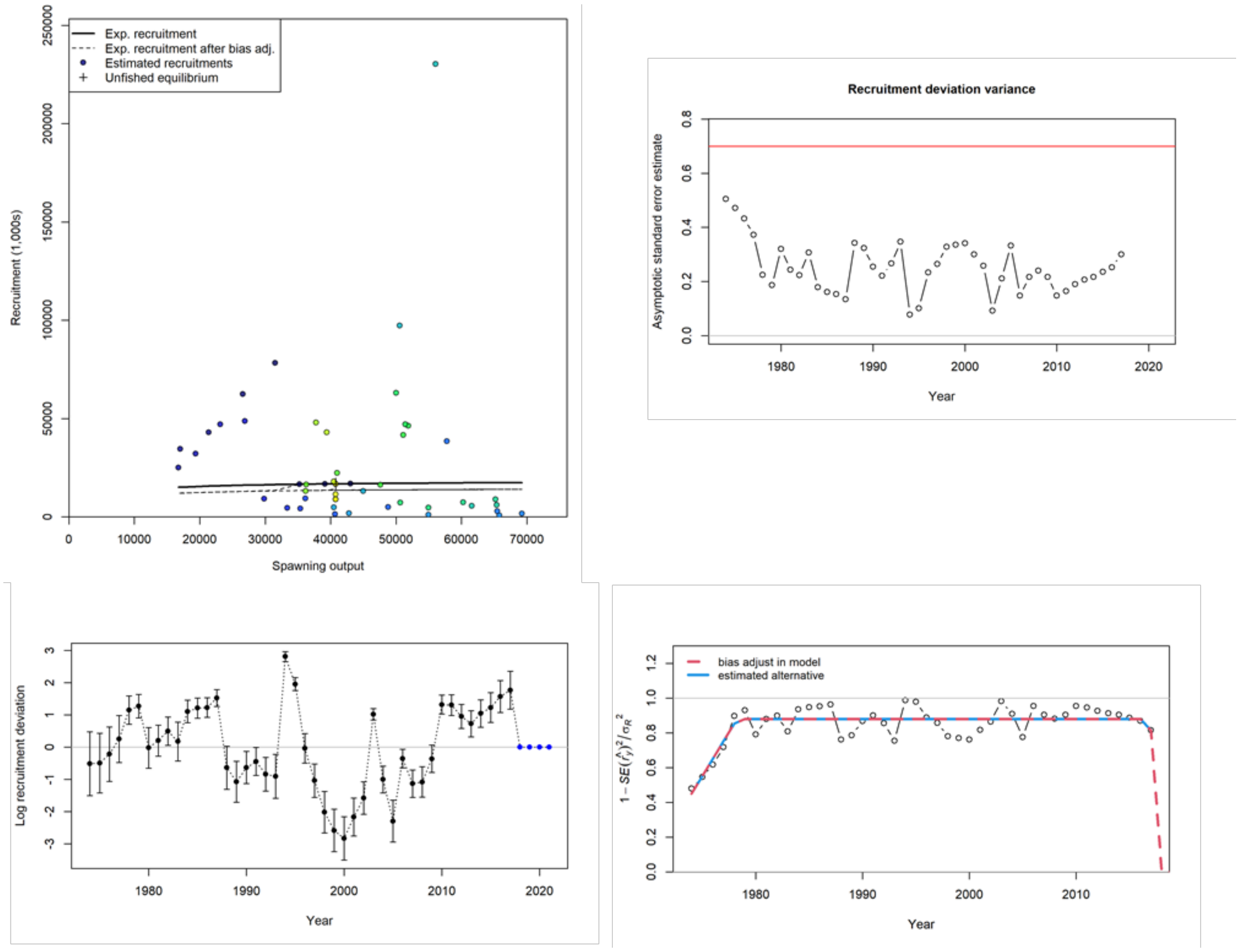


Figure 5.19. Time series showing the stock recruitment curve, recruitment deviations and recruitment deviation variance check for blue grenadier.

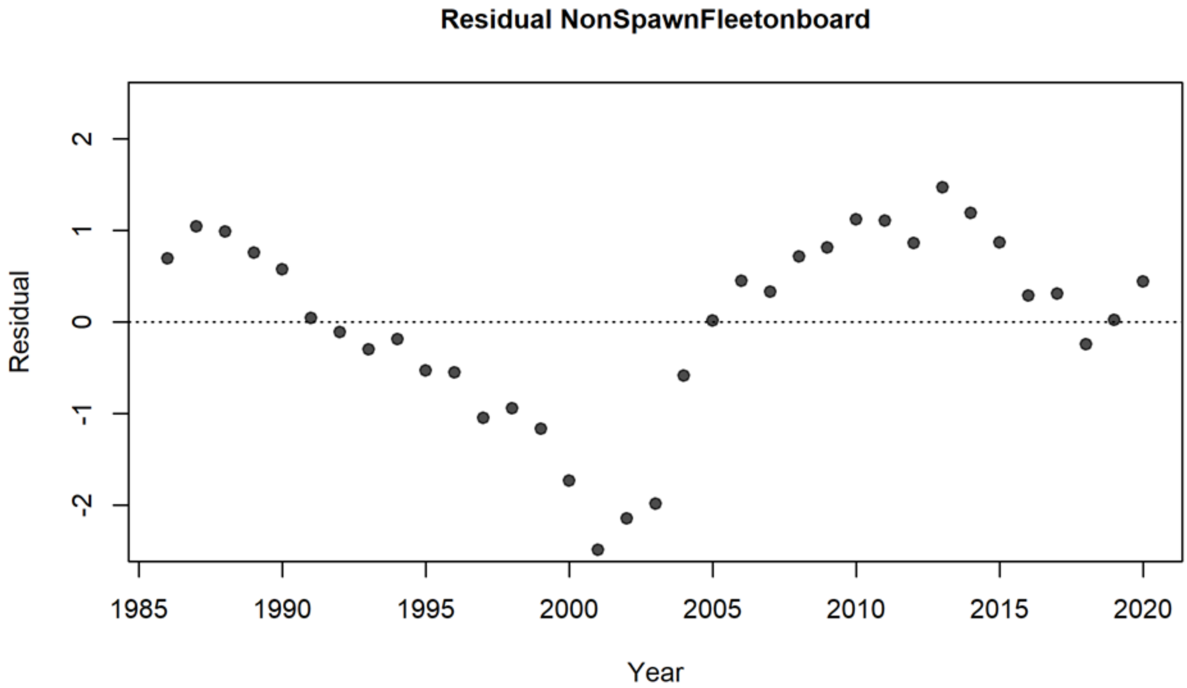


Figure 5.20. Residuals for fits to CPUE.

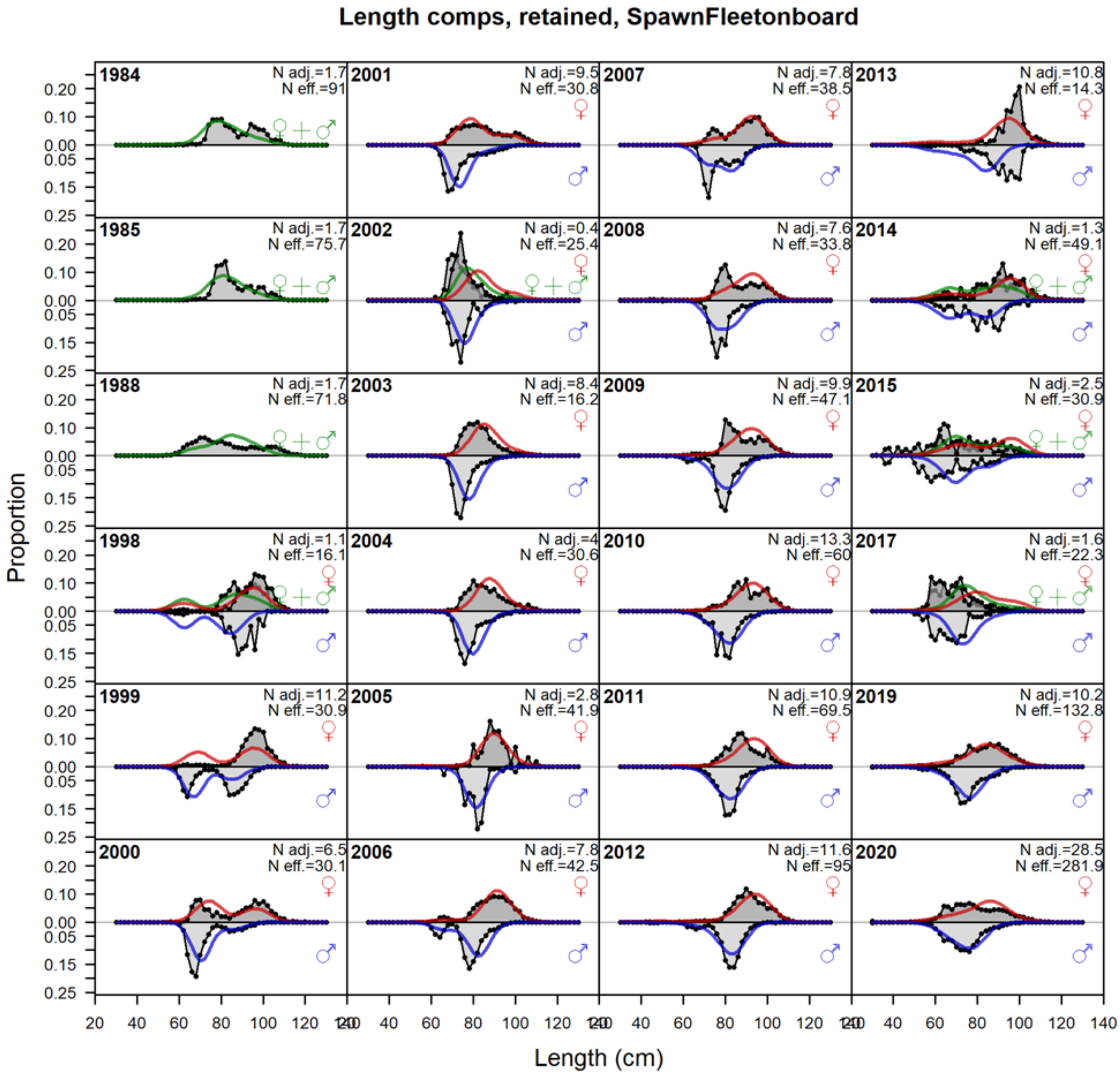


Figure 5.21. Length composition fits: onboard spawning fleet retained.

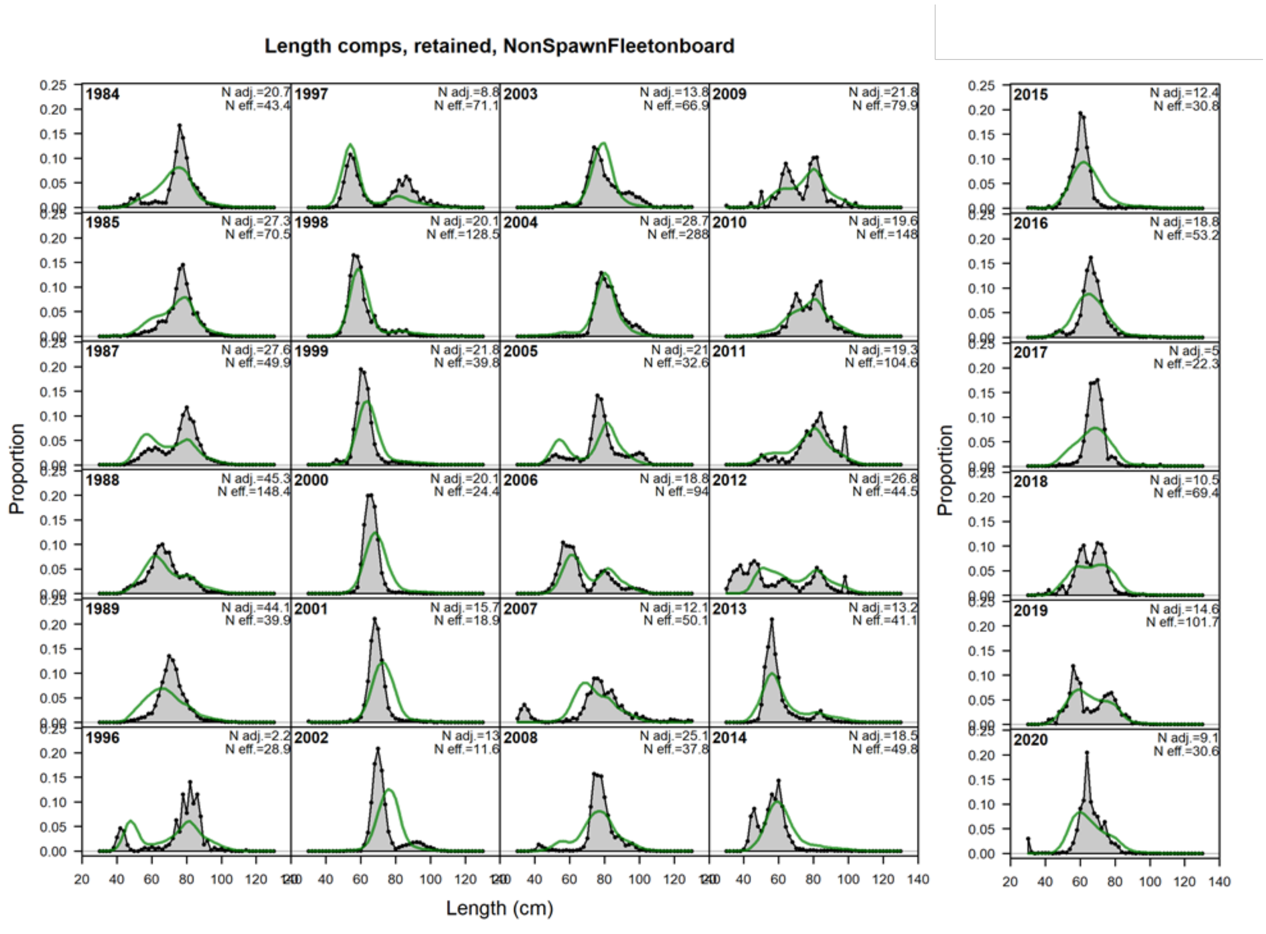


Figure 5.22. Length composition fits: onboard non-spawning fleet retained.

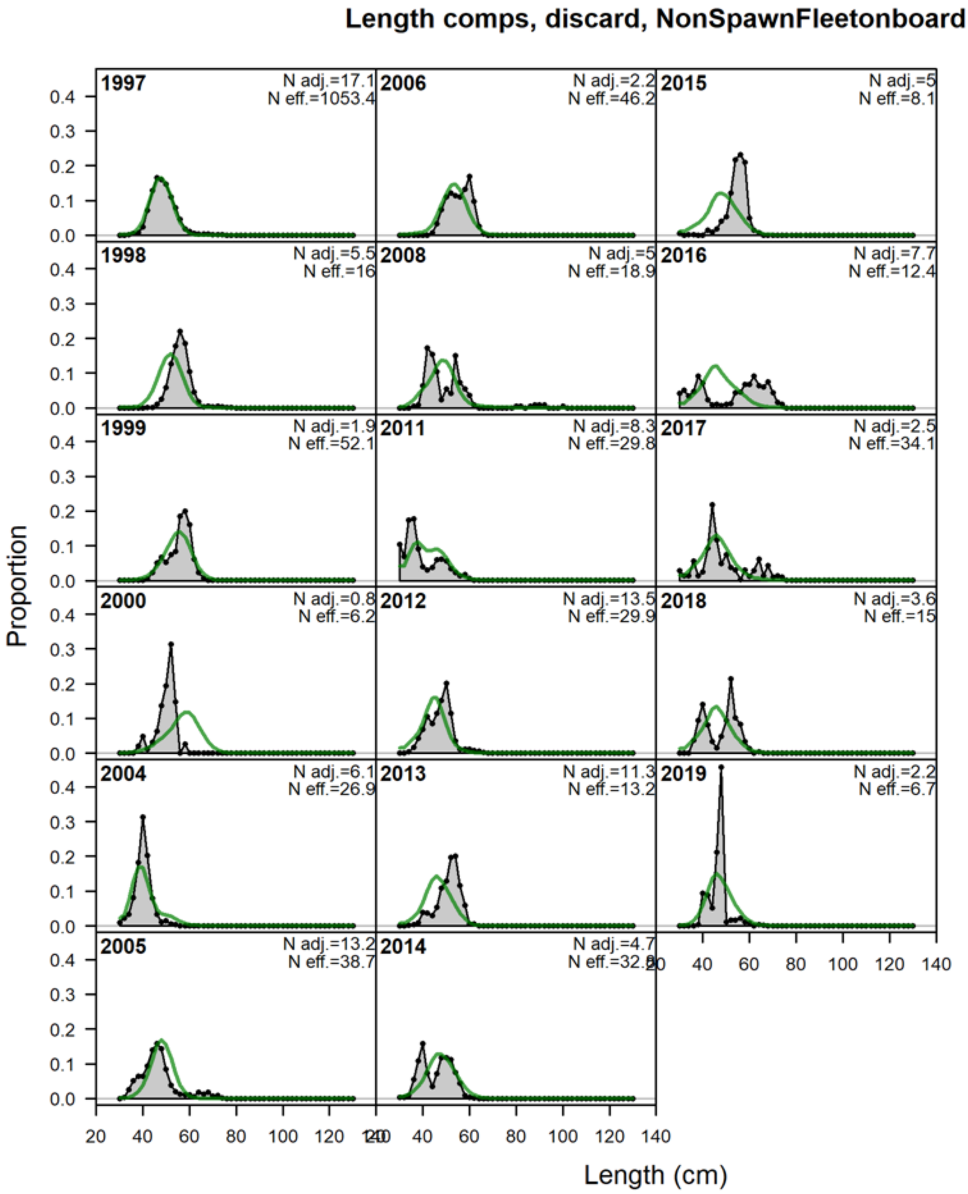


Figure 5.23. Length composition fits: onboard non-spawning fleet discard.

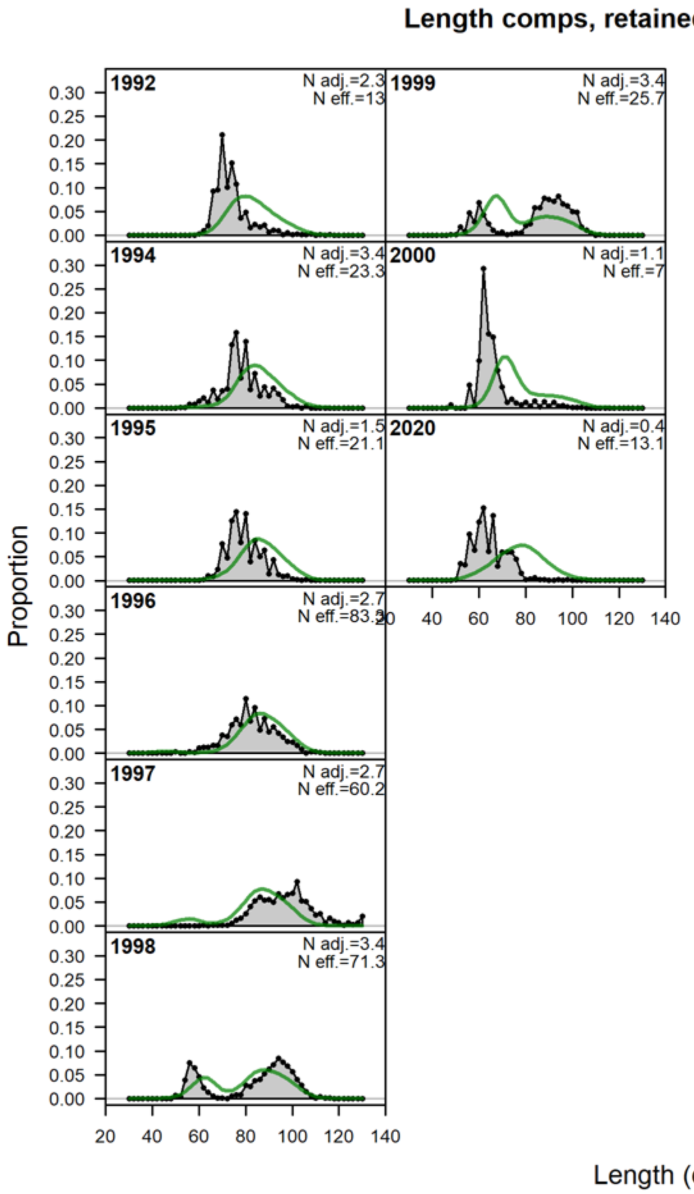


Figure 5.24. Length composition fits: port spawning fleet retained.

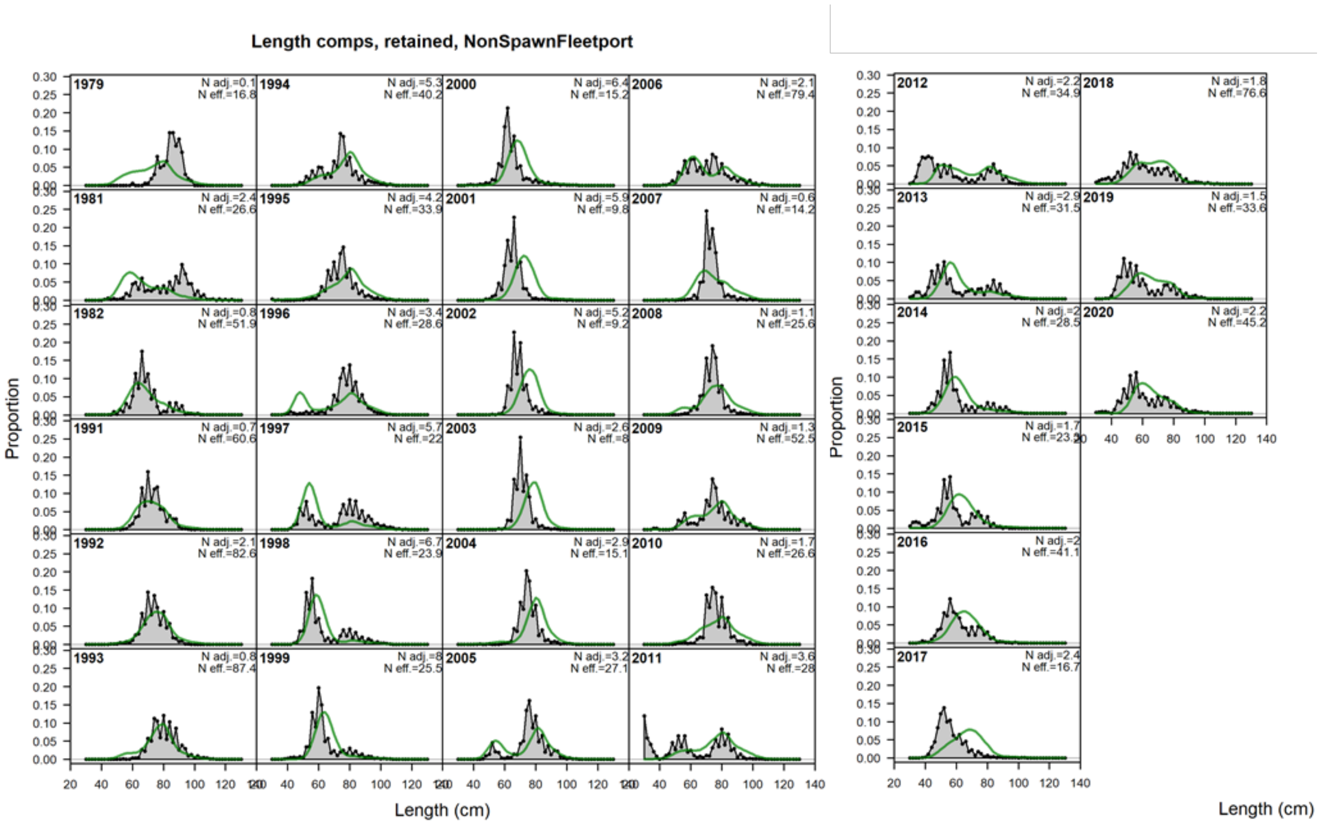


Figure 5.25. Length composition fits: port non-spawning fleet retained.

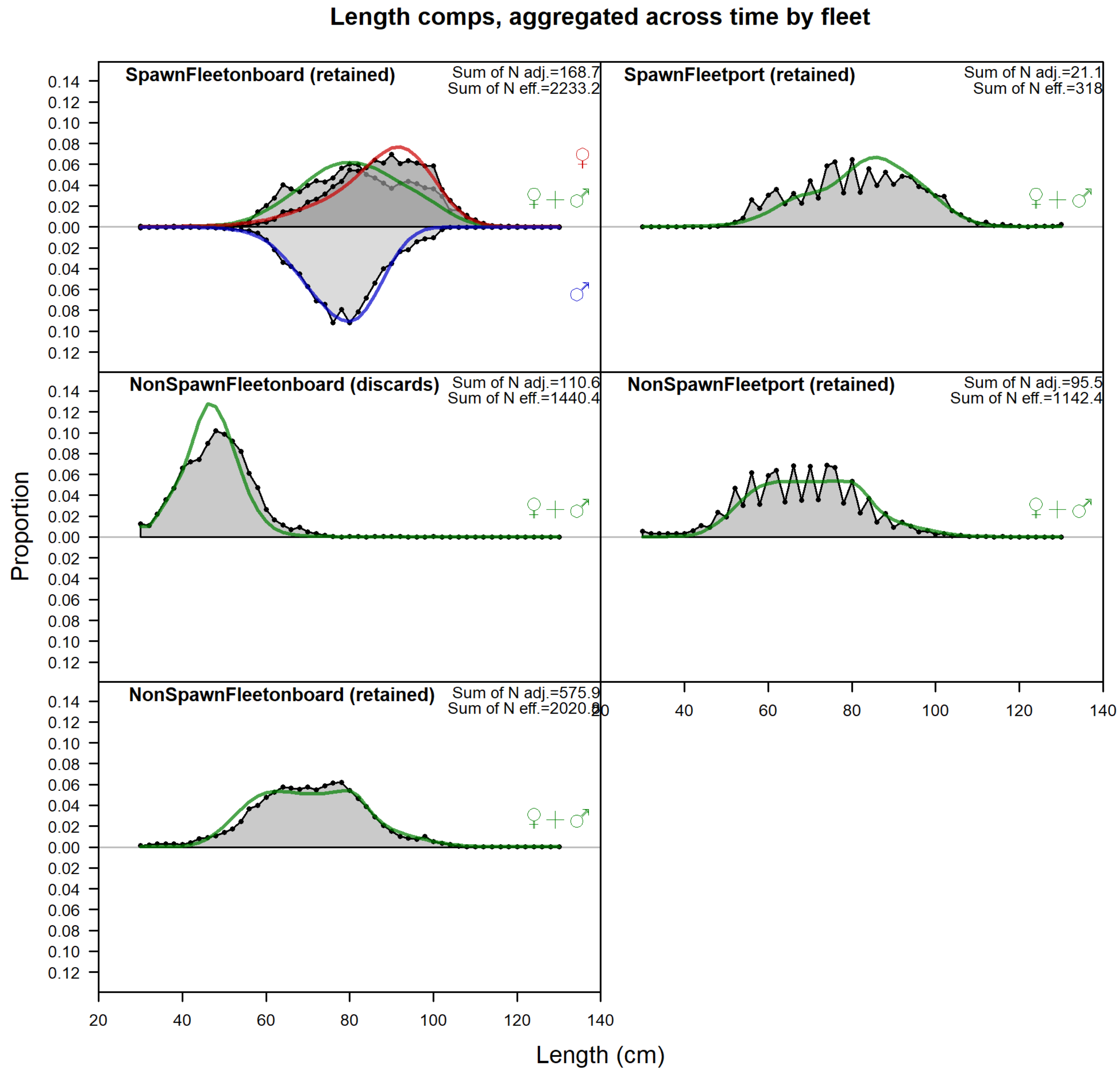
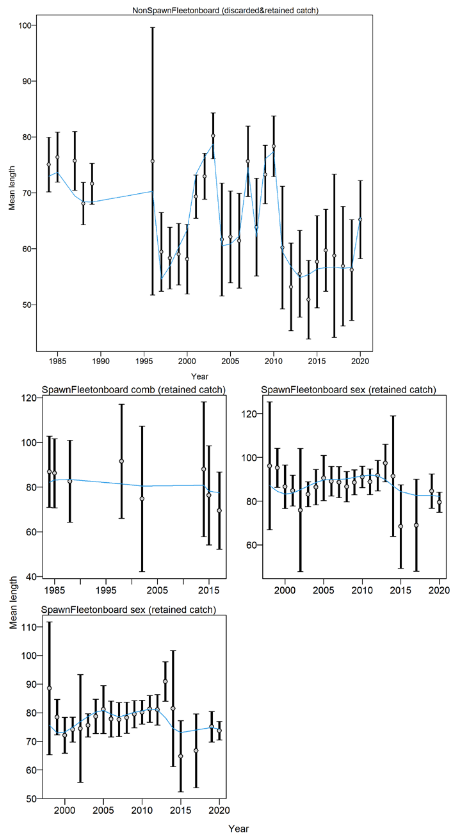


Figure 5.26. Length composition fits aggregated across years.



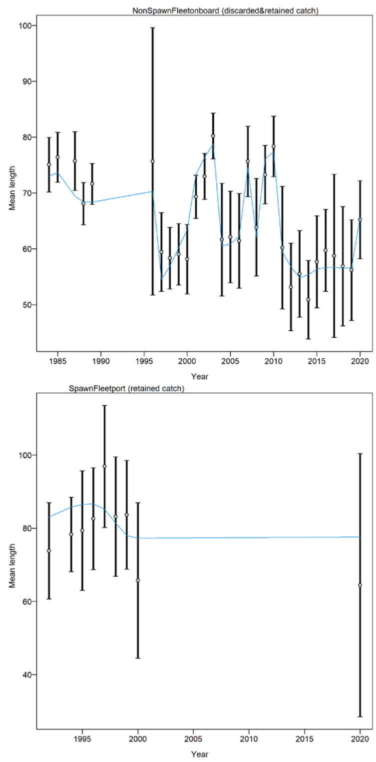


Figure 5.27. Length composition fit diagnostics from tuning. Francis data weighting method TA1.8: thinner intervals (with capped ends) show result of further adjusting sample sizes based on suggested multiplier (with 95% interval) for length data.

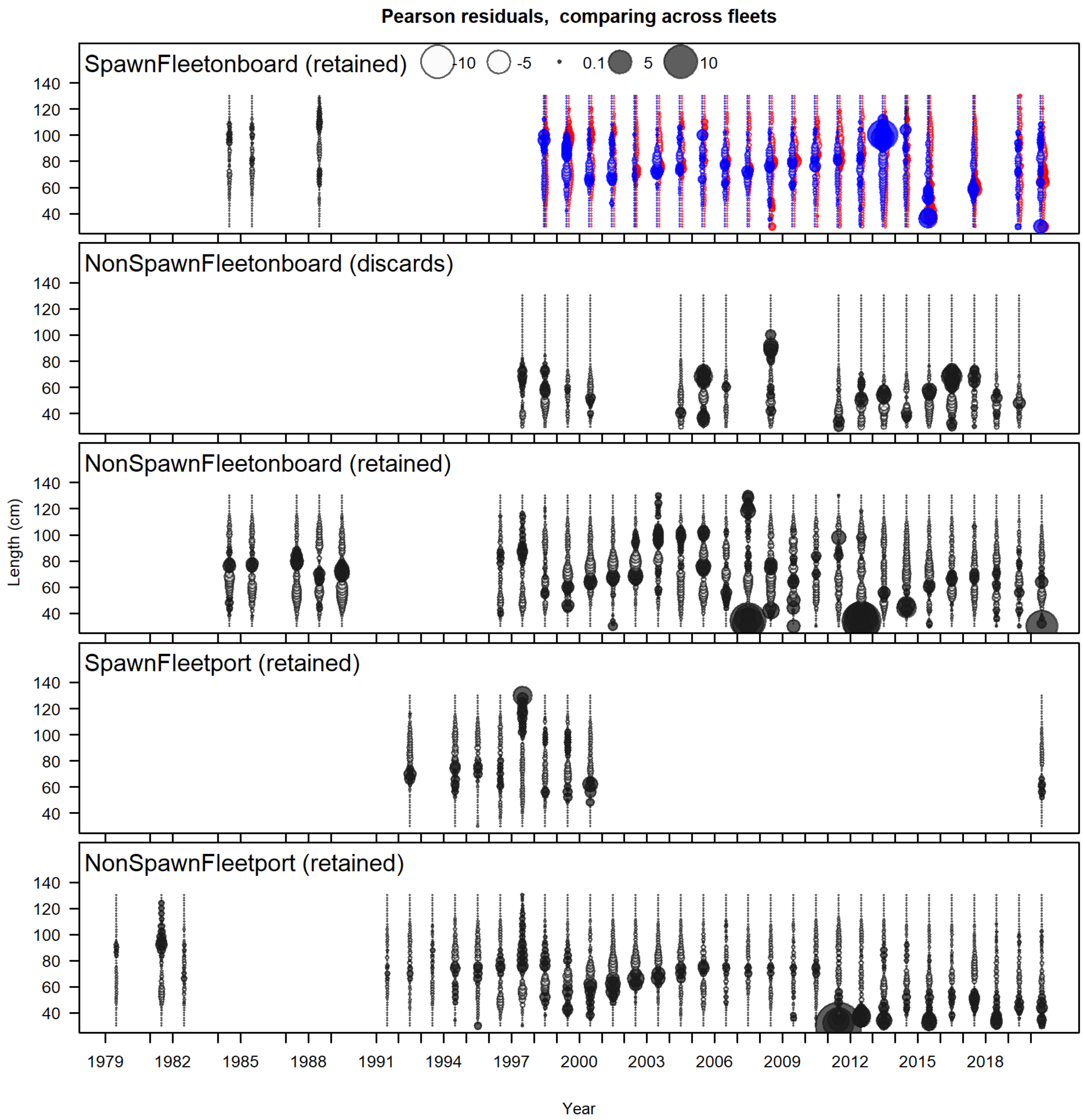
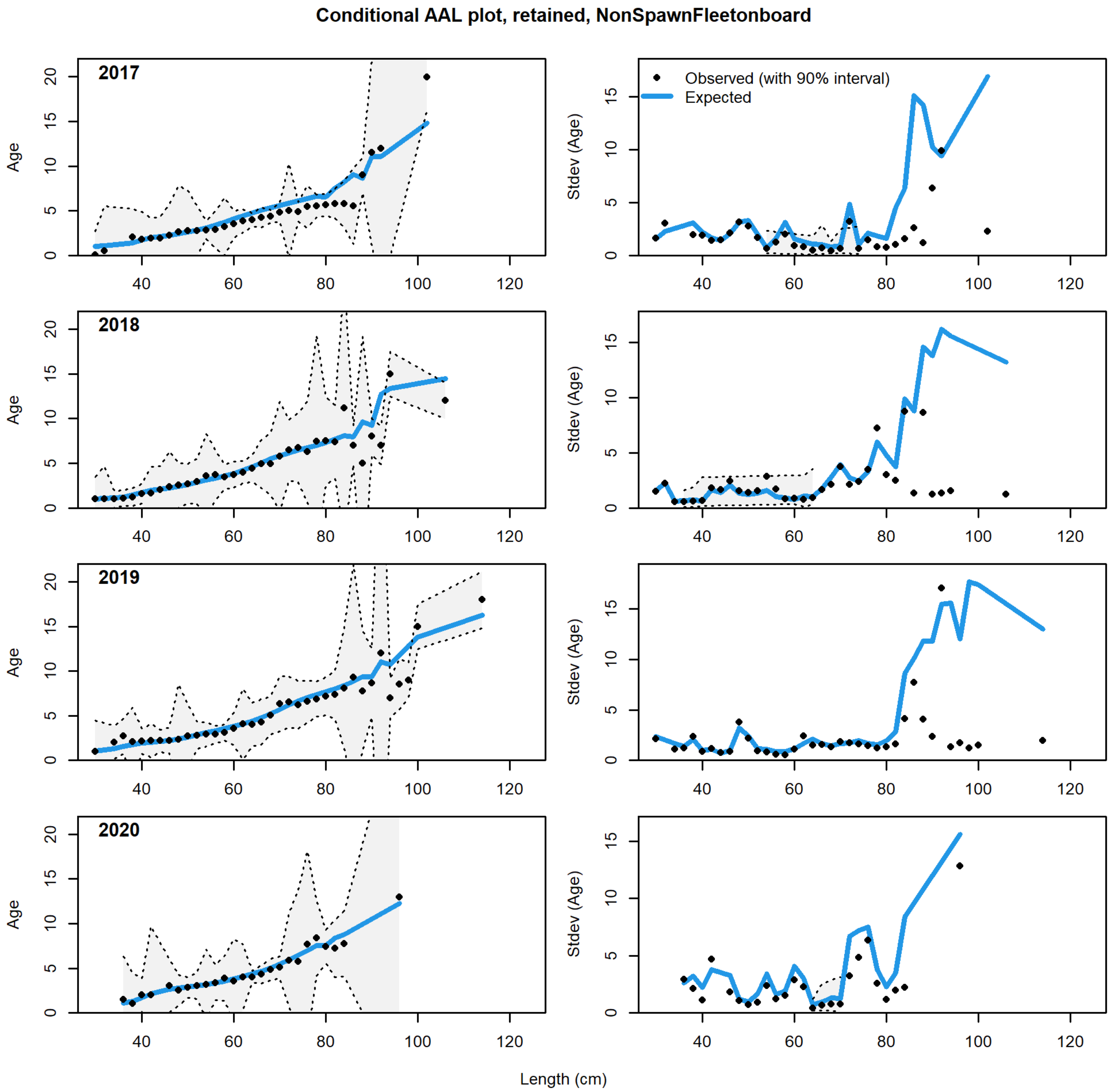
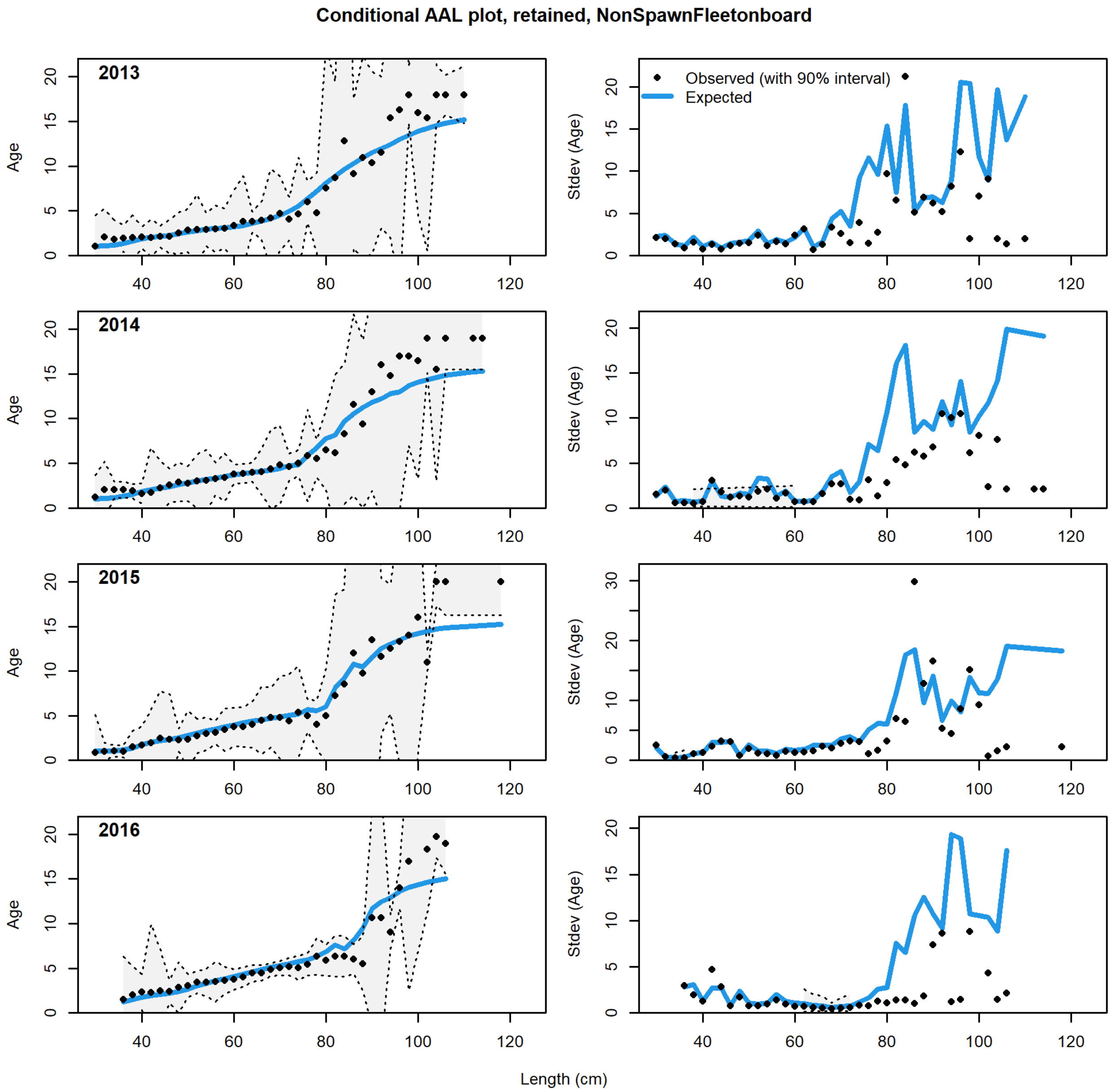
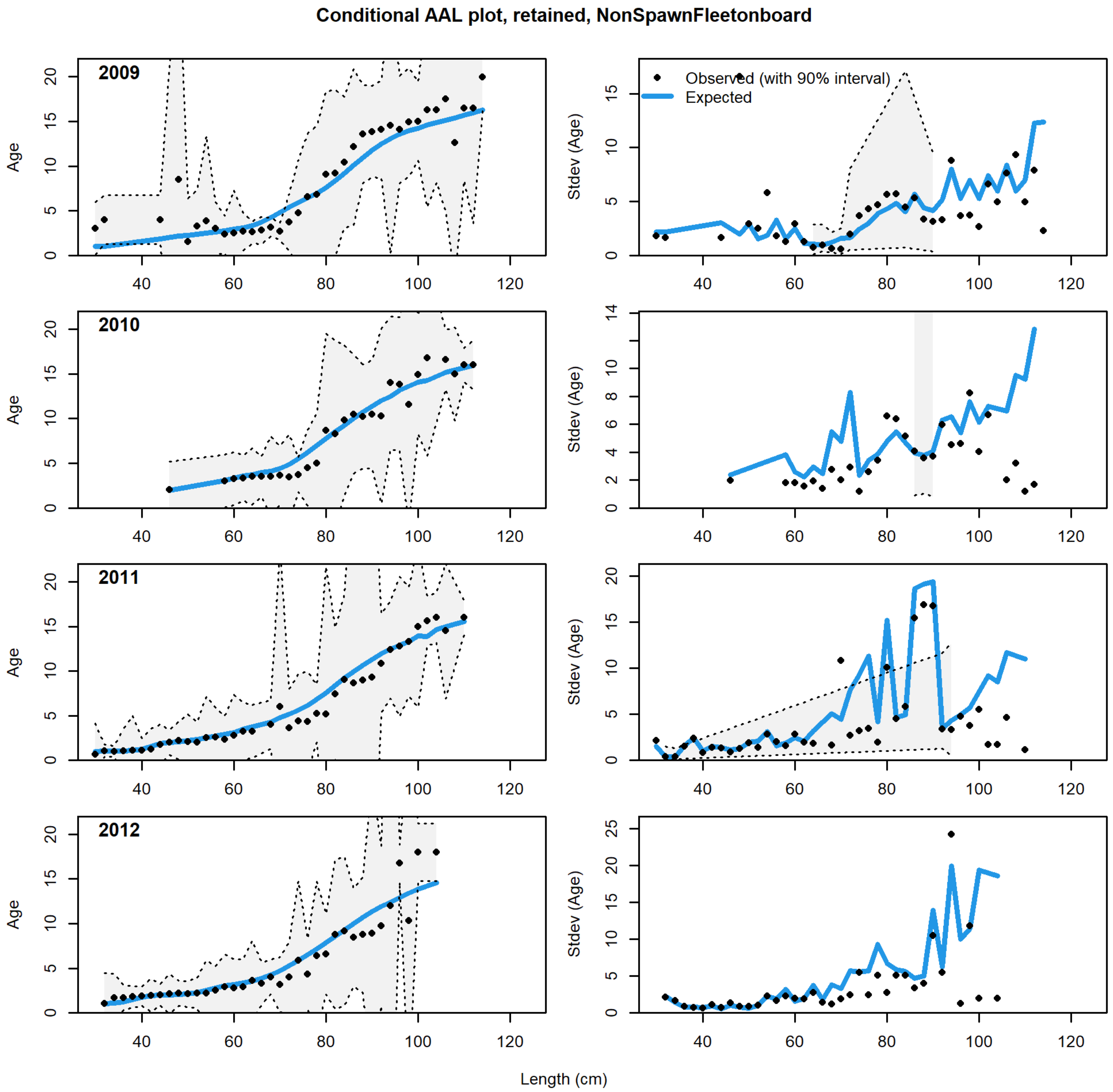
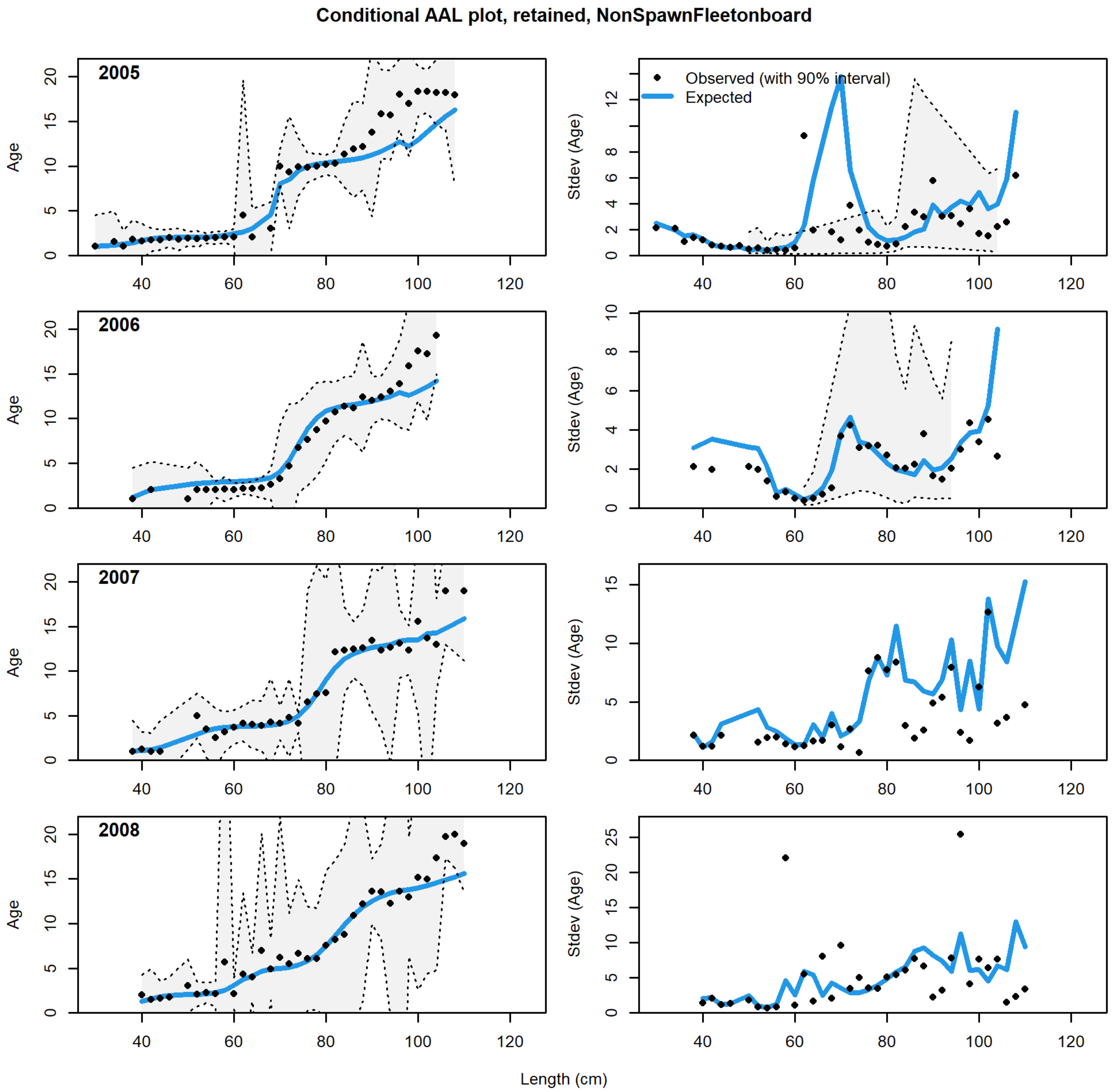


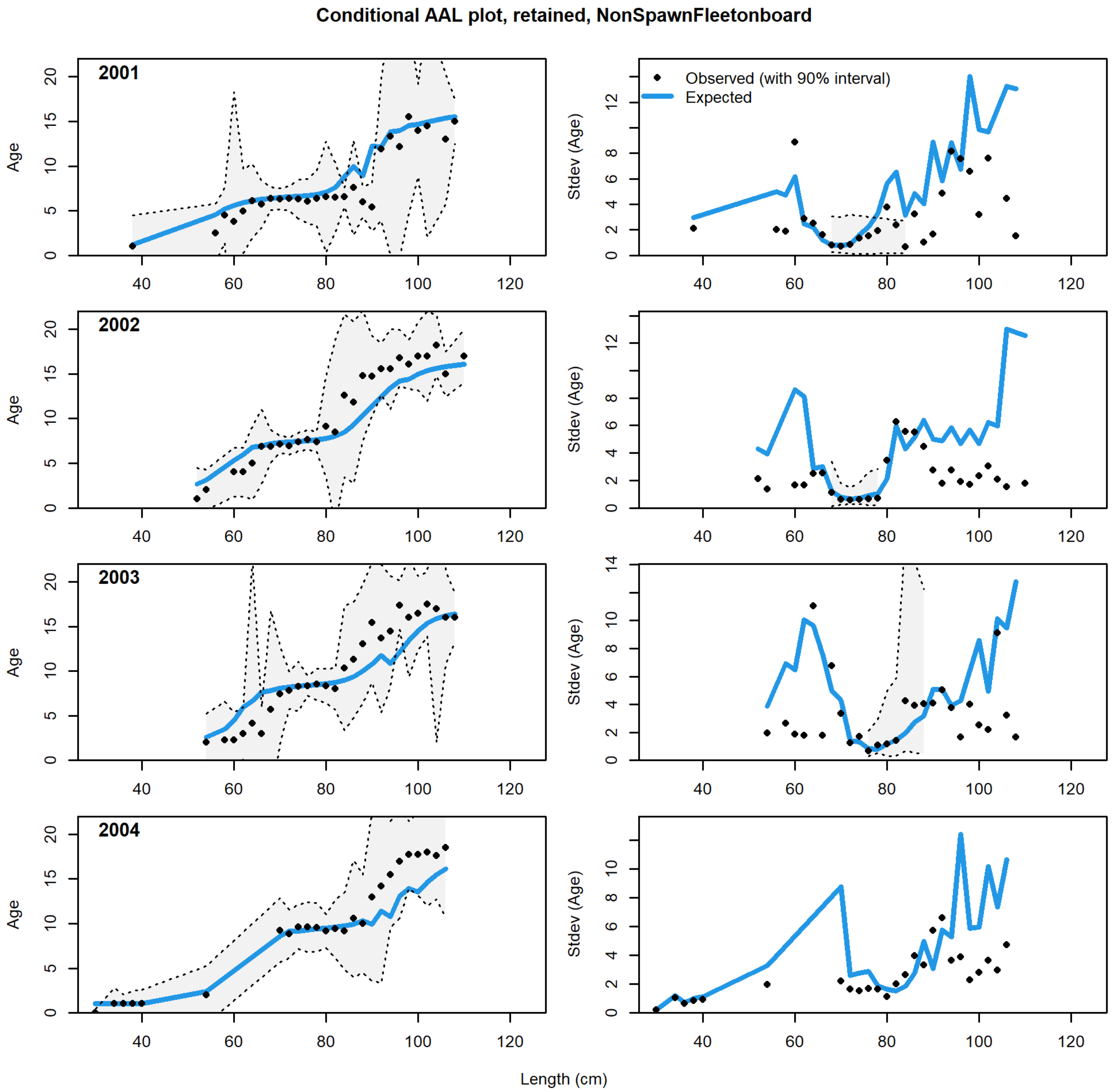
Figure 5.28. Residuals from the annual length compositions for base case.

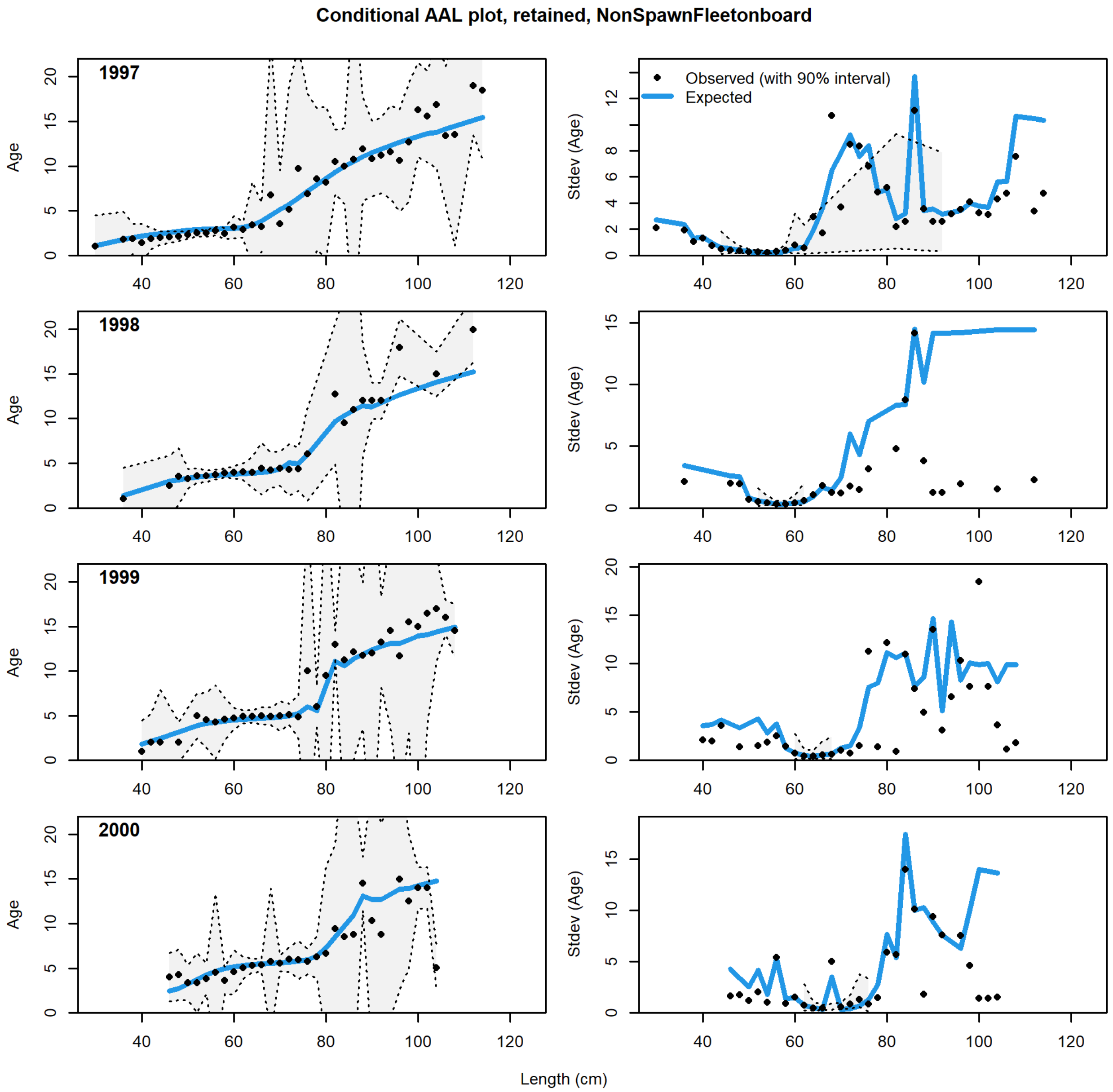

Conditional AAL plot, retained, NonSpawnFleetonboard
2017
2018
2019
2020
Age
Stdev (Age)
Observed (with 90% interval)
Expected
Length (cm)


Conditional AAL plot, retained, NonSpawnFleetonboard
2013
2014
2015
2016
Age
Stdev (Age)
Observed (with 90% interval)
Expected
Length (cm)

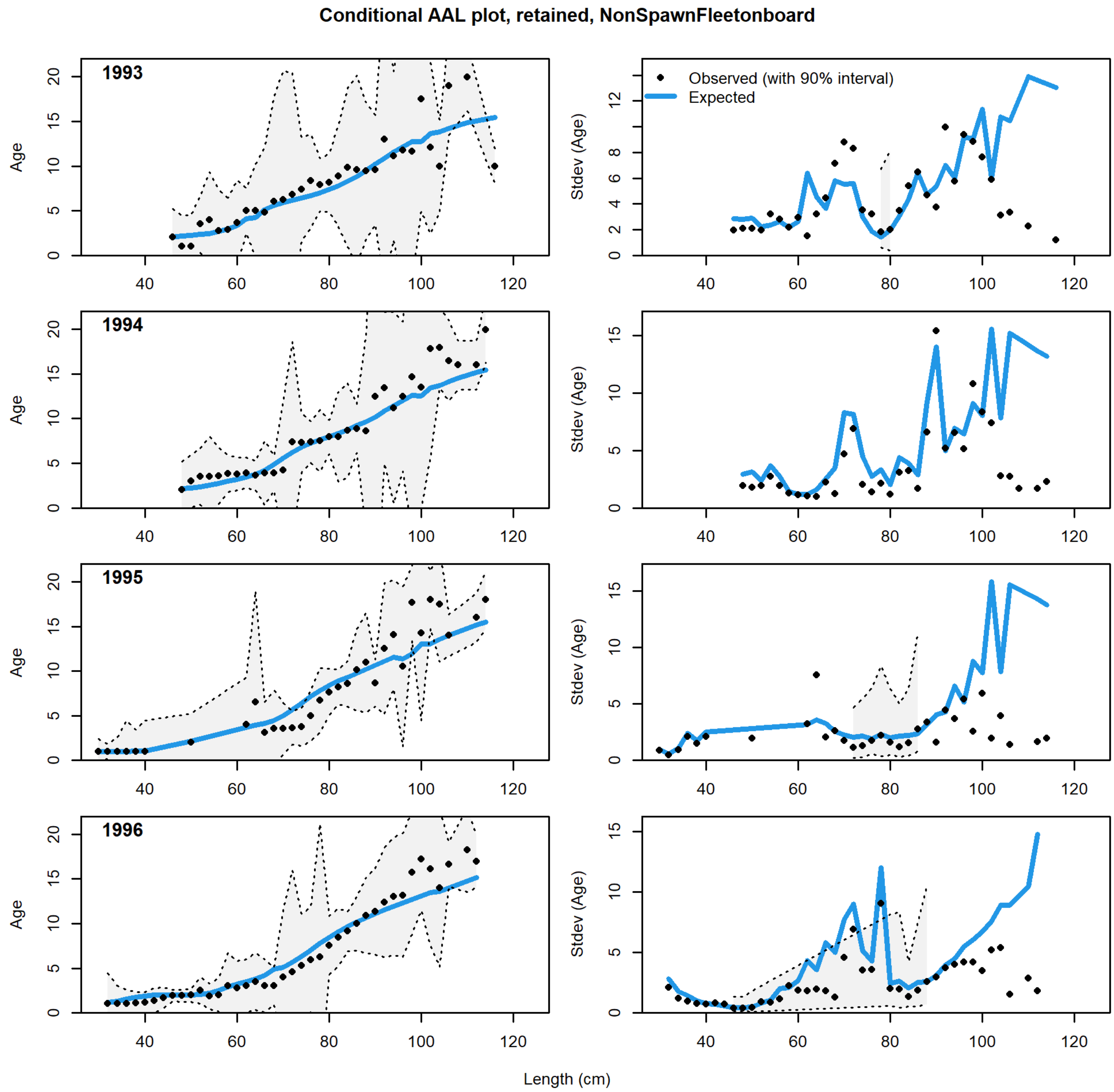

Conditional AAL plot, retained, NonSpawnFleetonboard
2009
2010
2011
2012
Age
Stdev (Age)
Observed (with 90% interval)
Expected
Length (cm)

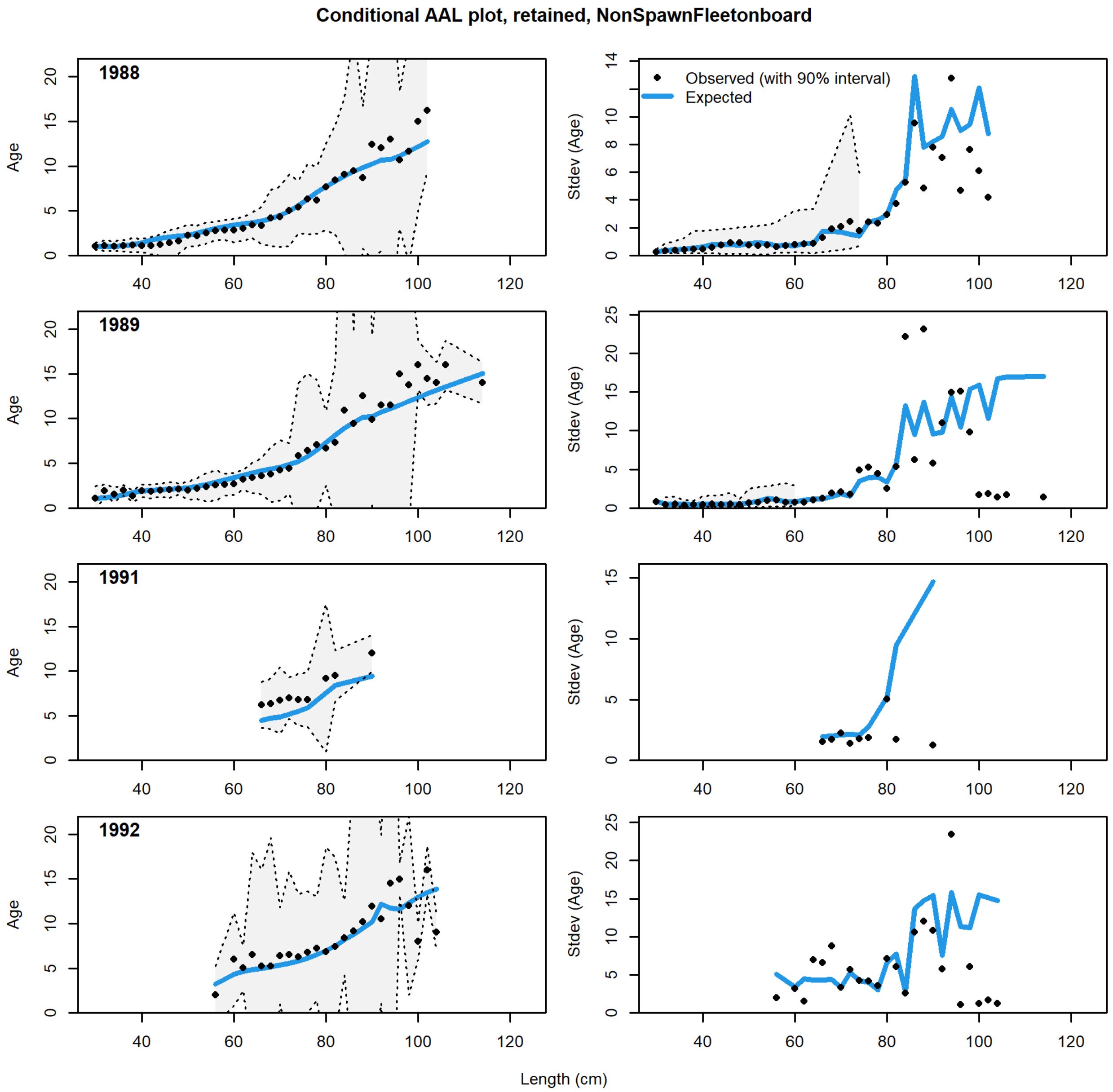

Conditional AAL plot, retained, NonSpawnFleetonboard
2005
2006
2007
2008
Age
Stdev (Age)
Observed (with 90% interval)
Expected
Length (cm)


Conditional AAL plot, retained, NonSpawnFleetonboard
2001
2002
2003
2004
Age
Stdev (Age)
Observed (with 90% interval)
Expected
Length (cm)

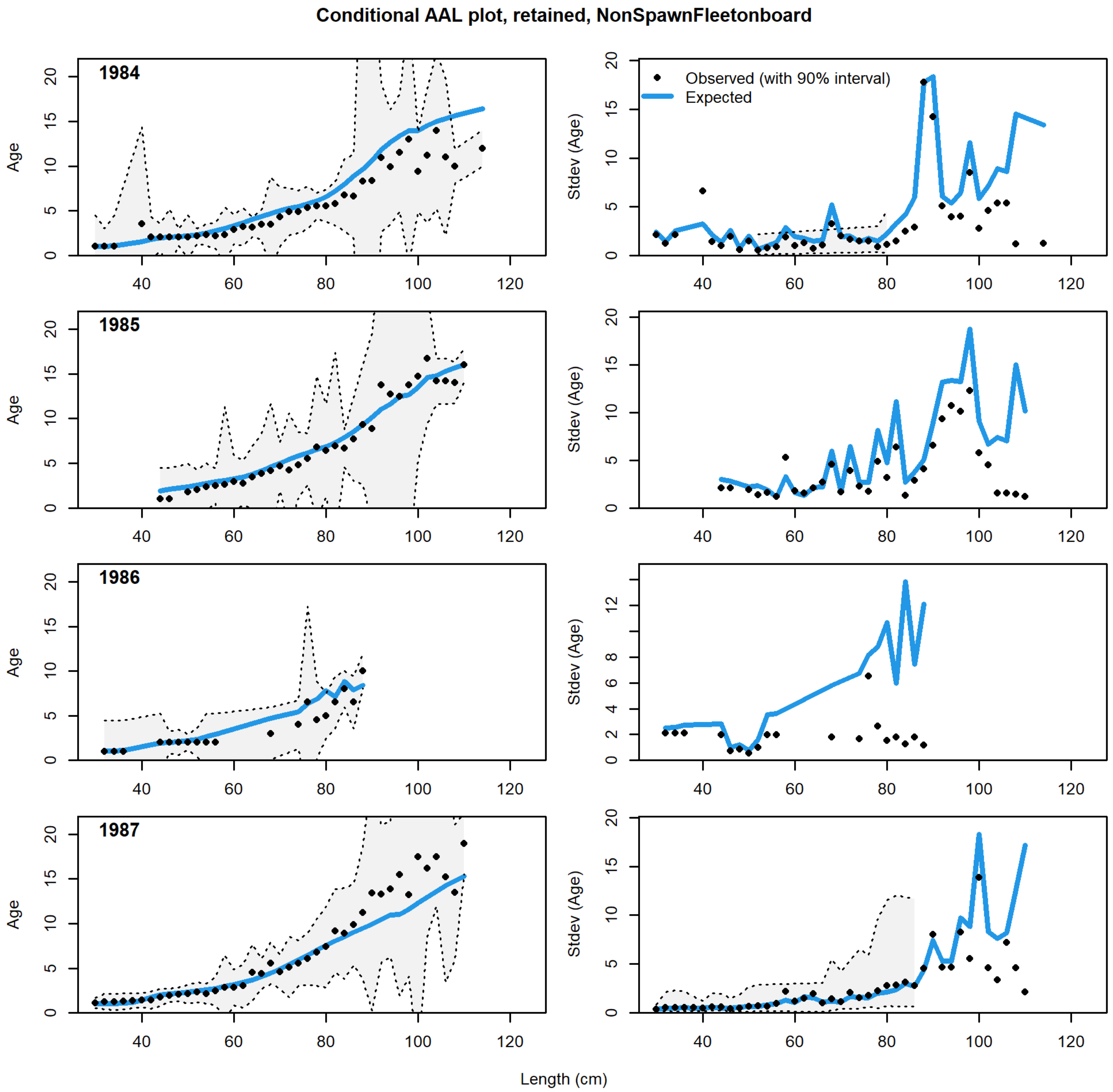


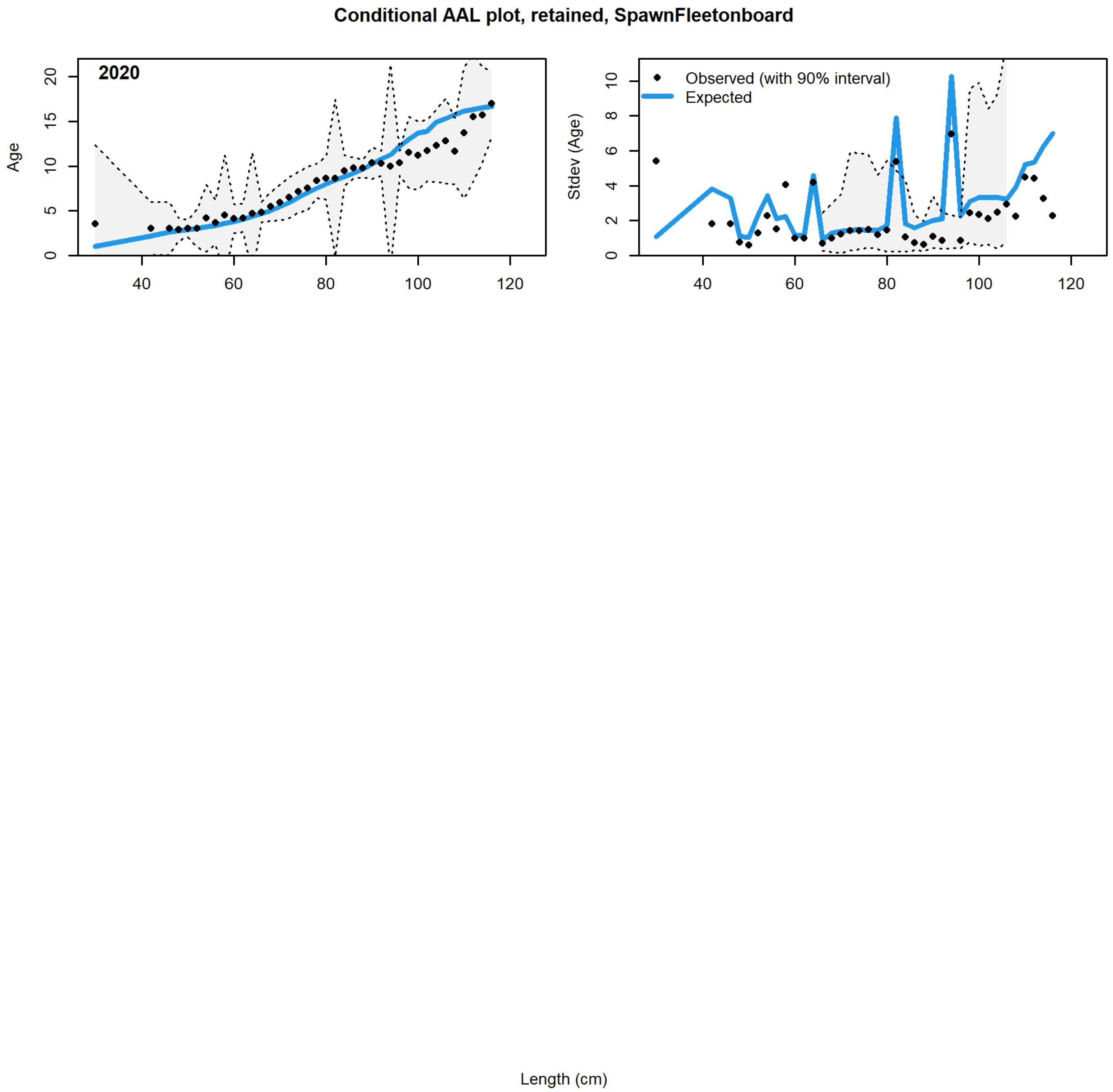
Conditional AAL plot, retained, NonSpawnFleetonboard
1997
1998
1999
2000
Age
Stdev (Age)
Observed (with 90% interval)
Expected
Length (cm)


Conditional AAL plot, retained, NonSpawnFleetonboard
1993
1994
1995
1996
Age
Stdev (Age)
Observed (with 90% interval)
Expected
Length (cm)

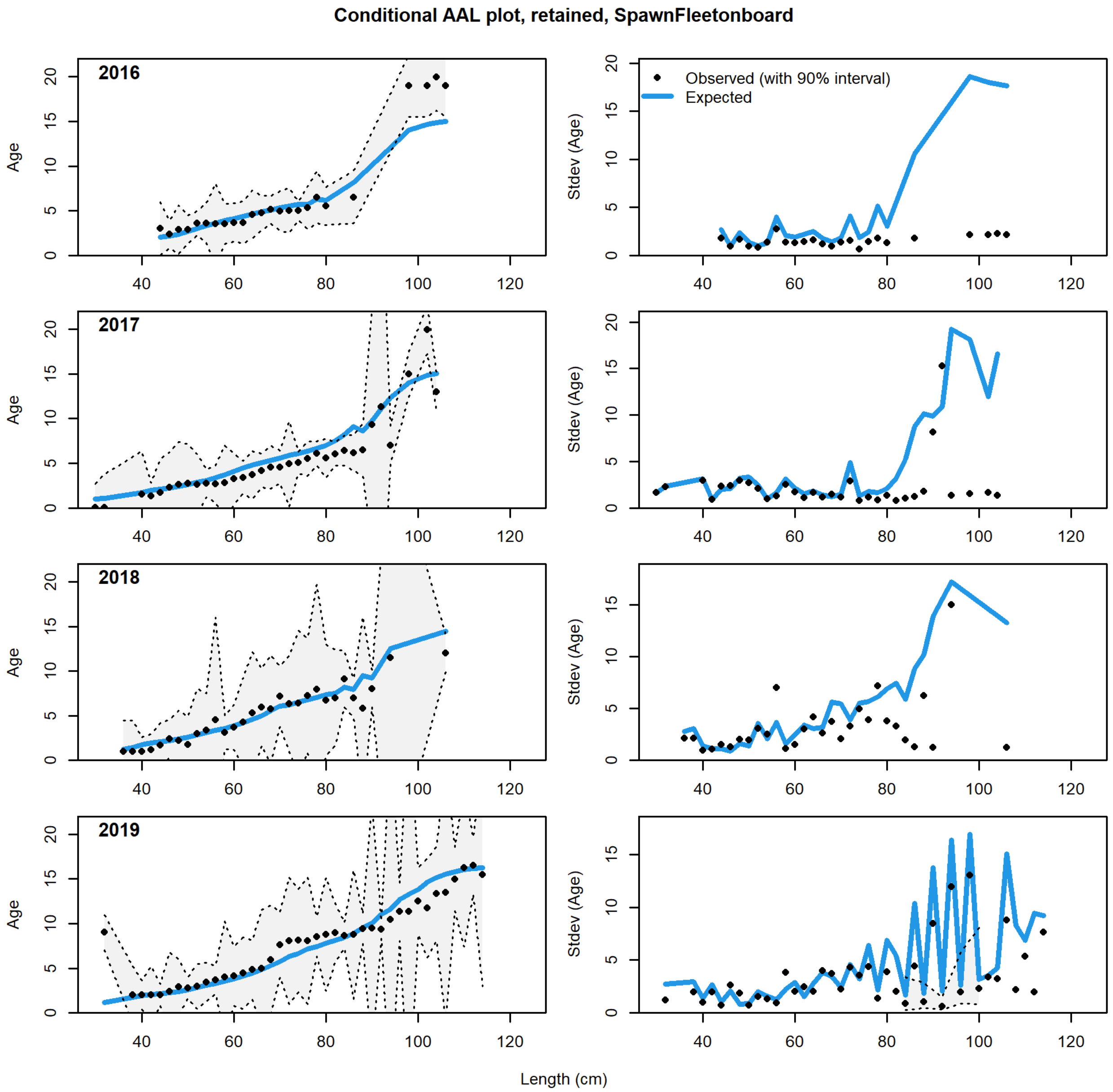


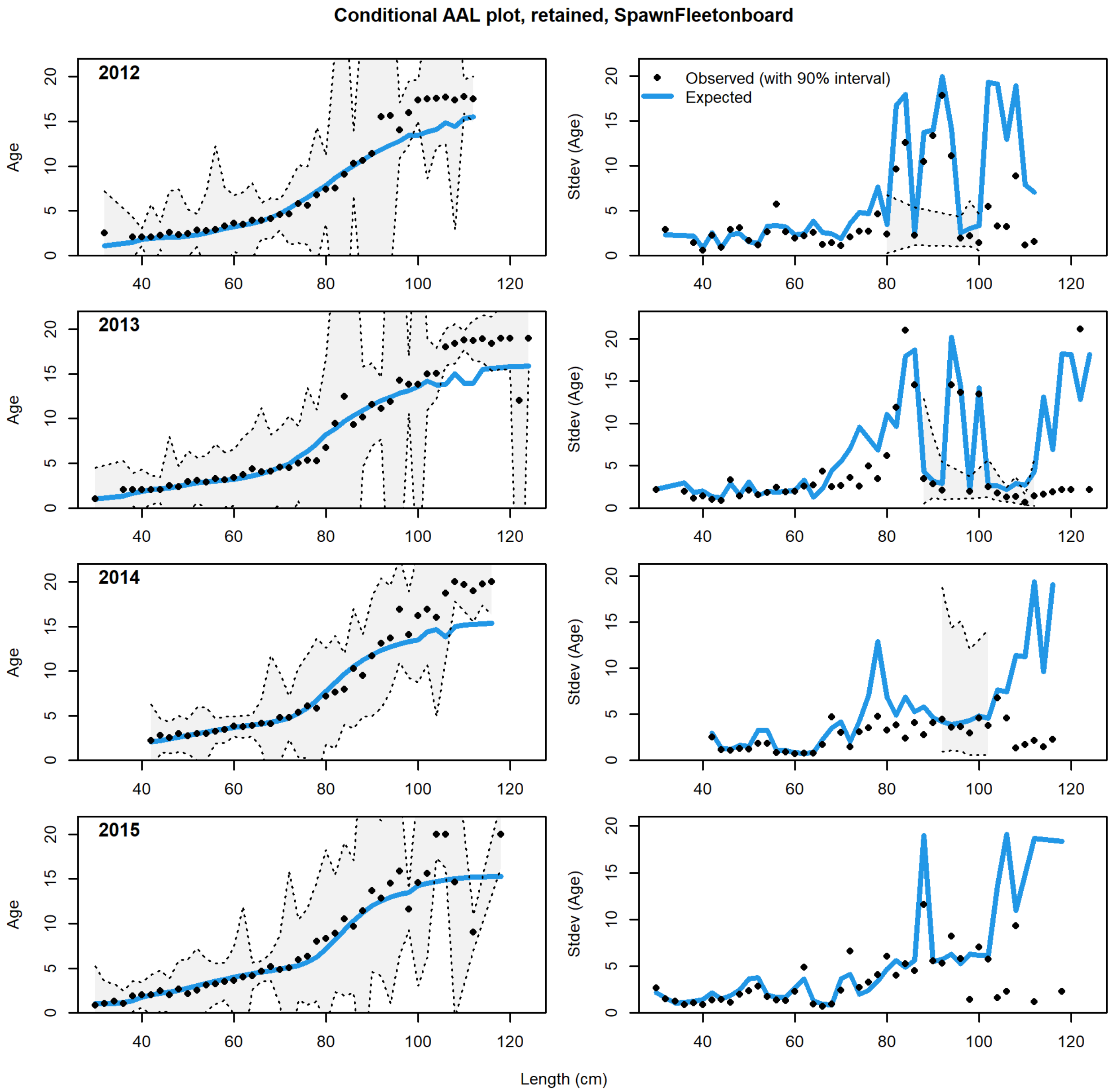
Conditional AAL plot, retained, NonSpawnFleetonboard
1988
1989
1991
1992
Age
Stdev (Age)
Observed (with 90% interval)
Expected
Length (cm)


Conditional AAL plot, retained, NonSpawnFleetonboard
1984
1985
1986
1987
Age
Stdev (Age)
Observed (with 90% interval)
Expected
Length (cm)

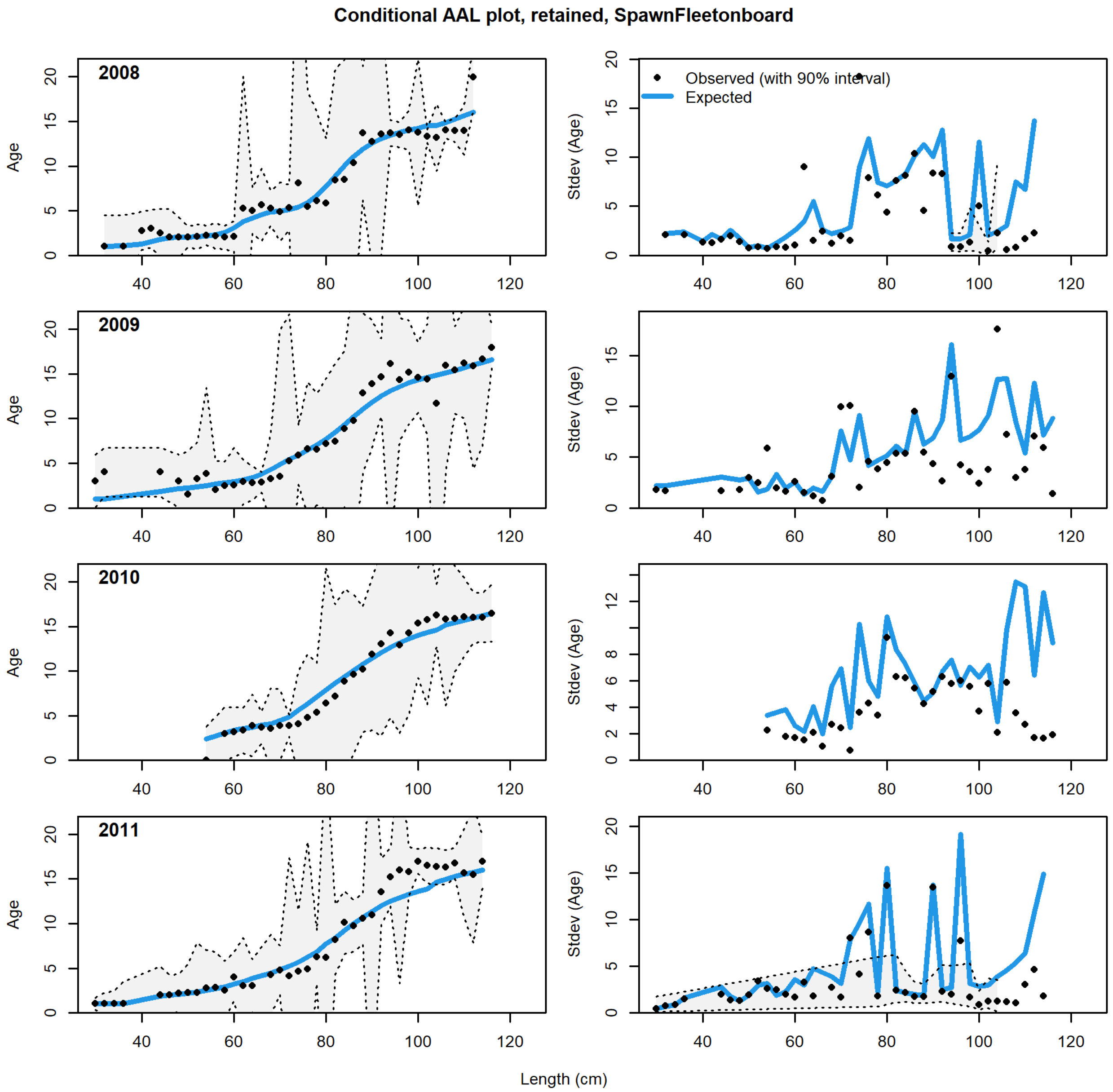


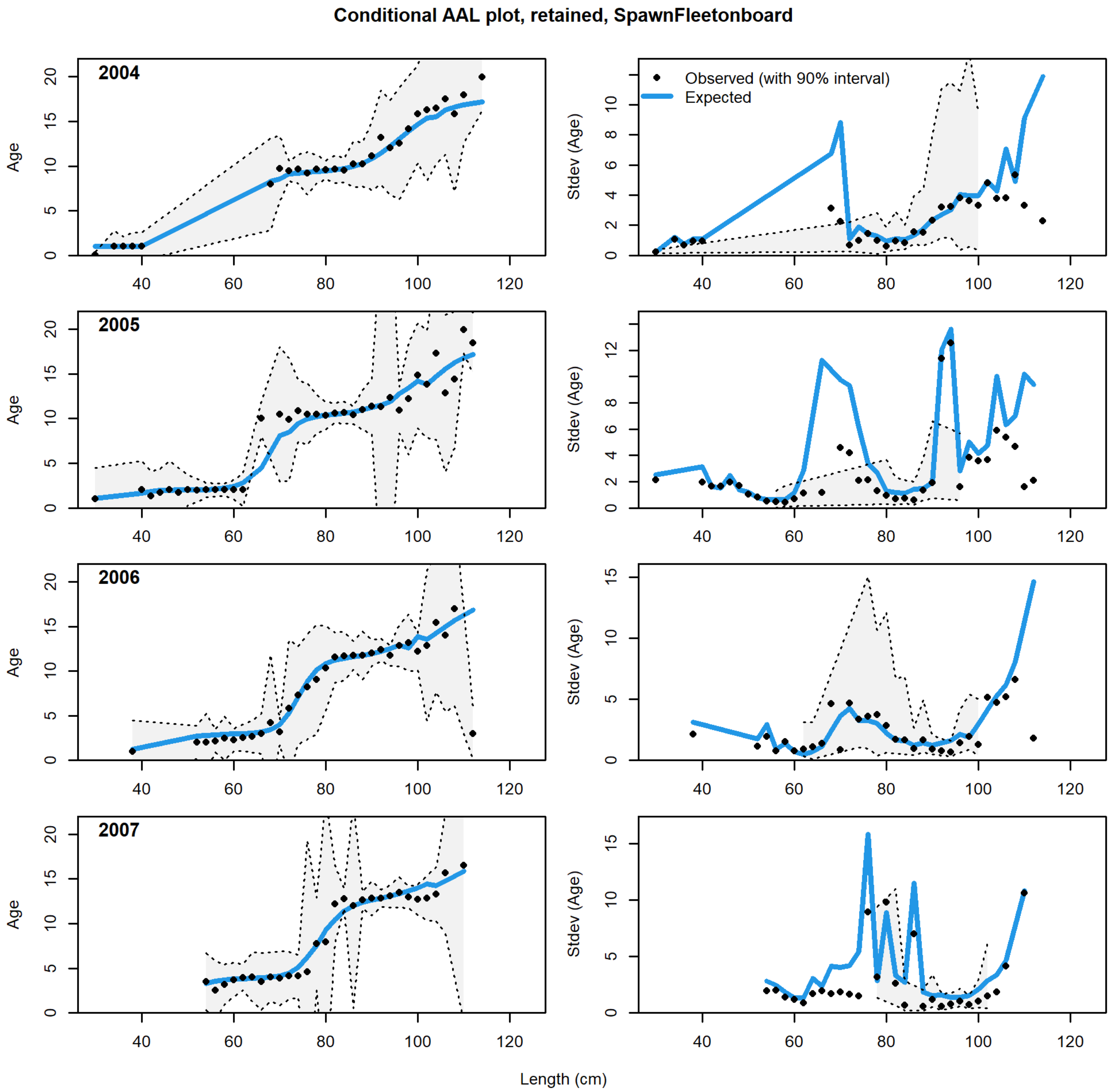
Conditional AAL plot, retained, SpawnFleetonboard
2020
Age
Stdev (Age)
Observed (with 90% interval)
Expected
Length (cm)

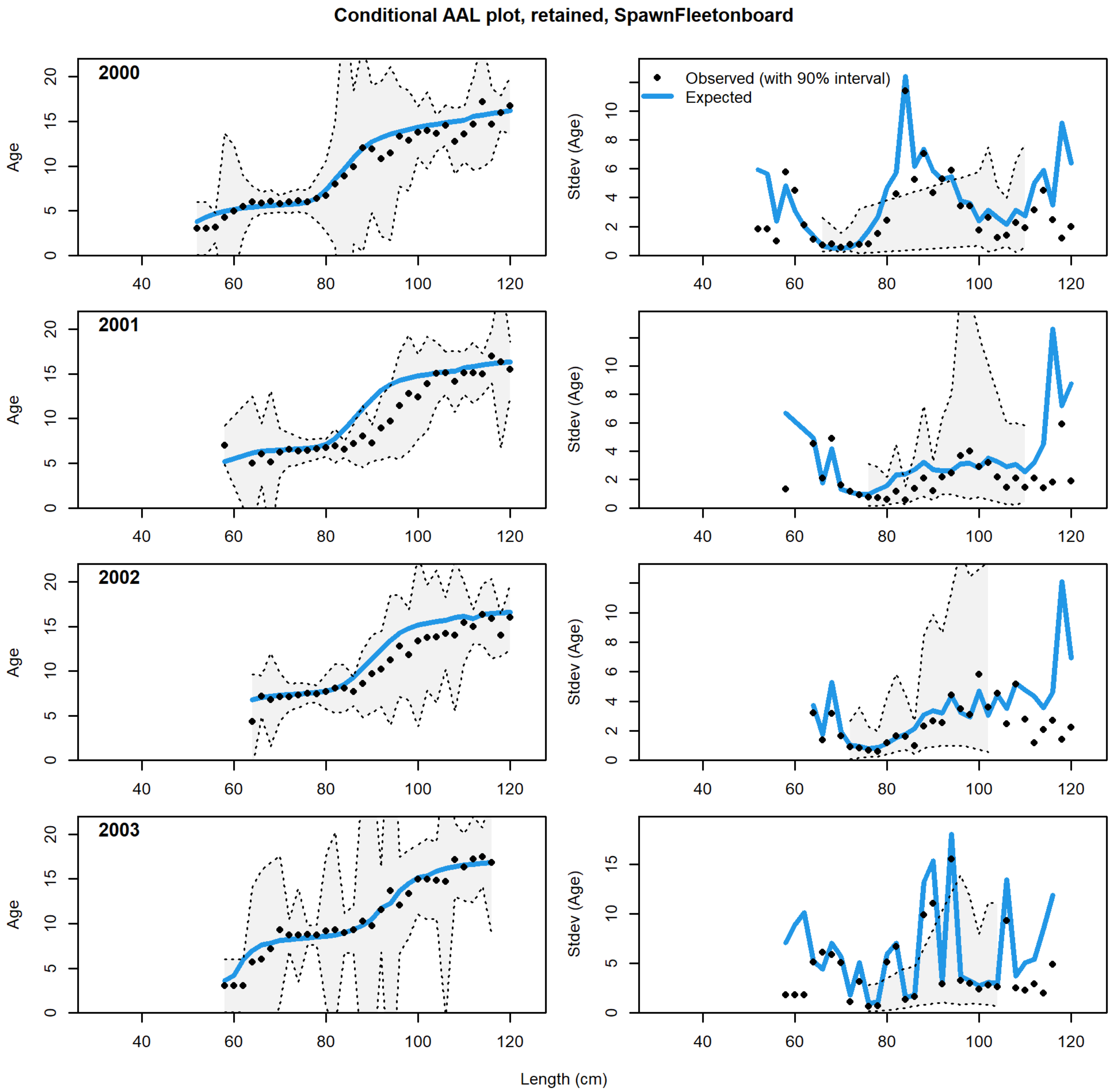

Conditional AAL plot, retained, SpawnFleetonboard
2016
2017
2018
2019
Age
Stdev (Age)
Observed (with 90% interval)
Expected
Length (cm)
0
5
10
15
20
40
60
80
100
120



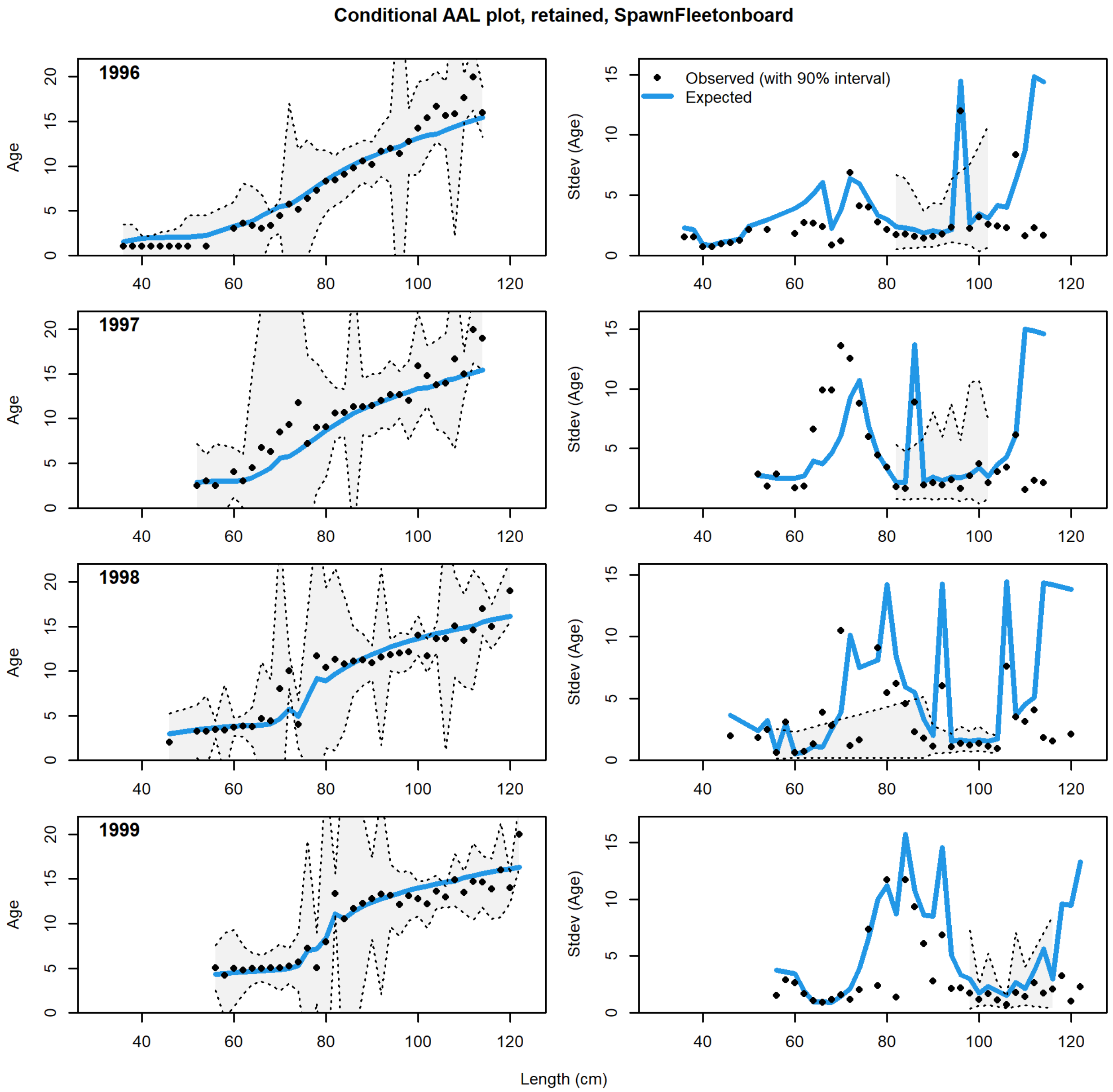
Conditional AAL plot, retained, SpawnFleetonboard
2012
2013
2014
2015
Age
Stdev (Age)
Observed (with 90% interval)
Expected
Length (cm)

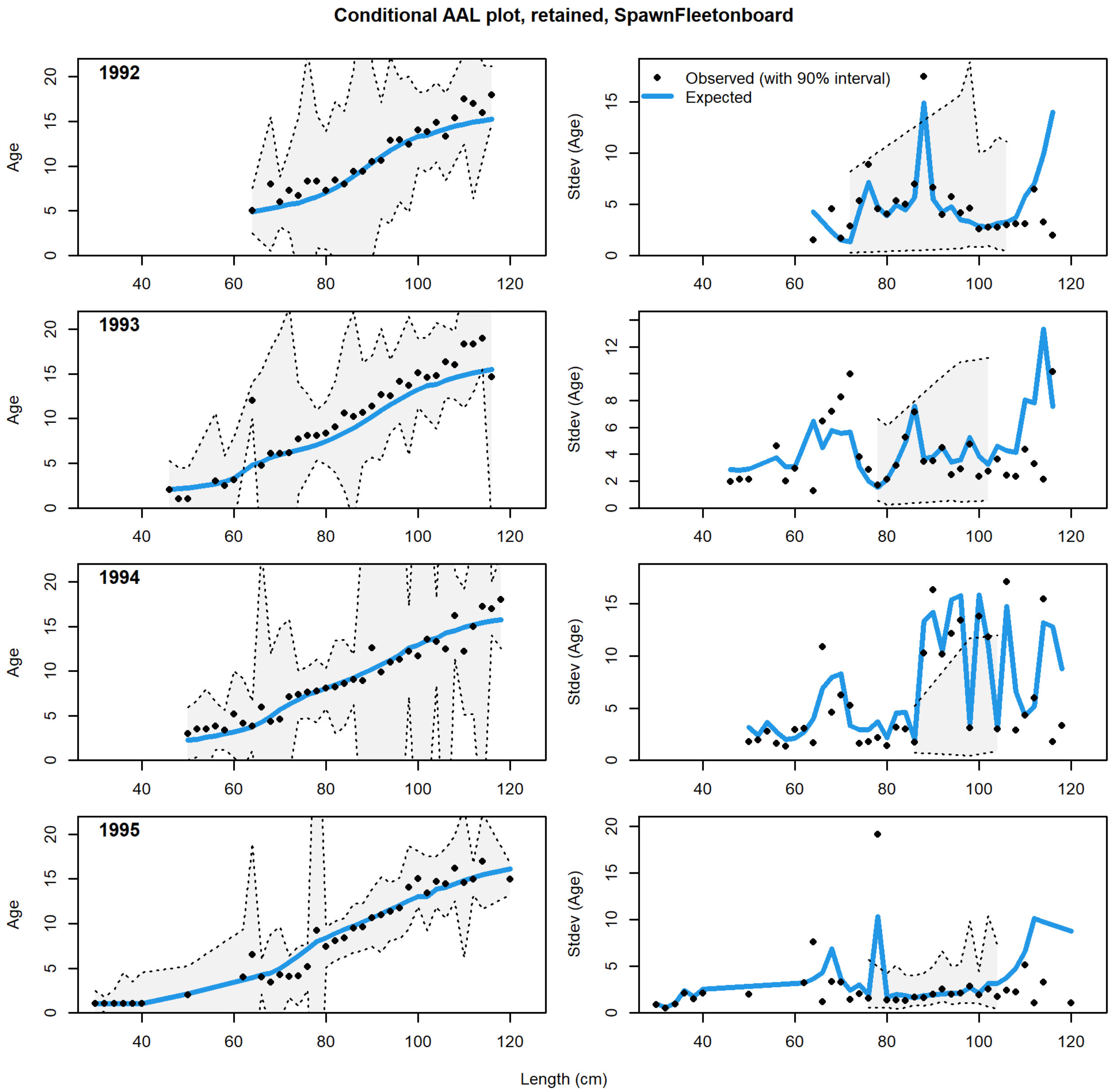

Conditional AAL plot, retained, SpawnFleetonboard
2008
2009
2010
2011
Age
Stdev (Age)
Observed (with 90% interval)
Expected
Length (cm)


Conditional AAL plot, retained, SpawnFleetonboard
2004
2005
2006
2007
Age
Stdev (Age)
Observed (with 90% interval)
Expected
Length (cm)



Conditional AAL plot, retained, SpawnFleetonboard
2000
2001
2002
2003
Age
Stdev (Age)
Observed (with 90% interval)
Expected
Length (cm)


Conditional AAL plot, retained, SpawnFleetonboard
1996
1997
1998
1999
Age
Stdev (Age)
Observed (with 90% interval)
Expected
Length (cm)



Conditional AAL plot, retained, SpawnFleetonboard
1992
1993
1994
1995
Age
Stdev (Age)
Observed (with 90% interval)
Expected
Length (cm)

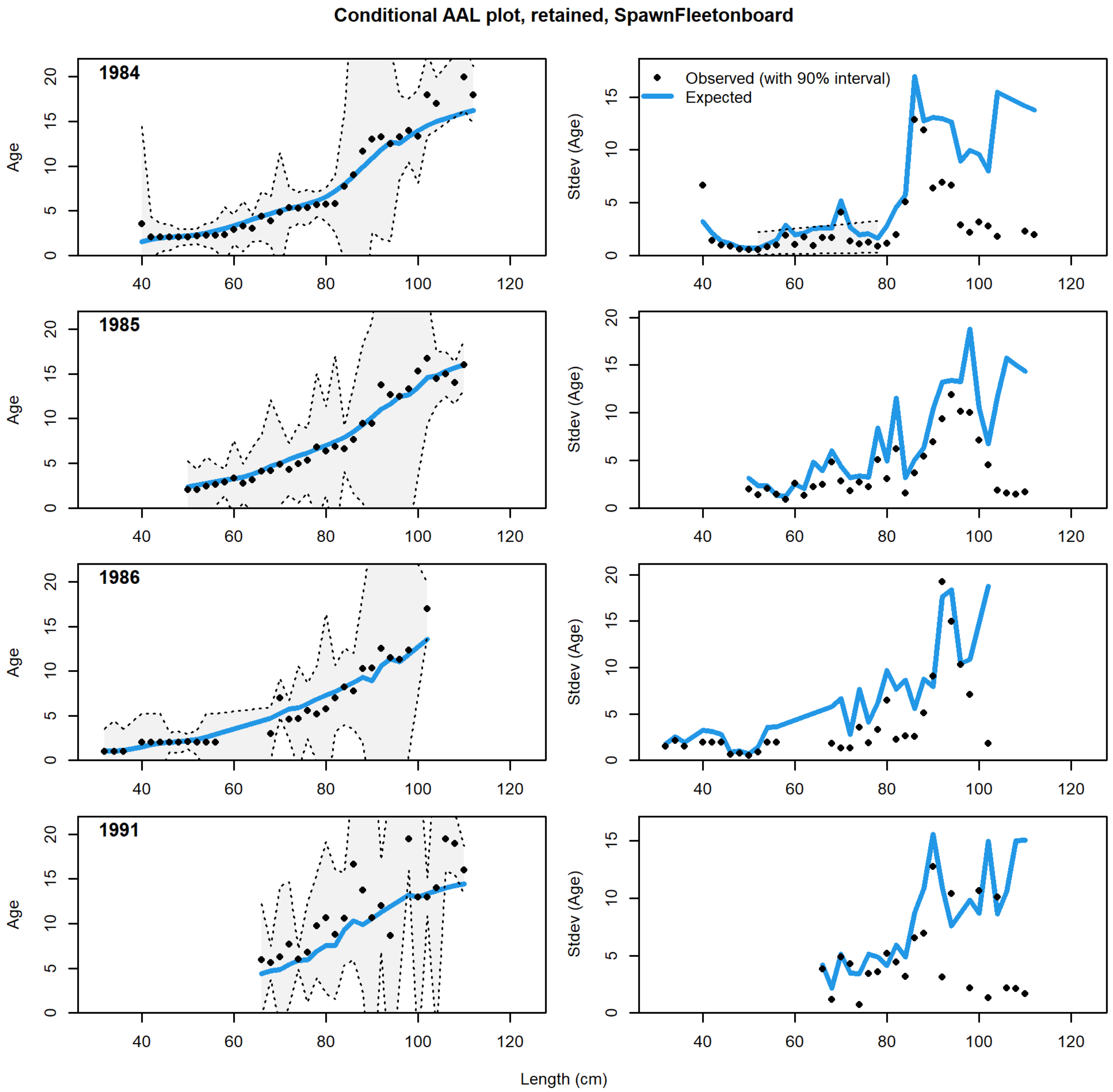


Figure 5.29. Fits to conditional age at length data.

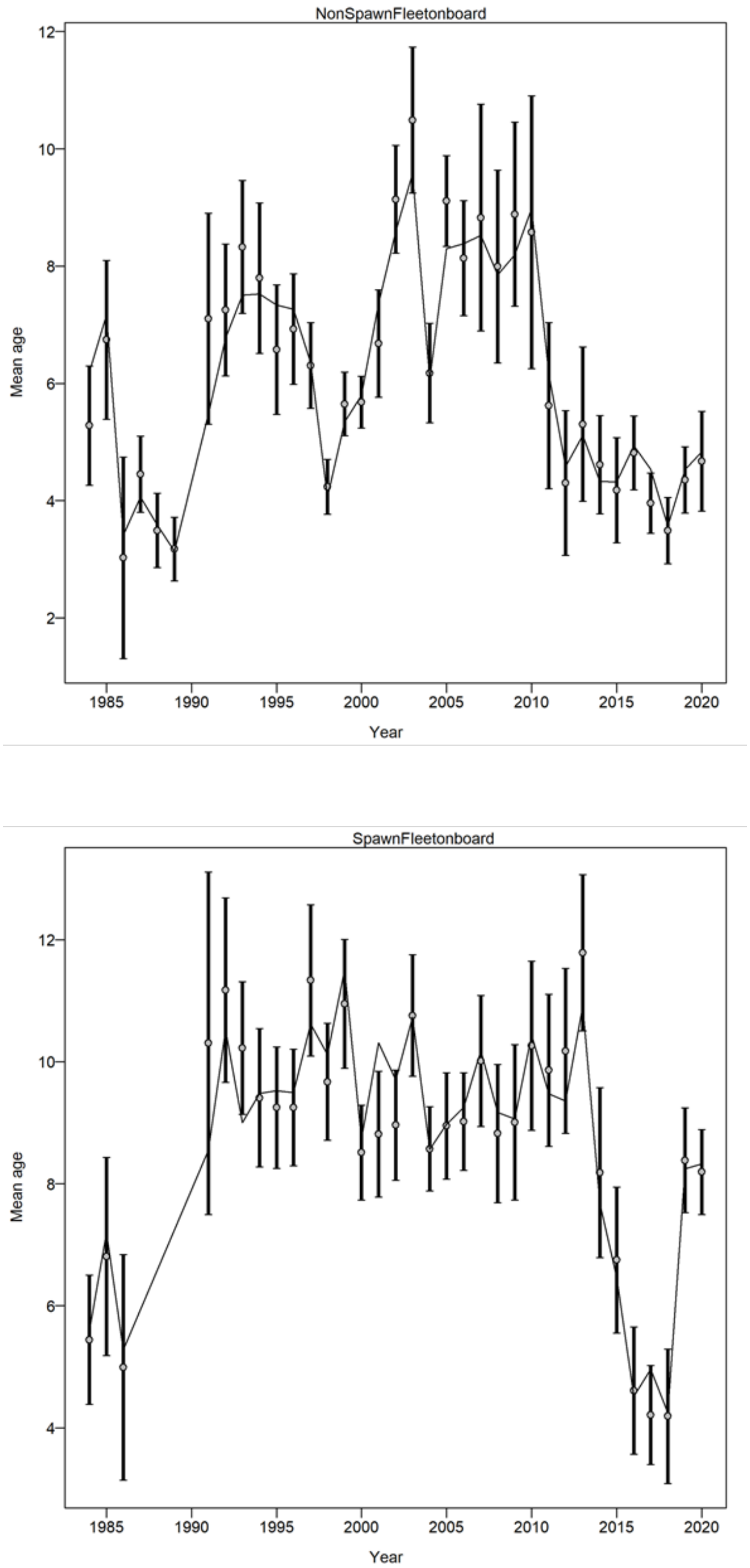
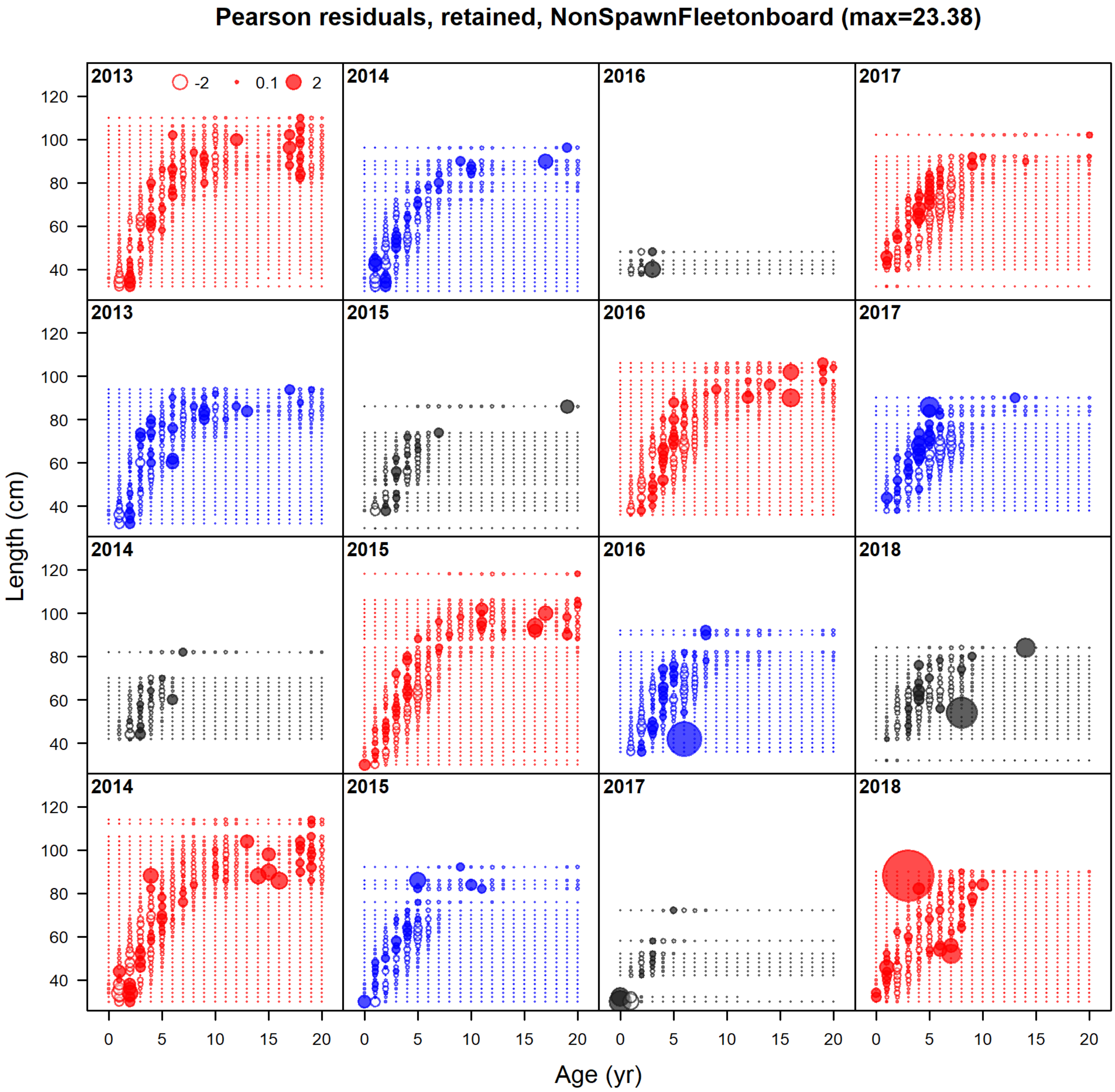
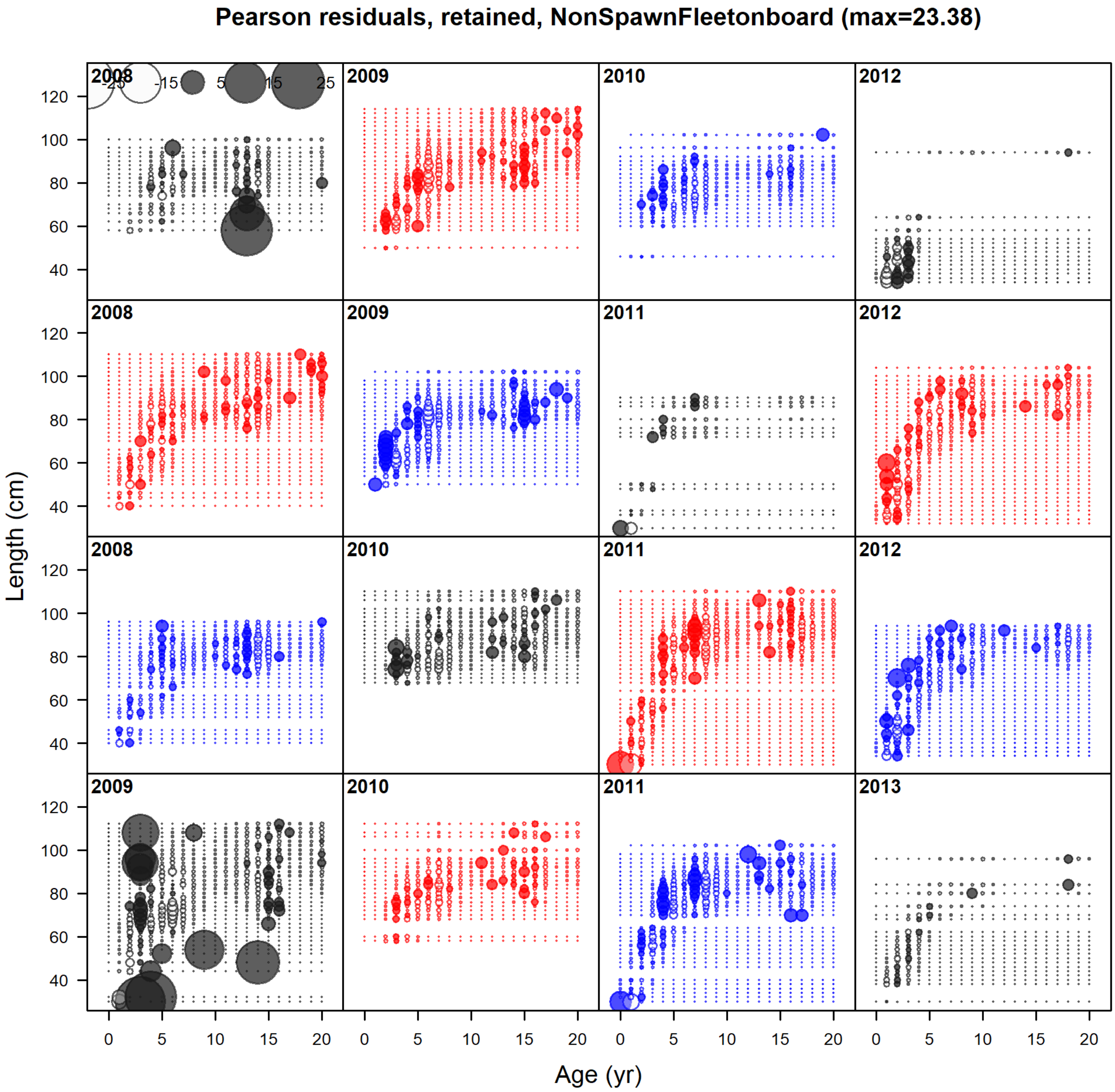
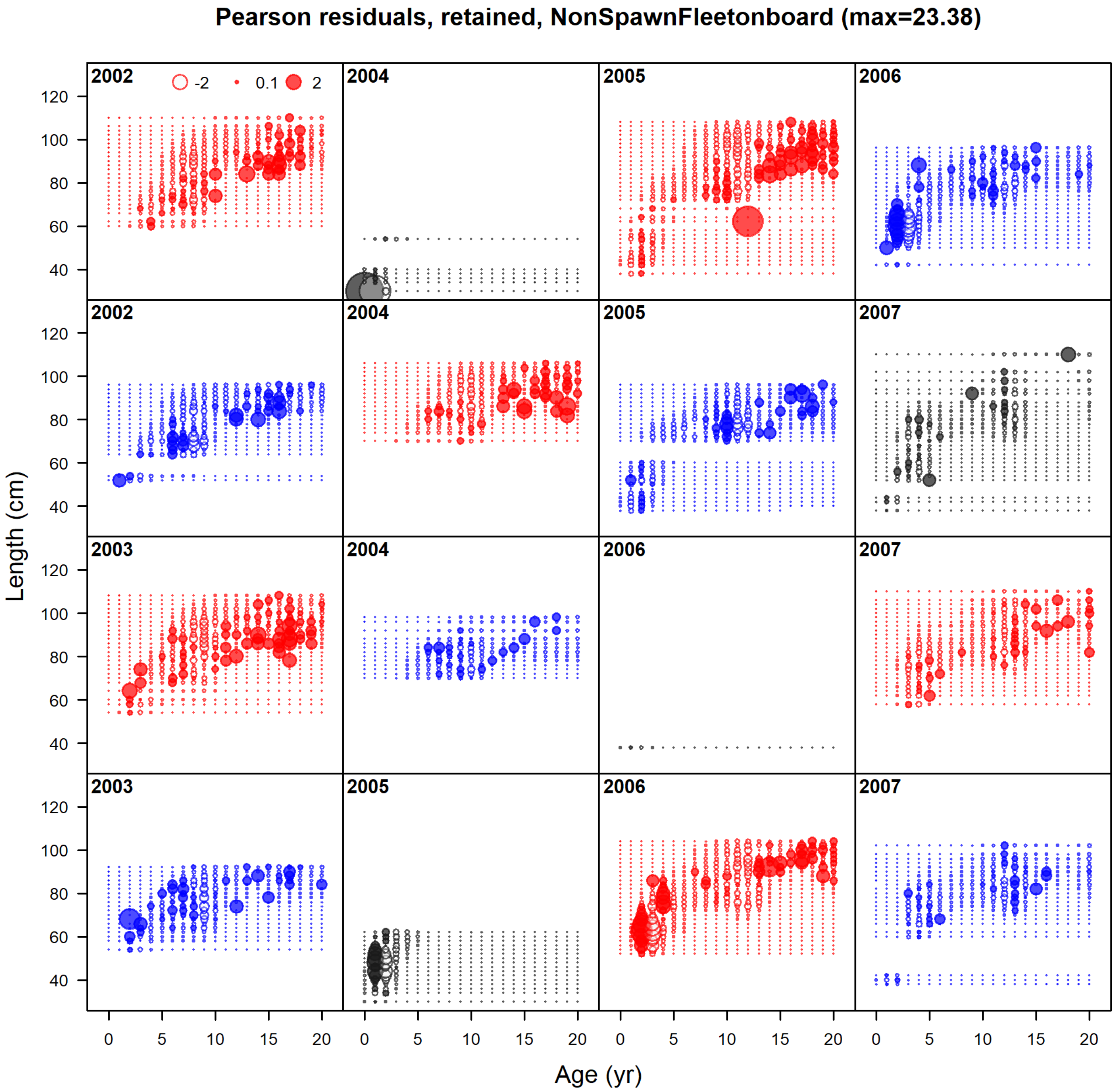


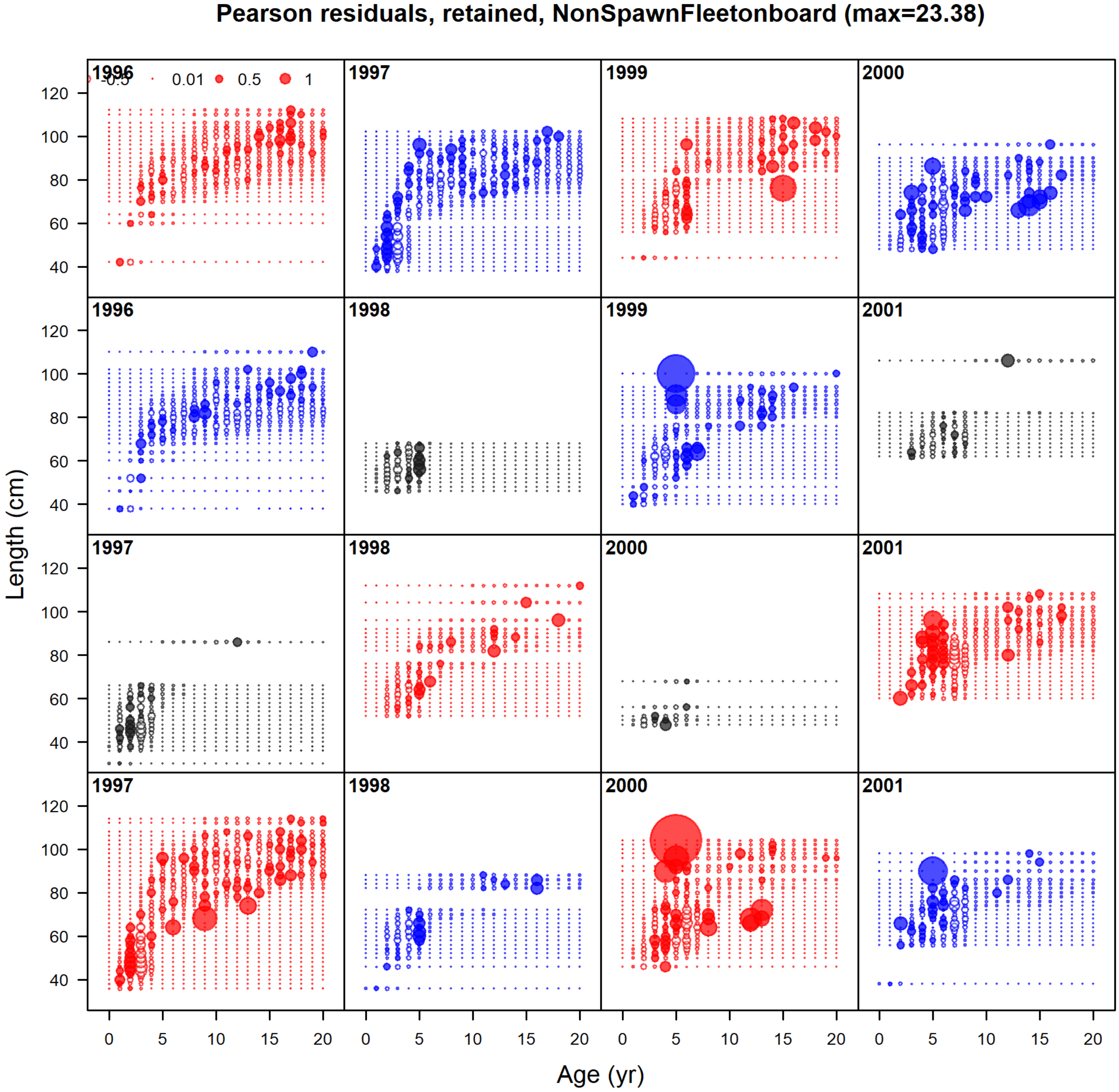
Figure 5.30. Data weighting of conditional age at length data for the onboard non spawning and spawning fleets.

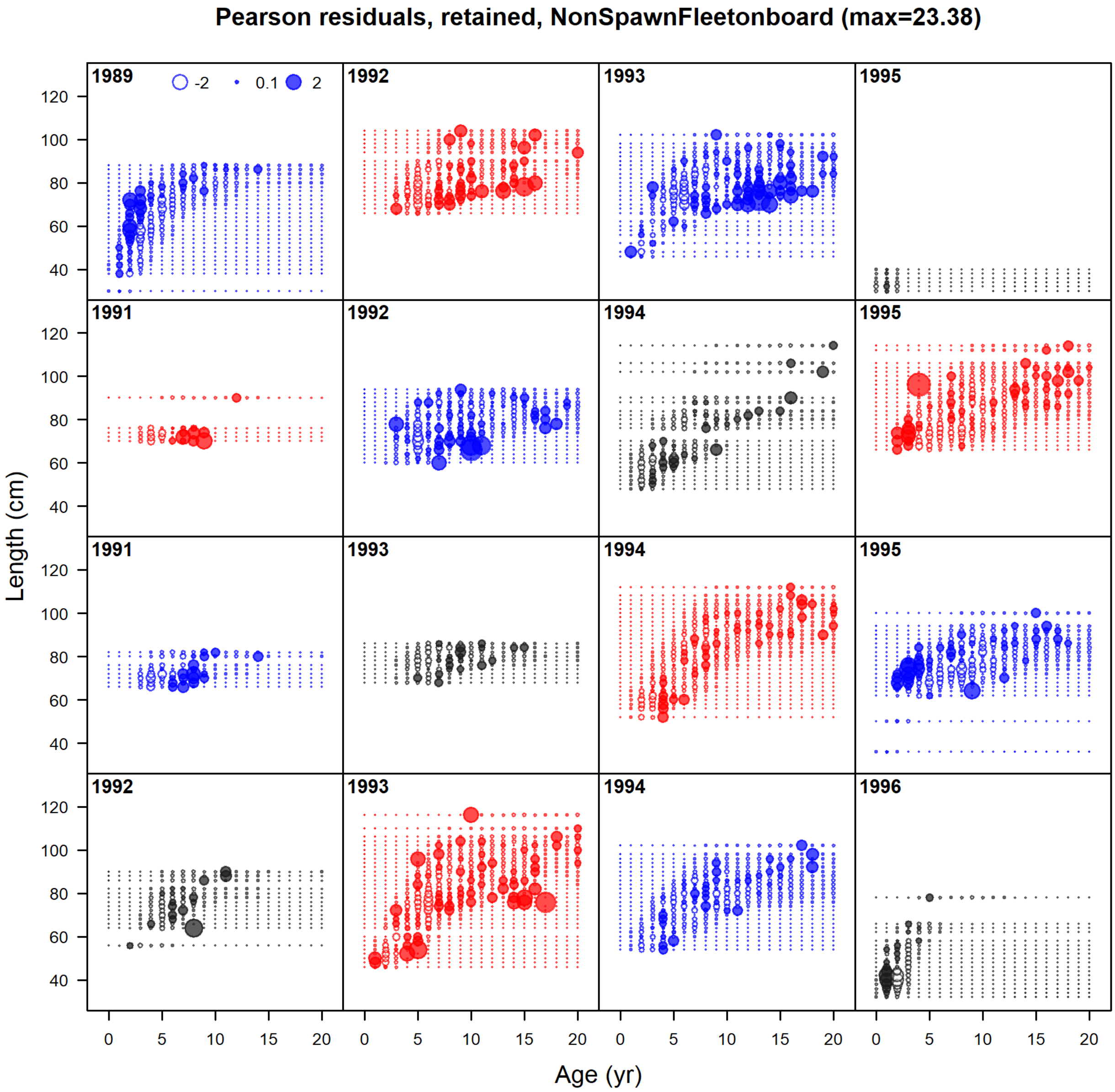

Pearson residuals, retained, NonSpawnFleetonboard (max=23.38)
2013
-2
0.1
2
2014
2016
2017
2013
2015
2016
2017
2014
2015
2016
2018
2014
2015
2017
2018
Length (cm)
Age (yr)

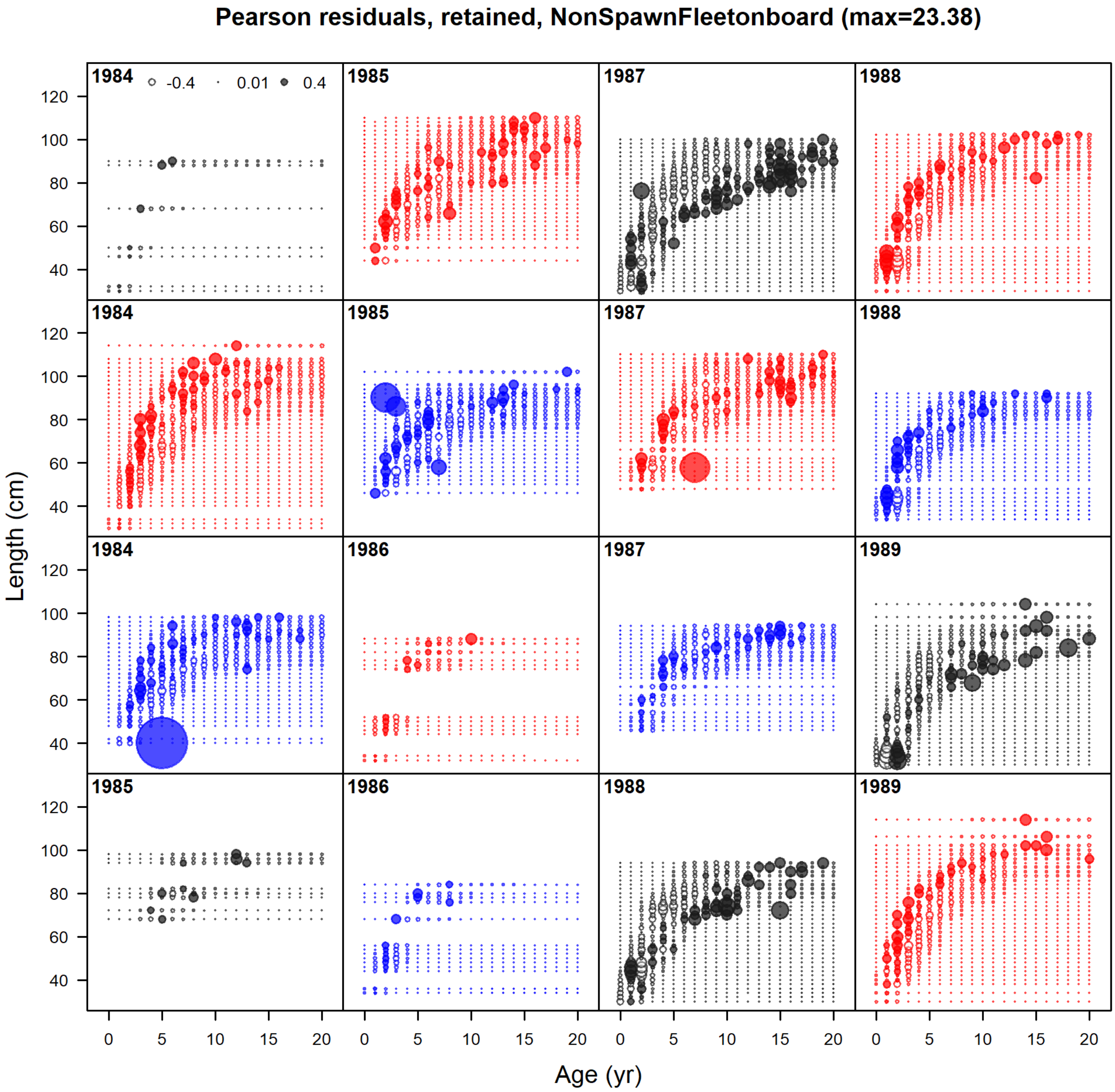


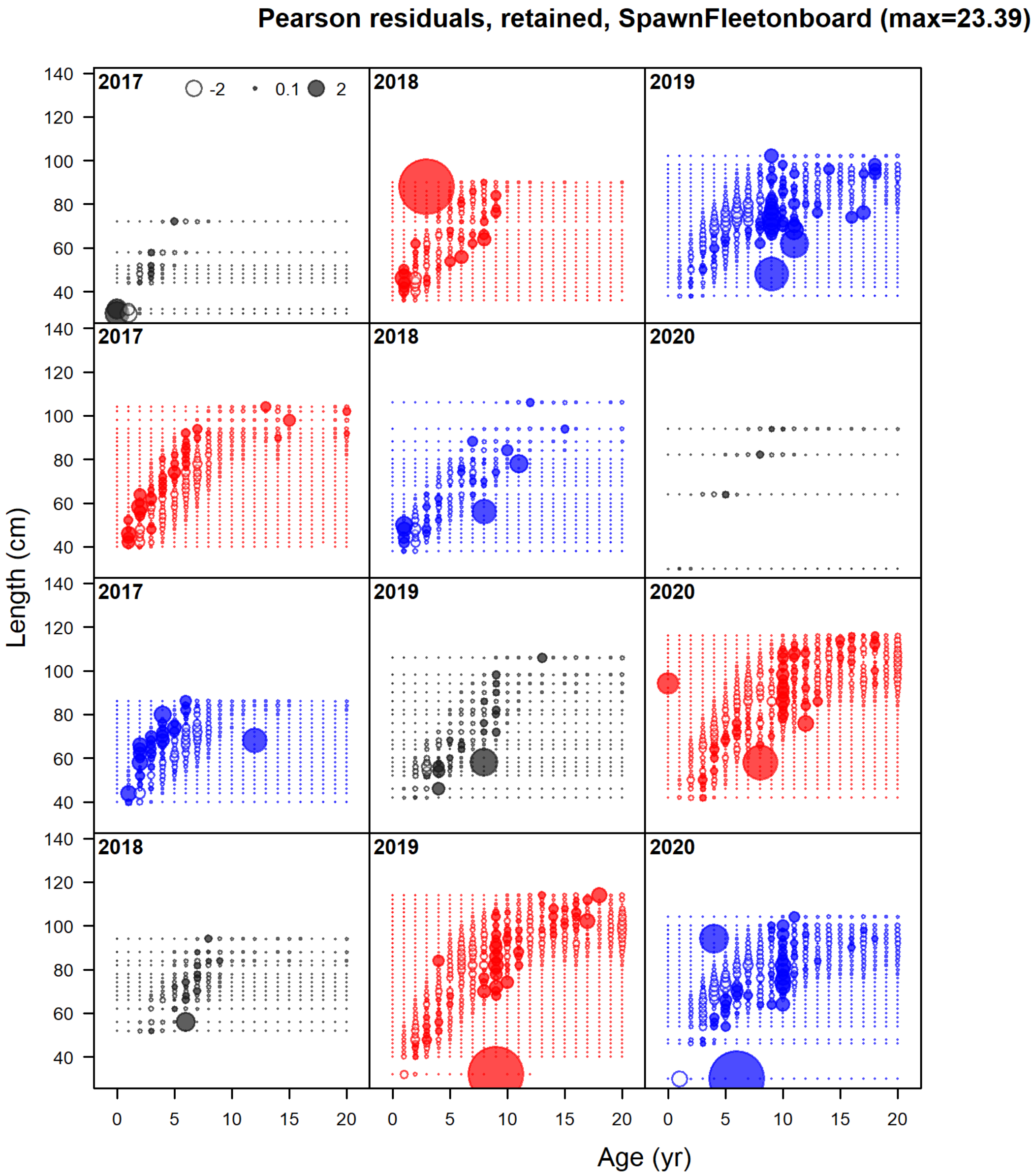
Pearson residuals, retained, NonSpawnFleetonboard (max=23.38)
-25
-15
5
15
25
2008
2009
2010
2012
2008
2009
2011
2012
2008
2010
2011
2012
2009
2010
2011
2013
Length (cm)
Age (yr)

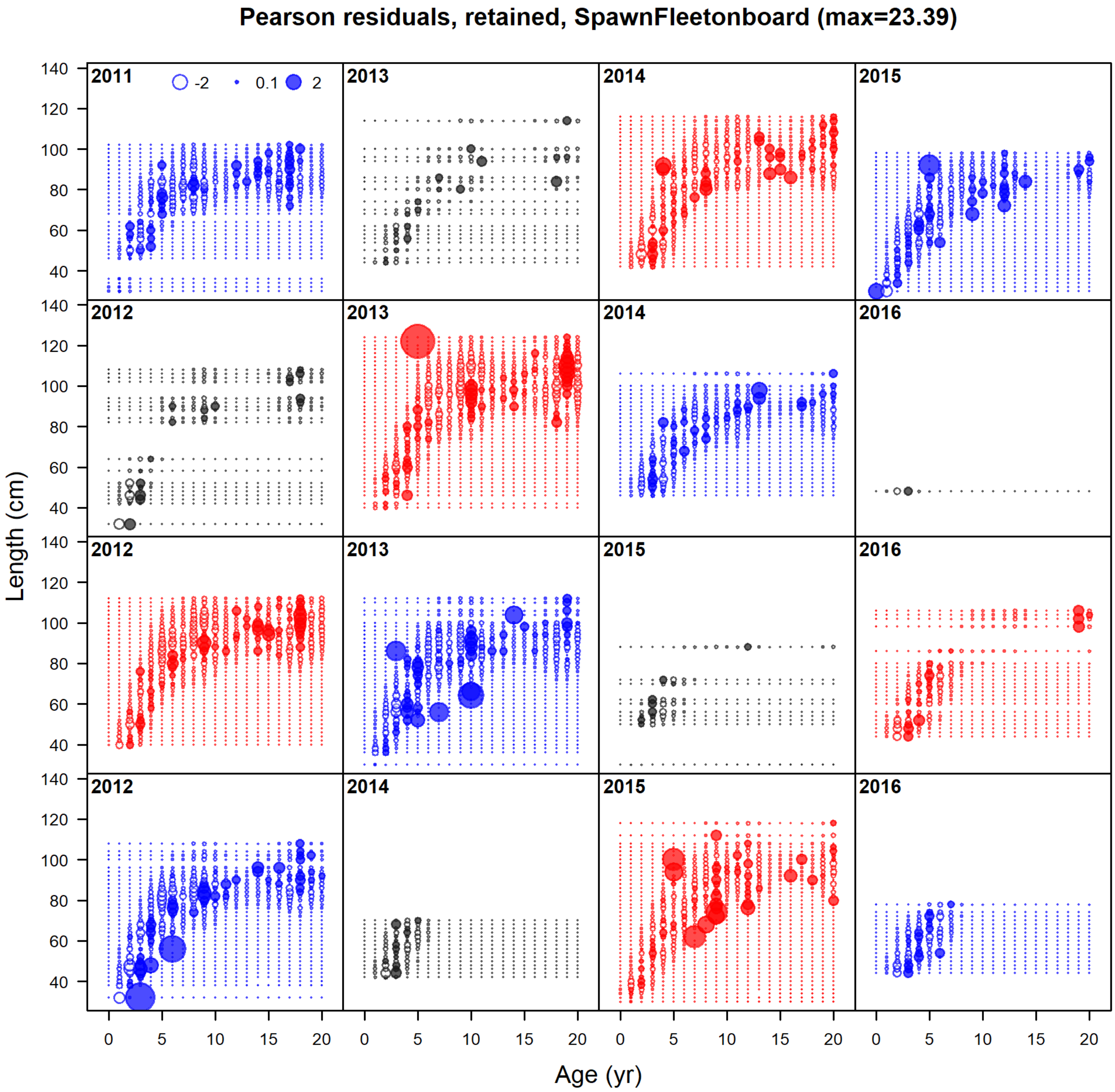

Pearson residuals, retained, NonSpawnFleetonboard (max=23.38)
2002
-2
0.1
2
2004
2005
2006
2002
2004
2005
2007
2003
2004
2006
2007
2003
2005
2006
2007
Length (cm)
Age (yr)

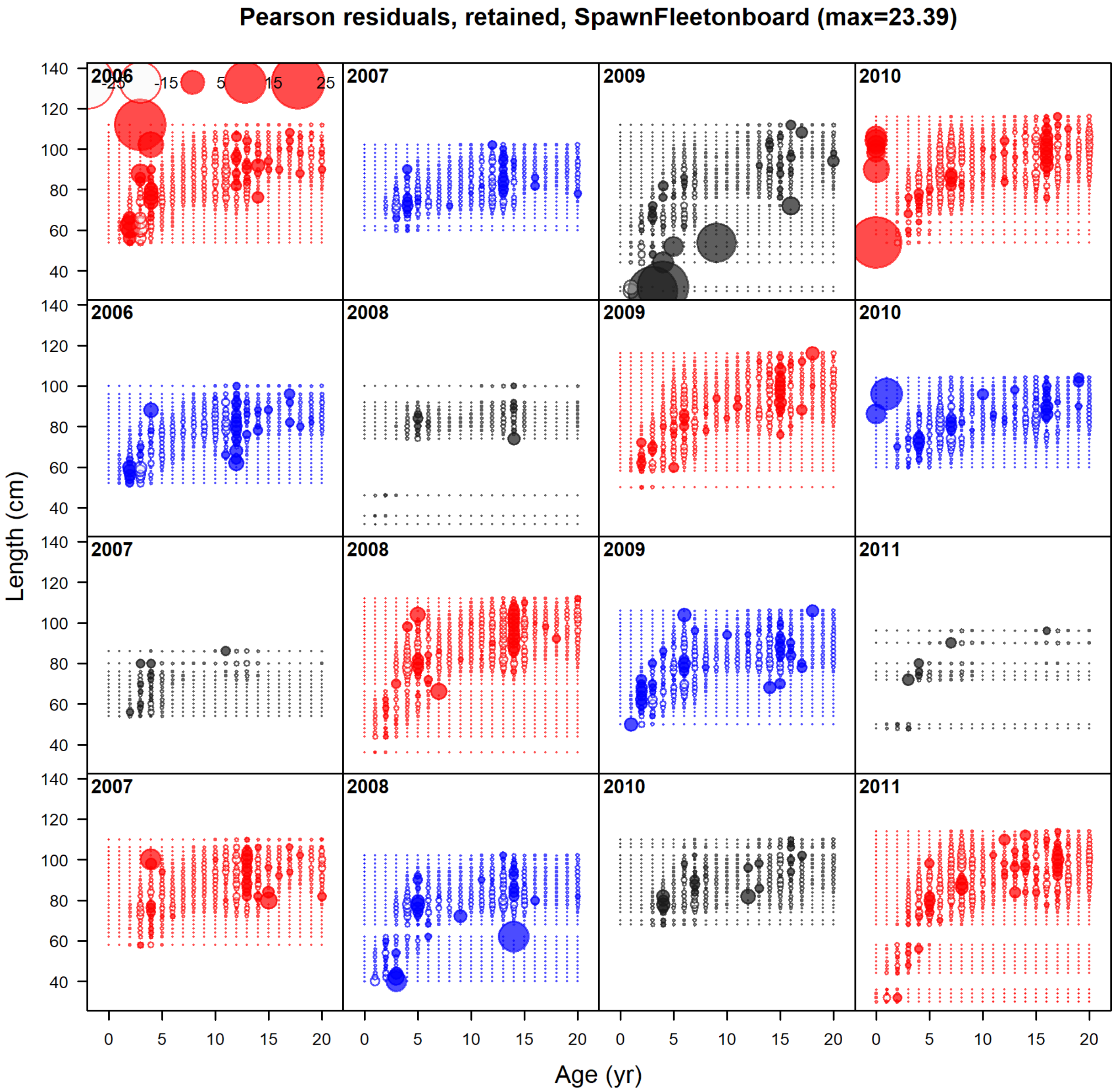

Pearson residuals, retained, NonSpawnFleetonboard (max=23.38)
-0.5
0.01
0.5
1
1996
1997
1999
2000
1996
1998
1999
2001
1997
1998
2000
2001
1997
1998
2000
2001
120
100
80
60
40
Length (cm)
0
5
10
15
20
Age (yr)

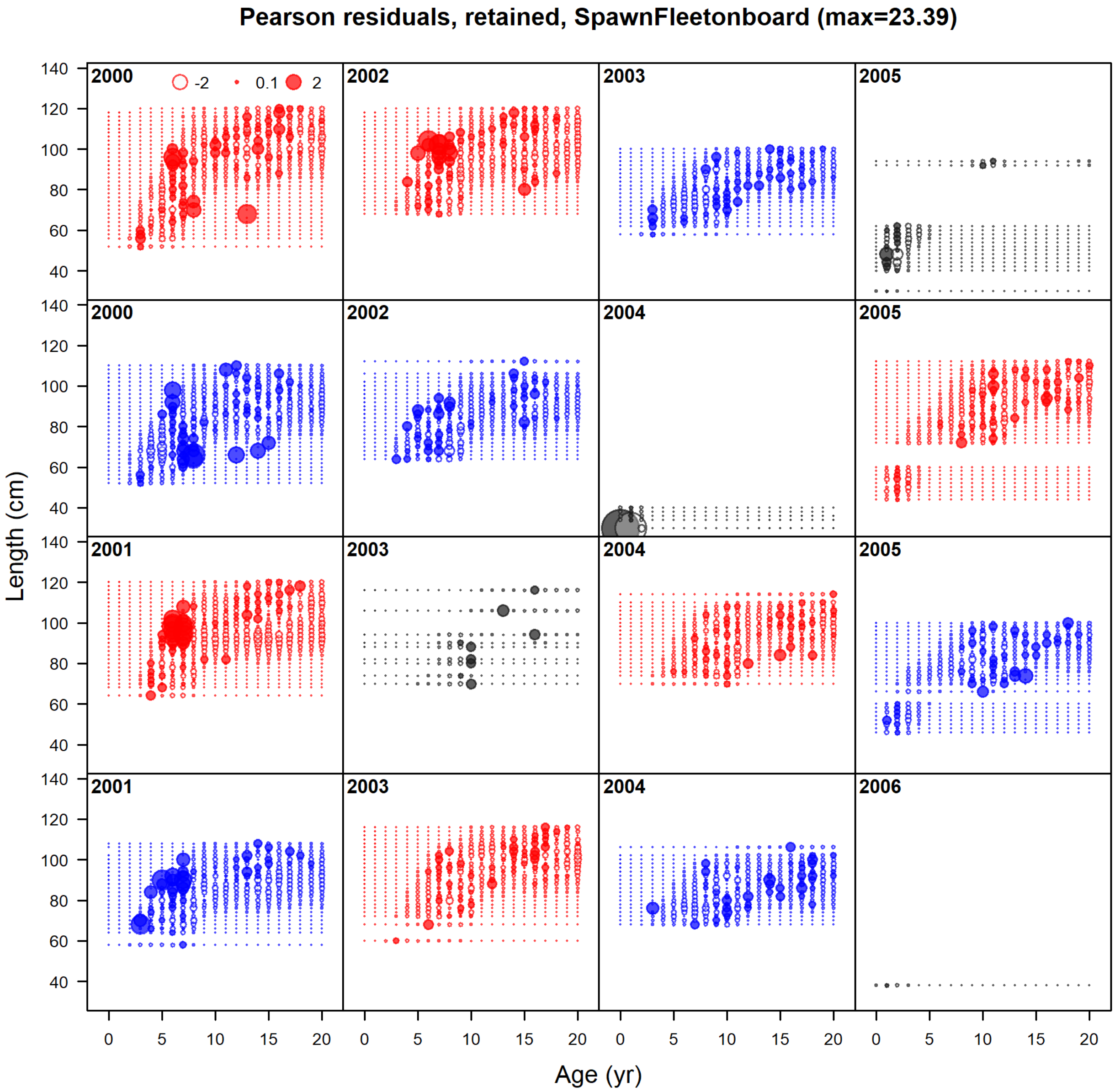

Pearson residuals, retained, NonSpawnFleetonboard (max=23.38)
1989
-2
0.1
2
1992
1993
1995
1991
1992
1994
1995
1991
1993
1994
1995
1992
1993
1994
1996
Length (cm)
Age (yr)

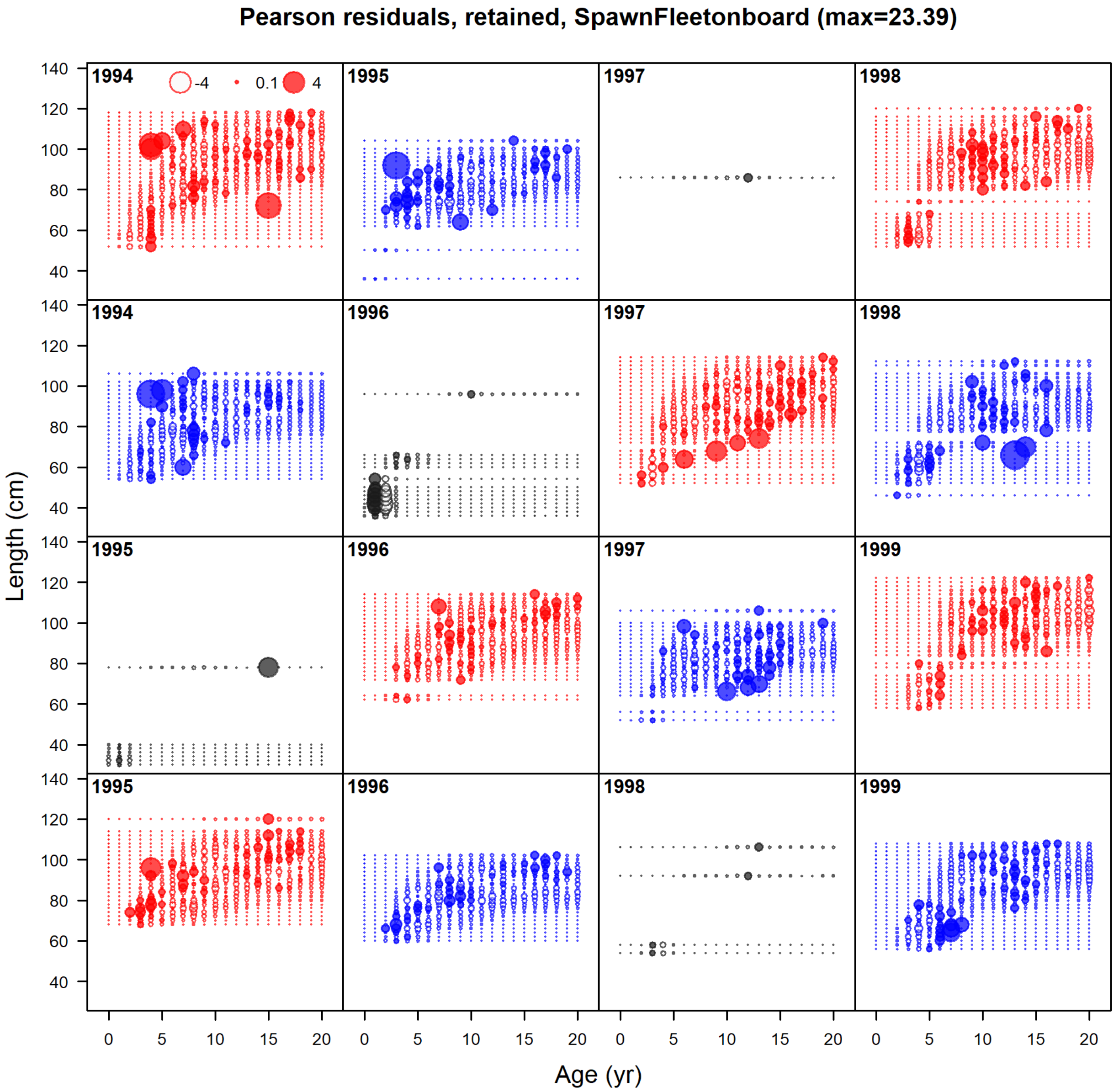

Pearson residuals, retained, NonSpawnFleetonboard (max=23.38)
1984
-0.4
0.01
0.4
1985
1987
1988
1984
1985
1987
1988
1984
1986
1987
1989
1985
1986
1988
1989
Length (cm)
Age (yr)
120
100
80
60
40
0
5
10
15
20

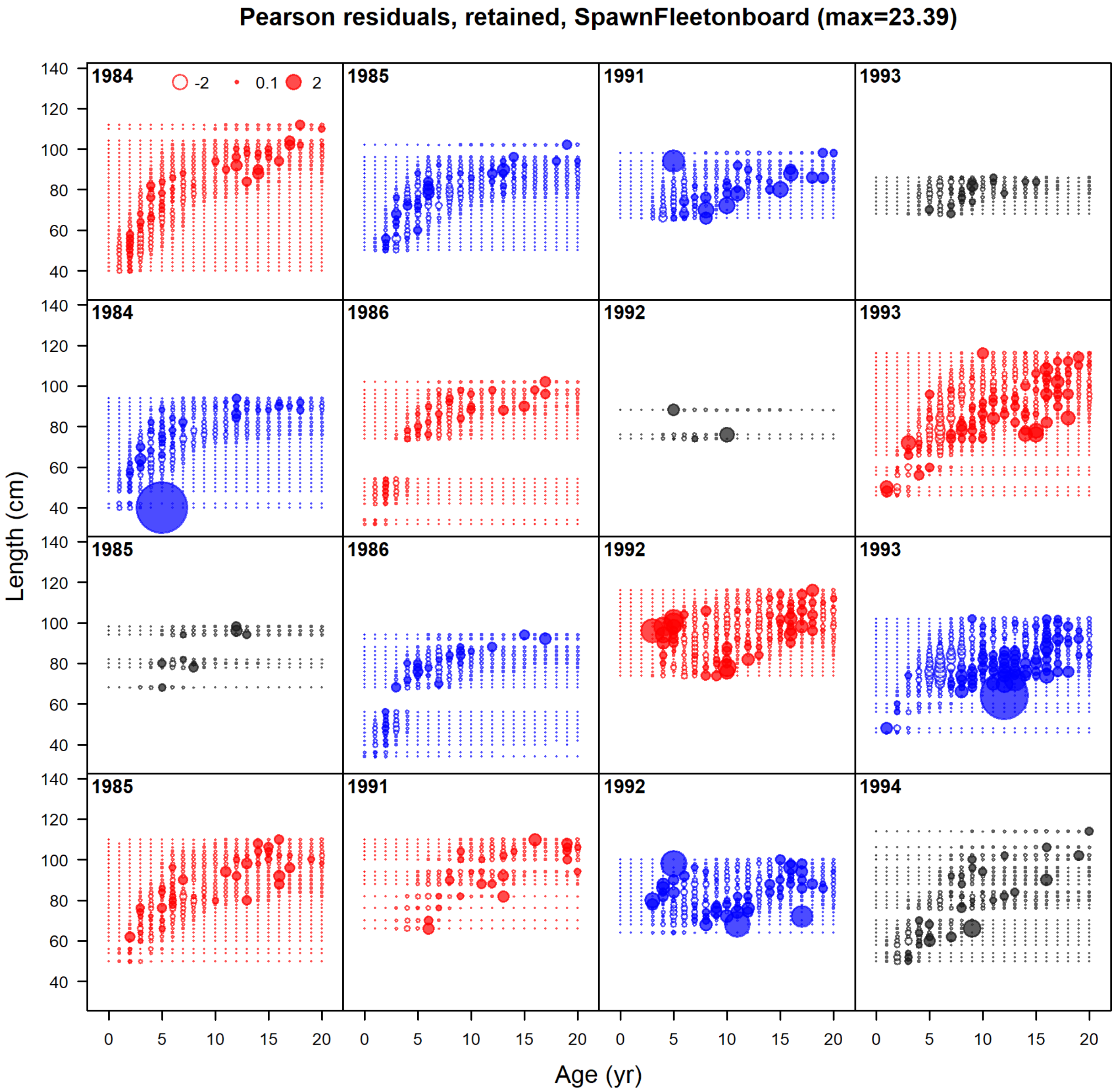

Pearson residuals, retained, SpawnFleetonboard (max=23.39)
-2
0.1
2
2017
2018
2019
2017
2018
2020
2017
2019
2020
2018
2019
2020
Length (cm)
Age (yr)
140
120
100
80
60
40
0
5
10
15
20


Pearson residuals, retained, SpawnFleetonboard (max=23.39)
-2
0.1
2
2011
2013
2014
2015
2012
2013
2014
2016
2012
2013
2015
2016
2012
2014
2015
2016
Length (cm)
Age (yr)


Pearson residuals, retained, SpawnFleetonboard (max=23.39)
-25
-15
5
15
25
2006
2007
2009
2010
2006
2008
2009
2010
2007
2008
2009
2011
2007
2008
2010
2011
Length (cm)
Age (yr)


Pearson residuals, retained, SpawnFleetonboard (max=23.39)
-2
0.1
2
2000
2002
2003
2005
2000
2002
2004
2005
2001
2003
2004
2005
2001
2003
2004
2006
Length (cm)
Age (yr)
140
120
100
80
60
40
0
5
10
15
20


Pearson residuals, retained, SpawnFleetonboard (max=23.39)
-4
0.1
4
1994
1995
1997
1998
1994
1996
1997
1998
1995
1996
1997
1999
1995
1996
1998
1999
Length (cm)
Age (yr)


Pearson residuals, retained, SpawnFleetonboard (max=23.39)
1984
-2
0.1
2
1985
1991
1993
1984
1986
1992
1993
1985
1986
1992
1993
1985
1991
1992
1994
Length (cm)
Age (yr)
140
120
100
80
60
40
0
5
10
15
20

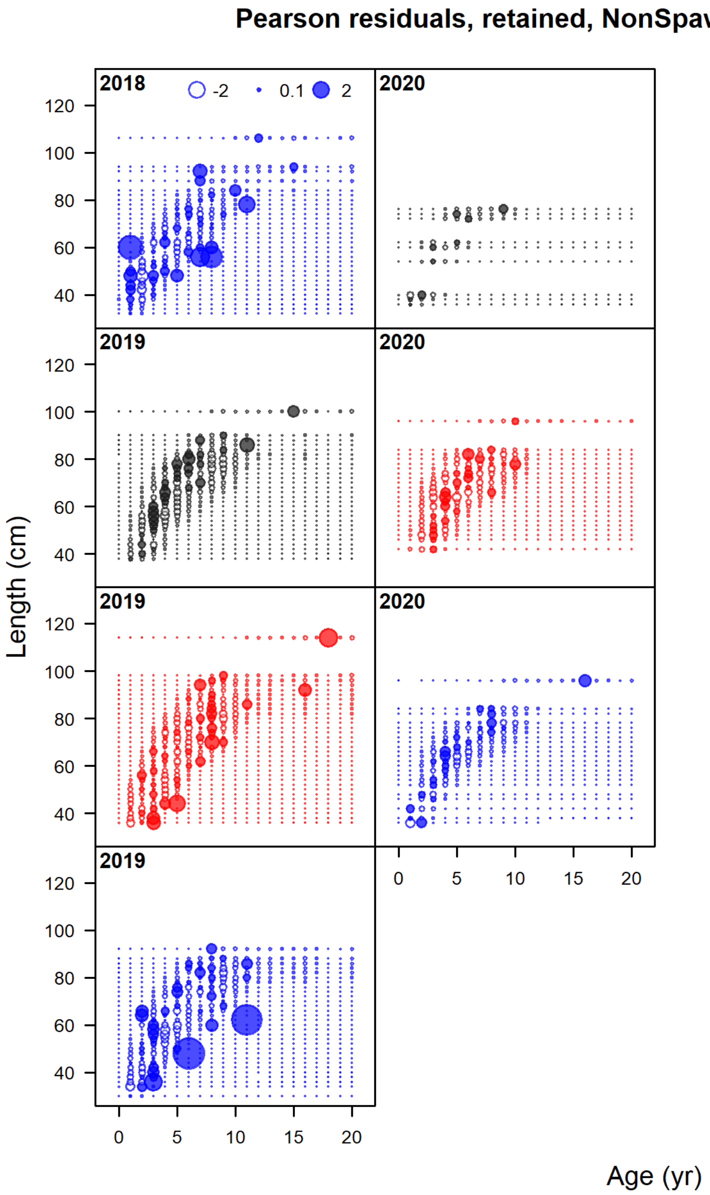


Figure 5.31. Pearson residuals of conditional age at length data.